Electron Reconstruction Study of
LDC01Sc and LDCPrime_02Sc_p01
(Based on FullLCDTracking and PandoraPFA)

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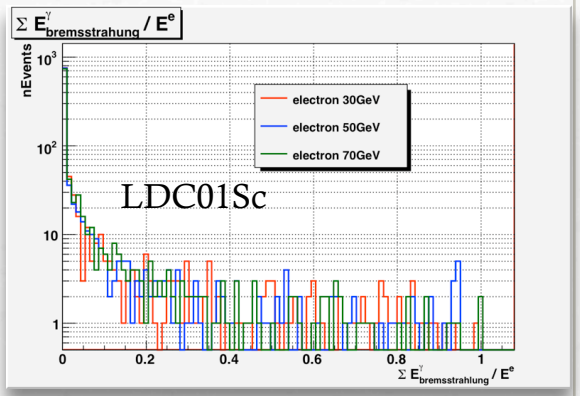
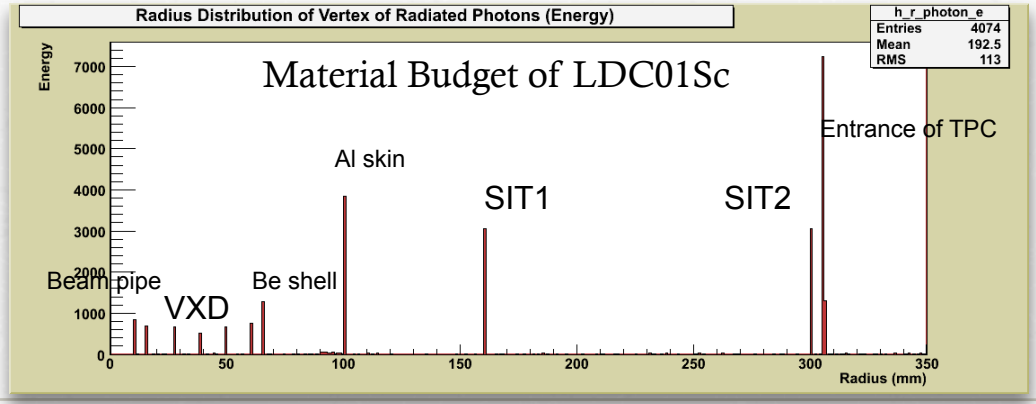
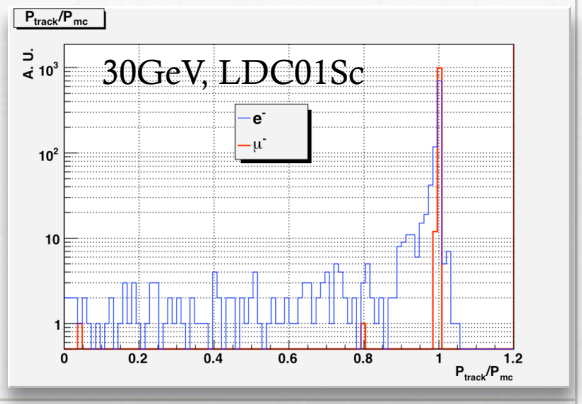
- **OUTLINE**
  - Introductory Remarks
  - Simulation/Reconstruction
  - Comparison of LDC01Sc and LDCPrime
    - Tracking
    - Clustering and Particle Flow
  - Conclusions

Introductory Remarks

- Electrons will occur in many final states of the physics channels envisaged to be studied at the ILC: e.g. Zh->eeX
- Bremsstrahlung Effects of Electrons
  - Largely depends on the Material Budget of detectors
  - Decreasing the quality and efficiency of tracking
  - The correct reconstruction of electrons maybe the biggest challenge to the capabilities of our detectors and our algorithms
- Electron reconstruction is therefore one of the key ingredients to the optimization studies for and beyond the LOIs







Simulation/Reconstruction

- Simulation
  - Mokka,
    - LDC01Sc (Sit01 instead of Sit00)
    - LDCPrime_02Sc_p01
  - Particle Gun
- Data Samples
  - 10, 30, 50, 70, 90 GeV
  - φ: 0-2π uniform smearing

- LDC01Sc
- θ: Uniform Smearing:
  - |cos(θ)|<0.8 (Barrel)
  - |cos(θ)|<0.98 (All)
- 1000 events each sample

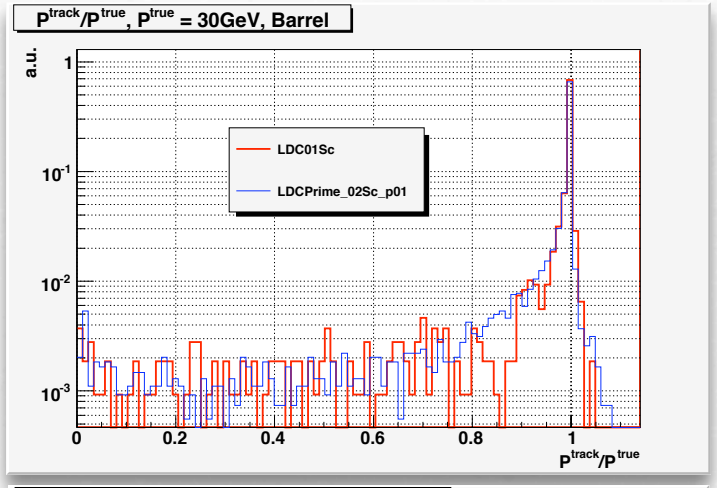
- LDCPrime_02Sc_p01
- θ: Uniform Smearing:
  - |cos(θ)|<0.8 (Barrel)
  - |cos(θ)|<0.99 (All)
- 5000 events each sample

