Muon Beam Studies in the H4 beam line and the Gamma Irradiation Facility (GIF++)

Rachel Margraf

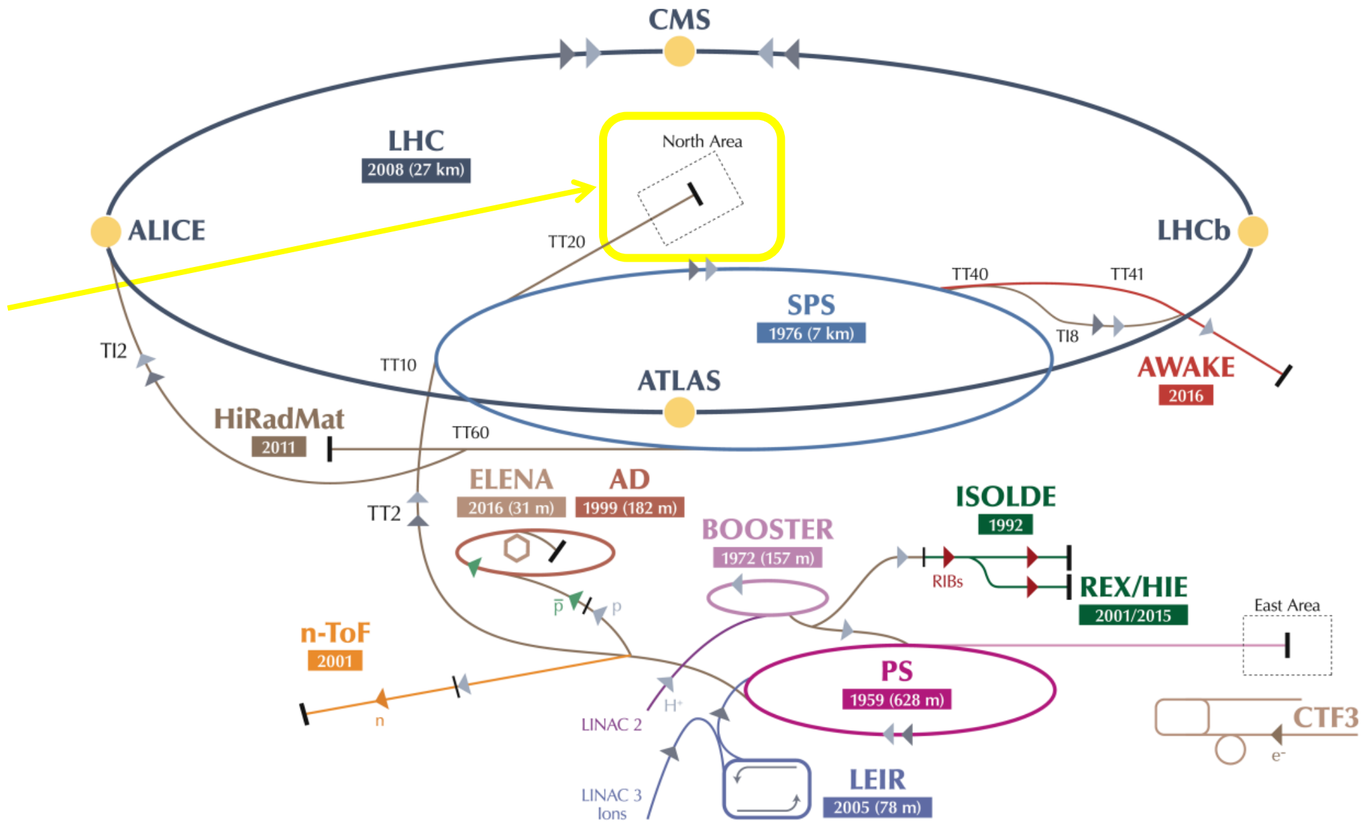
Supervisor: Nikolaos Charitonidis

Goliath Field Mapping performed in collaboration with:

- Nikos Charitonidis & Yiota Chatzidaki (EN-EA-LE)
- EP/DT magnet group (Felix Bergsma & Pierre-Ange Giudici),
- Henric Wilkens and the kind support of RD51 Collaboration (Eraldo Oliveri & Yorgos Tsipolitis) and GIF++.
- Field mapping interpolation script written by Marcel Rosenthal

H4 Beam Line

- Protons extracted from the SPS are incident on a target to form secondary beam lines of a variety of particles
- The H4 beam line in the North Area supplies GIF++ with charged particles



