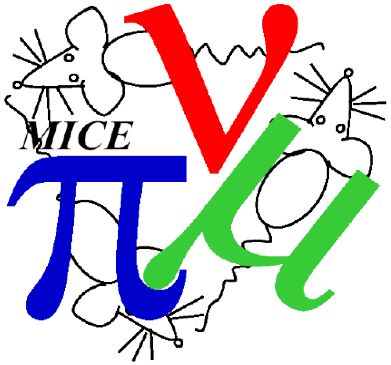
Emittance Evolution



C. Rogers, ISIS Intense Beams Group
Rutherford Appleton Laboratory

Overview

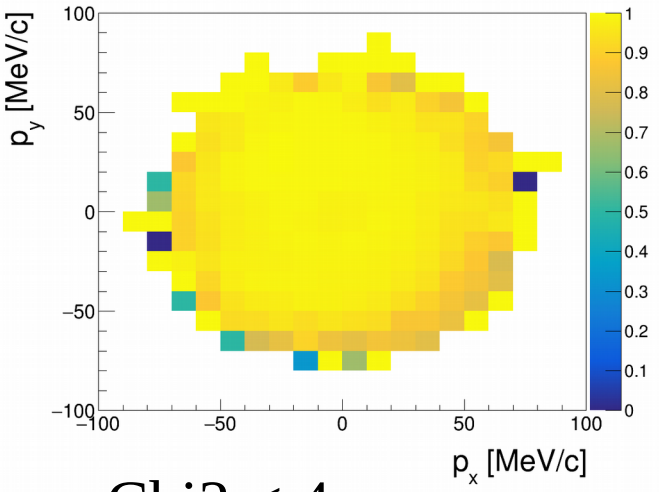
- Follow through referees comments on emittance evolution paper
  - Summary since last referees meeting
- Efficiency issue in TKD at low amplitude (vs Francois)
- TOF vs Tracker “banana plot” cut
  - Compare momentum distribution
- Averaging for high amplitude efficiency correction
- Systematic uncertainties – comparison MC vs data
- Fractional emittance plot
  - I have not yet implemented systematic correction/errors

Efficiency issue

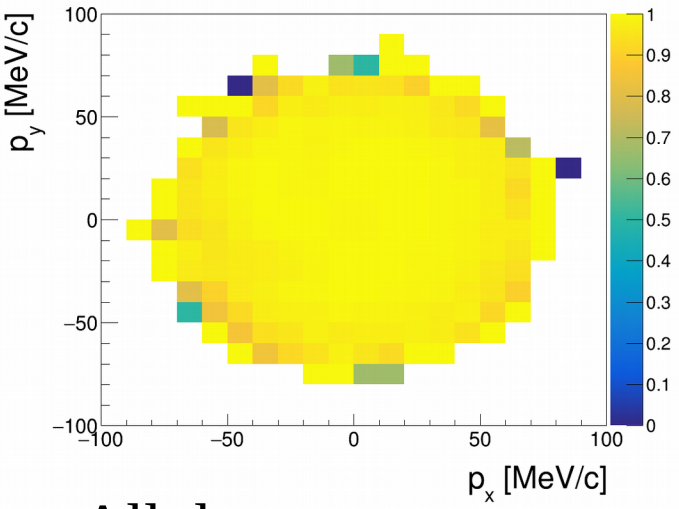
- Efficiency issue at low amplitude
- FD had better efficiency than CR
  - Isolated to chi2/dof cut
  - Increase chi2/dof cut to 8 improves efficiency

Efficiency issue - Solved

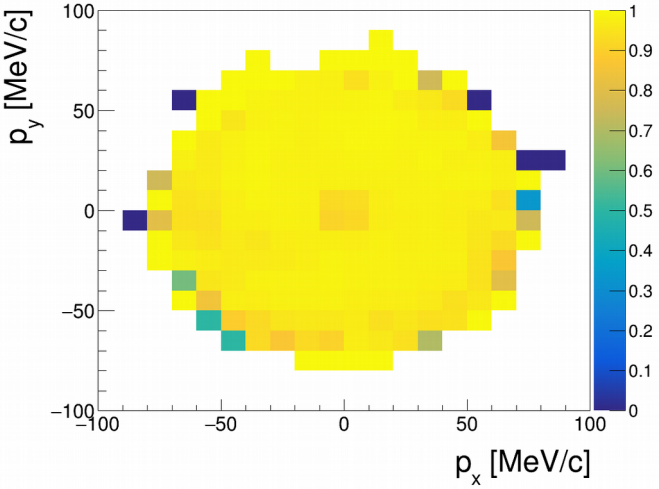
1 TKD Track



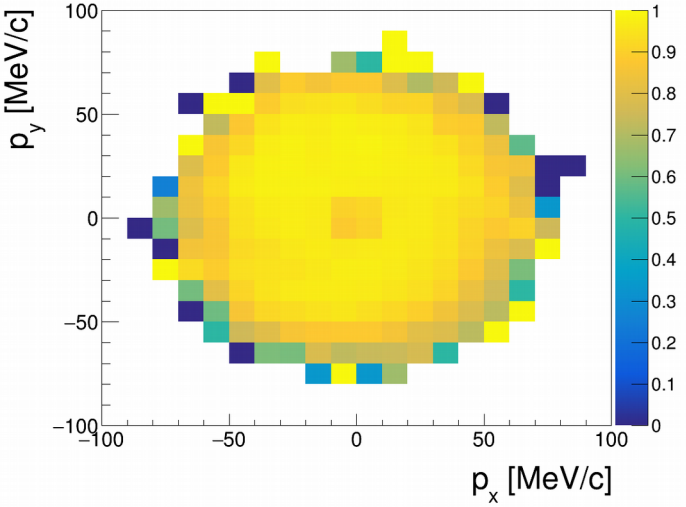
Track radius < 150 mm



Chi2 < 4



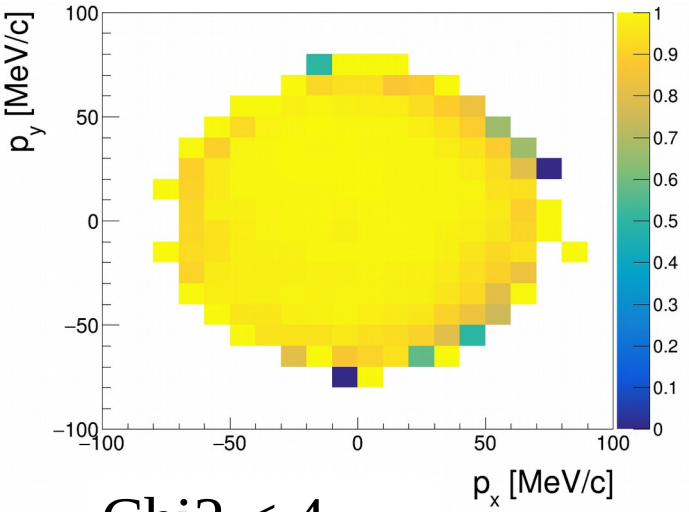
All downstream cuts



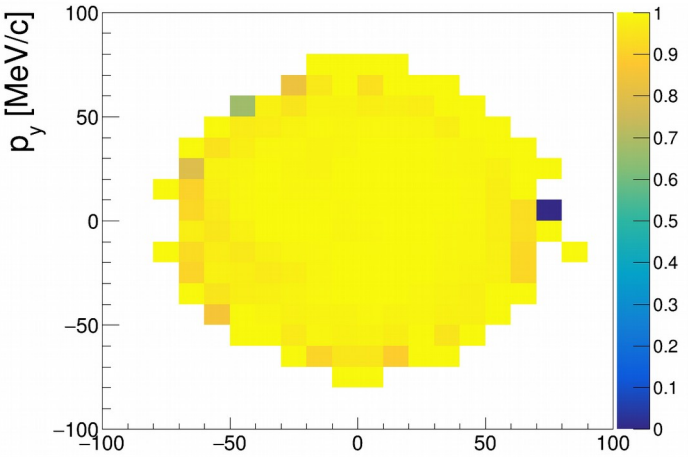
- Plot shows ratio of N(recon)/N(mc truth) in each px/py bin

Efficiency issue - Solved

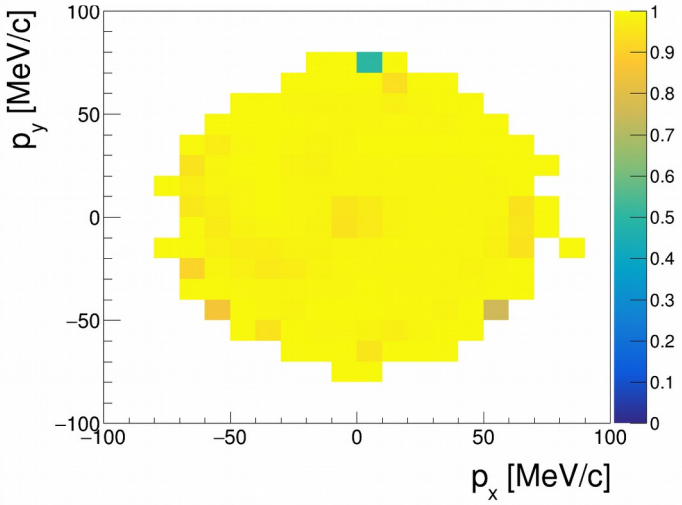
1 TKD Track



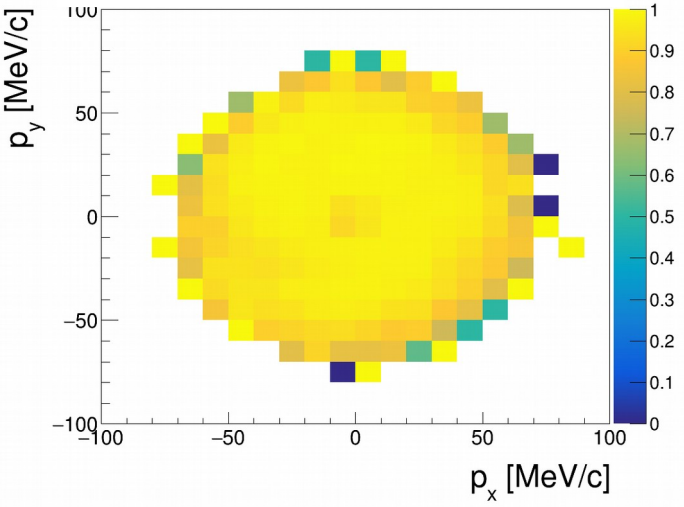
Track radius < 150 mm



Chi2 < 4



All downstream cuts

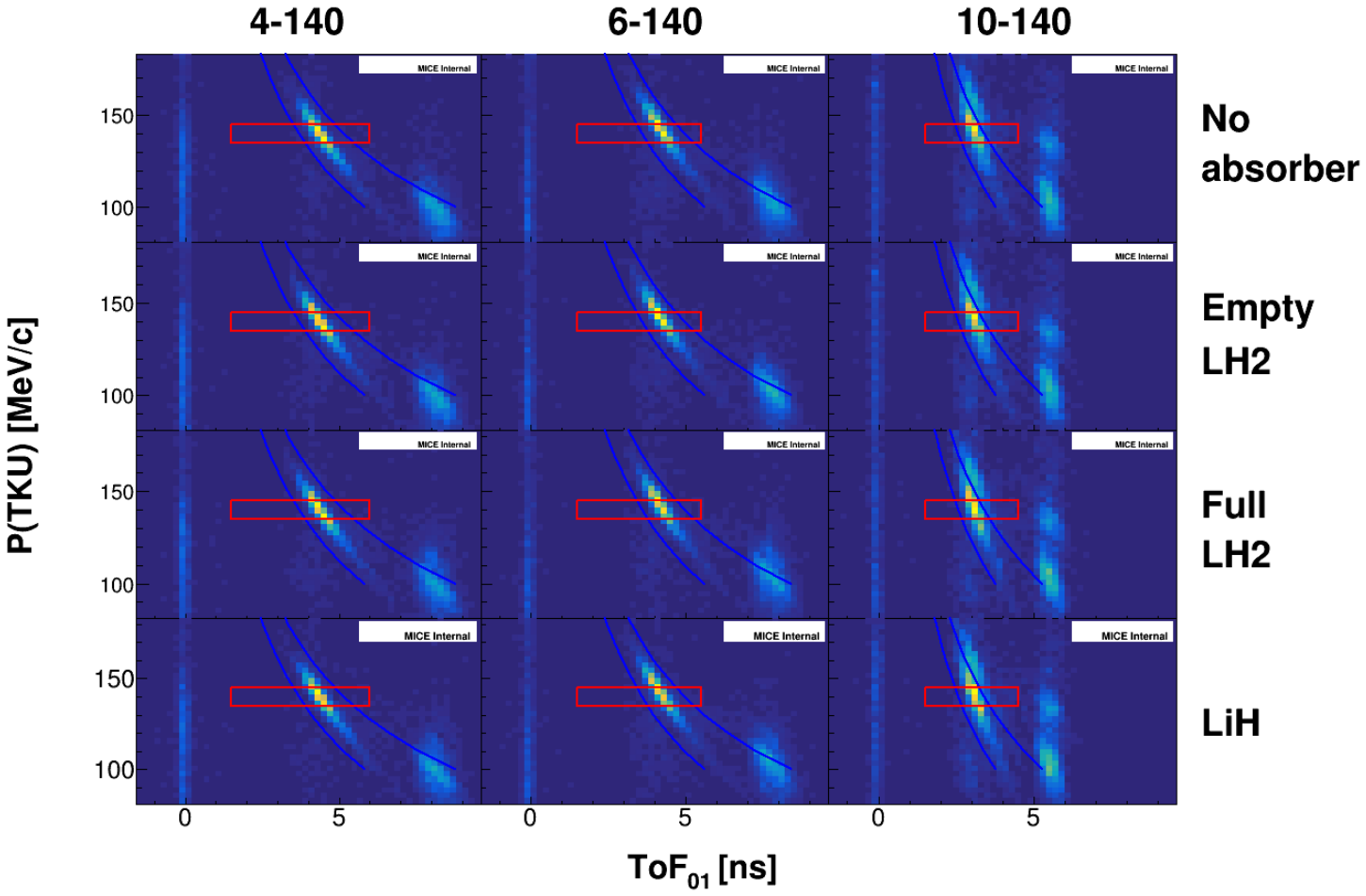


- Plot shows ratio of N(recon)/N(mc truth) in each px/py bin

Banana Plot

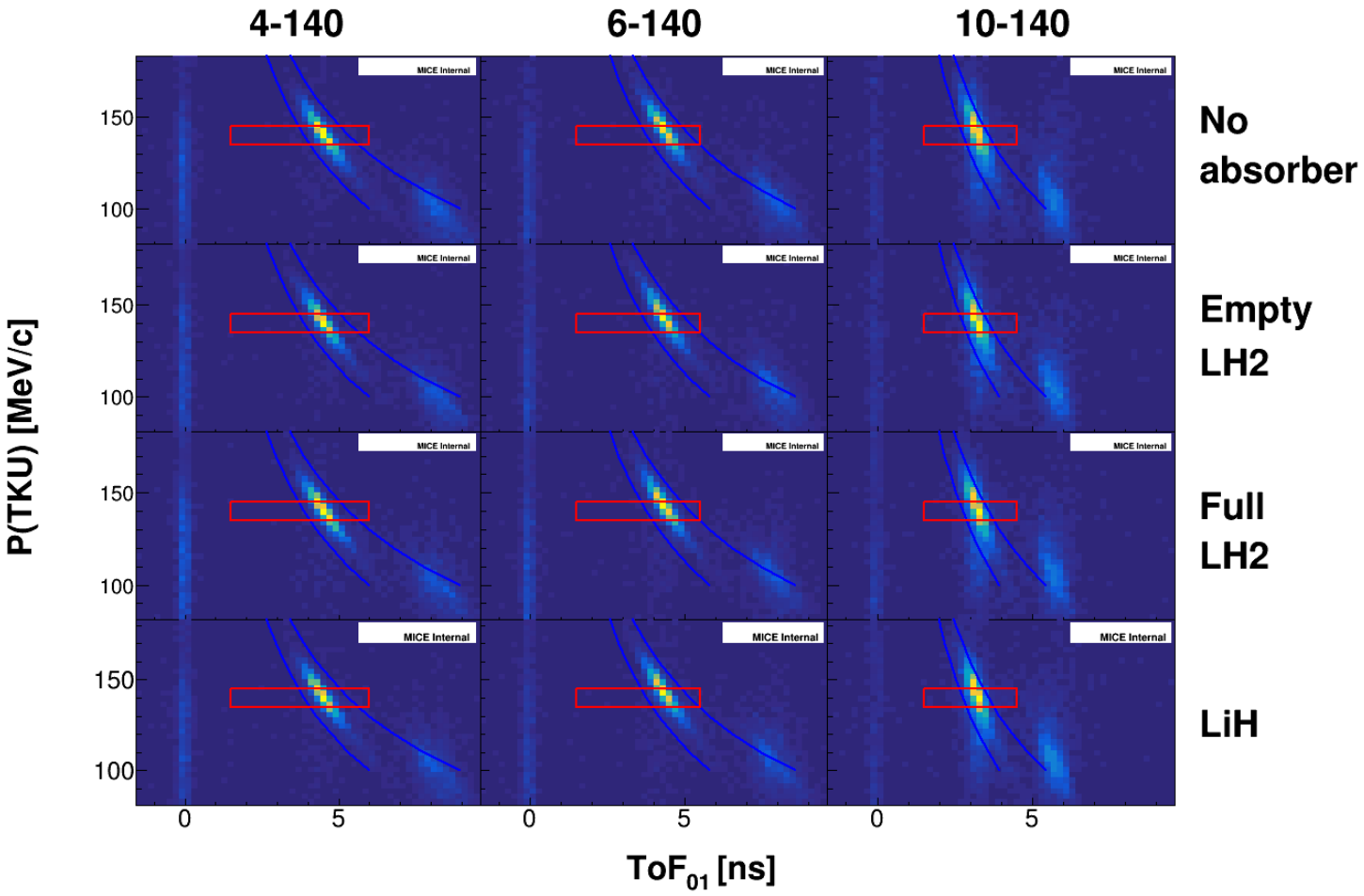
- Seek to mask data/mc comparison issues with additional "banana plot" cut
- Still excess in low p events outside of the sample
- This is outside of the sample
  - Note these issues with data - MC discrepancy have been ongoing for > 2 years
  - Deal with inconsistencies in momentum distribution during systematics

