CPS Magnet for Hall D KLong Experiment

3/22/2024

J. Ballard

Requirements from Physics

Magnet Function: Bending e-beam into a dump, which is below the beamline.

Note: magnet is downstream of radiator and in air; no vacuum chamber to accommodate

- Dipole field with a nominal field B_x=0.67 T (x-axis goes beam-left).
  - Uniformity is not important for CPS.
- Gap size 1.4 cm (x from -0.7mm to +0.7mm). Can be larger.
- Length of poles along Z=60cm to provide flat B_x between z=-30cm and z=+30cm.
- Closest coil point to the center in XY projection is 11cm to avoid high radiation exposure.
- The size limit in XY plane is 64cm in X and 48cm in Y. Defined by the shielding in FLUKA.
- The limit on total length of the magnet in Z is 80cm, including the coil return parts. Defined by the shielding in FLUKA.
- Pole height approximately $\Delta y \approx 8$cm. This is not very critical.
- The radiation dose in the magnet coils is expected to be on the order of 3×10^4 Gy. We need to have a factor of x10 or more overhead with the radiation hardness in the design of these coils.
  - I used bedstead coils instead of racetrack coils to avoid coils close to the beam.
- We need to be able to double the magnetic field without overheating coils or saturating the return yoke.
  - This is for potential JLAB upgrade in a distant future.
  - We may need to buy a new power supply if we upgrade.
  - The way CPS is designed, the magnet is replaceable without completely removing the shielding of CPS.

This is a screenshot of the list of requirements from Physics.

NOTE: Hovanes made a conceptual design that included a bedstead style coil. I chose to use a racetrack, as will be seen later.

Coil Design

PARAMETERS:

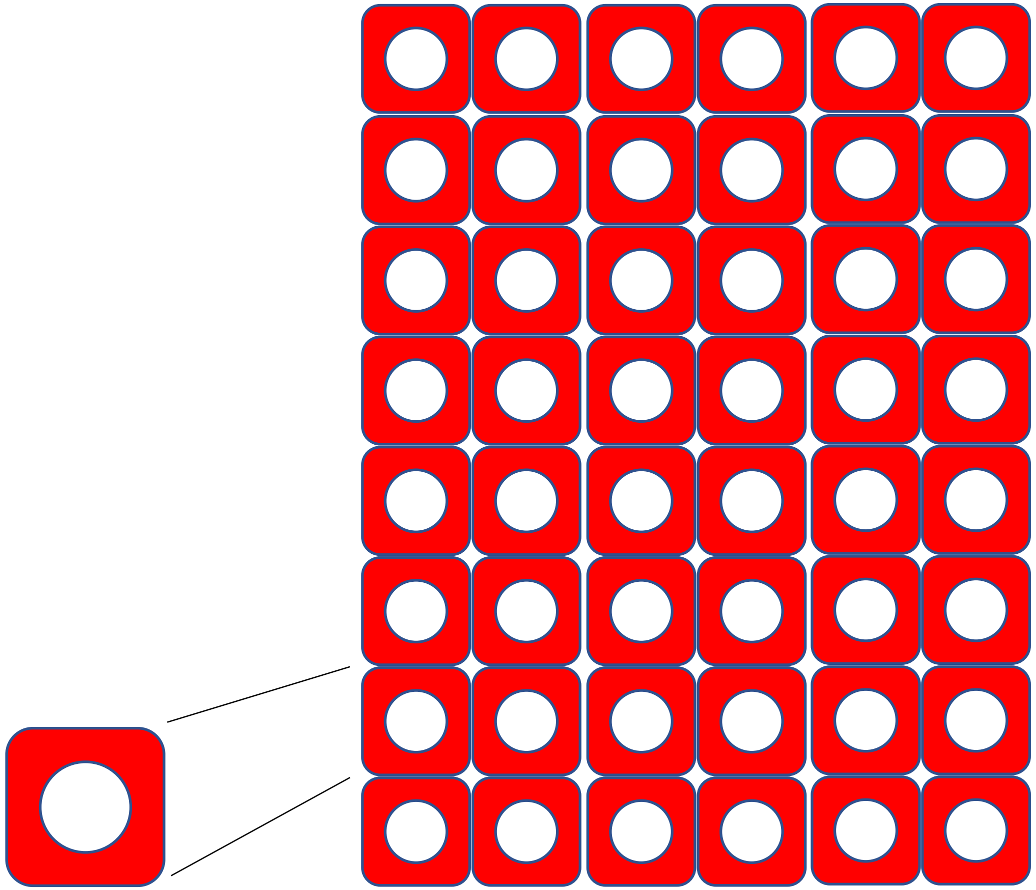
- B = 1.32 T (field)
- g = 0.014 m (gap)

