HCAL Jet/Neutron Energy Calibration

New results

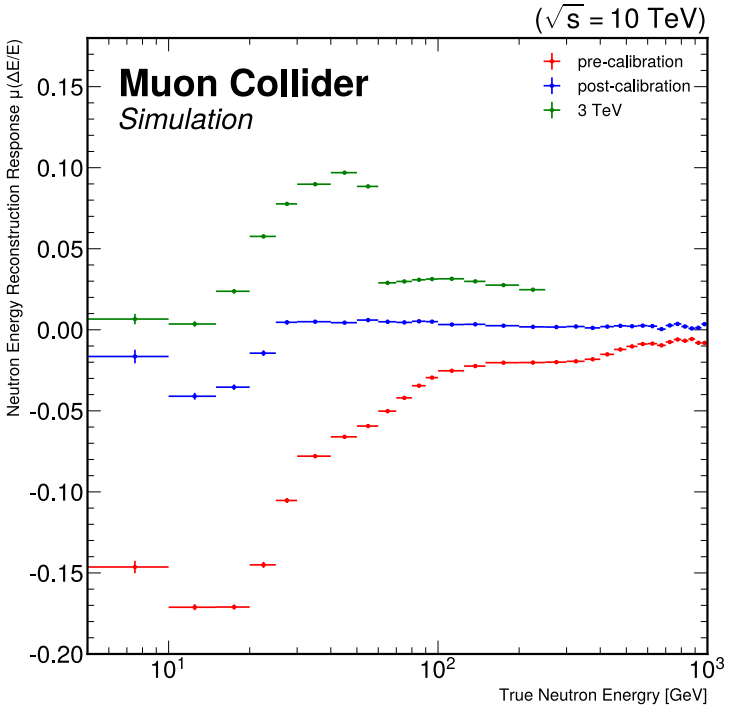
- **Previously**
  - Created histograms to find the digitization constant, but some issues arose from fitting
  - Discussed creating a group name
- **Summary for today**
  - Digitization constant fitting
    - Iterative gaussian fitting vs median vs standard gaussian
  - Creating the calibration matrix
    - Should the calibration matrix be generated from sim hits, reco hits, or anti-kT jets?
    - If using jets, how should I apply to digitization constant correction to the energy?
  - Applying calibration matrix to resolution, response, and efficiency plots w/ comparisons
  - Should we strive for a unified plot aesthetic?

Group name discussion!

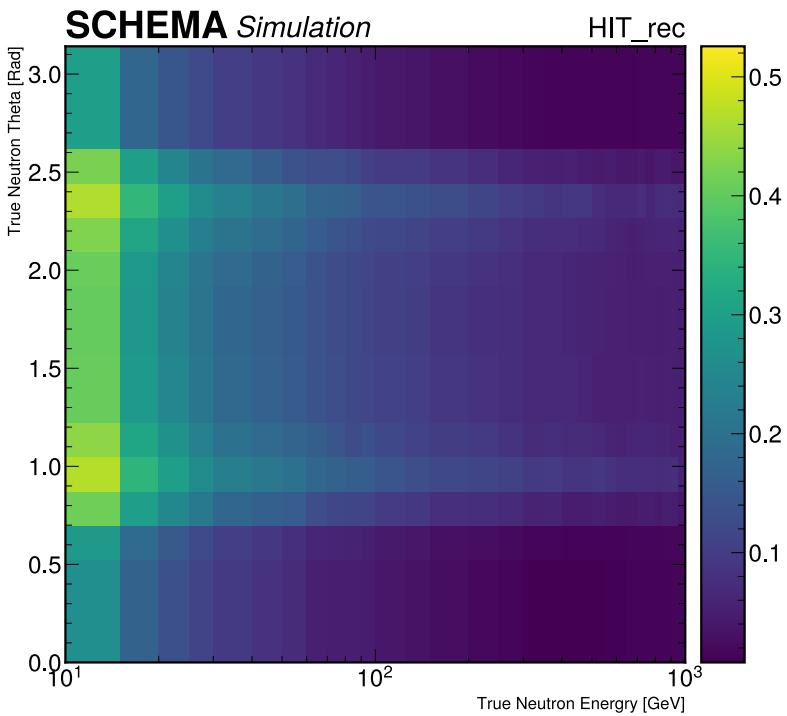
- **Submissions:**
  - Group name
    - SCHEMA
  - Should we have a detector name or should we keep our plots labeled (Muon Collider *Simulation*)?
  - Detector names/concepts
    - ACME: Accelerated (or Advanced) Colliding Muon Experiment (Kiley Kennedy)
      - Definition: the highest point or stage.
      - This is, however, an EDM experiment at Harvard
    - MUSE: Muon Underground Synchrotron Experiment (Kiley Kennedy)
      - Definition: a person or personified force who is the source of inspiration for a creative artist. In Greek/Roman mythology, the muses are goddesses who preside over the arts and sciences. NB: The other detector concept is, unfortunately, called MUSIC.
      - And this is proton scattering experiment at the Paul Scherrer Institute
    - MAIA: Muon Acceleration Integrated Appratus (Kiley Kennedy)
    - MAIA: Muon Accelerator experImental Apparatus (Isobel Ojalvo)
      - In Greek/Roman mythology, Maia is the daughter of Atlas (ATLAS-like detector concept); also the goddess of spring and growth. The etymology of Maia is connected to the adjective major ("larger, greater”)

