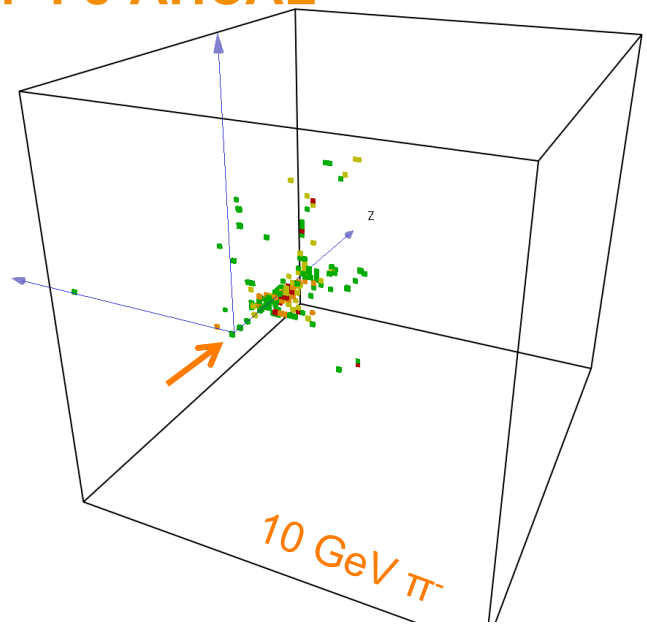
Towards the comparison of A- & (S-)DHCAL

MC simulation study of highly granular 1x1cm^2 Fe-AHCAL



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CALICE Collaboration Meeting @ MPP
München, 11.09.15

Eine Partnerschaft der Universität Hamburg und DESY

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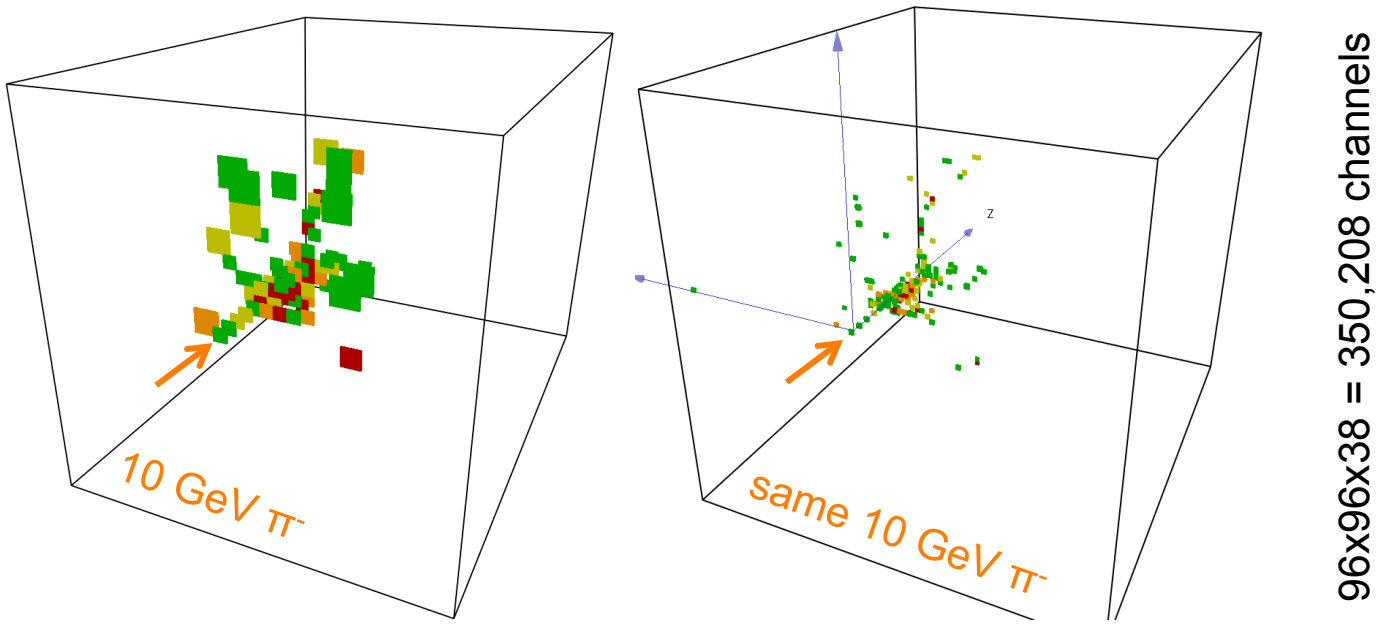
Fe-AHCAL with DHCAL granularity

"Real" Fe-AHCAL response **1x1cm^2 Fe-AHCAL response**

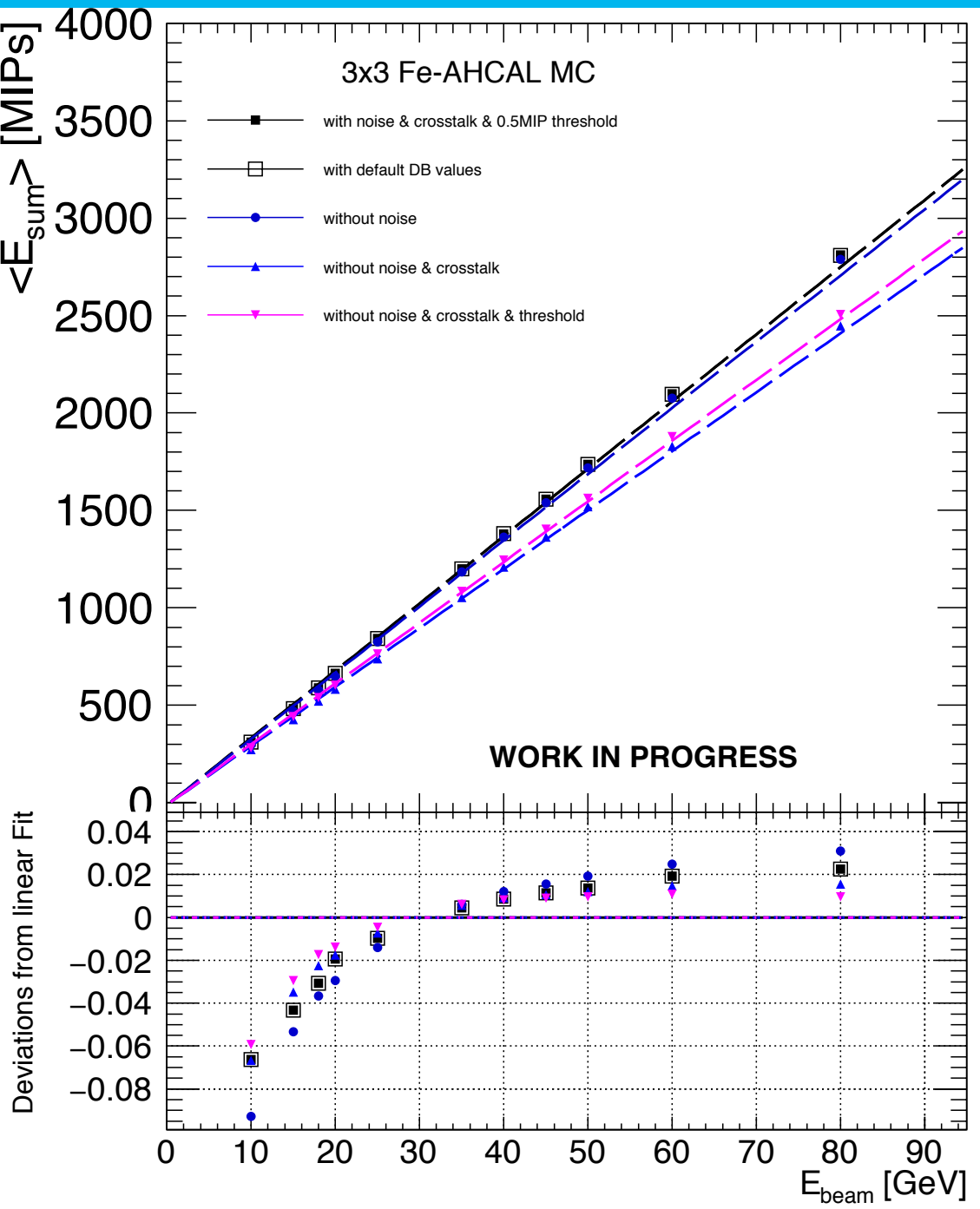


- Same underlying Mokka Simuation of π^- between 10-80GeV, FTFP_BERT
- Both simulations include SiPM response and its calibration + optical crosstalk
- Remaining differences:
  - No cell-wise calibration&correction constants for 1x1cm^2 (default values from database used)
  - No noise runs for 1x1cm^2 AHCAL

