Data analyses and comparison with simulations for the late Sep. runs

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Fermilab

MICE CM, Oct, 2016

Goals

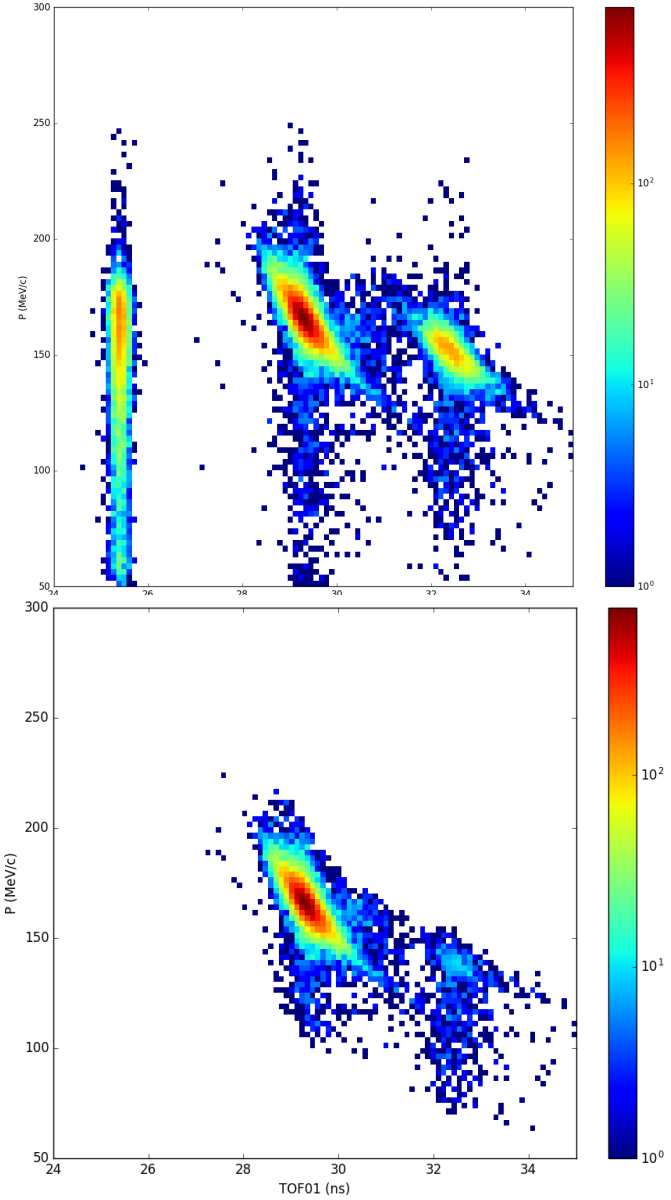
- Validate the data and optics
  - Check data quality
  - Compare data with the MC simulations, and understand the real beam v.s. designed beam, real optics v.s. designed optics.
  - Investigate the possible solutions to improve the transmission
- Develop a toolkit to “semi-automate” the analyses process for each run.
  - Each recon data – apply most basic cuts (requires data to be physical, numerical, and reasonable)
  - Apply more stringent cuts (e.g. fiducial, PID, number of trackpoints in each tracker, etc.)
  - Filter out muons – run MC – compare with data

Basic cuts on the data

- Exactly one SpacePoint in TOF0 and TOF1;
- No more than one track in TKU and TKD;
- TOF0→TOF1 positive but less than 50 ns;
  - OR, same for TOF1→2 (Should at least have one timing information)
- Reconstructed position, momentum, or their errors must be real numbers
  - Occasionally seeing NAN in X, Y, Z (observation: these NAN come and go together), or P_x , P_y, P_z (also appear together)
  - Occasionally seeing NAN in pos_error or mom_error (observation: these NAN DON'T appear together, i.e. when x and y are fine, z might be NAN)
- pos_error.x() and .y() less than 10 (mm), mom_error.x() less than 10 (MeV/c) and mom_error.z() less than 20 (MeV/c)
  - The reason is, this makes the next steps much easier if naughty tracks with bad behaviors are excluded already.

