Electron Reconstruction Study in LDC Model

- Based on FullLDCTracking andPandoraPFA -

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for
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Objective and Work Flow
Simulation / Data Samples
FullLDCTracking
PandoraPFA Clustering and PFA
Cut Based Electron Identification
Conclusion / Outlook

Introductory Remarks

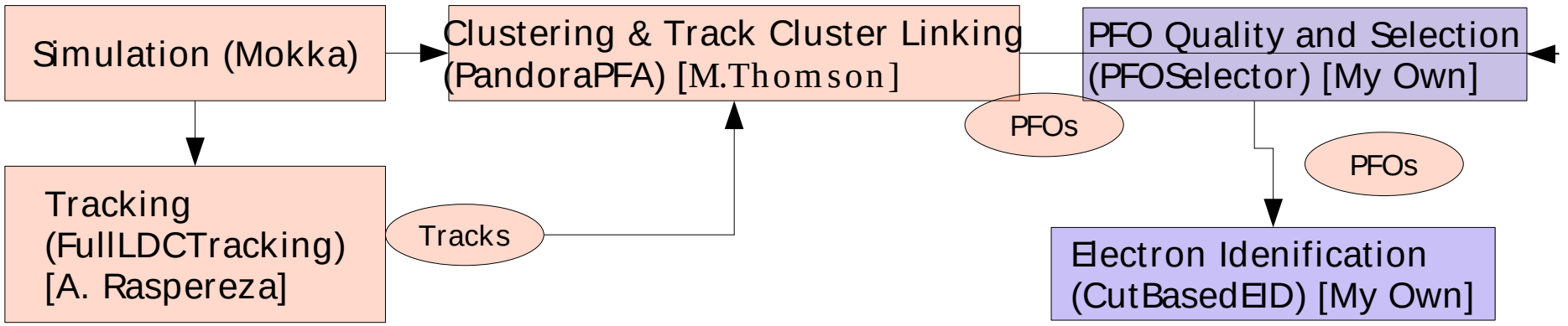
- Electrons will occur in many final states of the physics channels envisaged to be studied at the ILC

- (As will be shown) it's correct reconstruction poses maybe the biggest challenge to the capabilites of our detectors and our algorithms

- Electron reconstruction is therefore one of the key ingredients to the optimization studies for and beyond the LOIs

Objective and Work Flow

- Objective:
  - Provide good electron data sample for Higgs Recoil Mass Study (ee->ZH->eeX)
- Work Flow

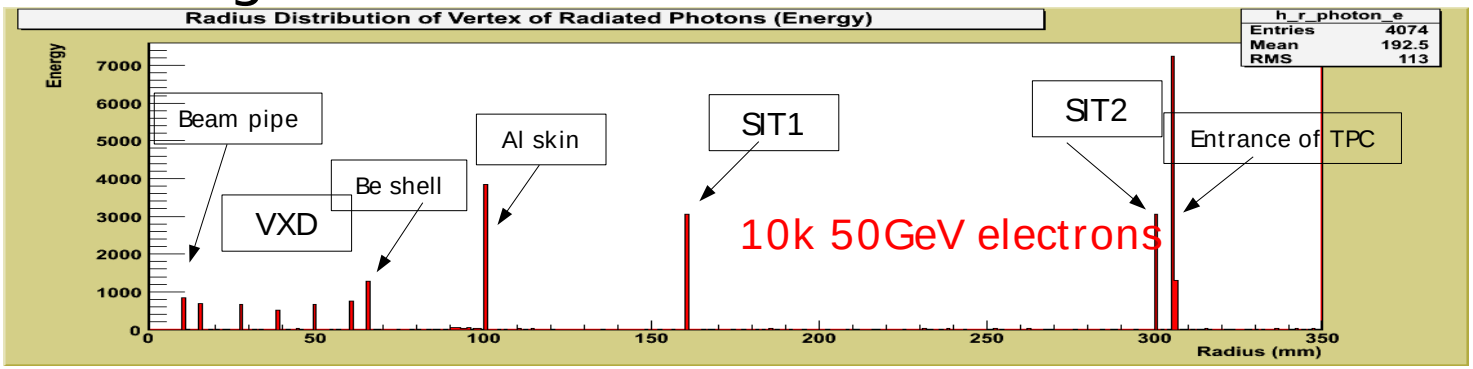


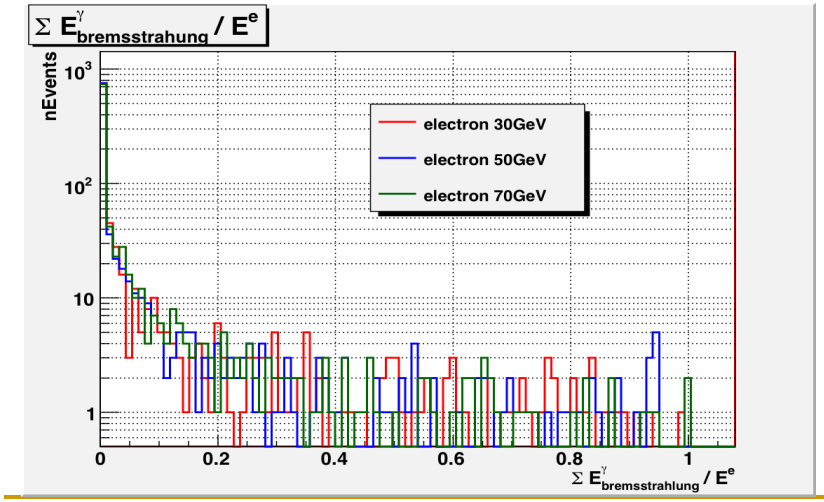
Simulation / Data Samples

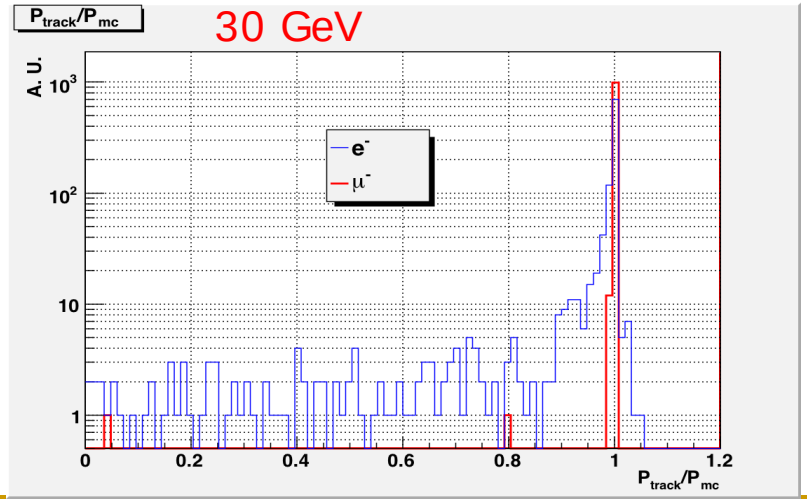
- Simulation
  - Mokka,
  - LDC01Sc Model, with Sit01 (instead of Sit00)
  - Particle Gun,
- Data Samples
  - e-, mu-, pi-
  - 10GeV, 30GeV, 50GeV, 70GeV, 90GeV
  - θ Uniform Smearing:
    - Barrel Only: $|\cos(\theta)| \in (0, 0.819)$; avoiding FTD
    - Barrel+Endcap: $|\cos(\theta)| \in (0, 9825)$
  - 1000 Events Each

Tracking Quality

- Bremsstrahlung Effect
  - Decreases the quality and efficiency of electron tracking

