HPS ELECTROMAGNETIC CALORIMETER CALIBRATION

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HPS BACKGROUND

A' production via standard model mixing

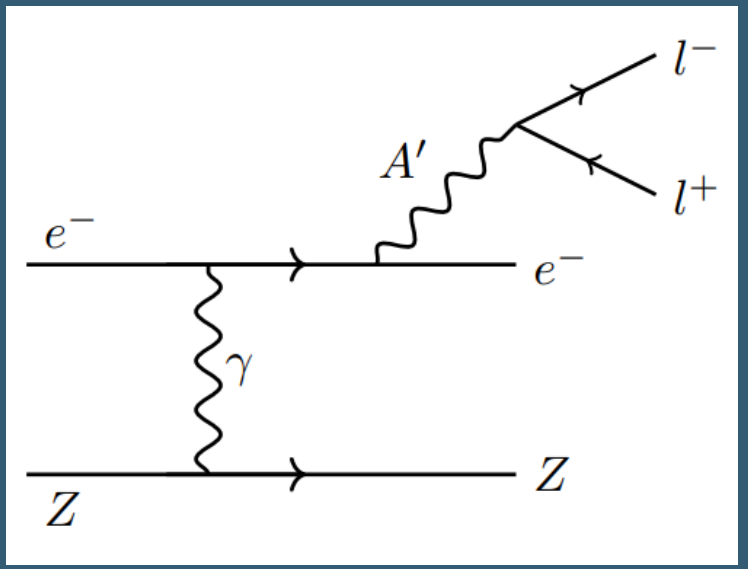
A' mediates spontaneously broken hidden U(1)' symmetry

Decays into detected e+/e- pair

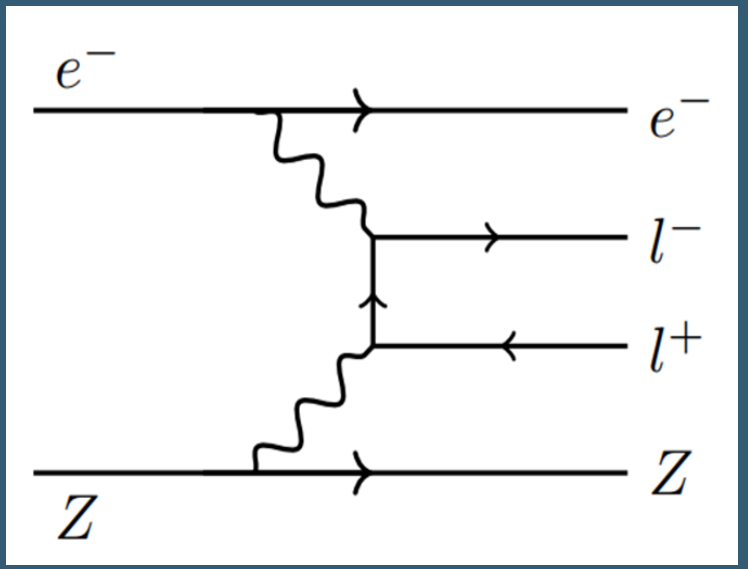
Very small coupling, need huge statistics => hall b

Bethe-Heitler trident production and wide-angle bremsstrahlung primarily interfere with A' signal

A' Electroproduction



Bethe-Heitler Trident



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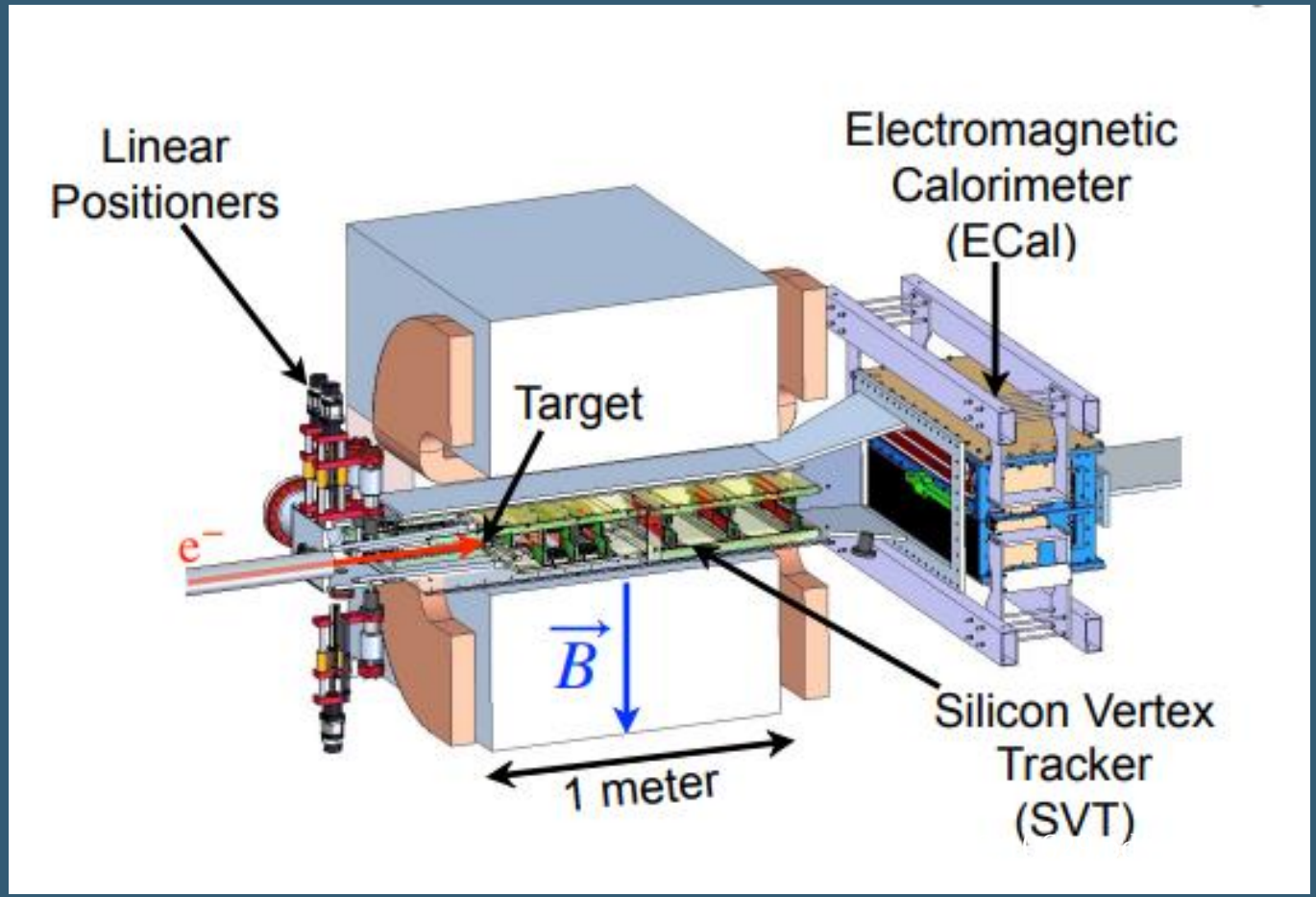
2212.10629.pdf (arxiv.org)

