HCal HLT Threshold Opt for MET

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- Motivation
- $\not{E}_T$ resolution v.s. cell energy thresholds
- $\not{E}_T$ resolution v.s. calotower transverse energy threshold
- $\not{E}_T$ resolution v.s. cell transverse energy thresholds
- $\not{E}_T$ resolution v.s. ADC count thresholds
- Proposal

Motivation

- Goal:
  - ◇ Understand $\not{E}_T$ resolution dependency on high level trigger (HLT) thresholds
  - ◇ HLT threshold optimization for background rejection
- Focus on HCal: MET resolution dominated by HCal
- Missing Transverse Energy Vector:

$$\vec{\not{E}_T} \equiv -\sum_n (E_n \sin\theta_n \cos\phi_n \hat{\mathbf{x}} + E_n \sin\theta_n \sin\phi_n \hat{\mathbf{y}}) = \not{E}_x \hat{\mathbf{x}} + \not{E}_y \hat{\mathbf{y}} \qquad (1)$$

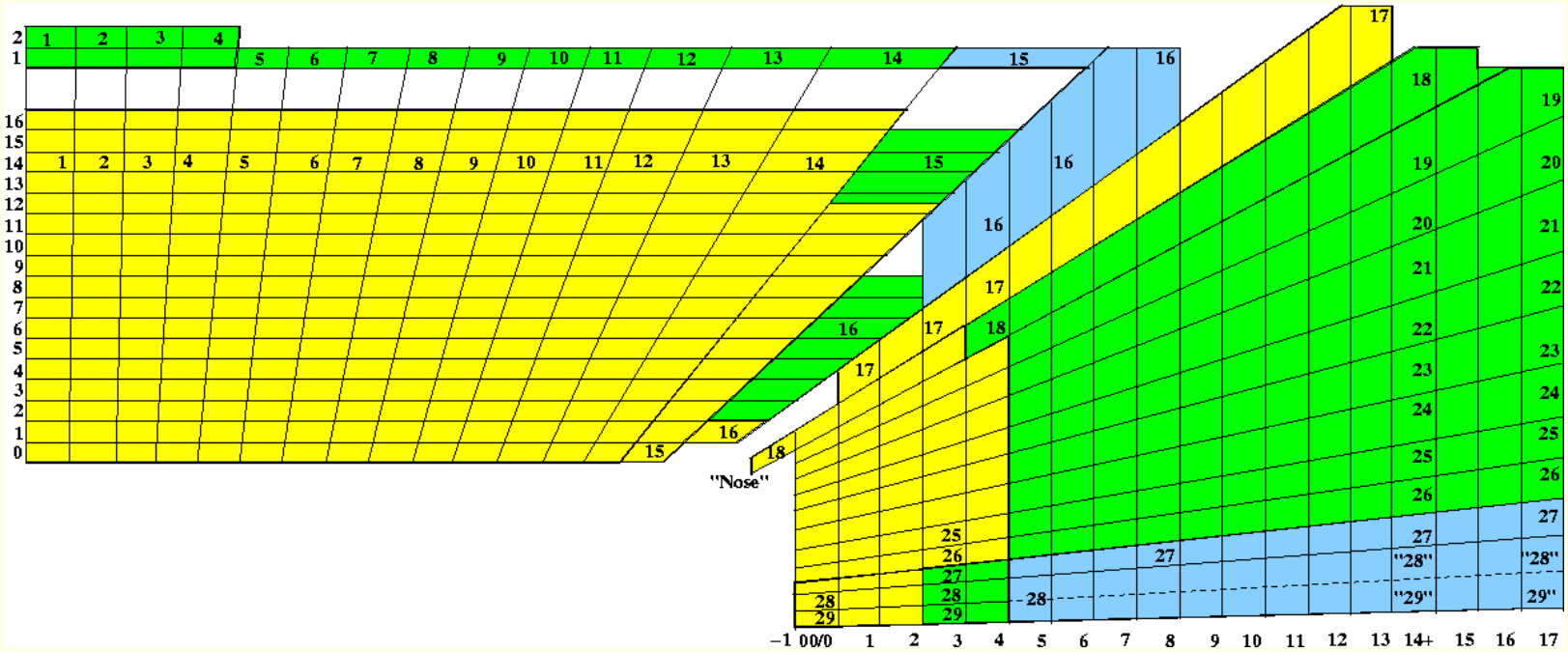
sum over all calo towers

- Missing Transverse Energy: $\not{E}_T$

$$\not{E}_T = \sqrt{(\not{E}_x)^2 + (\not{E}_y)^2} \qquad (2)$$

Hadron Calorimeter

- HCal: Barrel (HB), Outer (HO), Endcap (HE), Forward (HF, not shown)
  Separate HE $5^0/10^0$ cells in ϕ, HF long (HF1) and short (HF2) fiber.



- Default thresholds (Scheme B) for RecoMET (HCal/ECal energy in GeV):

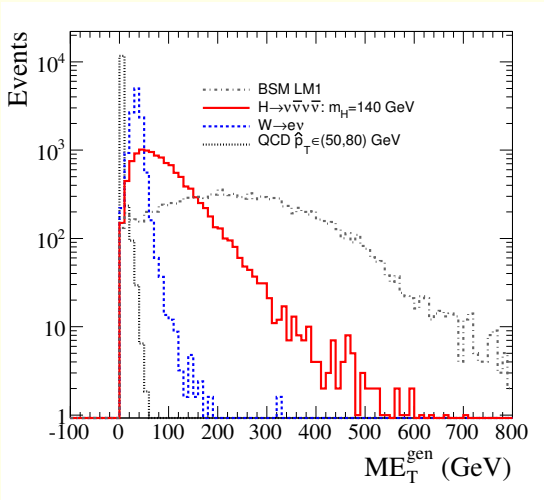
	HB	HO	HE (5^0)	HE (10^0)	HF1	HF2	EB	EE	EB/EE crystal
B	0.9	1.1	1.4	1.4	1.2	1.8	0.2	0.45	0.09/0.45
A	0.7	0.85	0.9	0.9	1.2	1.8	0.2	0.45	0.09/0.45

