GEANT Validation via Positrons

R. MacDonald

Ph.D. student, University of Alberta

with the *TWIST* collaboration

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- *TWIST* and GEANT
- Detector Response
- Comparisons with GEANT
- Monoenergetic Sources and Acceptance Issues
- "Partial Detector" Techniques
- Conclusion

TWIST and GEANT

Use GEANT to:

- understand our analysis system.
- test our understanding of the detector itself.
- to improve our understanding of our systematics.
- to help determine Michel parameters.

Need to validate GEANT! Particularly, validate GEANT's "detector response" simulation.

Detector Response

For a given detector event, what do we reconstruct?

- This gives the **"Response Function"**, which includes:
  - The physical detector.
  - The electronics.
  - The analysis software.
- The response function GEANT predicts must resemble the real response function.
  (*TWIST*'s GEANT includes the detector and electronics.)

Data vs. GEANT Comparisons

- Take real data measurements.

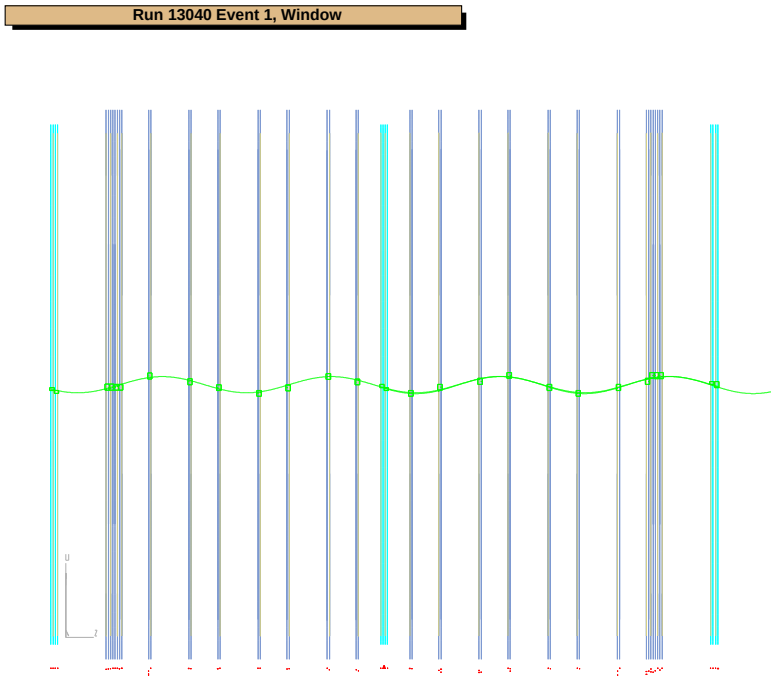
- Run GEANT simulation with similar beam characteristics (particles, momentum distribution, emittance, etc.).

  – Can look at particle track evolution through the detector to reduce impact of imperfectly reproduced beam characteristics.

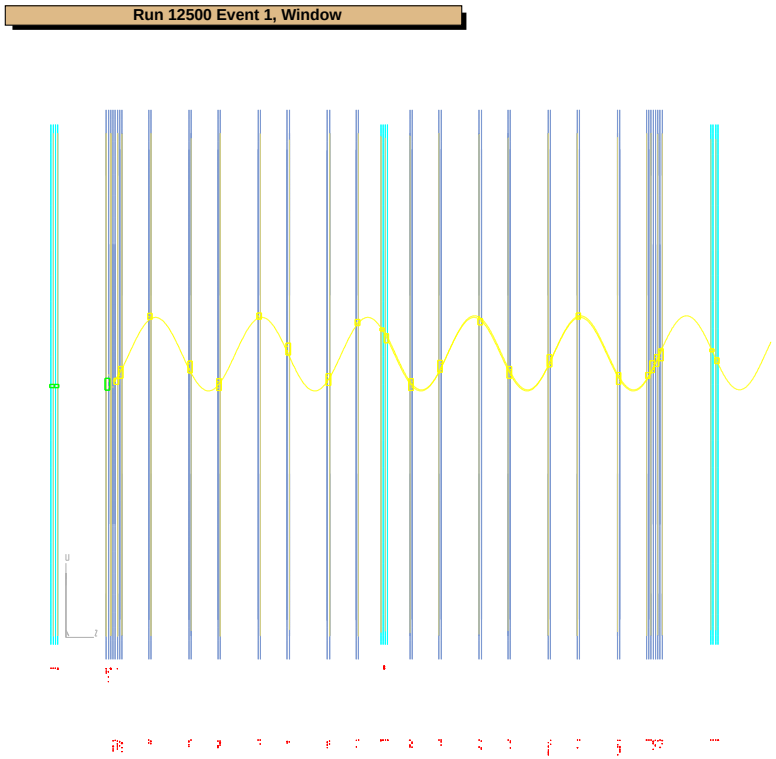
- See that the reconstructed characteristics are similar.

