Flux Concentrator Studies

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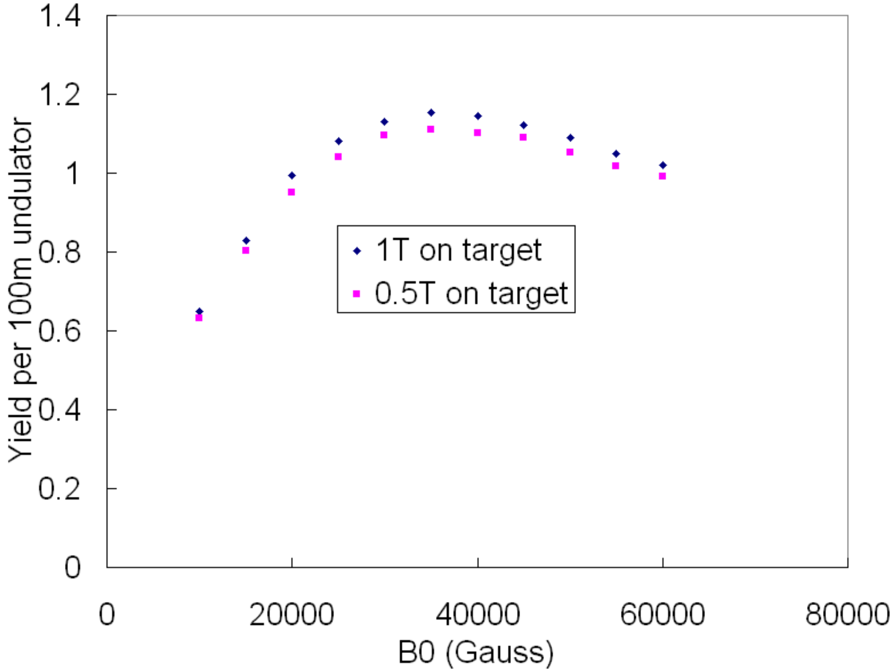
Increasing Positron Yield

- Flux concentrator design provides an external magnetic field after the target to increase positron yield



Graphic from W. Liu and W. Gai, Argonne National Laboratory

Approach

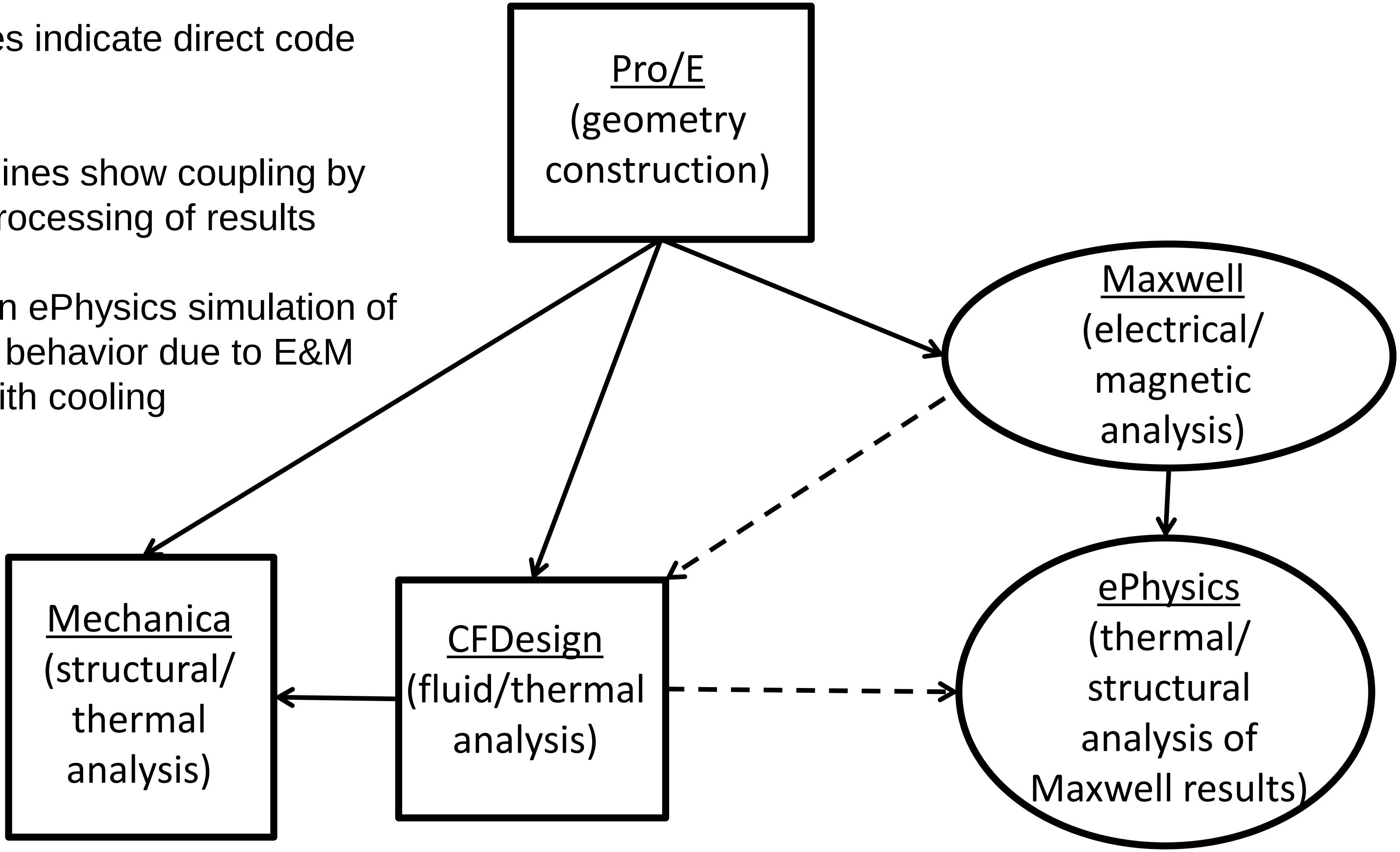
- Form an idea of what is really achievable
- Match this to the performance envelope, provide basis for an informed decision
- Look at produced magnetic field- power supply required
- Evaluate heating and mechanical loads on device
- Evaluate special loads due to operation area
- Evaluate effects of magnetic field on target

