



# LCD dataset: Centering window Update

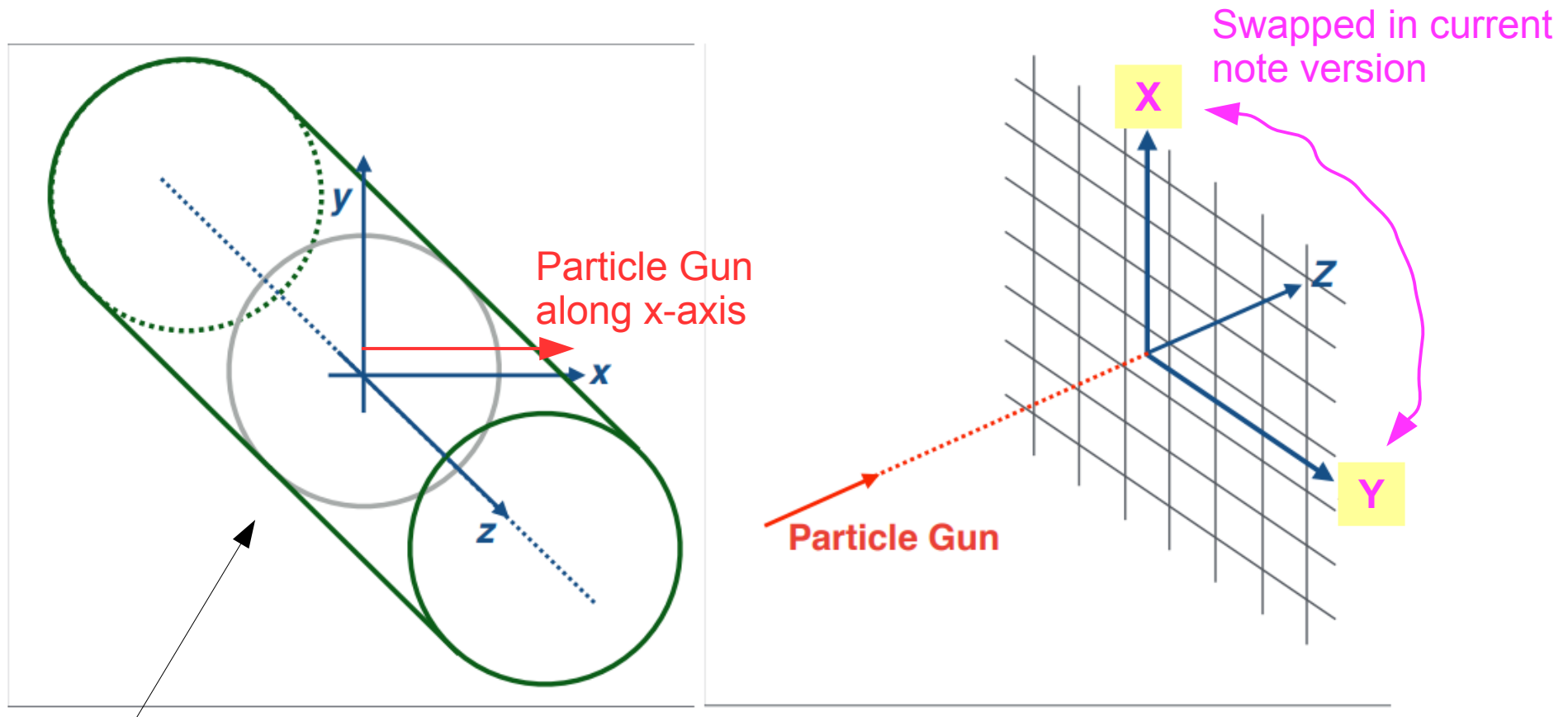
Dominick Olivito (UCSD)

# Issue

- Events in h5 dataformat are supposed to be **centered based on barycenter of ECAL energy deposit**
  - Save 25x25x25 in ECAL, 5x5x60 in HCAL
- **Doesn't always look centered**, based on **cells that are saved**
- Biggest effect for **charged pions** (~30% of events off-center)
  - Smaller for **electrons, photons, pi0** (1-5% off-center)
- Previously showed that **off-center electrons** (probably also photons and pi0) come from **large angle radiation**
  - e.g. hard brem off a low pt electron that curves outside our window
  - For photons/pi0: conversion with a low pt leg
  - Energy deposits outside window pull it off-center
  - [https://indico.cern.ch/event/682039/contributions/2803652/attachments/1564809/2465317/lcdml\\_centering\\_olivito\\_221117.pdf](https://indico.cern.ch/event/682039/contributions/2803652/attachments/1564809/2465317/lcdml_centering_olivito_221117.pdf)
- **Today**: focus again on **charged pions**

# Global vs Local Coordinates

- ECAL barycenter calculation is done in **global coordinates**
- Cells are saved based on **local coordinates**



From older note version:

<https://www.dropbox.com/s/ktu1ly0ge9n4jyd/CaloImagingDataset.pdf?dl=0>

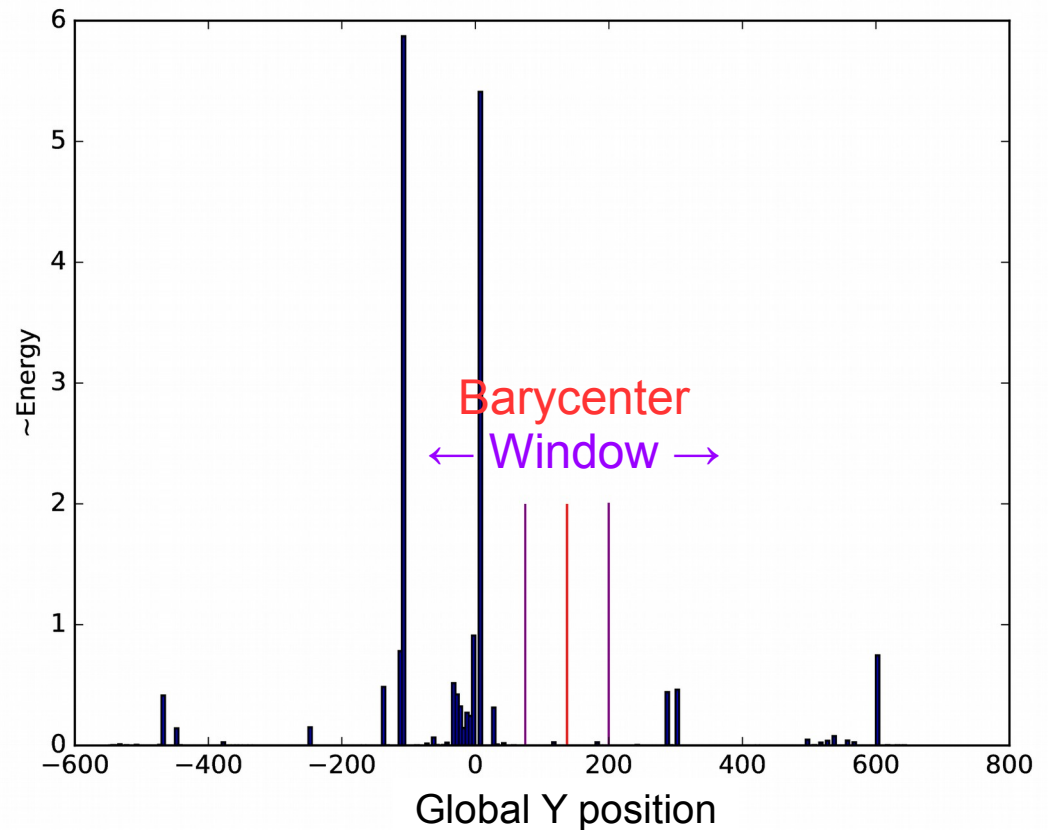
3

# Off-center events (Revisited)

# Off-Center ChPi 1

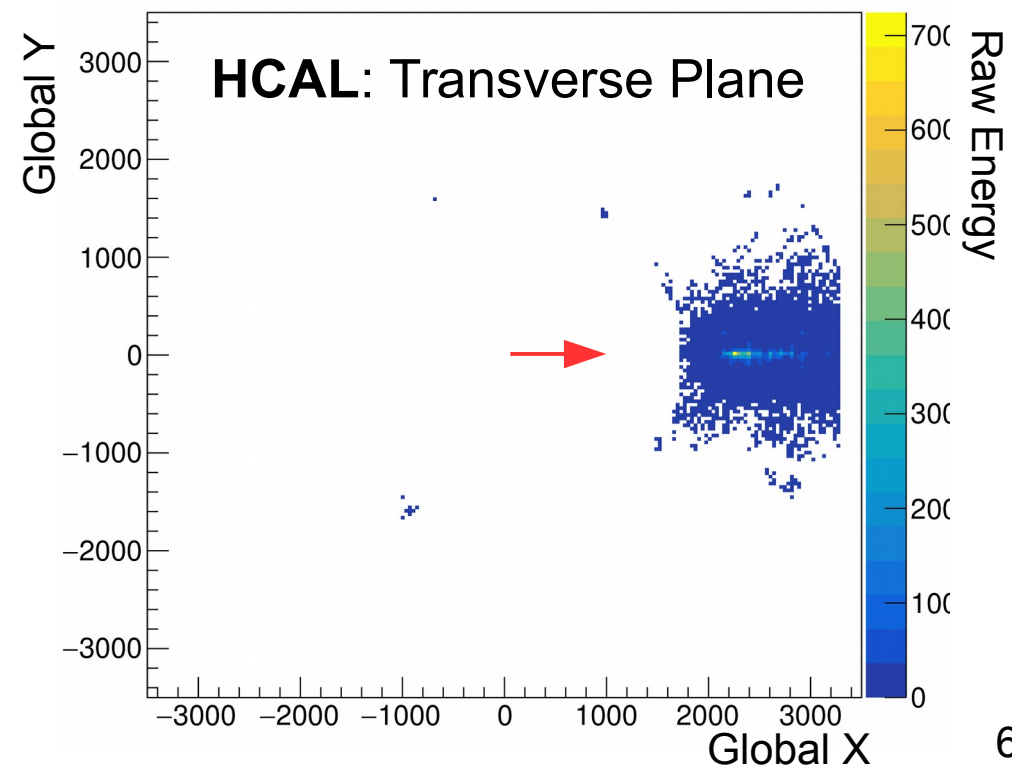
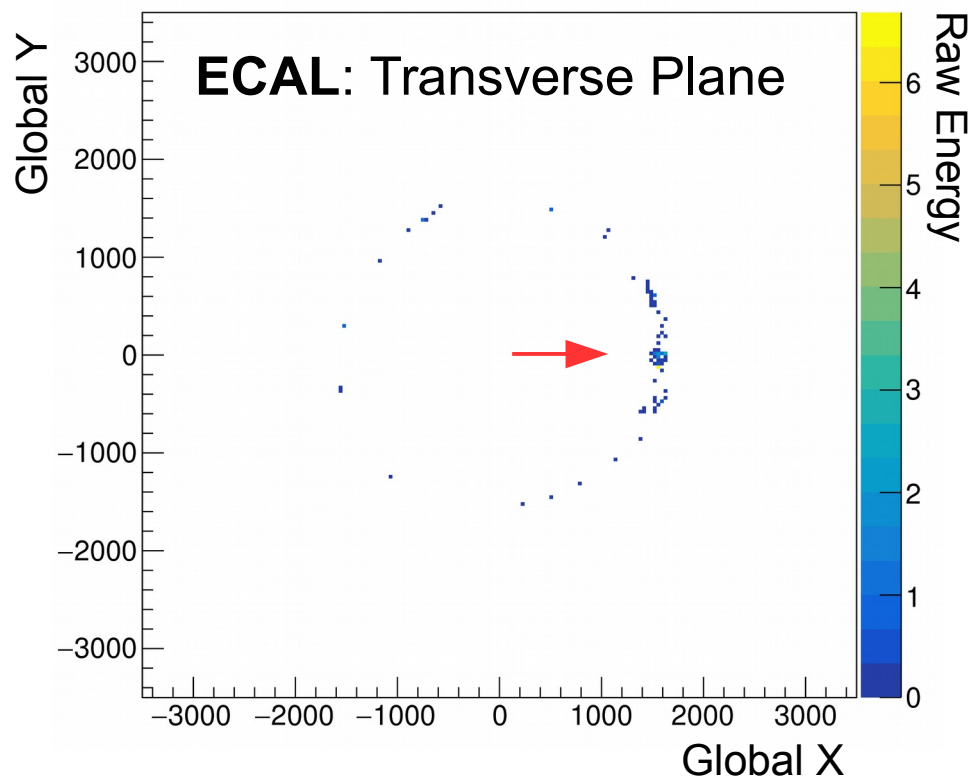
- Re-computed barycenter is **completely off in this case**
  - Selected window **misses almost all of the energy..**
- Was concerned last time about what all these large angle deposits actually came from

Generated charged pion at  $Y=0$   
With  $E = 503$  GeV



# ChPi 1: Full Event in 2D

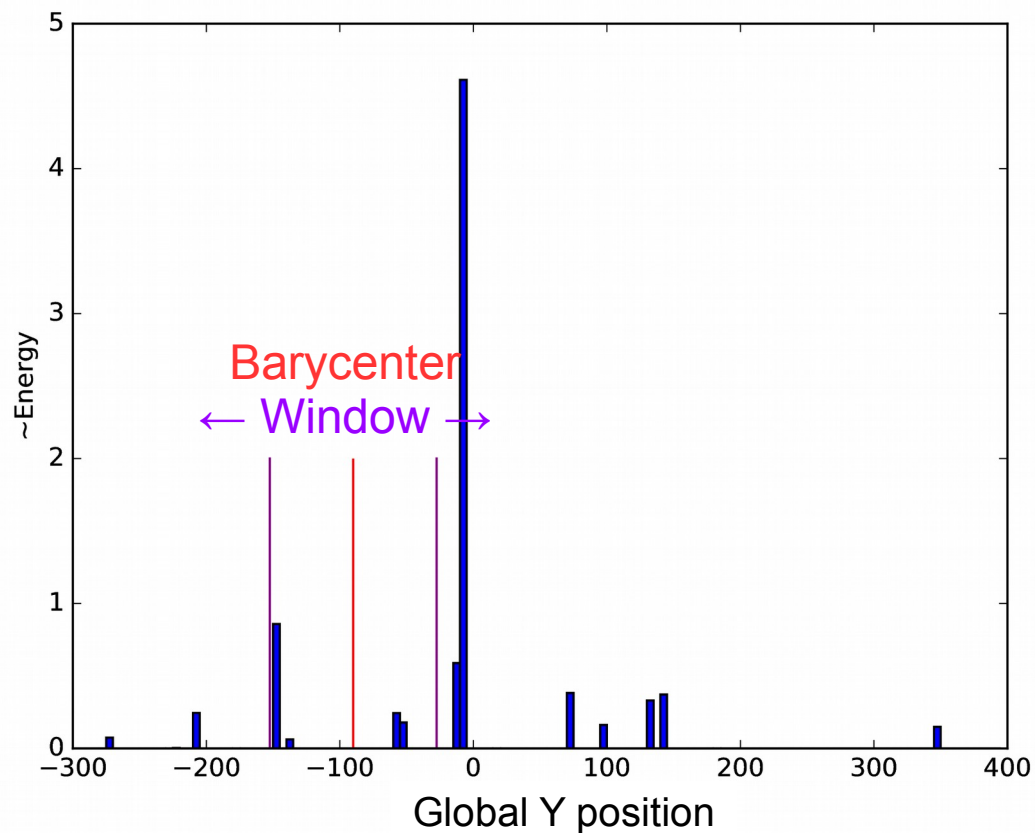
- Step back and look at the **full event, including HCAL**
- We rely on ECAL-only to center window, while some charged pions deposit **almost all of their energy in the HCAL**
- Several small deposits at large angle in ECAL/HCAL, not sure where they come from
  - But it's clear now that they **aren't the main problem**



