On HCAL needs beyond 3.0

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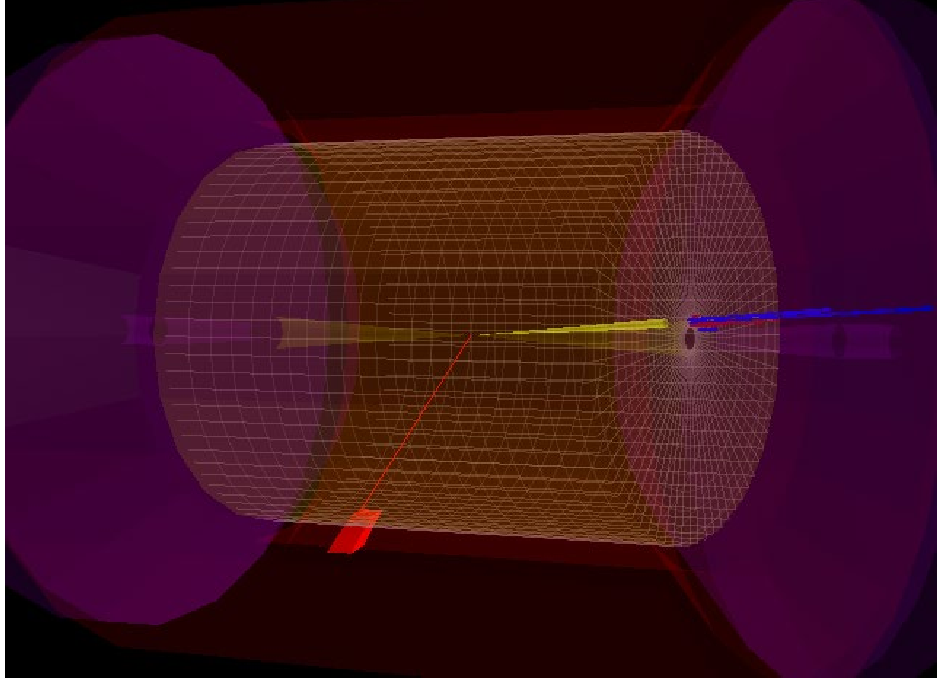
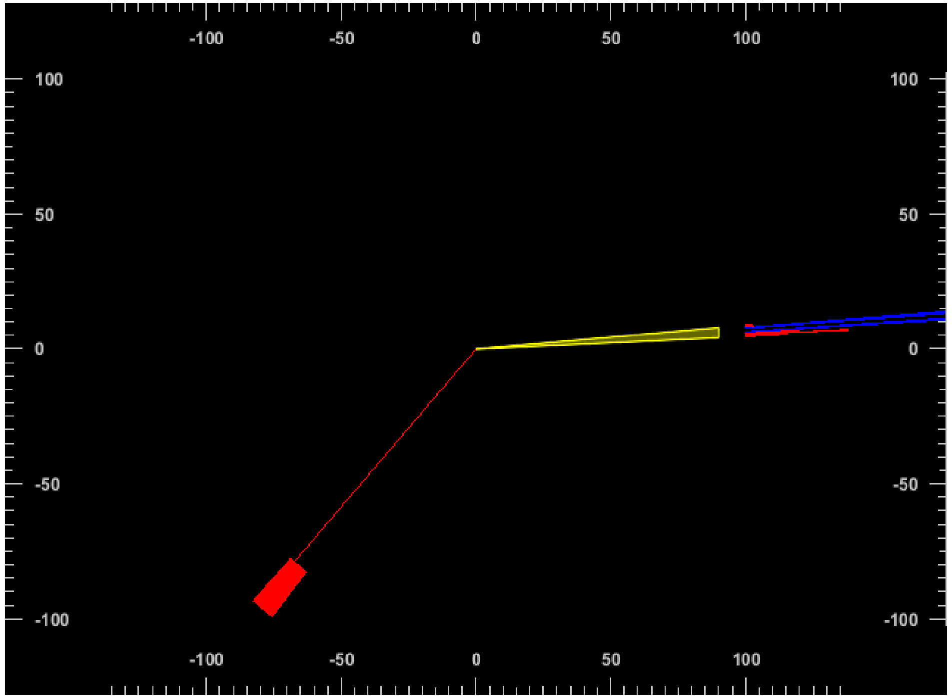
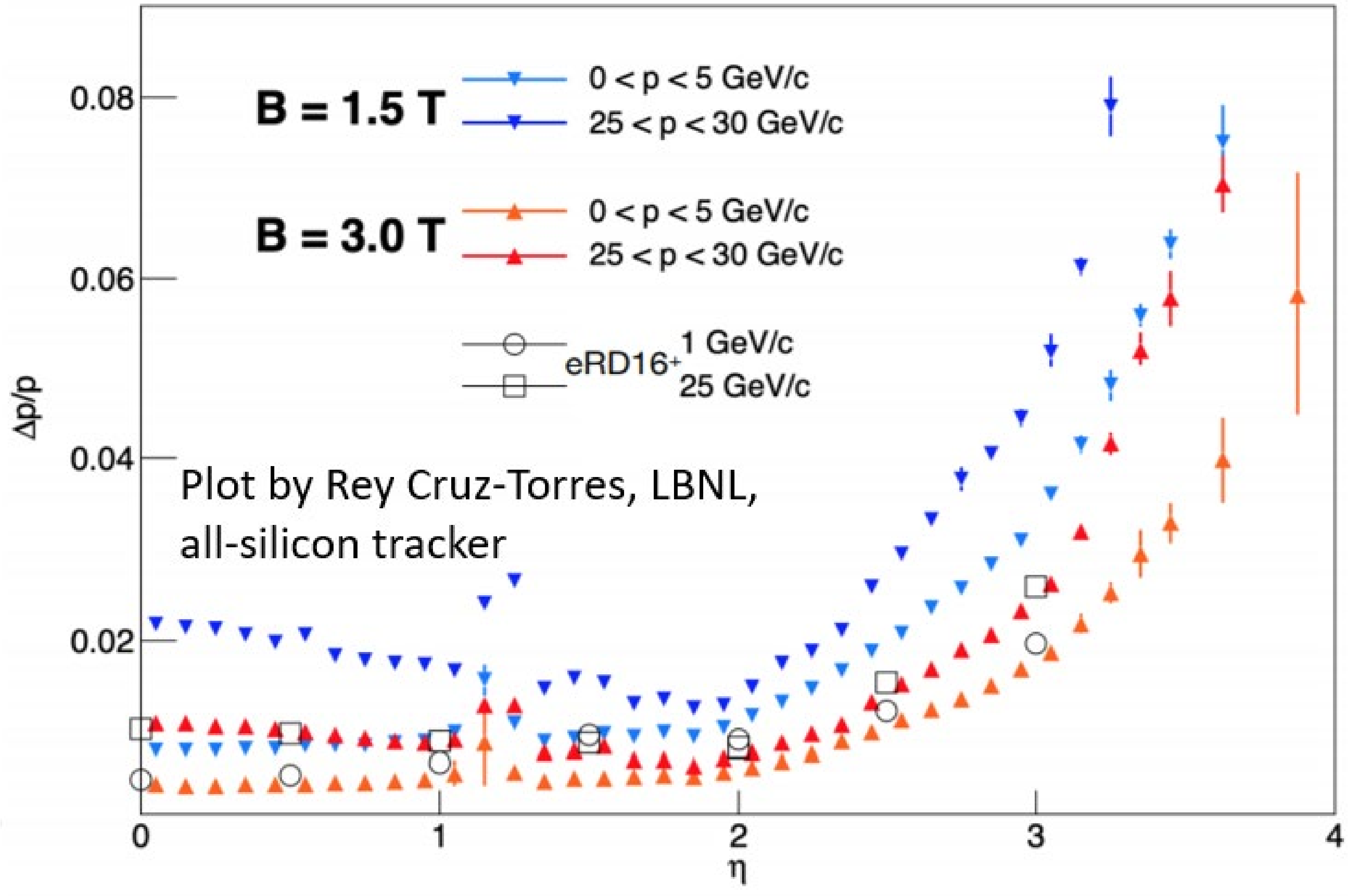




