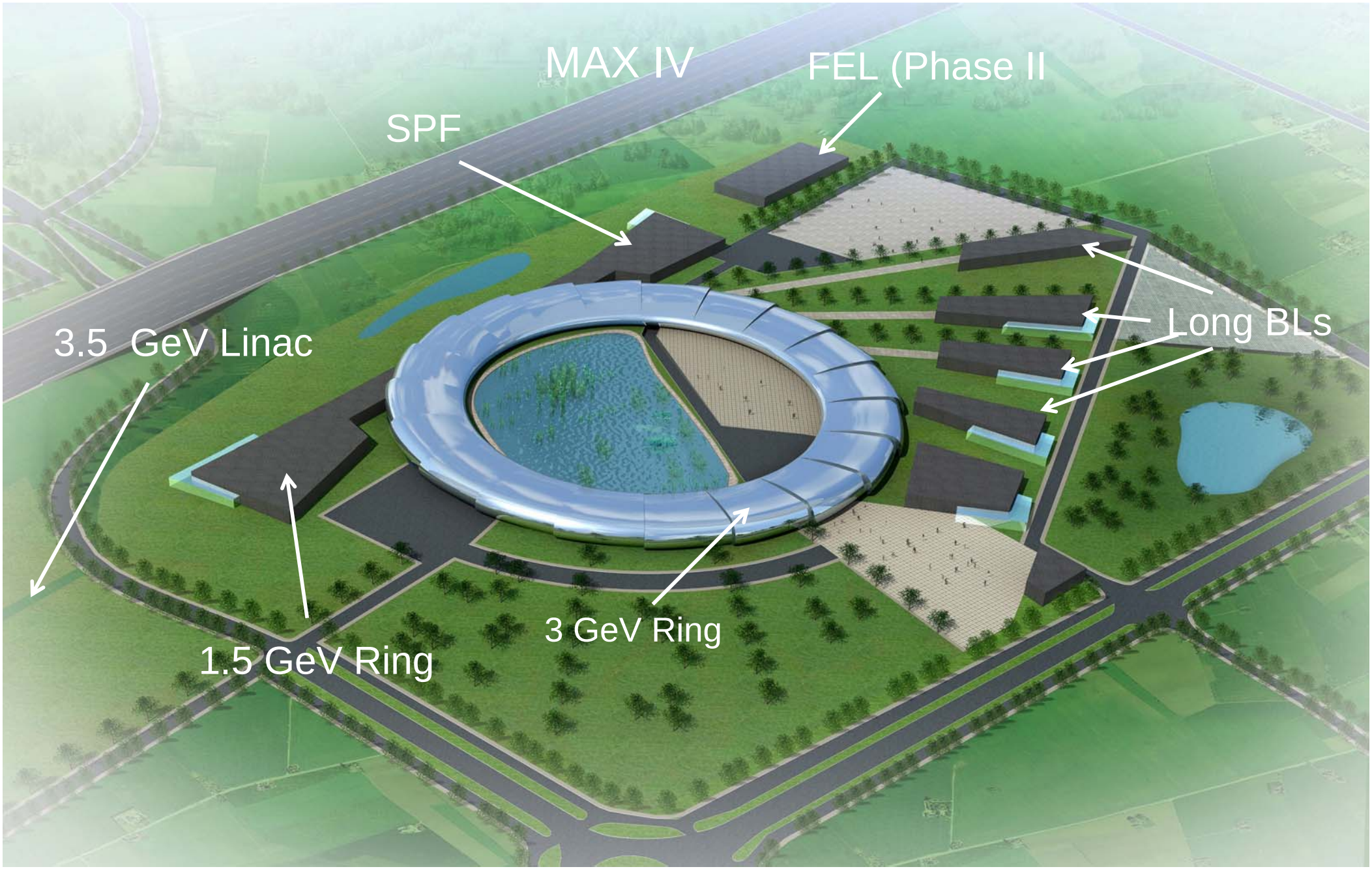
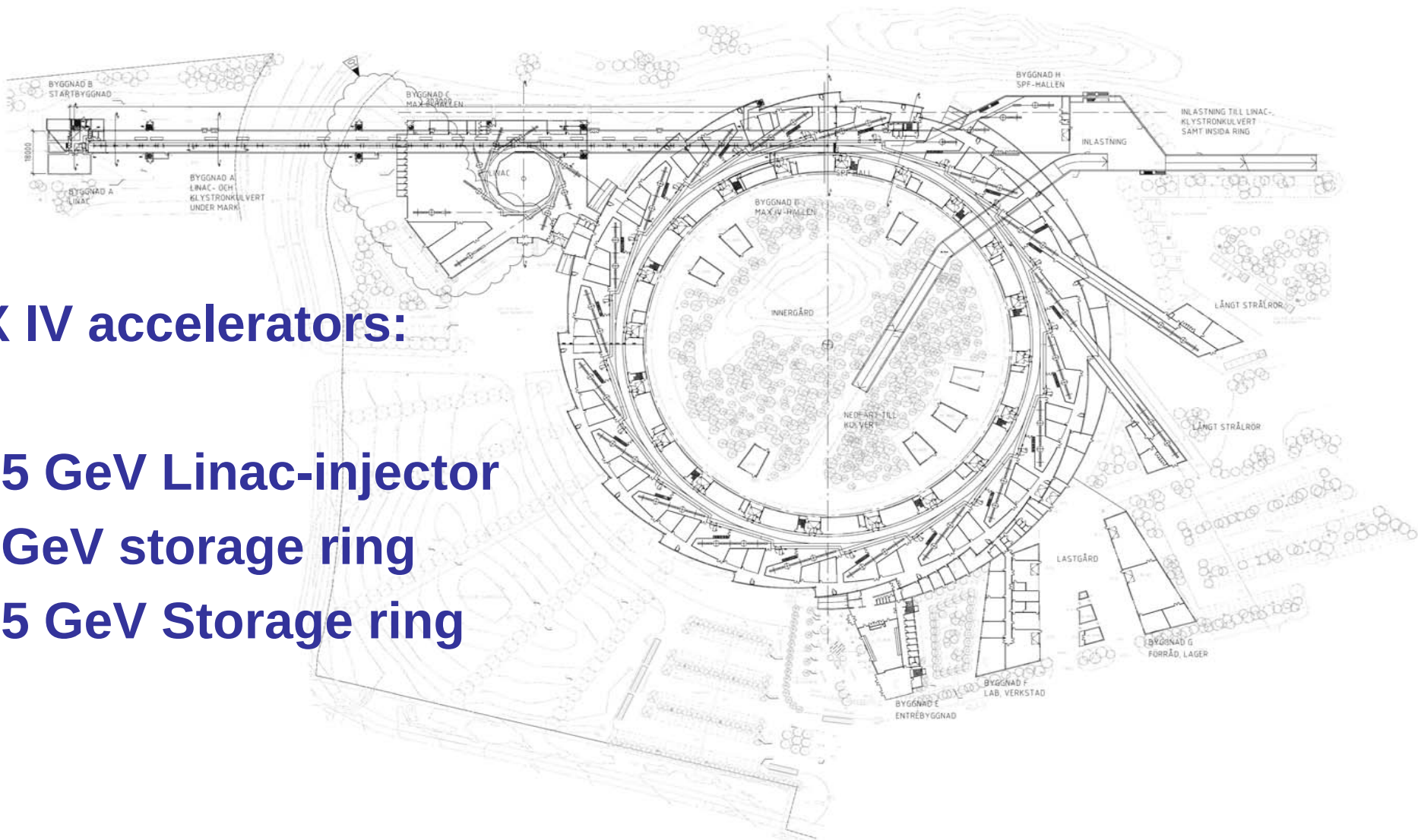
The MAX IV Facility

