Possible eID Improvements Using Tracker RecHits

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Introduction

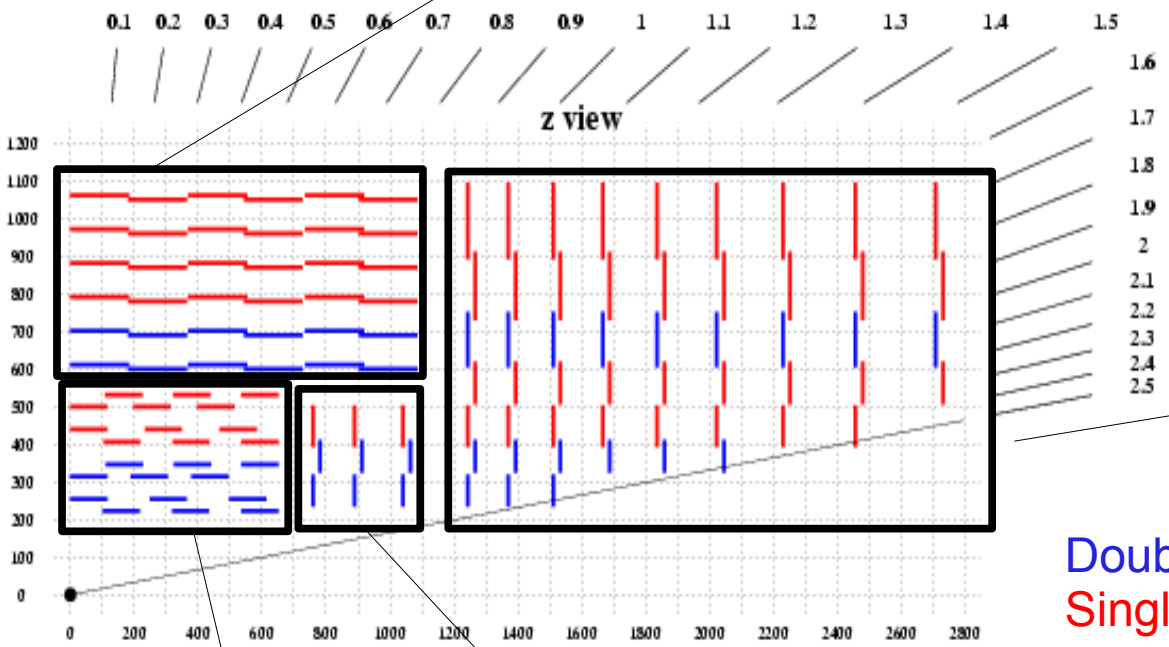
- In the CMS detector electrons has to cross a substantial amount of material before reaching ECAL.
- Hence electrons produce a lot of bremsstrahlung radiation:
  - in principle it can be used to discriminate electrons to charged pions.
- In the following we present a study on the feasibility of an electron ID discriminator using the number of Tracker Hits in the vicinity of the electron track.

Outline

1. Brief description of the CMS Tracker
2. Electron simulation parameters
3. Analysis and results
4. Conclusions

CMS Tracker

TOB (Tracker Outer Barrel)



TEC (Tracker EndCap)

Double sided
Single side

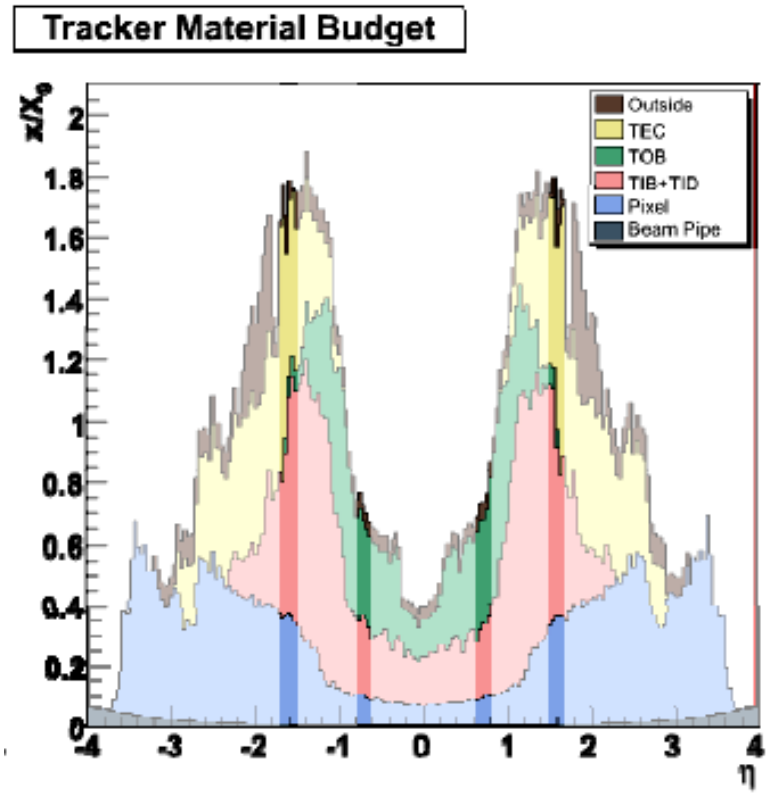
TID (Tracker Inner Detector)

TIB (Tracker Inner Barrel)

subdetector	layer	pitch (μm)	length (mm)	thickness (μm)	n° strips
TIB	layer 1-2	80	119.2	320	768
TIB	layer 3-4	120	119.2	320	512
TOB	layer 5-6	122	2 × 94.5	500	768
TOB	layer 7-10	183	2 × 94.5	500	512
TID	layer 1	81 - 112	89.5	320	768
TID	layer 2	113 - 143	90.3	320	768
TID	layer 3	124 - 158	112.8	320	512
TID	layer 4	113 - 139	117.1	320	512
TEC	layer 5-7	126 - 156	84.0 + 66.1	500	768
TEC	layer 8-10	163 - 205	99.0 + 87.8	500	512
TEC	layer 11-13	140 - 172	109.8 + 98.8	500	512

Tracker Material Budget

- The different sub-detector contributions to the total material budget are summarized in the picture.
- To simplify the study and to better understand the effect we restricted ourselves to two small η regions:
  - approximately flat distribution of the material budget
  - clear separation between barrel and endcap
    - barrel: $0.6 < \eta < 0.8$
    - endcap: $1.5 < \eta < 1.7$



Electron simulation

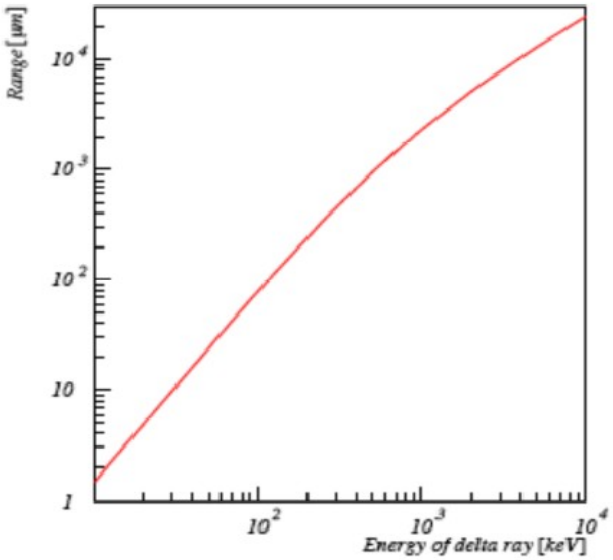
- Another important issue is the optimization of the simulation parameter:
  - delta ray production goes as $1/E^2$
  - high enough thresholds to save CPU time but to have accurate simulation
  - no significant change in observable quantities at lower thresholds.
- Previous studies have shown that the simulation parameter choice is accurate enough for many reconstruction aspects.

http://indico.cern.ch/conferenceDisplay.py?confId=23674 (L. Spiegel – L. Christofek)

pre-CMSSW era: "Delta rays and cuts validation in OSCAR" (Boccali et. al) (02-2002).

➔To check if the delta ray thresholds are ok for our study we have done a small private production of single electrons: with the following choice:

- SiStripDigi.cfi:
  - **`bool Noise = false`**
- trackerProdCuts.xml:
  - **`<Parameter name="ProdCutsForElectrons" value="10*cm"/>`**



Region	Default Thres.	Our Study
TrackerDeadRegion	10 cm	10 mm
TrackerSensRegion	0.1 mm	0.1 mm
TrackerPixelDeadRegion	1 mm	0.1 mm
TrackerPixelSensRegion	0.01 mm	0.01 mm

Used Samples

➔CMSSW_1_8_0:

