Beam Formation

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GSI Darmstadt

Ion generators

- Electron Cyclotron Resonance Ion Source ECRIS
- Laser Ion Source LIS
- Liquid Metal Ion Source LMIS
- Electron Beam Ion Source EBIS
- H^- source

Electron Cyclotron Resonance Ion Source ECR

no cathode

effective plasma confinement by magnetic field

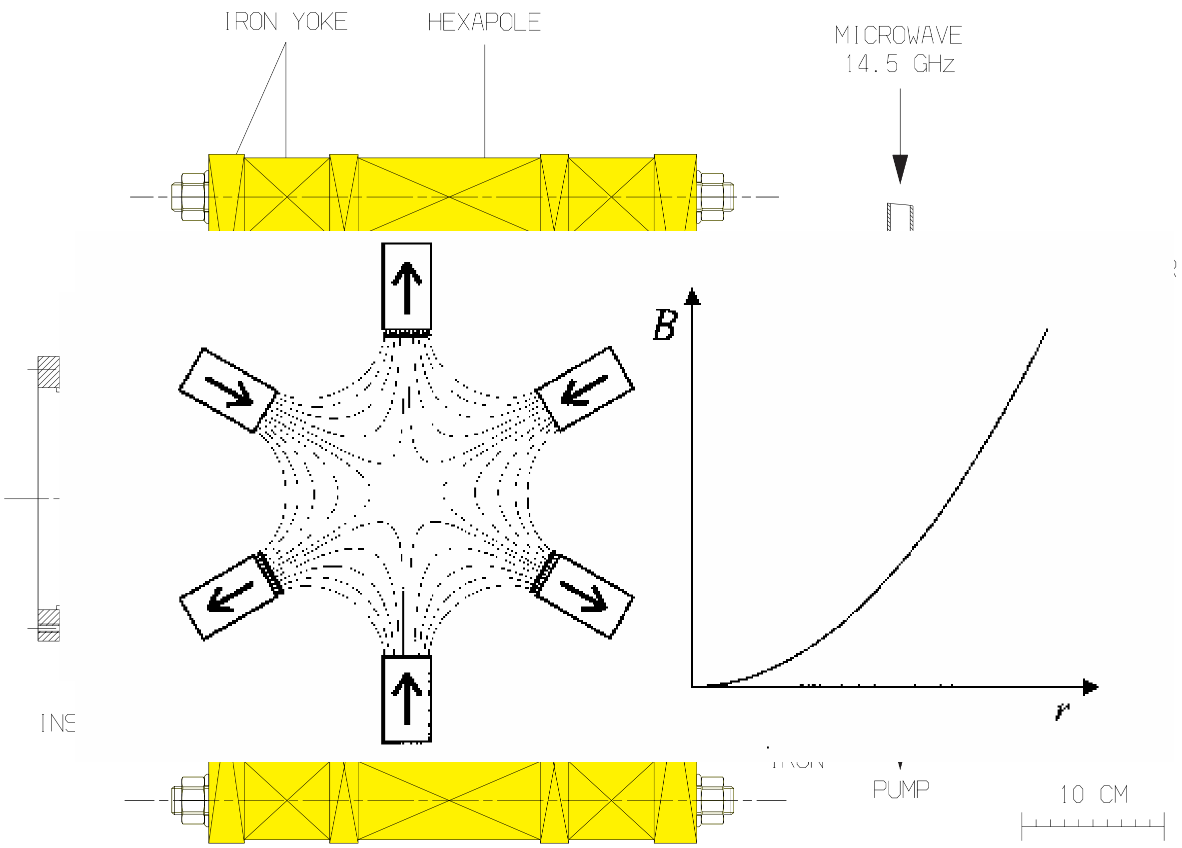
longitudinal solenoidal mirror

transversal hexapolar cusp

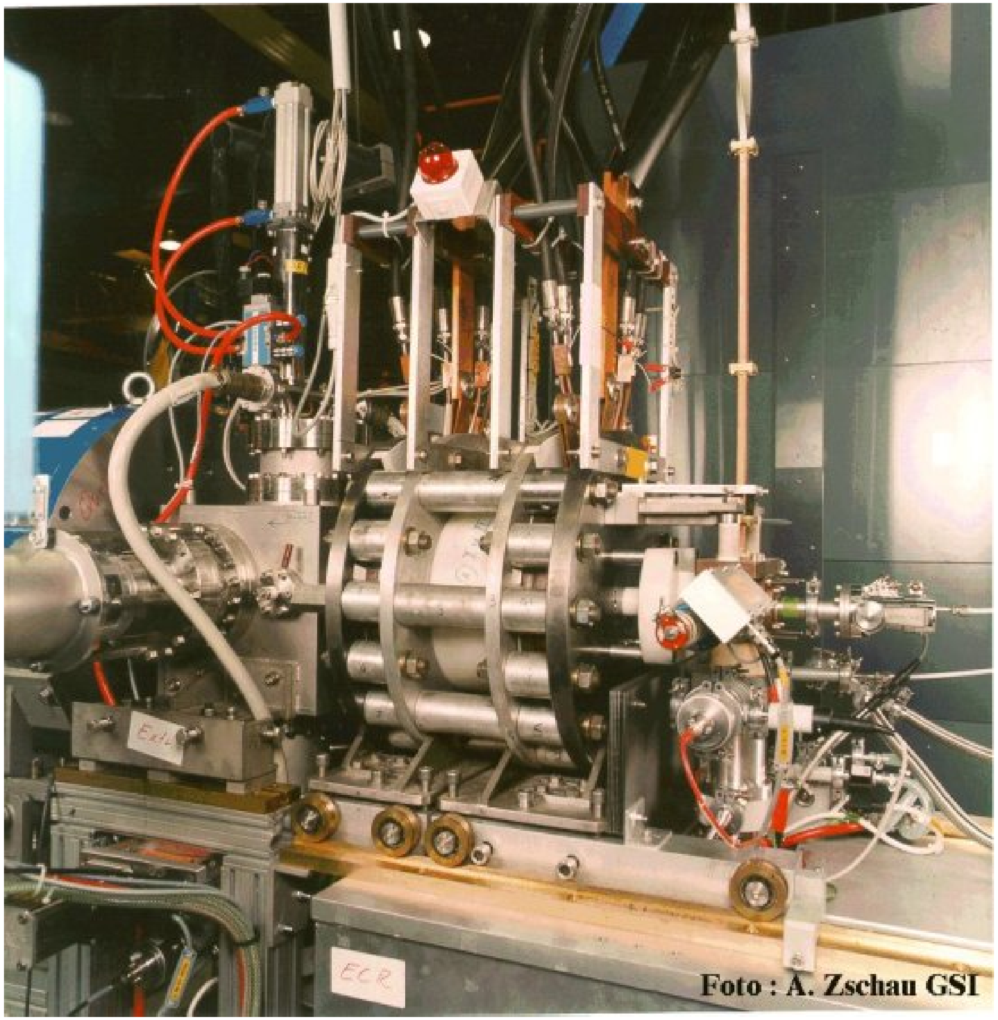
high electron energy (high charge states !) if the resonance condition is fulfilled

$$f\,[GHz] = 28\,|B[T]|$$

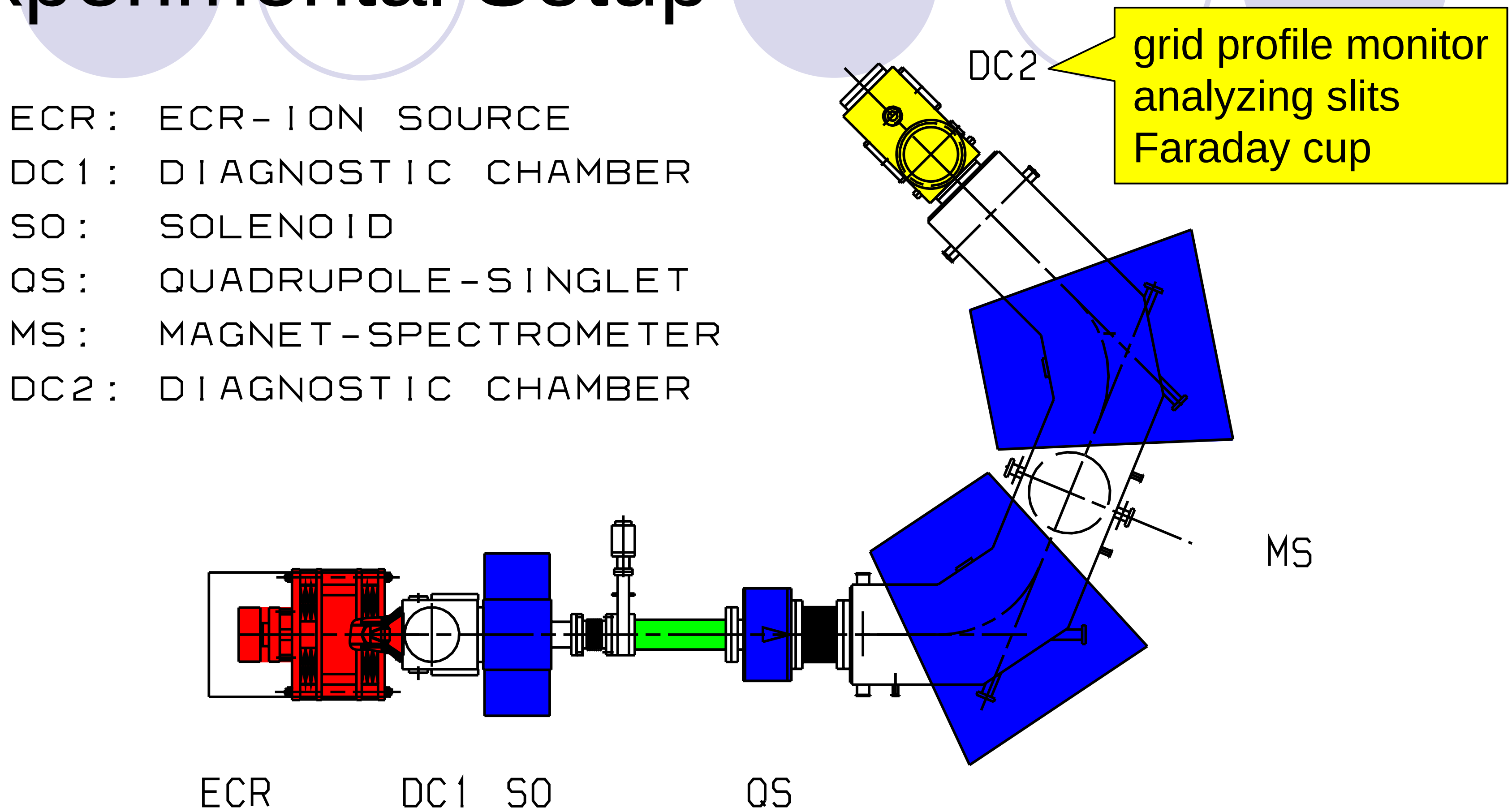
Electron Cyclotron Resonance Ion Source ECR



Electron Cyclotron Resonance Ion Source ECR

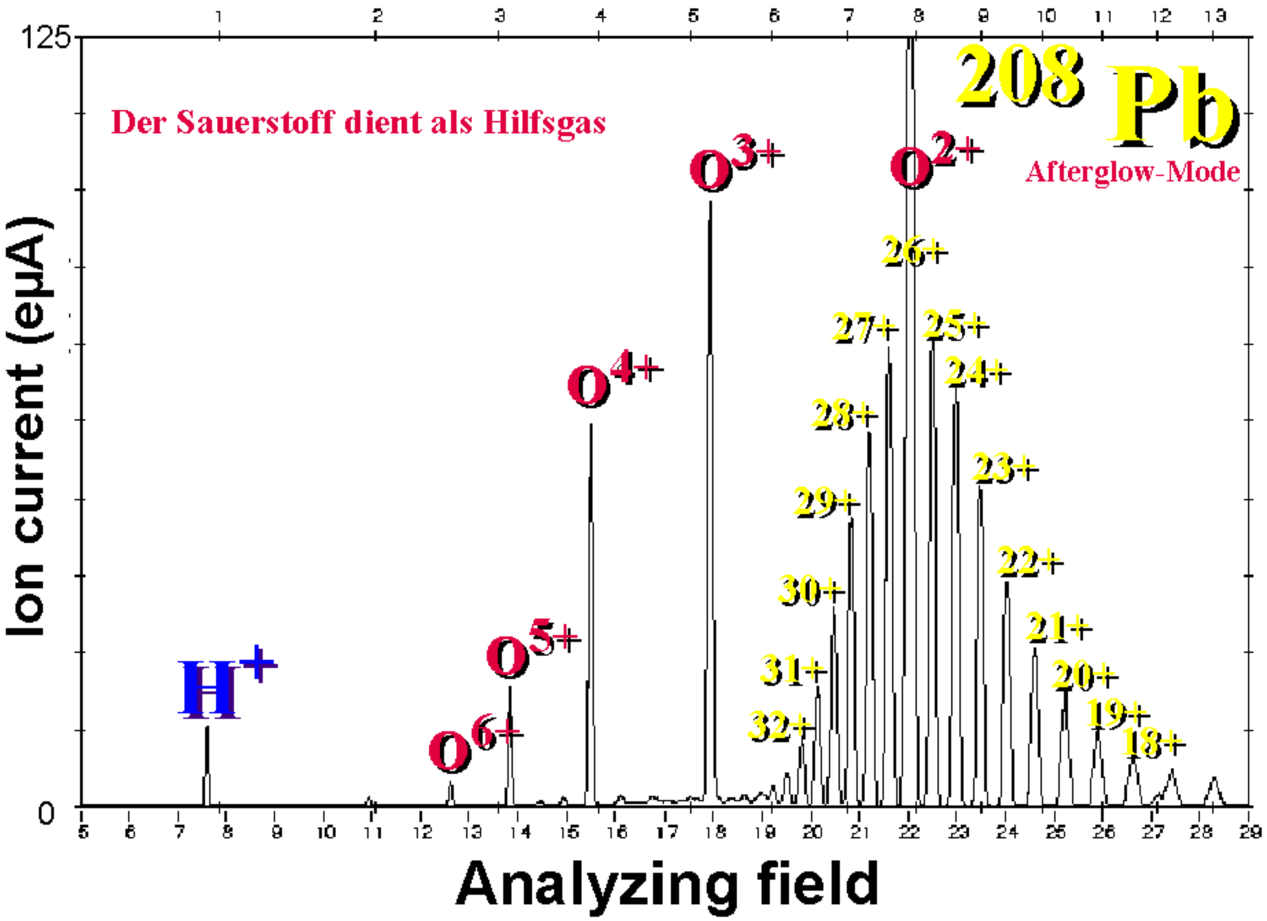


Experimental Setup



ECR Injector Test Setup ➡ Identical with the low energy beam line of the High Charge State Injector

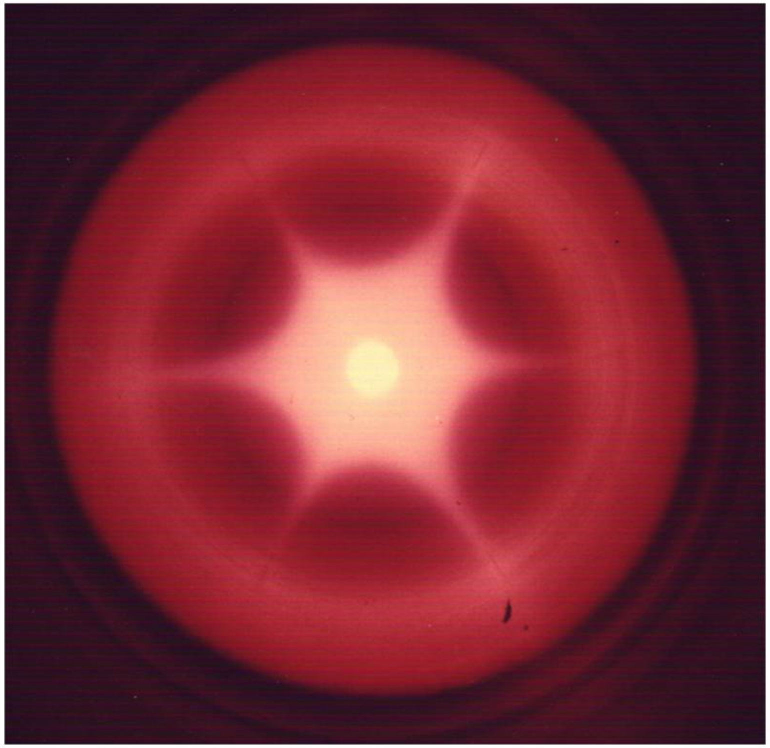
Electron Cyclotron Resonance Ion Source ECR



ELECTRON CYCLOTRON RESONANCE ION SOURCE

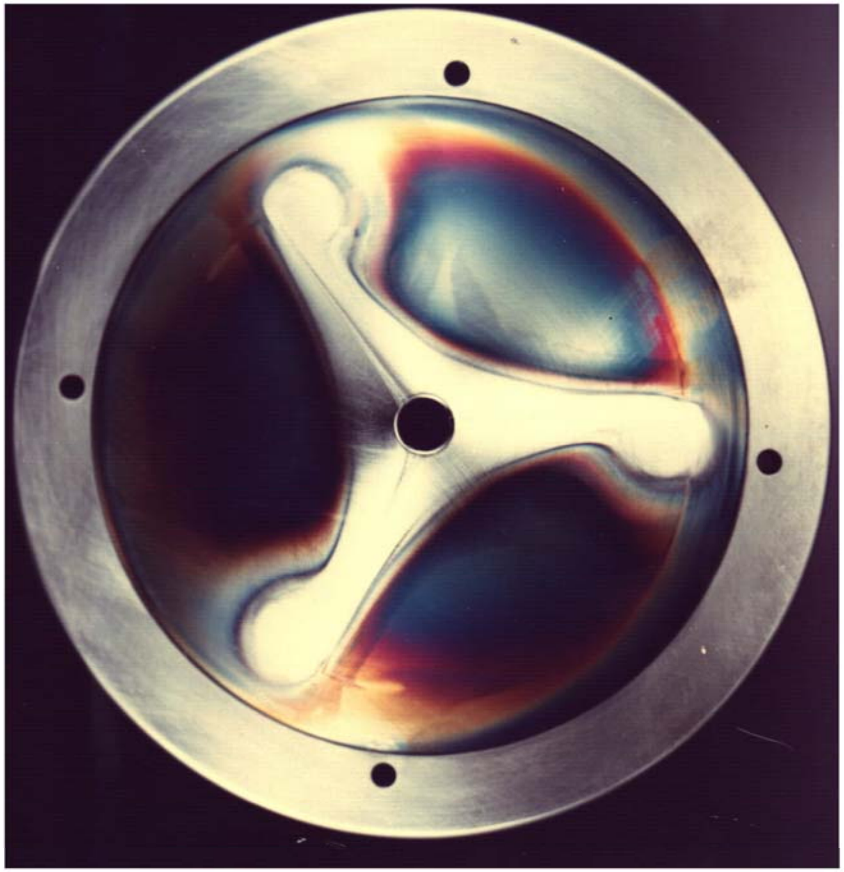
look into the plasma chamber

with plasma electrode removed



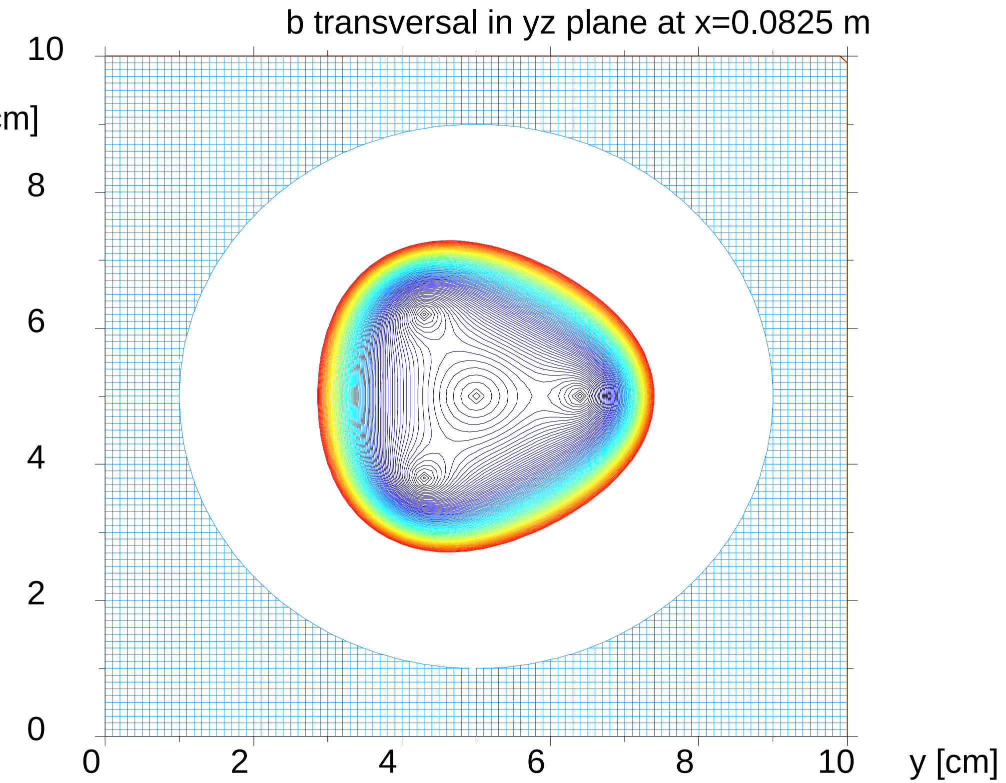
ELECTRON CYCLOTRON RESONANCE ION SOURCE

plasma electrode with sputter marks



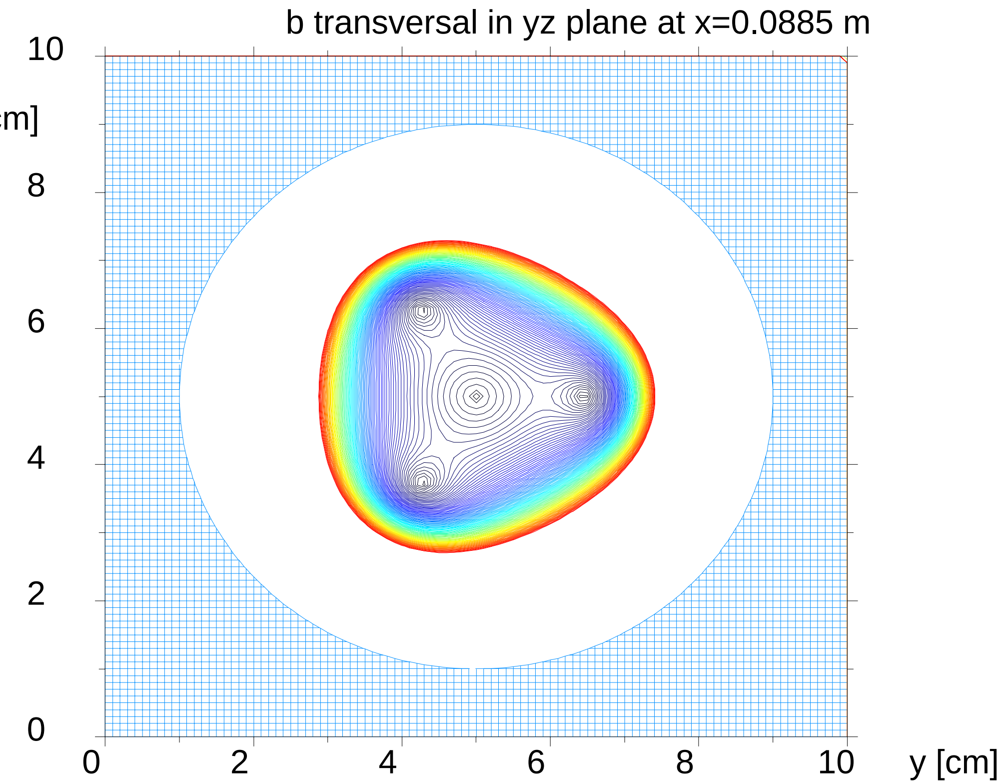
- Due to the magnetic confinement, the ion density distribution inside the source is not cylinder symmetric.
- The transverse magnetic field component defines the homogenity of the plasma.
- Lines of constant |B| in a series of transverse cuts within the plasma chamber indicate the plasma distribution.

KOBRA3-INP



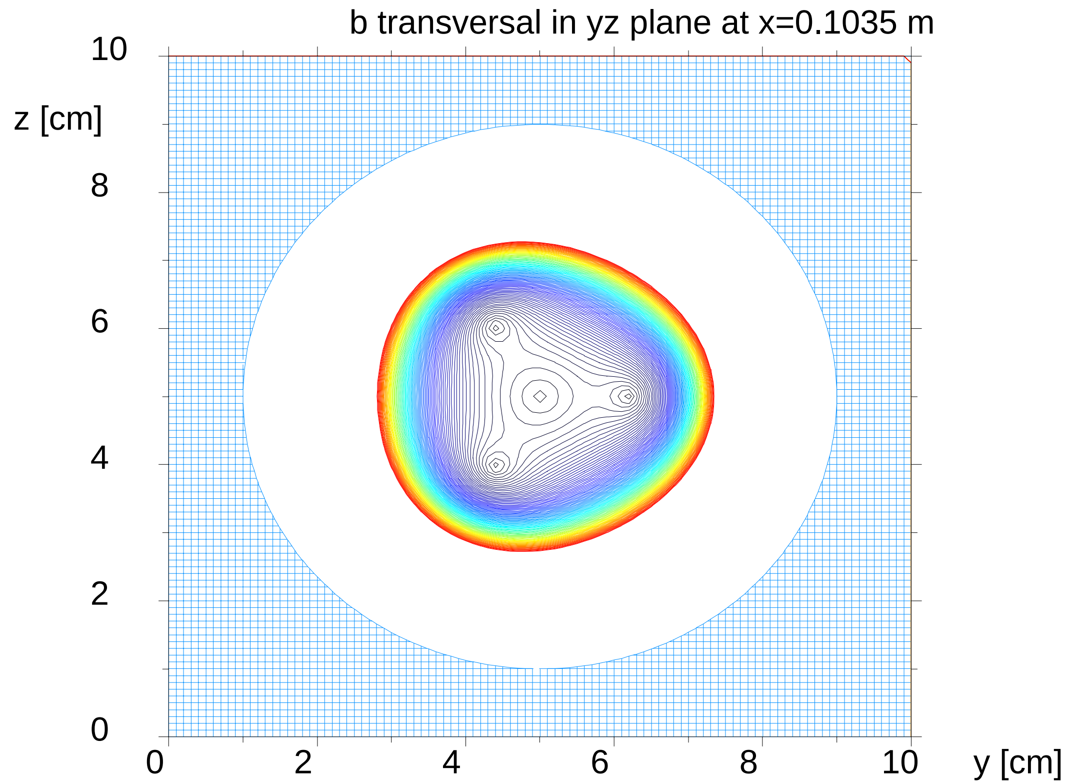
b transversal in yz plane at x=0.0825 m
z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]

KOBRA3-INP

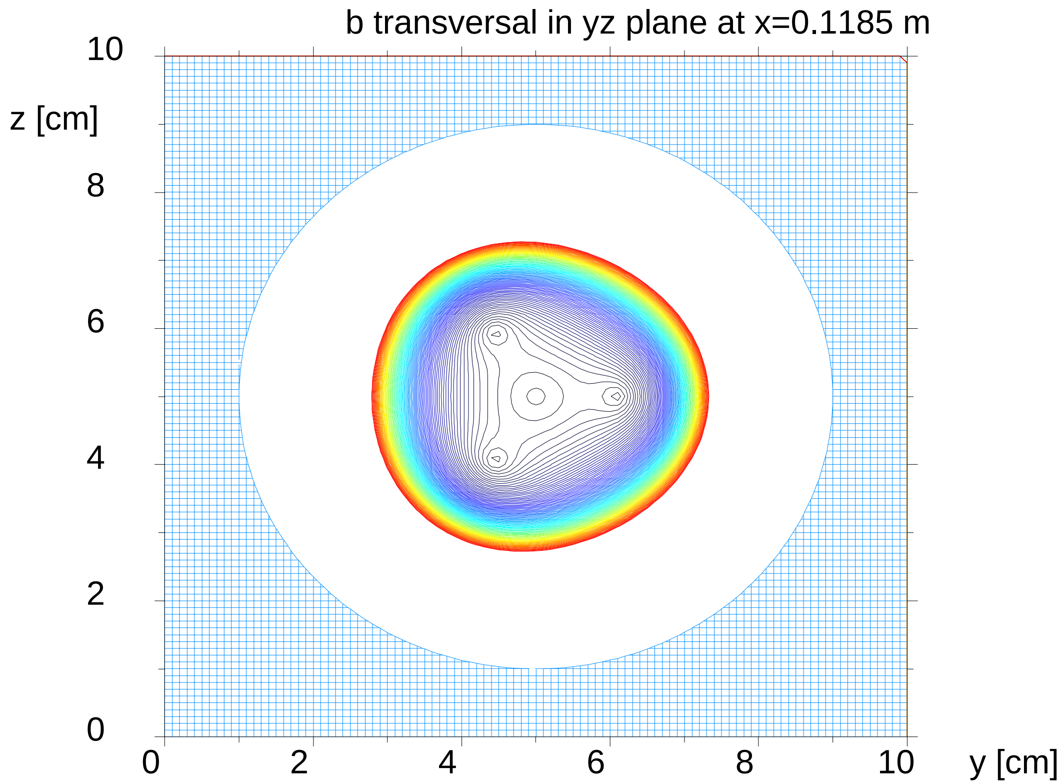


b transversal in yz plane at x=0.0885 m
z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]

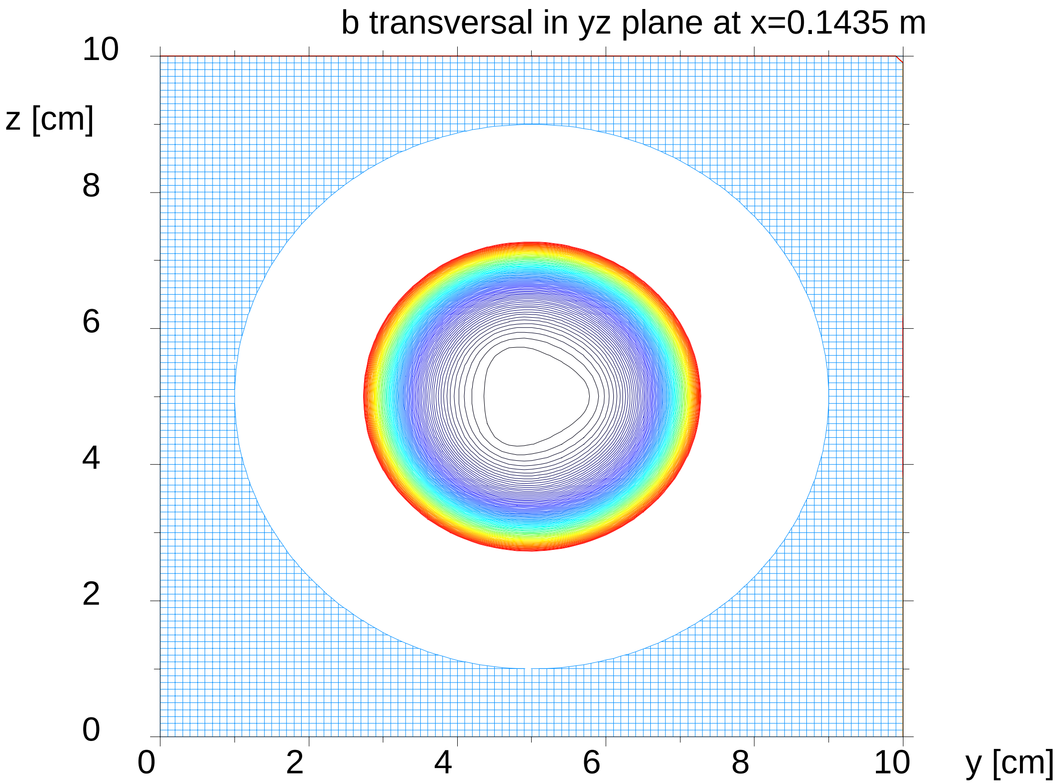
KOBRA3-INP


b transversal in yz plane at x=0.1035 m
10
z [cm]
8
6
4
2
0
0
2
4
6
8
10
y [cm]

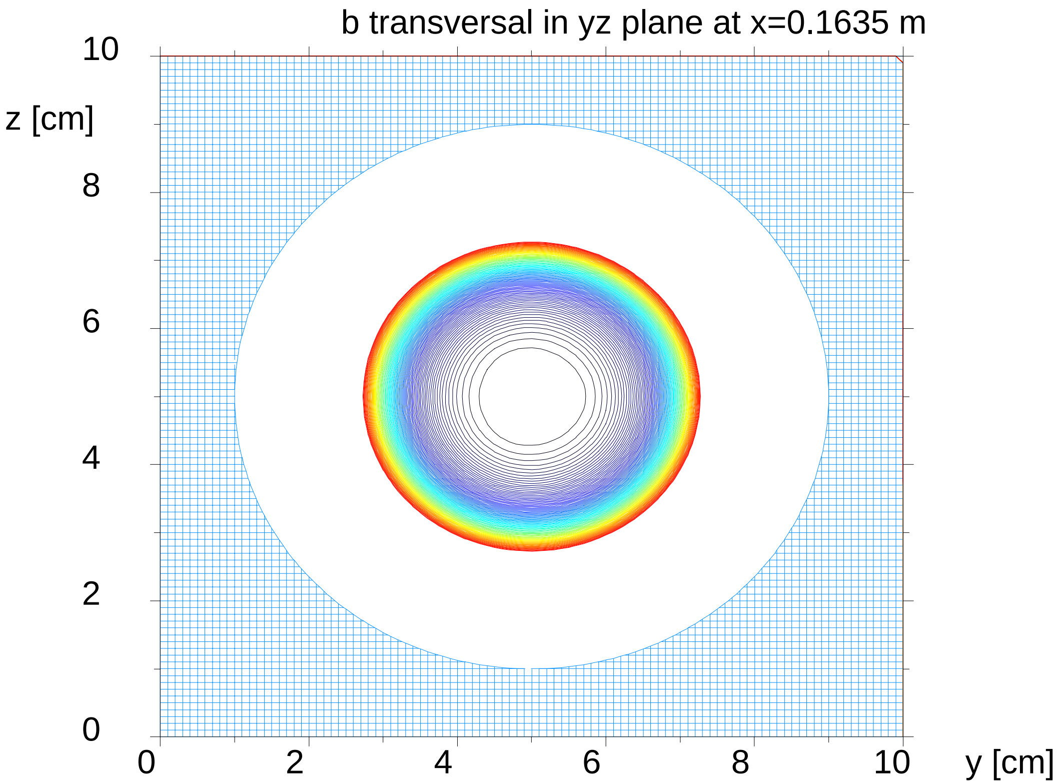
KOBRA3-INP


b transversal in yz plane at x=0.1185 m
z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]

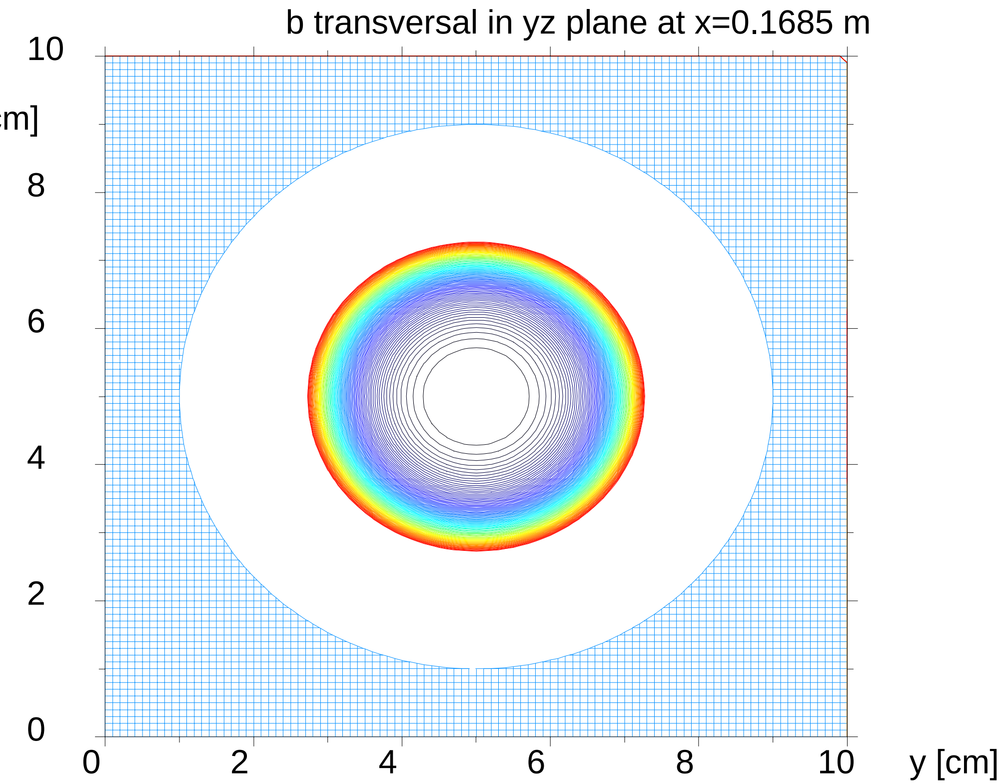
KOBRA3-INP


b transversal in yz plane at x=0.1435 m
10
z [cm]
8
6
4
2
0
0
2
4
6
8
10
y [cm]

KOBRA3-INP

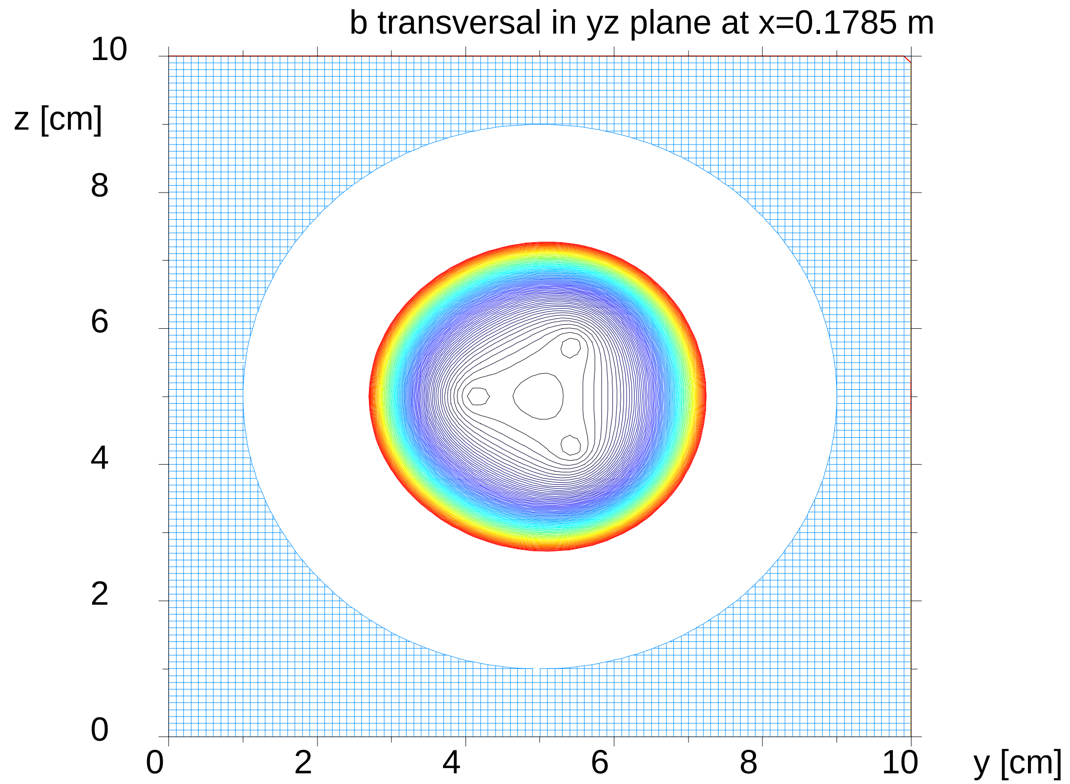


KOBRA3-INP



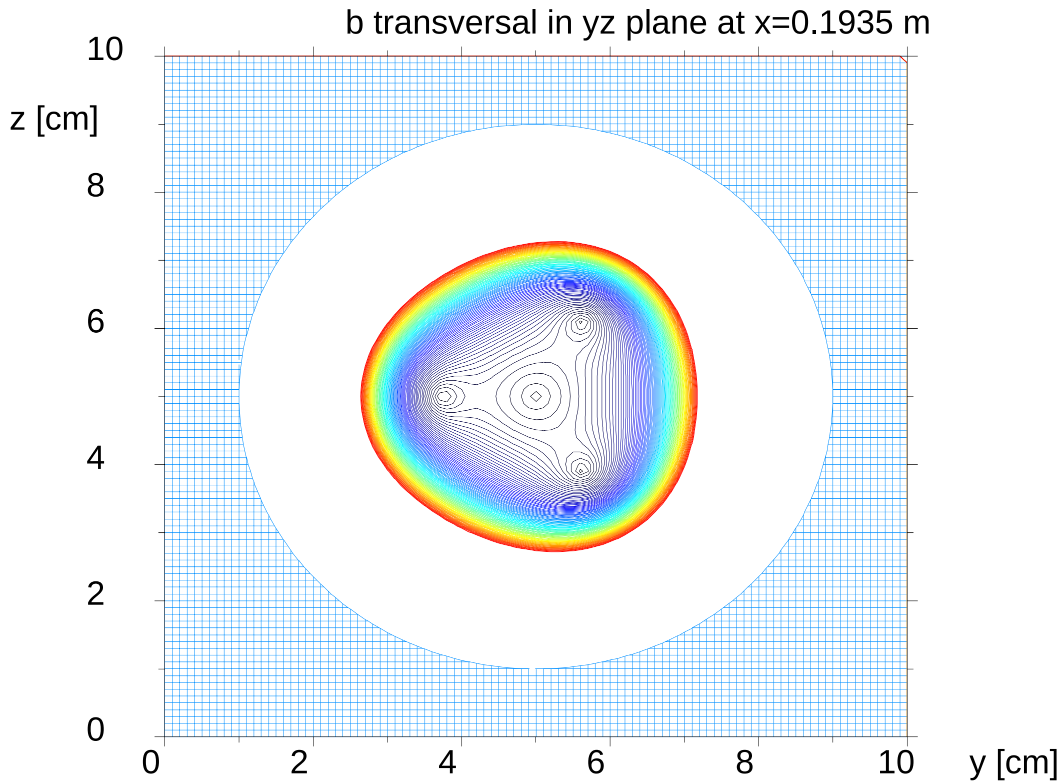
b transversal in yz plane at x=0.1685 m
10
z [cm]
8
6
4
2
0
0
2
4
6
8
10
y [cm]

KOBRA3-INP



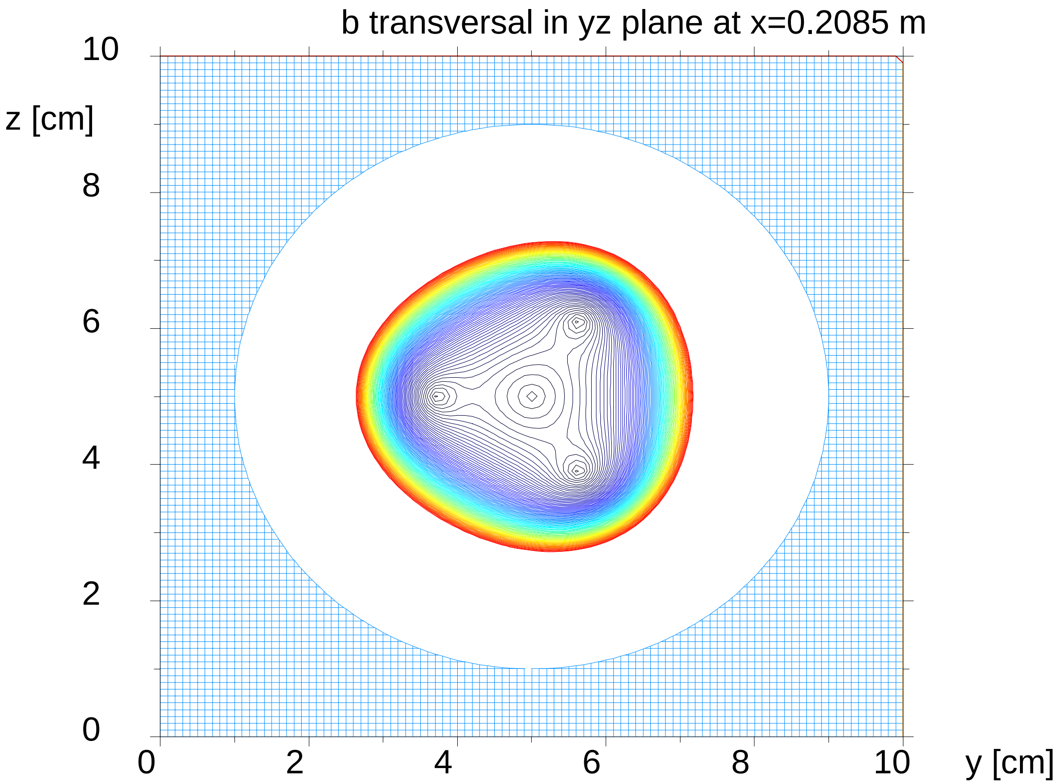
b transversal in yz plane at x=0.1785 m
10
z [cm]
8
6
4
2
0
0
2
4
6
8
10
y [cm]

KOBRA3-INP

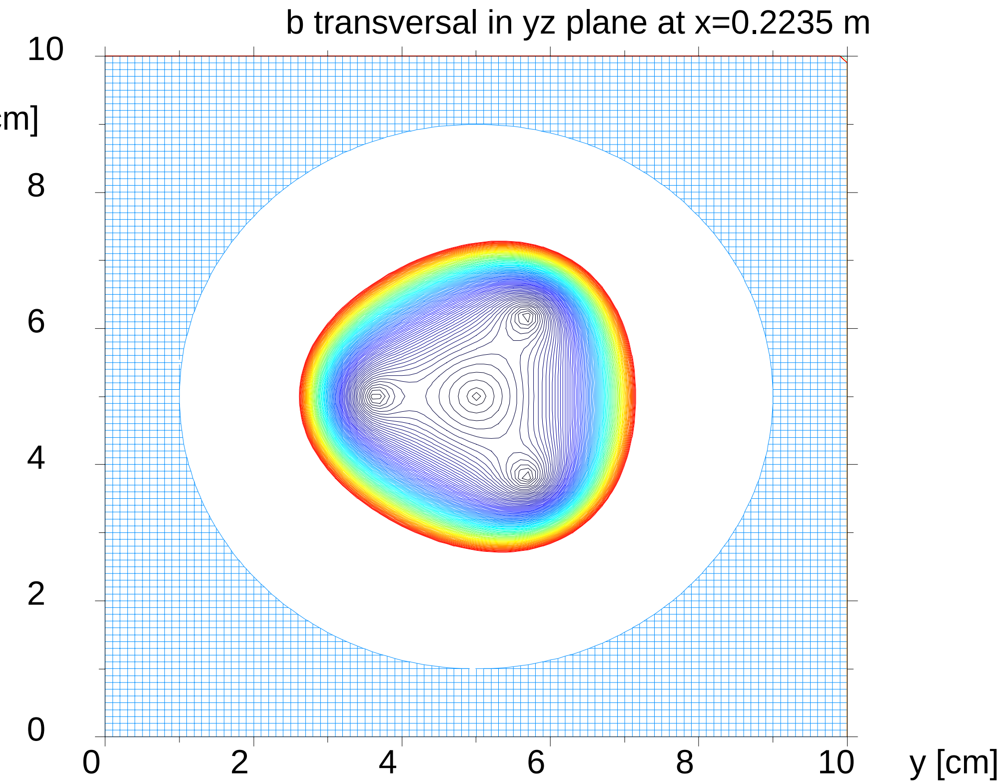


b transversal in yz plane at x=0.1935 m
10
z [cm]
8
6
4
2
0
0
2
4
6
8
10
y [cm]

KOBRA3-INP

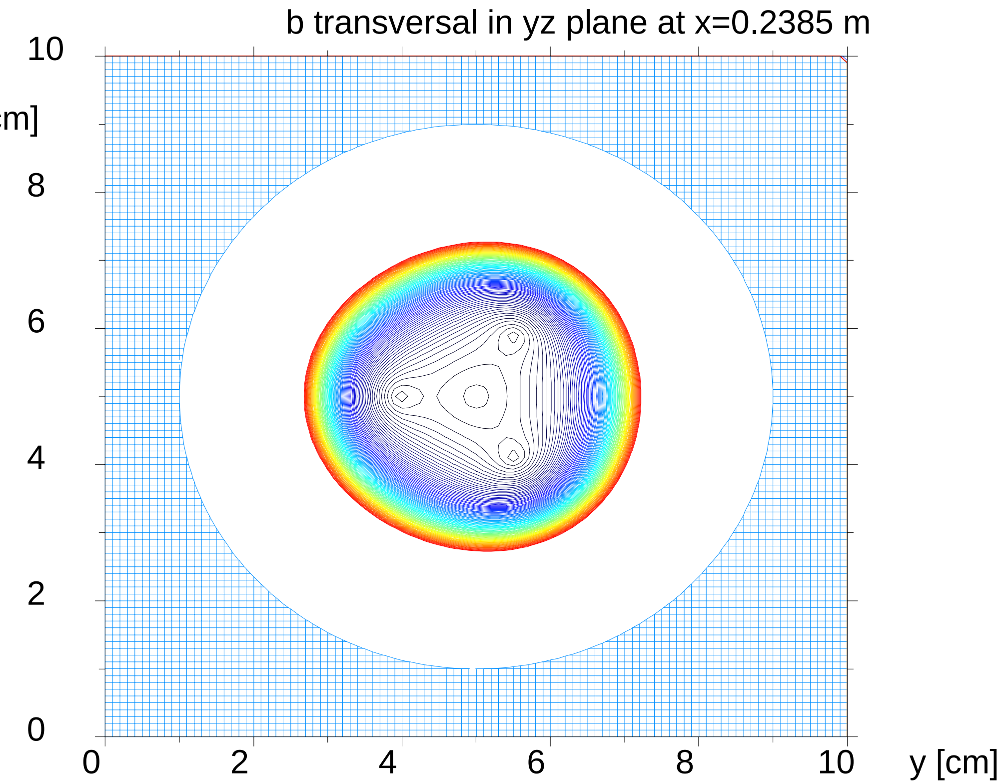

b transversal in yz plane at x=0.2085 m
z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]

KOBRA3-INP

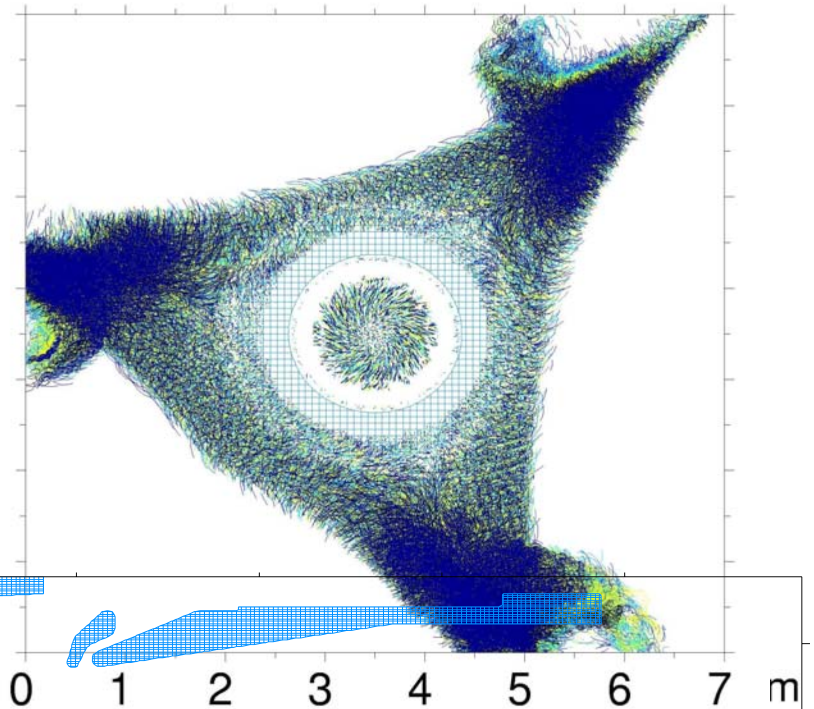


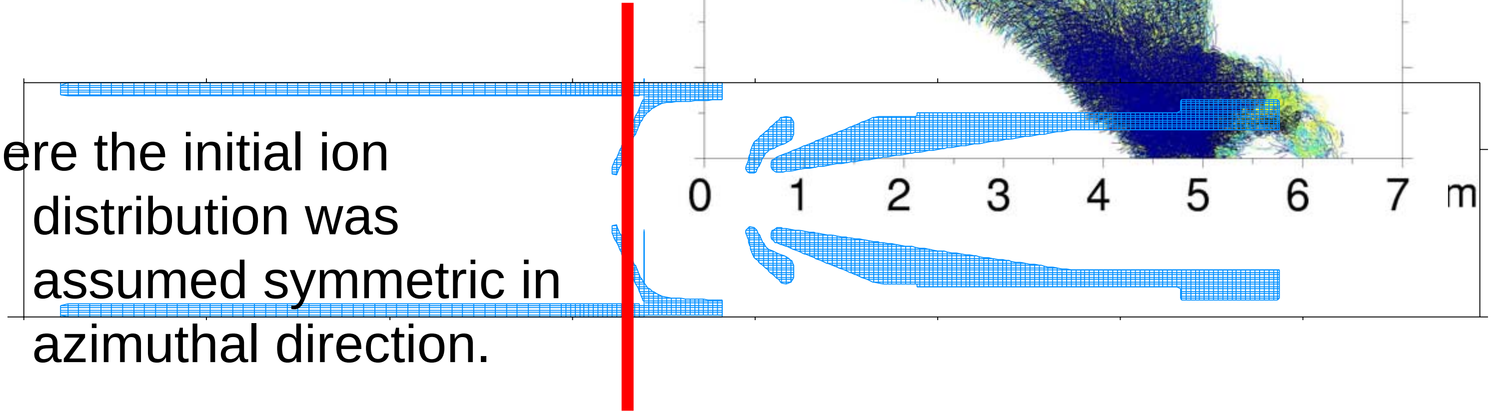
b transversal in yz plane at x=0.2235 m
10
z [cm]
8
6
4
2
0
0
2
4
6
8
10
y [cm]

KOBRA3-INP


b transversal in yz plane at x=0.2385 m
z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]

starting ions everywhere in the plasma chamber results in a large loss area. Ions on a large diameter start to move in azimuthal direction.

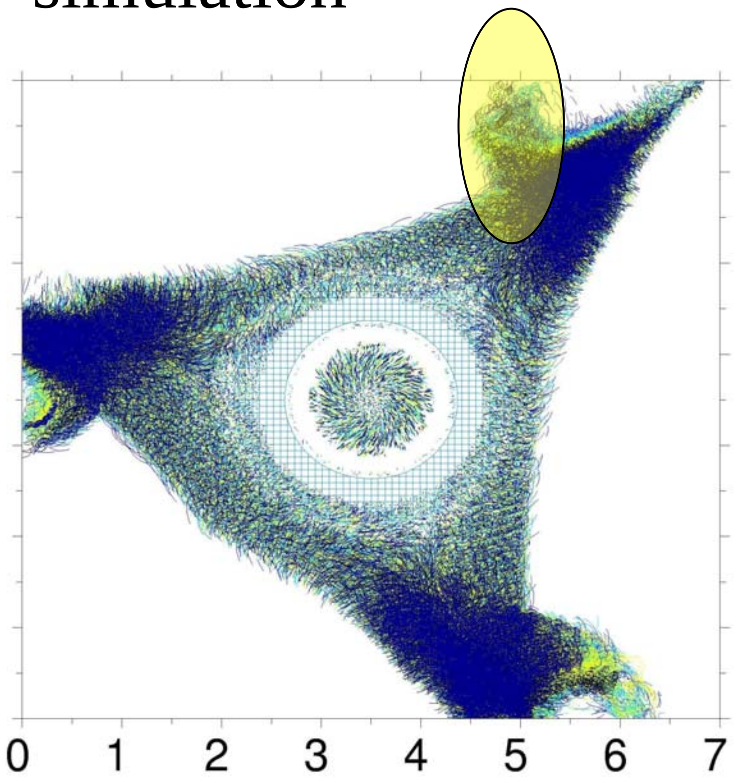


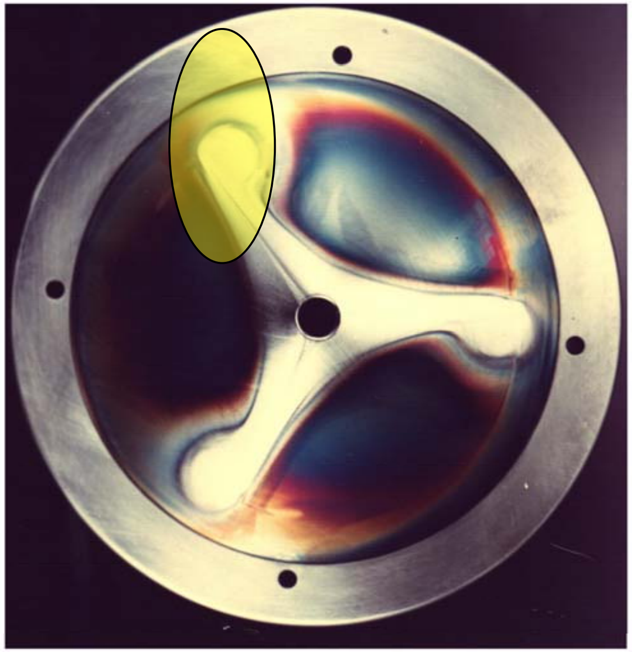


here the initial ion distribution was assumed symmetric in azimuthal direction.

simulation

experiment





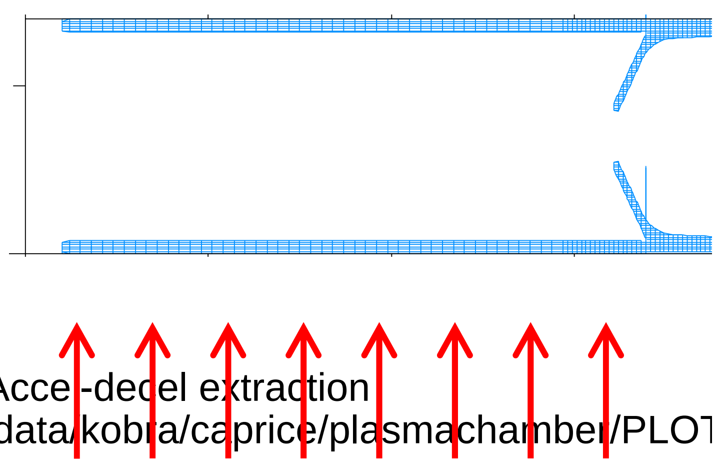
ions with large radius suffer from the stray field of the hexapole

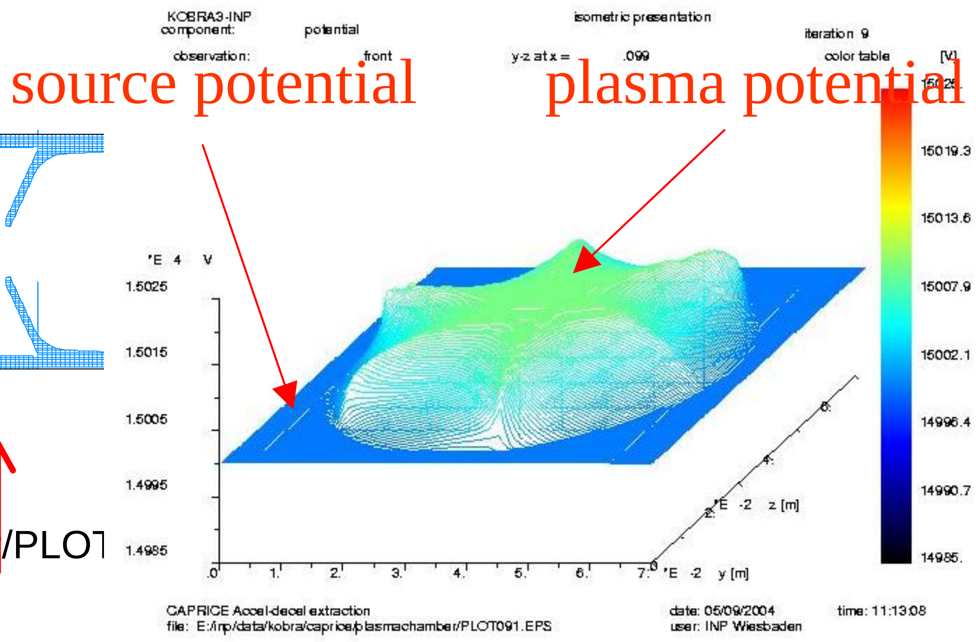
direction depends on magnetic field direction

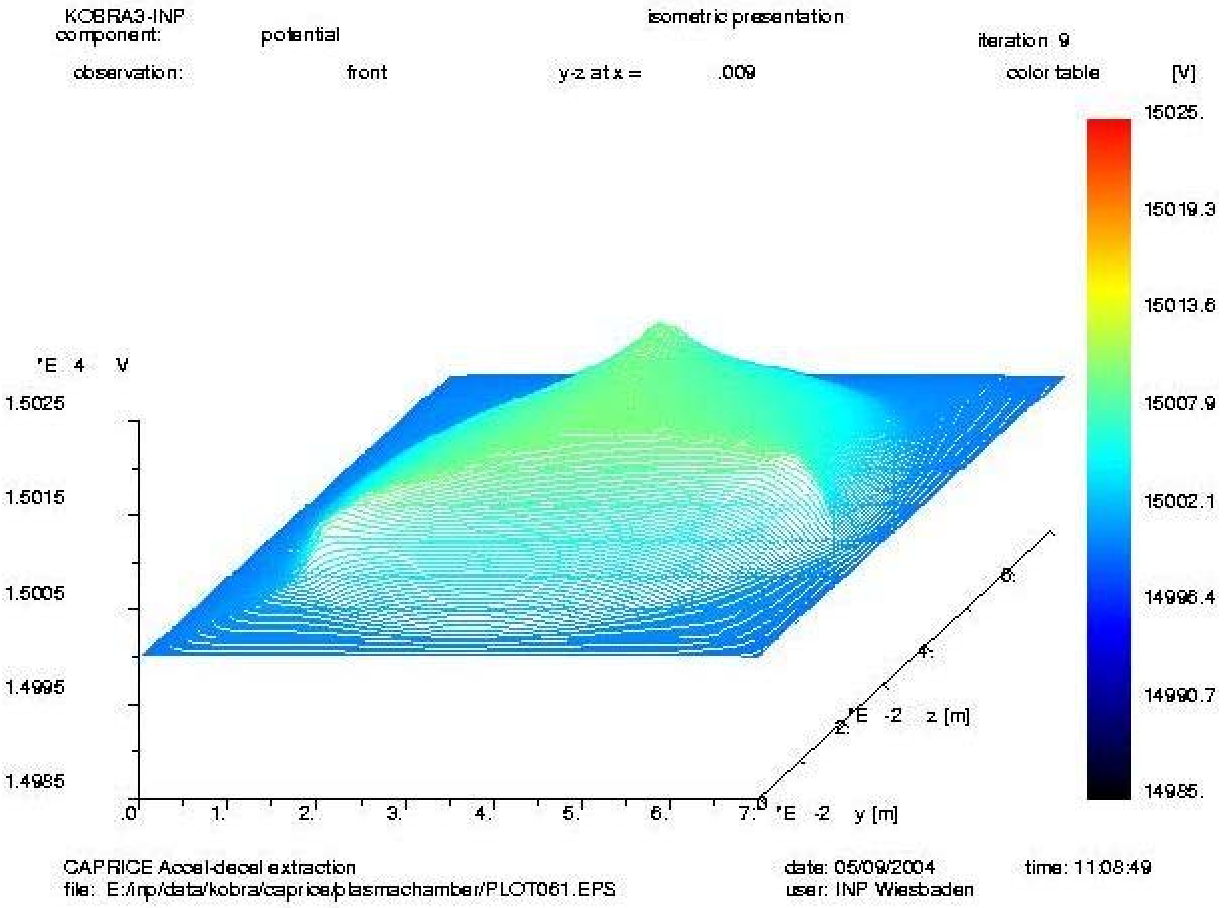
Shape of the plasma in the plasma chamber

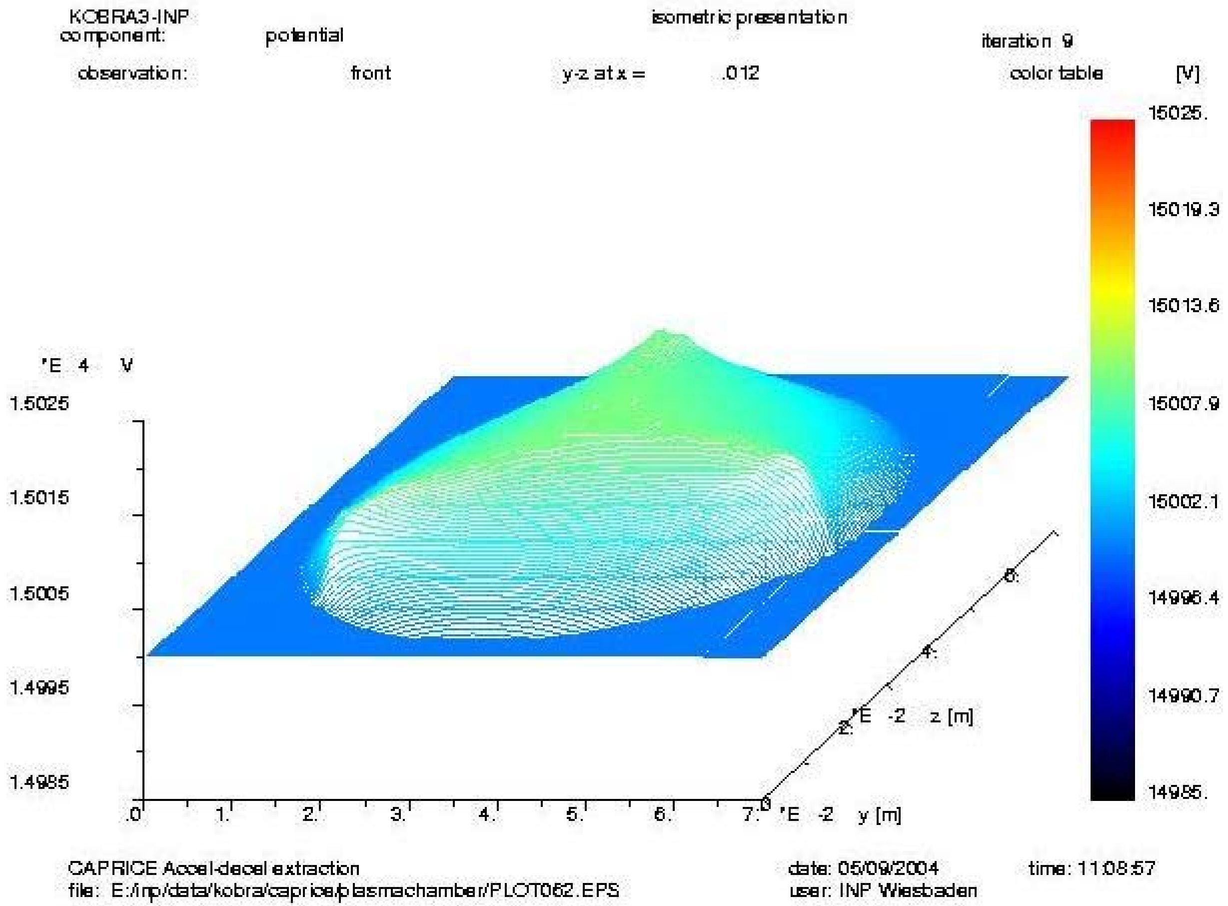
showing the potential in transverse planes, starting at injection side, moving towards extraction.

plasma chamber






KOBRA3-INP
component:
potential
isometric presentation
iteration 9
observation:
front
y-z at x =
.009
color table
[V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
2.
4.
6.
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT061.EPS
date: 05/09/2004
user: INP Wiesbaden
time: 11:08:49


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .012
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
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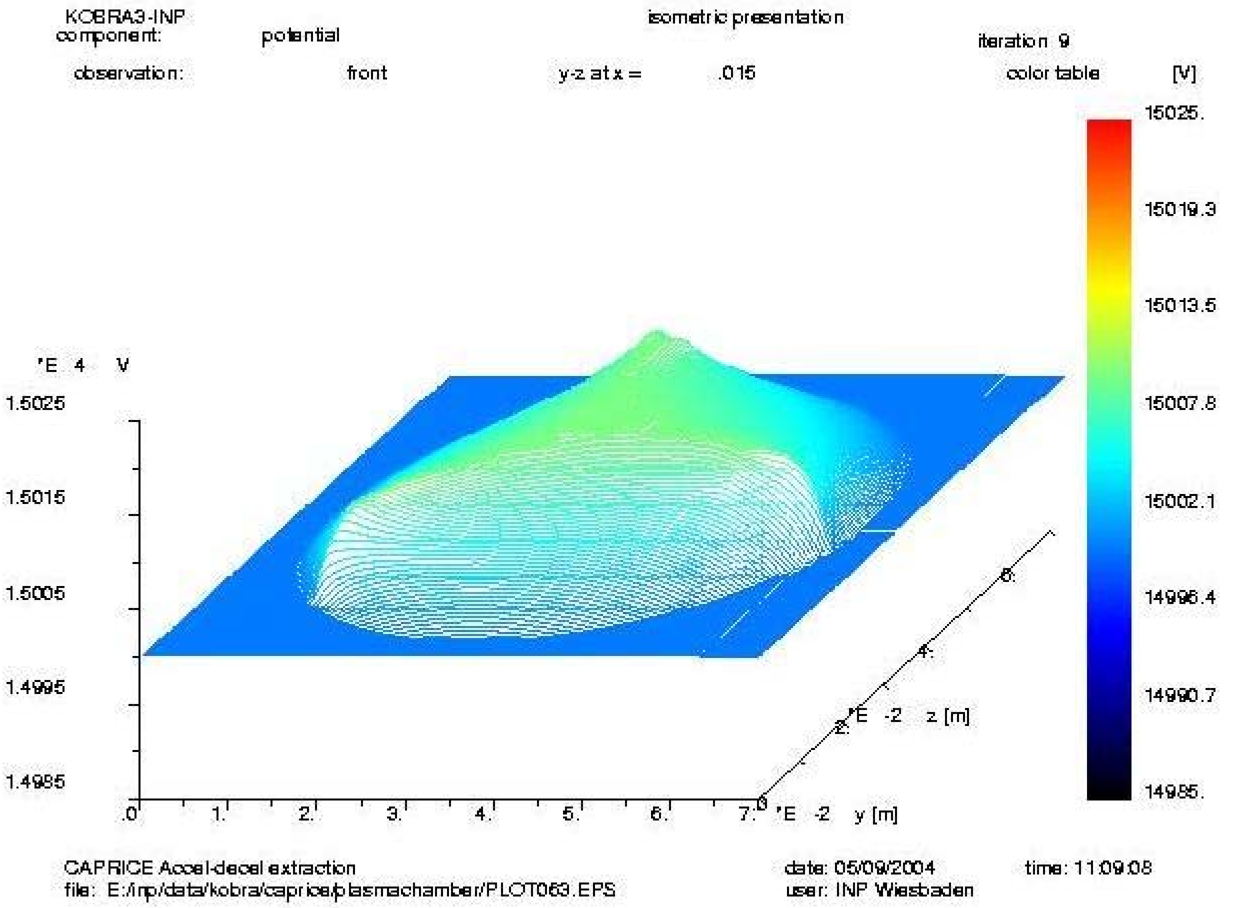
time: 11:08:57


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .015
color table [V]
15025.
15019.3
15013.5
15007.8
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
2. 4. 6.
CAPRICE Accel-decel extraction
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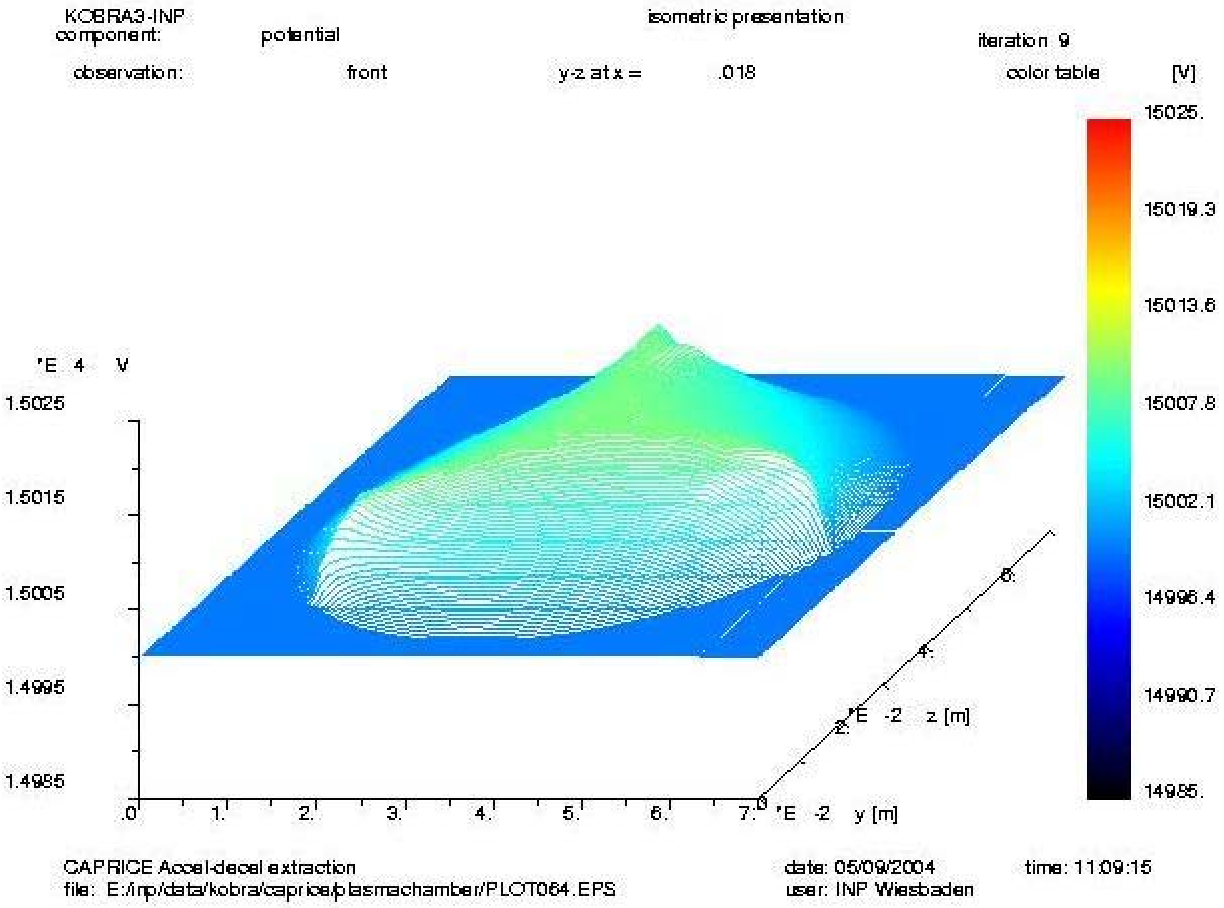

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .018
color table [V]
15025.
15019.3
15013.6
15007.8
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
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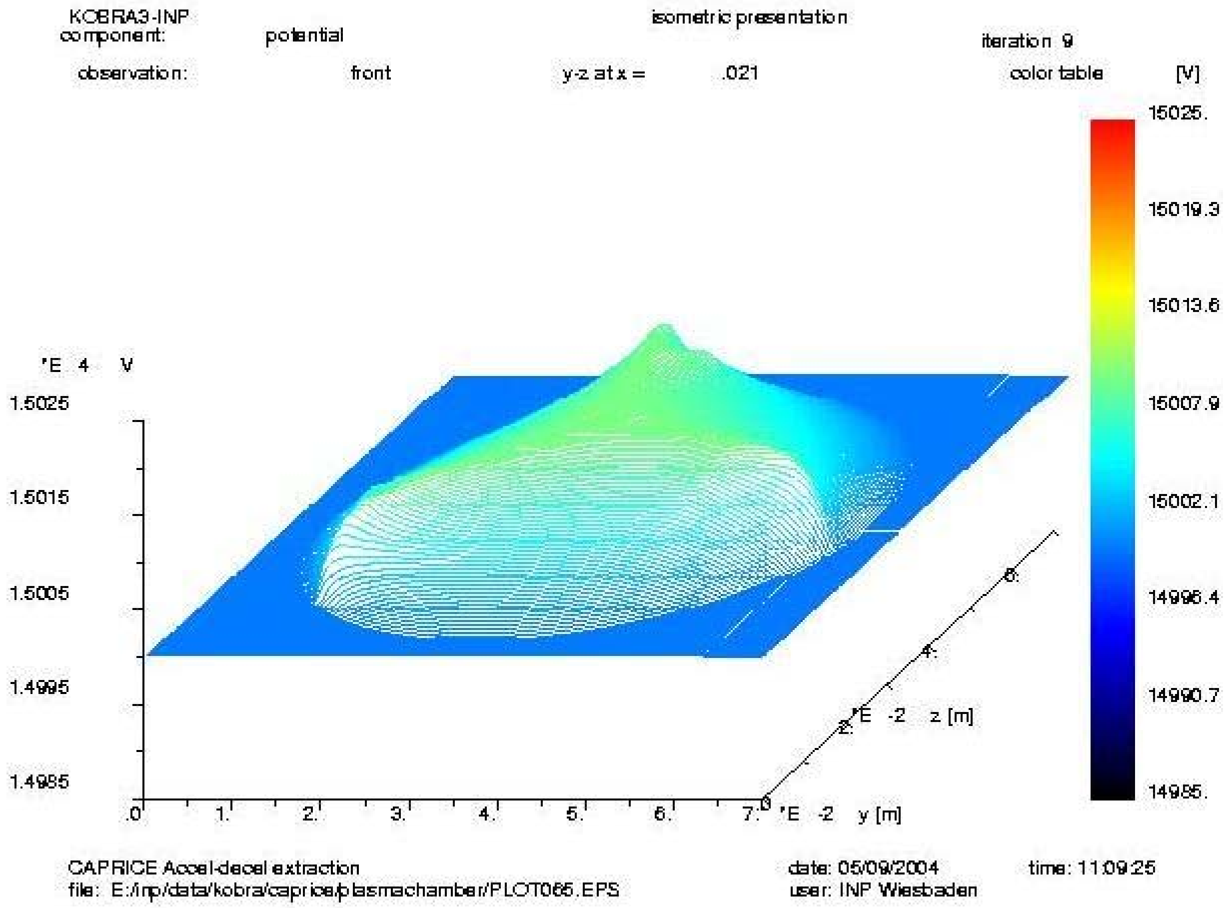

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .021
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
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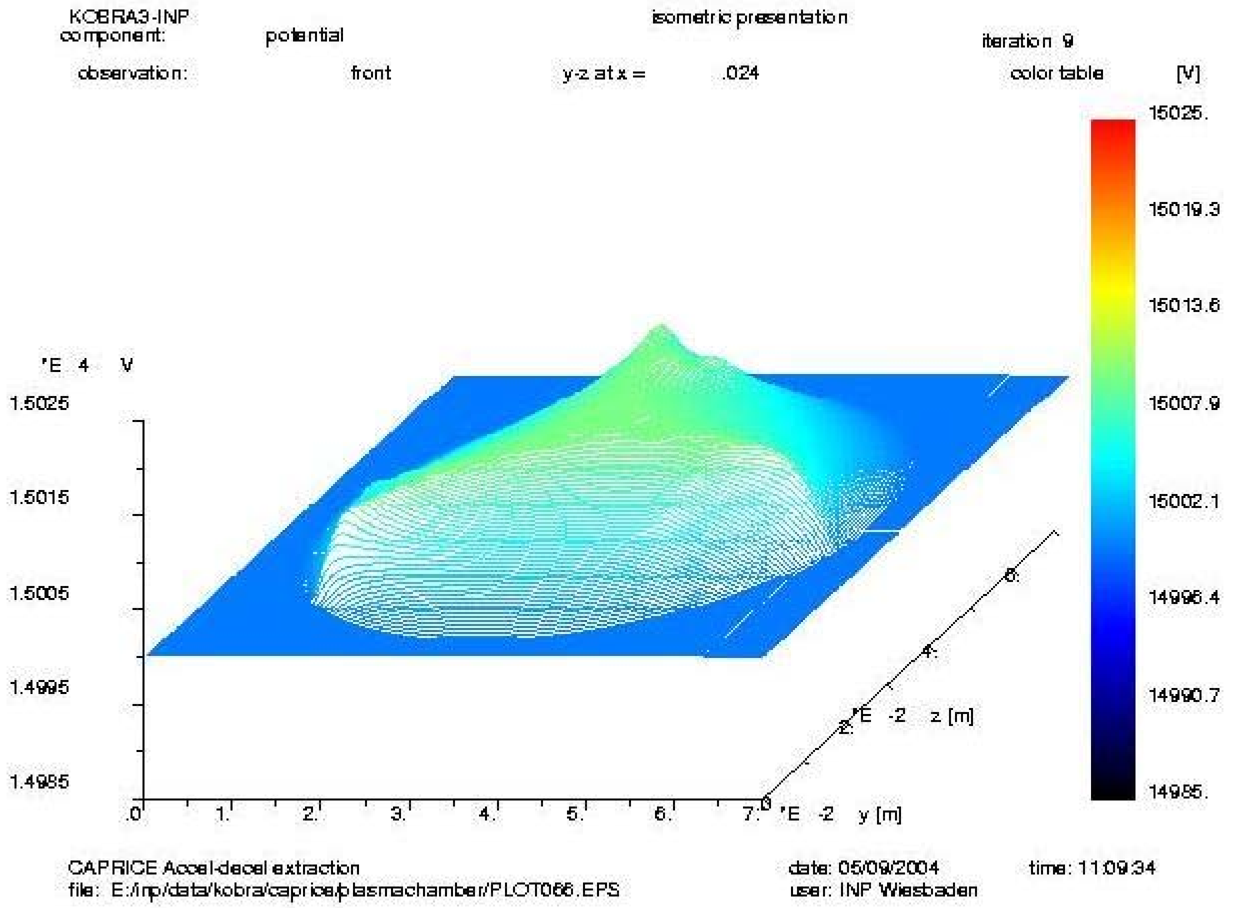
time: 11:09:25
user: INP Wiesbaden



KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .024
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
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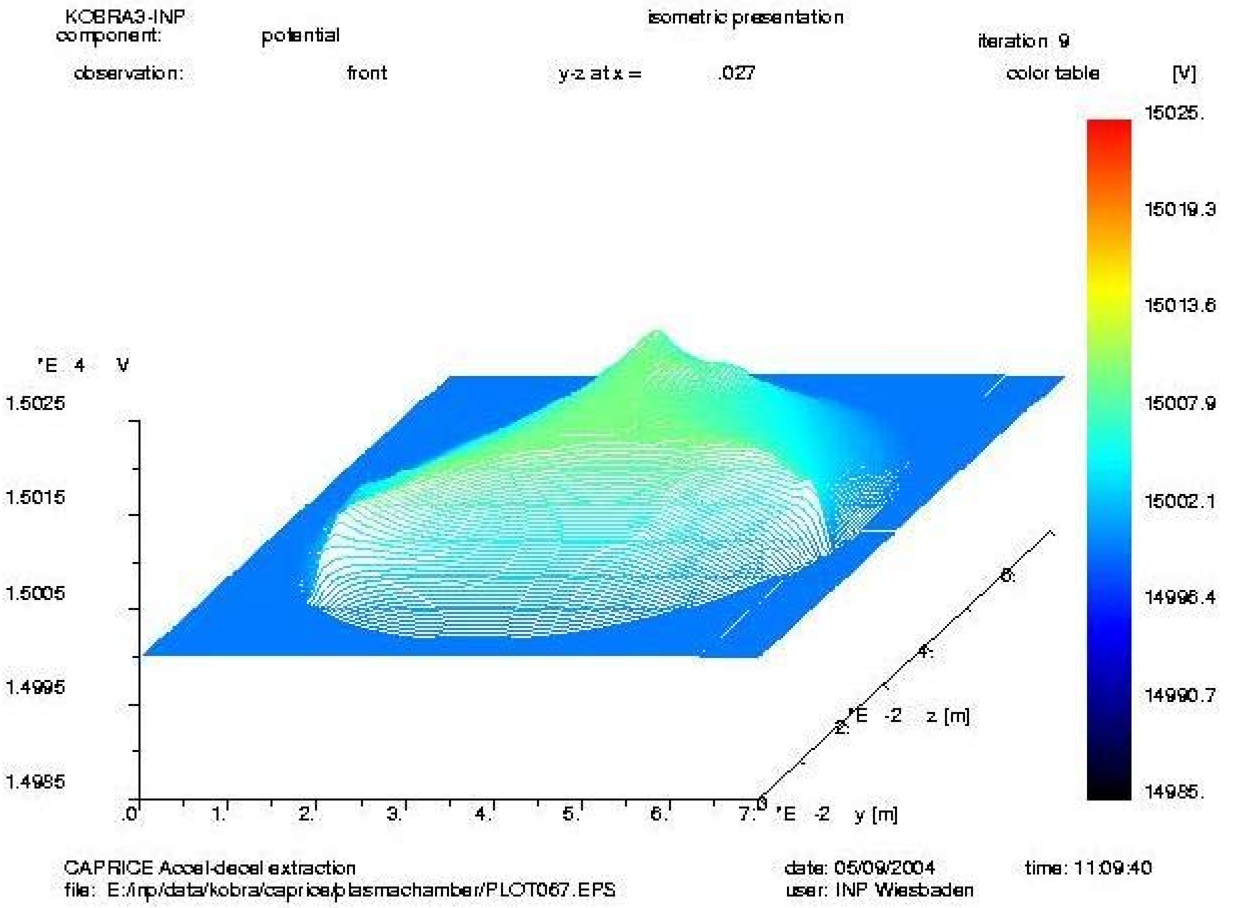
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .027
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
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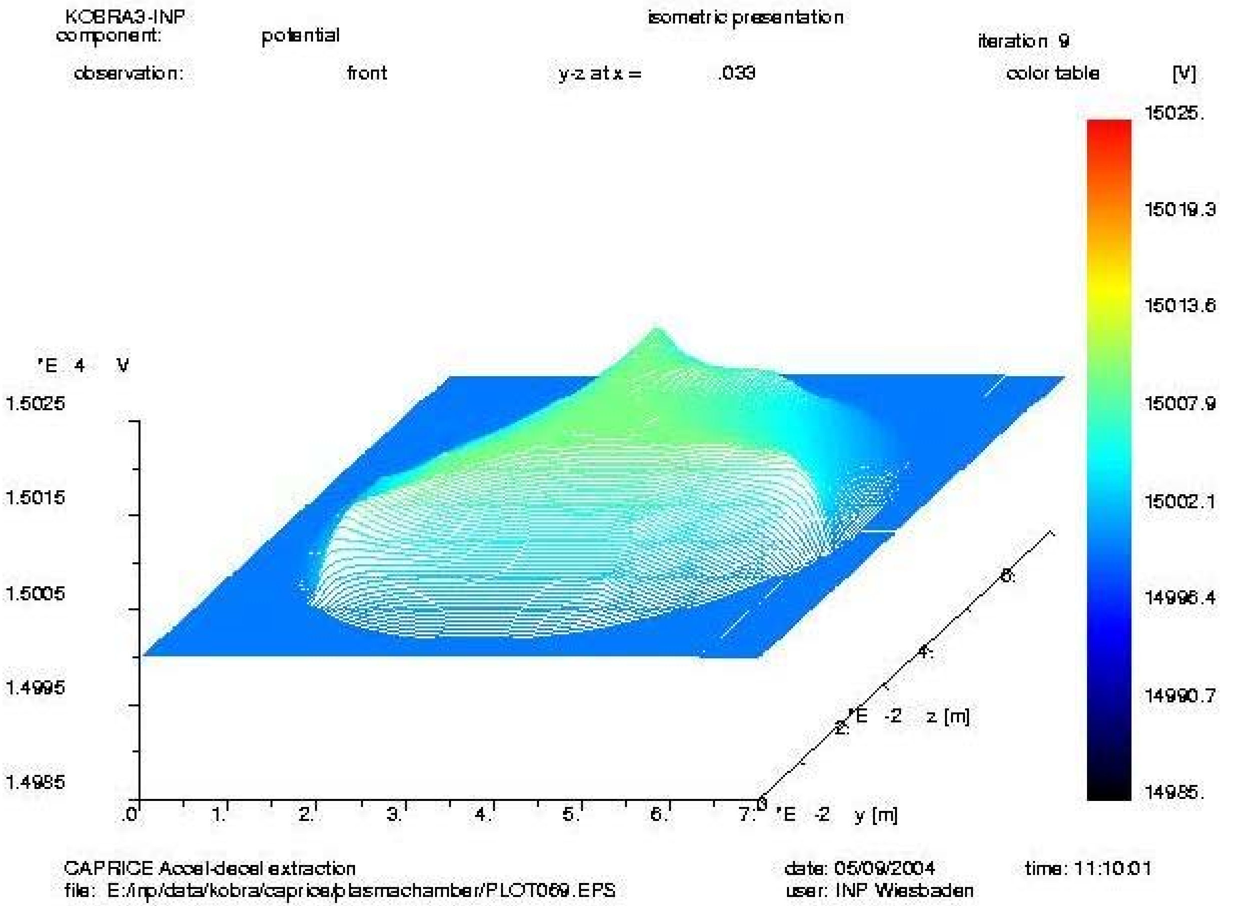
KOBRA3-INP
component:
potential
isometric presentation
iteration 9
observation:
front
y-z at x =
.033
color table
[V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
2.
4.
6.
*E -2 z [m]
CAPRICE Accel-decel extraction
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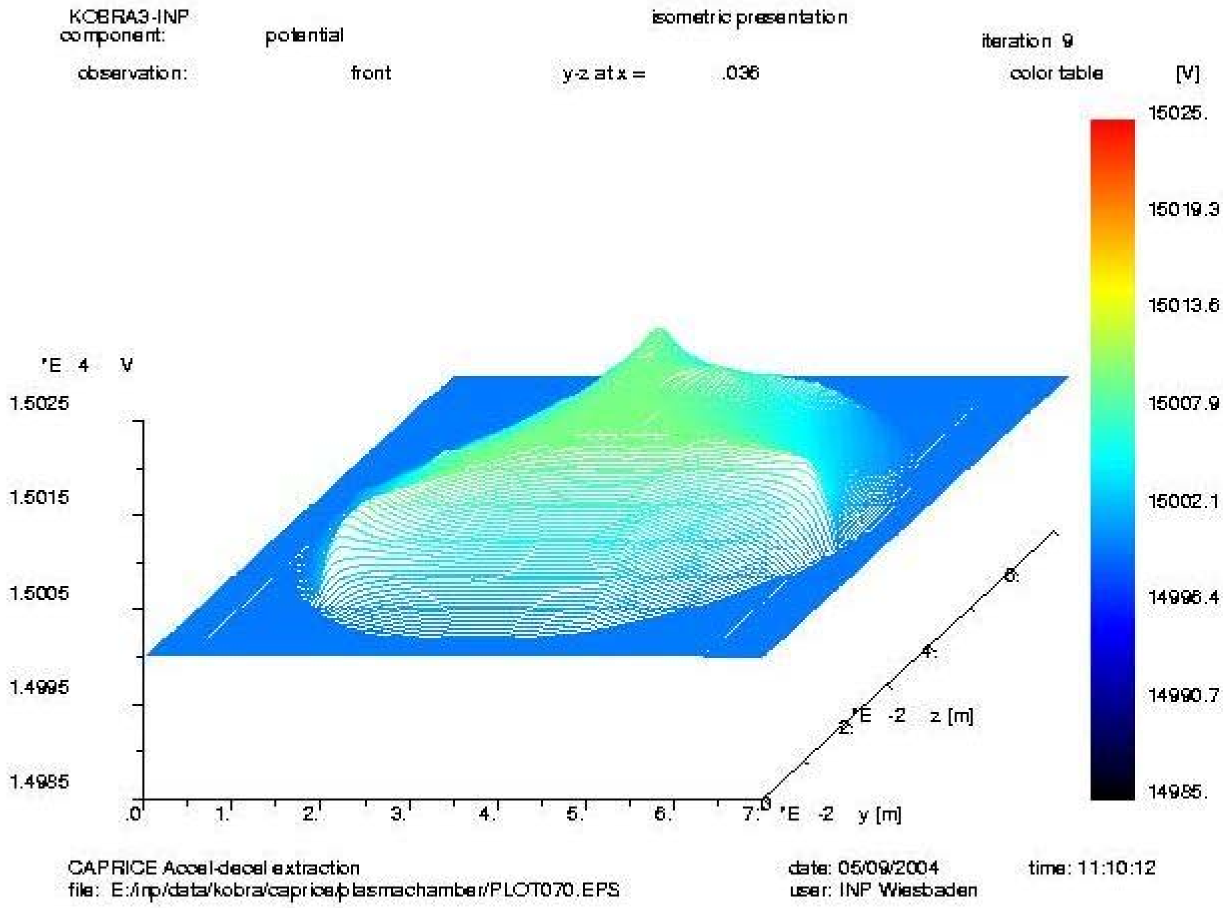
time: 11:10:01
user: INP Wiesbaden



KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .036
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
0 2. 4. 6.
'E -2 z [m]
CAPRICE Accel-decel extraction
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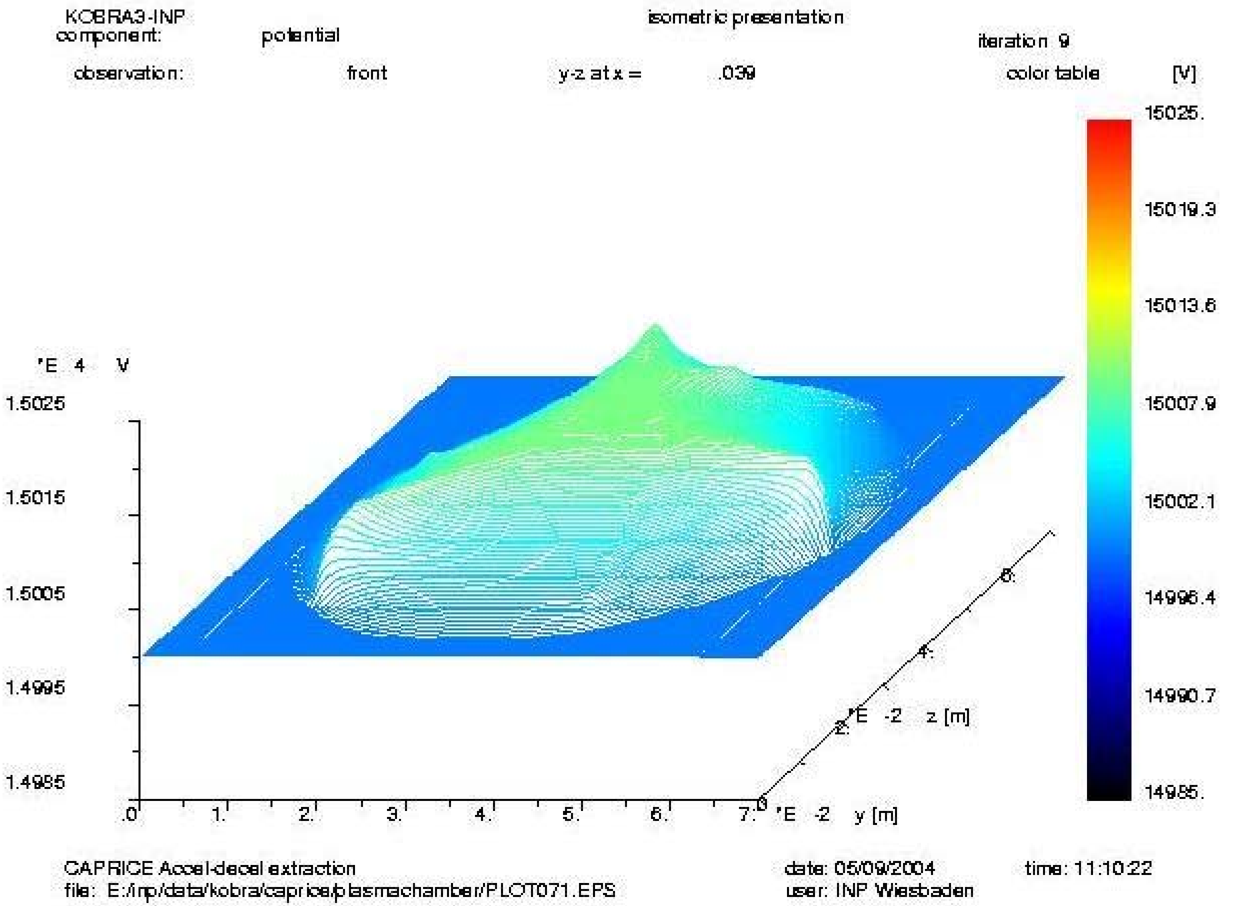
date: 05/09/2004
time: 11:10:12
user: INP Wiesbaden



KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .039
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
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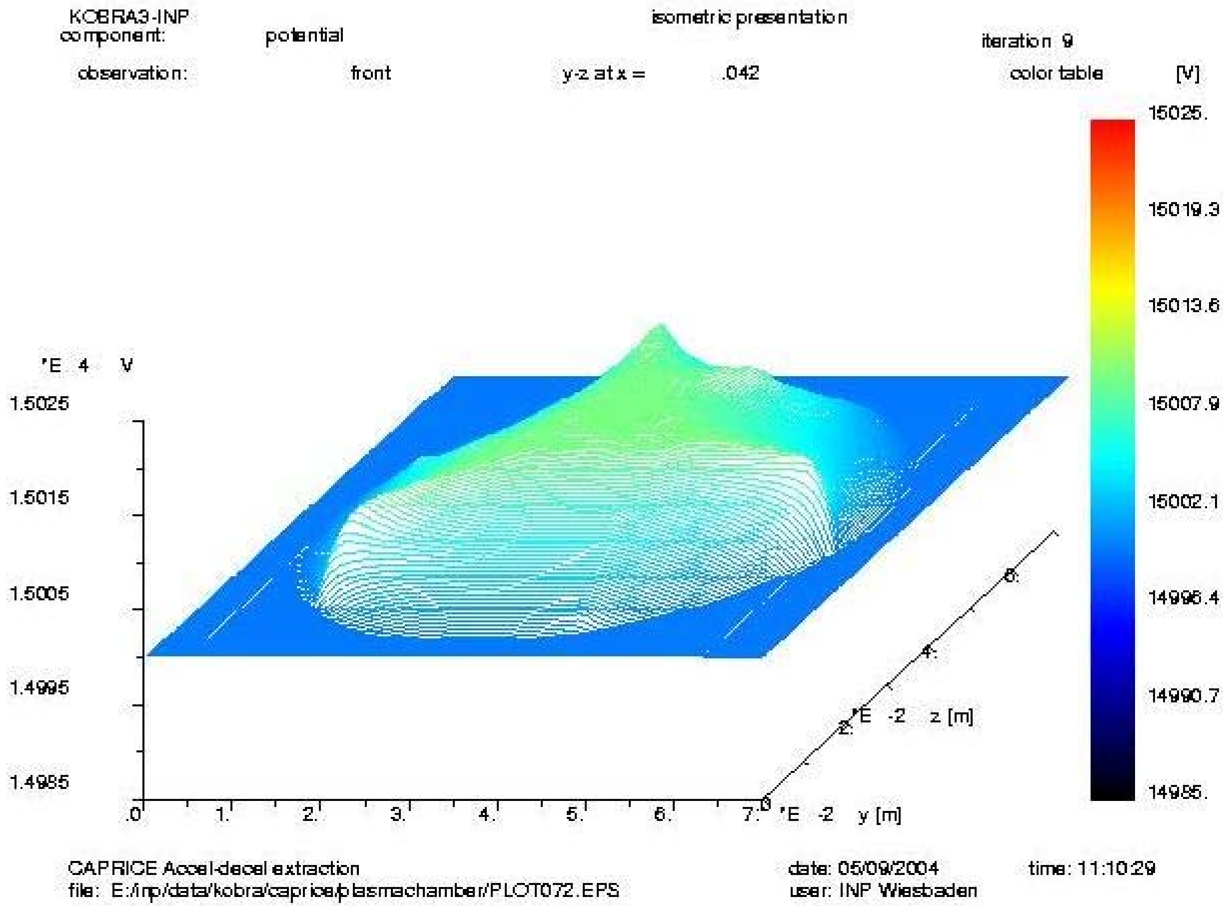
date: 05/09/2004
time: 11:10:22
user: INP Wiesbaden


