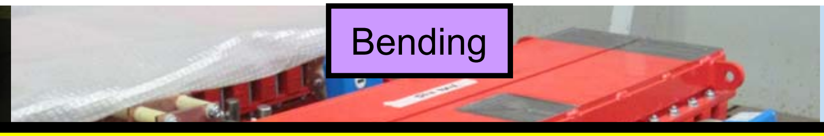

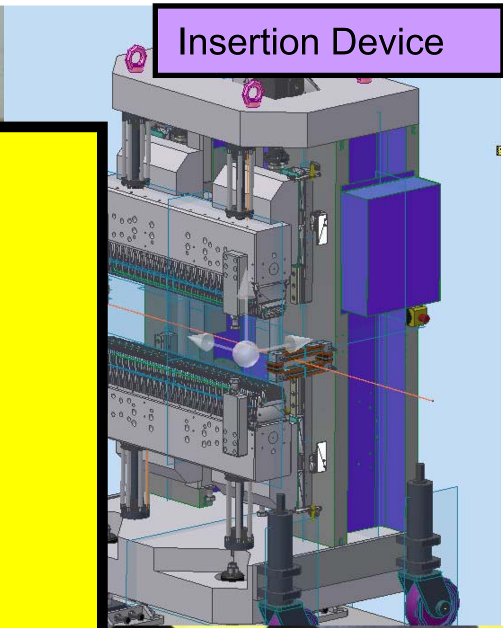

Specifications
Quality Control
Manufacturing
Testing
(Part I)

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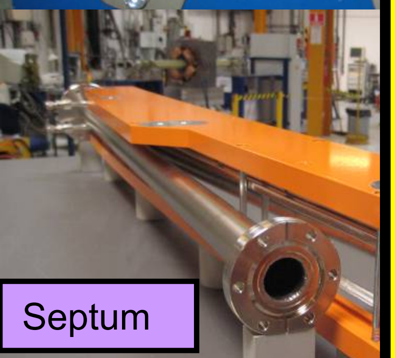
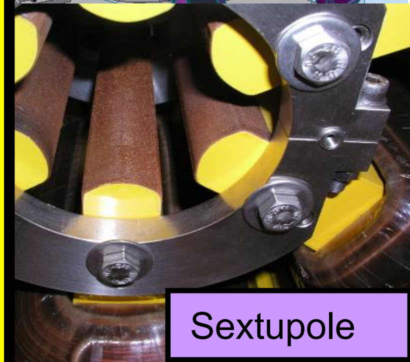
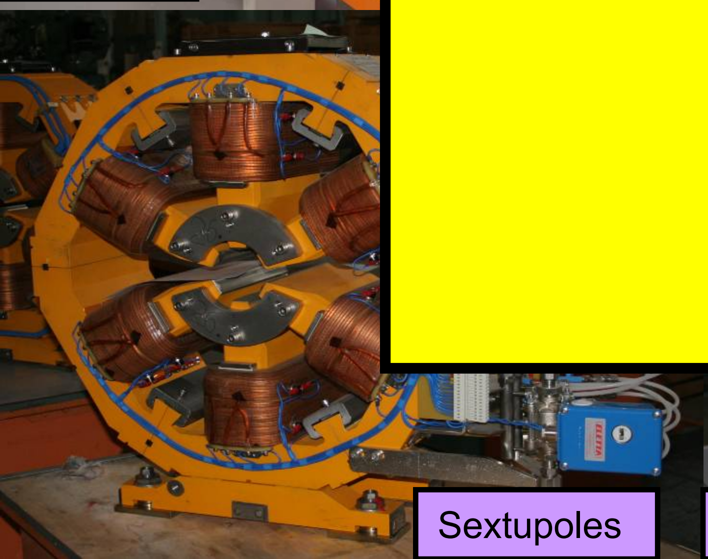
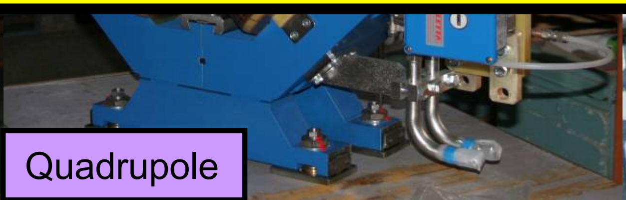
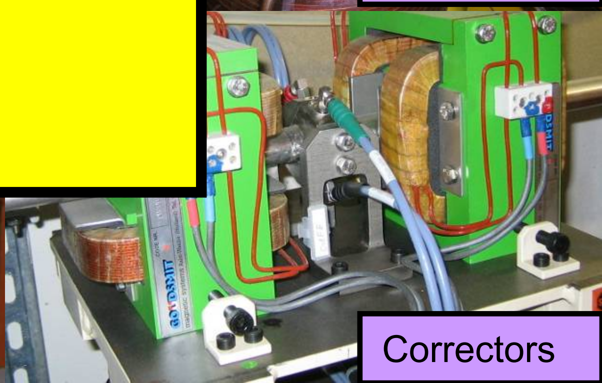










Introduction

During this course you have had the following presentations:

- ***Maxwell Equations***
- ***Beam optics***
- ***Basic Magnet Design***
- ***Magnet Types and Performances***
- ***Solenoids***
- ***Permanent Magnets***
- ***Injection and Extraction Magnets***
- ***Measurement of Magnetic Materials***
- ***SC Magnet***
- ***Eddy currents***

The conclusion is, that I haven't to say anything about the design and the types of the magnets, but nevertheless I have to make some remarks in the introduction.

Introduction

What is left for me is the:

- ***Specifications***
- ***Quality Control***
- ***Manufacturing***
- ***Acceptance Test***

All of these points have to be described in the so called ***"Technical Specifications",*** which have to be prepared for the "Call for Tender" process of the magnets and which will be the main documents of the contract with the manufacturer. Therefore I will concentrate, what you have to write down within the "Technical Specifications" for the different magnets (Bendings, Quadrupoles, Sextupoles, etc.)

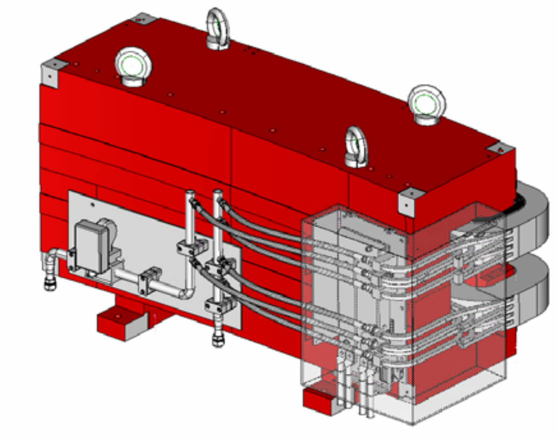
Scope of this lecture

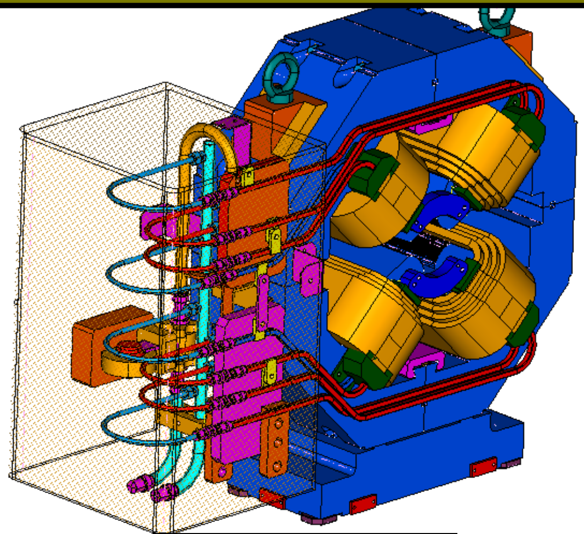
- **Accelerator magnets include:**
  - Normal-conduct magnets (bendings, quadrupole, sextupoles, correctors)
  - Super-conducting magnets
  - Magnets using permanent magnet material,
  - Fast pulsed magnets
  - Specialized magnets such as
    - septa and kickers used for injection and extraction.

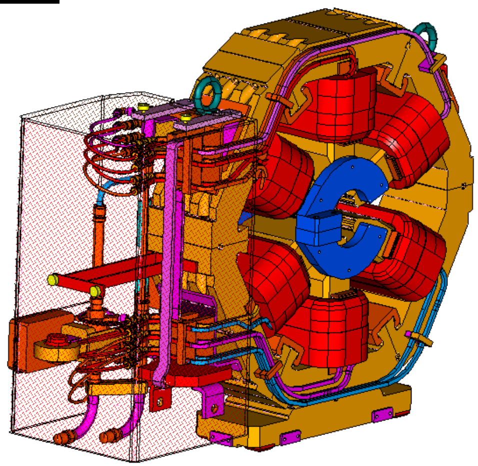
The scope of these lectures will be limited to *conventional room temperature, iron dominated accelerator magnet, mainly bendings, quadrupole, sextupoles and correctors*.

Scope of this lecture

Sextupole



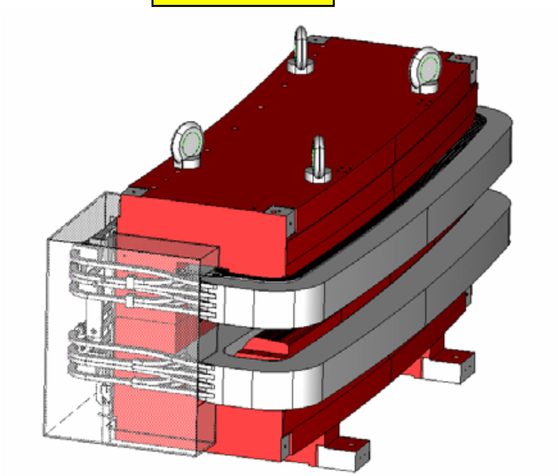


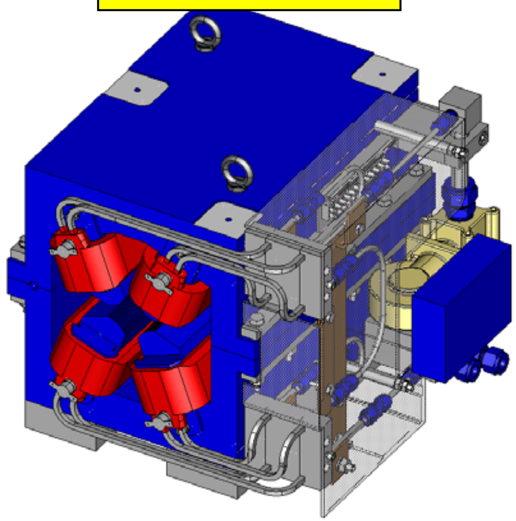


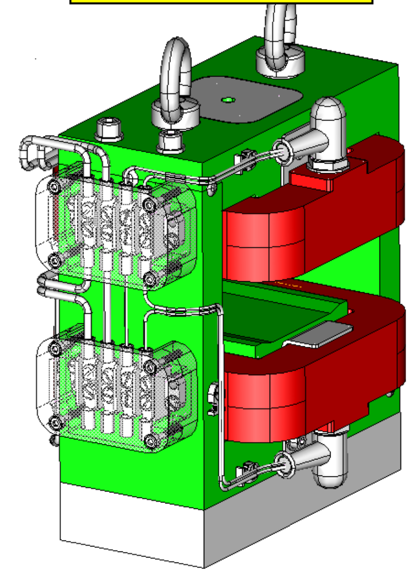
Dipole

Quadrupole

Corrector







Magnets within an Accelerator Complex

Bendings, Quadrupoles, Sextupoles and Correctors | **Bendings, Quadrupoles and Correctors**

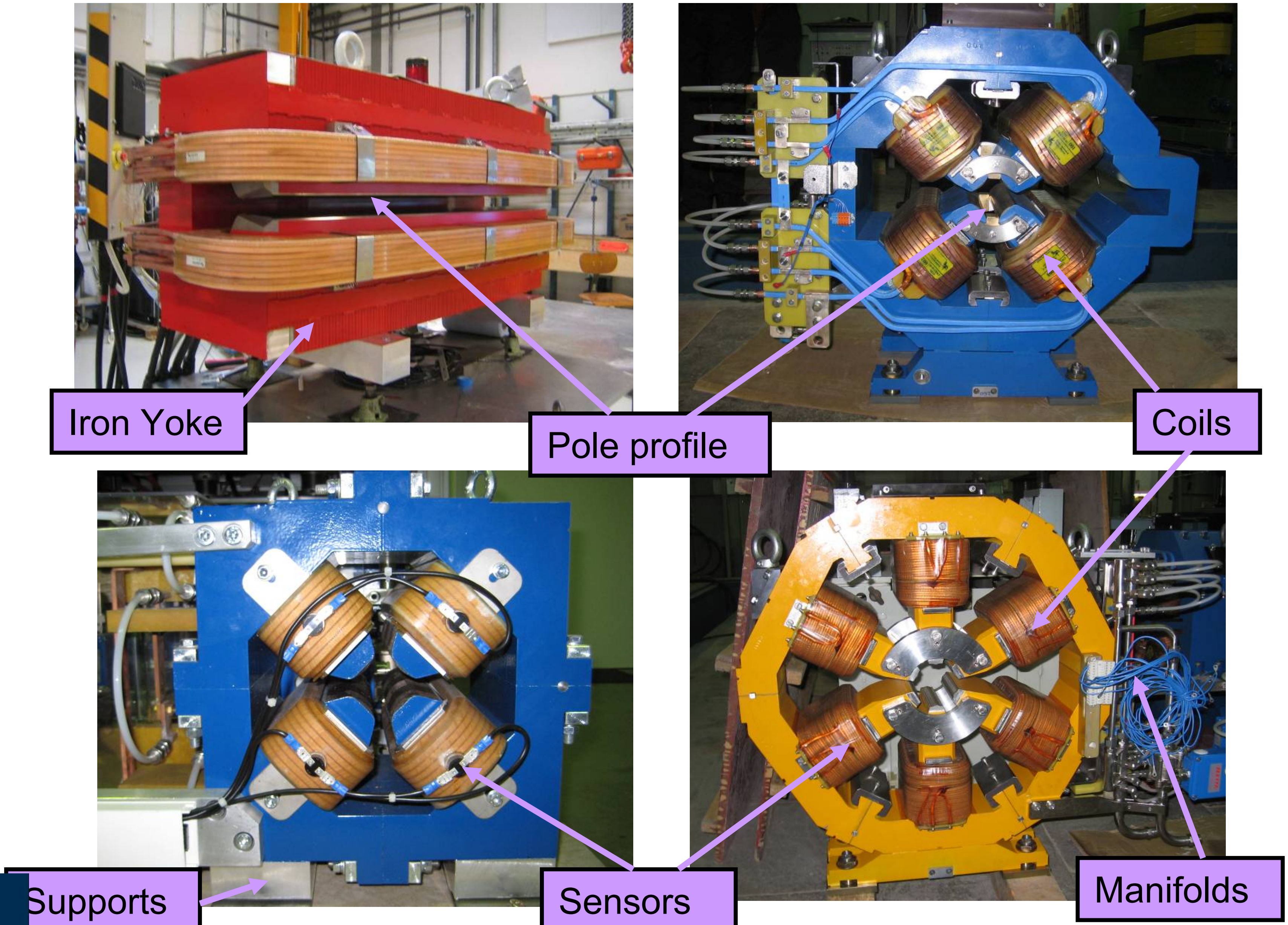
Storage Ring	Boost. Synchr.	Transfer Lines	Linac
Beam Optics	Beam Optics	Beam Optics	Beam Optics
Magnets	Magnets	Magnets	Gun
Vacuum Syst.	Vacuum Syst.	Vacuum Syst.	Bunching Section
Girders	Girders	Girders	Acceler.-Struct.
Alignment	Alignment	Alignment	Rad.-Freq.-Syst.
Power Supplies	Power Supplies	Power Supplies	Magnets
Diagnostics	Diagnostics		Girders
Rad-Freq-Sytem	Rad-Freq-System		Alignment
Pulsed Magnets	Pulsed Magnets		Power Suppl.
Puls-Power-Suppl.	Puls-Power-Suppl.		Diagnostic
Timing	Timing		Timing
Control System	Control Syst.		Control Syst.
Insertion Devices	Shielding		Shielding
Shielding			

For the design of the magnets one has to take into account:

1.) The requirements of the vacuum system, diagnostics and front ends.

2.) Fixation of the magnets on the girders / supports.

Main Components of a Magnet



Sequence for the Magnet Productions

1.) Requirements of the magnets (field, length, gradient, sextupole field, good field region, etc) have finished by the Beam Dynamics Group.

2.) Basic design of the magnets will be made by the Magnet Group (pole profile, H- or C-type of magnet, cross section of the lamination, coil design, supports, etc.) including the required space needed for vacuum, diagnostics, cooling, etc

3.) The steps 1.) and 2.) have to make according to the space requirements for the vacuum, diagnostics, etc. some cycles in order to finish the basic design.

4.) At this point one has to make a decision:

a.) will the detailed design be made in house by the magnet group / engineering group?

b.) will the detailed design made by the manufacturer?

Sequence for the Magnet Productions

In most of the cases the detailed design has been made by the manufacturer. Reason: the manufacturer has to make the production drawings nevertheless and therefore he should also make the detailed design.

6.) The specifications can only be determined by the magnetic measurements. A decision has to be made: who will make the magnetic measurements and where will it be done? This has to be written down in the *Technical Specifications* for the call for tender.

7.) Going out for the call for tender.

8.) Evaluation of the different offers, including some discussions with the bitters. Choice of the manufacturer.

9.) Signature of the contract

10.) Detailed design will be made by the manufacturer

11.) Acceptance of the detailed design (coils, manifolds, etc)

12.) Production of manufacturing drawings

Sequence for the Magnet Productions

13.) Production of stamping tools

14.) Procurement of steel, copper, etc

15.) Acceptance test of laminations

16.) Production of prototype or pre-series

17.) Magnetic measurement of prototype

18.) Determination of end chamfer, acceptance of prototype and
agreement of modifications for the series production

19.) Series production

20.) Mechanical test of the yokes

21.) Magnetic and electrical test of the coils

22.) Magnetic measurements of the magnets

23.) Acceptance of the different magnets

All this points have to be addressed in the *"Technical Specifications"*

1.) Contents of the Technical Specifications

1.) Contents of the Technical Specifications

1.) Contents of the Technical Specifications

Contents of the Technical Specifications

Before going into the details I have to repeat the main points concerning the design of the magnets (bendings, quadrupoles and sextupoles

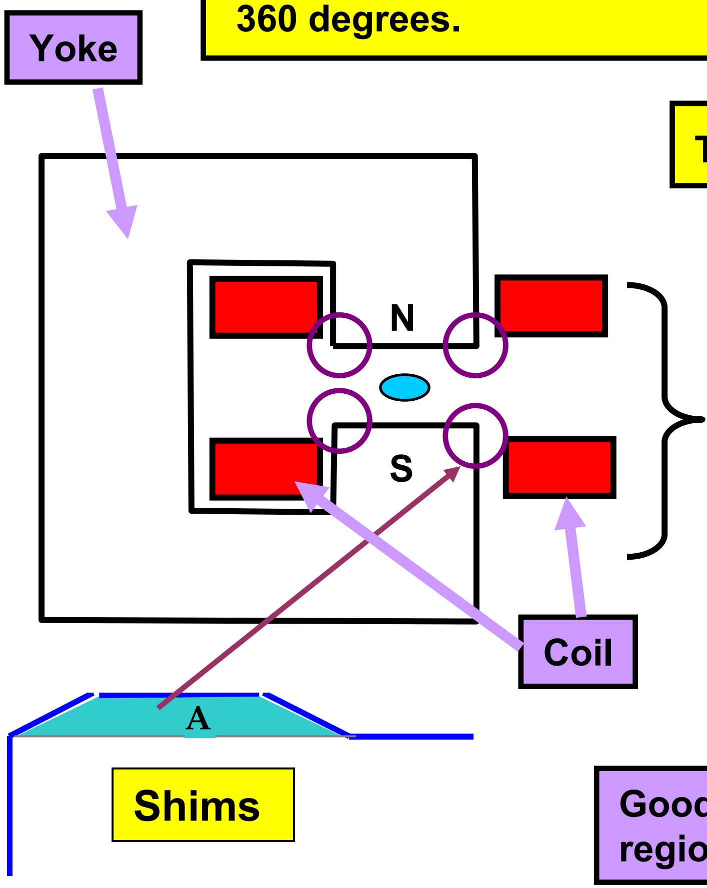
The Specifications of the Dipole Magnet

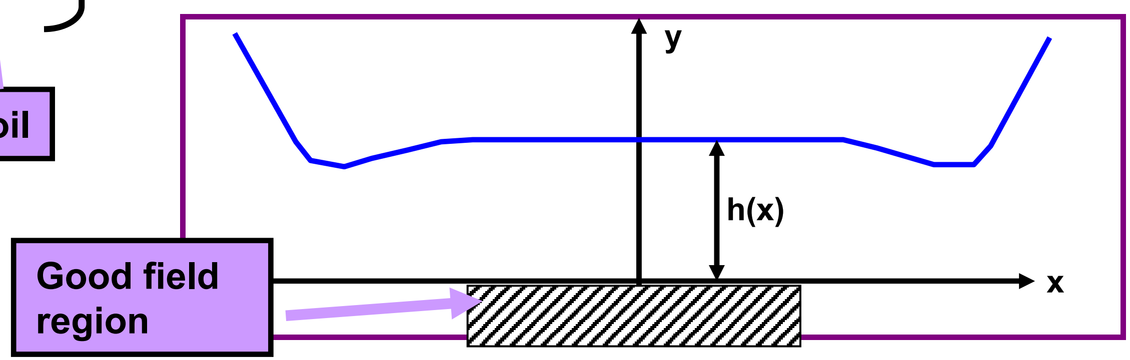
The dipole magnet has two poles, a constant field and steers a particle beam. The purpose of all bending magnets in a ring is to bend the beam by exactly 360 degrees.

The gap (g = 2*h) in a normal bending magnet is constant:

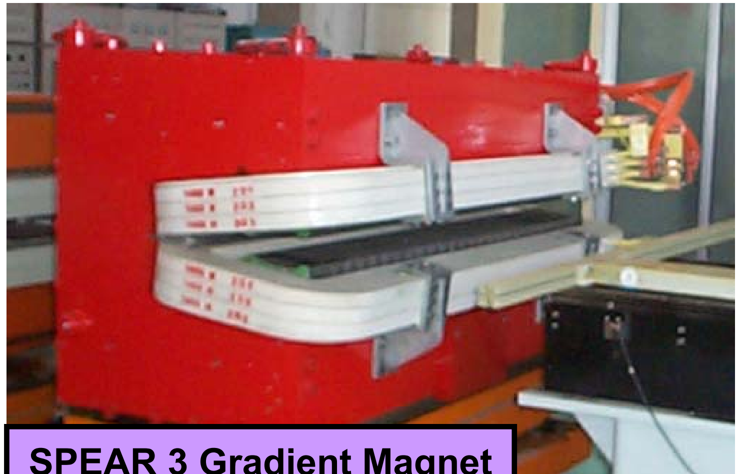
$$h(x) = const. = gap/2$$

To the ends of the pole there are shims introduced to optimize the "good field region area"

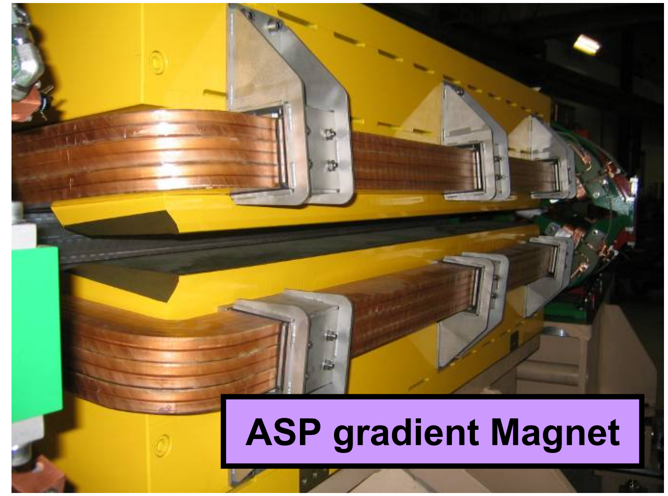




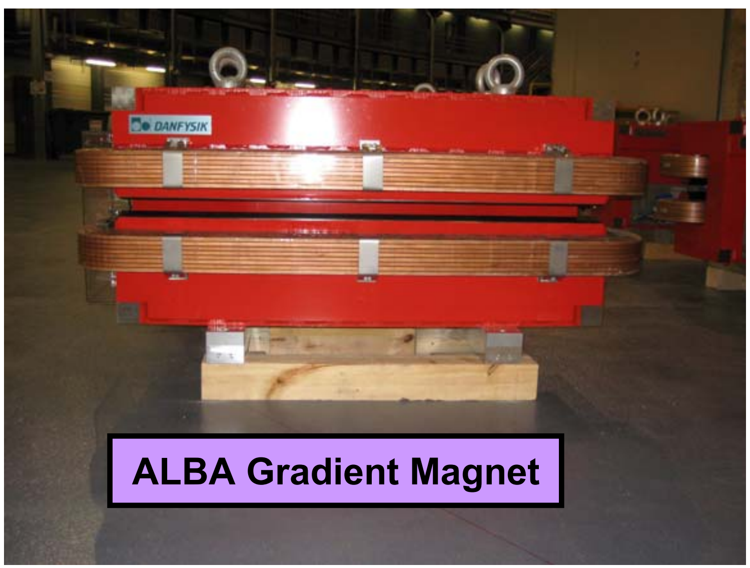
Dipoles



SPEAR 3 Gradient Magnet



ASP gradient Magnet

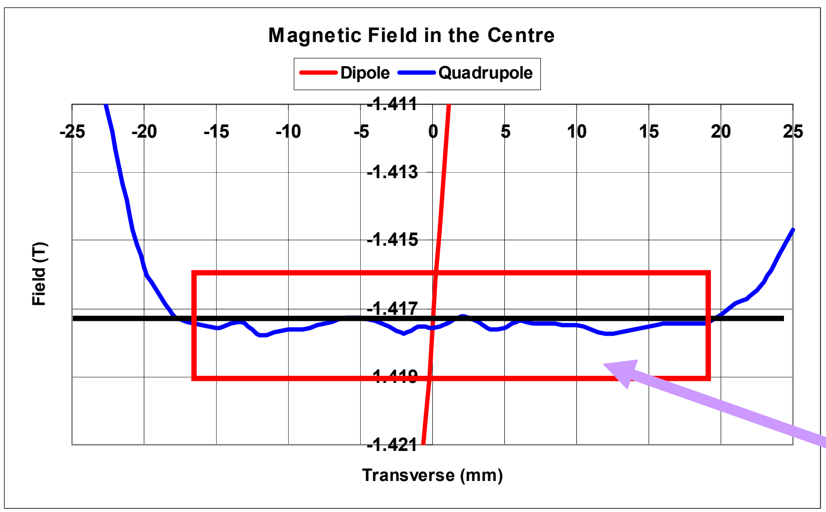


ALBA Gradient Magnet

ANKA Magnet

The Specifications of the Dipole Magnet

The size of a dipole is given by the required so called “good field area” of the magnet. The good field area is given by the accelerator physicist. For example in a bending magnet for a synchrotron light source a good field area of roughly +/- 15 to 20 mm is required. In heavy ion - or other machines it can be completely different (much larger). To optimize the pole profile one uses at the end of the poles so called shims (as given below). The contour of the shims have to be determined with a 2D (Poisson) or 3D (TOSCA) code



For accelerators operating with a fixed energy the flux density B can be up to 1.5 T or larger. For ramping machines the flux density should not be larger as roughly 1 T in order to avoid saturation effects.

Good field region

The Specifications of the Dipole Magnet

The characteristic of a bending magnet is to deflect the beam by an angle φ. The deflection angle is proportional to the integrated field and the change Δφ of the deflection angle is given by the change of the field (ΔB) over the length Δs. For the correction of Δφ correctors are introduced into the lattice.

$$\varphi = \frac{\int B \bullet ds}{B_0 \bullet \rho_0}$$

$$\Delta\varphi = \frac{\Delta B \bullet \Delta s}{B_0 \bullet \rho_0}$$

The bending angle of the SR-bending magnet of ALBA is 11.25 degrees or 196.35 mrad. The maximum allowed change of Δφ is determined by the acceptance of the machine. For ALBA it should be smaller as 0.3 mrad, which means Δφ/φ= 0.0015 or $1.5*10^{-3}$, normally one is asking for Δφ/φ= 0.001 or $1*10^{-3}$. This means, that with a constant field B_0 everywhere in the bending magnet the tolerance of the length has to be better as +/- $0.5*10^{-3}$. For a 1 meter long bending magnet it is +/- 0.5 mm. This can be reached.

