# L1 Triggering with Pixel Detector

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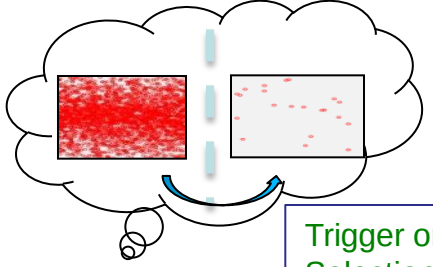
Thursday, 29 Oct 2009

# Outline

- Review
- L1 trigger on jets from pixel
- Monte Carlo selection criteria
- Jet Characteristics
- Track Characteristics
- Reconstructed Pixel-Hit maps
- Pixel Occupancies inside Jets
- Reconstruction Algorithm: ideas
- Summary

# Review




- **Goal: Use Pixel to reduce trigger rate at Higher Luminosities**
  - Contribute to Level-1 trigger decision.
- Approaches defined by I. Kravchenko and K. Ecklund with suggestions from Track Trigger group.
  - Find Primary Vertex (PV) list with Pixels at L1
  - Reconstruct jets with Pixels at L1
  - Provide isolation with Pixels to non-Pixel L1 objects
  - Do tracking with Pixels in the region of interest
- PV studies done by I. Kravchenko over summer
  - PV list reconstruction studies are documented in CMS IN 2009/037
  - Conclusion: may be possible, however use cases are not obvious

# Jet Reconstruction with Pixels

- Jet reconstruction:
  - No explicit track reconstruction if possible
  - Work with occupancy maps of pixel layers
  - Find jets at individual layers, then see if multi-layer correlation possible
  - Ideally, try to find jet direction and associated PV
- Prerequisite for jet reconstruction: understanding pile-up.
- Study relation between calorimeter jets and track hits on pixel layers
- Jet studies performed with Summer09 full-sim samples
  - Software Version for Analysis CMSSW_3_1_4
  - use superposition of MinBias events to model pile-up

# Monte Carlo Selection Criteria

- The selected samples contain

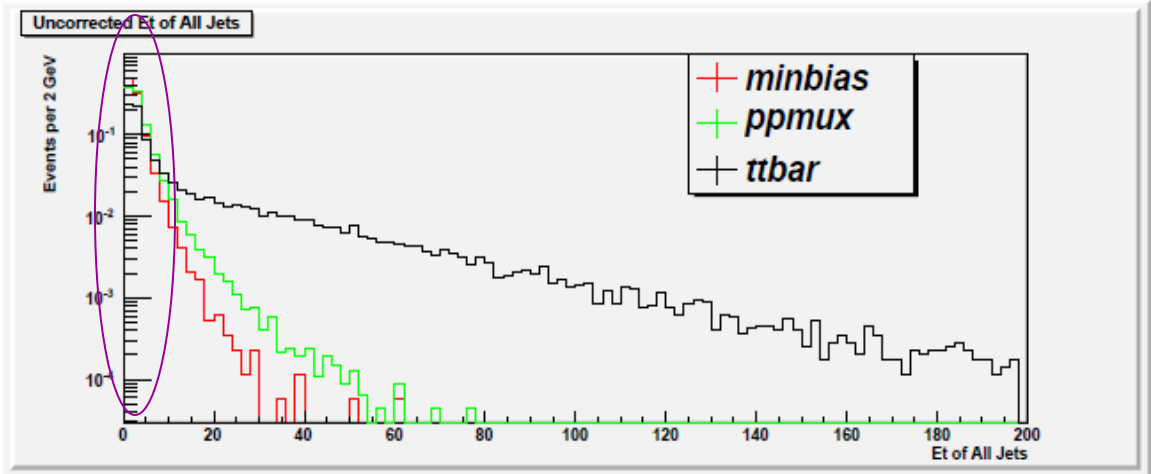
| Sample | MinBias | ppMuX | TTbar |
|---|---|---|---|
| No of Events | 13000 | 6291 | 2700 |

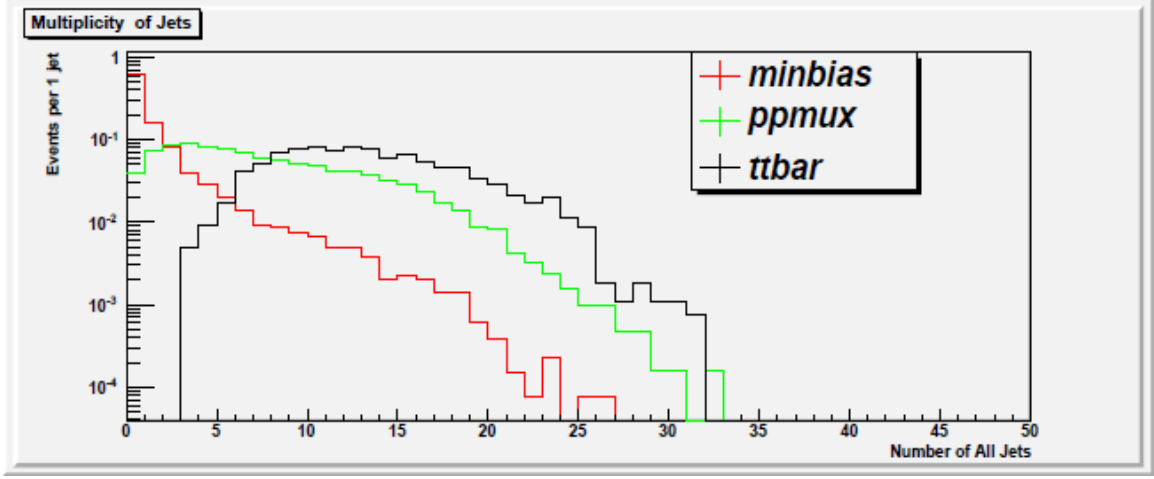
- Cut on Electro-Magnetic-Energy Fraction of Jets
  - keep 2% < emEnergyFraction < 98%
- Production Default cut for CaloJets :
  - inputEmin =0GeV, inputEtMin =0.5 GeV, jetPtMin=1 GeV
- Production Default cut for RecoTracks:
  - minPt =0.05
- No Extra EtCut on Jets or PtCut on Track
- From Tracks we build the Hits on pixel layer
  - Using magnetic field
  - Detector geometry
  - No Cut on Pt of tracks from which Hits are built