KOBRA3-INP
component:
potential
isometric presentation
iteration 9
observation:
front
y-z at x =
.042
color table
[V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
'E -2 y [m]
2.
4.
6.
'E -2 z [m]
CAPRICE Accel-decel extraction
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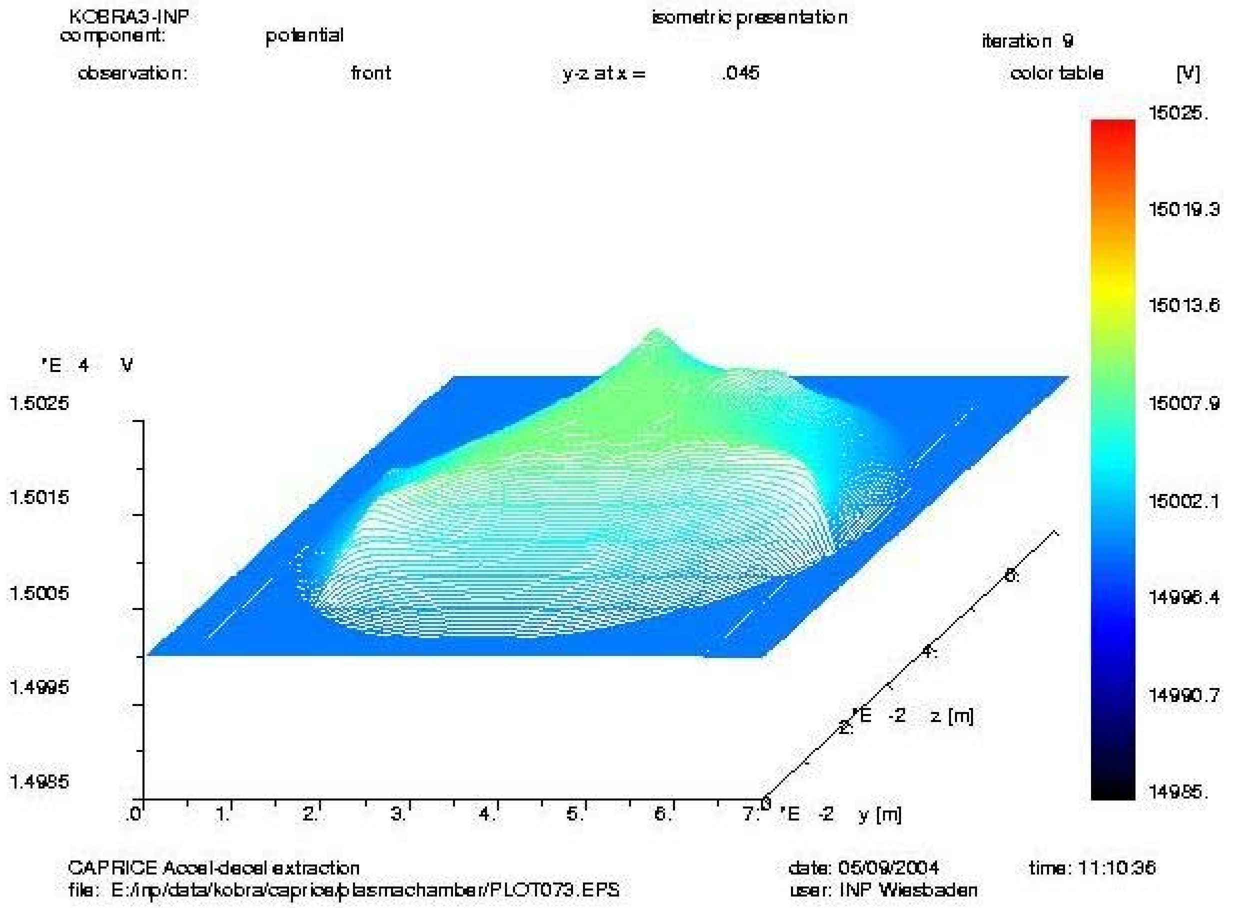
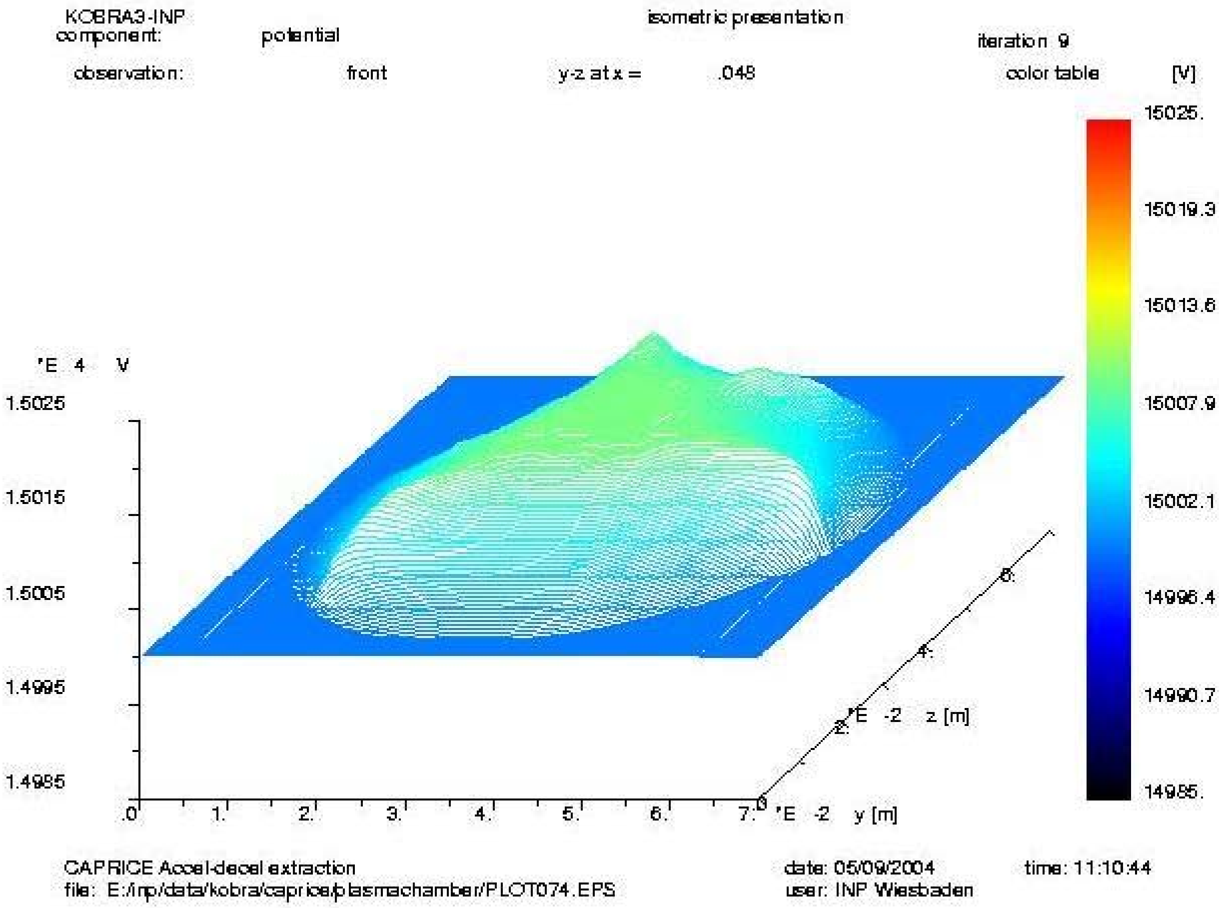
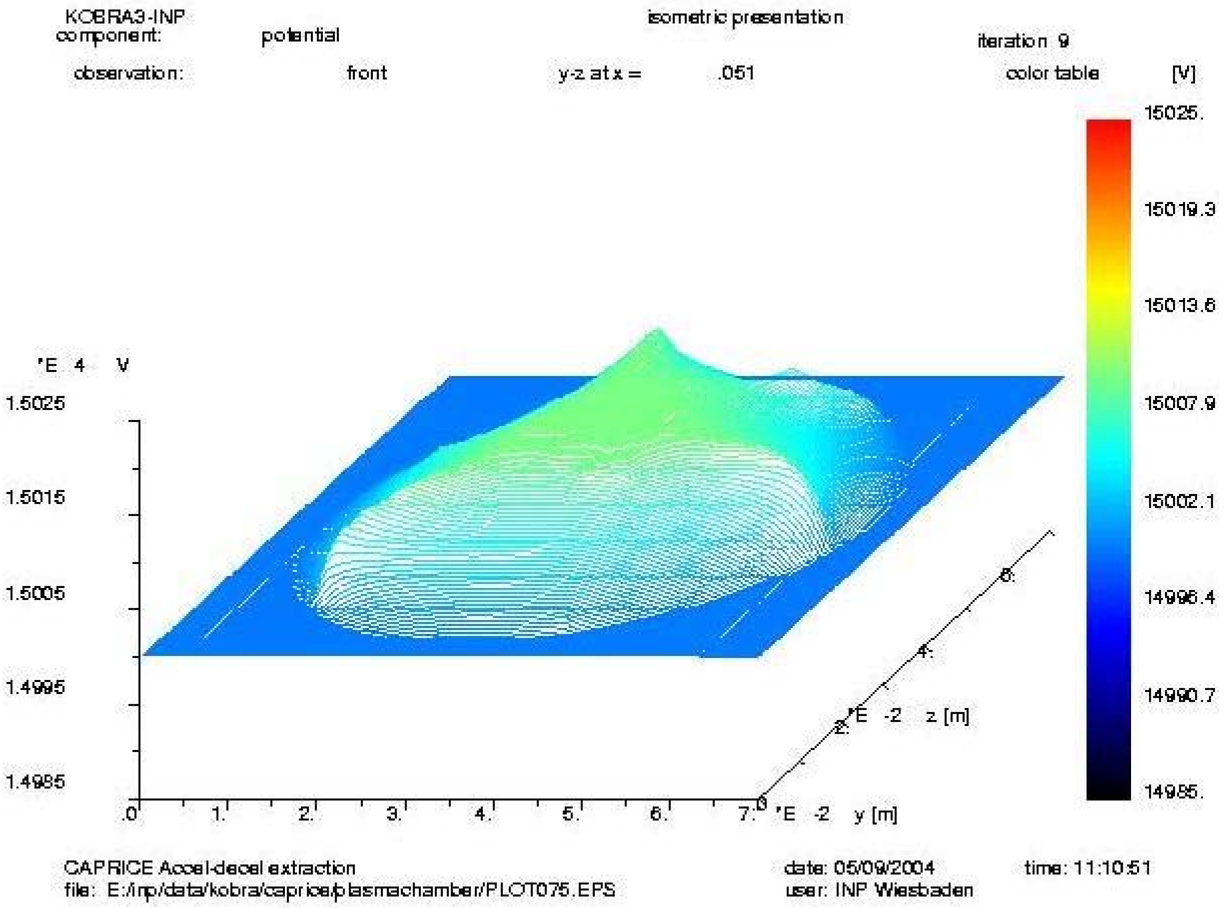
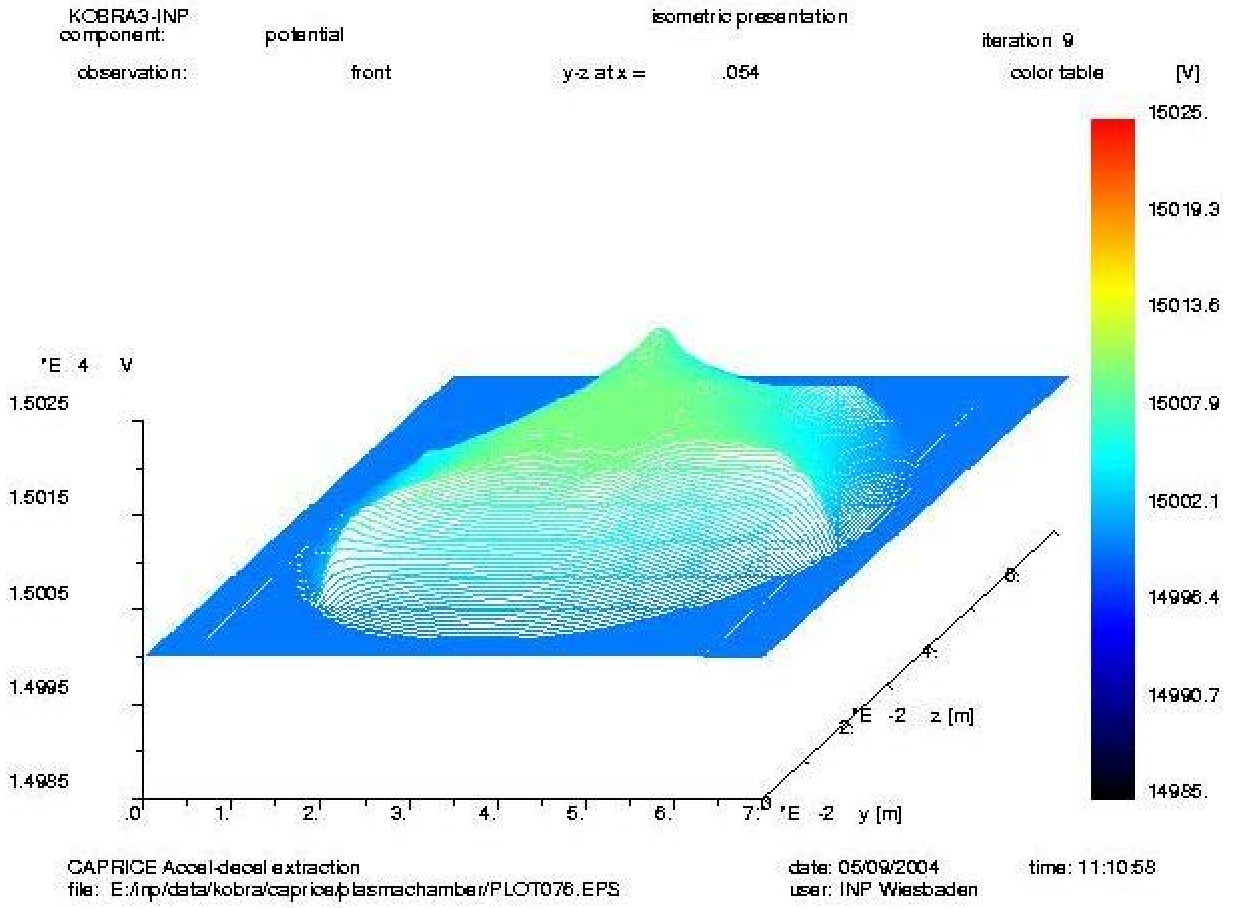
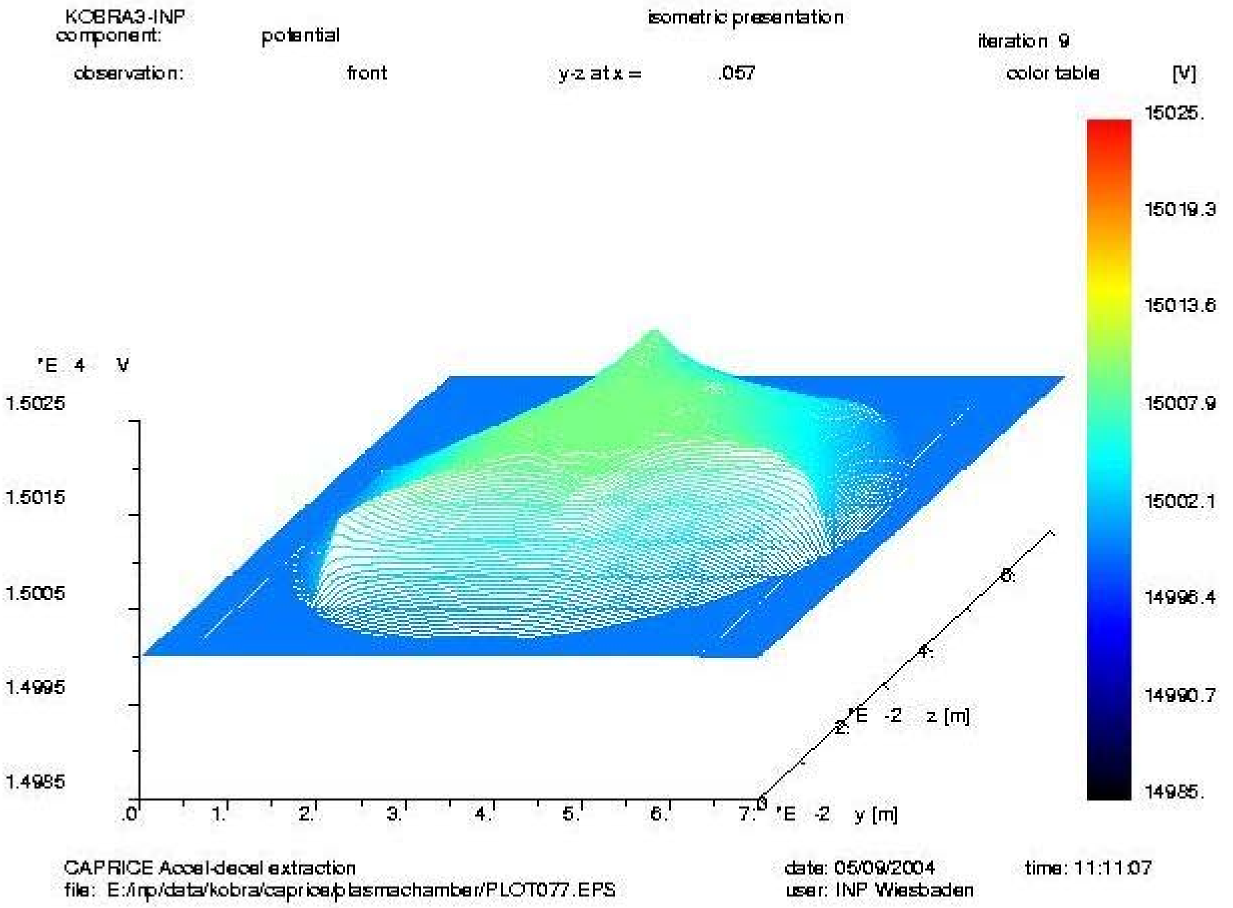

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .045
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
0
2.
4.
6.
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT073.EPS
date: 05/09/2004
time: 11:10:36
user: INP Wiesbaden

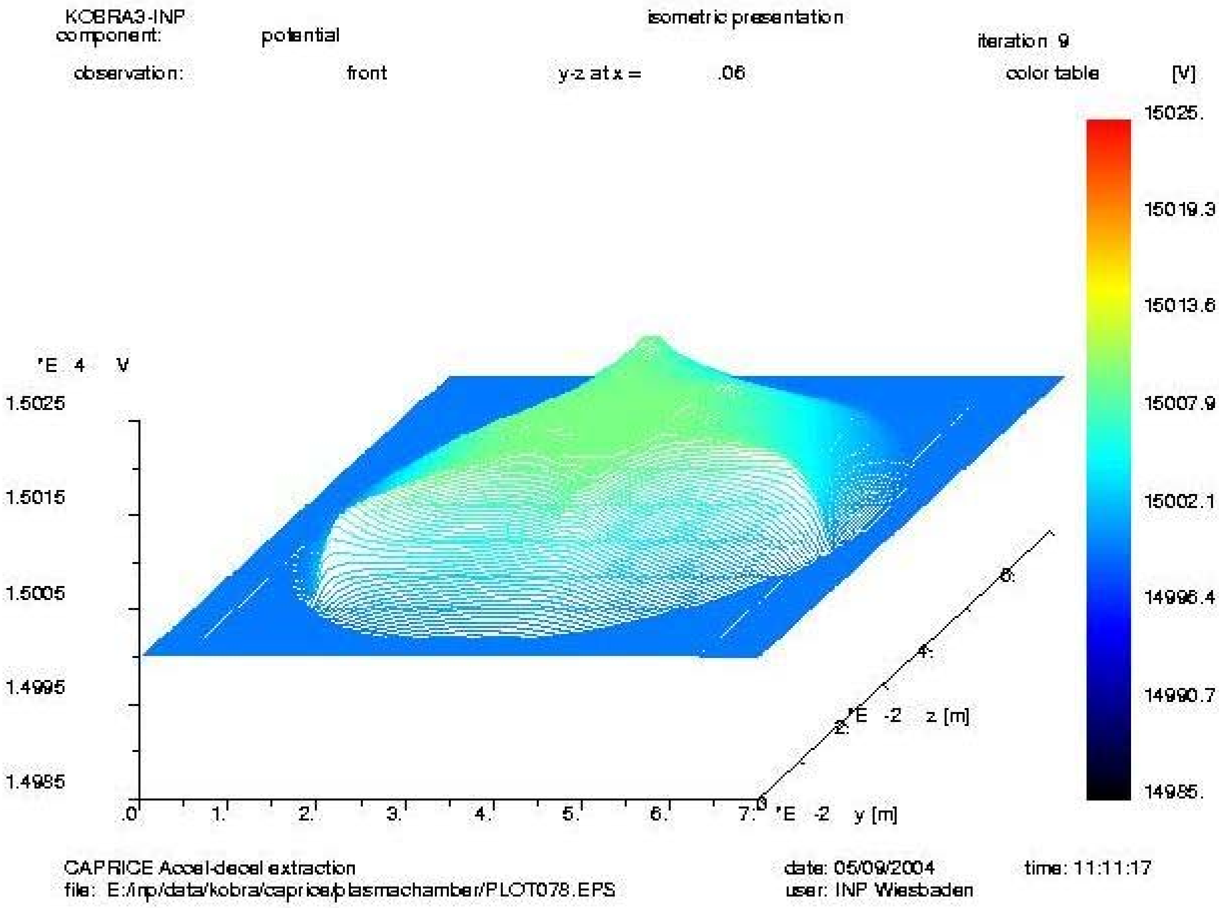

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .048
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT074.EPS
date: 05/09/2004
time: 11:10:44
user: INP Wiesbaden


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .051
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
2. 4. 6.
'E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT075.EPS
date: 05/09/2004
time: 11:10:51
user: INP Wiesbaden

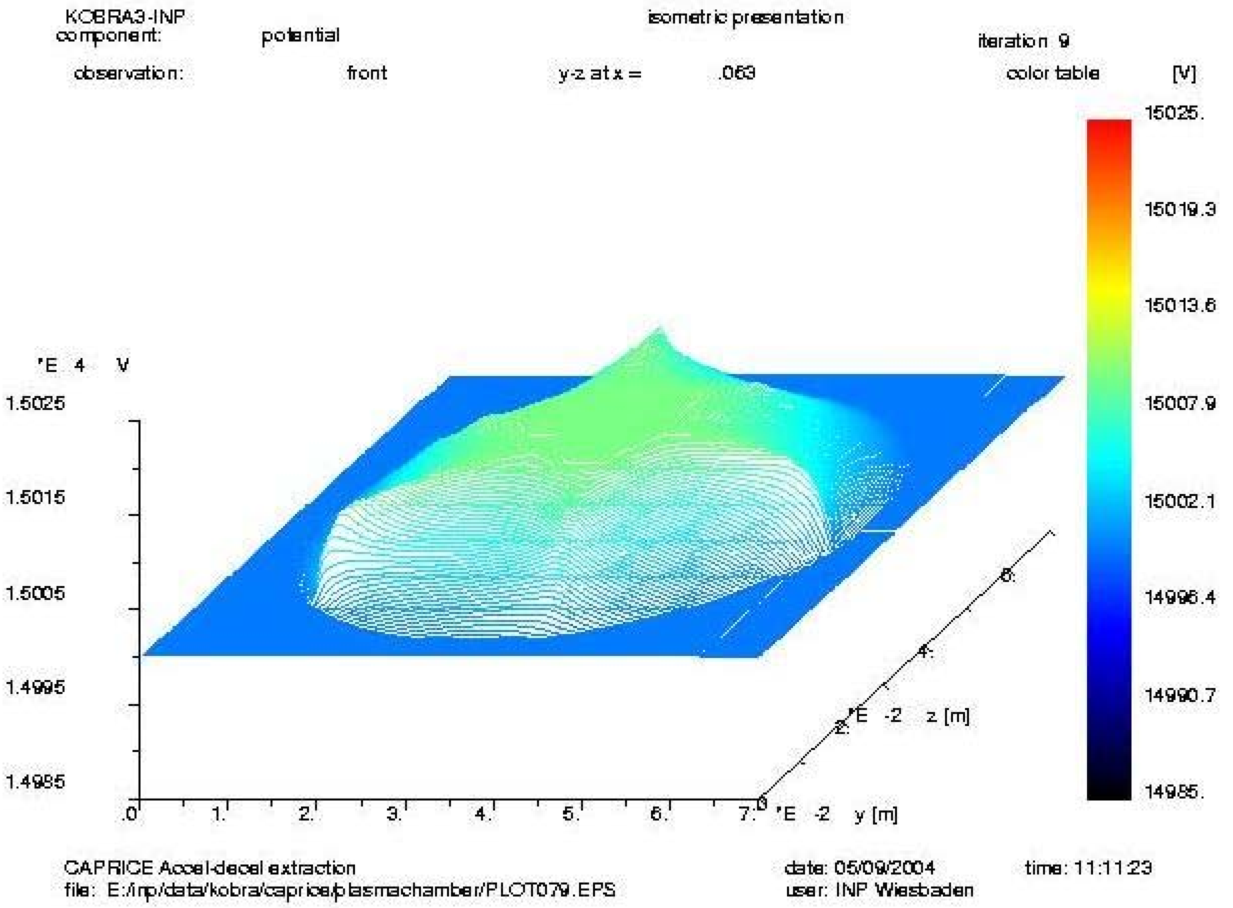


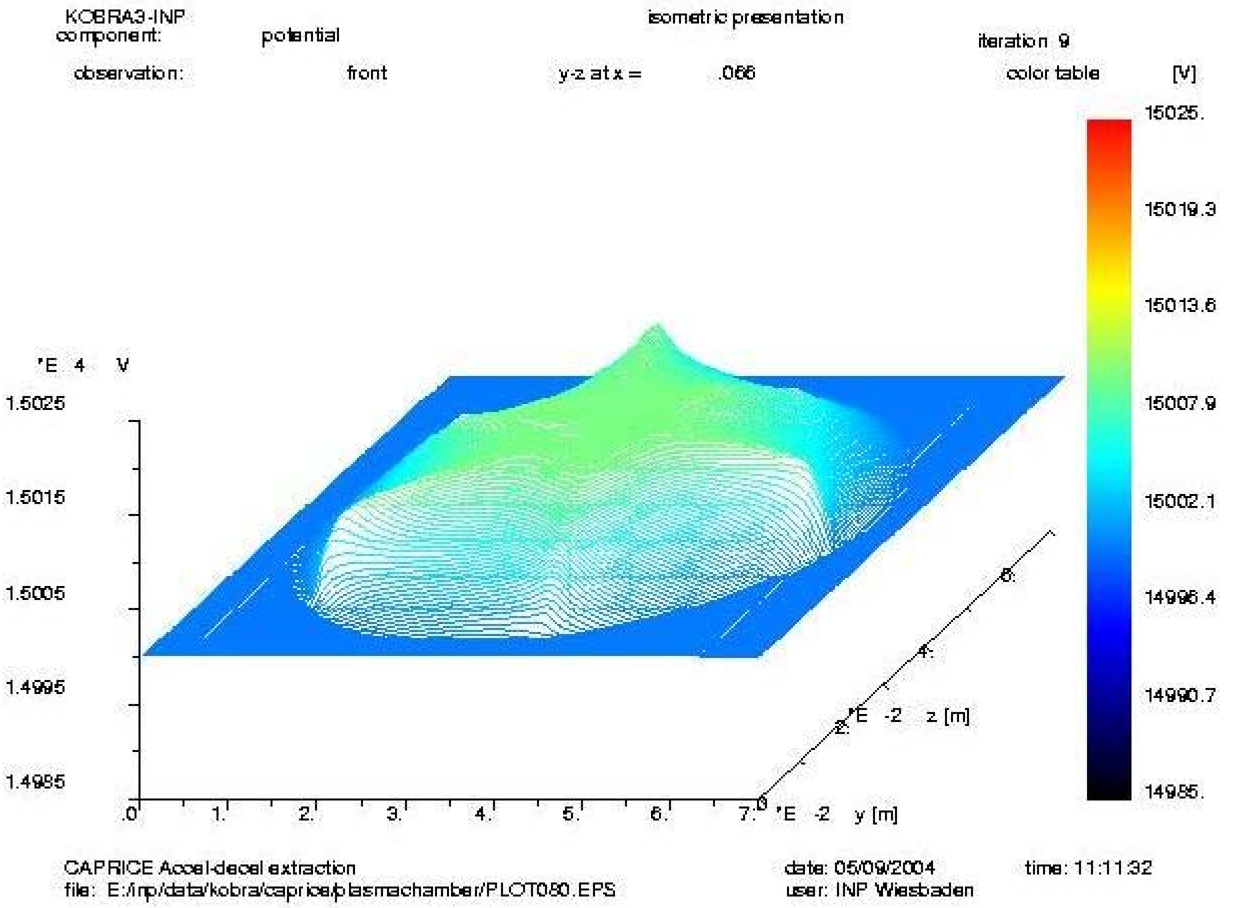
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .054
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT076.EPS
date: 05/09/2004
time: 11:10:58
user: INP Wiesbaden

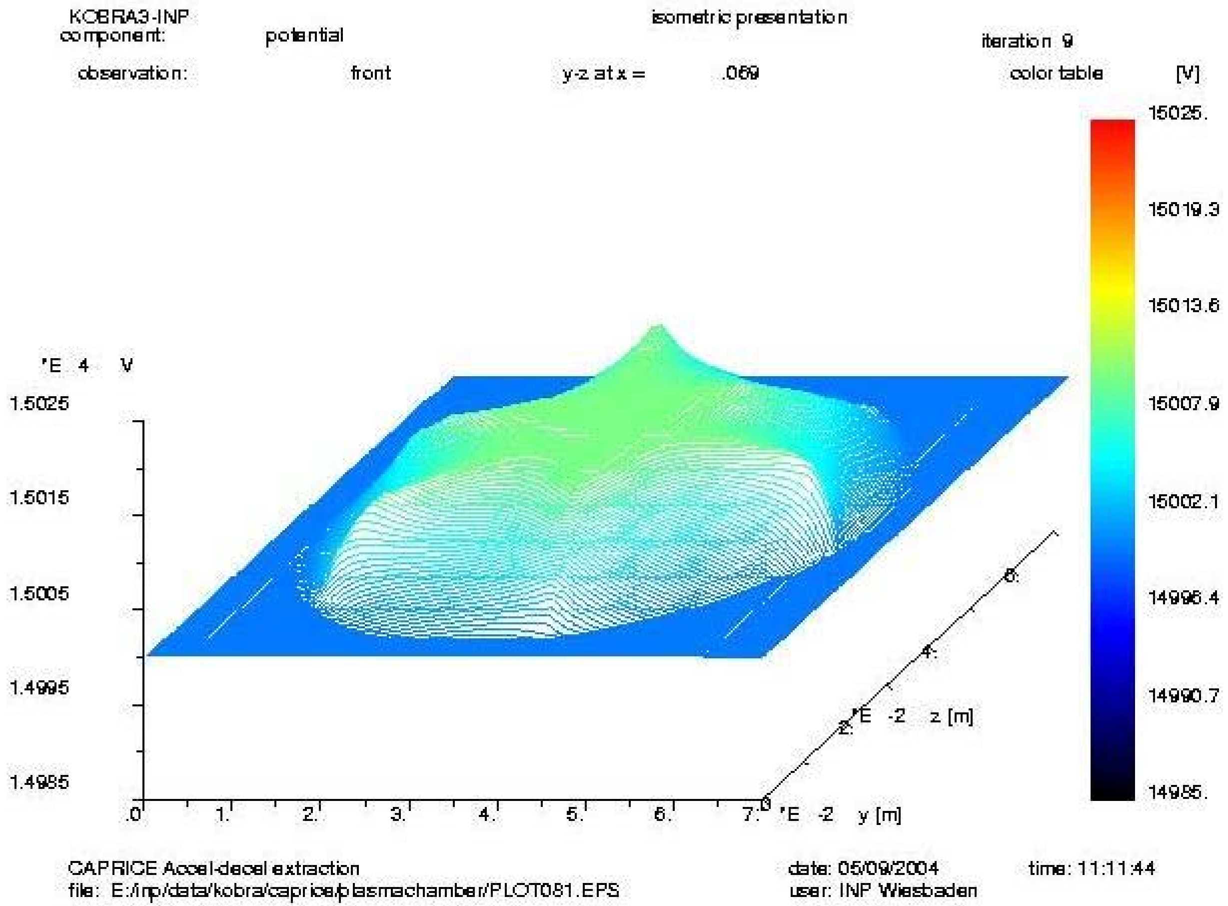

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .057
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT077.EPS
date: 05/09/2004
user: INP Wiesbaden
time: 11:11:07

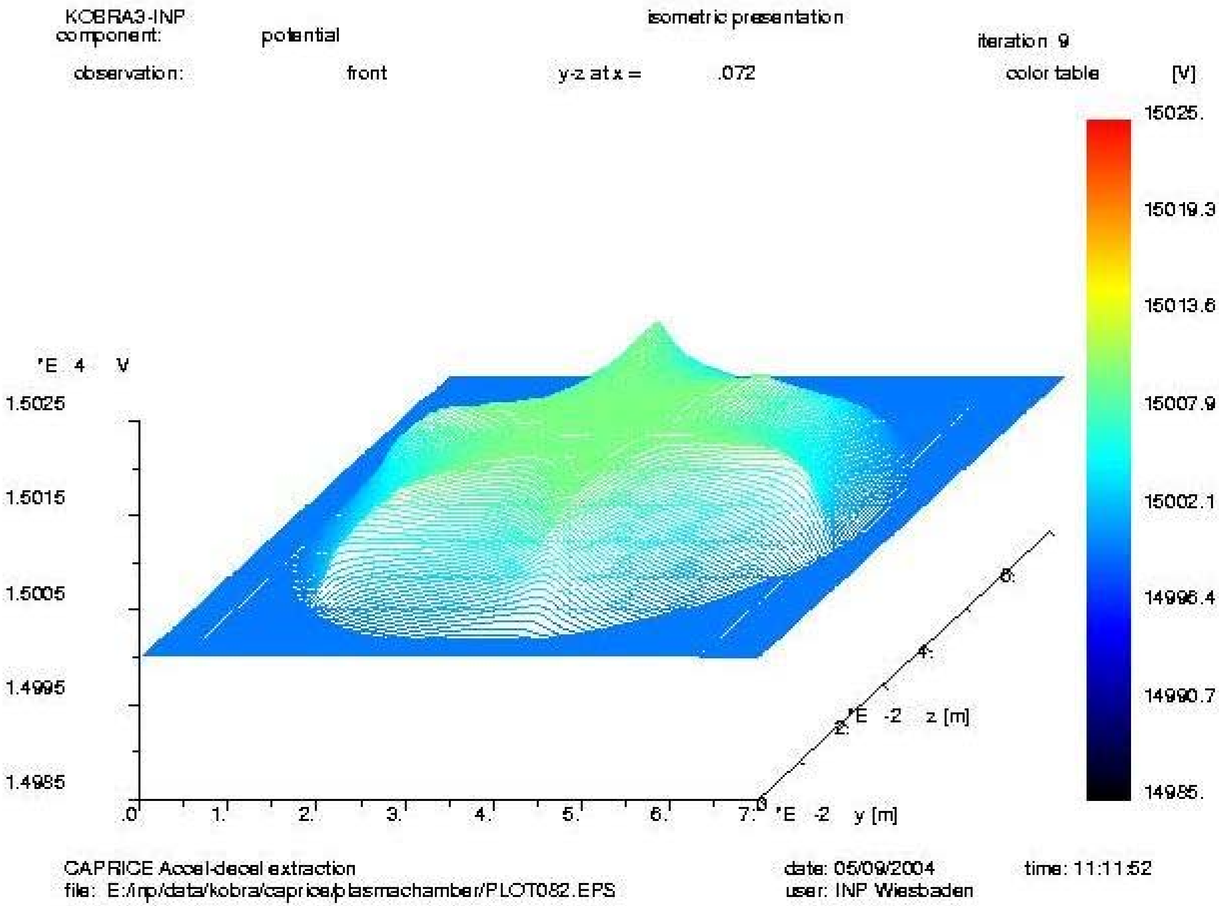


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .06
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT078.EPS
date: 05/09/2004
time: 11:11:17
user: INP Wiesbaden

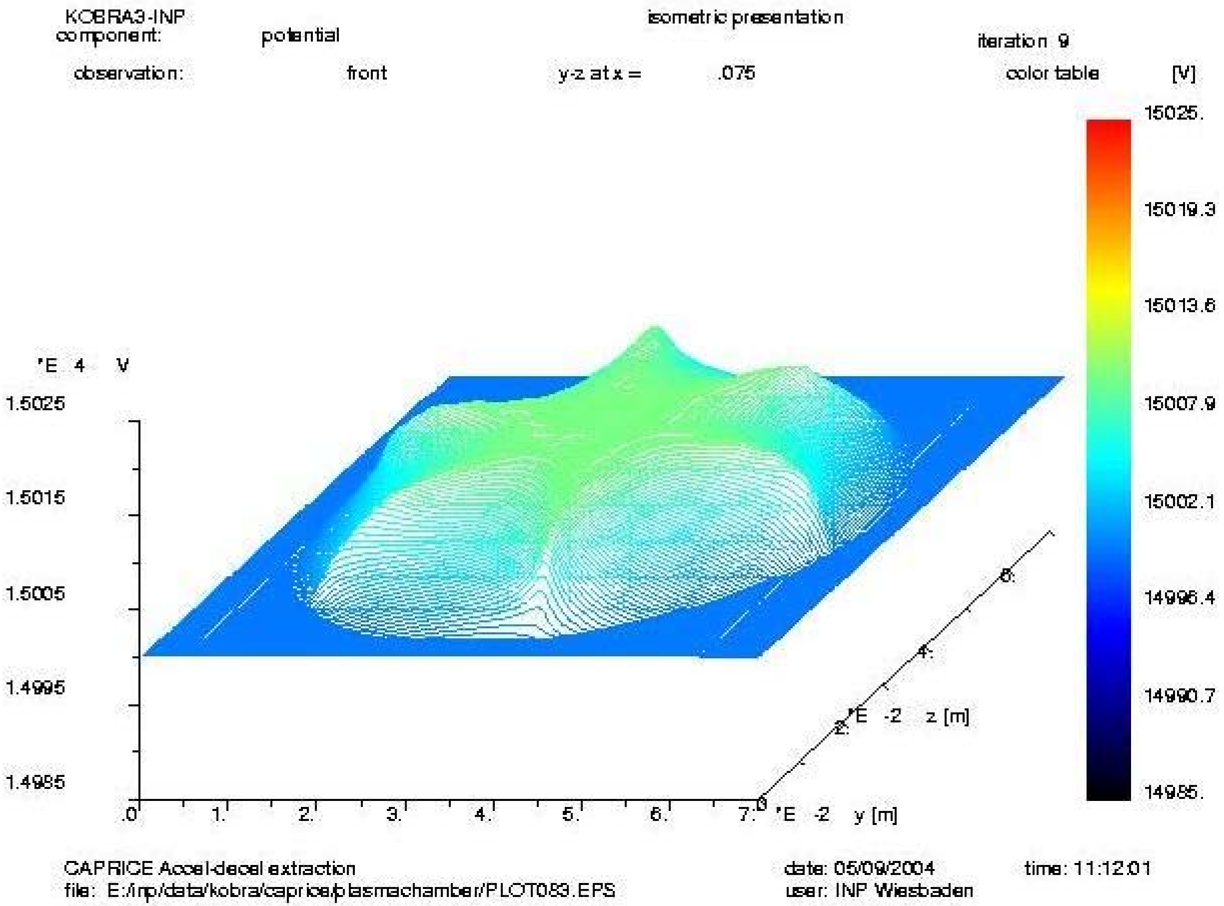

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .063
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT079.EPS
date: 05/09/2004
time: 11:11:23
user: INP Wiesbaden

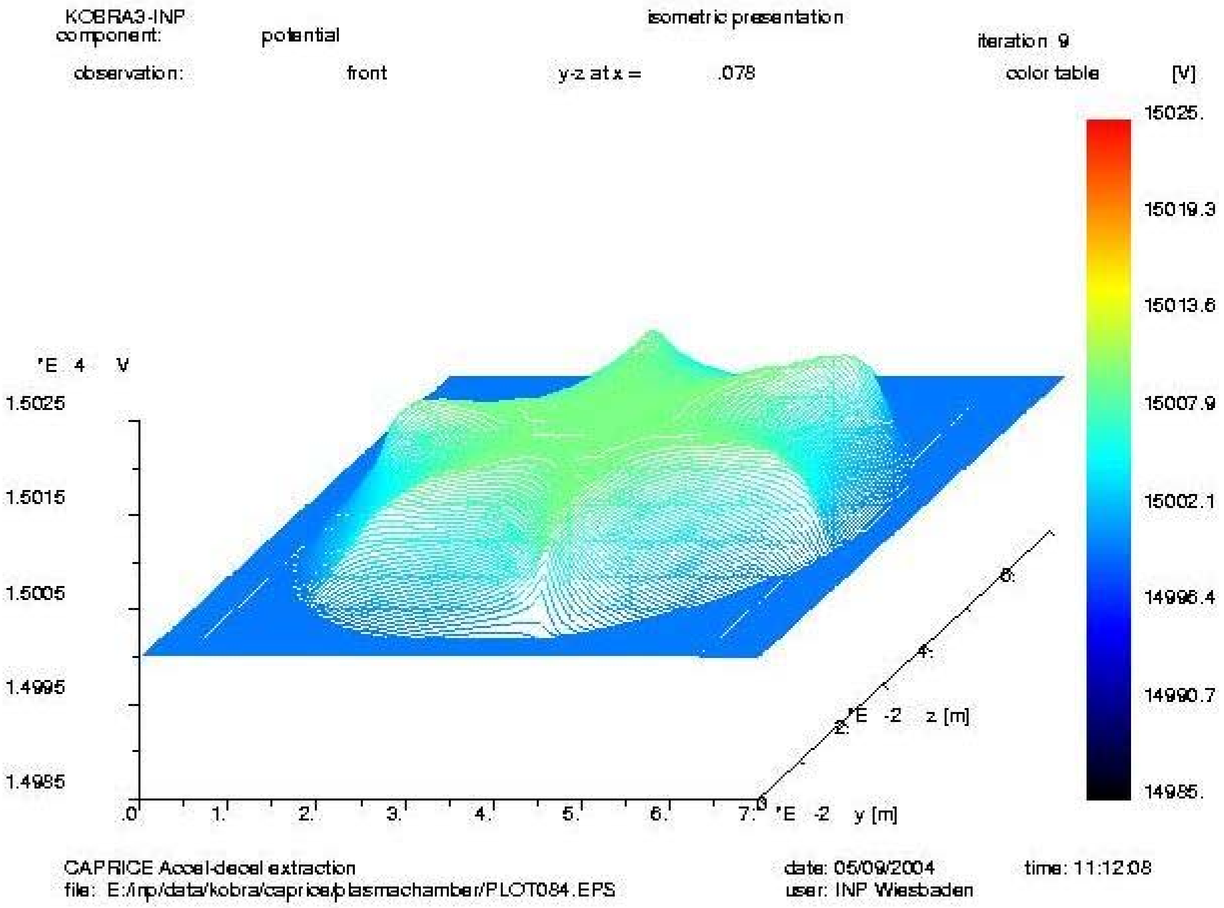

KOBRA3-INP
component:
potential
isometric presentation
iteration 9
observation:
front
y-z at x =
.066
color table
[V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
'E -2 y [m]
'E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT080.EPS
date: 05/09/2004
time: 11:11:32
user: INP Wiesbaden

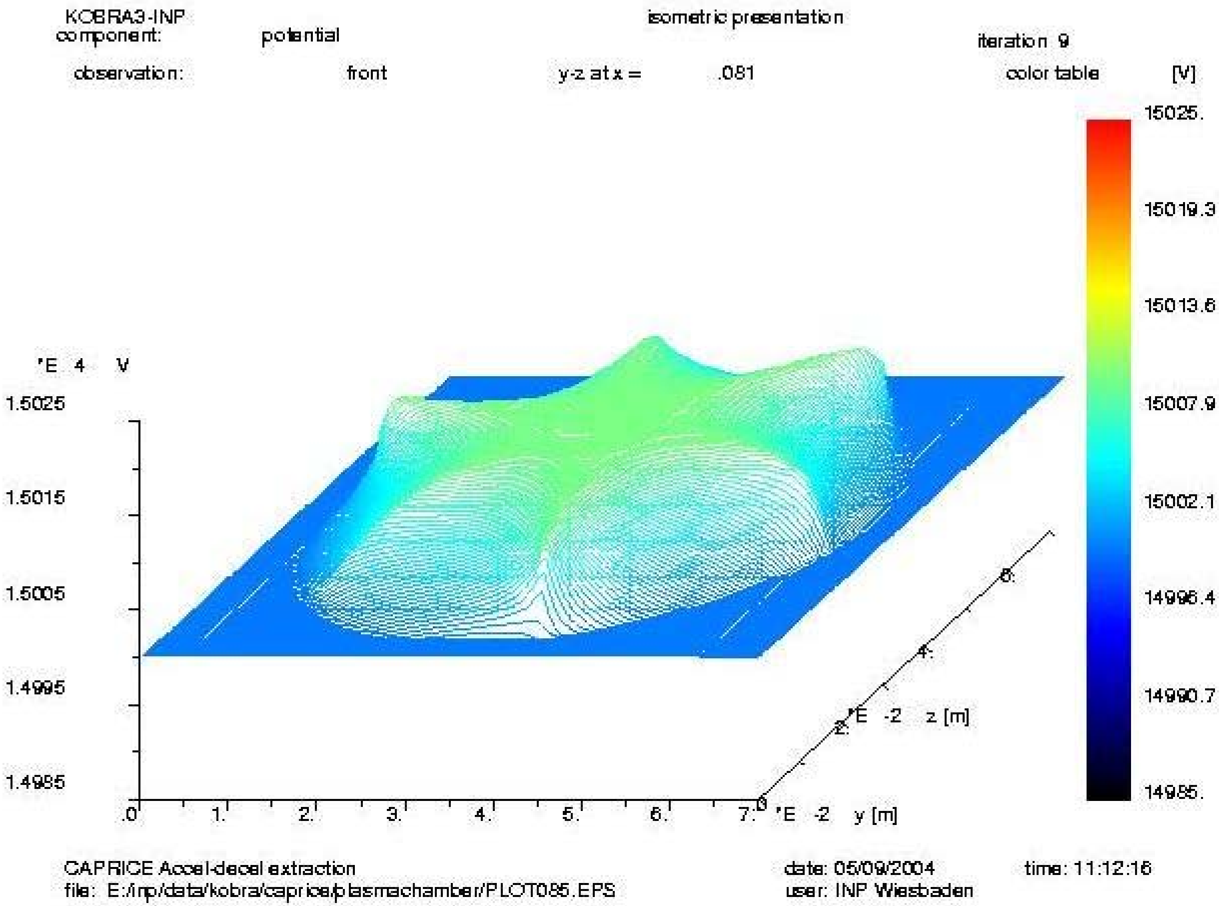

KOBRA3-INP
component:
potential
isometric presentation
iteration 9
observation:
front
y-z at x =
.069
color table
[V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
*E -2 z [m]
2.
4.
6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT081.EPS
date: 05/09/2004
time: 11:11:44
user: INP Wiesbaden



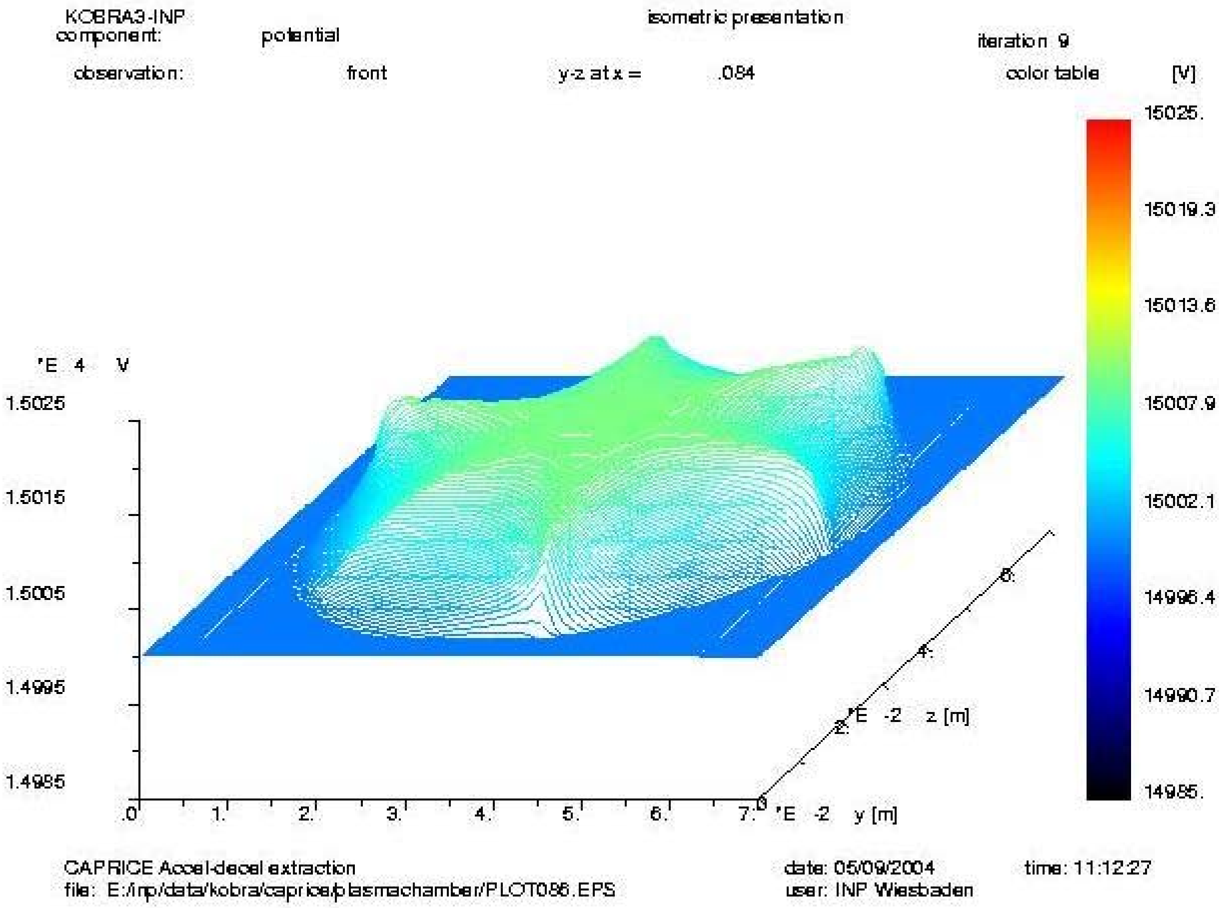
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .072
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT082.EPS
date: 05/09/2004
user: INP Wiesbaden
time: 11:11:52


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .075
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT083.EPS
date: 05/09/2004
time: 11:12:01
user: INP Wiesbaden

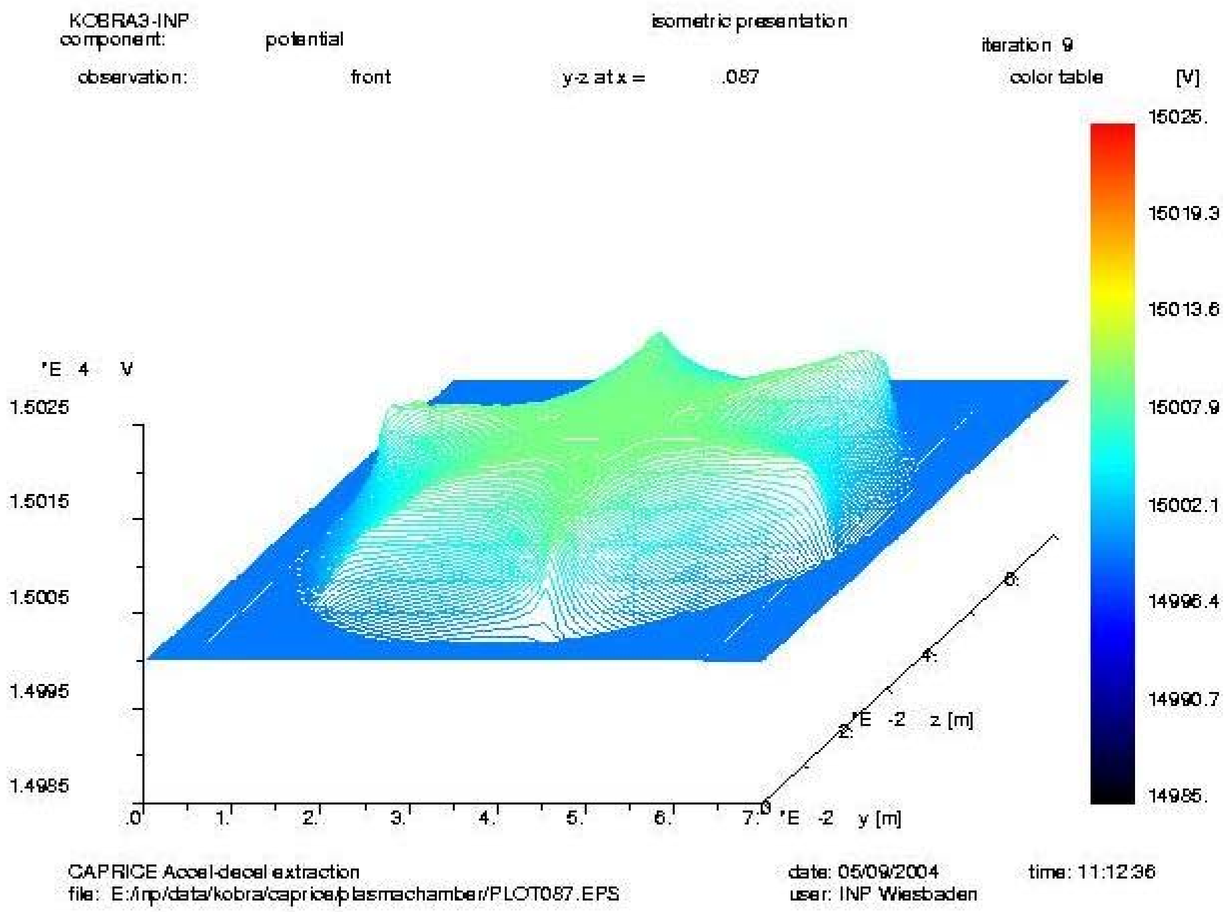

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .078
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT084.EPS
date: 05/09/2004
time: 11:12:08
user: INP Wiesbaden

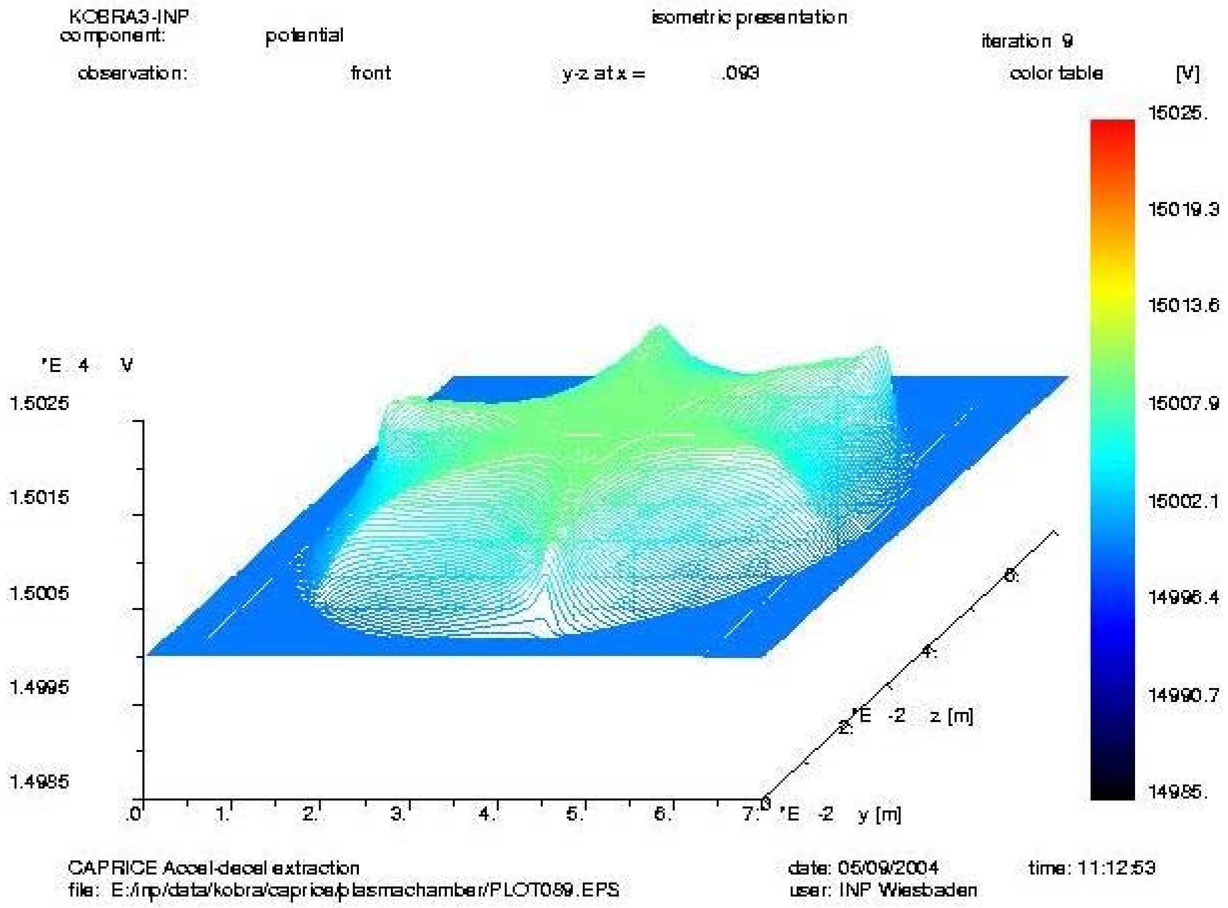


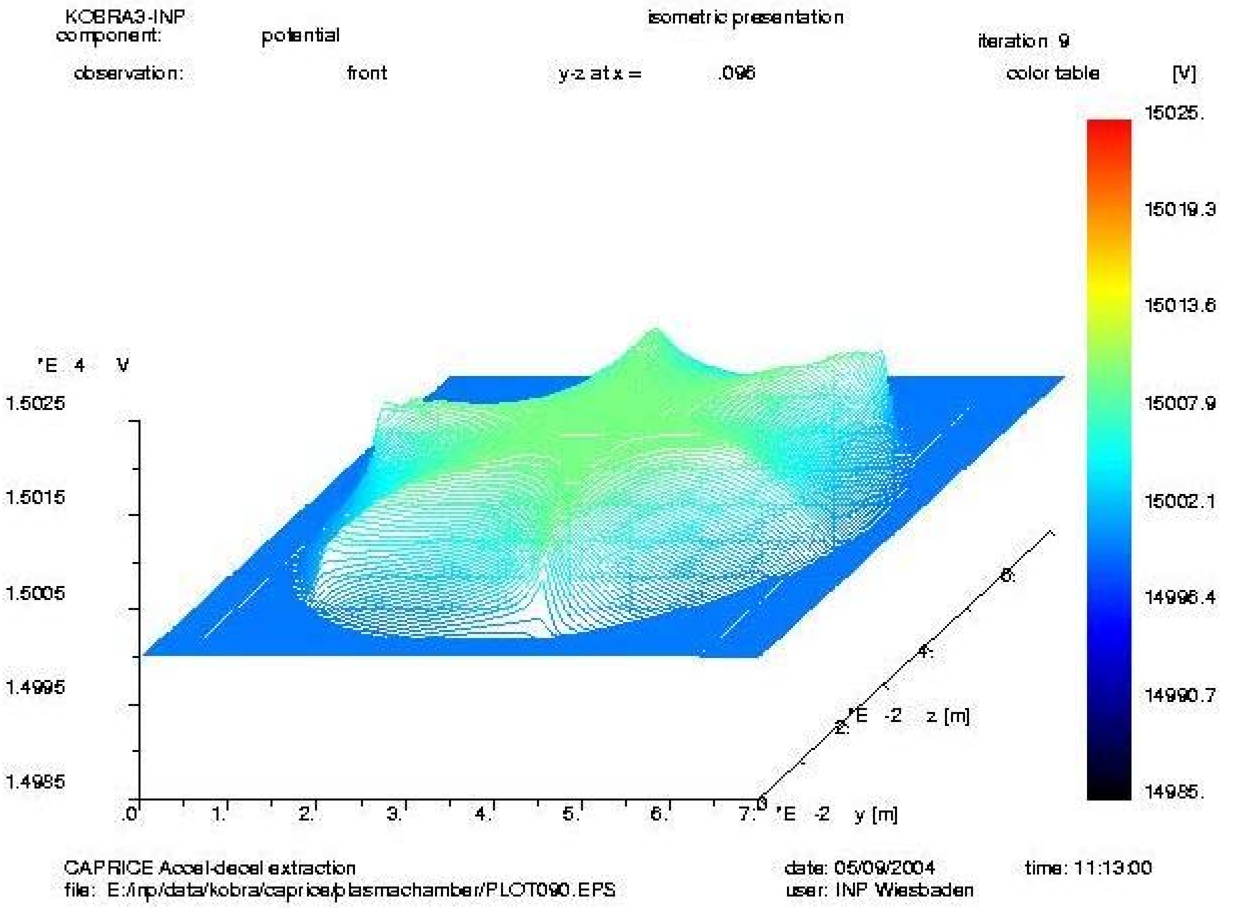
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .081
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT085.EPS
date: 05/09/2004
time: 11:12:16
user: INP Wiesbaden



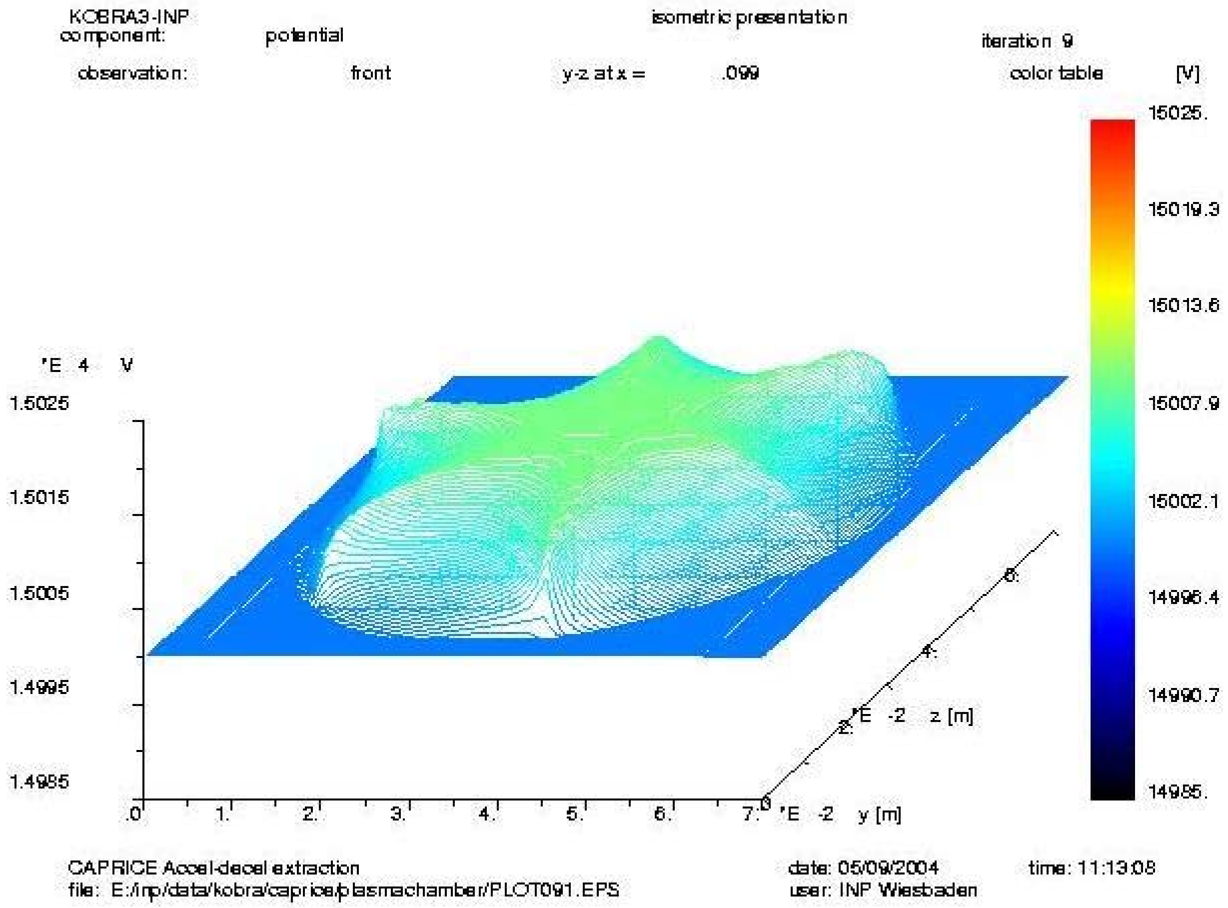
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .084
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT086.EPS
date: 05/09/2004
time: 11:12:27
user: INP Wiesbaden

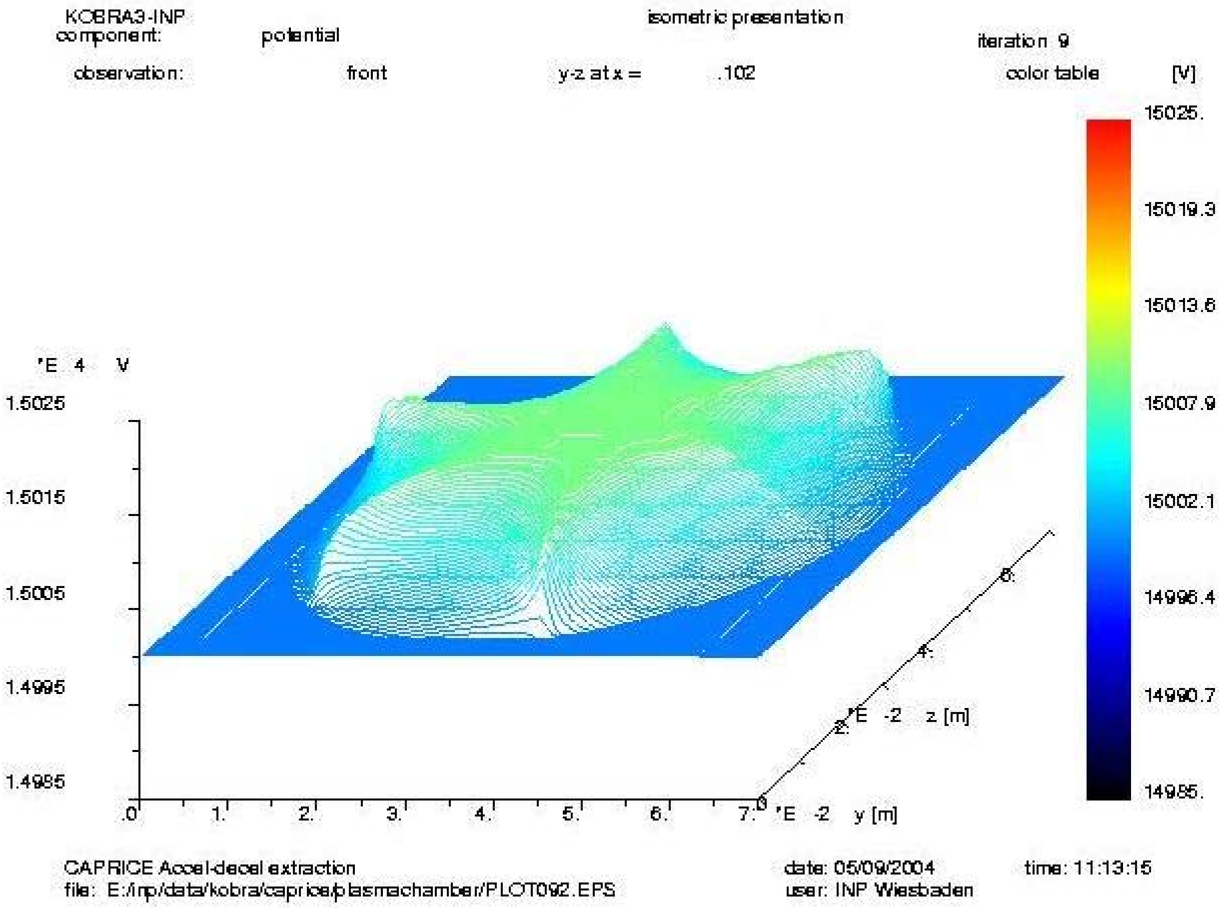

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .087
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT087.EPS
date: 05/09/2004
time: 11:12:36
user: INP Wiesbaden

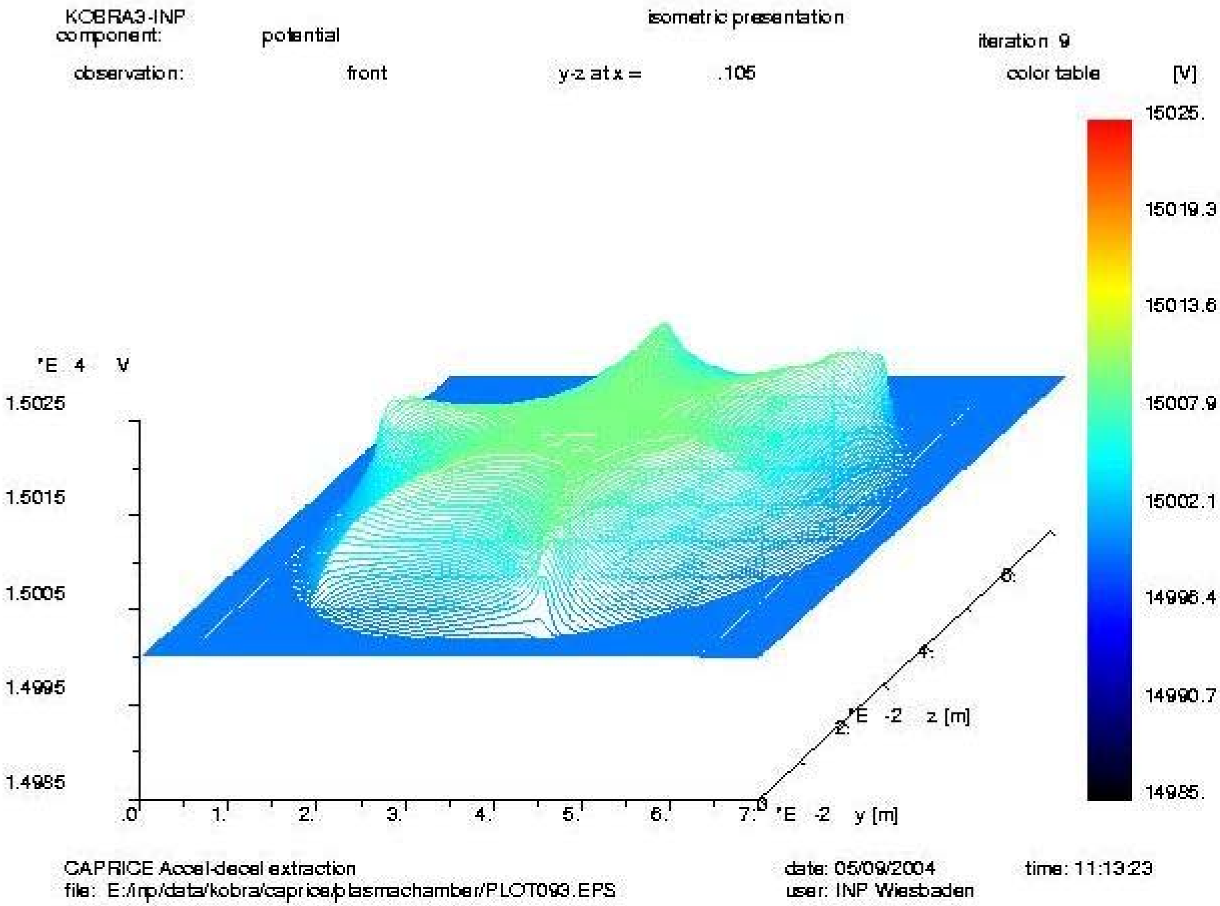

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .093
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT059.EPS
date: 05/09/2004
time: 11:12:53
user: INP Wiesbaden

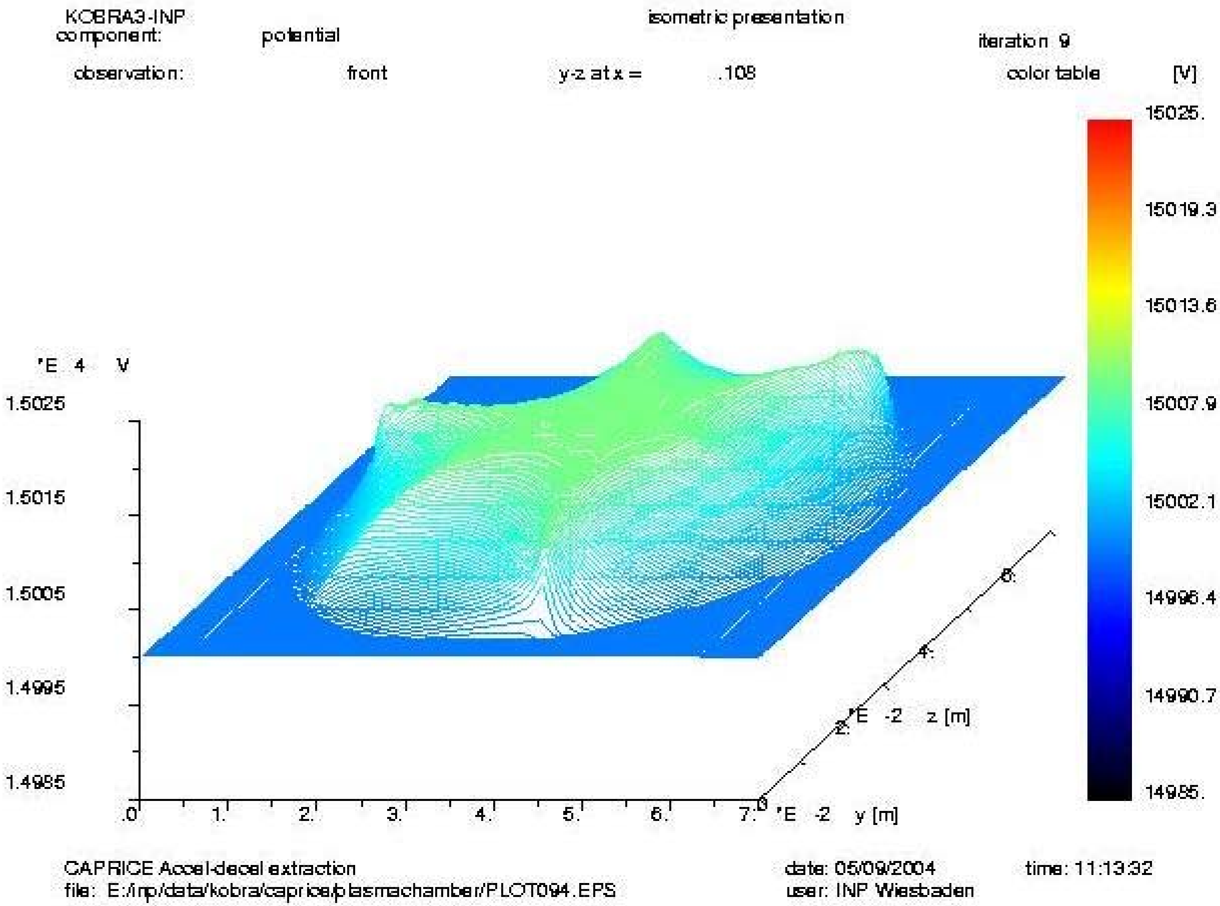


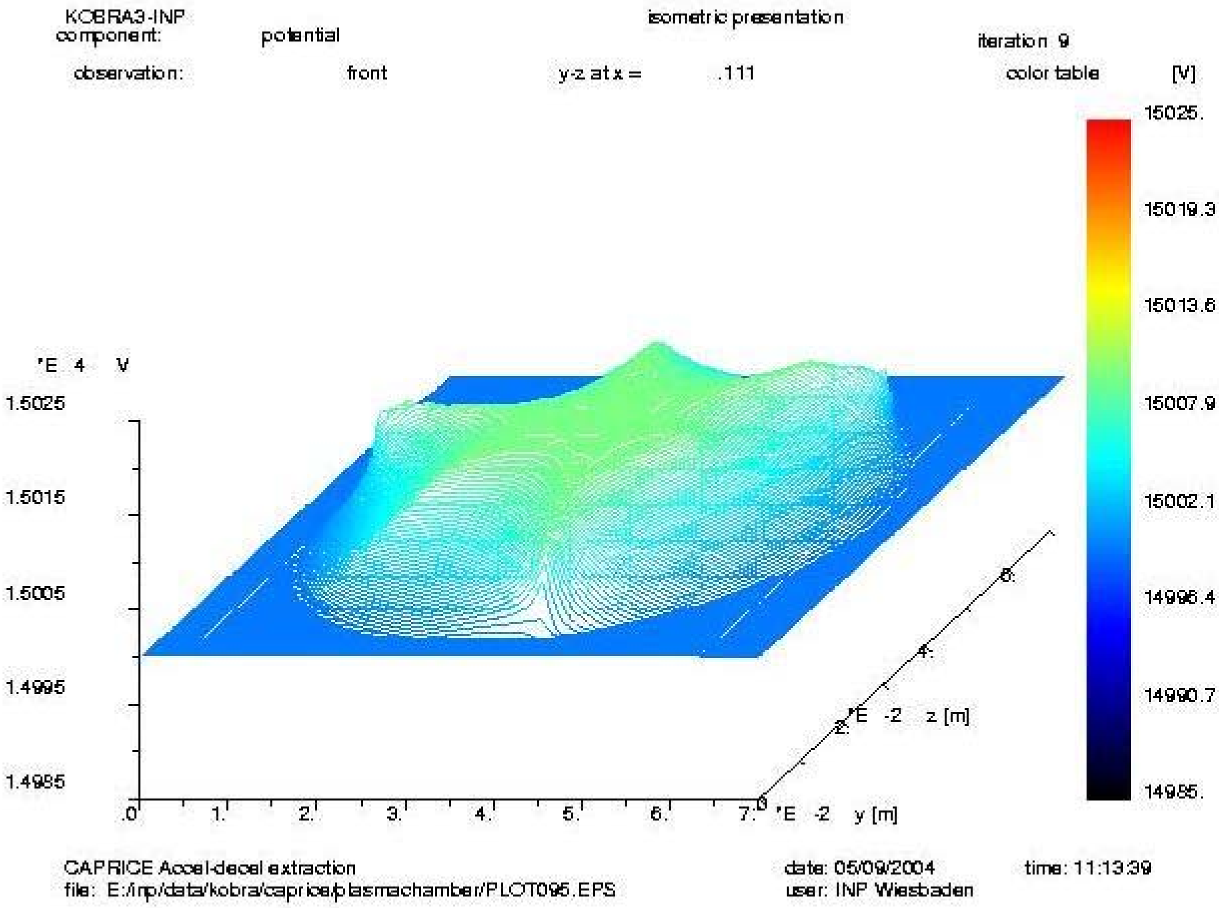
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .096
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT090.EPS
date: 05/09/2004
time: 11:13:00
user: INP Wiesbaden

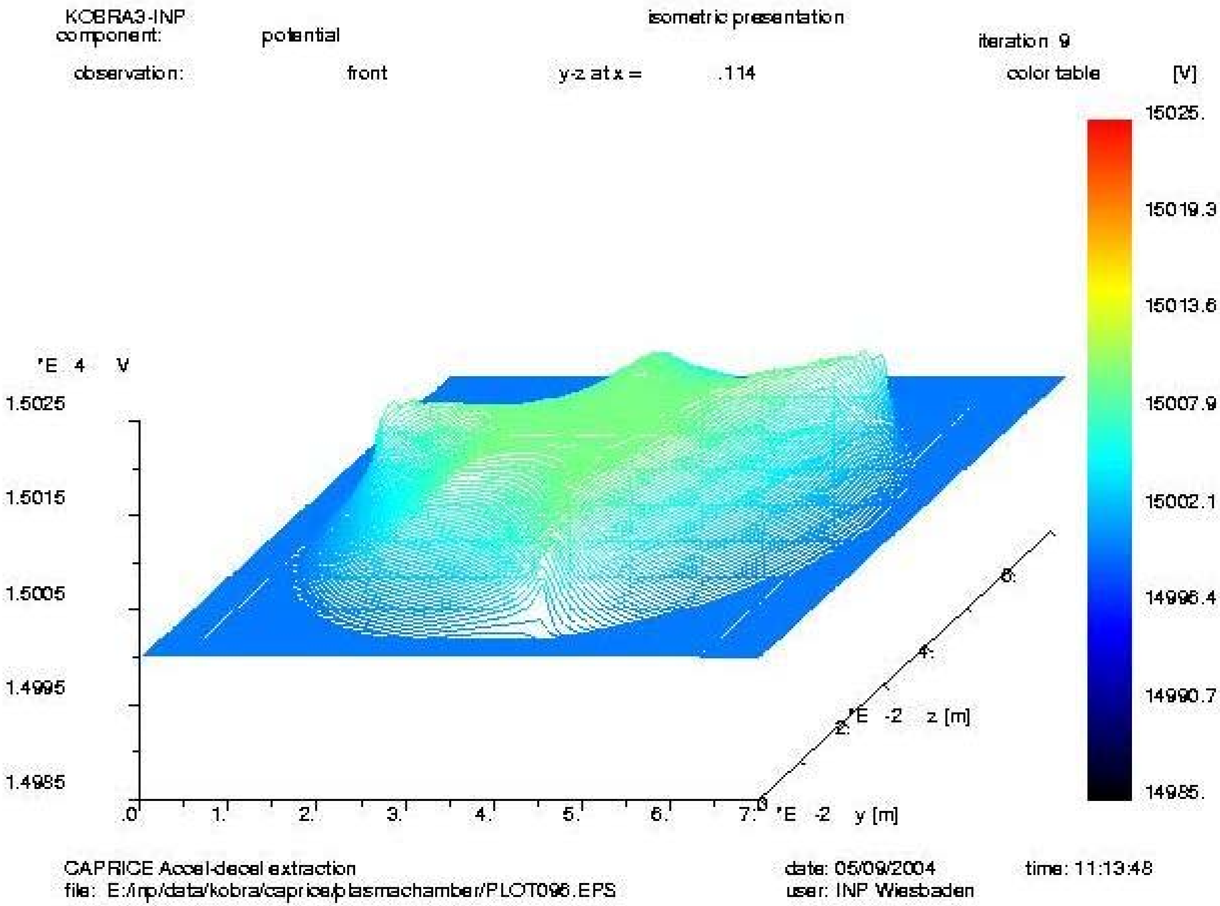

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .099
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT091.EPS
date: 05/09/2004
time: 11:13:08
user: INP Wiesbaden


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .102
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
2. 4. 6.
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT092.EPS
date: 05/09/2004
time: 11:13:15
user: INP Wiesbaden

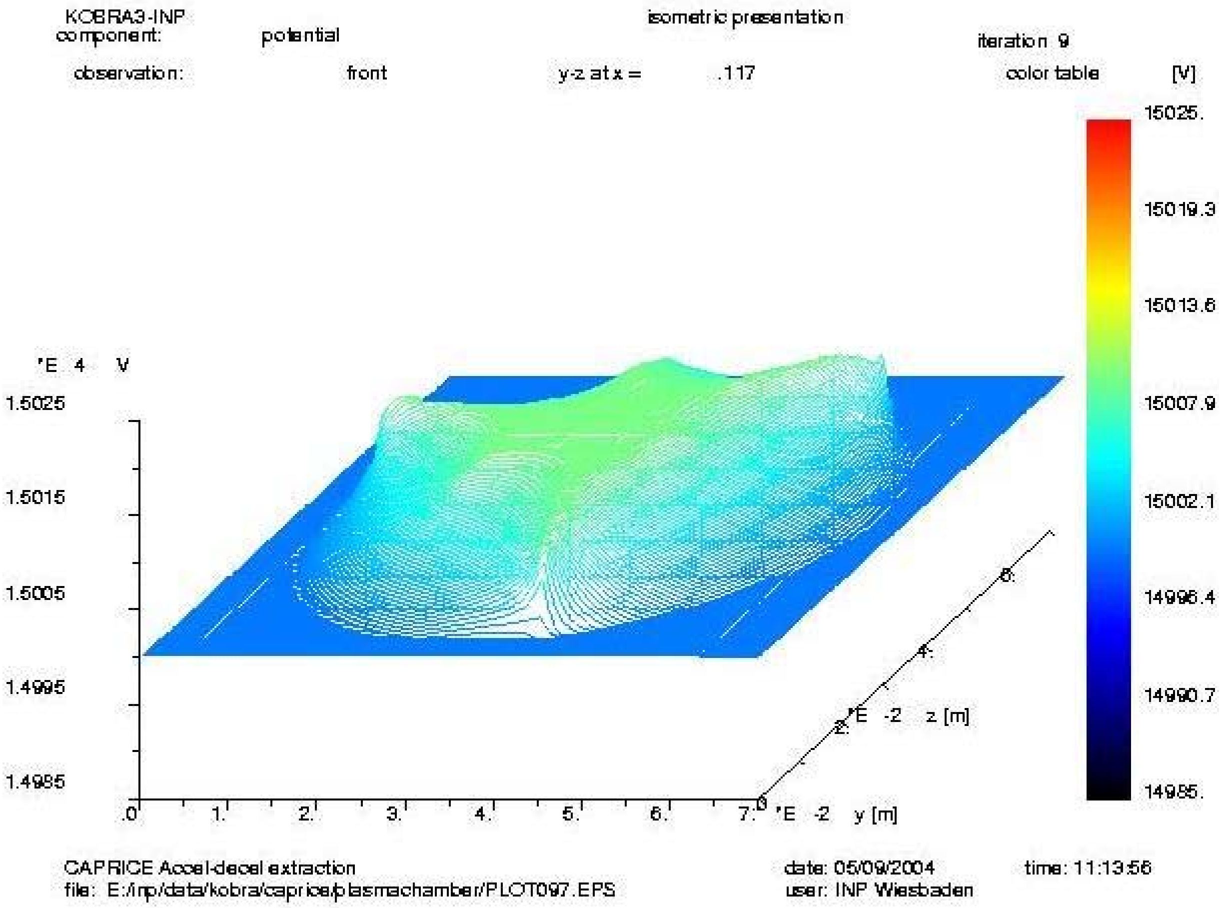

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .105
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT093.EPS
date: 05/09/2004
time: 11:13:23
user: INP Wiesbaden

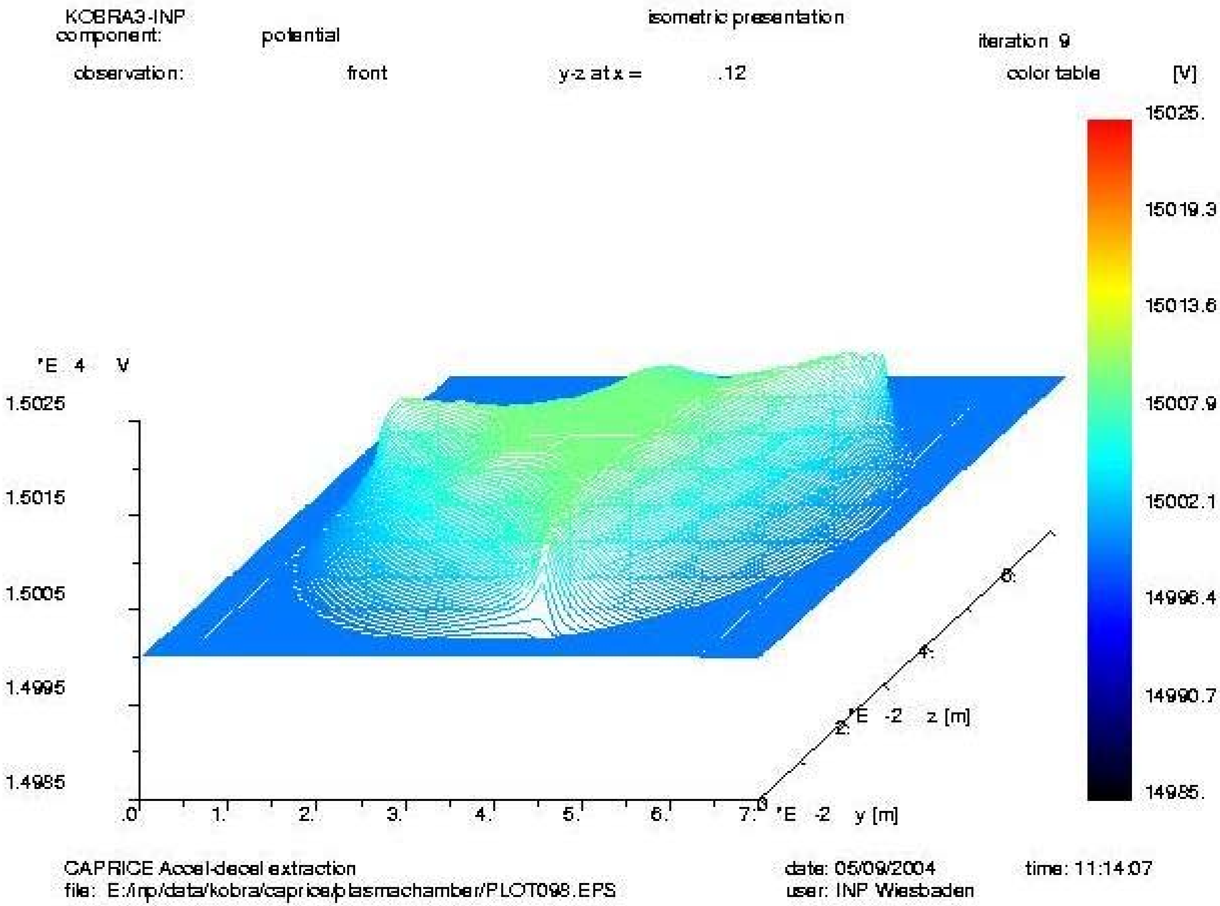

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .108
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT094.EPS
date: 05/09/2004
time: 11:13:32
user: INP Wiesbaden

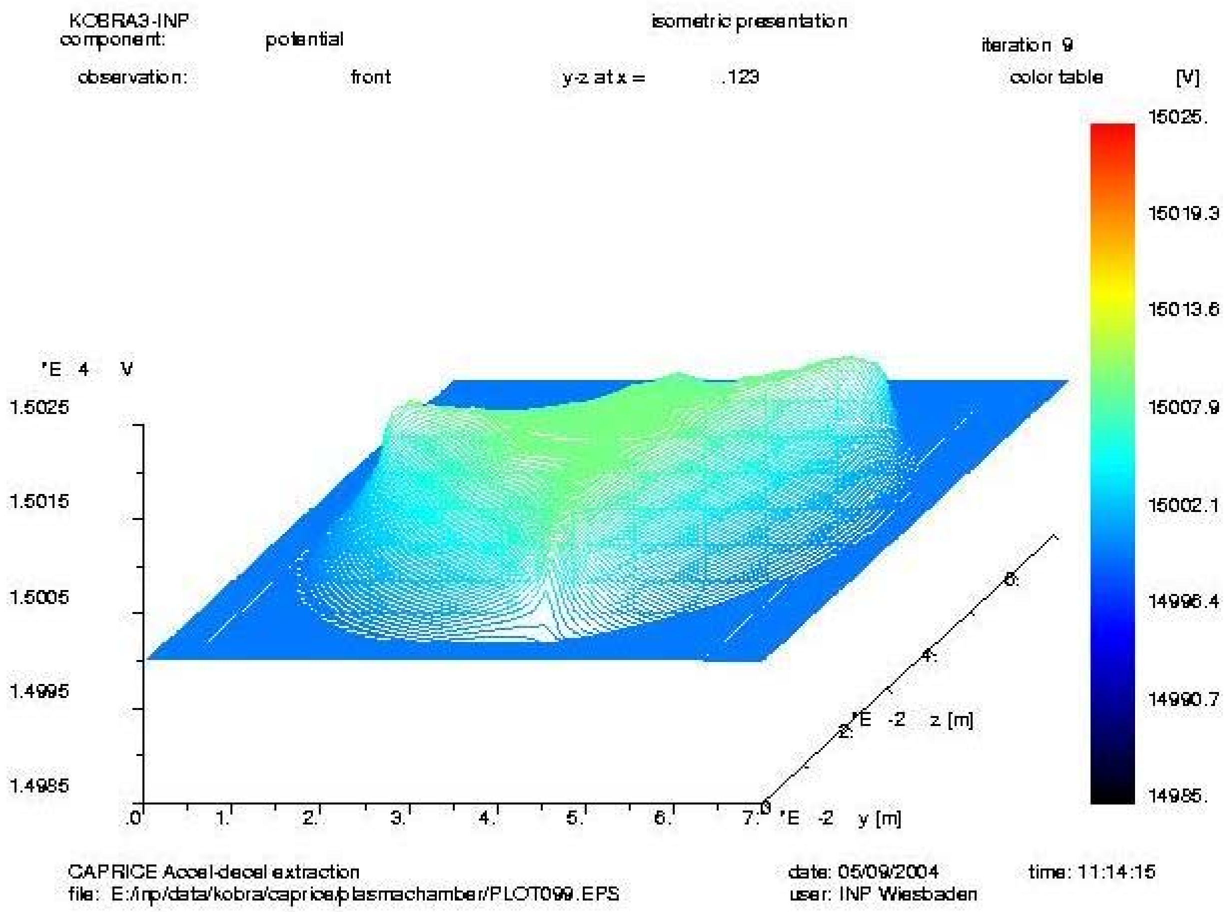

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .111
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT095.EPS
date: 05/09/2004
user: INP Wiesbaden
time: 11:13:39

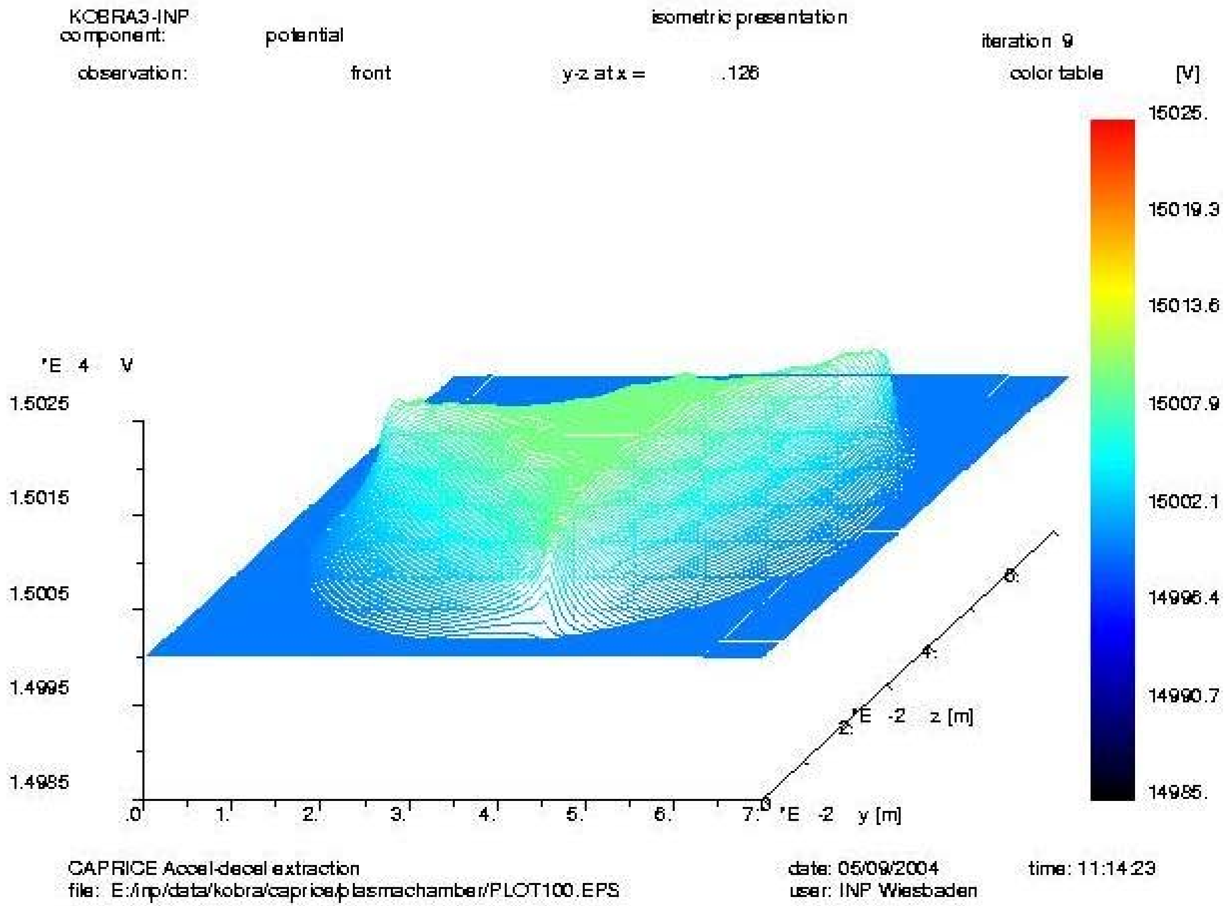


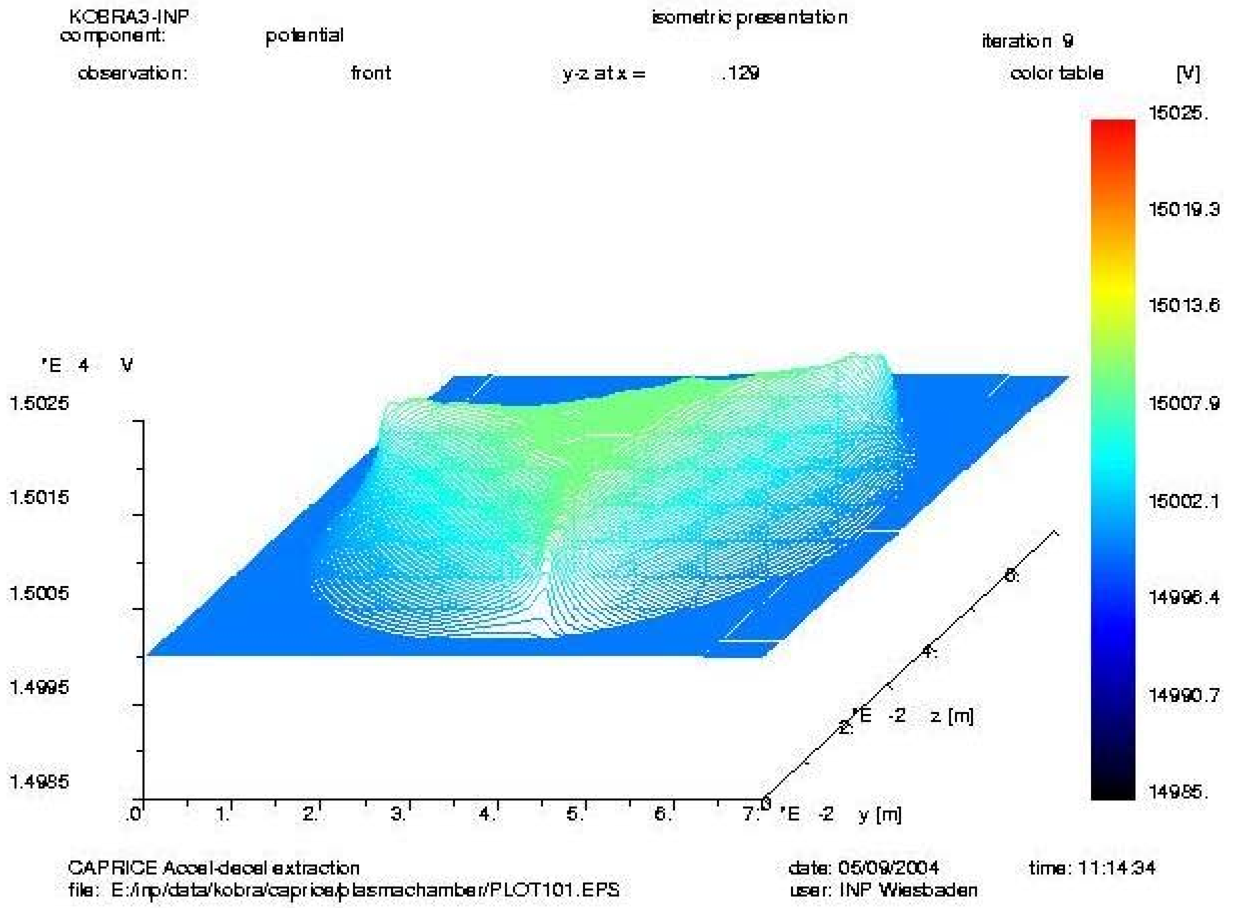
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .114
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
2.
4.
6.
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT096.EPS
date: 05/09/2004
time: 11:13:48
user: INP Wiesbaden

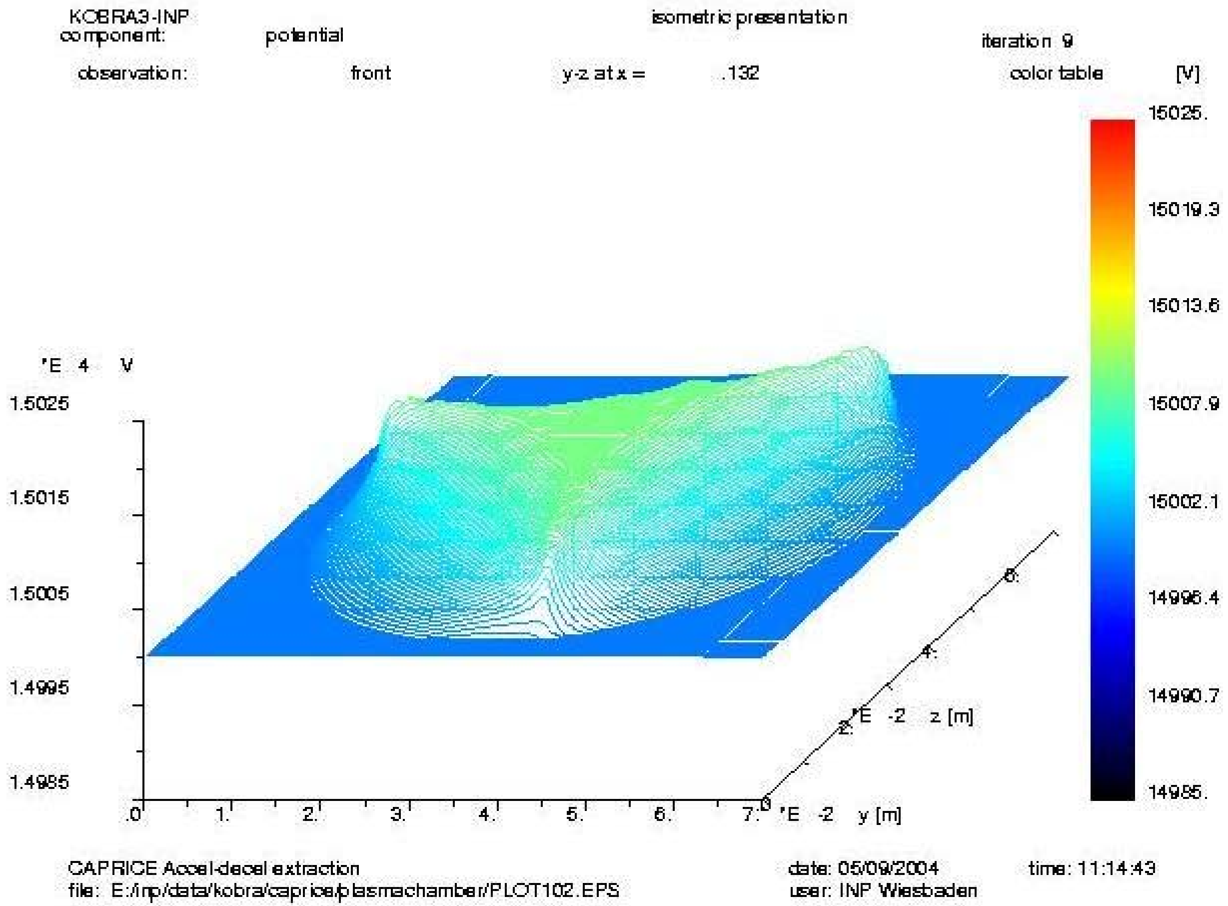

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .117
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT097.EPS
date: 05/09/2004
time: 11:13:56
user: INP Wiesbaden

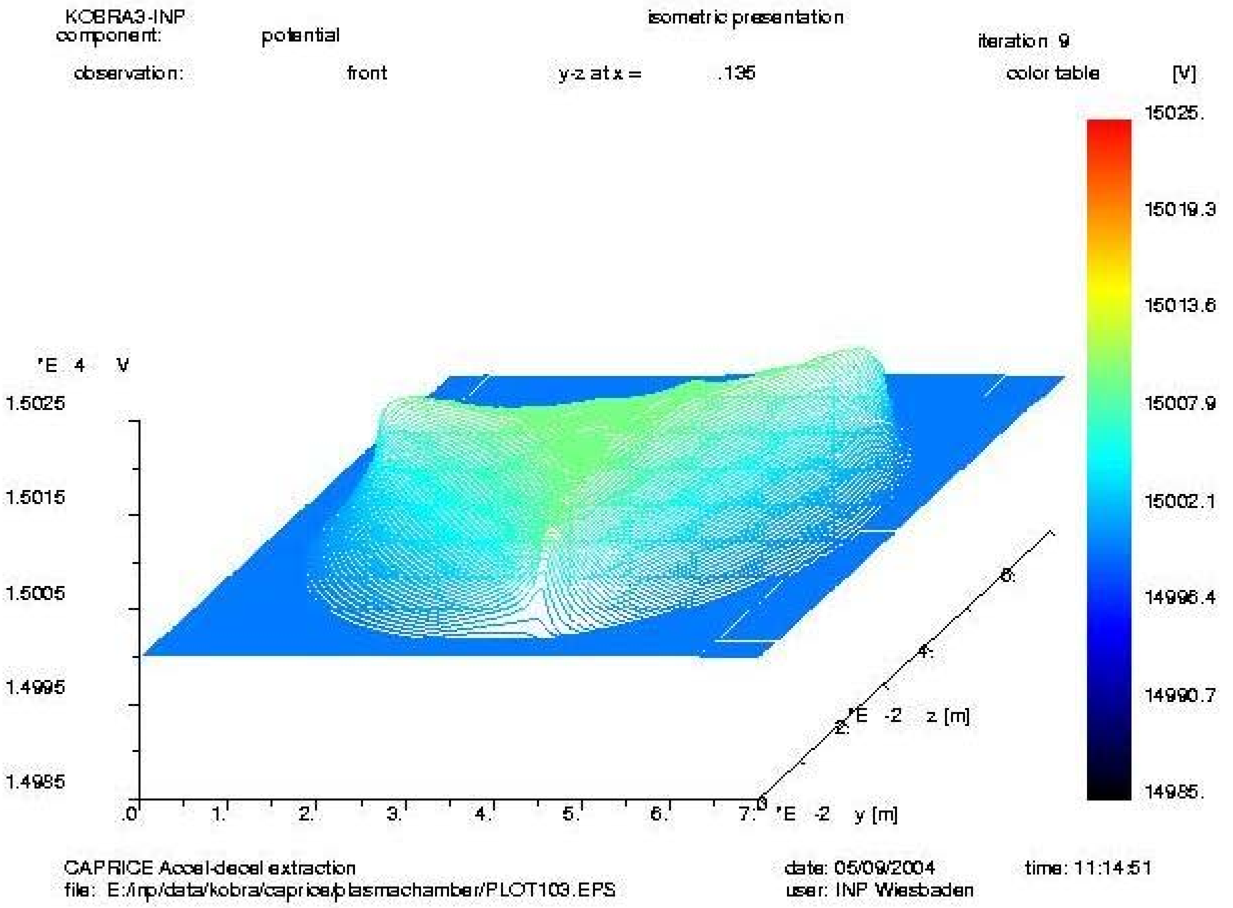

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .12
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT098.EPS
date: 05/09/2004
time: 11:14:07
user: INP Wiesbaden

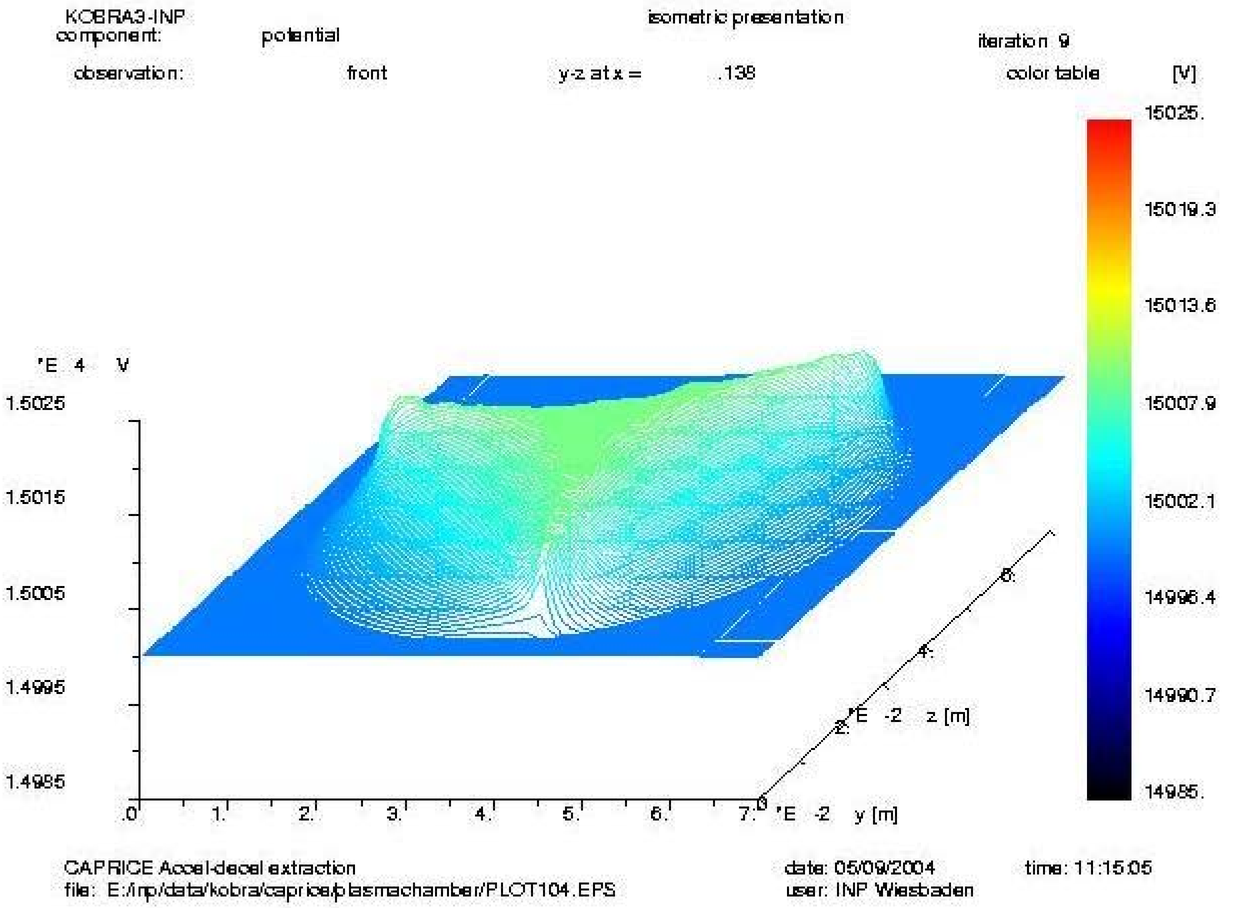

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .123
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
0 2. 4. 6.
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT099.EPS
date: 05/09/2004
time: 11:14:15
user: INP Wiesbaden


