Beam Formation

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Beam Formation

- particle generation
- electrons
- ions
- extraction
- drift
- post acceleration

What stands beam formation for ?

USEFUL EQUATIONS

$\lambda_D = \sqrt{(\varepsilon_0 kT_e / e^2 n_e)}$ Debye length

λ_D [m]= $7.43 \sqrt{(T_e [eV] / n_e [cm^{-3}])}$ practical units

$\omega_p = e^2 n_e / \varepsilon_0 m_e$ plasma frequency

ω_{pe} [Hz] = $8980 n_e [cm^{-3}]$ practical units for electrons

ω_{pi} [Hz] = $210 n_i [cm^{-3}] q / A[amu]$ practical units for ions

USEFUL EQUATIONS

$j = 4\varepsilon_0/9\sqrt{(2q / m_i}\ \ \Phi^{1.5}/d^2$ Child's law

$P = I / \Phi^{1.5}$ perveance

Beam Formation: Electrons

- How to create electrons
- How to create an electron beam

BEAM FORMATION

saturation current density j_{es} for different materials

$$j_{es} = AT^2 \exp(-e\Phi/kT)$$

Φ workfunction [V]

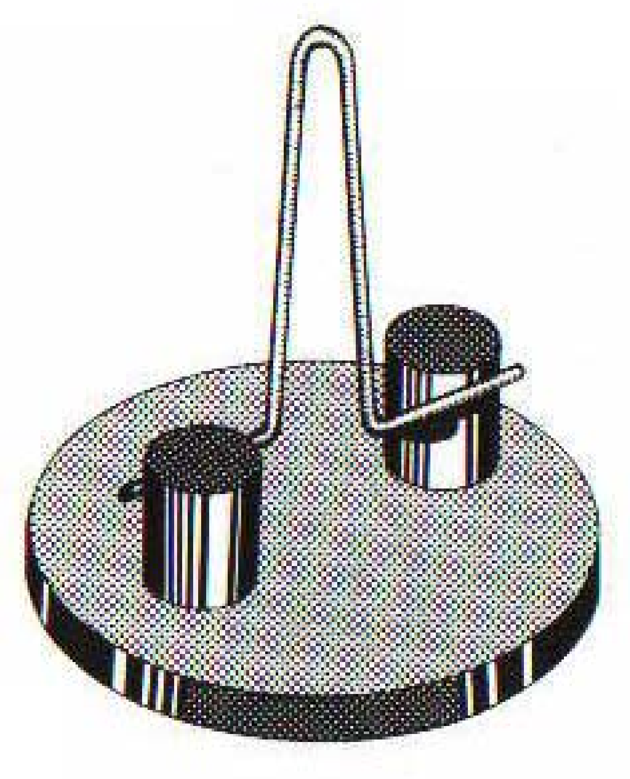
T temperature [K]

material	Φ[V]	A
molybdenum	4.15	55
nickel	4.61	30
tantalum	4.12	60
tungsten	4.54	60
barium	2.11	60
cesium	1.81	160
iridium	5.40	170

BEAM FORMATION

Simple cathode

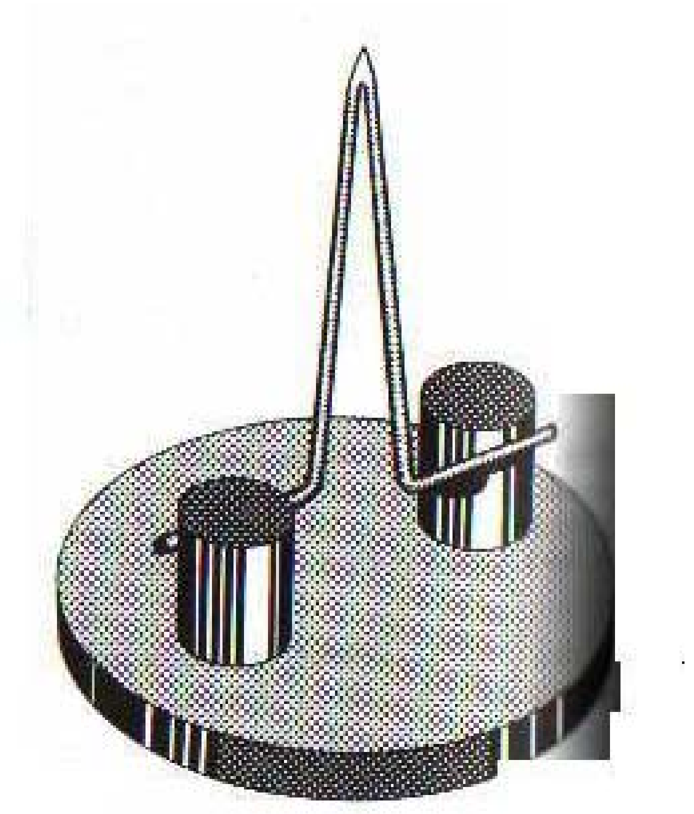
resistive heating



BEAM FORMATION

Pointed cathode

resistive heating



BEAM FORMATION

Alternative cathode materials

electron emission A/cm²

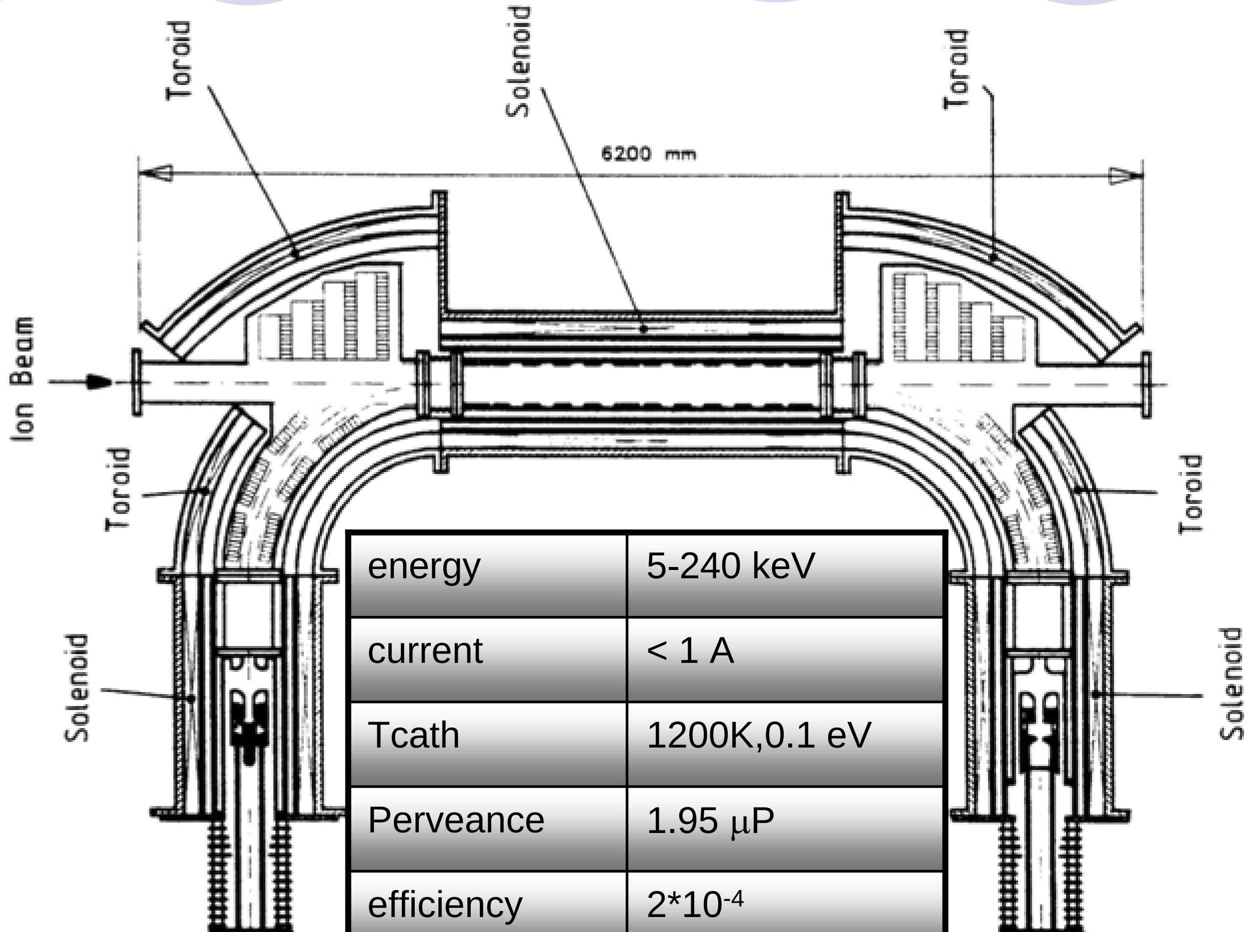
- dispenser cathodes
- LaB_6 cathodes

T (K)	tungsten	tantalum	BaO	LaB_6
1000			0.5	
1500			30	0.1
2000		[illegible]		[illegible]
2500	0.3	[illegible]		

dispenser cathodes maintain a thin film of the emitting material of a reservoir

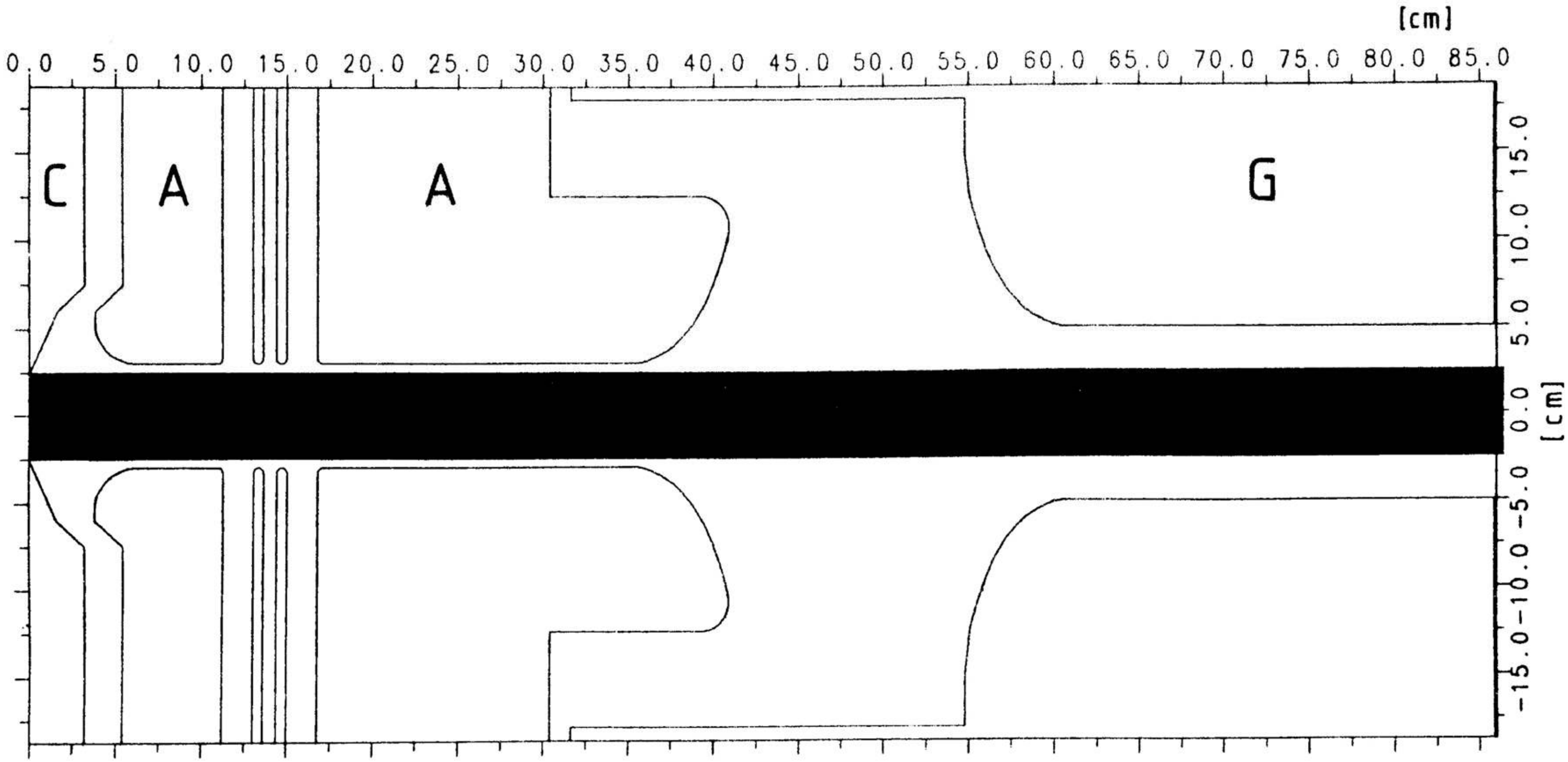
LaB_6 is an excellent electron emitter at medium temperatures (1600°C)

BEAM FORMATION



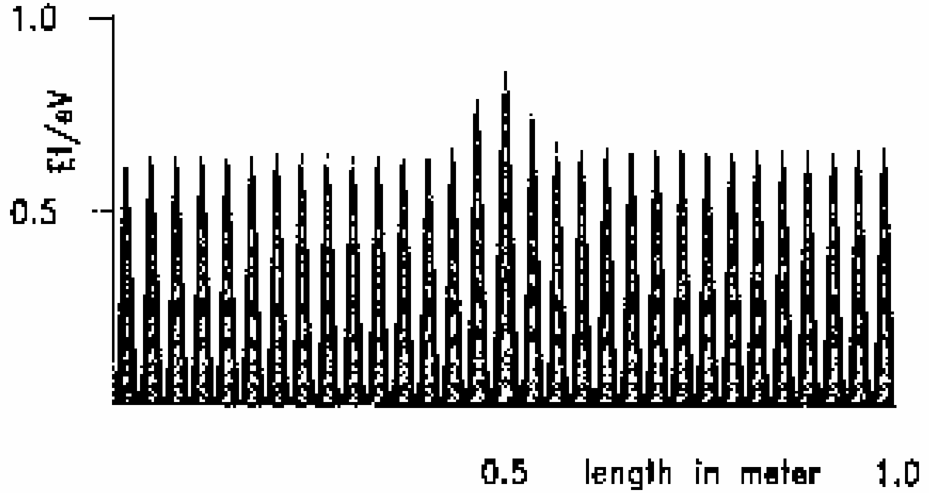
energy	5-240 keV
current	< 1 A
Tcath	1200K,0.1 eV
Perveance	1.95 μP
efficiency	$2*10^{-4}$
mag. flux den.	< 0.2 T
vacuum	< $2*10^{-11}$ mbar

BEAM FORMATION



BEAM FORMATION

transverse energy as function of longitudinal position for a 50 keV, 10 A electron beam, guided by a solenoid field with a symmetry error of 10^{-2} over a length of 30 cm.

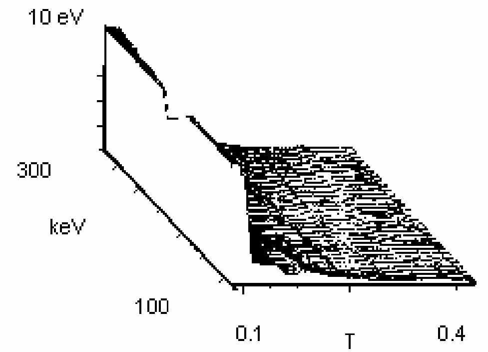


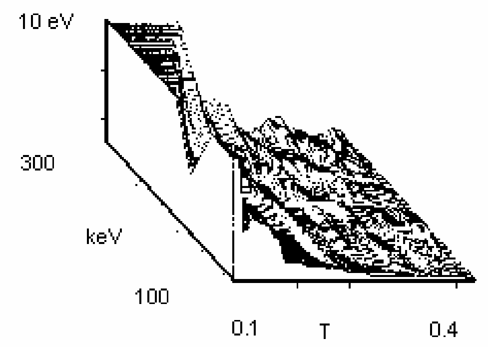
because of the magnetic field the transverse emittance is not constant!

BEAM FORMATION

transverse energy as function of beam energy and applied magnetic field for two different post acceleration geometries:

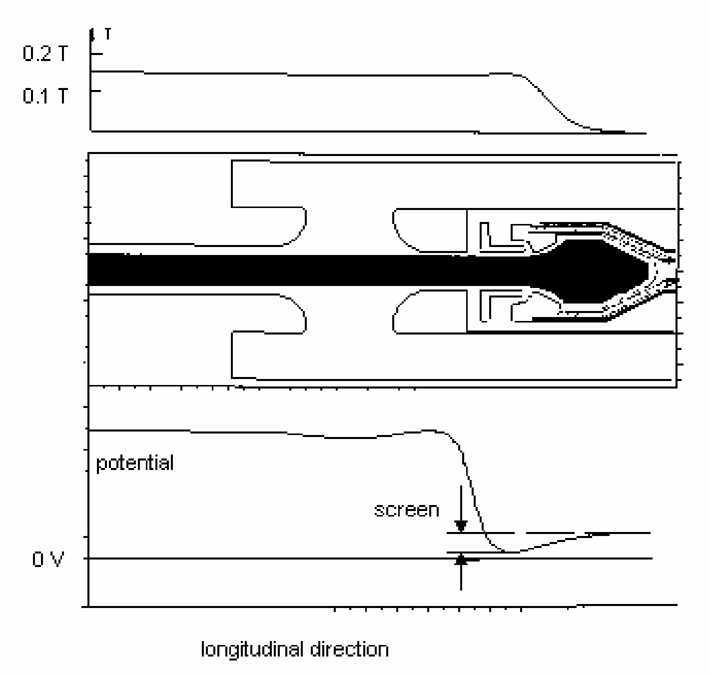
- single gap acceleration gap
- multi gap acceleration gap

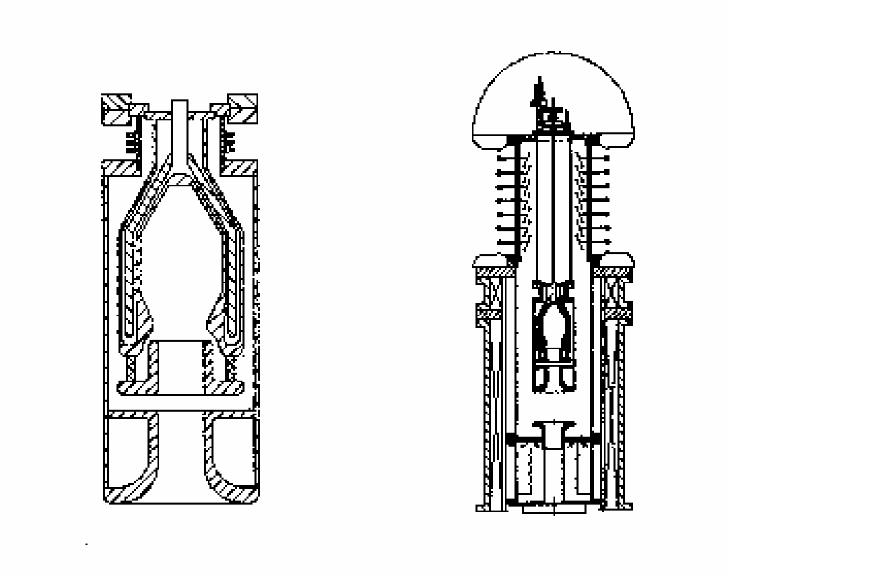




BEAM FORMATION

Collector to dump the electron beam at lowest possible cathode-collector voltage, but with highest possible efficiency.





BEAM FORMATION

A similar setup of electron gun and collector is used in most of rf-power tubes, such as klystrons and gyrotrons.

work function

cathodes

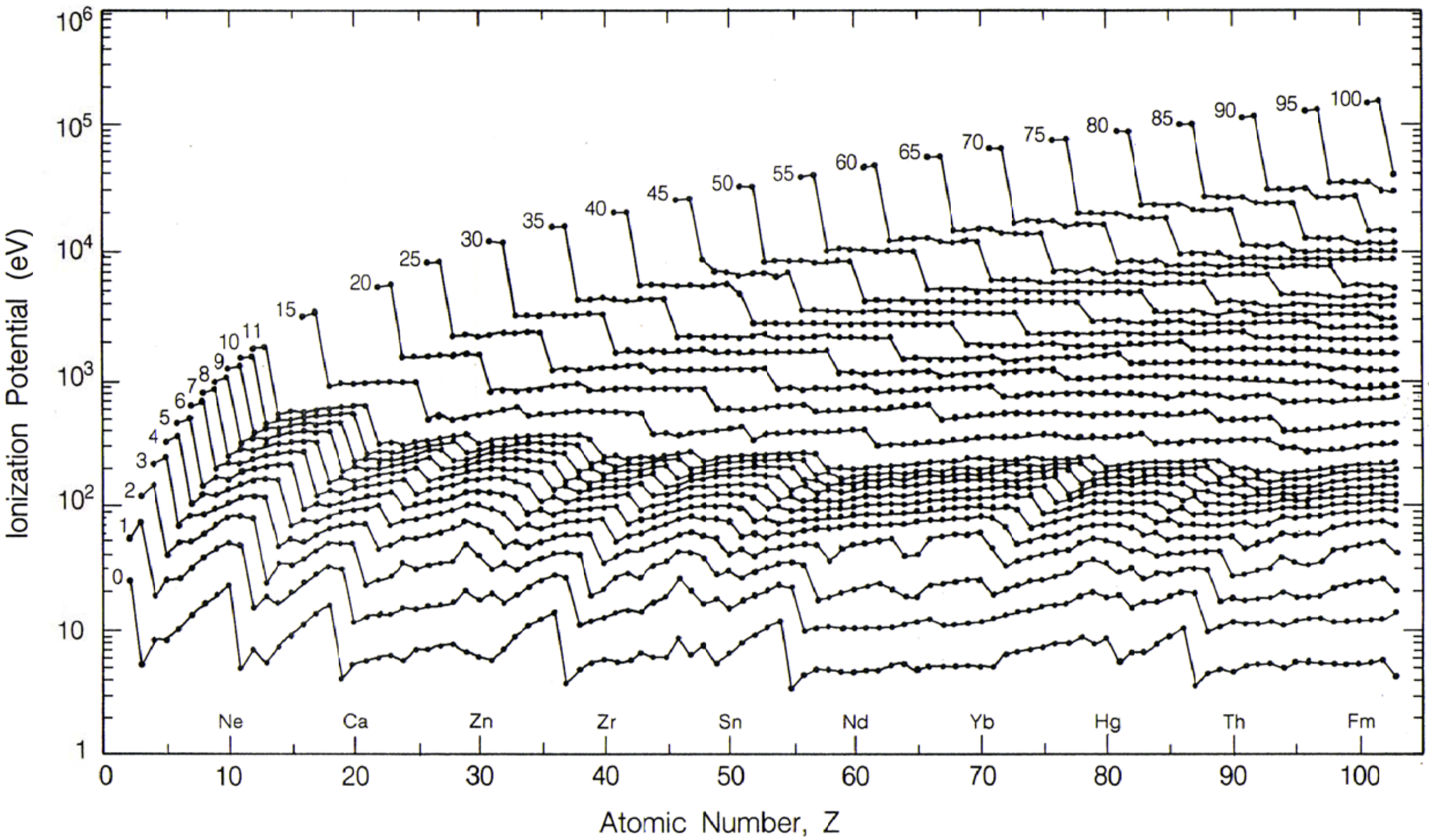
cooler

go back to ...

Ion generators

- MUCIS
- Mevva ion source
- PIG ion source

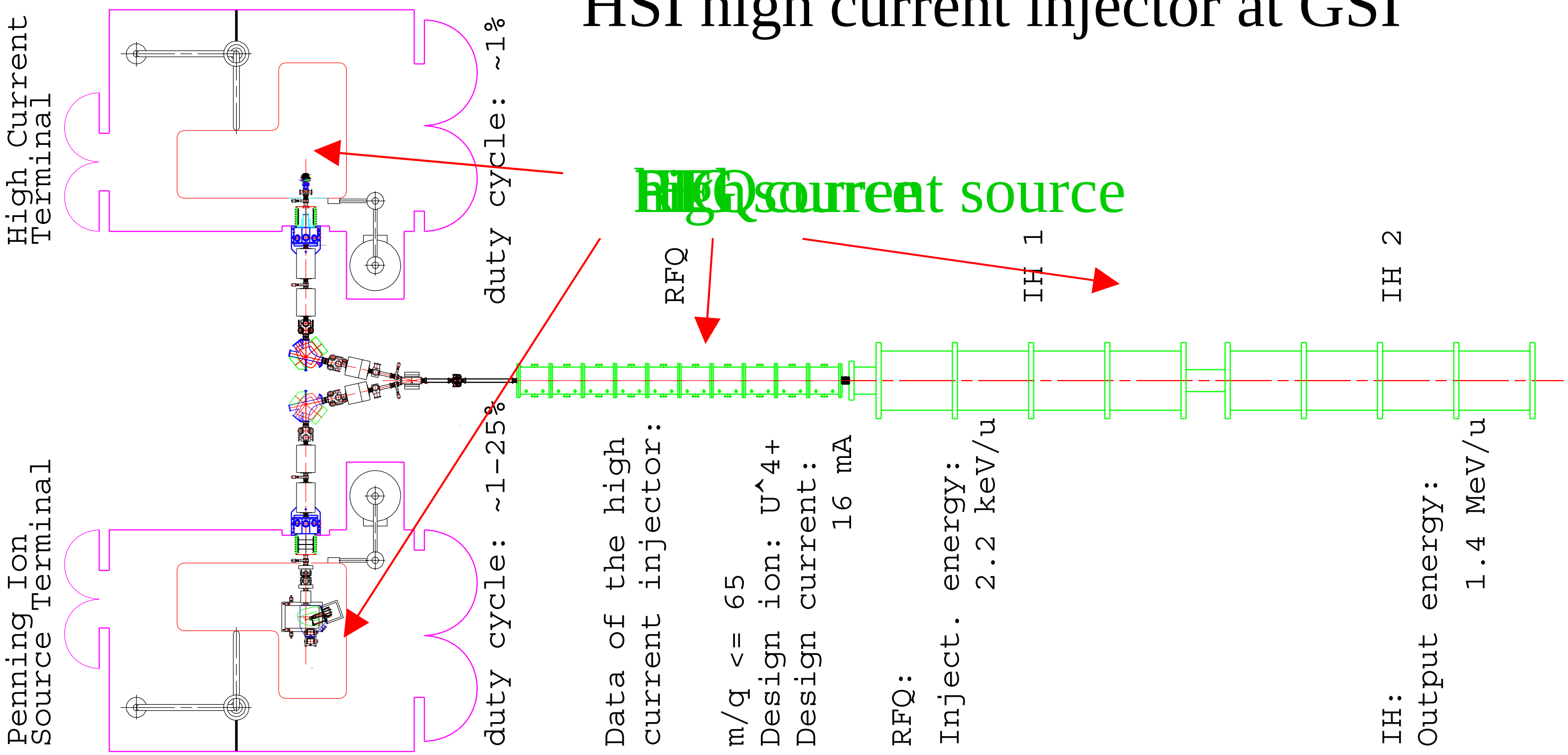
GENERAL



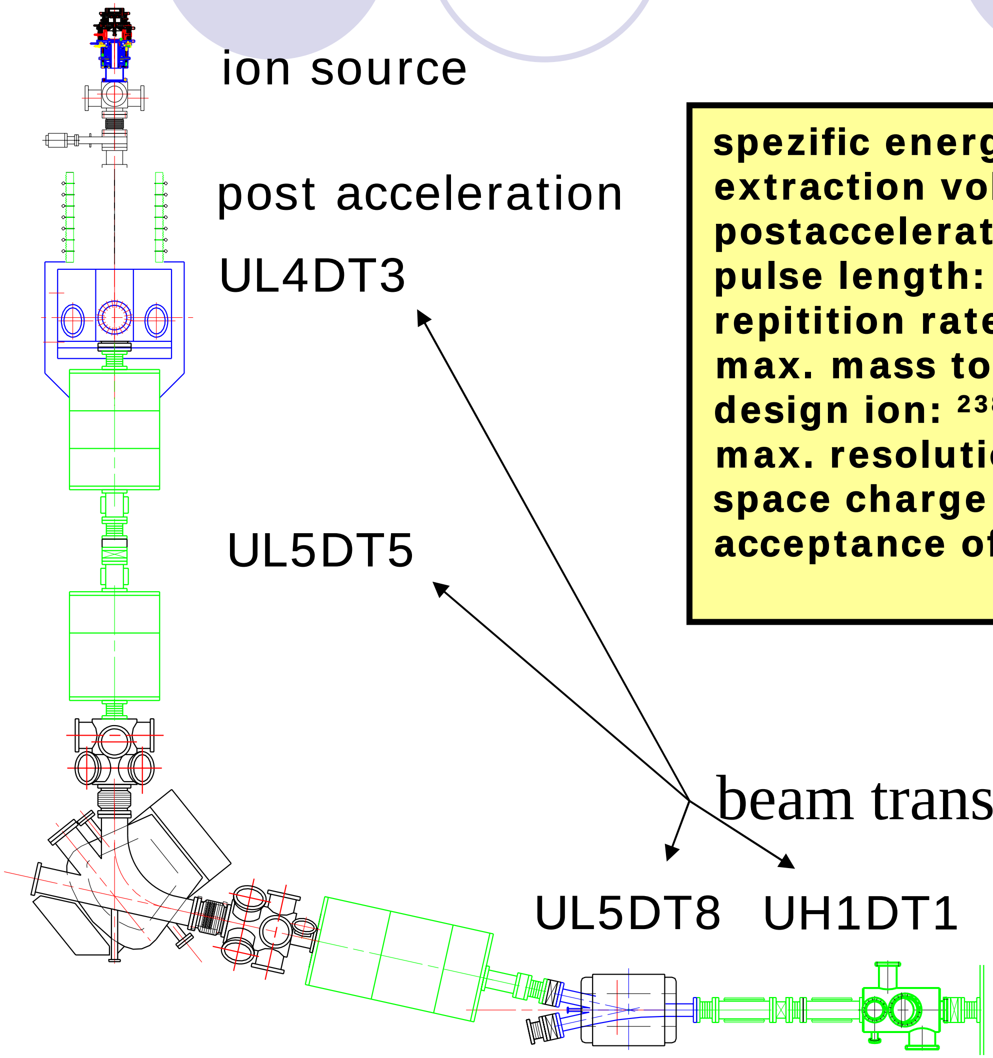
Ionization Potential (eV)
Atomic Number, Z
Ne
Ca
Zn
Zr
Sn
Nd
Yb
Hg
Th
Fm

BEAM FORMATION

HSI high current injector at GSI



Beamline



spezific energy: 2,2 keV/u
extraction voltage: 6 kV bis 35 kV
postacceleration voltage: 0 kV to 130 kV
pulse length: 0.1 ms to 6 ms
repitition rate: single shot to 50 Hz
max. mass to charge ratio, m/q < 65
design ion: $^{238}U^{4+}$, $^{130}Xe^{2+}$
max. resolution: Led isotopes can be separated
space charge limit of the RFQ: 0.25 $\times$ m/q [mA]
acceptance of the RFQ: $\varepsilon_{x,y}$ = 138 π mm mrad

High current ion sources at GSI:

- MUCIS MUlti Charge Ion Source
- MEVVA MEtal Vapor Vacuum Arc

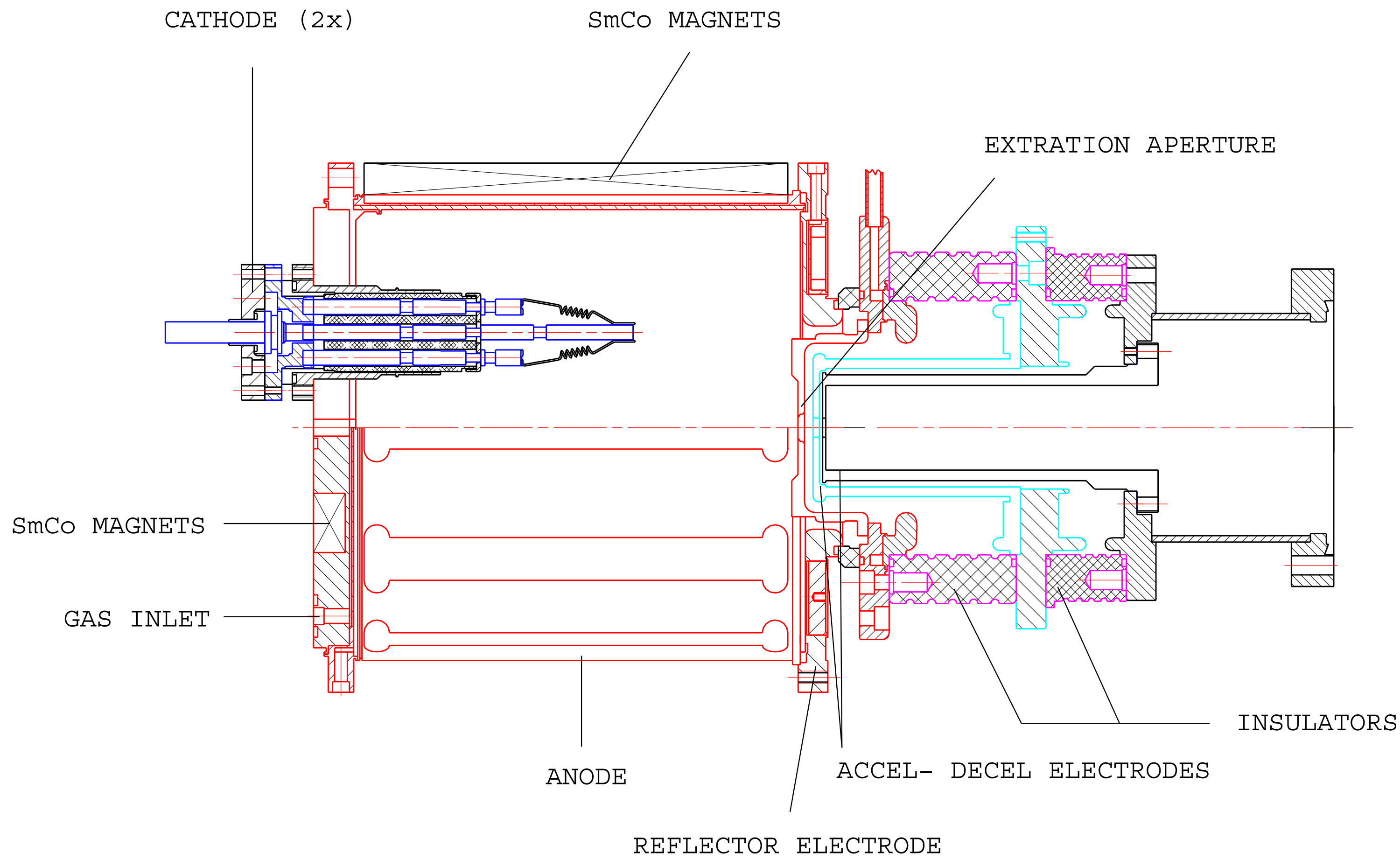
medium current ion source at GSI

- PIG ion source Penning Ionization Gauge

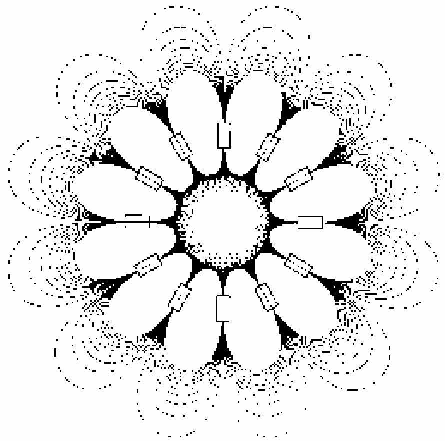
low current source

- ECR Electron Cyclotron Resonance

Multi Cusp Ion Source MUCIS



Multi Cusp Ion Source MUCIS



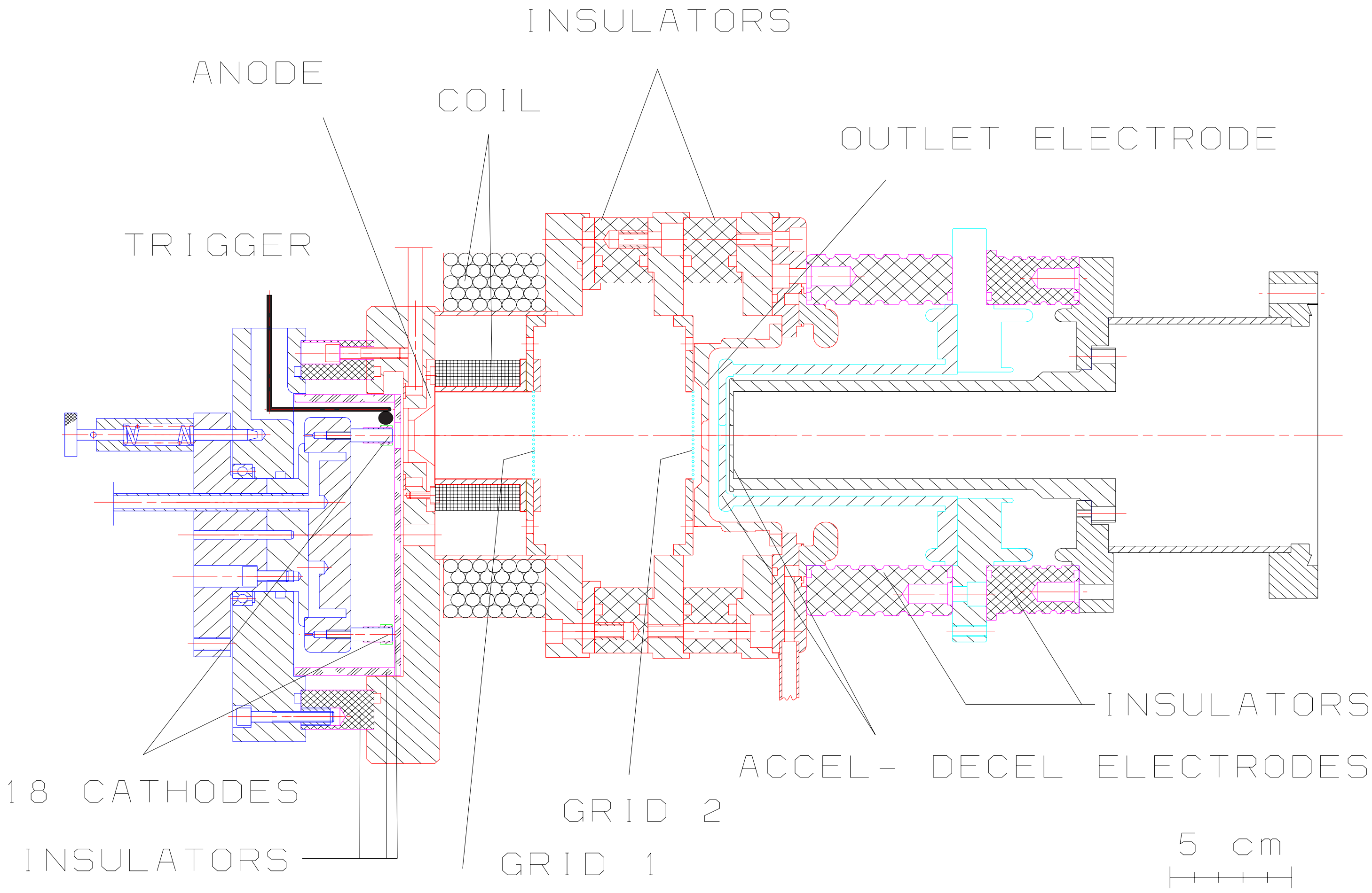
60 CoSm-magnets (2 Tesla)
cathode: 6 filaments. W/Ta
arc power: 30 kW
typical duty cycle: 5 Hz / 1 ms

Multi Cusp Ion Source MUCIS

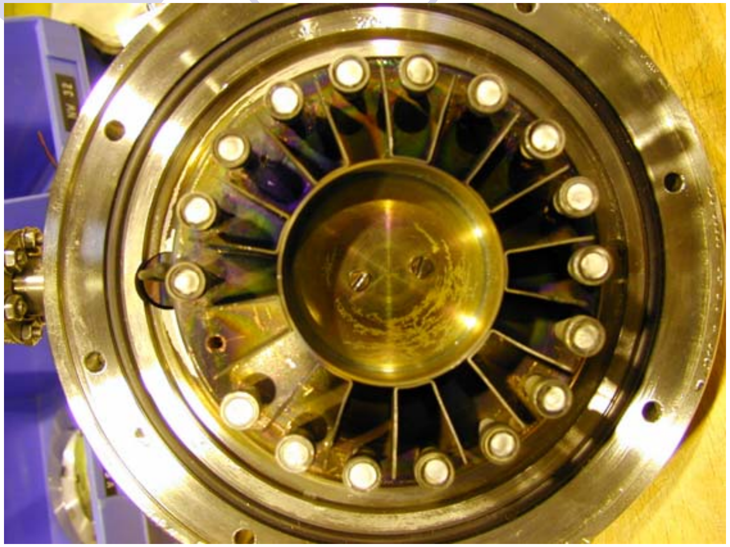
achieved ion currents from MUCIS
at the entrance of the RFQ with 2.2 keV/u

ion	RFQ sc limit	injector
$^{2}H_3^+$	1,5 mA	2.5 mA
$^{14}N^+$	3,5 mA	4 mA
$^{14}N_2^+$	7 mA	3 mA
$^{18}O_2^+$	9 mA	5 mA
$^{20}Ne^+$	5 mA	5.5 mA
$^{40}Ar^+$	10 mA	20 mA

Metal Vapor Vacuum Arc Ion Source MEVVA

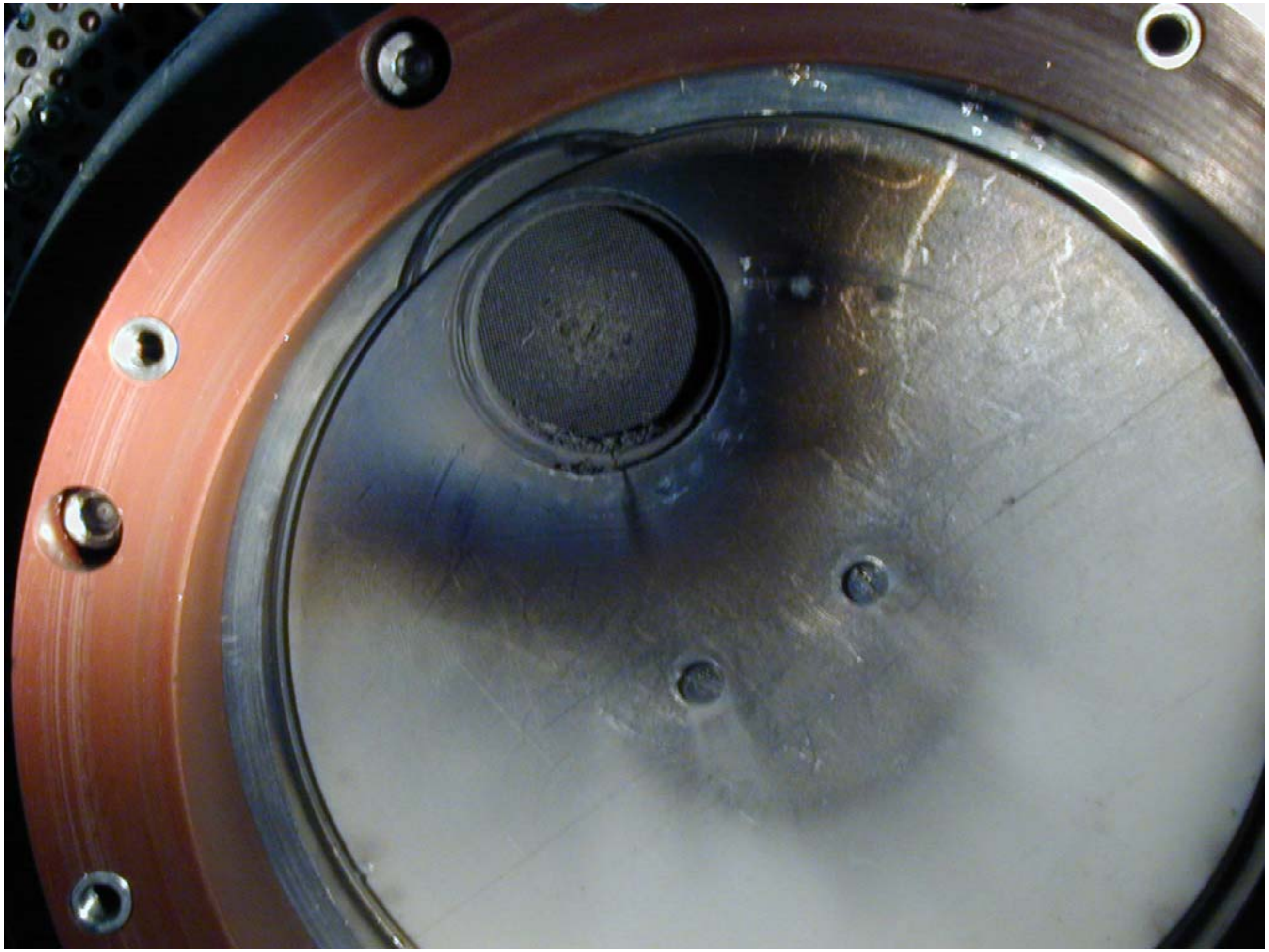


MEVVA IV

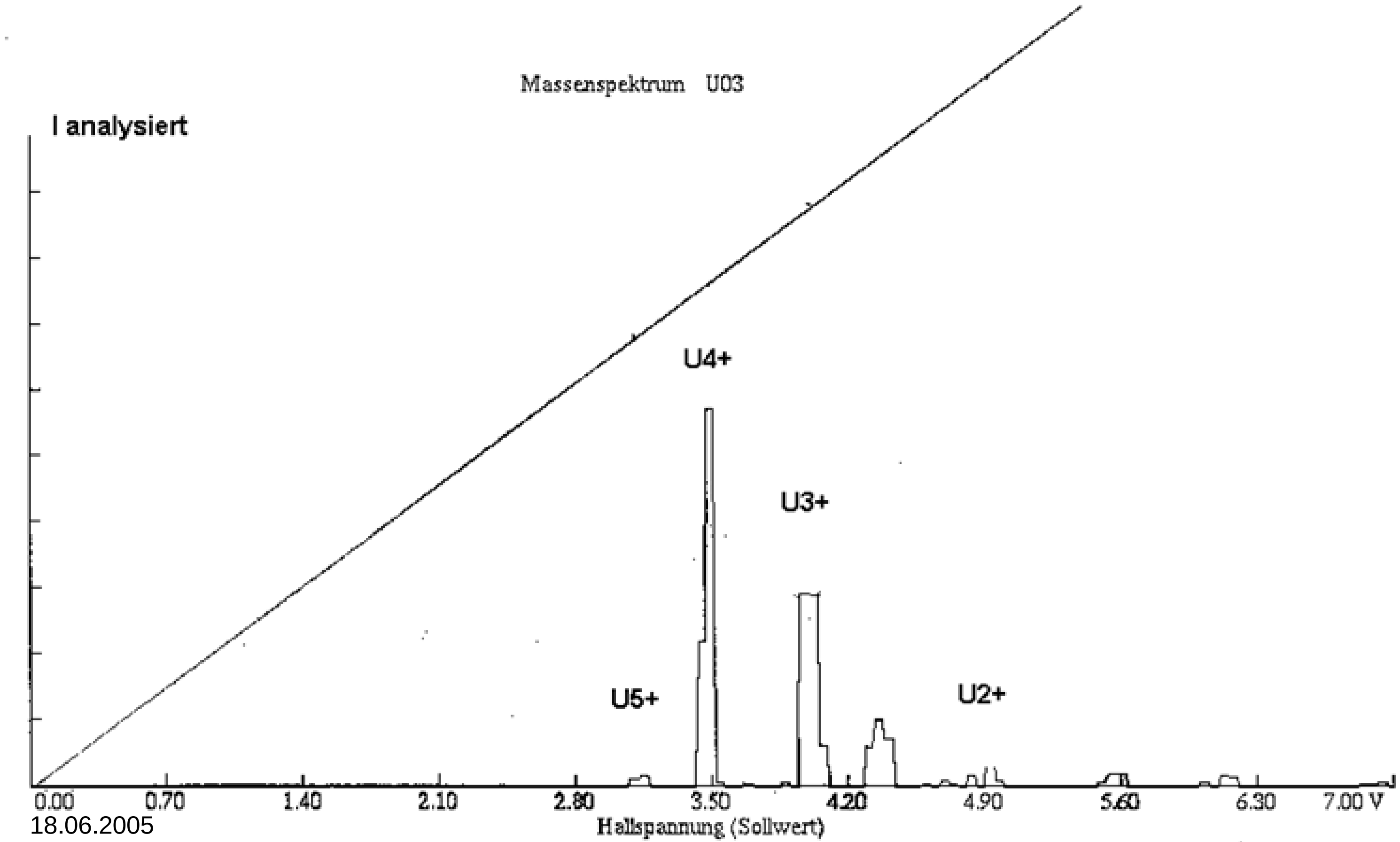


17 cathodes
2 solenoids (0.1 and 0.2 Tesla)
arc power: 50 kW (13,3 MW/cm^2)
arc current: ~1 kA
duty cycle: typical 1 Hz, 1 ms
service interval: 1 week (Uran)