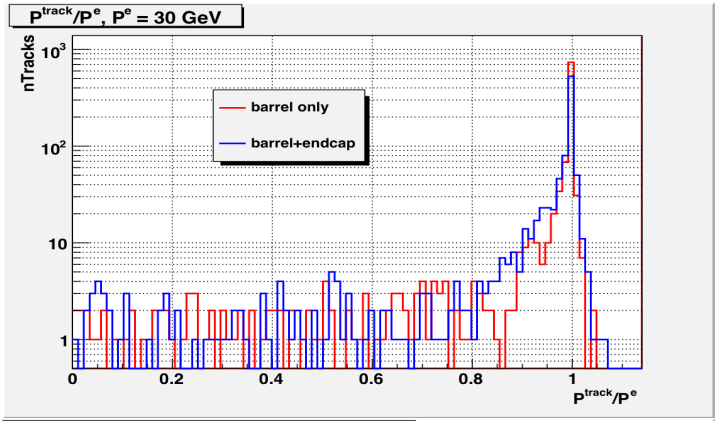


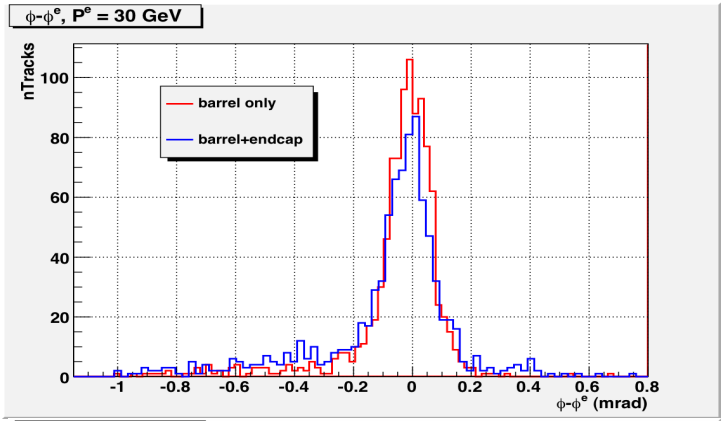


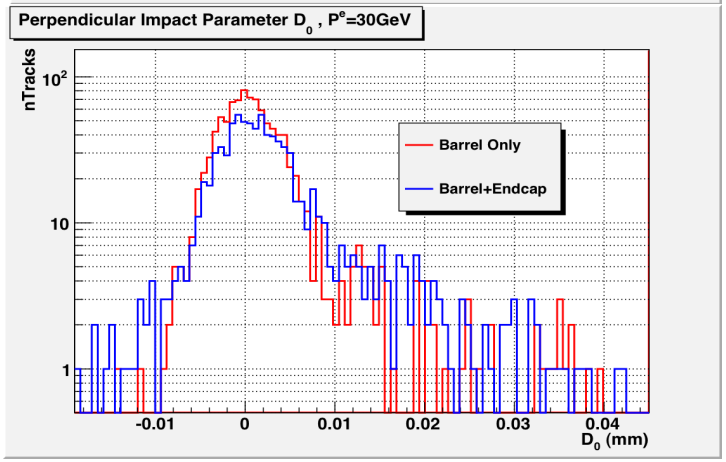


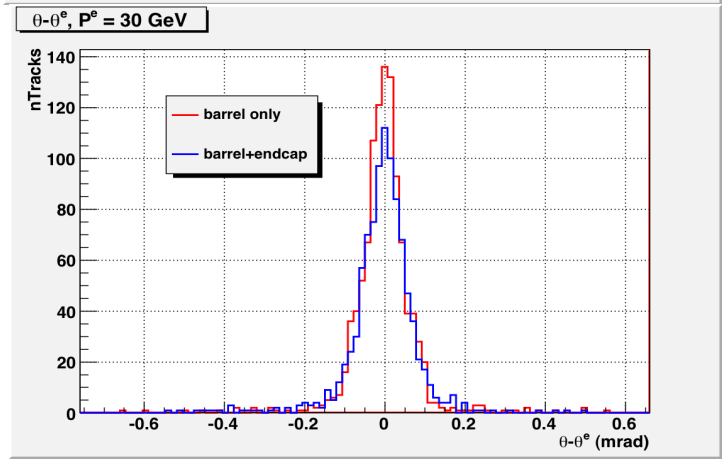
Tracking Quality

- Results for 30 GeV Electrons
  - resolution of 1/P, ϕ and Θ achieved 5.8×10^{-5} (1/GeV), 6.59×10^{-5} (rad) and 4.39×10^{-5}(rad), respectively.



