Magnet Design and Simulation

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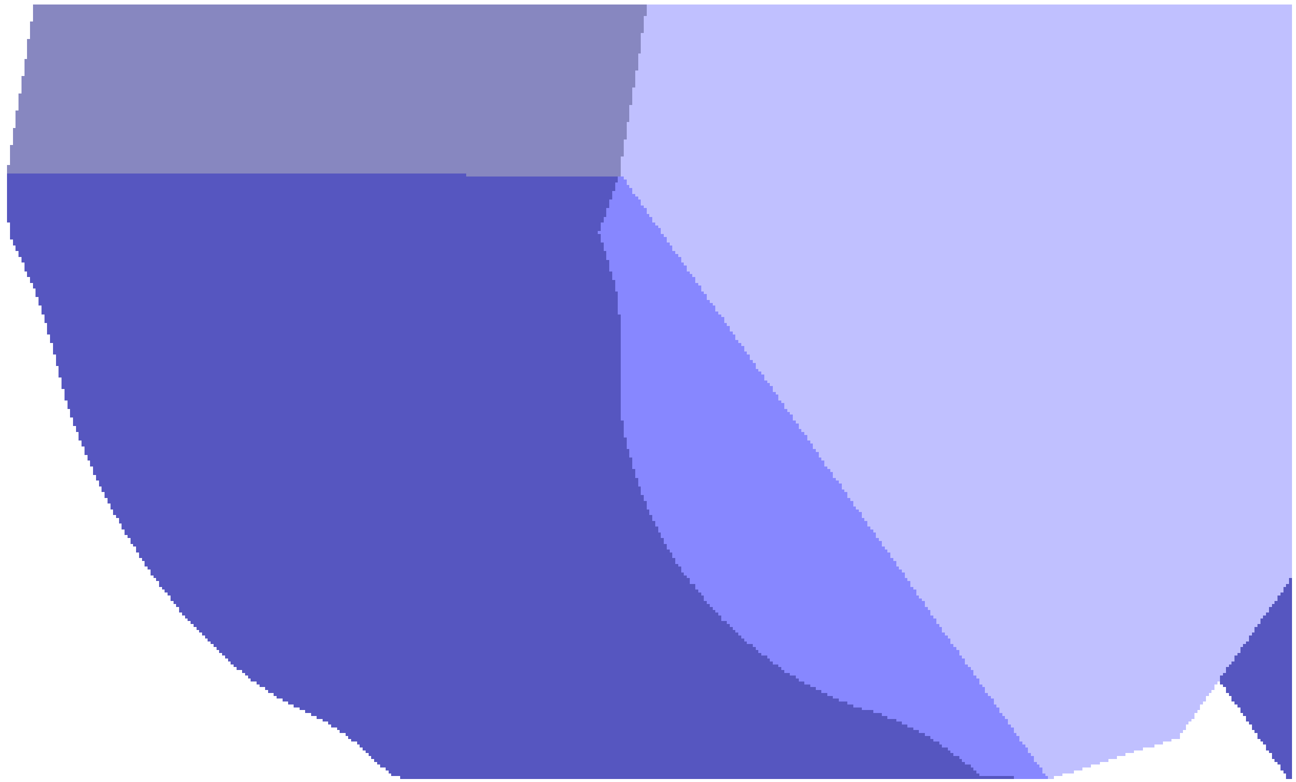
Magnet Simulations

- Design/Optimize/Shim Accelerator Magnets
- Study Interferences between Adjacent Magnets
- Compute Magnetic Field from Existing Magnets – Acquire Field Maps for HEP/NP Experiments (magnetic measurement for a large scale detector magnet is very difficult!)

Magnet Design/Optimization – SNS Ring Quadrupole

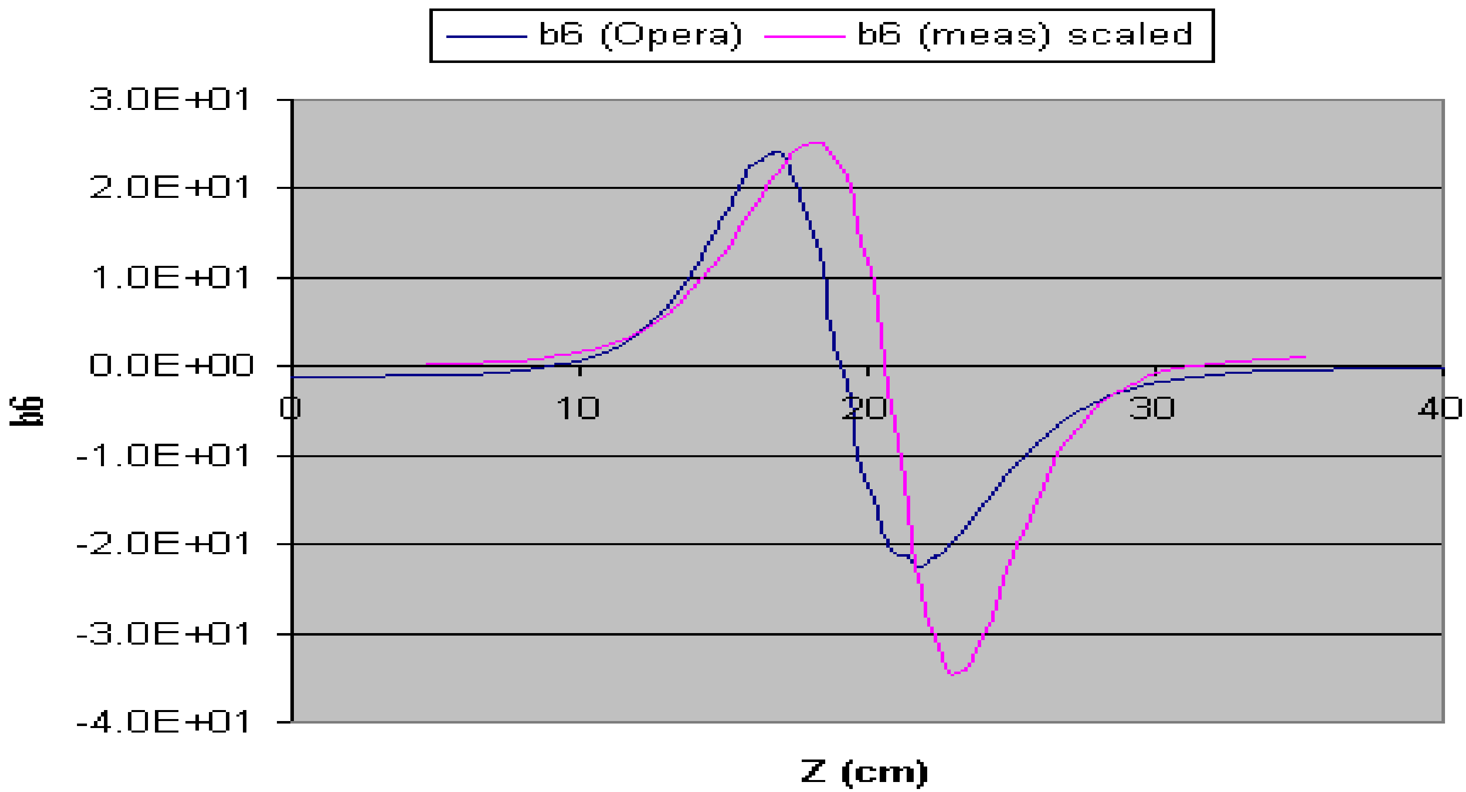


Edge Chamfers (to reduced 12-pole component)

Magnet Design/Optimization

Use edge chamfers to minimize integrated b6 (12-pole) component :

