Case Study ALBA – Magnet

Introduction

D.Einfeld
CELLS/Barcelona

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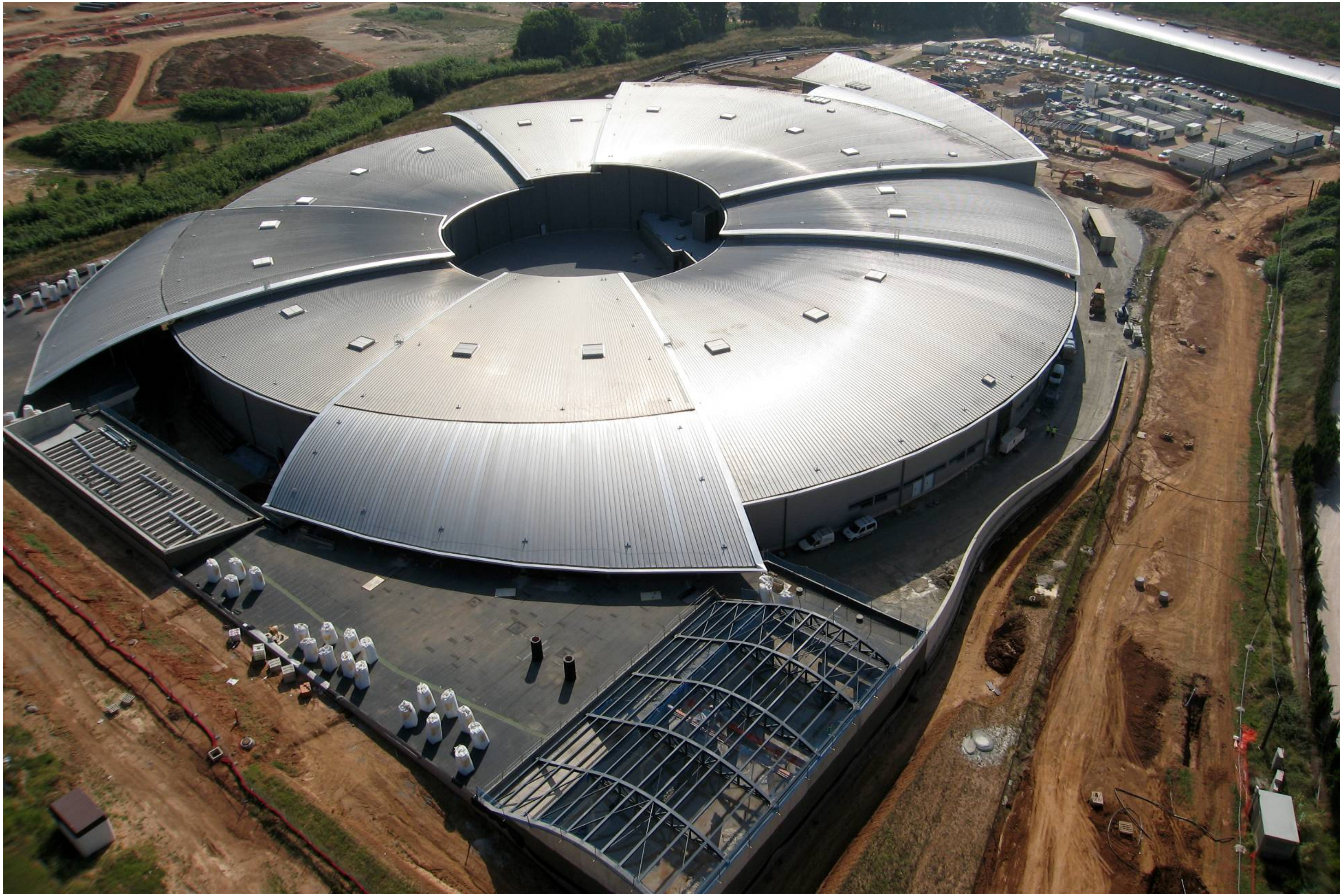

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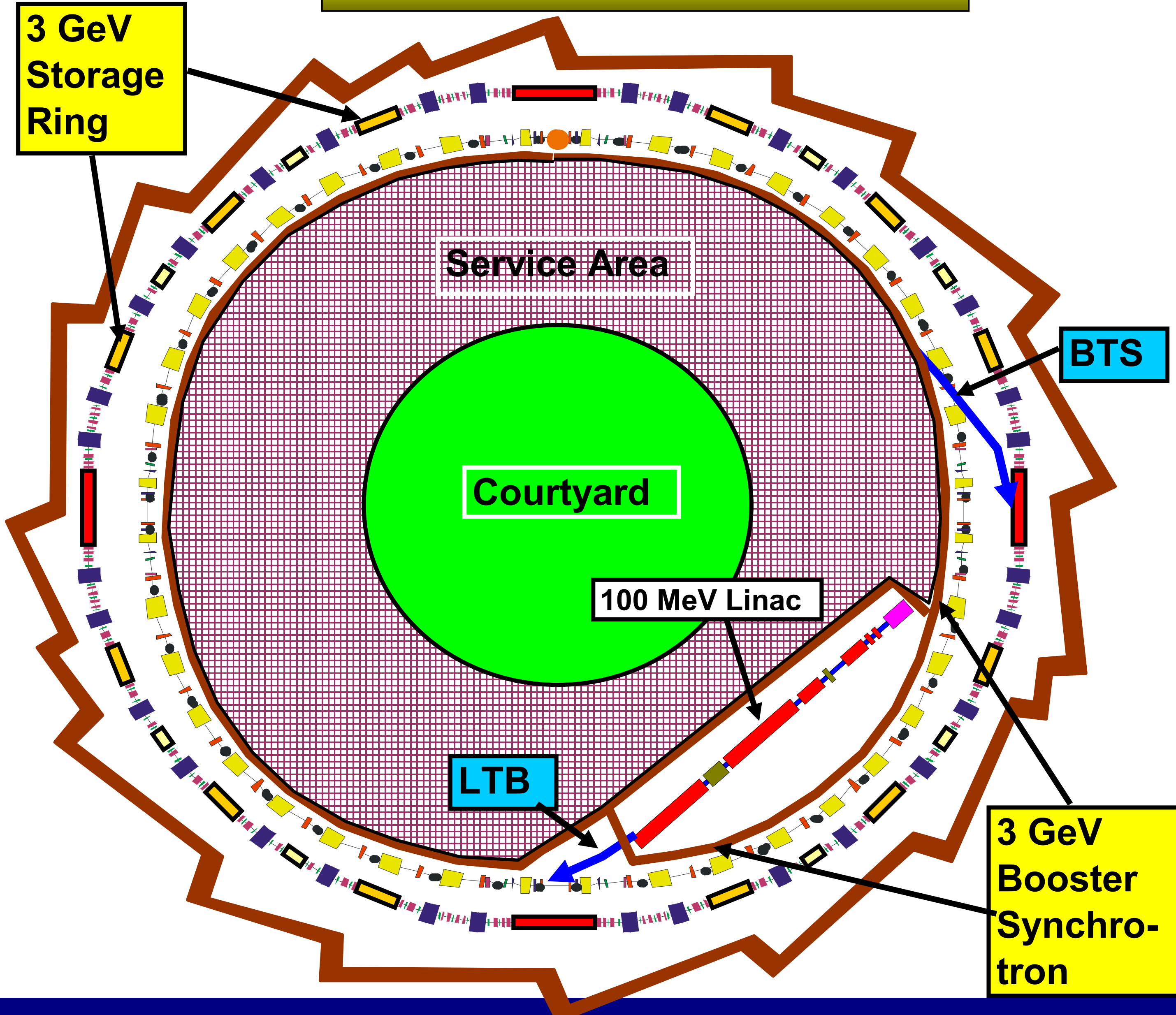
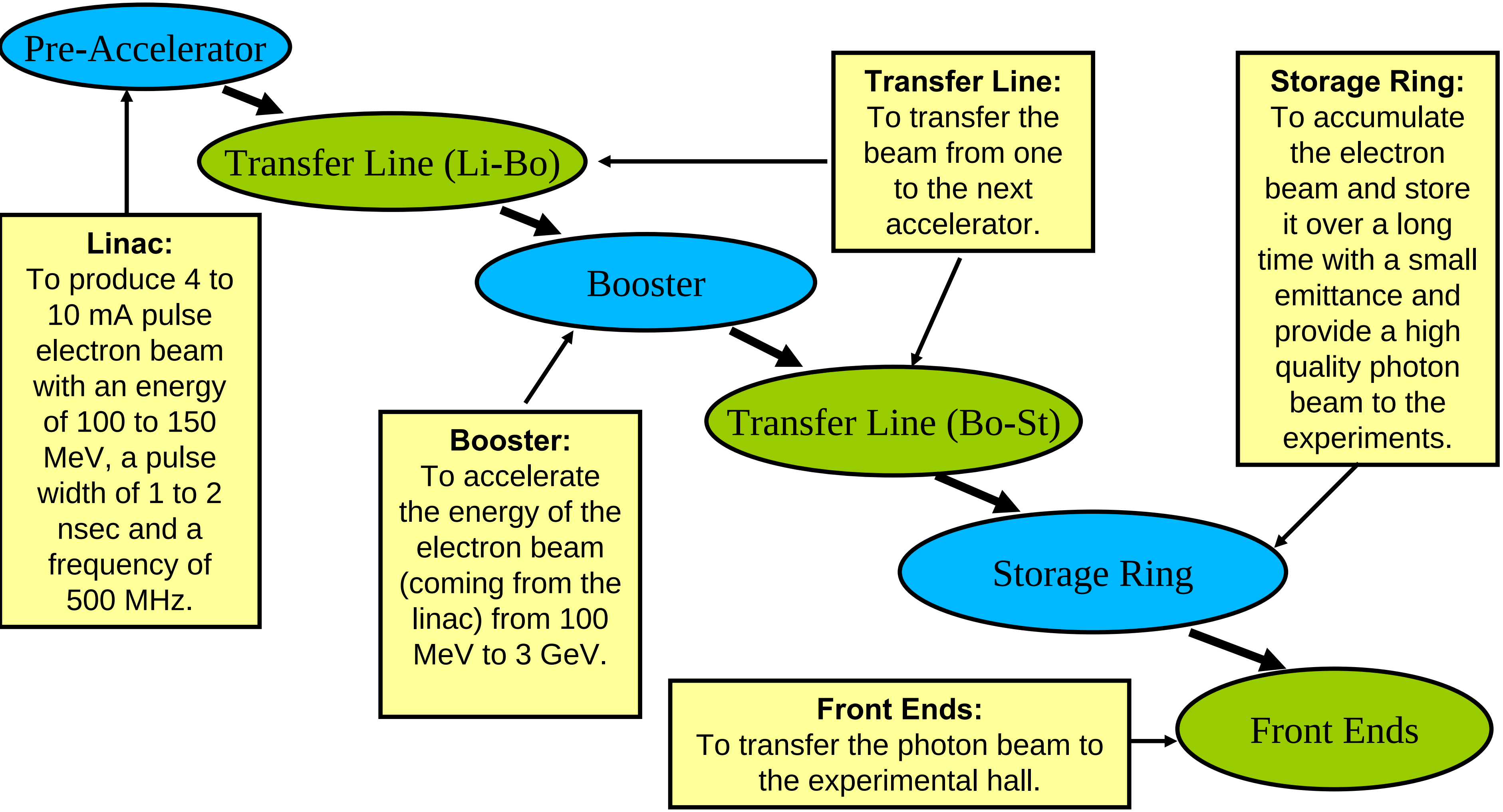
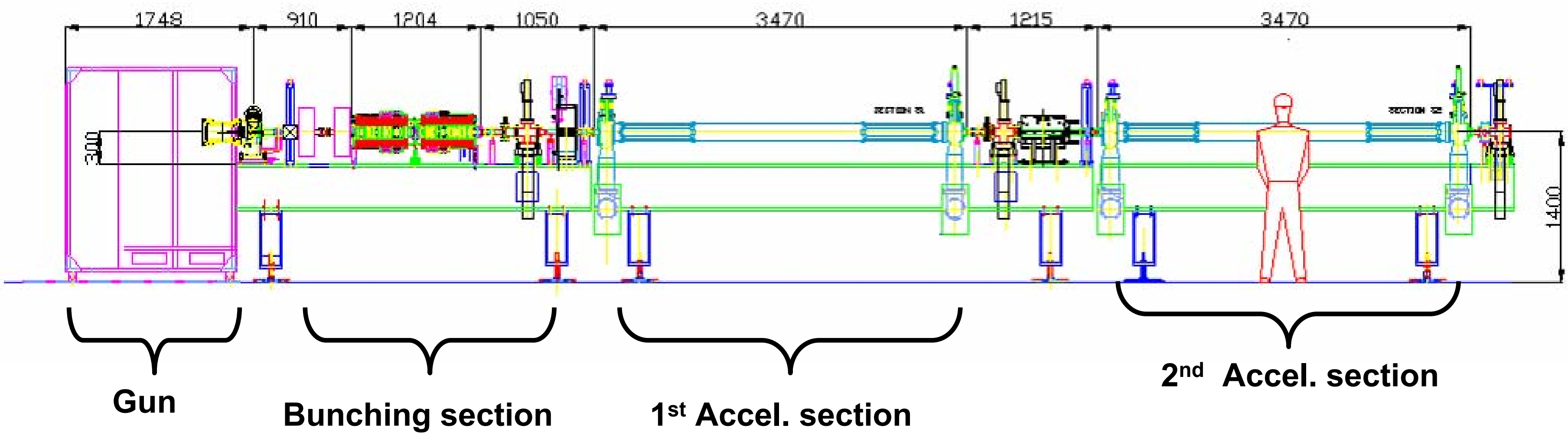


