Beamline Analysis & Emittance Measurement

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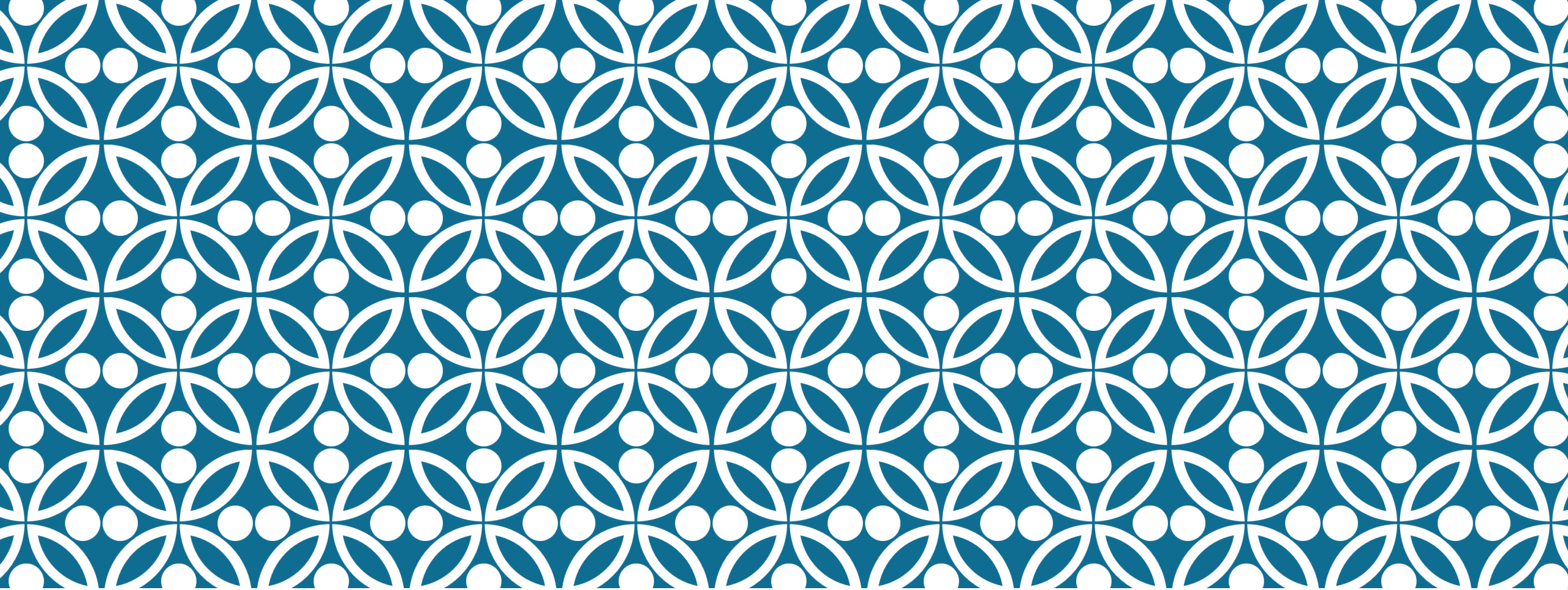
CM43
29th October 2015



Q123 Tuning

MICE Note 476

Analysis Issue 1730

Runs 6715—6729

Run Plan & Goals

- Run plan link
- Aim: Improve beam matching through the Decay Solenoid (DS), and thus the particle rate through to the experiment
  - J. Pasternak performed initial transport studies and provided new Q123 currents
- Complication: TOF1 was **out** of the beam.
- Analysis could only look at the relative intensity of different beam line settings at TOF0
- 500 spills/setting

Nominal (6,200) beamline settings

Run	Q1 A)	Q2 (A)	Q3 (A)	…
6715	**102.4**	**127.9**	**89.0**	(6,200) beamline
6718	97.3	124.1	86.3	
6719	90.1	118.9	80.1	
6720	95.2	117.7	74.8	
6721	132.6	188.3	89.4	
6724	158.3	179.2	198.5	
6726	85.97	146.61	117.65	
6727	94.41	140.64	110.9	
6728	38.18	115.7	110.12	
6729	87.39	138.82	113.5	

Reconstructing data

- Data **<u>are not</u>** part of the batch-processed data sets
- As TOF1 was not on the beam line, and TOF0 was the trigger, the unpacker had to be modified
  - Instruction was given by Yordan (see issue tracker)
- Data reconstructed with MAUS version 1.0
  - Analysis is independent of any detector geometry, so should be unaffected by recent TOF fixes

- **File** TOF_assumptions.pdf added
- **File** runs_6715_6729_ExtractedTOF0Data.zip added

Reading runs 6715--6729 with MAUS is not possible without two modifications:

1. A "hack" to the unpacker. Instructions from Yordan:

```
a. Open the file
/third_party/build/unpacking-mice/src/MDprocessManager.cpp
and edit the line 253
from     if (MDequipMap::GetName(GetEquipmentType())!="VRB") {
to          if (MDequipMap::GetName(GetEquipmentType())!="VRB" && MDequipMap::GetName(GetEquipmen

b. rebuild the unpacking:
source env.sh
cd /third_party/build/unpacking-mice/build/
cmake  -DCMAKE_INSTALL_PREFIX=${MAUS_ROOT_DIR}/third_party/install -DSTEPIV_DATA=1 ../
make
make install
```

2. Changing `TOF_trigger_station = "tof1"` to `TOF_trigger_station = "tof0"` in `$MAUS_ROOT_DIR$/src/common_py/ConfigurationDefaults.py` (line 535)

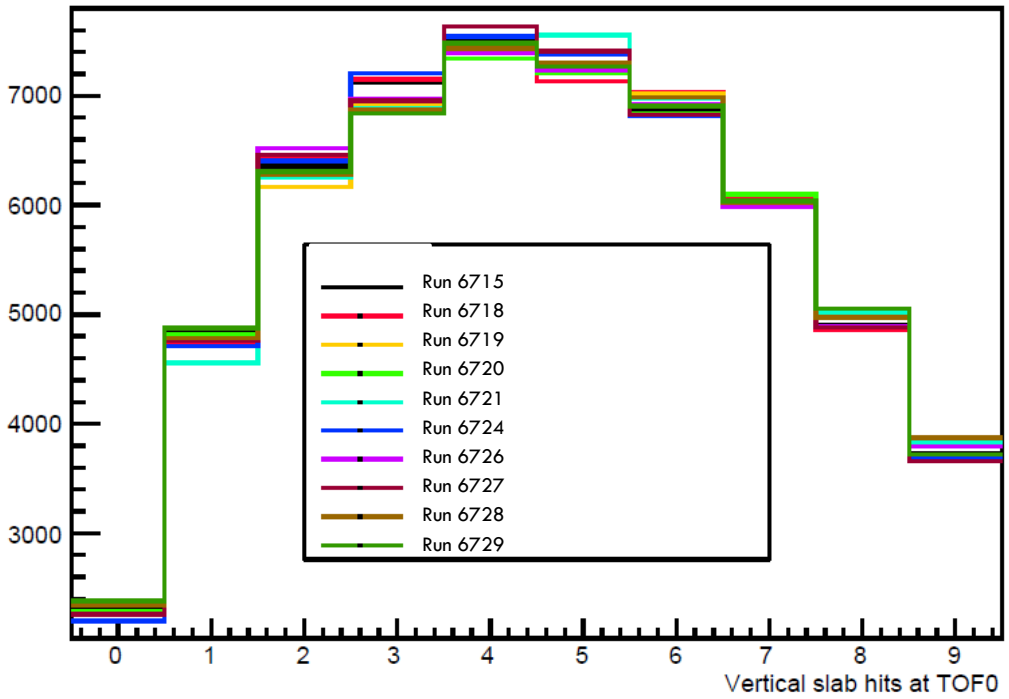
Doing the above has worked with MAUS version 1.0.

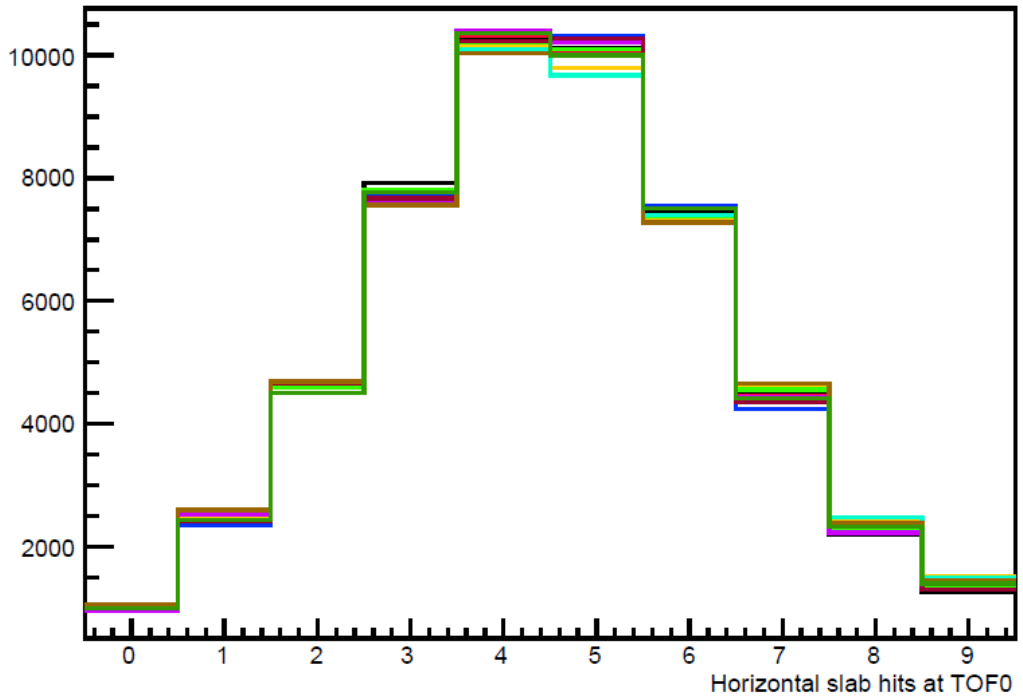
As there is no valid calibration for TOF0 during these runs, space point reconstruction is extremely poor. Instead, I have stripped off the horizontal and vertical slab hits into a separate root file (archive attached to this entry). Assumptions used when converting slab numbers to (x, y) co-ordinates are also attached.