Realistic simulations show tracking performance deteriorates fast beyond eta = 3.0

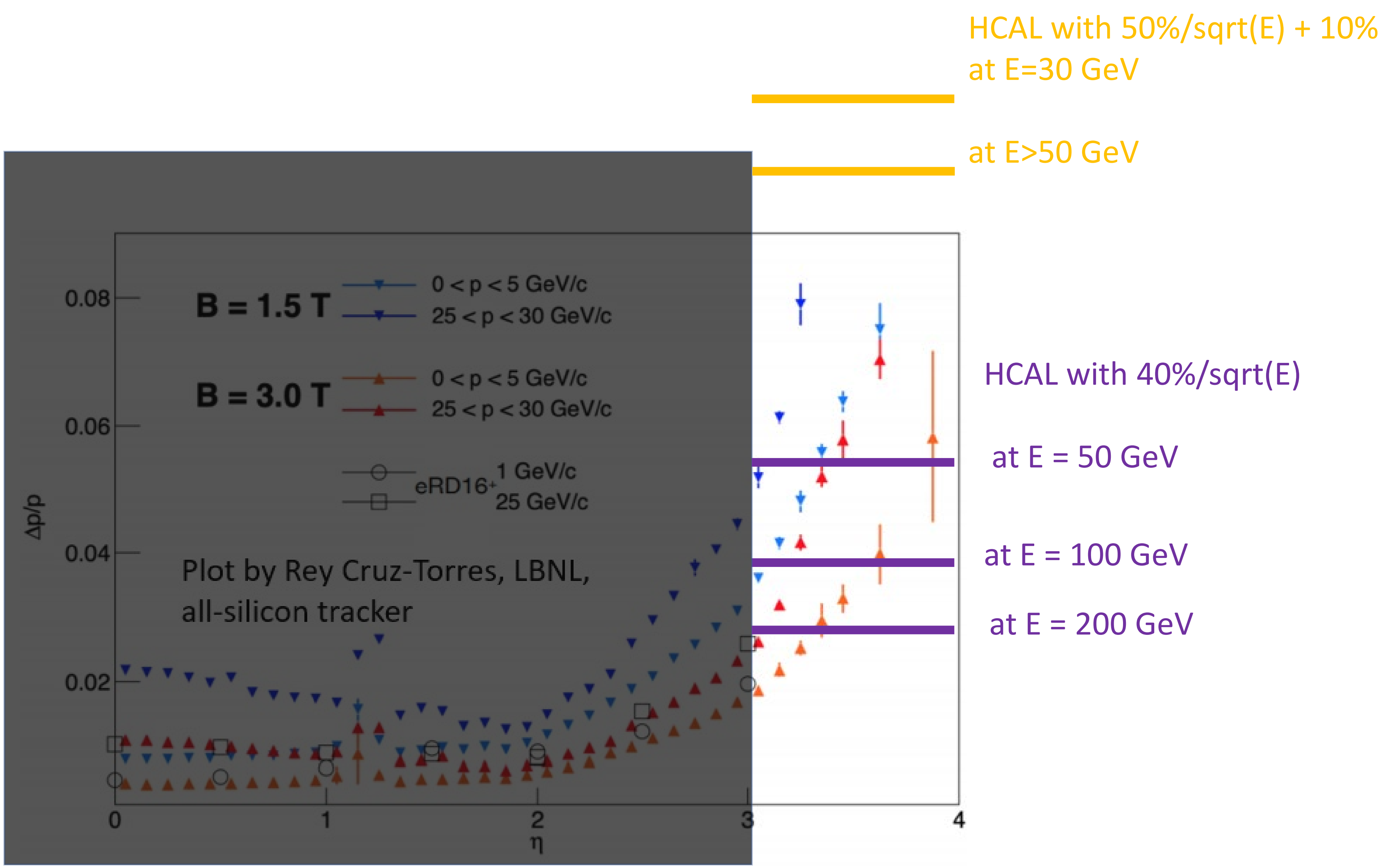


Realistic simulations show tracking performance deteriorates fast beyond eta = 3.0, but currently the detector matrix states:

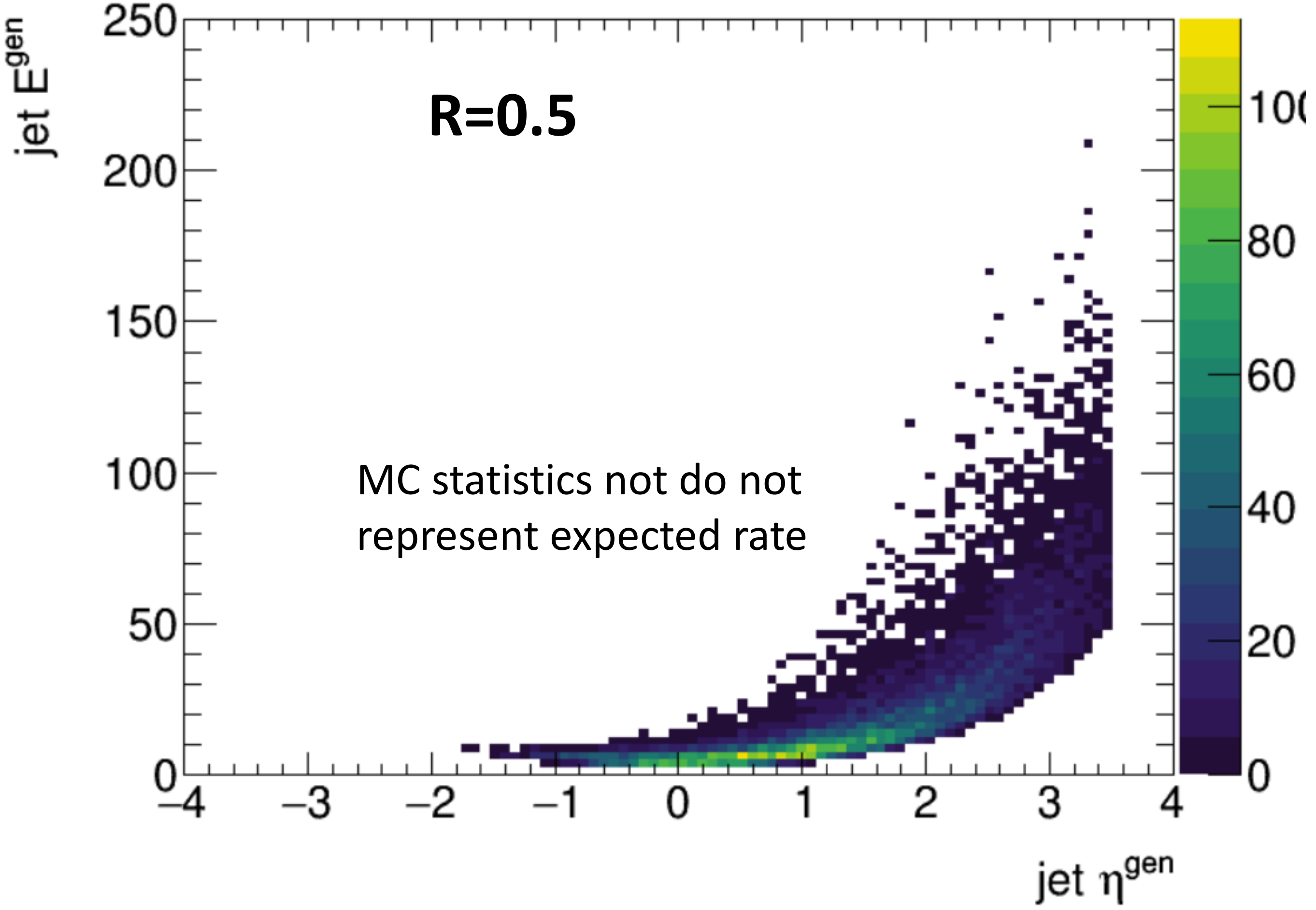
16	1.0 to 1.5				
17	1.5 to 2.0			Forward Detectors	σp/p ~0.05%×p+1.0%
18	2.0 to 2.5				
19	2.5 to 3.0				σp/p ~ 0.1%×p+2.0%
20	3.0 to 3.5				

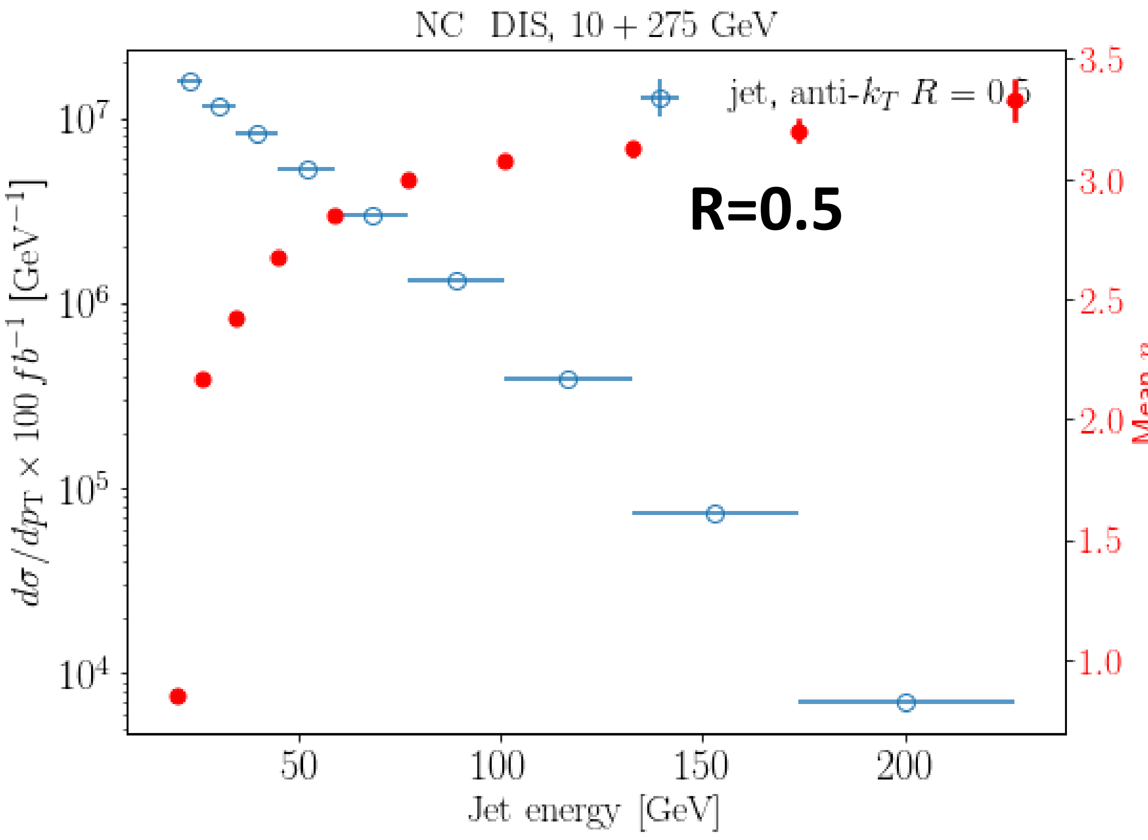
Totally unrealistic requirements in detector matrix?

- Are we misleading ourselves to wrongly conclude HCAL has little impact on jet and missing-energy measurements beyond eta=3.0?
- Given realistic performance, can PID even work beyond 3.0 up to 50 GeV, as currently stated in matrix?.