Study of effect of different digitisations on response

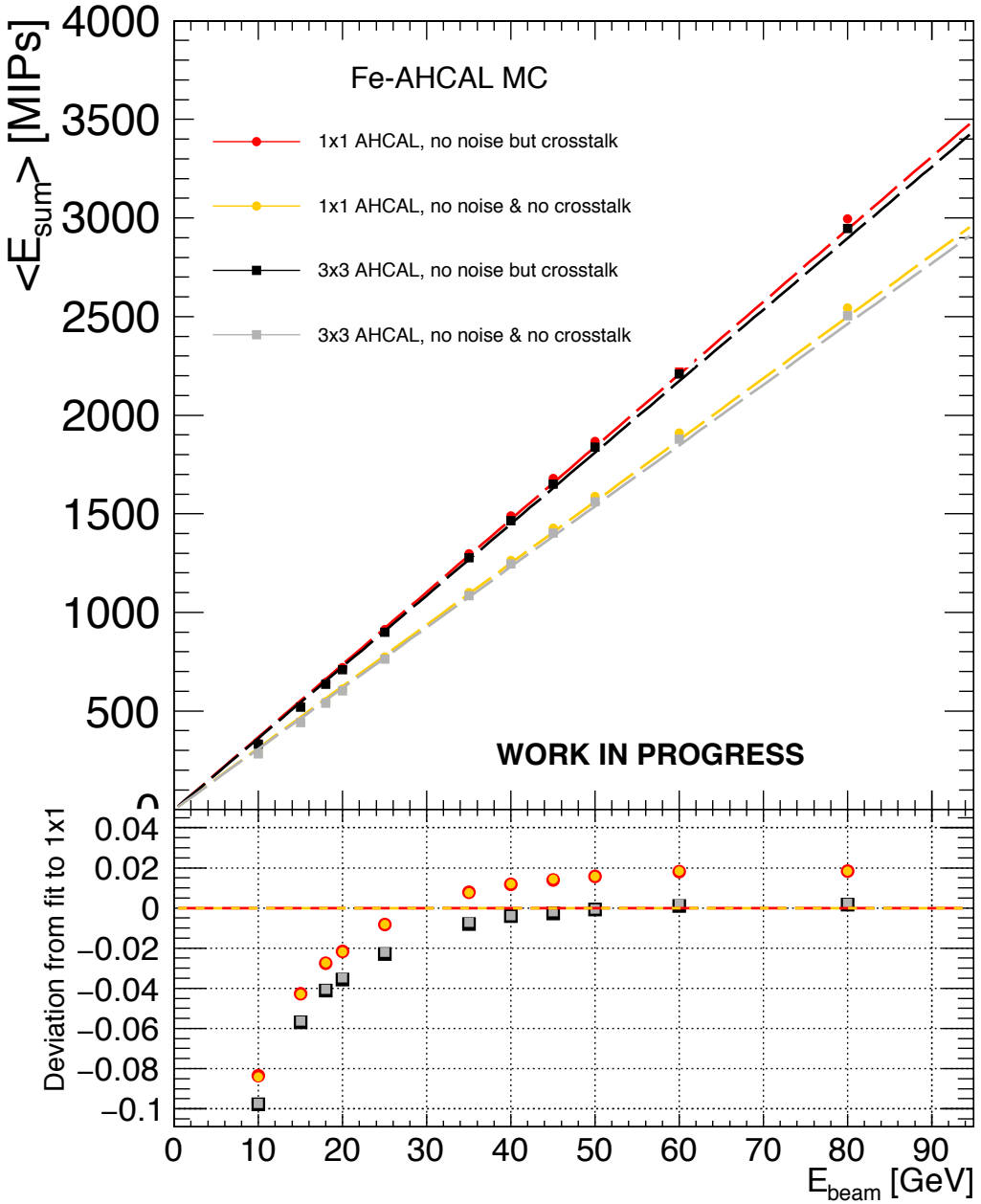
- Default db calibration parameters have no effect on response
- Linearity is worsening without noise
- Linearity improves without crosstalk
- Without threshold, still non-linearities (especially lower energies)