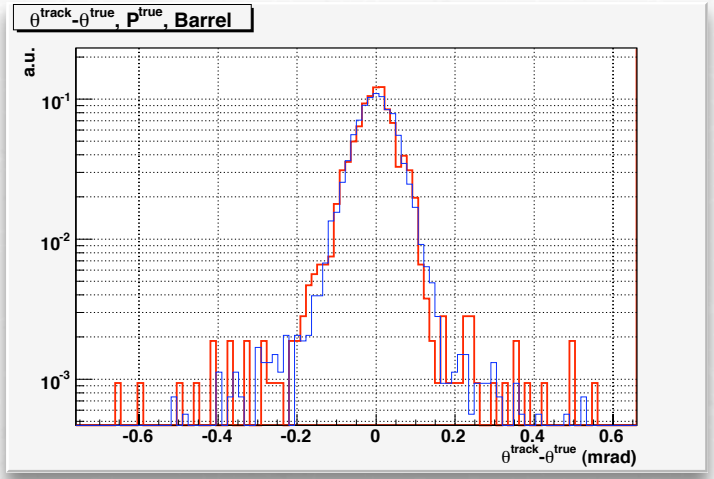
- Reconstruction Chain:
  - LDC01Sc:
    - Digitizers, etc.
    - FullLDCTracking
    - PandoraPFA
  - LDCPrime_02Sc_p01 (standard reconstruction chain, still unstable):
    - Digitizers, etc.
    - FullLDCTracking (updated)
    - PandoraPFA (updated)
    - (JetFinders, etc.)