21Q40 Prototype for SNS



SC Storage Ring for BNL Muon g-2 Experiment (E821) 1997-2001

Shimming Tools --- Good example: req. $\int (dB/B)dl \leq 1\,ppm$

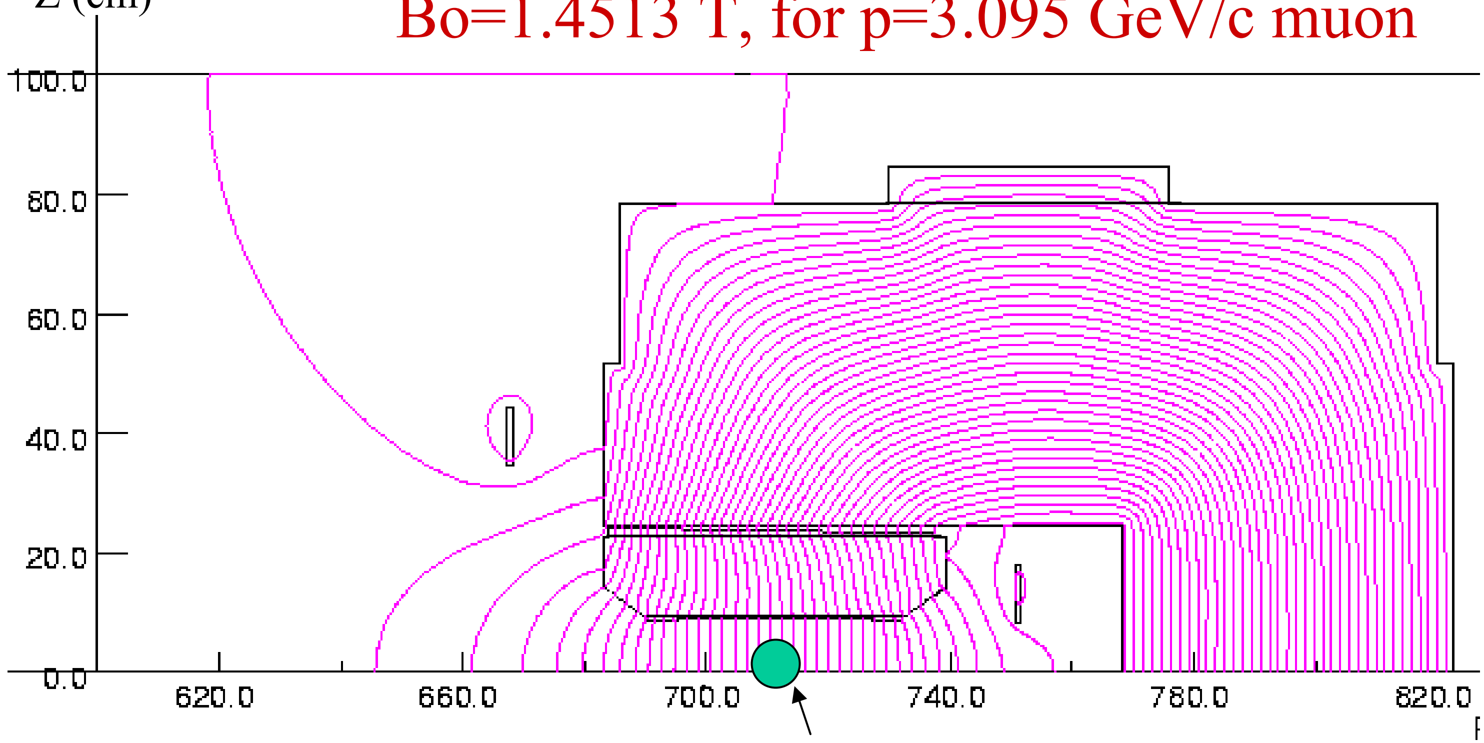
Dipole correction: top/bottom plates adjustments; wedge translation (for b1)

Quad correction: tilt pole angle, tapered wedge angle machining (for b2 ~ r)

Sextupole correction: pole chamfers, edge shims width/thickness (for b3 ~ r^2)

…… and more: azimuthal correction, surface coils fine tuning ...

Bo=1.4513 T, for p=3.095 GeV/c muon



1 ppm GFR

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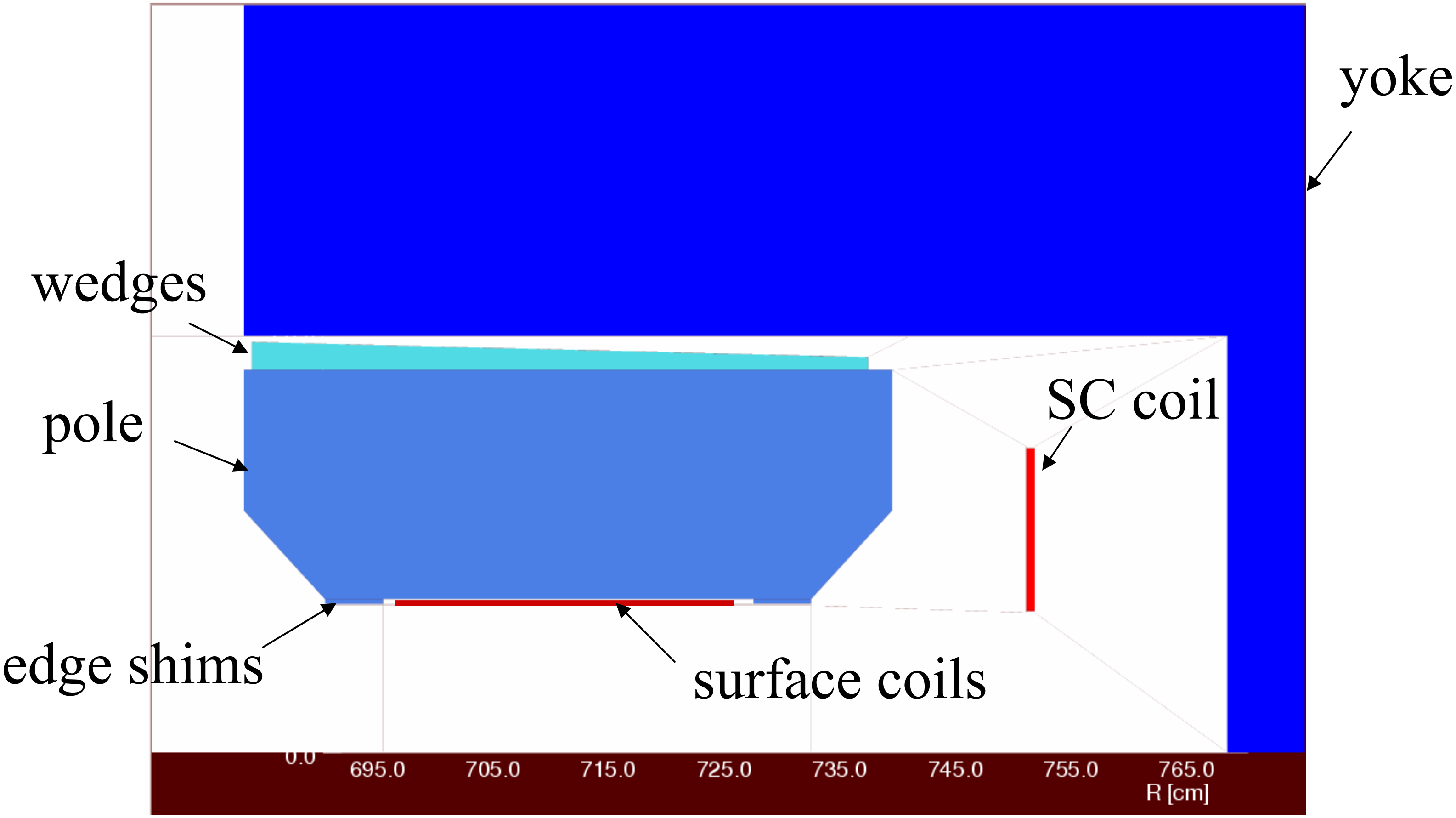
Built-in Shimming Tools --- Good example (cont.)

