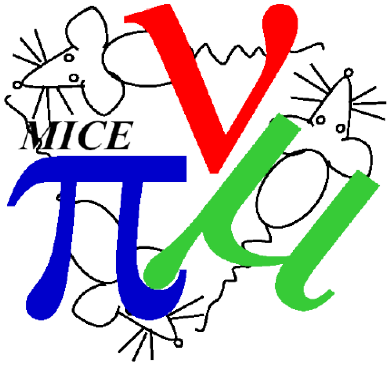
# Analysis

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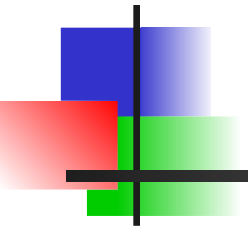
# Aim

- Thinking about what goes into the system paper
- Describe the algorithm
- Demonstrate self-consistency between detectors
  - Momentum measurement independent of SSU/SSD field
  - Show that we understand the magnetic fields
  - Show that the detectors are basically working okay
- Caveat: plots I show are for CM50 version of emittance evolution analysis (i.e. end of Feb)
  - Few cuts may have moved, etc



# Algorithm

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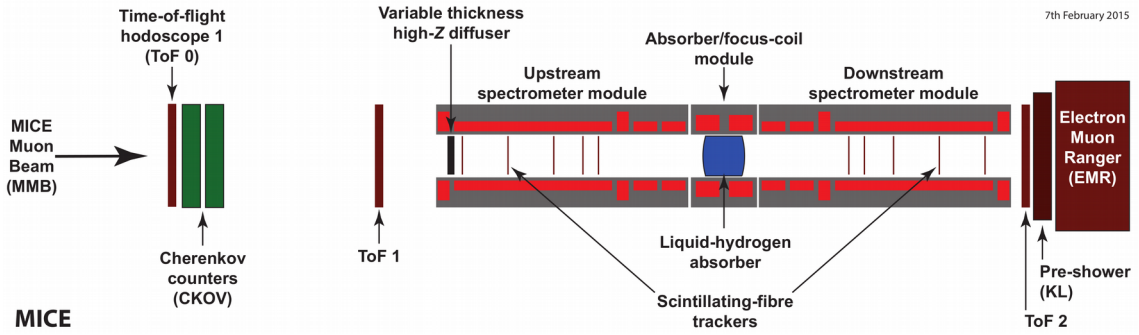
# Algorithm - overall




- Upstream track
  - Extrapolate tracks from TKU station 5 to TOF1
  - Offset all times s.t. time is consistent with measured time at TOF1
  - Extrapolate from TOF1 to TOF0
- Downstream track
  - Extrapolate tracks from TKD station 5 to EMR
  - Offset all times s.t. time is consistent with measured time at TOF2
- Through track
  - Extrapolate tracks from TKU station 1 to EMR
  - Offset all times s.t. time is consistent with measured time at TOF1

# Algorithm – track extrapolation

- For each track; integrate the Lorentz force law
  - $\underline{F} = q\underline{v} \hat{} \underline{B} - q\,\underline{E}$
- Integration uses GNU Scientific Library (GSL) dynamic RK4
  - Integrate each step using RK4; if the discrepancy between step and ½ step is too large, reduce the step size
- Material boundaries are found at “setup” by walking along the axis through the Geant4 geometry
  - Build a lookup table of the Geant4 on-axis materials
  - Can use full Geant4 model
- dE/dx using most probable energy loss
  - Can use mean energy loss as well
- I don't think we want to go into discussion of CPU efficiency/etc – this is not a computing paper

# dE/dx model

From PDG handbook:

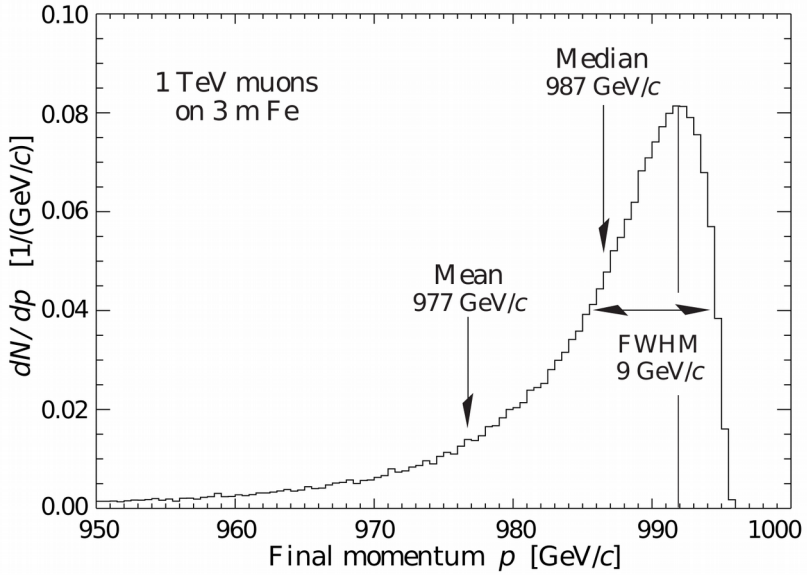
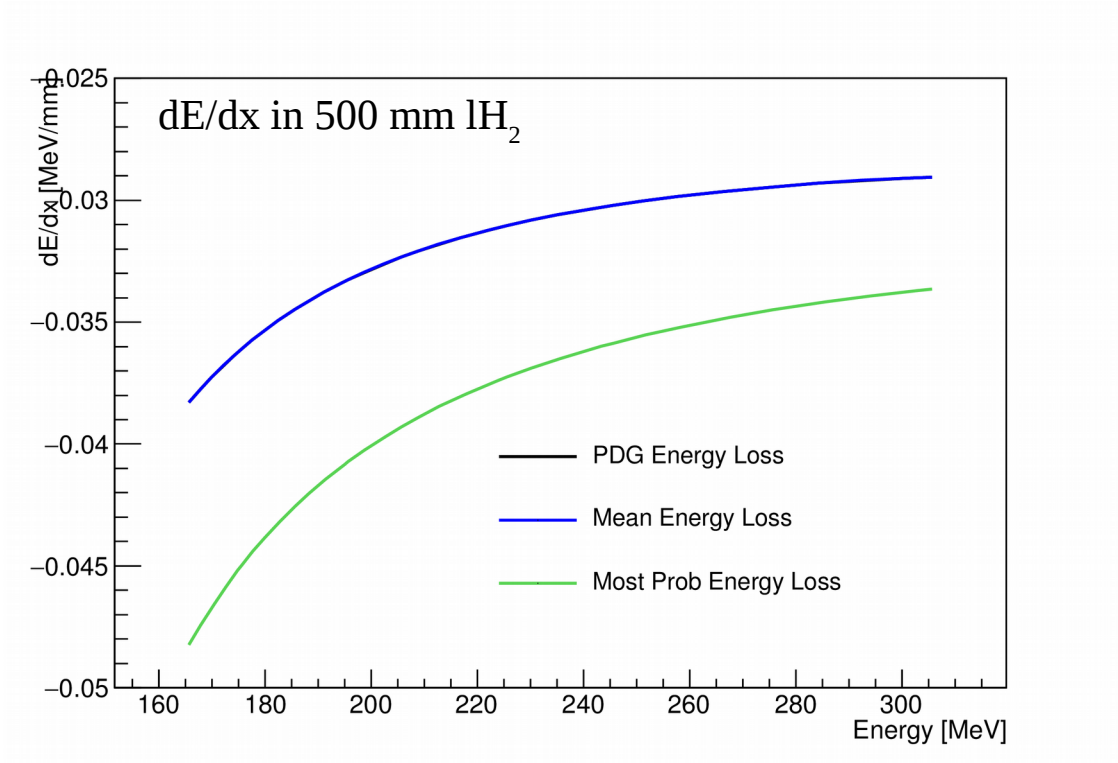