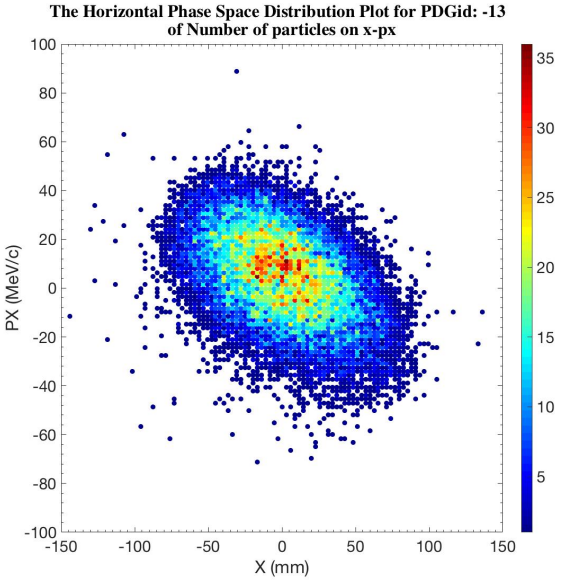
PID cut

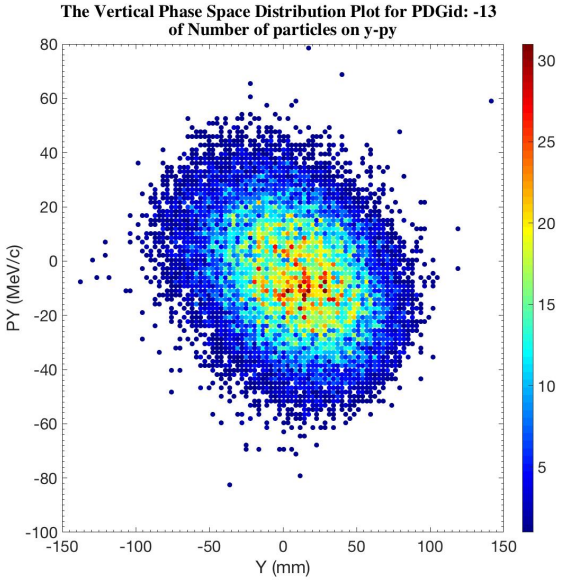
- To filter out muons for MC simulations
- Purely based on the momentum at TKU and TOF01, or if that failed, use momentum at TKD and TOF12
- Effectively selected out the main muon beam structure
- In principle, this can be used to identify a particle decay: if the particle TOF01 and momentum moves from one region to another, this could be either decay, or energy loss in SciFi.
  - Rare in the analysis. Assuming particle decay is excluded from tracker recon, this “feature” has been disabled

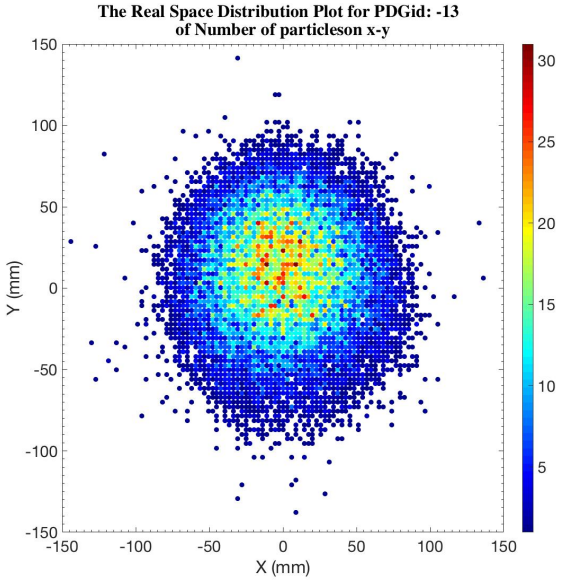


Run 8280 data (170 MeV/c)

- At TKU station 5:



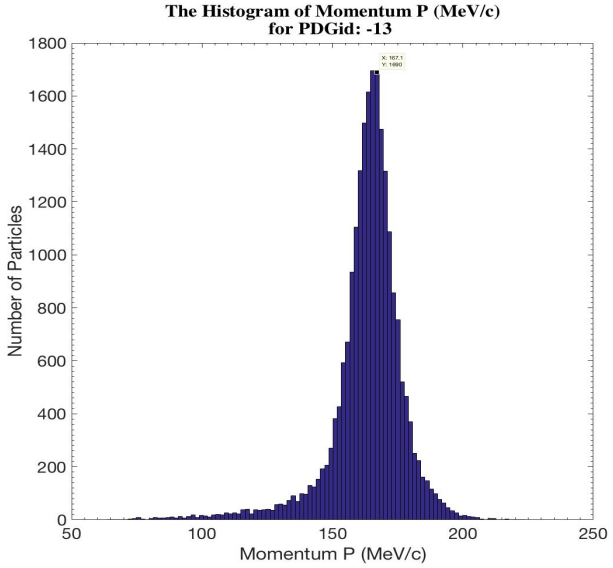




Upper: x-P_x, y-P_y, x-y;