- NI = 14706 A (total amp-turns, both coils)
- N = 96 Turns (total, both coils)
- I = 153 A (power supply current)
- N_{coil} = 48 Turns (one coil)
- R_{tot} = 0.191 Ω (both coils, 40 °C, 2m avg turn length)
- V = 29.2 V (across magnet, not including leads)

COIL CONSTRUCTION:

Each coil comprised of 3 double-pancakes: each 2 layers, 8 turns/layer

- Conductor: Luvata 8204
  - 7.9 A/mm^2 at 153 A
- Conductor Insulation
  - 1 wrap, half-lapped, .0027” Kapton
  - 1 wrap, half-lapped, 0.005” Fiberglass Tape
- Ground Wrap over Coil Assembly
  - 1 wrap, half-lapped, 0.005” Fiberglass Tape over entire pack
  - Additional wrap, half-lapped, 0.005” Fiberglass Tape over straight sections in contact with Iron yoke
- Vacuum Pot with CTD-403



Conductor:
6 mm x 6 mm
4.5 mm hole

Coil Construction:
3 double pancakes of 2 layers x 8 turns

Power and Water

Current Plan:

Use existing Tagger Magnet power supply, existing Tagger Magnet LCW, and existing power connections

Tagger Magnet Power Supply:

Output Current: 4 A - 300 A

Output Voltage: 2 V – 250 V

Tagger Magnet LCW Available:

Pressure: 70 psid

Flow: > 8 gpm

CPS Magnet LCW Requirements:

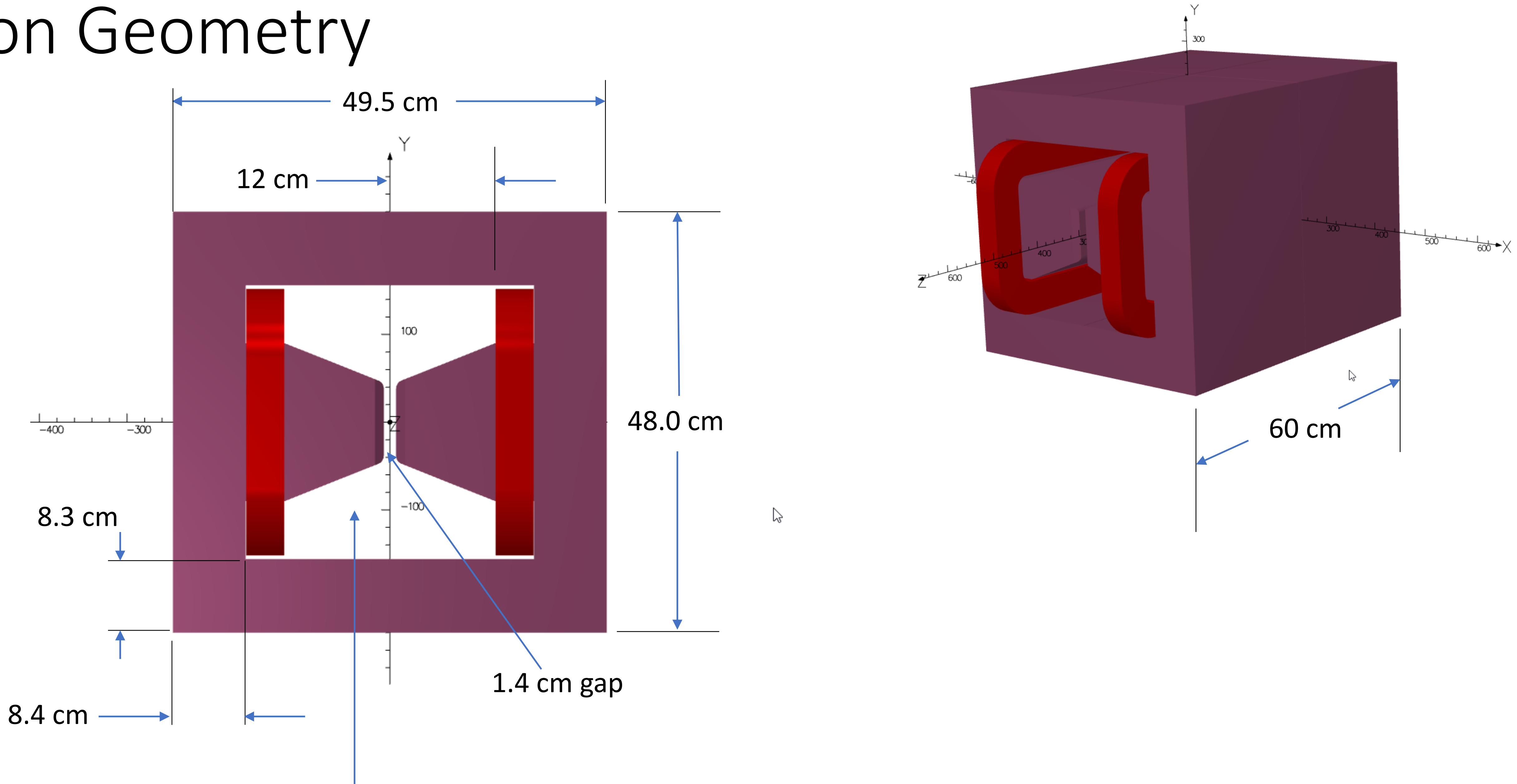
6 circuits (3 per coil) in parallel using existing Tagger LCW manifolds

