Local Software Compensation in the W-AHCAL

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Christian Winter

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Motivation

- Particle Shower consists of hadronic and e.m. component
- Different response to different component
- Apply weight to correct response

→ Software Compensation

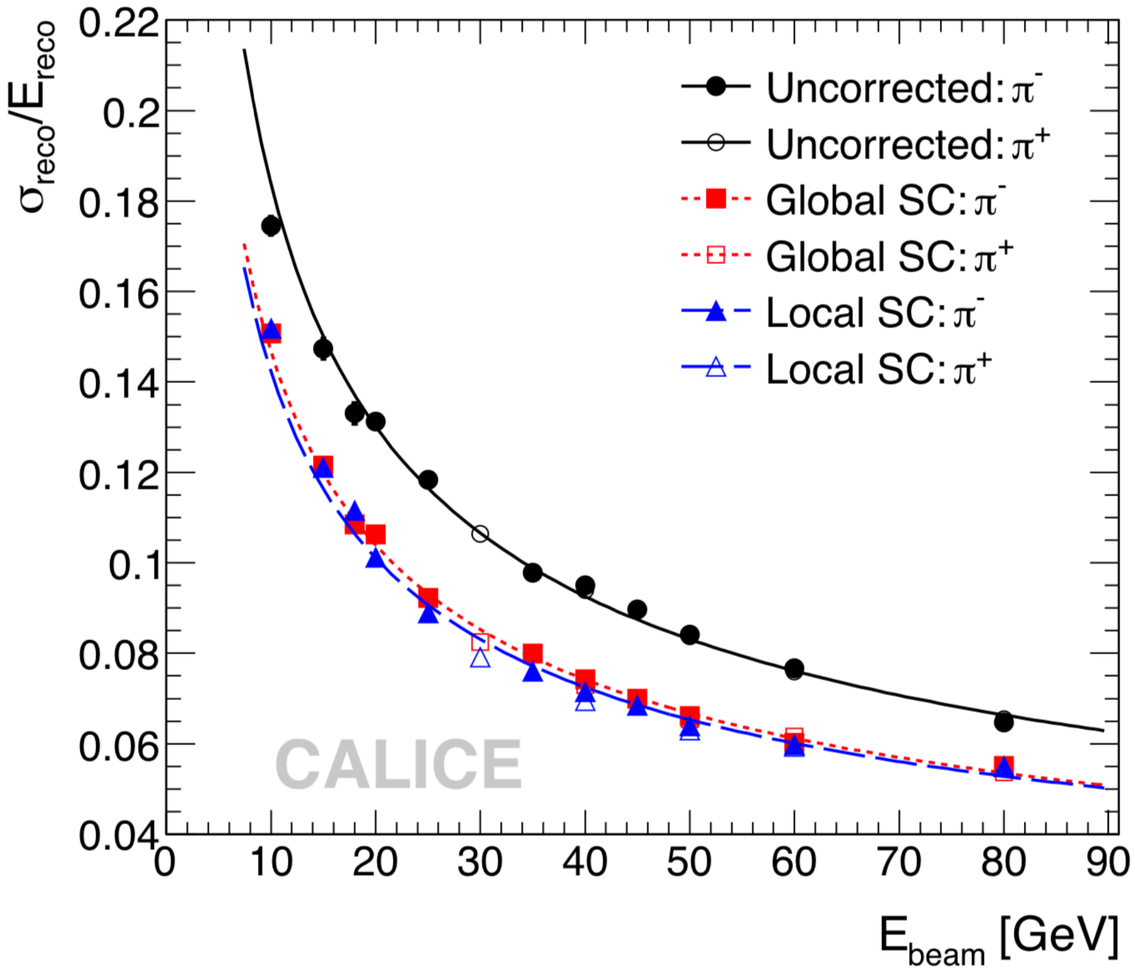
Global Software Compensation

- Weight whole event

Local Software Compensation

- Weight each hit based on the density of deposited energy

For steel absorber: Comparable results for global and local SC



Motivation

- W-AHCAL was considered for CLIC
  - Provide sufficient depth for high energy showers
  - Limit diameter of surrounding solenoid
- W-AHCAL prototype is compensating (e/h ≈ 1)
- How does global SC compare to local SC for W-AHCAL ?

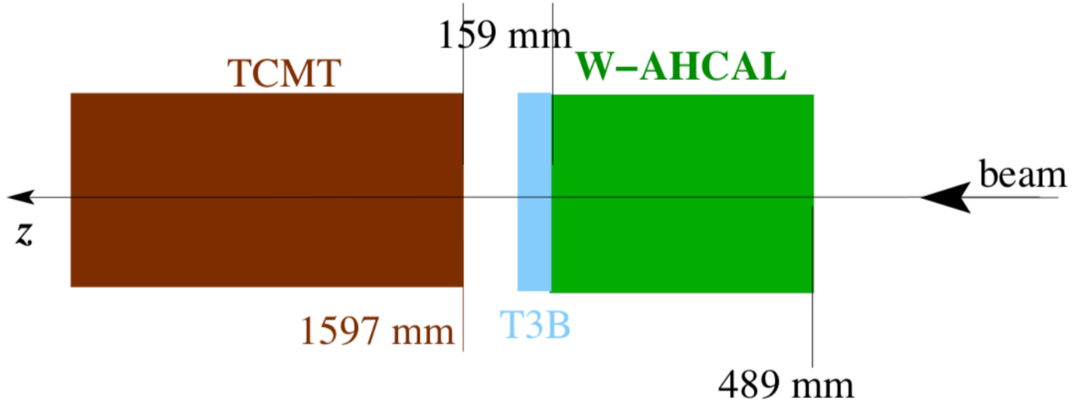
→ **Compare results to CAN 062**

Steel	**Tungsten**
$\lambda_I = 16.77\ cm$	$\lambda_I = 9.95\ cm$
$X_0 = 1.757\ cm$	$X_0 = 0.3504\ cm$

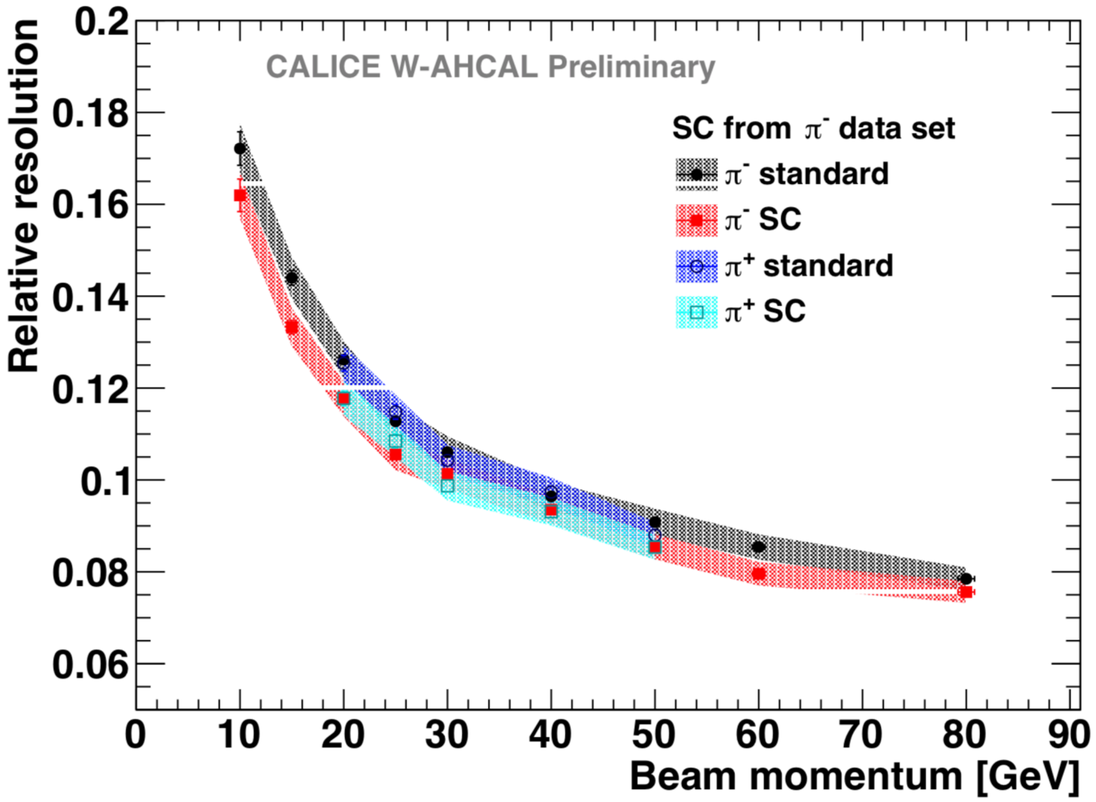
Data Sample

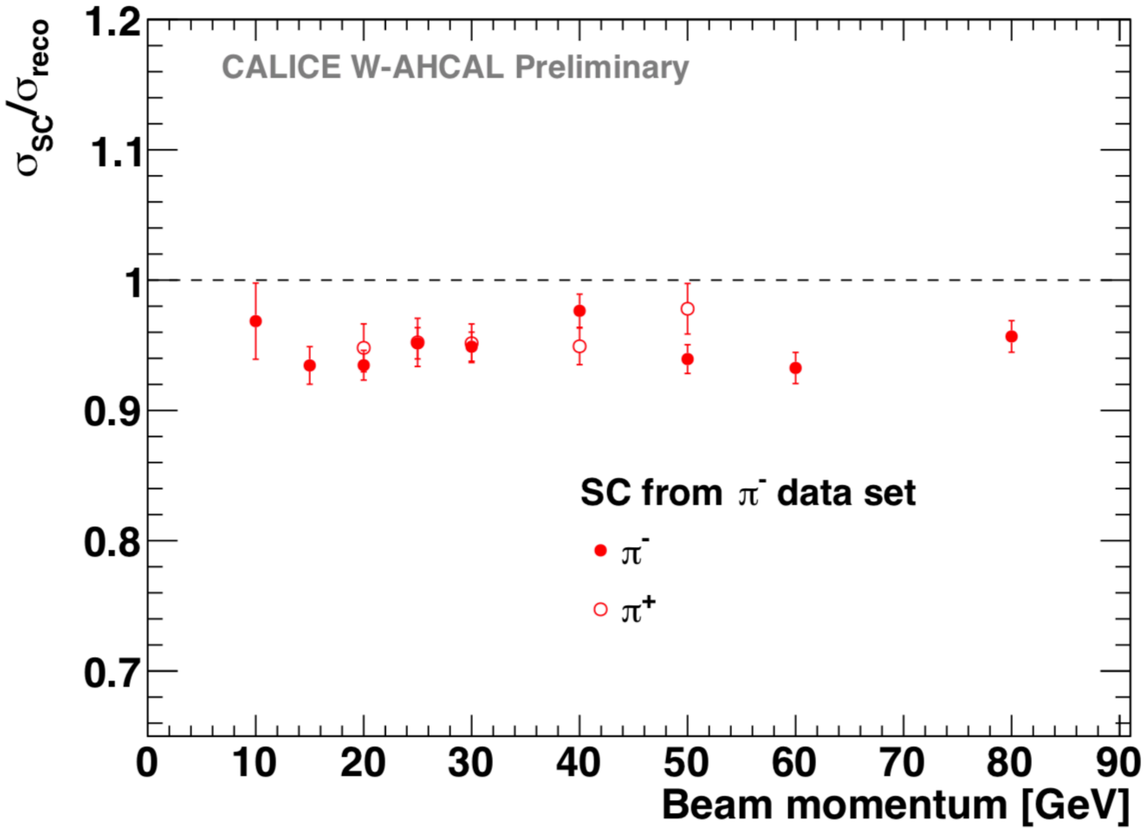
- Data recorded at CERN SPS in 2011
- 10 - 80 GeV π^- for analysis
- 20 - 80 GeV π^+ for crosscheck
- Two Cherenkov counters used to select pion sample
- Some runs without TCMT
- Only W-AHCAL considered
- Select events with shower start in the 2-4 layer

→ **Minimize leakage**



Global SC: Results





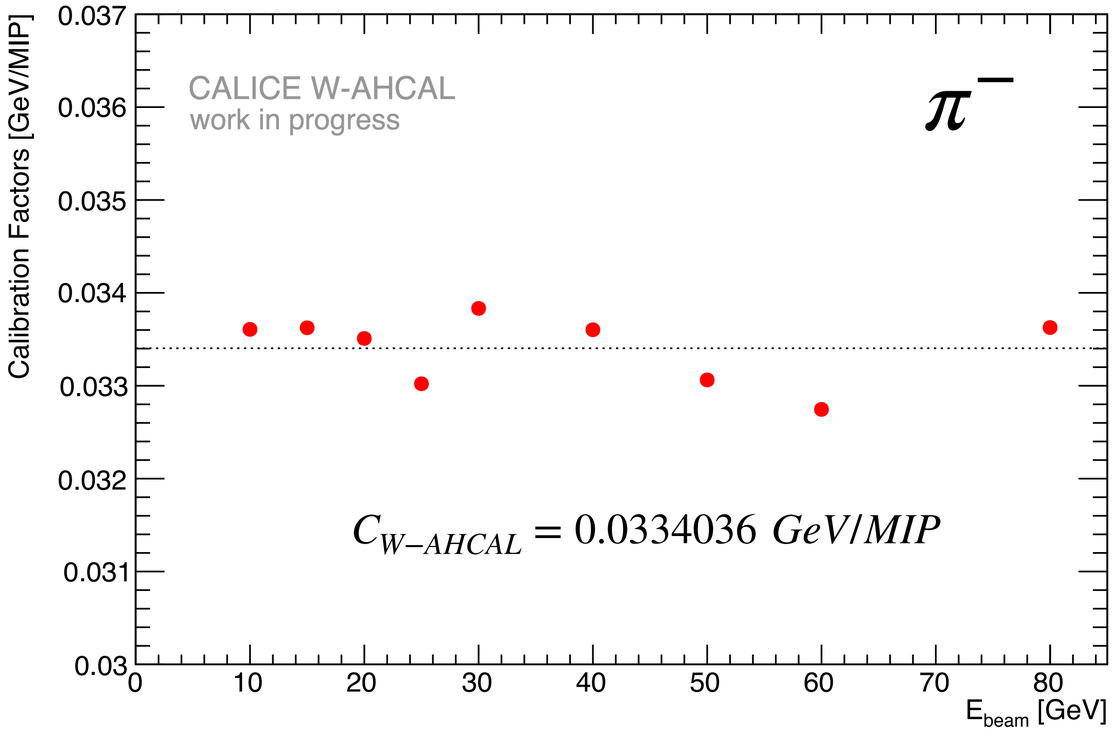
- Slight improvement of energy resolution
- Absolute resolution improved by 2-5%
- Expected for compensating calorimeter