The Specifications of the Dipole Magnet

The change of the deflection angle $\Delta\varphi$ is proportional to the change of the flux density ΔB and the change of the gap Δg. With a gap of roughly 40 mm and the requirement of $\Delta\varphi/\varphi = 1 \cdot 10^{-3}$, the change of the gap has to be smaller as 40 micro-meter. Which means that the gap height has to be very accurate, in the range of +/- 20µm.

$$\frac{\Delta B}{B} = \frac{\Delta\varphi}{\varphi} = \frac{\Delta g}{g}$$

$$\frac{\Delta y}{\Delta x} = \frac{G \bullet (g/2)}{B_0} = \frac{(g/2)}{X_0}$$

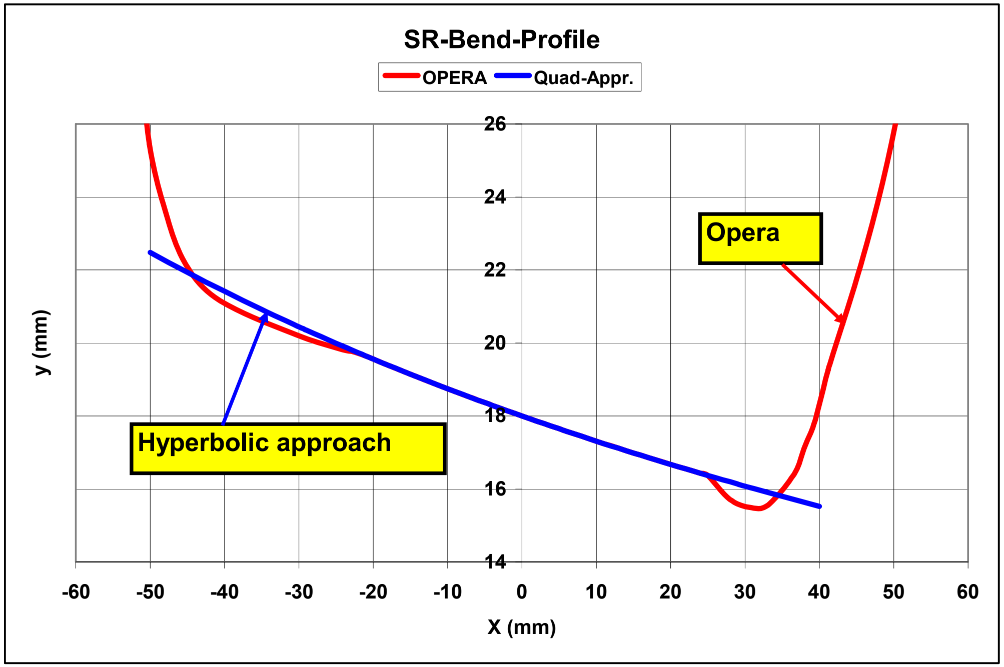
In some cases there is a gradient (G) in the bending magnet to have a so called combined function bending magnet. To reach this a slope has to be build into the gap of the bending magnet. The change of the slope is roughly given by the product of the gradient and the gap divided by the field. For ALBA (G=5.6T/m, g=40mm, B_0=1,42T) it means a slope of roughly 78.9 mrad or with a distance x = 25 mm from the centre a value of 2.5 mm. with a required tolerance of $1 \cdot 10^{-3}$, the change of the gap should have an accuracy of roughly 2.5 micro-meter. This is pretty tight and more or less not possible.

Pole Profiles in a Bending Magnet

If a gradient is introduced into the bending magnet the gap needs a slope or more accurate a hyperbolic shape. The change of the half gap is given by:

$$h(s) = \frac{h(0)}{1 - \frac{x \bullet G}{B}} = \frac{h(0)}{1 - \frac{x}{X_0}}$$

Hyperbolic approach



Pole Profiles in a Bending Magnet

If a sextupole component is introduced into the bending magnet the gap needs a quadratic shape. The change of the half gap is given by:

$$h(x) = h(0) \bullet (1 + \frac{x^2 / X_0^2}{1 - (x^2 / X_0^2)})$$

$$X_0 = \sqrt{\frac{2 \bullet B_0}{B''}}$$

For example for a sextupole component of B'' = 40 T/m, the half gap has to be increased (at a transverse distance of 30 mm) by 0.257 mm. The pole profile can be machined with an accuracy of roughly +/- 20 µm, which means the sextupole component in a dipole doesn't have any high accuracy (5 to 15 %) .

Multipoles in Magnets

Field expansion for the bending magnet with a gradient G = dB/dx and a sextupole component B'' = d²B/dx²

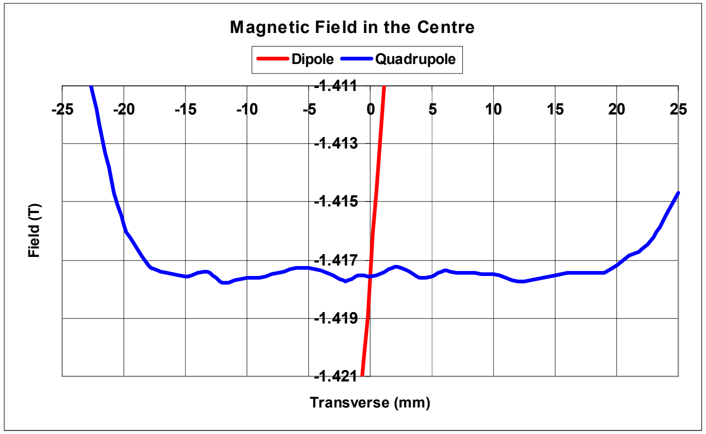
$$B(x) = B_0 + G \bullet x + \frac{1}{2} \bullet \frac{\partial^2 B}{\partial x^2} \bullet x^2 + \underbrace{\sum_{n=3}^{\infty} \frac{1}{n!} \bullet \frac{\partial^n B}{\partial x^n} \bullet x^n}$$

Homogeneous field

Quadrupole field

Sextupole field

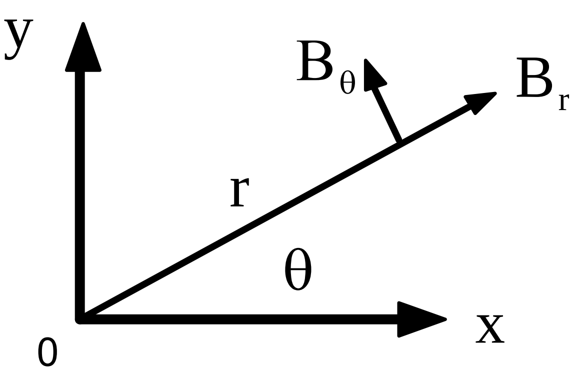
These are the higher multipoles. In a bending magnet with a gradient and a sextupole component they should be zero in the "good field region".



Multipoles in Magnets

$$B_r = -\sum_n (A_n r^{n-1} \cos n\Theta + B_n r^{n-1} \sin n\Theta)$$

$$B_\Theta = -\sum_n (-A_n r^{n-1} \sin n\Theta + B_n r^{n-1} \cos n\Theta)$$



B_n: are the normal components,

A_n: are the skew components,

$B_x = B_r \cos\theta - B_\theta \sin\theta$,
$B_y = B_r \sin\theta + B_\theta \cos\theta$,

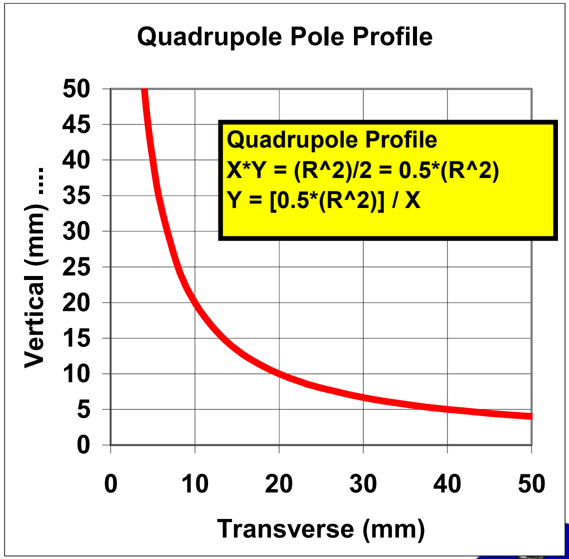
Quadrupole Design.

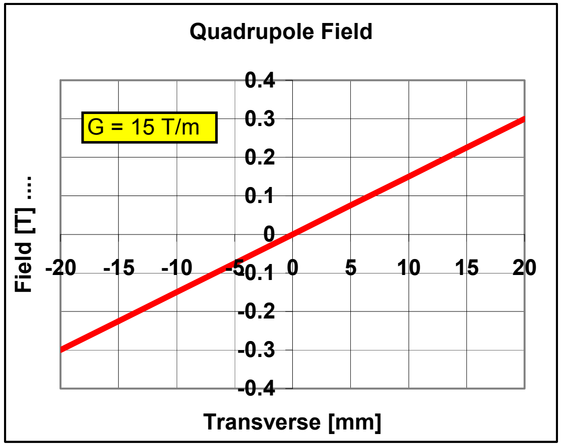
The Quadrupole Magnet has four poles. The field varies *linearly* with the distance from the magnet center. It focuses the beam along one plane while defocusing the beam along the orthogonal plane.

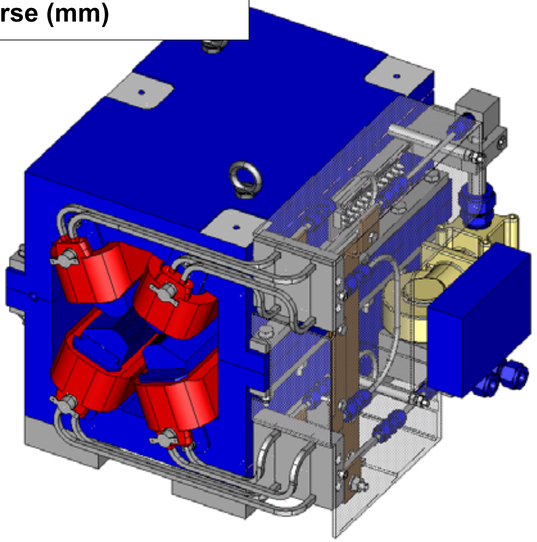
The field of the quadrupole has to be proportional to the distance from the centre (x or y). The excitation in general is given by:

$$B_0 = \mu_0 N^*I/g \text{ or } B(x) = \mu_0 N^*I/x$$

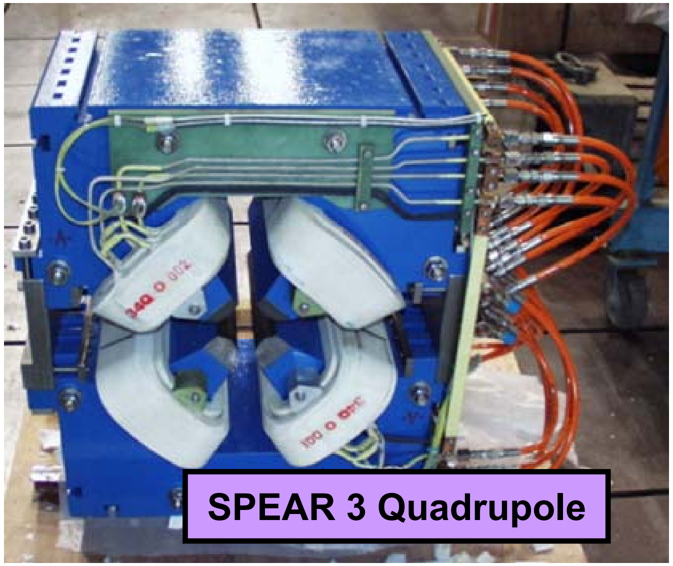
This means the pole profile of a quadrupole has to be a hyperbolic one.

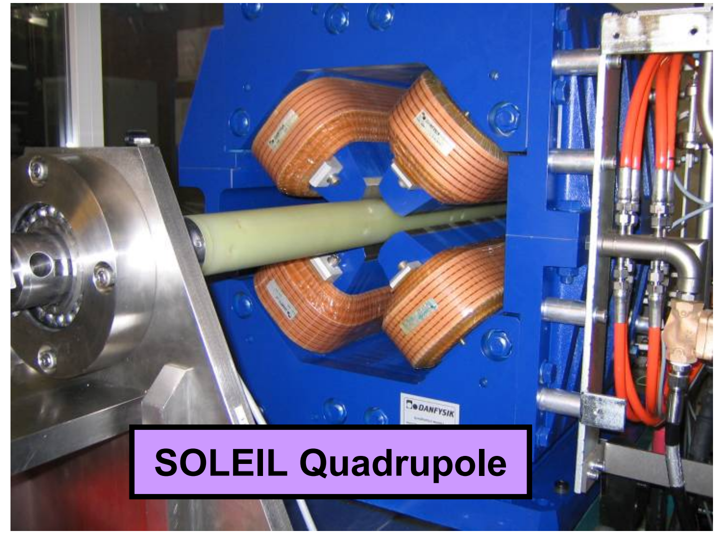




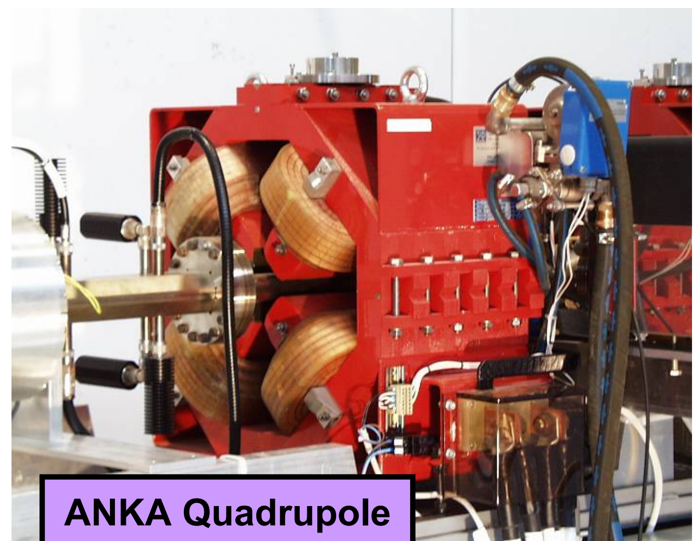


Quadrupole Magnets


SPEAR 3 Quadrupole

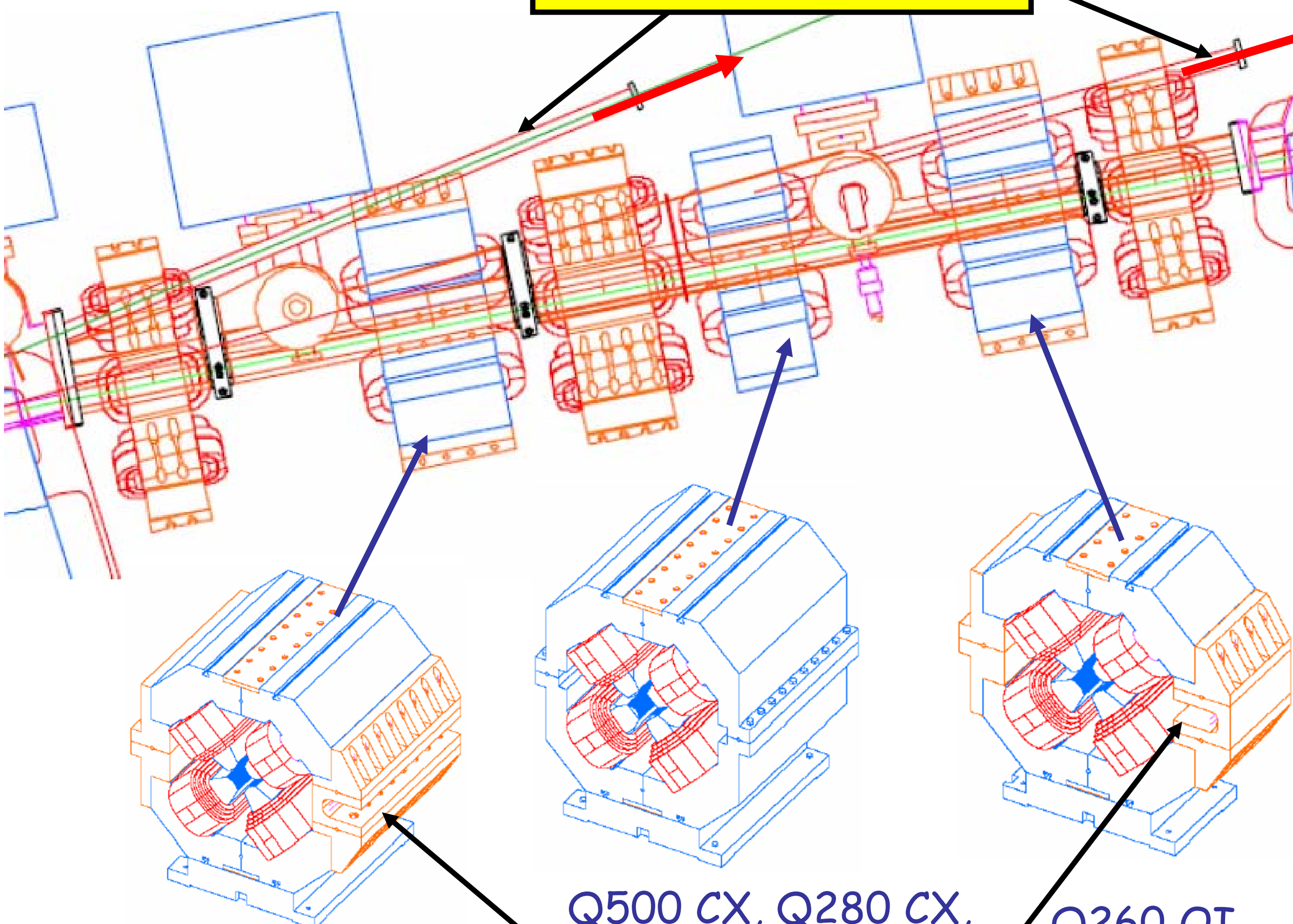

SOLEIL Quadrupole


ALBA Quadrupole

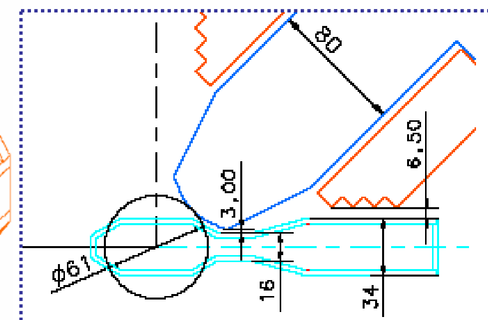

ANKA Quadrupole

Quadrupole and Beam-Lines: Spacers

Tubes for Beam-Lines



Type	Number
Q200CX	16+1
Q260CX	42+2
Q260OI	6+1
Q280CX	20+1
Q280OC	4+1
Q500CX	22+1
Q500OC	2+1



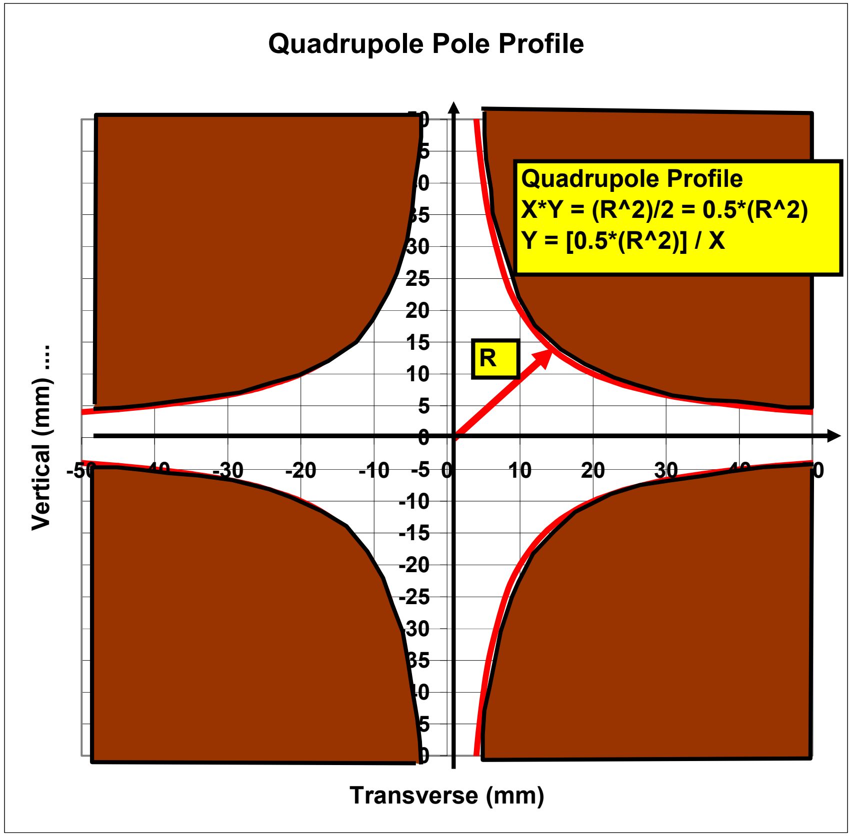
Q500 OC, Q280 OC

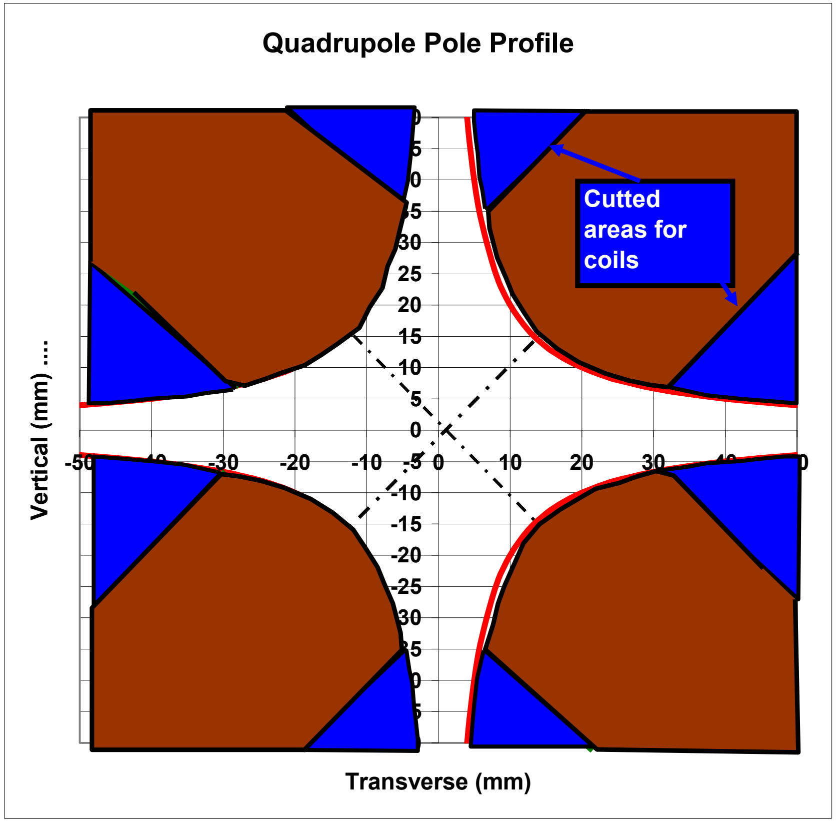
Q500 CX, Q280 CX,
Q260 CX, Q200 CX

Q260 OI

Opening for beam-Lines

Explanation for higher Multipoles

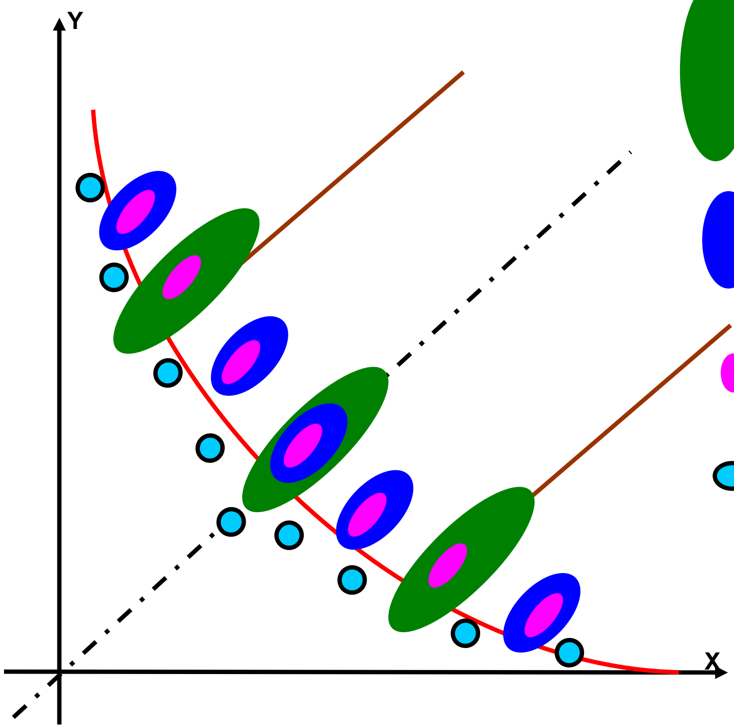




By cutting the pole profile in order to have space for the introduction of the coils, the field distribution will be disturbed and higher multipoles will be introduced.

Higher Multipoles in Magnets

A dipole has overall 2 poles, which is n = 1
A quadrupole has overall 4 poles, which is n = 2
A sextupole has overall 6 poles, which is n = 3



Dipole: Introduction of 3 poles, that means overall 6 poles, which is n = 3
Quadrupole: Introduction of 3 poles, that means overall 12 poles, which is n = 6
Sextupole: Introduction of 3 poles, that means overall 18 poles, which is n = 9

Dipole: Introduction of 5 poles, that means overall 10 poles, which is n = 5
Quadrupole: Introduction of 5 poles, that means overall 20 poles, which is n = 10
Sextupole: Introduction of 5 poles, that means overall 30 poles, which is n = 15

Dipole: Introduction of 7 poles, that means overall 14 poles, which is n = 7
Quadrupole: Introduction of 7 poles, that means overall 28 poles, which is n = 14
Sextupole: Introduction of 7 poles, that means overall 42 poles, which is n = 21

Dipole: Introduction of 9 poles, that means overall 18 poles, which is n = 9
Quadrupole: Introduction of 9 poles, that means overall 36 poles, which is n = 18
Sextupole: Introduction of 9 poles, that means overall 54 poles, which is n = 27

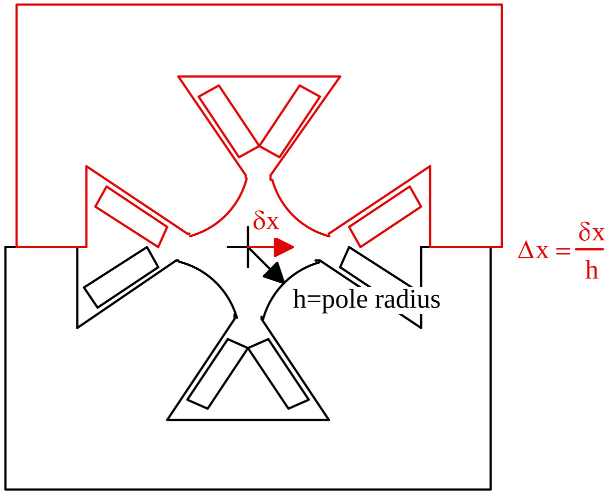
Summary - ‘Systematic’ Multipoles

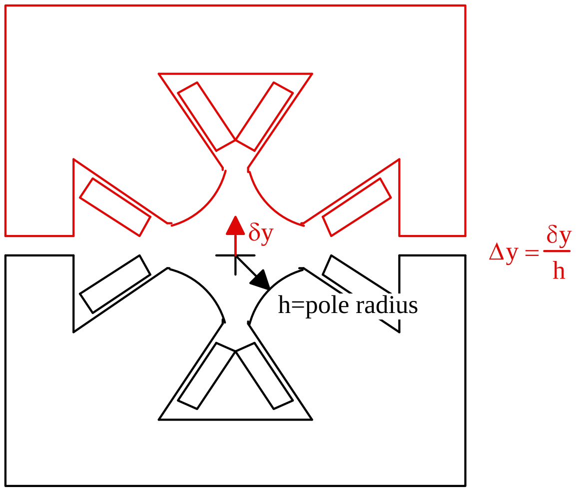
Summary of ‘systematic multipoles’ in <u>fully symmetric</u> magnets:

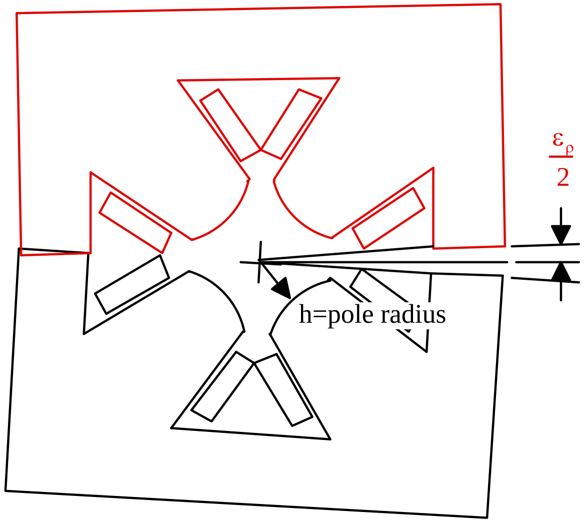
Fundamental geometry	‘Systematic’ multipoles
Dipole, n = 1	n = 3, 5, 7, ... (6 pole, 10 pole, etc.)
Quadrupole, n = 2	n = 6, 10, 14, ... (12 pole, 20 pole, etc.)
Sextupole, n = 3	n = 9, 15, 21, ... (18 pole, 30 pole, etc.)
Octupole, n = 4	n = 12, 20, 28, ... (24 pole, 40 pole, etc.)