# Off-Center ChPi 2

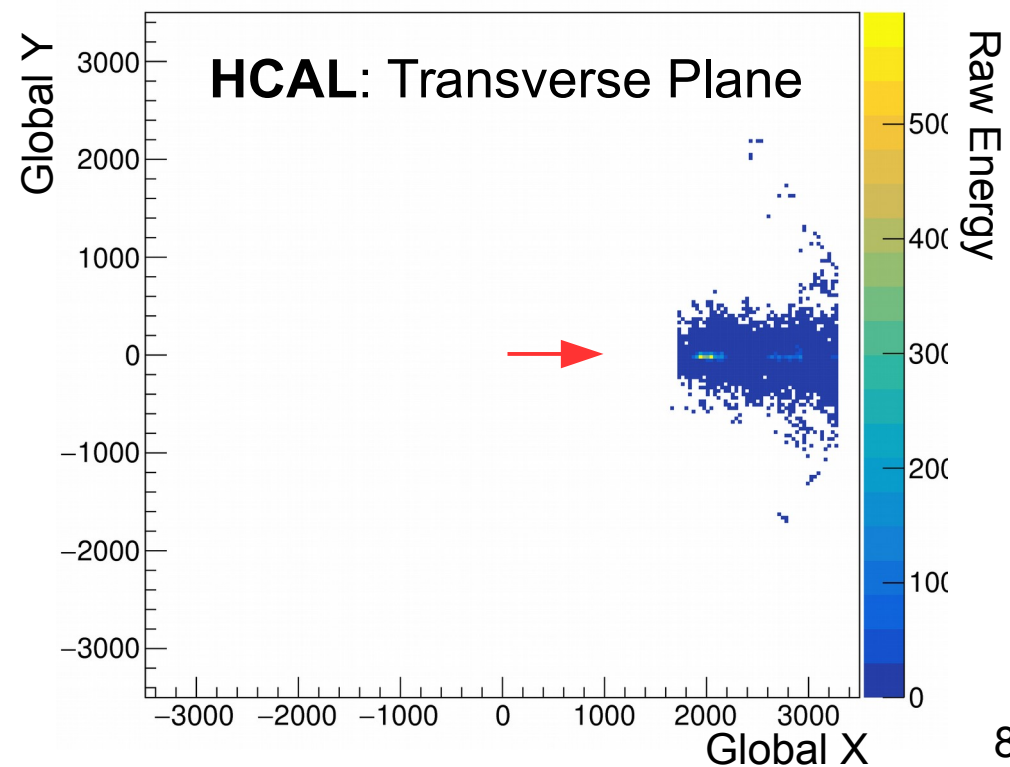
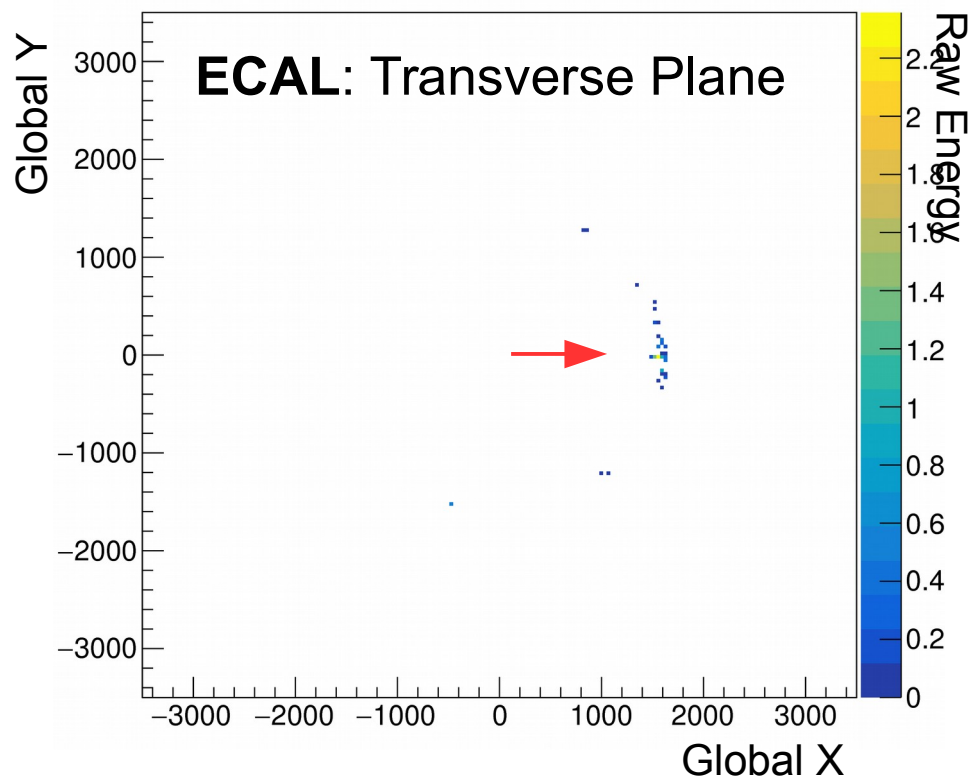
- Re-computed barycenter is **again completely off**
  - Selected window **misses biggest deposit**
- Only particle in MCParticle collection is original charged pion..