Unified plot aesthetic?

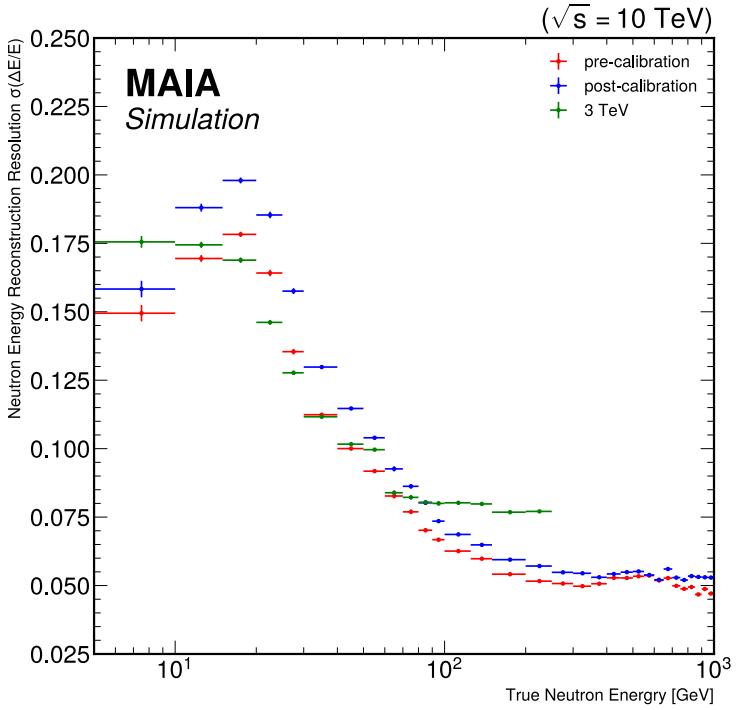
MC *Sim*



SCHEMA *Sim*



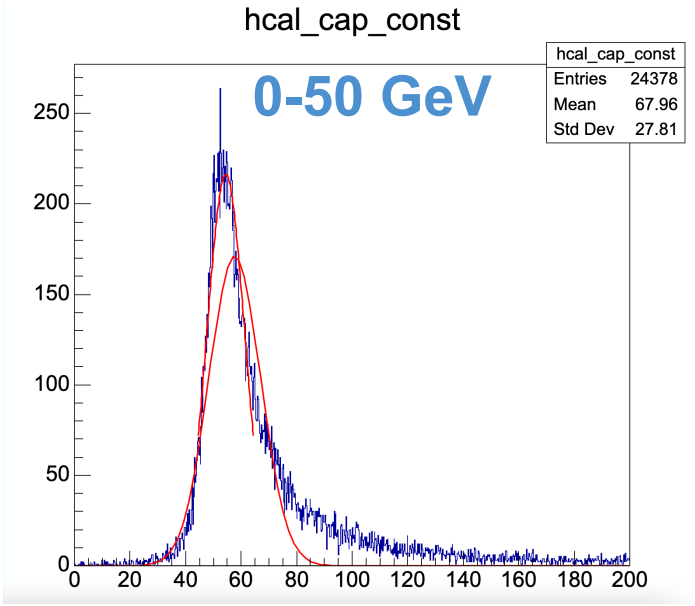
Detector_name *Sim*

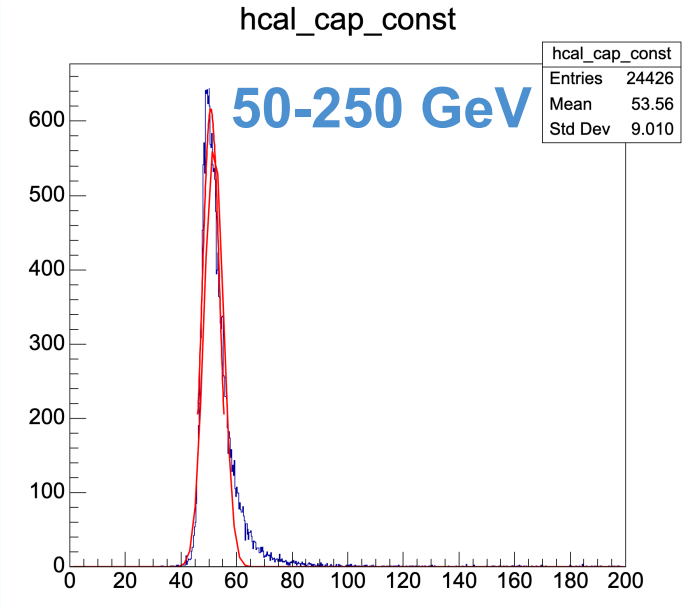


- As we have been discussing creating a more unified naming scheme/aesthetic for our group, I wanted to put forward 3 ideas for how we could more unify our plotting aesthetics
  - I generated all of these plots using uproot -> mpl4hep as recommended by IRIS-HEP

Digitization constant fitting

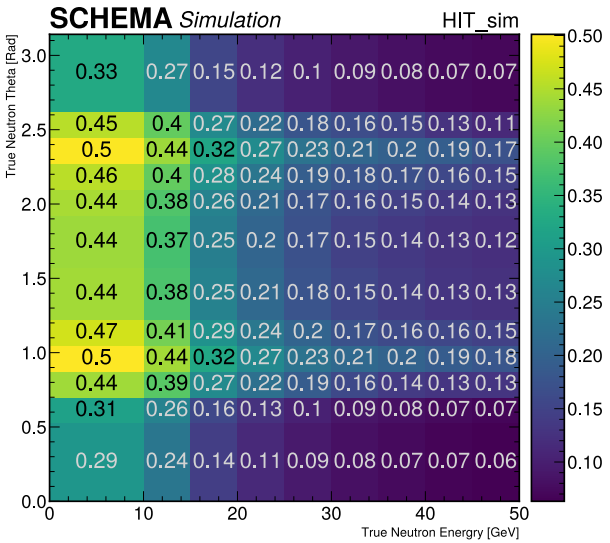
- **Current value**
  - $k_{HCAL} = 47.95$
- **3 Methods**
  1. Mode:
     - I. 0-50: 53
     - II. 50-250: 49
     - III. 250-1000: 49
  2. Standard Gaussian Fit
     - I. 0-50: 57.7
     - II. 50-250: 51.82
     - III. 250-1000: TBD
  3. Iterative Gaussian fit
     1. Iterates multiple gaussian fits over a range of +- 1.5 sigma from the previous fit until the error between the previous fit mean/sigma and the new mean/sigma is under a specified epsilon tolerance.
     - I. 0-50: 54.62
     - II. 50-250: 50.70
     - III. 250-1000: TBD
- **Chosen value (to be changed when fitting is determined)**
  - $k_{HCAL} = 49$