First checks

- Plot **all** slab hits in horizontal and vertical slabs
- Normalise to standard "(6, 200)" run
- Compare distributions

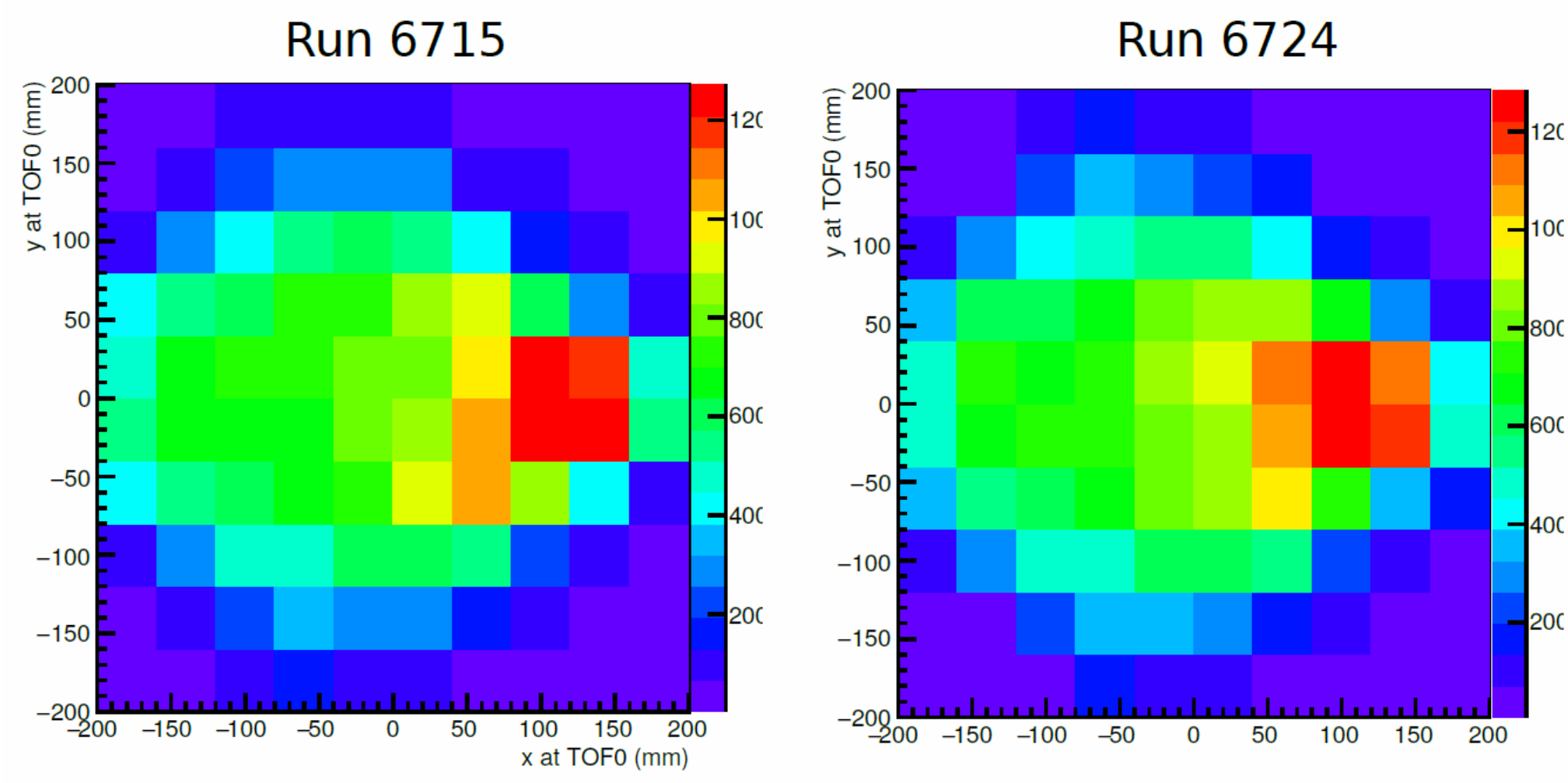
- No appreciable difference in plain slab hit distributions





Finding TOF Pixels

- TOF0 uncalibrated at this time
- Take pairs of one horizontal & one vertical slab hit as a 'pixel'
  - Subsequent matches within 'an event' are ignored
- Negligible changes to beam profile at TOF0



Conclusions

- Quantify beam intensity at TOF0 as the number of pixels made per spill.
- Nominal (6, 200) beam is optimal
- Suprising?
  - Beam is protons + pions in Q123
  - Fill DS aperture
  - Any 'improvements' scraped away
- Want to see more plots? See the issue tracker
- Better quality tables? See MICE note 467

Table 2: Mean x and y as measured at TOF0 in runs 06715–06729 and the relative number of pixels per spill produced.

Label	Run	$\bar{x}$ (mm)	σ_x (mm)	$\bar{y}$ (mm)	σ_y (mm)	Total pixels	Total spills	Pixels/spill	% of nominal intensity
Task 5.1: $(6\pi, 200)$	6718	-0.3332	96.76	-1.968	73.61	39016	1002	39	100
Task 5.2	6718	-0.63	96.43	-1.36	74.28	35236	998	35	90.6
Task 5.3	6719	-1.92	96.17	-1.61	74.54	31263	1000	31	80.3
Task 5.4	6720	-1.61	97.04	-1.18	73.45	31495	1002	31	80.7
Task 5.5	6721	-2.28	95.96	-1.20	74.54	26514	998	27	68.2
Task 5.6	6724	-1.53	95.74	-1.68	73.69	39647	994	40	102.4
Task 5.7	6726	-0.63	96.83	-1.74	73.81	32547	996	33	83.9
Task 5.8	6727	-0.66	96.38	-1.75	73.93	35583	1000	36	91.4
Task 5.9	6728	-0.83	96.99	-1.72	74.65	25669	1001	26	65.9
Task 5.10	6729	-1.49	96.97	-0.99	74.06	32724	997	33	84.3

SSU-on Data

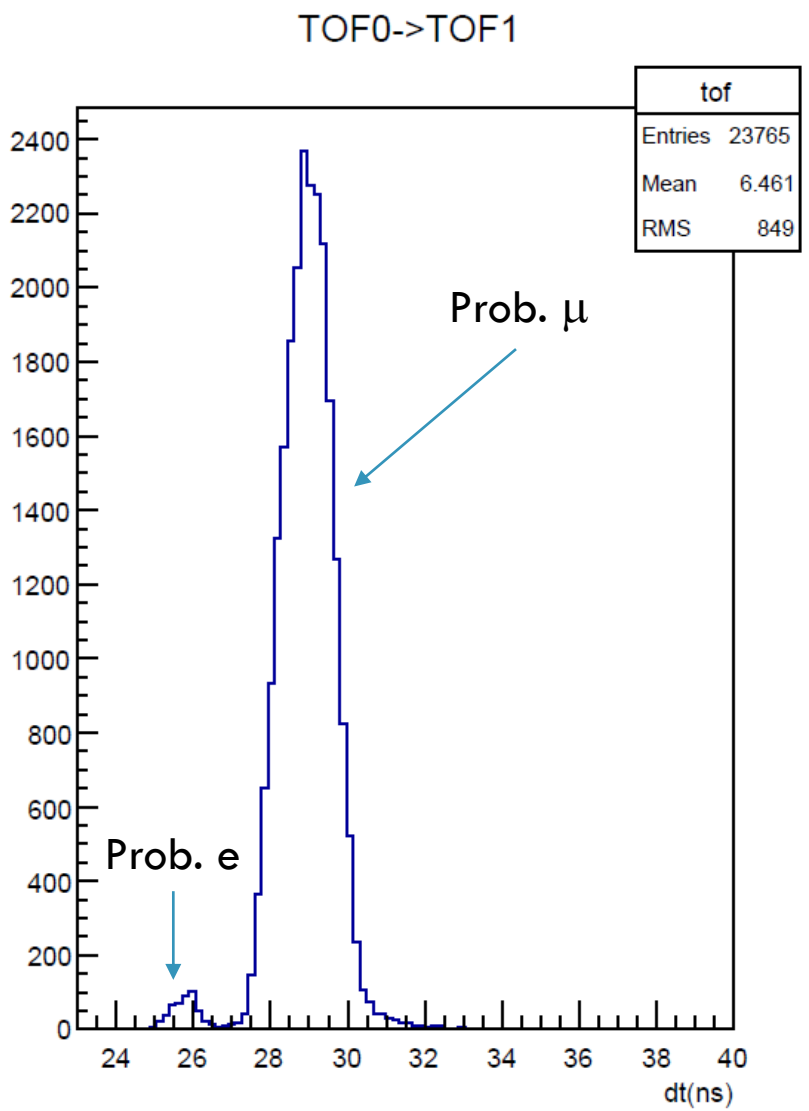
MAUS Issue 1782

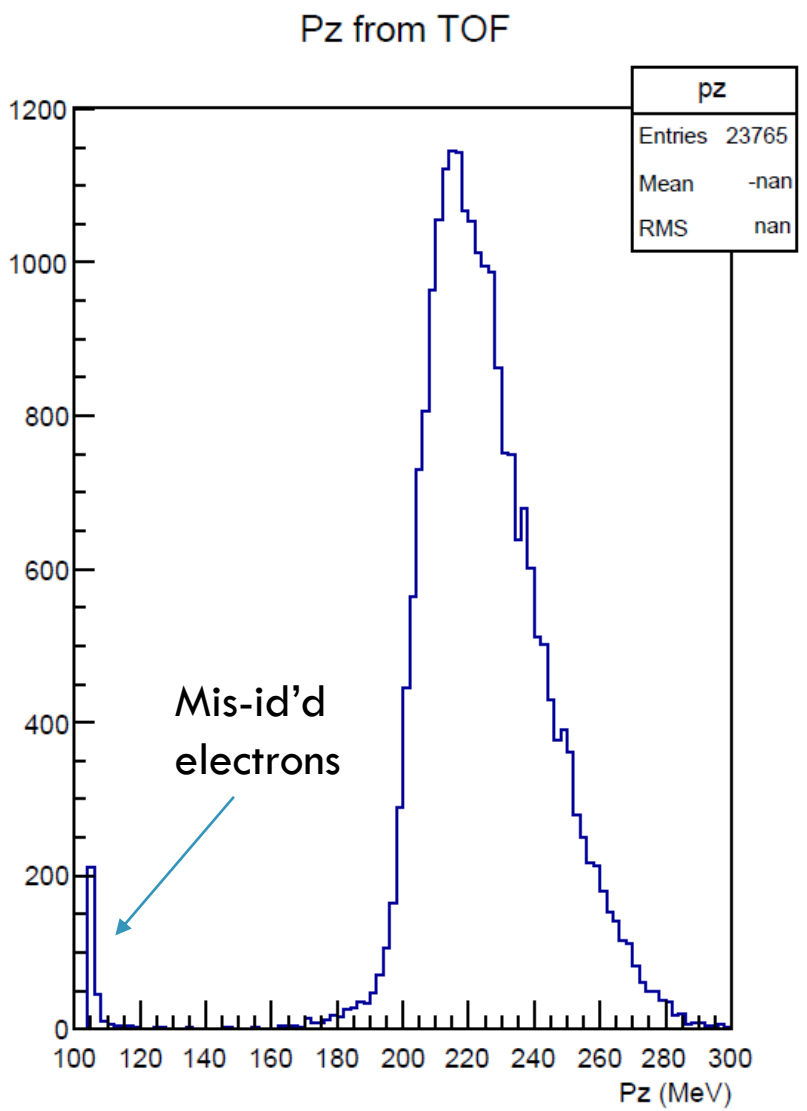
Run 7469

Run 7469

Unanswered Questions

- Looking at "that" data
  - SSU E1-C-E2 coils at nominal (4T) currents
  - Currents did not account for M1 & M2 being off
  - Currents did not account for PRY
- Simple analysis aims:
  - Get particles at TOF0, TOF1, TKU (from track points) planes 5—1
  - Assume particle is a muon
  - Calculate Pz from TOF
  - Compare to tracker reconstruction
  - Reconstruct emittance "slices"