XVII ESLS Meeting in Hamburg 2009

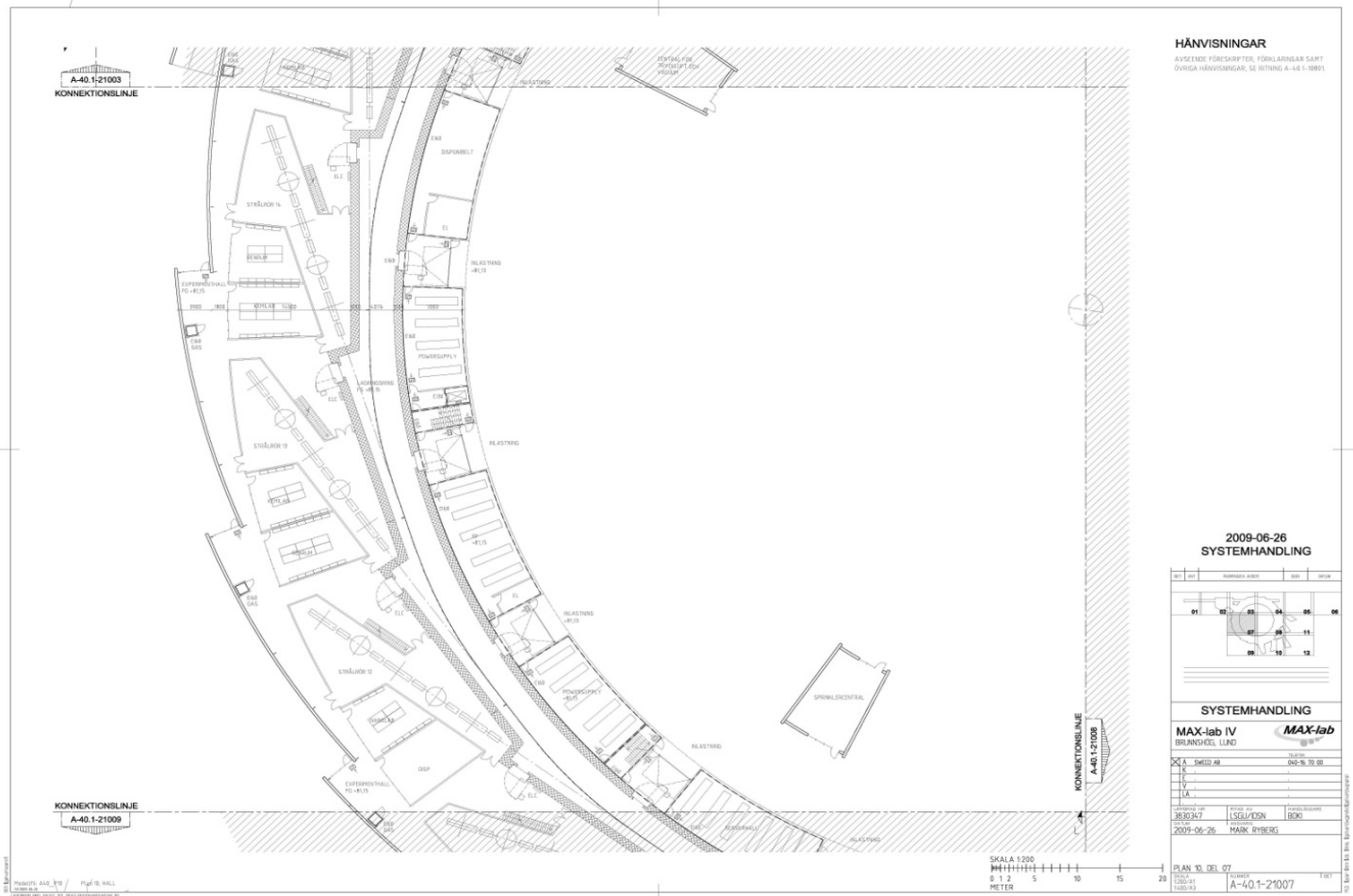

MAX IV
FEL (Phase II
SPF
Long BLs
3.5 GeV Linac
1.5 GeV Ring
3 GeV Ring

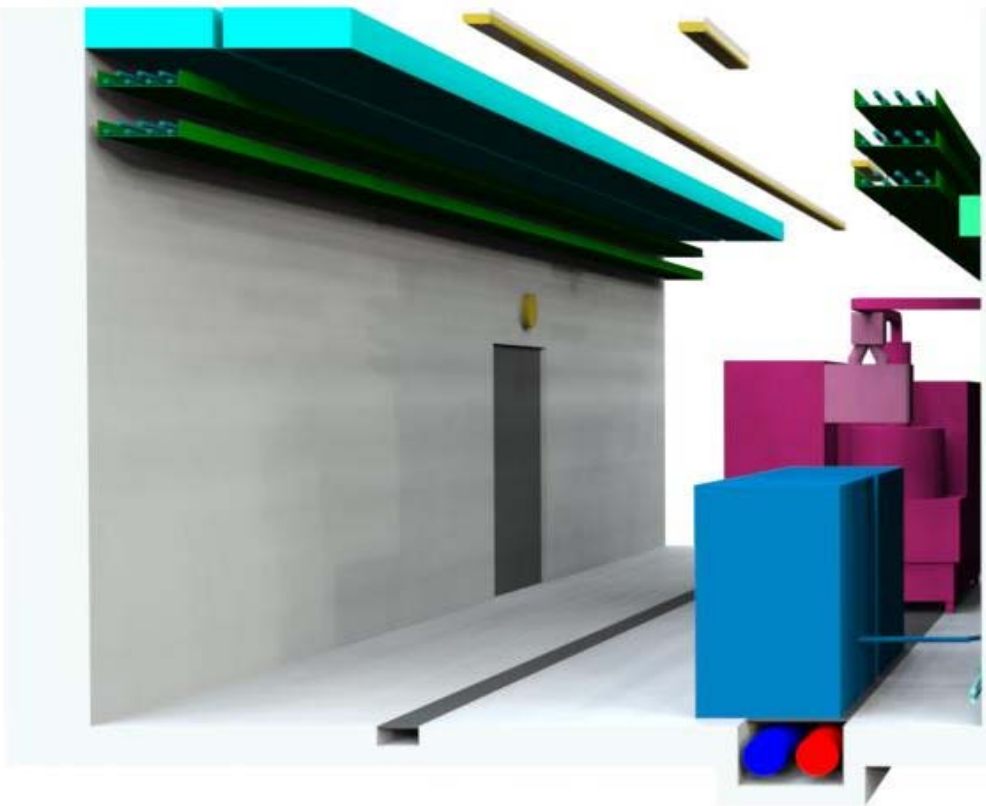


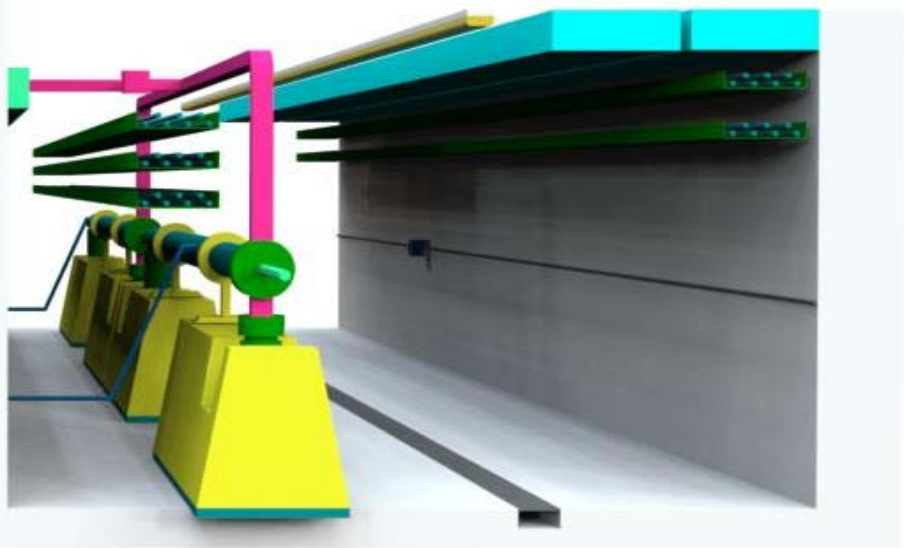
MAX IV accelerators:

- 3.5 GeV Linac-injector
- 3 GeV storage ring
- 1.5 GeV Storage ring

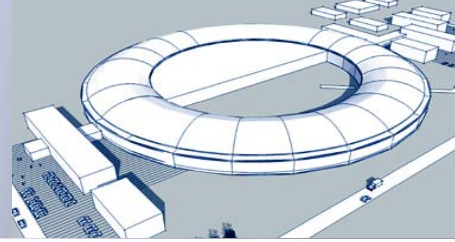
A Circle Section







Klystron gallery & LINAC



Specifications Linac

Linac

Frequency (GHz)	3
Temperature	Warm
End Energy (GeV)	3.5
Charge/pulse (nC)	0.1, 15*0.1 as injector
Bunch length (ps)	0.1
Rep Rate (Hz)	0-100
Emittance (mm mrad)	0.4
Energy spread	$2*10^{-3}$

MAX IV – Swedish / Nordic / Baltic SR facility

Specifications Storage Rings

Electron energy (GeV)	3	1.5
RF (MHz)	100	100
Circ current (mA)	500	500
Circumference (m)	528	96
Nr of long straights	20	12
Length (m)	5	3.5
Hor emittance (nm rad)	0.24	5.6
Hor RMS beam size (μm)	45	200
Vert RMS beam size (μm)	2.6	10
Beam life-time (h)	10	5

Top-up injection in both rings

MAX IV – 3 Gev Ring

