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

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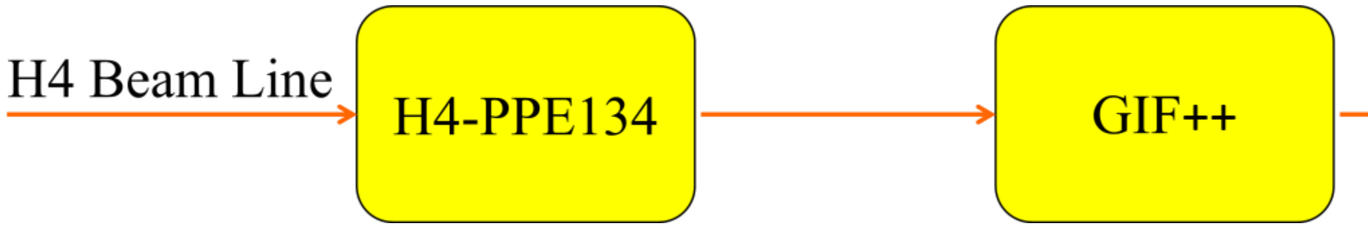
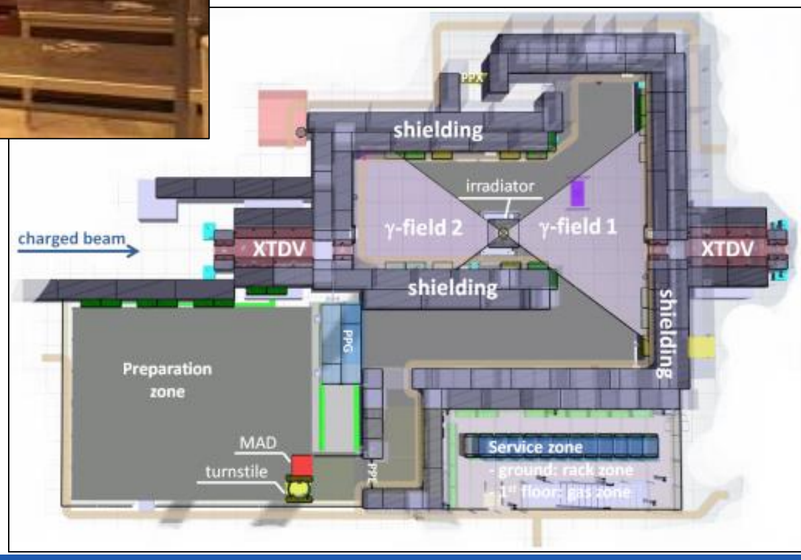
Goliath Field Mapping performed in collaboration with:

- 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

Muons in H4

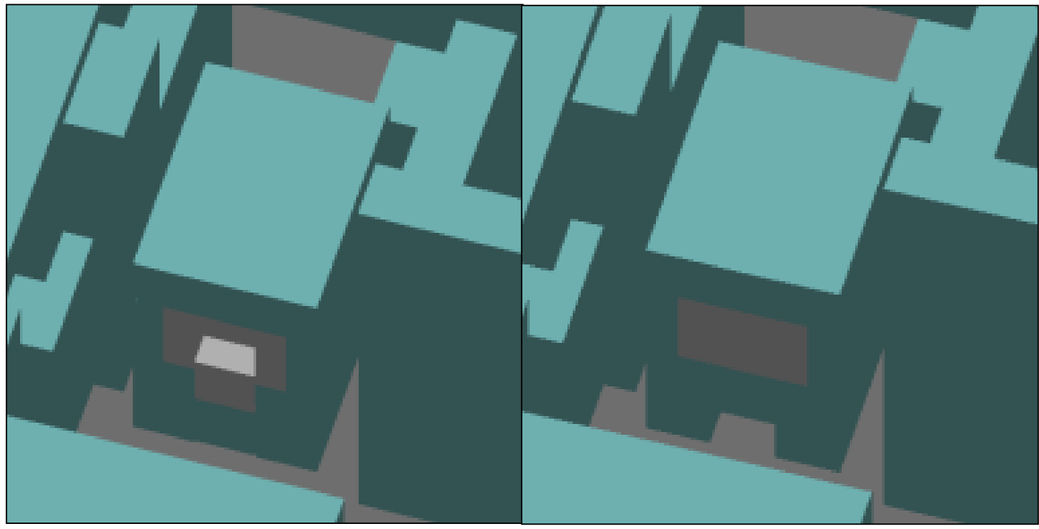


- The muon beam in the H4 beam line is shared by both PPE134 and GIF++ experimental areas
- PPE134 contains the GOLIATH magnet. When GOLIATH is on, the muon beam delivered to GIF++ is deflected from its normal center
- Goal: simulate trajectory of muon beam delivered to GIF++



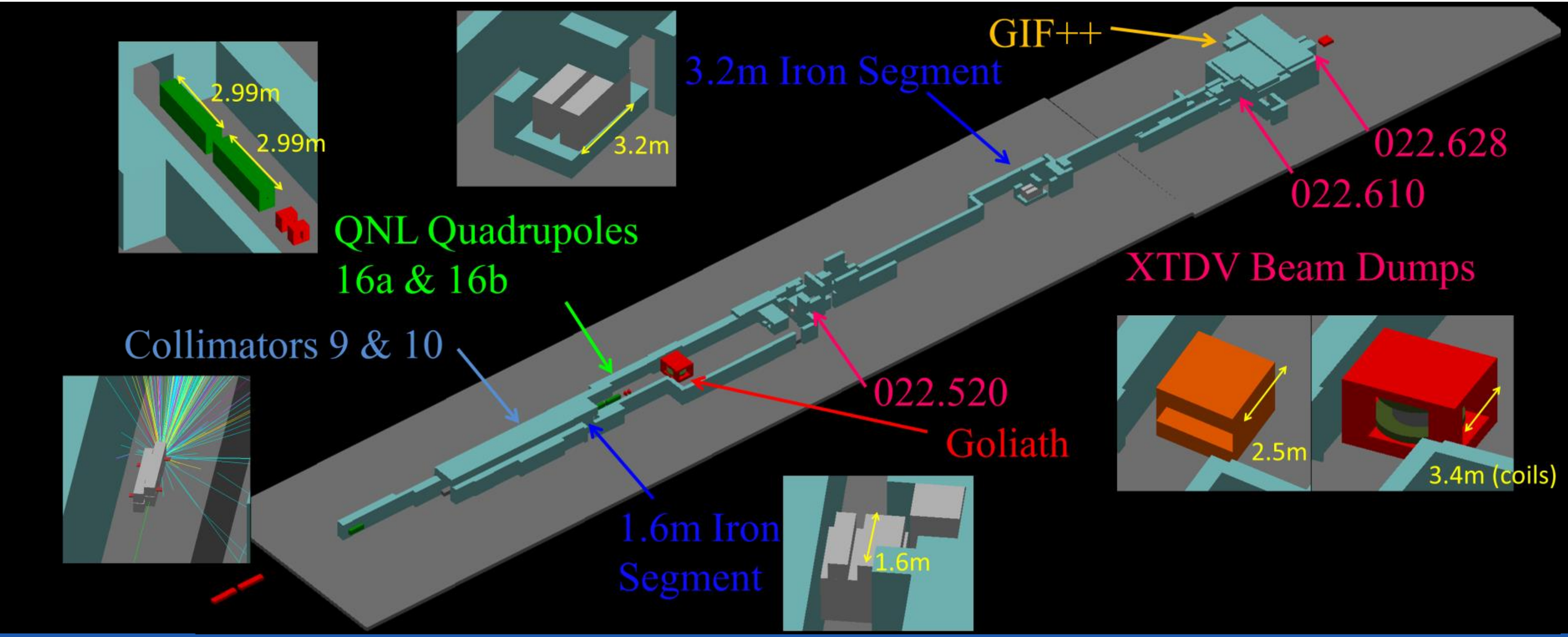
Modeling the H4 Beam Line - Steps

- 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 – Ongoing!



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

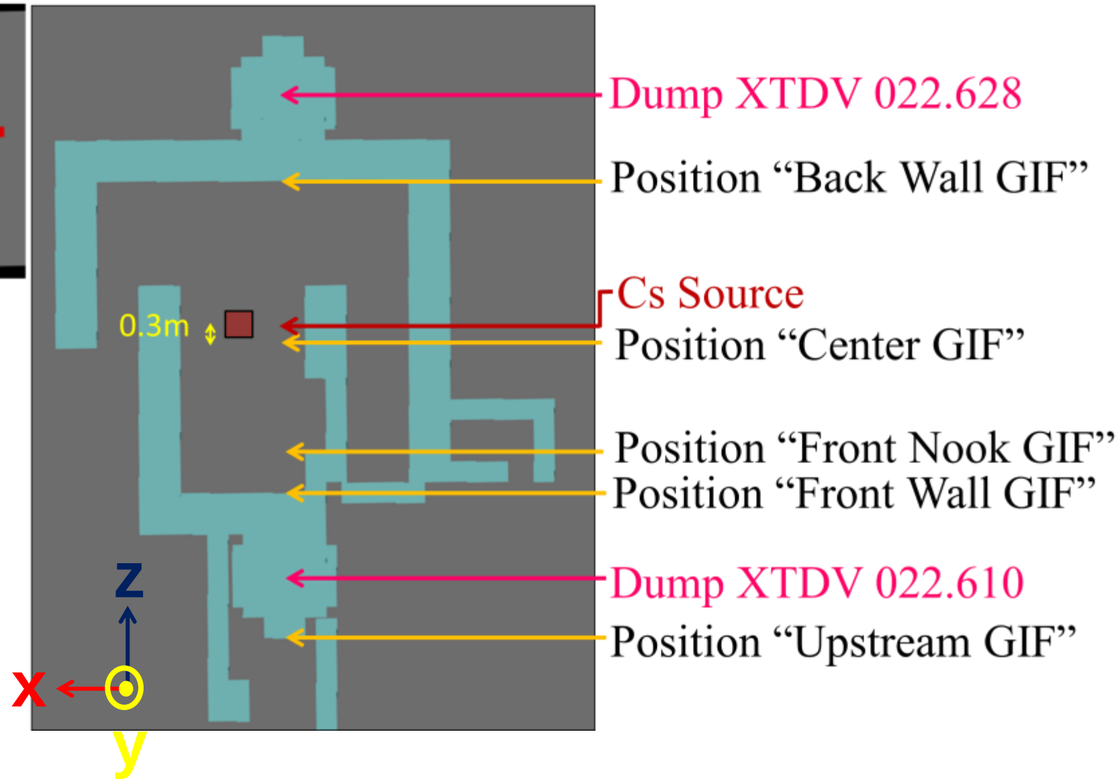
G4beamline Model of H4 Beam Line



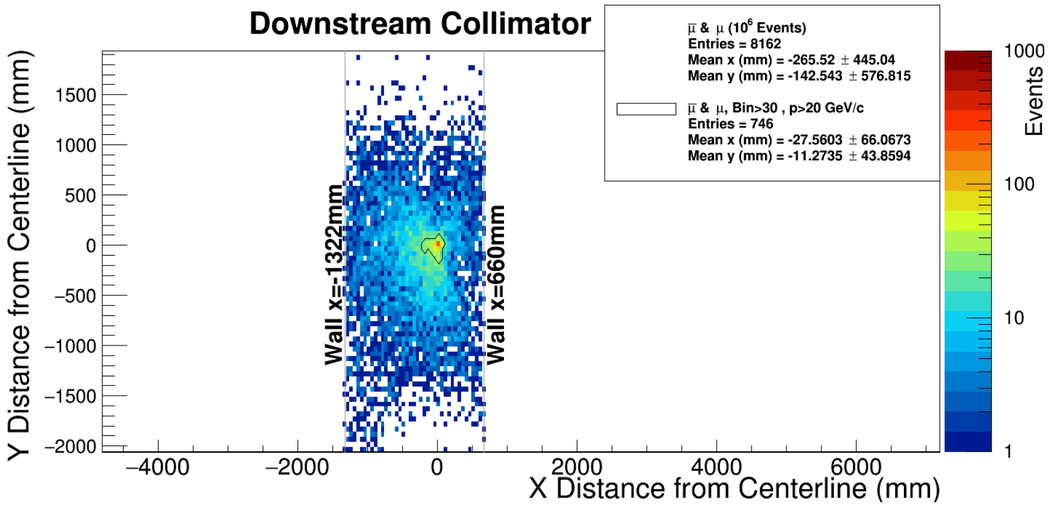
Analysis Points

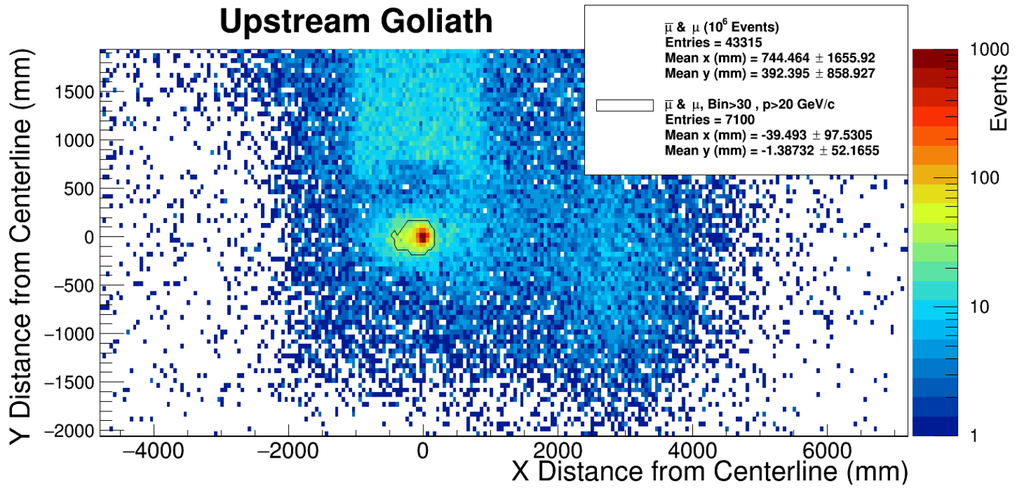
Collimators 9 & 10
Position "Downstream Collimator"
(5mm after collimator)