Banana Plot - MC

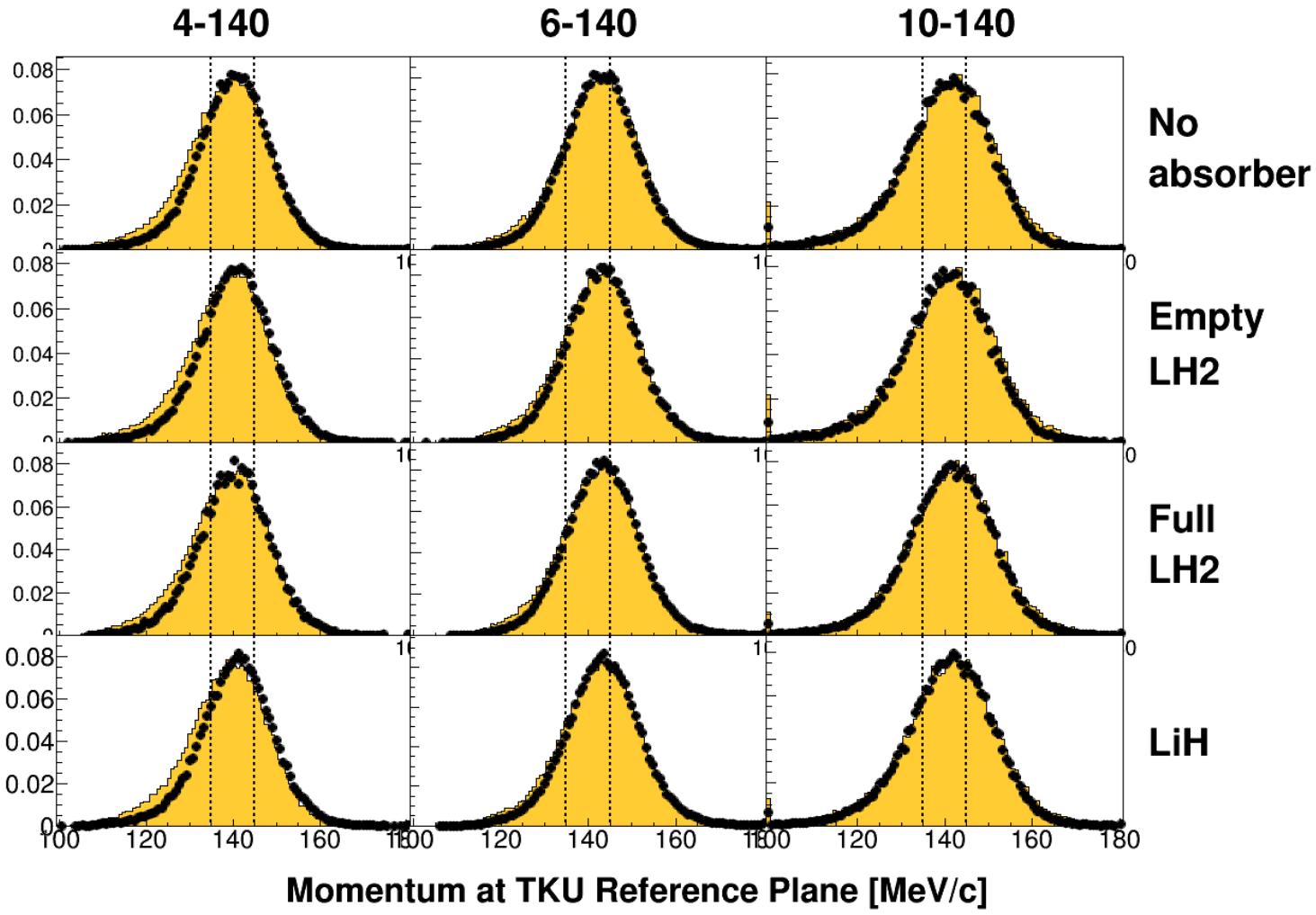


- Plot all data (even things that are excluded by cuts)
  - e.g. diffuser cut

Banana Plot - Data



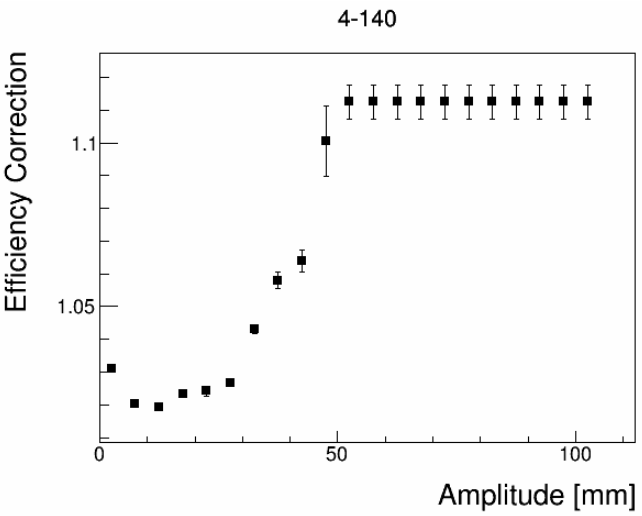
Momentum Distribution

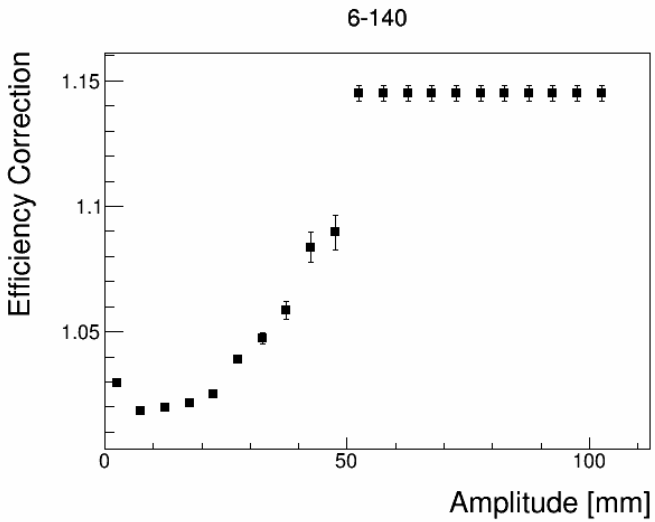


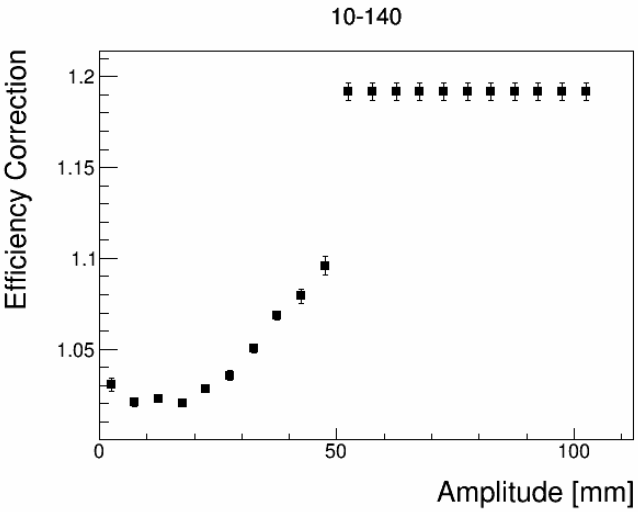
Efficiency correction

- Statistical noise in high amplitude efficiency correction
  - Even with ~1e6 events in hybrid MC
- Take average over high amplitude bins
  - Somewhat crude approach
  - But not much data to correct
  - May make a more refined averaging

High amplitude correction



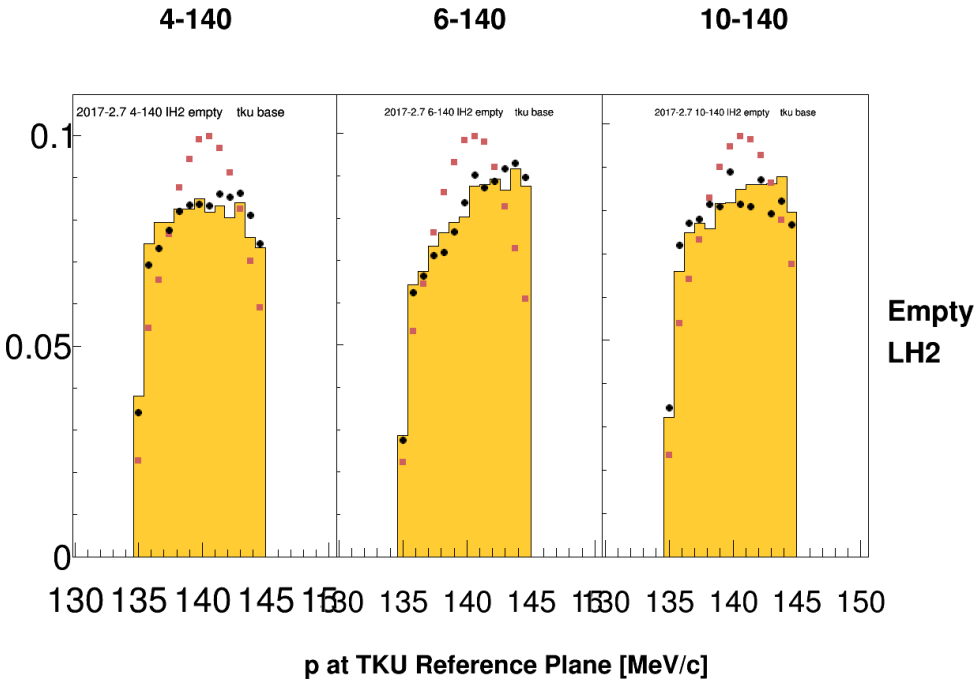




Systematic Correction

- Asked to show more details on systematic corrections
  - In particular, demonstrate that MC-data inconsistencies are covered by systematic corrections

Base Correction



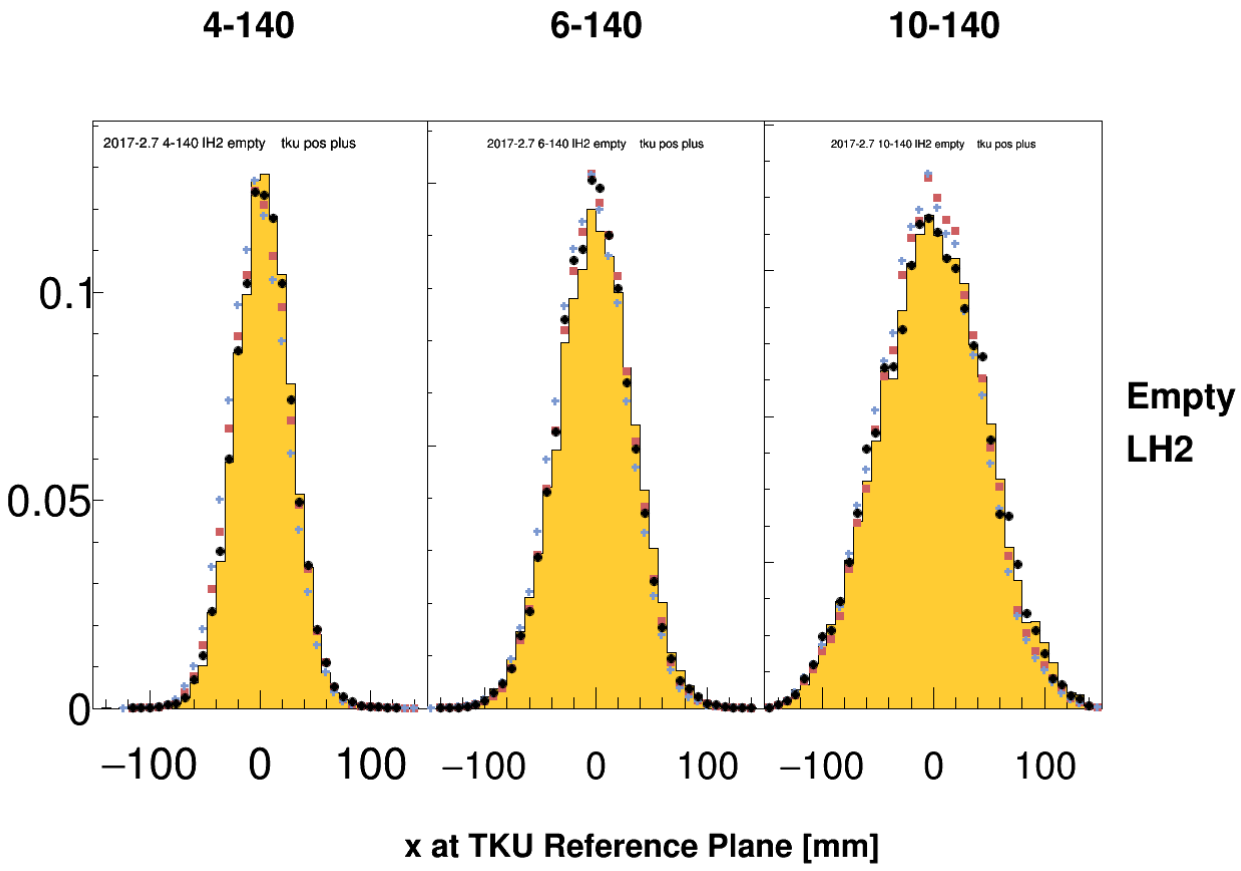
- Data (black dots), MC (mustard histo)
- “Baseline” Hybrid MC (red squares)
- Note effect of “reconstruct, simulate, reconstruct” loop
  - End up with narrower momentum distribution in hybrid MC

Systematic effects - SSU

- Effect of systematically varying the configuration
- I use hybrid MC
  - Passing reconstructed data measured at TKU station 5 through the cooling channel
- I split the hybrid MC job
  - Simulate the experiment and register particles trajectory through detectors
  - Reconstruct the particle trajectories based on the simulation
- The simulation model is varied
  - What if “the real experiment is different to our model”
- The reconstruction always uses the same “base” model

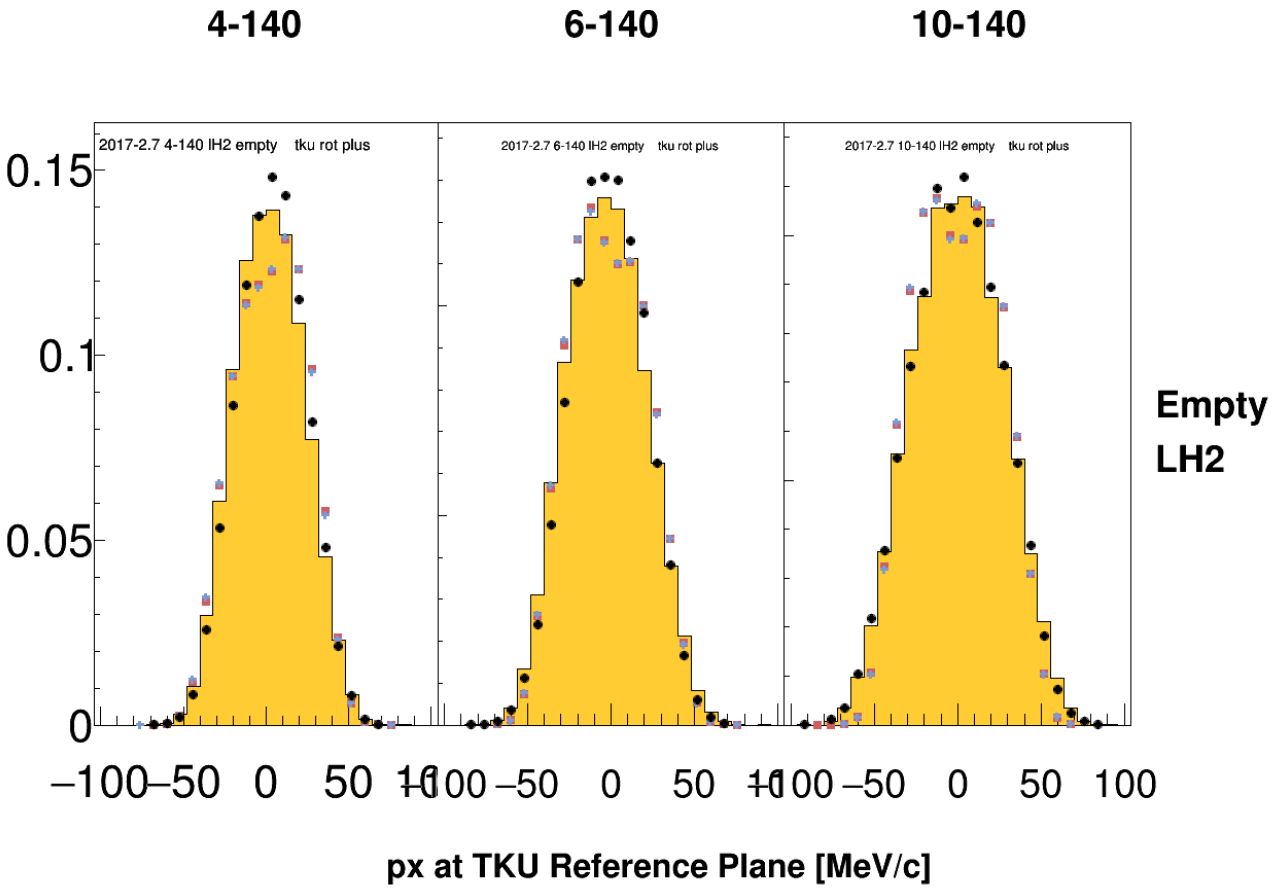
- Start with SSU
  - Pages of plots to follow...