GIF++

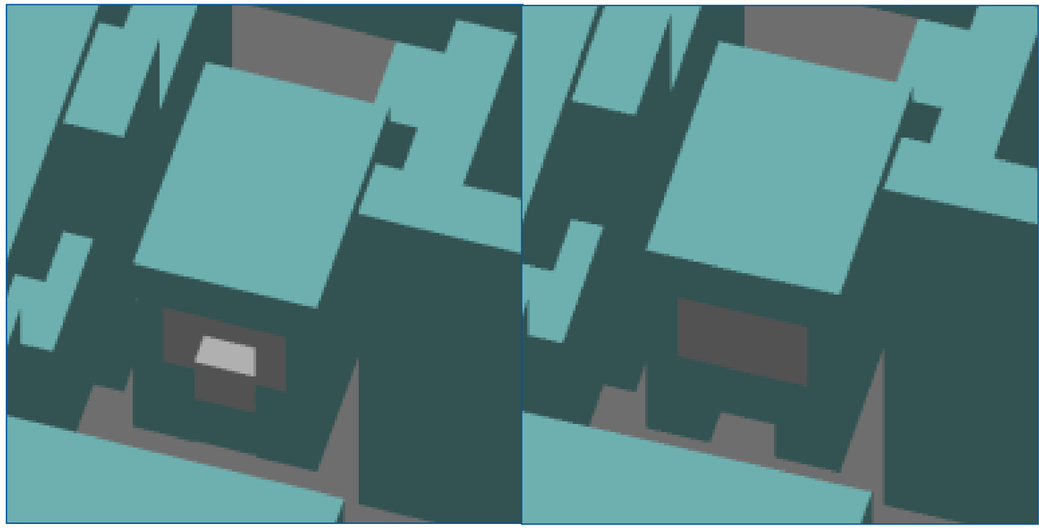
- CERN's **G**amma **I**rradiation **F**acility
  - Supplies users with a mixed field of charged particle beams and gamma photons
  - For this project, we are interested in supplying GIF++ with a muon beam

Sharing a Muon Beam

- Upstream GIF++ is a large dipole magnet, “GOLIATH”
- This magnet is used by experiments such as RD51 to test equipment in conditions of strong magnetic fields and charged particle beams
- Muons still reach GIF++ after passing through the magnet, however, their trajectory is bent
- Goal: determine muon trajectory so that GIF++ users can continue to receive muons while Goliath is on

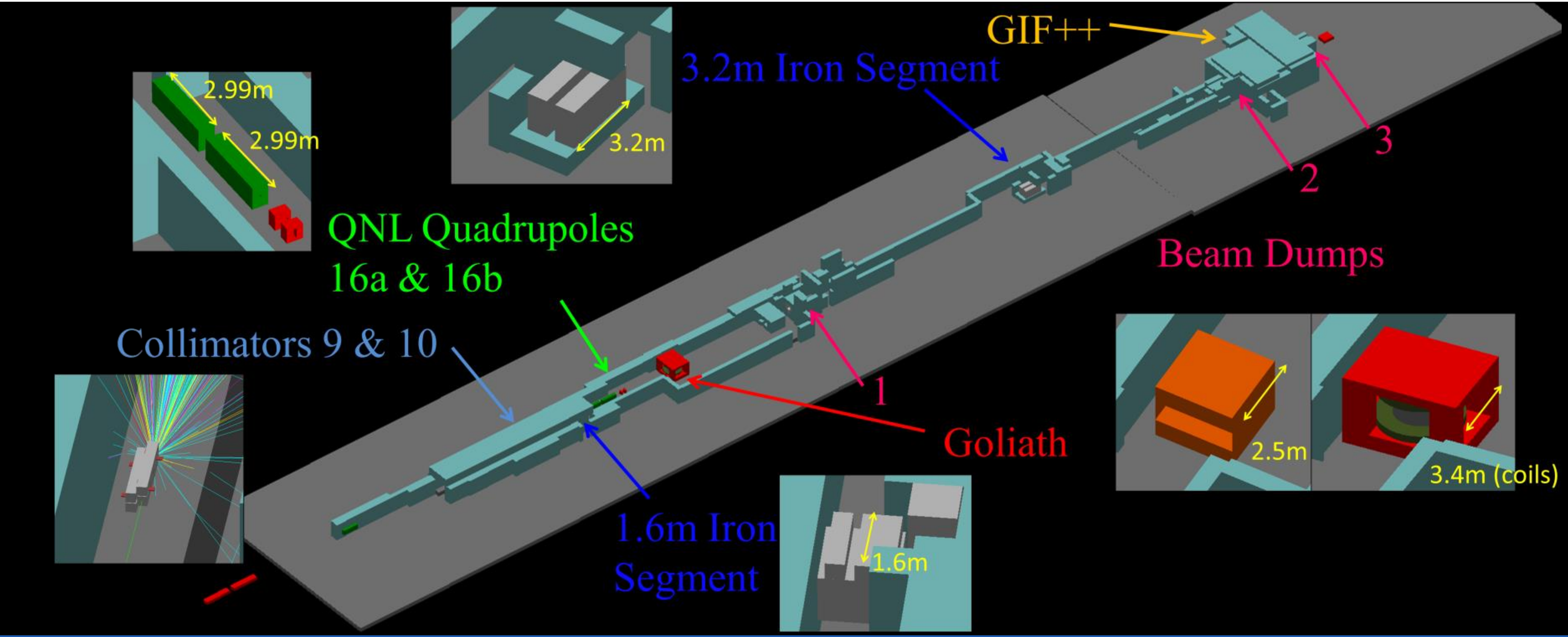
Modeling the H4 Beam Line - Steps

- Model shielding upstream GIF++ Hall using G4beamline software
- Simulate exact muon beam position under several different conditions:
  - GOLIATH at -1.5,-1, 0, 1, 1.5T
  - XTDV Dumps open/closed
- Measure the magnetic field map for Goliath and refine simulations using this map



