104 mm gap arc zero dipoles for positrons and FFA
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Abstract

Conceptual designs for 50 cm dipoles for the positron energy selection chicane and 100 cm dipoles for the transport from the LERF to the start of the North Linac are provided. 104 mm gap was chosen to match the quadrupole inner diameter. The positron capture cavity ID will be no more than 80 mm. Ten sigma for the positron beam in the arc is ~2.5 cm per Yves Roblin design. Pole width 20 cm to accommodate the sagittas for all applications in the arc, including the final vertical dipole which gets beam to 1L02.

Energy selection chicane dipole

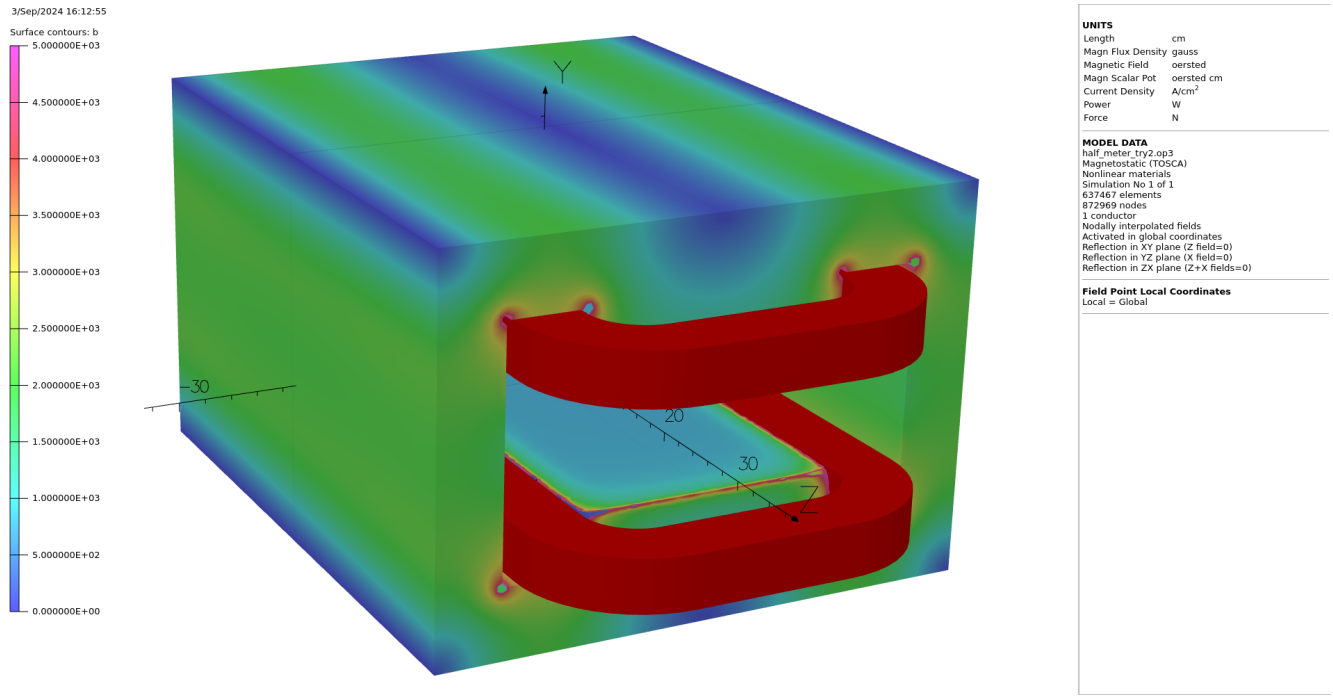

Figure 1. Field on the surface of the steel for 60 MeV positron selection.

5 cm steel plate assumed as we likely have enough 2” in the boneyard to build four of these. We certainly have enough 1” and 2” plate and the returns can be reduced to 2.5 cm from 5 cm given that the field is only 2 kG. Coil section is 4 cm by 5 cm so the pole should be fabricated from 2”. Pole could be chambered 0.5 cm X by 1 cm Z to reduce the coil length if desired. My initial thought on the coil was 9 mm square with 1 mm insulation but current density is only 150 A/cm^2, 3000 AT, so solid conductor suffices without cooling. #8 square is 0.3424 cm at maximum material condition. Sixteen turns by twelve layers is 5.478 cm by 4.108 cm, which fits in the coil pocket (4.3 cm by 6 cm). Total turns 192 by ~180 cm. Length of each coil ~34500 cm, ~1140' so resistance at 20 C ~0.59Ω. Current 15.625A for 3000 AT so power 144 W before copper heats up. At 60C copper, 170W. For eight coils, 1360 W. 20 A, 100 V power supply would suffice. One could put a water-cooled plate on one side of each coil to constrain temperature but that's unlikely to be necessary. Widen coil pocket slightly if needed.