Summary: "Random" Multipoles

Assembling errors introduce higher multipoles, they are called "random multipoles"

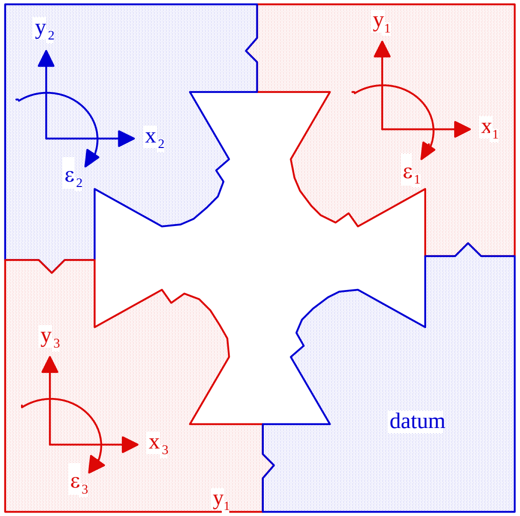




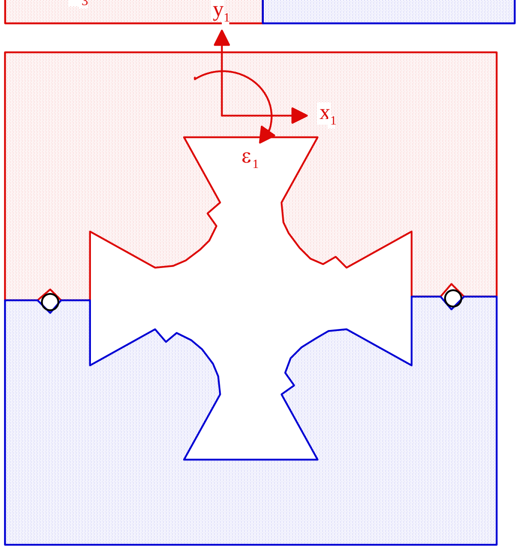


Assembling of Quadrupoles

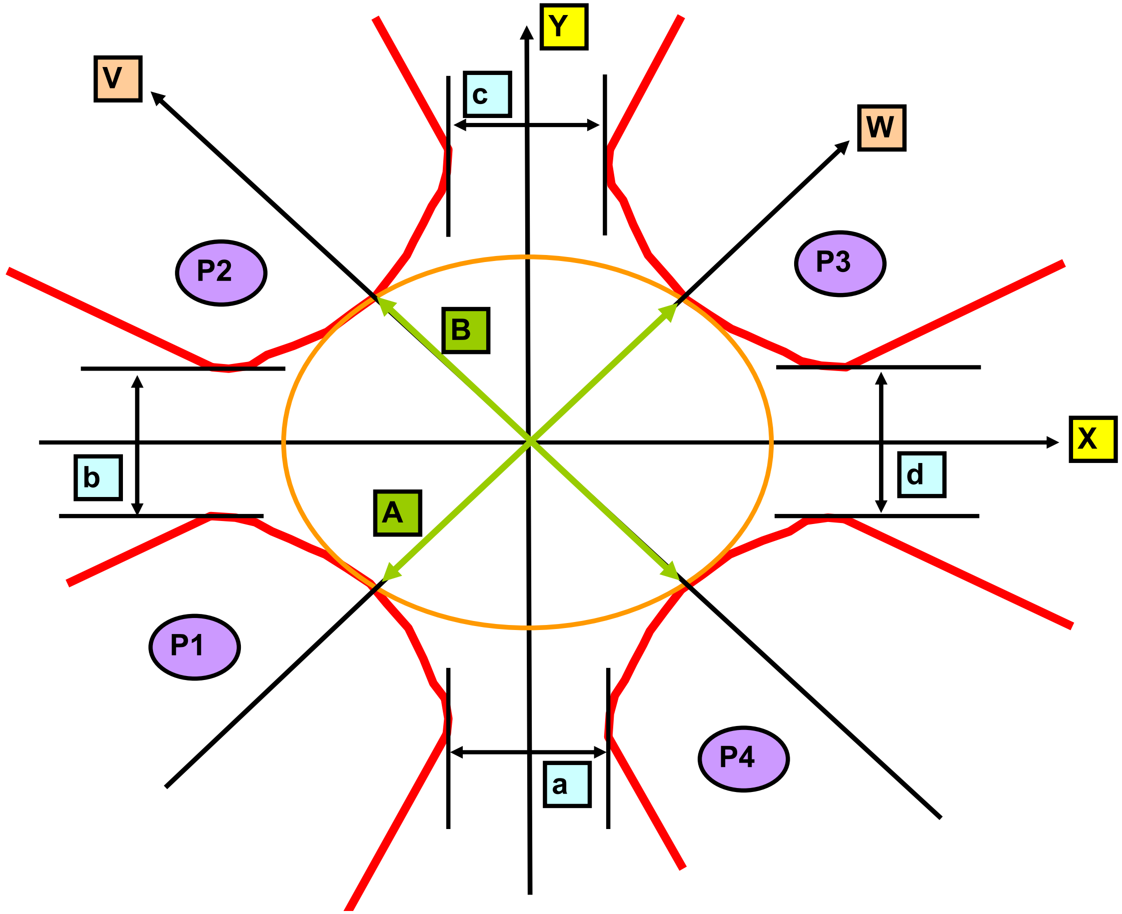
Each segment can be assembled with errors with three kinematic motions, x, y and e (rotation). Thus, combining the possible errors of the three segments with respect to the datum segment, the core assembly can be assembled with errors with 3x3x3=27 degrees of freedom.



This assembly has the advantage that the two core halves can be assembled cinematically with *only* three degrees of freedom for assembly errors. Thus, assembly errors are more easily measured and controlled.



Higher Multipoles in Quadrupoles



Pi — The 4 poles of the quadrupole

A B — Distances between the poletipes

X Y — Coordinate system

V W — Coordinate system

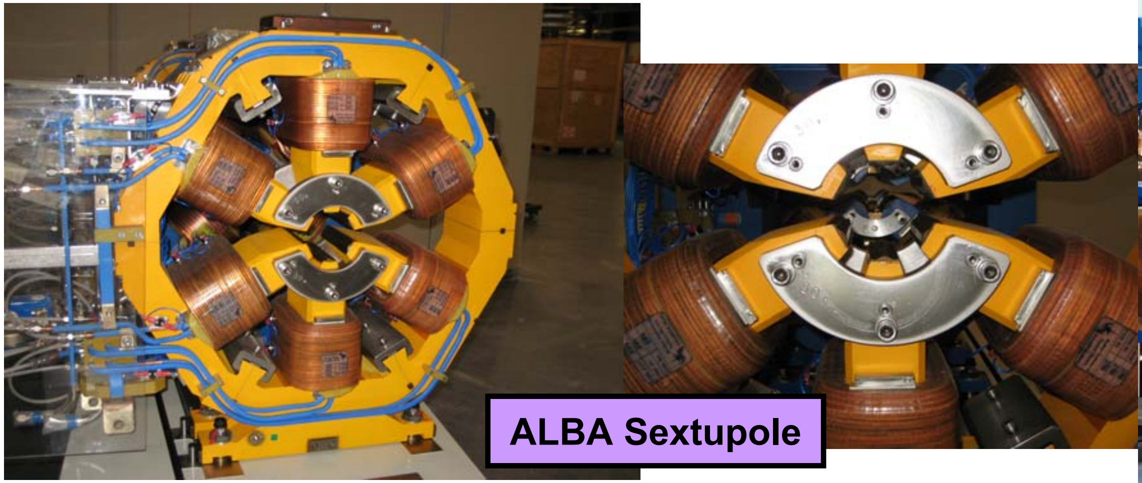
a b c d — Distances between the poles

Higher Multipoles in Quadrupoles

0.) Fully symmetric quadrupole; A=B and
a=b=c=d and poles are truncated: N=6
1.) P1 in neg W: N=3, N=4, N=5, N=6 and N=10
2.) P4 in neg V: N=3, N=4, N=5, N=6 and N=10
3.) P3 in neg W: N=3, N=4, N=5, N=6 and N=10
4.) P2 in pos. Y: N=3, N=4, N=5
5.) P2 in neg. Y: N=3, N=4, N=5
6.) P2 in neg. V
and P4 in pos.V: N=4, N=6, N=8, N=10
7.) P2 in pos. X: N=3, N=4, N=5
8.) P2 in neg. X: N=3, N=4, N=5
9.) A and B are increased by the same amount:
N=6, N= 10
10.) A and B are decreased by the same amount:
N=6, N=10
11.) A is unequal B : N=4, N=6, N=8, N=10

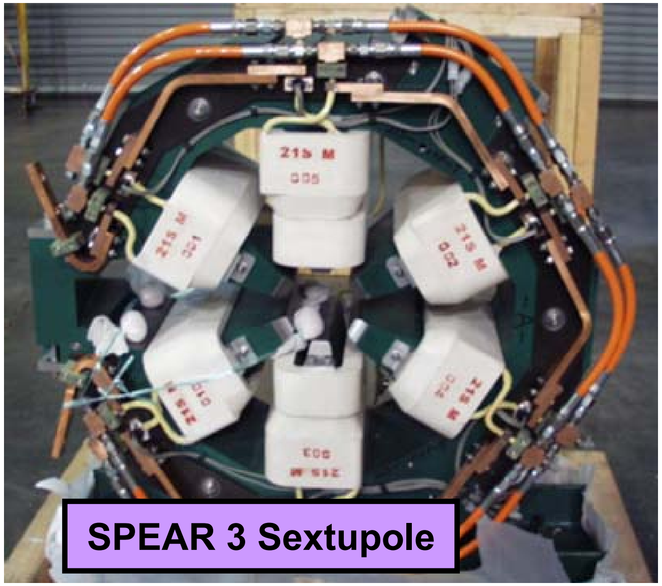
Conclusion: to avoid higher multipoles the manufacturing of the magnets have to be very accurate (A=B and a=b=c=d)

Sextupole Magnets

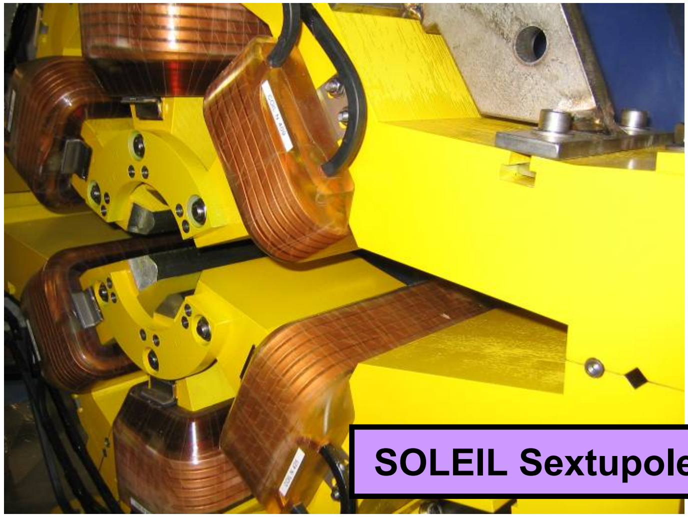


ALBA Sextupole

ANKA Sextupole



SPEAR 3 Sextupole

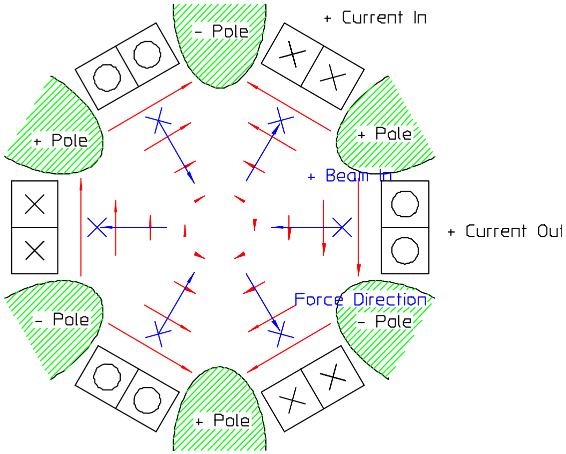


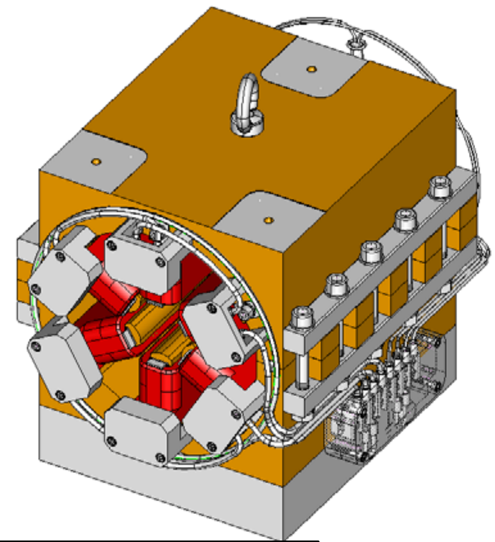
SOLEIL Sextupole

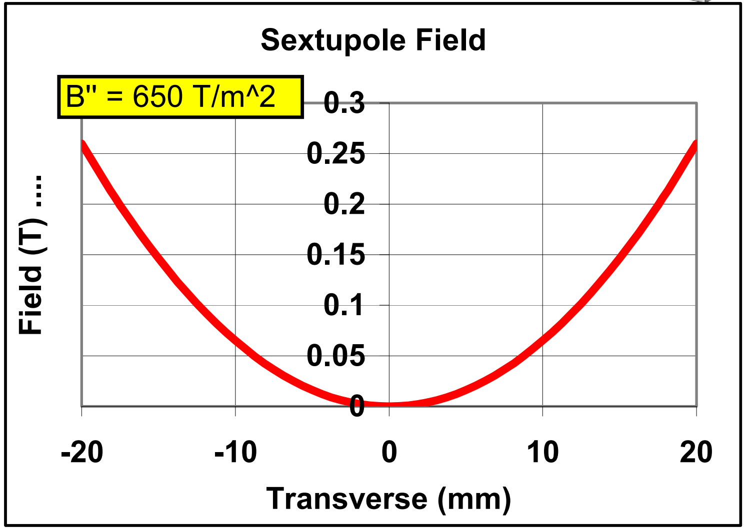
Sextupole Design.

The Sextupole Magnet has six poles. The field varies *quadratically* with the distance from the magnet center. It's purpose is to affect the beam at the edges, much like an optical lens which corrects chromatic aberration. Sextupole are needed for the compensation of the chromaticity to make in a small range the focusing of the machine energy independent.

Note that the sextupole also steers along the 60 and 120 degree lines.







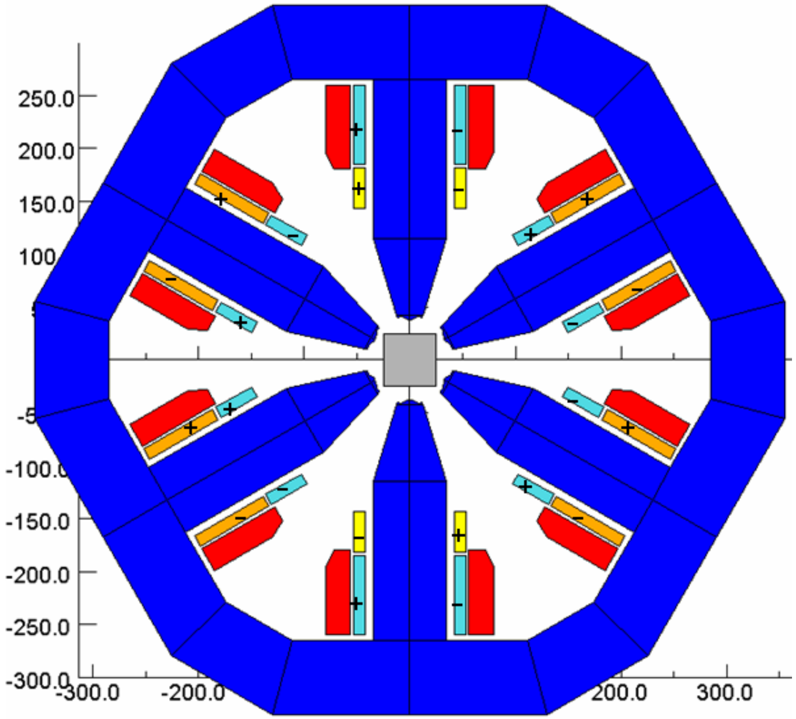
Steering (2D-models)

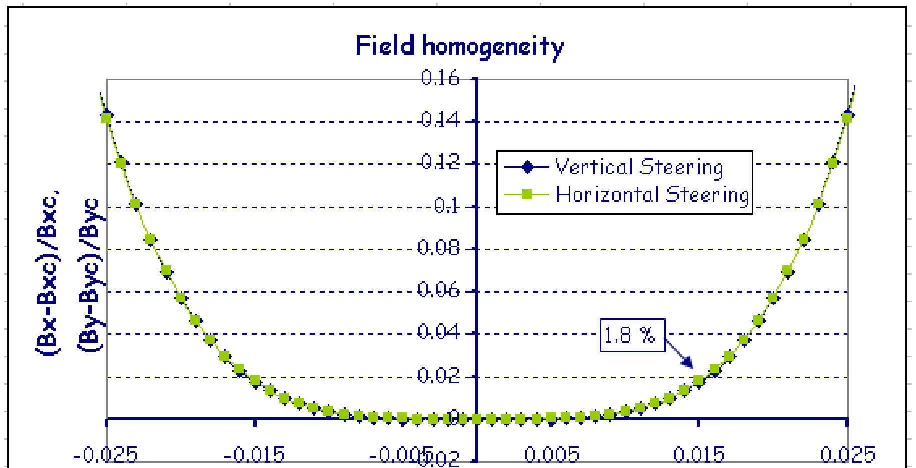
All sextupoles will be equipped with steering coils for:

Horizontal Steering 0.8 mrad
2 coil types (1806 A-turn, 903 A-turn)
By(x=0) = 0.0514 T

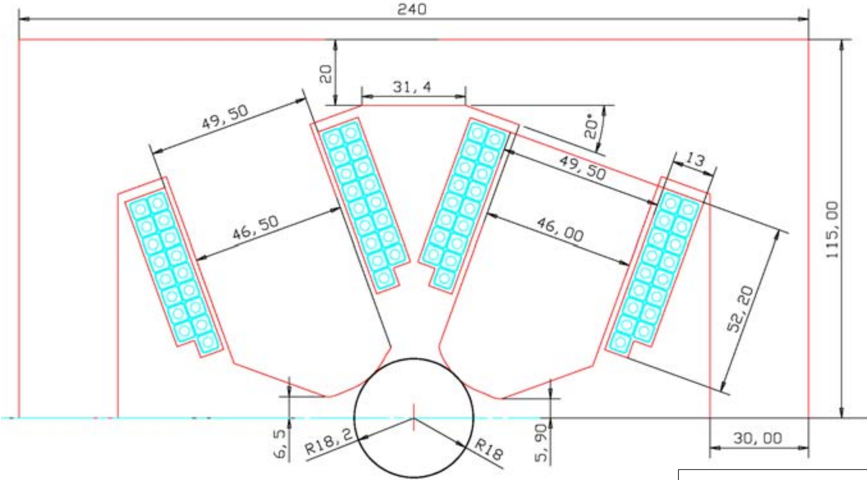
Vertical Steering 0.8 mrad
1 coil type (1520 A-turn)
Bx(y=0) = 0.0499 T

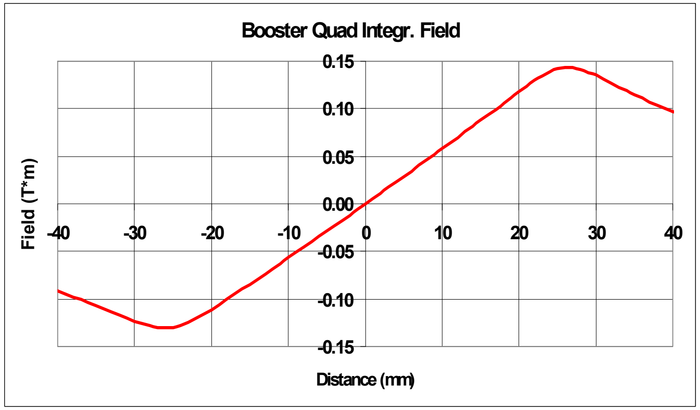
Skew Quadrupole gx=0.2 T/m
1 coil type (225 A-turn)



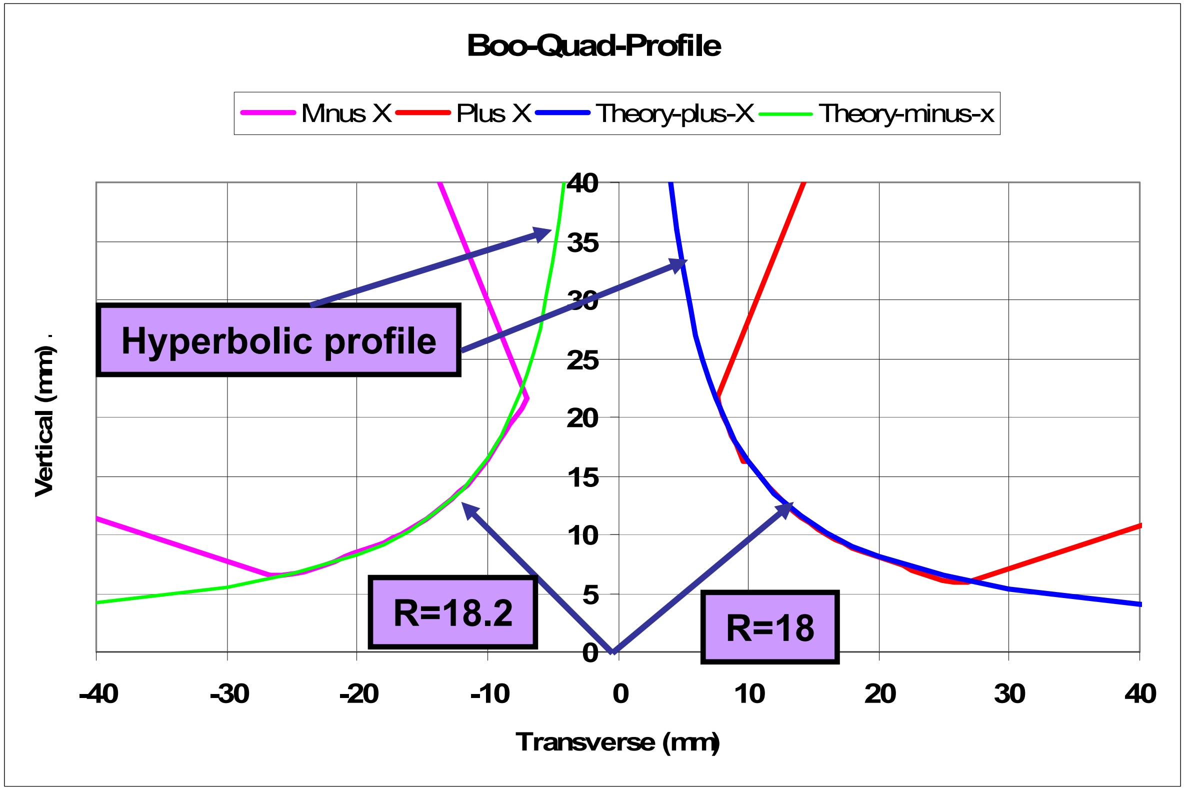


Combined Quadrupoles for the ALBA Booster

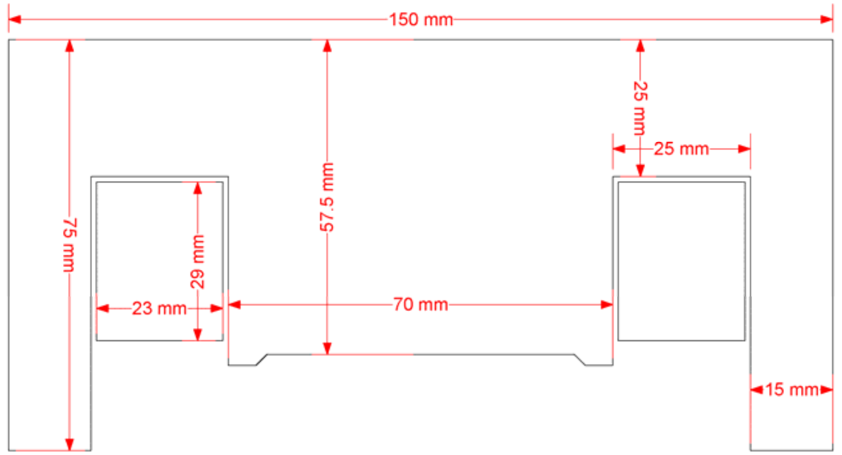


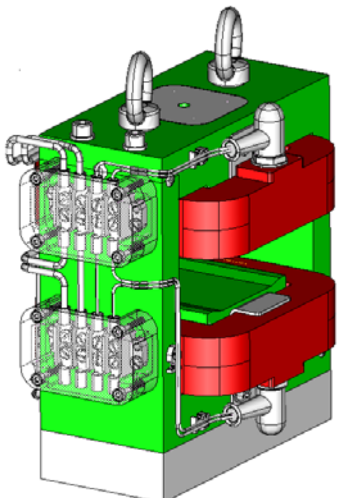


Introduction of a sextupole field in a quadrupole

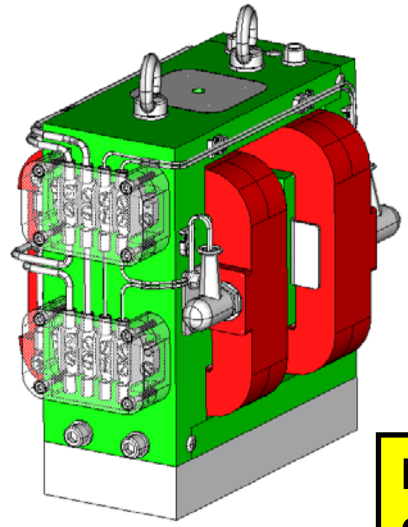


ALBA-Booster-Correctors





Horizontal corrector



Vertical corrector

P<150 W no cooling

Bending angle	mrad	1
Bending field	T	0.0503
Length of Fe yoke	mm	70
Gap	mm	35
Solid conductor size	mm^2	2
Number of ampere turns	amp-turn/coil	700
Number of turns per coil		174
Current	A	4
Dissipated power	W	20

1.) Technical Specifications: Introduction

1.1.) The Consortium for the Construction, Equipment and Exploitation of the Synchrotron Light Laboratory (CELLS) is responsible for the construction of a new synchrotron radiation facility, named ALBA. The facility will comprise a 3 GeV electron storage ring, injected from a 100 MeV Linac through a full energy booster synchrotron, and an initial complement of five beam lines.

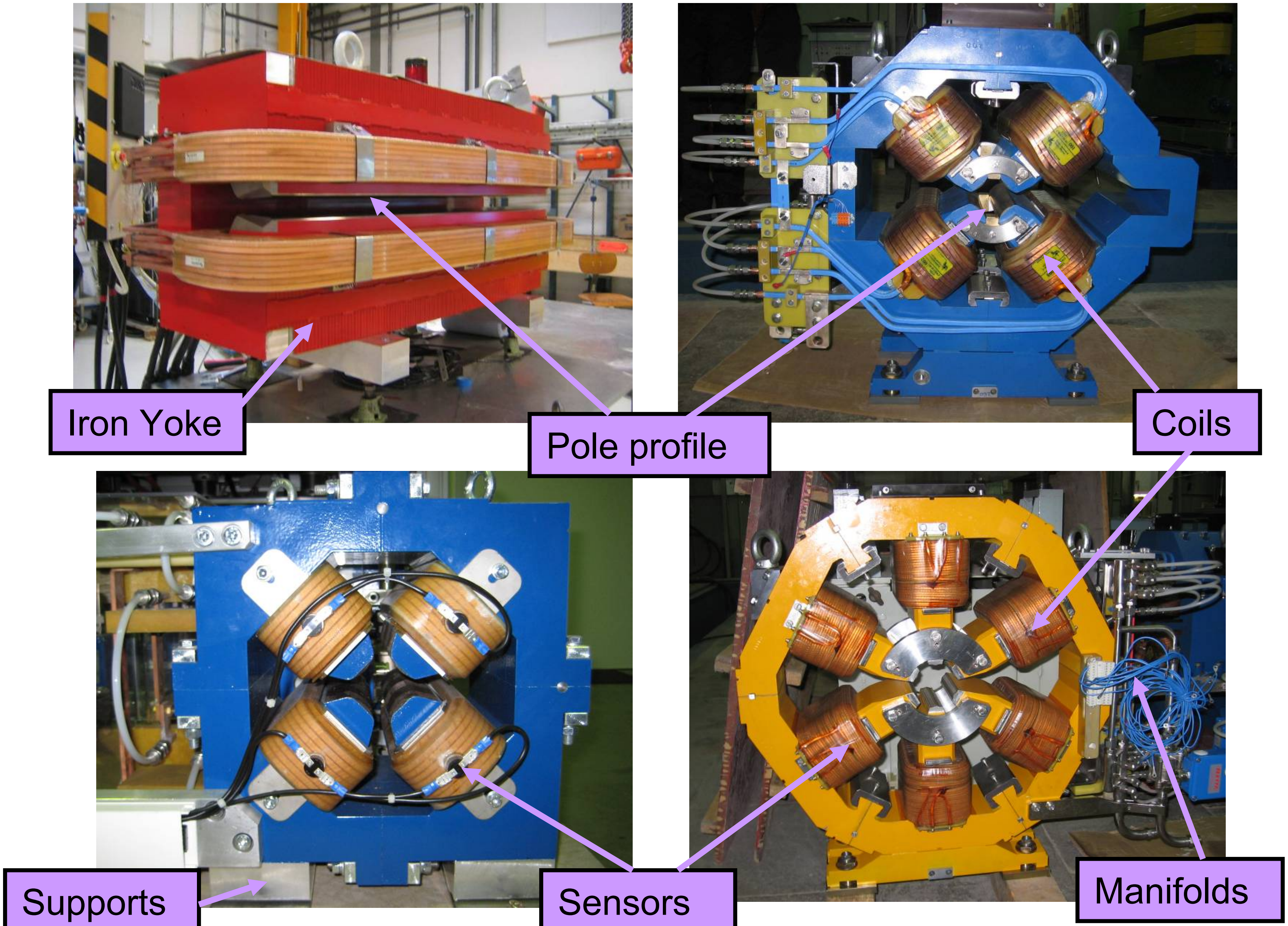
1.2) The Storage Ring is composed of 32 bending magnets, 112 quadrupole magnets and 120 sextupoles magnets, plus a given number of spare magnets.