Ref. G.T.Danby et al "The Brookhaven muon storage ring magnet"
NIM A 457 (2001) 151-174



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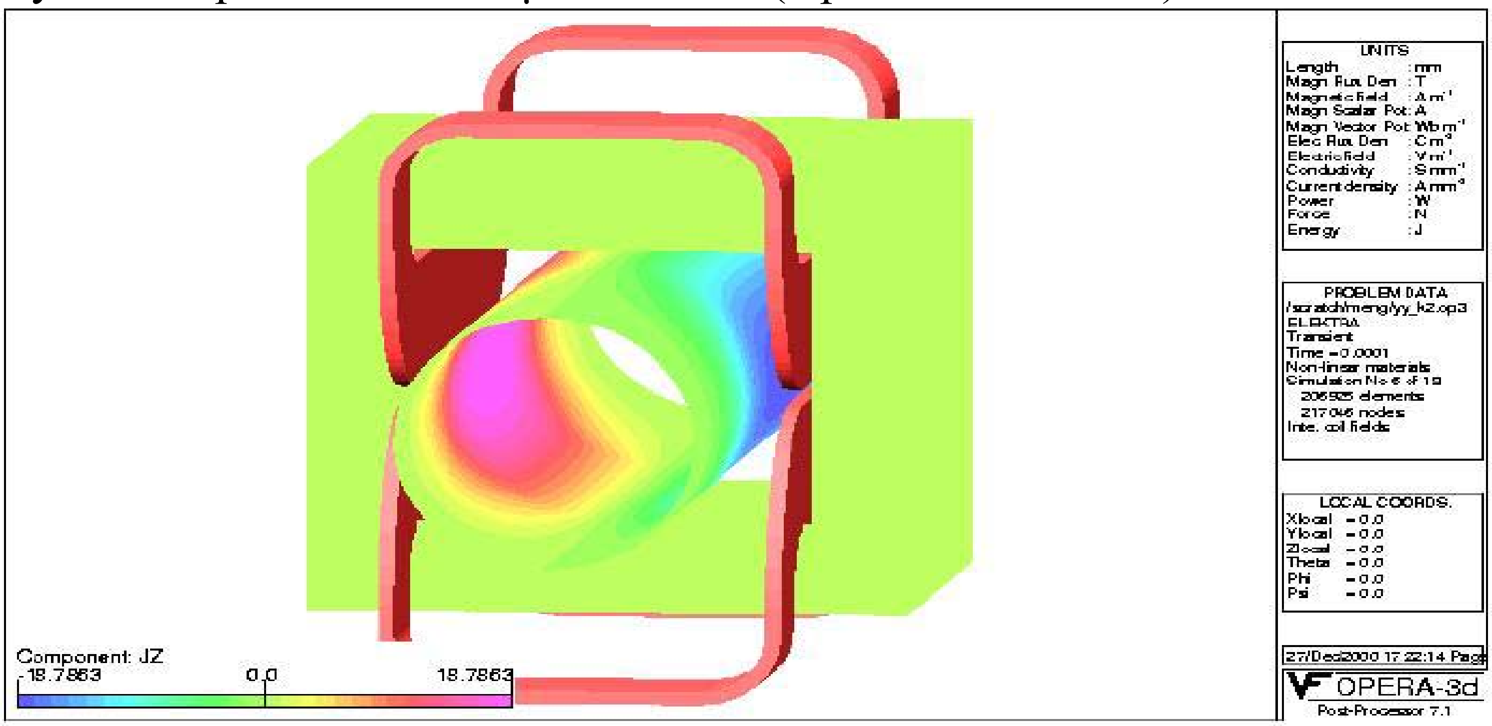
Design/Optimization (Feasibility Study)

SNS Injection Kicker Inconel Vacuum Chamber (early study)

Eddy Current Heating → Ceramic Vacuum Chamber

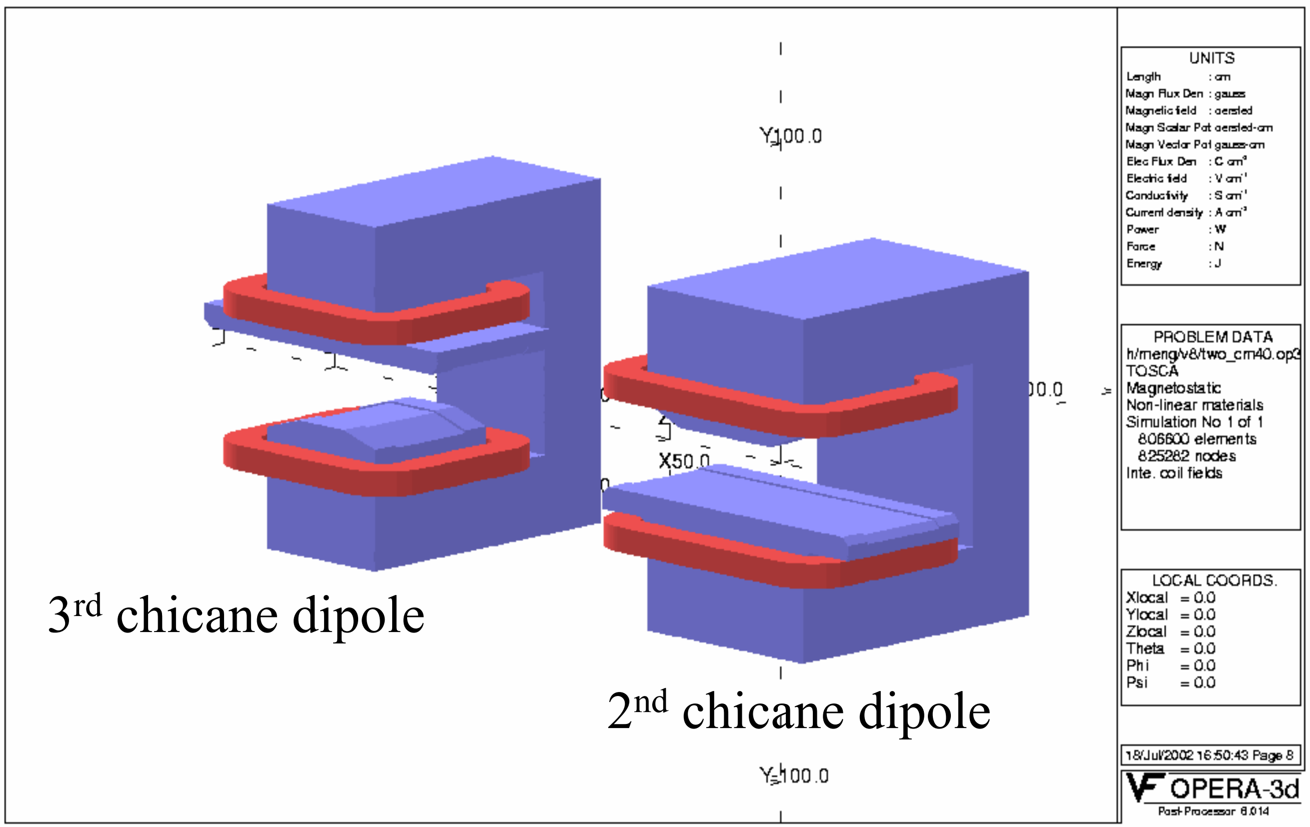
rise time constant $\tau = 200\ \mu s$

eddy current plot at $t = 100\ \mu s$ (Opear3d/Elektra/Tr)