XTDV beam dumps modeled in “open” (left) and “closed” (right) configurations

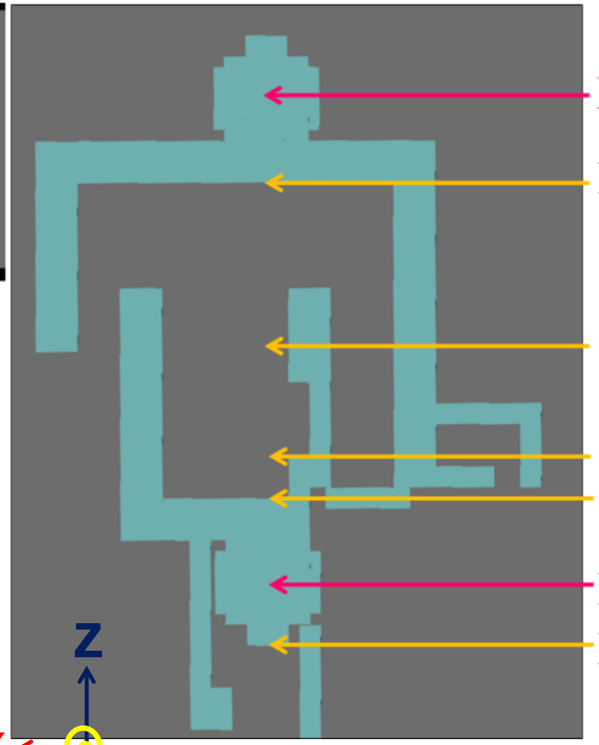
G4beamline Model of H4 Beam Line



Analysis Points

Collimators 9 & 10
Detector "Downstream Collimator"
(5mm after collimator)

Goliath (Coil diameter 3.4m)
Detector "Upstream Goliath"
Upstream edge of coil
Detector "Downstream Goliath"
Downstream edge of coil