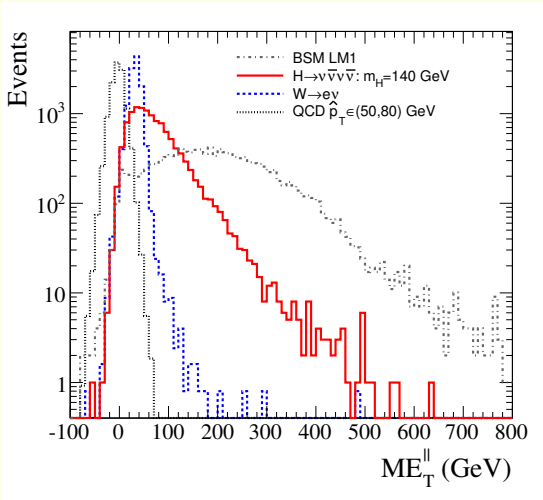
MET Resolution

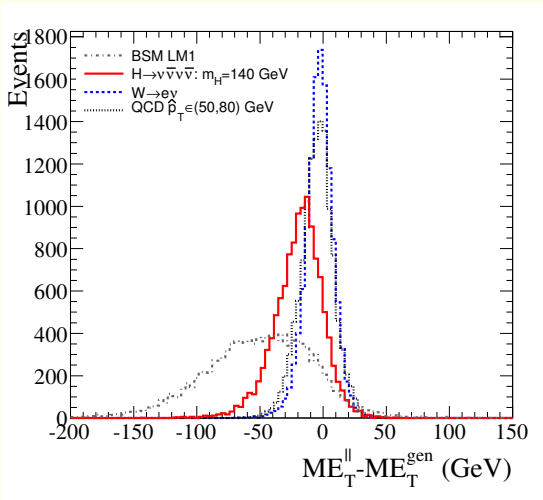
- $\not{E}_T$ Resolution:

$$\Delta \not{E}_T \equiv \vec{\not{E}_T}^{\,\mathbf{rec}} \cdot \vec{\not{E}_T}^{\,\mathbf{gen}} - \not{E}_T{}^{gen} \equiv \not{E}_T{}^{\parallel} - \not{E}_T{}^{gen}$$

- MC Samples in CMSSW_1_5_2: (resolution: RMS)
  - ◇ QCD ($\hat{p}_T \in (50, 80)$ GeV),
  - ◇ Vector boson fusion (VBF) $H \to ZZ$ ($Z \to \nu\bar{\nu}$) with $m_H = 140$ GeV,
  - ◇ Inclusive $W \to e\nu$,
  - ◇ BSM LM1.

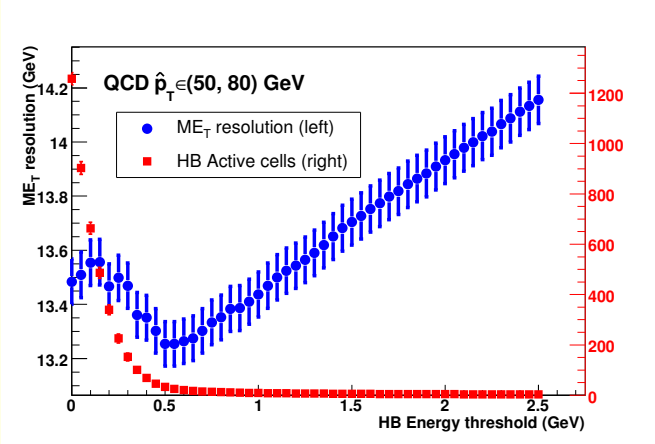


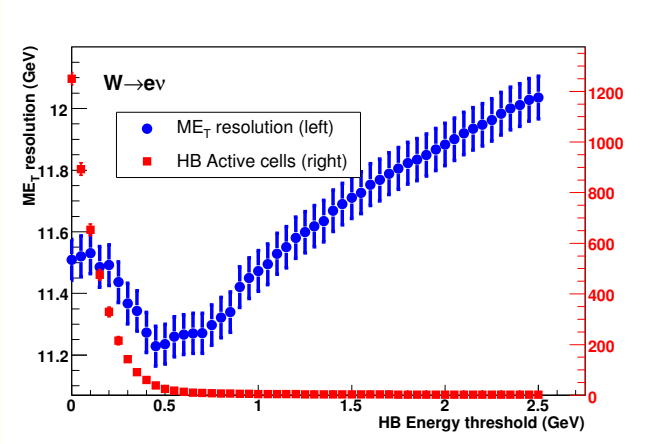




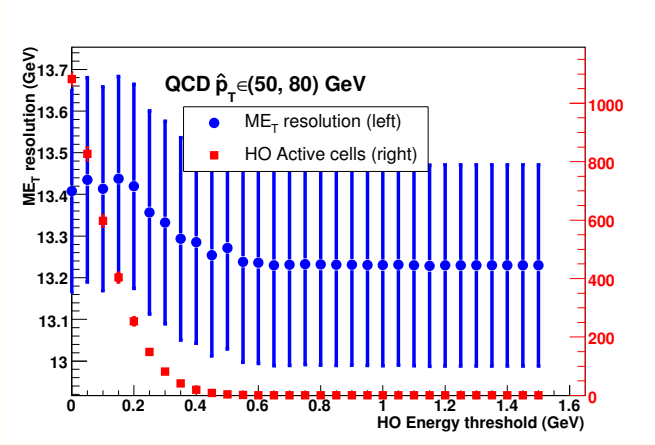
$\sigma_{\not{E}_T}$ v.s. HB/HO Cell Energy Thresholds

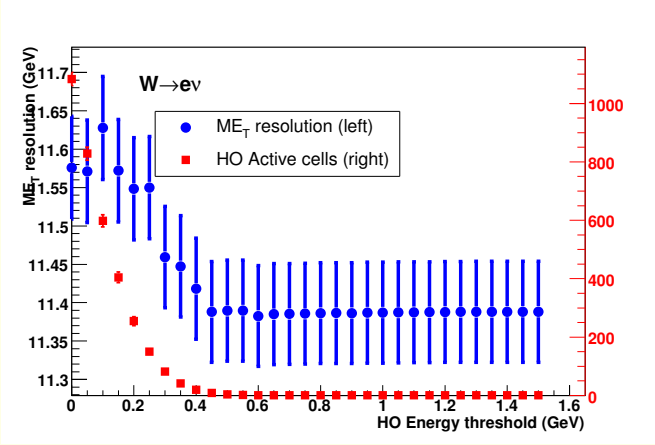
- $\not{E}_T$ resolution and active cells: default 0.9 GeV $\rightarrow$ 0.5 GeV (optimal).





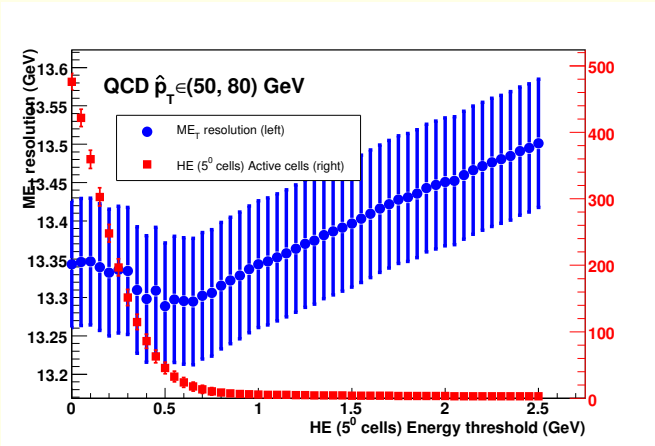
- $\not{E}_T$ resolution for HO: default 1.1 GeV $\rightarrow$ 0.5 GeV (optimal).