- Some types of data useful for Data vs. GEANT studies include:

Beam Positrons



Decay Positrons from muons stopping upstream



Measurements to Compare

We need to examine GEANT's response function in many ways, including:

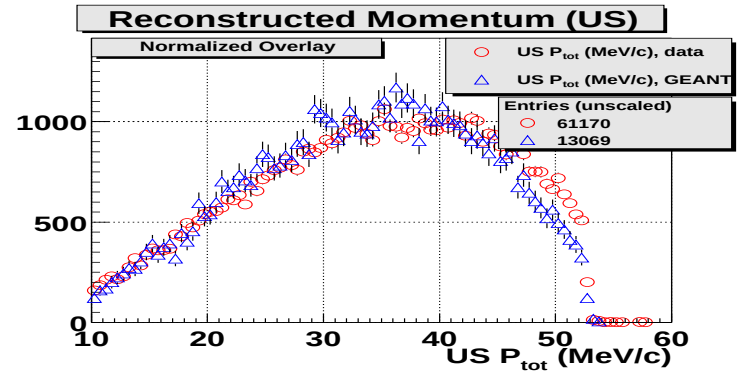
- Momentum.
- Angle.
- TDC Time Distributions.
- Hit Efficiencies (wire, plane).
- Reconstruction efficiencies (vs p and $\cos\theta$).
- Delta production, kinks.
- χ^2, confidence levels.
- Beam spot vs z.

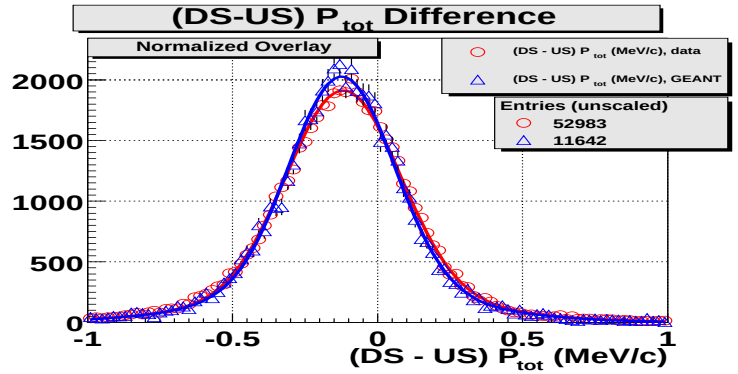
"Partial Detector" Techniques

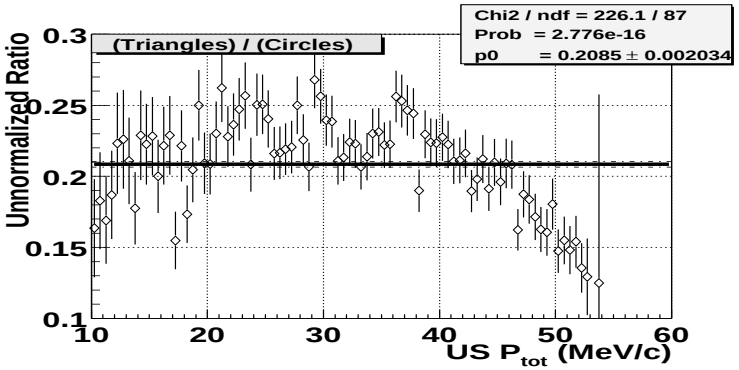
Reconstruct an event using only some of the chambers, then repeat with the rest. (eg: Reconstruct with upstream half, then with downstream half.)

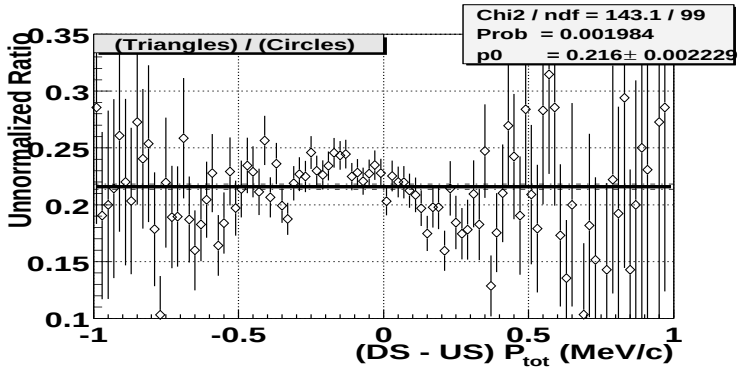
- Differences between the two reconstructions should be due to:
  - Real (and predictable) physics processes.
  - Response function (eg. resolution).
  - Systematics.
- Use this technique to test GEANT's modelling of physics, response function, and systematics.
- This technique does not need a monoenergetic beam.

