Cost-saving Design Choices for MAX IV

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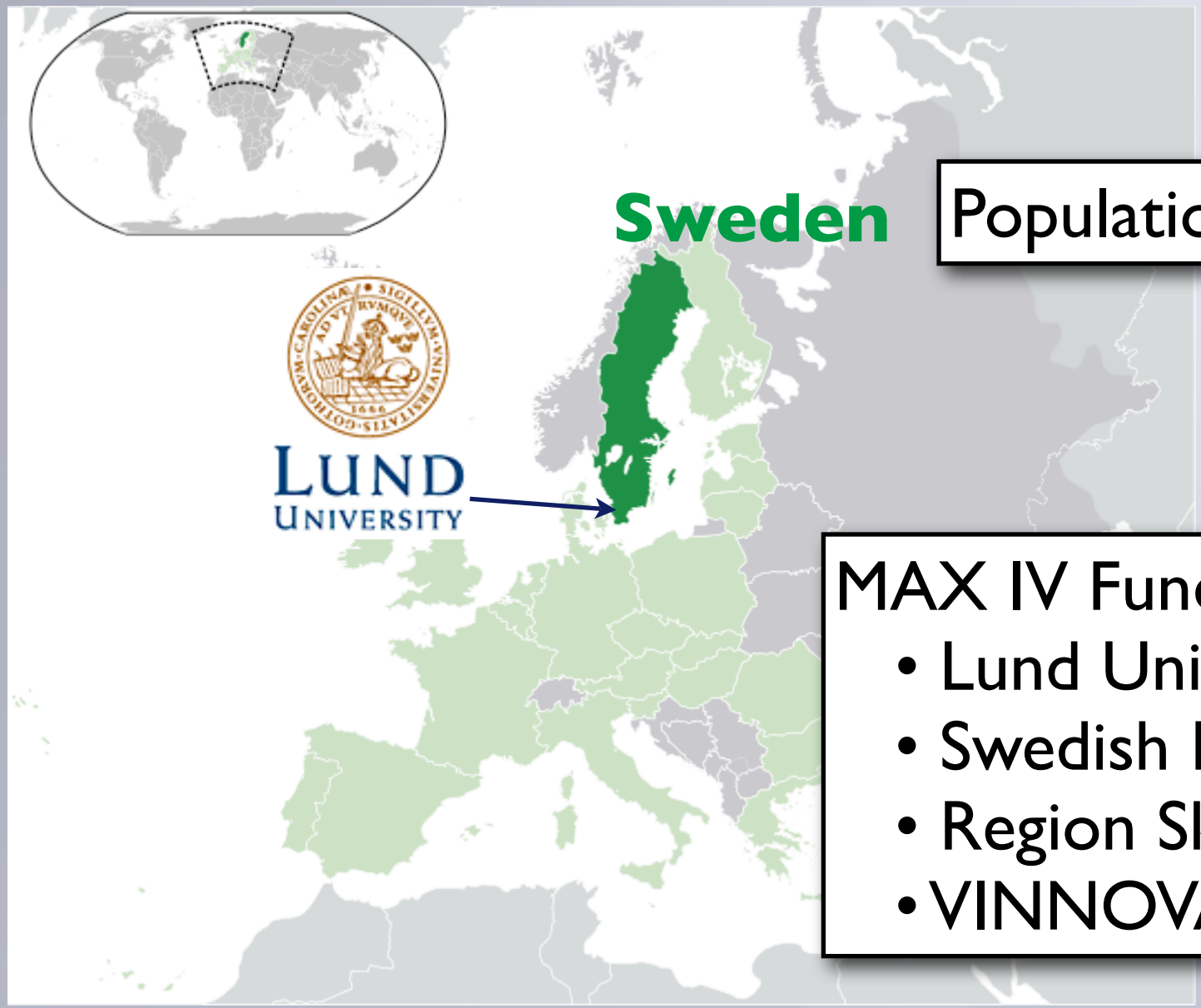
MAX-lab is a Swedish National Laboratory



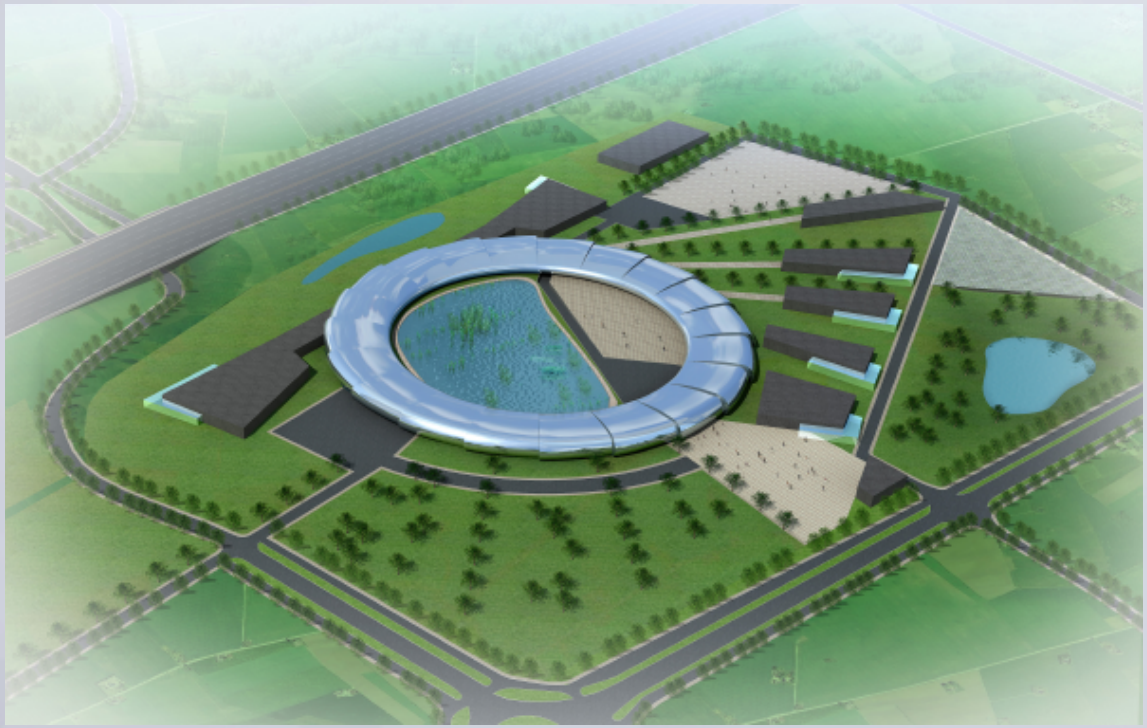
Population: 9,340,682 (2009)

MAX IV Funding:

- Lund University
- Swedish Research Council
- Region Skåne
- VINNOVA Foundation

Design and Technology Choices with Budget Constraints

- Lattice & Magnets
  - Multibend achromat lattice
  - Integrated magnet design
  - Girders / Supports
  - Soft-end dipoles
- Vacuum System
  - NEG-coated vacuum chamber
- RF Systems
  - 100 MHz RF
  - Harmonic Landau cavities
- Insertion Devices
  - Damping wigglers