Receipt for designing a low emittance ring:

Remember: $$Brilliance \propto \frac{1}{\varepsilon^2} \qquad \varepsilon = C_q \frac{Energy^2}{(N_{magnets})^3}$$

1. Try to minimize C_q (Theoretical Minimum Emittance)
   But: Doesn't work, the ring gets unstable.

2. Increase the number of magnets.
   But: The ring will get a 2 km or so circumference.
   (PETRA, PEP)

   So: We make the componenets small but keep a large number of magnets

Some FAQs:

Q1: Why don’t everyone increase the number of cells (magnets) to get ultra-small emittance?

A: The Chromaticity Brick Wall for Double Bend Achromats (DBA), so we use 7-bend achromats.
Then we can minimize the destructive Hamiltonian resonance driving terms within the cells.
Moreover: Conventional magnets are too bulky, need MAX III type magnets.

Q2: Why are we not using damping wigglers (DW) extensively?

A: The DWs have an eigenemittance, which you can’t go below. Undulators work fine, however.

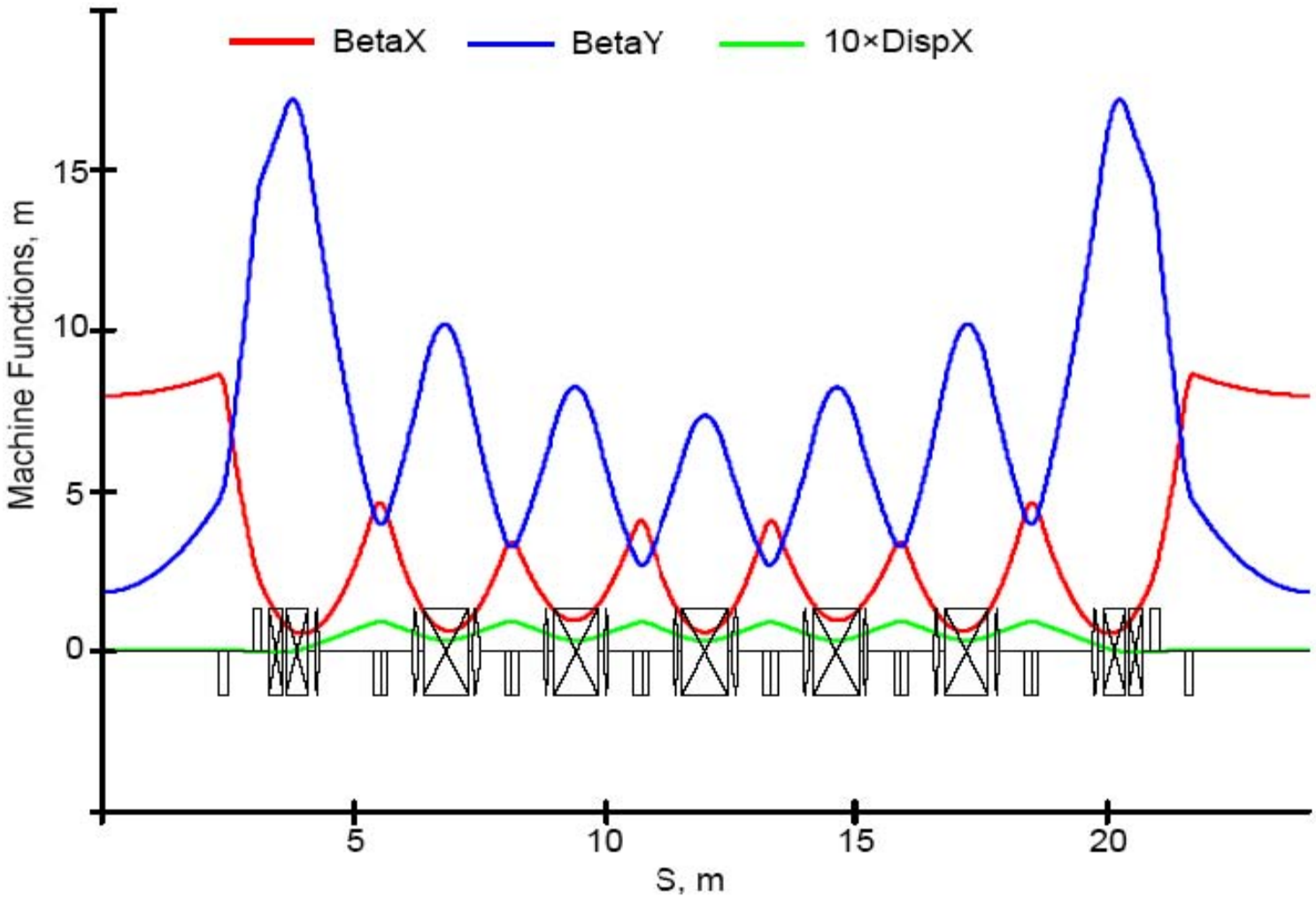
Q3: How about Touschek life-time? Will it kill small emittance rings?

