ZDC Studies for u-Channel Physics

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ePIC Current ZDC Design Parameters

ePIC current ZDC design
- 60×60 cm transverse area
- 2×2 cm transverse tower size
- Rough estimated high-energy resolution: $\Delta E/E \approx (2\%\text{-}5\%)/\sqrt{E} \oplus 1\%$

UC Riverside ZDC Design Parameters

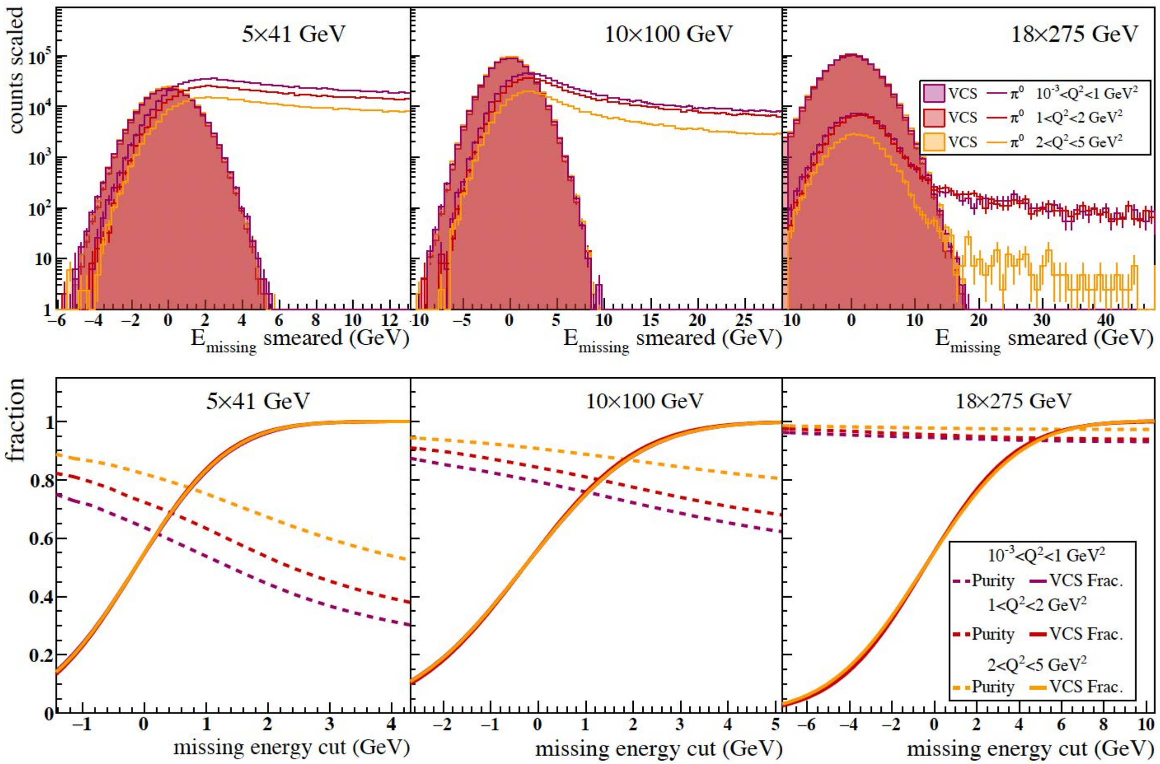
UCR ZDC design

- 60×60 cm transverse area
- 25 cm^2 hexagonal tiles
- Rough estimated resolution in x and y: $\sigma_{xy} \approx (19\%)/\sqrt{E} \oplus 1.4\% \approx 1mm$
- Rough estimated high-energy resolution: $\Delta E/E \approx (15\%\text{-}20\%)/\sqrt{E} \oplus 1\%$

Effect of Energy Resolution on DVCS Purity

- Larger stochastic ZDC energy resolution does not noticeably affect DVCS purity at 18x275 GeV