→ Remaining negative offset still needs to be understood

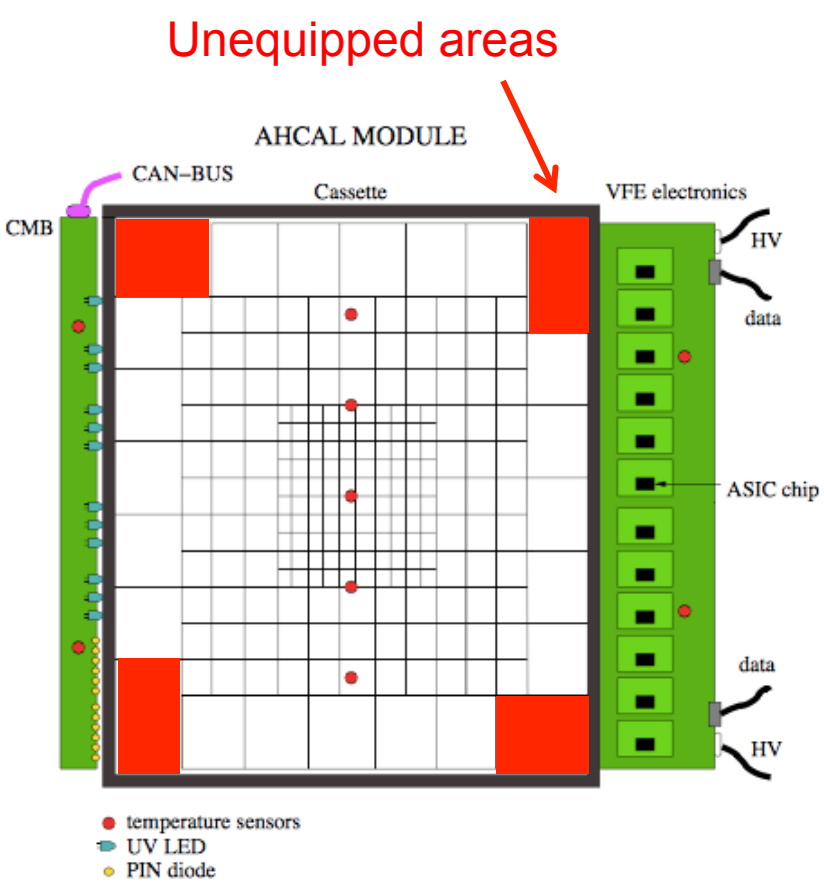


Responses of 3x3 versus 1x1 AHCAL

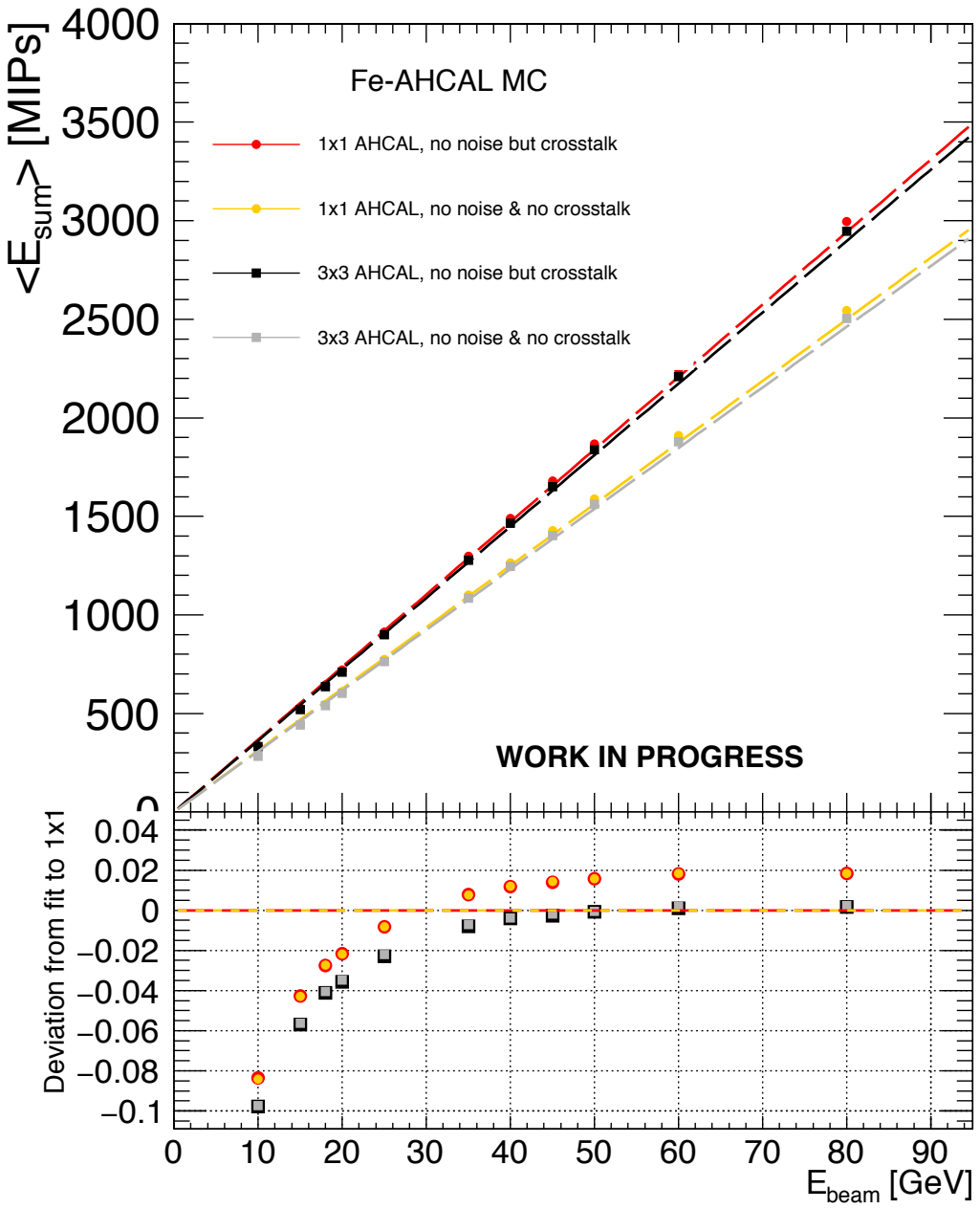
- Digitisation **without thresholds and noise**
- Effect of (15%) crosstalk, ~15% increase in response due to definition in digitiser
- Difference of ~2% in analogue response between 1x1 & 3x3AHCAL



Responses of 3x3 versus 1x1 AHCAL



- In total 7,236cm² sensitive area per layer
- In 1x1AHCAL MC, an area of 96x96cm² (9,216cm²) is fully sensitive

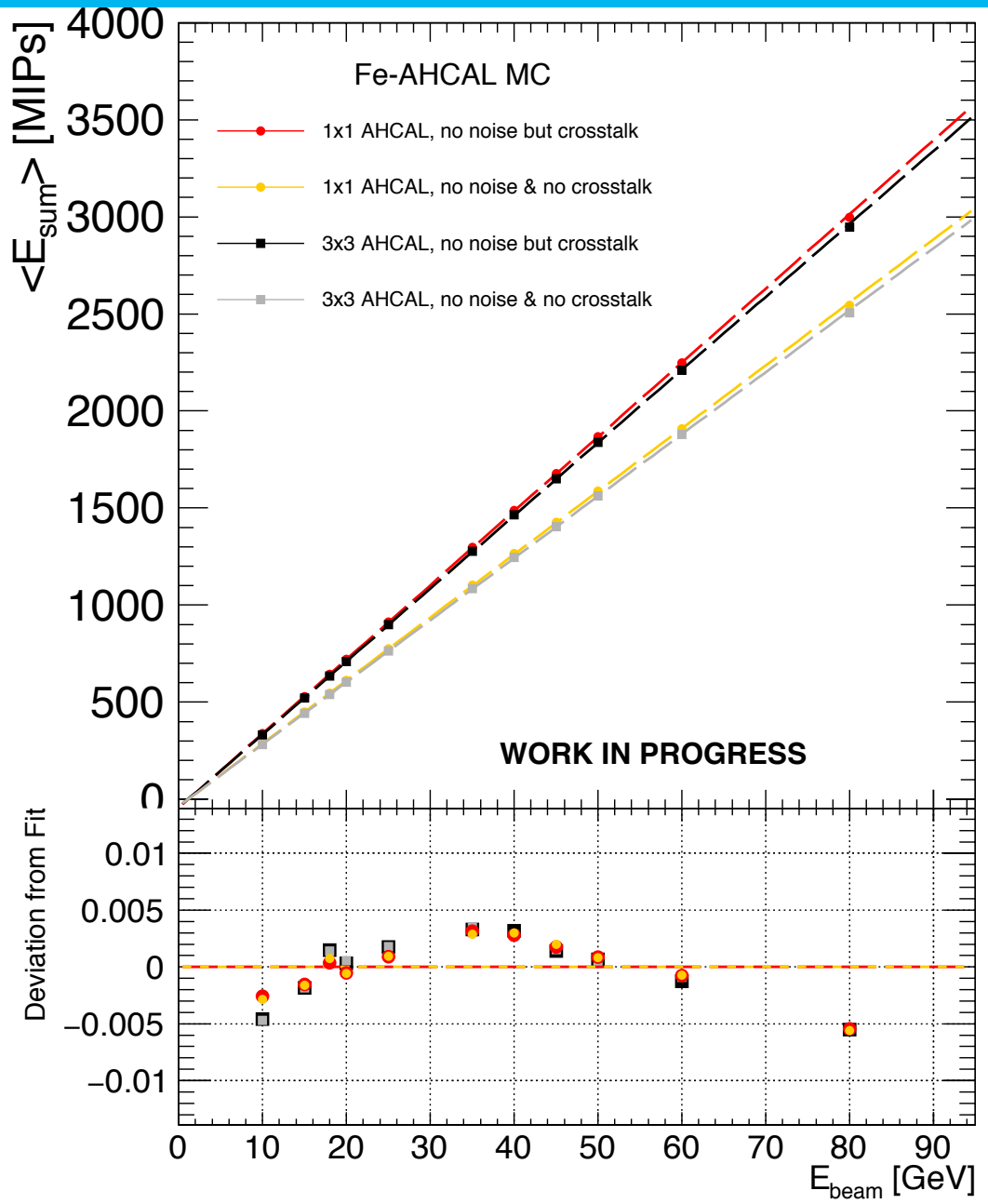


Responses of 3x3 versus 1x1 AHCAL

- Digitisation **without thresholds and noise**
- Linear fit w/ offset of response