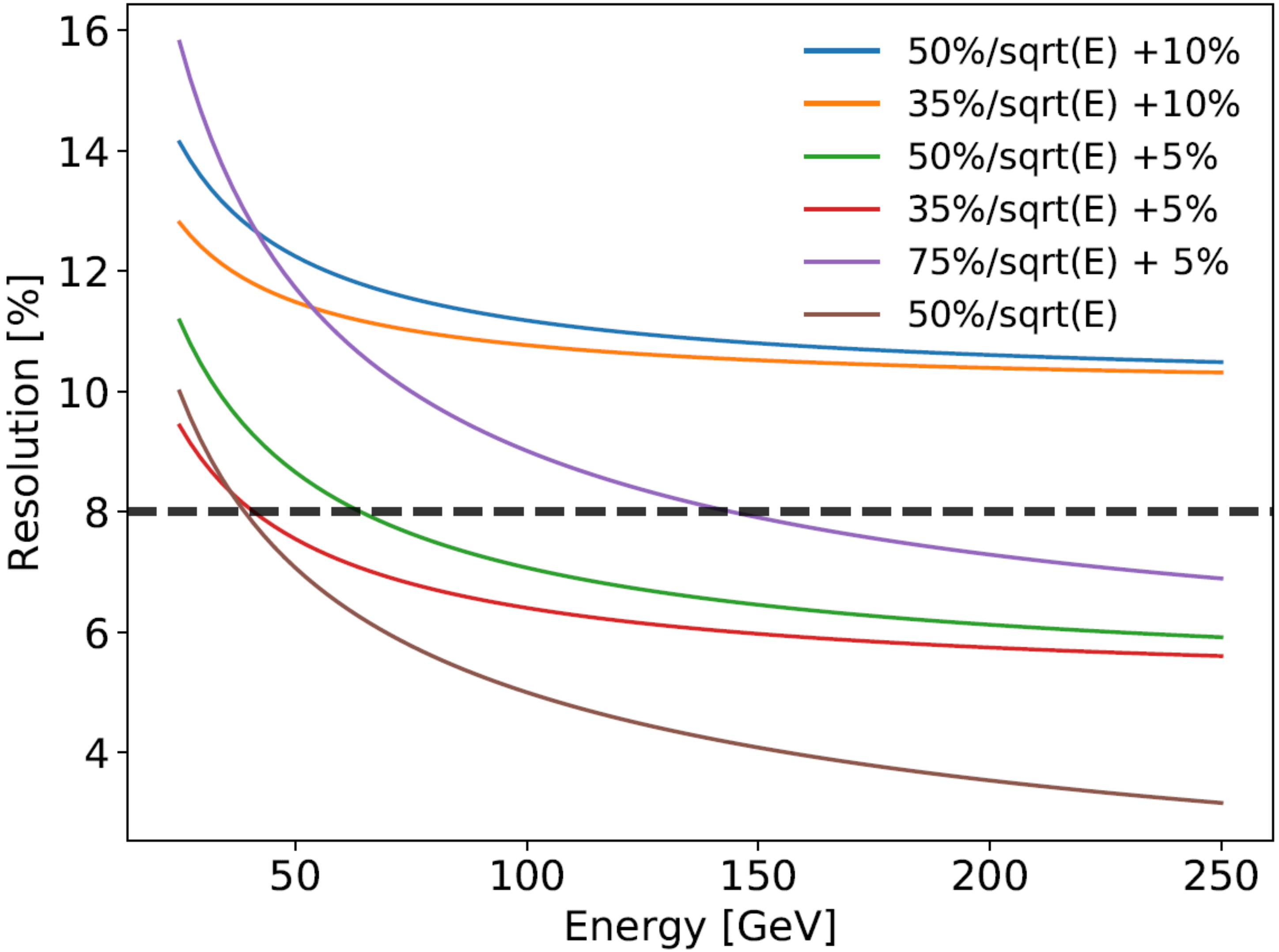

HCAL with 50%/sqrt(E) + 10%
at E=30 GeV
at E>50 GeV
B = 1.5 T
0 < p < 5 GeV/c
25 < p < 30 GeV/c
B = 3.0 T
0 < p < 5 GeV/c
25 < p < 30 GeV/c
eRD16+ 1 GeV/c
25 GeV/c
Δp/p
0.08
0.06
0.04
0.02
Plot by Rey Cruz-Torres, LBNL,
all-silicon tracker
HCAL with 40%/sqrt(E)
at E = 50 GeV
at E = 100 GeV
at E = 200 GeV
0
1
2
3
4
η