Lower: Momentum

Plotted are all muons at TKU station 5 that passed the previous cuts



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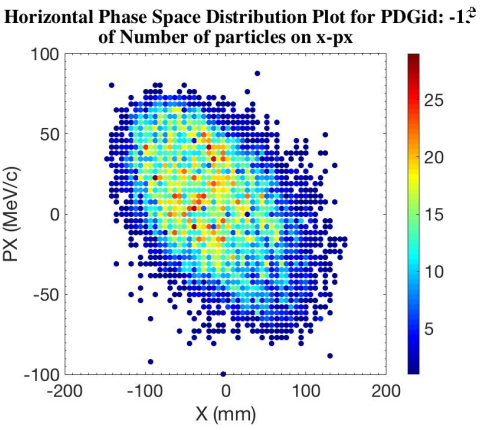
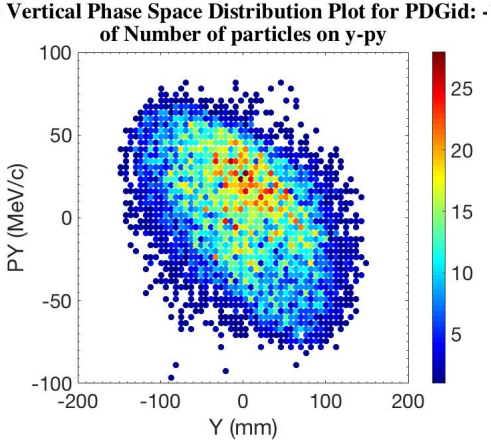
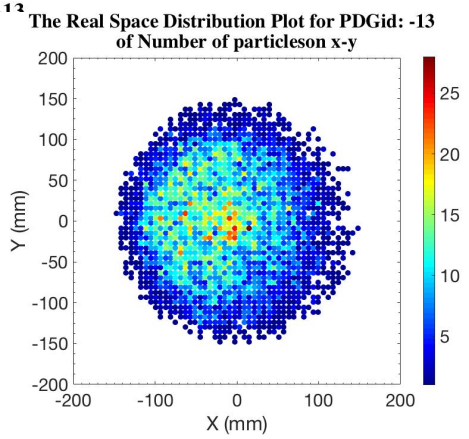
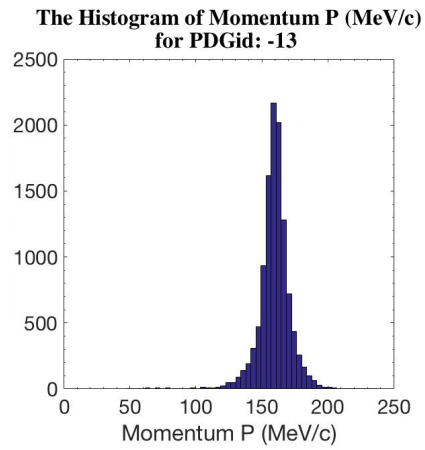
Run 8280 Data v.s. G4Beamline simulation

Looking at TKD Station 5 (muons only):