Vary TKU pos 3 mm



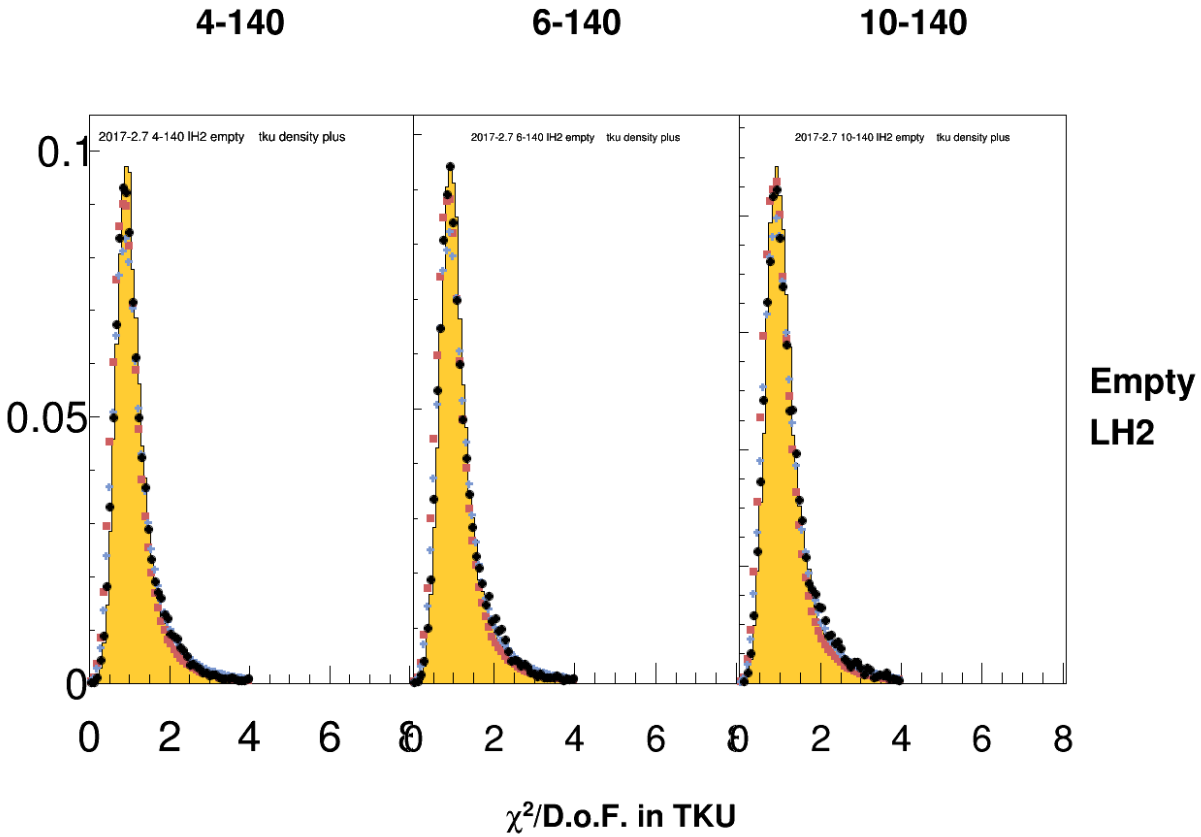
- Just visible movement of hybrid MC
- 3 mm is motivated by reasonable guess of positional alignment of TKU relative to SSU Coils

Vary TKU rot 3 mrad



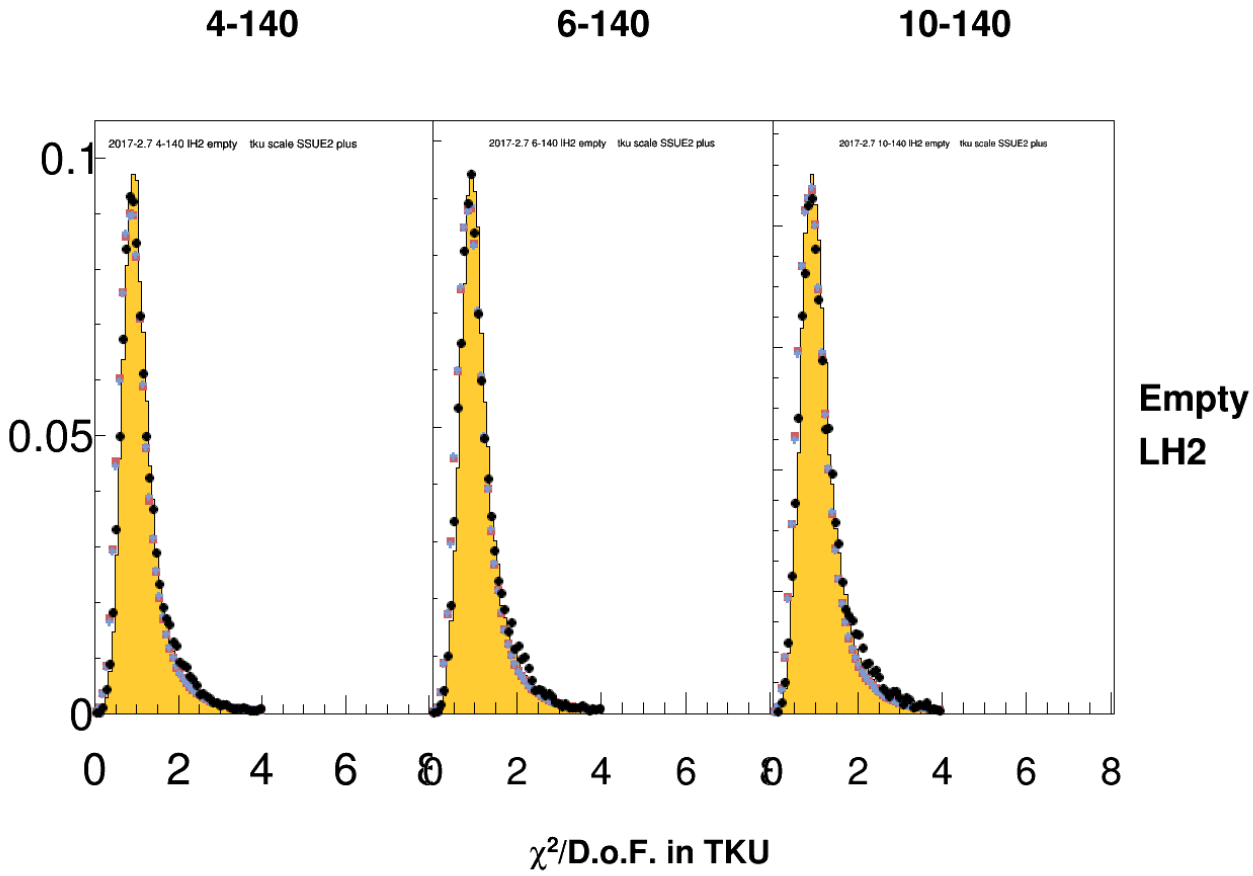
- 3 mrad → 0.5 MeV/c
- 3 mrad is motivated by reasonable guess of positional alignment of TKU relative to SSU Coils

Vary TKU glue density +50%



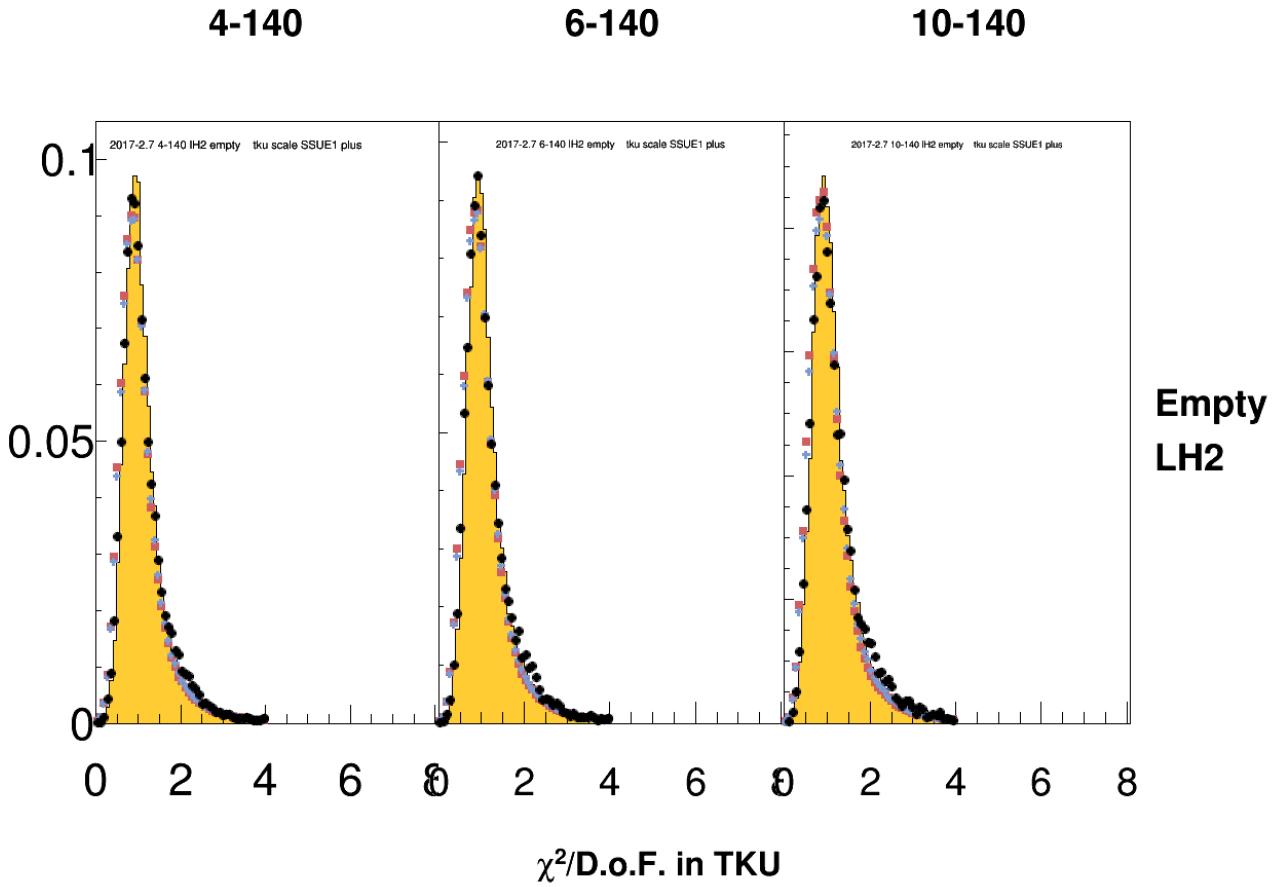
- SSU density 2 g/cm^3 → 3 g/cm^3 modifies the chi2 a bit
- 50 % glue density uncertainty motivated by uncertainty in build

Vary SSU E2 5%



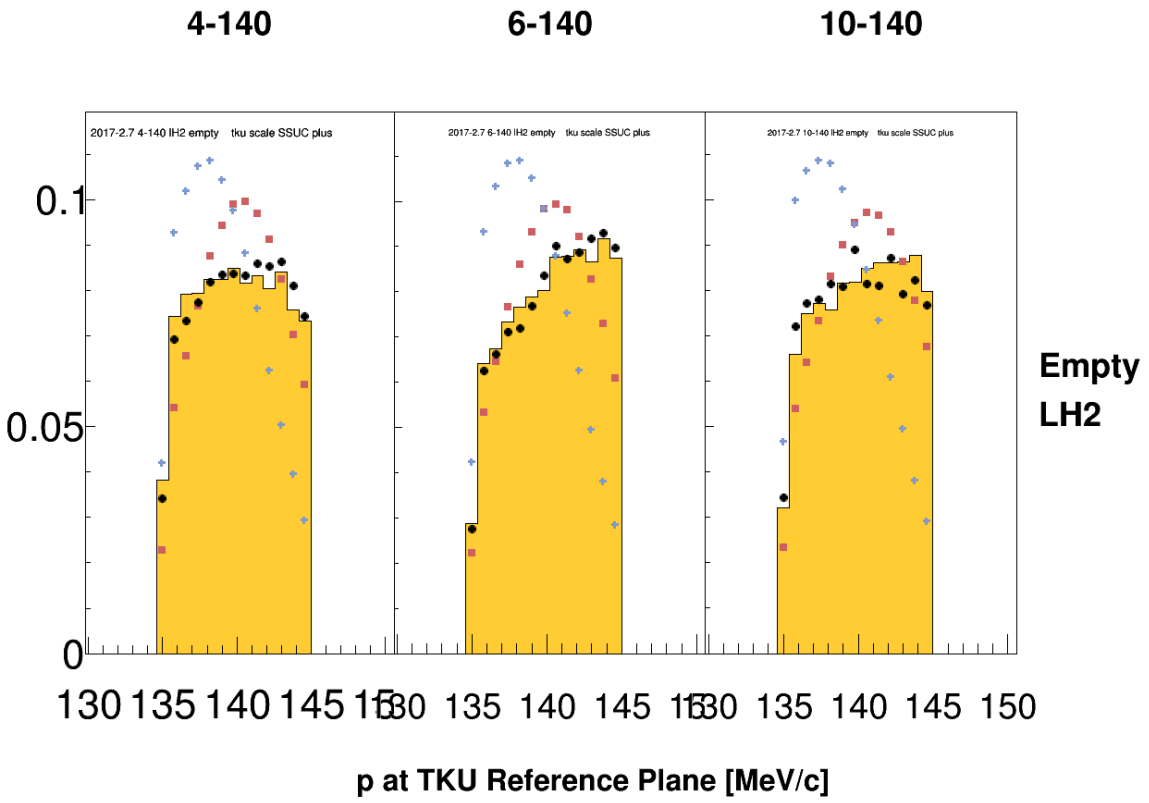
- 5 % motivated by Joe Langlands analysis
  - Could be reduced if/when his field map is brought into MAUS
- No visible effect

Vary SSU E1 5%



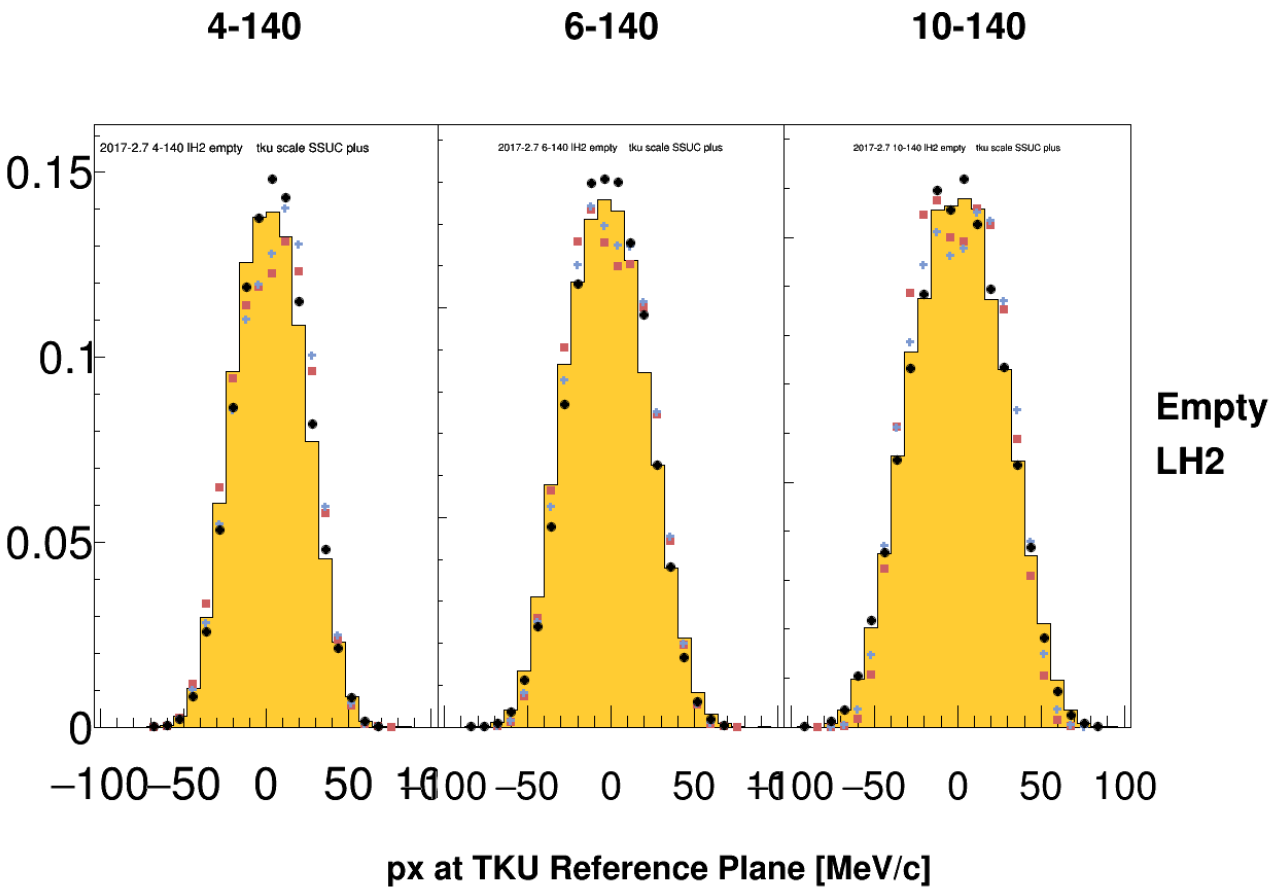
- 5 % motivated by Joe Langlands analysis
  - Could be reduced if/when his field map is brought into MAUS

Vary SSU Centre 3% - p



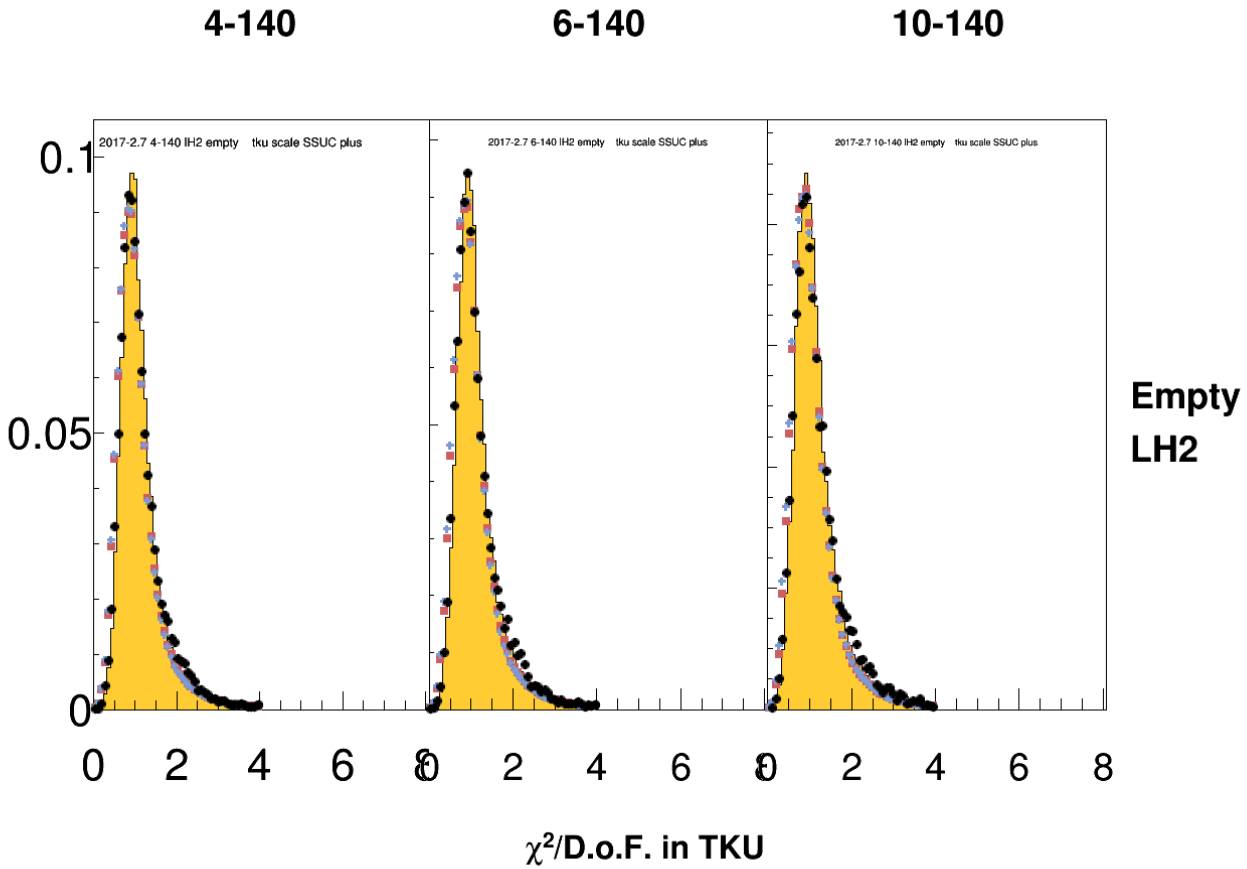
- Clear effect
- 3 % motivated by inconsistencies between
  - TOF and TKU (MC vs data)
  - TKU and TKD momenta (MC vs data)

