Possible Muon Beam Lines Serving BDX Behind Hall A

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5 September 2025

BDX and Beyond

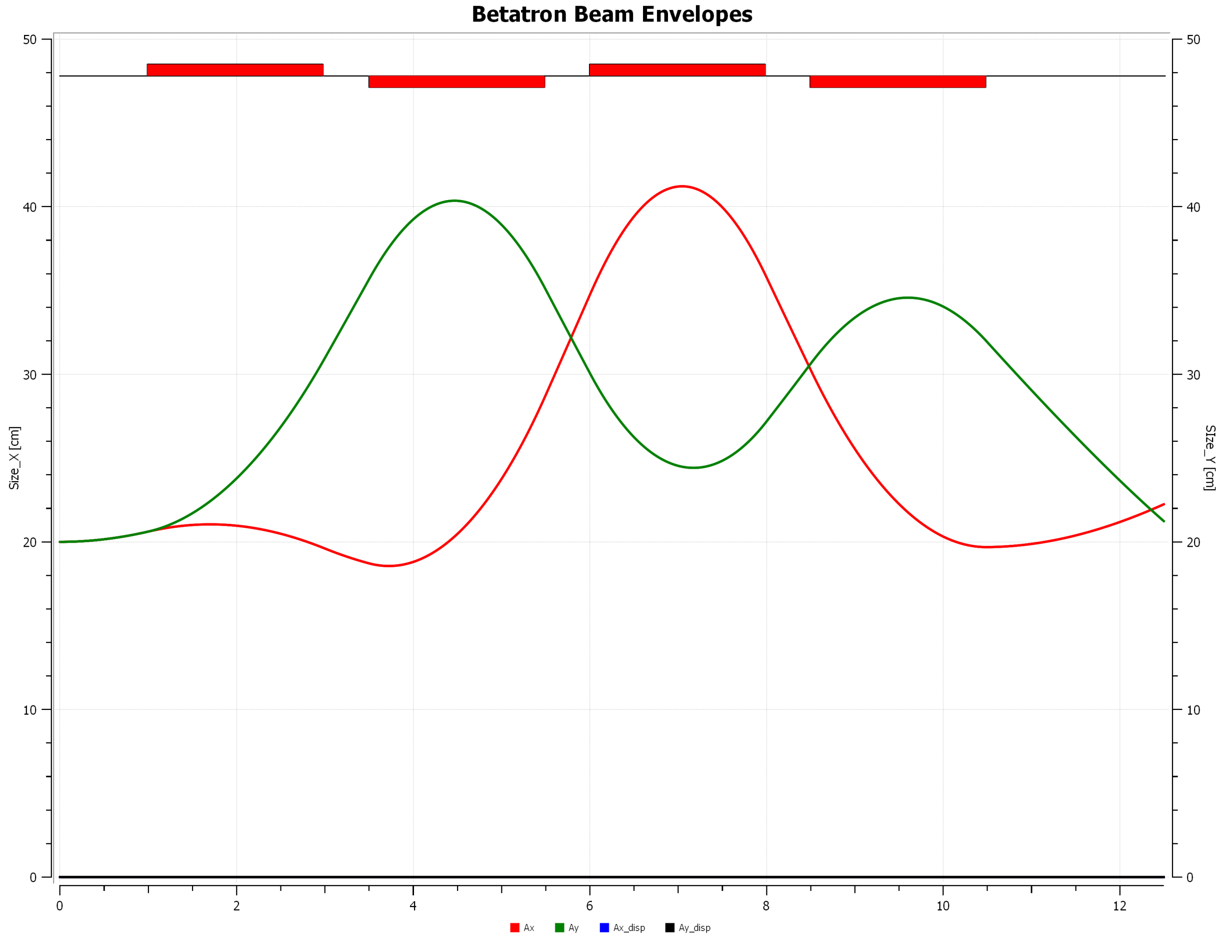
Muon capture

- Muon capture schemes for colliders include a very high field superconducting solenoid, e.g. 20T REBCO, immediately after the conversion target. This is not practical for BDX.
- I assume the beam parameters from Antonio Fulci's masters thesis of 2021 exiting the existing concrete.
- I assume about 12 m available from concrete to BDX wall. This can be reduced.

