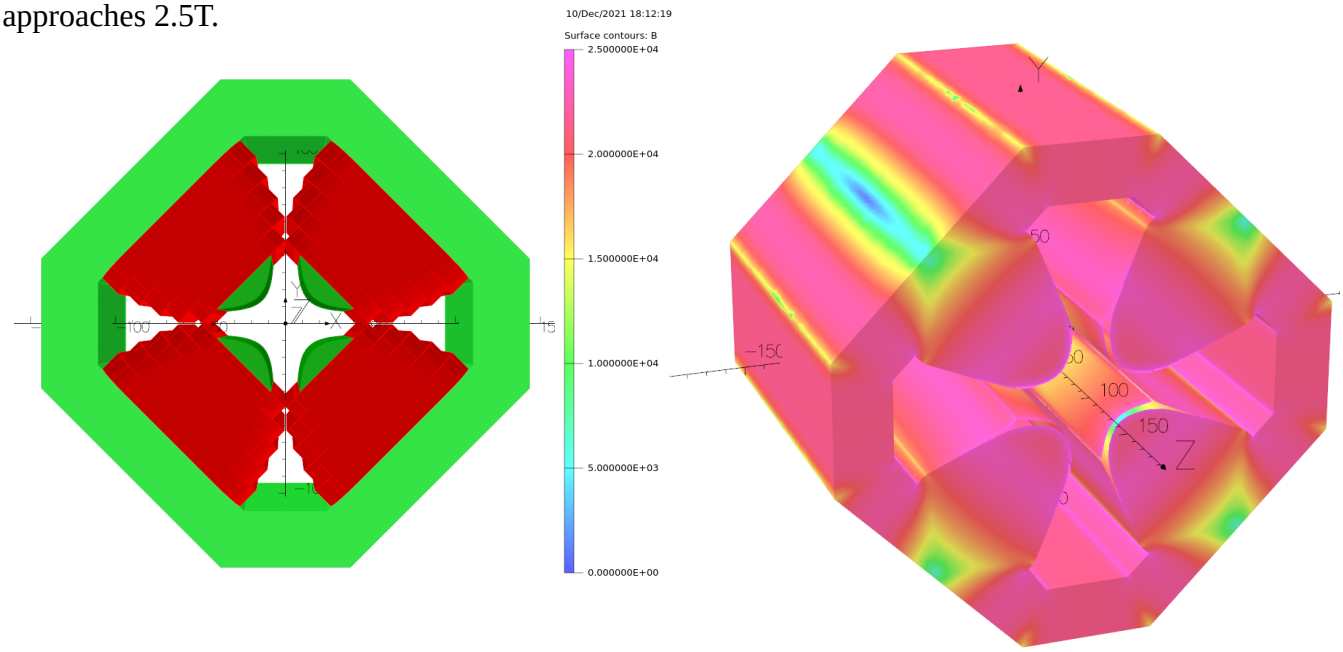
Possible Muon Beam Lines Serving BDX Behind Hall A
Jay Benesch

This work (1) was done in 2021 using Antonio Fulci's masters thesis as input. A 104 mm inner diameter (ID) by 350 mm long quadrupole design intended to improve the Hall A Moller polarimeter, not implemented, was scaled to 416 mm ID by 2000 mm length given the 200 mm sigma for 2 GeV muons in the thesis. The Luvata tools list was consulted for possible hollow conductors. An online pressure drop calculator which assumes straight tubes was consulted for hole size given length of the double pancake windings used. Opera was used for the field models. Current densitities 25 to 400 A/cm^2 were modeled; 275 A/cm^2 proved a practical limit given low carbon steel saturation and the 20 bar upper bound of cooling water pressure at JLab. At this current density the surface field on the poles approaches 2.5T.



(left) Perspective view of quadrupole. (right) Field on the surface at 300 A/cm^2, pink 2.5T

Using this quadrupole a four quad FODO line was modeled. For 2 GeV muons it has peak radius 400 mm so the muon beam will be clipped but the muons remaining can be brought to a 200 mm radius focus. 6 GeV muons cannot be brought to a focus and peak radius in the line is 600 mm so more will be clipped. Each quadrupole requires a 500 kW power supply and 3.5 l/s cooling water flow for 42 C temperature rise. These are far more than the facilities requirements of the BDX experimental hall.

Muon collider designs assume a high field superconducting capture solenoid, for example 20 T via REBCO. This is not practical in a hole behind Hall A. Siemens sells a 7 T whole body MRI scanner with self-contained cooling system. Two or three of these solenoids might be a better muon channel than the conventional quadrupoles discussed. The collaboration would have to determine if Siemens would sell just the solenoids for scientific purposes and would be willing to model the radiation damage and radiation heating effects on the system. Modern superconductor is optimized with artificial pinning centers; additional atomic displacements due to radiation damage degrade performance. Siemens would have to do the analysis; they won't provide the proprietary information needed for an outsider to do it.

(1) https://jlabdoc.jlab.org/docushare/dsweb/View/Collection-52838
416 mm ID quad for a possible muon beam line