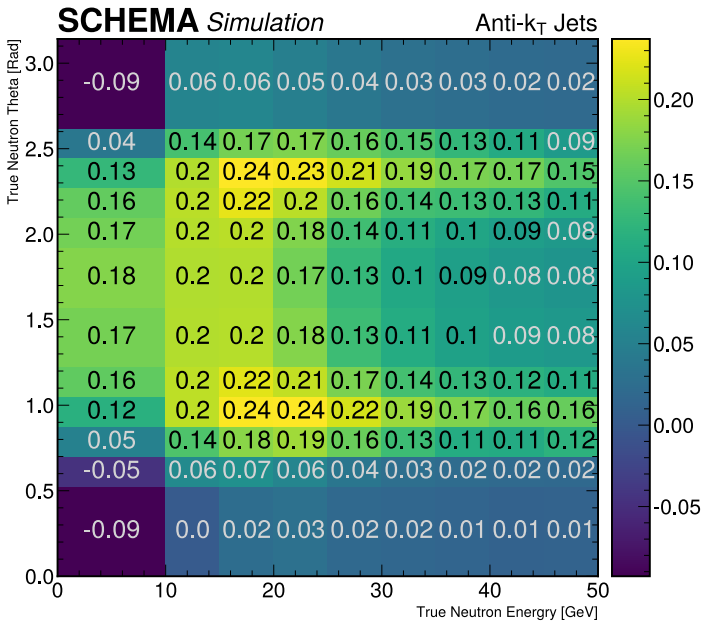


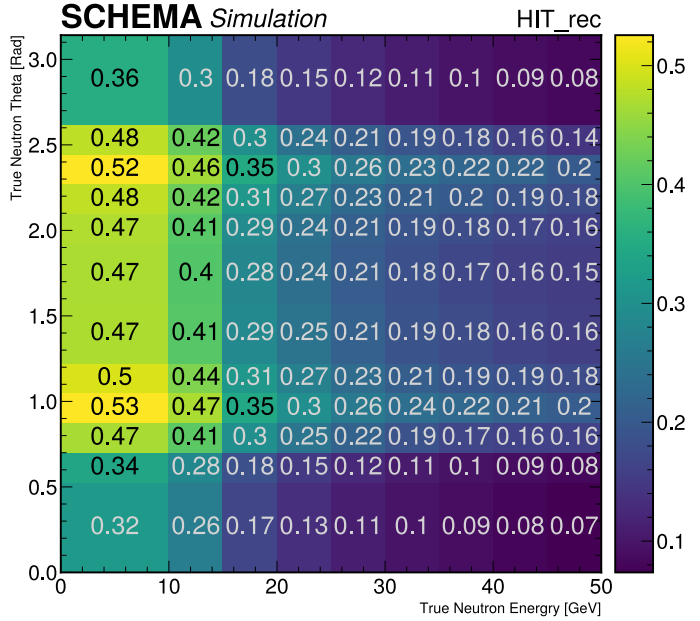


Calibration matrix generation

- **Methods**
  - Generated 3 batches of 3D histograms with (x,y) = (E_truth, theta_truth) and:
    1. $z = \frac{E_{truth} - (E_{HCAL,SIM,total} * k_{calc} + E_{ECAL,REC,total})}{E_{truth}}$: HIT_SIM
    2. $z = \frac{E_{truth} - (E_{HCAL,REC,total} * k_{calc}/k_{old} + E_{ECAL,REC,total})}{E_{truth}}$: HIT_REC
    3. $z = \frac{E_{truth} - E_{jet,matched}}{E_{truth}}$: Anti-kT jets
       1. How could I apply the new k_{calc} to jets outside of applying it to the steering macro?
1. Then, I fit a histogram of the z value in each enrgy/theta bin
   1. The mean of this fit is the calibration value for each bin so,
      1. $E_{corrected}(E_{true}, \theta_{true}) = E_{reco} * M_{calibratio}[E_{true}, \theta_{true}]$