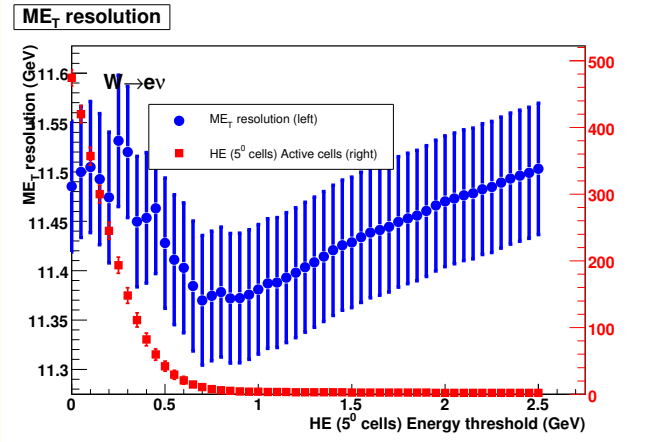




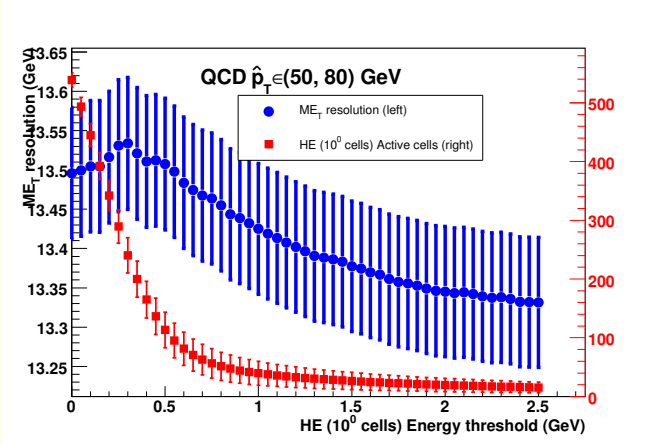
$\sigma_{\not{E}_T}$ v.s. HE Cell Energy Thresholds

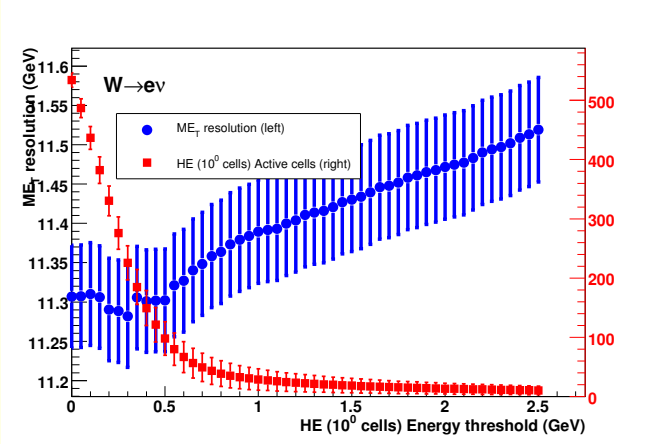
- $\not{E}_T$ resolution for HE 5^0 cells: default 1.4 GeV $\rightarrow$ 0.7 GeV (optimal).





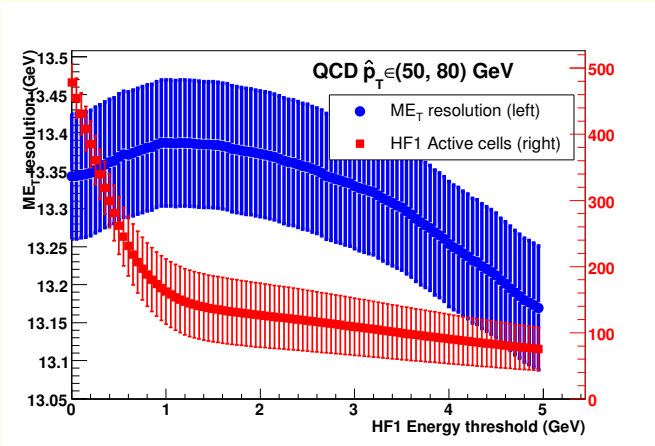
- $\not{E}_T$ resolution for HE 10^0 cells: default 1.4 GeV $\rightarrow$ 0.5 GeV (optimal).

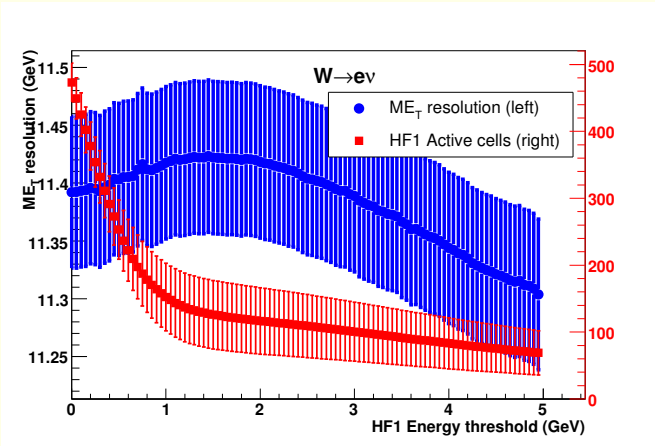




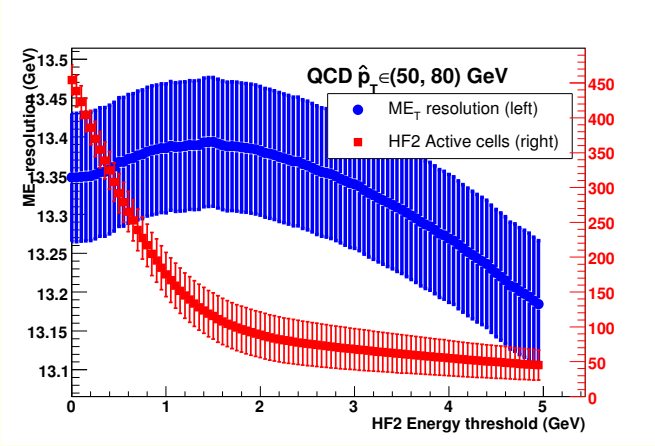
$\sigma_{\not{E}_T}$ v.s. HF Energy Thresholds