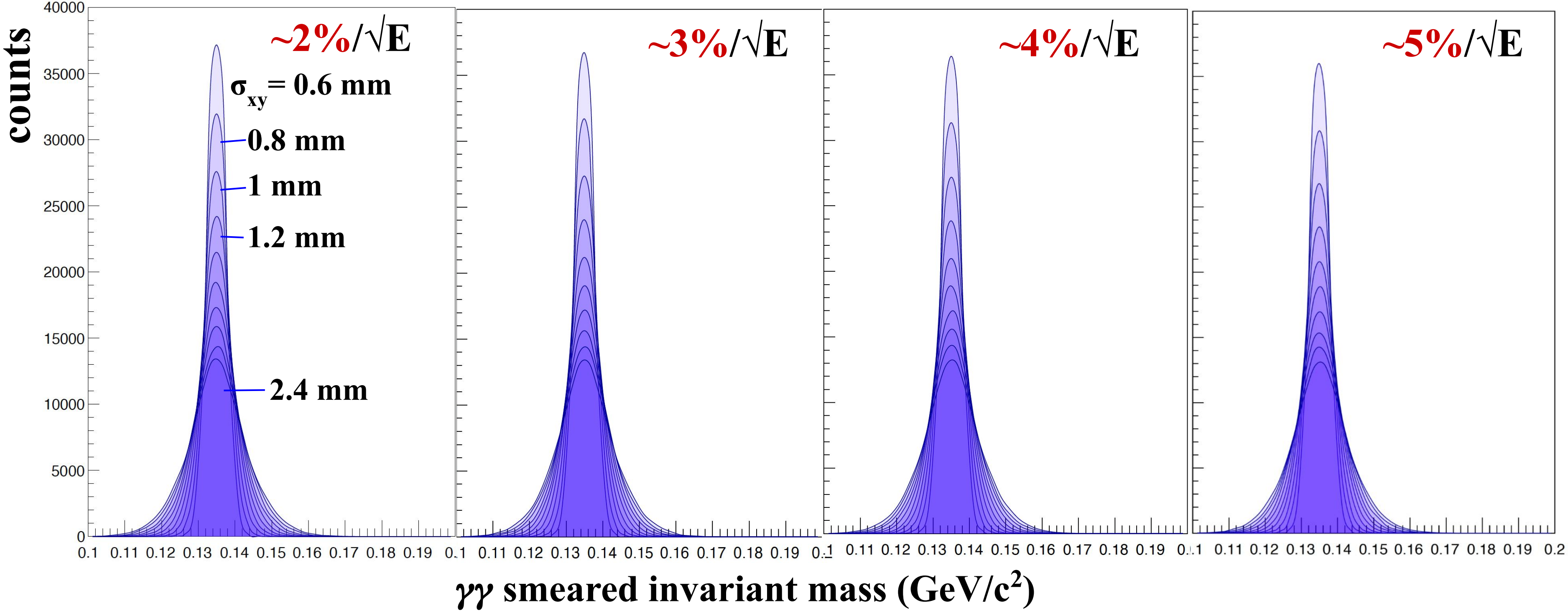
$\Delta E/E = 20\%/\sqrt{E} \oplus 1\%$



π^0 Reconstruction

- Stochastic energy resolution term does not affect π0 reconstruction resolution over expected range for ePIC ZDC design. Position resolution does.