HPS APPARATUS

- HPS apparatus located in hall b
- Most recent run at 3.742 GeV
- Tungsten target followed by 6 SVT layers within a .24T dipole magnet
- Electromagnetic Calorimeter at end of track



arXiv:2212.10629

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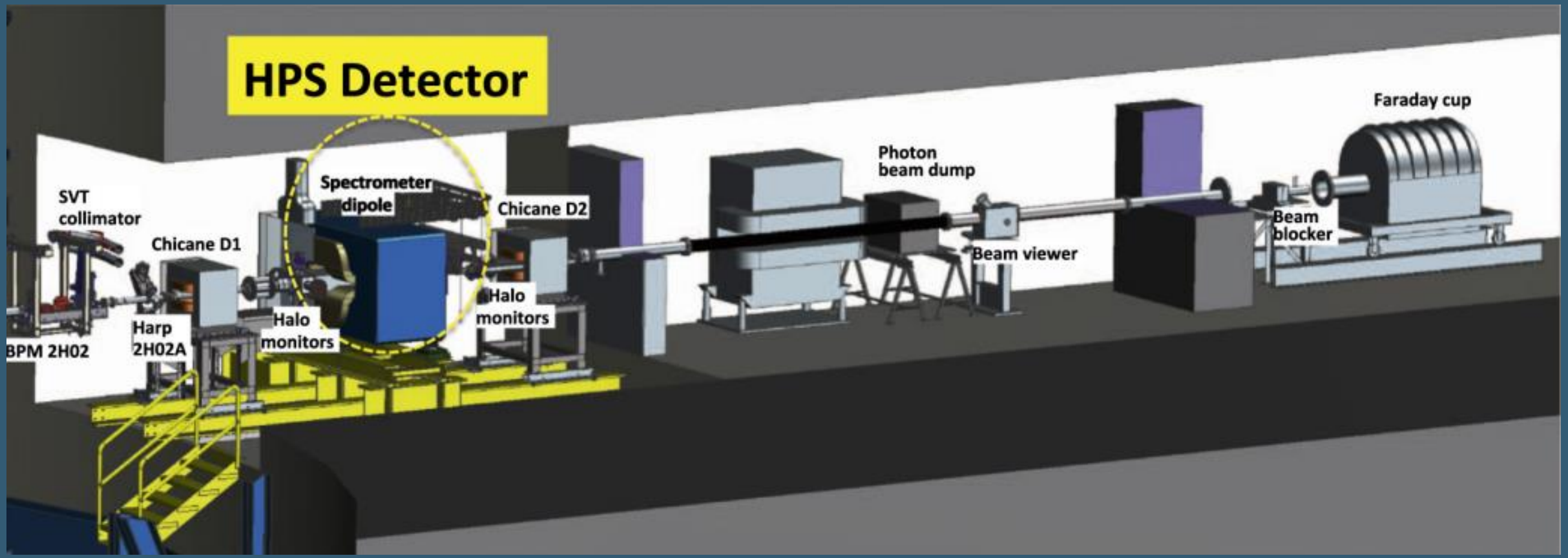
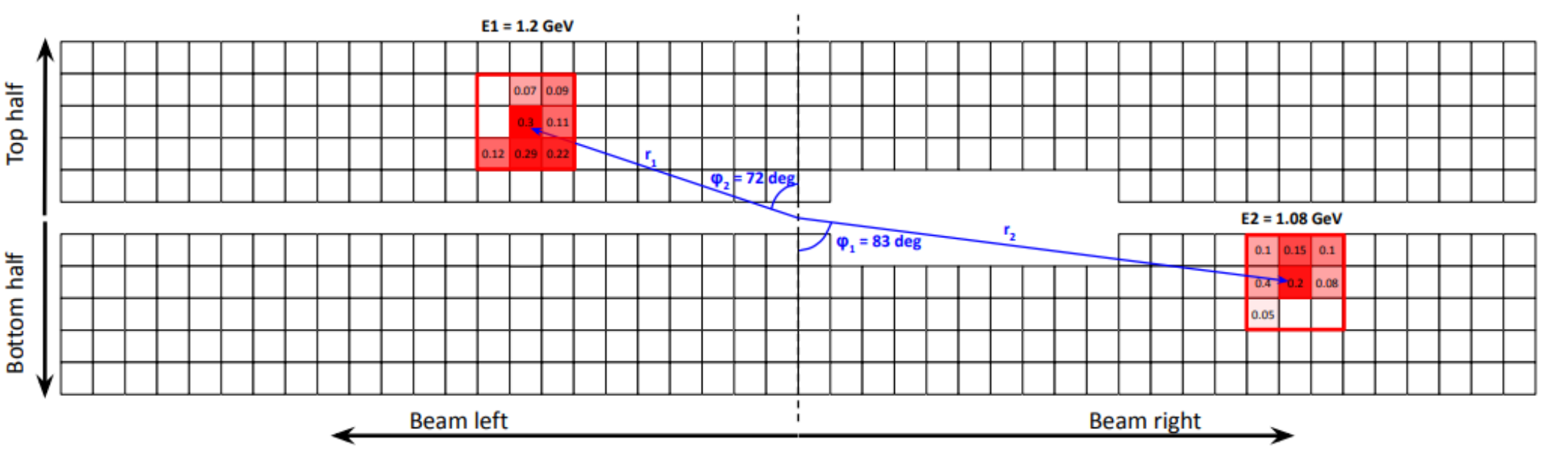


arXiv:2212.10629

THE ELECTRON CALORIMETER (ECAL)



arXiv:2212.10629

- ECal separated into two halves, each contain 5x46 $PbWo_4$ crystals
- Triggers only when e^+/e^- detected in opposing quadrants, filters out beamline e^-
- Beamline passes through central cavity depicted above