Schematic of an accelerator complex for a synchrotron light source



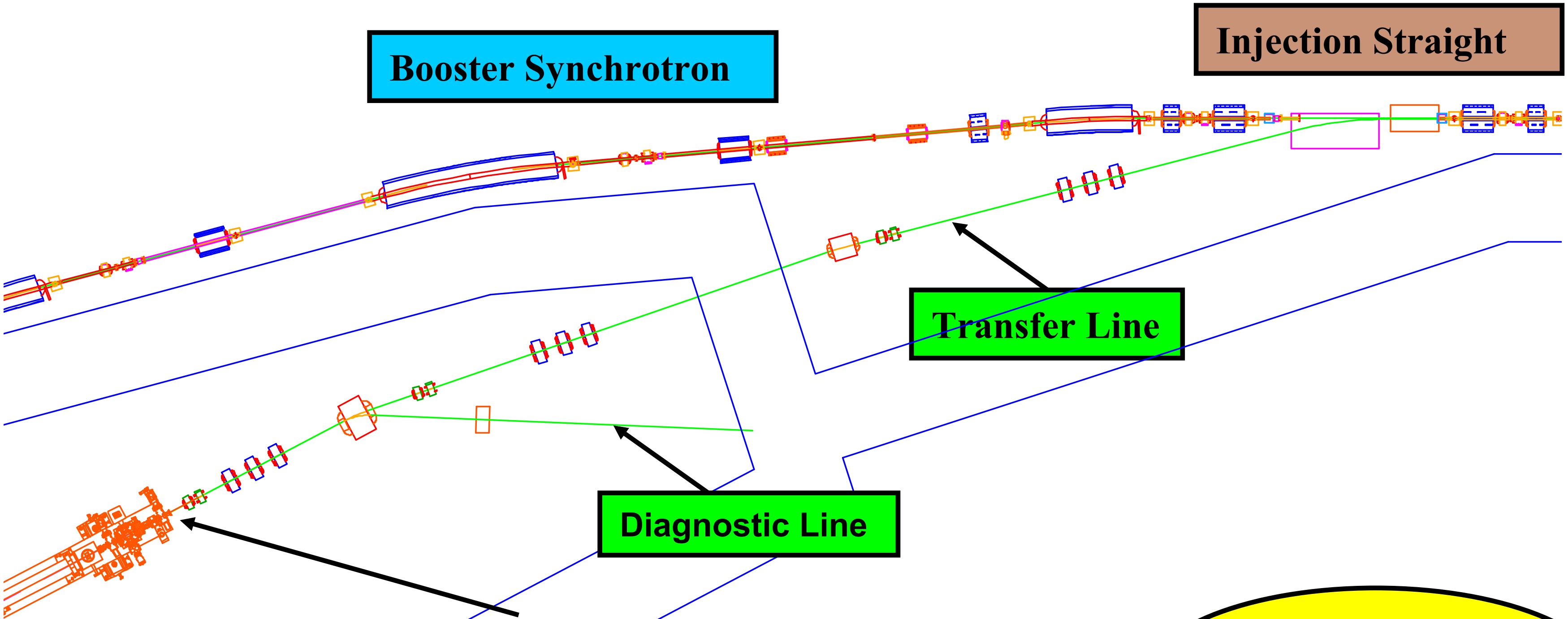
Layout of Linac



Parameter	Single-bunch	Multi-bunch
Frequency	3 GHz	3 GHz
Bunch length	< 1ns (FWHM)	0.3 to 1μs
Charge	≥ 2 nC	≥ 4 nC
Energy	≥100MeV	≥100MeV
Pulse to pulse (δE)	≤0.25 % (rms)	≤0.25 % (rms)
Energy spread (ΔE/E)	≤0.5 % (rms)	≤0.5 % (rms)
Norm. Emitt. ($1\sigma_{x,y}$)	≤ 30 π mm mrad	≤ 30 π mm mrad
Repetition rate	3 to 5 Hz	3 to 5 Hz