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

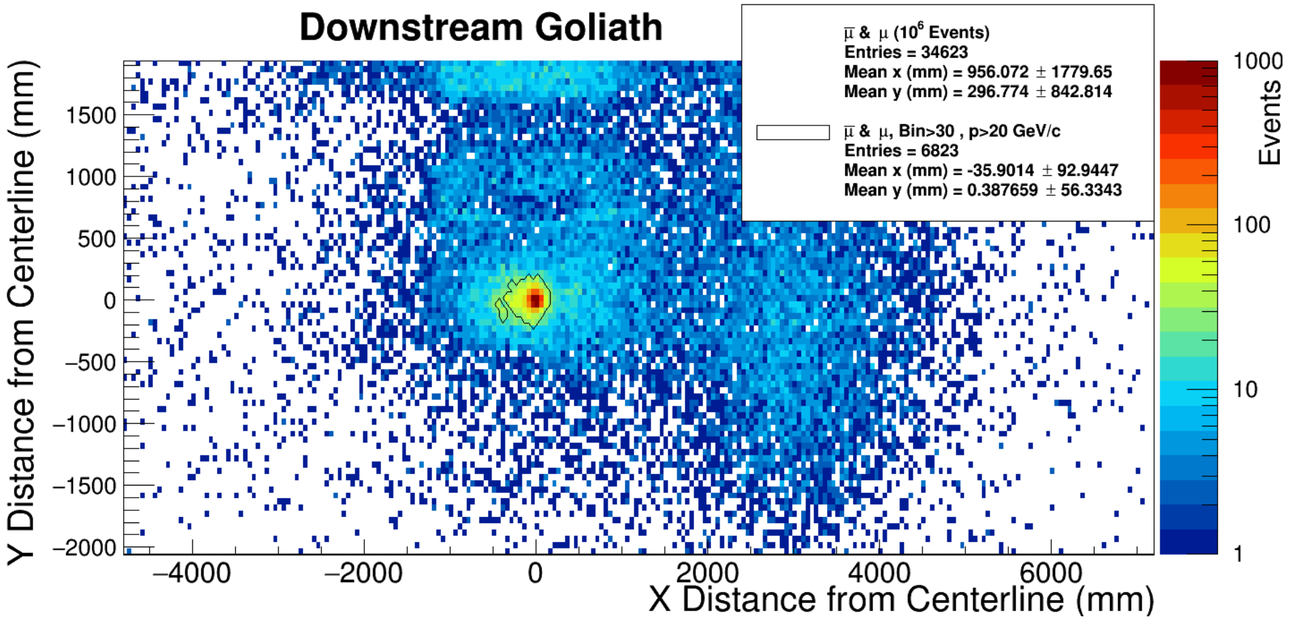


Upstream Sensors



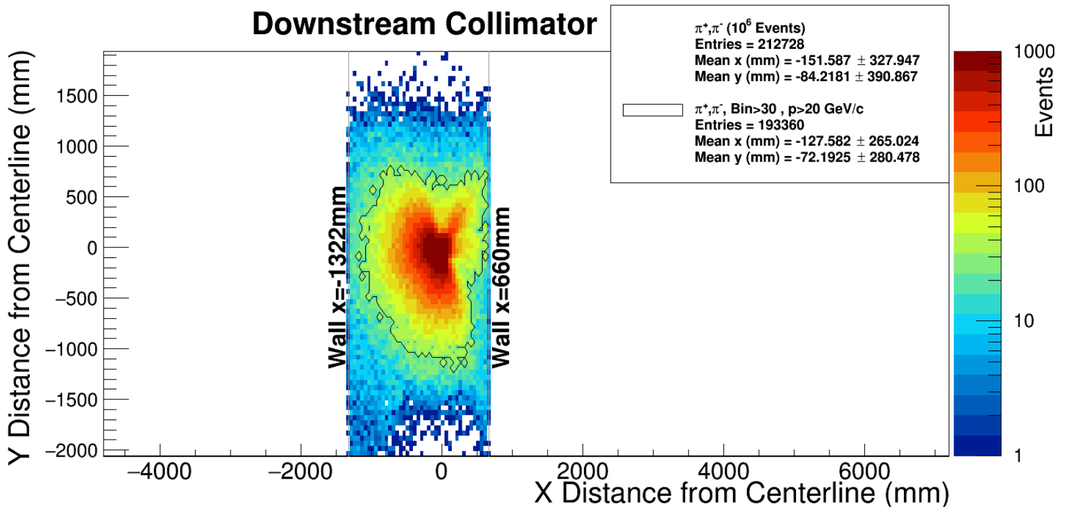


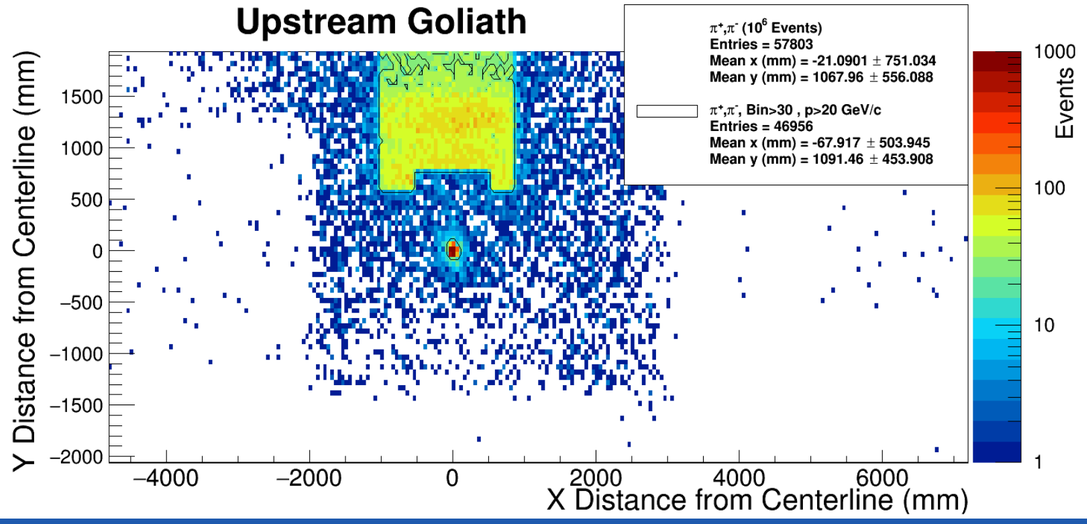
μ^+ and μ^- map

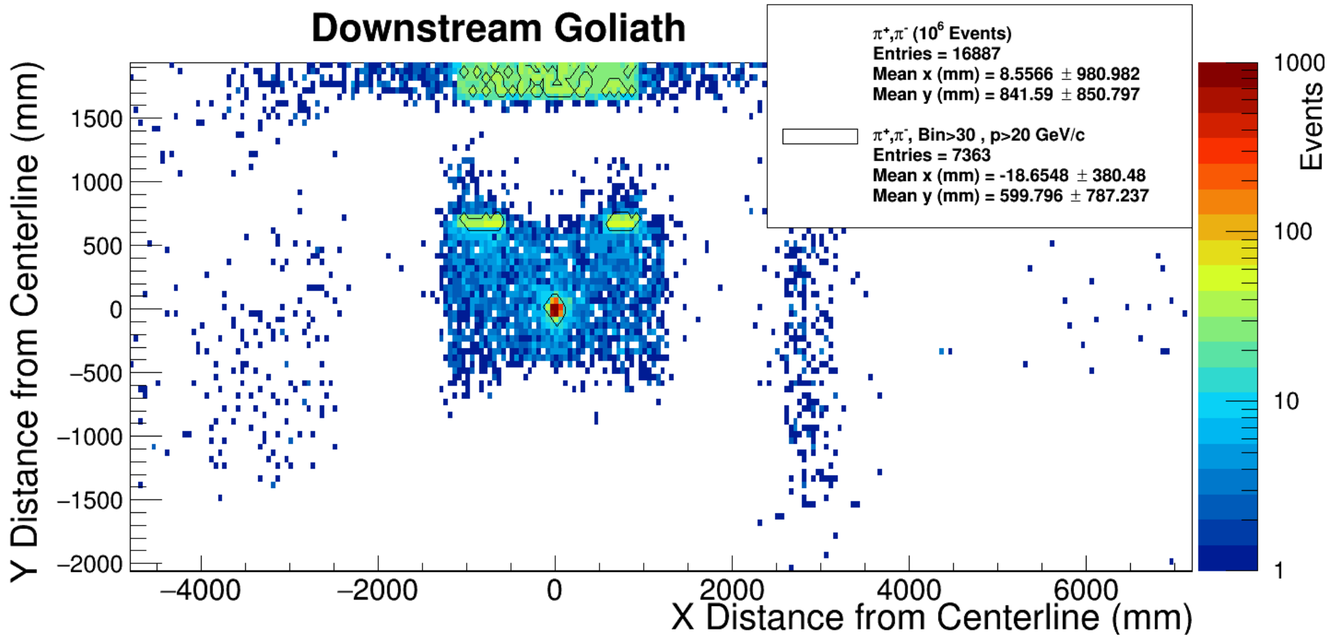


Similar for all Conditions

Upstream Sensors π^+ and π^- map



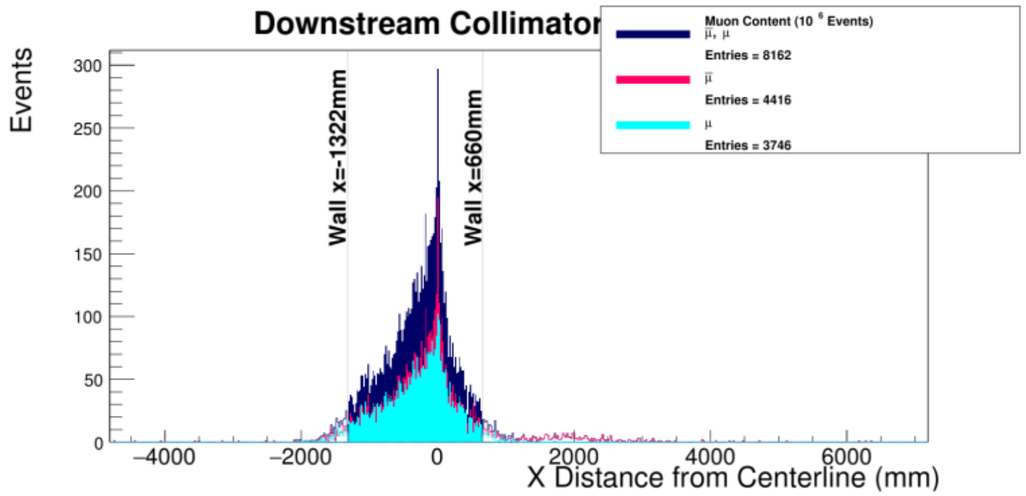


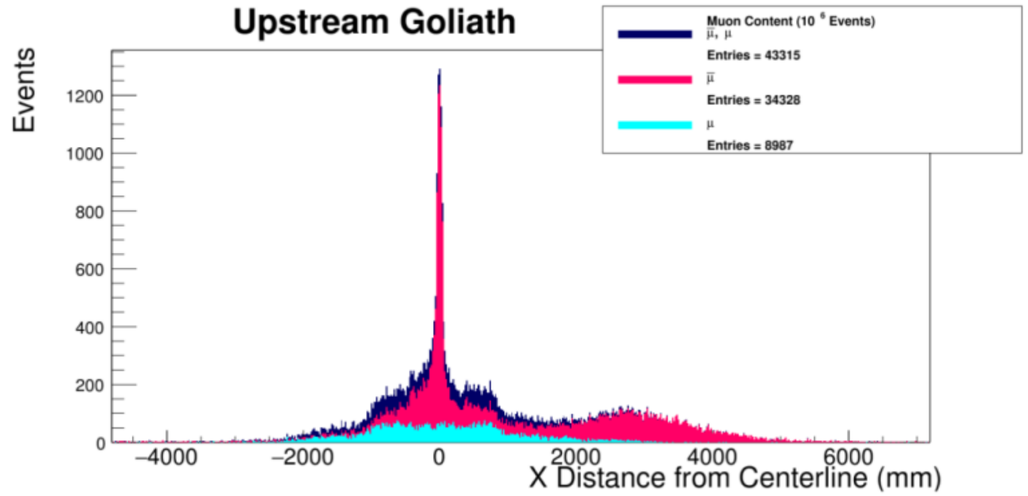