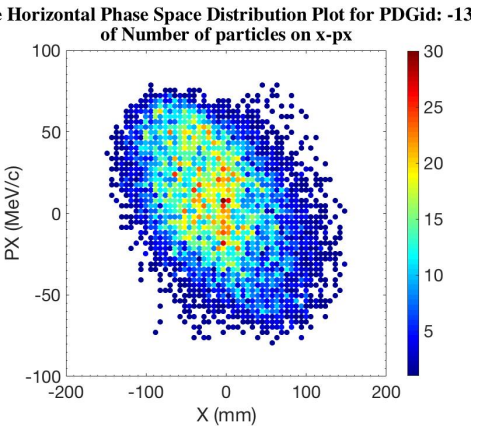


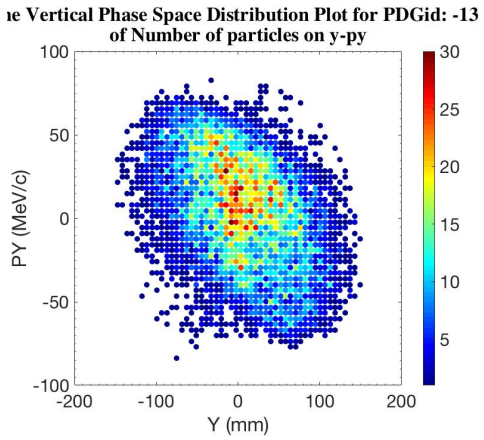


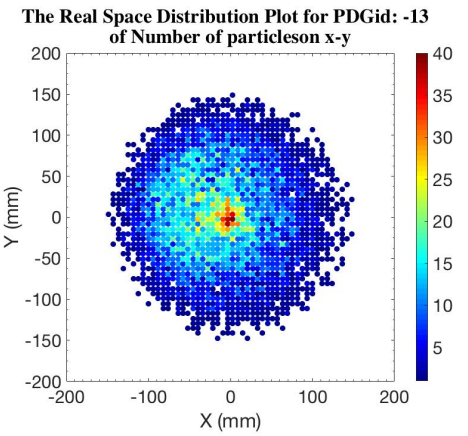


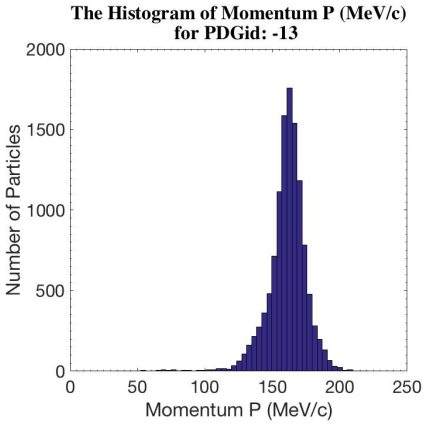


Start with the same beam in G4BL, look at TKD STN 5, muons only





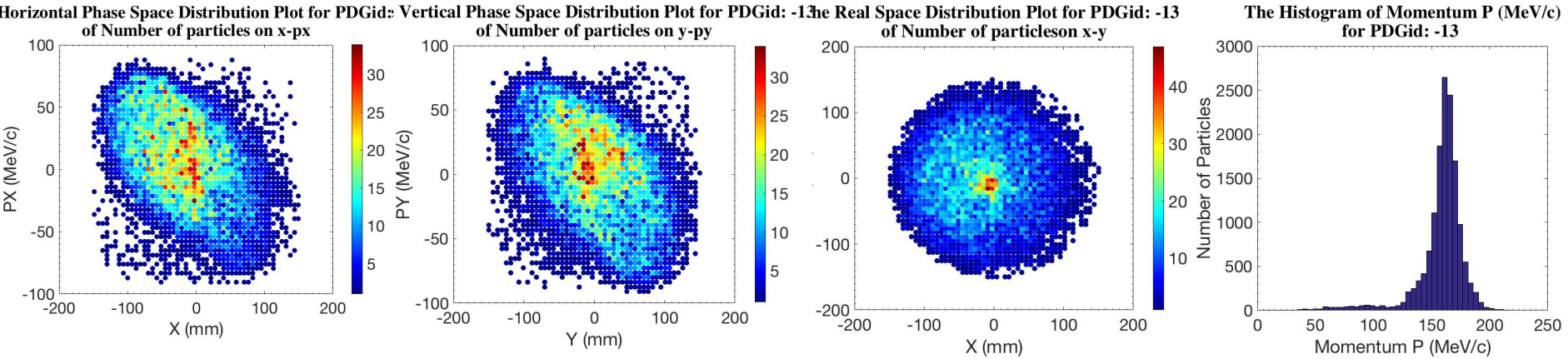




Transmission to TKD STN 5 in G4BL is 50%, compared with 47% from data

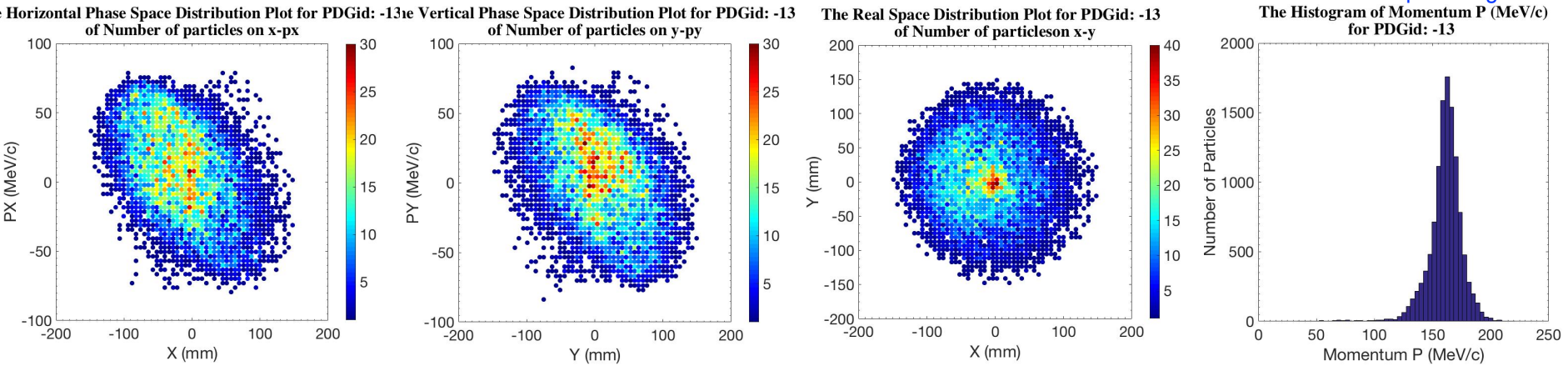
Run 8280 G4BL v.s. MAUS simulation

Looking at TKD Station 5 in MAUS (muons only): MAUS and G4BL agree well



Start with the same beam in G4BL, look at TKD STN 5, muons only

Note slightly different bin width, i.e. don't compare heights



Transmission to TKD STN 5 in G4BL is 50%, compared with 56% from MAUS

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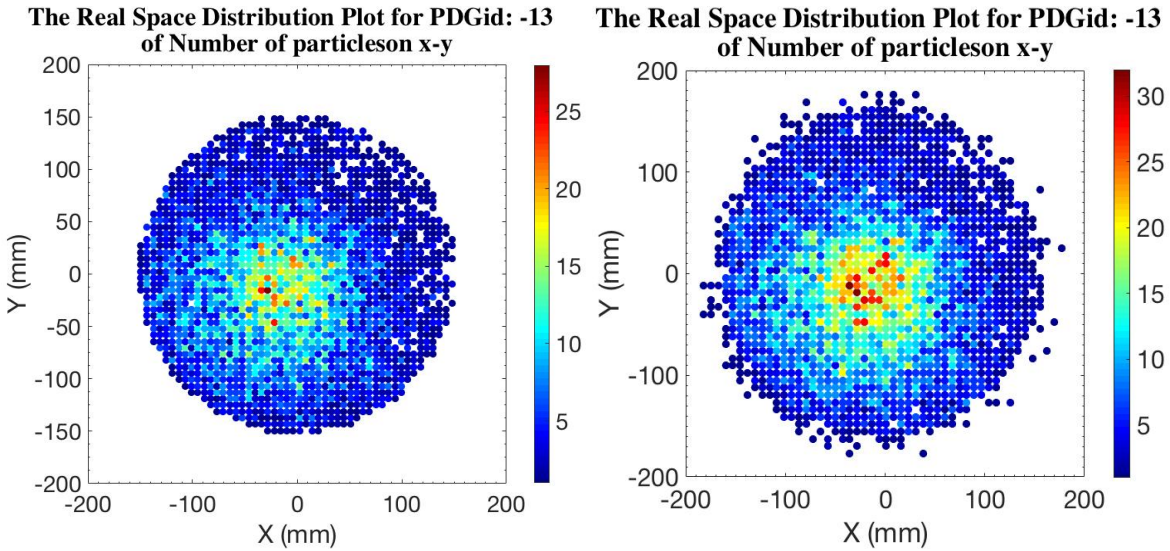
Run 8280, TKD STN 4

- After a fiducial volume cut, a “dip” in transmission at TKD STN 4 was seen
  - TKD STN 4 sees fewer tracks in fiducial volume than STN 5 (6% less);
  - Beam at STN 4 is larger than elsewhere. Confirmed by MC. Left: real data muons, with fiducial cut; Right: without.