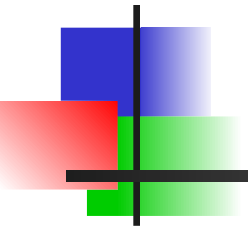

**Figure 27.23:** The momentum distribution of 1 TeV/$c$ muons after traversing 3 m of iron as calculated with the MARS15 Monte Carlo code [67] by S.I. Striganov [1].

Few concepts in high-energy physics are as misused as $\langle dE/dx \rangle$. The main problem is that the mean is weighted by very rare events with large single-collision energy deposits. Even with samples of hundreds of events a dependable value for the mean energy loss cannot be obtained. Far better and more easily measured is the most probable energy loss, discussed in Sec. 30.2.7. The most probable energy loss in a detector is considerably below the mean given by the Bethe equation.

# Algorithm - dE/dx




- Most probable energy loss for thickness *t* goes like
  - $a \ln(t)+b$
  - Use on-axis material thickness to estimate t
- Do we want a discussion of track matching with different energy loss models?



# Upstream track

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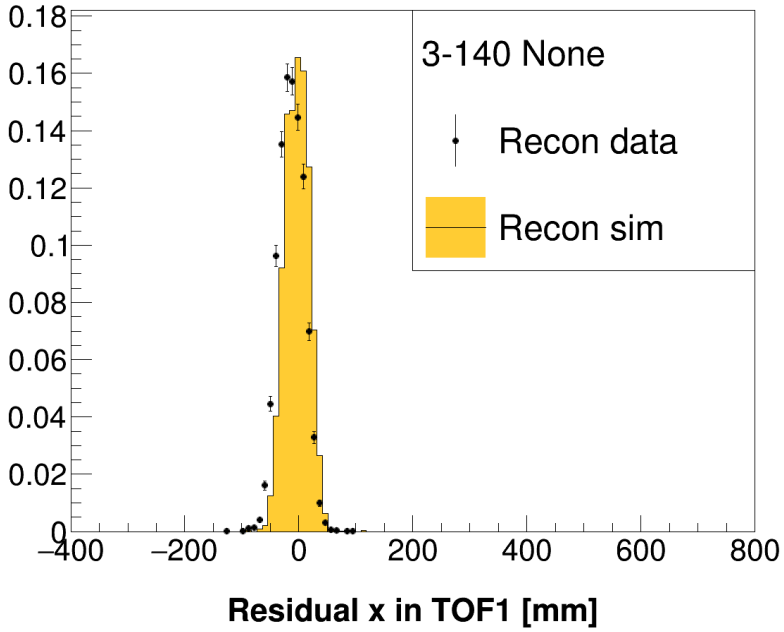
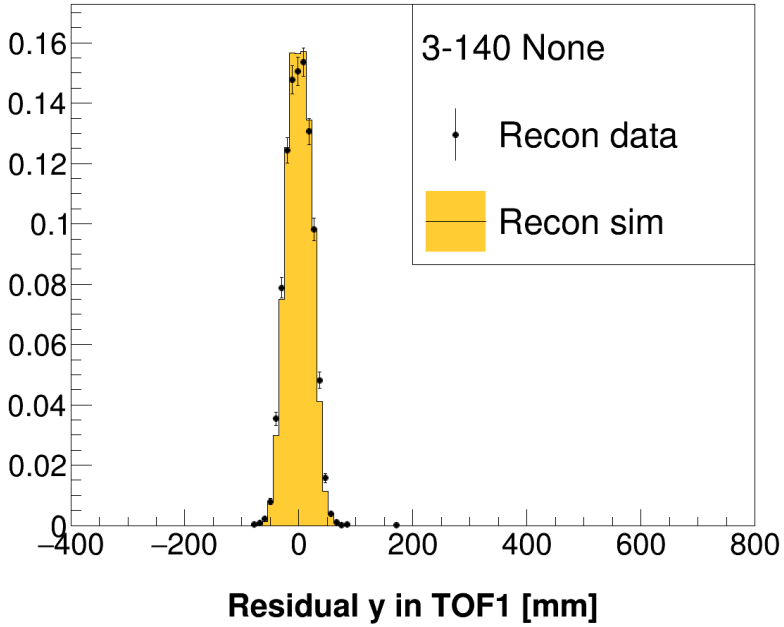
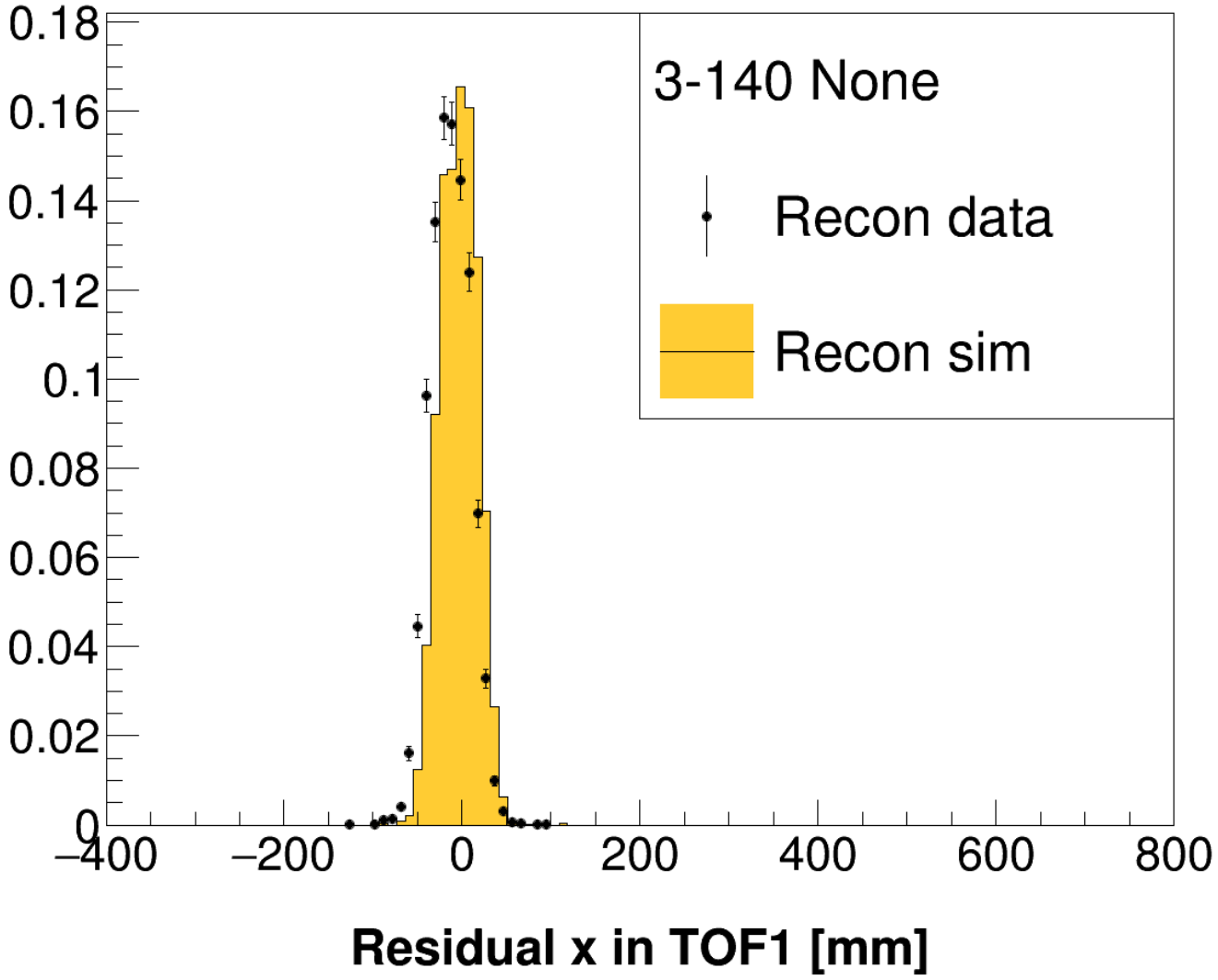
# Residuals - TOF1



