HIGH PRECISION MEASUREMENT OF EMITTANCE

V. Blackmore

MICE VC: 7th Feb 2016

RUN 7469

- Taken on Oct 7th 2015, from 15:39 to 16:48
- (3, 200) M0 mu+ optics
- TOF1 trigger
- No proton absorber (according to CDB)
- DS power supply faulted at the end of the run
- ISIS at 700MeV (not 800!)

Conventional Magnet	Current (A)
D1	304.99
D2	91.48
DS	637.55
Q1	97.71
Q2	122.13
Q3	84.91
Q4	153.52
Q5	205.76
Q6	136.40
Q7	133.91
Q8	202.58
Q9	172.96

Superconducting Coil	Current (A)
SSU-E2	100% Sol
SSU-C	100% Sol
SSU-E1	100% Sol
SSU-M2	0.0
SSU-M1	0.0
FCU-upstream	0.0
FCU-downstream	0.0
SSD-M1	0.0
SSD-M2	0.0
SSD-E1	0.0
SSD-C	0.0
SSD-E2	0.0

These slides use data from the reconstructed data set from http://reco.mice.rl.ac.uk/MAUS-v1.1.1/07469_offline.tar (MAUS version Patch-Release_1.1.1)

GOALS

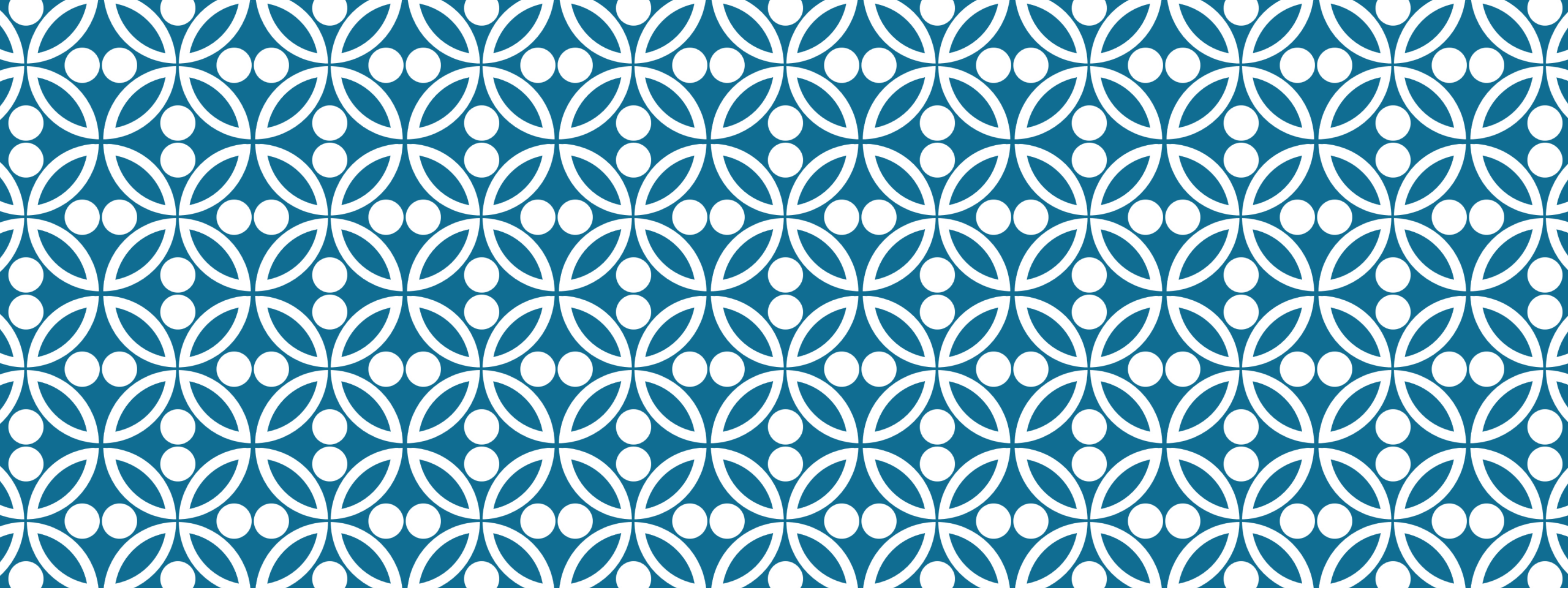
1. Does everything look sensible?
   a. Look at some events in an event viewer
   b. Compare the helix centre in the upstream tracker to the line between TOF0 and TOF1
2. Are the distributions believable?
   a. How do the (x, y) distributions at TOF1 compare to the Step I data?
   b. How does the |P| distribution at TOF1 compare to the Step I data?
   c. How does the trackers |P| distribution compare to TOF1
      a. Look at both the Kalman fit and Pattern Recognition
   d. What do the (x, y) distributions look like at the upstream tracker?
   e. Are the (Px, Py) distributions believable at the upstream tracker?
3. Calculate a covariance matrix
   a. Can do this for any tracker plane – start with plane 1 (closest to the absorber… which isn't present)
   b. Is emittance conserved between tracker planes?
   c. Track back to TOF1, compare ellipses (in an alternate reality where I didn't stumble upon 3b…)
4. Errors?
   a. Francois is heroically helping with MC!

SELECTION CRITERIA

Only use particles that satisfy **all** of the following:

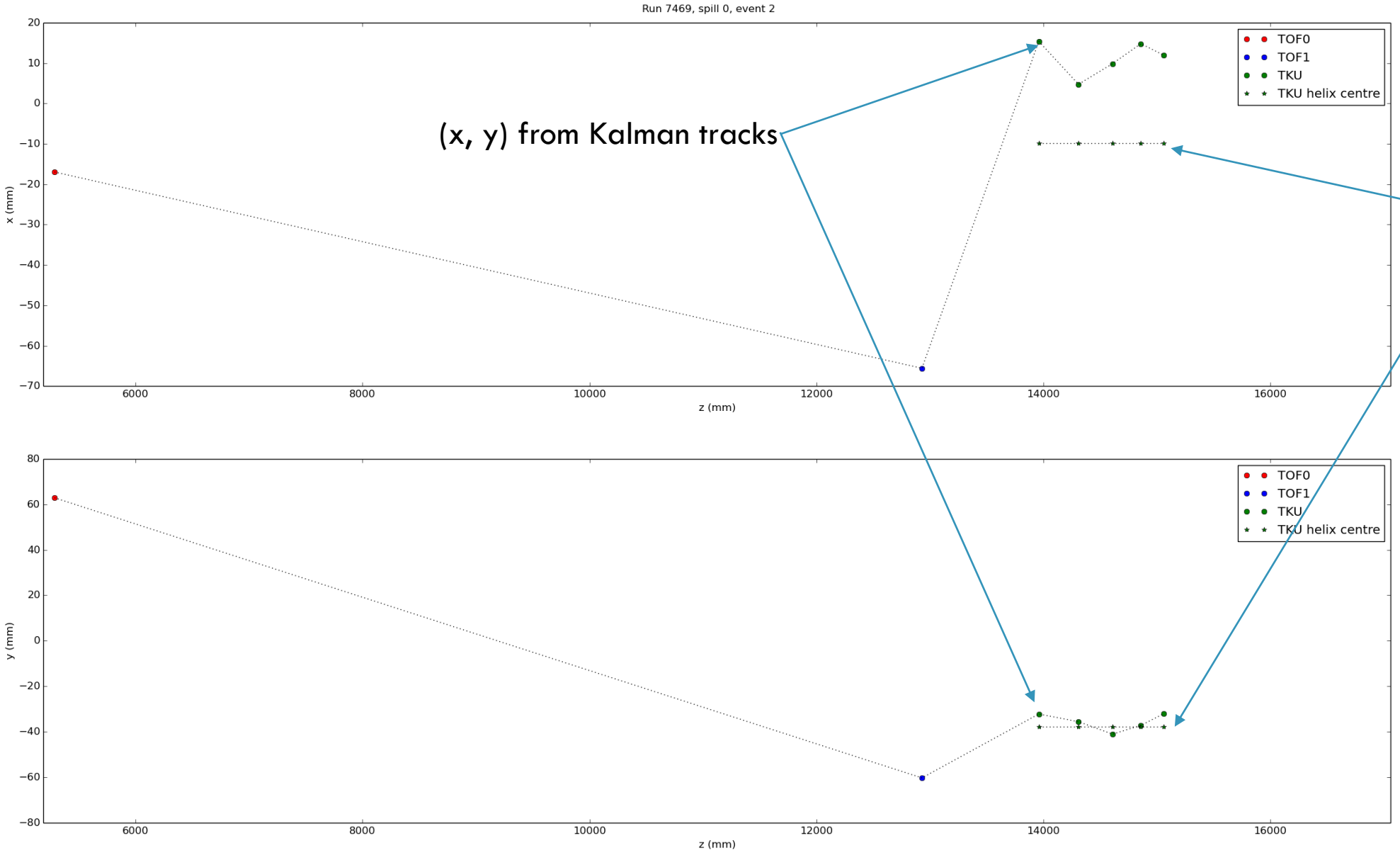
1. Have a hit in TOF0
2. Have a hit in TOF1
3. Have a hit in all 5 tracker planes
4. Have a time-of-flight from TOF0→TOF1 between 27 and 40ns (muons only please!)
5. Have a P-value greater than 0.05 assigned to them from the tracker

The downstream tracker is ignored, as is TOF2/KL/EMR for the moment.