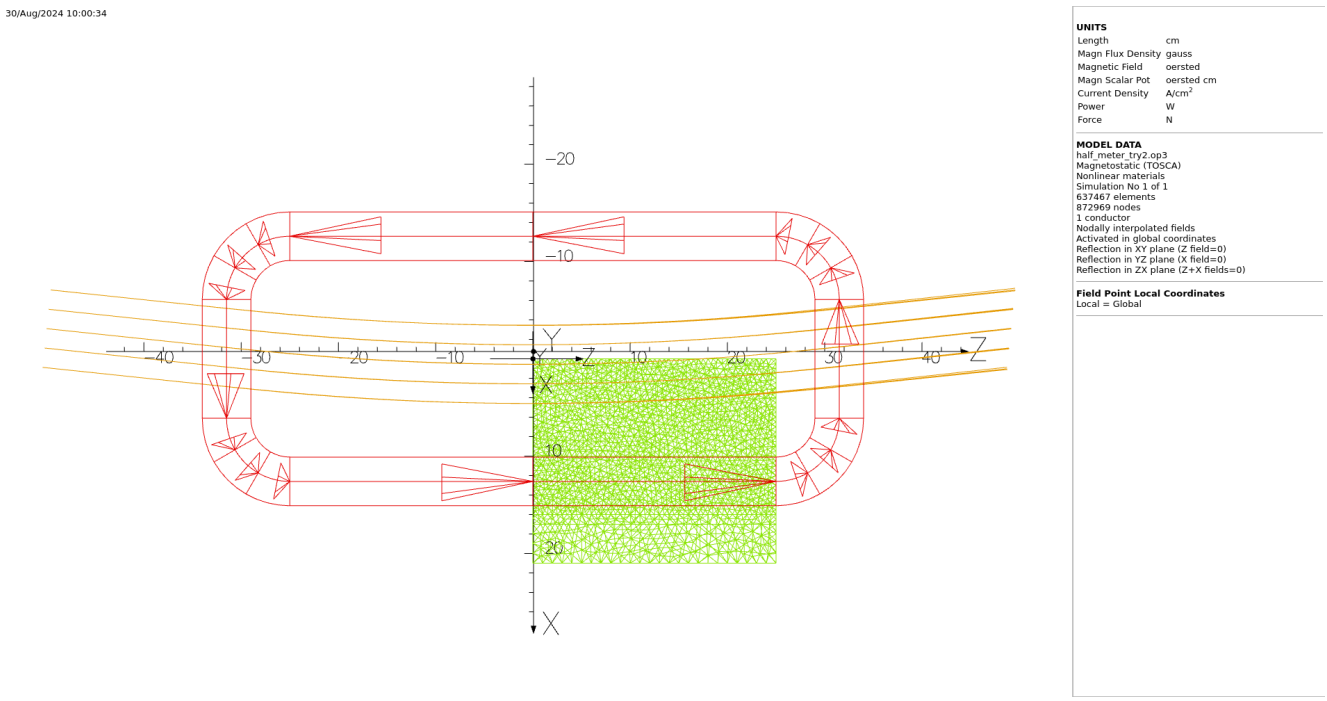

Figure 2. 8 cm square array of 60 MeV particles, 0.209 radian bend. The lines are thicker on exit. XZ