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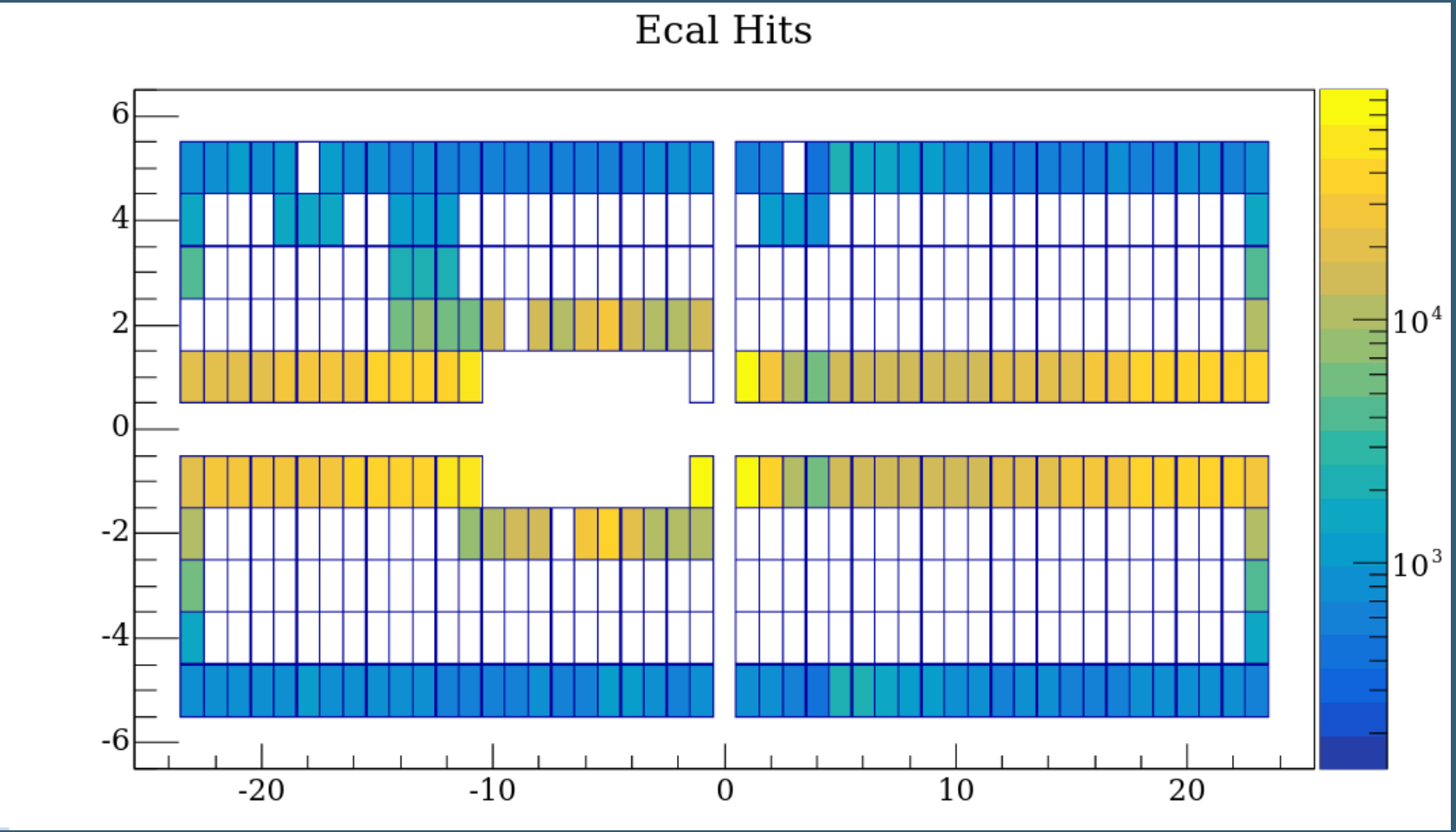
SETTING CONSTRAINTS

Create fiducial region to filter edge cases

Set a limit on the number of clusters each included event may contain, NClus>9,12