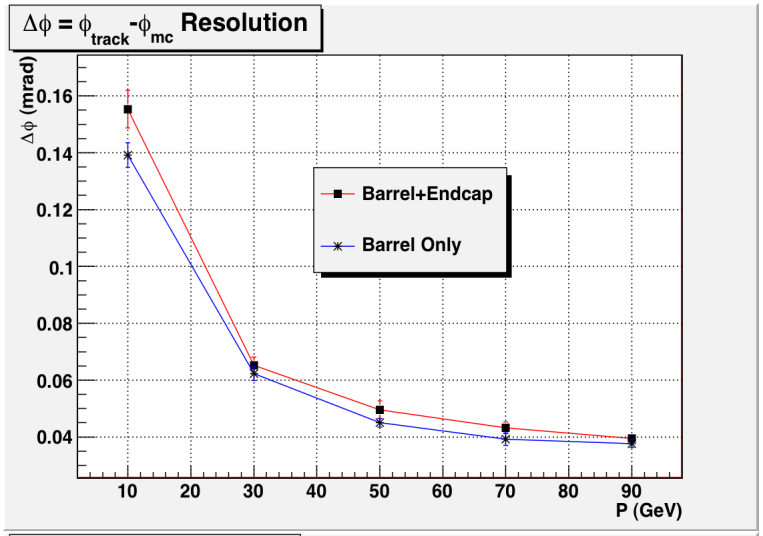


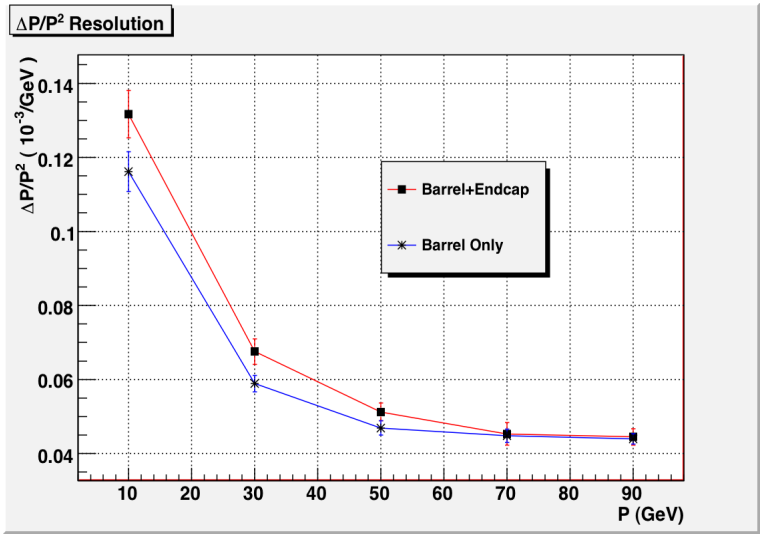


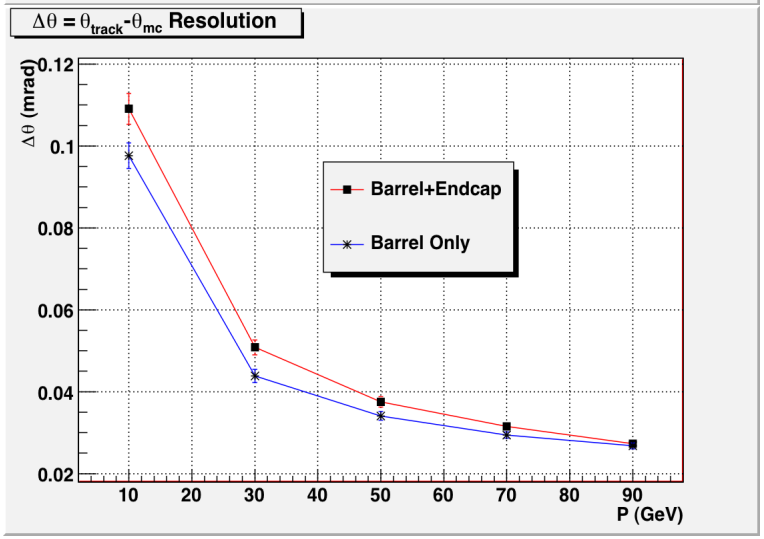


Tracking Quality

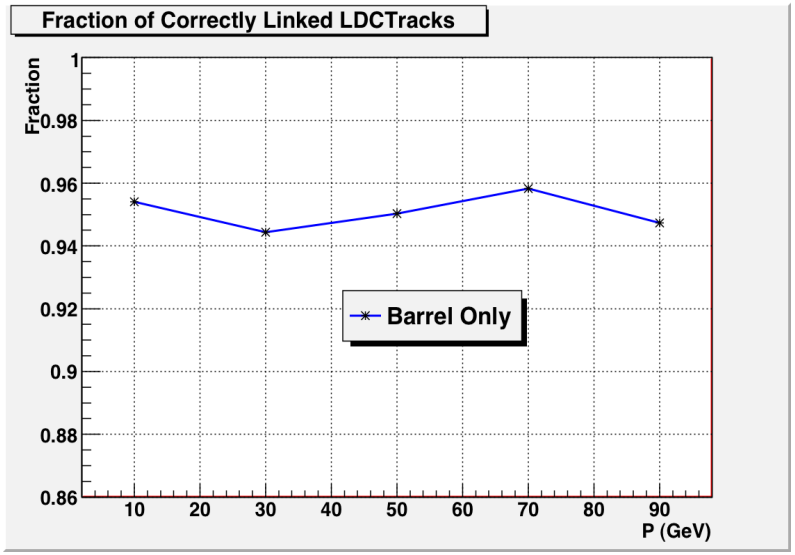
- Resolution
  - e.g. E > 30 GeV, Barrel
    - $\sigma(1/P) < 6 \times 10^{-5}$ (1/GeV)
    - $\sigma(\Theta) < 0.05$ mrad
    - $\sigma(\phi) < 0.07$ mred







Discussion on Tracking Quality

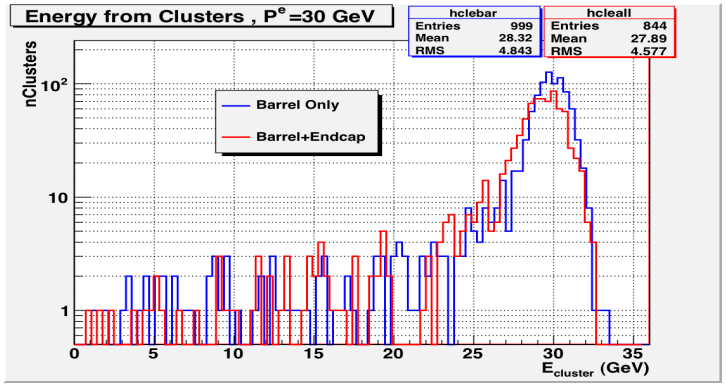


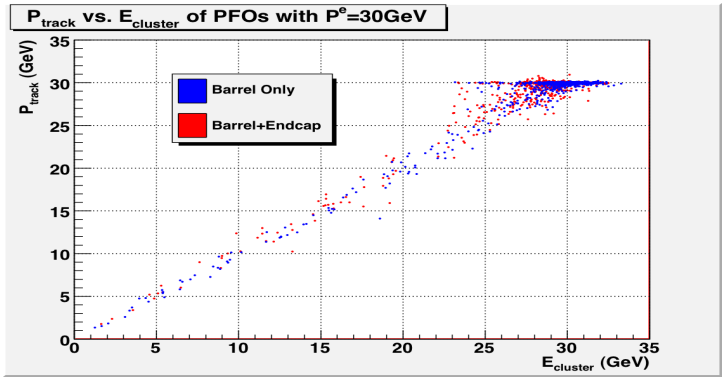
- Fraction of electrons with at least one correctly Linked LDCTrack
  - Barrel Only : ~95%

- Because of bremsstrahlung, more LDCTracks reconstructed than the number of initial electrons.
- e.g. for 1000 electrons with momentum of 30 GeV, barrel region
  - 1072 LDCTracks reconstructed
  - 934 electrons with only one LDCTrack (which is correctly linked)
  - remaining 138 LDCTracks belong to the remaining 65 electrons.
    - Mostly, (~53 electrons), due to SiTracks and TPCTracks cannot be linked together by Kalman Filter after photon radiated
    - rarely, (~9 electrons), due to more than one TPCTracks reconstructed in case that photon radiated within TPC,
    - Photon Conversion negligable (~3 electrons)

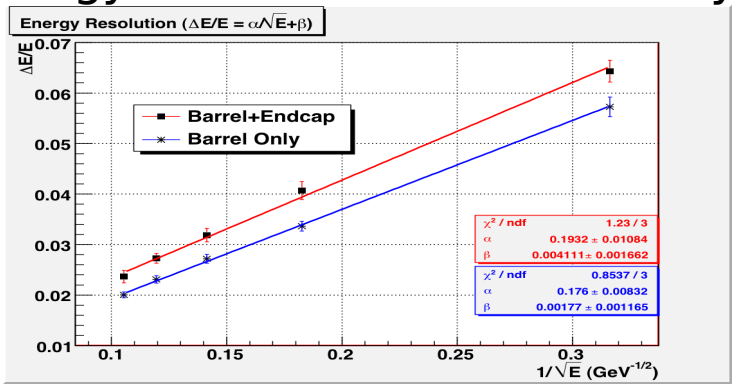
Clustering and PFA Quality

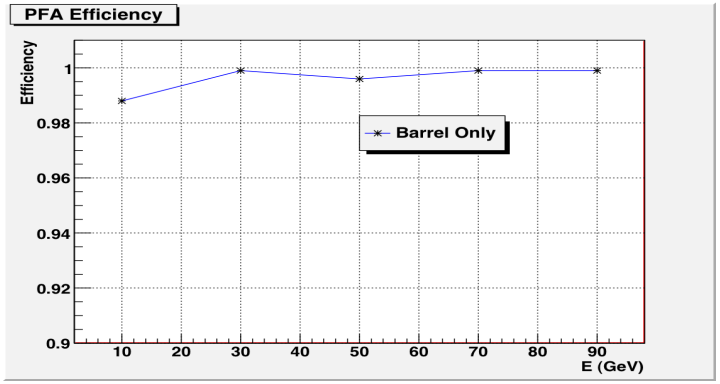
- Results for 30GeV Electrons





- Energy Resolution and Efficiency





- Resolution
  - Barrel Only: α=17.6%
  - Barrel+Endcap: α=19.3%
- Efficiency
  - $N_{PFOs\ Reconstructed} / N_{Initial\ Primary\ Electrons}$
  - Barrel Only: ~ 100%