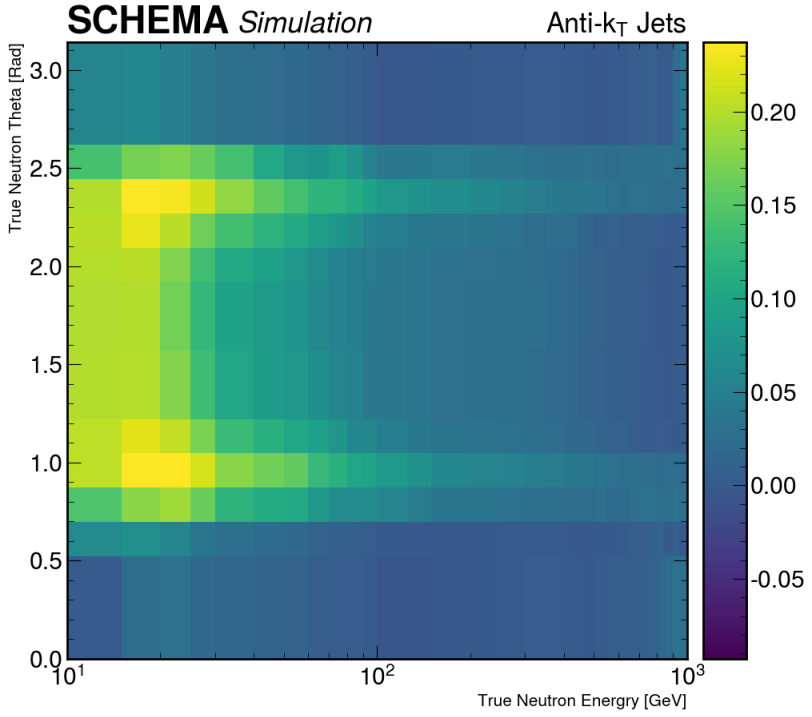




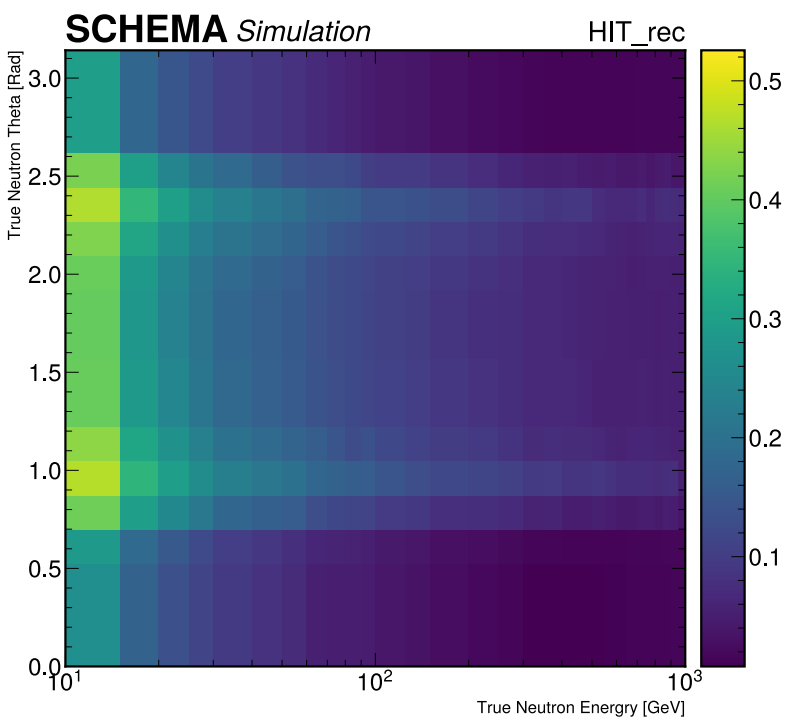


Calibration matrix totals

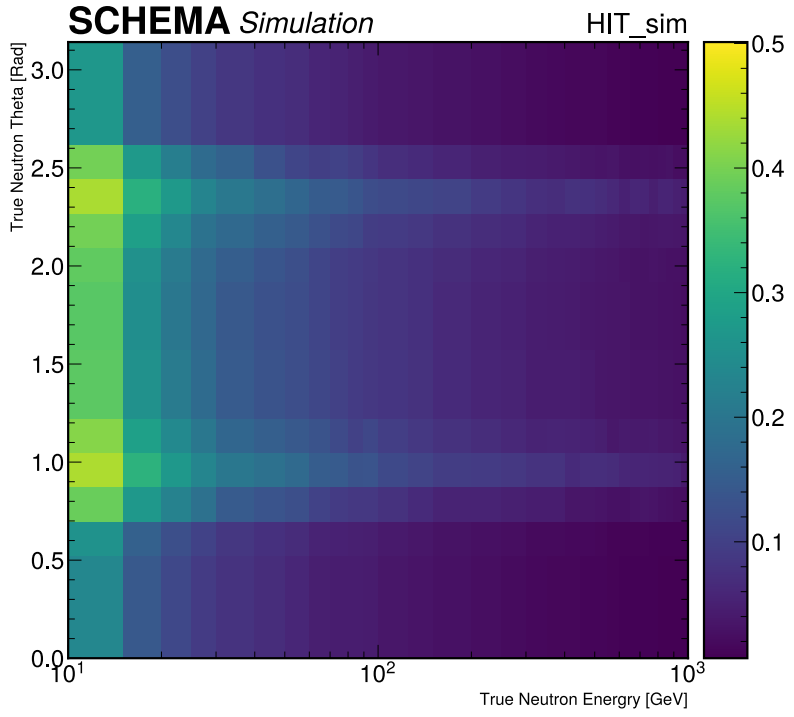
Anti-kT



Reco

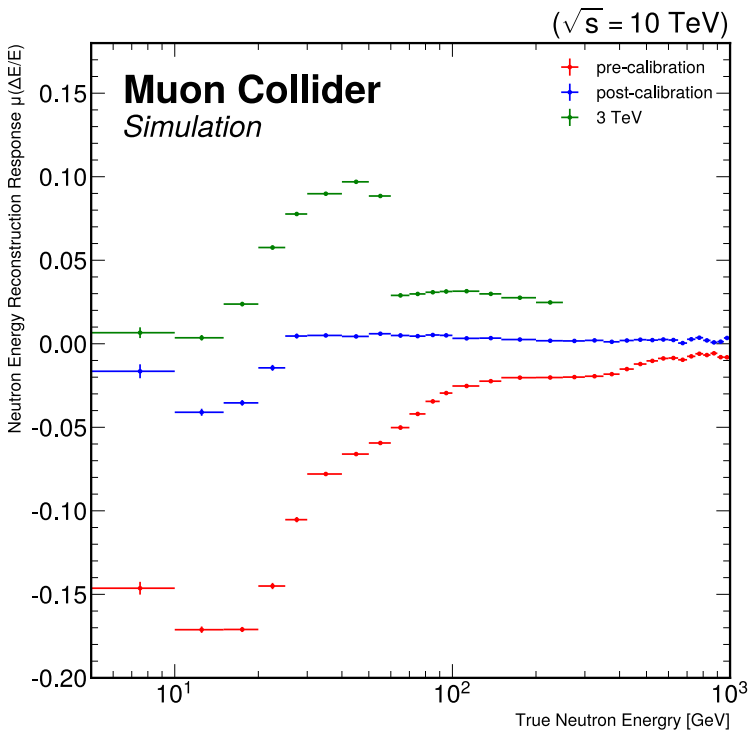


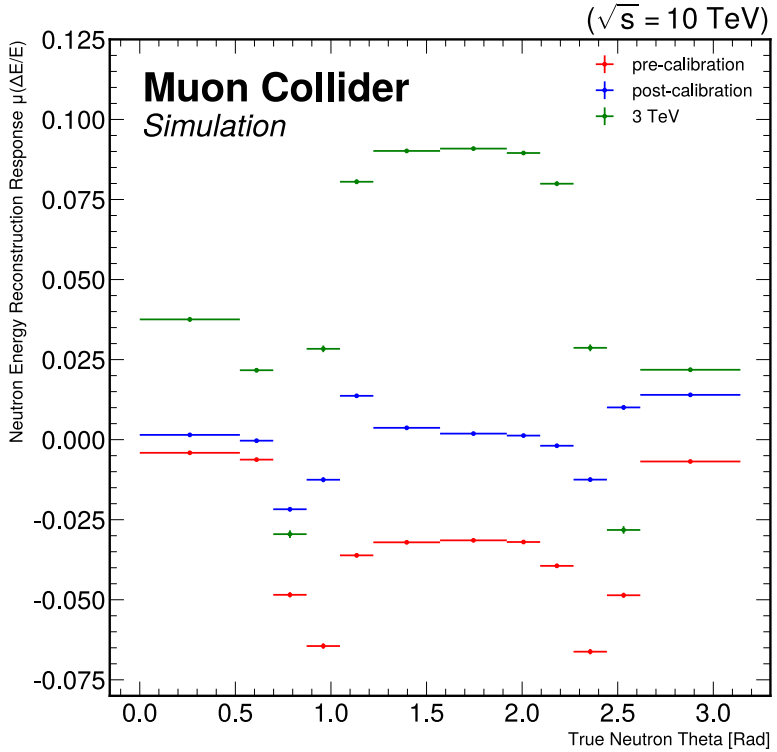
Sim



- After speaking with Fede, we decided to move forward with using the Anti-kT