A: Particle momenta are Coulomb-scattered from the transverse direction to the longitudinal one and could be lost when the scattered momenta exceeds the bucket heght. As you decrease the emittance, the collision rate increases, but the transverse momenta decreases.
MAX IV 3 GeV ring is on the right slope, as emittance decreases, life-time grows.

Q4: What is the hook?

A: A 7-bend achromat takes space. However, Sweden is empty to first approximation, so we have lots of space.

MAX IV – Swedish / Nordic / Baltic SR facility



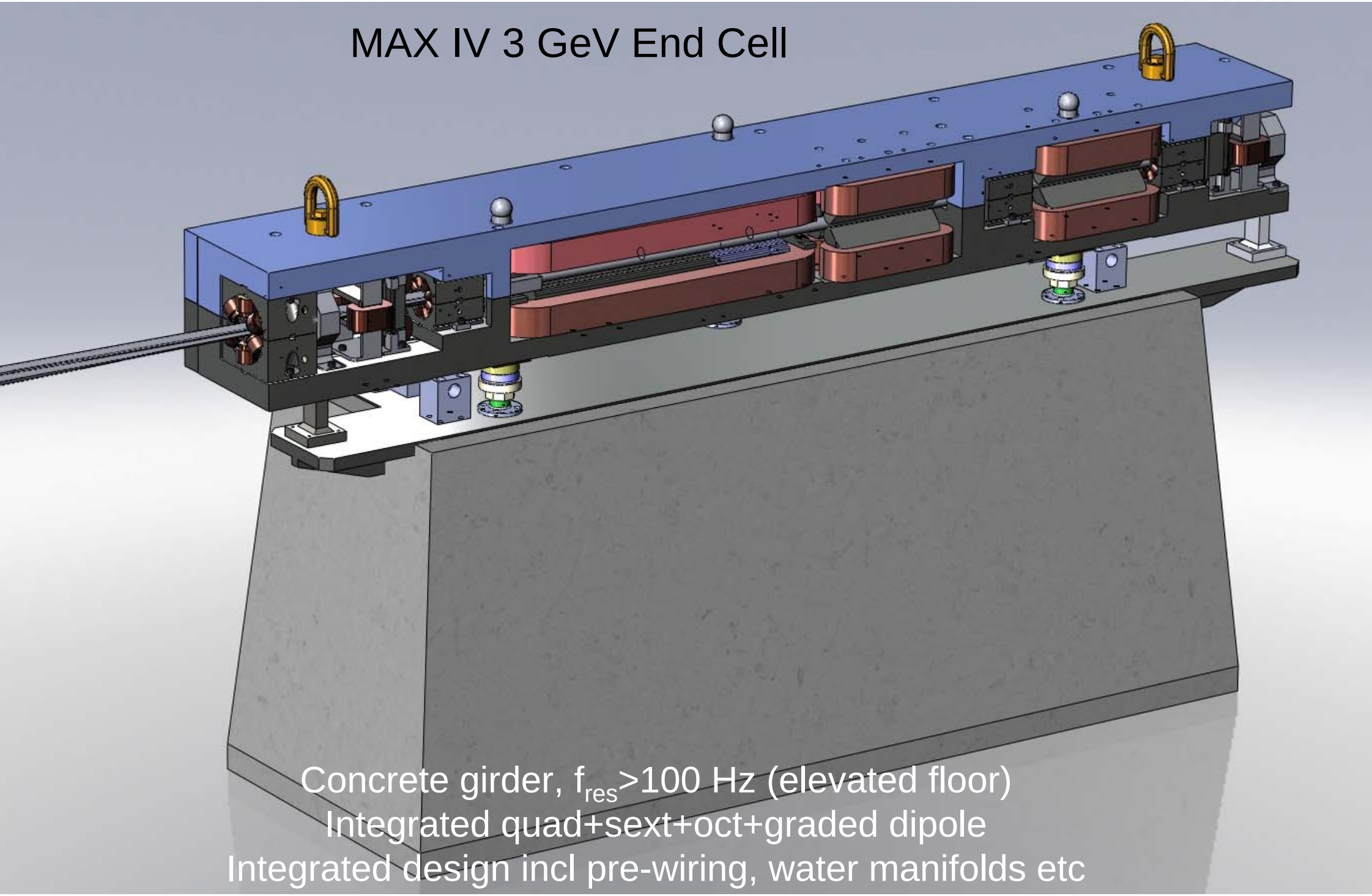
•Cromaticity brick wall:

•Sextupole magnets necessary for chromaticity correction, but they decrease the dynamic aperture.

•Conventional (DBA) lattices have few sextupoles=>can't minimize driving terms within cell

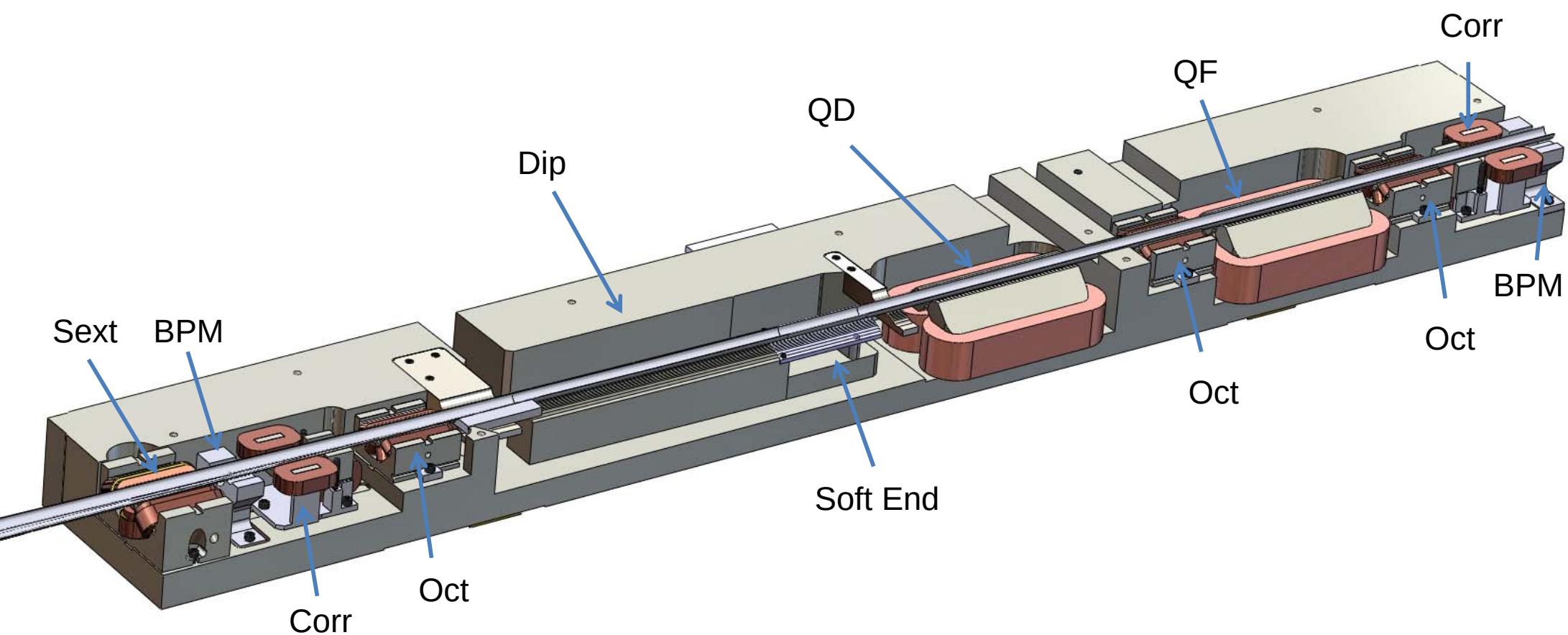
•7-bend achromats have several sextupoles so we can.