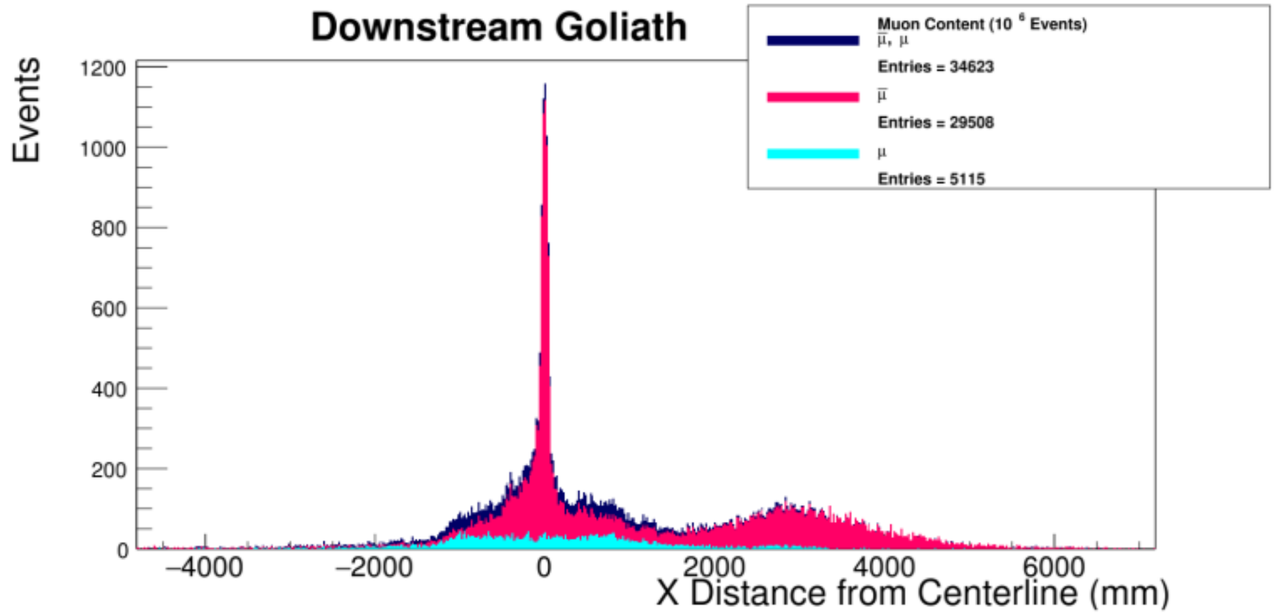
Similar for all Conditions

Upstream Locations

μ^+ and μ^- x distribution

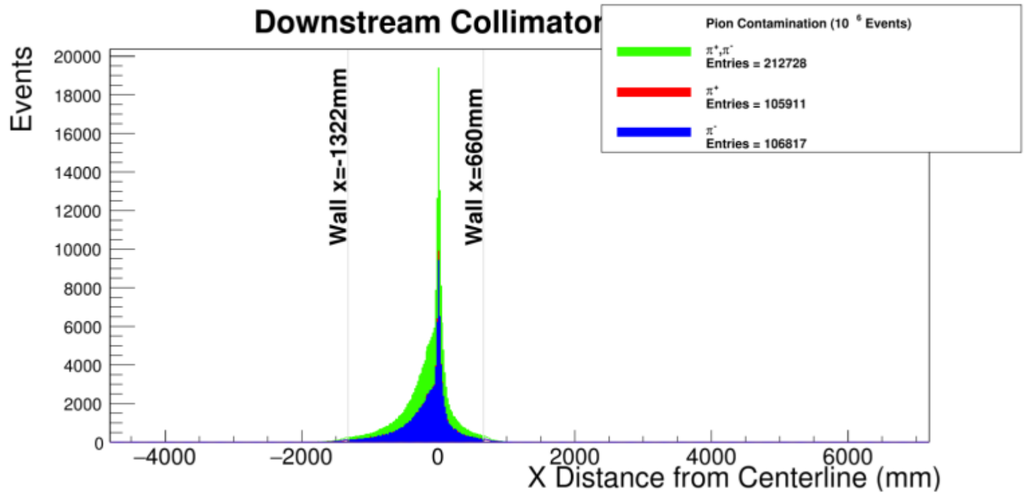


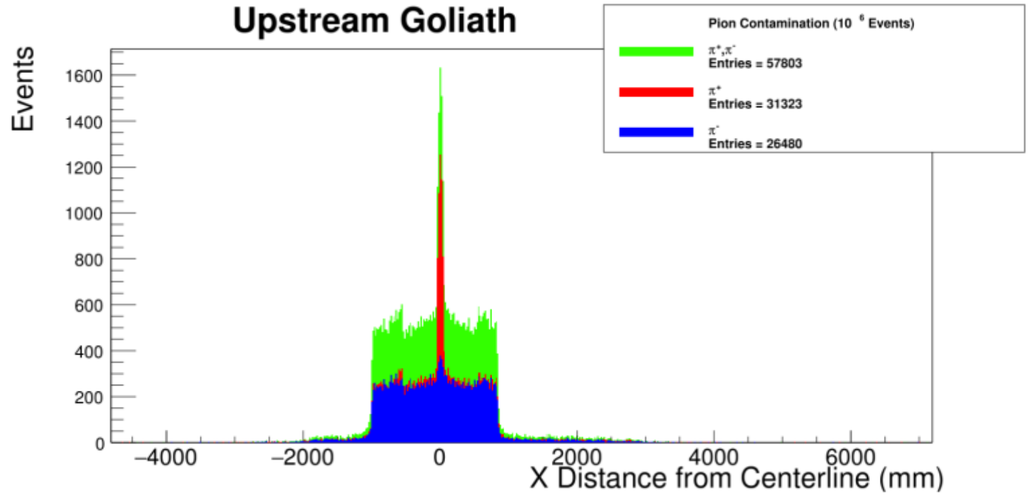


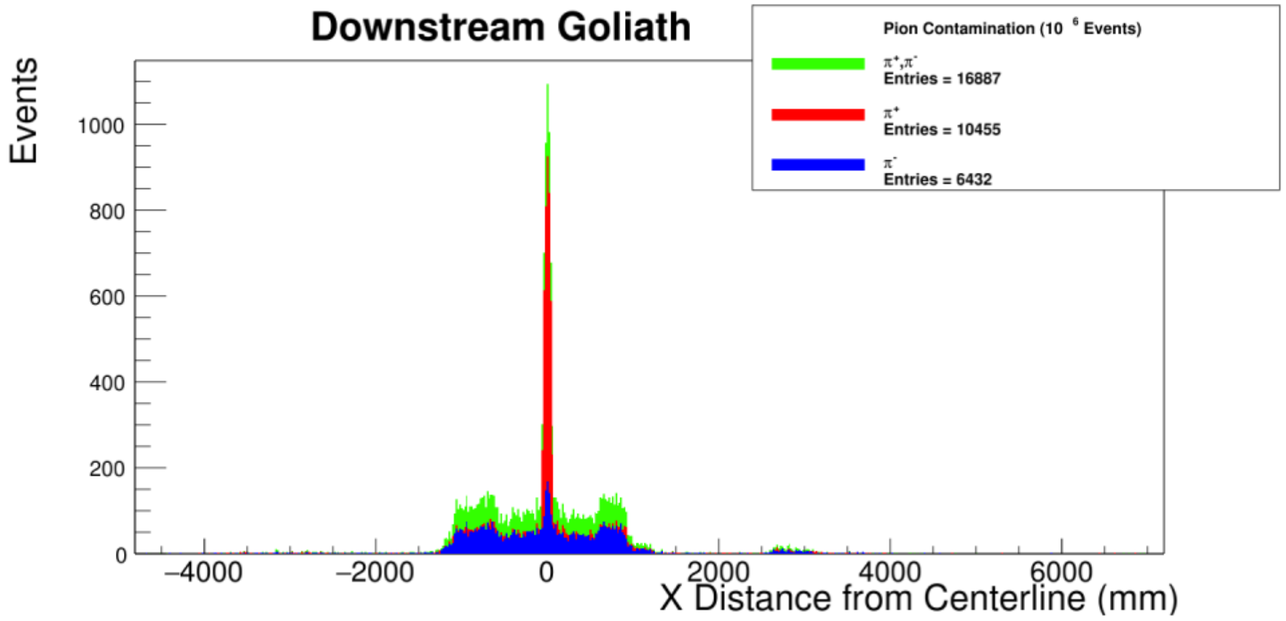


Similar for all Conditions

Upstream Locations π^+ and π^- x distribution

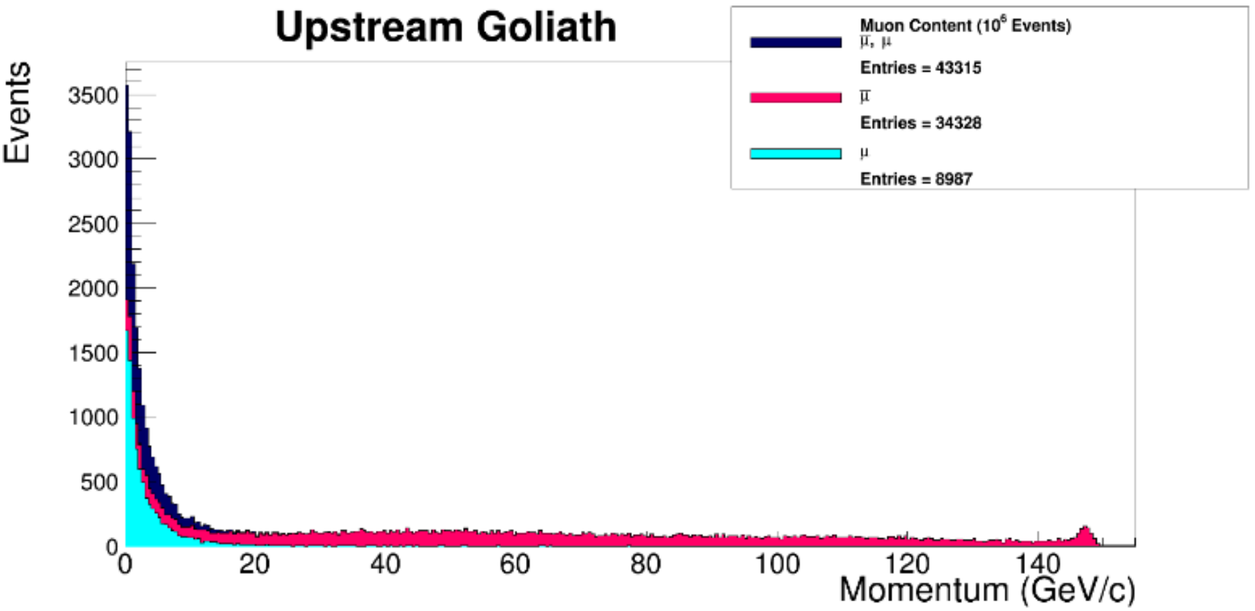


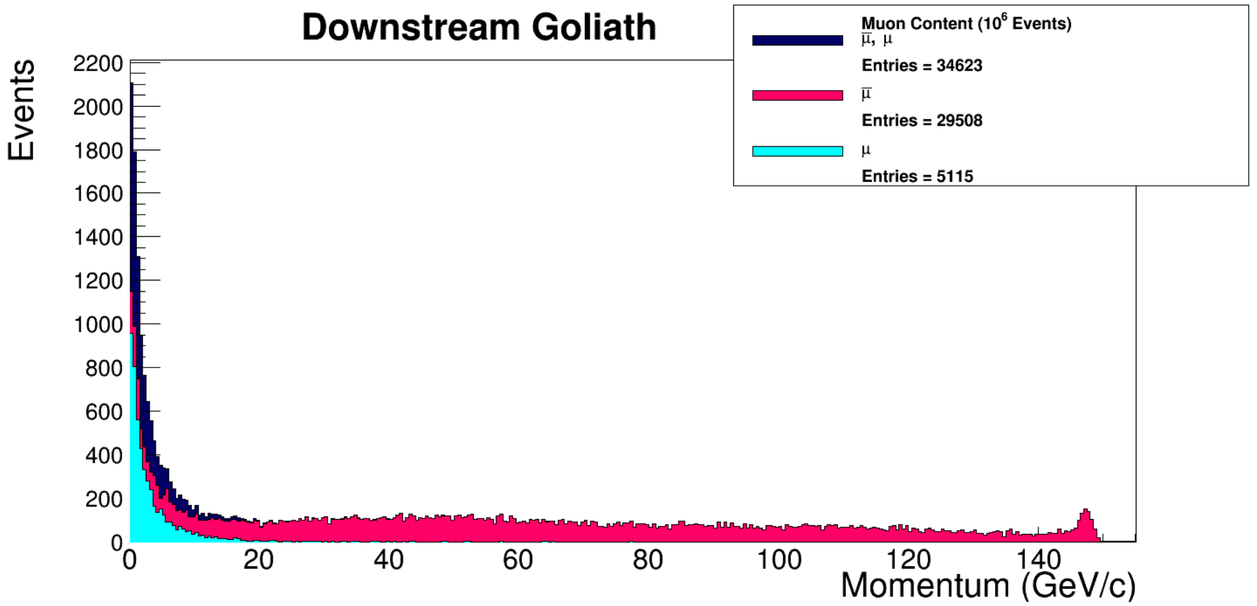




Similar for all Conditions