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .126
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
2. 4. 6.
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT100.EPS
date: 05/09/2004
time: 11:14:23
user: INP Wiesbaden

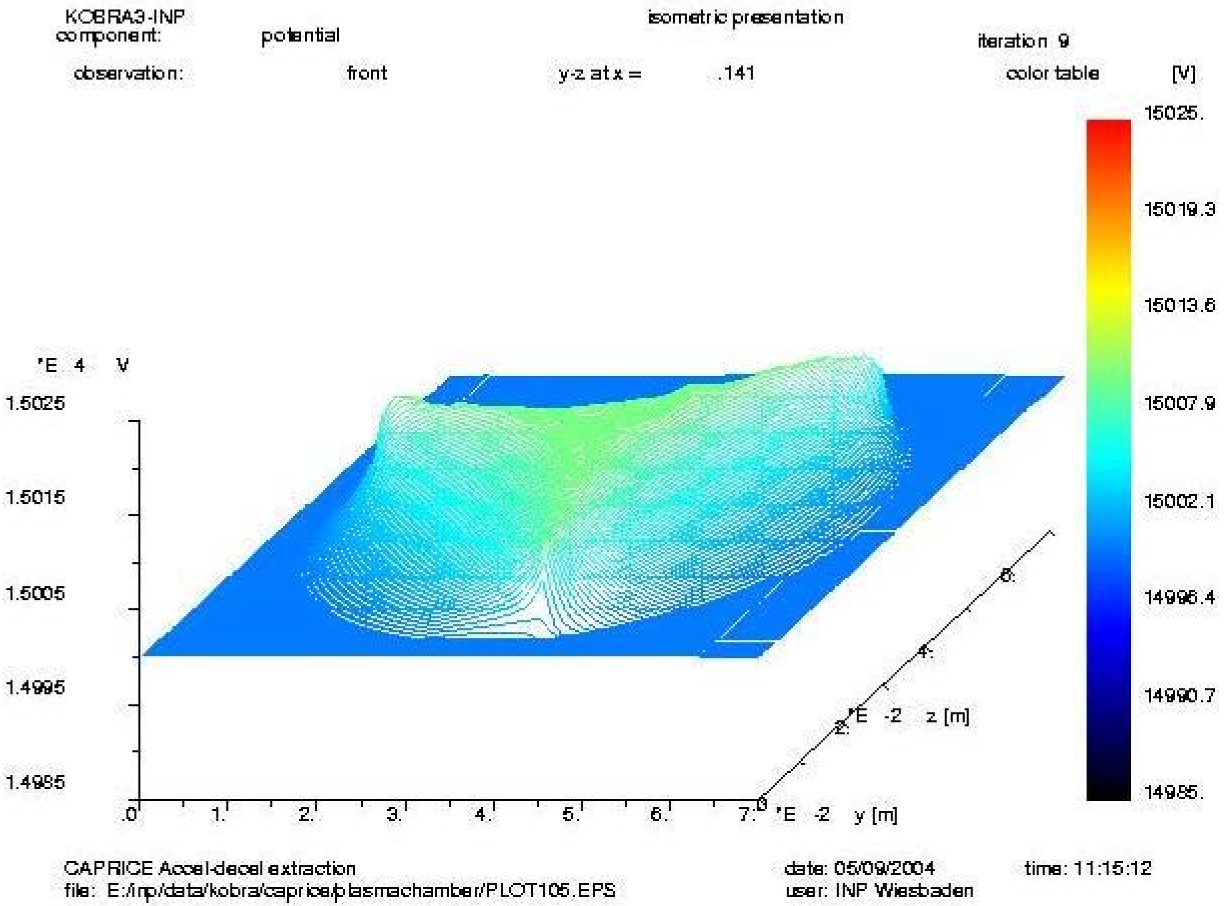

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .129
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT101.EPS
date: 05/09/2004
user: INP Wiesbaden
time: 11:14:34


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .132
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT102.EPS
date: 05/09/2004
time: 11:14:43
user: INP Wiesbaden

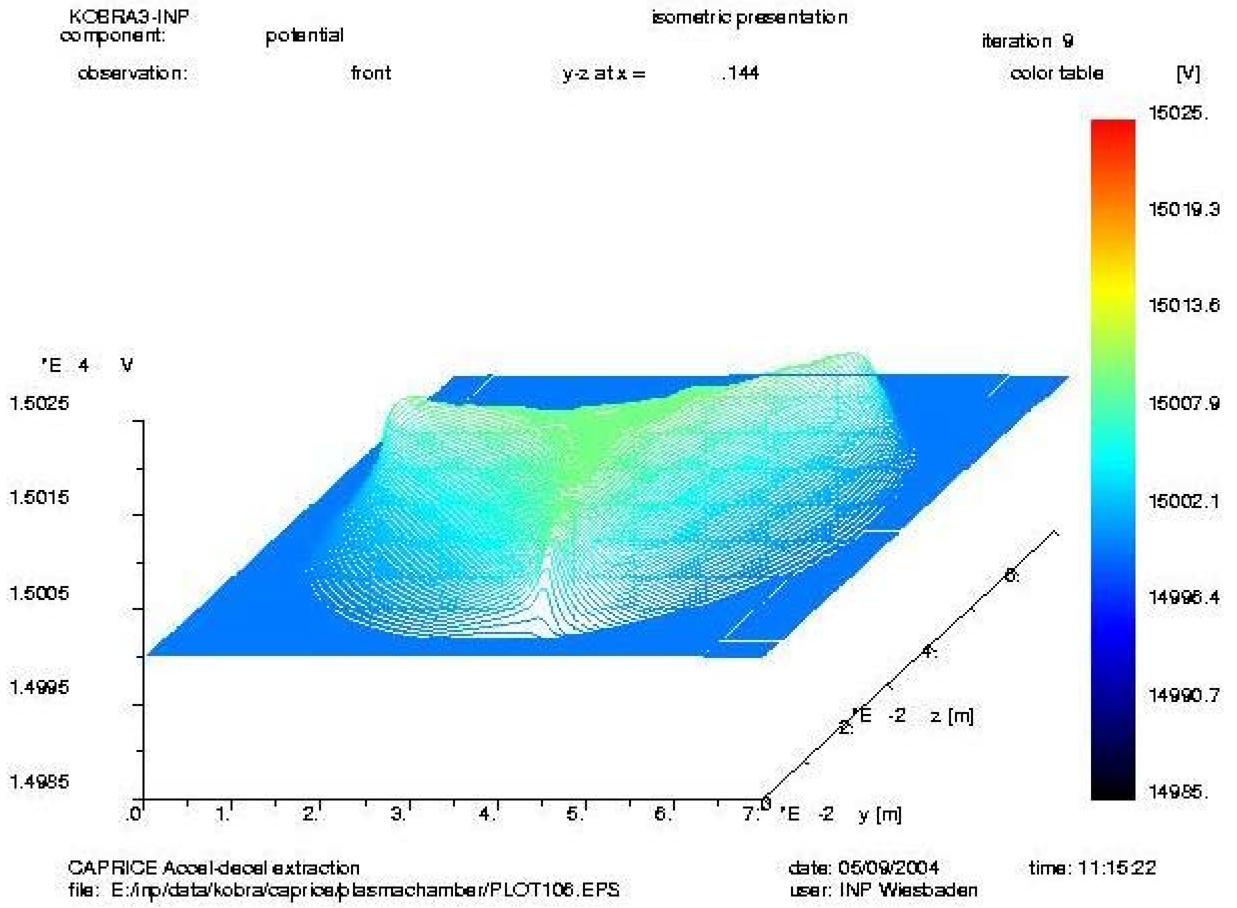

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .135
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT103.EPS
date: 05/09/2004
time: 11:14:51
user: INP Wiesbaden



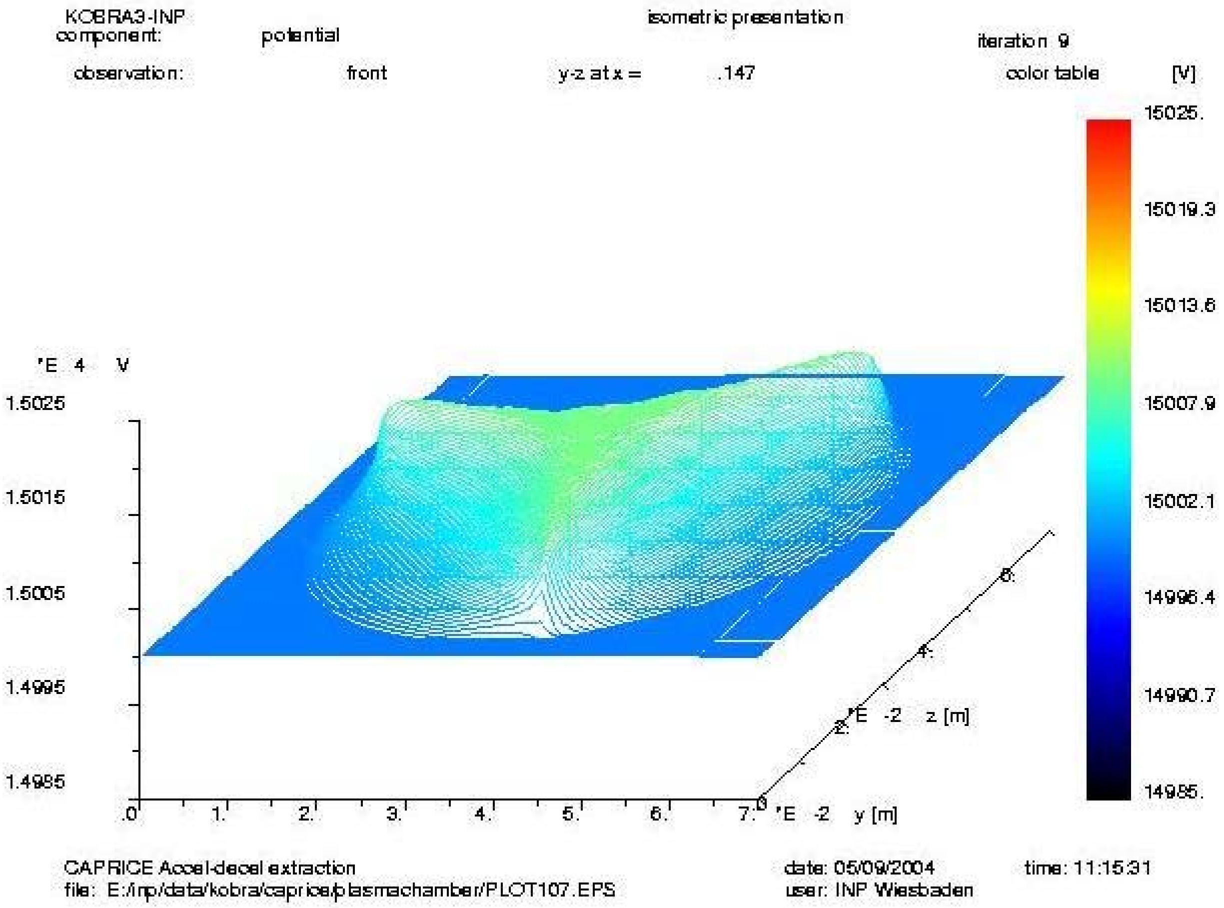
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .138
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT104.EPS
date: 05/09/2004
time: 11:15:05
user: INP Wiesbaden

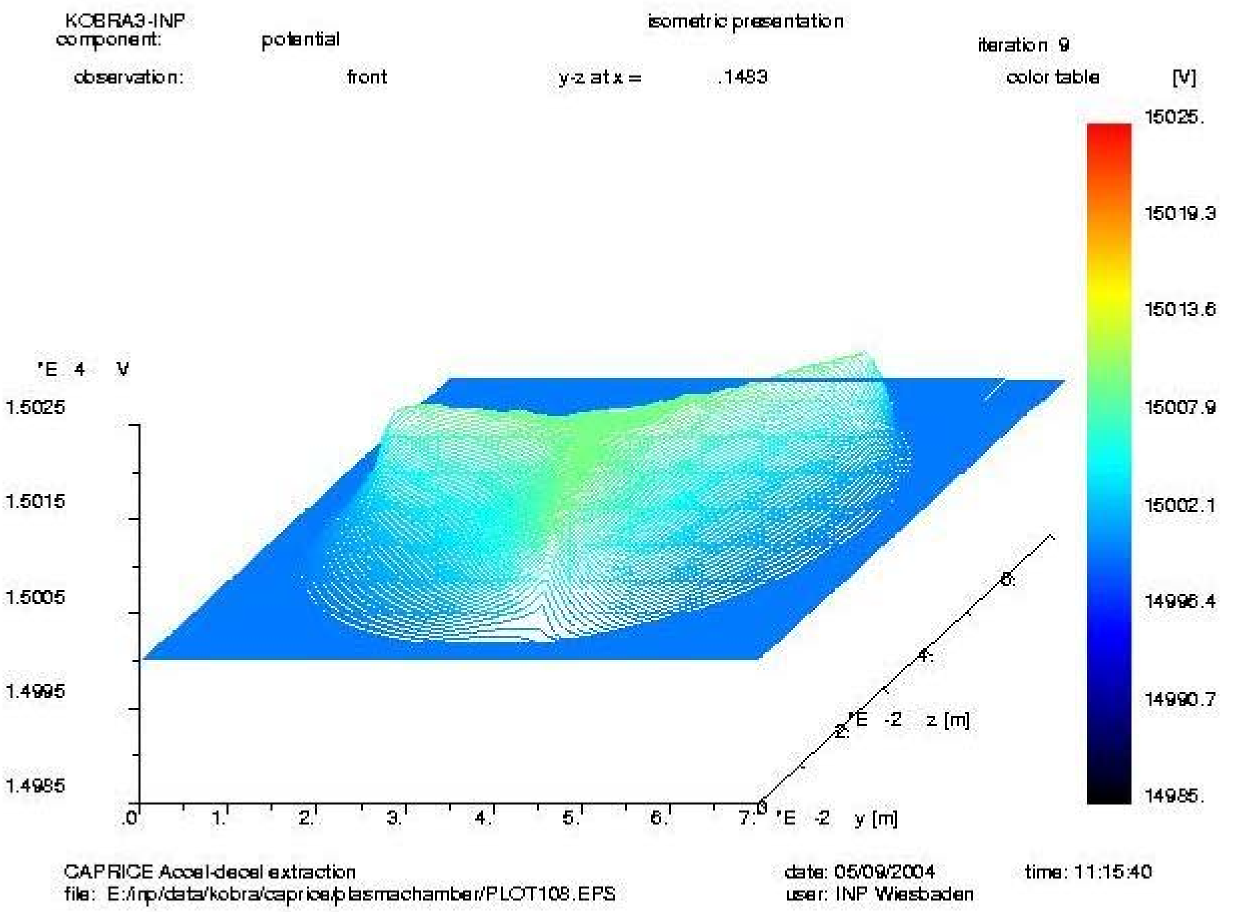


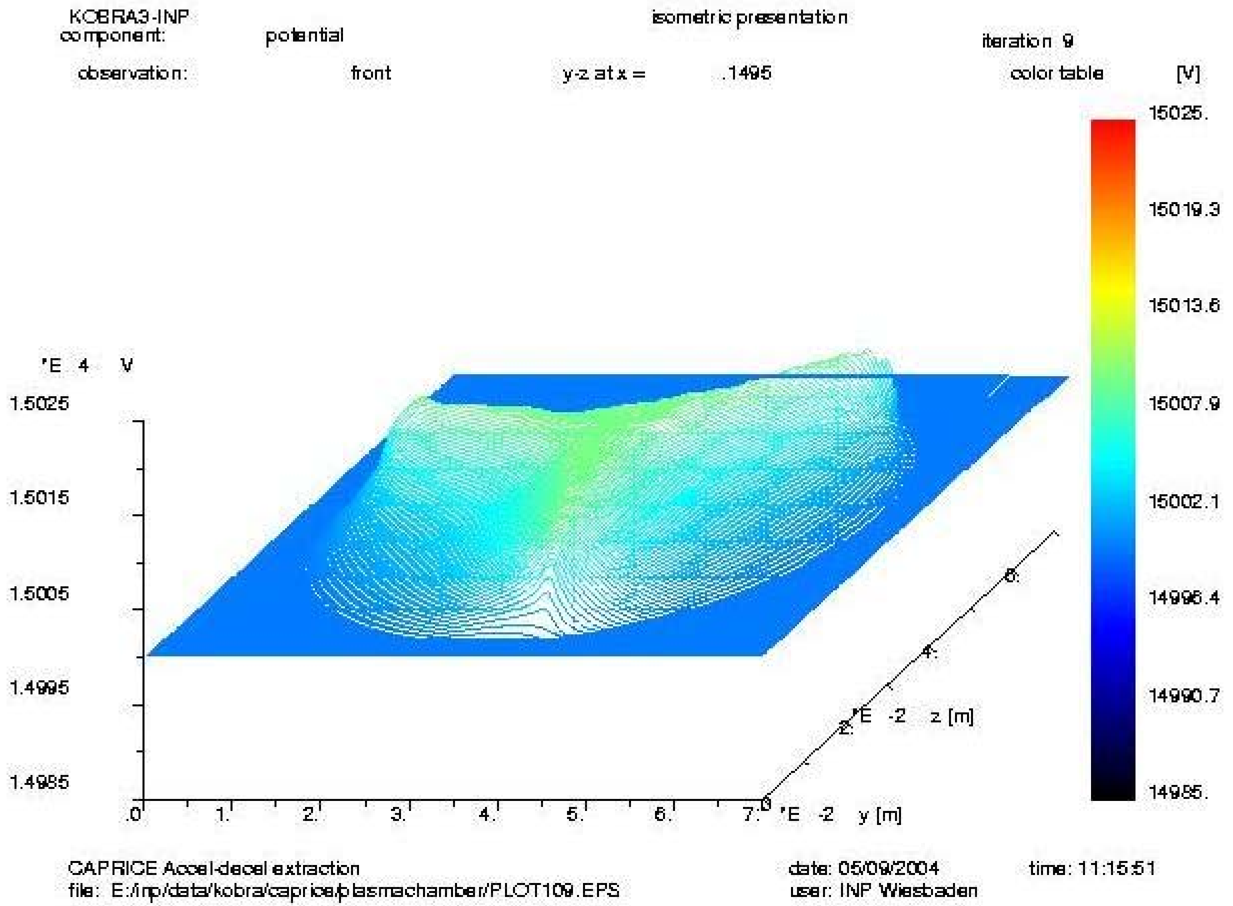
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .141
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT105.EPS
date: 05/09/2004
time: 11:15:12
user: INP Wiesbaden

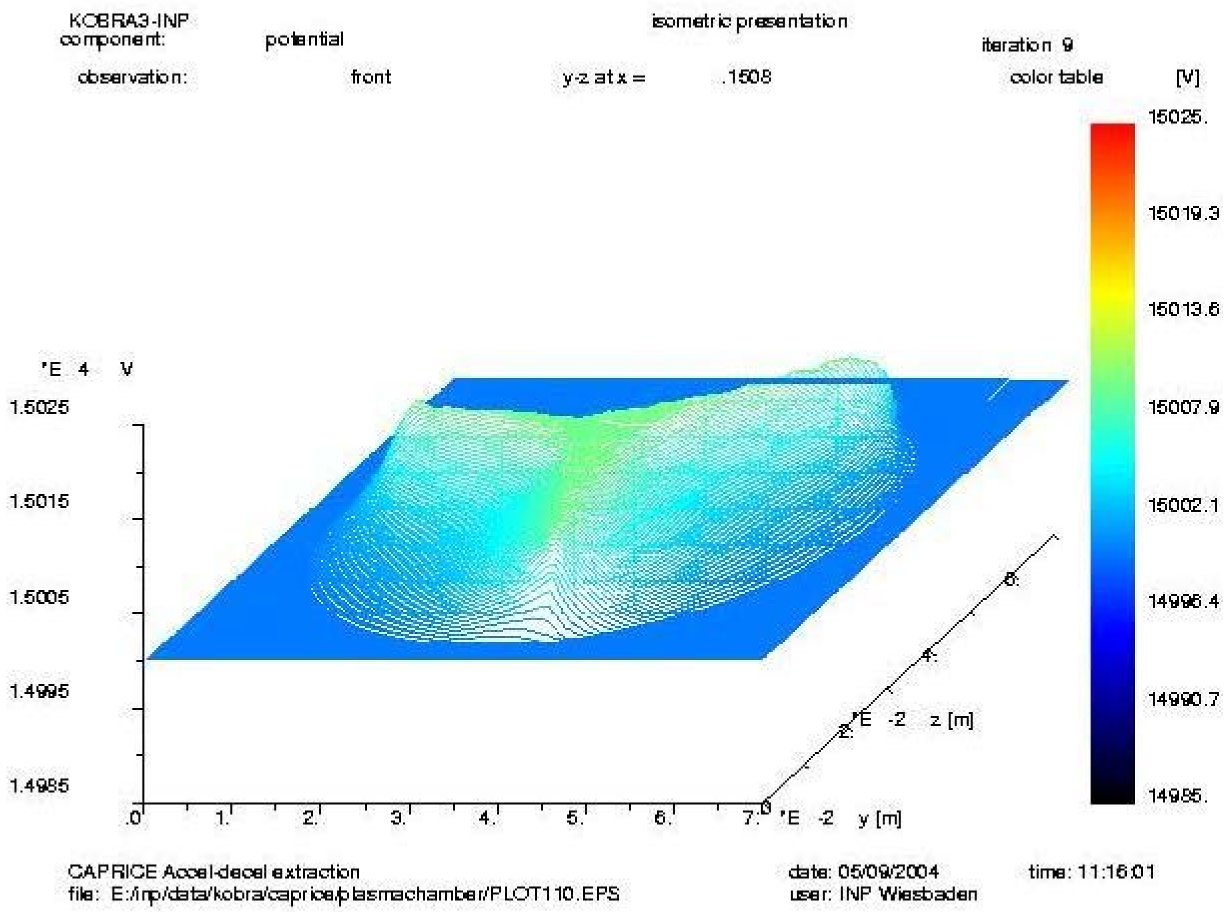


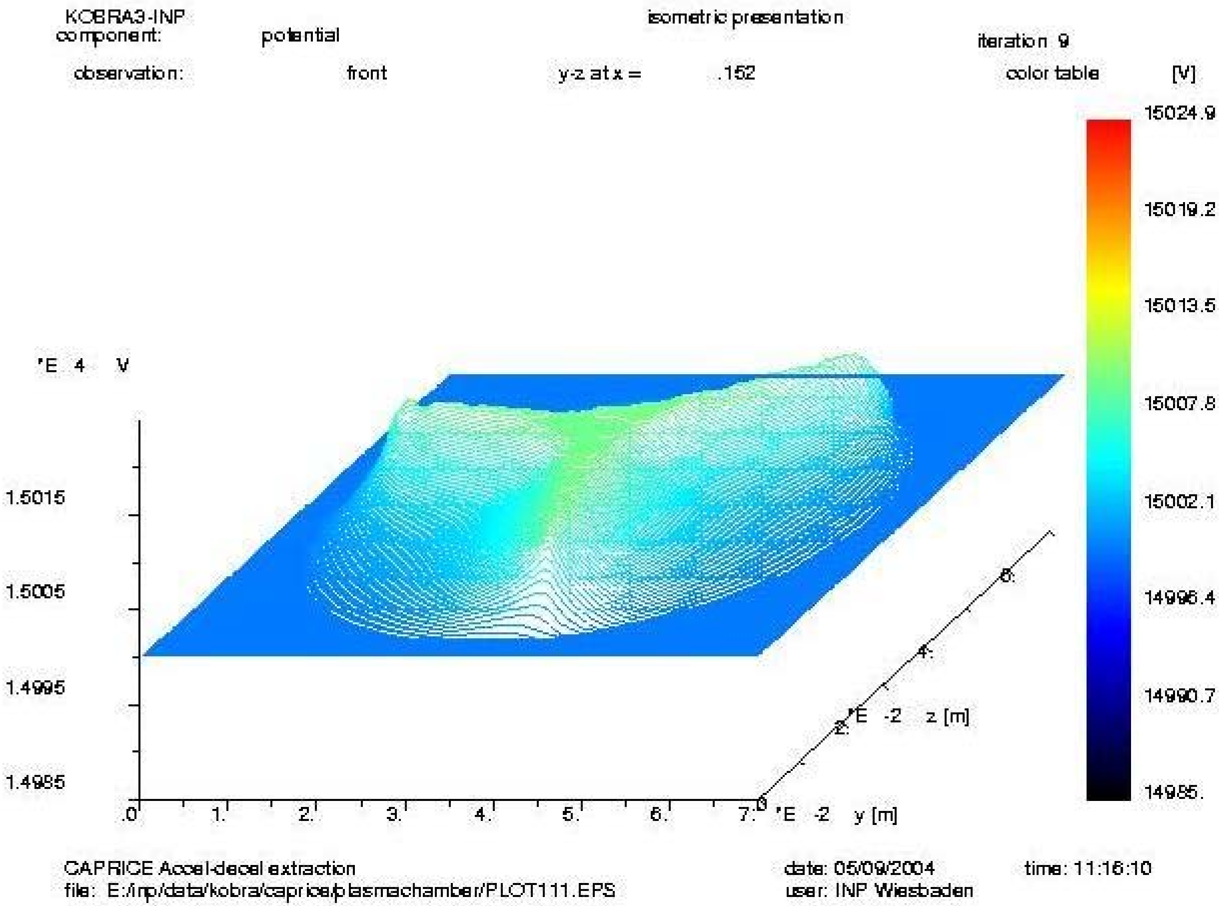
KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .144
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT106.EPS
date: 05/09/2004
time: 11:15:22
user: INP Wiesbaden

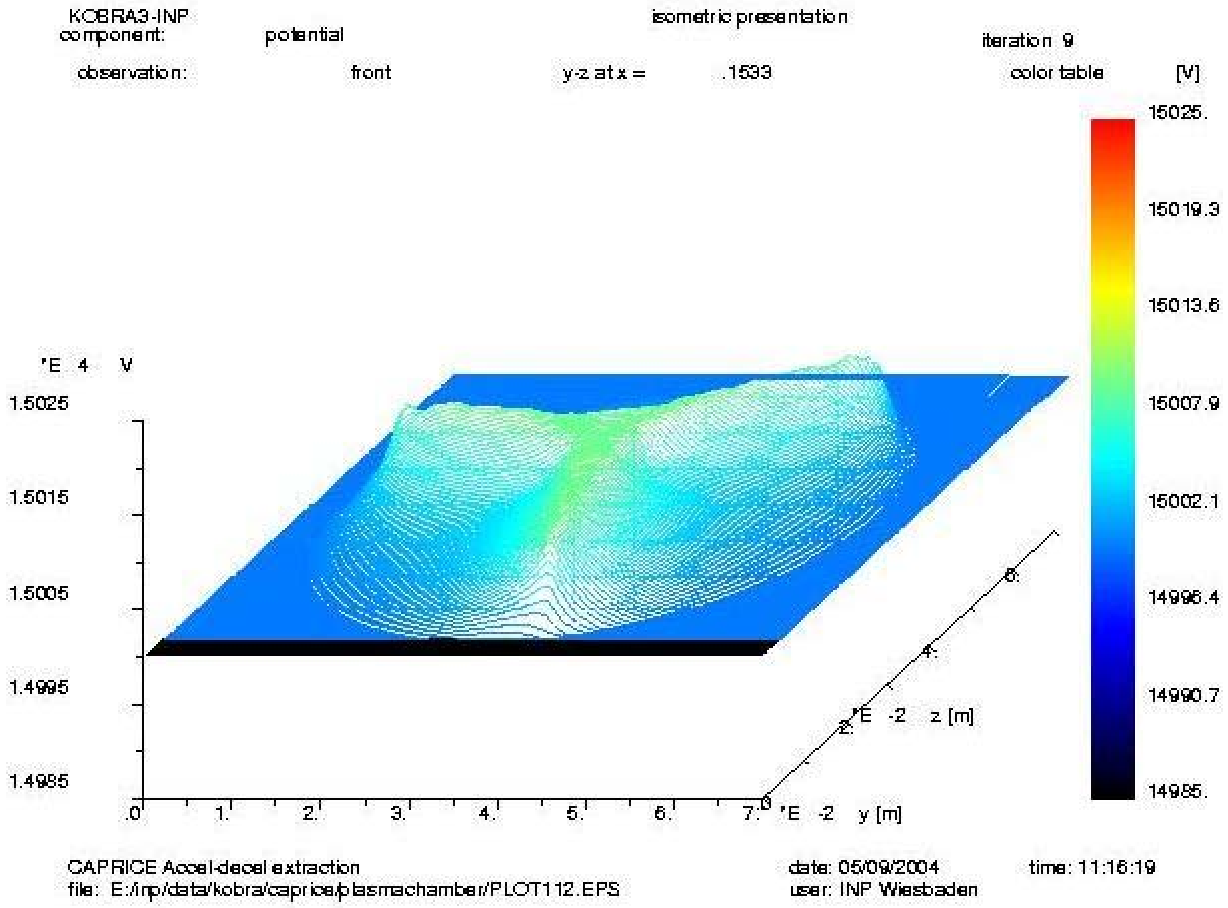

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .147
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
0 2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT107.EPS
date: 05/09/2004
user: INP Wiesbaden
time: 11:15:31

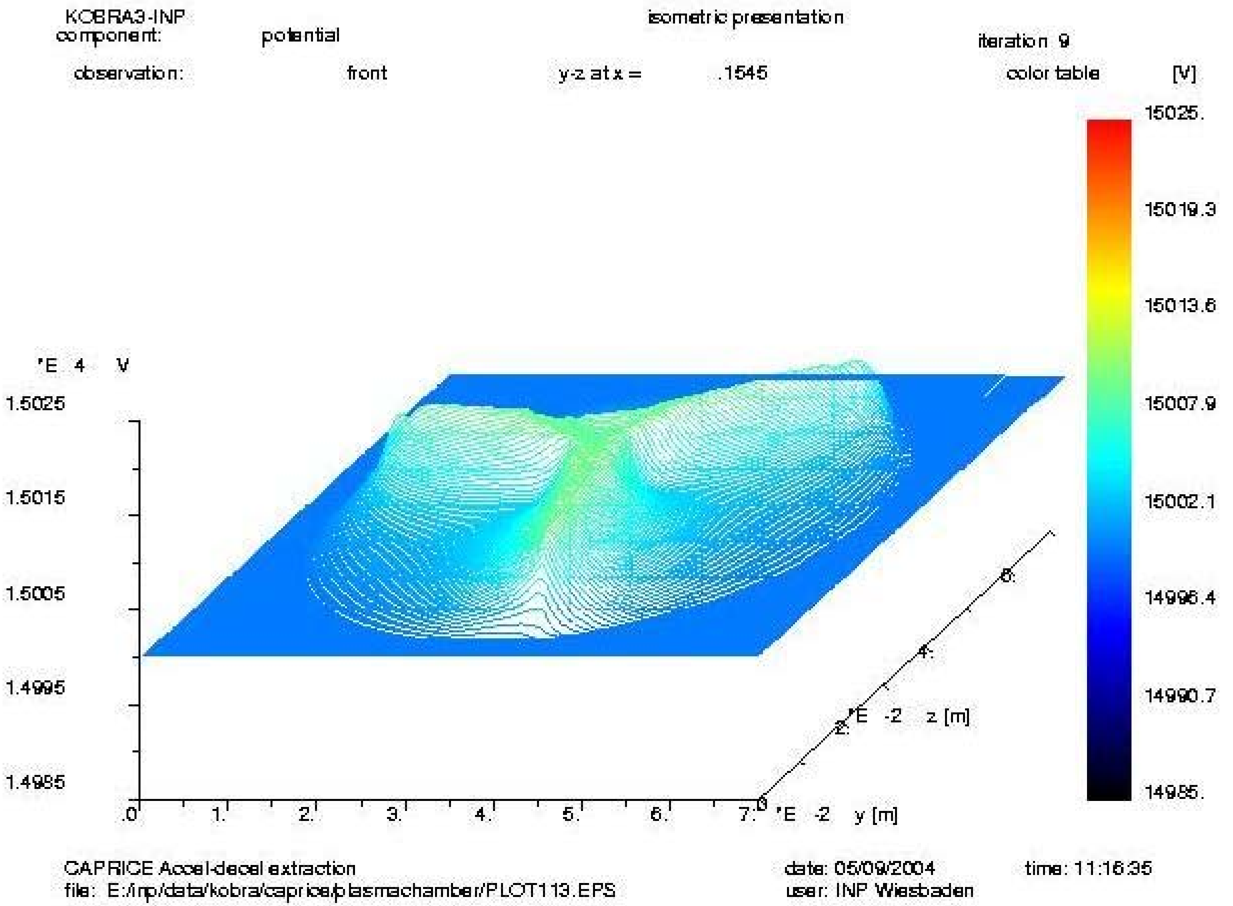

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .1483
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT108.EPS
date: 05/09/2004
time: 11:15:40
user: INP Wiesbaden

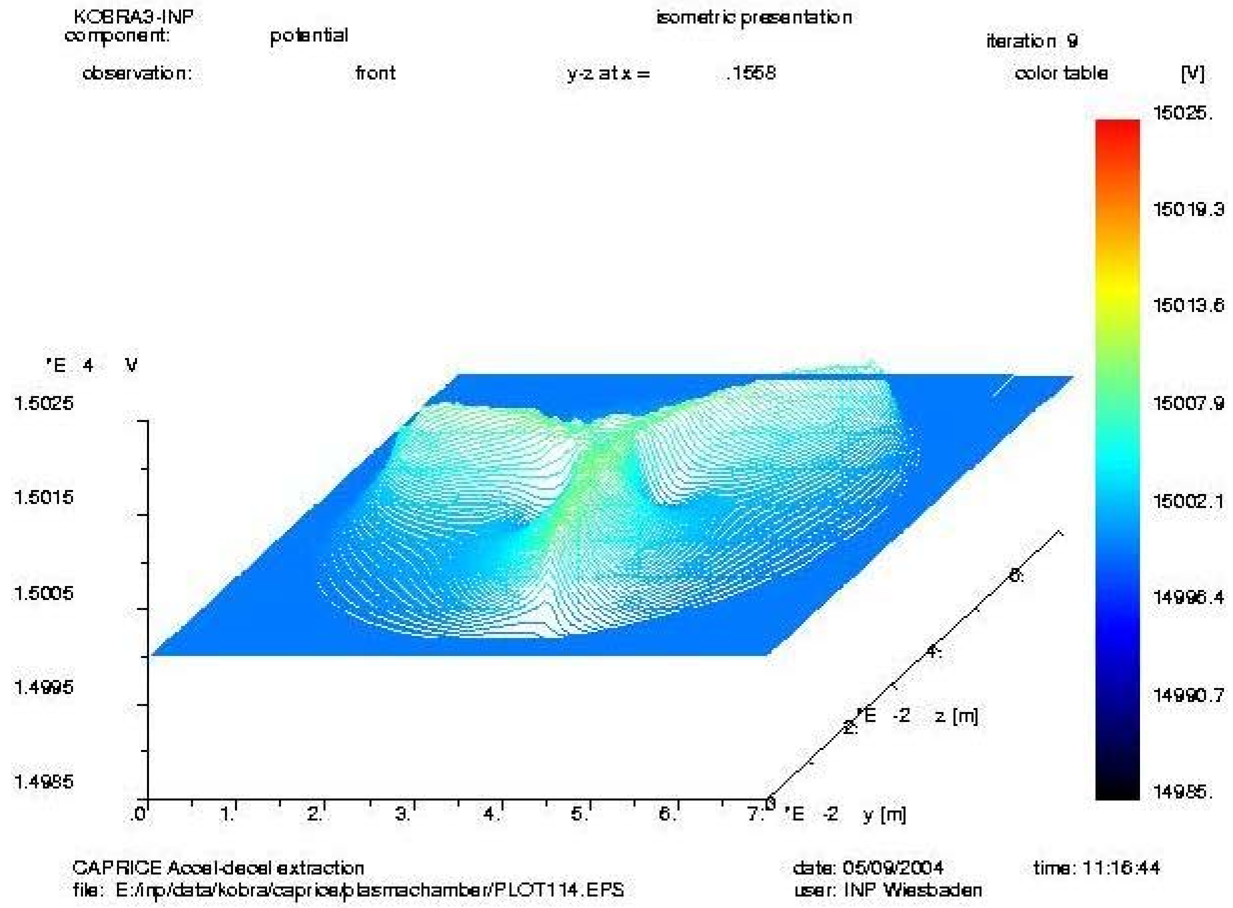

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .1495
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT109.EPS
date: 05/09/2004
time: 11:15:51
user: INP Wiesbaden

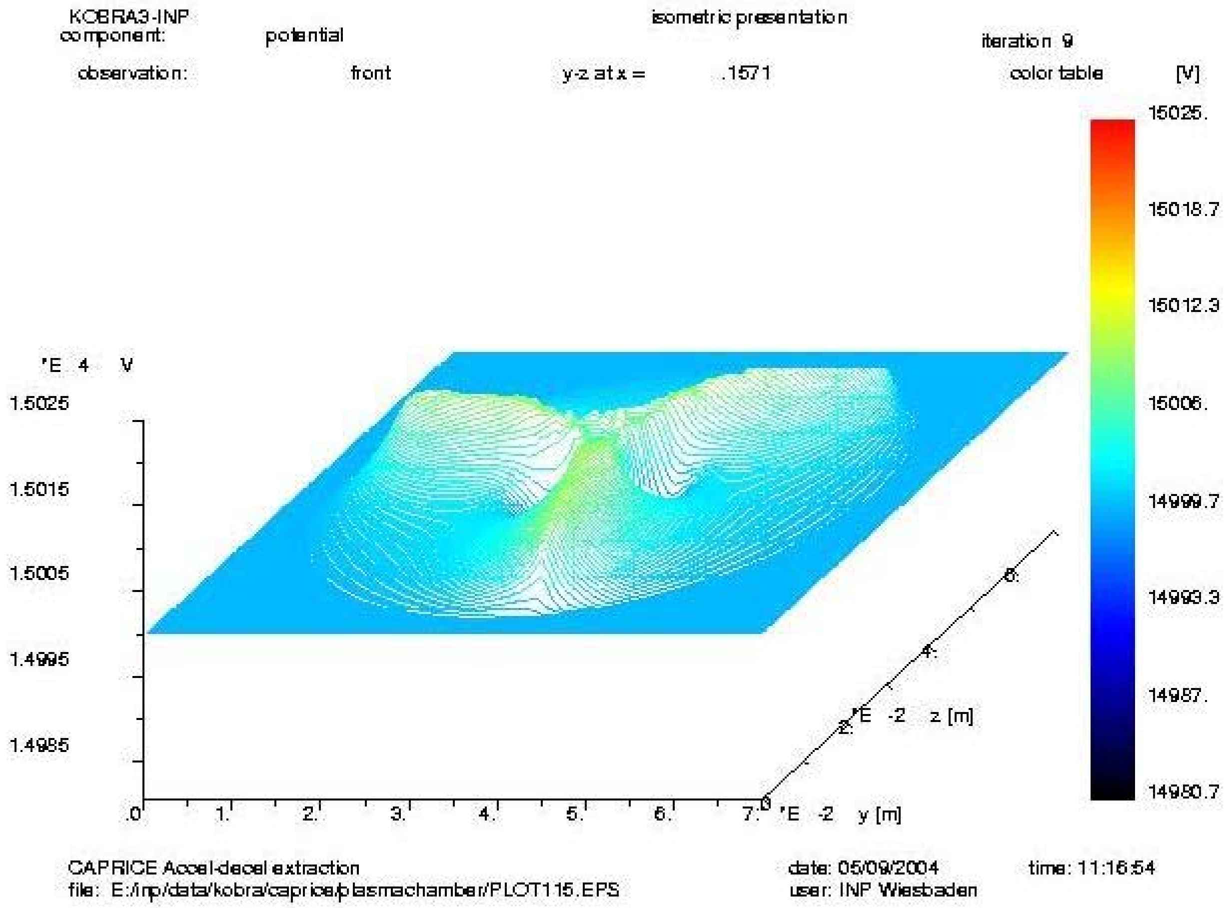

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .1508
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT110.EPS
date: 05/09/2004
time: 11:16:01
user: INP Wiesbaden


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .152
color table [V]
15024.9
15019.2
15013.5
15007.8
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT111.EPS
date: 05/09/2004
time: 11:16:10
user: INP Wiesbaden


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .1533
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT112.EPS
date: 05/09/2004
time: 11:16:19
user: INP Wiesbaden

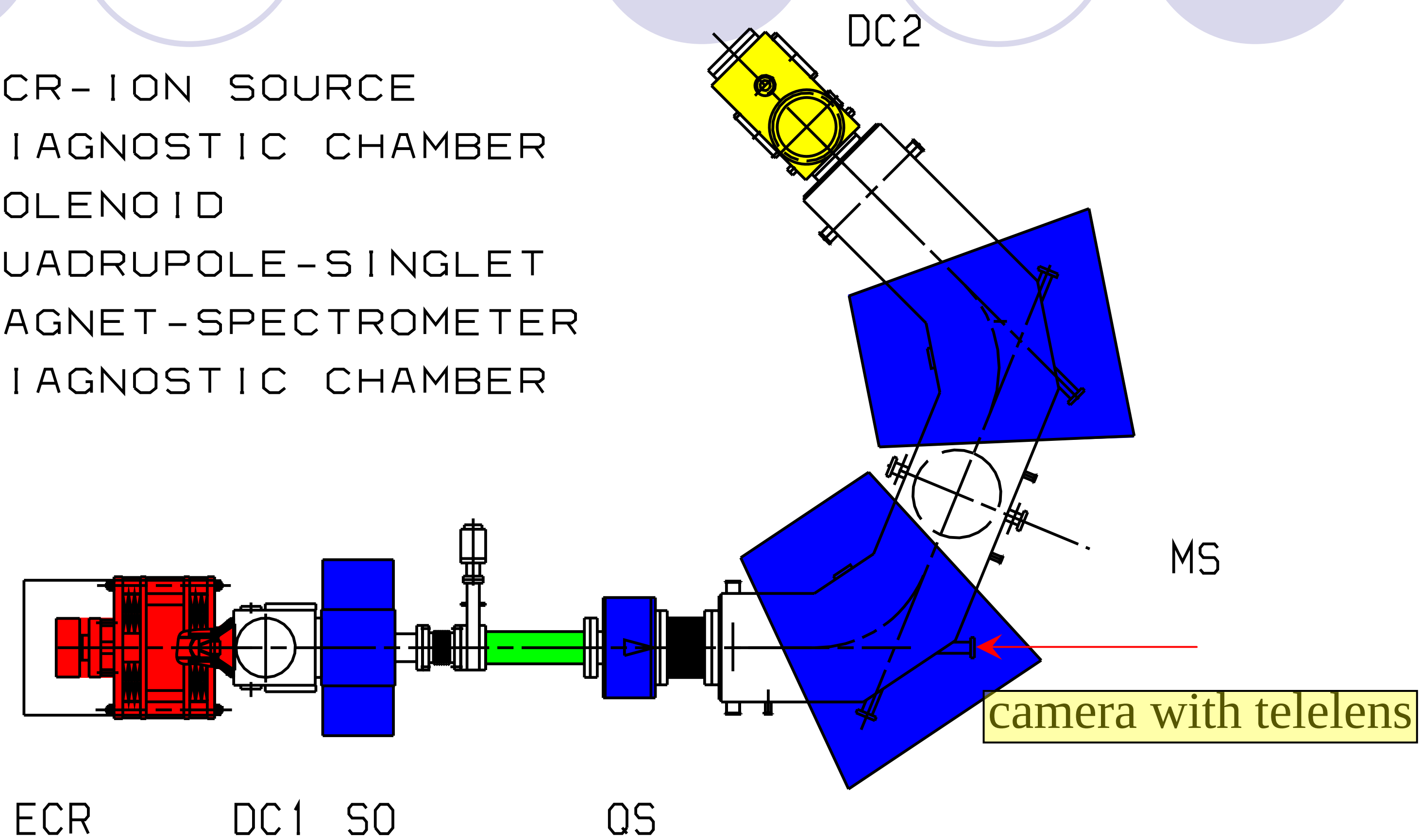

KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .1545
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0
1.
2.
3.
4.
5.
6.
7.
'E -2 y [m]
'E -2 z [m]
2.
4.
6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT113.EPS
date: 05/09/2004
time: 11:16:35
user: INP Wiesbaden


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .1558
color table [V]
15025.
15019.3
15013.6
15007.9
15002.1
14996.4
14990.7
14985.
*E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
*E -2 y [m]
2. 4. 6.
*E -2 z [m]
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT114.EPS
date: 05/09/2004
user: INP Wiesbaden
time: 11:16:44


KOBRA3-INP
component: potential
isometric presentation
iteration 9
observation: front
y-z at x = .1571
color table [V]
15025.
15018.7
15012.3
15006.
14999.7
14993.3
14987.
14980.7
'E 4 V
1.5025
1.5015
1.5005
1.4995
1.4985
.0 1. 2. 3. 4. 5. 6. 7.
'E -2 y [m]
'E -2 z [m]
2. 4. 6.
CAPRICE Accel-decel extraction
file: E:/inp/data/kobra/caprice/plasmachamber/PLOT115.EPS
date: 05/09/2004
time: 11:16:54
user: INP Wiesbaden

Experimental Setup

ECR: ECR-ION SOURCE
DC1: DIAGNOSTIC CHAMBER
SO: SOLENOID
QS: QUADRUPOLE-SINGLET
MS: MAGNET-SPECTROMETER
DC2: DIAGNOSTIC CHAMBER

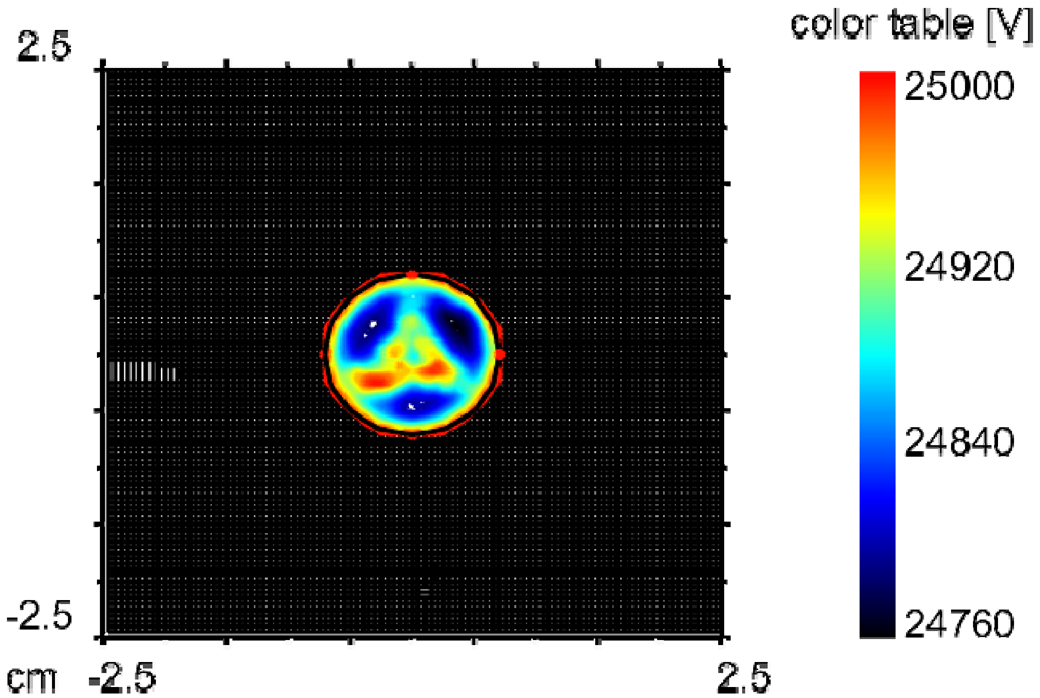


ECR Injector Test Setup ➡ Identical with the low energy beam line of the High Charge State Injector

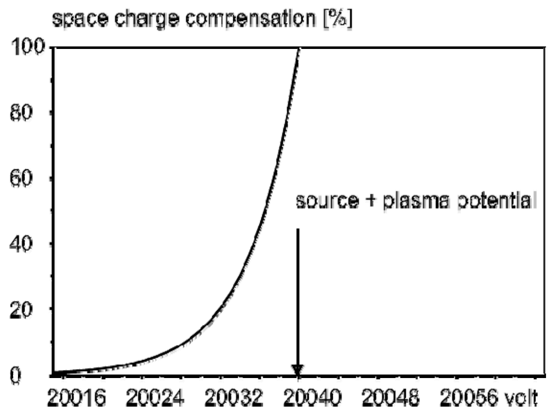
changing the plasma density by rf power

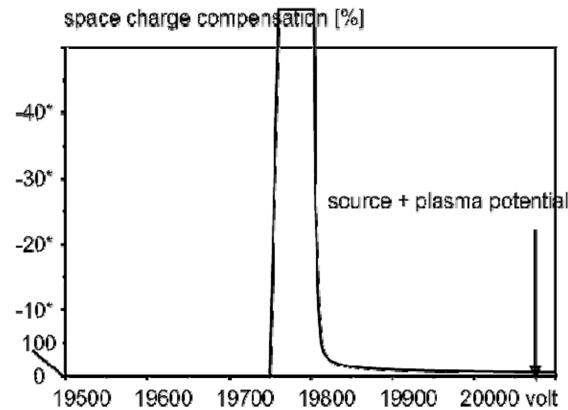
- The space charge compensation at the edge of the plasma will become zero when the ions entering the extraction system.

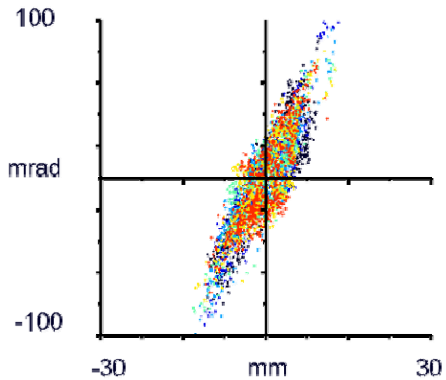
the resulting azimuthal electric field component causes emittance growth!

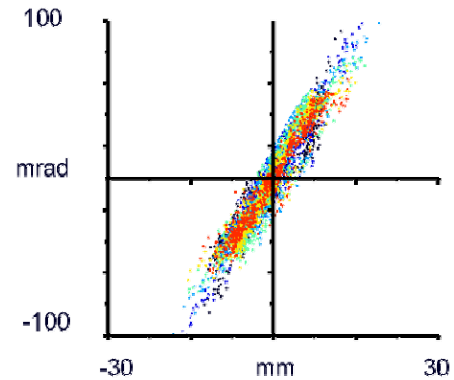


- Influence of higher energy electrons on the extracted beam







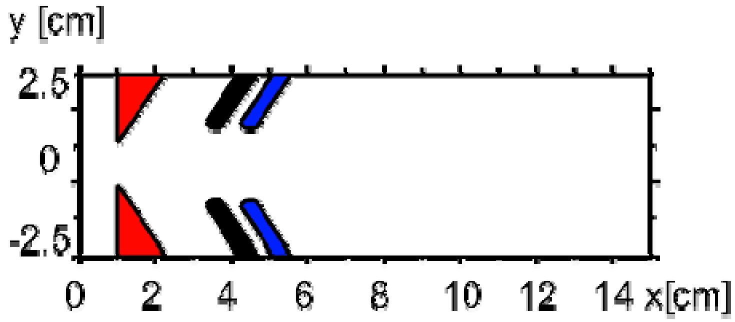


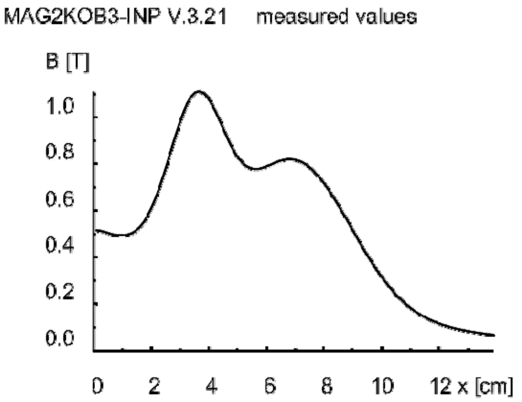
Influence of higher energy electrons

- All electrons are decelerated within the extraction system and accelerated back towards the source if their energy is below extraction voltage.
- This can introduce an over-compensation of the positive space charge.
- Simulations predict an improvement of emittance.

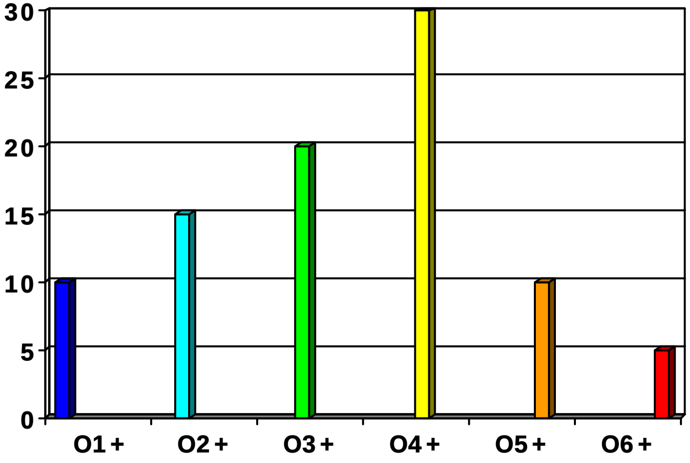
Influence of the solenoidal field

- Accel-decel extraction (12-18-18 mm).
- 25 kV, -10 kV, 0 kV.
- Magnetic flux density on axis used for the Taylor expansion (1T max).





Common parameter

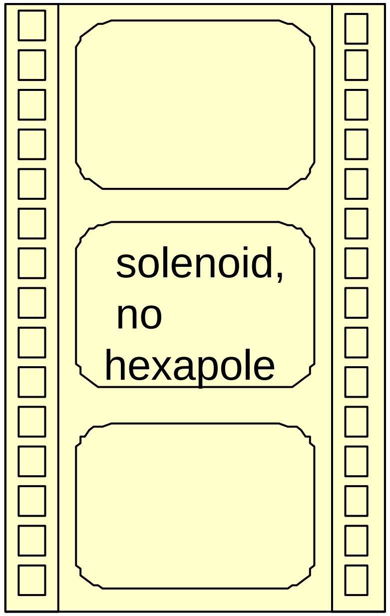


Charge state distribution.

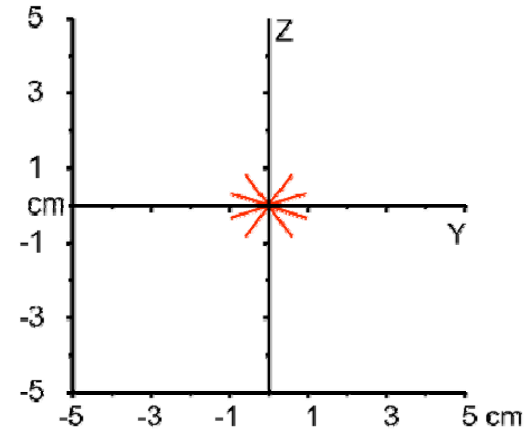
Different colors represent different charge states.

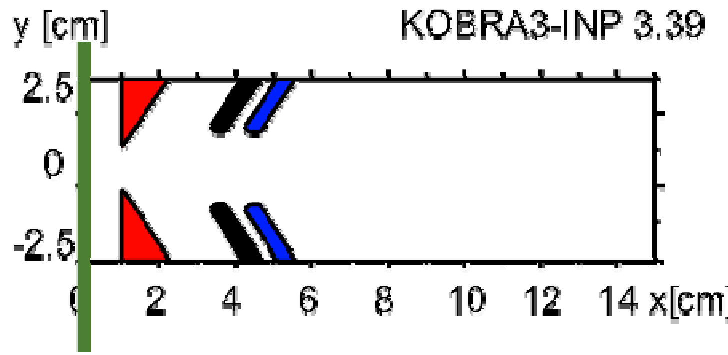
assumption

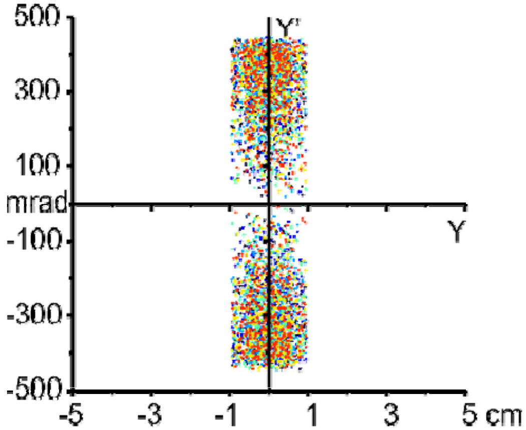
- Magnetic Flux density B = B_0 = 1 T
- Plasma model: Self Ti=1eV, Te=5eV
- No Hexapole
- Current 5 mA

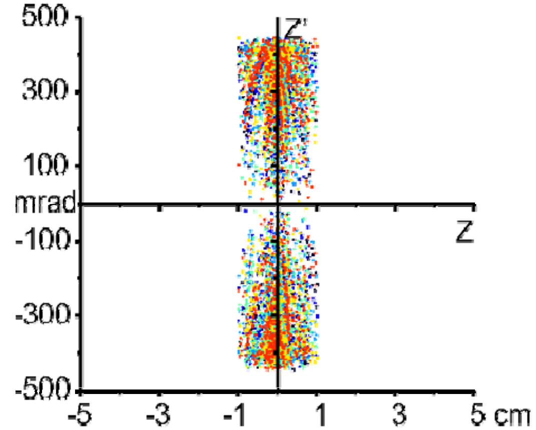


X = 0.00 m

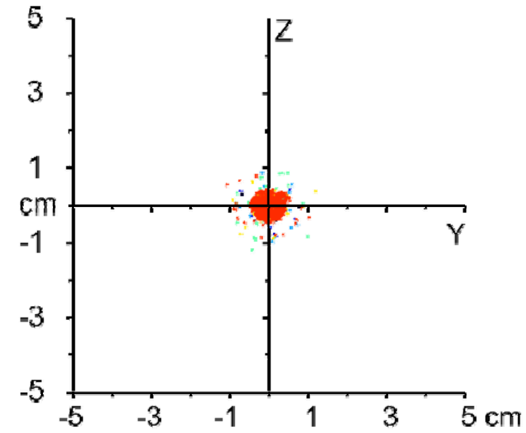

Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

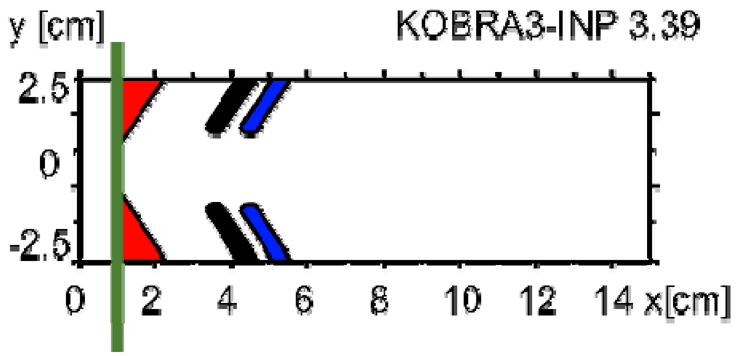

Y'
Y
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm


Z'
Z
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

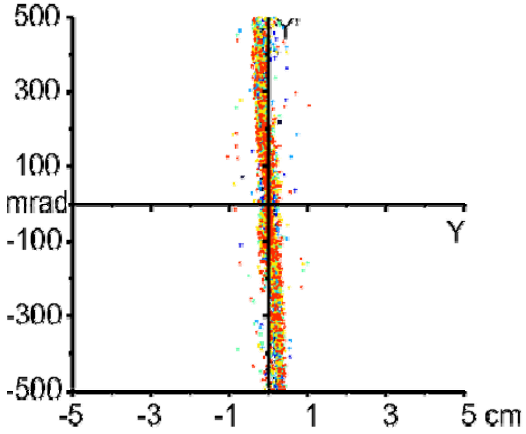
X = 0.01 m



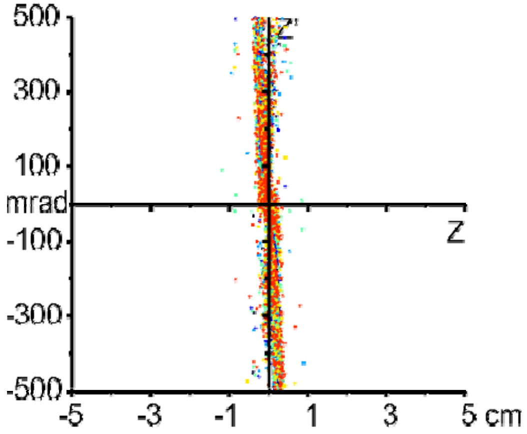
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

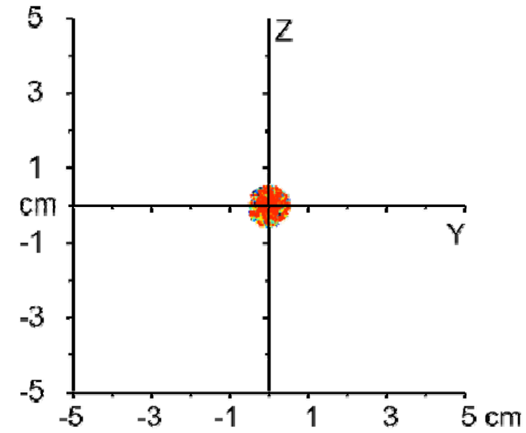


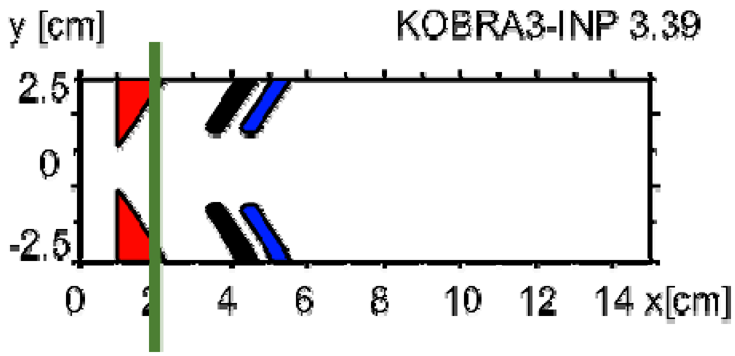
500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

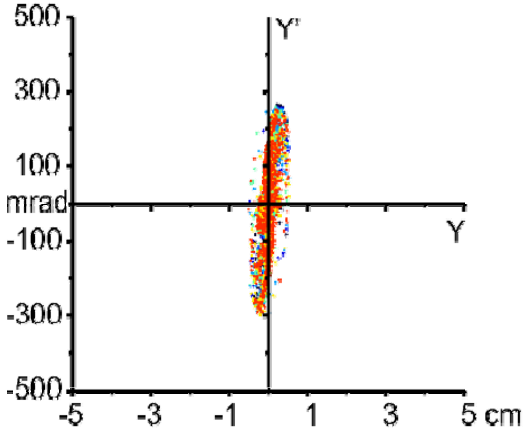


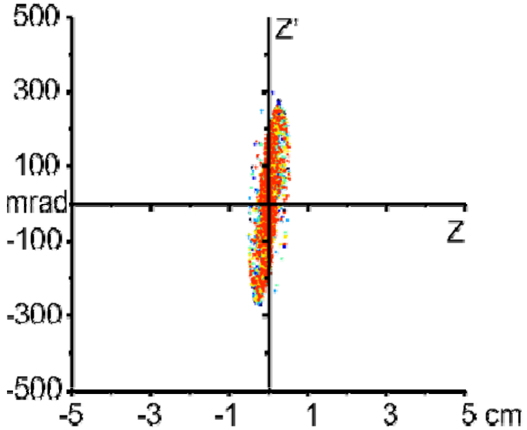
500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.02 m

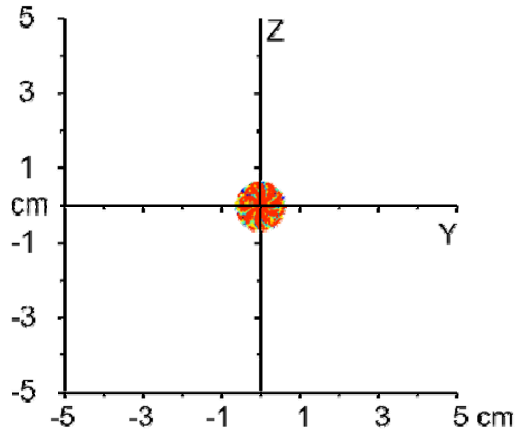


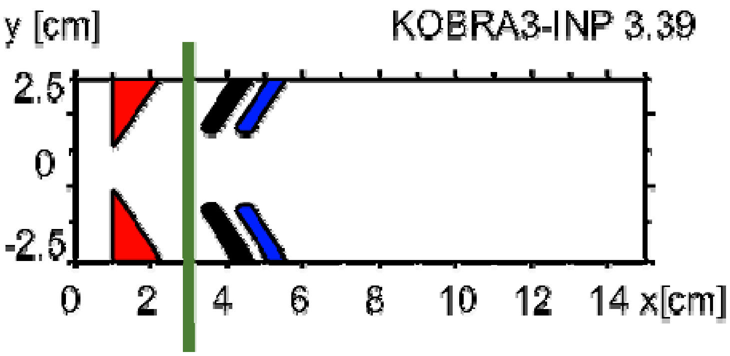


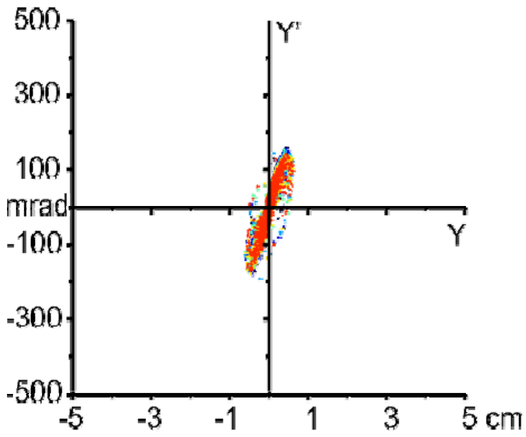


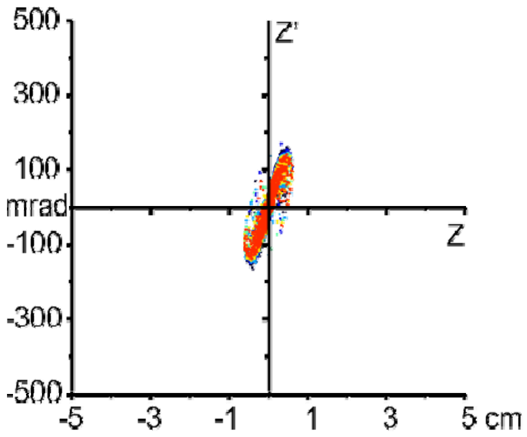


X = 0.03 m

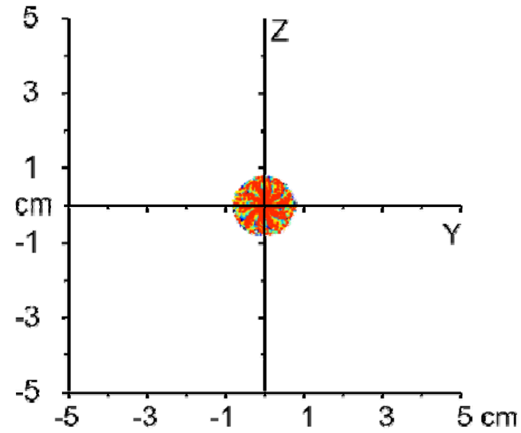

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm

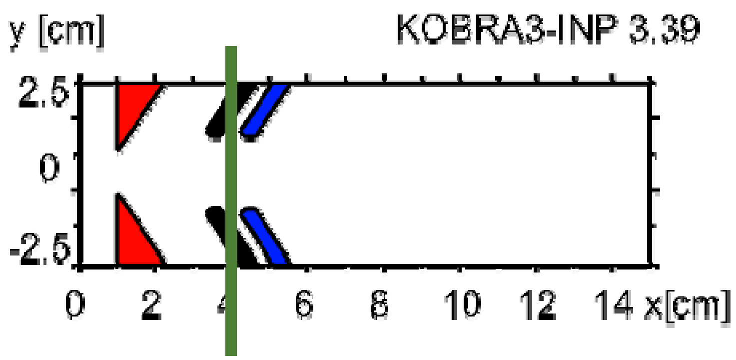

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

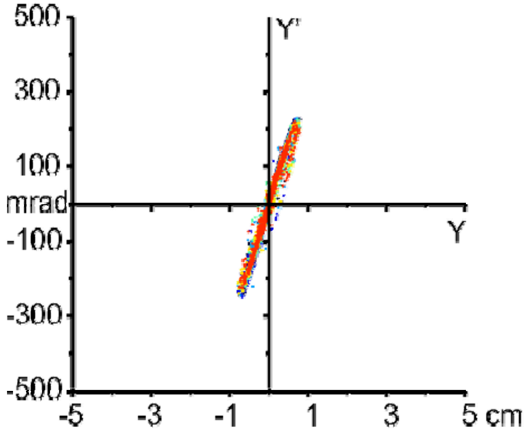

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

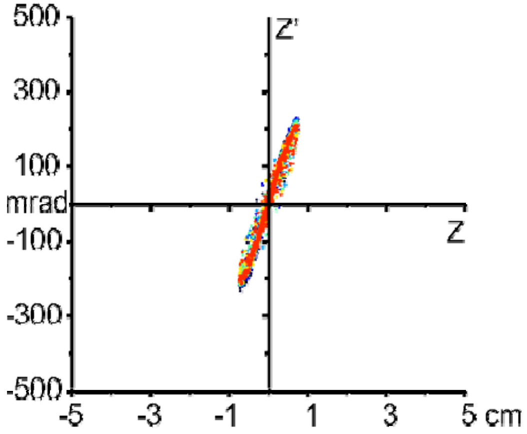

500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.04 m

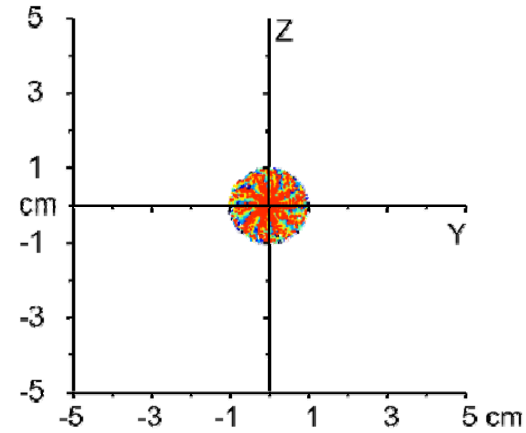

5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

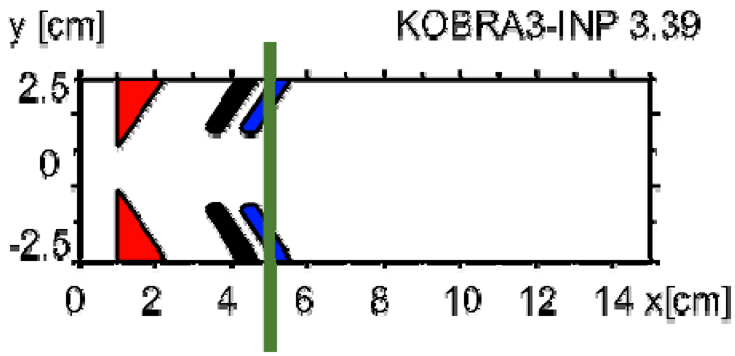

500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm


500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

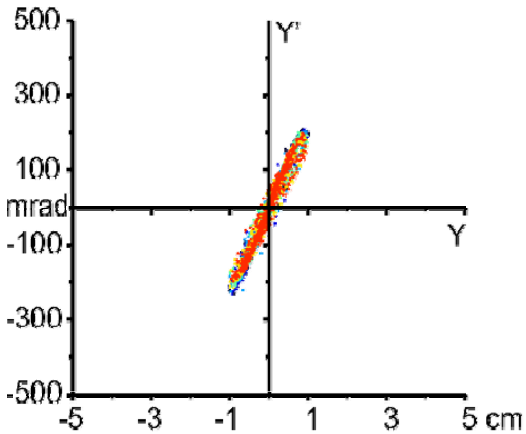
X = 0.05 m



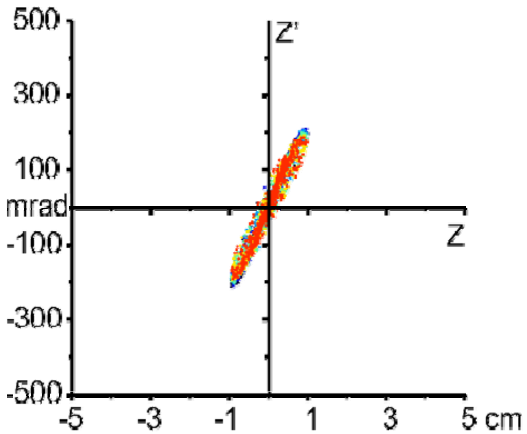
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

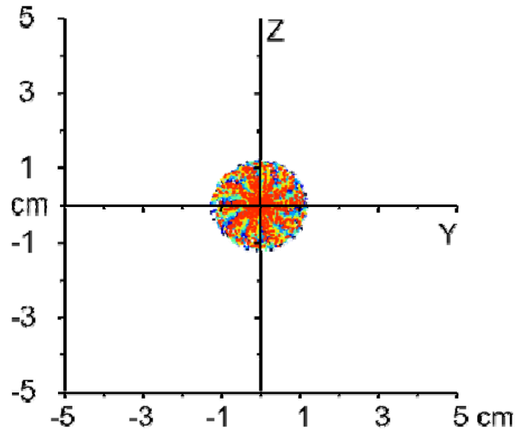


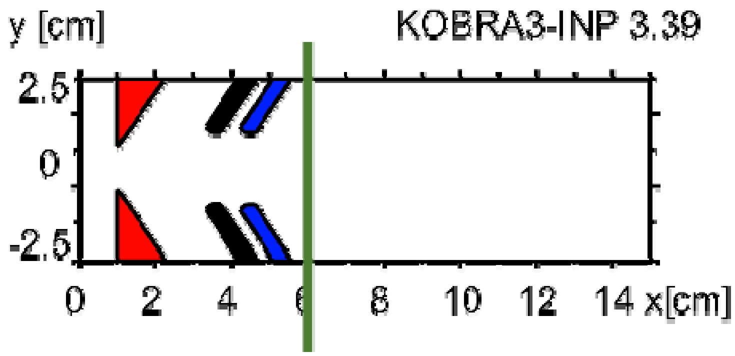
500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

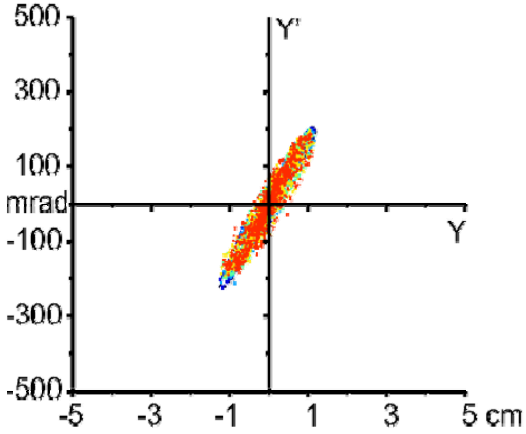


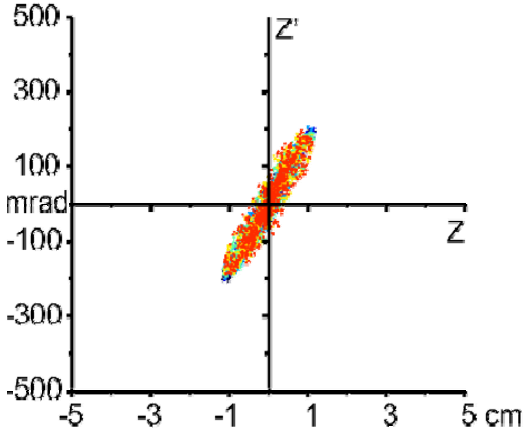
500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.06 m

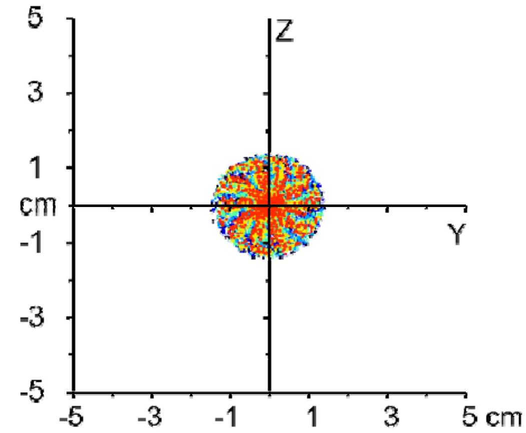

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm

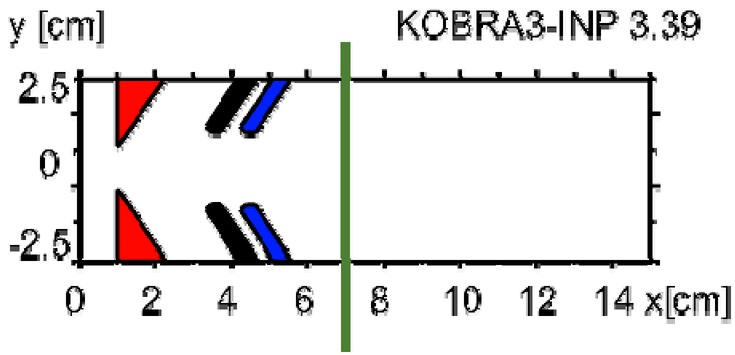

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
8
10
12
14 x[cm]

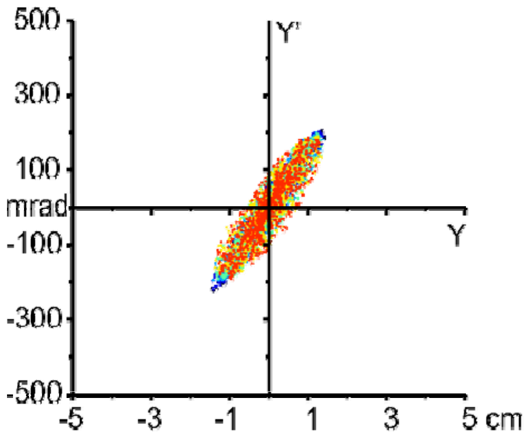

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

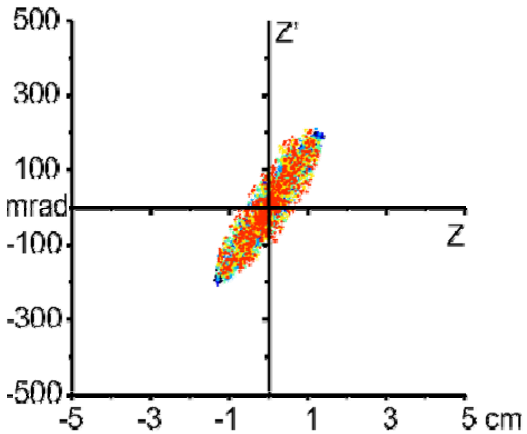

500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.07 m

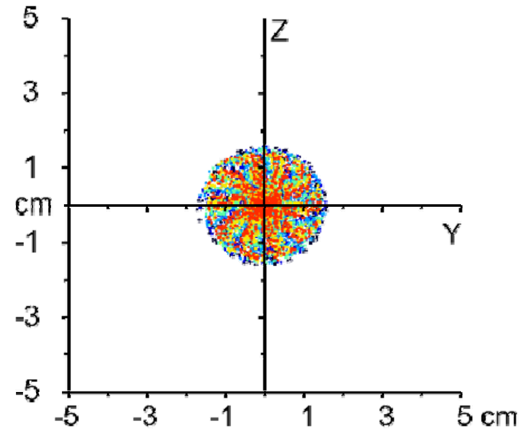

5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm

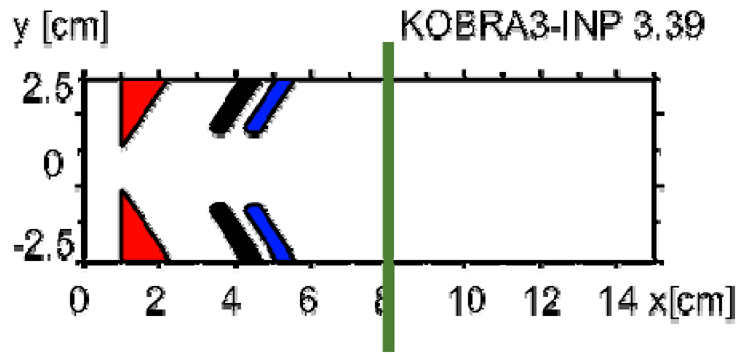

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

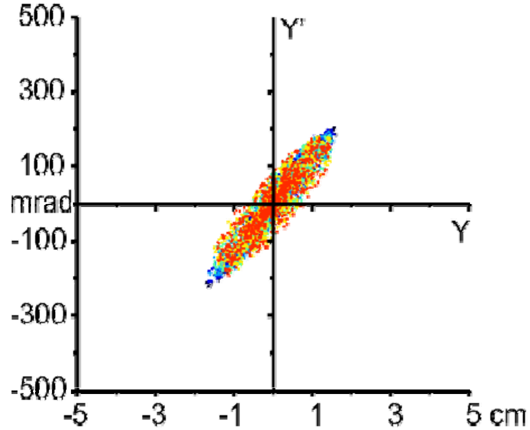

500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

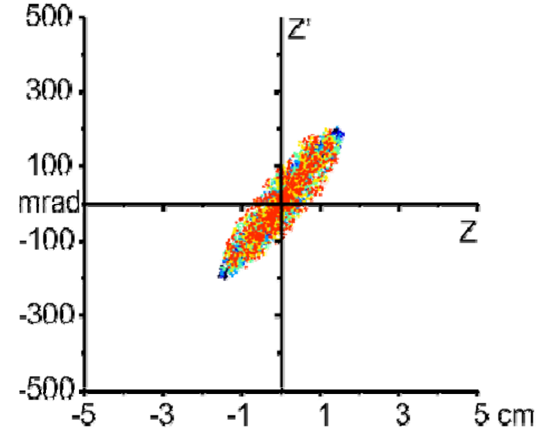

500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

X = 0.08 m

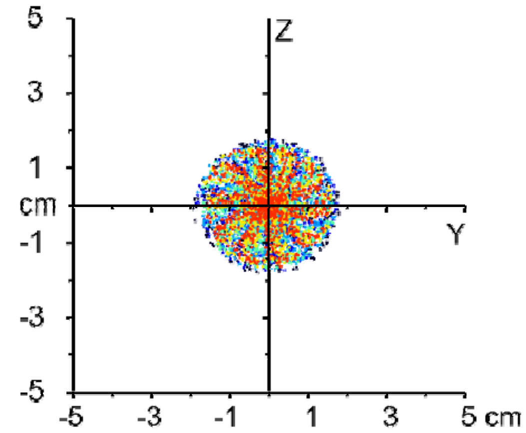

Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm

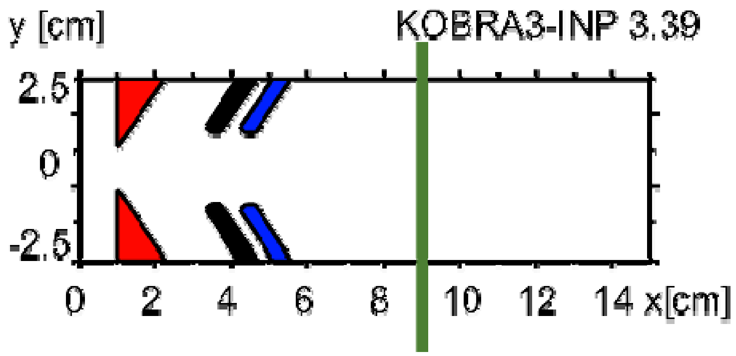

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

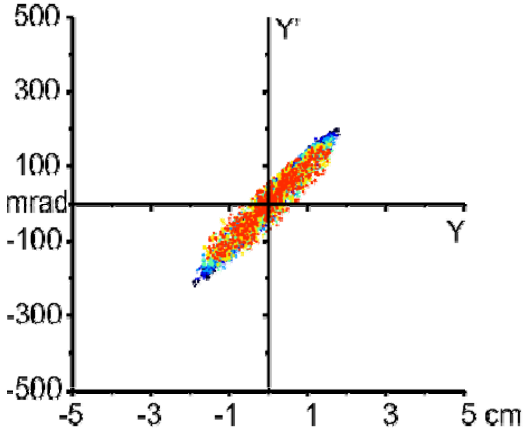

Y'
Y
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

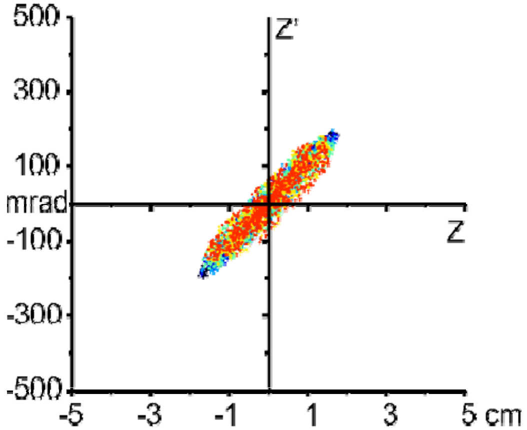

Z'
Z
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

X = 0.09 m

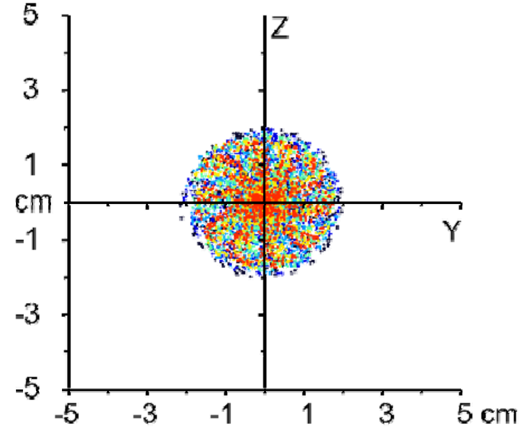




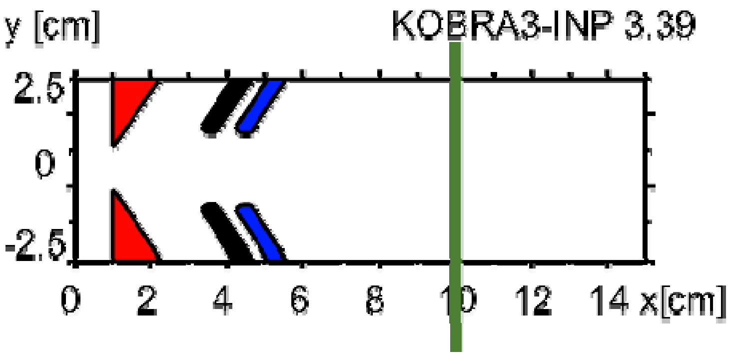




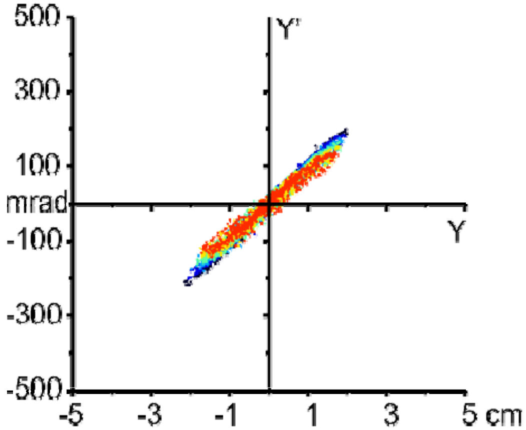
X = 0.10 m



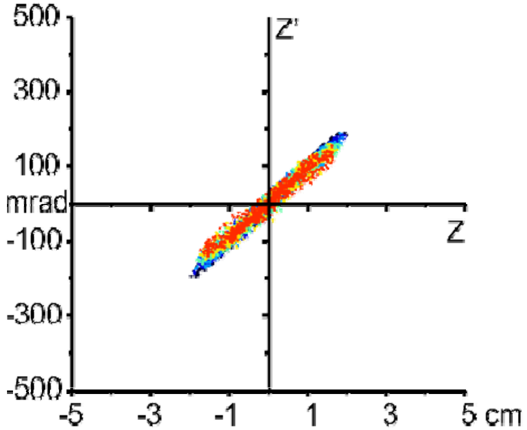
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

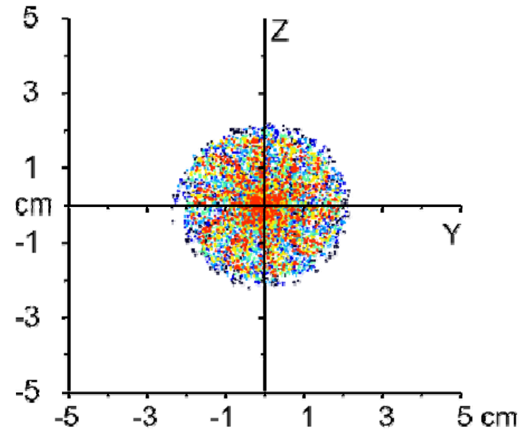


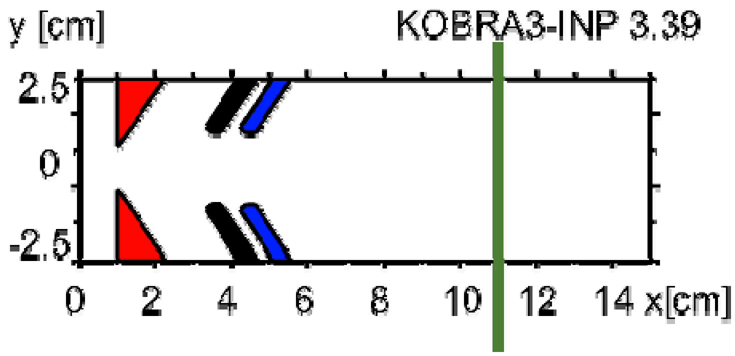
500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

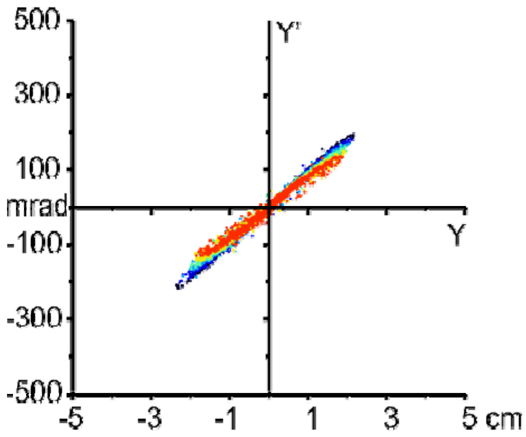


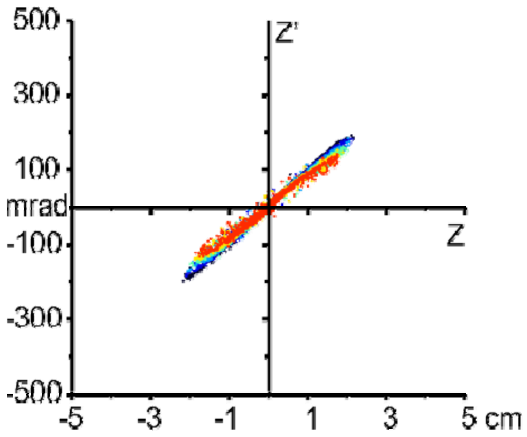
500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

X = 0.11 m

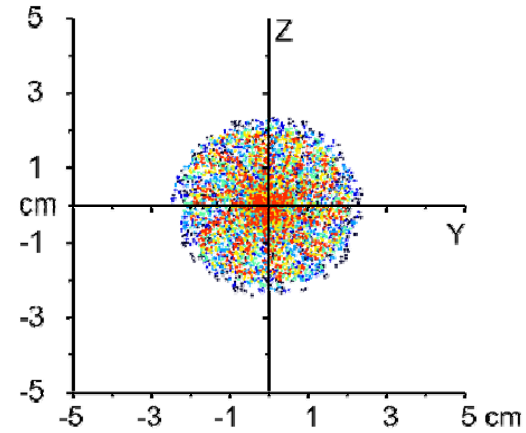

5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

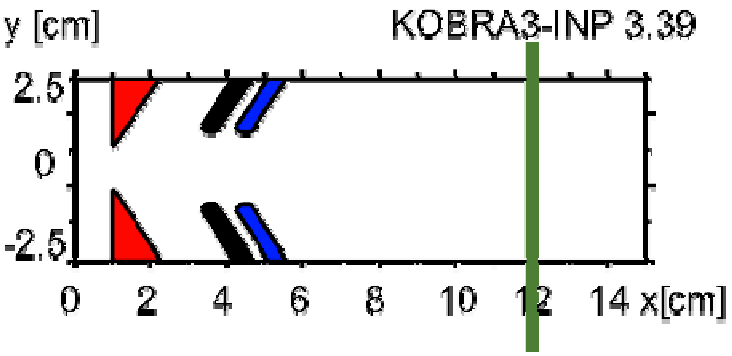

500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm


500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

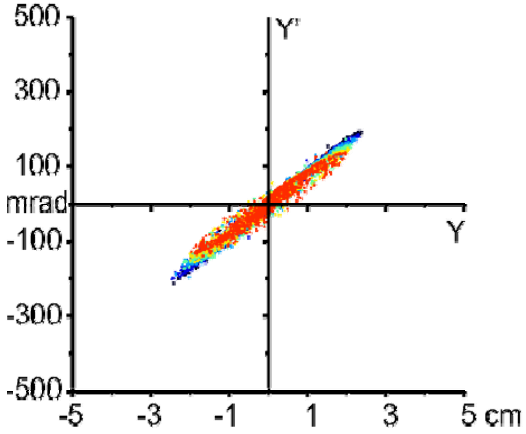
X = 0.12 m



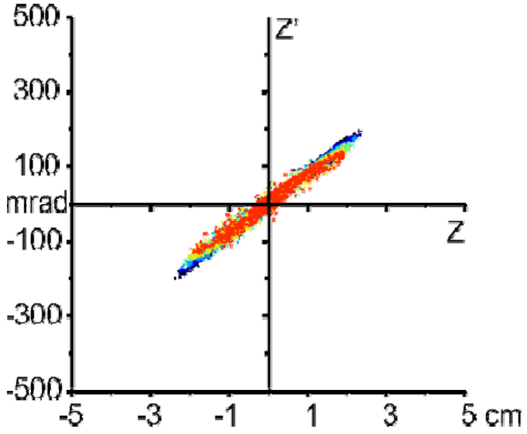
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

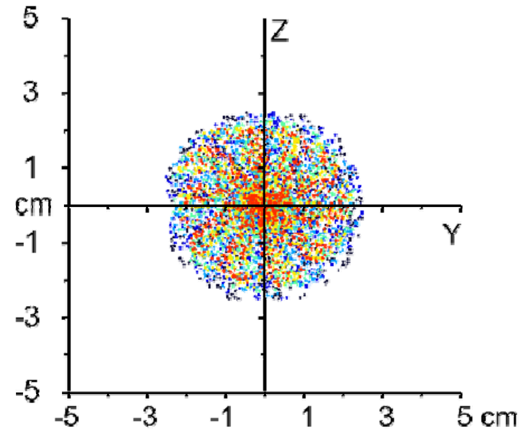


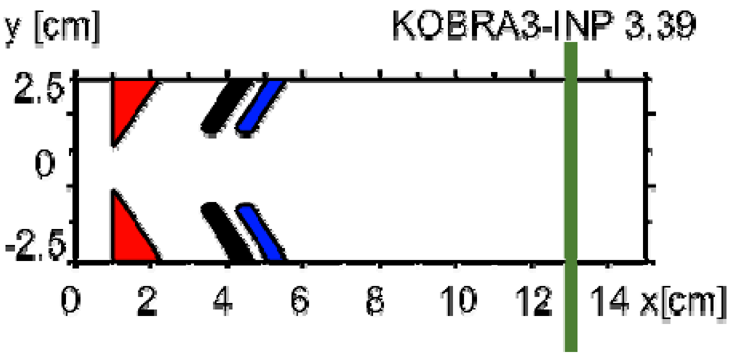
500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

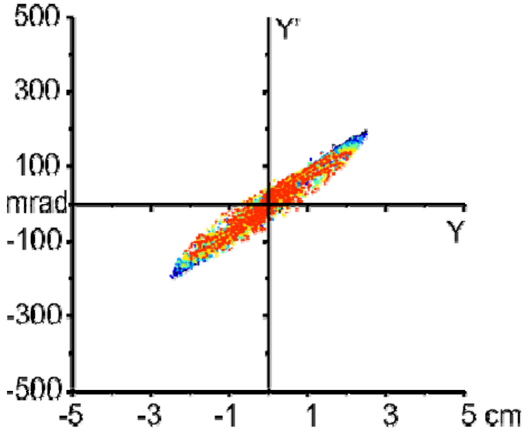


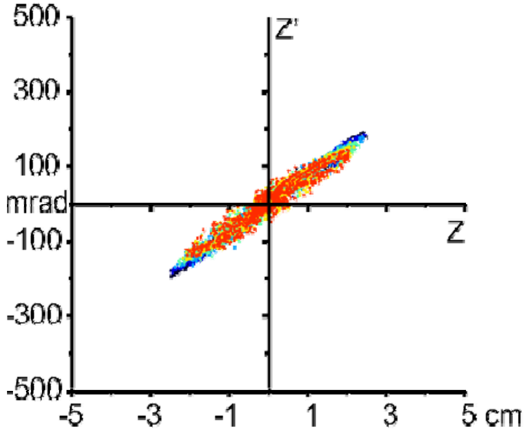
500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.13 m

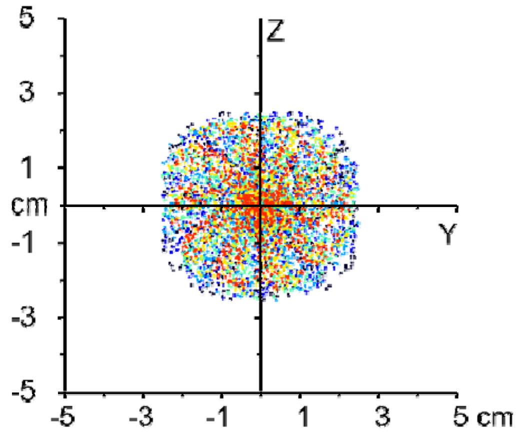

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm

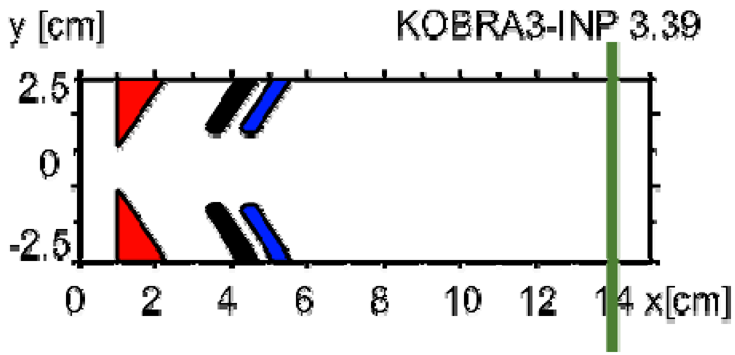

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

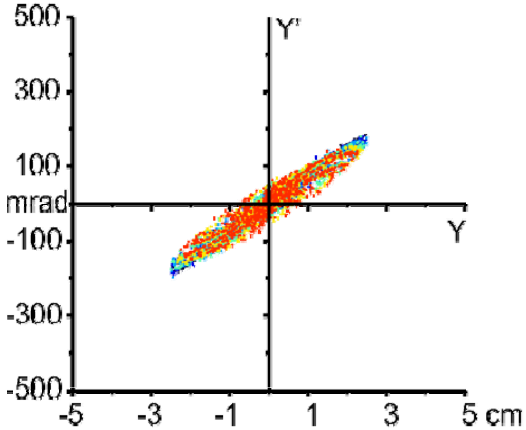

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

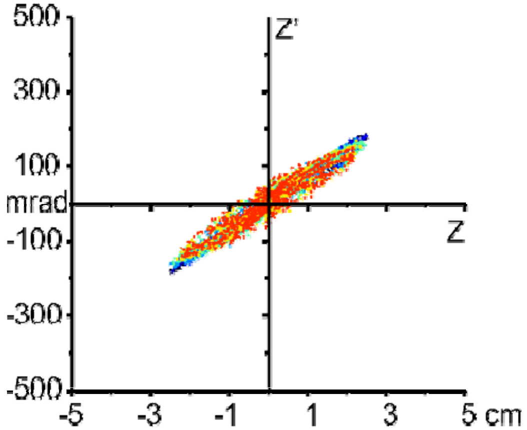

500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.14 m

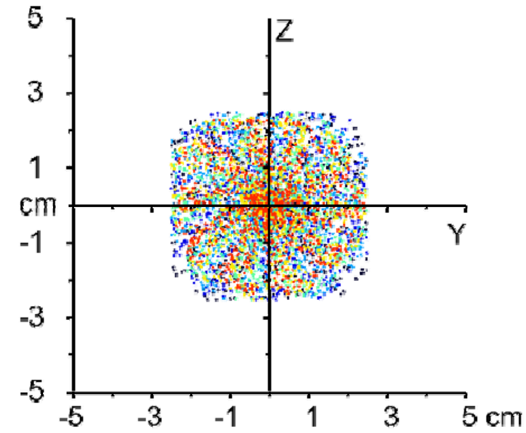


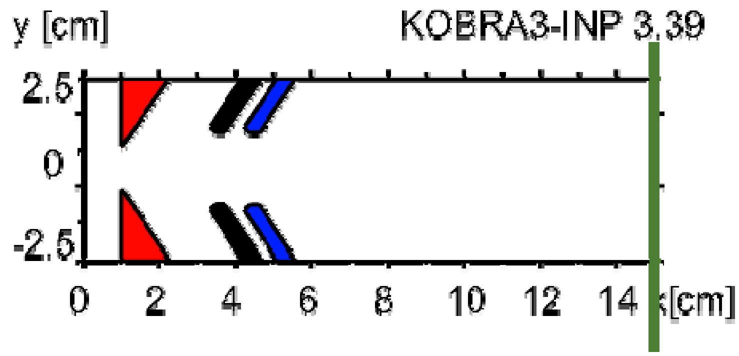


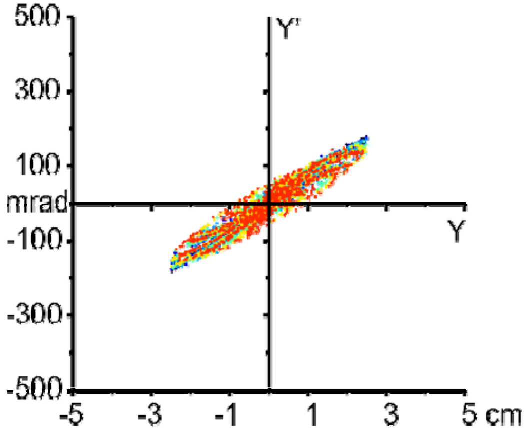


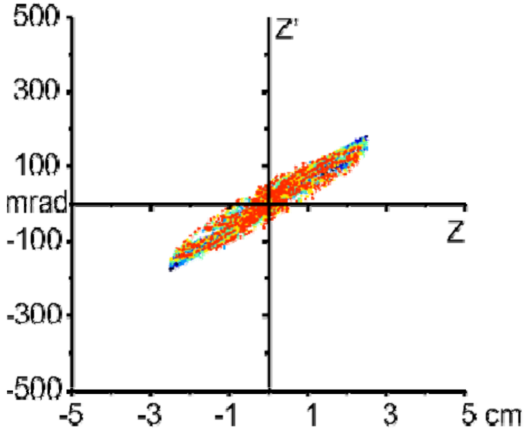


X = 0.15 m



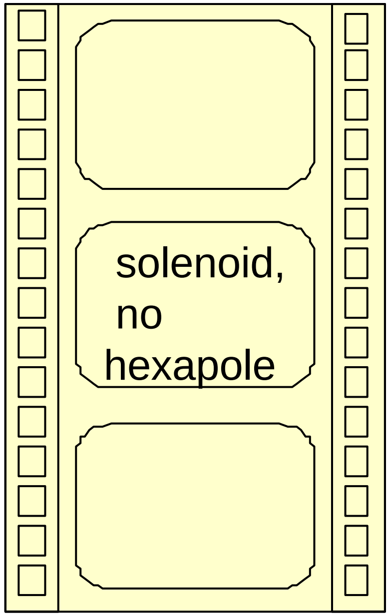




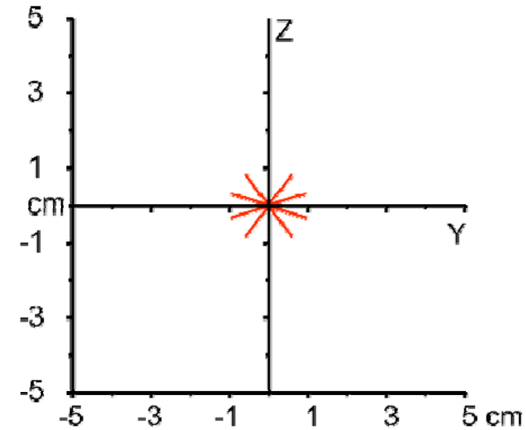


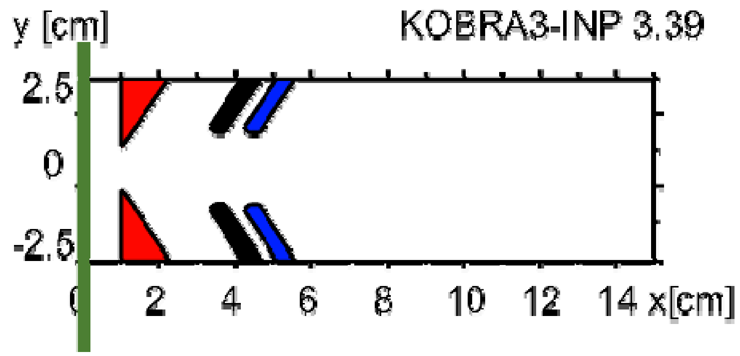
assumption

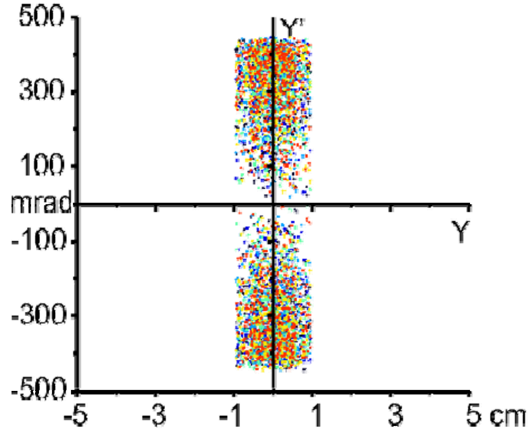
- Magnetic Flux density B = $2*B_0$
- Plasma model: Self Ti=1eV, Te=5eV
- No Hexapole
- Current 5 mA