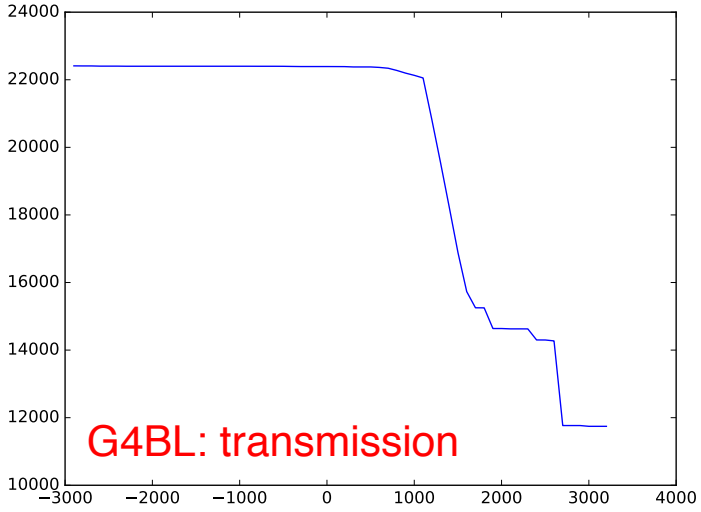


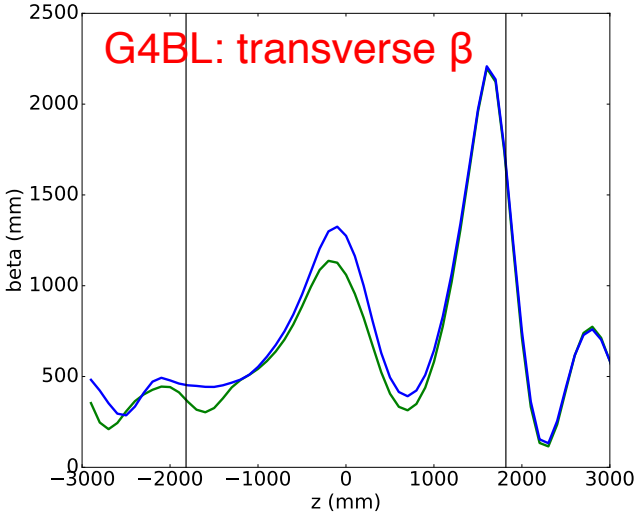
Notice that bins are automatically generated by max. *x* and *y*. With different beam size and low stat., # of particles in a certain bin, especially at the center may fluctuate

  - Scenario 1: particles get out of the fiducial volume, and get back at STN 5. Recon extrapolates at STN 4;
  - Scenario 2: particles get out and are lost. Recon extrapolates from previous 3 STNs.

Run 8280 – investigate the optics

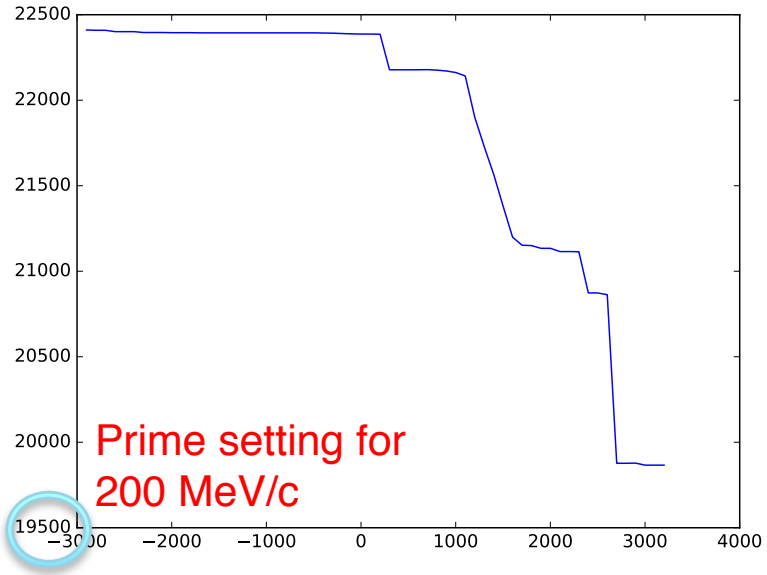
- Where do we lose beam?
  - Almost all lost adjacent to M2D
  - With the mismatch, beam has huge beta function at M2D
- Also consistent with the "transmission dip" with fiducial cut at TKD STN4: beam slightly bigger but reduces at STN 5