# Uncorrected Et Spectrum and Jet Multiplicity

- TTbar events clearly show more high Et Jets than PPmuX or Minbias
- Jet Multiplicity is different for Minbias than TTbar, PPmuX, which seem to be similar.
  - Reminder: No Et Cut
  - Note: logscale of plots
  - Note: All plots normalized to 1

Et Spectrum



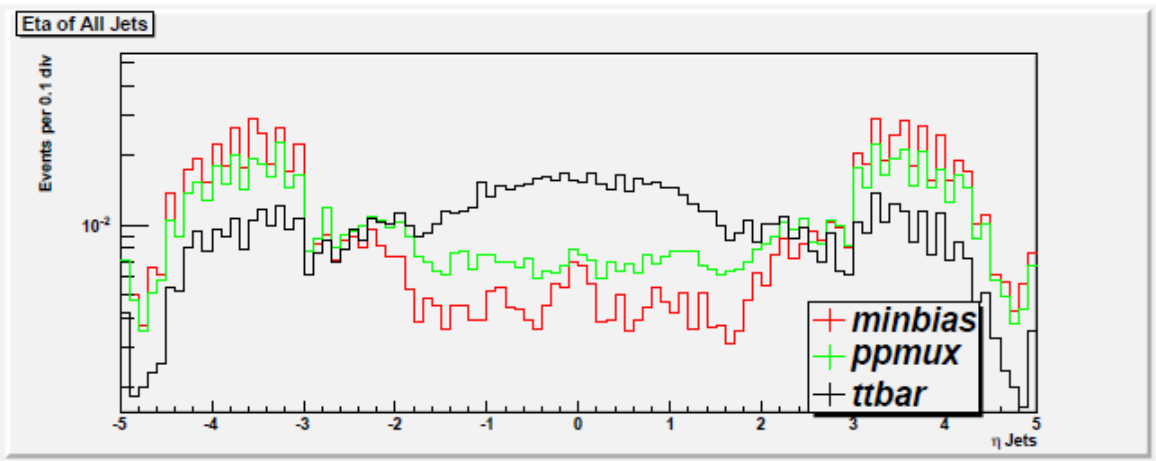

Jet Multiplicity

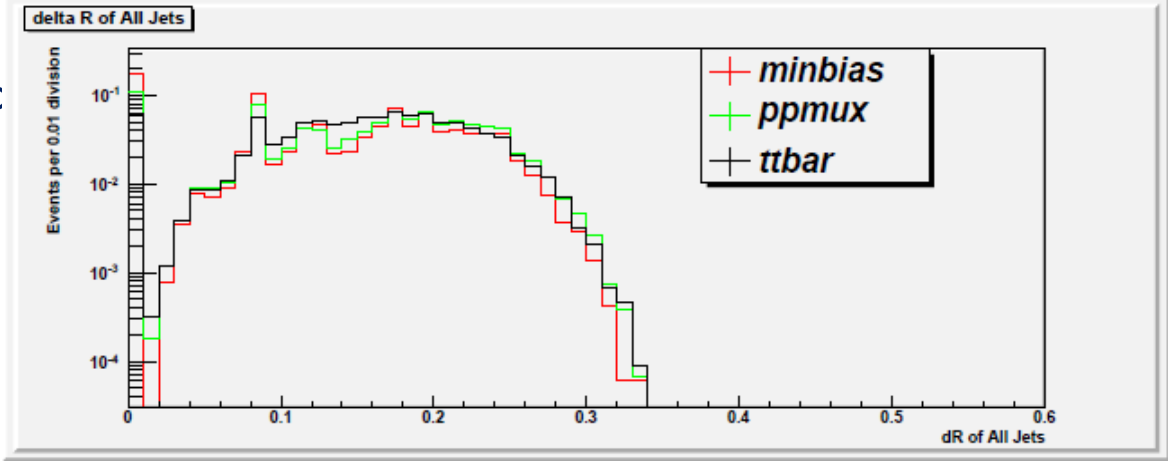
# Eta and delta R Distribution of Jets

- TTbar events tend to be more on 0 eta region
- PPmuX and Minbias tend to peak at higher eta region
- dR for all Jets is same.

  - Reminder: No Et Cut
  - Note: logscale of plots
  - Note: All plots normalized to 1