Jet calibration matrix since the jet resolution, response, and efficiencies are the quantities we are looking to optimize
  - Furthermore, the calibration matrix values generated by the jets are significantly lower than for the cell-level calibrations

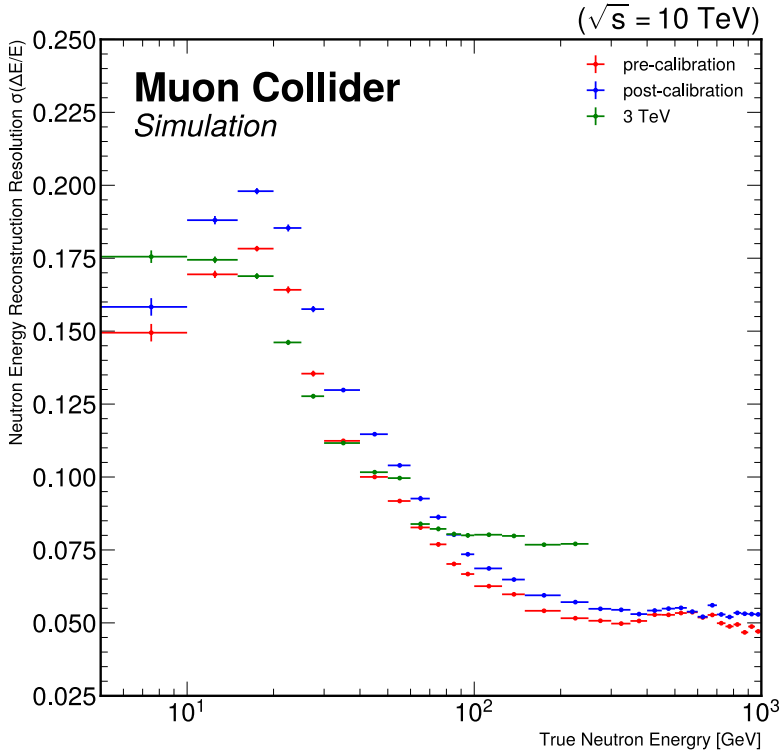
Applying the calibration matrix: Response