Smaller emittance and higher transmission as at other Linacs

Layout of the Linac to Booster Transfer Line

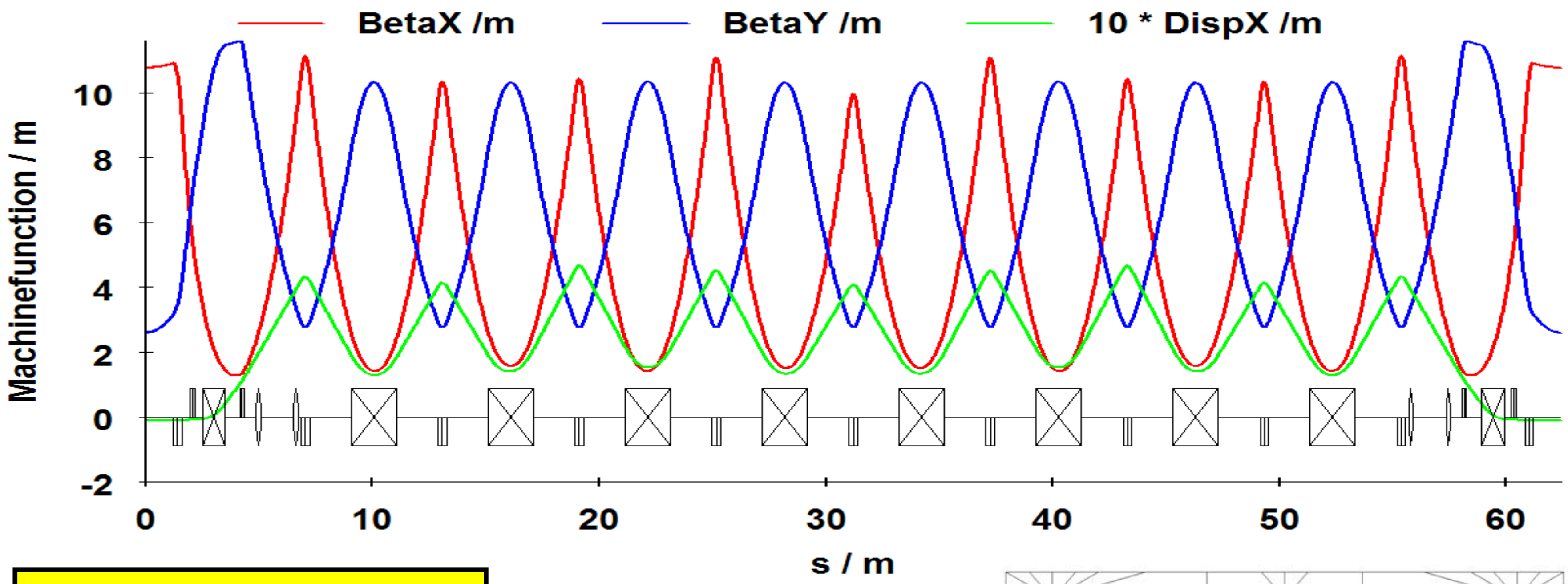


Exit conditions Linac:

ε(norm)= 30 π mm*mrad, ε(100)= 150 π nm*mrad, β= 2 to 10 m/rad, α = -2 to 0, ΔE/E = 0.005

Design is similar as to other light sources

Final Lattice of Booster



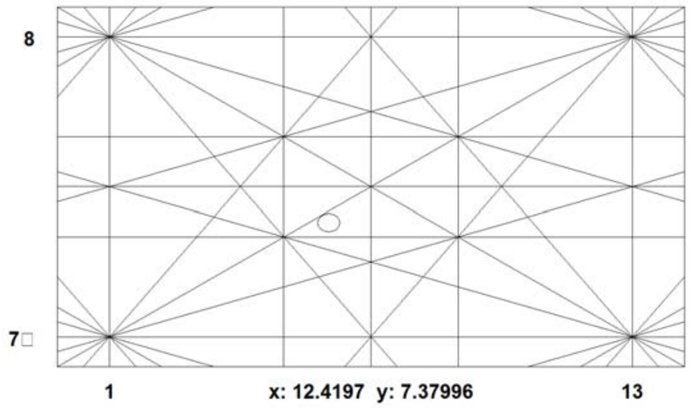
ALBA design:

defocussing bending magnets and focussing quadrupoles

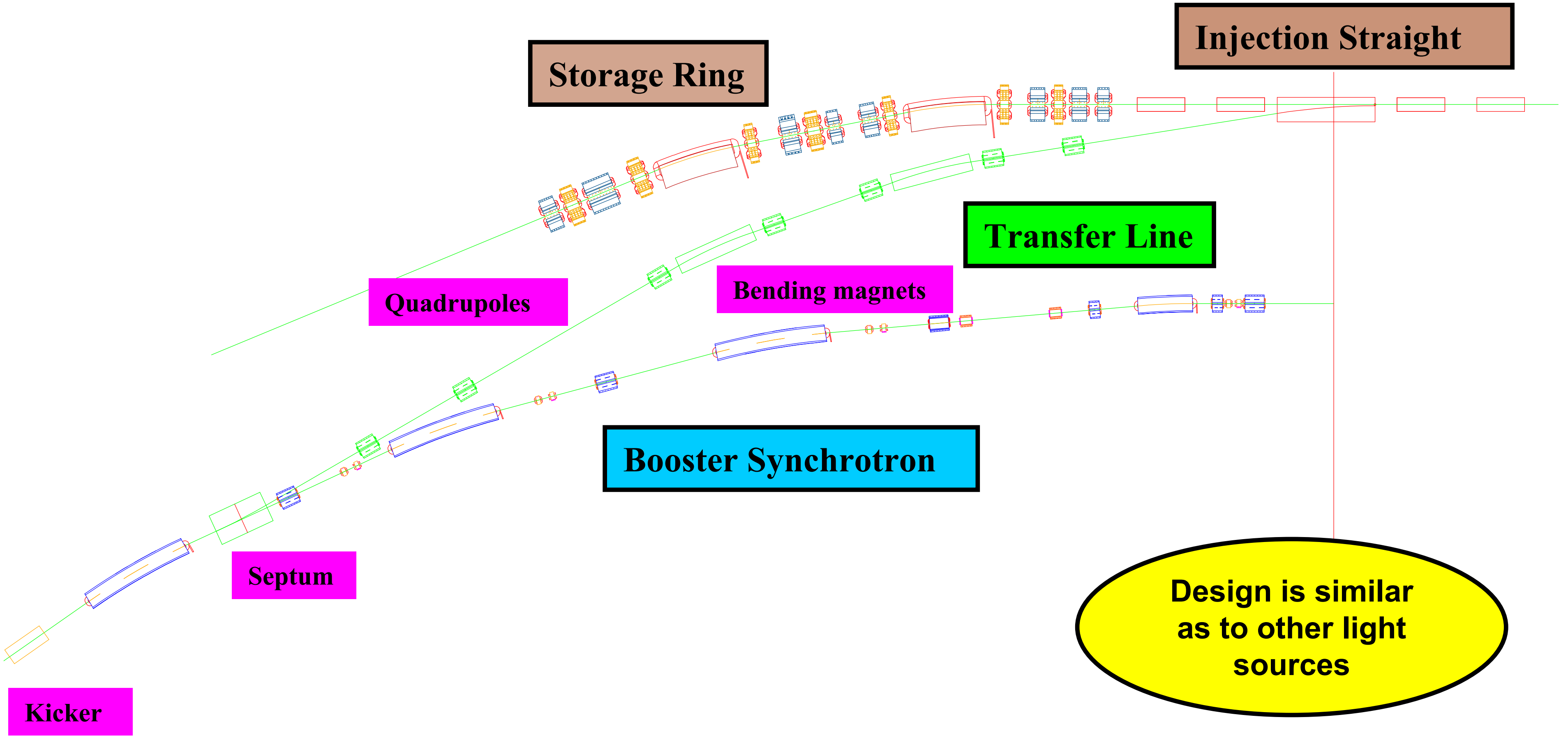
ε_x = 10 nmrad

smaller emittance, higher flexibility and lower costs

Sextupole components within the bendings and quadrupoles



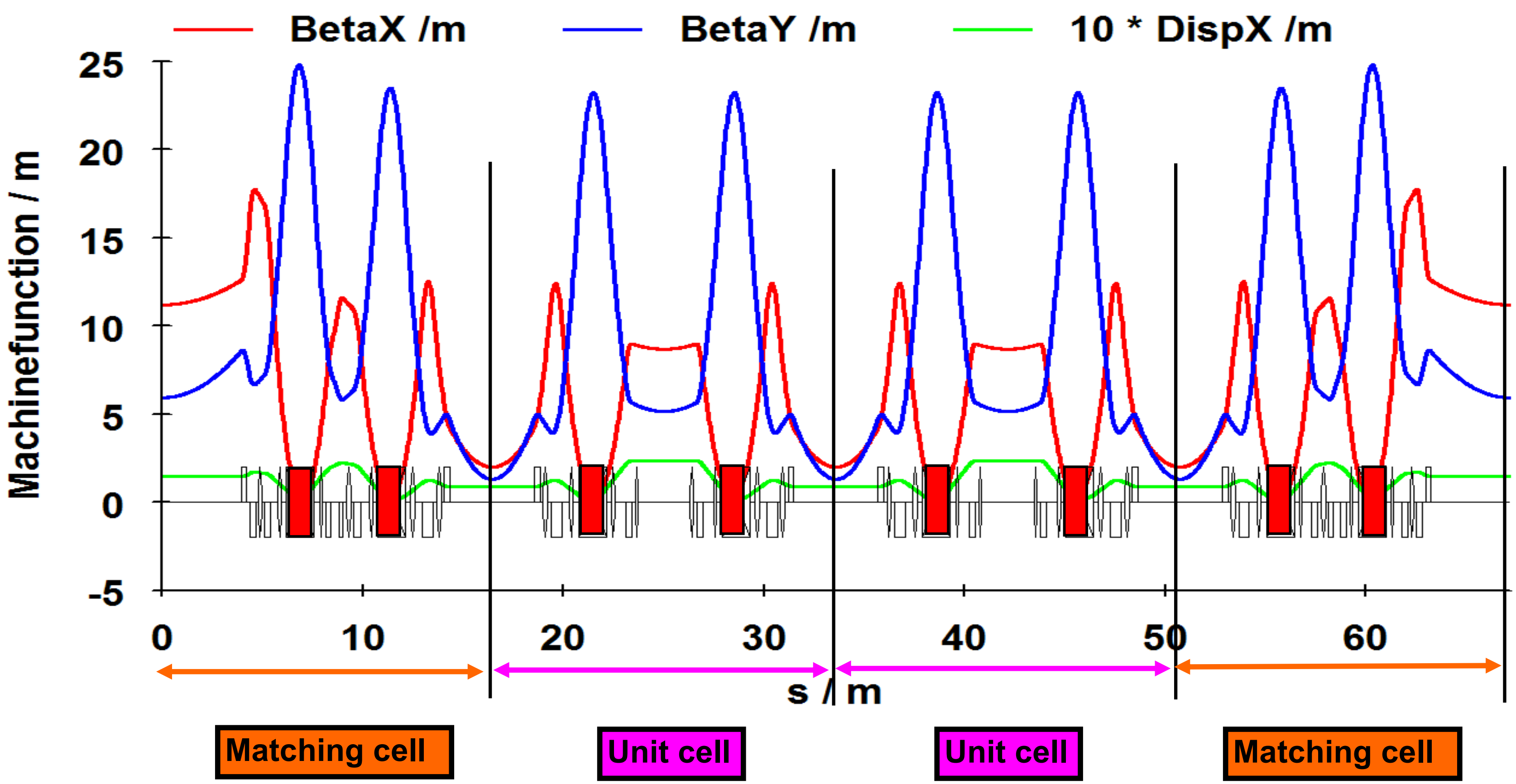
Layout of the Booster Storage Ring Transfer Line