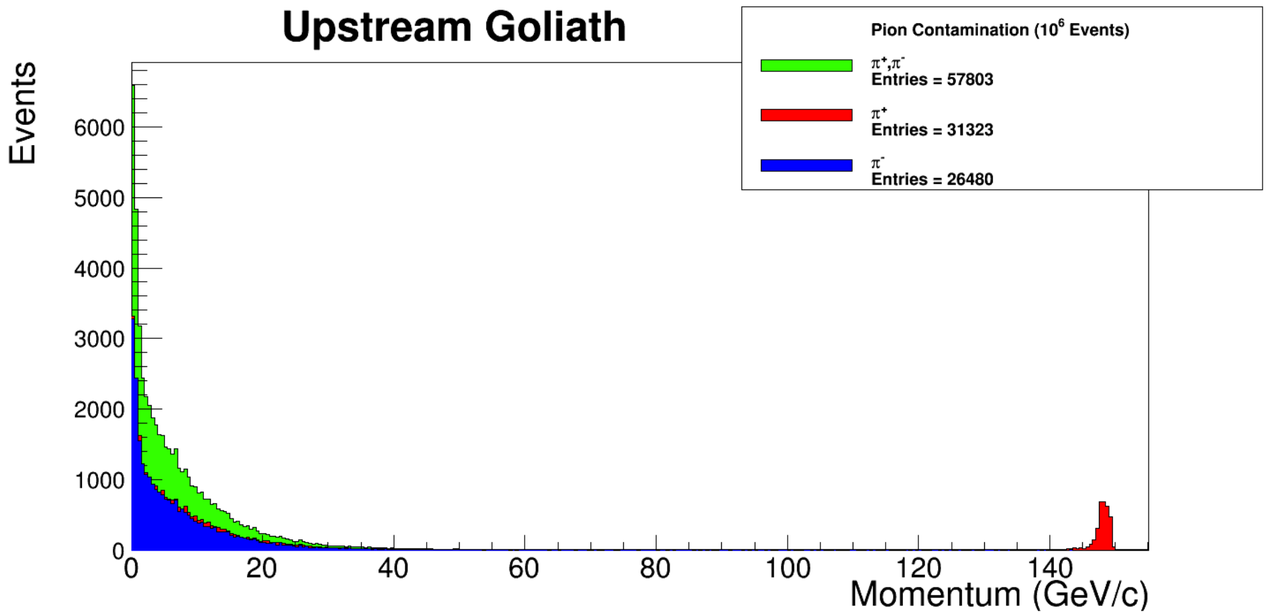
Upstream Locations Momentum of μ^+ and μ^-

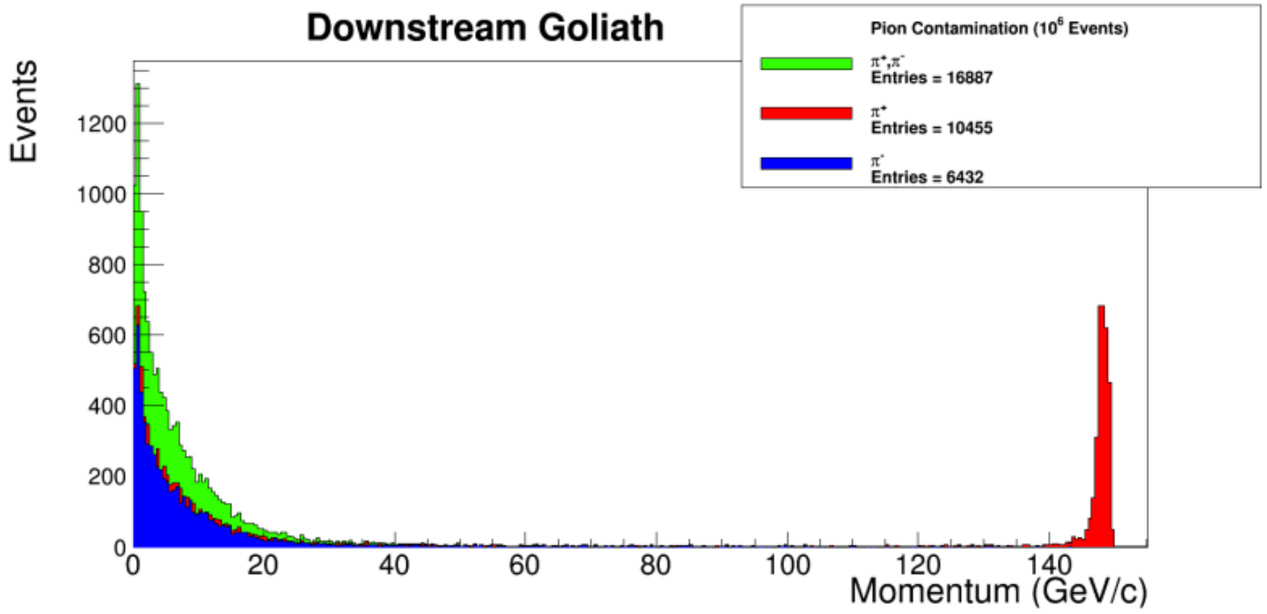




Similar for all Conditions

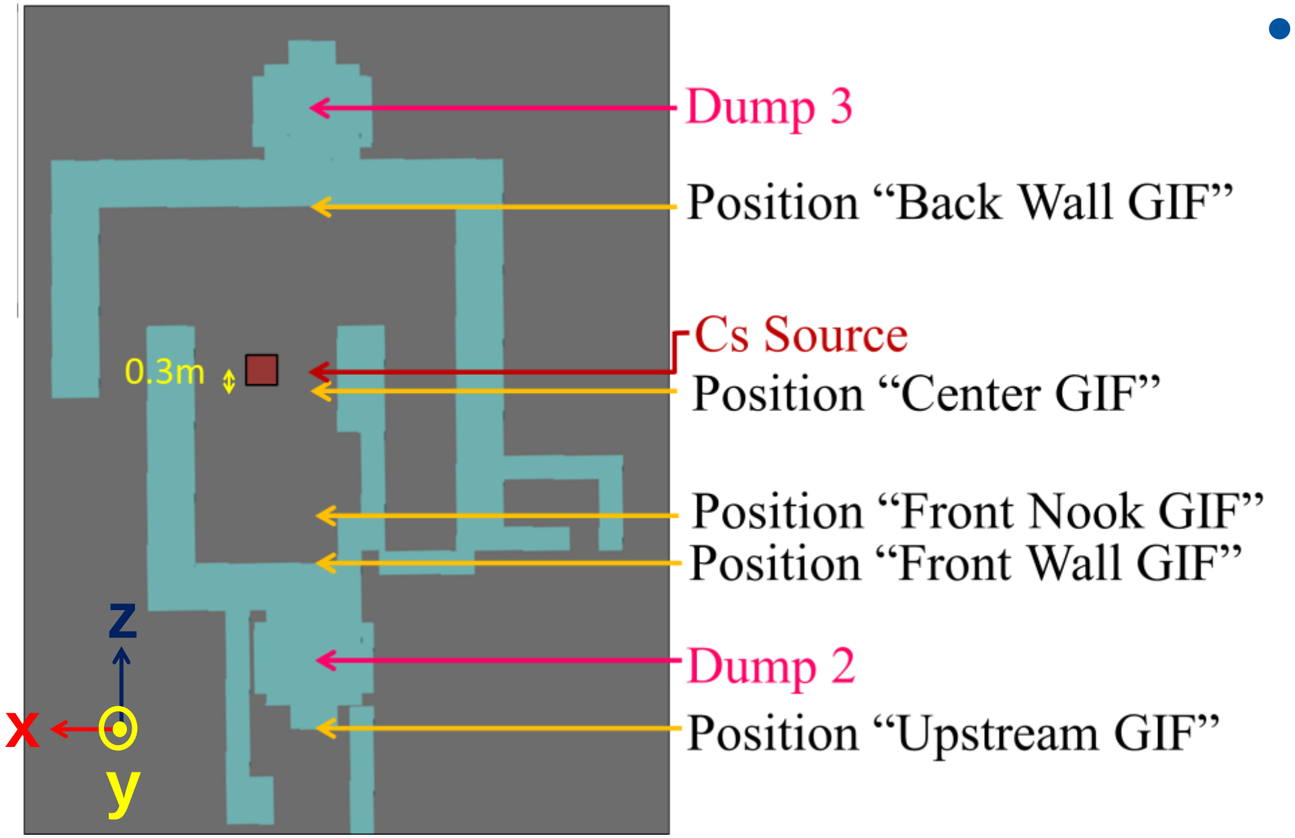
Upstream Locations Momentum of π^+ and π^-



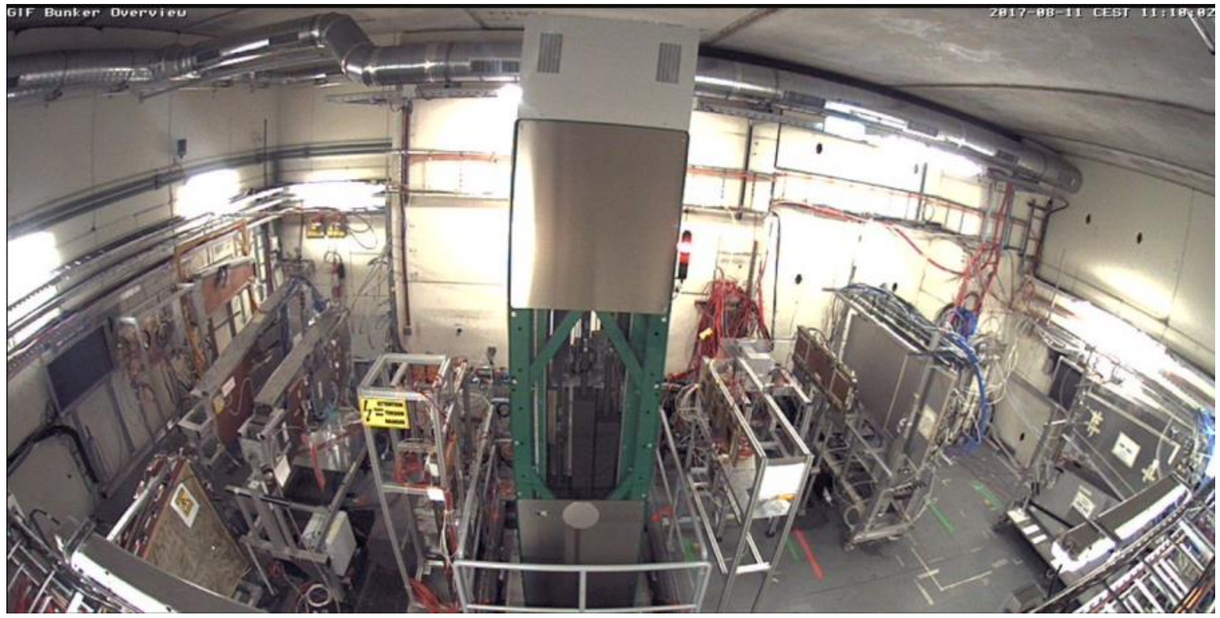


Similar for all Conditions

GIF++ Interesting Points



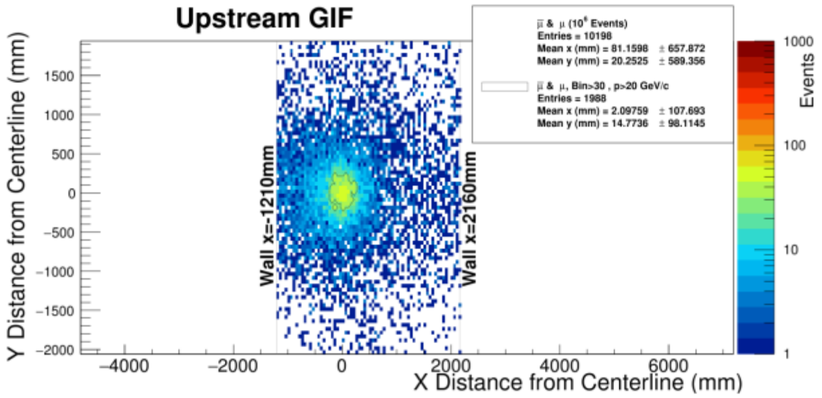
- Beam Trajectory within GIF++ changes for GOLIATH Strength