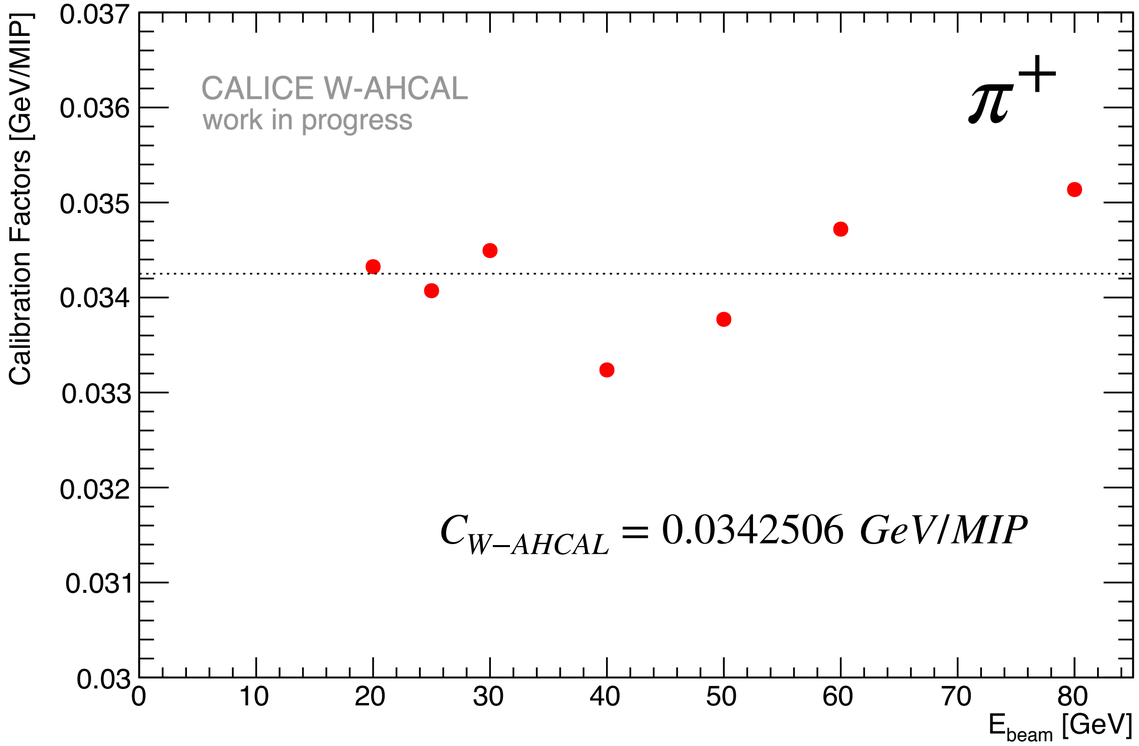
Results from CAN 062

Calibration

For each run:

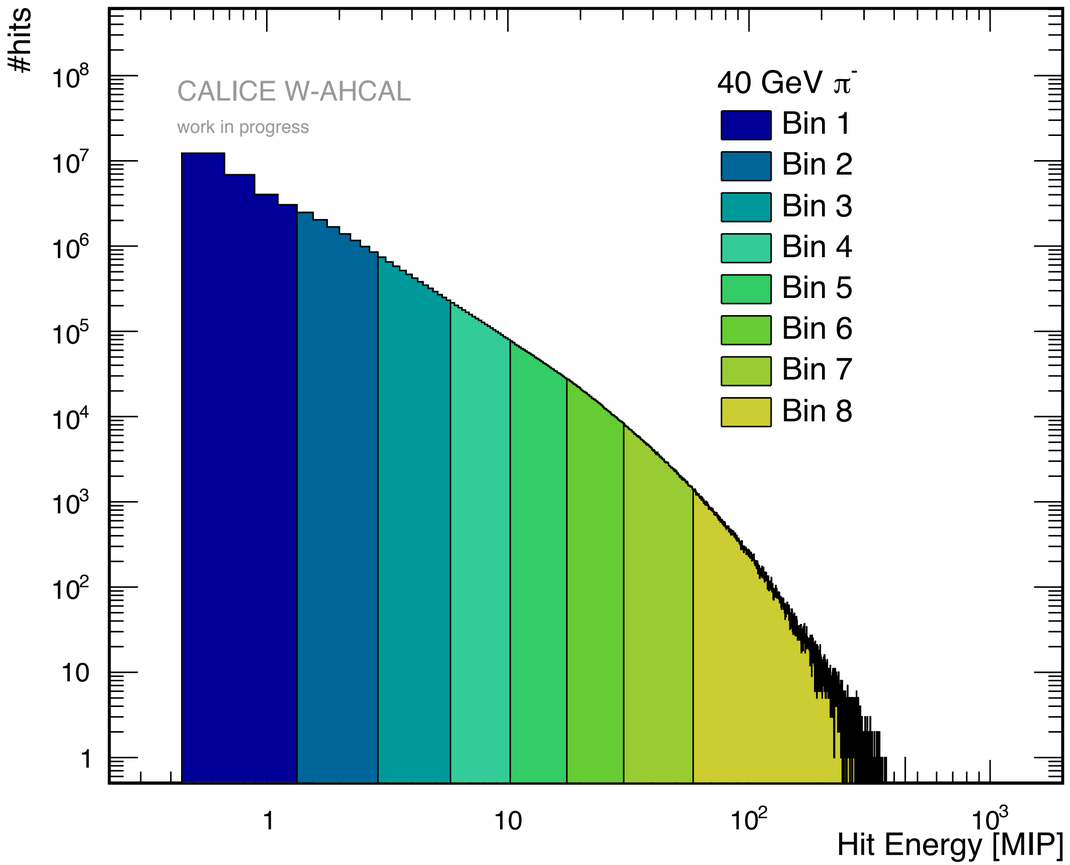
$$\chi^2 = \sum_{events} \frac{(E_{reco} - E_{beam})^2}{E_{beam} \cdot N_{events}} \longrightarrow E_{reco} = C_{W-AHCAL} \sum_{i}^{hit} E_i$$





Local Software Compensation

- Divide hit energy spectrum into bins with same amount of energy
- Applying weight for each bin for each event



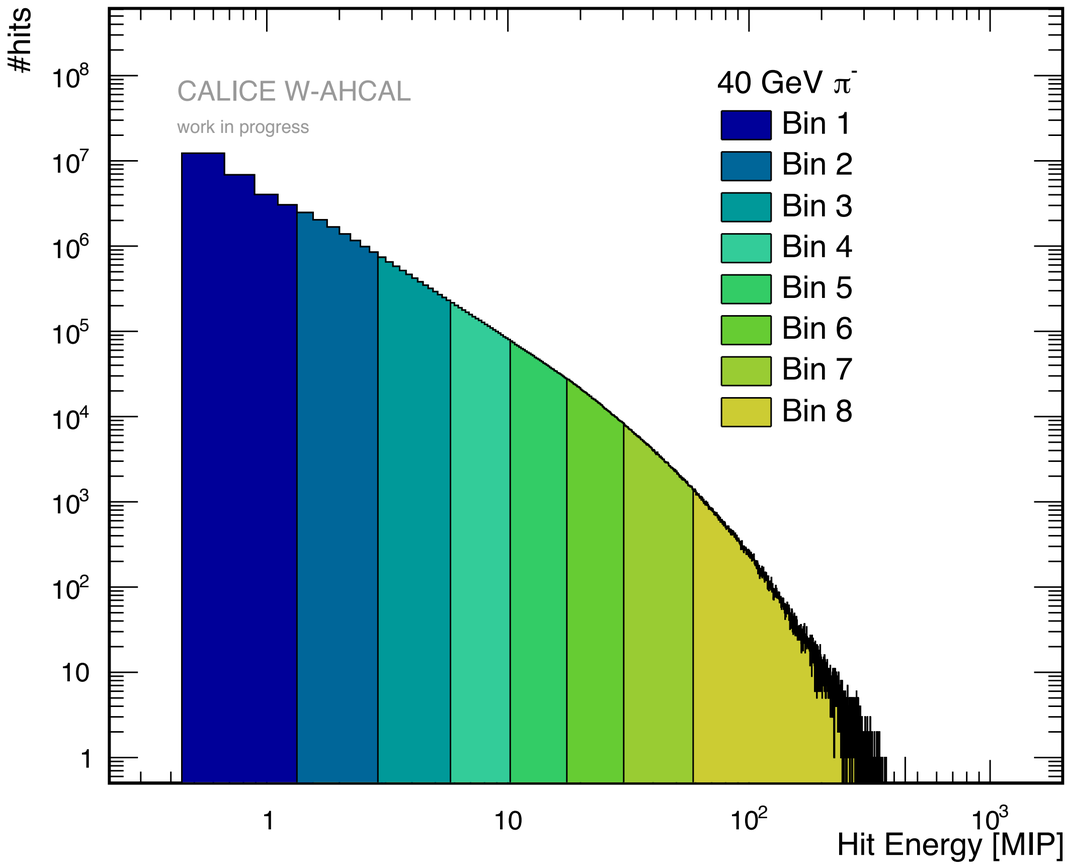
Local Software Compensation

- Divide hit energy spectrum into bins with same amount of energy
- Applying weight for each bin for each event

For each bin 3 parameters : a_i, b_i, c_i

For W-AHCAL in total 3 x 8 = 24 free parameter:

$$\omega_i(E) = a_i + b_i \cdot \frac{E}{S} + c_i \cdot \left(2 \cdot \left(\frac{E}{S}\right)^2 + 1\right)$$



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Optimal weights are found by minimizing the χ^2 function:

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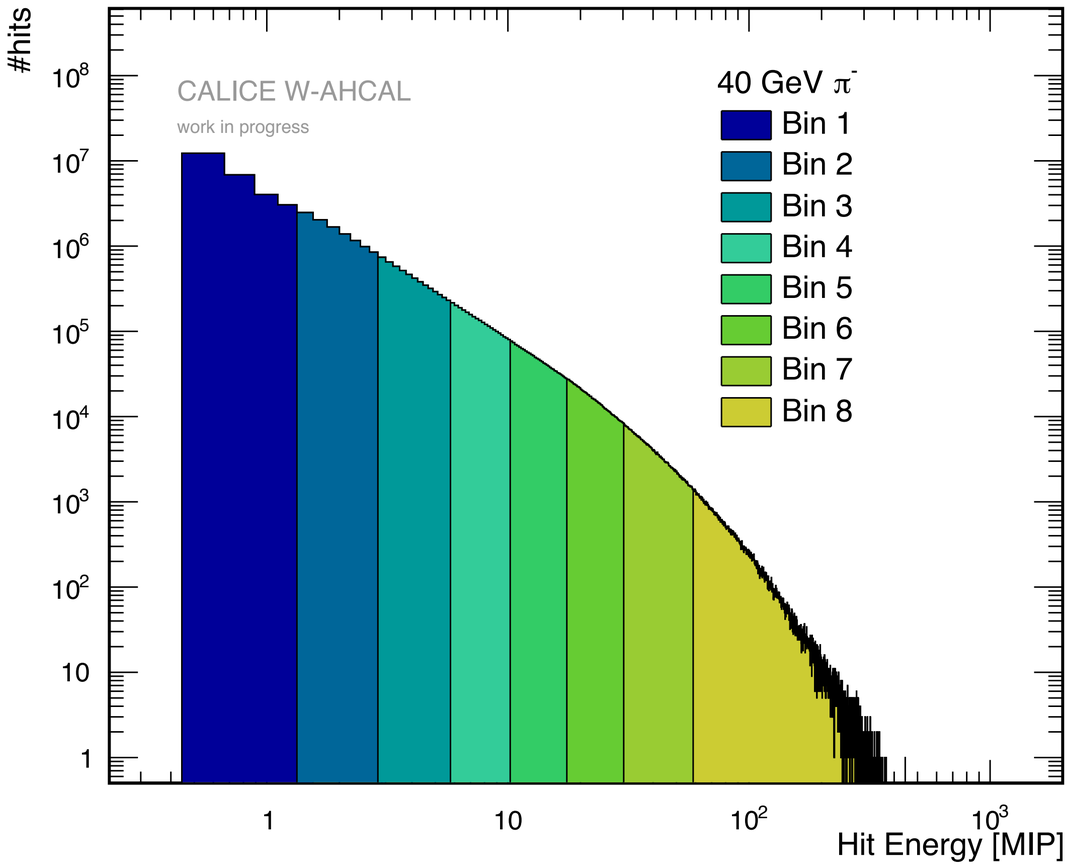