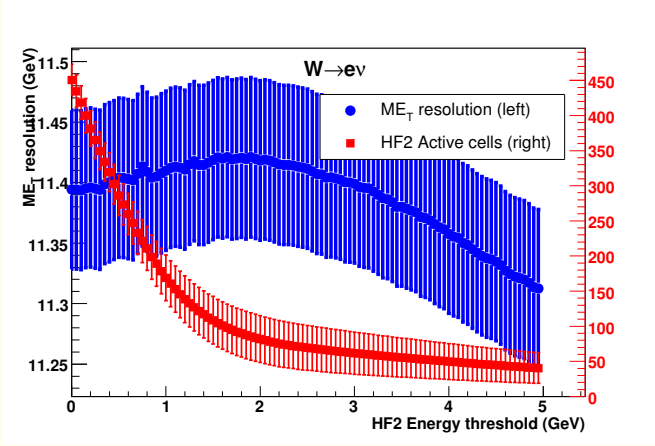
- $\not{E}_T$ resolution for HF long fiber (default 1.2 GeV)





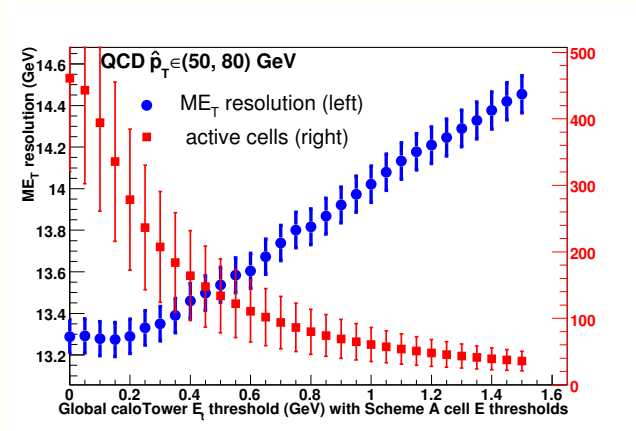
- $\not{E}_T$ resolution for HF short fiber (default 1.8 GeV)

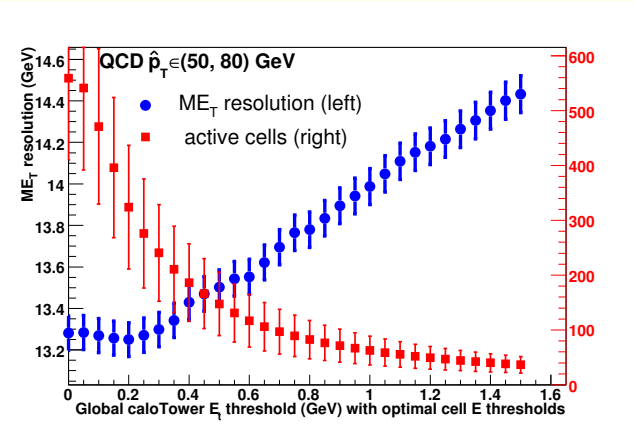


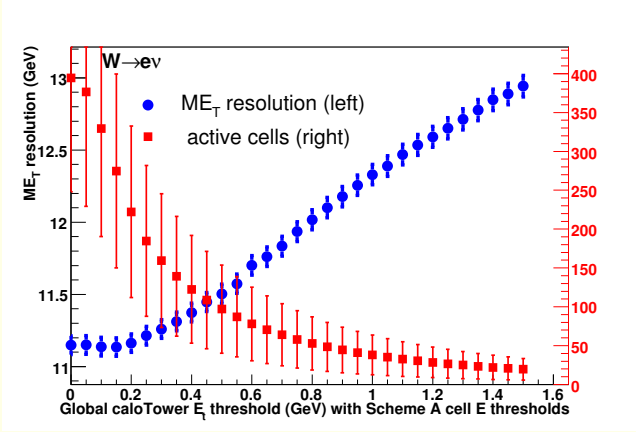


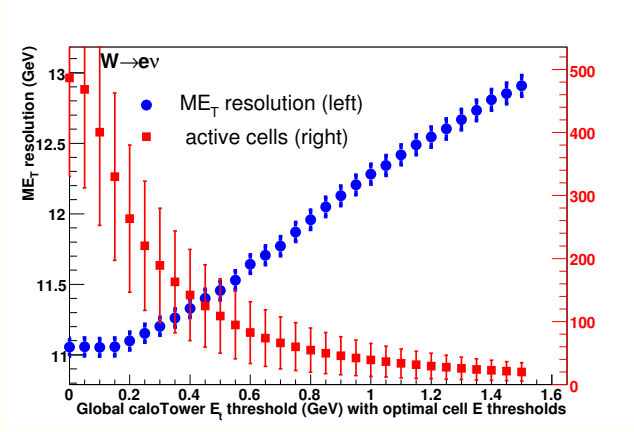
$\sigma_{\not{E}_T}$ v.s. Calotower E_t Threshold

- CMSSW: cell E + calotower transverse energy (E_t) threshold (not applied)
  - Scheme A cell E thresholds (left)
  - Optimal cell E thresholds (right)





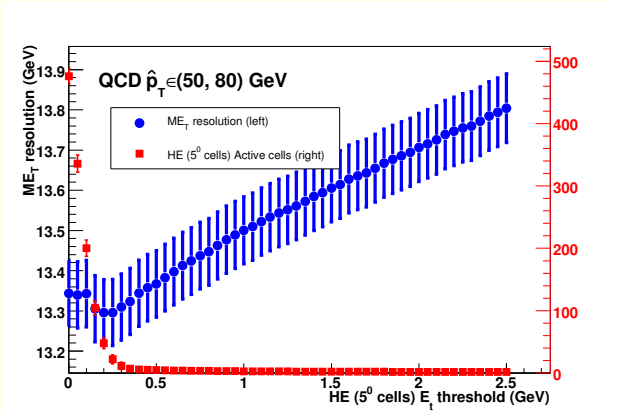


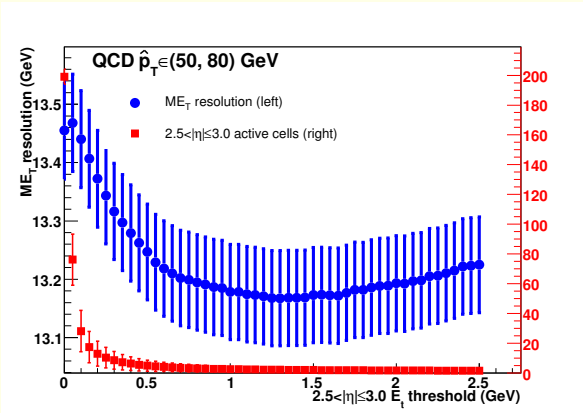


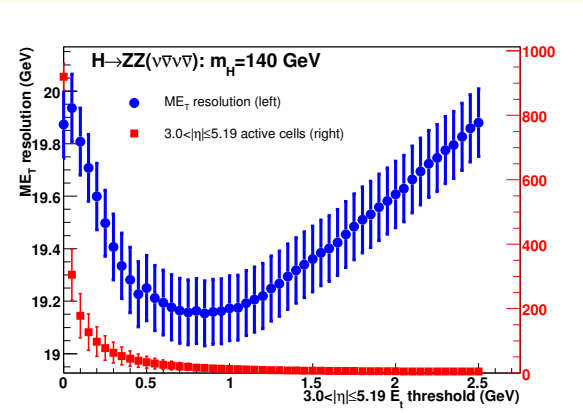
- Optimal calotower E_t threshold: 0.2 GeV (Scheme B too, $\not{E}_T$ σ later)