Decay Positron Reconstructed Momentum





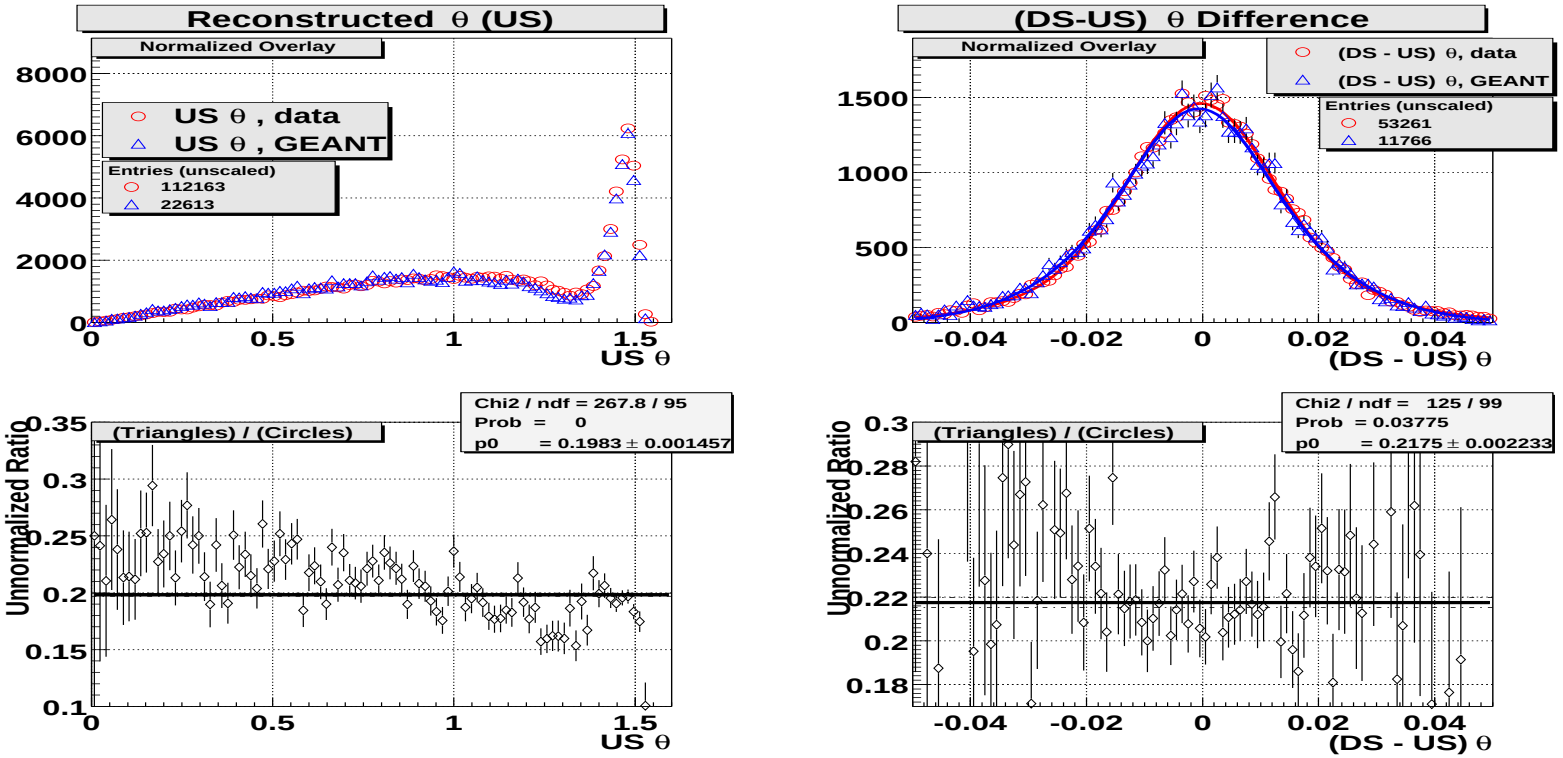




Reconstructed momentum is lower in GEANT.

Differences between downstream and upstream are narrower in GEANT.