$$\Delta E/E = (2\%\text{-}5\%)/\sqrt{E} \oplus 1\%$$



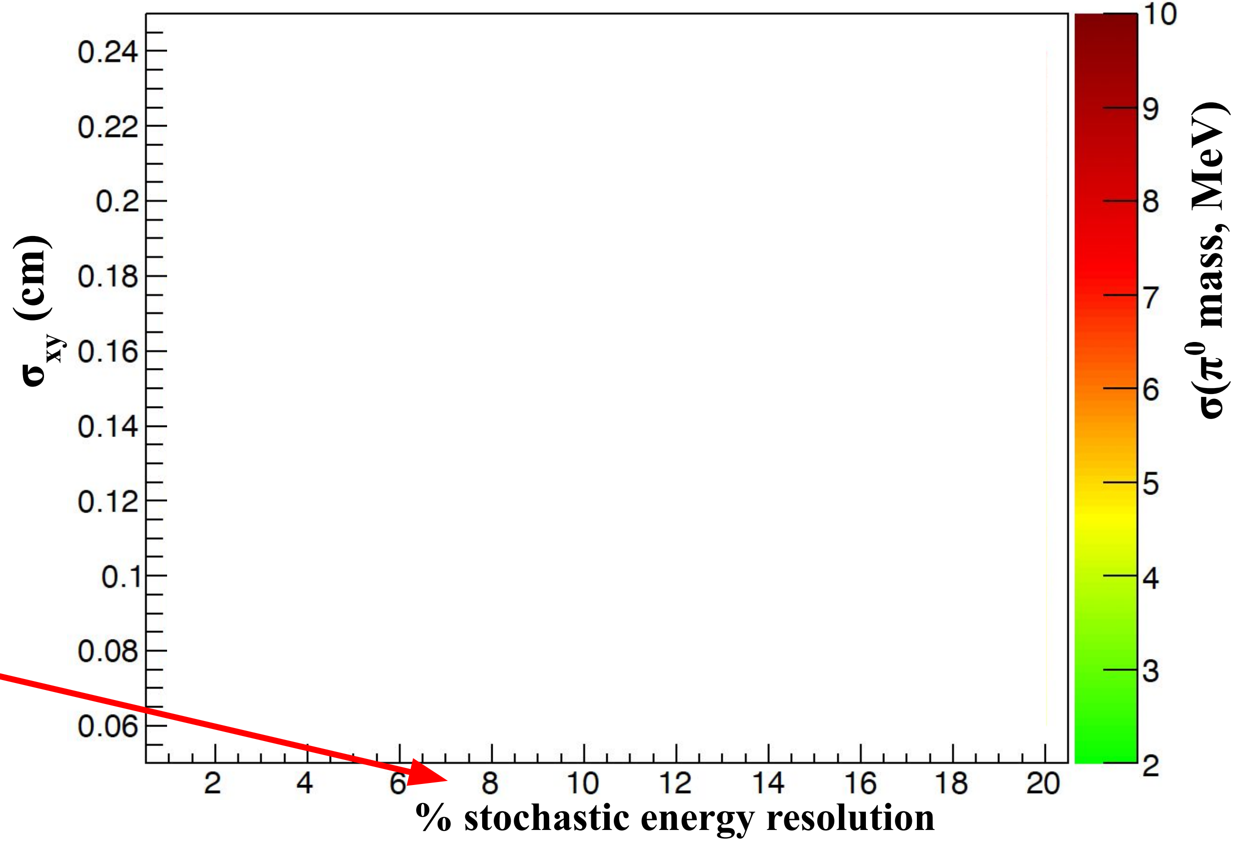
π^0 mass resolution

π^0 was reconstructed with various position resolutions σ_{xy}

For each position resolution, the stochastic energy resolution term was varied

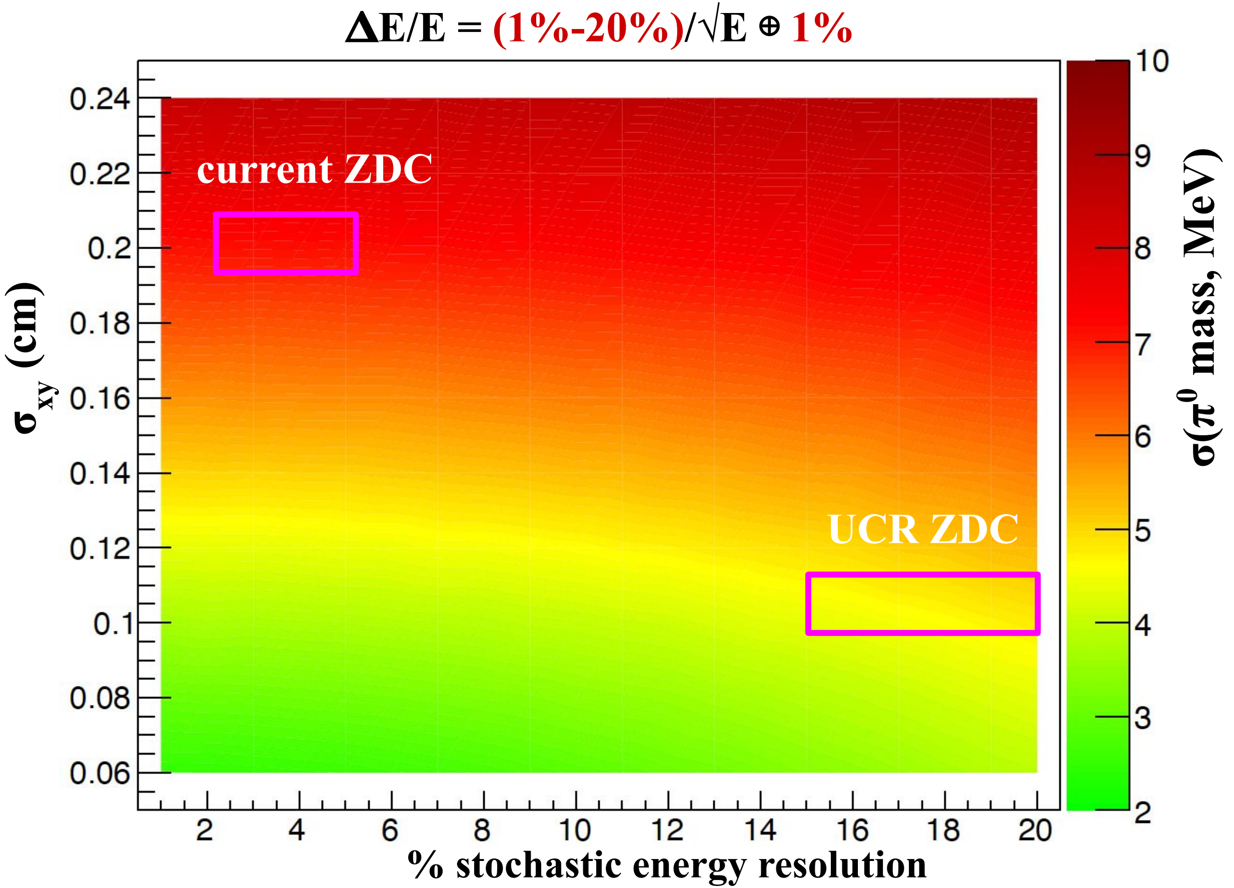
$$\Delta E/E = (1\%\text{-}20\%)/\sqrt{E} \oplus 1\%$$

The standard deviation of the mass peak is represented on the color axis in MeV



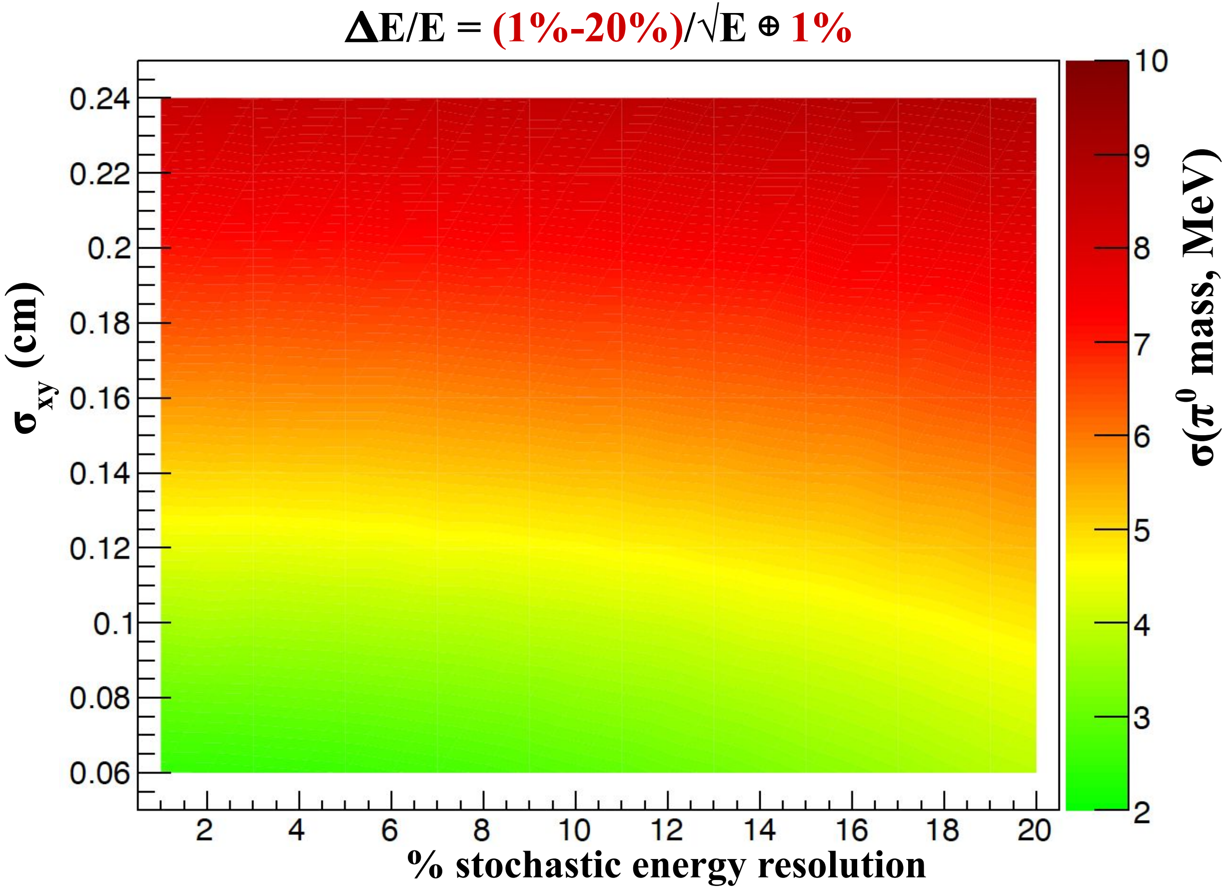
π^0 mass measurement with $\oplus$1% term