MAX IV 3 GeV End Cell

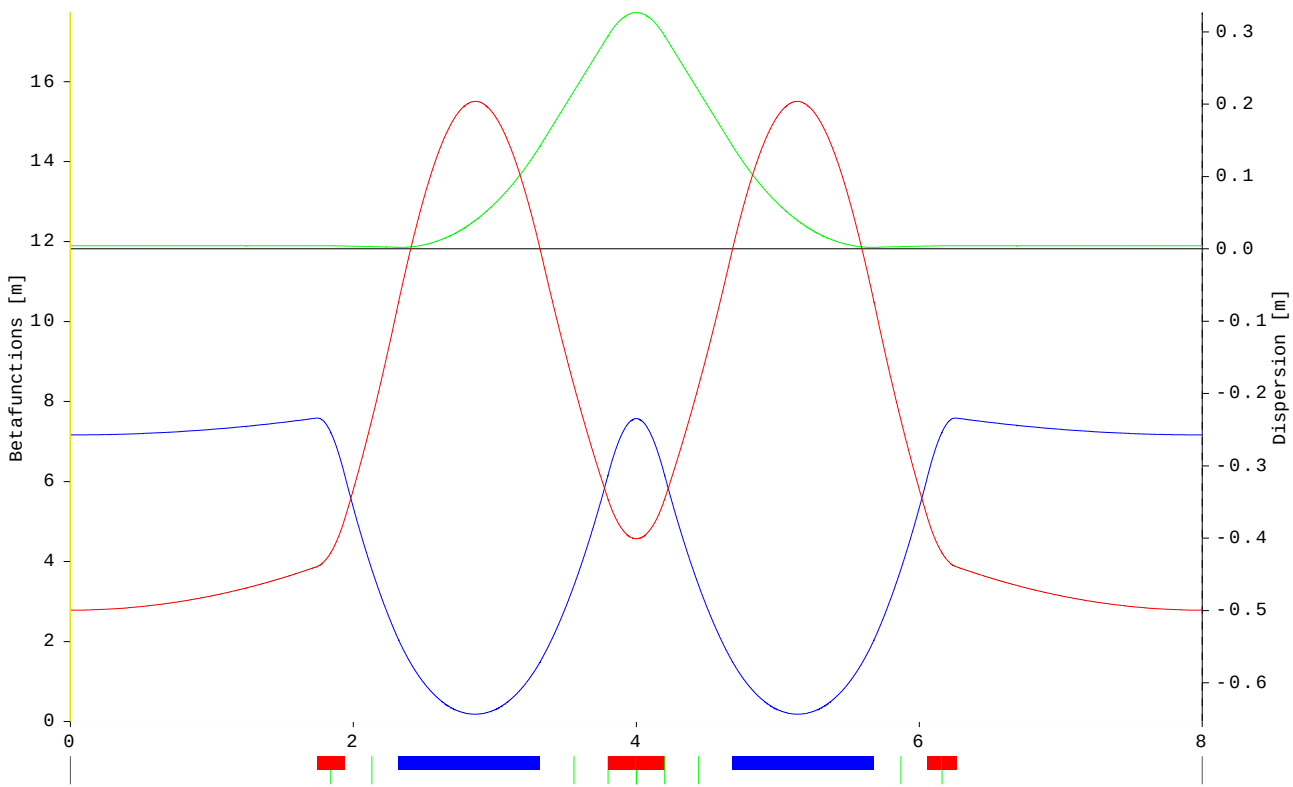


Concrete girder, f_{res}>100 Hz (elevated floor)
Integrated quad+sext+oct+graded dipole
Integrated design incl pre-wiring, water manifolds etc