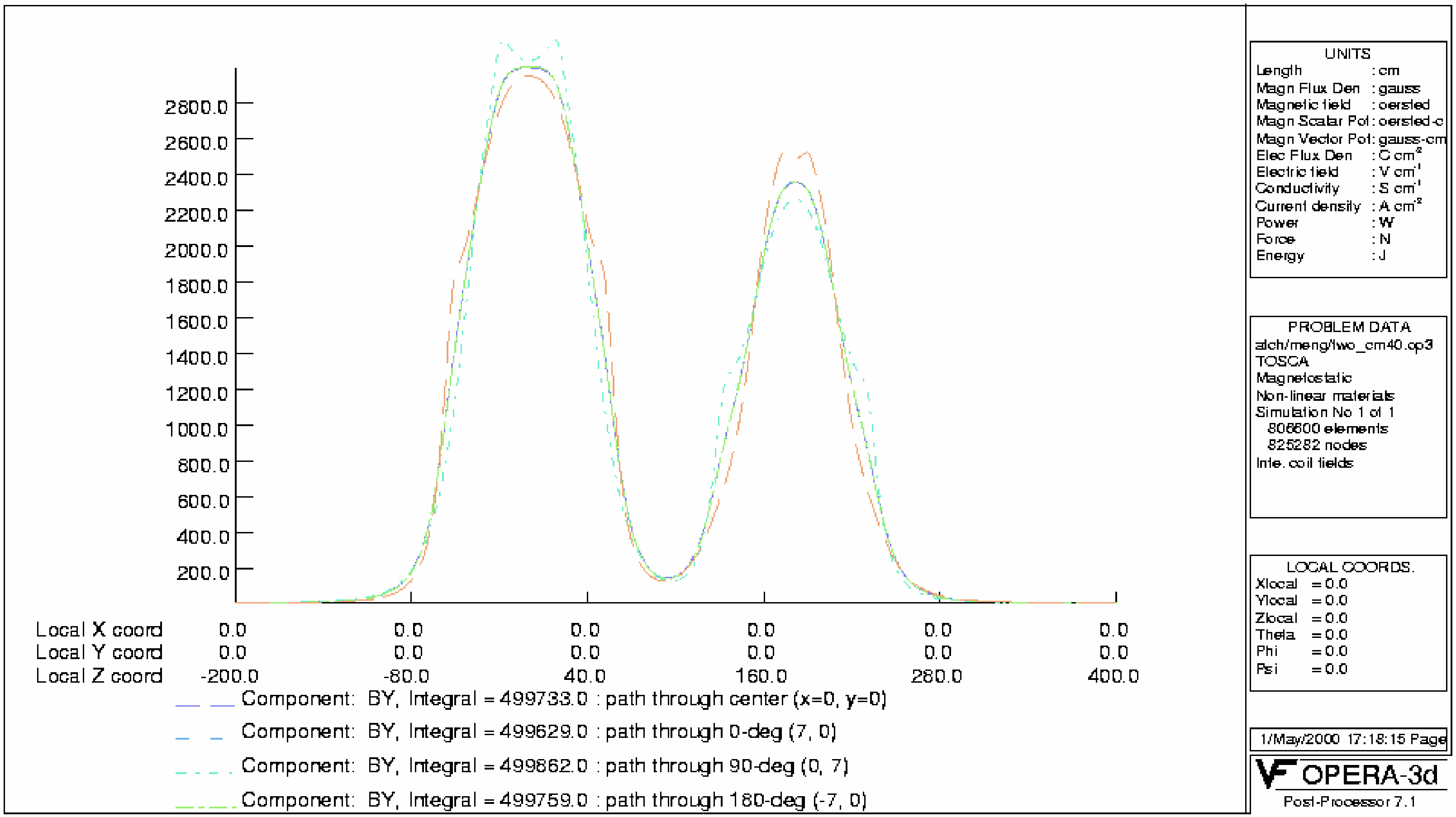


SNS Chicane Dipoles Design (in Injection Section)

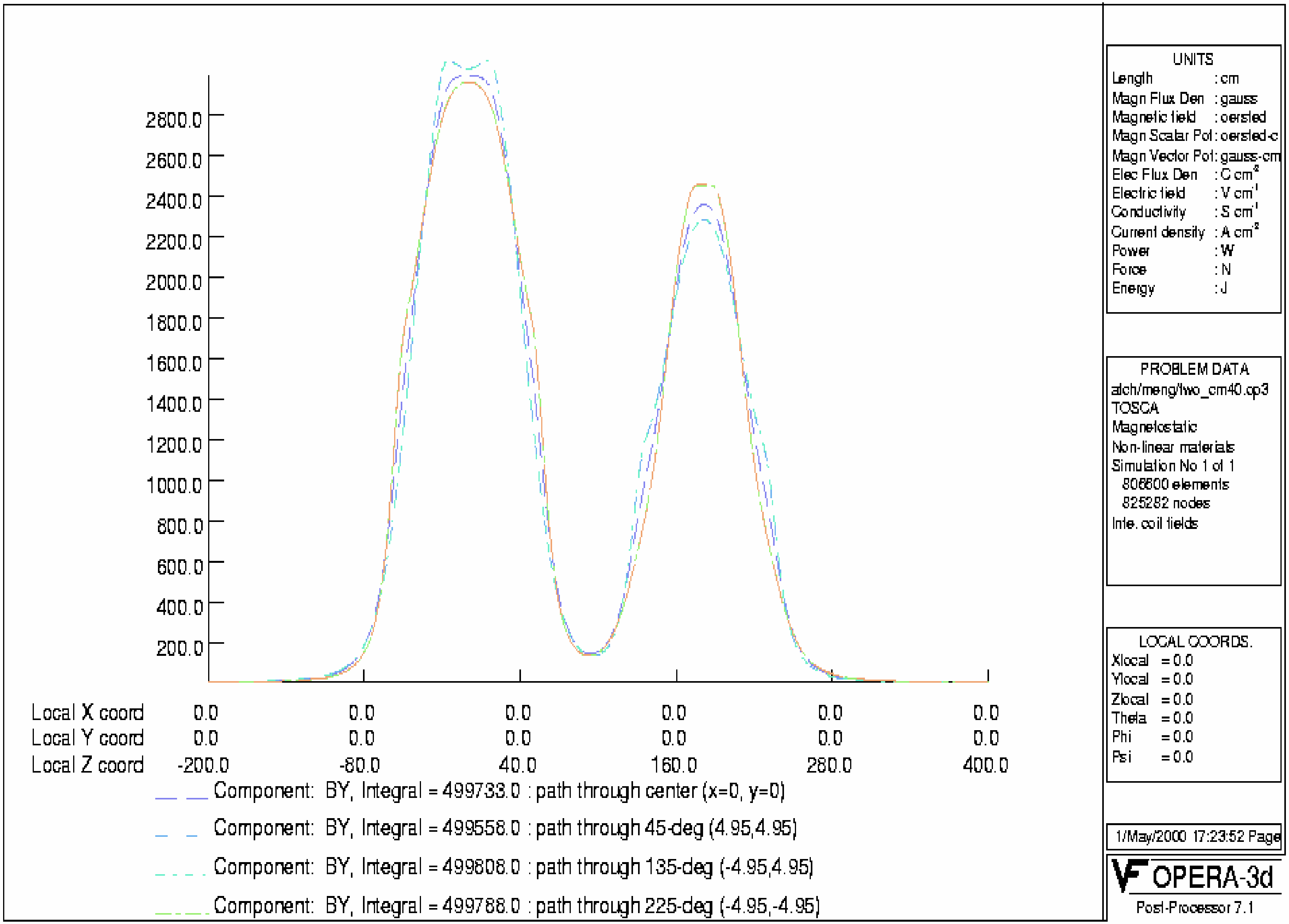
Ref: (1) EPAC2000, p2107; (2) PAC05, WPAE035