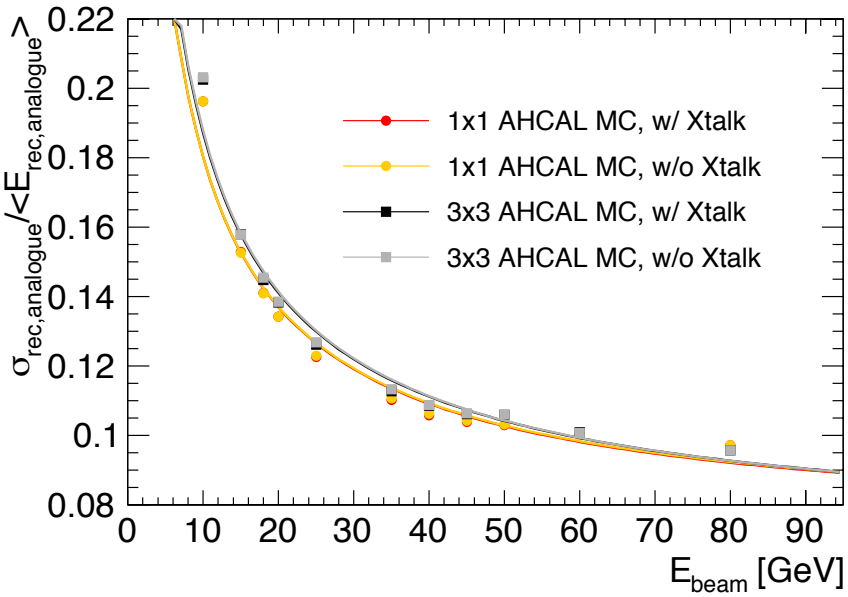
$$\langle E_{Sum} \rangle = \frac{\left(E_{beam} - E_{track}\right)}{e/\pi \cdot \omega} - n$$

- Agrees within 1-percent-level

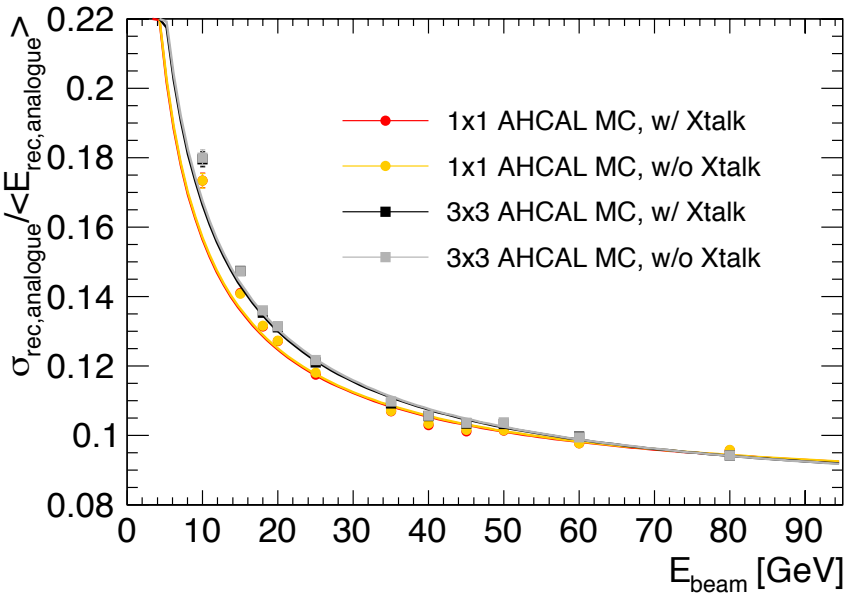


Comparison of reconstruction procedures

$$E_{rec} = E_{track} + {}^{e}\!/\!_{\pi} \cdot \omega \cdot E_{Sum}$$



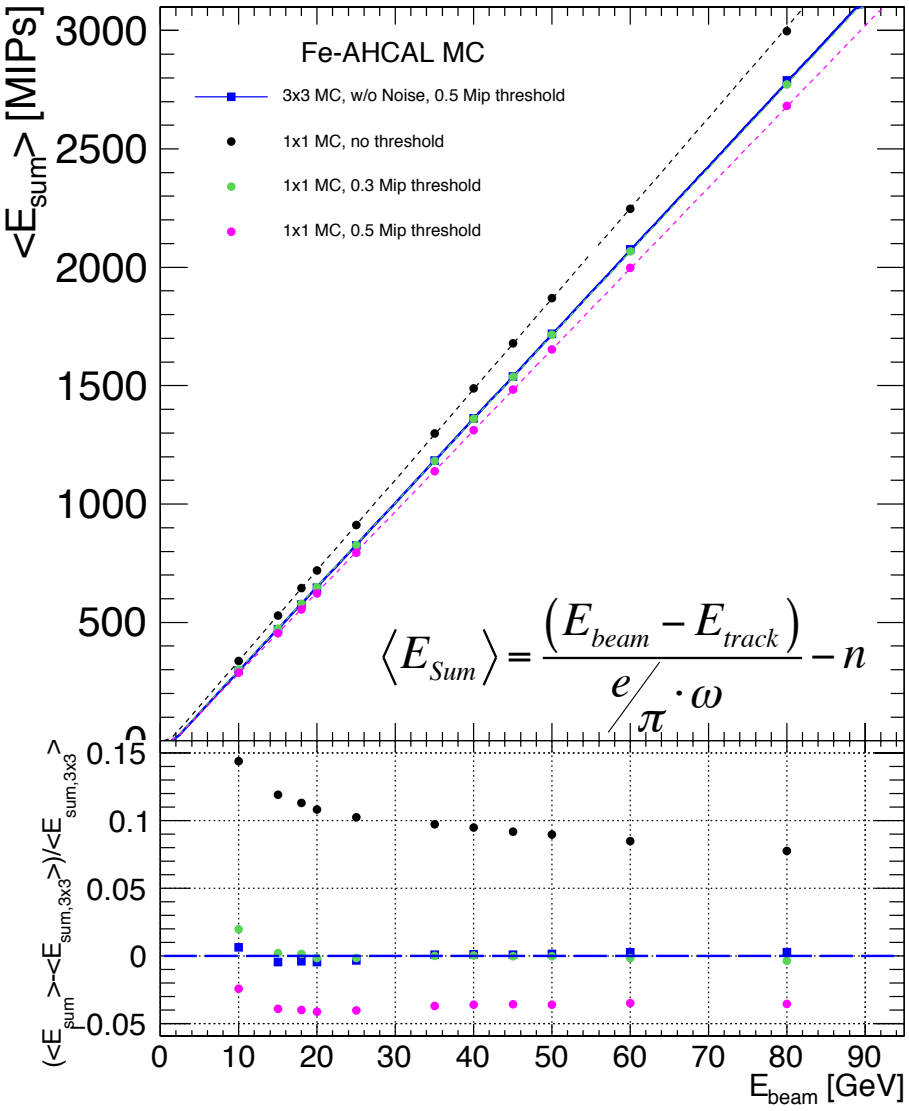
$$E_{rec} = E_{track} + {}^{e}\!/\!_{\pi} \cdot \omega \cdot \left(E_{Sum} + n\right)$$

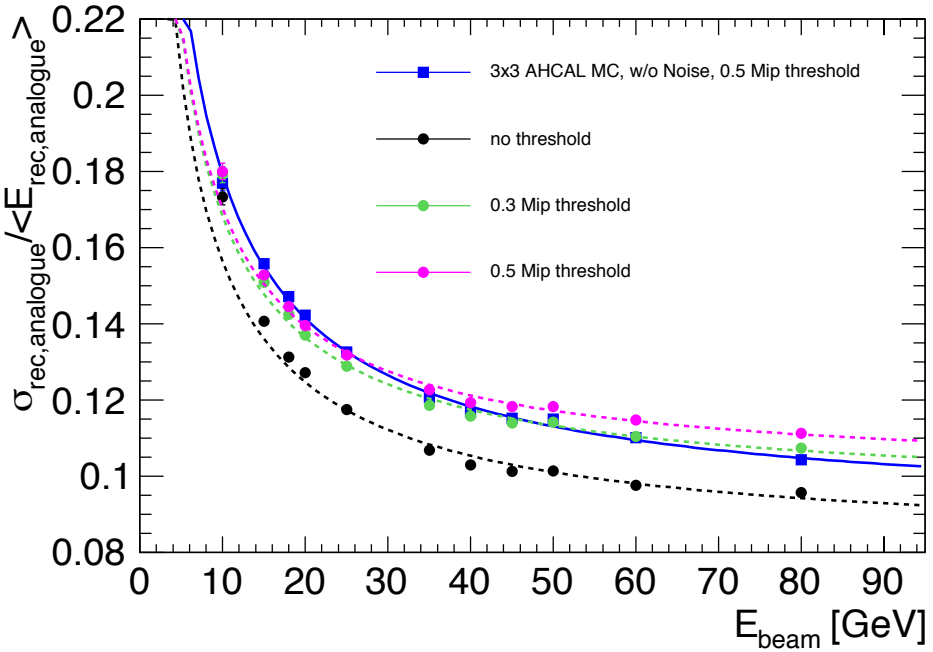


- By correcting for non-linearities, resolution improves
- Crosstalk has no effect on resolution
- Slight improvement in higher granular AHCAL, for energies < 35GeV