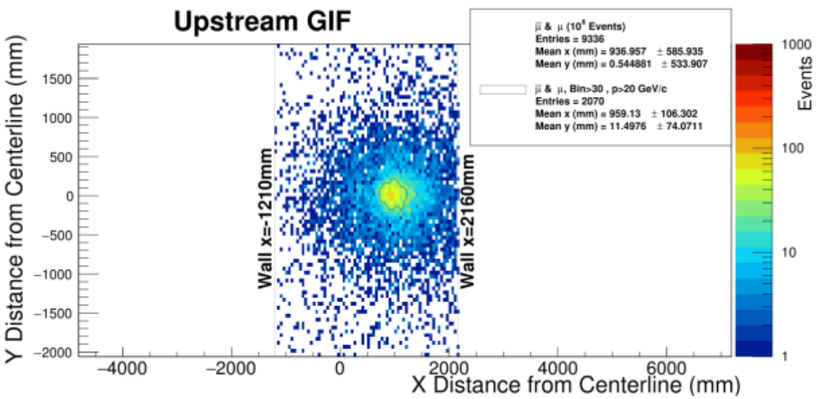
Upstream GIF

μ^+ and μ^- map

0T



-1.5T



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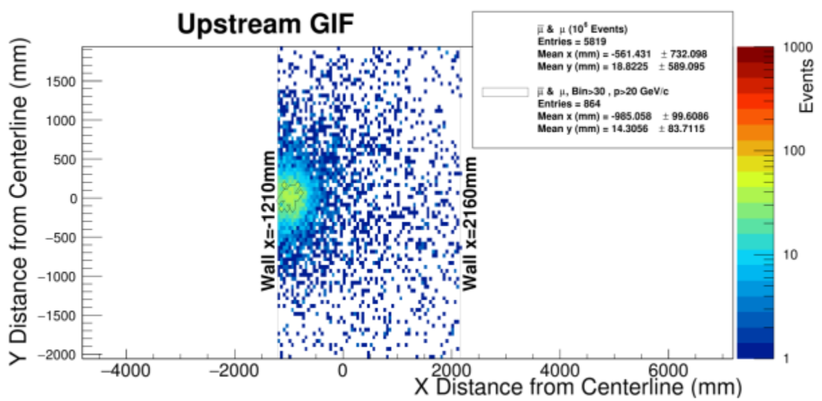

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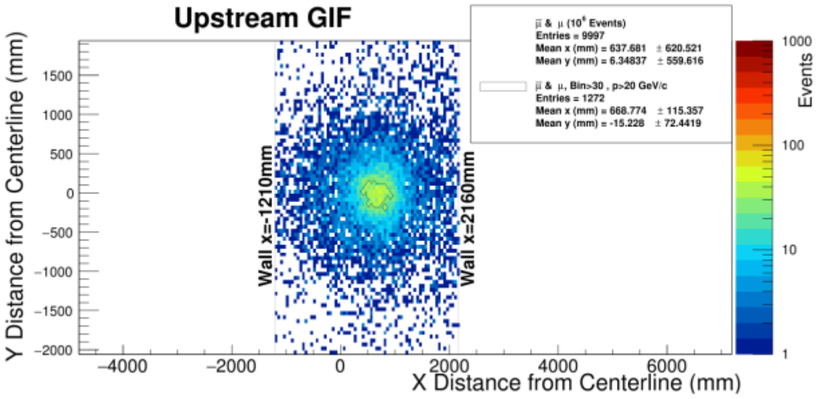

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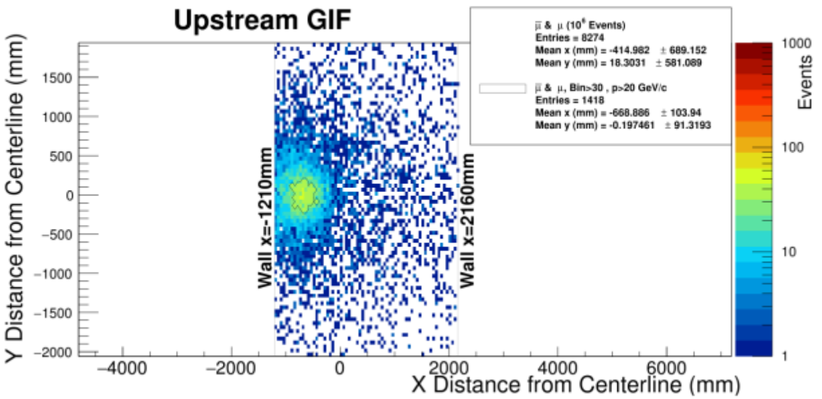
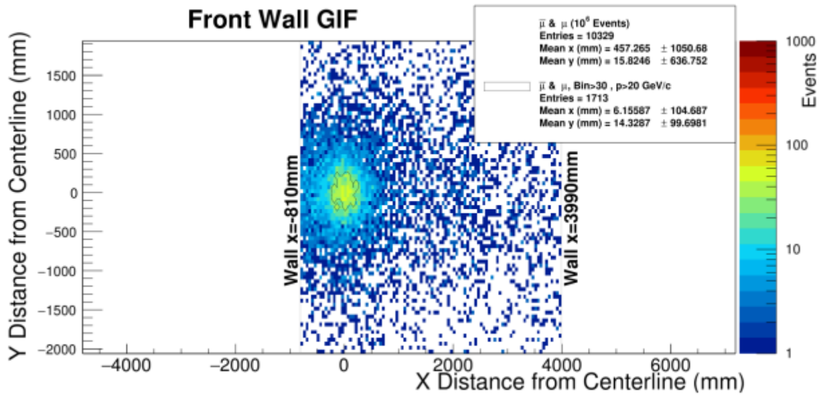


Front Wall GIF

μ^+ and μ^- map

0T



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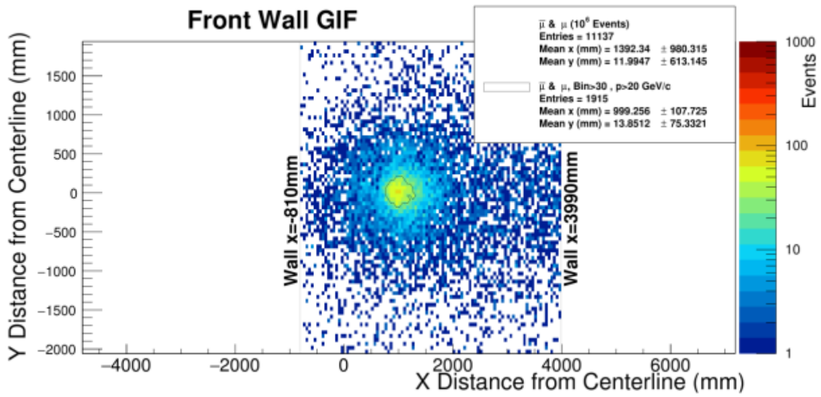

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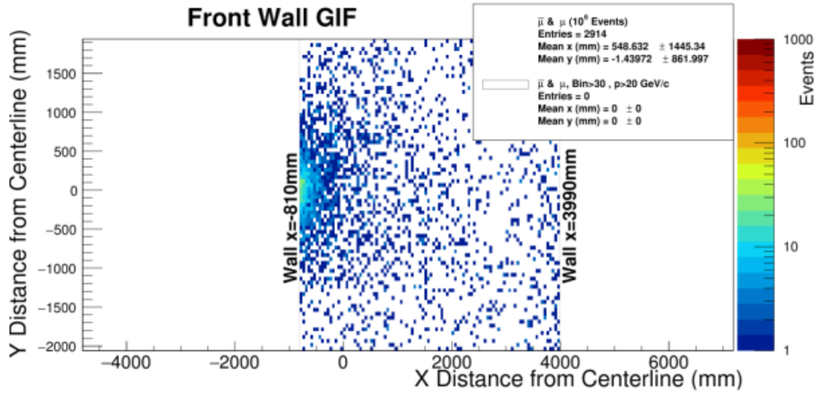

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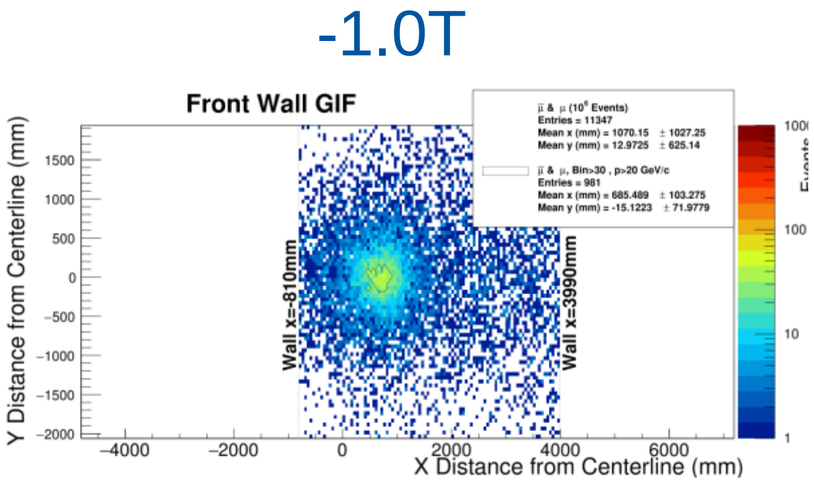

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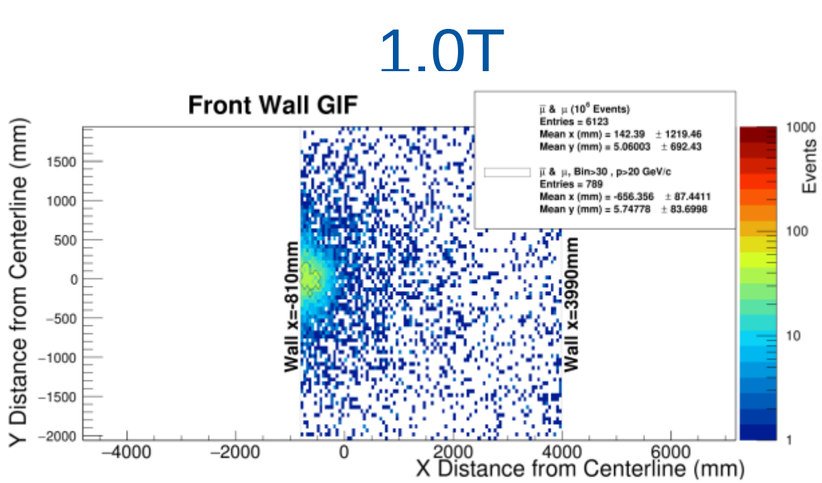
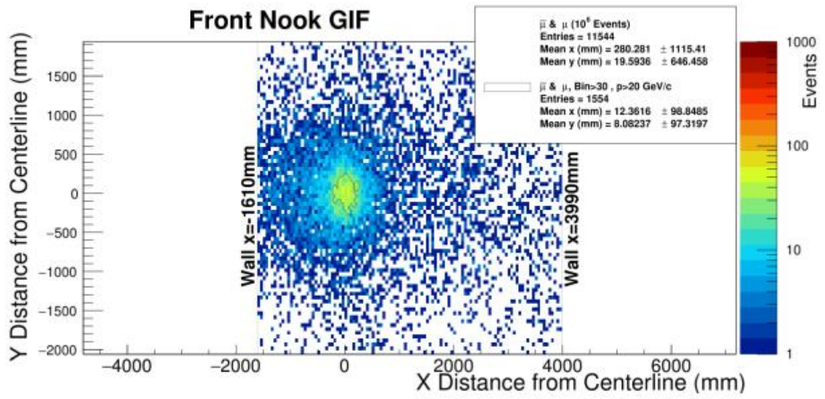


Front Nook GIF

μ^+ and μ^- map

0T



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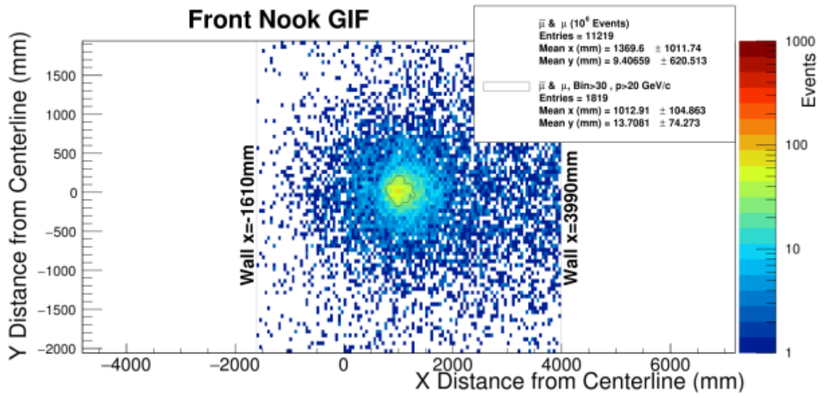

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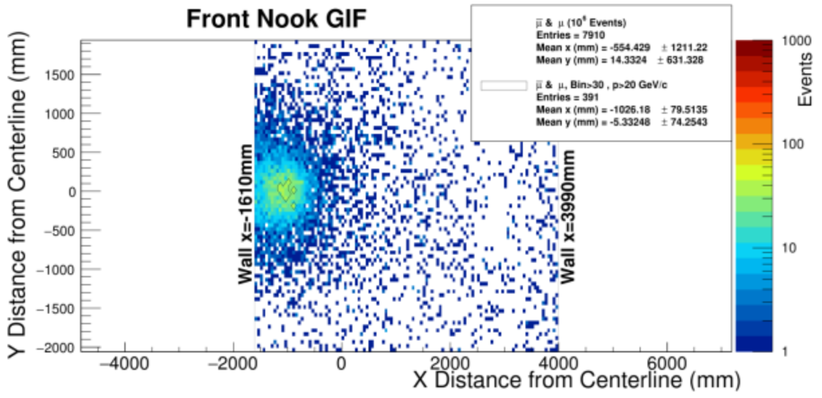