1. DOES EVERYTHING LOOK SENSIBLE?

Hrmmm…

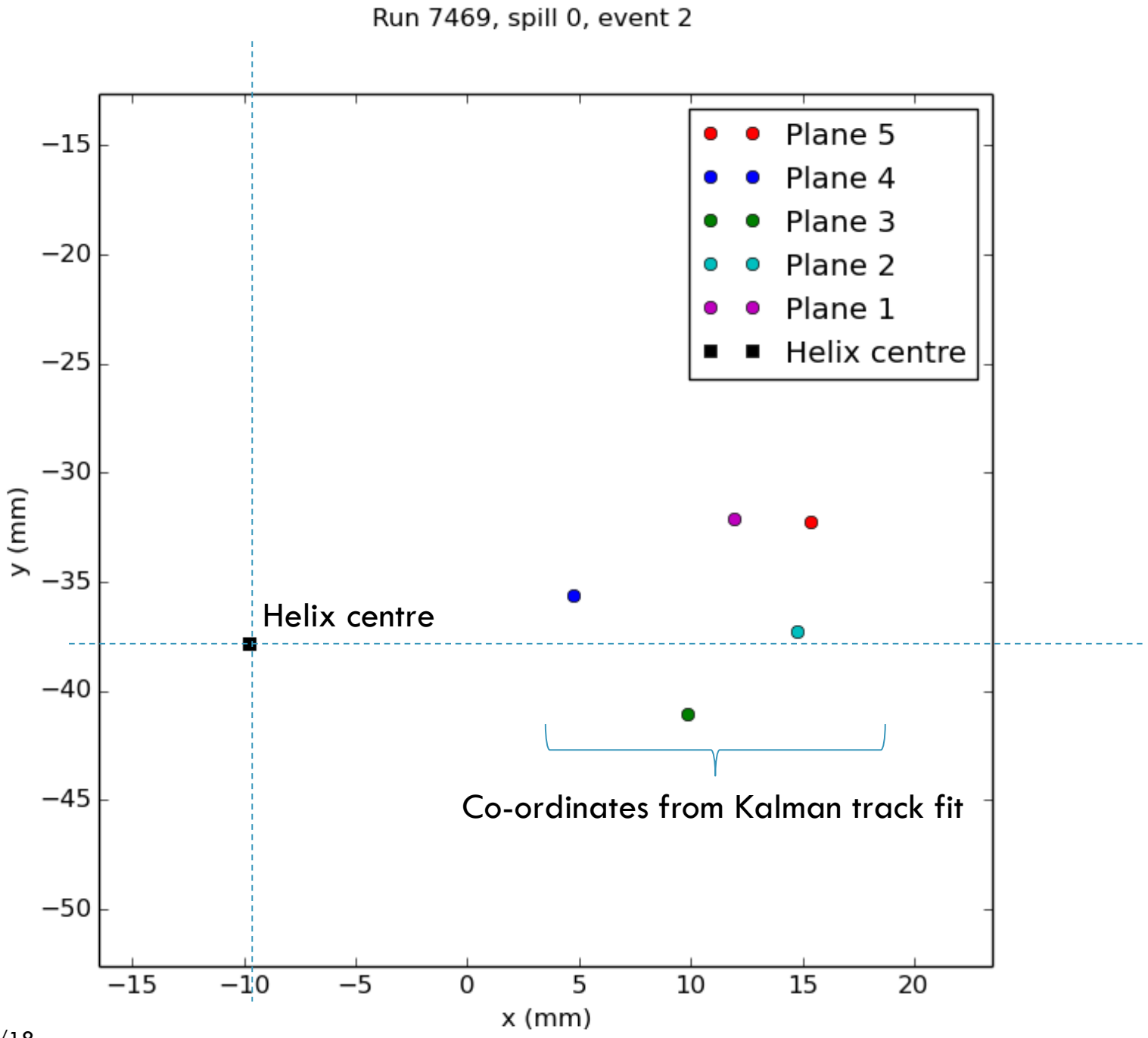


(x, y) from Kalman tracks

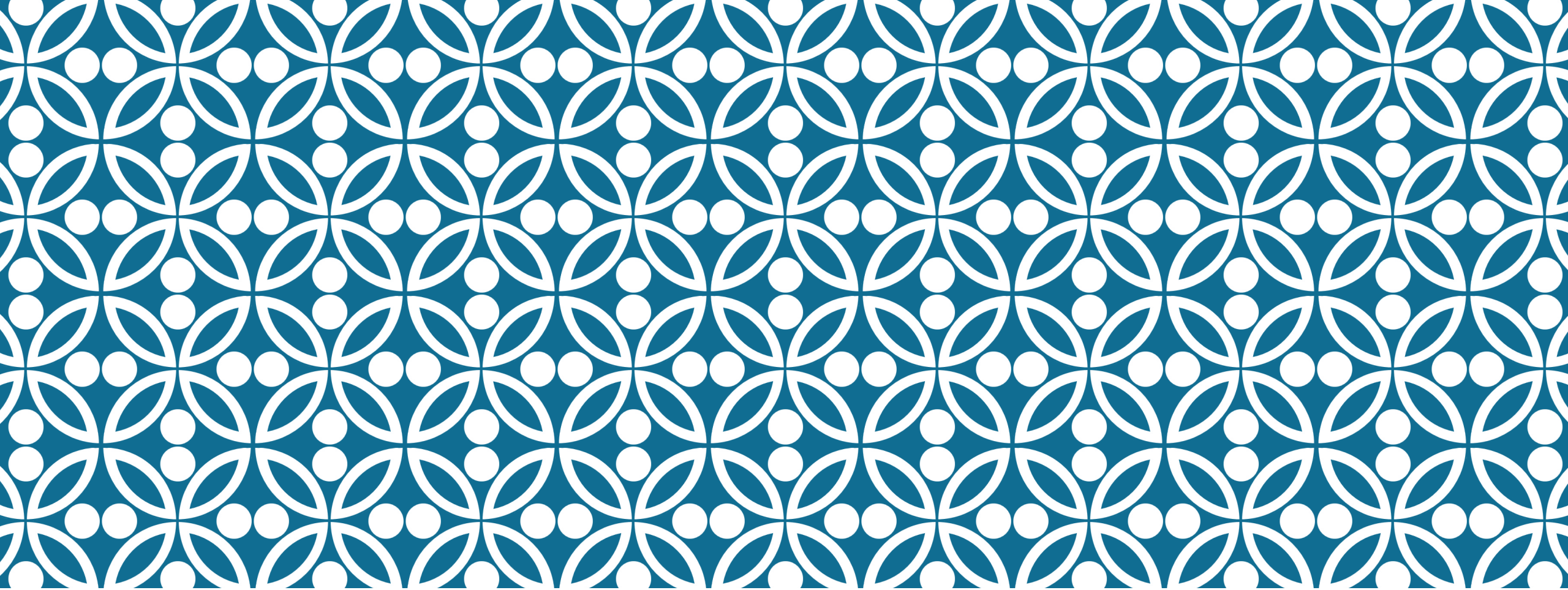
Centre of the circle fitted by Pattern Recognition (don't believe x…)

Q: Do Pattern Recognition and Kalman both report co-ordinates in the global co-ordinate system?

Q: Do the (x, y) flips in the tracker software affect the **upstream** tracker? (MAUS 1.1.1 doesn't have this fix, I believe)



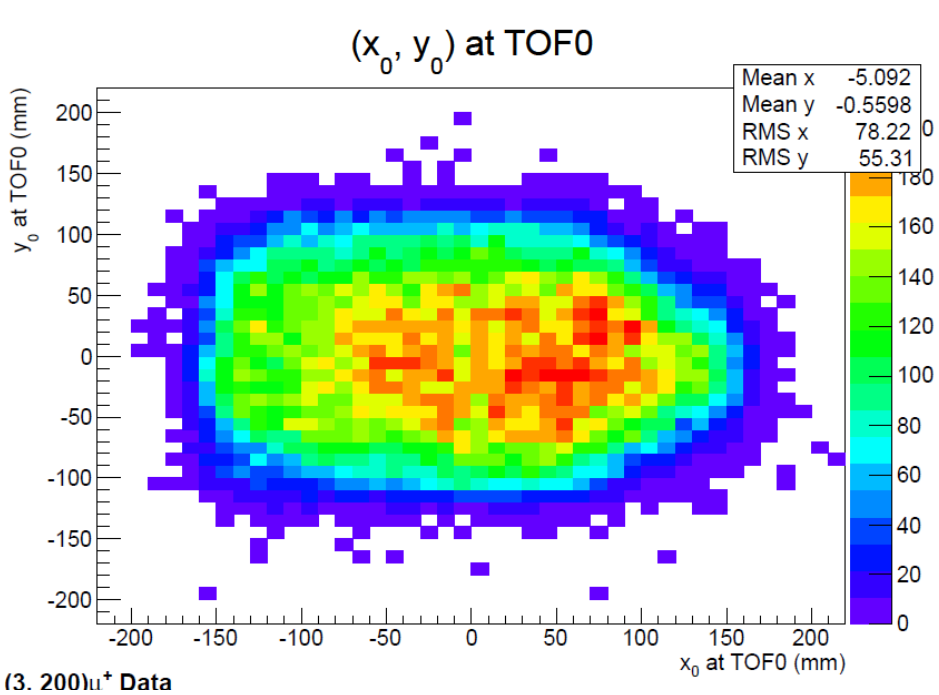
- P-value of this track ~0.68
  - Same effect seen in tracks with P-value > 0.9
- Park this until data reprocessed with tracker improvements