- I previously presented my best estimates for the position and energy resolutions of the ZDC designs
- The projections for the current ZDC are contentious so I was asked to leave the plot unlabeled



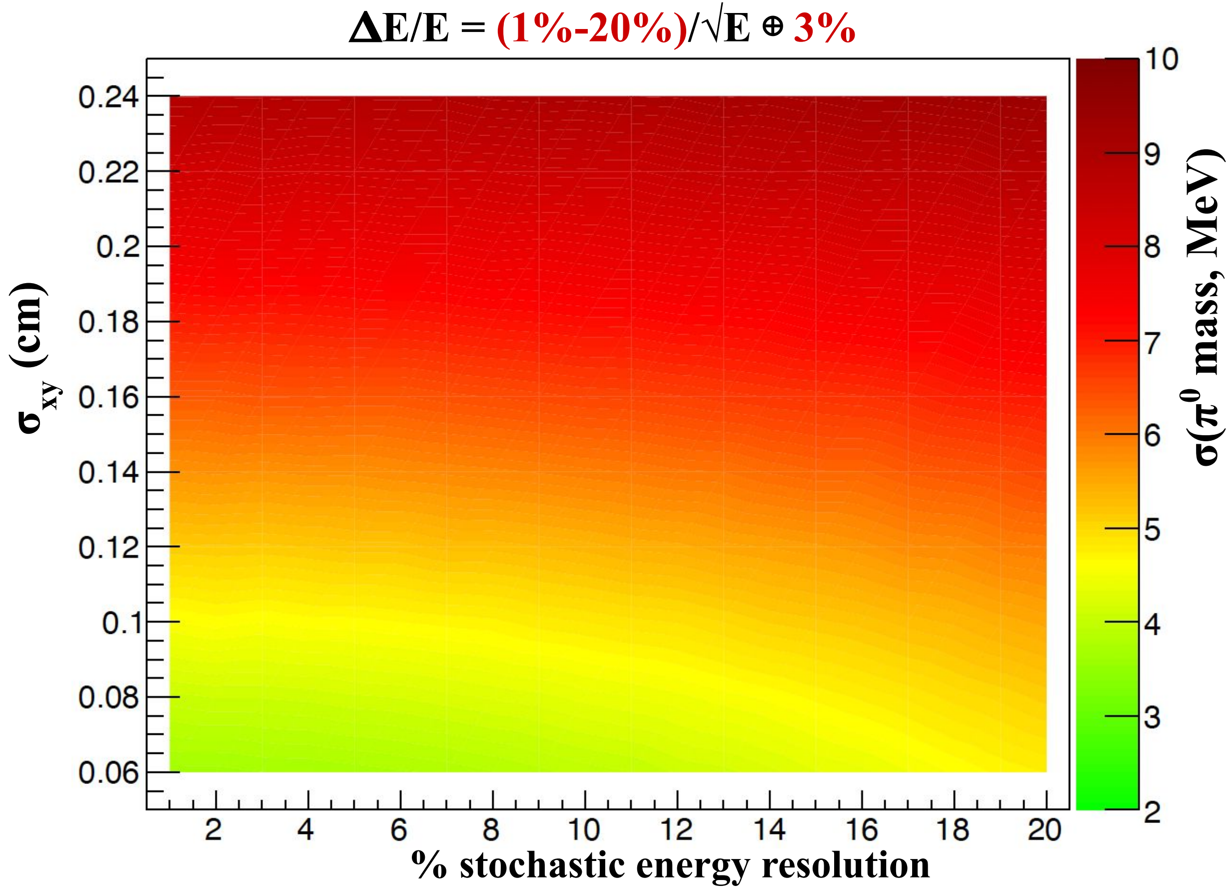
π^0 mass measurement with $\oplus 1\%$ term

- Position resolution drives reconstruction resolution



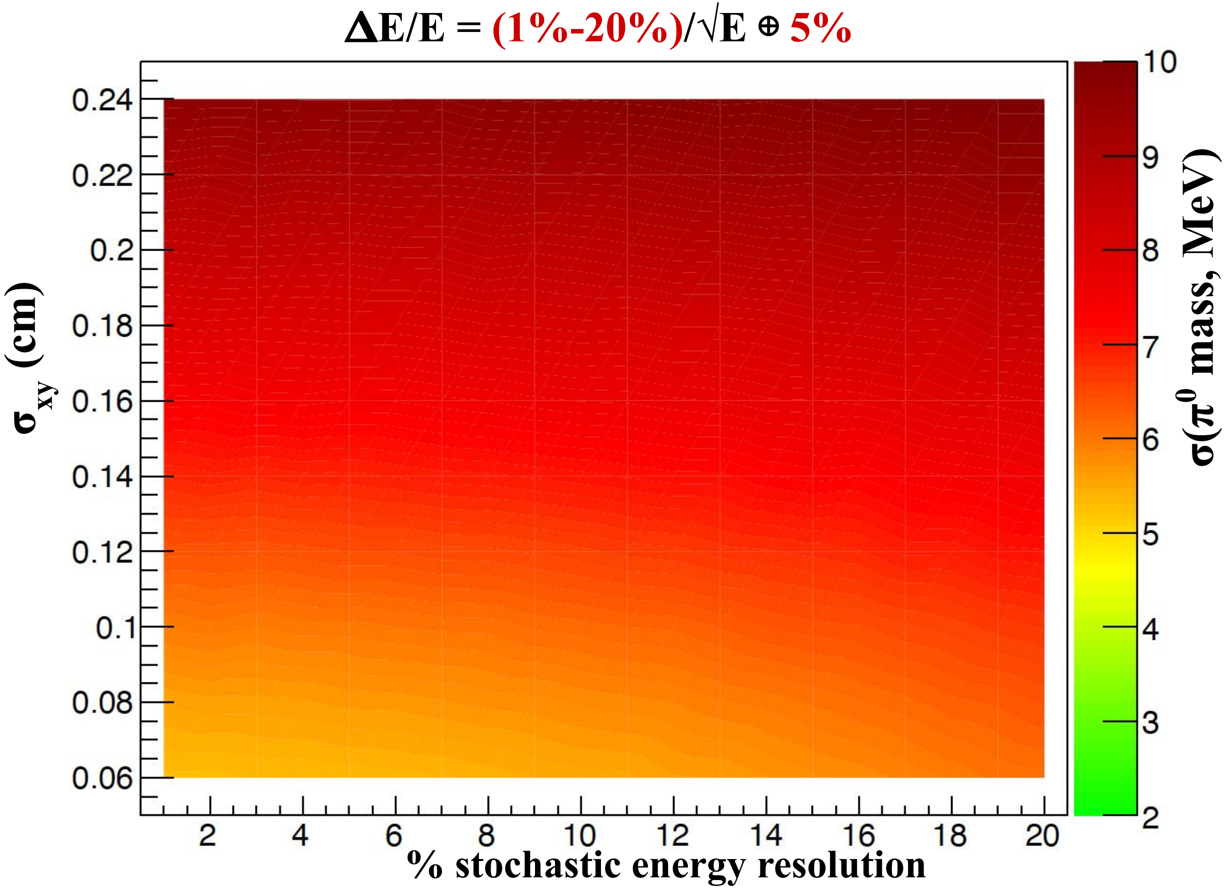
π^0 mass measurement with $\oplus$3% term

