RUN 7469 PAPER UPDATE

V. Blackmore
CM47
14th Feb 2017

FLASHBACK WARNING

CM45

ICHEP16 prelim-plot approval: http://micewww.pp.rl.ac.uk/projects/analysis/wiki/Direct_measurement_of_emittance_using_the_MICE_scintillating_fibre_tracker

+ Description and effect of cuts

+ Momentum-loss cut to remove tracks that pass through the outer ring of the diffuser

+ Analysis procedure

+ MC does not fully represent data

CM46

+ Improved cuts?

+ Extrapolate TKU tracks to diffuser region (courtesy of C. Rogers)

+ Use to remove tracks that pass through the outer ring of the diffuser

+ This cut, if vetted, would replace momentum-loss cut from CM45

+ Still questions to answer...

Video Conference (Jan 12th 2017)

+ Monte Carlo cross-checks
  + Biases, reconstructed vs. truth

  + *Diffuser-tracking cut check*
  + *Bias correction, reiterate analysis and check*
  + *Compare to run 8590*

(All waiting on new Monte Carlo)

Yesterday...

MAUS 2.8 suggests a huge improvement to run 7469 data.

Waiting with much excitement!

In other words, what you're about to see may look oddly similar to the last VC talk.

Except this time, in person.

With a few additions.

Video Conference (Jan 12th 2017)

+ Monte Carlo cross-checks
    + Biases, reconstructed vs. truth

    + Diffuser-tracking cut check
    + Bias correction, reiterate analysis and check
    + Compare to run 8590
(All waiting on new Monte Carlo)

Status

- There are no new plots in this talk to take away and show off. The official preliminary plots are still the ones taken to ICHEP:
  - Link to wiki page
- The cuts used for the plots shown in this talk are the same "everything passes" ones as used for the ICHEP plots *for now*.
  - See the very long CM45 talk here for what exactly these are
- Effort has been focused on answering the following:
  1. What effect has the non-uniform field had on track reconstruction? Errors/corrections needed?
  2. Is the proposed cut on particle radius at the diffuser effective? Does the "back tracking" between TKU and TOF1 work? Errors/corrections needed?
  3. Is there a reason for losing so much momentum between TOF1 and TKU?
  4. How good is our magnetic field model?

CM47 comment:
→ This is still true. We need a MC with virtual planes at the diffuser, which is proving tricky. It's essential if we're to verify the replacement cut.

Have depended on MC with virtual planes in new locations. It's taken a while to get something that works, but we're getting there.

The answers to these questions will help all of our analyses, not just 7469.

MC study checklist

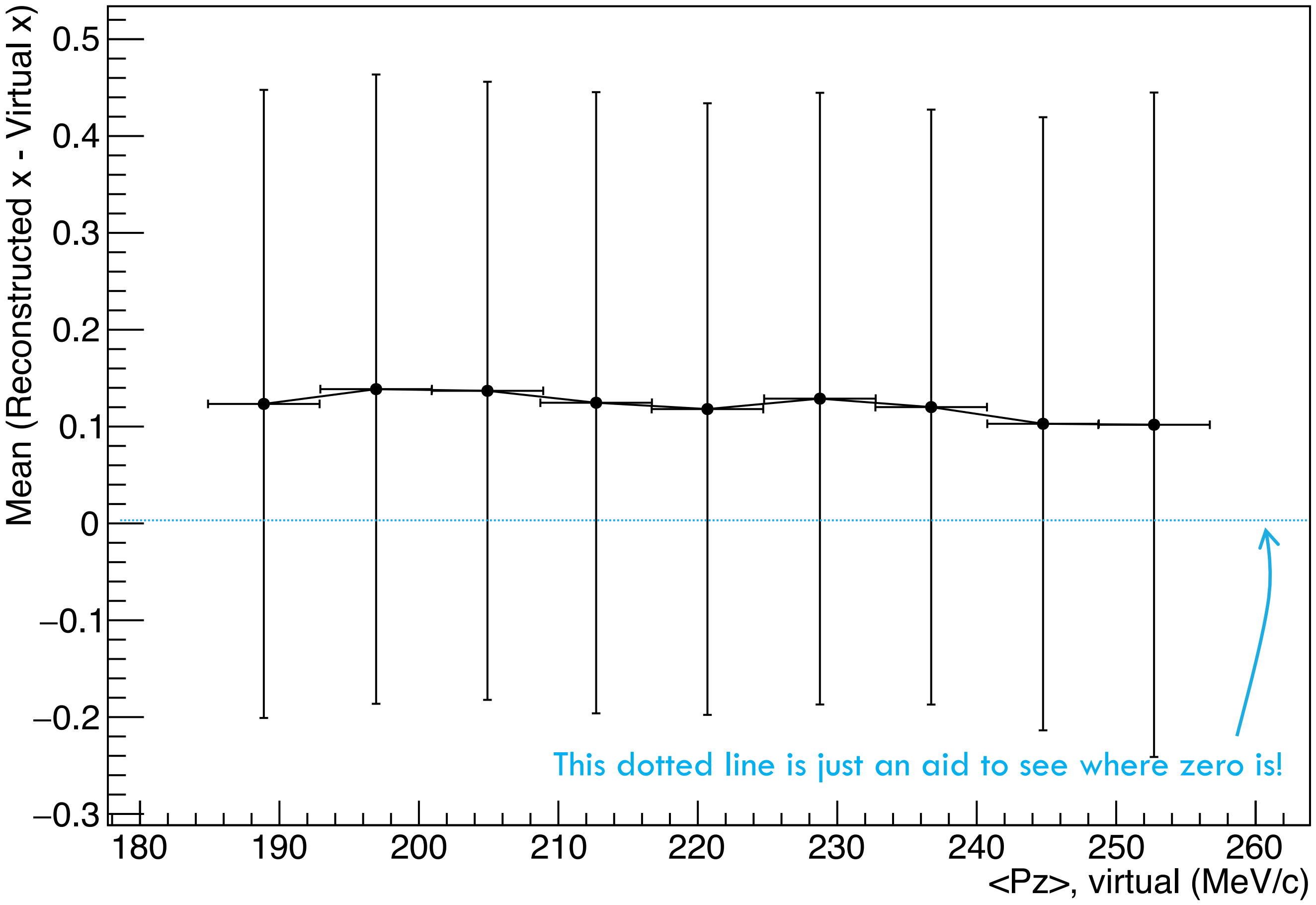
- ❑ Reconstructed tracker variables vs. MC truth
  - ❑ As a function of the true Pt and Pz of the particle
  - ❑ What corrections do we need to apply to our data?
  - ❑ Do we expect the non-uniform field used in 7469 to have an effect on the tracker recon?
  - ❑ Momentum biases, covariance matrix corrections?

- ❑ *I expect all of this will change with MAUS 2.8*

Recon TKU variables vs true Pt & Pz

<u>An example plot:</u>

- Particles have passed all cuts
- Compare reconstructed particle with the same particle at a virtual plane
- Bin sample according to the **true** Pz
  - *Caution: This will change later in the talk to the reconstructed Pz*
- Marker position indicates mean of residual
  - Residual = reconstructed value - true value
- Horizontal error indicates Pz bin width
- Vertical error indicates $\pm\sigma$ of residual



Recon TKU variables vs true Pt & Pz

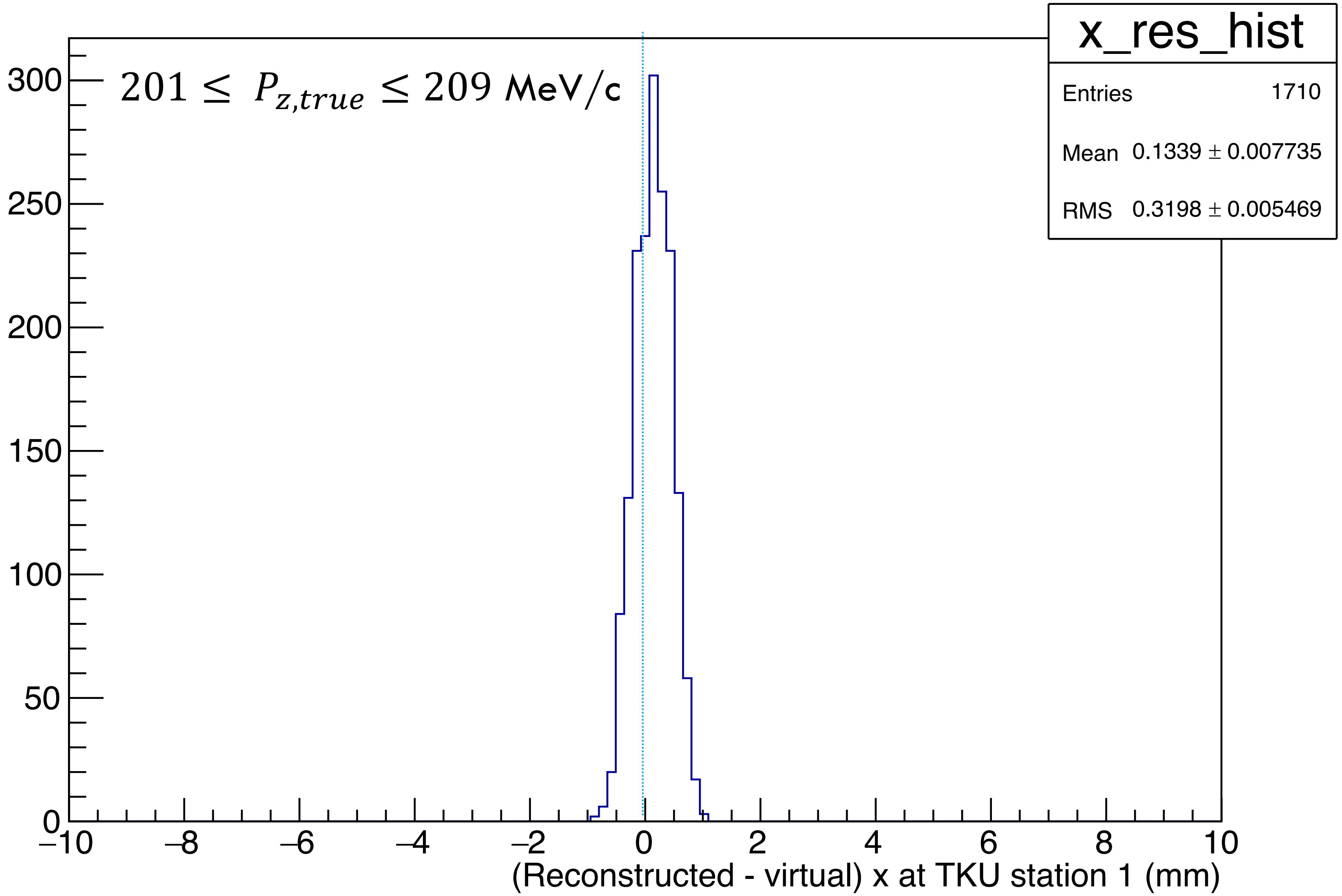
<u>An example plot:</u>

- Particles have passed all cuts
- Compare reconstructed particle with the same particle at a virtual plane
- Bin sample according to the **true** Pz
  - *Caution: This will change later in the talk to the reconstructed Pz*

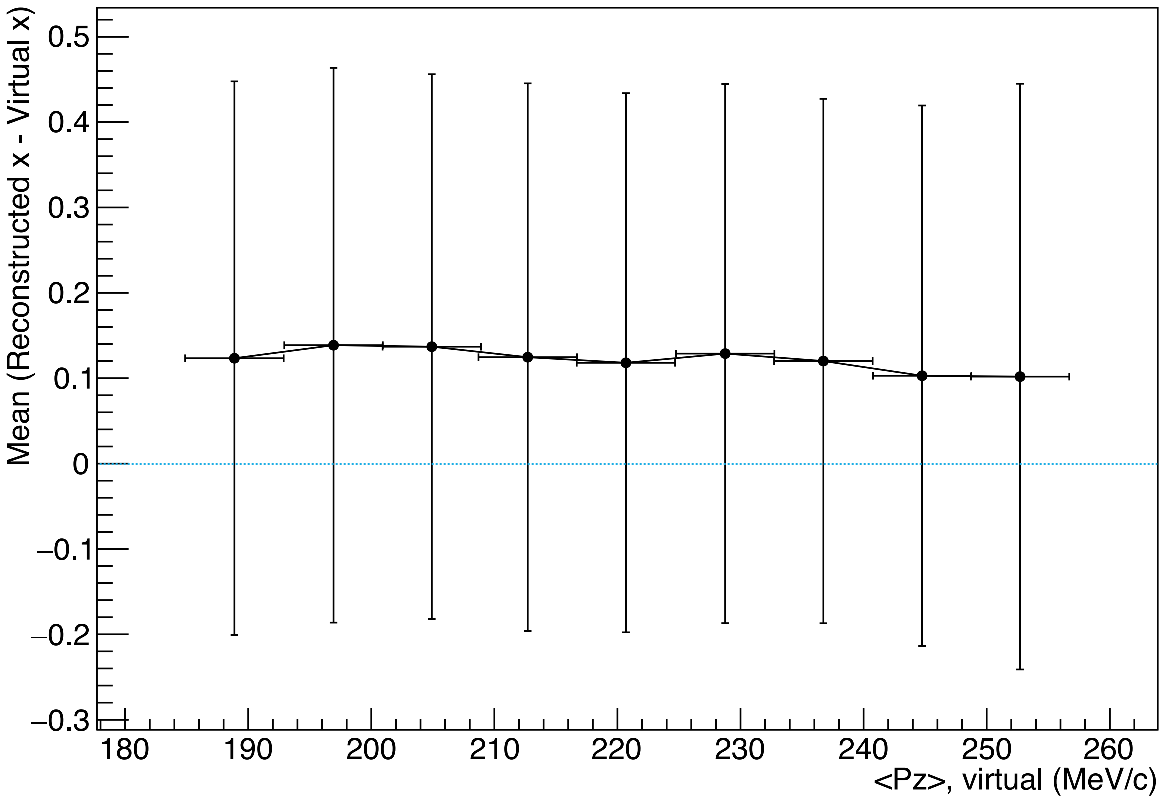
- For each Pz bin, we also have the original histogram of residuals

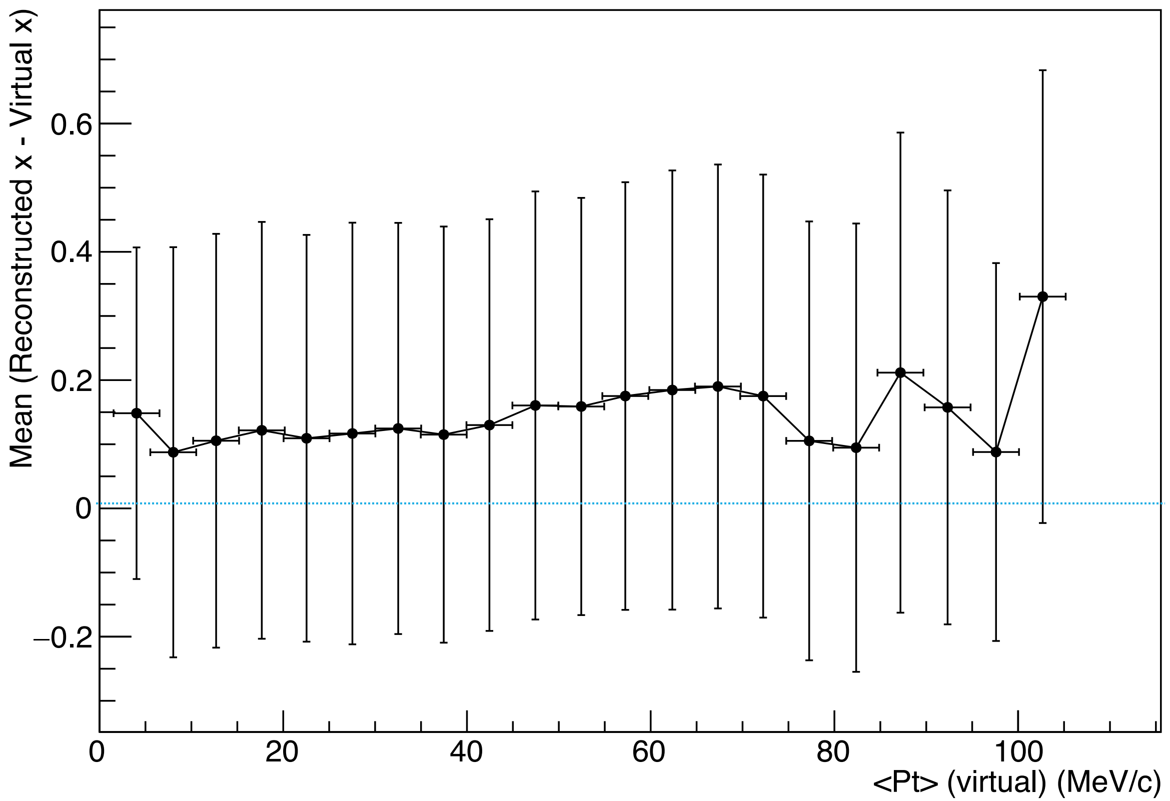
- Residual = reconstructed value - true value