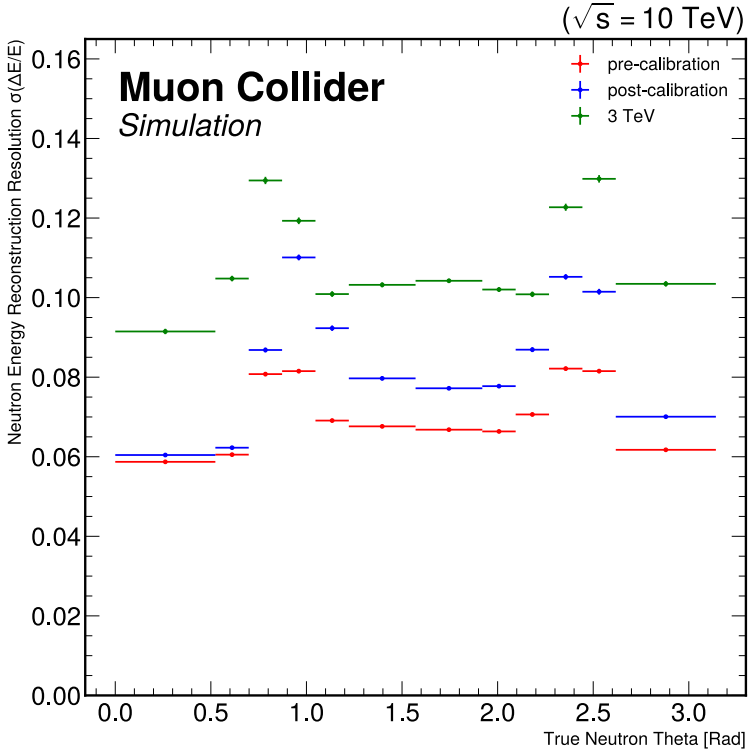




- Thankfully, the calibration has dramatically improved the response for jets however there are still some weird features
  - The transition region has the worst response
  - The shape of the 3 TeV v2 response curve is quite strange