Vary SSU Centre 3% - px



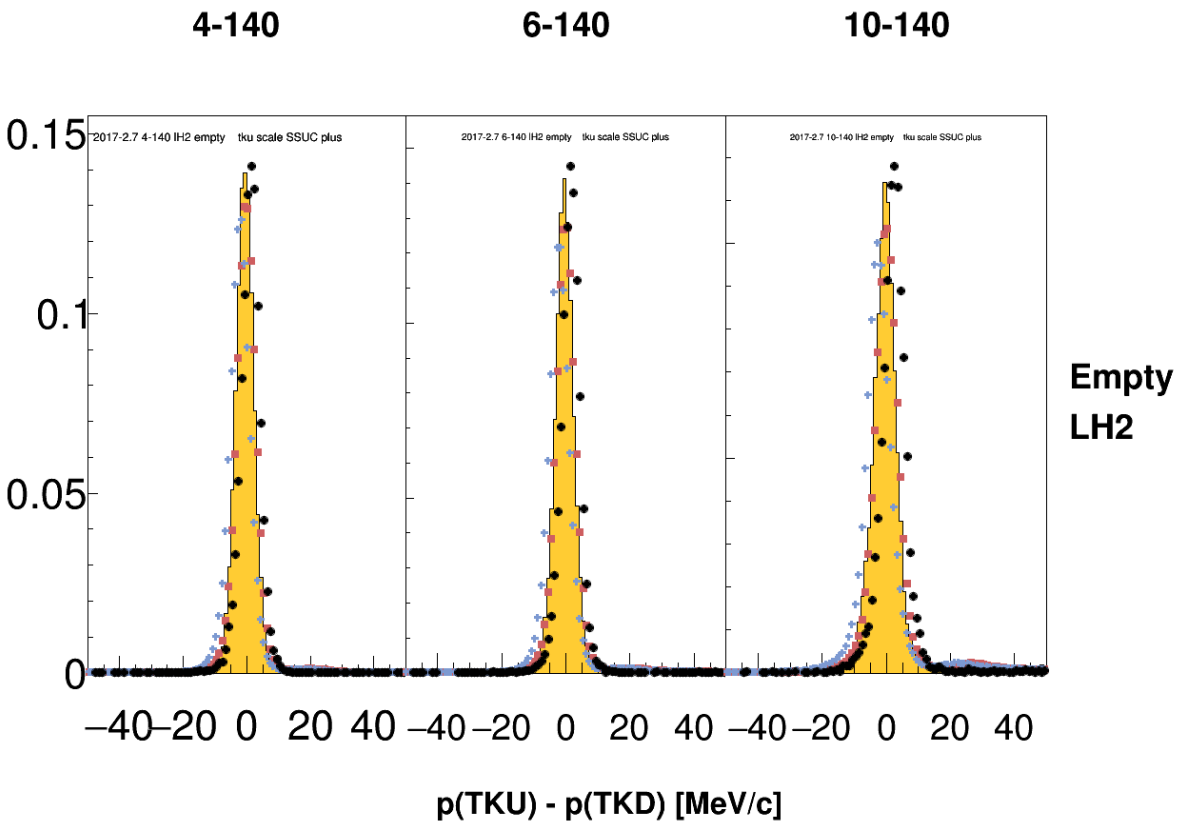
- Not a big effect on transverse phase space
- In principle distribution should be 3 % narrower

Vary SSU Centre 3% - chi2



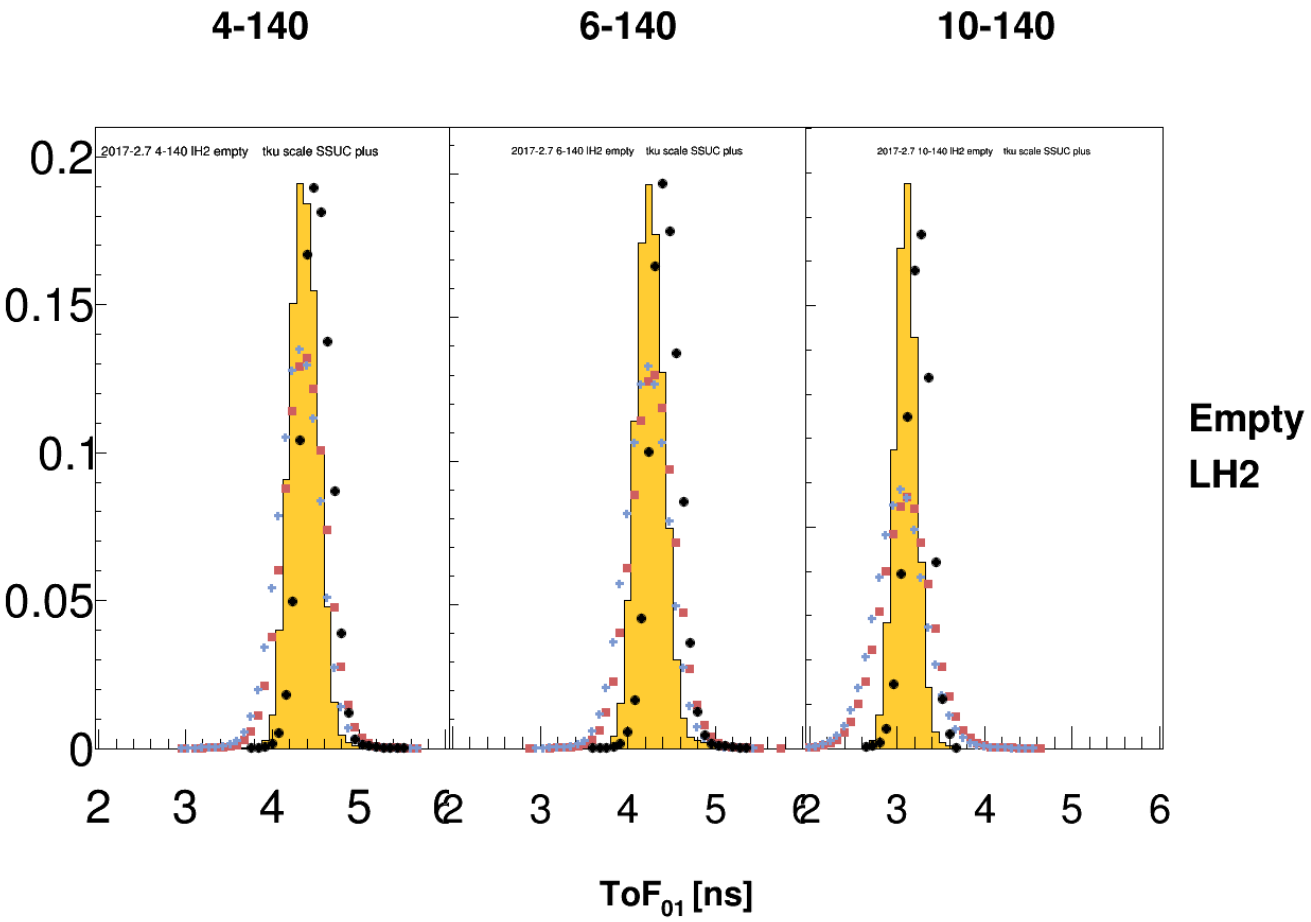
- Not a big effect on chi2
  - Still make helices (but with incorrect “pitch”)

Vary SSU Centre 3% - dp



- Moves momentum change

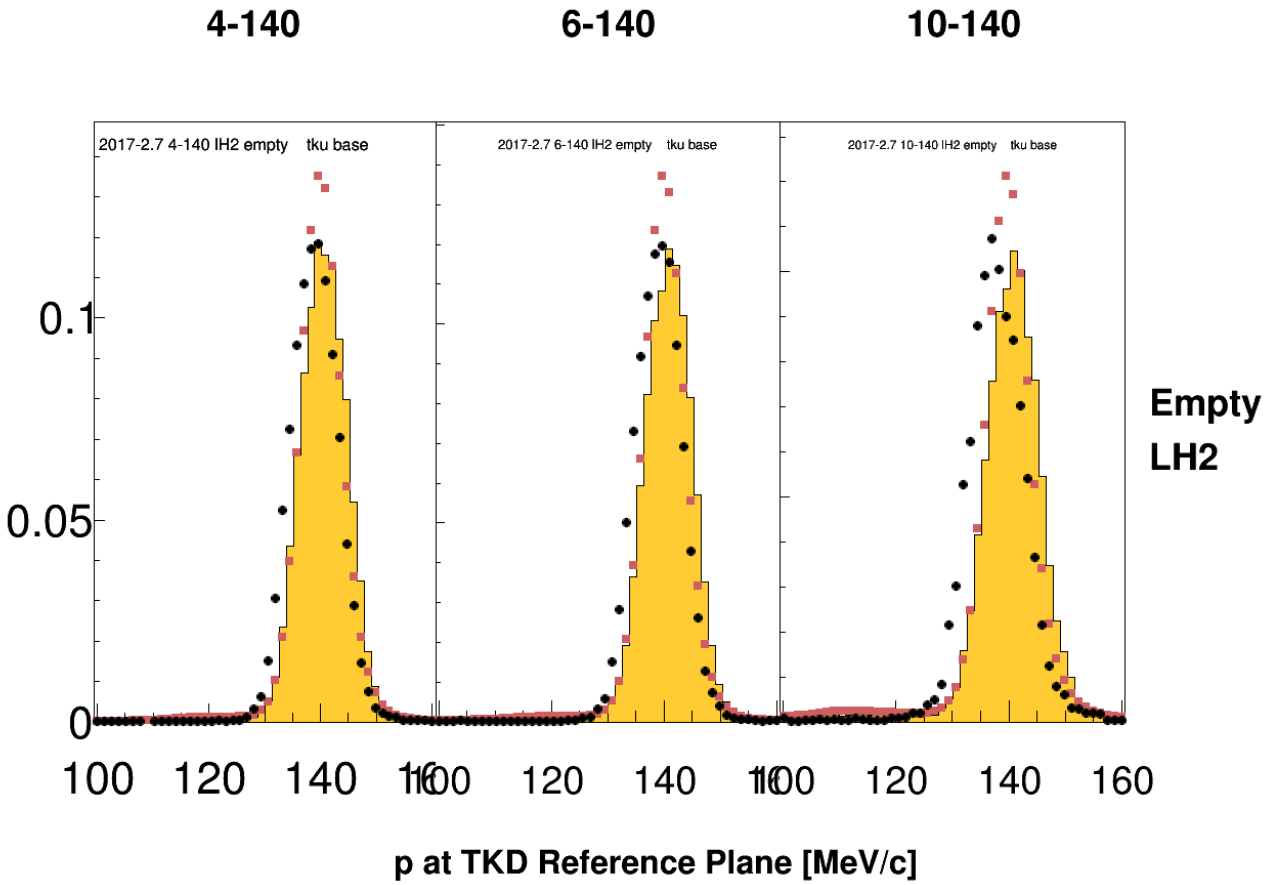
Vary SSU Centre 3% - TOF01



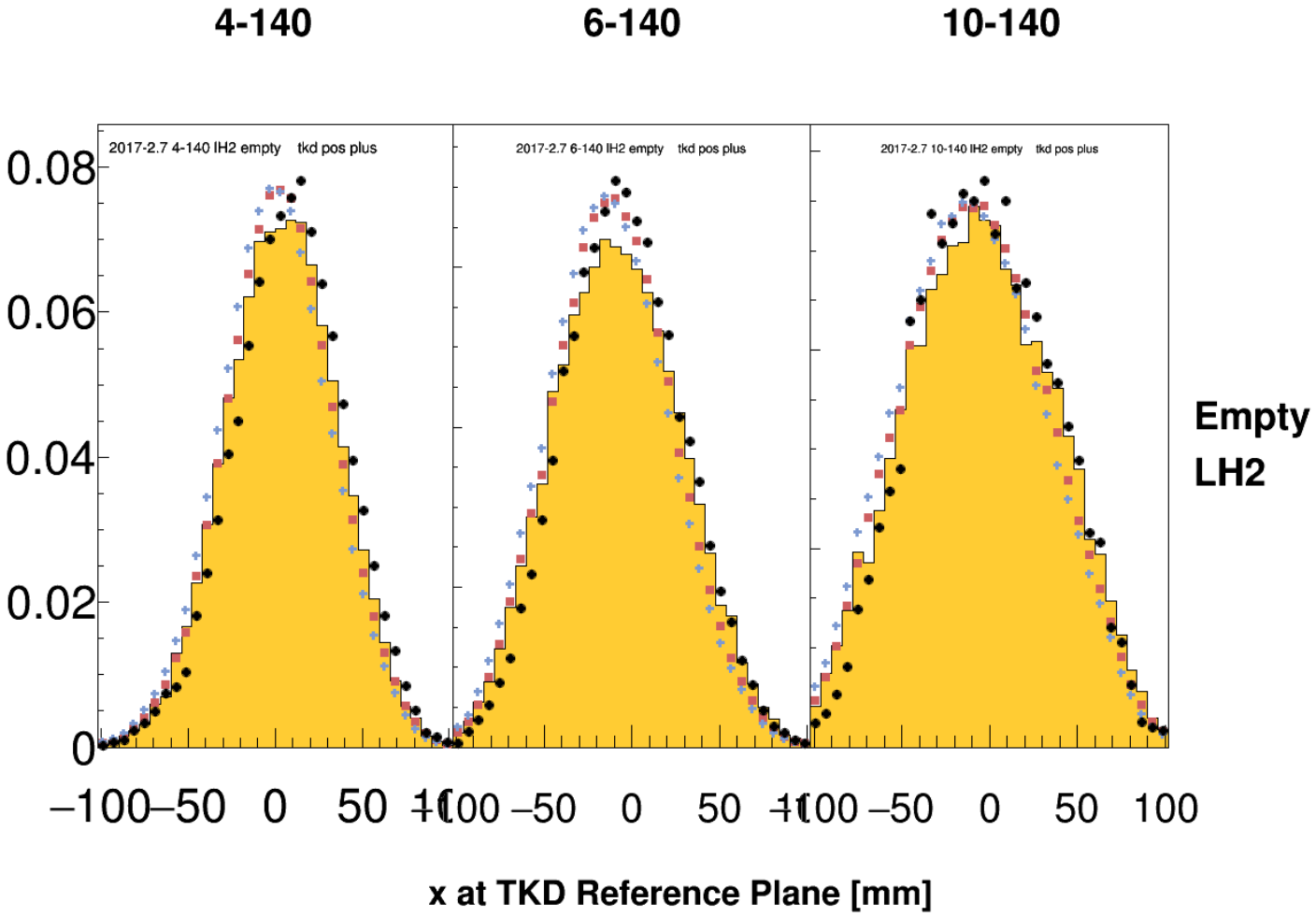
- Visible effect on the TOF01 distribution as well
  - Nb TOF01 is generated based on input TKU “true” p, so a bit hacky

Systematic effects - SSD

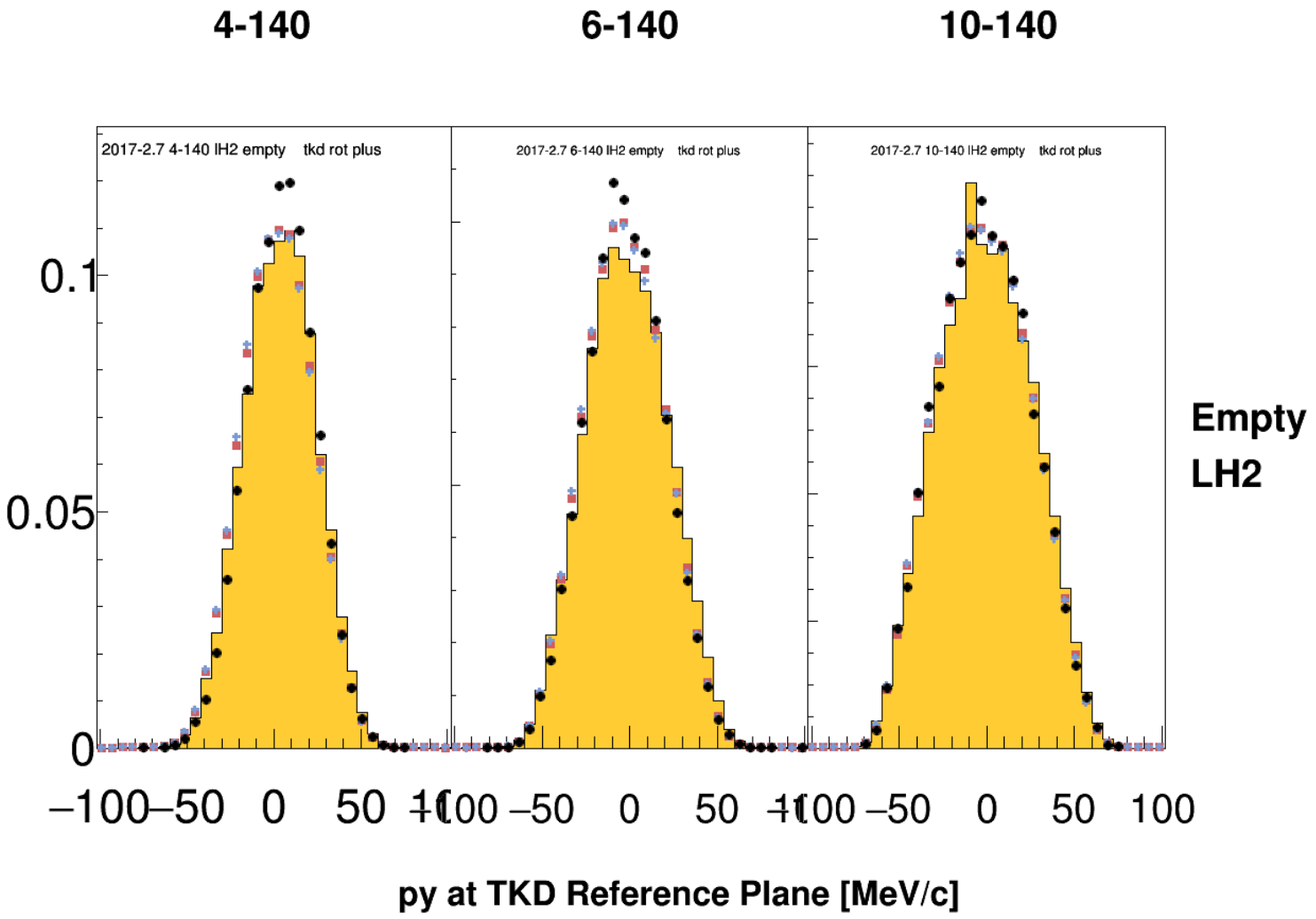
- Now SSD
- Note TKD momentum width still a bit narrower than data