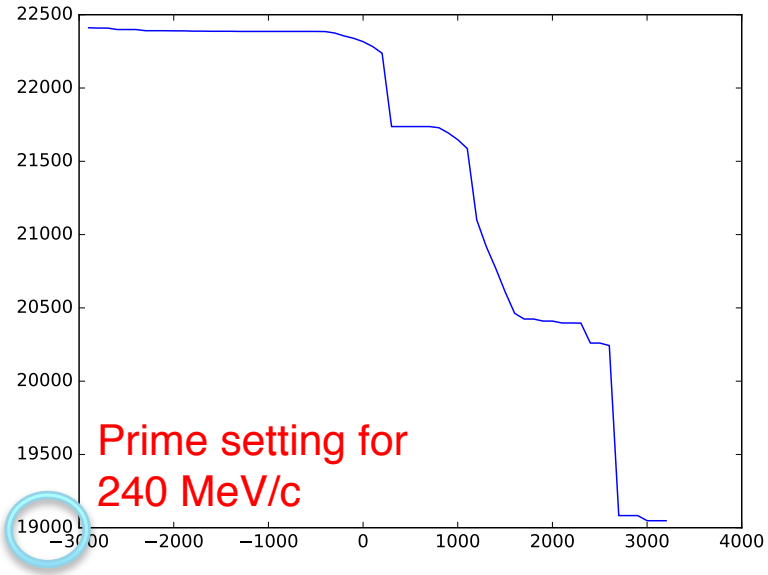




Run 8280 v.s. Run 8280 prime

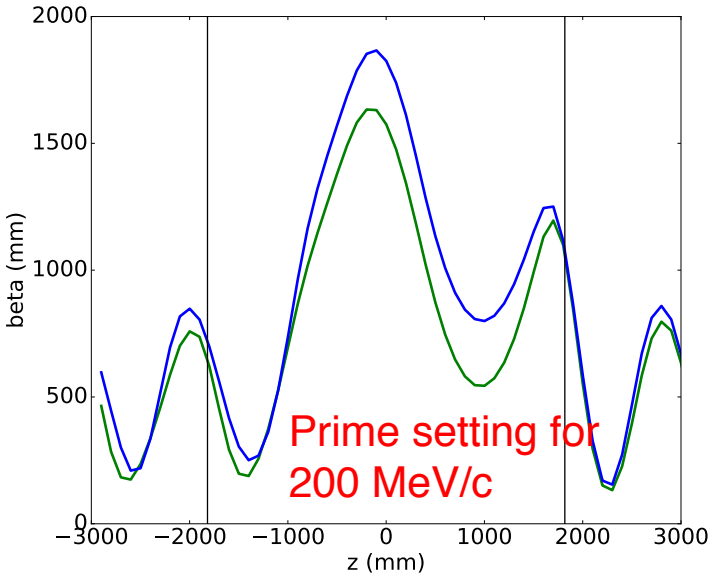
- From the GA optimization, the best setting for 200 MeV/c was proposed in the “prime version” of the run plan. However we have not reached that far yet.
- If we ran with “8280 prime”, the transmission would have looked like: (results were both obtained with G4BL) 88.6% and 85% to TKD STN5