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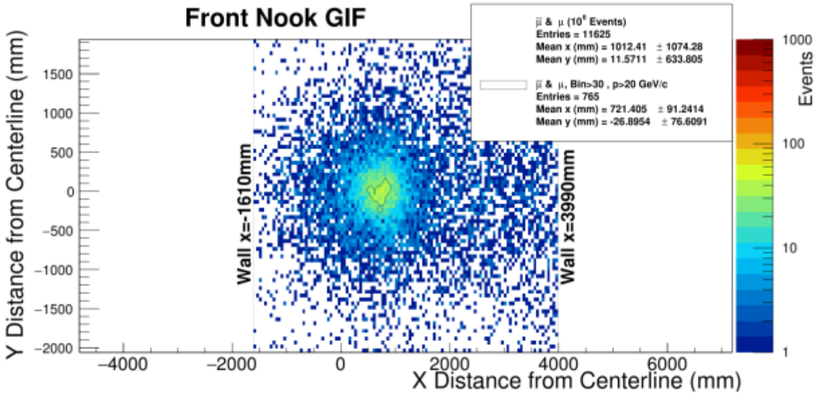

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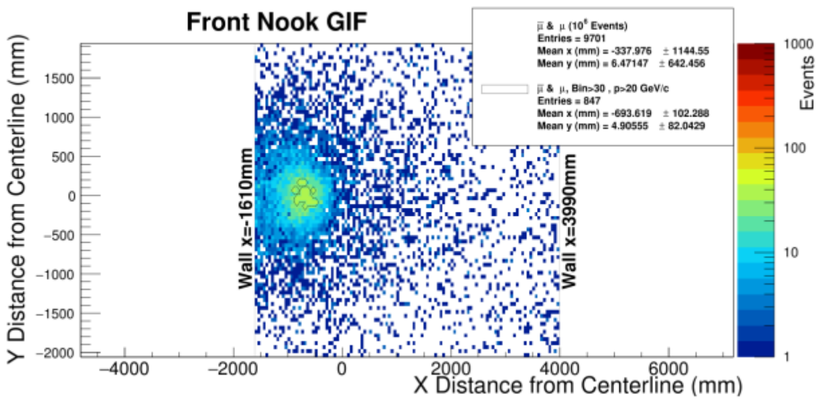
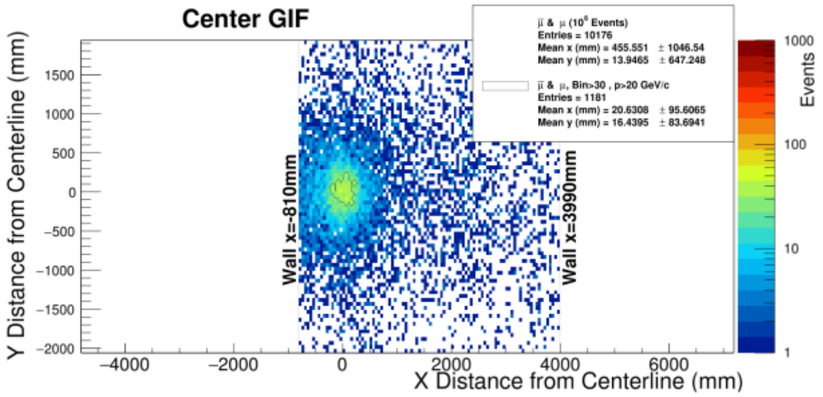


Center GIF

μ^+ and μ^- map

0T



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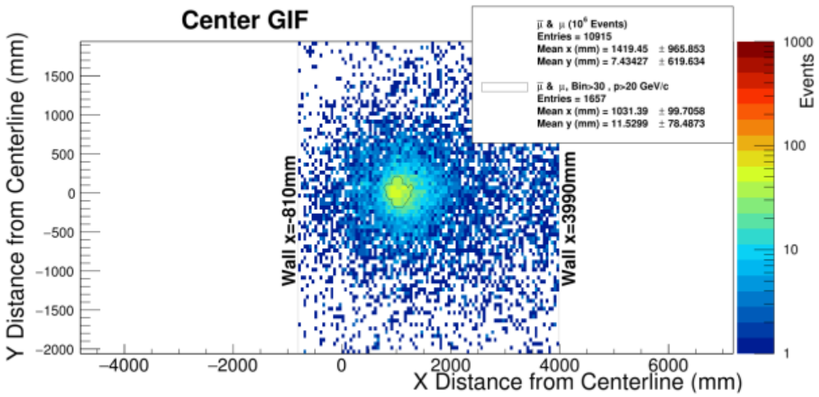

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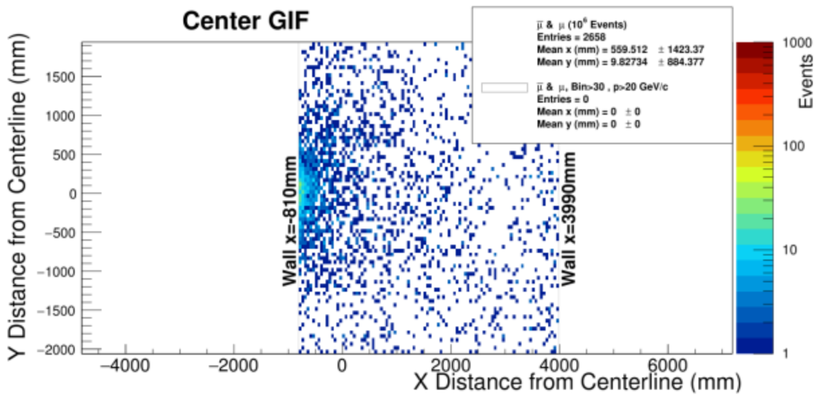

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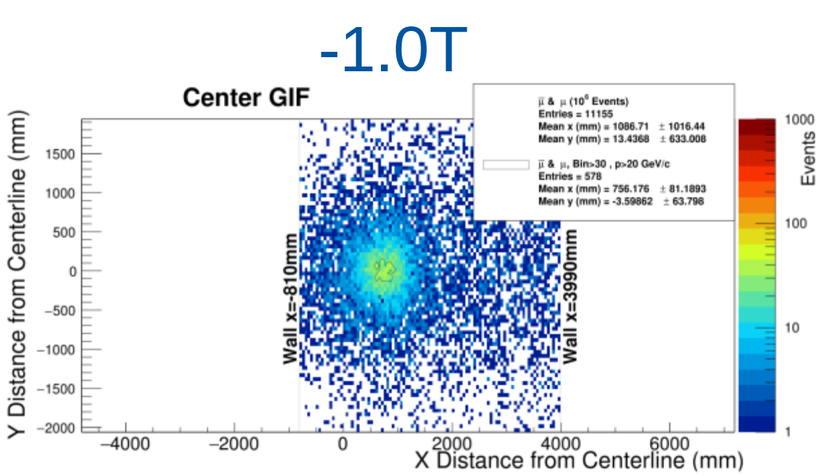

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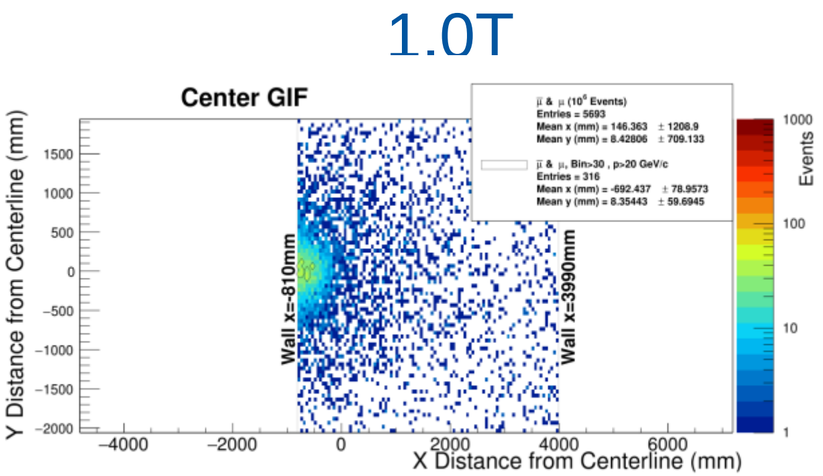
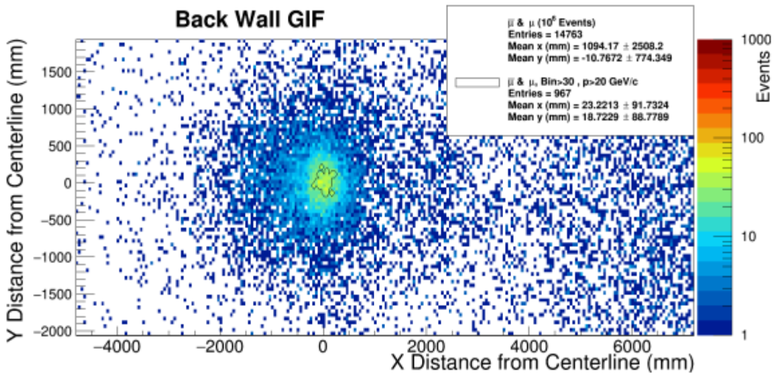


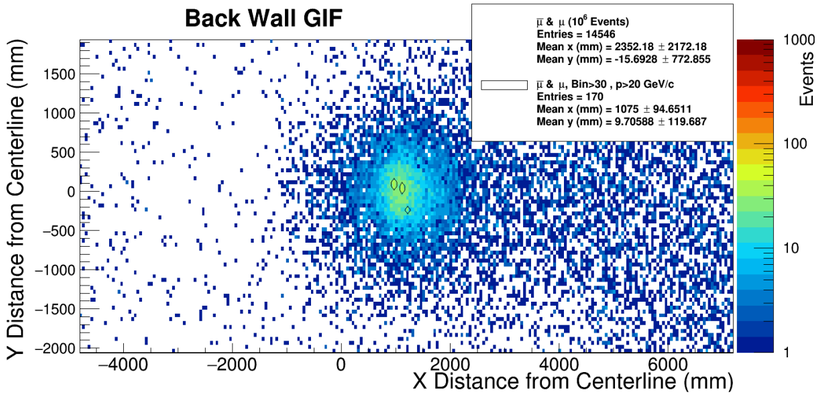
Back Wall GIF

μ^+ and μ^- map

0T



-1.5T



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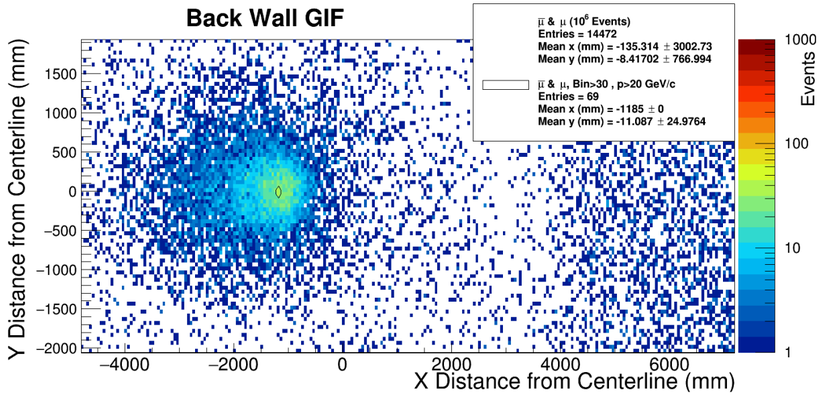
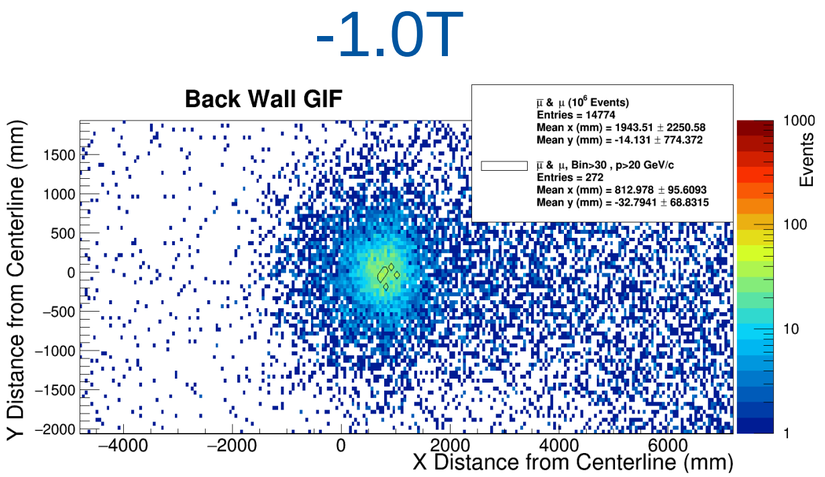