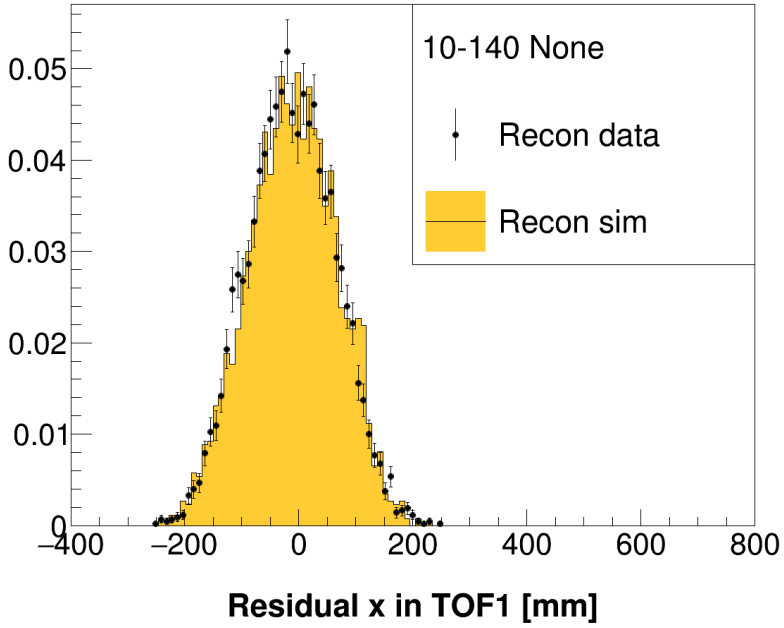



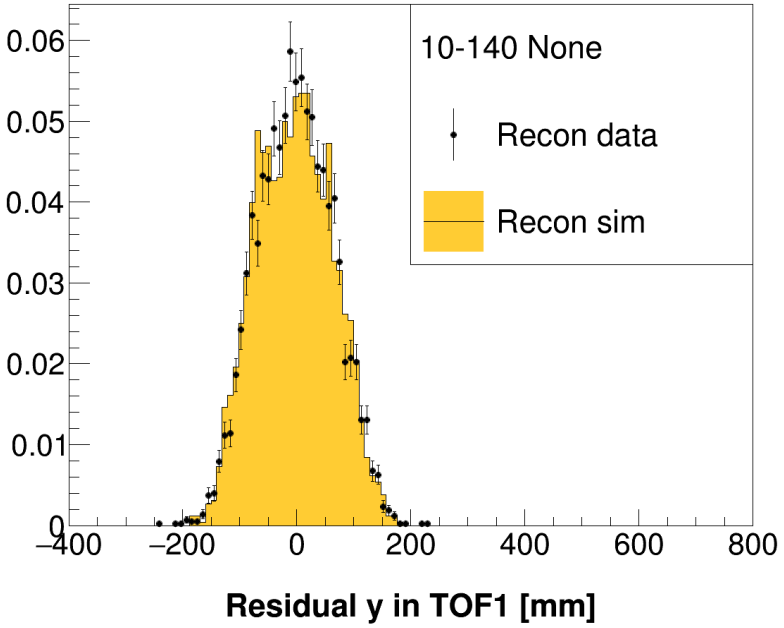

- Residual = (measured x in TOF1) – (extrapolated x in TOF1)
- Note horizontal misalignment
  - Magnets? Detectors?

# Residuals - TOF1



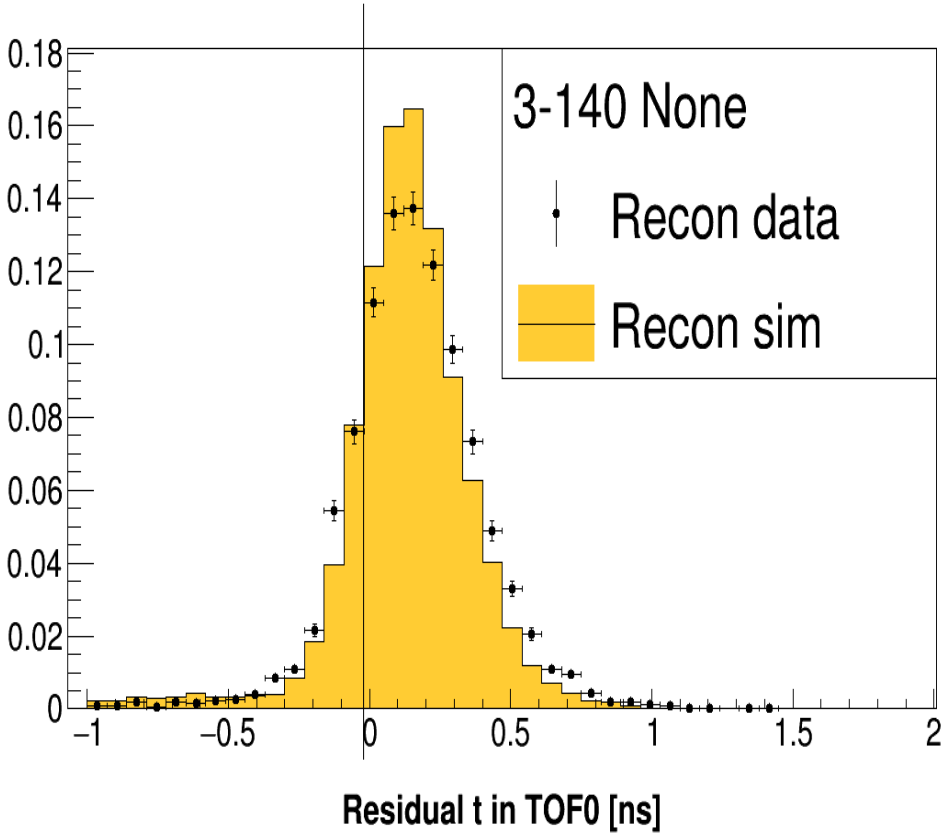
# Residuals - TOF1



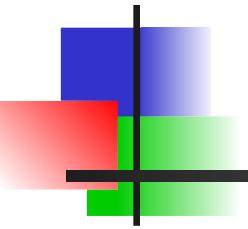




- Residuals are wider for 10 mm beam
  - Effect of diffuser
  - Should we show it?

# Residuals - TOF0




- Note offset of peak from 0 – amplitude momentum correlation?
- Pretty good agreement between MC and data
- Note also this is after cuts (and this is a cut variable)
  - Cut at -1 < dt < 1.5
  - There are features in the negative tail