Generated charged pion at  $Y=0$   
With  $E = 278$  GeV



# ChPi 2: Full Event in 2D

- Similar picture to previous event
- Can't center properly only using ECAL info

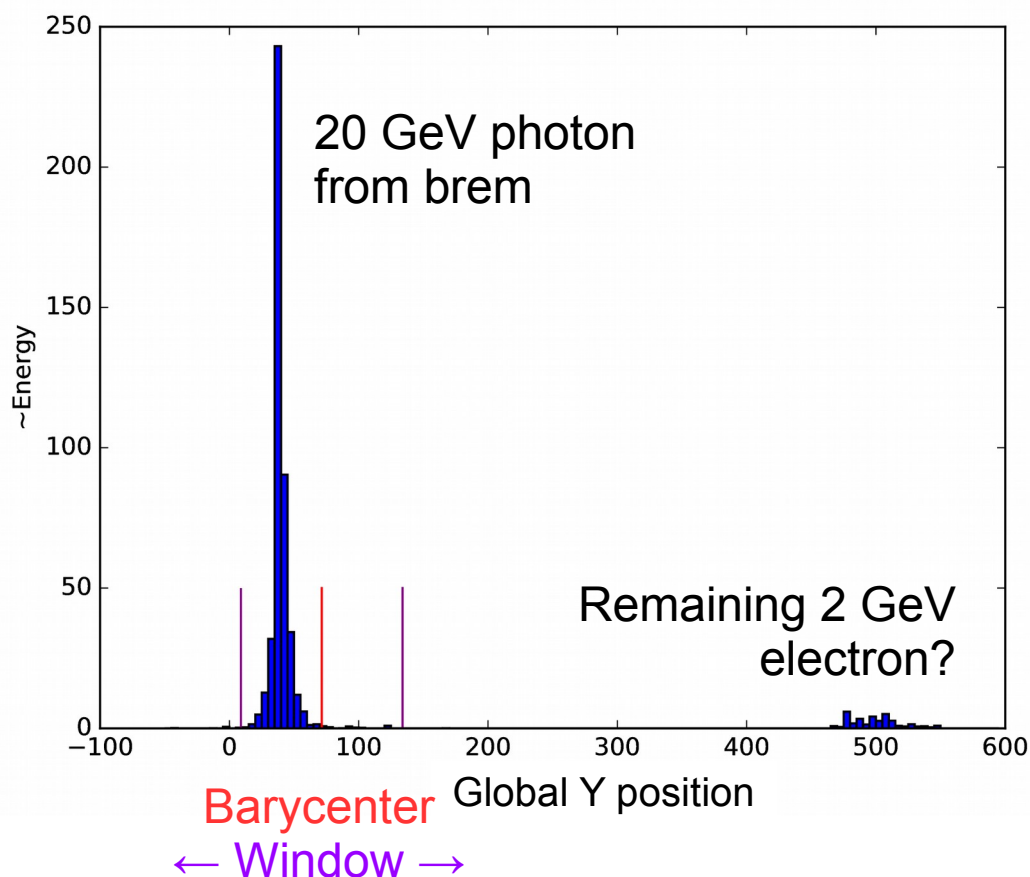




# Off-Center Electron 1

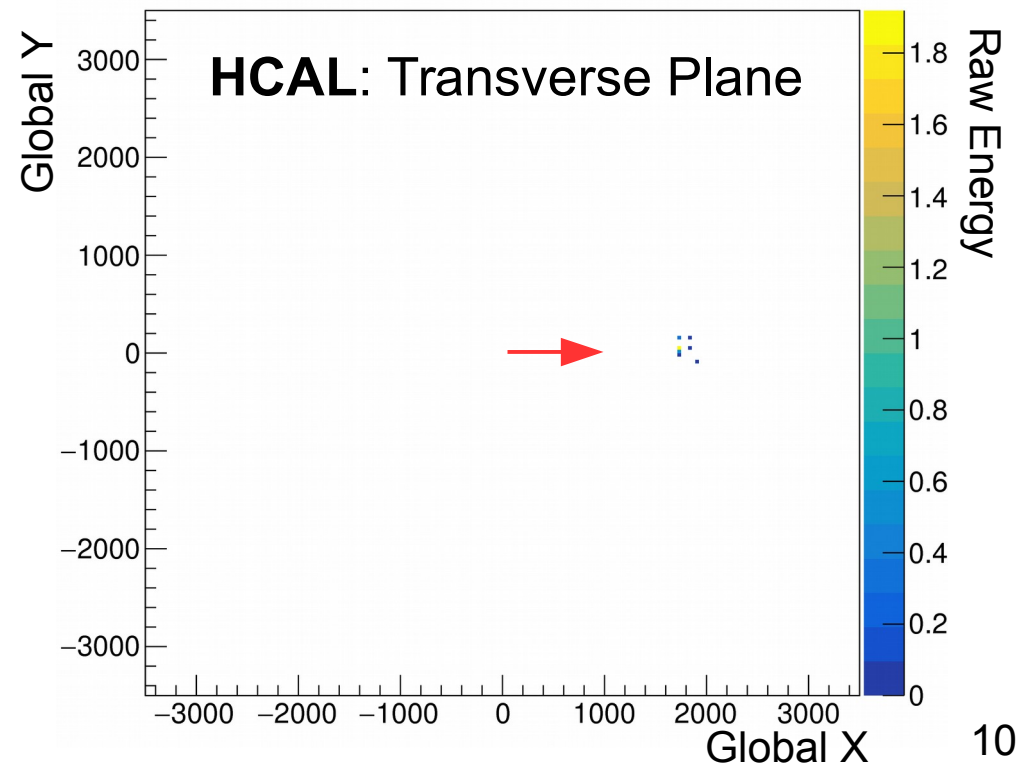
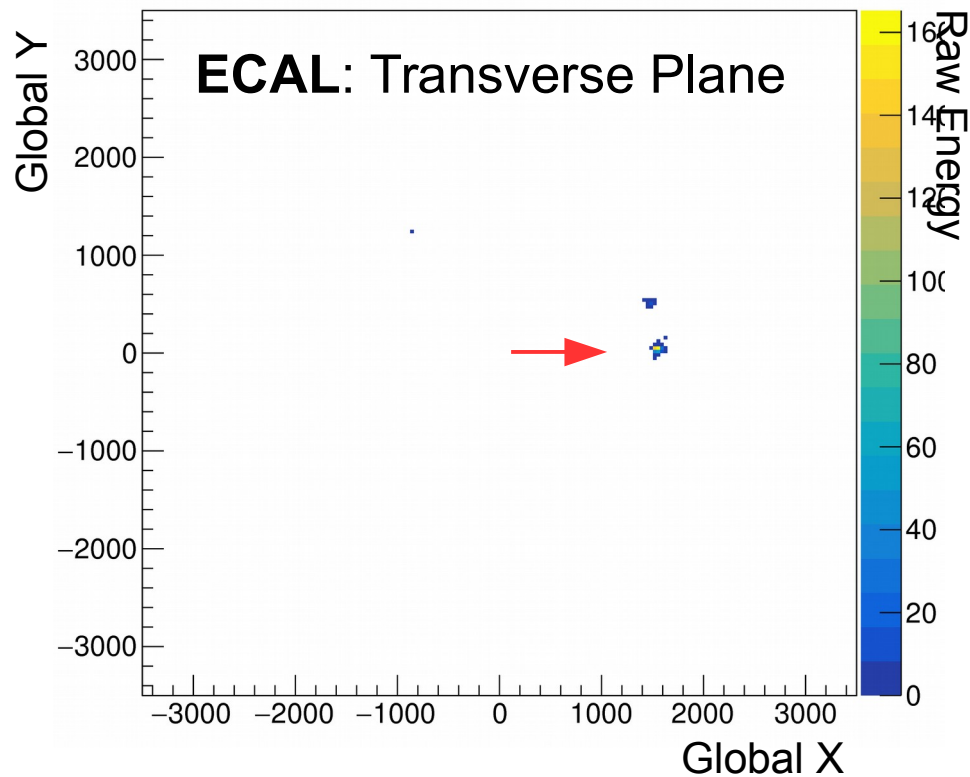
- Re-computed barycenter from h5: **off in global\_y (local\_x)**
- From gen level, looks like a **hard brem takes most of the energy**, remaining electron energy **pulls window off-center**

Generated electron at Y=0  
With E = 22 GeV



# Ele 1: Full Event in 2D

- As expected, almost no HCAL activity for typical electron



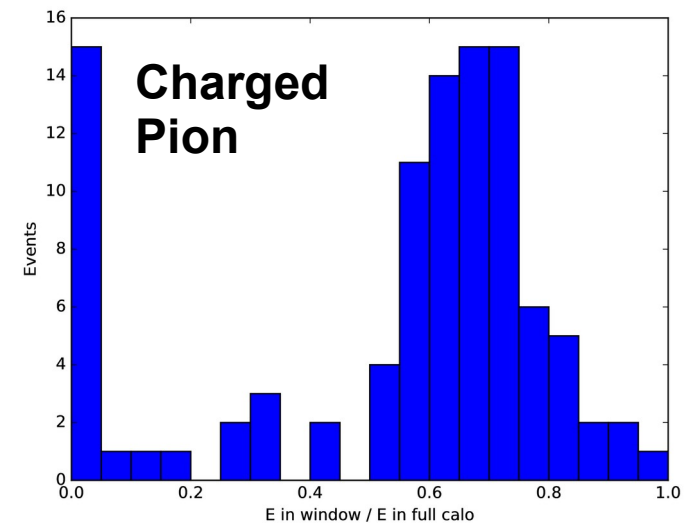
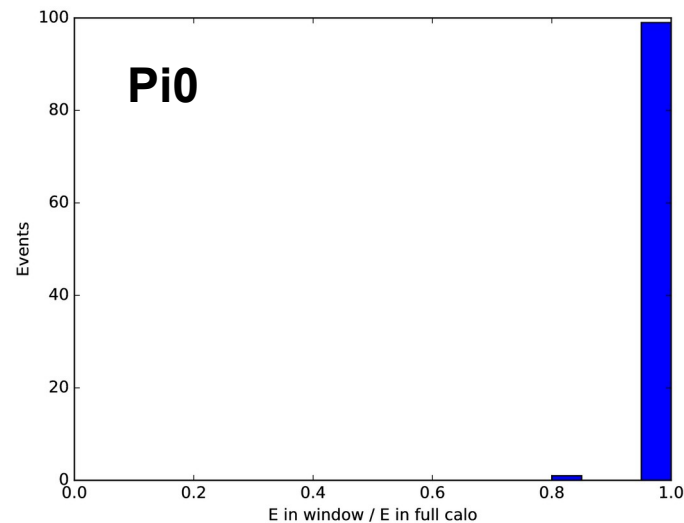
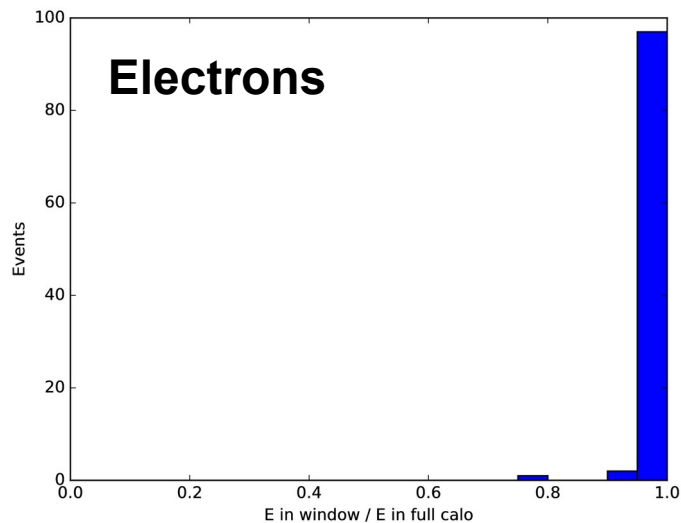
# Barycenter Centering Issue