Specifications

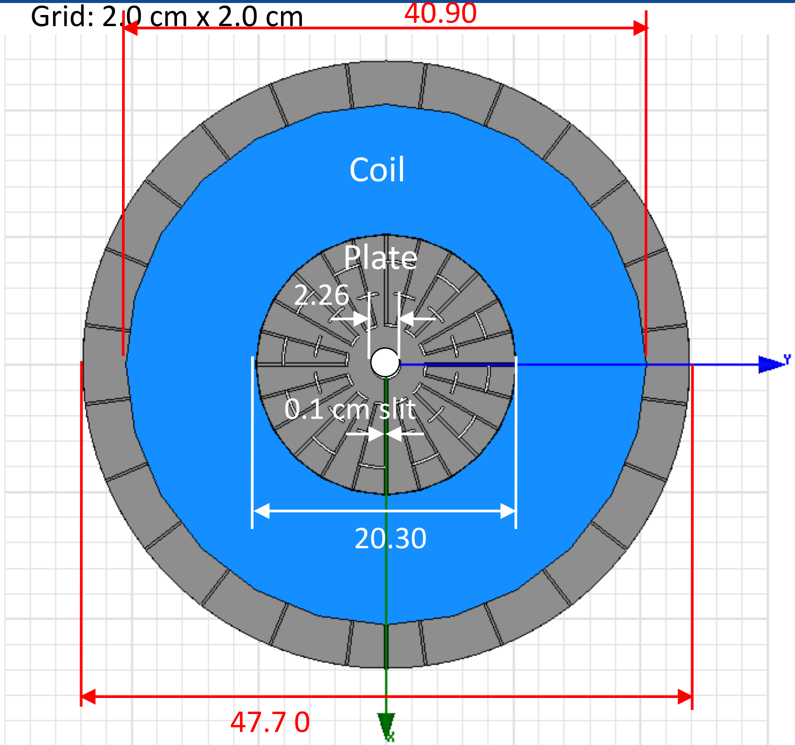
- ~4 T max field, with 1 ms pulse length, operated at 5 Hz for 9 months at a time
- Placed behind target to provide focusing effect
- Consulting outside sources and working on analysis
- Future analysis will need to look into effects of beam particles impacting the device as well

Code Structure for Analysis

- Solid lines indicate direct code coupling
- Dashed lines show coupling by manual processing of results
- Results in ePhysics simulation of structural behavior due to E&M loading with cooling



Modeled Geometry: Overall

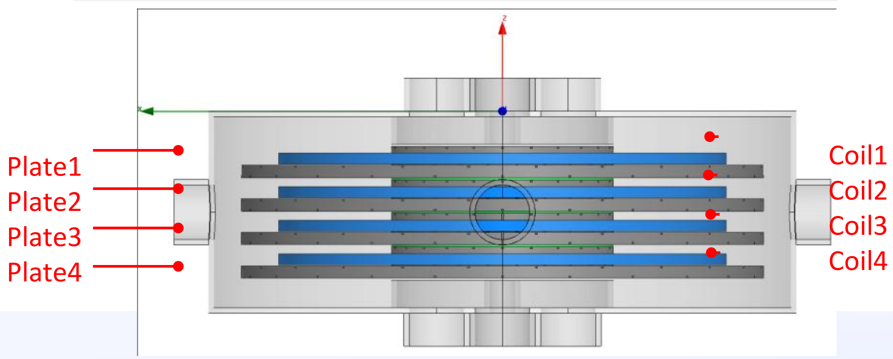


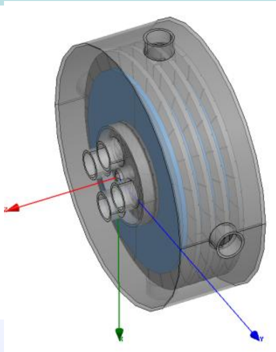
Note1: This geometry is our depiction of Wang's Flux Concentrator model where 4 Coils and 4 disks with a straight bore are modeled.
H. Wang, et. al., "Modeling of Flux Concentrator, Argon National Lab, WF-NOTE-234, August 2006. ANL.