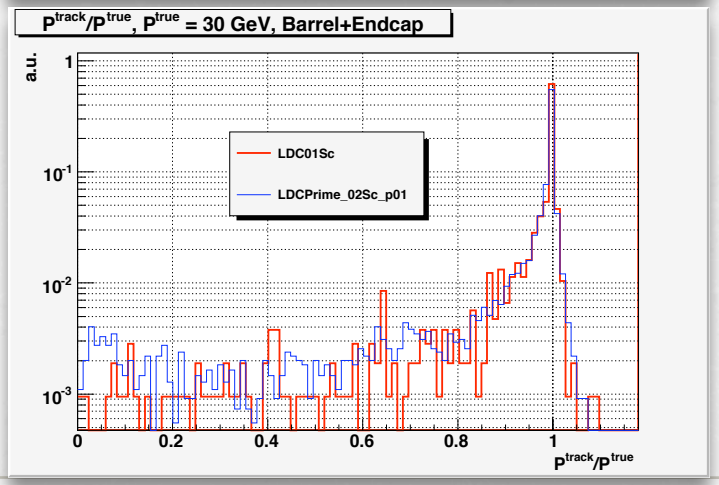
Tracking Quality

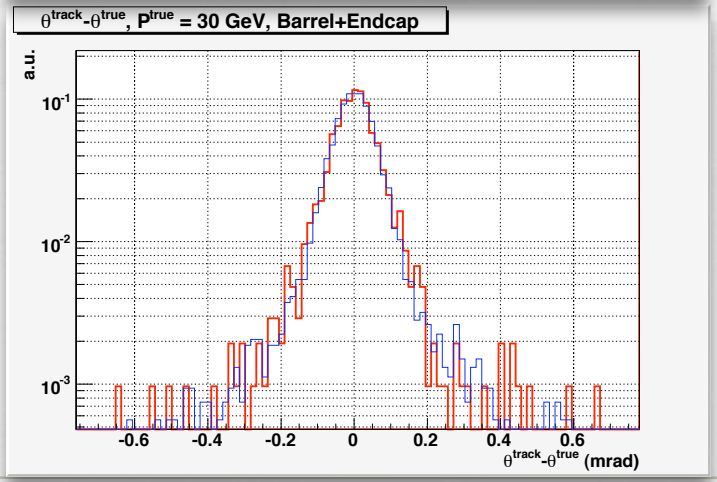
- Results for 30 GeV Electrons

No Large Difference of P and θ





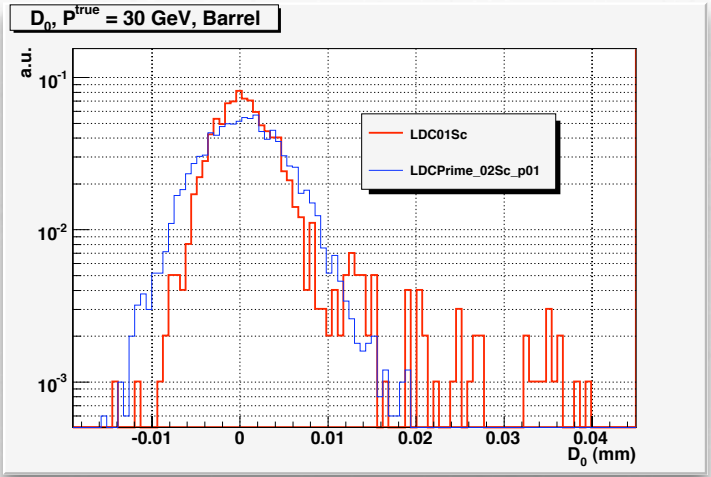


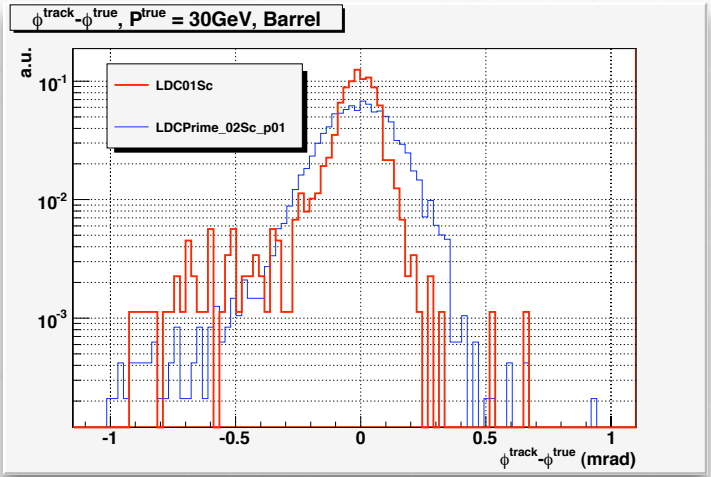


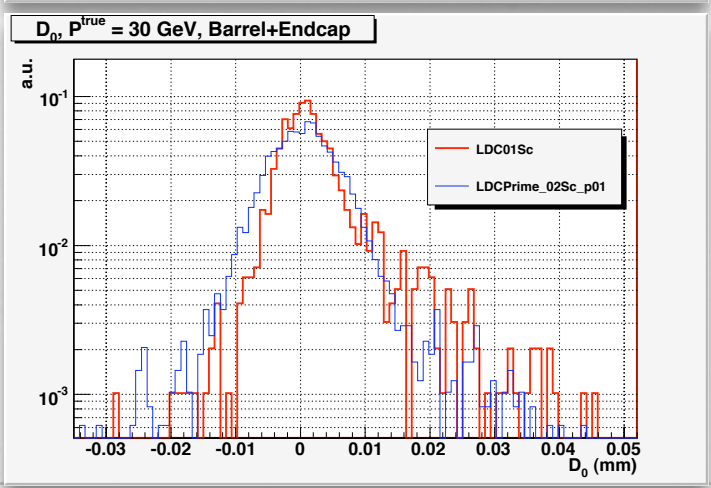
Tracking Quality

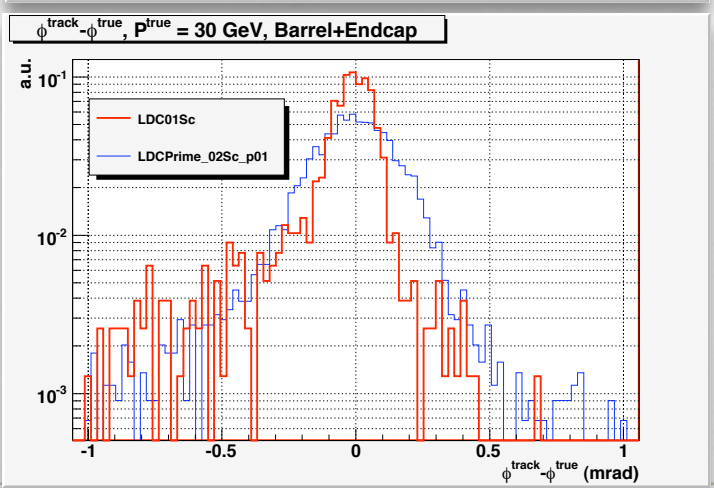
- Results for 30 GeV Electrons

For D0 and φ, LDCPrime seems worse than LDC01Sc



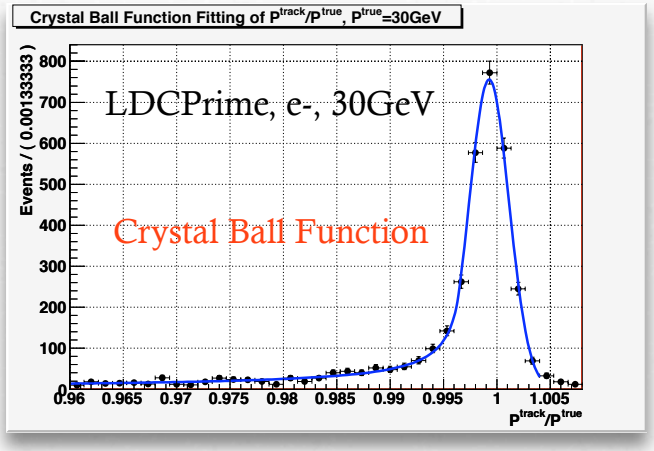


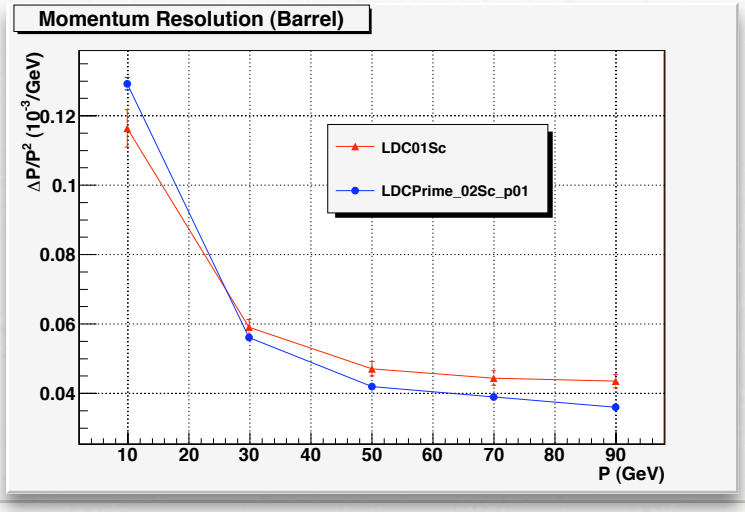


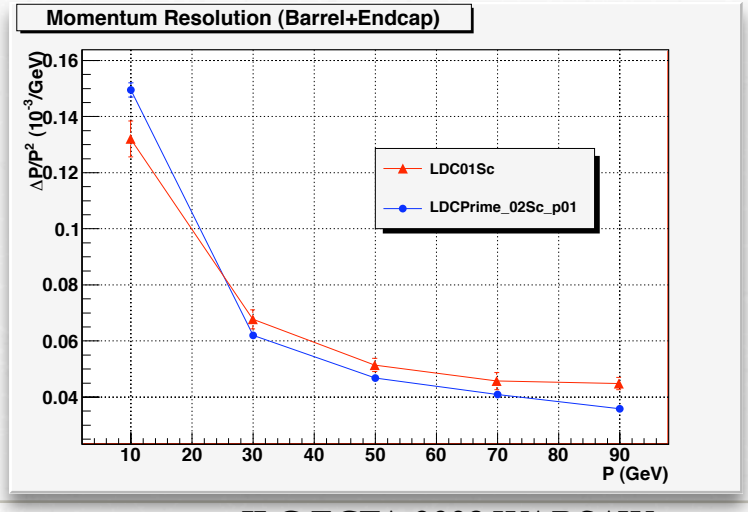


Track Momentum Resolution

- Using Crystal Ball Function to Fit : good match of the energy loss spectrum
- Results:
  - (LDCPrime) Better resolution than LDC01Sc for large momentum
  - For Momentum larger than 30GeV, $\sigma(1/P)<6\times10^{-5}(1/GeV)$