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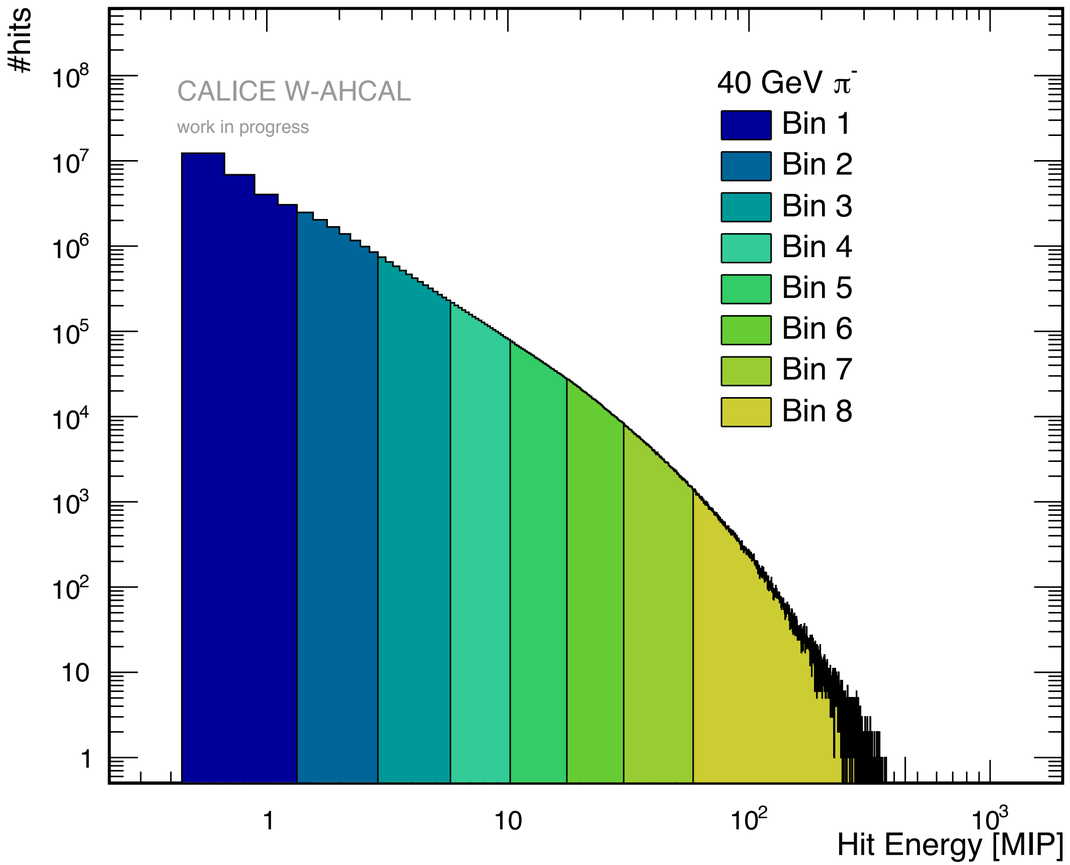
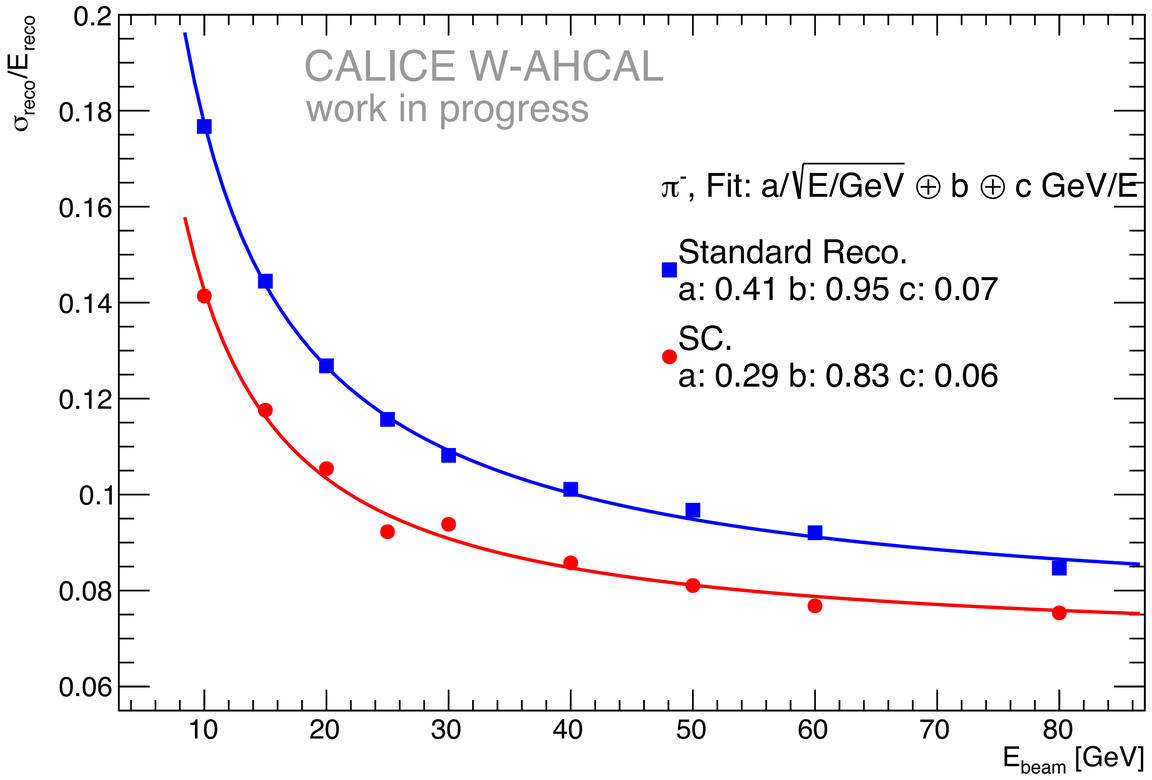
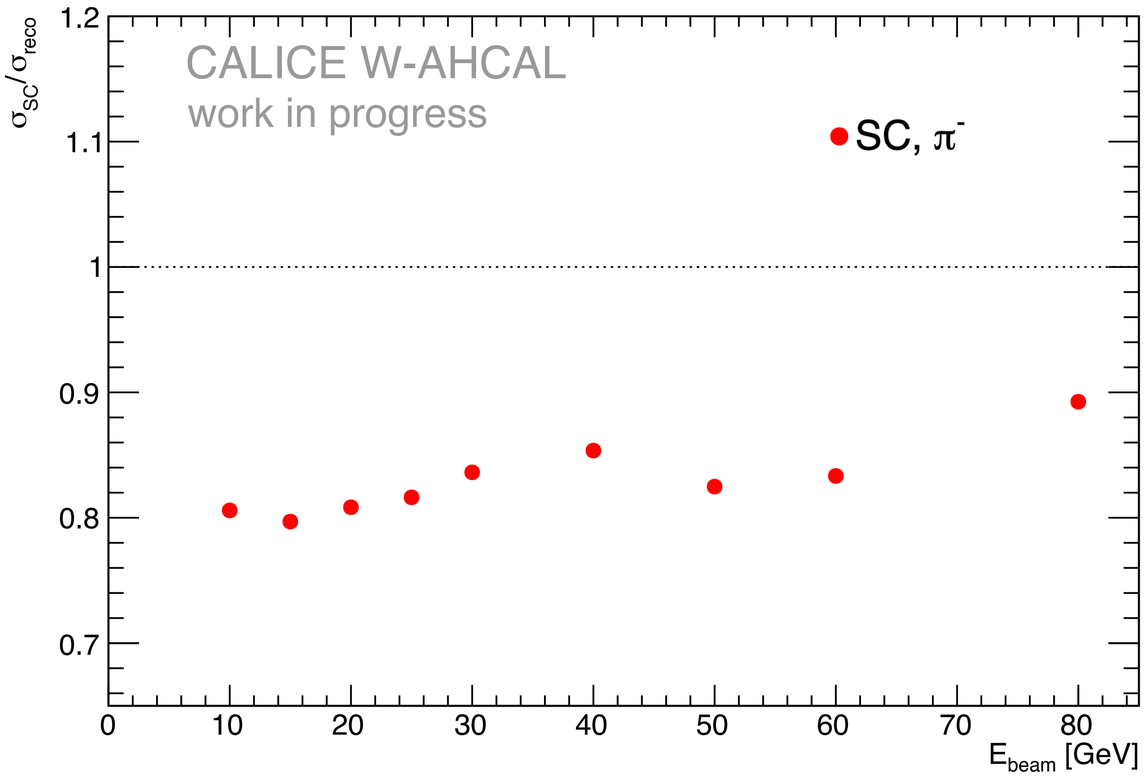


$$E_{SC} = C_{W-AHCAL} \sum_{i}^{bins} \omega_i \cdot E_i$$

Local SC: Results

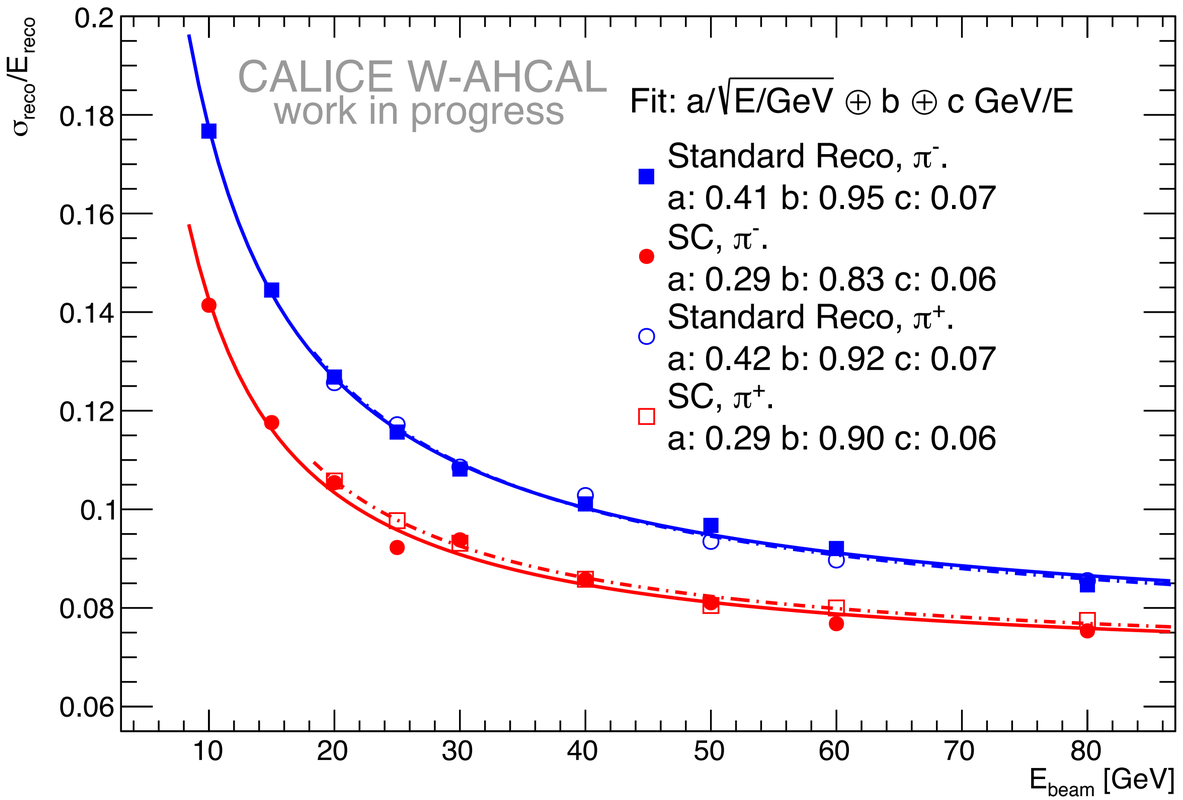


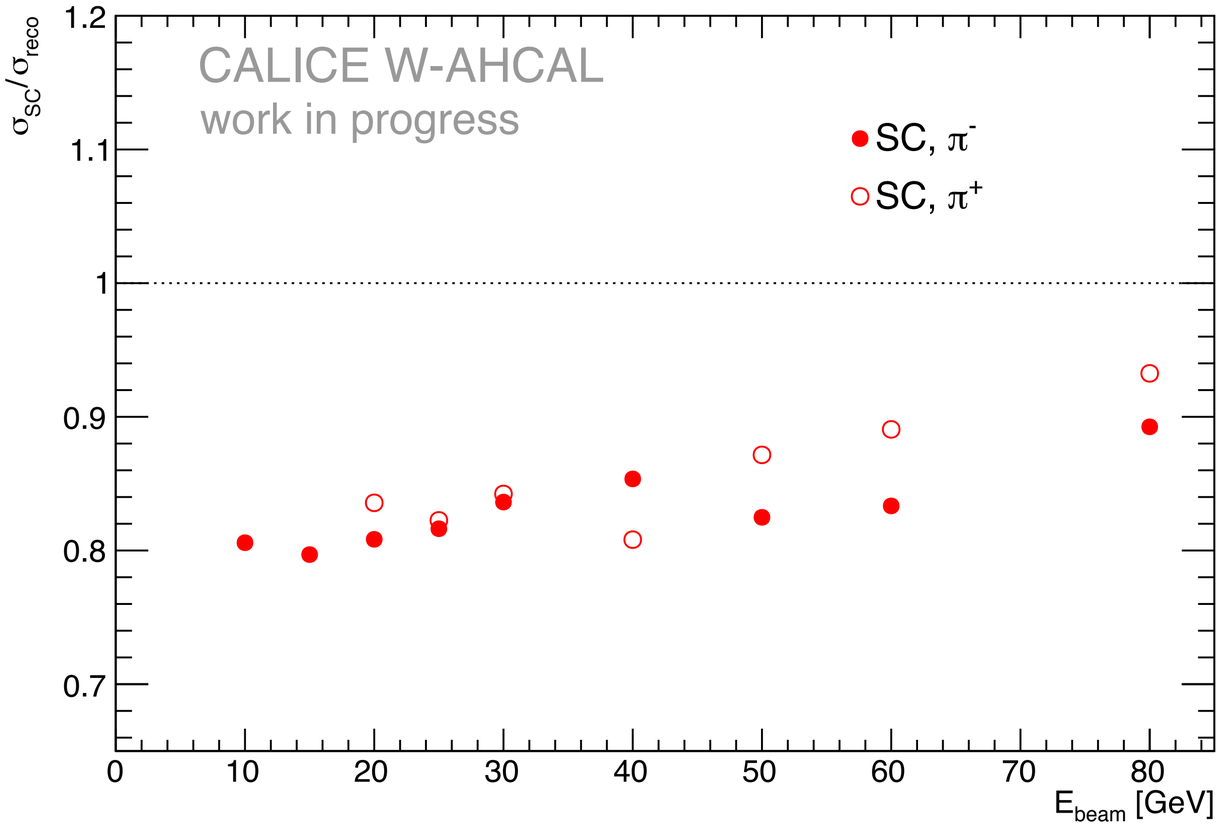


- Significant improvement of energy resolution compared to global SC
- Improvement between 10 - 20 %

→ **Results not expected**

Local SC: Crosscheck



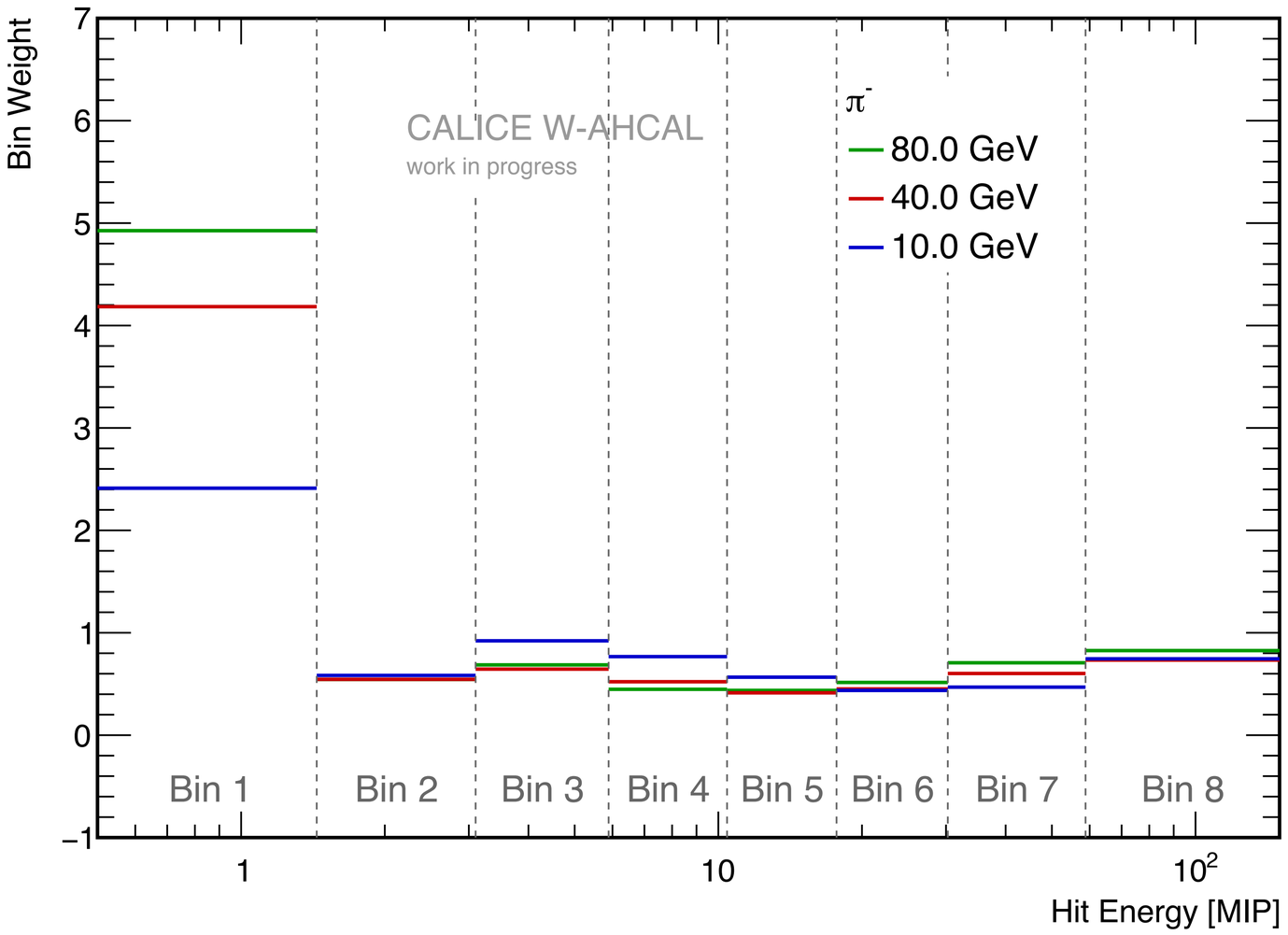


- π^+used for crosscheck
- In the range 20 - 80 GeV
- Similar improvement between 6 - 20 %

Local SC: Weights

- Hits in the first bin get weighted up
- Minor change in other bins
- Software compensation improvement mainly from low energetic hits
- Improvement possibly caused by larger number of neutrons released in tungsten