-1.0T



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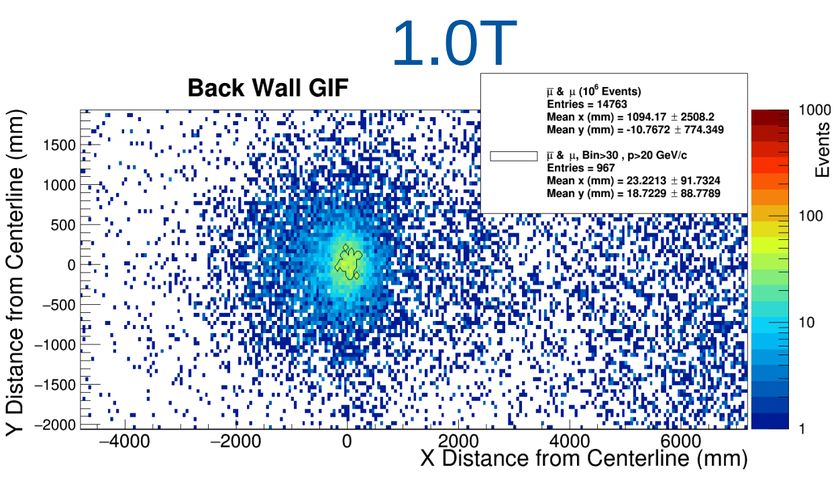
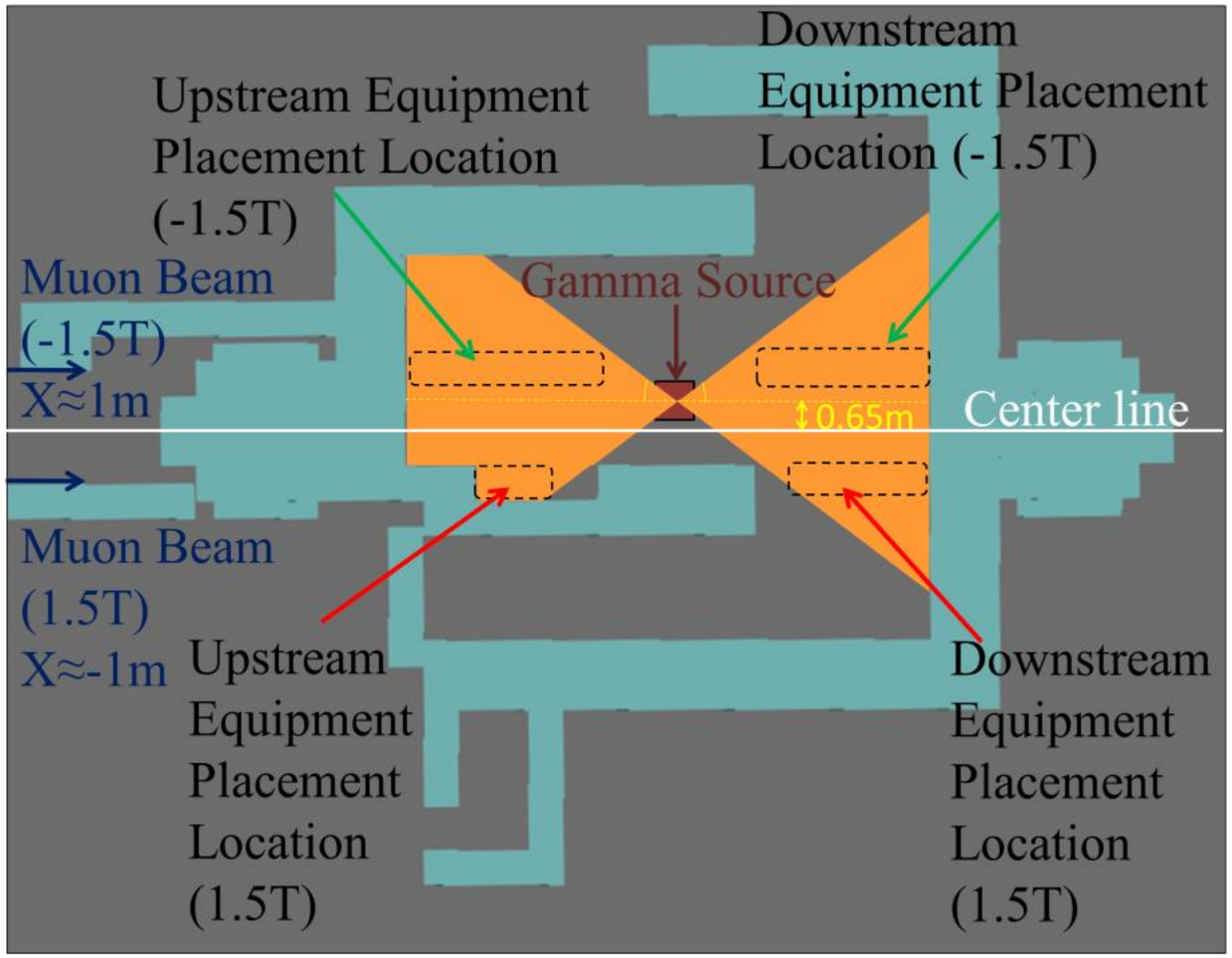


Locations with Usable Beam

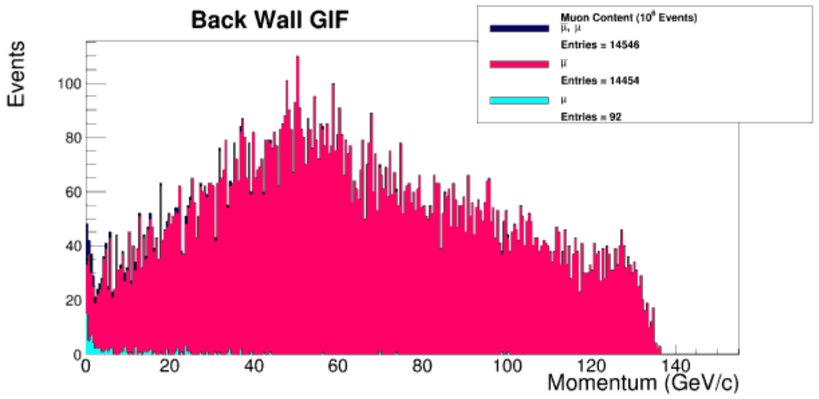
- With these simulations, we can advise correct equipment placement to receive muons and gamma photons while Goliath is on



Momentum

Momentum, Back Wall GIF

-1.5T



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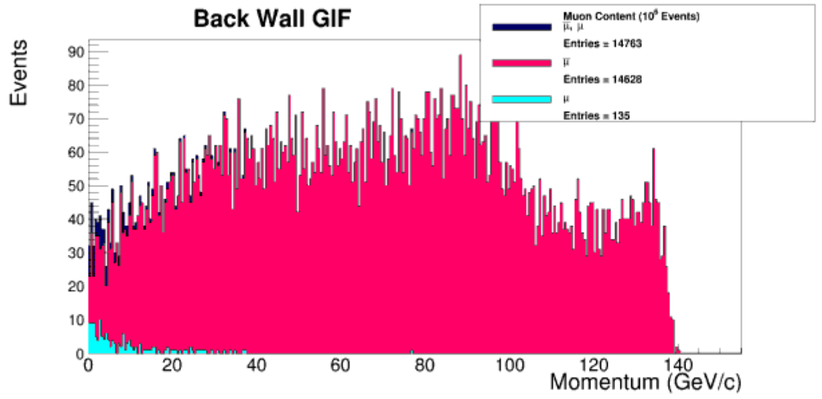

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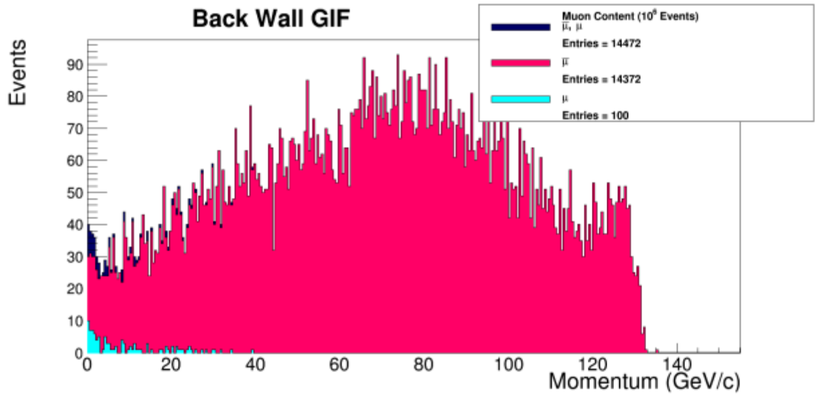

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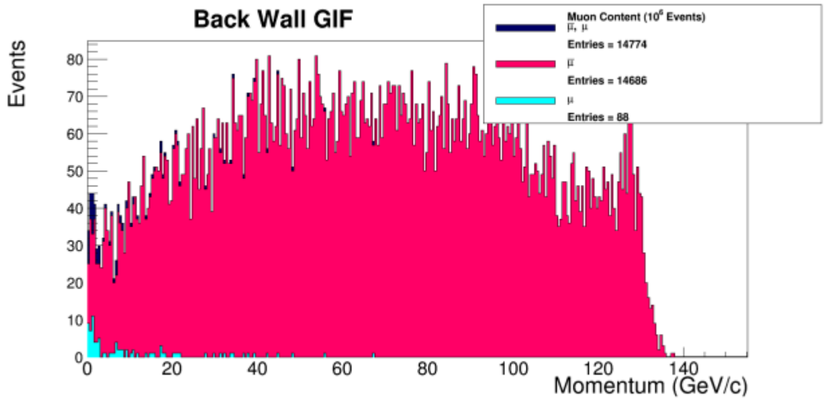
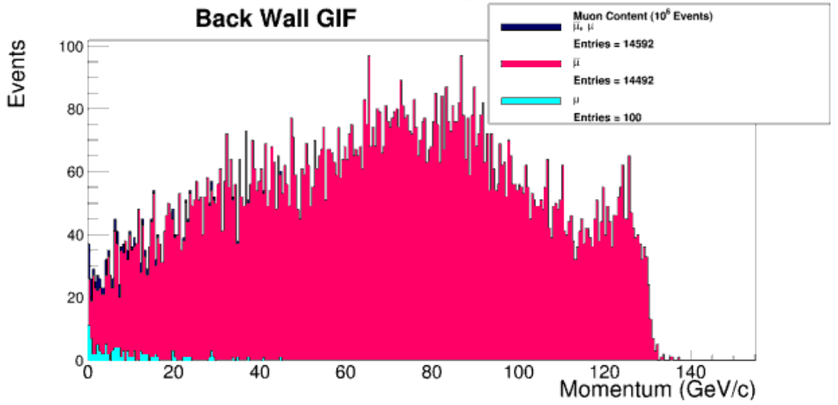