$\sigma_{\not{E}_T}$ v.s. Cell Transverse Energy Thresholds

- $\not{E}_T$ resolution as a function of cell transverse energy thresholds with default cell energy thresholds for other subdetectors and for different η regions







- Preliminary cell transverse energy thresholds (in GeV):

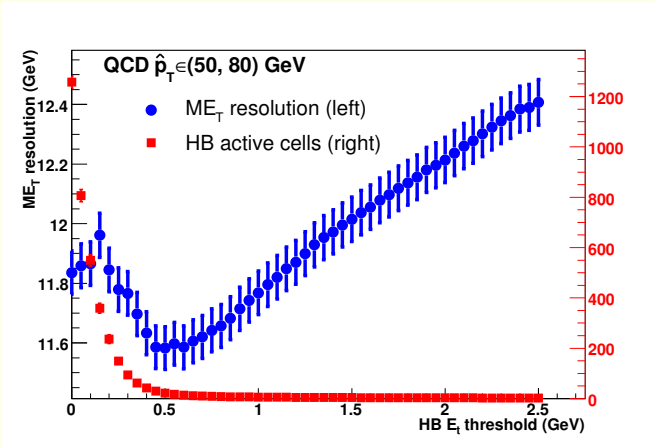
	HB	HO	HE (5^0)	HE (10^0)	HF (long)	HF (short)
optimal	0.4	0.4	0.3	0.2	1.0	1.0

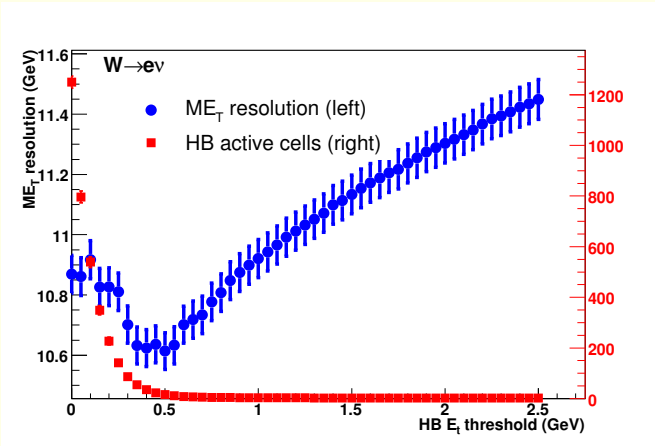
- Using the above cell transverse energy thresholds, repeat the above study with cell transverse energy thresholds applied

	HB	HO	HE (5^0)	HE (10^0)	HF (long)	HF (short)
optimal	0.4	0.5	0.3	0.4	0.7	1.0

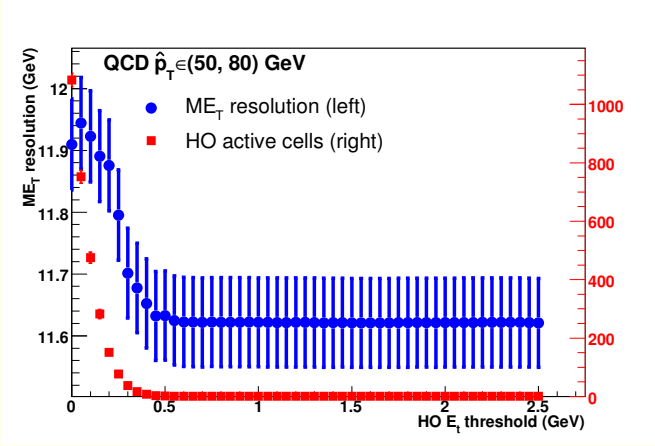
$\sigma_{\not{E}_T}$ v.s. Cell Transverse Energy Thresholds

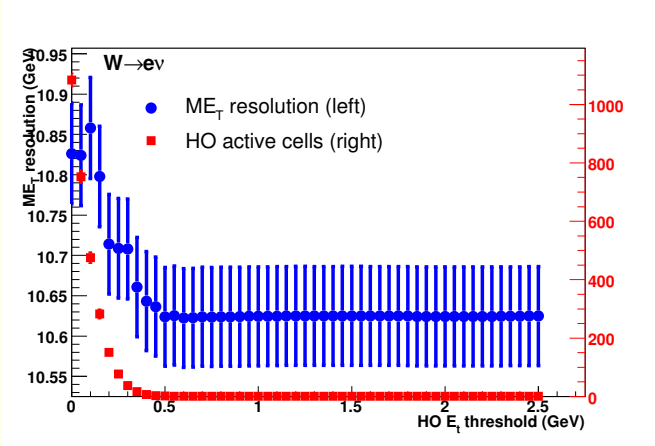
- Optimal cell E_t threshold: 0.4 GeV (HB)





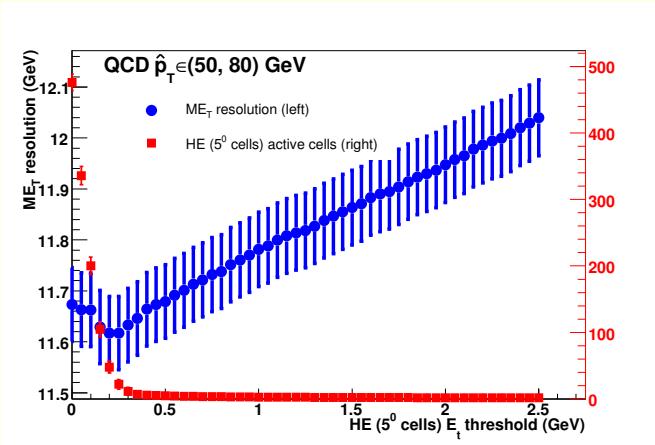
- Optimal cell E_t threshold: 0.5 GeV (HO)

