Effects of Pileup on Electron and Photon Reconstruction

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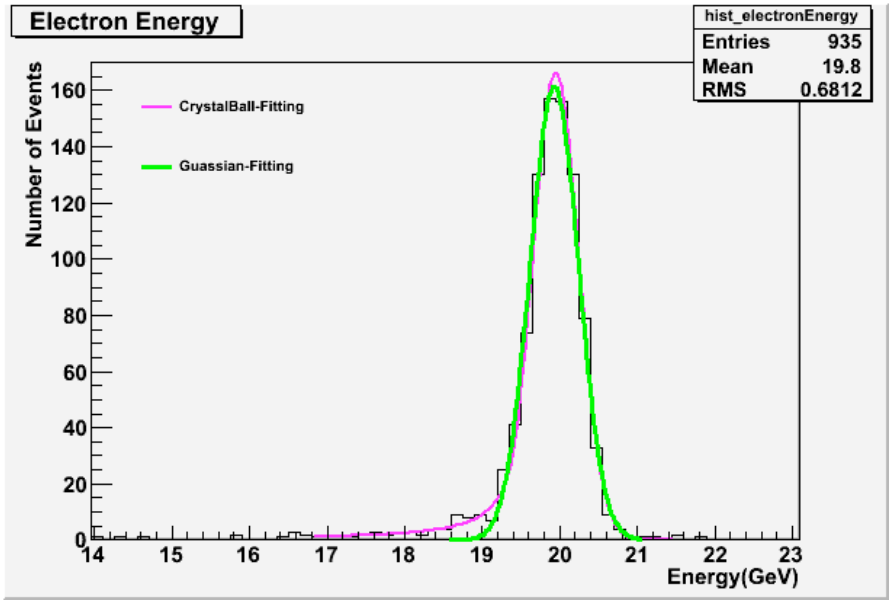
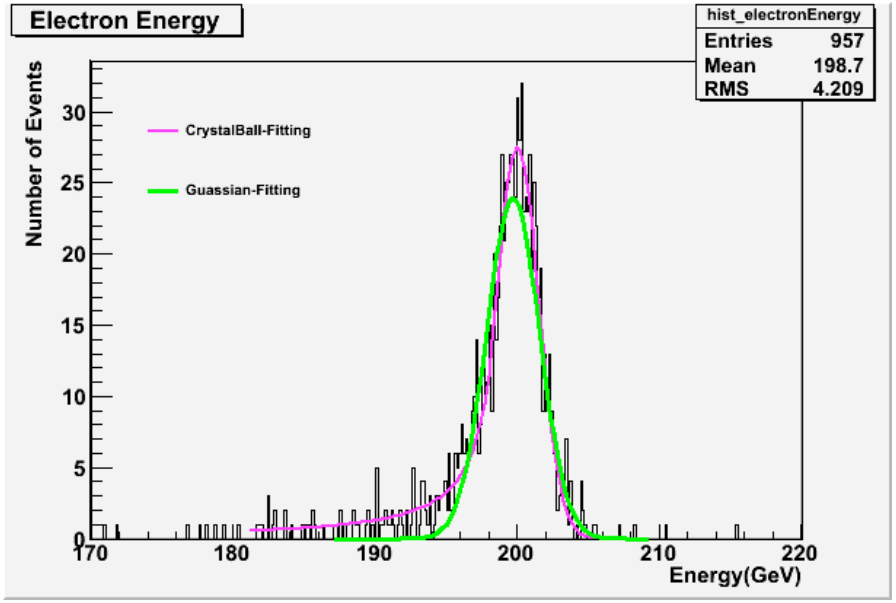
- Study of pileup effects on the electron resolution
- Effects on the Z' resonance width and reconstruction efficiency
- Study of the photon isolation with pileup
- Work in Progress! (e.g. LY loss still not taken into account, electrons are reconstructed as SC or BC, etc.)

Effects on the Electron Energy Resolution

1 PU; Energy = 20GeV; Eta = 0



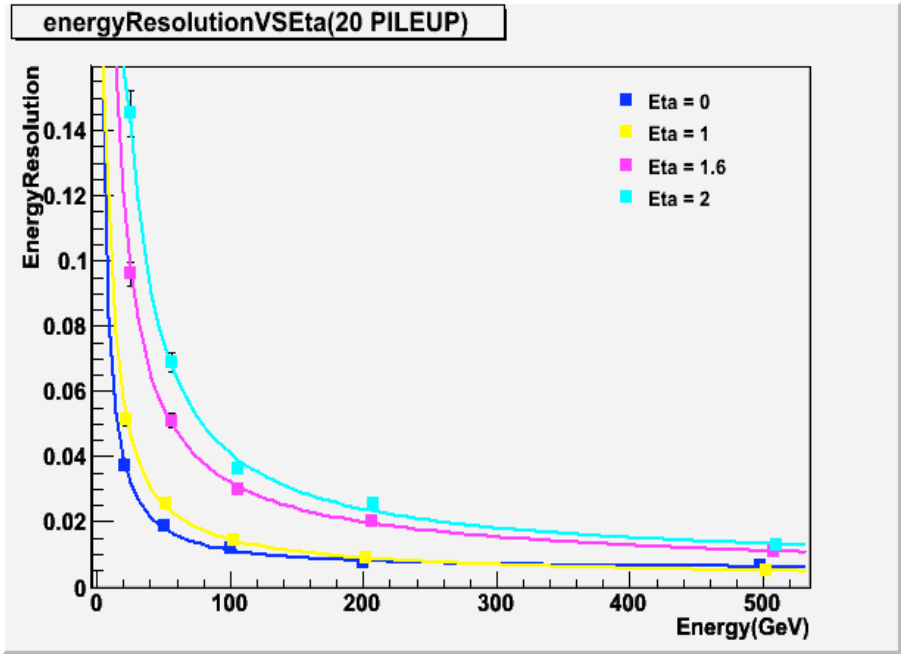
20 PU; Energy 200GeV; Eta = 0



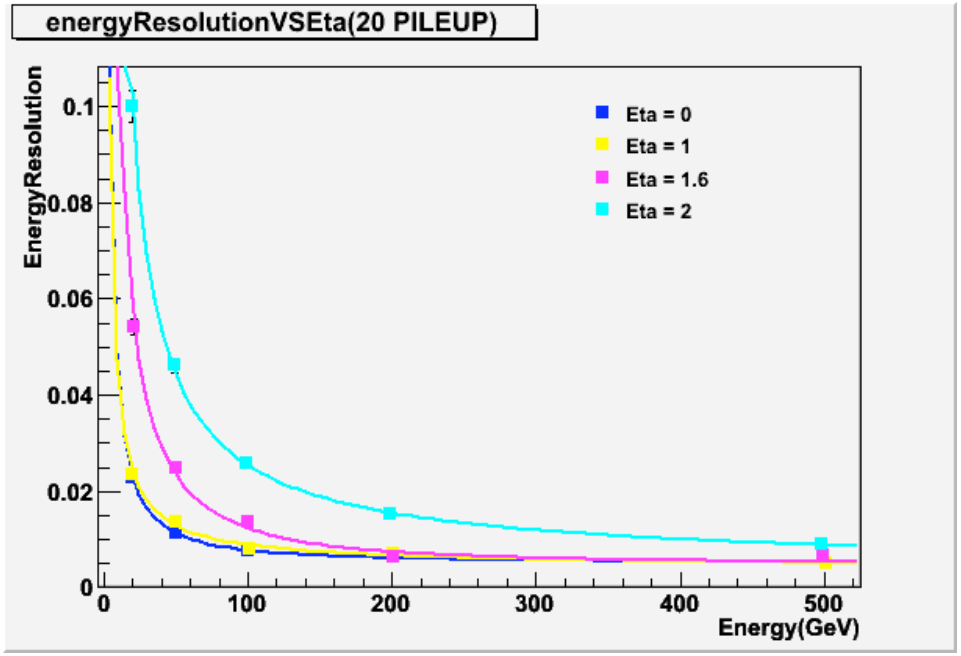
- Samples of ~1000 electron-gun events produced for different energies and rapidity values (scanning!), with different pileup settings
- Since the peak is assymetric and there is a tail on left side, the crystal ball fit works a little better (used in the following slides)

(Virginia)