→ Check if effect originates from smaller read-out area is ongoing

Analogue Response & Resolution



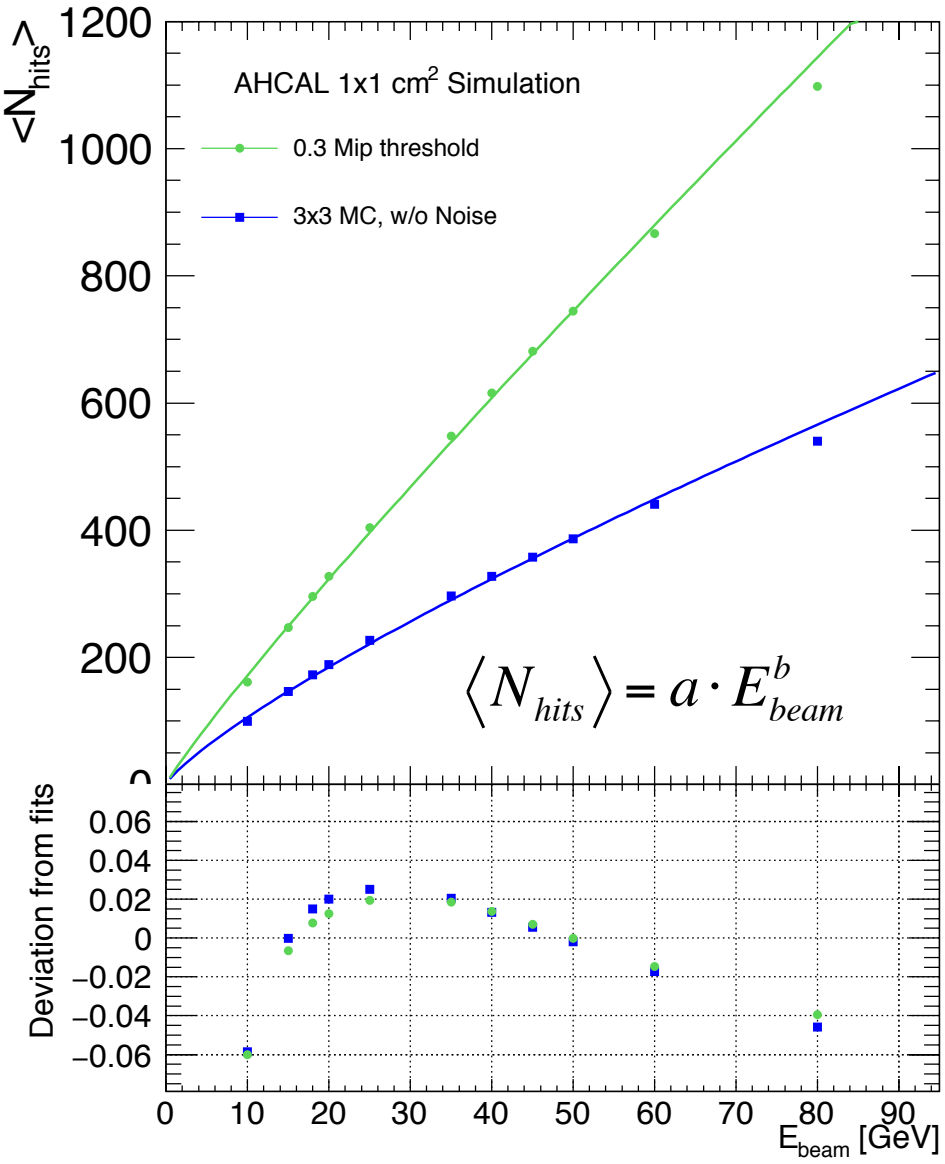


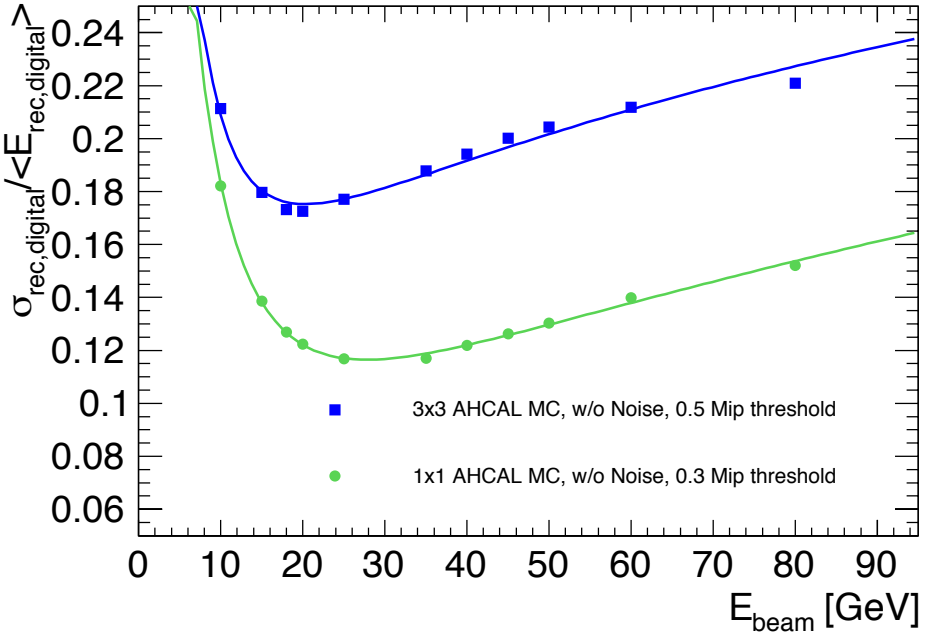
- 0.3MIP threshold in 1x1AHCAL mimics response of 3x3AHCAL with 0.5Mip

→ 0.3MIP threshold applied for digital & semi-digital energy reconstruction

- Resolution improves for small energies with increased (1x1cm^2) granularity
- For higher energies, difference depends on threshold