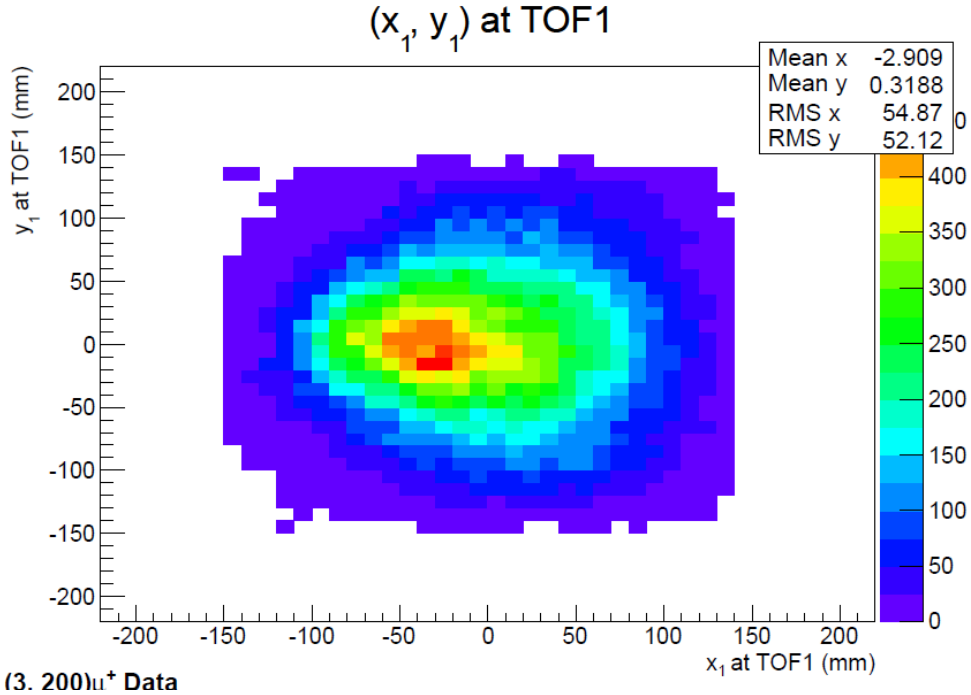


2. ARE THE DISTRIBUTIONS BELIEVABLE?

Some…

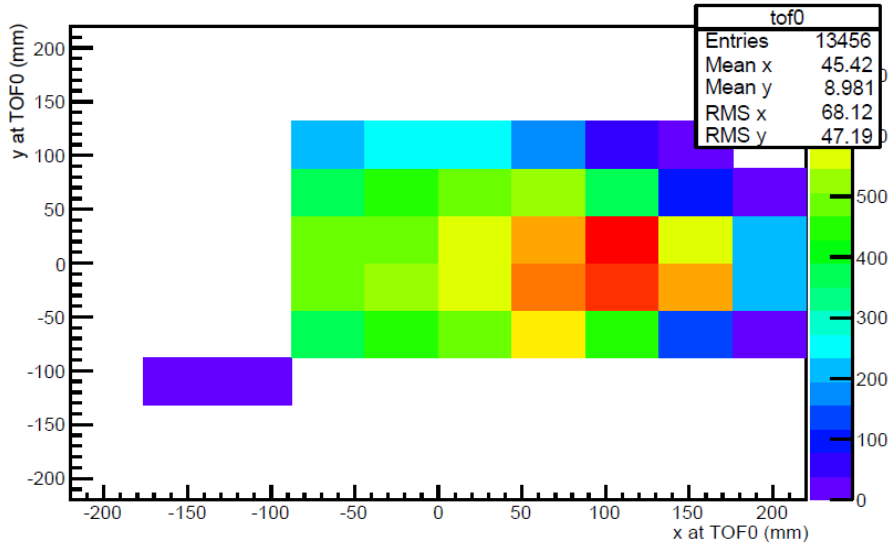
(X, Y) AT TOF1, NOW VS. STEP I

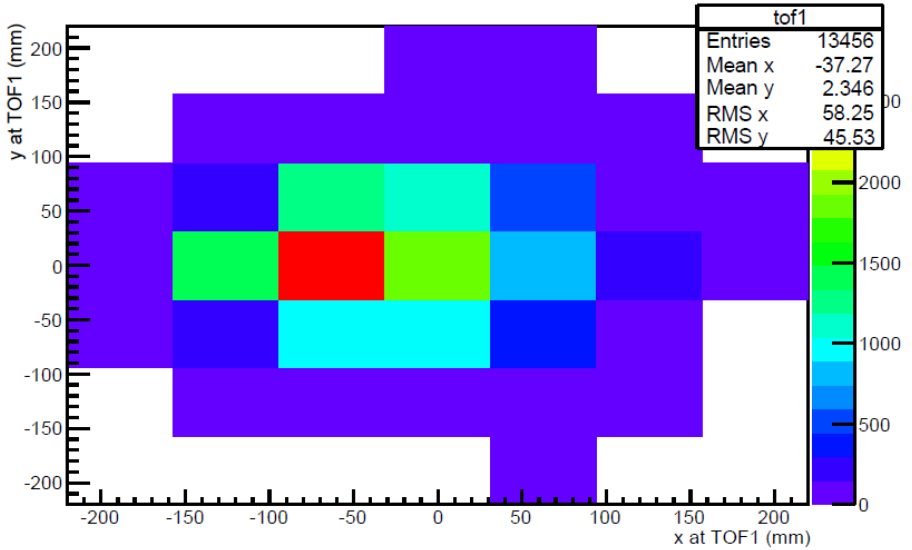




Step I

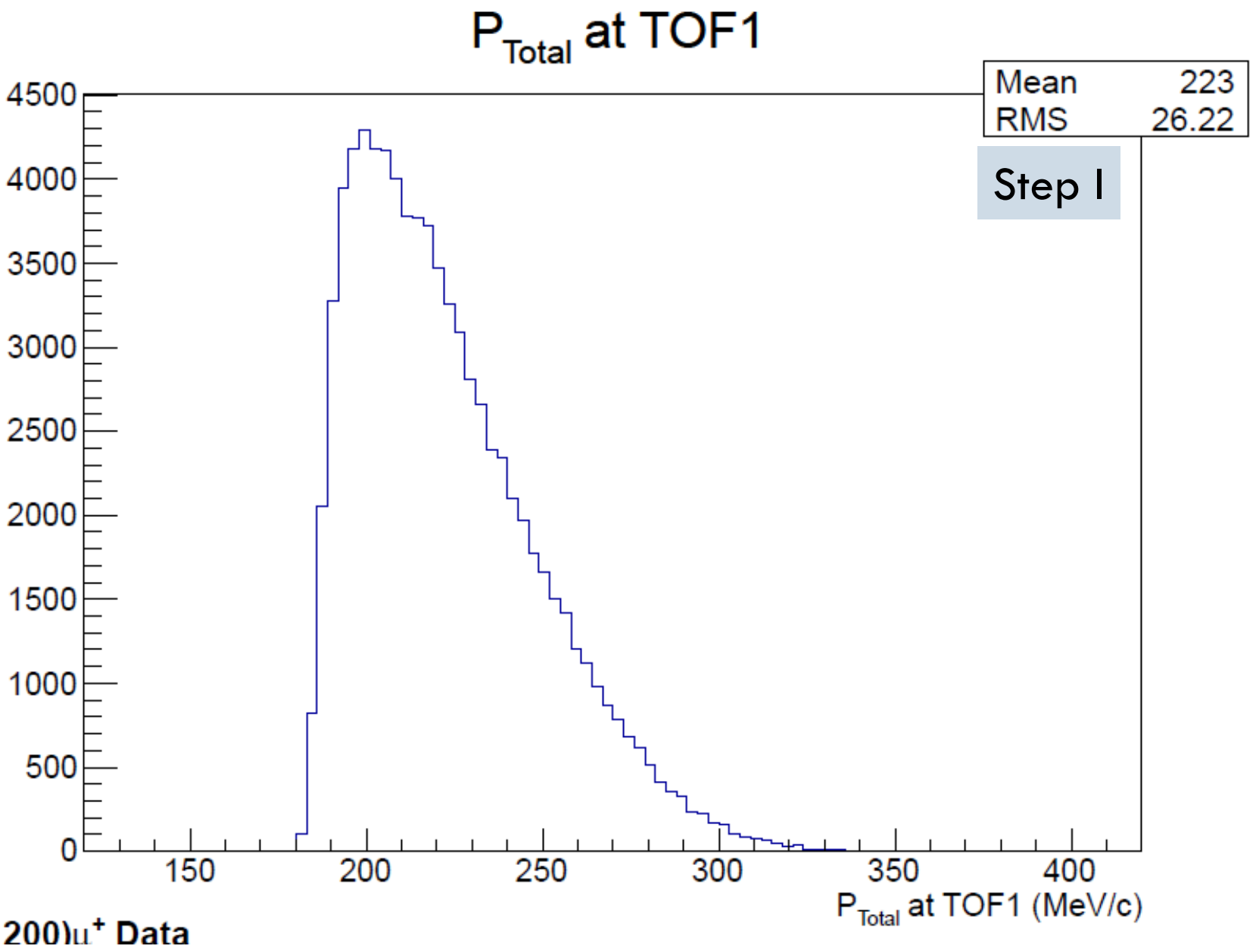
(uses PMT-based positions)