Comparison Between Super Cluster and Basic Cluster analysis with 20 PU/crossing



Super Cluster

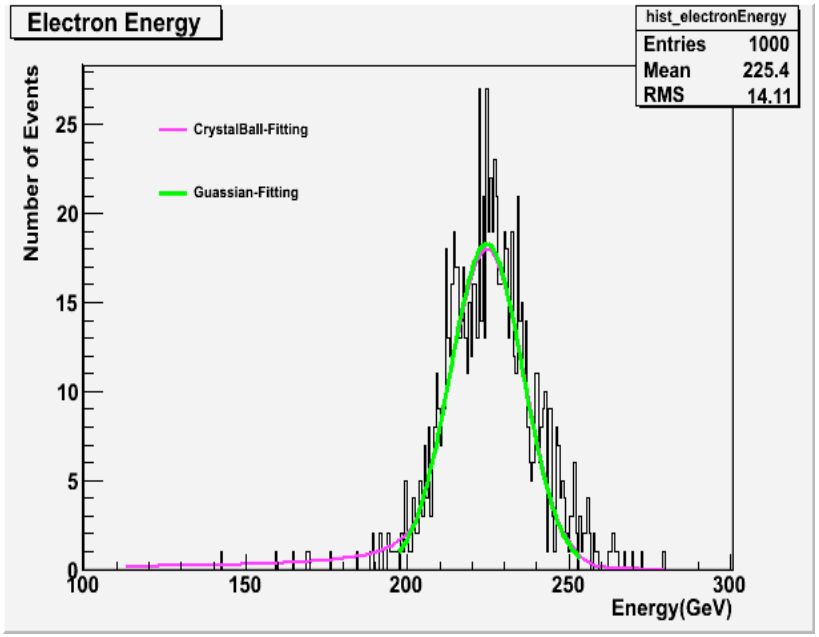


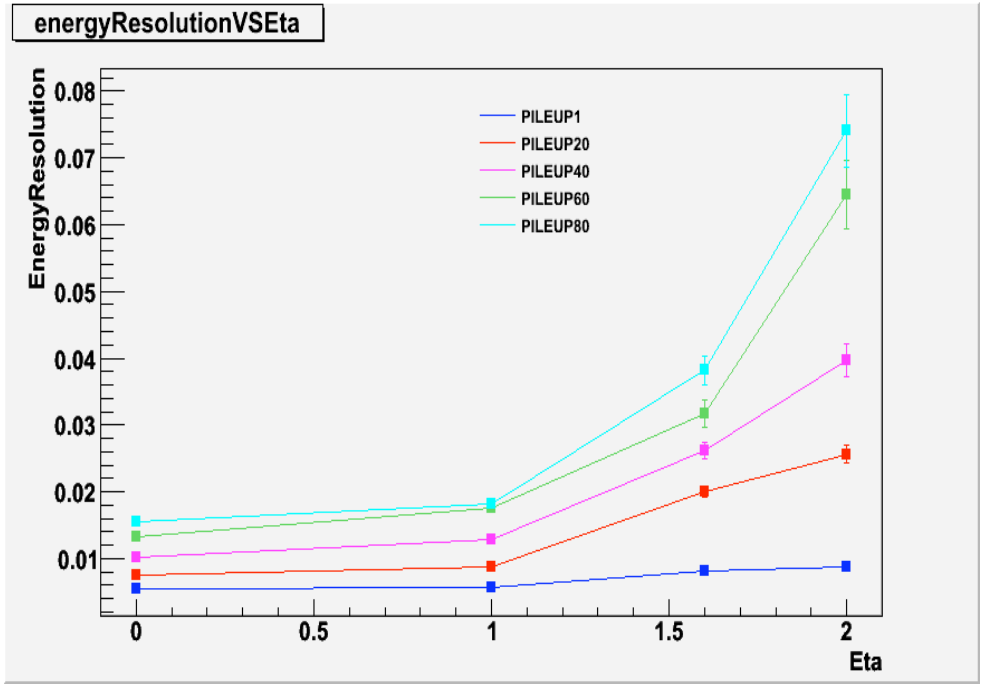
Basic Cluster

- Energy resolution is worse at higher rapidity.
- As expected, it gets better at higher energies. Basic clusters perform a little better (more on that later).

Dependence on Pileup

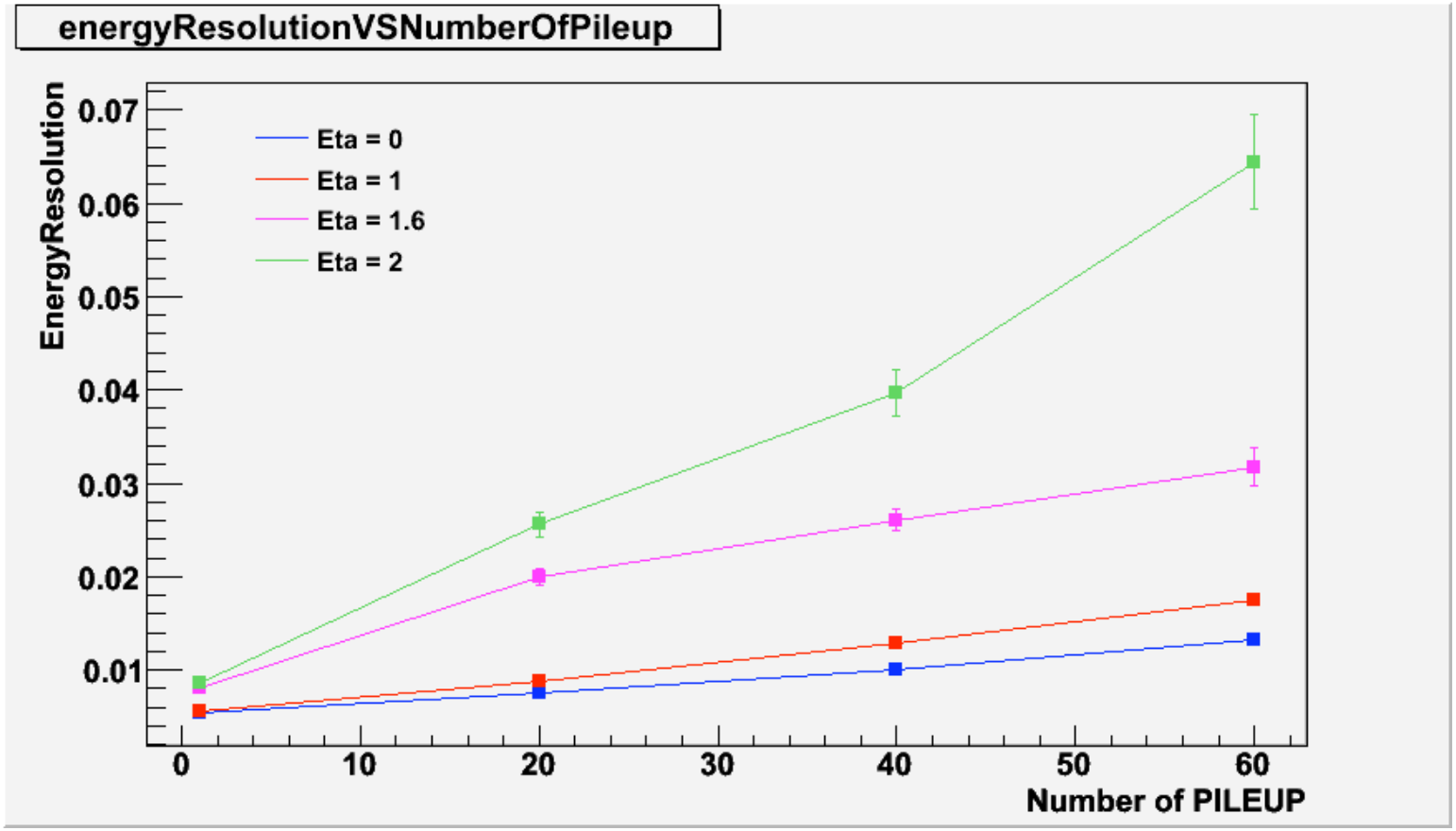
80 PU; Energy 200GeV; Eta = 2





- With more pileup the resolution at higher rapidities worsens
- Hint of a right-side tail in the energy spectrum, but the peak is still symmetric

Dependence on Pileup (2)



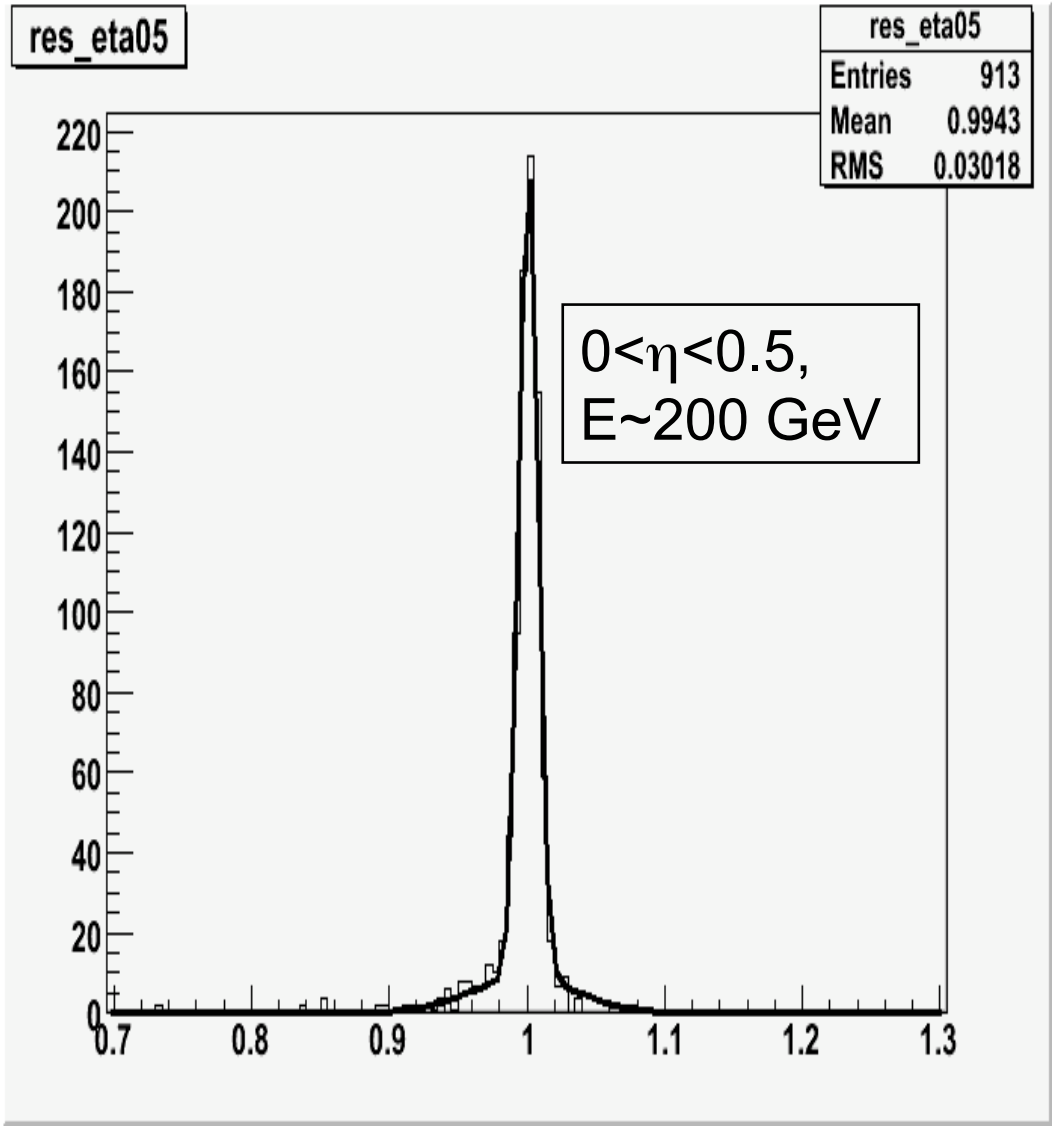
Steady dependence on the number of PU events/crossing