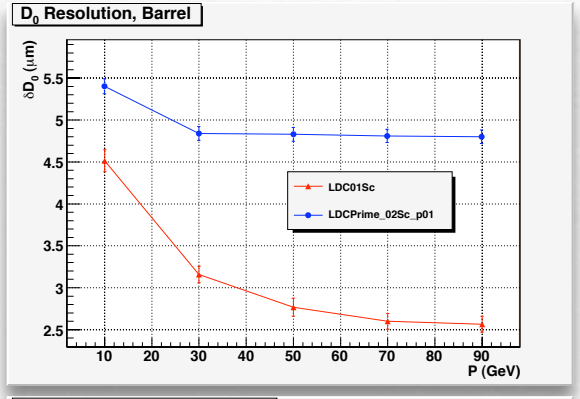


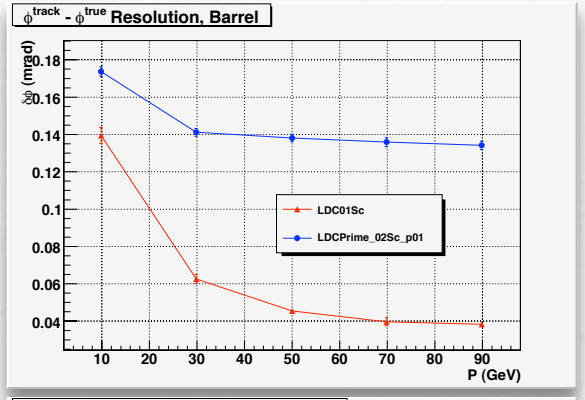


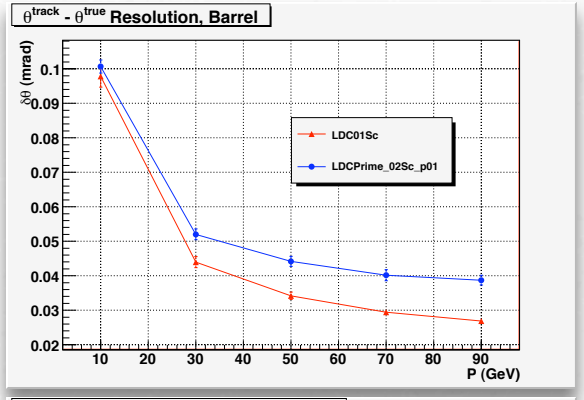
Track D_0, φ, and θ Resolution

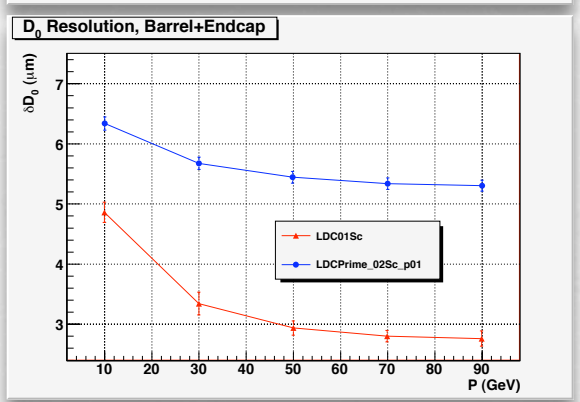
Problems for electron tracks?
- No big difference for muons as checked by Alexei

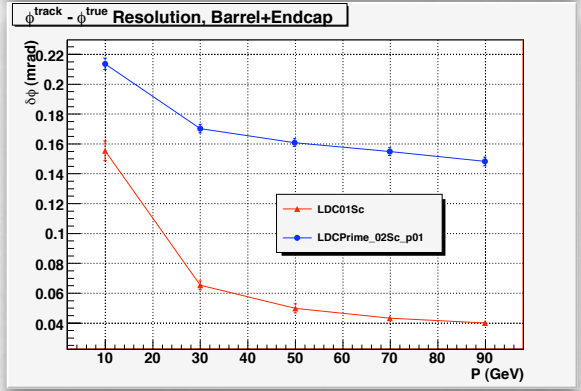
- D_0 Resolution:
- φ Resolution:
- θ Resolution:

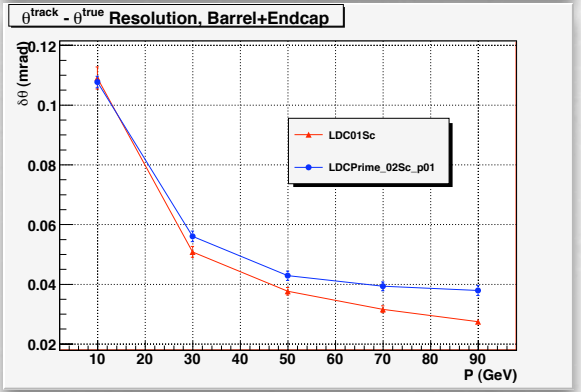








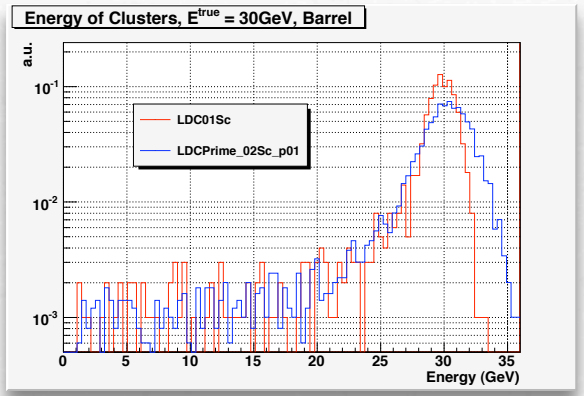


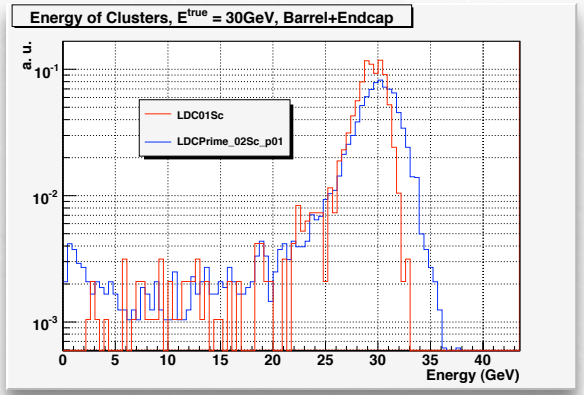


Clustering and PFA

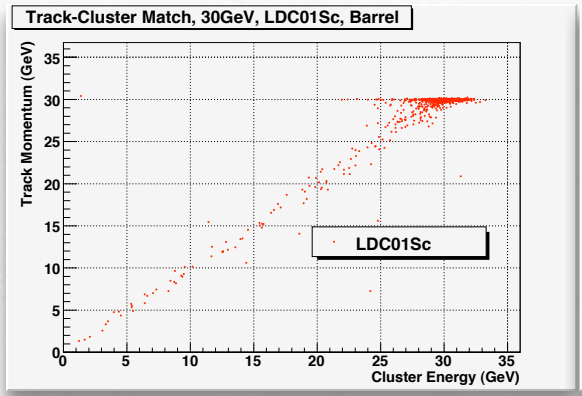
- Results for 30 GeV Electrons

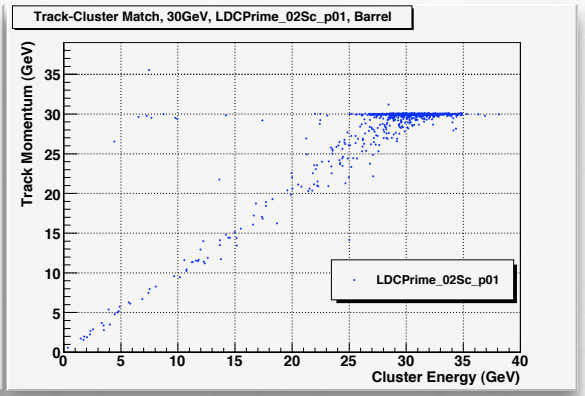
- Cluster Energy Spectrum
  seems to be worse of LDCPrime

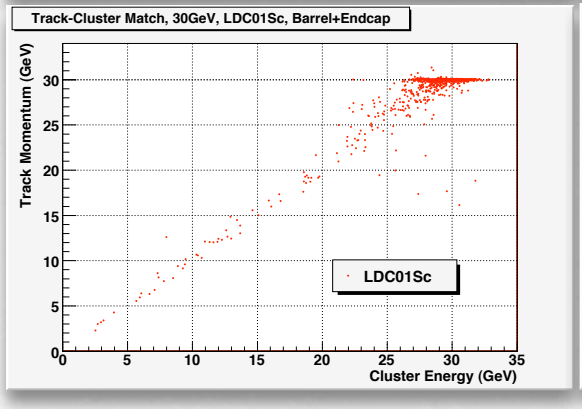


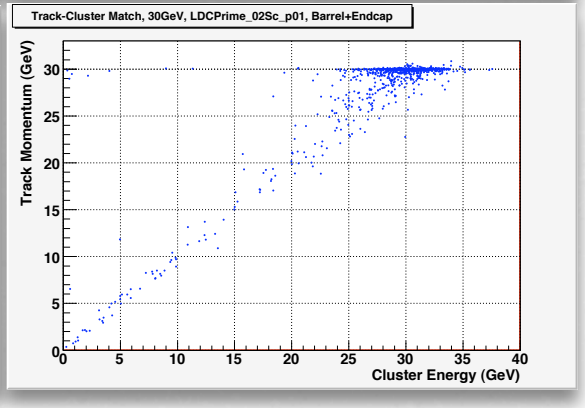


- Cluster-Track Association (good!)



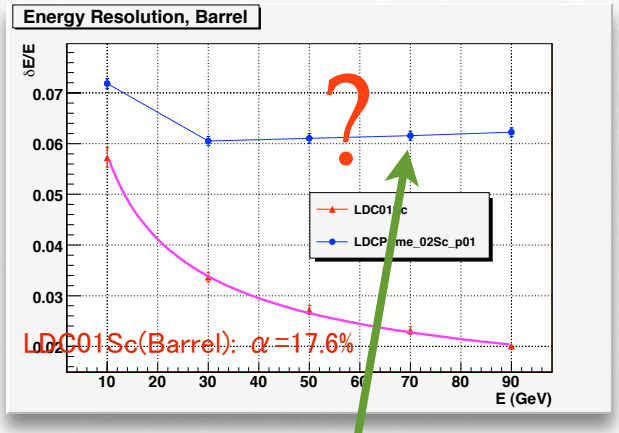


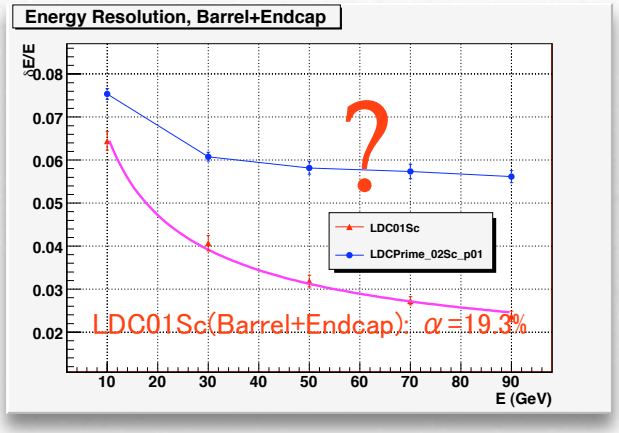


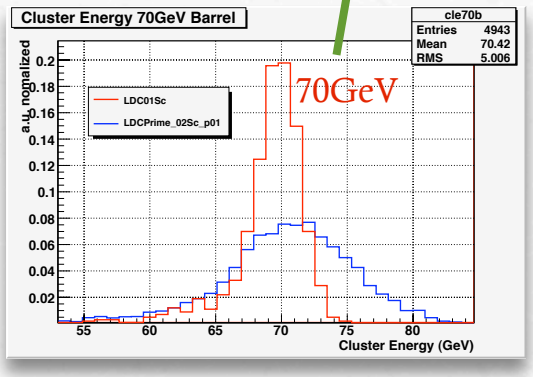


Clustering and PFA

- Energy Resolution: Problems of LDCPrime_02Sc_p01 ?