Total LCW flow: 3.2 gpm (0.53 gpm per circuit)

$\Delta T = 5.3\ ^{\circ}C$

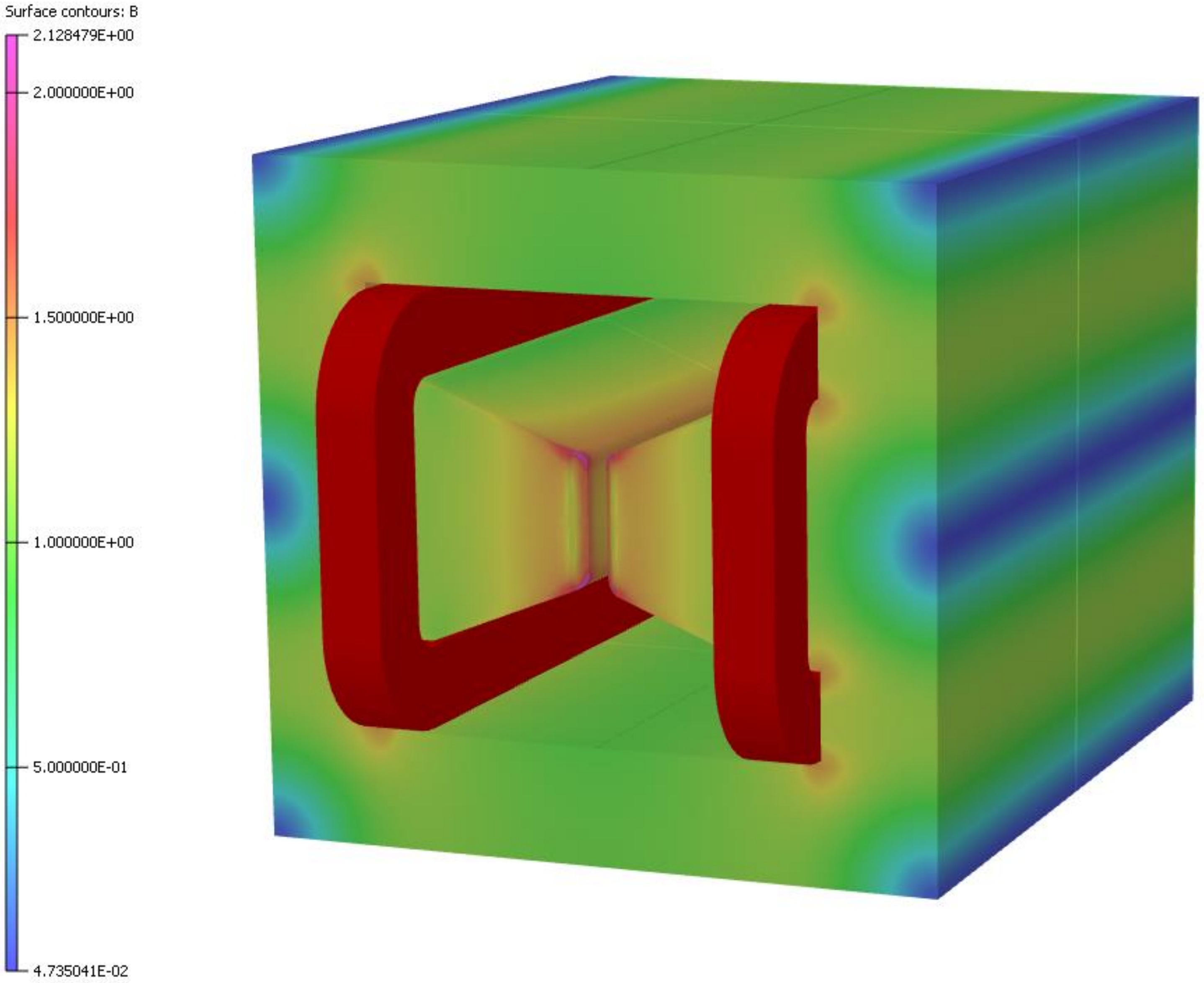
Velocity = 6.9 ft/s

Iron Geometry