Eta for all jets

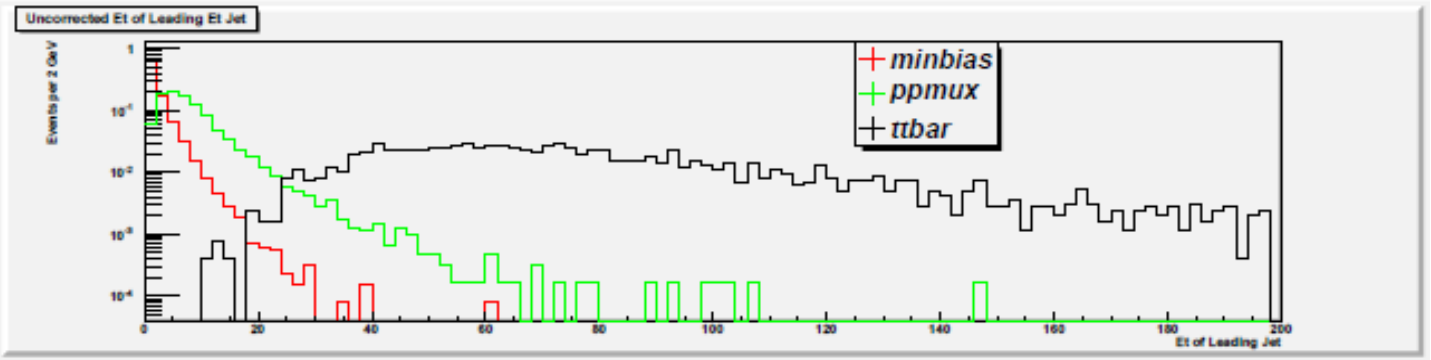


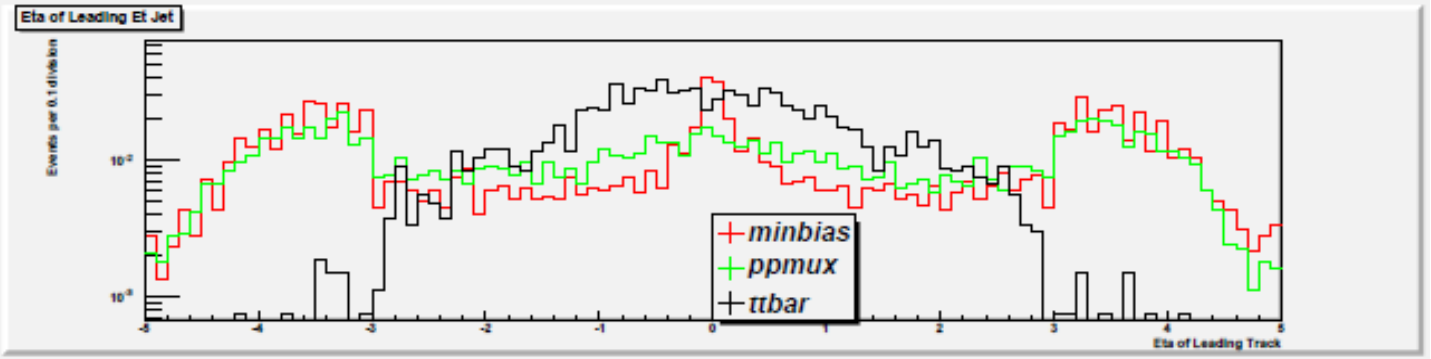



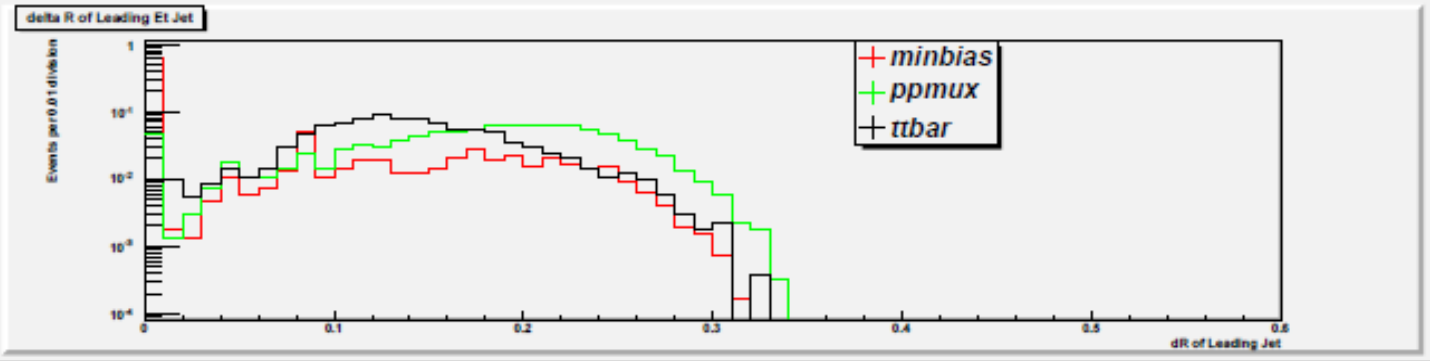

Delta-R for all Jets

# Leading Jets

- Leading Jet: Et Spectrum, Eta and delta-R distribution

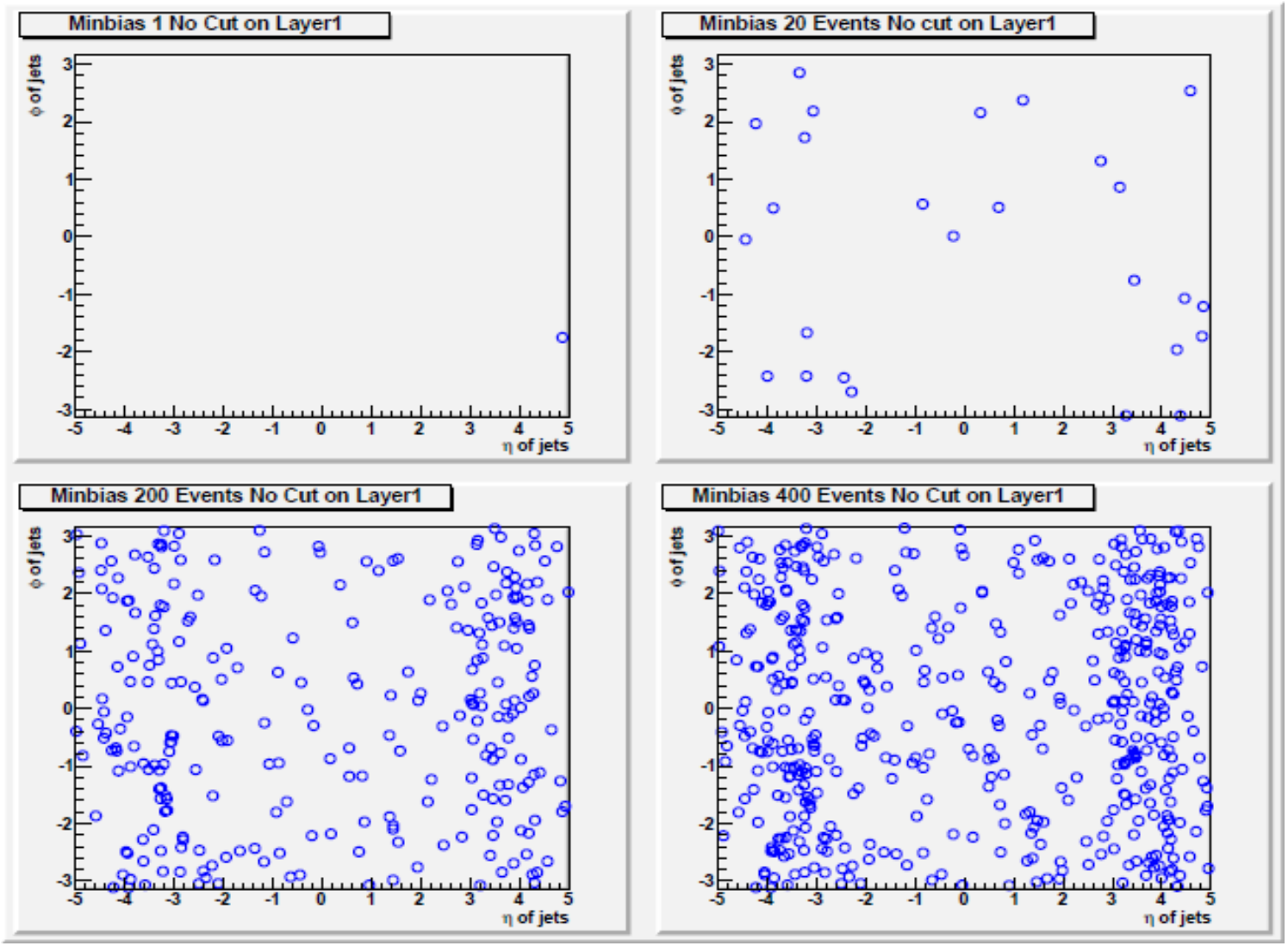


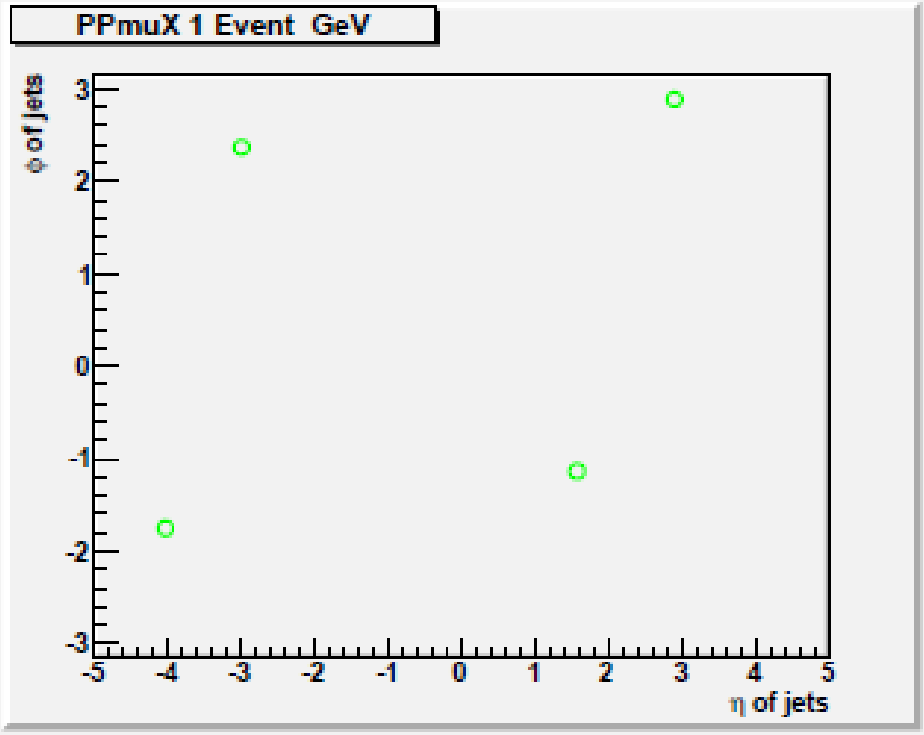
# Jet η–φ Distribution for Minbias Events

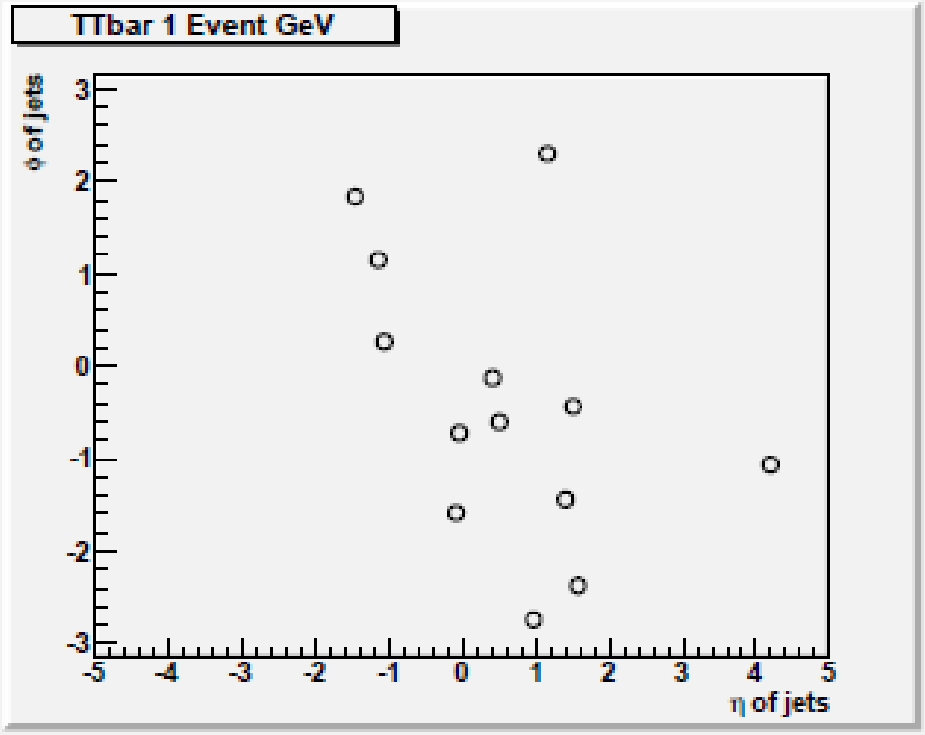
- Eta-phi of jets for superimposed MinBias events simulating a single bx with pile-up
  - 1 event
  - 20 (nominal LHC)
  - 200 (SuperLHC Scenario-A)
  - 400 (SuperLHC-Scenario-B)



# Jet η–ϕ Distribution II

- Eta-phi distribution of Single Event for
- PPmuX
- Ttbar
- Note: Eta range for these plots covers full detector i.e Barrel and Forward detector