MEVVA IV



charge state distribution

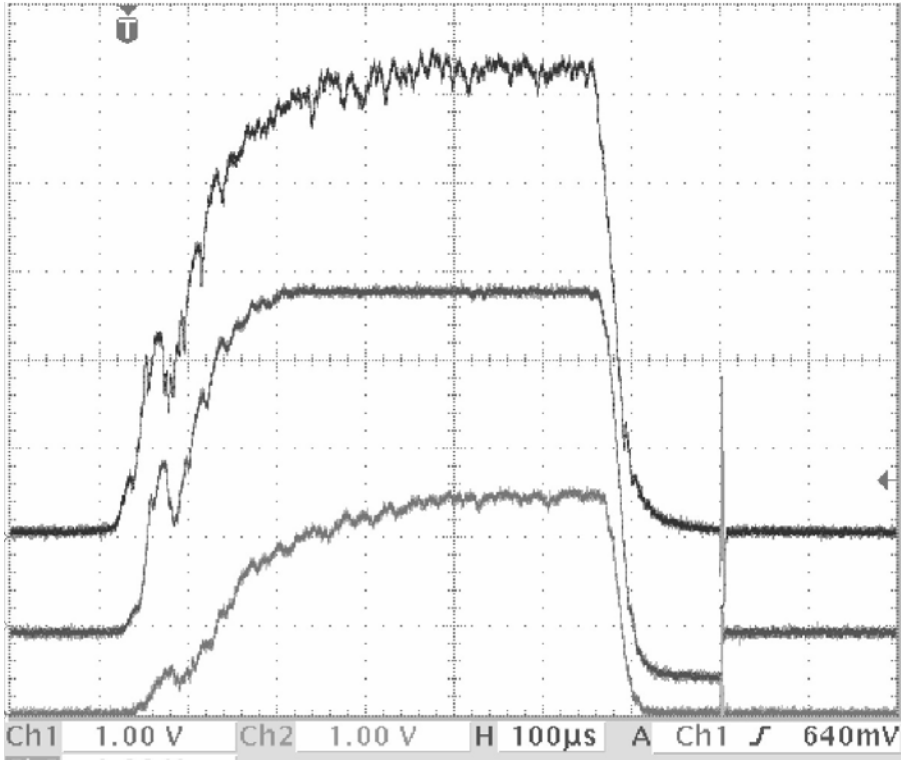


MEVVA IV

achieved currents

ion	design	injector	testbench
$^{12}C^{+}$	3 mA	7 mA	
$^{24}Mg^{+}$	6 mA		20 mA
$^{24}Mg^{2+}$	3 mA		70 mA
$^{48}Ti^{+}$	12 mA	3 mA	
$^{48}Ti^{2+}$	6 mA	20 mA	35 mA
$^{48}Ti^{3+}$	4 mA	20 mA	35 mA
$^{52}Cr^{+}$	13 mA	6 mA	
$^{58}Ni^{+}$	14,5 mA	10 mA	
$^{58}Ni^{2+}$	7,25 mA	5 mA	35 mA
$^{92}Mo^{2+}$	11,5 mA	6 mA	
$^{238}U^{4+}$	15 mA	20 mA	30 mA

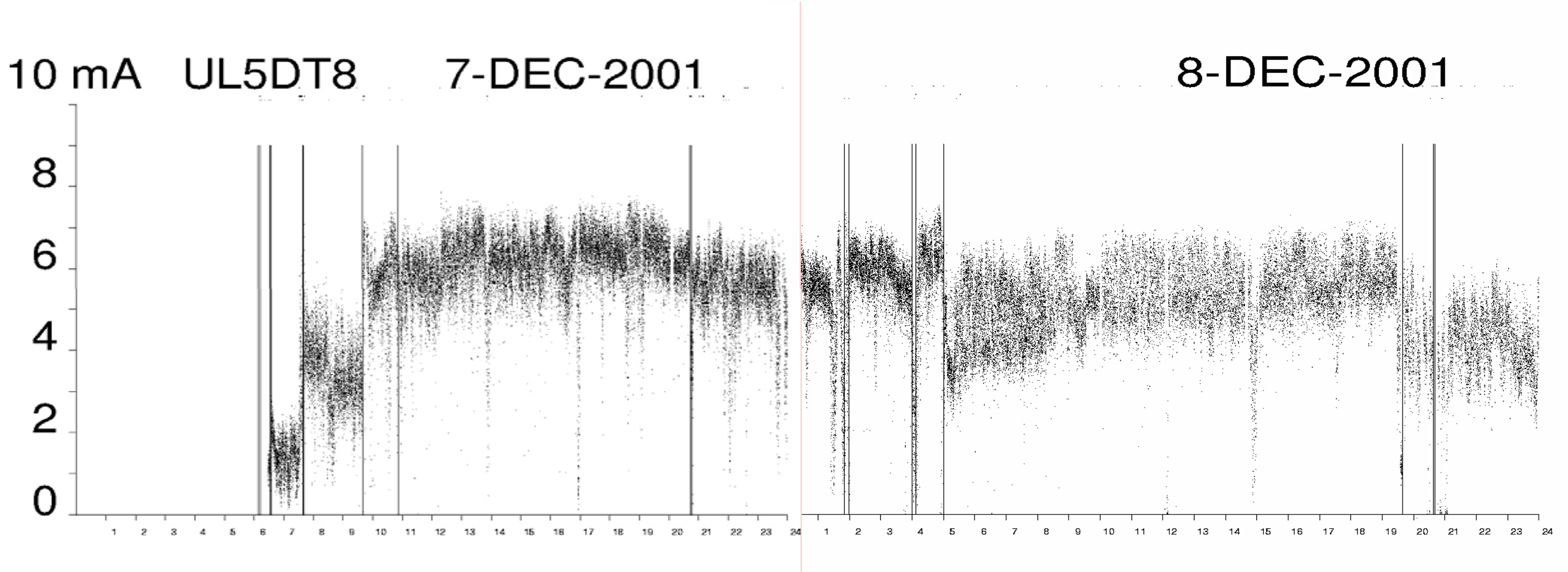
MEVVA IV



UL4DT3: 10 mA / div (~ 55 mA)

UL5DT5: 10 mA / div (> 40 mA)

UL5DT8: 10 mA /div (~ 25 mA)



long time stability

Simulation of the ion beam along the beam line

- assume how an ion will feel:
- electric field is more important than gravity to you
- go ahead and good luck

The ion beam has been simulated from extraction from the ion source to the front of the dipole magnet by trajectory tracking.

The space charge of the beam is active within the extraction system and in the post acceleration.

External electric fields are present only in these two sections.

External magnetic fields are present in the quadrupole section.

Simulation along the beam line

Ion: $^{238}U^{4+}$

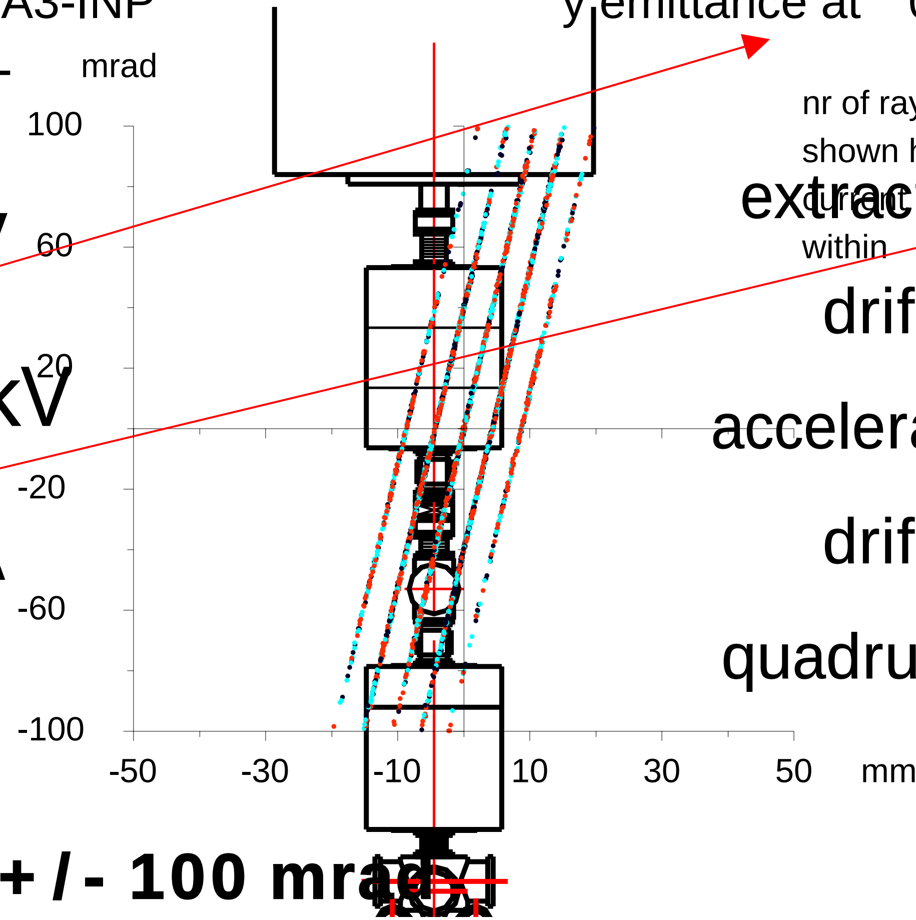
Uex 30 kV

location in longitudinal direction

Uacc 100.9 kV

total current

Itot 25 mA



extraction

drift

acceleration

drift

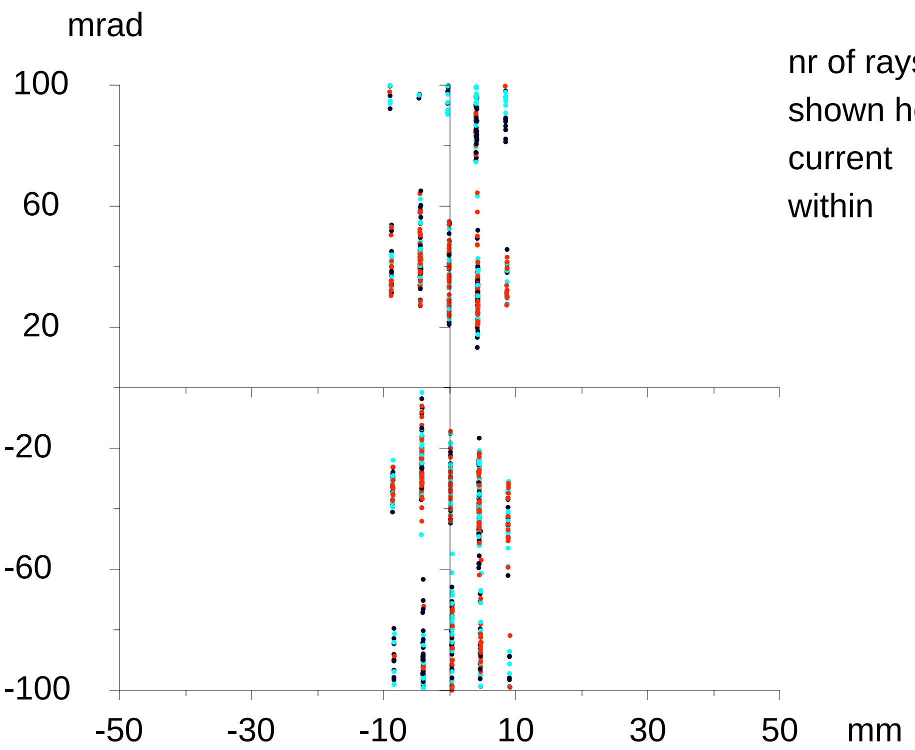
quadrupole

Y-emittance +/- 100 mrad

+/- 50 mm

Fasten seat belt: extraction !!!

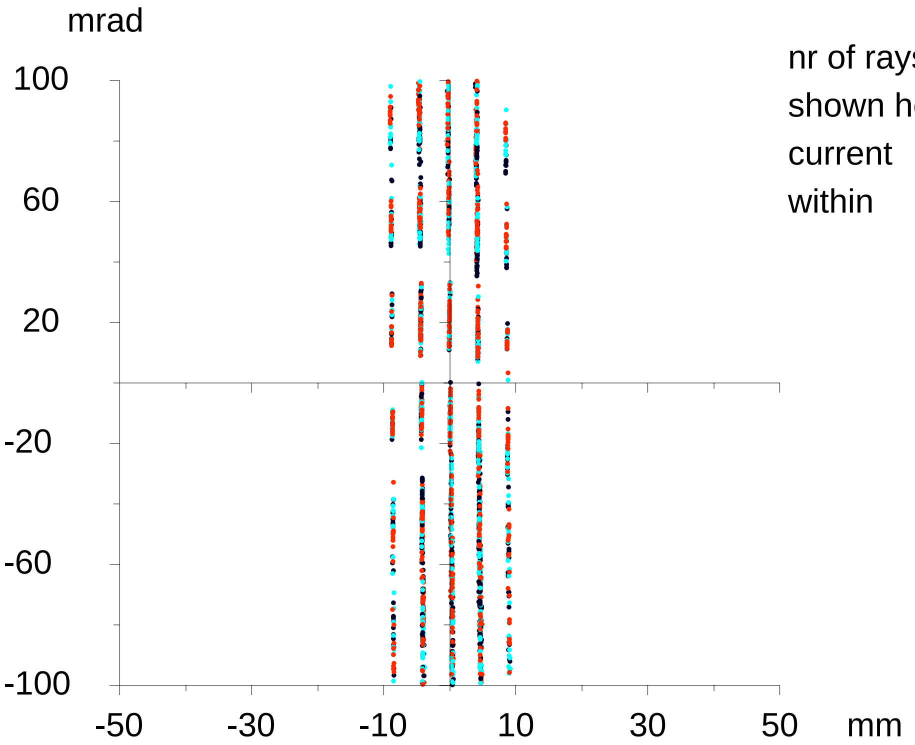
KOBRA3-INP y emittance at 0.004 m



nr of rays	3672
shown here	1135
current	.0552 A
within	.0178 A

Fasten seat belt: extraction !!!

KOBRA3-INP   y emittance at 0.006 m

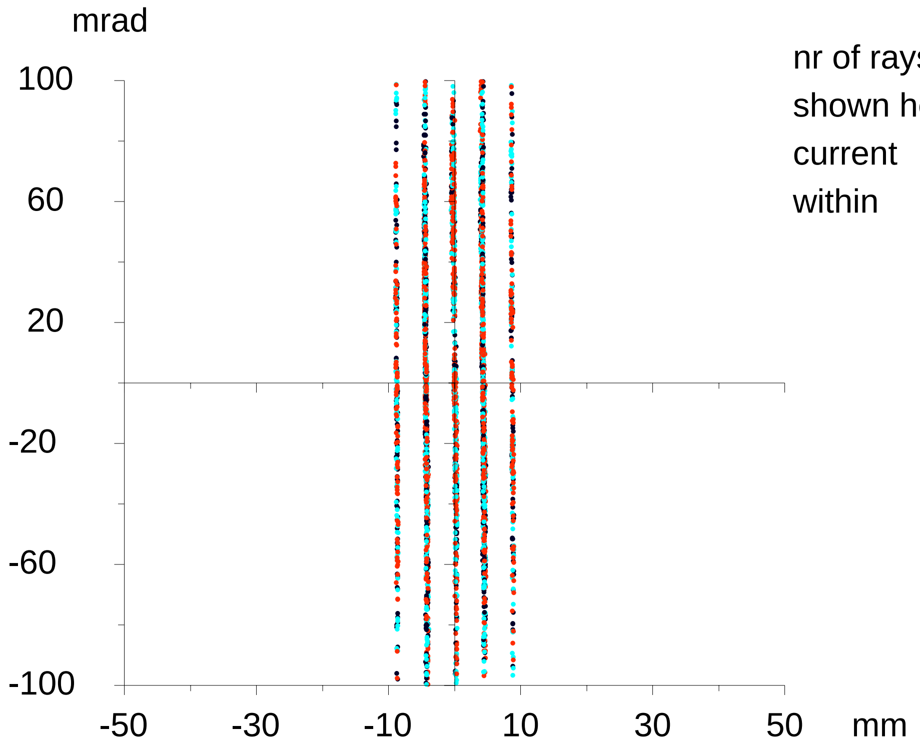


nr of rays	3672
shown here	2411
current	.0552 A
within	.0371 A

Fasten seat belt: extraction !!!

KOBRA3-INP

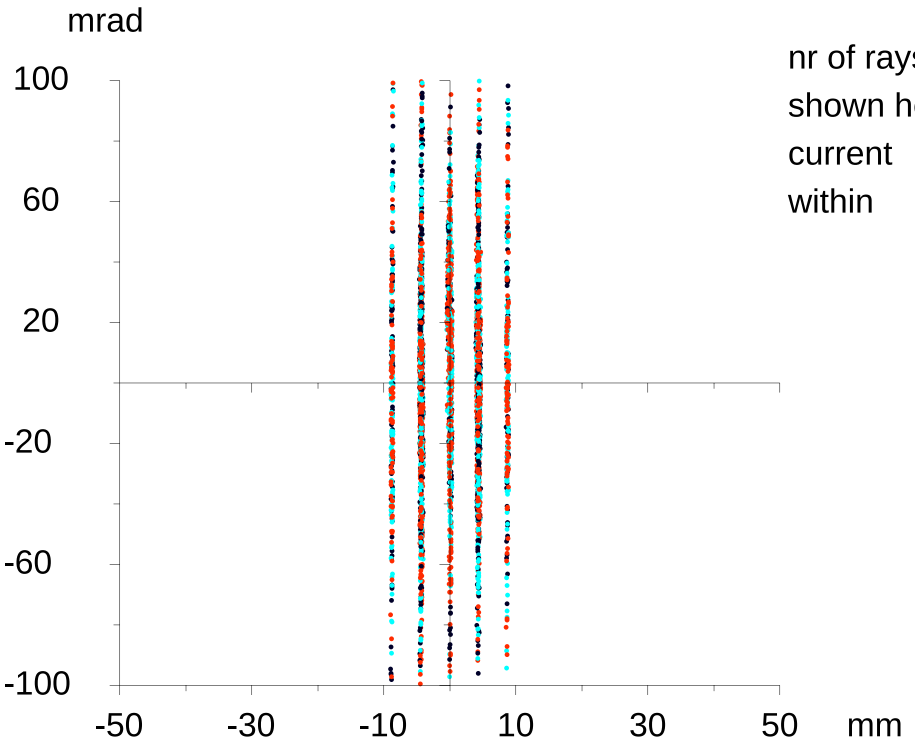
y emittance at 0.008 m



nr of rays	3672
shown here	3407
current	.0552 A
within	.0524 A

Fasten seat belt: extraction !!!

KOBRA3-INP y emittance at 0.010 m

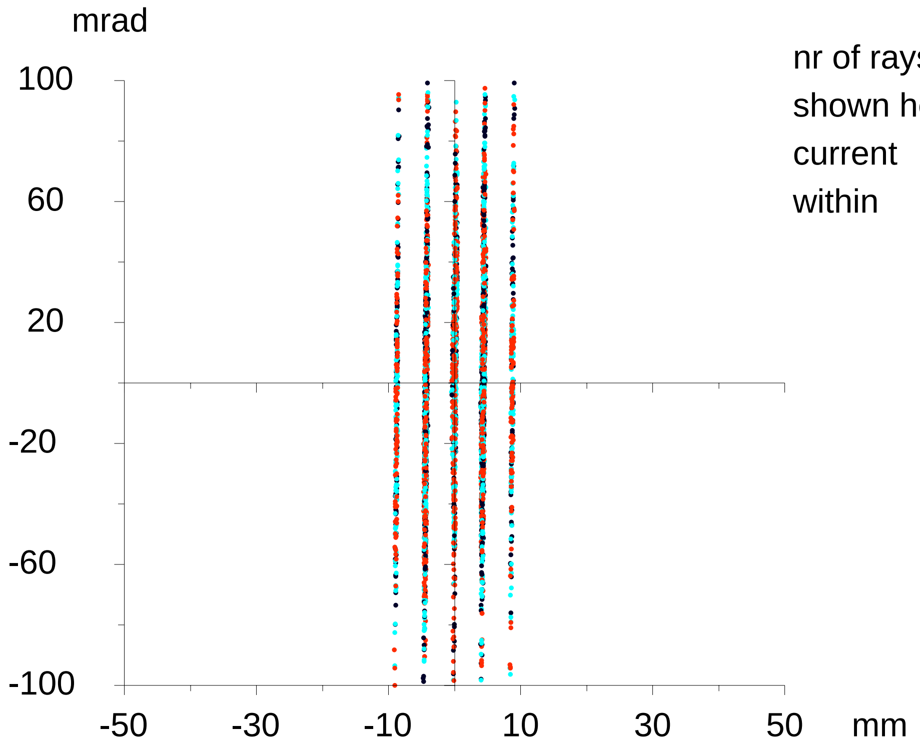


nr of rays	3672
shown here	3496
current	.0552 A
within	.0534 A

Fasten seat belt: extraction !!!

KOBRA3-INP

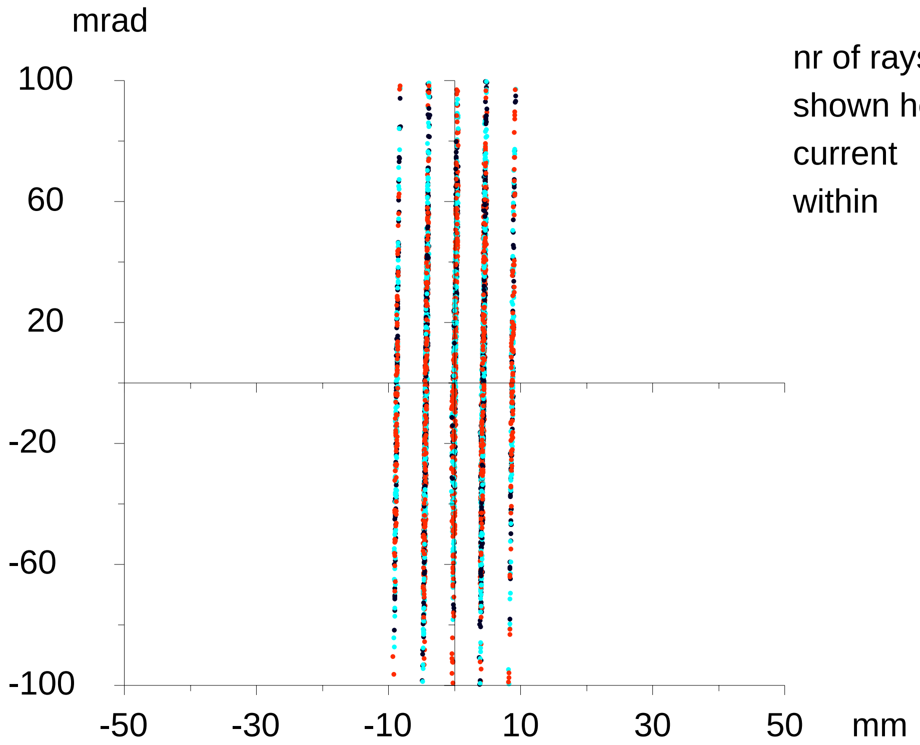
y emittance at 0.012 m



nr of rays	3672
shown here	3456
current	.0552 A
within	.0530 A

Fasten seat belt: extraction !!!

KOBRA3-INP y emittance at 0.014 m

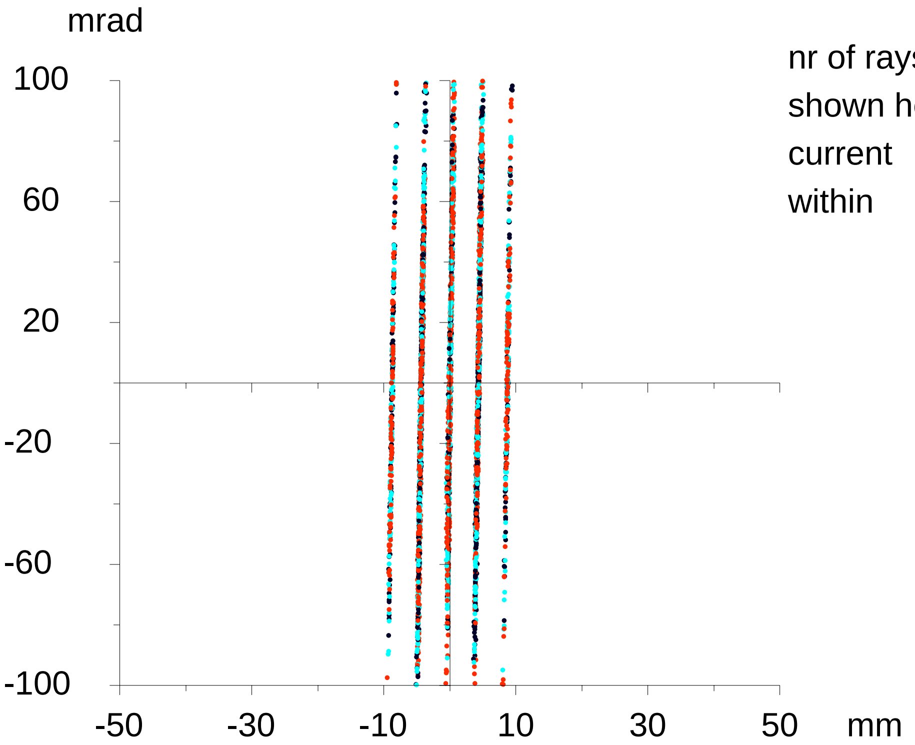


nr of rays	3672
shown here	3423
current	.0552 A
within	.0526 A

Fasten seat belt: extraction !!!