- Position resolution drives reconstruction resolution



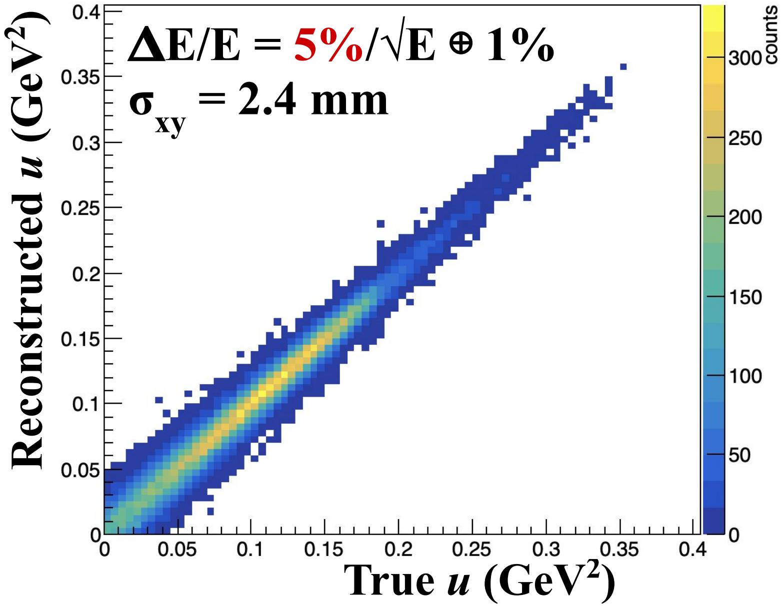
π^0 mass measurement with $\oplus$5% term

- Position resolution drives reconstruction resolution

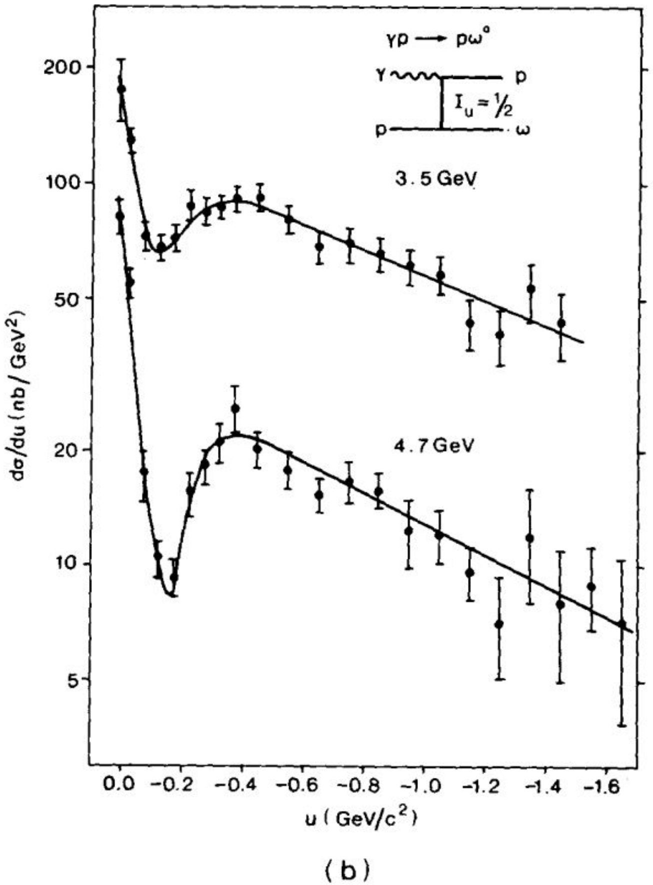


u-channel cross section measurement

- We aim to measure backward cross sections as a function of the Mandelstam $u = (p_{proton\ beam} - p_{meson})^2$
- So the ability to reliably measure the true u value will determine how useful these measurements are
- We would like $\sigma(u) < \sim 0.05\ GeV^2$