Location constraints

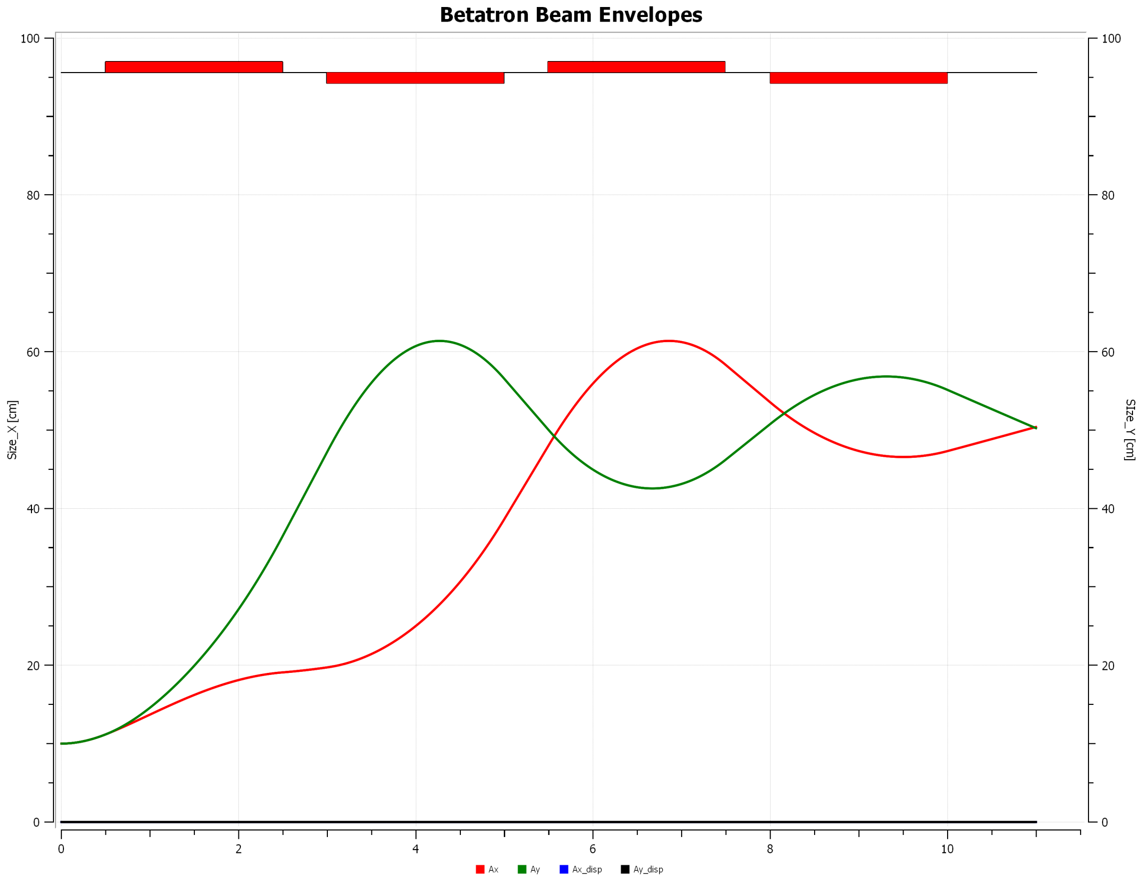
Magnets must either be conventional quadrupoles, requiring only DC current and cooling water, or commerical MRI superconducting solenoids incorporating GM or pulse-tube refrigeration. Siemans sells a 7T whole-body scanner. If three of the solenoids can be purchased without the MRI systems they might be a better solution than what follows.