Specify minimum seed energy

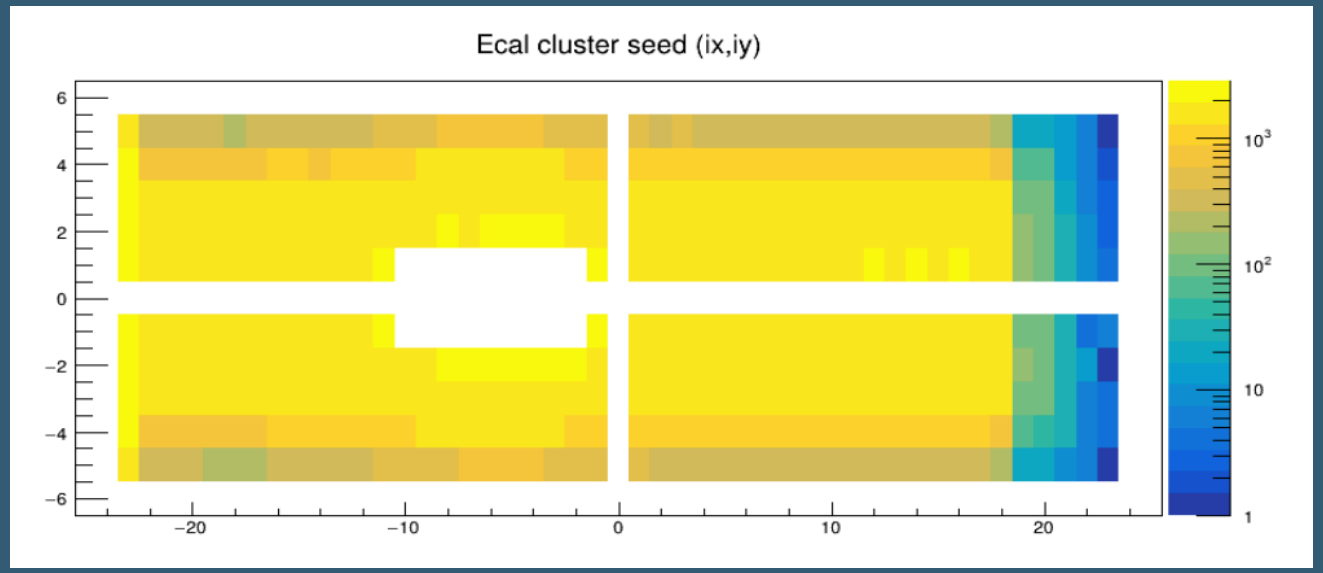
Account for bad crystals



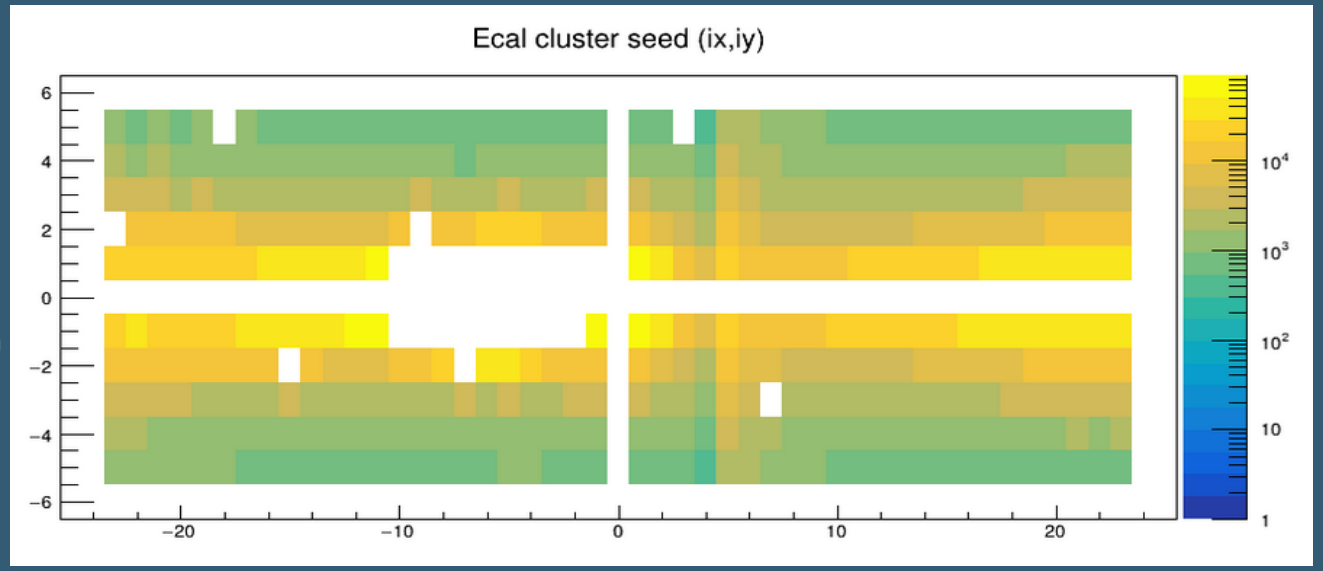
MONTE CARLO IN THE ECAL

- More crystals on right side of ECal, beam skewed toward left of center
- MC evenly distributed over entire Ecal face shown in top plot
- Real data show hot spots and dead zones