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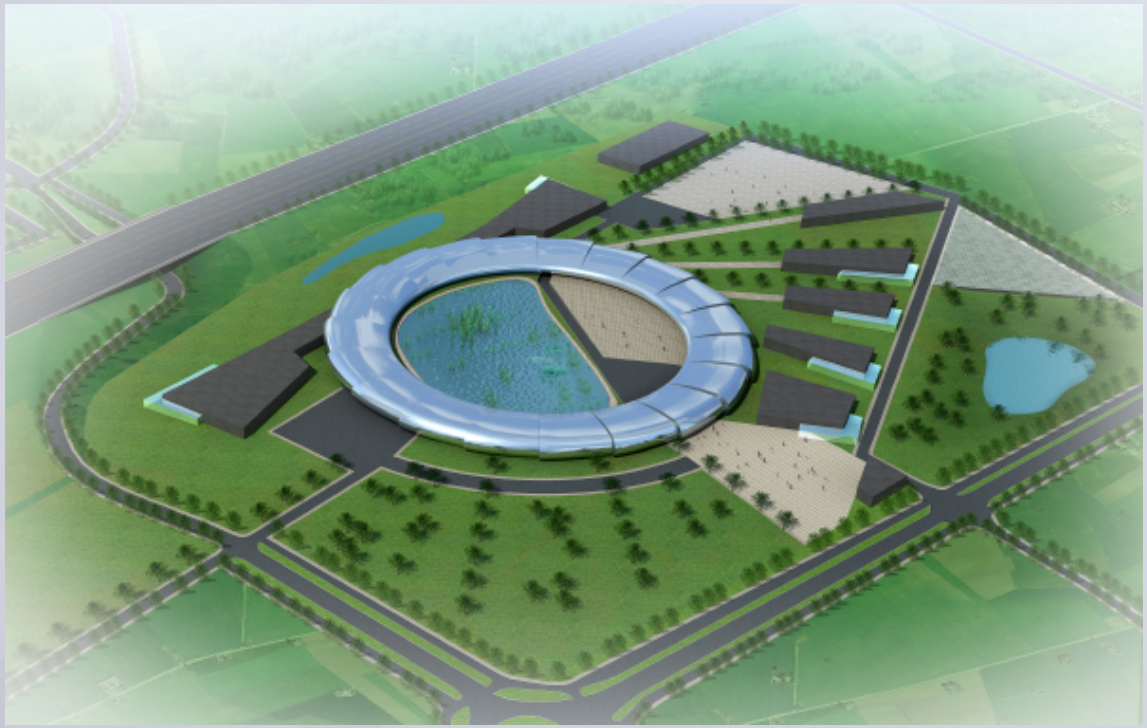


Multibend Achromats for Ultralow Emittance

- Simple & robust method to reach ultralow ε_x
  → inexpensive (if ring remains compact!)

$$\varepsilon_x = C \frac{E^2}{N_d^3}$$

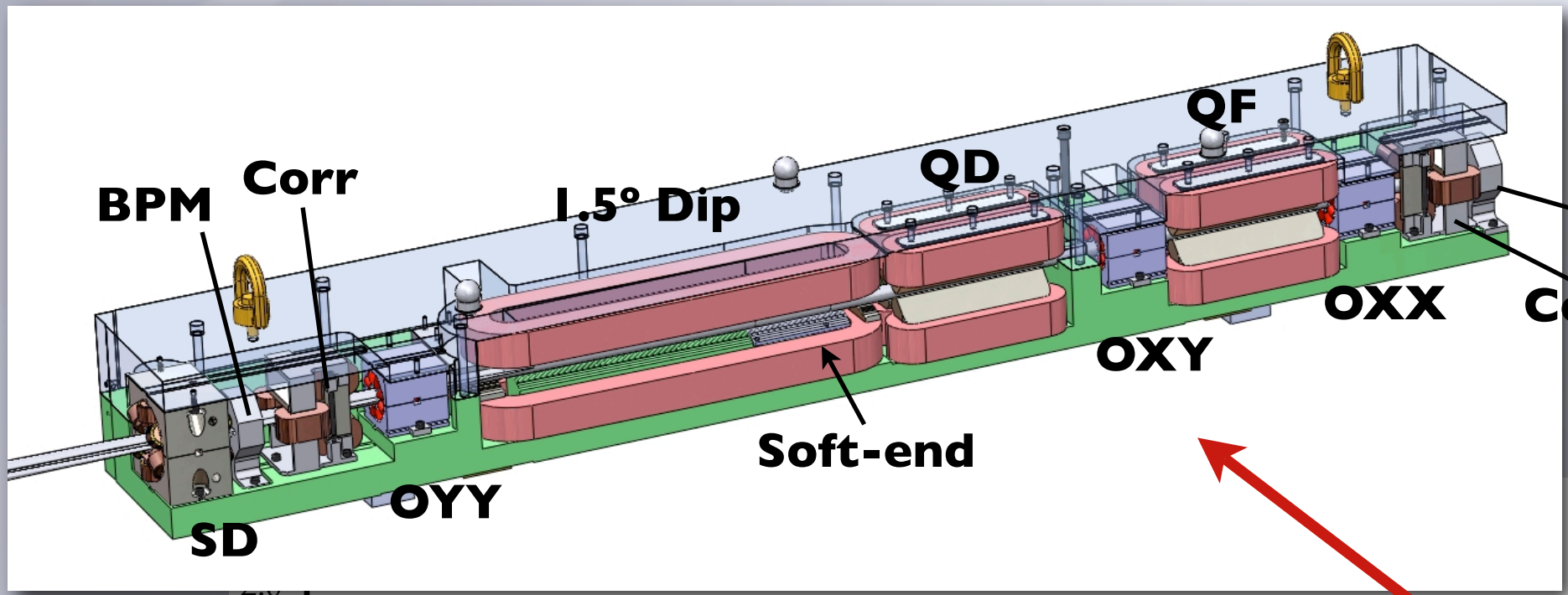
TME

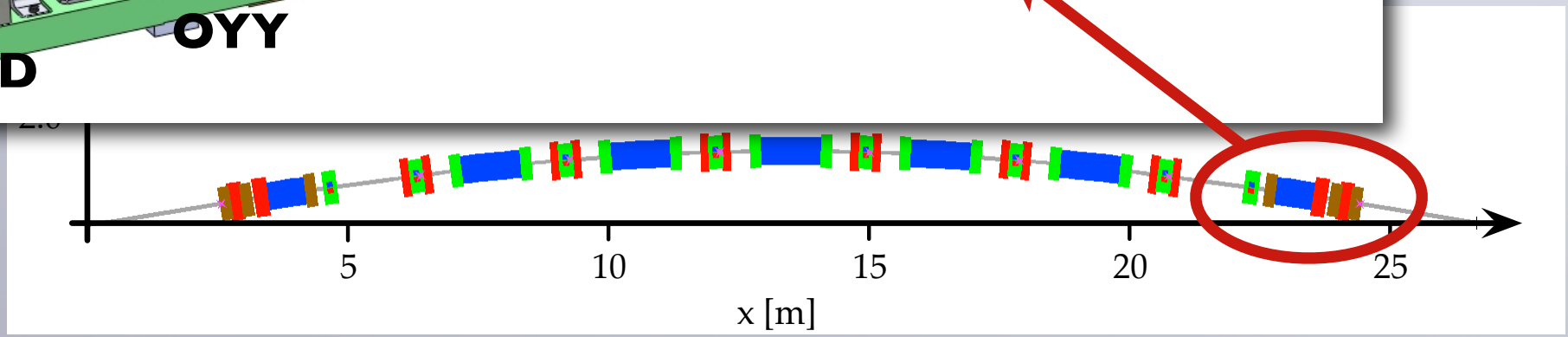
MBA

- Combined-function magnets and/or integrated magnet design
- Need strong quadrupoles and sextupoles
- Many (mechanically identical) small magnets → 25 mm magnet gap
  → less expensive to manufacture
  → reduce operational cost
- Power magnets in families; add floating power supplies where necessary
  → reduce cabling costs
  → reduce complexity

Integrated Magnet Design (3 GeV Storage Ring)

- Each unit cell and matching cell is machined from two solid blocks of iron (demonstrated at MAX III → NIM A **601** (2009) 229)
- Excellent in terms of alignment and comparably inexpensive to manufacture