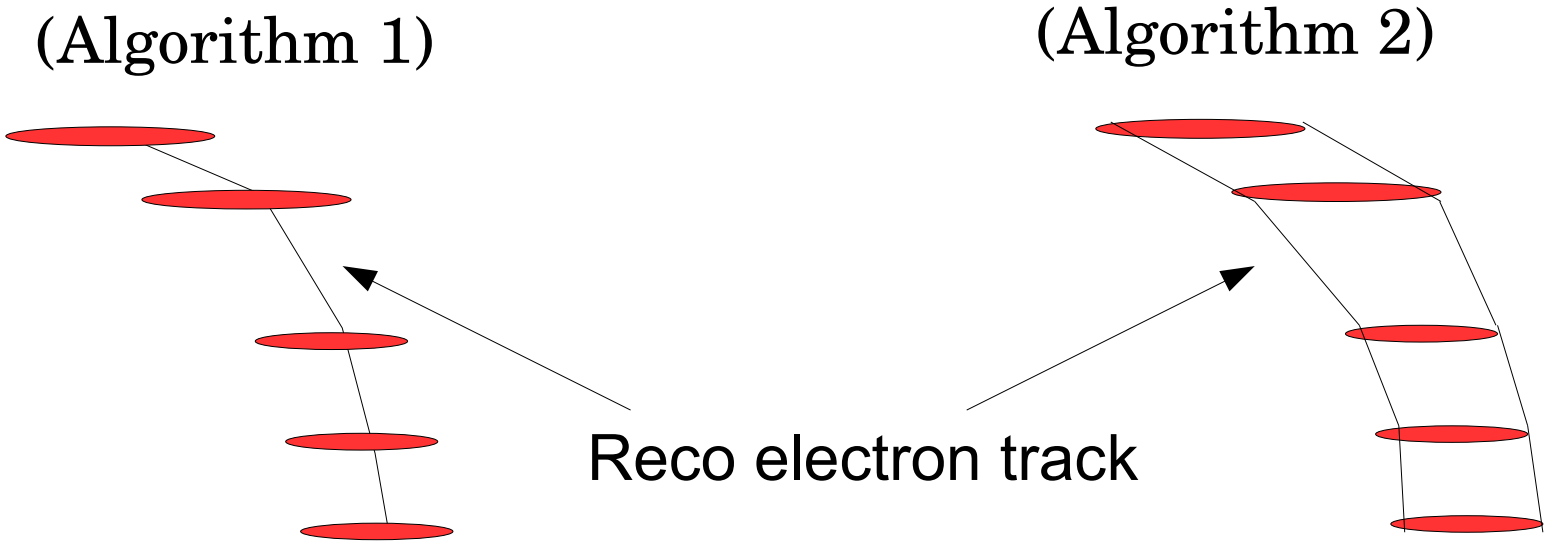
- DiElectrons (two different samples according simulation settings):
  - Energy 5 to 100 GeV
  - Eta flat distribution
- DiPions:
  - Energy 1 to 300 GeV
  - Eta flat distribution

➔CMSSW_1_6_7:

- Zee events
- QCD electron enriched sample:
  - pT bin 50-170 GeV

Hit Collector

- Radiation emission should be locally collinear to electron direction.
- Two different functions have been tried to count the hits with almost the same results.
- Given a hit of the reco-electron track, we collected all the other hits belonging to the same tracker layer:



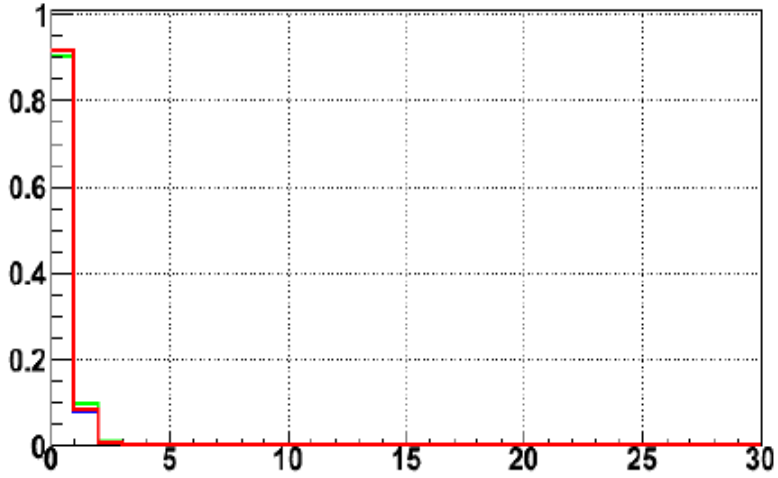
Particle Gun Barrel: 0.5 mm

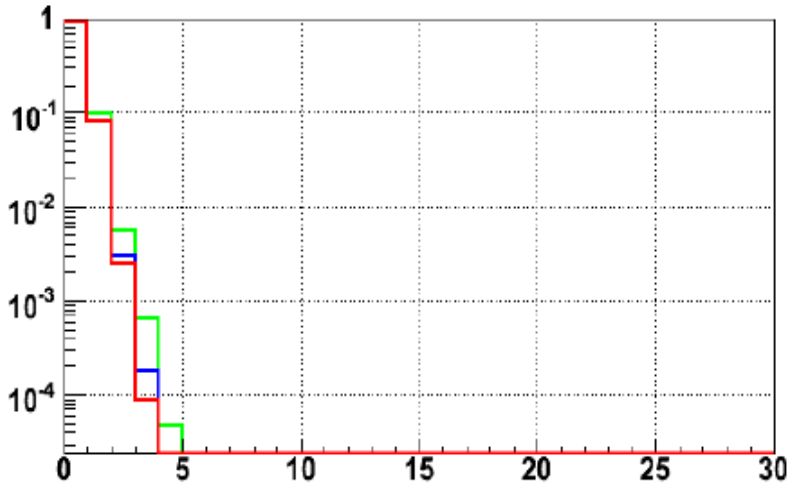
single e

single e new range

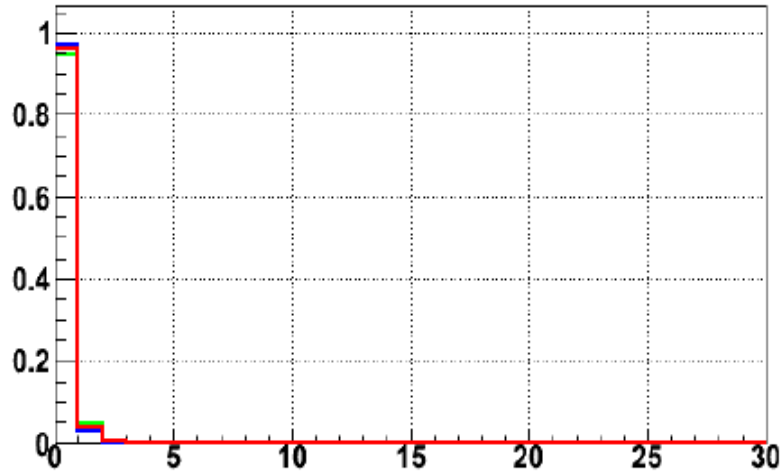
π

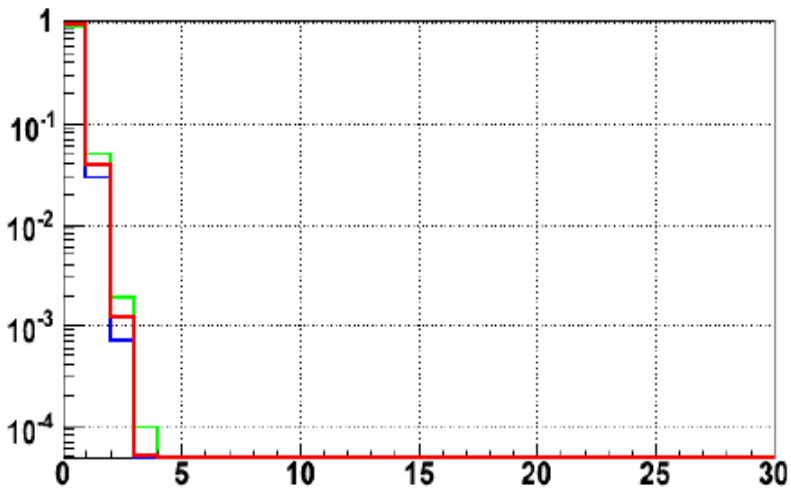
TIB





TOB





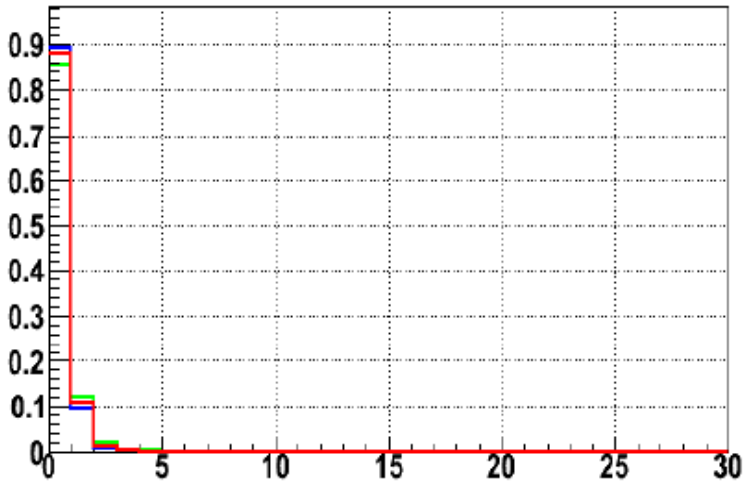
Particle Gun Barrel: 1.0 mm

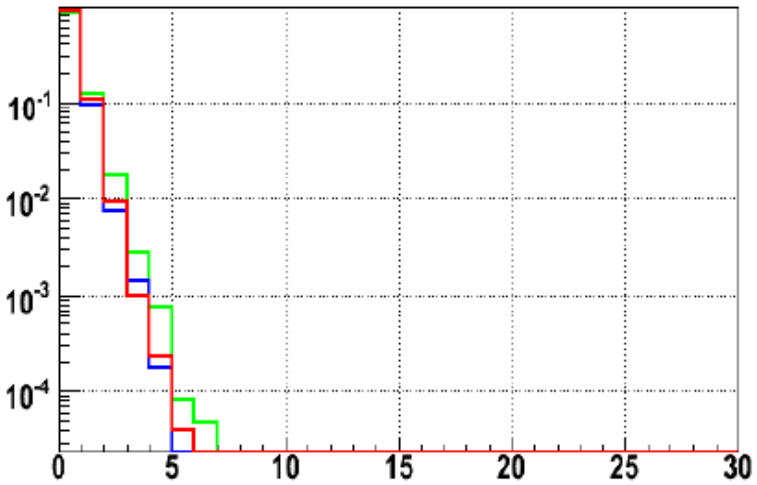
single e

single e new range

π

TIB





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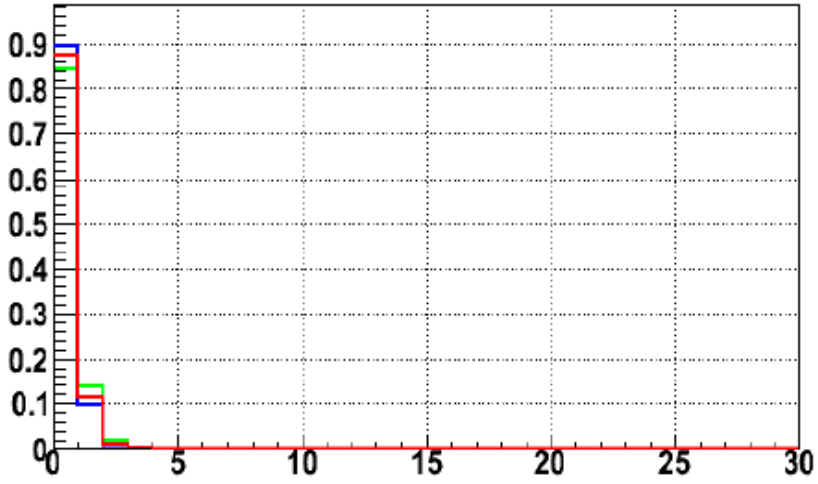
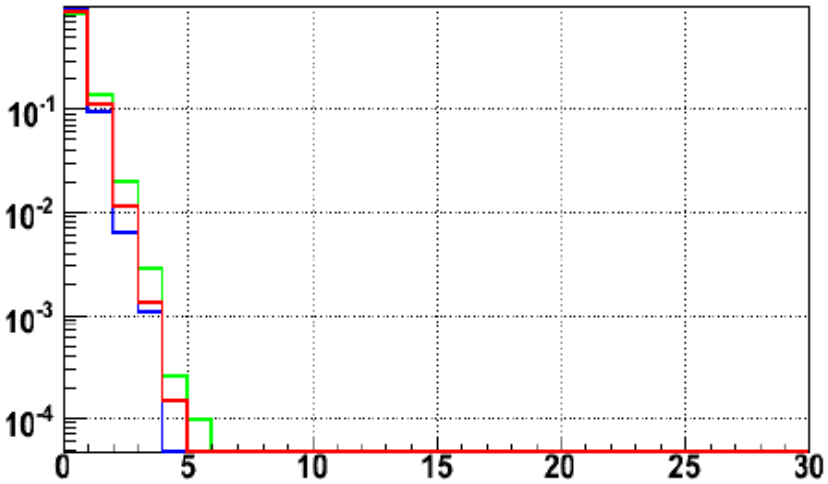




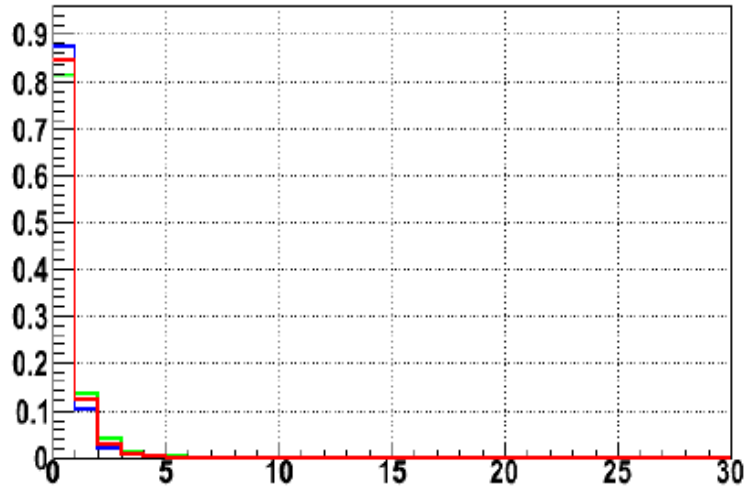
Particle Gun Barrel: 2.0 mm

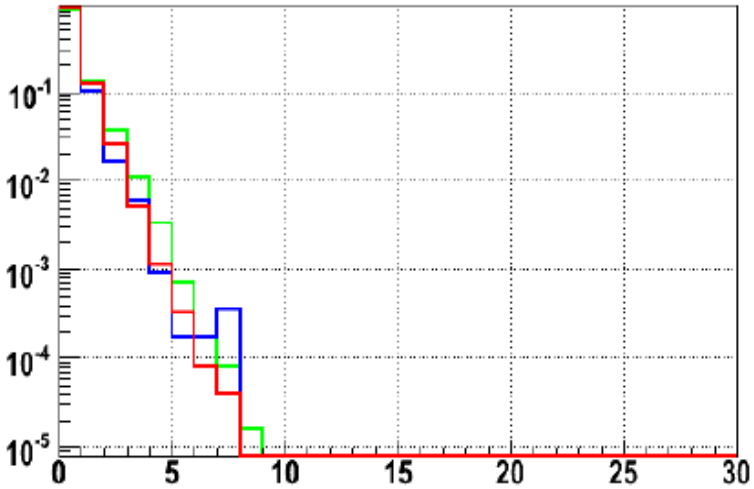
single e

single e new range

π

TIB





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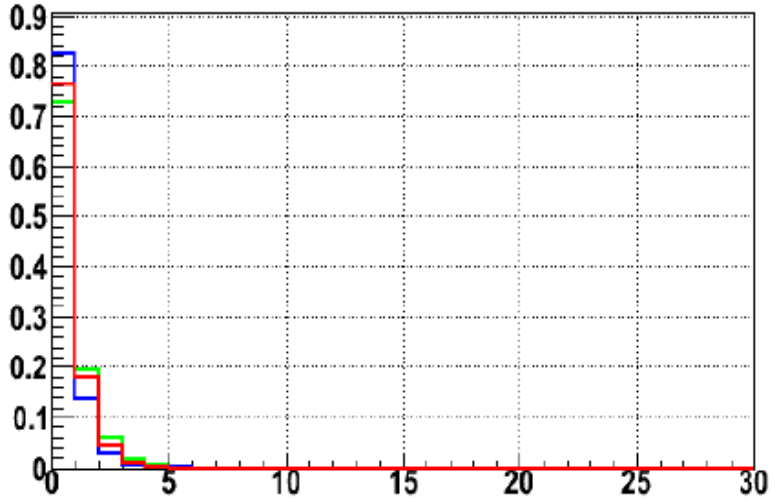
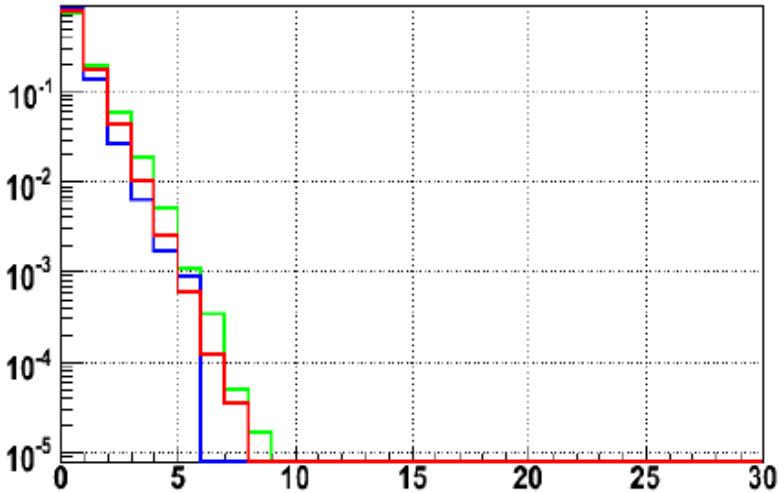