Applying the calibration matrix: Resolution

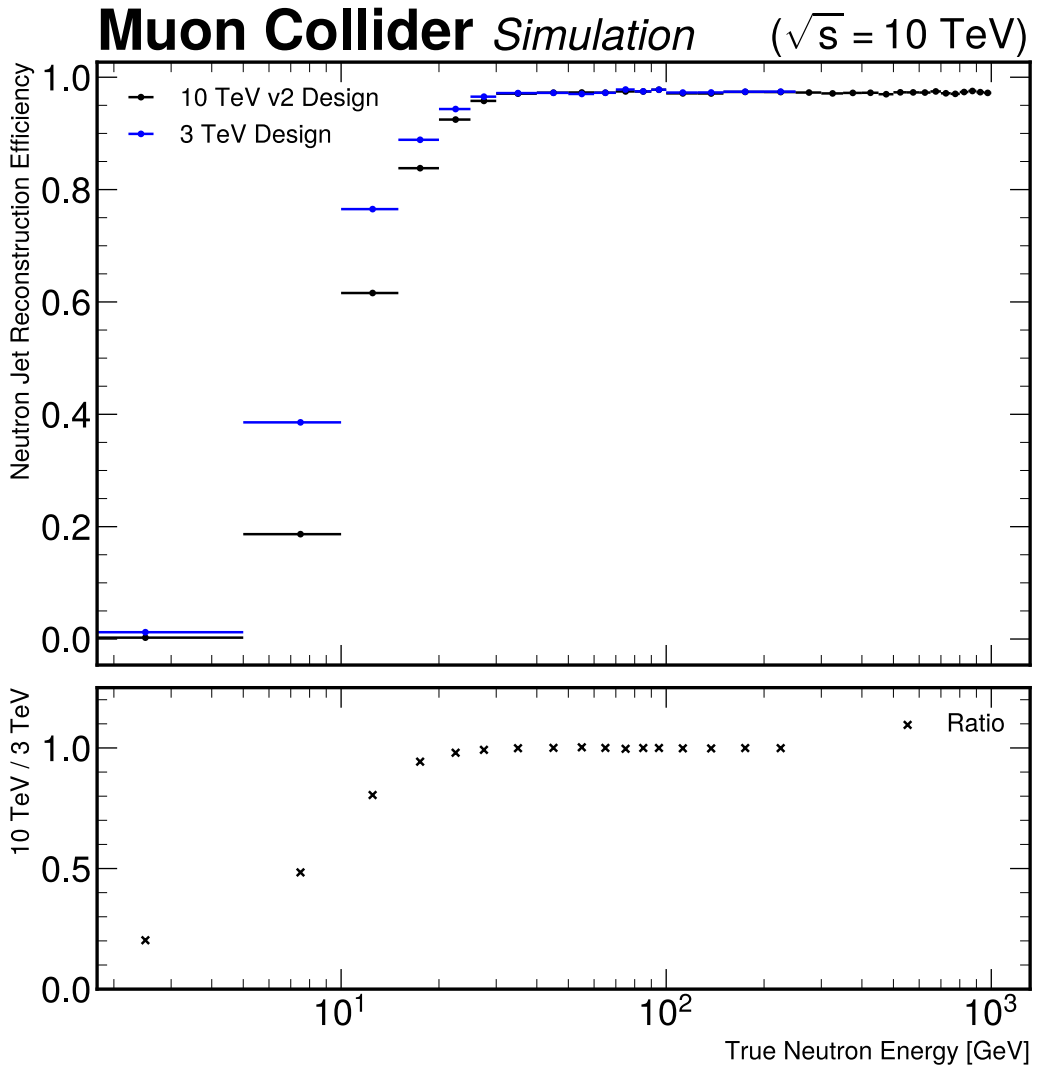




- The calibration has had a very minor negative effect of the resolution
  - Should we adjust the calibration since there is a negative impact of the resolution?
  - There is still an improvement at high E over the 3 TeV v2 design
  - Am I fitting the proper value for resolution and response? Some plots have $\sigma(\frac{\Delta E}{E_{true}^2})$ where I am fitting $\sigma(\frac{\Delta E}{E_{true}})$
    - This is important because I want to get my final fitting parameters in %Error/sqrt(E)

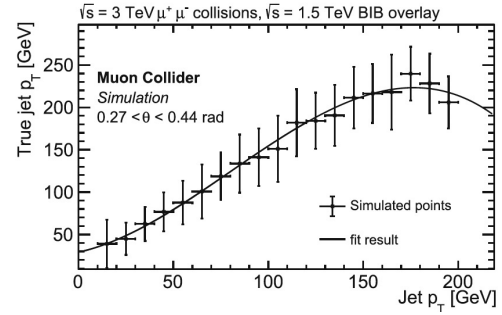
Applying the calibration matrix: Efficiency

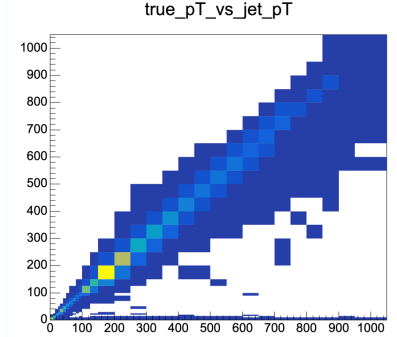
- The calibration does not impact the efficiency
  - These values look good both compared to the 3 TeV results and previous 1.5 TeV studies