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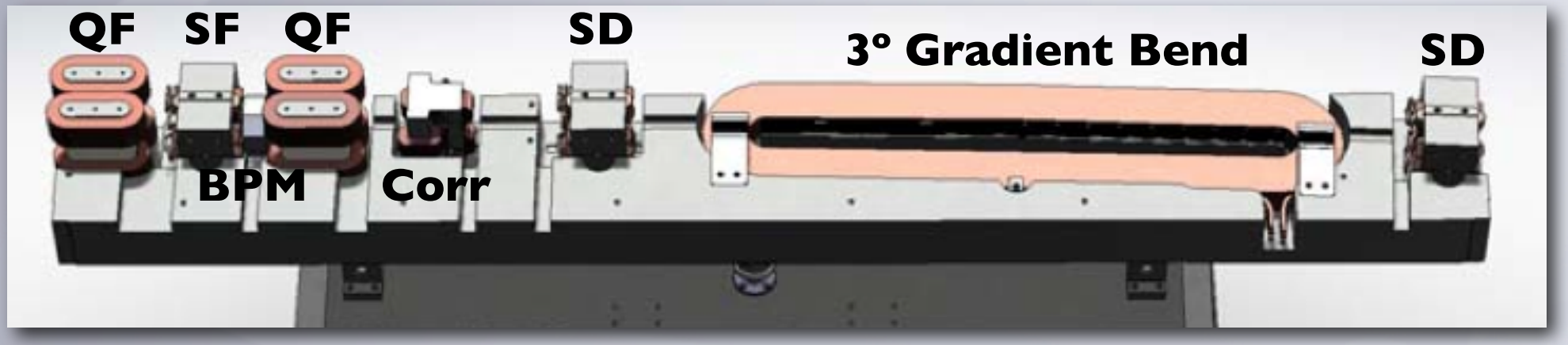
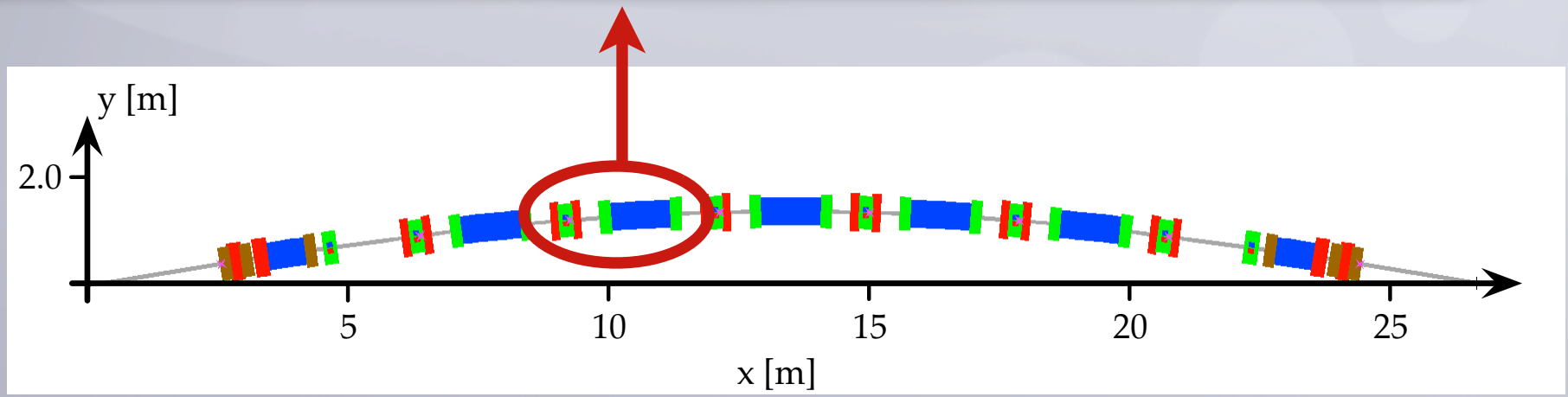
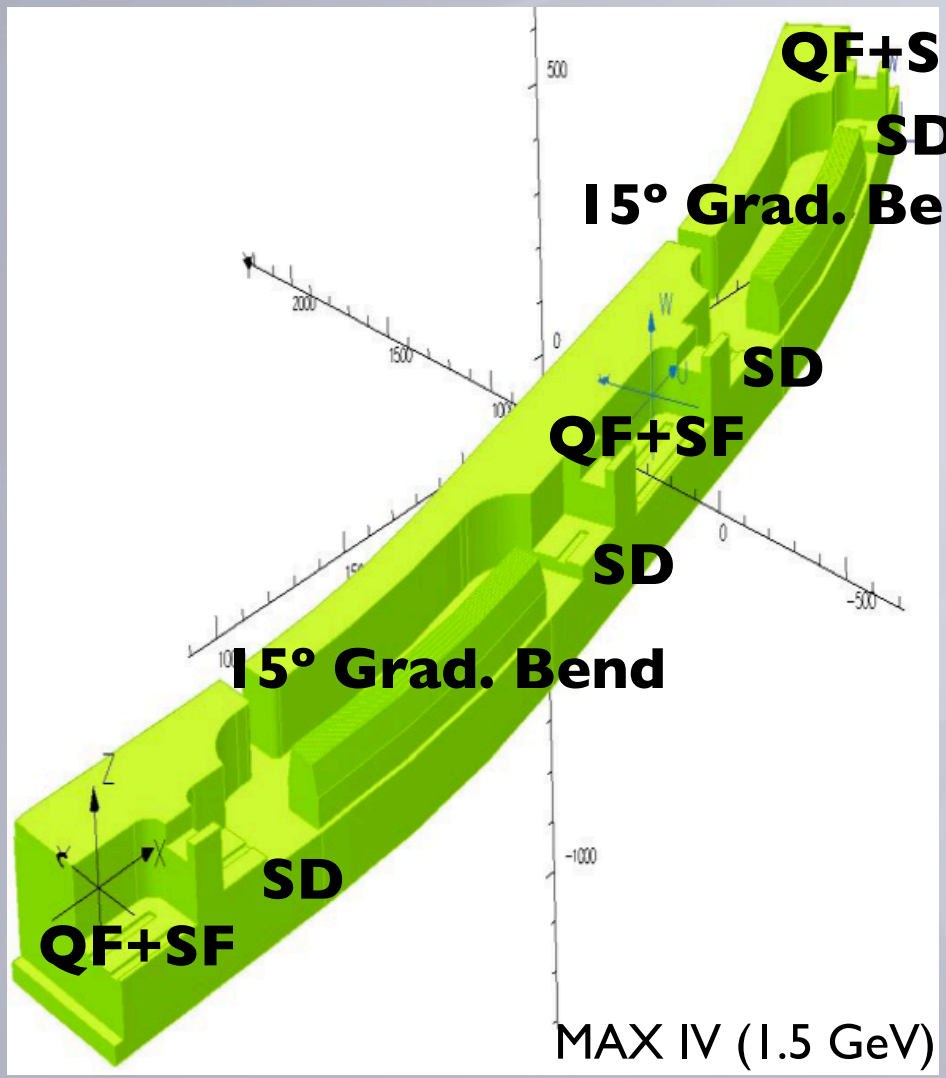
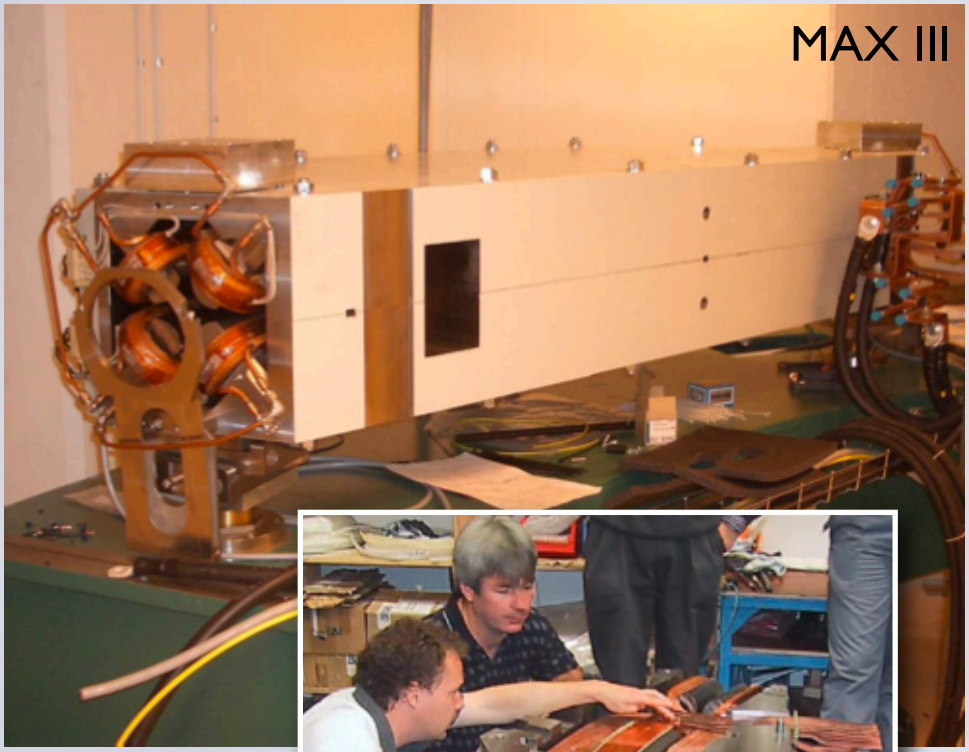