Particle Gun Barrel Summary

single e

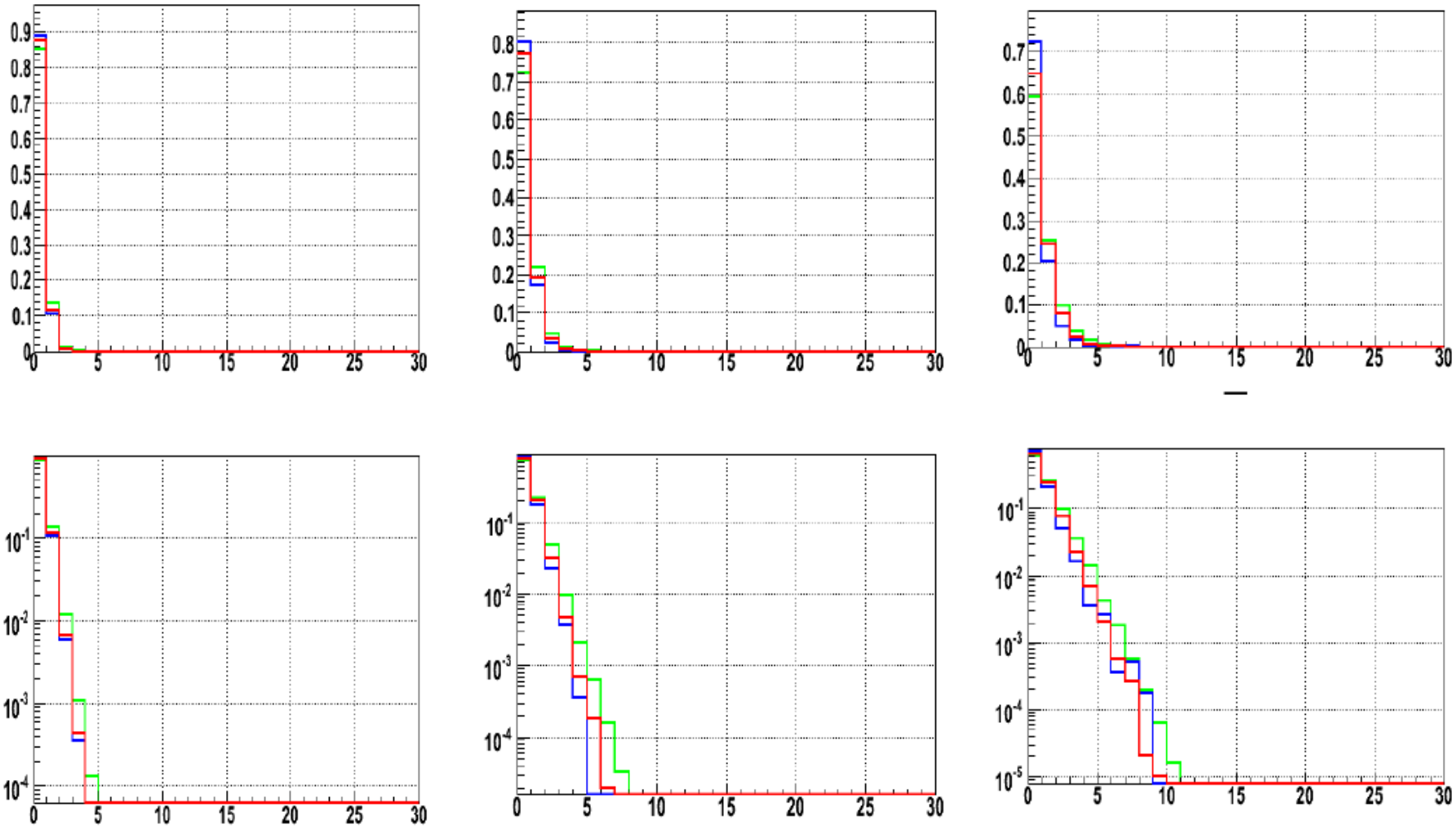
single e new range

π

0.5 mm

1 mm

2 mm



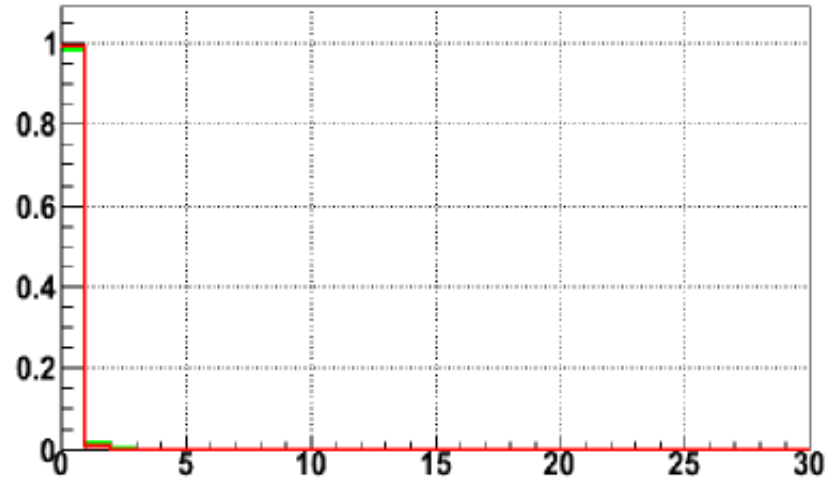
Particle Gun Endcap: 0.5 mm

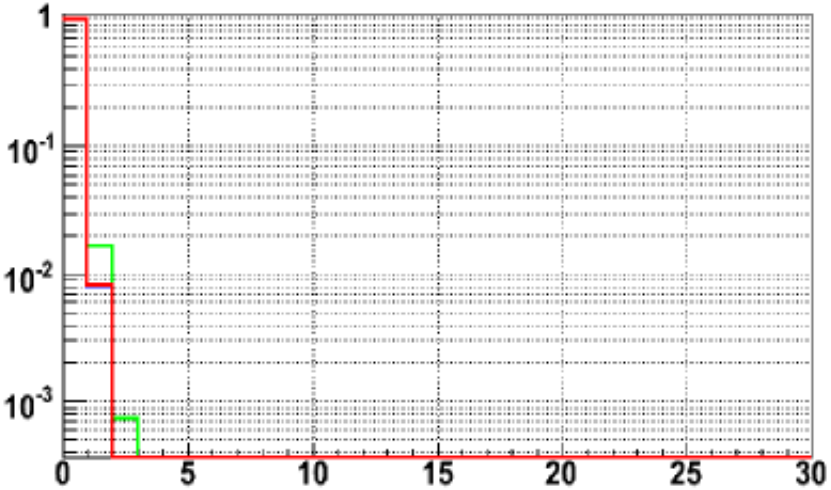
single e

single e new range

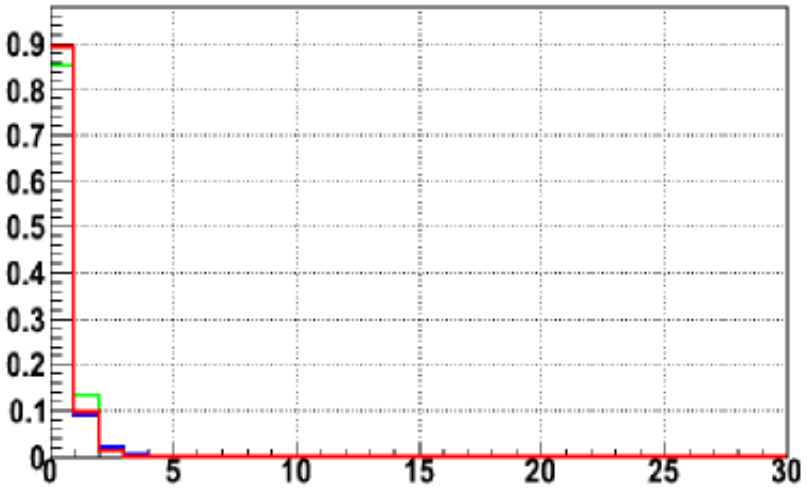
π

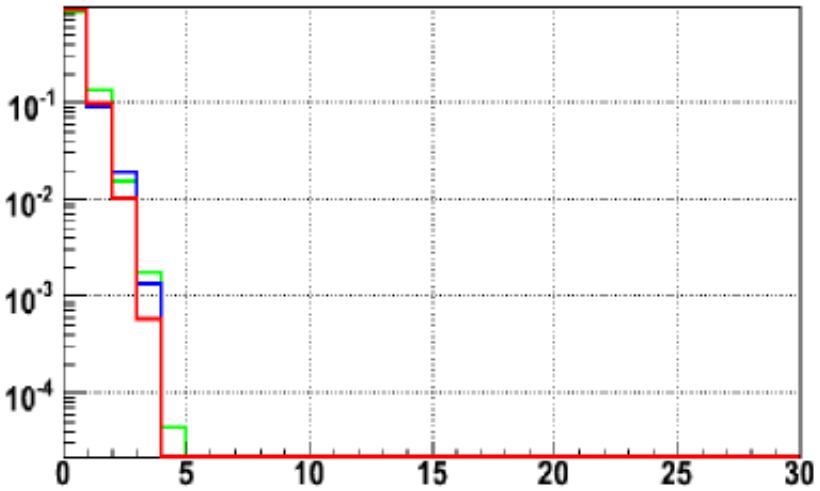
TID





TEC





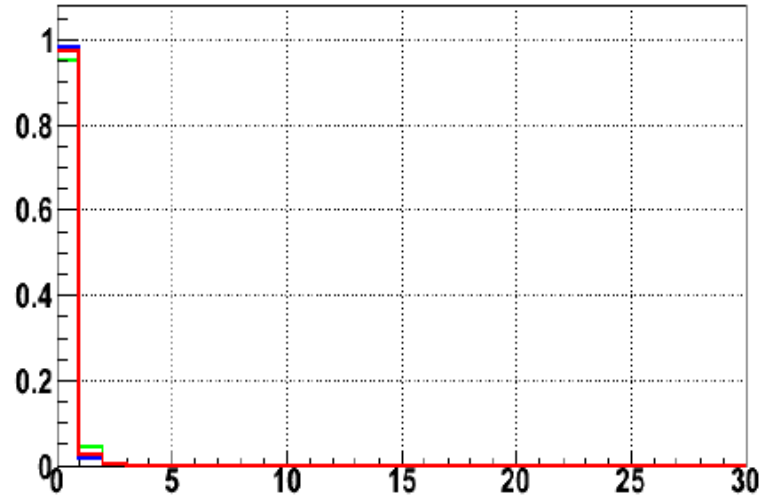
Particle Gun Endcap: 1.0 mm

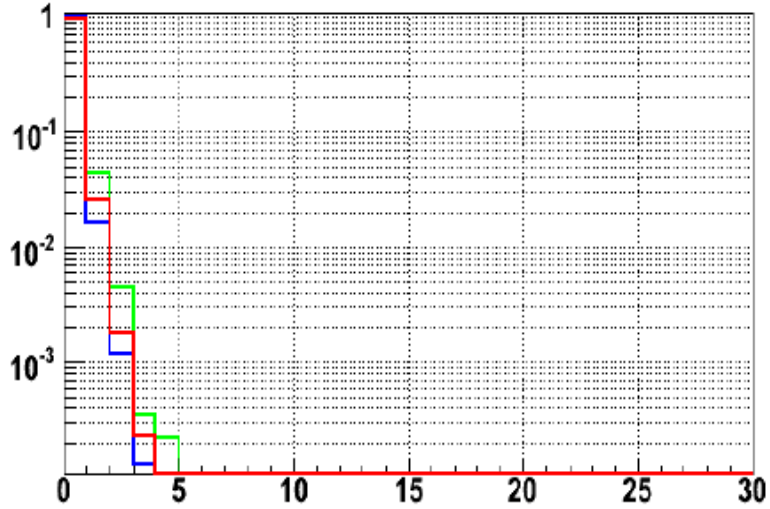