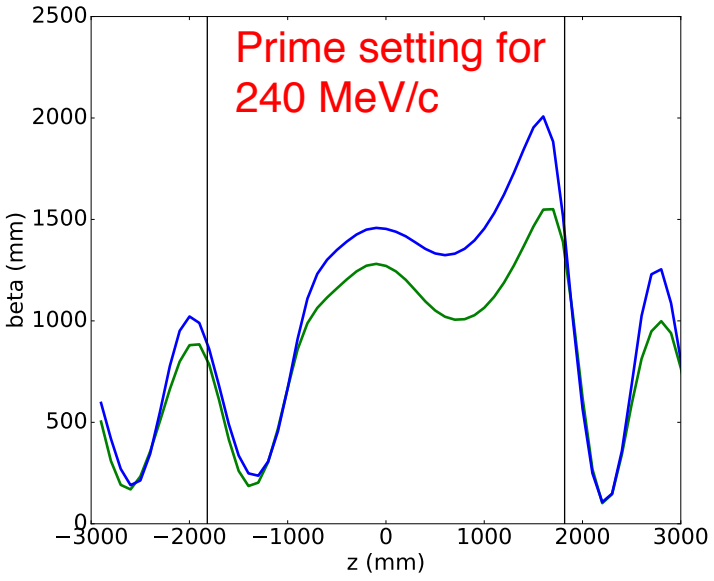




Run 8280 v.s. Run 8280 prime

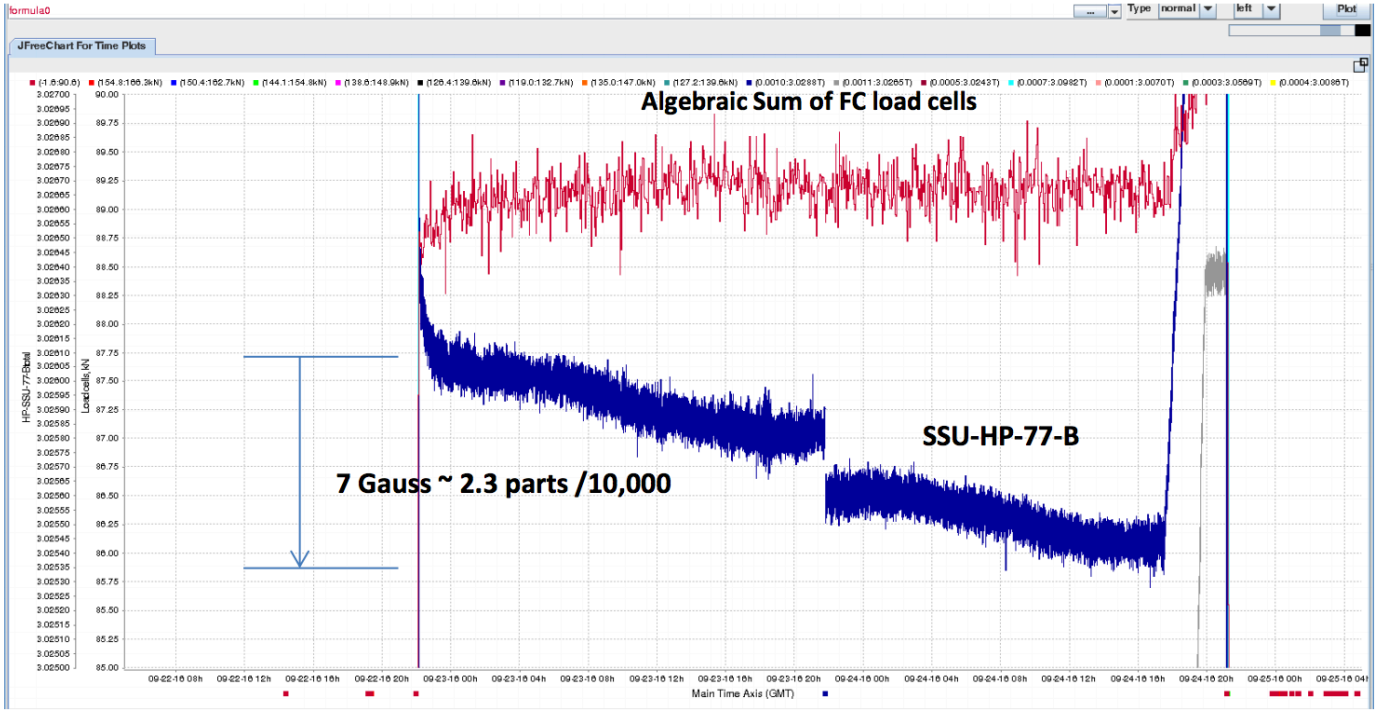
- From the GA optimization, the best setting for 200 MeV/c was proposed in the “prime version” of the run plan. However we have not reached that far yet.
- If we ran with “8280 prime”, beta functions would have been like:





Run 8277 and 8280

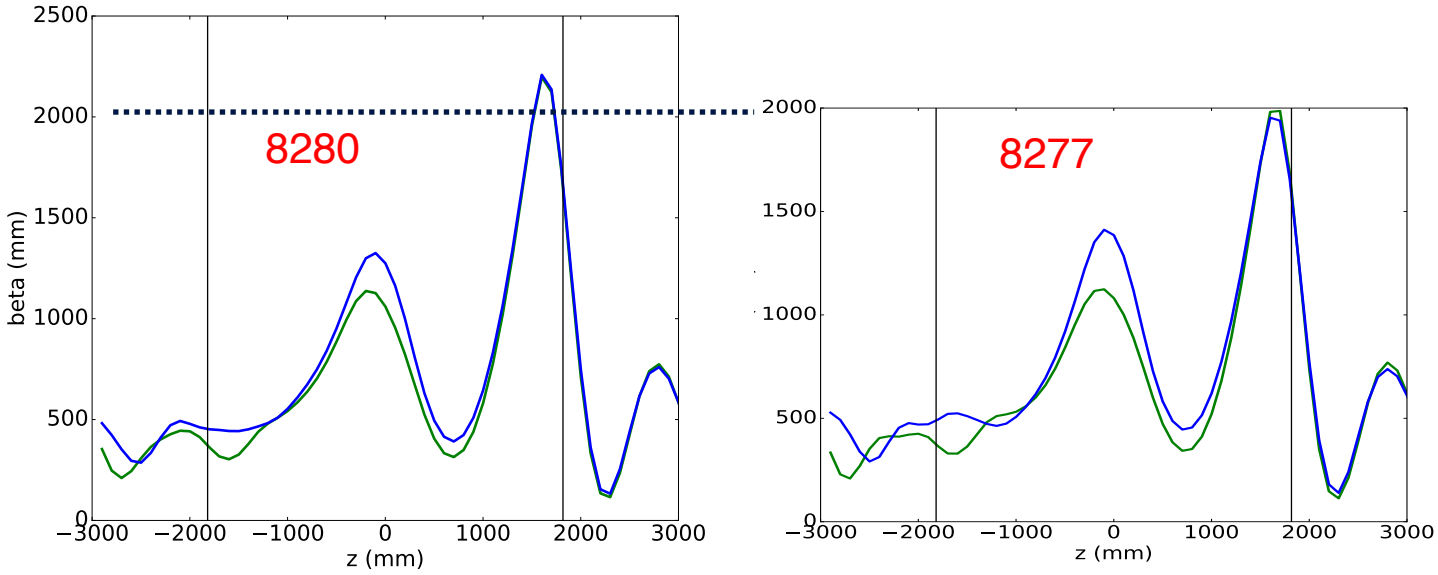
- 8277 had very low statistics – 5500 muons to start with at TKU STN 5;
- It is, however, the only other 170 MeV/c beam run before the hall probe observed a shift in force: (Sep. 23, 22:00)