# Through track

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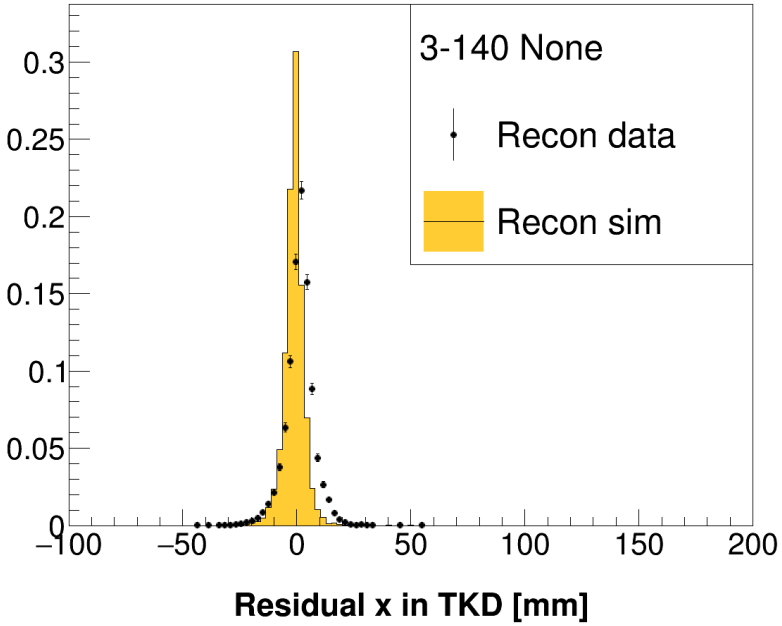
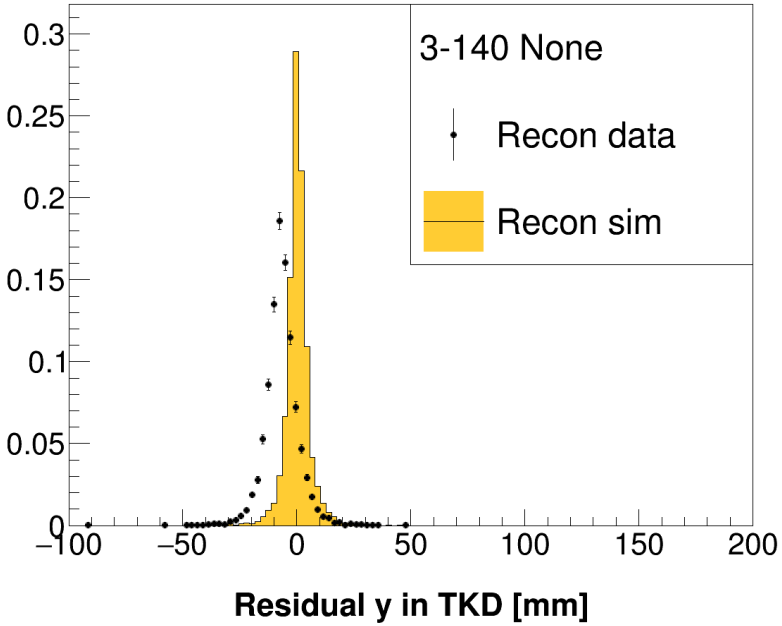
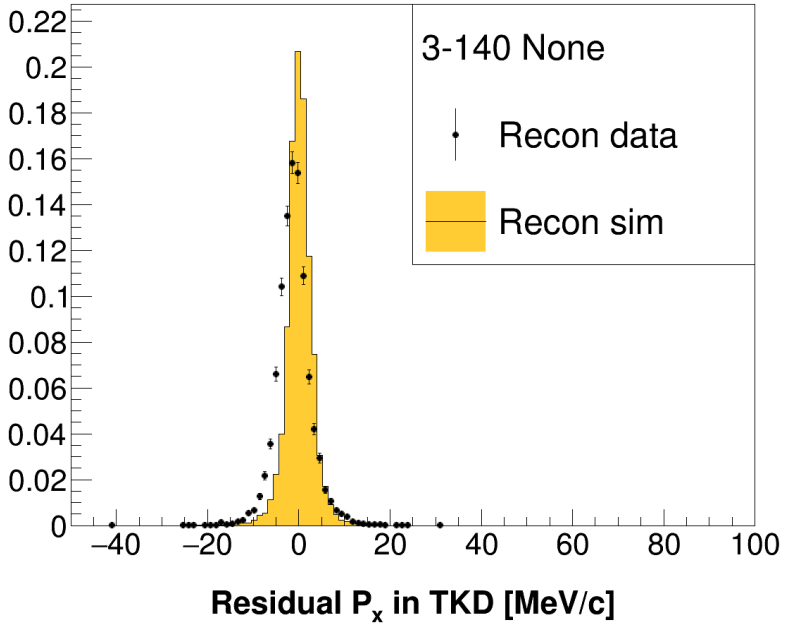
# Residuals – TKD (position)