- Appears to be two pathological cases:
  - A) Electrons/photons/pi0: hard brem or asymmetric conversion
  - B) Charged pions: deposit only a small fraction in ECAL
- (A) more of an issue for **lower pt electrons in events with a hard brem or photon conversion**
  - Due to bending in magnetic field
  - Get **2+ clusters that can be further apart than window size**
  - Probably the best way to eventually solve is to **treat each cluster independently**
- (B) seems to affect **all energies of charged pions**
  - **can't center with ECAL information alone**
  - Solve by centering with **ECAL+HCAL info**

# Comparison of Centering Schemes

# Old Centering: ECAL only

- Old centering was **mostly ok** for electrons, pi0, (photons)
  - Off-center cases from radiation were a **small fraction of events**
- **Didn't work well at all** for charged pions
  - High fraction of events where **almost none of total ECAL+HCAL** deposits are in the selected window

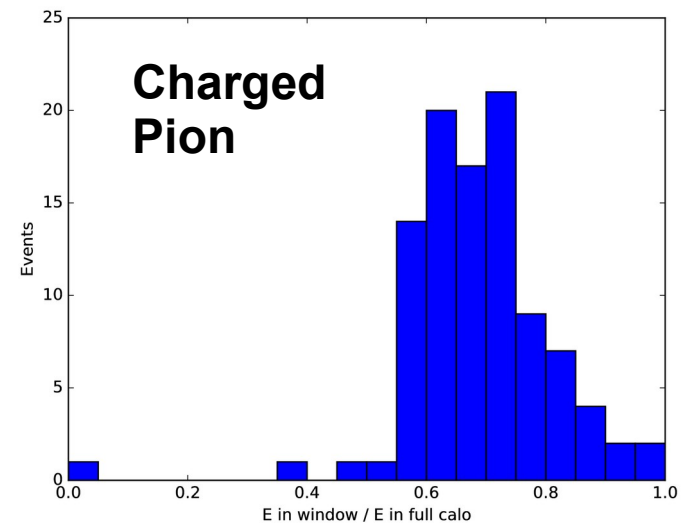
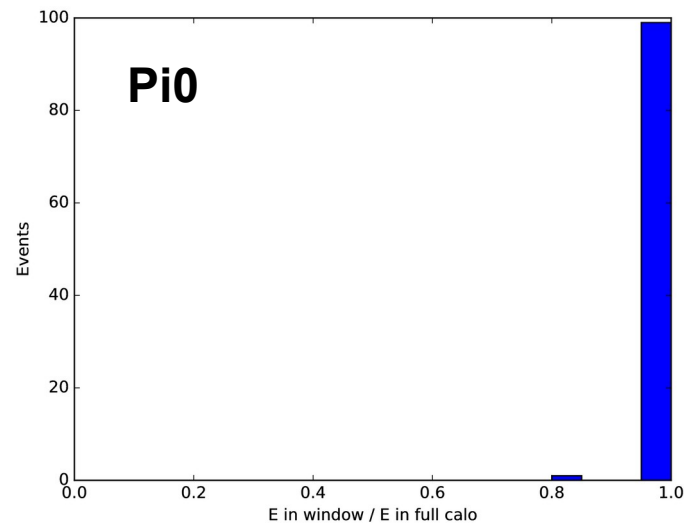
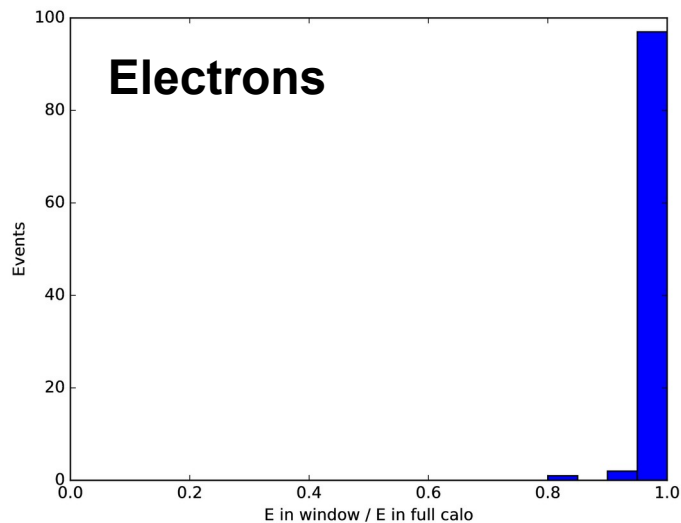


Fraction of ECAL+HCAL total energy contained in window

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# New Centering: ECAL+HCAL

- Try centering based on **ECAL+HCAL energies, proposal (1)**
  - Still using global coordinates, not local yet
- Electrons and pi0 **basically unchanged**
- **Significant improvement** for charged pions
  - Large peak at 0 reduced (not sure about the last event..)
  - Still, **large fraction** of the energy in charged pion events **doesn't fit into window..**
  - Are pion showers expected to be **so wide?**



Fraction of ECAL+HCAL total energy contained in window

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# Done / Next Steps

- **Code change integrated** to use **ECAL+HCAL** for centering
  - <https://github.com/UTA-HEP-Computing/CaloSampleGeneration/pull/1>
- Next step would be moving to **local coordinates**
  - Needed to handle jets, possibly different angles (need to check)
  - Need to know values at which indexing wraps around for ECAL and HCAL cell numbering..
  - Maurizio mentioned he can extract the information from the .txt files
- Eventually may want to **treat calo clusters separately**

# Bonus Slides



# Inputs

- Used root/text files on lxplus from CERN eos:
  - /eos/project/d/dshep/LCD/DDHEP/
  - Specific events in bonus slides
- Workflow:
  - root → txt: save calorimeter hits as (ix,iy,iz,E,x,y,z)
    - ix,iy,iz are cell numbers in “local coordinates”
    - x,y,z are distance in “global coordinates”
    - [https://github.com/UTA-HEP-Computing/CaloSampleGeneration/blob/master/Converting/python/Convert\\_to\\_txt.py](https://github.com/UTA-HEP-Computing/CaloSampleGeneration/blob/master/Converting/python/Convert_to_txt.py)
  - txt → h5: save subset of calo cell info around ECAL barycenter
    - [https://github.com/UTA-HEP-Computing/CaloSampleGeneration/blob/master/Converting/python/Convert\\_to\\_h5.py](https://github.com/UTA-HEP-Computing/CaloSampleGeneration/blob/master/Converting/python/Convert_to_h5.py)
- Focused on txt → h5 conversion, barycenter calculation