KOBRA3-INP

y emittance at 0.016 m

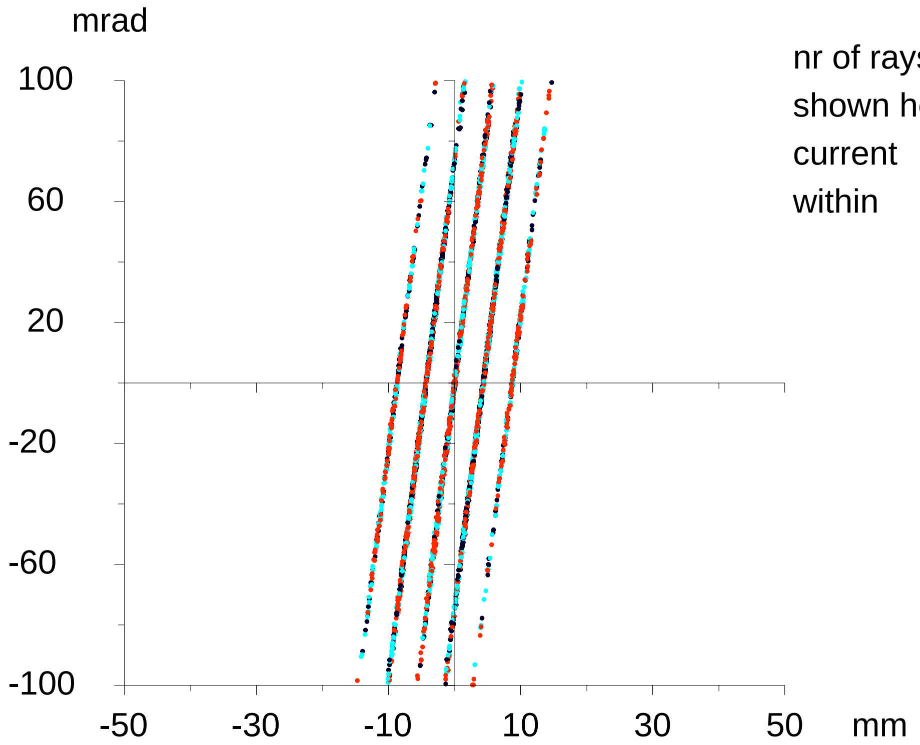


nr of rays	3672
shown here	3385
current	.0552 A
within	.0521 A

relax and drift

KOBRA3-INP

y emittance at 0.070 m

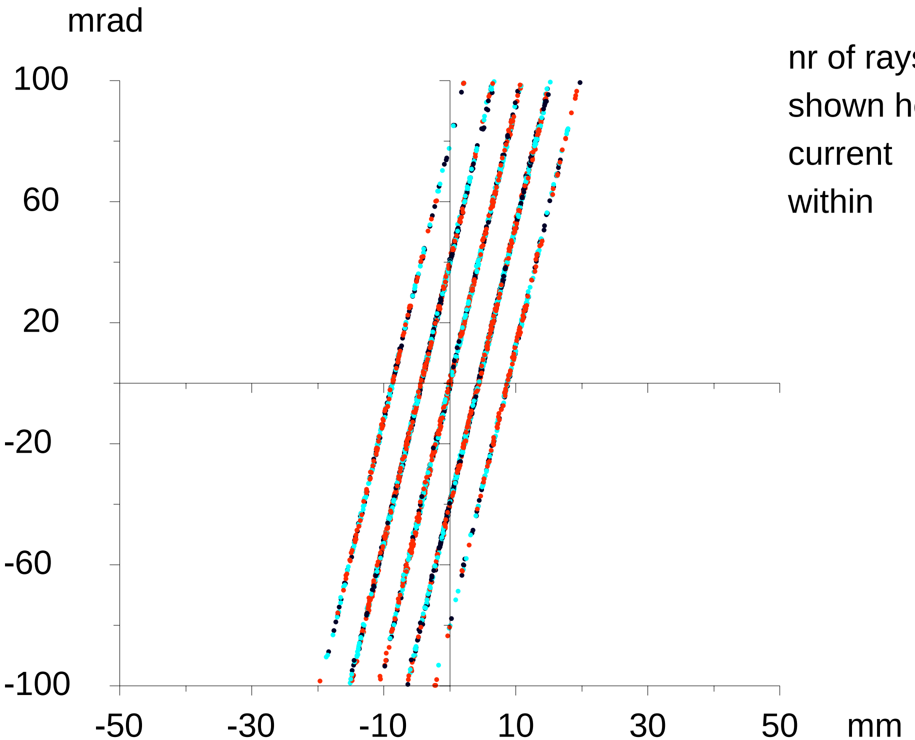


nr of rays	3672
shown here	3348
current	.0552 A
within	.0515 A

relax and drift

KOBRA3-INP

y emittance at 0.120 m

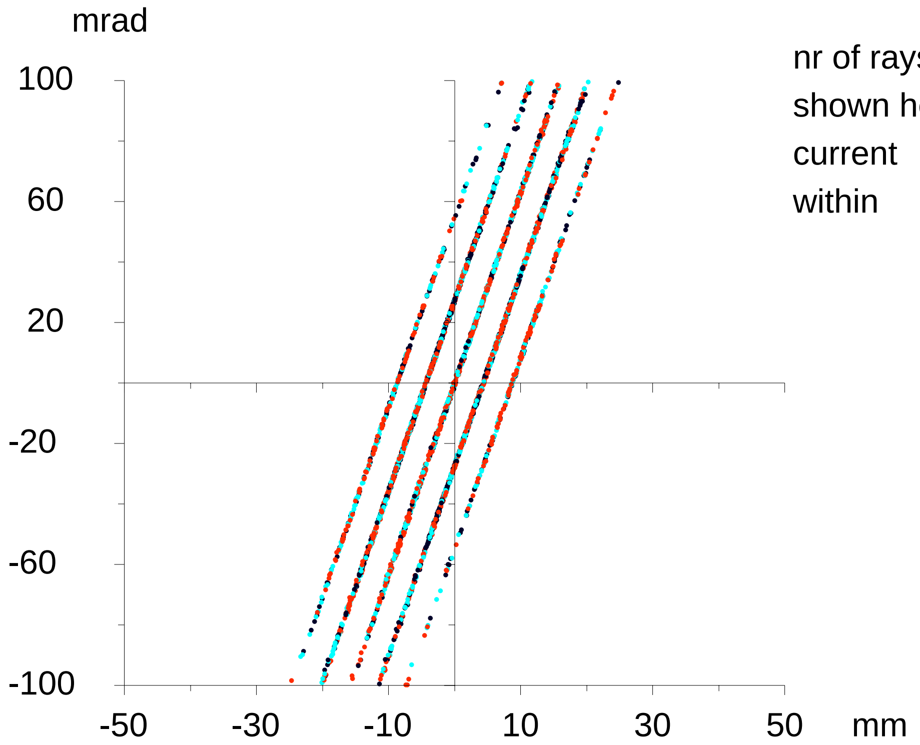


nr of rays	3672
shown here	3348
current	.0552 A
within	.0515 A

relax and drift

KOBRA3-INP

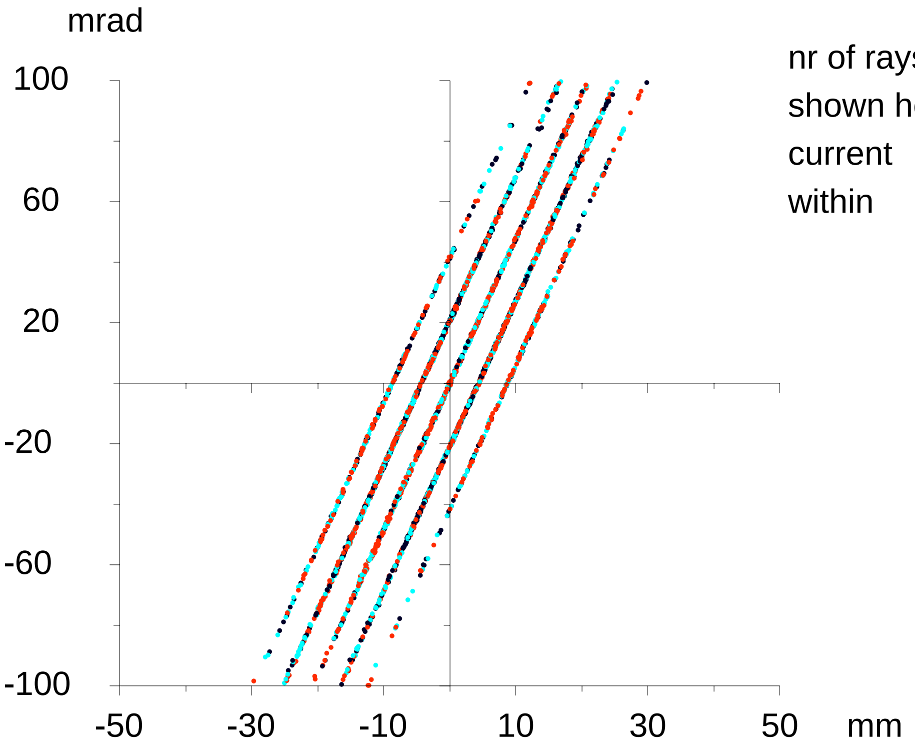
y emittance at 0.170 m



nr of rays	3671
shown here	3348
current	.0552 A
within	.0515 A

relax and drift

KOBRA3-INP y emittance at 0.220 m

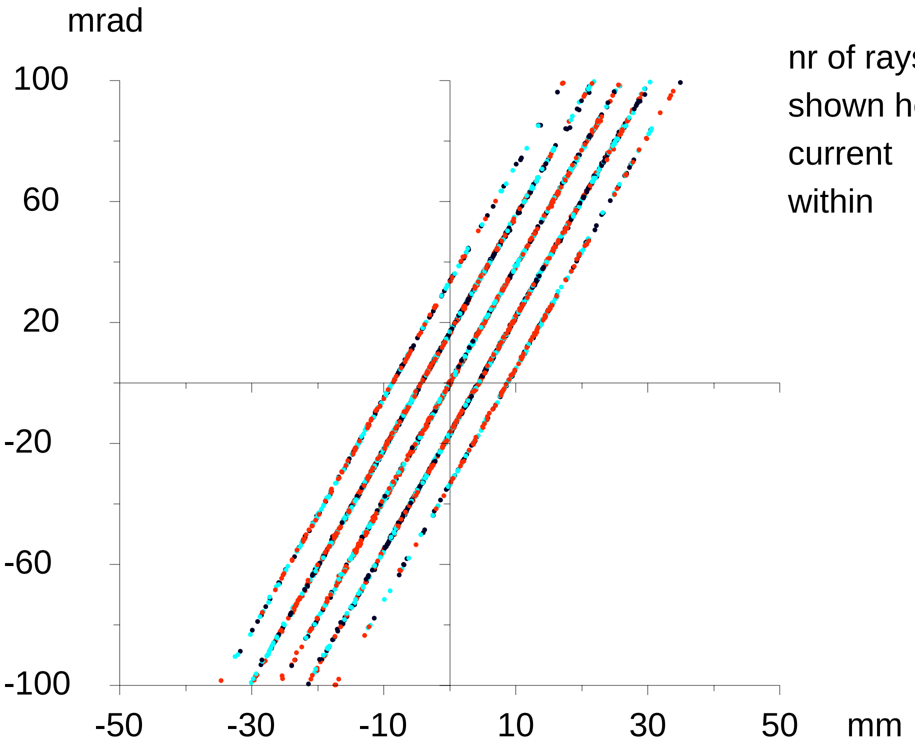


nr of rays	3665
shown here	3343
current	.0551 A
within	.0514 A

relax and drift

KOBRA3-INP

y emittance at 0.270 m

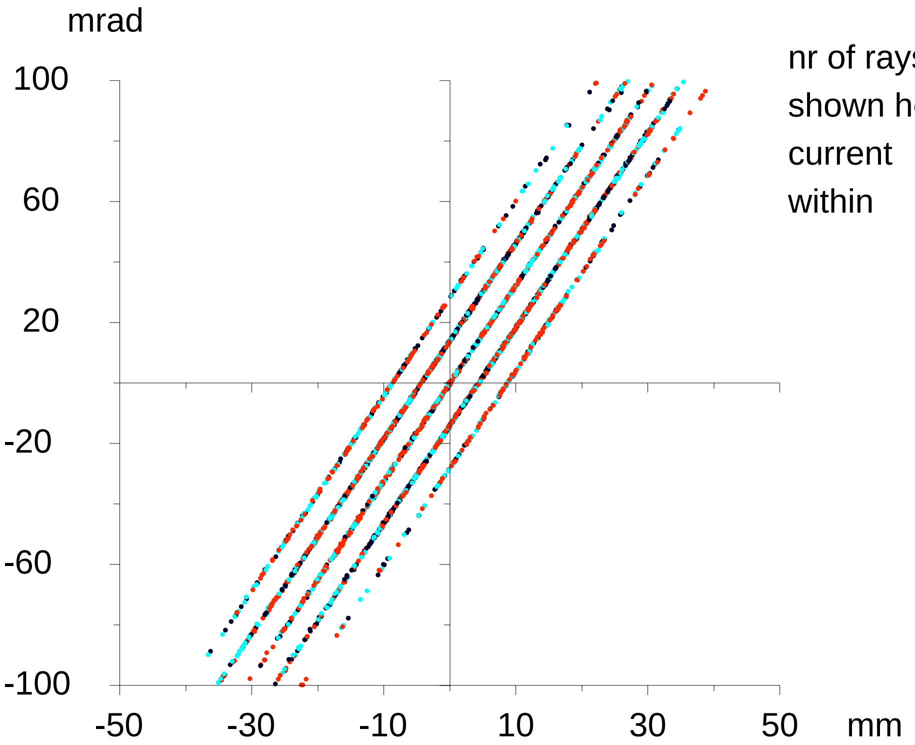


nr of rays	3611
shown here	3324
current	.0545 A
within	.0512 A

relax and drift

KOBRA3-INP

y emittance at 0.320 m

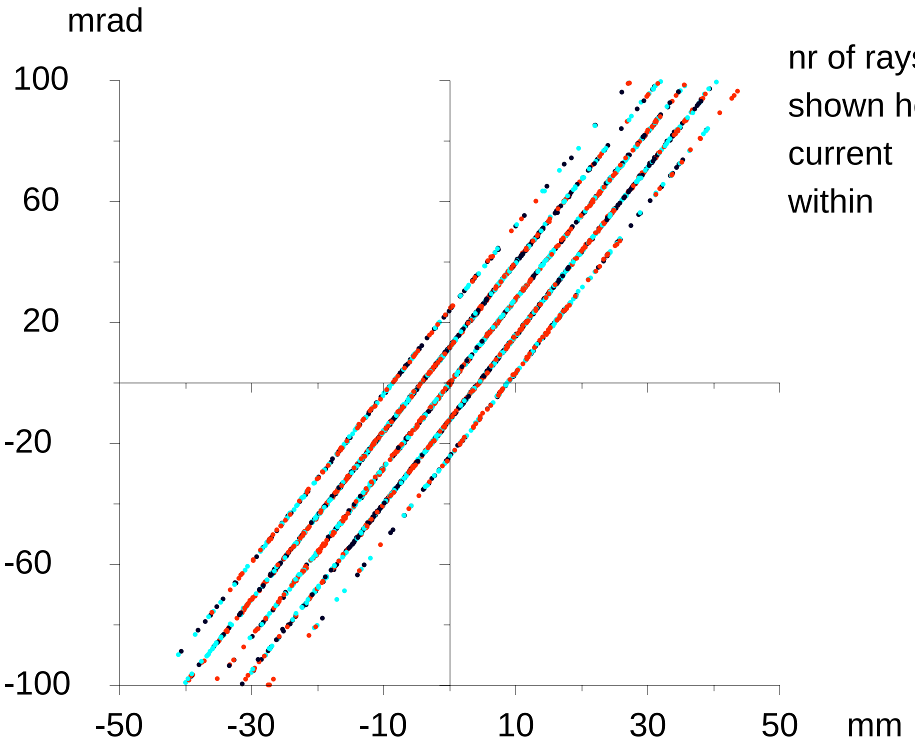


nr of rays	3503
shown here	3280
current	.0534 A
within	.0507 A

relax and drift

KOBRA3-INP

y emittance at 0.370 m

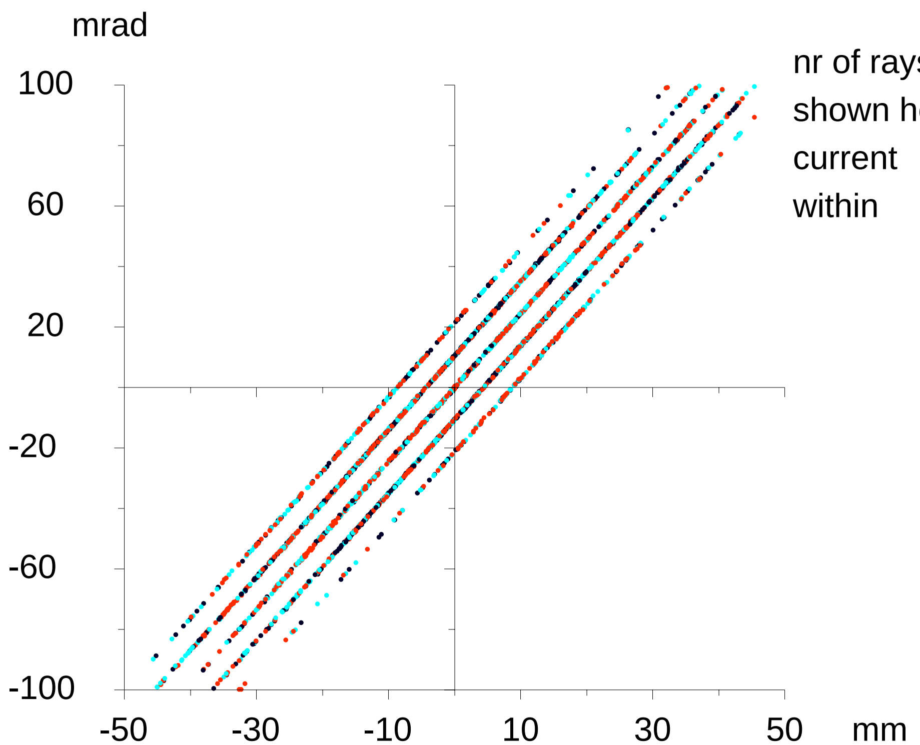


nr of rays	3315
shown here	3196
current	.0513 A
within	.0498 A

relax and drift

KOBRA3-INP

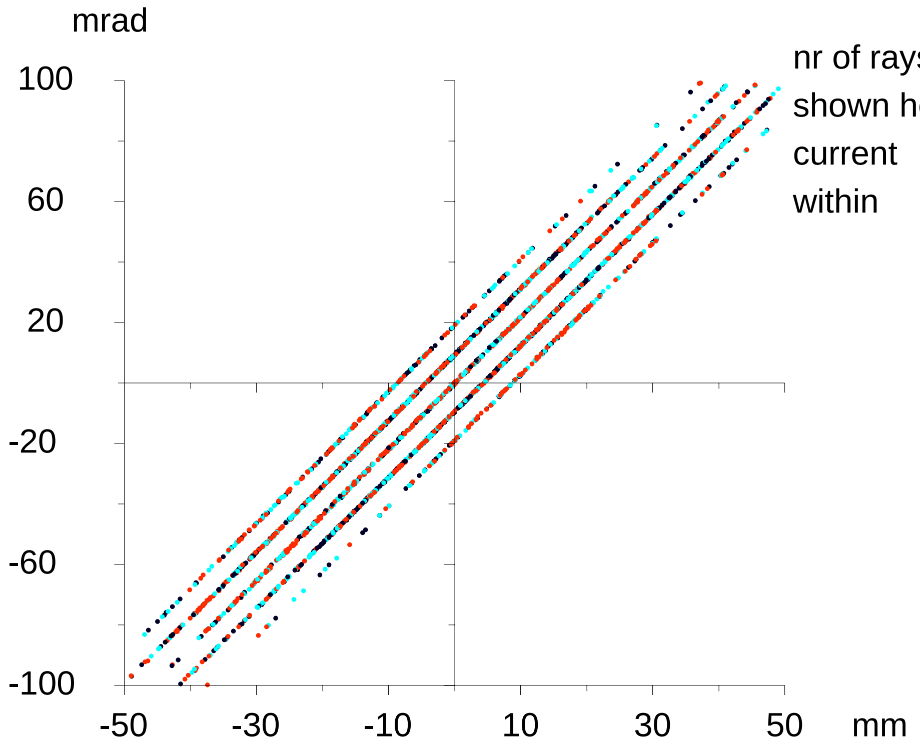
y emittance at 0.420 m



nr of rays	3169
shown here	3109
current	.0494 A
within	.0485 A

relax and drift

KOBRA3-INP y emittance at 0.470 m

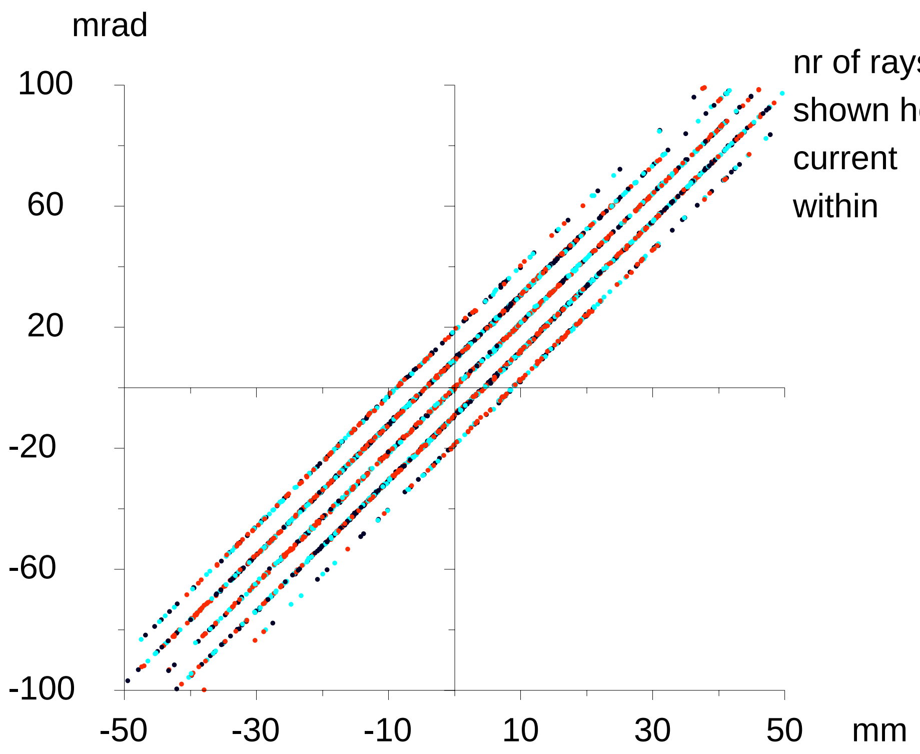


nr of rays	3016
shown here	3001
current	.0468 A
within	.0466 A

relax and drift

KOBRA3-INP

y emittance at 0.480 m

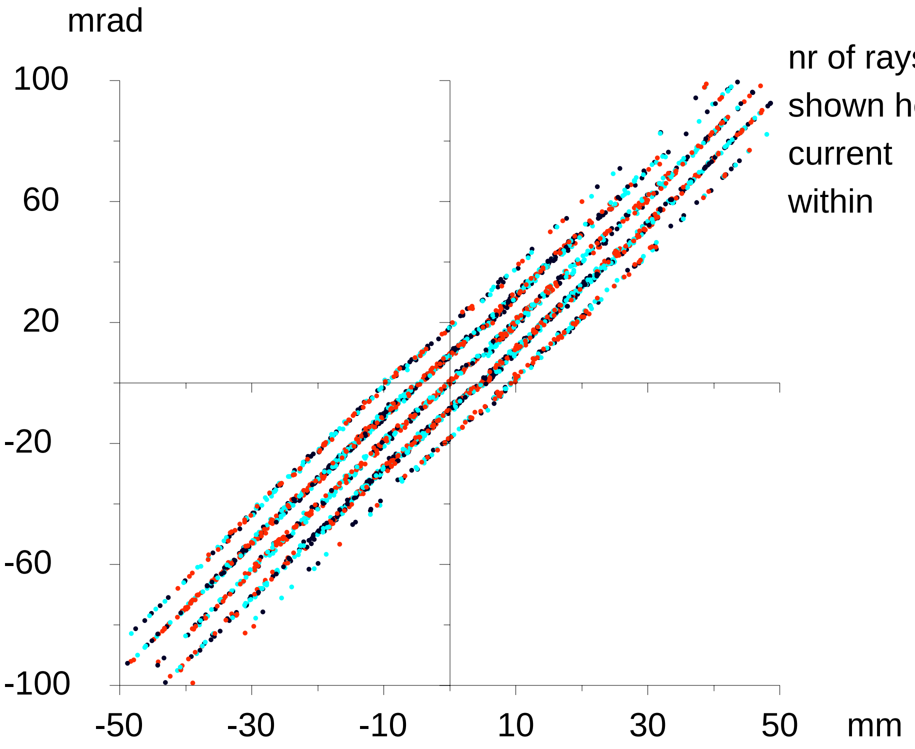


nr of rays	2997
shown here	2984
current	.0465 A
within	.0464 A

relax and drift

KOBRA3-INP

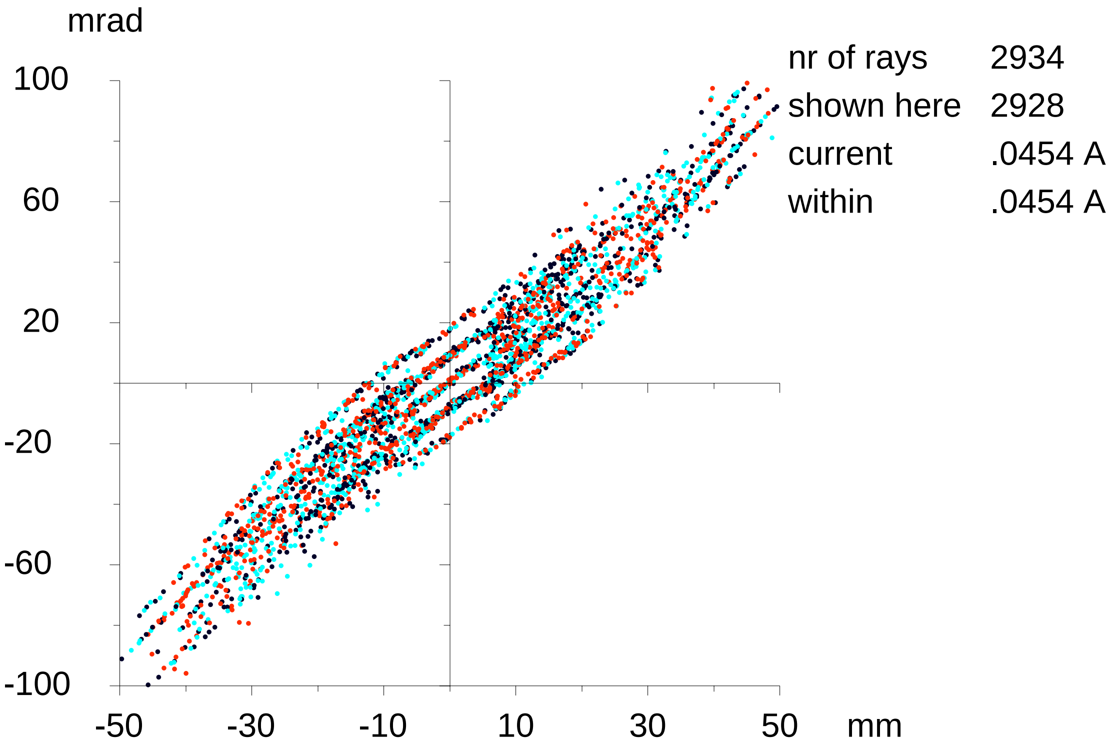
y emittance at 0.490 m



nr of rays	2971
shown here	2960
current	.0460 A
within	.0459 A

be aware: acceleration

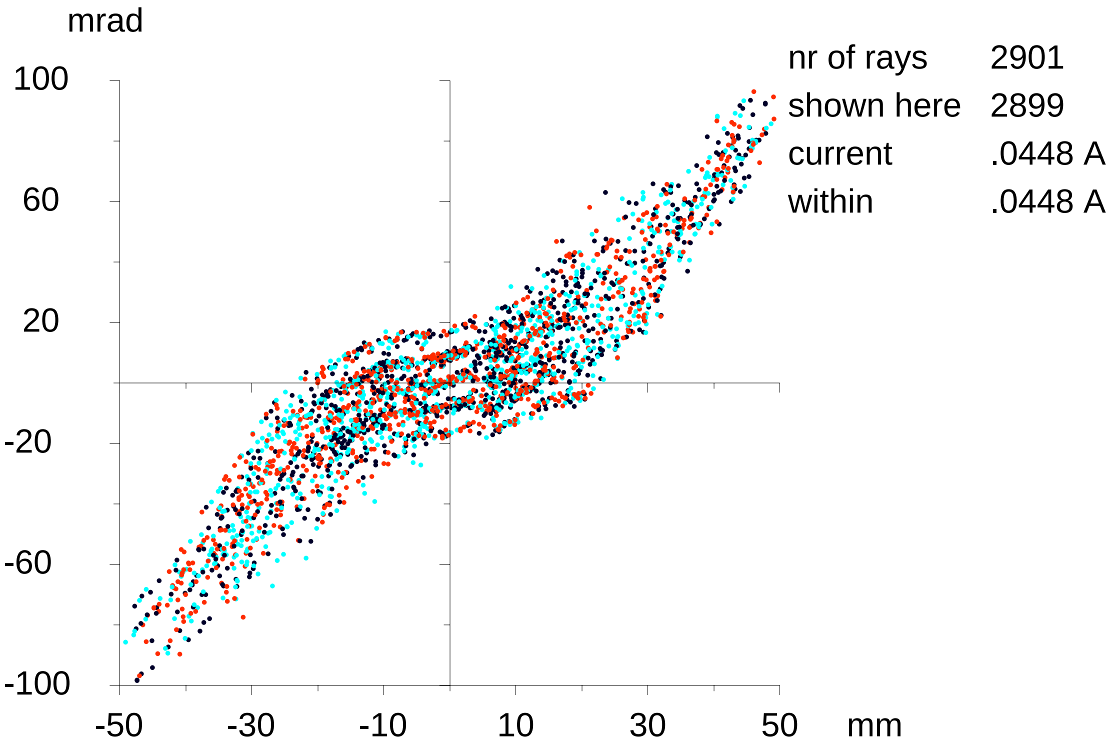
KOBRA3-INP y emittance at 0.500 m



be aware: acceleration

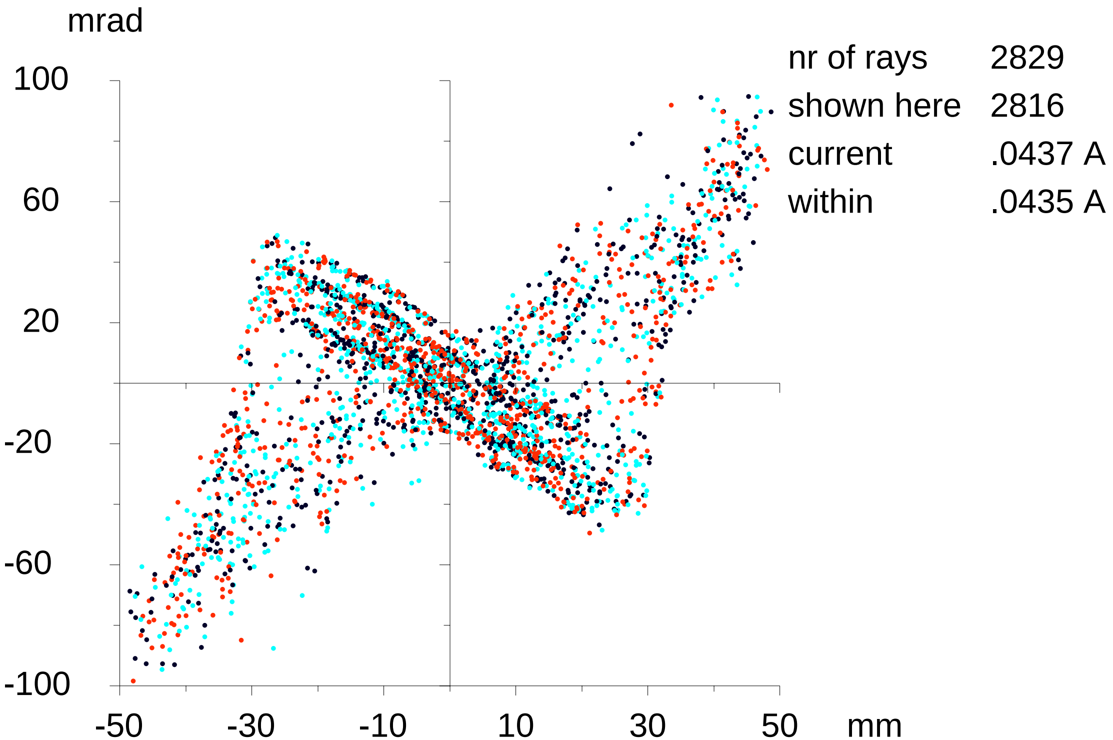
KOBRA3-INP

y emittance at 0.510 m



be aware: acceleration

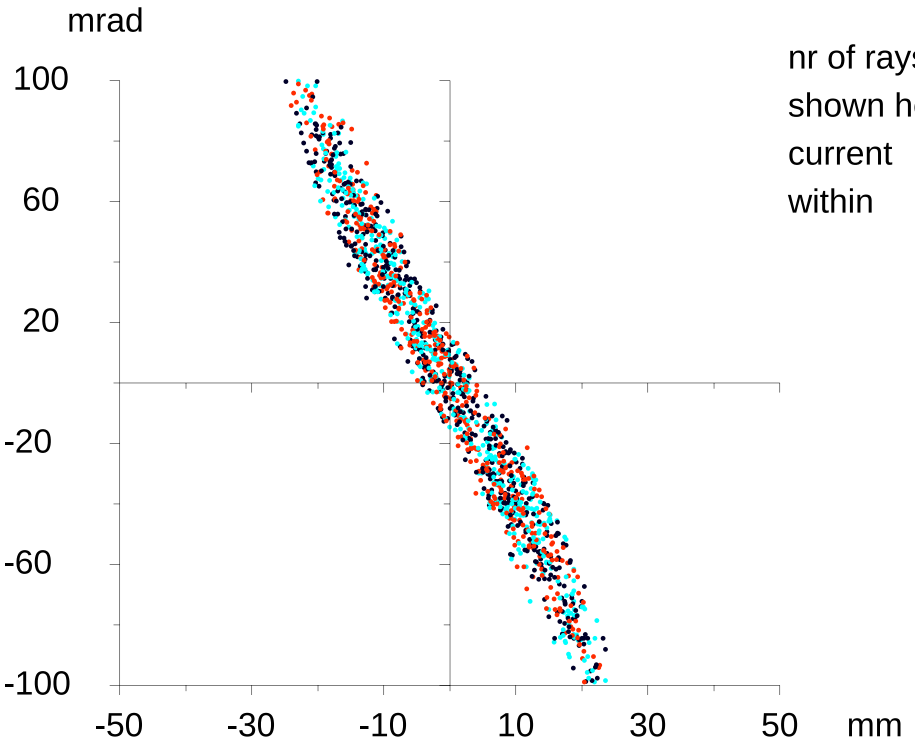
KOBRA3-INP y emittance at 0.520 m



be aware: acceleration

KOBRA3-INP

y emittance at 0.530 m

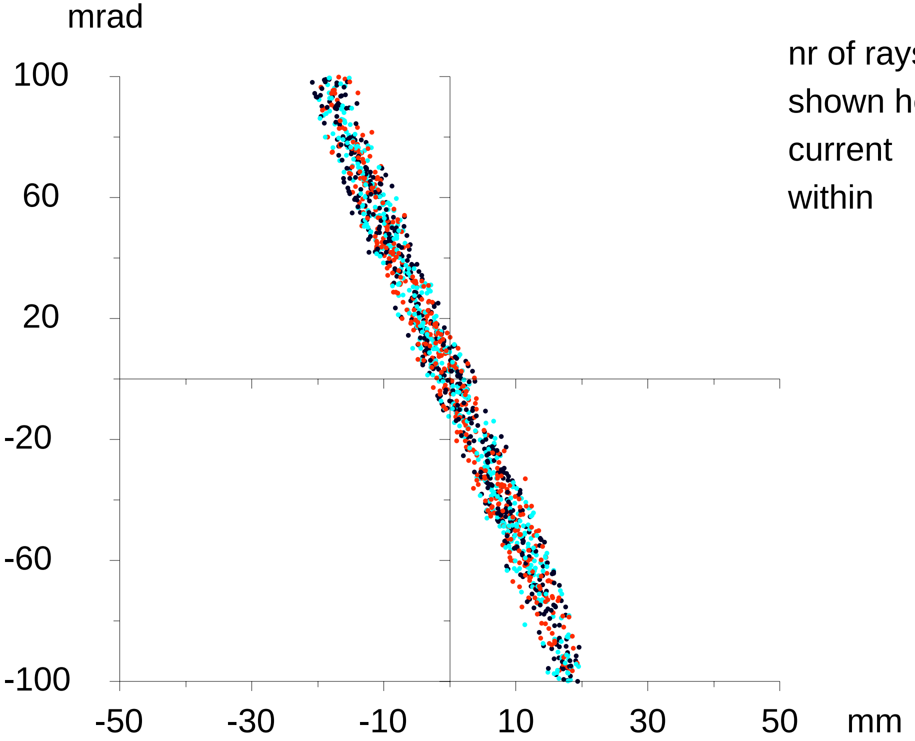


nr of rays	1664
shown here	1506
current	.0247 A
within	.0221 A

be aware: acceleration

KOBRA3-INP

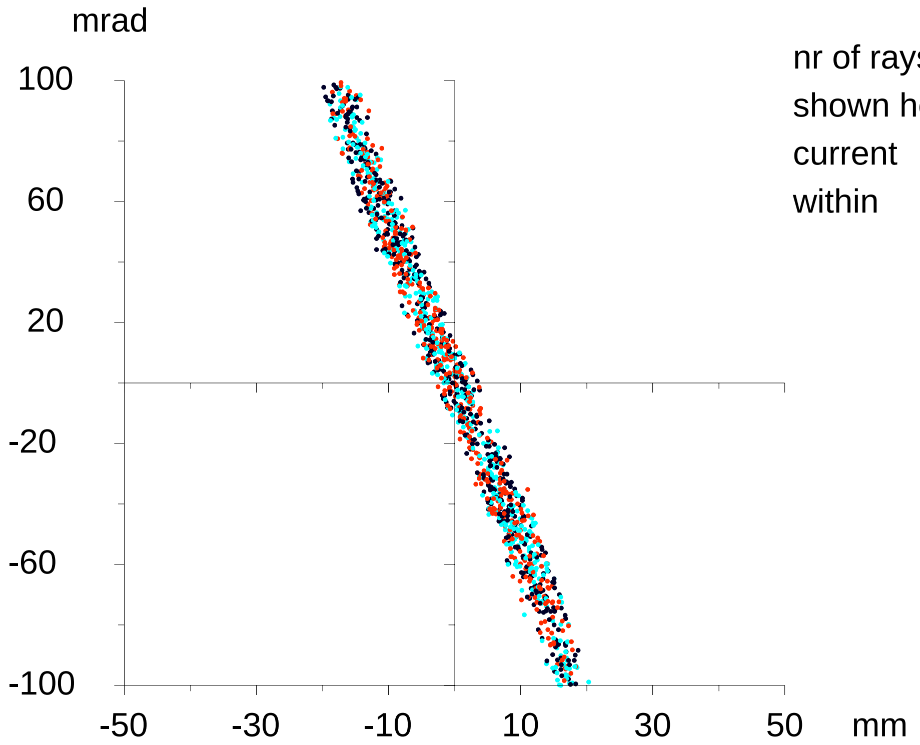
y emittance at 0.540 m



nr of rays	1664
shown here	1424
current	.0247 A
within	.0209 A

be aware: acceleration

KOBRA3-INP y emittance at 0.550 m

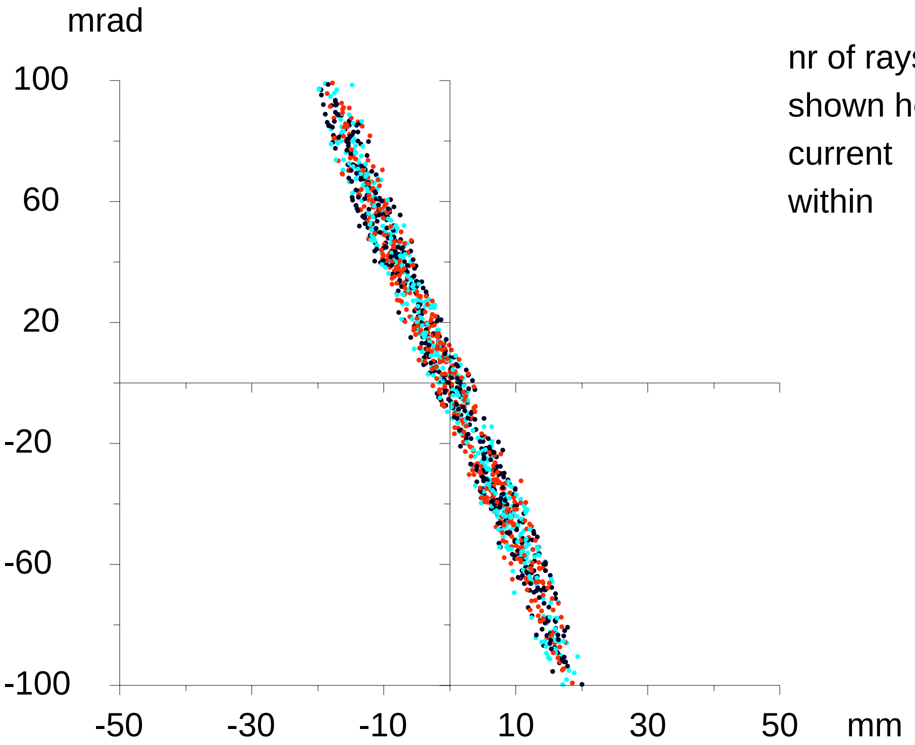


nr of rays	1664
shown here	1438
current	.0247 A
within	.0211 A

be aware: acceleration

KOBRA3-INP

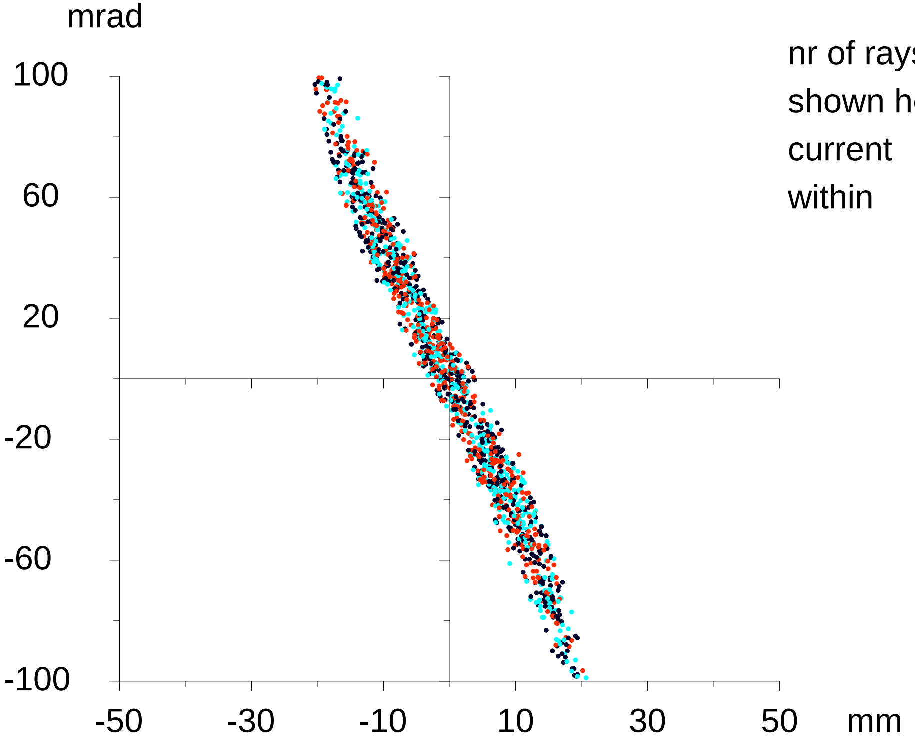
y emittance at 0.560 m



nr of rays	1664
shown here	1476
current	.0247 A
within	.0217 A

be aware: acceleration

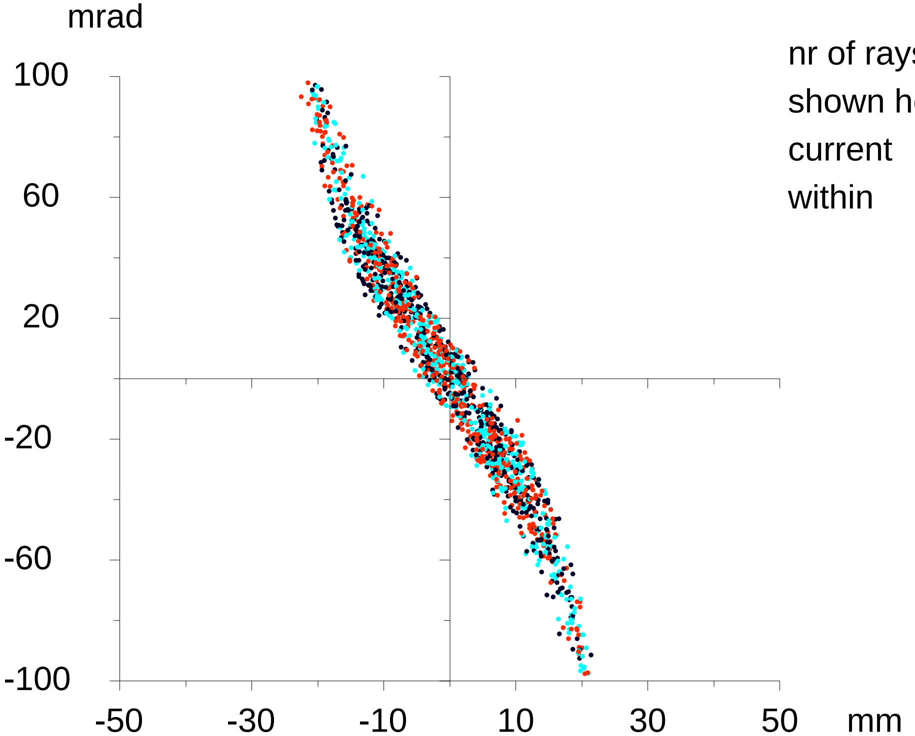
KOBRA3-INP y emittance at 0.570 m



nr of rays 1664
shown here 1543
current .0247 A
within .0226 A

be aware: acceleration

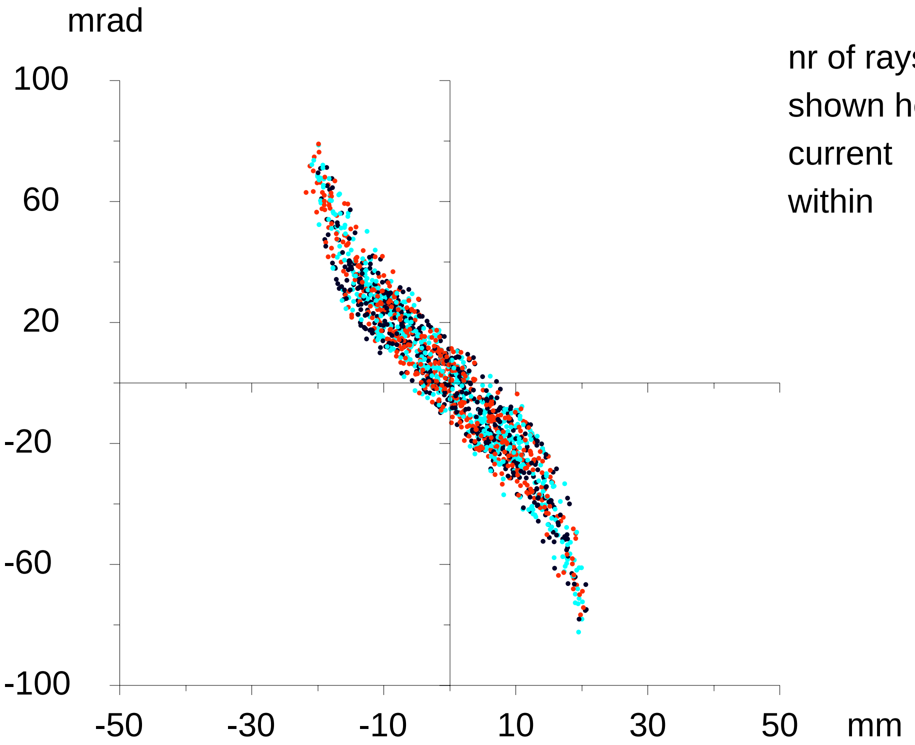
KOBRA3-INP y emittance at 0.580 m



nr of rays 1664
shown here 1650
current .0247 A
within .0245 A

be aware: acceleration

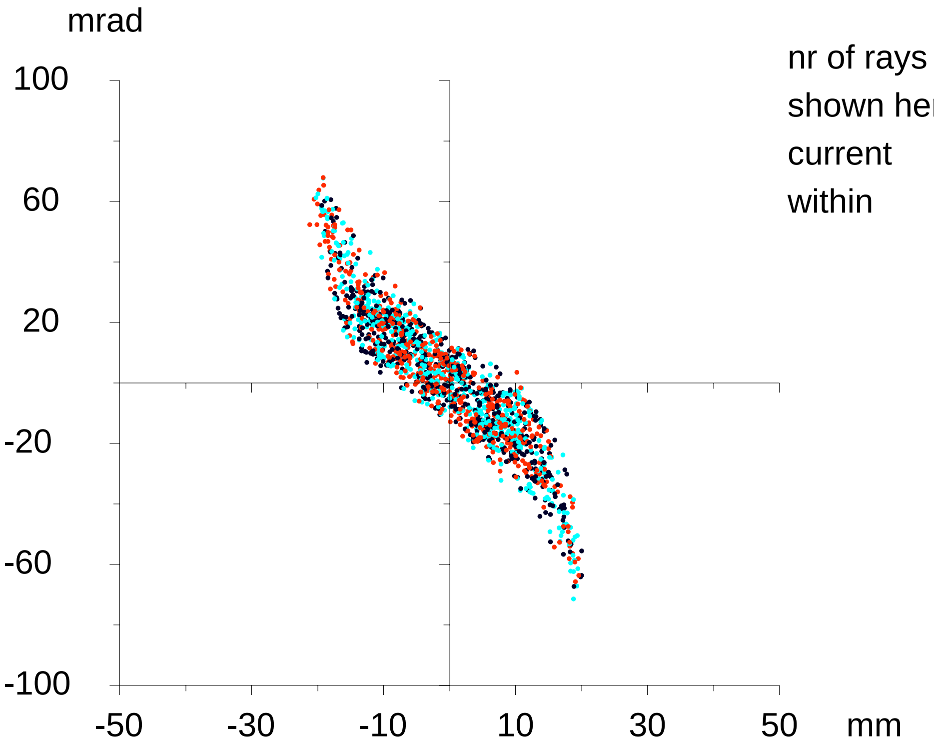
KOBRA3-INP y emittance at 0.590 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

be aware: acceleration

KOBRA3-INP y emittance at 0.600 m

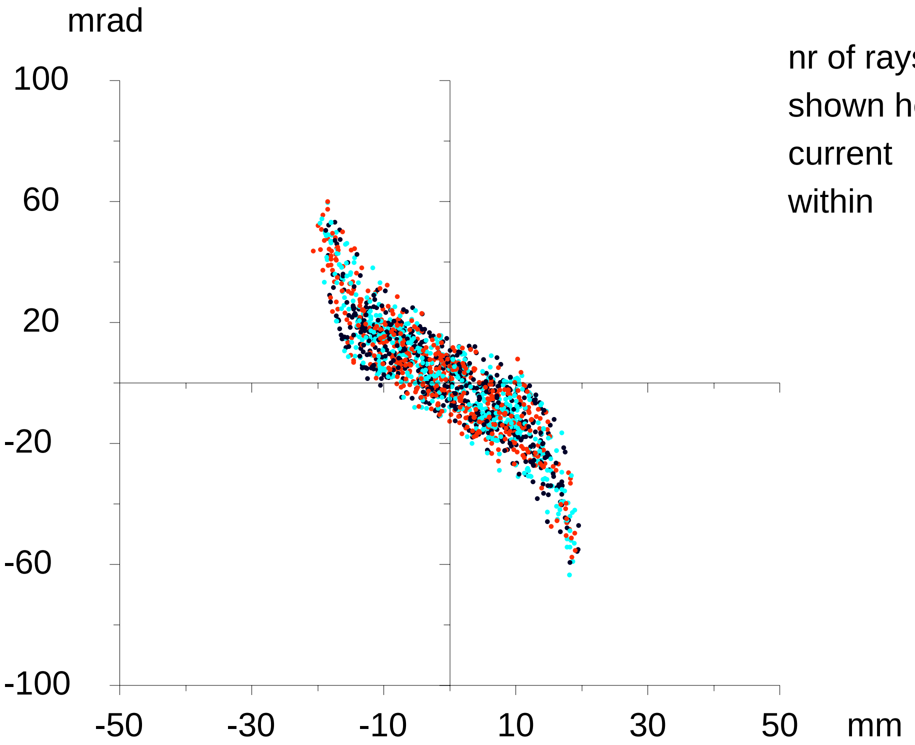


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

be aware: acceleration

KOBRA3-INP

y emittance at 0.610 m

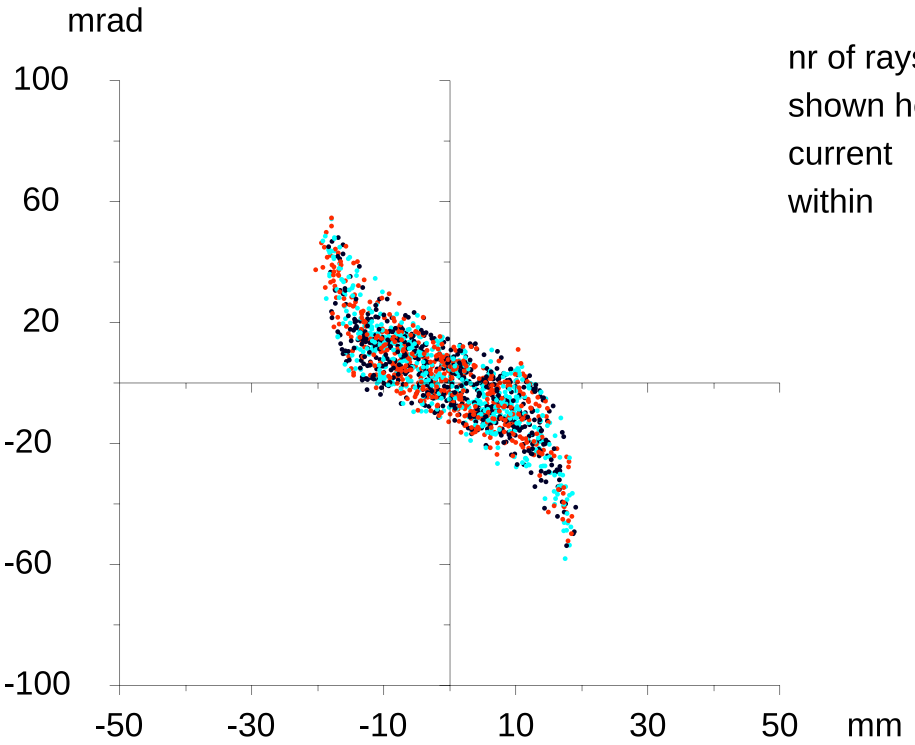


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

be aware: acceleration

KOBRA3-INP

y emittance at 0.620 m

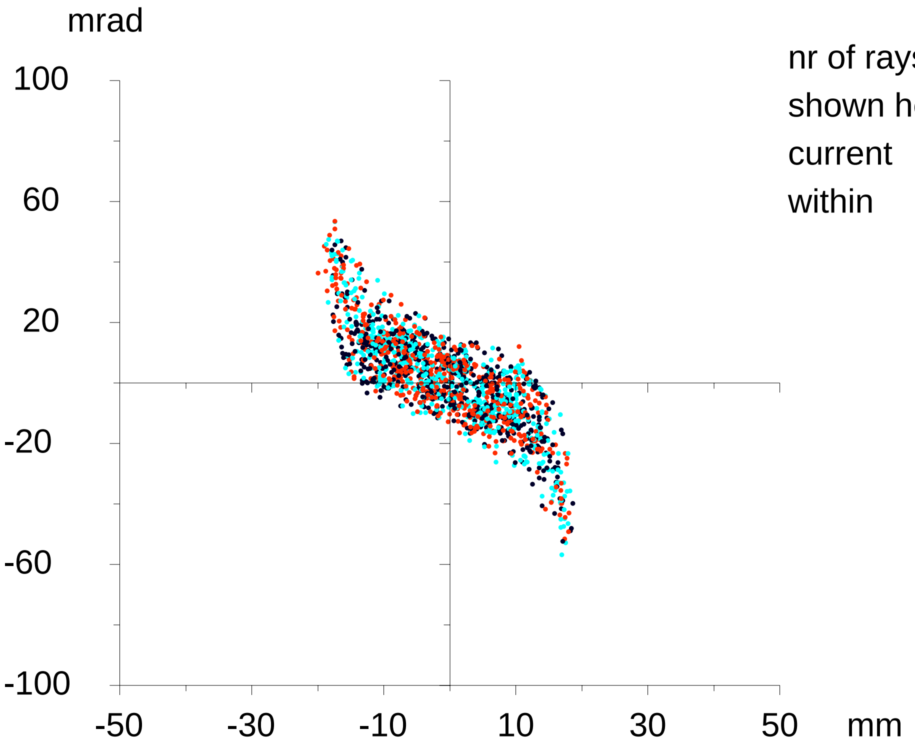


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

be aware: acceleration

KOBRA3-INP

y emittance at 0.630 m

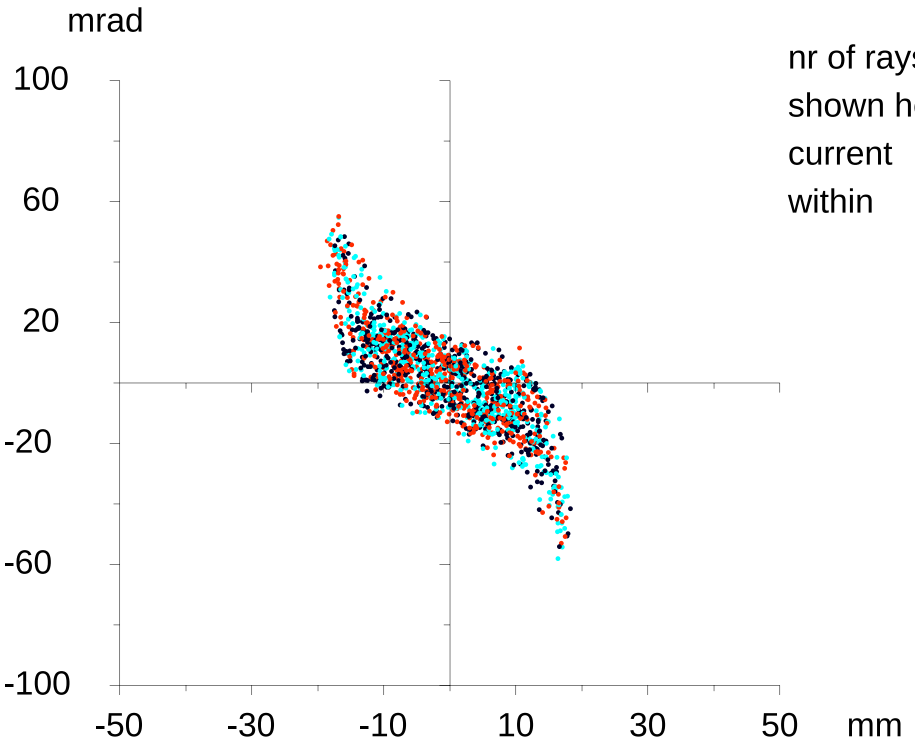


nr of rays 1664
shown here 1664
current .0247 A
within .0247 A

be aware: acceleration

KOBRA3-INP

y emittance at 0.640 m

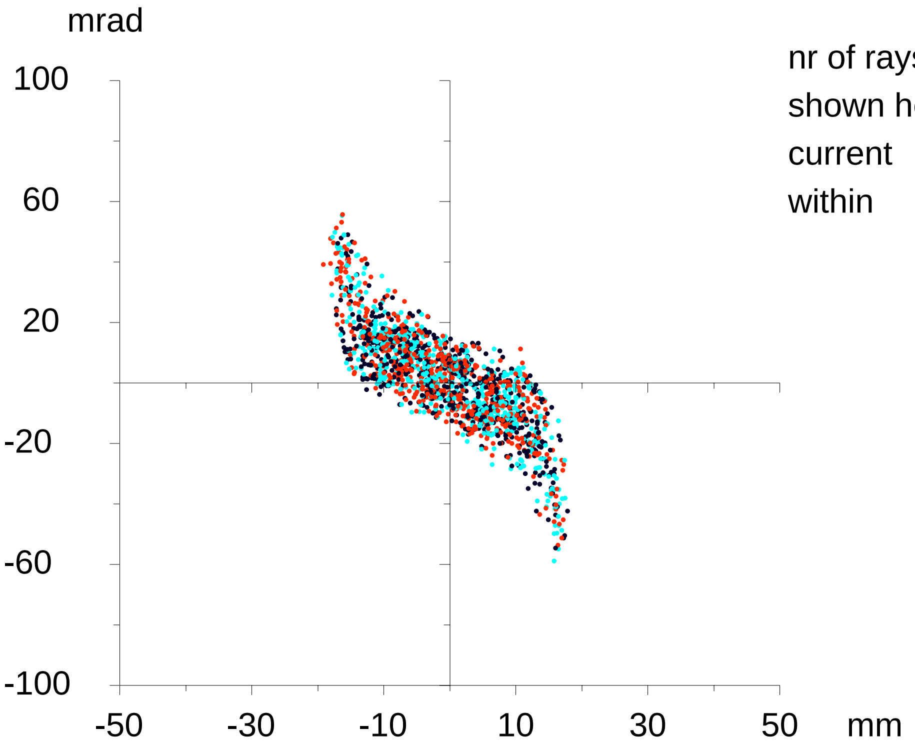


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 0.650 m

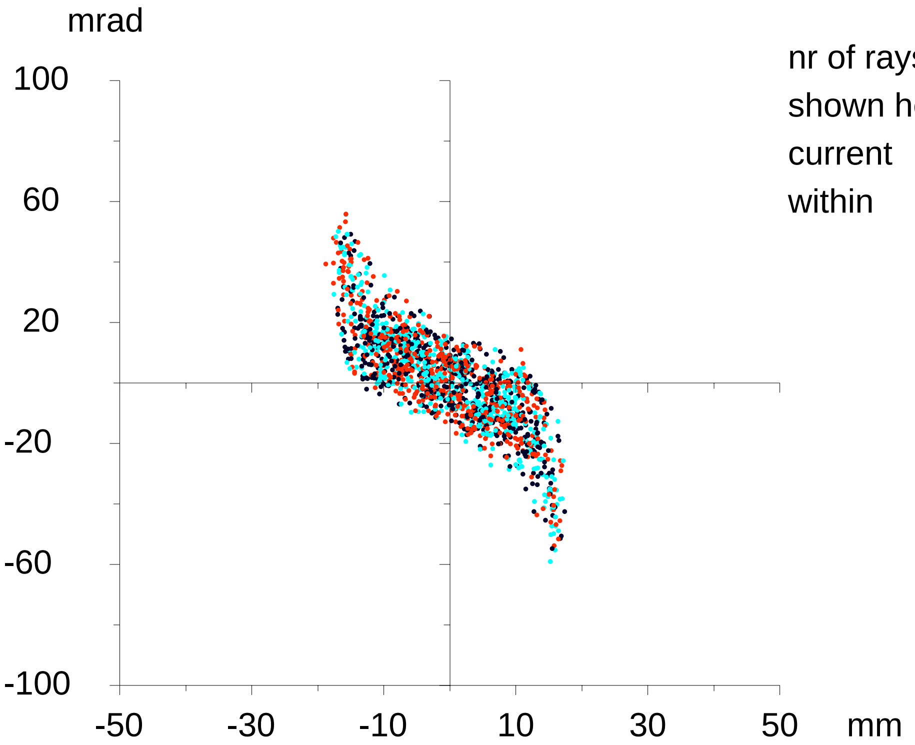


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 0.660 m

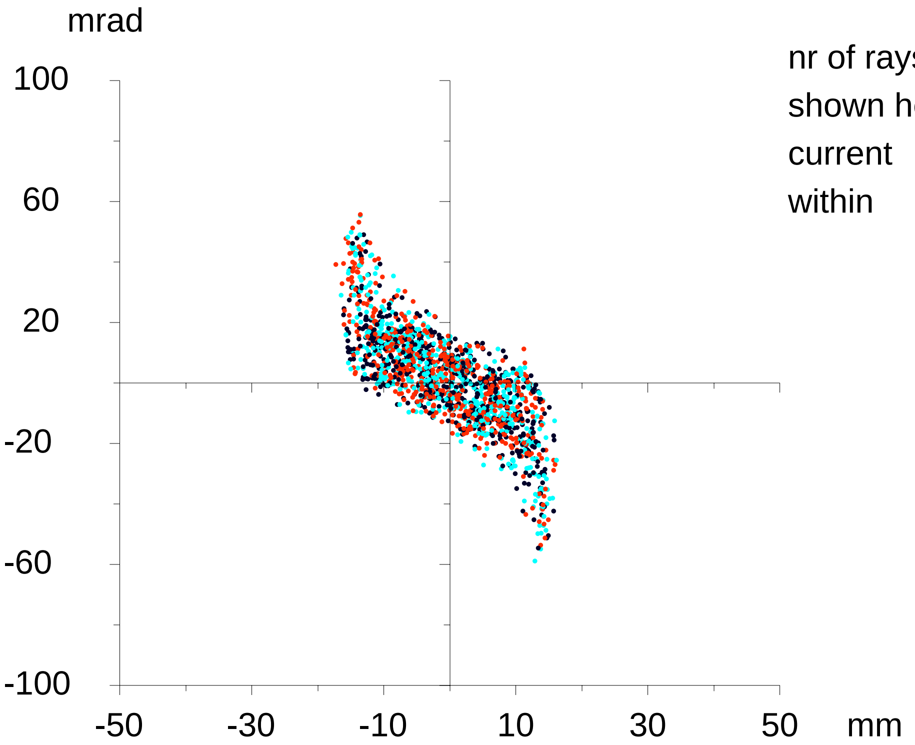


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

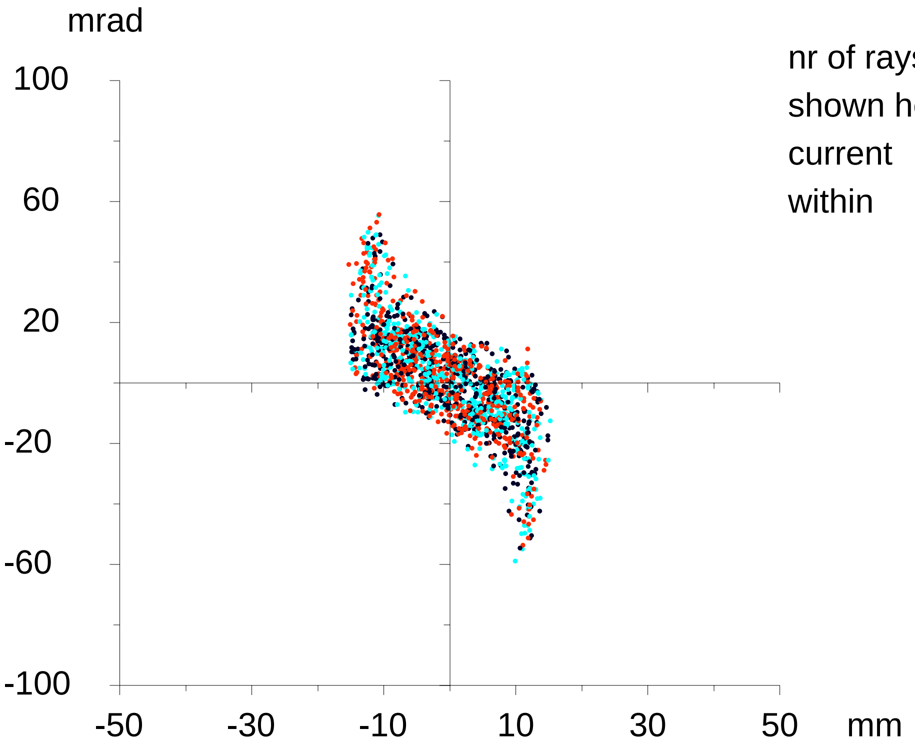
y emittance at 0.710 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP y emittance at 0.760 m