Dump 3
Detector "Back Wall GIF"
Detector "Center GIF"
Detector "Front Nook GIF"
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Dump 2
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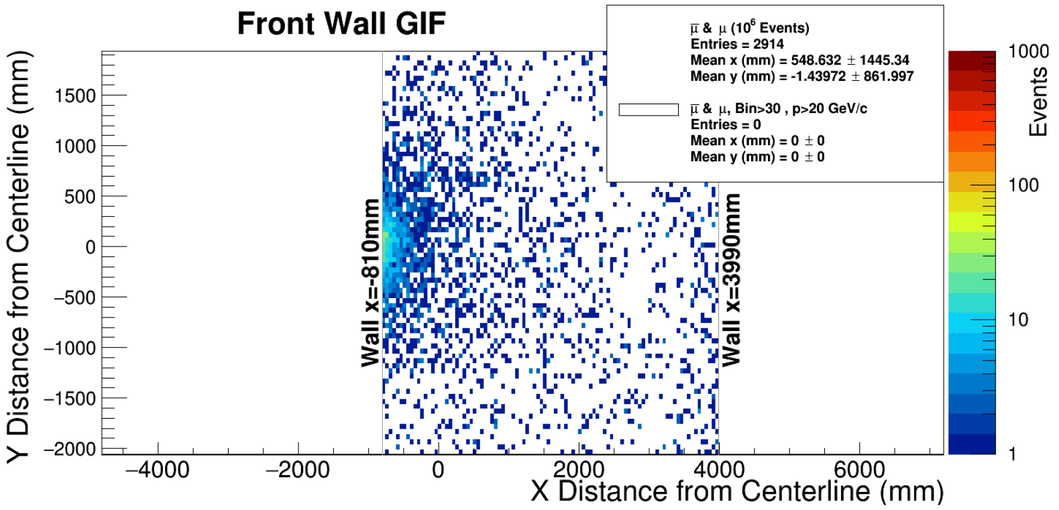
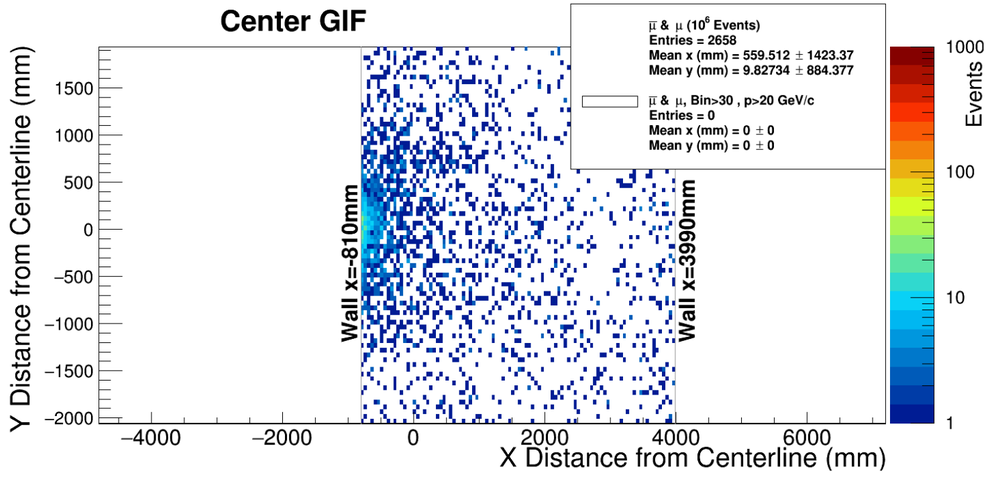
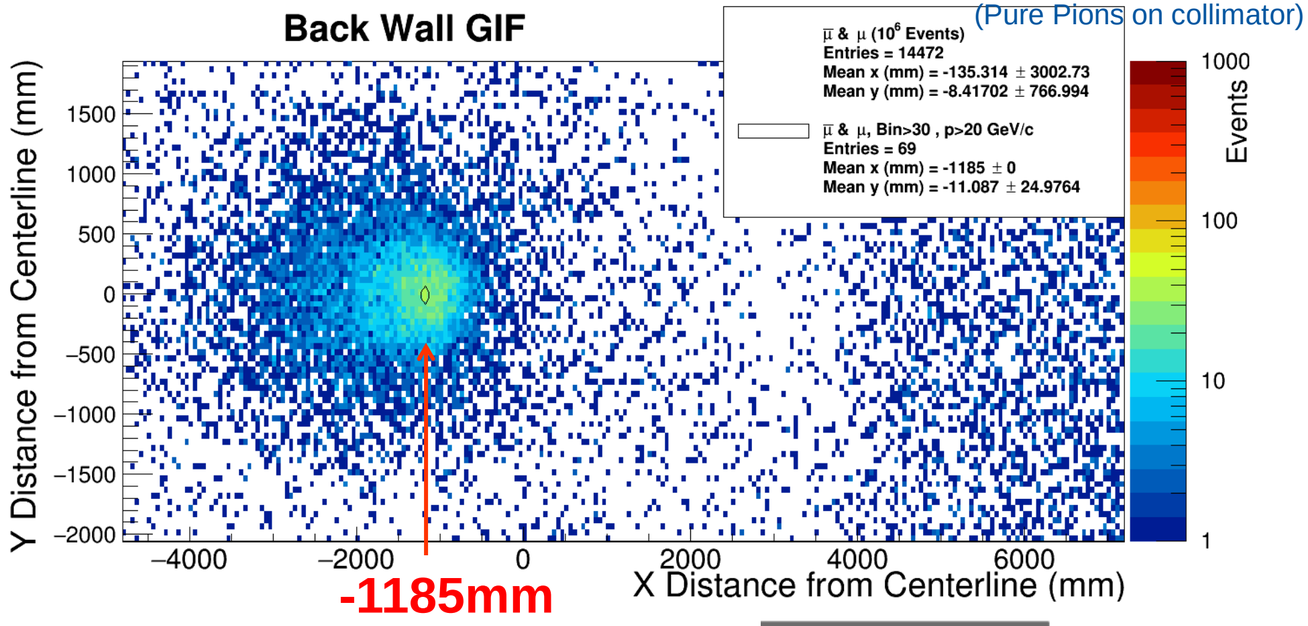
Analyzing Simulation in ROOT (1.5T)

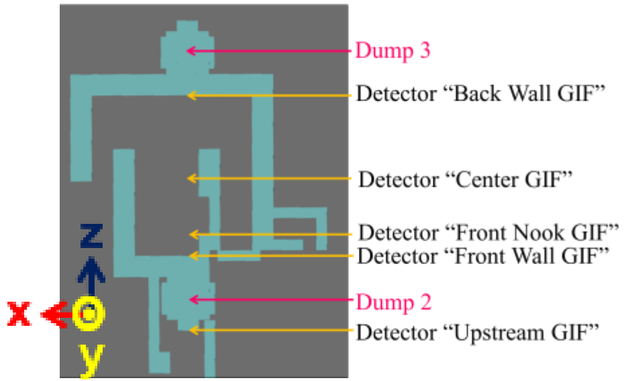




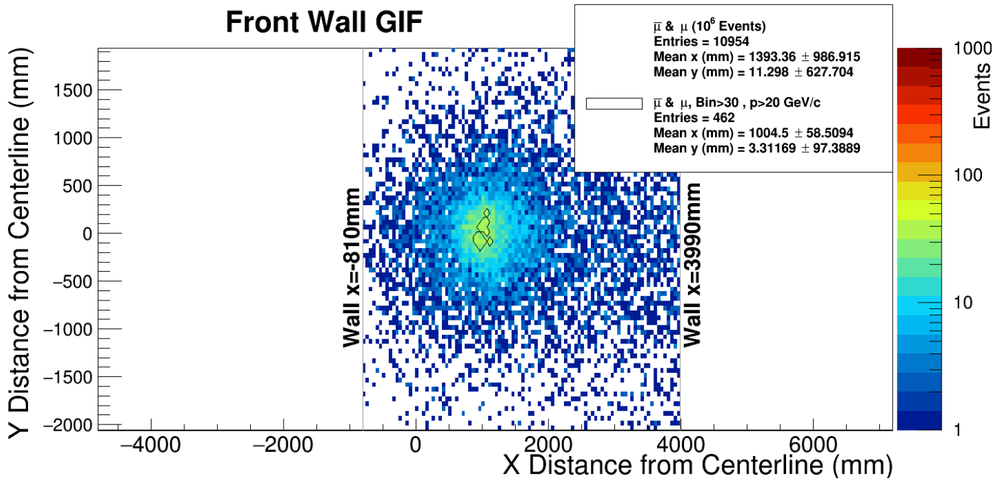
(Pure Pions on collimator)