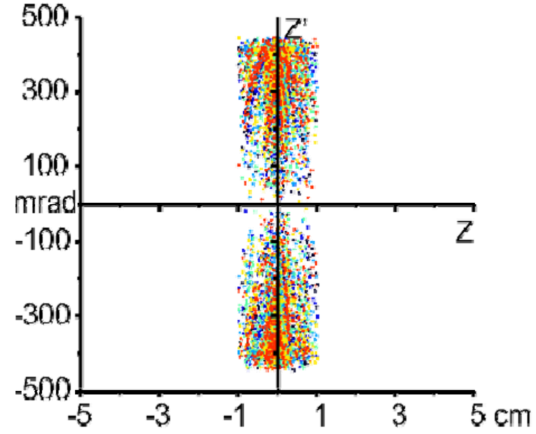


X = 0.00 m

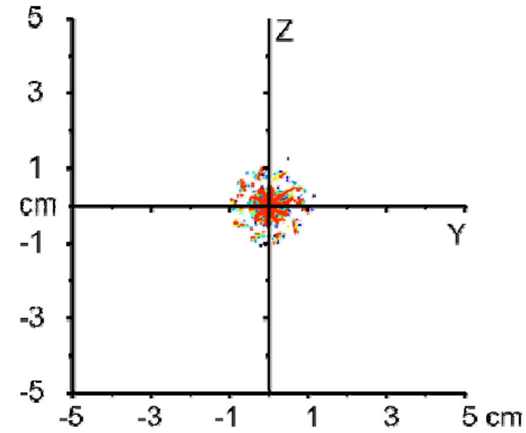

Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
2 4 6 8 10 12 14 x[cm]

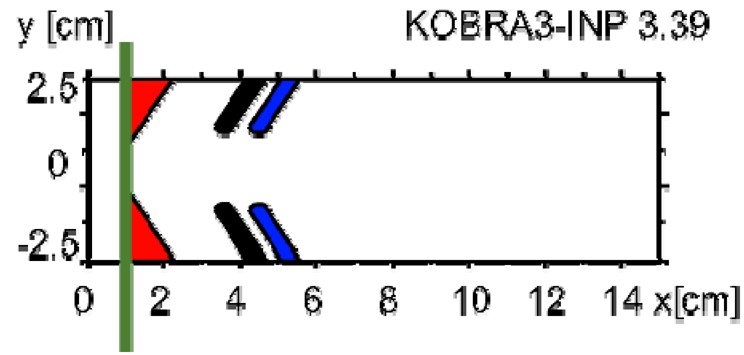

Y'
Y
500
300
100
mrad
-100
-300
-500
-5 -3 -1 1 3 5 cm


Z'
Z
500
300
100
mrad
-100
-300
-500
-5 -3 -1 1 3 5 cm

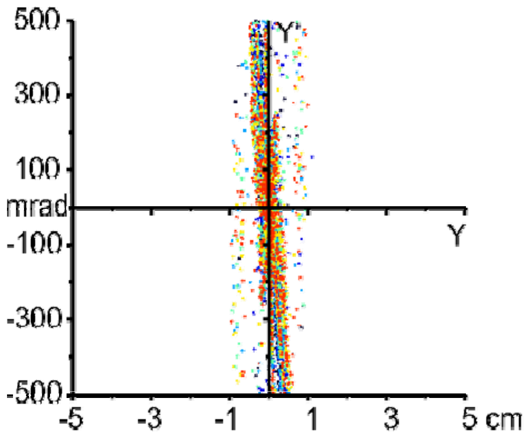
X = 0.01 m



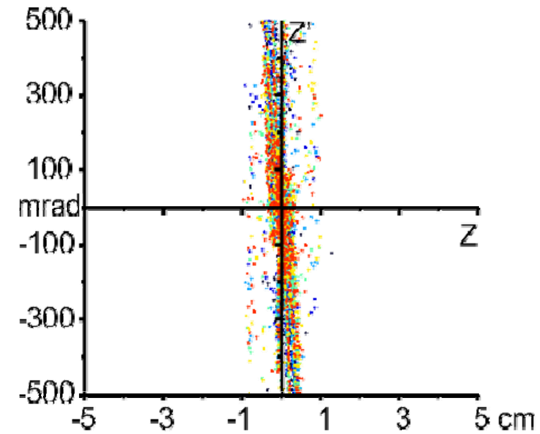
Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

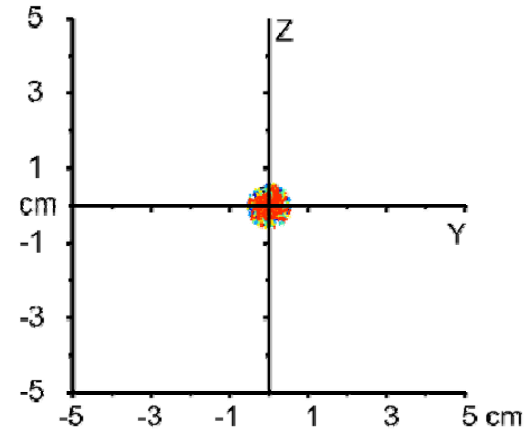


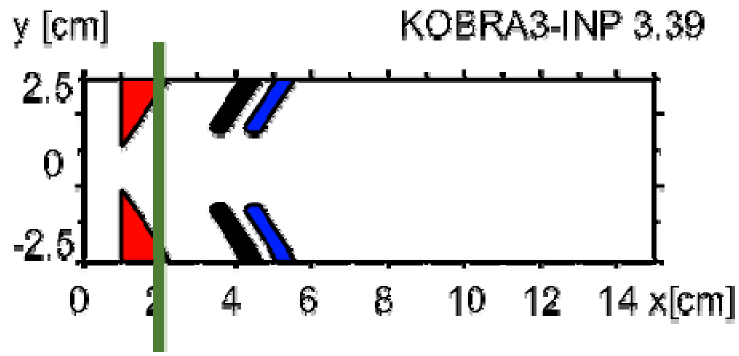
Y'
Y
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

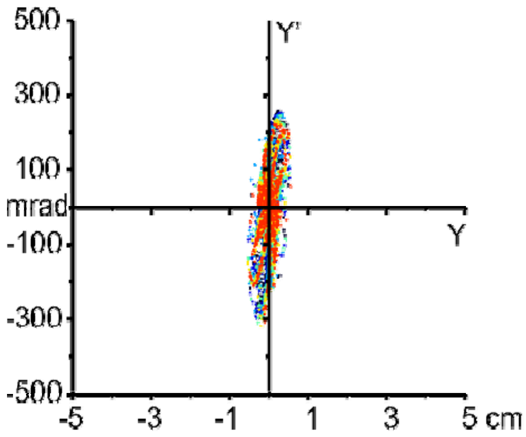


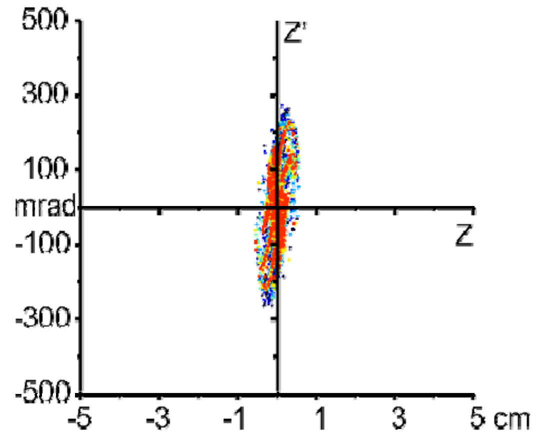
Z'
Z
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

X = 0.02 m

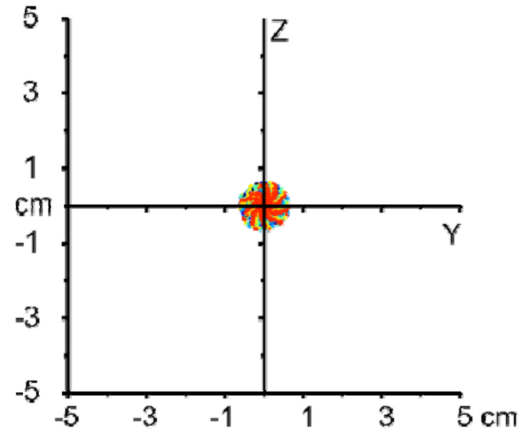

5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

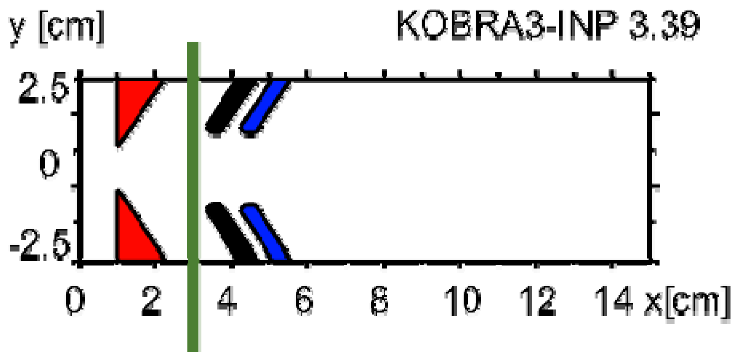

500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm


500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

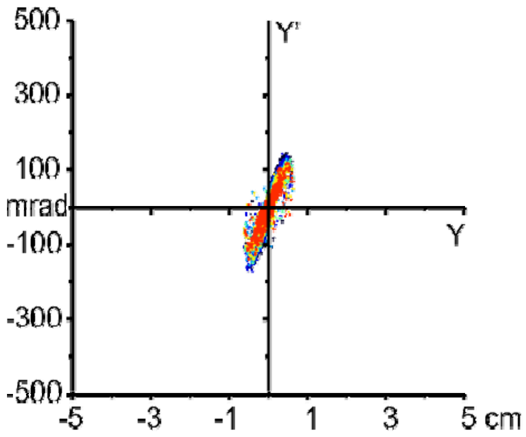
X = 0.03 m



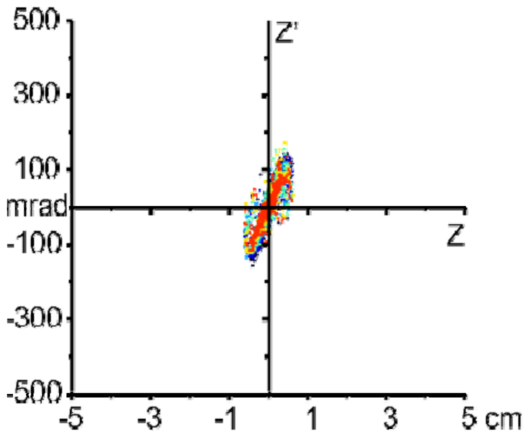
Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

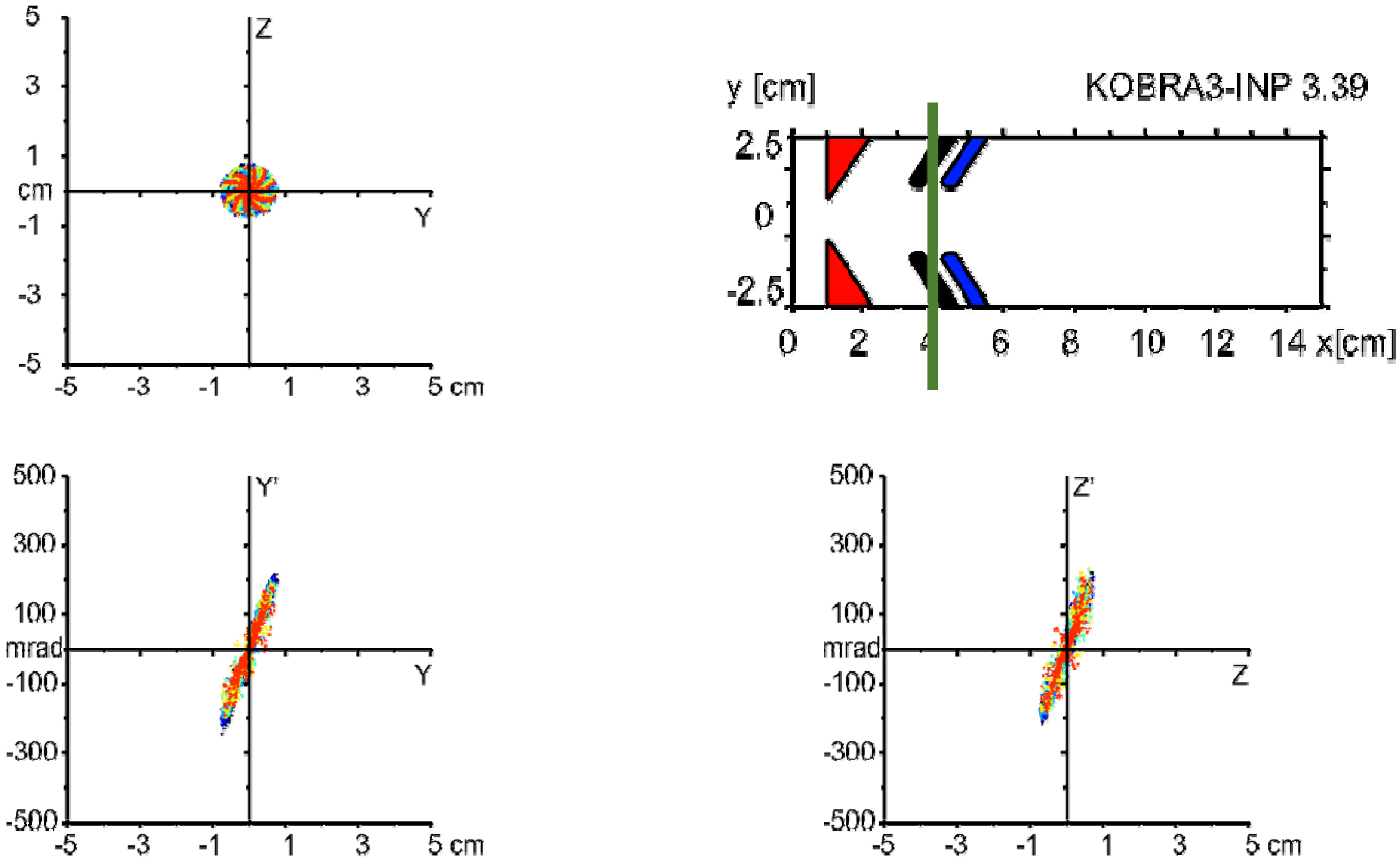


Y'
Y
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm



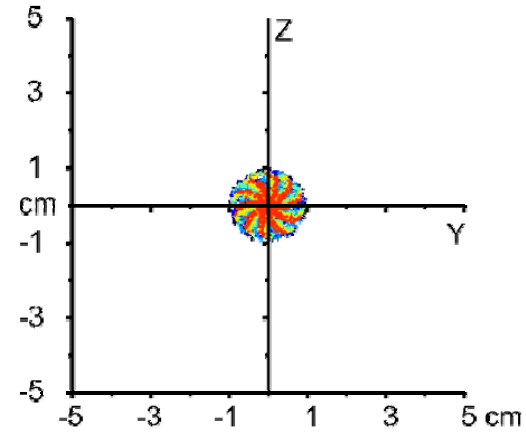
Z'
Z
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

X = 0.04 m

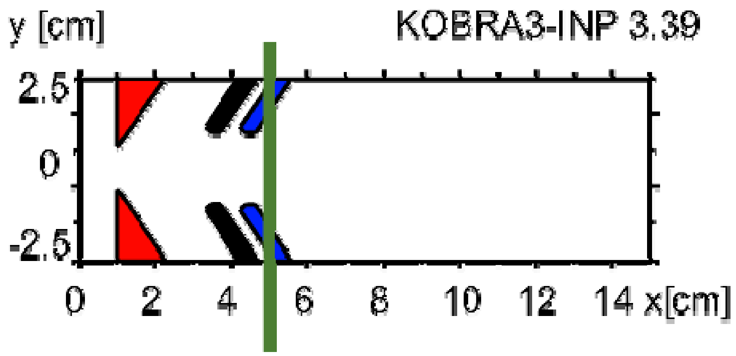


5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm
y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]
500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm
500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

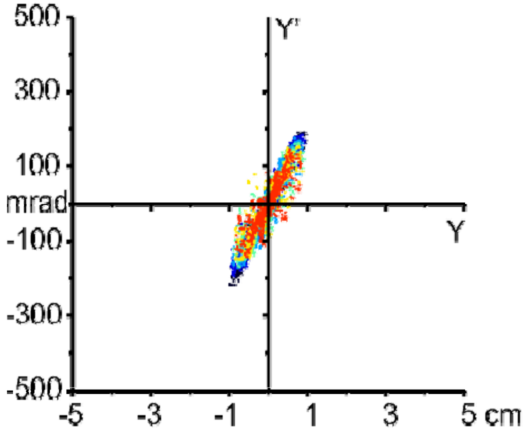
X = 0.05 m



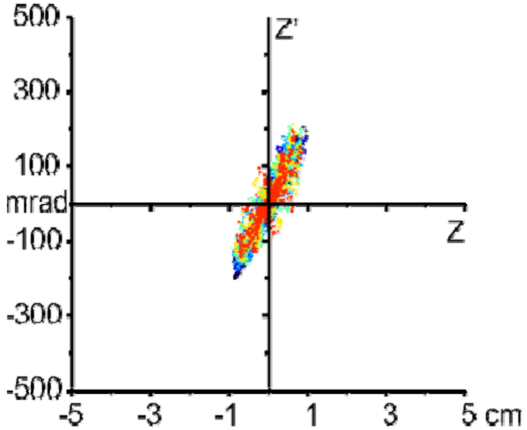
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

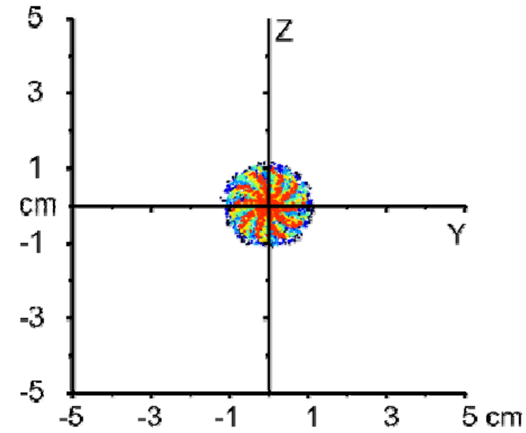


500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

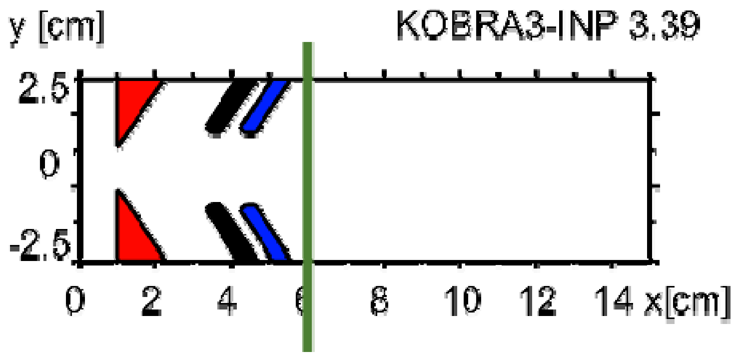


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

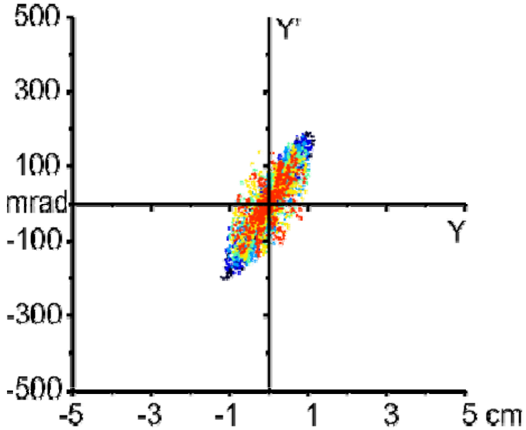
X = 0.06 m



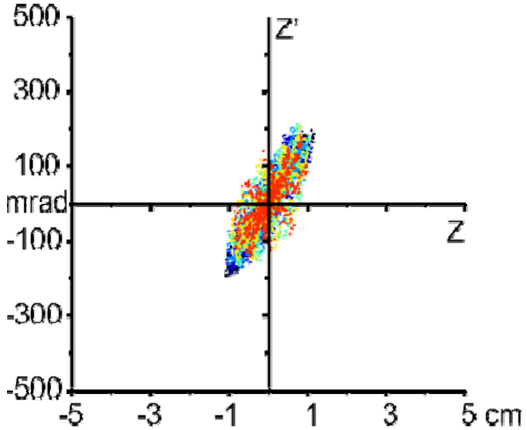
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 8 10 12 14 x[cm]

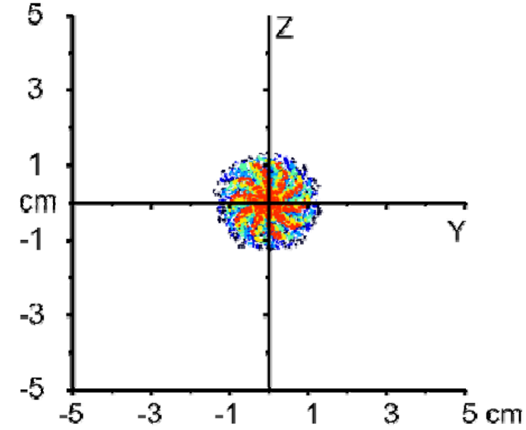


500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

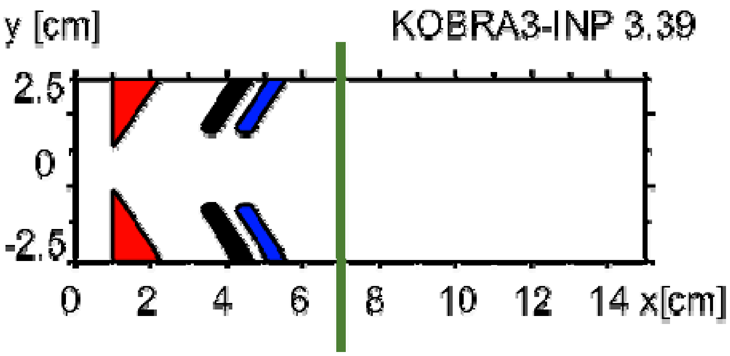


500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

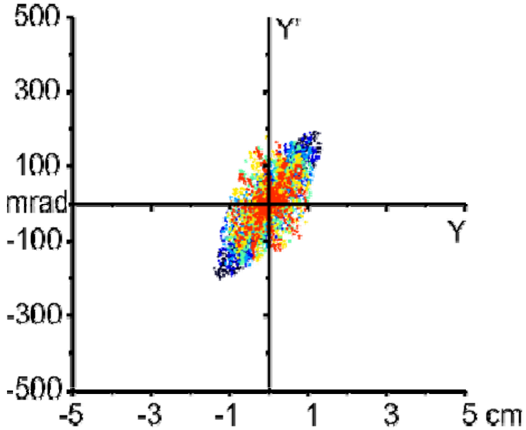
X = 0.07 m



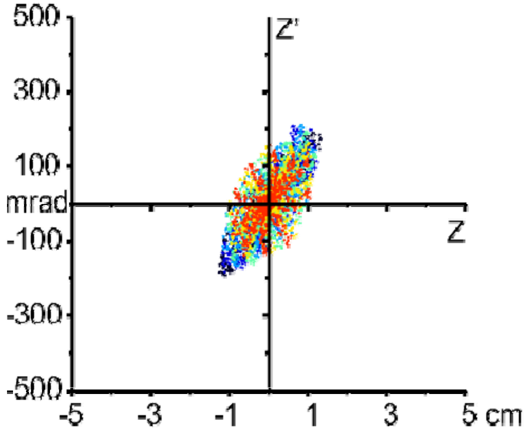
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

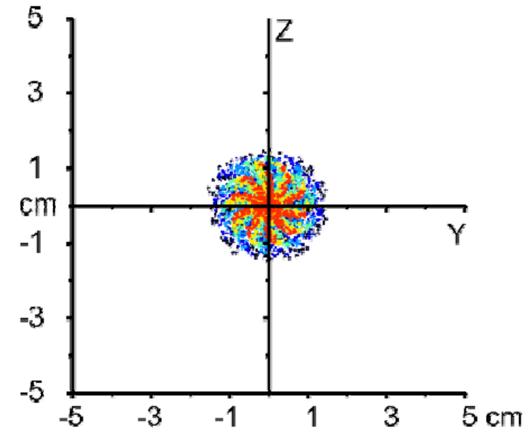


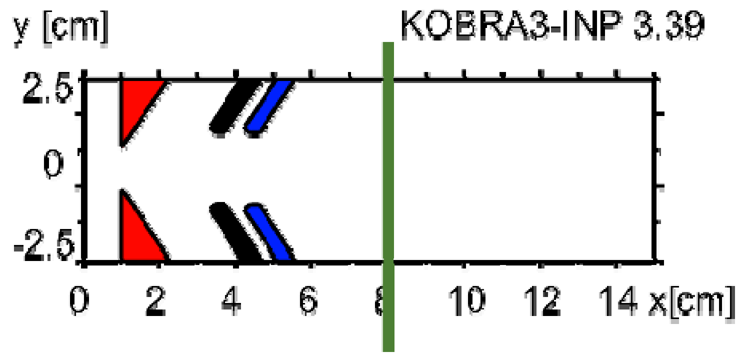
500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

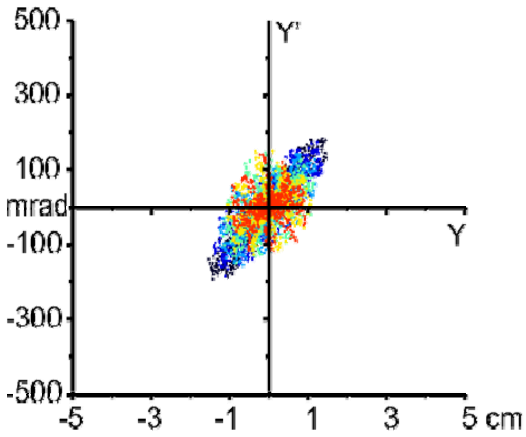


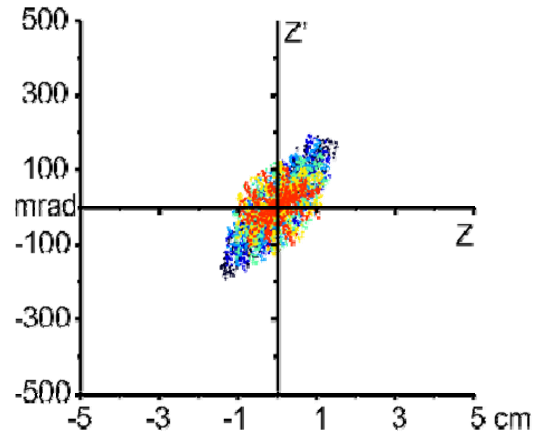
500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

X = 0.08 m

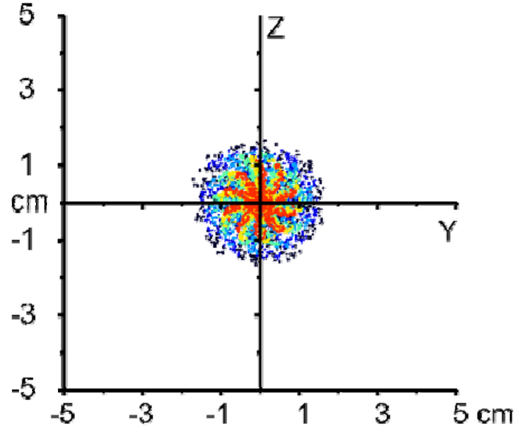


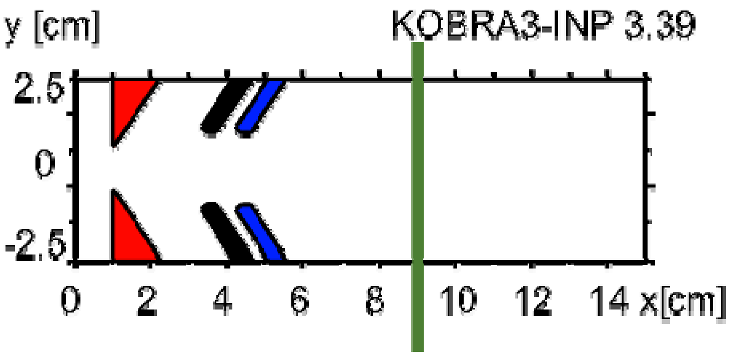


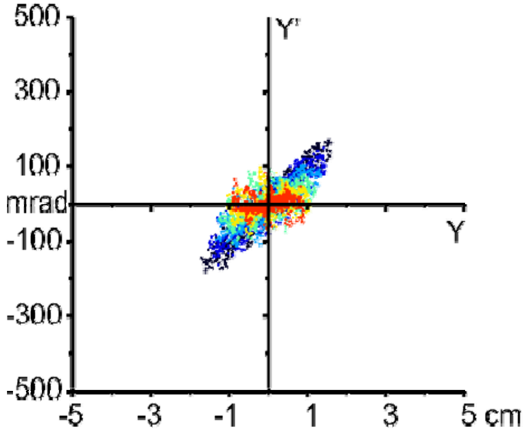


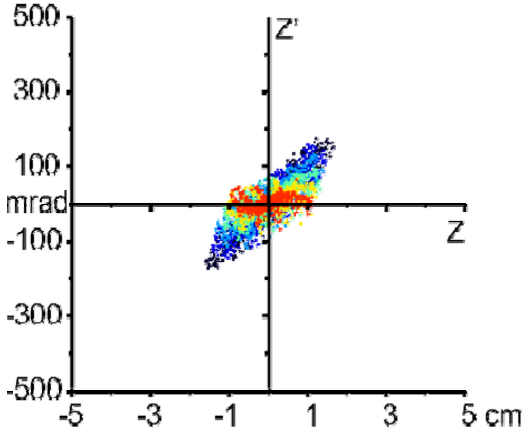


X = 0.09 m

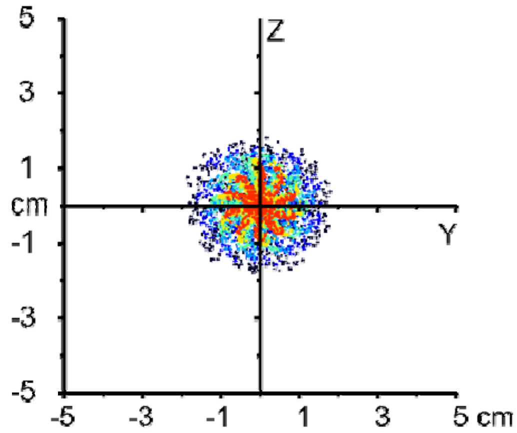

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

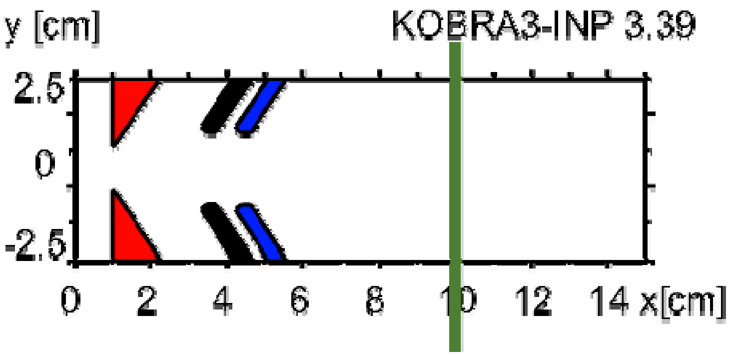

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

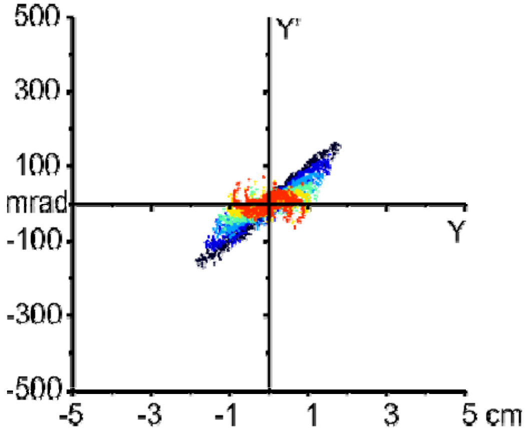
X = 0.10 m



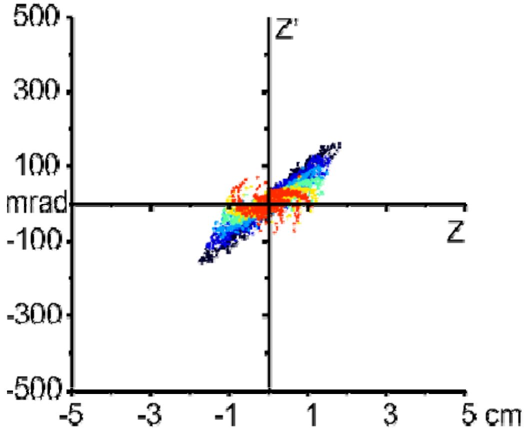
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

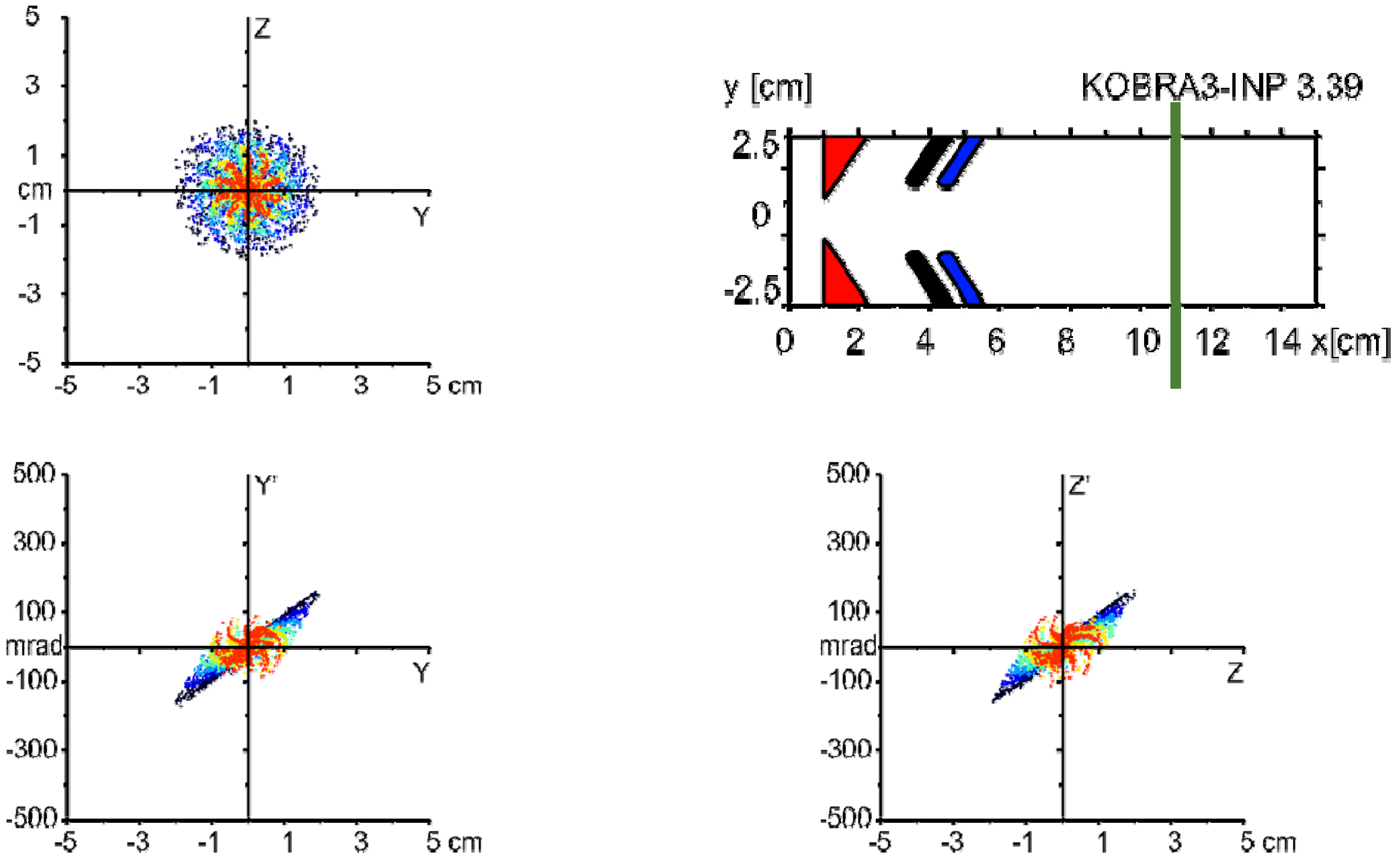


500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

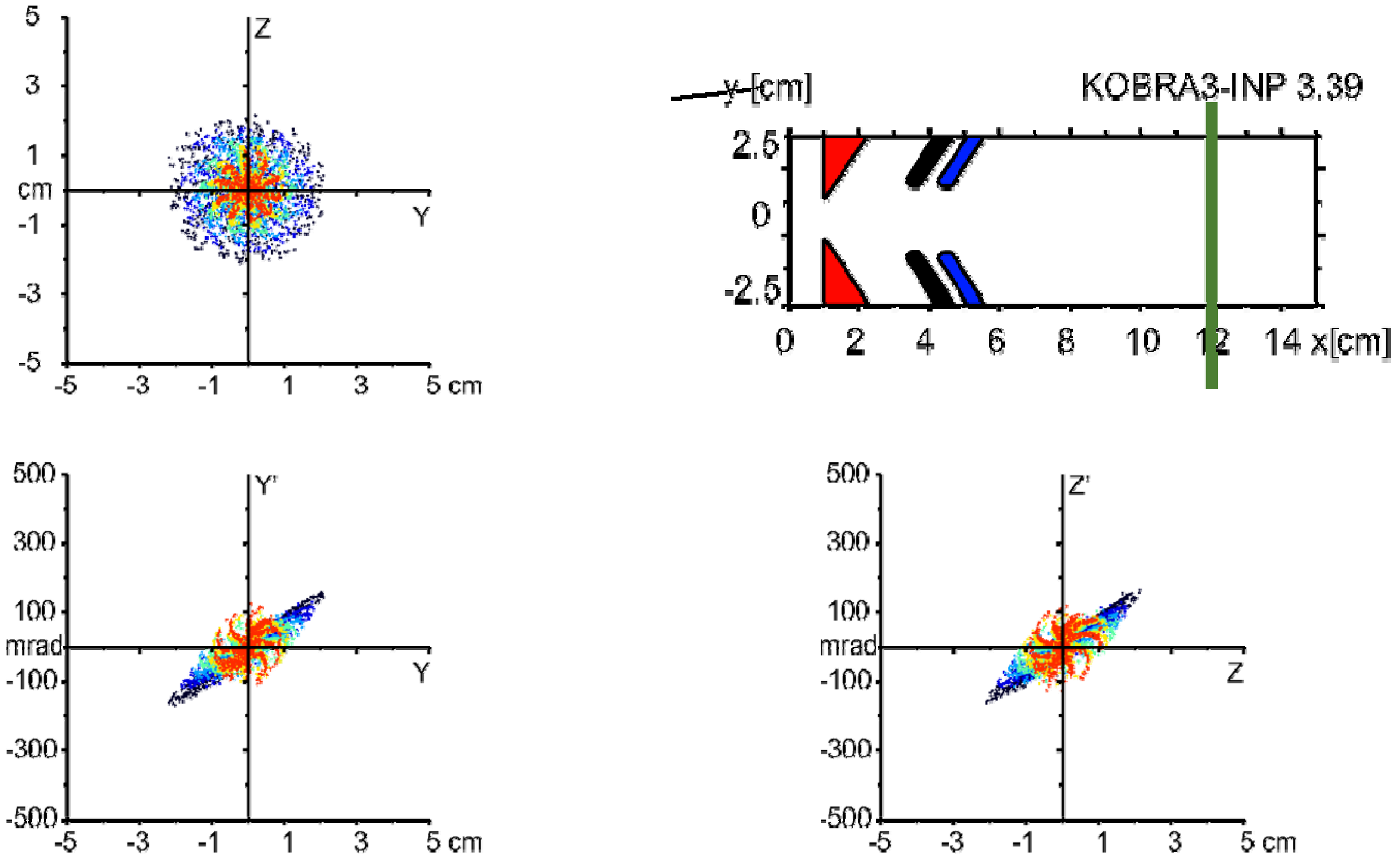


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

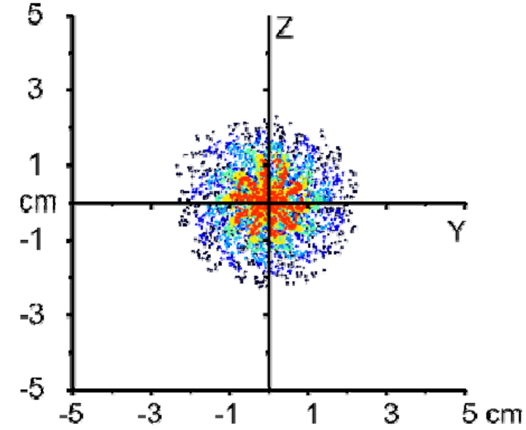
X = 0.11 m

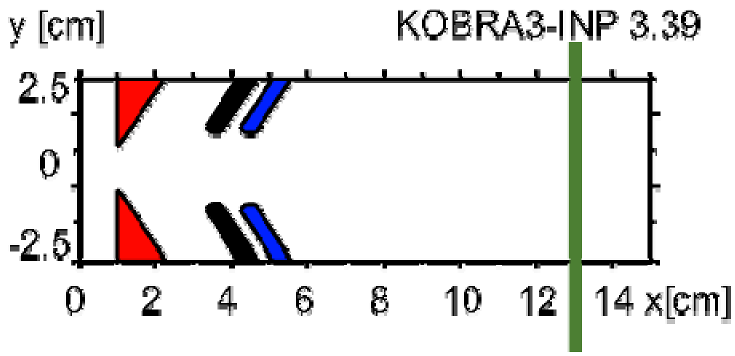


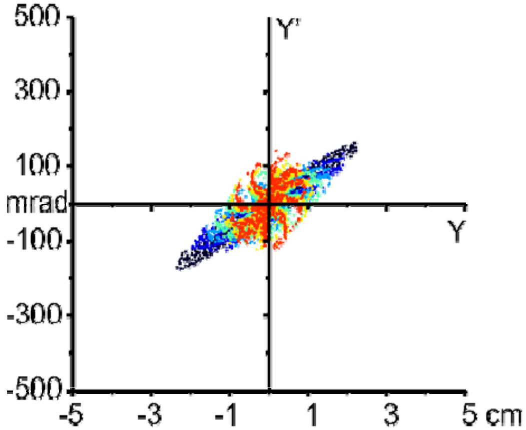
X = 0.12 m

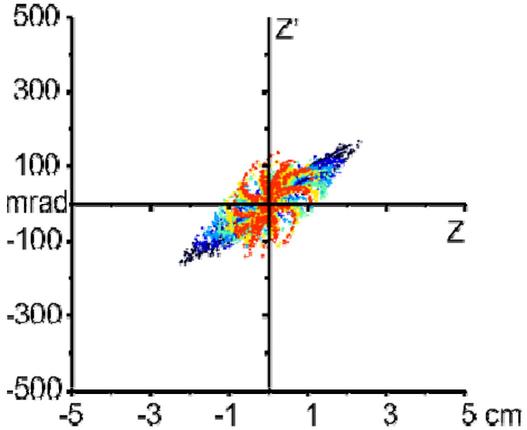


X = 0.13 m

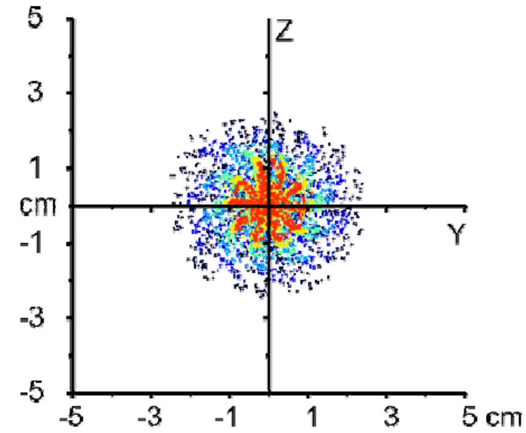

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

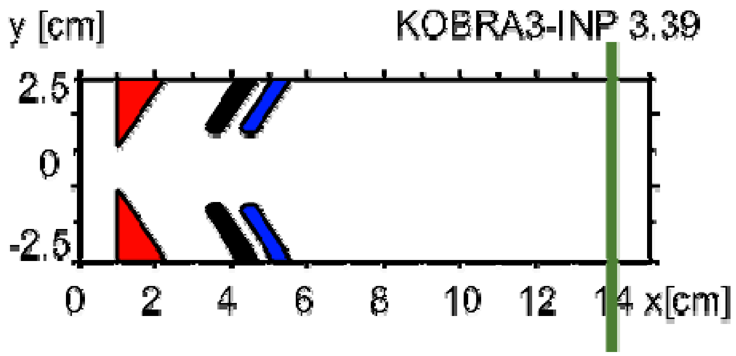

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

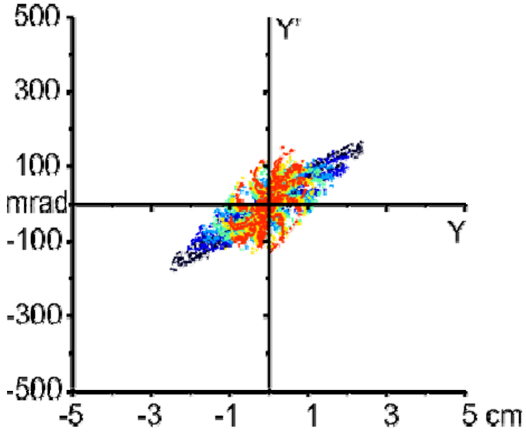
X = 0.14 m



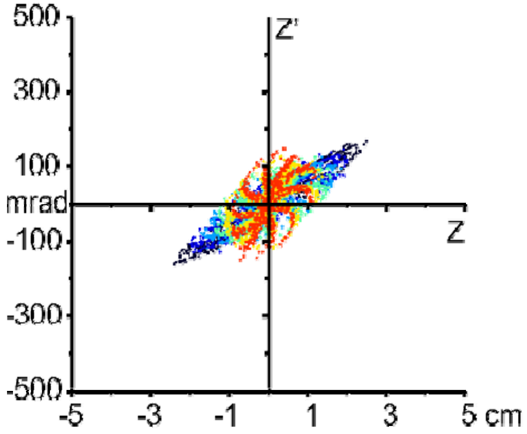
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

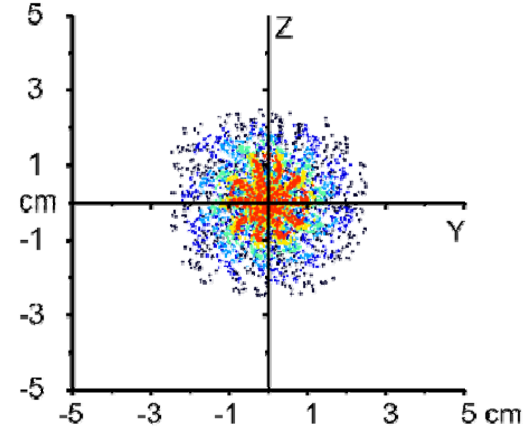


500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

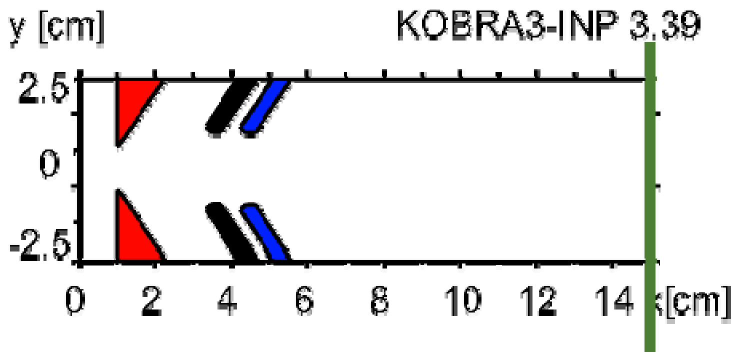


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

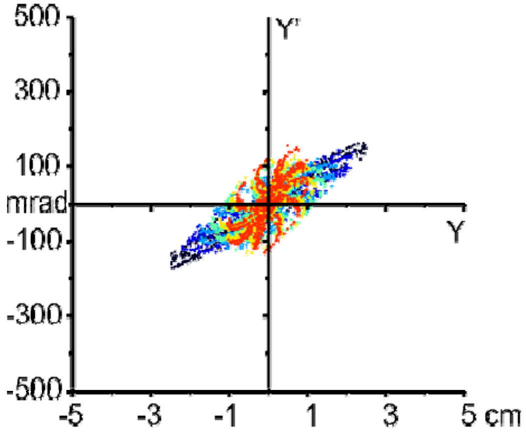
X = 0.15 m



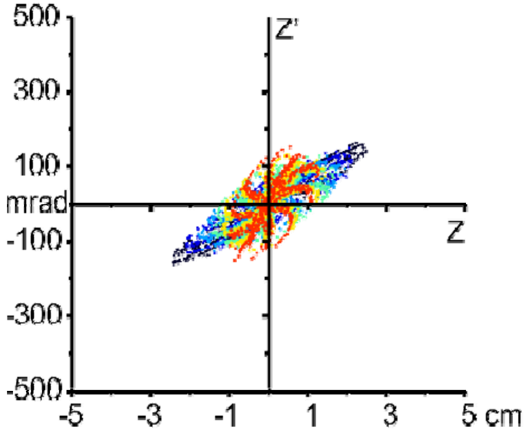
Z
Y
cm
5
3
1
-1
-3
-5
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14
[cm]



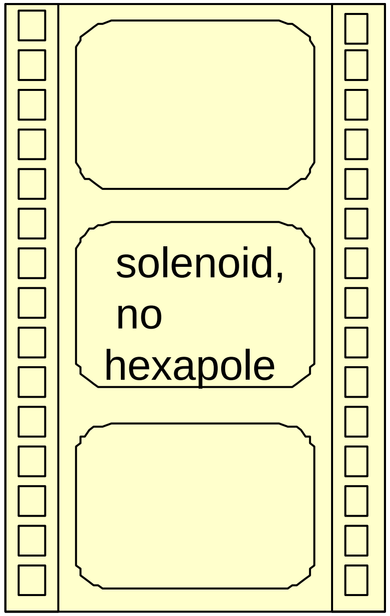
Y'
Y
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm



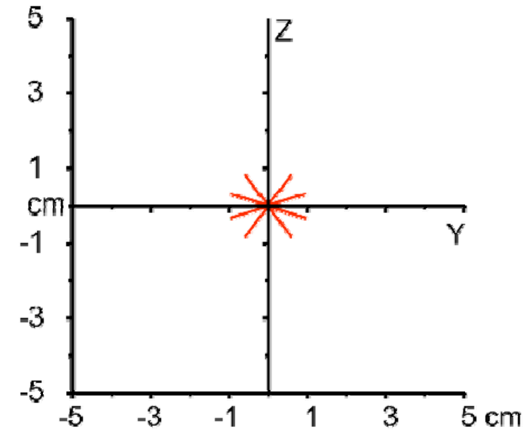
Z'
Z
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm

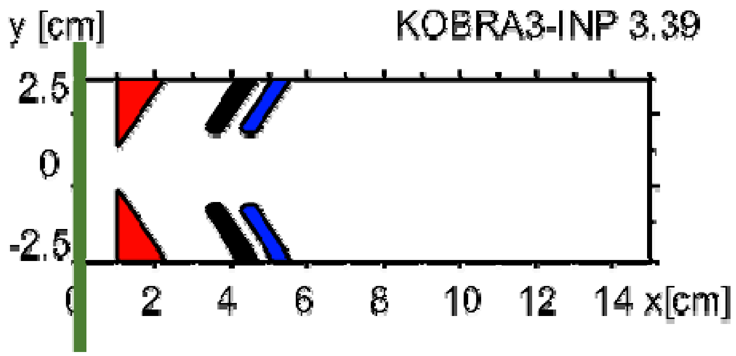
assumption

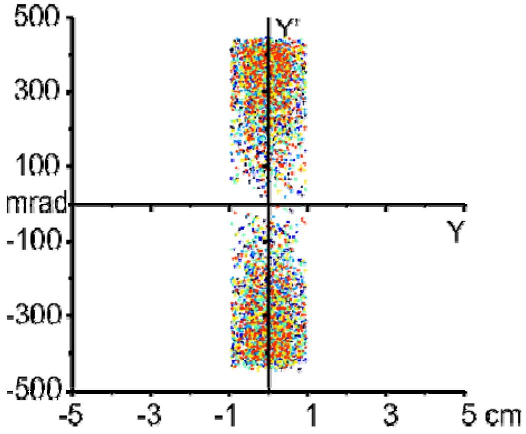
- Magnetic Flux density B = $3*B_0$
- Plasma model: Self Ti=1eV, Te=5eV
- No Hexapole
- Current 5 mA

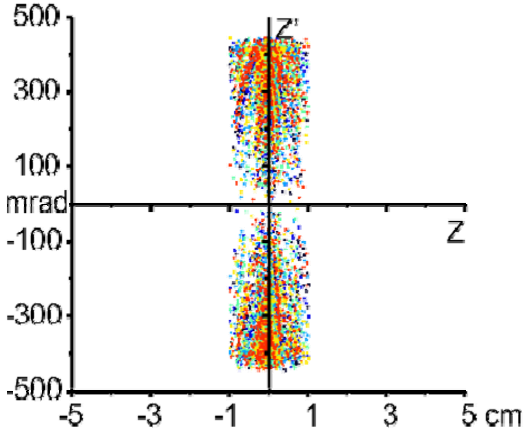


X = 0.00 m

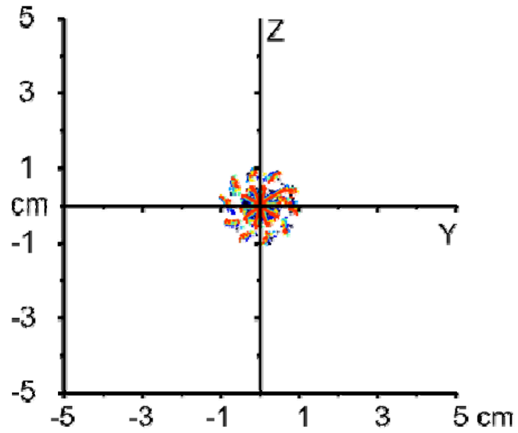




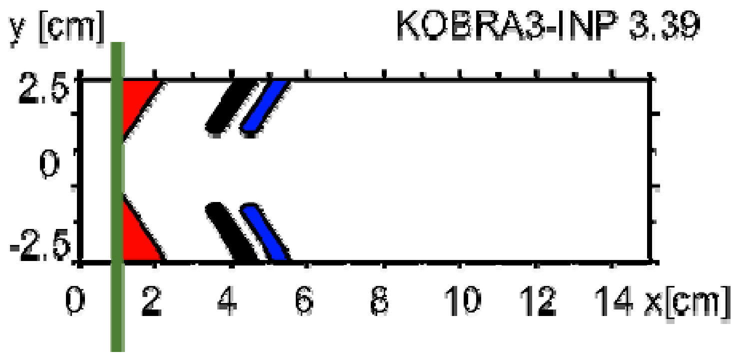




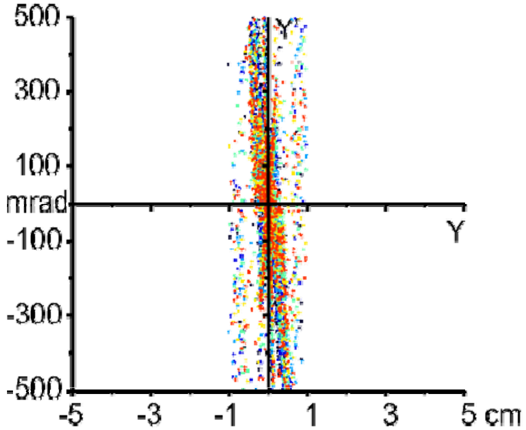
X = 0.01 m



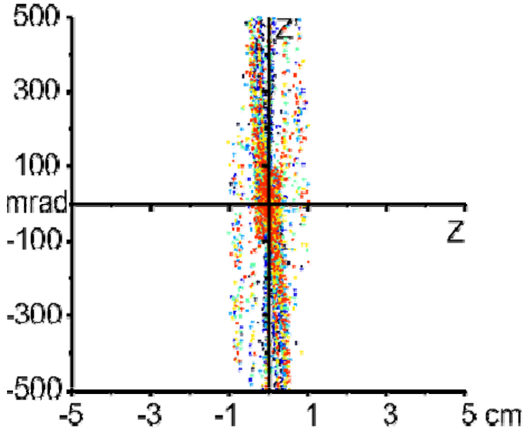
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

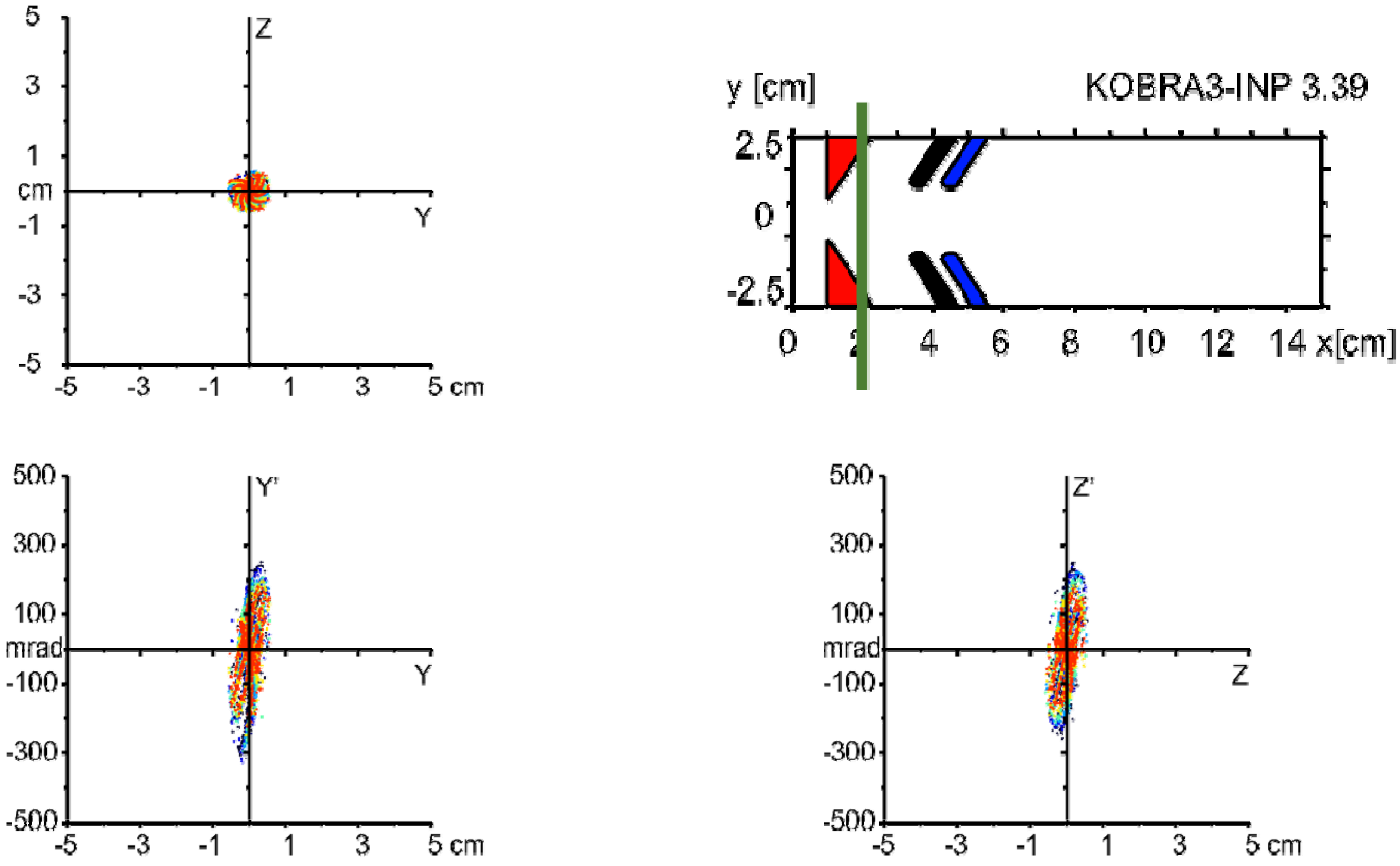


500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm



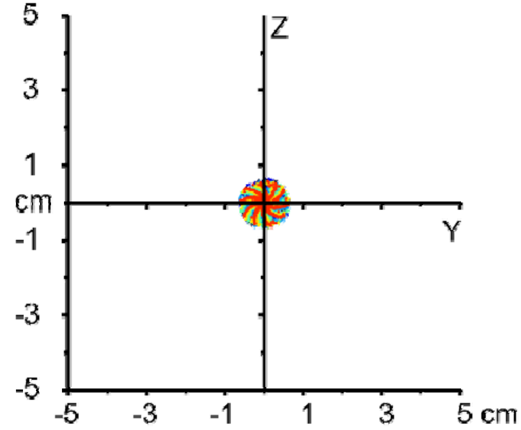
500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

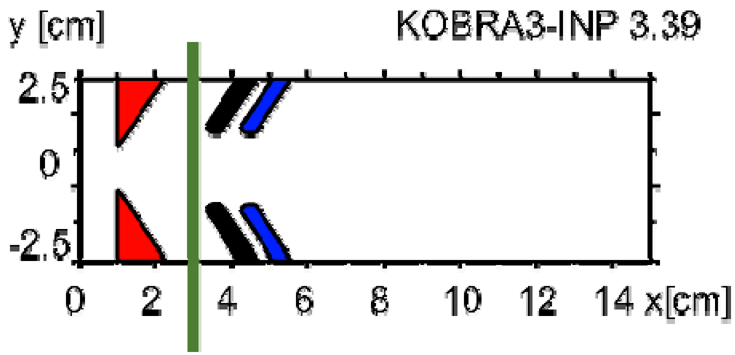
X = 0.02 m

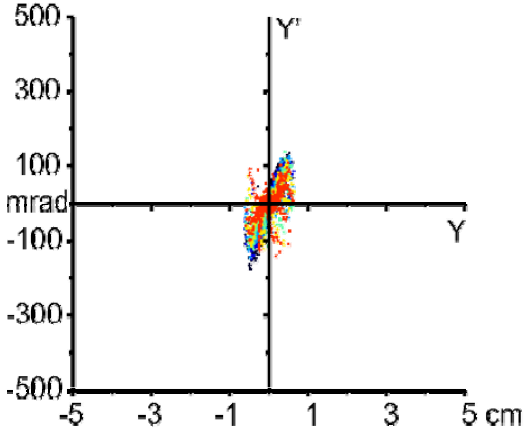


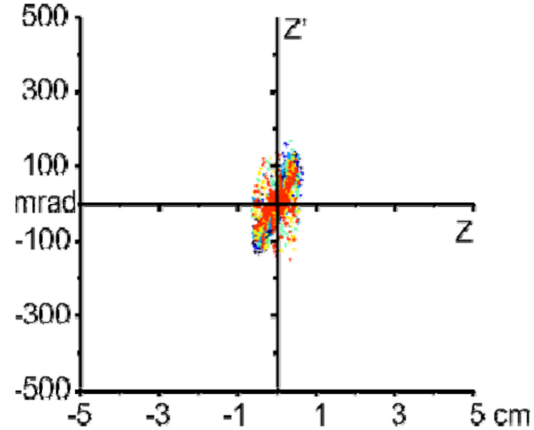
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm
y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]
500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm
500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

X = 0.03 m

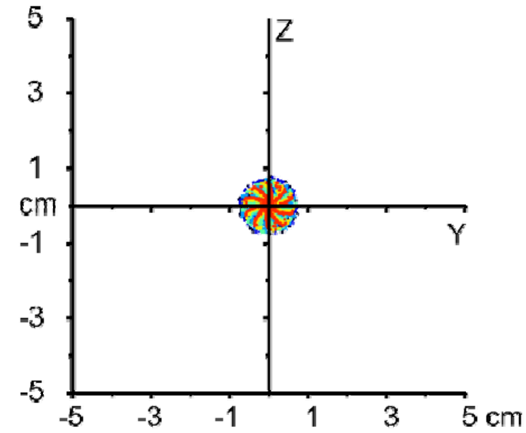

5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm

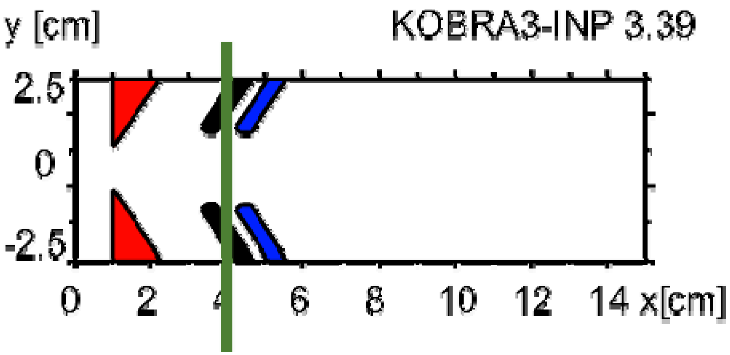

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

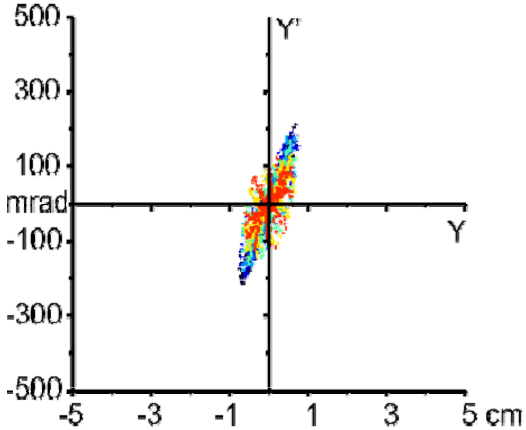

500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

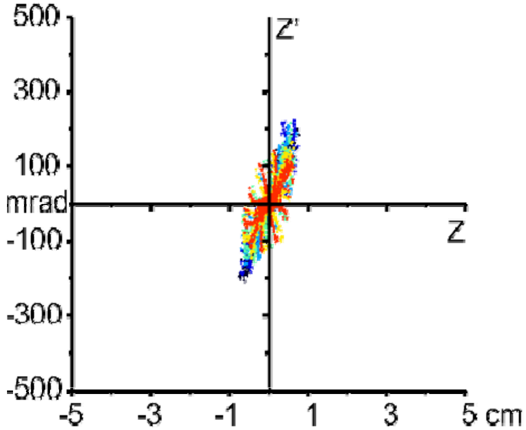

500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

X = 0.04 m

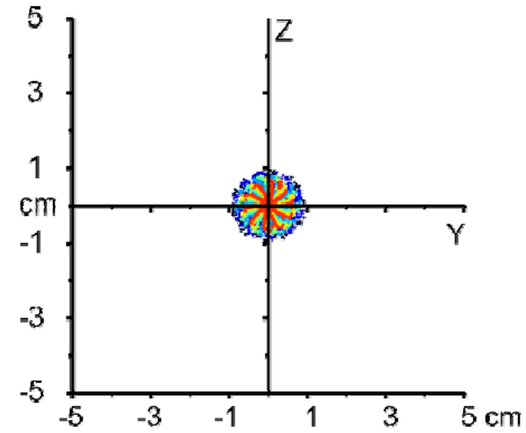


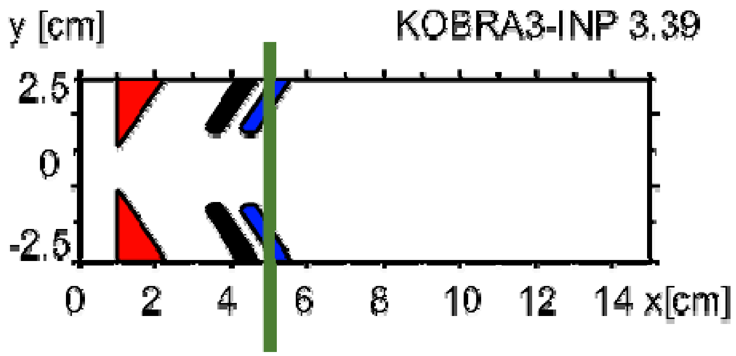


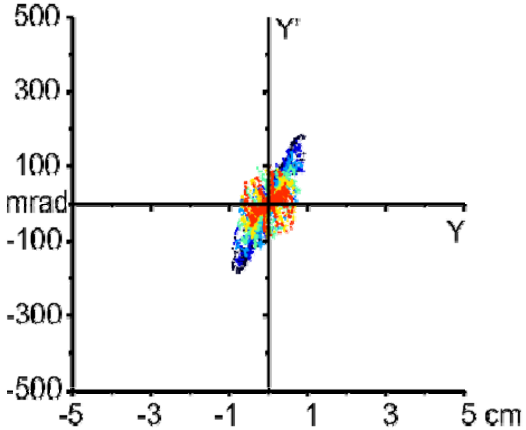


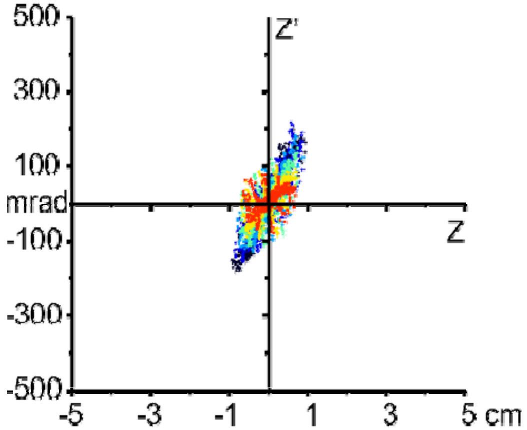


X = 0.05 m

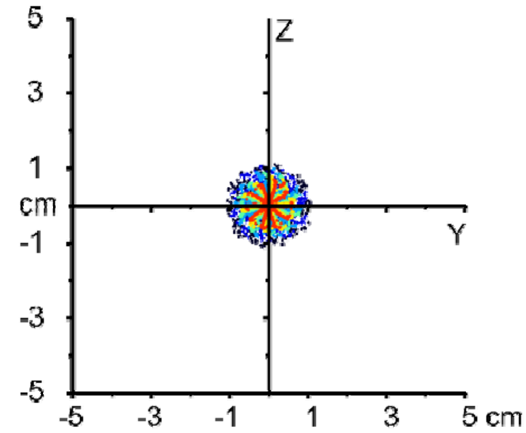


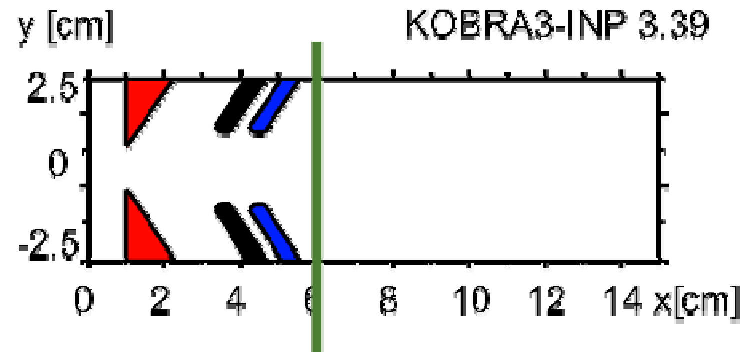


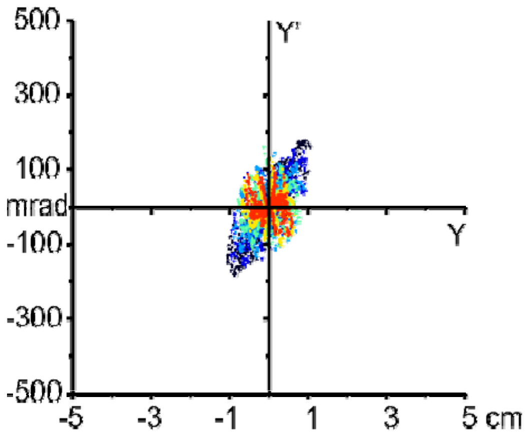


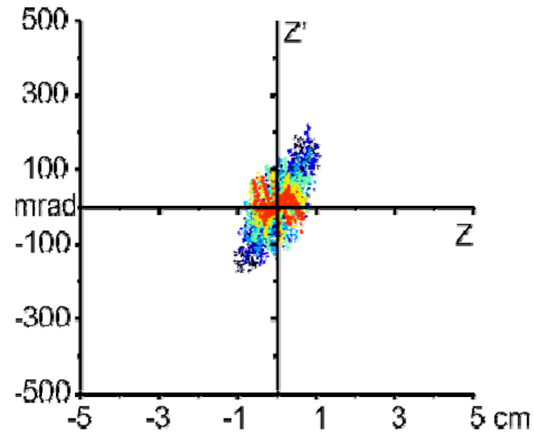


X = 0.06 m

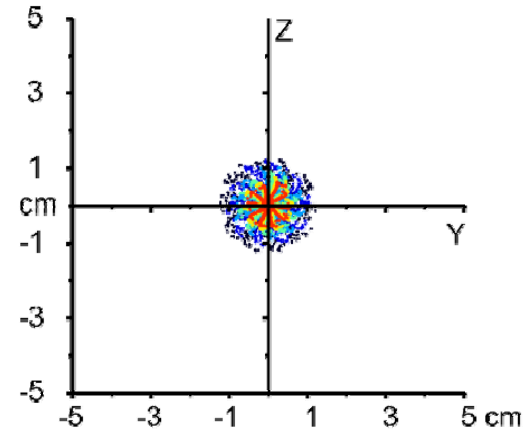

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
8
10
12
14 x[cm]

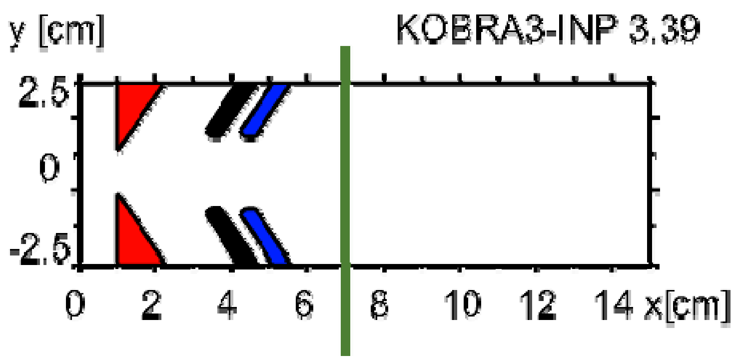

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

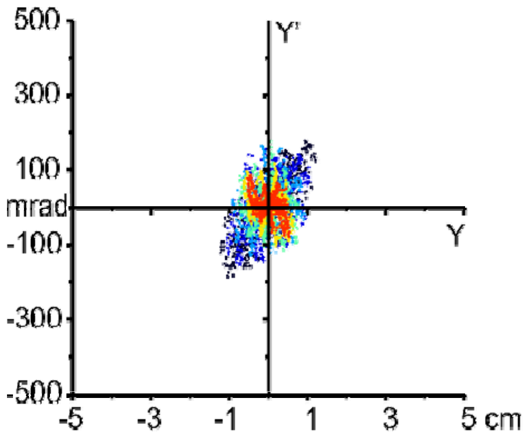
X = 0.07 m



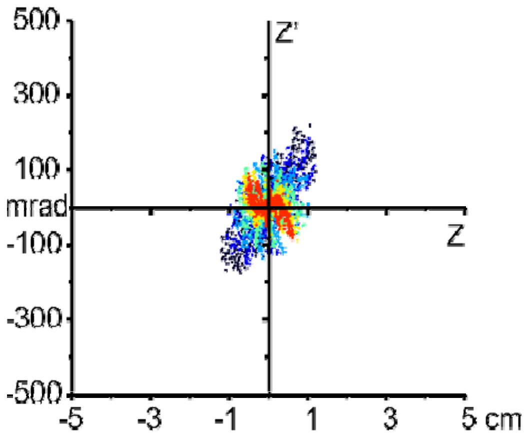
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

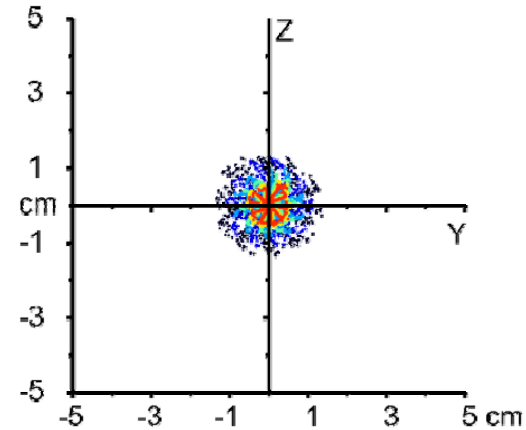


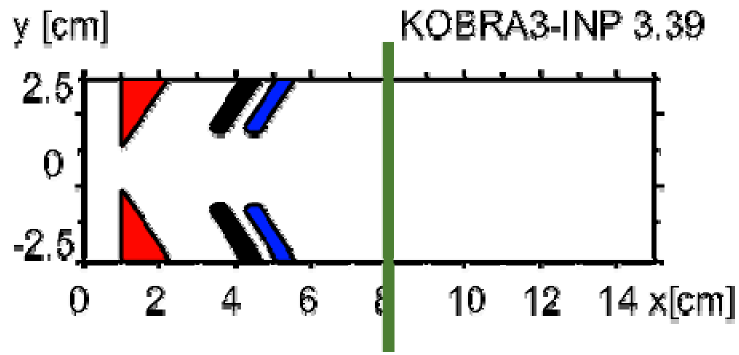
500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

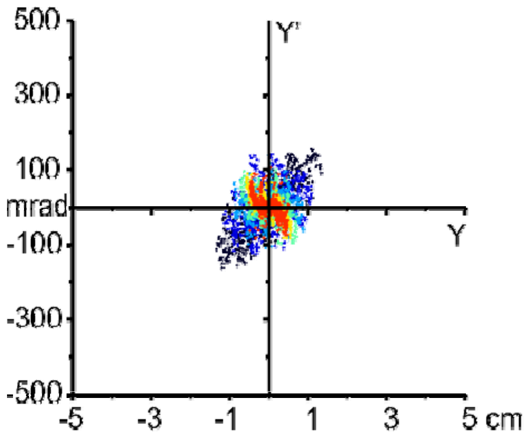


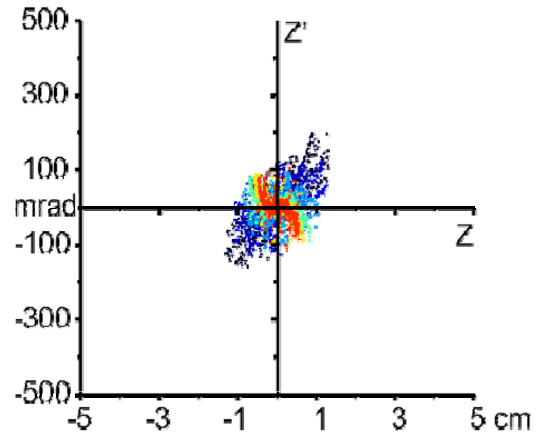
500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

X = 0.08 m

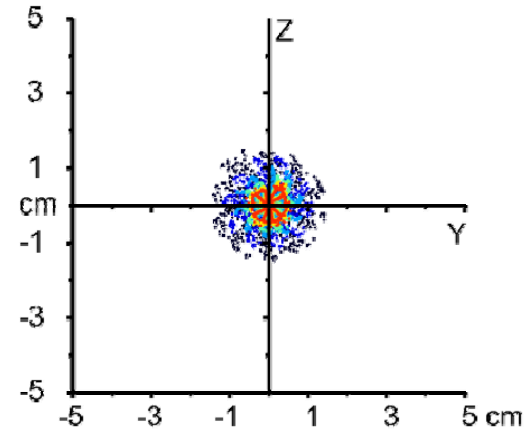

Z
Y
cm
5 3 1 -1 -3 -5
-5 -3 -1 1 3 5 cm

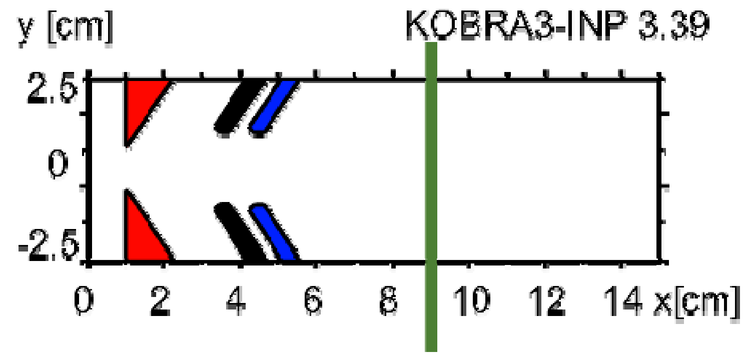

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

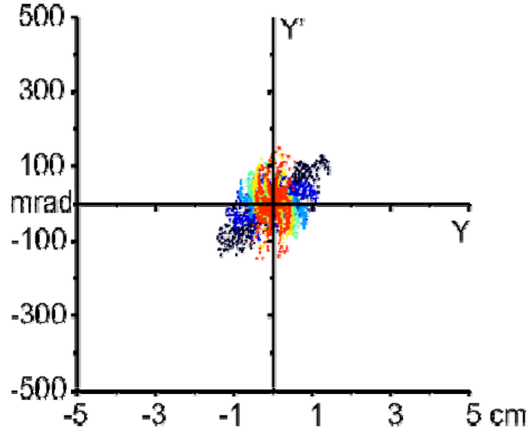

Y'
Y
mrad
500 300 100 -100 -300 -500
-5 -3 -1 1 3 5 cm

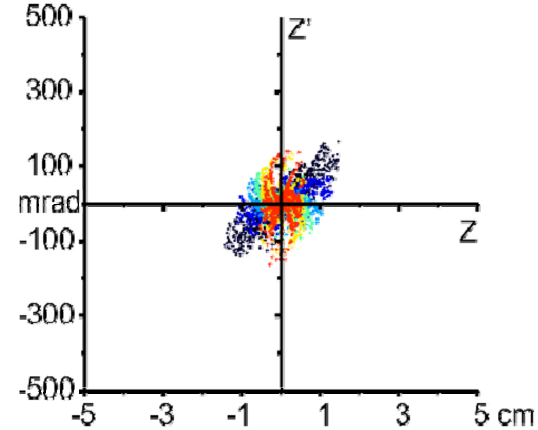

Z'
Z
mrad
500 300 100 -100 -300 -500
-5 -3 -1 1 3 5 cm

X = 0.09 m

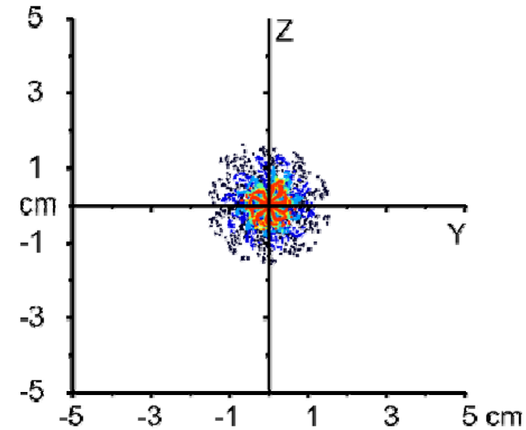

Z
Y
5
3
1
cm
-1
-3
-5
-5 -3 -1 1 3 5 cm

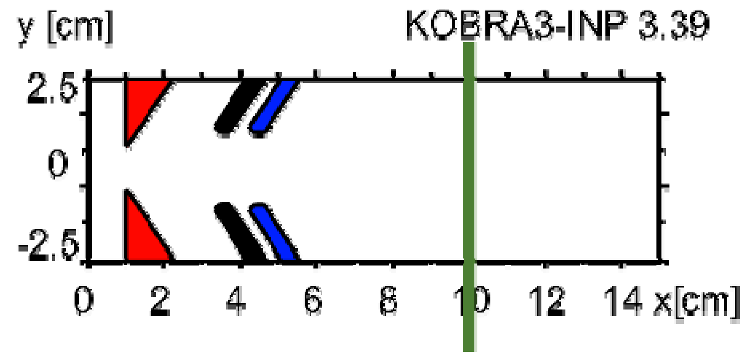

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

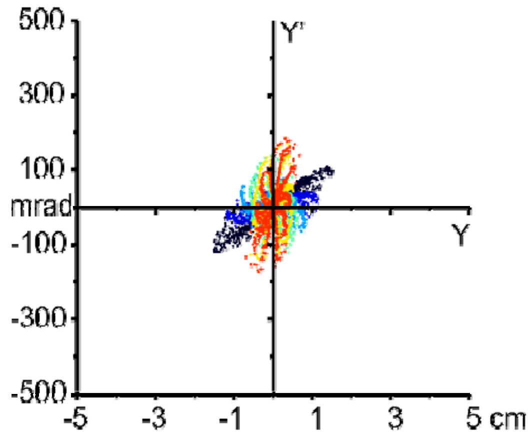

Y'
Y
500
300
100
mrad
-100
-300
-500
-5 -3 -1 1 3 5 cm

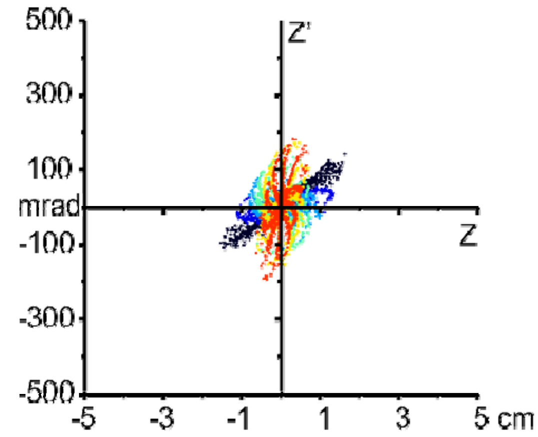

Z'
Z
500
300
100
mrad
-100
-300
-500
-5 -3 -1 1 3 5 cm

X = 0.10 m

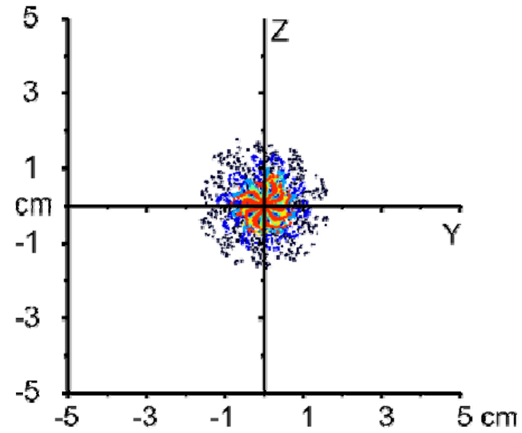

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm

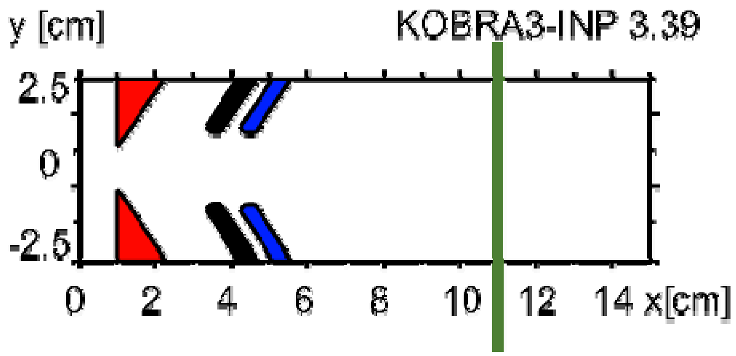

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

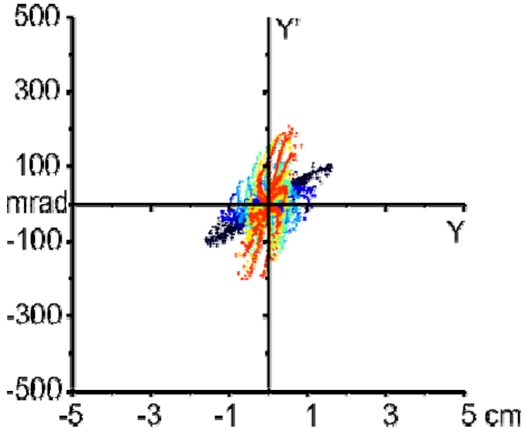

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

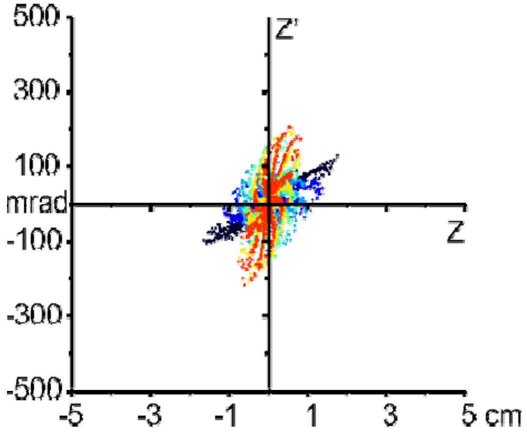

500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.11 m

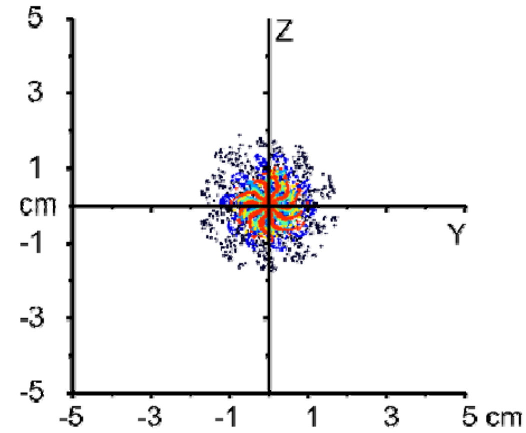

Z
Y
cm
5
3
1
-1
-3
-5
-5
-3
-1
1
3
5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

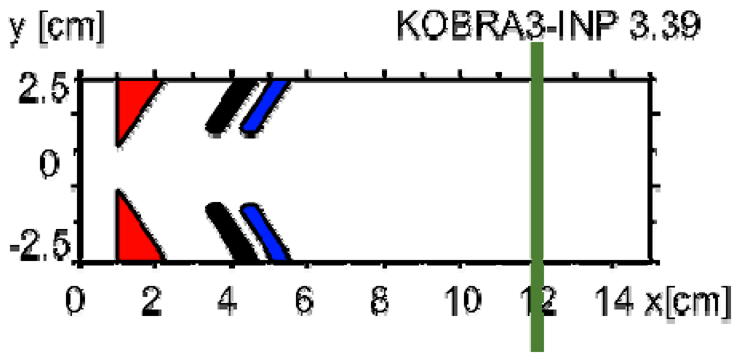

Y'
Y
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm


Z'
Z
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm

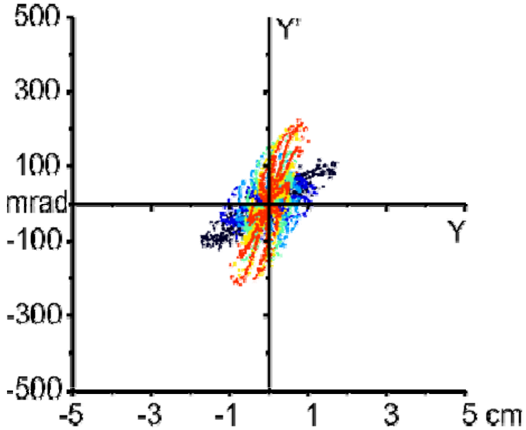
X = 0.12 m



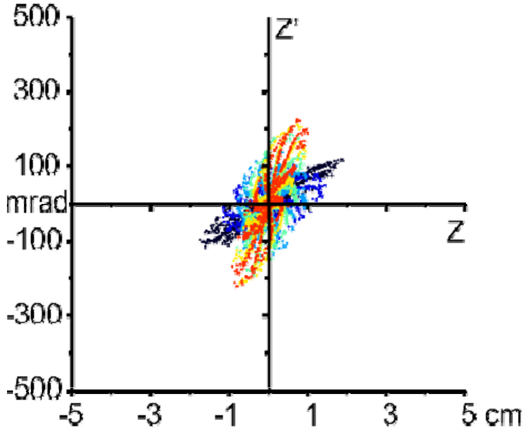
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

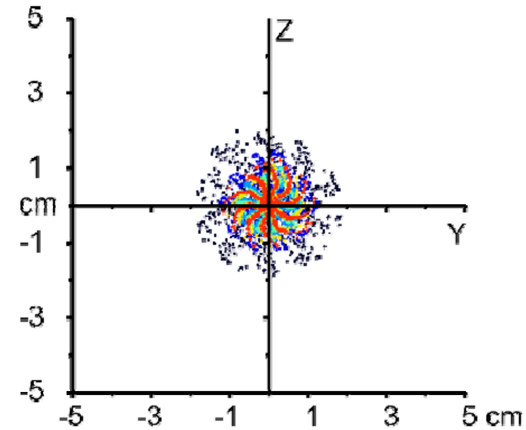


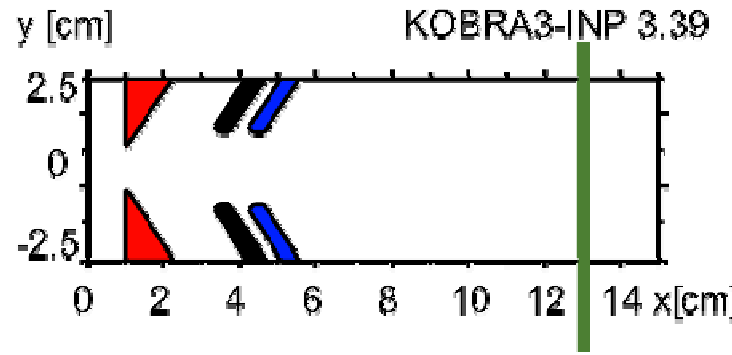
500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

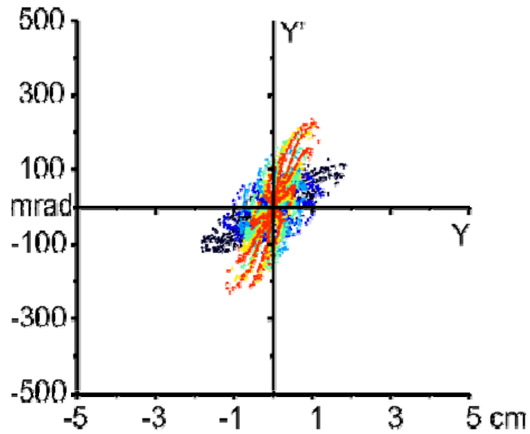


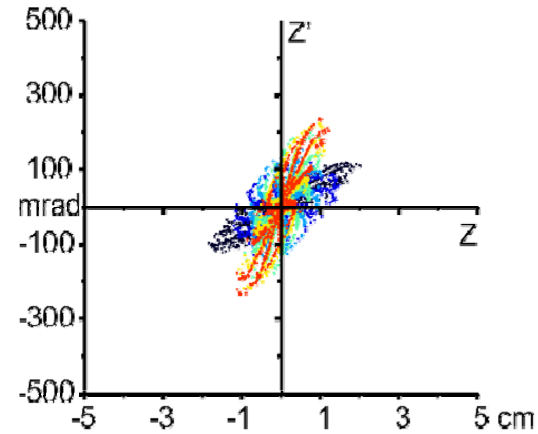
500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

X = 0.13 m

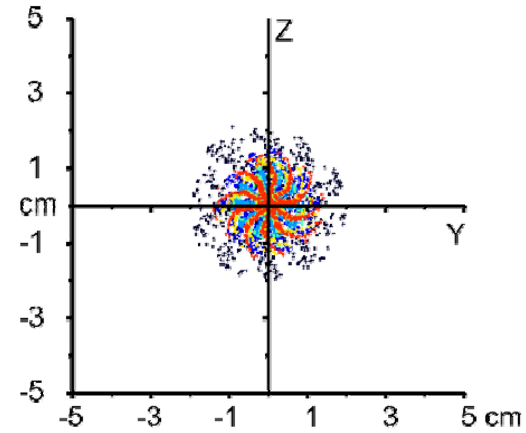

Z
Y
cm
5
3
1
-1
-3
-5
-5
-3
-1
1
3
5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

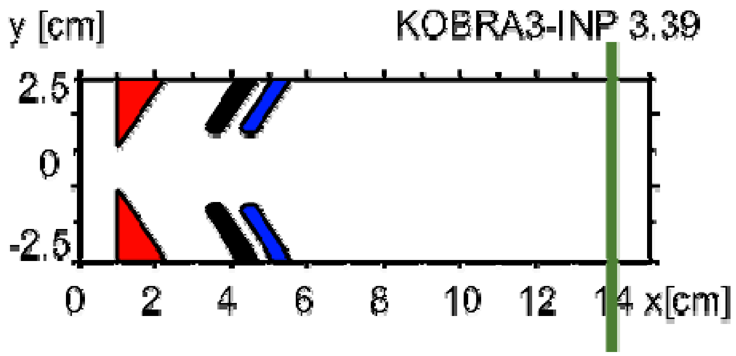

Y'
Y
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm


Z'
Z
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm

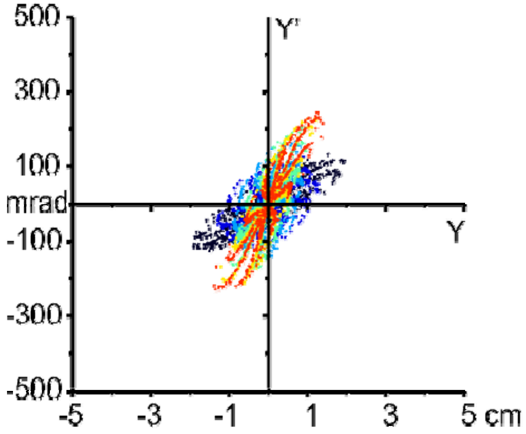
X = 0.14 m



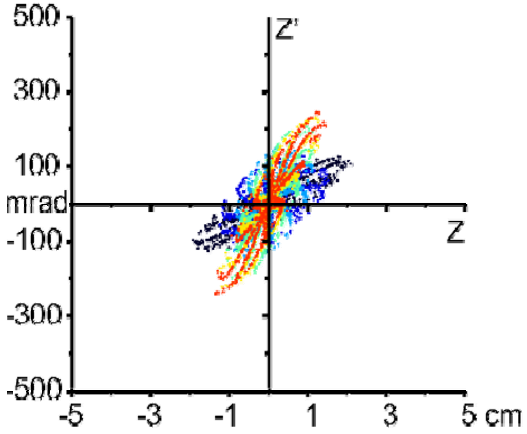
Z
Y
cm
5
3
1
-1
-3
-5
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

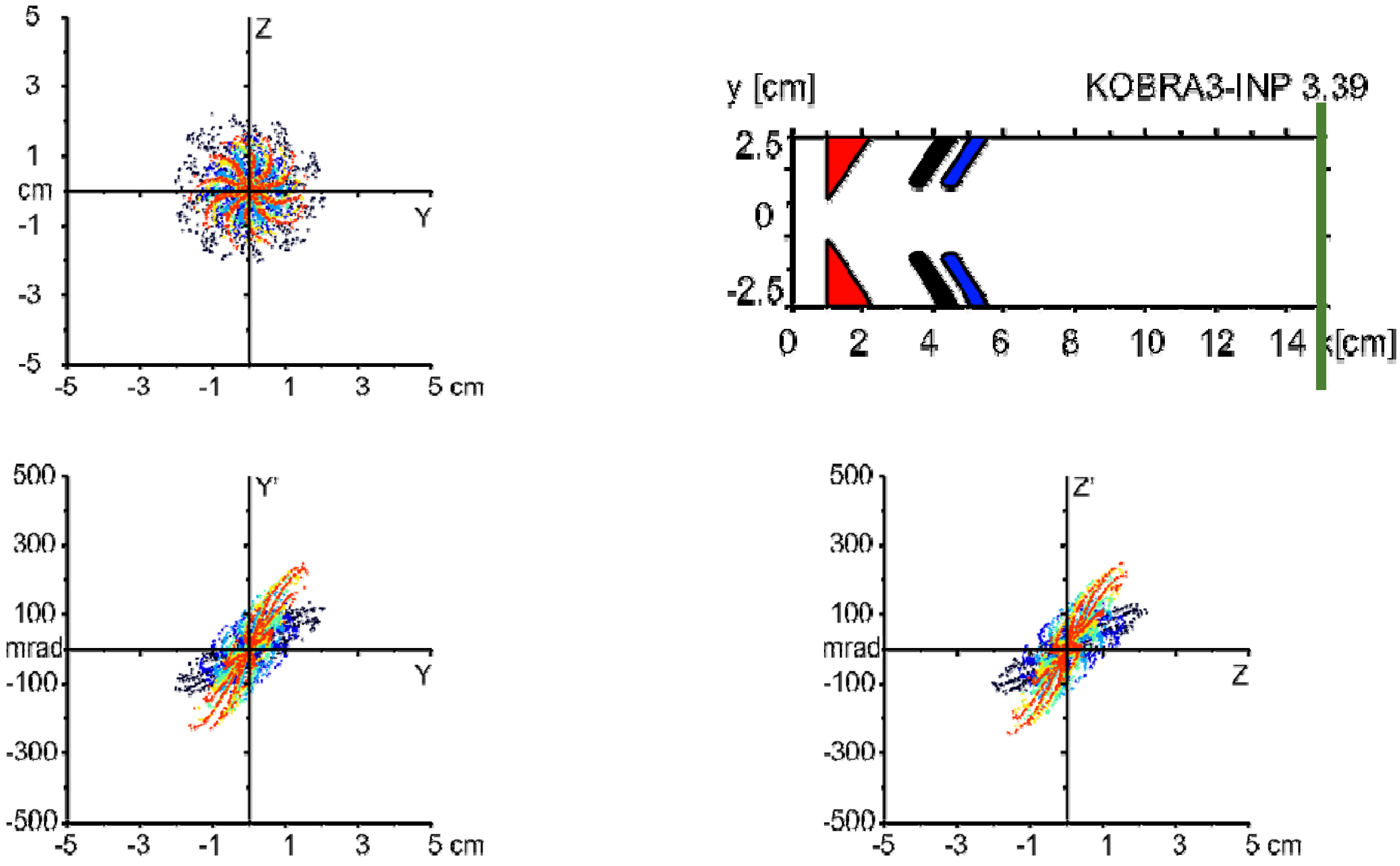


Y'
Y
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm



Z'
Z
mrad
500
300
100
-100
-300
-500
-5
-3
-1
1
3
5 cm

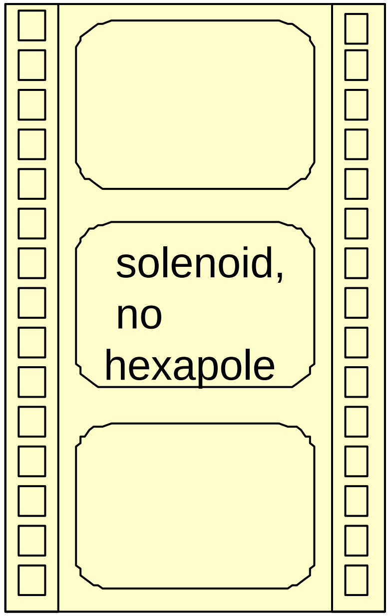
X = 0.15 m



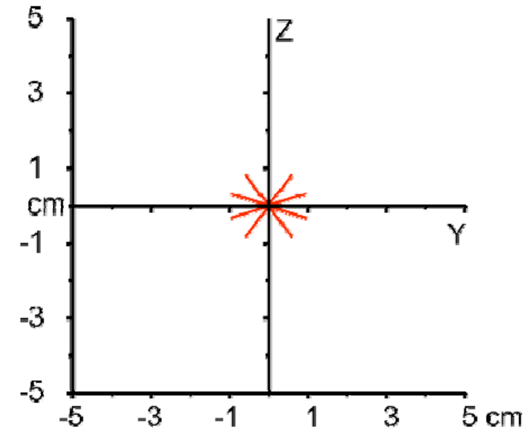
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm
y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14
x[cm]
500
300
100
mrad
-100
-300
-500
Y'
Y
Z'
Z

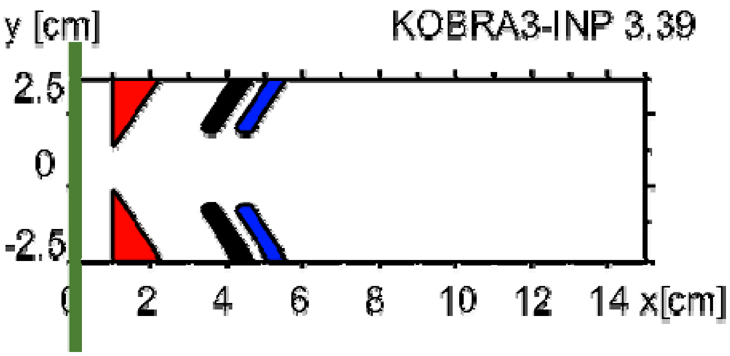
assumption

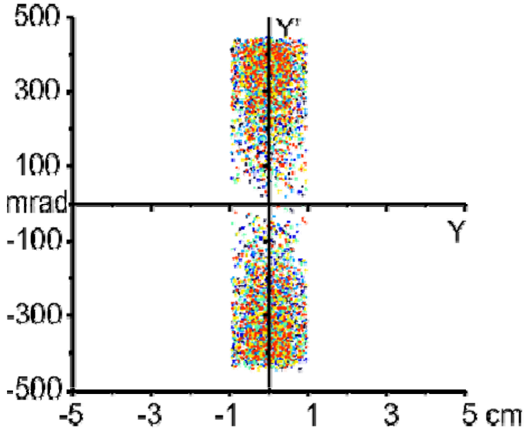
- Magnetic Flux density $B = 4*B_0$
- Plasma model: Self Ti=1eV, Te=5eV
- No Hexapole
- Current 5 mA