MAX IV 3 GeV End Cell

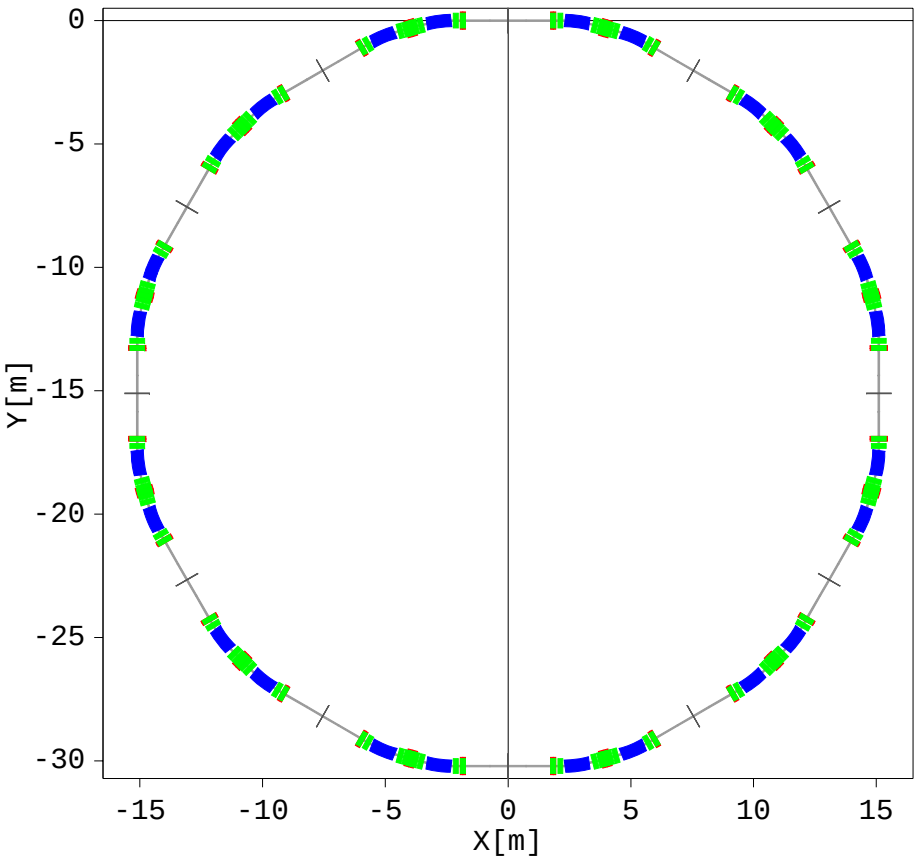


MAX IV 1.5 GeV

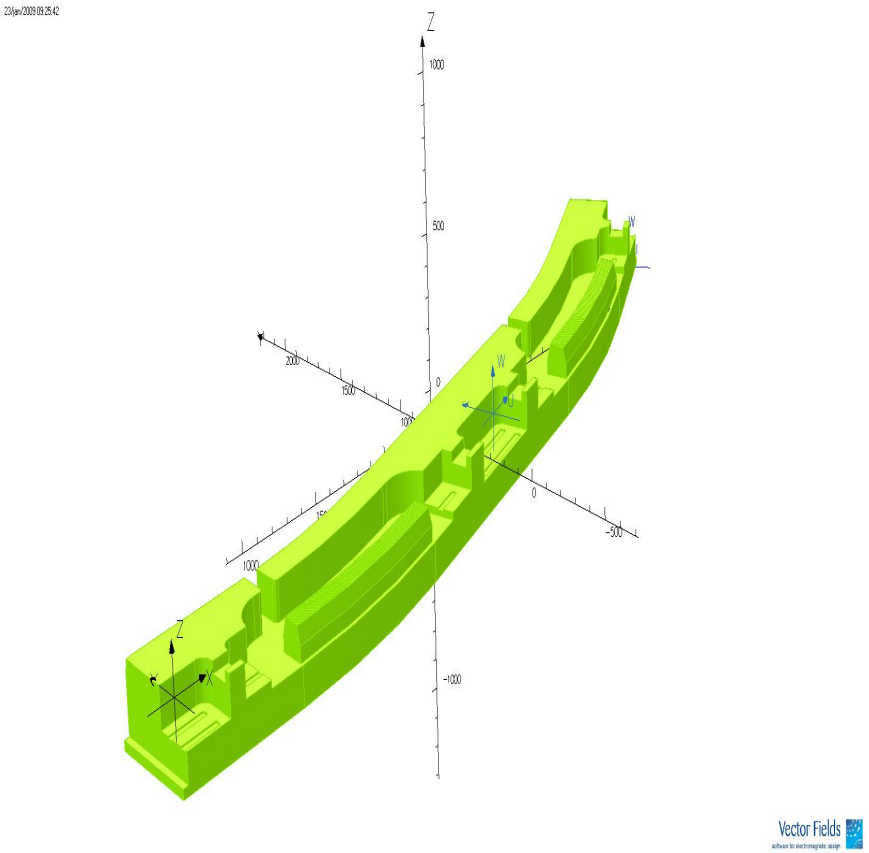


Energy	1.5 GeV
Circ current	0.5 A
Circumference	96 m
Hor emittance	5.6 nm rad
Achromat nr	12
Straight section	3.5 m
Hor RMS beam size	0.200 mm

MAX IV 1.5 GeV lattice

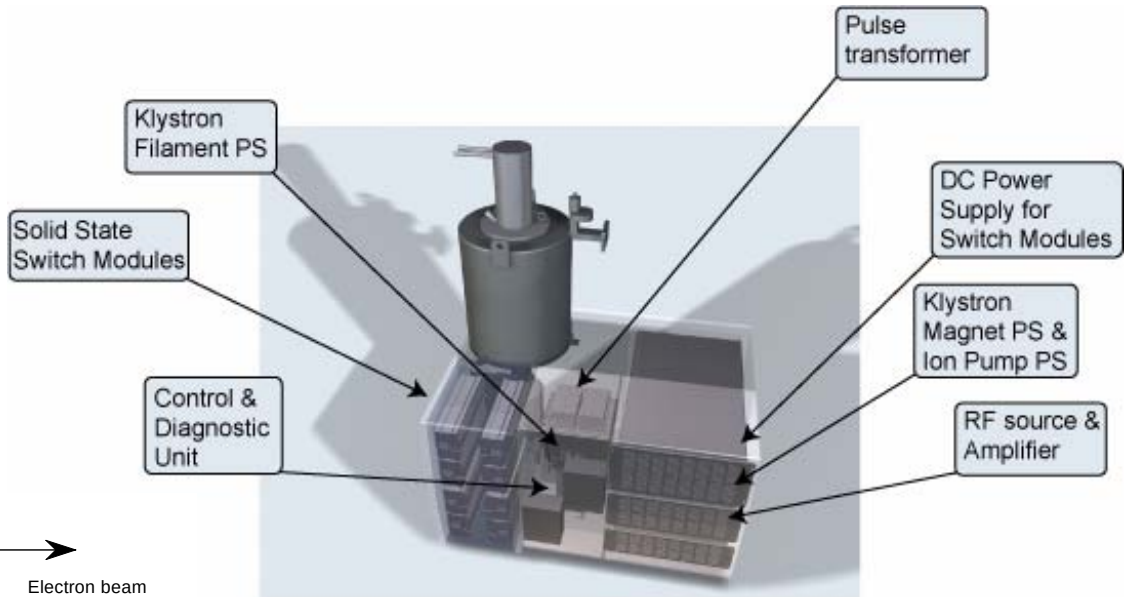


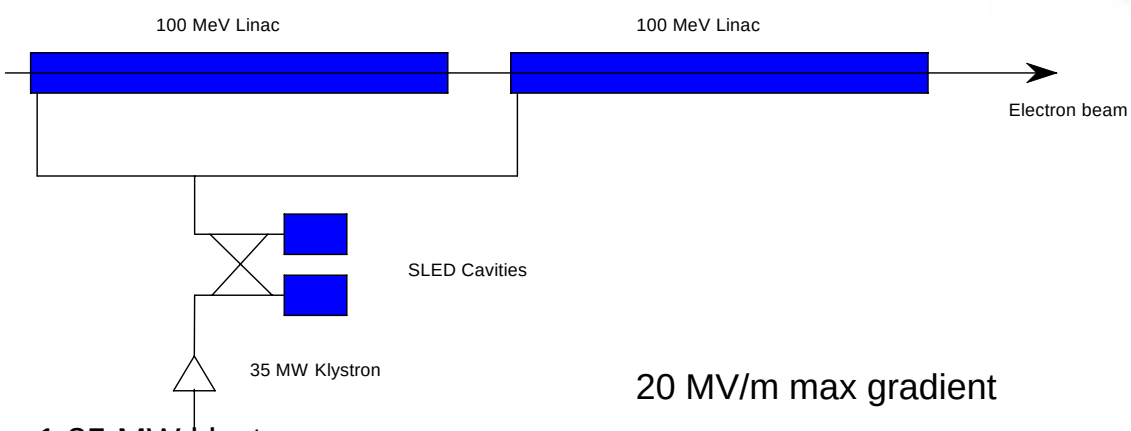
Achromat



MAX IV – linac

Linac Module (18 of them)