2 GeV Beam Envelope



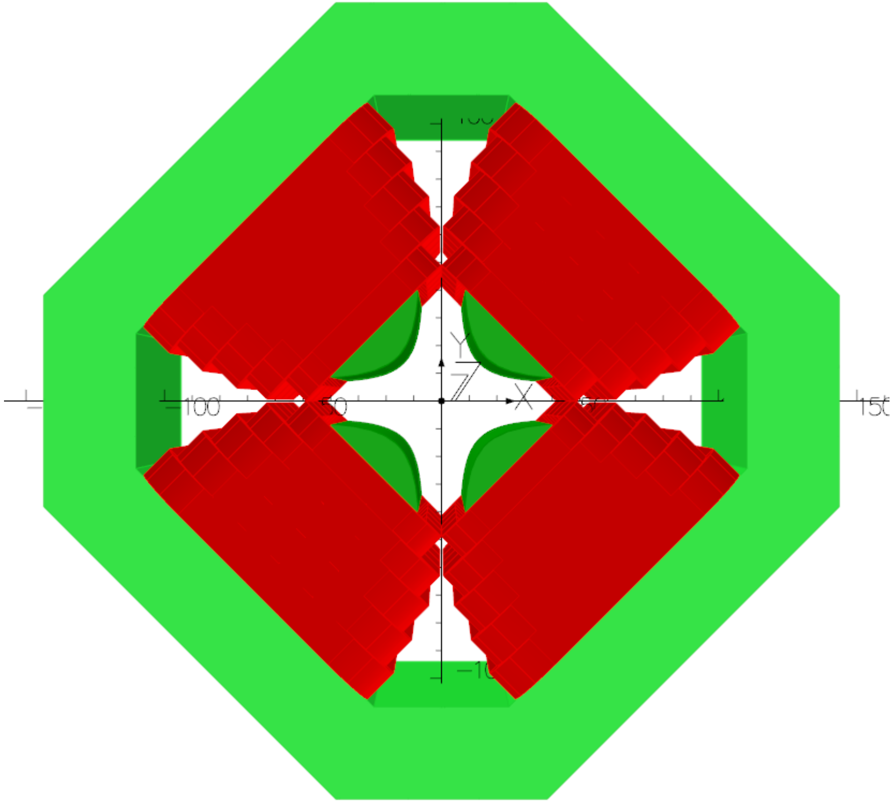
Red bars are 200 cm long, 416 mm ID quadrupoles. Muon beam radius assumed 20 cm. First quad is 100 cm from the concrete. Quad spacing 12 cm coil to coil. Beam divergence exiting from concrete NOT included. Red horizontal, green vertical. Peak radius 40 cm so there will be lots of clipping. One could also use a triplet, reducing length from 12 m shown.

6 GeV Beam Envelopes



Limited by focusing strength available with steel. Peak radius 60 cm so clipping much greater yet than 2 GeV.