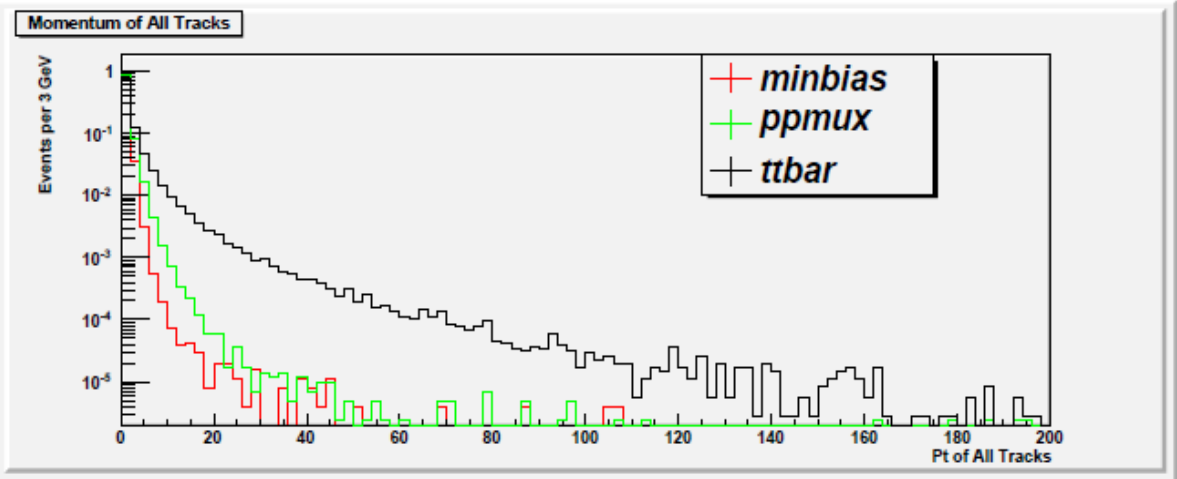


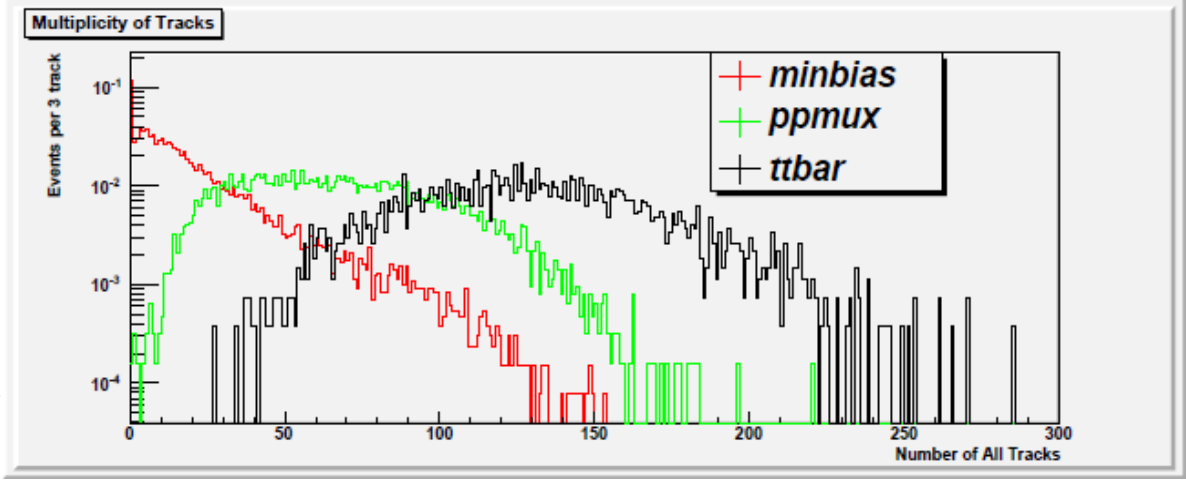



# Pt Spectrum and Track Multiplicity

- TTbar events clearly show more high Pt Tracks than PPmuX or Minbias
- Track Multiplicity is also high for TTbar. The shape is different for Minbias than other samples. TTbar and PPmuX have similar shape.