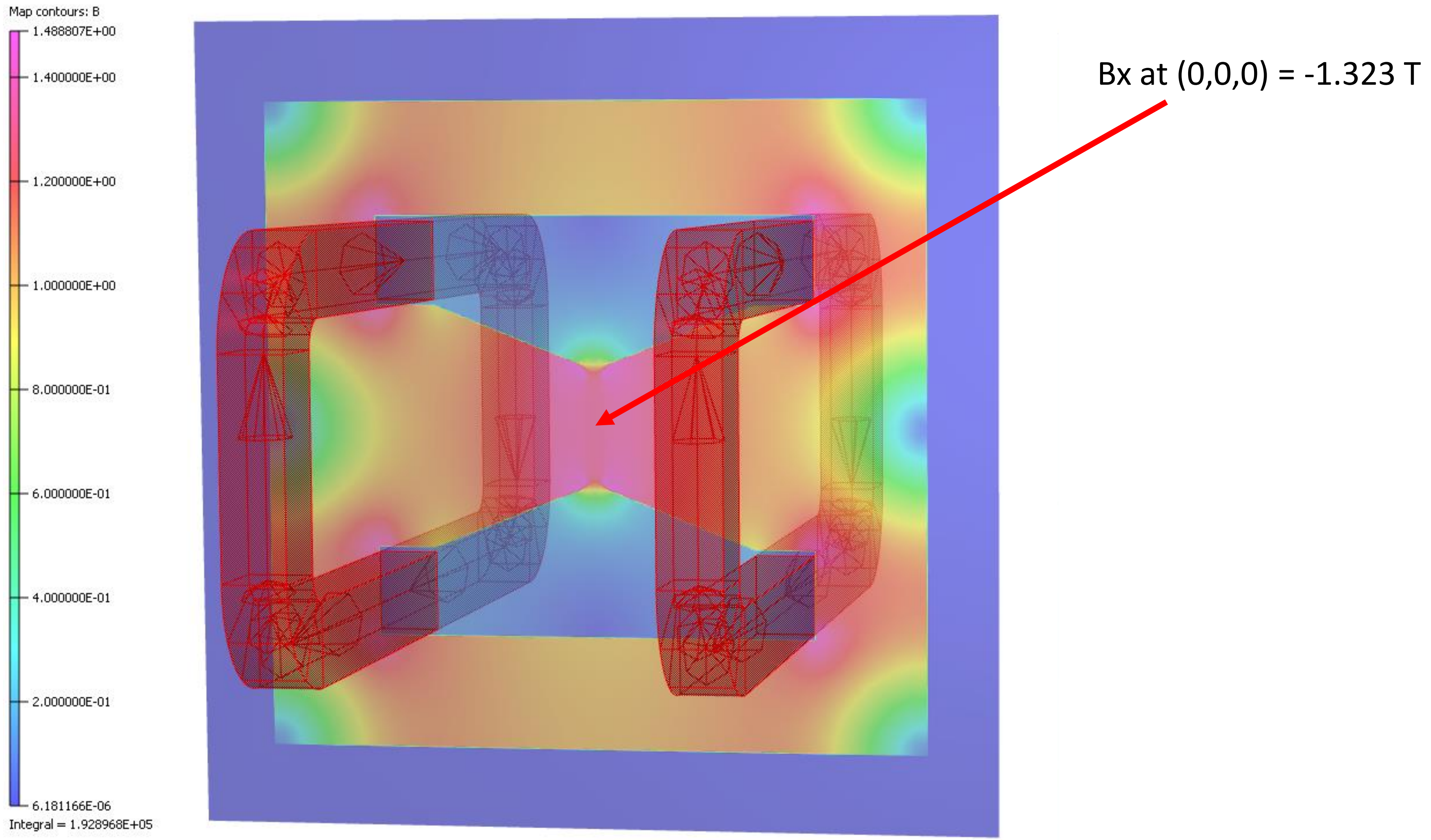


NOTE: Physics requests void between coils to be filled with WCu for radiation shielding.

Flux Density (B)



Flux Density on XY Plane at Z=0



Bx vs. Z