Monte Carlo



Experimental



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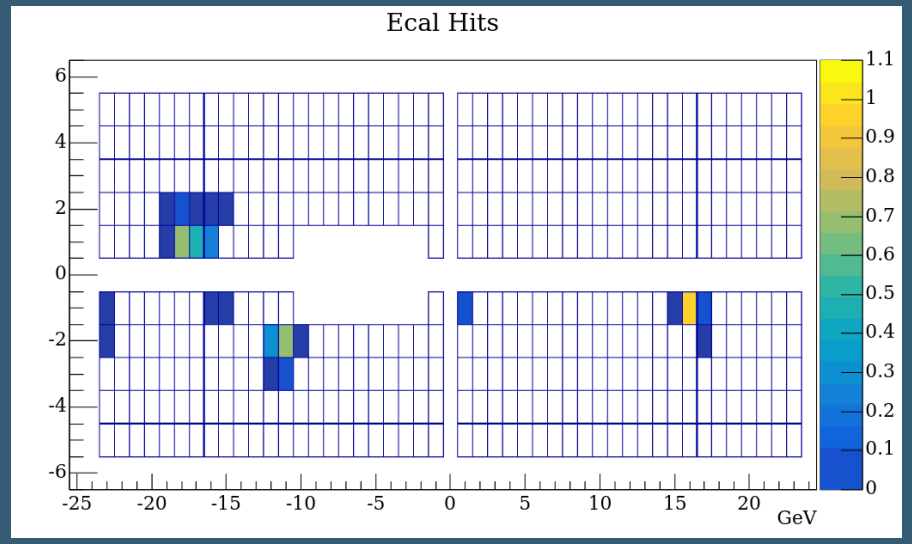
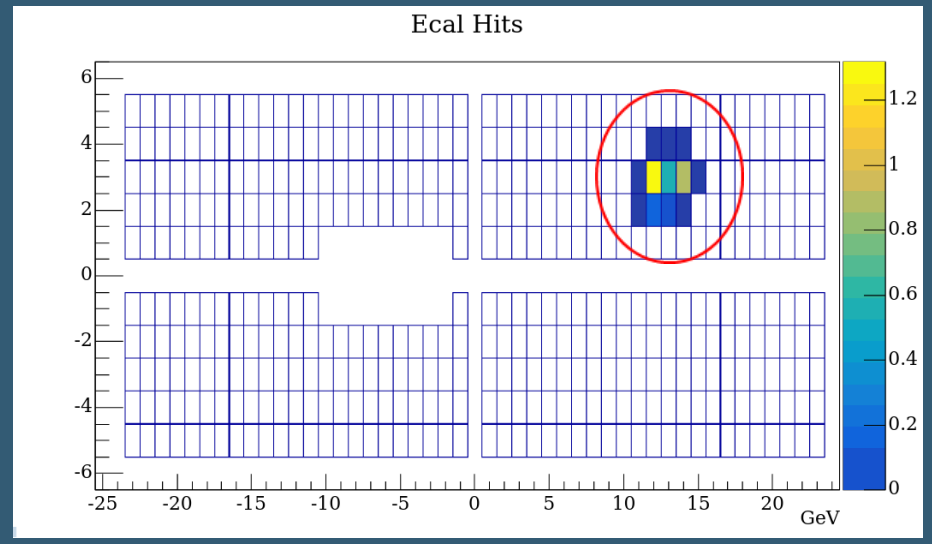
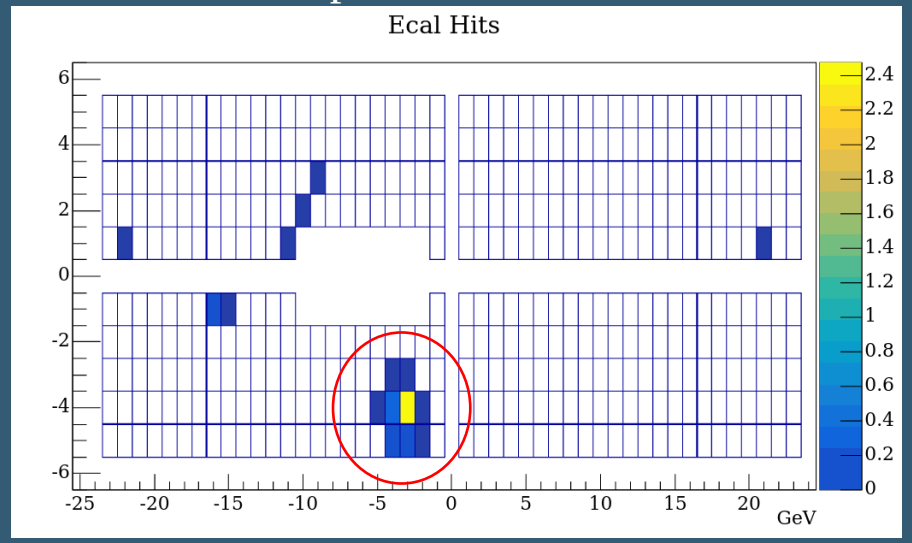
CLUSTERING

- Top left: bad event selection with real data
- Bottom left: good event selection with real data
- Top right: Good event selection with MC data
- Bottom right: bad event selection with MC data