Digital Response & Resolution

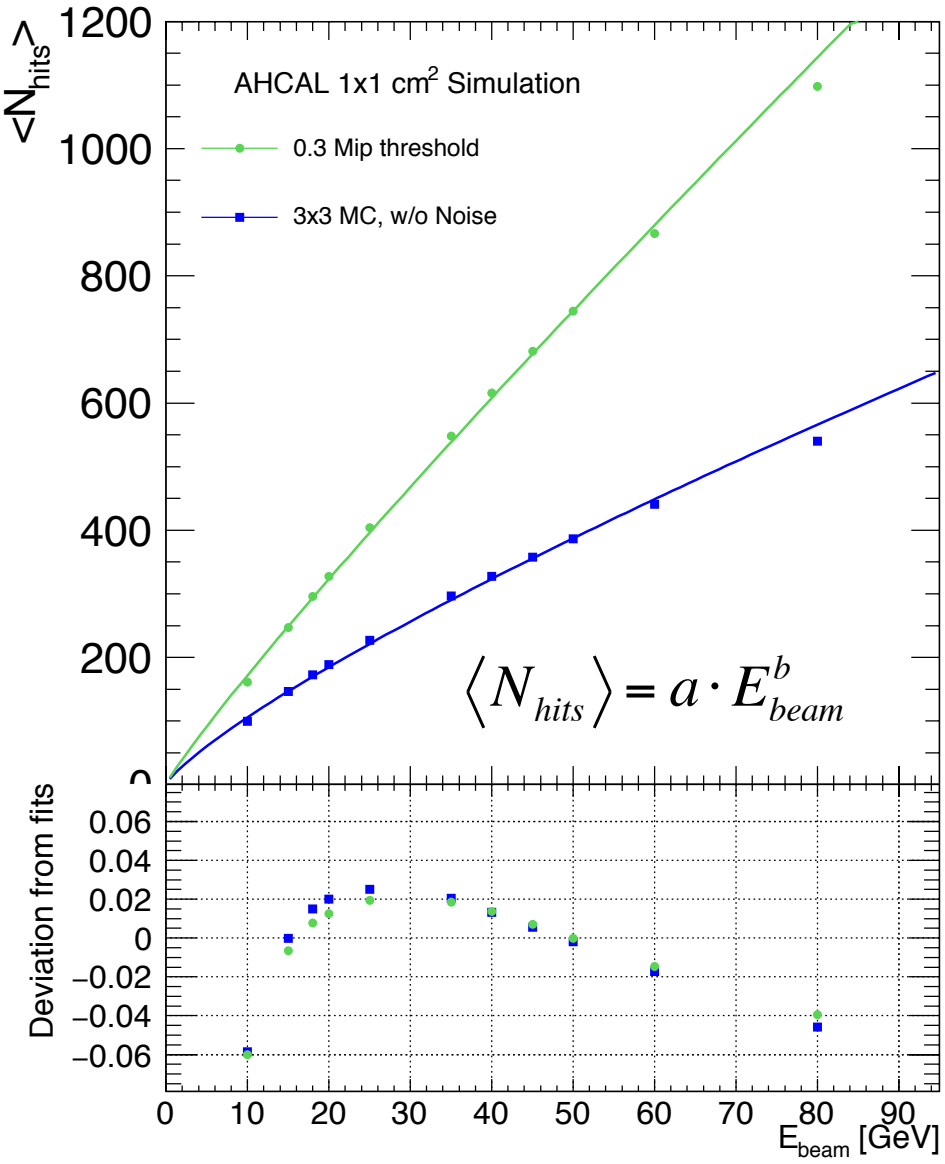


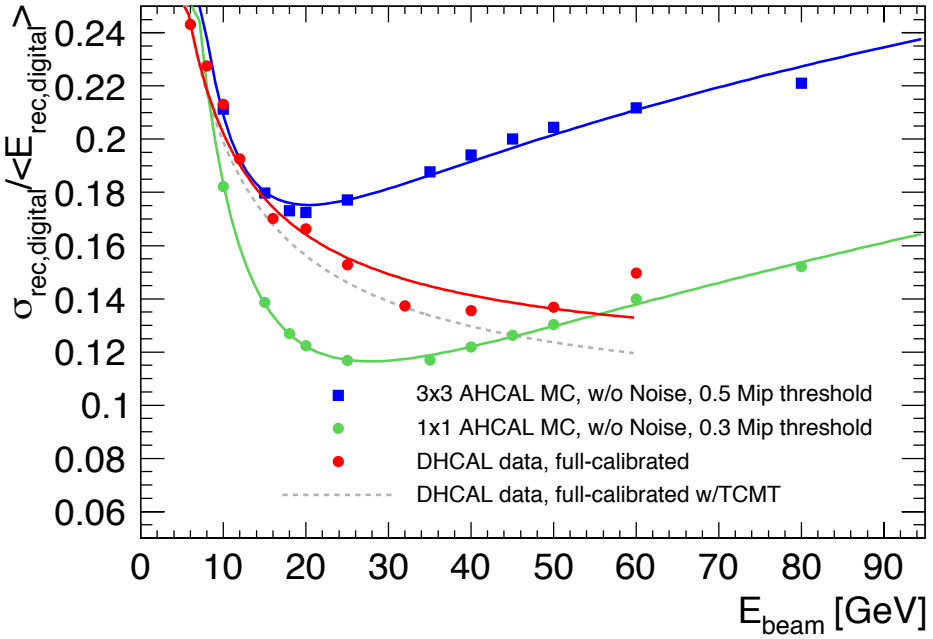


- 1x1cm² granularity beneficial
- Resolution already degrading above 30GeV

→ Shape is not effected by granularity

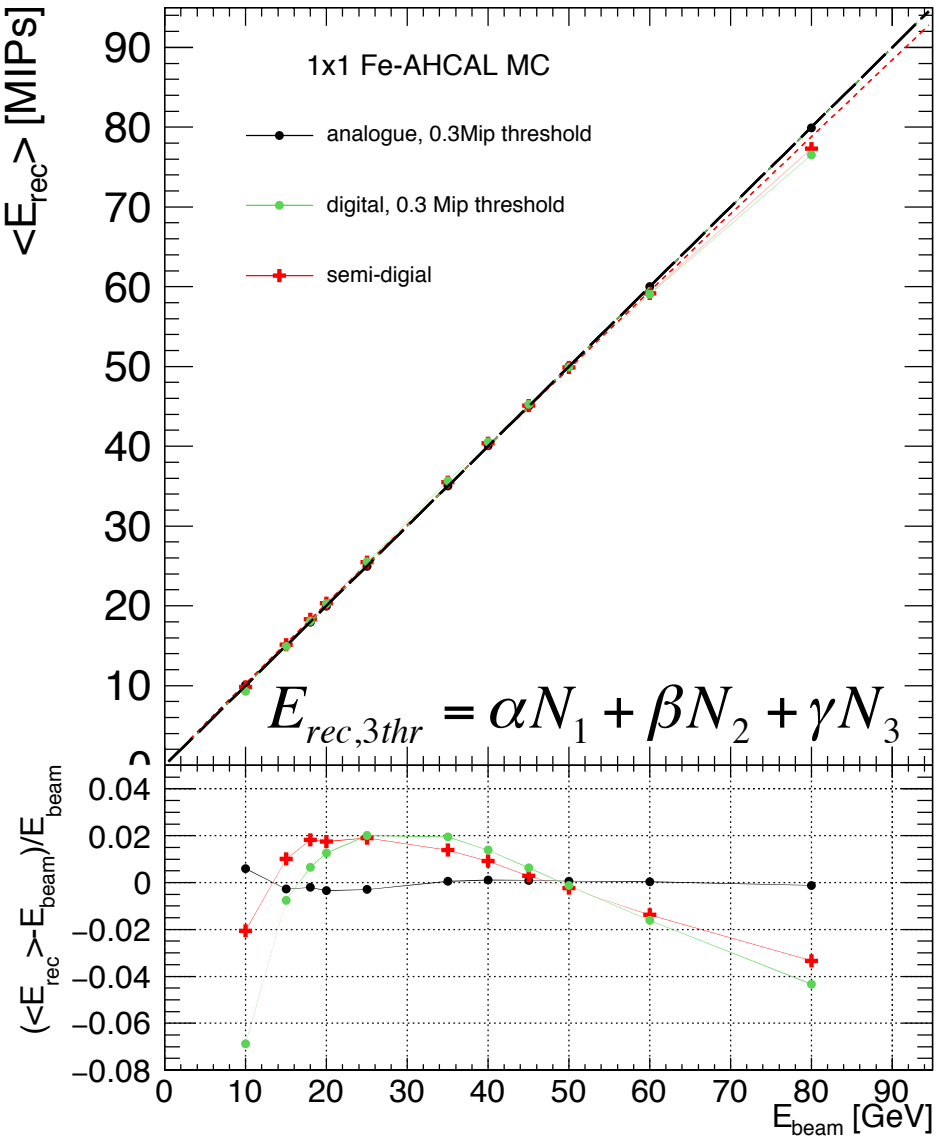
Digital Response & Resolution

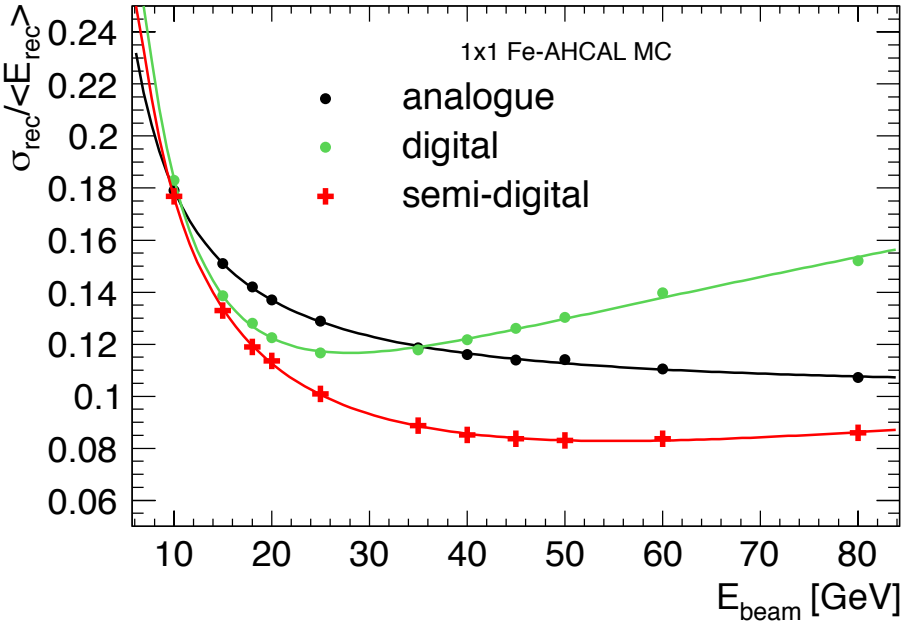




- 1x1 AHCAL MC in digital mode better than 1x1 DHCAL data.. but room for improvement for DHCAL!

Semi-Digital Reconstruction

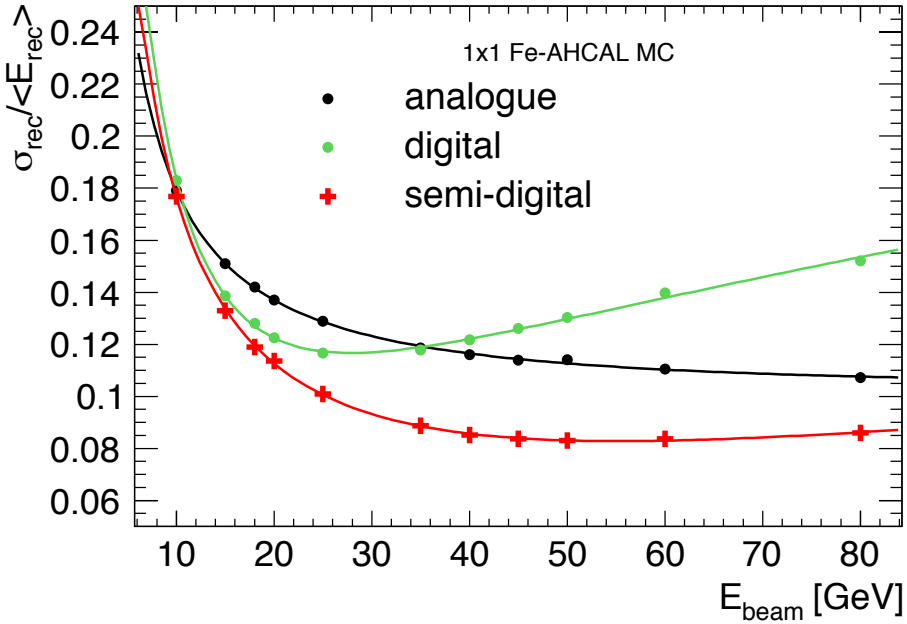




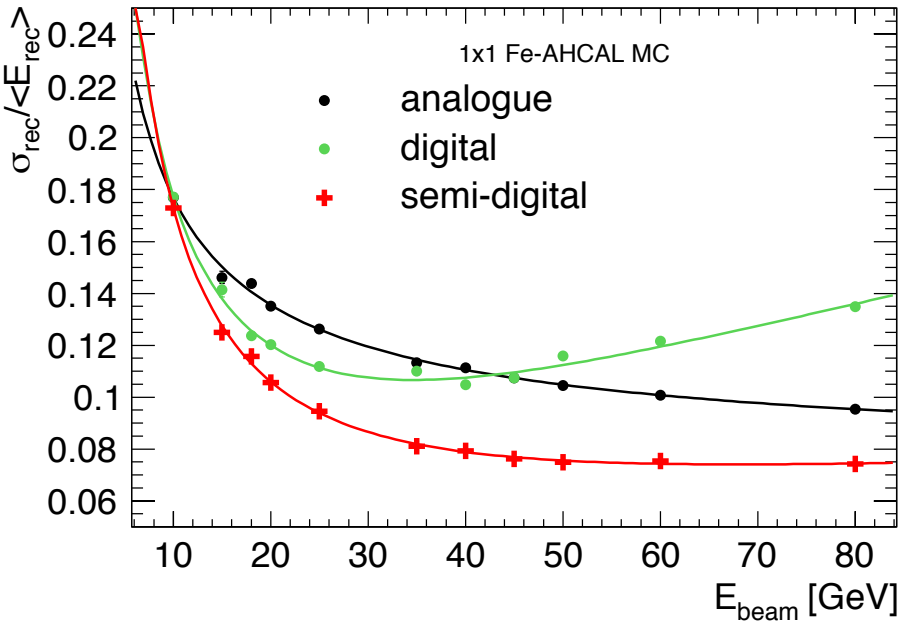