Run 7469

(using pixels)



Total momentum at Step I, using emittance reconstruction routine*

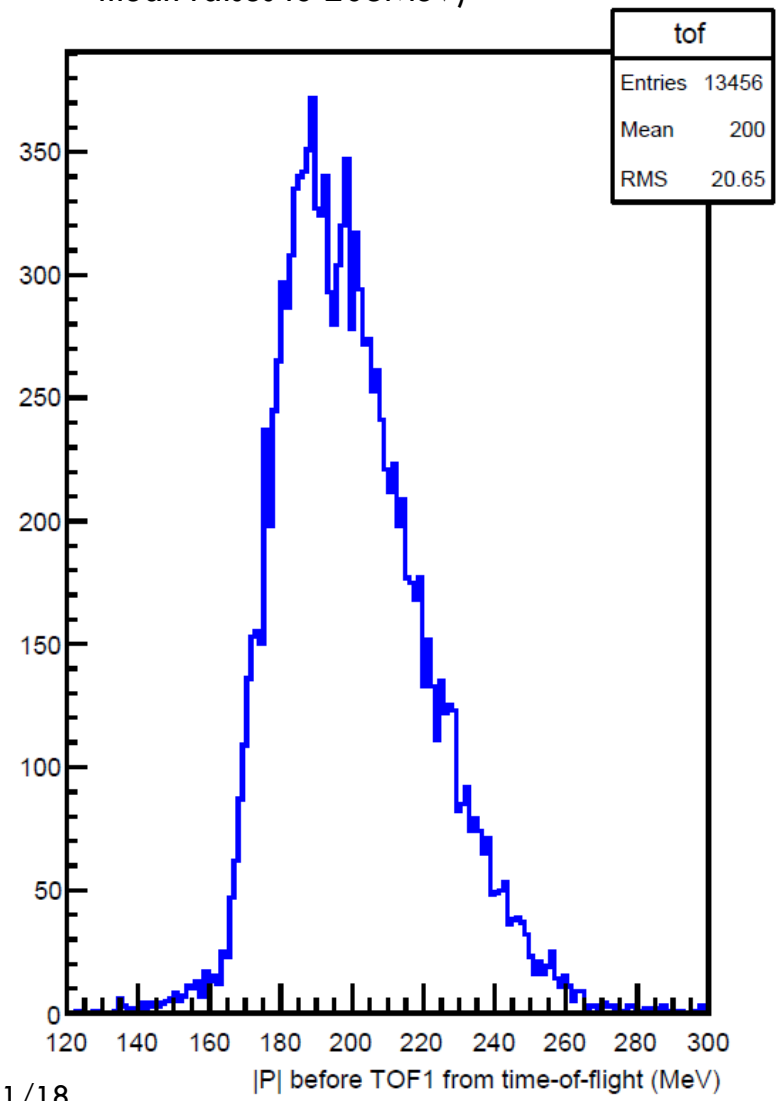
Accepted range was $180 < P < 600$

* This plot is from the set used for the publication, not the reimplentation of this routine for MAUS.

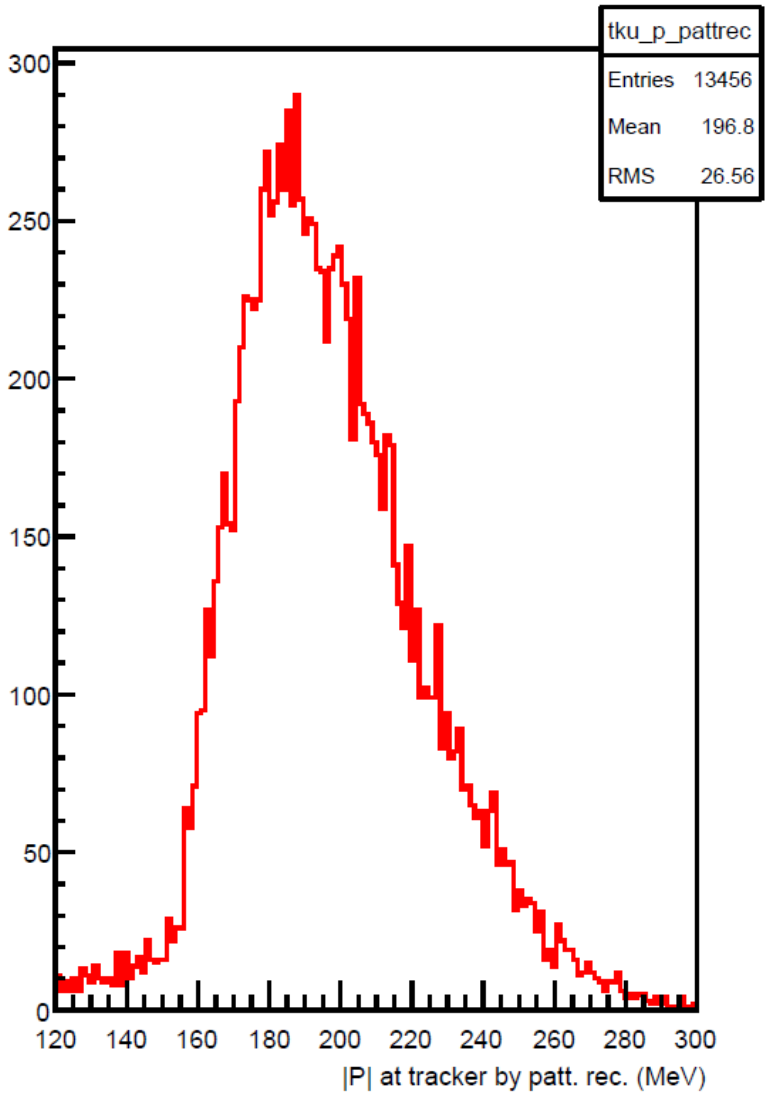
Q: Does a G4BL/MAUS simulation back up the Step I mean P, or <u>this</u> mean P?

TOF0→TOF1 (pixel → pixel)

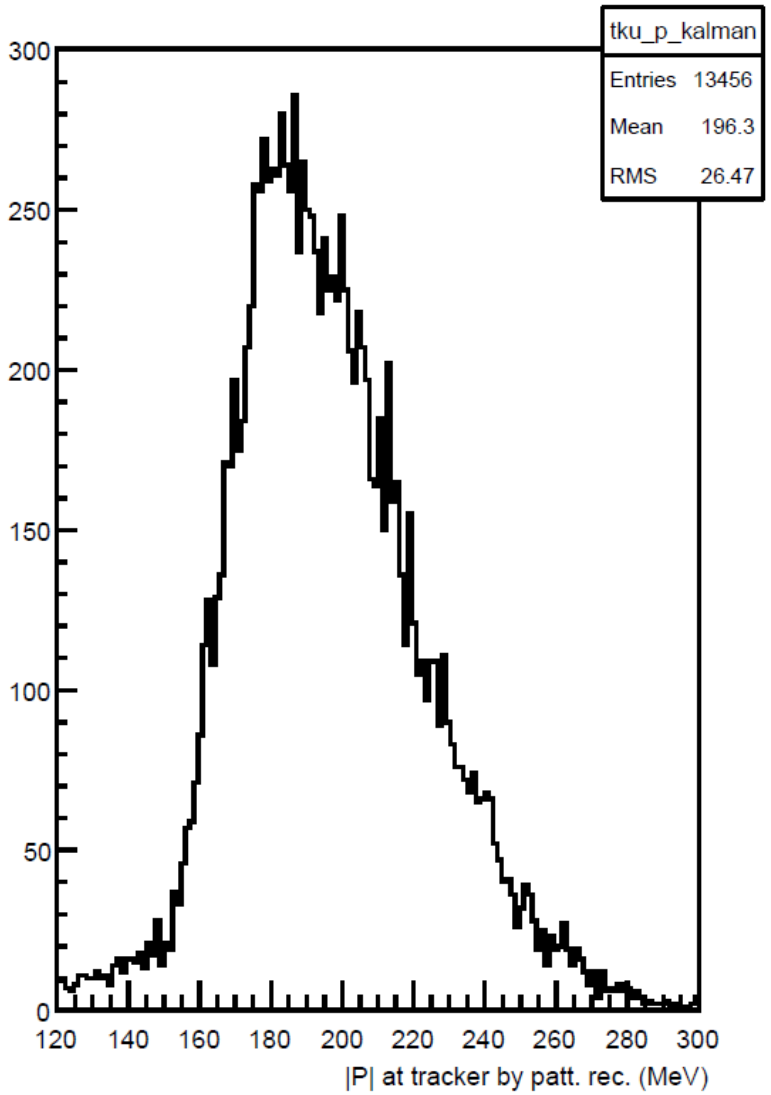
(Under the same cuts as the Step I data, the mean raises to 205MeV)