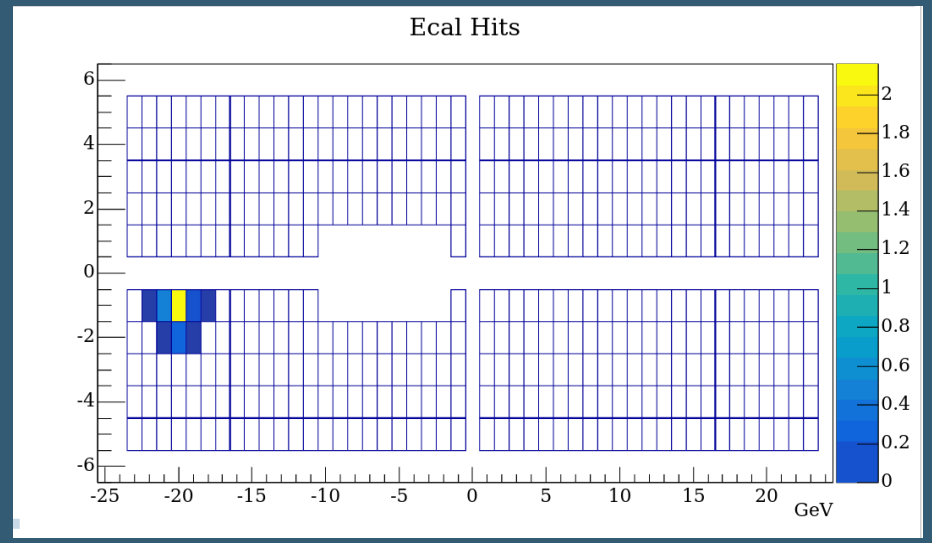




Experimental Data



Monte Carlo Data



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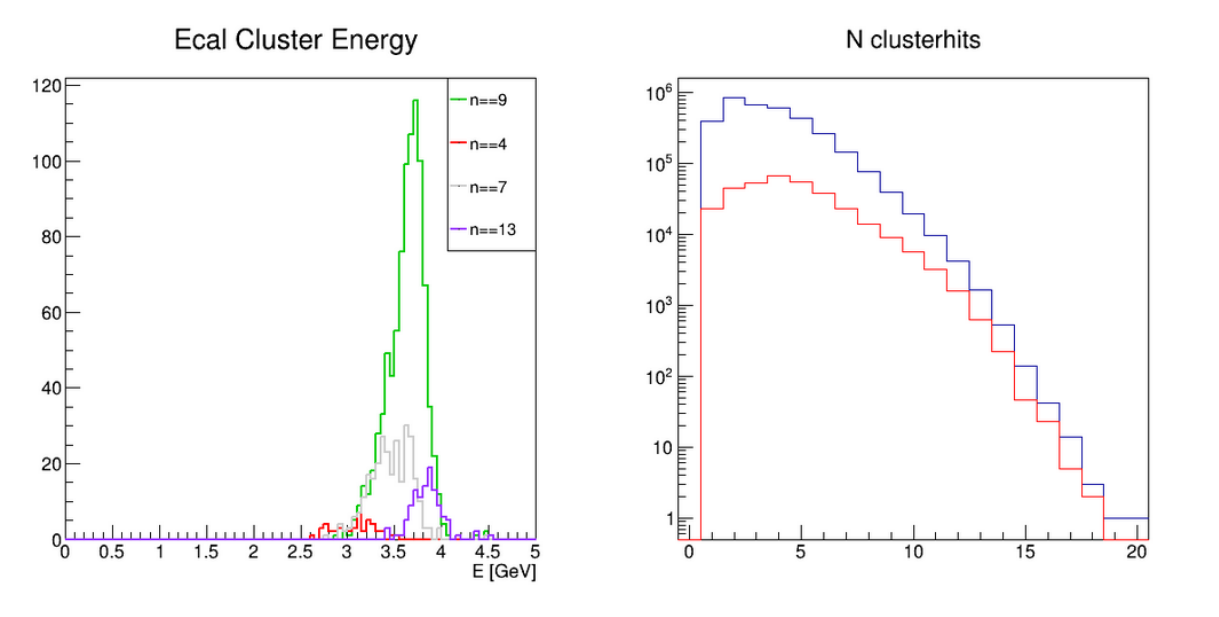
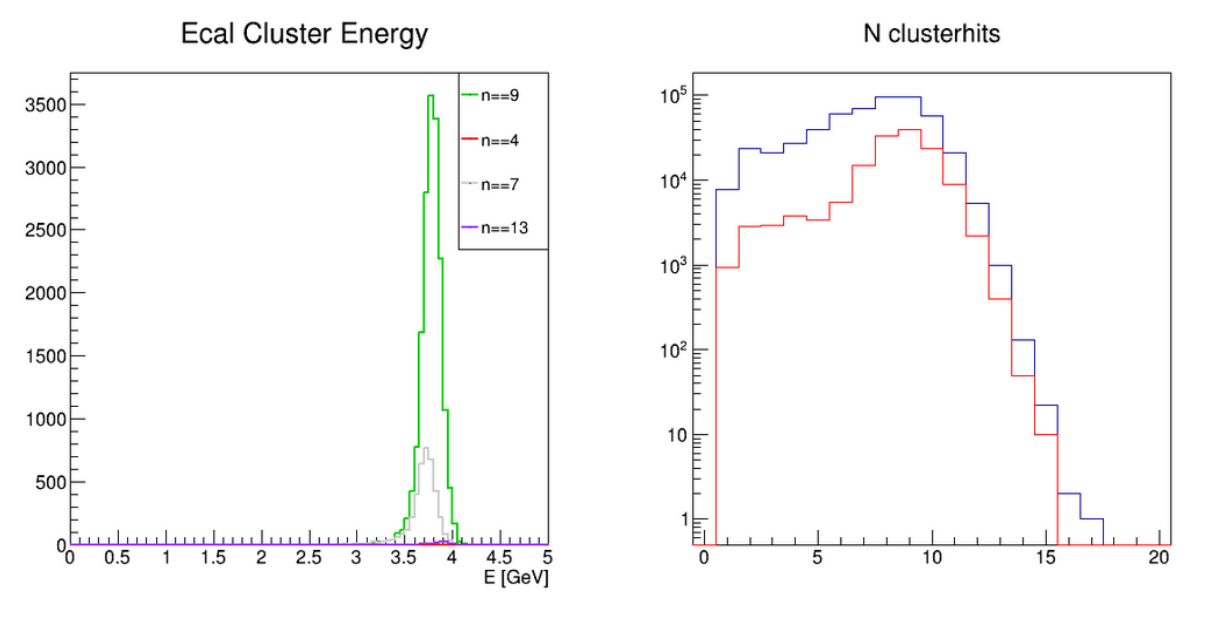
CLUSTER HITS AND SEED CUT



Experimental



Monte Carlo

Depending on how the statistics required, set limits on the number of hits in each cluster required for event selection. In real data analysis, minimum usually set to 9, reflected in MC data as well

Minimum ‘seed’ or primary particle energy is hugely important, here it is set to 2.1GeV

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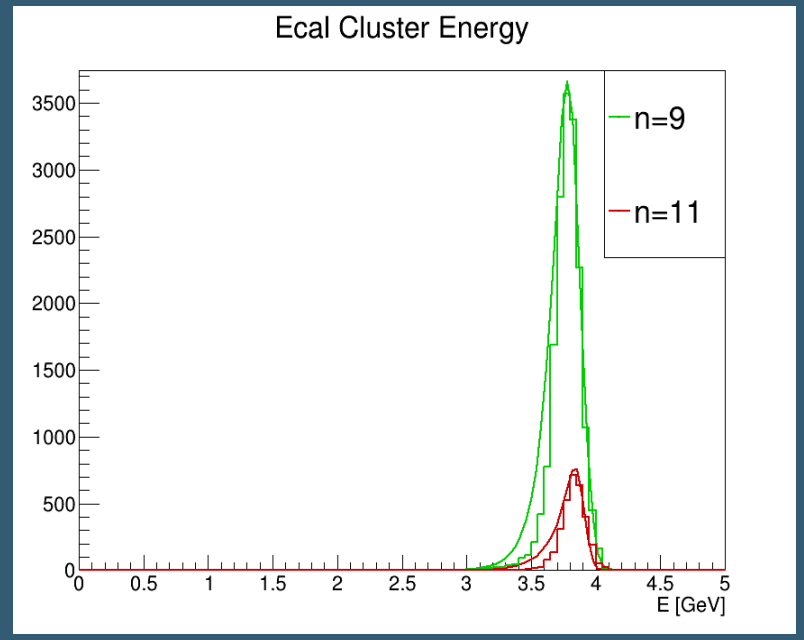
CLUSTER ENERGY VALUE

Sampling fraction is important, tendency for overcorrection to total cluster energy when summing hits