Quadrupole design

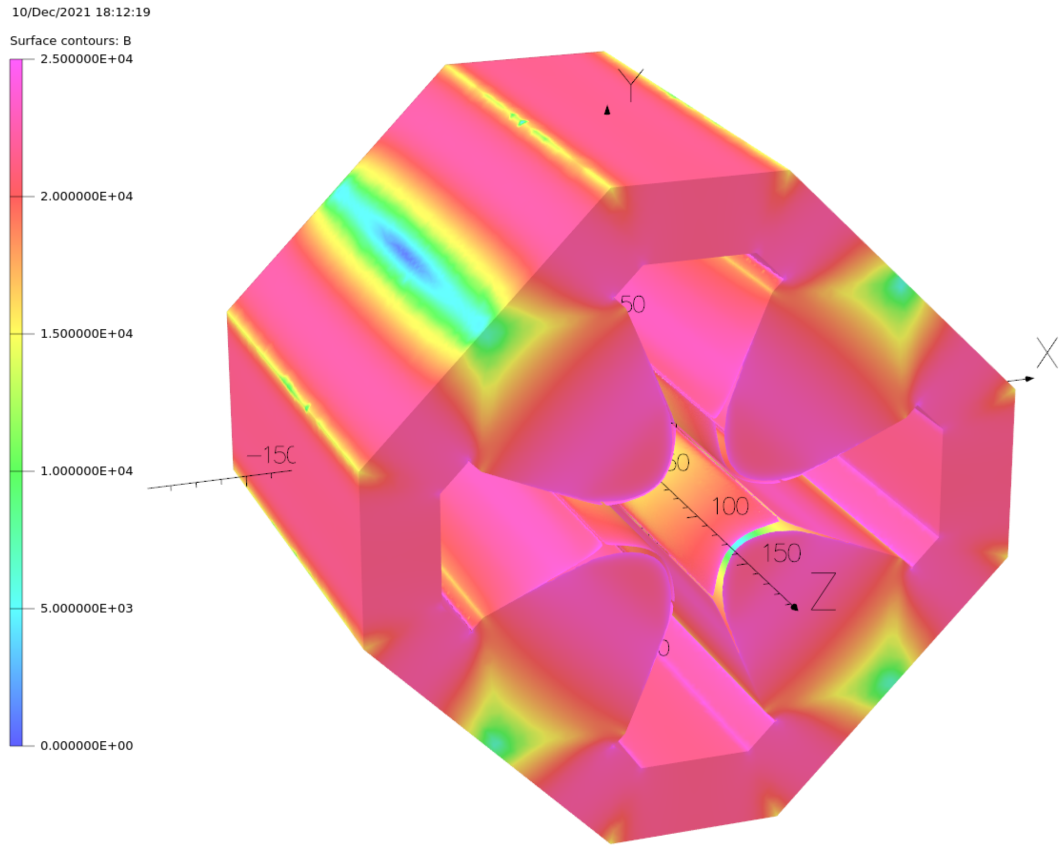


Luvata 8549, 11.5 mm square with 8.5 mm round hole, chosen as conductor. Using an online pressure drop calculator without bends, 150 g/s of water is driven by 12.7 bar in longest double pancake. Temperature rise at 300 A/cm^2 then ~42 C. Resulting field integral at 1 cm radius 130000 G.

Yoke 30.5 cm thick, 30 cm acceptable.

At 200 mm radius, 12-pole component is 5% of quadrupole. 20-pole is 0.8%. Adequate given the quality of beam being focused.

Quadrupole steel



Opera's “good magnet steel” BH curve used. 300 A/cm^2 in coil. Pink is 2.5T on surface. If yoke thickness is increased from 30.5 to 40 cm, peak in yoke decreases to 2T and integrated focusing increases 3%. Field in pole doesn't change significantly. Not cost effective.

Focusing is only 56% of what would be available if steel BH was linear out to 2.5T, but of course it isn't.

Power supply and cooling water

- At 275 A/cm^2, current is 396 A and integrated field 128 kG. Resistance ~2.75 Ω. A 1200 V, 500 kW supply will have about 5% current headroom. One per quad.
- 23 double pancakes per quad pole at 150 g/s each yields 13.8 l/s water flow per quad. Pressure, and flow rate <u>per quad</u>, are comparable to that needed for the MOLLER spectrometer.
- Significant power and cooling water upgrades would be required.

Conclusion

- A conventional FODO quadruplet or triplet is possible in the space available but would be quite expensive.
- It may be that the Siemens 7T self-contained, persistent superconducting solenoids would be a more economical solution. I have not modeled this option. Radiation heating and damage to the superconductor must be considered. Contracting with Siemens for the analysis would be required as they won't provide the proprietary information needed for an outsider to do it.
- Or accept no focusing at all, leaving the soil as is.