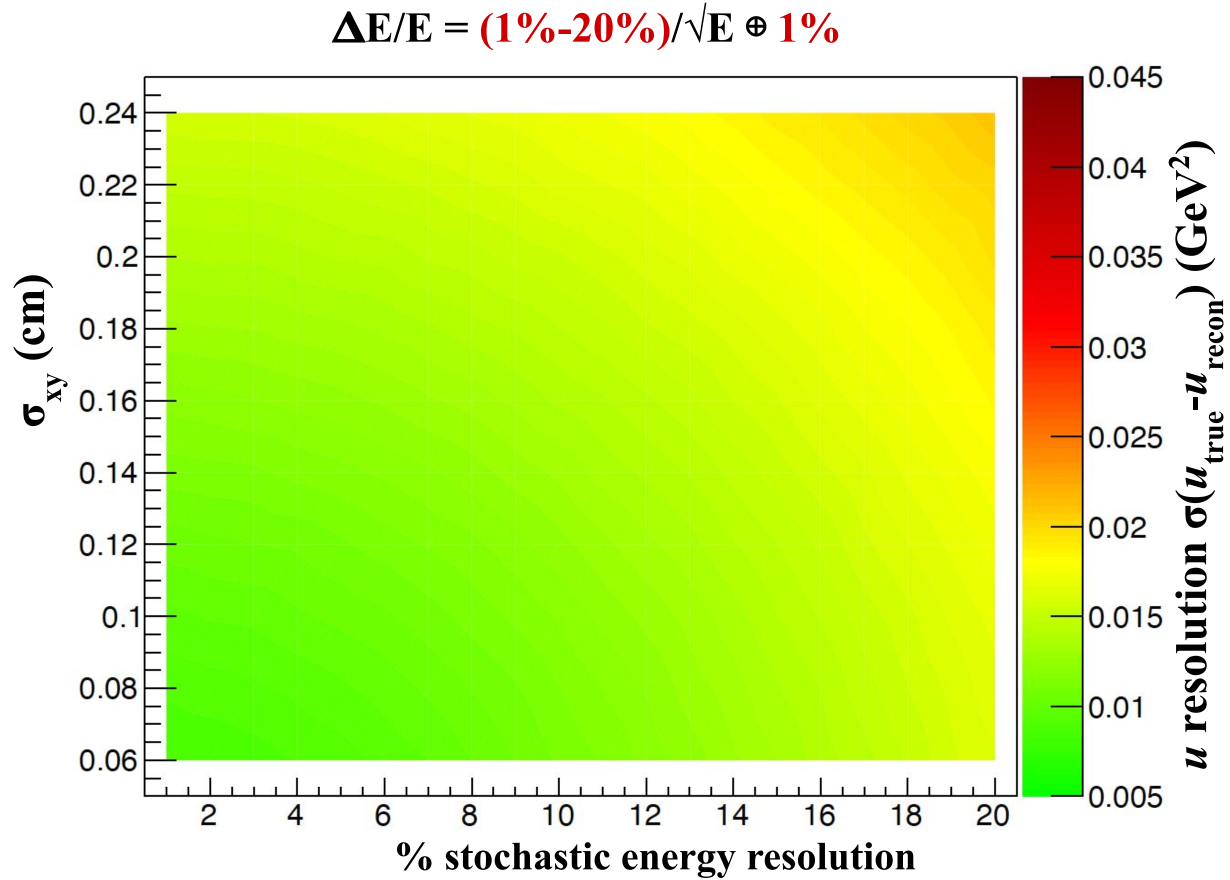


R. W. Clifft et al., Phys. Lett. B 72, 144 (1977)



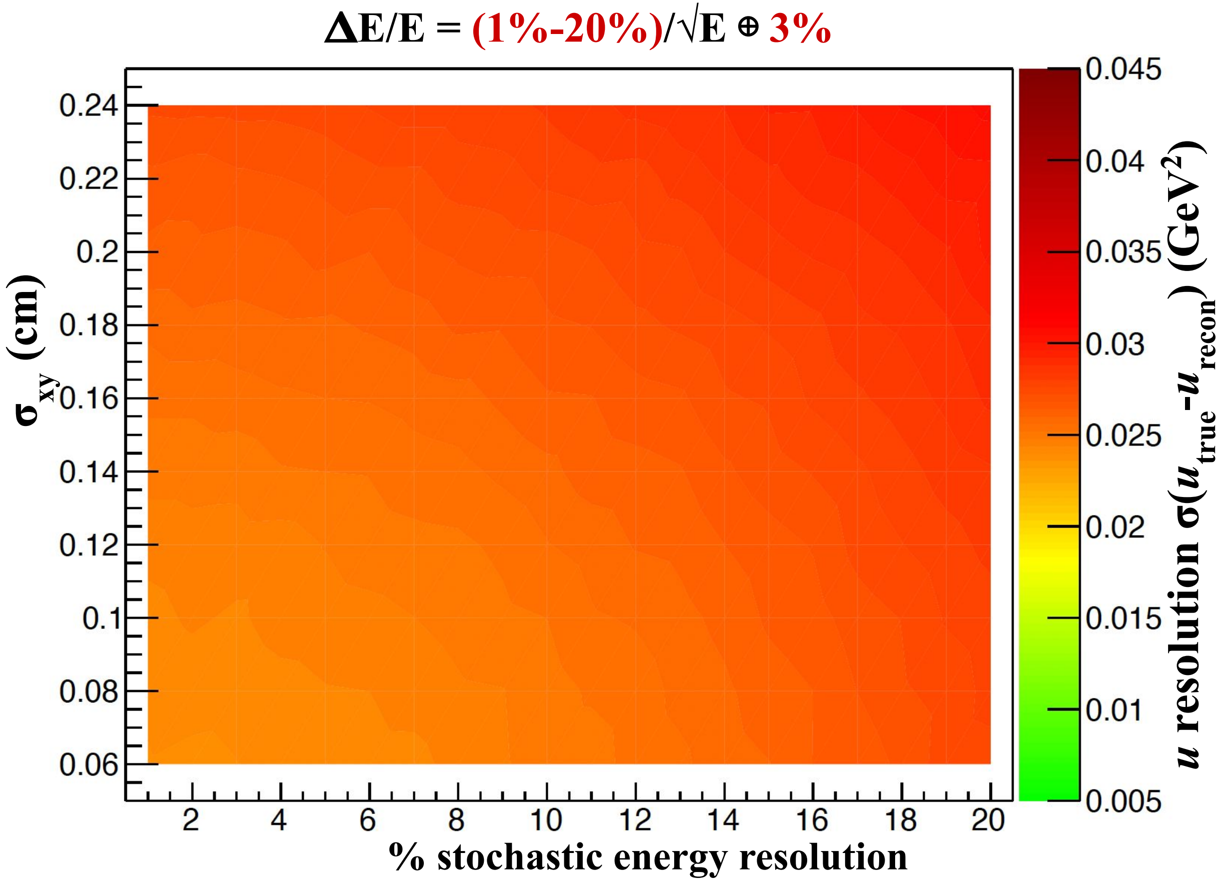
Mandelstam-u resolution with ⊕1% term

- With a 1% constant efficiency term, ZDC designs are likely well within tolerance for measuring u