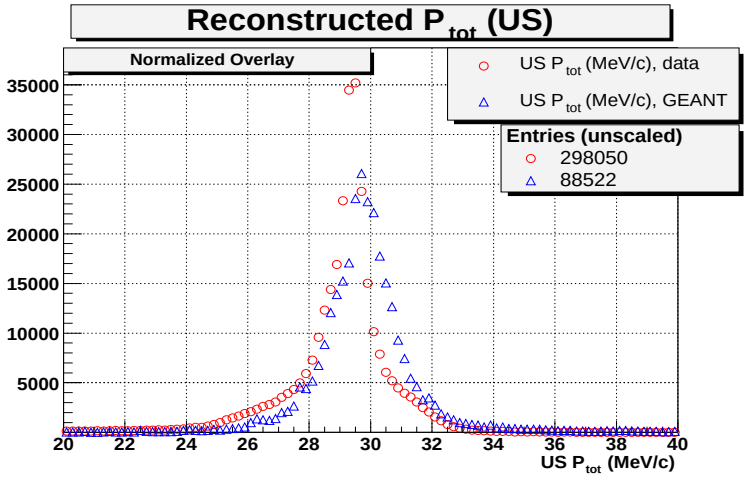
Decay Positron Reconstructed θ

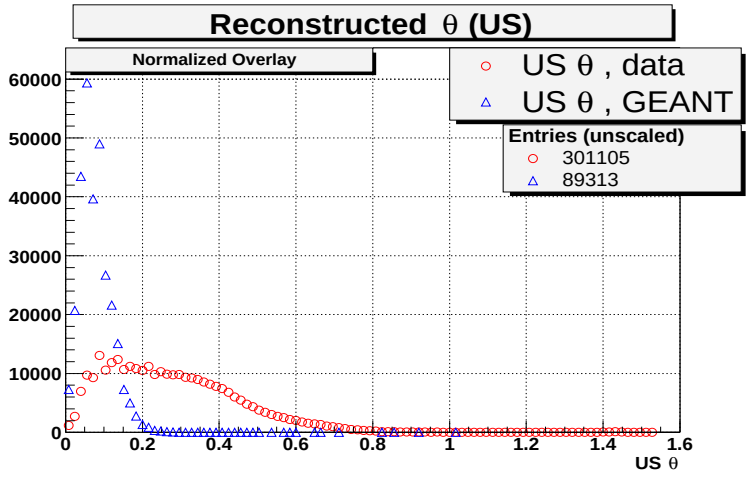


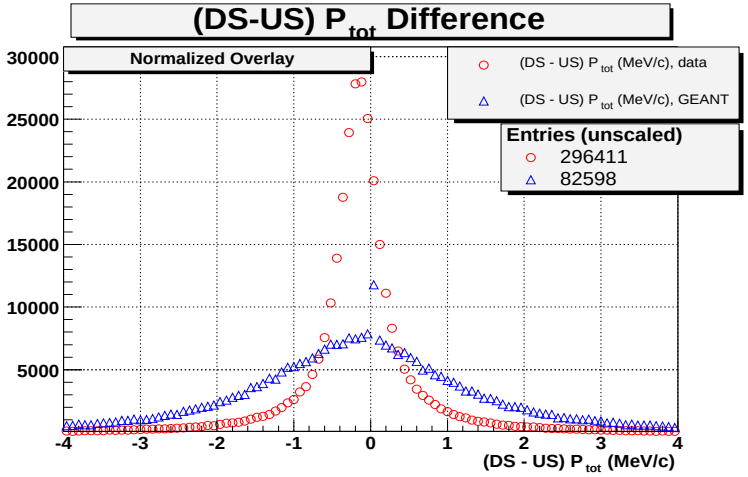
Reconstructed θ is smaller in GEANT.

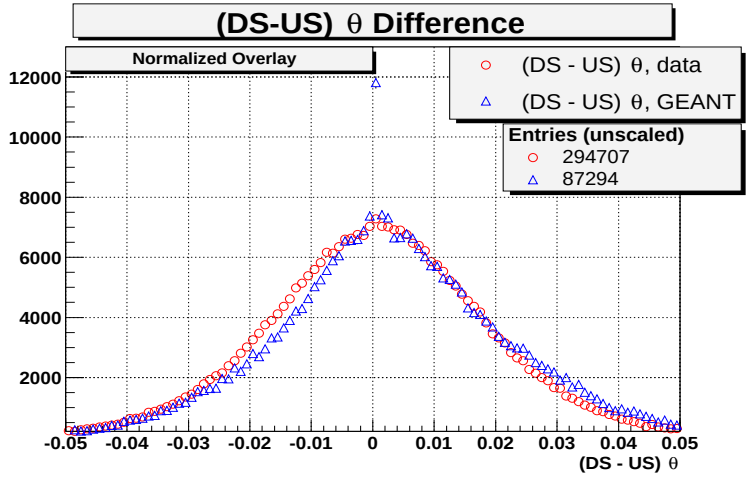
Differences between downstream and upstream are similar; GEANT may be slightly wider.