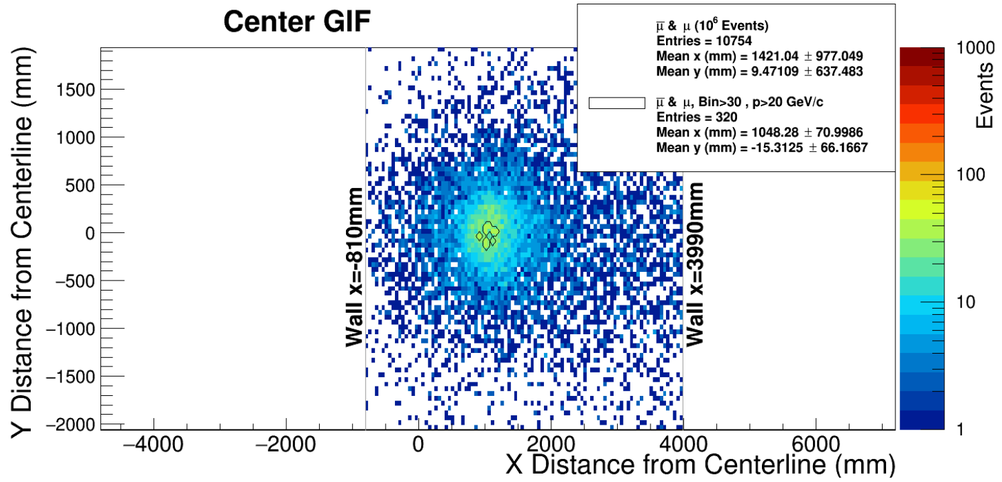


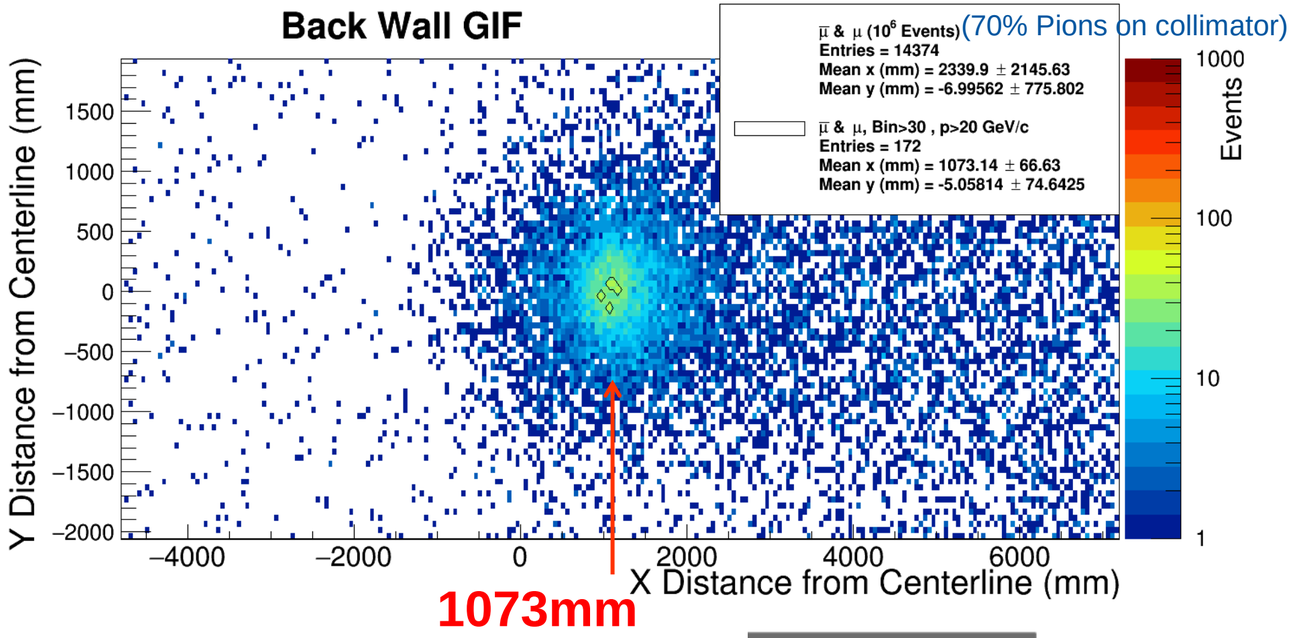
For the 1.5T setting of Goliath, muon beam passes through the right wall of GIF++



Analyzing Simulation in ROOT (-1.5T)