Pt Spectrum

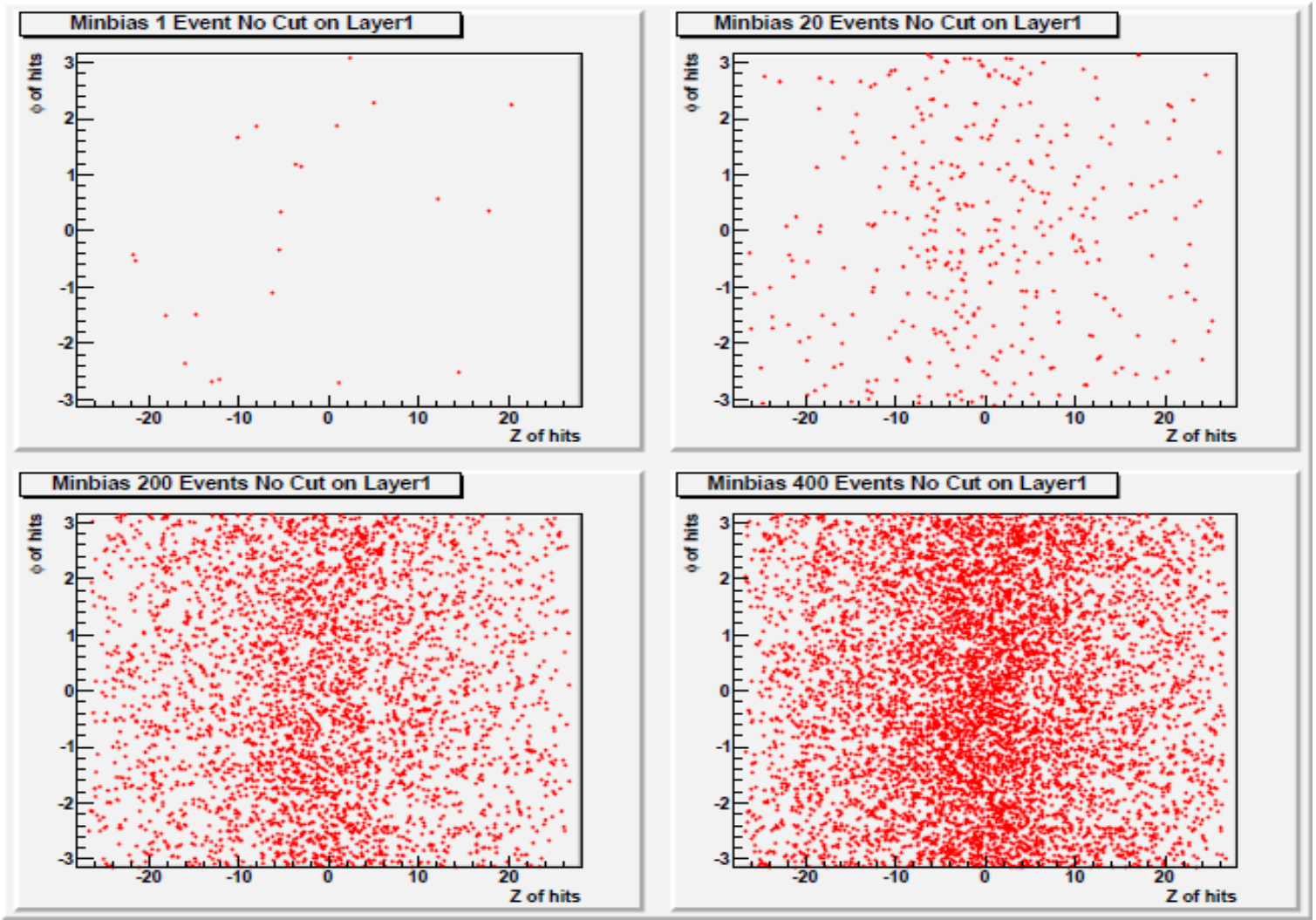



- Reminder: No Pt Cut
- Note: logscale of plots
- Note: All plots normalize to 1

# Hits on Pixel LayerI for Minbias

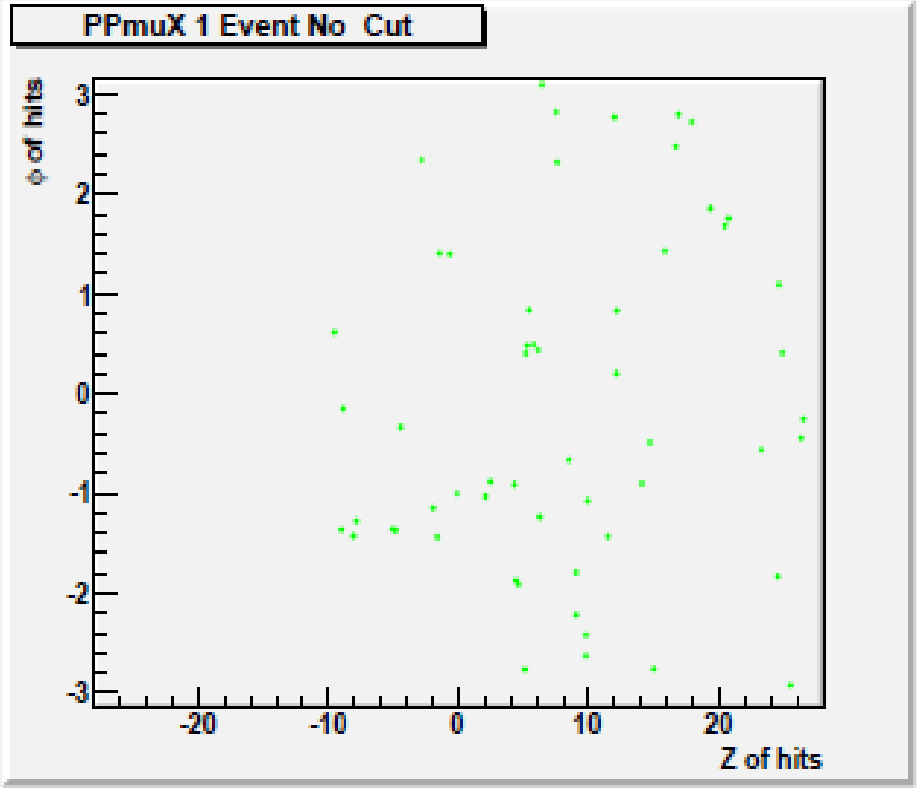
- Z-phi of pixel hits built from tracks for superimposed MinBias events simulating a single bx with pile-up events

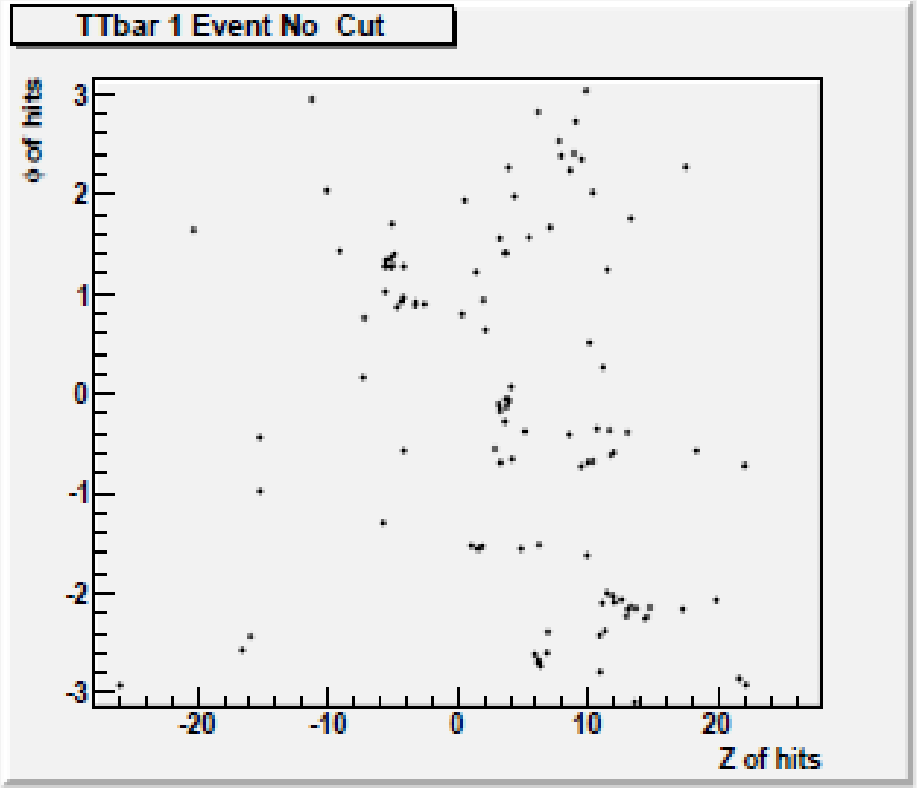



- 1
- 20
- 200
- 400

# Hits on Pixel LayerI For other samples

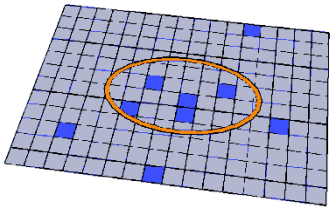
- Z-phi distribution of Single Event for
- PPmuX
- TTbar