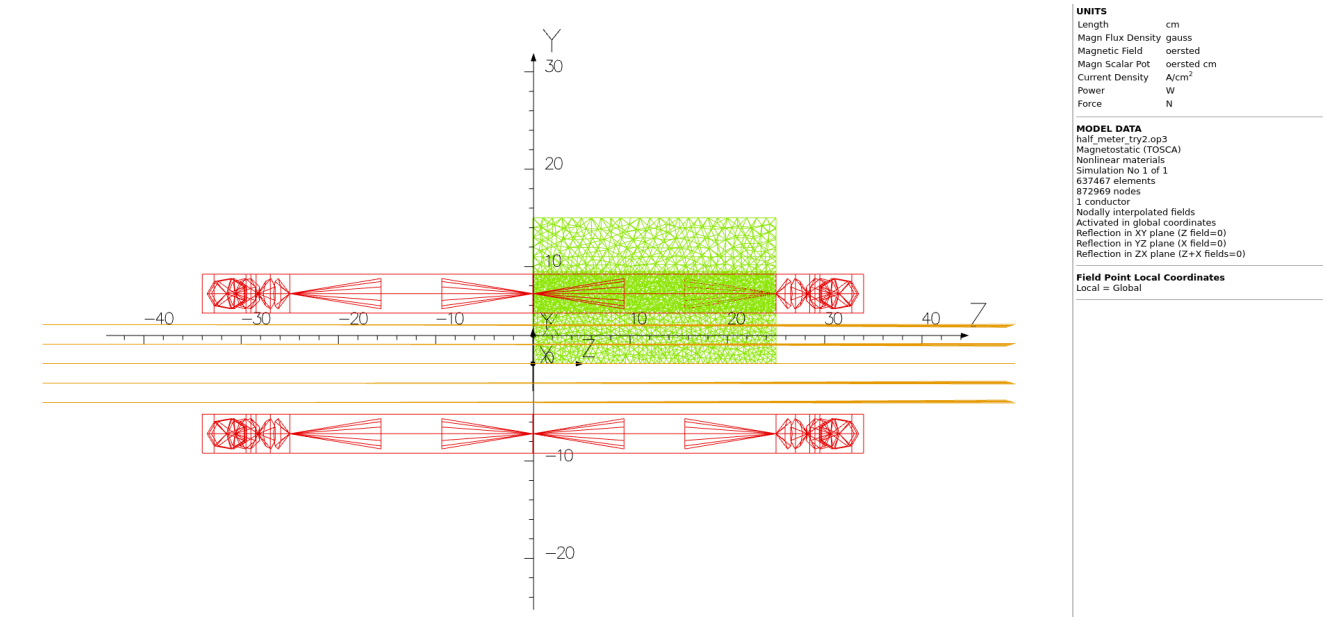

Figure 3. 8 cm square array of 60 MeV particles, 0.209 radian bend. The lines are thicker on exit. YZ

One meter dipole

Per Salim Ogur, the arc zero dipoles bend 0.098 radians and the maximum bend in the entry to the North Linac is 0.256 radians. I designed for the latter at 650 MeV so the line would work for both 123 MeV positrons and 650 MeV electrons. As mentioned above for positrons ten sigma is 2.5 cm so the 20 cm pole width is still appropriate. Here a larger coil pack is required, five turns by six layers of water cooled conductor. 710 A/cm^2 for the largest bend at 650 MeV. Under 300 A in the arc so multiple power supplies required for the system.