Z' and Di-Electron Study

- **Sample of two randomly generated dielectrons – 25k events (50k total electrons)**
- **$M_{Z'}$ = 425 GeV – 10k total events**
- **$M_{Z'}$ = 2 TeV – 10k total events**
- **Add 2 to 100 PU events.**

(Minnesota)

Fit example, sigma and yield

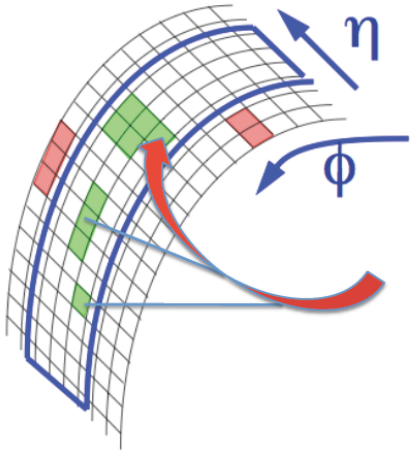


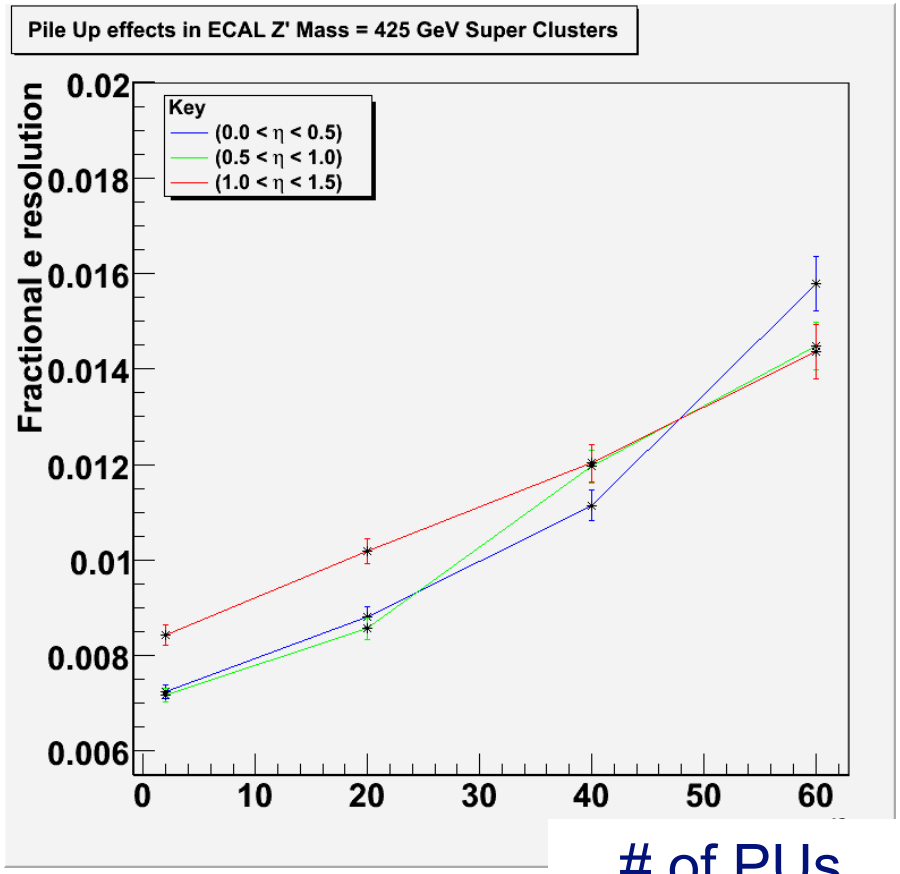
- **Find best fit in η-φ space to the generated electrons**
- **Fit E_{meas}/E_{gen} with two Gaussians, the wider one describing "background"**
- **Width and area of the narrow Gaussian are used as resolution and yield**

PU dependence of energy resolution

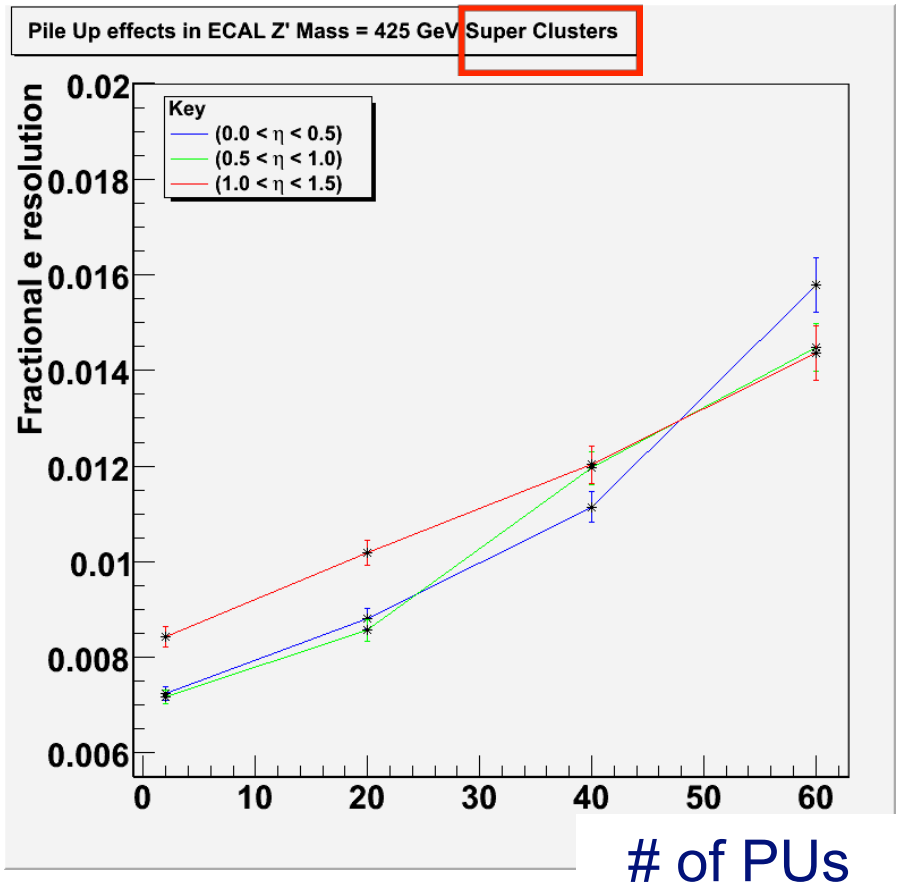
Energy resolution deteriorates by a factor of ~2 with 60 PUs even in the barrel.

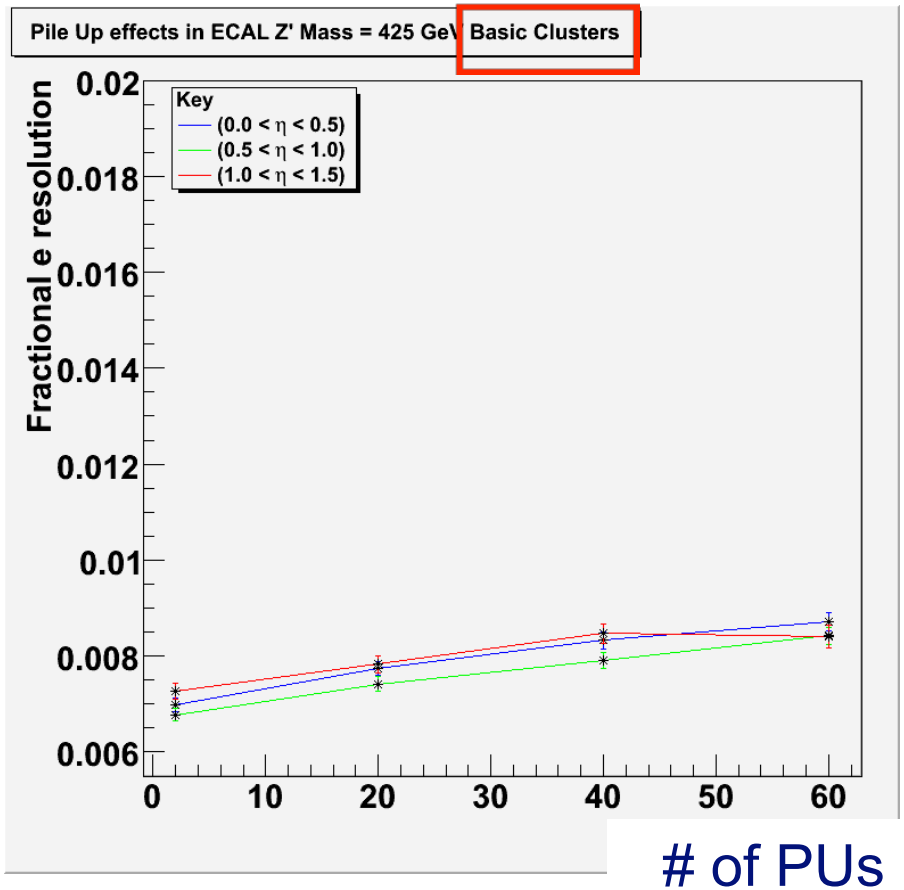
With ~200 PUs, a factor of ~4 deterioration?