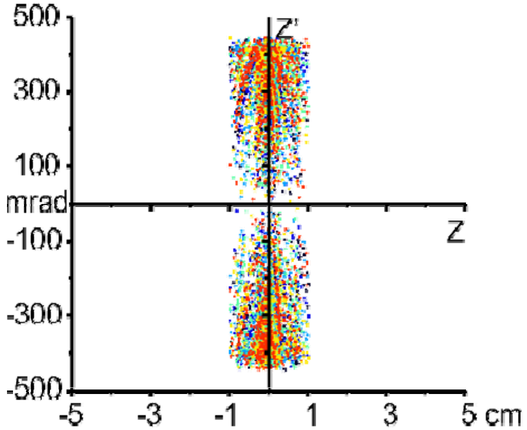


X = 0.00 m

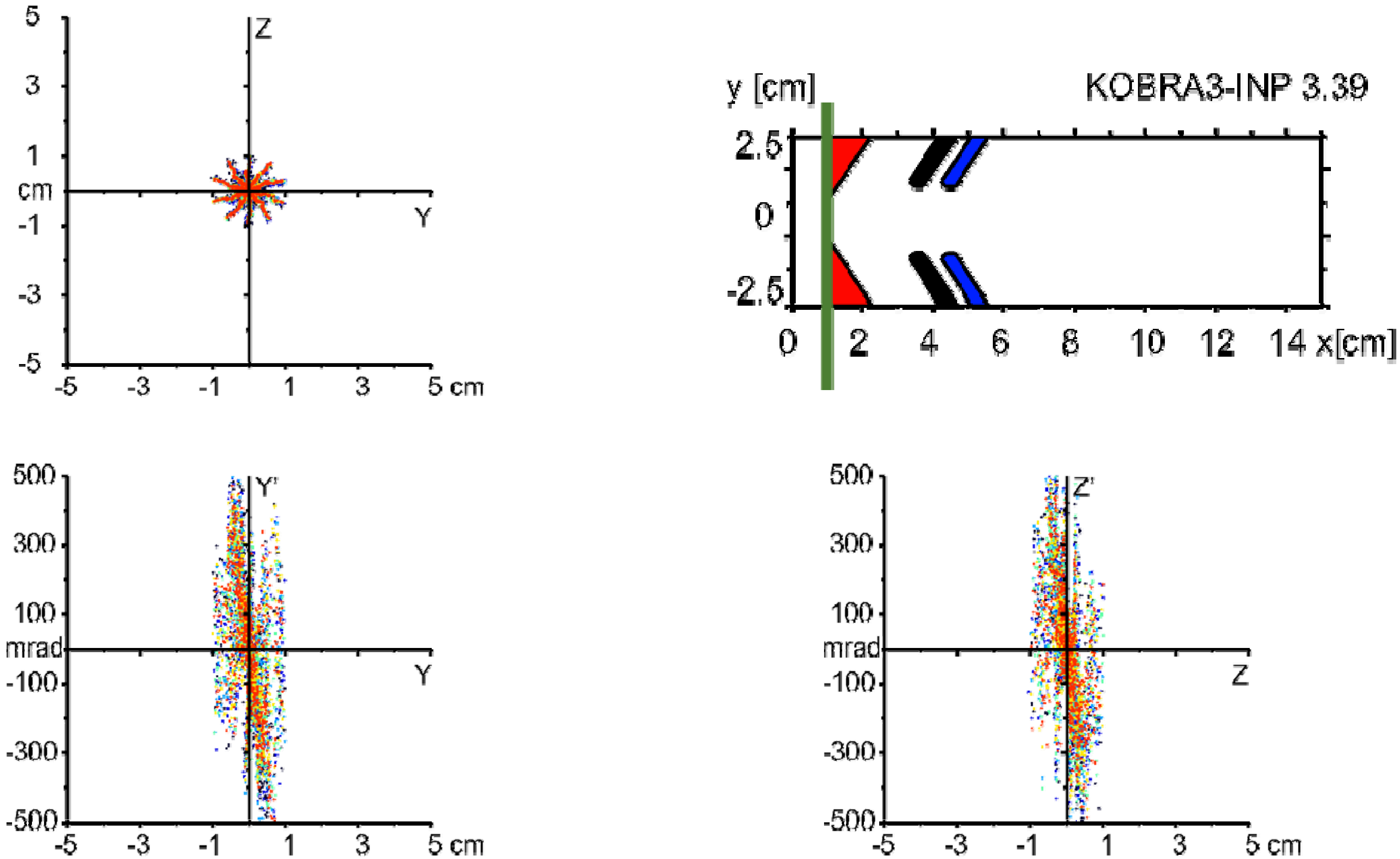




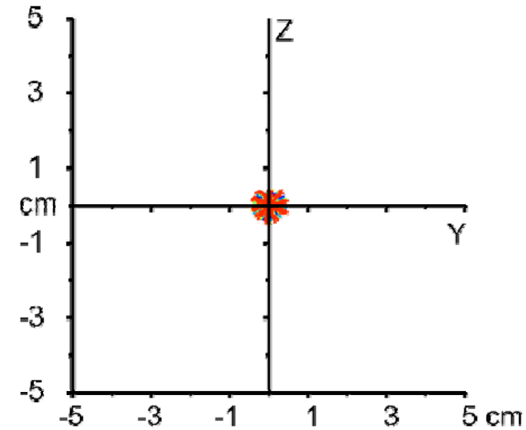




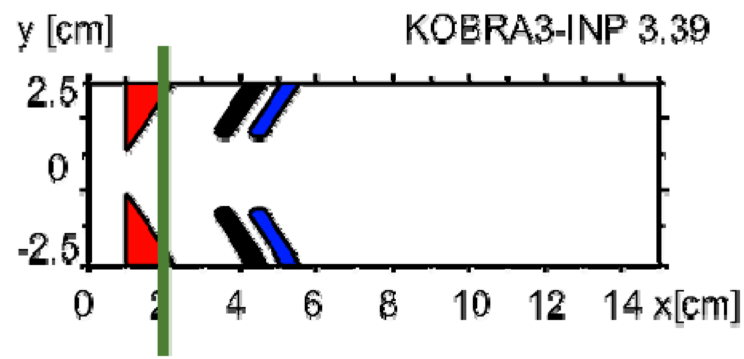
X = 0.01 m



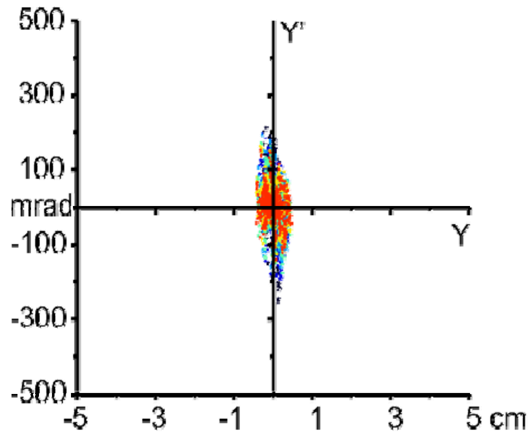
X = 0.02 m



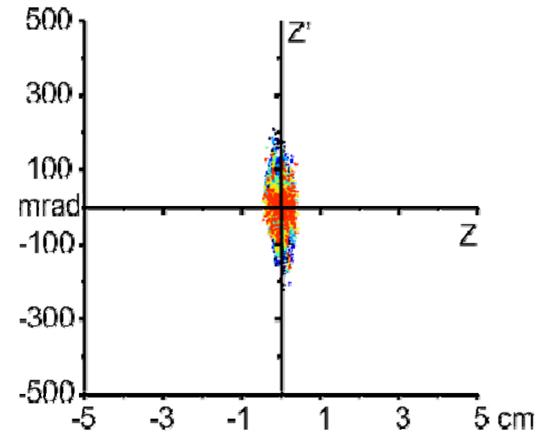
Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

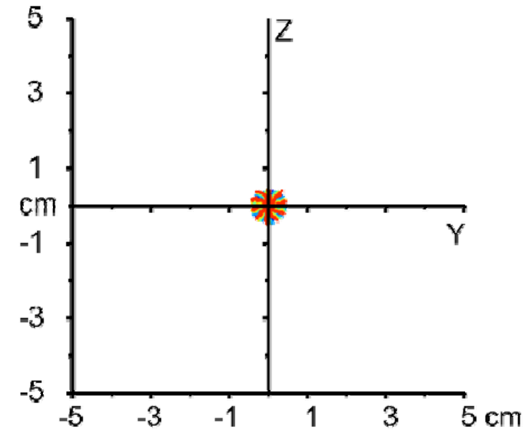


Y'
Y
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

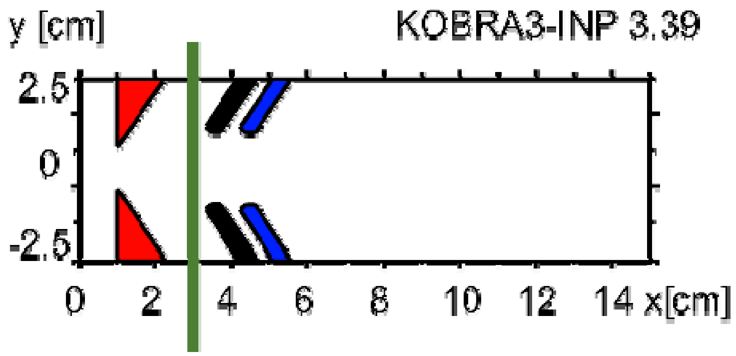


Z'
Z
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

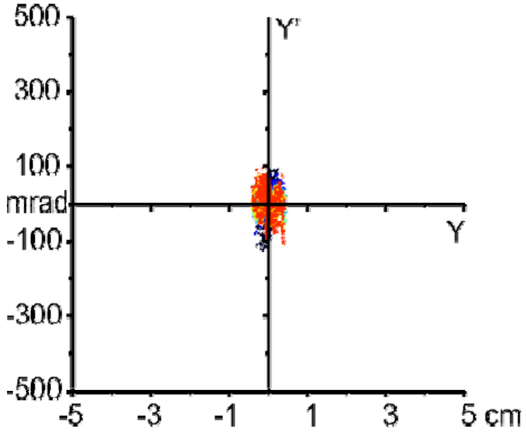
X = 0.03 m



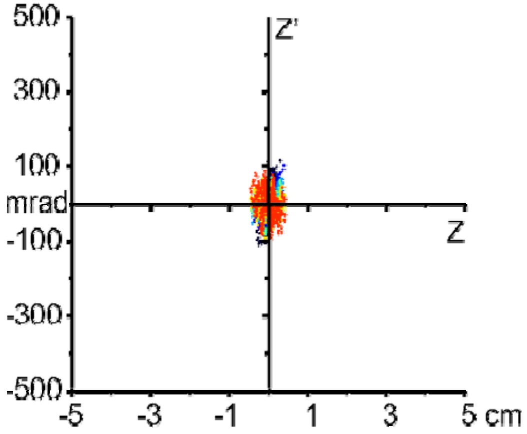
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

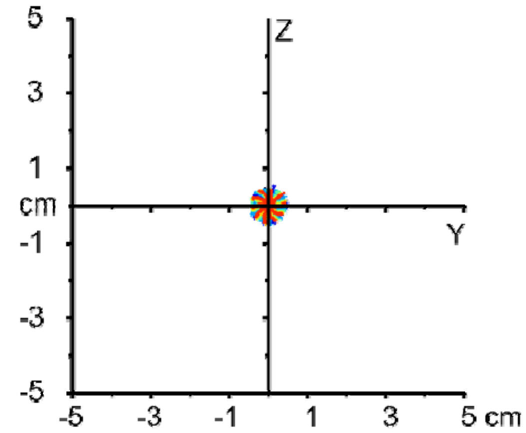


500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

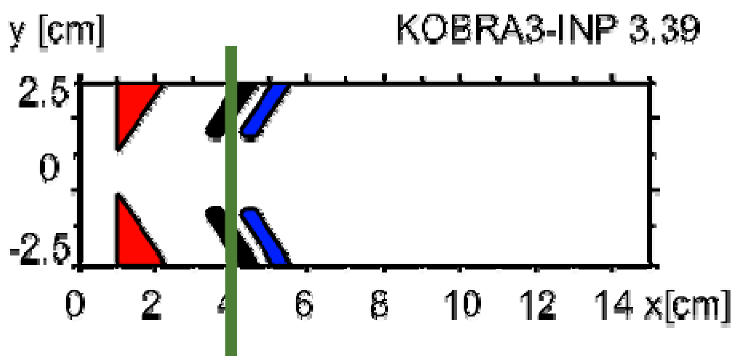


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

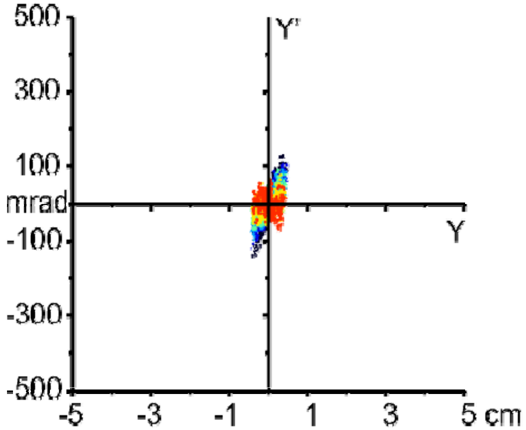
X = 0.04 m



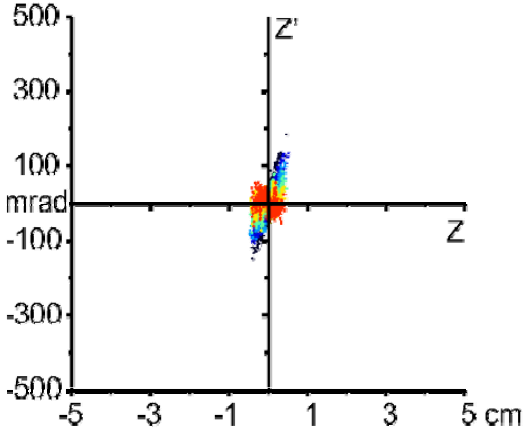
Z
Y
cm
5
3
1
-1
-3
-5
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
6
8
10
12
14 x[cm]

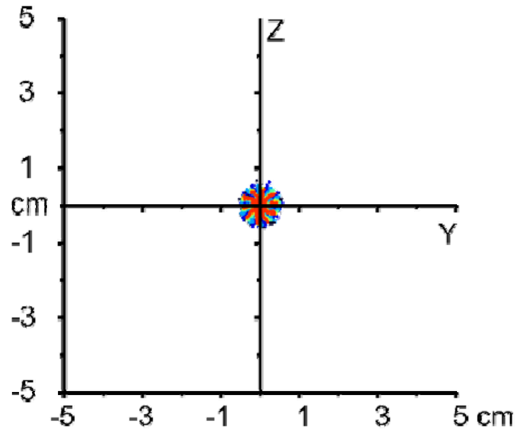


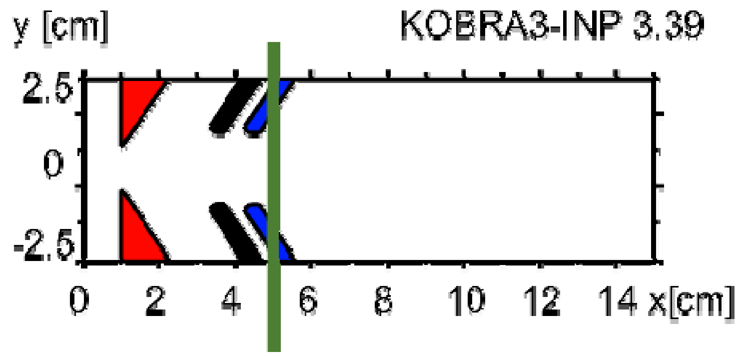
Y'
Y
500
300
100
mrad
-100
-300
-500
-5
-3
-1
1
3
5 cm

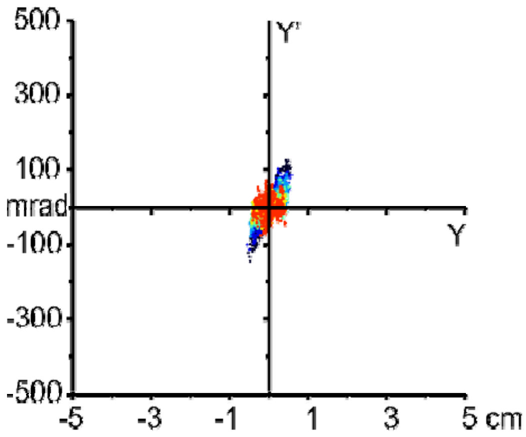


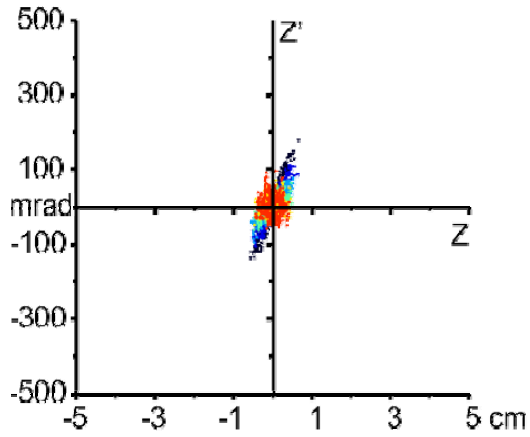
Z'
Z
500
300
100
mrad
-100
-300
-500
-5
-3
-1
1
3
5 cm

X = 0.05 m

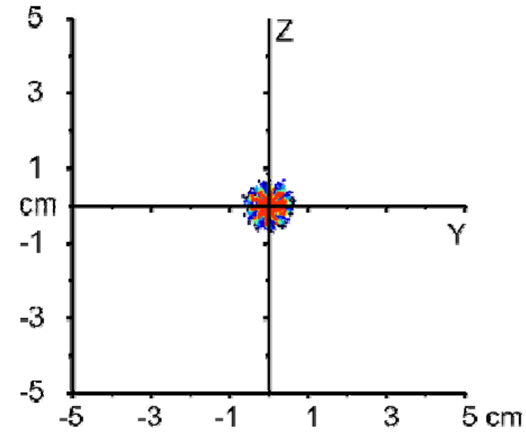

5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

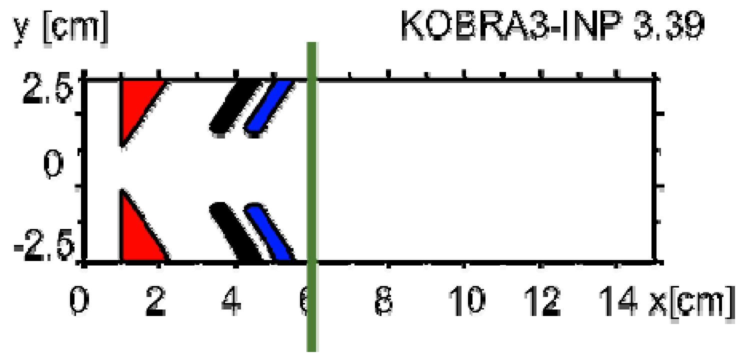

500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm


500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

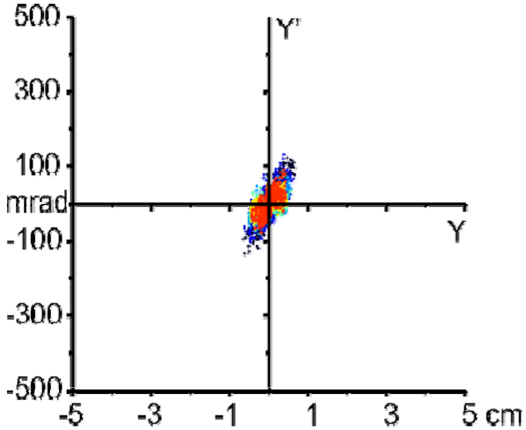
X = 0.06 m



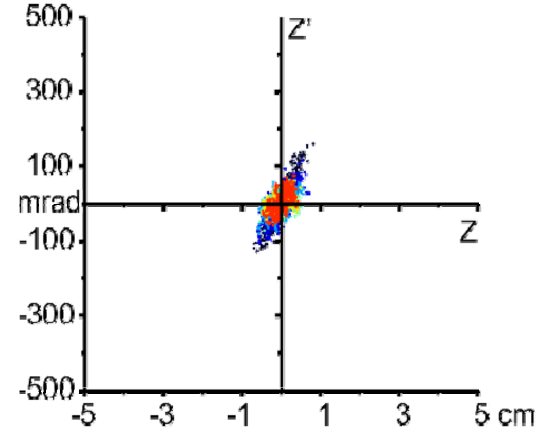
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

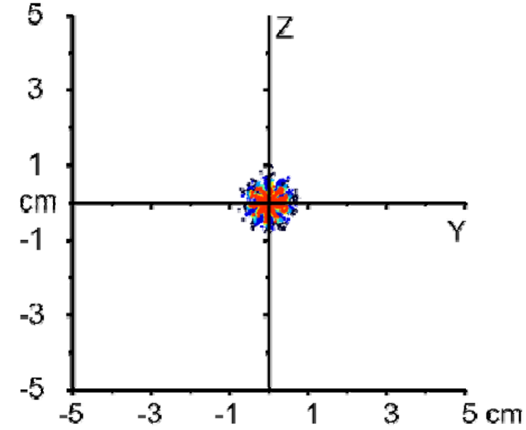


500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm

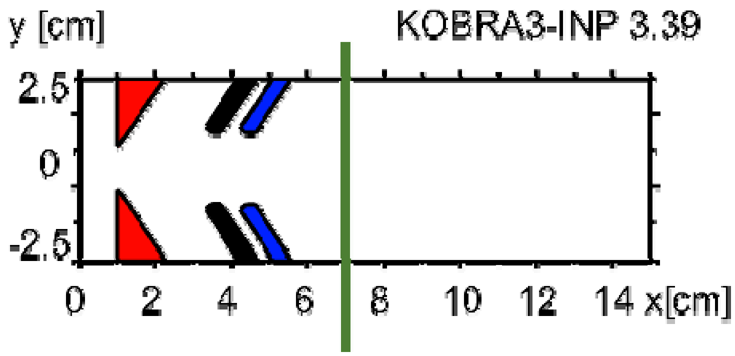


500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

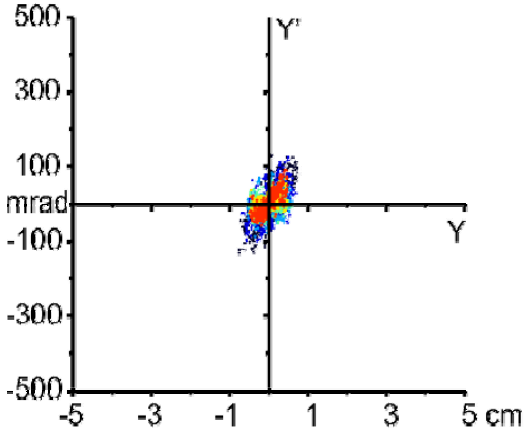
X = 0.07 m



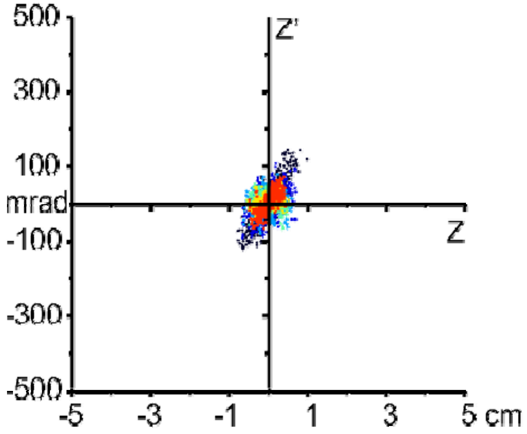
Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

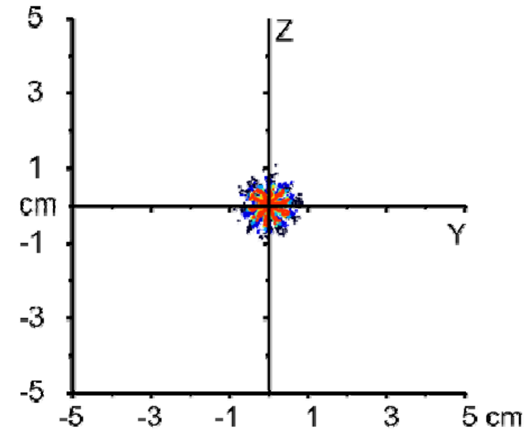


Y'
Y
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

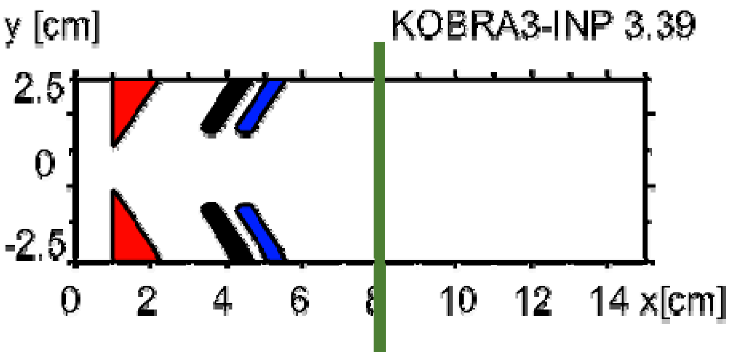


Z'
Z
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

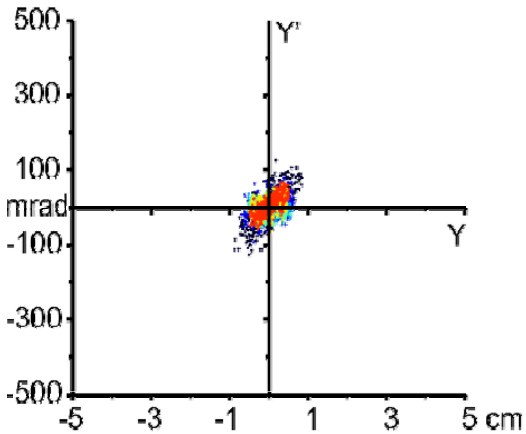
X = 0.08 m



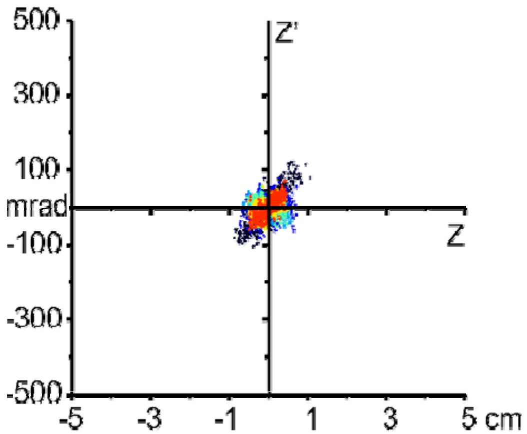
Z
Y
cm
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

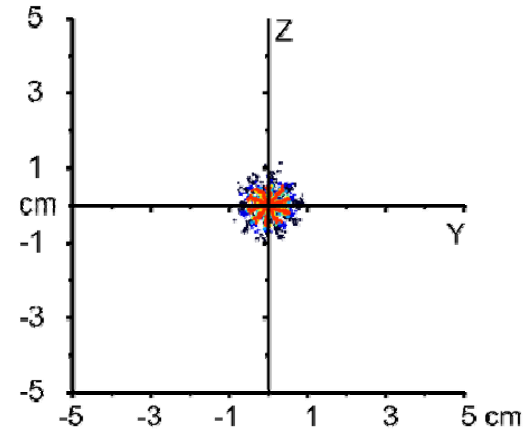


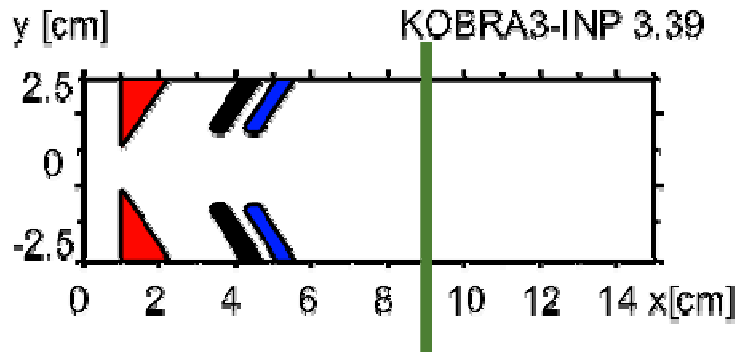
Y'
Y
mrad
5 cm

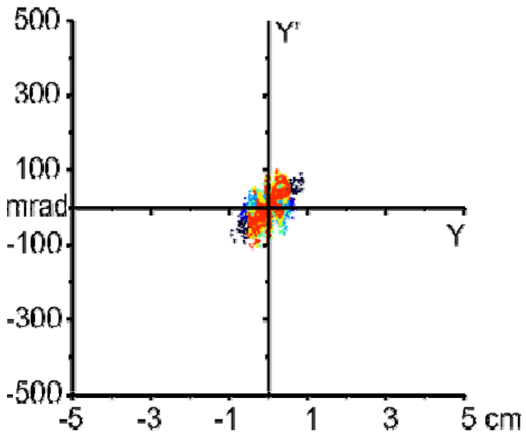


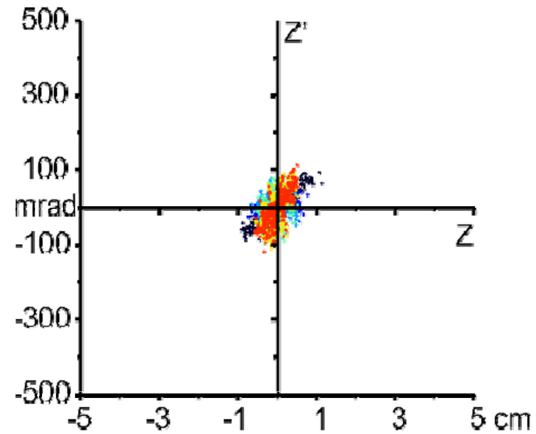
Z'
Z
mrad
5 cm

X = 0.09 m

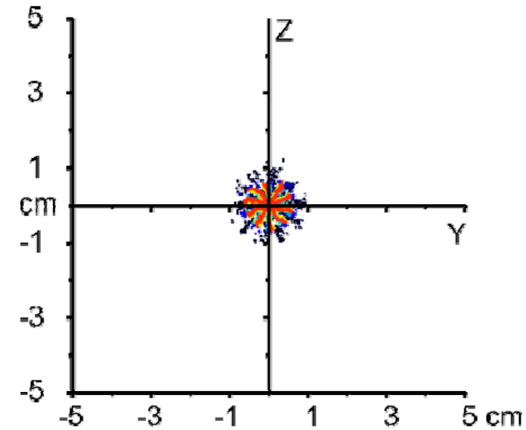

5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm

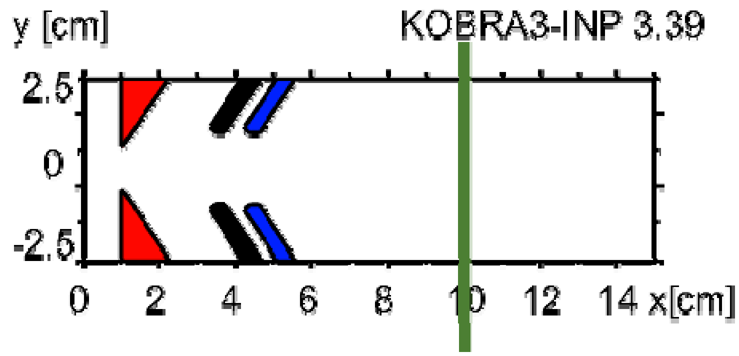

y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

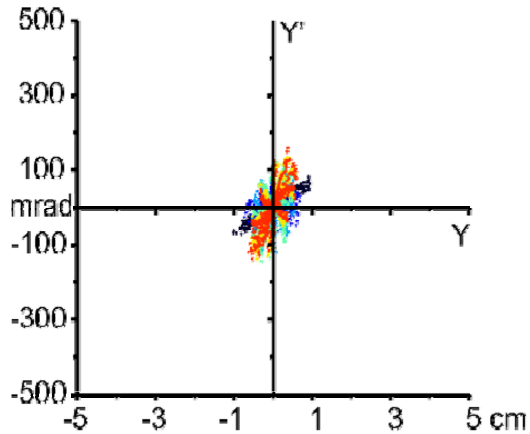

500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

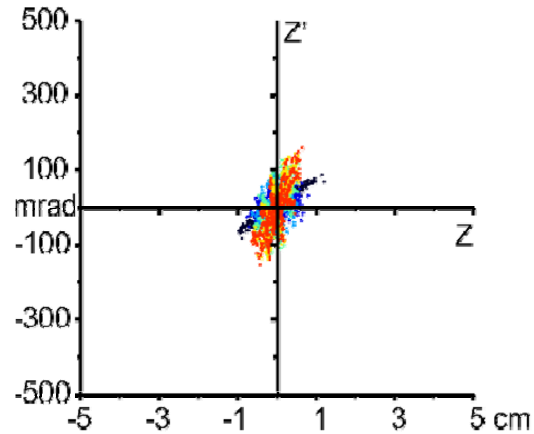

500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

X = 0.10 m

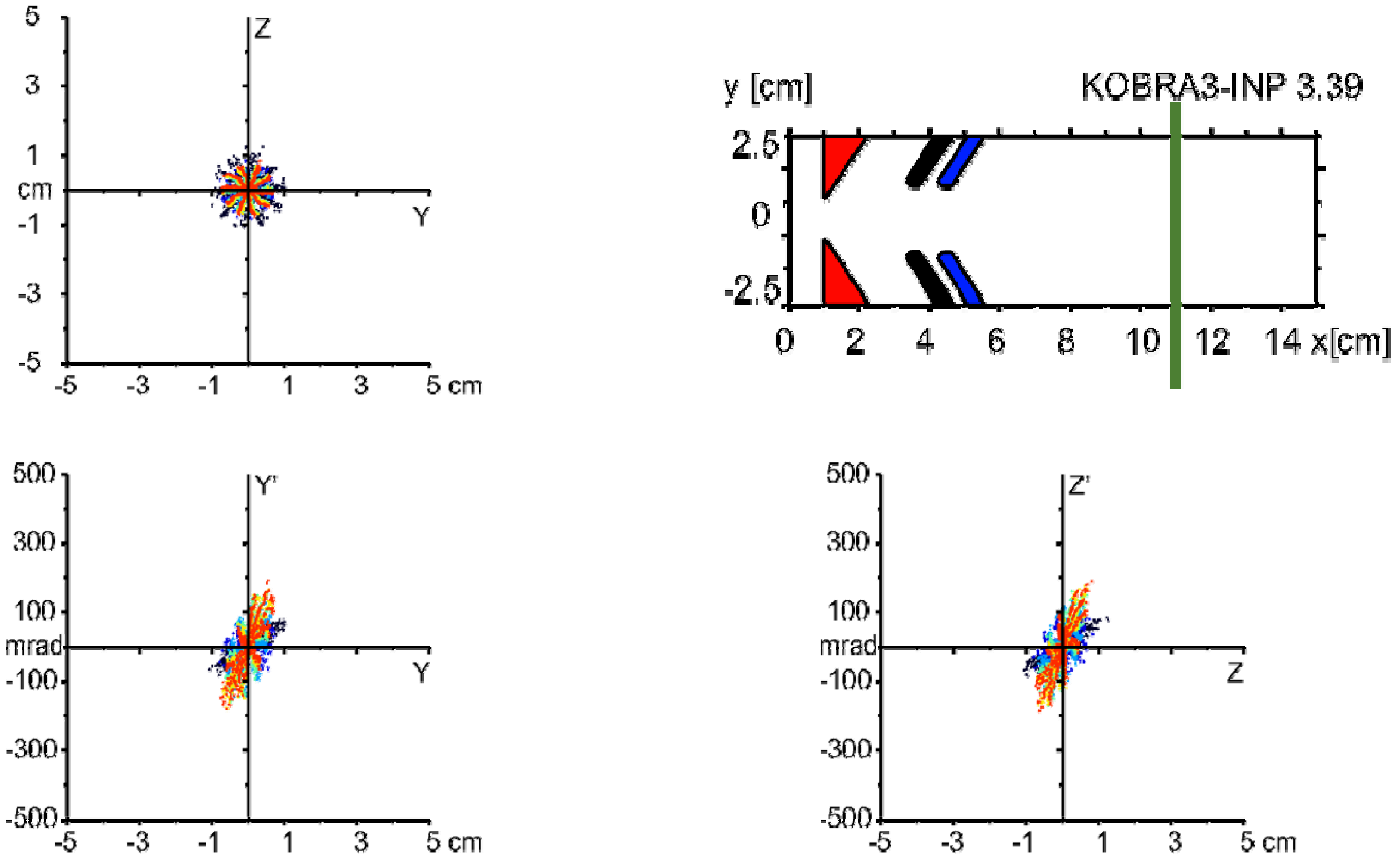






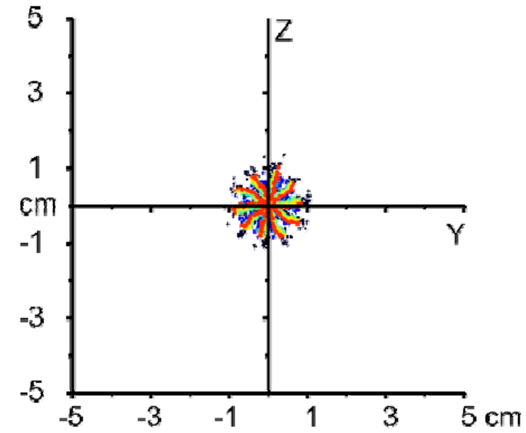


X = 0.11 m

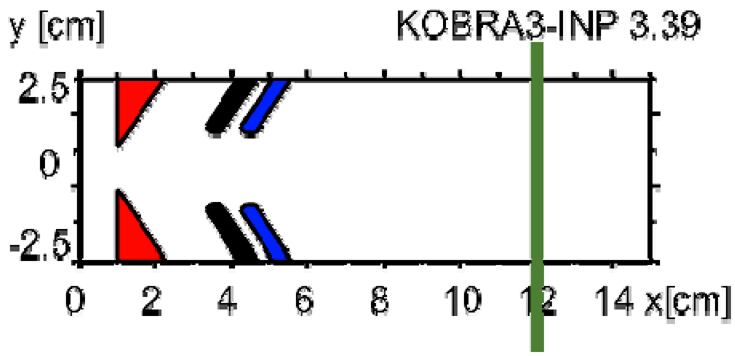


y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]
Z
Y
Y'
Z'
cm
mrad
5
3
1
-1
-3
-5
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

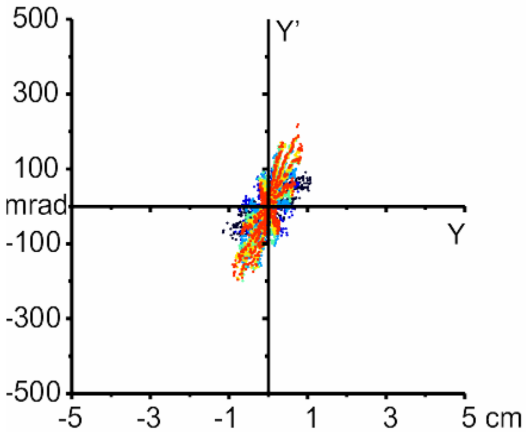
X = 0.12 m



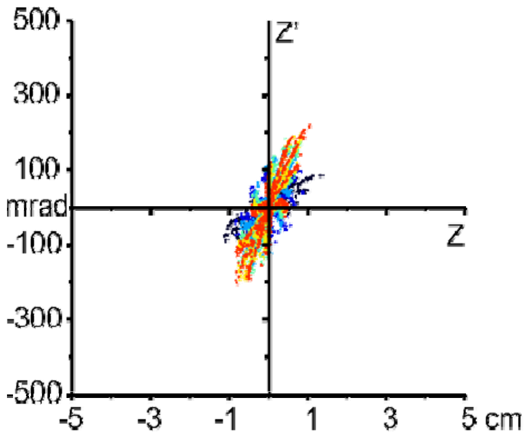
5
3
1
cm
-1
-3
-5
Z
Y
-5
-3
-1
1
3
5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0
2
4
6
8
10
12
14 x[cm]

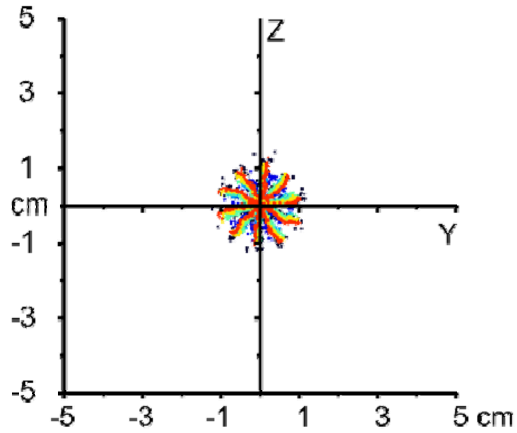


500
300
100
mrad
-100
-300
-500
Y'
Y
-5
-3
-1
1
3
5 cm

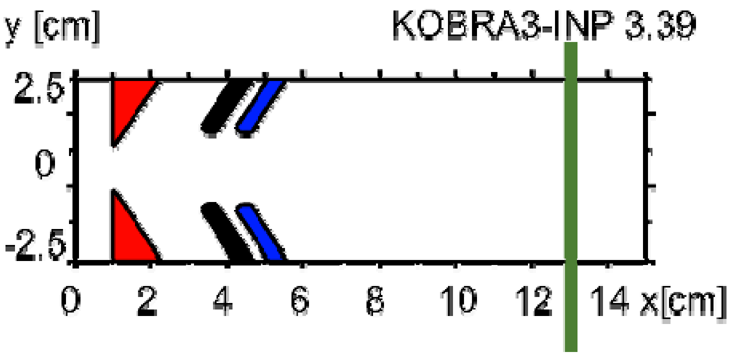


500
300
100
mrad
-100
-300
-500
Z'
Z
-5
-3
-1
1
3
5 cm

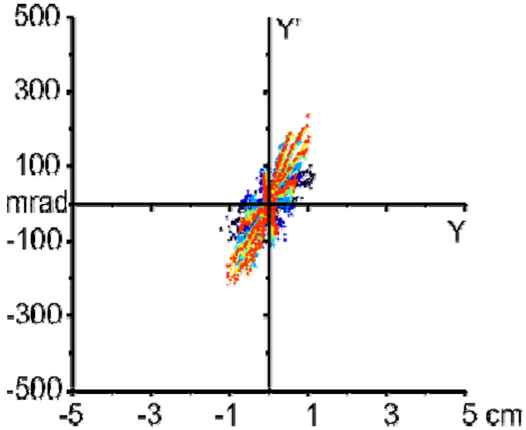
X = 0.13 m



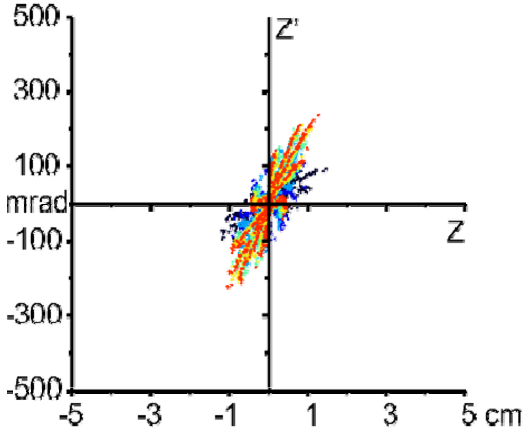
Z
Y
cm
5
3
1
-1
-3
-5
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]

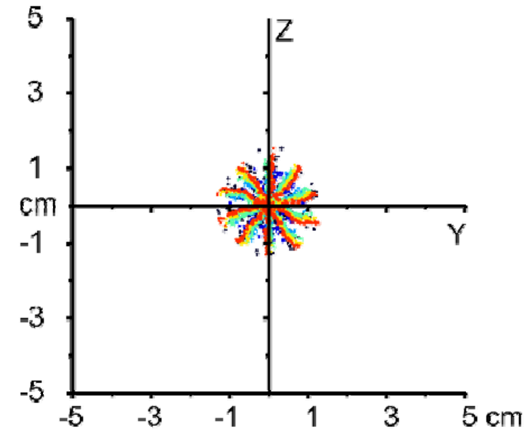


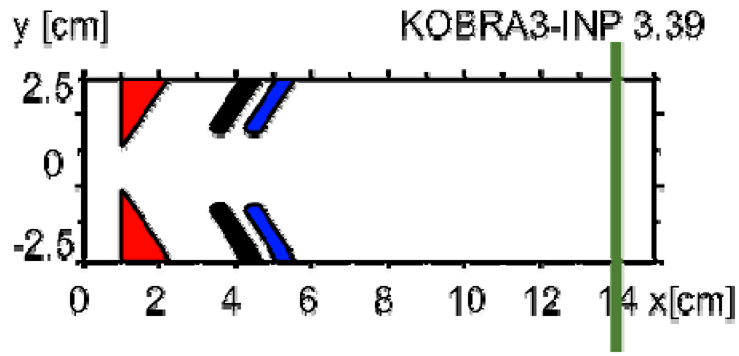
Y'
Y
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

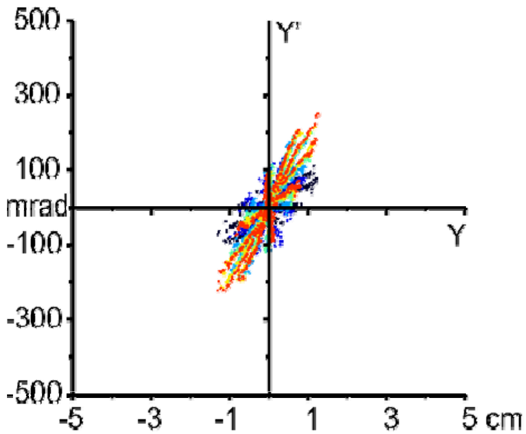


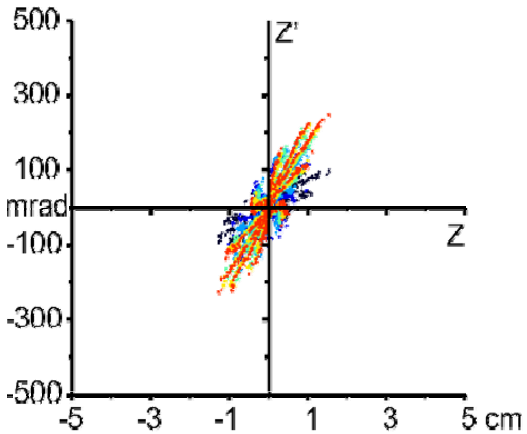
Z'
Z
mrad
500
300
100
-100
-300
-500
-5 -3 -1 1 3 5 cm

X = 0.14 m

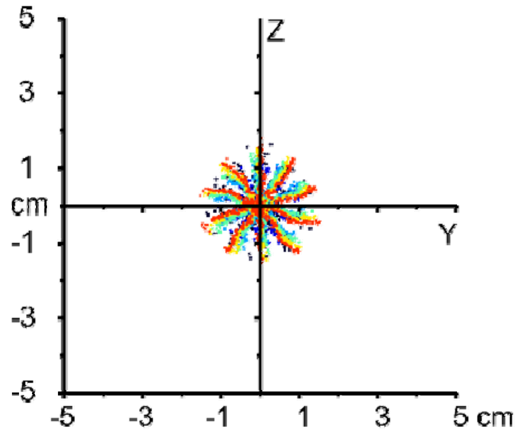




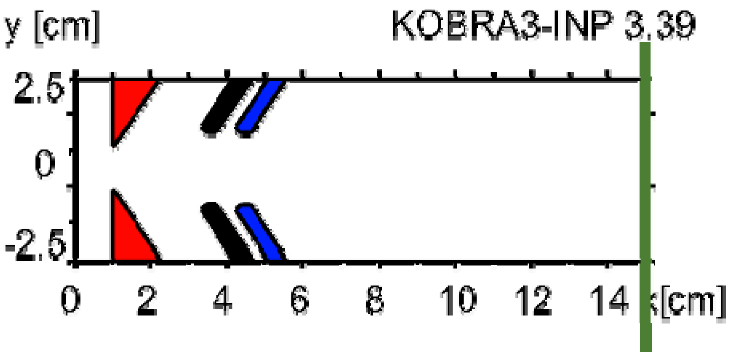




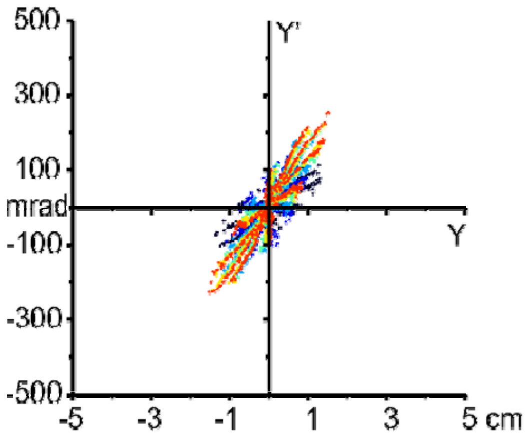
X = 0.15 m



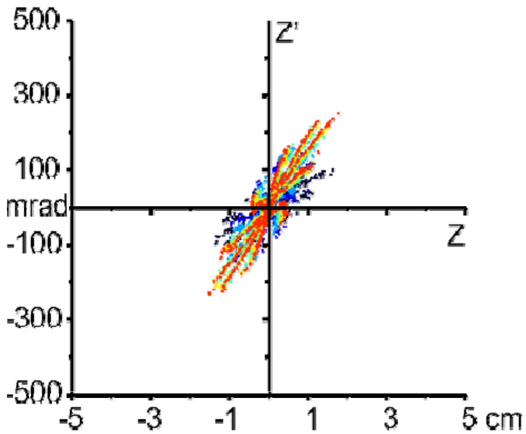
5
3
1
cm
-1
-3
-5
Z
Y
-5 -3 -1 1 3 5 cm



y [cm]
KOBRA3-INP 3.39
2.5
0
-2.5
0 2 4 6 8 10 12 14 x[cm]



500
300
100
mrad
-100
-300
-500
Y'
Y
-5 -3 -1 1 3 5 cm



500
300
100
mrad
-100
-300
-500
Z'
Z
-5 -3 -1 1 3 5 cm

Conclusion

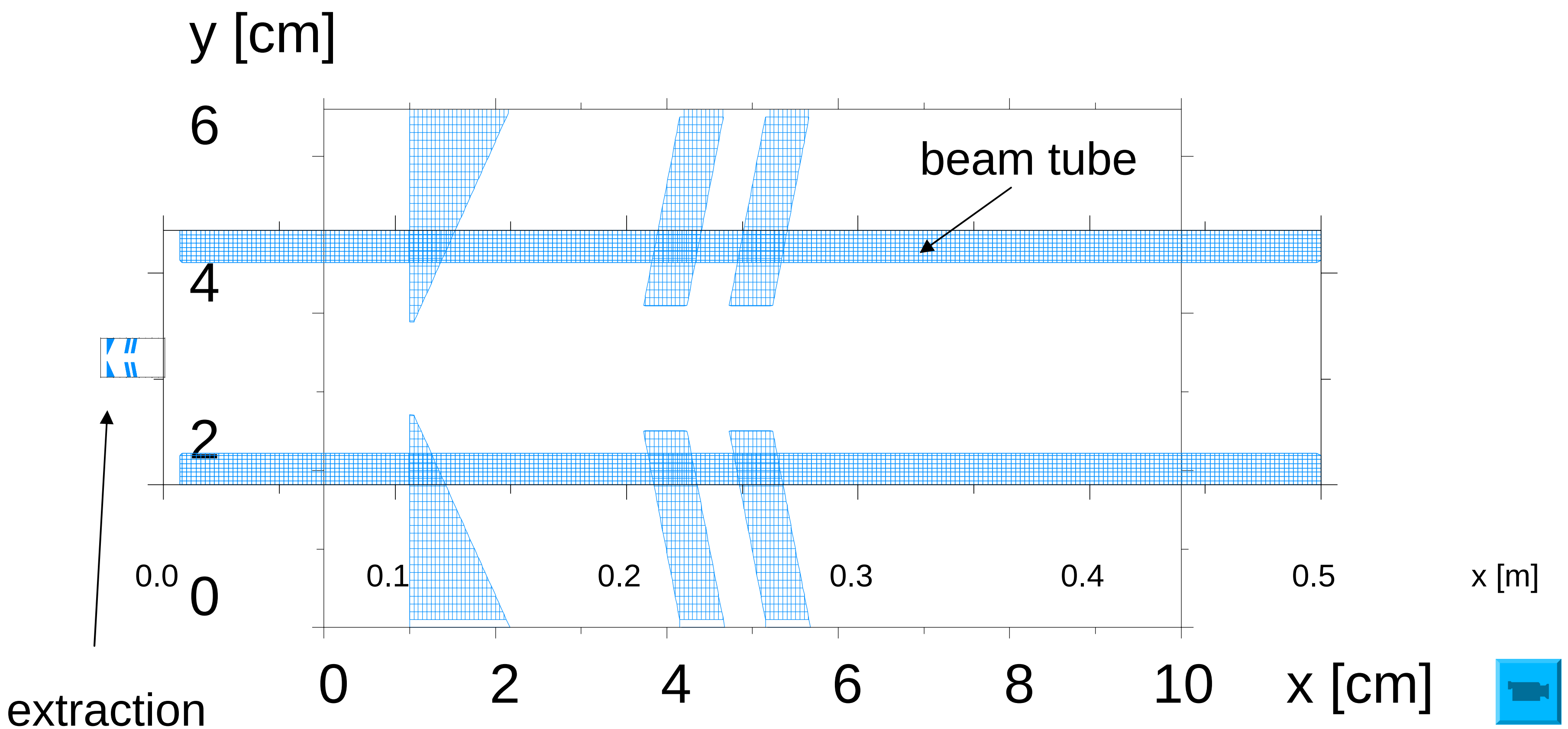
- The solenoidal component of the magnetic field will influence the extracted ion beam.
- The influence can even be helpful to focus the beam.

general rules for the extraction from an ECRIS

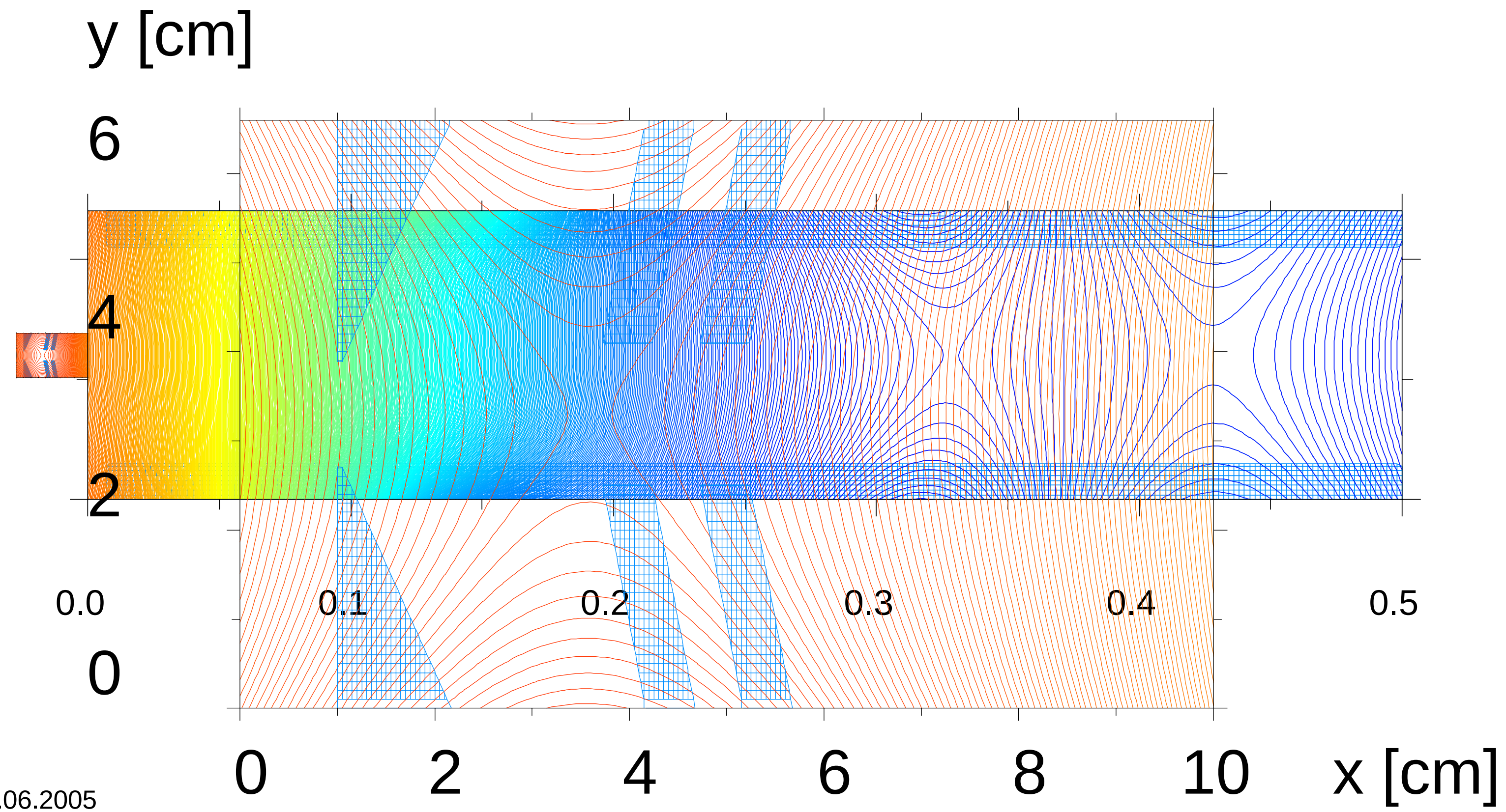
- minimize the force created by radial electric field and longitudinal magnetic field. -> Pierce geometry
- minimize the force created by azimuthal electric field and longitudinal magnetic field. -> homogeneous plasma density
- to stay in the perveance matched optimum, extraction voltage and plasma density has to be changed accordingly.
- use of an accel-decel extraction system is required to preserve space charge compensation.

Switching on/off the negative screening electrode changes the light because of the action of electrons extracted from the beam

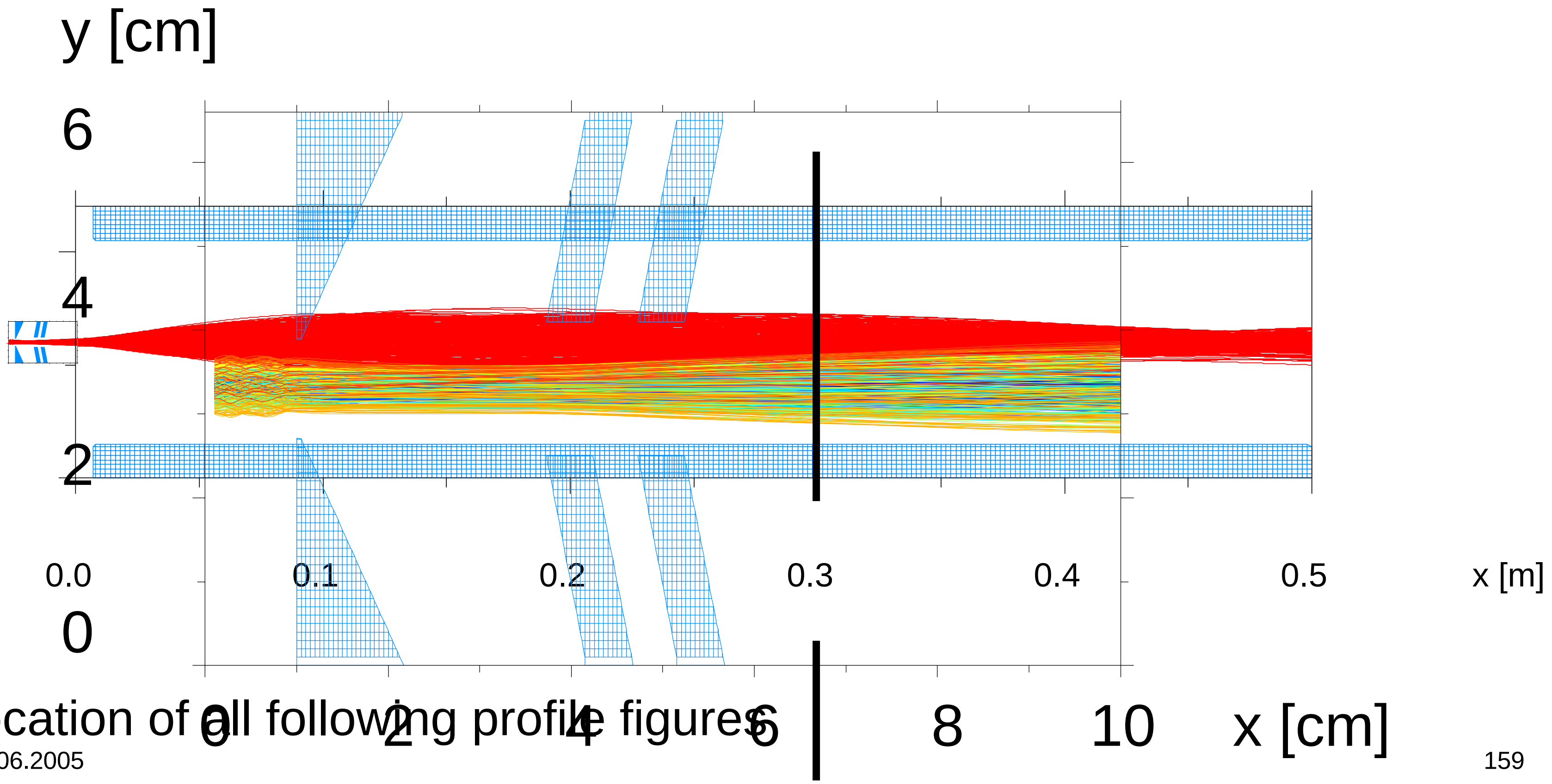
Accel-decel extraction system for the GyroSERSE



lines of constant longitudinal component of the magnet flux density



beam envelope for charge state $^{18}O^{1+}$



location of all following profile figures the beam profile is an assembly of the different profiles for different charge states.

EXAMPLE

working gas:

oxygen isotope 18, charge states 1+ ... 6+

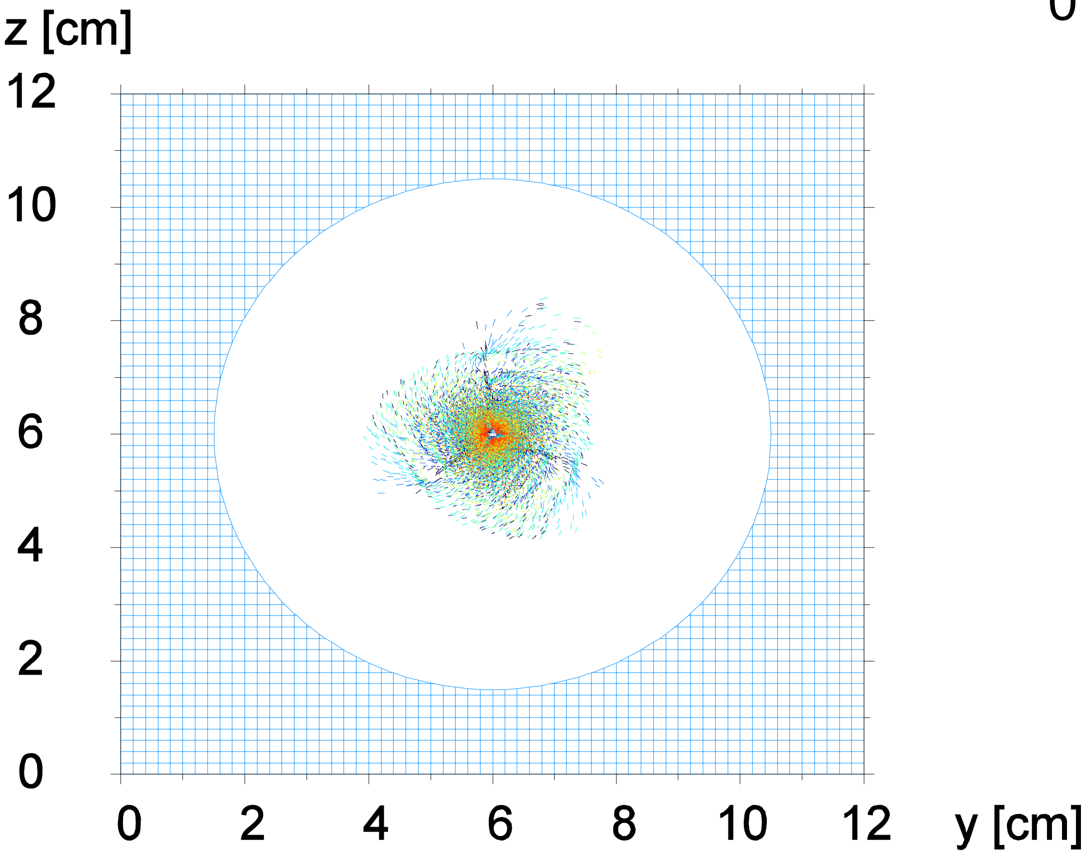
required ion

xenon isotope 129, charge states 9+ ... 24+

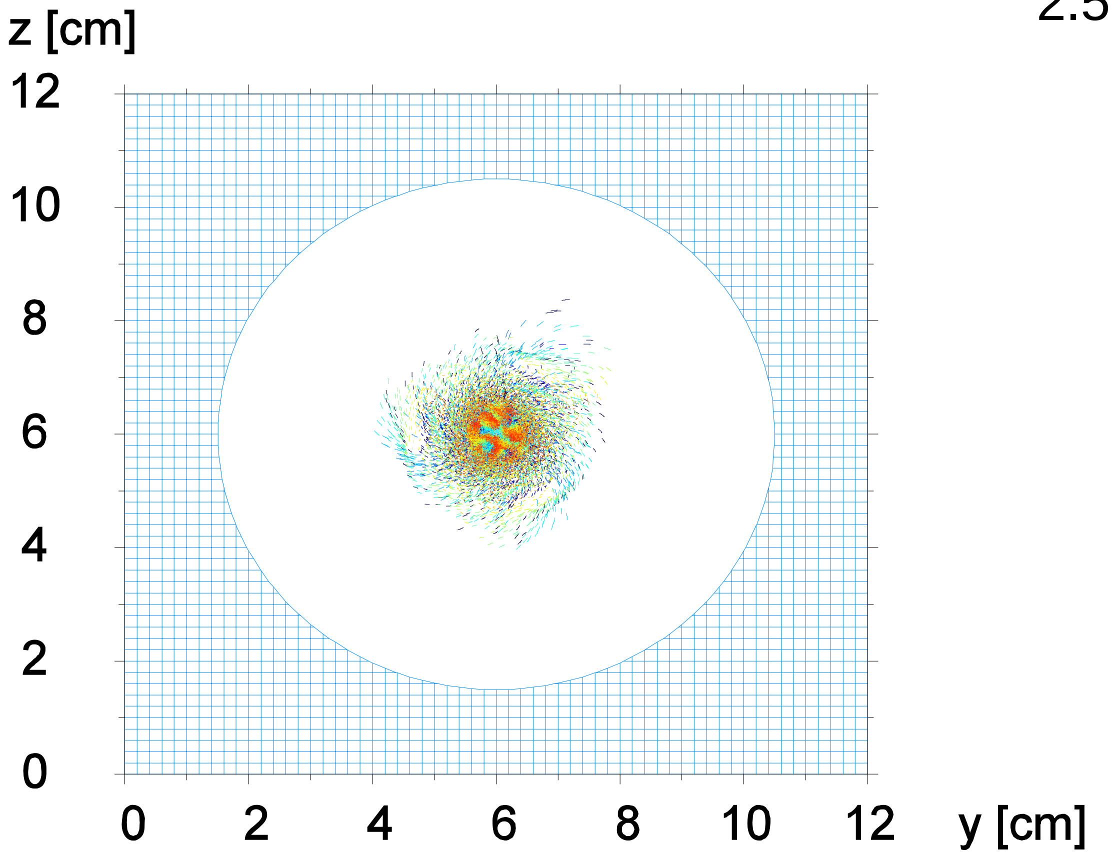
Profile of all charge states after 0.3 m of the beam line for different total currents

0 mA current
2.5 mA current
16 mA current

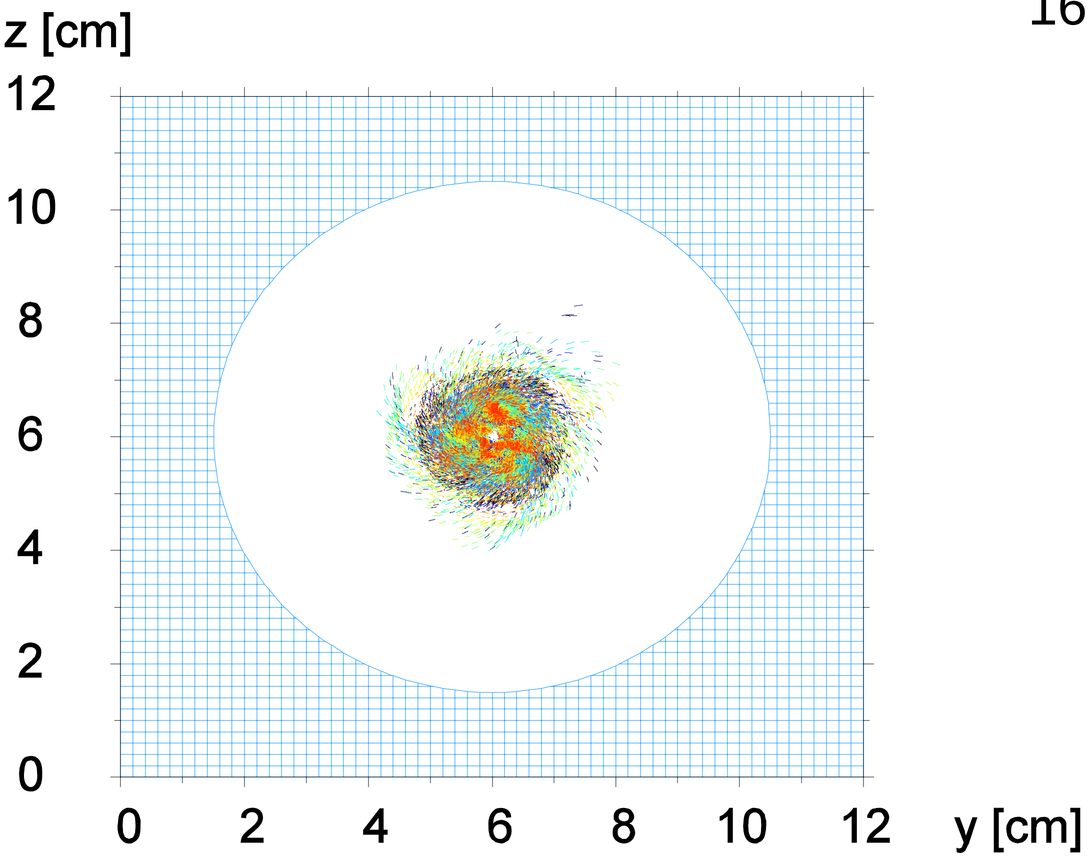
0 mA



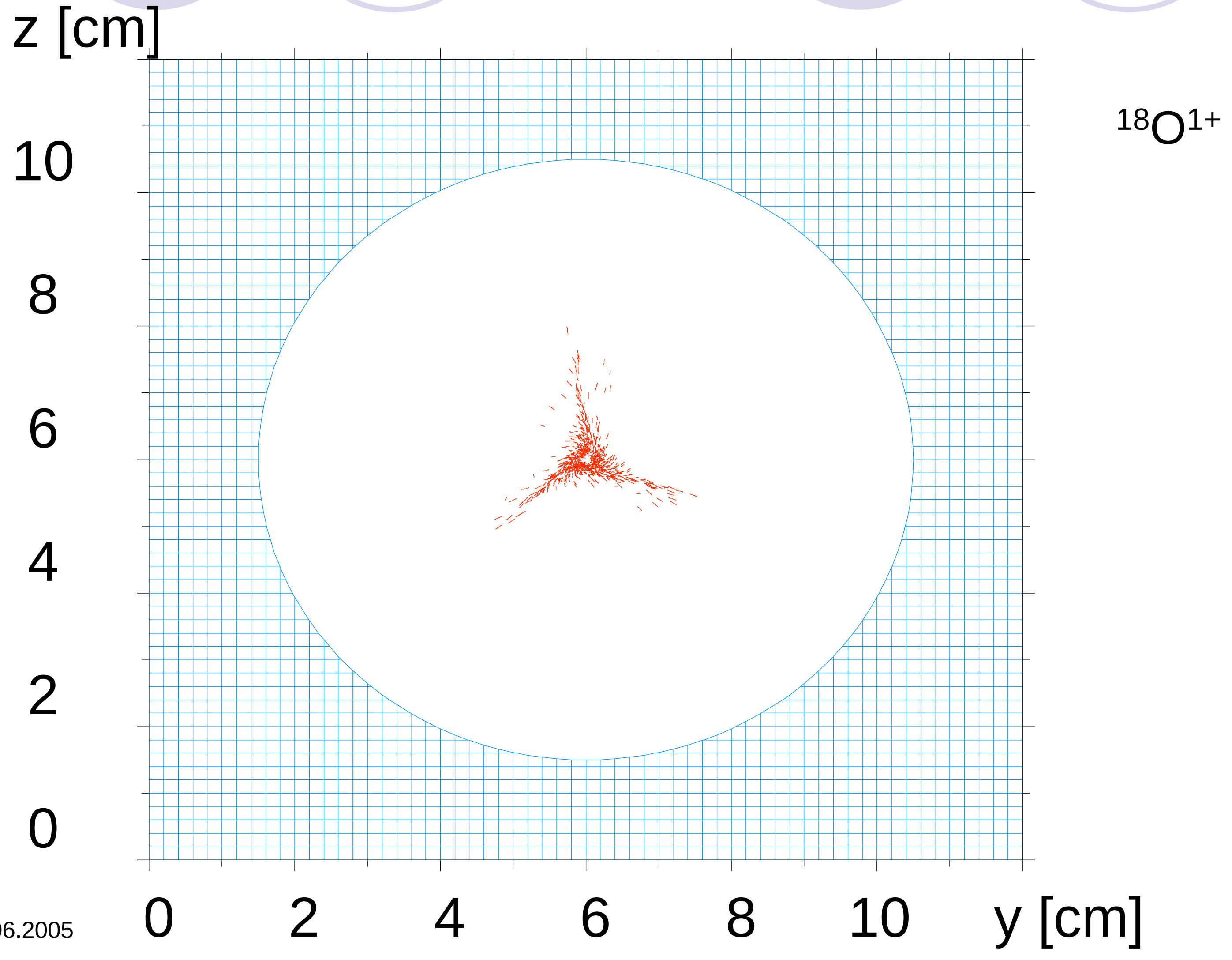
2.5 mA



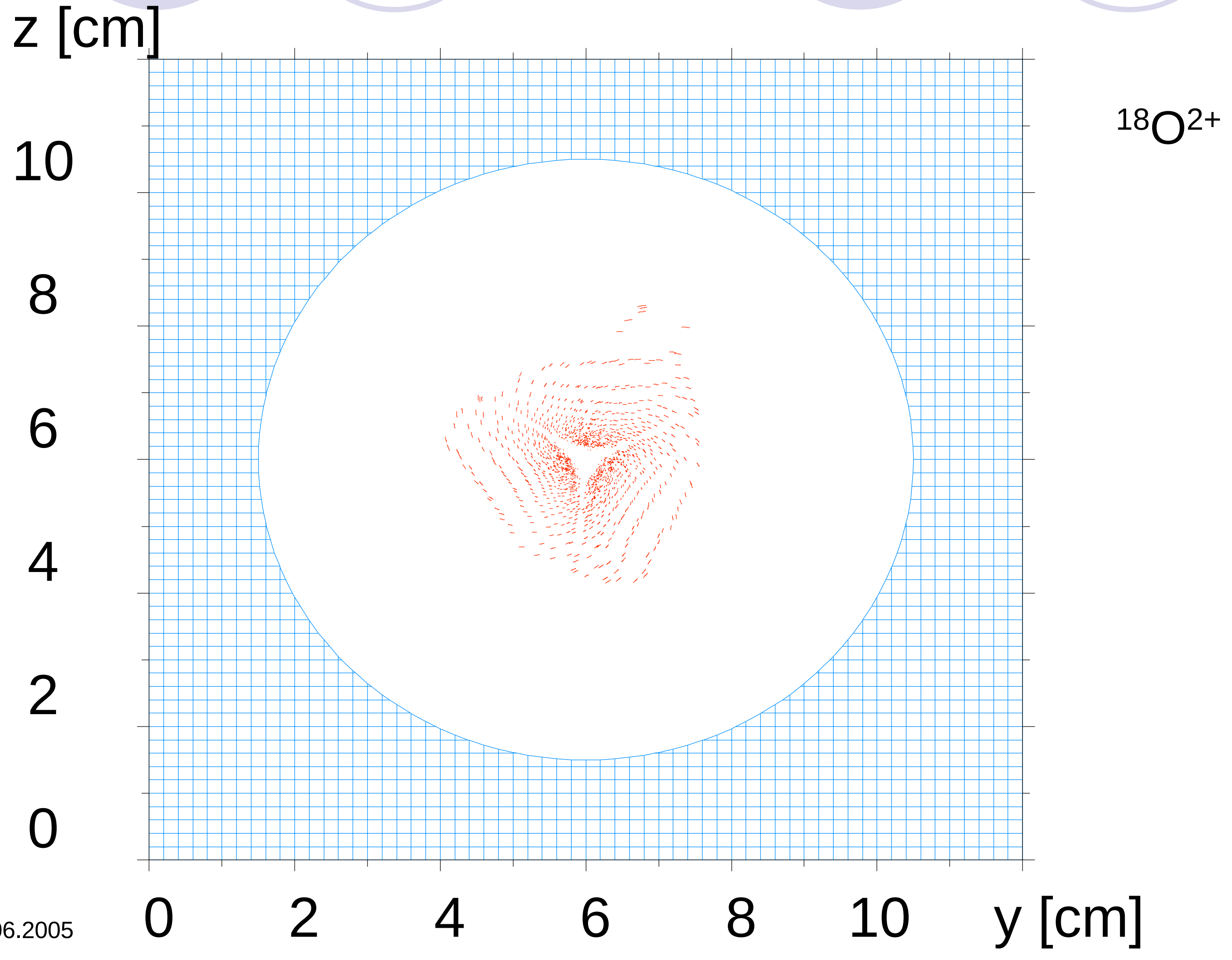
16 mA

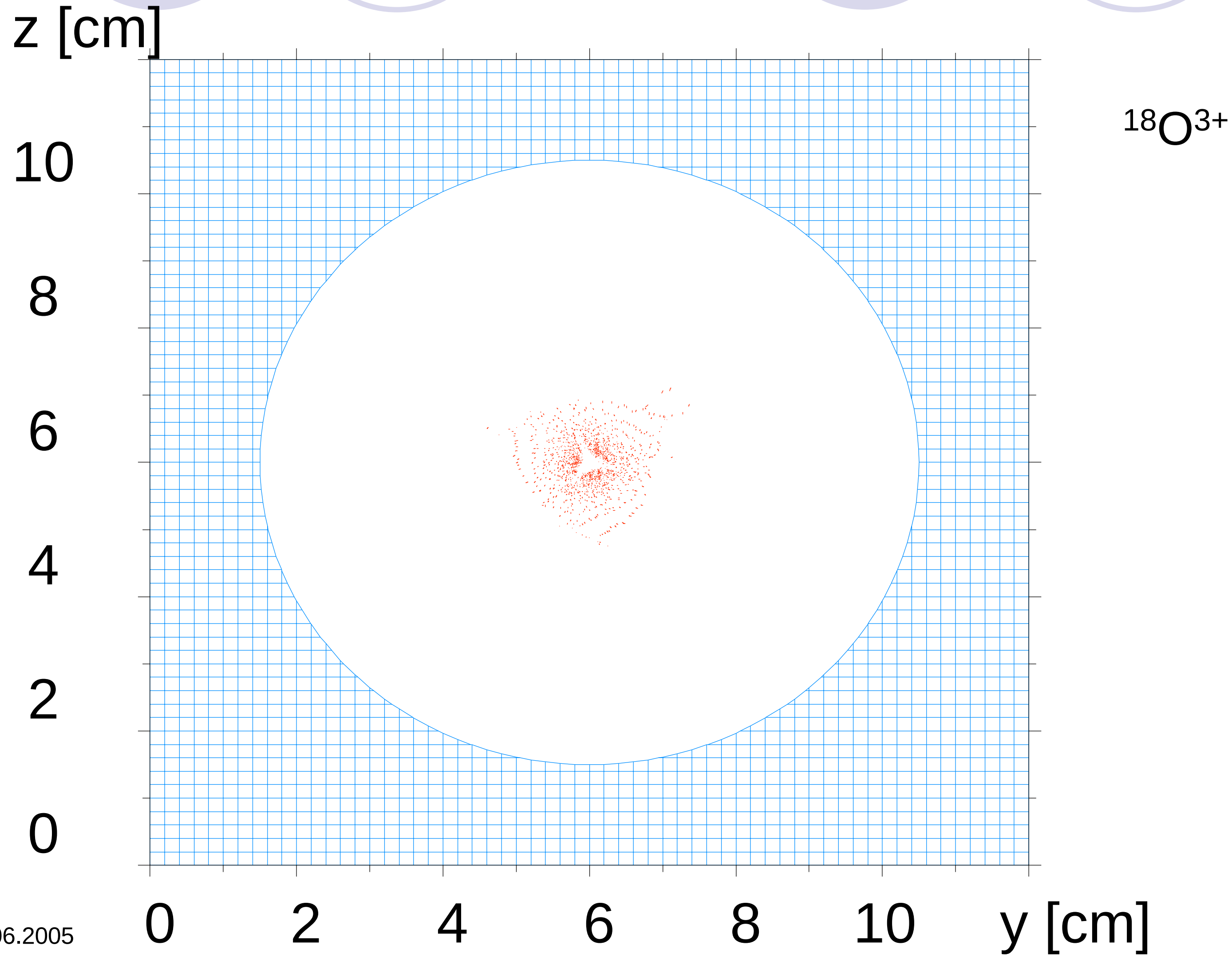


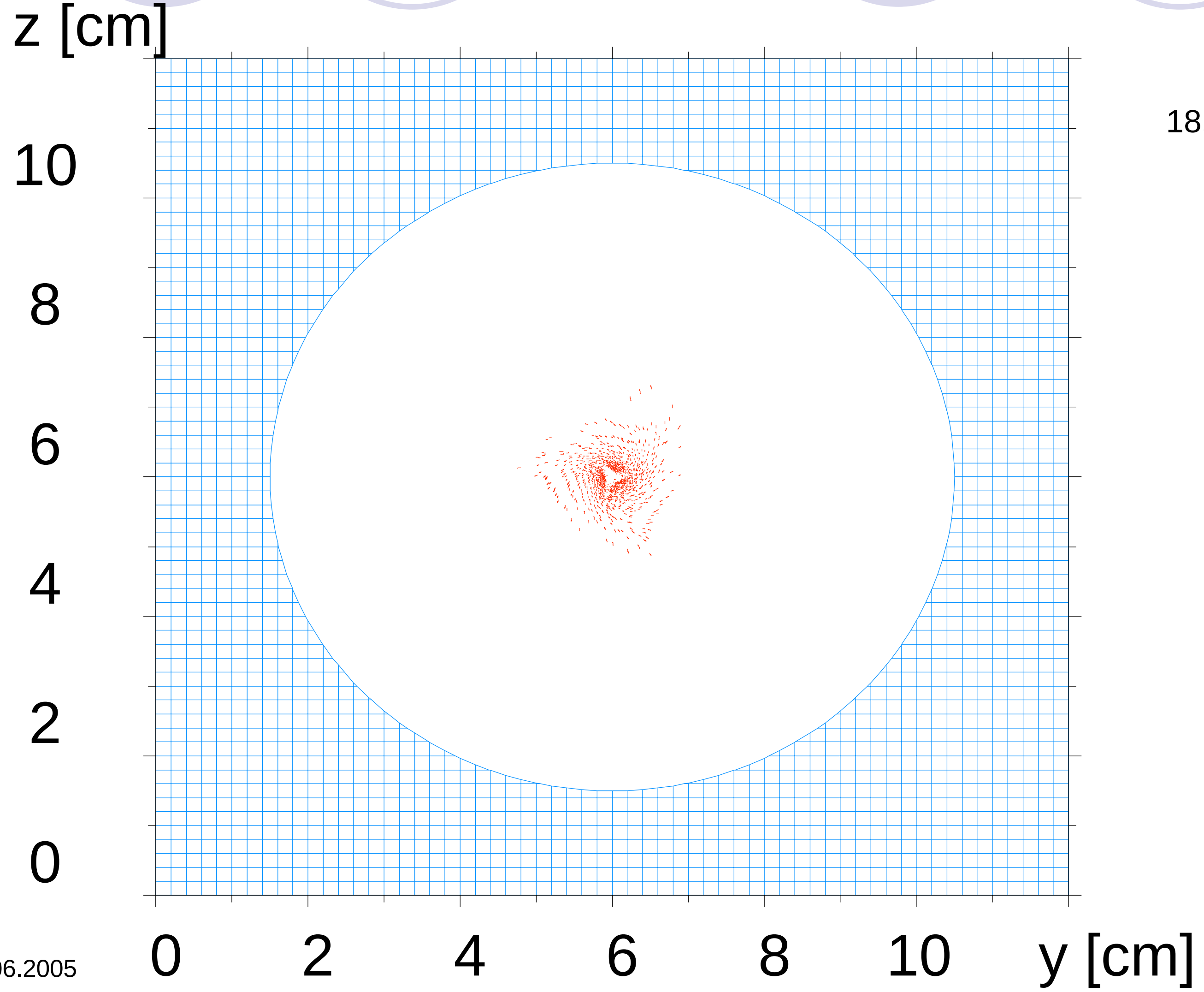
now individual charge states
with 0 mA current



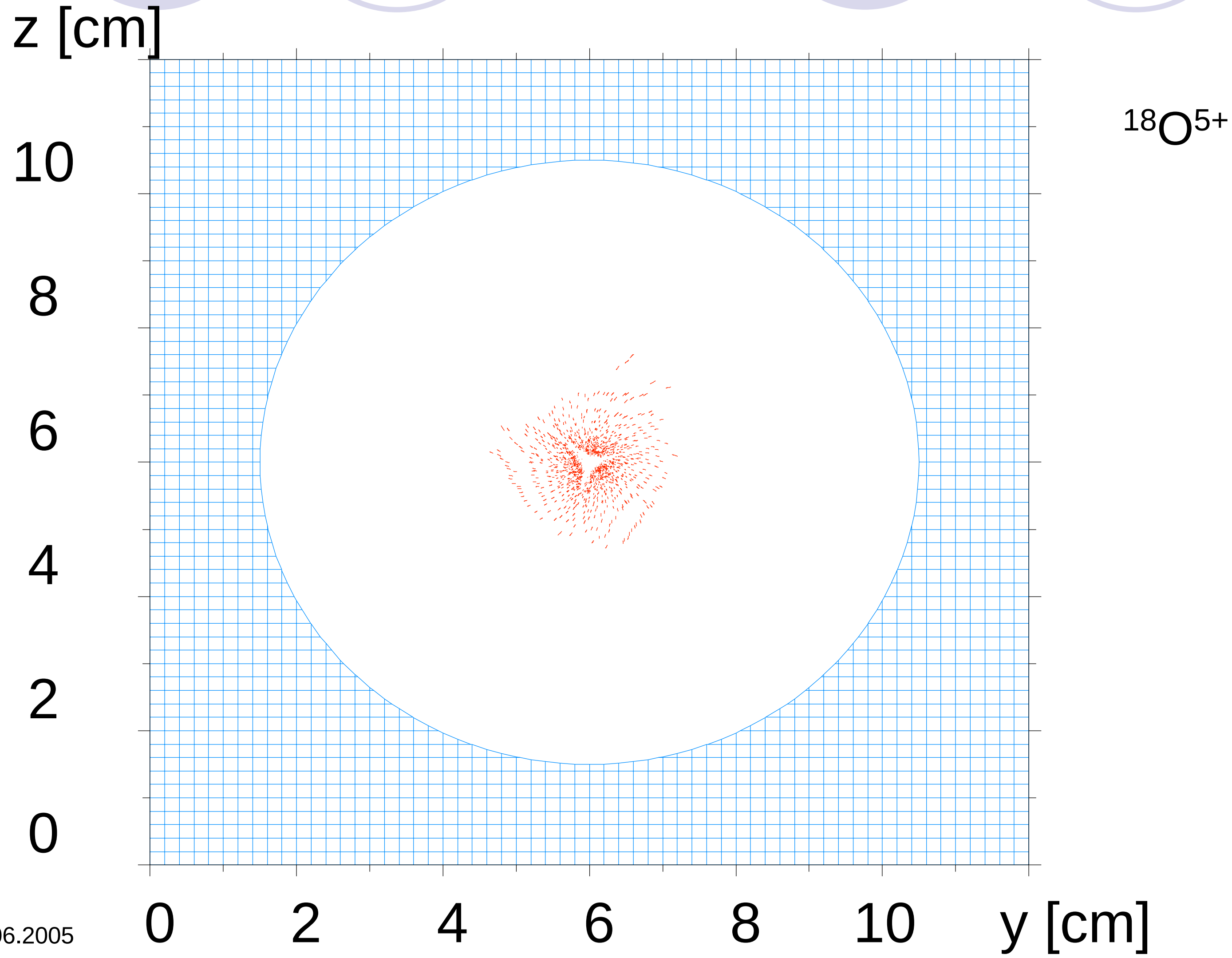
z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{18}O^{1+}$