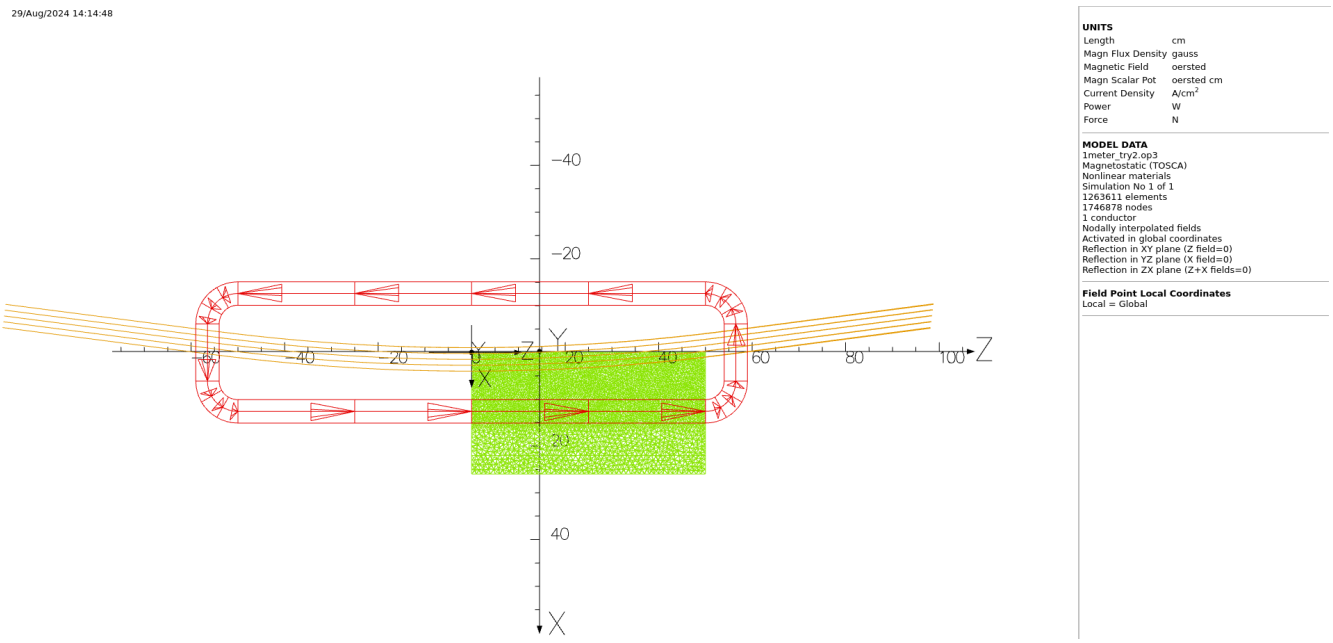

Figure 4. 5 cm square array of 650 MeV particles, 0.256 radian bend. XZ view. Particles move left to right. Launch x -7 Z -100 angle 7.33º is best if CF flanges are at Z= -65, 65. Clearance 2 cm minimum to 15 cm wide vacuum vessel, discussed on next page.

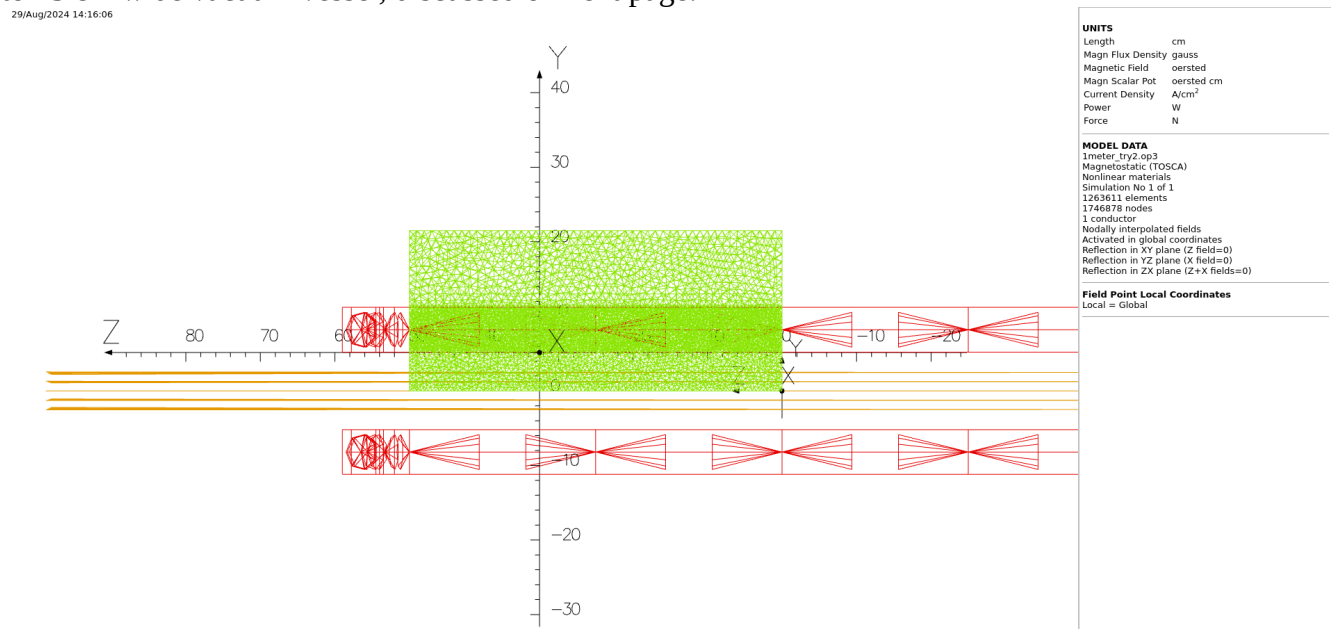

Figure 5. 5 cm square array of 650 MeV particles, 0.256 radian bend. YZ view. Particles move right to left. (I goofed.)

I have not calculated power and derived required water flow for this coil. CEBAF has many magnets up to 4 m in length consisting of ten turn double pancakes wound with 3/8” square with 3/16” hole conductor so Luvata 8182, 9 mm square with 4.5 mm hole should be fine at 1 meter even with 20 cm wide pole (versus 10 cm typical). Luvata 7076, 9 mm square with 4 mm hole or 8106 with 5 mm hole are the alternates.