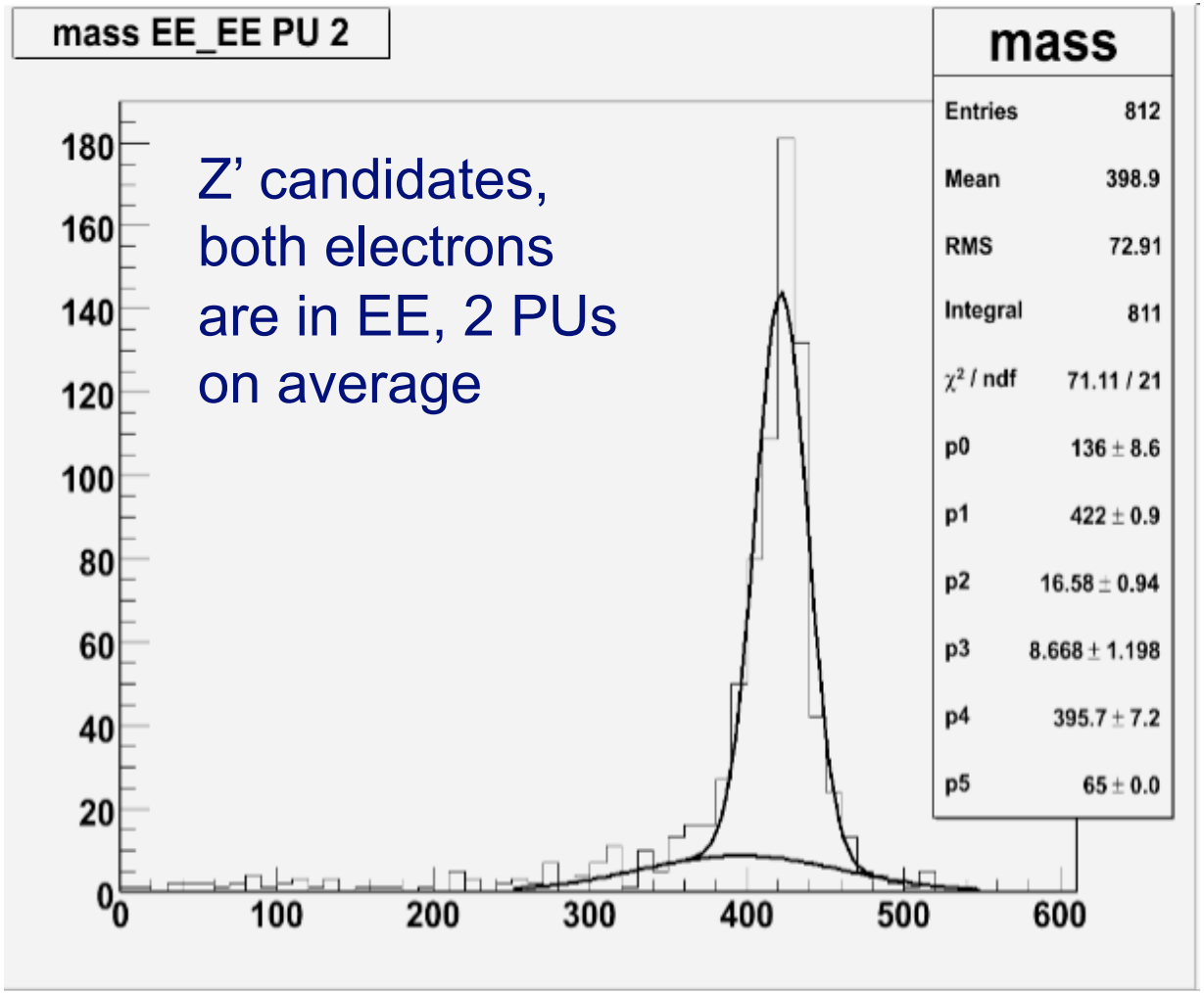
Basic cluster behaves much better





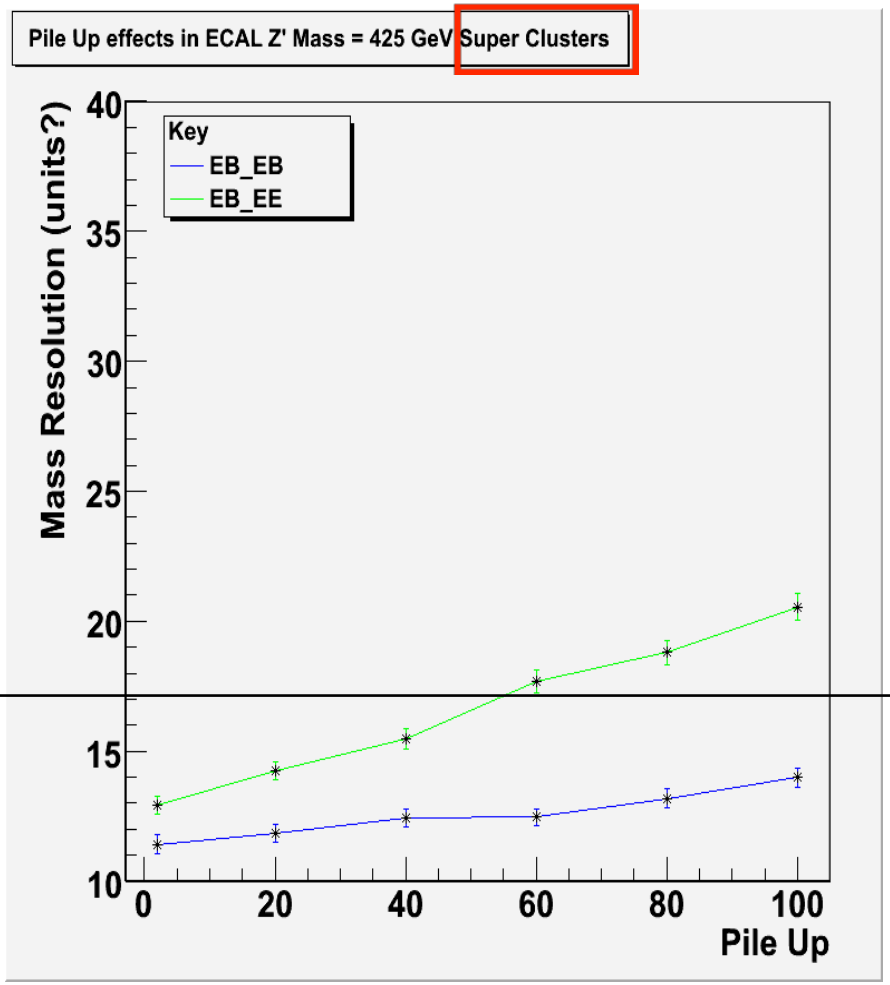
- Even w/ 200 PUs, excellent ECAL resolution can be maintained for basic clusters if the light loss can be contained.
- As expected: the hybrid SC algorithm collects too much pileup

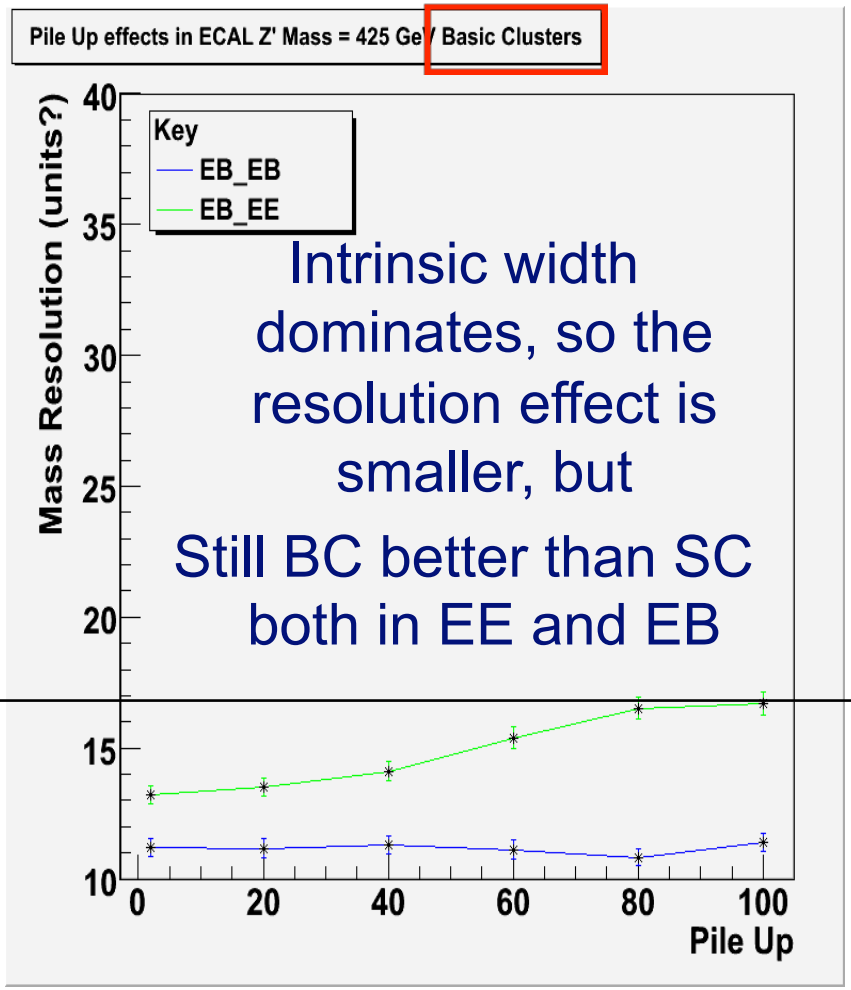
Example of a Z' Fit



- **Fit mass spectrum with two Gaussians, wider one describing "background"**
- **Width and area of the narrow Gaussian are used as resolution and yield**
- **Intrinsic width of Z' (>10 GeV) dominates at small PUs**