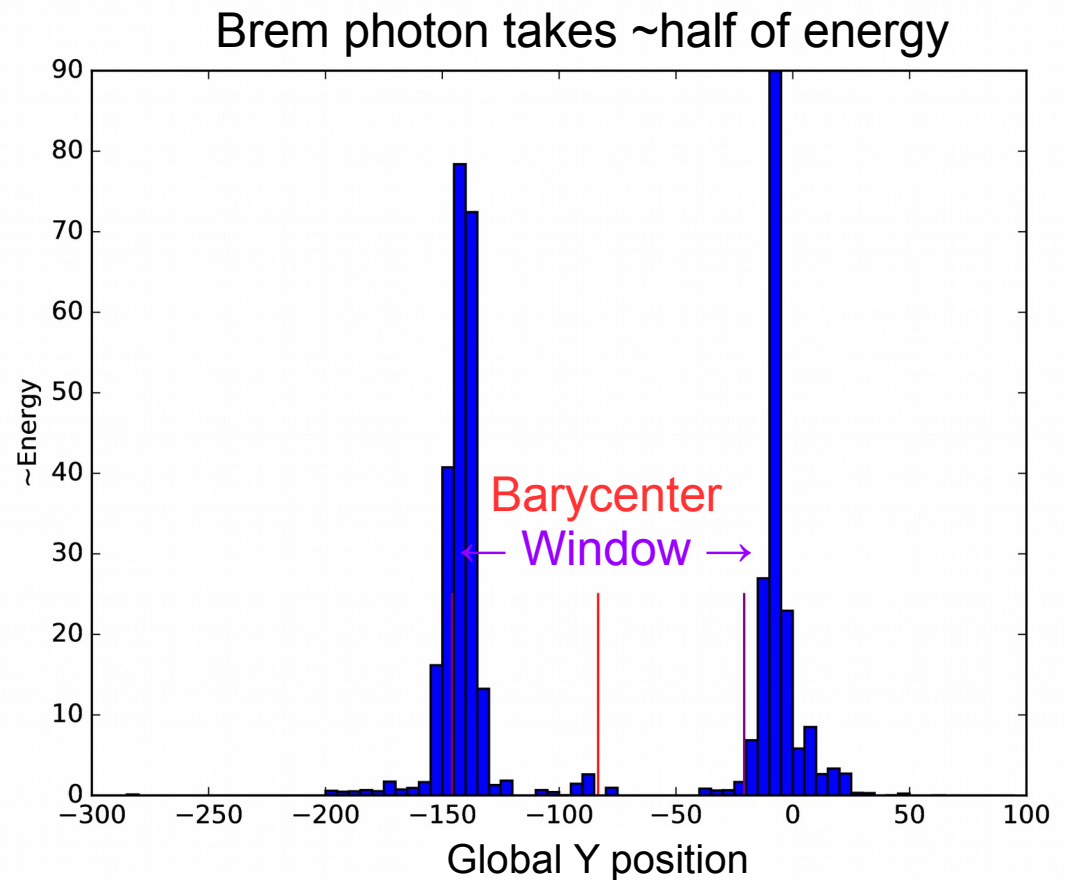
# Events used

- **Electron #1: line 84 in**
  - /eos/project/d/dshep/LCD/DDHEP/EleEscan\_1/EleEscan\_1\_0.txt
- **Electron #2: line 625 in**
  - /eos/project/d/dshep/LCD/DDHEP/EleEscan\_1\_MERGED/EleEscan\_1\_1.txt
- **Charged pion #1: line 8 in**
  - /eos/project/d/dshep/LCD/DDHEP/ChPiEscan\_1/ChPiEscan\_1\_0.txt
- **Charged pion #2: line 9 in**
  - /eos/project/d/dshep/LCD/DDHEP/ChPiEscan\_1/ChPiEscan\_1\_0.txt

# Off-Center Electron 2

- Re-computed barycenter from h5: **off in global\_y**
- From gen level, looks like a **hard brem takes half of the energy**, remaining electron energy **pulls window off-center**

Generated electron at Y=0  
With E = 18 GeV

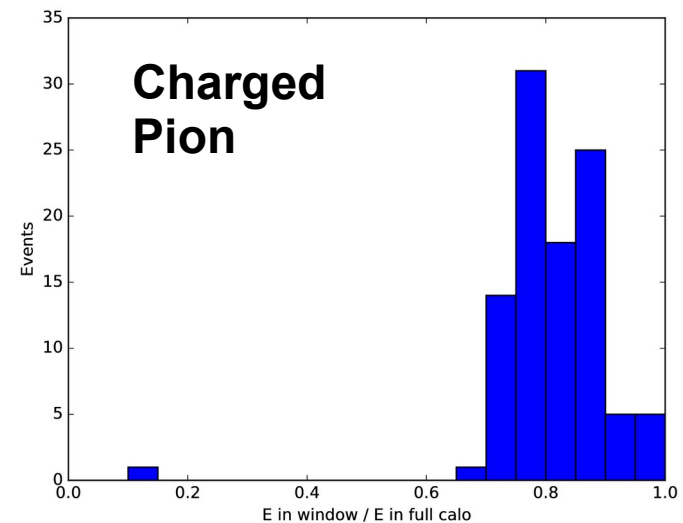
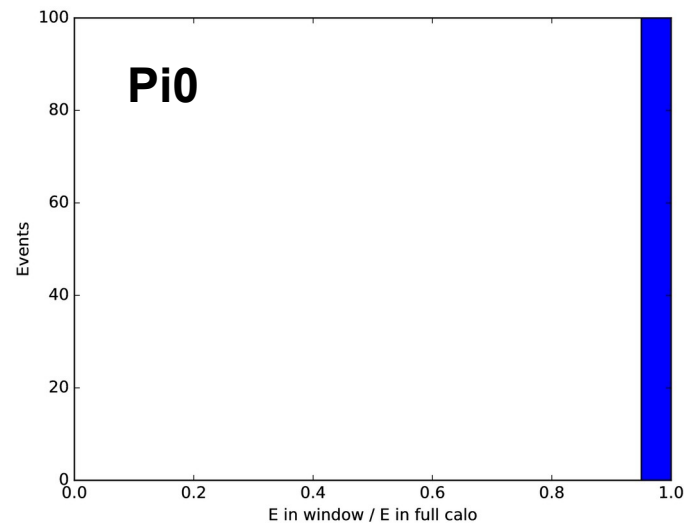
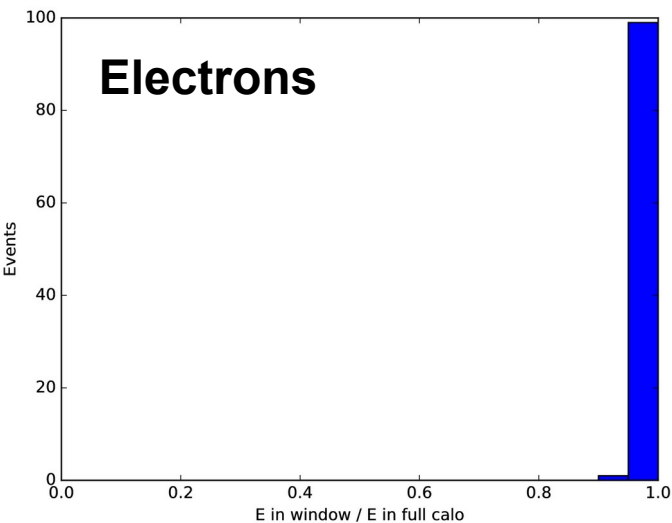


# Centering Ideas

- 1) Use both ECAL and HCAL info to compute barycenter
  - Should solve the big issue (B) for charged pions
  - But will still have issues with case (A), brem/conversions
- 2) Always center on global  $y=0, z=0$ 
  - Captures maximum deposit in examples considered here
  - Fixes the big issue (B) for charged pions (for now)
  - But charged particles still bend, some examples would be off-center
    - Doesn't solve issue of 2<sup>nd</sup> deposits being outside of chosen window size
- 3) Center window on largest “cluster”
  - Would require defining “clusters” though. Could use energy in 5x5 ECAL window + HCAL cell behind
  - Doesn't solve issue of 2<sup>nd</sup> deposits being outside of chosen window size
  - (like jet images): could also rotate image so 2<sup>nd</sup> cluster is always on a specific axis
- 4) Larger window (can be combined with other ideas)
  - window size effectively related to charged pT acceptance for case (A)

# New Centering: Larger window

- Try **doubling window size, proposals (1)+(4)**
  - ECAL: 49x49x25, HCAL: 9x9x60
  - In addition to using ECAL+HCAL
- Collects a **couple tail events** for electrons and pi0
  - Wide angle radiation events from earlier
- Charged pions are **improved, still not 100%**
  - Energy deposits in the HCAL can be quite wide
  - **Does this make sense?**