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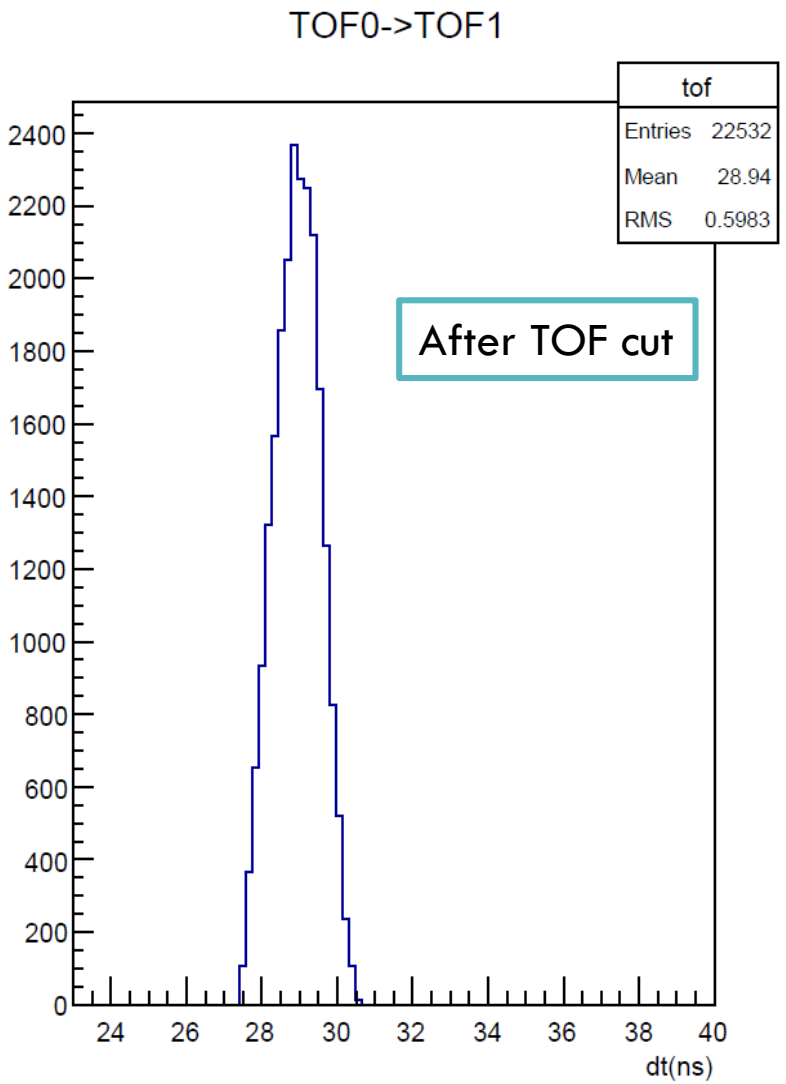
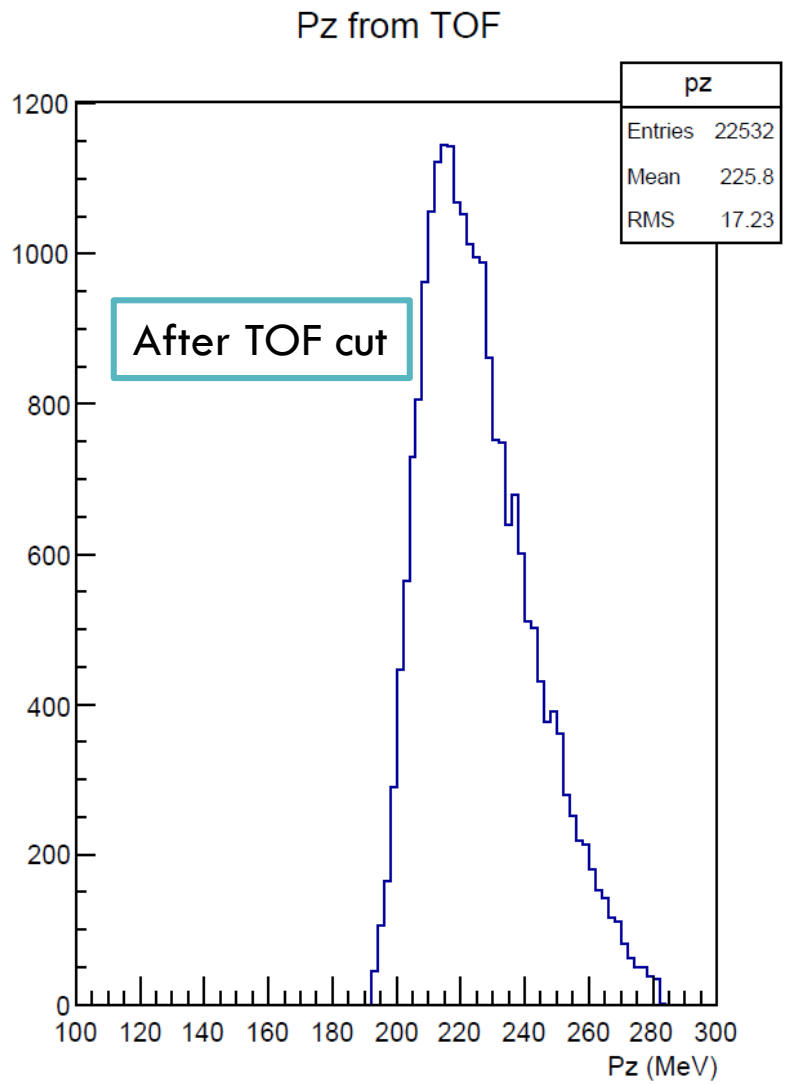
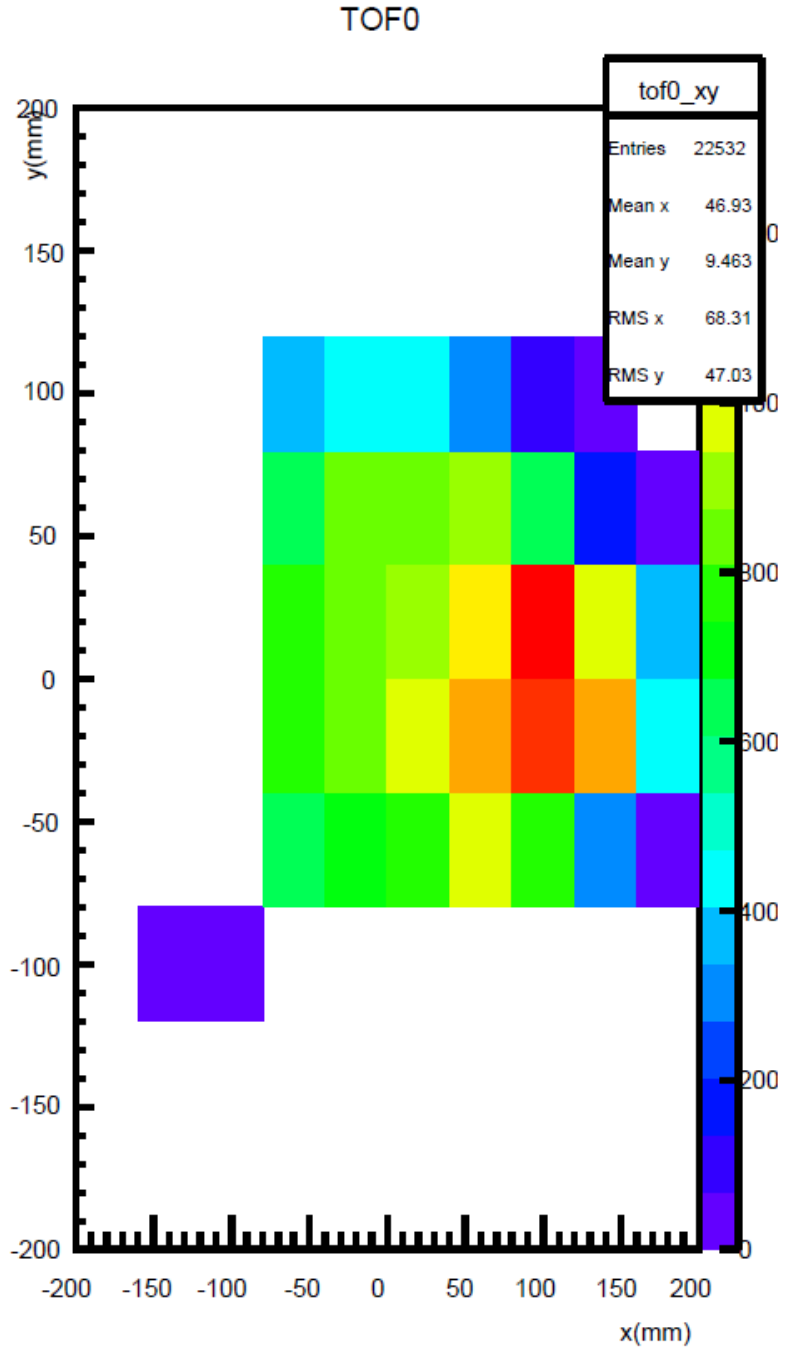


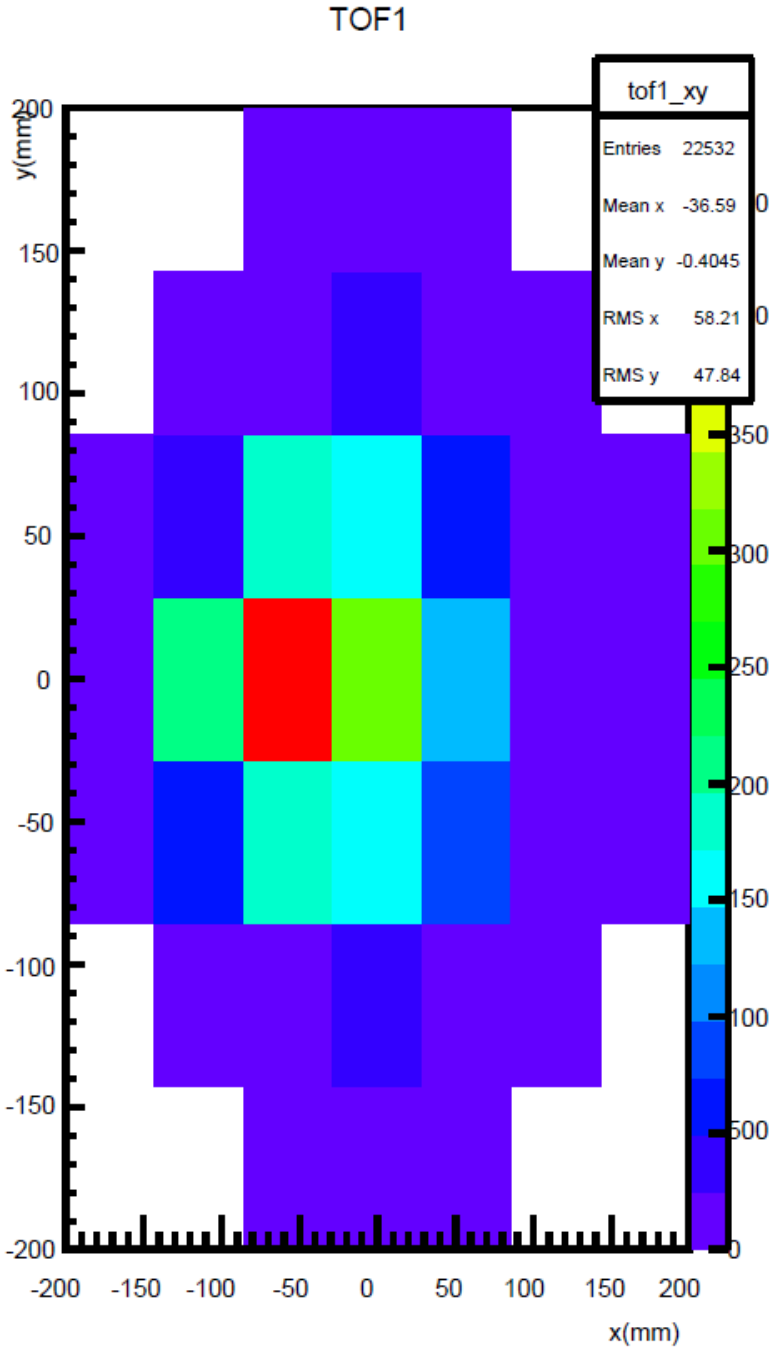


Beam profile at TOFs (TOF Spacepoints)

Full disclosure:

- Analysis uses MAUS v1.1.0
- Link to reconstructed data
- Data reconstructed using MAUS v1.1.1
- Seems OK with no conflicts?
  - But then, only reading the ROOT file data structure…

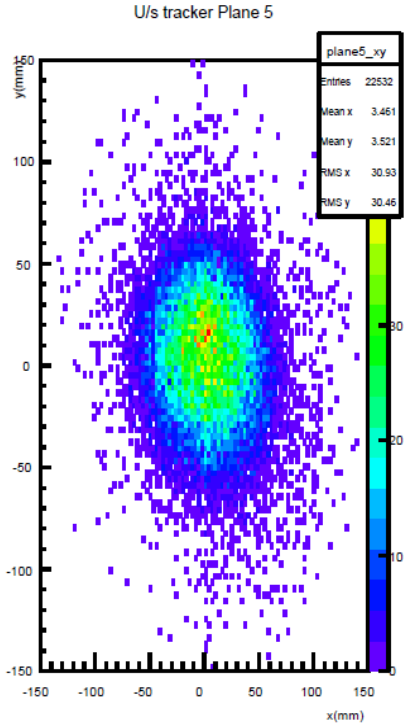


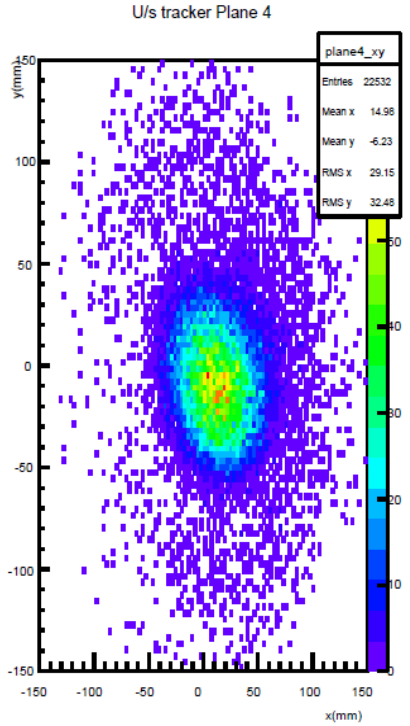


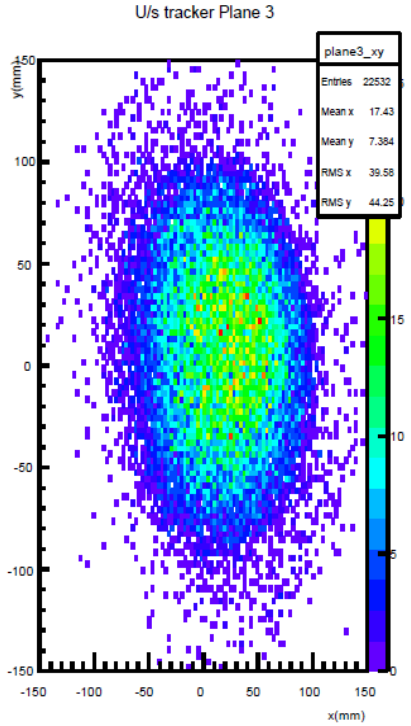
Beam profile at TKU planes (Track Points)

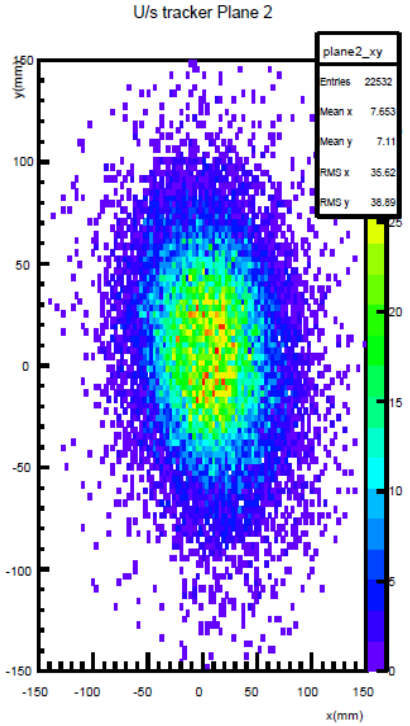
Plane	5	4	3	2	1
# Entries	22523	22523	22523	22523	22523
$\langle x \rangle$	3.46	14.98	17.43	7.65	7.12
σ_x	30.93	29.15	39.58	35.62	30.25
$\langle y \rangle$	3.52	-6.23	7.38	7.11	1.78
σ_y	30.46	32.48	44.25	38.89	33.22

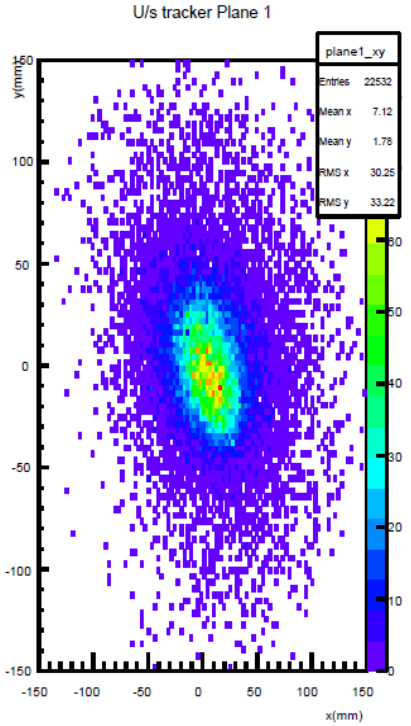
Most upstream







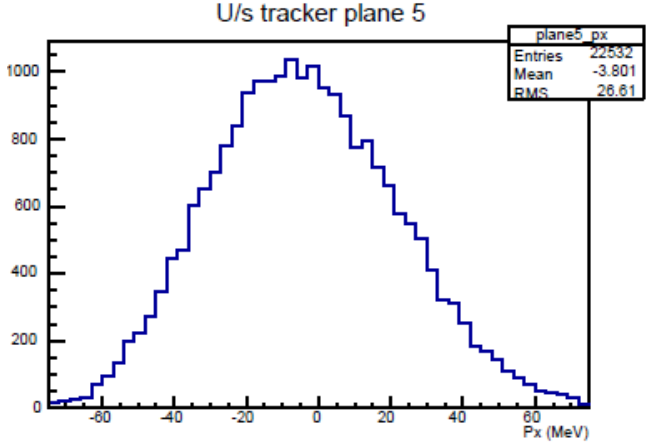


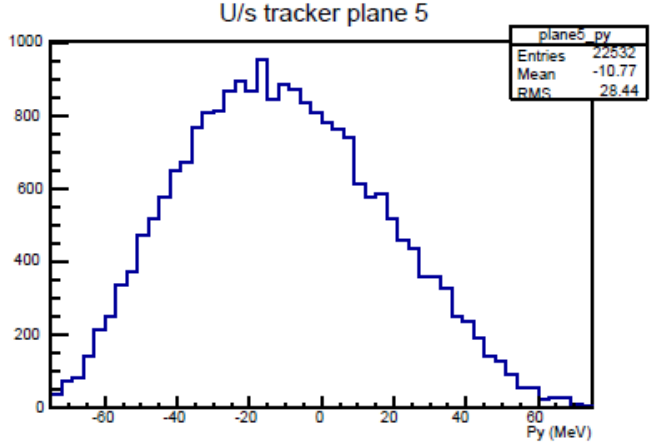


Most downstream

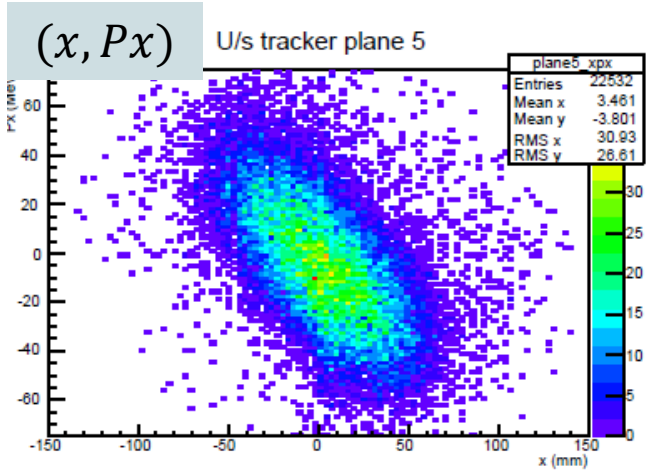
Momentum at TKU plane 5
(Track points)

	$\langle \dots \rangle$	$\sigma_{\dots}$
x (mm)	3.46	30.93
y (mm)	3.52	30.46
Px (MeV)	-3.80	26.61
Py (MeV)	-10.77	28.44

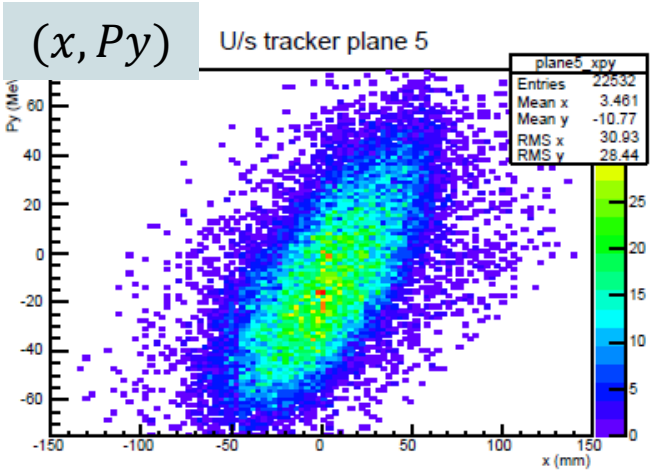




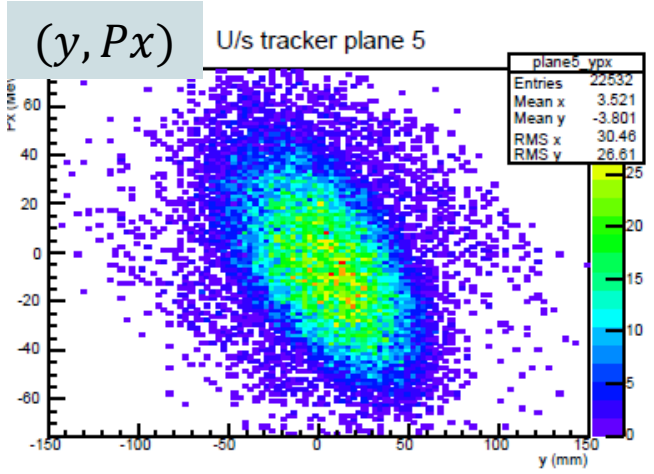
(x, Px)



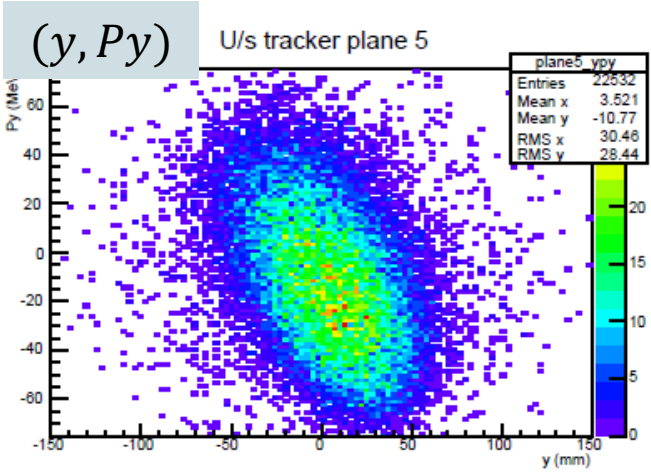
(x, Py)



(y, Px)