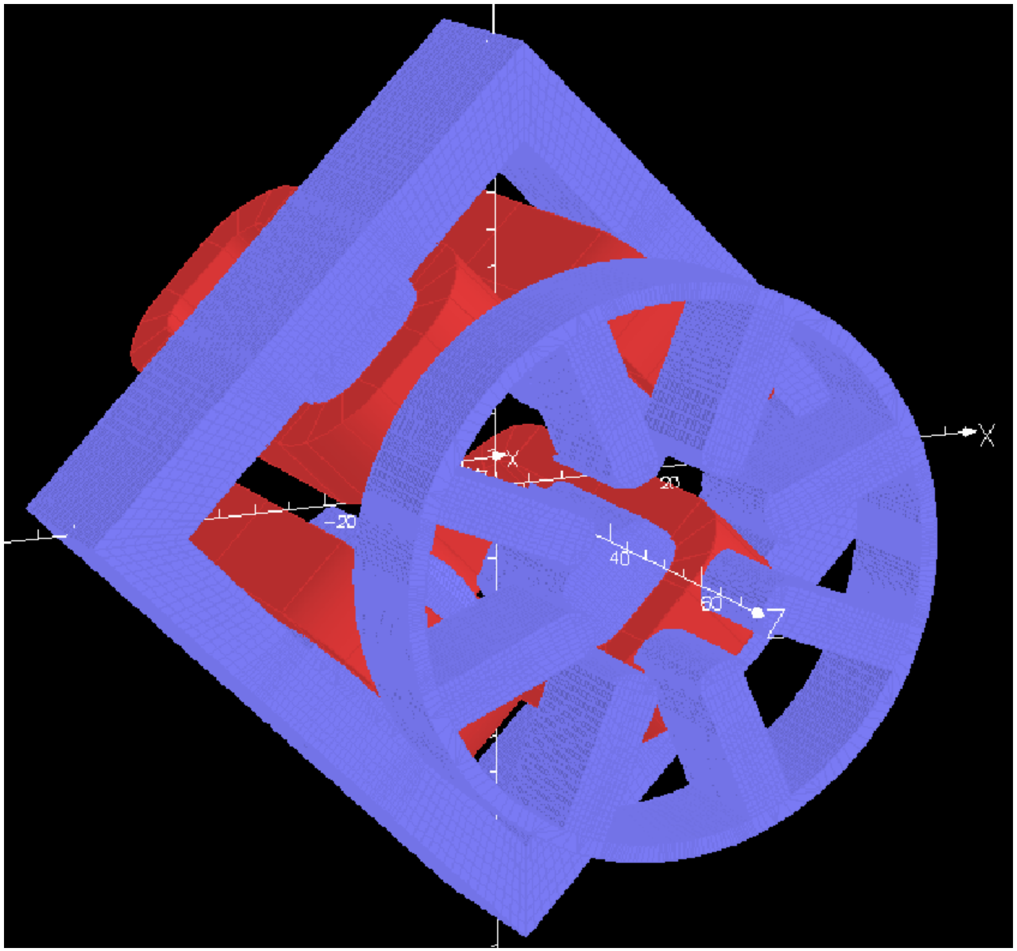
SNS Chicane Dipoles Integral Field Uniformity



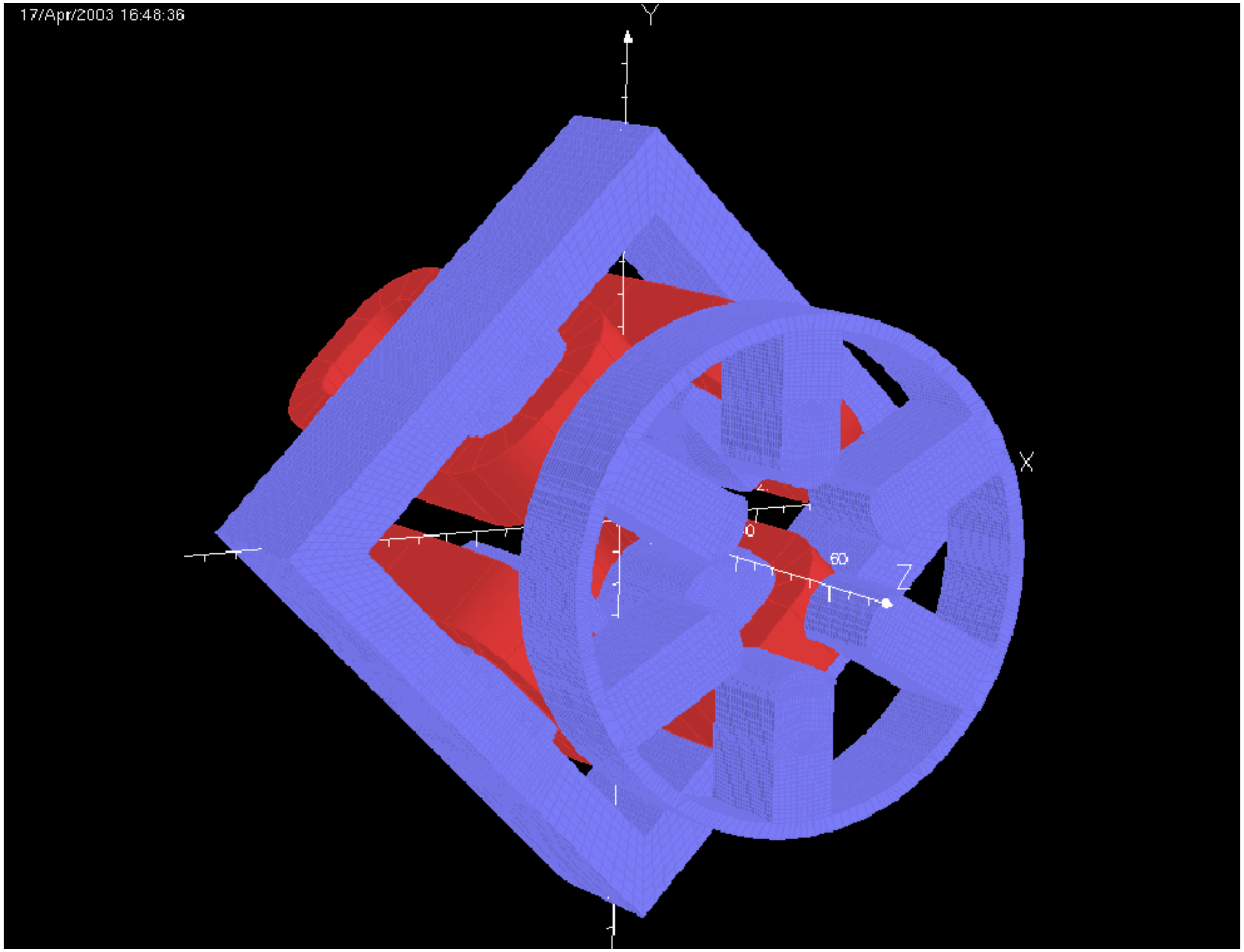
- Total Integral along 45, 135, 225, 315 degree lines