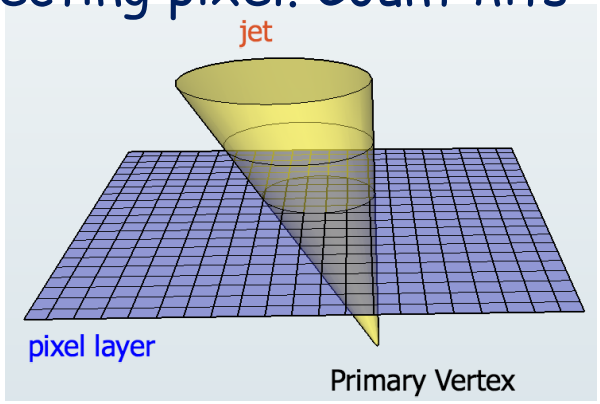


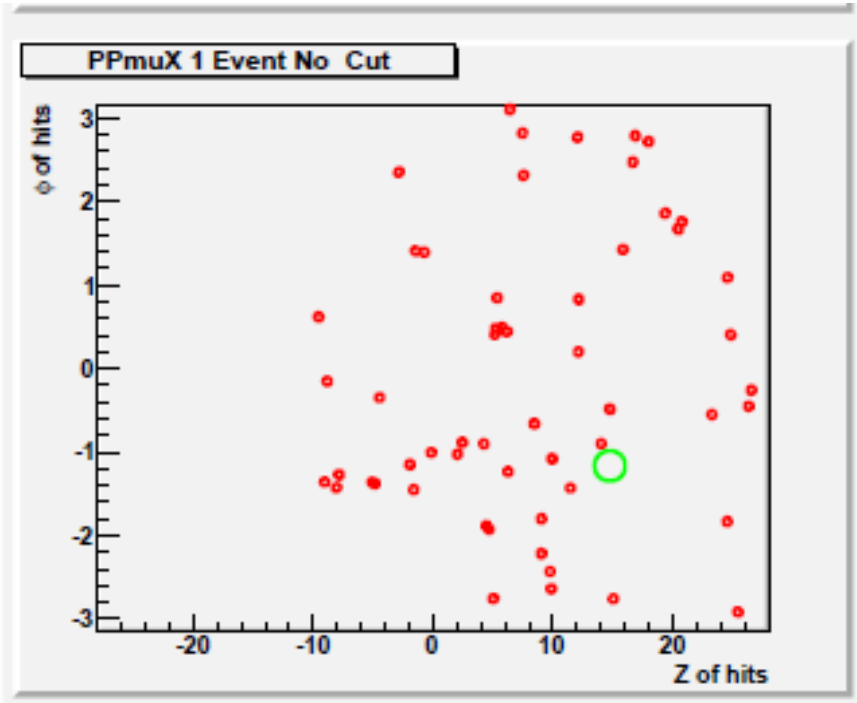
# Pixel hits in/outside Jets: In progress

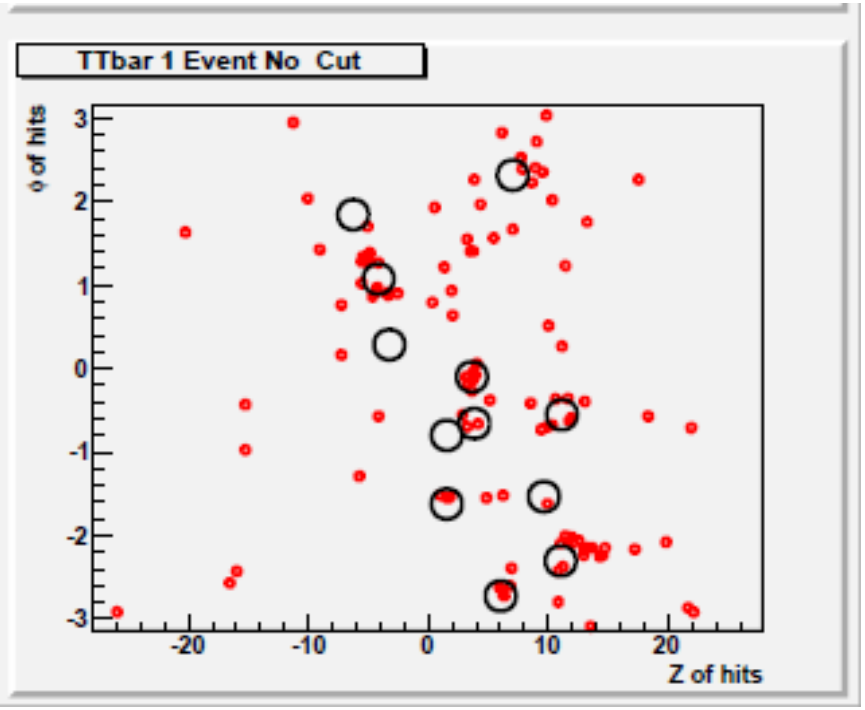
- Find ellipse corresponding to jet, intersecting pixel. Count hits inside the ellipse
  - Jets not scaled
  - Need to confirm if no over-counting is done





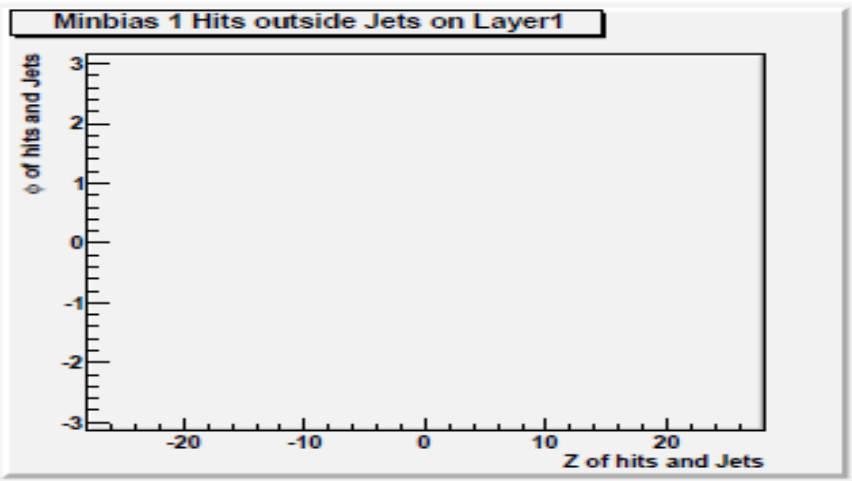

- Hits inside a jet for a single
- PPmuX (left)
- TTbar (right)