Beam Positrons, Centred Beam

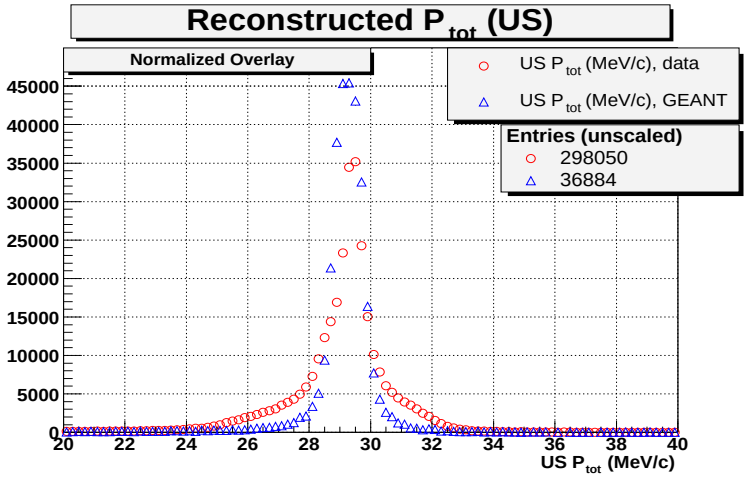


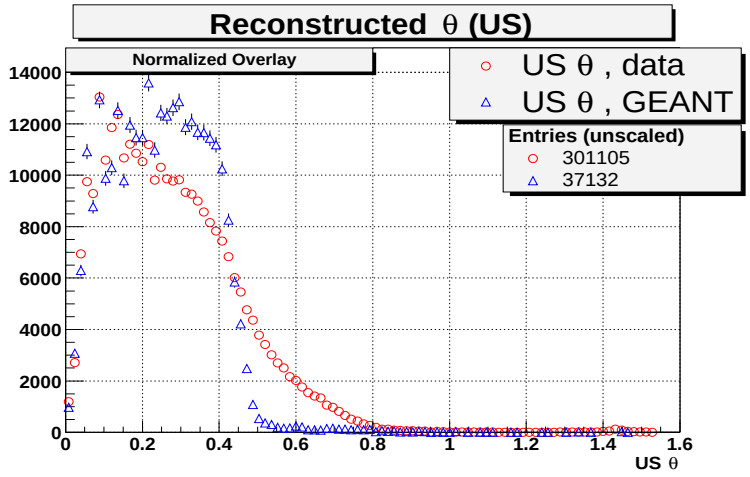


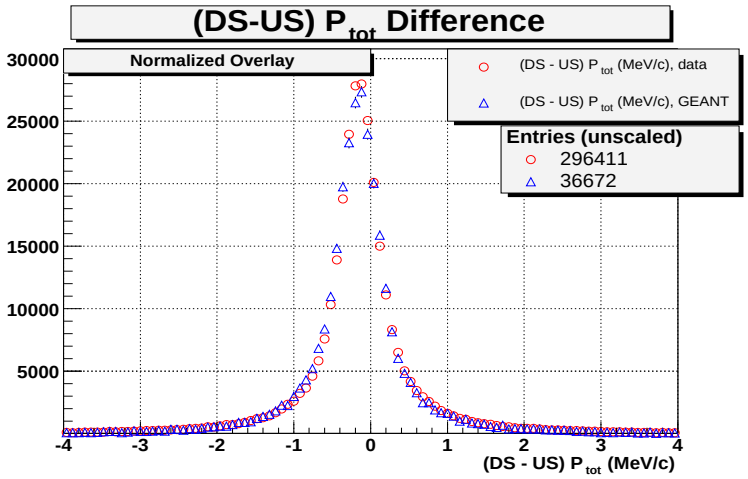


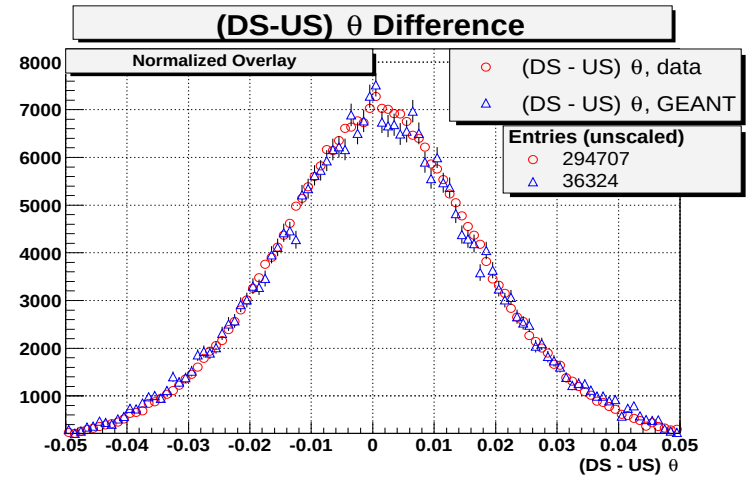


Beam Positrons, Offset Beam





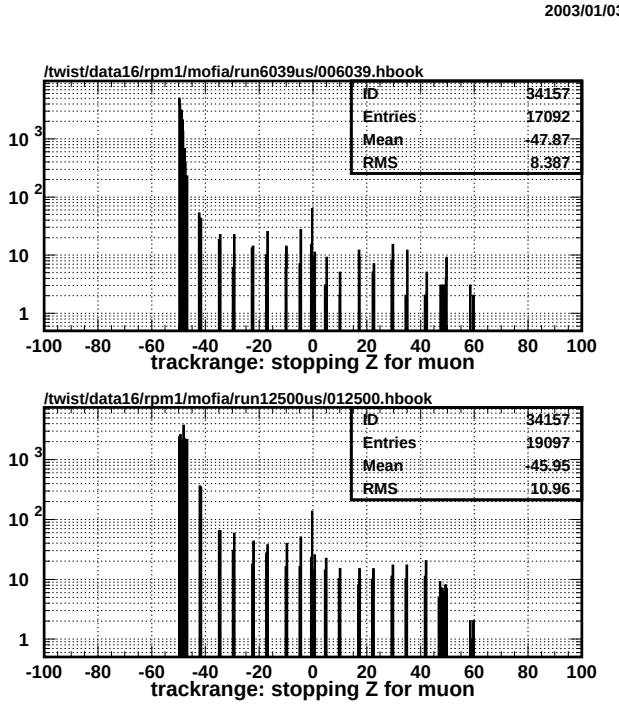




Summary

- *TWIST* makes extensive use of GEANT simulation to understand the experiment, and to help extract physics.
- It is vital to validate GEANT, making sure it correctly simulates the detector response function.
- Techniques are available to validate GEANT without having to perfectly simulate beam properties, and without having a monoenergetic source.
- Early analysis shows good agreement between GEANT and real data; slight differences are evident which can be corrected by tuning GEANT.