Design is similar as to other light sources

For the lattice design one has to make pretty soon the decision to use combined bending magnets or not. The usage of combined bending magnets has two advantages: 1.) reduction of the emittance by roughly 30 % because of Jx and 2.) building a more compact machine and therefore having more space for insertion devices (for a 3 GeV machine and a circumference of 300 m it is roughly 10%)

The ALBA lattice within a quadrant



Booster Design Criteria

- Full energy Booster
- Small emittance and beam cross section
- Top-up injection
- In the same tunnel as the S.Ring

✓ Share shielding

✓ Share engineering services

✘ No independent access to both rings

But if top-up is running there is no access in any case

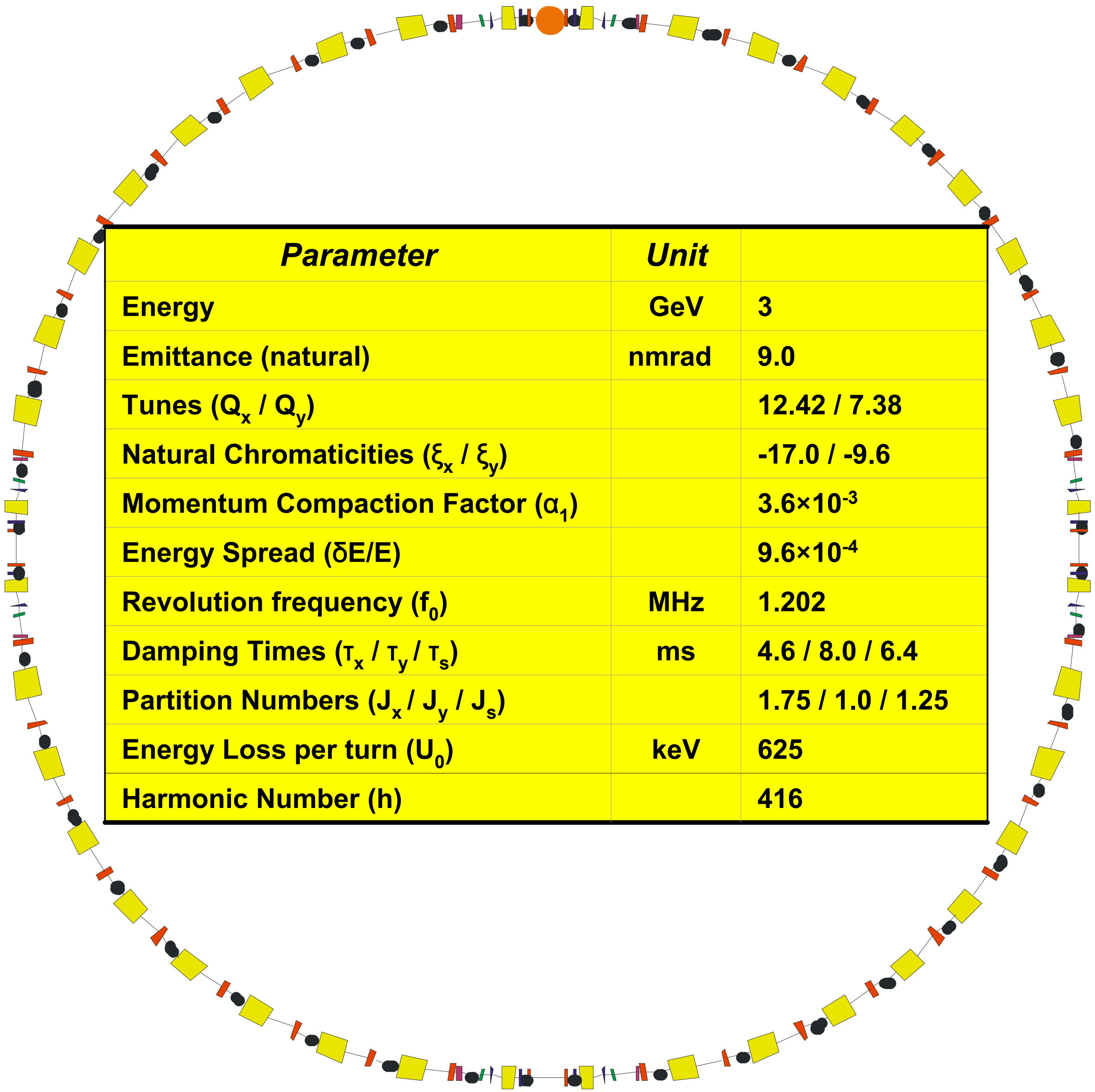
✘ Installation and commissioning require good organisation

✘ What happens to stray fields?

Do some calculations to find acceptable distance between both rings.

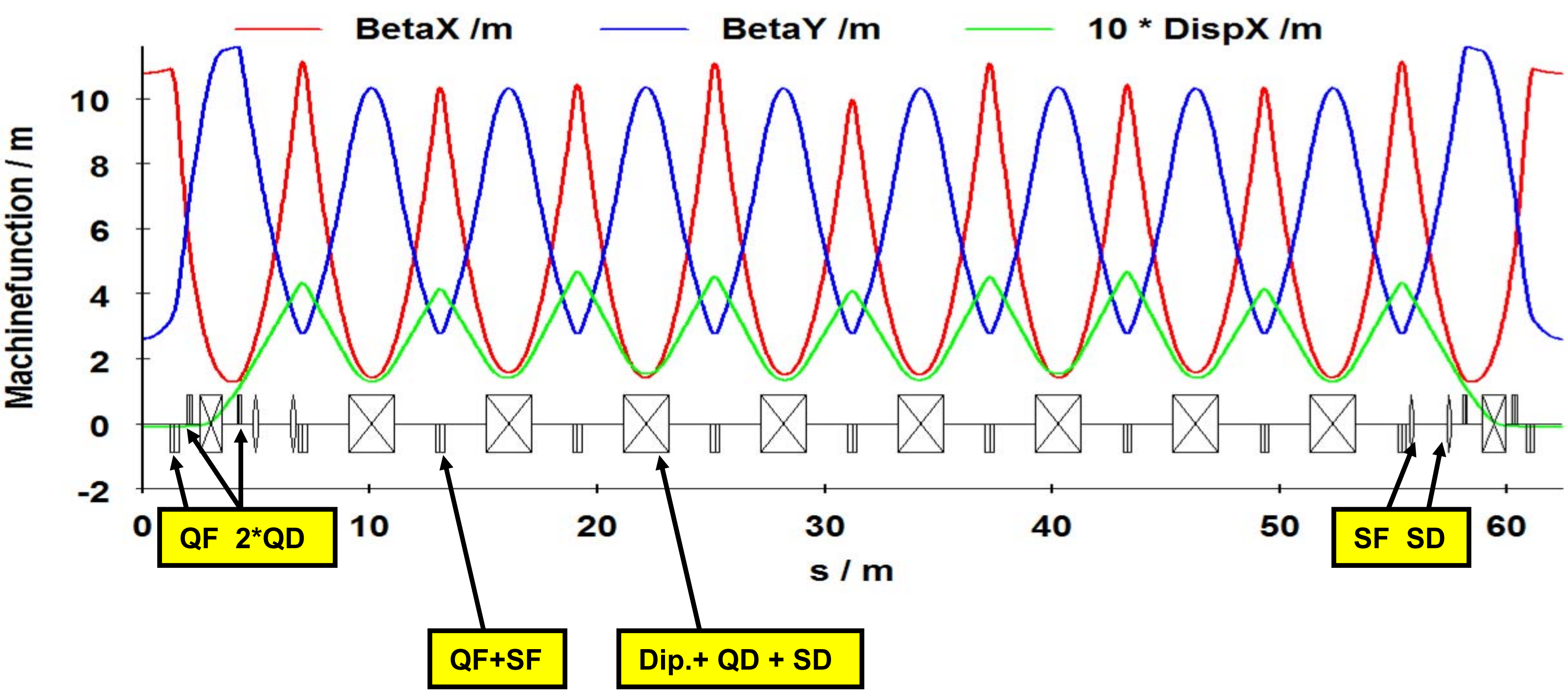
Take maximum magnetic field into consideration

Parameters of Booster Synchrotron



Parameter	*Unit*	
Energy	GeV	3
Emittance (natural)	nmrad	9.0
Tunes (Q_x / Q_y)		12.42 / 7.38
Natural Chromaticities (ξ_x / ξ_y)		-17.0 / -9.6
Momentum Compaction Factor (α_1)		3.6×10^{-3}
Energy Spread (δE/E)		9.6×10^{-4}
Revolution frequency (f_0)	MHz	1.202
Damping Times (τ_x / τ_y / τ_s)	ms	4.6 / 8.0 / 6.4
Partition Numbers (J_x / J_y / J_s)		1.75 / 1.0 / 1.25
Energy Loss per turn (U_0)	keV	625
Harmonic Number (h)		416