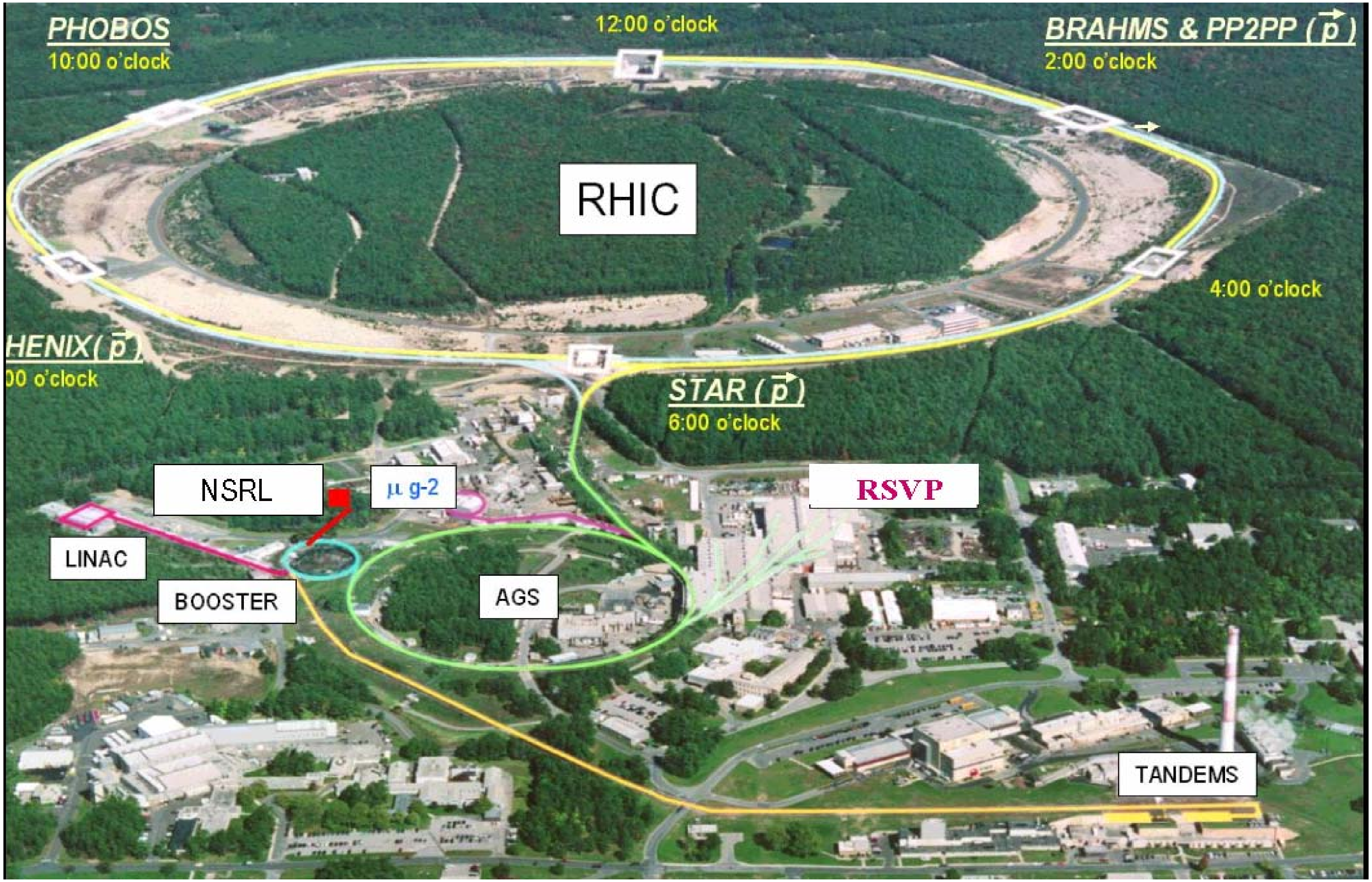
SNS Interference Study (Quad + Oct)



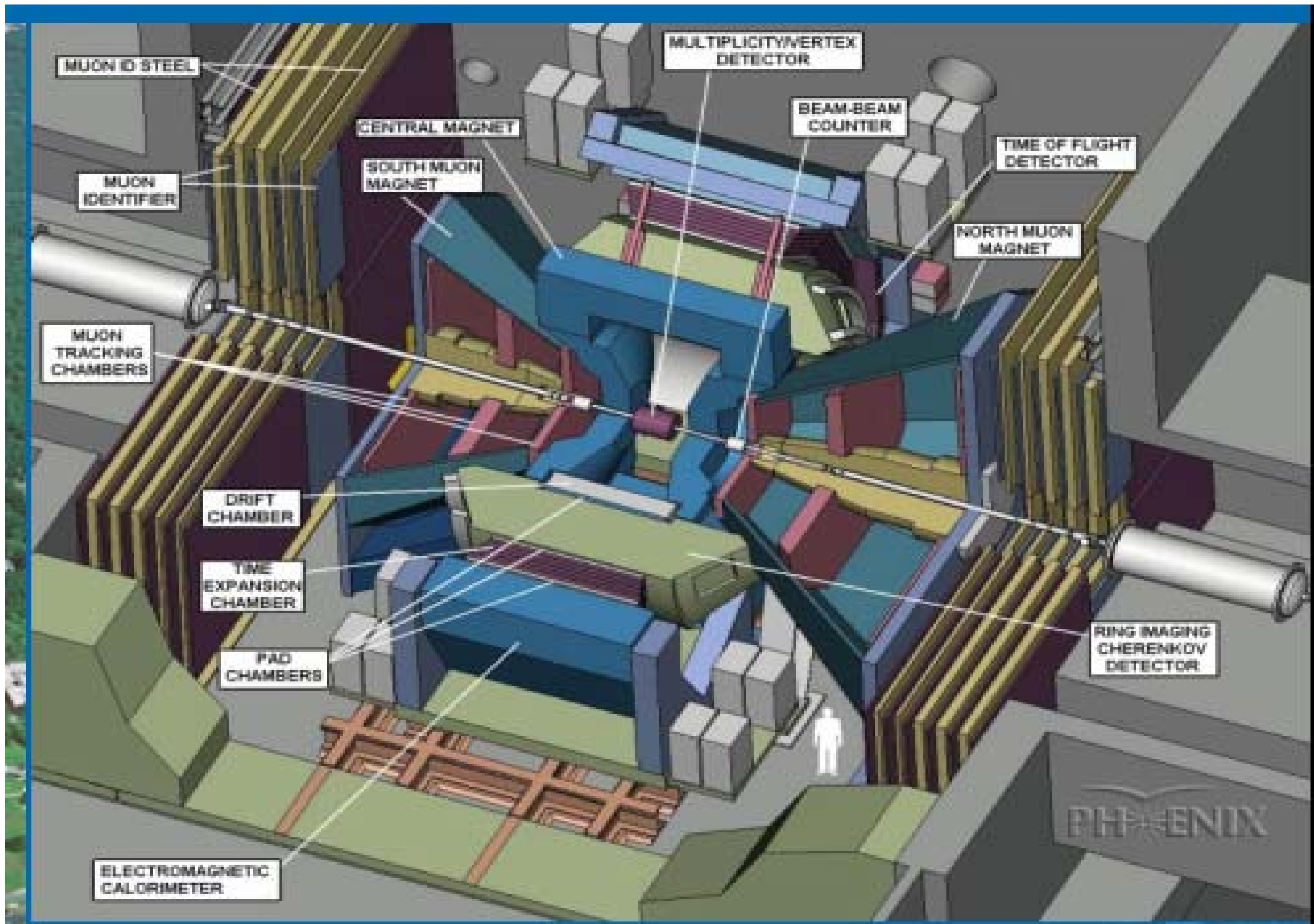
Interference Study (Quad + Sext)