- *Happy to show more on demand*



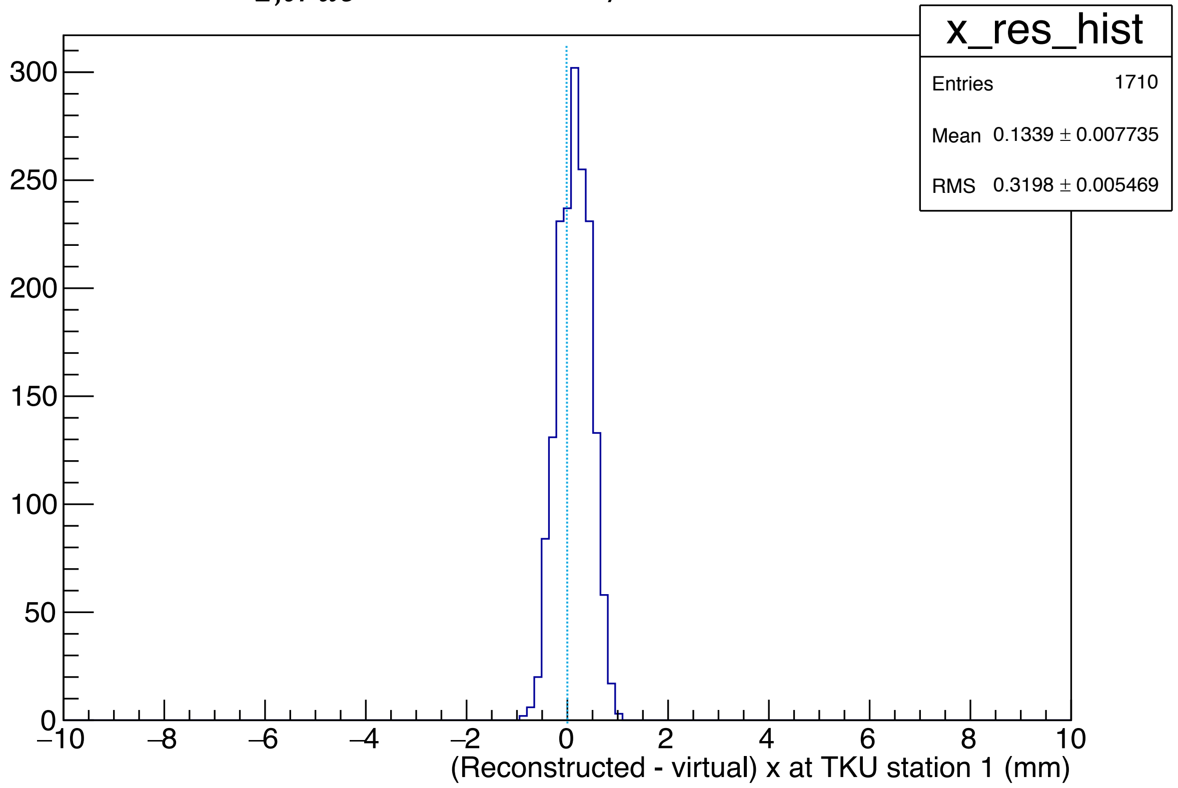
x at TKU station 1



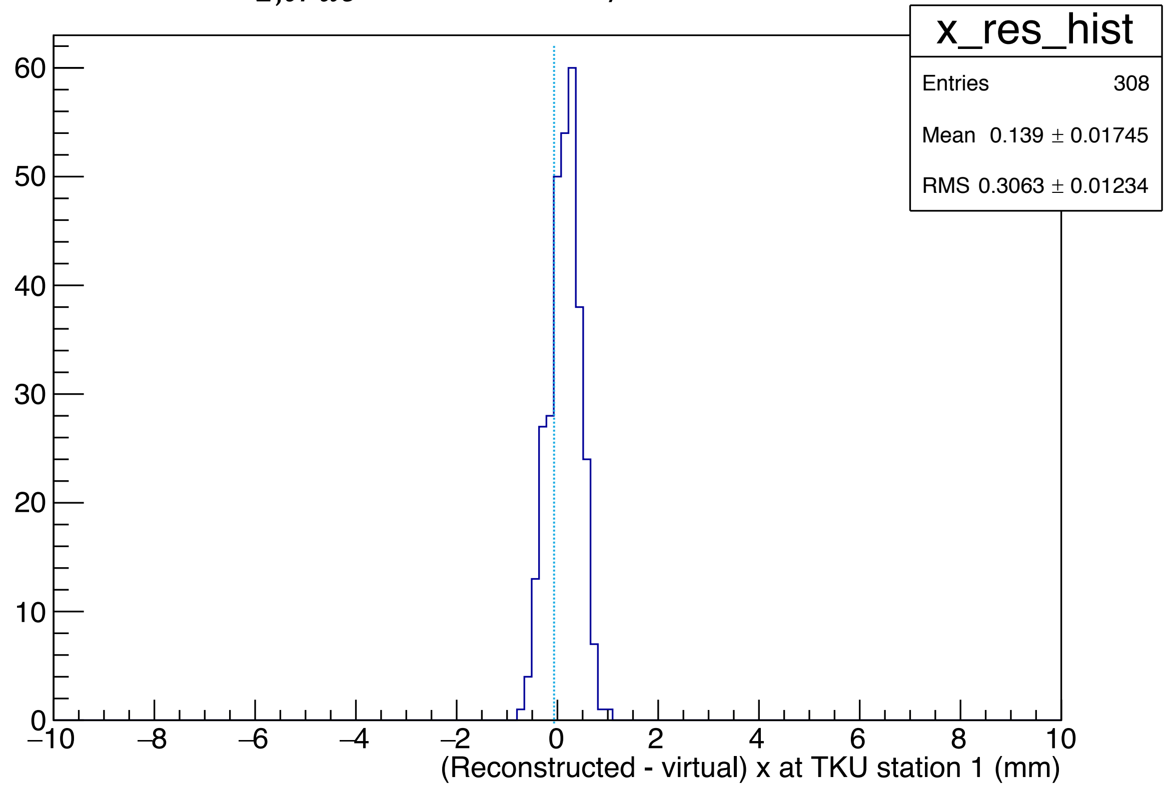


x at TKU station 1

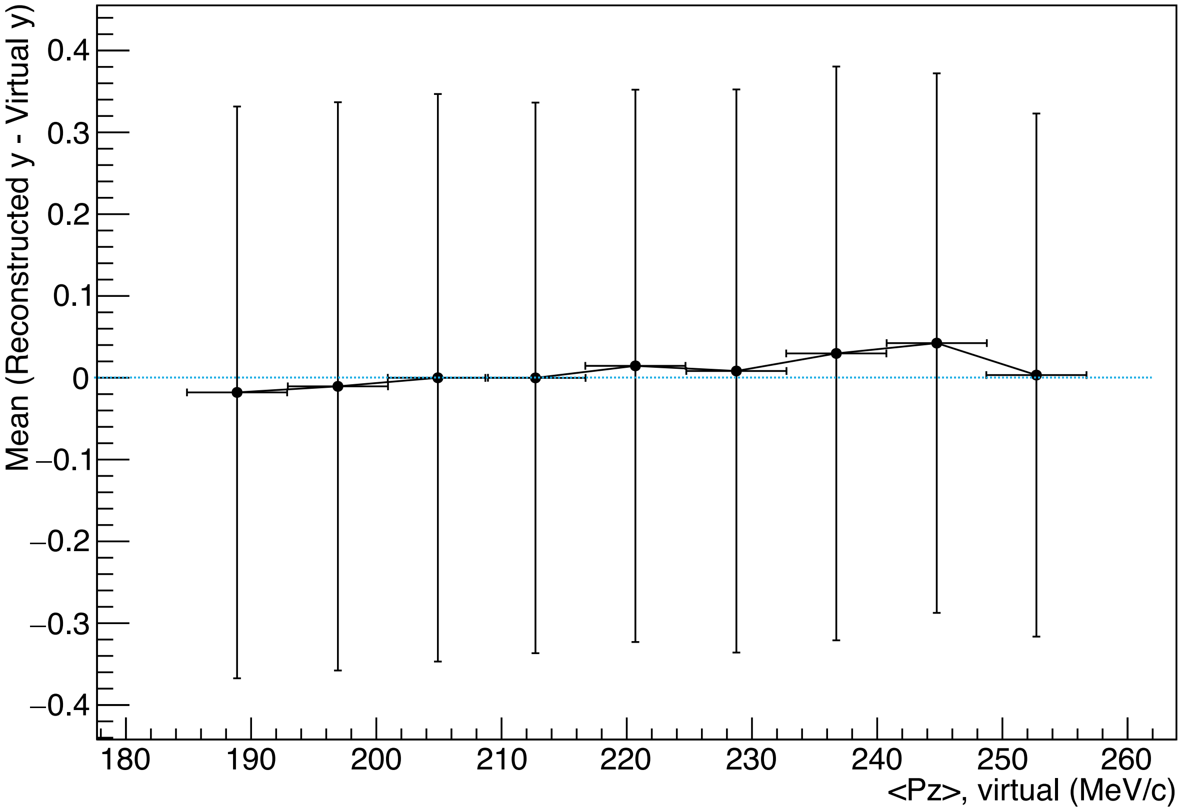
$201 \leq P_{z,true} \leq 209$ MeV/c

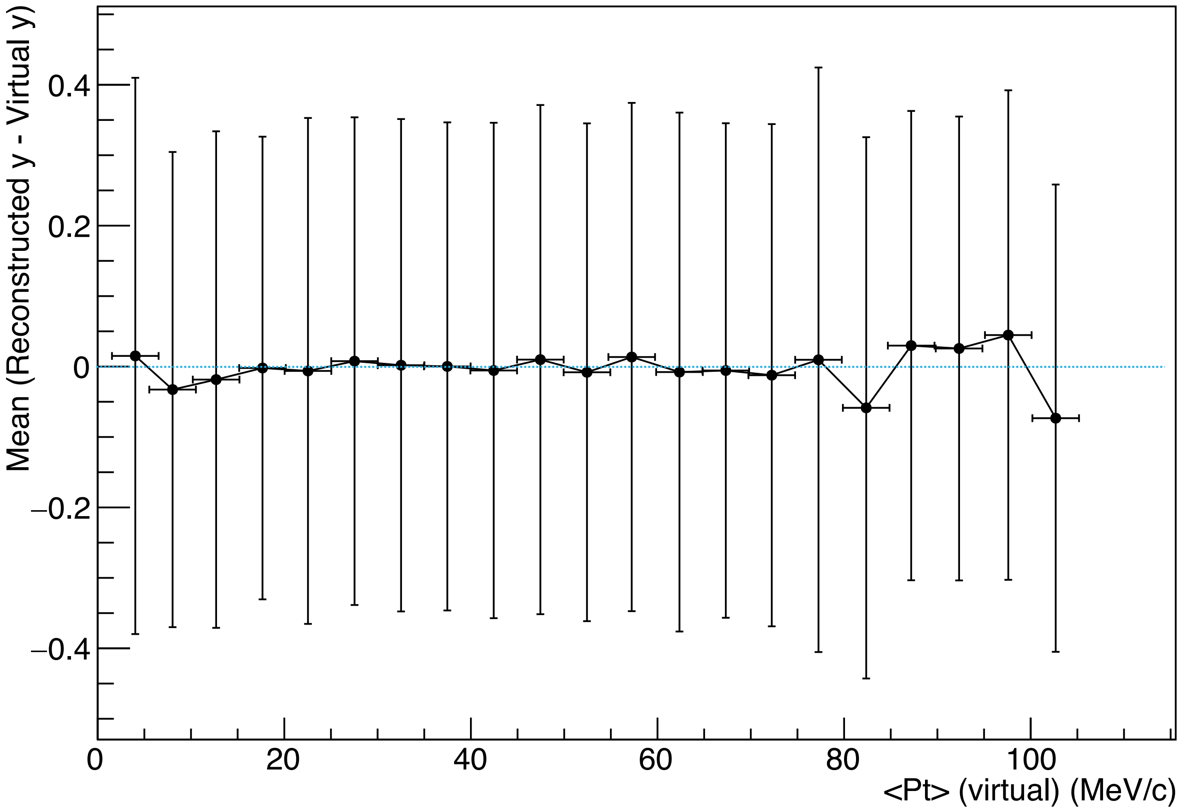


$233 \leq P_{z,true} \leq 241$ MeV/c



y at TKU station 1





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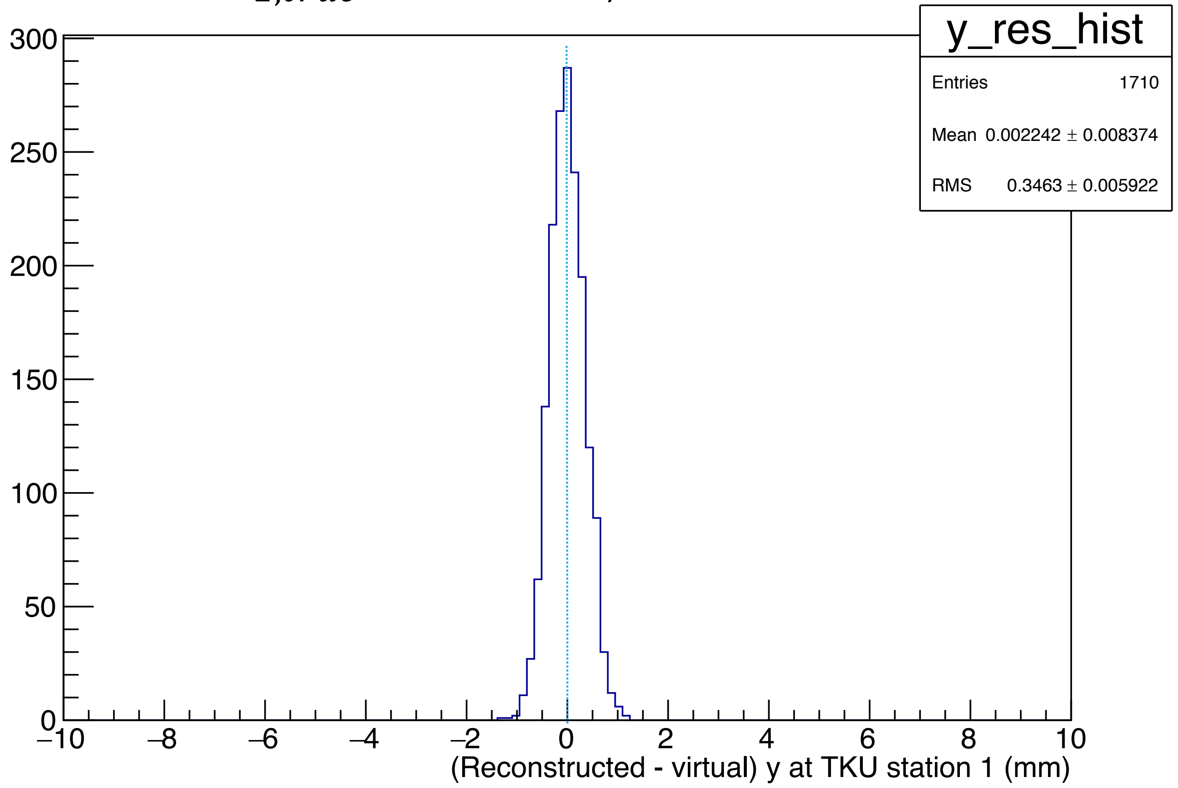

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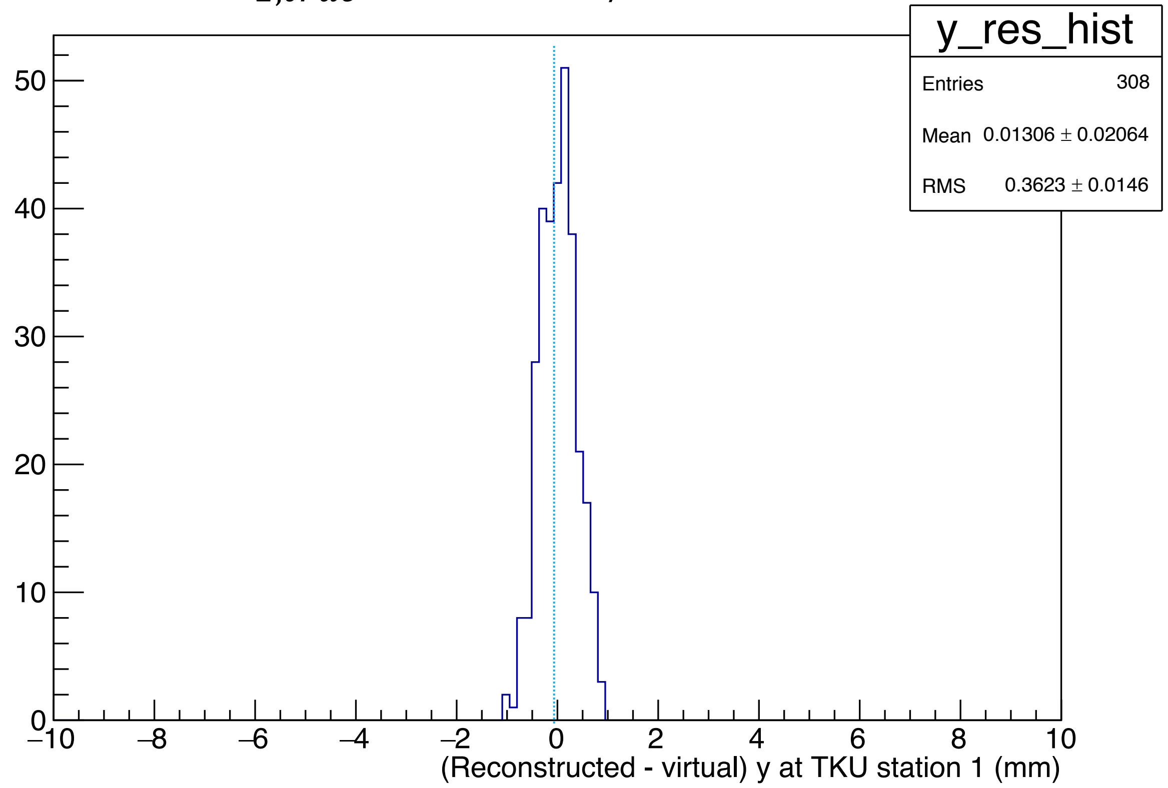
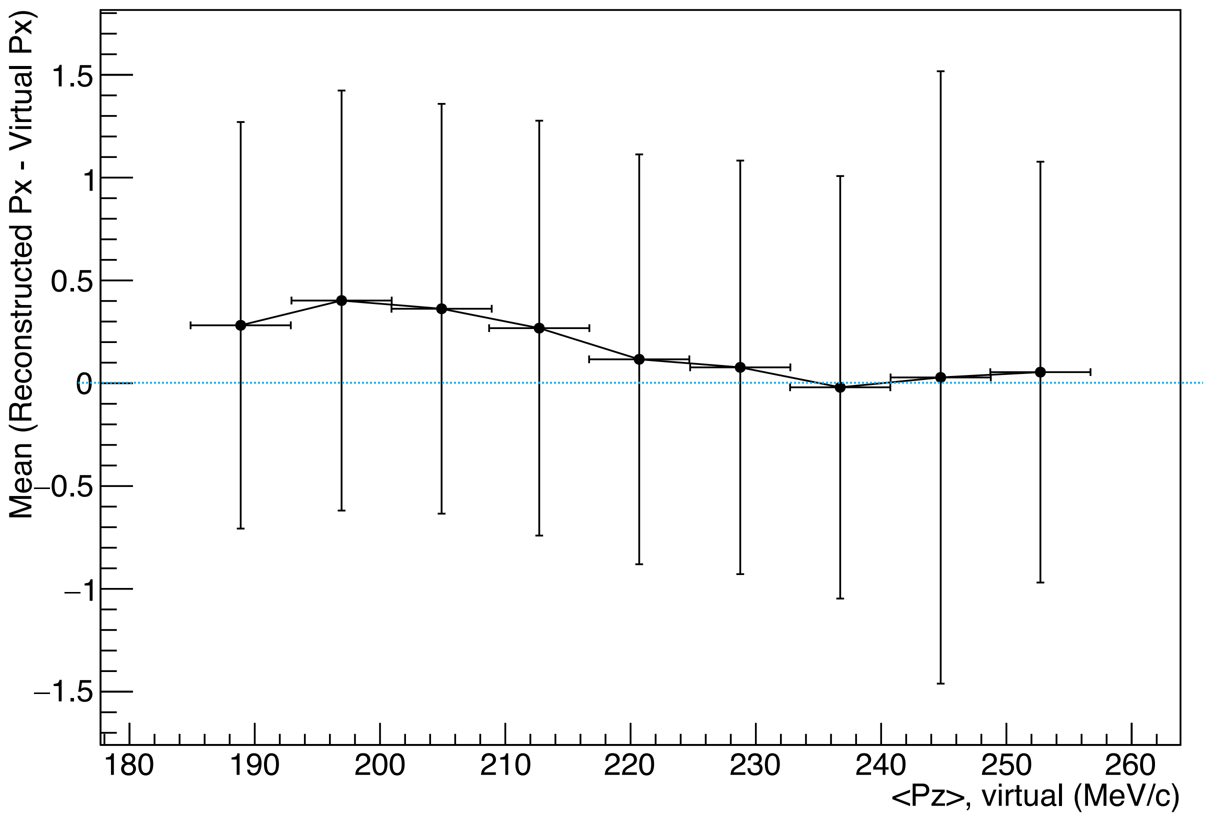
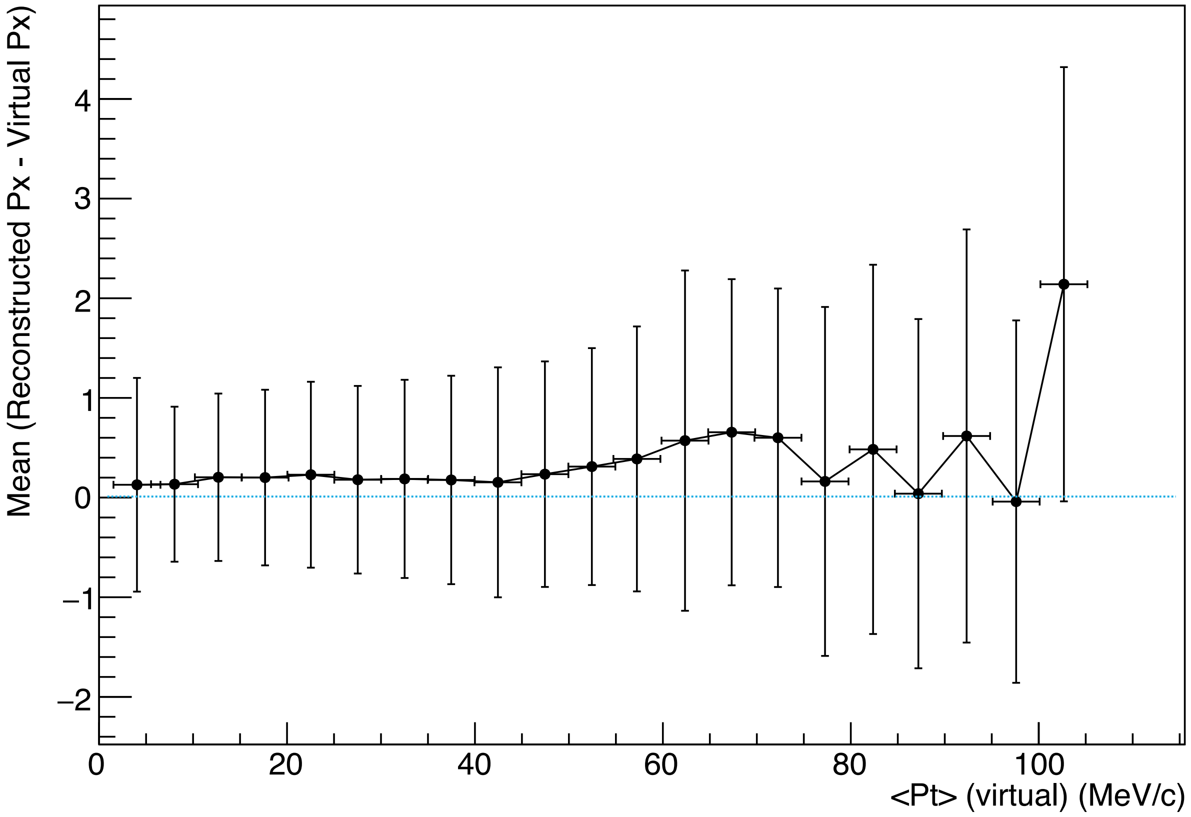