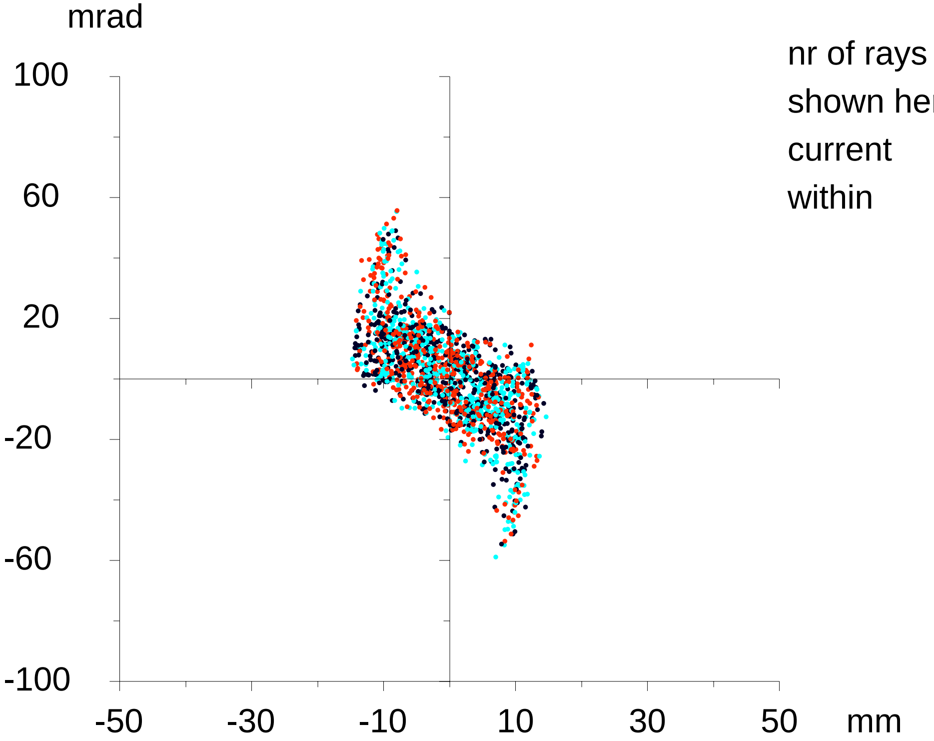


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 0.810 m

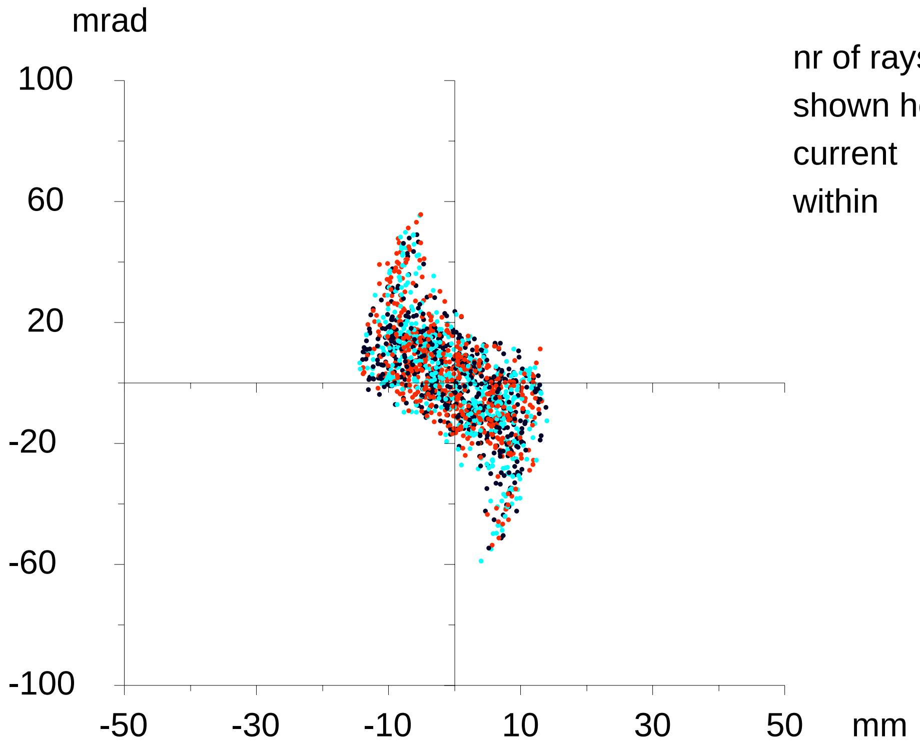


nr of rays 1664
shown here 1664
current .0247 A
within .0247 A

relax and drift

KOBRA3-INP

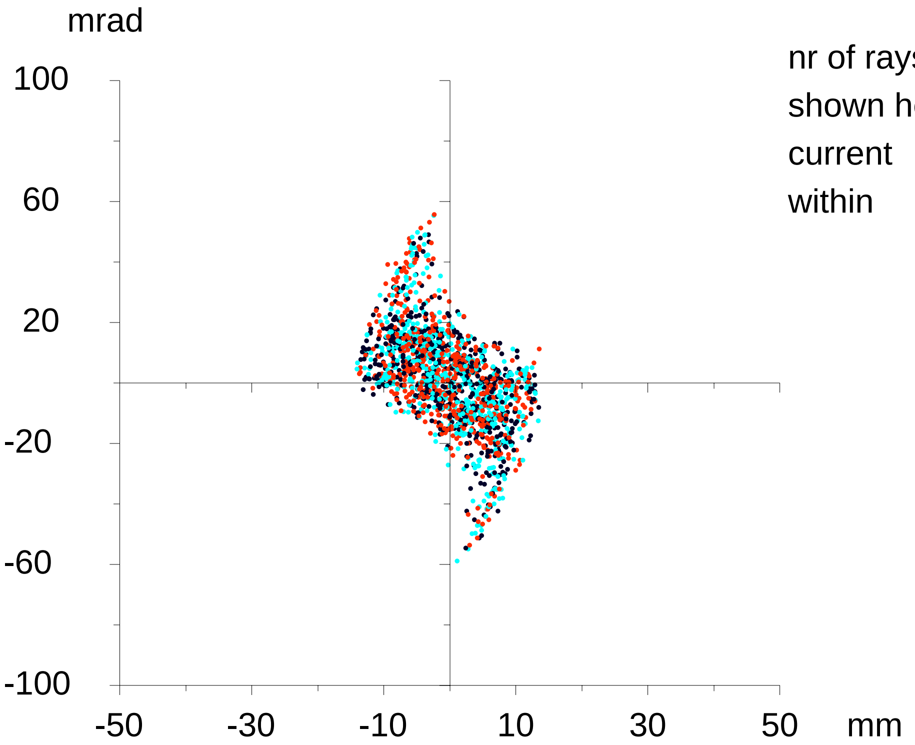
y emittance at 0.860 m



nr of rays 1664
shown here 1664
current .0247 A
within .0247 A

relax and drift

KOBRA3-INP y emittance at 0.910 m

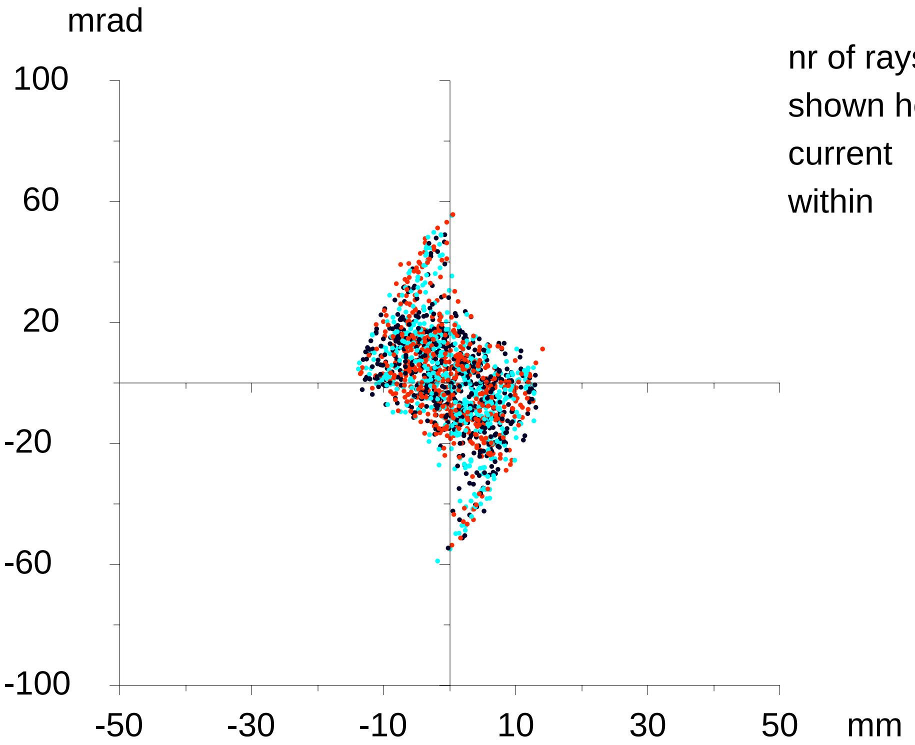


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 0.960 m

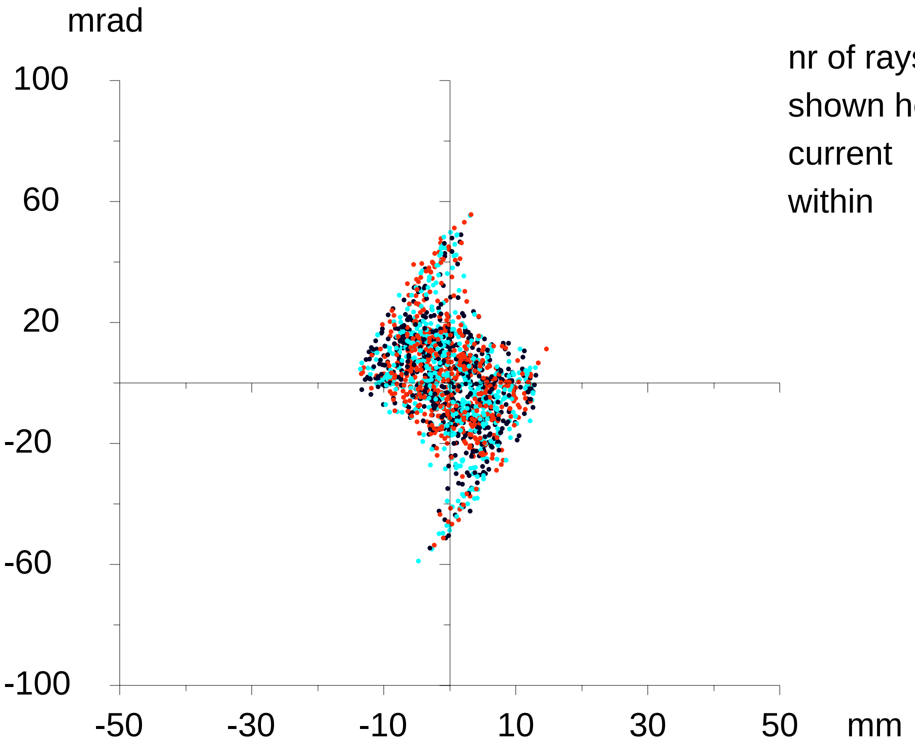


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 1.010 m

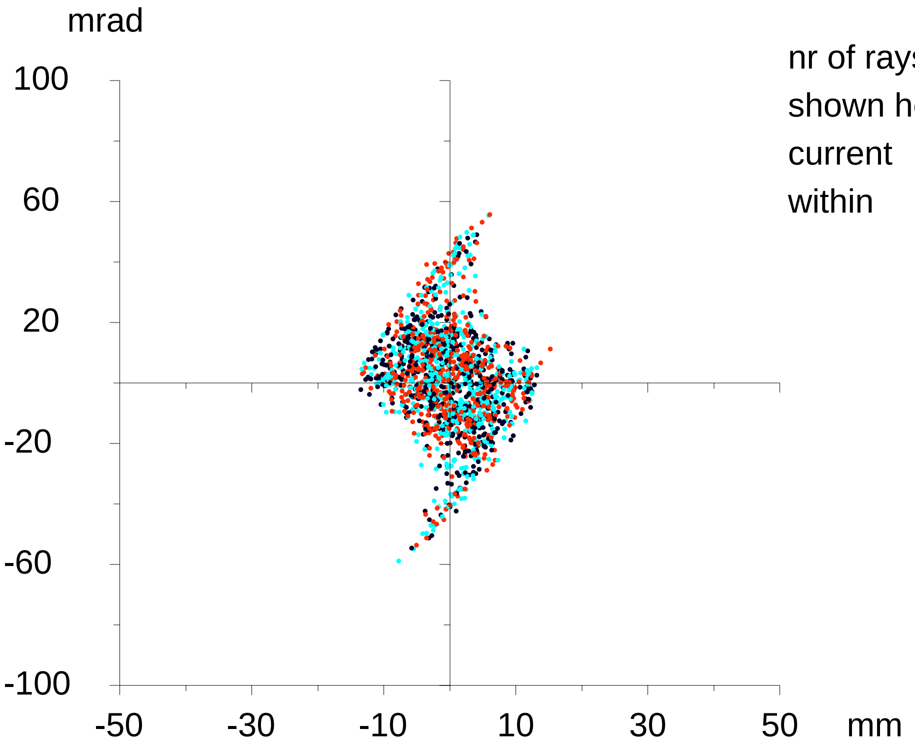


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 1.060 m

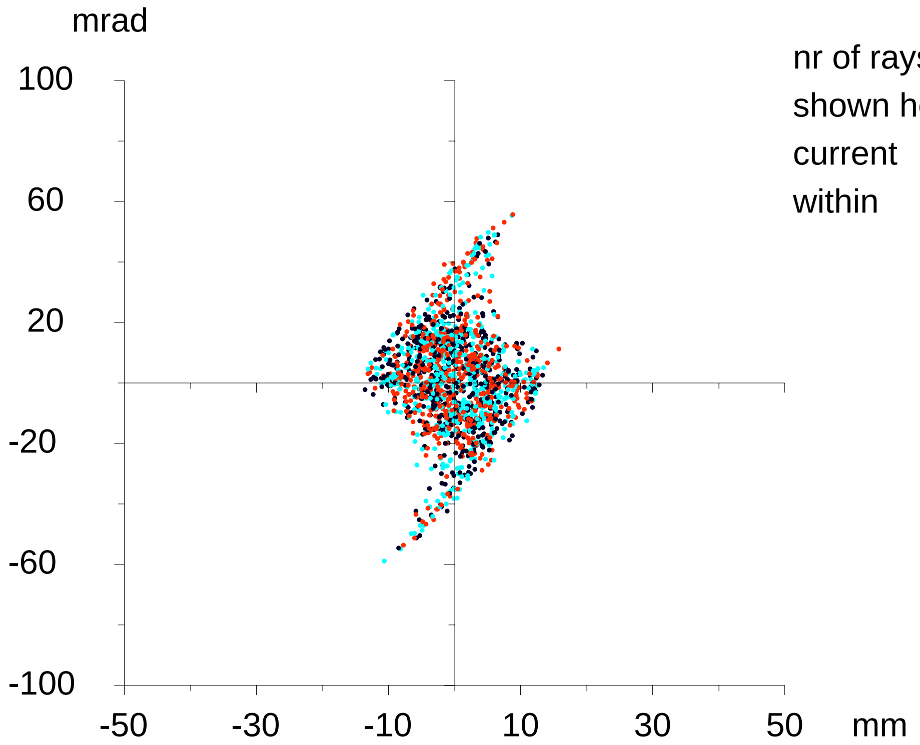


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 1.110 m

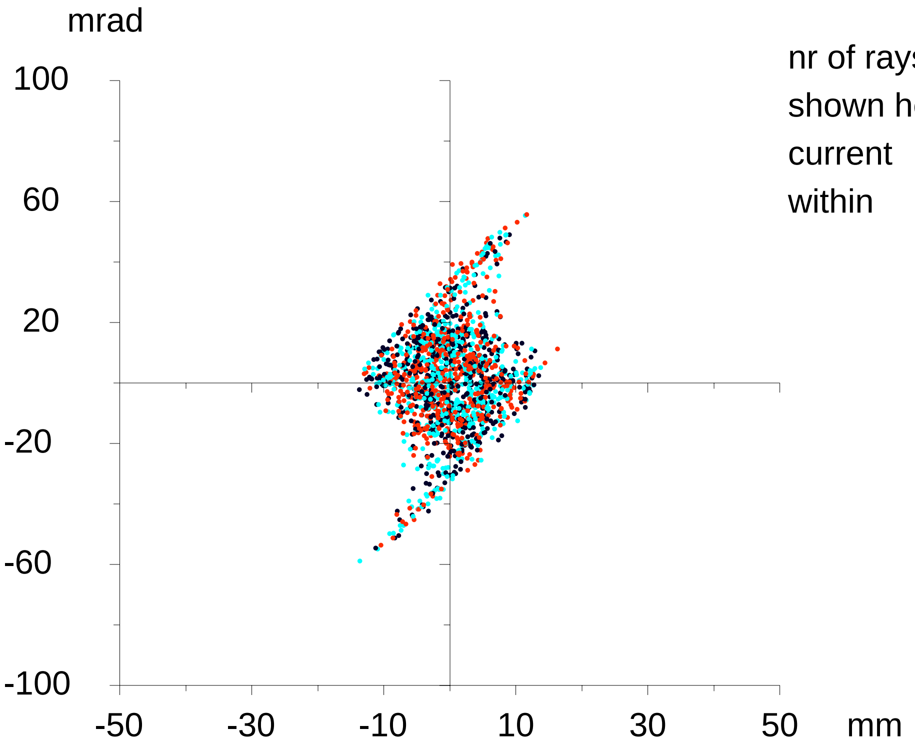


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

y emittance at 1.16 m

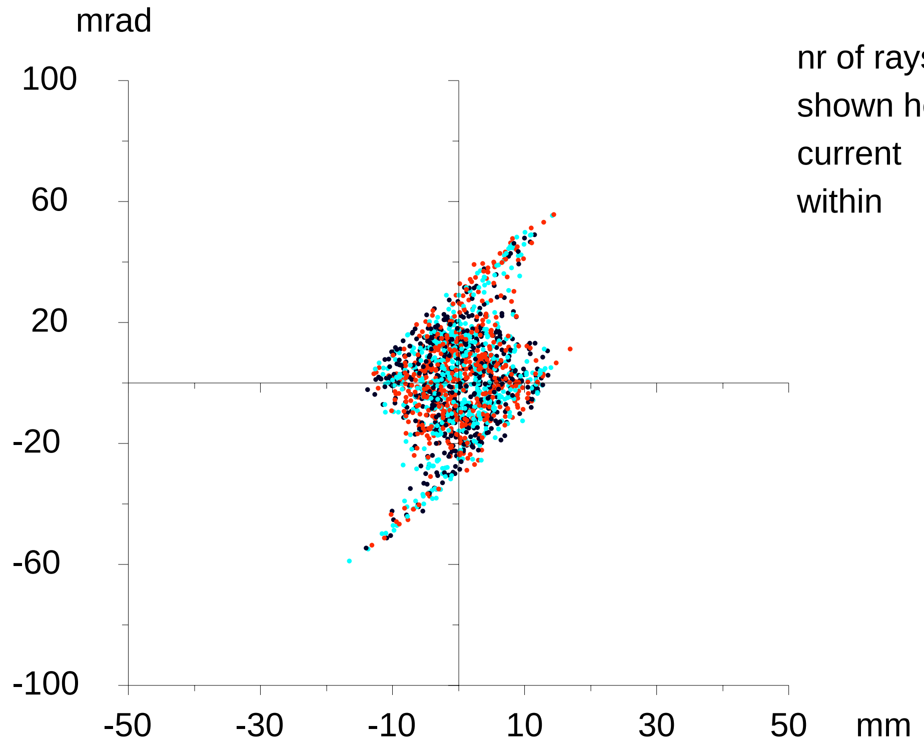


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

KOBRA3-INP

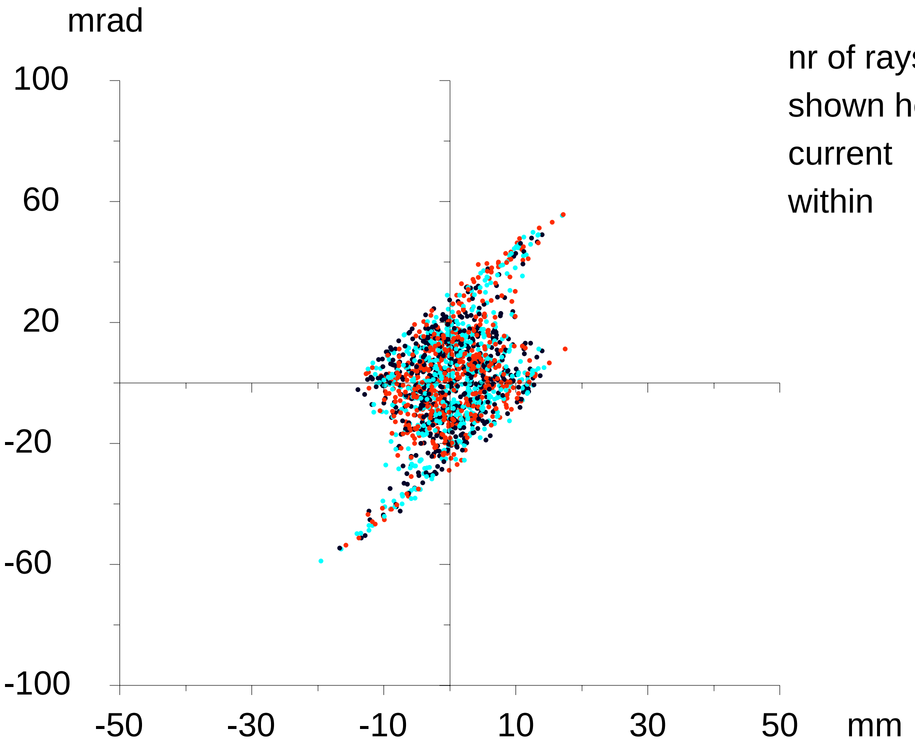
y emittance at 1.210 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

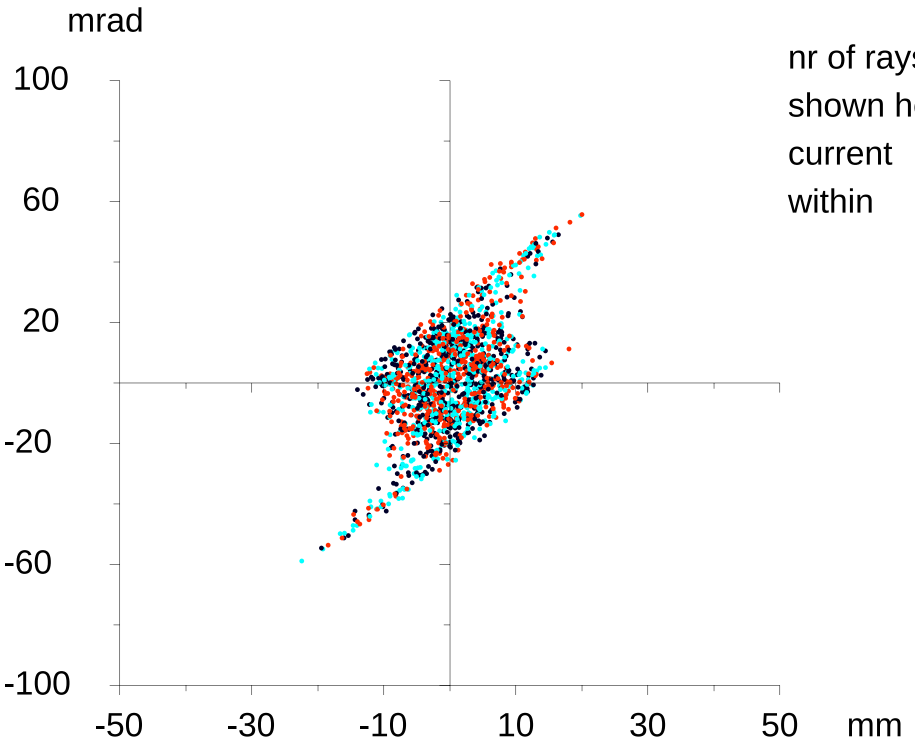
KOBRA3-INP y emittance at 1.260 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

relax and drift

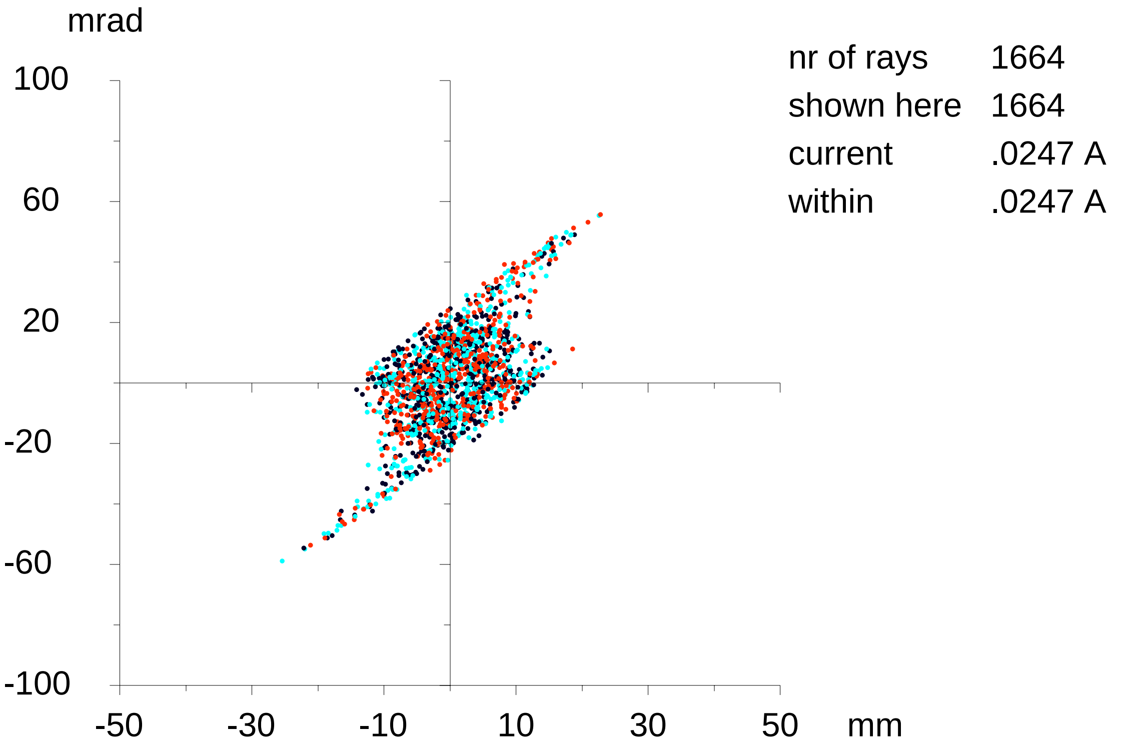
KOBRA3-INP y emittance at 1.310 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

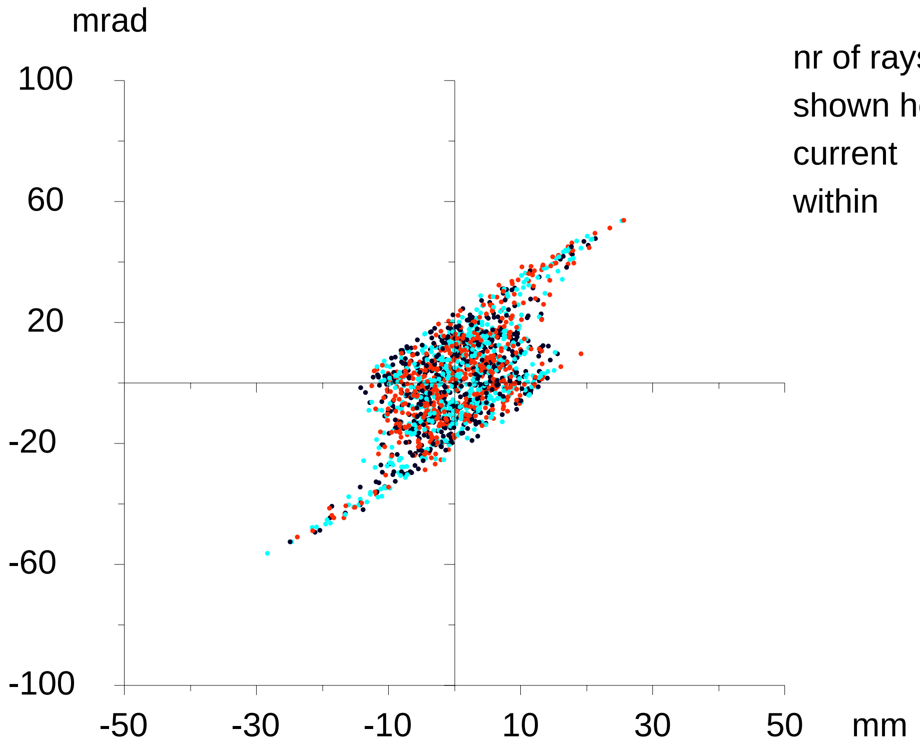
relax and drift

KOBRA3-INP y emittance at 1.360 m



relax and drift

KOBRA3-INP　　　　　　　　　　　y emittance at　1.410 m

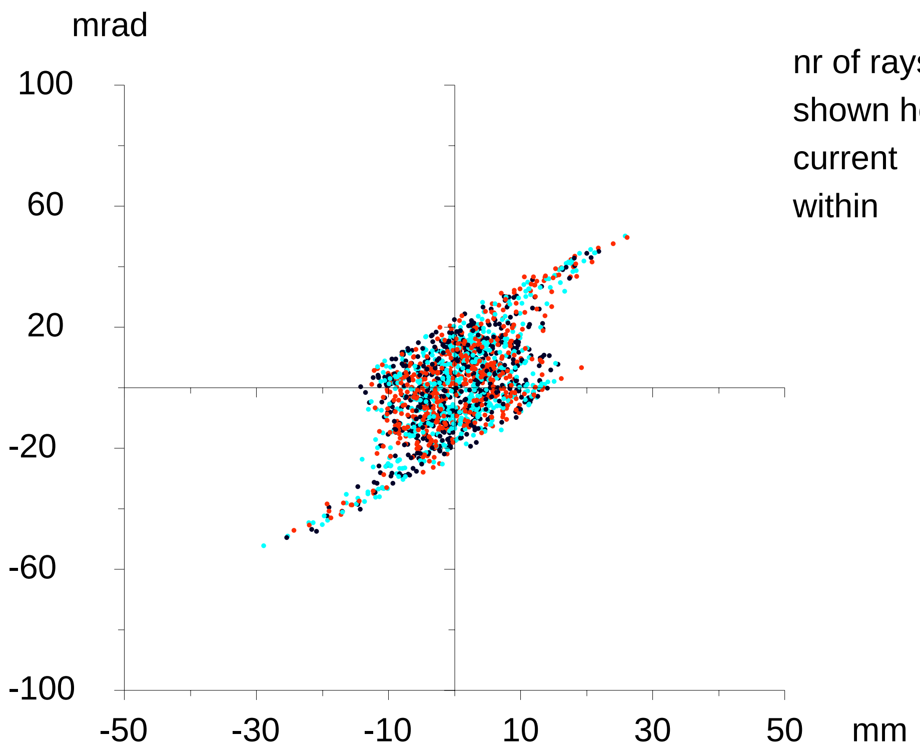


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

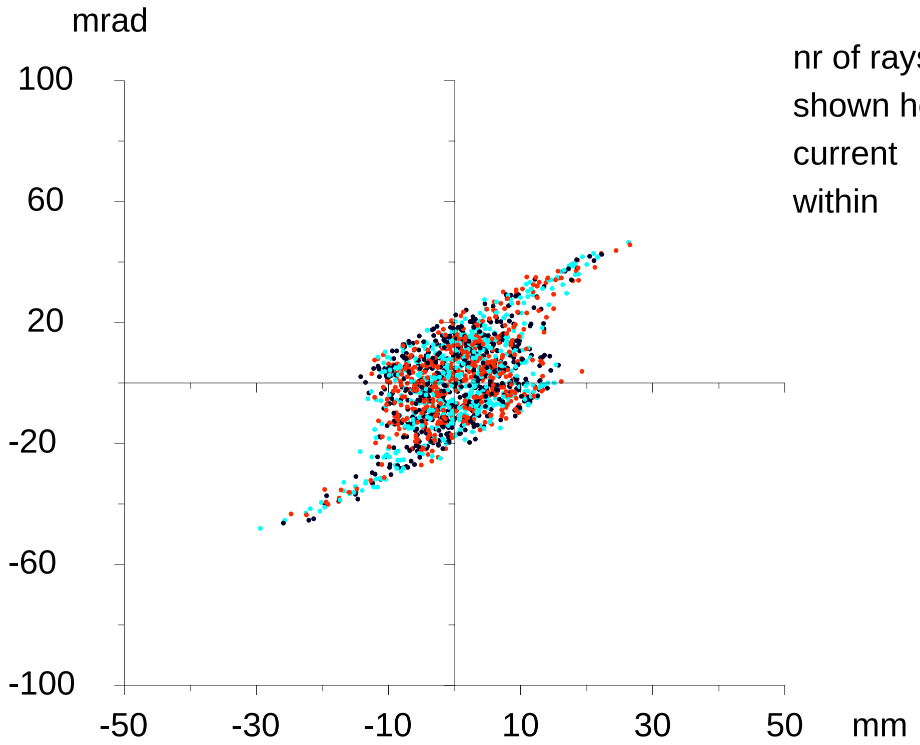
y emittance at 1.420 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP y emittance at 1.430 m

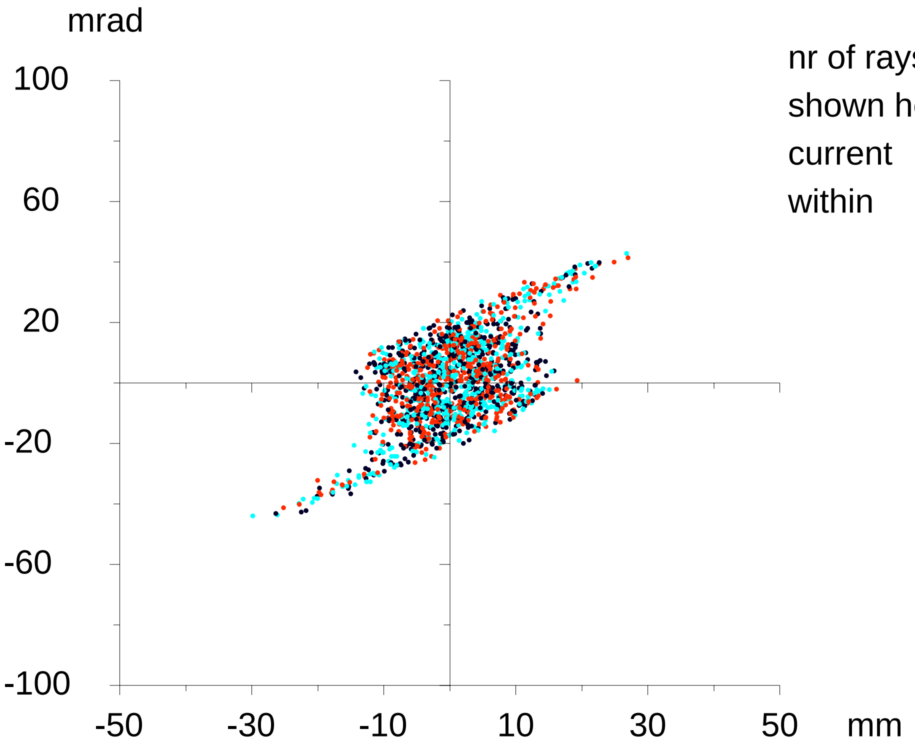


nr of rays 1664
shown here 1664
current .0247 A
within .0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.440 m