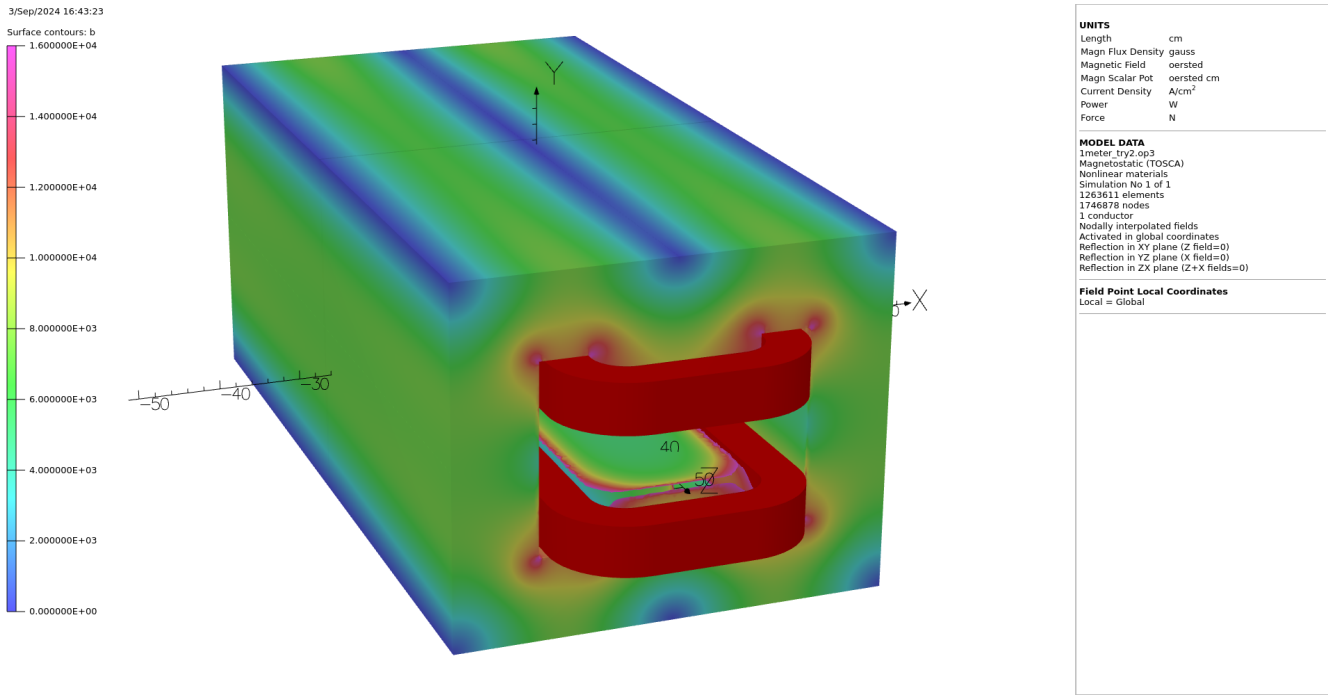

Figure 6. Field on the surface of the steel of the one meter dipole with field to bend 650 MeV electrons 0.256 radians. Coil pocket is 6.5 cm high by 6 cm wide, coil is 6 cm by 5 cm. 6 cm width allows for the transition between the two layers of the double pancake. That transition will be on the inside of the coil, not at the outside as assumed here. Perhaps at the end of the coil, allowing for a narrower coil pocket. Details I haven't taken into account. Return steel is 10 cm here but could be reduced to 7.5 cm with some increase in coil current.

Vacuum vessel

Looking at Figures 2 and 4, a vacuum vessel with inner width 15 cm will suffice. A full width vessel would require thicker walls to reduce the deflection from atmospheric loading. Using Roark's Formulas for Stress and Strain with E for 300 series stainless, a fully constrained plate, as in a welded vacuum vessel with CF flanges on either end, will deflect under 250 microns maximum if 3 mm thick. In US units, 6” width and 0.125” wall. The diagonal of a 4” by 6” rectangle is 7.2” so a 10” CF flange works. Less beam clearance than a 4” tube with 0.06” wall, but more than adequate.

Conclusion

The magnets required for the positron energy selection chicane and arc zero from LERF to the NL will not be difficult to engineer and fabricate. Since the arc dipoles are designed for 650 MeV it may be that different power supplies would be needed for 123 MeV positrons: power supplies don't like to run at 20% of capacity.