Note 2: Disks and Coils material is Cu-OFHC; electrical conductivity of 3.5714E+08 S/m. The cooling container is of stainless steal with electrical conductivity of 1.E+06 S/m.
H. Brechna, et. al, "150 kOe Liquid Nitrogen Cooled Pulsed Flux-Concentrator Magnet," Review of Scientific Instruments, V.36, No. 11, Nov 1965, pp. 1529-1535.

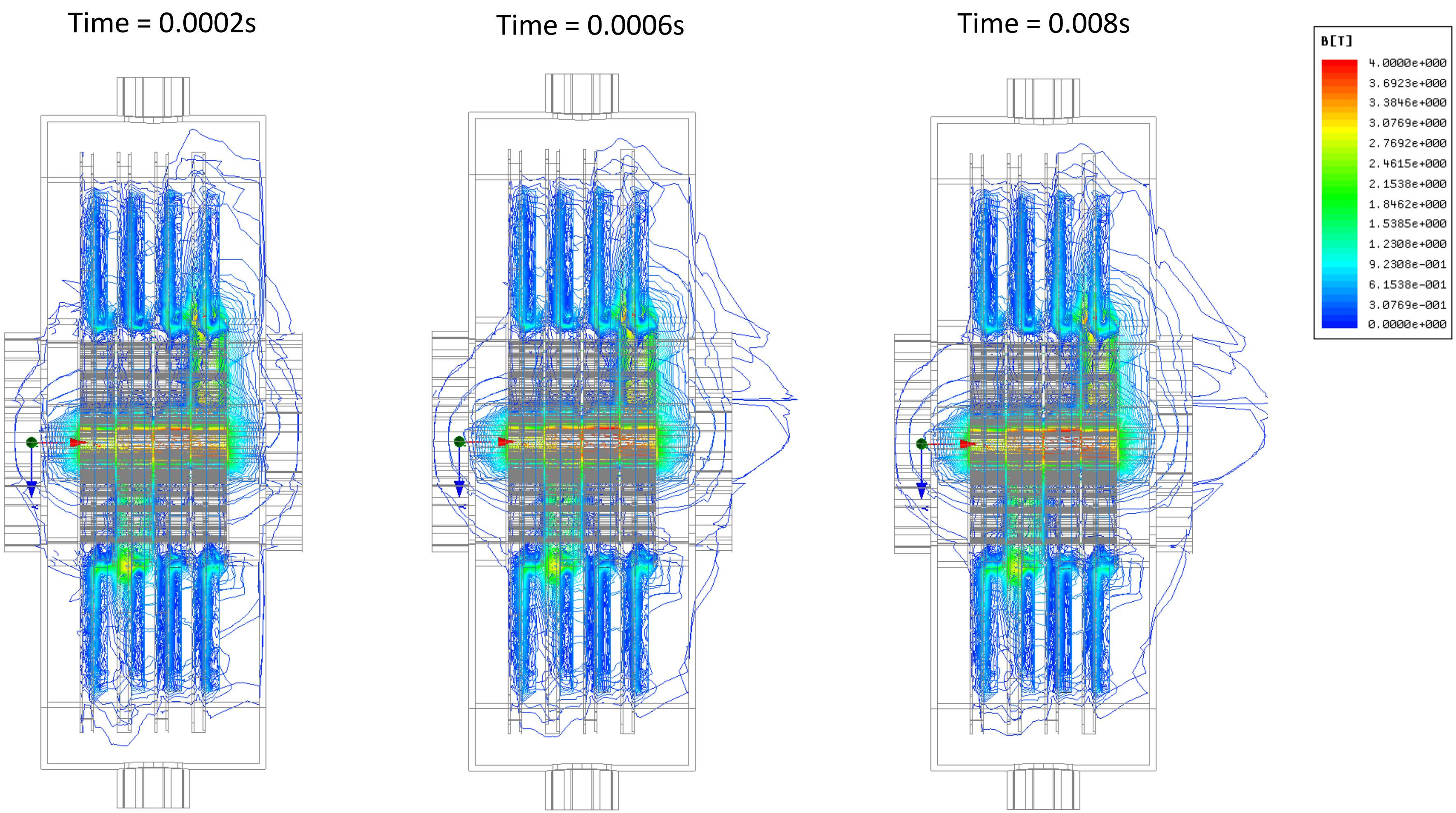
Note 3: Each plate has a 0.2 cm wide slit and each slit is rotated by 90° in each successive plate.

Note 4: Cooling Channels were added based on Bitter Magnet Design.
http://www.magnet.fsu.edu/education/tutorials/magnetacademy/makingmagnets/page2.html