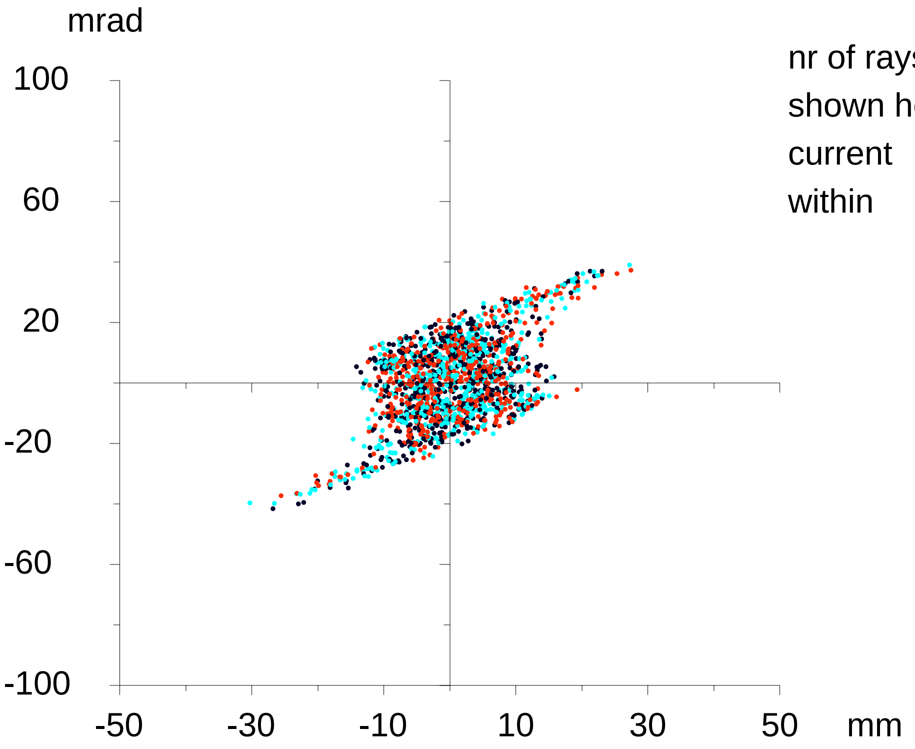


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.450 m

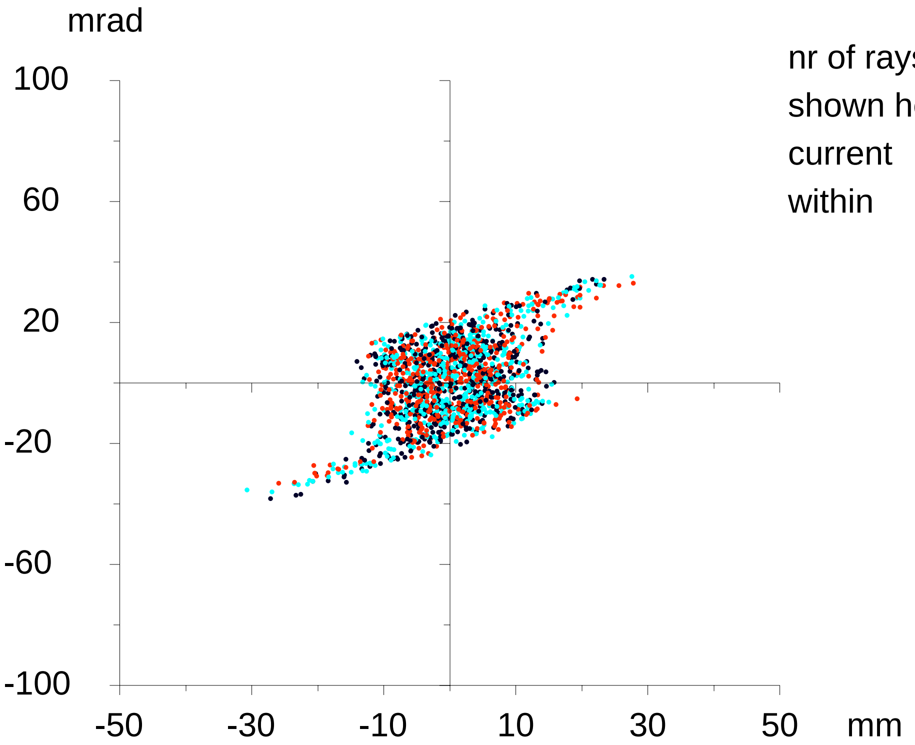


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.460 m

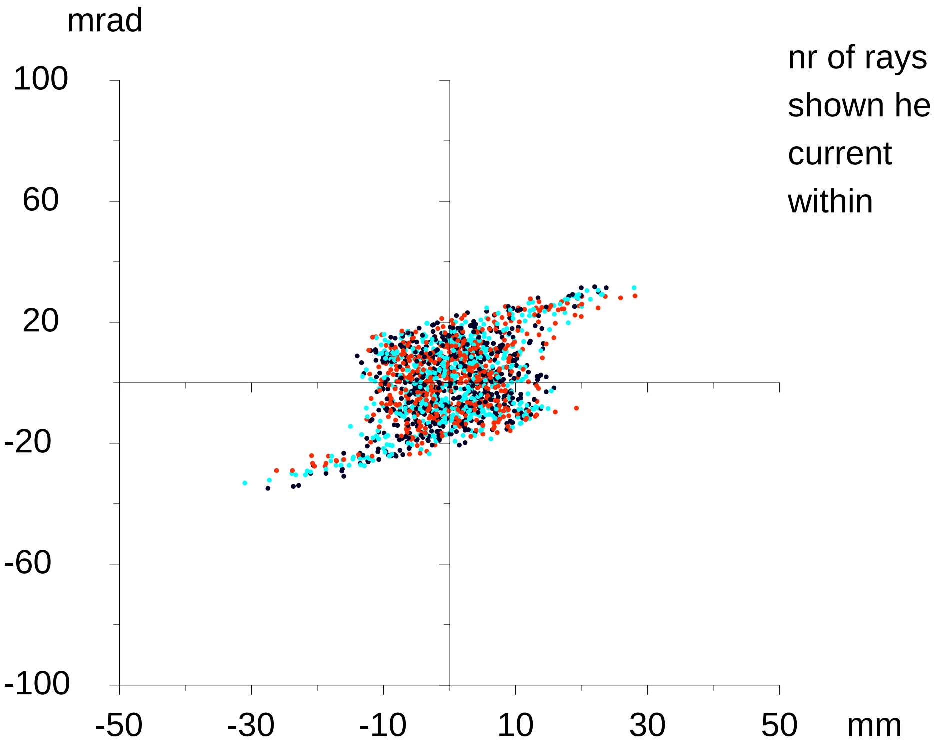


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

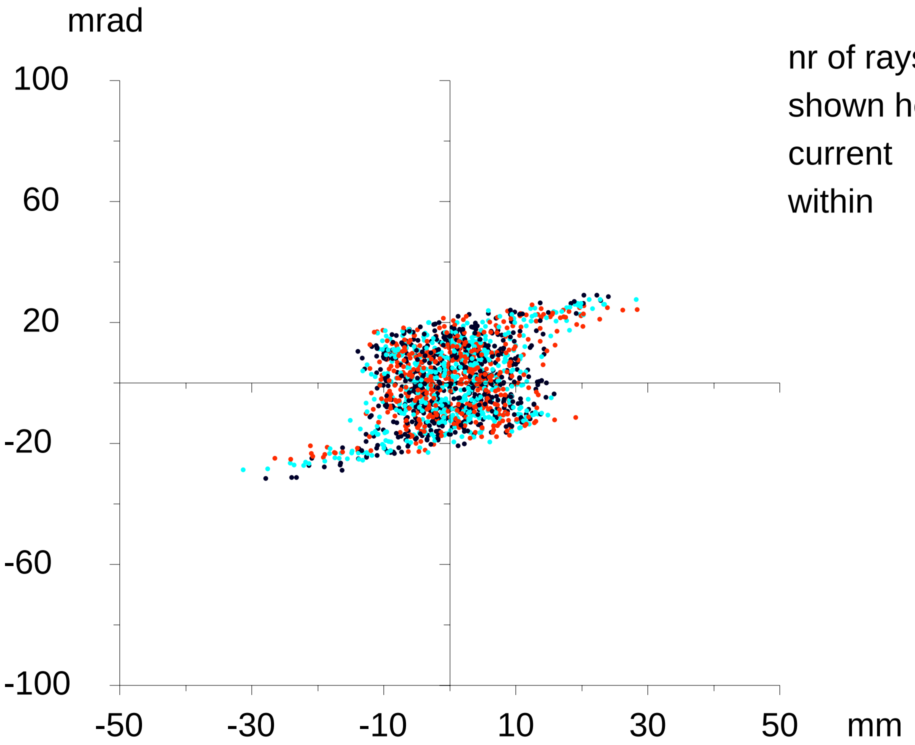
y emittance at 1.470 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

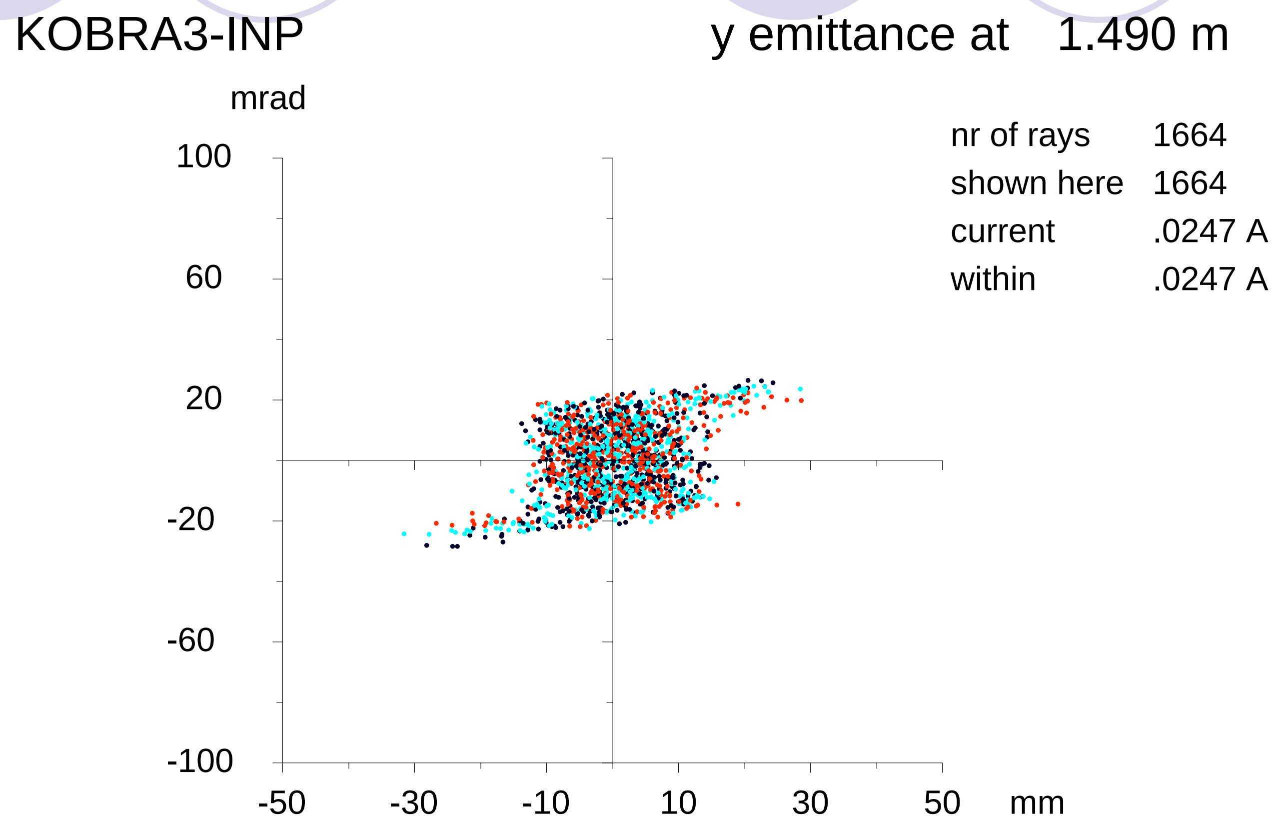
quadrupole ahead

KOBRA3-INP y emittance at 1.480 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

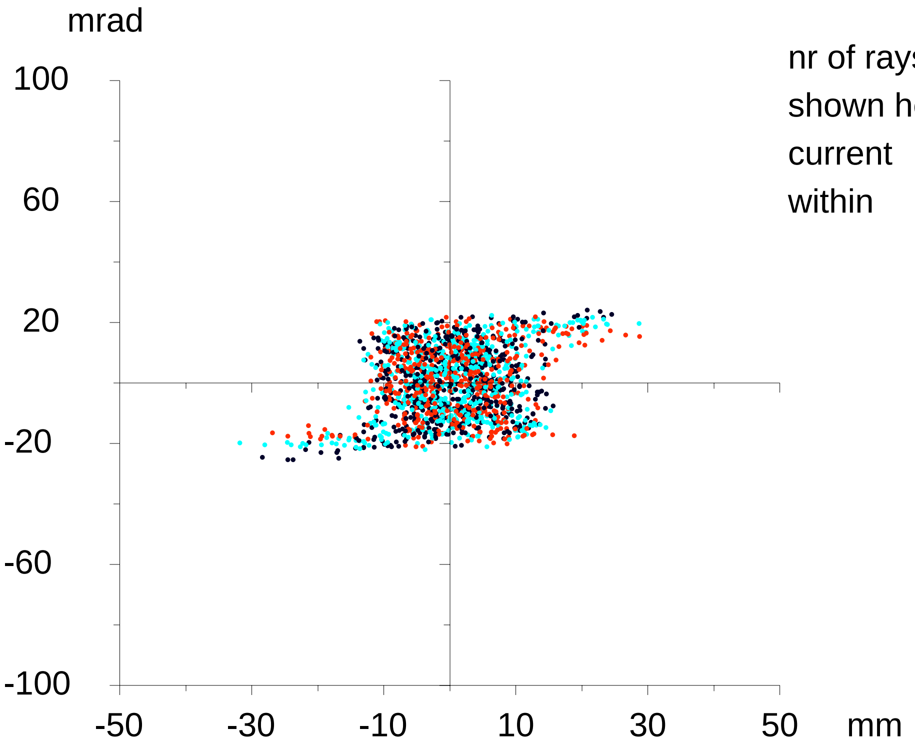
quadrupole ahead



quadrupole ahead

KOBRA3-INP

y emittance at 1.500 m

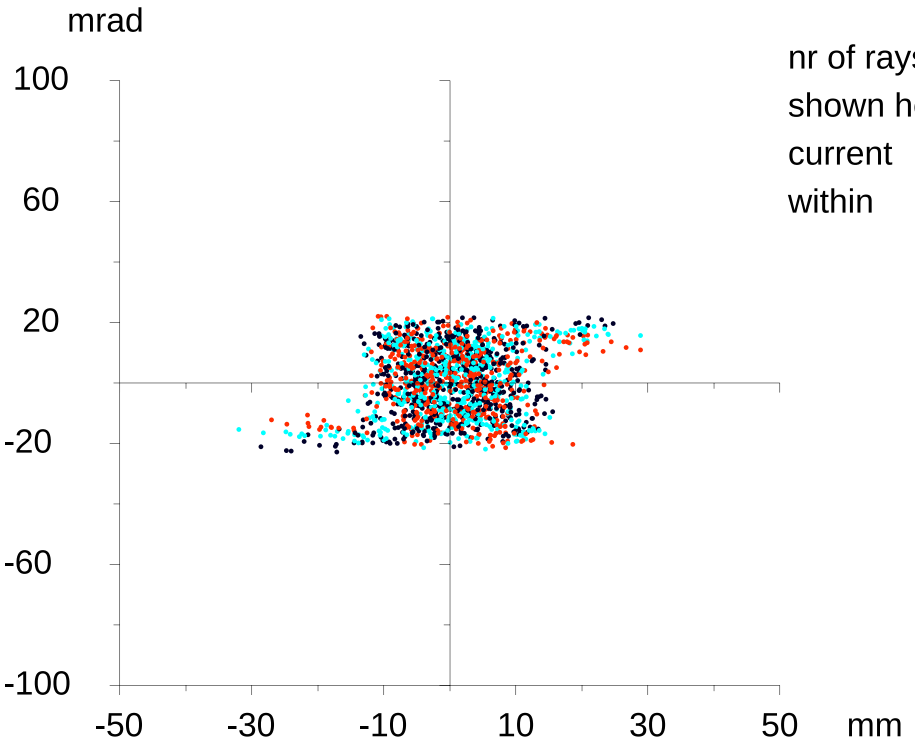


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.510 m

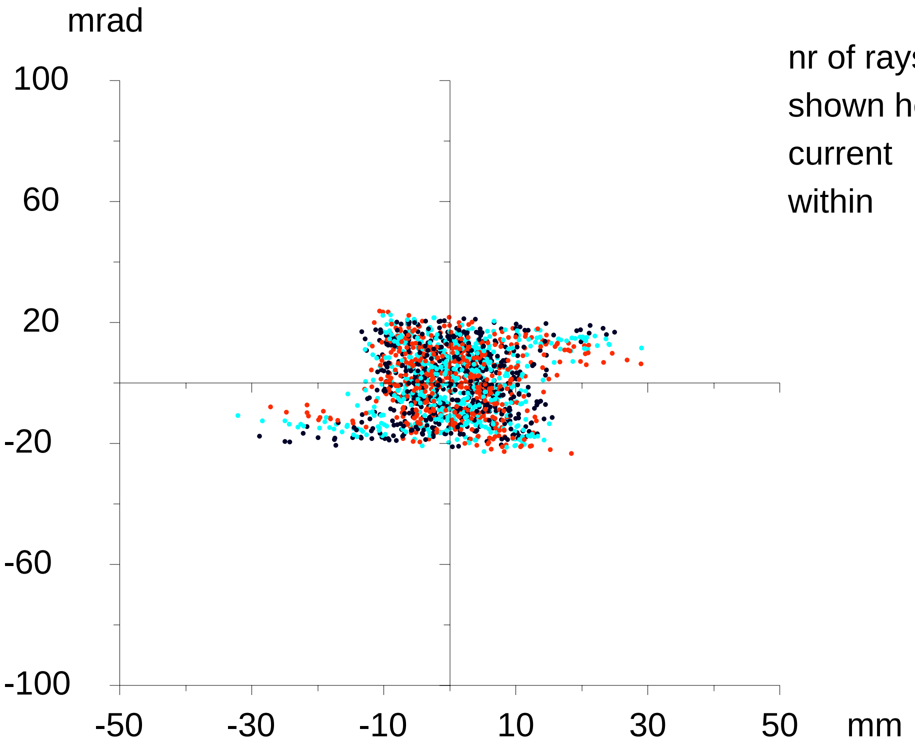


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.520 m



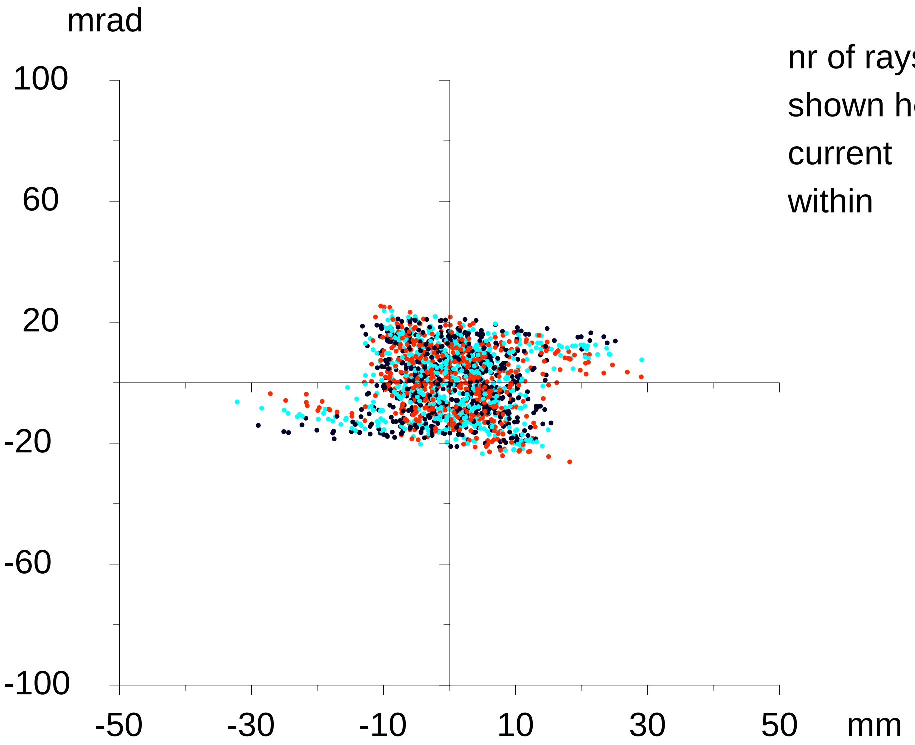
nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.530 m

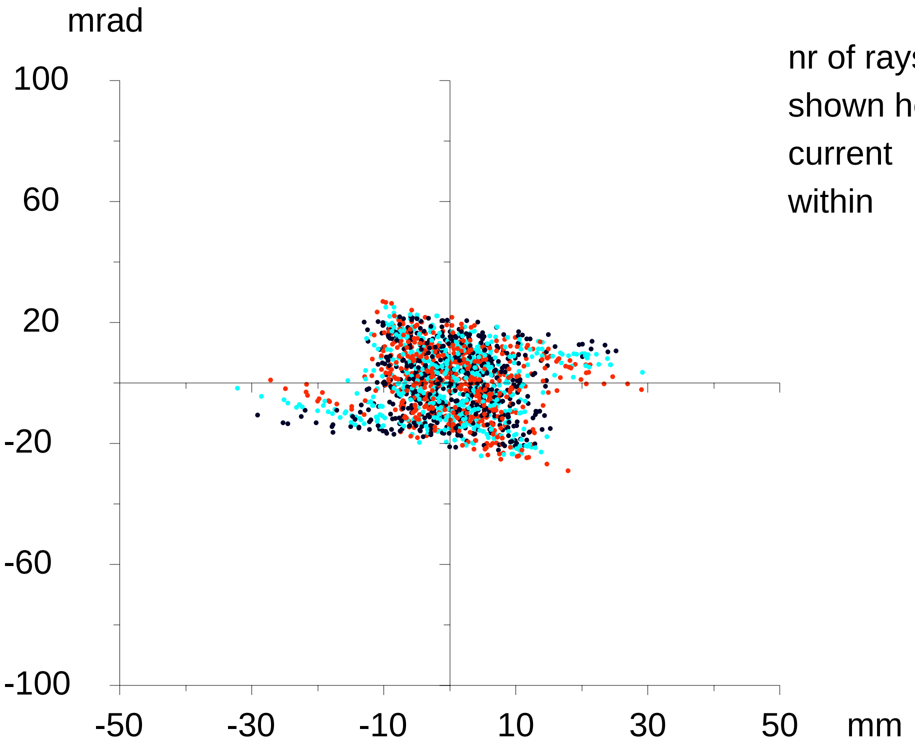
nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A



quadrupole ahead

KOBRA3-INP

y emittance at 1.540 m

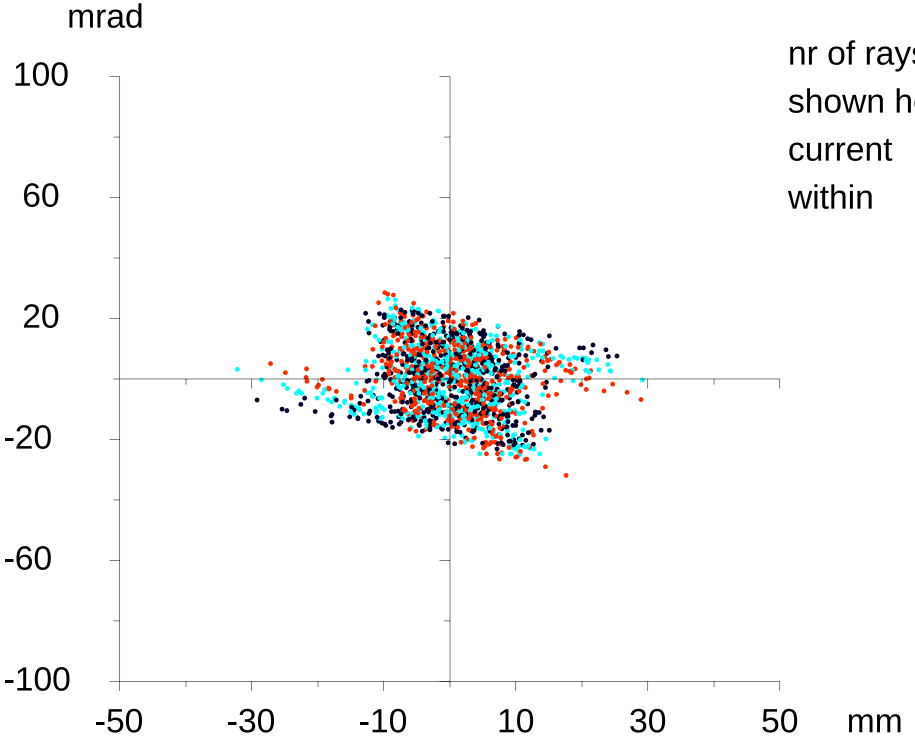


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.550 m

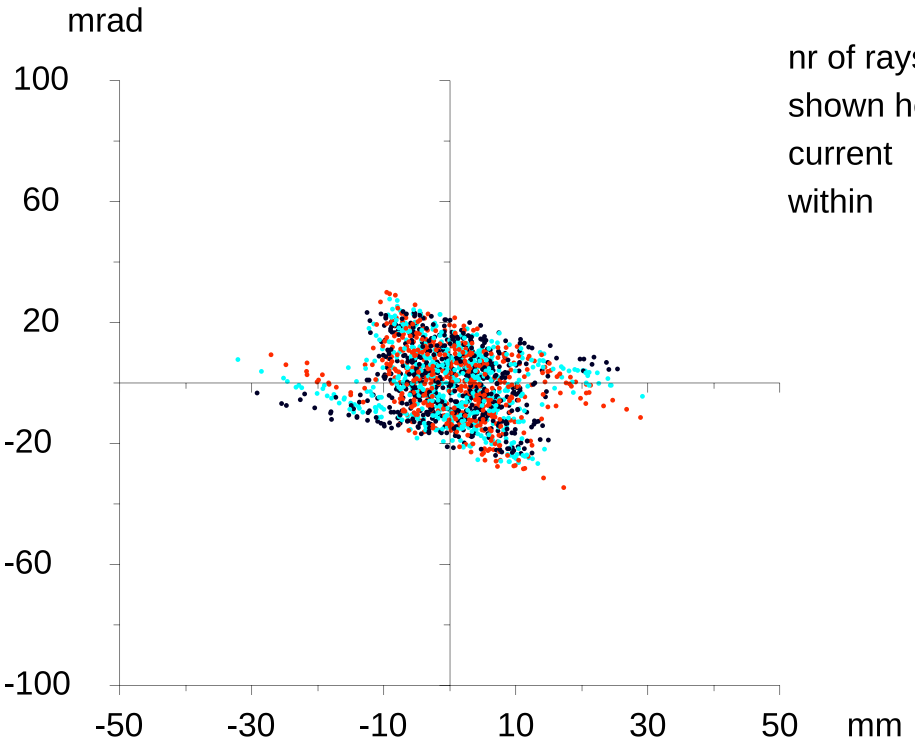


nr of rays 1664
shown here 1664
current .0247 A
within .0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.560 m

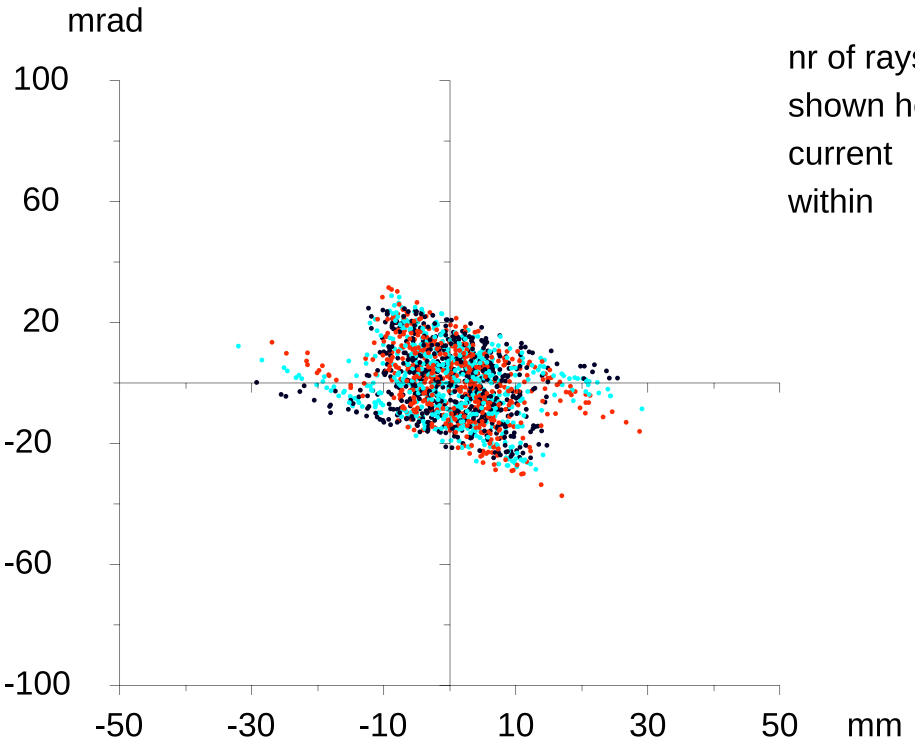


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.570 m

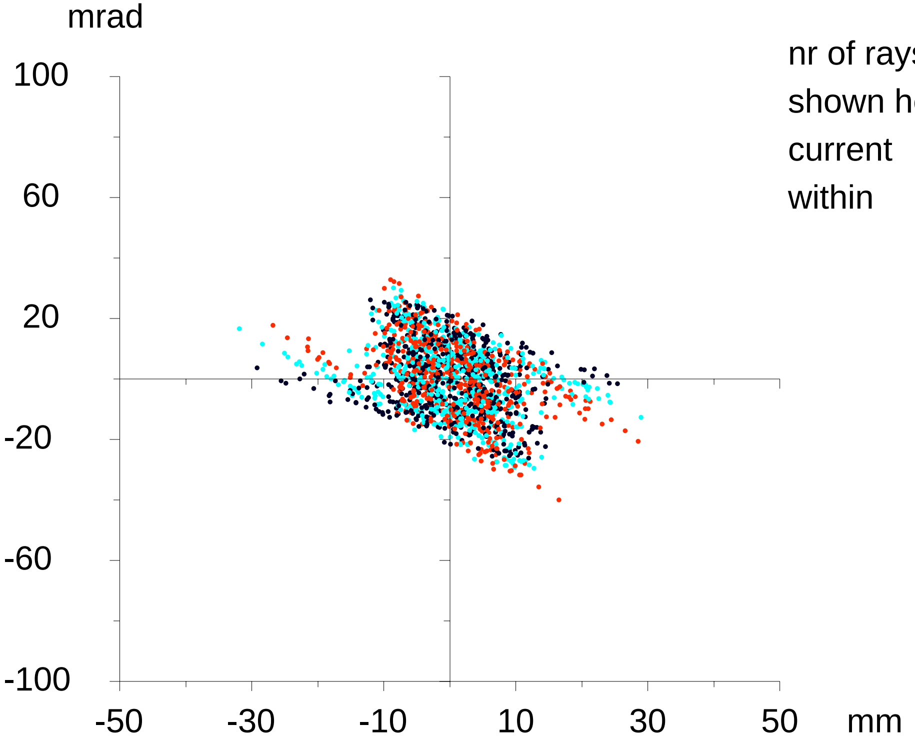


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

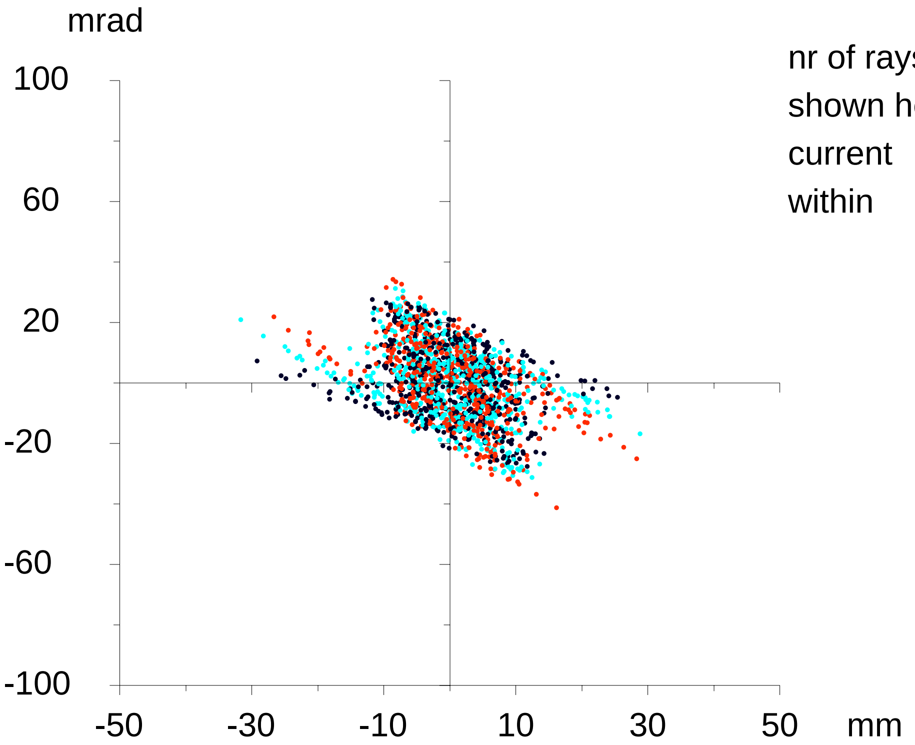
y emittance at 1.580 m



nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP y emittance at 1.590 m

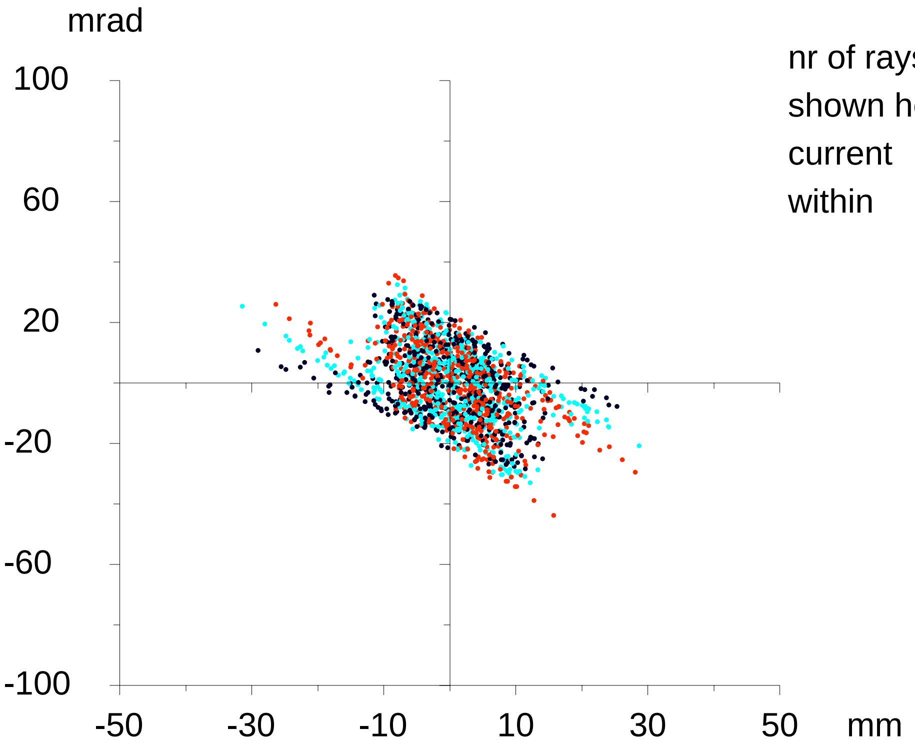


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

KOBRA3-INP

y emittance at 1.600 m

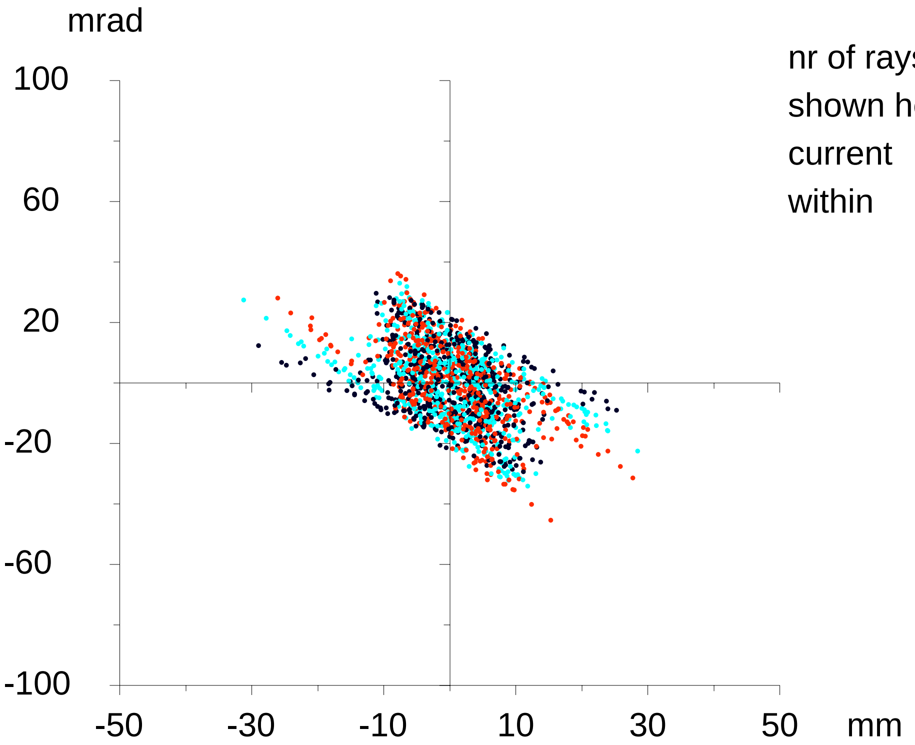


nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

quadrupole ahead

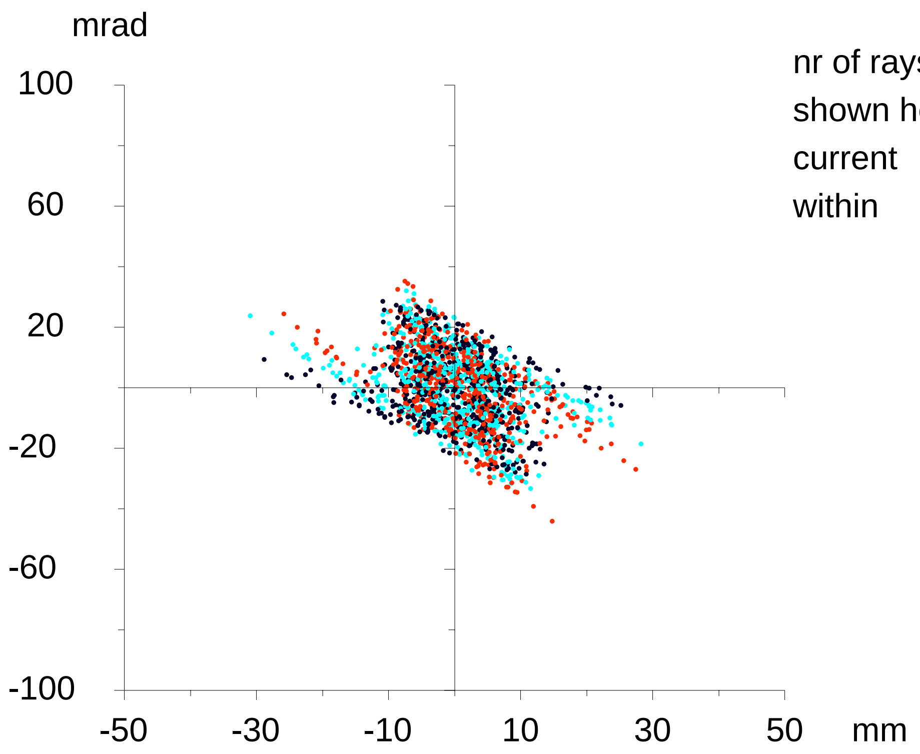
KOBRA3-INP

y emittance at 1.610 m



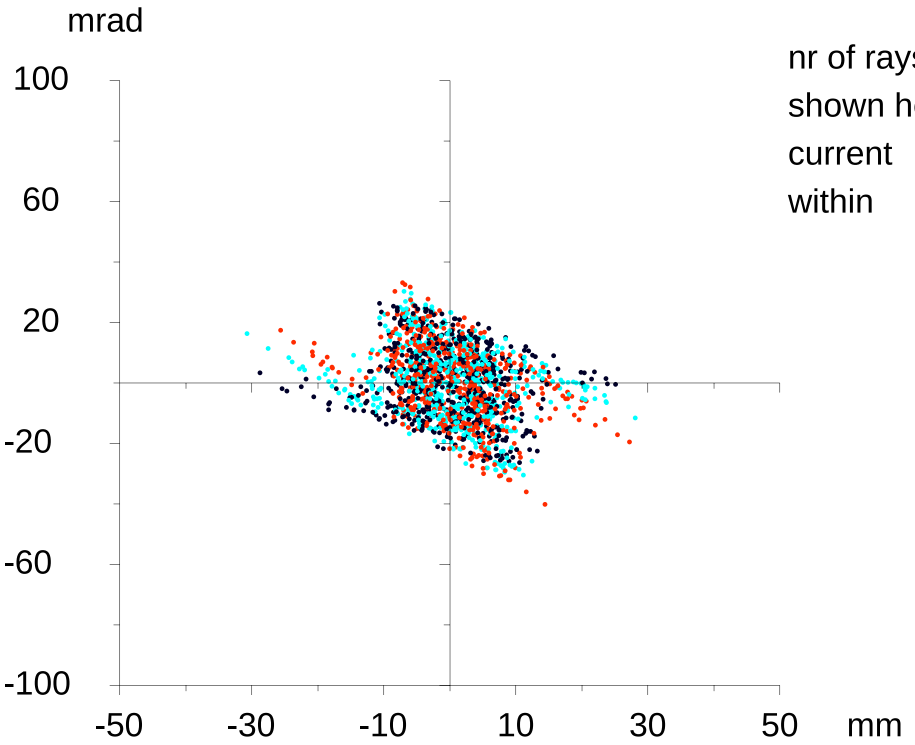
nr of rays	1664
shown here	1664
current	.0247 A
within	.0247 A

KOBRA3-INP y emittance at 1.620 m



nr of rays	1663
shown here	1663
current	.0247 A
within	.0247 A

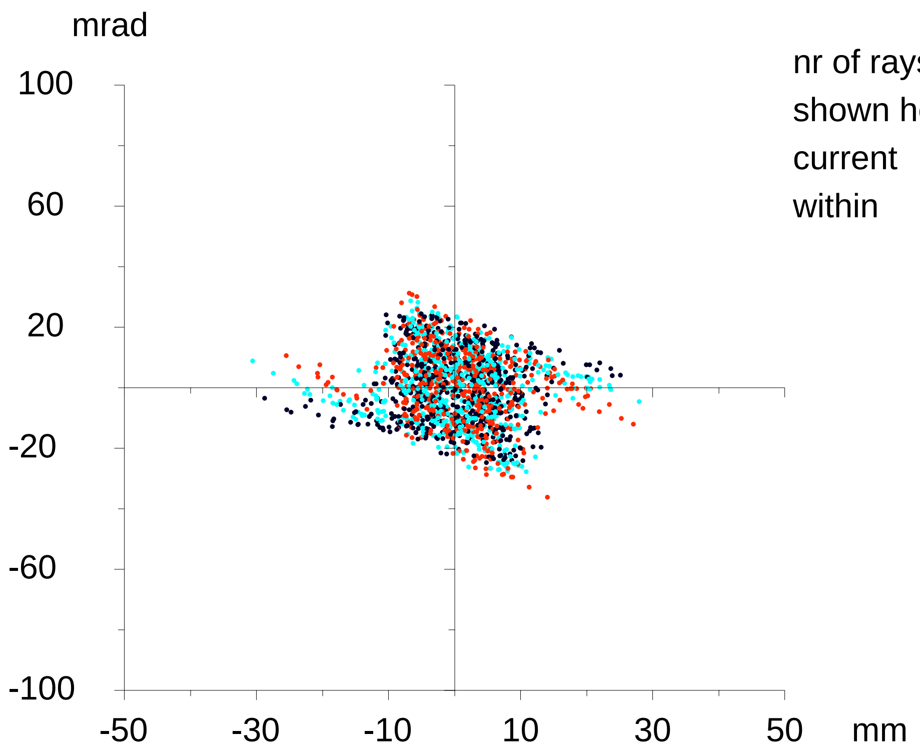
KOBRA3-INP y emittance at 1.630 m



nr of rays	1663
shown here	1663
current	.0247 A
within	.0247 A

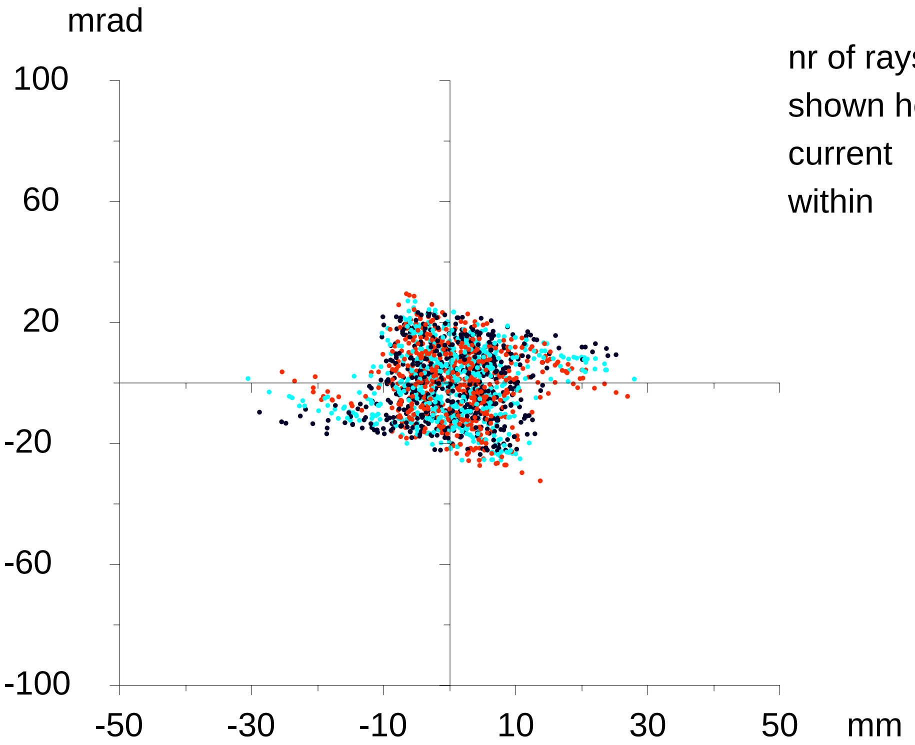
KOBRA3-INP

y emittance at 1.640 m



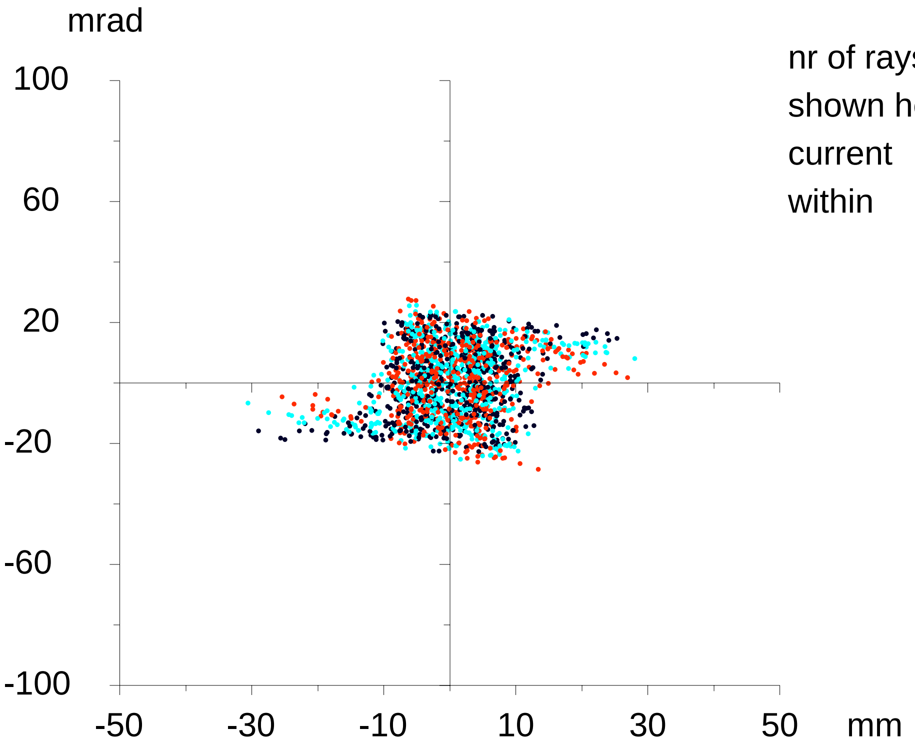
nr of rays 1660
shown here 1660
current .0246 A
within .0246 A