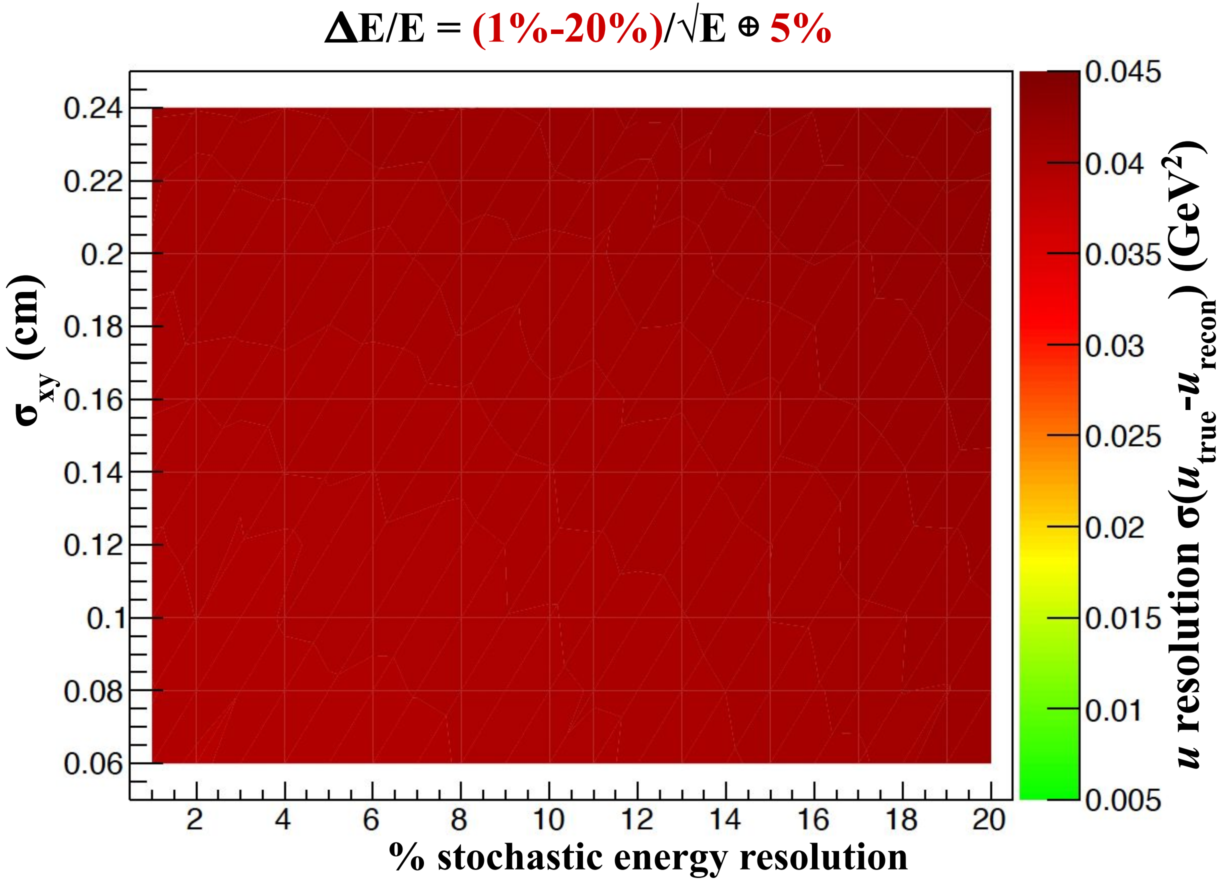
Mandelstam-u resolution with ⊕3% term

- With a 3% constant efficiency term, we are likely within tolerance for measuring u
- Resolution is ~0.025 GeV^2
- Worse but not horrible