(y, Py)

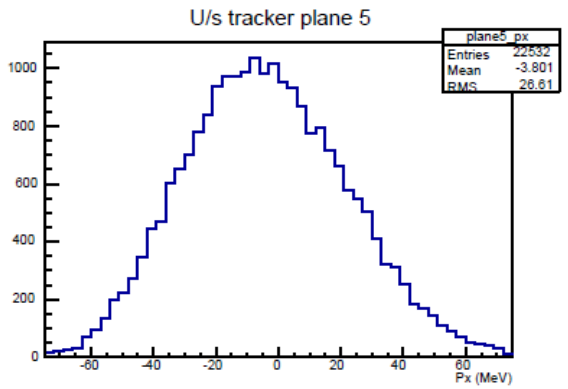


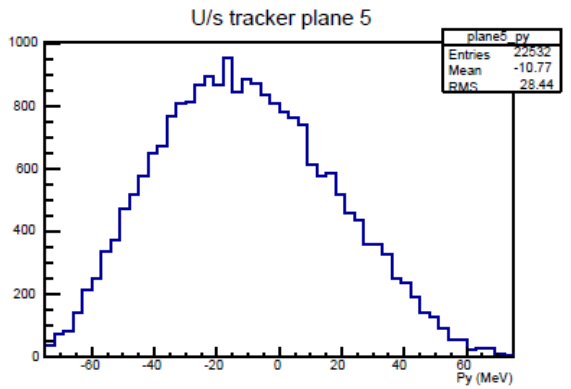
Momentum at TKU plane 5 (Track points)

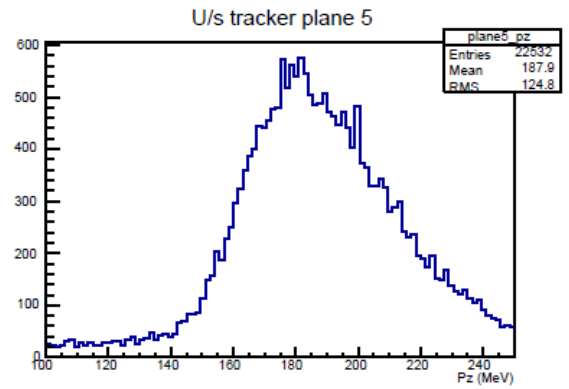
Now for the full story…

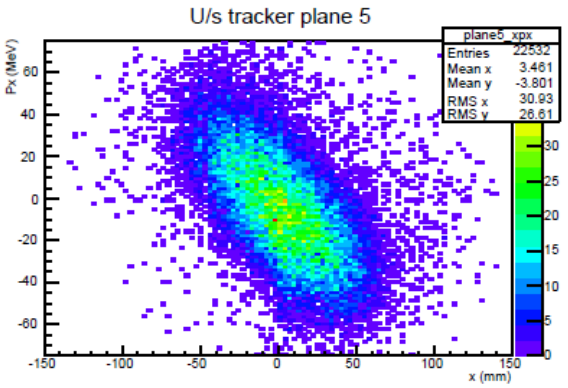
Only cut applied to the following plots is the initial time-of-flight cut

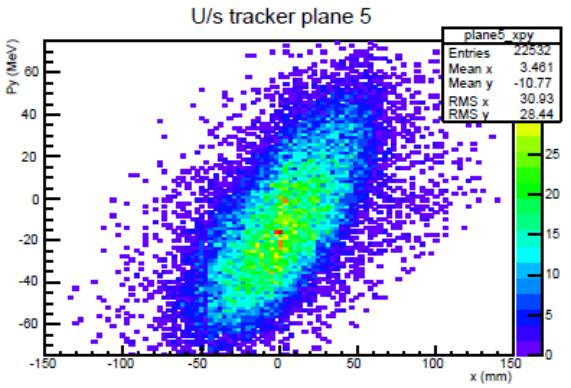
All plotted quantities come from tracker ‘track points’

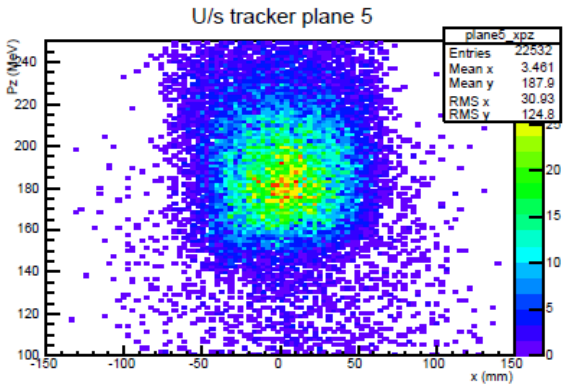


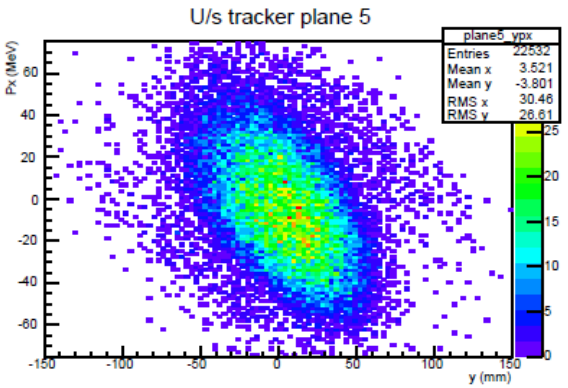


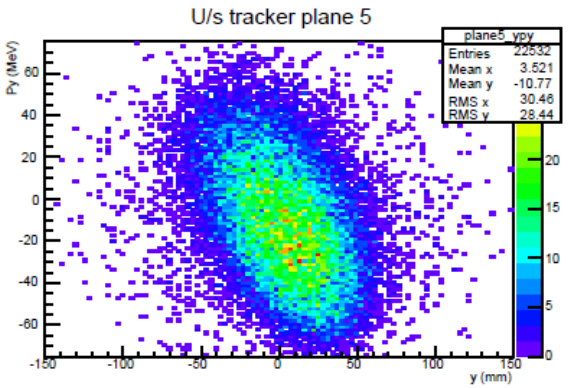


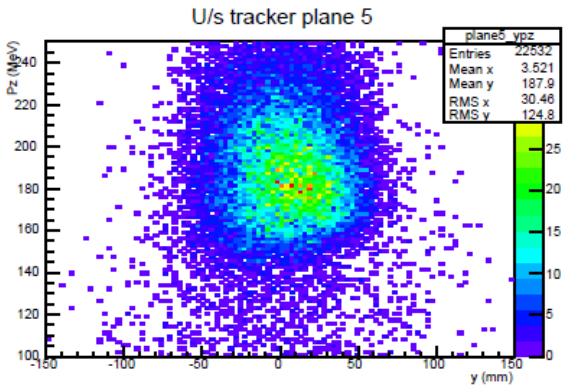












Momentum at TKU plane 4 (Track points)

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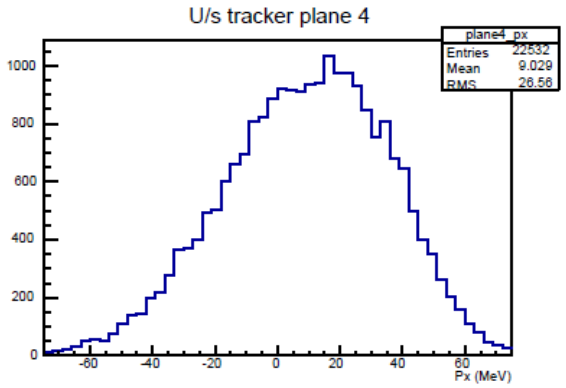

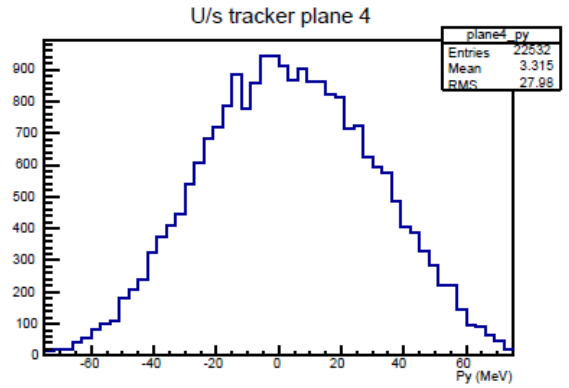

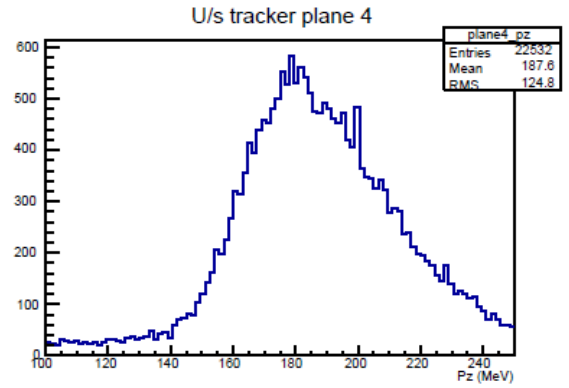

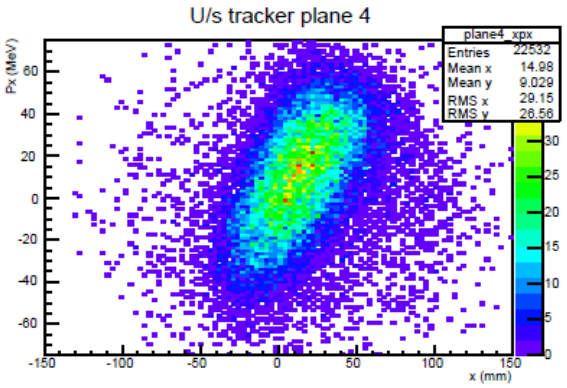

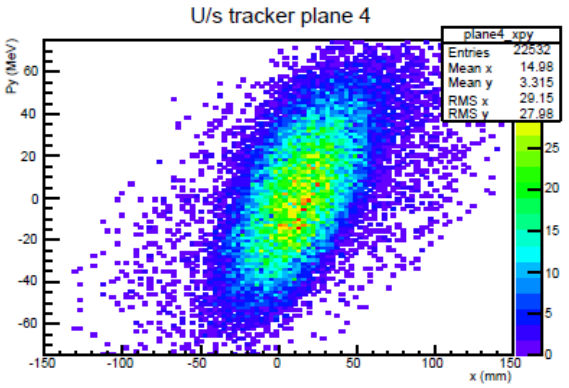

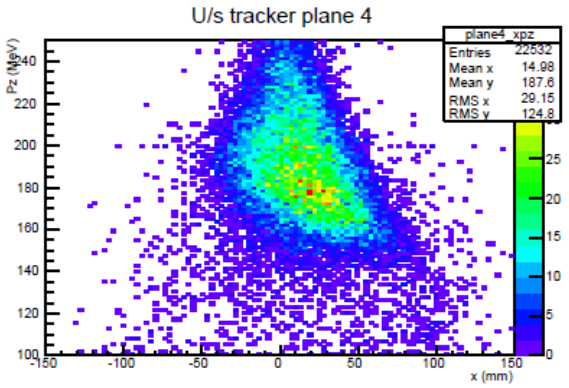

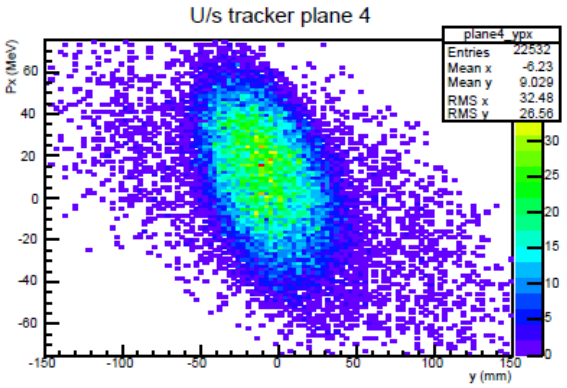

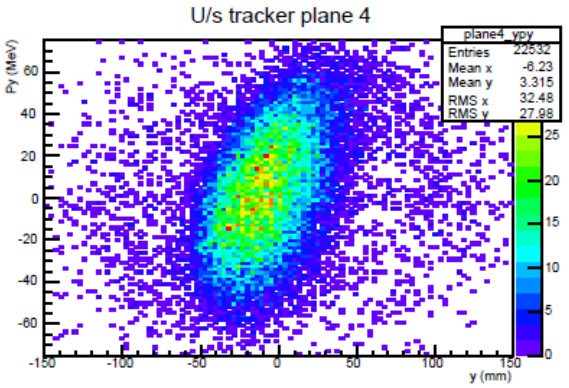

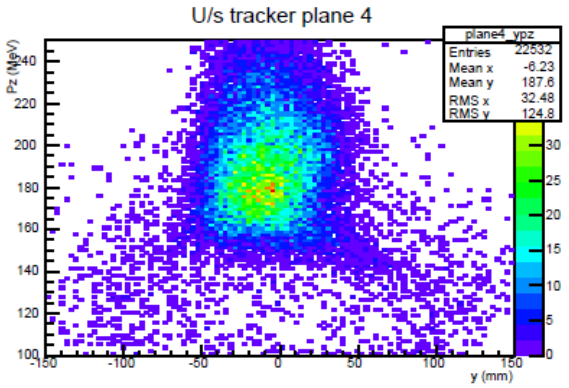

Momentum at TKU plane 3 (Track points)