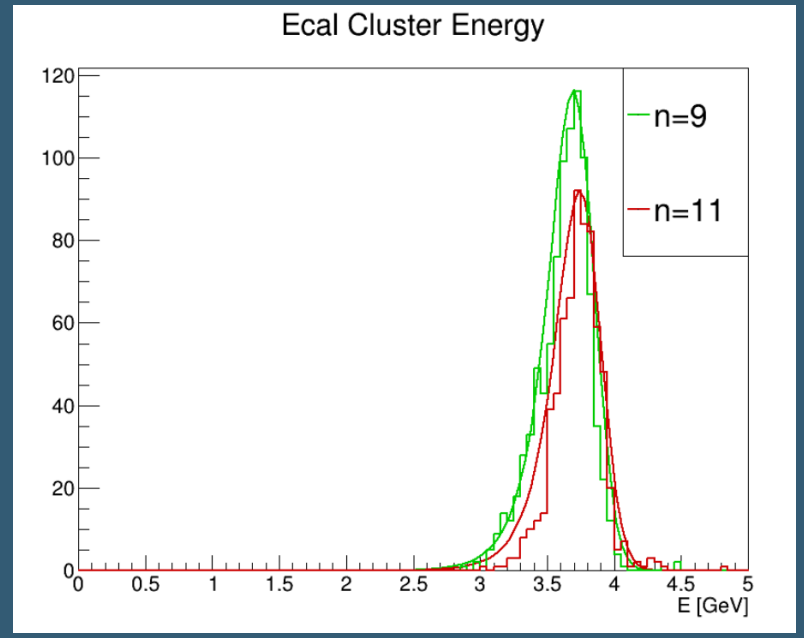
Using seed energy cut of 2.1GeV, nClusterhits=9, and only selecting events within the fiducial region, the ECal shows little discrepancy between MC data (top) and real data (bottom)

*Fits are purely visual aid

Experimental



Monte Carlo



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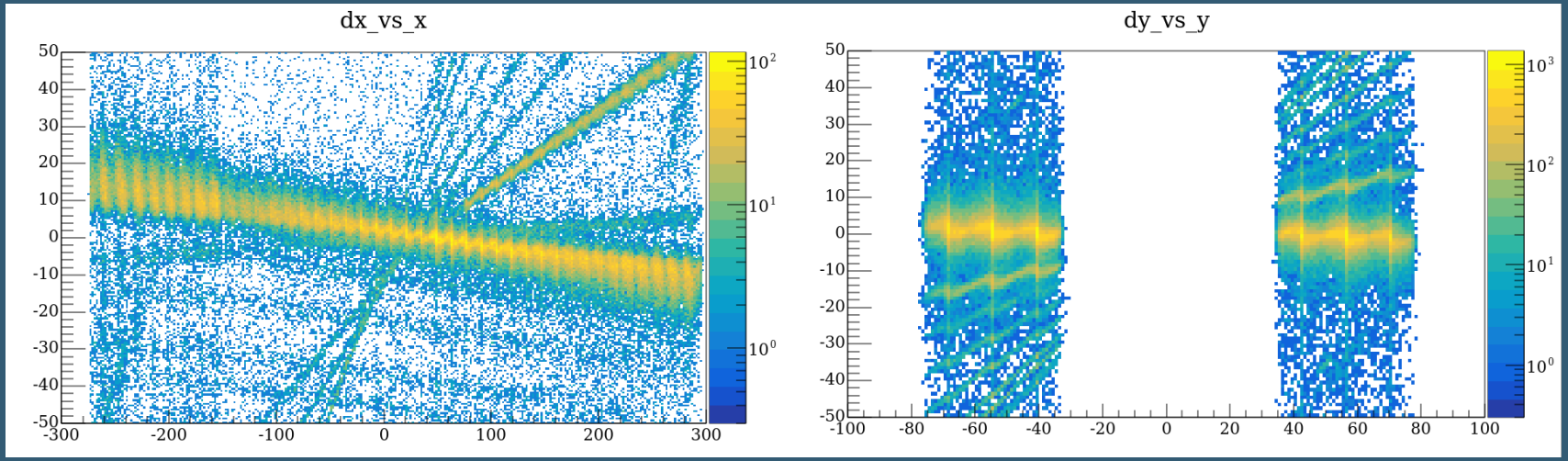
FINDING A FIT FOR CLUSTER POSITION

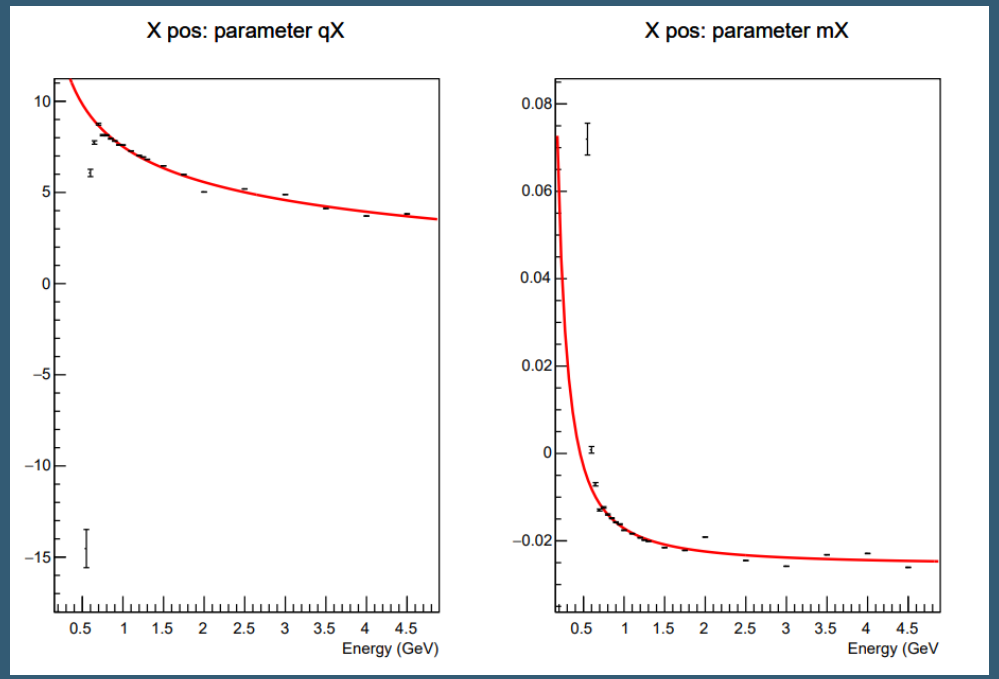
Plotting the difference between the true MC final x and y positions and the values that the Ecal gives reveals further complications