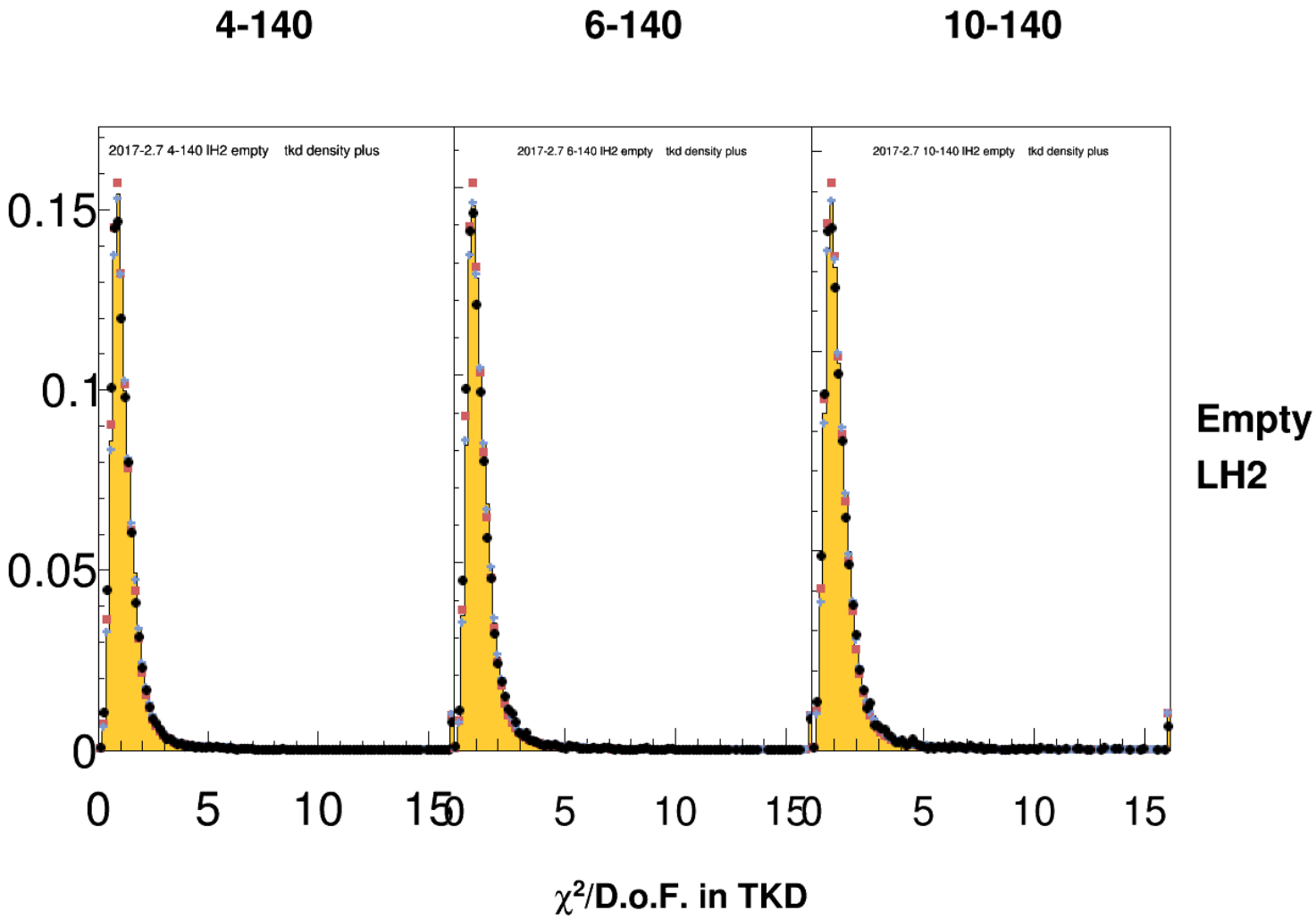
Vary TKD Pos 3 mm



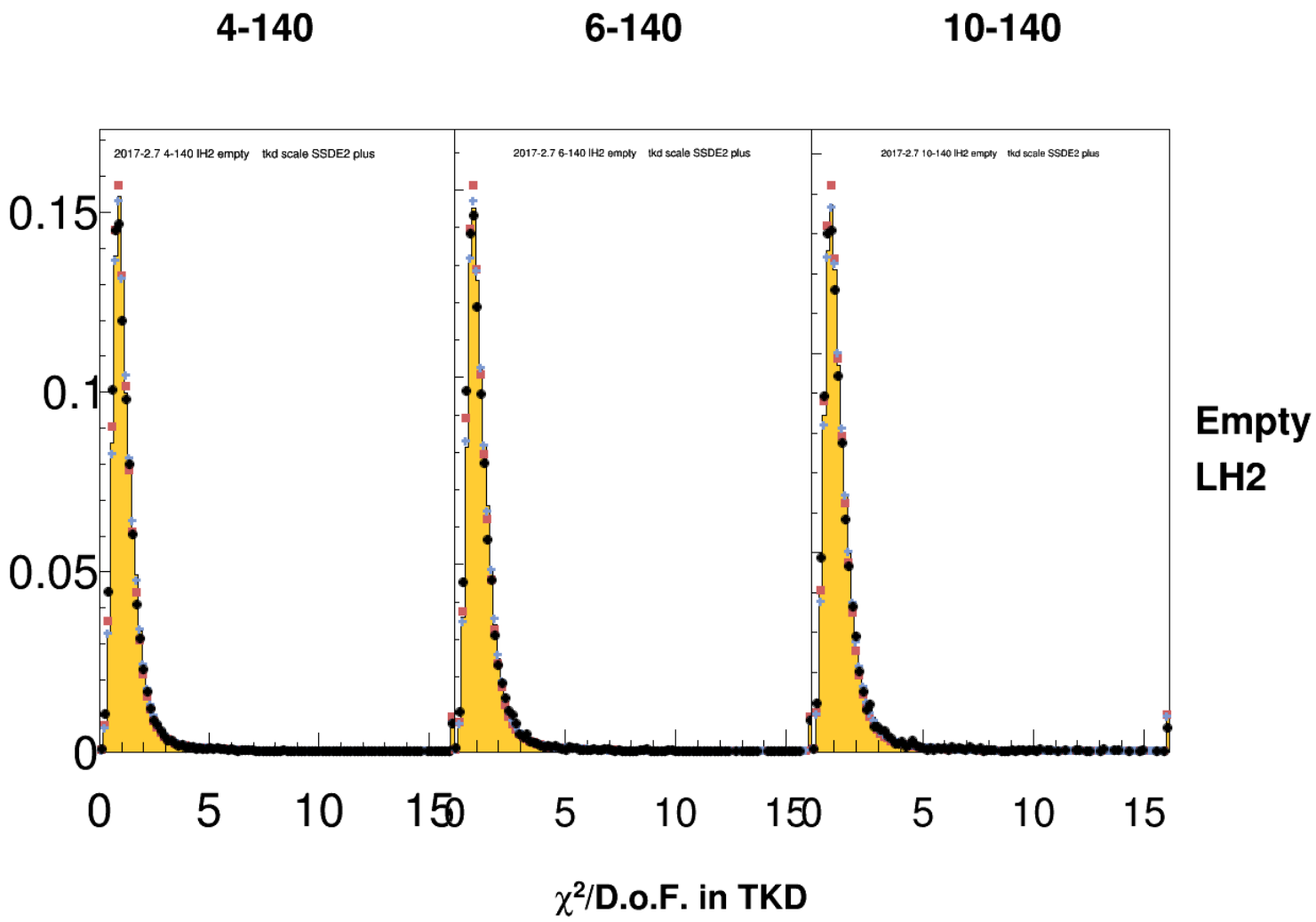
Vary TKD Rot 3 mrad



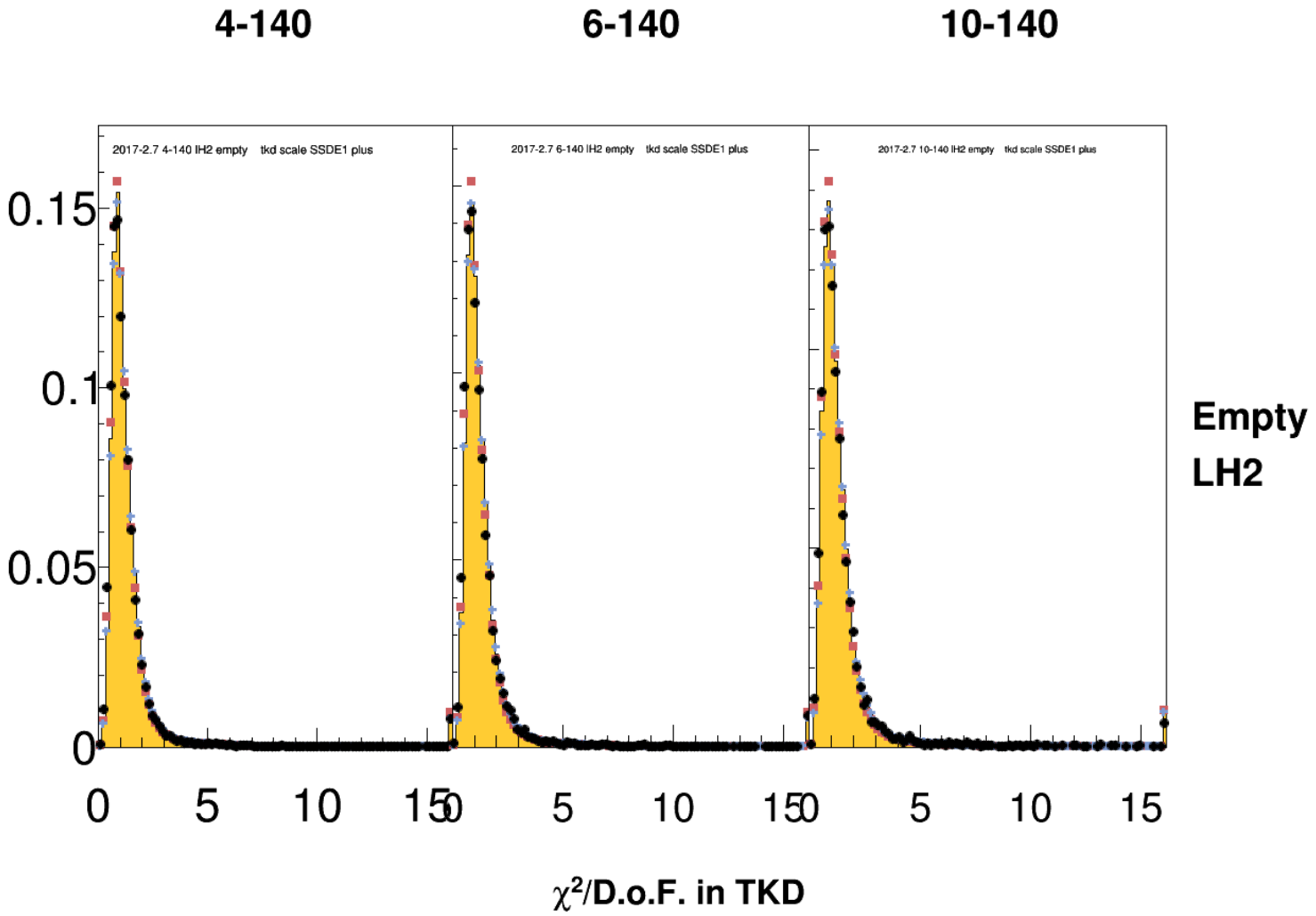
Vary TKD glue density 50%



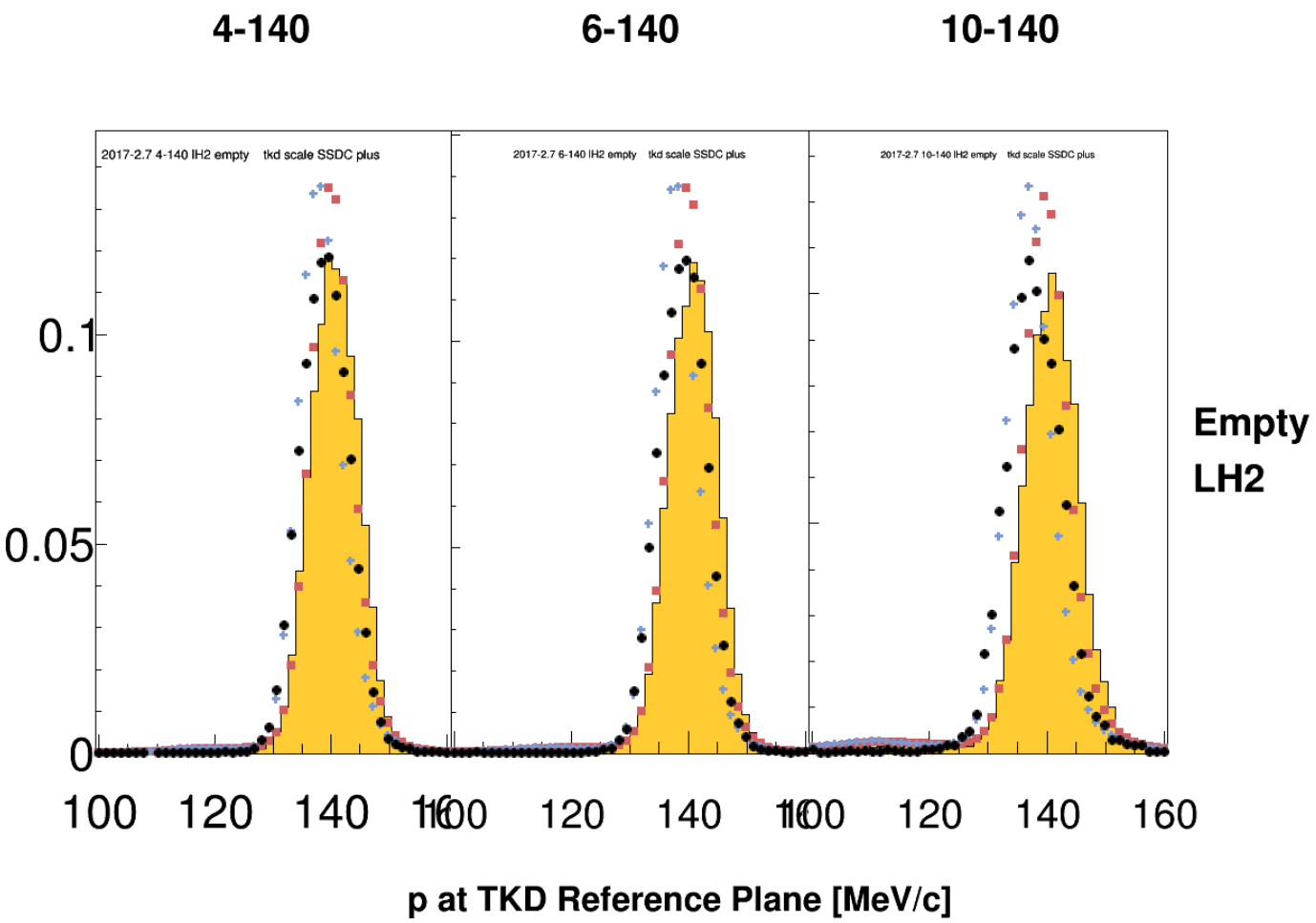
Vary TKD E2 5%


4-140
6-140
10-140
2017-2.7 4-140 lH2 empty tkd scale SSDE2 plus
2017-2.7 6-140 lH2 empty tkd scale SSDE2 plus
2017-2.7 10-140 lH2 empty tkd scale SSDE2 plus
0.15
0.1
0.05
0
0 5 10 15
0 5 10 15
0 5 10 15
Empty
LH2
χ²/D.o.F. in TKD

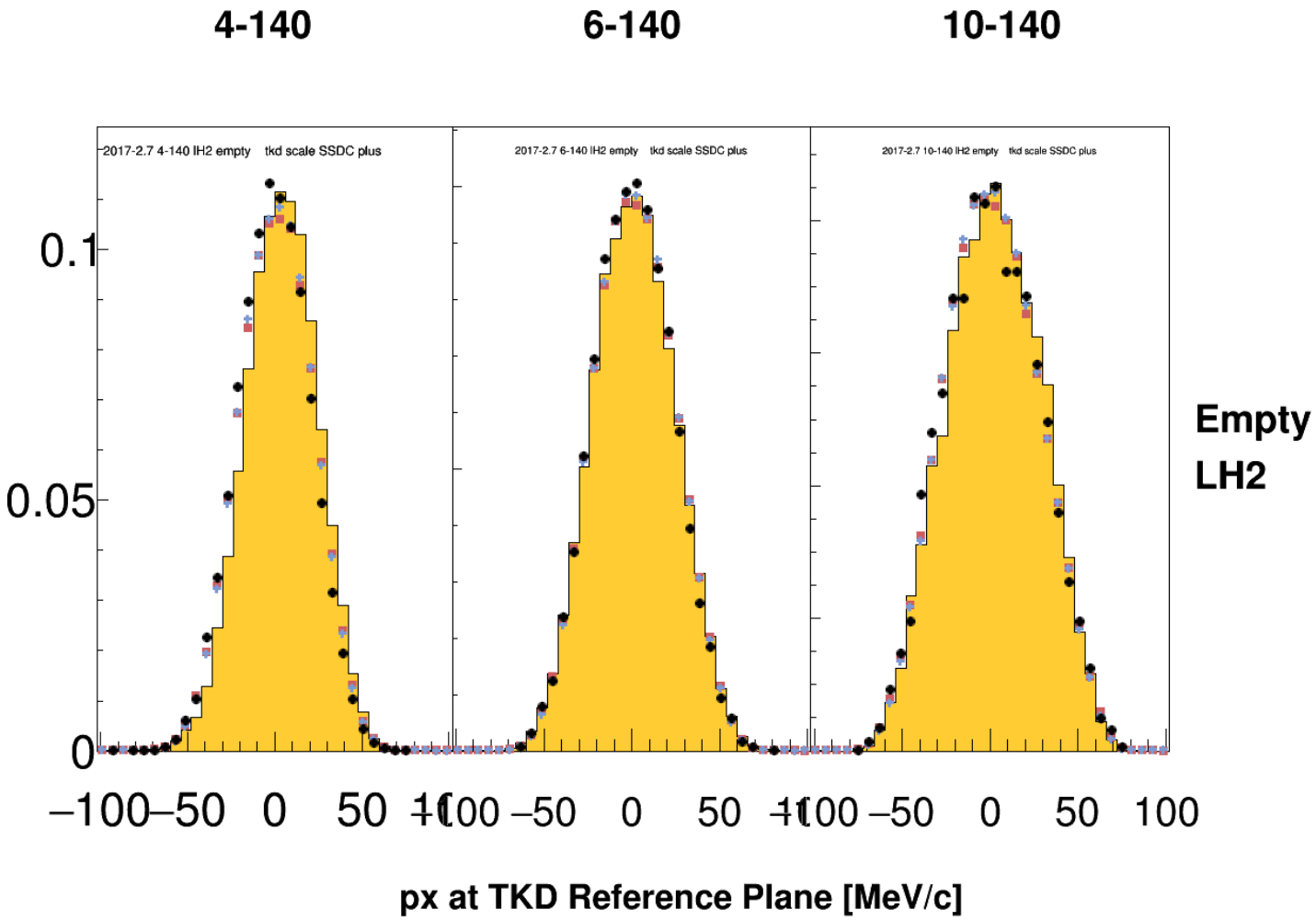
Vary TKD E1 5%


4-140
6-140
10-140
2017-2.7 4-140 lH2 empty tkd scale SSDE1 plus
2017-2.7 6-140 lH2 empty tkd scale SSDE1 plus
2017-2.7 10-140 lH2 empty tkd scale SSDE1 plus
0.15
0.1
0.05
0
0 5 10 15
χ²/D.o.F. in TKD
Empty
LH2