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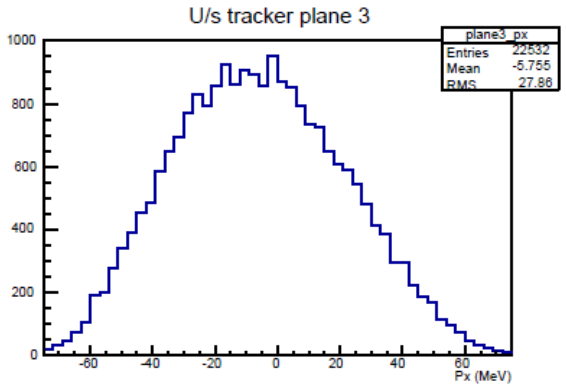
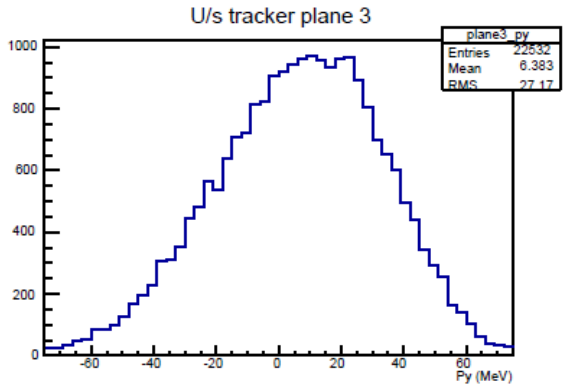
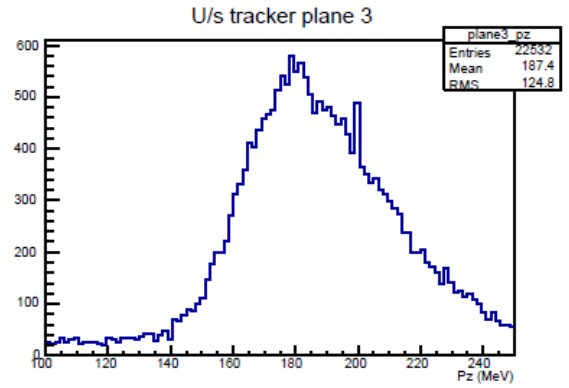
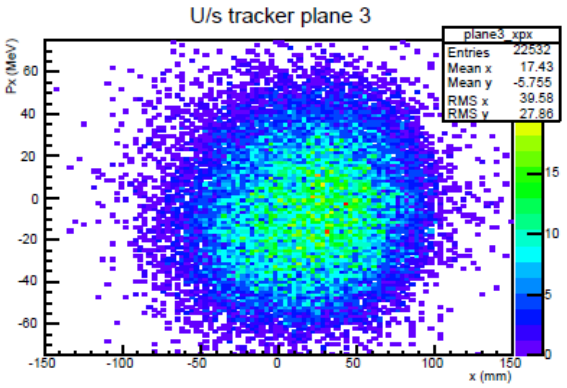
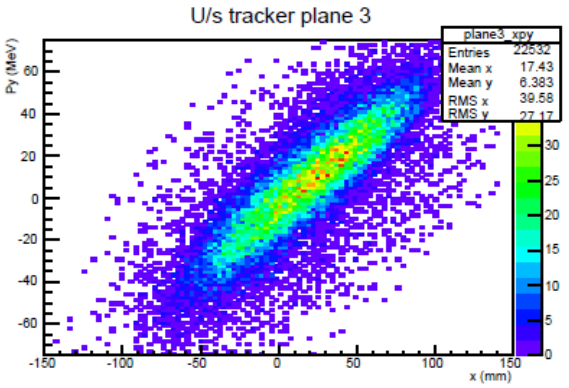
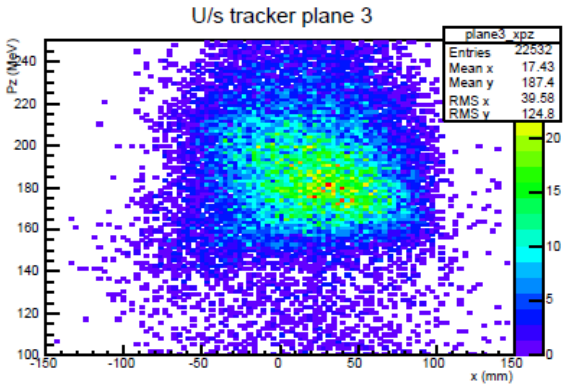


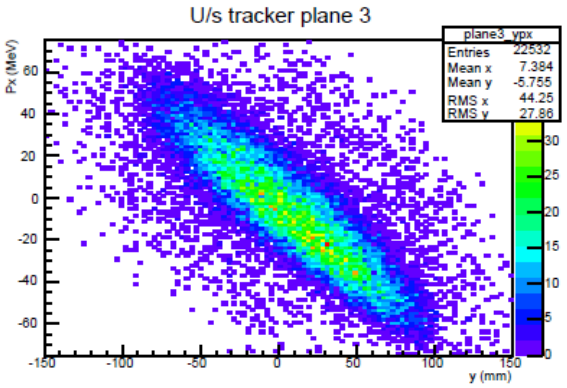


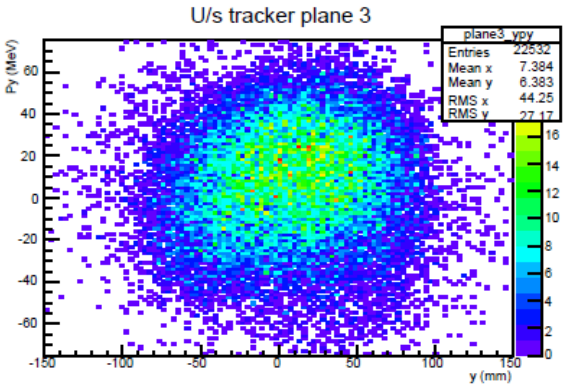


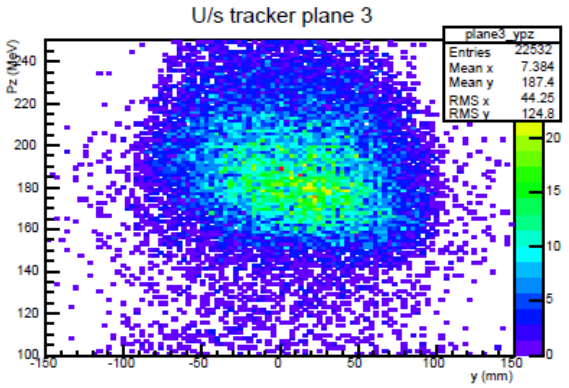










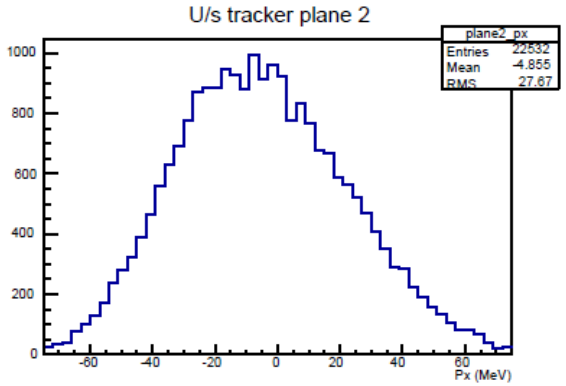


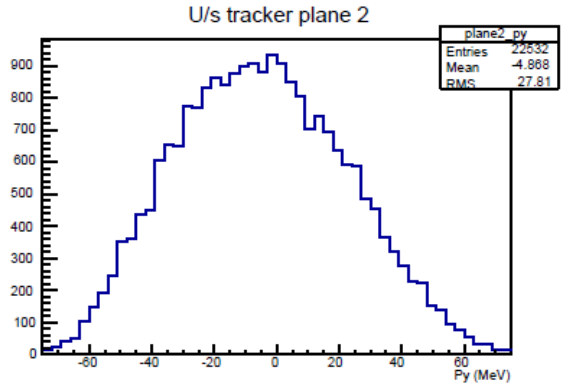
Momentum at TKU plane 2 (Track points)

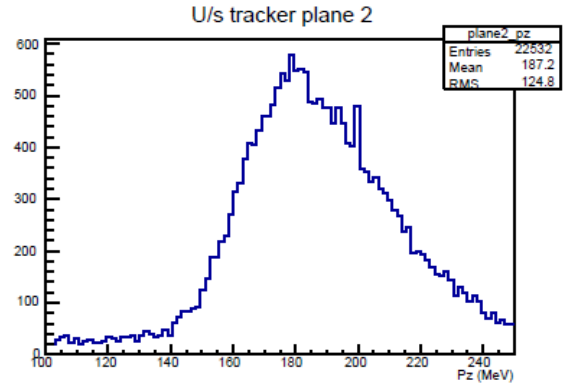
Now for the full story…

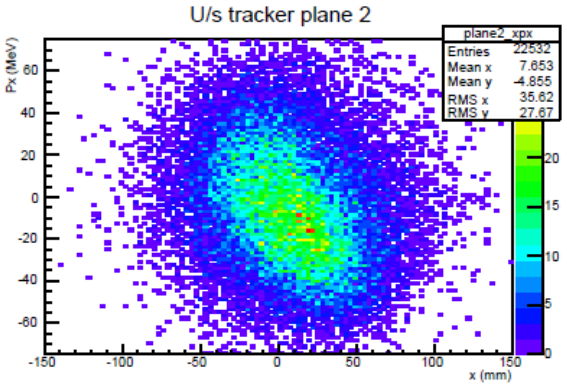
Only cut applied to the following plots is the initial time-of-flight cut