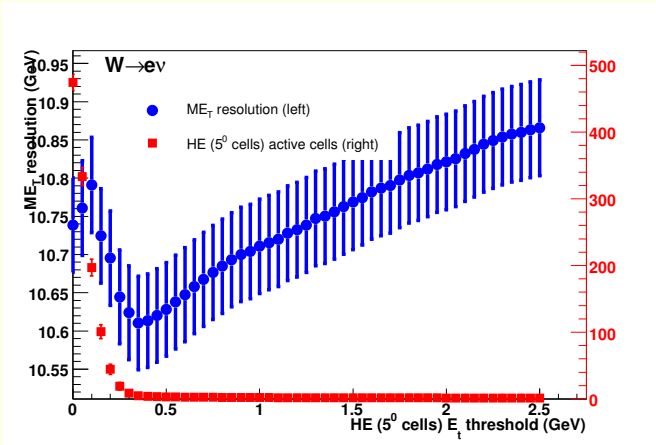




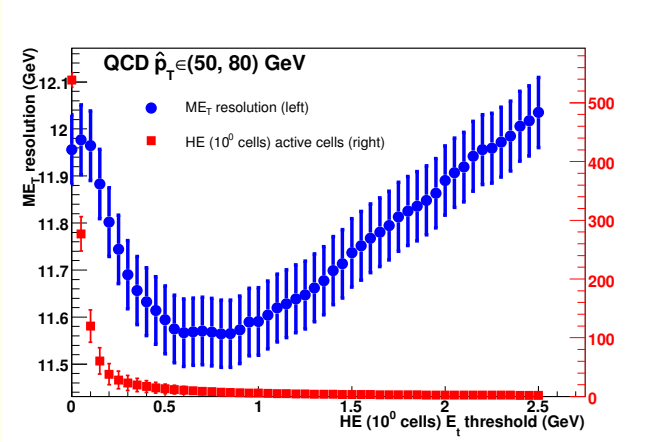
$\sigma_{\not{E}_T}$ v.s. Cell Transverse Energy Thresholds

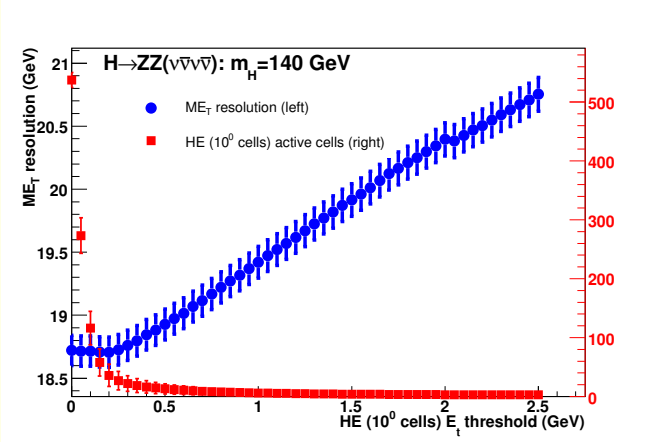
- Optimal cell E_t threshold: 0.3 GeV (HE 5^0 cells)





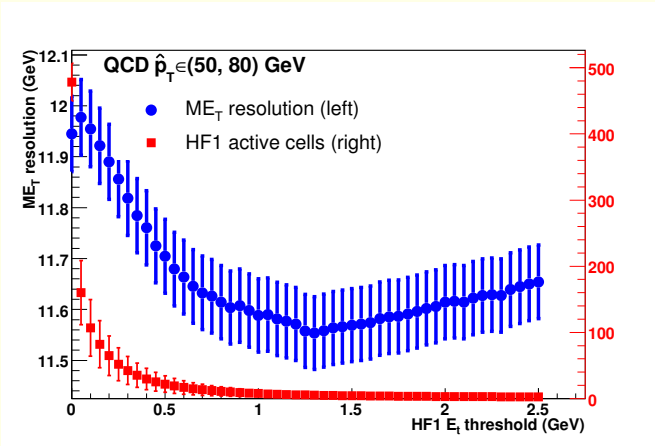
- Optimal cell E_t threshold: 0.4 GeV (HE 10^0 cells)

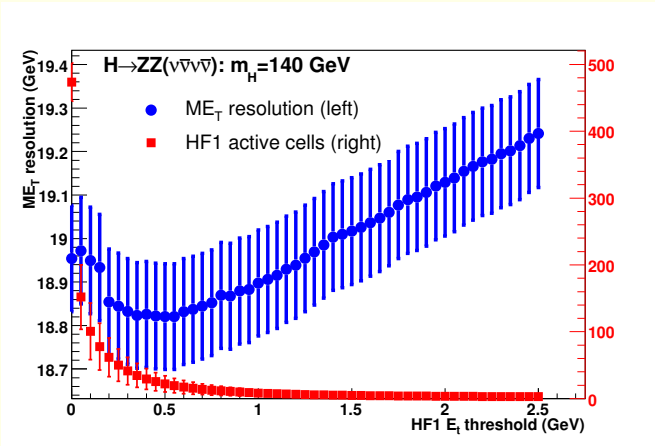




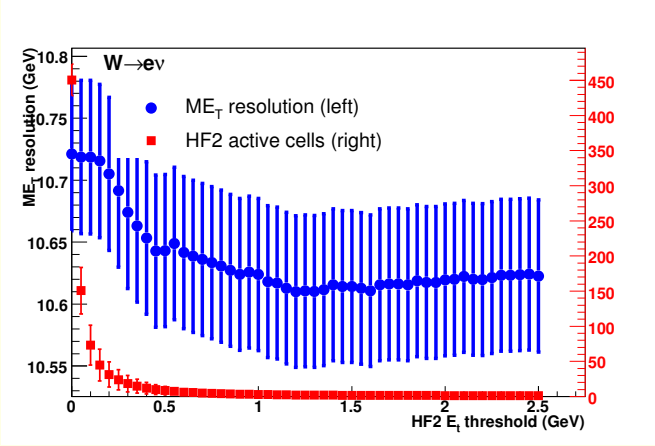
$\sigma_{\not{E}_T}$ v.s. Cell Transverse Energy Thresholds

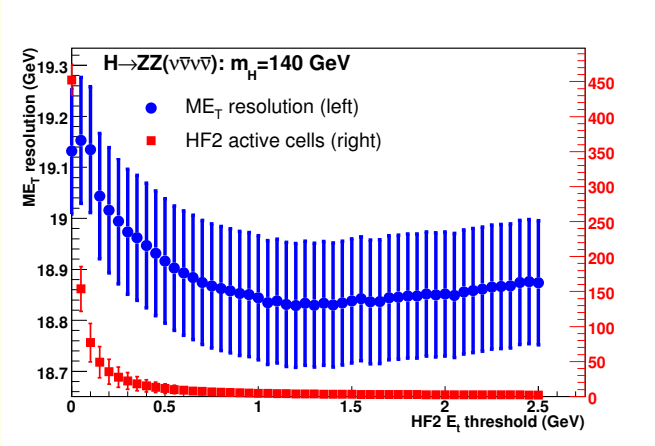
- Optimal cell E_t threshold: 0.7 GeV (HF long fiber)