1 35 MW klystron

1 Pair of SLED cavities

2 pcs 5 m linac structures

20 MV/m max gradient

Max dutyfactor 0.001

Solid state modulators
=>variable pulse length

MAX IV Linac

- SPF-operation gun

  Charge/bunch decreased from 1 nC to 0.1 nC

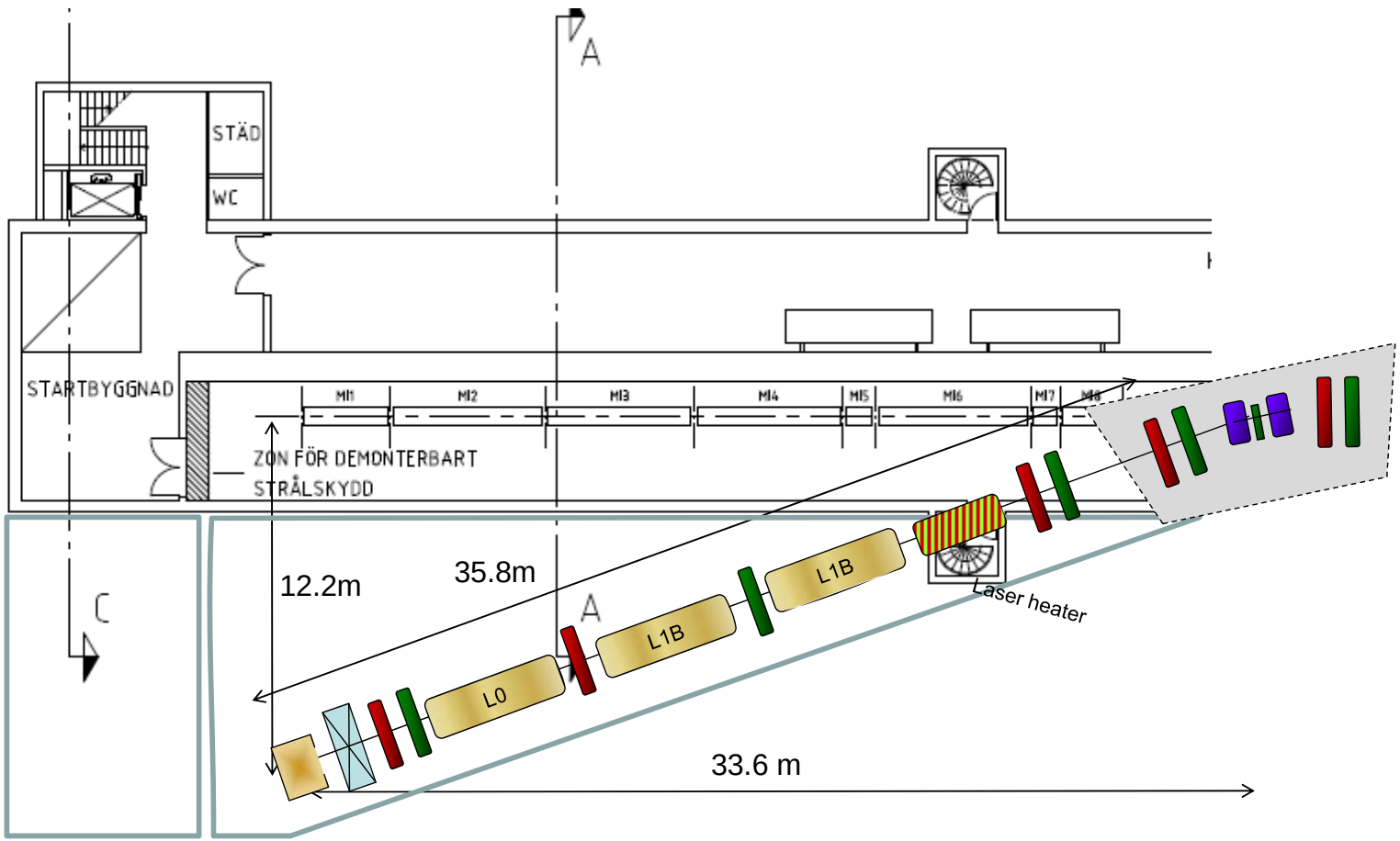
  One bunch/RF pulse

  Low emittance operation eventually permits longer undulators for SASE gain (not fully explored yet).

- Injection gun

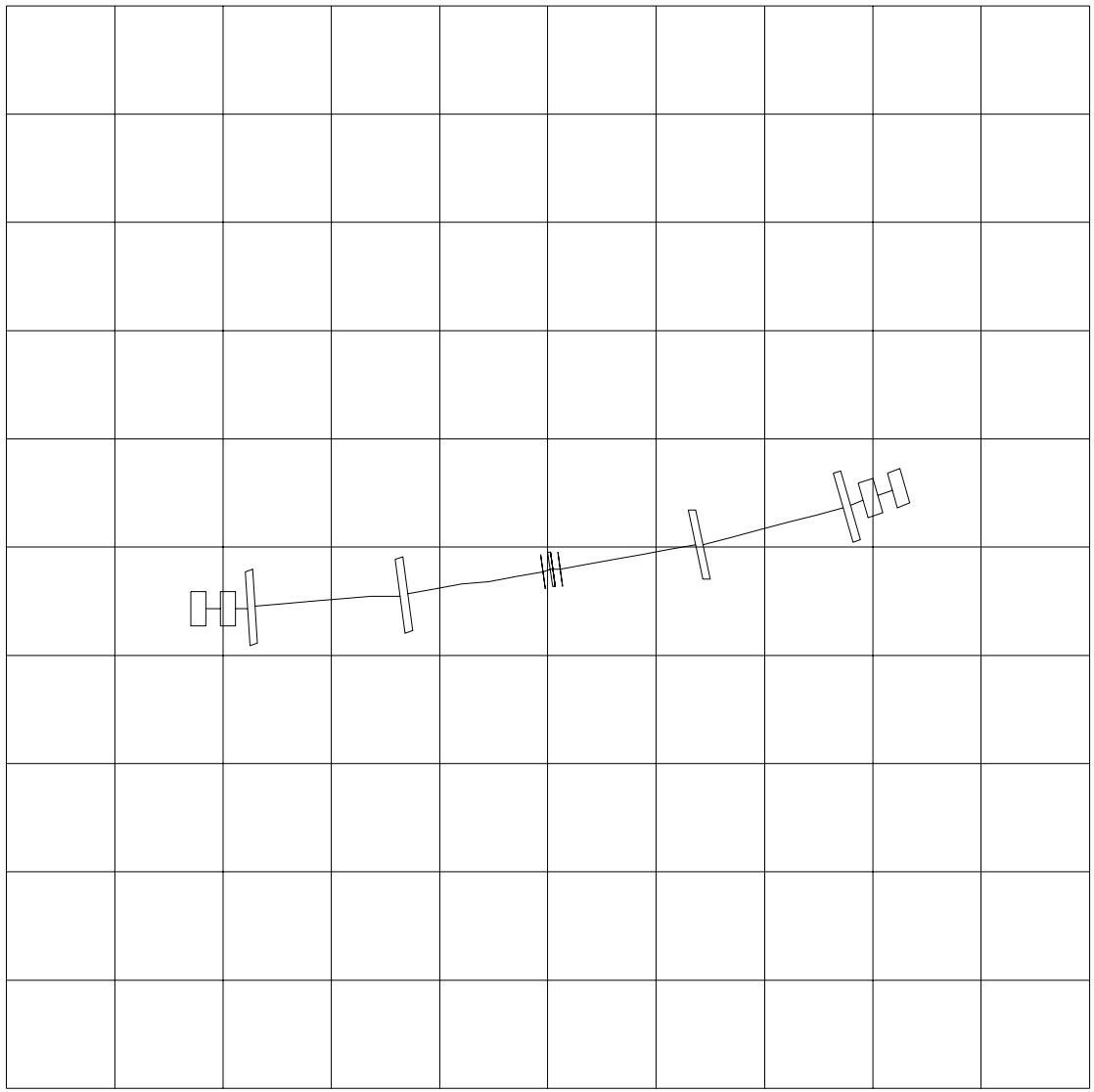
  15 bunch train, 0.1 nC/bunch (1.5 nC)