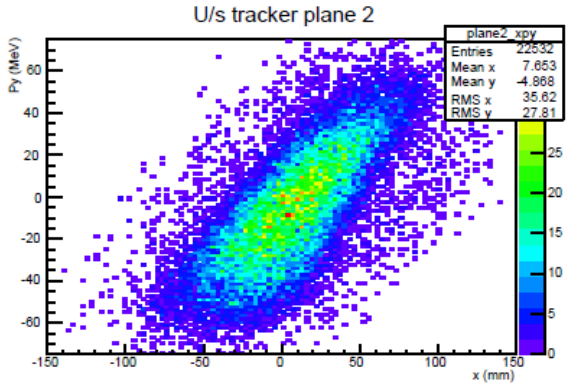
All plotted quantities come from tracker ‘track points’

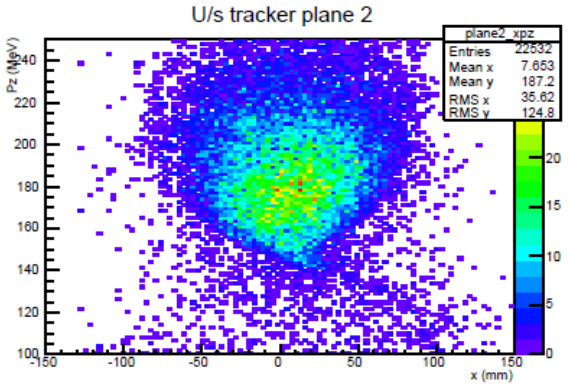


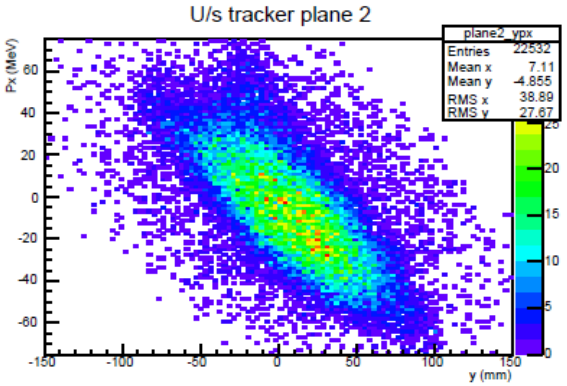


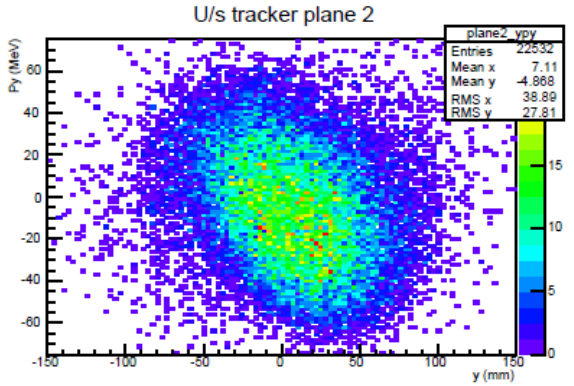


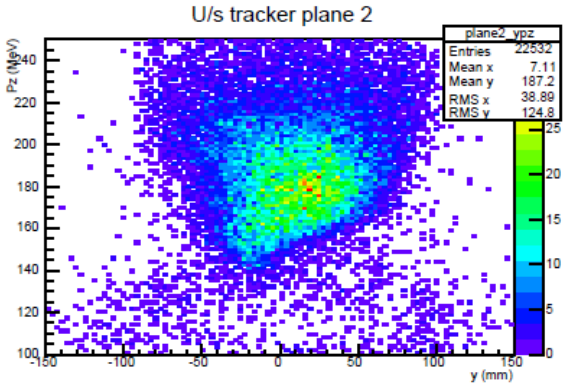










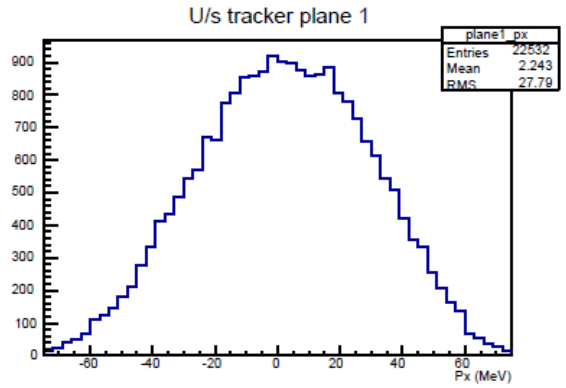


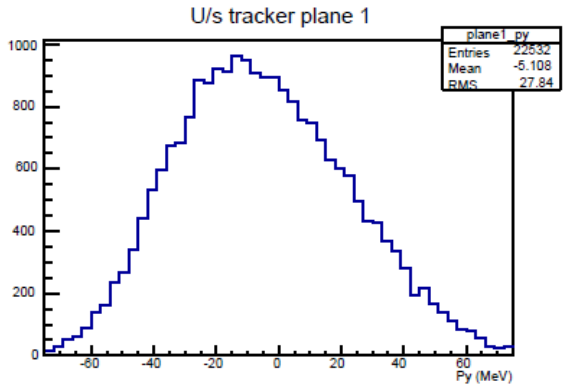
Momentum at TKU plane 1 (Track points)

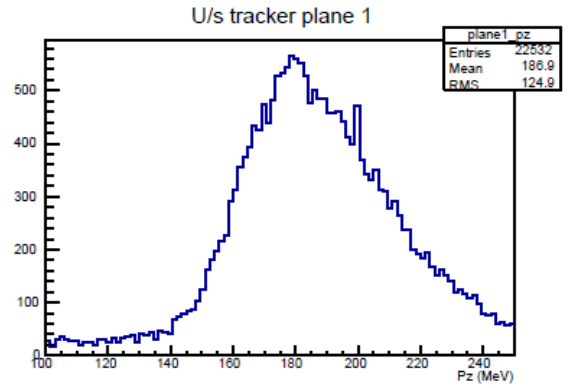
Now for the full story…

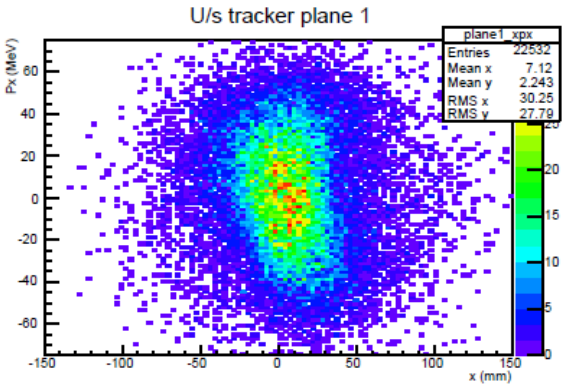
Only cut applied to the following plots is the initial time-of-flight cut

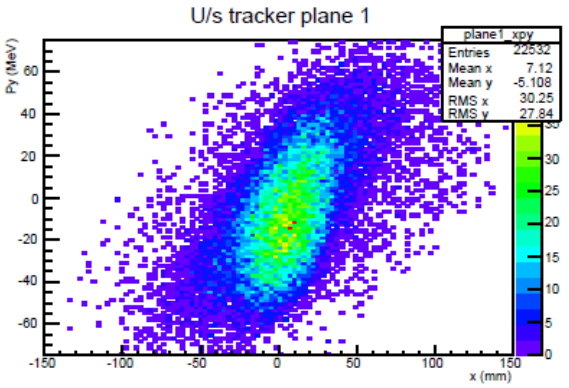
All plotted quantities come from tracker ‘track points’