Px at TKU station 1





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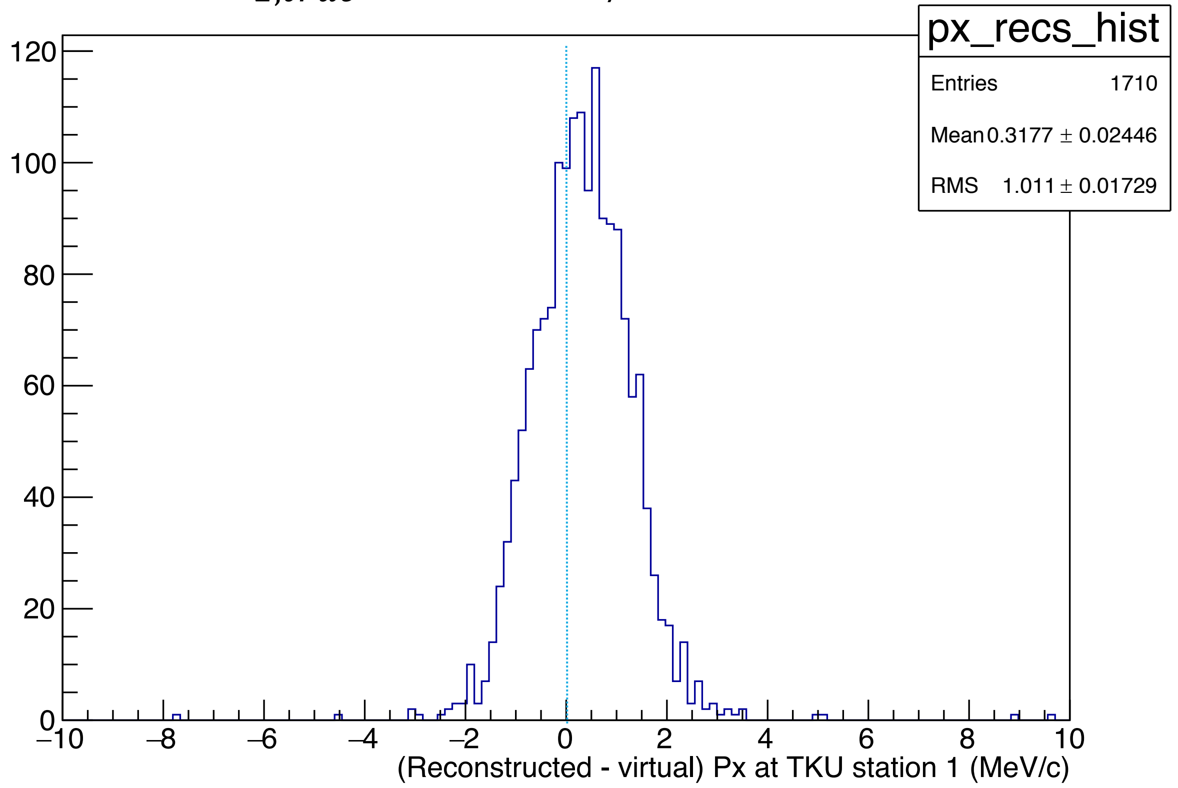

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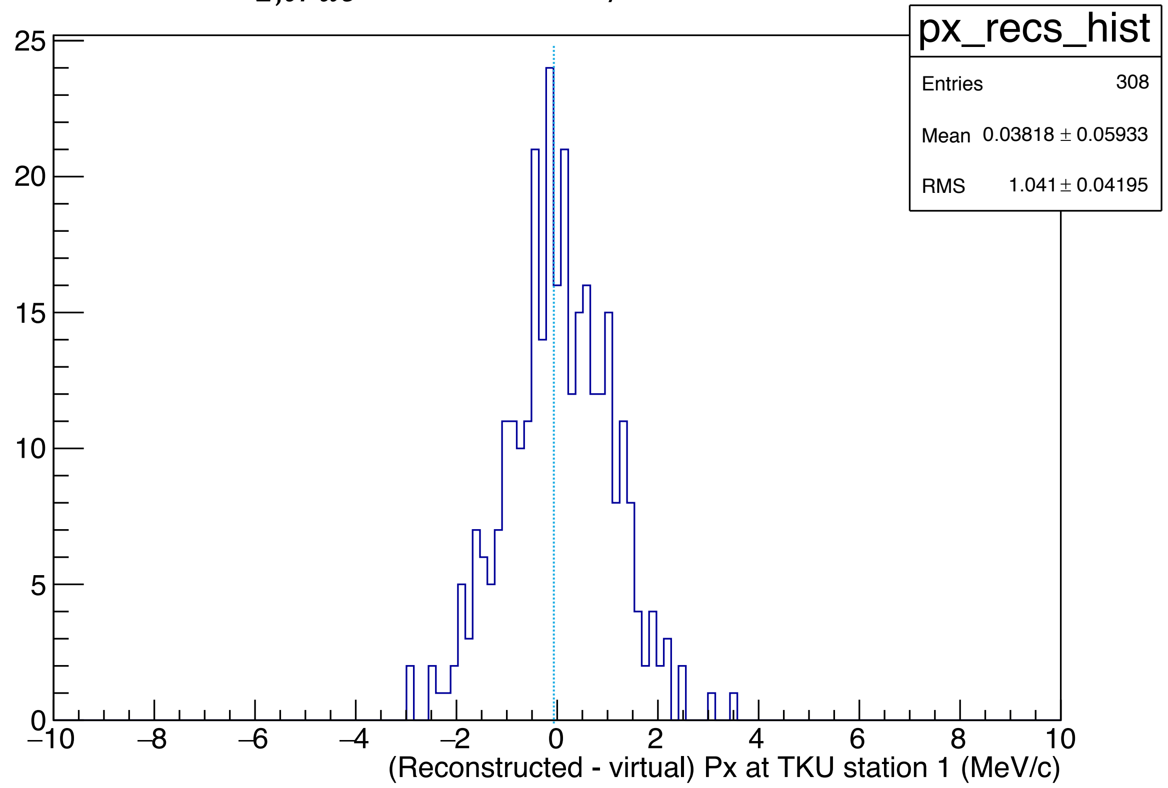
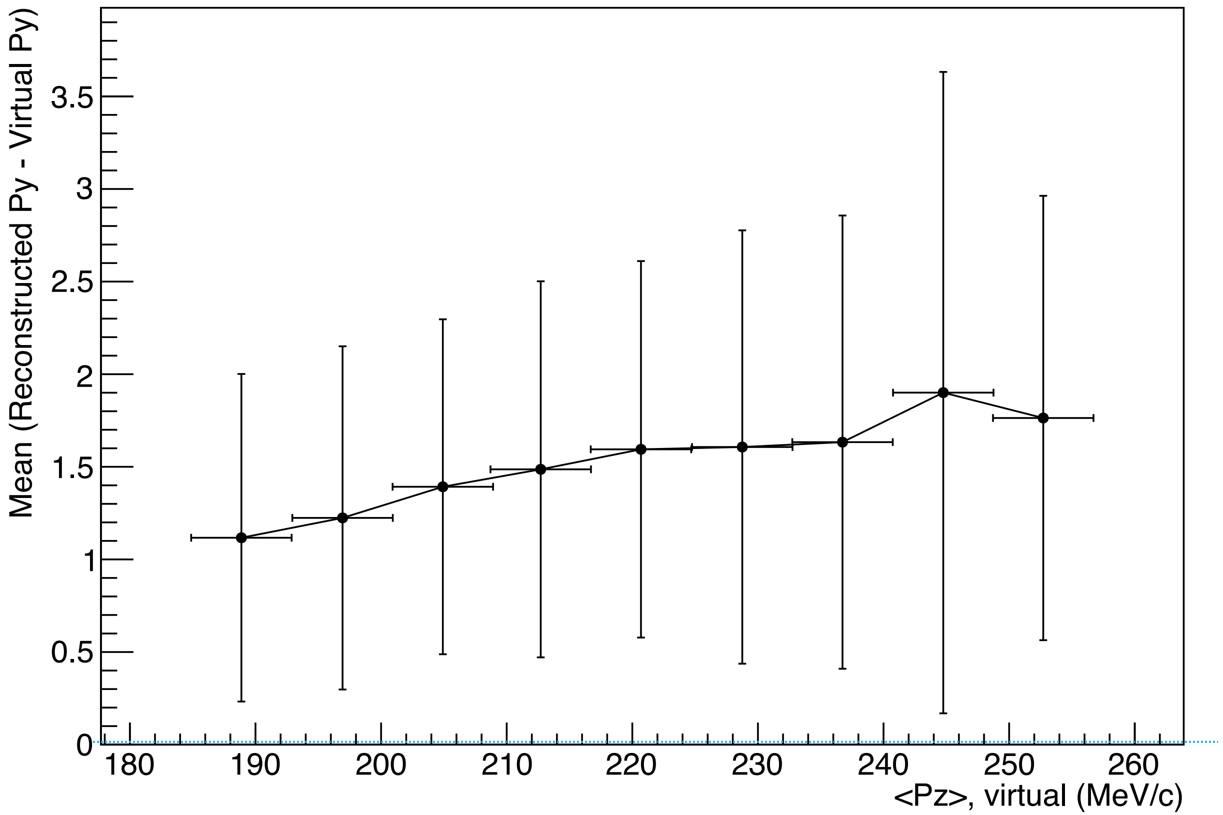
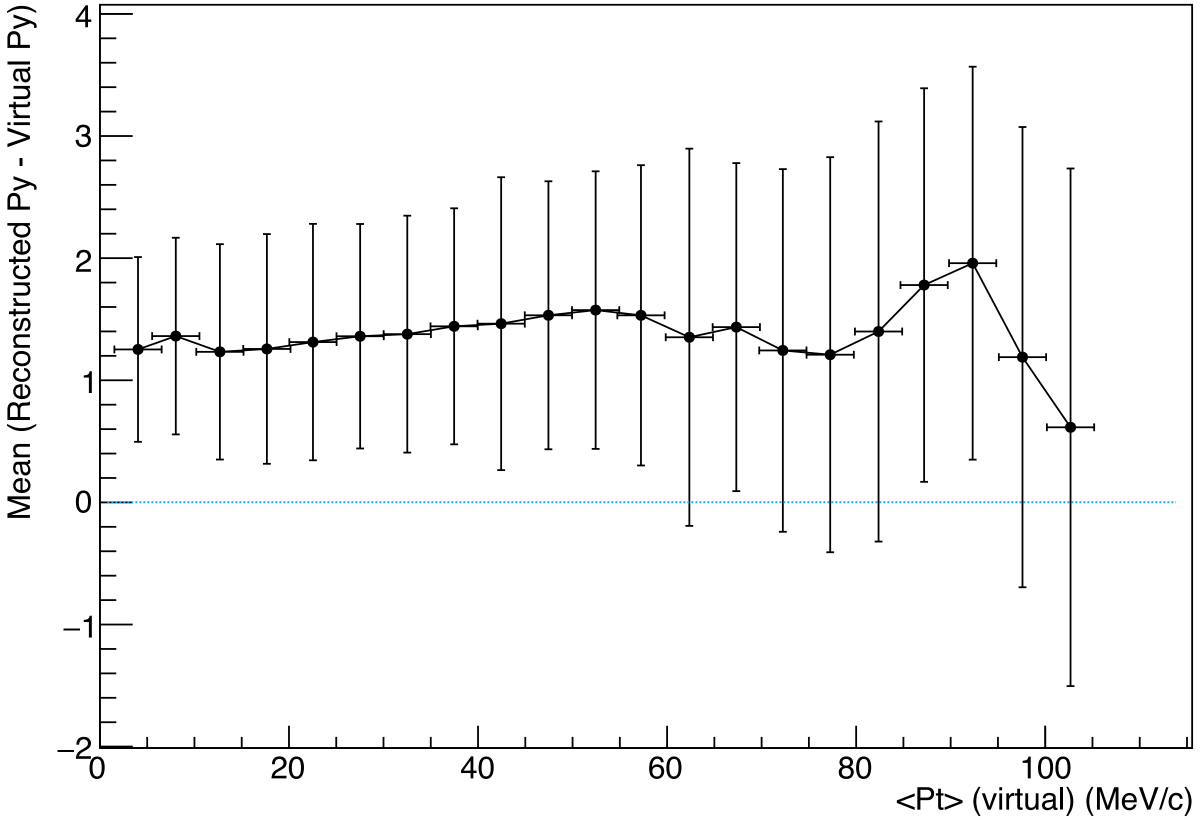