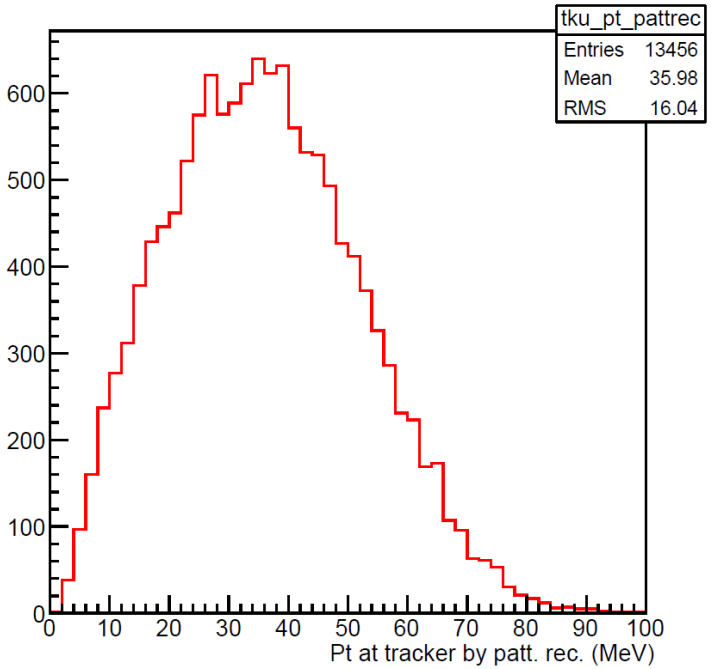


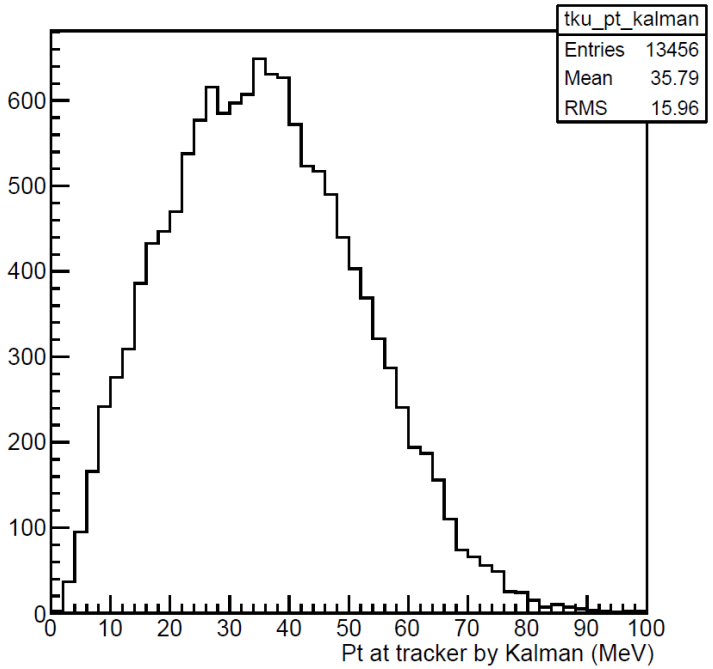
Plane 5 of the tracker,
Pattern Recognition (assuming 4T)