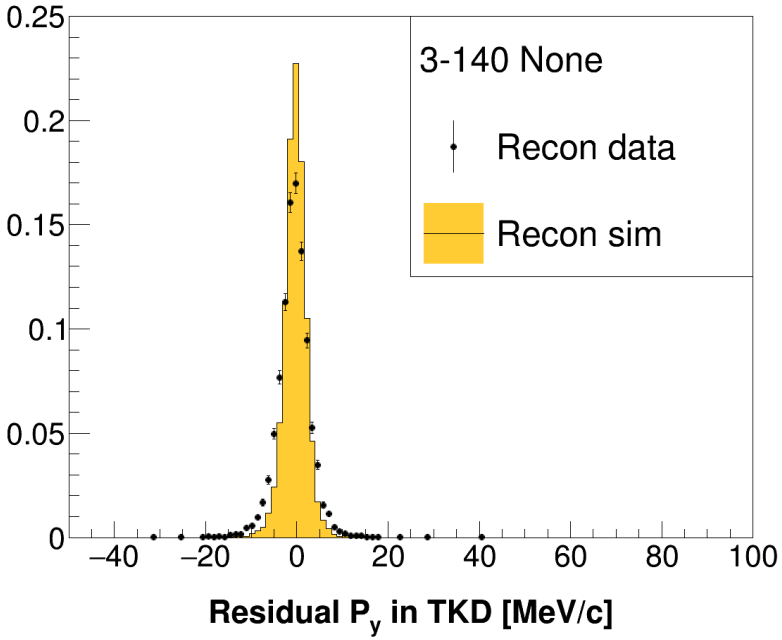



- Now look at extrapolation from TKU to TKD
- Note big deviation in y

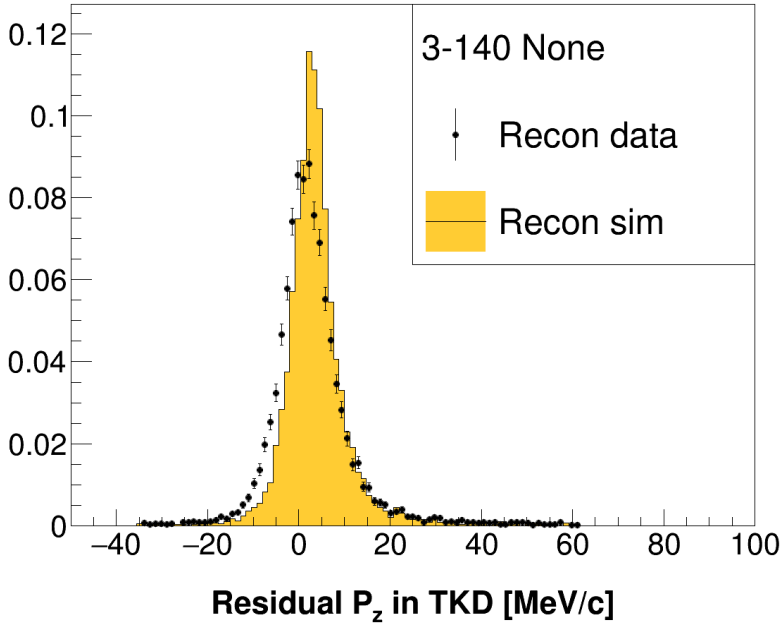
# Residuals – TKD (momentum)