Mandelstam-u resolution with ⊕5% term

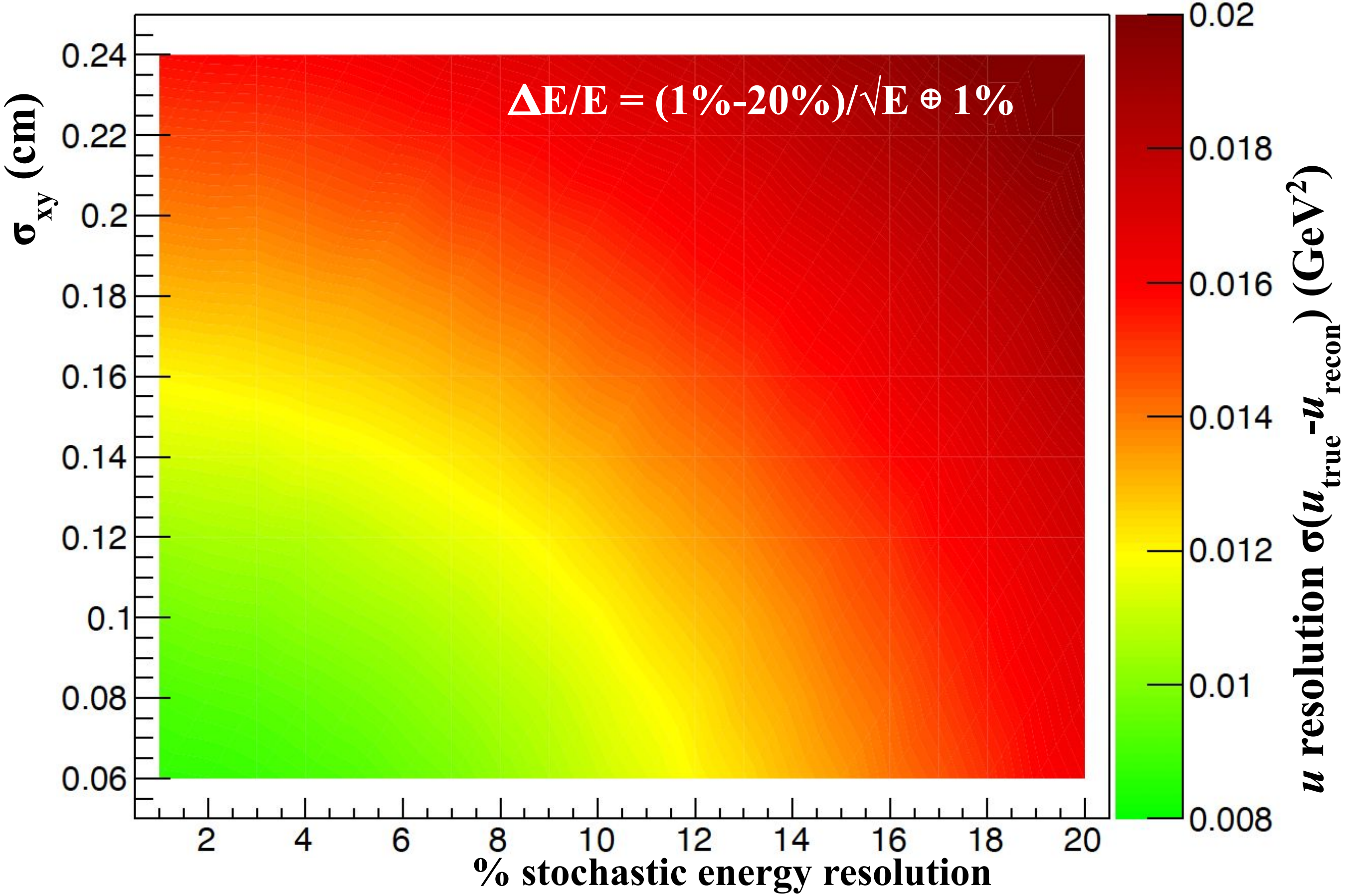
- With a 5% constant efficiency term, u resolution approaches tolerance limit
- Resolution is ~0.04-0.045 GeV^2
- Getting concerning



u Resolution Zoomed

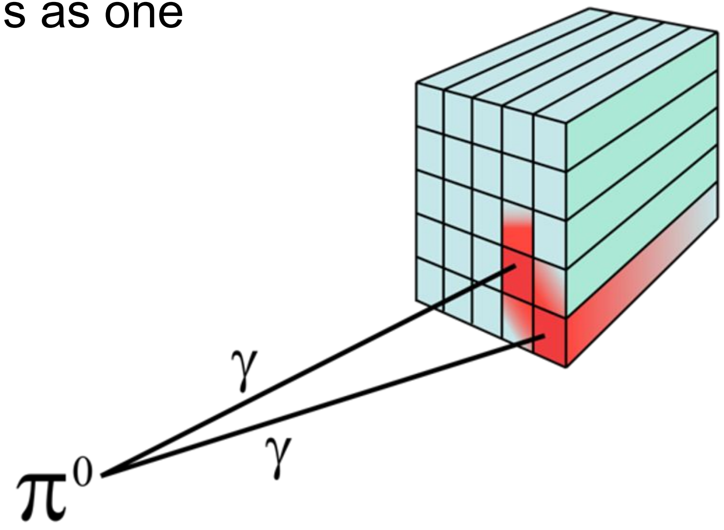
I've zoomed in on the z-axis to make a point.

A loss in energy resolution can be compensated by an improvement in position resolution



A final (very important) consideration

- The elephant in the room here is that position resolution may be complicated by two adjacent clusters from π0 decay
- The two photons will never be closer than 3.4 cm, but it's possible that those clusters overlap in a difficult way
- Validating which detector design is able to do this separation is very important, because these can easily be mistaken for DVCS if the clustering algorithm categorizes the two photons as one

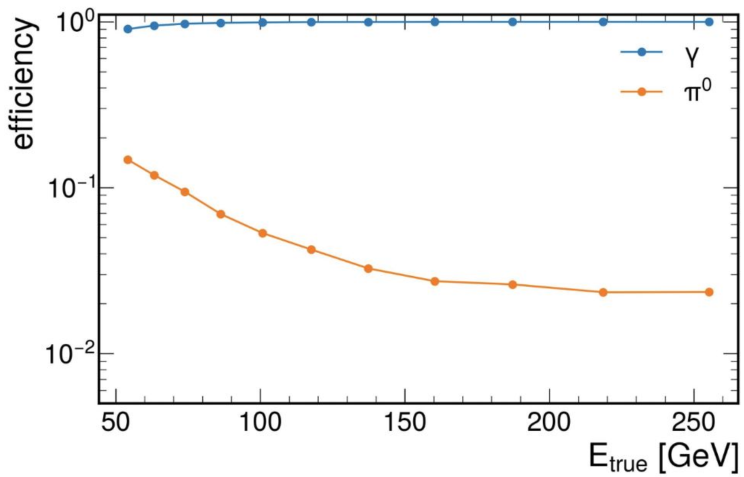


A final (very important) consideration

- Sebouh Paul at UCR has been working on simulating their ZDC design performance. (I've just sent them u-channel events to help)
- Comparable studies with other ZDC designs would be very helpful

Preliminary performance plots for γ/π0 identification

- Baseline identification algorithm:
  - Only a few percent of the π0s are misidentified as photons
    - Some of these could be events where one of the two photons from the π0 decay misses the ZDC
- Improvements in the algorithm could reduce this number even further.



Conclusions

- **DVCS sample purity**
  - Worst-case scenario energy resolutions do not affect DVCS purity at 18x275 GeV
- **π^0 mass reconstruction**
  - greatly improved by better positioning resolution
  - energy resolution has little effect on width
- **Mandelstam-u reconstruction**
  - Upper limits of $\Delta E/E \sim \oplus$ 5% approach the measurement tolerance. The 1% and 3% constant terms are much better
- **Two-photon separation**
  - We don’t know which of the designs will better separate two-photon showers