KOBRA3-INP y emittance at 1.650 m



nr of rays	1660
shown here	1660
current	.0246 A
within	.0246 A

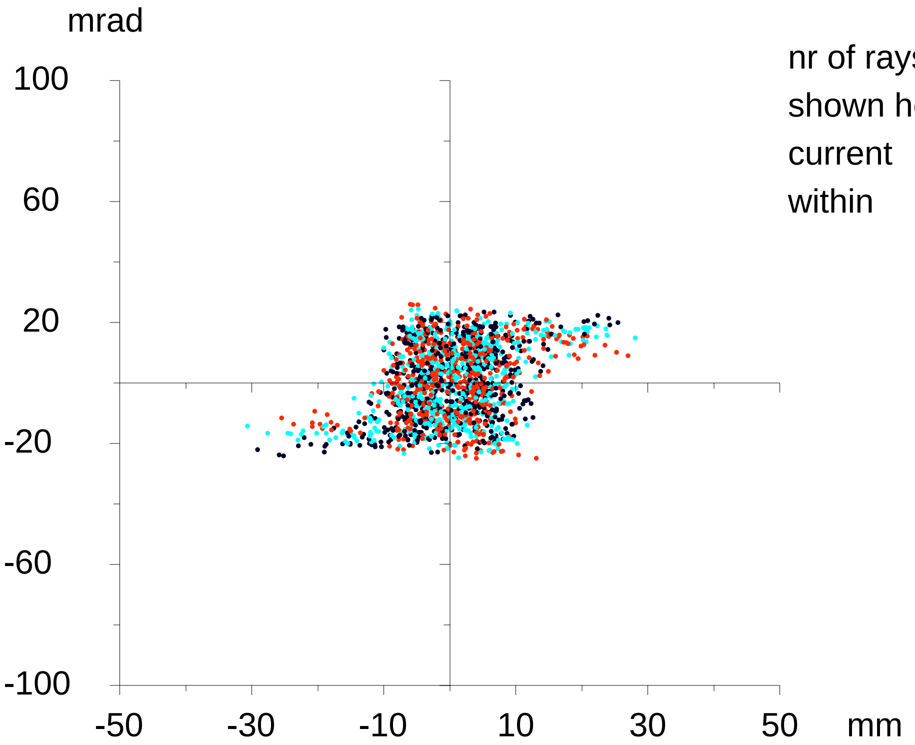
KOBRA3-INP y emittance at 1.660 m



nr of rays	1659
shown here	1659
current	.0246 A
within	.0246 A

KOBRA3-INP

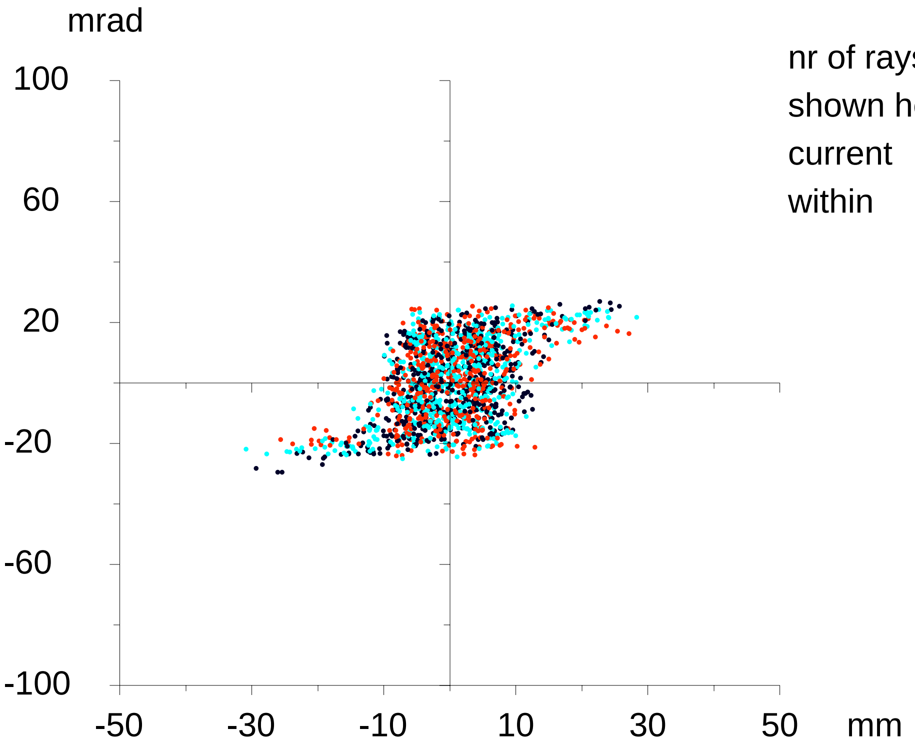
y emittance at 1.670 m



nr of rays 1659
shown here 1659
current .0246 A
within .0246 A

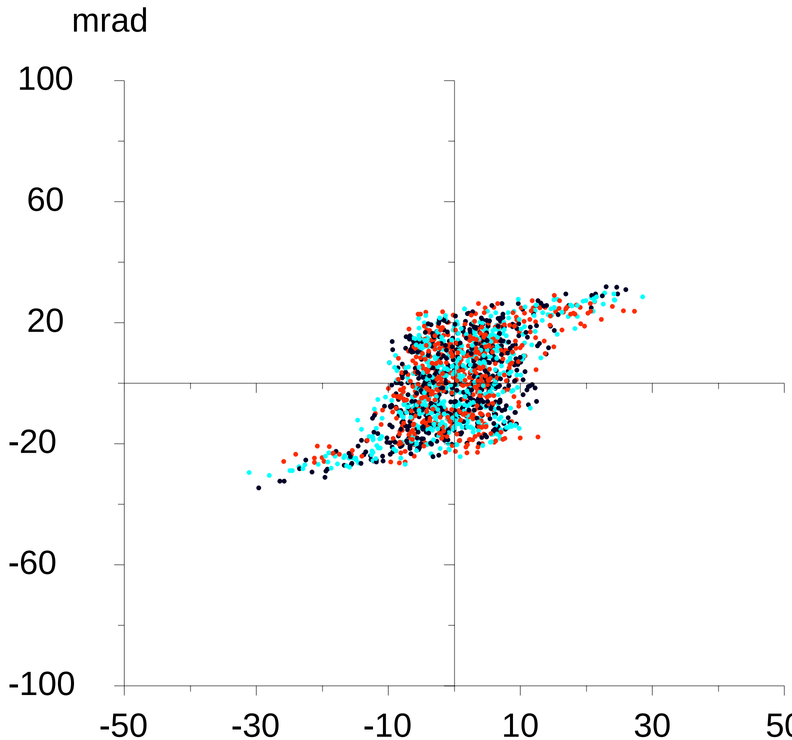
KOBRA3-INP

y emittance at 1.680 m



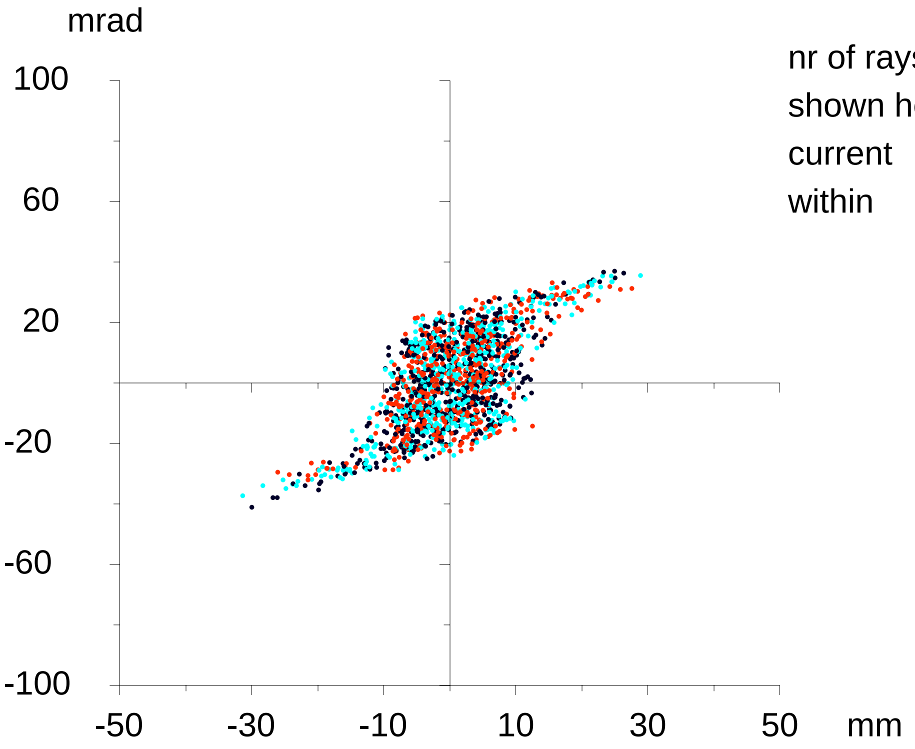
nr of rays 1657
shown here 1657
current .0246 A
within .0246 A

KOBRA3-INP y emittance at 1.690 m



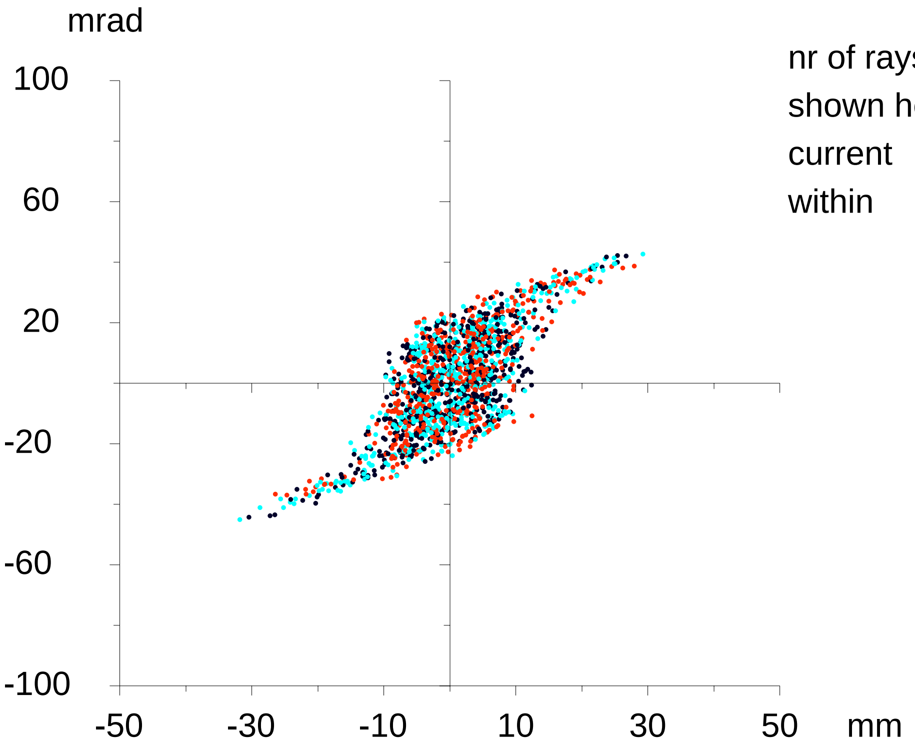
nr of rays	1656
shown here	1656
current	.0246 A
within	.0246 A

KOBRA3-INP y emittance at 1.700 m



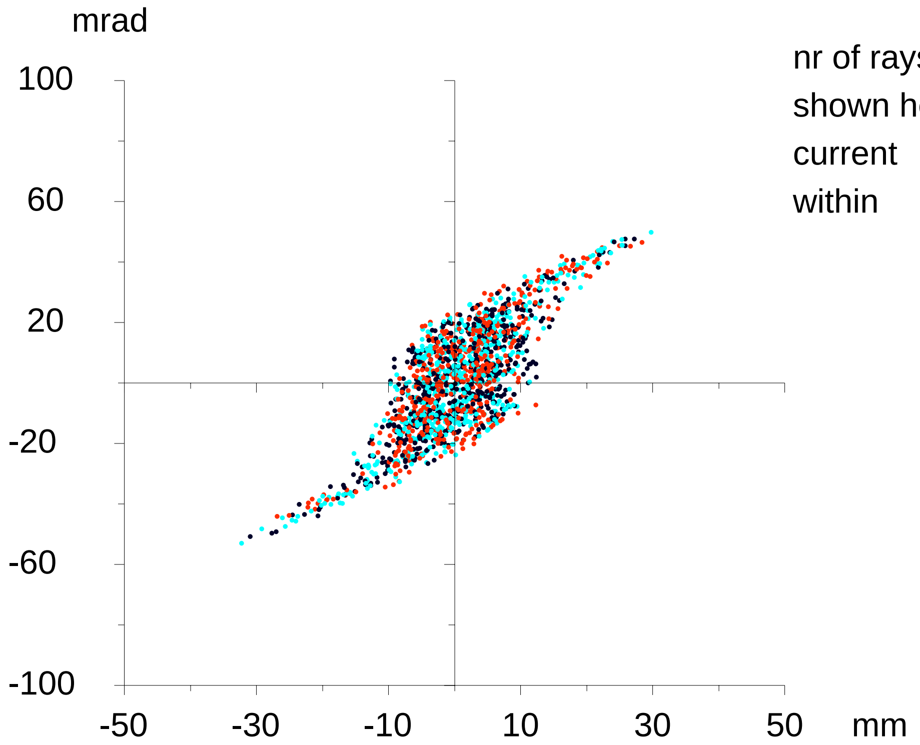
nr of rays 1654
shown here 1654
current .0245 A
within .0245 A

KOBRA3-INP y emittance at 1.710 m



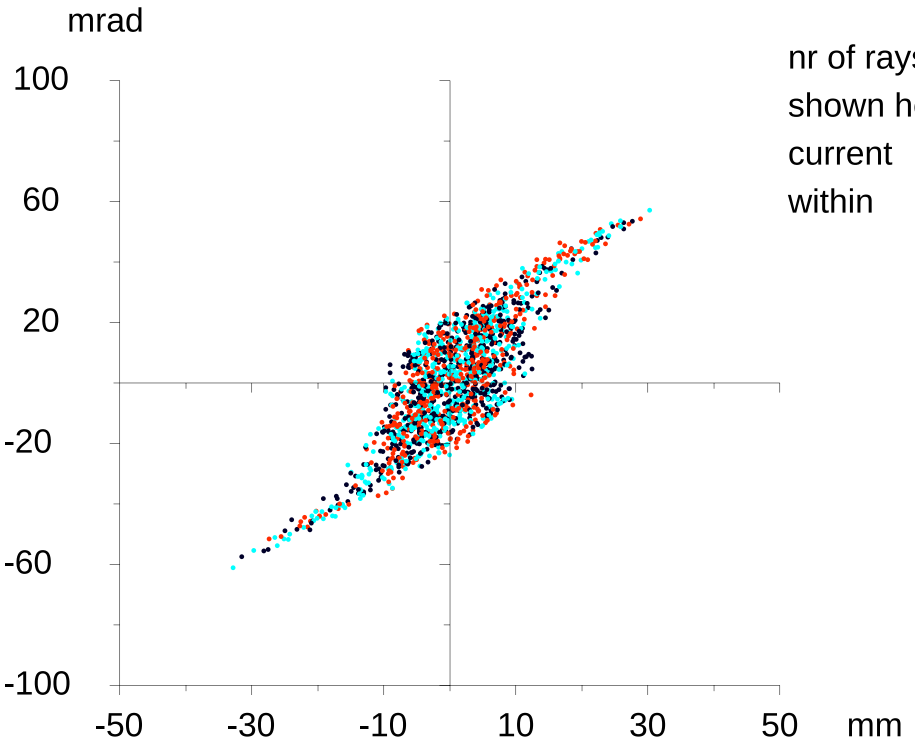
nr of rays	1653
shown here	1653
current	.0245 A
within	.0245 A

KOBRA3-INP y emittance at 1.720 m



nr of rays	1653
shown here	1653
current	.0245 A
within	.0245 A

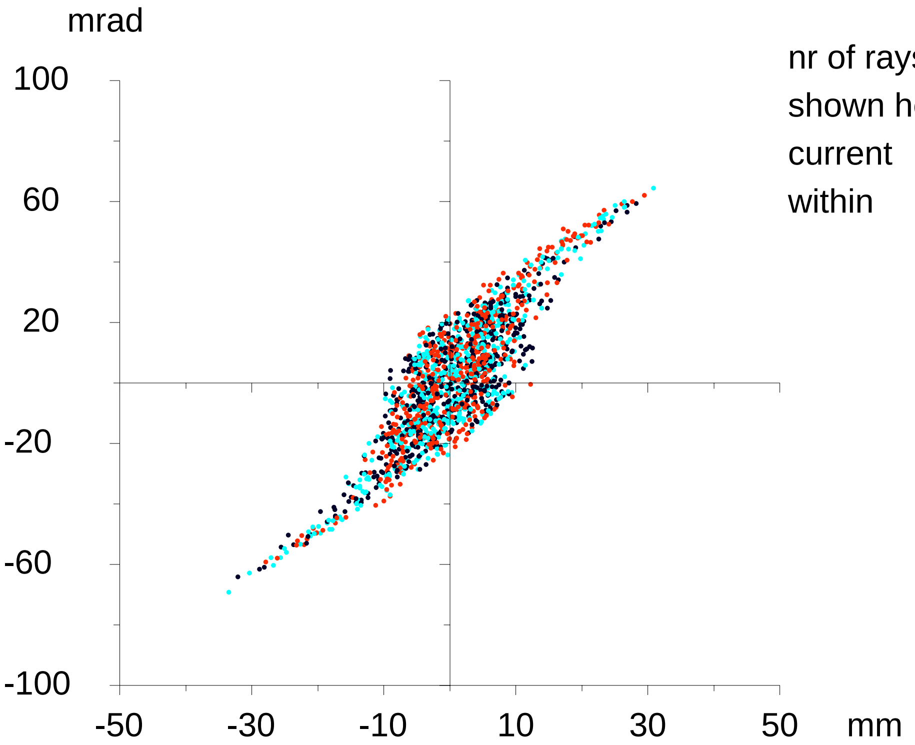
KOBRA3-INP y emittance at 1.730 m



nr of rays	1652
shown here	1652
current	.0245 A
within	.0245 A

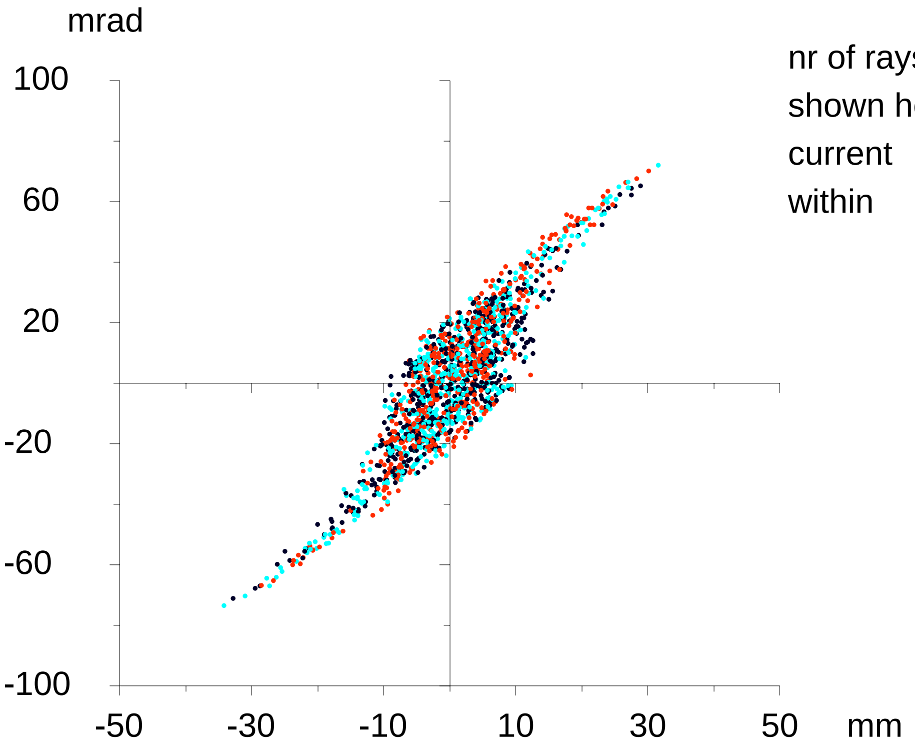
KOBRA3-INP

y emittance at 1.740 m



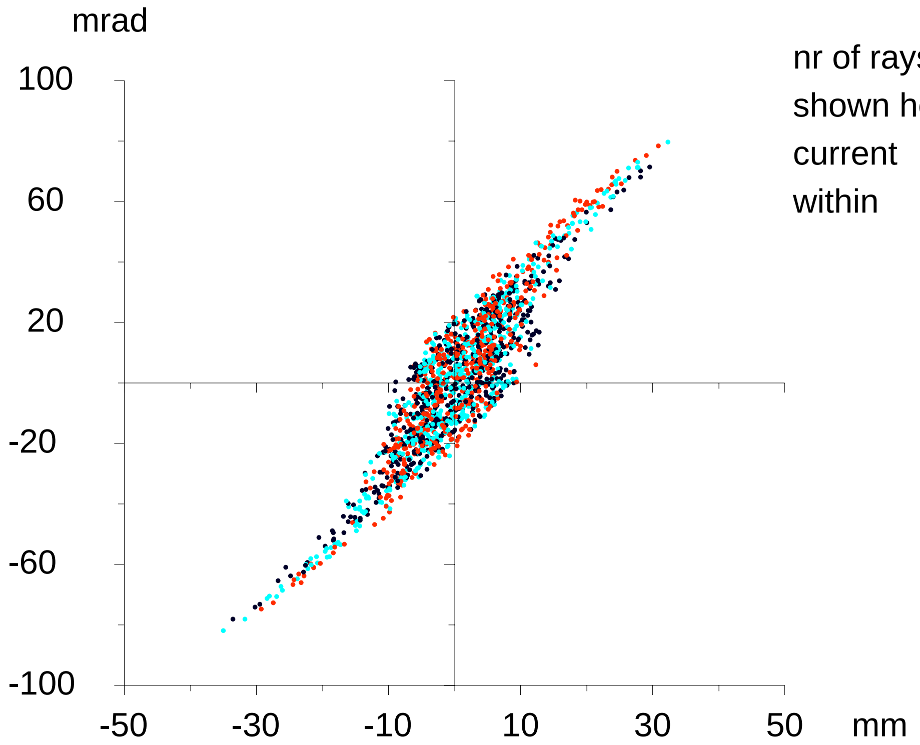
nr of rays	1652
shown here	1652
current	.0245 A
within	.0245 A

KOBRA3-INP y emittance at 1.750 m



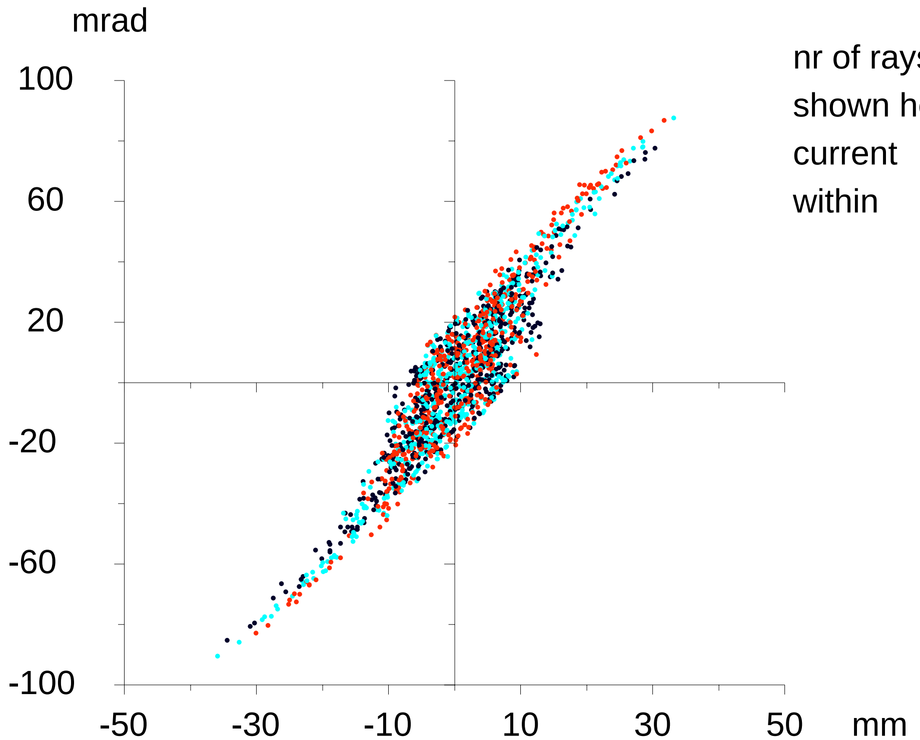
nr of rays	1652
shown here	1652
current	.0245 A
within	.0245 A

KOBRA3-INP y emittance at 1.760 m



nr of rays	1652
shown here	1652
current	.0245 A
within	.0245 A

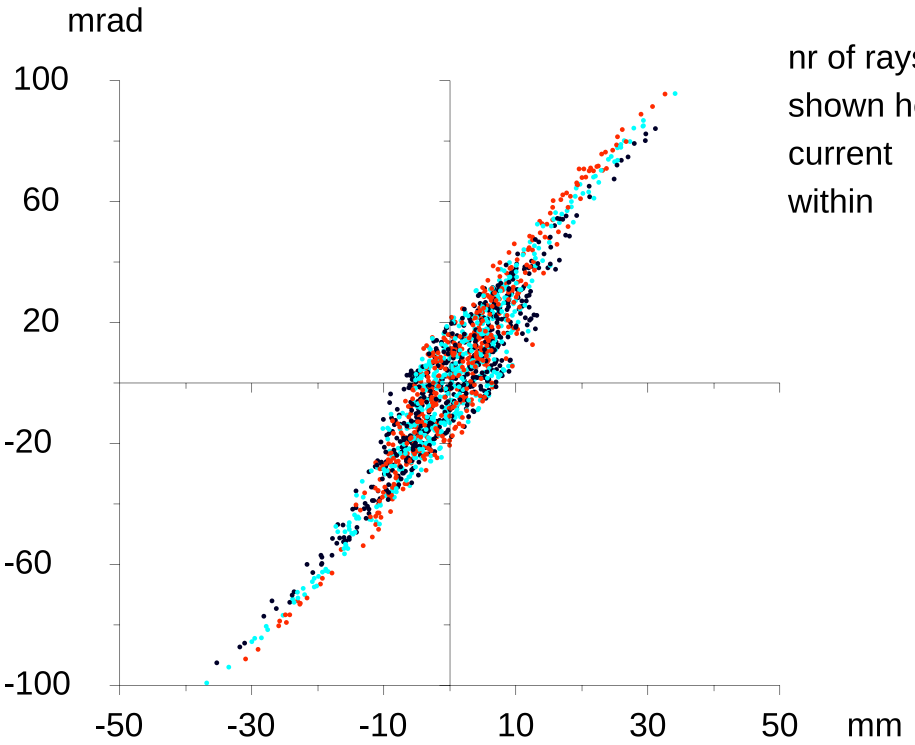
KOBRA3-INP y emittance at 1.770 m



nr of rays	1652
shown here	1652
current	.0245 A
within	.0245 A

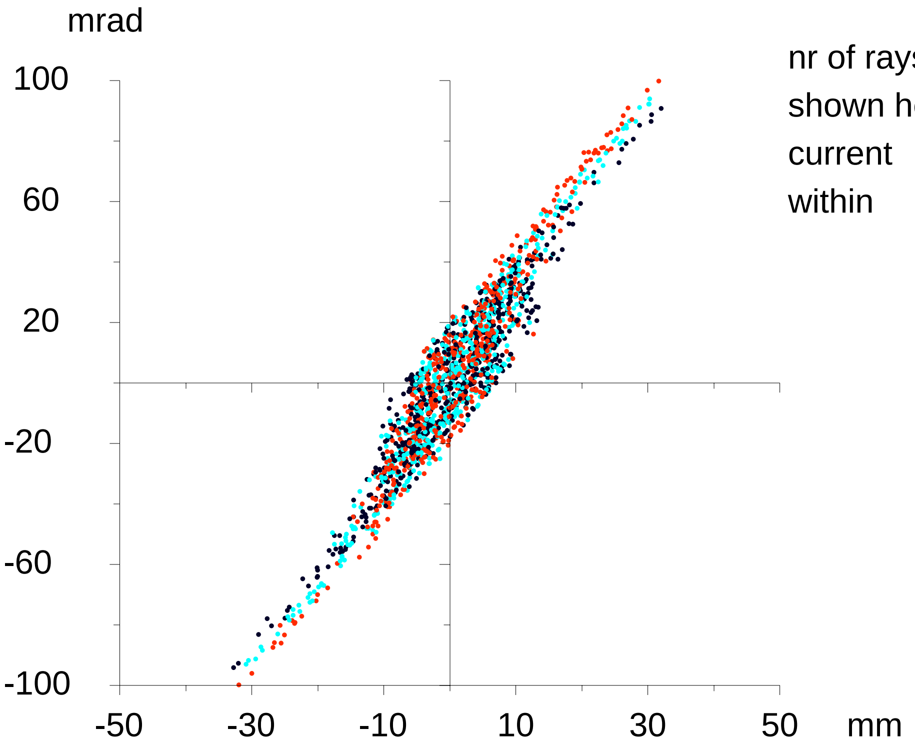
KOBRA3-INP

y emittance at 1.780 m



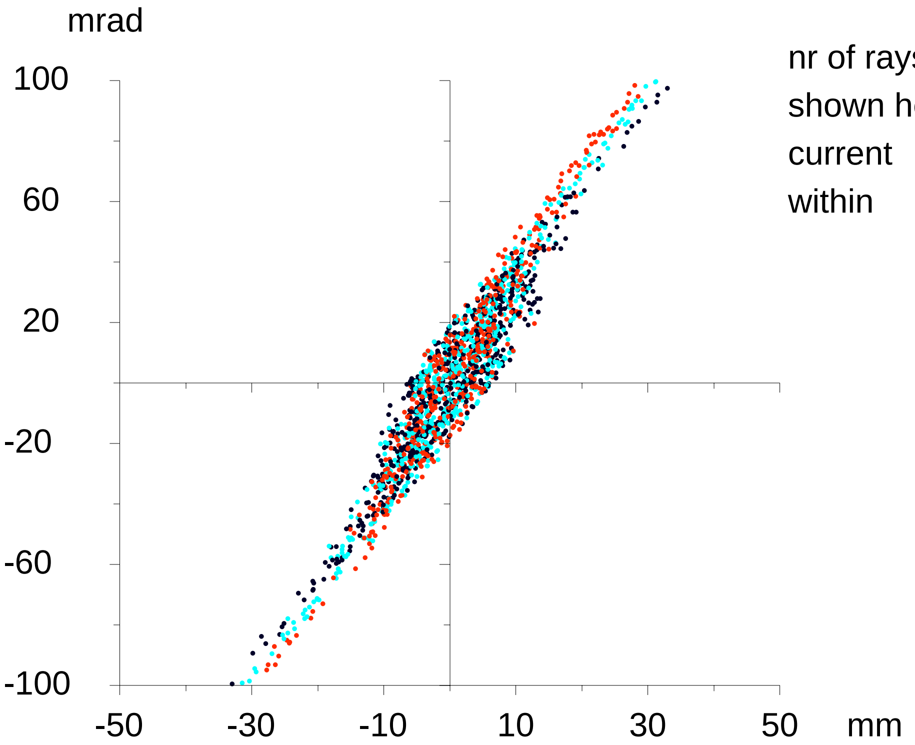
nr of rays 1652
shown here 1652
current .0245 A
within .0245 A

KOBRA3-INP y emittance at 1.790 m



nr of rays	1652
shown here	1647
current	.0245 A
within	.0244 A

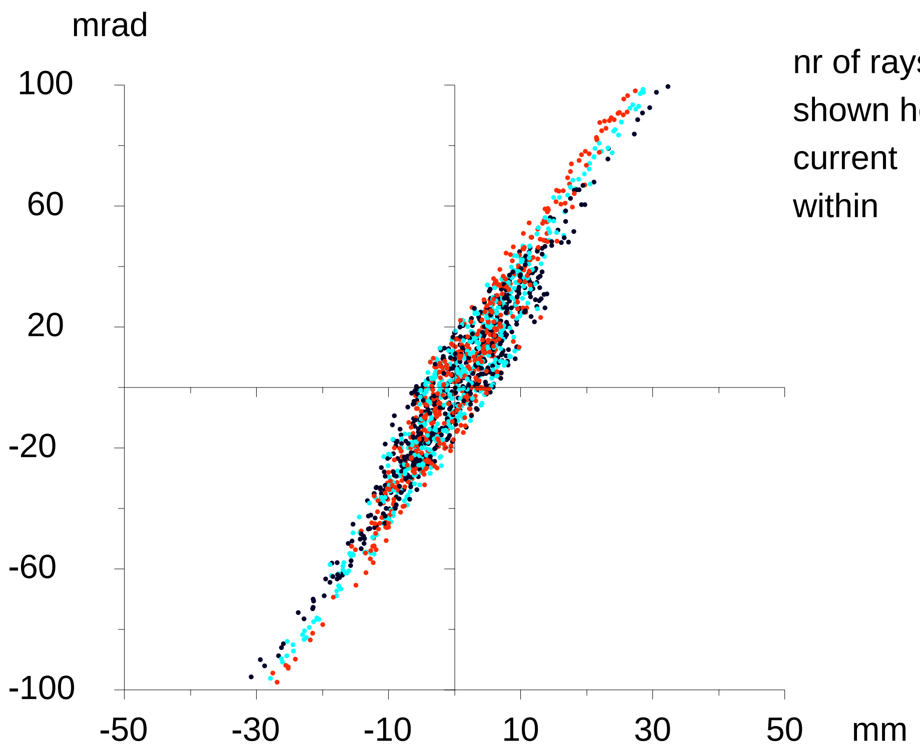
KOBRA3-INP y emittance at 1.800 m



nr of rays	1652
shown here	1640
current	.0245 A
within	.0243 A

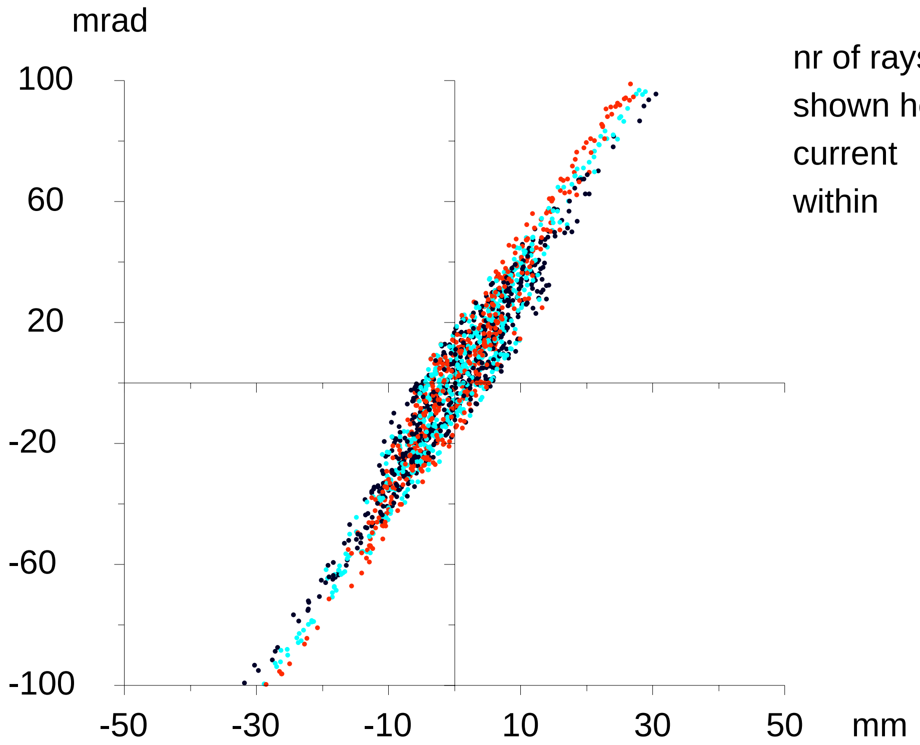
KOBRA3-INP

y emittance at 1.810 m



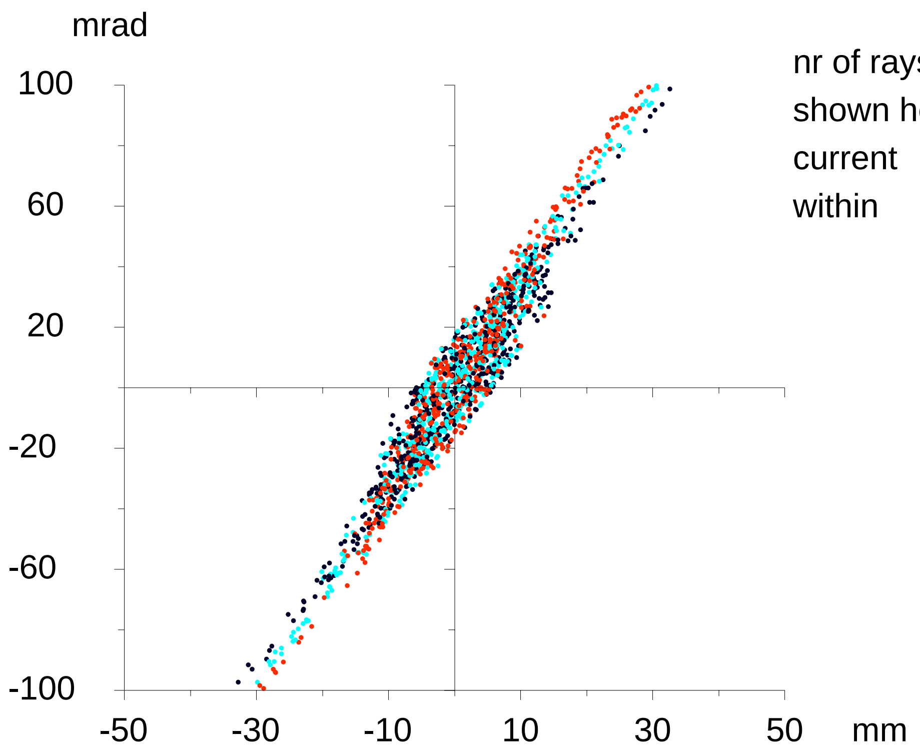
nr of rays	1652
shown here	1621
current	.0245 A
within	.0240 A

KOBRA3-INP y emittance at 1.820 m



nr of rays	1652
shown here	1612
current	.0245 A
within	.0238 A

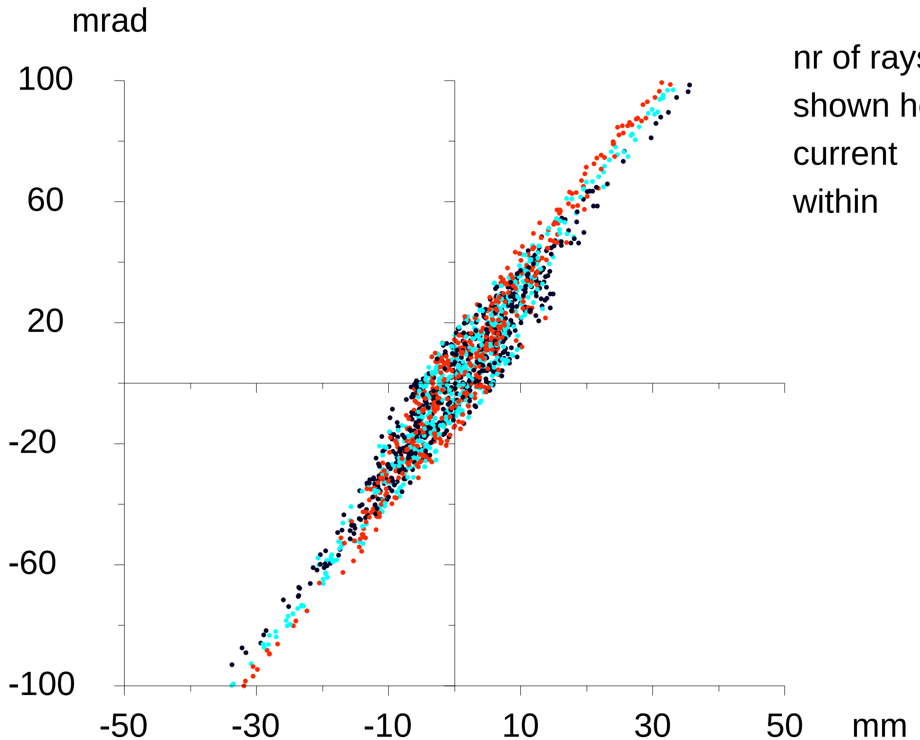
KOBRA3-INP y emittance at 1.830 m



nr of rays 1652
shown here 1620
current .0245 A
within .0240 A

KOBRA3-INP

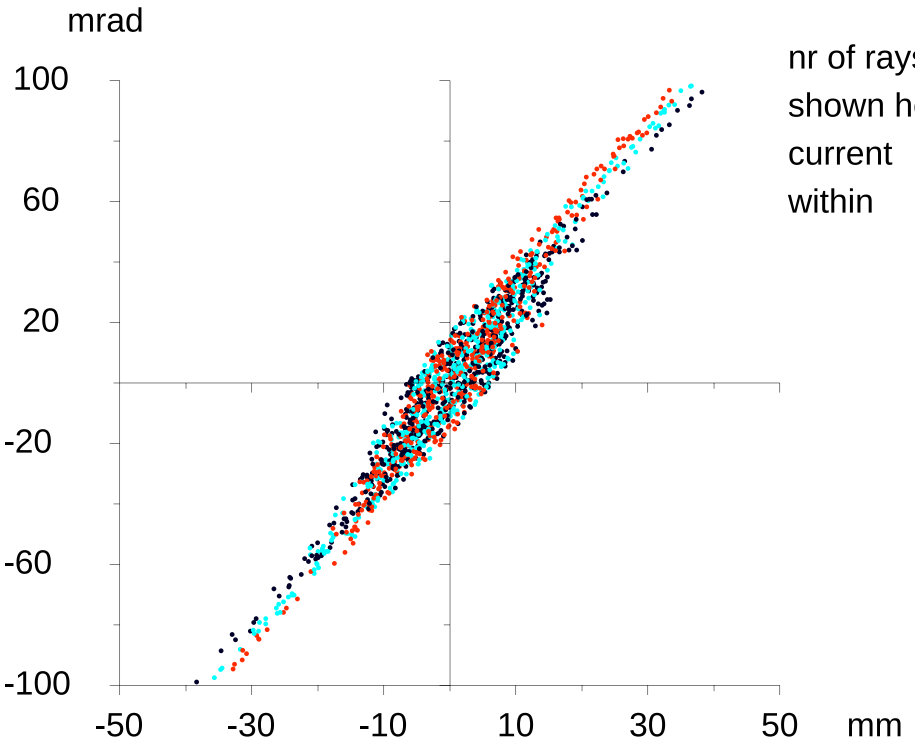
y emittance at 1.840 m



nr of rays	1652
shown here	1632
current	.0245 A
within	.0242 A

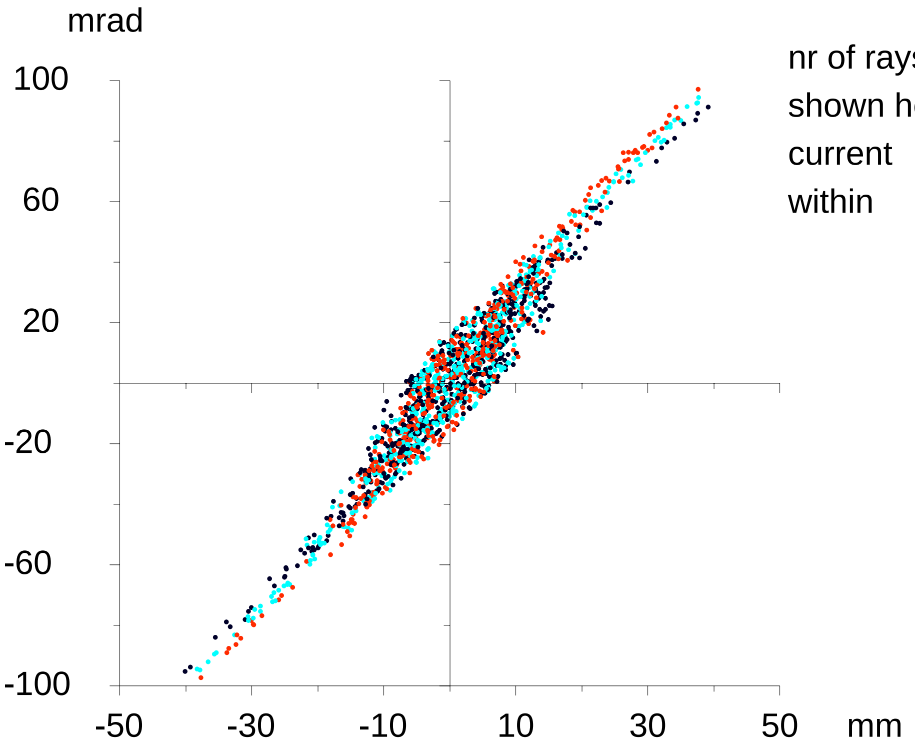
KOBRA3-INP

y emittance at 1.850 m



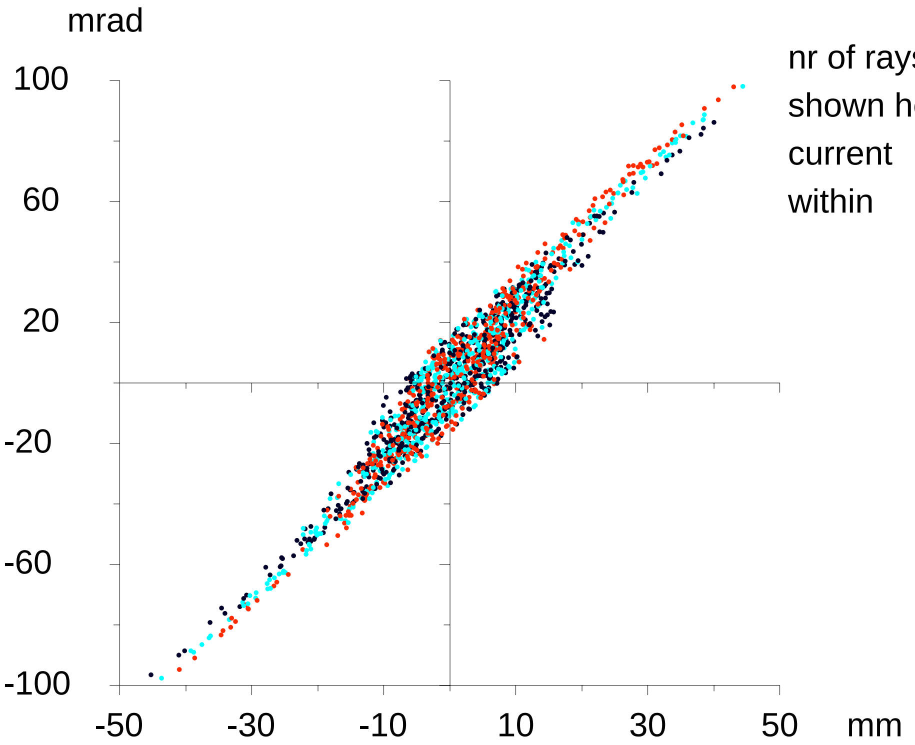
nr of rays	1652
shown here	1639
current	.0245 A
within	.0243 A