  750 shots to fill 3 GeV ring to 0.5 A (75 s at 10 Hz)



Linearizing 1st bunch compressor

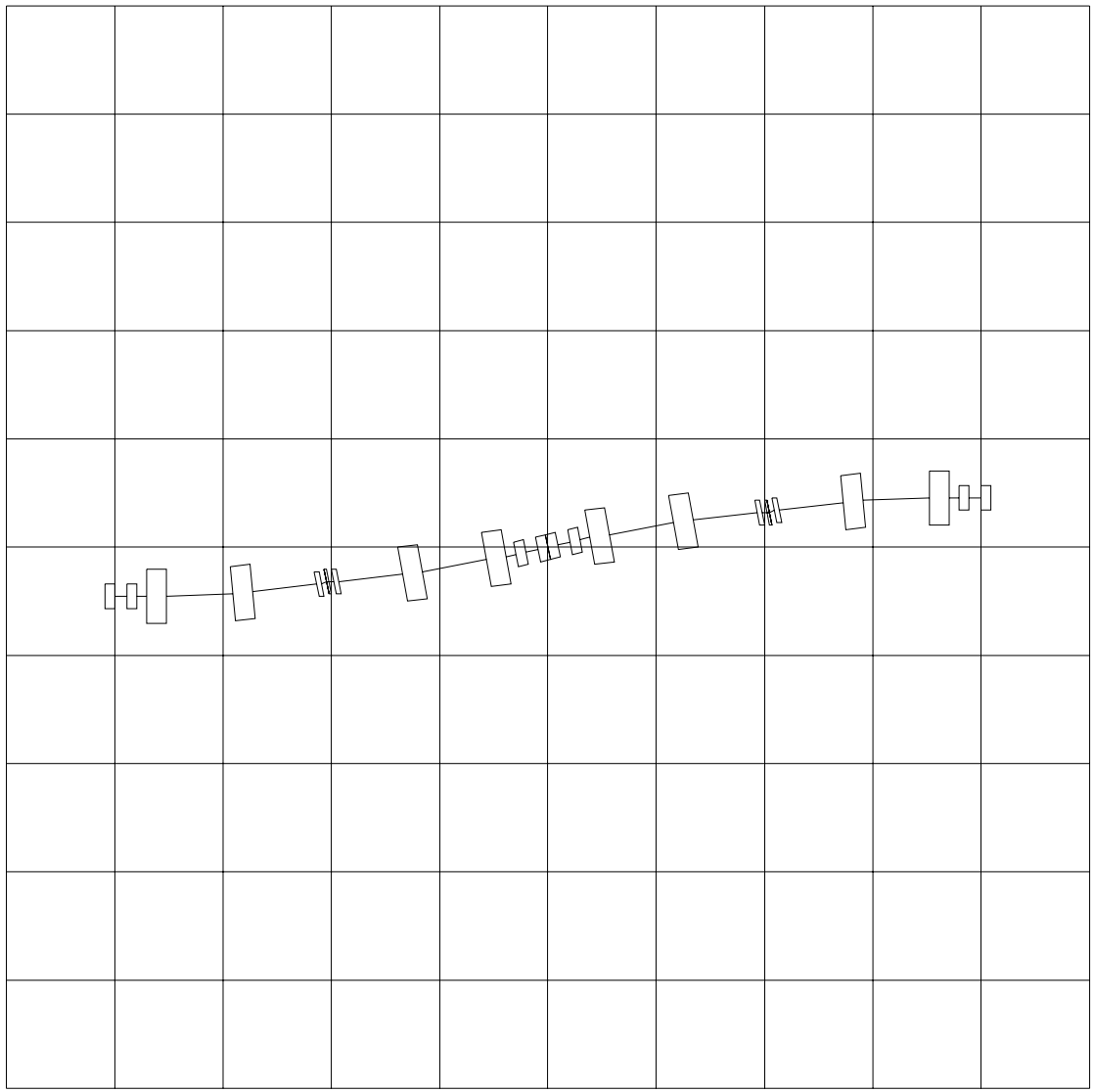
Horizontal plan view [X-Y plane]



Grid size 1.5000 [m]

First achromat compressor at 0.25 GeV

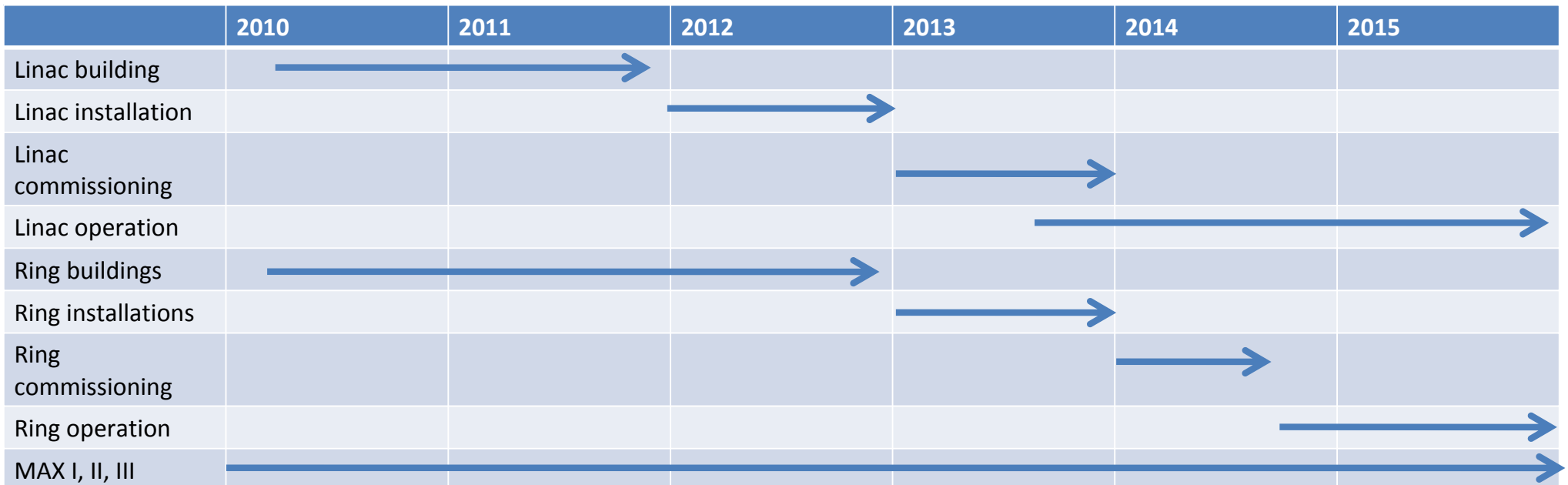
Horizontal plan view [X-Y plane]



Grid size 2.0000 [m]

2nd compressor at 3 GeV

Time schedule MAX IV



Acknoledgement

MAX-lab staff

END