1.3) The present specification contains the technical specifications for the bending magnets. All dimensions and tolerances of the magnets are defined in the specification and the attached drawings. The small electron beam size of ALBA and its stability results in tight tolerances on the magnets.

1.) Technical Specifications: Introduction

1.4) The contracts for the bending magnets will include the responsibility for the electrical, mechanical and thermal design of the magnets, their construction, followed by their mechanical and electrical testing; CELLS will retain responsibility for the magnetic field generated by the magnet poles and for the magnetic measurements. This specification therefore defines the required pole profile, together with the electrical and mechanical operational performance. The final design arrangements to achieve the specified features in a reproducible way in a correctly engineered magnet will be the responsibility of the manufacturer.

Main Components of a Magnet



1.) Technical Specifications: Introduction

1.5) The contracts for the quadrupoles will include the responsibility for the electrical, mechanical and thermal design of the magnets, their construction, followed by their mechanical and electrical testing, and the measurement of their magnetic performance; CELLS will retain responsibility for the magnetic field generated by the magnet poles. This specification therefore defines the required pole profile, together with the electrical and mechanical operational performance. The final design arrangements to achieve the specified features in a reproducible way in a correctly engineered magnet will be the responsibility of the manufacturer.

1.6) It is desired to have full magnetic measuring of the production magnets carried out at the manufacturer under his responsibility. The manufacturer will provide the necessary magnetic field measuring equipment and suitable technical operators. After testing, it may be necessary to store magnets on the manufacturer’s premises. Both these requirements are more fully described in this specification.

2.) Scope of contract: Technical specifications

2.1) This specification covers the engineering design, manufacture, assembly, testing and delivery of bending magnets for the Storage Ring of the ALBA facility.

2.1) The specification also covers the supply of all materials and the construction of all tools, jigs and fixtures required to complete the contract.

2.3) The magnets, as manufactured will consist of a magnetic yoke, coils, and all other mechanical brackets and fittings required for their full assembly. They will also be fitted with support feet, water manifolds, electrical termination blocks, coil interconnections and insulated protective covers.

2.4) There aren't any items which have to be provided by CELLS

3.) Technical Specifications: Magnet Details

3.1) Description of the bending magnets

3.1.1) ALBA requires a total of 32+1 bending magnets.
3.1.2) The bending magnets are curved parallel-ended C-type with a central gap of 36 mm.
3.1.3)The magnets generate a magnetic field with a gradient (G=5.656 T/m) and operate at a maximum induction of 1.42 T at the central point.
3.1.4)The cores will be laminated and the laminations will be stacked together along a curved line with uniform radius thus forming a curved magnet with parallel ends or you have sector magnets.
3.1.5)The bending magnets are required with an iron yoke length of 1340 mm.
3.1.6)The location of the electron photon beam vacuum chamber in the gap of the magnets leads to the definition of a “vacuum chamber stay clear area”. This is defined in the appropriate drawings. It will be part of the manufacturer’s responsibility, during the mechanical and electrical design of the magnet, to keep this space clear for the vacuum components and to make allowance for this when designing the coil.

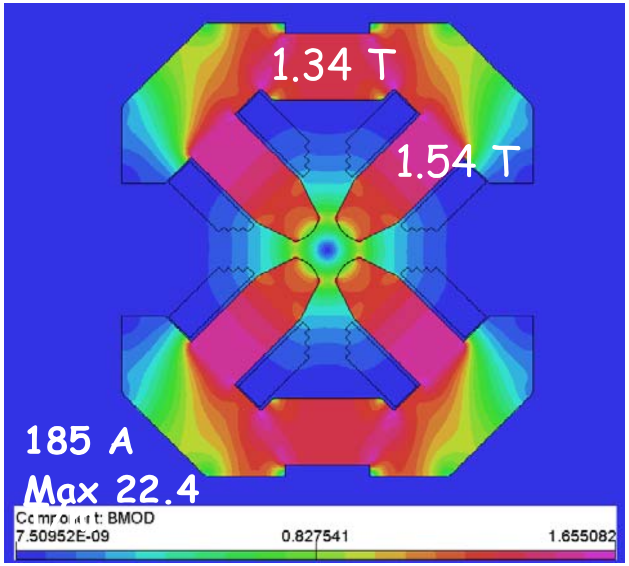
3.) Technical Specifications: Bending Magnet Details

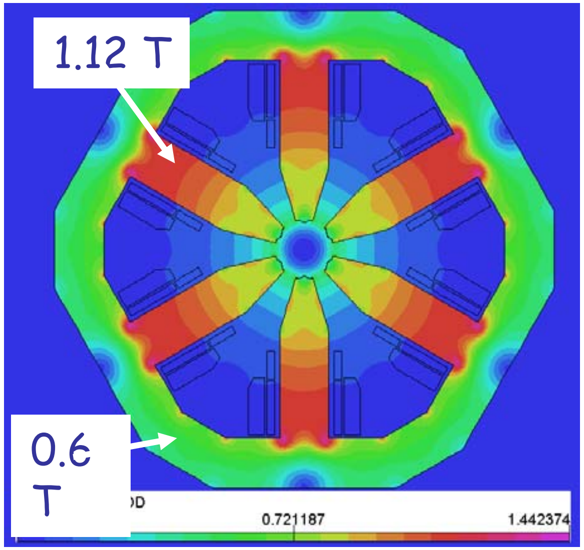
3.1) Description of the bending magnets

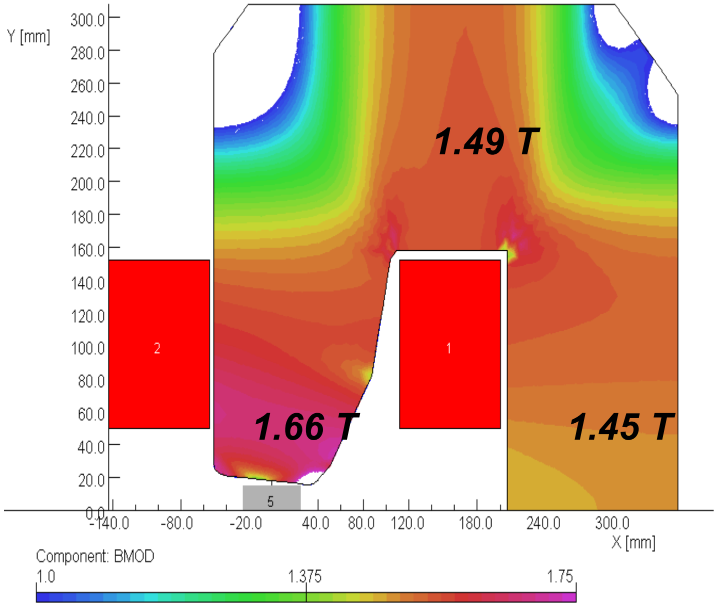
3.1.7)The magnets will be excited by coils mounted on the poles. These coils will be wound from solid conductor with a central water cooling hole. The bending magnets will be powered by one power supply, all magnets are in series.

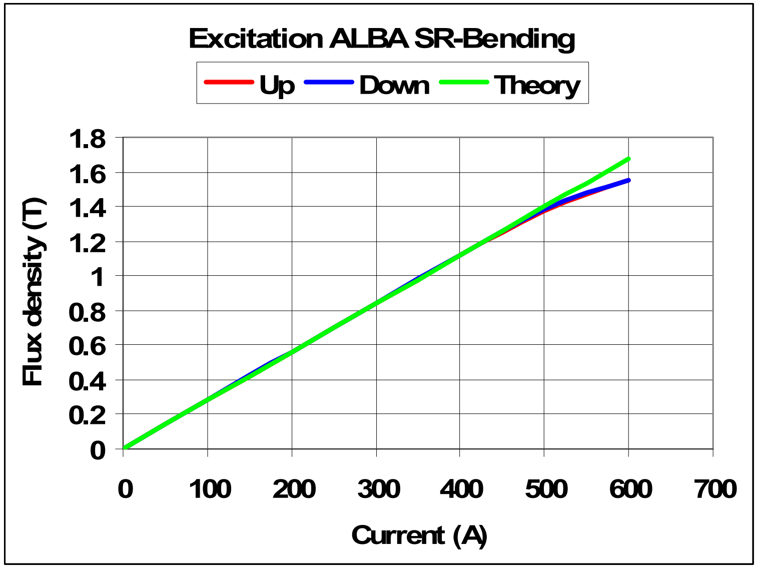
3.2) Parameter list

(see the next slice)


1.34 T
1.54 T
185 A
Max 22.4
Component: BMOD
7.50952E-09
0.827541
1.655082


1.12 T
0.6 T
0.721187
1.442374


Y [mm]
1.49 T
1.66 T
1.45 T
X [mm]
Component: BMOD
1.0
1.375
1.75


Excitation ALBA SR-Bending
Up
Down
Theory
Flux density (T)
Current (A)

Parameters of the ALBA Bending Magnets

Storage Ring Bending Magent		
Magnetic properties		
Beam Energy (E)	GeV	3
Central Field (Bo)	T	1.42
Field gradient (Go)	T/m	5.656
Sextupole component (B")	T/(m^2)	0
Effective length (Lo)	m	1.384
Mechanical properties		
Bending radius (Ro)	m	7.047
Bending angle (phi)	degrees	11.25
Central Gap (h)	mm	36
Length of Fe-yoke L(Fe)	mm	1340
Coil and conductor		
Number of coils		2
Number of pancakes per coil		4
Number of turns per pancake		10
Concductor size	mm^2	16.3*10.8
Cooling channel diameter (D)	mm	6.6
Number of ampere turns per coil	A-turns	20340
Current (I)	A	509
Current density (j)	A/mm^2	3.59
Resistance at 23 degrees	mΩ	34.5
Inductivity	mH	40
Voltage drop	V	17.6
Power	kW	8.93
Cooling		
Maximim DT	Celsius	8.6
Nominal input temperature	Celsius	23
Number of cooling circuits per coil		2
Maximum pressure drop per magnet	bar	7

Booster Bending Magents			
		5 Degr.	10 Degr.
Magnetic properties			
Beam Energy (E)	GeV	3	3
Central Field (Bo)	T	0.8733	0.8733
Field gradient (Go)	T/m	2.292	2.292
Sextupole component (B")	T/(m^2)	18	18
Effective length (Lo)	m	1	2
Mechanical properties			
Bending radius (Ro)	m	11.4592	11.4592
Bending angle (phi)	degrees	5	10
Central Gap (h)	mm	22.6	22.6
Length of Fe-yoke L(Fe)	mm	0.972	1.972
Coil and conductor			
Number of coils		2	2
Number of pancakes per coil		1	1
Number of turns per pancake		12	12
Concductor size	mm^2	12*12	12*12
Cooling channel diameter (D)	mm	5	5
Number of ampere turns per coil	A-turns	7906	7906
Current (I)	A	659	659
Current density (j)	A/mm^2	6.08	6.08
Resistance at 23 degrees	mΩ	9.2	18.2
Inductance	mH	1.3	2.6
Voltage drop	V	6.1	31.8
Power	kW	2	3.94
Cooling			
Maximim DT	Celsius	11	11
Nominal input temperature	Celsius		23
Number of cooling circuits per coil		1	2
Maximum pressure drop per magne	bar	7	7

3.) Technical Specifications: Bending Magnet Details

3.3) Specification drawings

3.3.1) The drawings are specified in chapter 13. To produce a comprehensive set of drawings for the specification, it has been necessary to make certain assumptions concerning parts of the magnet design that will be the responsibility of the manufacturer. Tenderers shall therefore be aware that certain features shown on the drawings are tentative, and will be subject to adjustment by the manufacturer during the design phase. This reservation applies particularly to:

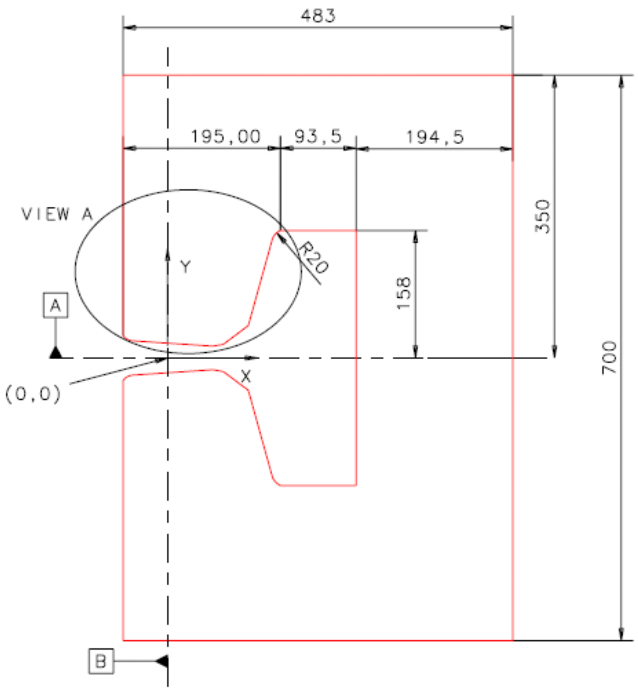
coil shape and cross section

Shape of magnet lamination, except for the pole profile

(the drawings for the bending magnet and the quadrupoles are given in the next slices)

3.) Techn. Specs.: Parameter List (SR-Dipole)

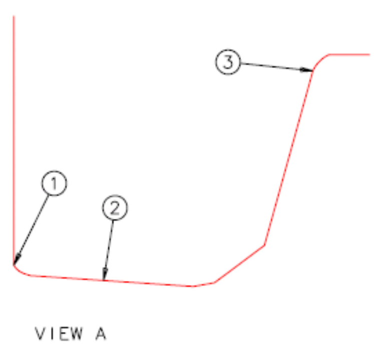
DRAWING FOR INFORMATION ONLY



Lamination tolerance ±0.015 mm
Maximum burr size 0.025 mm

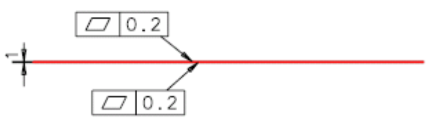
NOTE: Do not scale off drawing. Pole profile not drawn (refer to coordinate table only).

Dimensions of the laminations



Pole coordinates

	X	Y		X	Y
1	-55.000	27.745		1.000	17.929
	-53.463	25.665		2.000	17.858
	-51.541	23.986		3.000	17.787
	-48.703	22.571		4.000	17.718
	-25.000	19.991		5.000	17.649
	-24.000	19.903		6.000	17.580
	-23.000	19.815		7.000	17.512
	-22.000	19.729		8.000	17.444
	-21.000	19.643		9.000	17.377
	-20.000	19.558		10.000	17.311
	-19.000	19.474		11.000	17.244
	-18.000	19.390		12.000	17.179
	-17.000	19.307		13.000	17.114
	-16.000	19.225		14.000	17.049
	-15.000	19.144		15.000	16.985
	-14.000	19.063		16.000	16.922
	-13.000	18.983		17.000	16.858
	-12.000	18.904		18.000	16.796
	-11.000	18.825		19.000	16.734
	-10.000	18.747		20.000	16.672
	-9.000	18.669		21.000	16.611
	-8.000	18.592		22.000	16.550
	-7.000	18.516		23.000	16.489
	-6.000	18.441		24.000	16.429
	-5.000	18.366		25.000	16.370
	-4.000	18.291		55.900	14.570
	-3.000	18.218		69.130	16.900
	-2.000	18.145		100.000	40.000
	-1.000	18.072	3	130.000	148.000
2	0.000	18.000			



Tolerances of laminations is +/- 15 µm

PARTS LIST

CELLS

BENDING MAGNET
Lamination

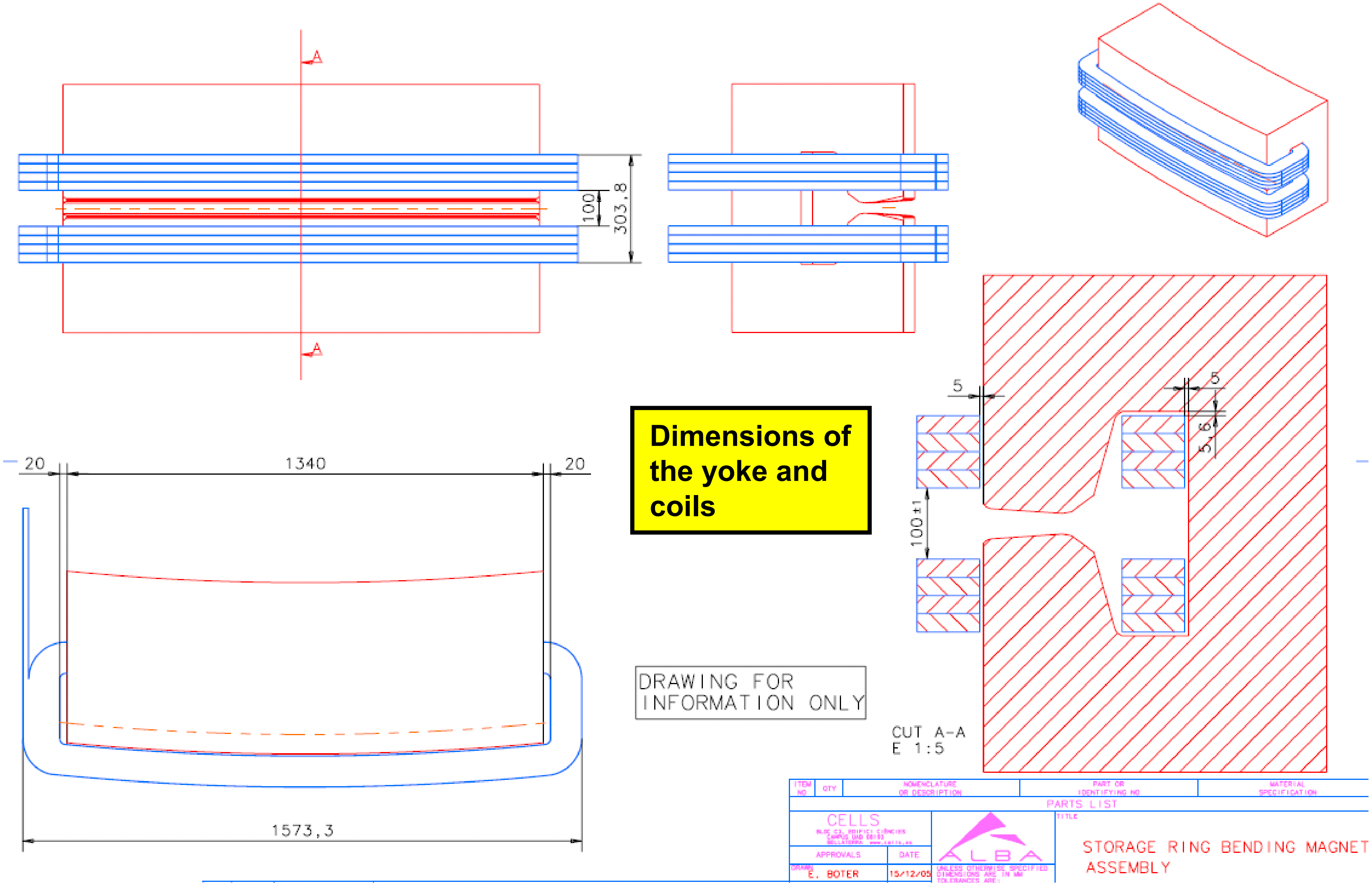
DRAWN E. BOTER 14/12/05
CHECKED X. PERMANYER 15/12/05
RELASED E. BOTER 15/12/05
APPROVED M. PONT 15/12/05

SCALE 1:5 SIZE A3

CALL FOR TENDER, 19/12/05

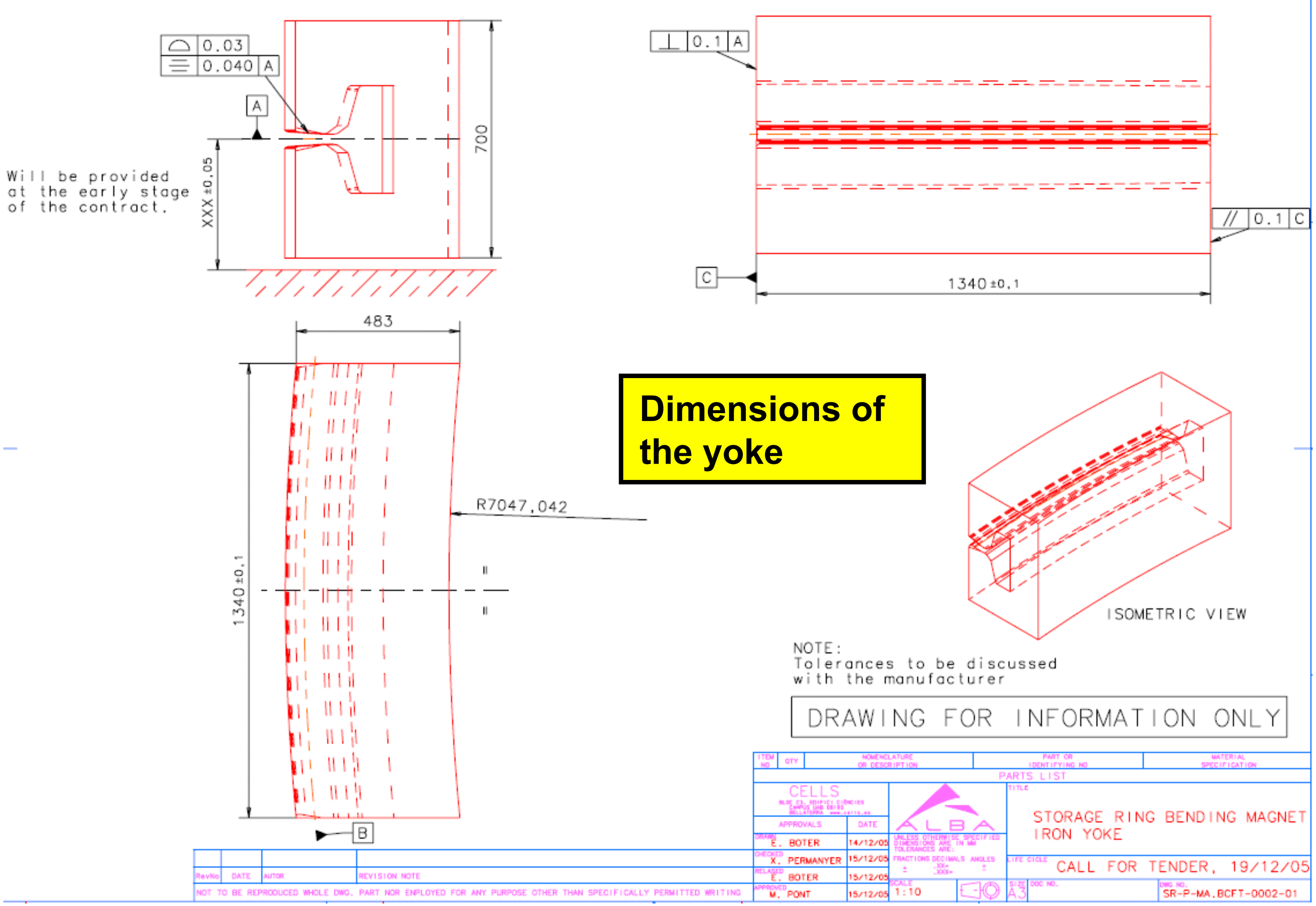
DWG NO. SR-P-MA.BCFT-0001-01

3.) Techn. Specs.: Parameter List (SR-Dipole)

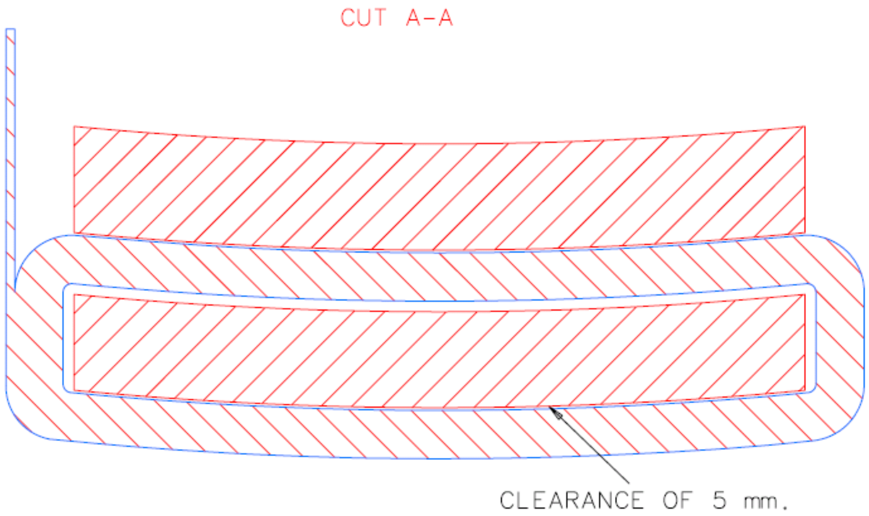


Dimensions of the yoke and coils

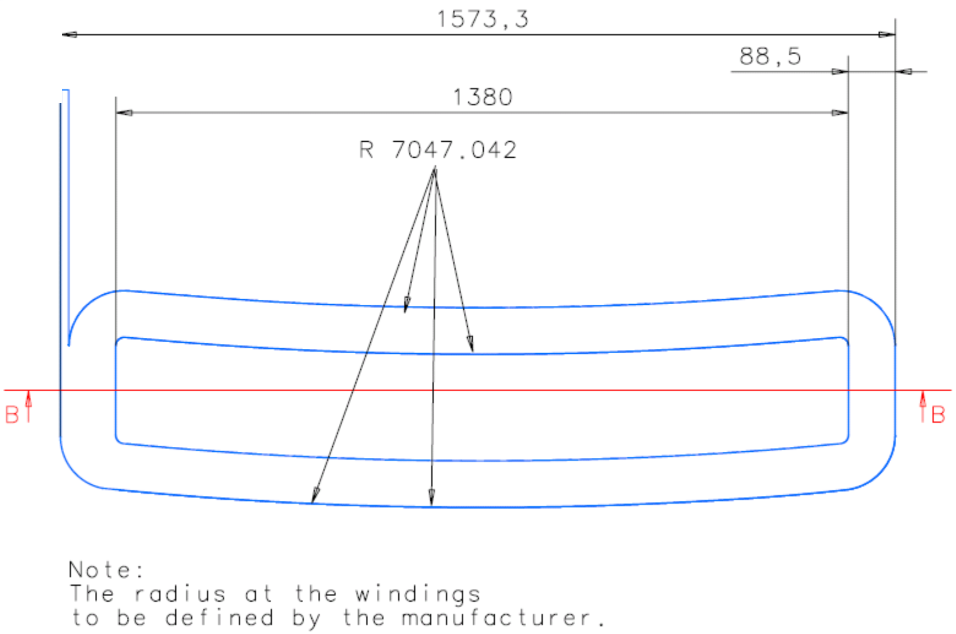
3.) Techn. Specs.: Parameter List (SR-Dipole)



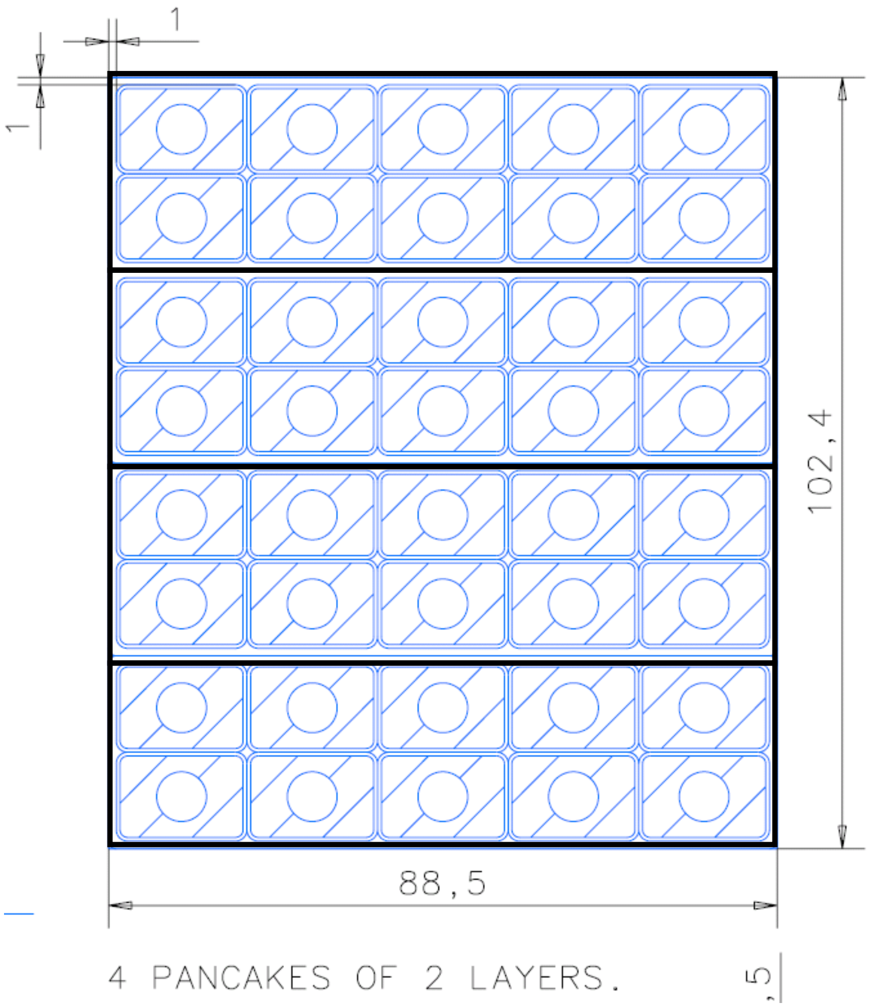
3.) Techn. Specs.: Parameter List (SR-Dipole)