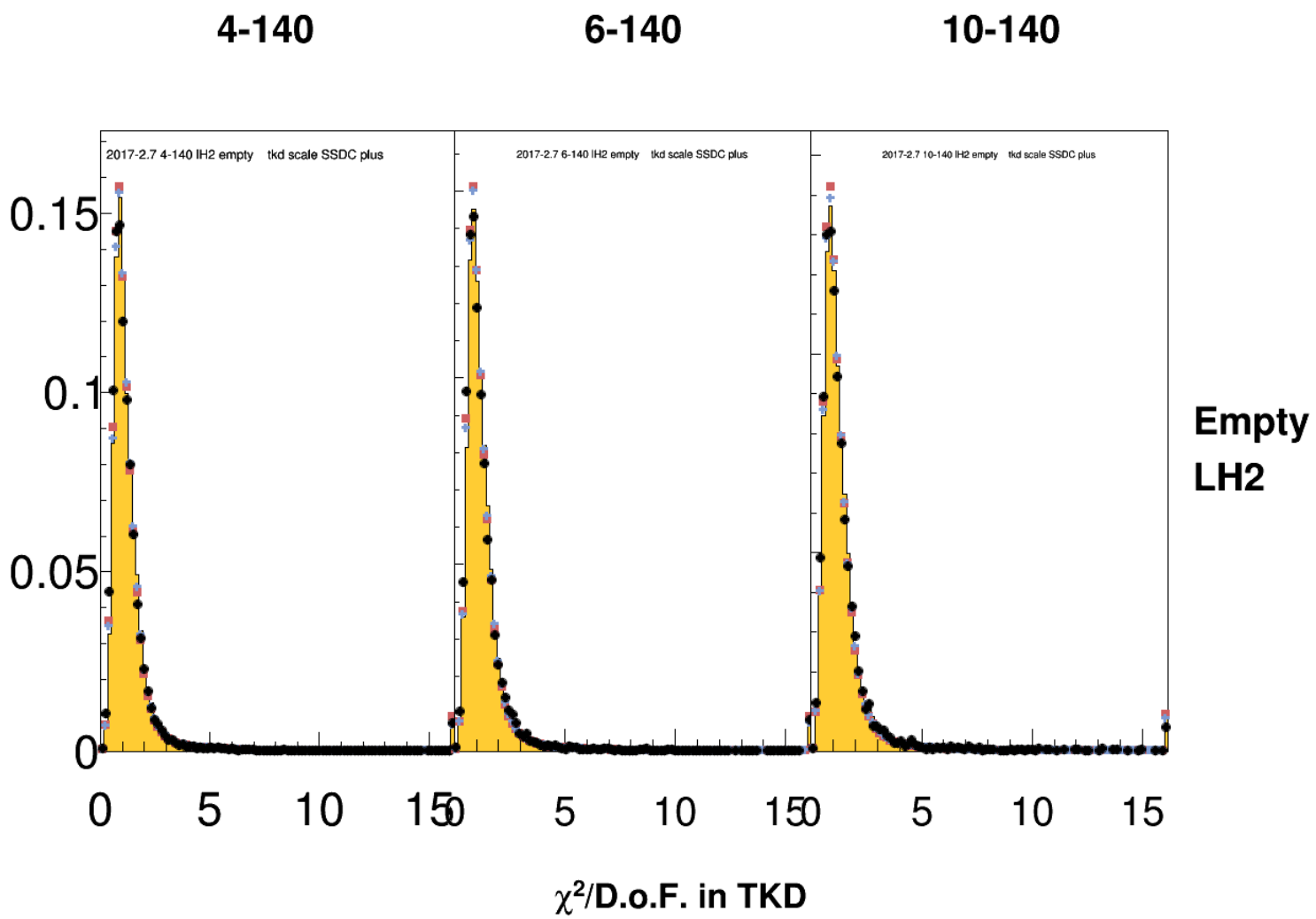
Vary SSD Centre 3 %



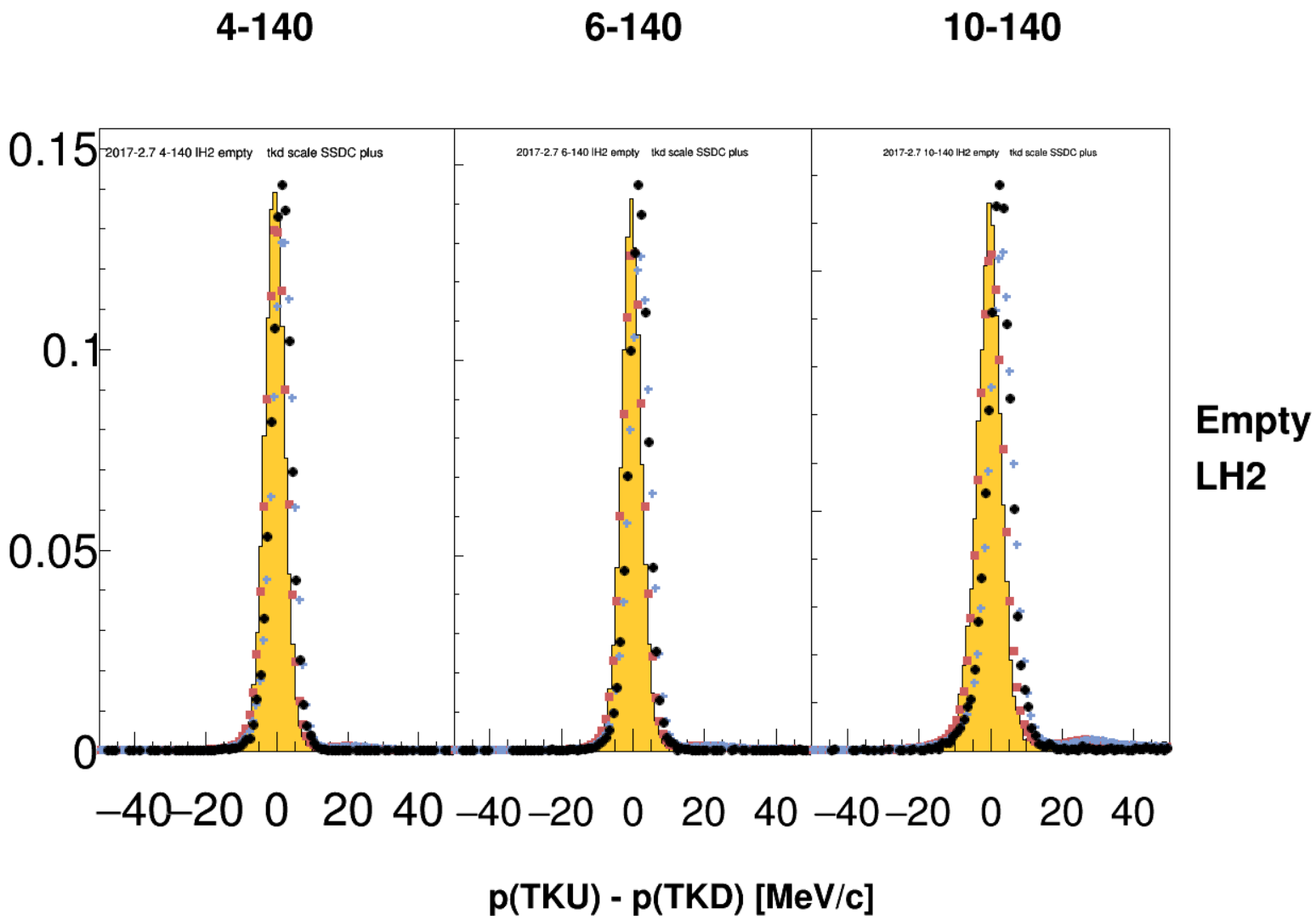
Vary SSD Centre 3 %



Vary SSD Centre 3 %



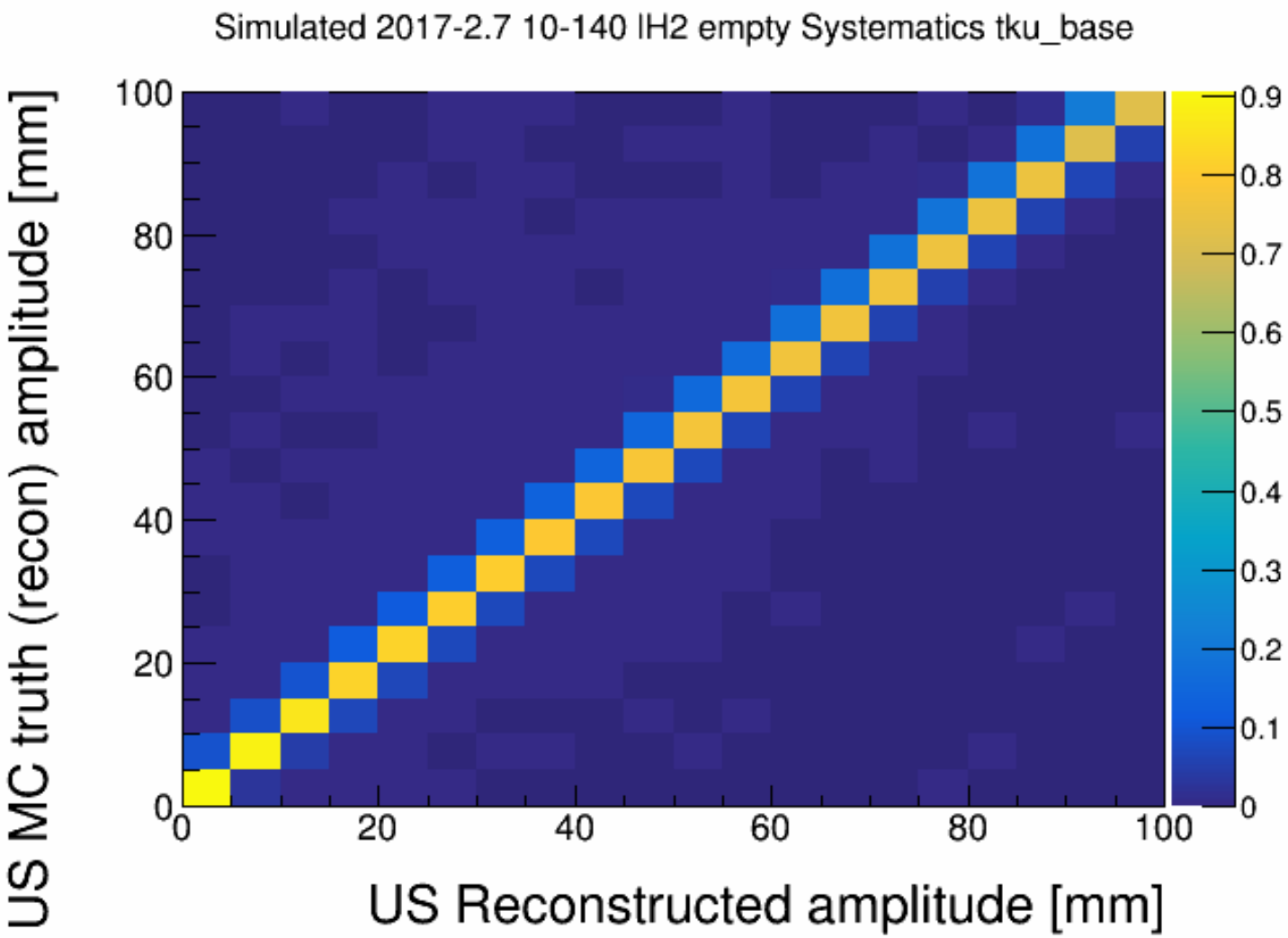
Vary SSD Centre 3 %



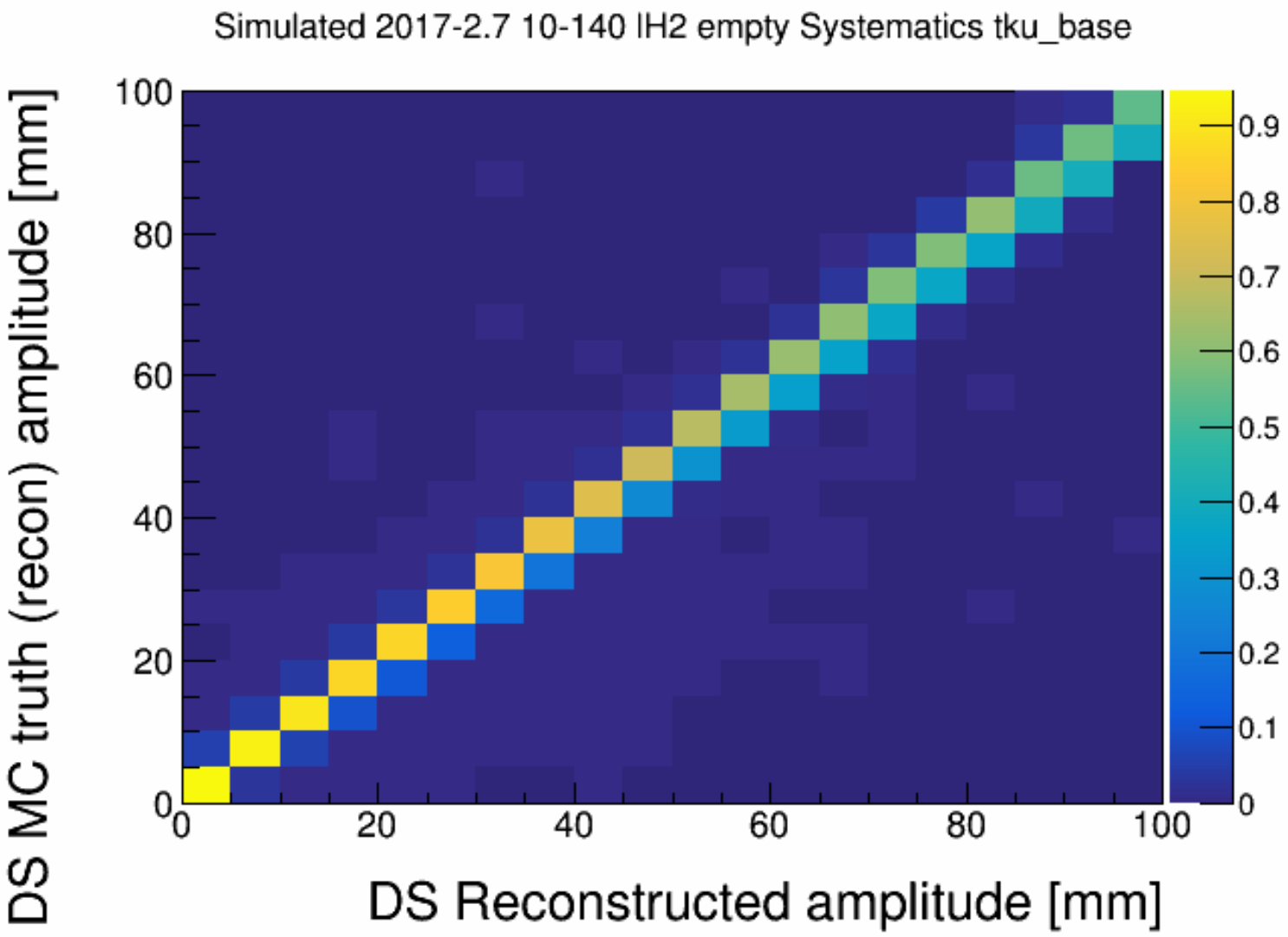
Systematic effects - Amplitude

- I use the base hybrid MC to calculate correction matrix
- I use the systematically shifted MC to look at uncertainty in the correction matrix