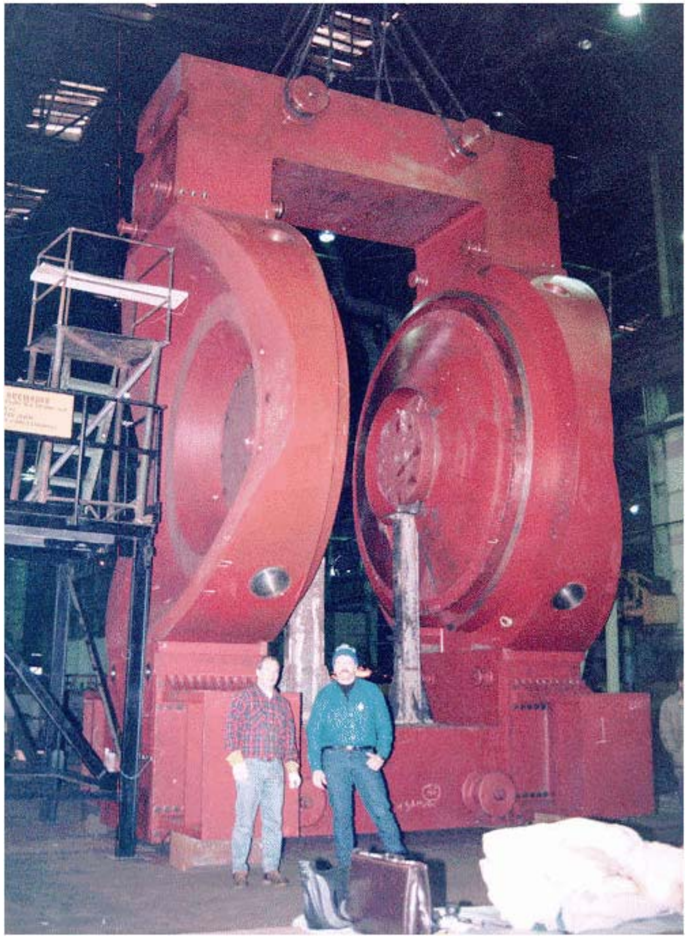
BNL Collider Accelerator Complex



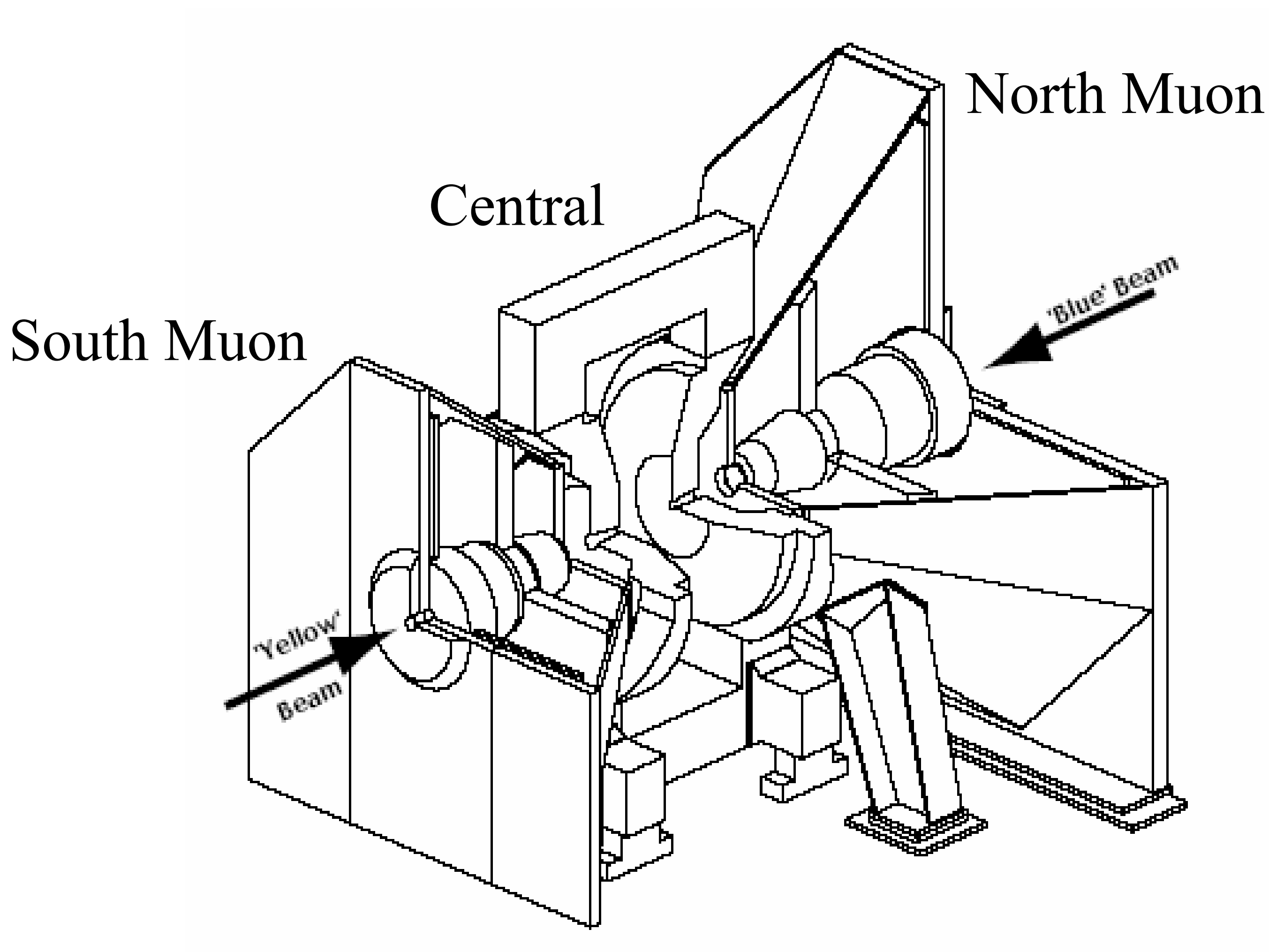
RHIC PHENIX Detector



PHENIX Central Magnet/Coils

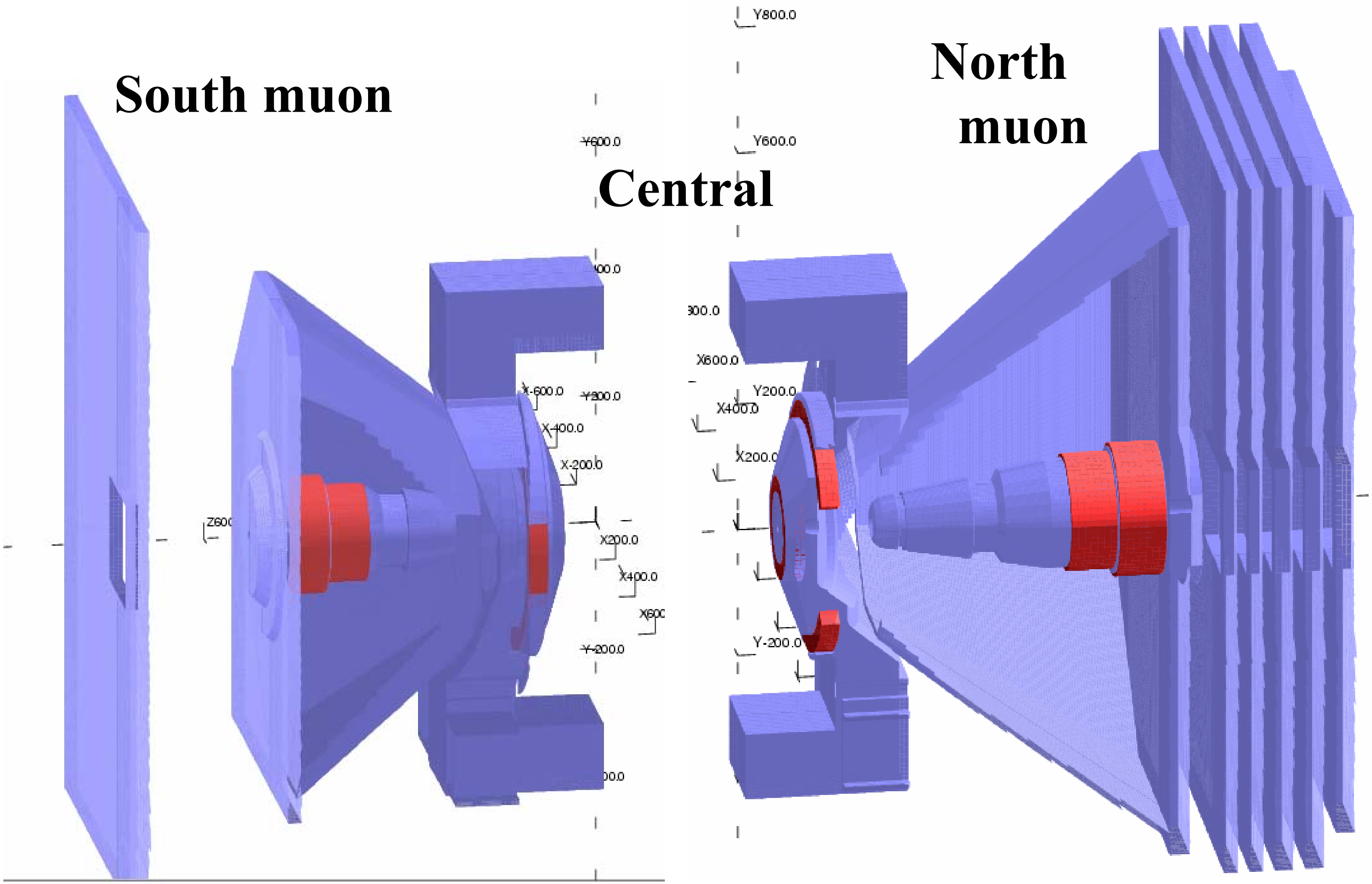


PHENIX (all Magnets)