Integrated Magnet Design (1.5 GeV Storage Ring)

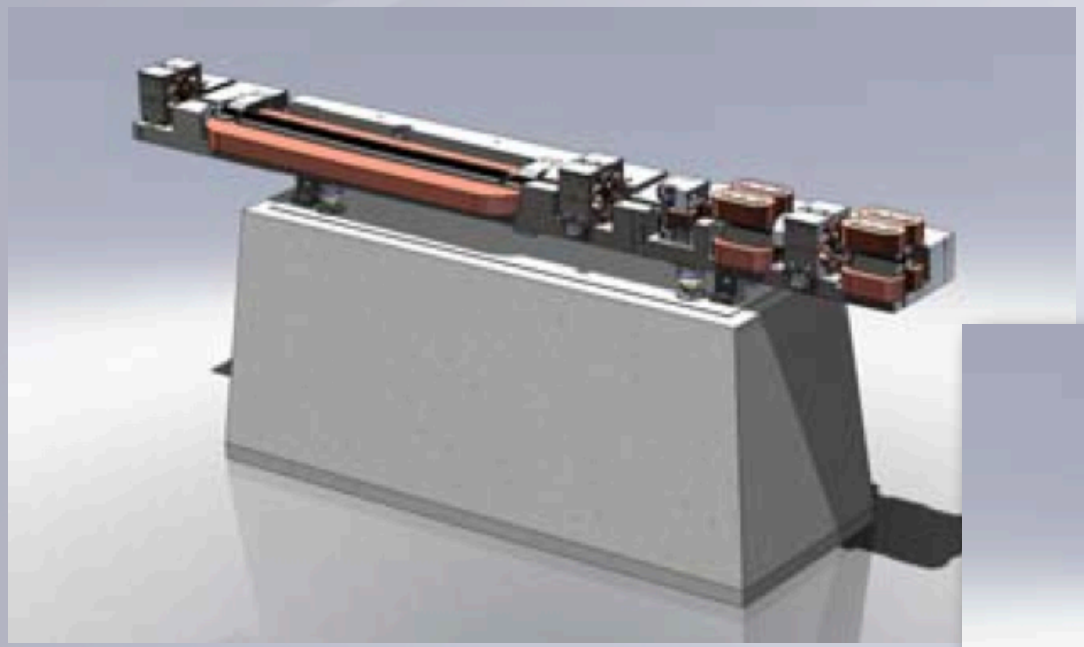
- Combined-function magnets
- Compact design → 12 DBAs
  (to replace 10 DBAs in MAX II)





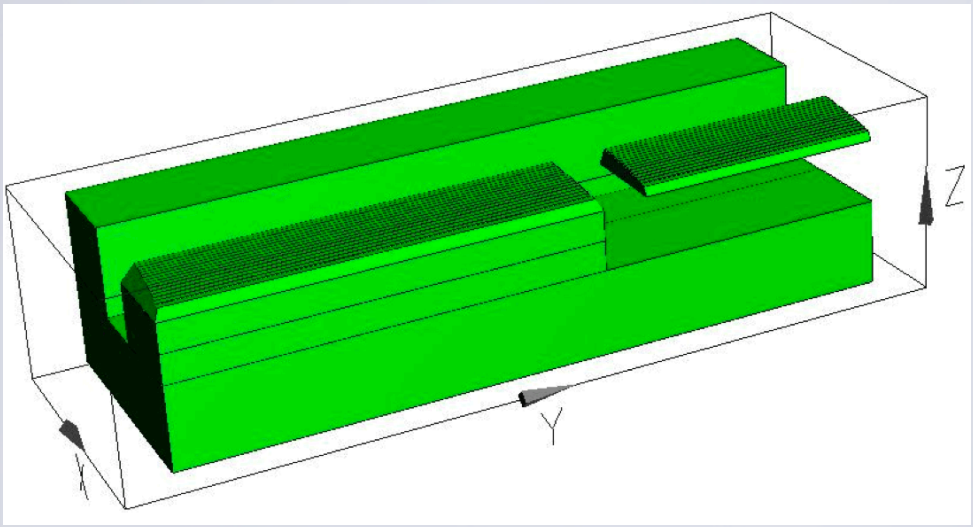
Supports

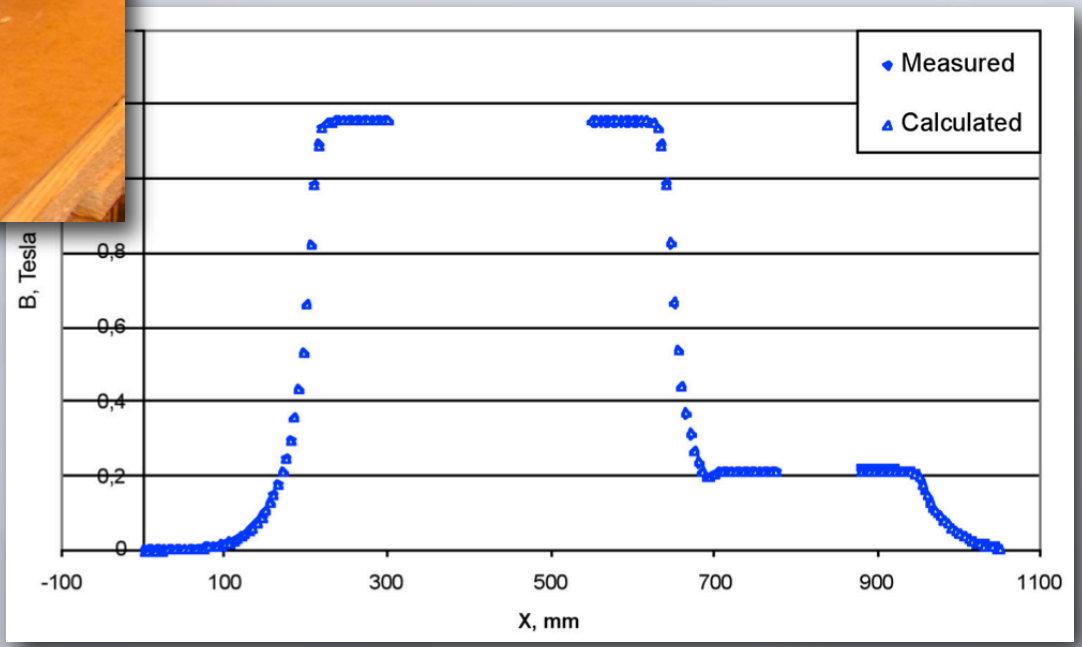
- Solid iron magnet blocks = "girders"
- Install on simple but massive concrete supports → inexpensive
- Vibrational eigenfrequencies pushed beyond 100 Hz → stability