Z' mass resolution



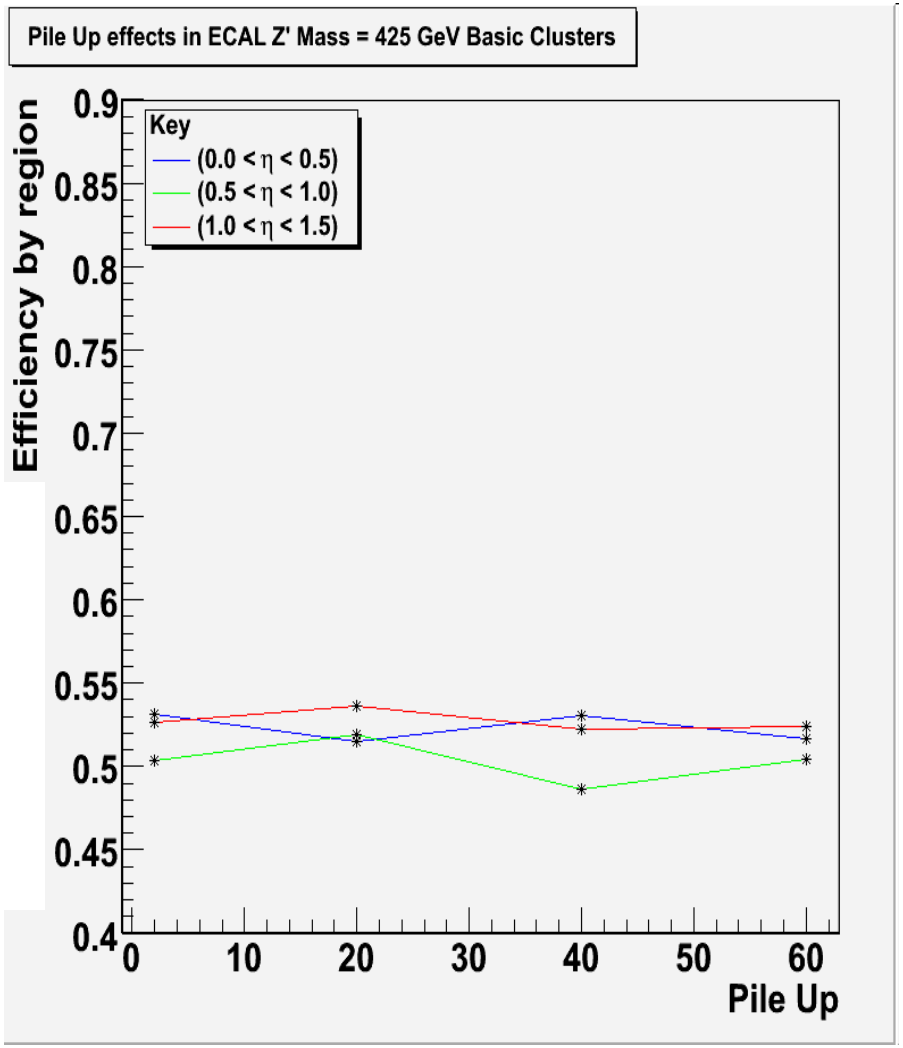


Intrinsic width dominates, so the resolution effect is smaller, but

Still BC better than SC both in EE and EB

Efficiency to find Z' (two electrons)

- Two highest E_T clusters were used to calculate the invariant mass.
  - Does not rely on MC truth – more realistic way to find efficiencies
- Mass distribution was fitted to a Gaussian plus background.
- The area of the Gaussian was used to calculate the efficiency
- For BClusters, there is no change in the efficiency up to 60 PU/crossing.



Z' Study Summary

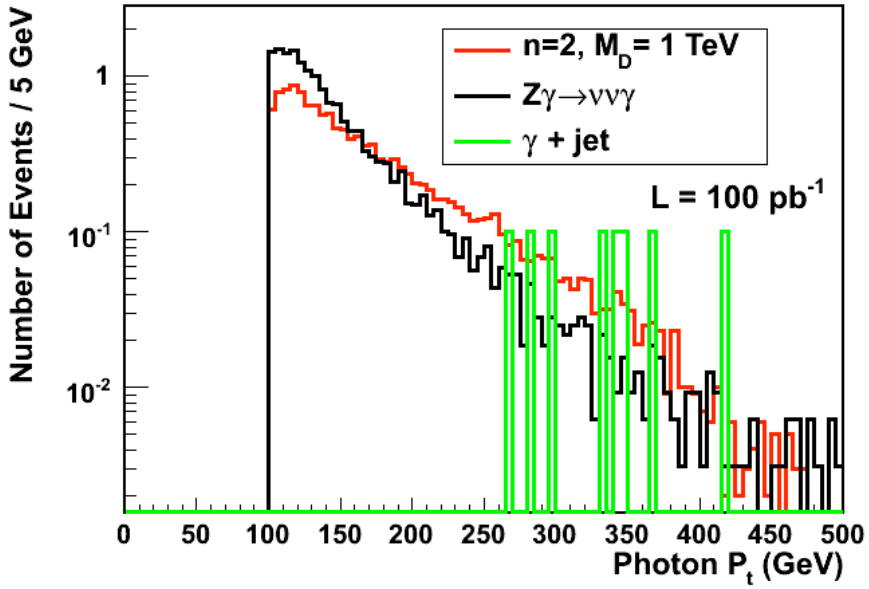
- **In the presences of significant pileup, basic clusters perform better than superclusters at E > 200 GeV.**
- **For $M_{Z'}$ = 425 GeV, PUs has**
  - **Some effect on electron energy resolution (w/ BC),**
  - **but the effect is minimal so that if we can construct good ECAL (crystals w/minimal light loss, etc.) pileup will not "kill it".**
  - **Pileup does not seem to significantly affect the cluster reconstruction efficiency.**

Photon Reconstruction in Pileup

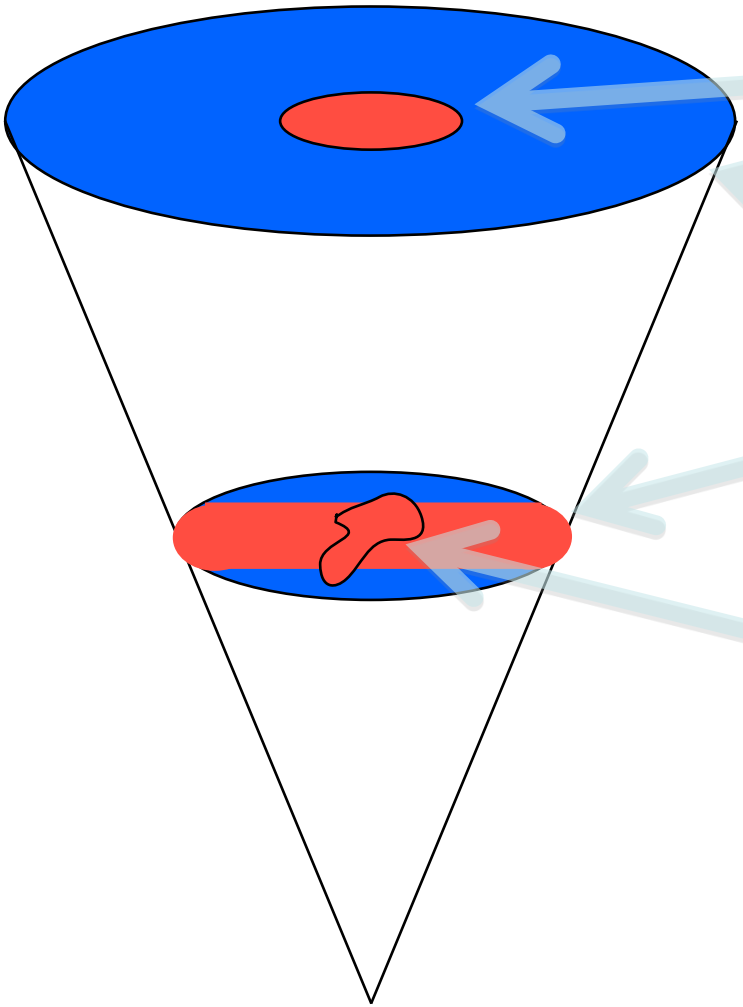
(Caltech)

- **Samples of 50K 80 GeV photons in the barrel and endcaps with different pileup settings (up to 100 GeV)**
- **Higgs and Z samples also studied (see backup) albeit with lower pileup settings**
- **The goal is understand how a realistic photon and electron reconstruction can be done at sLHC in the presence of backgrounds:**

- **For instance: search for ADD monophotons requires a good understanding of jet-fake backgrounds, as are many other photon and electron searches**