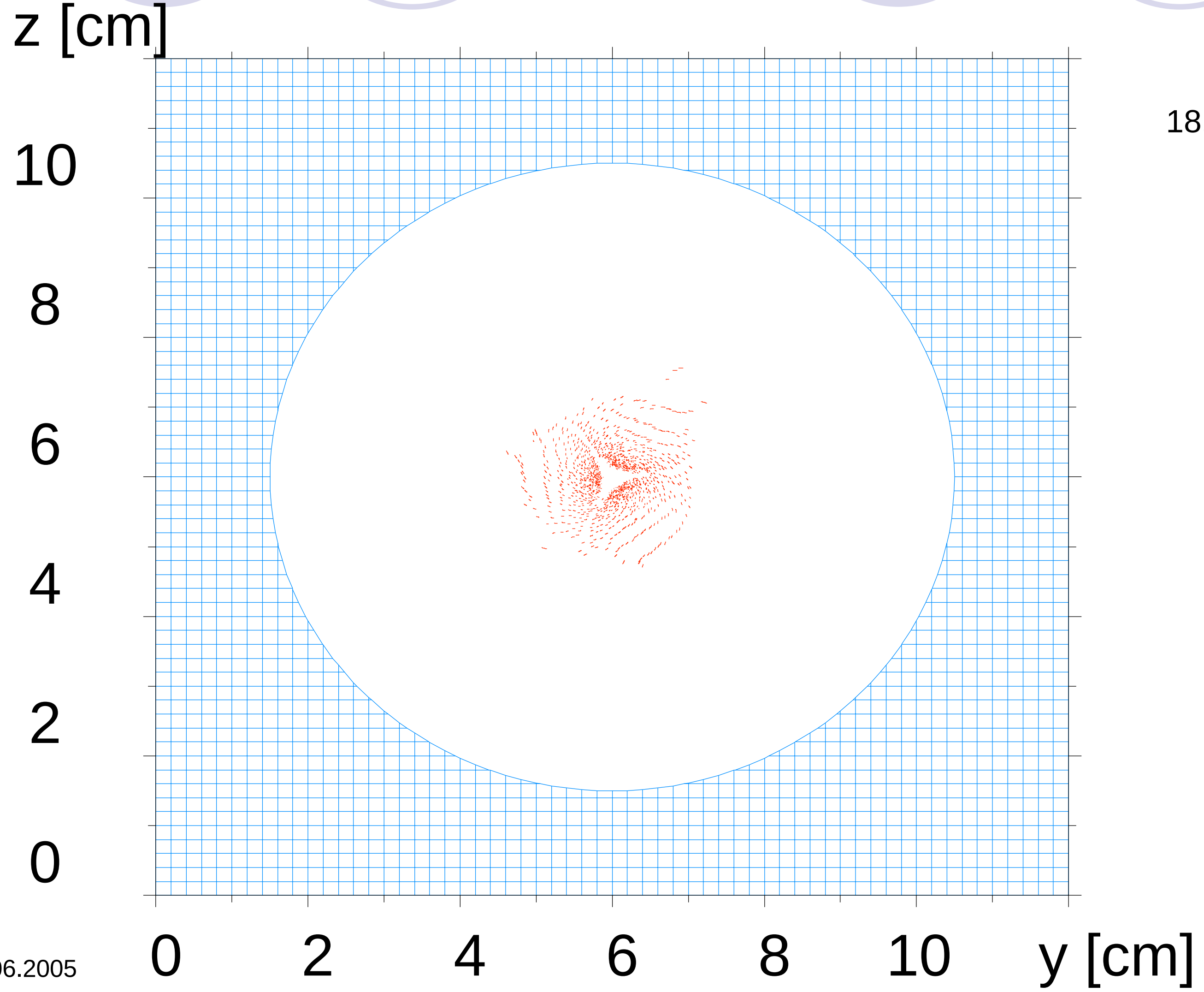

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
18O2+


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{18}O^{3+}$

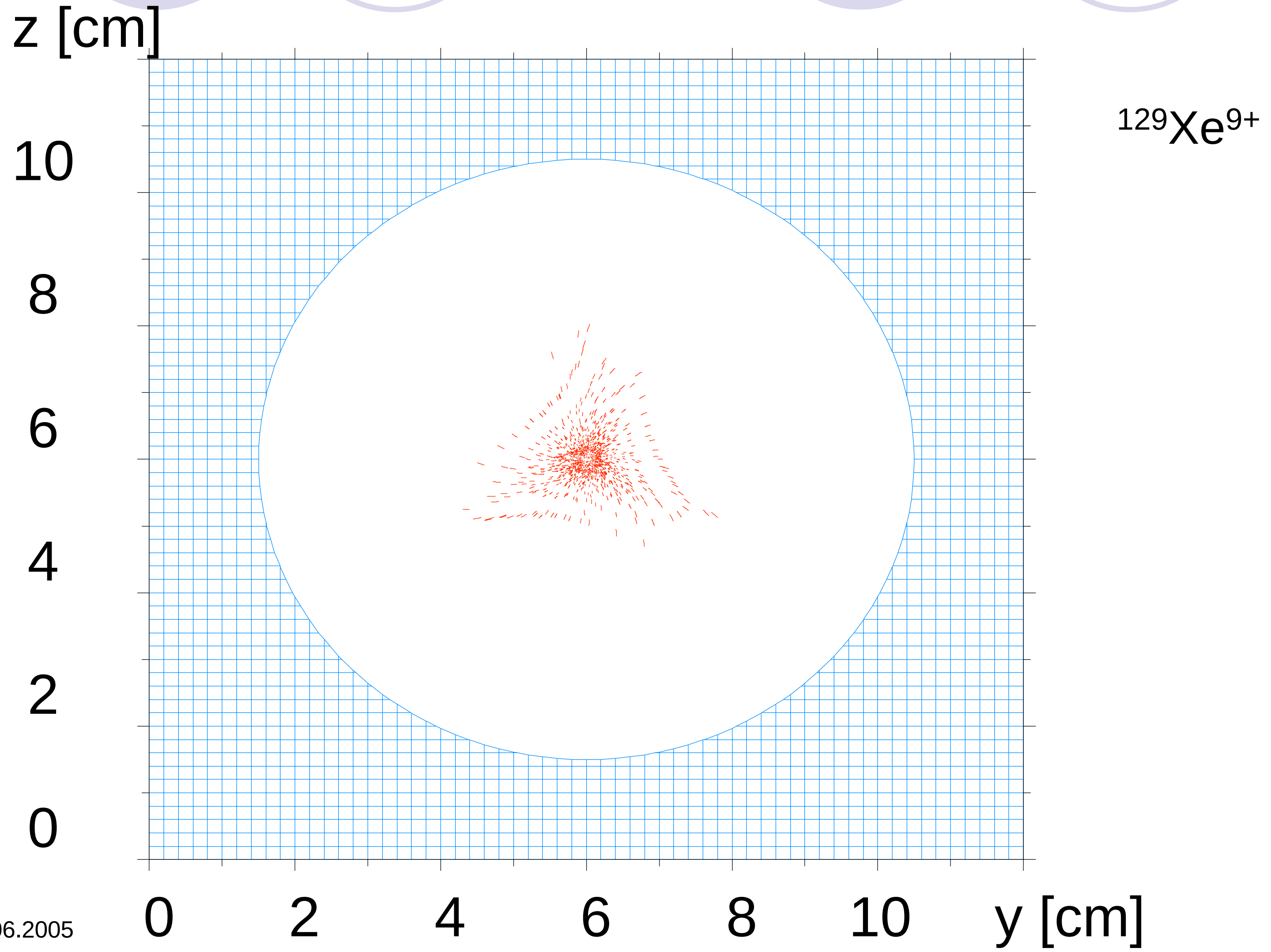


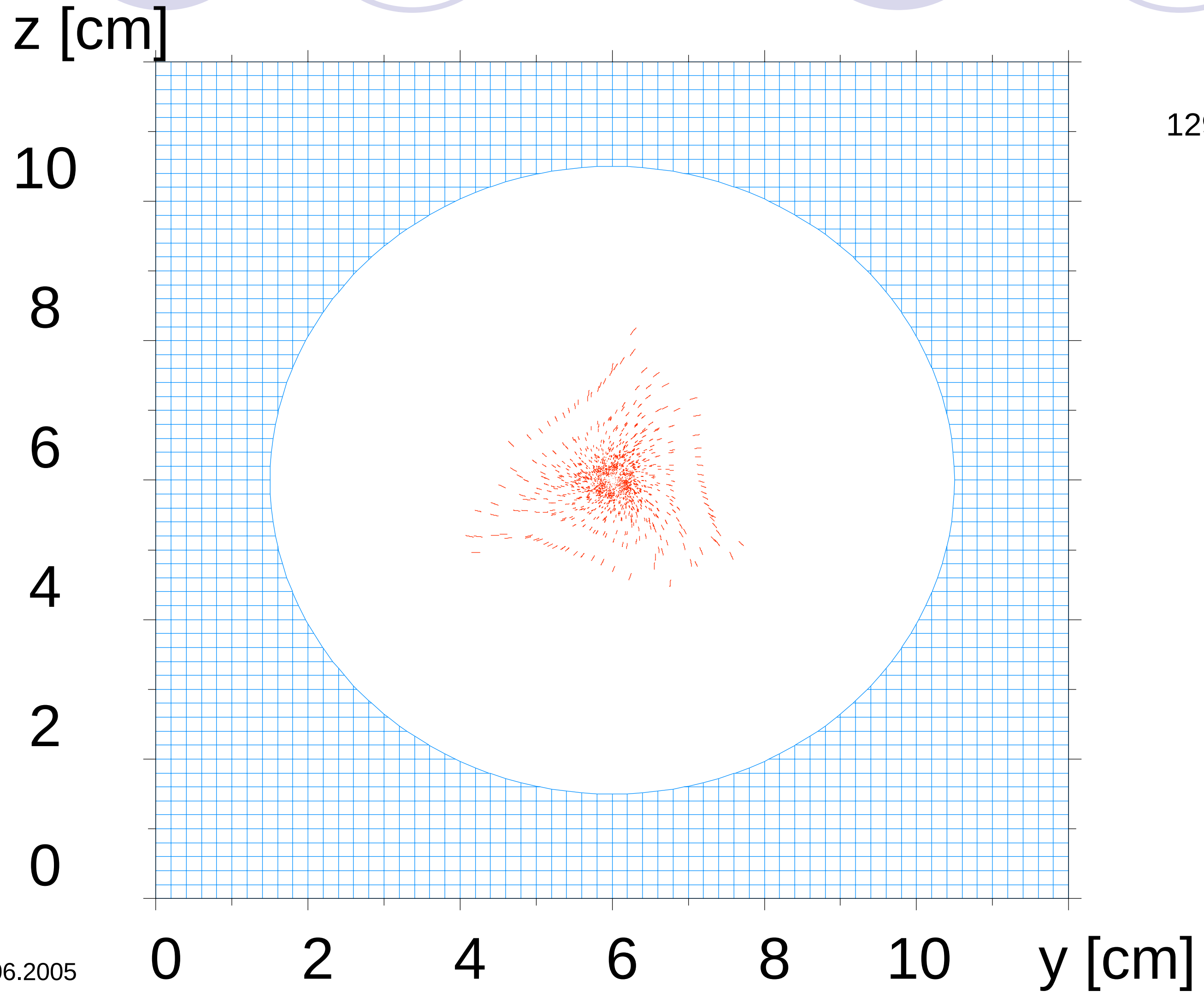
$^{18}O^{4+}$


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{18}O^{5+}$

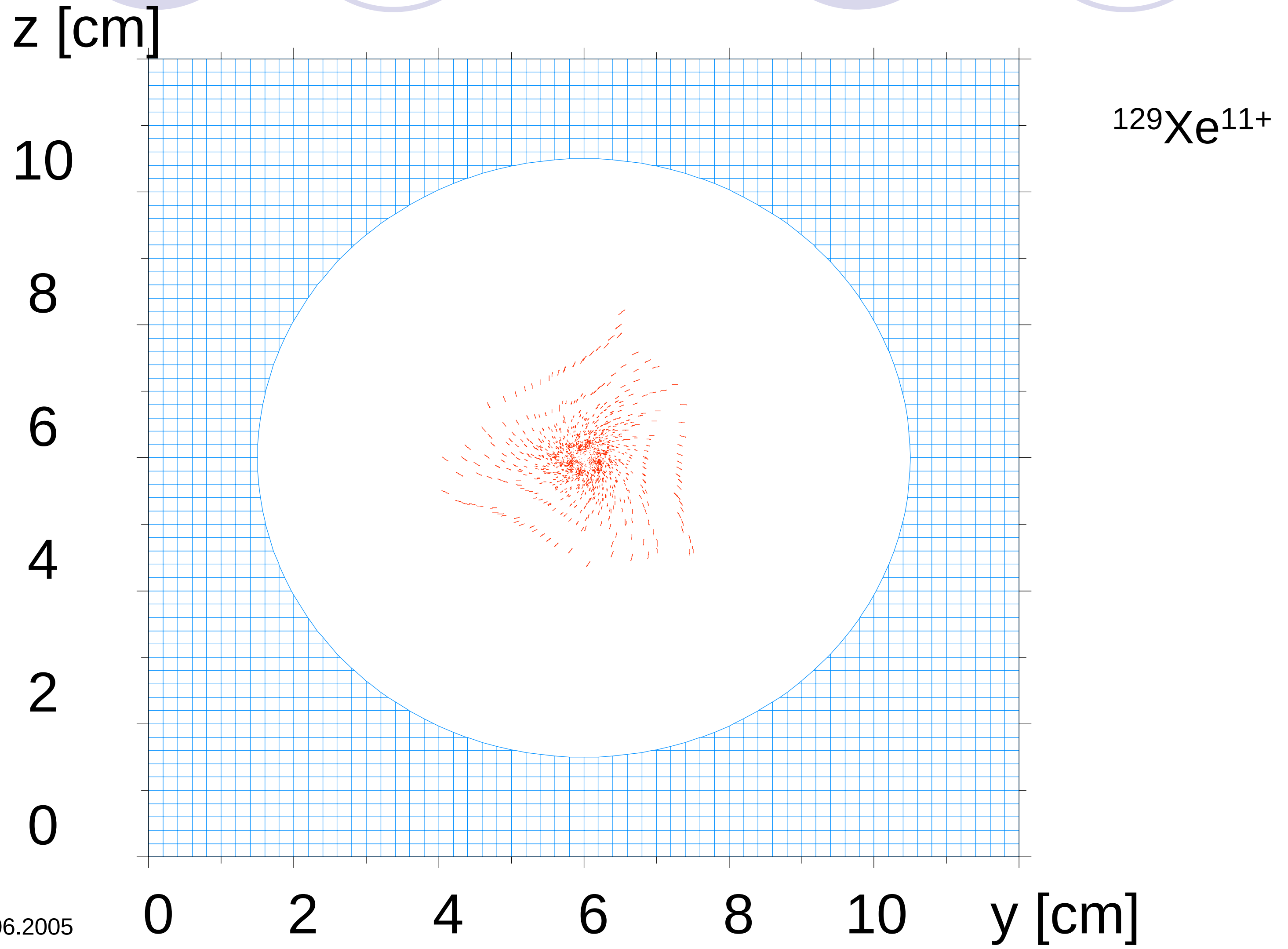


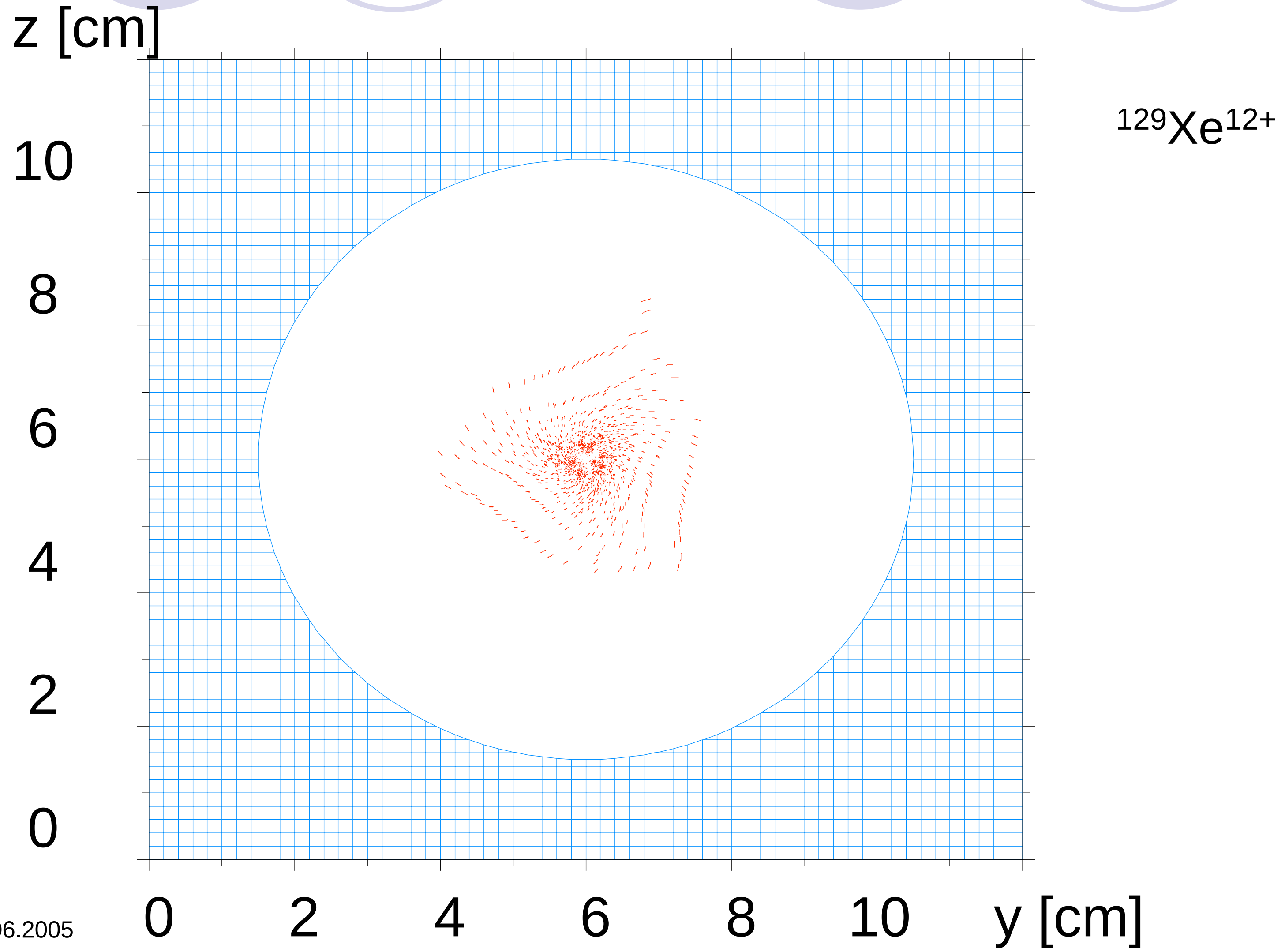
$^{18}O^{6+}$

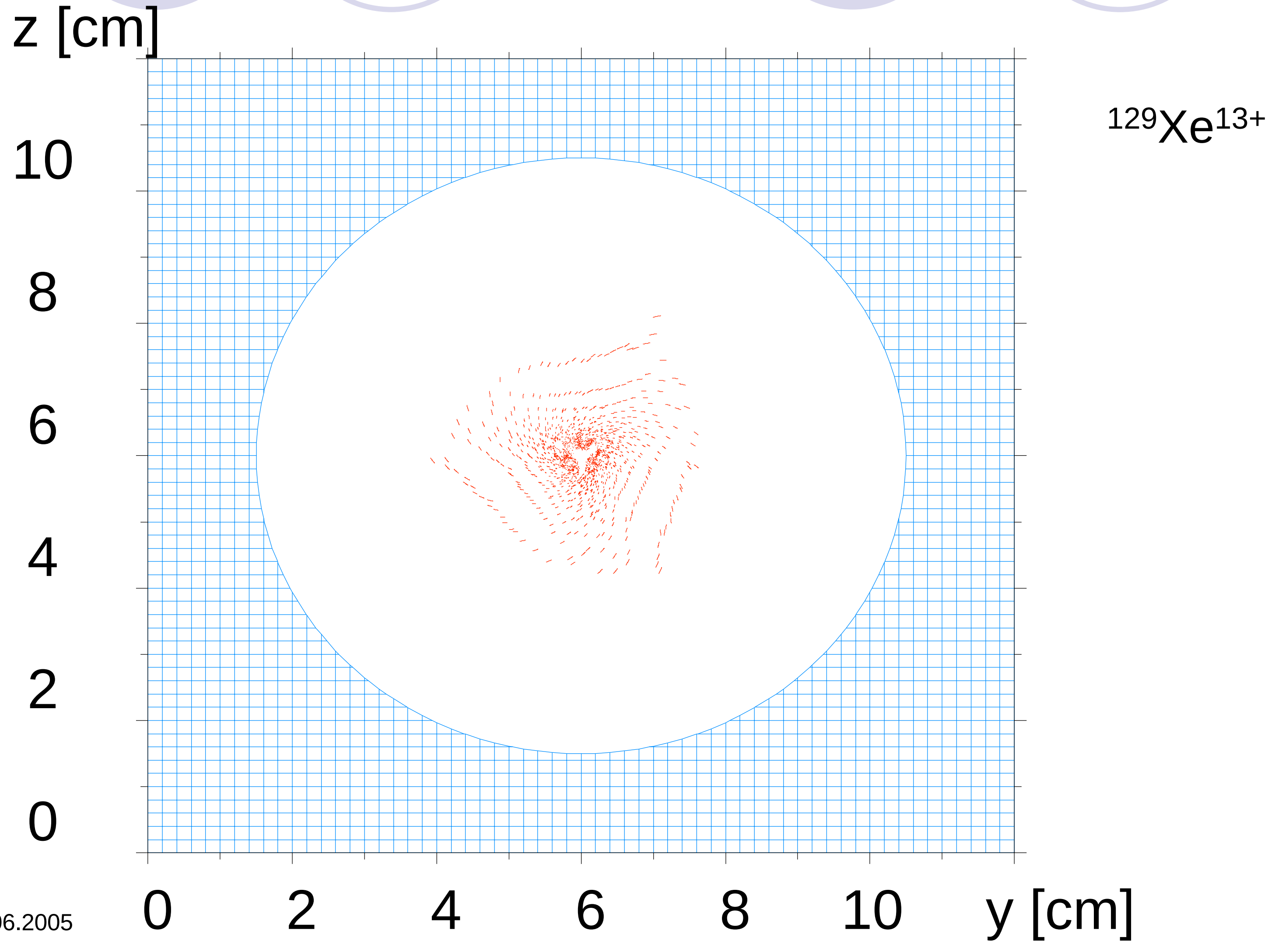

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{9+}$

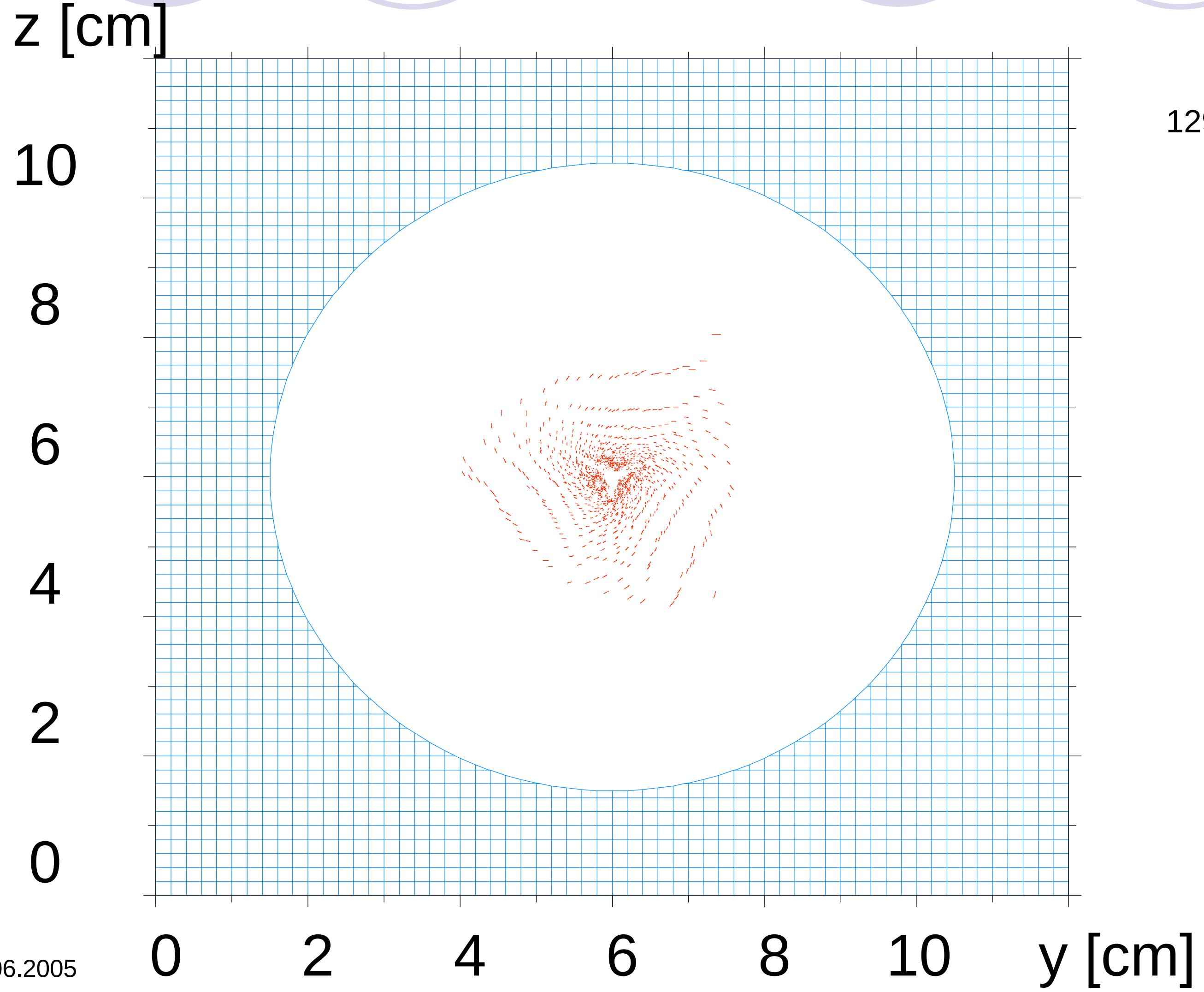


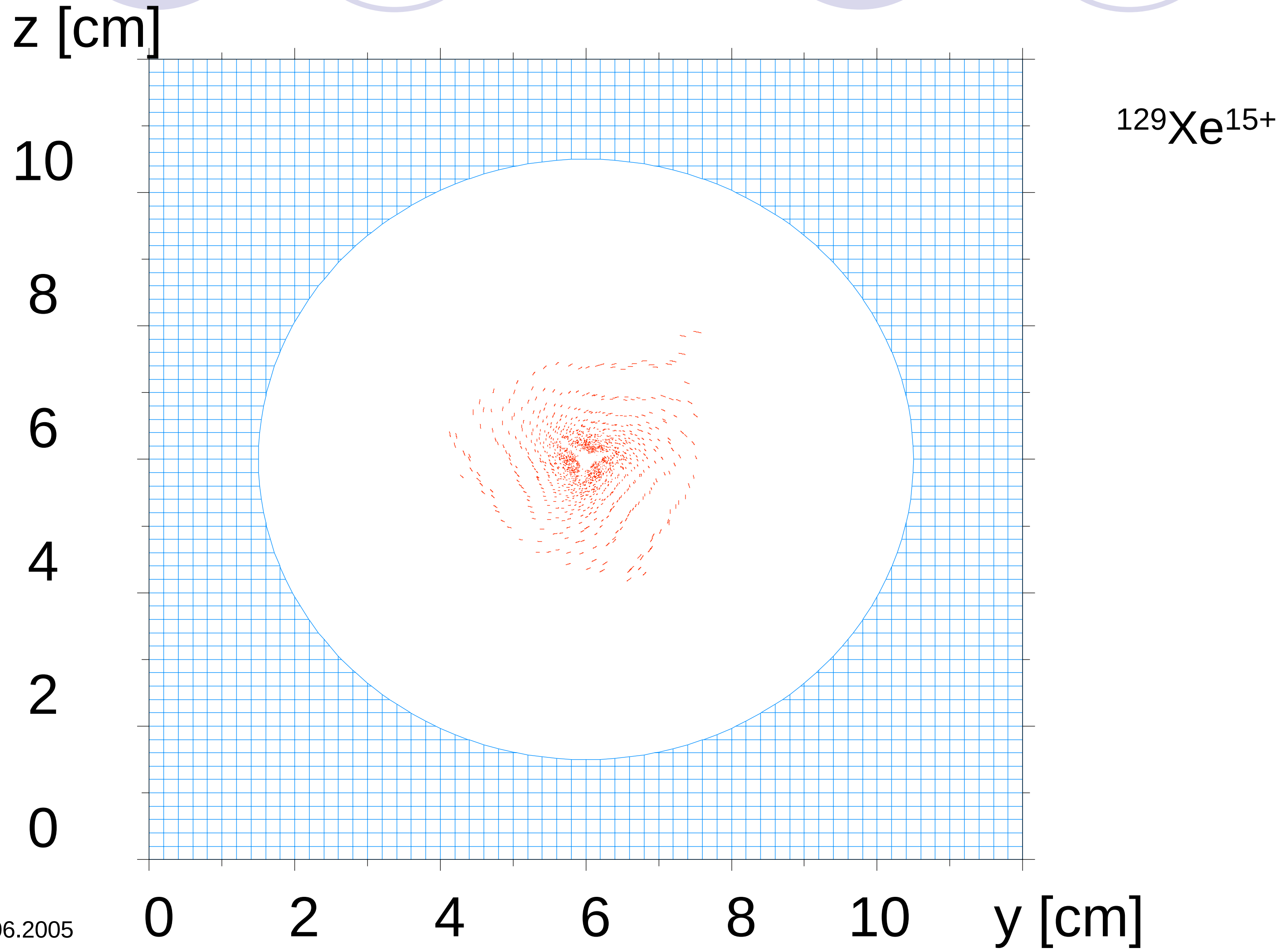
$^{129}Xe^{10+}$

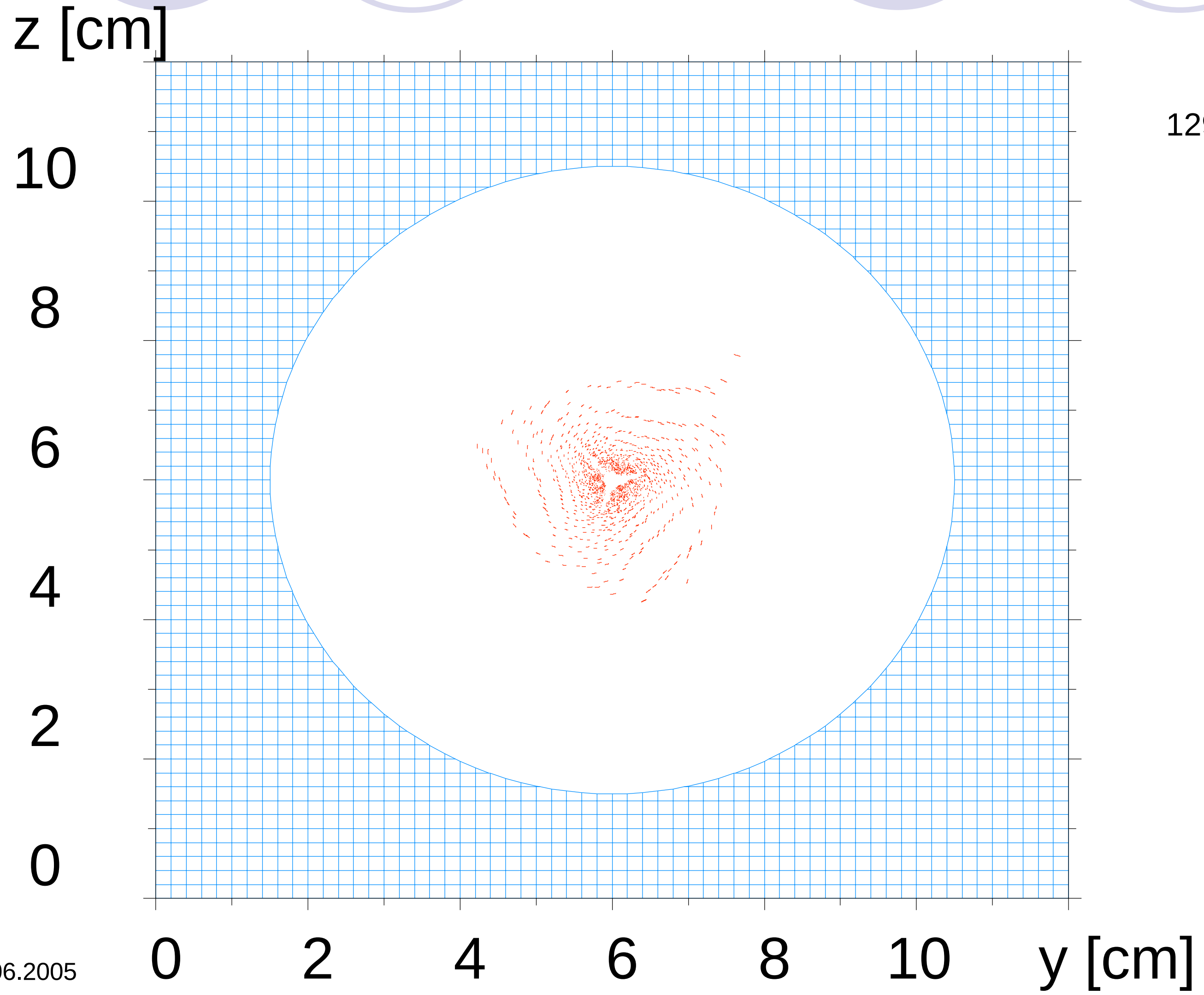

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{11+}$


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{12+}$

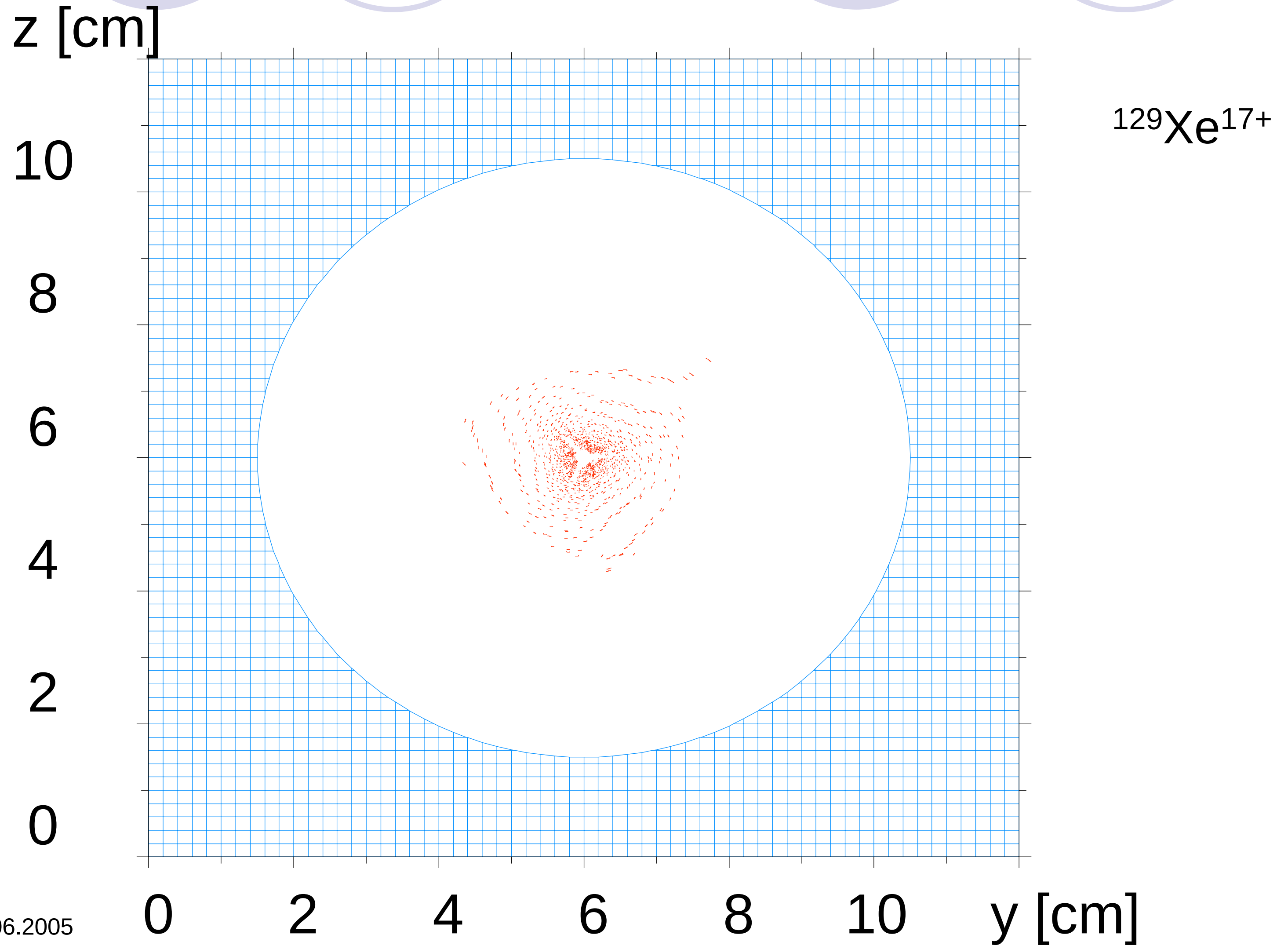

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{13+}$

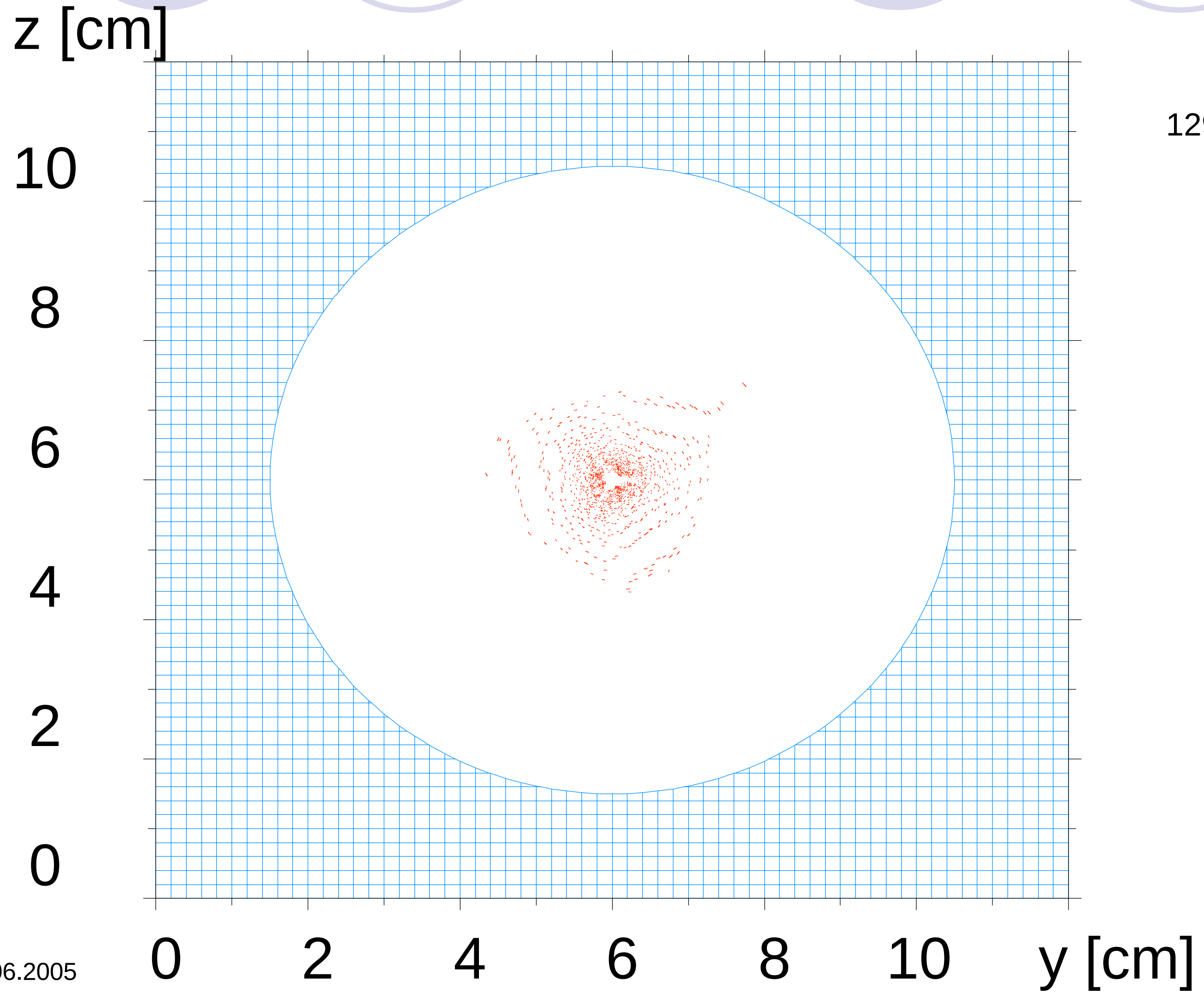

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{14+}$


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{15+}$

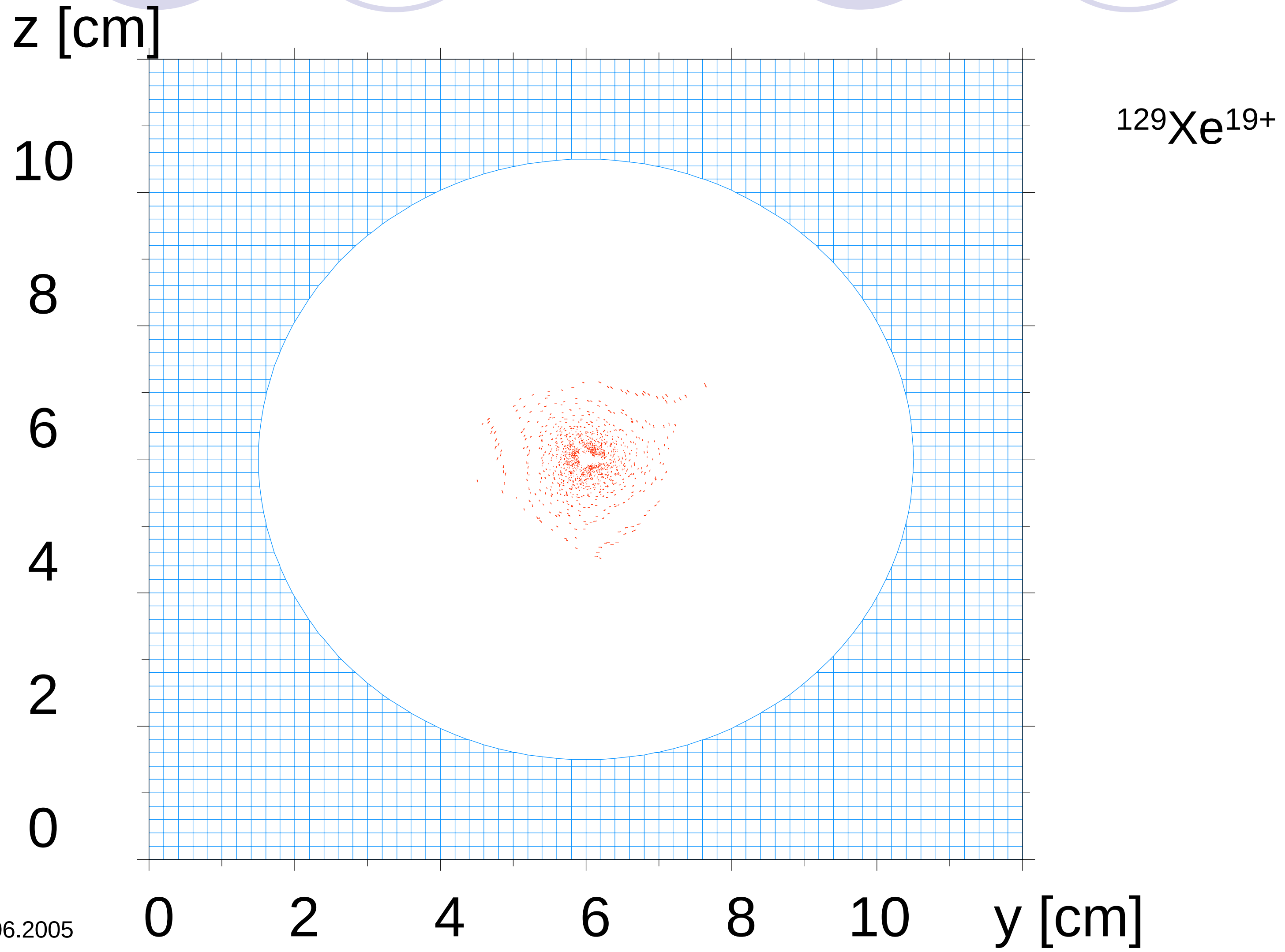


$^{129}Xe^{16+}$

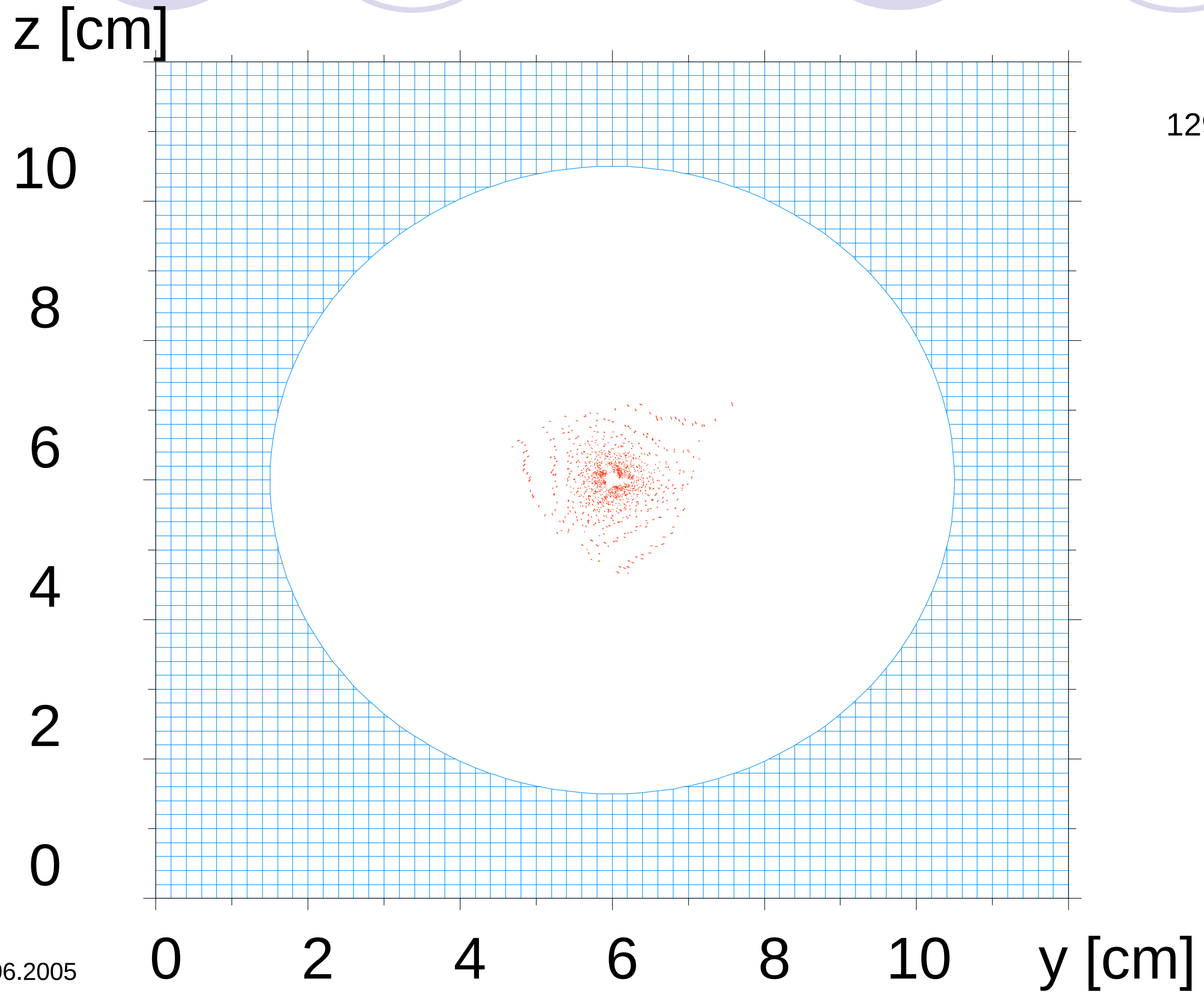

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{17+}$

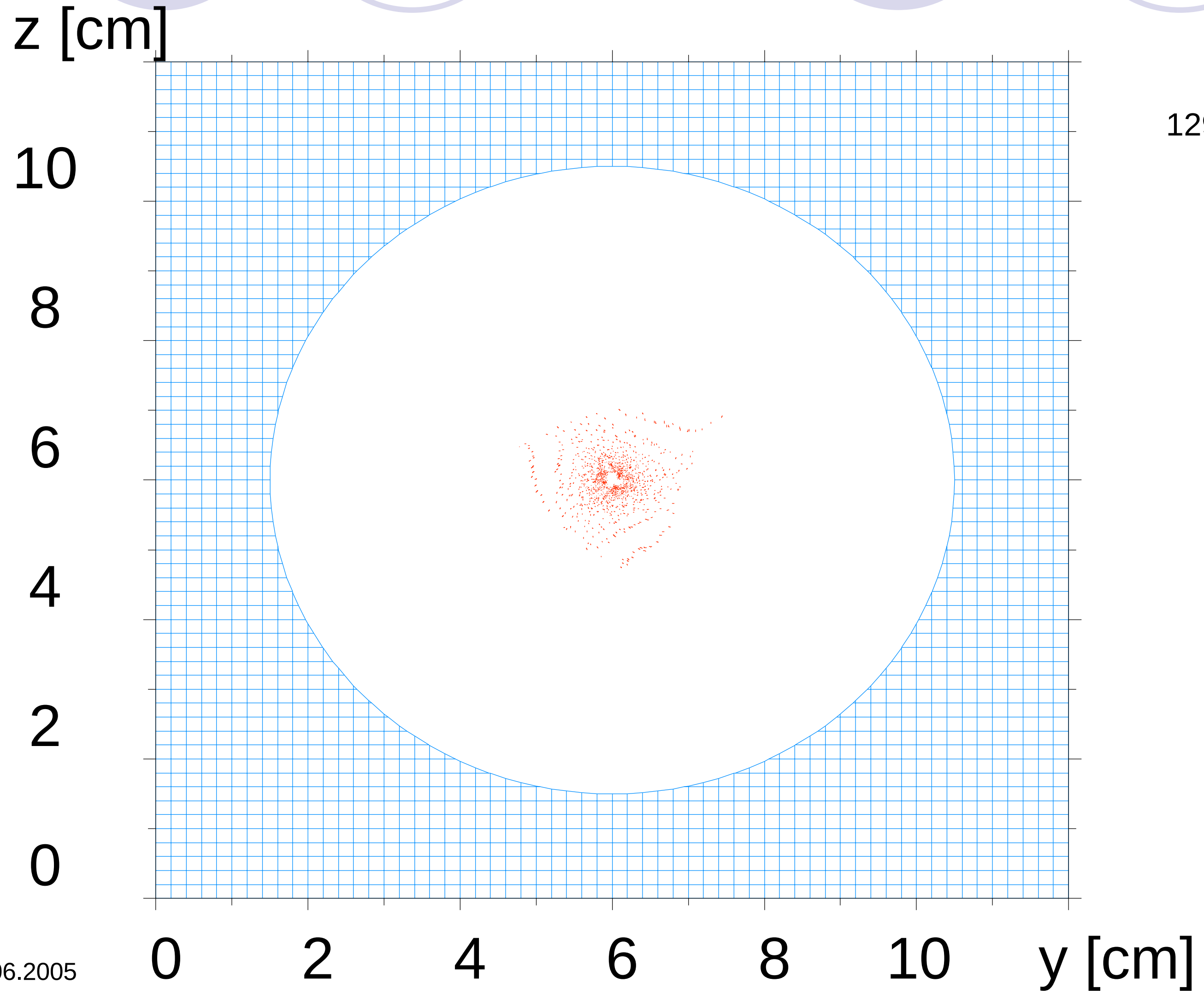


$^{129}Xe^{18+}$

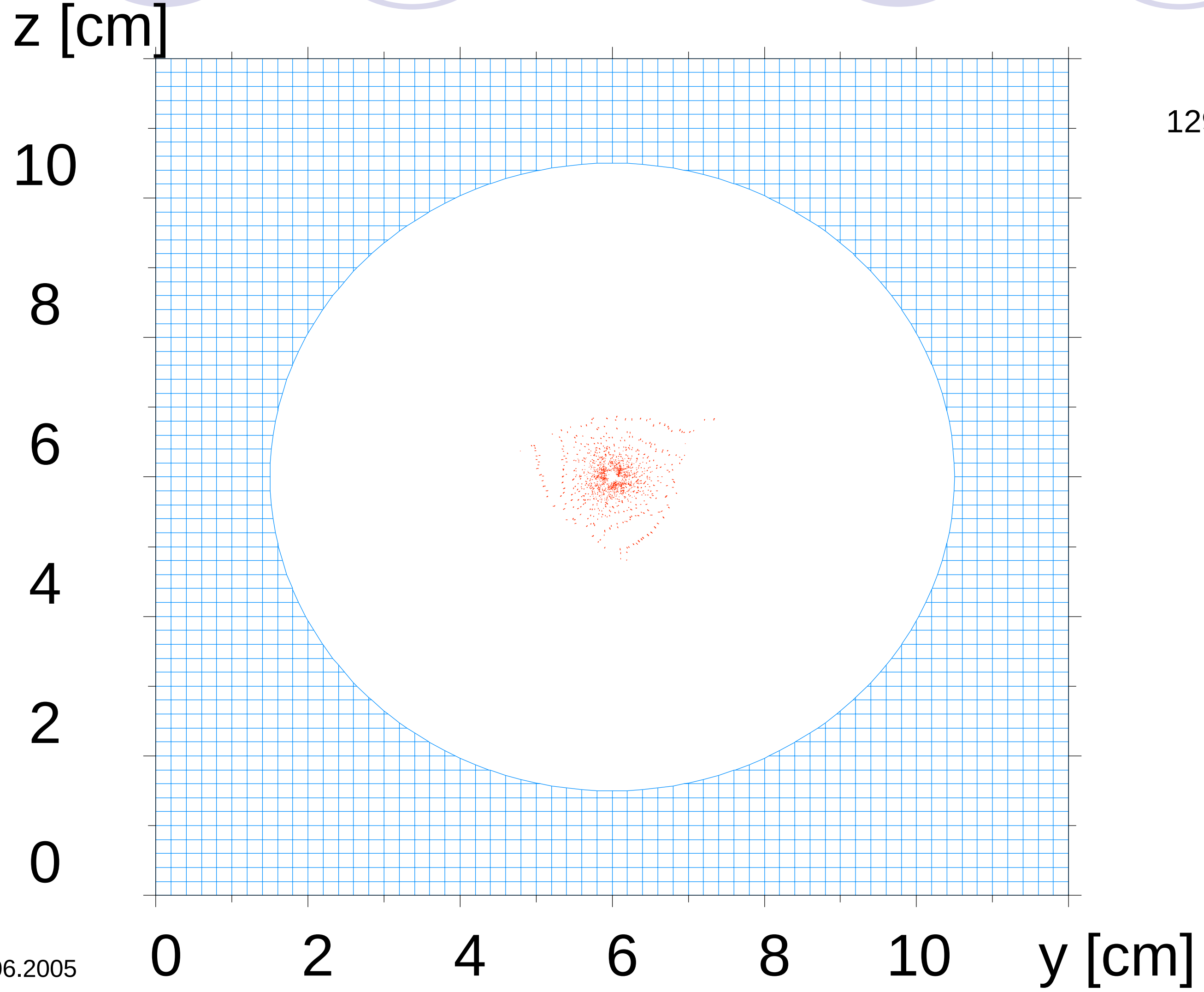

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{19+}$

$^{129}Xe^{20+}$



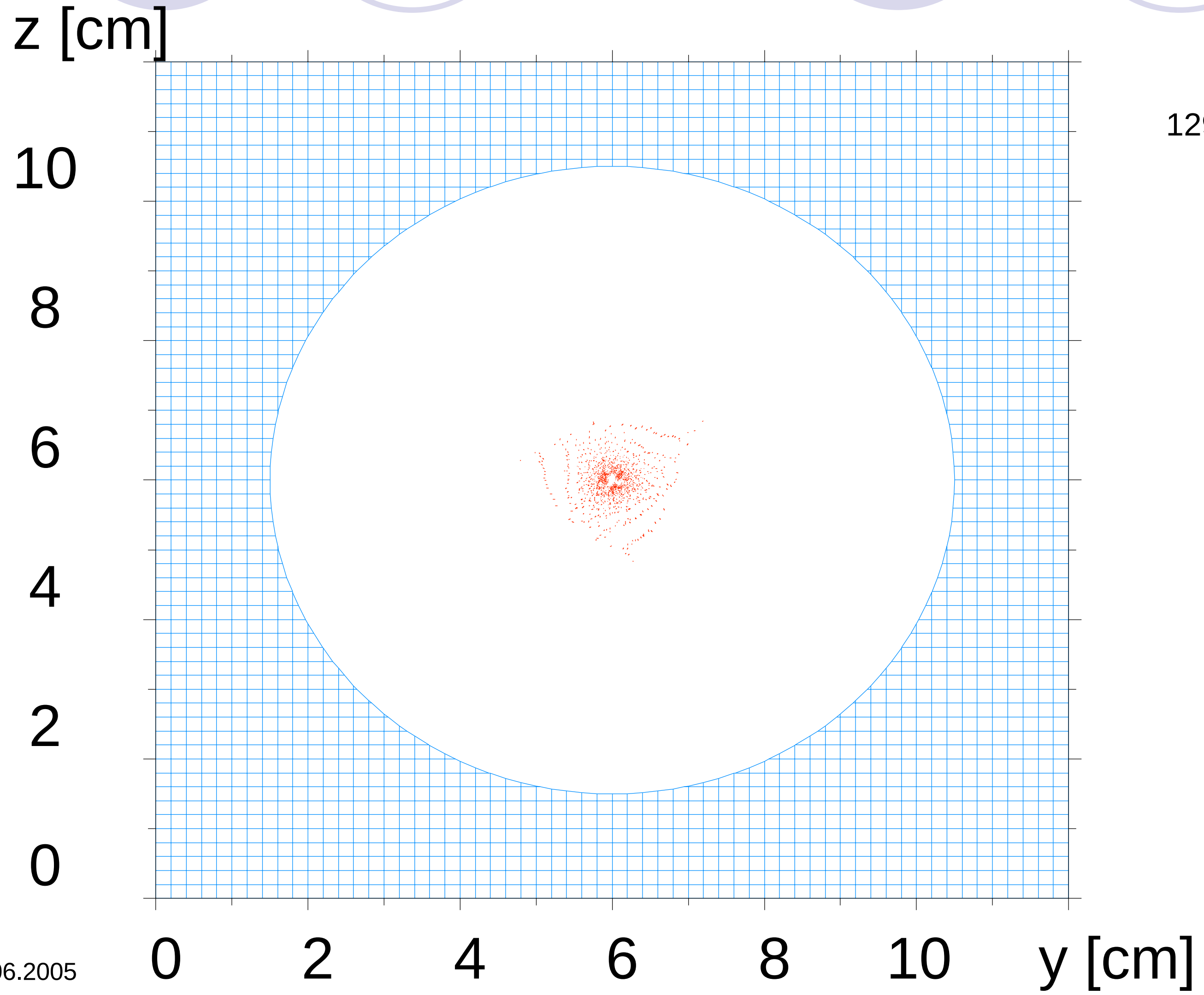


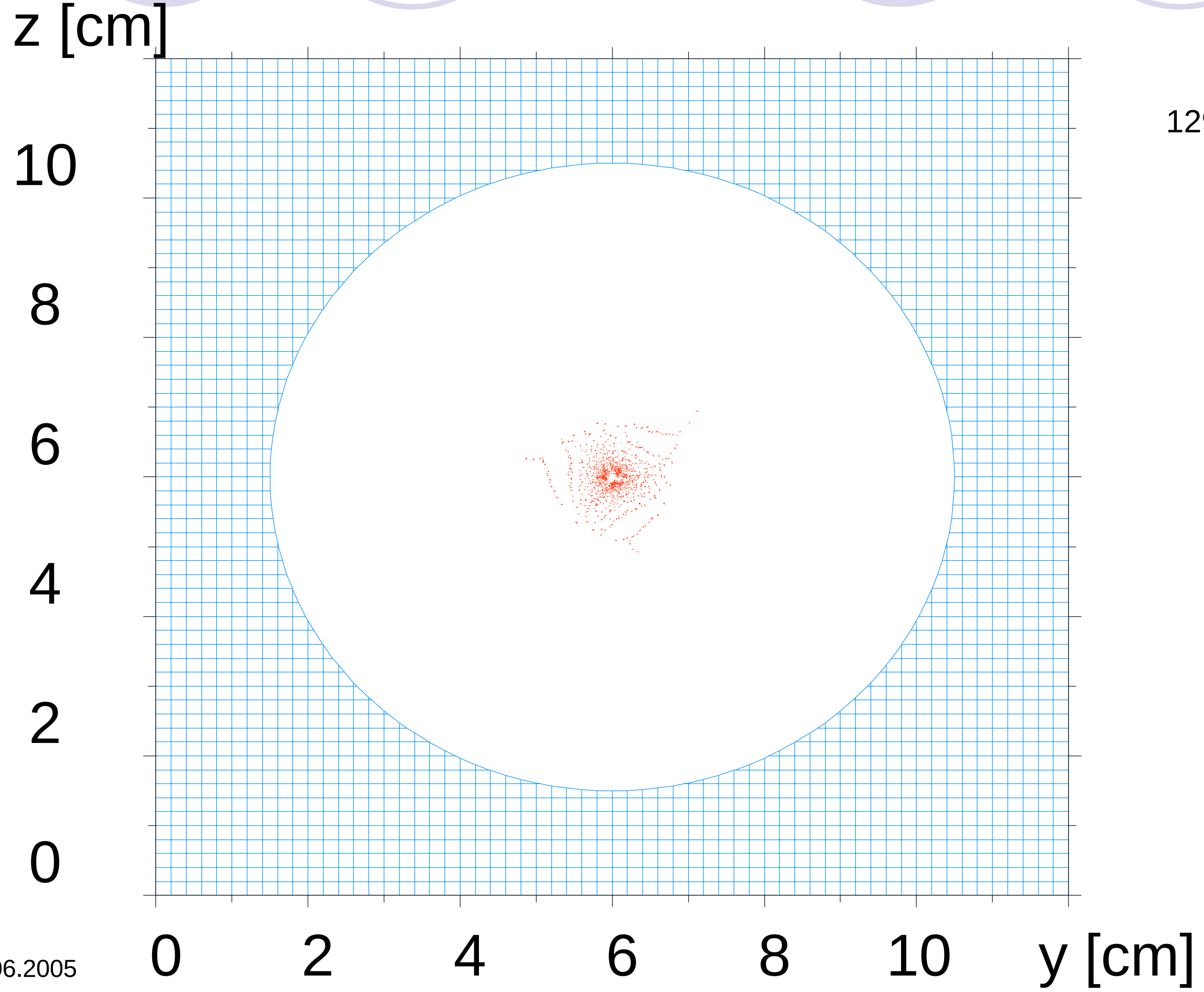
$^{129}Xe^{21+}$



$^{129}Xe^{22+}$

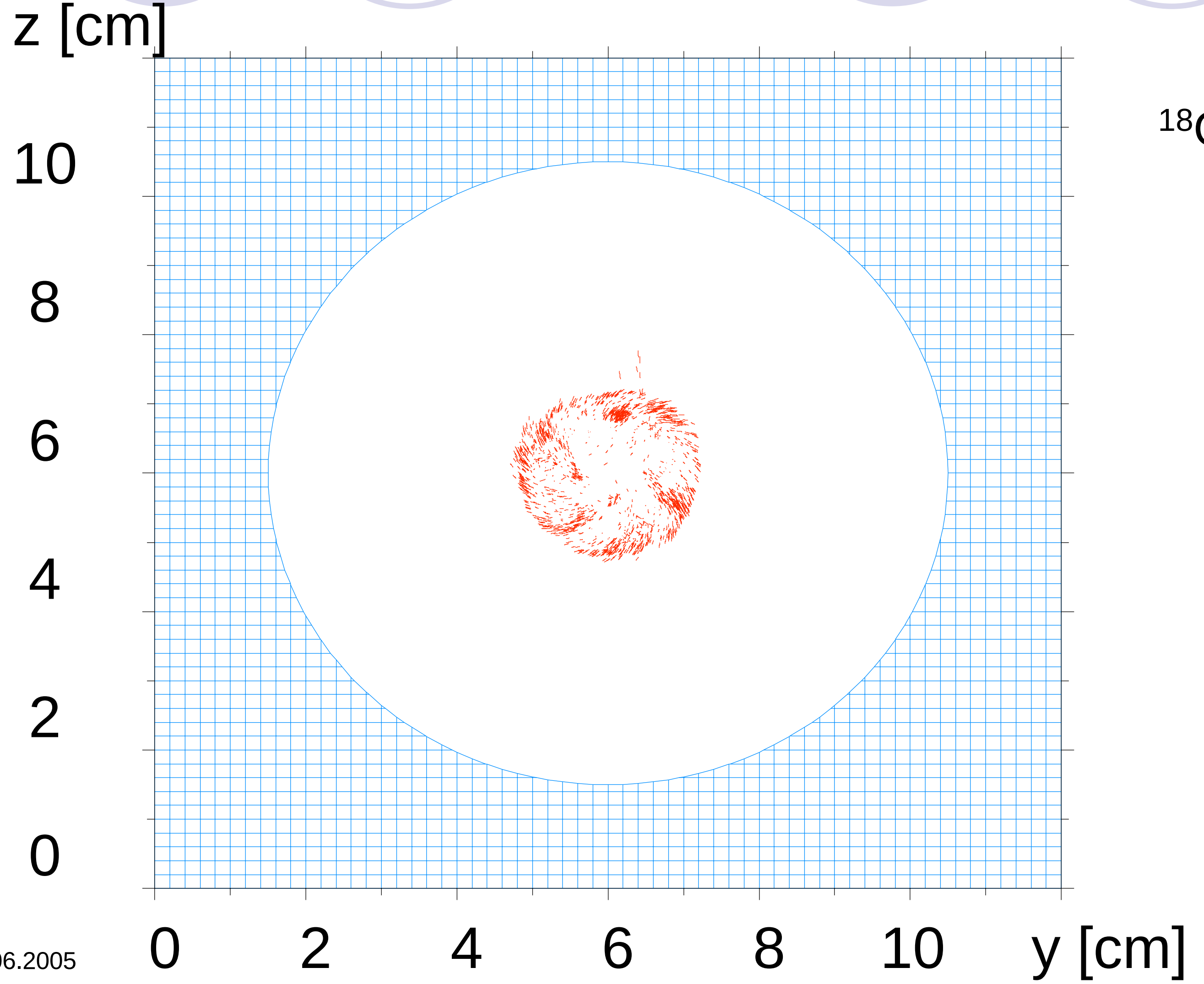
$^{129}Xe^{23+}$



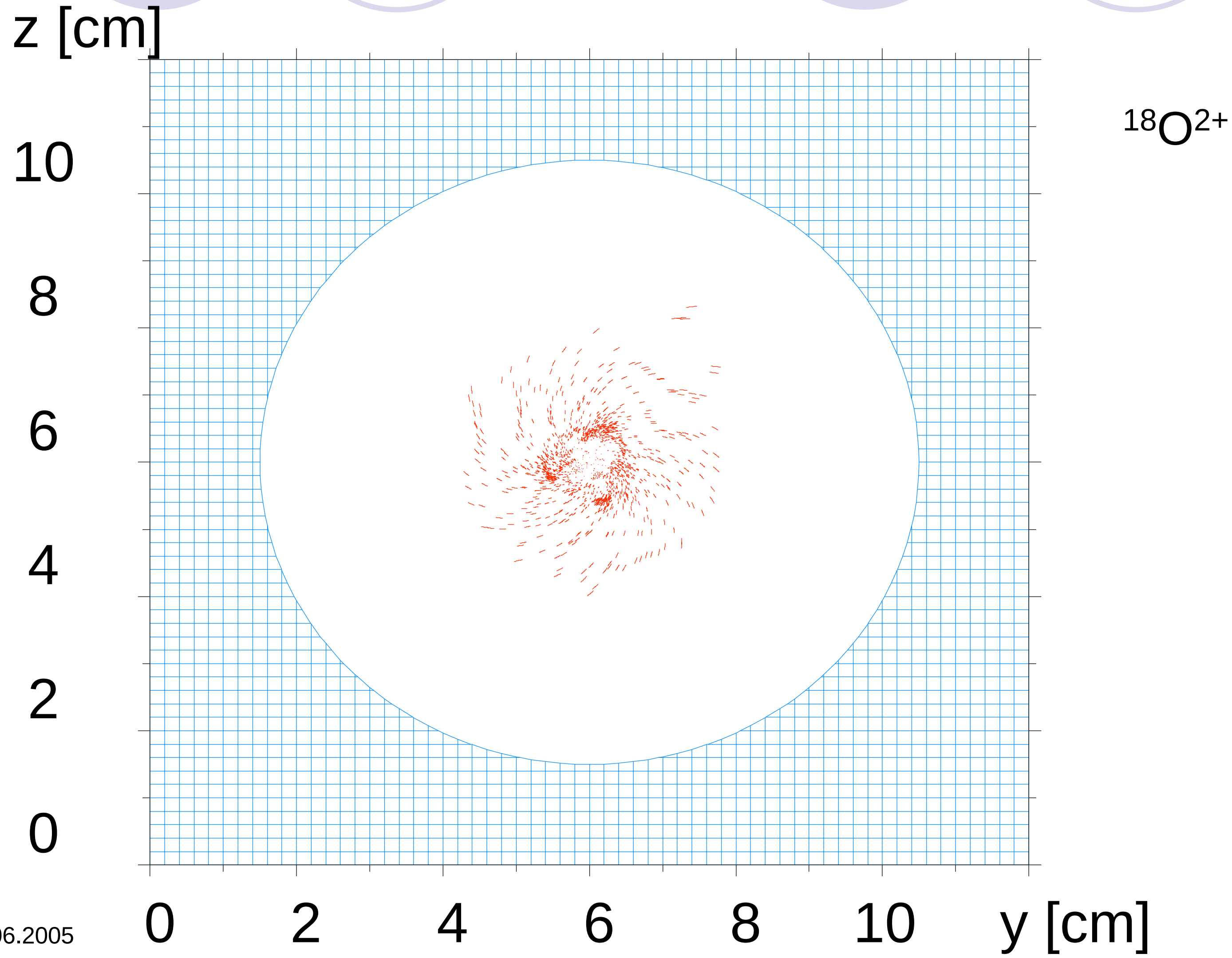


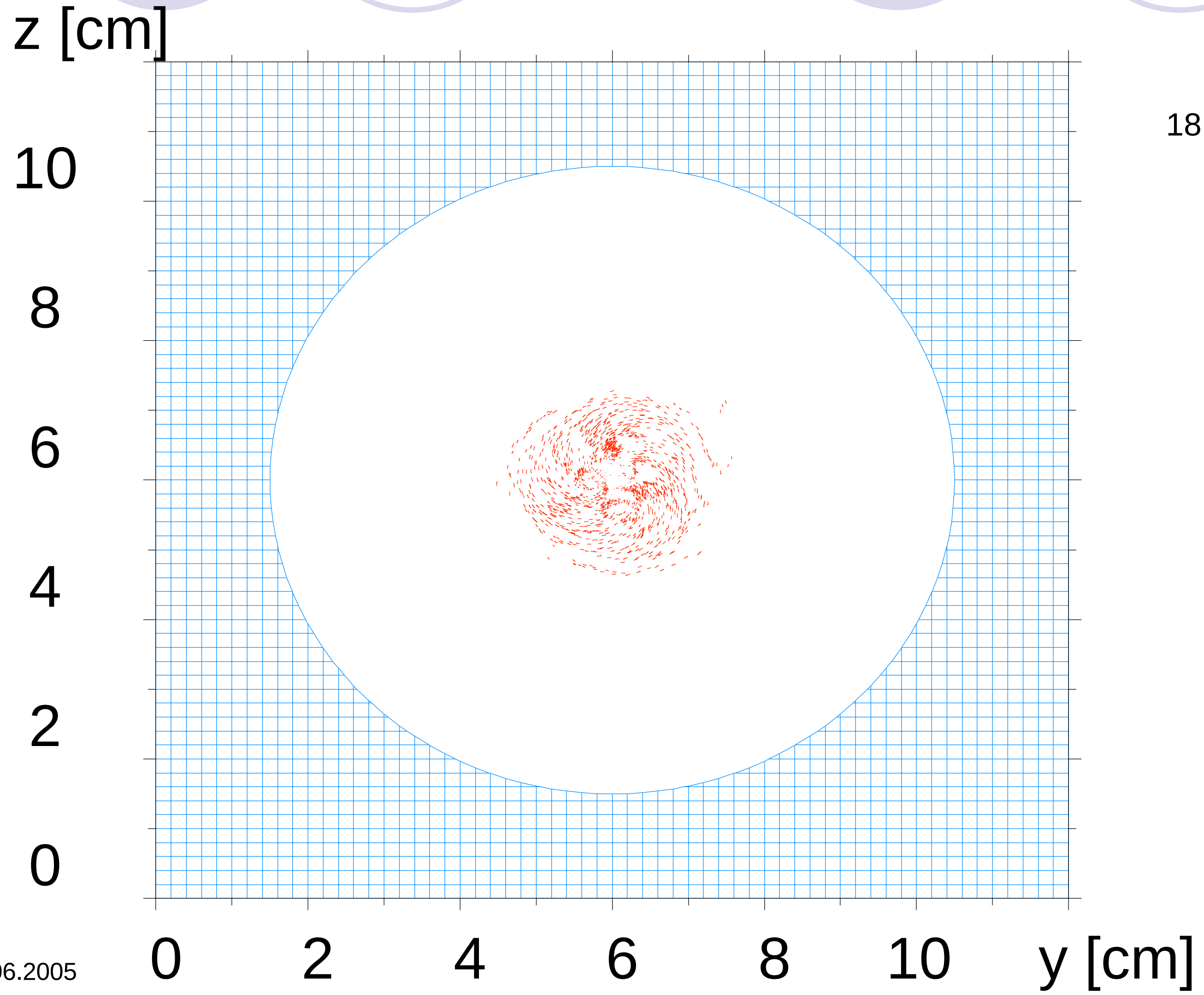
$^{129}Xe^{24+}$

individual charge states
for 16 mA current

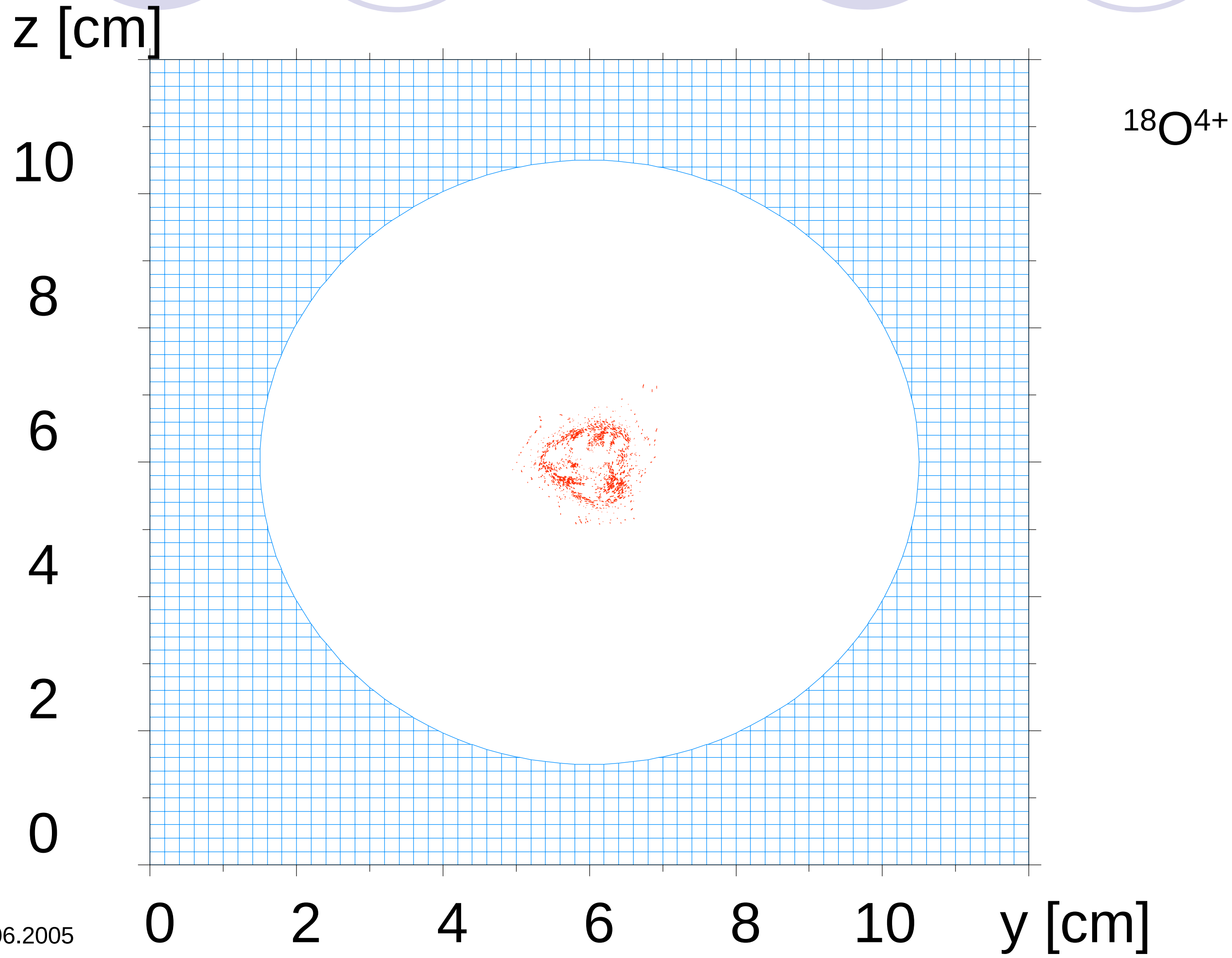


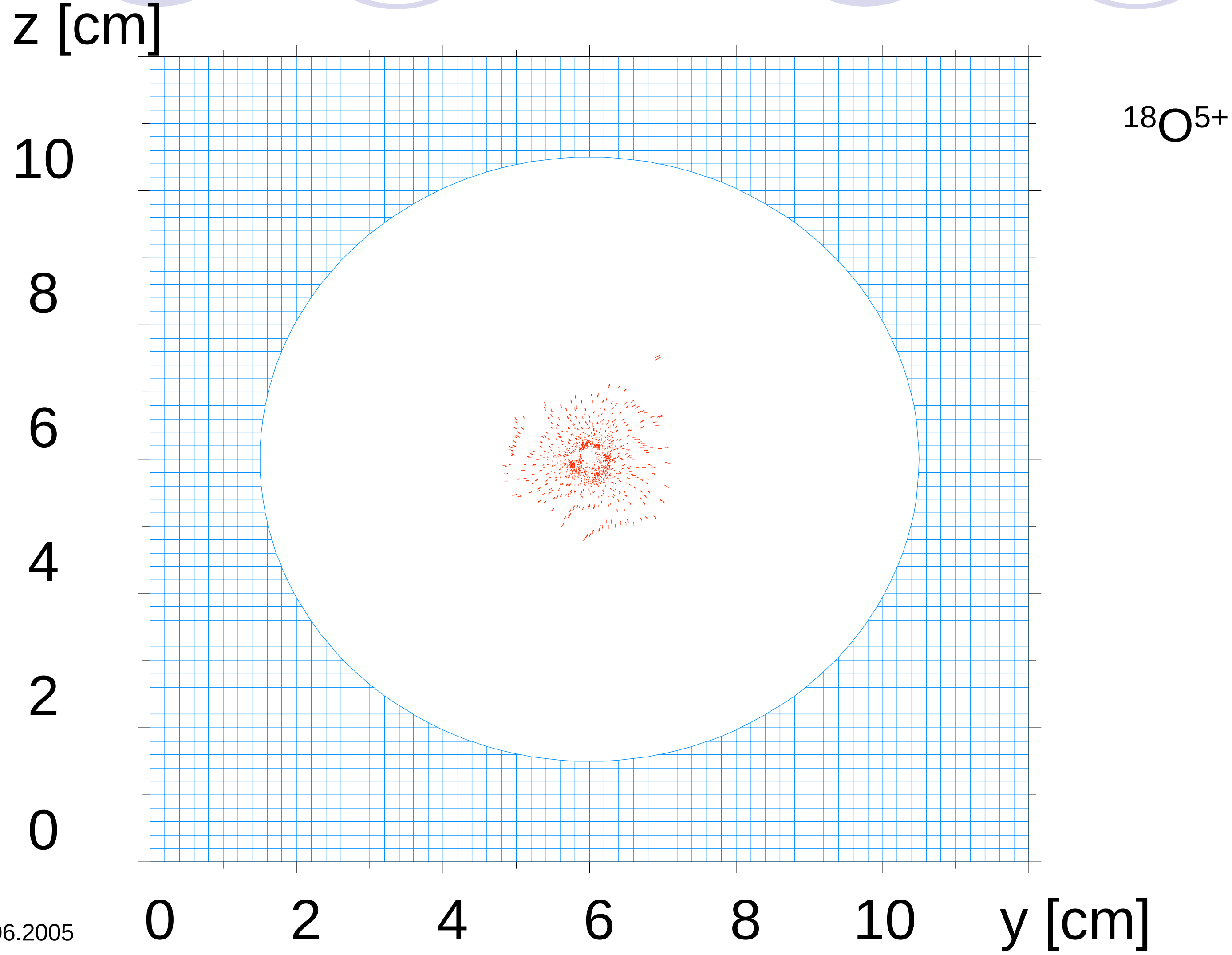
$^{18}O^{1+}$

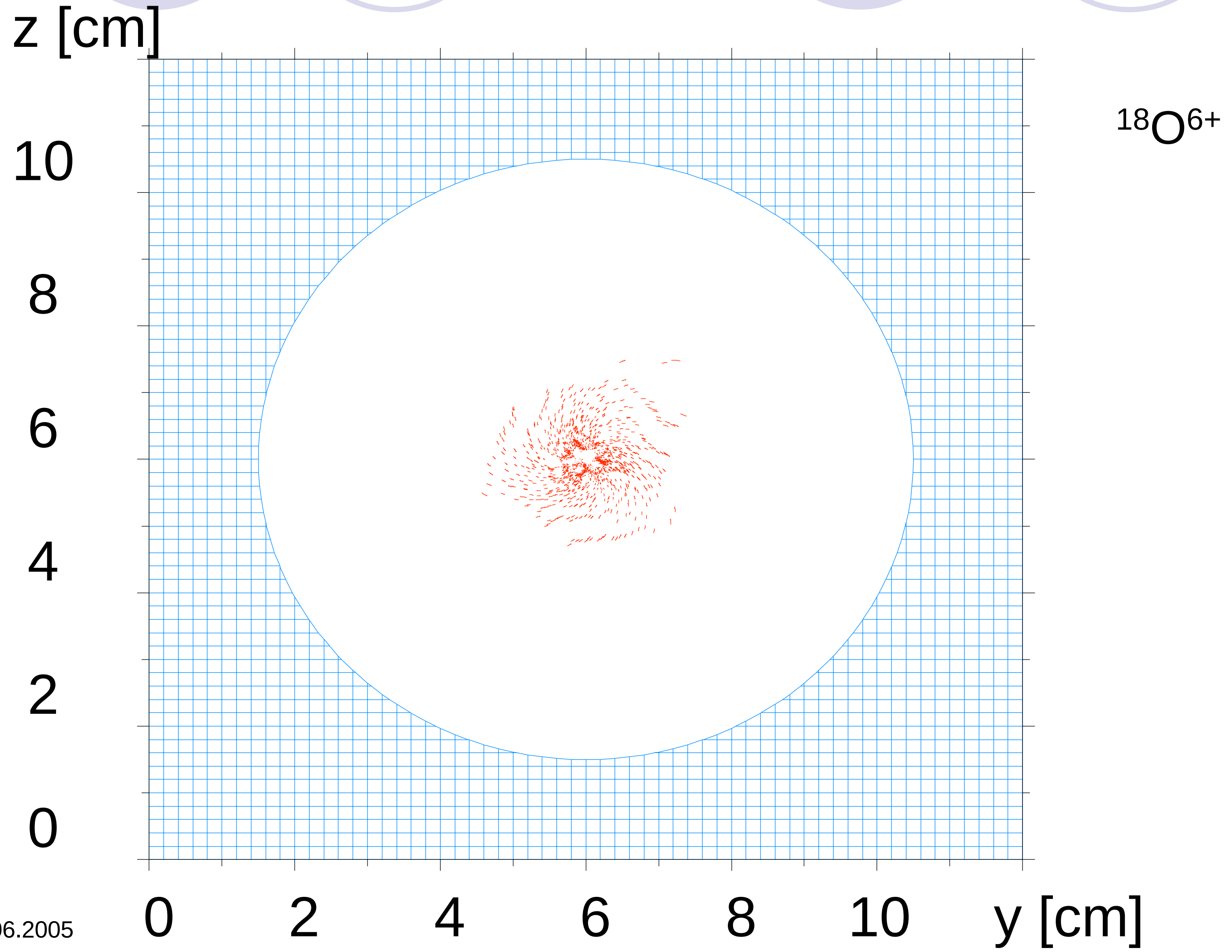

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{18}O^{2+}$

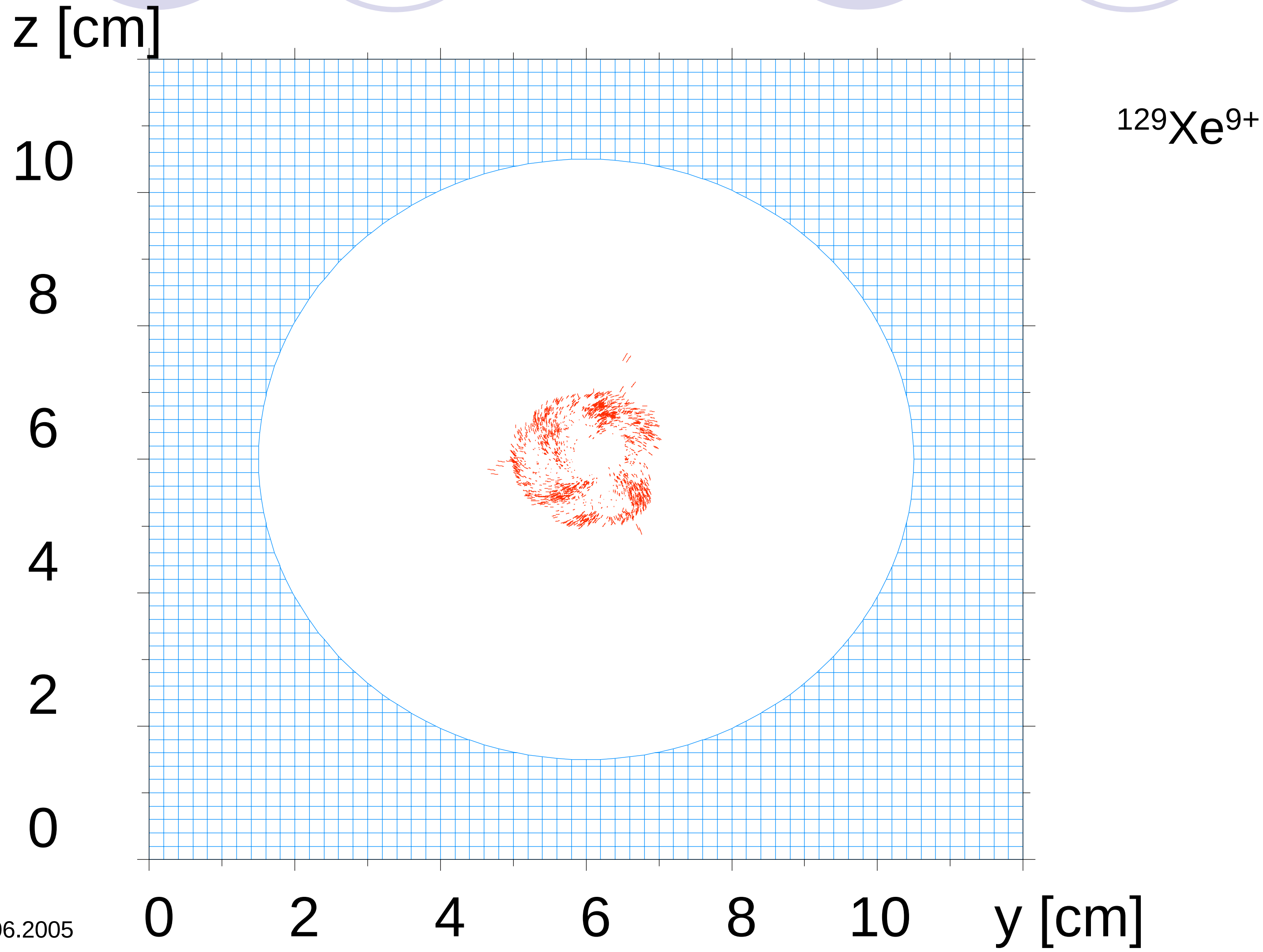


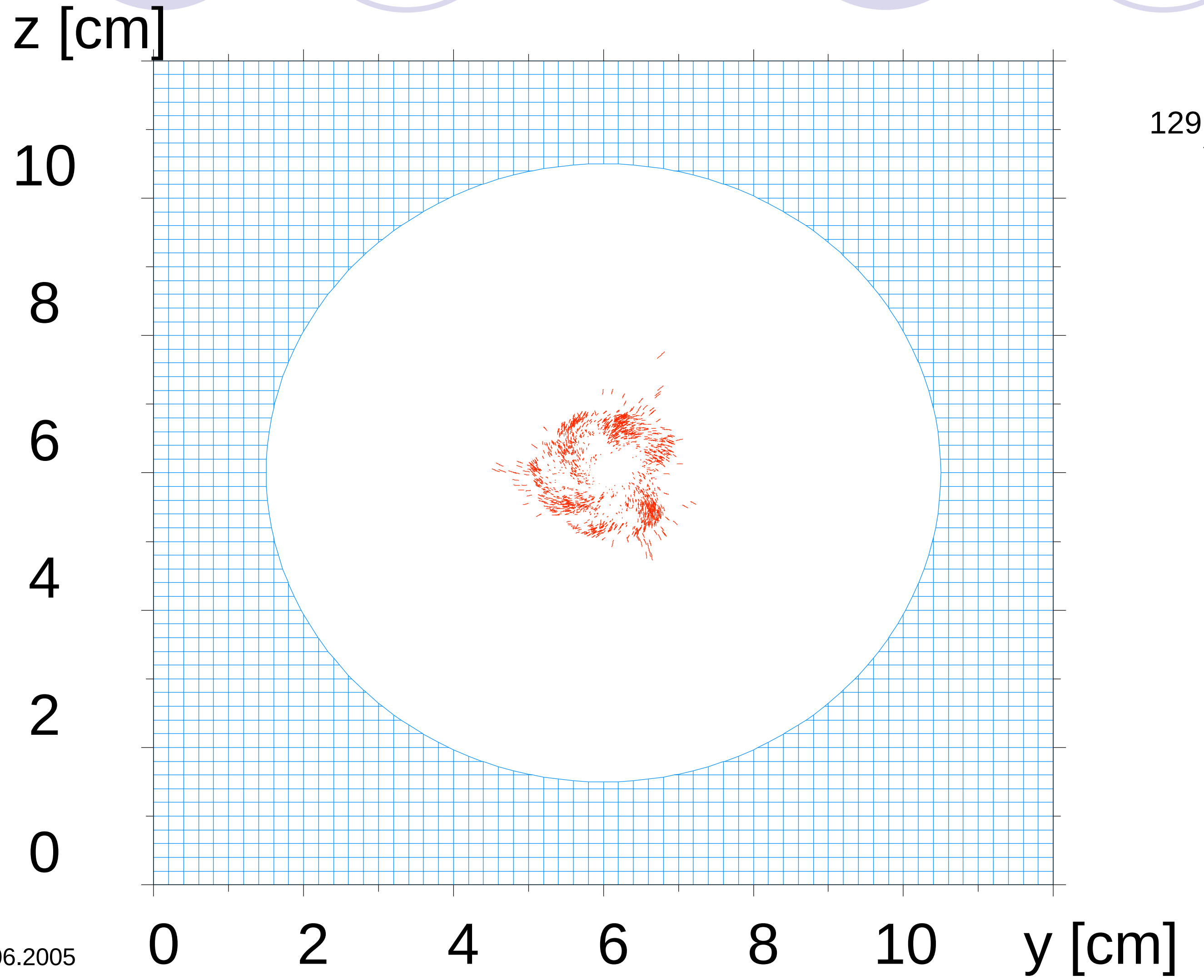
$^{18}O^{3+}$


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{18}O^{4+}$

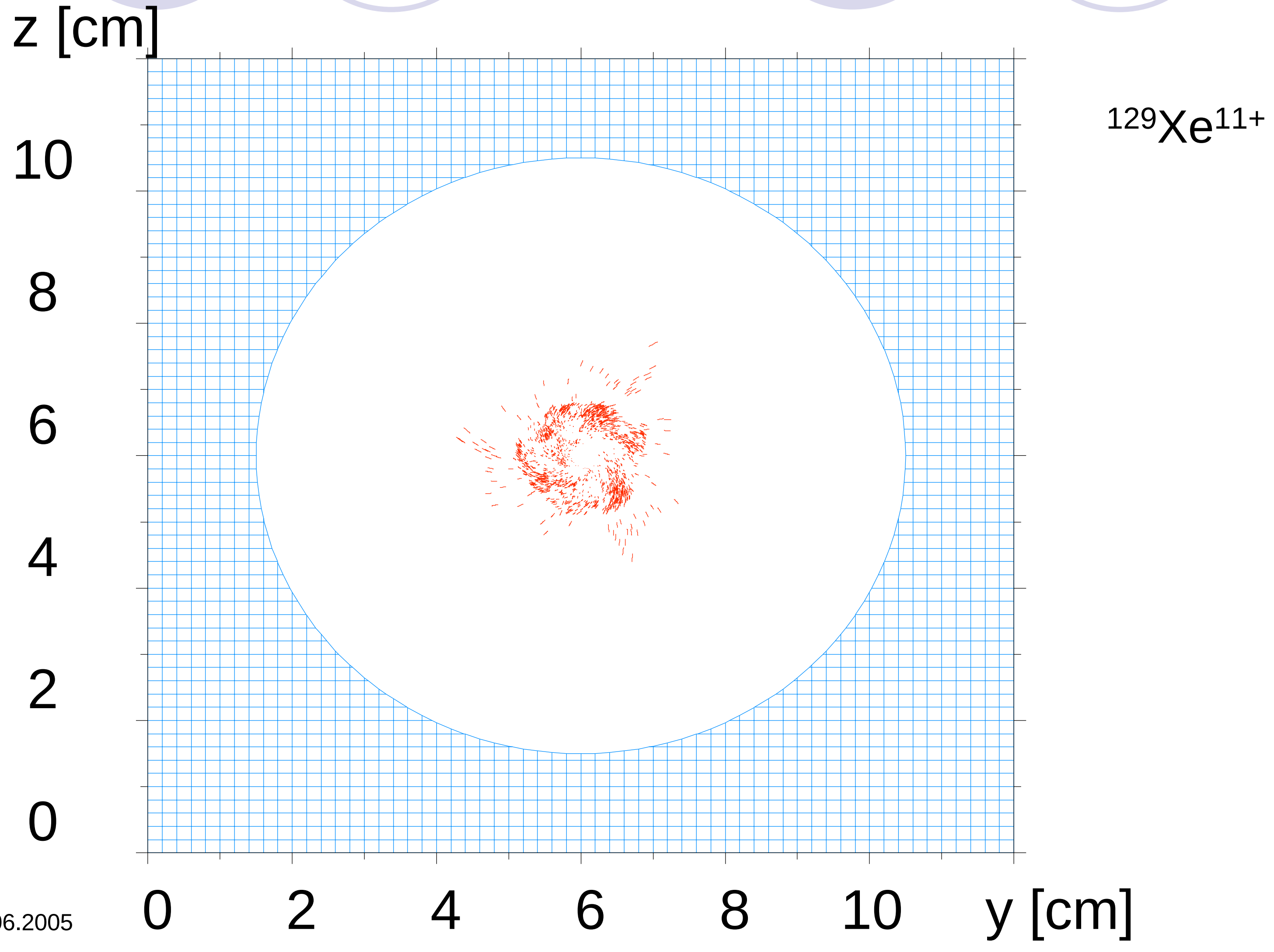

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{18}O^{5+}$

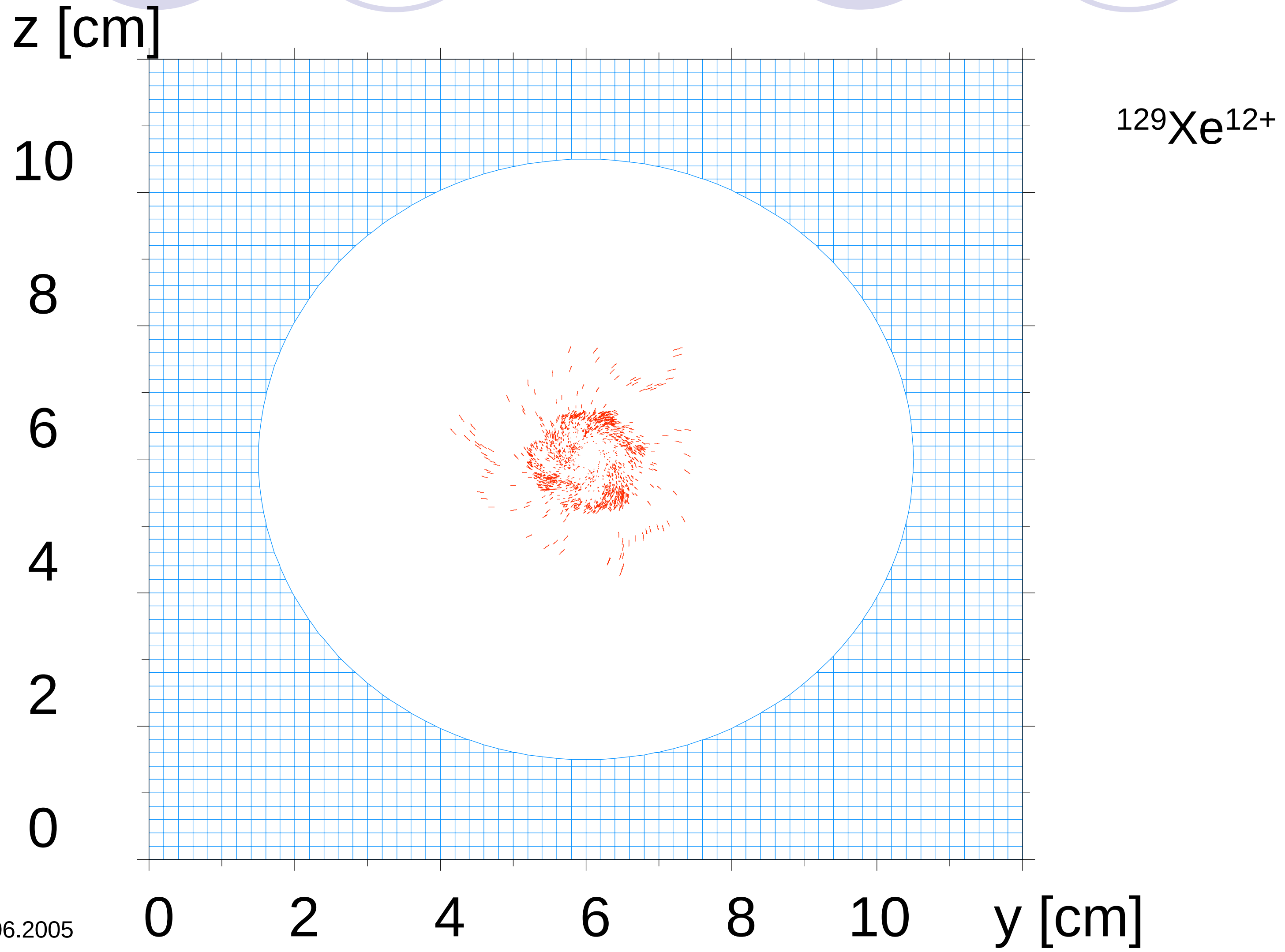

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{18}O^{6+}$


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{9+}$

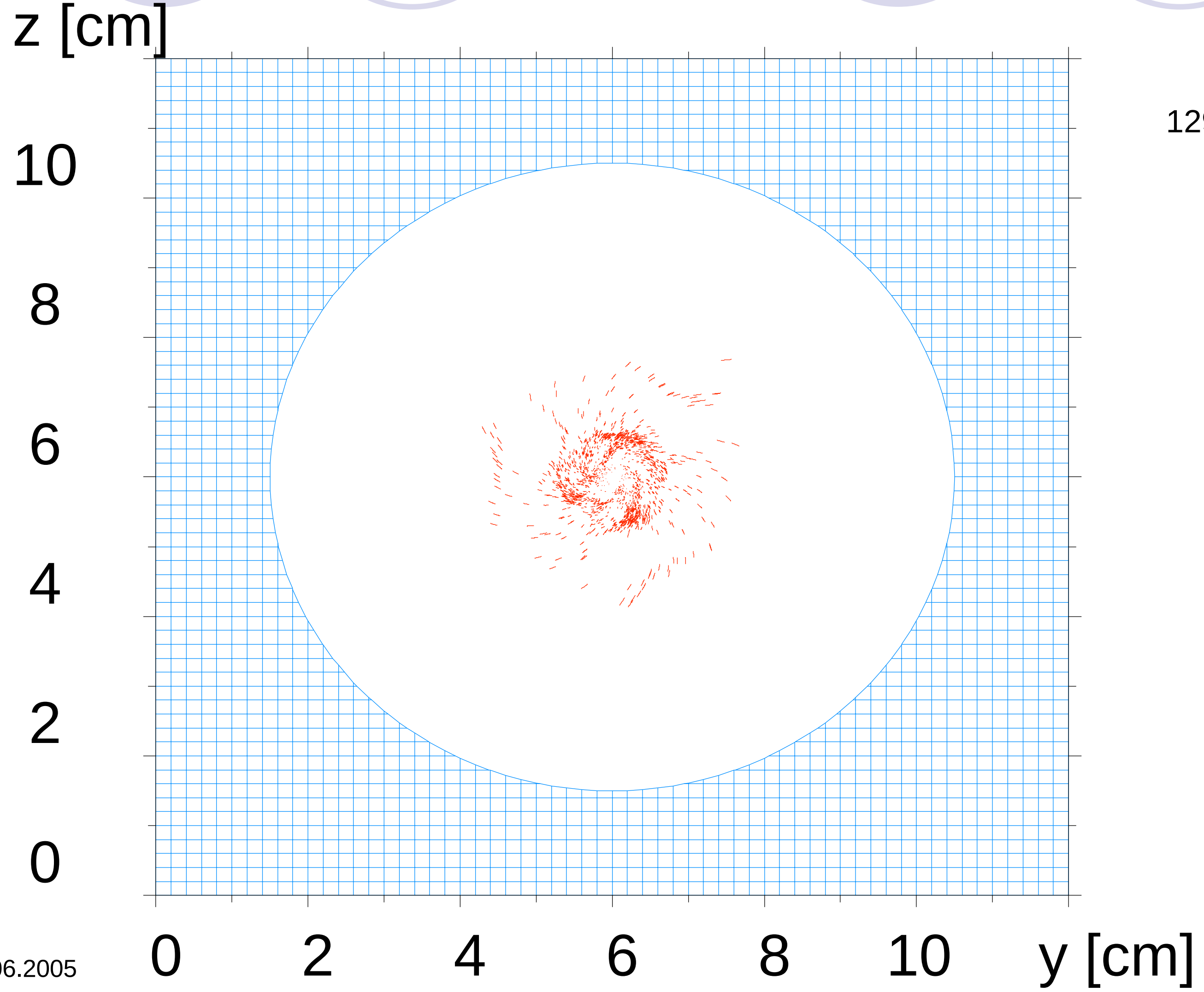


$^{129}Xe^{10+}$

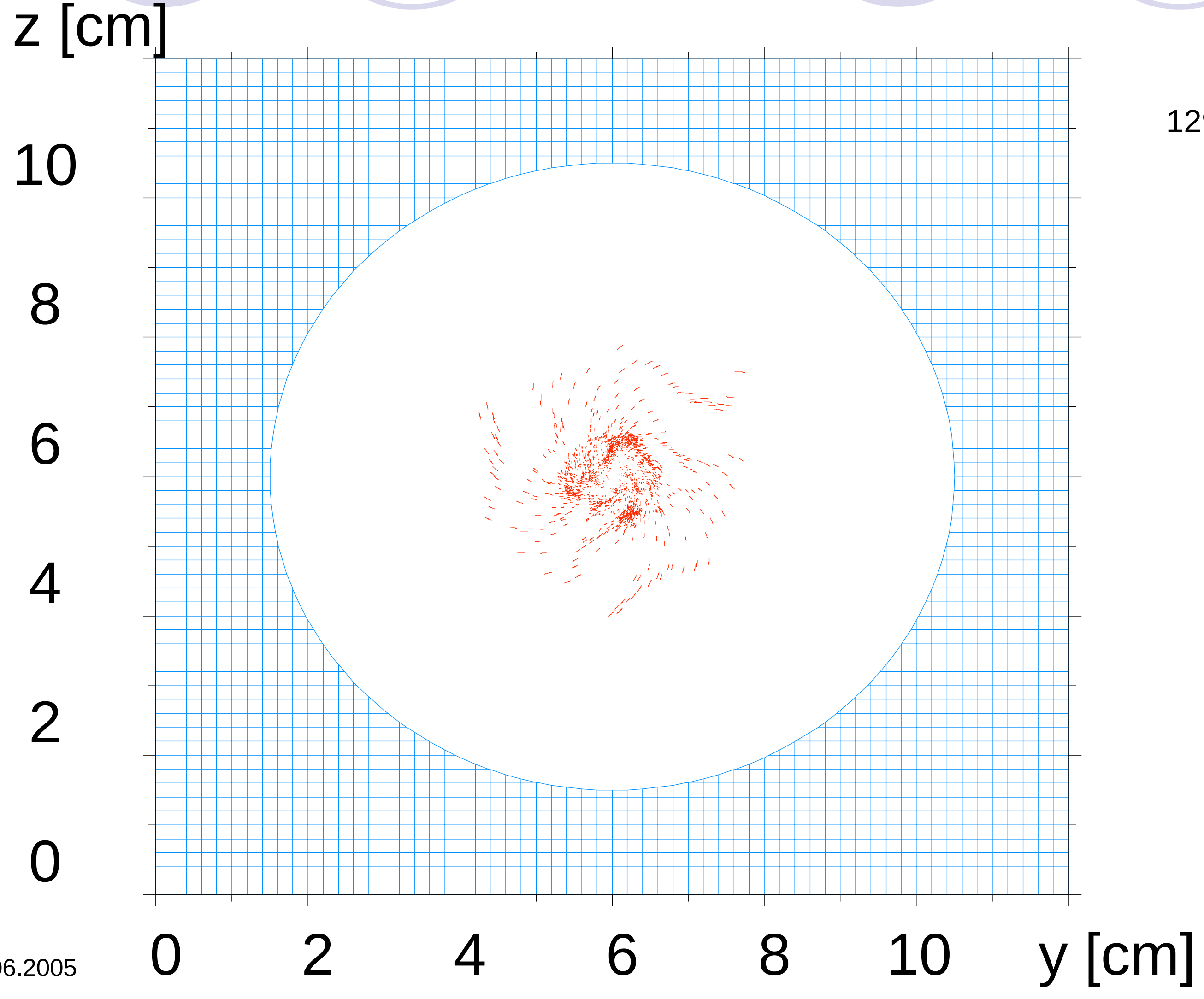

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{11+}$



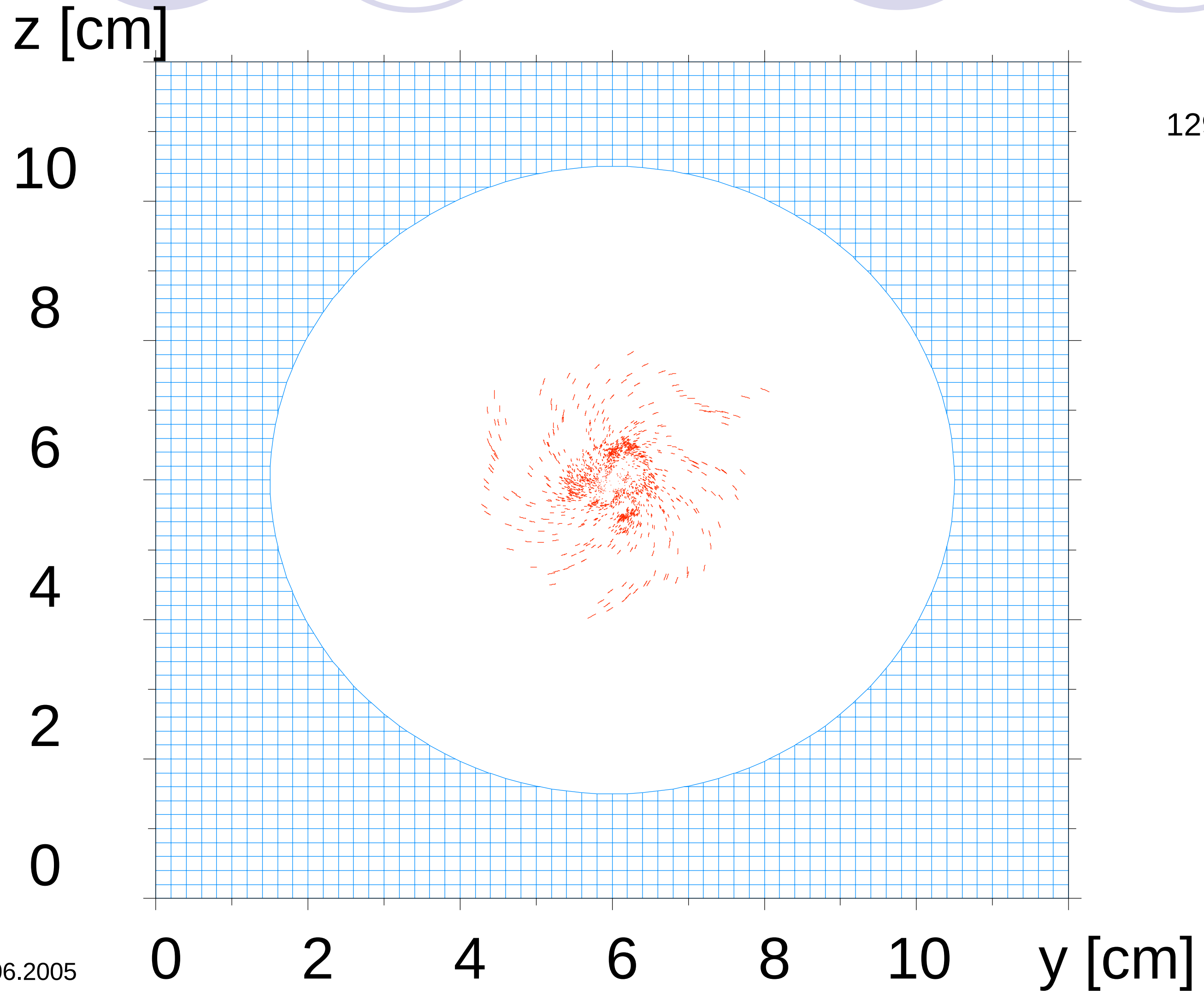
z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{12+}$