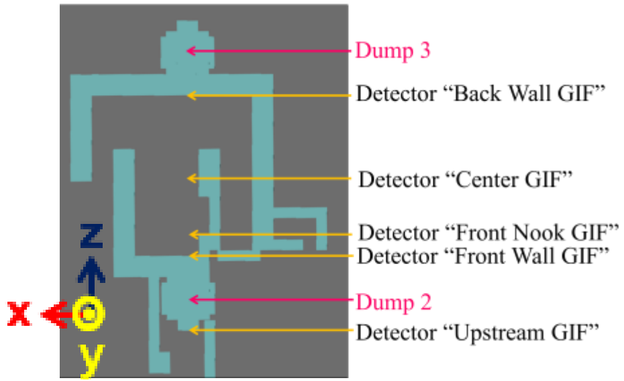






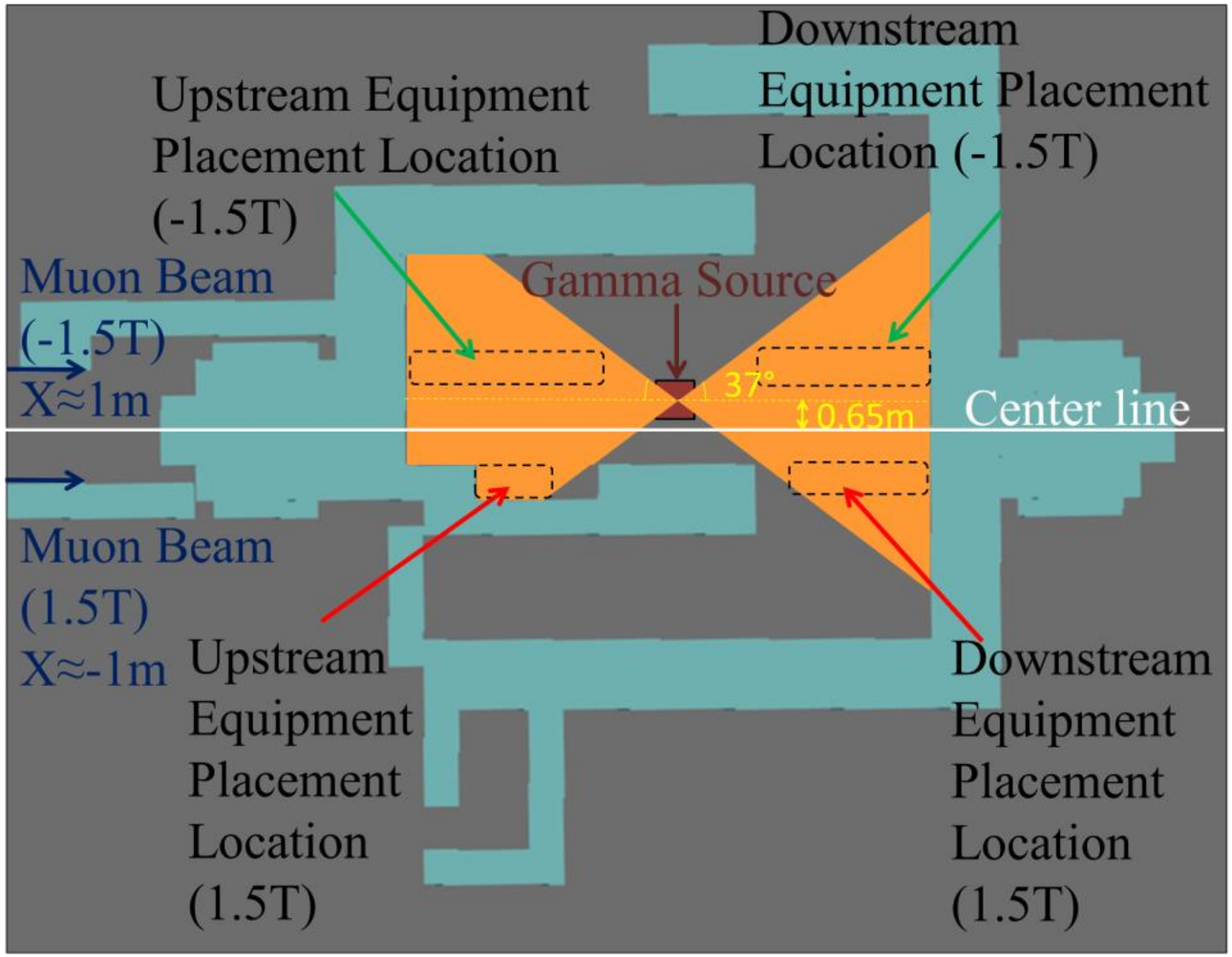
(70% Pions on collimator)

For the -1.5T setting of Goliath, muon beam is deflected to the left, away from the wall



Locations with Usable Beam

- With these simulations, we can advise GIF++ users on where to place their equipment to receive muons and gamma photons while Goliath is on