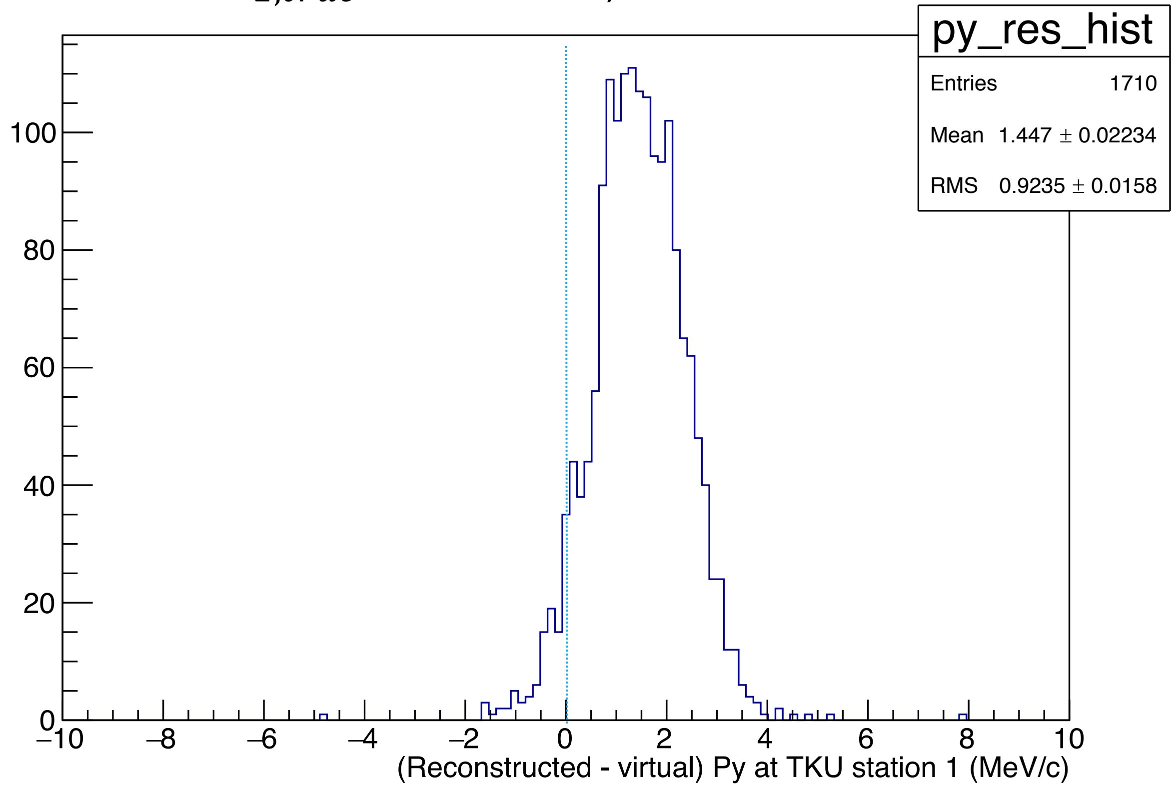
Py at TKU station 1





P_y at TKU station 1

$201 \leq P_{z,true} \leq 209$ MeV/c



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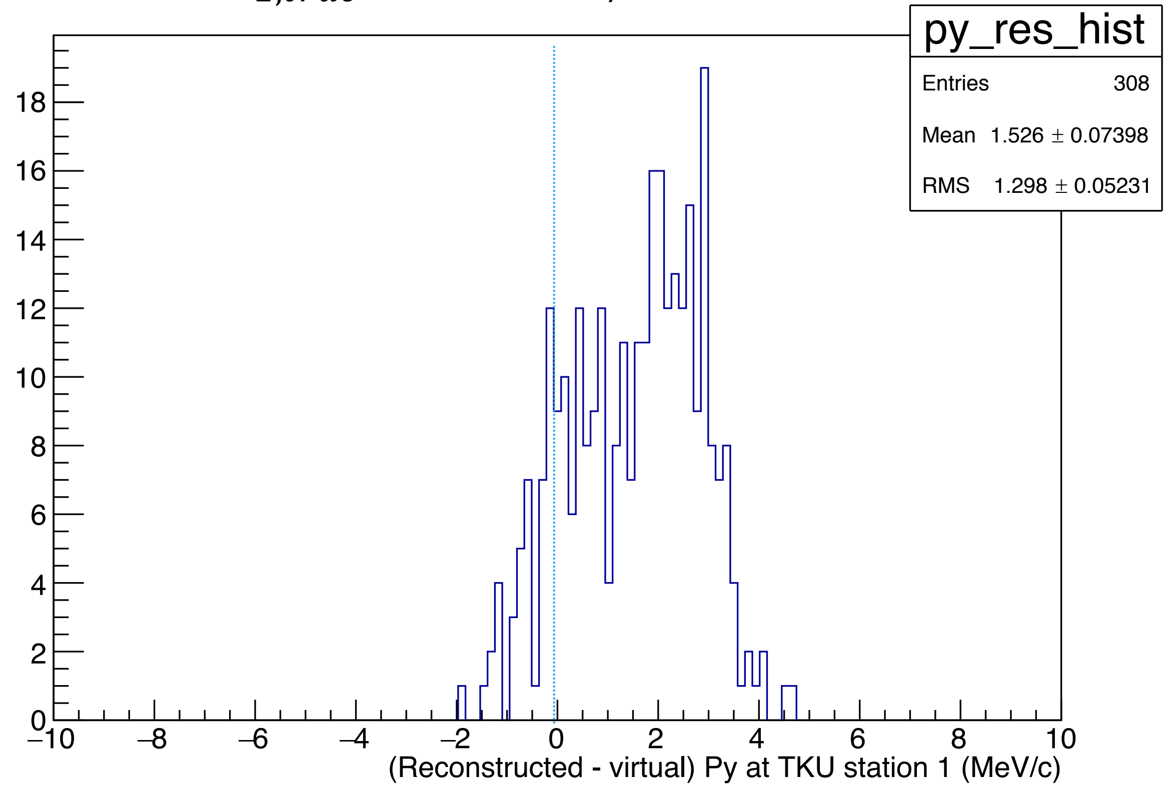
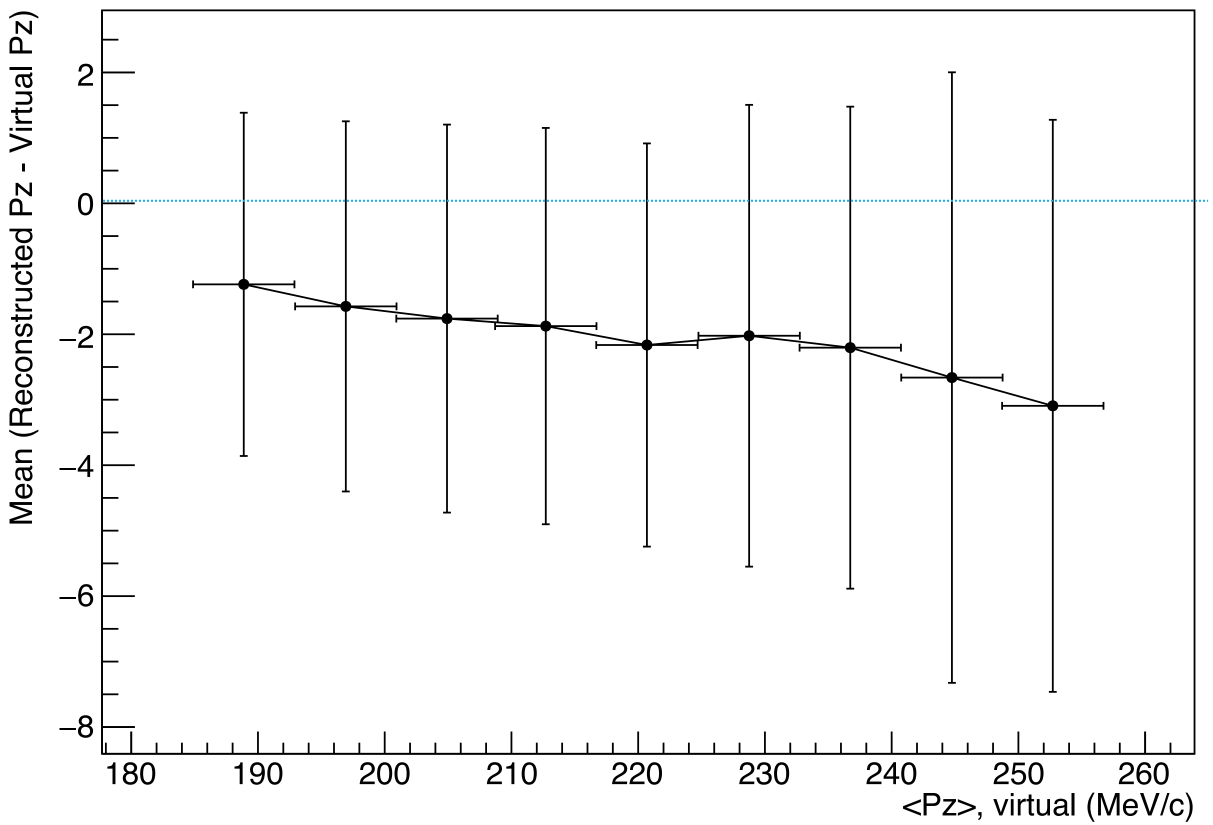
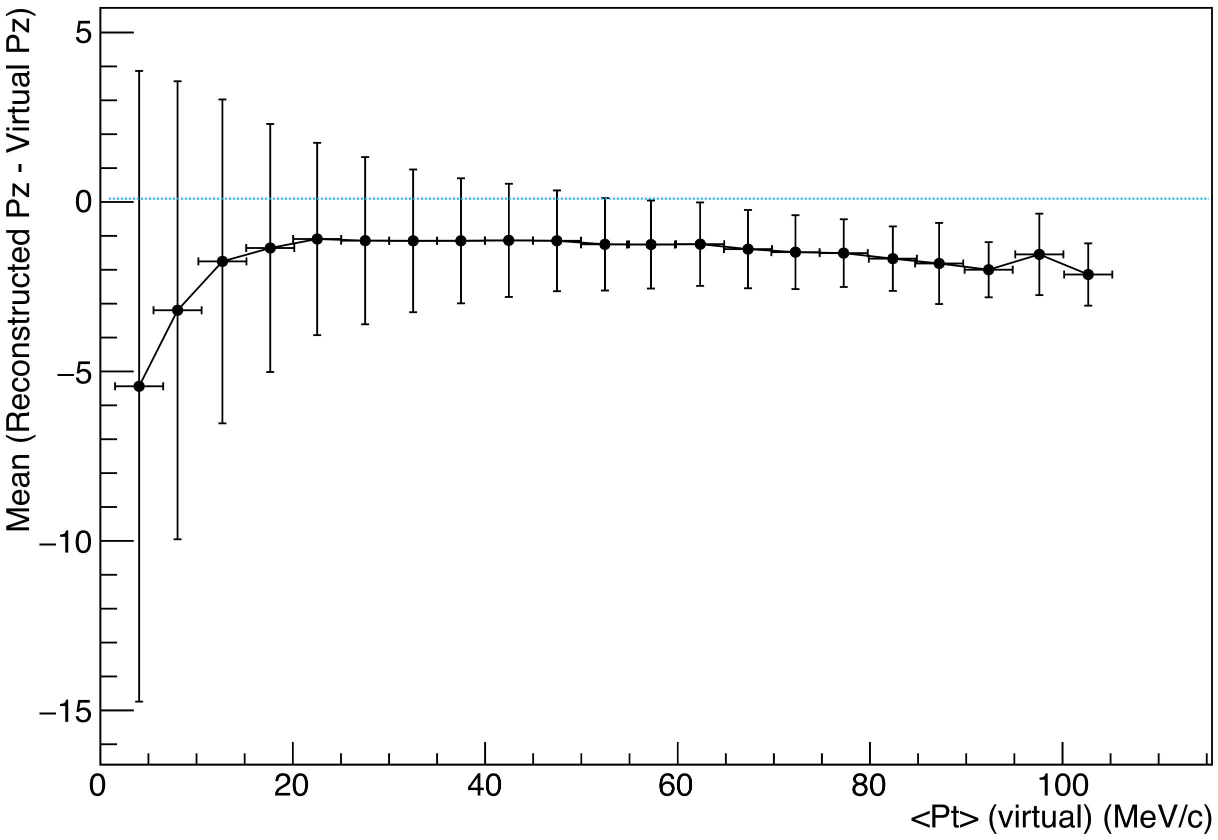


Pz at TKU station 1





Pz at TKU station 1

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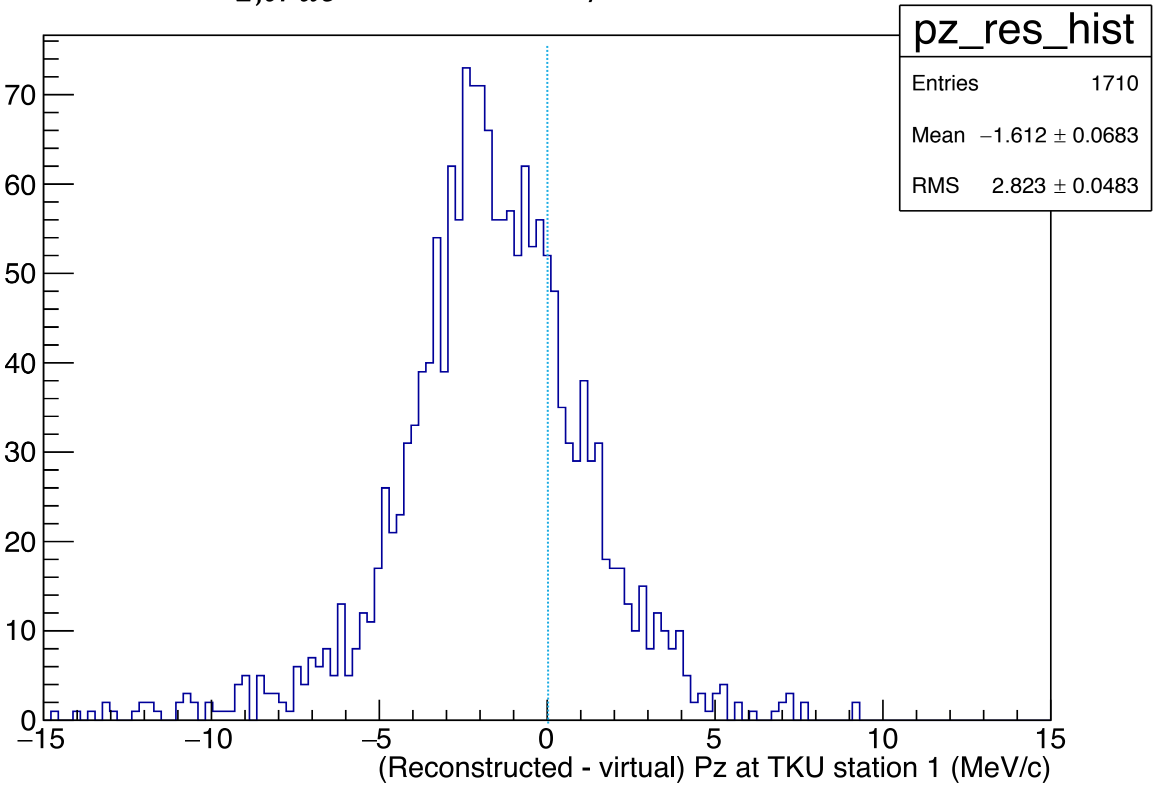

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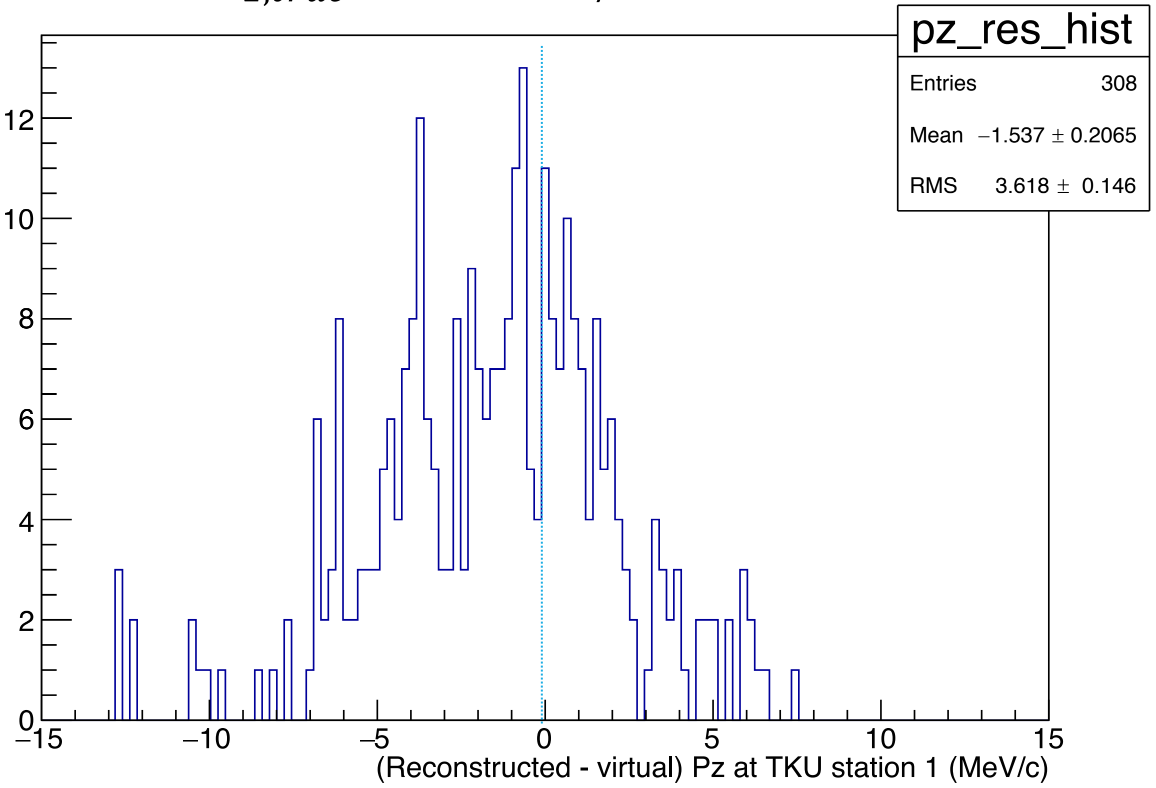
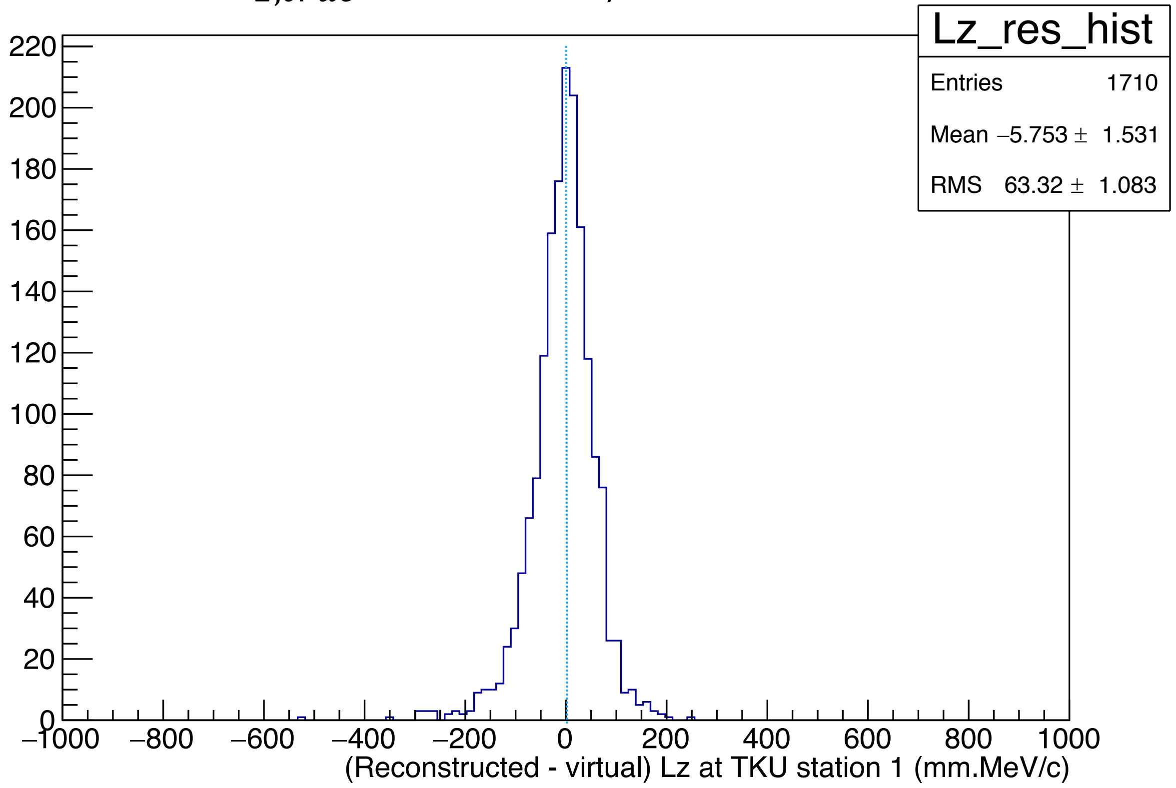