Please Note:

At this stage of its development
Pandora PFA desitinguishes only between

(Generic) Neutral paticles i.e. Photons and
(Generic) Charged particles i.e. Pions

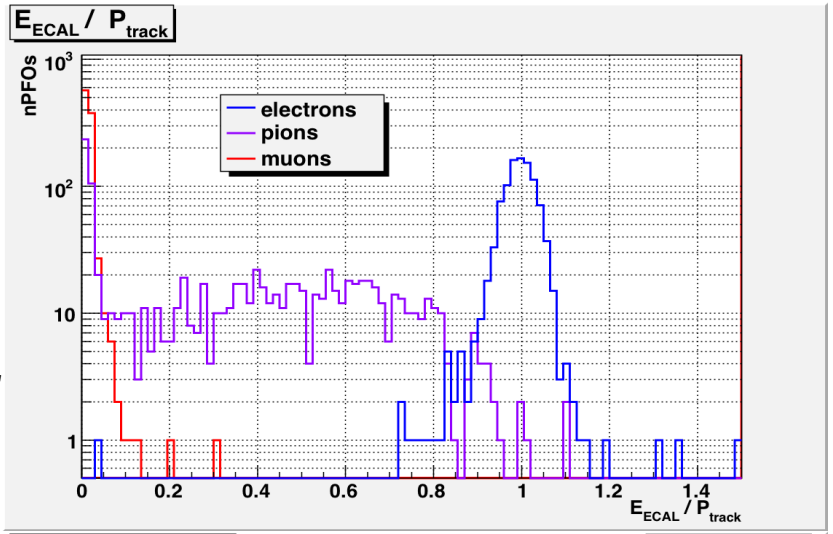
So far mainly conceived to investigate 30%/√E
Jet Energy Resolution

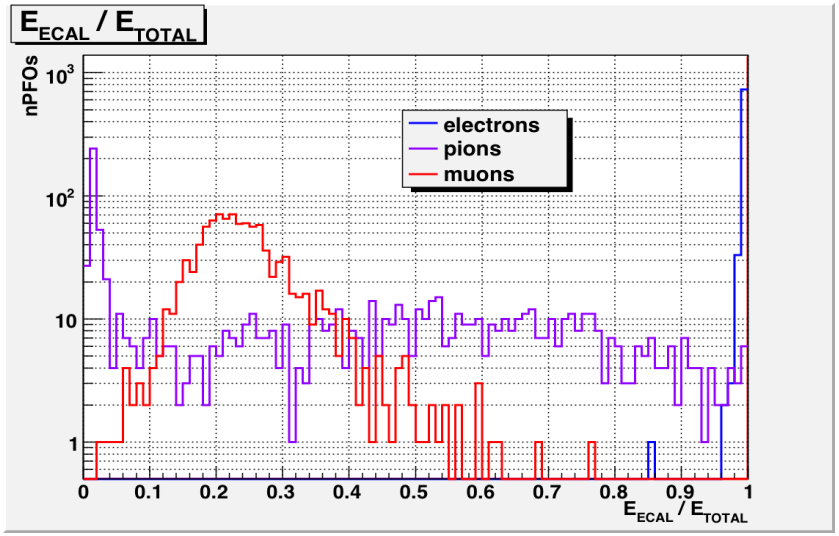
'Correct' particle ID still to be done!!!

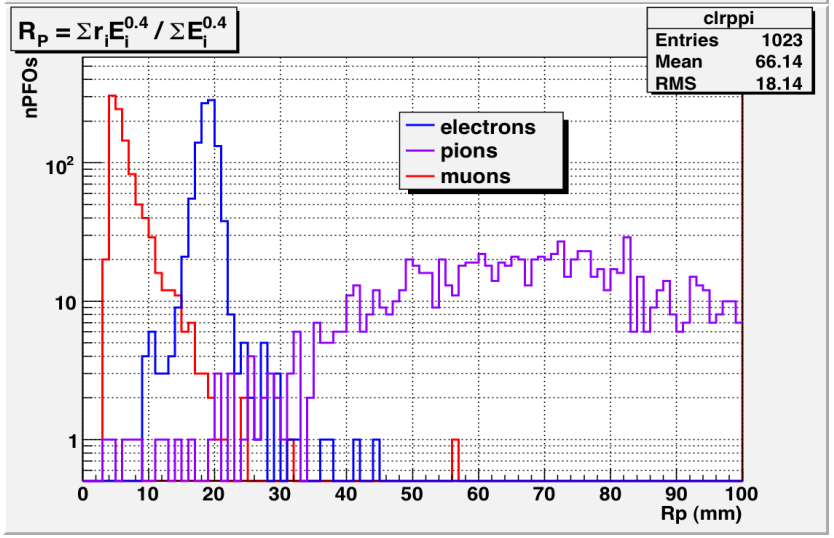
Cut Based Electron ID

30GeV e-, μ- and π- sample

- Estimators
  - $EPratio = E_{ECAL}/P_{Track}$
  - $Efrac = E_{ECAL}/E_{total} \quad of\ a\ \ Cluster$
  - $R_P = \sum_{i=nHits} r_i E_i^{0.4} / \sum_{i=nHits} E_i^{0.4} of\ a\ \ Cluster$