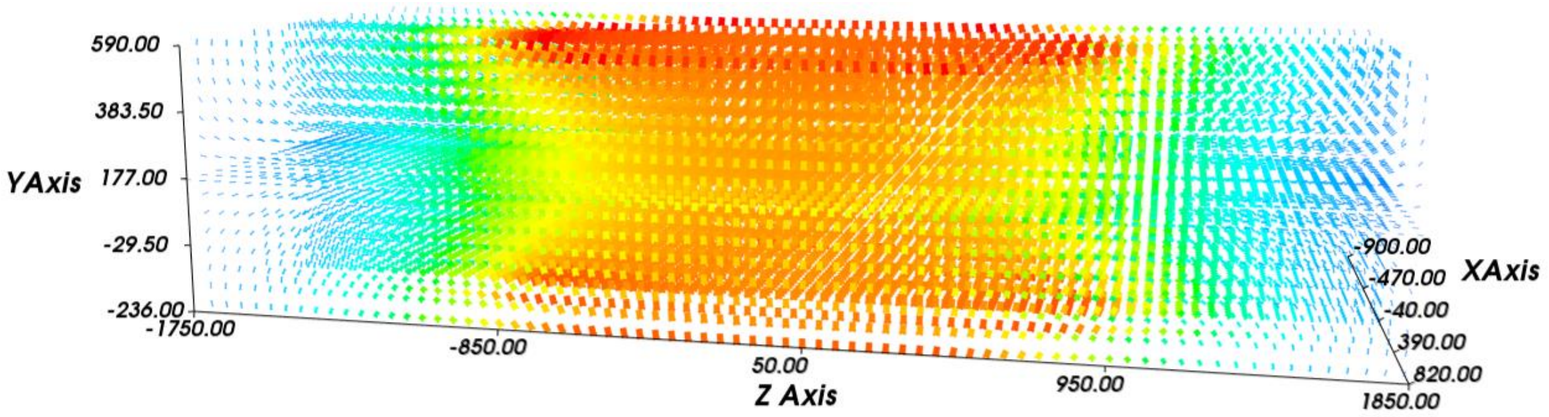


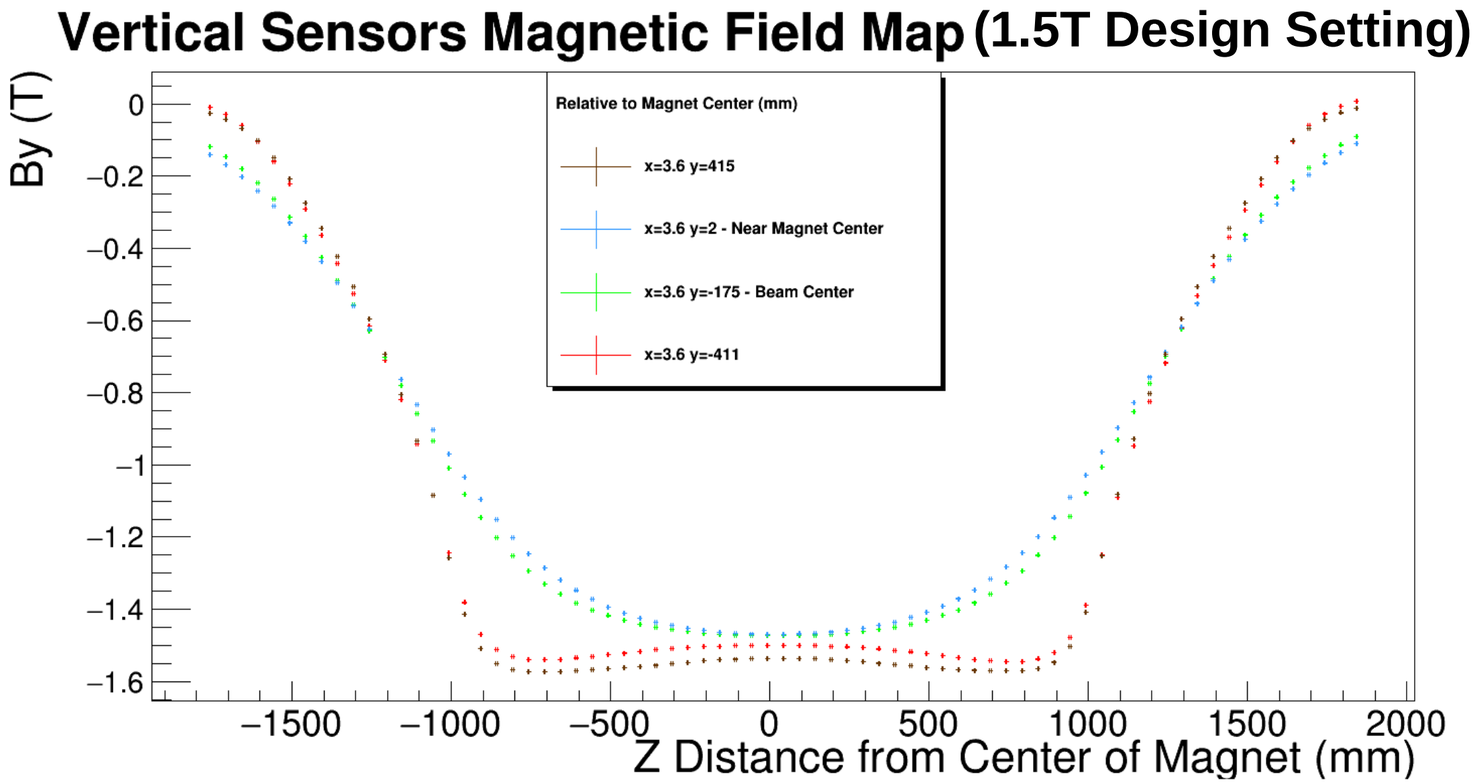
Mapping of Goliath

- To refine these and future simulations, need up to date magnetic field map of Goliath
- I spent several days working with a team to measure the magnetic field of Goliath (July 4-6, Aug 2-4)