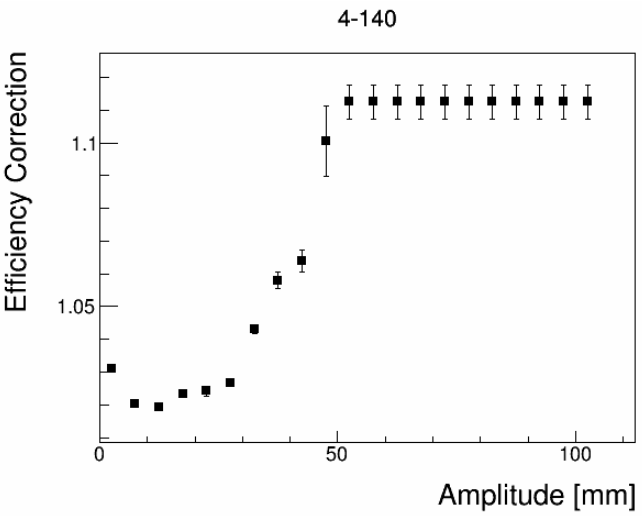
Migration - Upstream

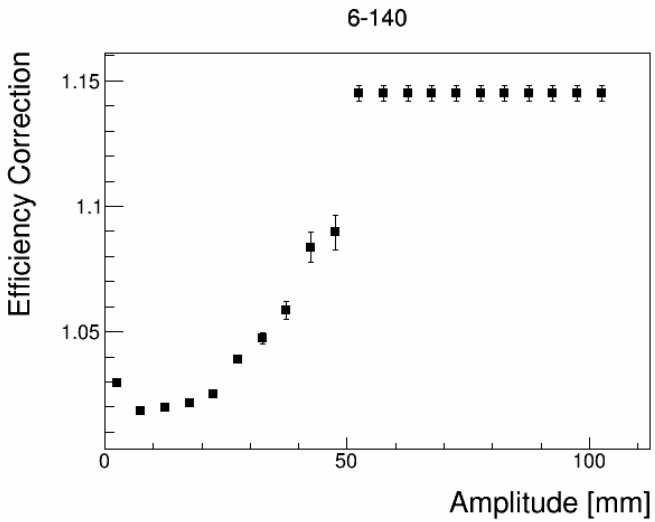


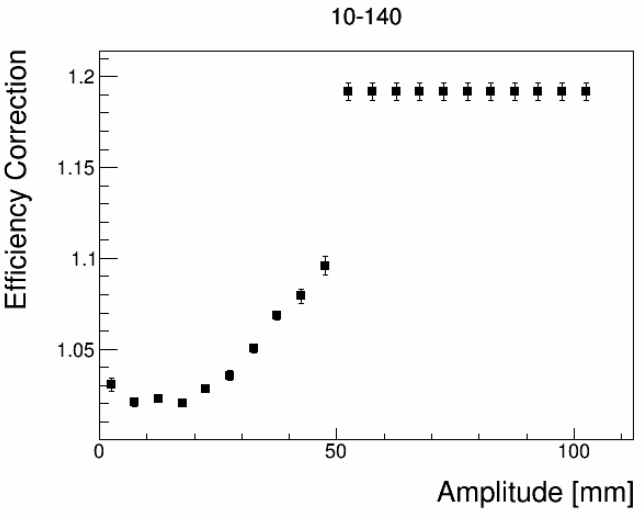
Migration - Downstream



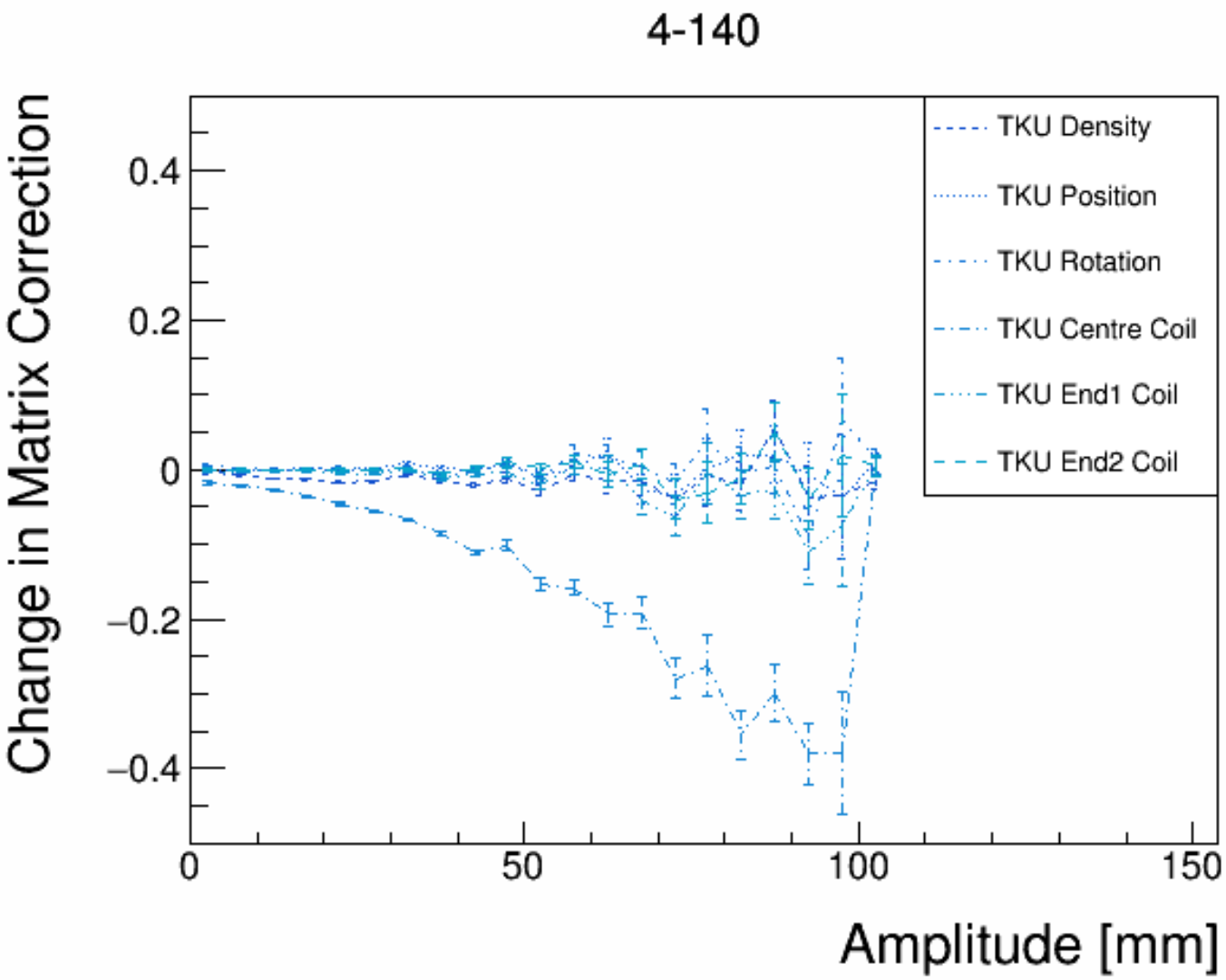
High amplitude correction



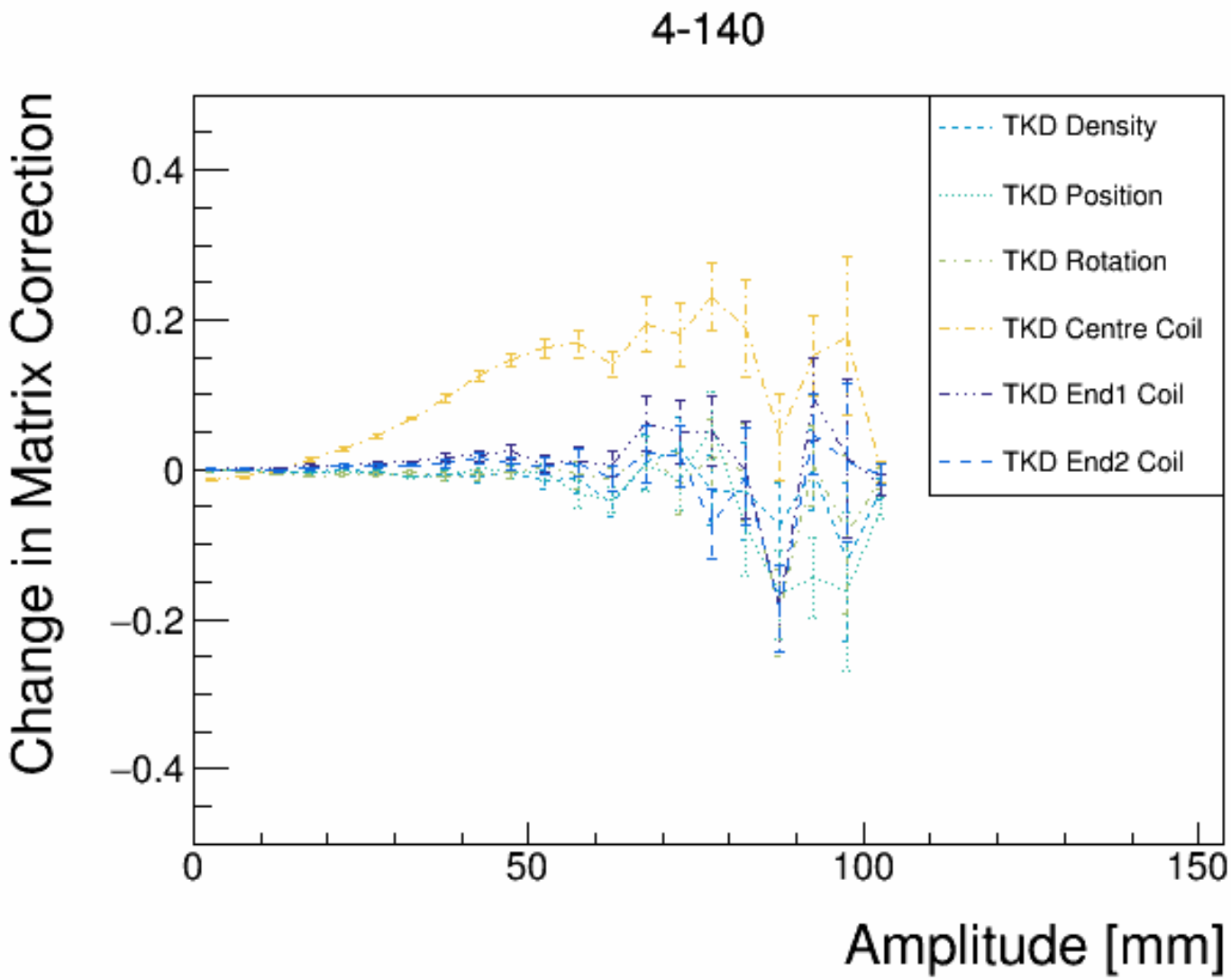




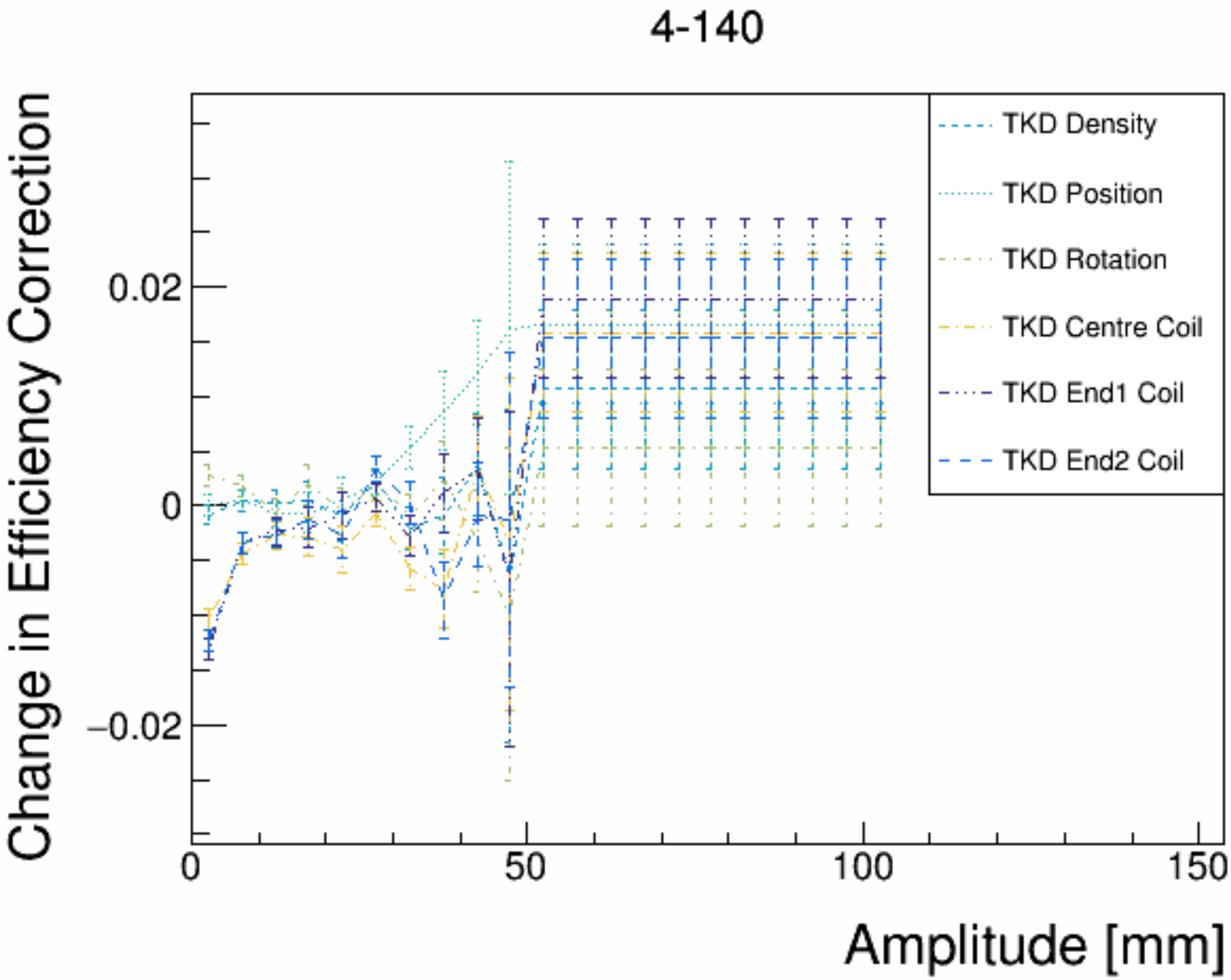
Systematics - Upstream



Systematics - Downstream



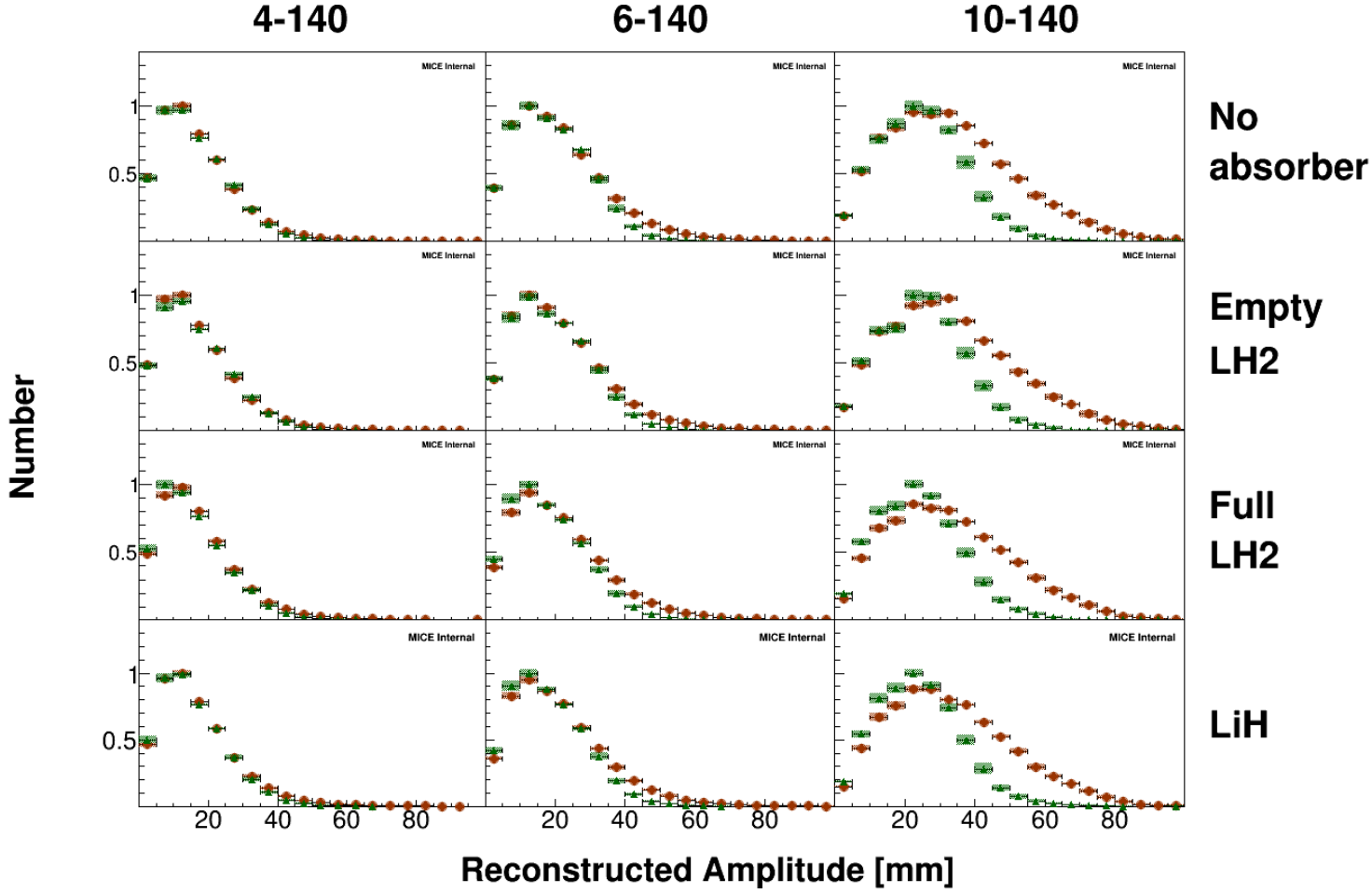
Systematics - Downstream



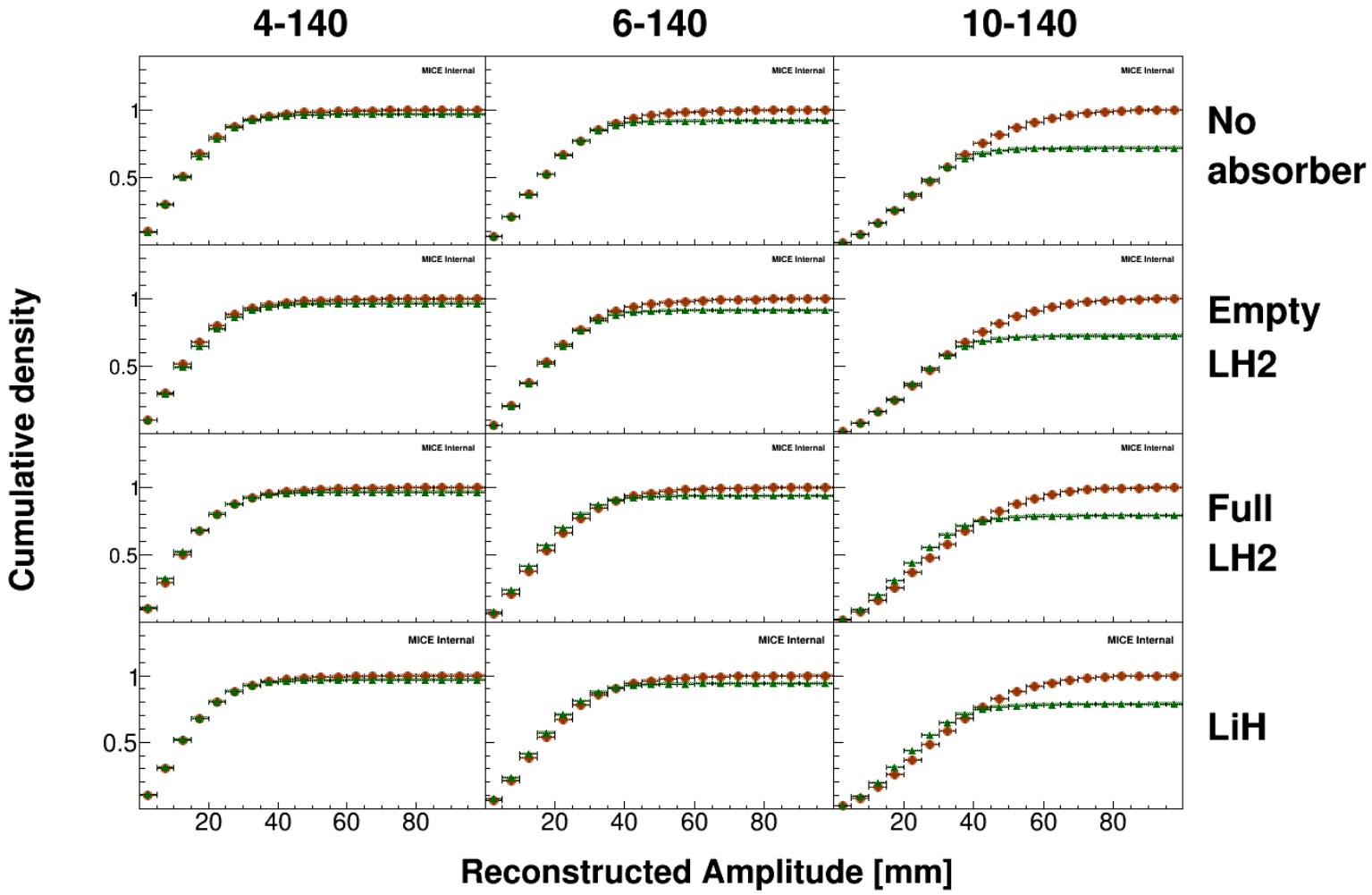
Results

- I will show the usual round of pdf/cdf and ratios

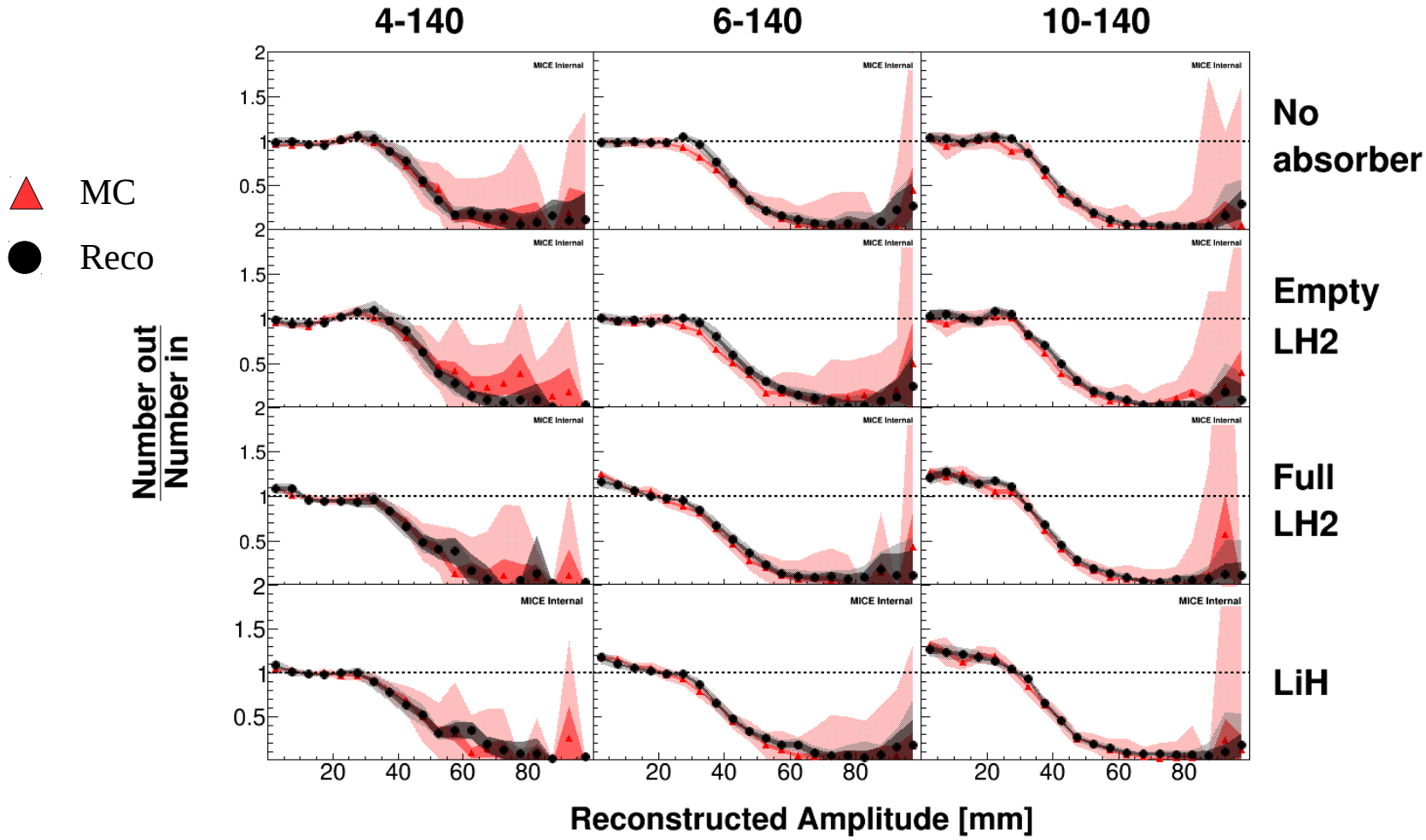
PDF


4-140
6-140
10-140
No absorber
Empty LH2
Full LH2
LiH
Number
Reconstructed Amplitude [mm]
MICE Internal
Downstream
Upstream

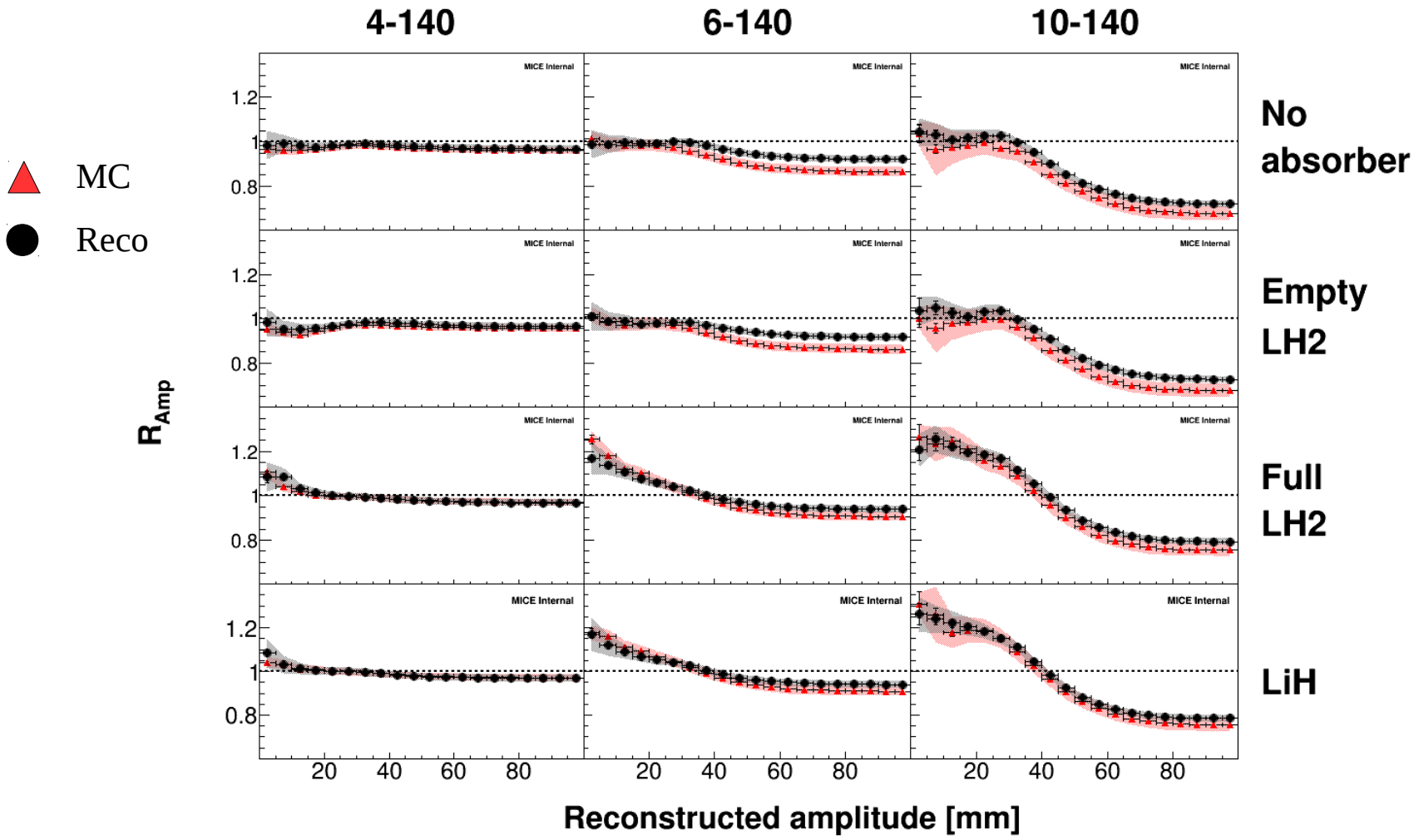
CDF


4-140
6-140
10-140
MICE Internal
Cumulative density
Reconstructed Amplitude [mm]
No absorber
Empty LH2
Full LH2
LiH
Downstream
Upstream

PDF Ratio


4-140
6-140
10-140
MC
Reco
Number out / Number in