Soft-end Dipoles → 2004 Prototype

- Reduce radiation load on downstream ID cold bore → superconducting IDs





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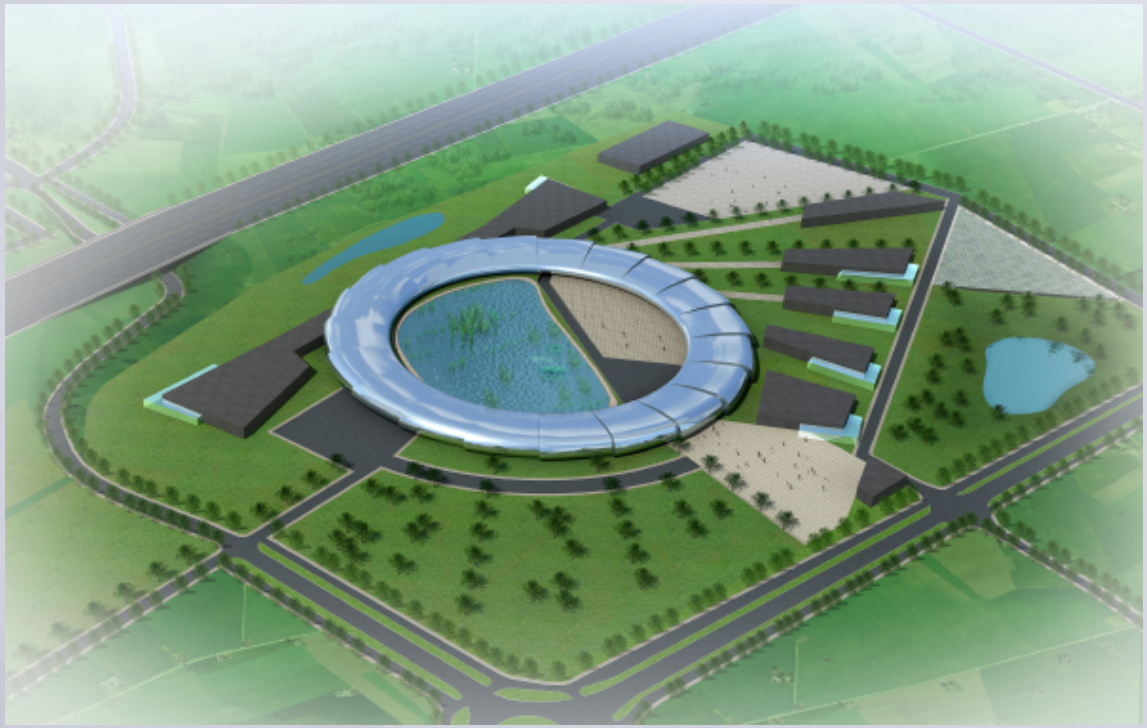
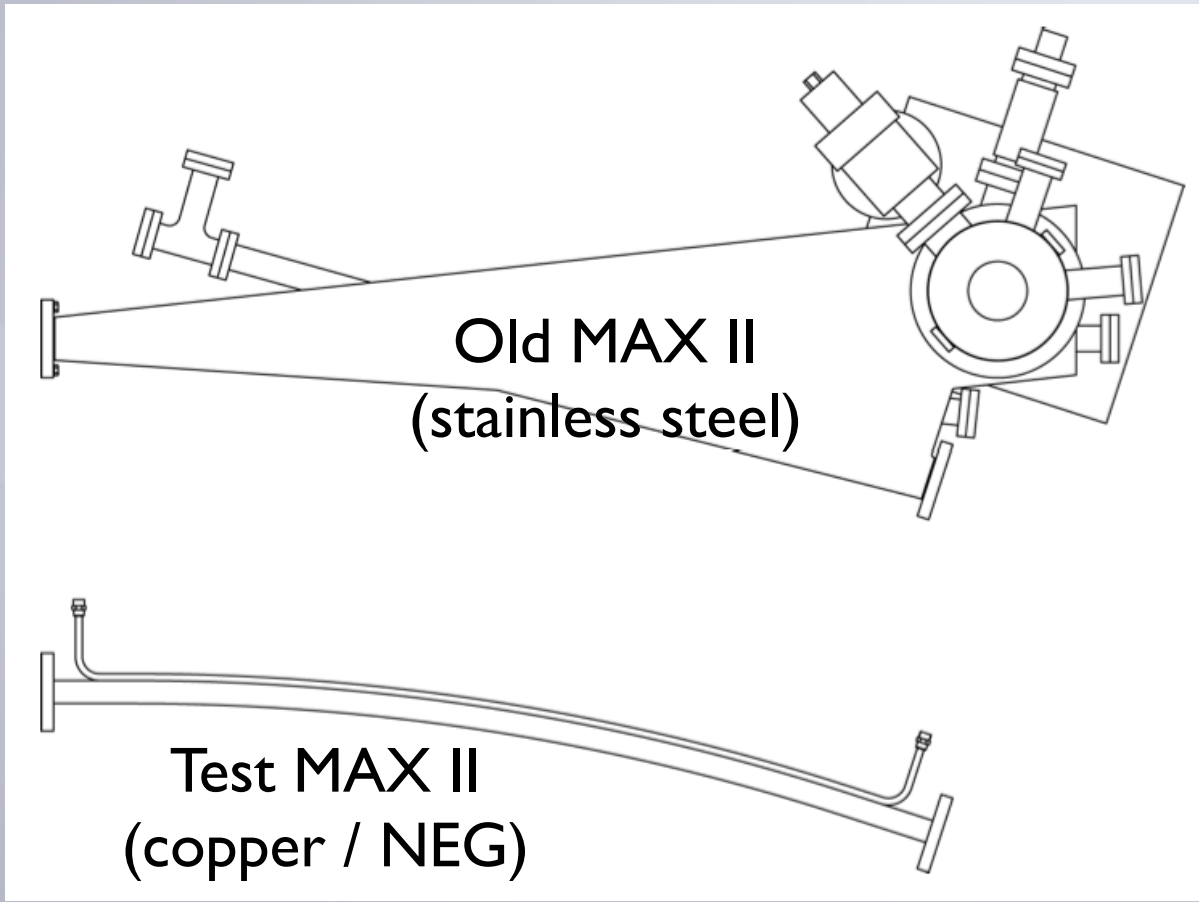


Vacuum System

- Problem: available apertures narrow, space for only few pumps
- Proposed solution: NEG-coated OFHC copper vacuum chamber
  → simple design, narrow apertures, no lumped absorbers, reduce no. of pumps
- Encouraging results @ MAX II → J. Vac. Sci. Technol. A **28**(2), Mar/Apr 2010



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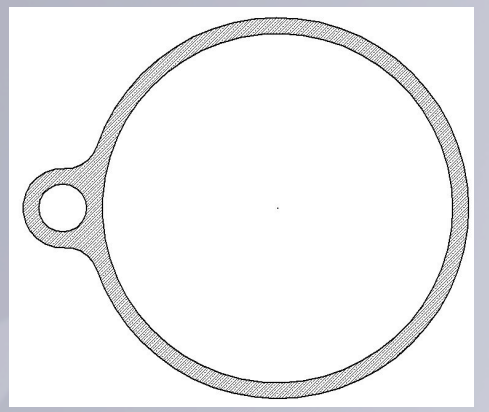
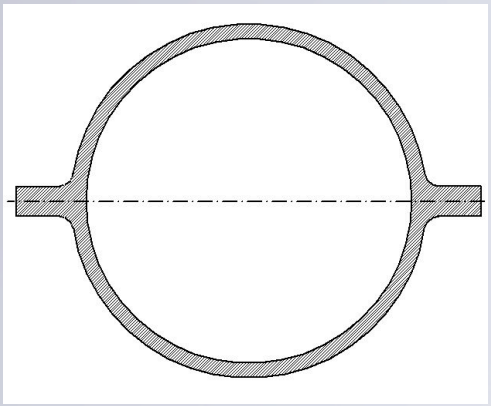
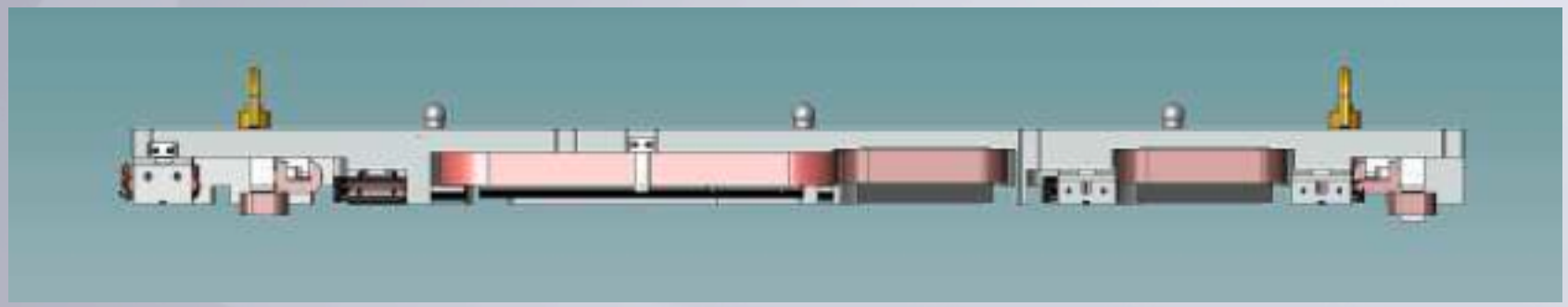
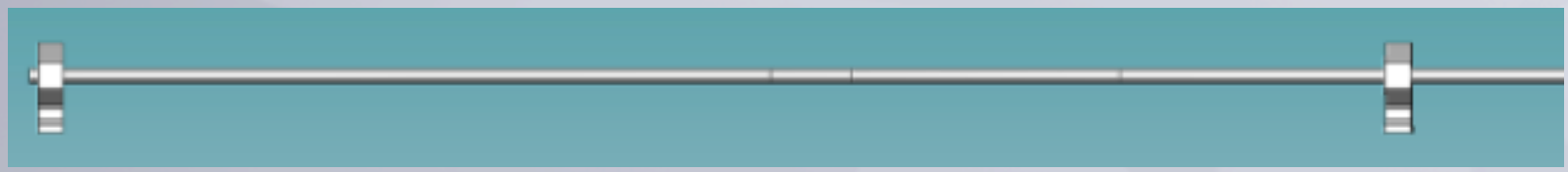