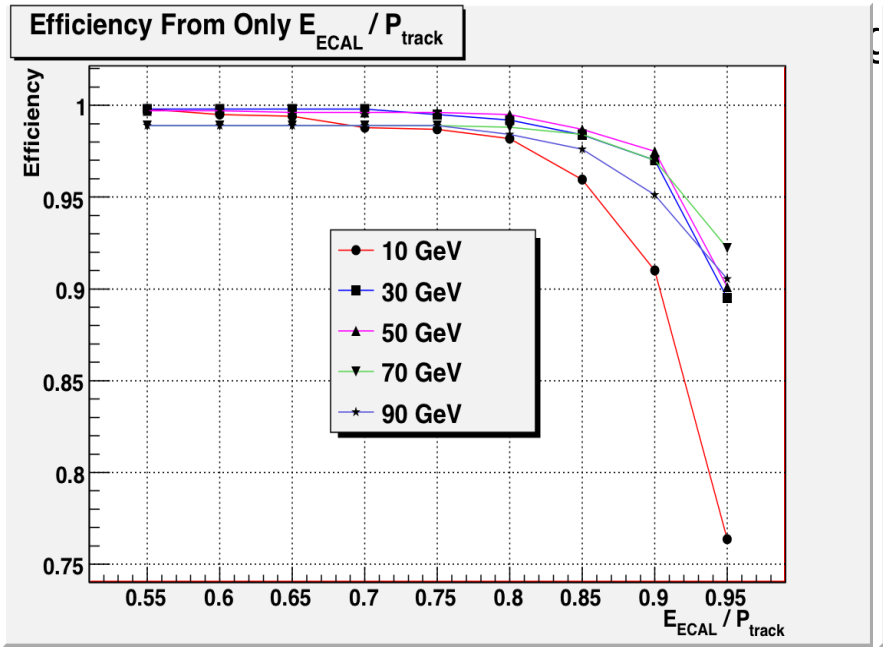


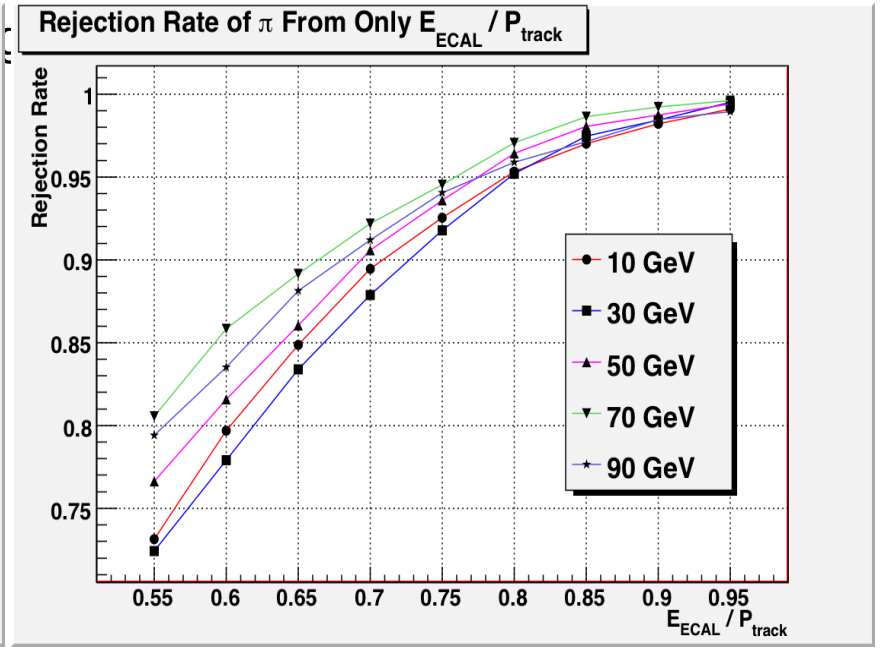




Cut Based Electron Identification

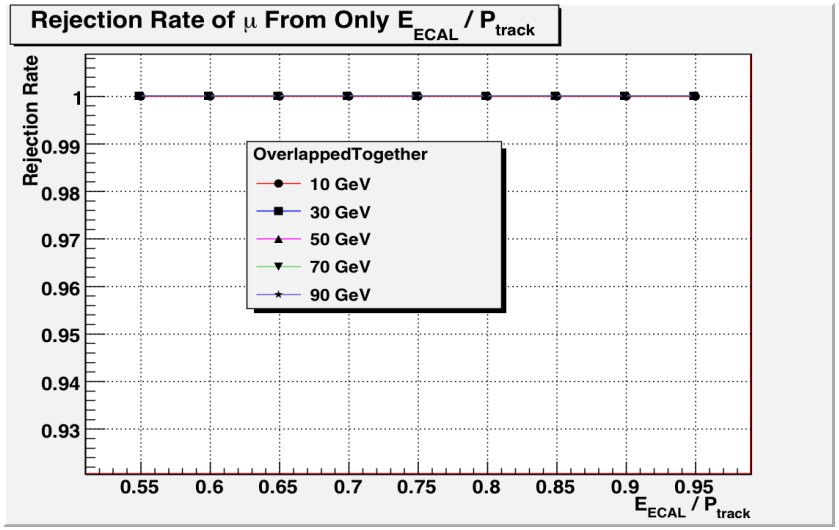
- Definition of Efficiency and Rejection Rate
  - Efficiency: $Eff = N_{\text{Electrons Identified}} / N_{\text{Electron PFOs from PFA}}$
  - Rejection Rate: $Rej = 1 - N_{\text{Mis-Identified}} / N_{\text{Background PFOs from PFA}}$
- Efficiency and Rejection Rate for particular Identification Variable





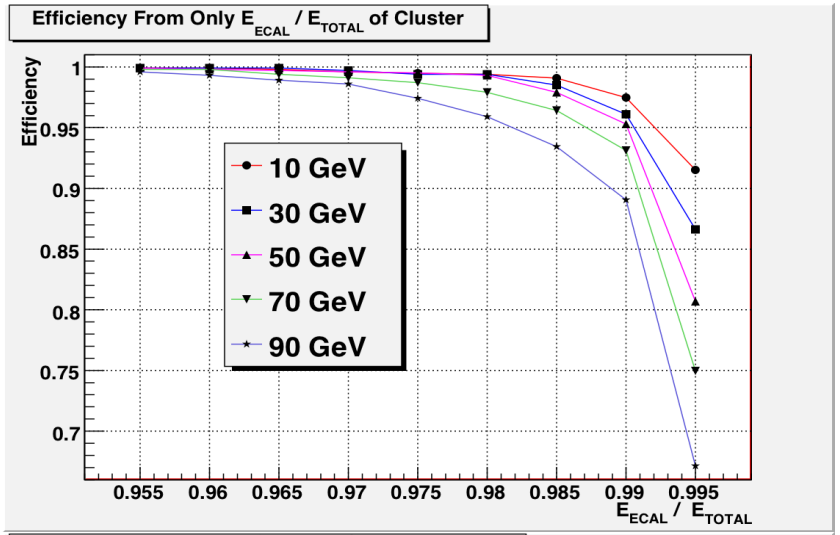
Cut Based Electron Identification

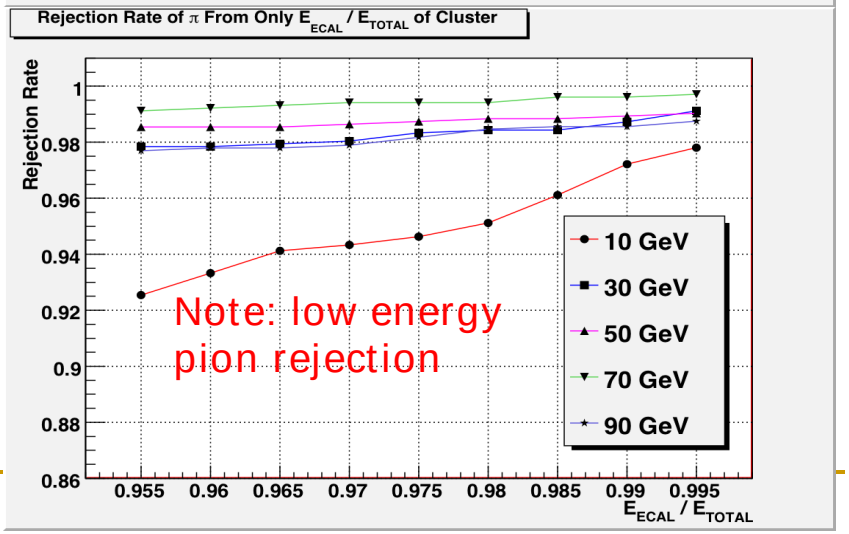
- Ep ratio: (continue)



- Muons are fully rejected by Epratio variable only.

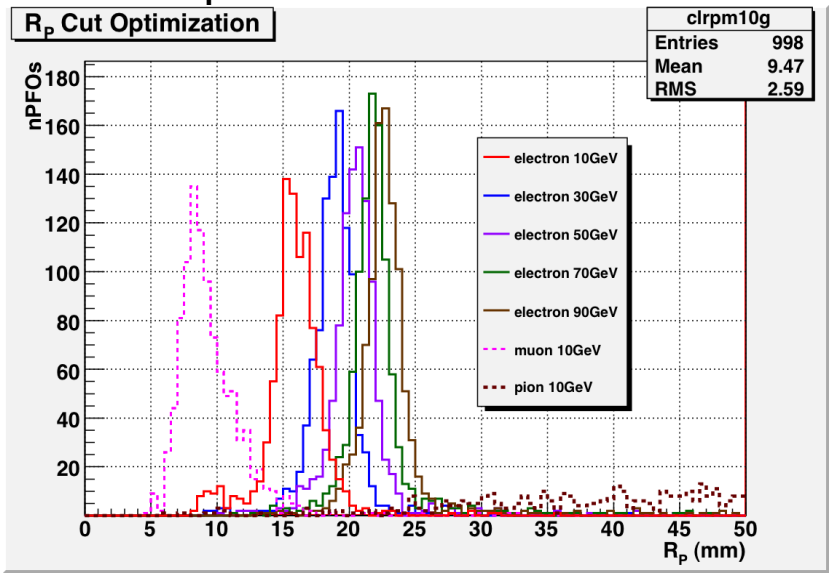
- Efrac Only: (for Barrel Region Only)