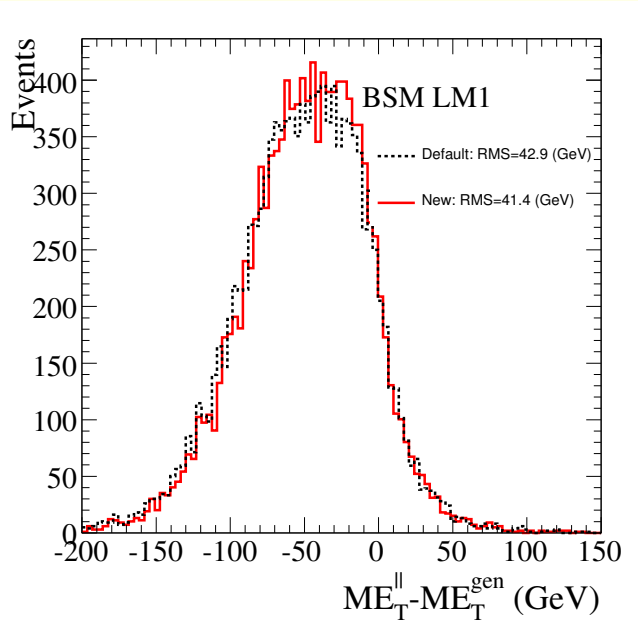
- Optimal cell E_t threshold: 1.0 GeV (HF short fiber)

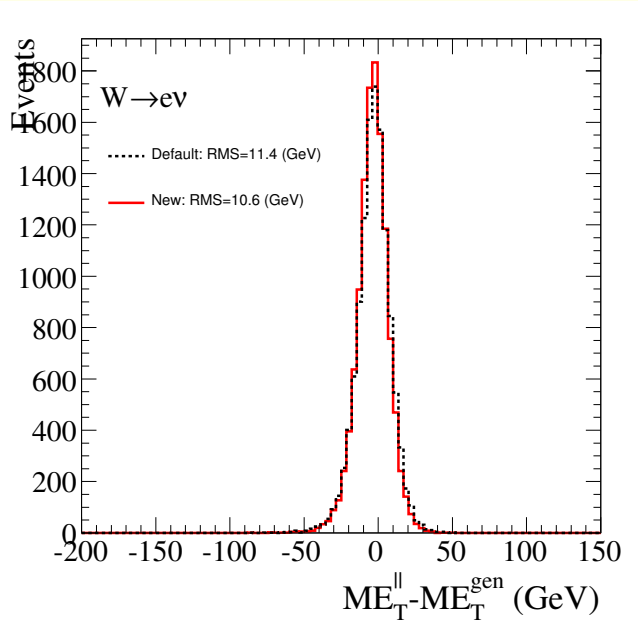


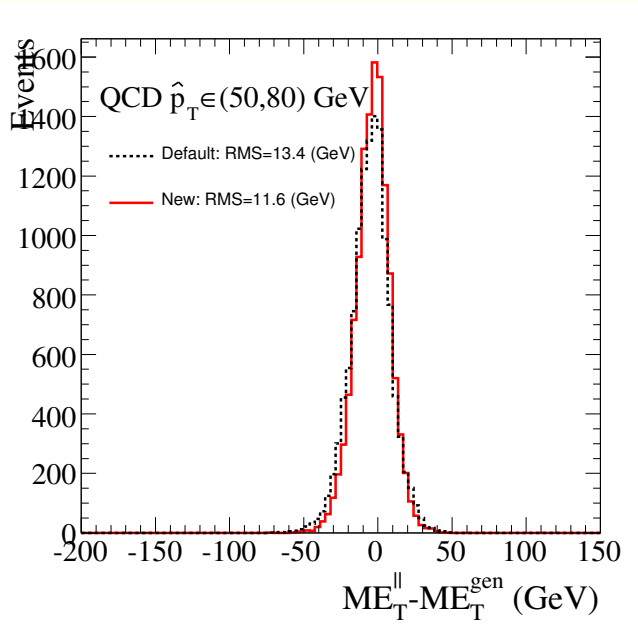


Comparison of $\sigma_{\not{E}_T}$

- $\sigma_{\not{E}_T}$ with default cell energy thresholds and new cell E_t thresholds
- $\sigma_{\not{E}_T}$ improved by 3.5% (BSM LM1), 5% ($H \to ZZ$, $Z \to \nu\bar{\nu}$), 7% ($W \to e\nu$), and 13.5% (QCD)