→ **Boost hadronic part**



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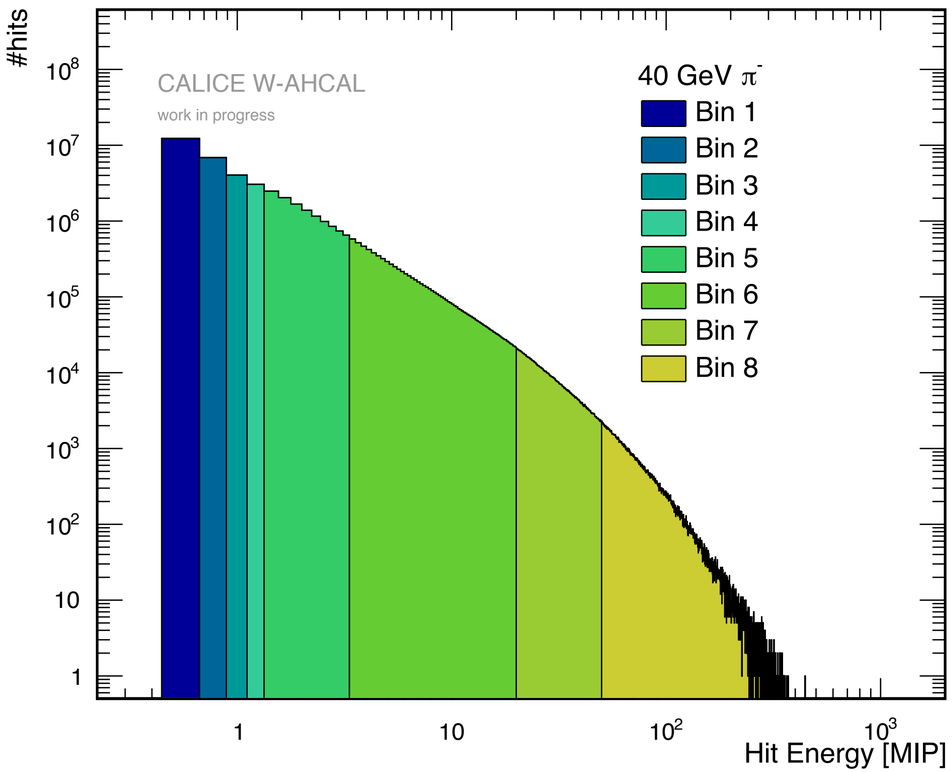

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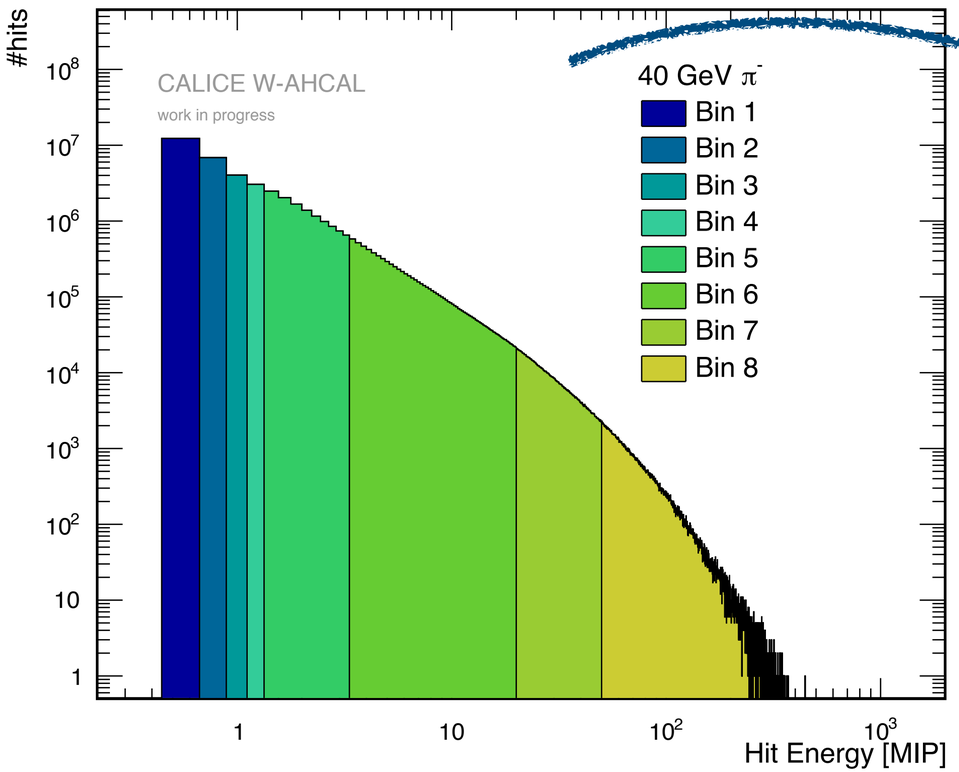

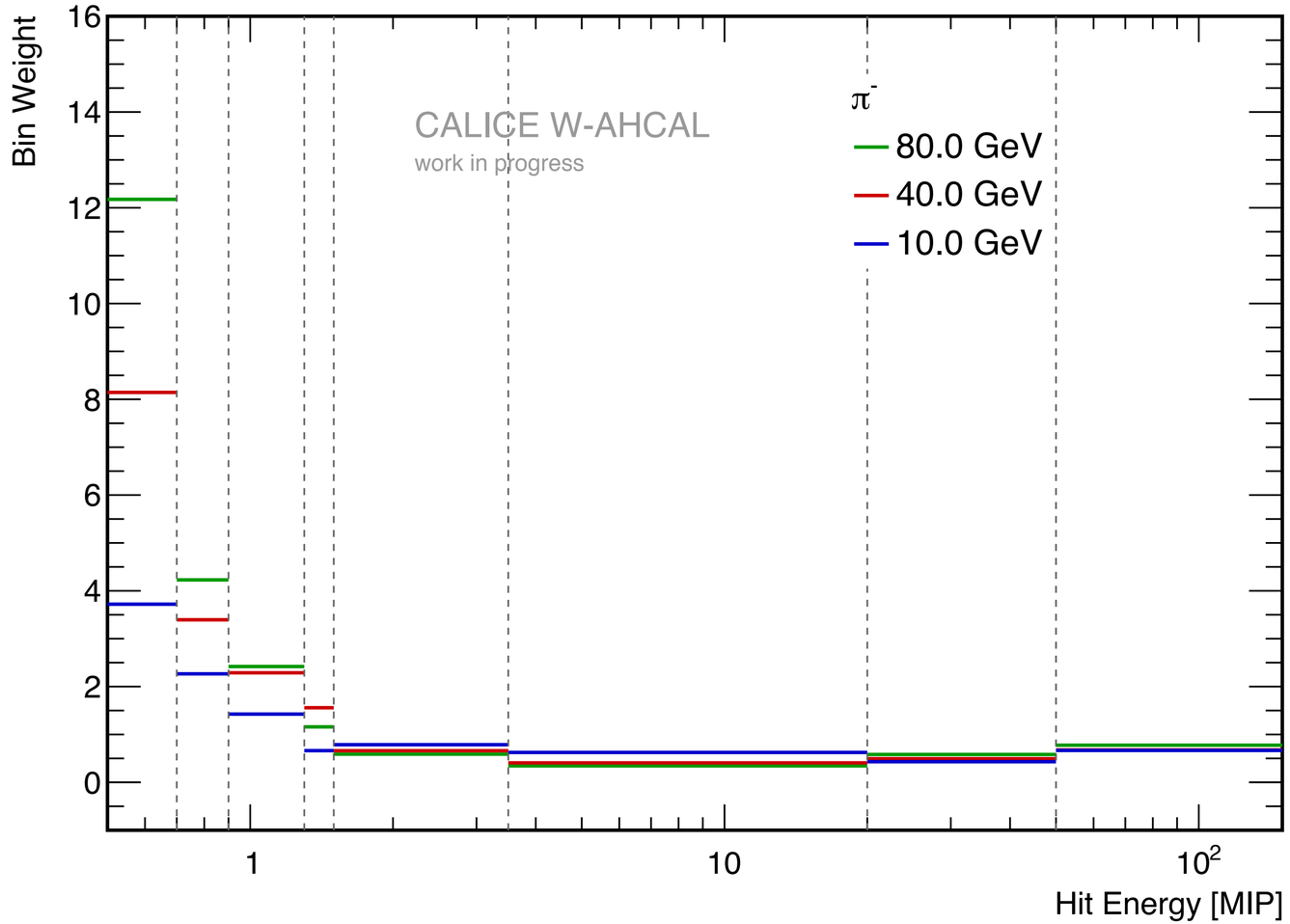

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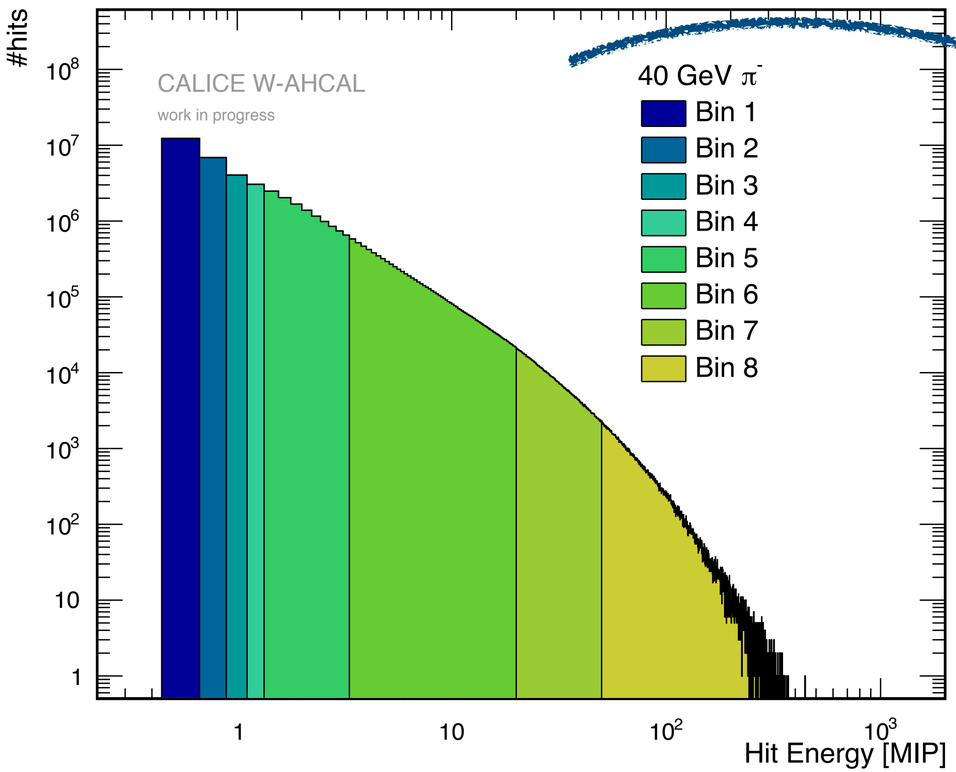
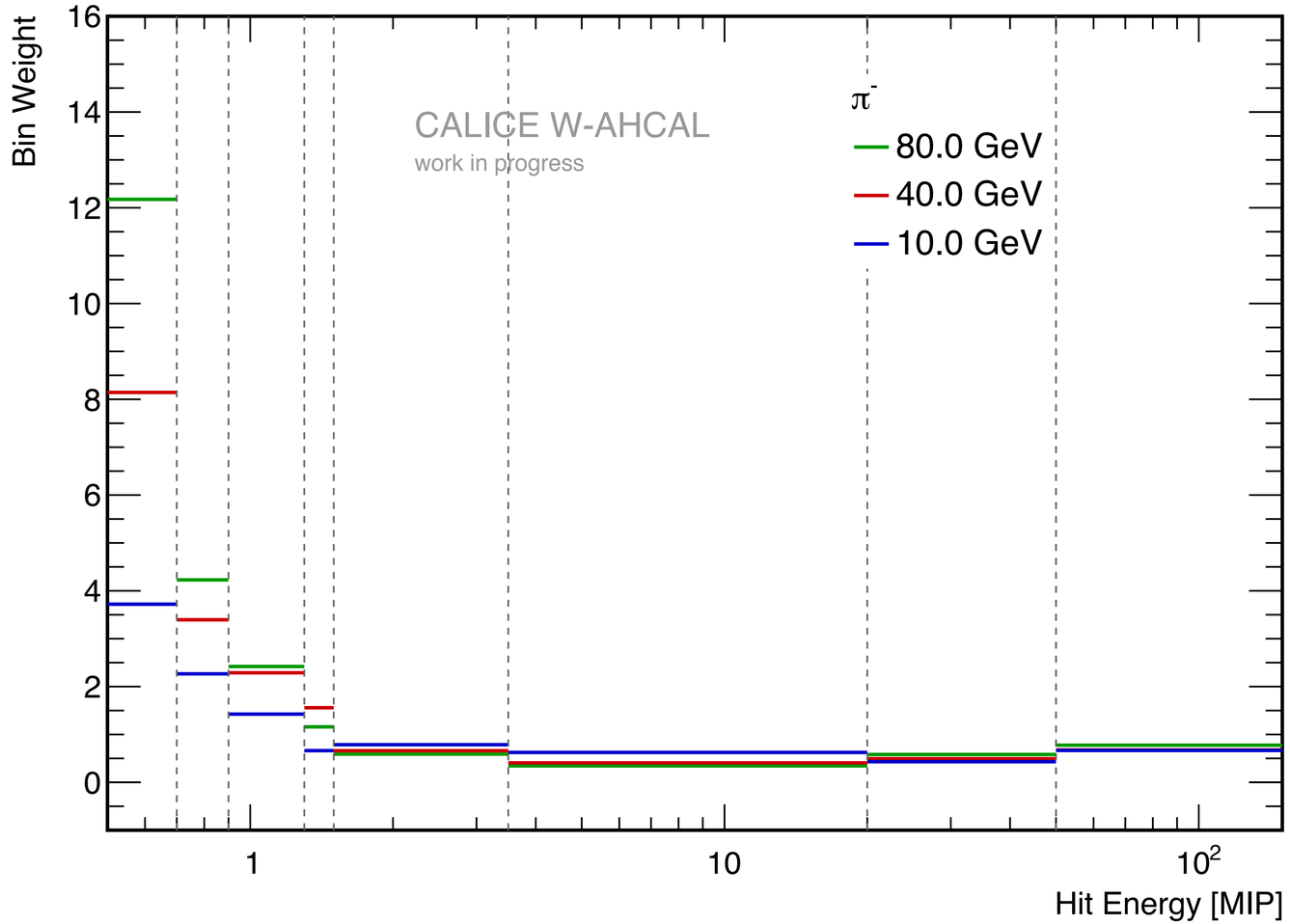