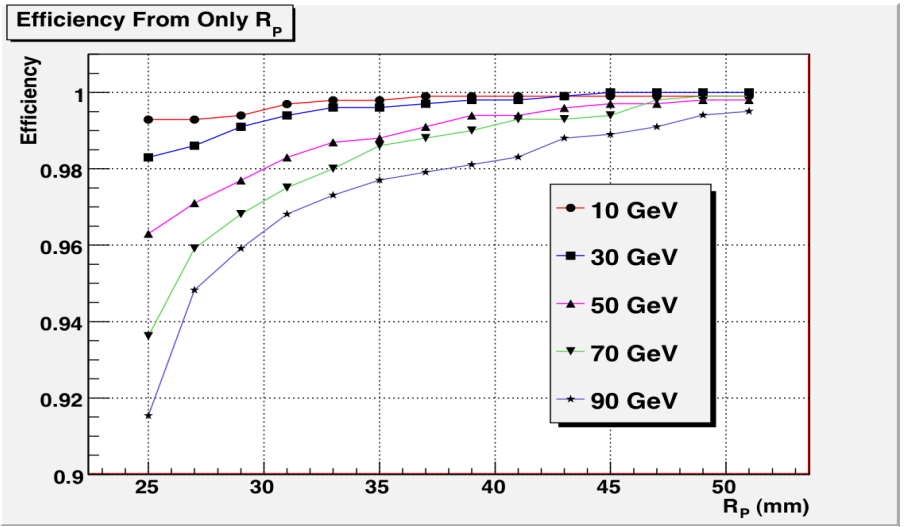


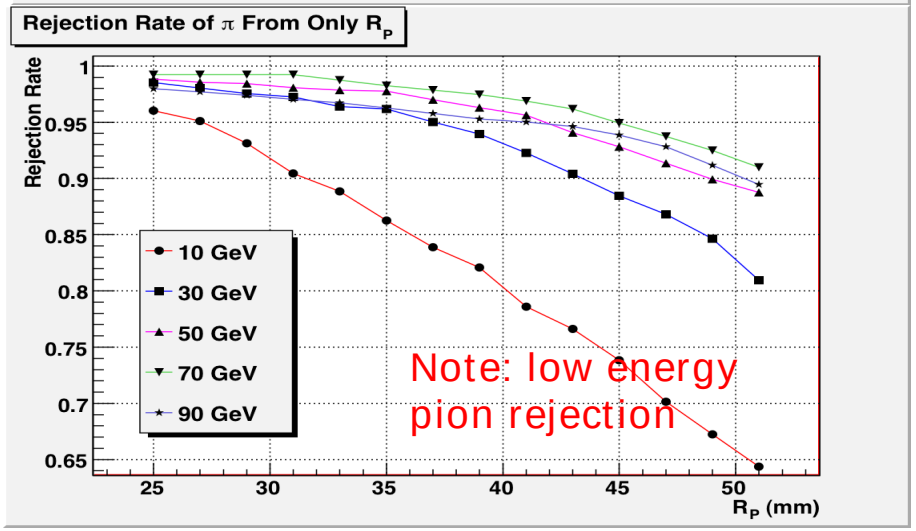


Cut Based Electron Identification

- Rp Only: (for Barrel Region Only)
  - Since muons are fully rejected by EPratio
  - Fix the Rp lower cut of 7 mm, adjust upper cut for optimization



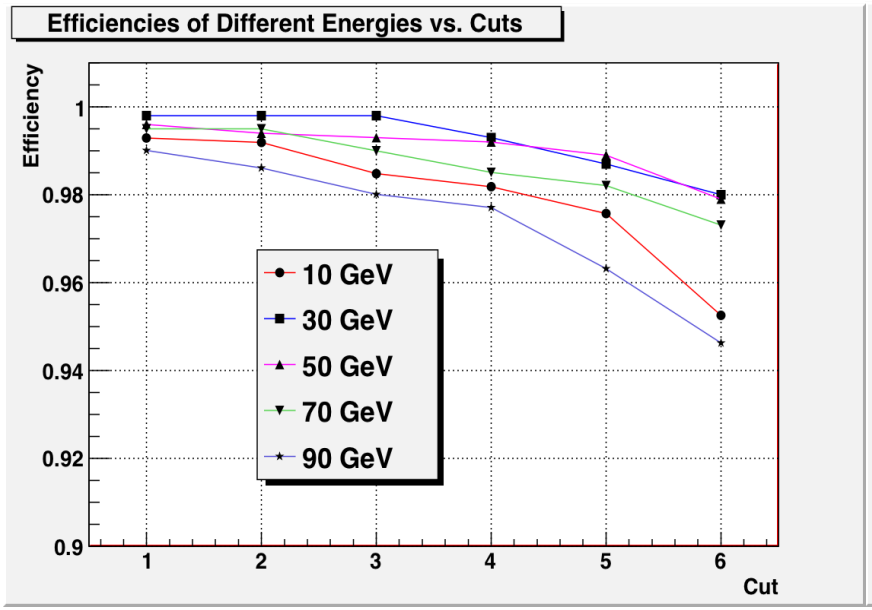


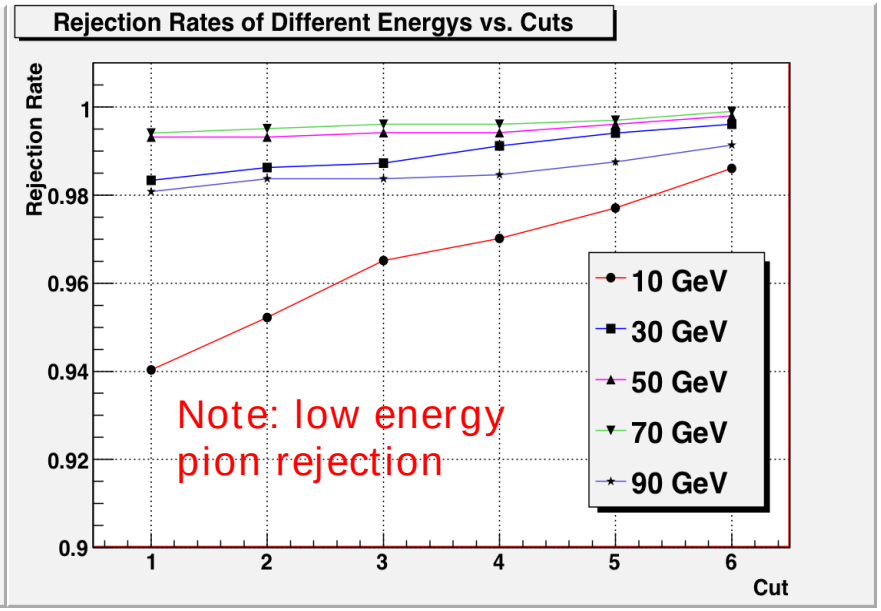


Cut Based Electron Identification

- Overall Efficiencies and Rejection Rates of Different Cut Scenarios
  - Cut Scenarios: 1 to 6, looser to tighter (or softer to harder)

Cut Scenario	1	2	3	4	5	6
Epratio	0.6	0.65	0.7	0.75	0.8	0.85
Efrac	0.96	0.96	0.97	0.97	0.98	0.98
Rp	51	49	47	45	43	41