single e

single e new range

π

TID





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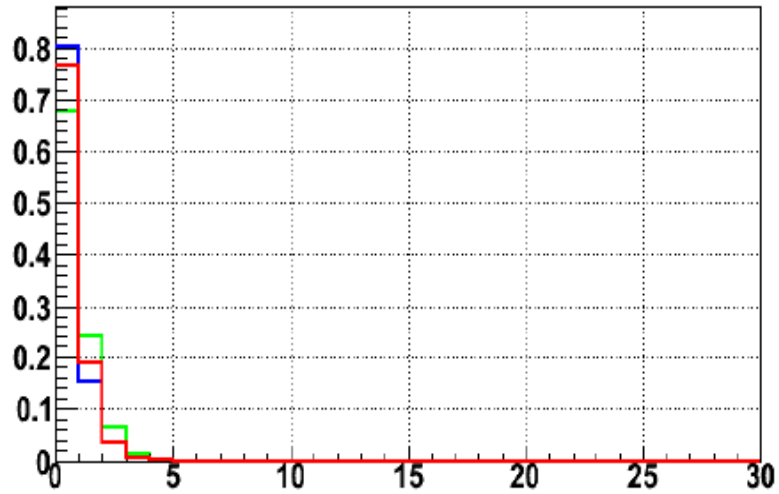
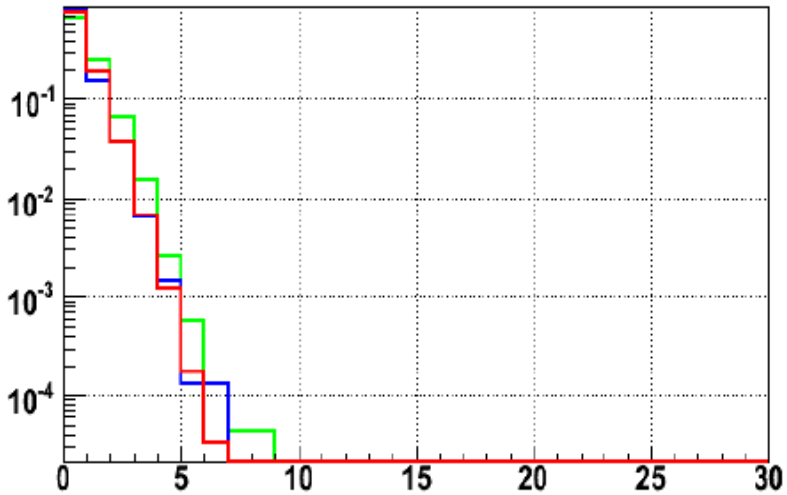




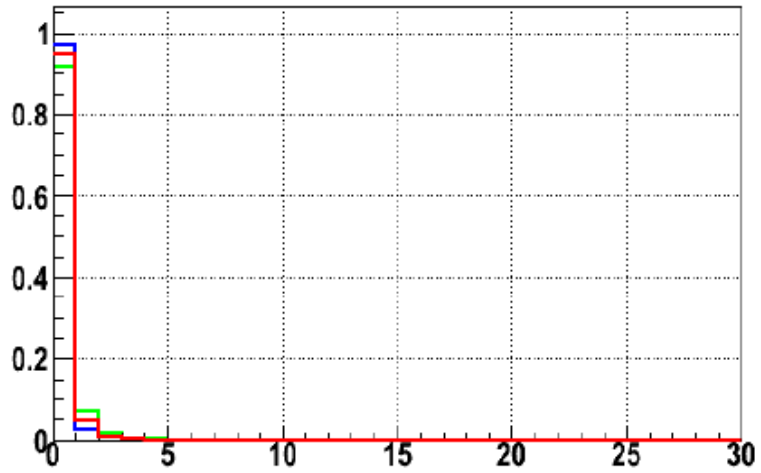
Particle Gun Endcap: 2.0 mm

single e

single e new range

π

TID



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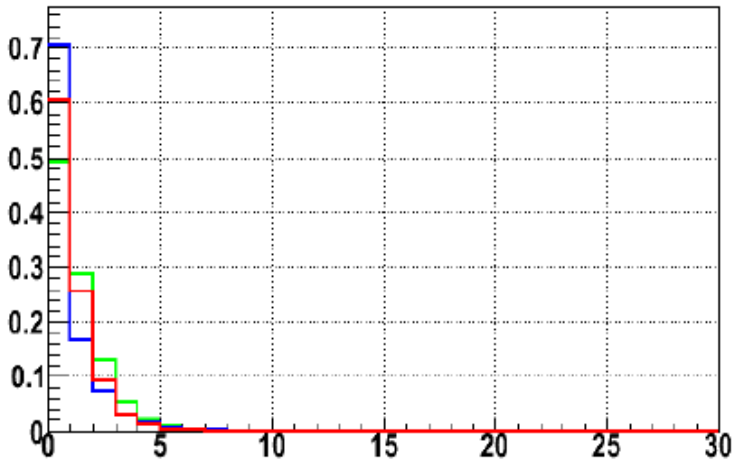
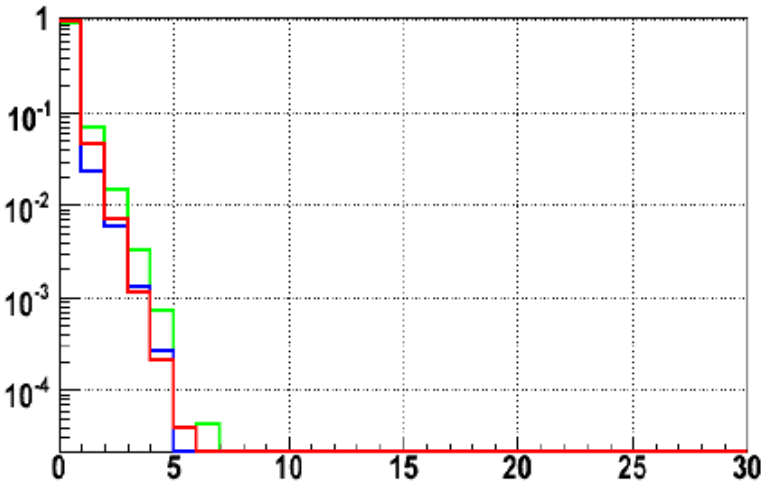
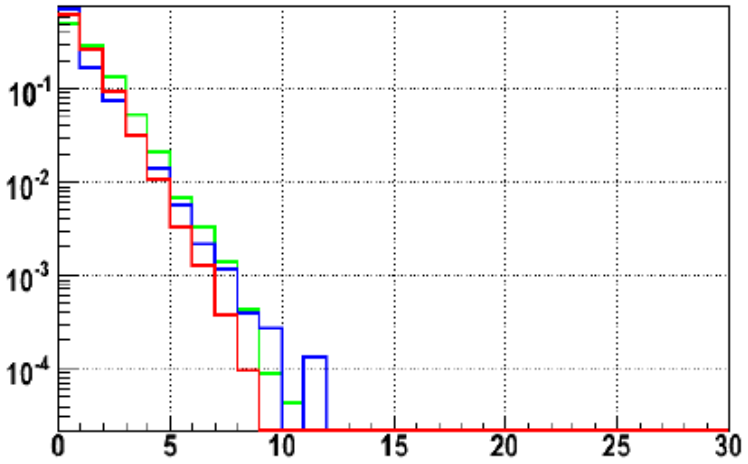