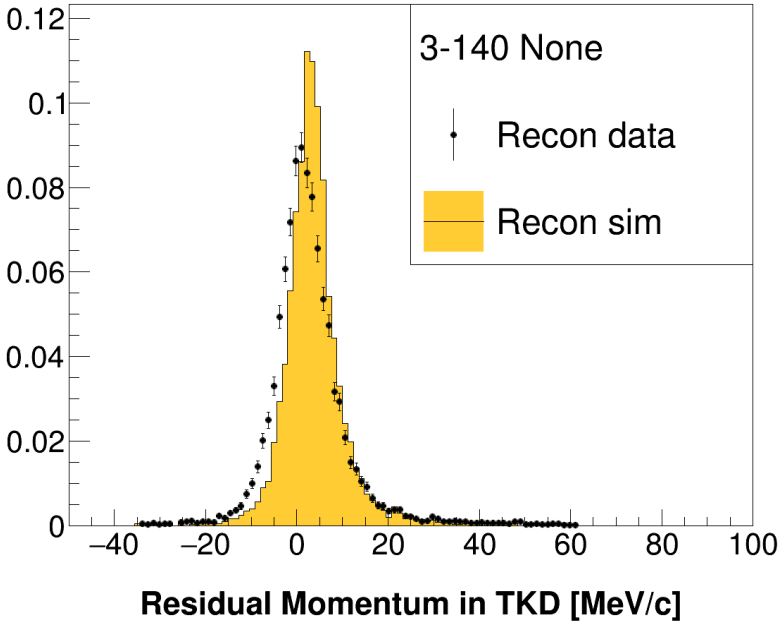



- Transverse momentum

# Residuals – TKD (momentum)

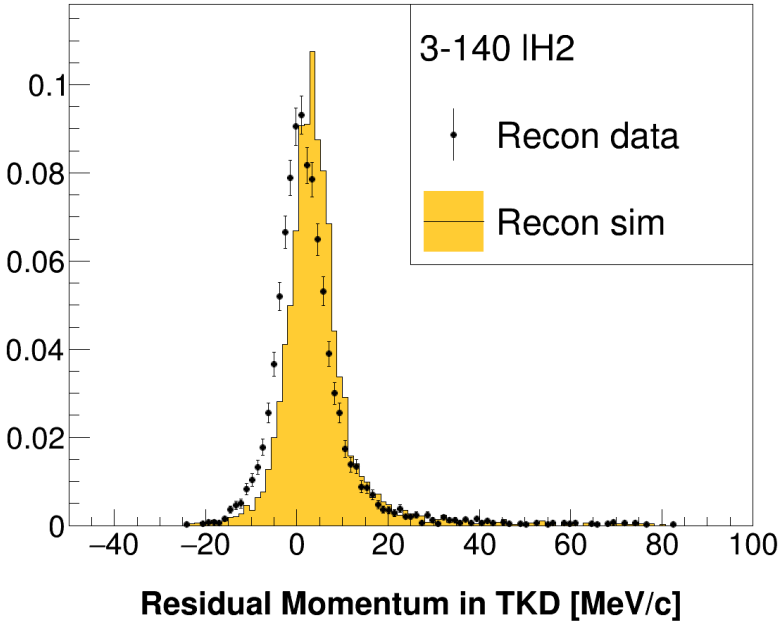


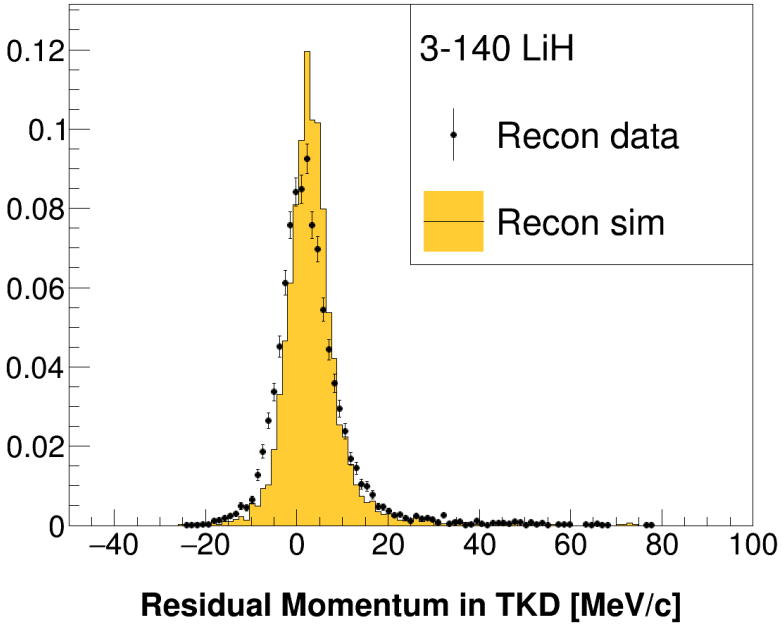




(Total momentum)