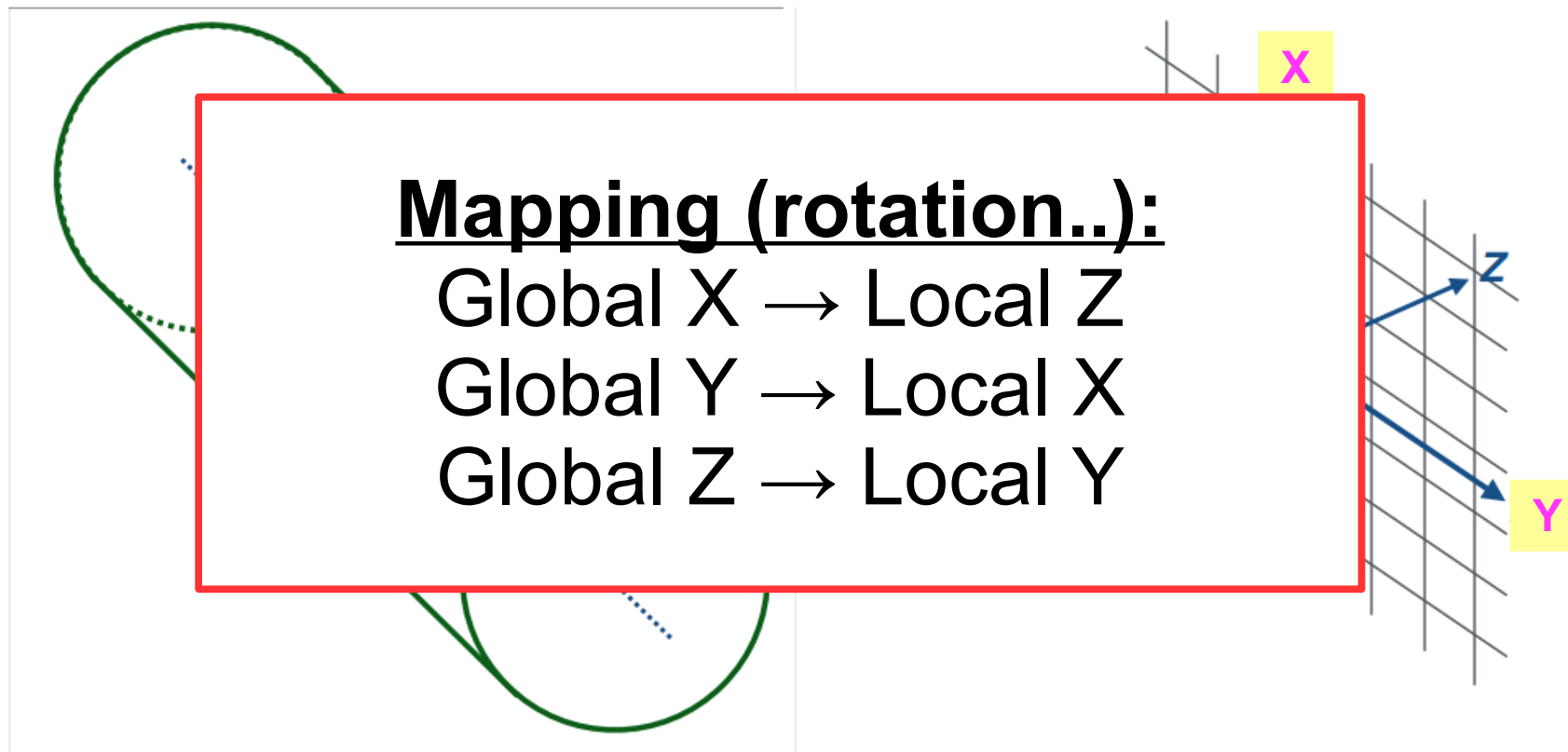
Fraction of ECAL+HCAL total energy contained in window

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# Other Issue: Global vs Local Coordinates

# Global vs Local Coordinates

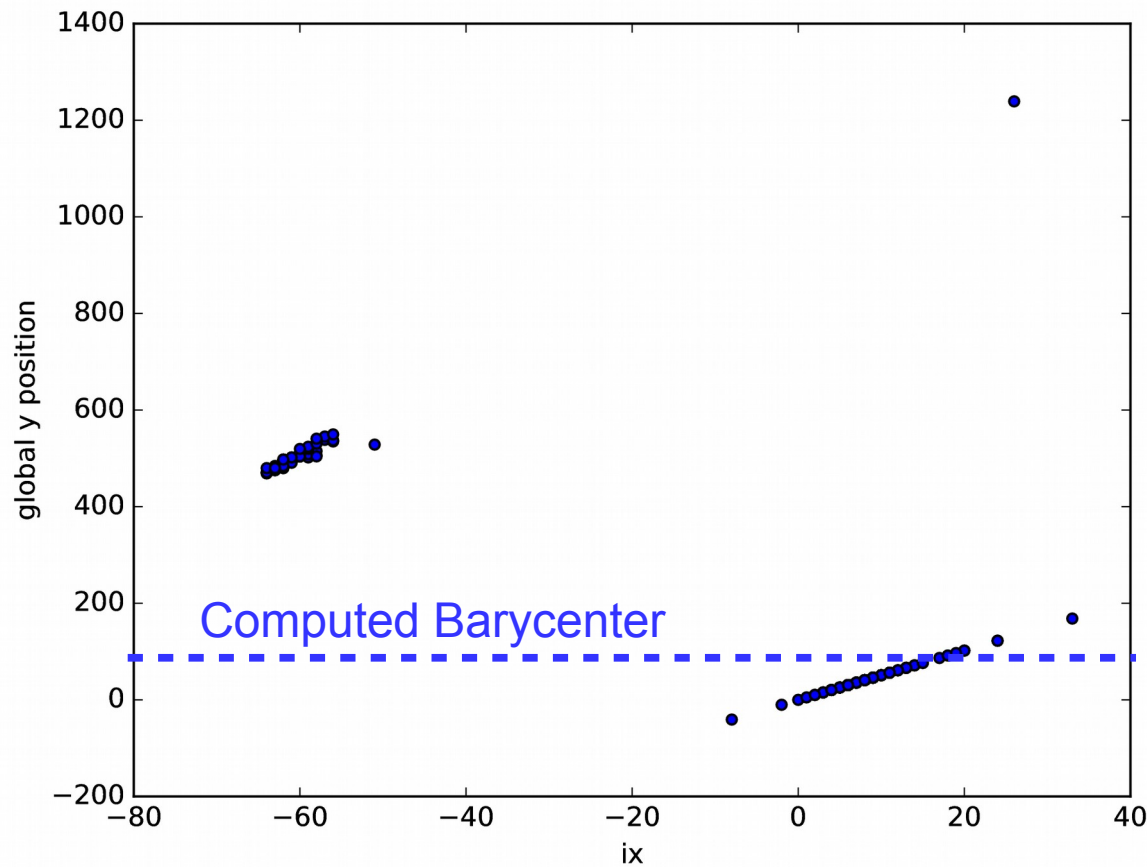
- ECAL barycenter calculation is done in global coordinates
- Cells are saved based on local coordinates
  - See later slides



# Potential wrap-around Effects

- **Global\_y position** used for **barycenter calculation**
- Eventually wraps around to **negative values of local\_x** for cell numbering

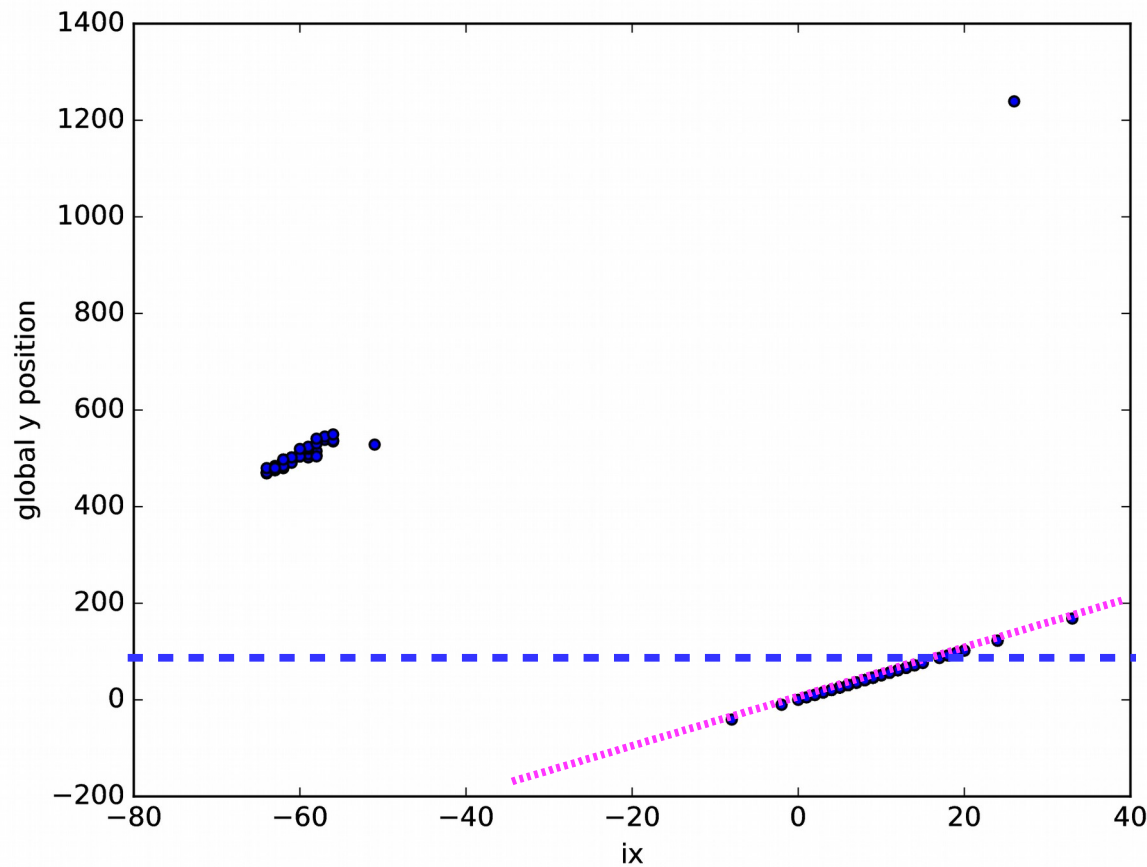
Off-center  
electron  
event #1





# Potential wrap-around Effects

- Mapping from `global_y`  $\rightarrow$  `local_x` doesn't consider wrap-around of `local_x` cell numbering