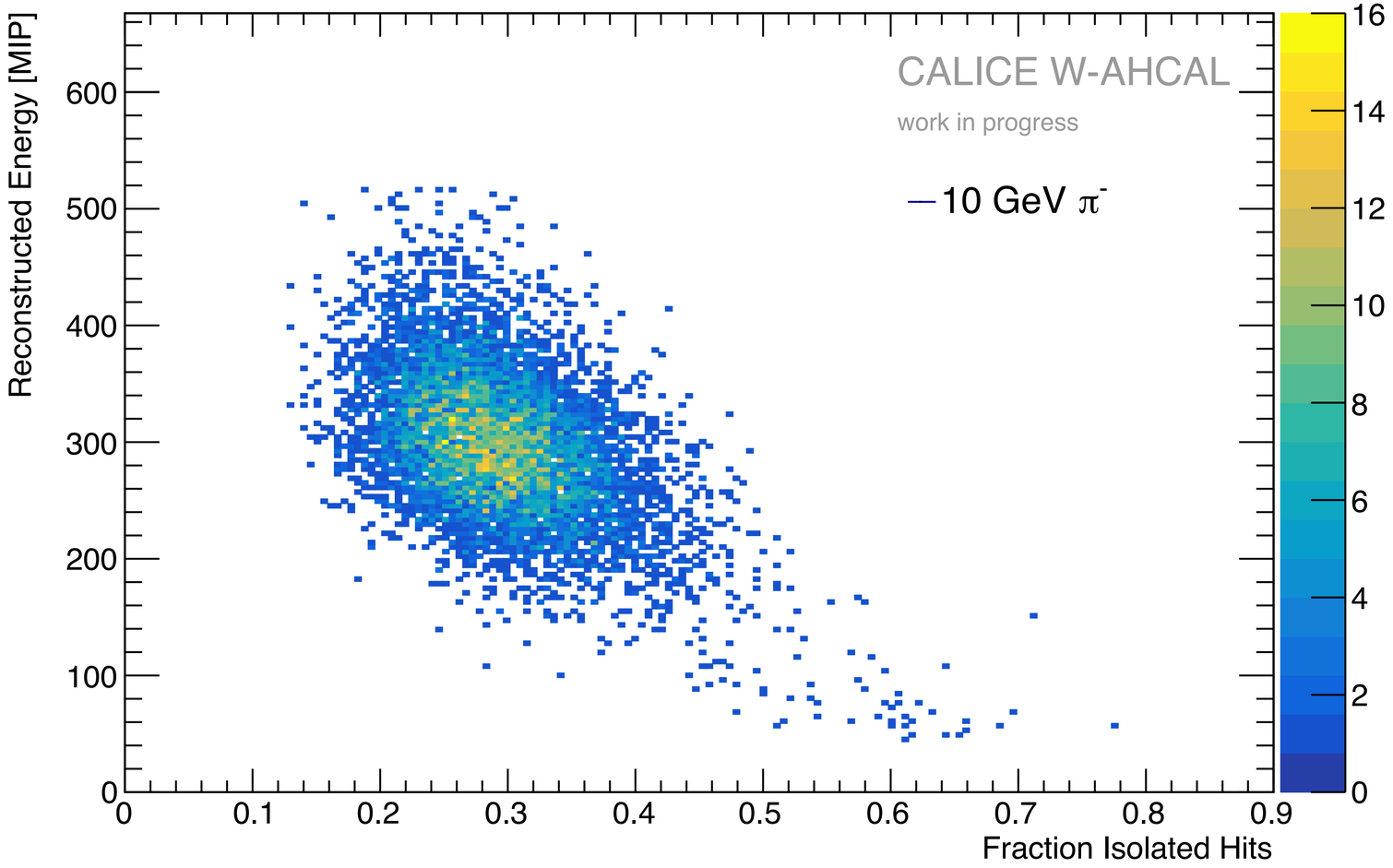
- Shift bin boarders to investigate first bin

→ **Lowest energies get boosted most**

Local SC: Correlation

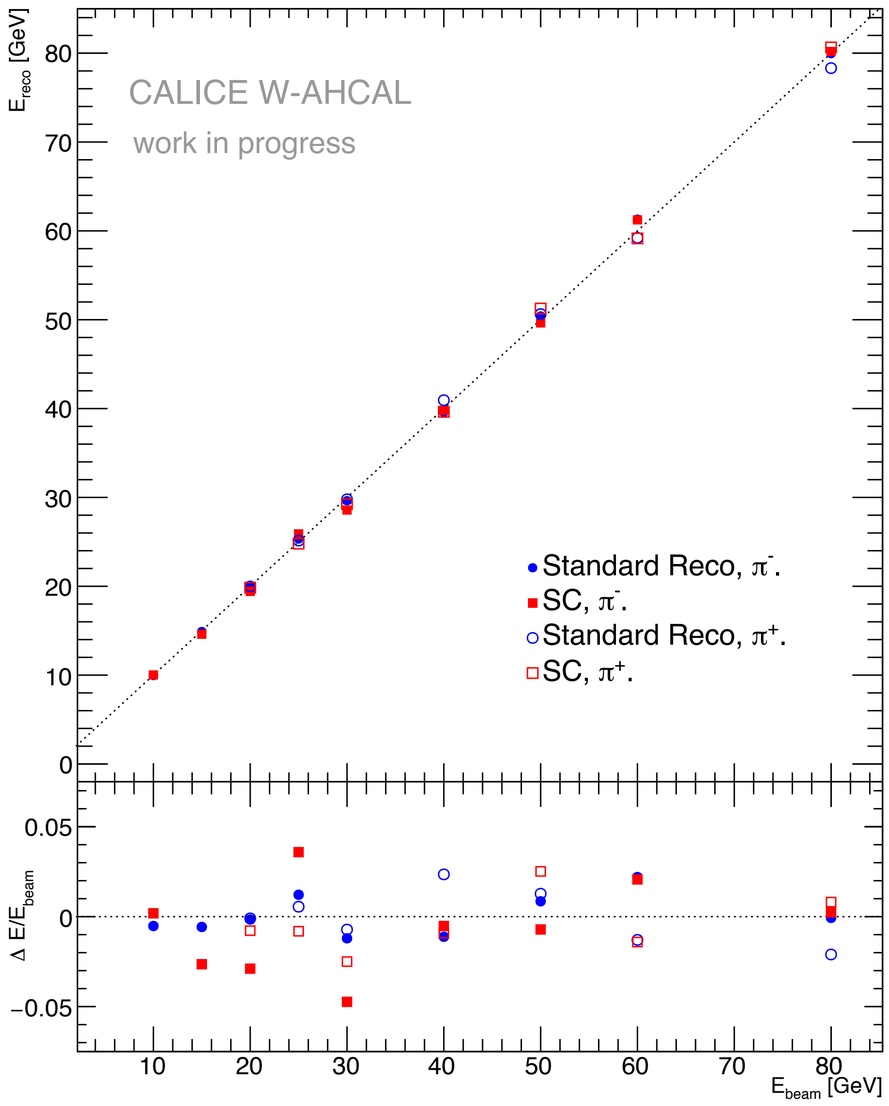
- Correlation for low energies
- Origin ?
  - Neutrons
  - Noise

→ **Has to be investigated further**



Local SC: Linearity

Promising results, but .....



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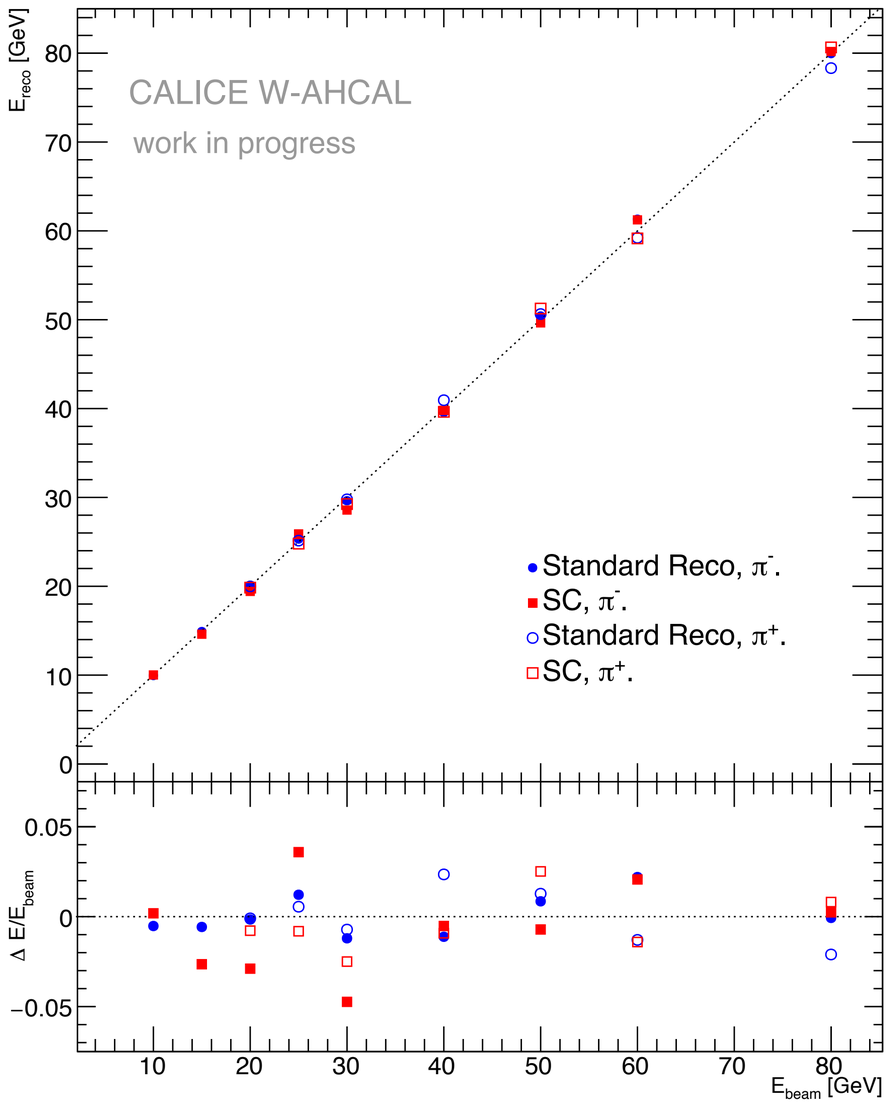
- Still work in progress
- Stability issues, non linearity is amplified for certain energies
- Maybe caused by data quality?



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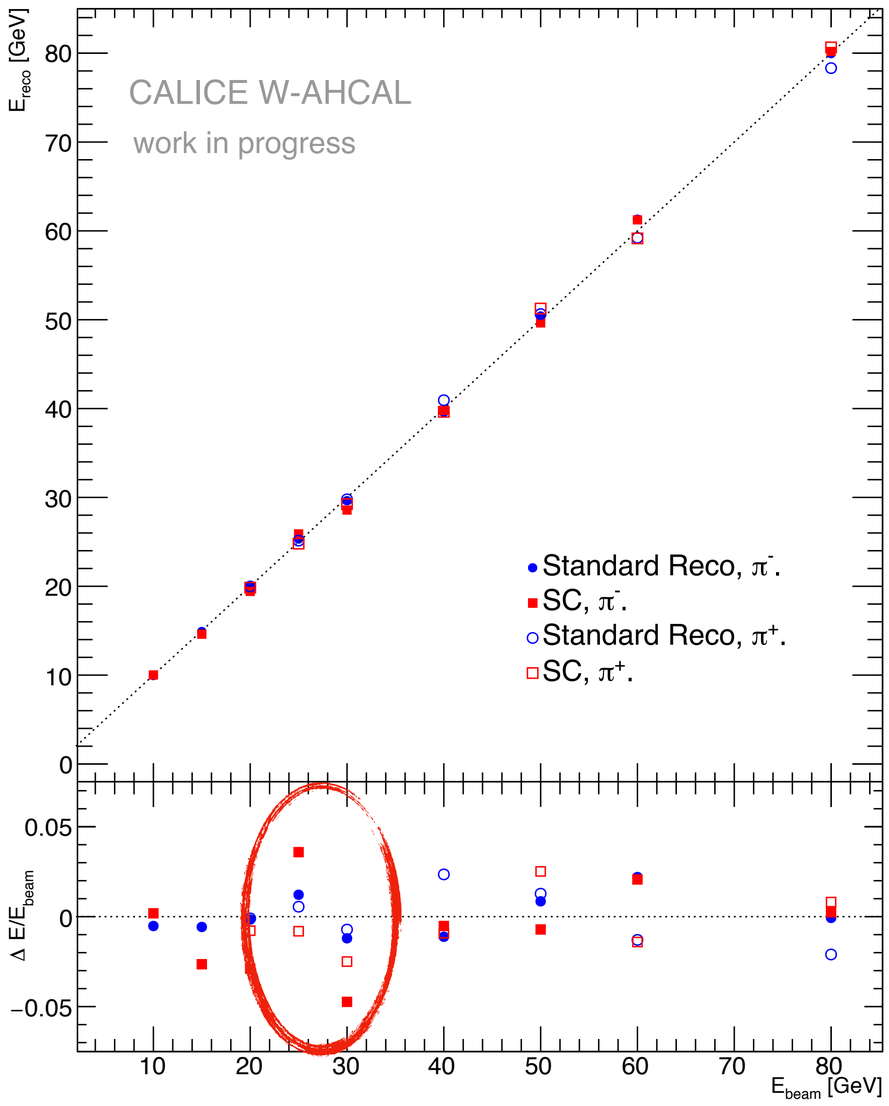

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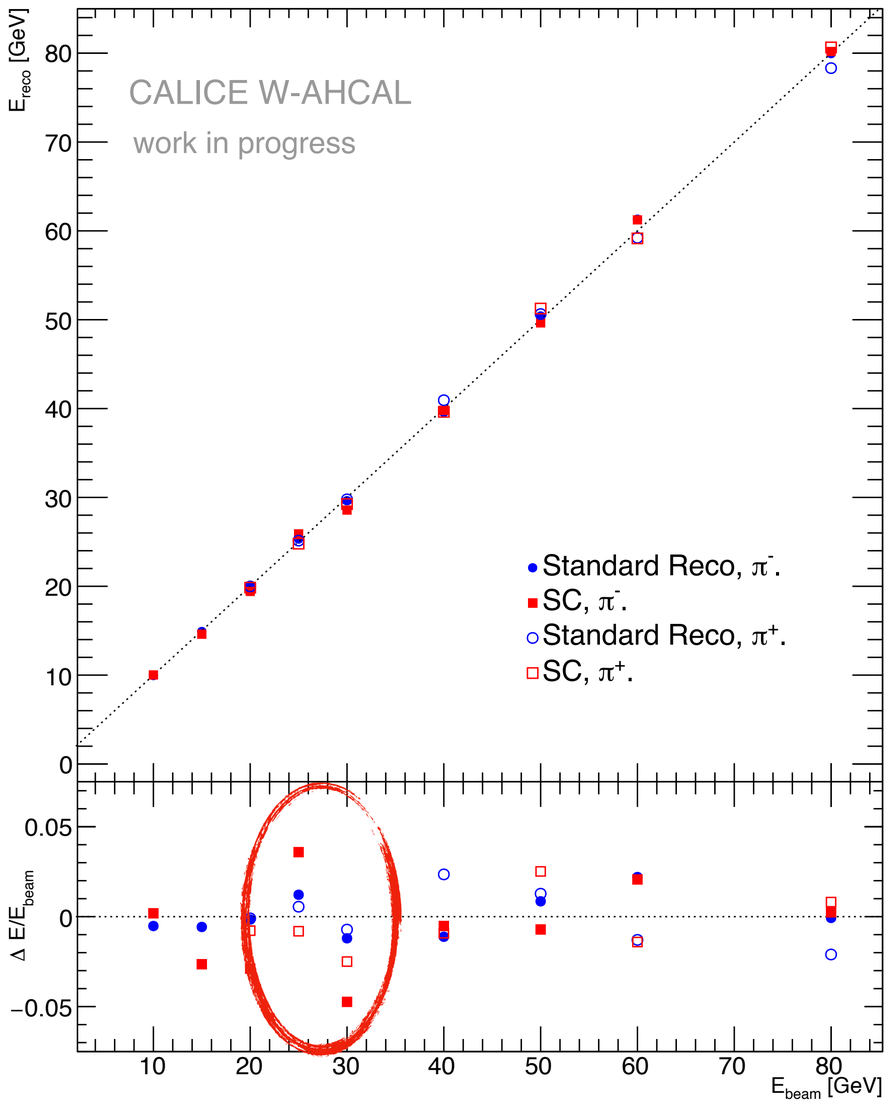
Next steps:

- Replace bad runs
- Noise measurement



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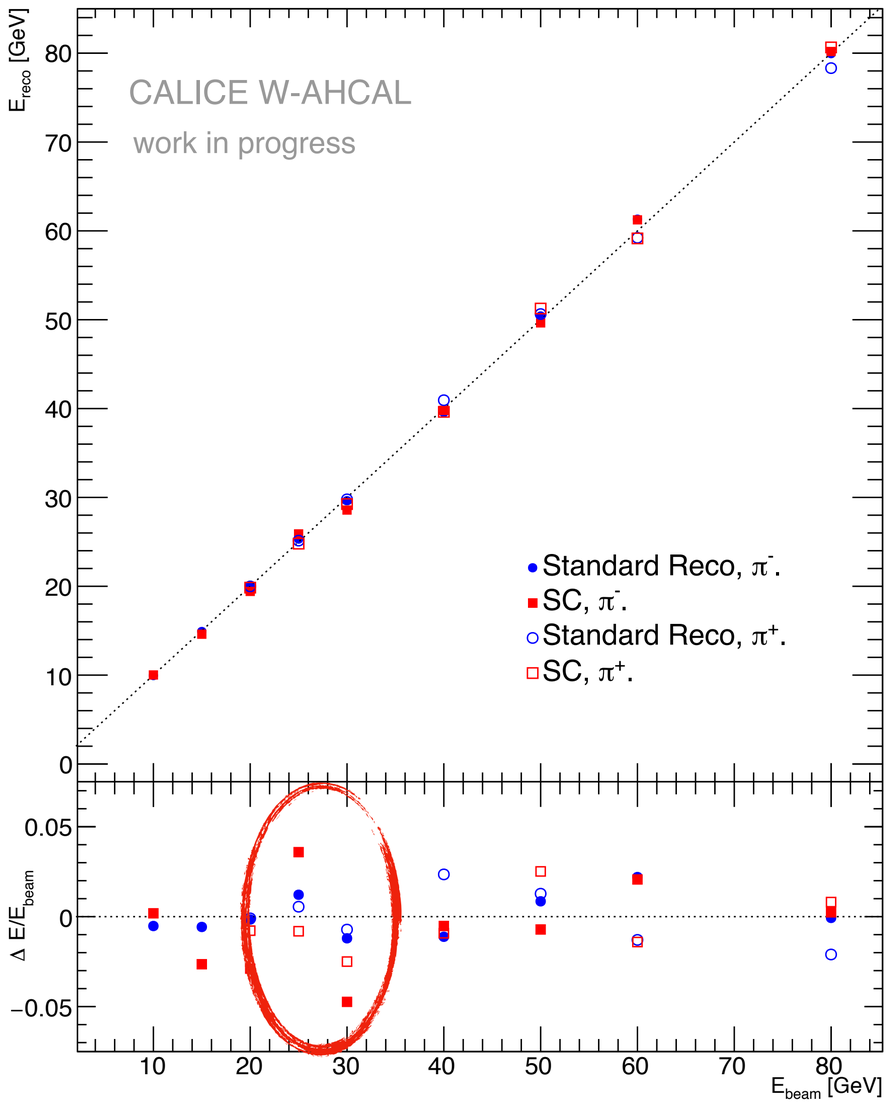
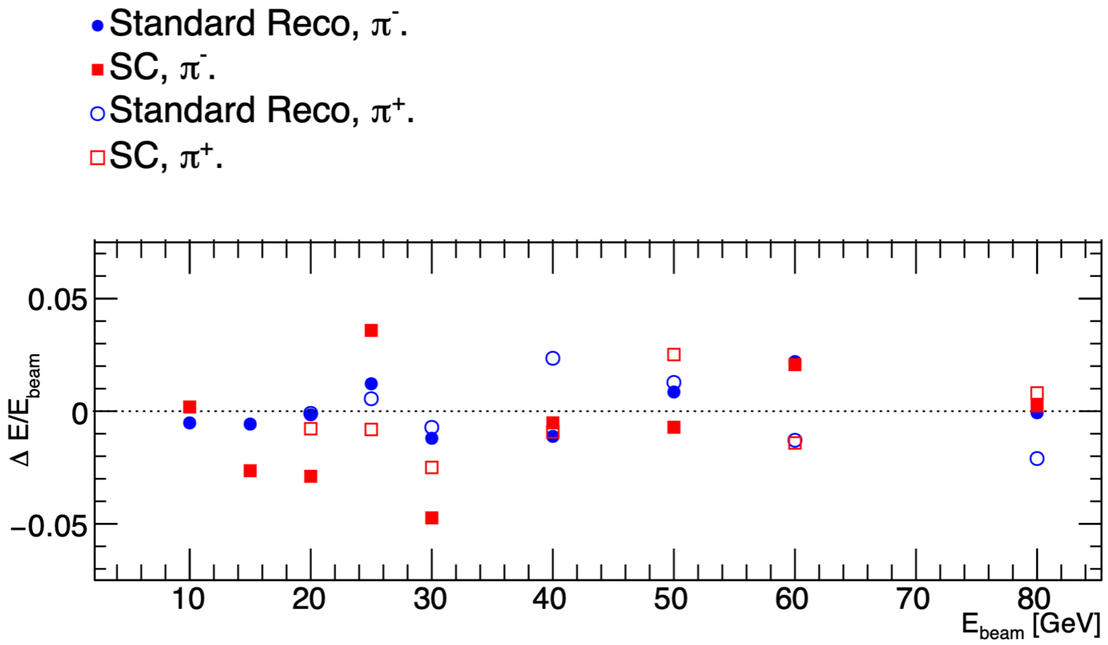


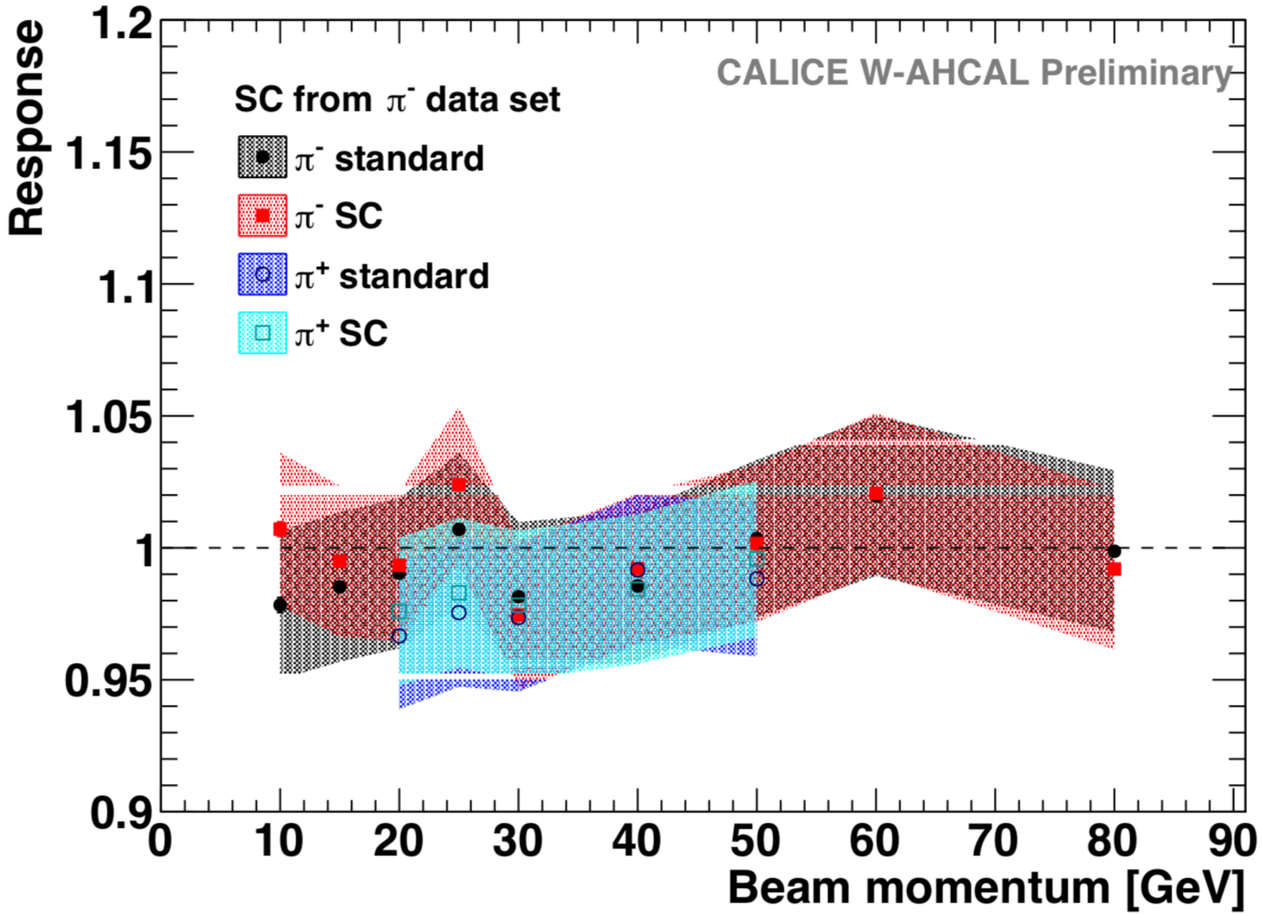
Comparison Response

Local



- Global and local SC follow similar pattern
- Amplification higher for local SC

Global



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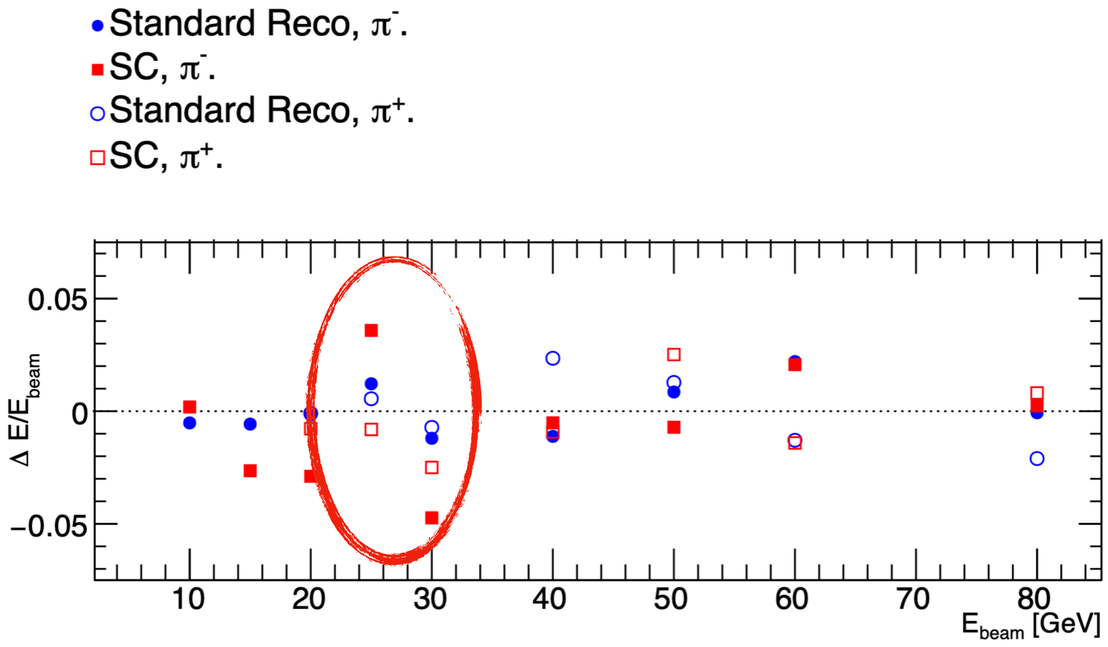

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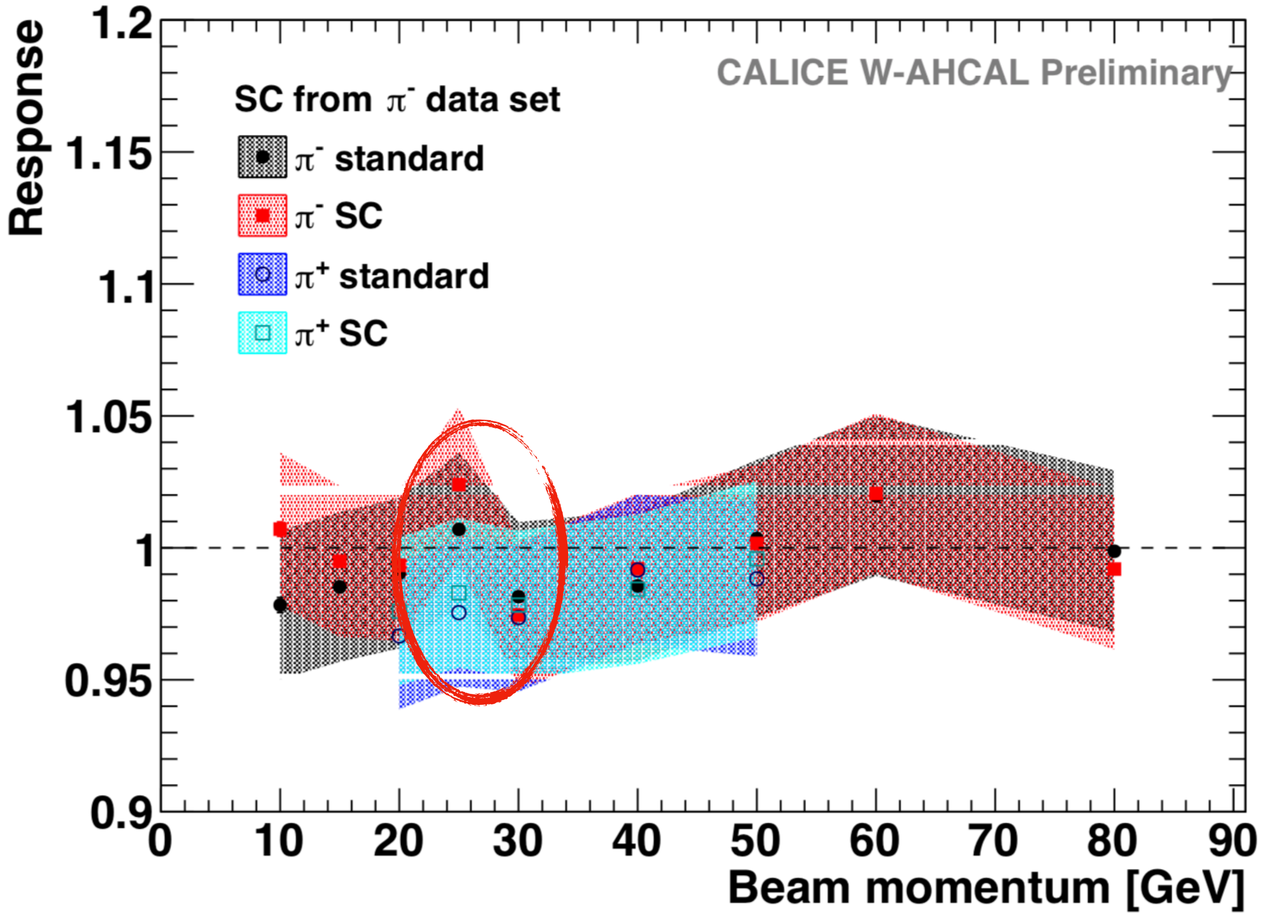


Summary & Outlook

- Similar improvement of energy resolution in AHCAL with steel absorber
- Small improvement with global SC in W-AHCAL (up to 5%)
- High gain in energy resolution with local SC (up to 20%)
- Stability issues for certain energies
- Amplification by SC