- SDHCAL thresholds used, 0.3MIP, 5MIP & 15MIP
- Chi² minimization determines αβγ
- Semi-digital reconstruction shows best resolution > 10GeV
- Analogue resolution will improve for higher energies

Comparison of reconstruction methods

Novosibirsk fitted, histogram filled → Mean&RMS



Gauss fitted, within ±1.5σ



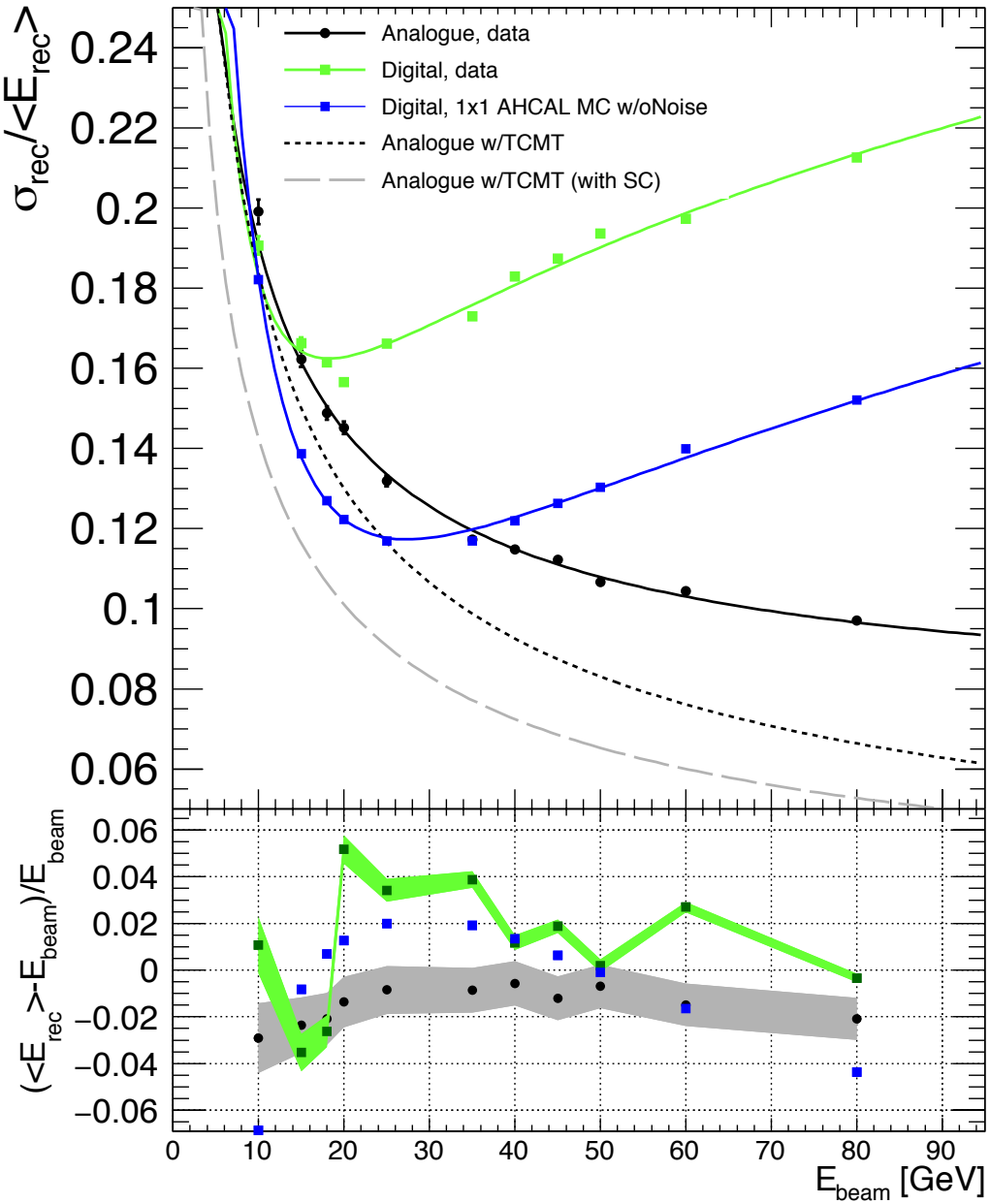
- Excluding tails in distributions, especially improves digital resolution
- Semi-digital reconstruction include energy dependent weighting
  → corrects response for e/h≠1