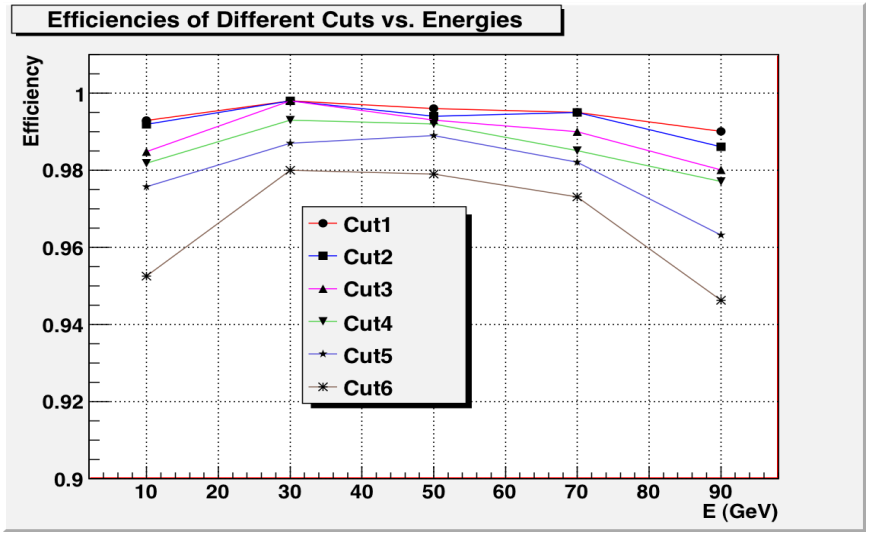


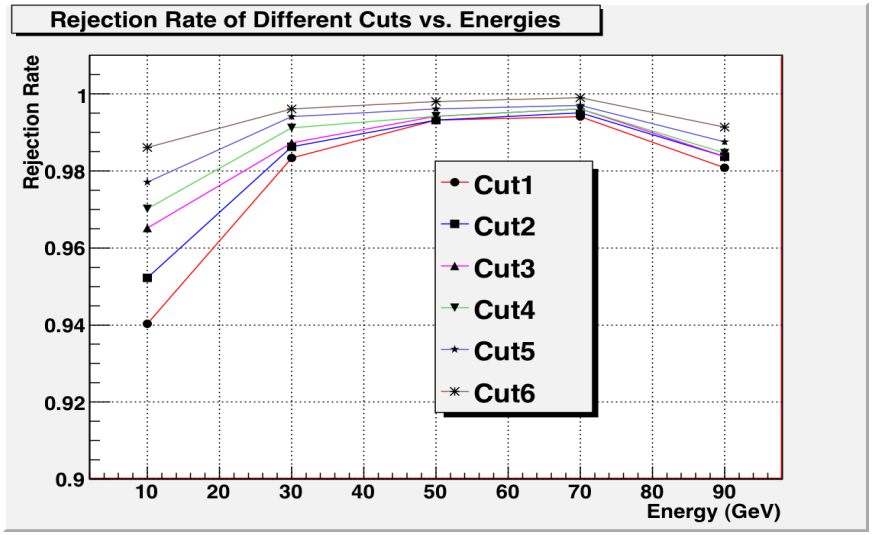
For Barrel Only

Cut Based Electron Identification

- Overall Efficiencies and Rejection Rates (continue)

For Barrel Only





- e.g. For ee->ZH->eeX ,
  - di-electron momentum mainly within 20 – 70 GeV
  - Cut Scenario2 and Cut Scenario3 are suitable:
    - Efficiency > 99.5 %;
    - Rejection Rate for pions
      - E of > 30 GeV: > 98%
      - E of 10 to 30 GeV: > 95%

Benchmark Processes ... from N.Graf this morning

$e^+e^- \rightarrow ZH$, $H \rightarrow e^+e^-X$, $\mu^+\mu^-X$ ($M_H = 120$ GeV, $E_{cms} = 250$ GeV)

- ✔ **tracking efficiency and momentum resolution**
- ✔ **material distribution in the tracking detectors**
- ✔ **EM shower ID, kink reconstruction (bremsstrahlung)**
- ✔ **Higgs Mass and cross section**

⇒ Study is fully compliant with requirements formulated by WWS Software Panel

Conclusion and Outlook

- During this analysis:
  - FullLDCTracking performance : good! :D
  - PandoraPFA perfomance: good! :D
- Electron Identification Objective achieved
  - Efficiency > 99.5%; Rejection Rate for pion > 98%*
  - EID cuts optimization for physics study is on going
  - Need to understand low energy pions -> CALICE testbeams!!
  - Likelihood method might lead to higher electron yield
- Bremsstrahlung: Comprimizes reco of basic interaction at IP
  - Algorithm to detect radiative events
  - Tracking to be improved or optimized for electrons

Moving on to Higgs Production X-Section in e channel

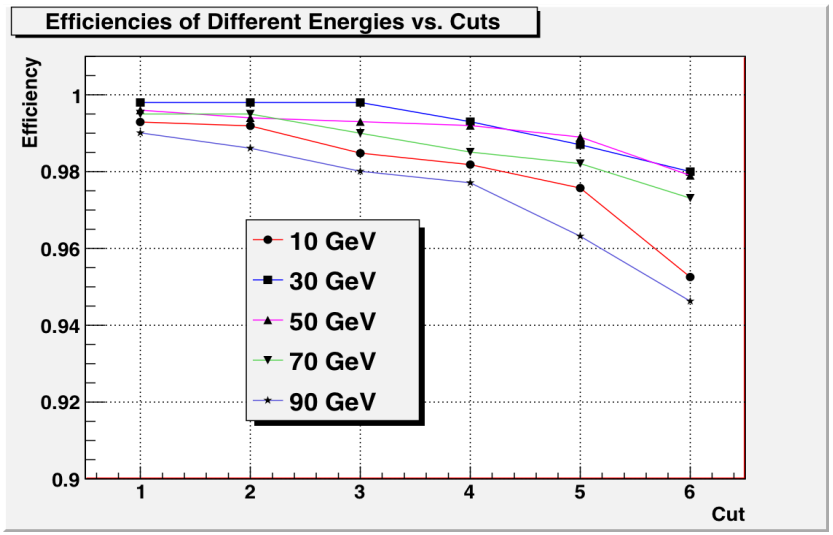
* For Barrel, pion Energy > 30 GeV,

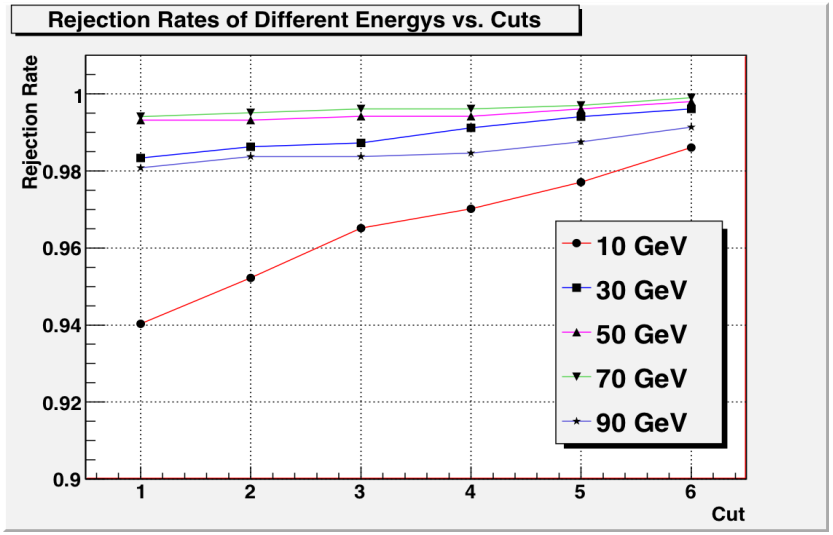
Backup Slides

* For Barrel, 30 to 70 GeV,

Cut Based Electron Identification

- Overall Efficiencies and Rejection Rates (continued) For Barrel Only





- Optimization of Cuts
  - Define Optimization Factor as:
  - reflects the efficiency and rejection rate together, and respects to different background rate of different physics channel to be studied.