- Longitudinal and total momentum

# Residuals – TKD (momentum)

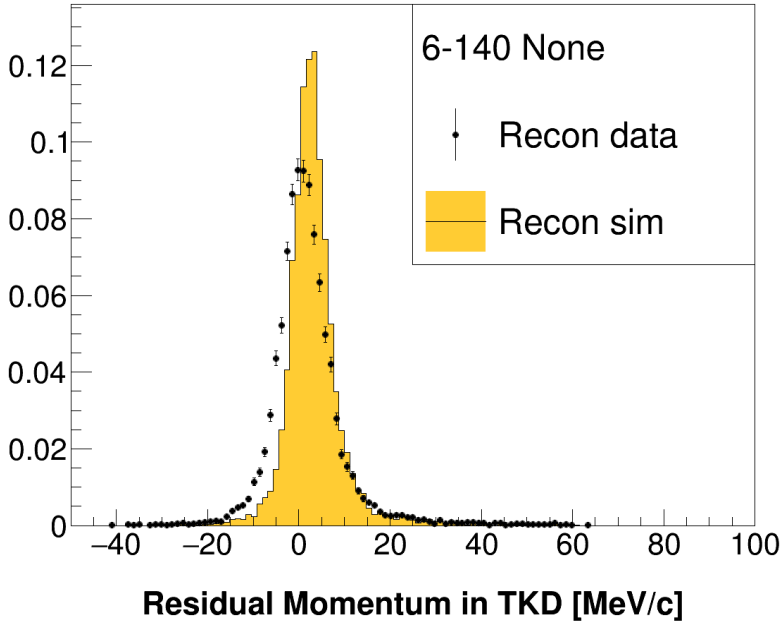


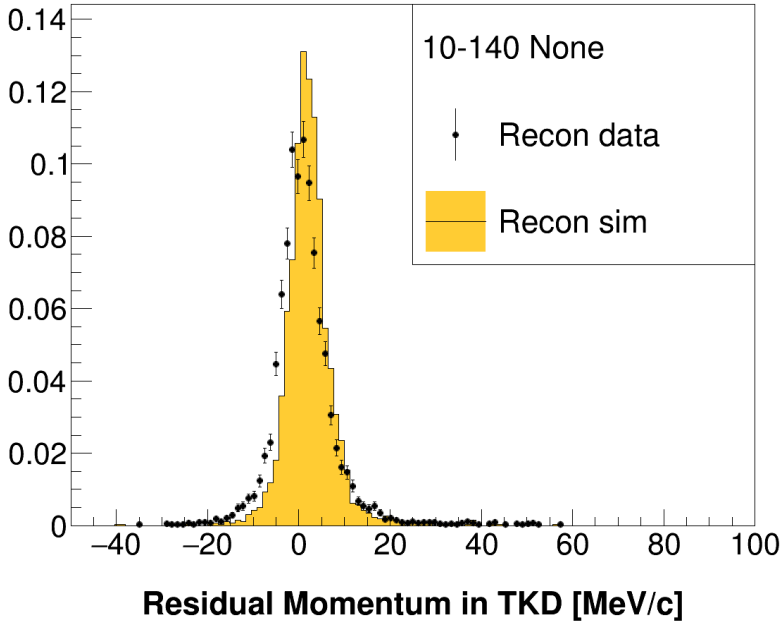




(Total momentum)