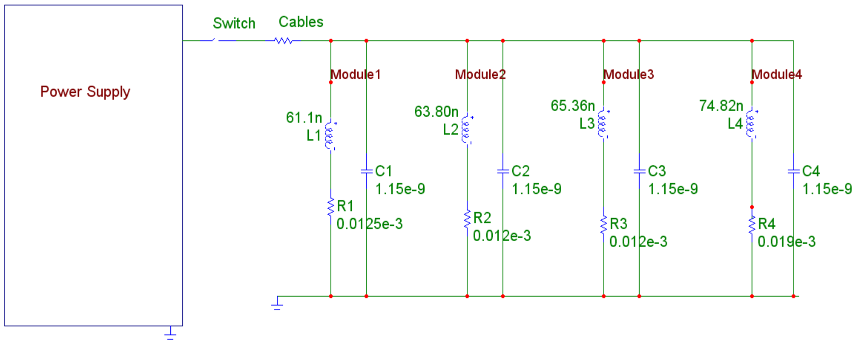


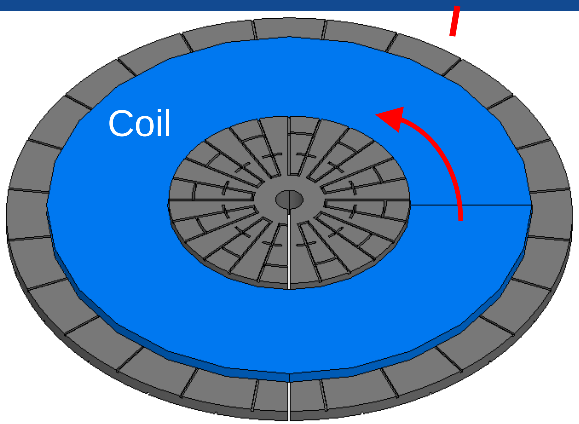


Maxwell 3D used to predict magnetic field

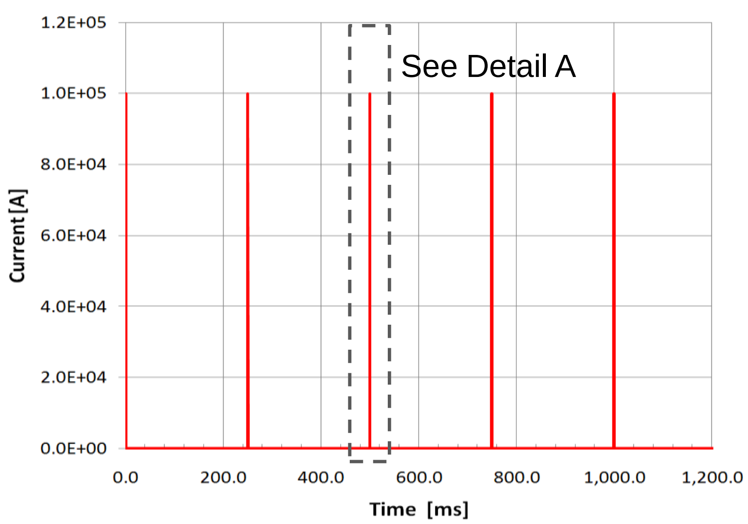


Current injection scheme

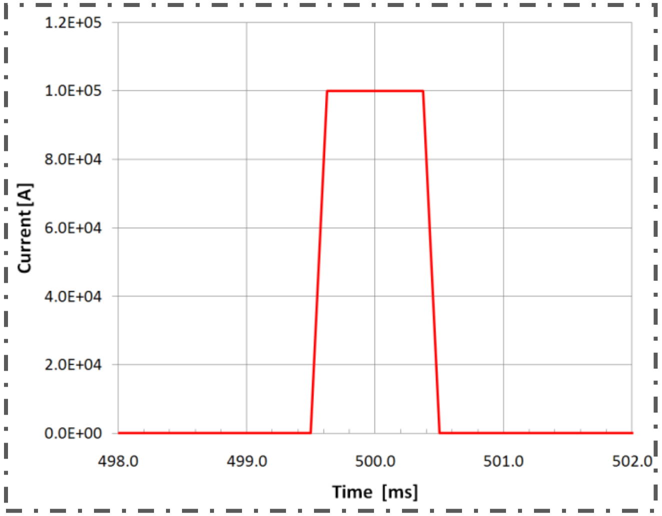




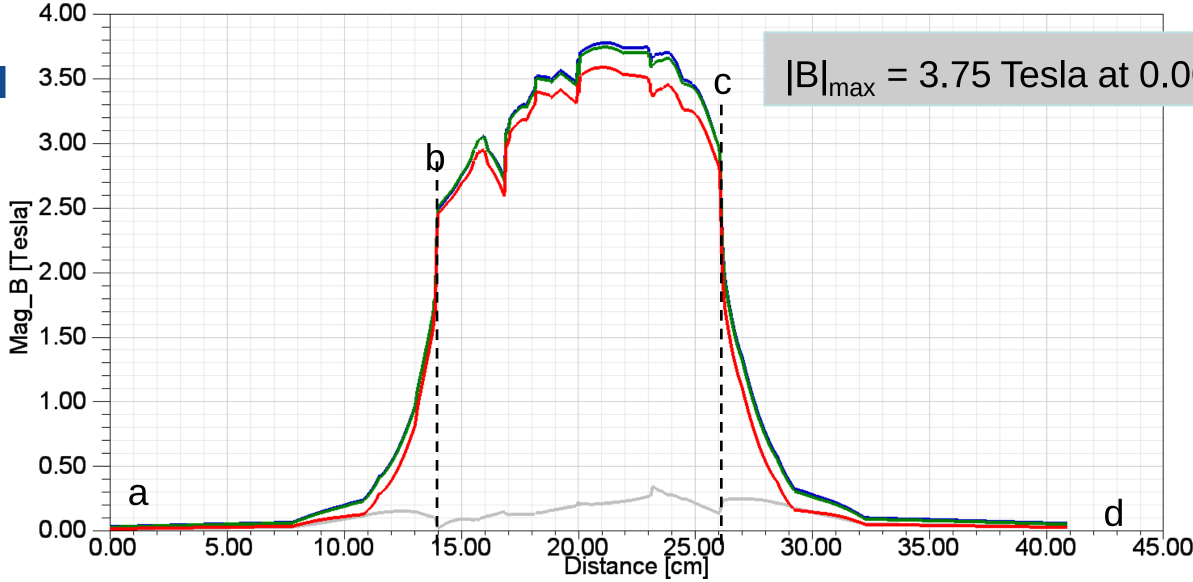
100 kA of 1.0 ms pulses at 5 Hz for ~2.3E+07s (9 months) for each coil