Lz = xPy - yPx at TKU station 1

$201 \leq P_{z,true} \leq 209$ MeV/c



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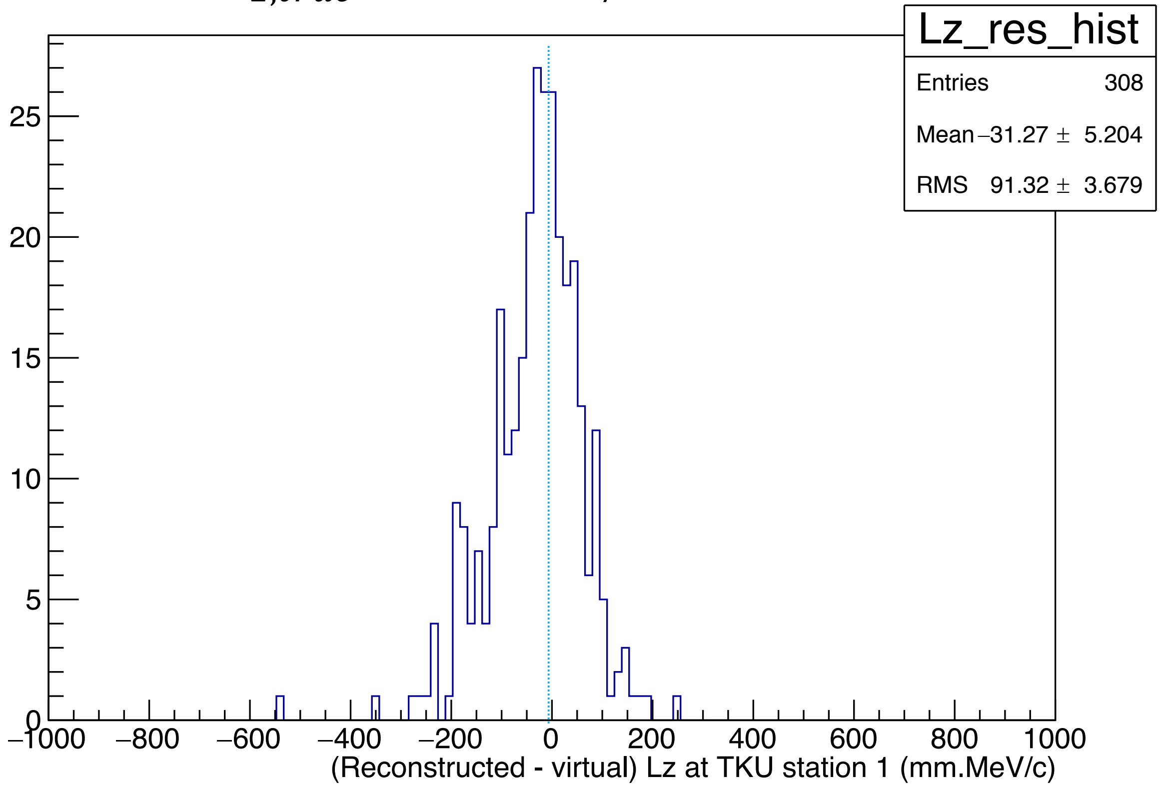
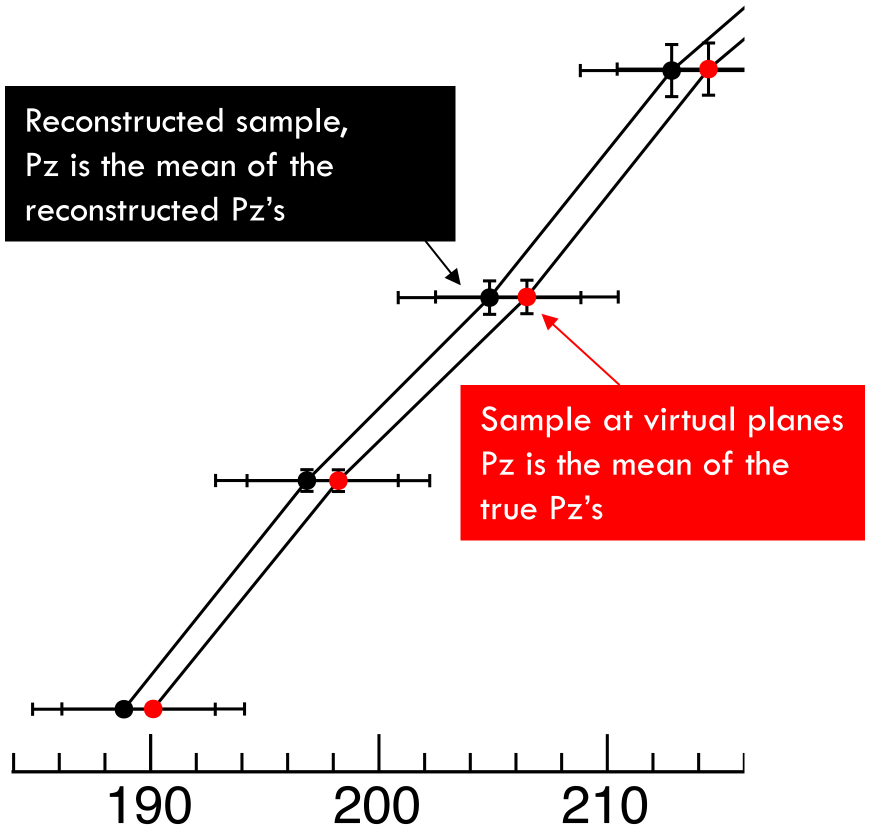


$$\Sigma_{4D} = \begin{pmatrix} \sigma_{xx} & \sigma_{xPx} & \sigma_{xy} & \sigma_{xPy} \\ \sigma_{xPx} & \sigma_{PxPx} & \sigma_{yPx} & \sigma_{PxPy} \\ \sigma_{xy} & \sigma_{yPx} & \sigma_{yy} & \sigma_{yPy} \\ \sigma_{xPy} & \sigma_{PxPy} & \sigma_{yPy} & \sigma_{PyPy} \end{pmatrix}$$

Recon cov elements vs true cov elements

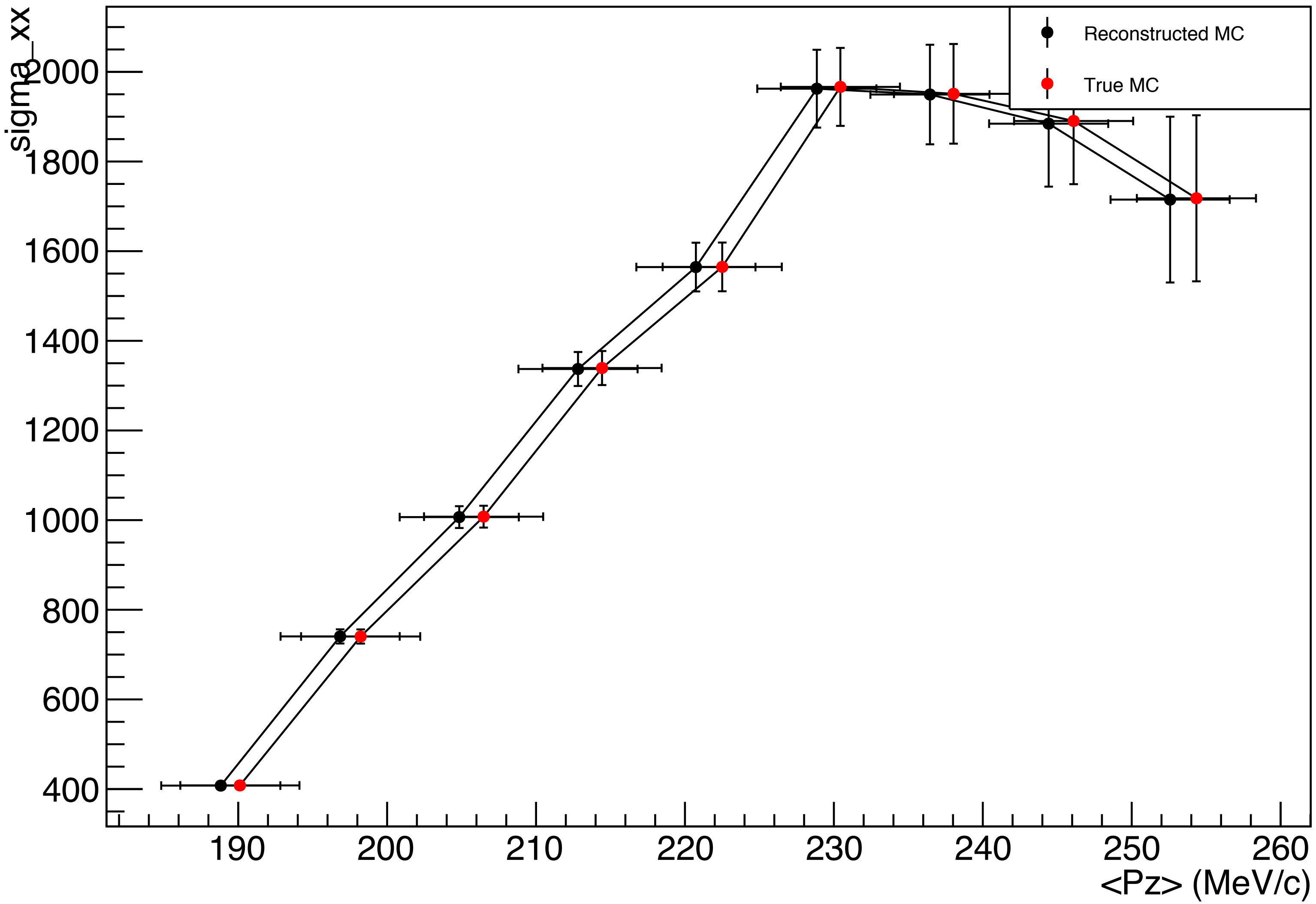


<u>An example plot:</u>

- Particles have passed all cuts
- Compare reconstructed particle with the same particle at a virtual plane
- Bin sample according to the **reconstructed** Pz
  - *Want to look at covariance matrix elements as we would data, so our binning uses the reconstructed Pz this time*
- Marker position indicates value of covariance matrix element
  - Position on horizontal axis is the mean of the sample's true or reconstructed Pz
  - They are the <u>**same sample**</u>, selected by <u>reconstructed Pz</u>, but when plotting I calculated the mean Pz of the recon and true samples to put here so we can see the Pz bias
- Horizontal error indicates Pz bin width (8MeV)
- Vertical error is the statistical error

σ_{xx}

$$\Sigma_{4D} = \begin{pmatrix} \sigma_{xx} & \sigma_{xPx} & \sigma_{xy} & \sigma_{xPy} \\ \sigma_{xPx} & \sigma_{PxPx} & \sigma_{yPx} & \sigma_{PxPy} \\ \sigma_{xy} & \sigma_{yPx} & \sigma_{yy} & \sigma_{yPy} \\ \sigma_{xPy} & \sigma_{PxPy} & \sigma_{yPy} & \sigma_{PyPy} \end{pmatrix}$$



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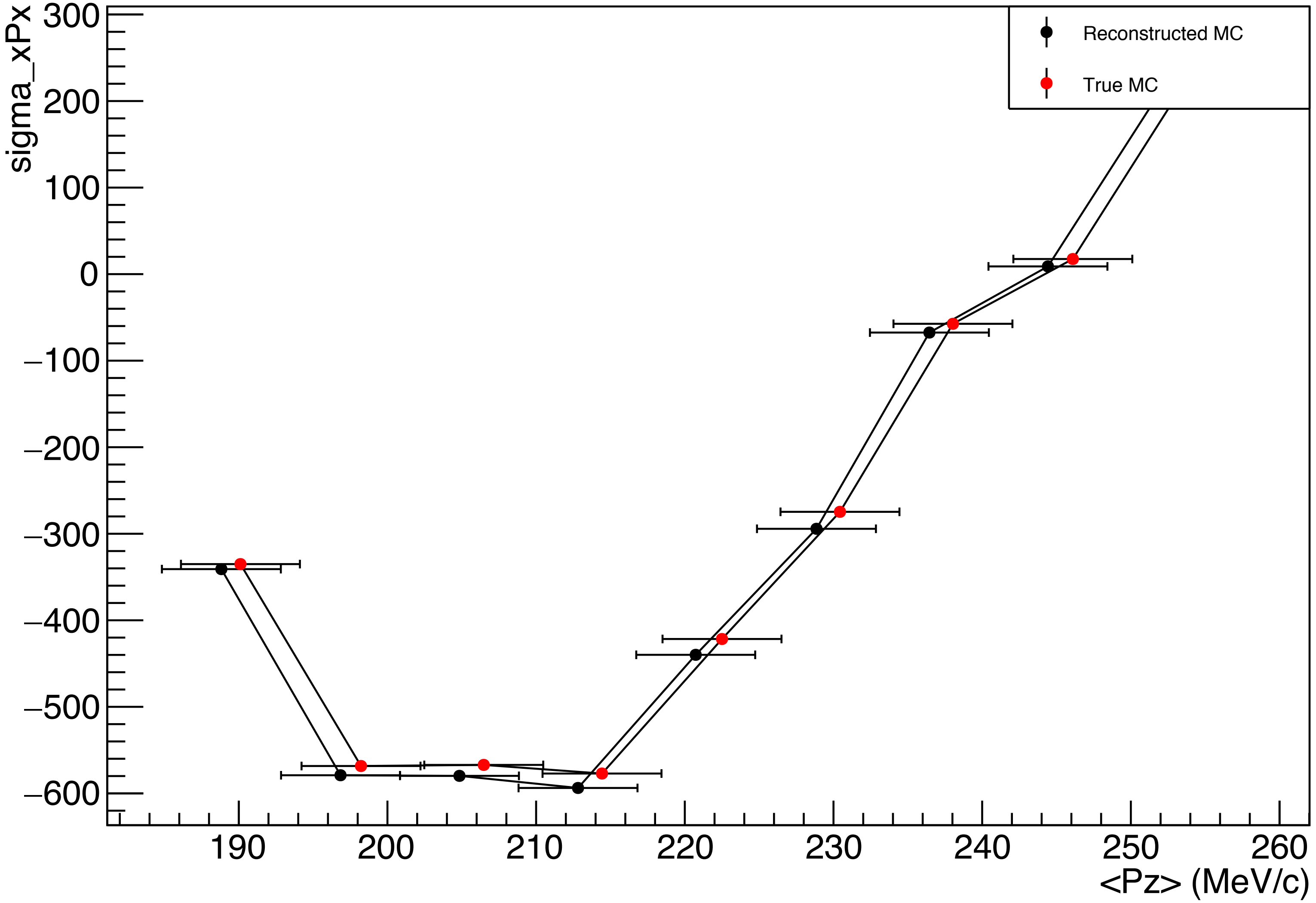
σ_{xPx}



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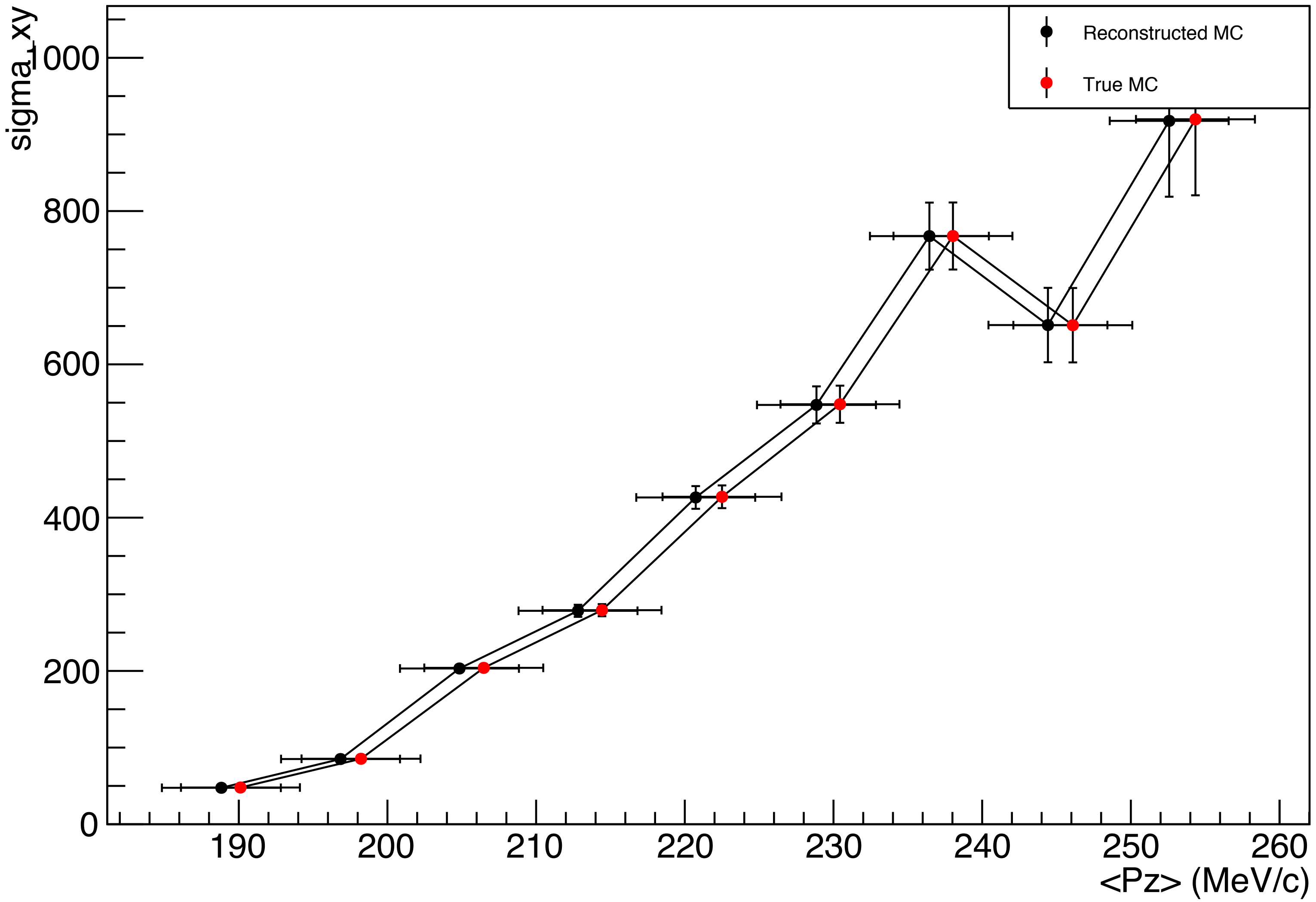
σ_{xy}