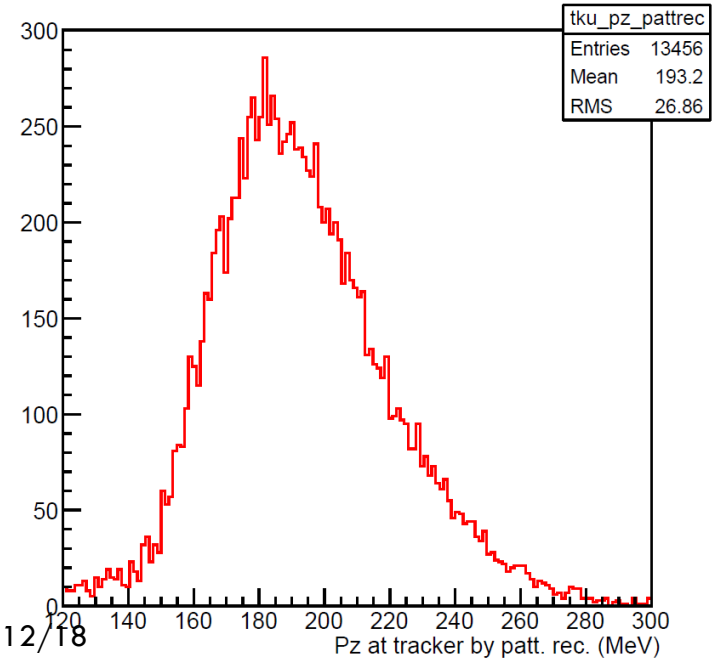


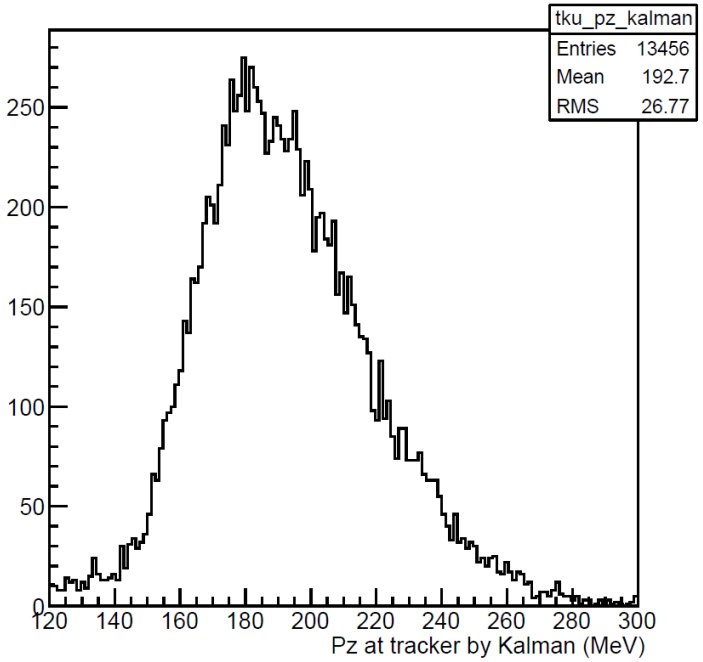
Plane 5 of the tracker,
Kalman fit



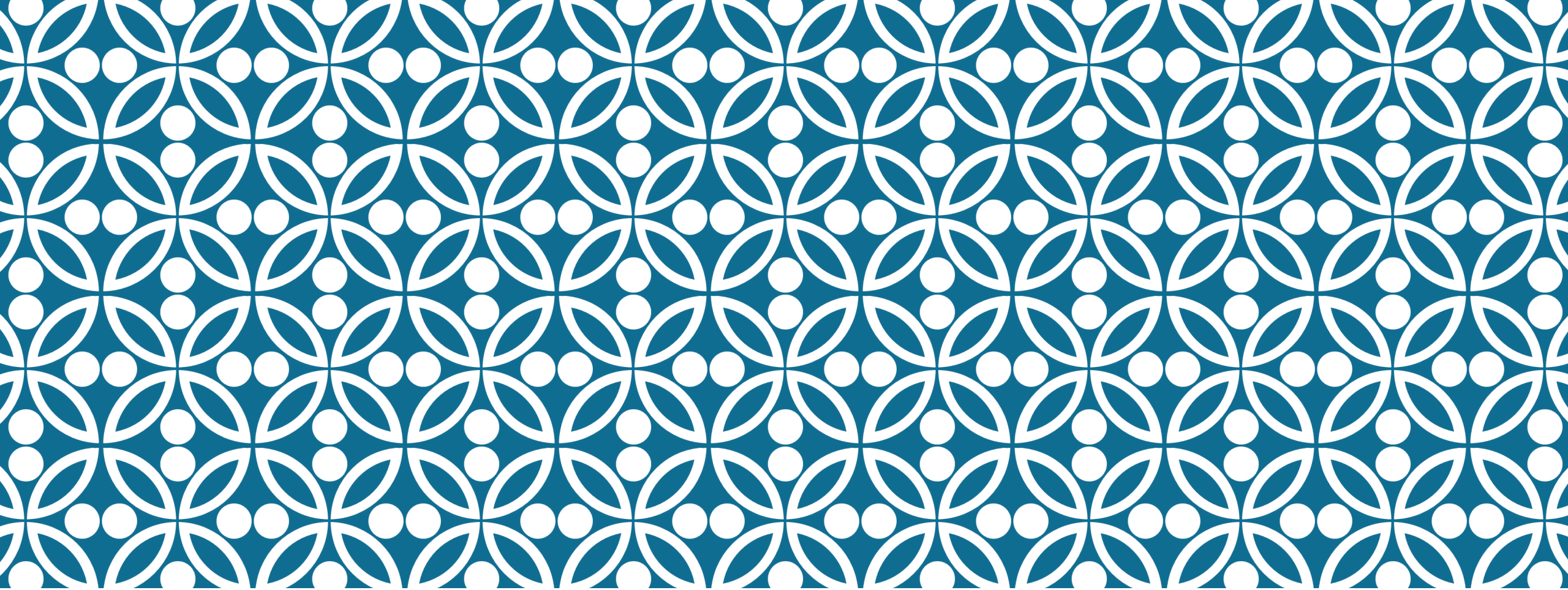








Get good agreement between Pattern Recognition and Kalman if you assume a 4T field



3. CALCULATE A COVARIANCE MATRIX

Alright!

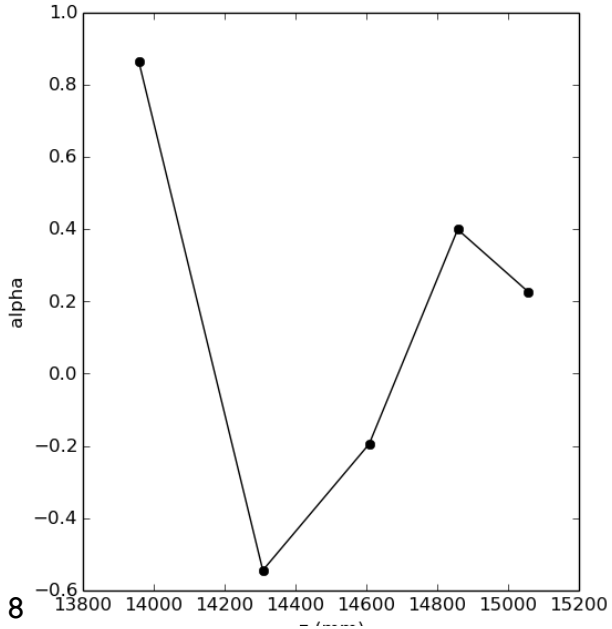
COVARIANCE MATRIX AT TKU

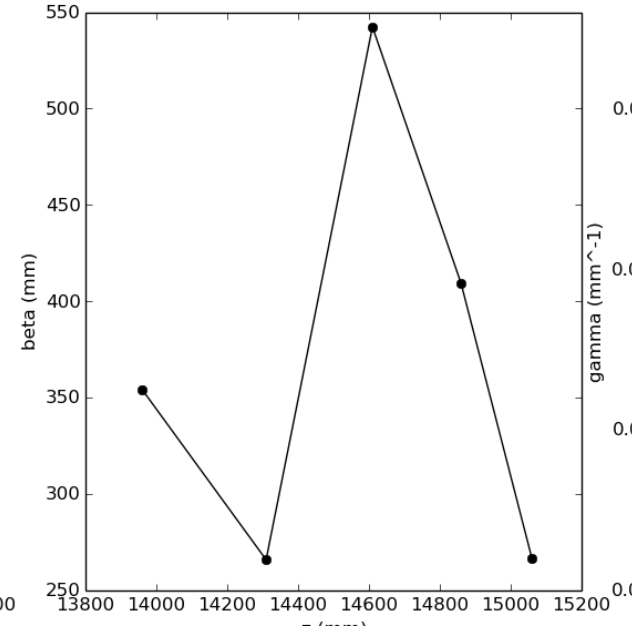
At tracker plane 1:

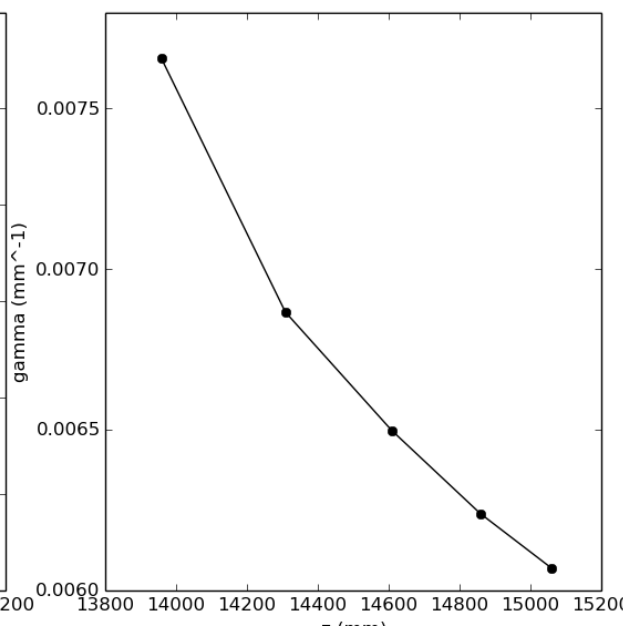
	x	y	Px	Py
x	860.55	-197.15	-109.78	501.95
y	-197.15	932.26	-422.60	-178.28
Px	-109.78	-422.60	717.33	4.38
Py	501.95	-178.28	4.38	756.41

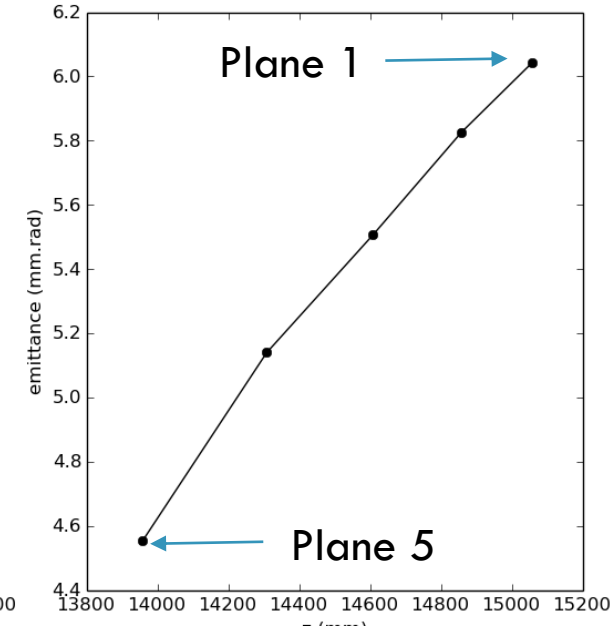
At tracker plane 5:

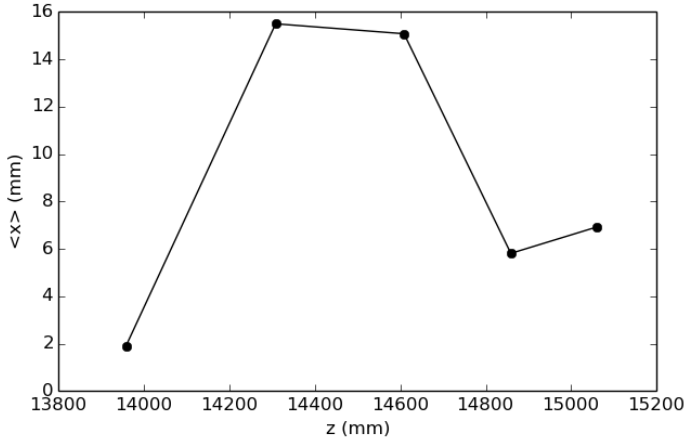
	x	y	Px	Py
x	955.89	-134.23	-461.30	576.35
y	-134.23	829.68	-322.77	-369.70
Px	-461.30	-322.77	717.33	-100.31
Py	576.35	-369.70	-100.31	792.46