Similar for all z positions in GIF++

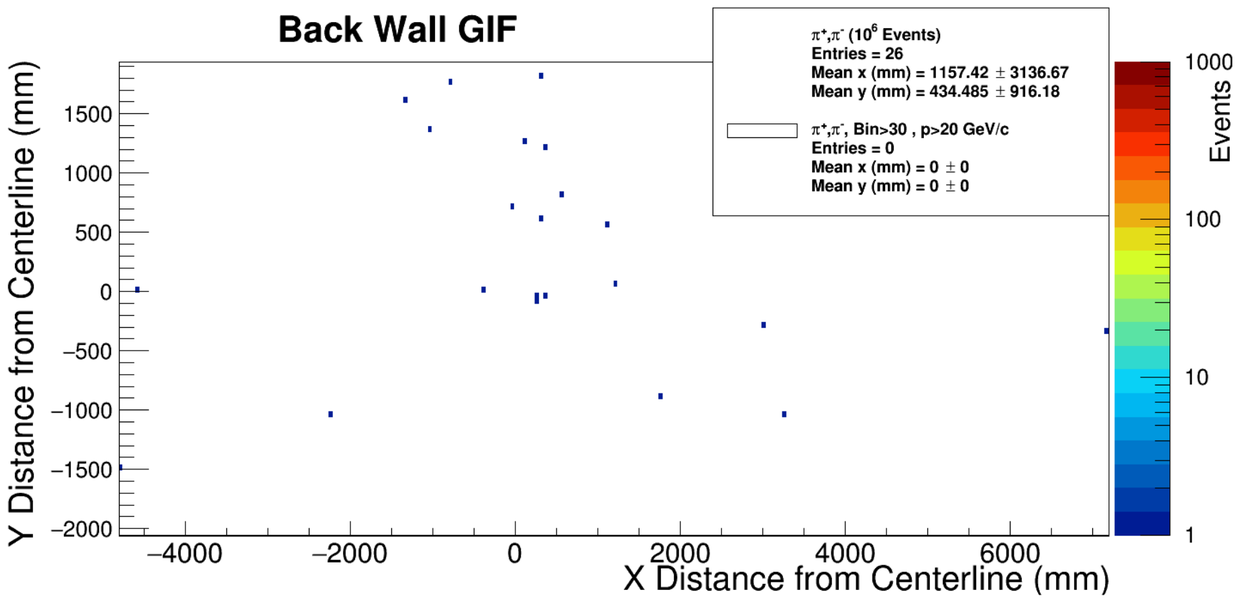
1.0T



Pion Contamination

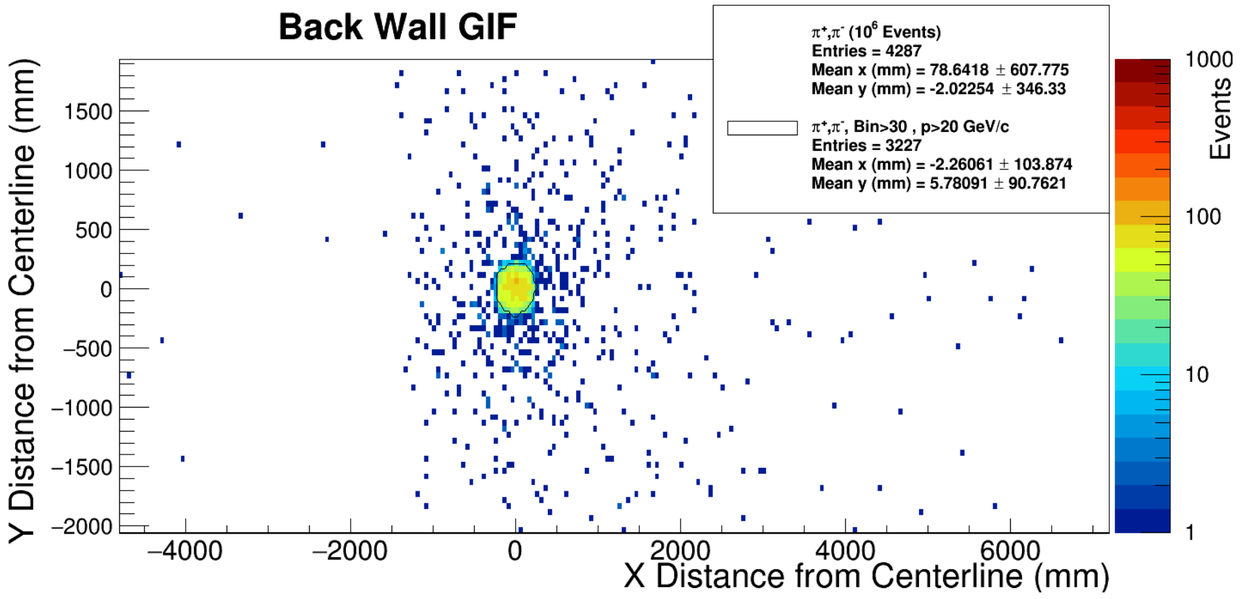
π^+ and π^- map

0T, Both Dumps Closed



(26 events)

0T, Both Dumps Open

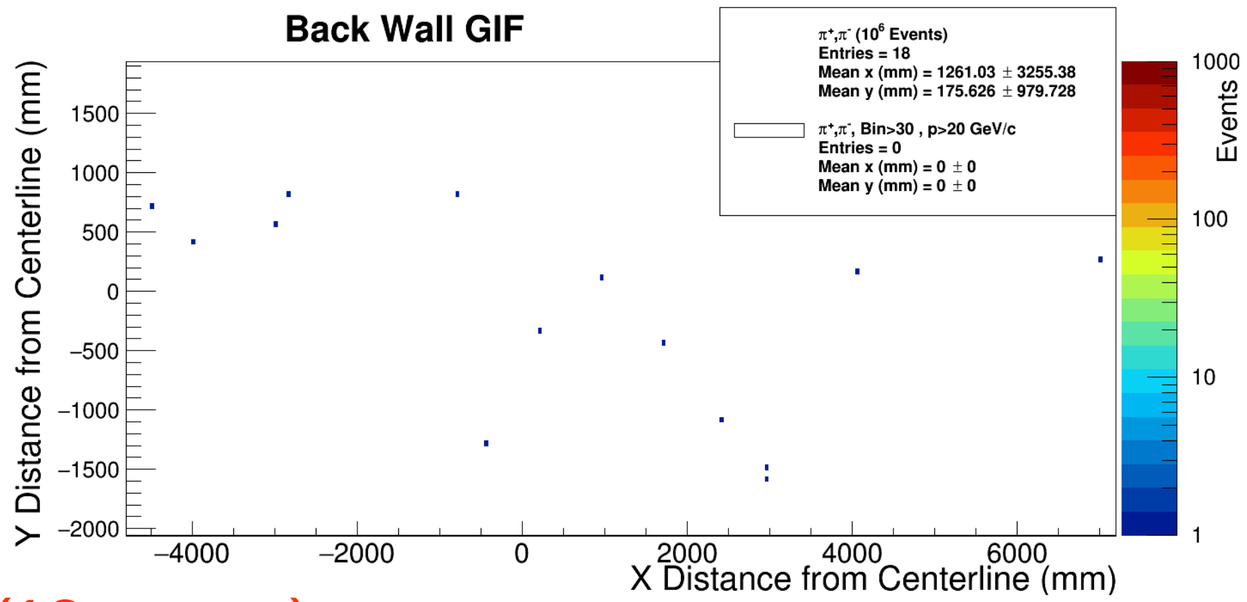


(4287 events)

Pion Contamination

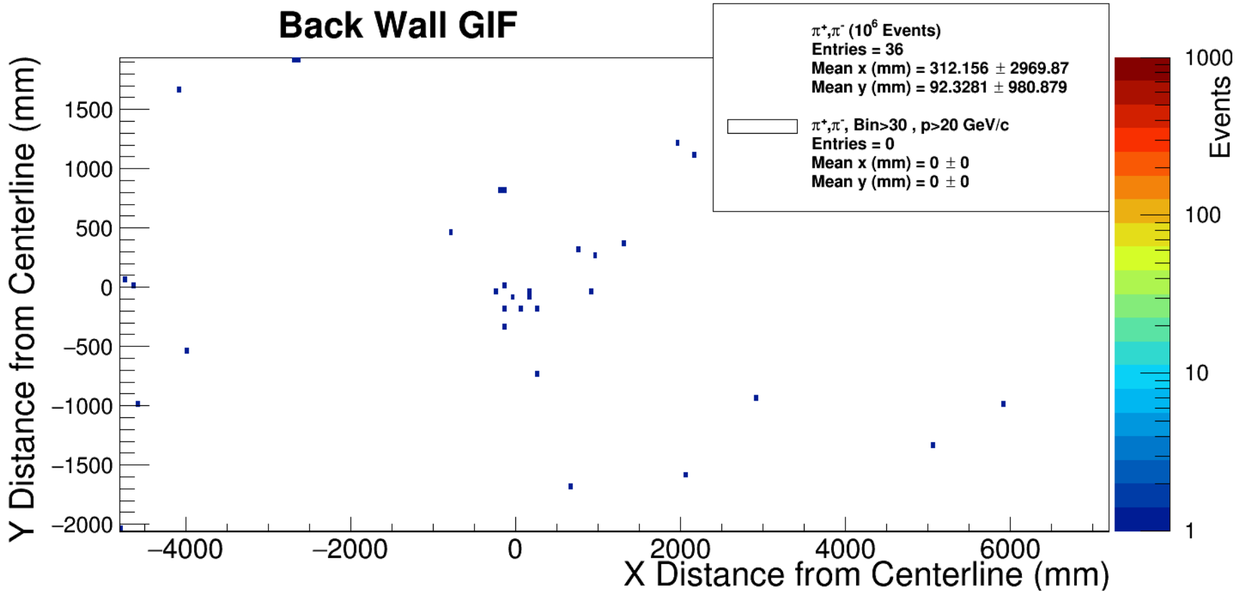
π^+ and π^- map

-1.0T, Both Dumps Closed

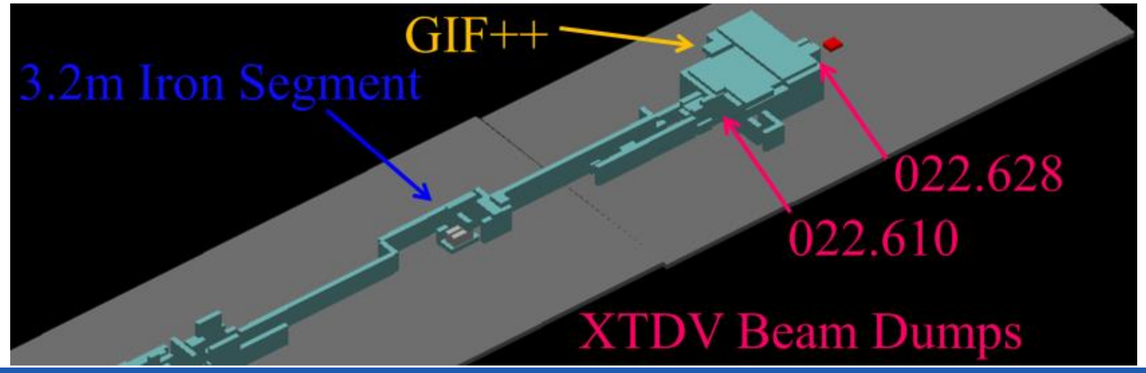


(18 events)

-1.0T, Both Dumps Open



(36 events)

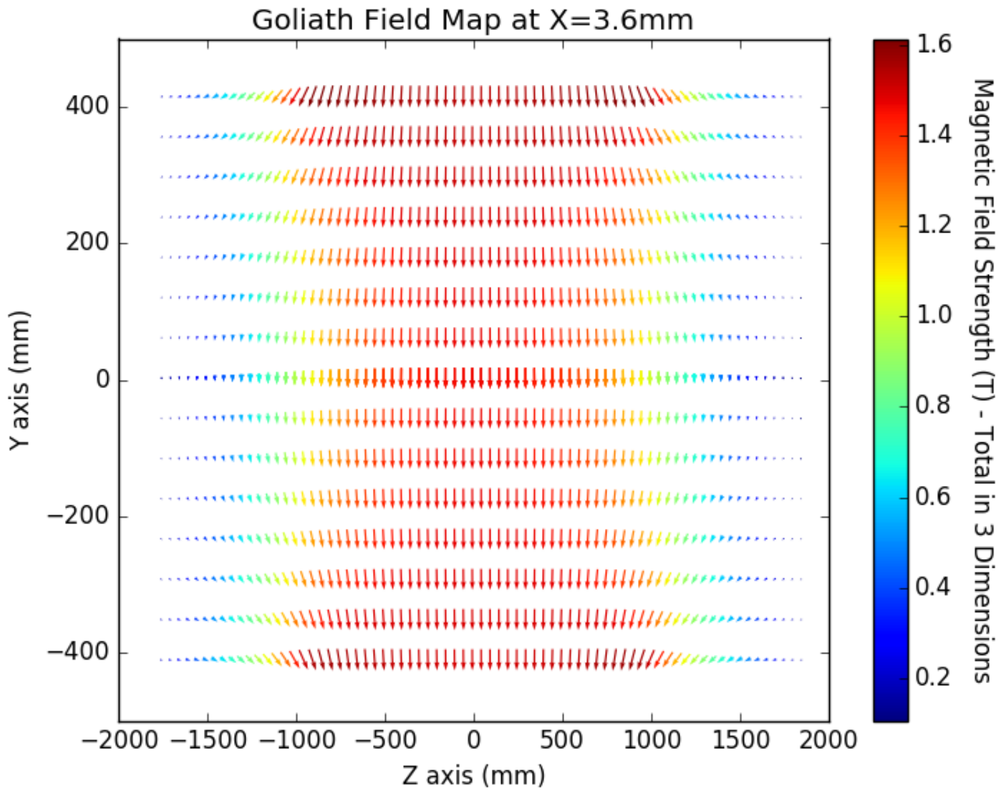


Summary

- GOLIATH field affects the muon beam at GIF++.
  - Minus polarity pushes the muons into the free space and not into the wall → Preferred for GIF++!
  - Wide spectrum of the muons' momentum arriving at GIF++
  - Pion contamination negligible when the XTDV's are "IN", or when GOLIATH is on

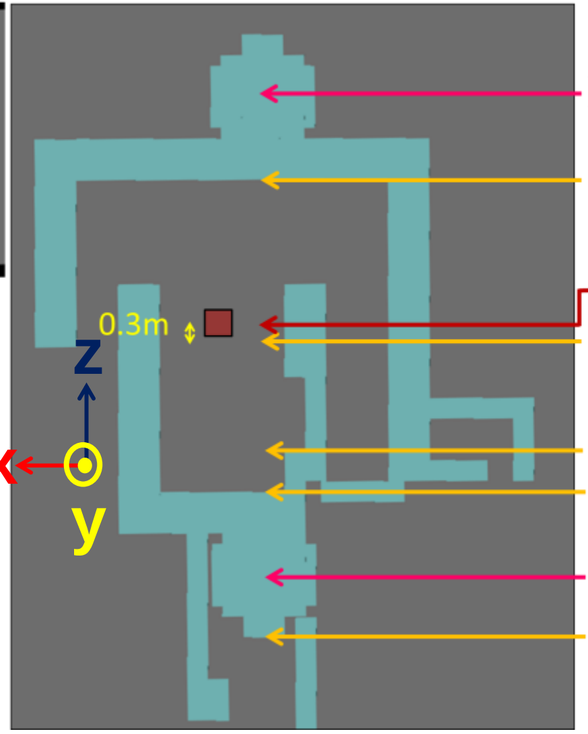
Final Remarks

- Last step is to incorporate the correct field map of Goliath into the G4beamline simulation
- 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



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

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



Dump XTDV 022.628
Position "Back Wall GIF"
Cs Source
Position "Center GIF"
Position "Front Nook GIF"
Position "Front Wall GIF"
Dump XTDV 022.610
Position "Upstream GIF"

Questions?

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