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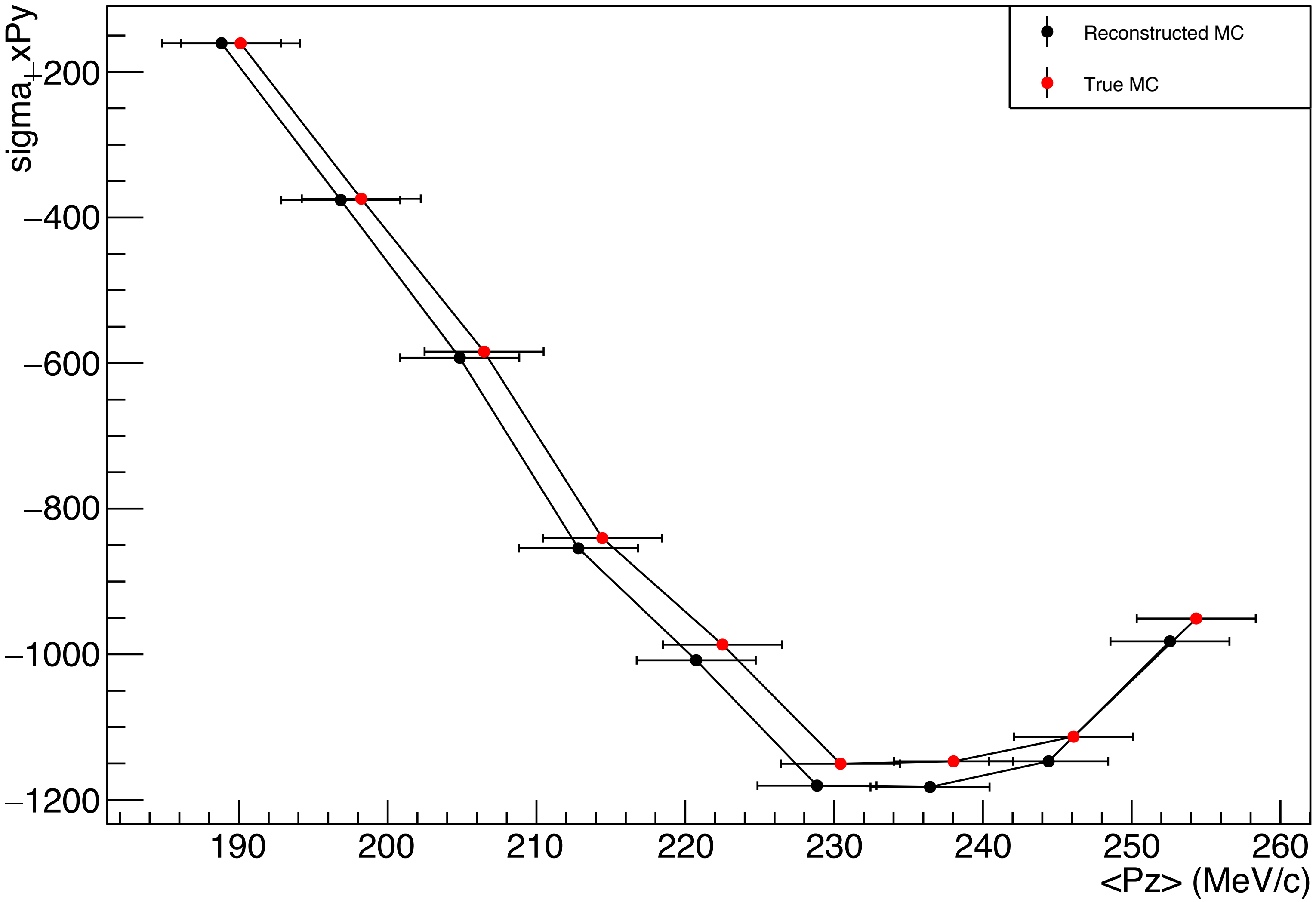
σ_{xPy}



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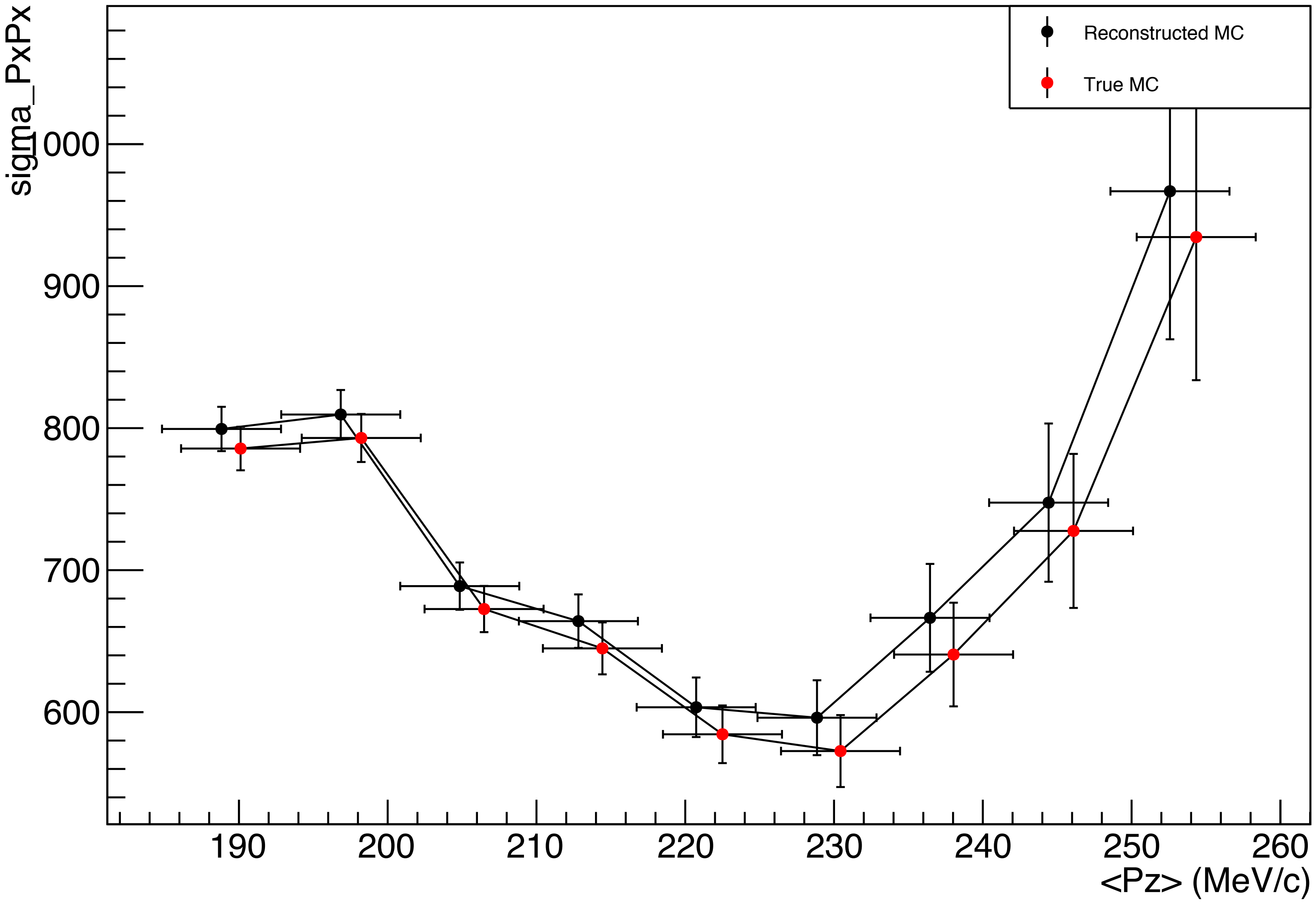
σ_{PxPx}



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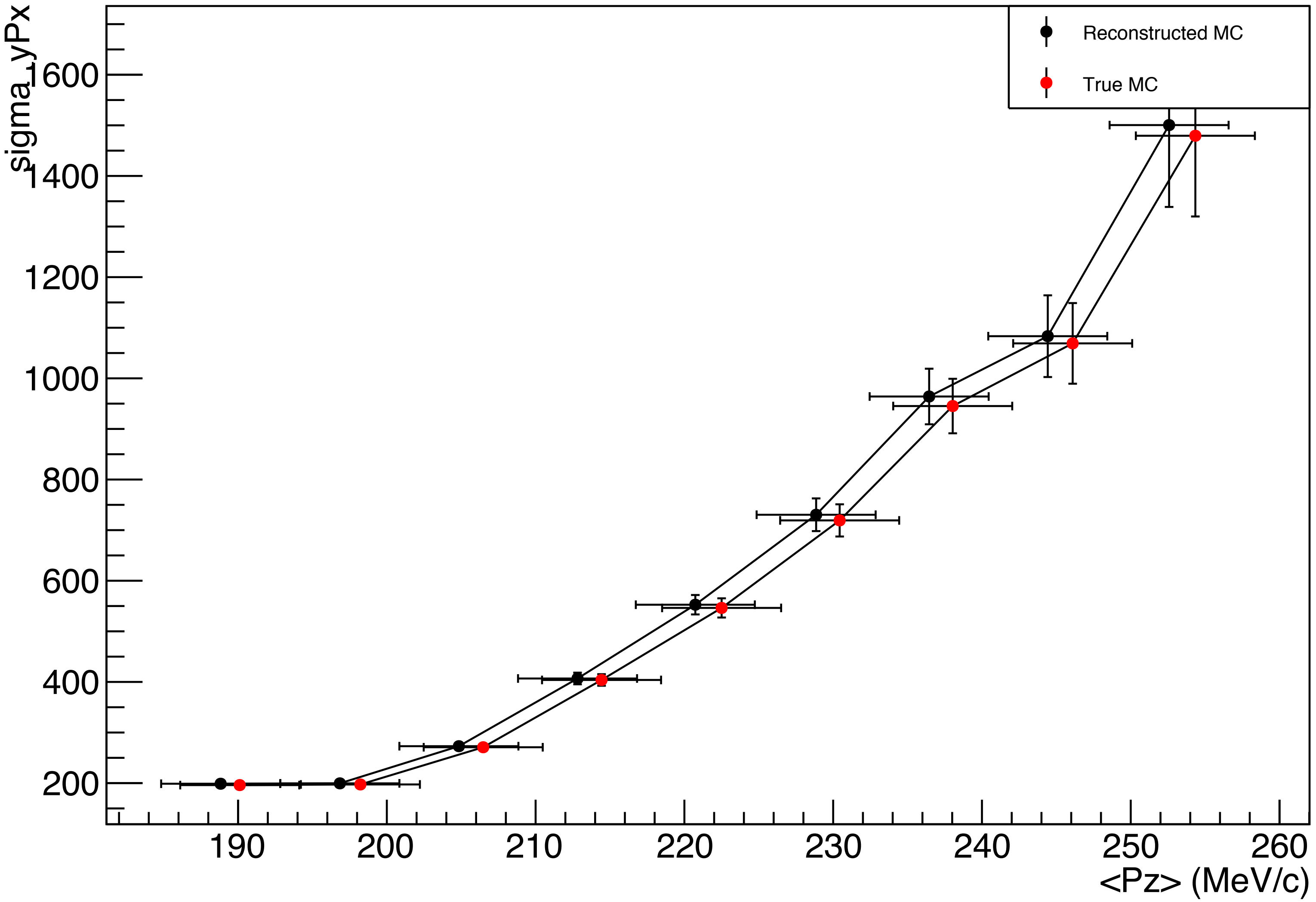
σ_{yPx}



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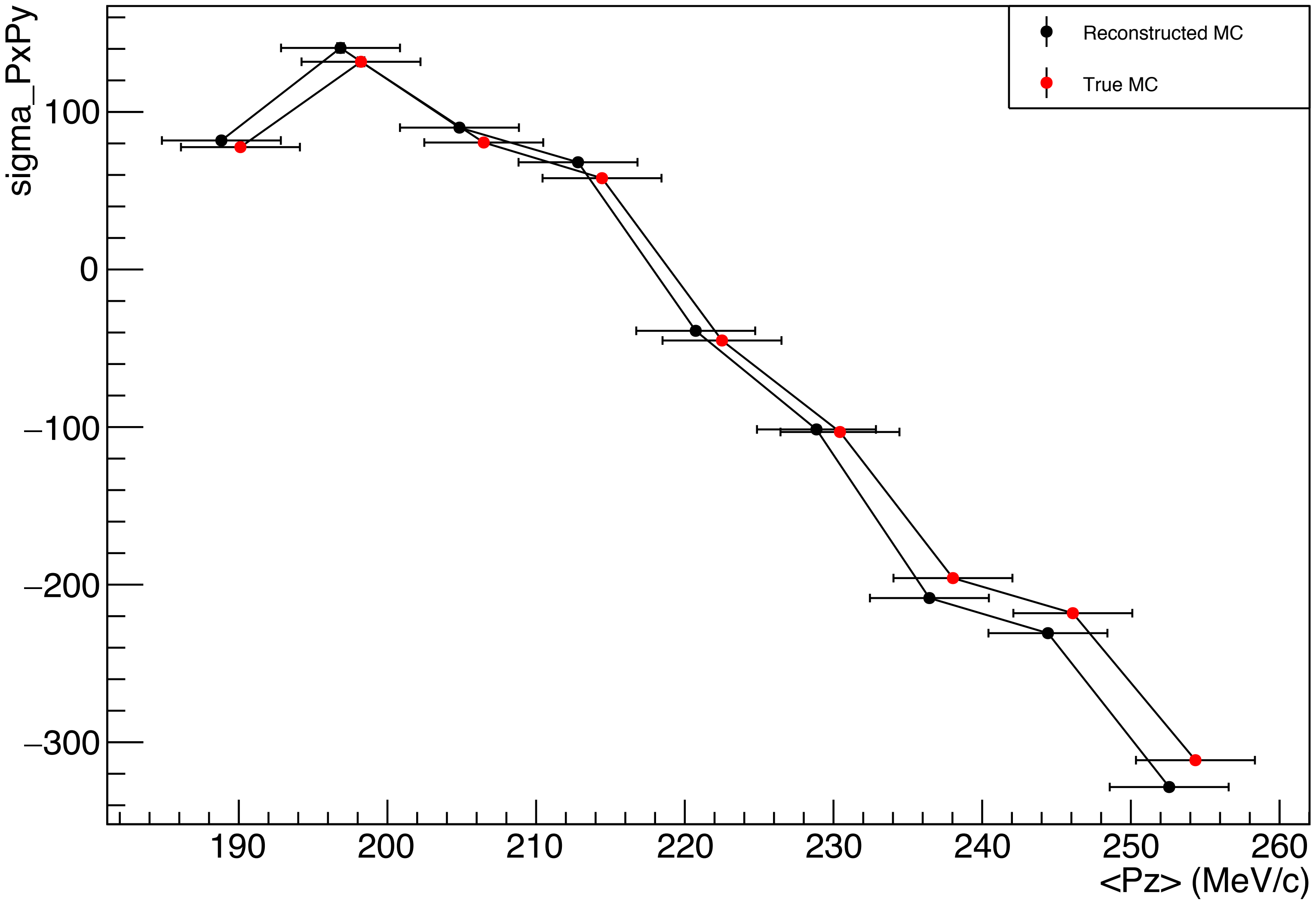
σ_{PxPy}



σ_{yy}

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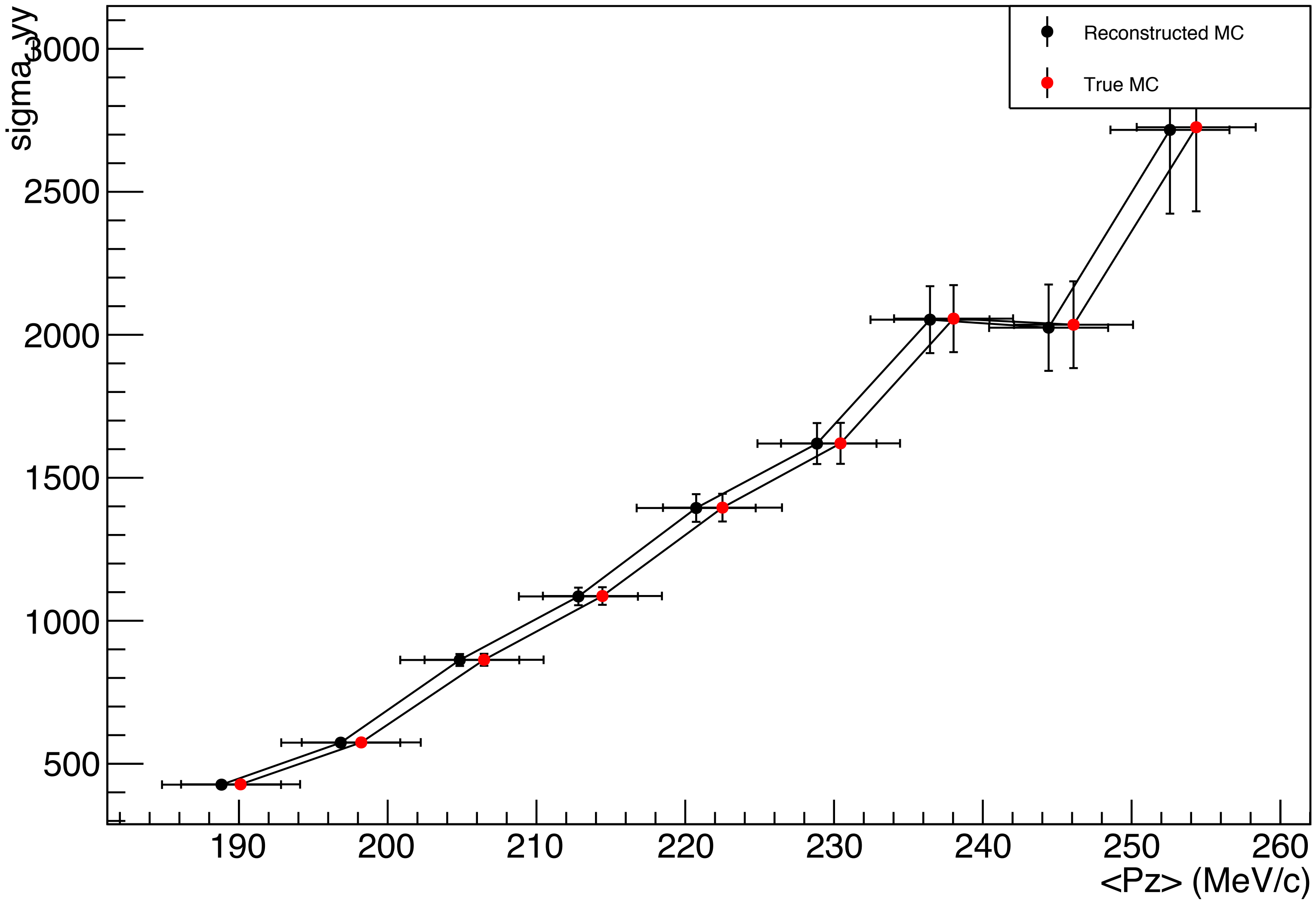