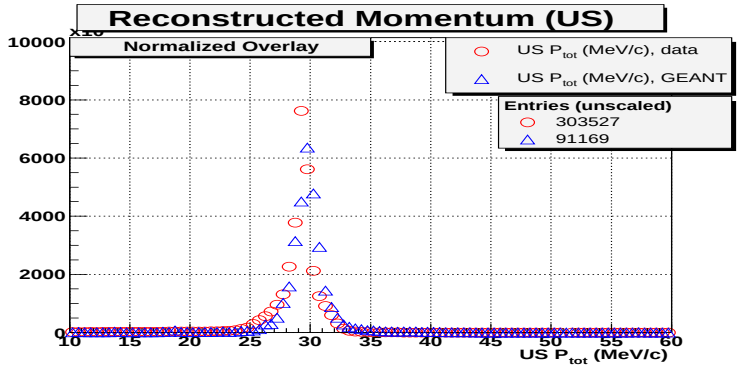
Muons Stopping Upstream

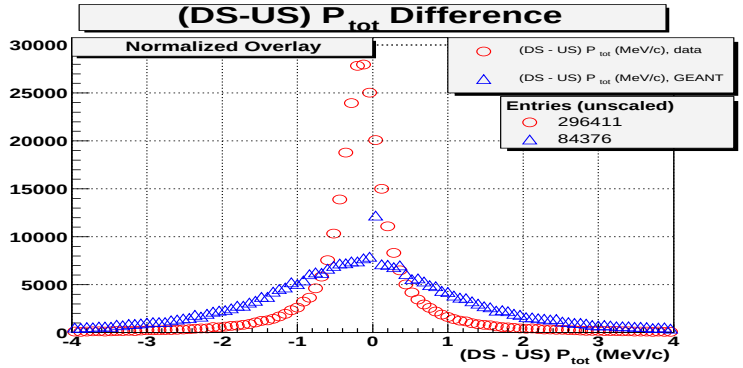


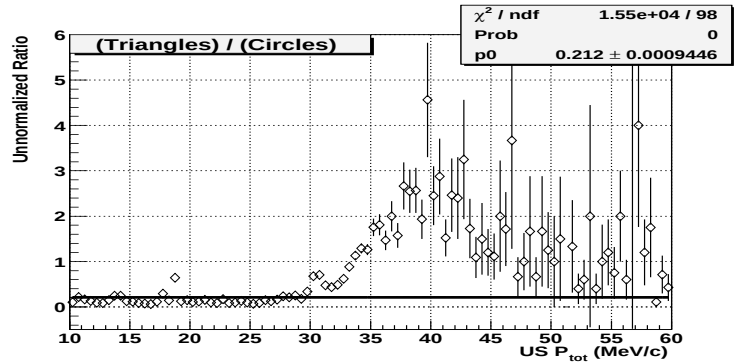
z of last hit in muon window. Top: Geant. Bottom: Data.

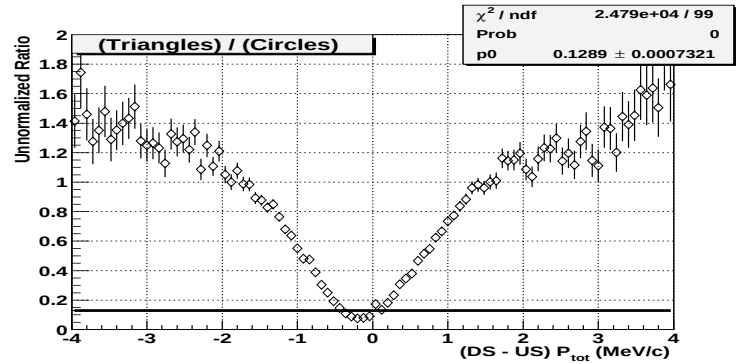
Stop muons upstream and track decay positrons through the detector. Gives full distributions in momentum and angle.