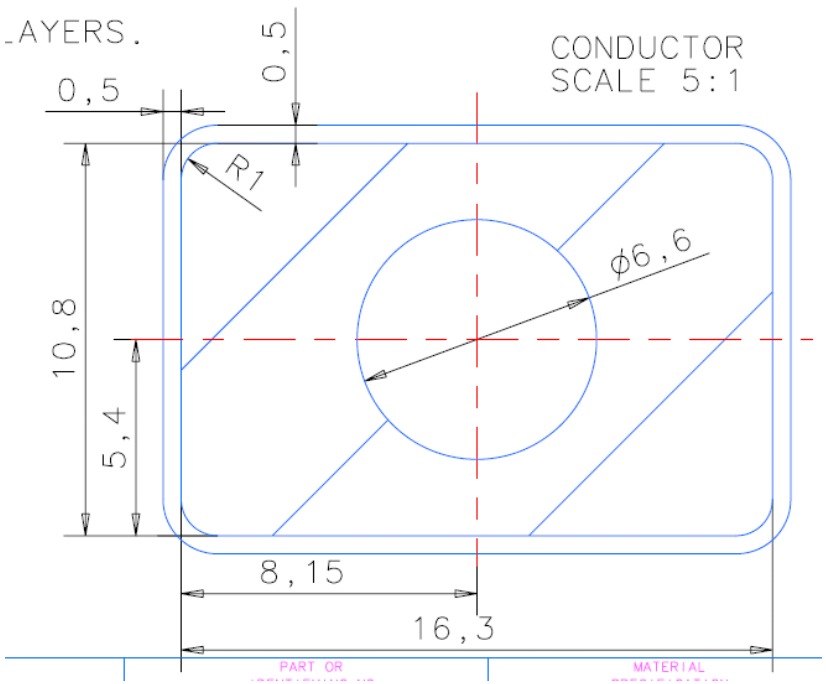
Dimensions of the coil



3.) Techn. Specs.: Parameter List (SR-Dipole)

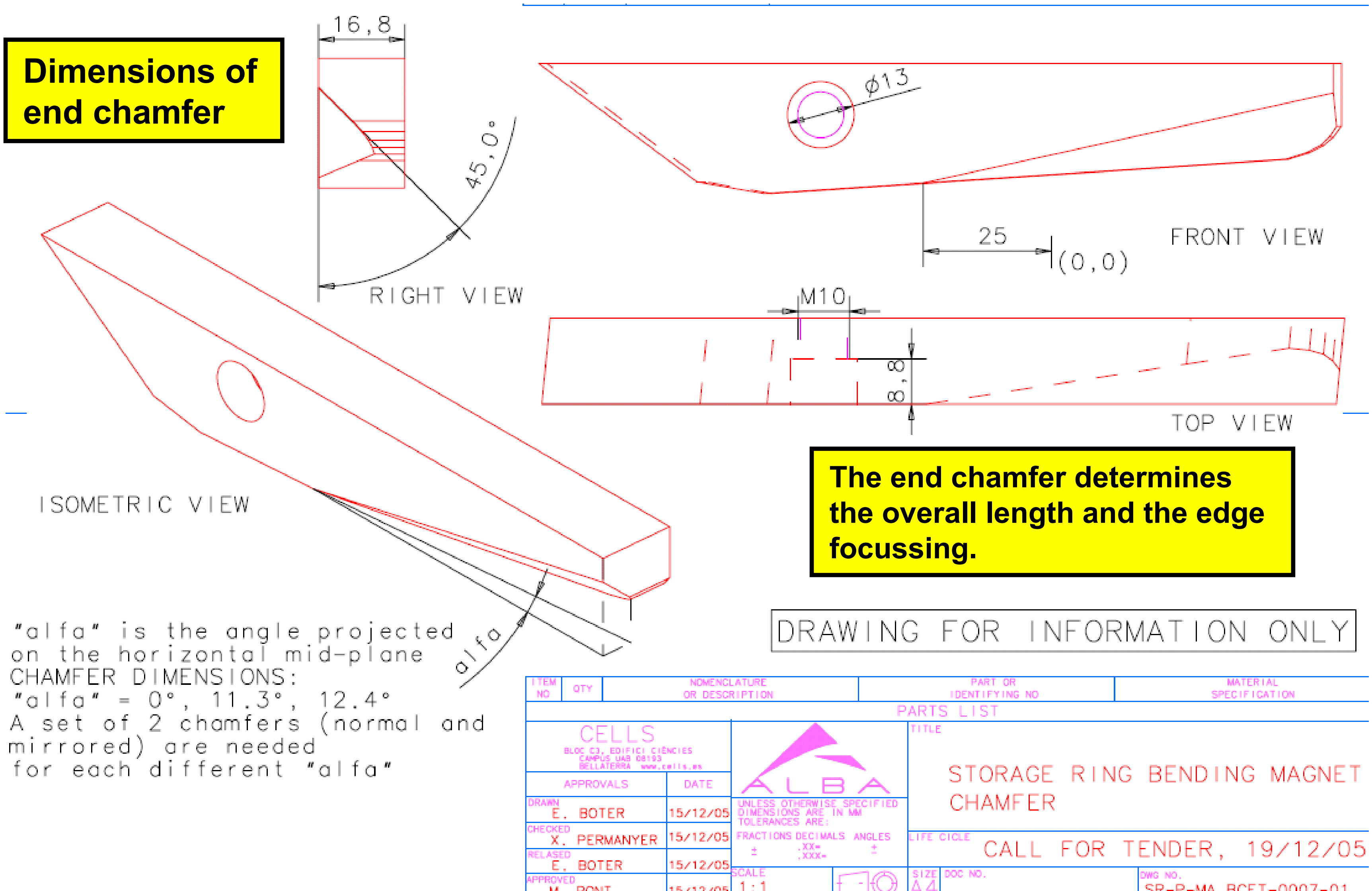


Dimensions of the coil. The coil exist of 4 pancakes



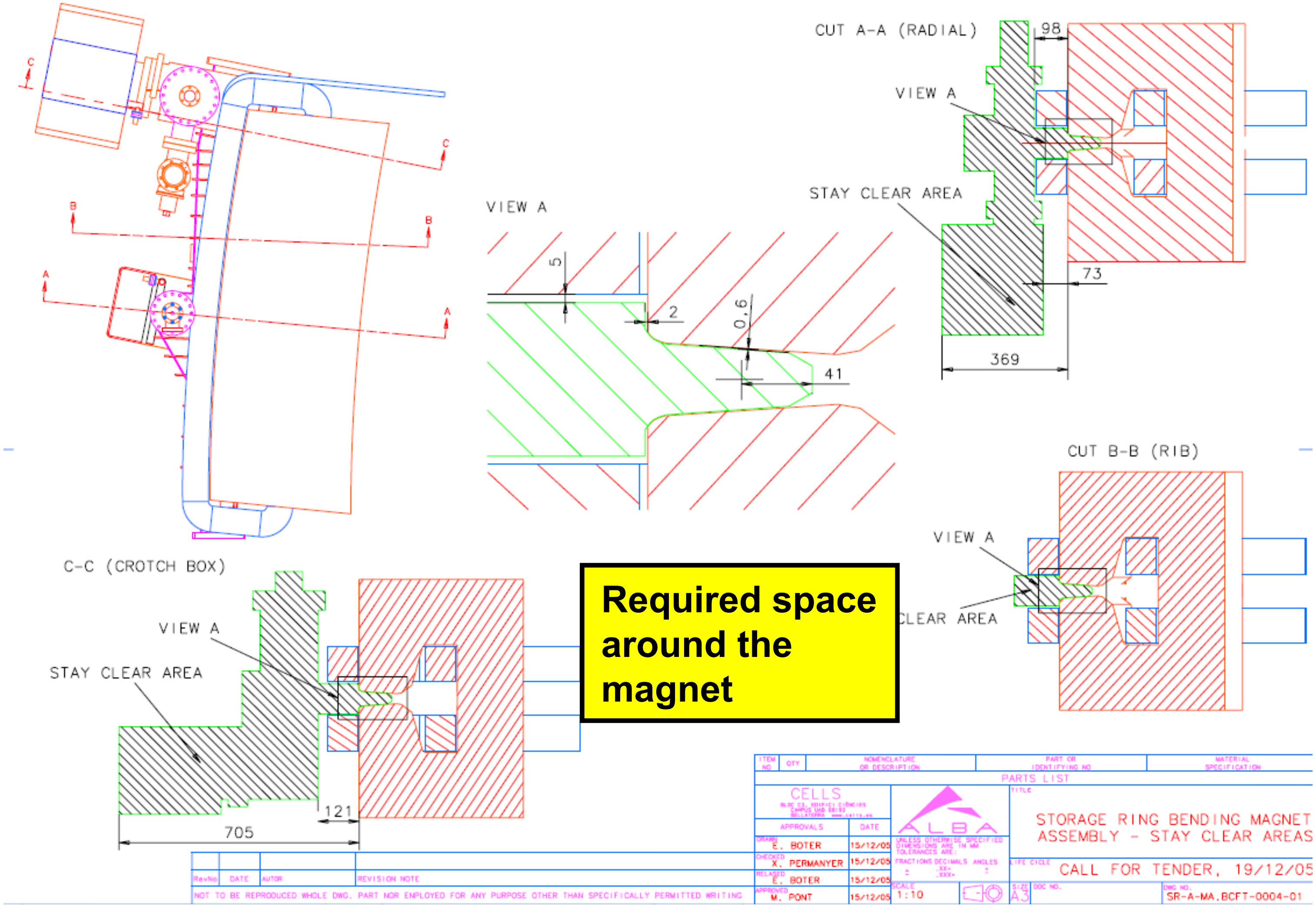
3.) Techn. Specs.: Parameter List (SR-Dipole)

Dimensions of end chamfer



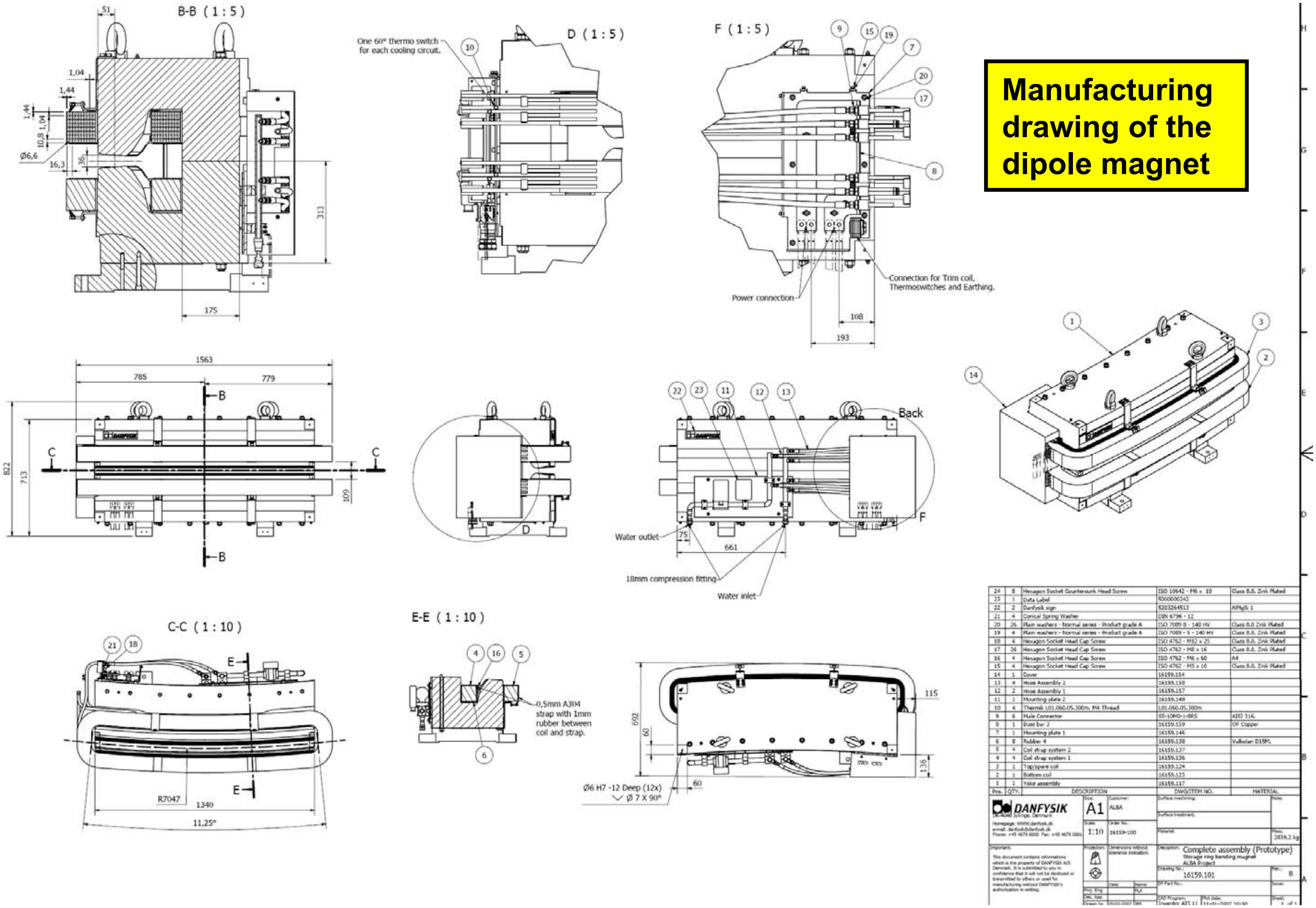
The end chamfer determines the overall length and the edge focussing.

3.) Techn. Specs.: Parameter List (SR-Dipole)



Required space around the magnet

Manufacturing drawing of the dipole magnet



Pos.	QTY.	DESCRIPTION	DWG/ITEM NO.	MATERIAL
24	8	Hexagon Socket Countersunk Head Screw	ISO 10642 - M6 x 10	Class 8.8. Zink Plated
23	1	Data Label	5000000342	
22	2	Danfysik sign	5203264513	AlMgSi 1
21	4	Conical Spring Washer	DIN 6796 - 12	
20	26	Plain washers - Normal series - Product grade A	ISO 7089 8 - 140 HV	Class 8.8 Zink Plated
19	4	Plain washers - Normal series - Product grade A	ISO 7089 - 5 - 140 HV	Class 8.8. Zink Plated
18	4	Hexagon Socket Head Cap Screw	ISO 4762 - M12 x 25	Class 8.8. Zink Plated
17	26	Hexagon Socket Head Cap Screw	ISO 4762 - M8 x 16	Class 8.8. Zink Plated
16	4	Hexagon Socket Head Cap Screw	ISO 4762 - M6 x 60	A4
15	4	Hexagon Socket Head Cap Screw	ISO 4762 - M5 x 10	Class 8.8. Zink Plated
14	1	Cover	16159.154	
13	4	Hose Assembly 2	16159.158	
12	2	Hose Assembly 1	16159.157	
11	1	Mounting plate 2	16159.149	
10	4	Thermik L01.060.05.300m, M4 Thread	L01.060.05.300m	
9	6	Male Connector	SS-10M0-1-8RS	AISI 316.
8	1	Buss bar 2	16159.159	OF Copper
7	1	Mounting plate 1	16159.146	
6	8	Rubber 4	16159.138	Vulkolan D15M.
5	4	Coil strap system 2	16159.137	
4	4	Coil strap system 1	16159.136	
3	1	Top/spare coil	16159.124	
2	1	Bottom coil	16159.123	
1	1	Yoke assembly	16159.117	

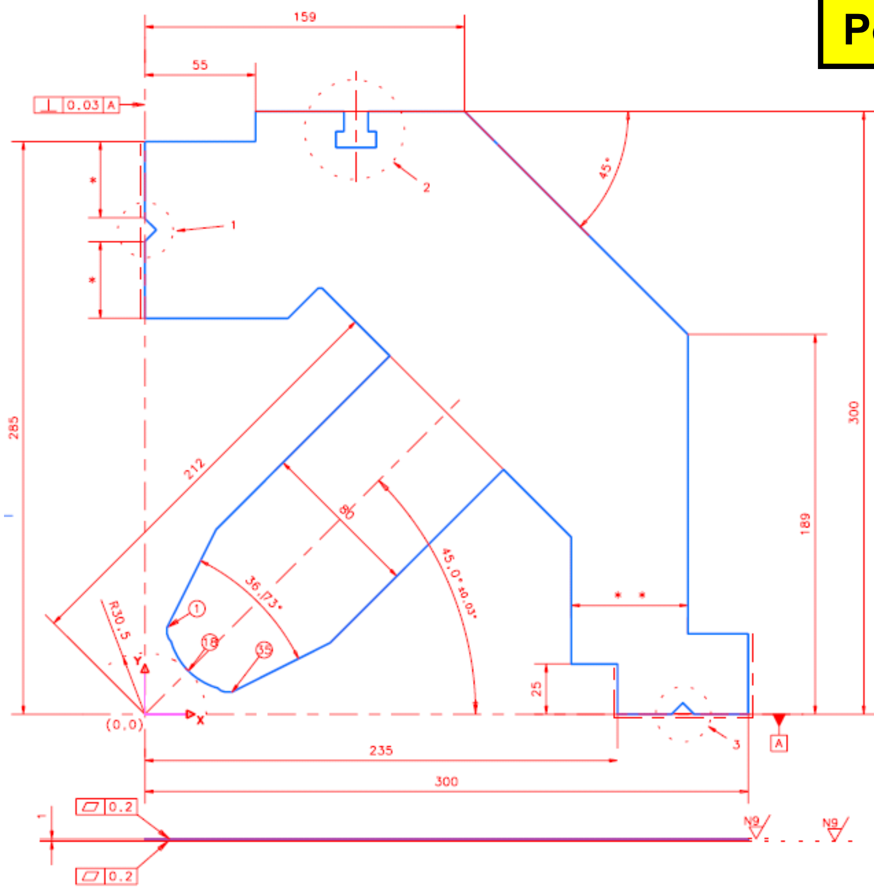
Parameters of the ALBA Quadrupoles

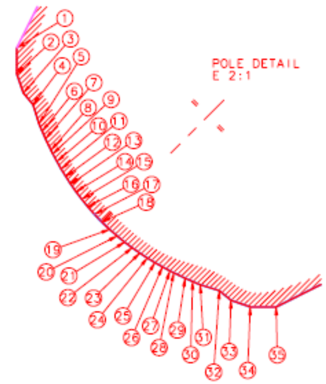
Storage Ring Quadrupole Magents					
		Q200	Q260	Q280	Q500
Magnetic properties					
Beam Energy (E)	GeV	3	3	3	3
Field gradient (Go)	T/m	19.8	21	21.4	21.9
Sextupole component (B")	T/(m^2)	0	0	0	0
Effective length (Lo)	m	0.23	0.29	0.31	0.53
Mechanical properties					
Aperture radius	mm	30.5	30.5	30.5	30.5
Length of Fe-yoke L(Fe)	m	0.2	0.26	0.28	0.5
Maximum length of magnet	m	0.298	0.358	0.378	0.598
Coil and conductor					
Number of coils		4	4	4	4
Number of turns per coil		46	46	46	46
Concductor size	mm^2	8*8	8*8	8*8	8*8
Cooling channel diameter (D)	mm	5	5	5	5
Number of ampere turns per coil	A-turns	7327	7771	7919	8104
Current (I)	A	160	169	172.1	176.2
Current density (j)	A/mm^2	3.59	3.81	3.88	3.97
Resistance at 23 degrees	mΩ	51.9	60.8	63.8	96
Inductivity	mH	24.6	32.4	34.6	59.2
Voltage drop	V	8.26	10.3	11	16.9
Power	kW	1.32	1.73	1.89	2.98
Cooling					
Maximim DT	Celsius	8	8	8	8
Nominal input temperature	Celsius	23	23	23	23
Number of cooling circuits per coil		2	2	2	4
Maximum pressure drop per magnet	bar	7	7	7	7

Booster Quadrupole Magents				
		QS180	QS340	QC340
Magnetic properties				
Beam Energy (E)	GeV	3	3	3
Field gradient (Go)	T/m	17.45	17.45	17.45
Sextupole component (B")	T/(m^2)	0	0	5
Effective length (Lo)	m	0.2	0.36	0.36
Mechanical properties				
Aperture radius	mm	18	18	18
Length of Fe-yoke L(Fe)	m	0.18	0.34	0.34
Maximum length of magnet	m	0.28	0.44	0.44
Coil and conductor				
Number of coils		4	4	4
Number of turns per coil		17	17	17
Concductor size	mm^2	5*5	5*5	5*5
Cooling channel diameter (D)	mm	3	3	3
Number of ampere turns per coil	A-turns	2250	2250	2250
Current (I)	A	132.4	132.4	132.4
Current density (j)	A/mm^2	3.78	4.02	4.22
Resistance at 23 degrees	mΩ	34.6	59	59
Inductivity	mH	3	6	6
Voltage drop (resistive)	V	4.6	7.8	7.8
Power	W	606	1034	1034
Cooling				
Maximim DT	Celsius	8	8	8
Nominal input temperature	Celsius	23	23	23
Number of cooling circuits per coil		1	1	1
Maximum pressure drop per magne	bar	7	7	7

3.) Techn. Specs.: Parameter List (Quadrupole)

Pole profile





Pole coordinate tolerances ±0.015

Form tolerance (0.03) for all points of the surface marked by

Form tolerance (0.1) for all points of the surface without any mark

1,2,3 To be defined by the manufacturer.

* Total lenght of combined faces to be 80mm or greater
* * Minimum length of 58mm

Pole angle is mandatory

Mating face features are shown for illustration purpose only. Final details will be the responsibility of the manufacturer to meet the tolerances of the assembled magnets

Point	X	Y
1	11.000	43.200
2	11.000	40.000
3	11.825	37.608
4	13.033	36.158
5	13.767	33.784
6	14.161	32.846
7	14.575	31.907
8	15.250	30.500
9	15.484	30.031
10	15.991	29.092
11	16.517	28.153
12	17.089	27.215
13	17.700	26.277
14	18.356	25.338
15	19.060	24.400
16	19.829	23.461
17	20.646	22.523
18	21.567	21.567
19	22.523	20.646
20	23.461	19.829
21	24.400	19.060
22	25.338	18.356
23	26.277	17.700
24	27.215	17.089
25	28.153	16.517
26	29.092	15.991
27	30.031	15.484
28	30.500	15.250
29	31.907	14.575
30	32.846	14.161
31	33.784	13.767
32	36.158	13.033
33	37.608	11.825
34	40.000	11.000
35	43.200	11.000

PARTS LIST

CELLS — ALBA

QUADRUPOLE
Lamination Type CX

DRAWN	Ll. Ribó	09/06/05
CHECKED	E. Boter	13/07/05
RELASED	M. Pont	14/07/05
APPROVED	D. Einfeld	14/07/05

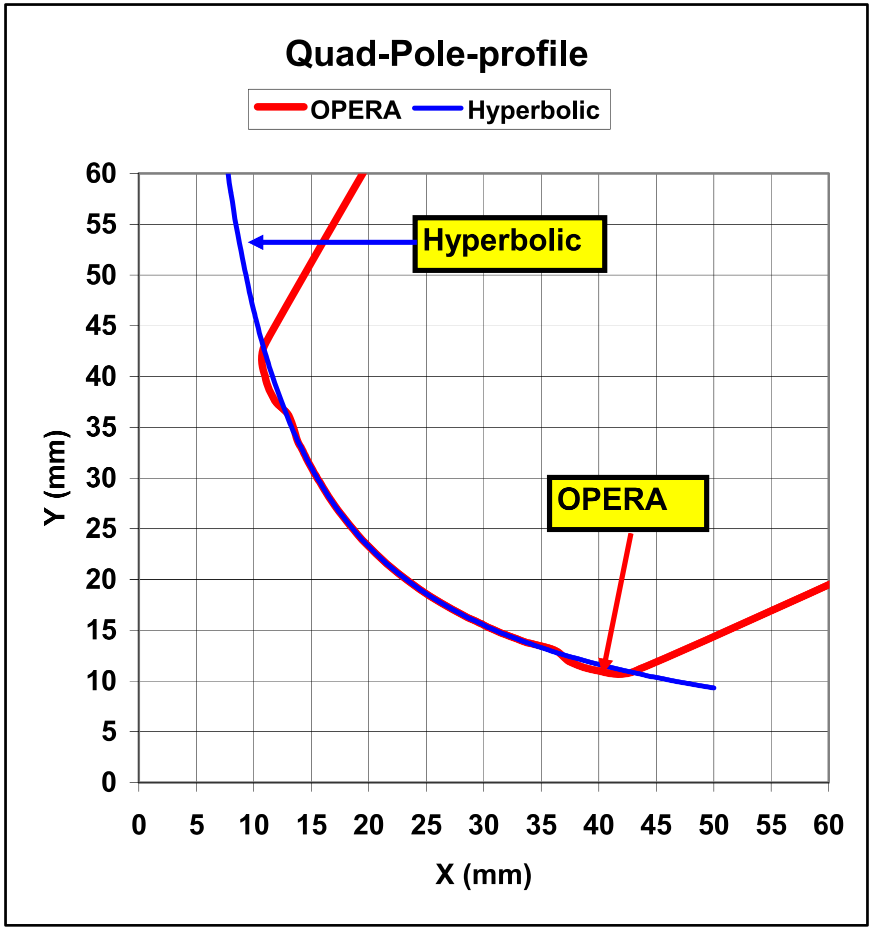
SCALE 1:2 — SIZE A3

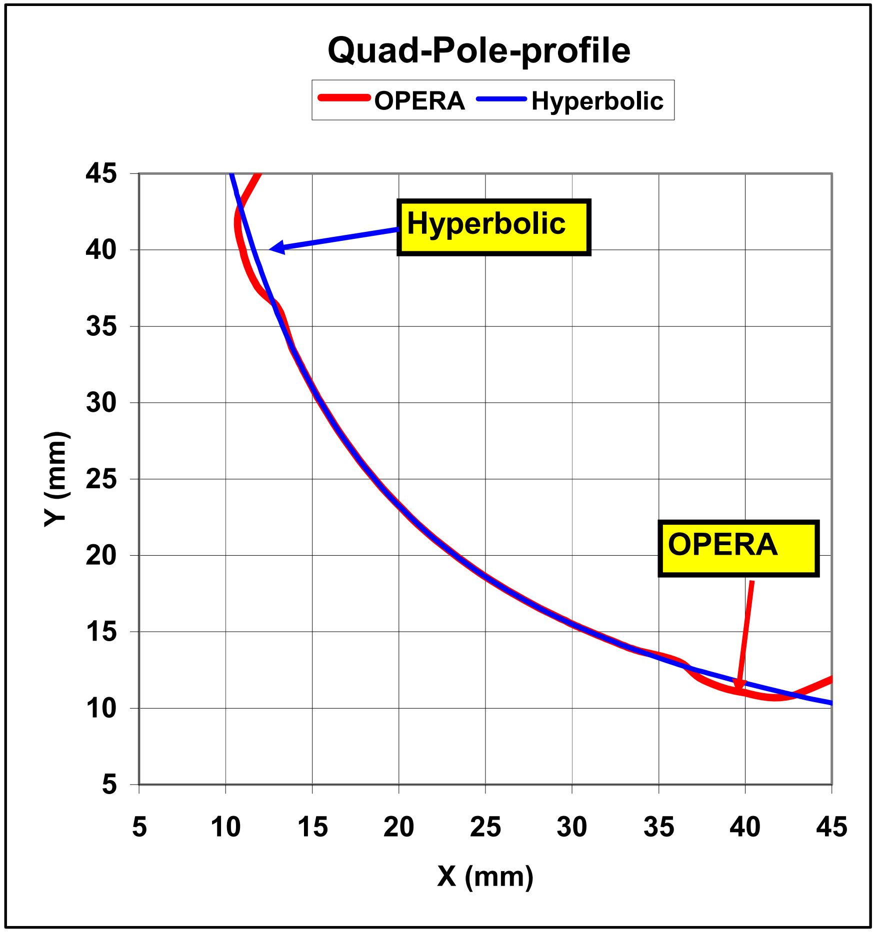
CALL FOR TENDER, 19/07/05

DWG NO. SR-P-MA.QCFT-0001-01

3.) Techn. Specs.: Parameter List (Quadrupole)