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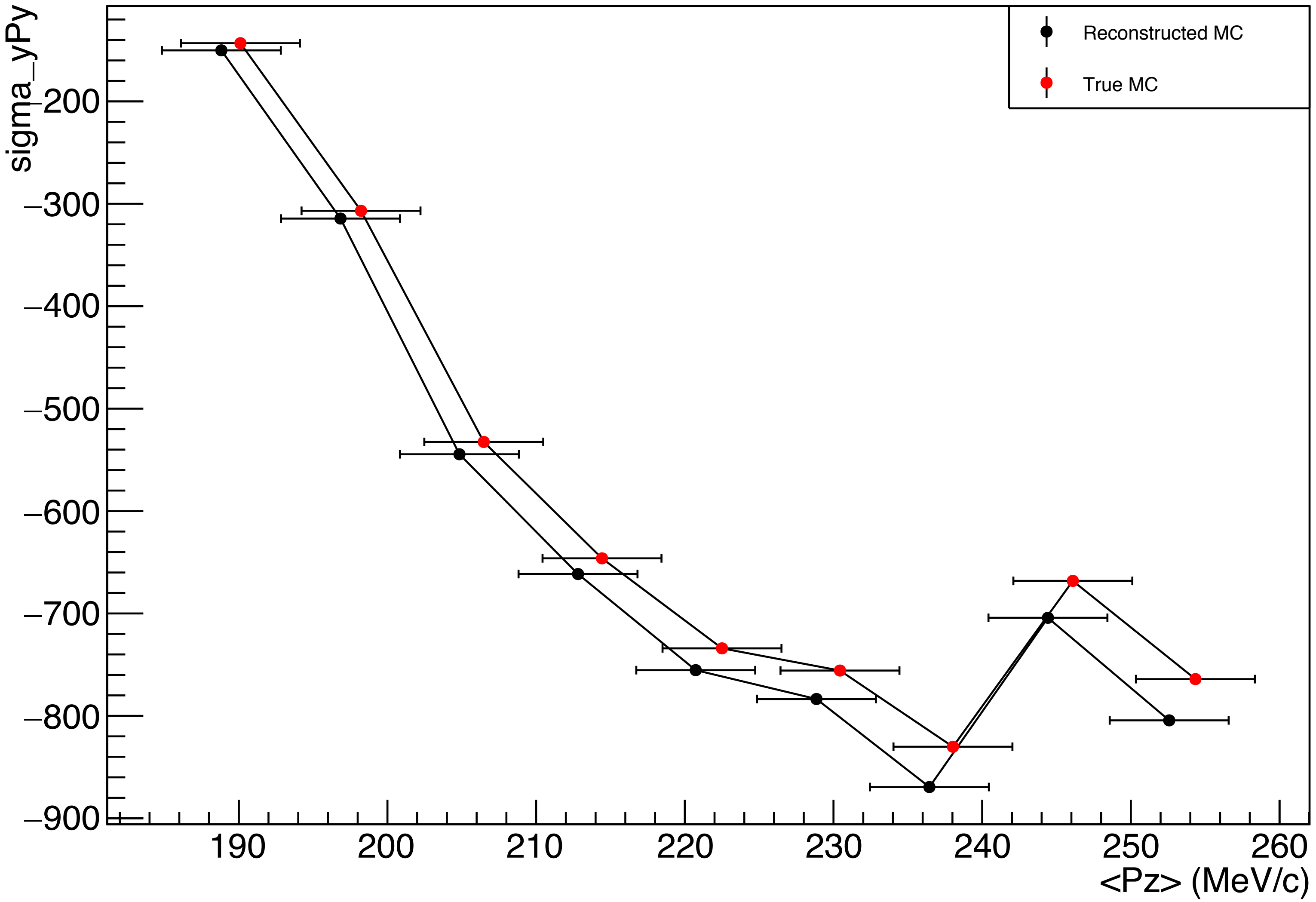
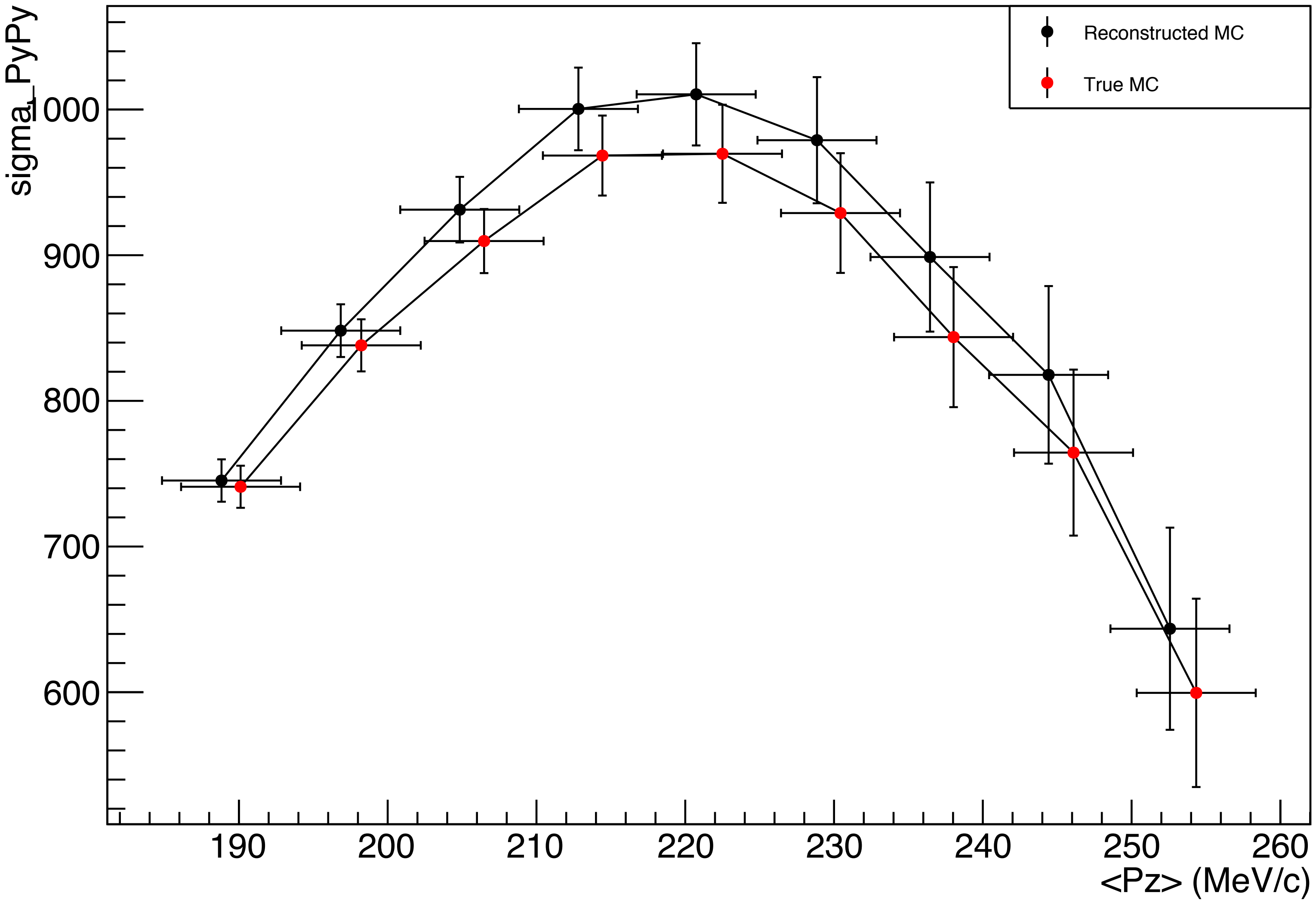
σ_{yPy}



$$\Sigma_{4\mathrm{D}} = \begin{pmatrix} \sigma_{xx} & \sigma_{xPx} & \sigma_{xy} & \sigma_{xPy} \\ \sigma_{xPx} & \sigma_{PxPx} & \sigma_{yPx} & \sigma_{PxPy} \\ \sigma_{xy} & \sigma_{yPx} & \sigma_{yy} & \sigma_{yPy} \\ \sigma_{xPy} & \sigma_{PxPy} & \sigma_{yPy} & \sigma_{PyPy} \end{pmatrix}$$

σ_{PyPy}



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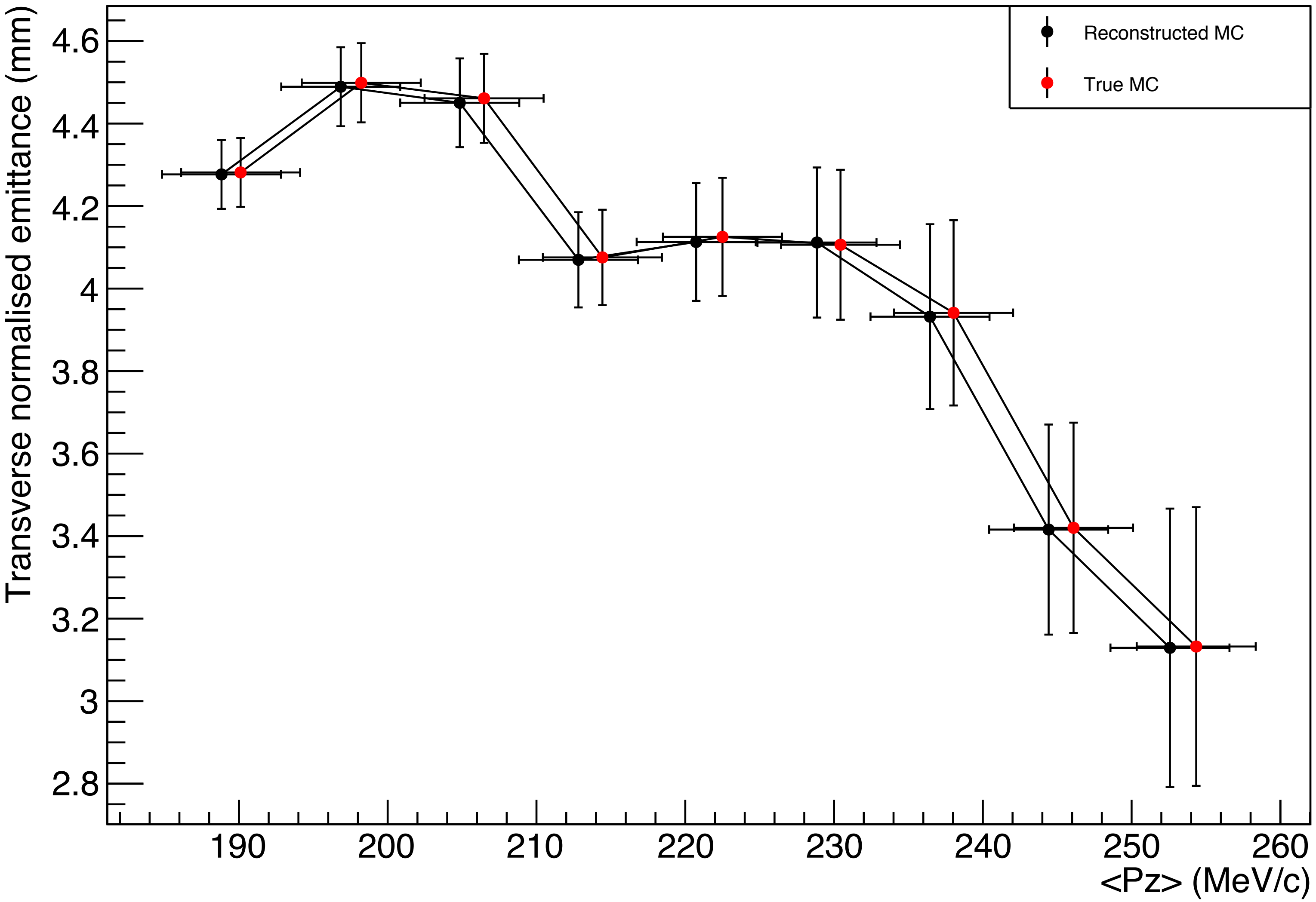
4D normalised RMS emittance



NB: Our MC emittance plot has never looked like our data…

Still to do

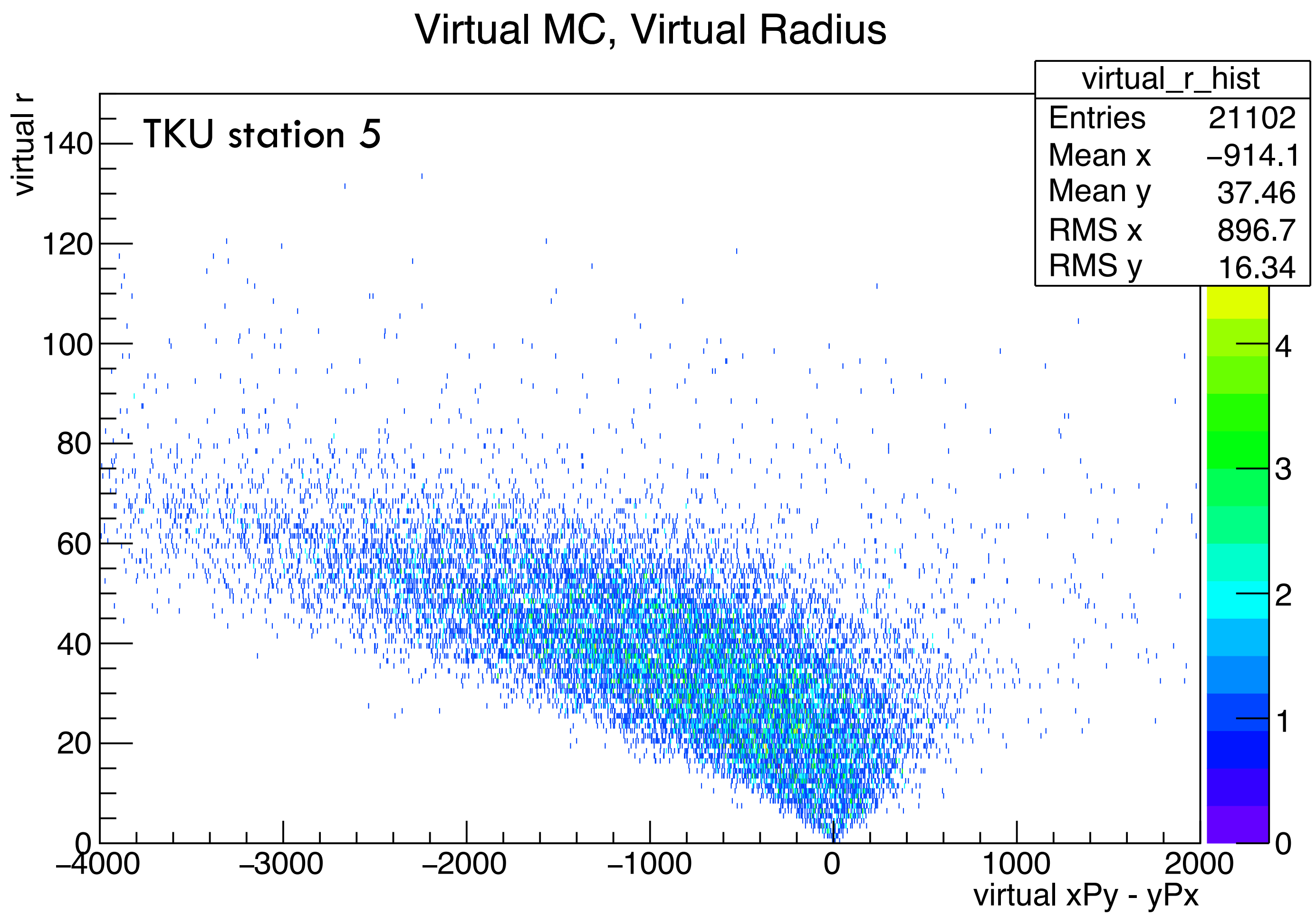
- Check "back-tracked" particles to diffuser aperture virtual planes
  - Needs MC with virtual planes at diffuser
- Use new diffuser cut, re-check residual plots, check nothing's changed
- Apply corrections to track data:
  - Repeat residual plots, check for pathological behaviour
  - Repeat covariance matrix element plots, check for pathological behaviour
- Check |B| used in MC model with that recorded at Hall probes on TKU stations
  - Extra field alignment-ish check
- Look at run 8590, total P reconstruction in tracker
  - Same input beam as 7469, different fields.
  - |P| should be approximately the same, modulo a different proportion of tracks that might go through the diffuser aperture thanks to a different fringe field
  - Extra control on field-induced systematics

NOW.. FOR A PUZZLE!

Whilst waiting for the new MC, we found an interesting "feature" that may turn out to be nothing at all.

Still.. if we have the time...

Lz = xPy − yPx



Other than a brief foray into canonical co-ordinates, the mechanical angular momentum had been left alone

Mechanical angular momentum vs. particle radius (w.r.t. global co-ordinates) has an interesting feature in both data and *reconstructed* MC

(MC shown here is of all particles that were reconstructed and are shown on the recon plot)

Red line = area occupied by a particle with *zero canonical* angular momentum (assuming a 4T uniform field)

Clearest at station 5, but visible at all stations

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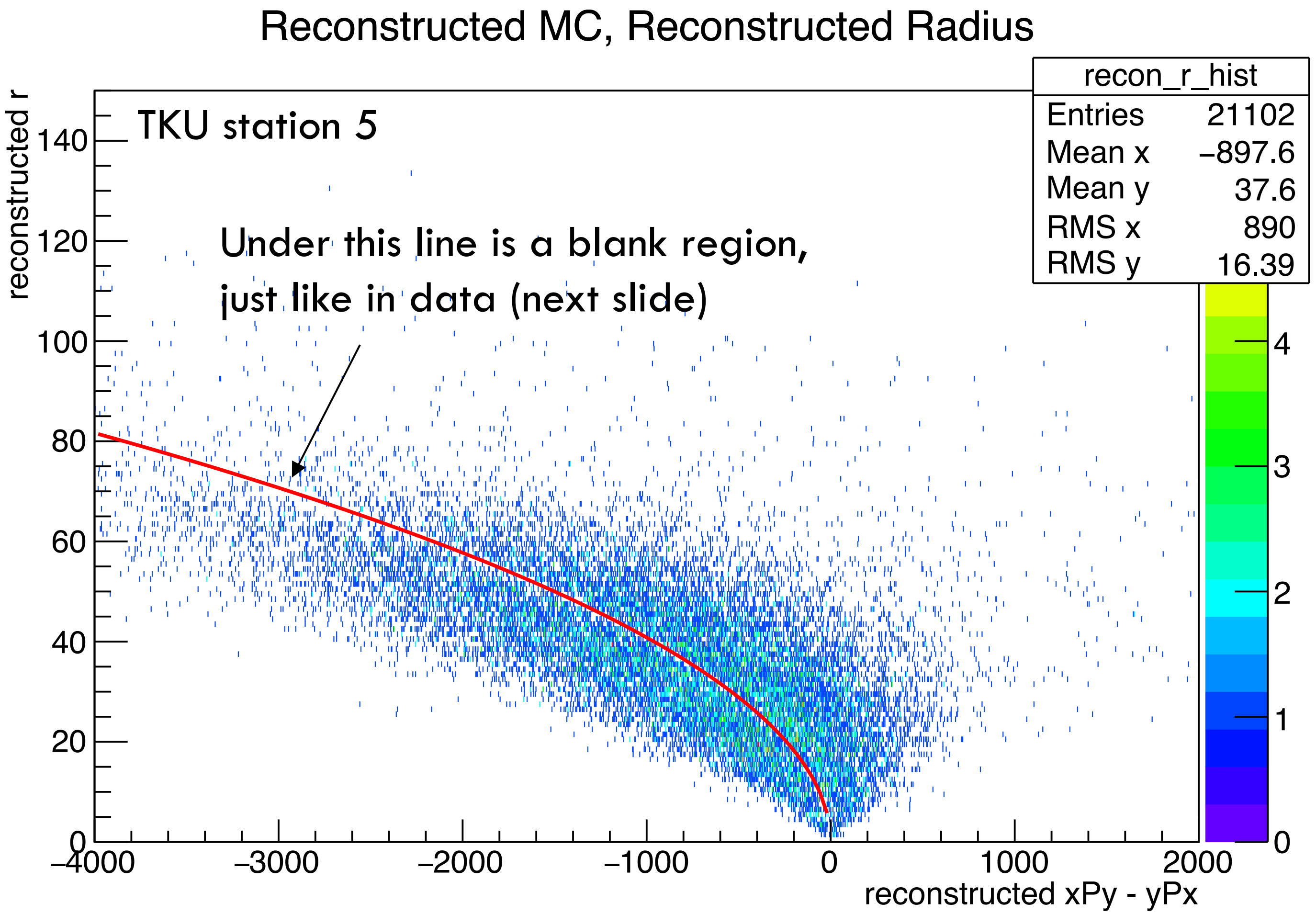