Field Maps

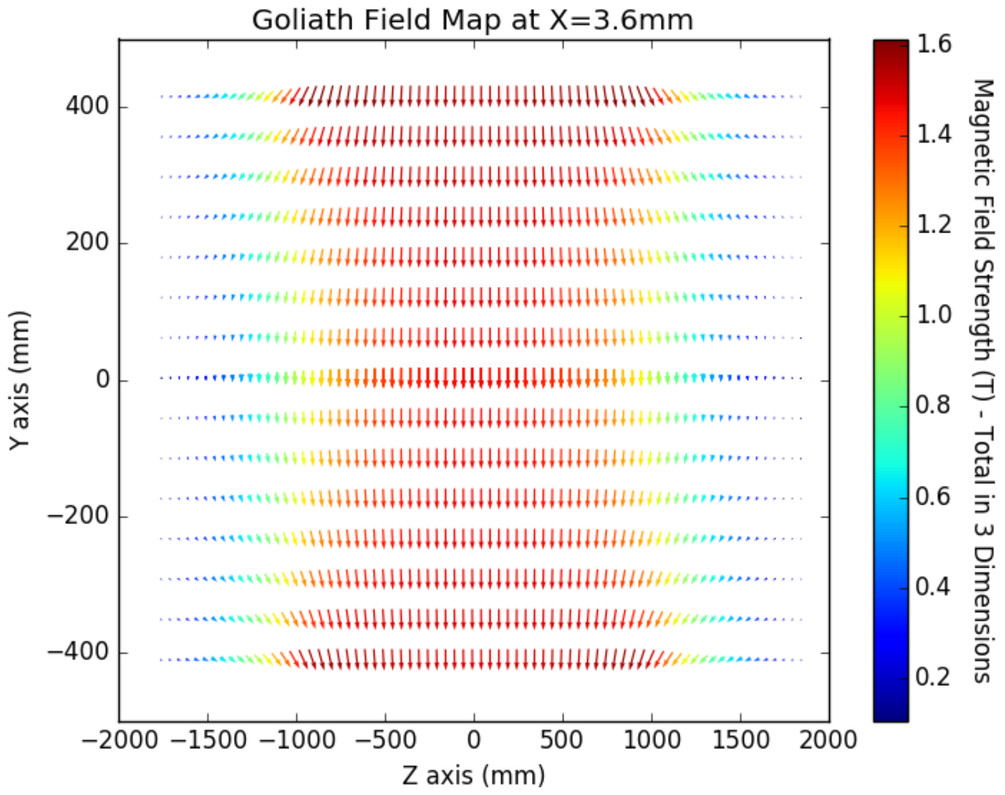
- I constructed ROOT macros to plot our field measurements, and utilized Mayavi and Matplotlib Python packages to produce vector plots of our field map





Final Remarks

- Last step is to incorporate the field map of Goliath into the G4beamline simulation
- These simulations will allow GIF++ users to place their equipment correctly in the muon beam while Goliath is on
  - Allows users of Goliath and GIF++ to share a muon beam on the H4 beam line
- Future analysis could also examine additional steering of the muon beam by placing another dipole downstream Goliath



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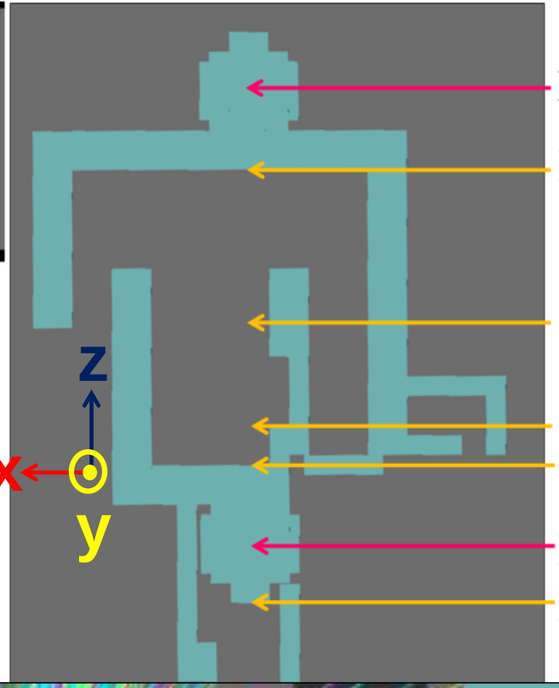

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Questions?

Special thanks to the UM-CERN REU program, funded by the National Science Foundation, for making this experience possible!

Producing a Muon Beam