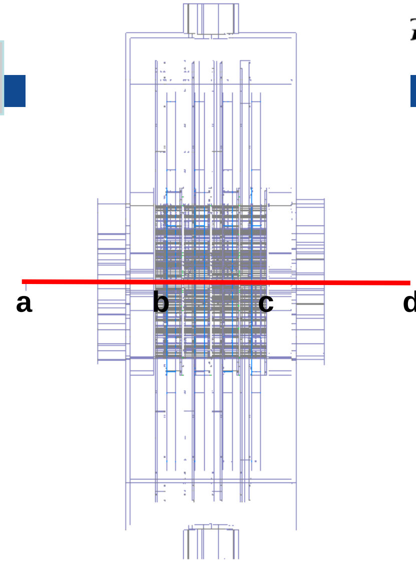
Detail A

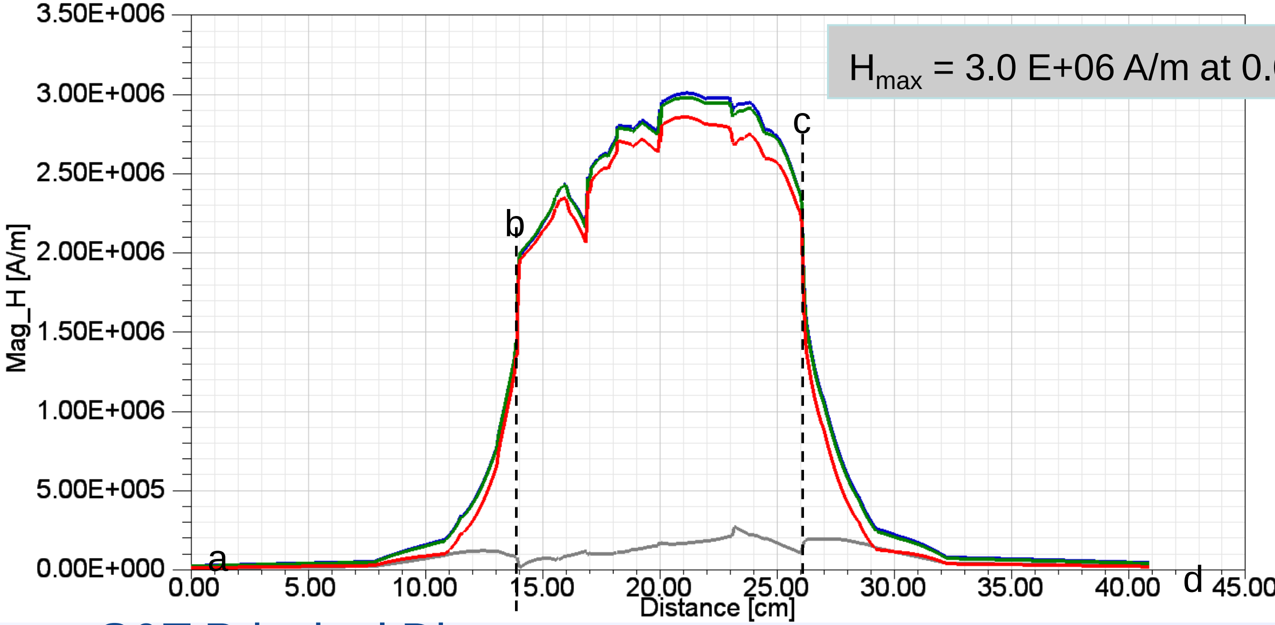


|B| and H along center-line



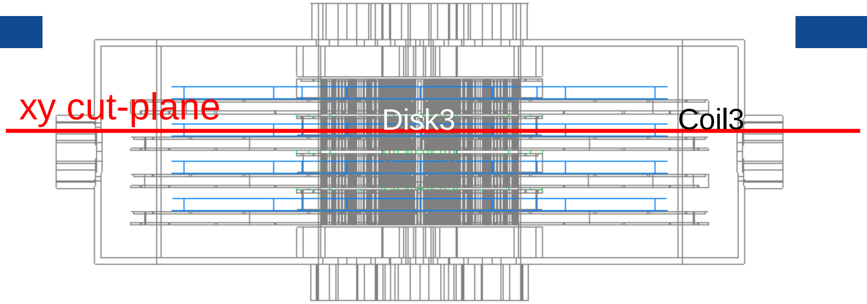
|B|$_{max}$ = 3.75 Tesla at 0.0006 s