- The first electron study of the new model (LDCPrime)
- Many issues are still unsettled
- Need some investigations of the new model (for electrons)

Conclusion and Outlook

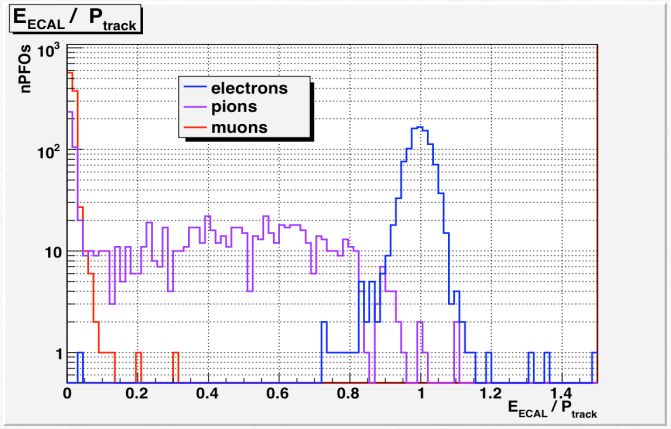
- Tracking and PFA Performances:
  - LDC01Sc: very good!
  - LDCPrime_02Sc_p01: need some investigations together with the authors
- Bremsstrahlung: most painful/challenging nature of electrons
  - Tracking story needs some more efforts (for electrons)

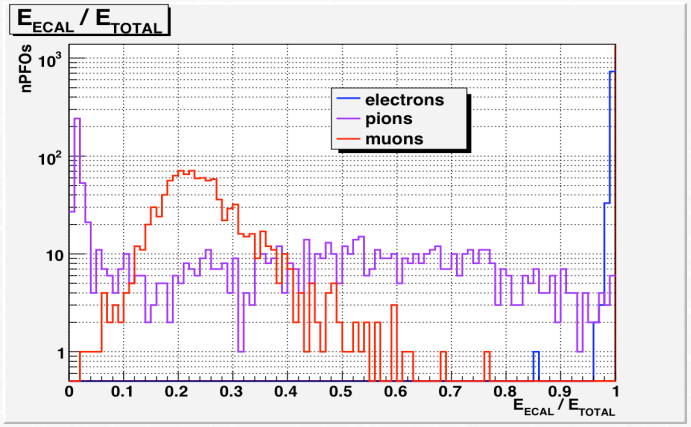
Backup Slides

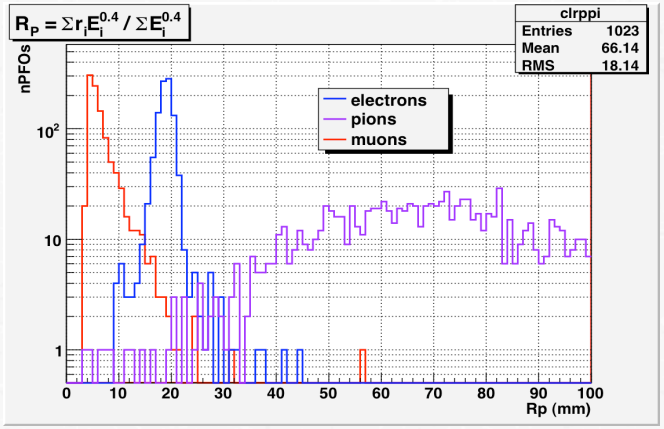
Cut Based Electron Identification

30GeV e-, mu- and pi- samples of LDC01Sc

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



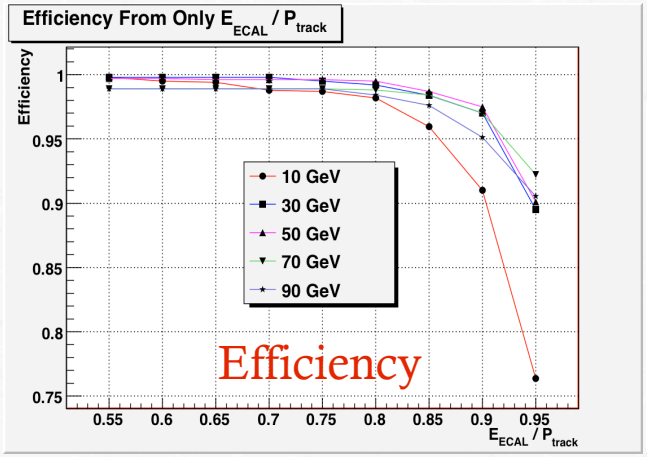


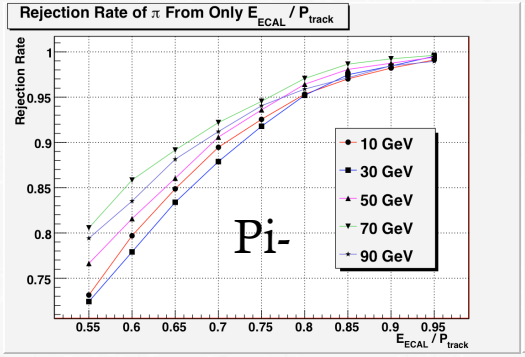


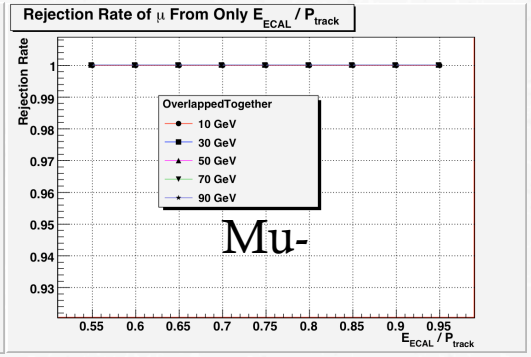
Cut Based Electron Identification

- 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
  - EPratio Only (for only Barrel Region)