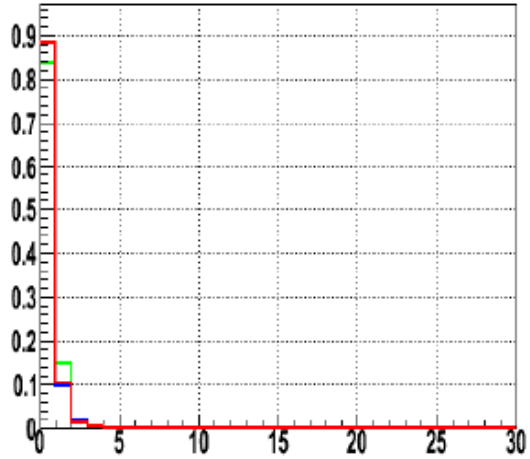
Particle Gun Endcap Summary

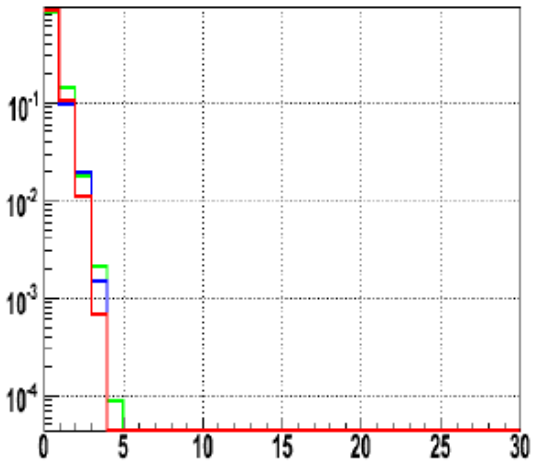
single e

single e new range

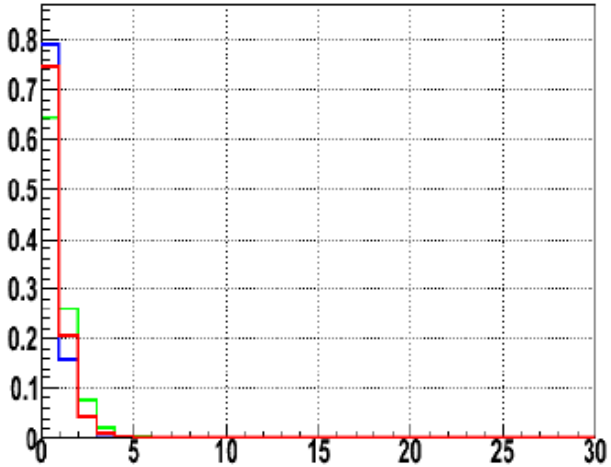
π

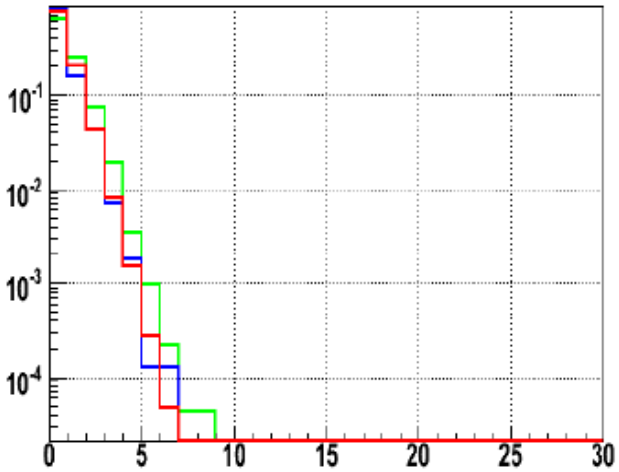
0.5 mm



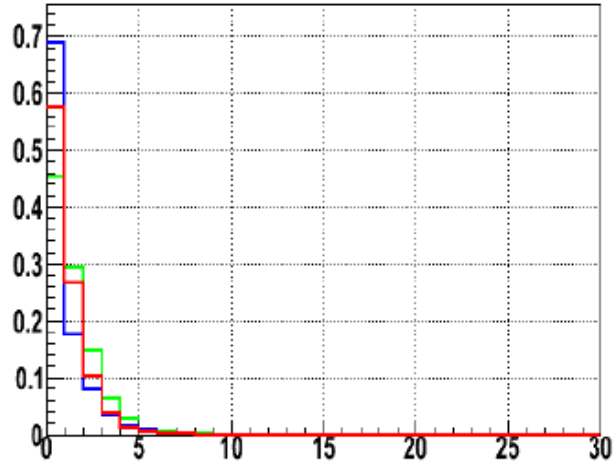


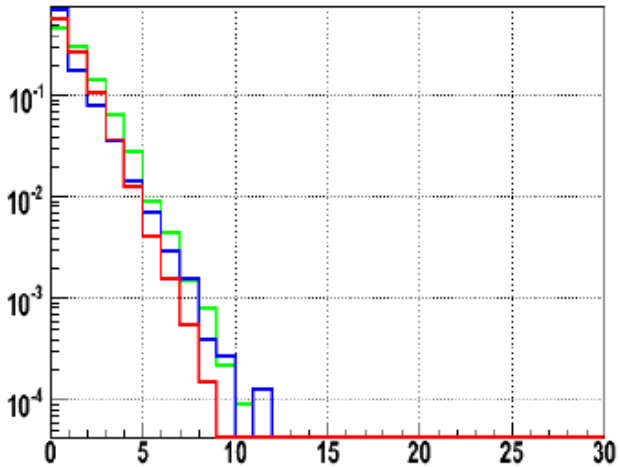
1 mm





2 mm



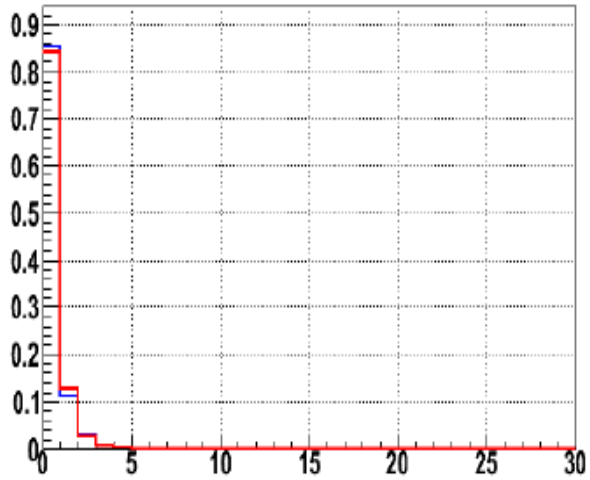


Zee/QCD Barrel: 2.0 mm

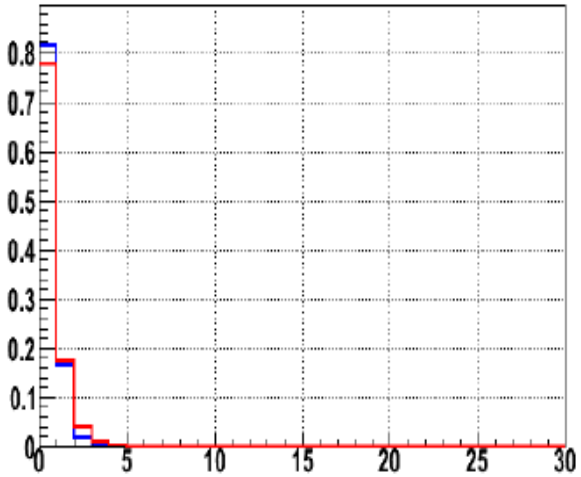
Zee

QCD

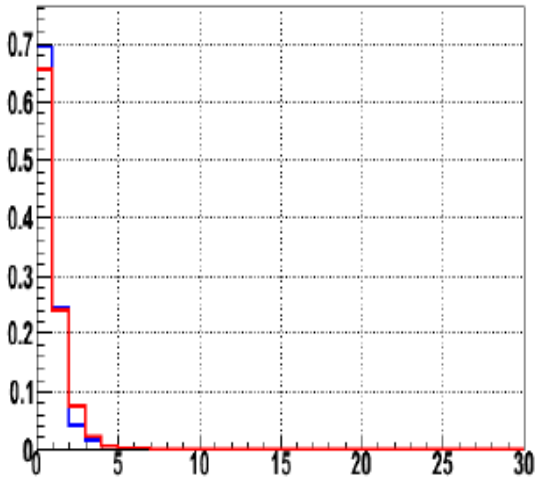