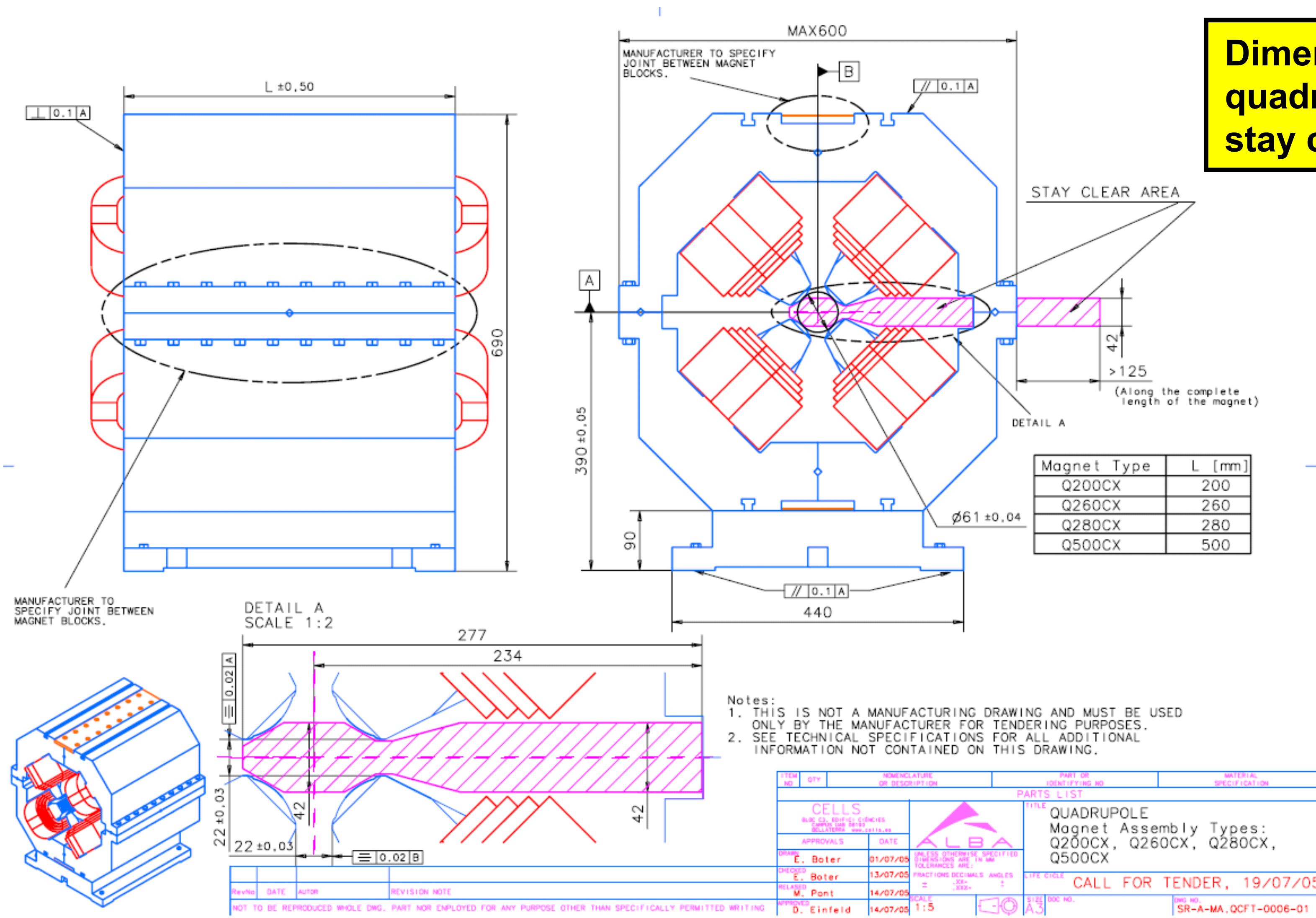
Quadrupole Pole Profile





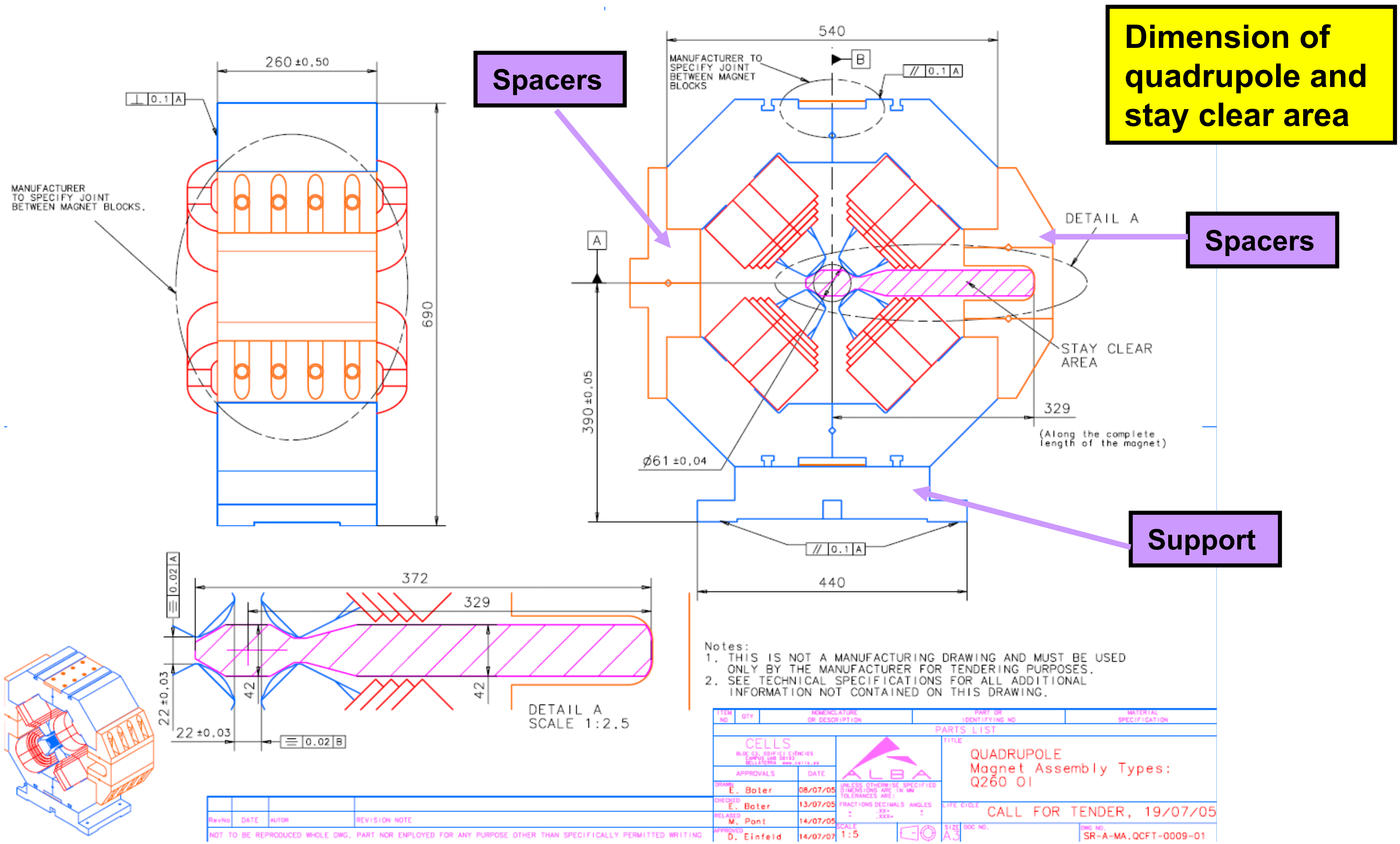
3.) Techn. Specs.: Parameter List (Quadrupole)

Dimension of quadrupole and stay clear area



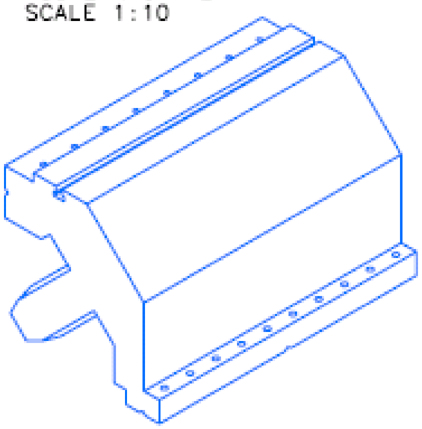
Magnet Type	L [mm]
Q200CX	200
Q260CX	260
Q280CX	280
Q500CX	500

3.) Techn. Specs.: Parameter List (Quadrupole)

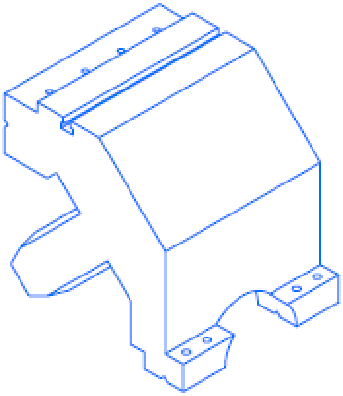


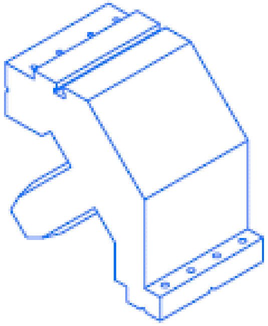
3.) Techn. Specs.: Parameter List (Quadrupole)

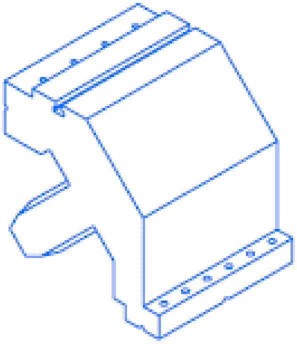
Different quadrupole types

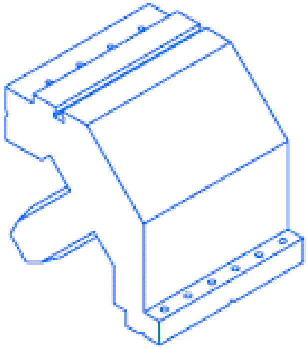


Quadrupole Type	Length(L)
Q500CX	500
Q280CX	280
Q260CX	260
Q200CX	200

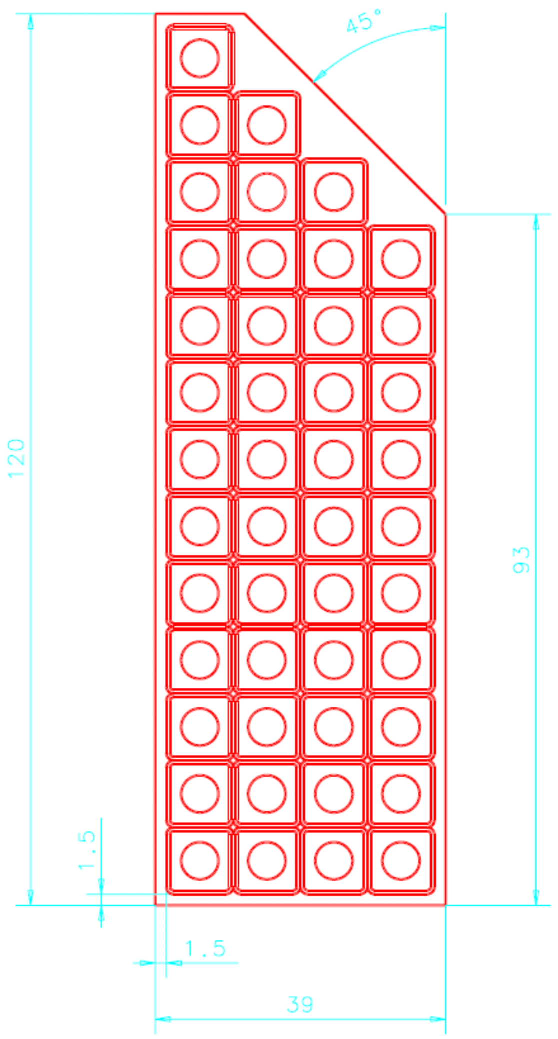




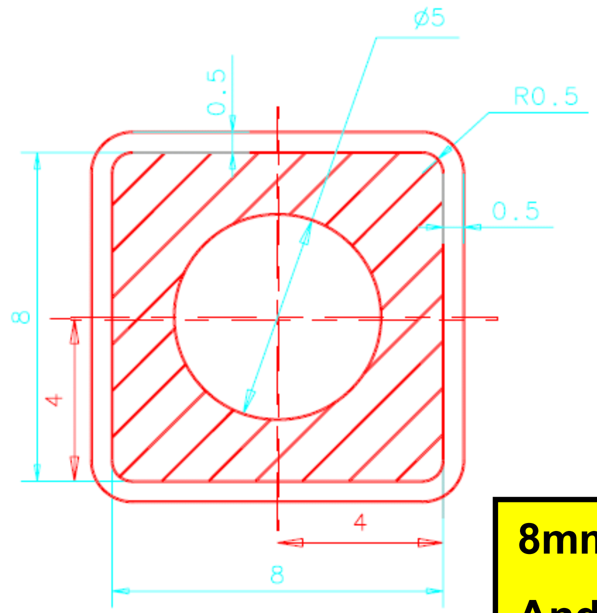




3.) Techn. Specs.: Parameter List (Quadrupole)



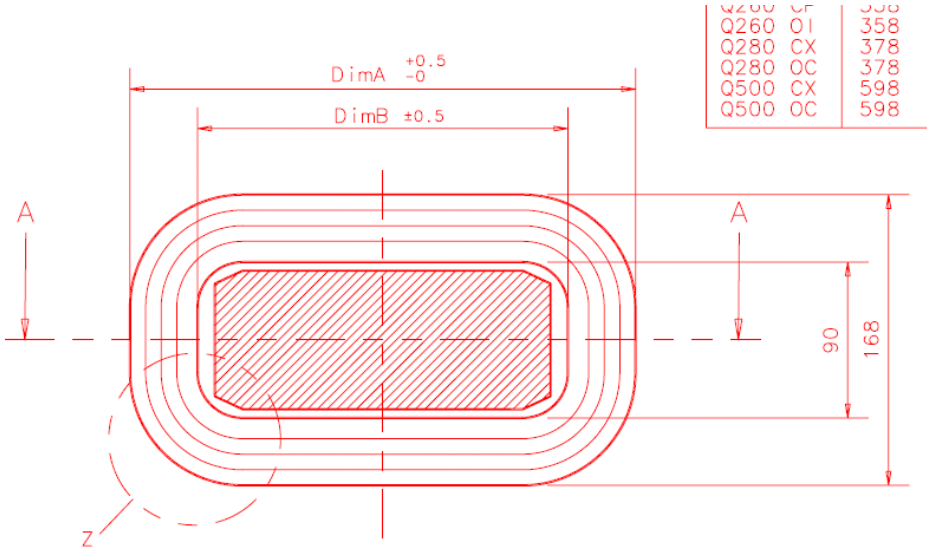
Dimension of coil.



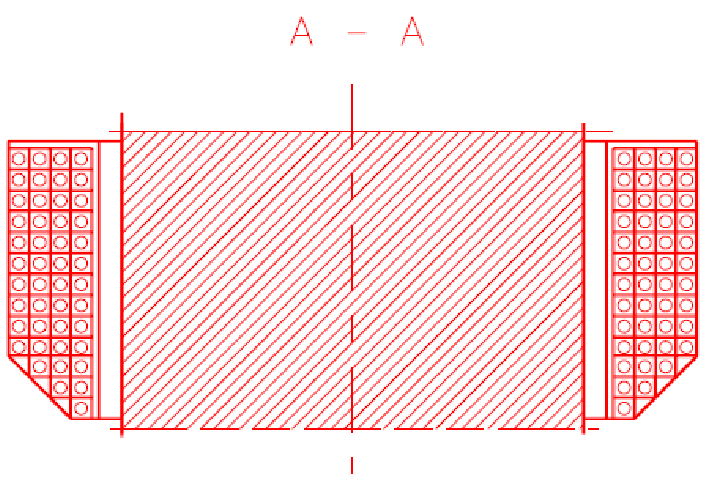
8mm*8 mm

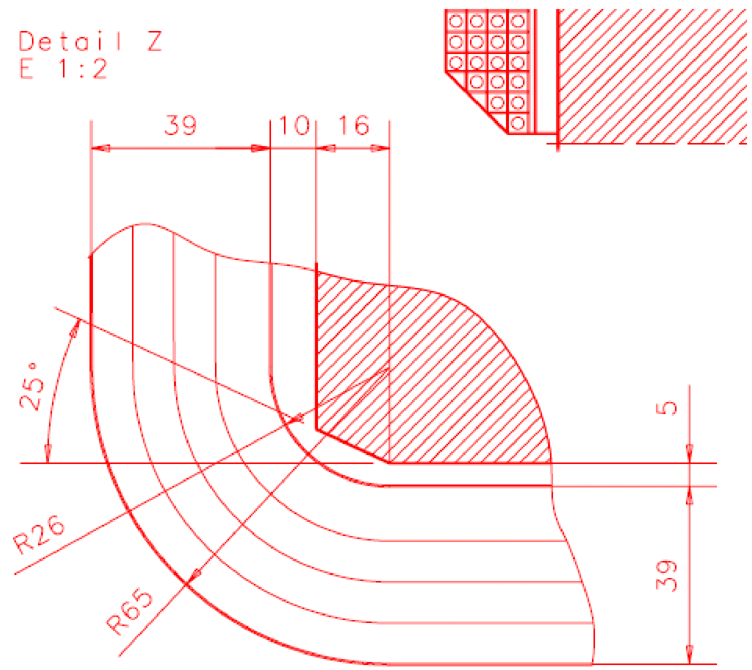
And D = 5 mm

3.) Techn. Specs.: Parameter List (Quadrupole)



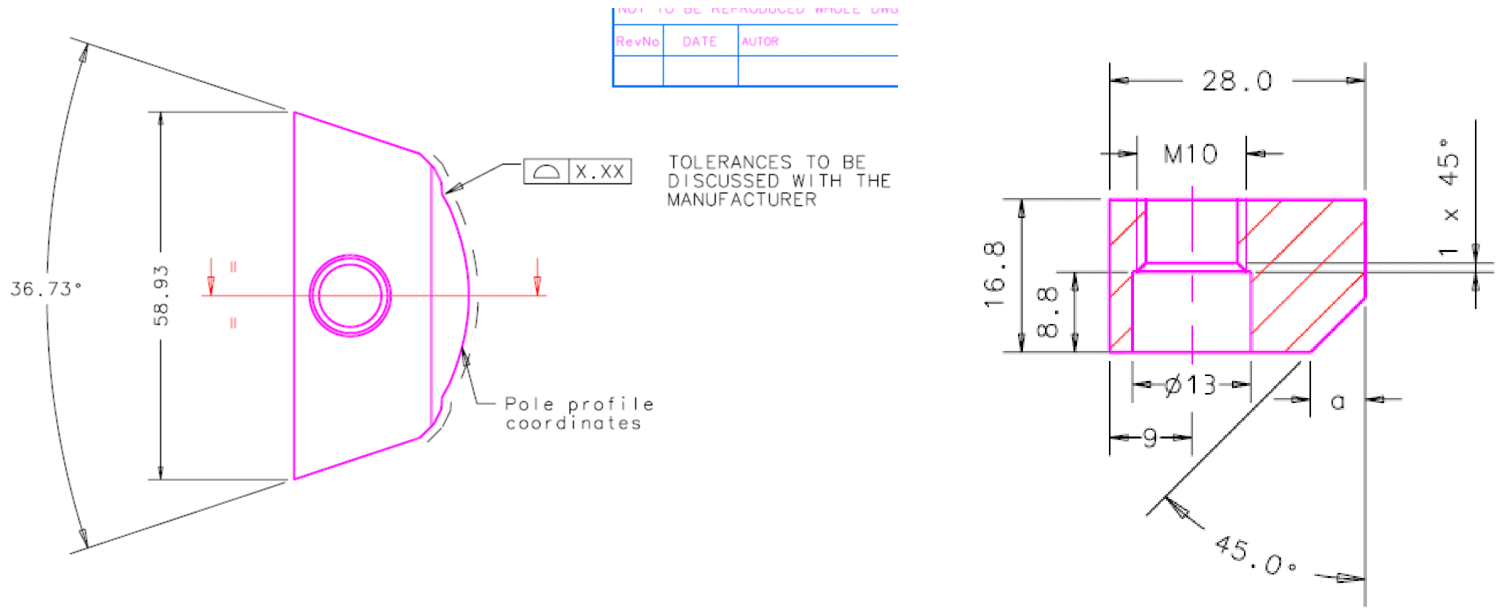
Dimension of coils and the winding around the yoke



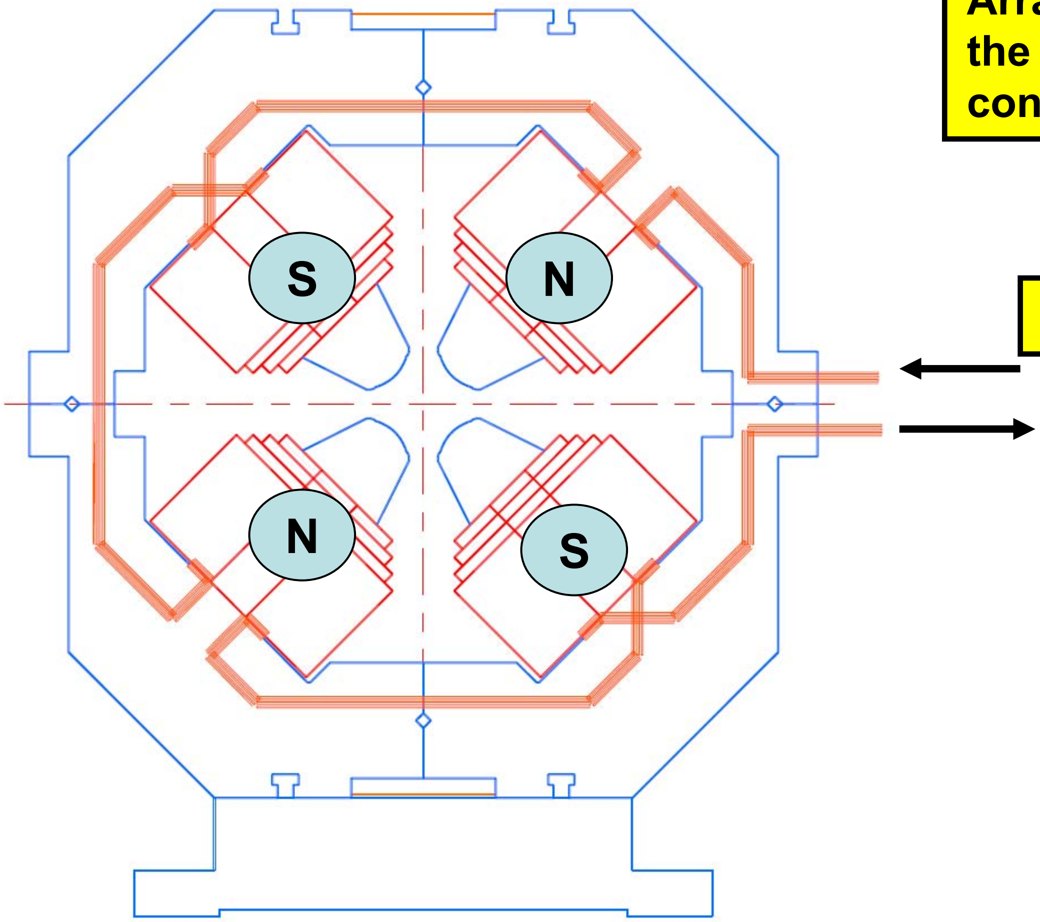


3.) Techn. Specs.: Parameter List (Quadrupole)

End chamfer to reduce the 6th multipole.



3.) Techn. Specs.: Parameter List (Quadrupole)

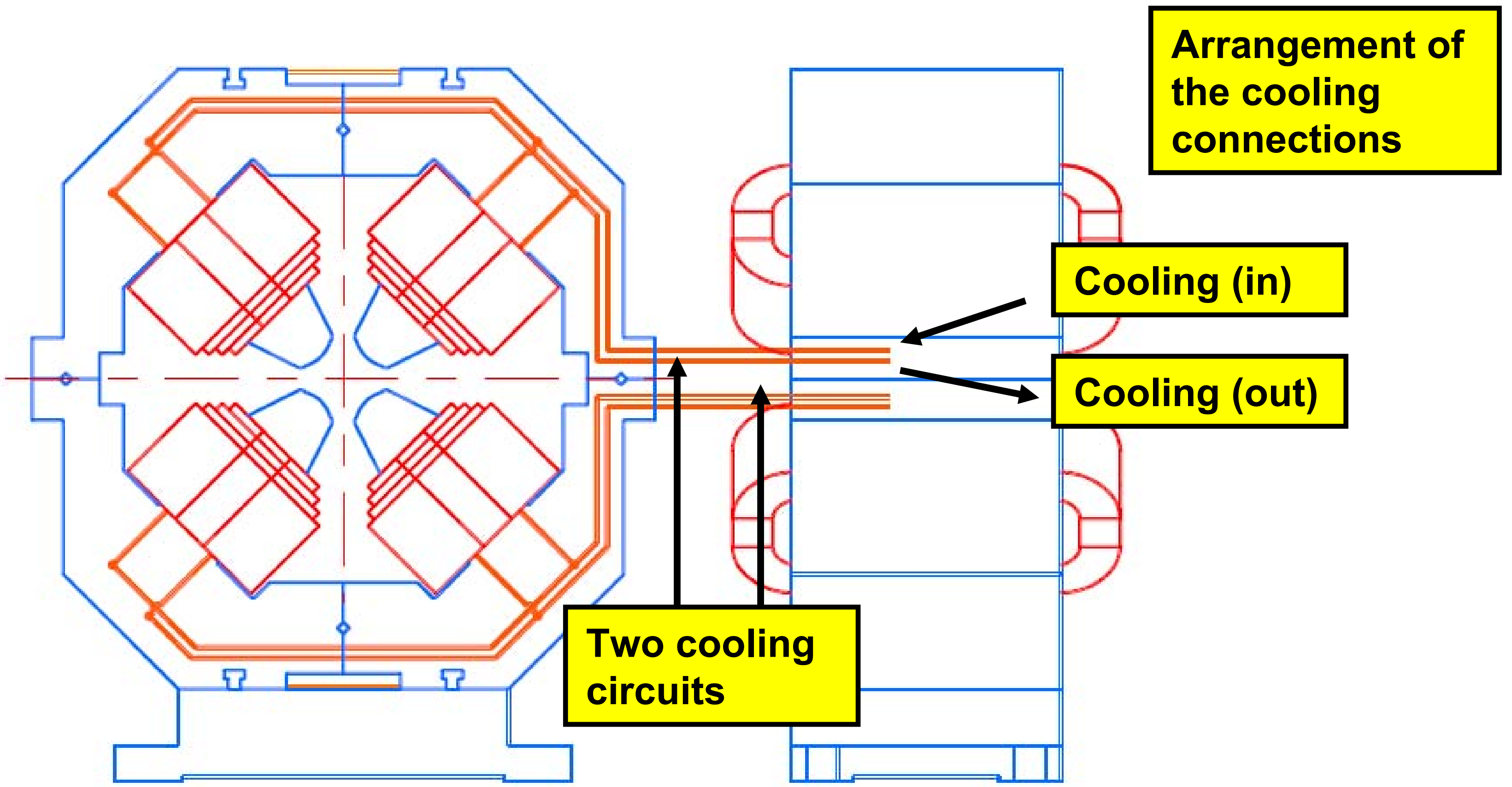


Arrangement of the coil connections

I(in)

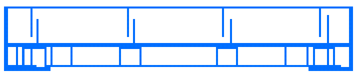
I(out)

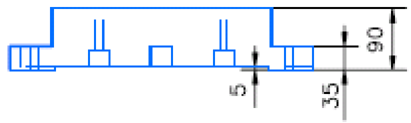
3.) Techn. Specs.: Parameter List (Quadrupole)

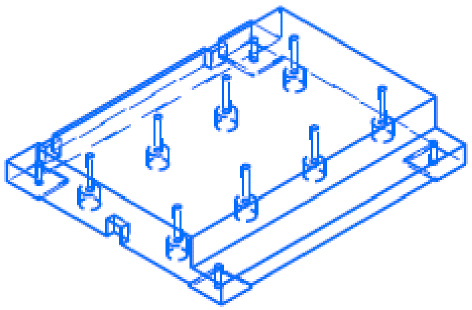


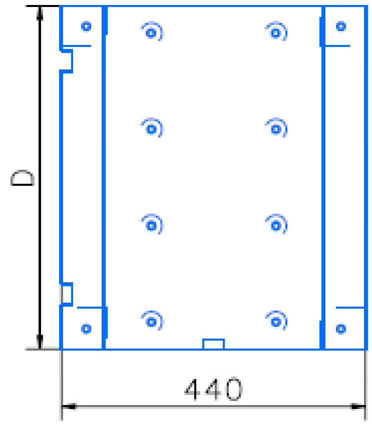
3.) Techn. Specs.: Parameter List (Quadrupole)

Groundplate





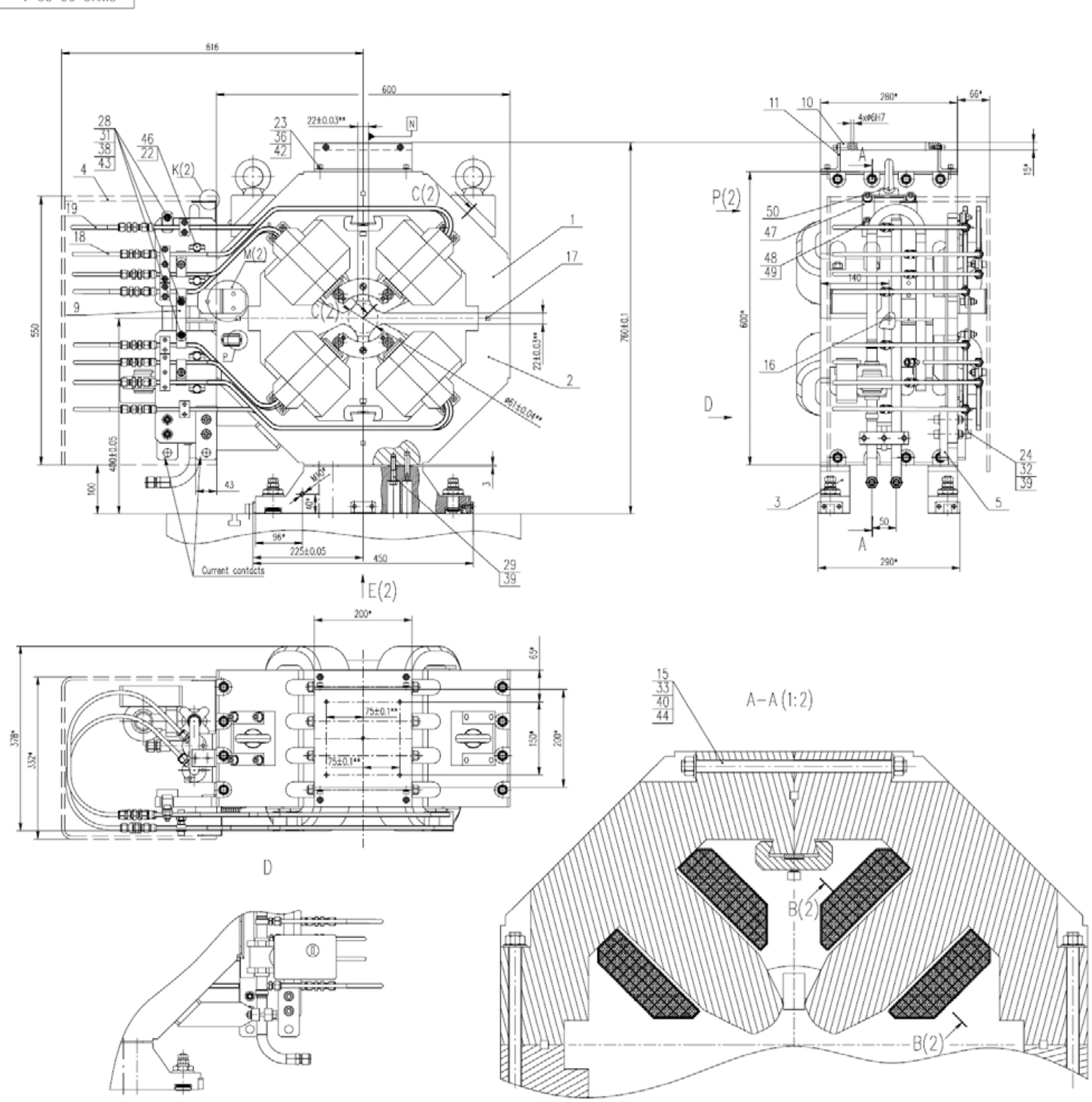


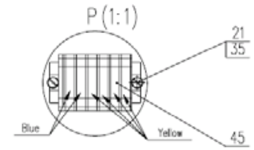


Magnet Type	Support Length (D) [mm]
Q200 CX	200
Q260 CX	260
Q260 CP	260
Q260 OI	260
Q280 CX	280
Q280 OC	280
Q500 CX	500
Q500 OC	500

Magnetic axes should be the closed orbit

Manufacturing drawing of the quadrupole magnet





1. * Reference dimensions.
2. Unless otherwise stated tolerances are H12, h12, ±IT12/2.
3. Prior to parts items 1, 2 assembly clean closed contact surfaces from foreign inclusions. Durt, swarf, fat stains etc. are not allowed.
4. Prior to parts items 1, 2 clamping with fasteners items 15, 33, 40, 44 match parts faces; deviation shall not be more than 0.15 mm.
   After fasteners tightening drill holes for pins item 16; ensure a tightness of 0.005 ... 0.03 mm.
5. After stands item 3 assembly fix them with pins item 16. Holes for pins have to ensure a tightness of 0.005 ... 0.03 mm.
6. For electrical connections see electric circuits (Sheet 2).
7. Use removable transport block item 47 for magnet transportation.
8. Prior to transportation coat uncoloured surfaces of poles and input current contacts with a consistent grease.
9. Attach nameplate according to View P (Sheet 2).
10. During storage and transportation protect plate item 10 from damages according to Fig. 1 (Sheet 2).