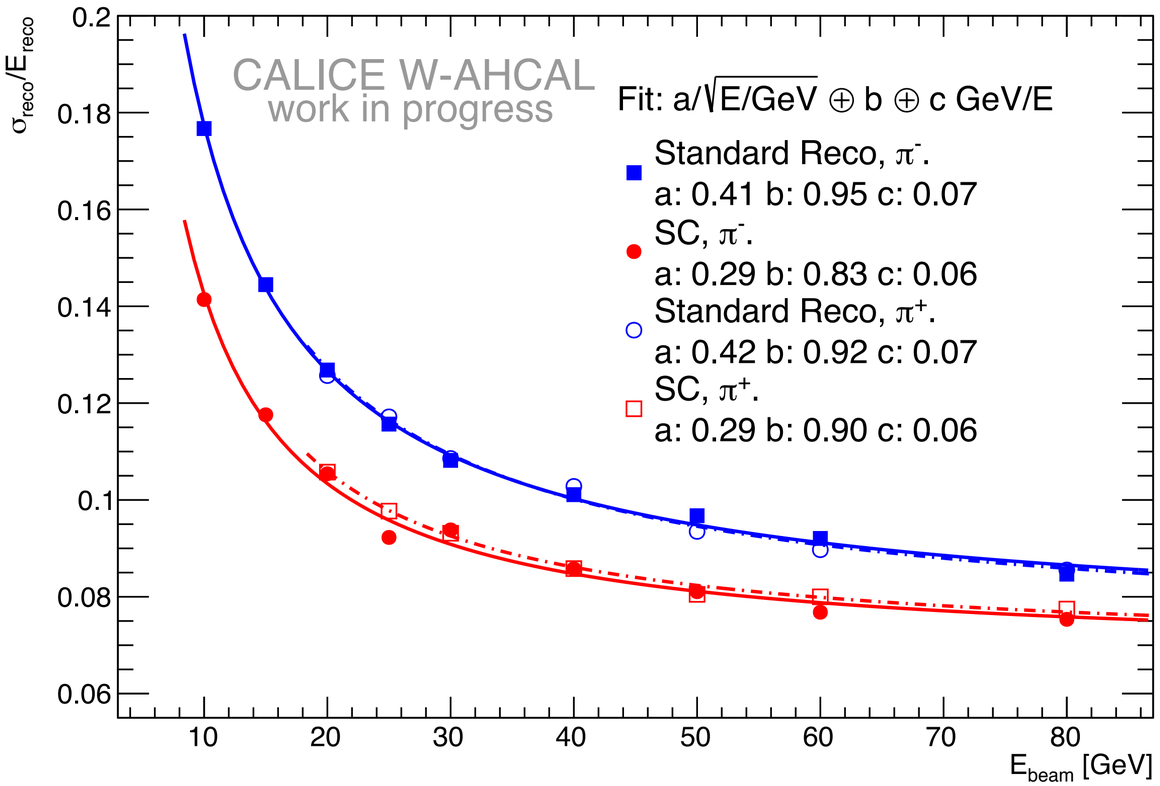
Outlook:

- Consider uncertainties
- Noise measurement

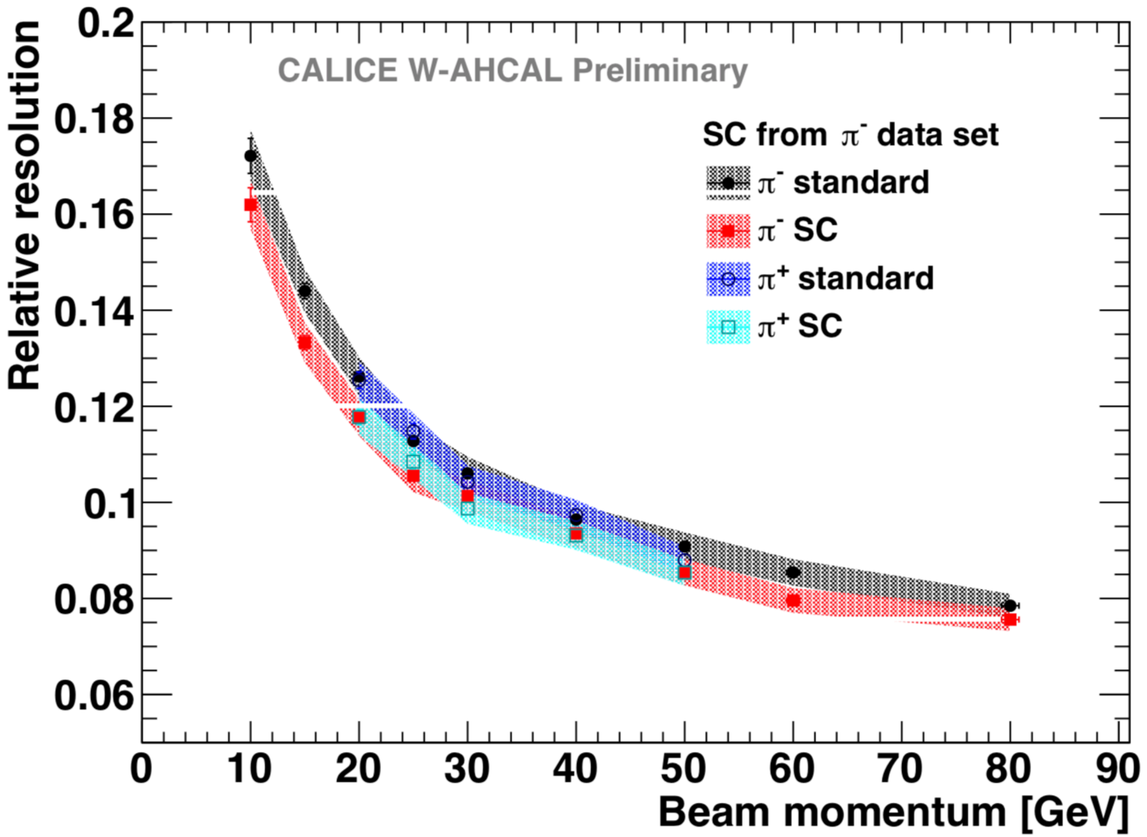
Backup

Backup: Energy Resolution

Local

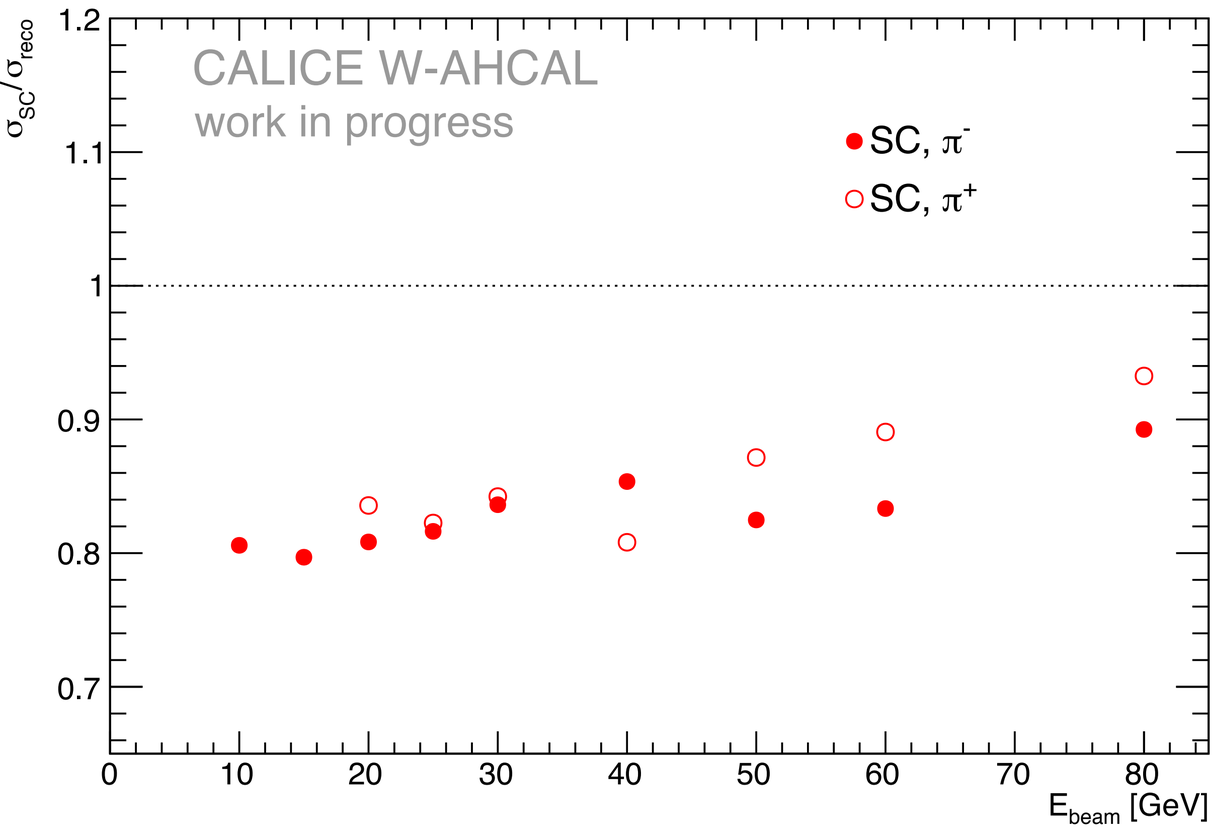


Global

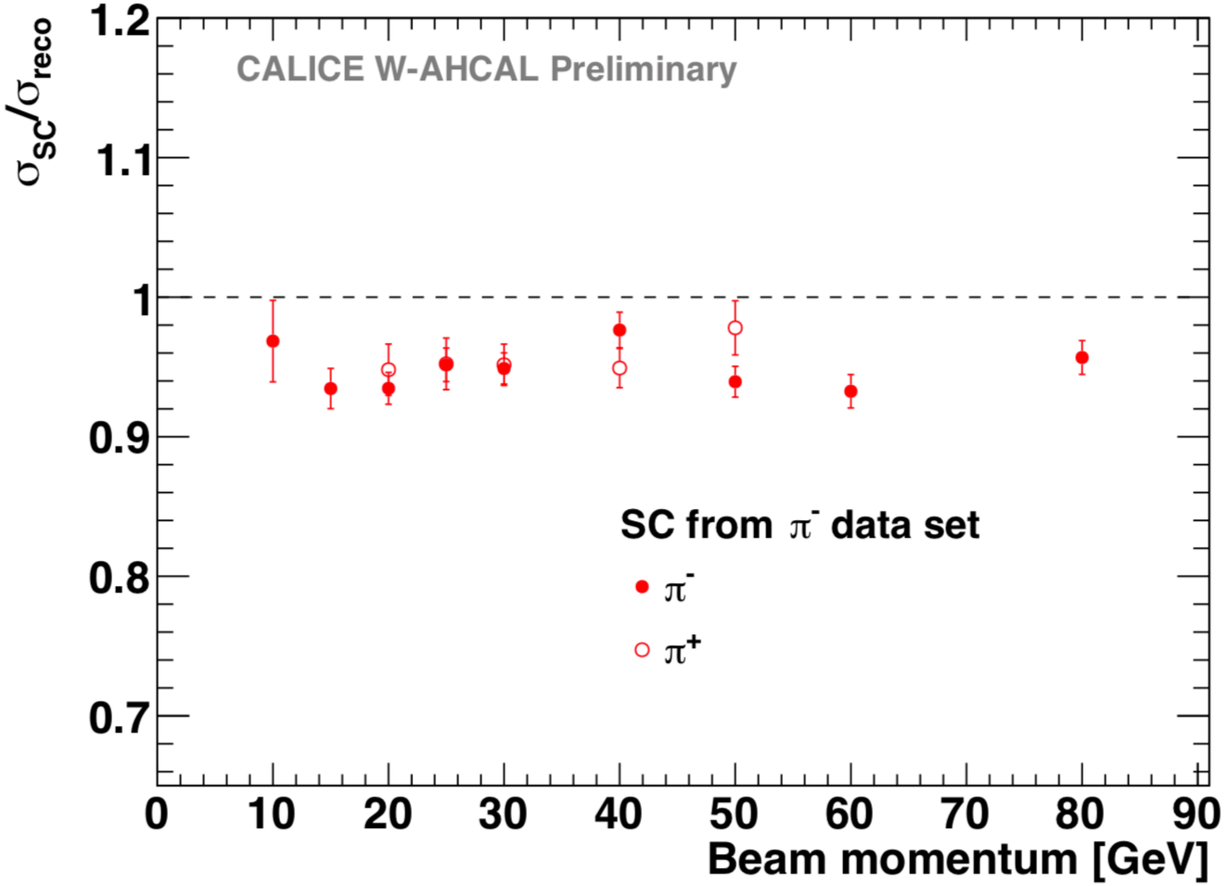


Backup: Energy Resolution

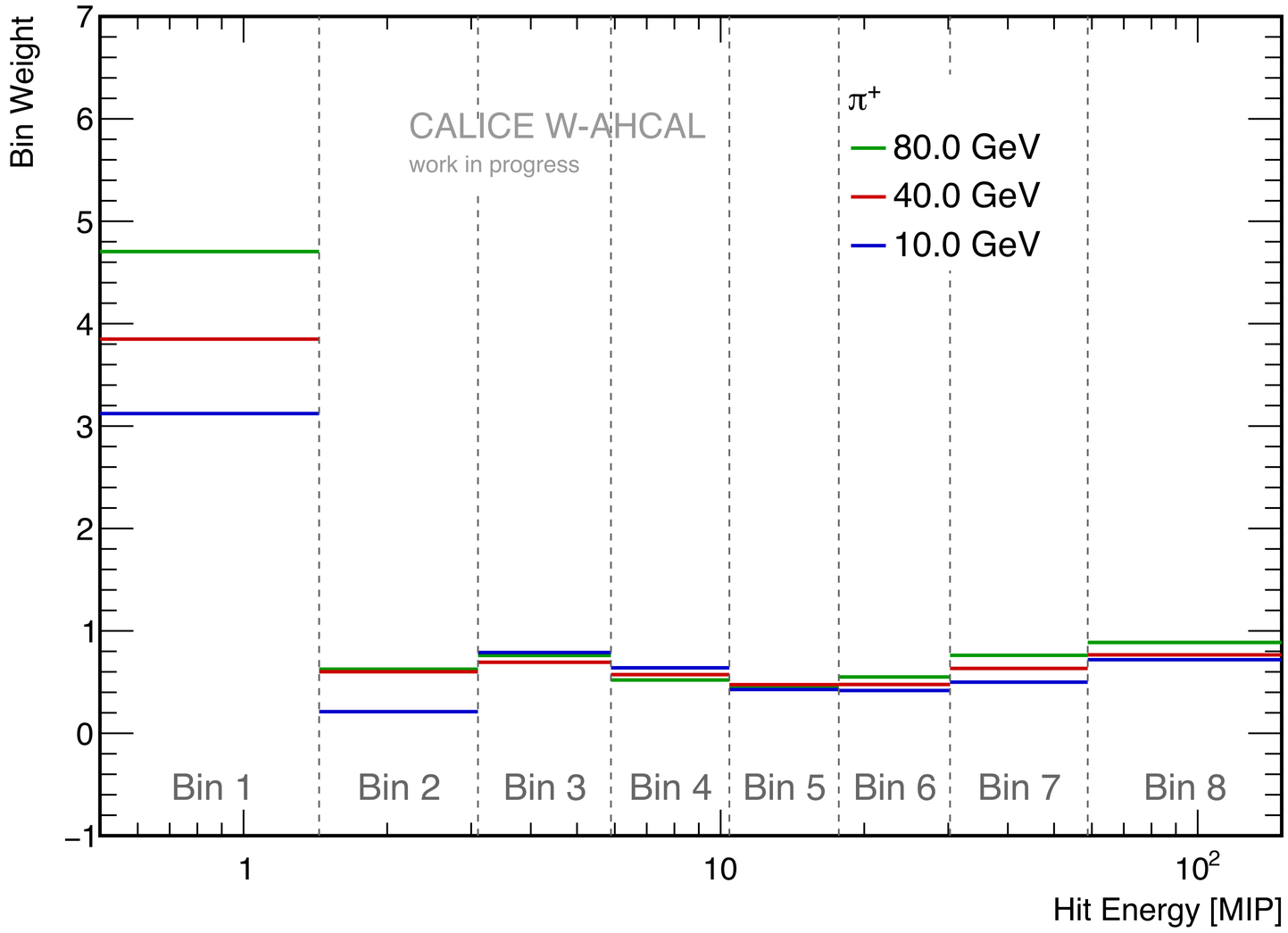
Local



Global



Backup: Bin Weight



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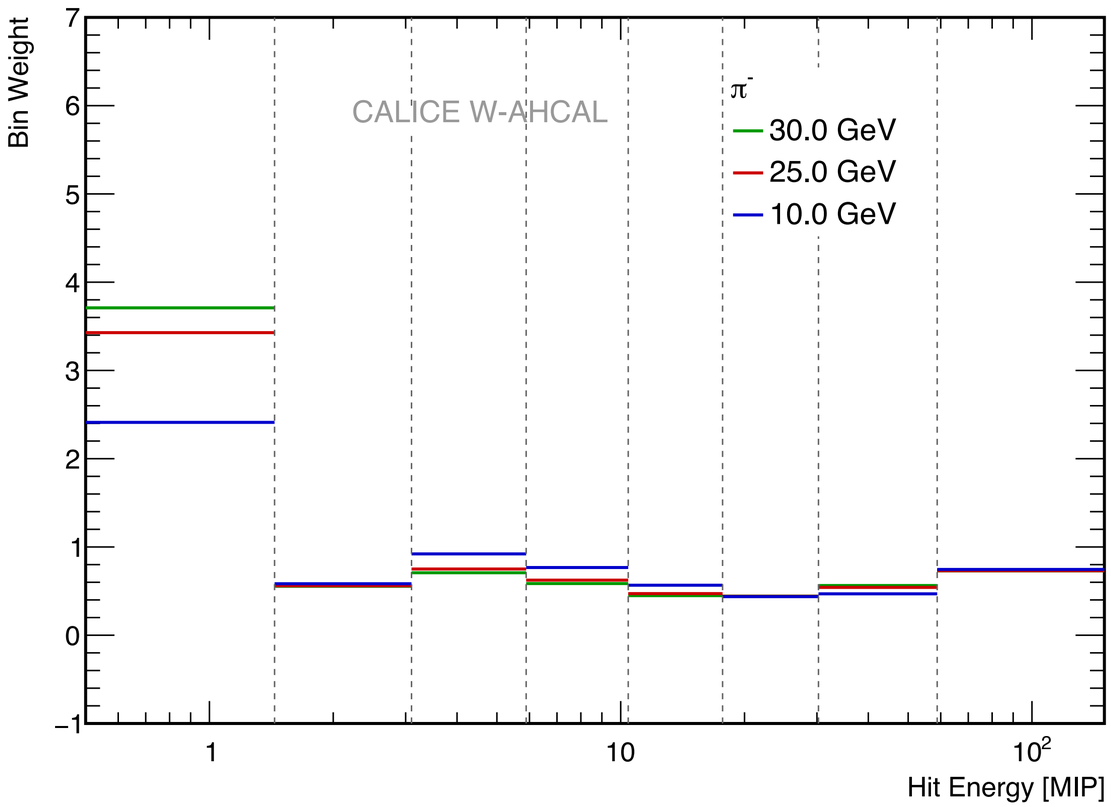
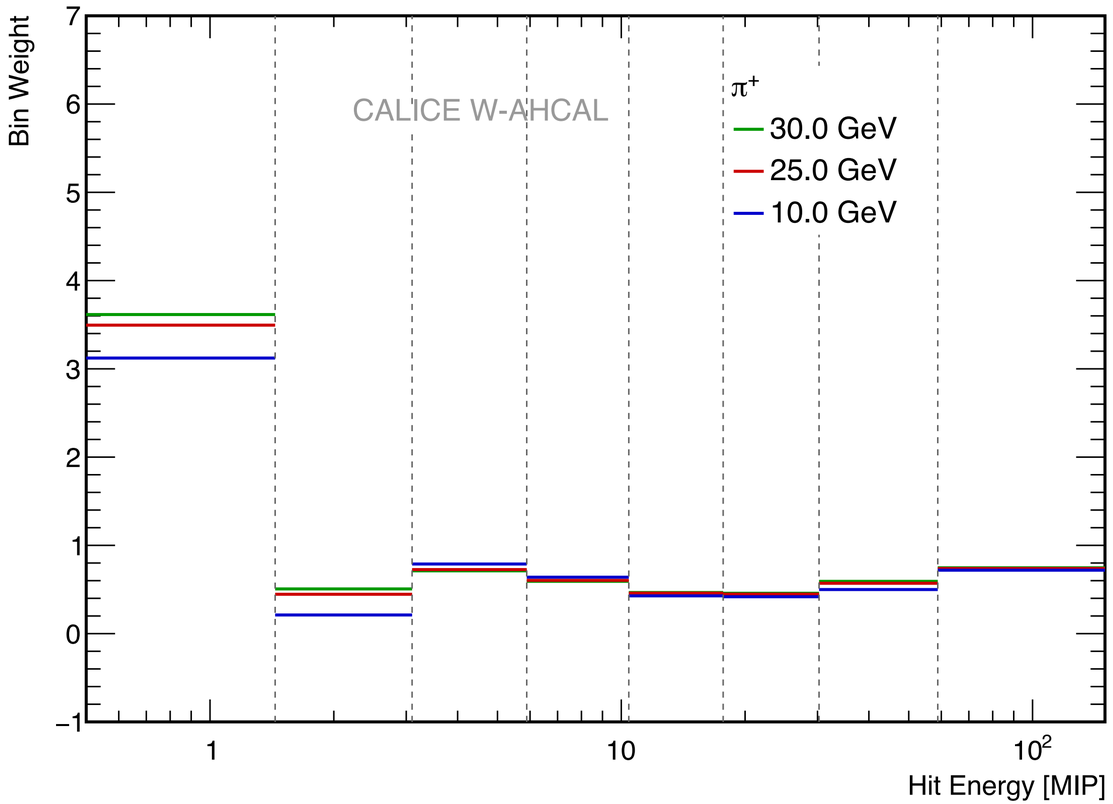
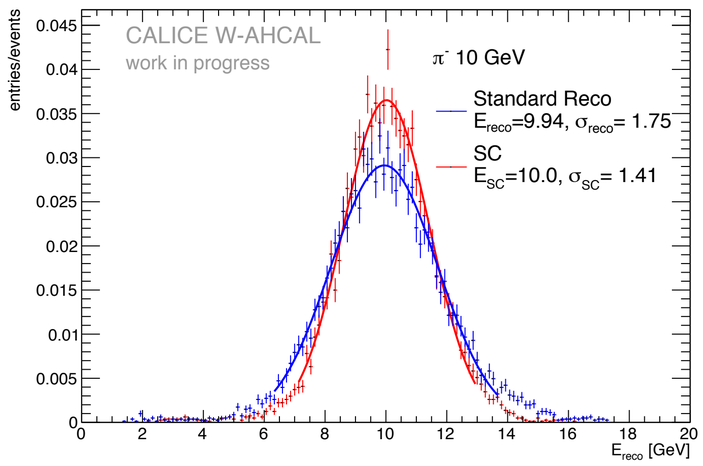
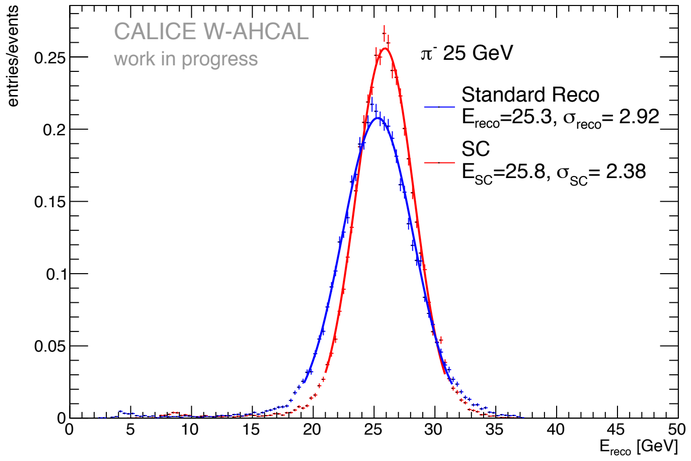
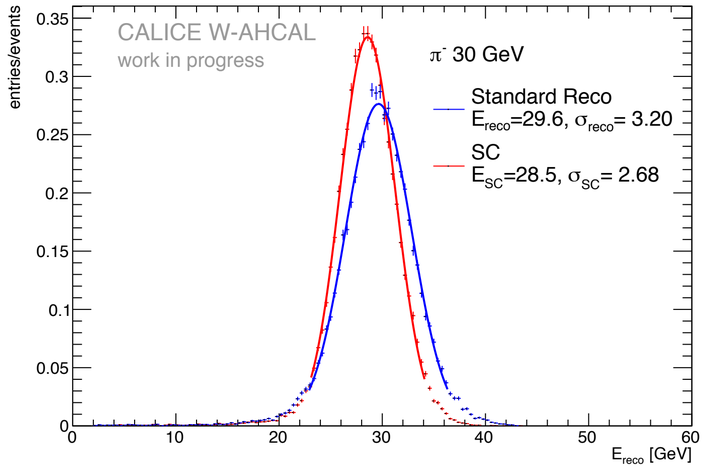


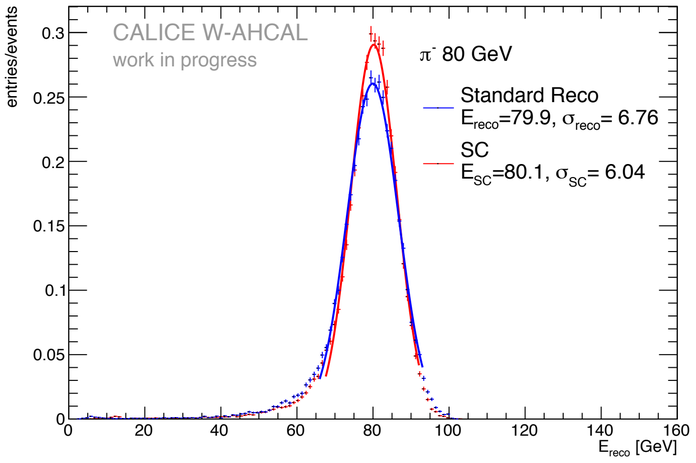


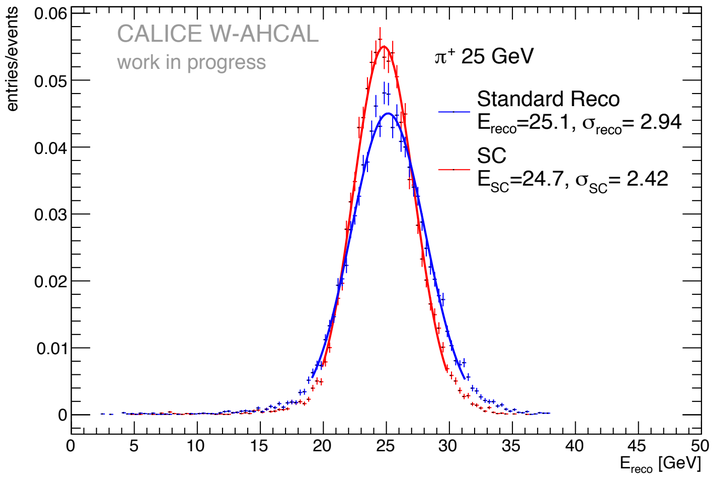
Backup: Reconstructed Energy

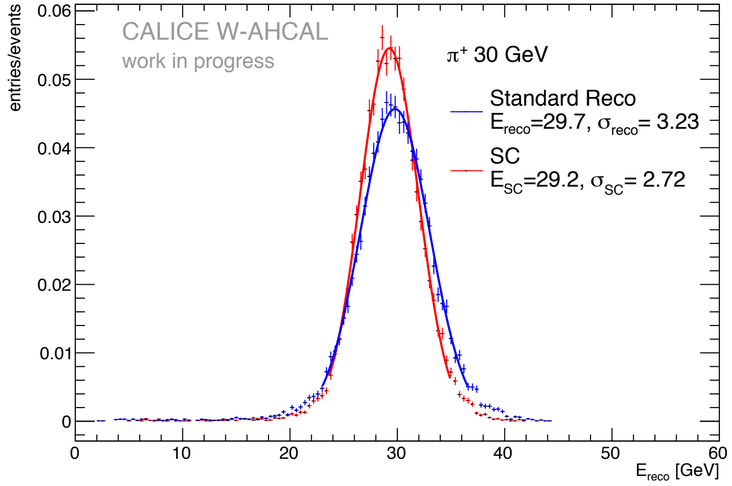




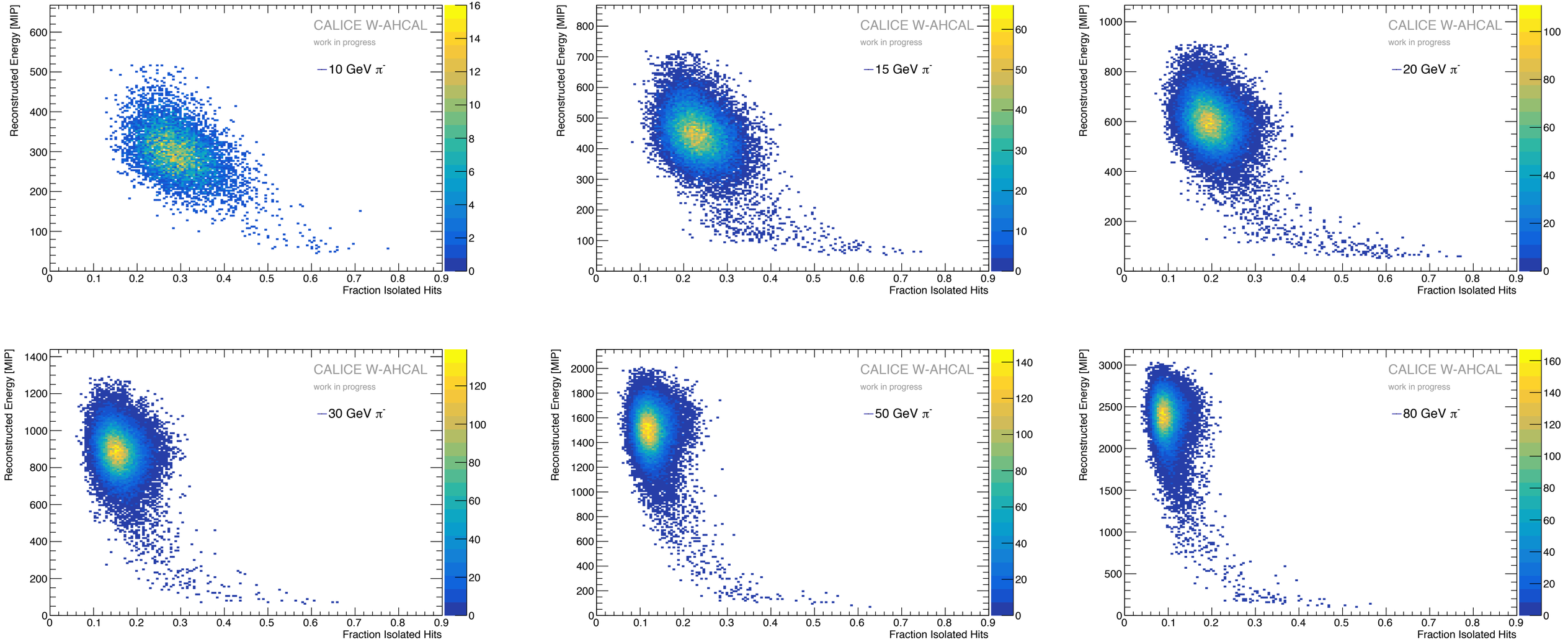








Backup: Correlation



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