TIB

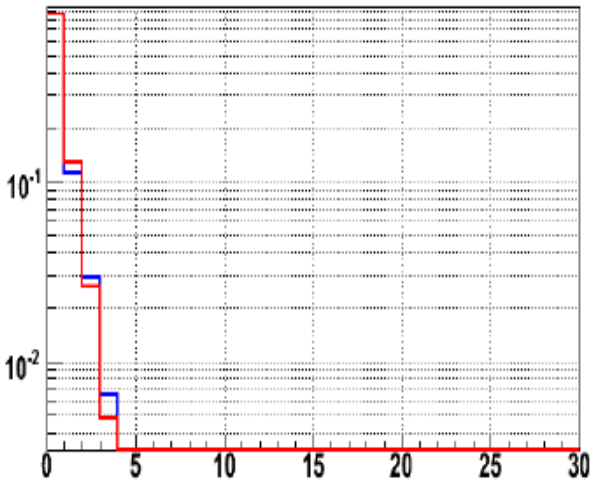


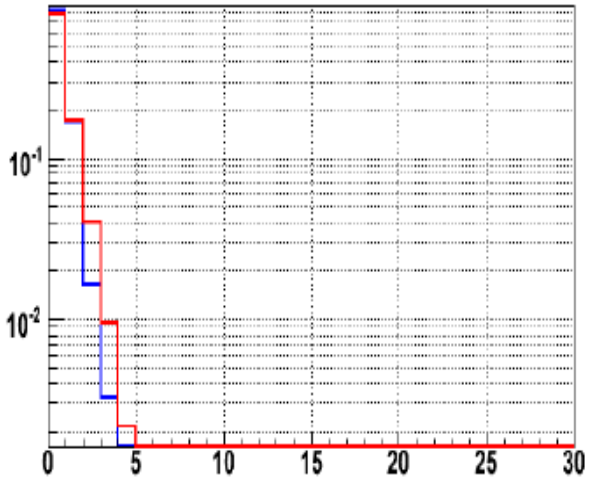
TOB

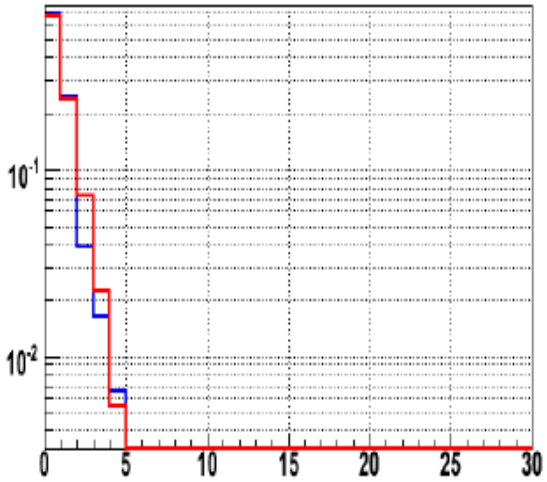


TOT





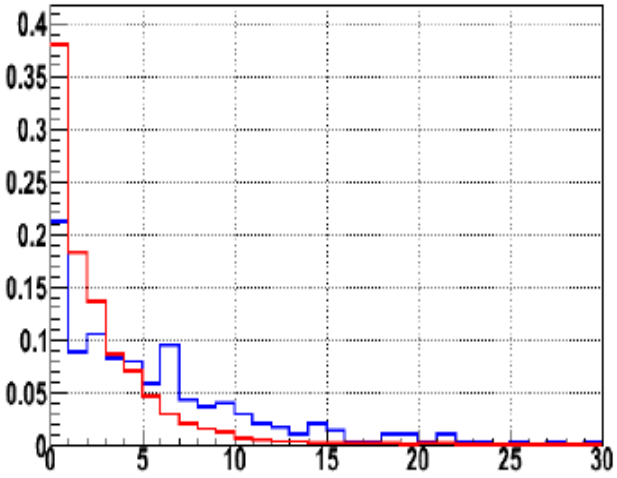




Zee/QCD Barrel: wide wind.

Zee
QCD

TIB



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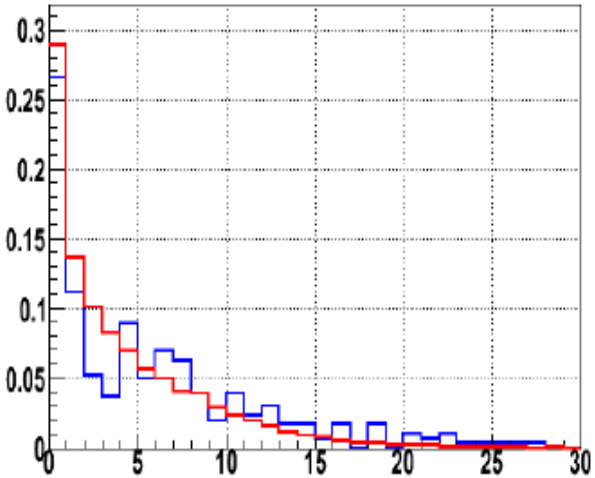
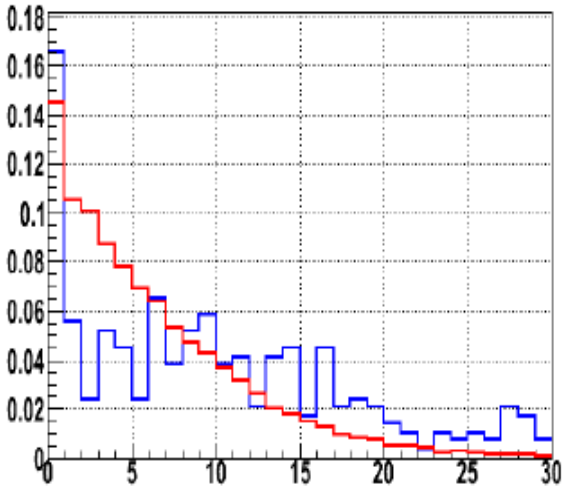
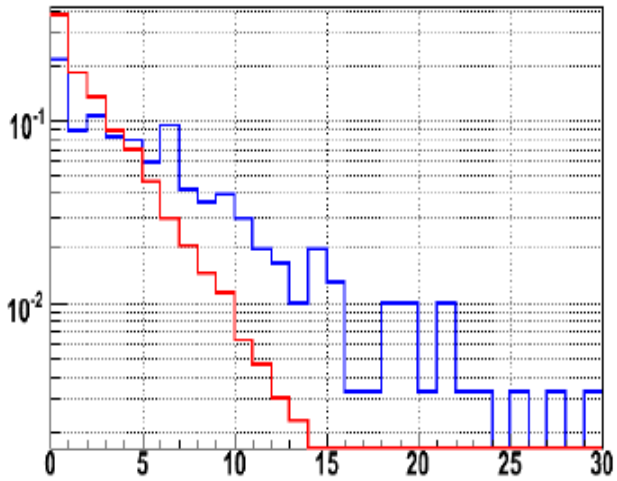
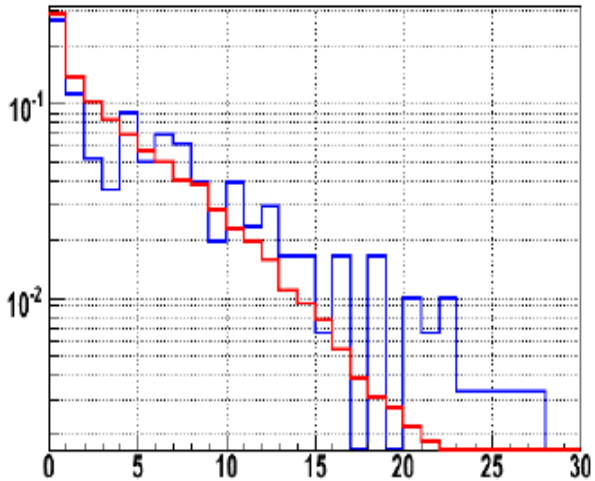
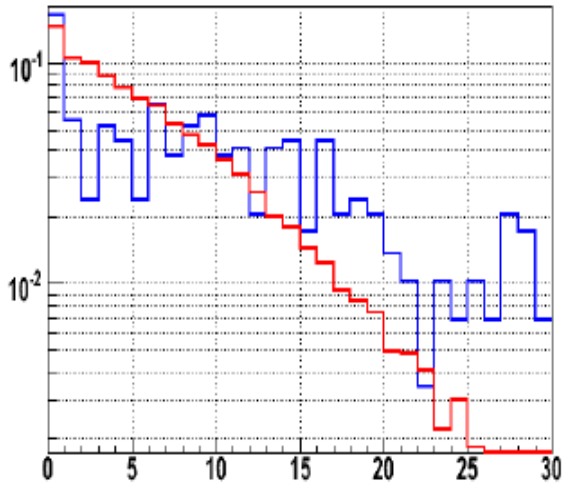