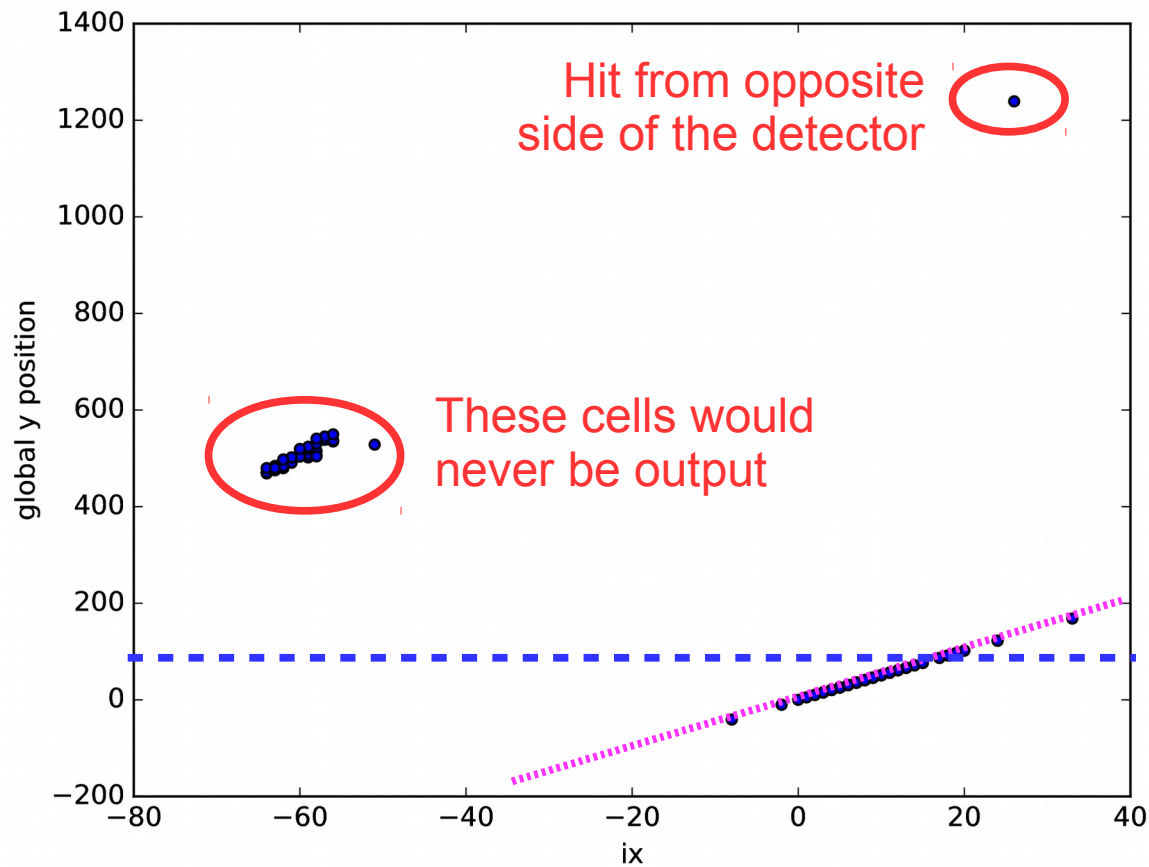


Cells grabbed for h5 file  
assuming `ix = y/5`

i.e. that they lie  
on this line

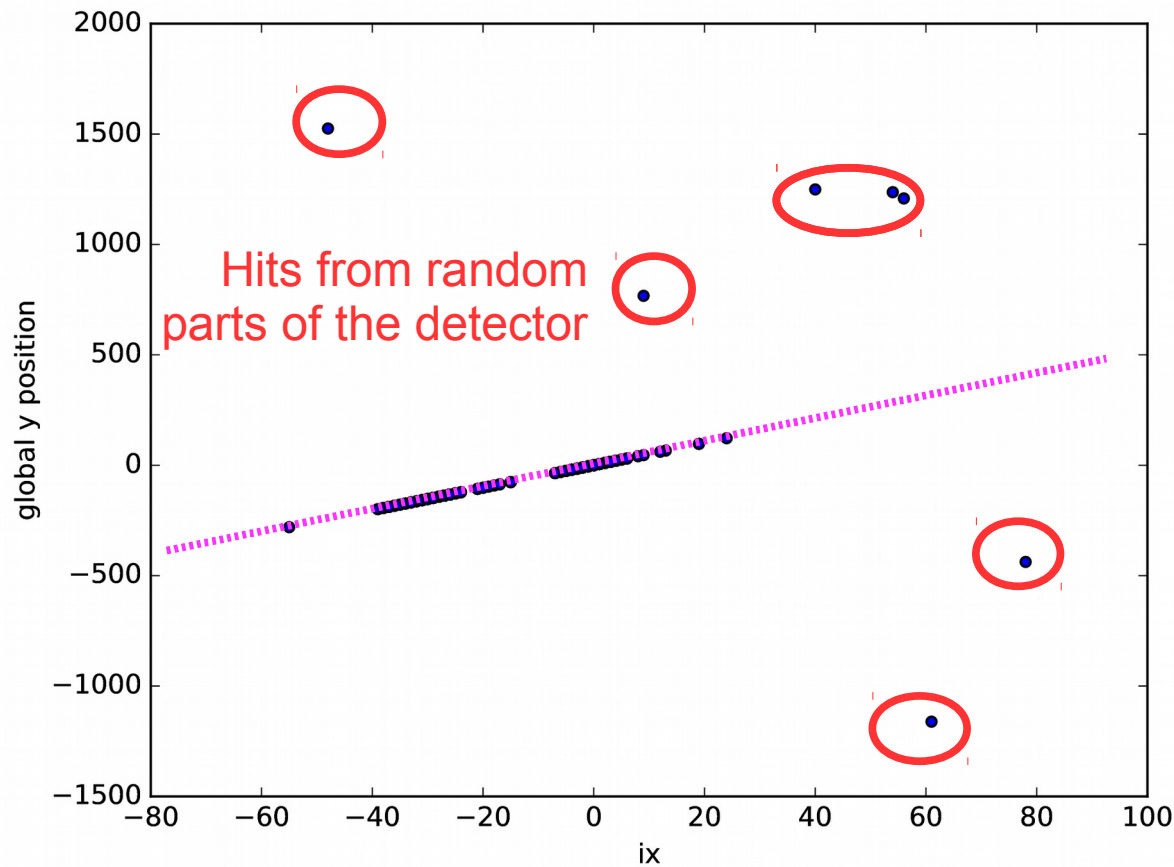
# Potential wrap-around Effects

- Some cells would never be output as a result



# More typical event

- Typical event: most hits clustered near  $\text{global\_y} = 0$ ,  $\text{ix} = 0$ 
  - Expected, since particle gun fires at  $\text{global } y, z = 0$
- So wrap-around typically not an issue



Off-center electron event #2: still ok

# Coordinates for Barycenter

- Preface: **this probably doesn't matter for single particle events at fixed position**
  - But **may matter** for wider objects (jets) or particles fired at angles
- Was there a reason to prefer current scheme of **computing barycenter in global coordinates?**
- Could instead **use local coordinates**, assume unrolled calorimeter, and compute barycenter there
- Seems more directly relevant for what we're doing
  - More straightforward to address **wrap-around effects**