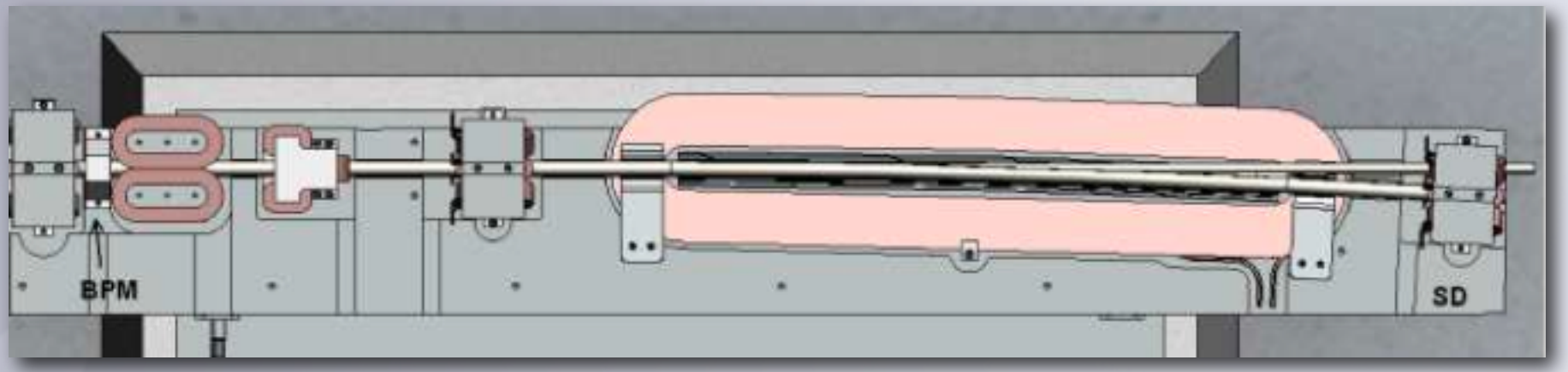
Ø 22 / 24 mm

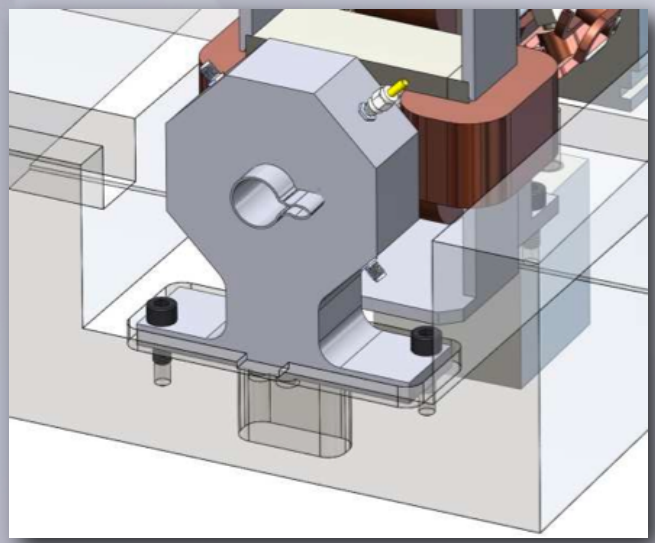


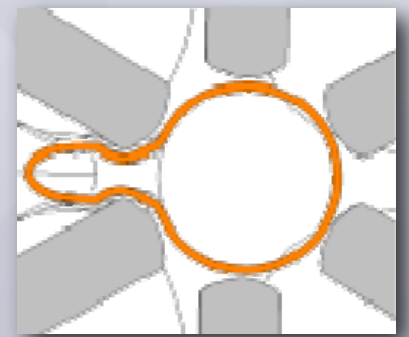


MAX IV
(copper / NEG)