CONTROL TESTS

1. After assembly completion measure dimensions indicated with the sign "**".
   Write results down to magnet passport.
2. Measure insulation resistance:
   apply 5 kV DC voltage between coils ends and core for 1 min. Write leakage current; it shall not be more than 500 mcA. Breakdowns are not allowed.
3. Test at peak operating current:
   apply peak operating current of 191 A for 2 hours; ensure cooling distilled water pressure drop of 7 atm at that. Measure flow rate & inlet / outlet water temperature. Measure temperature of coils surfaces, connections and outputs with contact thermometers; accuracy 1°C.
   Any coil with signs of breakdown, local hot spots or other defects should be rejected.
4. At the close of tests at peak operating current measure voltage drop on lens coils ends and calculate a resistance.
5. Check thermoswitches operation:
   connect magnet to test bench and heat coils with current to 60°C (at low water flow), cool after that.
   Control conductor temperature with accuracy of 1°C by electrical resistance. Fix actuation (i.e. switching on/off) temperature of thermoswitches and flowmeter.
6. Test for tightness:
   connect nipples to test bench and pass no less than 5 liters of water. Plug nipple of drain branch and increase a pressure to 30 ... 33 atm. Dam pressure line forward of pressure gage. Observe lens hydrosystem for 15 min.
   If pressure drop is more than 10% or there are some leaks, remove defect origin.
7. Control water flow rate: feed water at 7 atm to pressure branch nipple. Water drain is free. Measure flow rate.
8. Write tests results down to the passport.

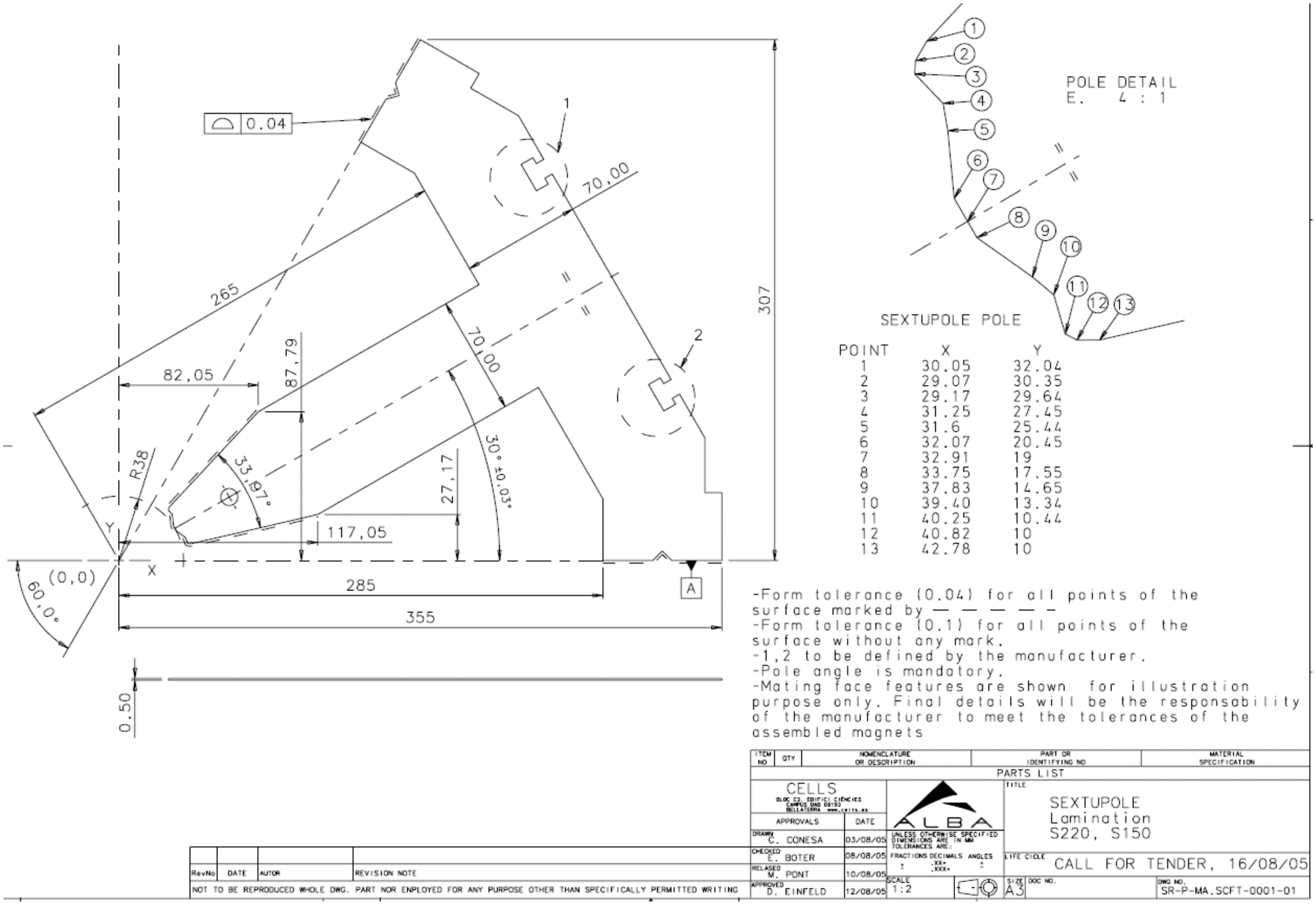
Rev.	Sheet	Docum. No	Signat.	Date	CWK6 00 00 As		
Designed		S.I.Ruvinskiy		21.03.08	Quadrupole Q280CX	Letter	Mass	Scale
Checked							525	1:4
			44-55			Sheet 1	of 2	
Approved						Institute of Nuclear Physics Novosibirsk, Russia		

Parameters of the ALBA Sextupoles

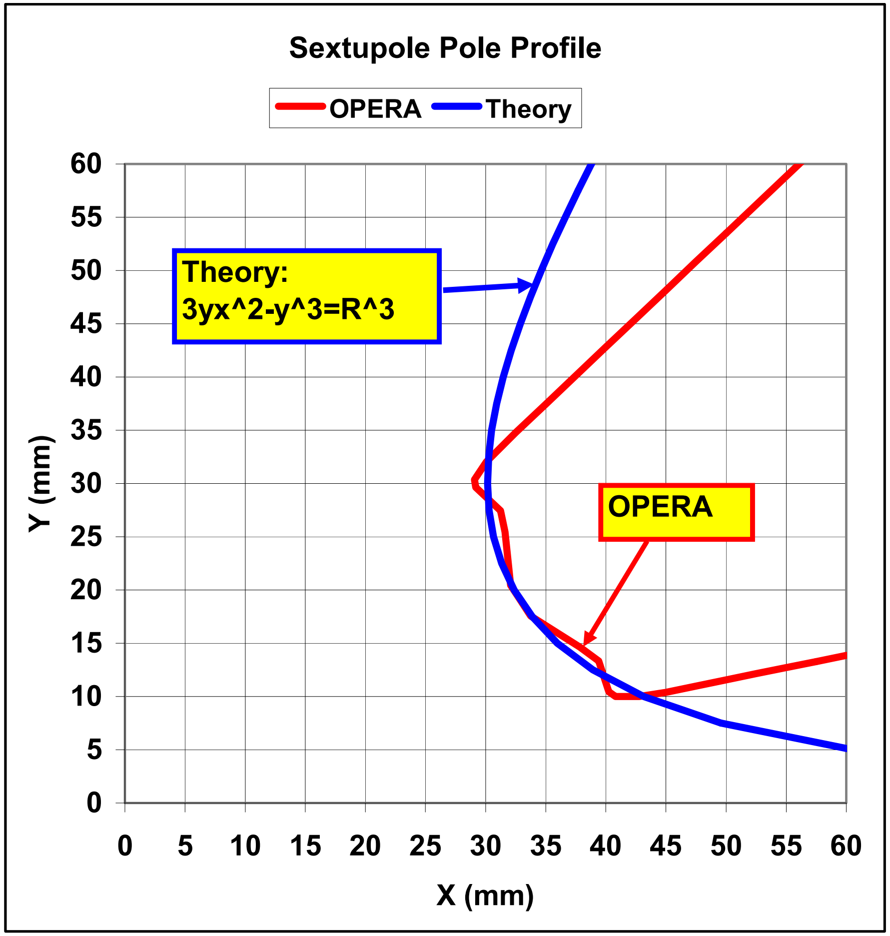
Storage Ring Sextupole Magents			
		S-150	S-220
Magnetic properties			
Beam Energy (E)	GeV	3	3
Sextupole component (B")	T/(m^2)	700	700
Magnetic field at pole tip	T	0.51	0.51
Effective length (Lo)	m	0.175	0.245
Mechanical properties			
Aperture radius	mm	38	38
Length of Fe-yoke L(Fe)	m	0.15	0.22
Maximum length of magnet	m	0.252	0.322
Coil and conductor			
Number of coils		6	6
Number of turns per coil		28	28
Concductor size	mm^2	7*7	7*7
Cooling channel diameter (D)	mm	3.5	3.5
Number of ampere turns per coil	A-turns	5094	5094
Current (I)	A	182	182
Current density (j)	A/mm^2	4.62	4.62
Resistance at 23 degrees	mΩ	54.2	60.1
Inductivity	mH	13.1	18.3
Voltage drop	V	9.87	11
Power	kW	1.8	2
Cooling			
Maximim DT	Celsius	9	9
Nominal input temperature	Celsius	23	23
Number of cooling circuits per coil		3	3
Maximum pressure drop per magnet	bar	5.6	7.46

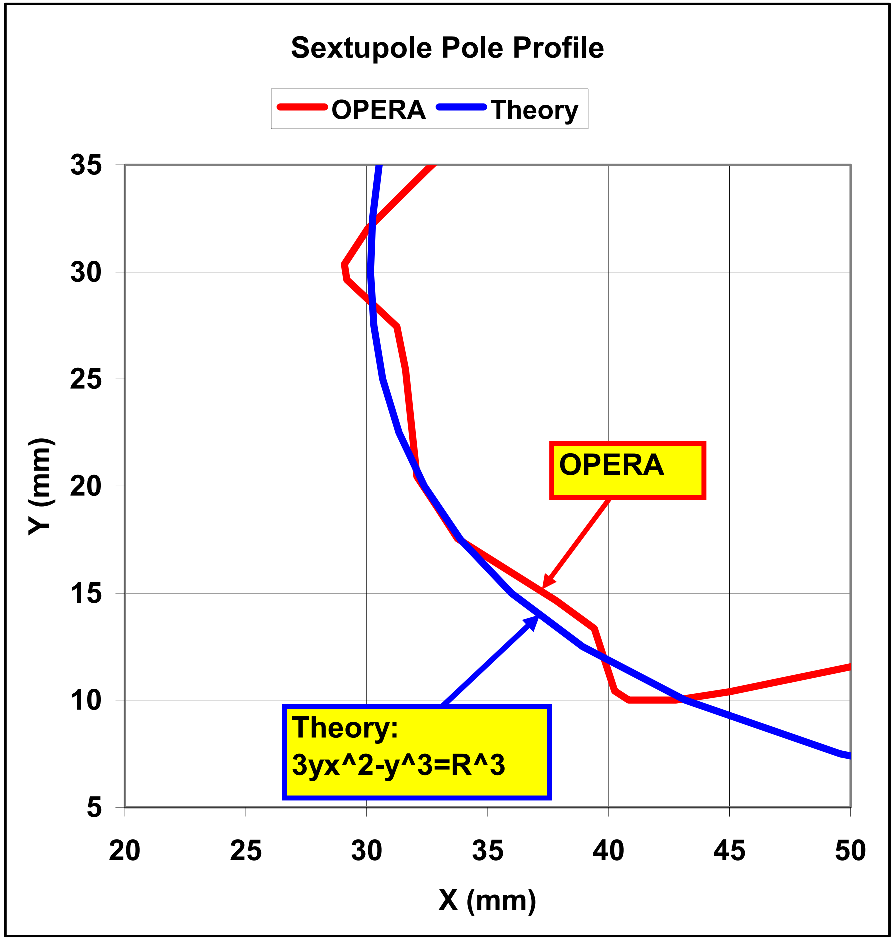
Booster Sextupole Magents		
		S-200
Magnetic properties		
Beam Energy (E)	GeV	3
Sextupole component (B")	T/(m^2)	400
Magnetic field at pole tip	T	0.065
Effective length (Lo)	m	0.2
Mechanical properties		
Aperture radius	mm	18
Length of Fe-yoke L(Fe)	m	0.2
Maximum length of magnet	m	0.3
Coil and conductor		
Number of coils		6
Number of turns per coil		50
Concductor size	mm^2	2.8*1
Cooling channel diameter (D)	mm	
Number of ampere turns per coil	A-turns	310
Current (I)	A	6.2
Current density (j)	A/mm^2	2.21
Resistance at 23 degrees	mΩ	886
Inductivity	mH	34
Voltage drop (resistive)	V	5.5
Power	W	33
Cooling		
Maximim DT	Celsius	
Nominal input temperature	Celsius	
Number of cooling circuits per coil		
Maximum pressure drop per magne	bar	

Parameters of the ALBA Sextupoles

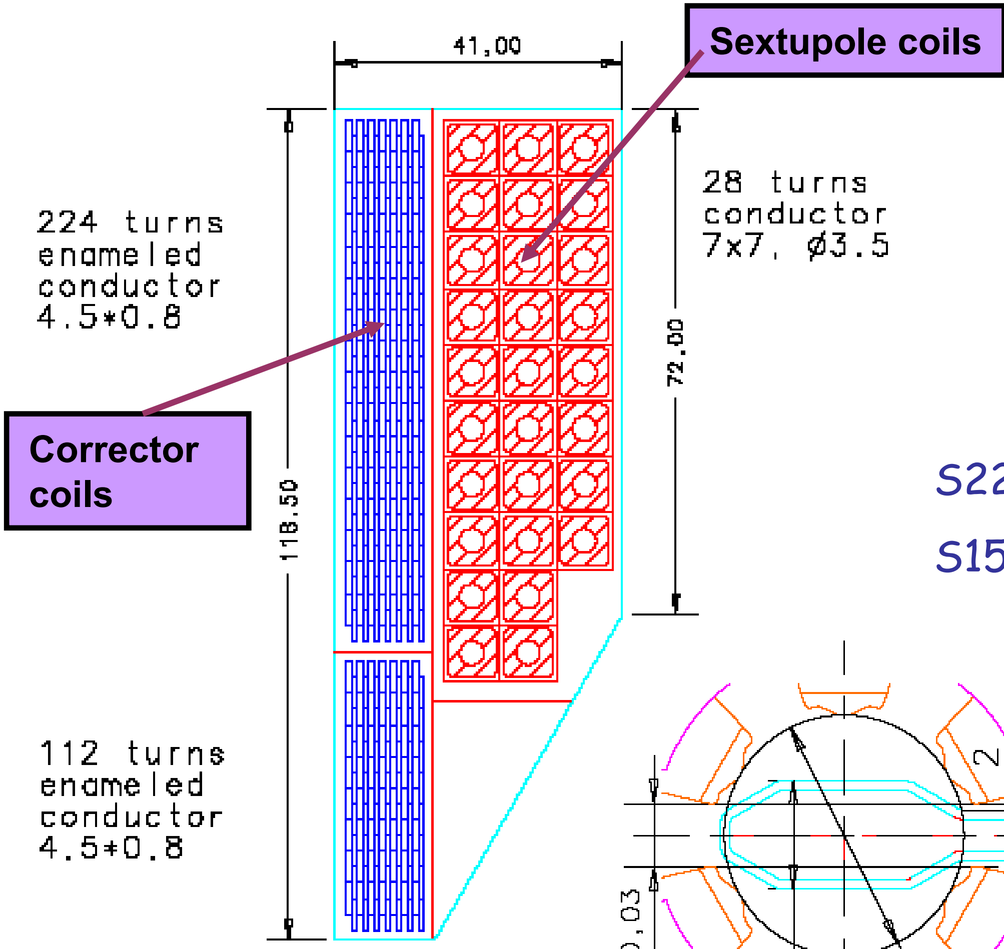


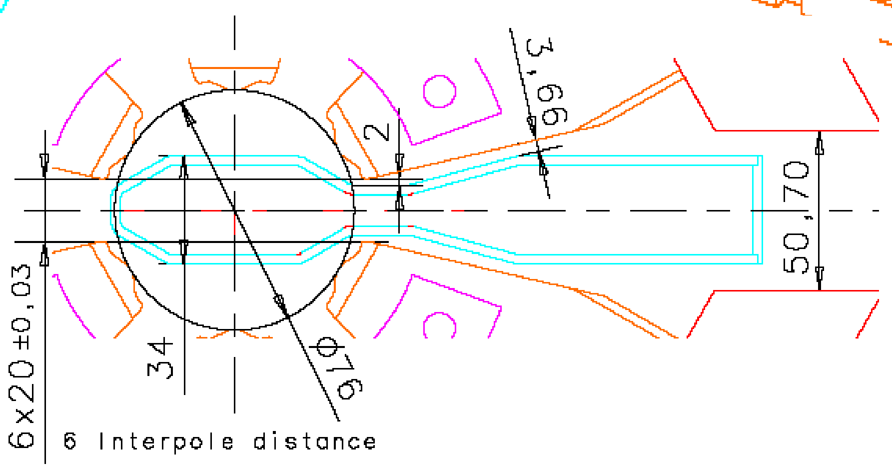
Parameters of the ALBA Sextupoles

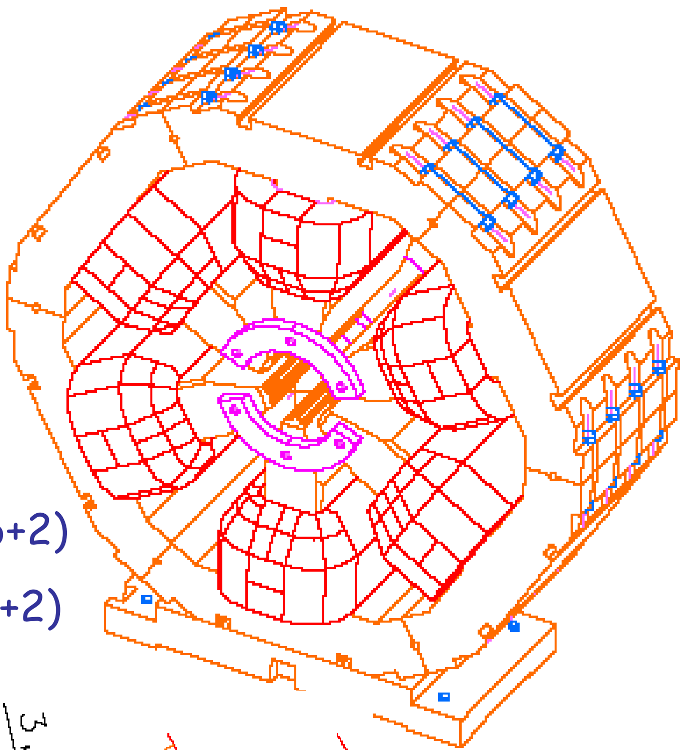




ALBA-Sextupoles: Mechanical design

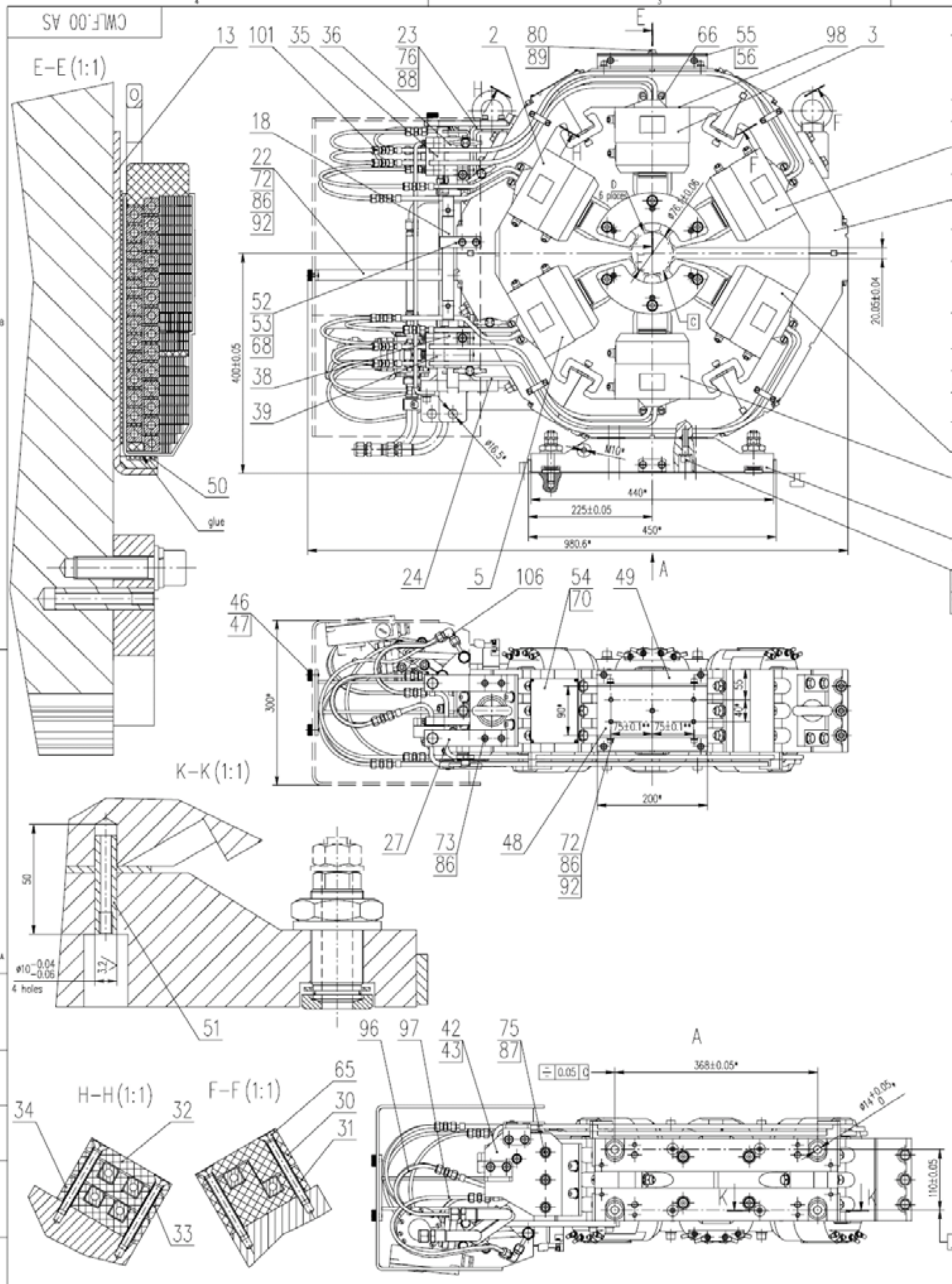


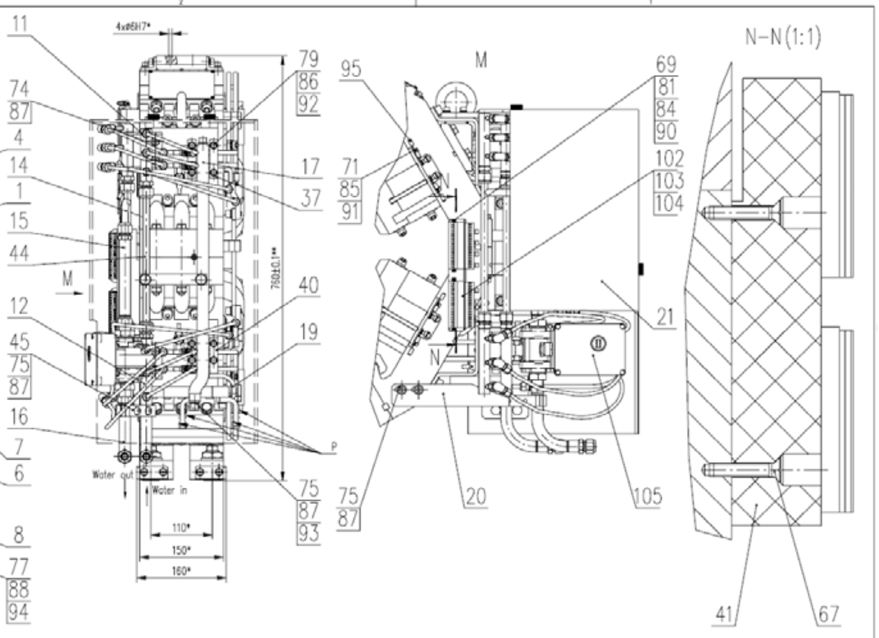




S220 (56+2)

S150 (64+2)





CONTROL TESTS

1. Measure insulation resistance: apply 5 kV DC voltage between ends of each sextupole coil and core for 1 min. Write leakage current.
   Any coil with signs of breakdown or considerable decrease of insulation resistance (R<10 MOhm) should be rejected.
2. Measure insulation resistance: apply 1 kV DC voltage between ends of each corrective coil and core for 1 min. Write leakage current.
   Any coil with signs of breakdown or considerable decrease of insulation resistance (R<10 MOhm) should be rejected.
3. Test with maximum operating direct current during sextupole coil drive current of 200 A (water pressure drop of 7 atm) for 2 hours. Control water temperature at the input and output.
   Measure temperature of coils surfaces, all cois connections and terminals with the help of contact thermometers (accuracy of 1℃). Estimate results at corresponding requirements to coils temperature.
   Any coil with signs of breakdown, local spots and other defects should be rejected.
4. Test with maximum operating direct current during corrective coil drive current of 10 A (water pressure drop of 7 atm) for 2 hours. Measure temperature of coils surfaces, all coils connections and terminals. Estimate results at corresponding requirements to coils temperature.
   Any coil with signs of breakdown, local spots and other defects should be rejected.
5. Test cooling channel hydraulic tightness: pass no less than 8 l of water at 30 ... 33 atm for 15 min.
   Magnet with any leaks in coils or connections should be rejected and reassembled.
6. Measure water flow at pressure drop of 7 atm. Water drainage should be free and steady.
   Write water flow down to the passport.
7. At the close of maximum operating current test measure voltage drop on lens ends and lens resistance.
8. Connect lens with test stand and heat coils with current and a low water flow to 65℃. Then cool to normal temperature (20℃±5℃). Control conductor temperature with accuracy of 1℃ by electrical resistance value. Make sure of thermoswitches operation (either sextupole coils or corrective ones).
9. Control efficiency of flowmeter maintenance: low decrease water input to live magnet.
10. Weight a magnet.
11. Write tests results down to magnet passport.