KOBRA3-INP y emittance at 1.860 m



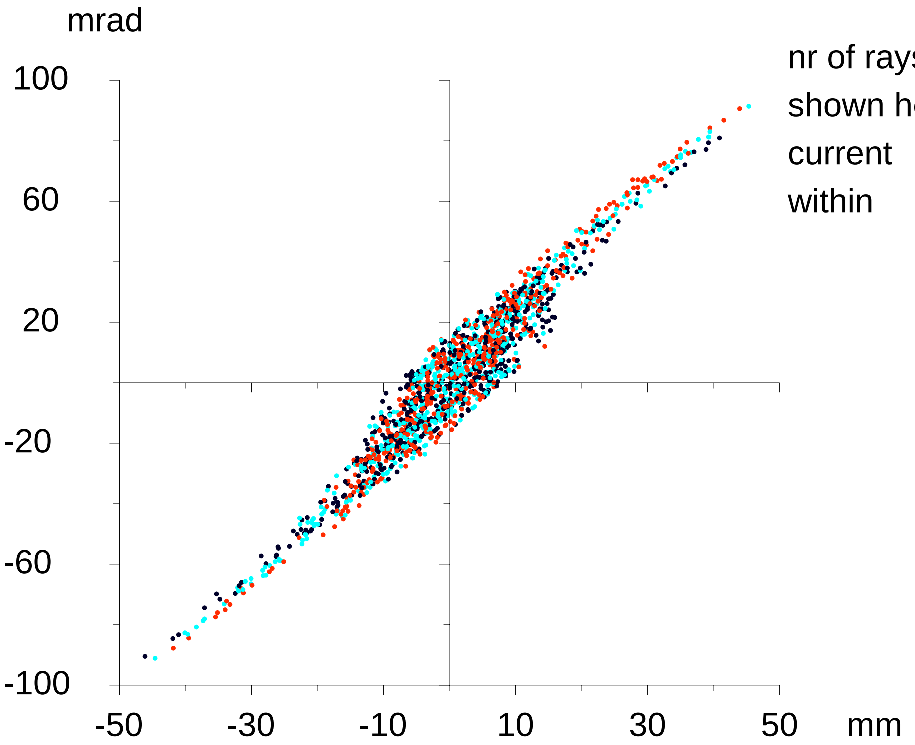
nr of rays	1652
shown here	1645
current	.0245 A
within	.0244 A

KOBRA3-INP y emittance at 1.870 m



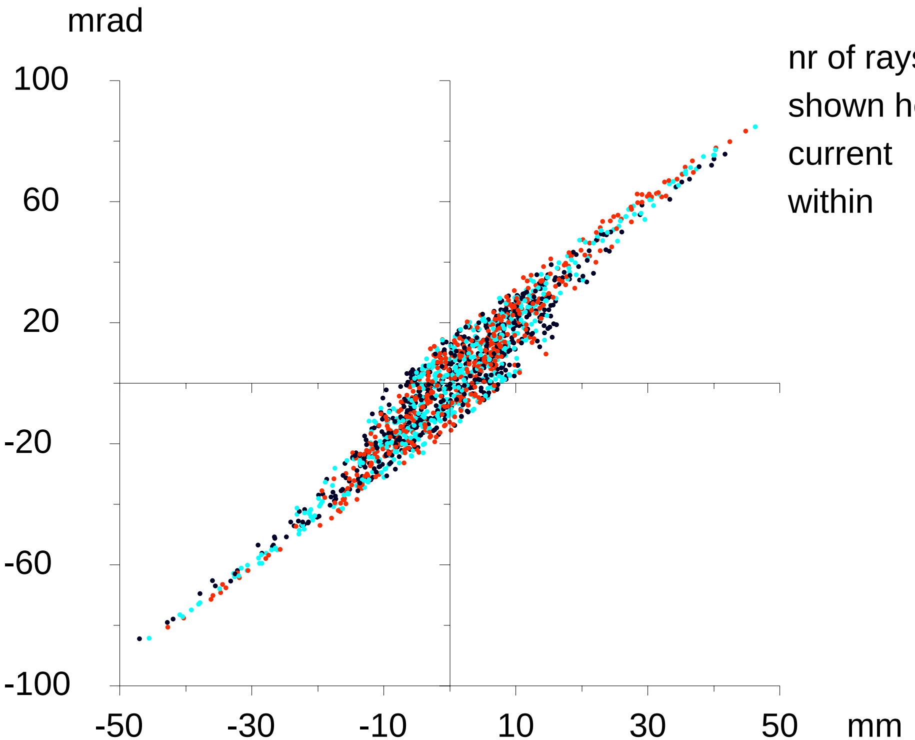
nr of rays	1652
shown here	1651
current	.0245 A
within	.0245 A

KOBRA3-INP y emittance at 1.880 m



nr of rays 1651
shown here 1651
current .0245 A
within .0245 A

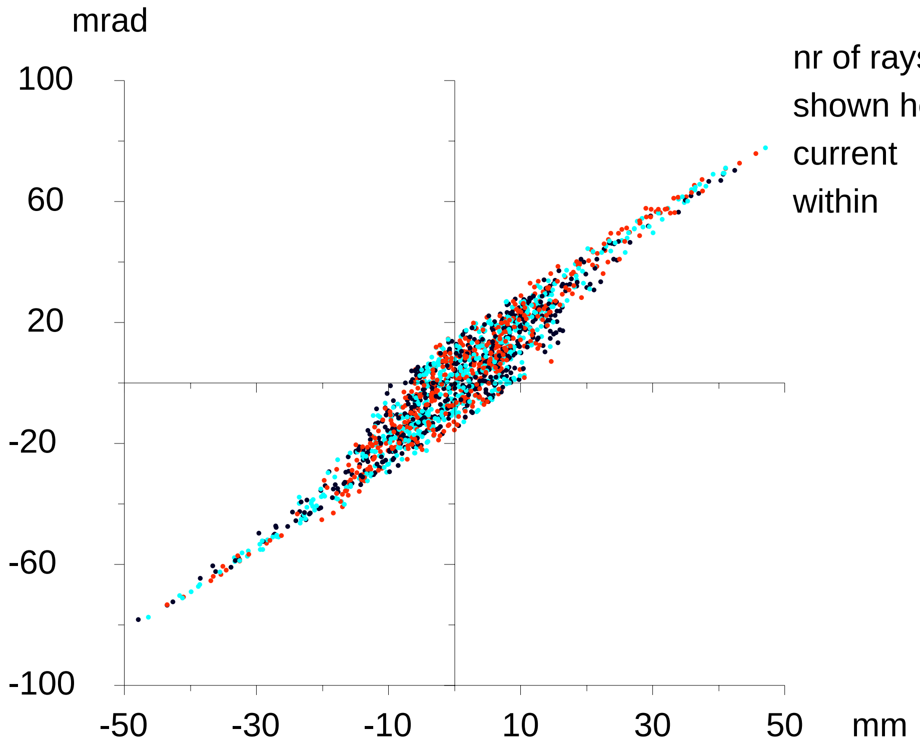
KOBRA3-INP y emittance at 1.890 m



nr of rays 1651
shown here 1651
current .0245 A
within .0245 A

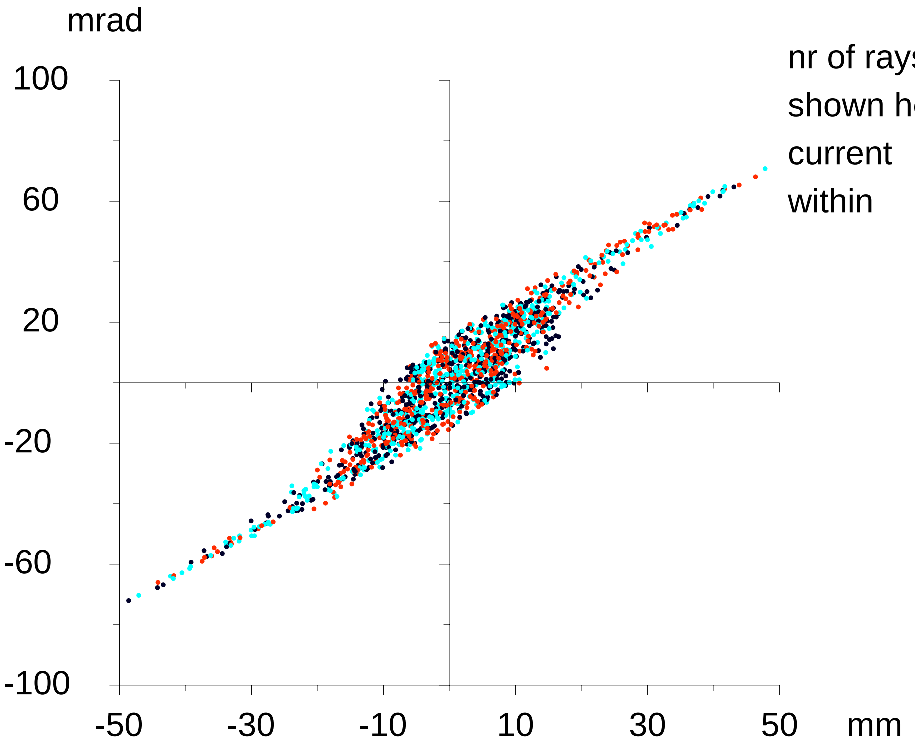
KOBRA3-INP

y emittance at 1.900 m



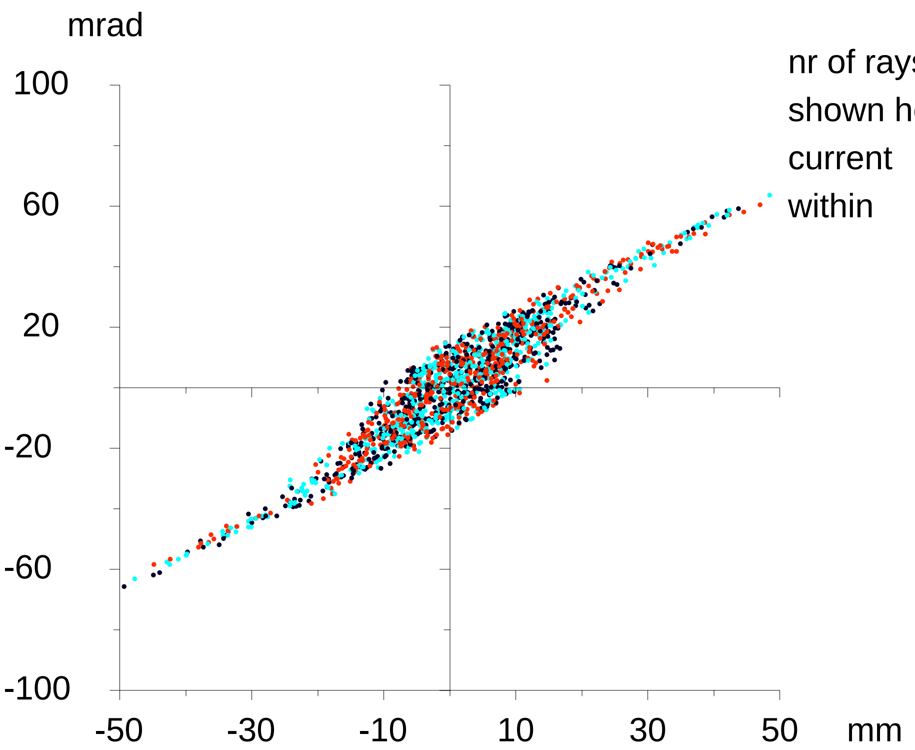
nr of rays	1651
shown here	1651
current	.0245 A
within	.0245 A

KOBRA3-INP y emittance at 1.910 m



nr of rays	1651
shown here	1651
current	.0245 A
within	.0245 A

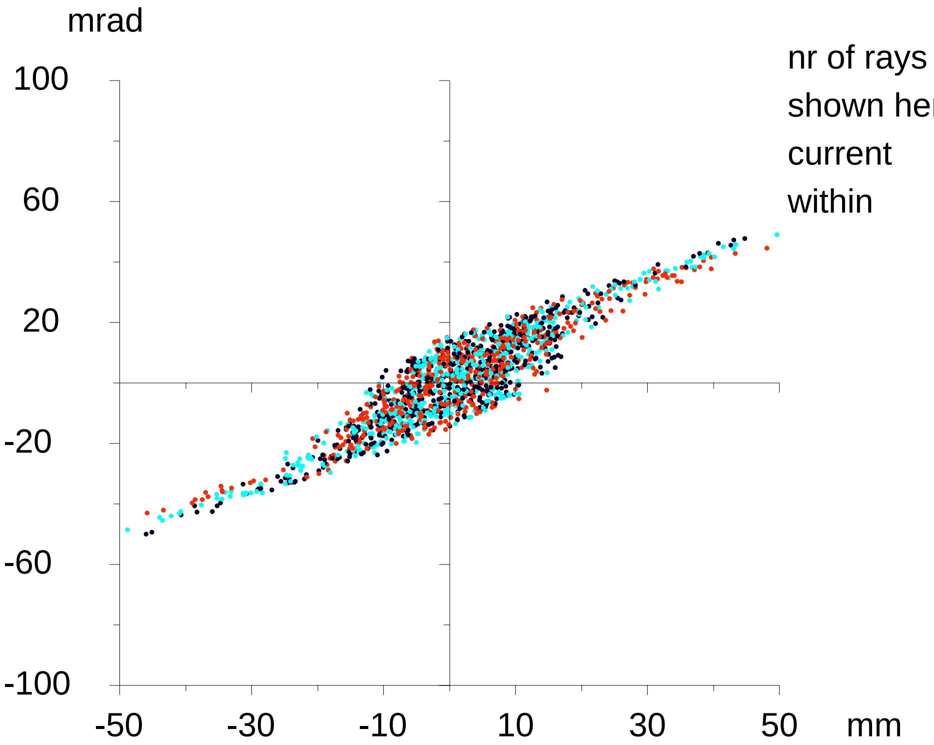
KOBRA3-INP y emittance at 1.920 m



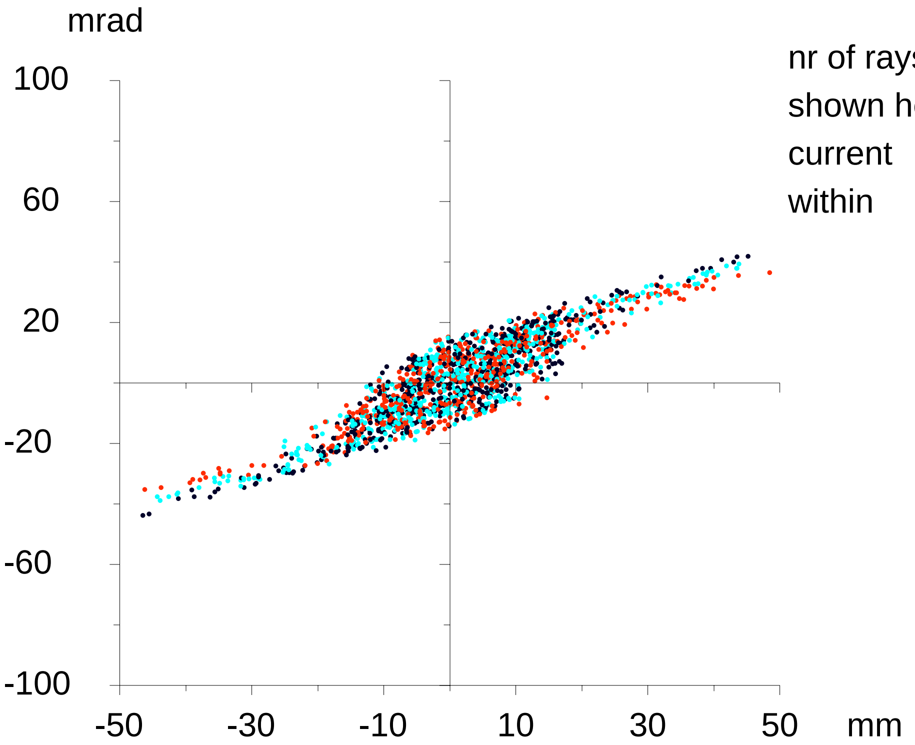
nr of rays 1651
shown here 1651
current .0245 A
within .0245 A