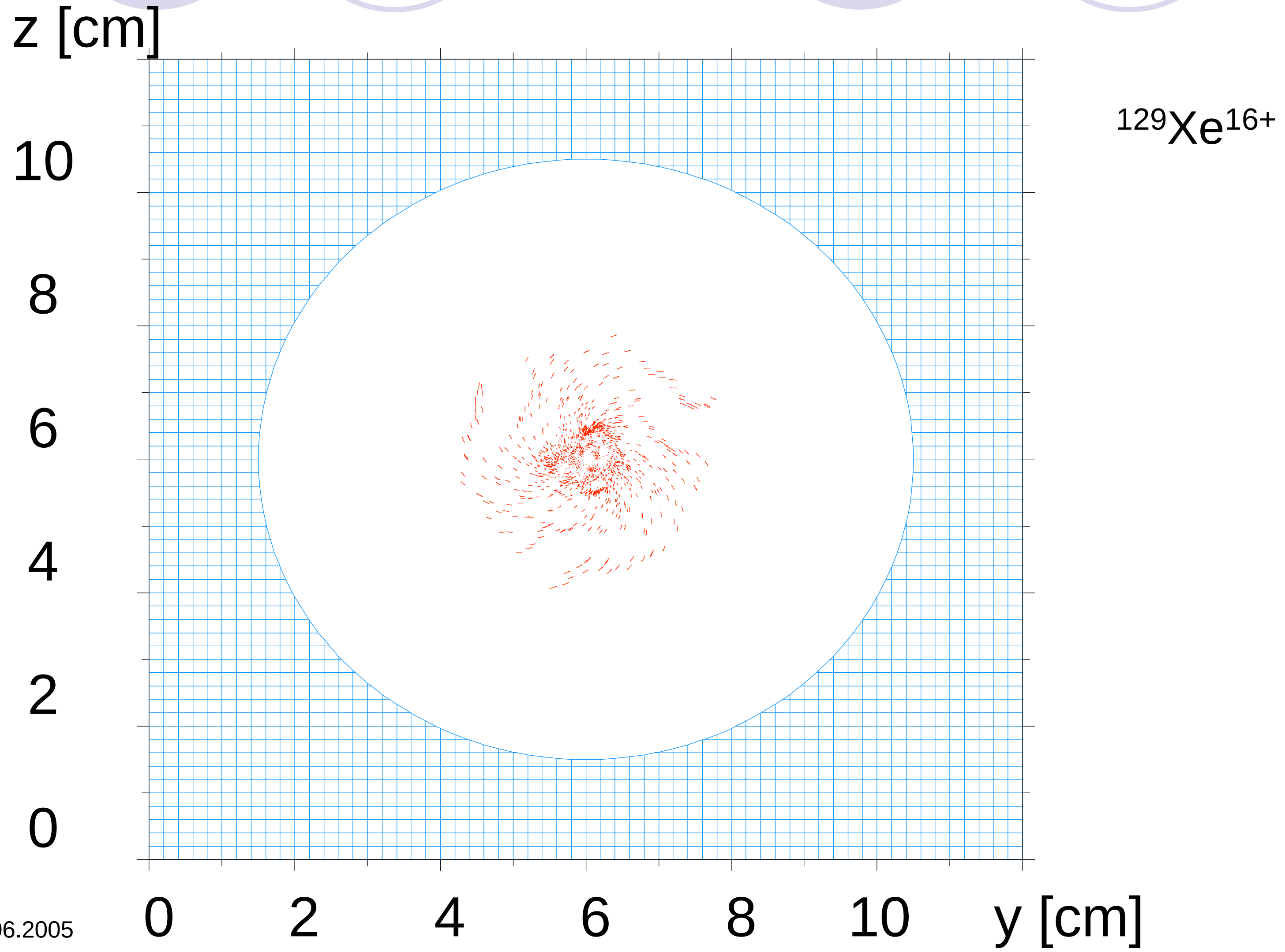
$^{129}Xe^{13+}$

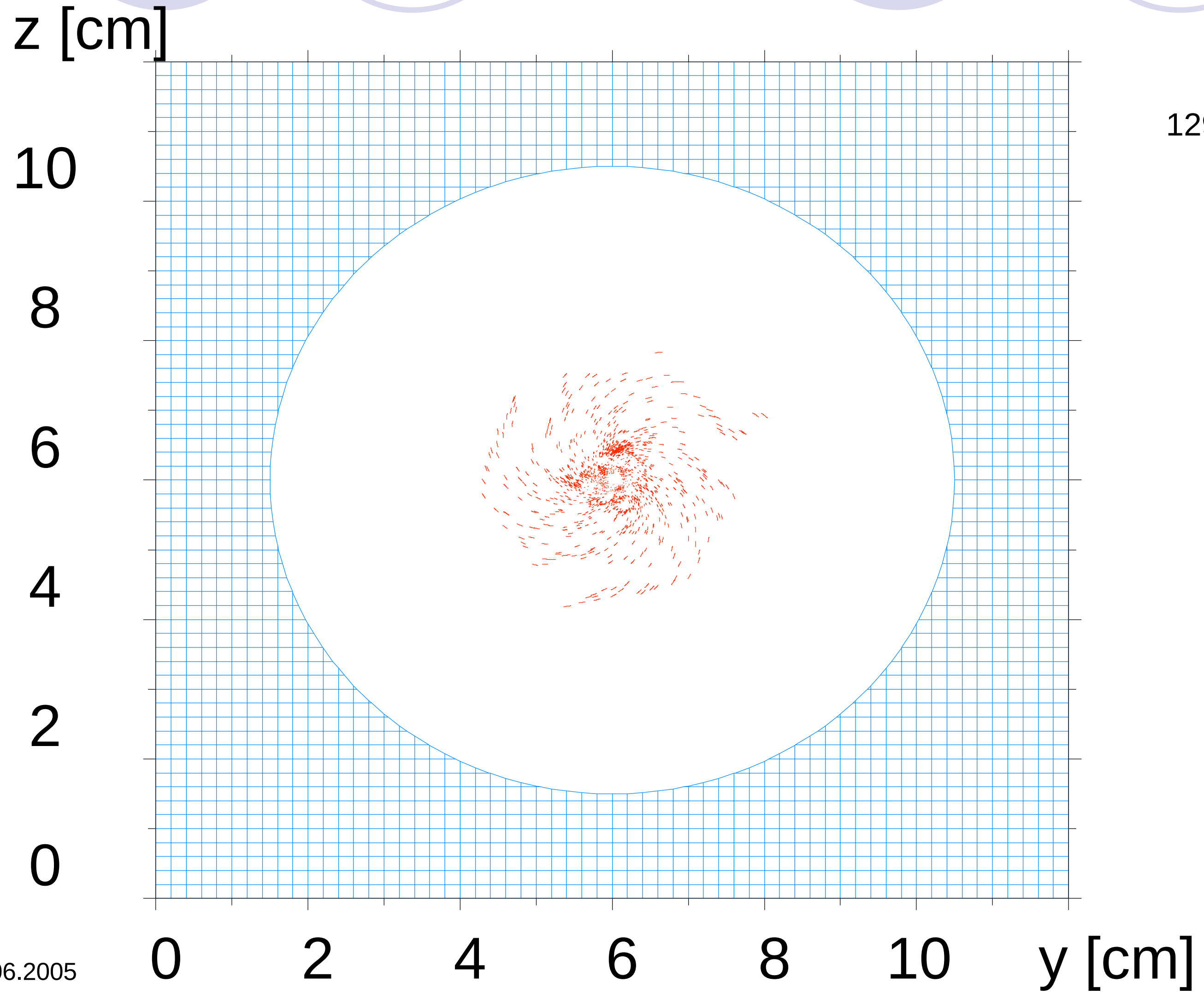


$^{129}Xe^{14+}$

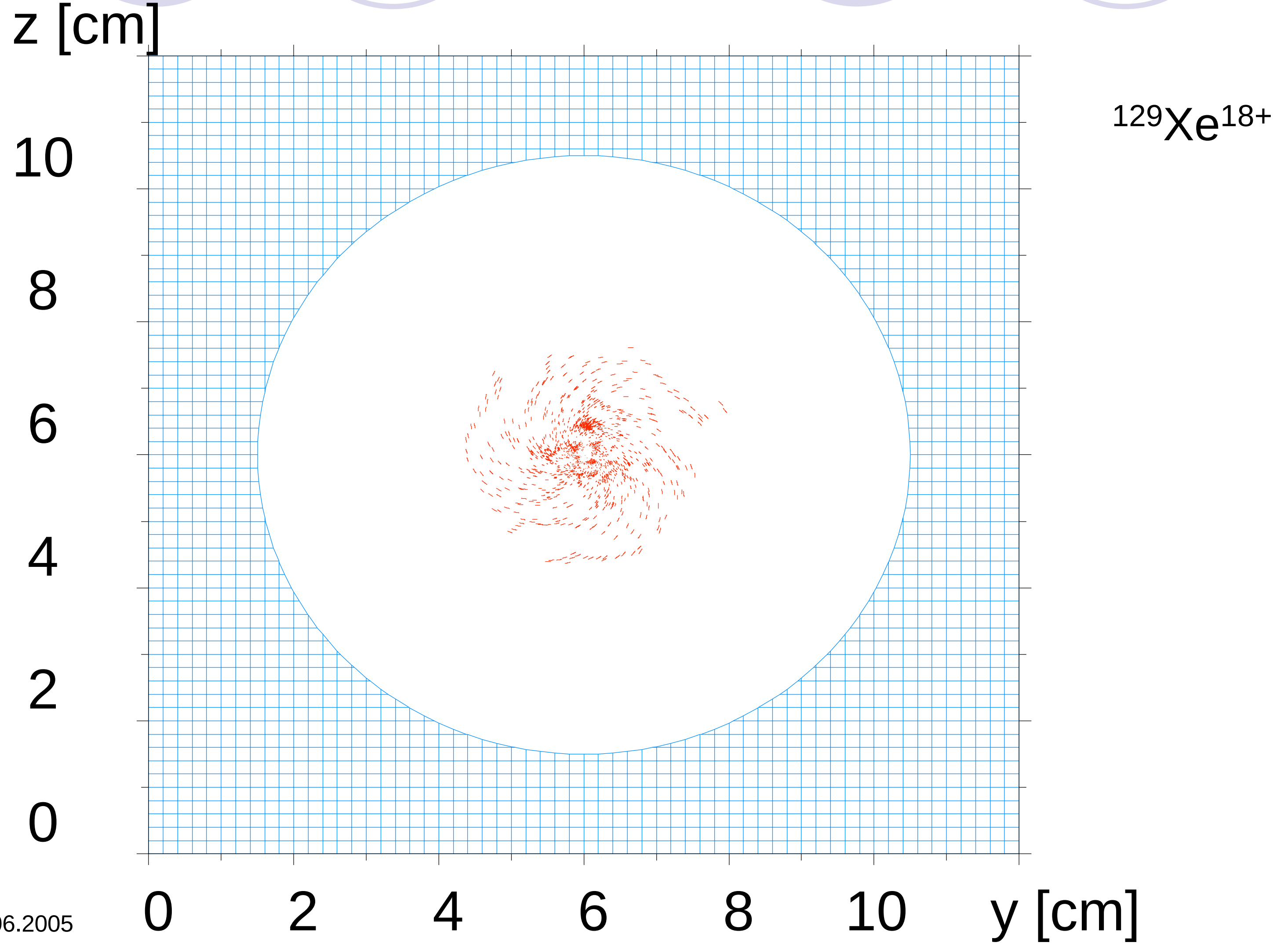


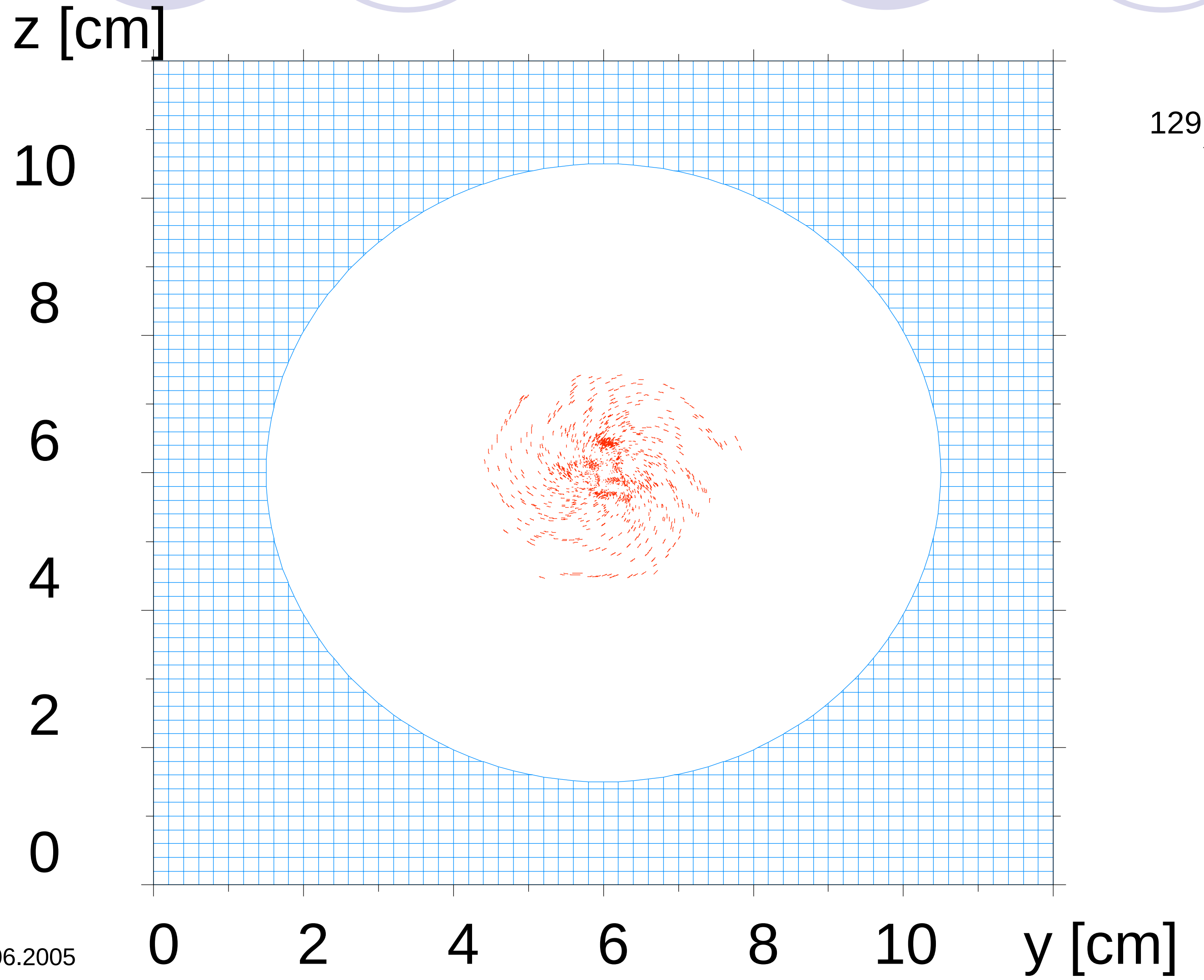
$^{129}Xe^{15+}$


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{16+}$

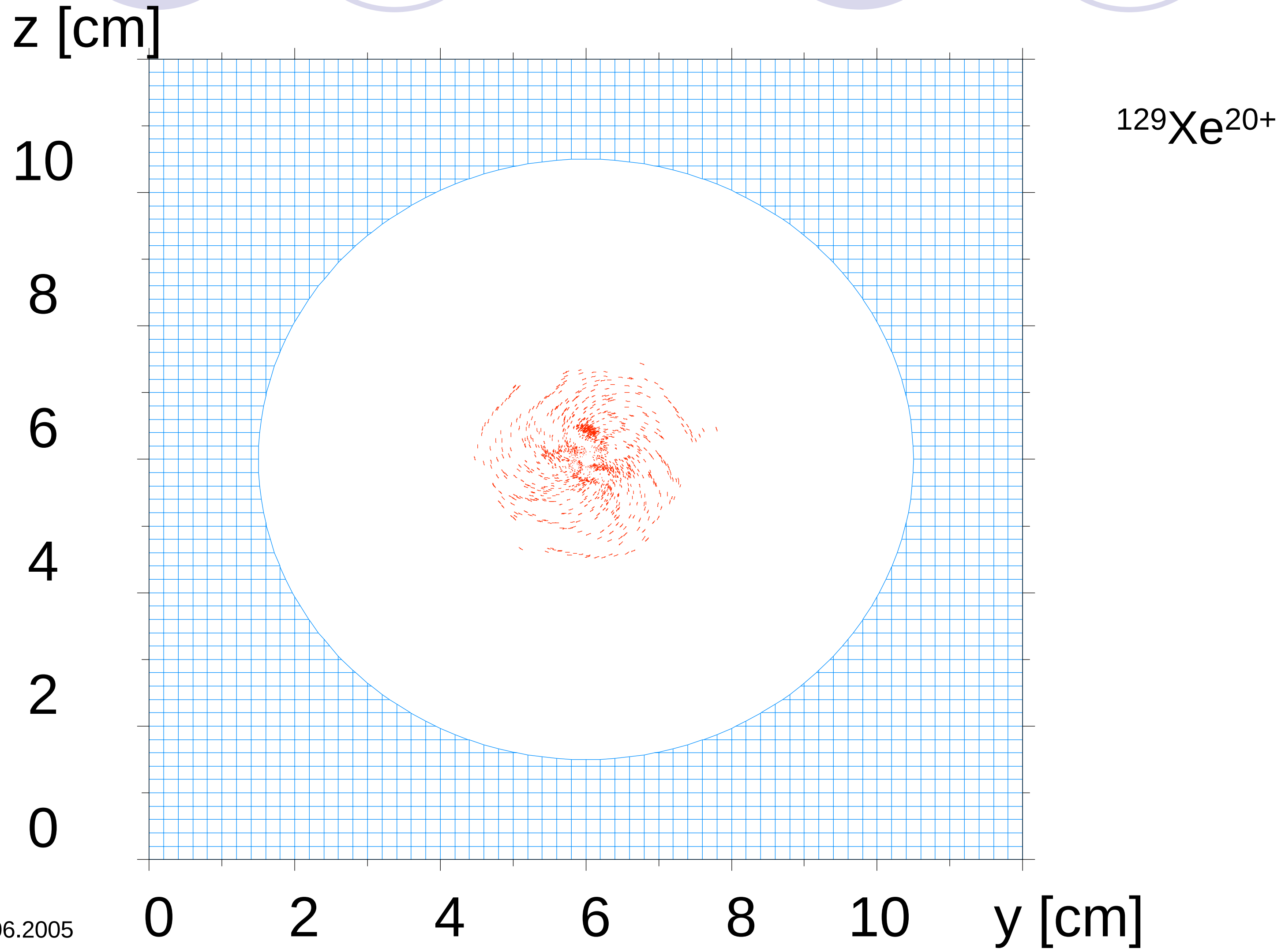


$^{129}Xe^{17+}$


z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{18+}$



$^{129}Xe^{19+}$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4
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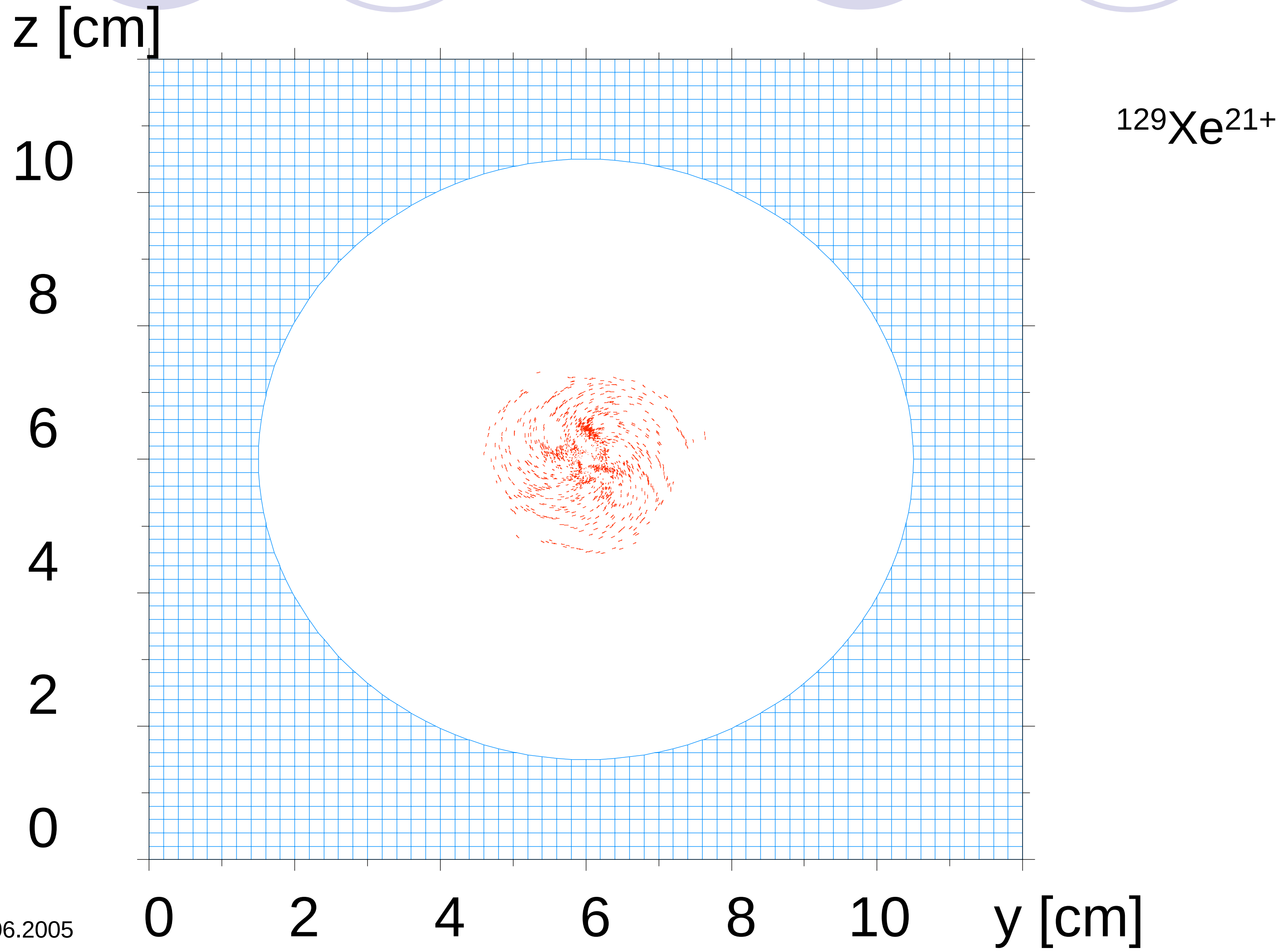
2
4
6
8
10
y [cm]
$^{129}Xe^{20+}$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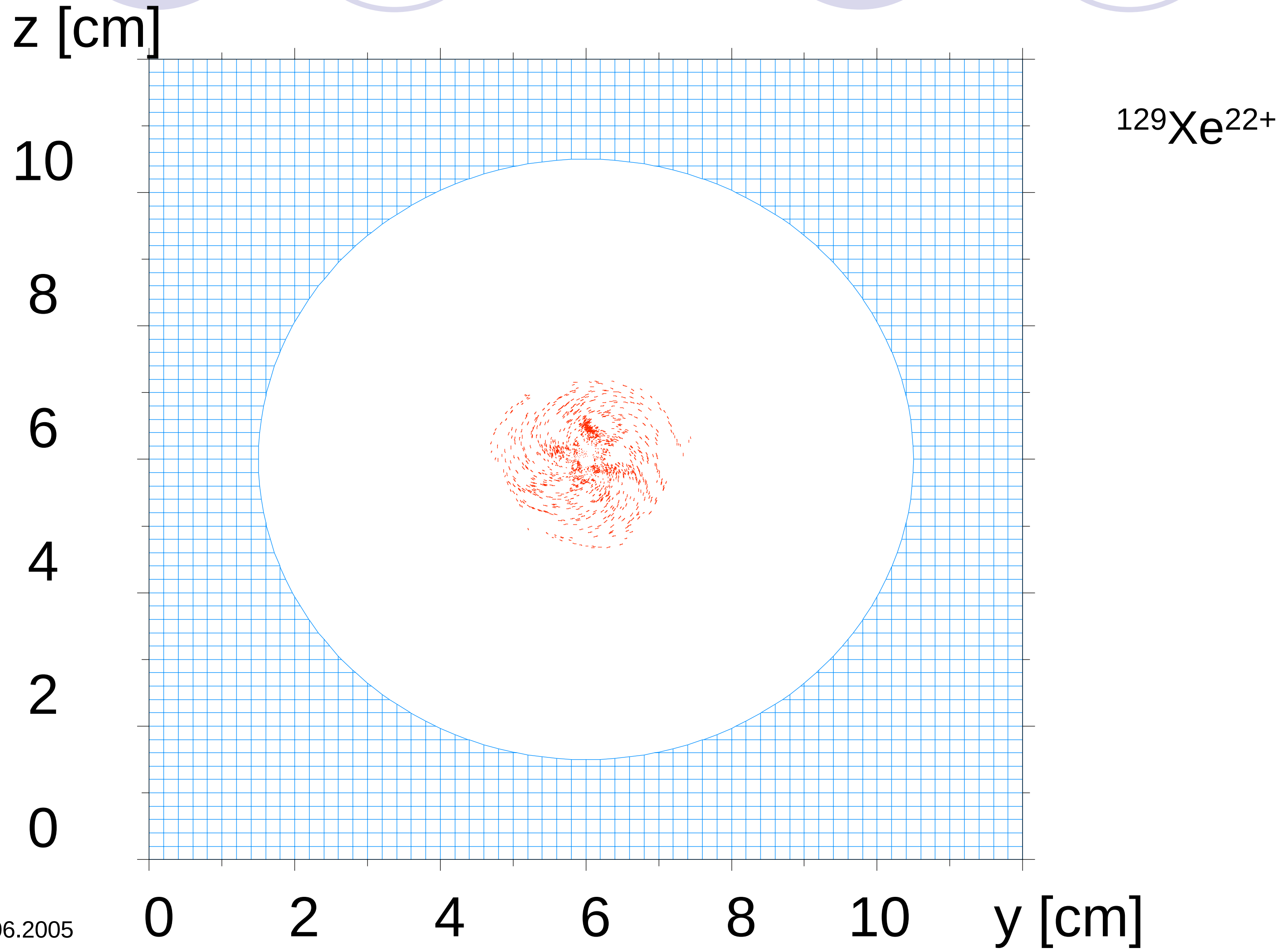
4
6
8
10
y [cm]
$^{129}Xe^{21+}$


z [cm]
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8
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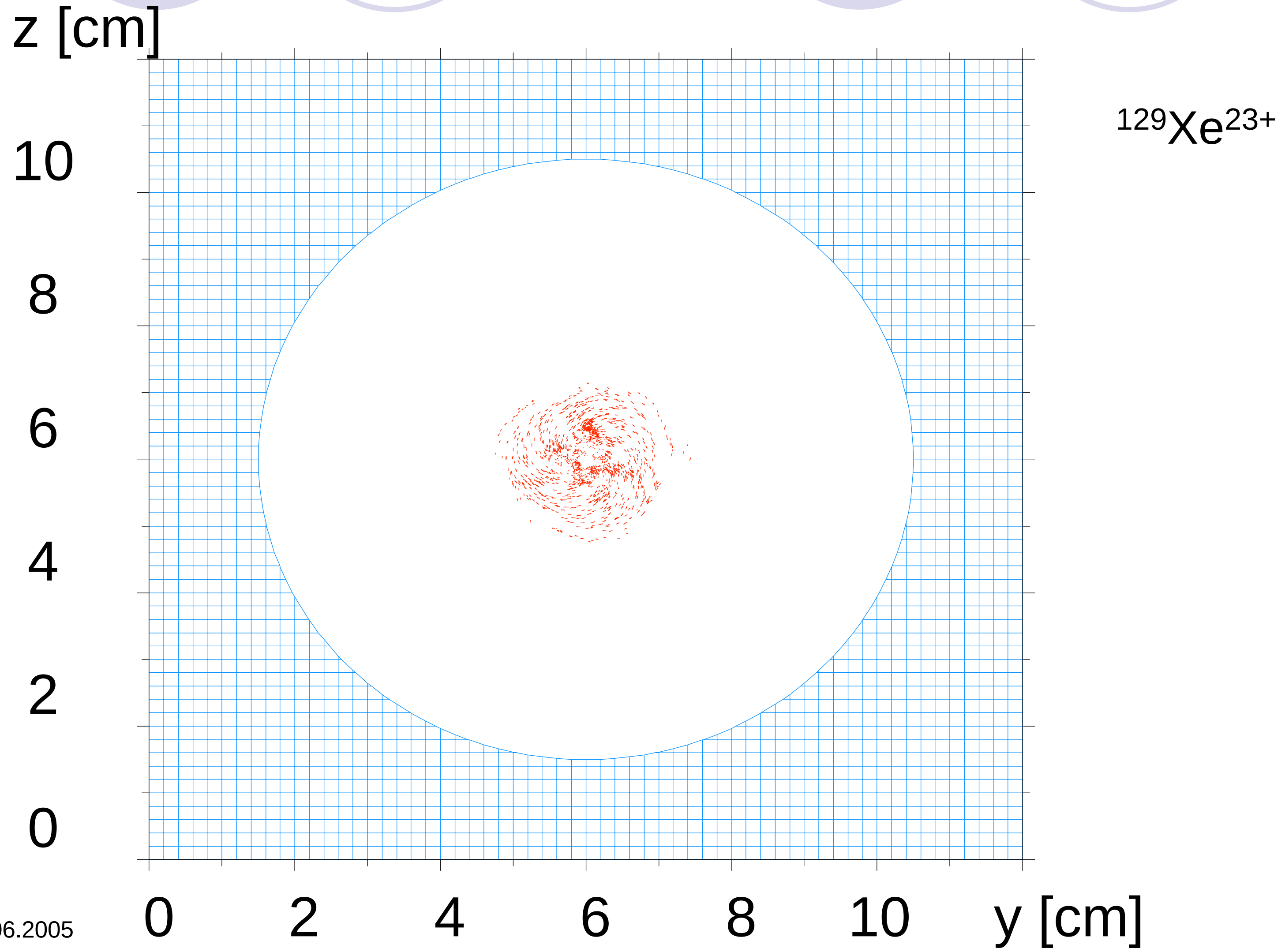
y [cm]
$^{129}Xe^{22+}$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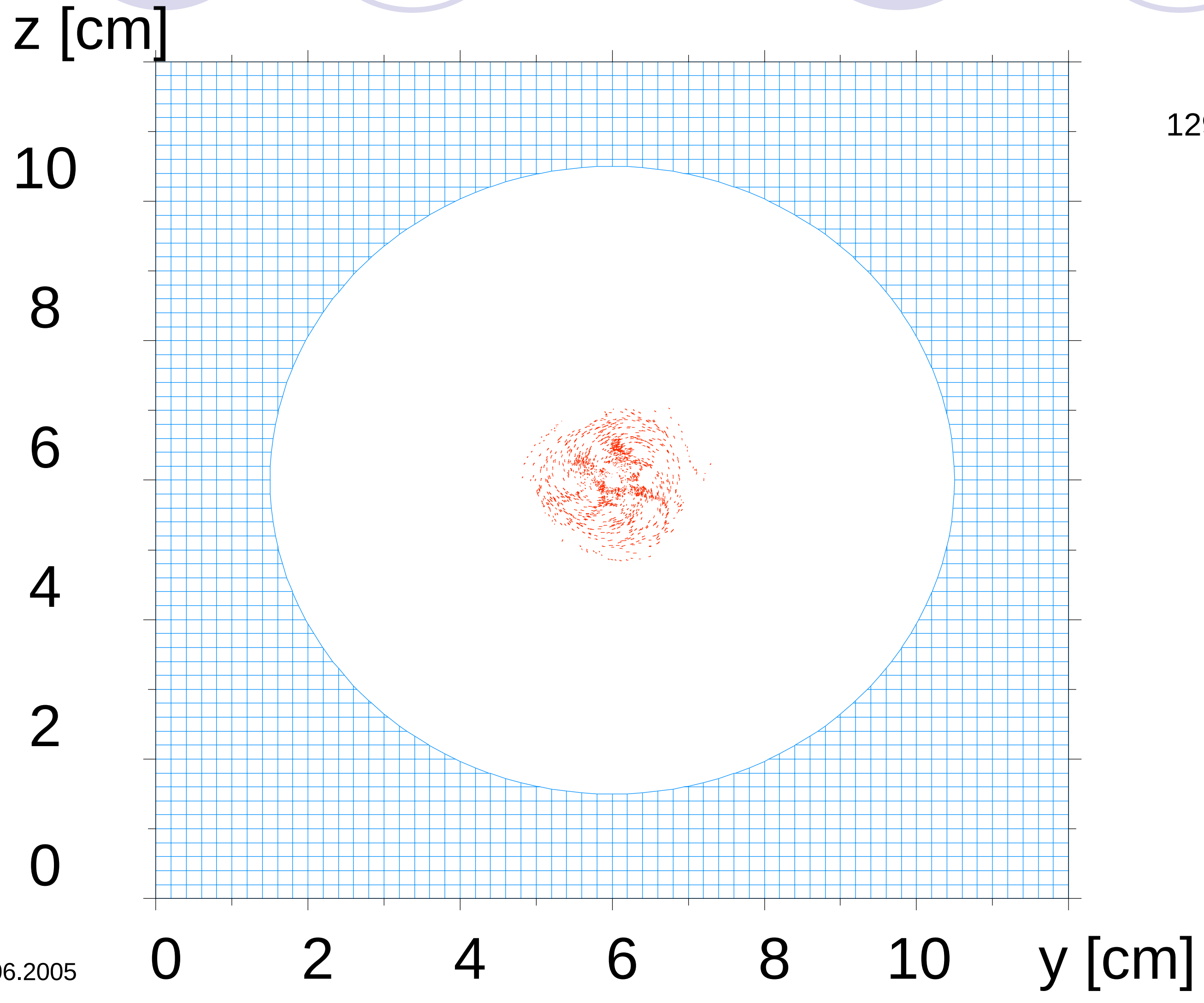
8
10
y [cm]
$^{129}Xe^{23+}$


z [cm]
10
8
6
4
2
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0
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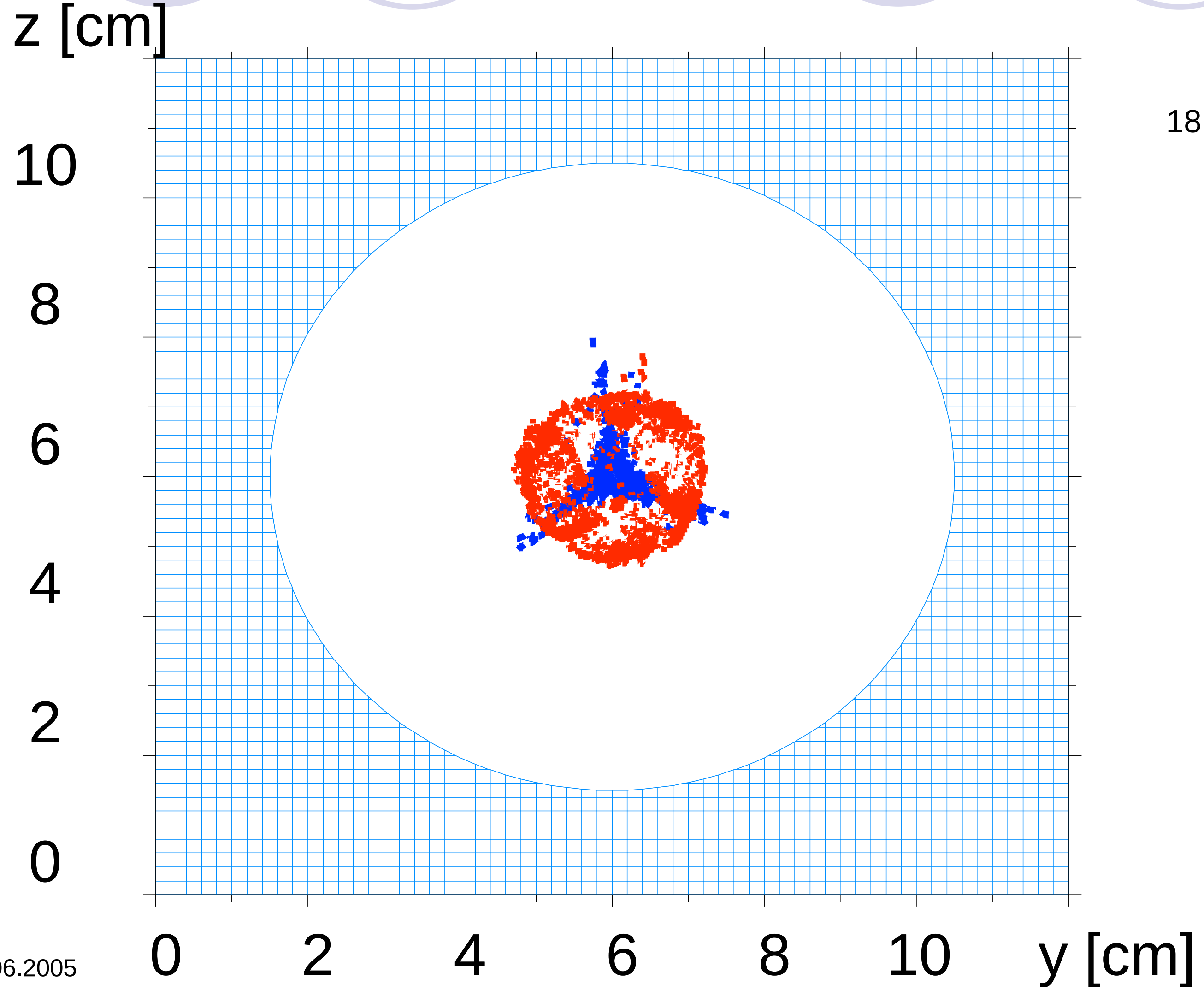
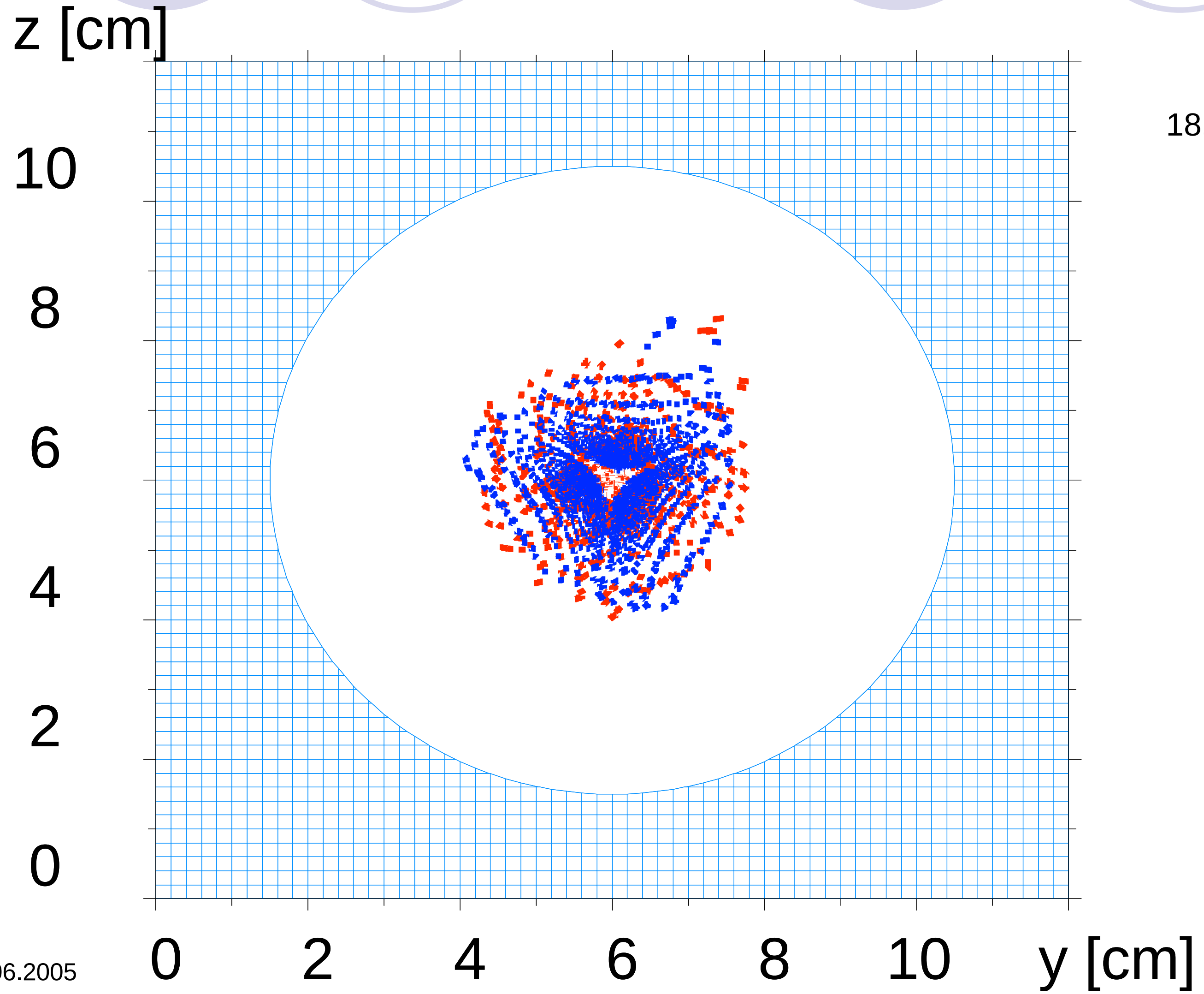
4
6
8
10
y [cm]
$^{129}Xe^{24+}$

to compare both solutions, the different cases are shown simultaneously:

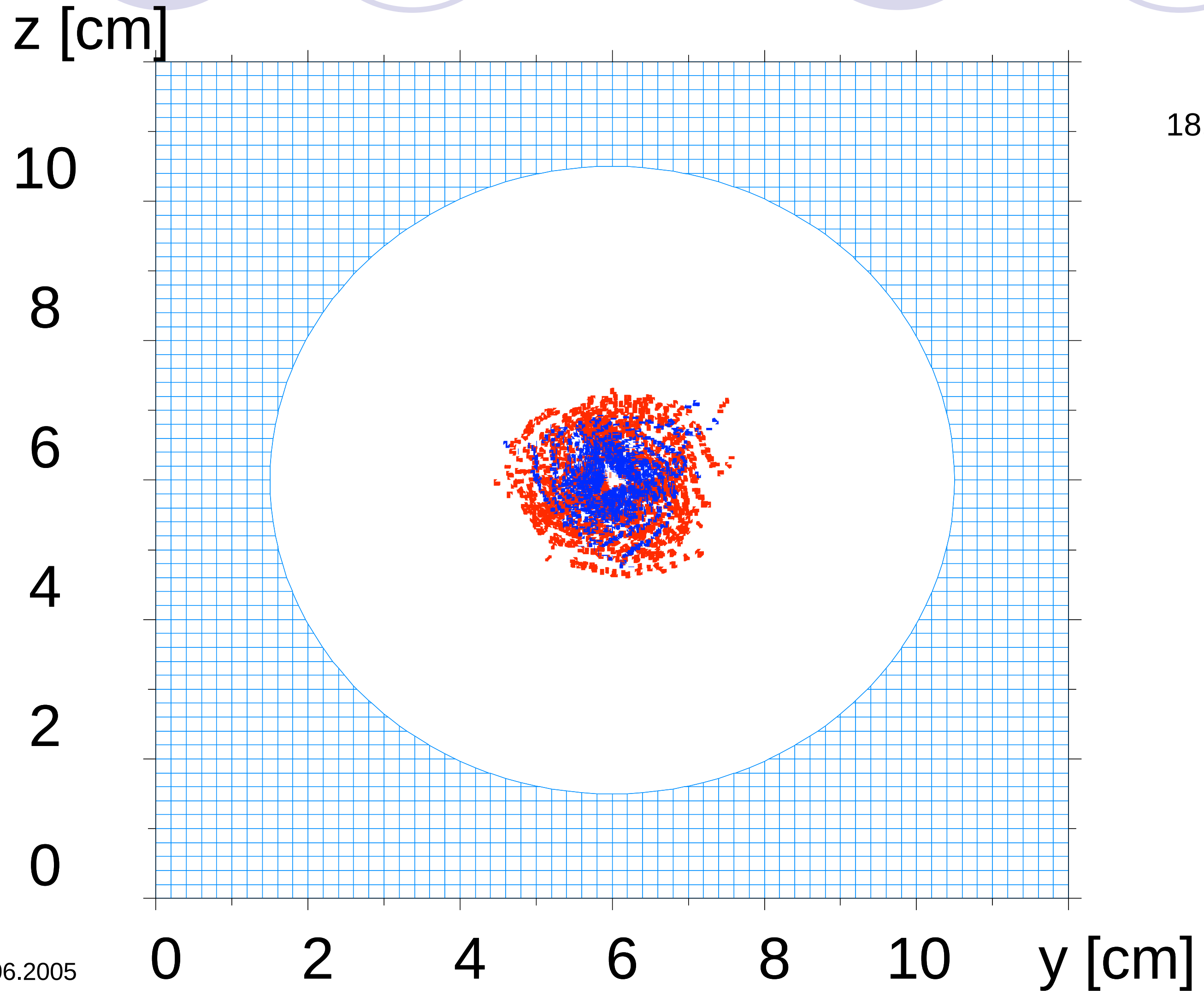
blue: 0 mA
red: 16 mA



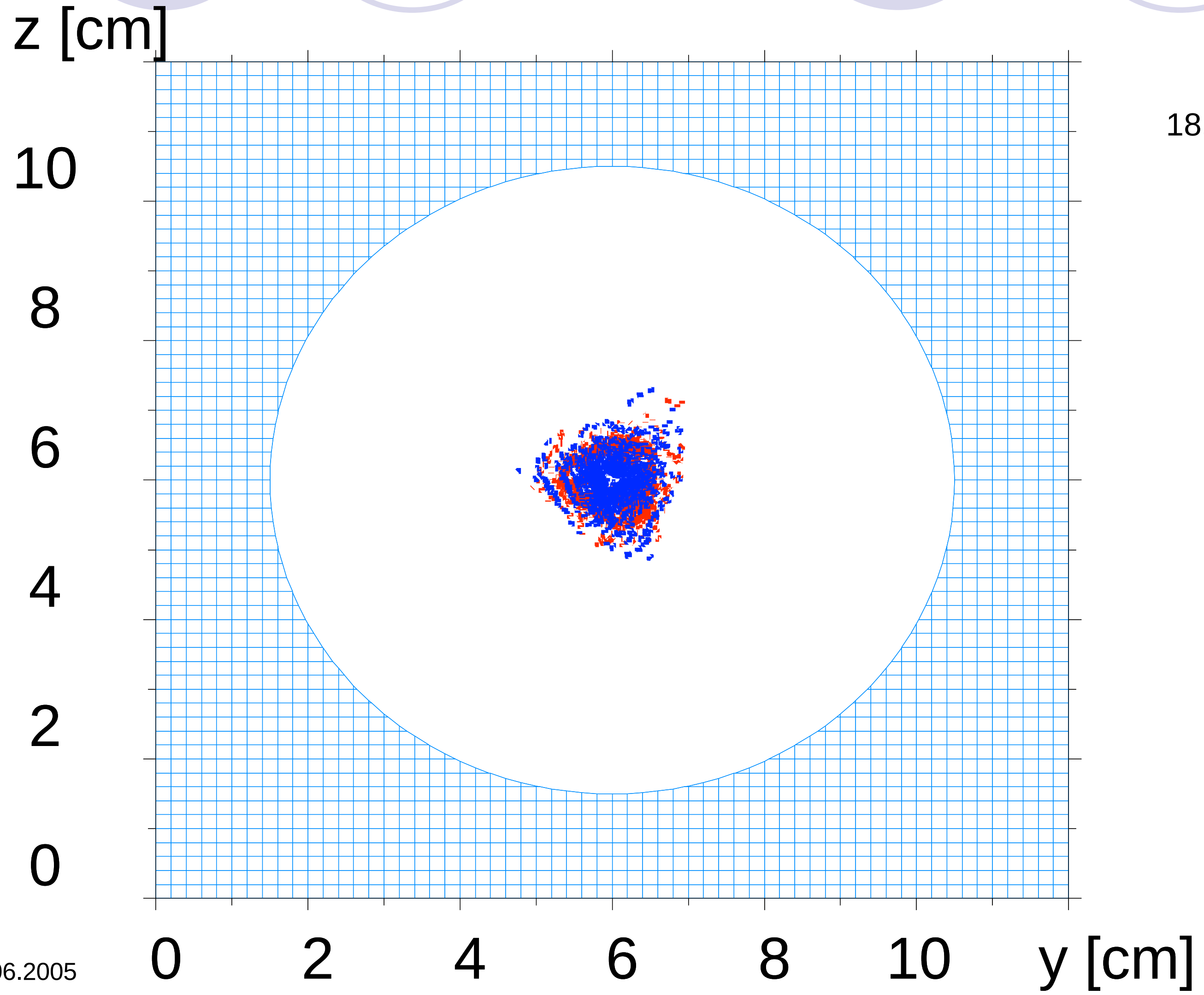
$^{18}O^{1+}$



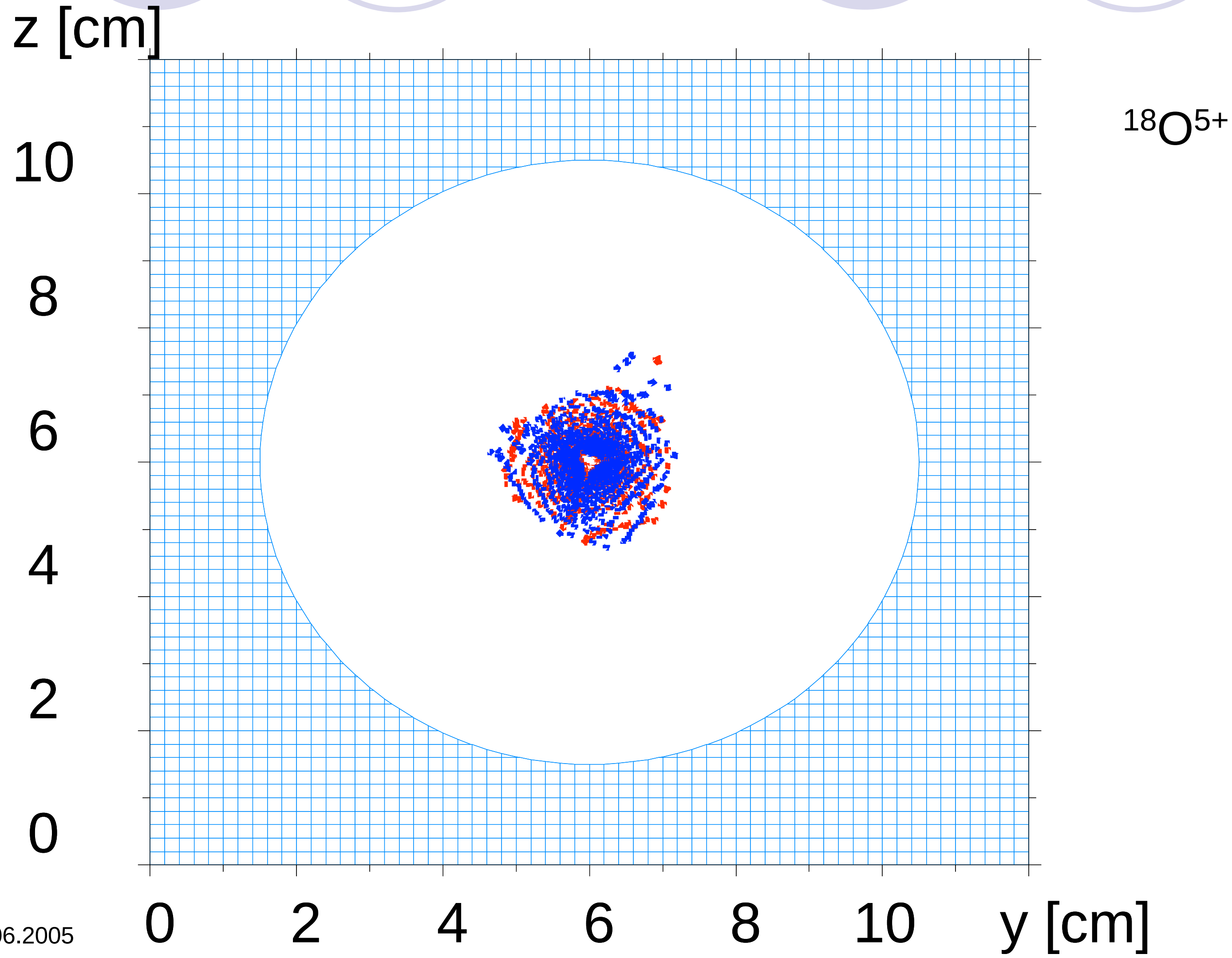
$^{18}O^{2+}$



$^{18}O^{3+}$



$^{18}O^{4+}$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2
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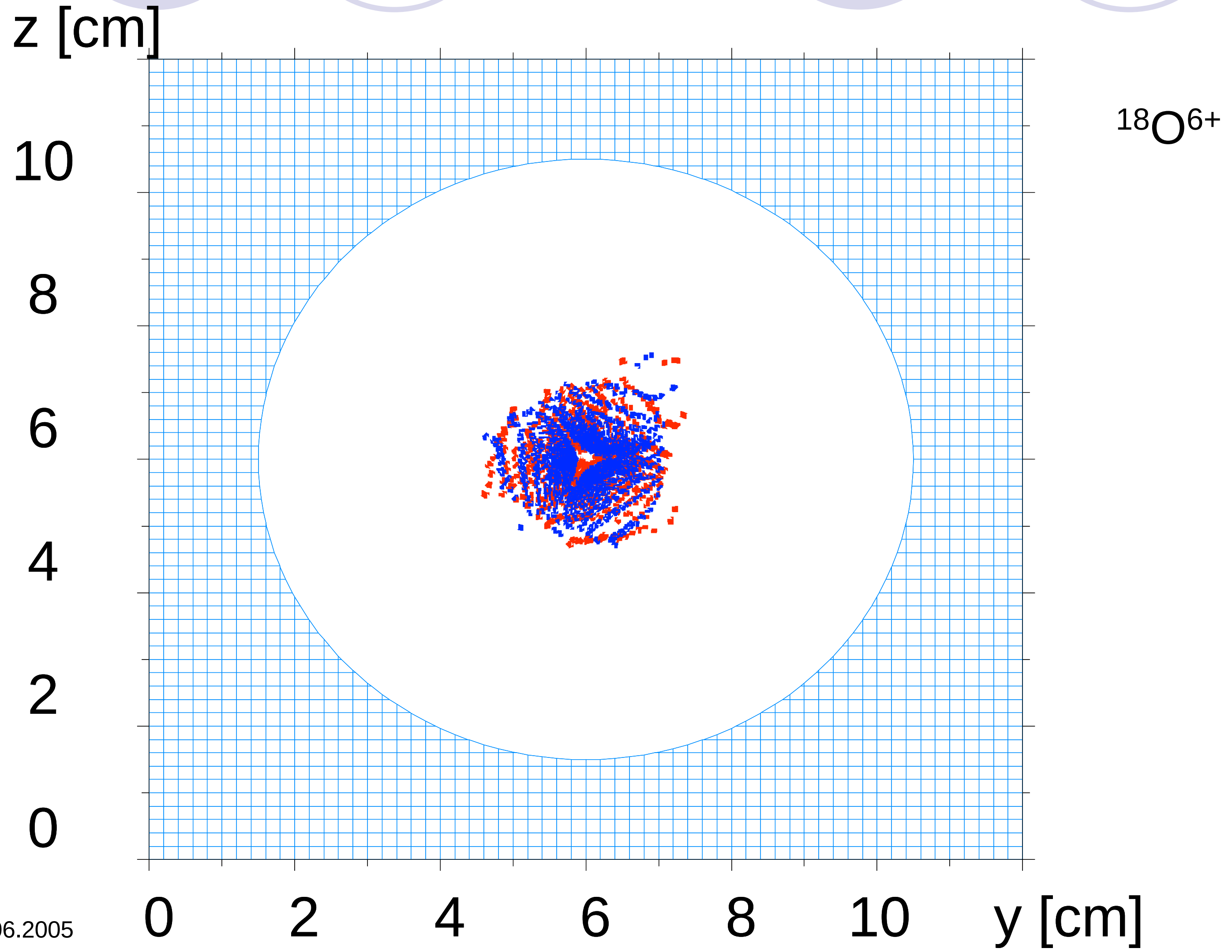
0
2
4
6
8
10
y [cm]
$^{18}O^{5+}$



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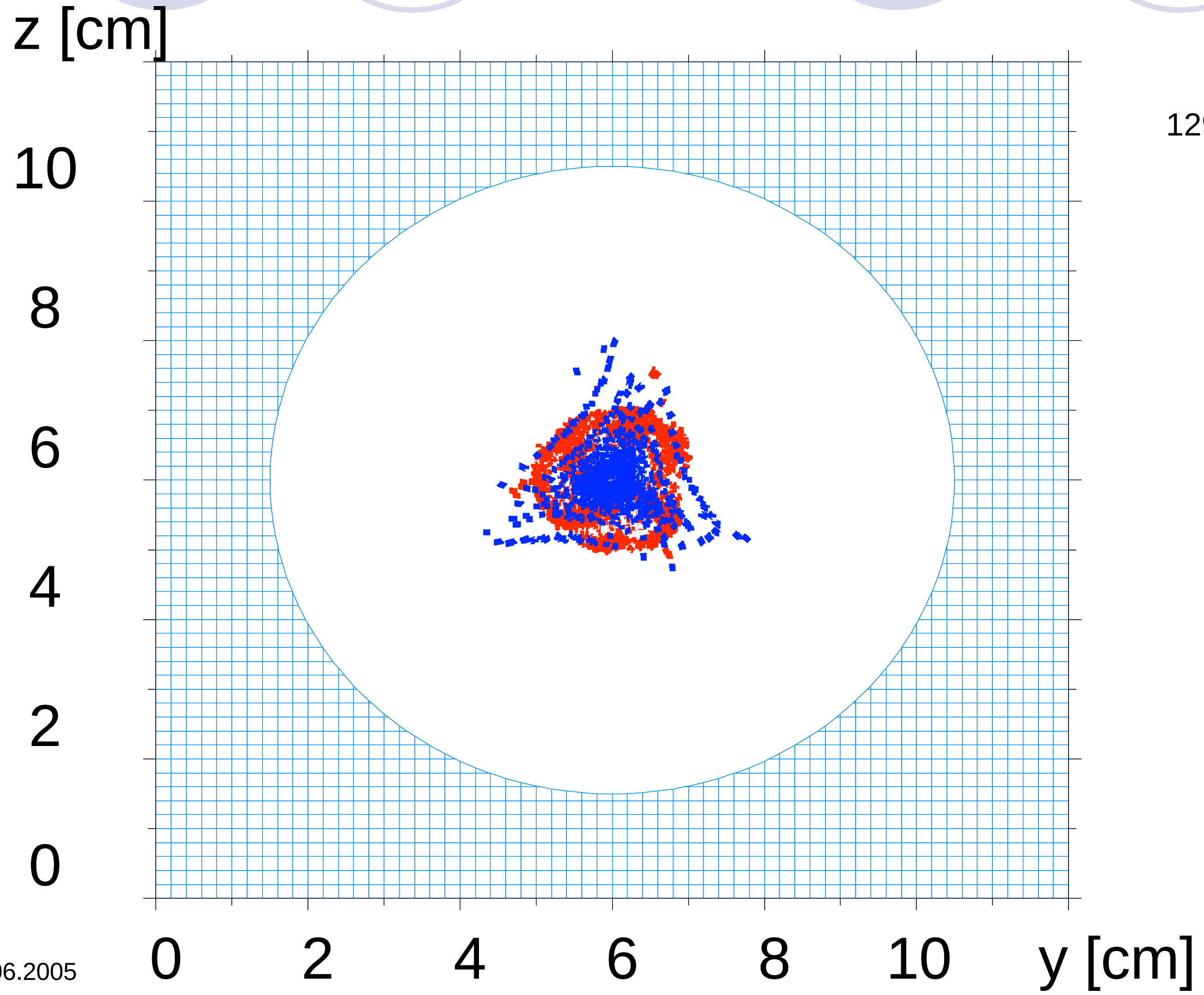
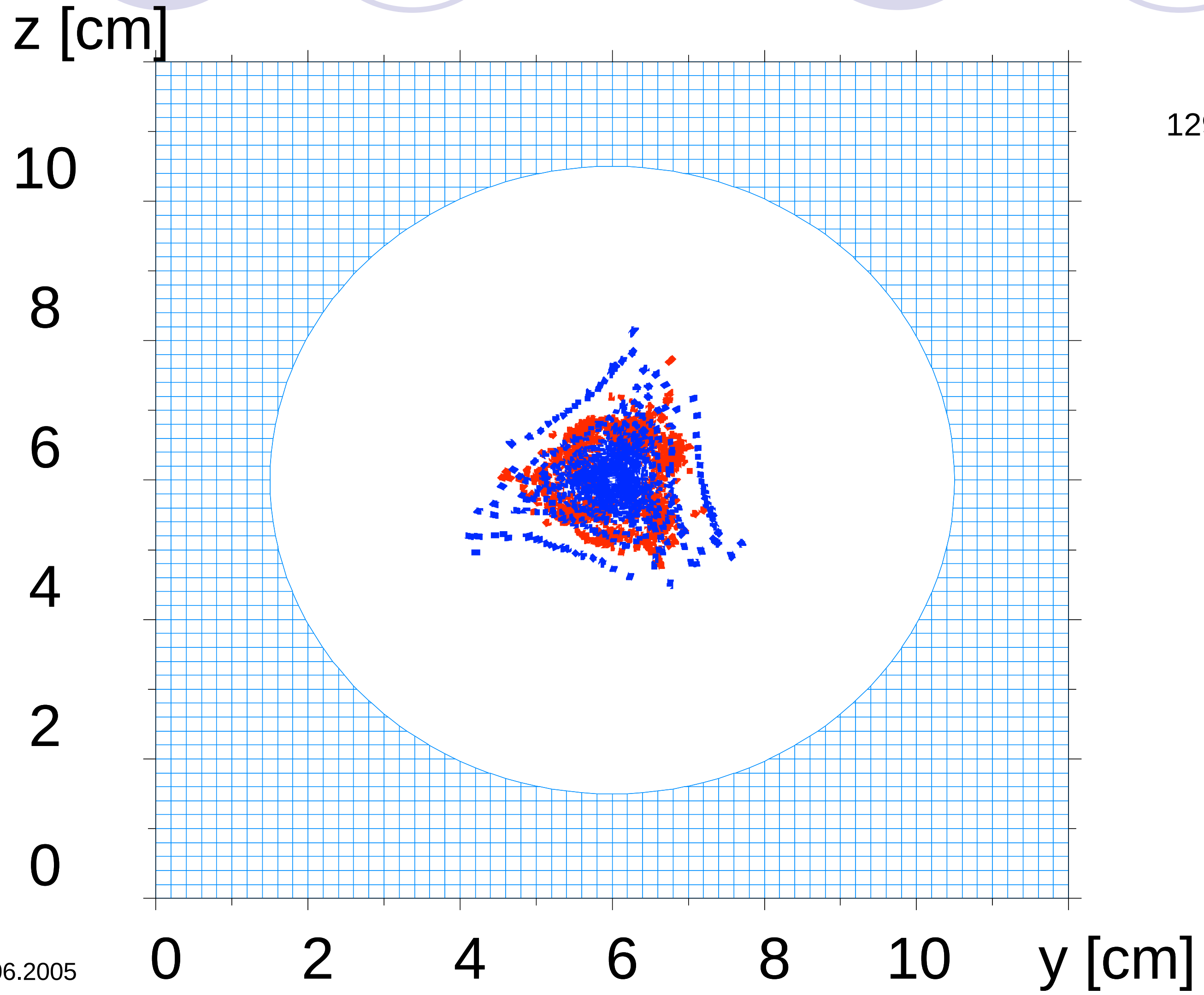
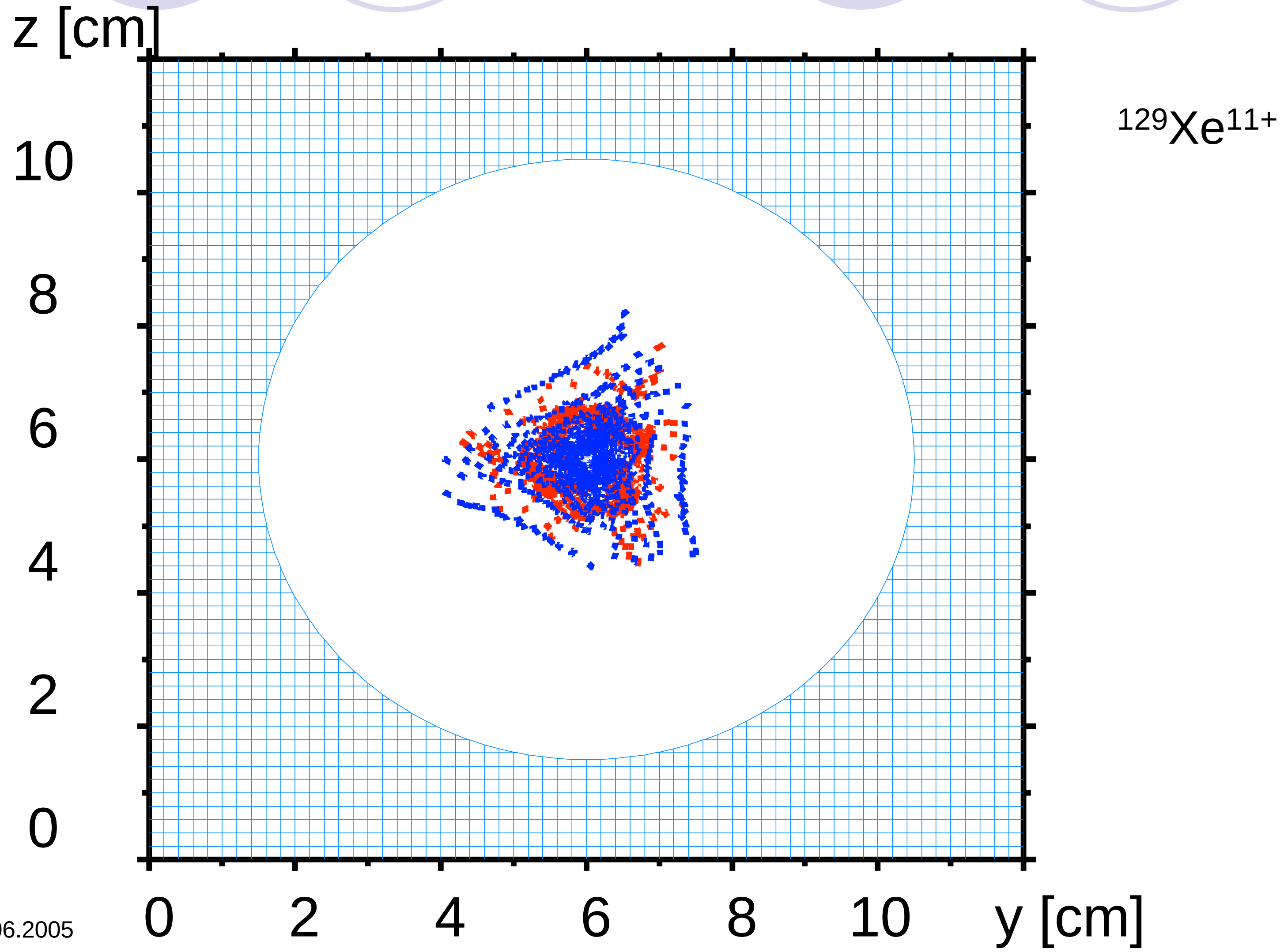
4
6
8
10
y [cm]
$^{18}O^{6+}$



$^{129}Xe^{9+}$



$^{129}Xe^{10+}$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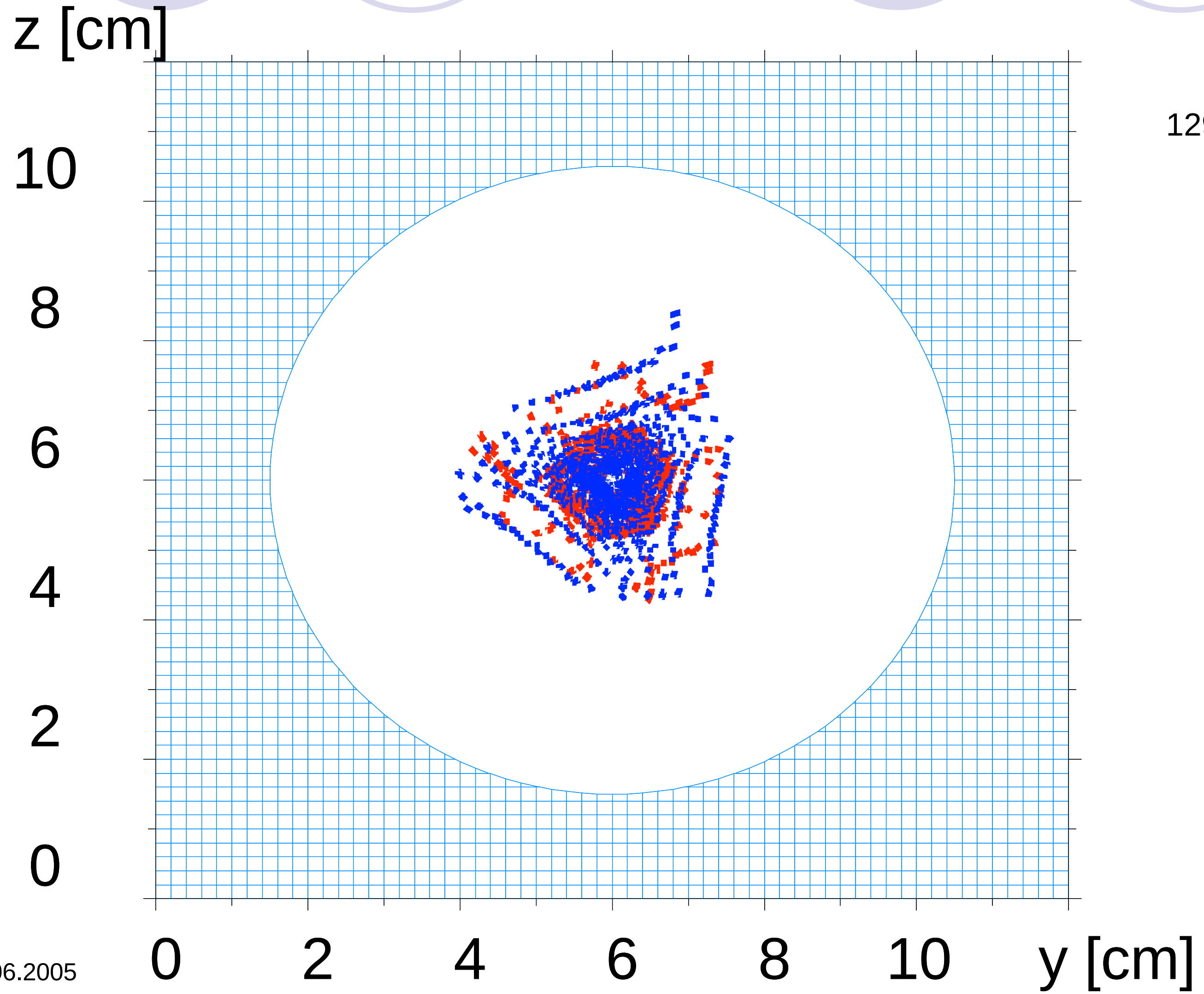
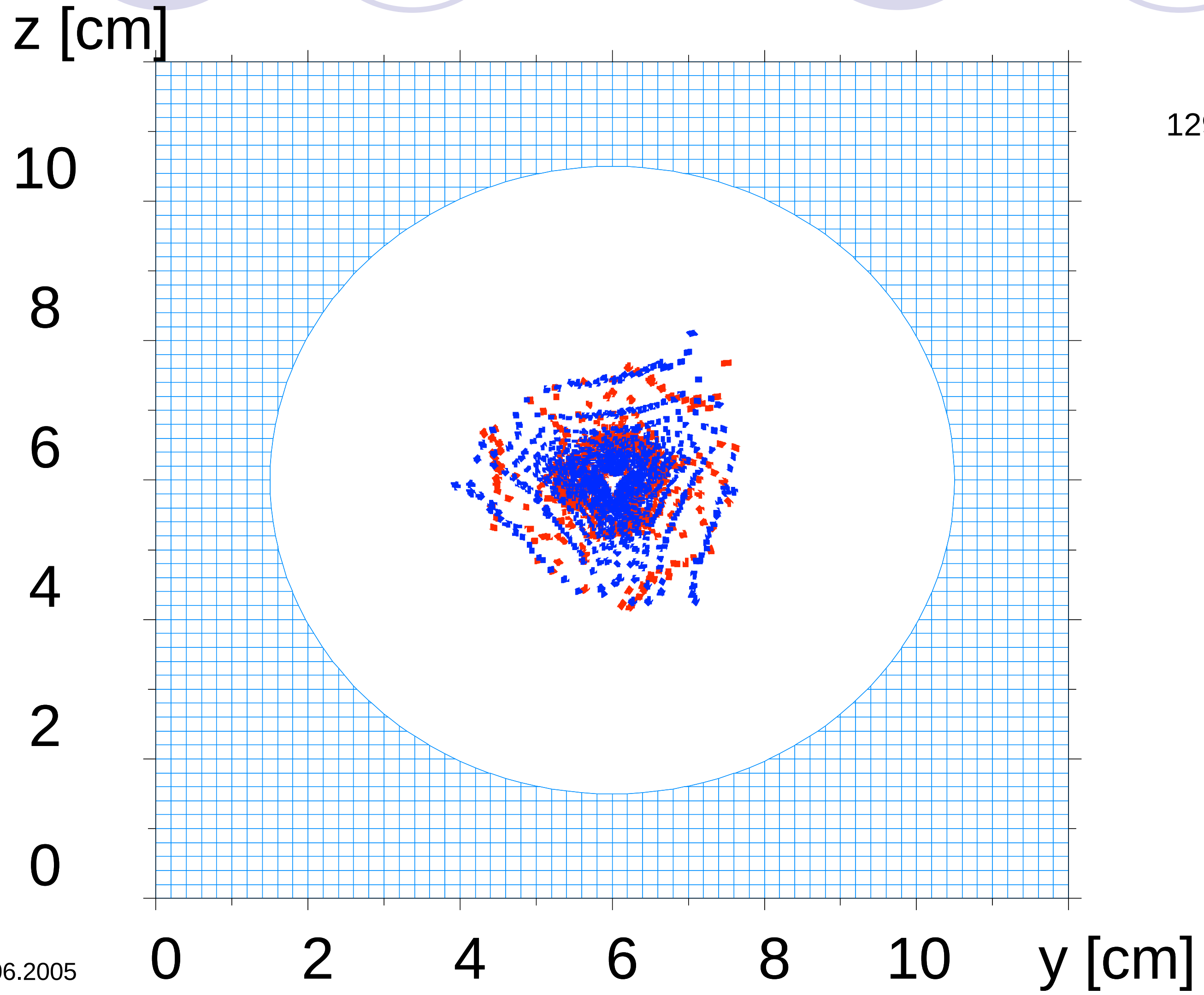
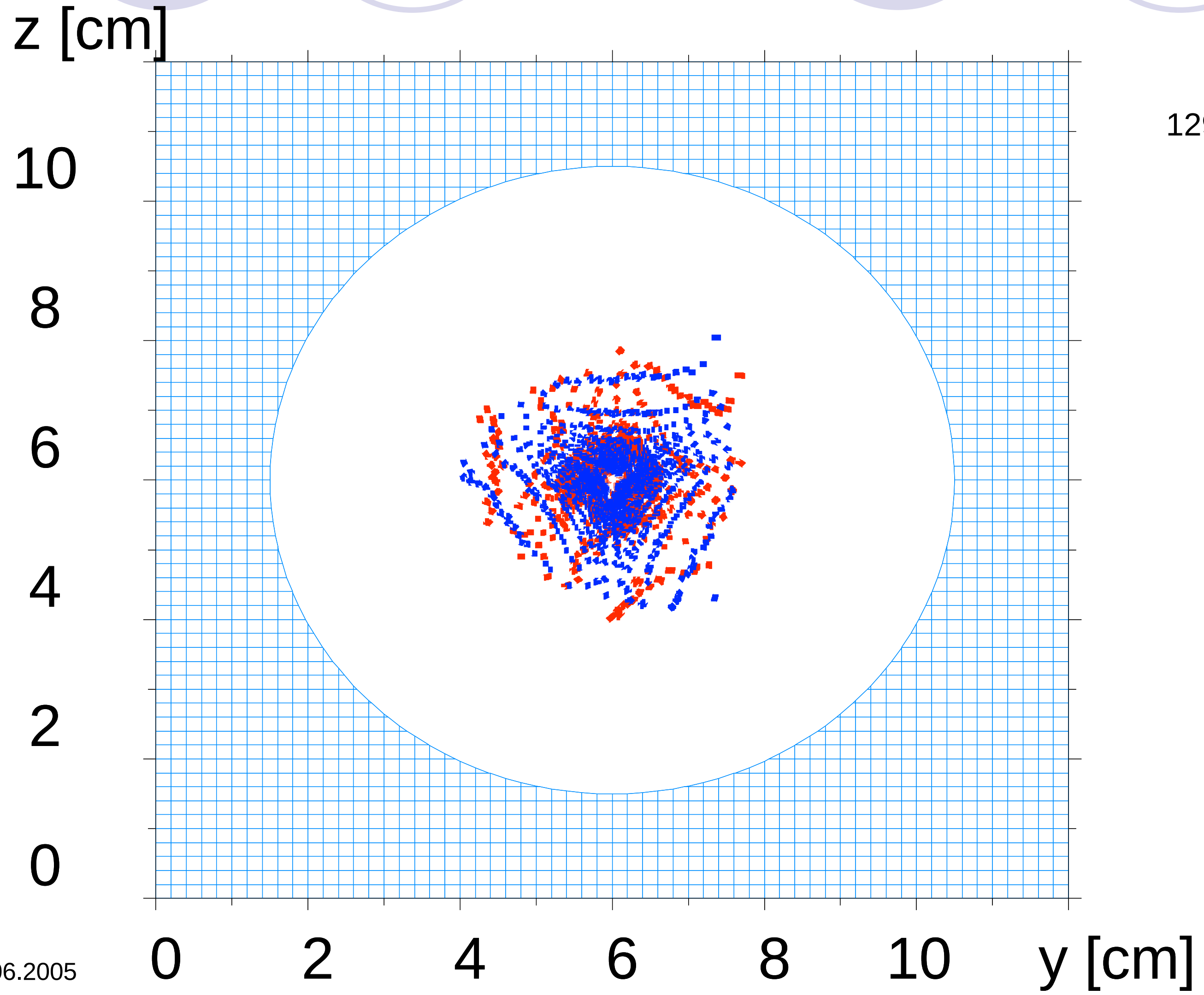
0
2
4
6
8
10
y [cm]
$^{129}Xe^{11+}$



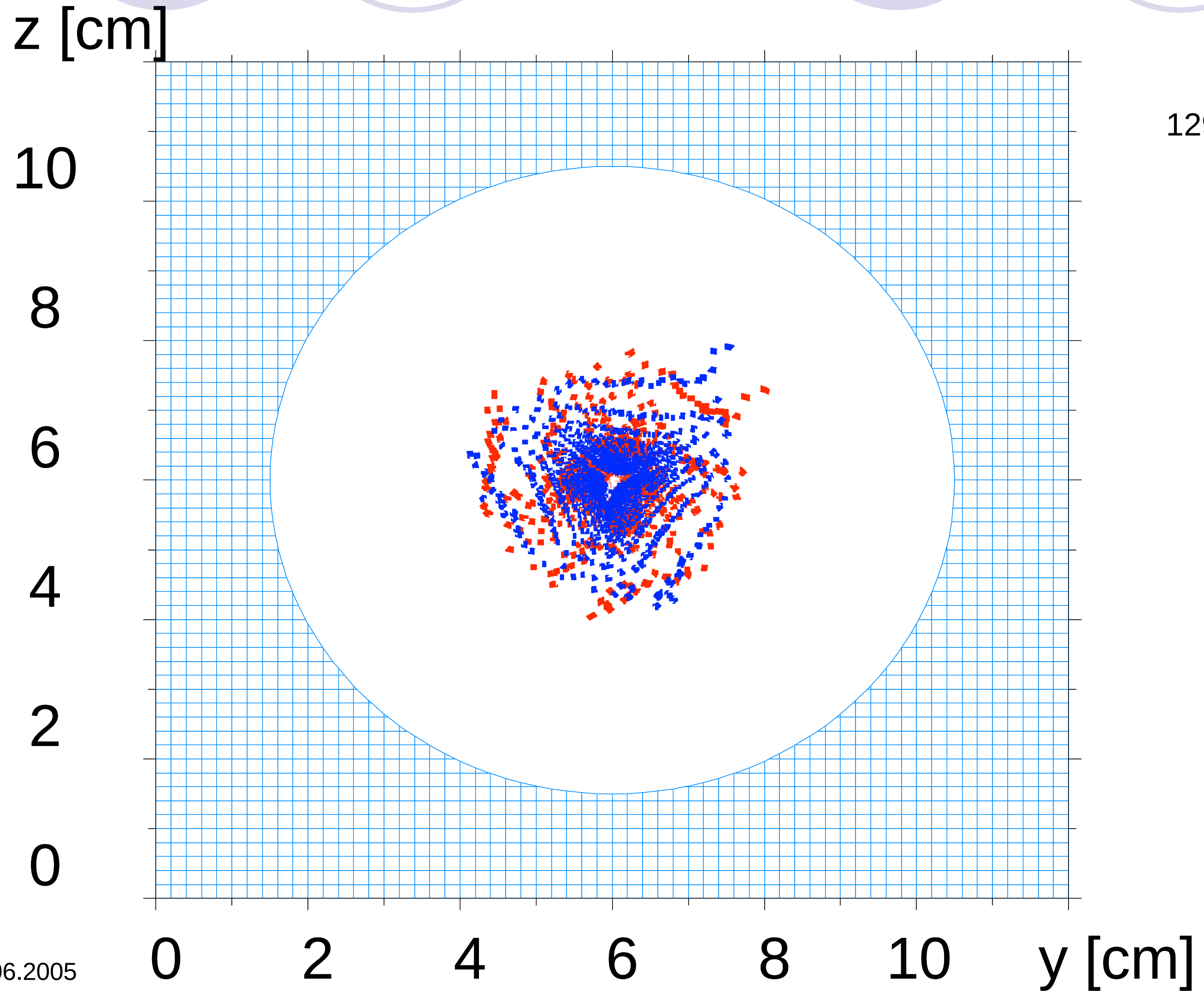
$^{129}Xe^{12+}$



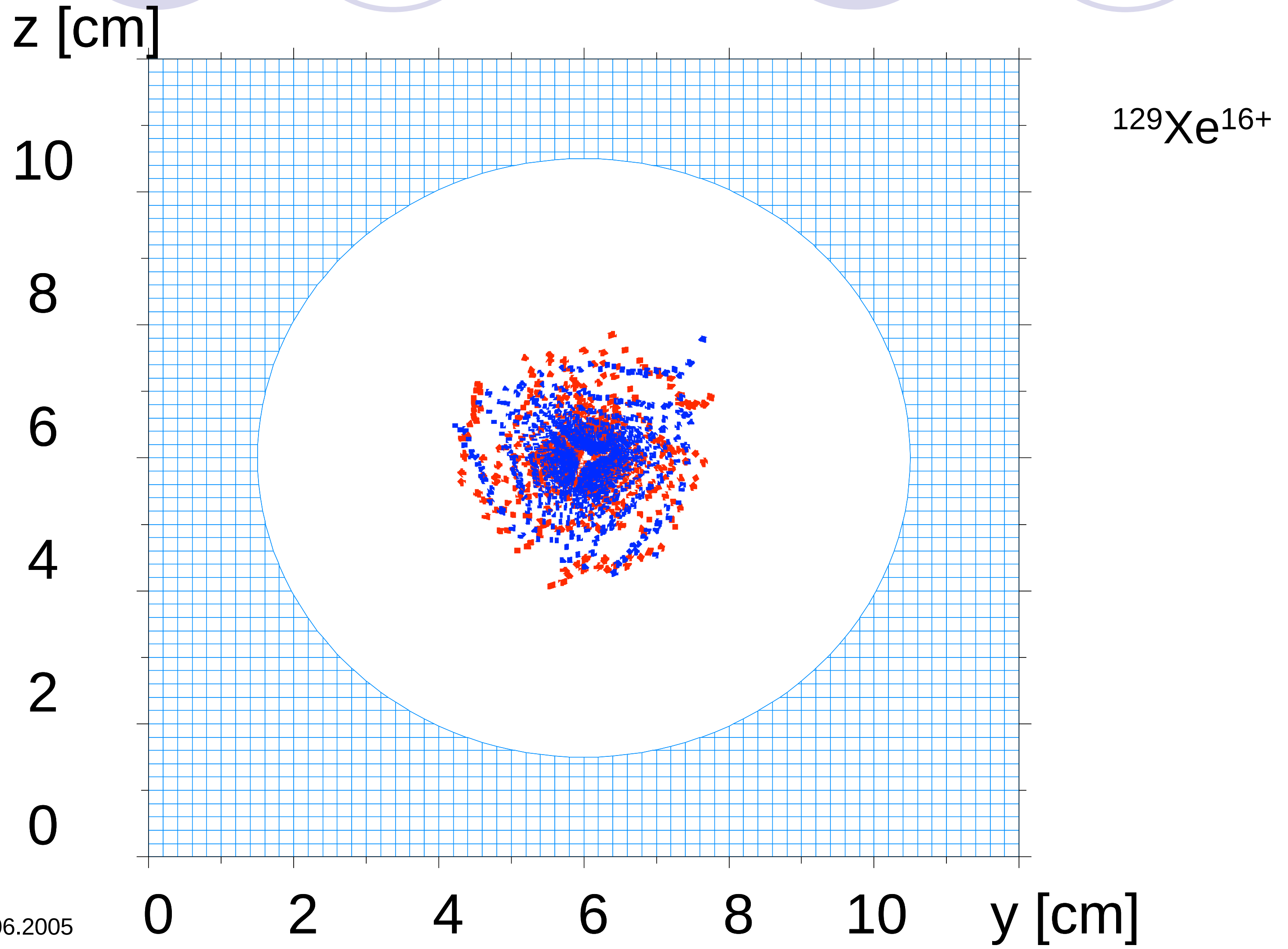
$^{129}Xe^{13+}$



$^{129}Xe^{14+}$



$^{129}Xe^{15+}$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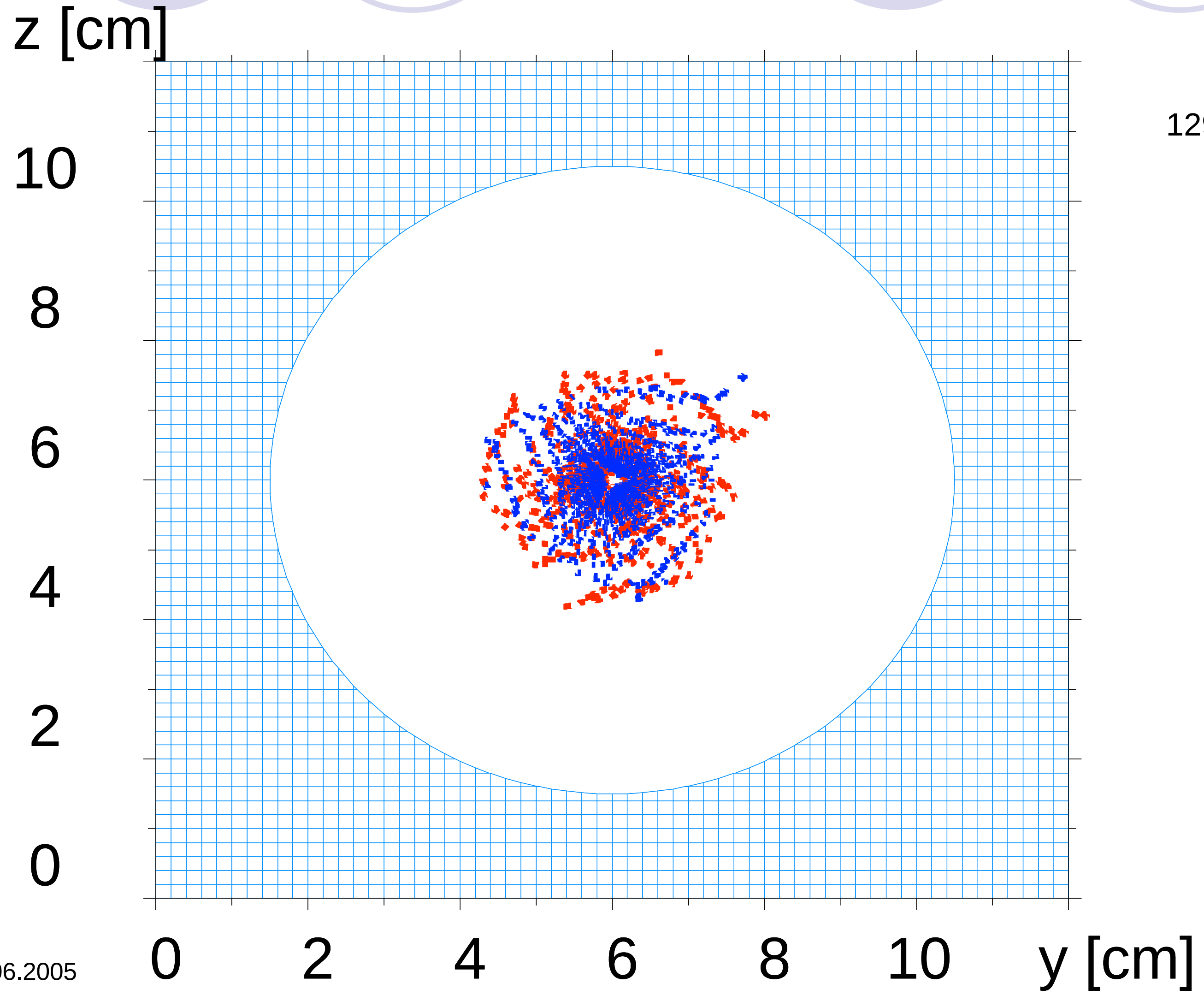
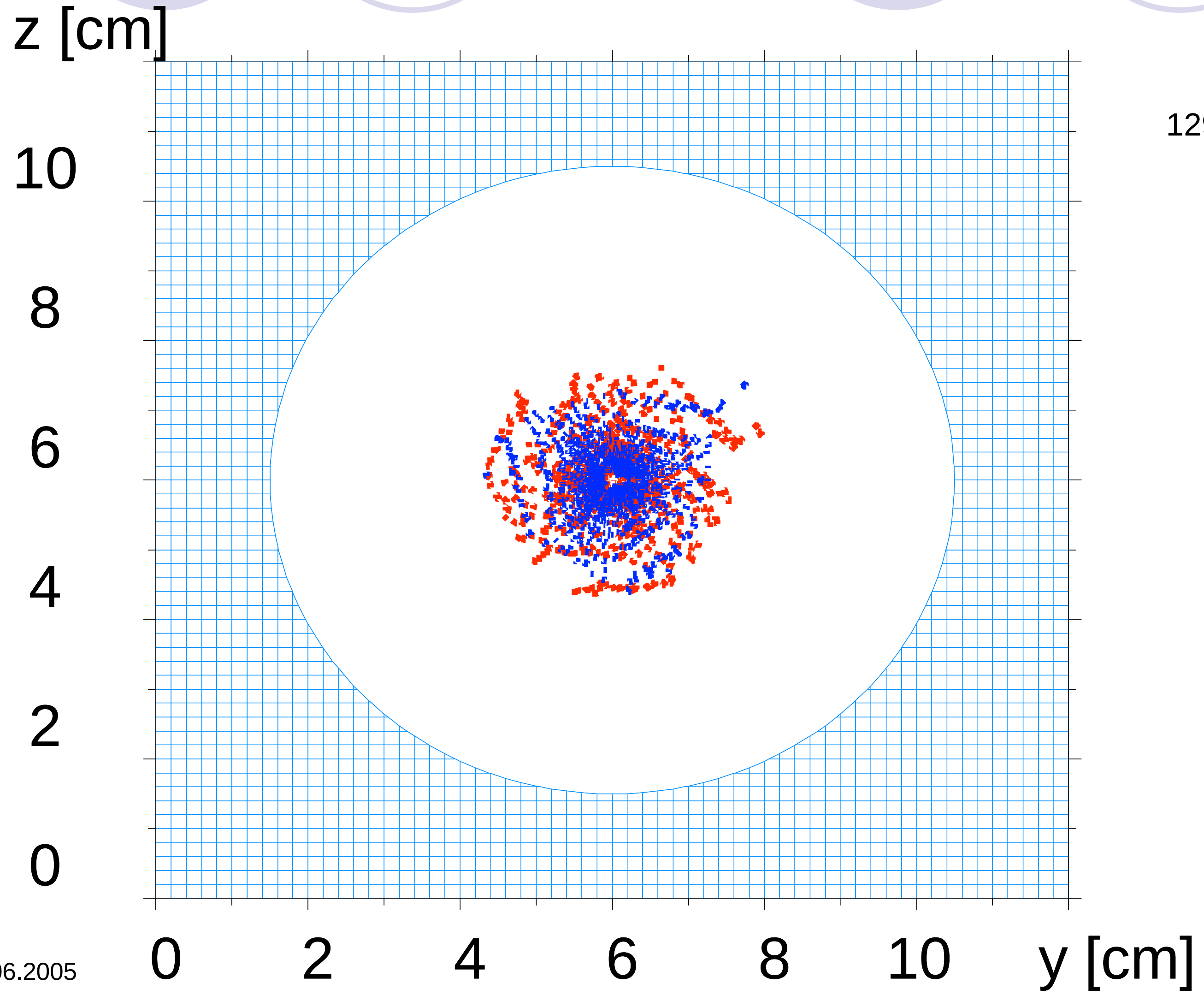
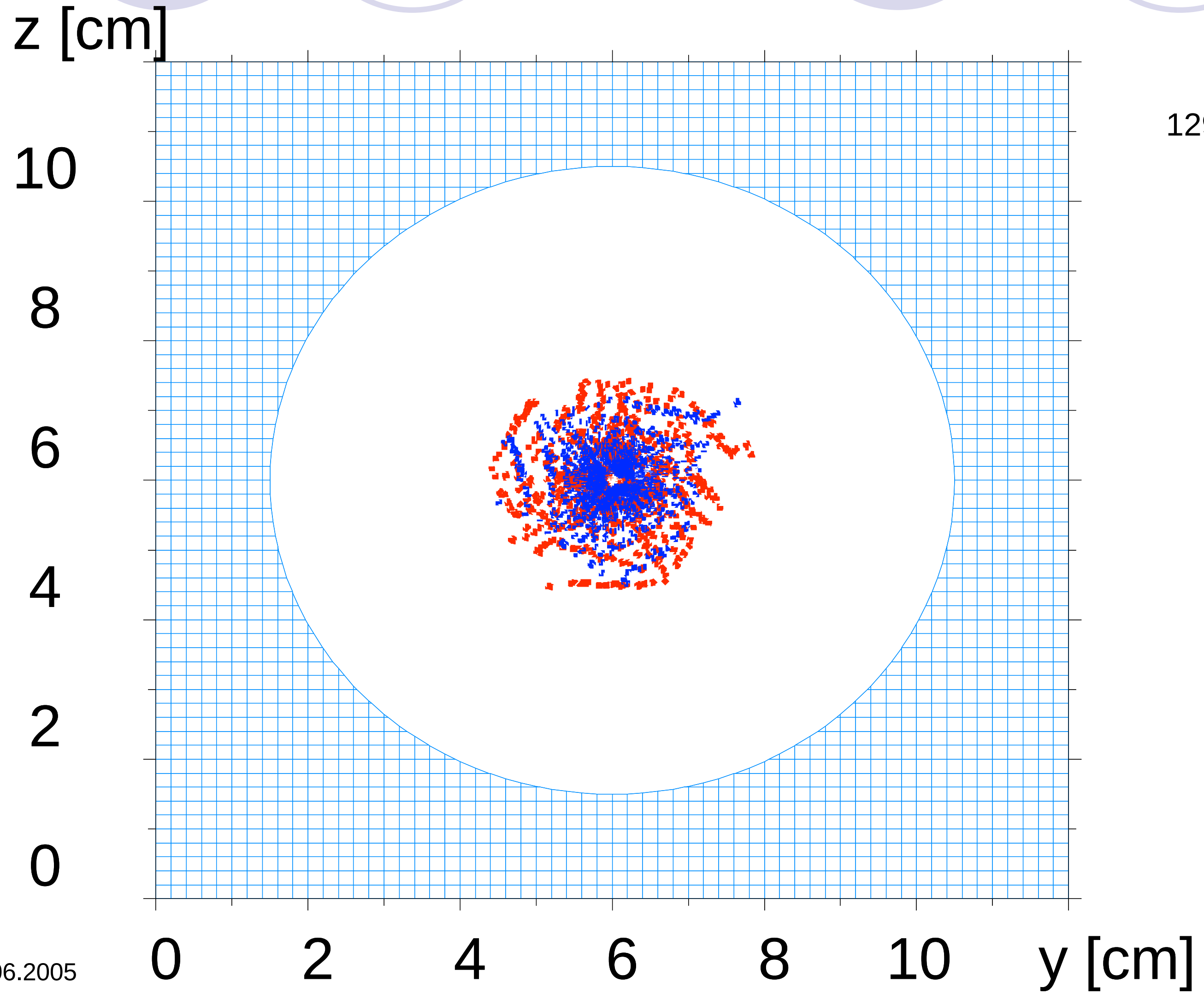
4
6
8
10
y [cm]
129Xe16+

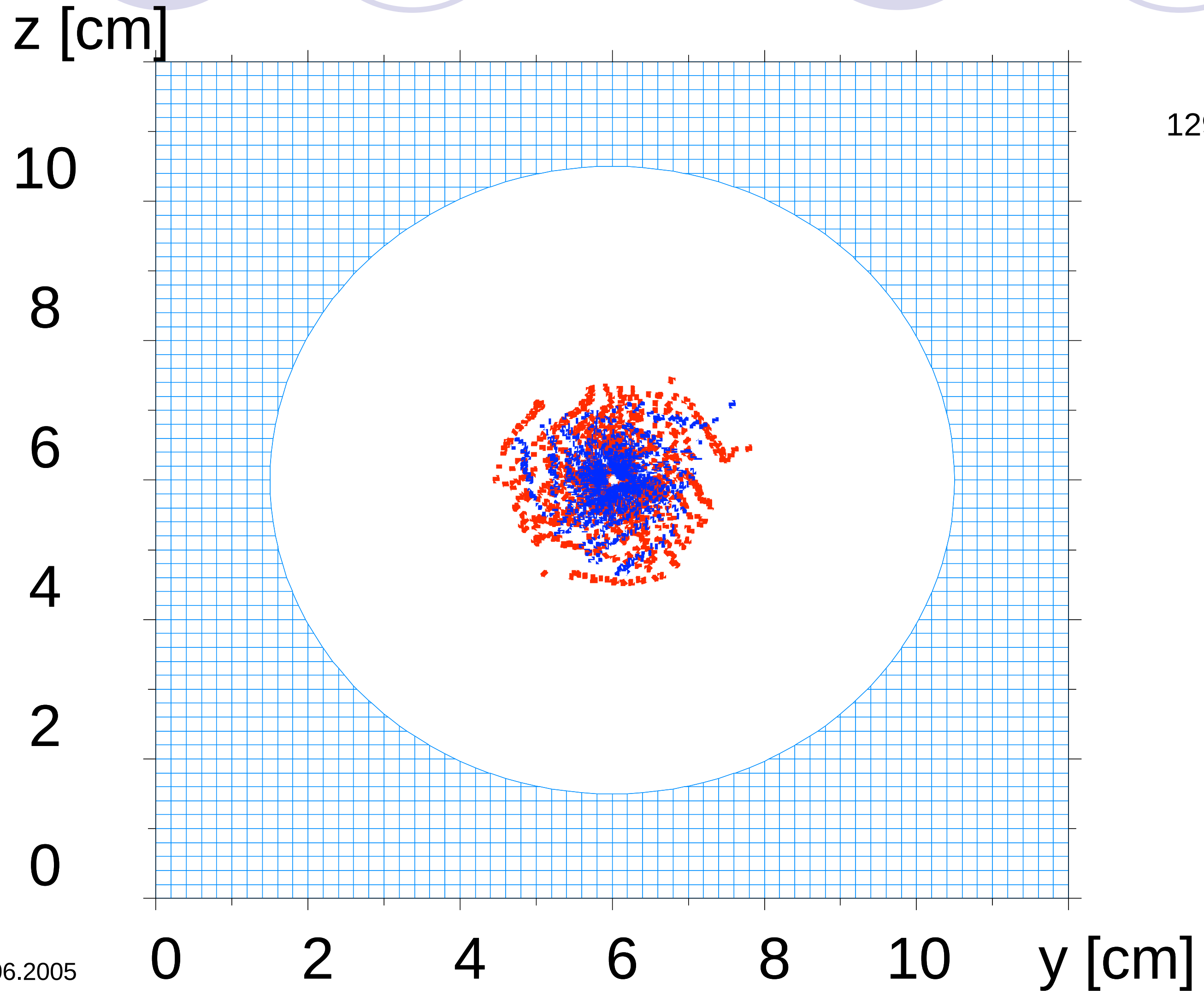

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{17+}$



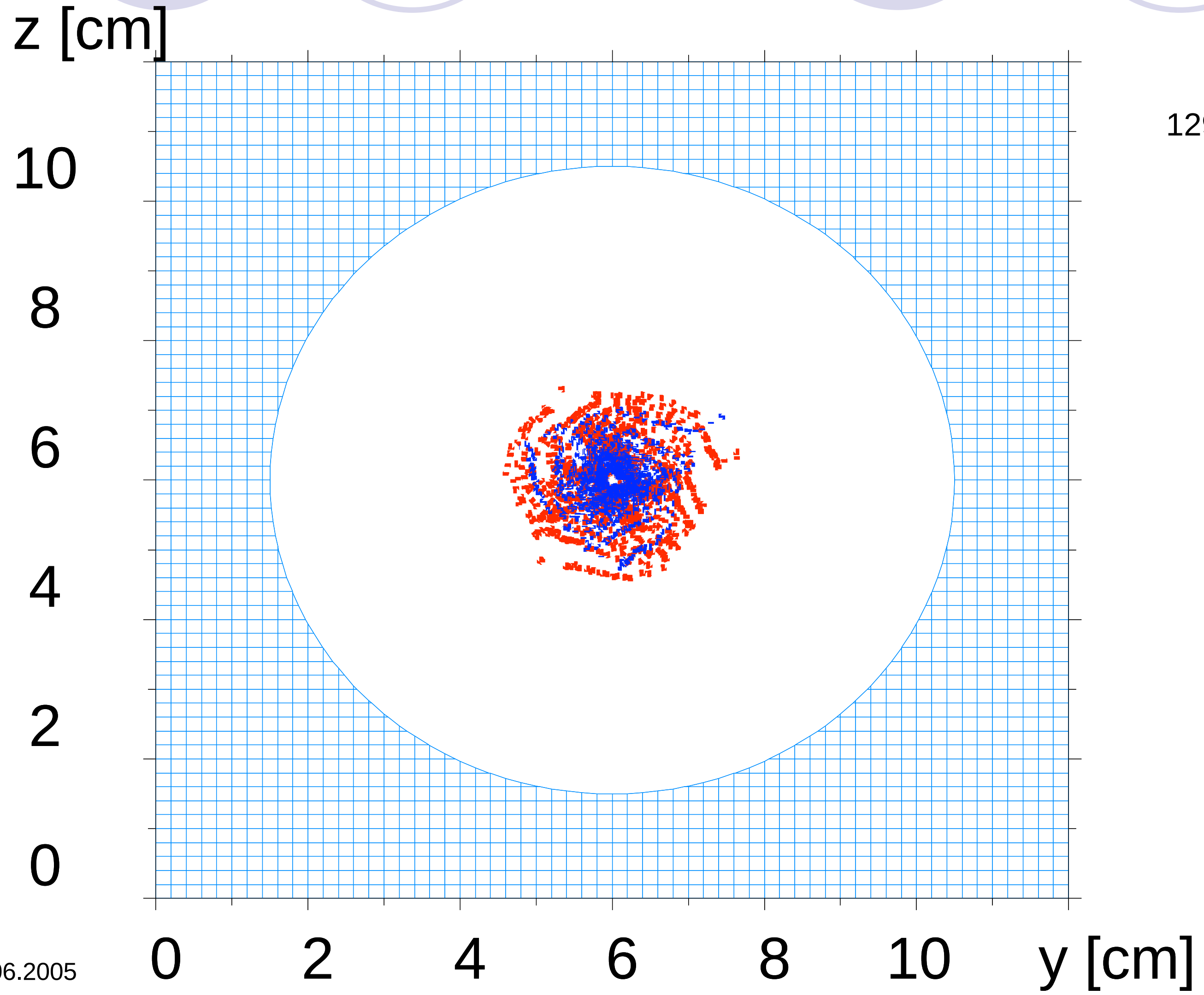
$^{129}Xe^{18+}$



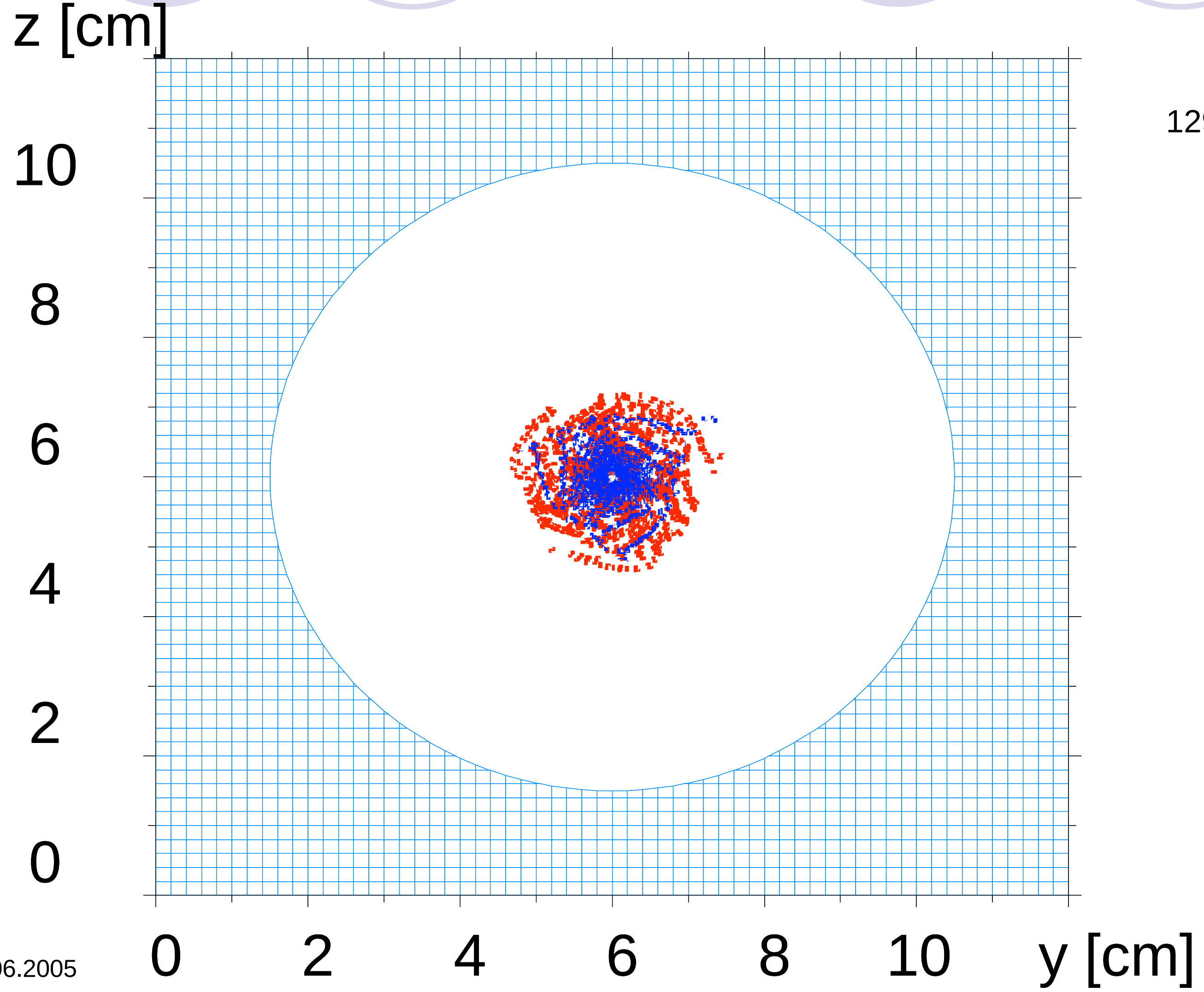
$^{129}Xe^{19+}$



$^{129}Xe^{20+}$

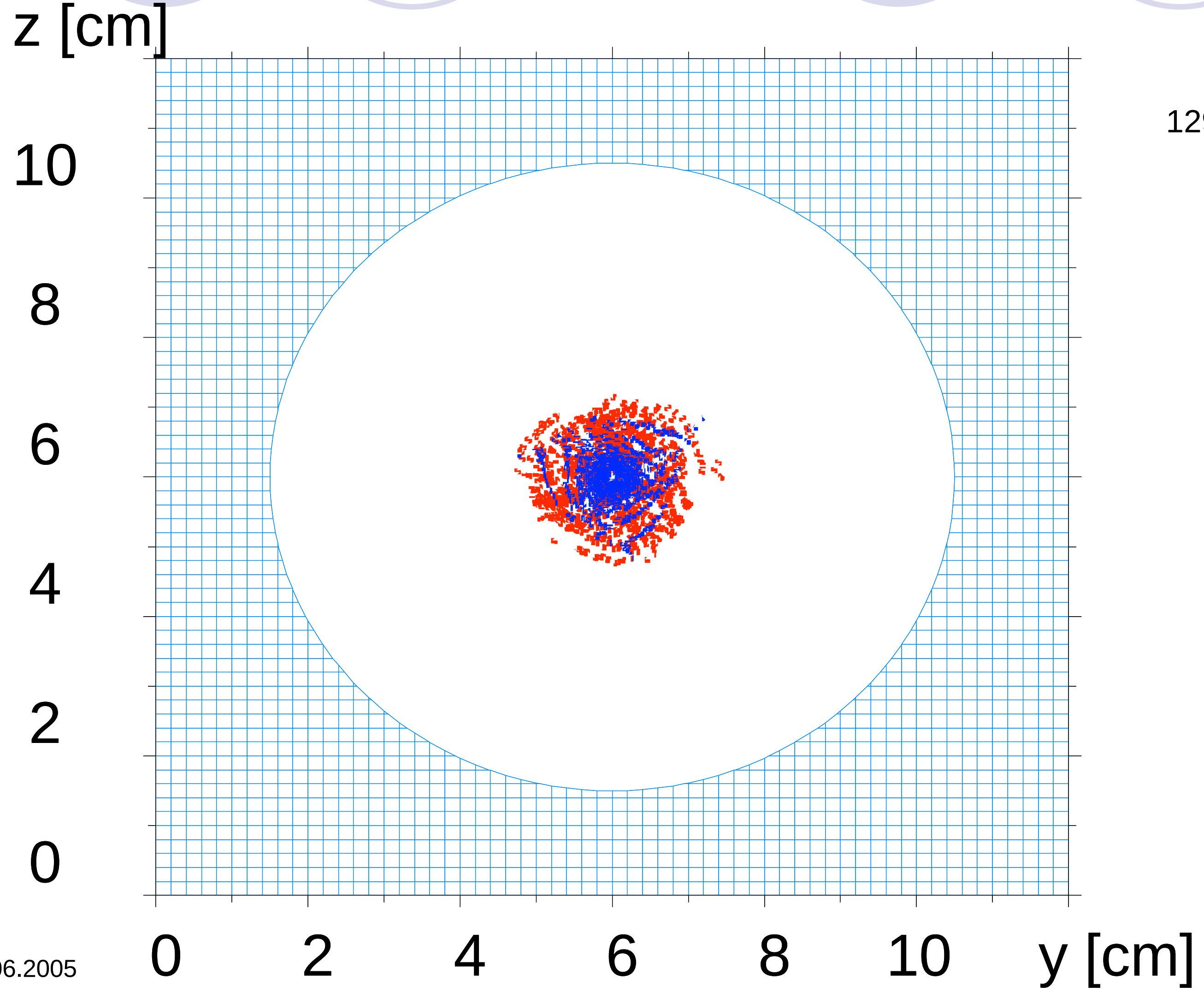


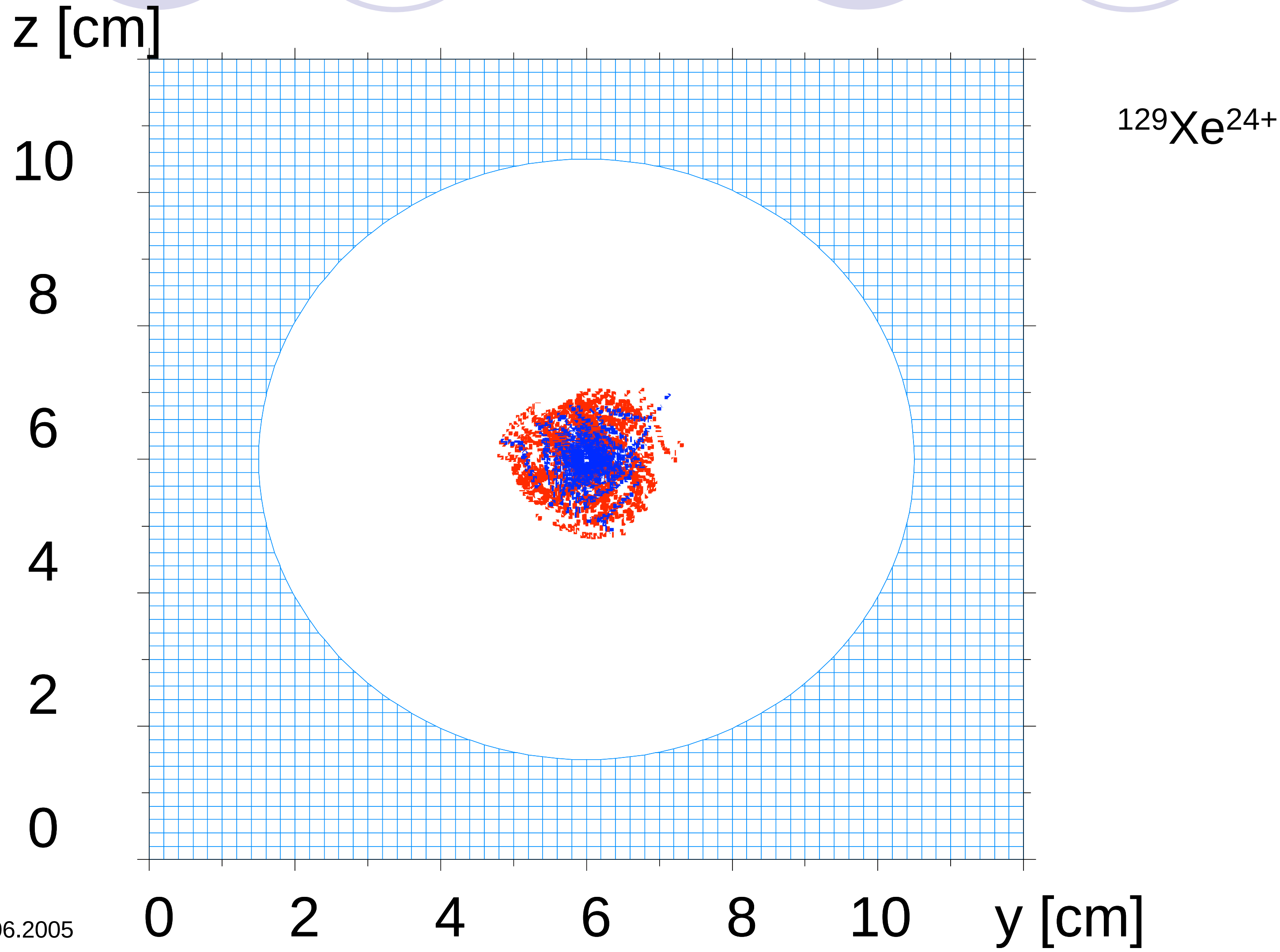
$^{129}Xe^{21+}$



$^{129}Xe^{22+}$

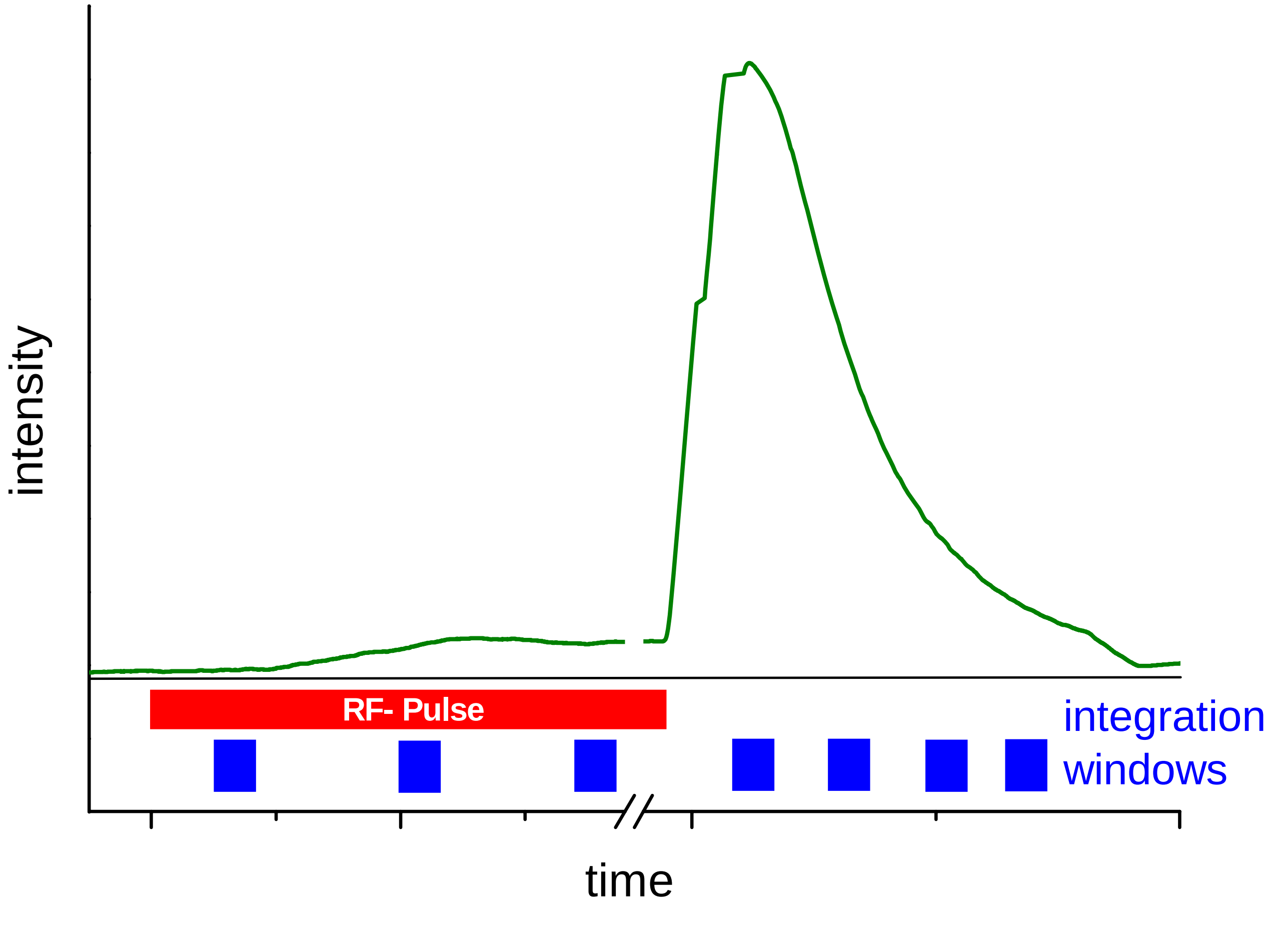
$^{129}Xe^{23+}$



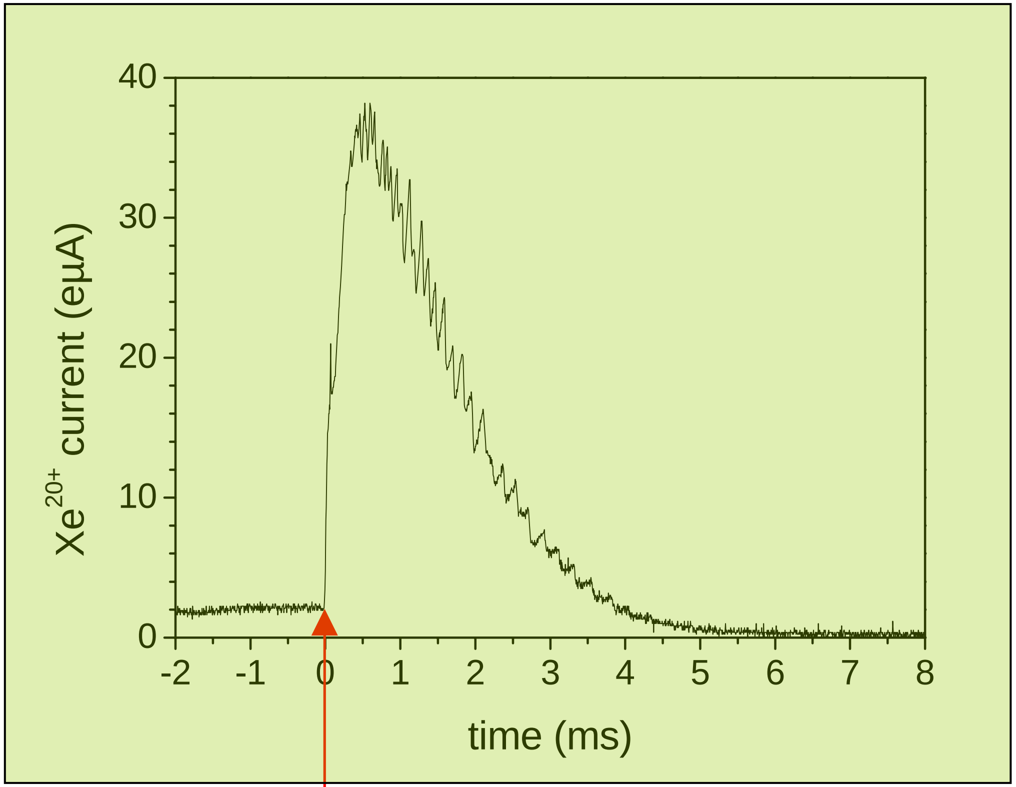

z [cm]
10
8
6
4
2
0
0
2
4
6
8
10
y [cm]
$^{129}Xe^{24+}$

AFTERGLOW

Afterglow Timing



AFTERGLOW

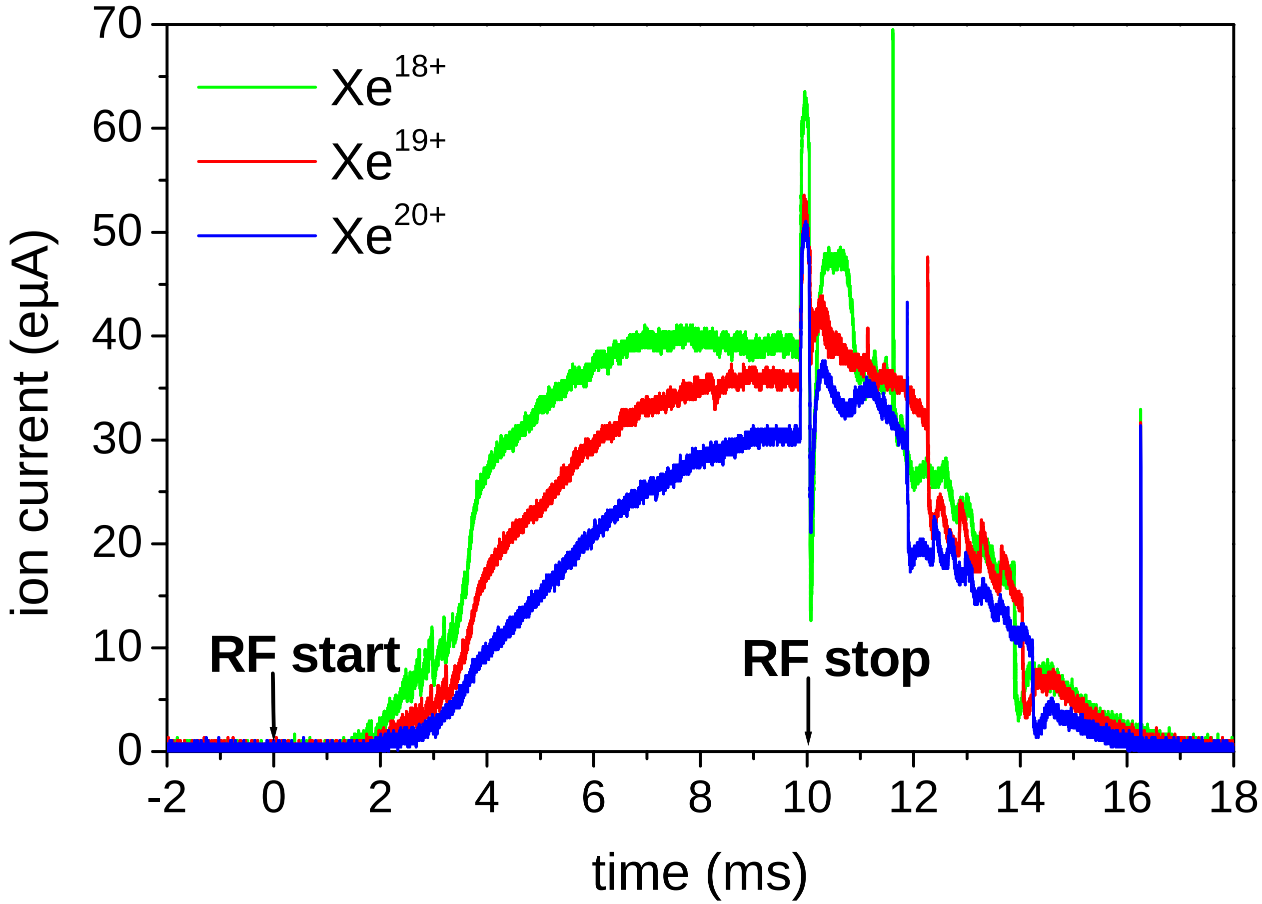


FC signal

rf off

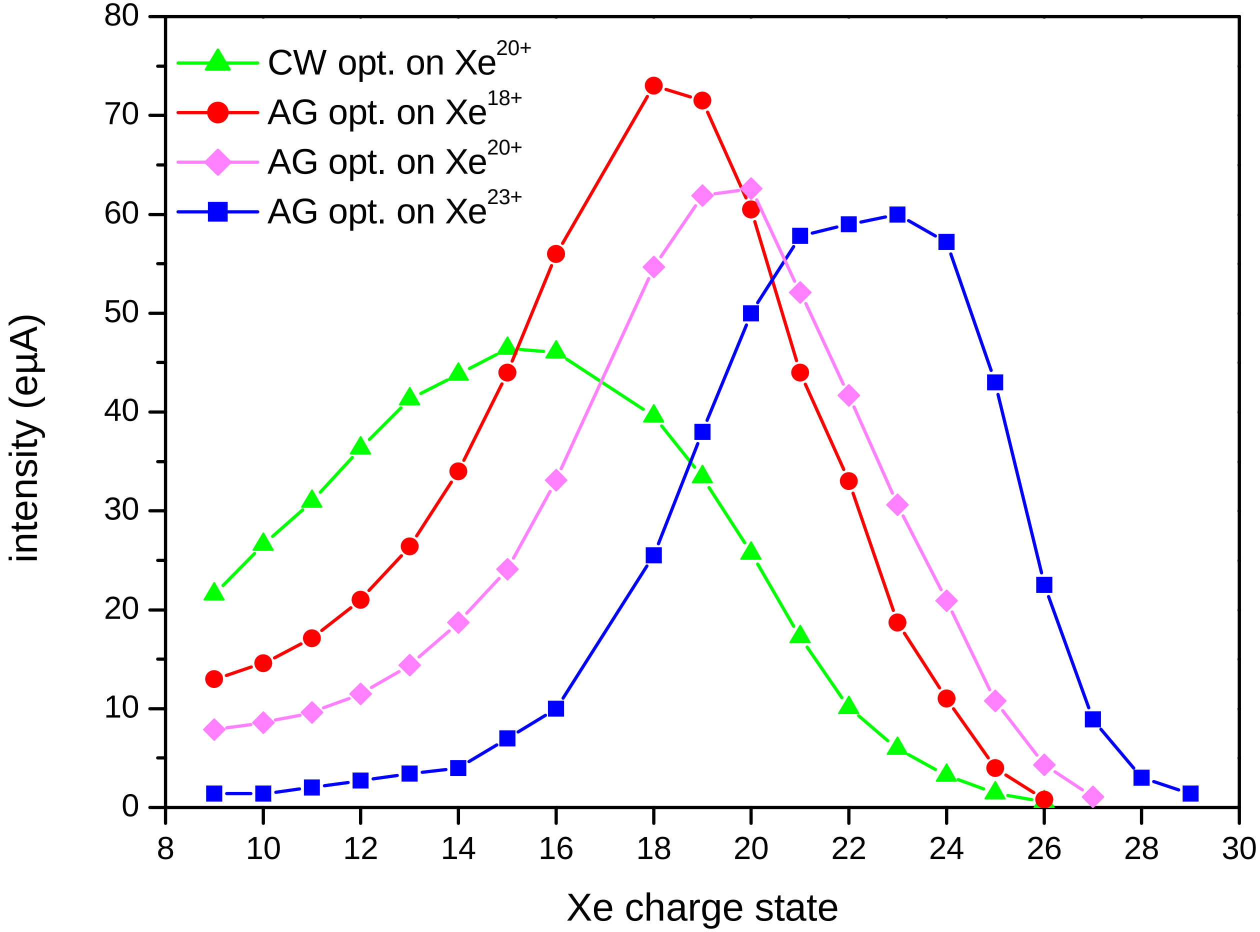
AFTERGLOW

Timing conditions: t_{on} = 10 ms, t_{off} = 10 ms ➡ duty cycle = 0.5



build up times of charge state distributions

AFTERGLOW



Comparison of Afterglow and CW mode

AFTERGLOW

Operating mode	Optimized for charge state	Maximum of CSD	FWHM charge states
afterglow	18+	18+	7.5
afterglow	20+	20+	7.0
afterglow	23+	23+	7.0
CW	20+	16+	11.5