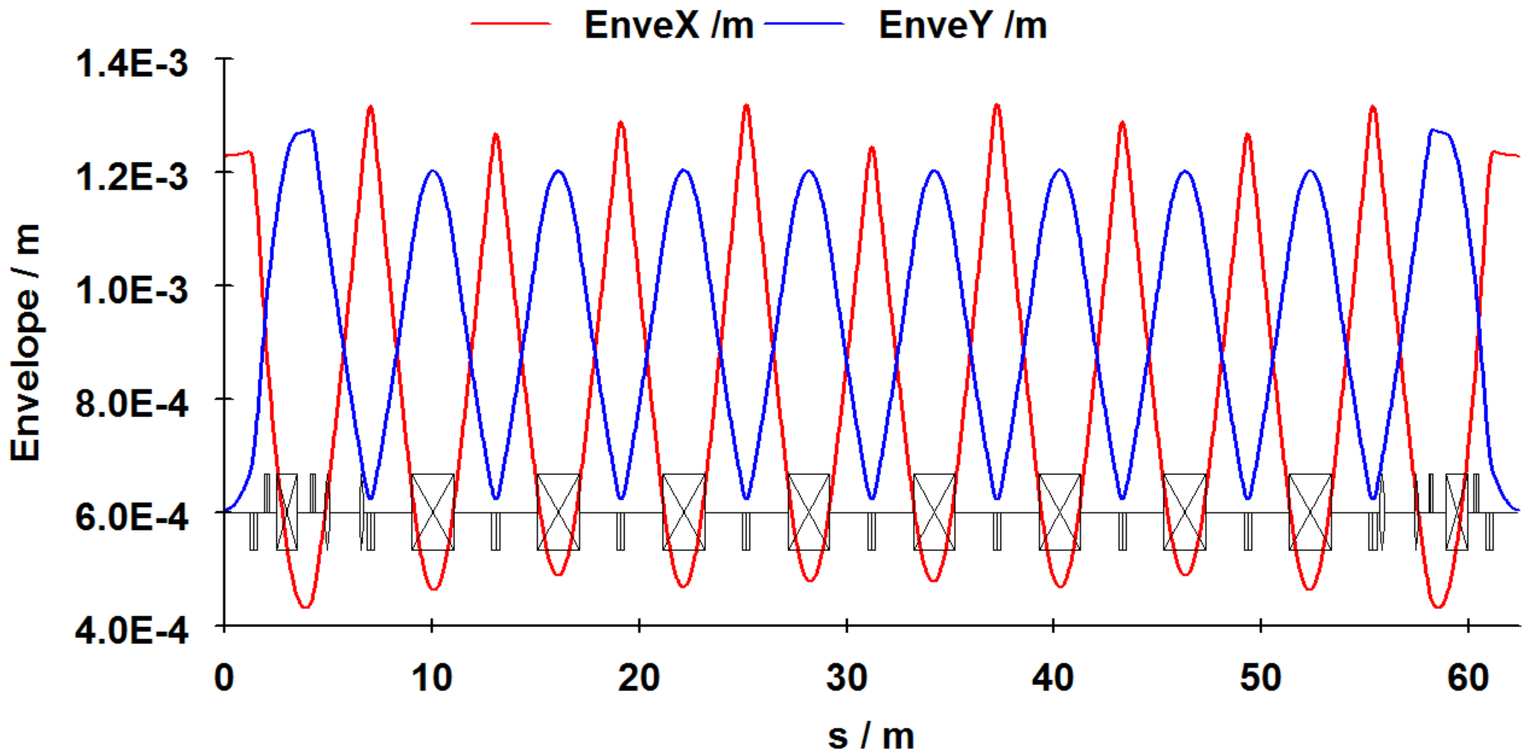
Booster Lattice



Gradient within the bending magnet and

sextupole components within the bendings and quadrupoles

Beam Size



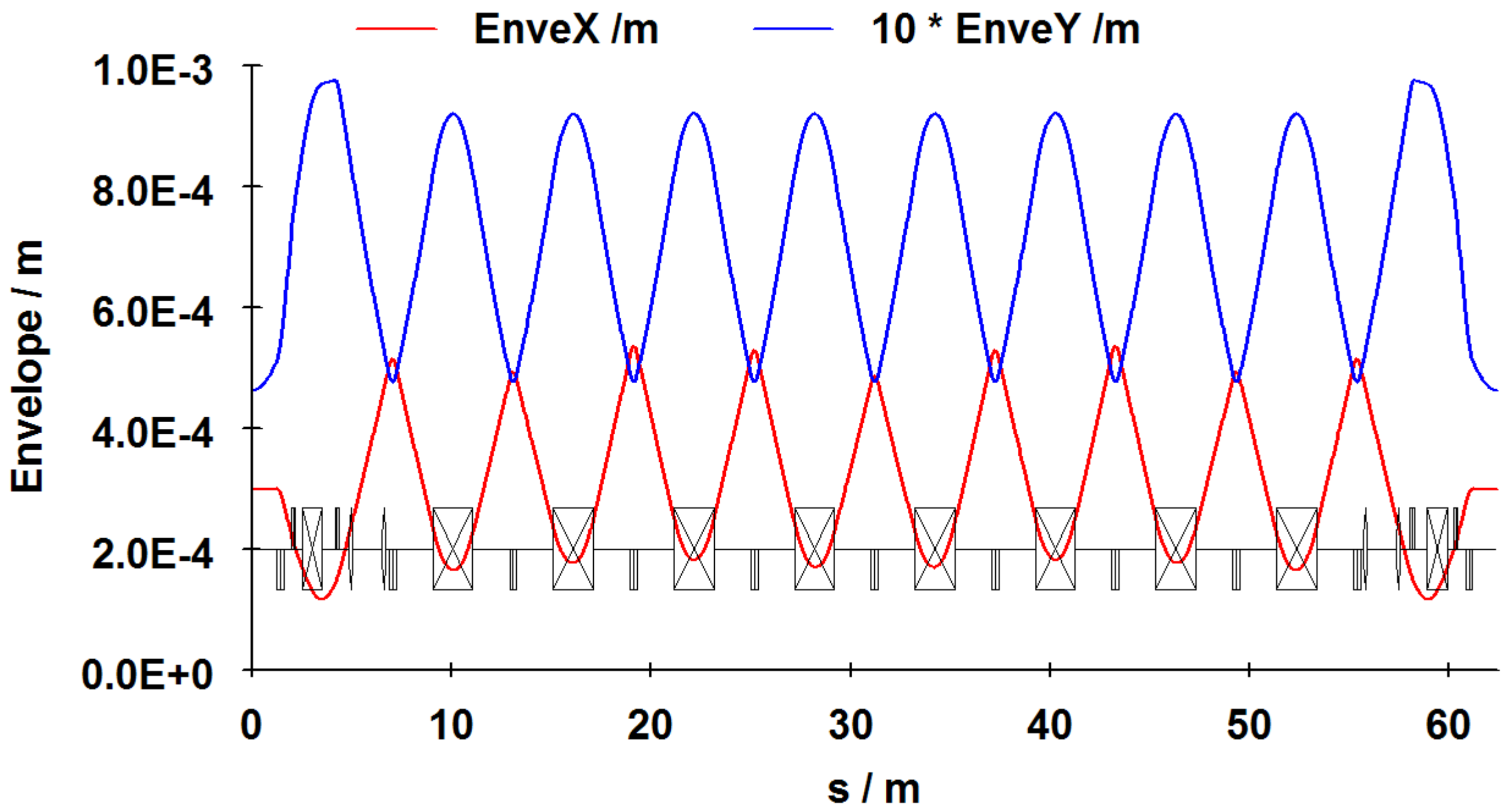
Beam size at injection (1σ)

ε_x = 140 nm.rad

100 % coupling

$\sigma_{x,max}$=1.3 mm, $\sigma_{y,max}$=1.25 mm

Beam Size



Beam size at extraction (1σ)

ε_x = 9 nm.rad

10 % coupling

$\sigma_{x,max}$=0.5 mm, $\sigma_{y,max}$=0.10 mm

Chromaticity correction:

ξ_x = -16.9 ξ_y = -10.0

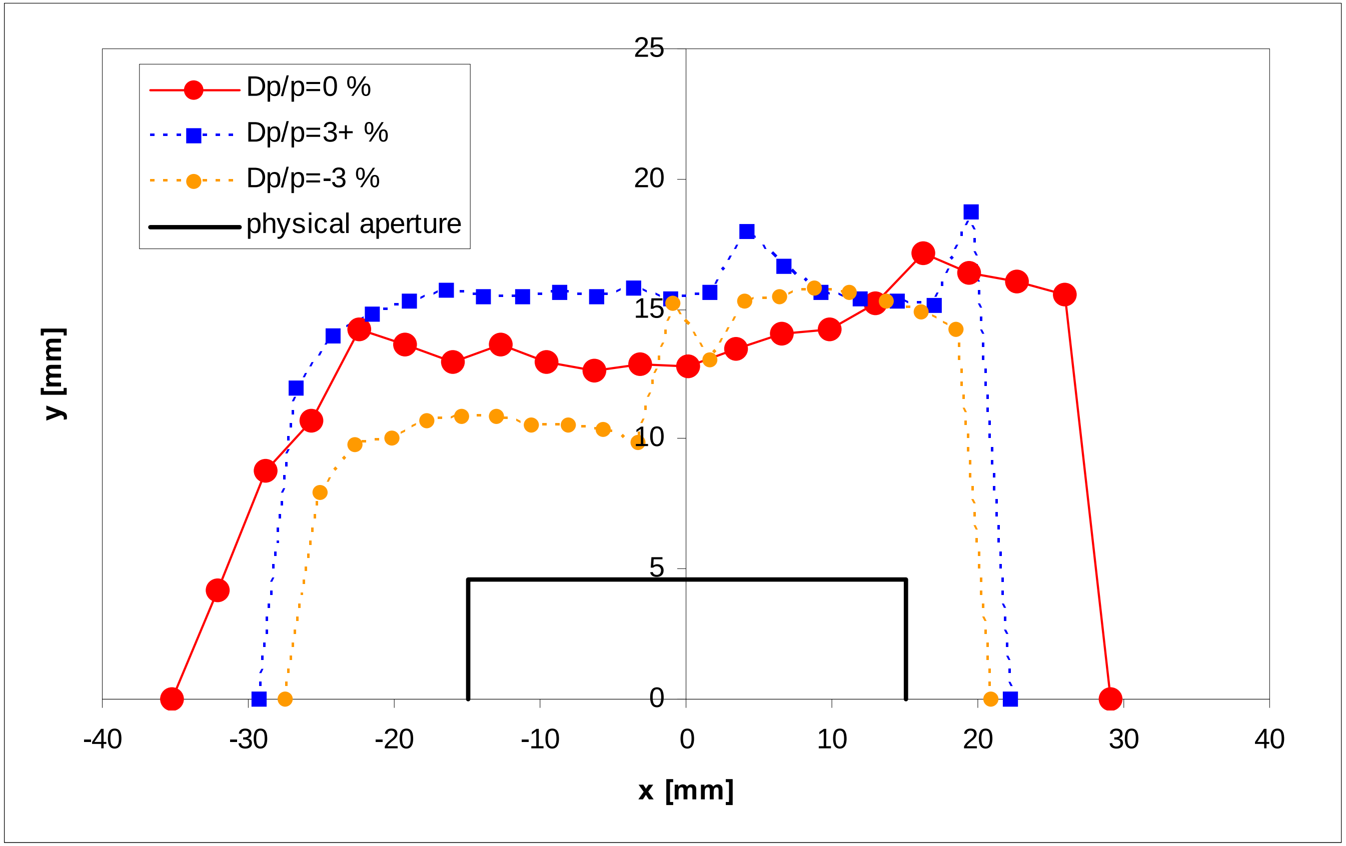
Chromaticity is corrected to +1 in the dipoles and quadrupoles pole profile.

Bend, sext. component is 18 T/m^2 at 3 GeV
Quad, sext component is 44 T/m^2 at 3 GeV

In addition

2 families of 8 sextupoles/each add flexibility
max sext. component is 400 T/m^2 at 3 GeV

Dynamic aperture: Only sextupoles, no magnets errors



mid of straight section

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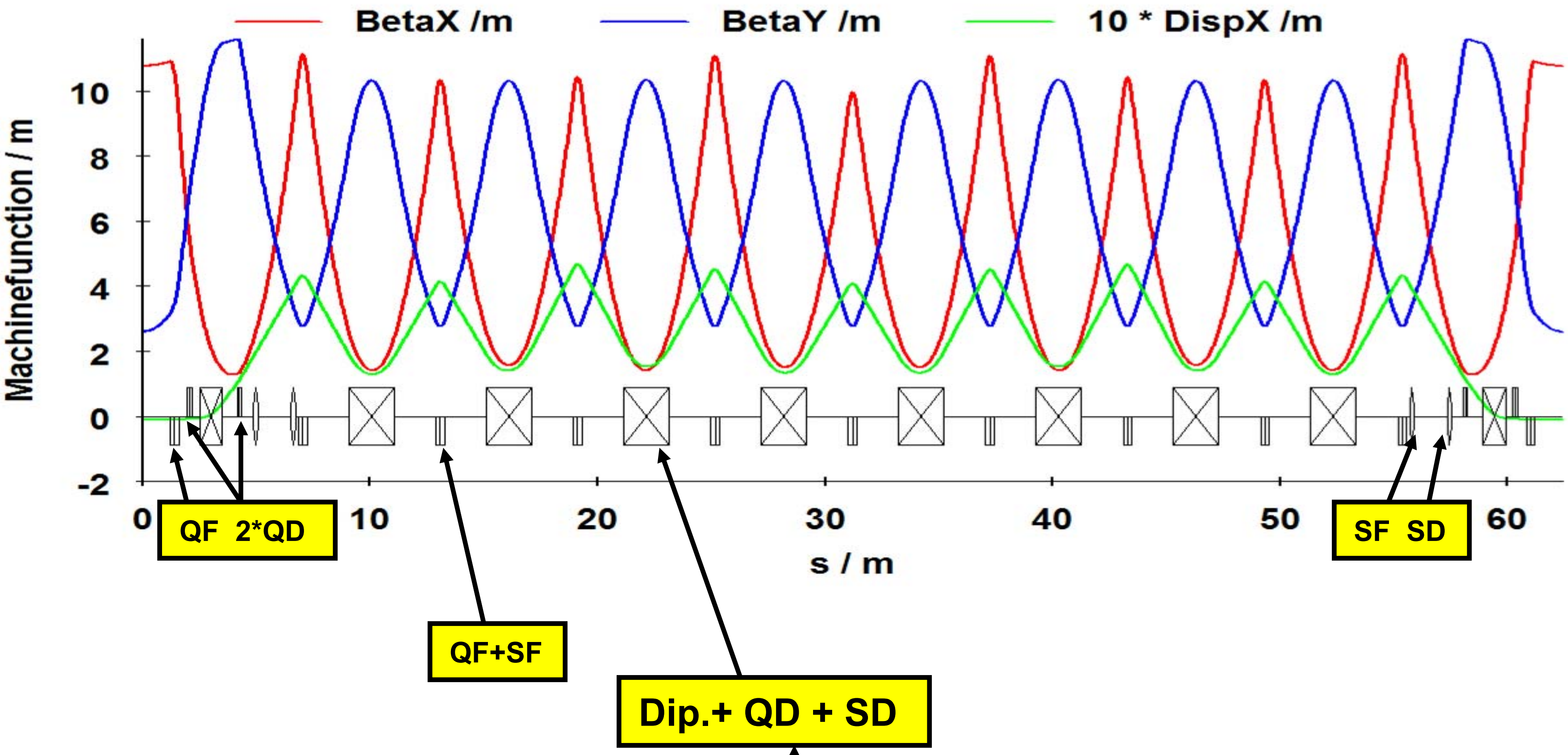
Booster Lattice



This magnet has been chosen for the "Case Study"

The specifications of the bending magnet are the following

1.) The deflection angle is:

$$\varphi = 10\_\deg. = 0.174533\_rad$$

2.) The corresponding integrated flux density is:

$$\int B \bullet ds = -1.74652\_Tm$$

3.) The integrated gradient is:

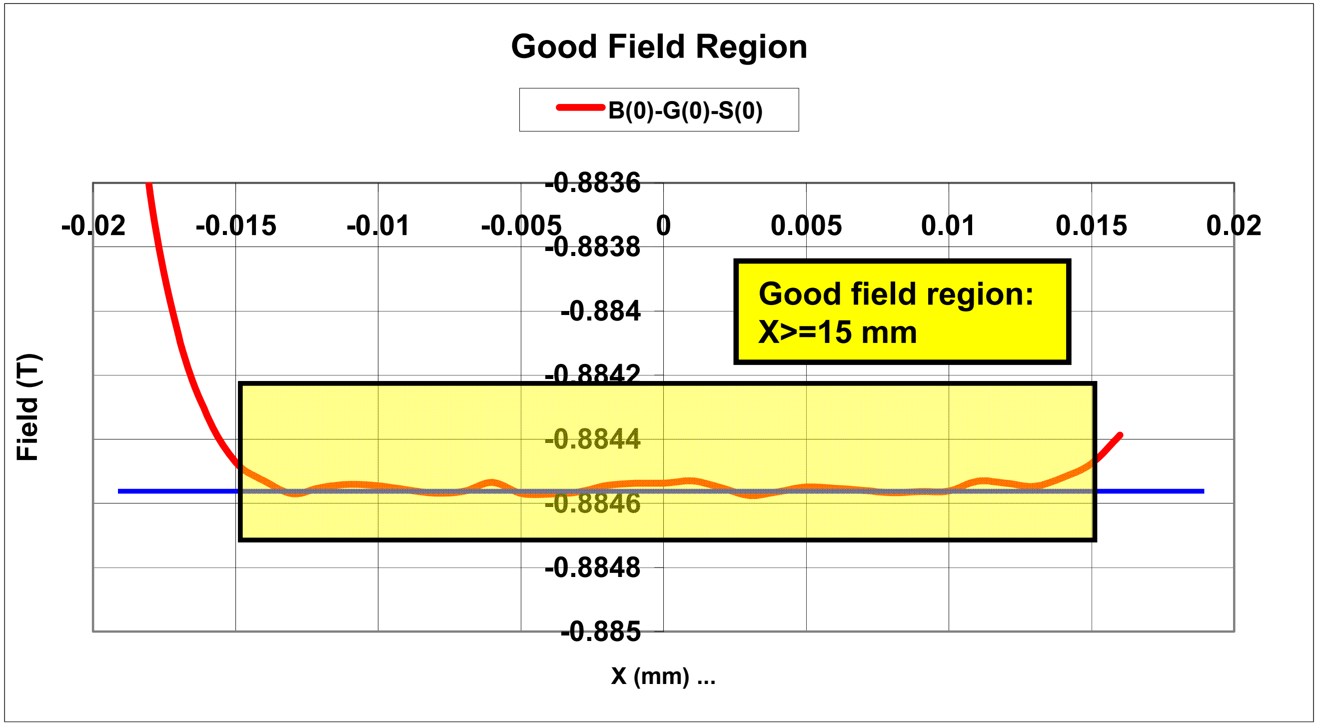
$$\int G \bullet ds = 4.58\_T$$

4.) The integrated sextupole component is:

$$\int \frac{1}{2} \bullet B'' \bullet ds = 18\_T/m$$

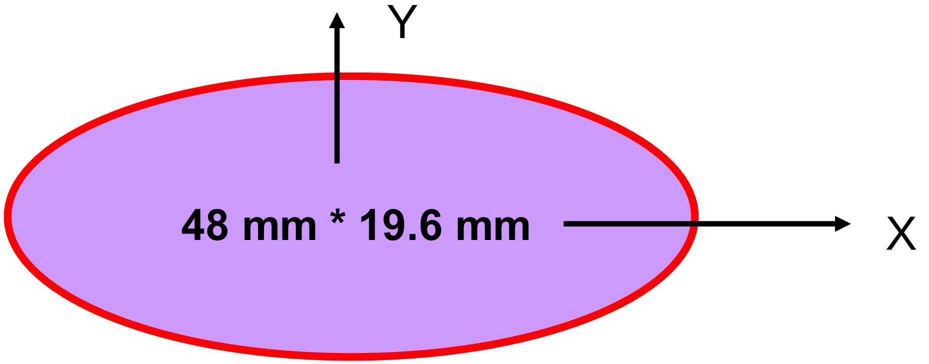
The specifications of the bending magnet are the following

6.) The good field region is:



The specifications of the bending magnet are the following

7.) The size of the vacuum chamber (outer dimensions) is:



8.) The temperature and pressure drop is :

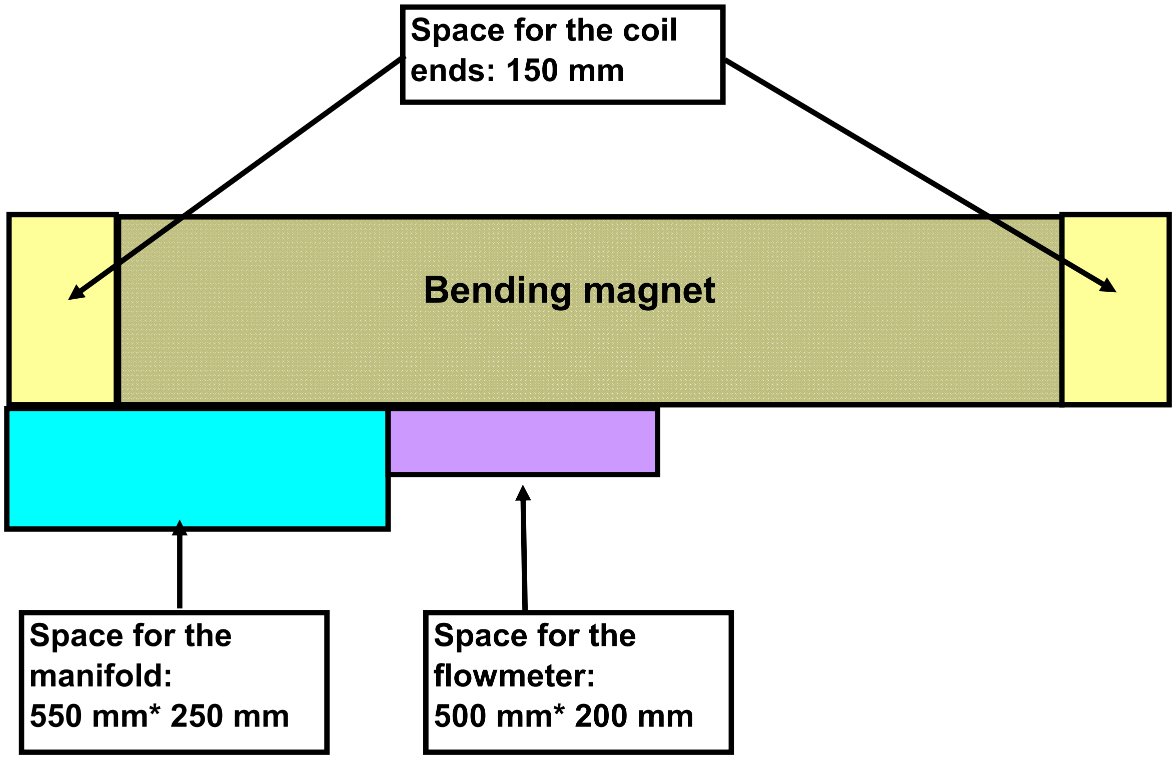
$$\Delta \vartheta = 11\_{}^{0}C\_and\_\Delta p = 7bar$$

9.) The repetition rate is :

$$f(rept.) = 3\_Hz$$

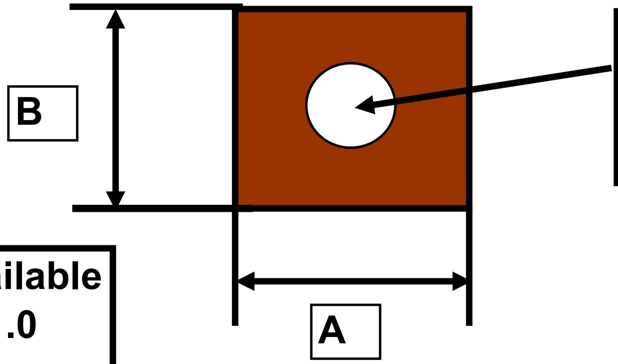
The specifications of the bending magnet are the following

10.) Available space around the :



The specifications of the bending magnet are the following

11.) Sizes of the conductor :



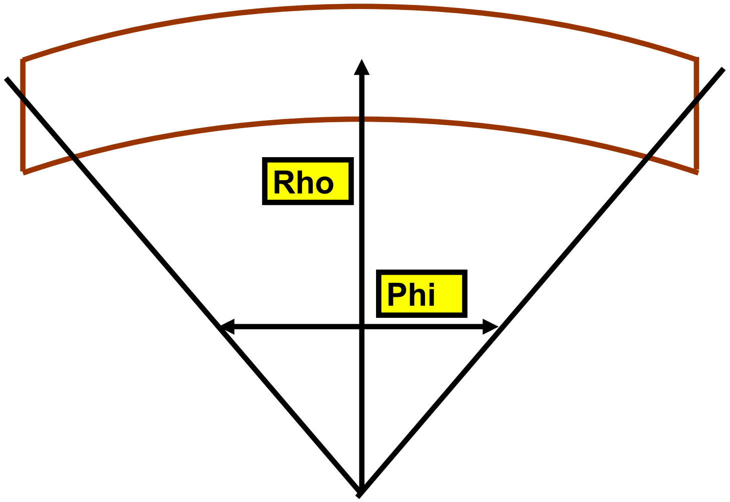
Diameter is a vailable with steps of 0.5 mm

A and B are vailable with steps of 1.0 mm

The specifications of the bending magnet are the following

12.) Shape of the magnet :

It is a so called "curved rectangular bending magnet"



The specifications of the bending magnet are the following

Some people of this course know the specification of this bending Magnet very well.

For these peoples I changed the specifications to the following:

The specifications of the bending magnet are the following

1.) The deflection angle is:

$$\varphi = 11.25\_\deg . = 0.19634954\_rad$$

2.) The corresponding integrated flux density is:

$$\int B \bullet ds = -1.96528\_Tm$$

3.) The integrated gradient is:

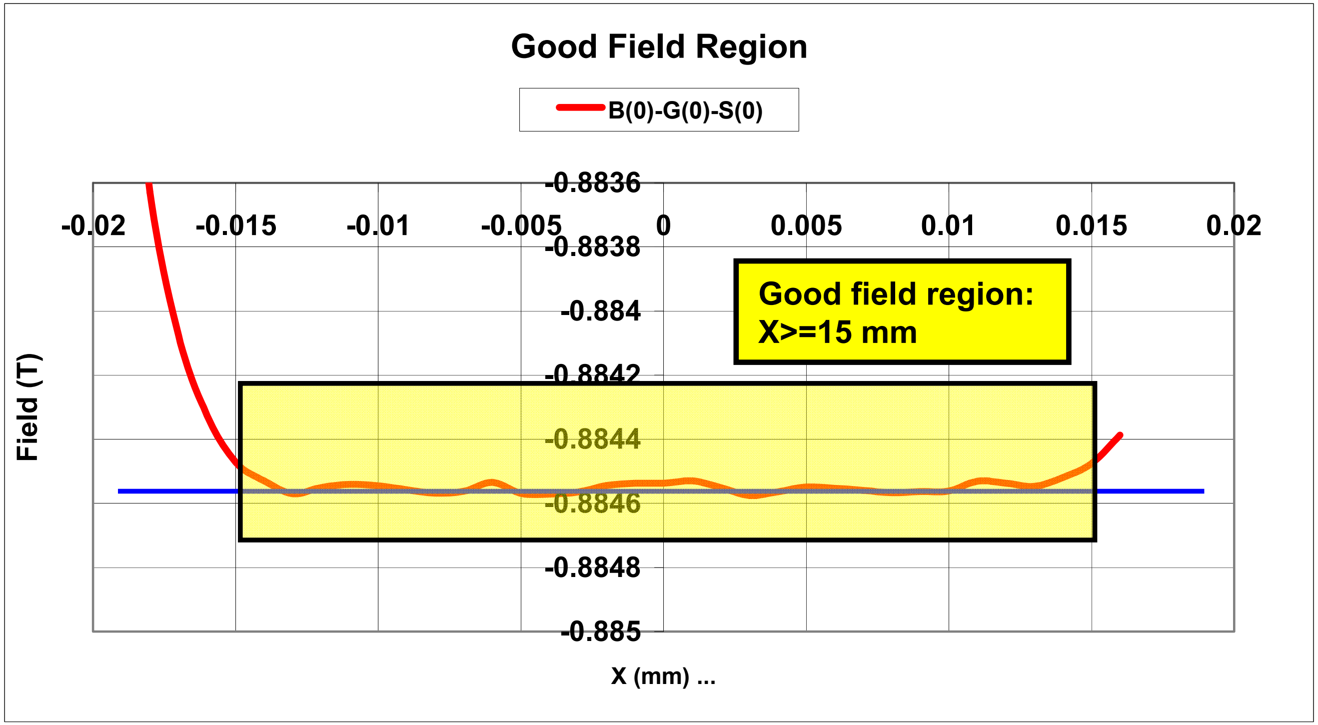
$$\int G \bullet ds = 7.8279\_T$$

4.) The integrated sextupole component is:

$$\int \frac{1}{2} \bullet B'' \bullet ds = 38\_T/m$$

The specifications of the bending magnet are the following

6.) The good field region is:



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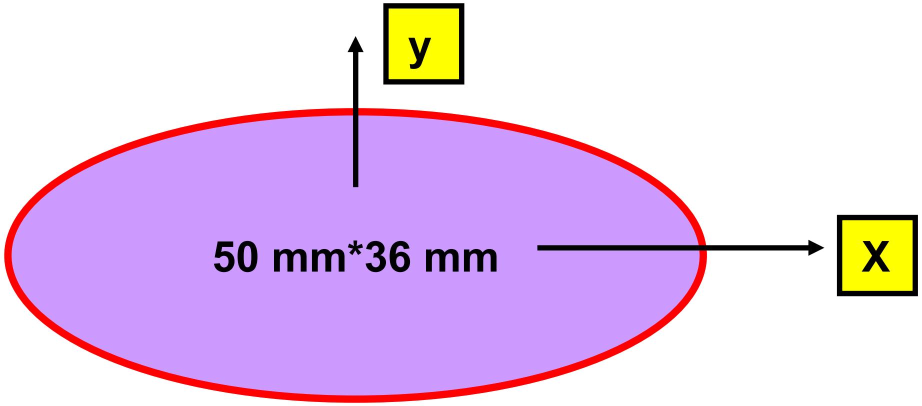
7.) The size of the vacuum chamber (outer dimensions) is:



8.) The temperature and pressure drop is :

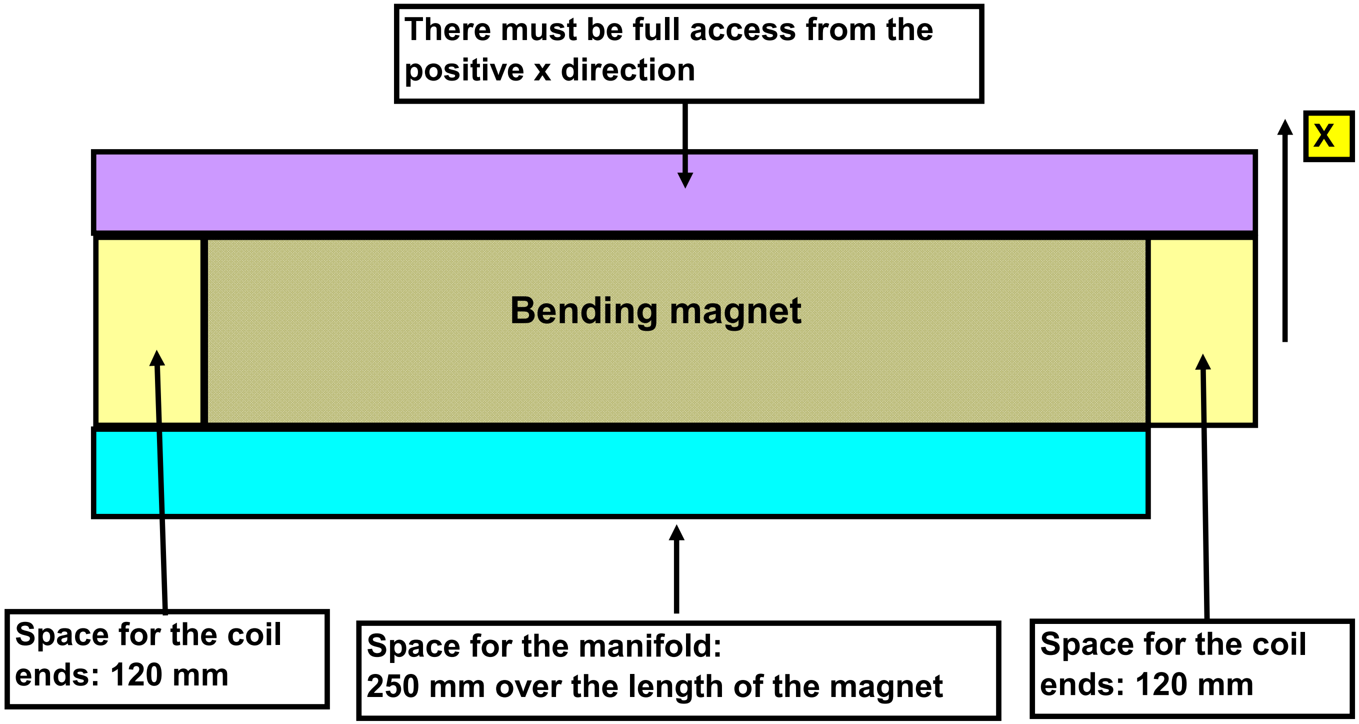
$$\Delta \vartheta = 11\_{}^{0}C\_and\_\Delta p = 7bar$$

9.) The repetition rate is :

$$f(rept.) = 3\_Hz$$

The specifications of the bending magnet are the following

10.) Available space around the :



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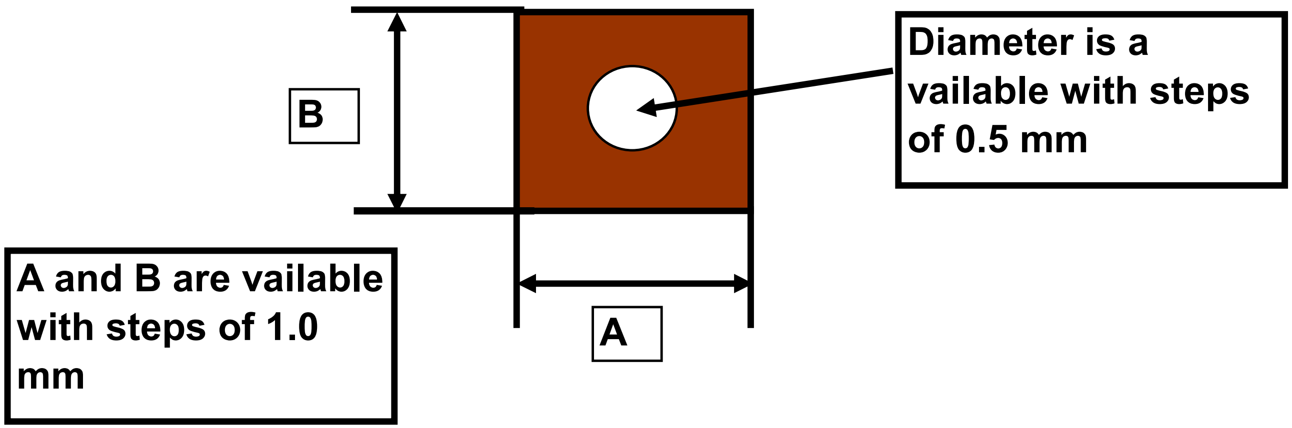

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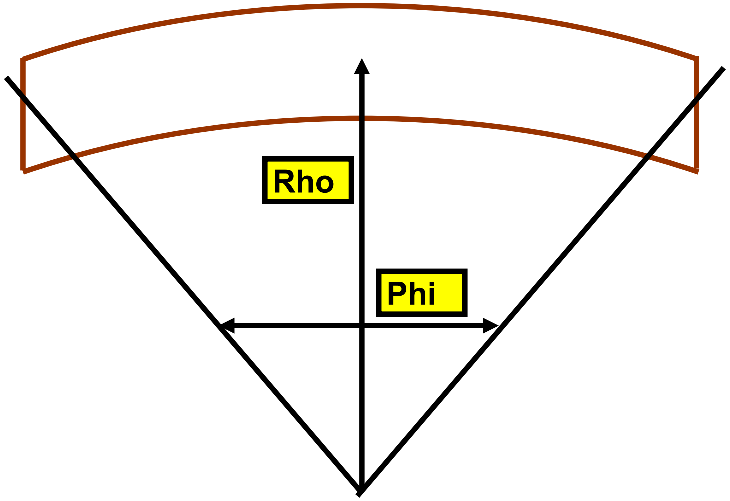

Thanks

and

I wish you a lot of success

D.Einfeld