    - The 3 TeV design is slightly better than the 10 TeV design up to around 30 GeV

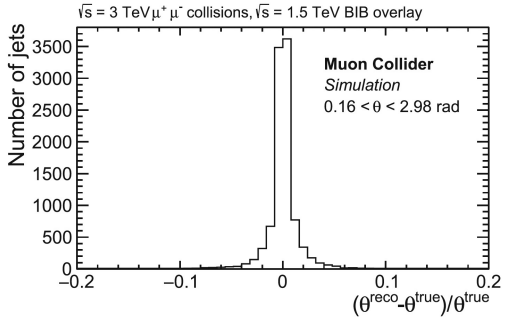


Next Steps

- **Next Goals**
  - Redo digi_const fitting and calibration matrix calculations with the new ideas from today's meeting
    - Re-apply the calibration matrix to the resolution, response, and efficiency plots
  - Time to add in BIB overlay?
  - Are there other important jet calibrations that should be completed for the paper?
    - The EPJC paper includes these plots that seem interesting
      - Using di-jet samples for jet calibration
        - Dijet invariant mass; b,c,light jet selection efficiency; calorimeter timing cutoff and selection; fake jet rate from BIB; transfer function vs E,theta; p_t resolution; jet-flavor ID; etc.







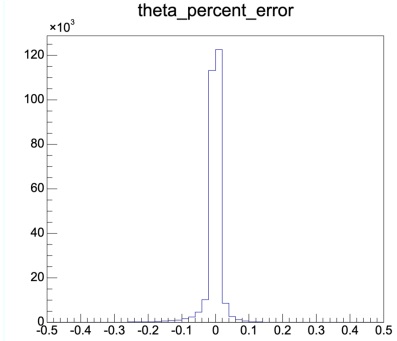


Fig. 57 Relative difference between reconstructed and true jet pseudo-rapidity