→ Applying SC techniques to analogue reconstruction needed for comparison

Discussion

- Reconstruction procedures decisive for cell-size/granularity optimization
- Application of SC algorithms to analogue energy reconstruction
  - Expect stronger improvement than in 3x3 AHCAL
- How effective are Semi-digital and Software-Compensation reconstruction procedures in particle flow algorithms ? (→ see Lan's study)

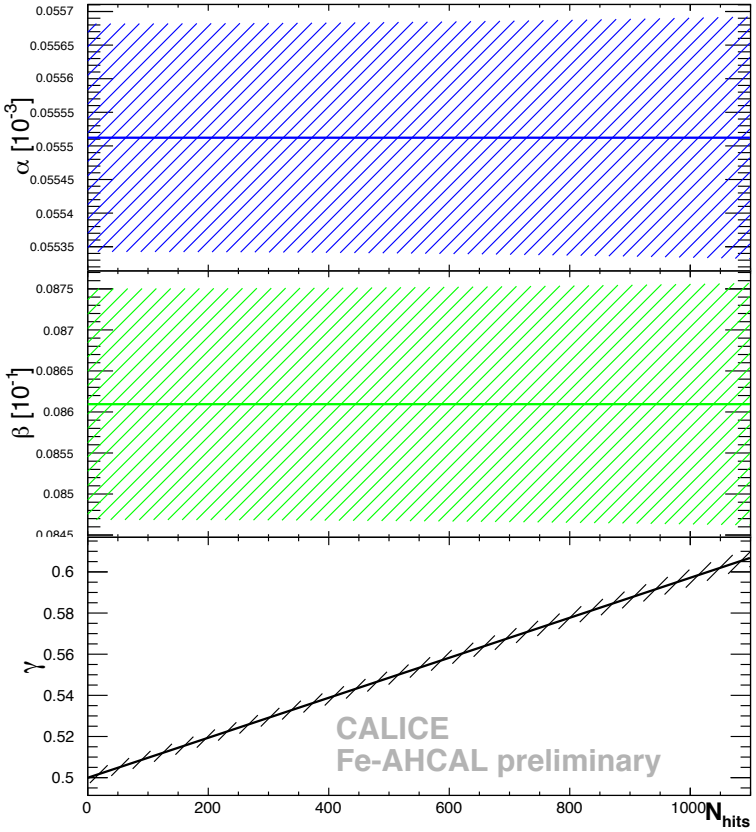
Backup



- Highly granular digital AHCAL achieves better resolution than 3x3 Analogue HCAL (for energies below 30GeV)

Backup: Semi-digital energy reconstruction

$$E_{rec,3thr} = \alpha N_1 + \beta N_2 + \gamma N_3$$



- Weighting hits depending on energy content

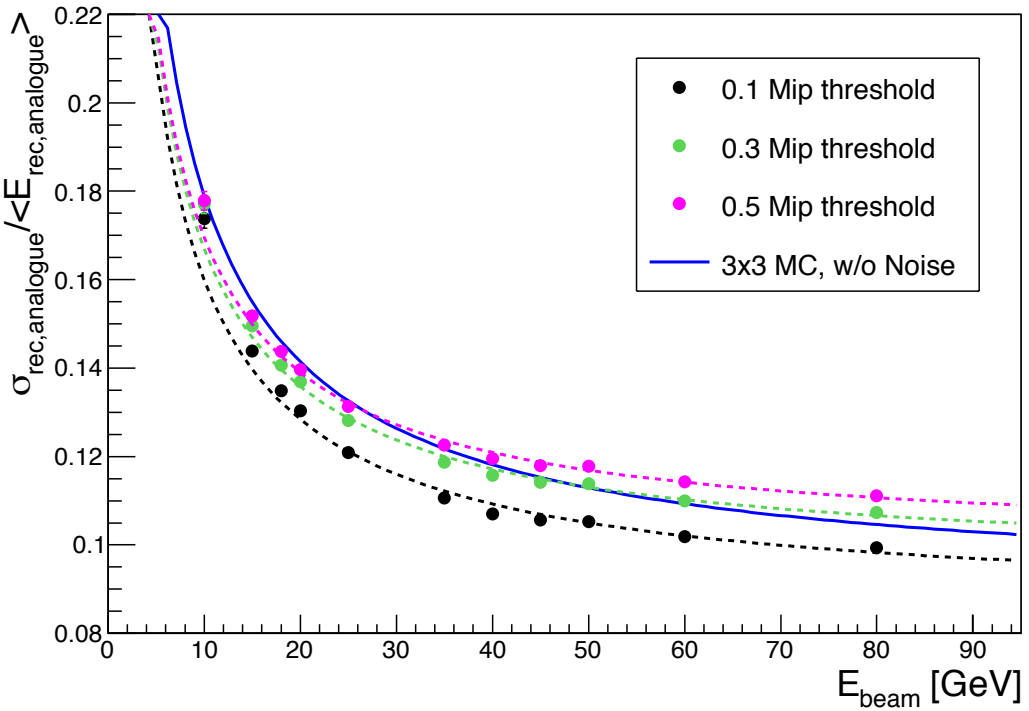
$$N_1 : 0.3MIP < E_{hit} < 5MIP$$
$$N_2 : 5MIP < E_{hit} < 15MIP$$
$$N_3 : E_{hit} > 15MIP$$

- α,β and γ assumed to be quadratic polynomials of N_{hits}

$$\chi^2 = \sum_{i=1}^{N} \frac{\left(E^i_{beam} - E^i_{rec,semi-digital}\right)^2}{E^i_{beam}}$$

- From minimisation: α,β and γ show none or linear dependence on N_{hits}
- Results in sufficient linearity

Backup: 1x1 cm² AHCAL resolution



3x3cm²

$$\frac{\sigma_{rec}}{\langle E_{rec}\rangle} = \frac{49.14}{\sqrt{E_{beam}[GeV]}} \oplus 8.903$$

1x1cm²

$$\frac{\sigma_{rec}}{\langle E_{rec}\rangle} = \frac{43.45 \pm 0.34}{\sqrt{E_{beam}[GeV]}} \oplus 9.95 \pm 0.03$$

$$\frac{\sigma_{rec}}{\langle E_{rec}\rangle} = \frac{43.46 \pm 0.33}{\sqrt{E_{beam}[GeV]}} \oplus 9.49 \pm 0.03$$

$$\frac{\sigma_{rec}}{\langle E_{rec}\rangle} = \frac{42.67 \pm 0.30}{\sqrt{E_{beam}[GeV]}} \oplus 8.59 \pm 0.03$$

- For small energies 1x1cm² granularity beneficial
- For higher energies, difference depends on threshold
- Higher granularity decreases stochastic term