Vacuum System







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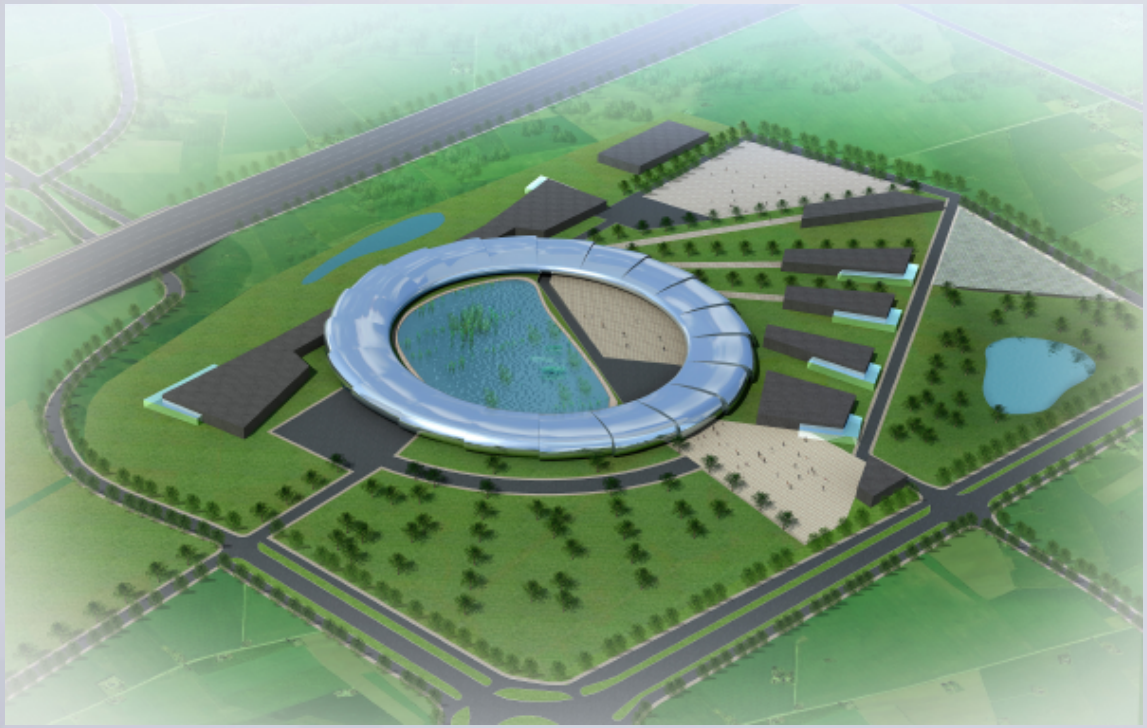
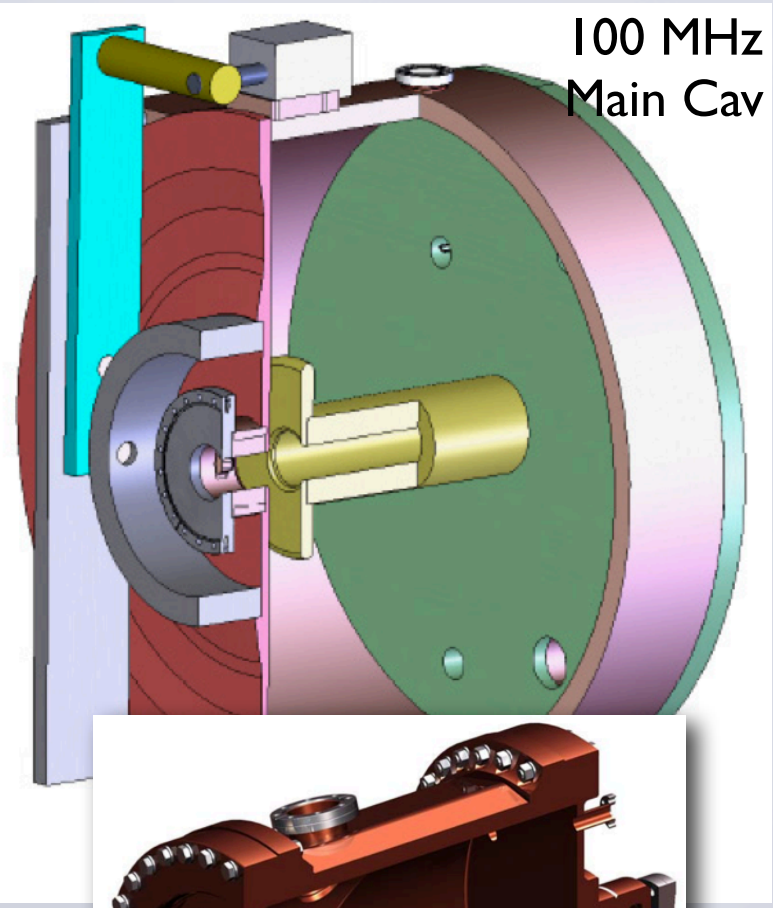
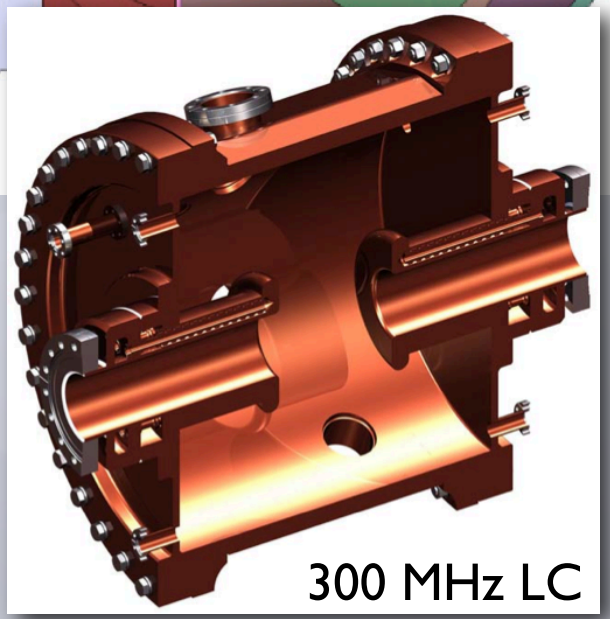


100 MHz RF System & Harmonic Landau Cavities

- 100 MHz RF system developed and implemented at MAX II and MAX III (→ EPAC'02, p.2118)
  → effectively suppresses HOMs in the accelerating cavities
- Inexpensive technology available (FM radio)
- Tetrode amplifiers are inexpensive and have low power consumption → low running cost



- Landau cavities @ 300 MHz: linearize RF
- Long bunches (~ 50 mm)
  → increase Touschek lifetime
  → counteract instability (narrow chamber!)
  → run at lower lin. $\xi_{x,y}$ → large MA
  → reduce ε blow-up from IBS



http://www.maxlab.lu.se/maxlab/max4

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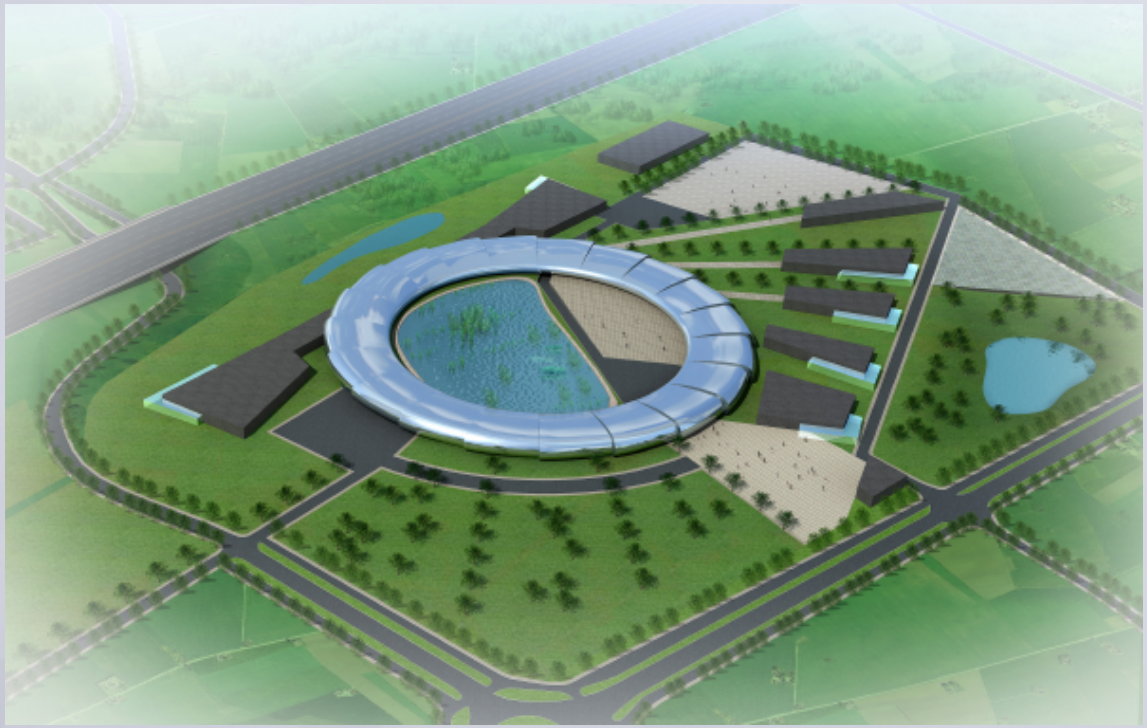
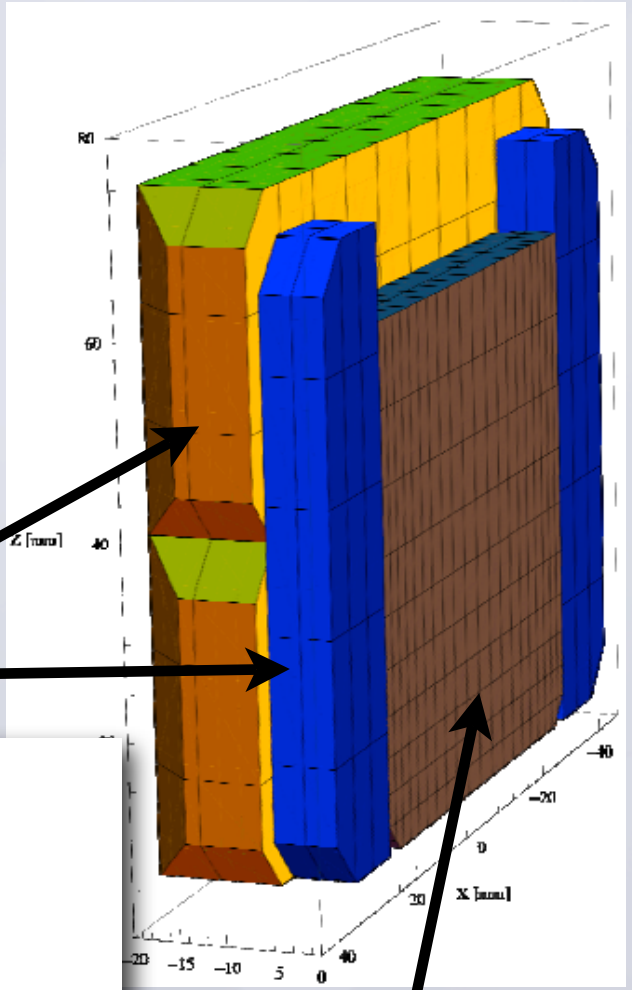