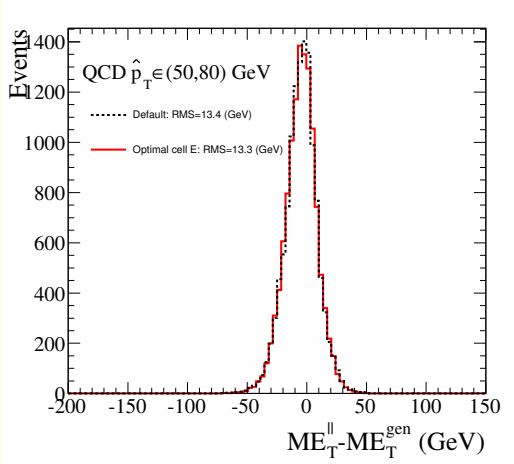


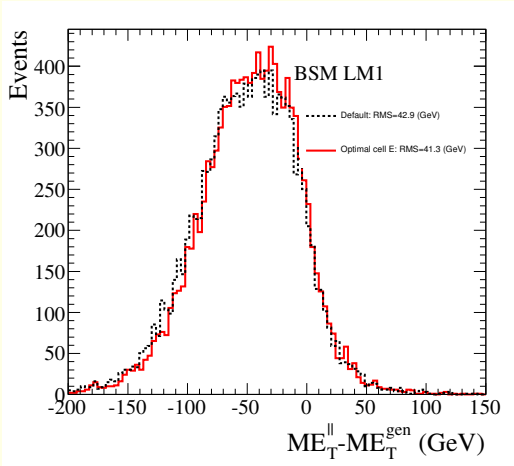




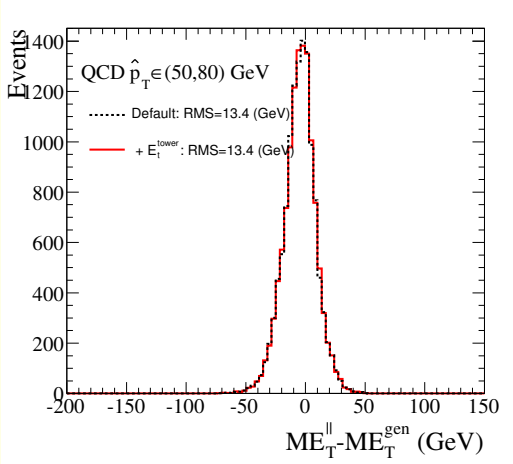
Comparison of $\sigma_{\not{E}_T}$

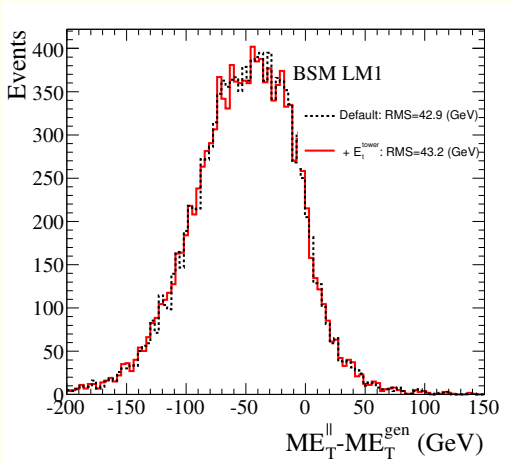
- Improved by 1∼4% with optimal cell energy thresholds





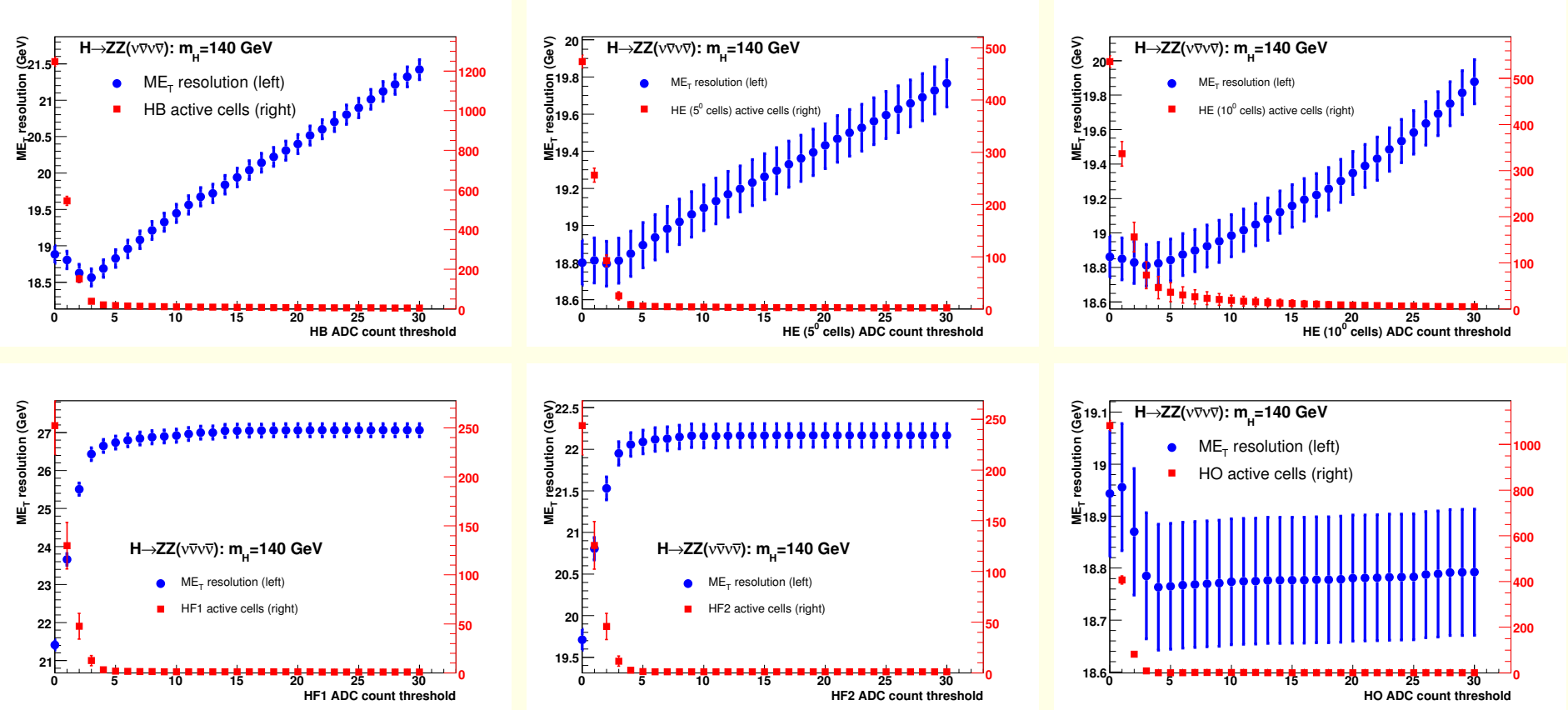
- Improved by −0.5∼0% with default cell energy + calotower E_t thresholds





$\sigma_{\not{E}_T}$ v.s. ADC Count Thresholds

- Different detector response in each sub-detector
- $\sigma_{\not{E}_T}$ as a function of ADC counts with pedestals subtracted
- We found universal ADC count thresholds ≥ 3 for all subdetectors



Summary

- We found optimal cell energy thresholds for HCal, current default thresholds for HF long fiber (1.2 GeV) and short fiber (1.8 GeV) look reasonable

Subdetector	HB	HO	HE (5^0)	HE (10^0)	HF (long)	HF (short)
Energy (GeV)	0.5	0.5	0.7	0.5	1.2 (default)	1.8 (default)

- We found optimal calotower transverse energy threshold (0.2 GeV) with cell energy thresholds applied
- We found universal ADC count thresholds (≥ 3) for all subdetectors
- We found optimal cell transverse energy E_t thresholds for HCal

Subdetector	HB	HO	HE (5^0)	HE (10^0)	HF (long)	HF (short)
E_t (GeV)	0.4	0.5	0.3	0.4	0.7	1.0

- With the above optimal E_t thresholds, $\sigma_{\not{E}_T}$ improved by 4% to 14% dependent on the physics processes, compared to the default cell energy thresholds (Scheme B) for recoMET, all others by <4%.
- We'd like to propose the above cell transverse energy E_t thresholds for recoMET instead of cell energy thresholds which can be implemented in paralell to E thresholds in CMSSW