Photon Isolation



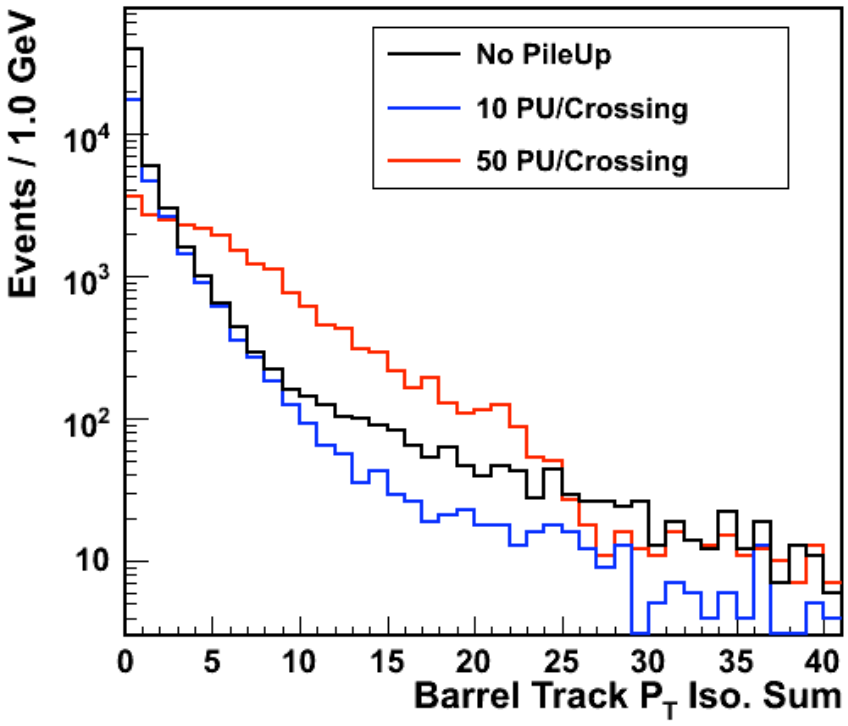
HadOverEM Area

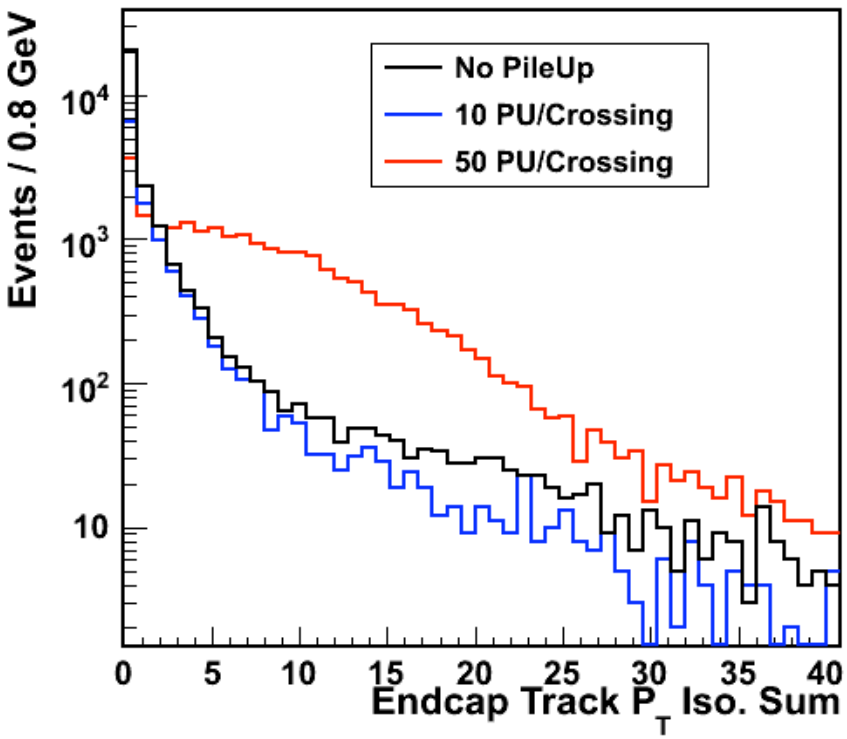
HCAL Isolation Cone

ECAL Isolation Cone and Strip

Clustered Energy

Track Isolation

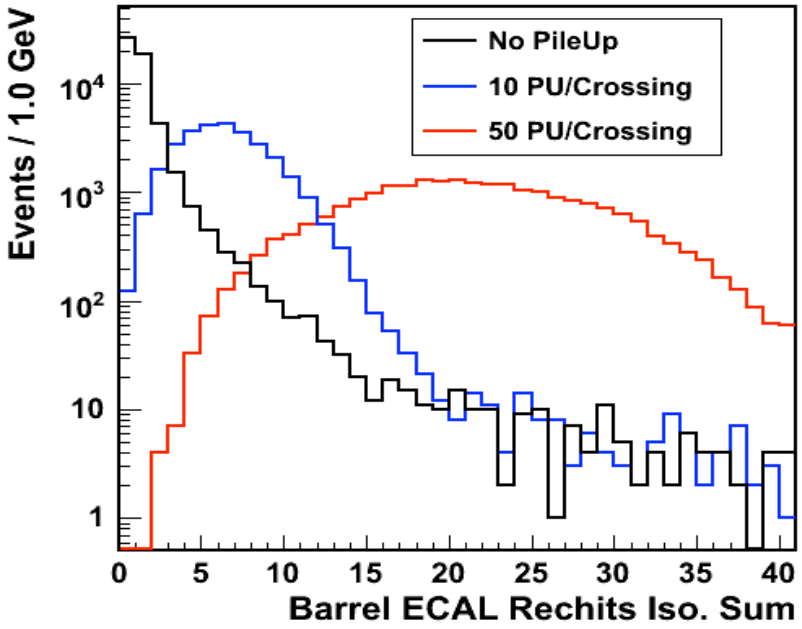


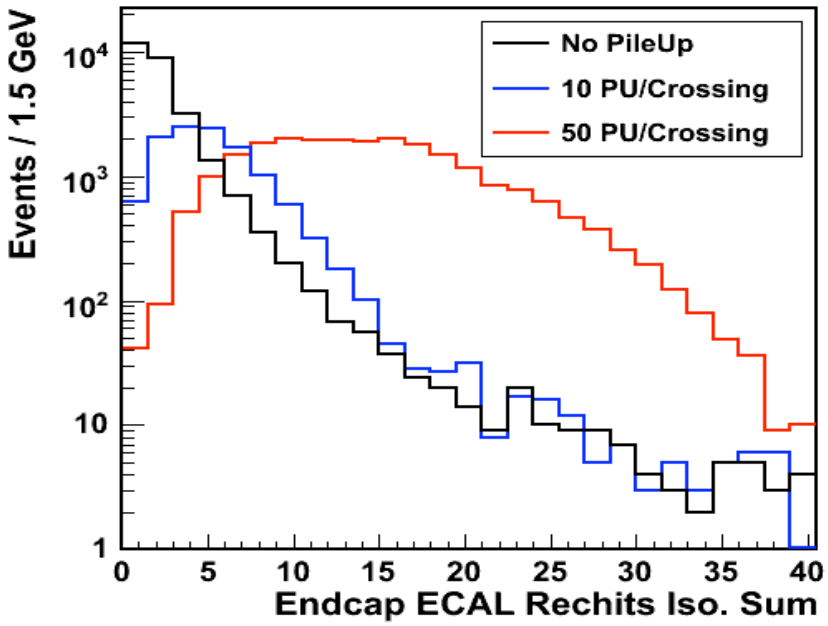


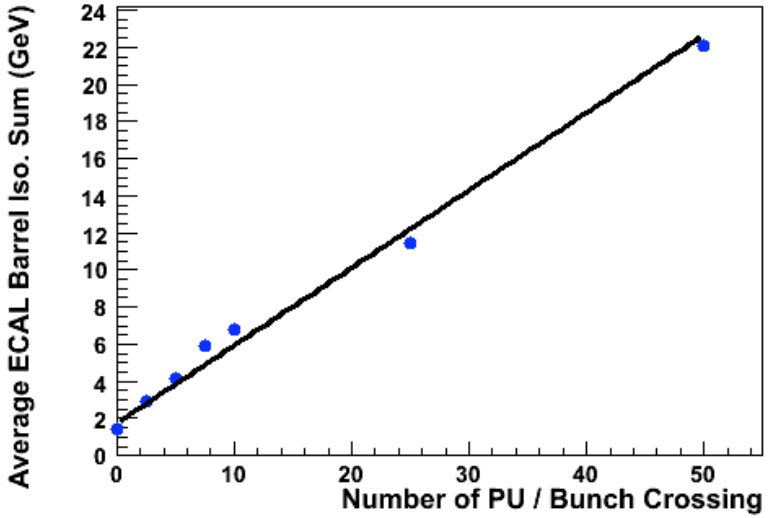
Fairly “standard” isolation cone size (DR<0.4) and thresholds were used everywhere

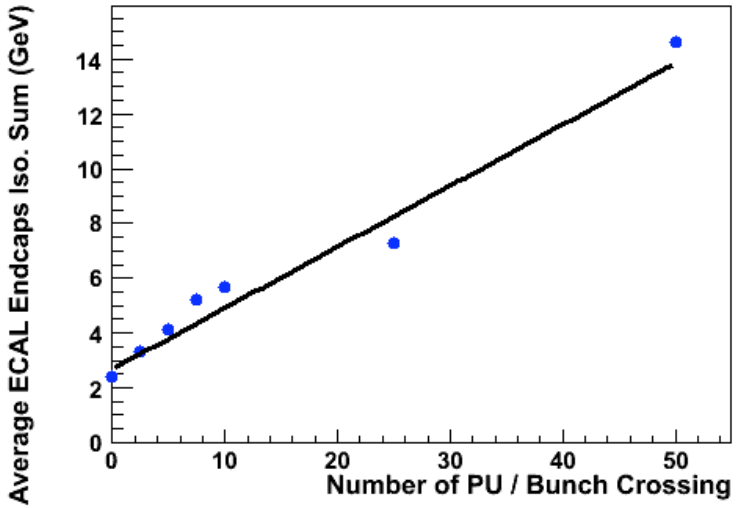
For tracks: need to understand and improve the use of event vertex

ECAL Isolation (Jurrasic, Rechits)