MICE Internal
No absorber
Empty LH2
Full LH2
LiH
Reconstructed Amplitude [mm]

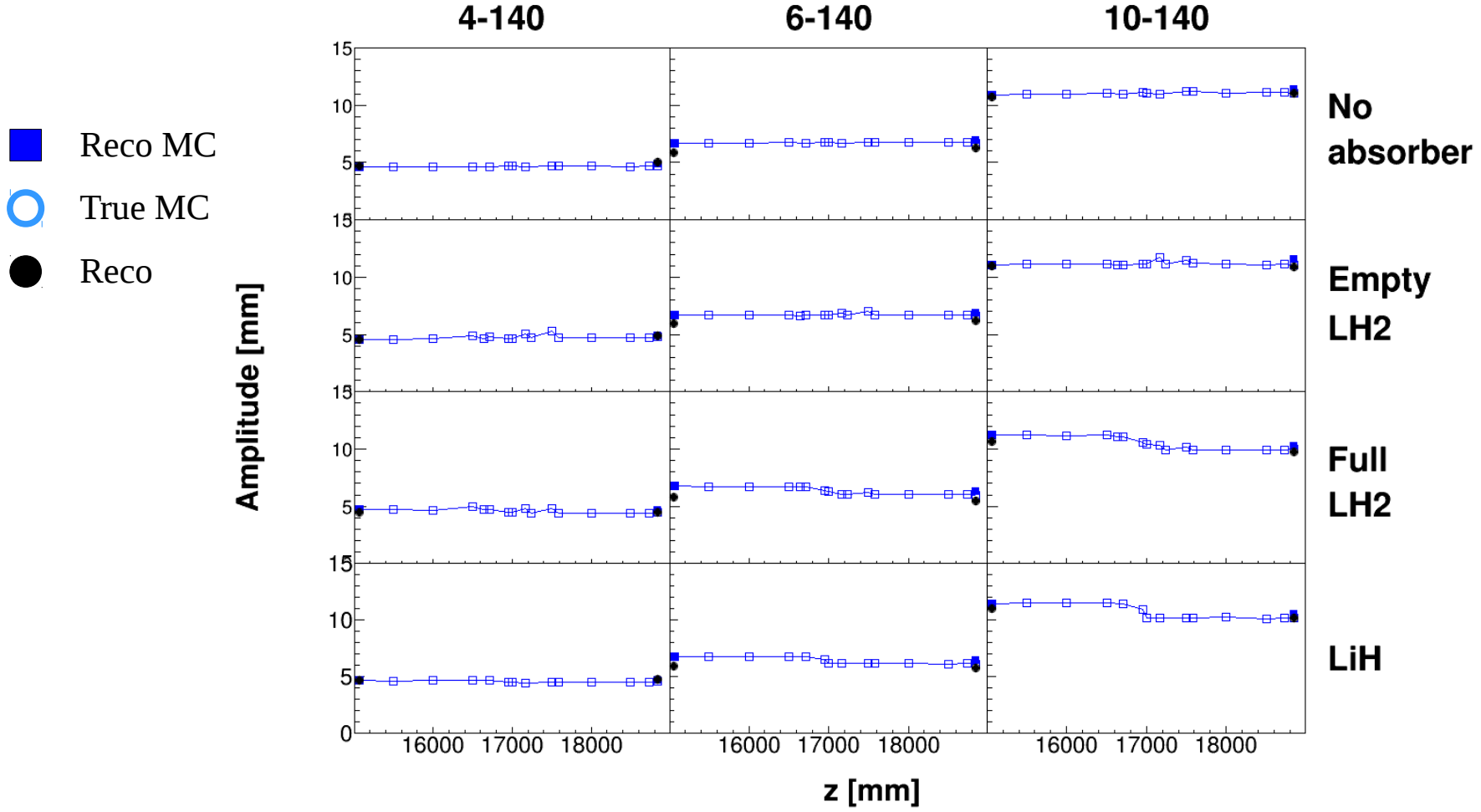
CDF Ratio


4-140
6-140
10-140
MC
Reco
No absorber
Empty LH2
Full LH2
LiH
R_{Amp}
Reconstructed amplitude [mm]
MICE Internal

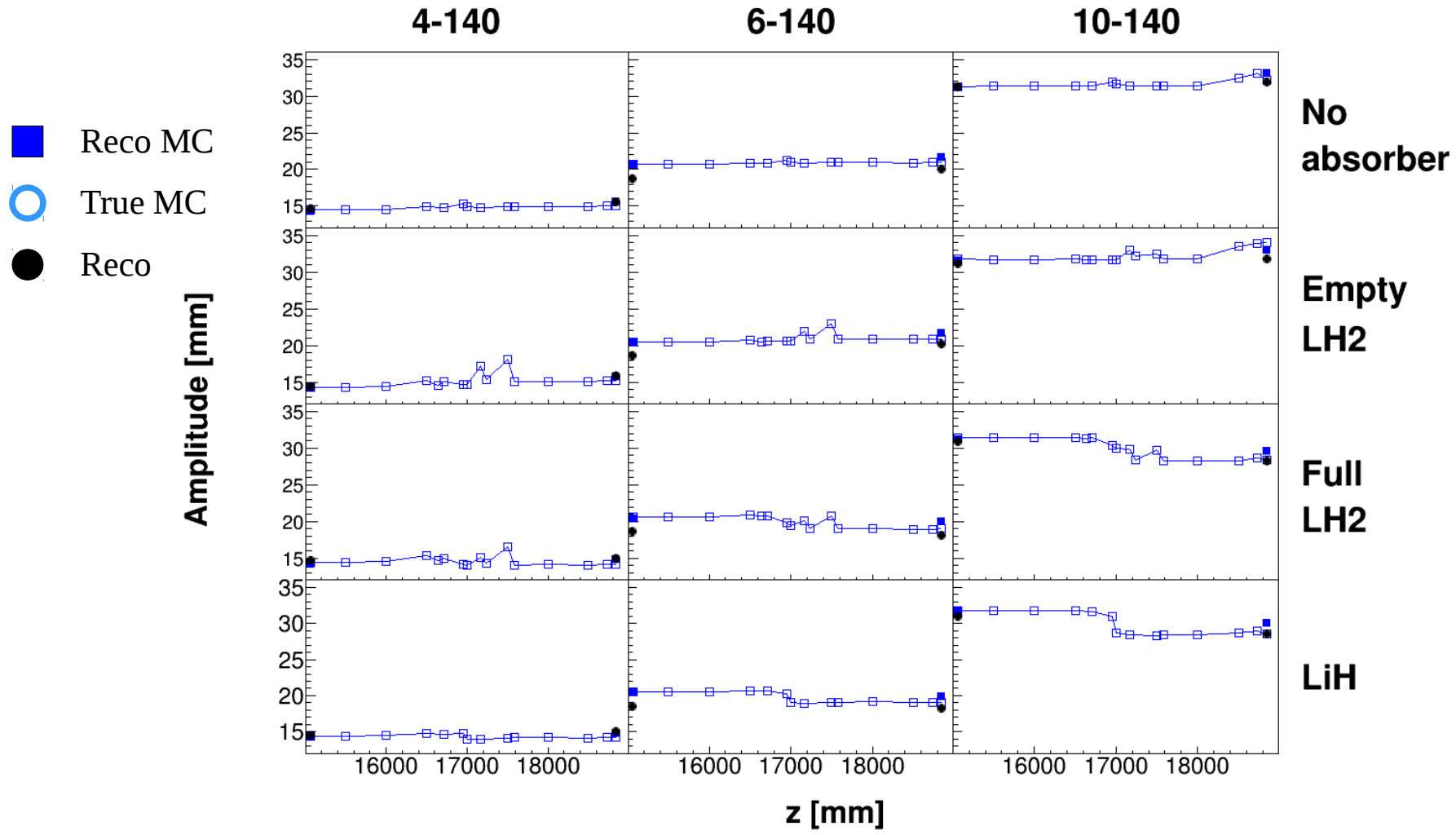
Fractional Amplitude

- Introduce “fractional amplitude”
  - Amplitude of the n % quantile
- Statistical uncertainty is included (and small)
- Systematic correction and uncertainty has not yet been calculated

Fractional Amplitude – 9 %



Fractional Amplitude – 50 %



Conclusions

- Things are looking pretty settled
  - The low amplitude inefficiency is fixed
  - The momentum discrepancies remain, but these are handled adequately in systematic uncertainty
- I would like to do a “negative shift” of the Centre coils
  - E.g. check that the systematic is linear
  - Is 3 % current shift okay here?
- Working on implementing a fractional emittance routine, as requested by collaboration