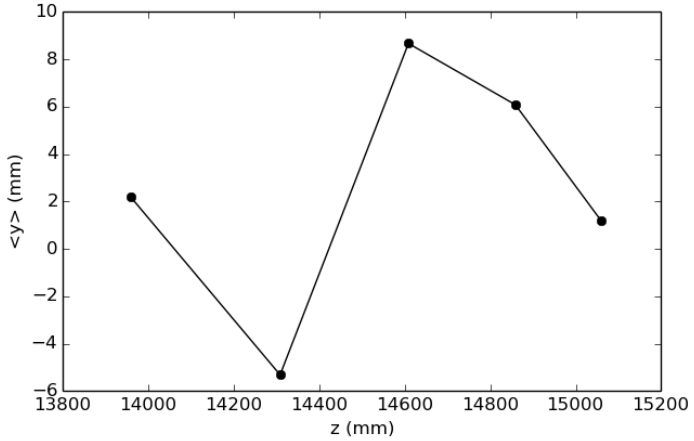


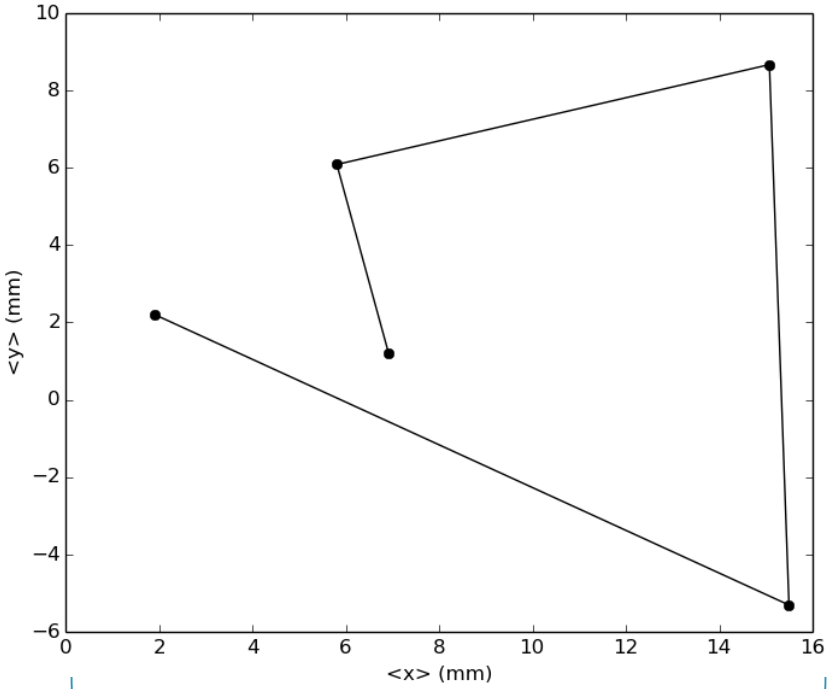




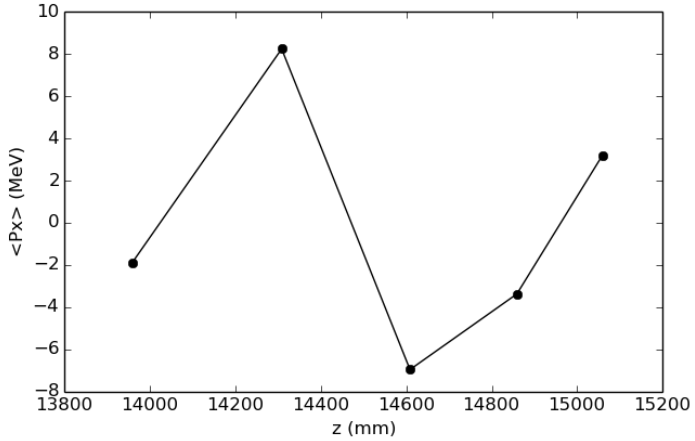


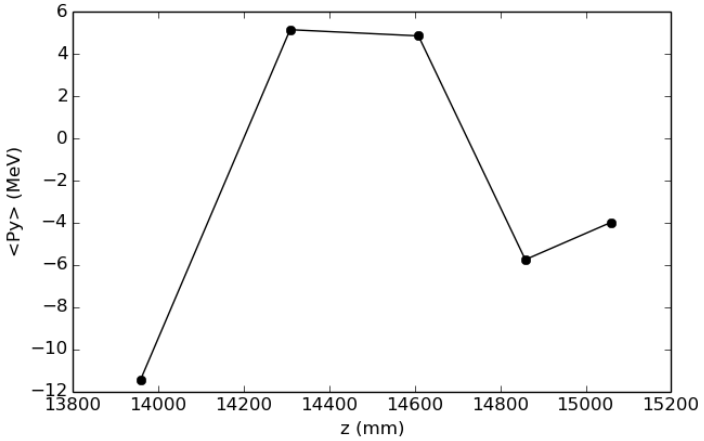


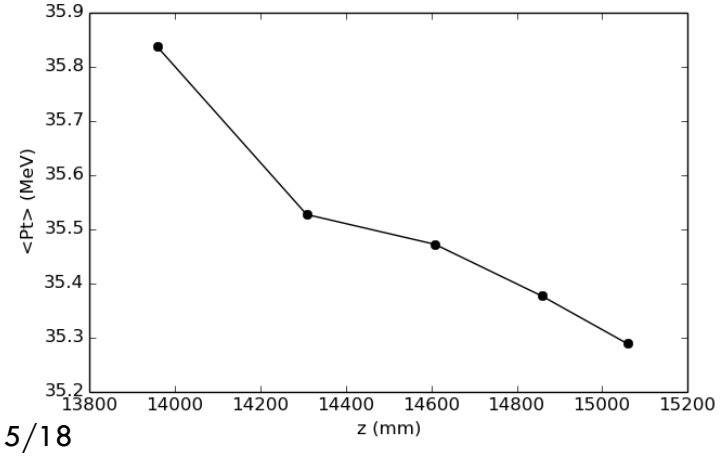


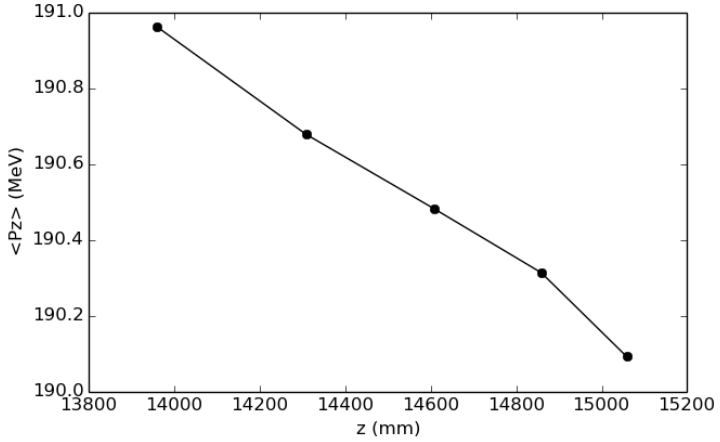


Beam centre wiggles about

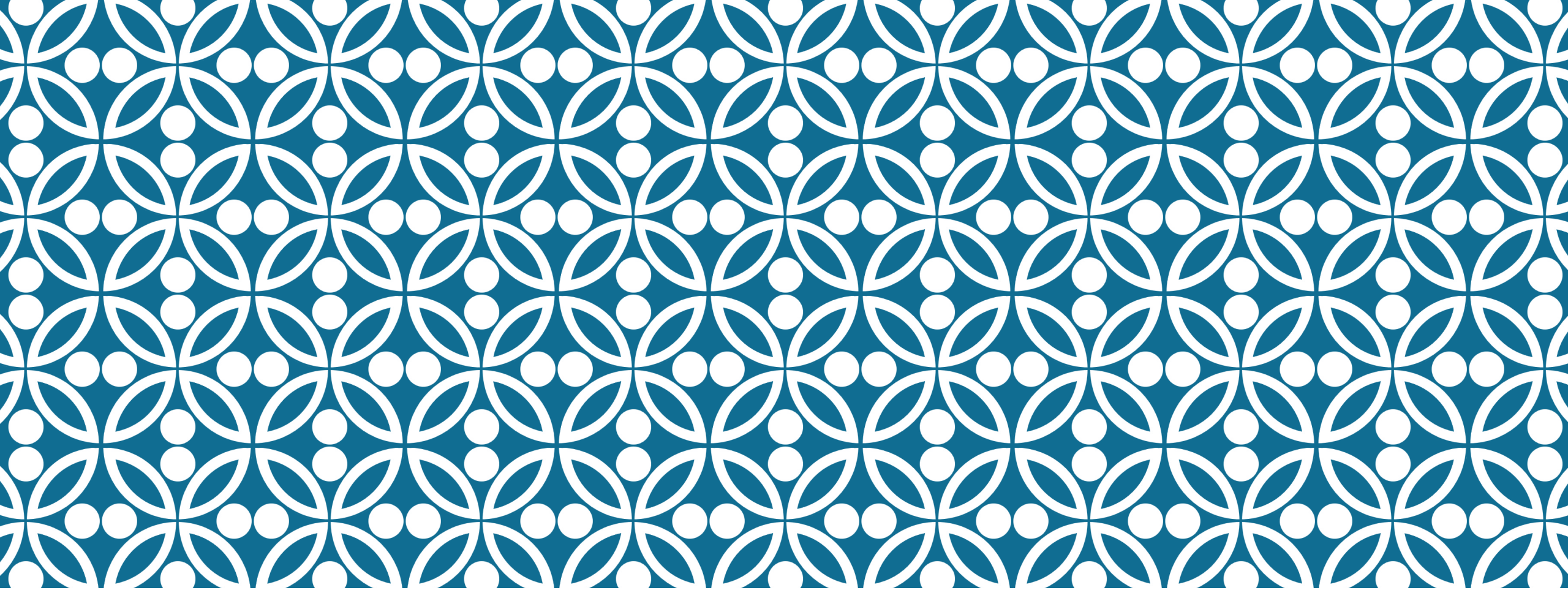






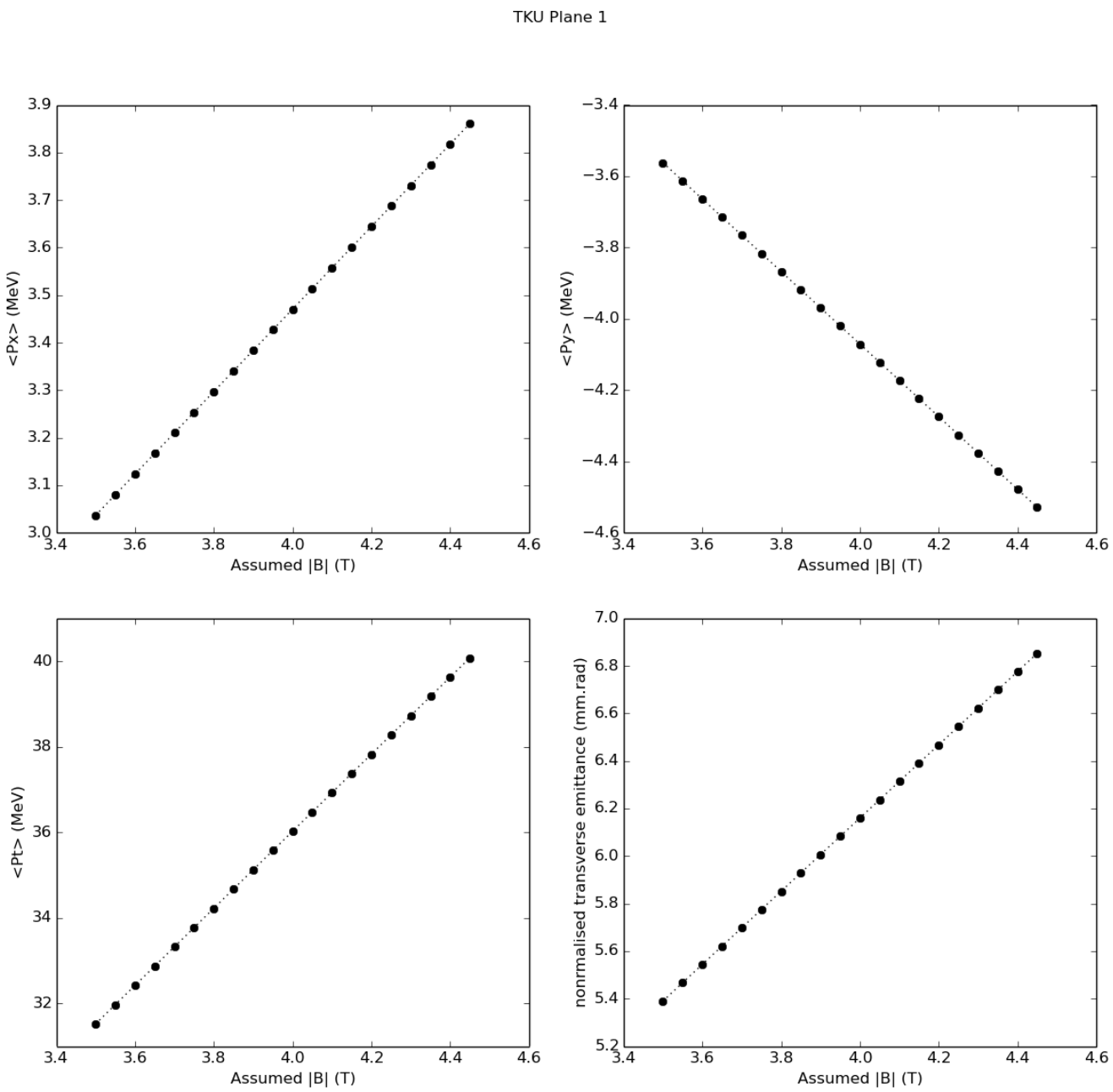


Momentum decreases across the tracker



4. ERRORS?

B field is the most obvious one…



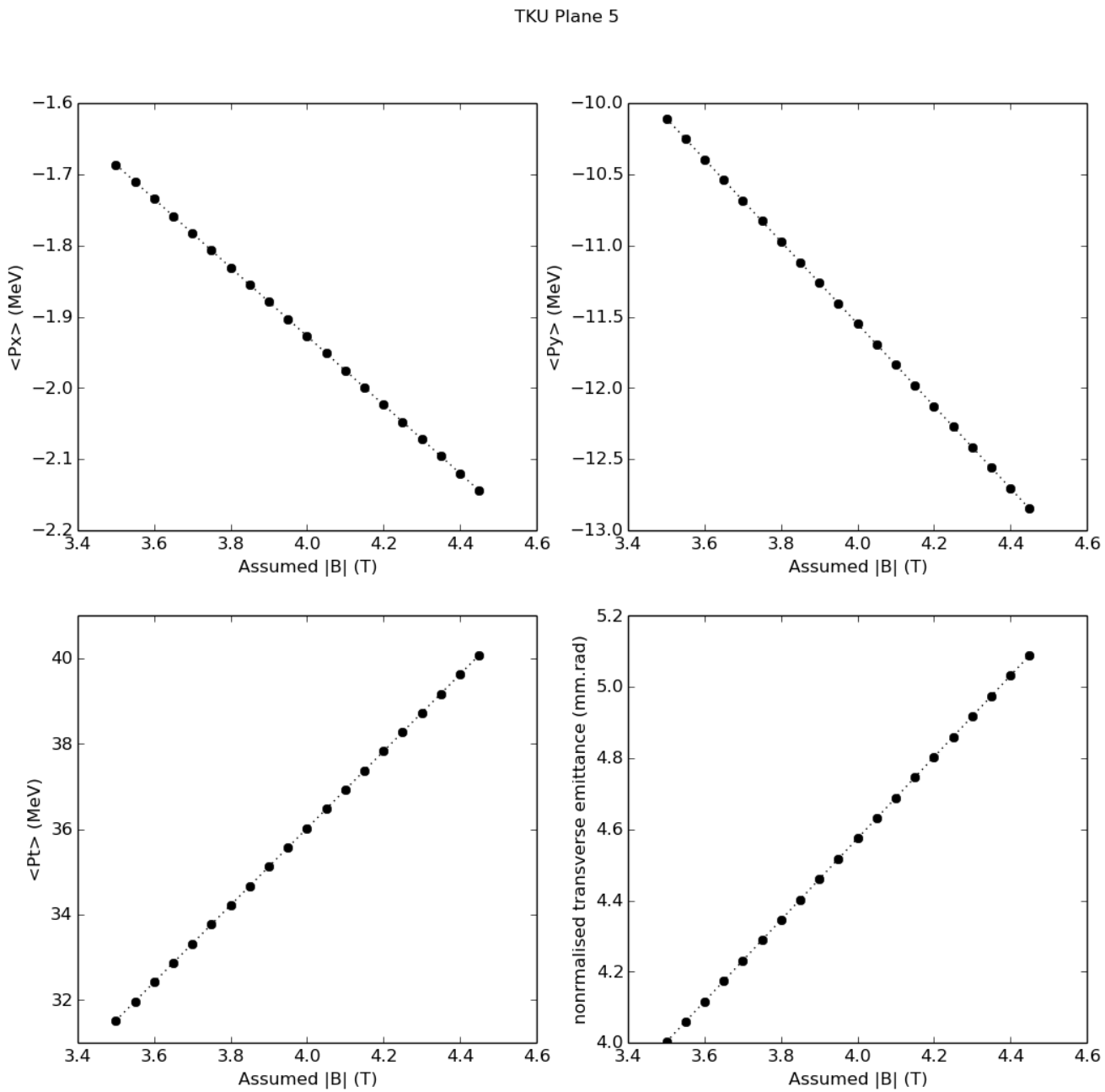
- Believe Kalman assumes 4T flat field
- Unlikely field was flat in reality
- PRY enhances field

- Pattern Recognition just looks for circles
- The size of the circle fitted assumes **nothing** about the field
- Then get Pt from 0.3*B*R

- B = 4T gave good agreement with Kalman
- What if we assume B != 4T…

- Extra assumption: Assume Kalman gets the angle between the Px and Py vectors correct → use this and Pt from pattern recognition to calculate covariance matrices for a range of fields

- If field varied over tracker… what **would** Kalman do..?



- Believe Kalman assumes 4T flat field
- Unlikely field was flat in reality
- PRY enhances field

- Pattern Recognition just looks for circles
- The size of the circle fitted assumes **nothing** about the field
- Then get Pt from 0.3*B*R

- B = 4T gave good agreement with Kalman
- What if we assume B != 4T…

- Extra assumption: Assume Kalman gets the angle between the Px and Py vectors correct → use this and Pt from pattern recognition to calculate covariance matrices for a range of fields

- If field varied over tracker… what **would** Kalman do..?

- Emittance must be conserved.. error from field must be large.