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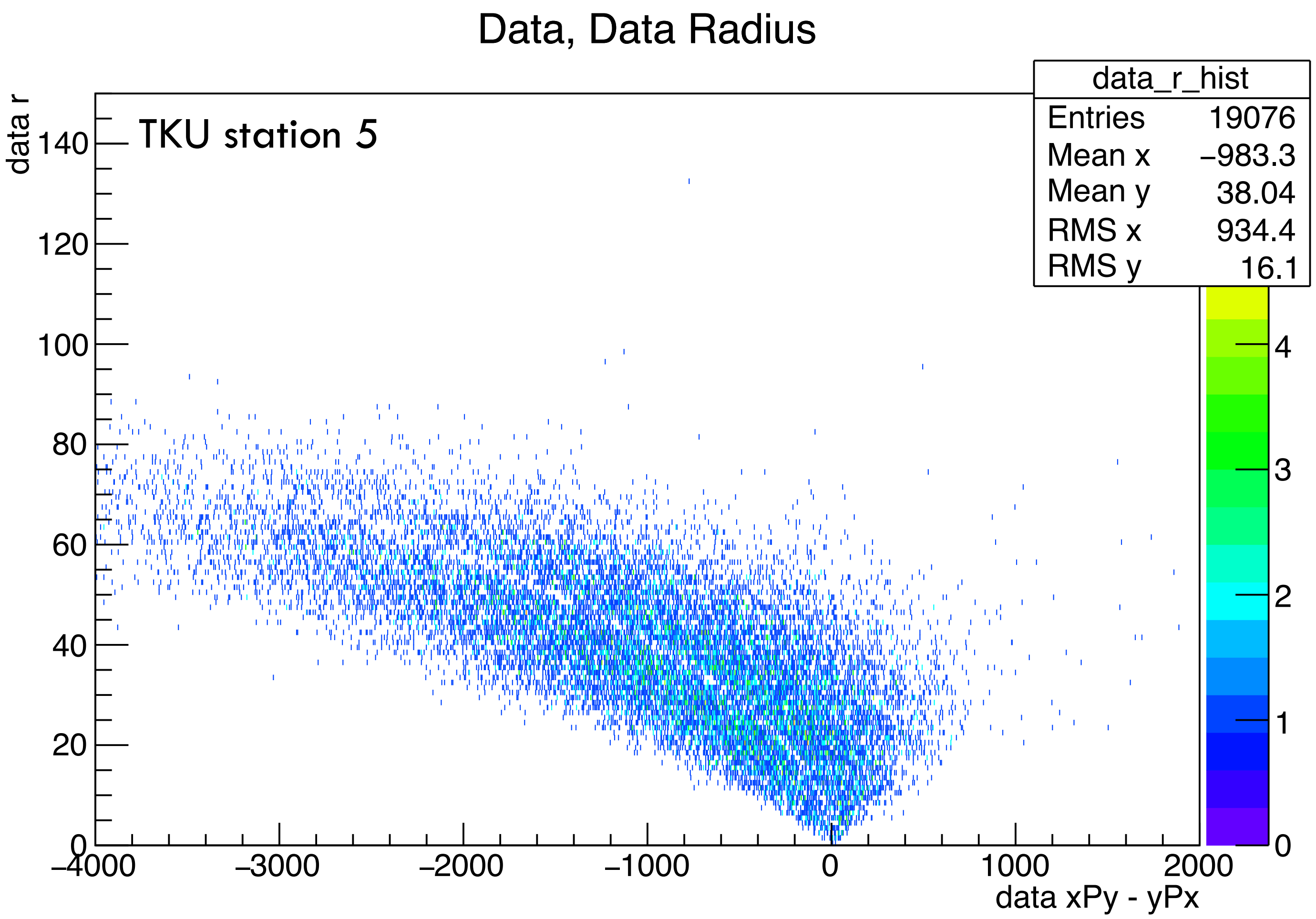

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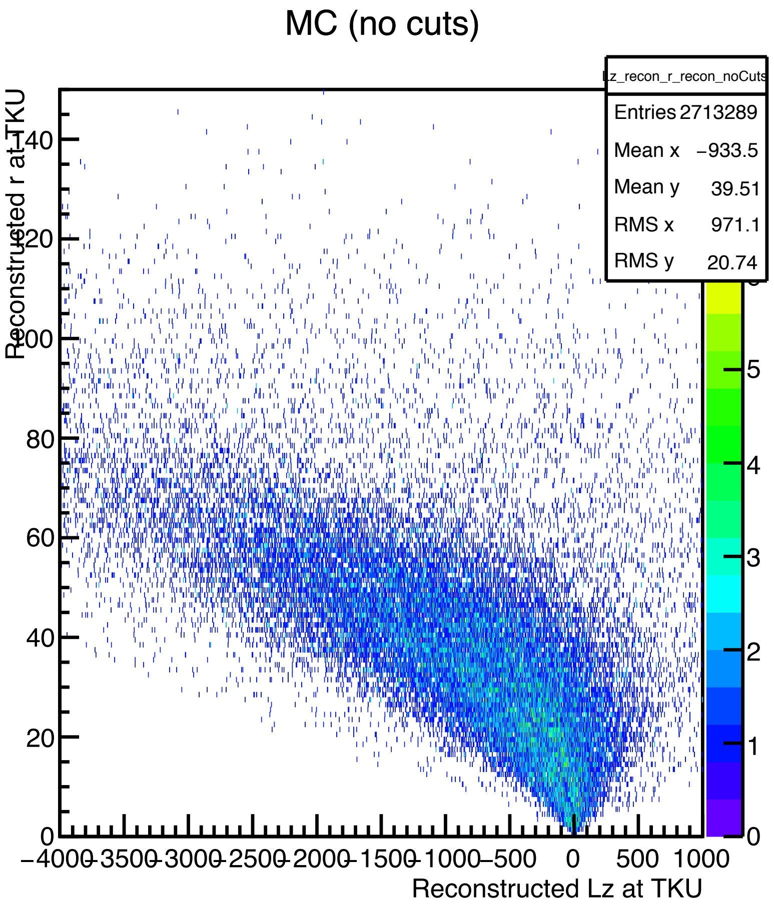
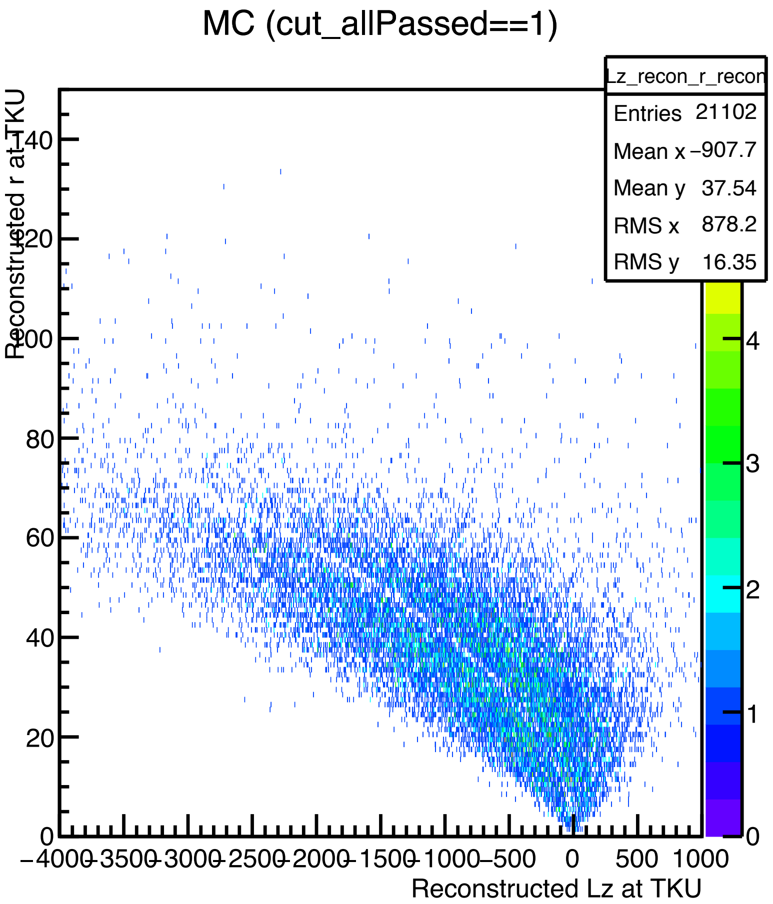
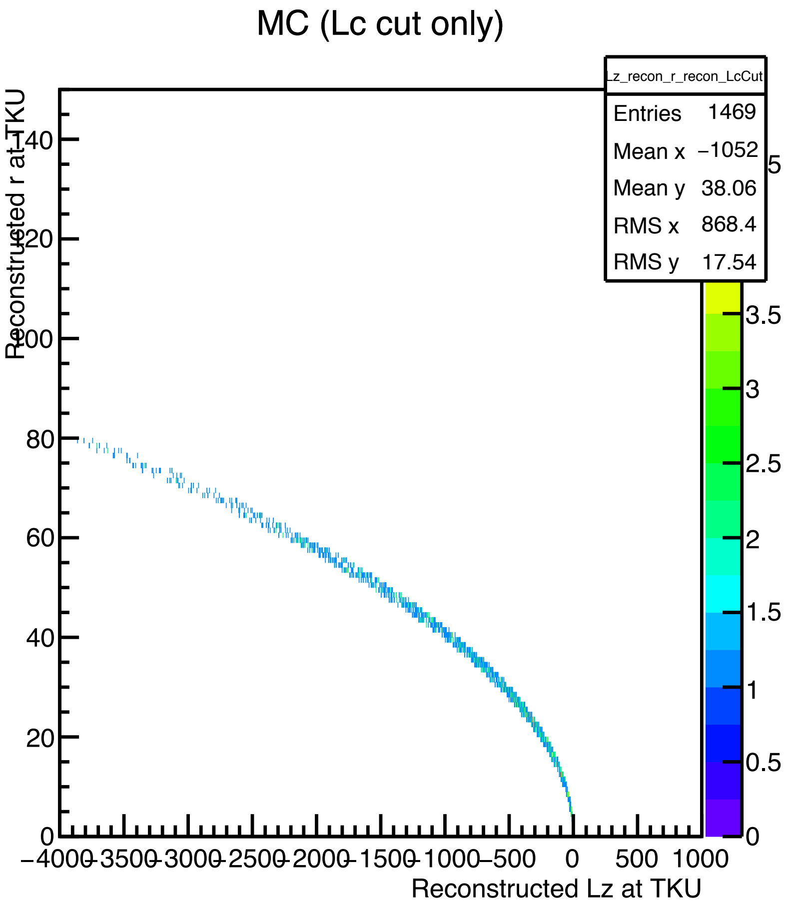
Trial and error



Every reconstructed particle, no cuts at all



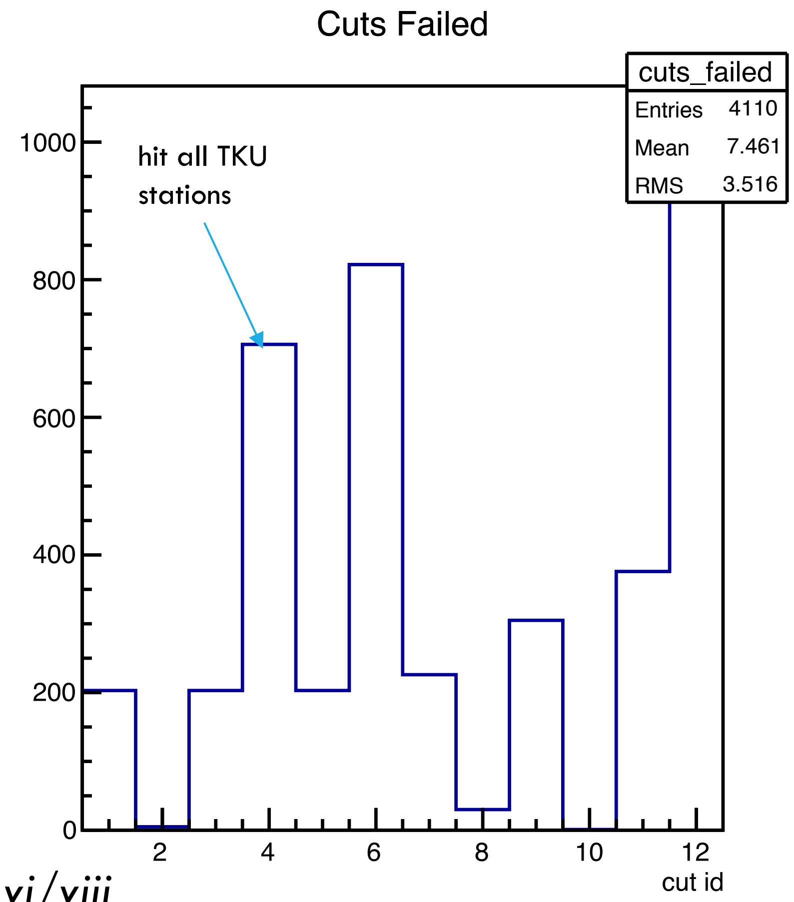
The cuts I've used since CM45

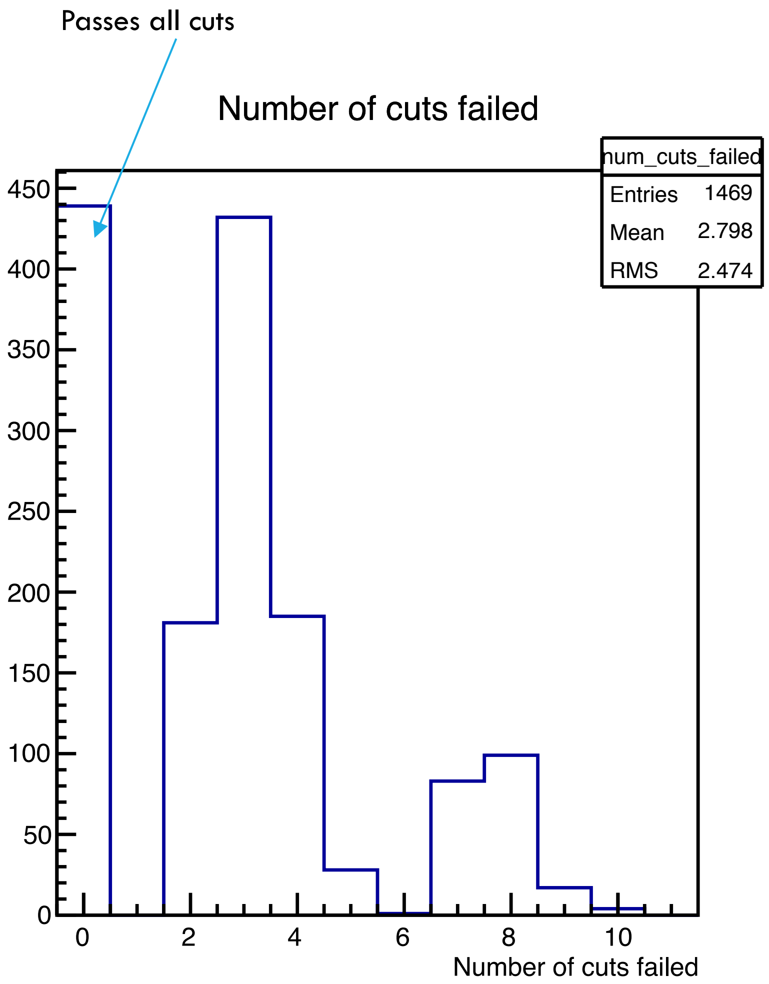


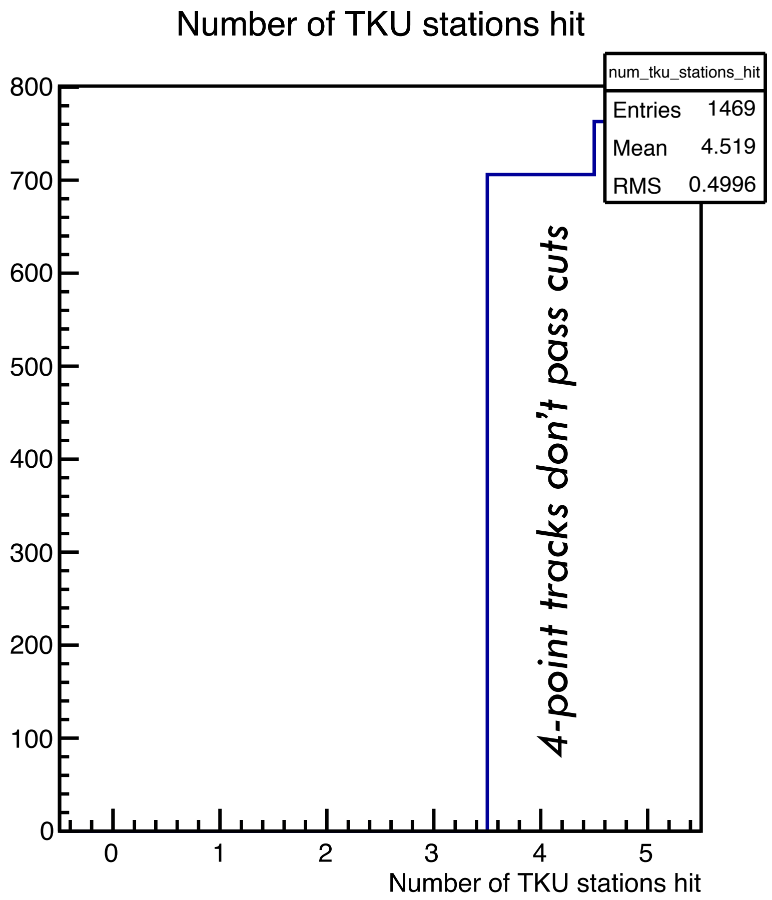
No cuts, except selecting particles that would be within +/- 1mm of the "missing line"

Trial and error

- Look at the properties of the particles that fall in the "Lc cut" plots.
- Nothing looks suspicious in other distributions
- Does look like there's something particular about particles that fail some cuts....
- Need to also remove particles that actually pass all cuts







Cut ‘aide memoire’

‘Cut number’	Cut
1	cut_TOF0_goodPMTPosition
2	cut_TOF1_goodPMTPosition
3	cut_goodRaynerReconstruction
4	cut_TKU_hitAllStations
5	cut_TimeOfFlight
6	cut_hit_all_detectors
7	cut_TOF0_singleHit
8	cut_TOF1_singleHit
9	cut_TKU_singleTrack
10	cut_TKU_PValue
11	cut_momentum_loss

Same numbering as at CM45

“Cut 12” on the preceeding slide is the “passed everything” cut

Ideas on a postcard (email) please.