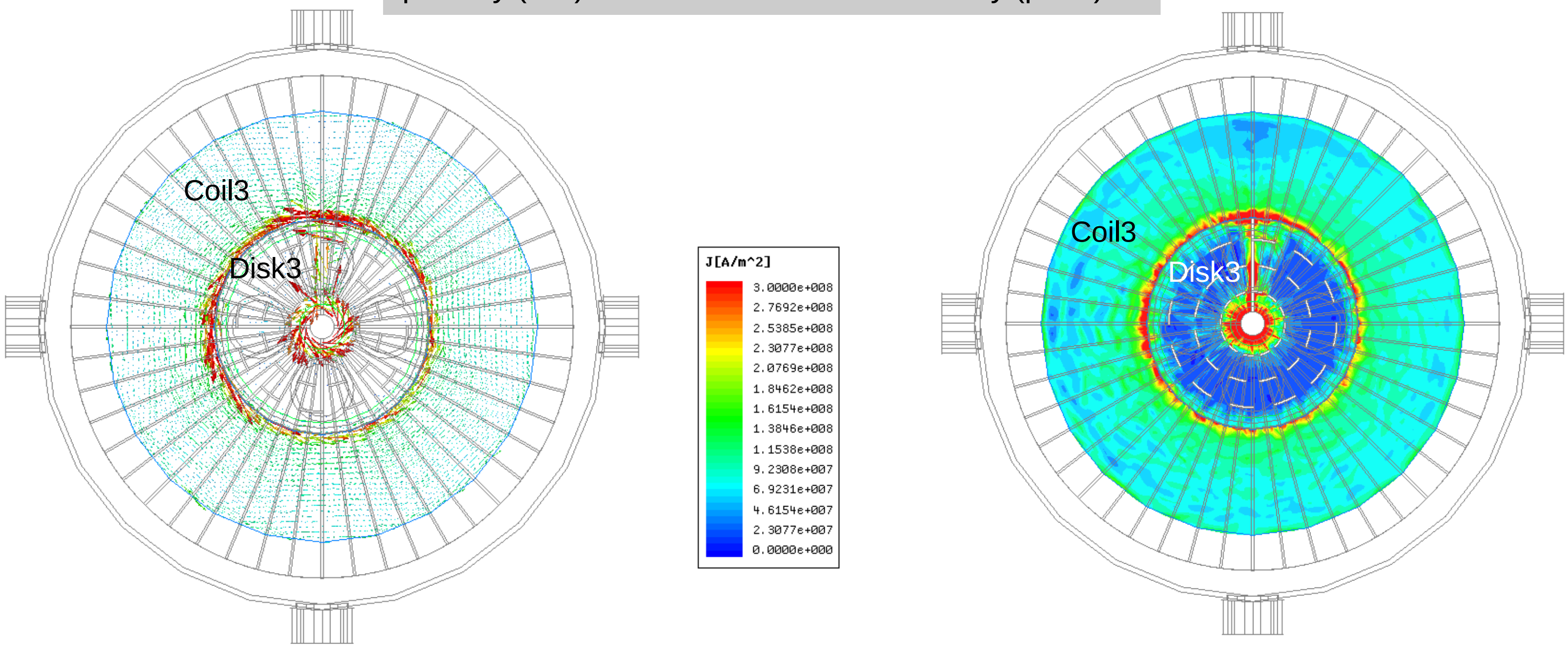


H$_{max}$ = 3.0 E+06 A/m at 0.0006 s = 37.5 kOe

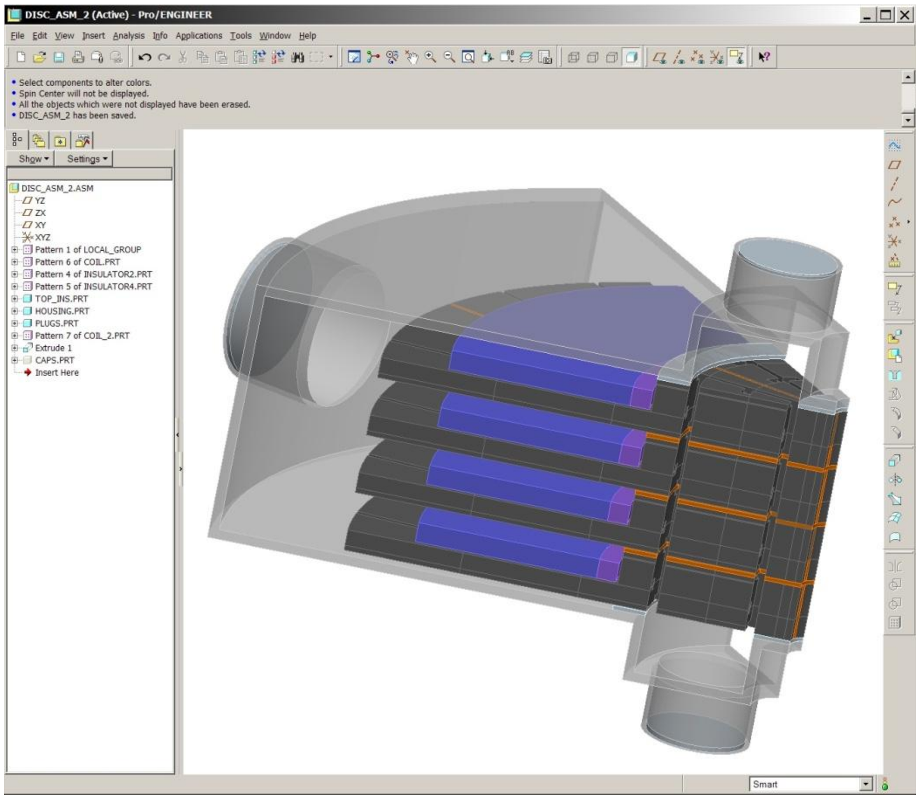
J and |J| at the xy cut-plane of plate3 and coil3 at 0.0006 s