- Different materials

# Residuals – TKD (momentum)

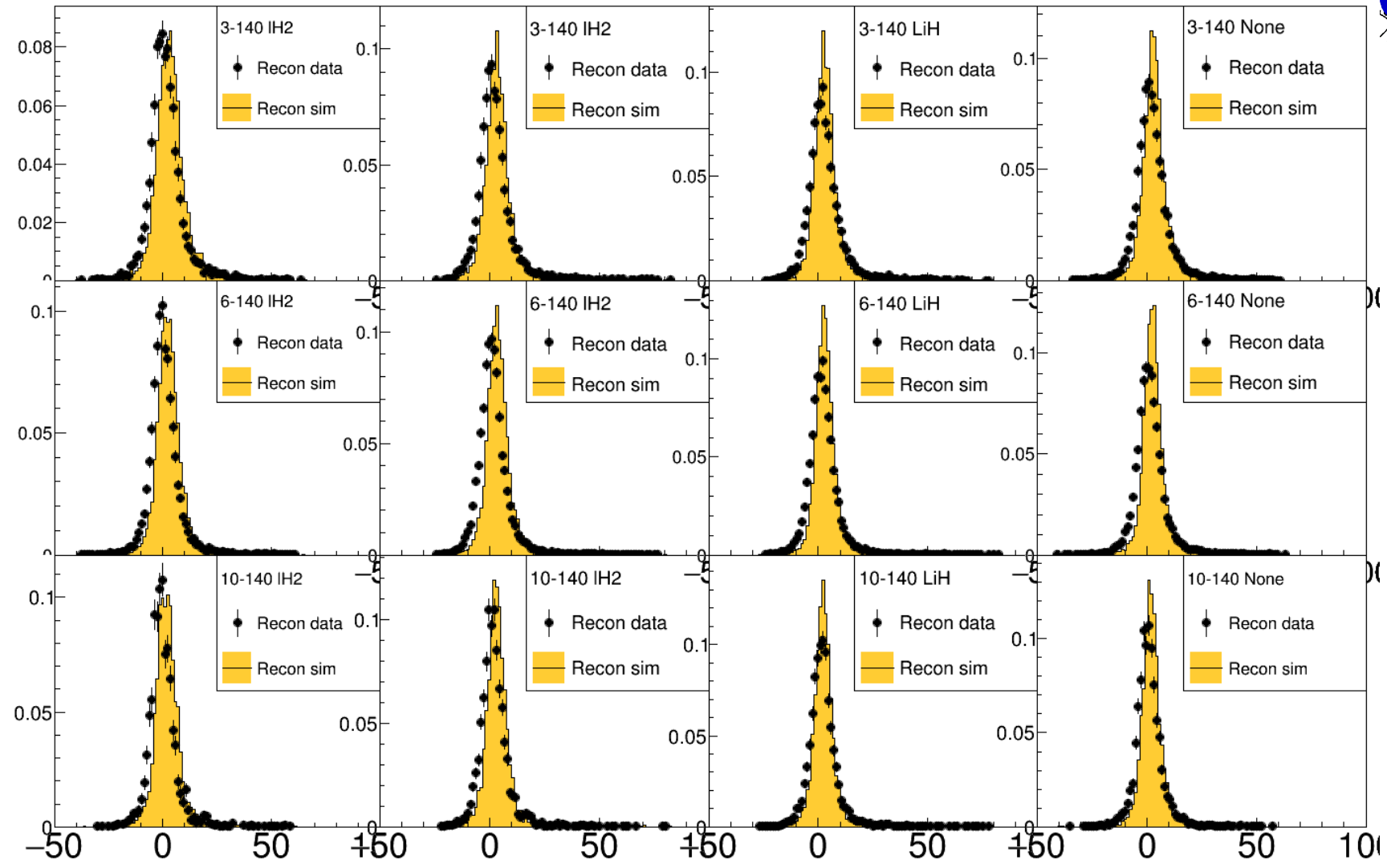


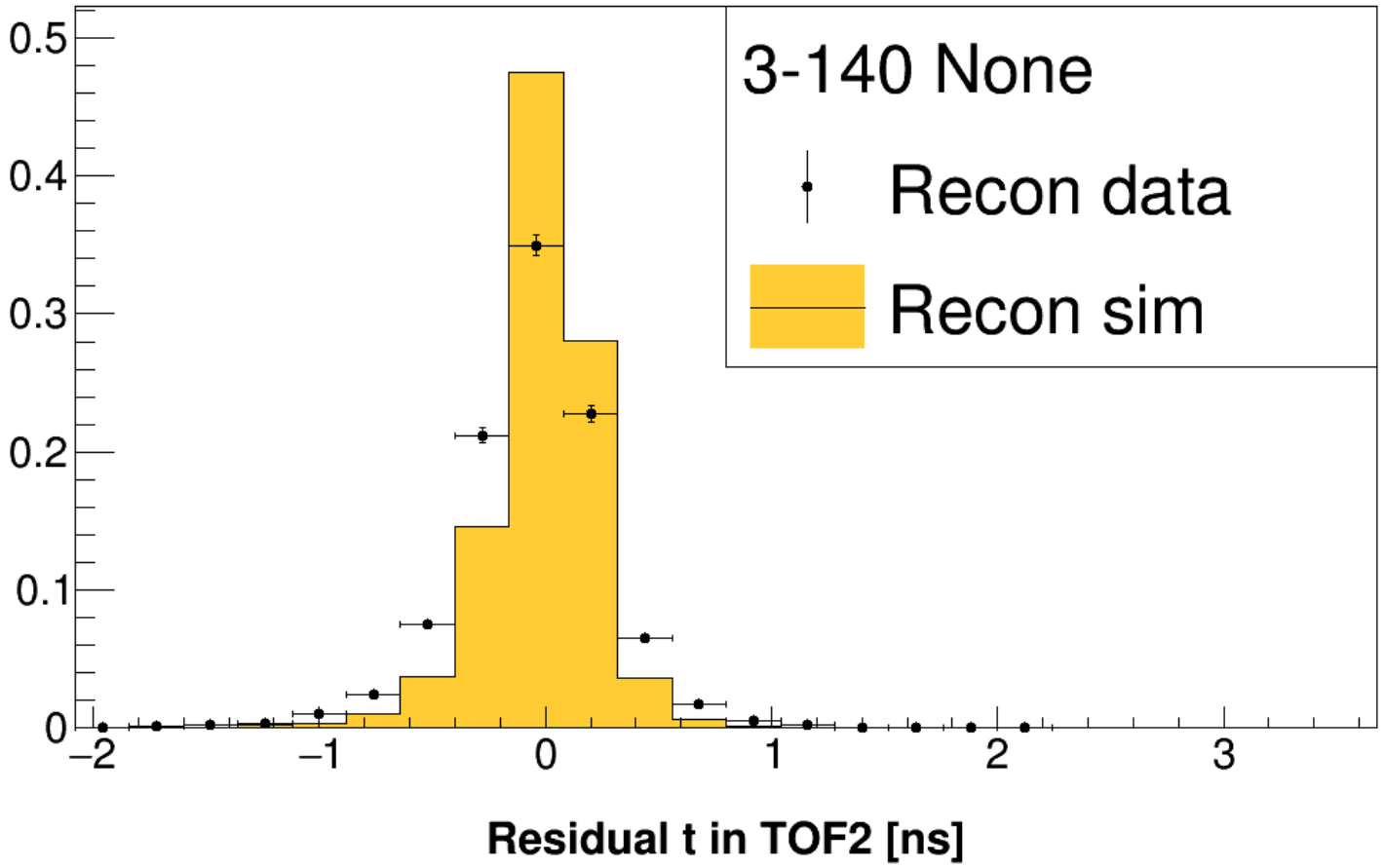

(Total momentum)

- Different beam emittances

# Residuals – TKD (momentum)



# Residuals – TOF2




- Need smaller bins
- Some discrepancy, esp in width

# Conclusion

- Need to write words
- Is MC → data agreement good enough?
  - Probably not
- Is detector → detector agreement good enough?
  - Probably not
- Do we understand our measurements well enough?