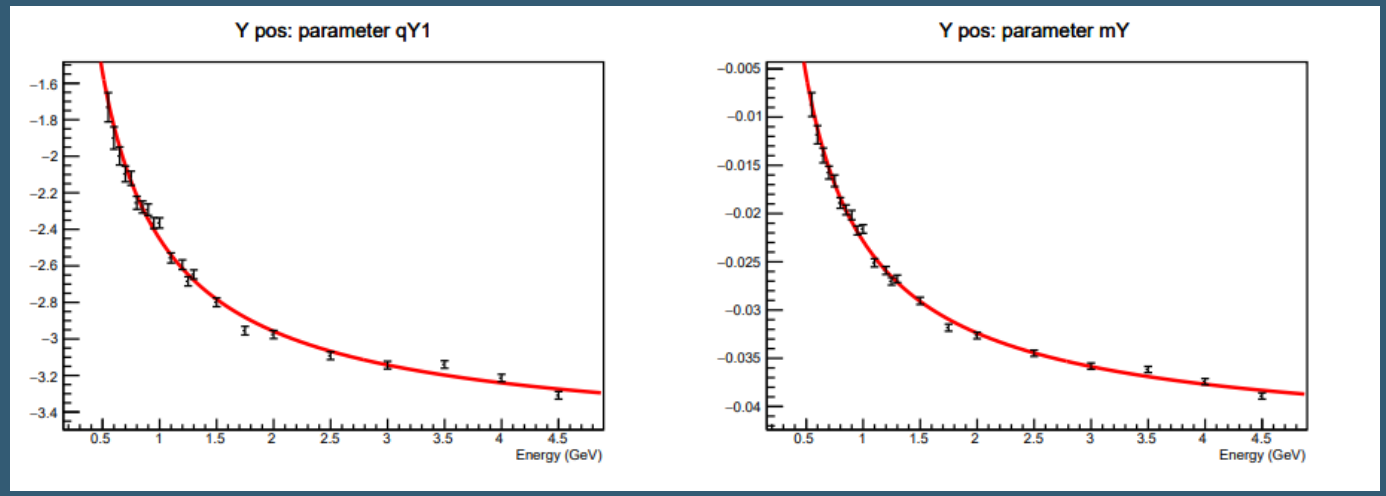


Courtesy of Andrea Celetano and Luca Marsicano

BINNING AND SLICE FITTING

- Find average of slices of MC data within a bin width
- Fit a linear function to the average of each slice
- Fit a nonlinear function to each parameter of the linear function to generate an overall x and y fitting function
- Plots from Andrea Celetano, Luca Marsicano





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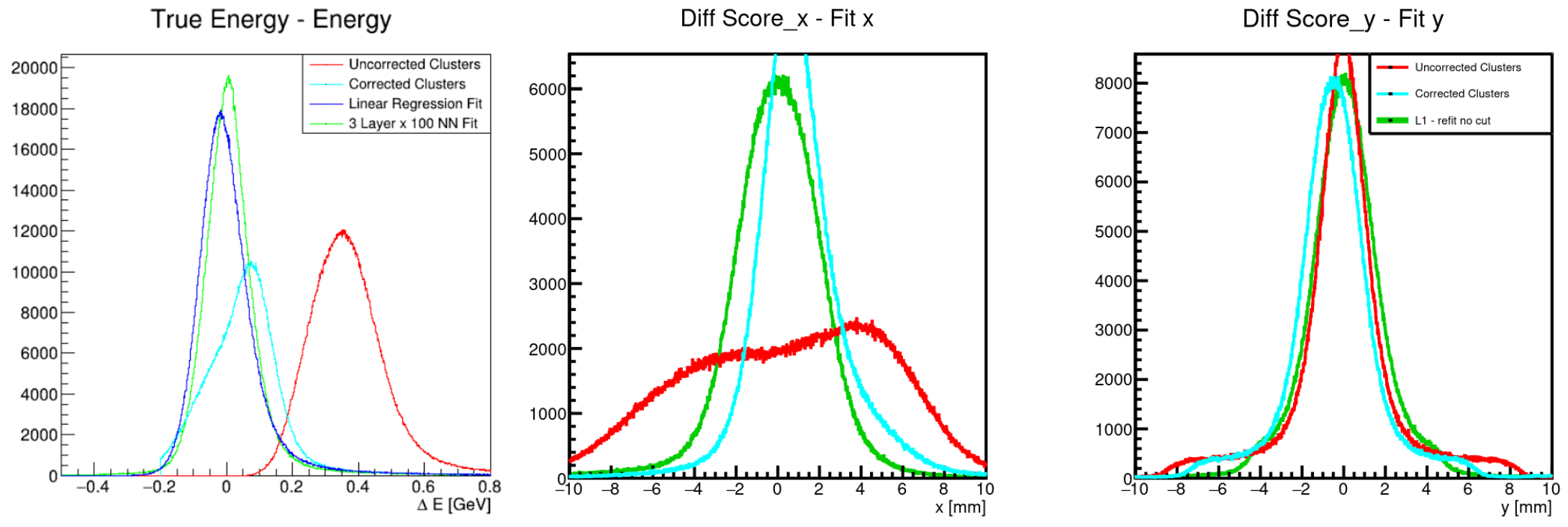
LOOKING FORWARD: MACHINE LEARNING



- ML is a promising way to calibrate the ECal with great precision. Marginal gains when moving from a linear regression model to a deep learning model. Plots created by Maurik Holtrop.
- So far, ML isn't significantly better than currently used energy and position correction methods

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THANK YOU

Sources and Acknowledgements:

P.H.Adrian et al, *Searching for Prompt and Long-Lived Dark Photons in Electro-Produced e +e − Pairs with the Heavy Photon Search Experiment at Jlab*, arXiv:2212.10629 **[hep-ex],** 2023

I'd like to thank Andrea Celetano and Luca Marsicano for their work on the Ecal calibration and allowing me to use some of their plots. I'd also like to thank my advisor Maurik Holtrop for providing code used is this analysis.

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