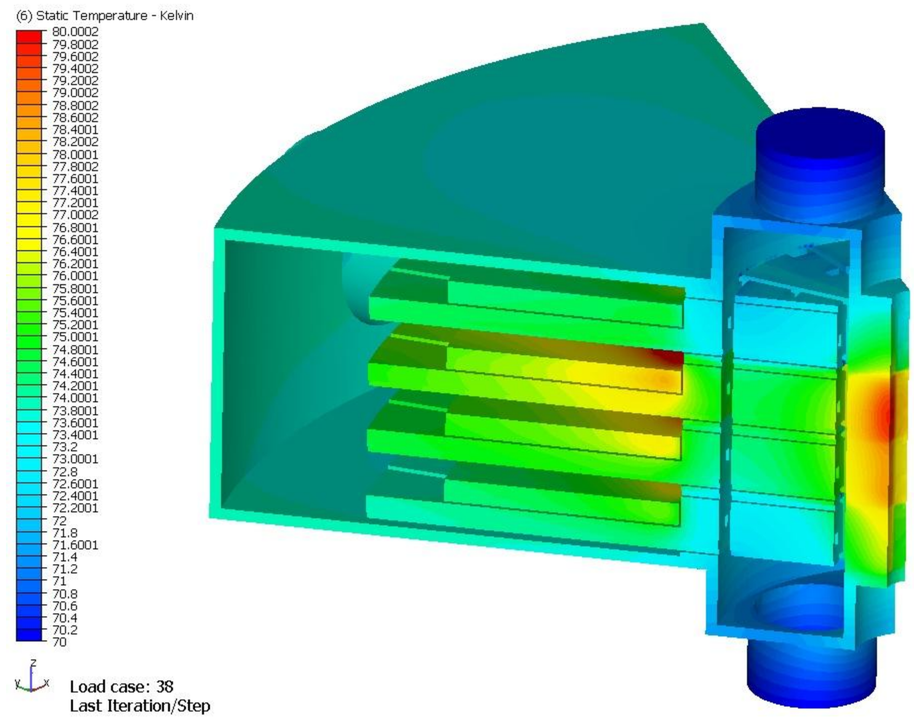


Flux Concentrator at work!
The slit channels the current from the large radius primary (coil) to the small radius secondary (plate).