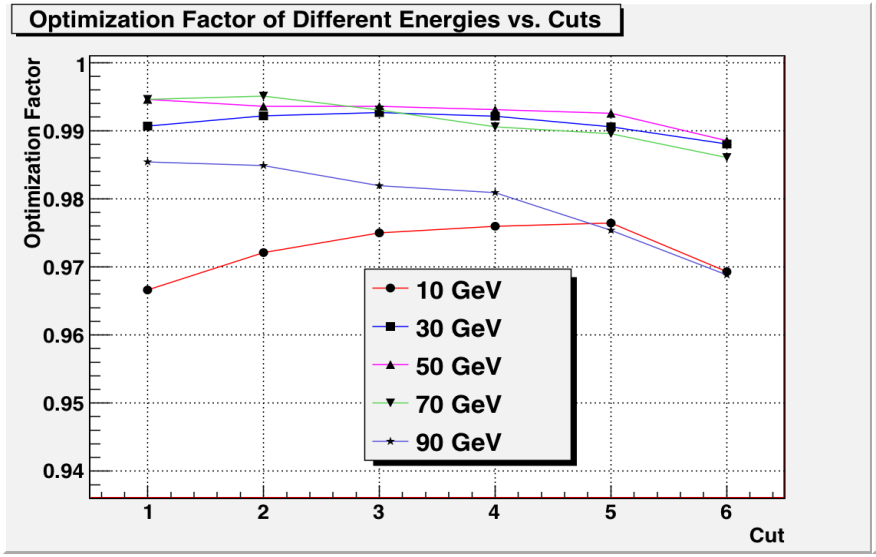
$$F_{opt} = (f_e Eff + f_b Rej)/(f_e + f_b),$$

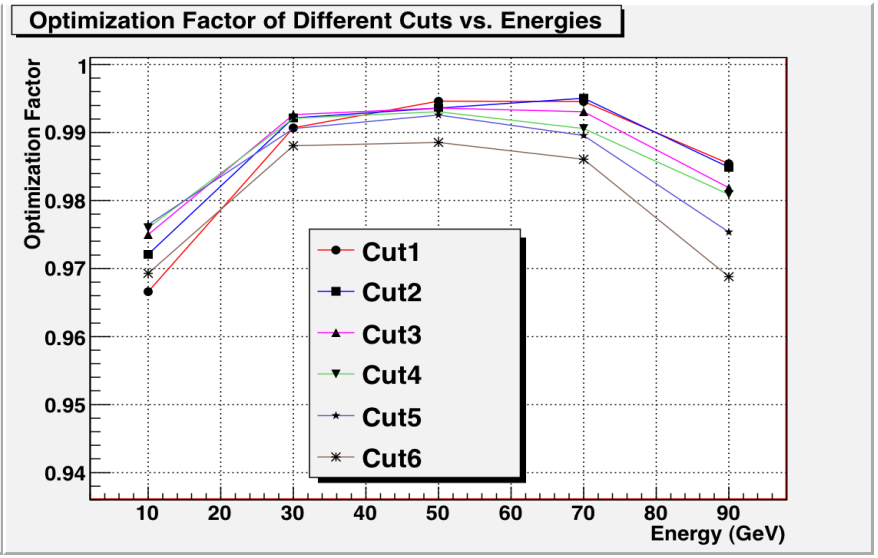
where f_e is the fraction of final state electrons,
f_b is the fraction of final state background particles

Cut Based Electron Identification

- Cut Optimization (continue)
  - e.g. assume fe = fb

For Barrel Only



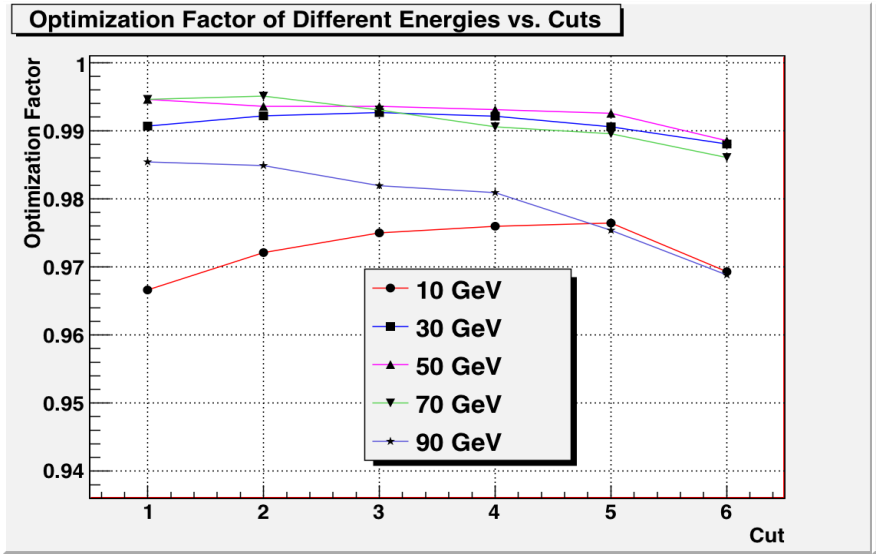


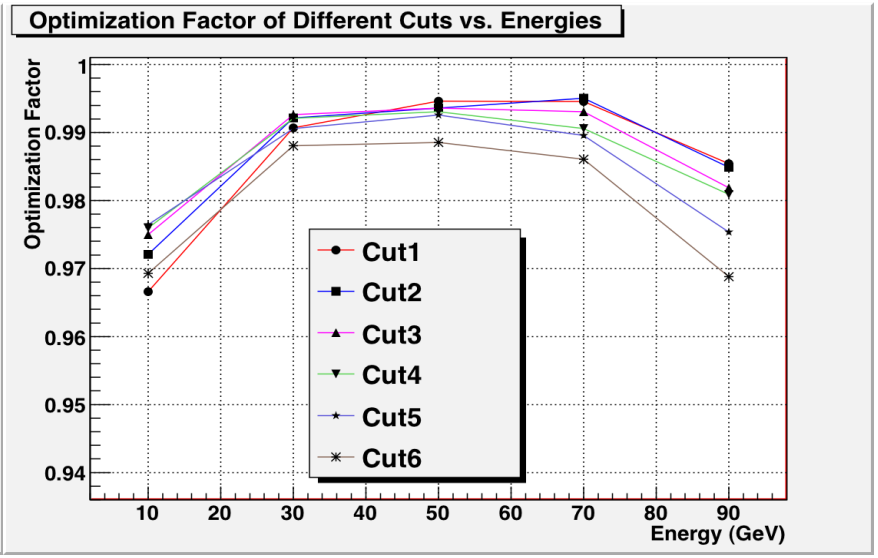
- e.g. For ee- > ZH- > eeX ,
  - di- electron momentum mainly within 20 – 70 GeV
  - Cut2 and Cut3 are suitable:
    - Eff > 99.5 %; Rej ~ 99.0%

Cut Based Electron Identification

- Cut Optimization (continue)
  - e.g. assume fe = fb

For Barrel Only





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