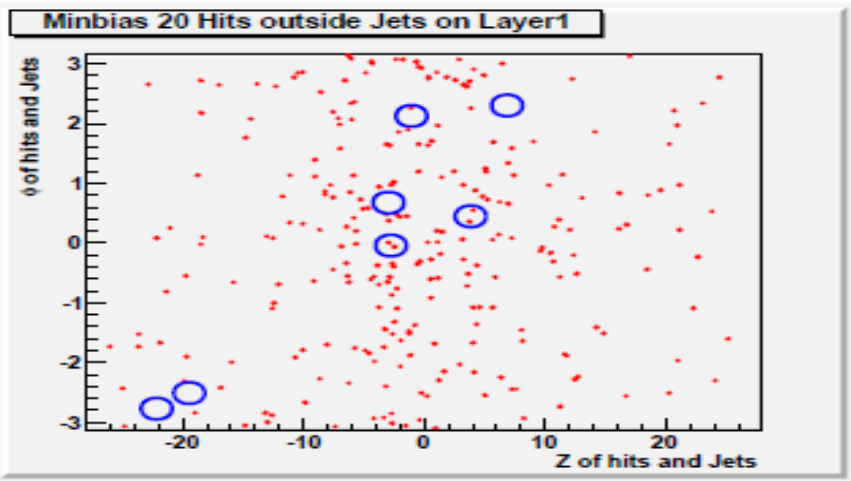


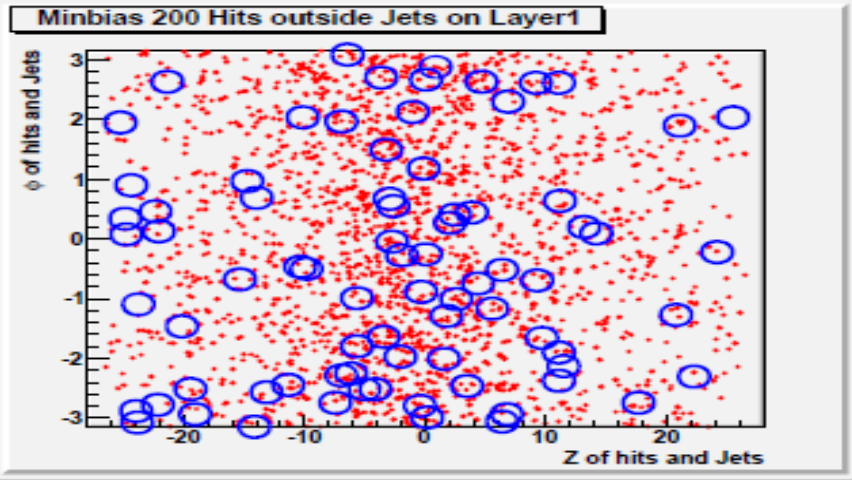



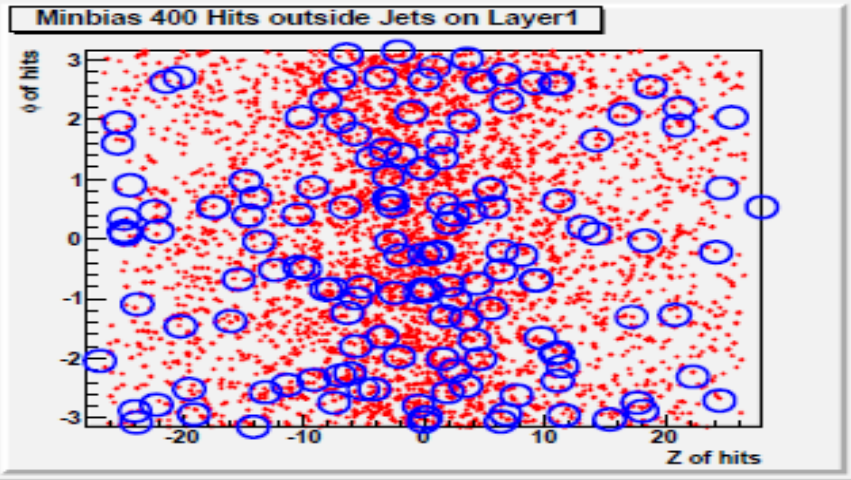
# Pixel hits in/outside Jets for Minbias: In Progress

- Jets eta-phi map is not in one to one correspondence with Z-phi map as pixel covers < 2.5 eta region
- Jets are not scaled to actual size



# In progress: Pixel hits per ROC

- Pixel hits/ROC Plot
- See if there are some pattern at ROC level for different data sample.
- See Number of fired ROC changes with data sample

# Reconstruction Algorithms

- Verify hit density difference in/outside Jets.
- Study of Algorithm: next step
- Work on specific algorithms after checking feasibility
- Some ideas for algorithms are
  - E1/E9 and E9/E25 approach
  - Sliding window approach
  - The PSI approach of module-level jets described in Marlon Barbero's thesis
  - Ideas from ring-reconstruction algorithms from DIRC@BaBar
  - Divide-and-conquer algorithm for recursive division of a layer

# Summary

- Conclusions from studies of CaloJets in Minbias and other samples:
  - Jet multiplicity is very different in MinBias vs others
  - Jet eta is different among samples, more "physics" jets in the central region
  - Leading jets in physics events are especially distinct, in Et, eta and cone size
- Conclusions from studies of pixel hit occupancies
  - One ttbar event has similar occupancy to 10-20 pile-up events
  - Presently studying hit counts inside/outside of jets
- Jet reconstruction algorithms with pixels:
  - Work to be done, if feasibility is confirmed by hit occupancy studies.