TOT







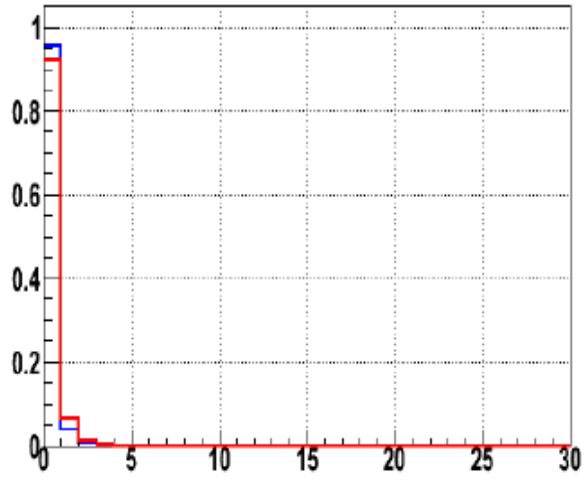


Zee/QCD Endcap: 2.0 mm

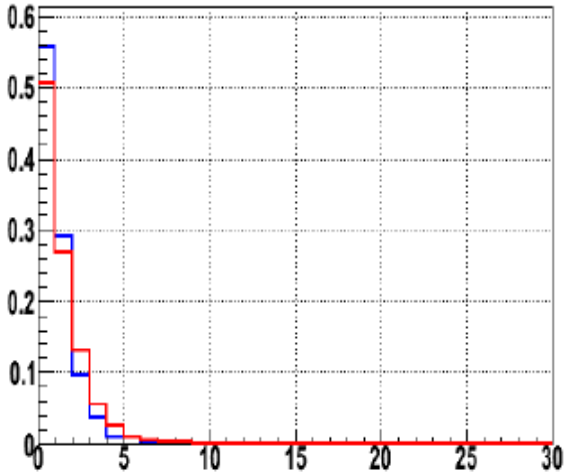
Zee

QCD

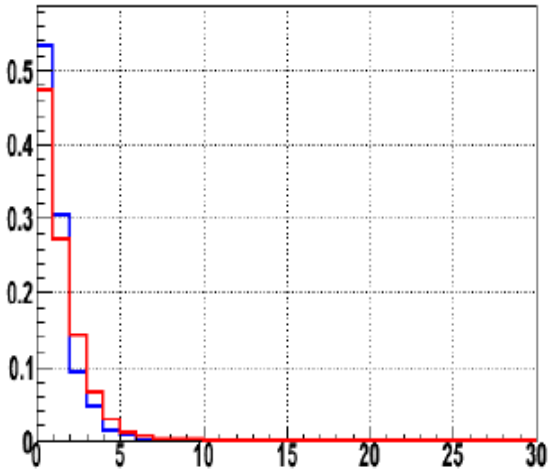
TID

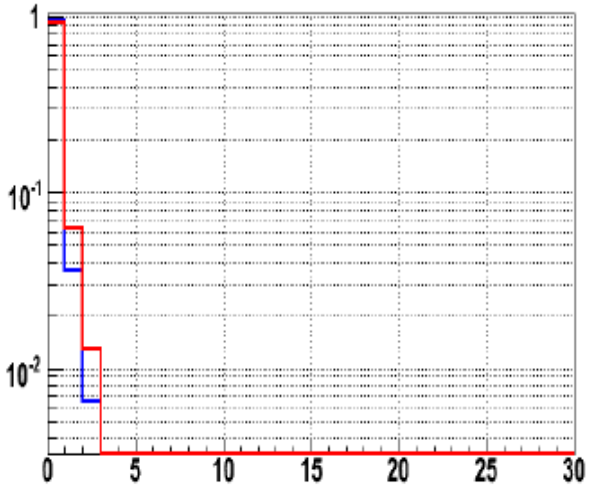


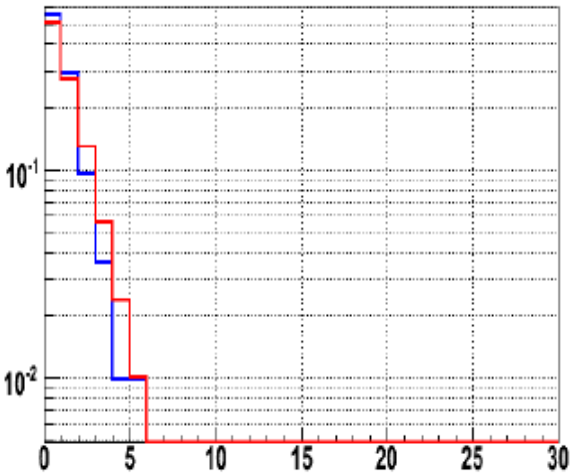
TEC

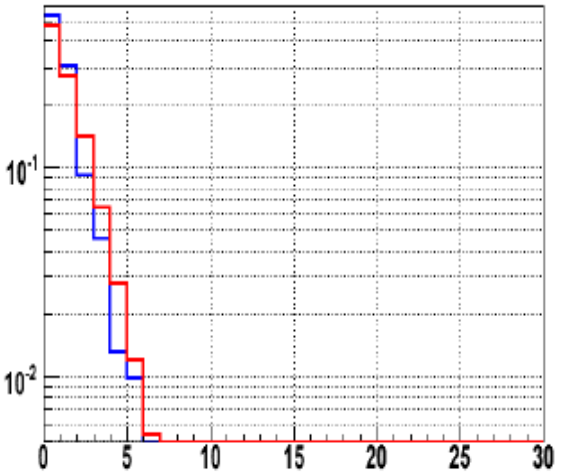


TOT







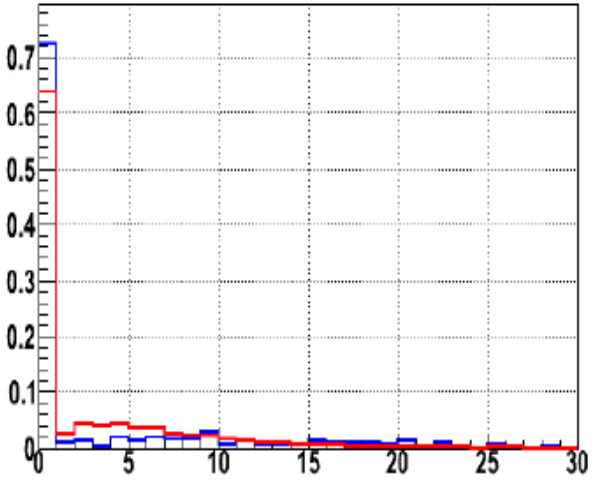


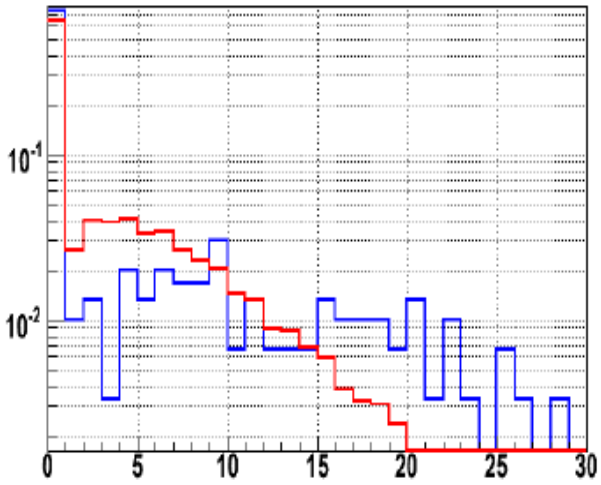
Zee/QCD Endcap: wide wind.

Zee

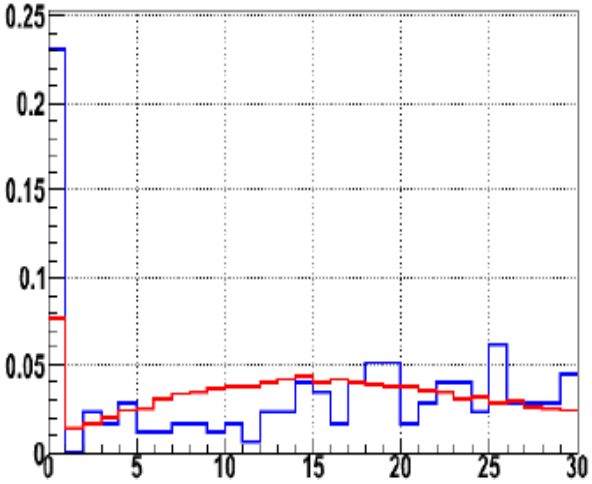
QCD

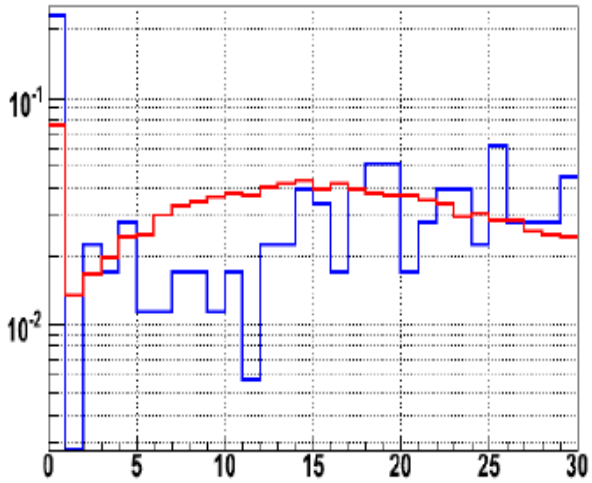
TID





TEC





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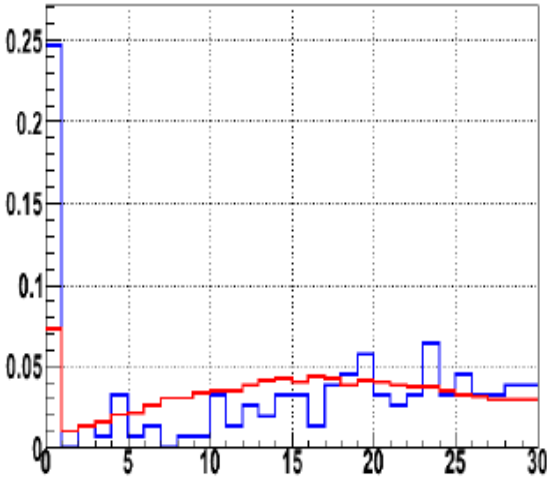

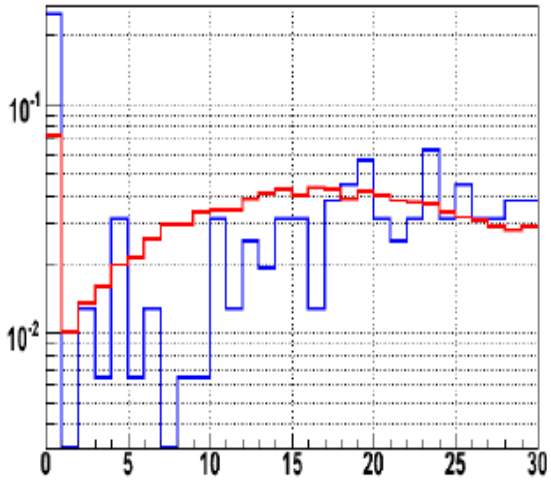

Conclusions

- The feasibility of electron/pion discrimination using exctra hits around electron candidate tracks has been studied.
- Different parameter settings for delta-ray simulation have been tried.
- An excess of hits has been observed in the vicinity of the electron tracks but it is not enough to allow eID.
- Using a more precise electron simulation (relaxed thresholds for the energy deposit propagation) the discrimination power of the number of hit variable is still not enough.