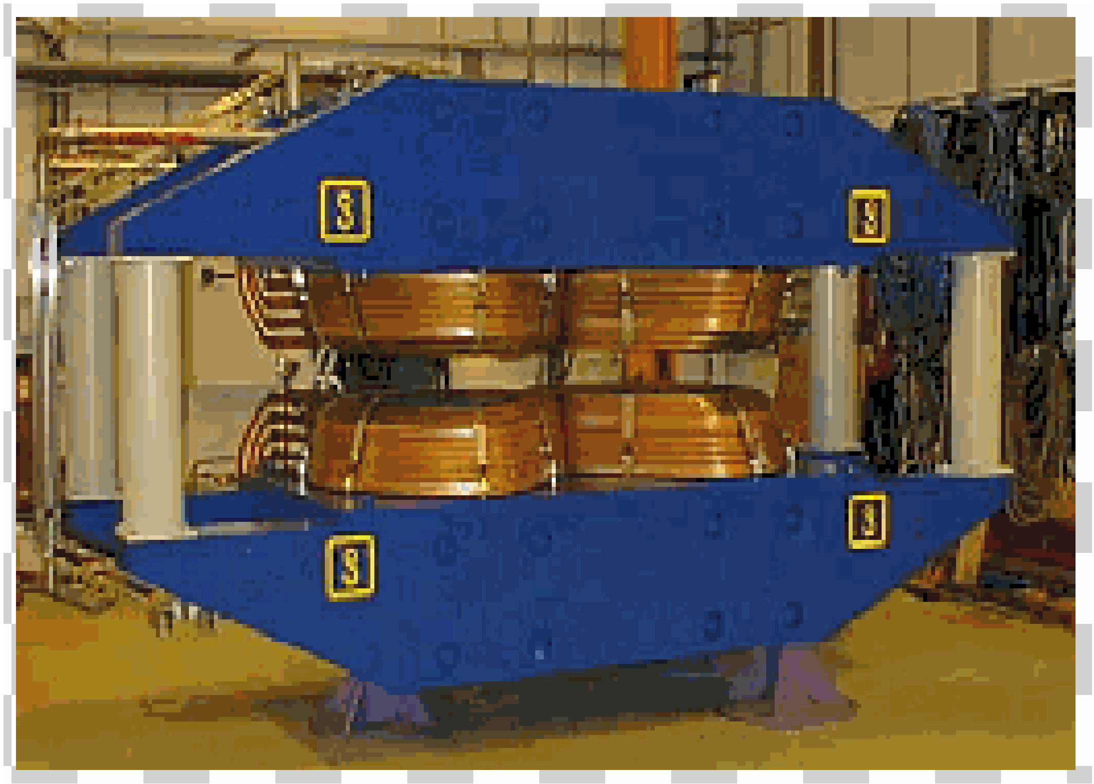


Overall size
10 m (H)
10 m (W)
20 m (L)
Ctr. B=0.49 T

Opera Models for PHENIX Magnets

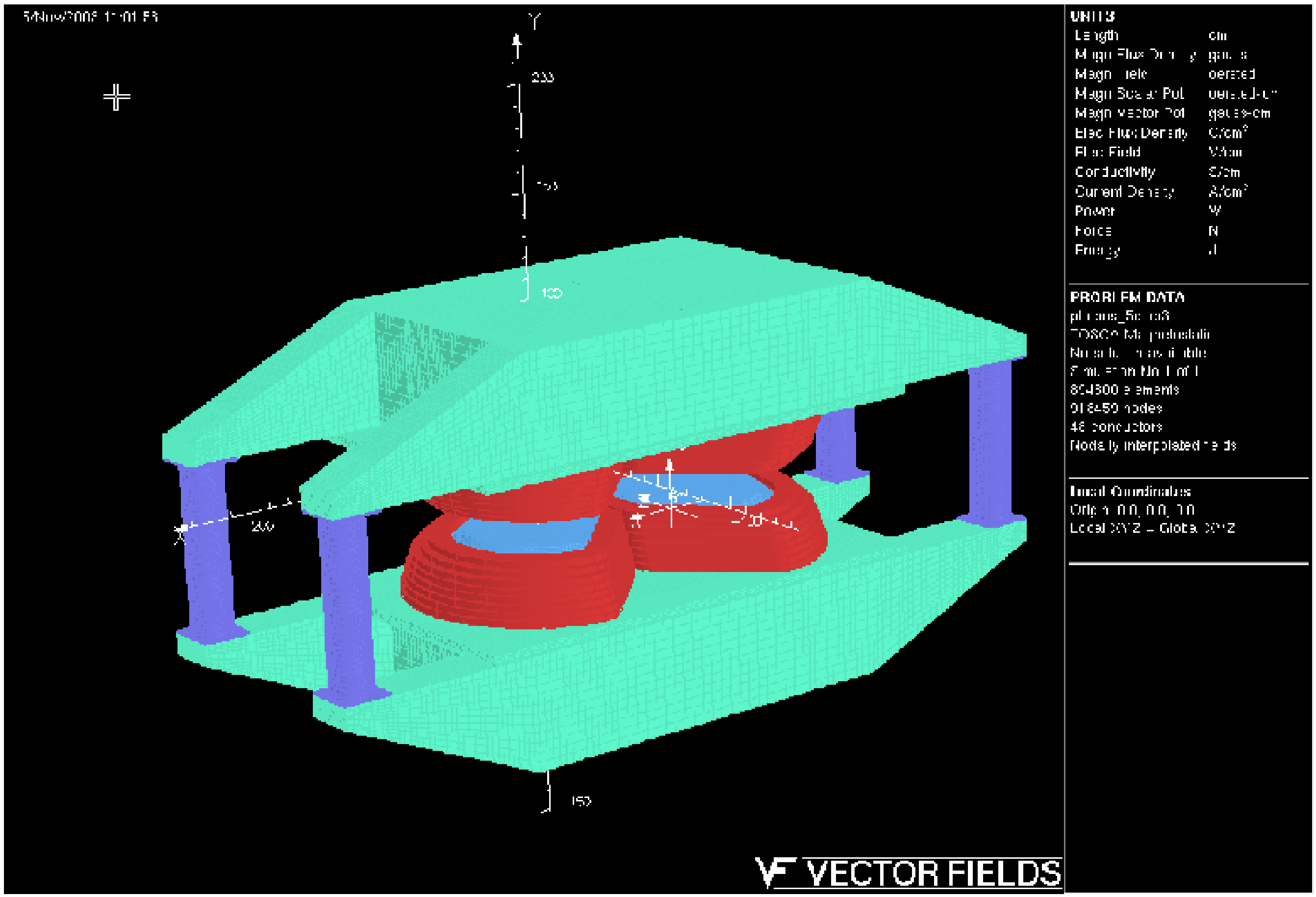


RHIC PHOBOS Detector Magnet (opposite dual dipole)



Overall size
1.5 m (W)
2 m (H)
4 m (L)
Bo = 2.1 T

Opera3d Model PHOBOS Magnet



Simulation and Measurement

For Large HEP/NP Detector Magnets

Measurement is always difficult due to the position uncertainty;

Measurement is expensive (in structure, time and labor);

Measurement is not possible after detectors are installed

Simulation is Flexible: even after detectors are in place;

or, new magnetic object added at vicinity

Field Maps for PHENIX / PHOBOS detector magnets have been officially used for Data Analysis since 2001/2002)

Conditions --- careful simulate the geometry details is essential!

Carefully checked by point measurements; or compared with Reconstructed Field in the fringe field region from Maxwell Equation based computing code ($\nabla \bullet \mathbf{B} = 0$)

Thanks

Vector Fields !