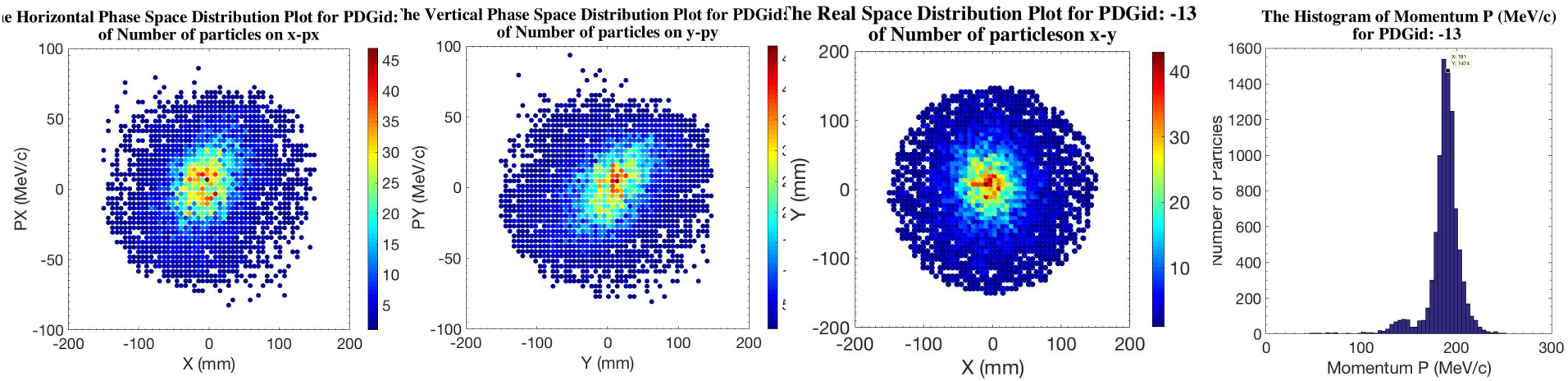
- Beamline setting are almost the same: except for D2, Q1 – Q3

Run 8277 and 8280

- 8277 had very low statistics – 5500 muons to start with at TKU STN 5
- Transmission remains the same: 46% v.s. 47% from data, 50% v.s. 50% from G4BL
- With low statistics it's not too necessary to check the optics, but here it is



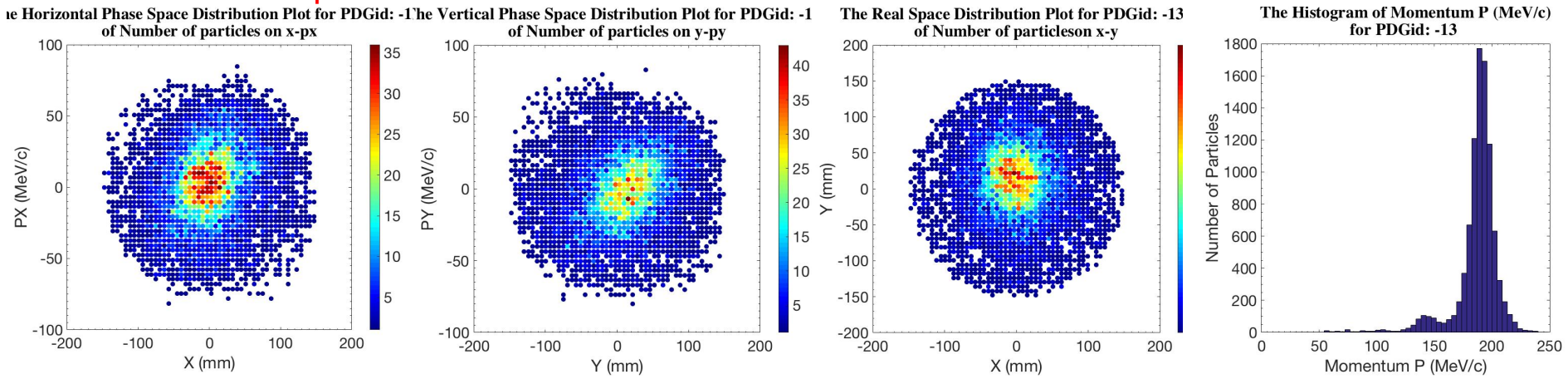
Comparing Run 8281 (200 MeV/c) with G4BL



Upper: measured muons at TKD, STN 5. Transmision is ~ 62 %

Lower: tracked muons at TKD, STN 5. Transmission is ~ 66 %

Muon momentum peaks at ~ 193 MeV/c



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Conclusions

- Data matches G4BL and MAUS simulations qualitatively
  - Additionally, MAUS and G4BL match well.
  - Working on quantitative analyses and adjustments to the G4BL model to fit the data
- With the realistic mismatched input beam in the channel, transmission will be a lot better with the prime settings
- To do
  - How to do PID better (tools are there but not easy to implement)
  - Optimize the cooling channel setting with realistic input beam (with LiH)
  - More stringent optics analyses are under way!