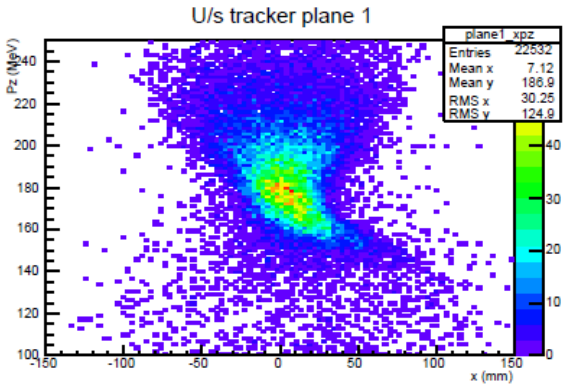


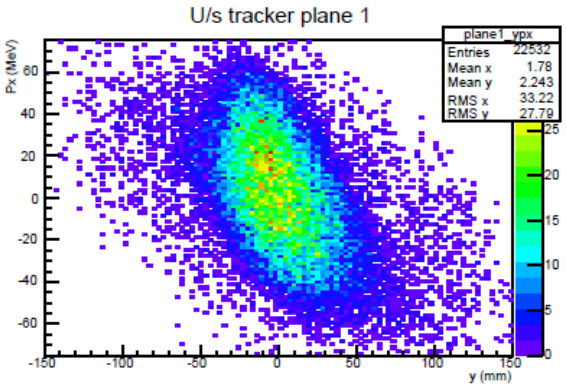


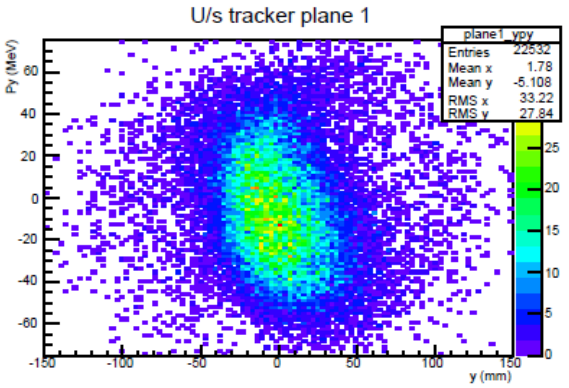


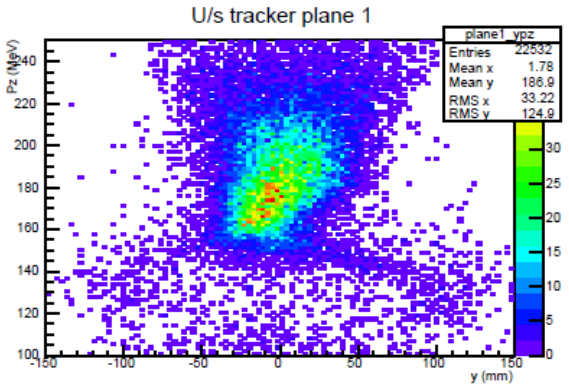








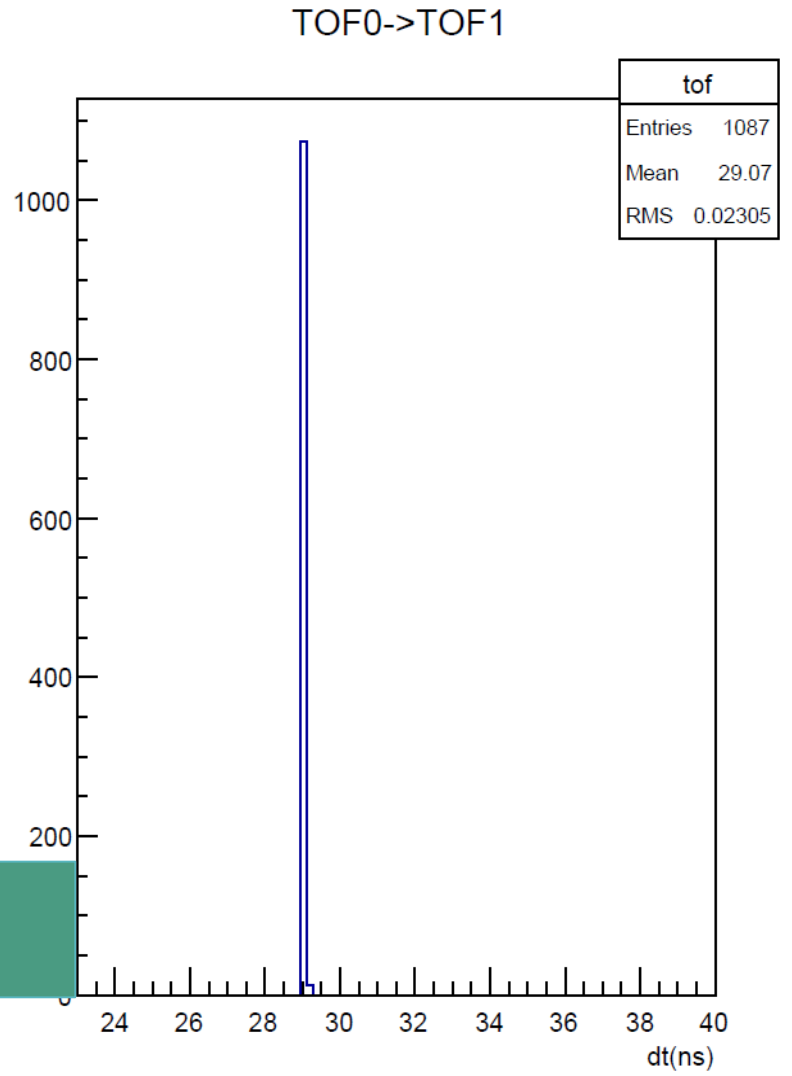


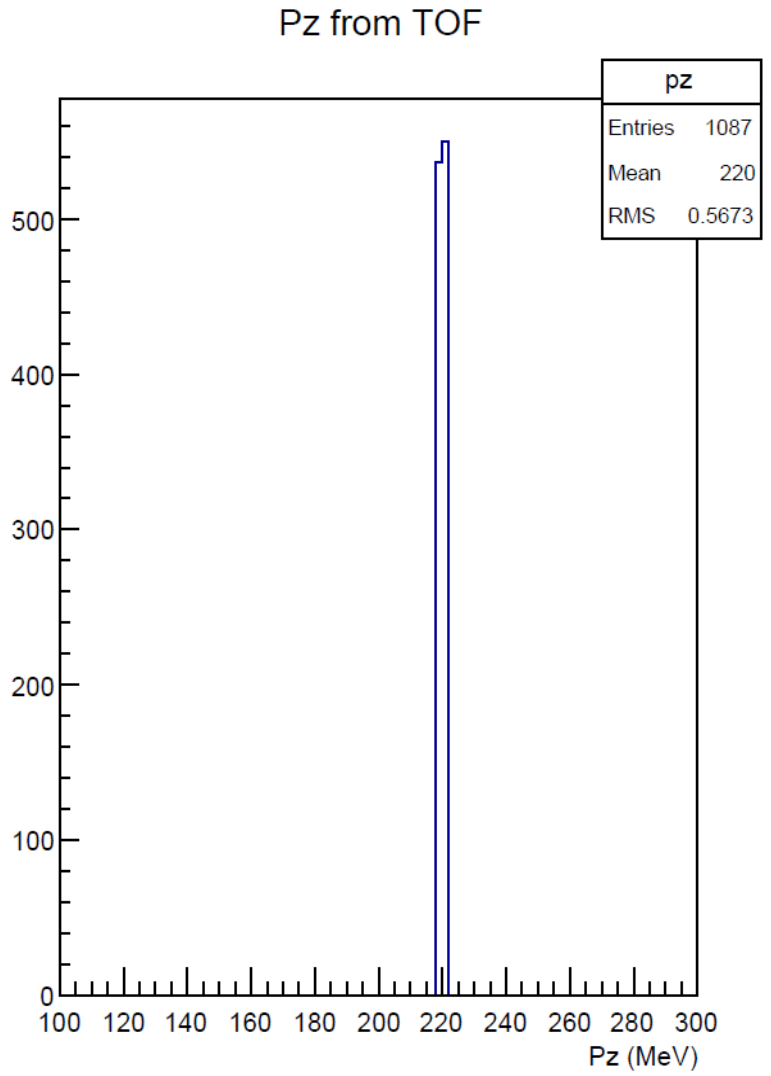


So… Pz looks odd.

- Use “Pz” from TOF (assuming particle is a muon)
- Take a 2MeV wide “slice” to study chromatic effects
- What do these particles look like in the tracker?

Pz at TOF1 = 220 MeV
(1087 muons)

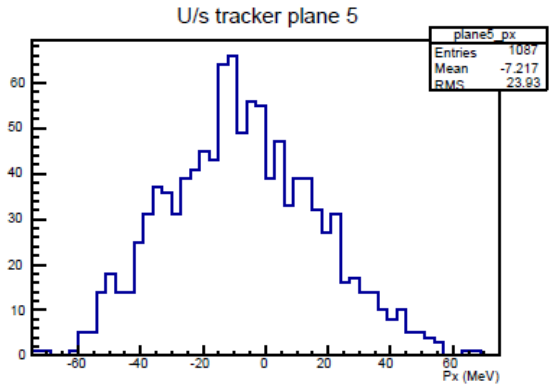


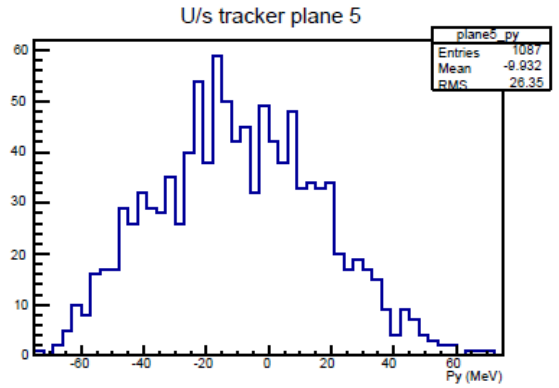


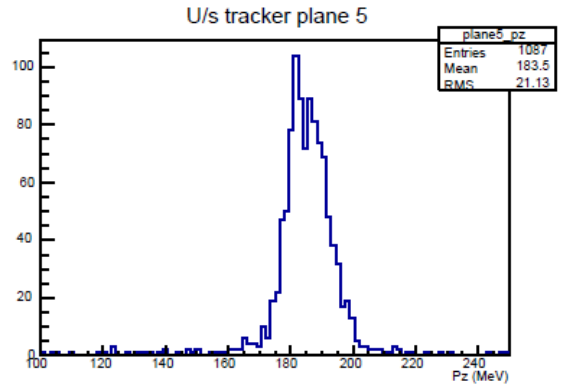
At TKU plane 5

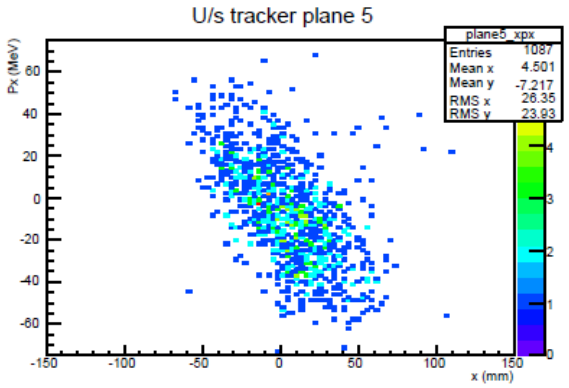
- Closest plane to TOF1

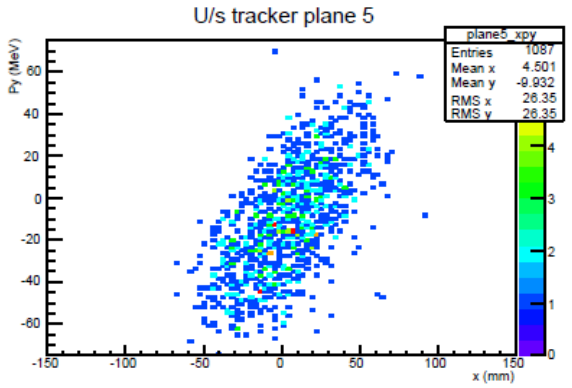
	$\langle \dots \rangle$	$\sigma_{\dots}$
x (mm)	4.50	26.35
y (mm)	7.95	28.3
Px (MeV)	-7.22	23.93
Py (MeV)	-9.93	26.35
Pz (MeV)	183.5	21.13

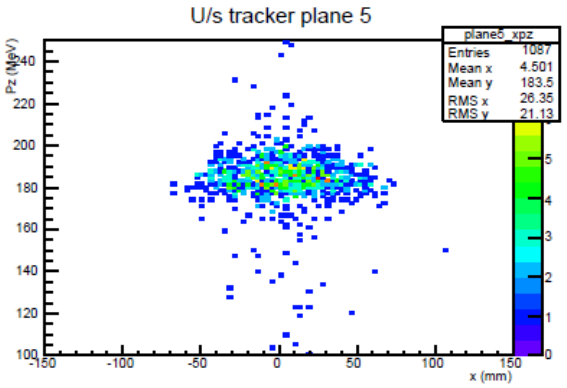


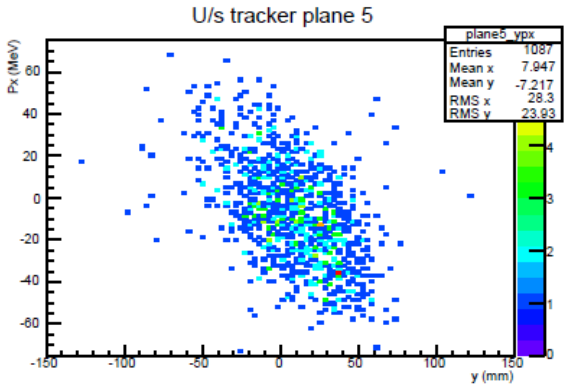


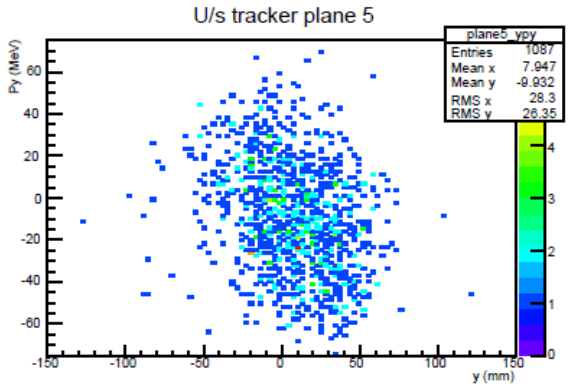


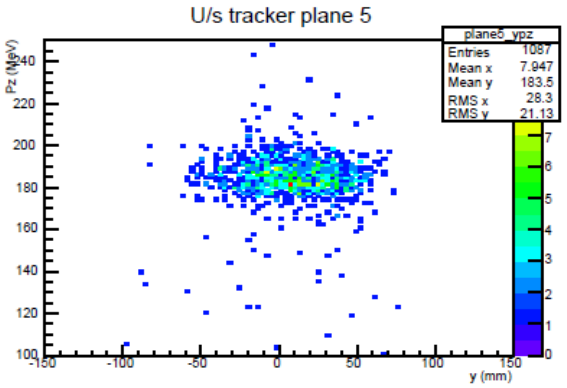












Conclusions

- Selecting 220 MeV +/- 1 MeV at TOF1 'turns into' a 180 MeV (with large spread) beam at the upstream tracker
- Maximum expected beam loss between TOF1 and tracker is ~ 10 MeV

- Tracker Pz reconstruction "cannot be trusted" right now, even at 4T (*C. Hunt*)
- Don't recall hearing of a 40 MeV discrepancy between reconstructed and true MC in the past… C. Hunt is going to find out what's going on

- Other ways of validating **Pt** reconstruction of tracker?
  - Emittance from TOF measurements
  - Not enough time this CM.. May have opened a small can of worms. Oops.
    - *If I go missing, make sure Durga & Yordan are questioned on my whereabouts intensively!*
  - *Other ideas?*