Jet kinematics and cross-section

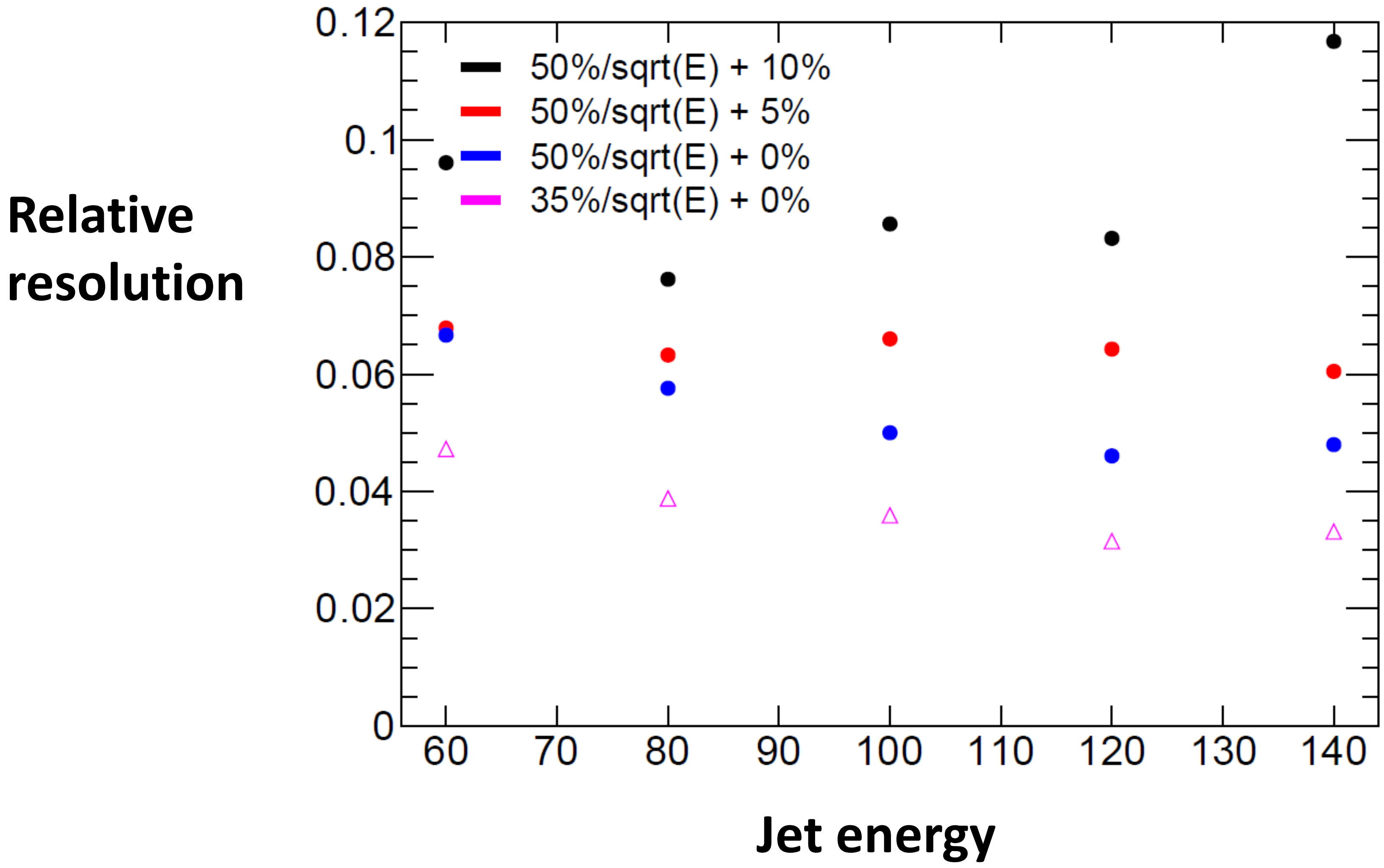




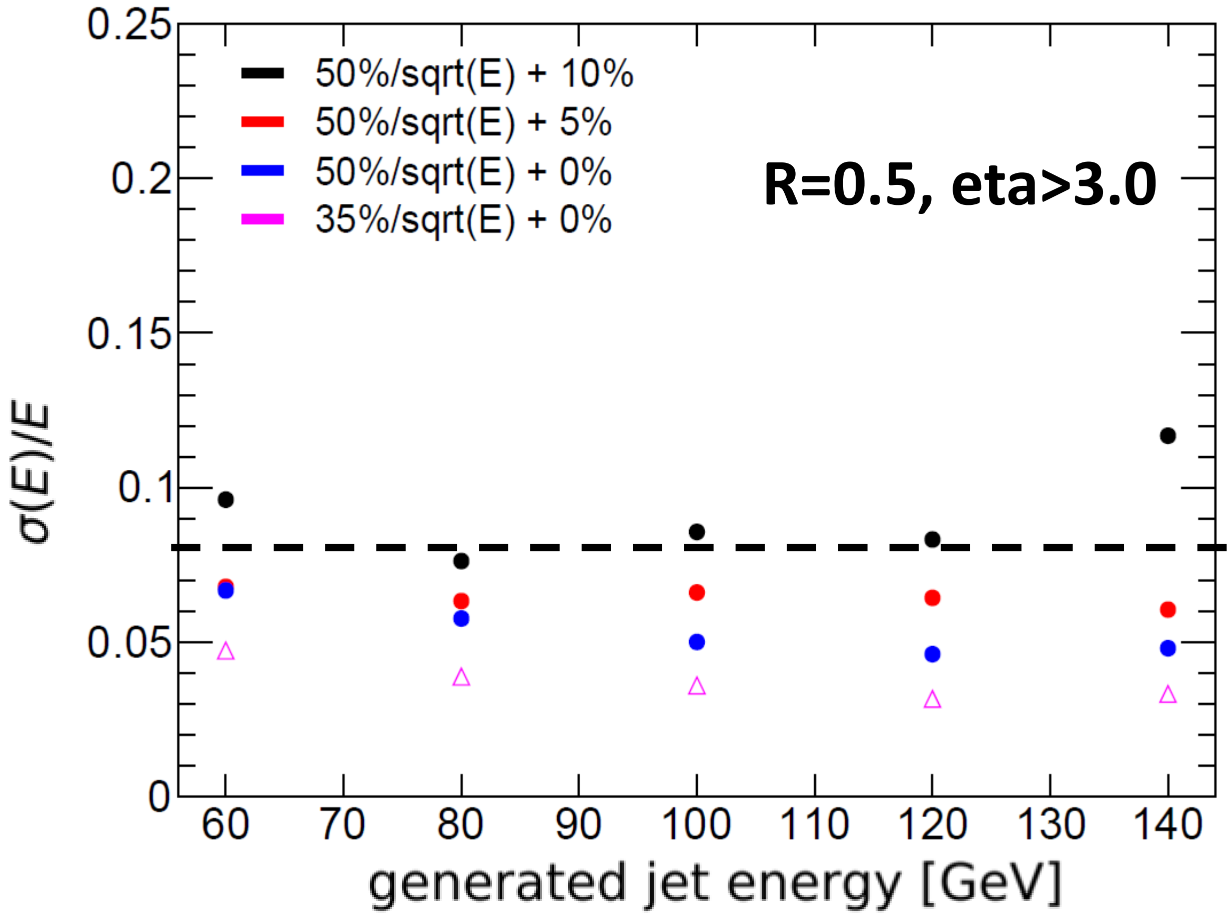
Role of stochastic and constant term for the relevant energies:

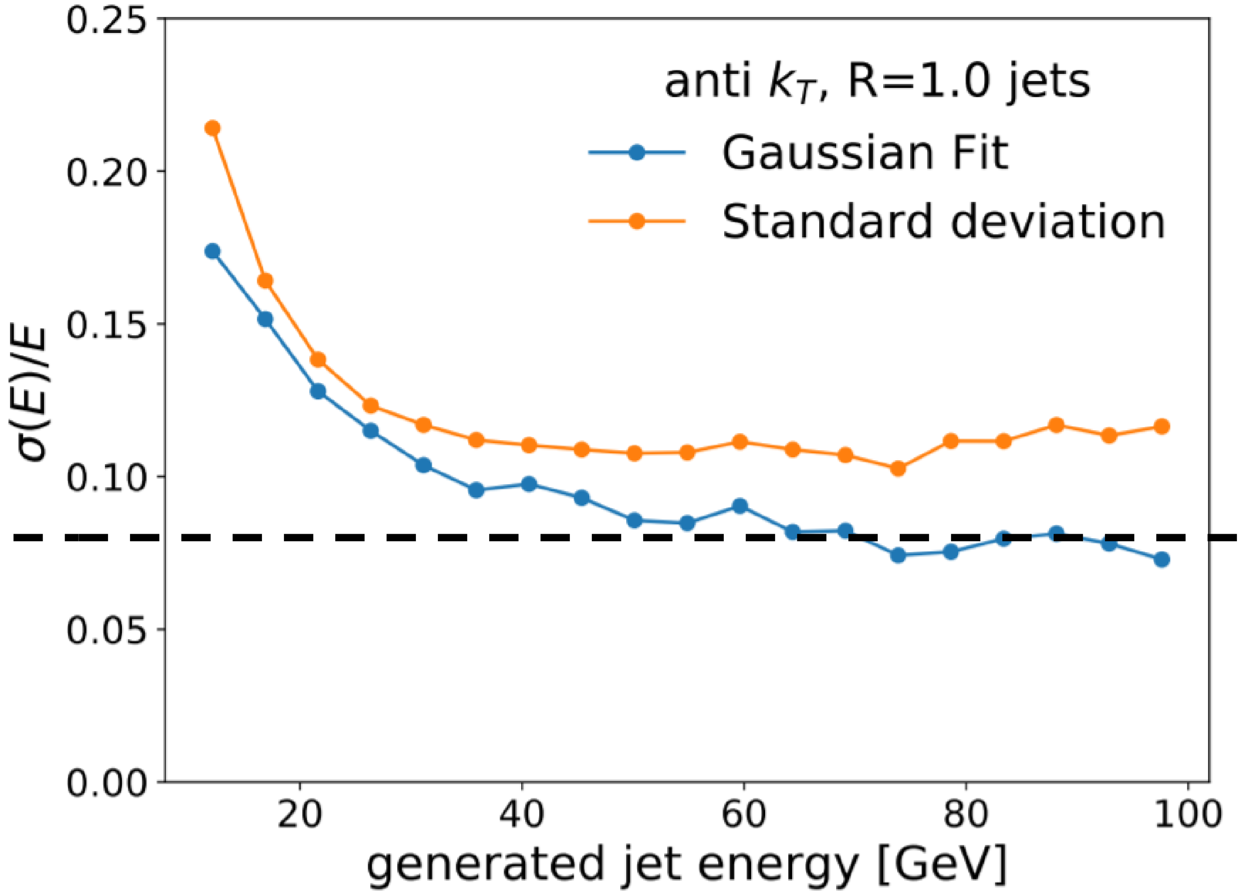


Jet energy resolution for jets with eta > 3.0

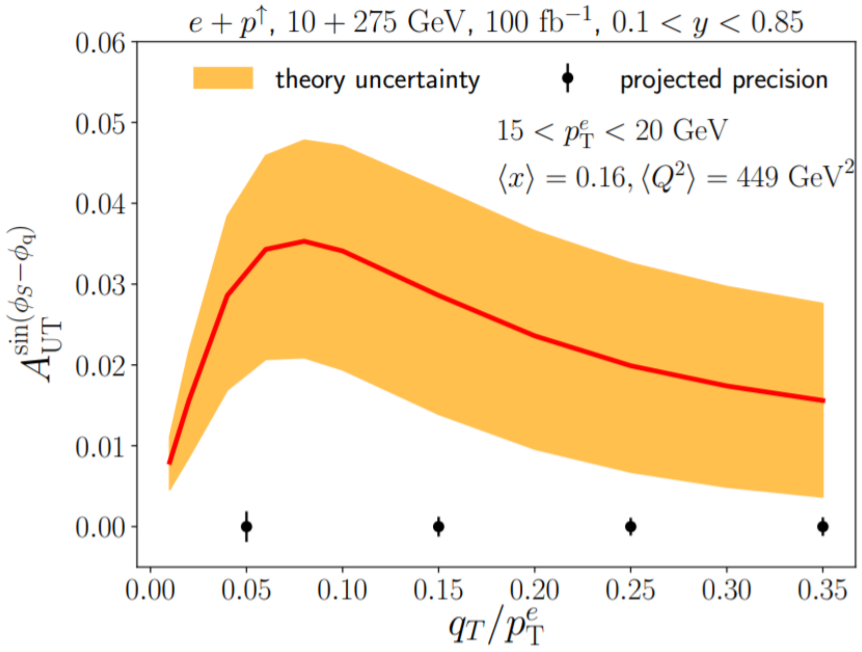


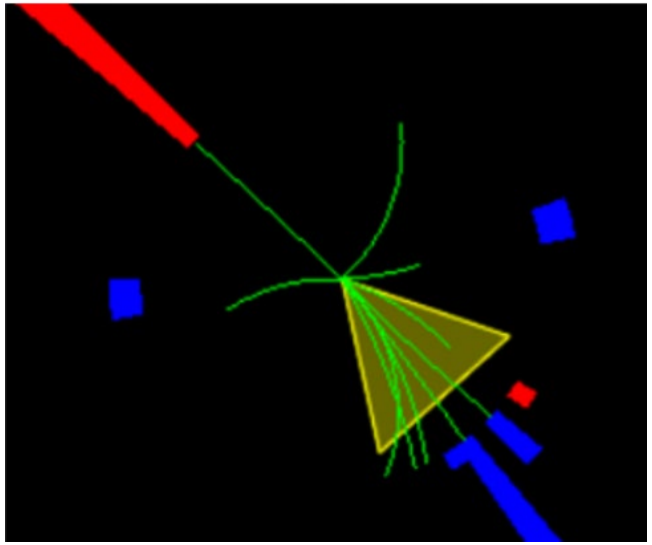
Jet energy resolution for forward and central jets

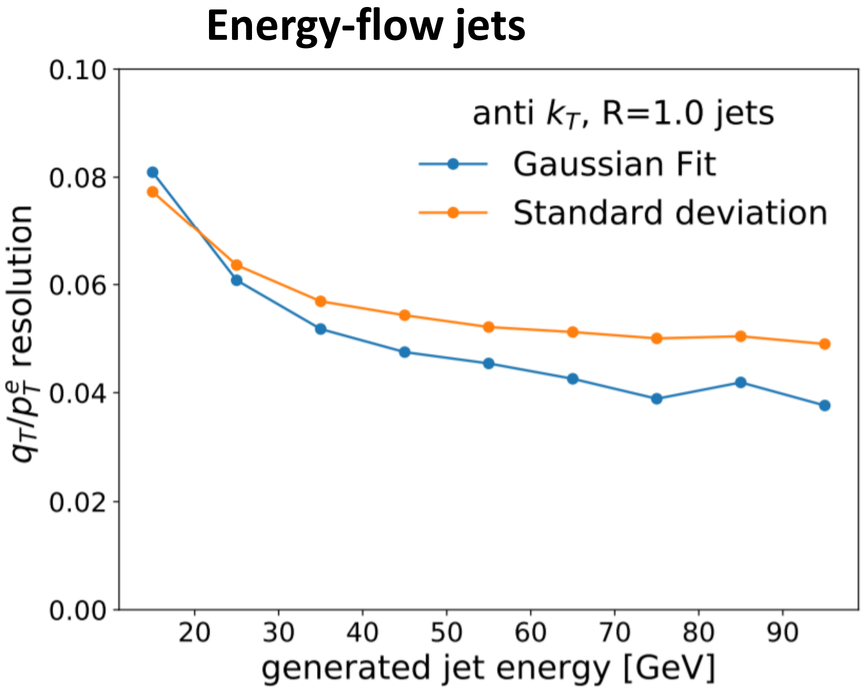




We estimated in arXiv:2007.07281 that for central jets (eta<2.5) we could measure the electron-jet Sivers asymmetry differentially:

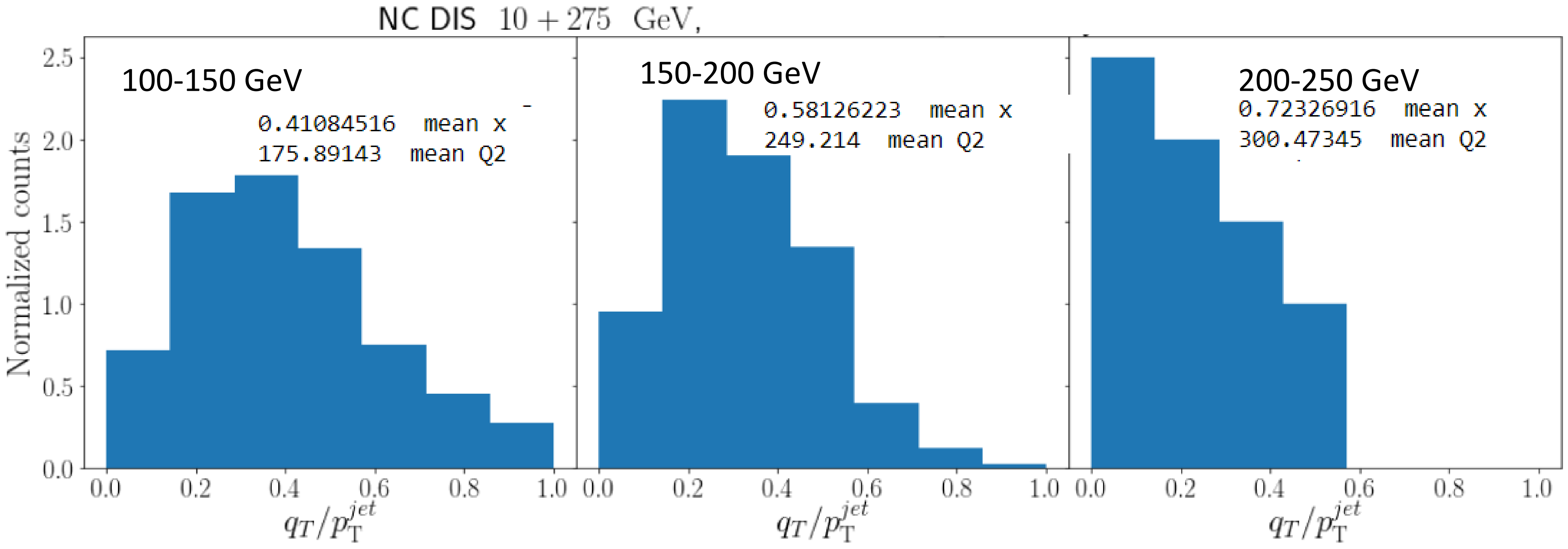




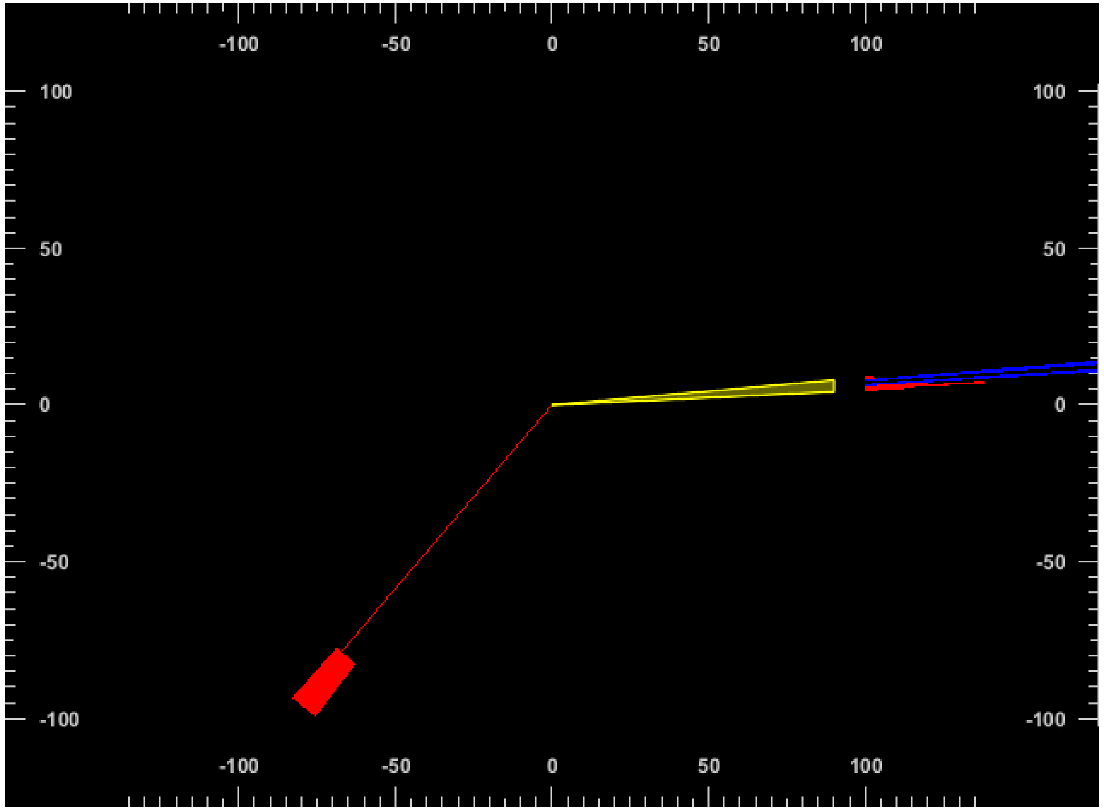


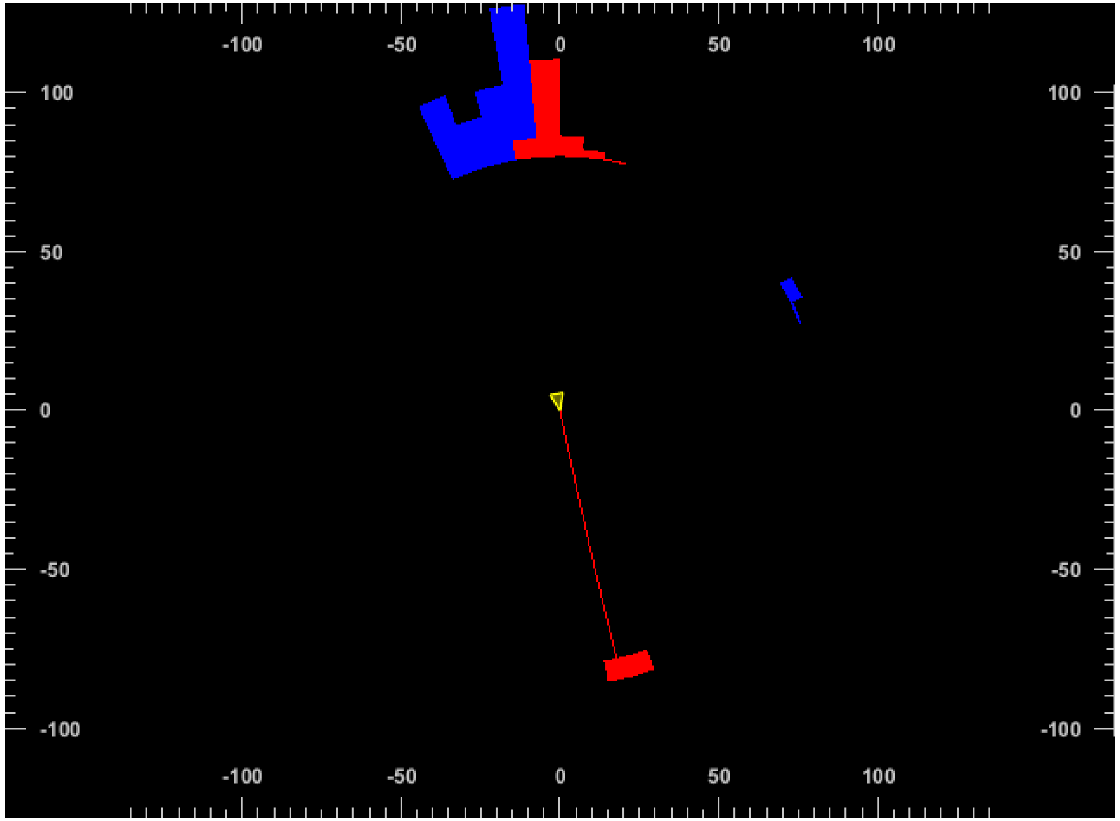
Although at the edge of what could be called differential.
With worse resolution we would have only 2 bins in the “TMD region”

The higher the jet energy, the narrower the qT peak -> need higher resolution to sample the peak



Electron-jet Sivers at high-x is more demanding…

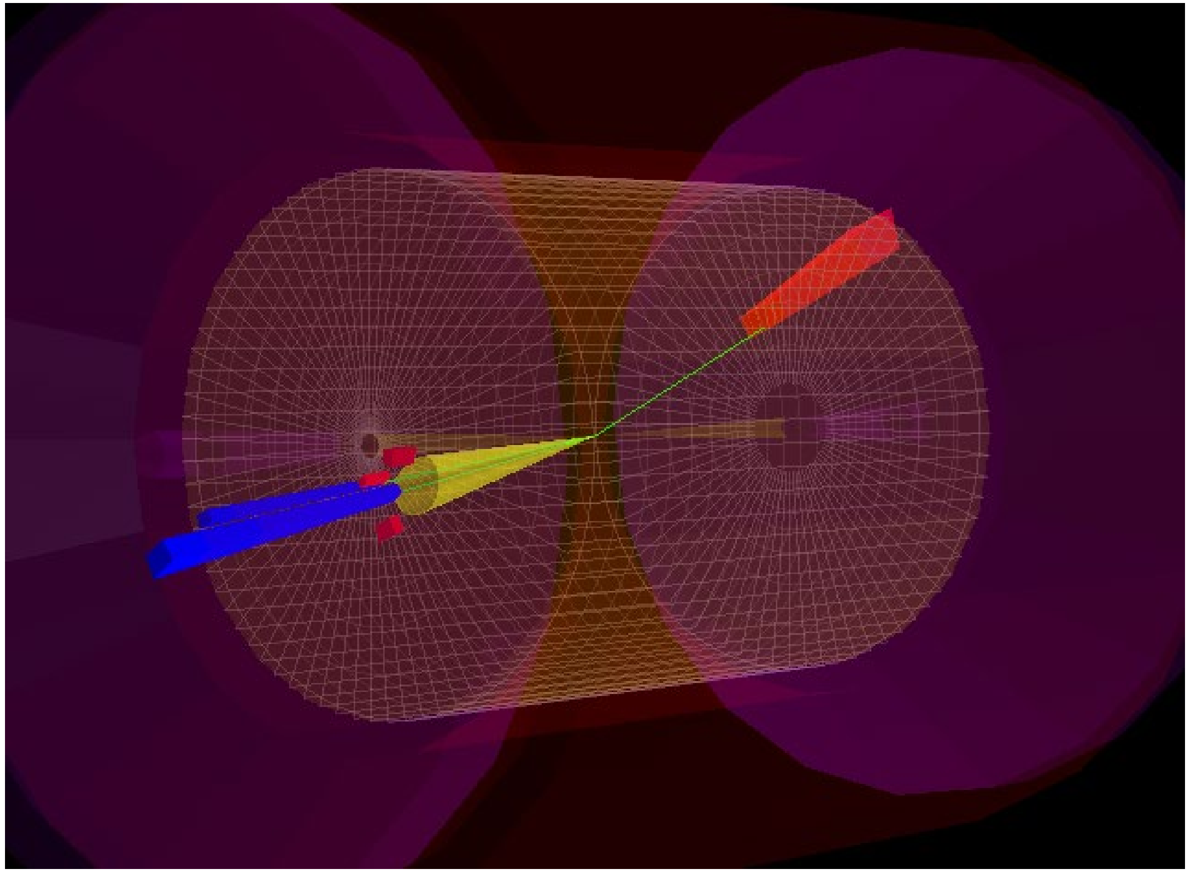




Constant term of ~5% at region 3.0-4.0
would put electron-jet Sivers within reach.

What would you gain optimizing acceptance and resolution of forward calorimetry?

High-x physics
(inclusive DIS, electron-jet Sivers and others TMDs)
Low-x physics
(forward jets sensitive to BFKL dynamics)
Spin physics
(polarized photoproduction)
Diffractive jets
(quark and gluon GPDs, saturation)
High-x pi0/eta SIDIS
…
…



Summary

- Realistic tracking performance suggest role of HCAL beyond 3.0 will be critical for jet, diffractive and high-x measurements. The seemingly unrealistic tracking performance assumed in the detector now at 3.0 and beyond can be misleading.
- HCAL required up to eta=+4.0 for acceptance of high-x events.
- HCAL resolution will likely drive jet-energy resolution for eta>3.0.
- Physics targets get more demanding at higher energies.
  HCAL constant term required to be ~5% to place differential measurement of electron-jet Sivers at high-x within reach.

Post scriptum:

The potential for a high-resolution (<50%) forward (3.0-4.0) HCAL is great, potentially jet (and Bjorken x) measurements with twice the resolution! One could make a strong case for forward physics program (3.0-4.0), which covers the EIC core science from end to end.