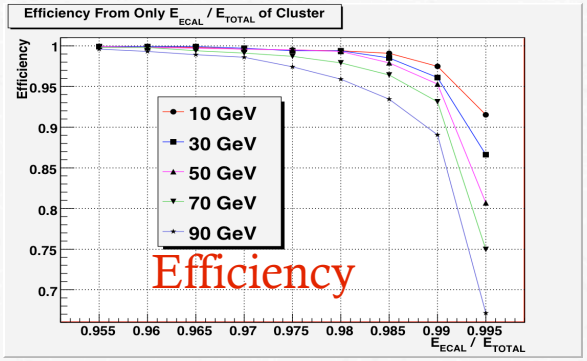


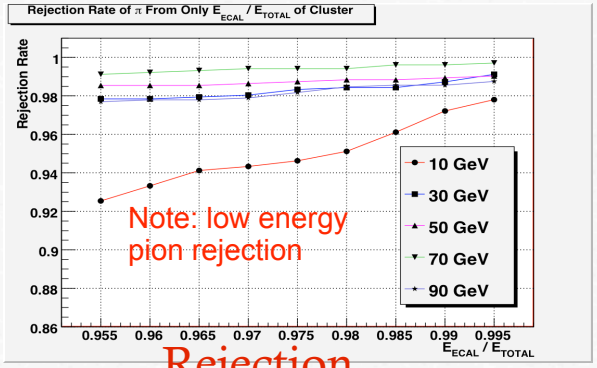
- Muons are totally rejected with only Epratio variable.

Rejection

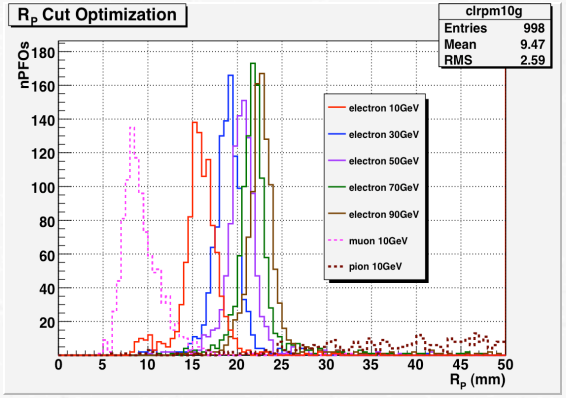
Cut Based Electron Identification

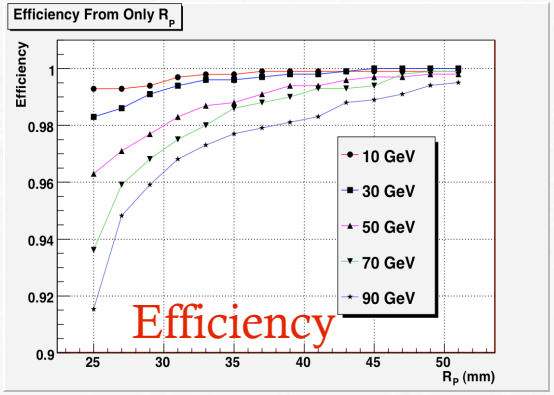
- Efrac Only: (for Barrel Region Only)

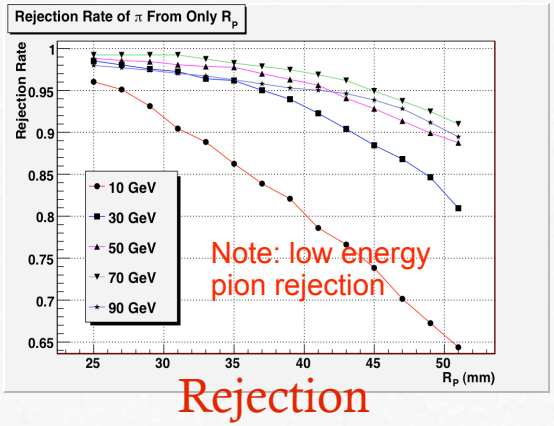




- Rp Only: (for Barrel Region Only)
  - Since muons are totally rejected by EPratio
  - Fix the Rp lower cut of 7 mm, adjust upper cut for optimization