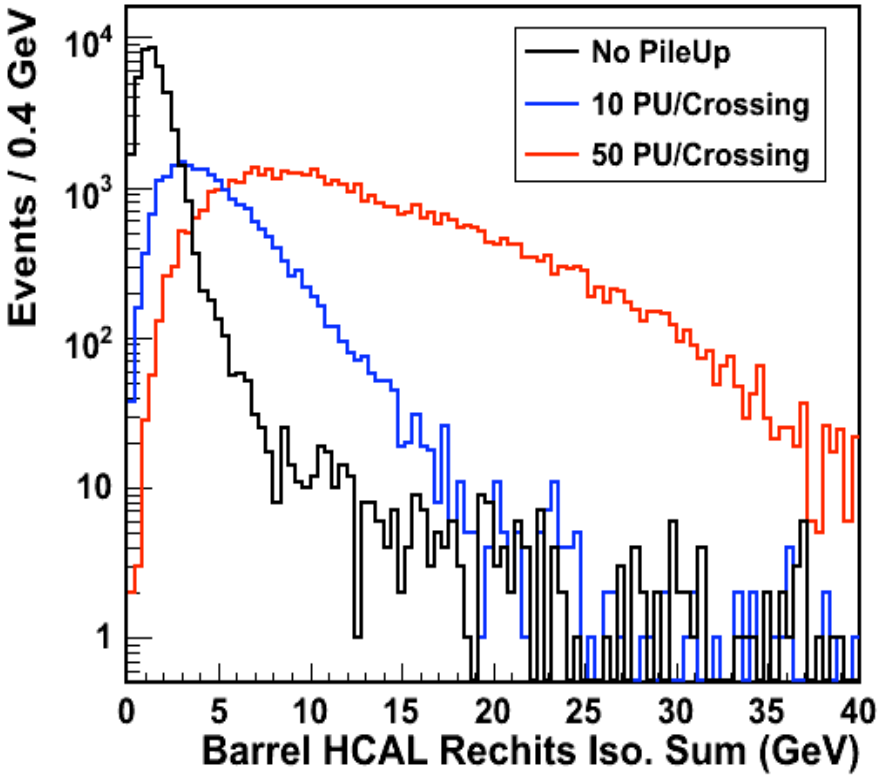


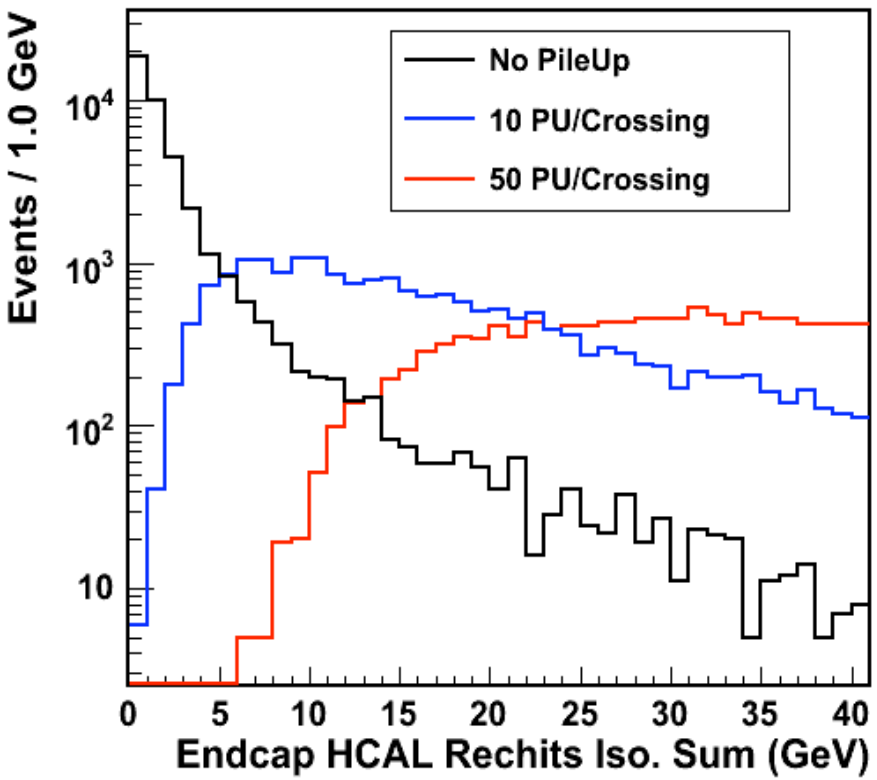


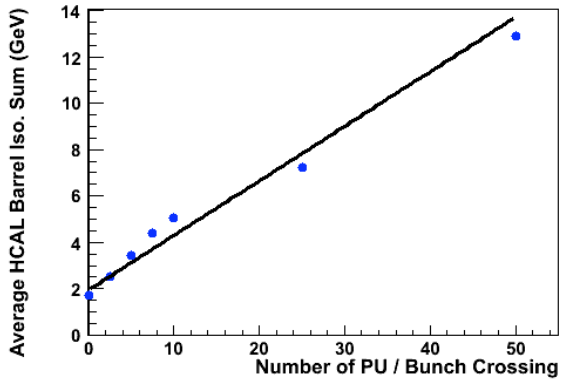


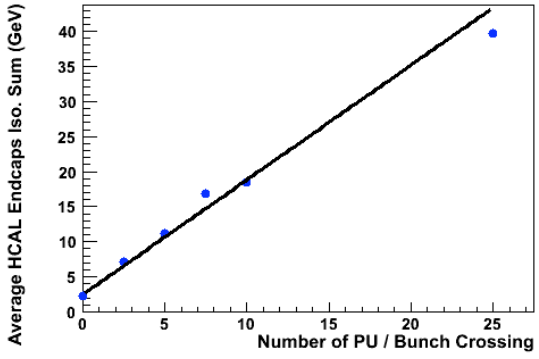


HCAL Isolation (Rechits)









“Photon Summary”

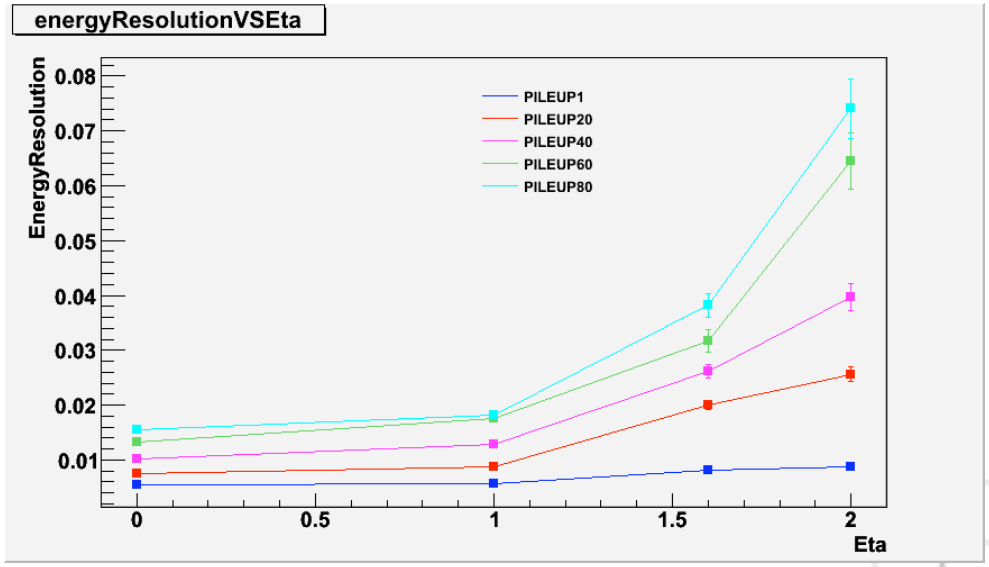
- **“Standard” reconstruction efficiency drops from ~90% to 50% in the endcaps and to ~70% in the barrel for PU=50 (no tracking cuts used)**
- **At PU=200, isolation sums start reaching 100 GeV values. (no isolated photons/ electrons at sLHC?).**
- **Currently trying to get a realistic understanding of the fake rates with relaxed selection cuts**

Summary

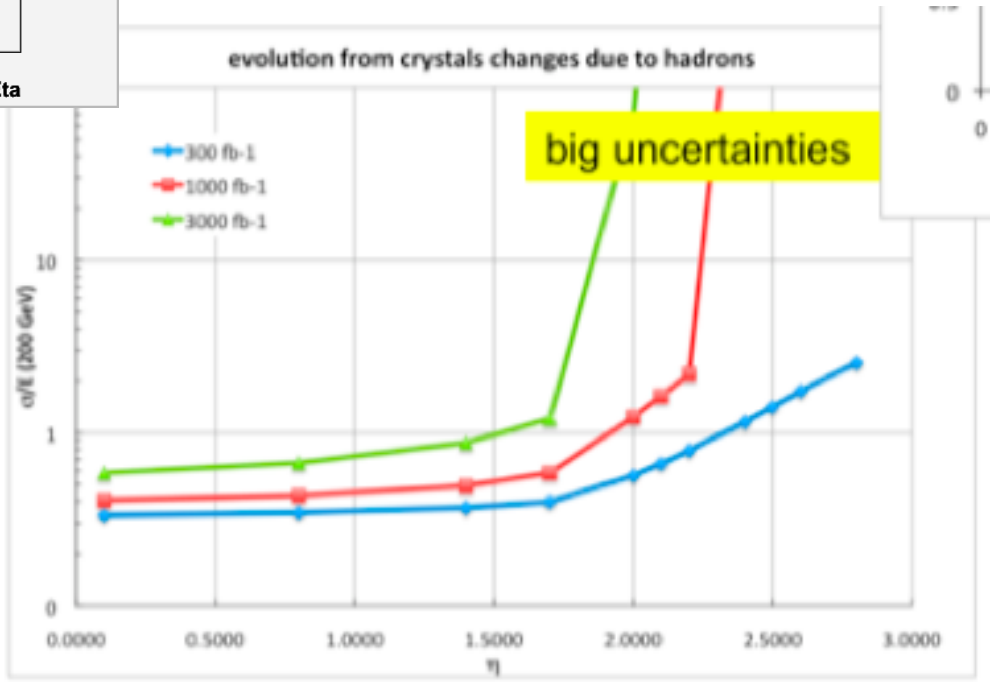
- **We are re-learning a lot of things about pileup. Very first results are not discouraging.**
- **Better suited simulation tools needed.**
- **Also need to study realistic SRP/ZS thresholds both in the ECAL and HCAL.**
- **Try to do more realistic physics studies in the presence of real backgrounds.**
- **Study is actually quite useful for the LHC analyses! Visible effects with just ~5-10PU.**