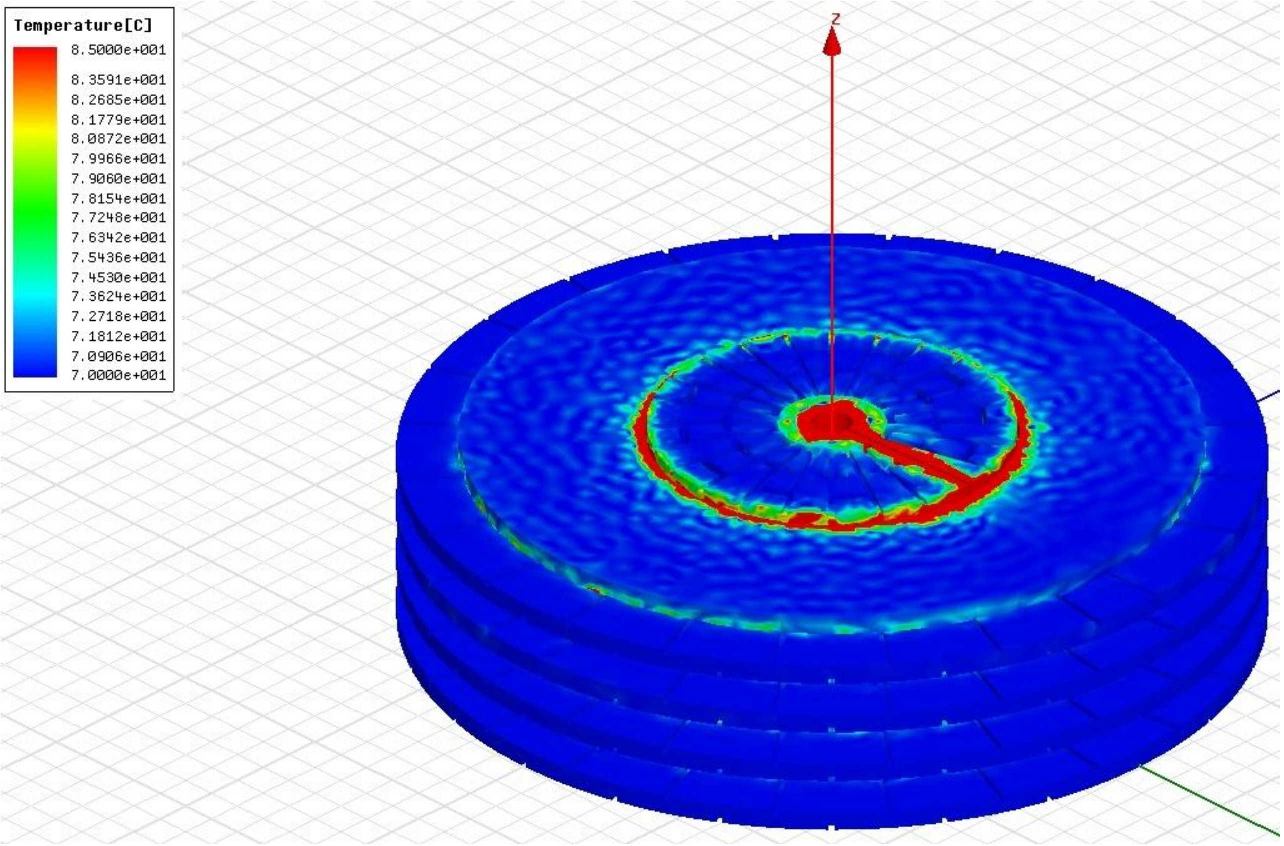


Cfdesign predicts the heat transfer conditions from the cooling flow





Geometry, EM loads, and cooling conditions are being analyzed in ePhysics

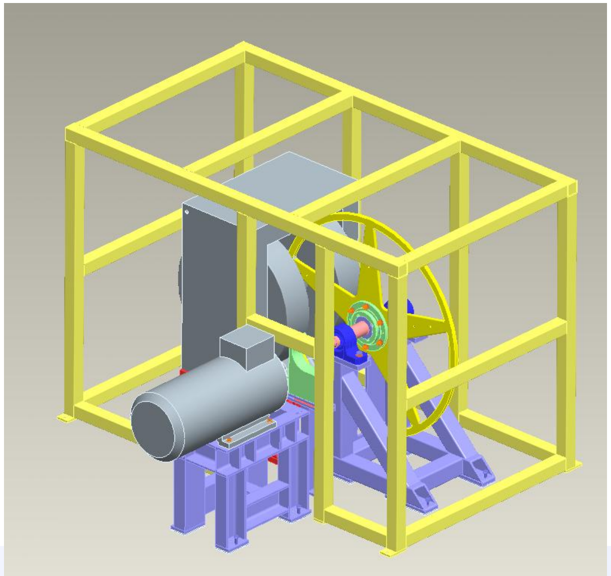


Further Steps

- Determine what can realistically be built
- Linear effects only modeled- check to ensure this is the operating range- device lifetime indicates probable failure outside this regime
- Investigate effects of temperature on material properties (do thermal, mechanical, or electrical properties vary enough to be important)

Rotordynamics

- Working with experimental team at Daresbury Laboratory
- Produced an FEA model of rotordynamic system
  - Aids in interpretation of experimental data from rotor system
  - Useful in predicting important behavioral features in dynamic behavior of wheel experiment

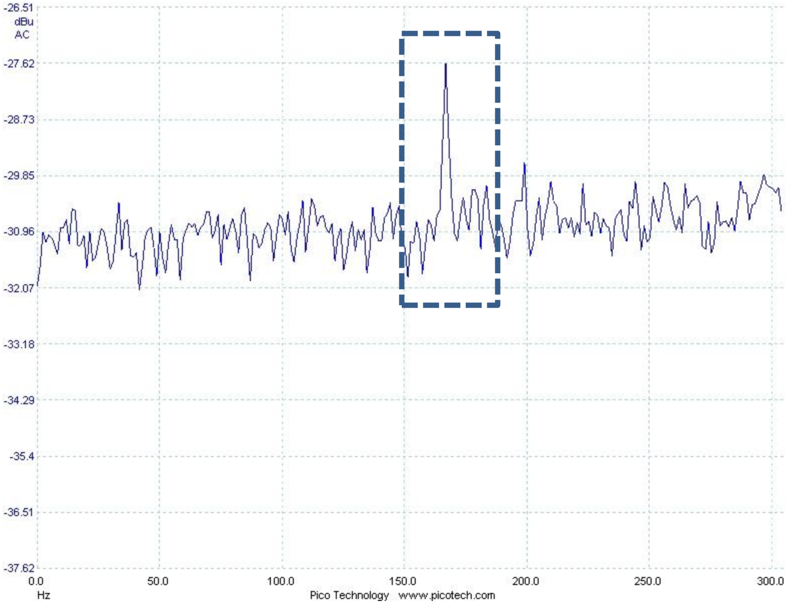


Rotordynamics

FEA Predicted Modal Frequency = 184 Hz

1st Transverse Bending Mode

Experimentally Observed Modal Frequency ~ 170 Hz



LLNL Areas of Work

- Flux concentrator studies
- Magnetic simulations of Daresbury Laboratory spinning wheel experiment
- Rotordynamics analysis of Daresbury Experiment