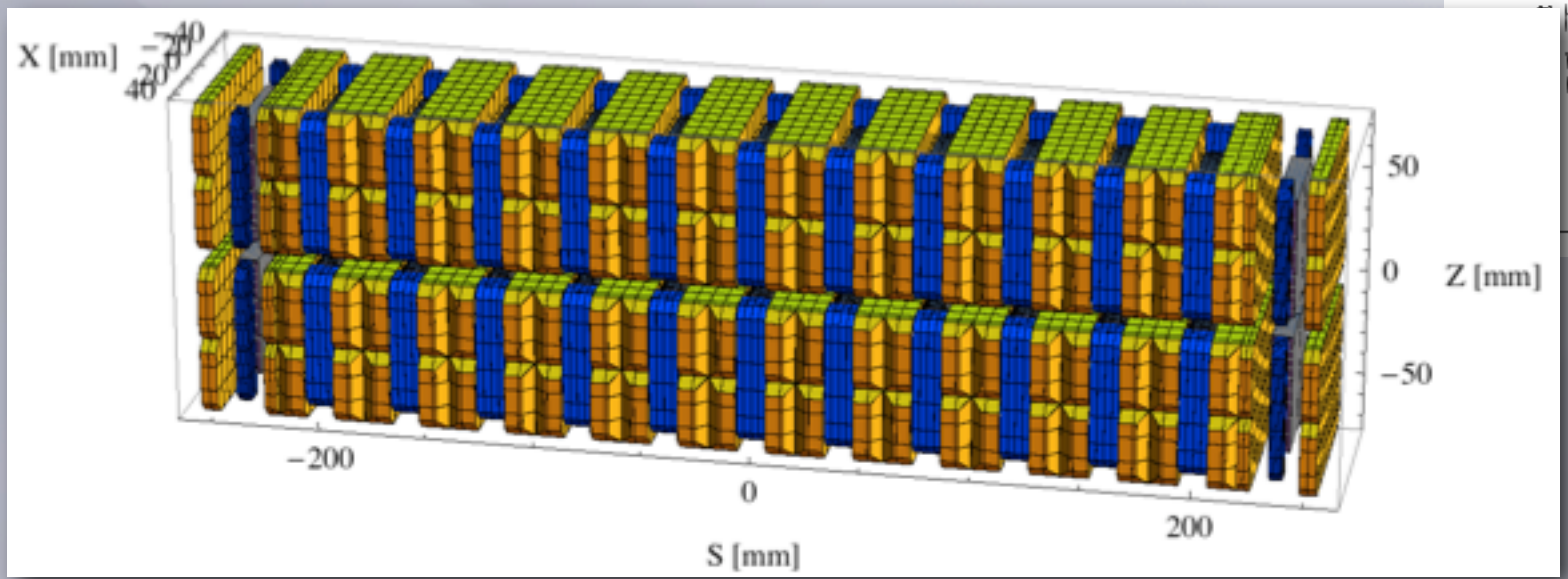
Damping Wigglers

- Originally, considered superconducting DWs (lots of experience @ MAX-lab)
  NIM A **467** (2001) 118, NIM A **521** (2004) 530
- However, SCDWs come with high operational cost
  → Instead: Hybrid-type permanent-magnet DWs
- λ = 80 mm, 9 mm gap, B_{peak} = 2.2T, B_{eff} = 1.9T
- L = 2 / 4 m → P = 20 / 40 kW (@500mA)



NdFeB: Remanence 1.25 T, Intr. Coerc. 25 kOe

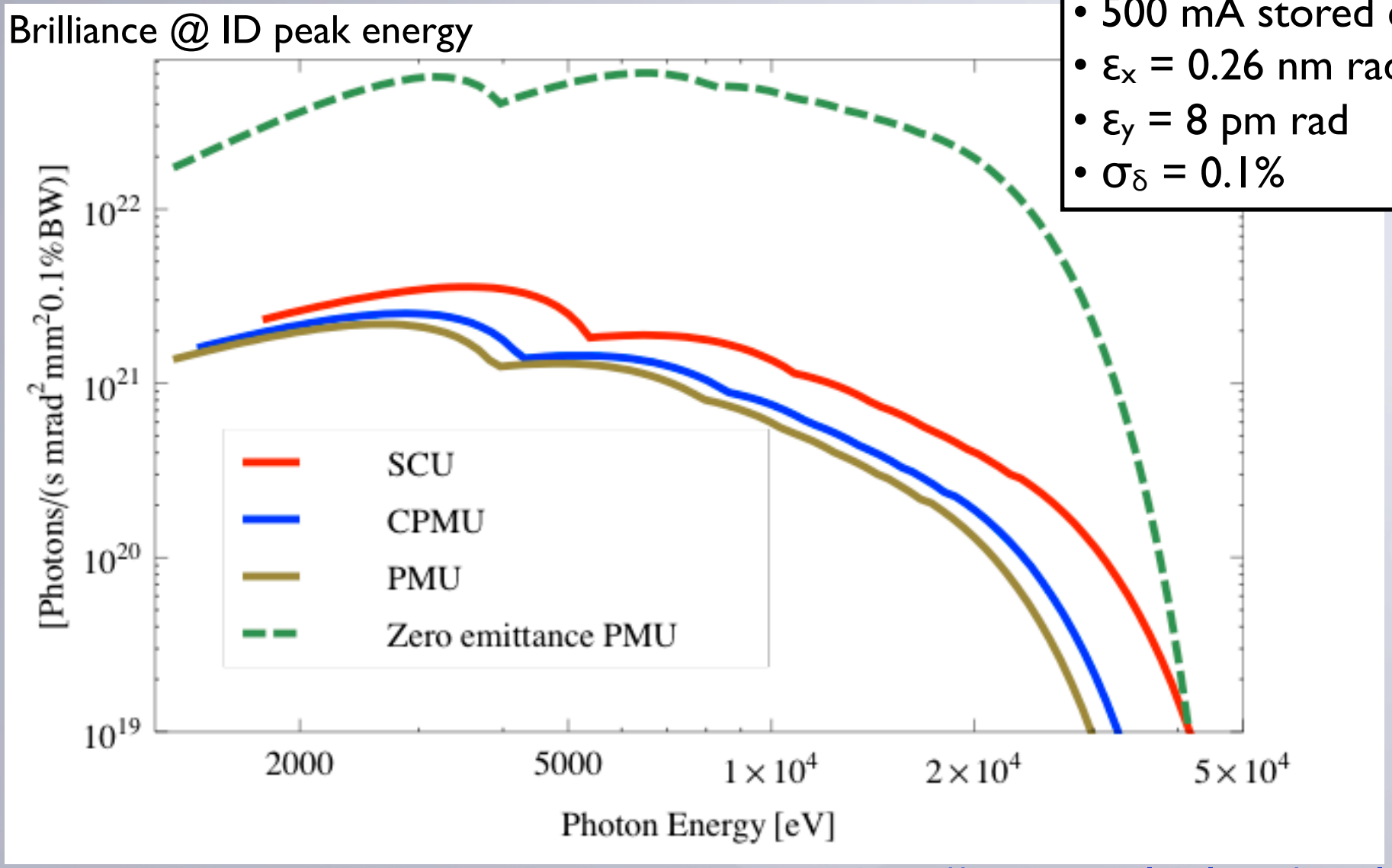
NdFeB: Remanence 1.28 T, Intr. Coerc. 21 kOe



Vanadium Permendur
(Fe: 49%, Co: 49%, V:2%)

Work on IDs has just started... → performance outlook

Brilliance @ ID peak energy



- 500 mA stored current
- ε_x = 0.26 nm rad
- ε_y = 8 pm rad
- σ_δ = 0.1%

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