Beam Positron Reconstructed Momentum





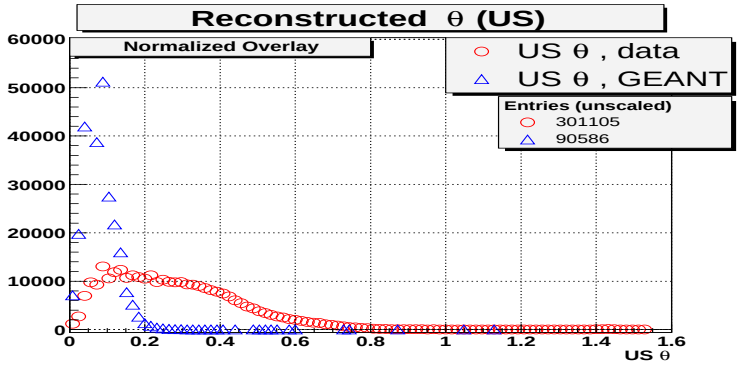


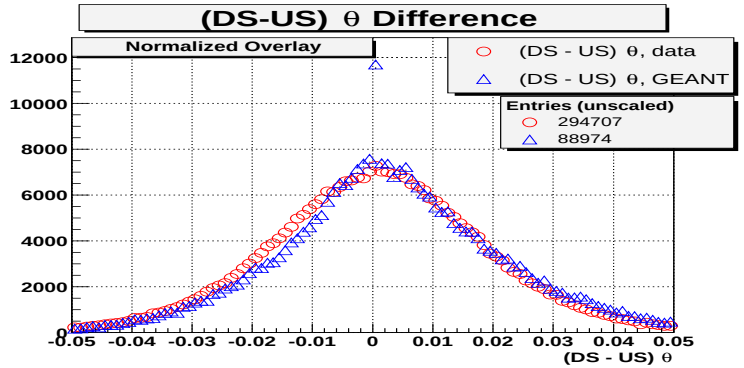


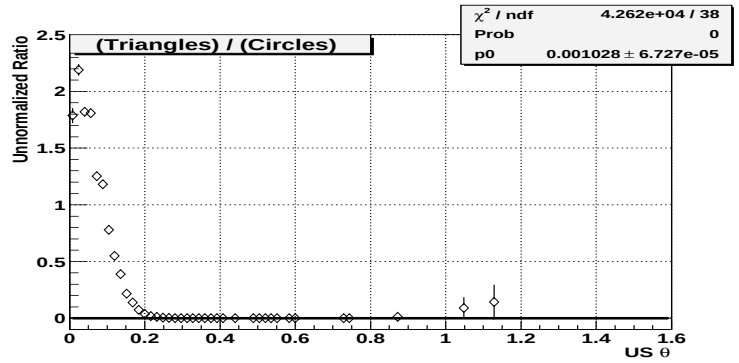
Reconstructed momentum is higher in GEANT. Tails are wrong.

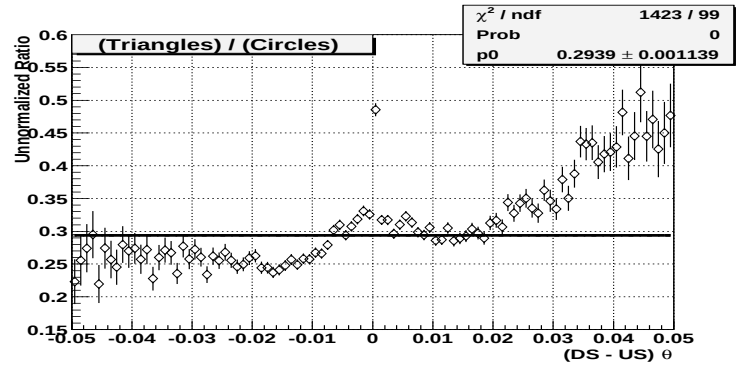
(DS-US) differences are much broader in GEANT.

Beam Positron Reconstructed θ





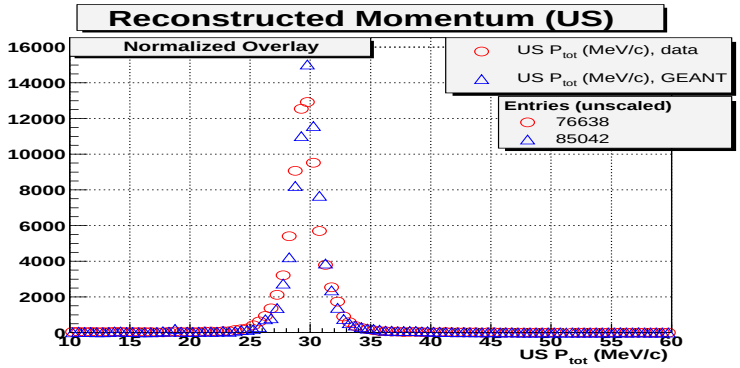


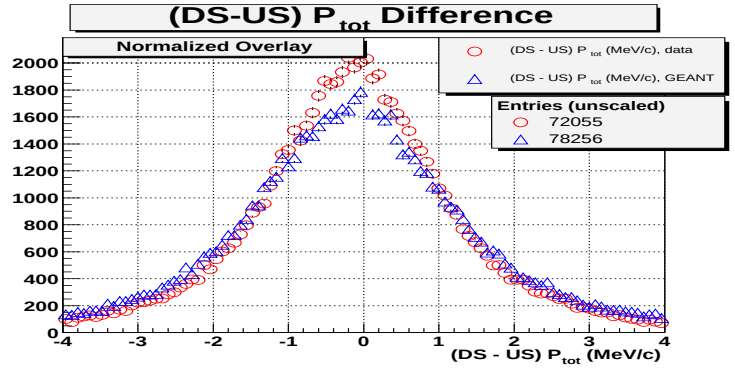


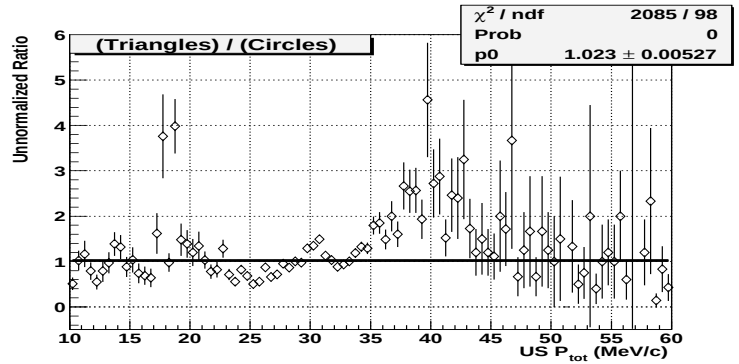
θ distribution very different between GEANT and data.