BACKUP and EXTRAS

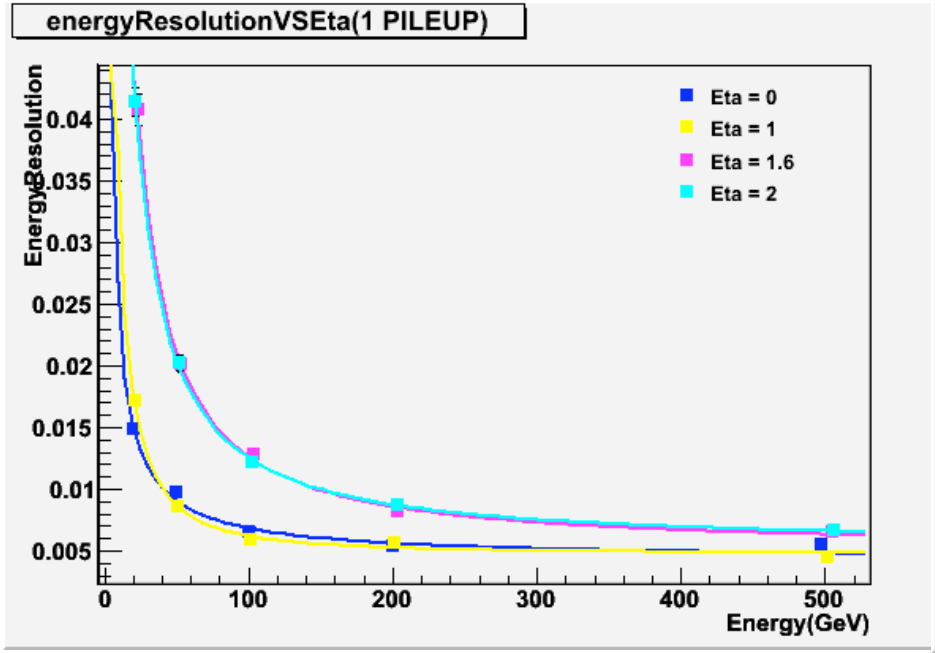
EnergyResolution VS Eta



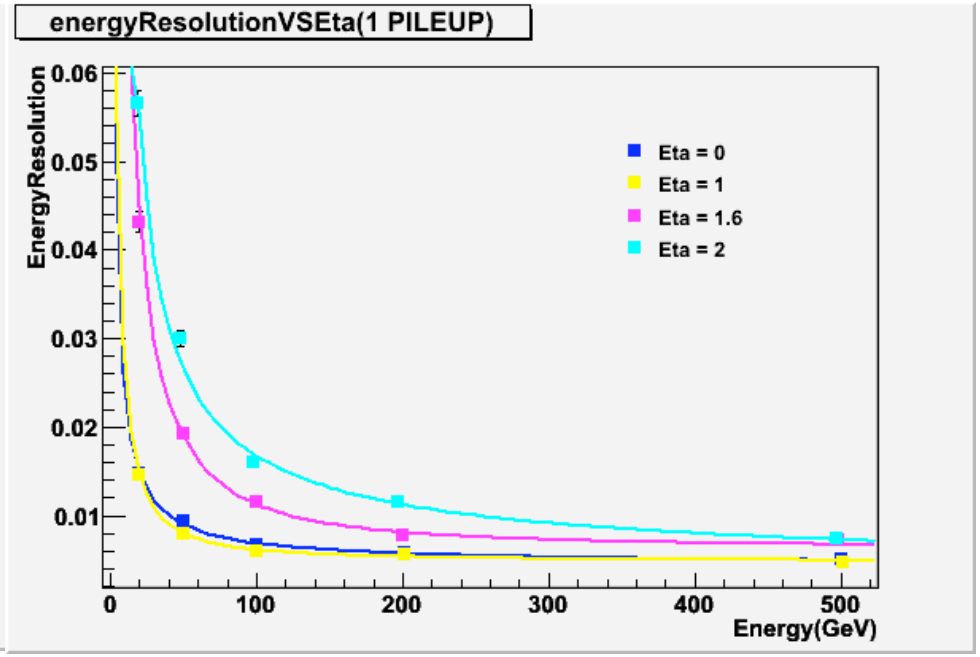
Comment: For higer PILEUP, the energy resolution increases with Eta increasing.



Comparison Between Super Cluster and Basic Cluster analysis with 1 PILEUP



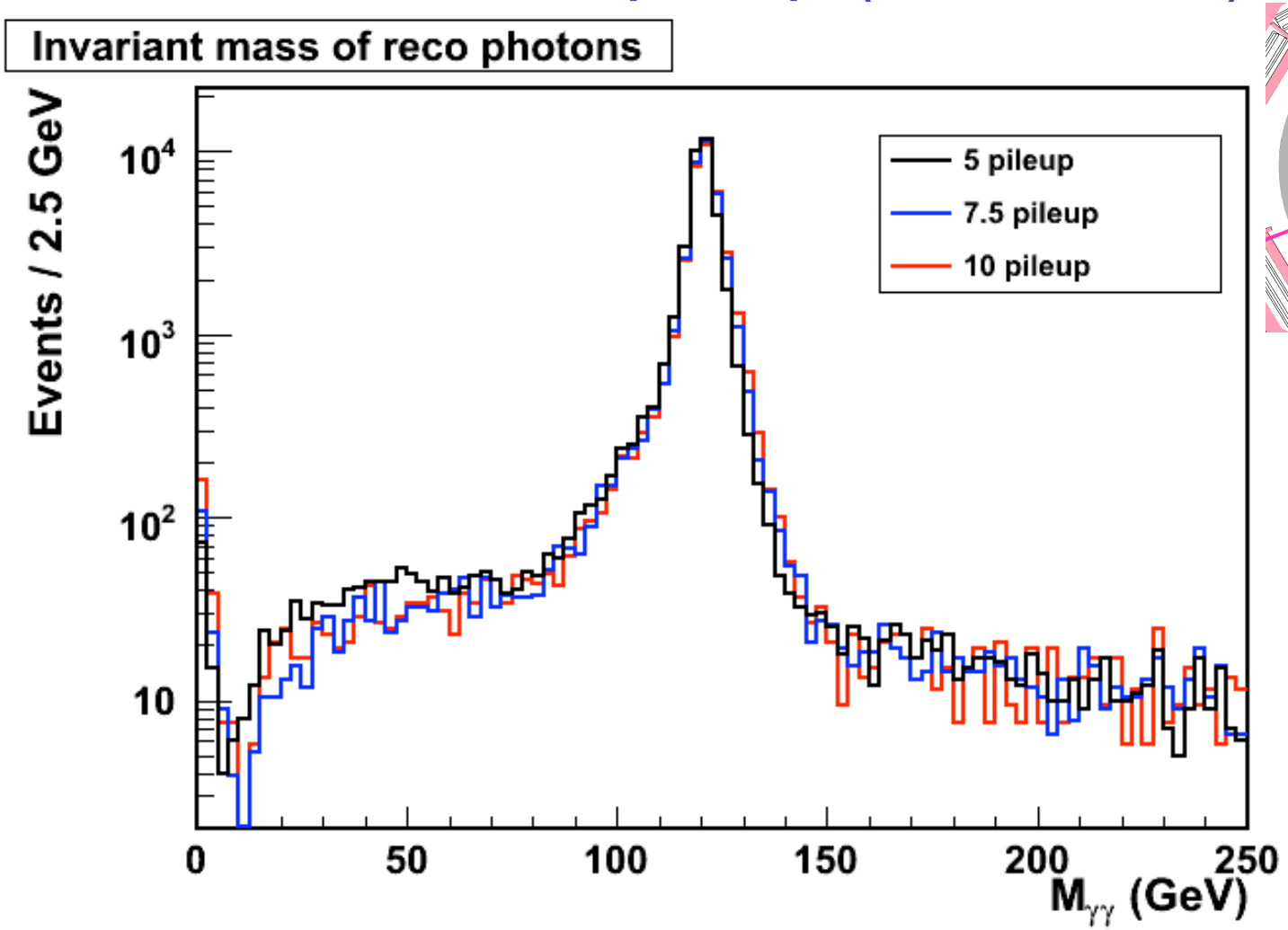
Super Cluster

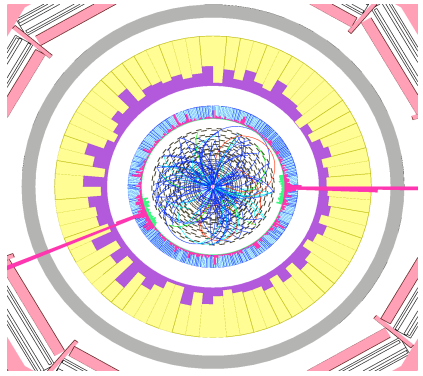


Basic Cluster

Comment: Since there is only 1 PILEUP, the energy resolution should have the similar behavior either at barrel or endcap region. The analysis based on Super Cluster looks more reasonable.

Reconstructed Higgs->diphoton mass Good news: does not depend much on pileup (5x5 matrix)





Z peak fit

Z peak fitting function: bin chi-squared

$$f(x) = N \times \exp[-\frac{(x-m)^2}{2(\sigma^2 + \alpha(x-m)^2)}]$$

σ = resolution, N = norm, m = mean value

Background fitting function: inverse power law

$$f(x) = \frac{A}{x^a}$$

Z peak fits

Upper left: no pileup

Lower left: 5 pileup

Lower right: 10 pileup

Peak position, width increase with number of pileup events