KOBRA3-INP y emittance at 1.940 m

nr of rays	1649
shown here	1649
current	.0245 A
within	.0245 A



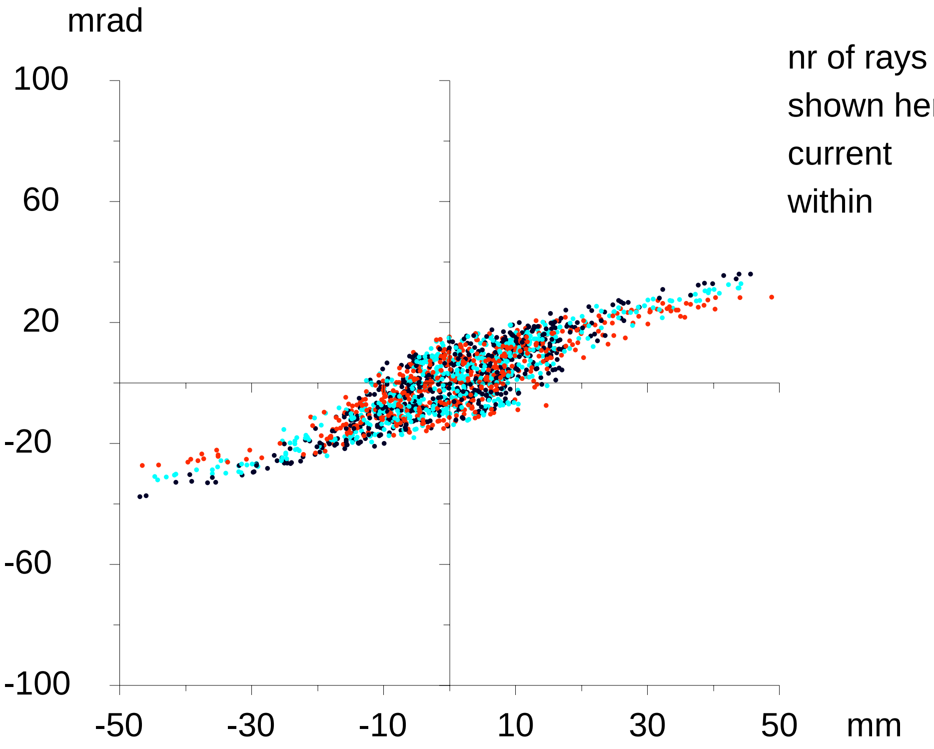
KOBRA3-INP y emittance at 1.950 m



nr of rays	1647
shown here	1647
current	.0244 A
within	.0244 A

KOBRA3-INP

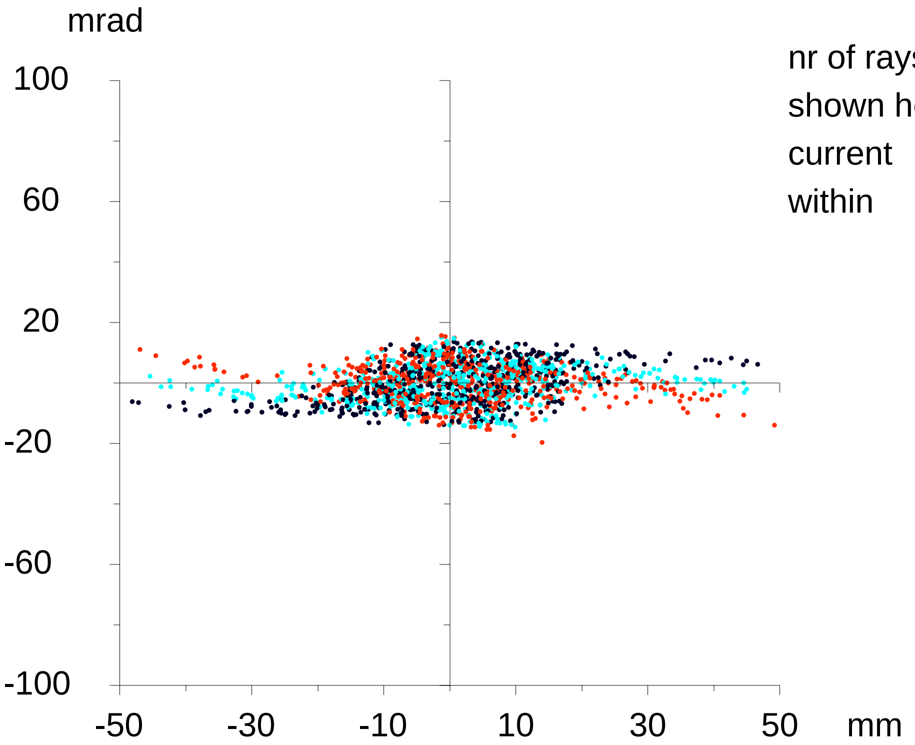
y emittance at 1.960 m



nr of rays	1647
shown here	1647
current	.0244 A
within	.0244 A

KOBRA3-INP

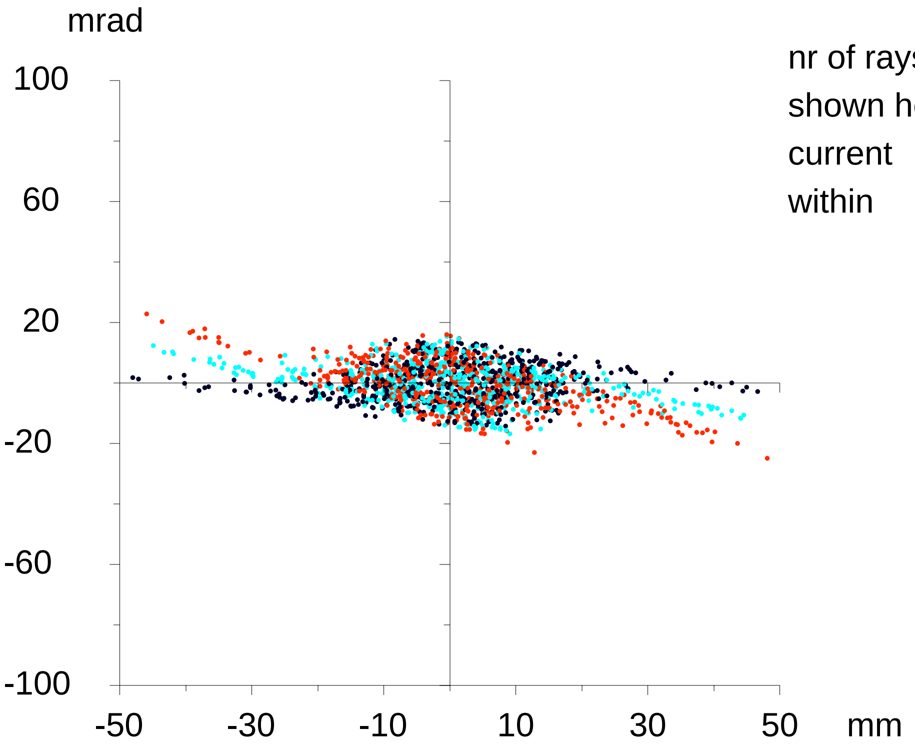
y emittance at 2.010 m



nr of rays	1646
shown here	1646
current	.0244 A
within	.0244 A

KOBRA3-INP

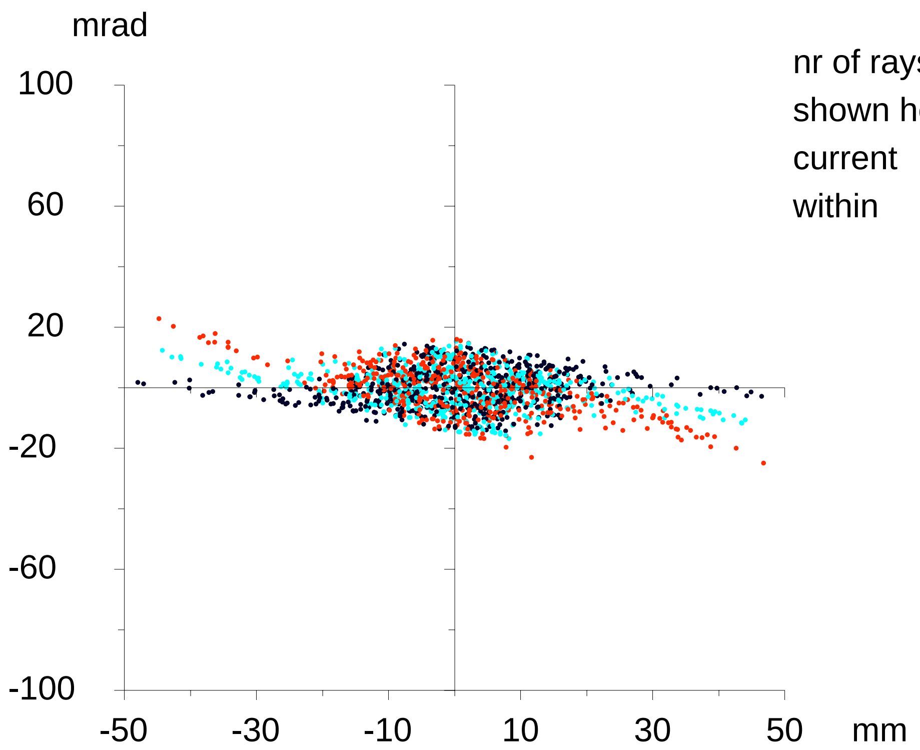
y emittance at 2.060 m



nr of rays	1646
shown here	1646
current	.0244 A
within	.0244 A

KOBRA3-INP

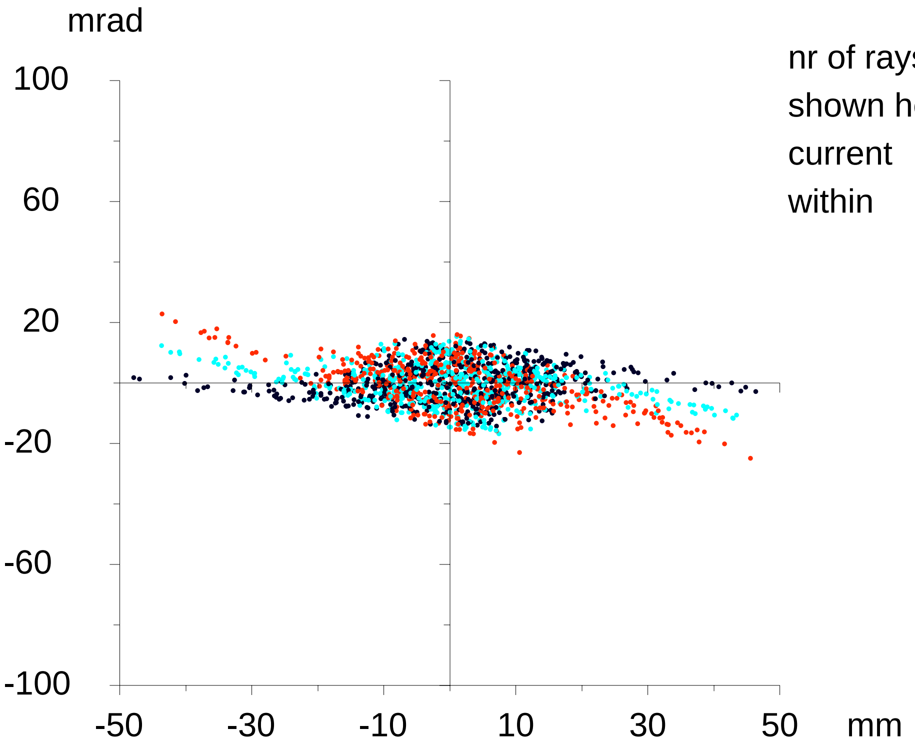
y emittance at 2.110 m



nr of rays	1646
shown here	1646
current	.0244 A
within	.0244 A

KOBRA3-INP

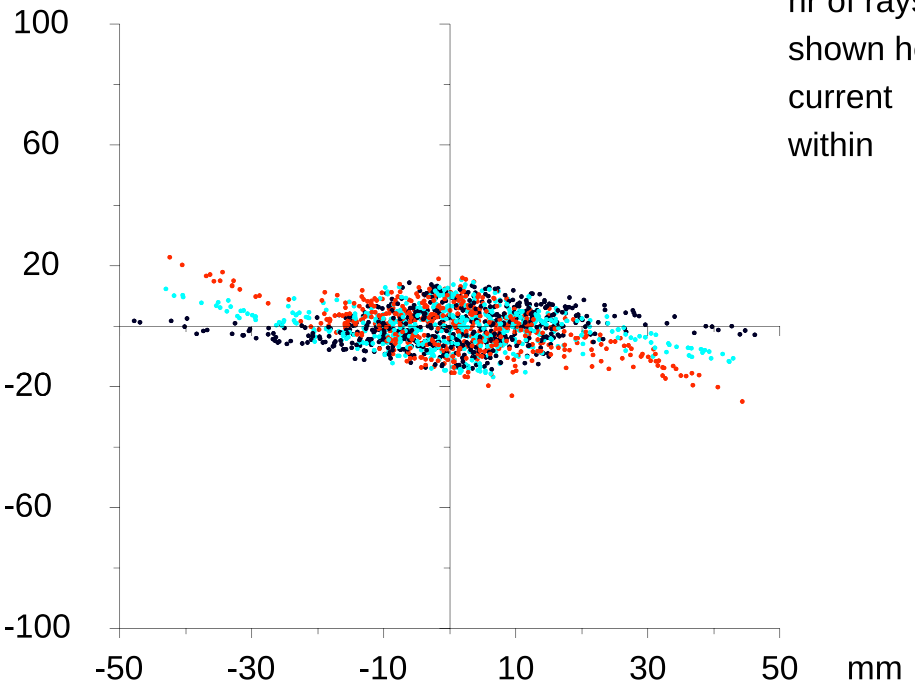
y emittance at 2.160 m



nr of rays	1646
shown here	1646
current	.0244 A
within	.0244 A

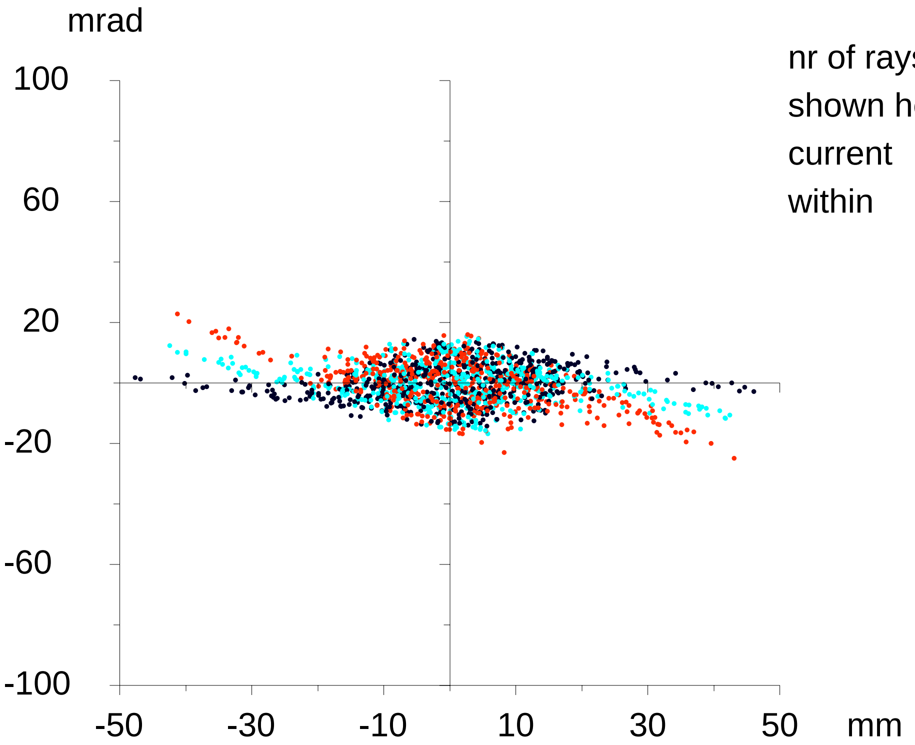
KOBRA3-INP

y emittance at 2.210 m



nr of rays	1646
shown here	1646
current	.0244 A
within	.0244 A

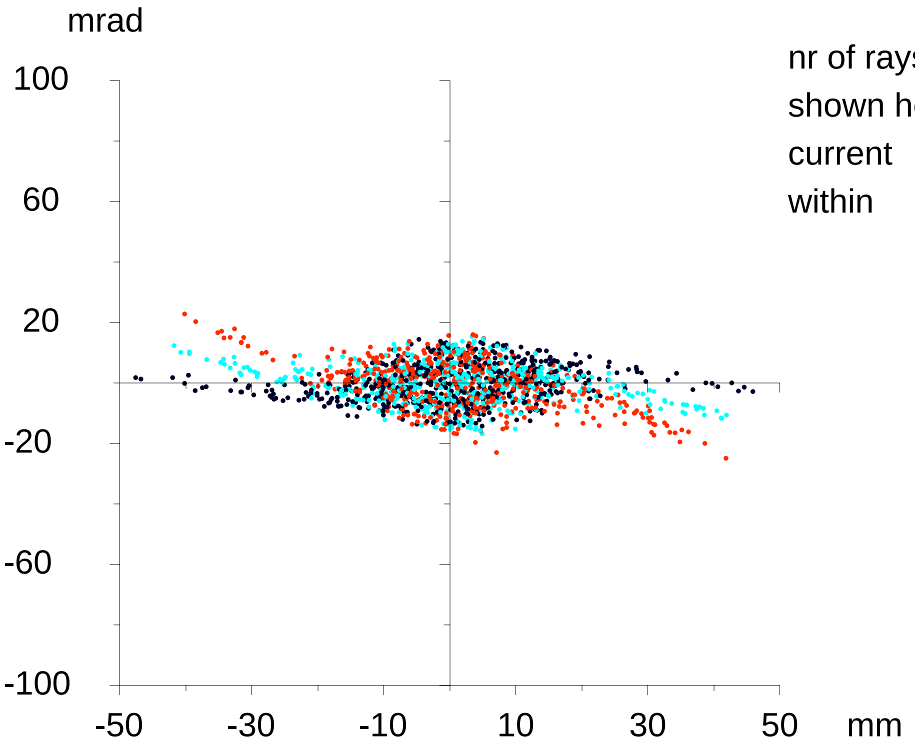
KOBRA3-INP y emittance at 2.260 m



nr of rays	1644
shown here	1644
current	.0244 A
within	.0244 A

KOBRA3-INP

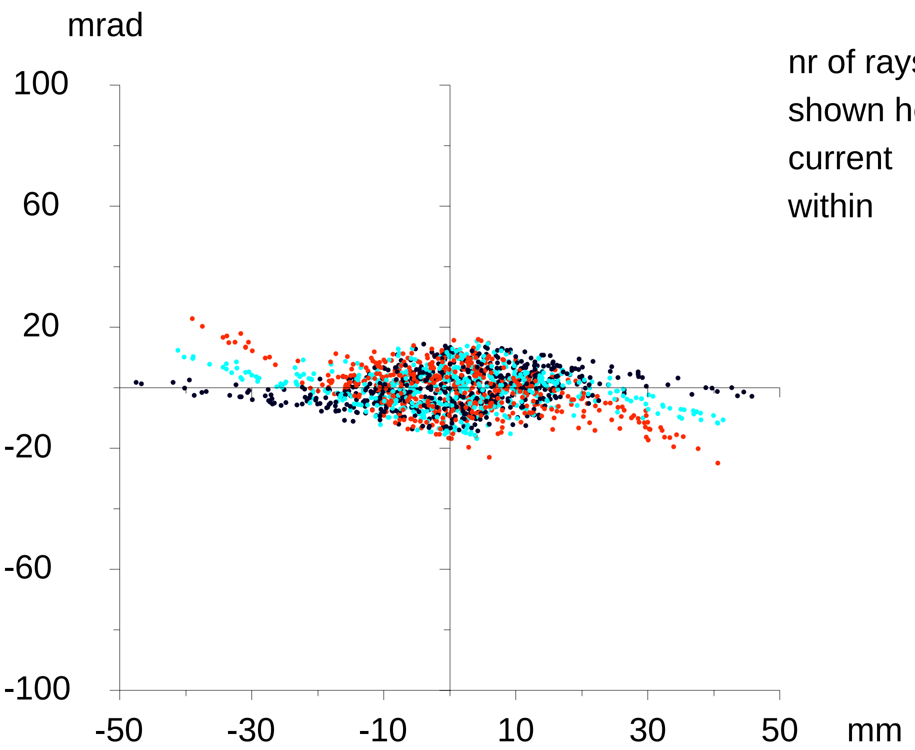
y emittance at 2.310 m



nr of rays	1643
shown here	1643
current	.0244 A
within	.0244 A

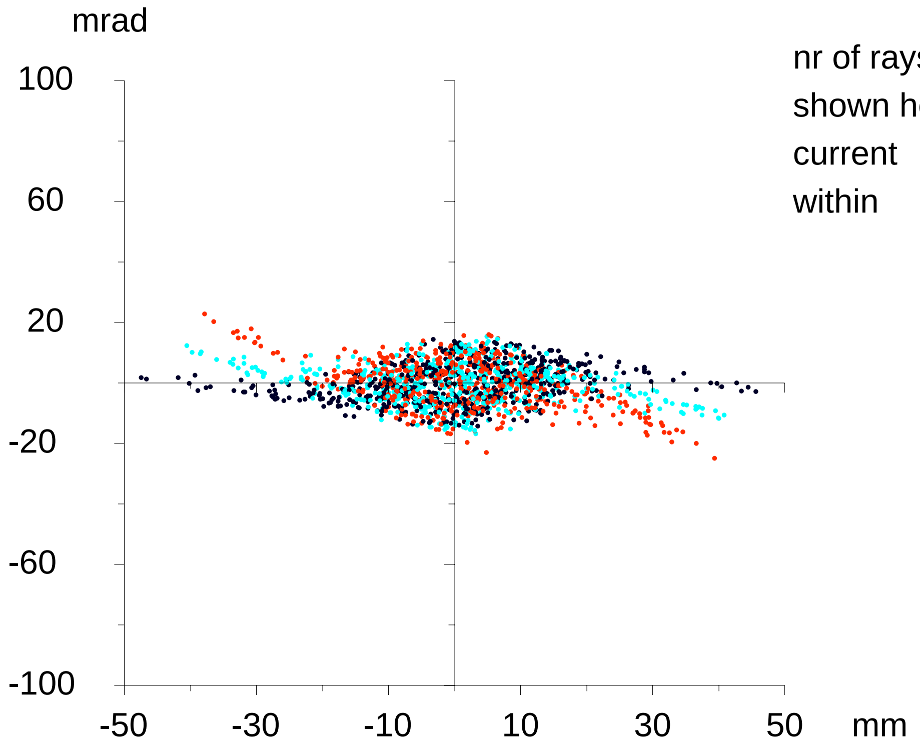
KOBRA3-INP

y emittance at 2.360 m



nr of rays	1641
shown here	1641
current	.0244 A
within	.0244 A

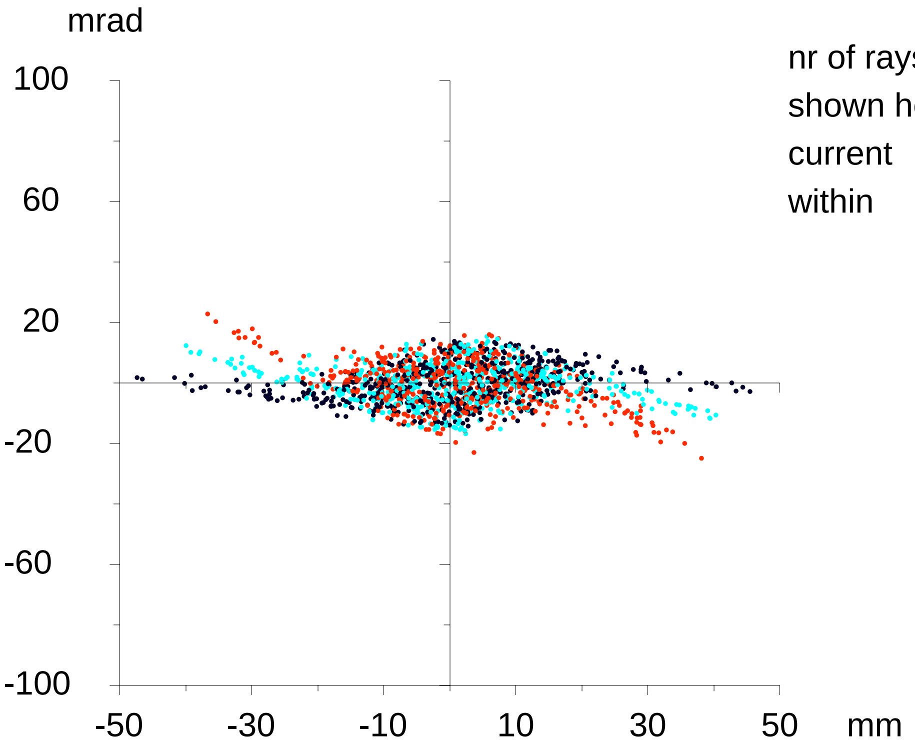
KOBRA3-INP y emittance at 2.410 m



nr of rays	1638
shown here	1638
current	.0243 A
within	.0243 A

KOBRA3-INP

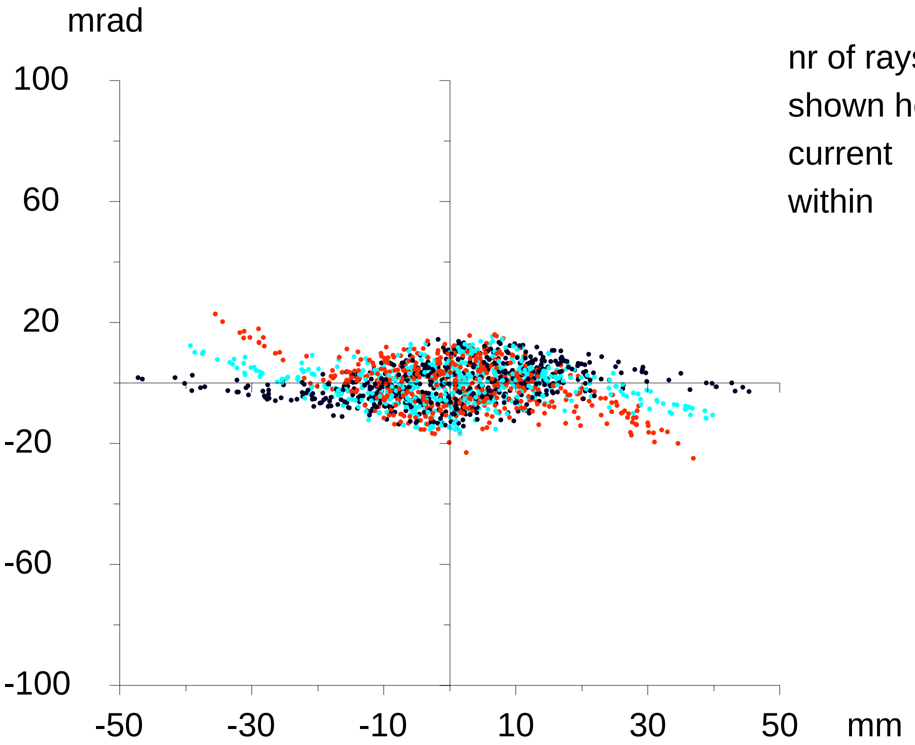
y emittance at 2.460 m



nr of rays	1638
shown here	1638
current	.0243 A
within	.0243 A

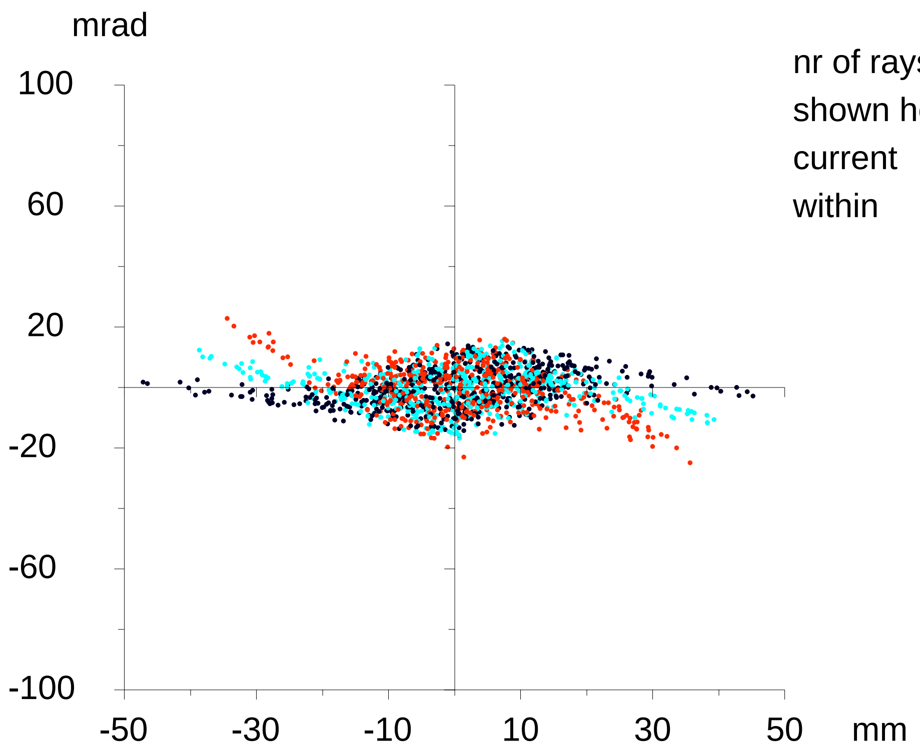
KOBRA3-INP

y emittance at 2.510 m



nr of rays 1636
shown here 1636
current .0243 A
within .0243 A

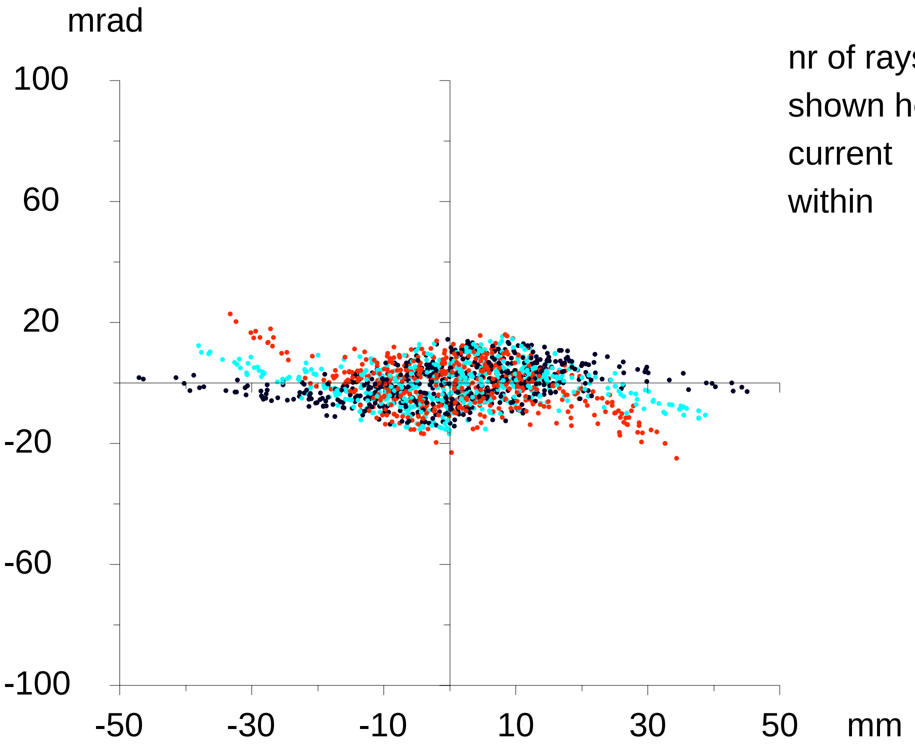
KOBRA3-INP y emittance at 2.560 m



nr of rays	1634
shown here	1634
current	.0243 A
within	.0243 A

KOBRA3-INP

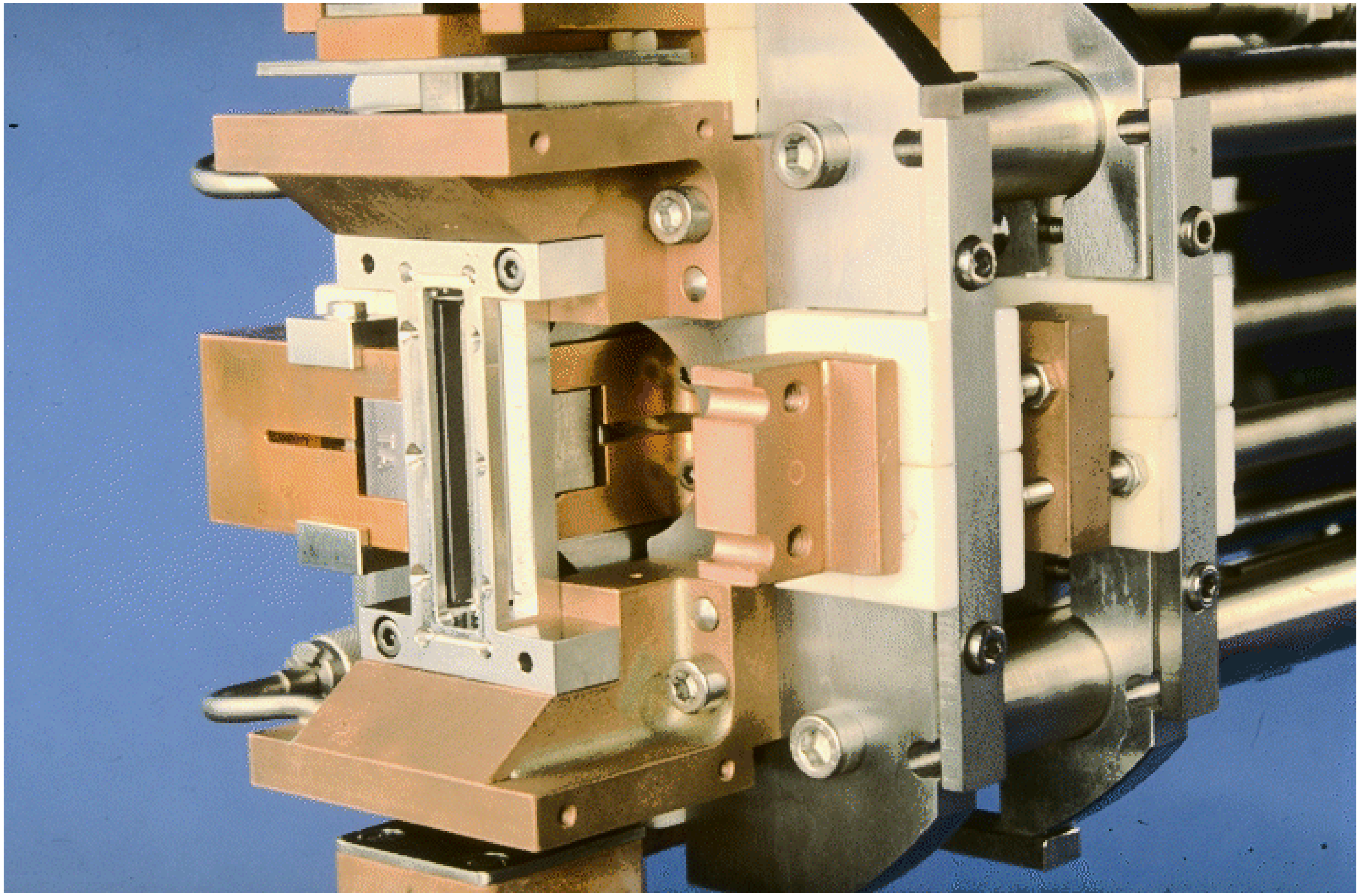
y emittance at 2.610 m



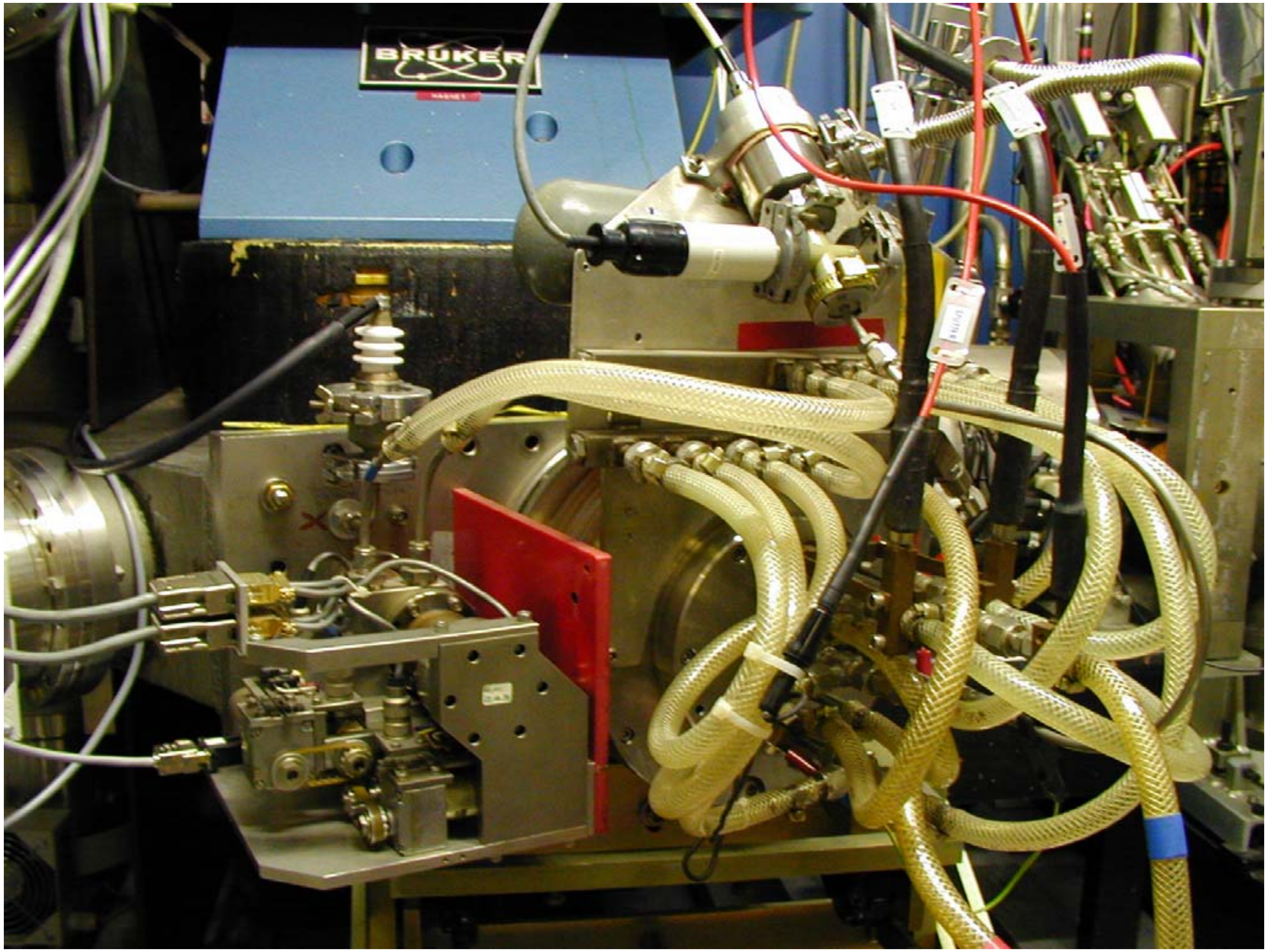
nr of rays	1634
shown here	1634
current	.0243 A
within	.0243 A

- Simulation confirms the experimental data:
- Strong influence of space charge within the extraction system and strong influence of space charge in the acceleration column.
- No influence of space charge has been observed in the drift sections and within the magnetic lenses.

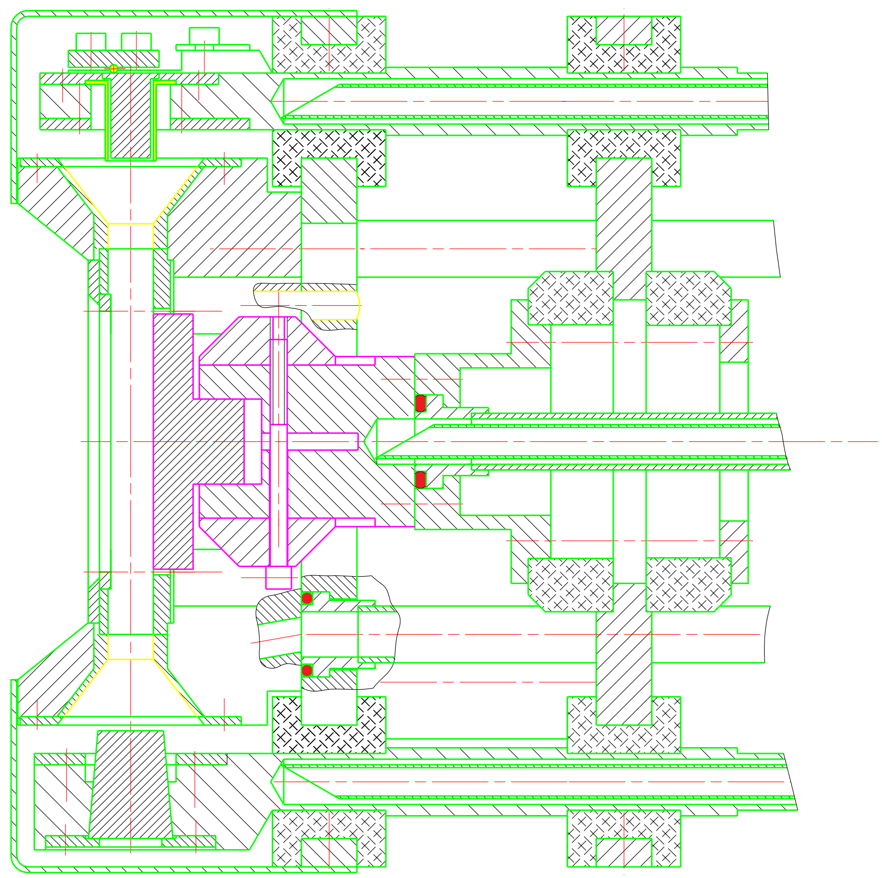
Penning Ionization Gauge PIG



Penning Ionization Gauge PIG



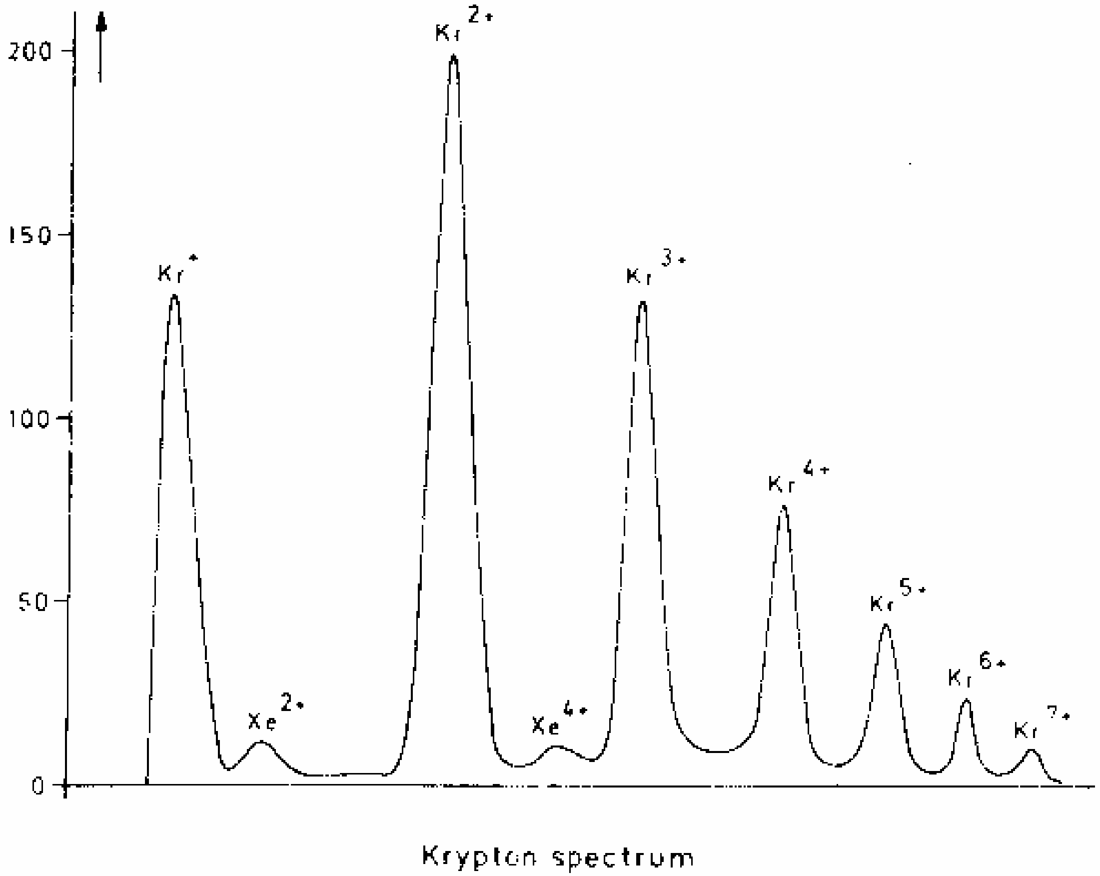
Penning Ionization Gauge PIG



FRAME 1 APRIL 4, 2002 09.44.37

neymach

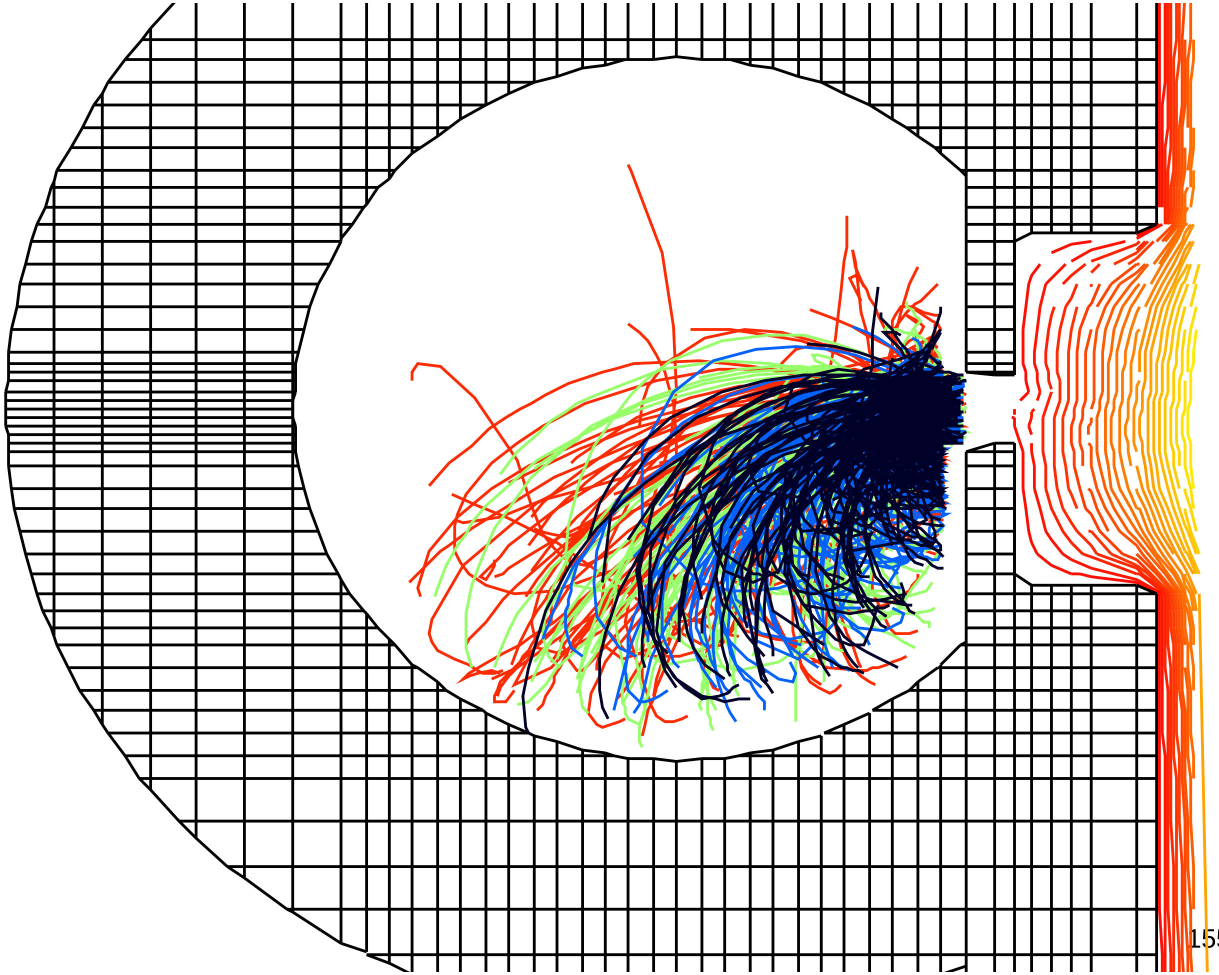
Penning Ionization Gauge PIG



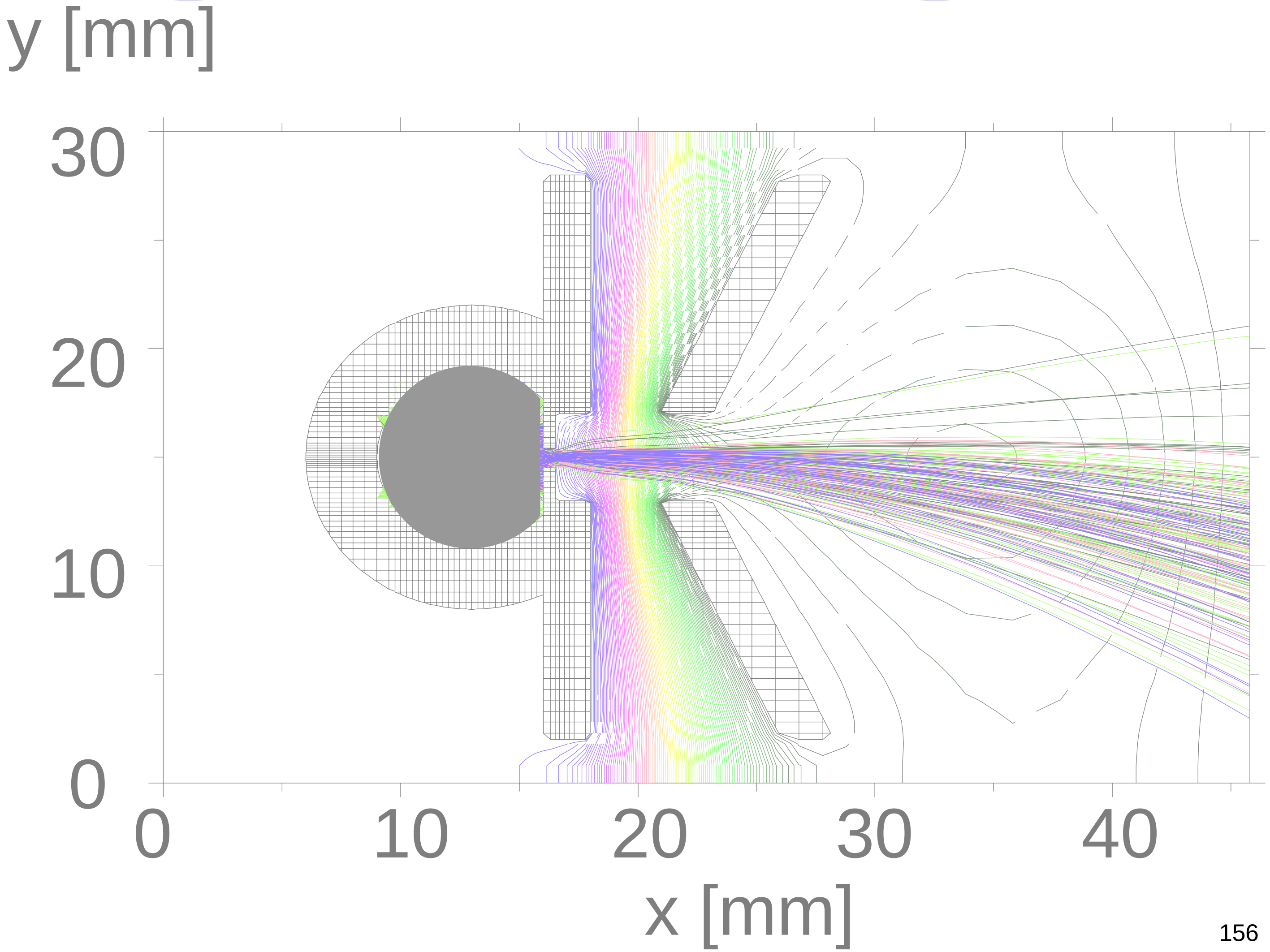
mA/cm^2.

le or able

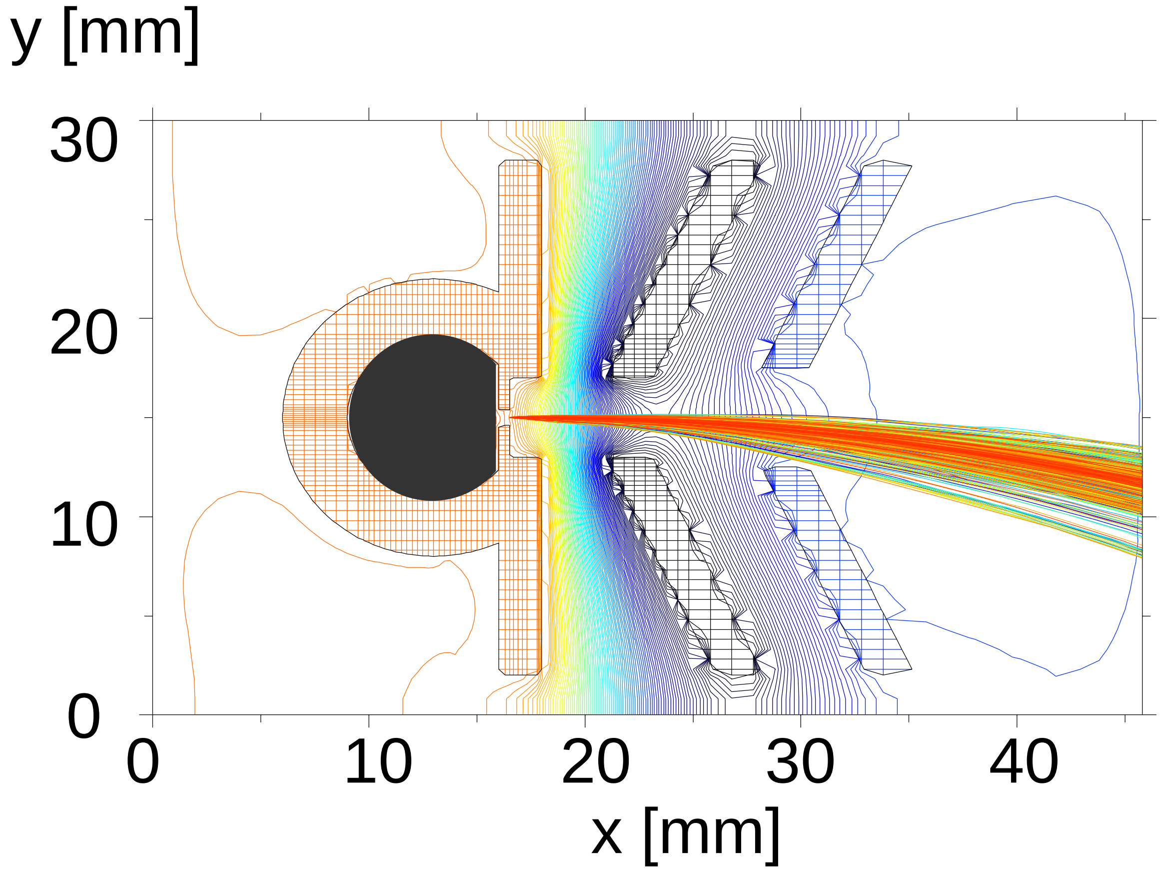
Penning Ionization Gauge PIG



Penning Ionization Gauge PIG

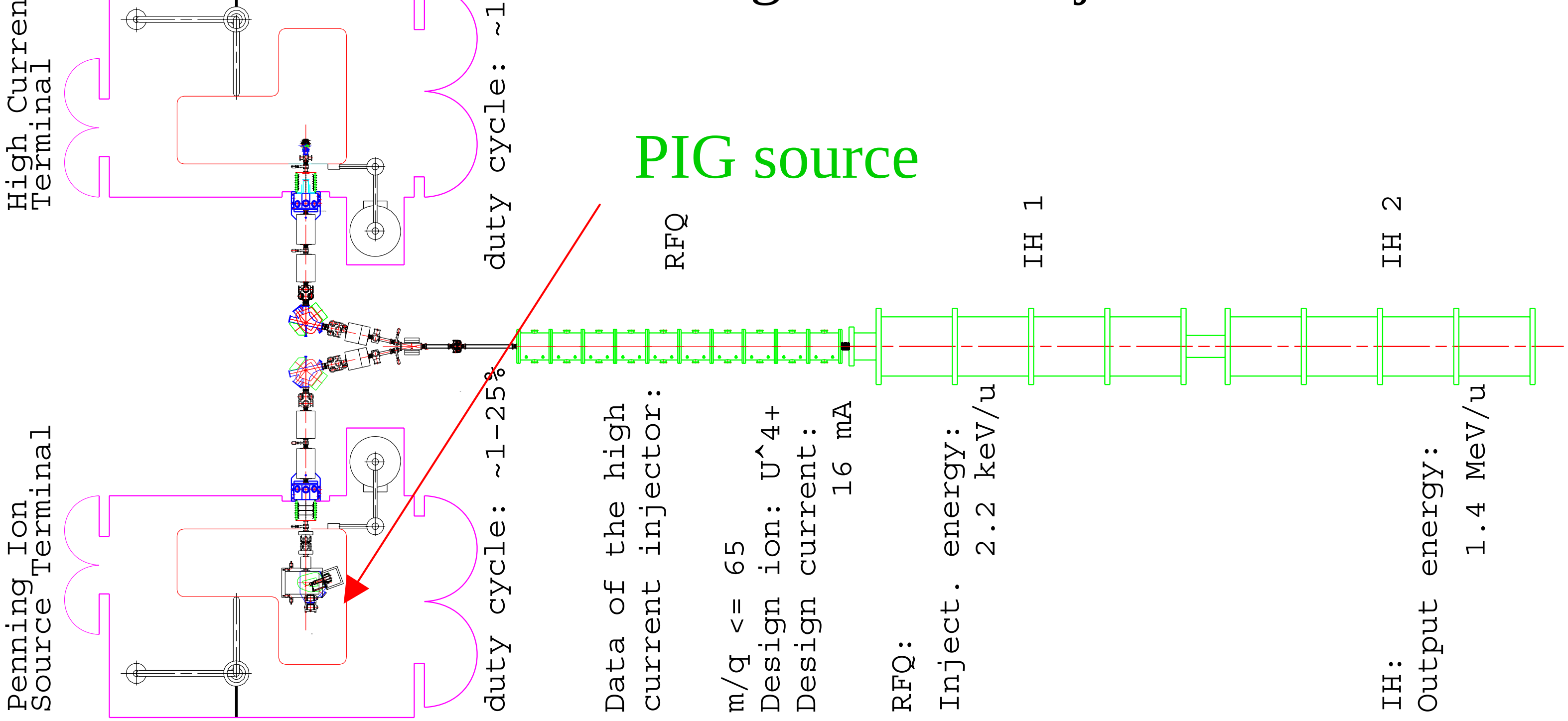


Penning Ionization Gauge PIG

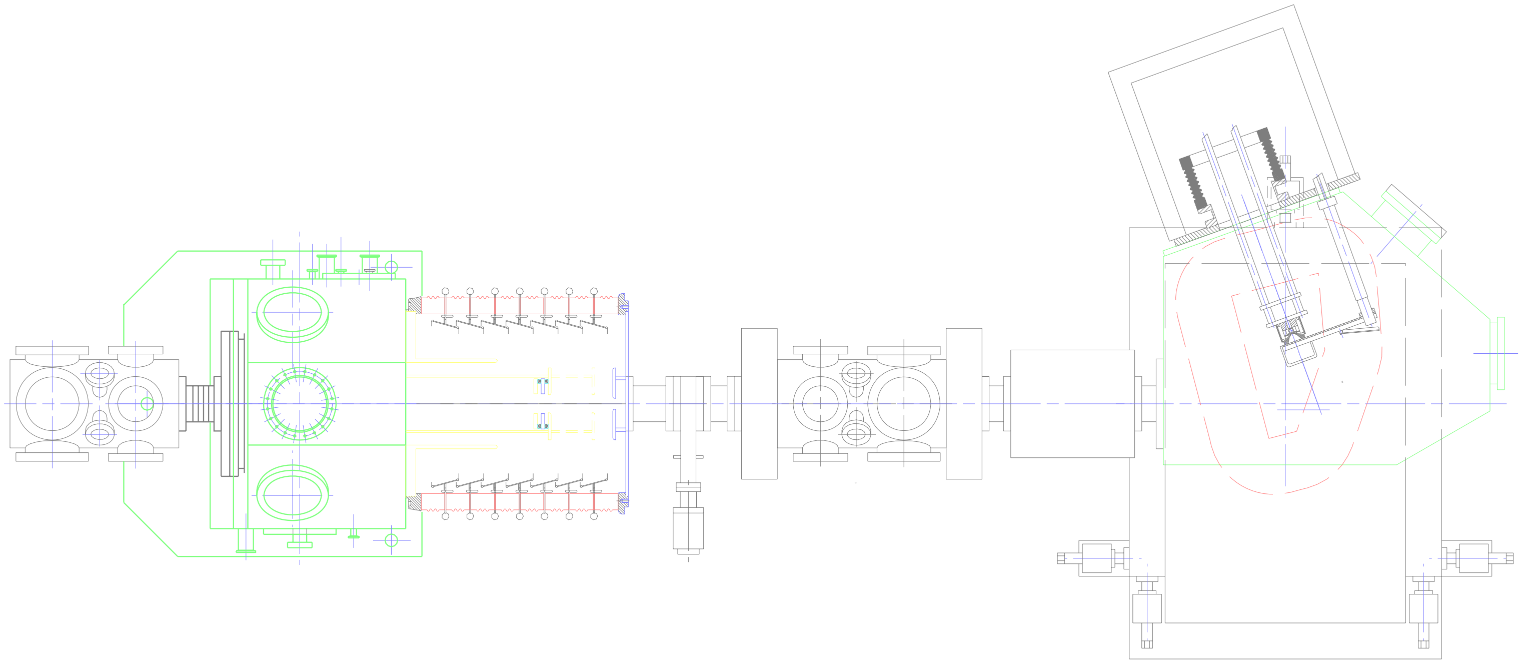


BEAM FORMATION

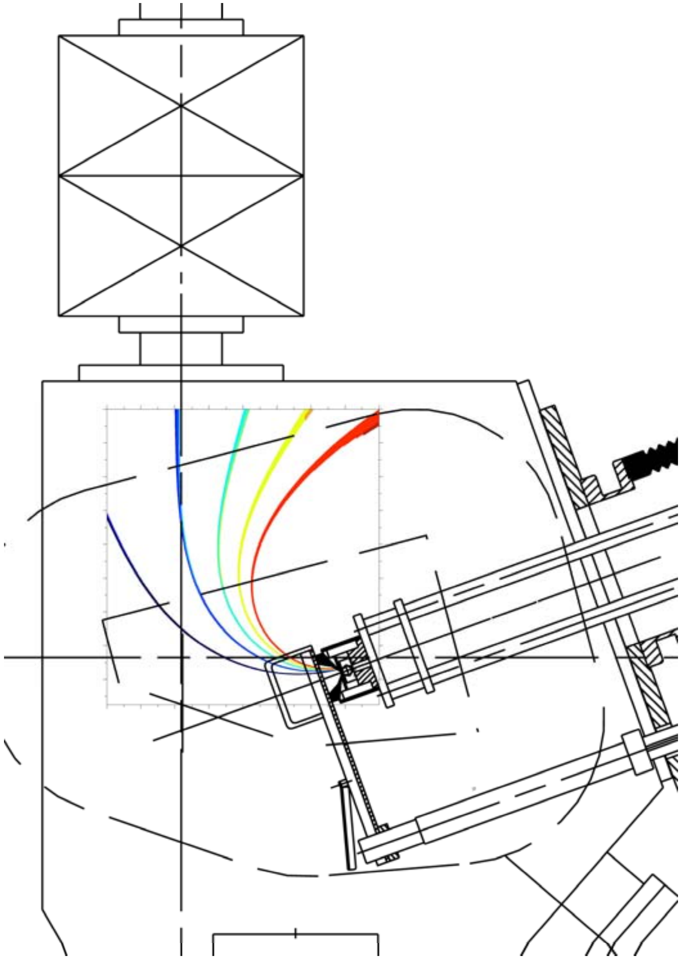
HSI high current injector at GSI



Penning Ionization Gauge PIG



Penning Ionization Gauge PIG



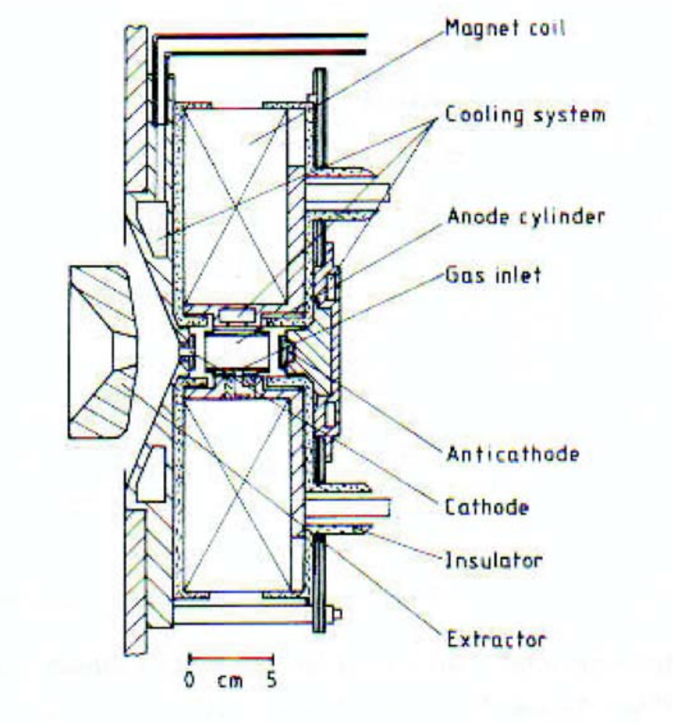
BEAM FORMATION

achieved ion currents from the PIG IS at the entrance of the RFQ with 2.2 keV/u

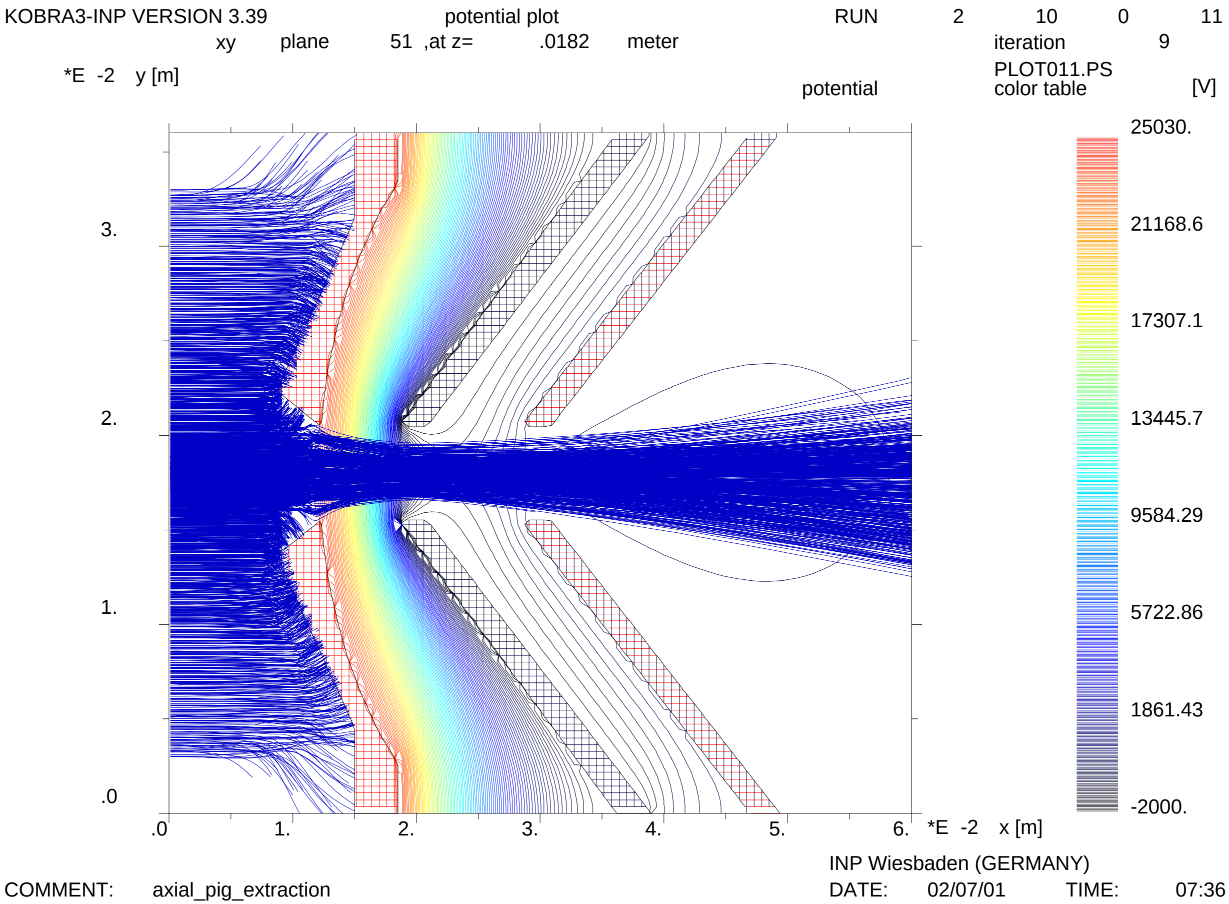
$^{12}C^{+}$	500	...	680	μA
$^{16}O^{+}$	700	...	890	μA
$^{18}O^{3+}$	1000	...	1100	μA
$^{20}Ne^{+}$	1000	...	4000	μA
$^{40}Ar^{2+}$	700	...	820	μA
$^{40}Ca^{3+}$	400	...	570	μA
$^{50}Ti^{2+}$	50	...	81	μA
$^{52}Cr^{3+}$	30	...	42	μA
$^{56}Fe^{4+}$	60	...	72	μA

$^{58}Ni^{3+}$	400	...	450	μA
$^{121}Sb^{7+}$	10	...	12	μA
$^{162}Dy^{7+}$	3	...	5	μA
$^{187}Re^{8+}$	100	...	165	μA
$^{197}Au^{8+}$	300	...	410	μA
$^{207}Pb^{9+}$	100	...	150	μA
$^{209}Bi^{9+}$	200	...	240	μA
$^{238}U^{10+}$	350	...	400	μA

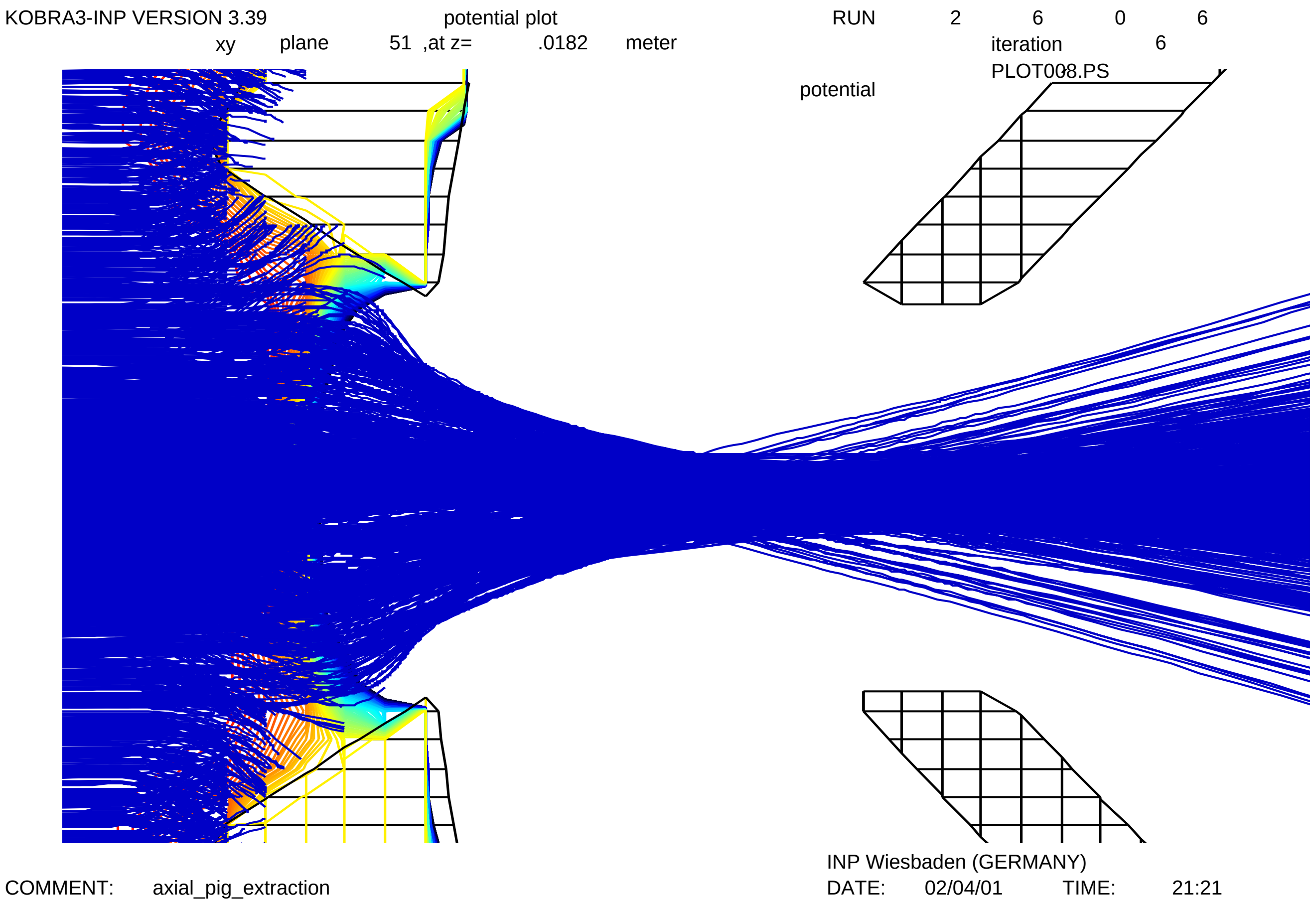
Penning Ionization Gauge PIG



Penning Ionization Gauge PIG



Penning Ionization Gauge PIG



Ion generators to come

- general
- mucis ion source
- mevva ion source

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