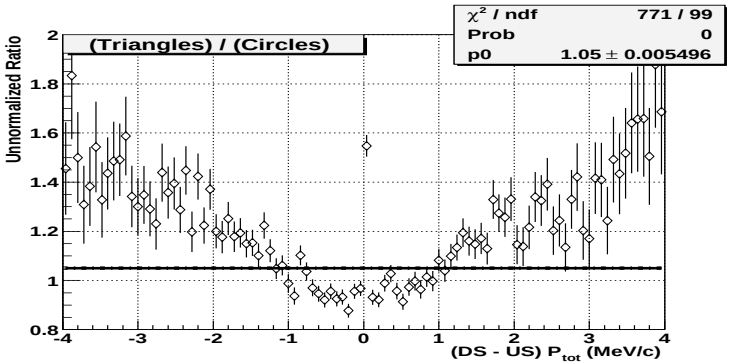
Differences between downstream and upstream are similar; GEANT is offset and narrower.

Beam Positron Reconstructed Momentum





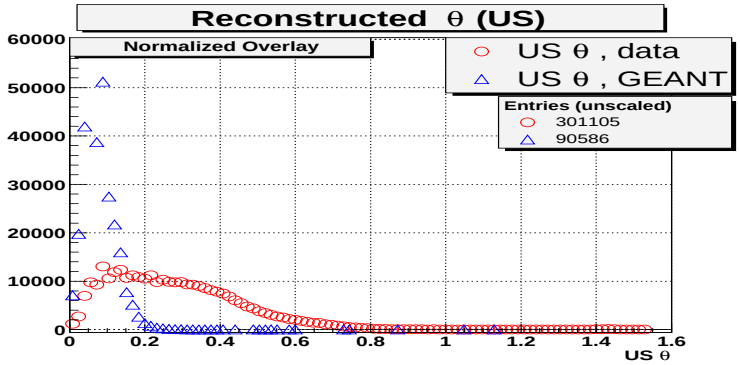


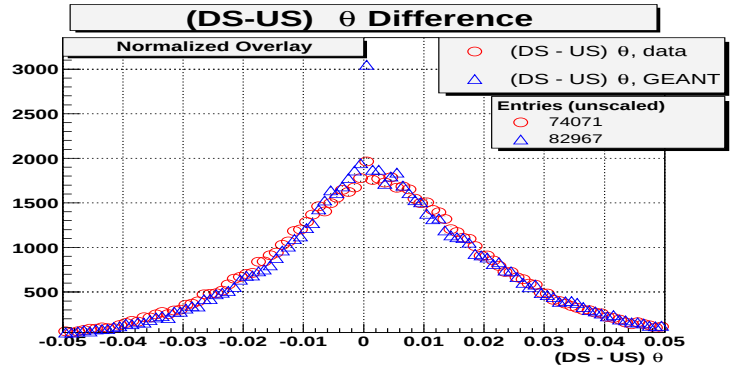


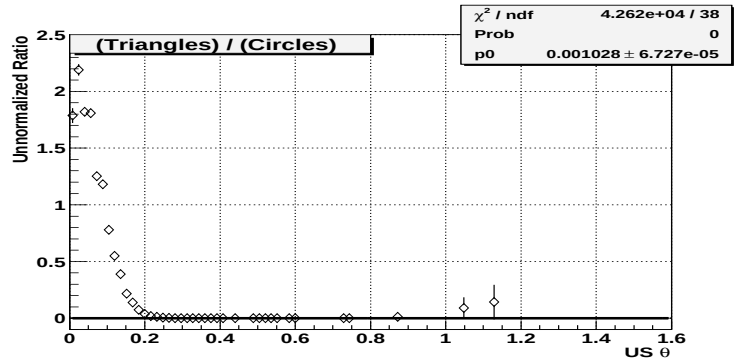
With cut ($\cos\theta > 0.99$), discrepancies are smaller.

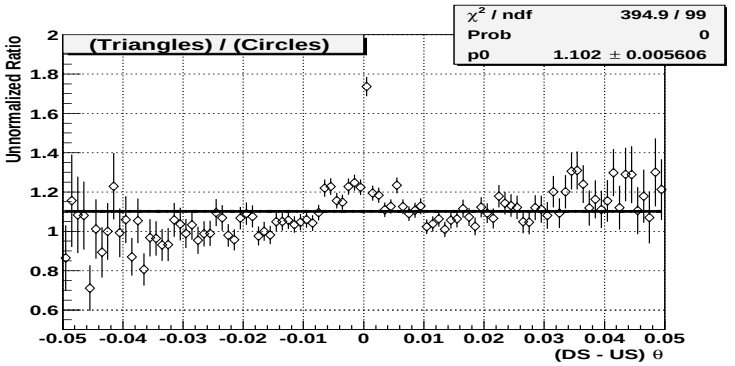
(DS-US) differences still broader in GEANT.

Beam Positron Reconstructed θ









With cut ($\cos\theta > 0.99$) or ($\theta \lesssim 0.14$), (DS-US) differences are much closer (though there are still discrepancies).