TECHNICAL REQUIREMENTS

1. * Reference dimensions.
2. Unless otherwise stated tolerances are H12, h12, ±IT12/2.
3. After installation of pins item 51 into parts item 8 center-punch connection place at 3 points.
4. Prior to assembly wipe poles surfaces and segments connected surfaces thoroughly, remove dust, durt and grease.
   After control measurements coat poles surfaces and uncoloured surfaces with a thin layer of consistent grease CIATIM-201.
5. Attach polyimide film item 98 to segments contact places.
6. After magnet final assembly measure pole-to-pole gap and a bore along all the length of magnet.
   Write measurement results down to magnet passport.
7. Perform electric connections according to electric circuits.
   Select conductors length on site.
   Sold noses item 95 with wires using POS-61 solder (Sn – 61%, Pb – the rest; soldering temperature 200℃).
   Connect "Wago" plug with conductors and links mechanically, with a help of special instruments.
8. Use "Loctite 577" fluid for water connections sealing.
   After hydrotests dry a channel with compressed air. 9. Fix coils with part item 50 (glue the part later).
10. After adjustment of plate item 48 fix it with glue. Then coat the plate with protective spacers items 55, 56.
11. After magnetic measurements fix adjusting screws with "Loctite 243" fluid.
12. During movement of magnet round a workshop and for transportation install protective shoes on rests item 8.
13. Prior to transportation coat surfaces D, P and all uncoloured surfaces with a thin layer of consistent grease CIATIM-201.
14. **The dimensions measure with accuracy ±0.03 mm and put into inspection report of the corresponding magnet.

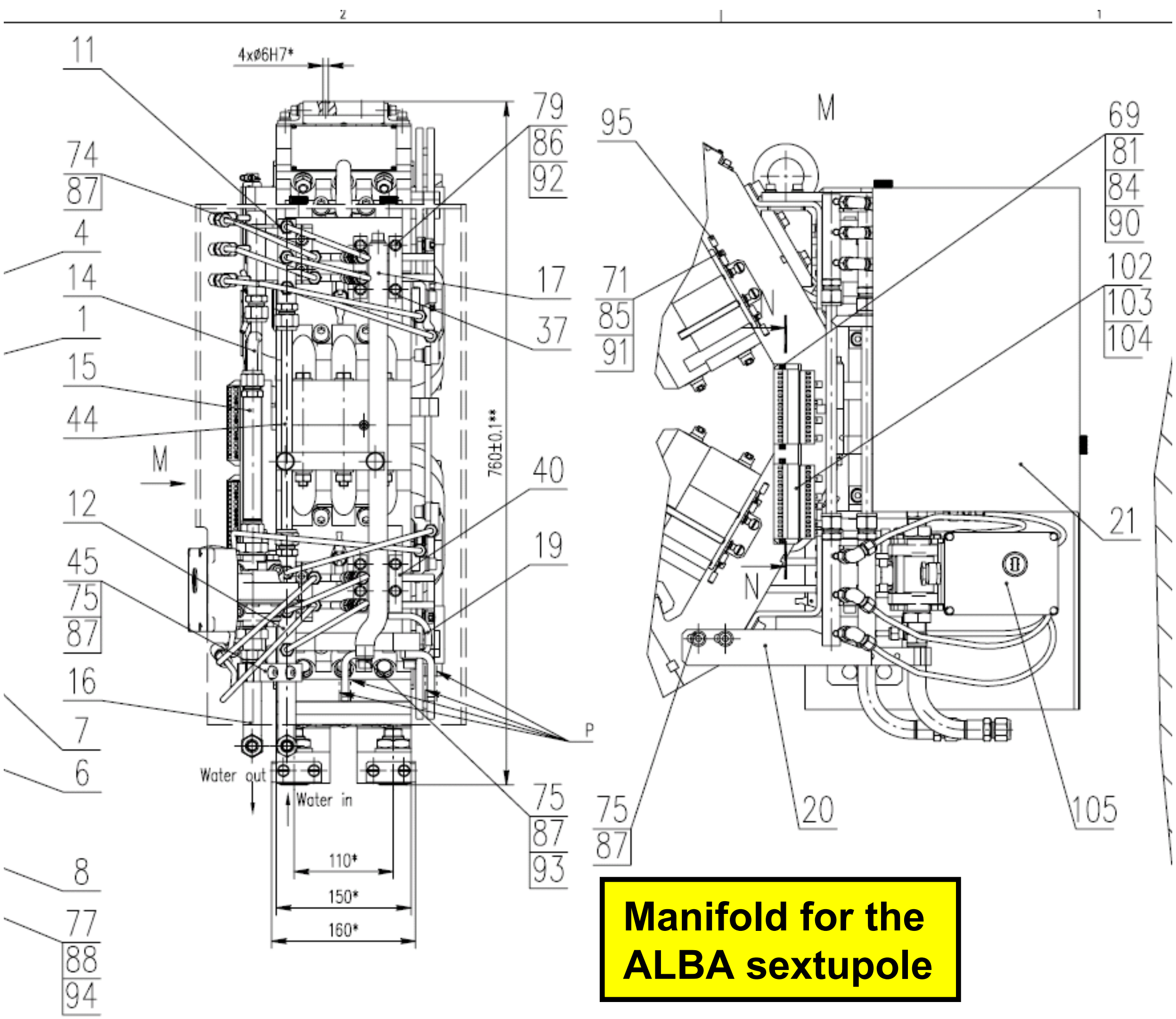
CWLF.00 AS

Sextupole magnet S150

387kg 1:4

Institute of Nuclear Physics Novosibirsk, Russia

ALBA-Sextupoles: Mechanical design

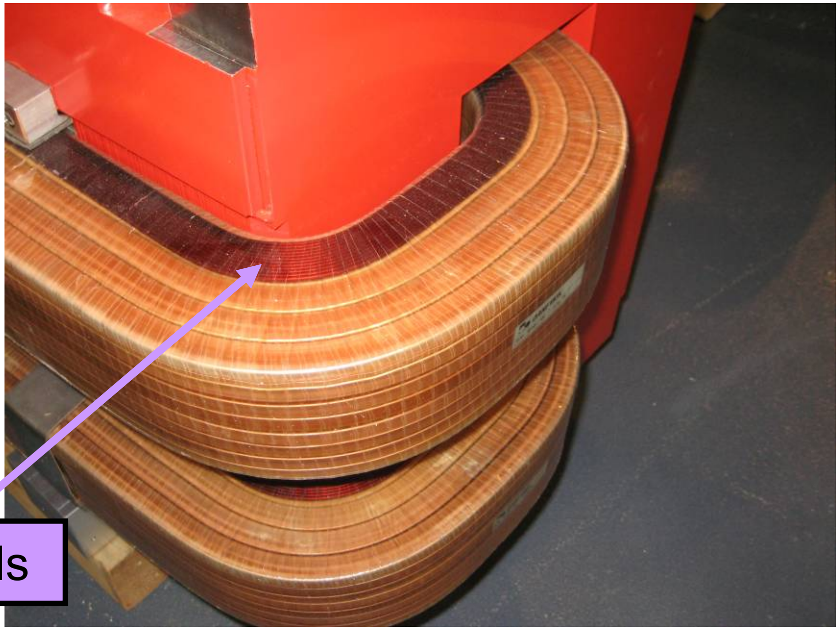


Manifold for the ALBA sextupole

3.) Technical Specifications: Bending Magnet Details

3.4)Trim coils

3.4.1)The bending magnets shall be equipped with trim coils capable of a 5 per mil variation in the magnetic field. These coils are not shown in the drawings.



3.) Technical Specifications: Bending Magnet Details

3.5)Magnet support feet

3.5.1)The bending magnets shall be supplied with supporting feet. Details of these feet, as well as of their location will be agreed with the manufacturer at an early stage of the contract.

3.6)Survey monument

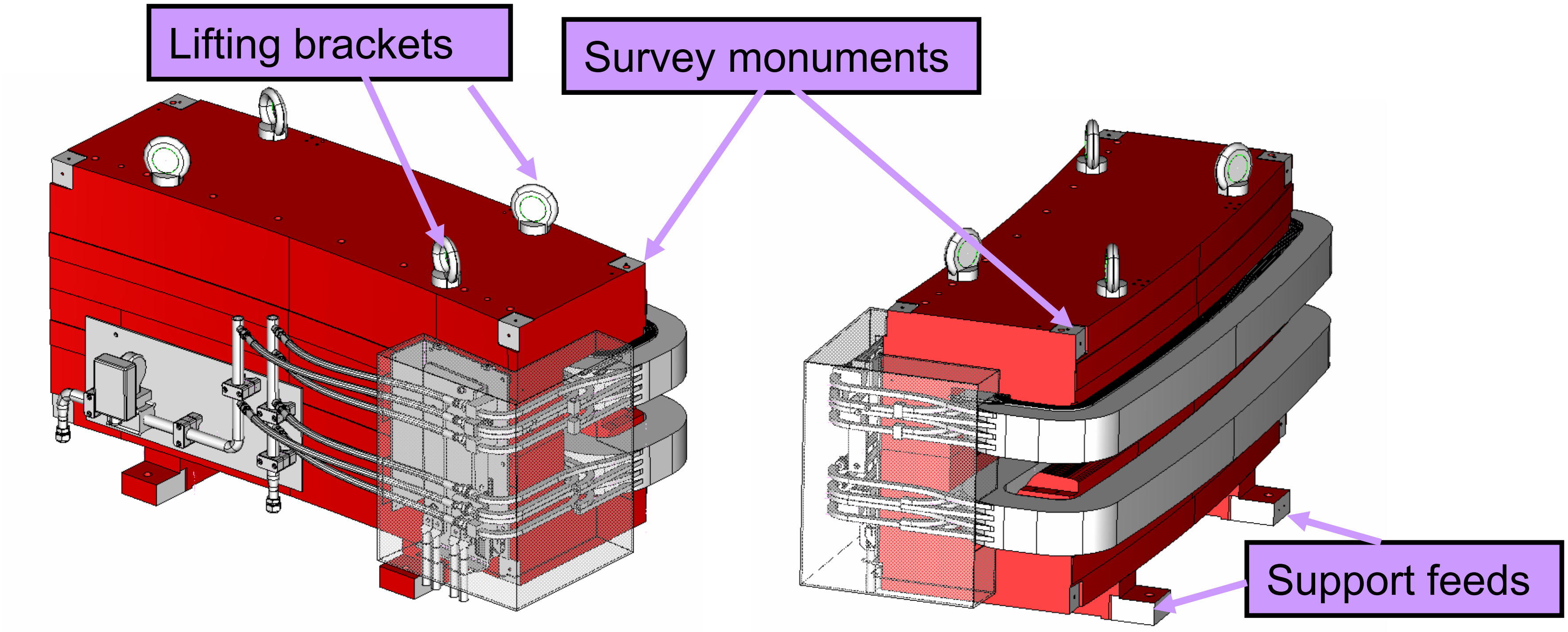
3.6.1)The bending magnets shall be supplied with target mounting features on their upper face which are required to mount up to 3 survey monuments. Details of these monuments will be provided by CELLS at an early stage of the contract.

3.6.2)The bending magnets shall be supplied with reference surfaces in the front and the side of the magnet. These surfaces shall be adequate for aligning the magnet with the magnetic bench by using, for example, a dial indicator. Details of these surfaces will be provided by CELLS at an early stage of the contract.

3.) Technical Specifications: Bending Magnet Details

3.7) Lifting brackets

3.7.1)The bending magnets shall be supplied with at least four lifting brackets adequate to support the complete magnet.



4.) Technical specifications: Phasing of the Contract

4.1.1)The contract will have two phases.

4.1.2)The first phase includes:

- All mechanical and electrical design
- The provision of all tools, jigs and fixtures
- The procurement of all materials for one (1) pre-series magnet
- The procurement of all materials that are not available “ex-stock” for the series production magnets
- The manufacture, mechanical and electrical testing of one (1) pre-series magnet
- The manufacture of 3x2 different sets of end chamfers as shown on the appropriate drawing
- The mechanical measurement and testing of the pre-series magnet, as specified in section 10.1.

4.) Technical specifications: Phasing of the Contract

4.1.3) CELLS will perform the magnetic measurements of the pre-series magnet with the provided end chamfer pieces in order to define the final end chamfer to be used on the production series magnets and asses the viability of the magnet design

4.1.4)The second phase includes:

- Any necessary modification of the tooling, which results from the mechanical and magnetic testing of the pre-series
- The provision of all additional materials required for the production of magnets
- Manufacture, electrical and mechanical testing and delivery of thirty two (32) bending magnets
- Manufacture, testing and delivery four (4) sets of spare coils:

4.) Technical specifications: Phasing of the Contract

4.1.5) CELLS will not authorise the second phase until tests and measurements on the pre-series magnet have been successfully completed by the manufacturer and approved by CELLS.

4.1.6) All designs, tools and materials obtained during phase one shall remain the property of CELLS, and shall be surrendered to CELLS at any time during the contract, within one month of the receipt of written notification.

4.1.7)Tenderers are required to provide separate quotations for the two phases, which together will fully cover the 'scope of contract' defined above.

4.1.8)The quotation for both phases of the contracts will be fixed price.

5.) Technical Specifications: Schedule

5.1) The following program is required for the timescales of the design, construction and delivery:

Contract award	Week 0
Engineering design ready (including tooling design)	Week 16
Pre-series magnet completed	Week 32
Completion of pre-series tests at the factory	Week 34
Magnetic measurements at CELLS and approval of pre-series	Week 42
Completion of delivery of production bendings	Week 66

6.) Techn. Specs: Tendering and Contract Management

6.1) Tendering

6.1.1) All interested contractors are strongly encouraged to contact CELLS and discuss details of the specification so to ensure that the bidder understands completely the requirements and implications of the specification before making an offer. Enquiries of a technical nature shall be directed to X.YYYY, CELLS, tel: xx-xx-xxxyyyy, e-mail: x.yyy@cells.es. Enquiries of a contractual nature shall be directed to Mr. z.wwwwww, CELLS, Tel: xx-xx-xxxwwww, e-mail: z.wwwwww@cells.es.

6.1.2)CELLS shall adjudicate the bids by considering the technical, and value for money aspects of the formal bid. See the folder of administrative clauses.

6.) Techn. Specs: Tendering and Contract Management

6.2) Information required with the tender

6.2.1)The bidder shall provide with the tender documents sufficient information to allow an informed choice of contractor. These shall include:

- A confirmation of acceptance of every clause of the present specification or a detailed explanation of any departure from the conditions defined in this specification.
- A breakdown of the price into main categories.
- Details of the quality assurance scheme that the contractor operates.
- A draft time schedule showing the principal design, ordering, manufacturing, and testing of the bending magnets.
- Indications of proposed work packages to be undertaken by any sub-contractors with the identity of the proposed subcontractor.
- A list of previous projects, similar or comparable in size and scope, to enable CELLS to assess the contractors viability and ability to accomplish the contract.

6.) Techn. Specs: Tendering and Contract Management

6.2.2) Specific information on:

- Engineering Design

  Where major features of the magnet design have been left to the judgement of tenderers, an indication of the solutions or parameters shall be given.

  Proposed method to hold the yoke together.

  Proposed method to keep the strict mechanical tolerances on the gap region as set in the corresponding drawings.
- Magnetic Steel

Proposed source of supply of the steel that will be used in the magnet yokes

Technical information required for the proposed steel shall include:

Thickness / Grade or type designation / Proposed nature of insulated coating / Quoted permeability / Quoted coercivity

The tenderer shall indicate the test and measurement methods that are proposed for quality control of the mechanical, electrical and magnetic properties of the magnet steel.

6.) Techn. Specs: Tendering and Contract Management

- Lamination Stamping and Yoke Assembly

A brief description of the tooling proposed for stamping laminations, and whether a one or two stage process is intended shall be given. The size of the stamping press to be used shall be indicated.

An estimate of the burr height and extent of shear edge taper expected on the lamination, together with the estimated frequency of tool regrinding to meet the specification, shall be given.

Details of the methods proposed and the equipment available for the accurate measurement of the lamination profile.

Details of the storage procedure and the method of the subsequent shuffling operation.

A description of proposed lamination stacking fixture, including stacking technique. The proposed method for holding the laminations together, and the techniques recommended for maintaining the required dimensional tolerances on the yoke shall be explained.

6.) Techn. Specs: Tendering and Contract Management

● Lamination Stamping and Yoke Assembly

Details of the measurement procedures proposed for mechanical checking of the yoke after stacking and bonding/welding, and indication of how the dimensional tolerances given by CELLS can be checked.

Details of the proposed techniques for any required machining .

A preliminary proposal of the instrument that is to be used for the continuous measurement of the gap, taking into account that the gap is not constant in the transversal direction

● Coil Production and Testing

Indication of the expected source of supply for copper conductor, and details of the proposed conductor dimensions.

Details of the proposed coil winding operation, including information on the glass cloth to be used. The method of production and all materials to be used (including required packing pieces) must be described. The number of coil winding formers to be used must be stated.

6.) Techn. Specs: Tendering and Contract Management

- Coil Production and Testing

The tenderer shall indicate the proposed source of supply of the epoxy resin chemical system, together with details of its expected mechanical, thermal and radiation properties.

Details of the proposed impregnation technique and curing operation for the resin system must be given, including information on all jigs, tools and moulds which will be required. The number of moulds to be used must be stated.

A brief description shall be given of the equipment, which is proposed for the various tests listed in the coil test schedule.

Details of the proposed over-temperature switches shall be given. The proposed method of mounting the temperature sensor on the coil shall also be explained.

Details of the proposed water flow switch shall be given. The proposed method of mounting the sensor on the magnet shall also be explained

6.) Techn. Specs: Tendering and Contract Management

- Electrical Connections

The tenderer shall indicate which type of connections are proposed for the power cables as well as the proposed layout of terminal boards and protective covers.

The tenderer shall indicate the proposed method of coil electrical interconnection and the way that radiation damage is to be avoided.

The tenderer shall give details of the proposed connections of the interlock switches that are proposed.

- Water Connections

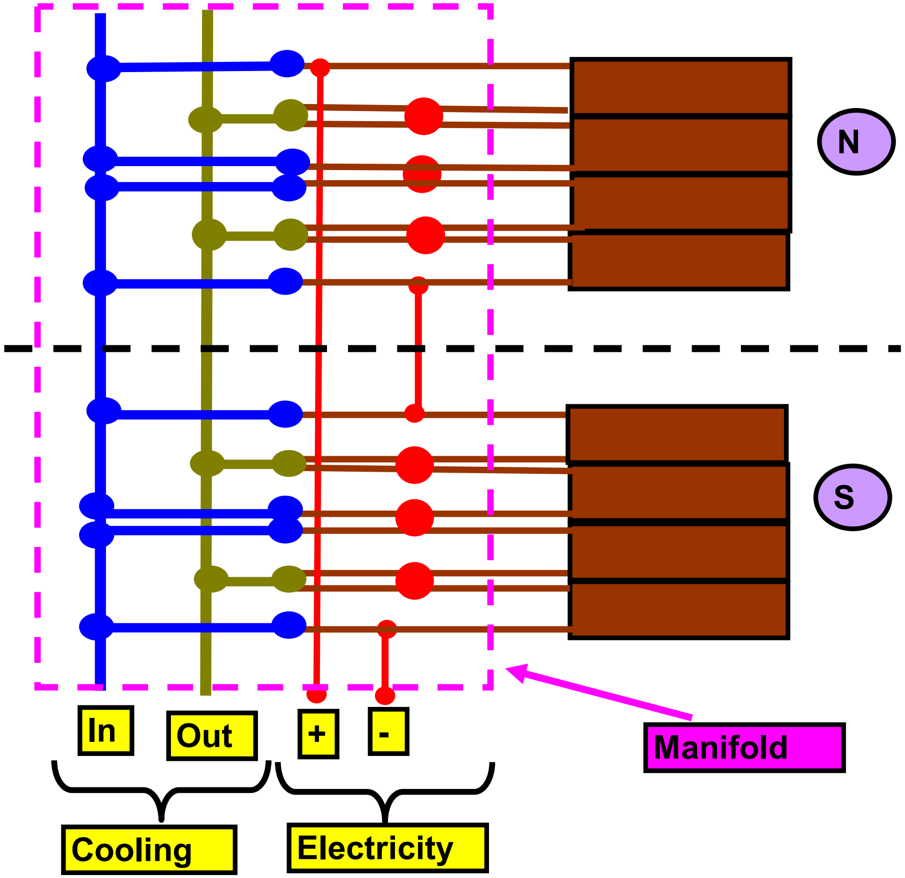
The tenderer shall give details of the proposed water distribution, including drawings of the manifolds and indicating which materials will be used.

The water flow rate shall be given

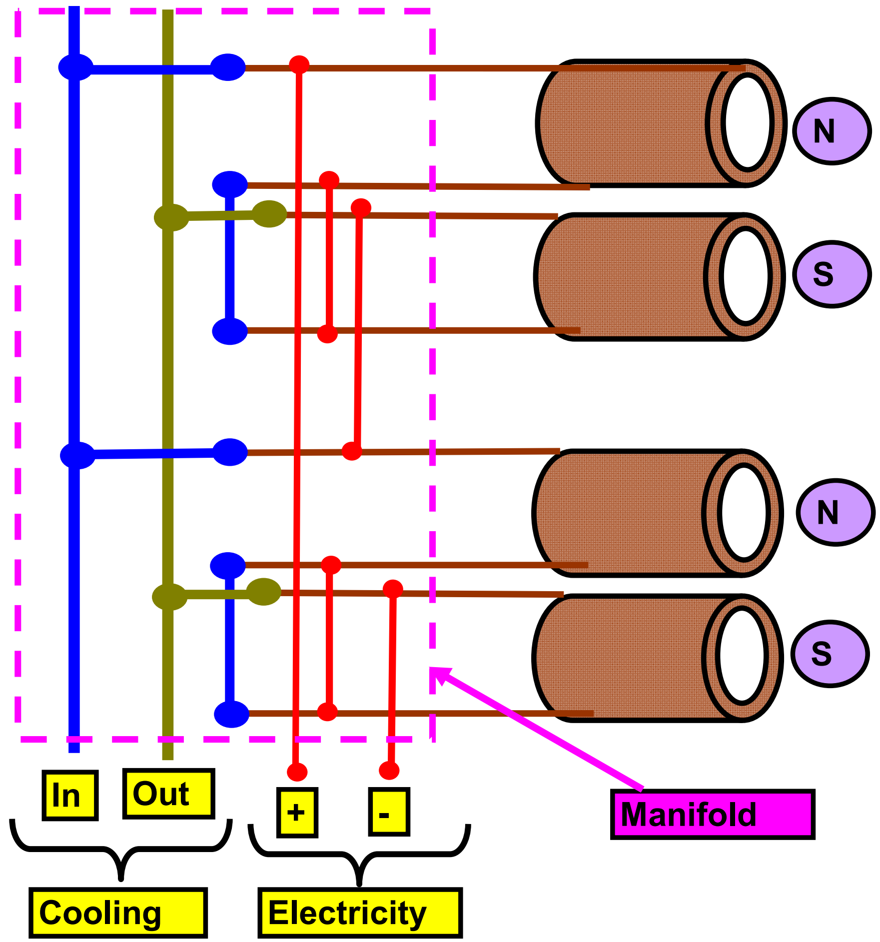
The proposed layout, avoiding organic materials in the bending magnet vertical median plane shall be described.

The Specifications of the Dipole Magnet

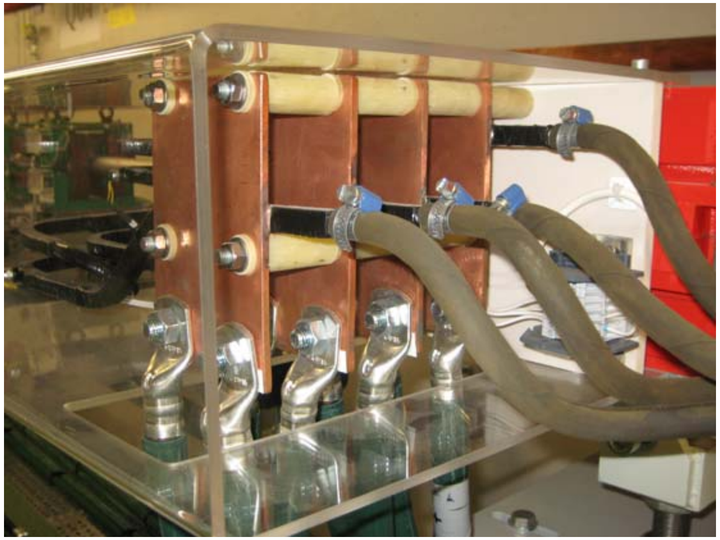
Manifold: Cooling and Electricity connections (ALBA-Bending)



Manifold: Cooling and Electricity connections (ALBA - quadrupole)



6.) Techn. Specs: Tendering and Contract Management



6.) Techn. Specs: Tendering and Contract Management

6.3)Contract management

6.3.1)At the start of the contract the contractor shall assign contact persons for Technical and Administrative matters who will be responsible for all reporting to, and contact with CELLS.

6.3.3)Within 2 weeks of the commencement of the contract the contractor must issue a detailed program covering the design, manufacturing, and testing phases in sufficient detail to allow regular progress monitoring.

6.3.3)Within 2 weeks of the commencement of the contract a program of technical and progress meetings will be agreed between the contractor and CELLS.

6.3.4)Thereafter, and throughout the contract, the Technical Contact shall supply a written report to CELLS every month detailing progress with respect to the program.

6.3.5)The manufacturer will be responsible for the final design, the production methods and the correct manufacture of all magnets, irrespective of whether they have been chosen by the contractor or suggested by CELLS.

6.) Techn. Specs: Tendering and Contract Management

6.3)Contract management

6.3.6)CELLS's approval of the design and components does not release the contractor from his responsibility to correct errors, oversights and omissions to ensure conformance to the specifications in this document.

6.3.7)In the event of the contractor having misinterpreted any of the specifications provided by CELLS, CELLS expects that the misinterpretation will be corrected at no extra cost.

6.3.8)The contractor must declare any sub-contractor that will be used in the execution of this contract and inform CELLS of any change of sub-contractor. The change must be accepted by CELLS in writing.

6.3.9)Nominated members of CELLS staff, or their appointed representatives must be guaranteed reasonable access to the premises of the contractor, for the purpose of progress meetings, inspection visits etc., even without notice.

6.) Techn. Specs: Tendering and Contract Management

6.3)Contract management

6.3.10)Nominated members of CELLS staff, or their appointed representatives must be guaranteed reasonable access to the premises of any subcontractor, for the purpose of progress meetings, inspection visits etc., with the main contractor present, even at short notice.

6.3.11)CELLS will have the right to observe the tests and suggest additional ones. The contractor shall give at least 10 working days notice of any test date to allow the necessary travel arrangements to be made.

6.3.12)CELLS reserves the right to require additional or more extensive tests to be conducted in the event of marginal design or performance.

6.3.13)The contract will be completed when the magnets have been delivered to the CELLS indicated site and satisfactorily completed the acceptance tests and comply fully with this specification document.

6.) Techn. Specs: Tendering and Contract Management

6.4)Quality assurance

6.4.1)The contractor shall maintain and apply a quality assurance program compliant with ISO-9001 for the design, manufacture and testing of all systems and equipment provided by them.

6.4.2) All equipment shall be manufactured in accordance with the best existing techniques and recognised good engineering practices available at the time of construction. All systems shall be designed and constructed with an expected operational lifetime longer than 10 years. The magnets shall be designed and constructed for continuous use.

6.) Techn. Specs: Tendering and Contract Management

6.5)Documentation

6.5.1)The contractor shall provide 2 (two) sets of paper copies of the following documentation as soon as it becomes available and in accordance with the schedule presented in section 5:

- Schedule
- Construction drawings of coils and magnetic circuit
- Travellers of control executed at each step of the manufacturing
- A manufacturing booklet which will be composed of:
  - For the coils: Mechanical, hydraulic and electric tests
  - For the magnetic yoke: Dimensional checks
  - For the magnet assembled: Mechanical, hydraulic and electric tests
  - The list of the non compliances processed

6.5.2) All the technical documents delivered by the contractor shall be in English.

6.5.3) The contractor shall provide 2 (two) full sets of paper copies of construction drawings.

6.5)Documentation

6.5.4) In addition, the contractor shall provide 2 (two) full sets of electronic copies on physical media of construction drawings. These shall be preferably in IDEAS format, although other formats e.g. DXF, or IGES are acceptable.

6.6) Numbering

6.6.1) Each individual coil, yoke and each completed magnet will be identified and numbered. The position of the identification number shall be agreed with CELLS.

6.6.2) A stainless steel or aluminium plate shall be fixed on each magnet. The following information shall be on the plate:

Magnet name & Serial number
Year of manufacture & Maximum current
Gross weight of the unit & Cooling requirements (if required)
Coolant flow rate (l/min) & Pressure drop (MPa)
Maximum Temperature Rise (K) & Contractor's name

6.) Techn. Specs: Tendering and Contract Management

6.7) Guarantee

The contractor shall guarantee the magnets against failure due to either faulty components or faulty manufacture for a period of 24 months after the magnets have been accepted by CELLS. It is warranted that no modifications will be undertaken without the written permission of the contractor.

Thank you very much

And see you again at the next lecture

(einfeld@cells.es)