Width of different charge state distributions of Xe^{q+}
FWHM = Full Width of Half Maximum

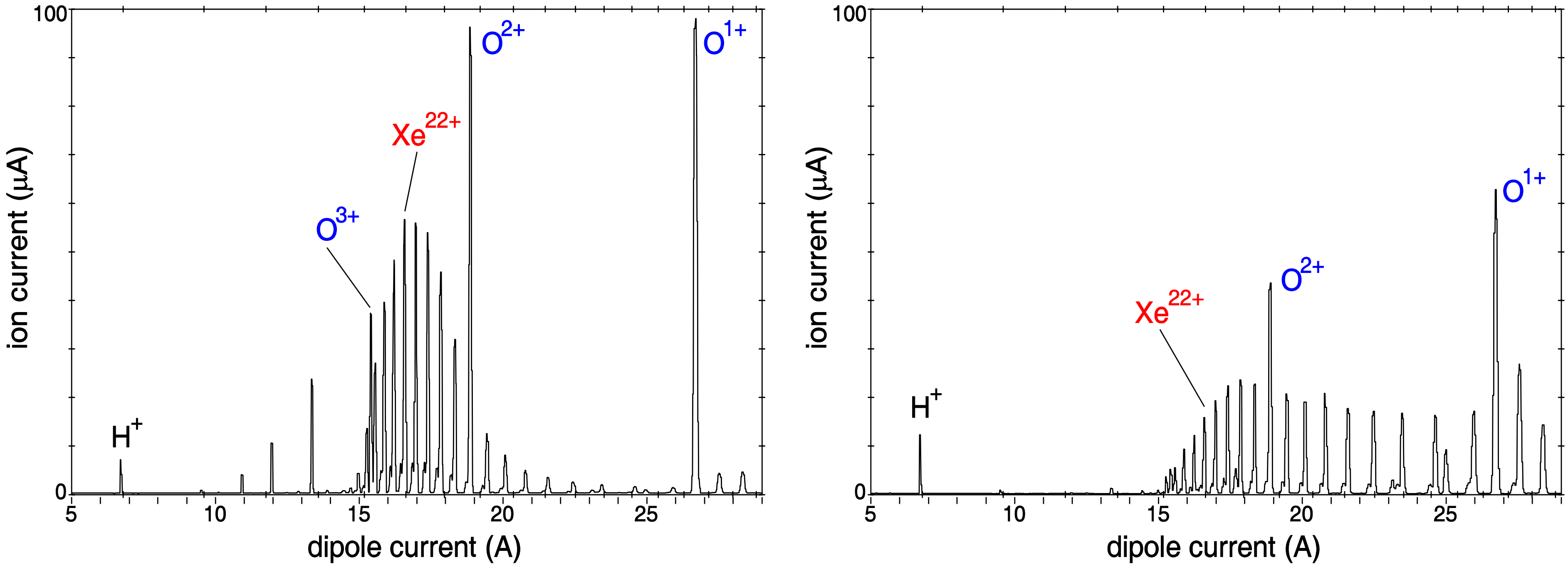
Gain factors of optimized afterglow mode versus optimized CW mode

Xe charge state	afterglow (µA)	CW (µA)	gain
18+	85	42	2
20+	80	27	3

- Optimization on the same charge state in CW mode and in afterglow mode:
  - different settings of the ion source
  - no smooth transition from one mode to the other.
- Afterglow mode: good confinement for charge state breeding within the RF pulse
  - efficient release of highly charged ions in the afterglow
- CW mode: compromise between confinement and steady state extraction

MIXING GAS

All ionic plasma components are simultaneously extracted from the ECR plasma!



Role of the Auxiliary Gas

What is important for the simulation of the extraction from an ECRIS ?

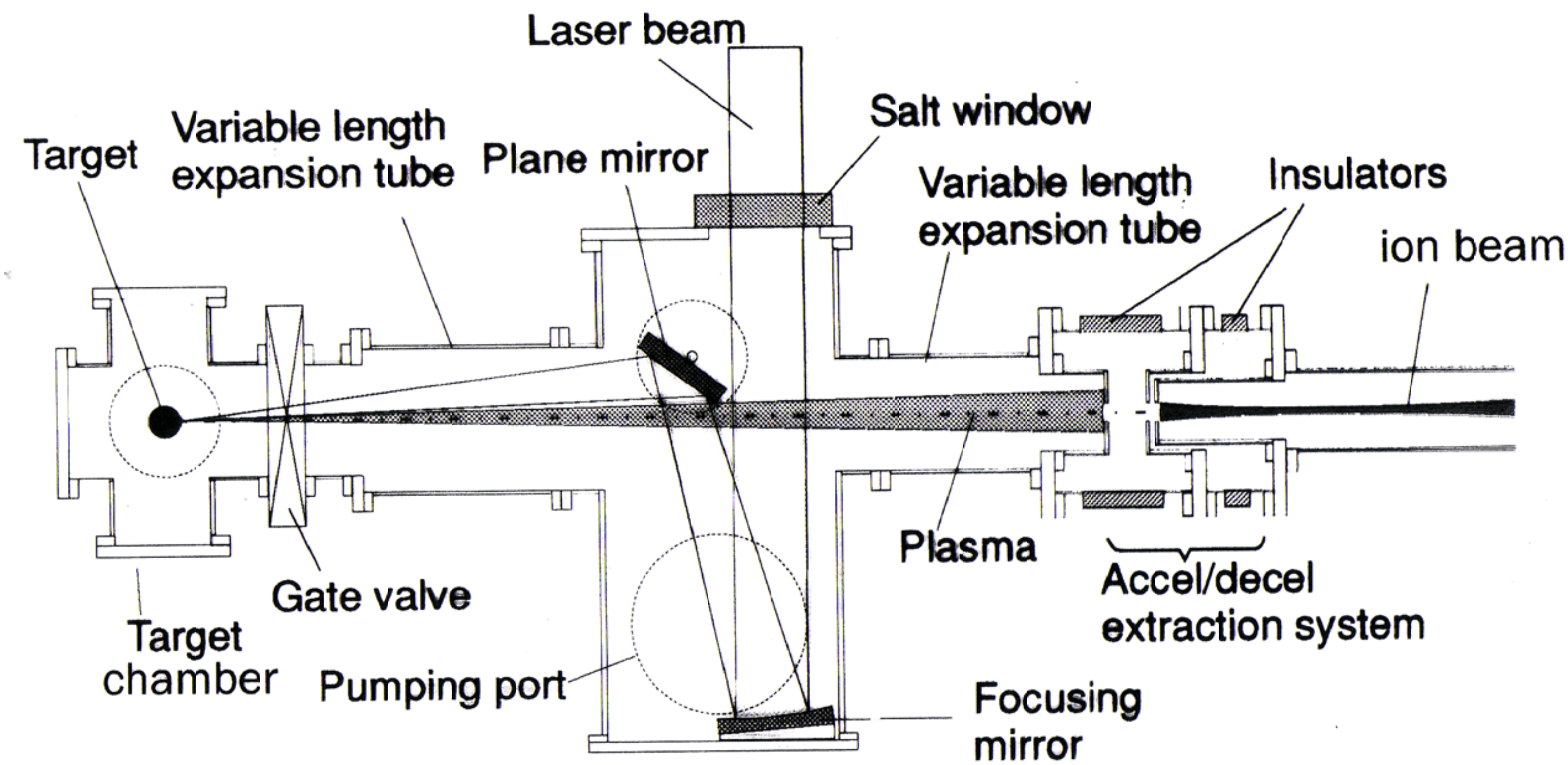
- geometry
- electric potentials
- magnetic flux density
- compensation model
- spectral distribution of ions
- spatial distribution of ions and electrons
- Current of each charge state

LASER ION SOURCE

Experiment at GSI with a LIS in front of the MAXILAC RFQ:

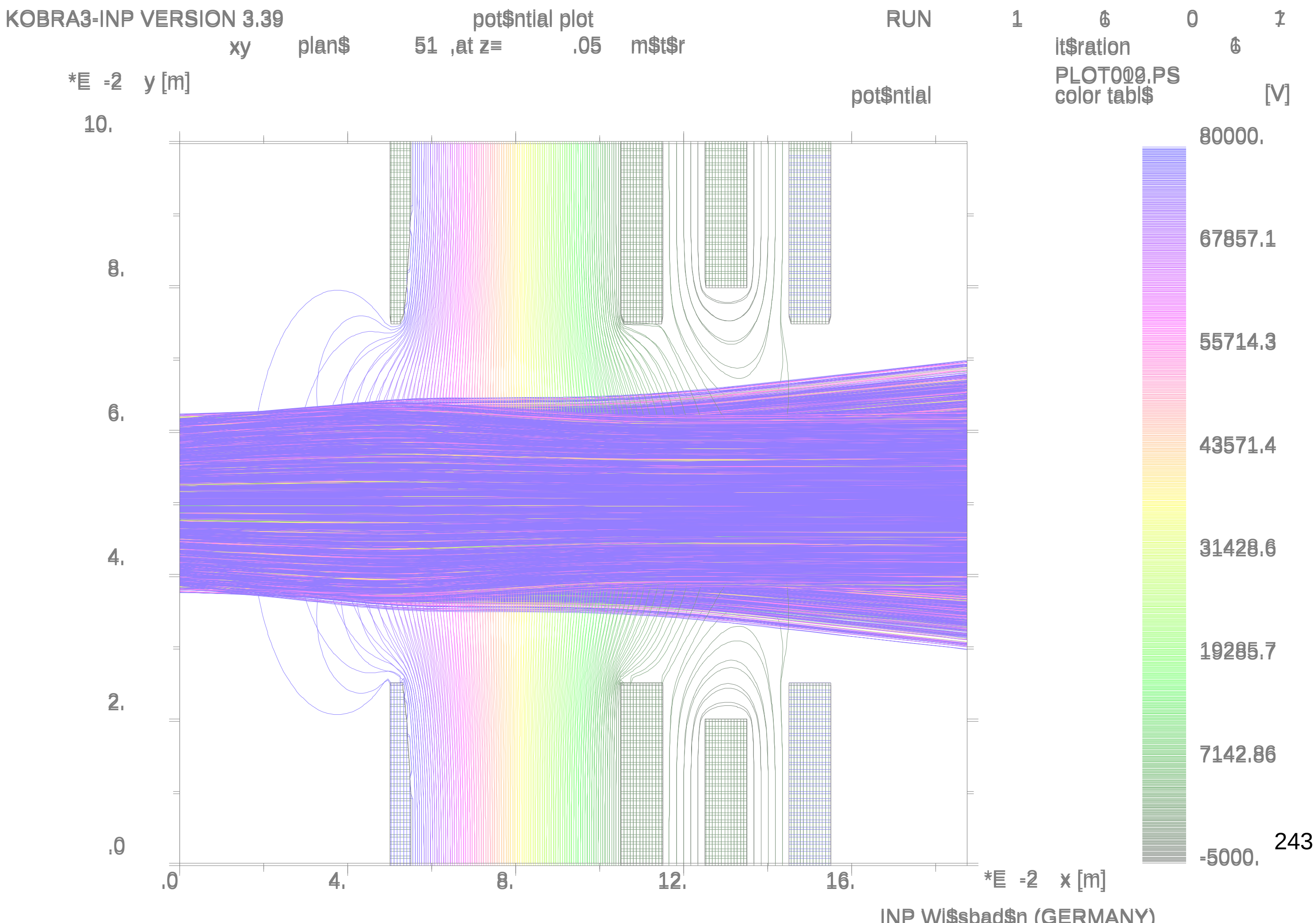
up to 1.8 mA Ta^{10+} could be measured at the exit of the RFQ where the velocity is 45 keV/u.

LASER ION SOURCE

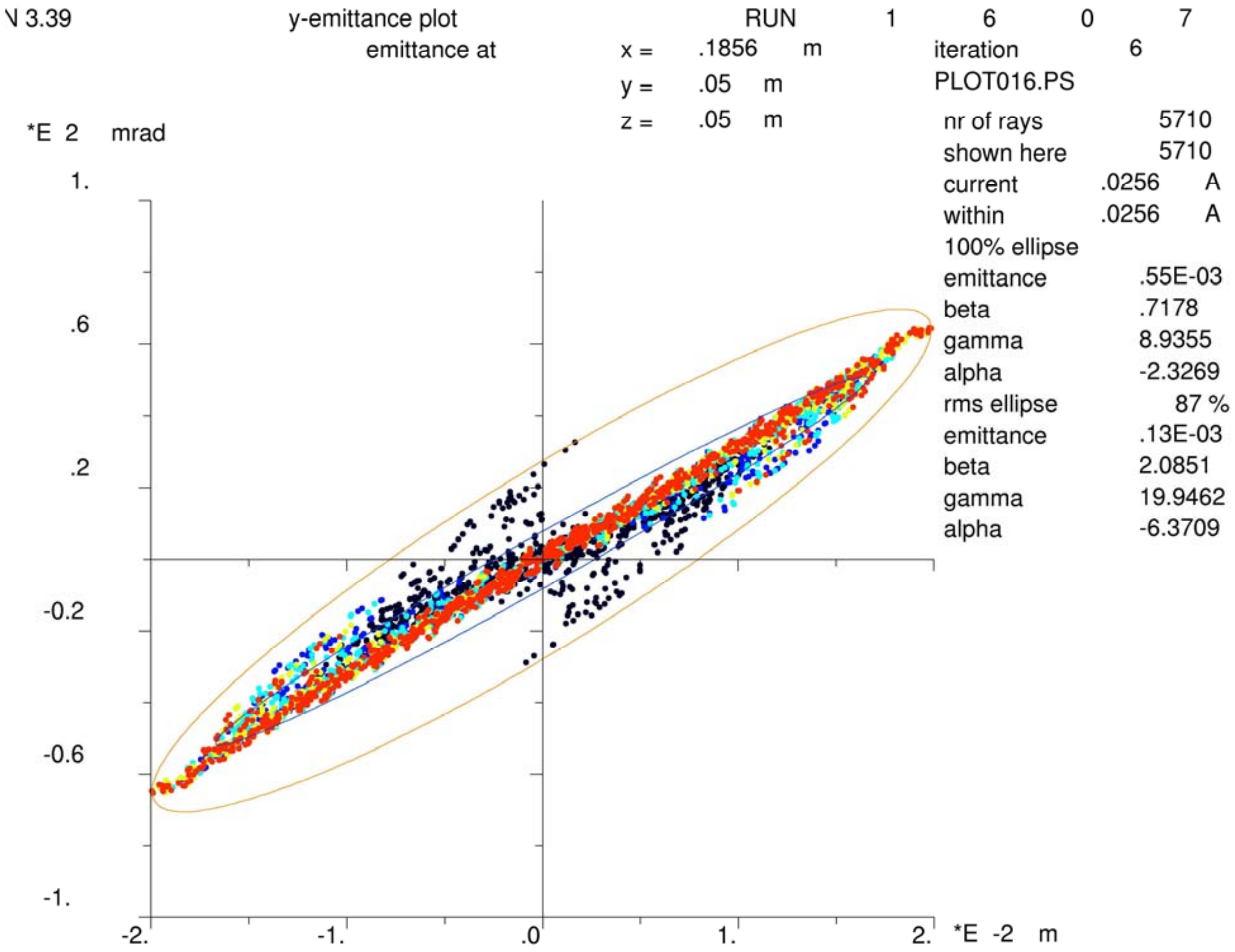


CO_2-laser with 4J, pulse length 1 μs, repetition rate 1Hz

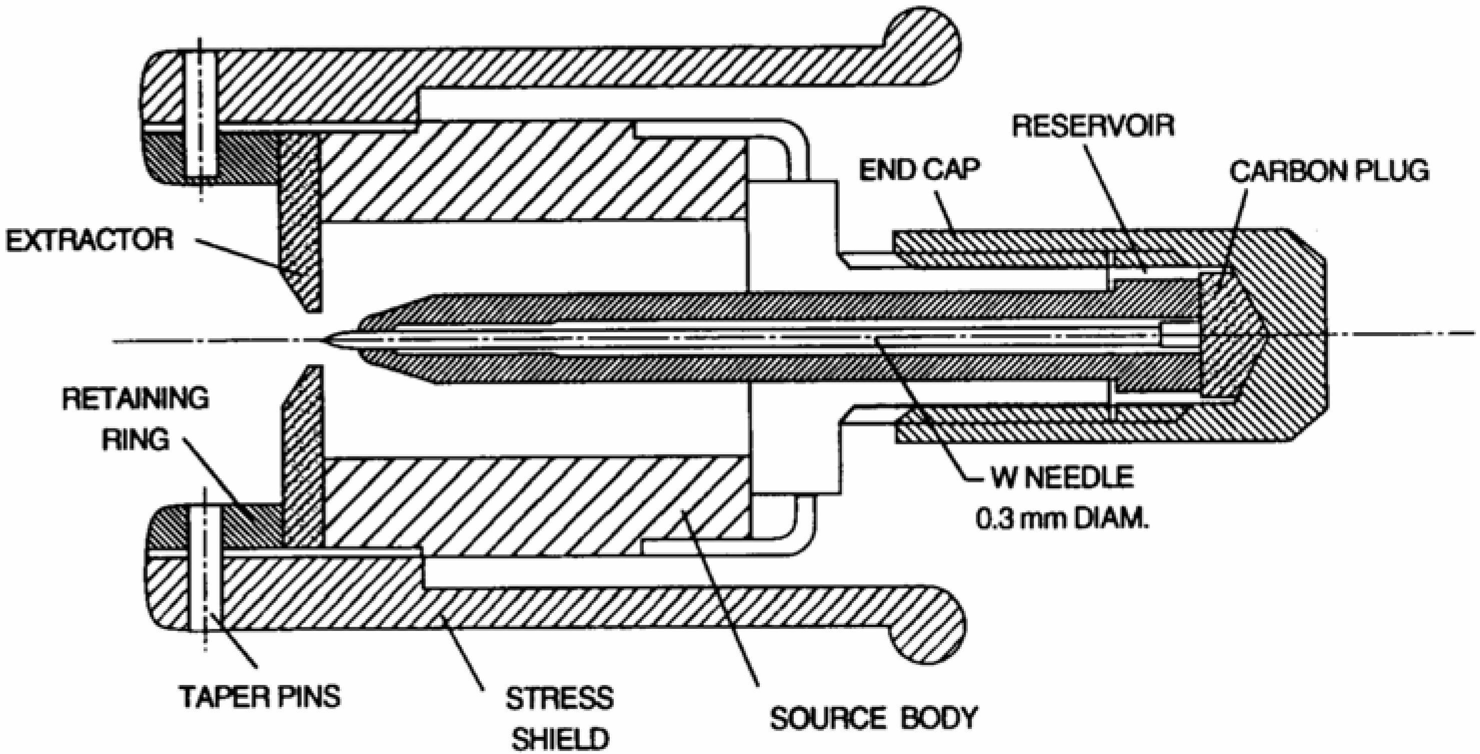
LASER ION SOURCE



LASER ION SOURCE

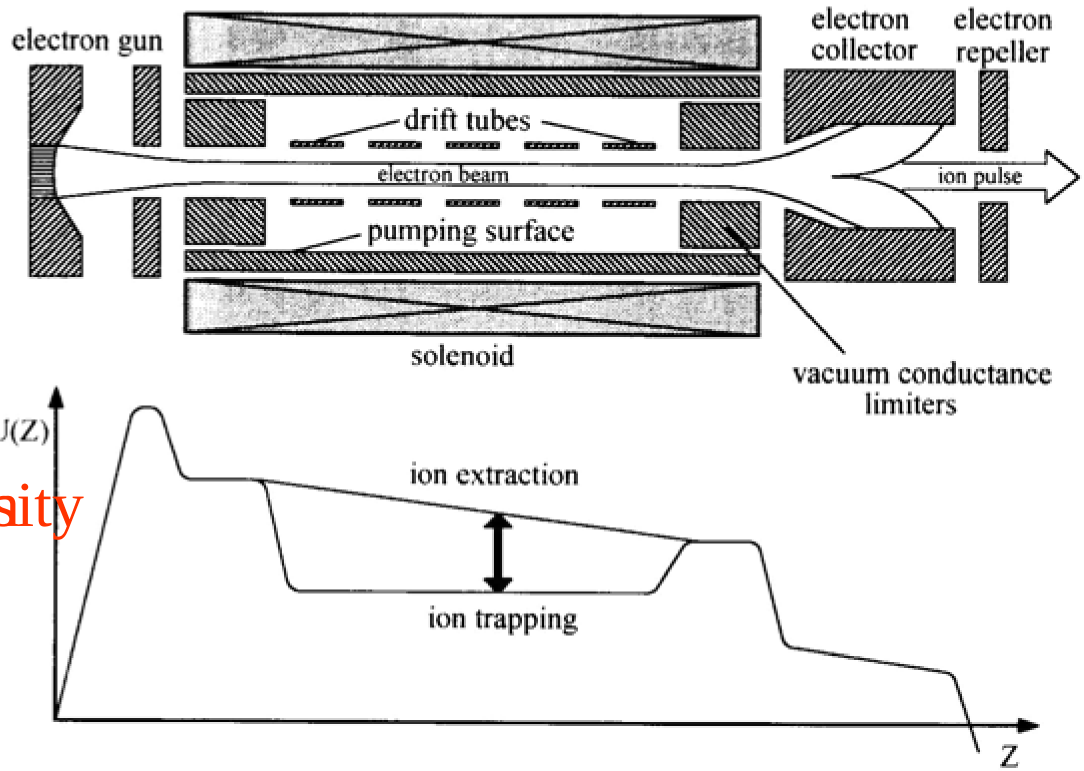


LIQUID METAL ION SOURCE



Electron Beam Ion Source

simple idea, but technological problems:



electron beam density

$j > 1$ kA/cm^2

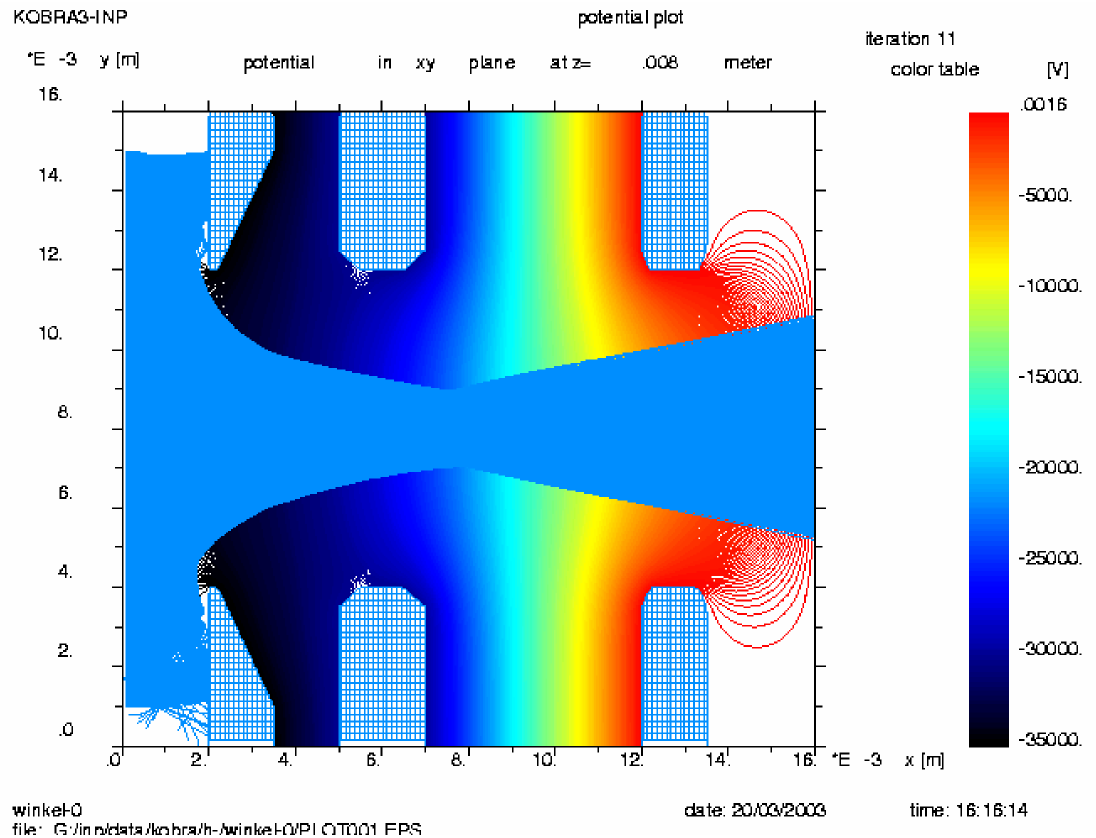
magnetic flux

$B > 1$ T

vacuum

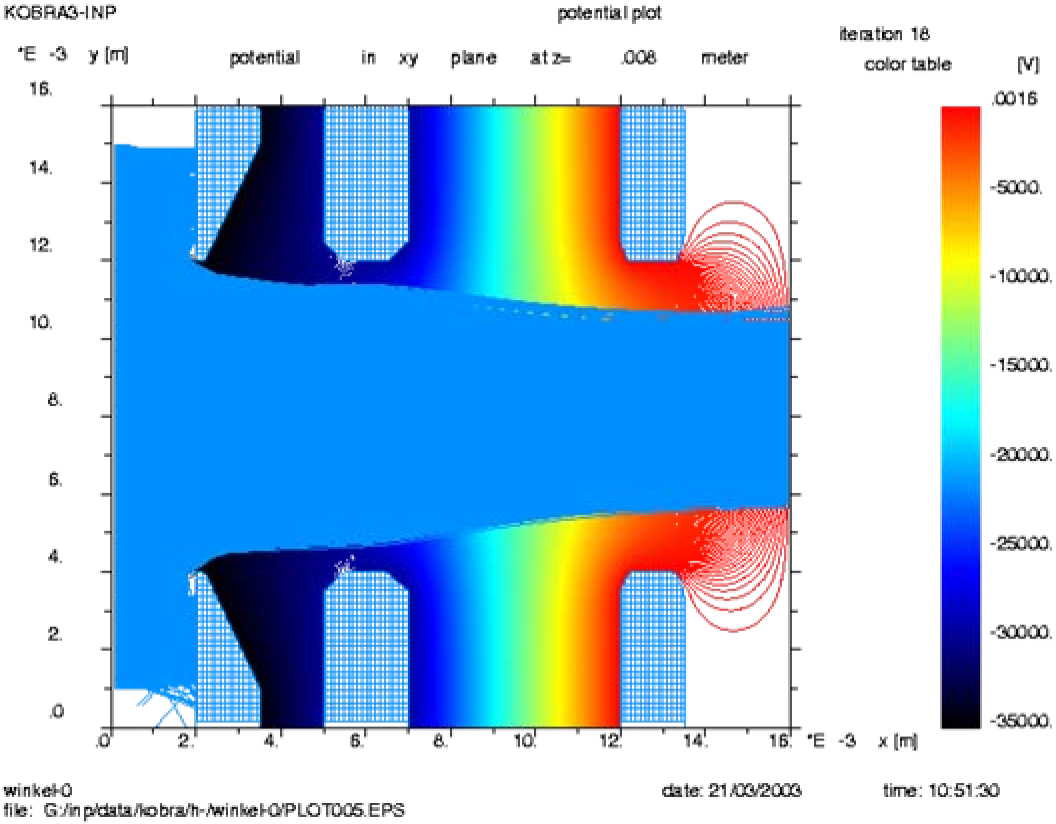
better 10^{-12} mbar

H⁻ Source



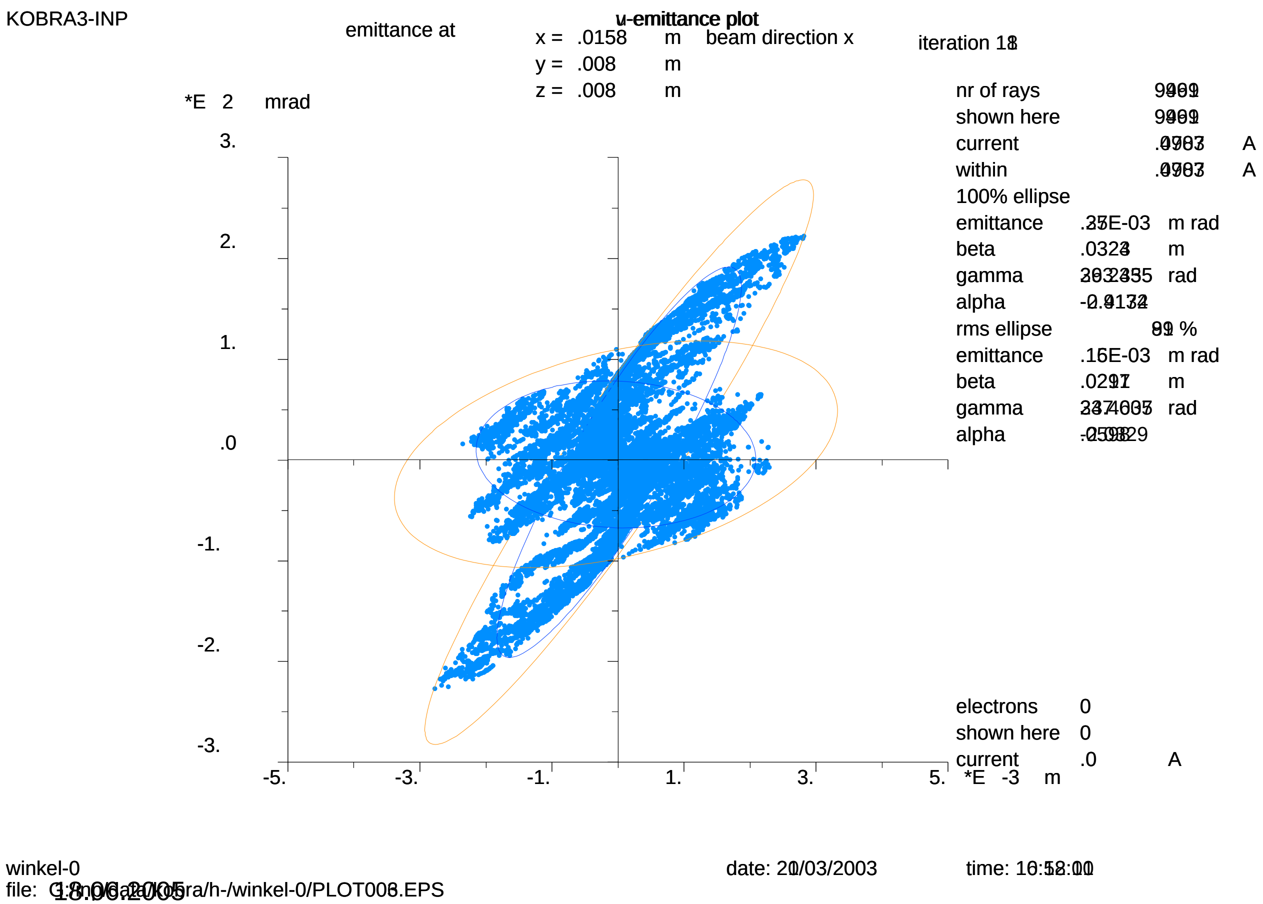
100 mA

H$^-$ Source



500 mA

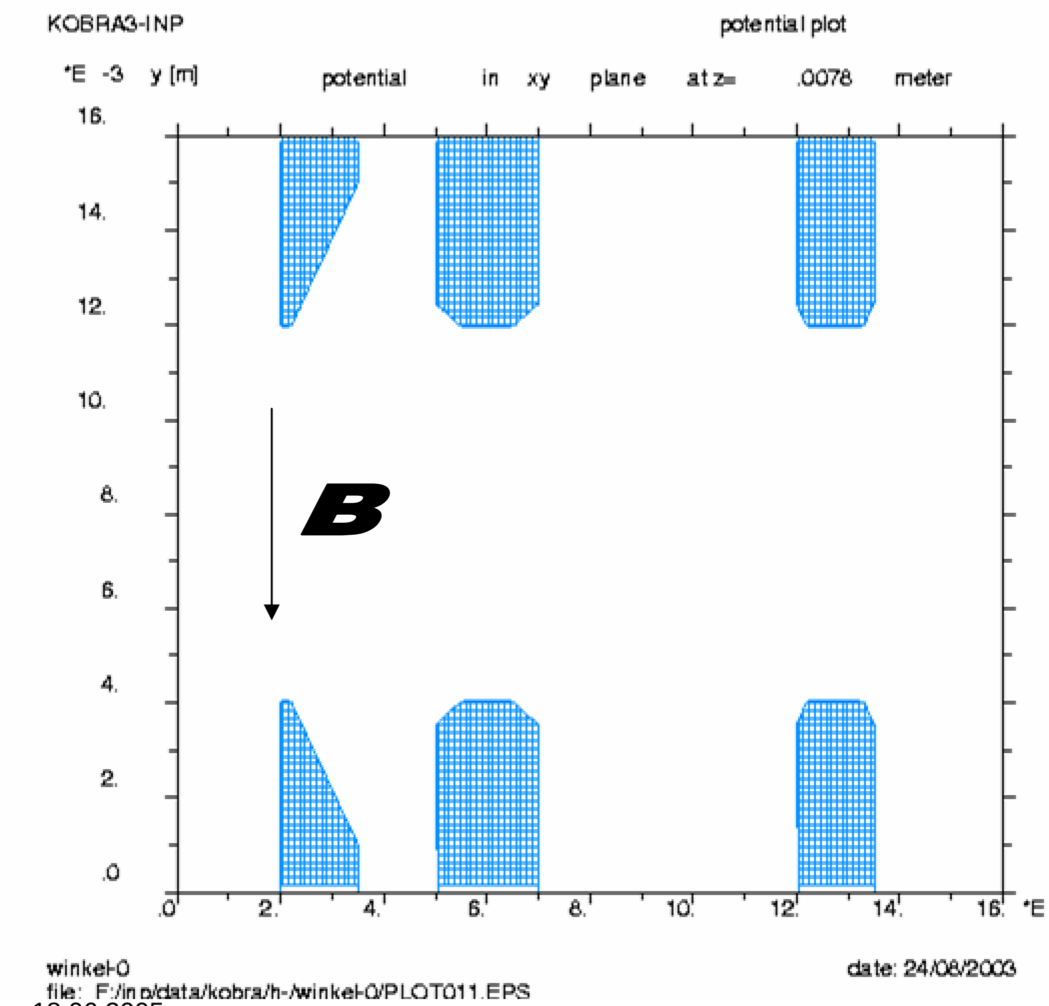
H^- Source



500 mA

ε = 250 π mm mrad

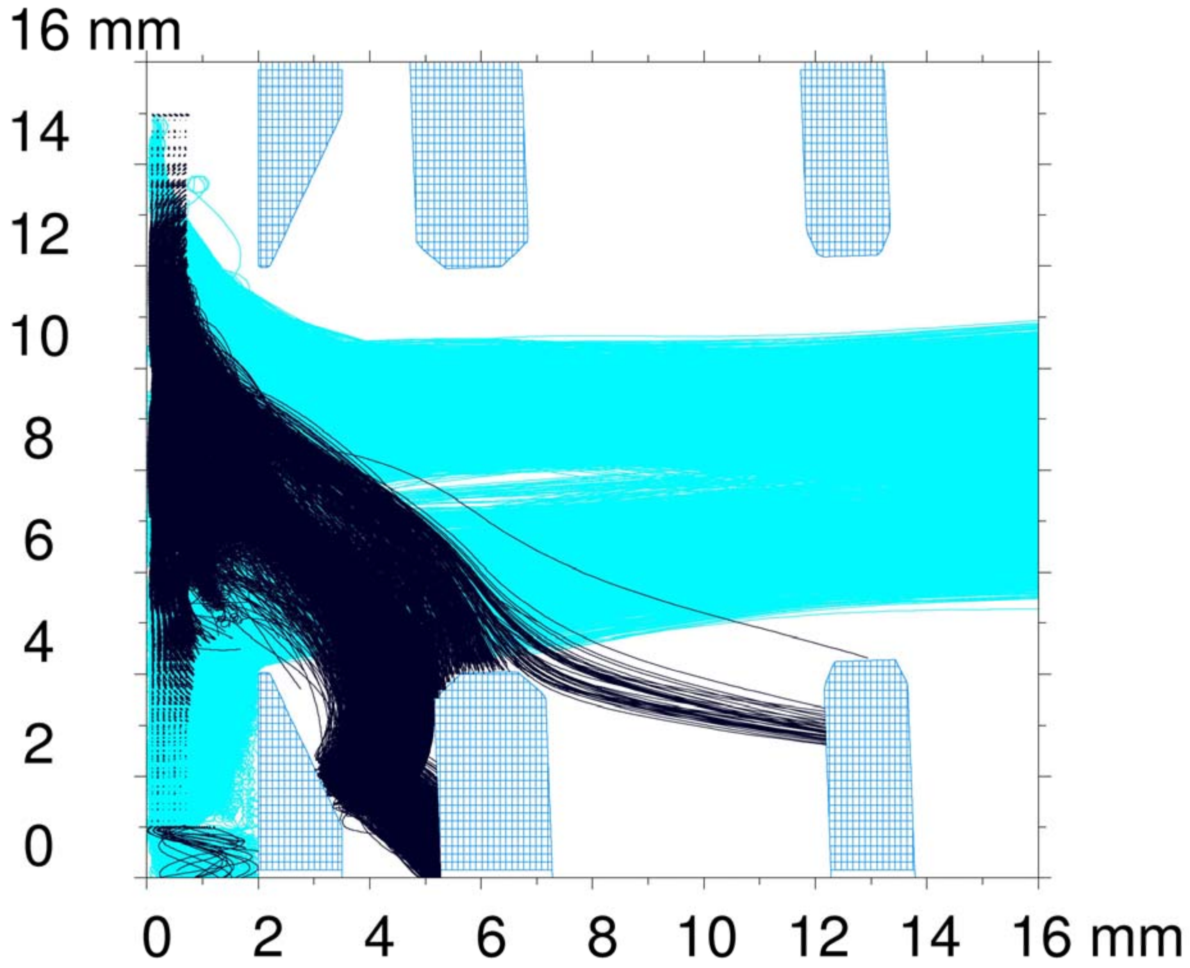
H^- Source



To avoid the electron component in the extracted beam
a magnetic filter can be applied.

Beam steering caused by the magnetic field can be compensated by tilting the electrodes.

H$^-$ Source



H^- Source

already small modifications of the source operating conditions influencing the plasma density

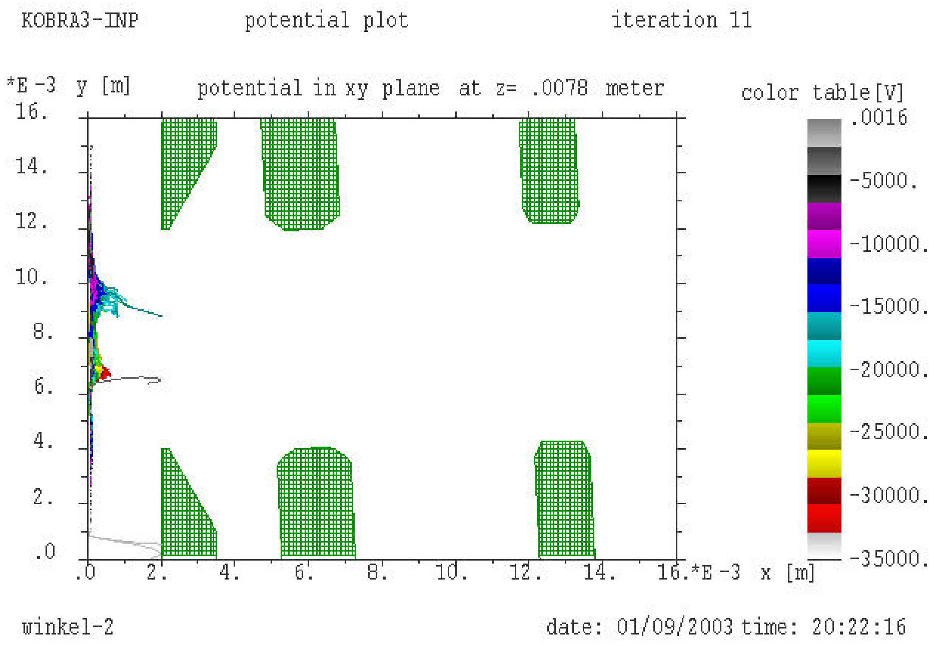
and/or

the ratio of electron density and ion density

can influence

the effectivity of electron dumping:

H$^-$ Source


KOBRA3-INP
potential plot
iteration 11
*E -3 y [m]
potential in xy plane at z= .0078 meter
color table [V]
16.
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12.
10.
8.
6.
4.
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6.
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14.
16.*E -3 x [m]
.0016
-5000.
-10000.
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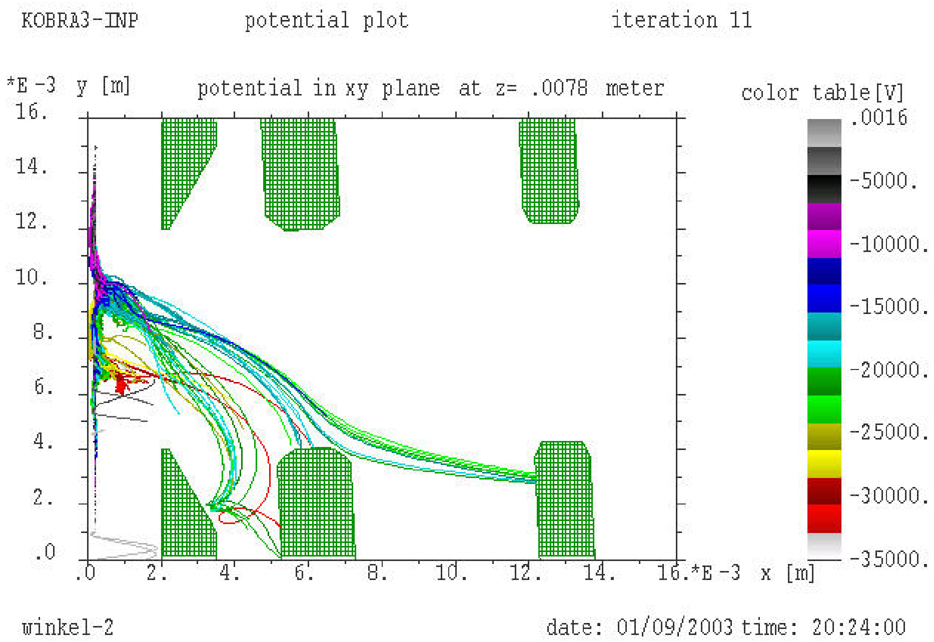
-30000.
-35000.
winkel-2
date: 01/09/2003 time: 20:22:16

H⁻ Source


KOBRA3-INP
potential plot
iteration 11
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potential in xy plane at z= .0078 meter
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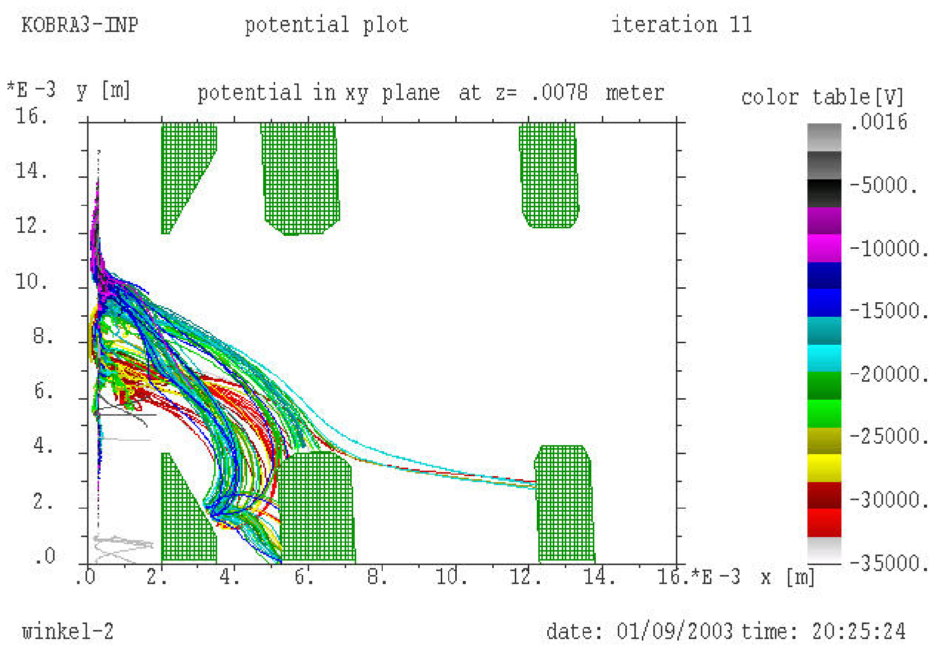
winkel-2
date: 01/09/2003 time: 20:24:00

H^- Source



KOBRA3-INP
potential plot
iteration 11
*E -3 y [m]
potential in xy plane at z= .0078 meter
color table[V]
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16.*E -3 x [m]
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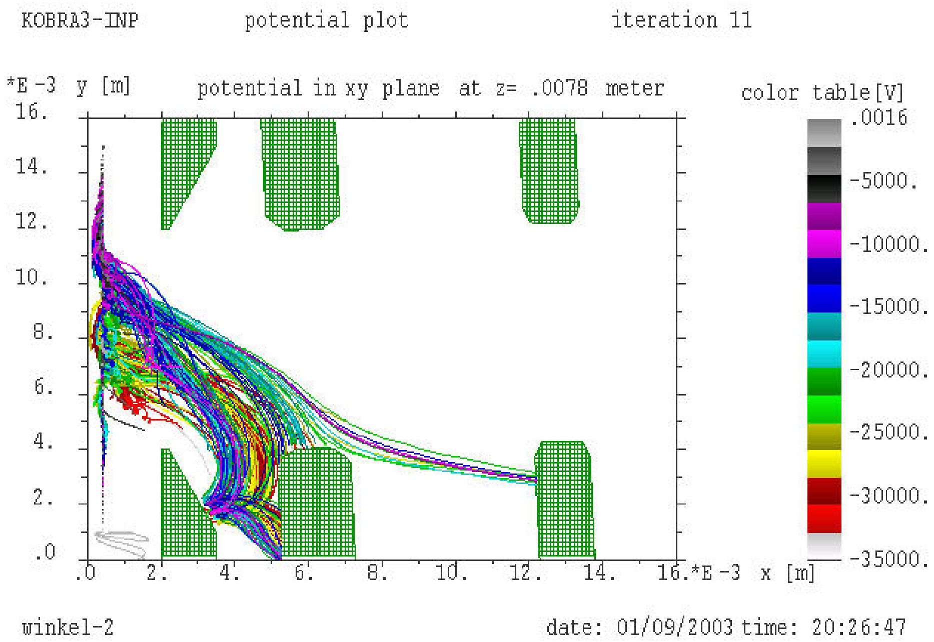
date: 01/09/2003 time: 20:25:24

H^- Source


KOBRA3-INP
potential plot
iteration 11
*E -3 y [m]
potential in xy plane at z= .0078 meter
color table[V]
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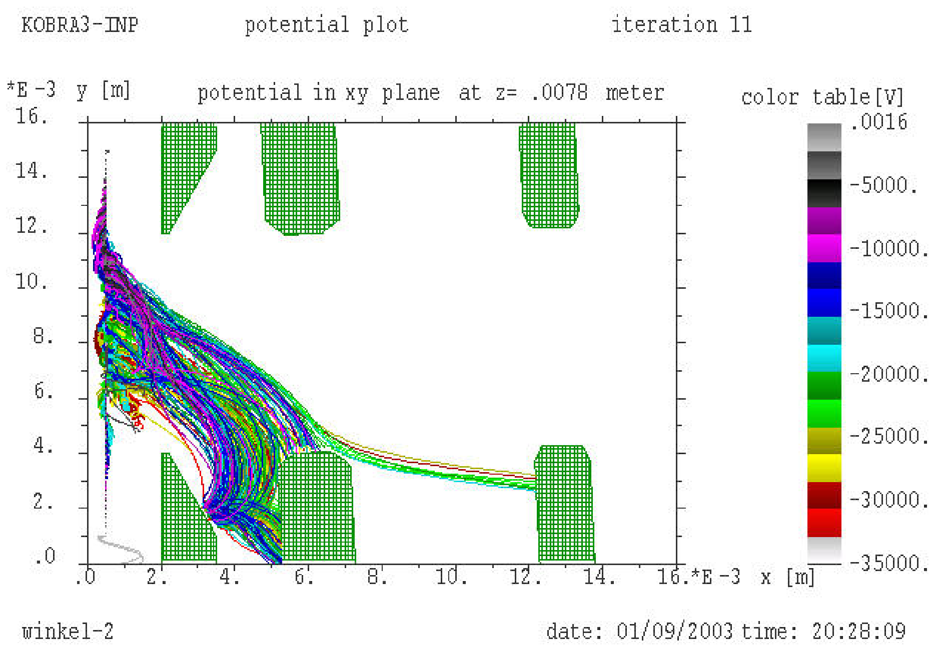
16.*E -3 x [m]
winkel-2
date: 01/09/2003 time: 20:26:47

H^- Source



KOBRA3-INP
potential plot
iteration 11
*E -3 y [m]
potential in xy plane at z= .0078 meter
color table[V]
.0016
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-10000.
-15000.
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16.*E -3 x [m]
winkel-2
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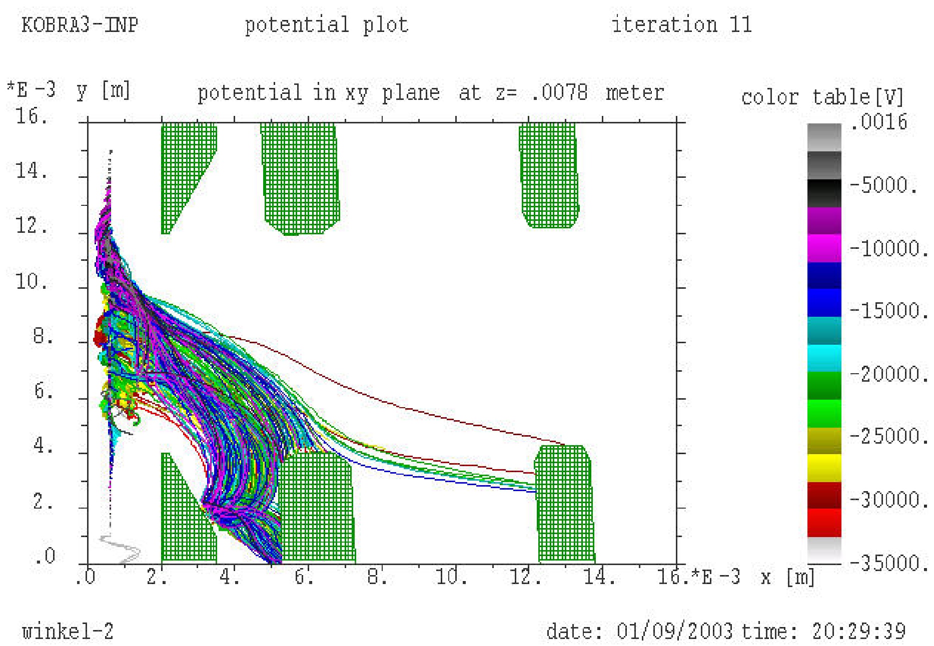
H$^-$ Source



KOBRA3-INP
potential plot
iteration 11
*E -3 y [m]
potential in xy plane at z= .0078 meter
color table[V]
16.
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6.
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14.
16.*E -3 x [m]
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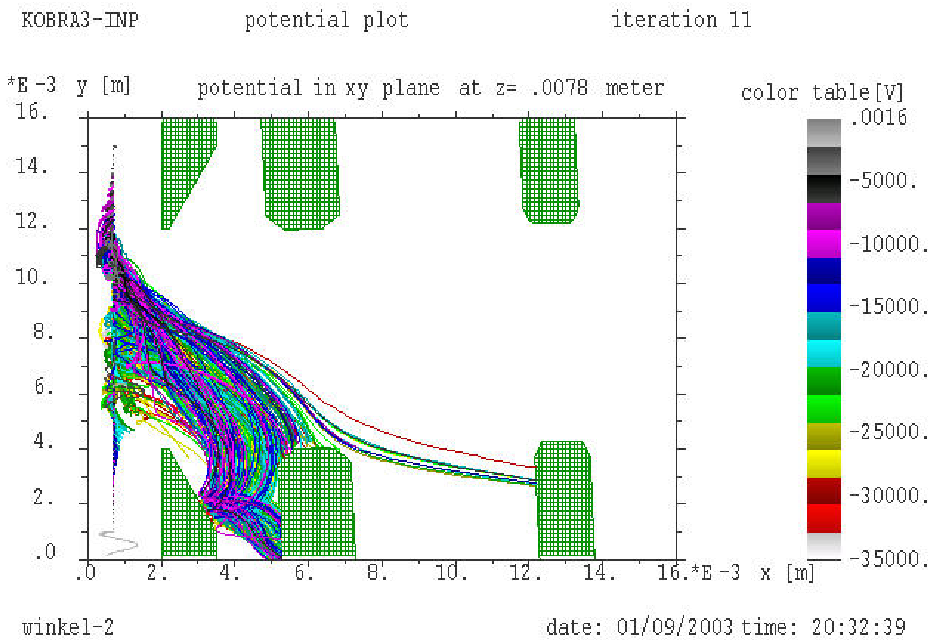
winkel-2
date: 01/09/2003 time: 20:29:39

H^- Source


KOBRA3-INP
potential plot
iteration 11
*E -3 y [m]
potential in xy plane at z= .0078 meter
color table[V]
.0016
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-10000.
-15000.
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-25000.
-30000.
-35000.
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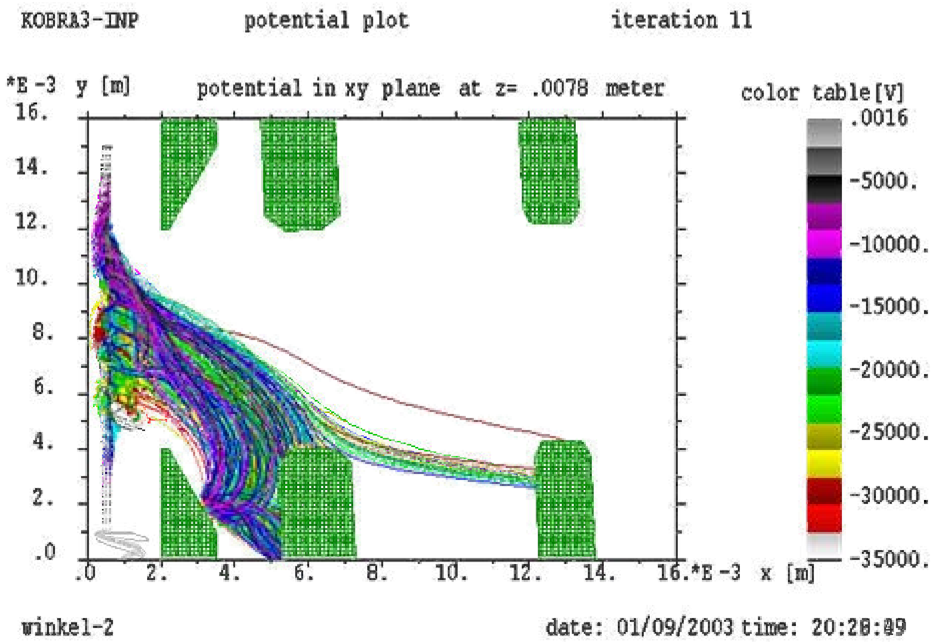
16.*E -3 x [m]
winkel-2
date: 01/09/2003 time: 20:32:39

H^- Source


KOBRA3-INP
potential plot
iteration 11
*E -3 y [m]
potential in xy plane at z= .0078 meter
color table [V]
.0016
-5000.
-10000.
-15000.
-20000.
-25000.
-30000.
-35000.
16.
14.
12.
10.
8.
6.
4.
2.
.0
.0
2.
4.
6.
8.
10.
12.
14.
16. *E -3 x [m]
winkel-2
date: 01/09/2003 time: 20:28:49

H^- Source

• reducing the total extracted current by a magnetic dipole field.

Assume a required H^- beam with 100 mA intensity and a ratio n_e/n_i in the order of 10 would require an hv-power supply for extraction with 35 kV / 1 A. instead of 35 kV / 100 mA.

• bending out the electrons with low energy

will reduce the loss power from 35 kW without bending to 5 kW with bending in vacuum (assuming 1 A and 5 kV)

• the tilt of the extracted ion beam can be corrected by a tilt of the extraction electrode.

• however, keep in mind that the efficiency of electron dumping will depend on the specific ion source operating conditions...

What is important for the simulation of the extraction from a H^- source ?

- geometry
- electric potentials
- magnetic filter field
- compensation model
- spatial distribution of ions and electrons
- Current of H^- and electrons

Extraction

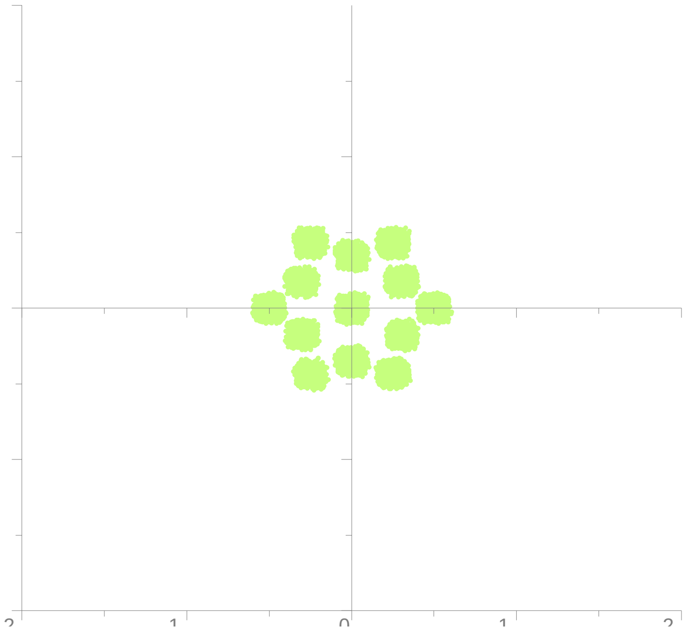
- "0" order recipe for a design

Extraction

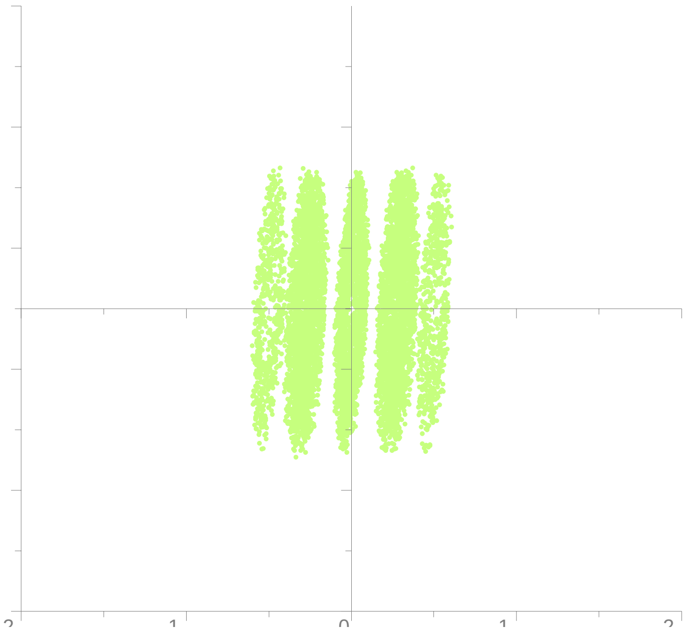
- choose the extraction voltage.
- a minimum distance between the extraction electrodes follows because of the HV breakdown limit.
- with an optimum aspect ratio (approx. 0.7) the hole diameter is fixed.
- the theoretical current can be estimated by Child's law, but is applicable only if the plasma density can be provided by the generator.
- if a higher current is required a multi aperture extraction system can be used on the cost of emittance.

Extraction

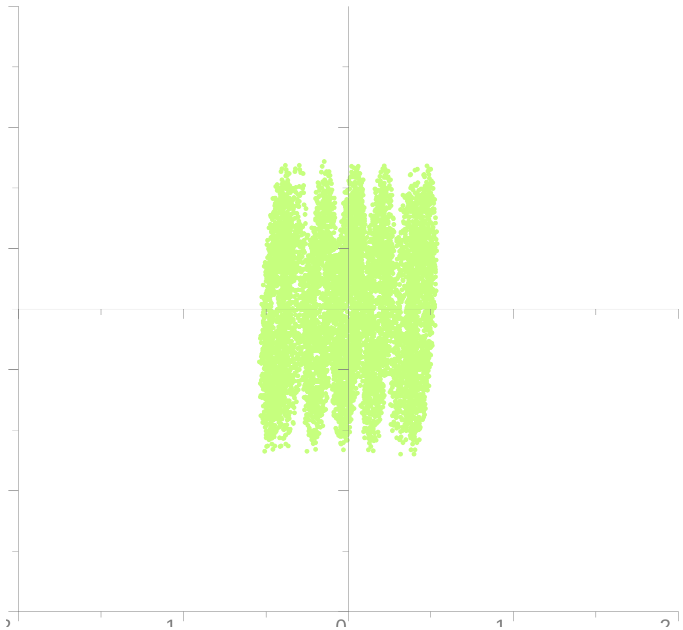
real space plot directly behind extraction of a multi aperture extraction system with 13 holes.



Extraction



horizontal emittance



vertical emittance

Drift

- Simpliest way of beam transport
- no external forces

Drift

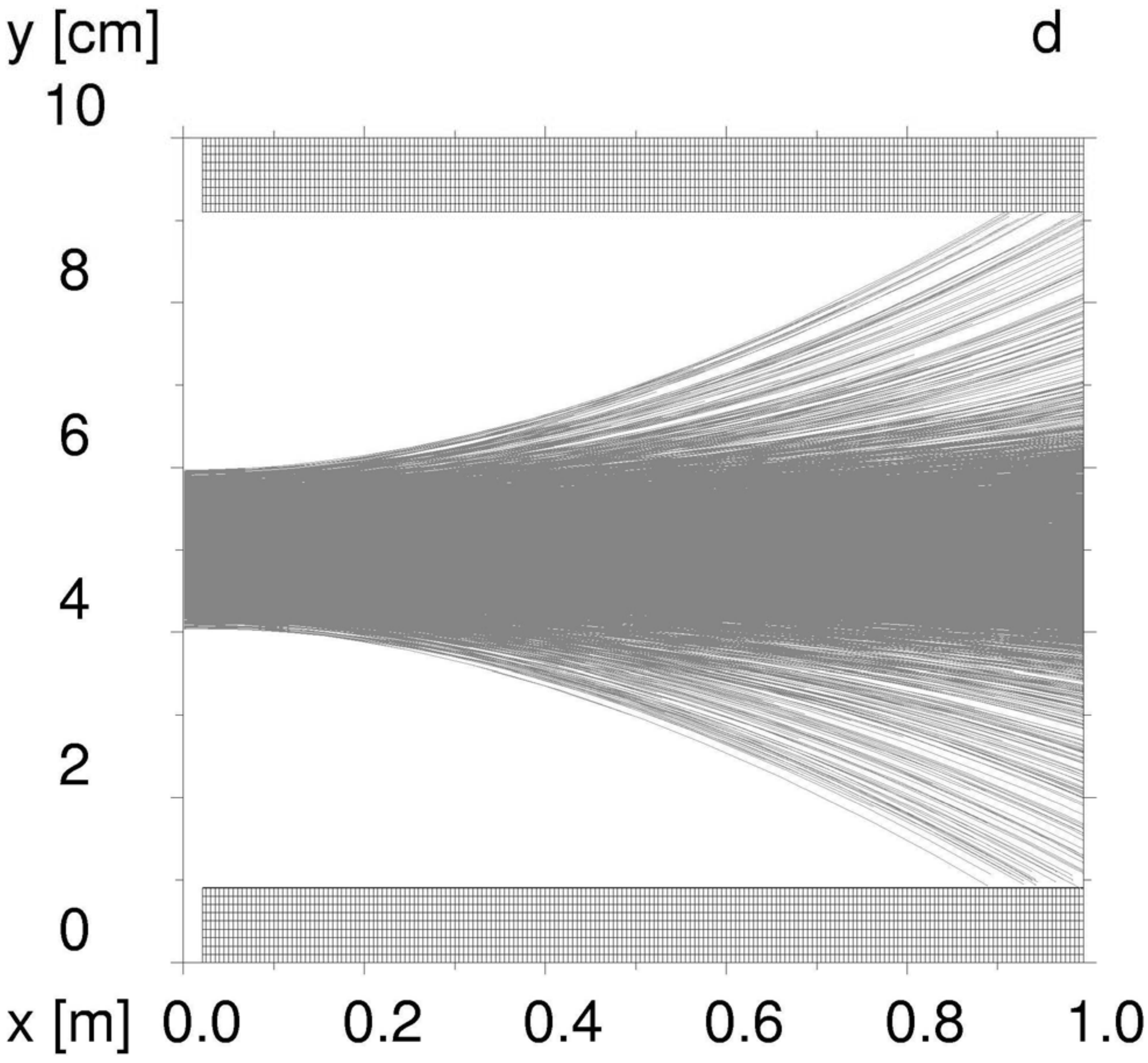
<u>Assume a drifting ion beam</u>

Species	Ar^{1+}
energy	30 keV
emittance	100 π mm mrad

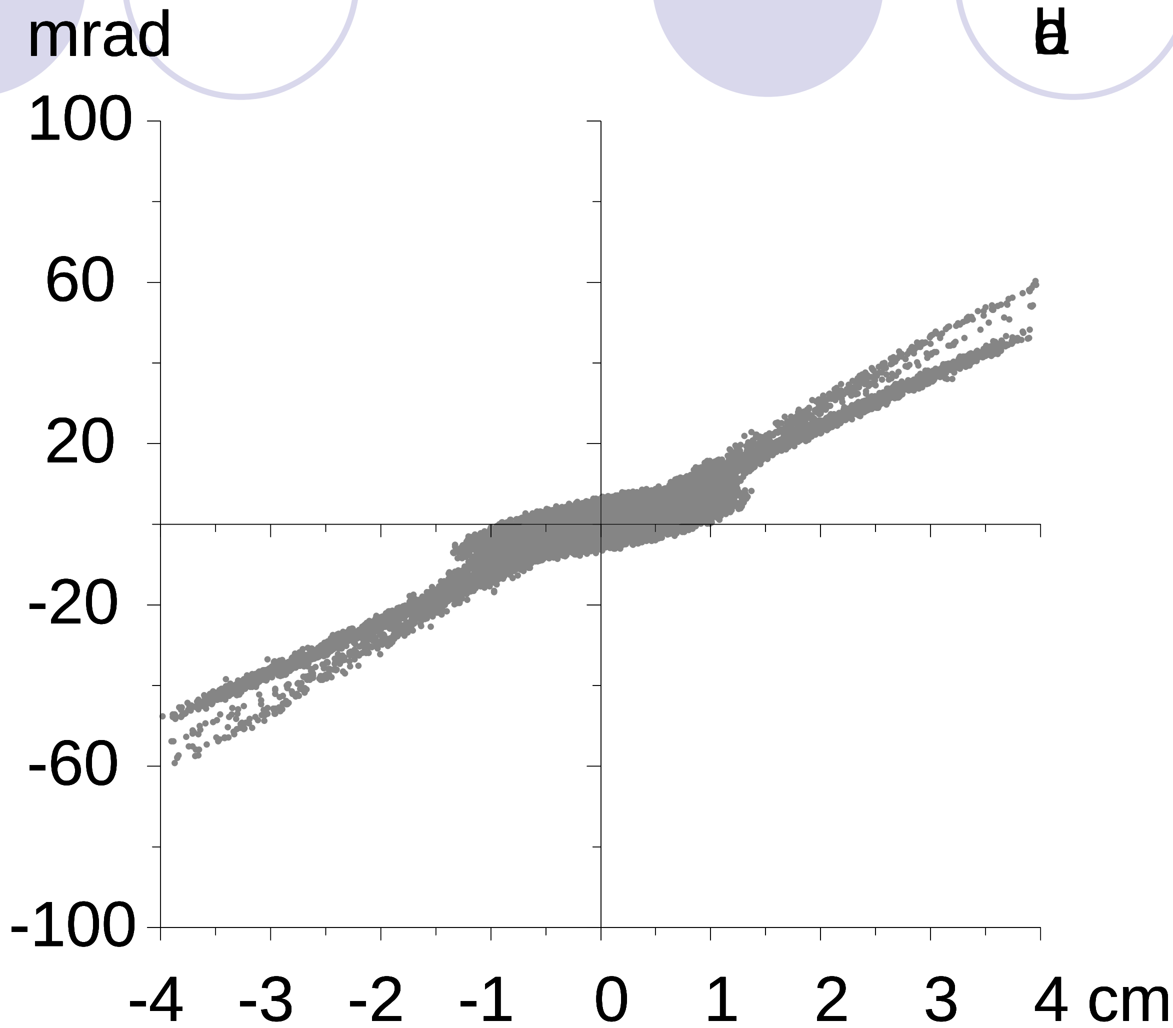
different models for neutralization:

- zero current (no space charge)
- 10 mA current (full space charge)
- with space charge compensation, assuming a certain degree (e.g. 90% compensation)
- with space charge compensation, assuming a certain beam plasma potential (e.g. 80 V)

Drift



Drift



Drift

potential caused by the space charge

$$\rho = I/(\varepsilon_0 v)$$

$$\Phi = I / (2 \pi \varepsilon_0 v) (1/2 + \ln r_w / r_b)$$

BUT

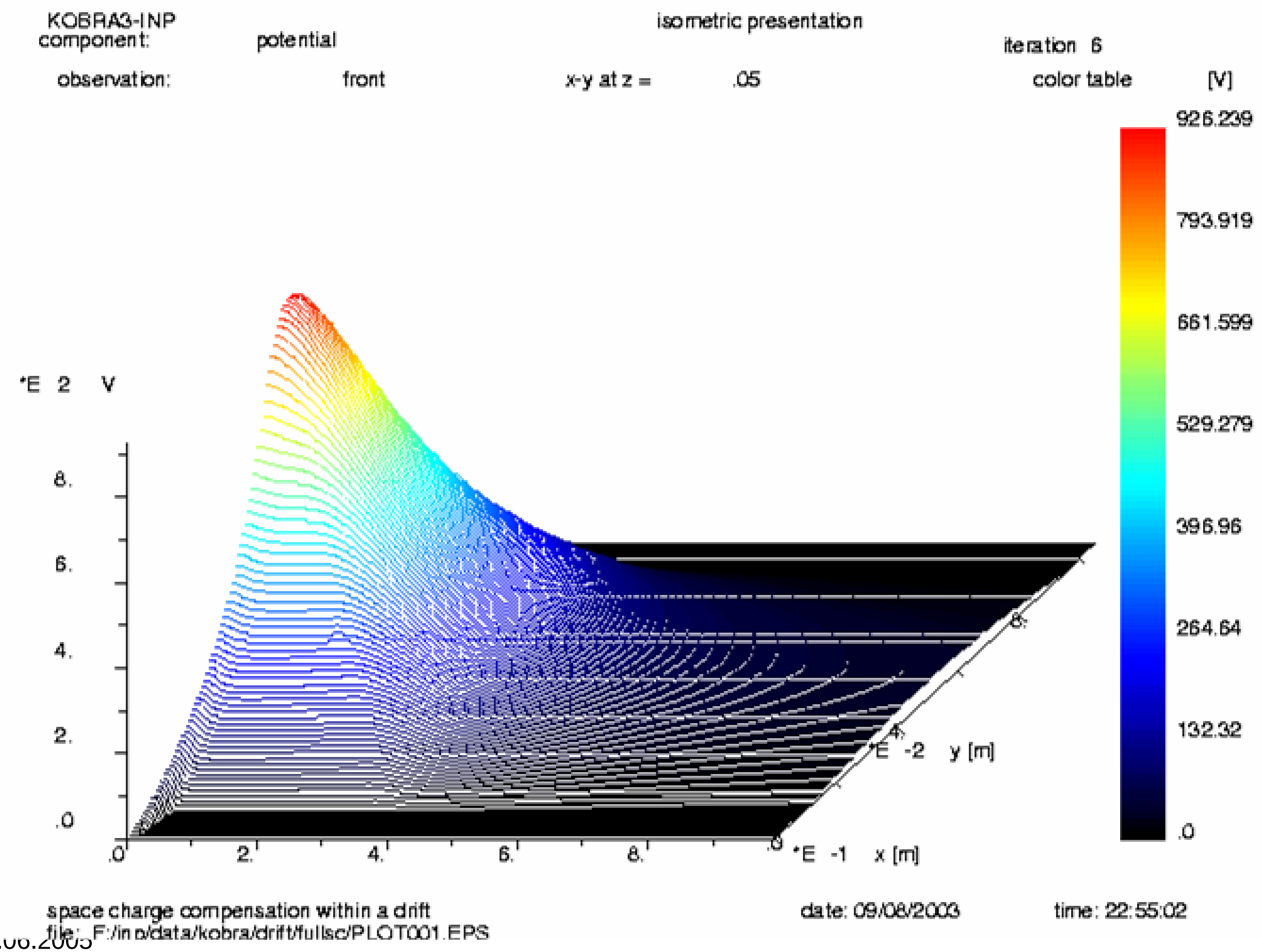
collisions of primary ions with residual gas atoms

AND

with surfaces (sputtering) will produce secondary ions and electrons:

only the coldest electrons will be trapped within the space charge potential of the beam, whereas the secondary ions will be repelled from the beam.

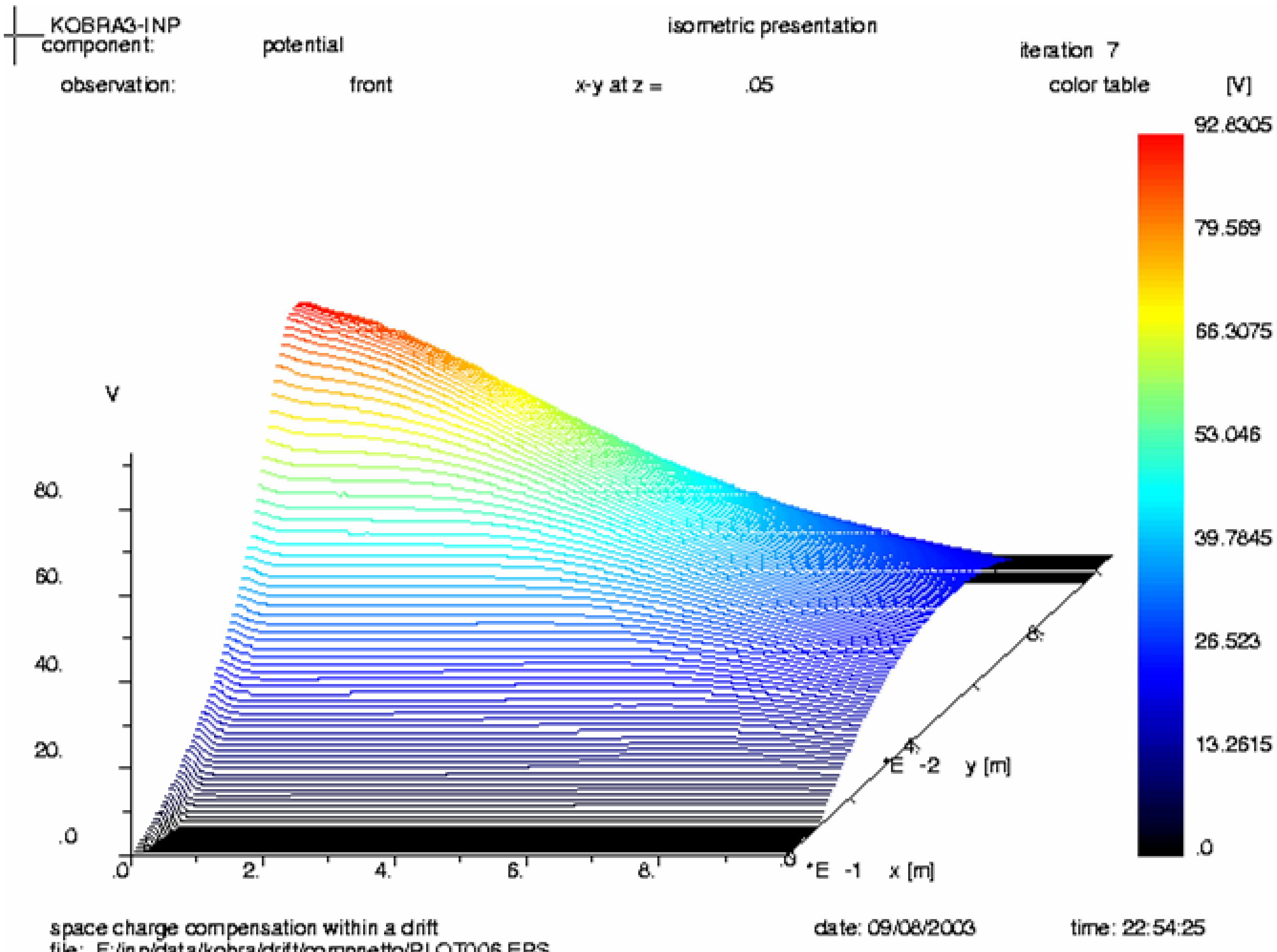
Drift



potential caused by the space charge

no neutralisation

Drift

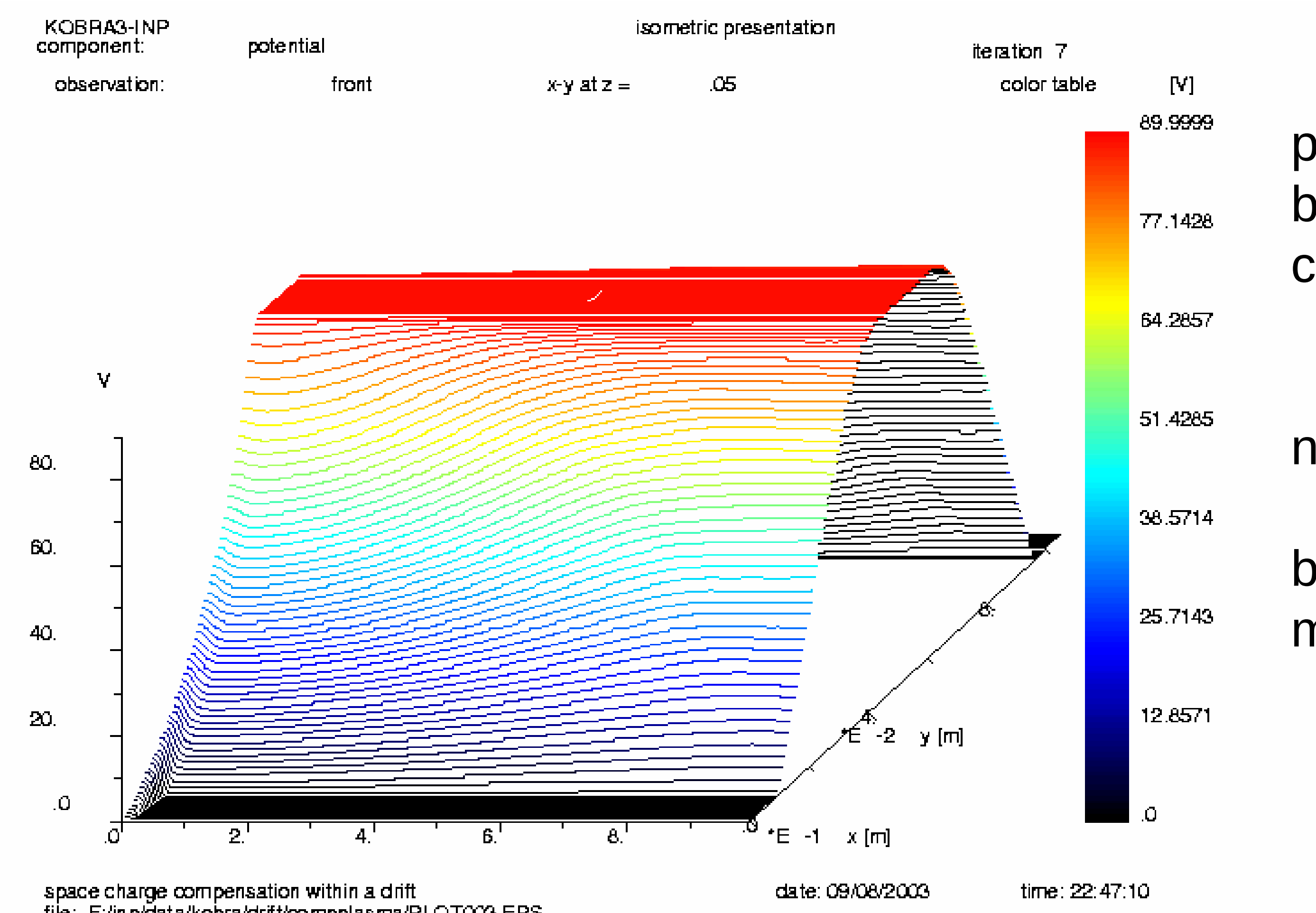


potential caused by the space charge

90% neutralisation

effective current

Drift



potential caused by the space charge

90% neutralisation

beam plasma model

Drift

$$L = k\, r_0 * \sqrt{q/m} \,/\, \sqrt{P}$$

Estimation of the characteristic length L until the beam doubles its initial diameter due to the space charge force.

	U_{ex} kV	Φ_b V	L cm
e	-15	-0.175	430
p	15	30	40
Ar^{+}	15	189	16
Ar^{3+}	5	189	9
Ar^{3+}	15	109	20

Drift

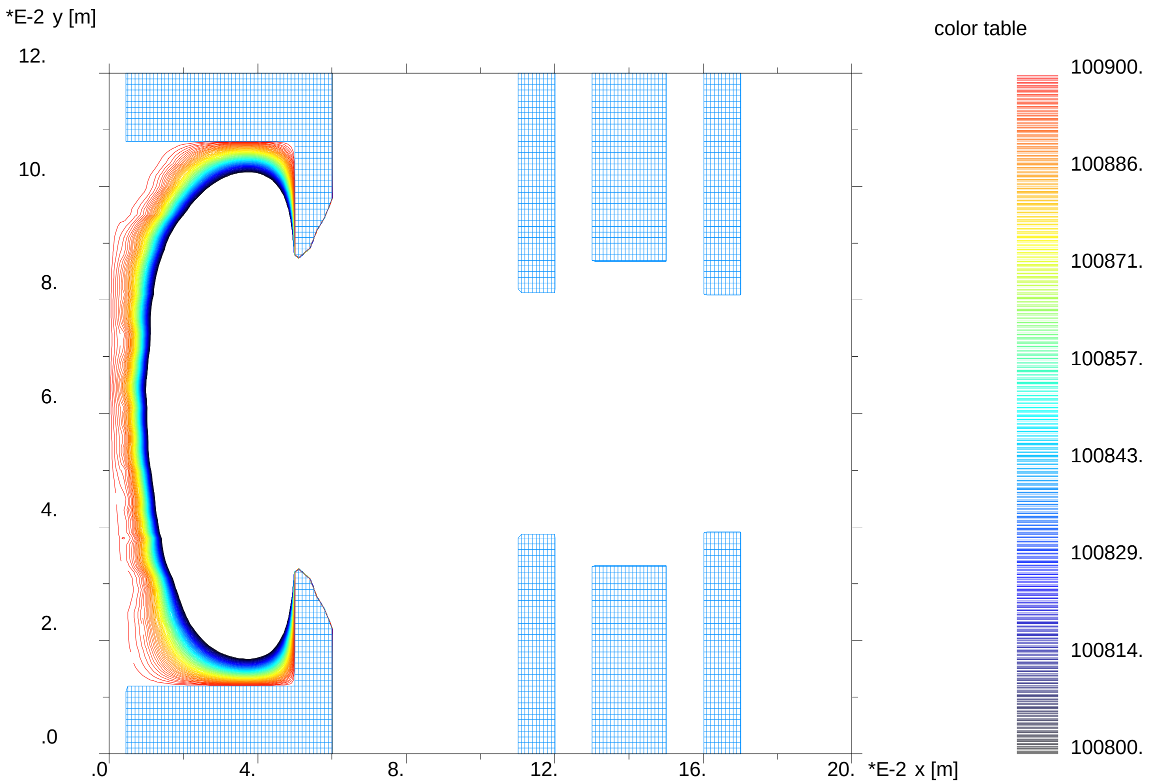
What is important for the simulation of a drifting beam?

- electric potentials
- geometry
- magnetic flux density
- compensation model
- spectral distribution of ions
- spatial distribution of ions and electrons
- Current of each charge state

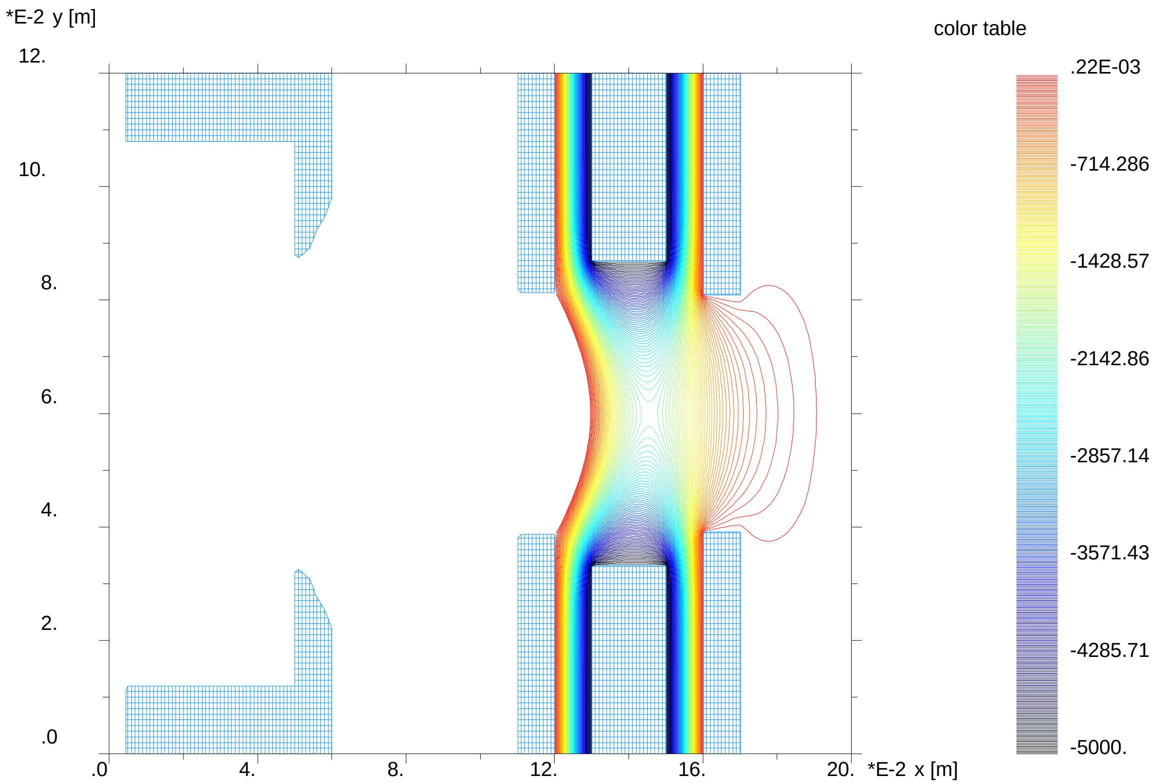
Postacceleration

If the required beam energy cannot be achieved with extraction voltage, the beam can be further accelerated (decelerated) to provide the required energy.

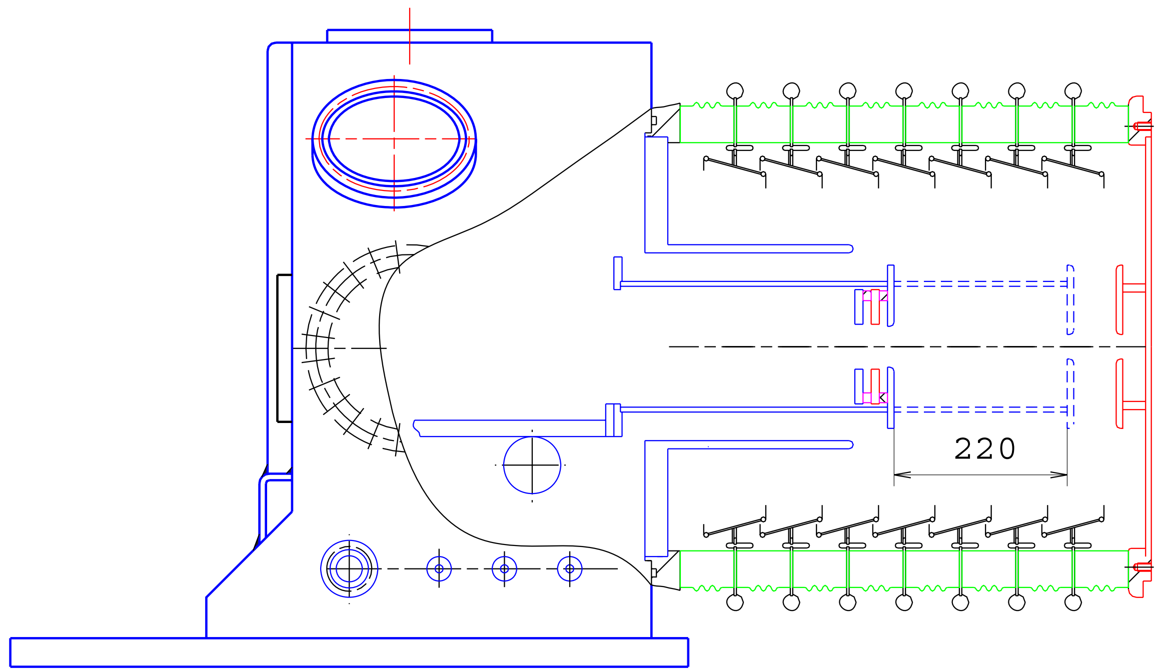
Post acceleration



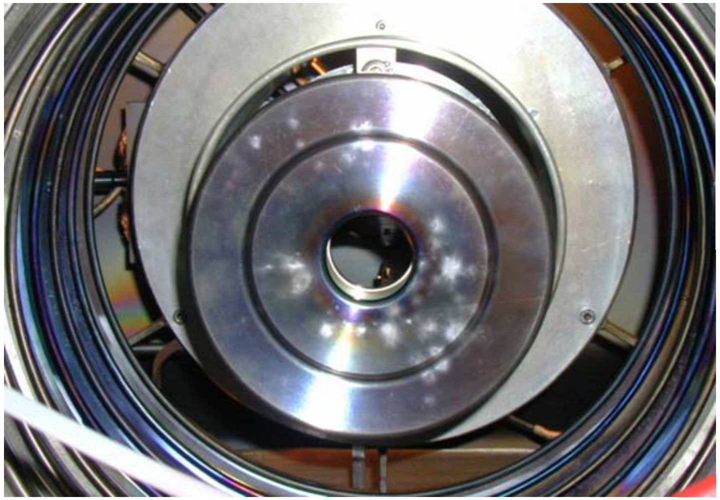
Post acceleration



Post acceleration



Post acceleration



4 electrodes, moveable

HV-electrode: ∅ 60 mm

ground eleromctrode: ∅ 50 mm

screening electrode: ∅ 60 mm

ground electrode: ∅ 50 mm

aspect ratio from 0.2 to 3

BEAM GENERATION

ECR source

magnetic field in the plasma chamber

plasma potential in the plasma chamber

B=1T, no hexapole, I = 5mA, Ti=1eV, Te=5eV

B=2T

B=3T

B=4T

LIS

H^-

drift

postacceleration

EXIT

Final conclusion

I have tried to show different types of electron guns and ion sources together with some simulations, indicating that some models for different applications are available; other applications might require further model studies.

Remember:

simply choose the most promising particle generator.

to increase the number of ions on "target":

increase the current from the source

or

decrease the emittance of the extracted beam