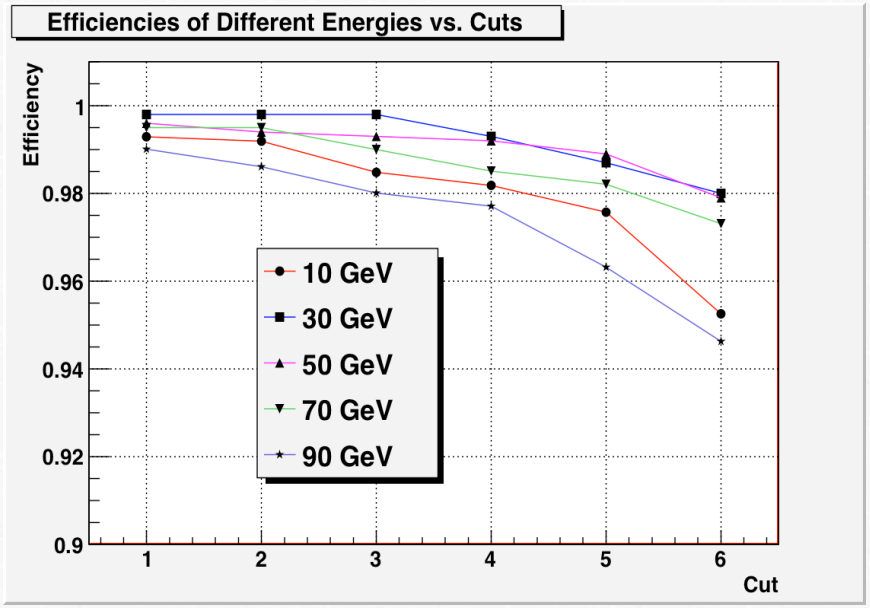


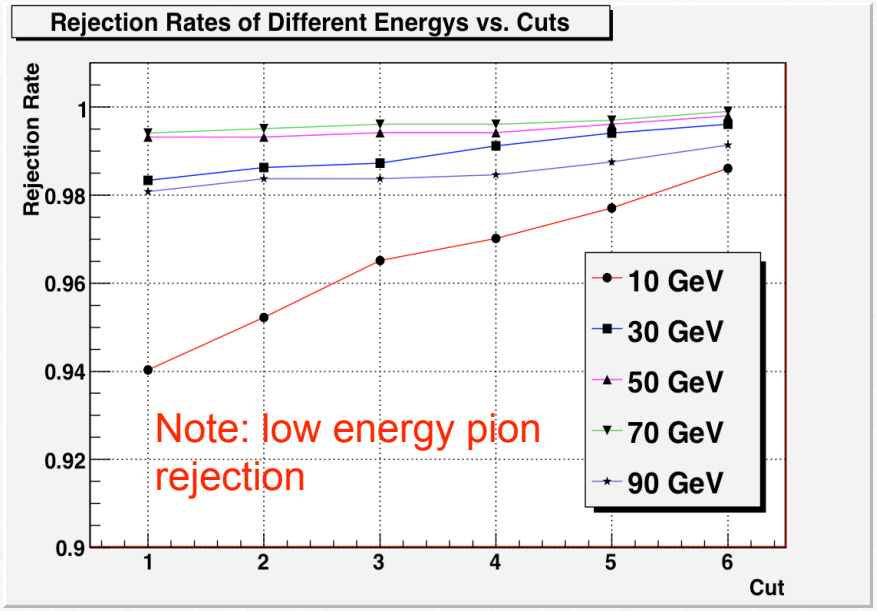


Cut Based Electron Identification

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

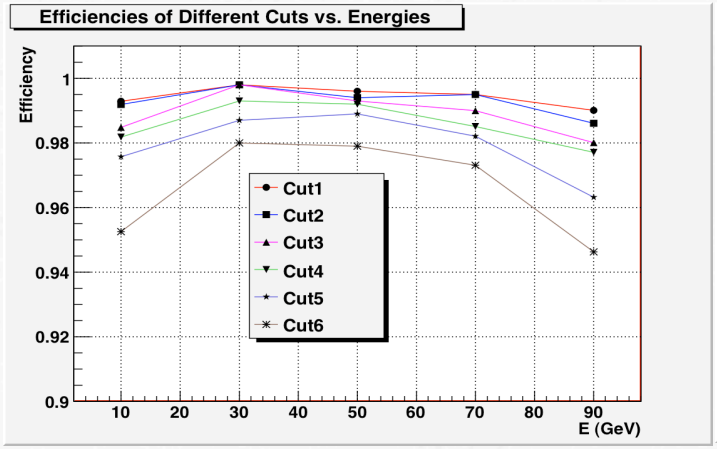
Cut Scenario	1	2	3	4	5	6
Epratio	0.6	0.65	0.7	0.75	0.8	0.85
Efrac	0.96	0.96	0.97	0.97	0.98	0.98
Rp	51	49	47	45	43	41

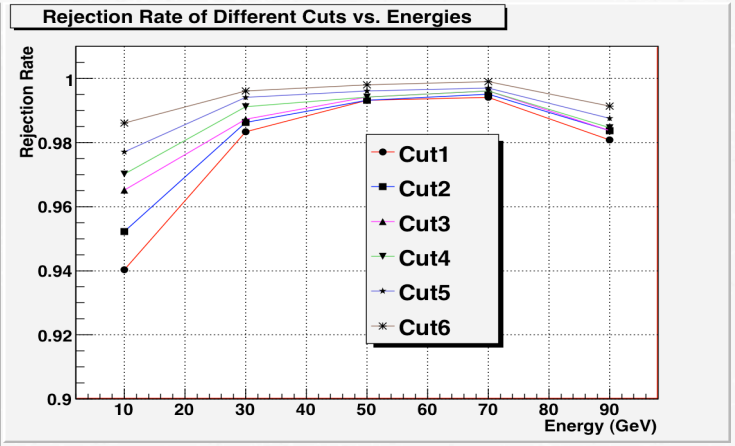




Cut Based Electron Identification

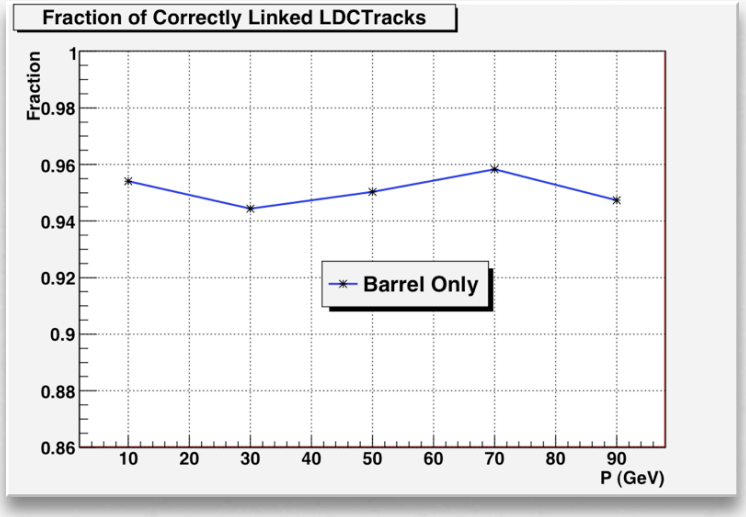
- Overall Efficiencies and Rejection Rates (continue)





- 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%

Tracking Quality



Fraction of electrons with at least one correctly Linked LDCTracks

- Barrel Only : ~95%

Discussion

- Because of bremsstrahlung, more LDCTracks reconstructed than the number of initial electrons.
- e.g. for 1000 electrons with momentum of 30GeV, 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,
- More rarely, (~3 electrons), due to the conversion of radiated photon into an electron/positron pair.

Conclusion and Outlook

- Tracking and PFA Performances:
  - LDC01Sc: very good!
  - LDCPrime_02Sc_p01: need some investigations together with the authors
- Electron Identification object achieved
  - Efficiency > 99.5%; Rejection Rate for pion > 98%
  - EID cuts optimization for physics study is on going
  - Likelihood implementation is on going
- Bremsstrahlung: most challenging nature of electrons
  - Tracking should be improved or optimized for electrons