BeamCal Simulation for CLIC

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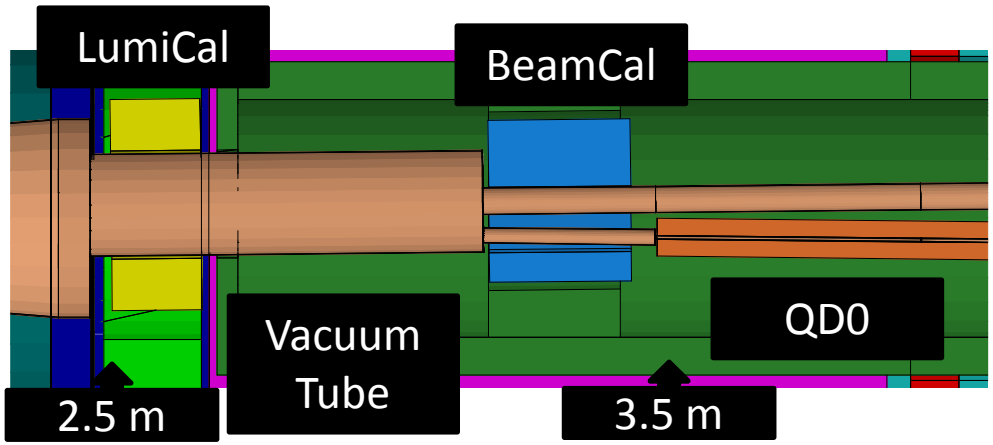
FCAL Collaboration Meeting

October 2009: CERN

Detector Model

- Using Mokka with CLIC01_ILD(fwp04)
- 20 mrad crossing angle
- LumiCal at 2.5 m from IP
- BeamCal at 3.2 m
- QD0 at 3.5 m
- 4 T Solenoid Field
- No Anti-DiD
- QGSP_BERT_HP

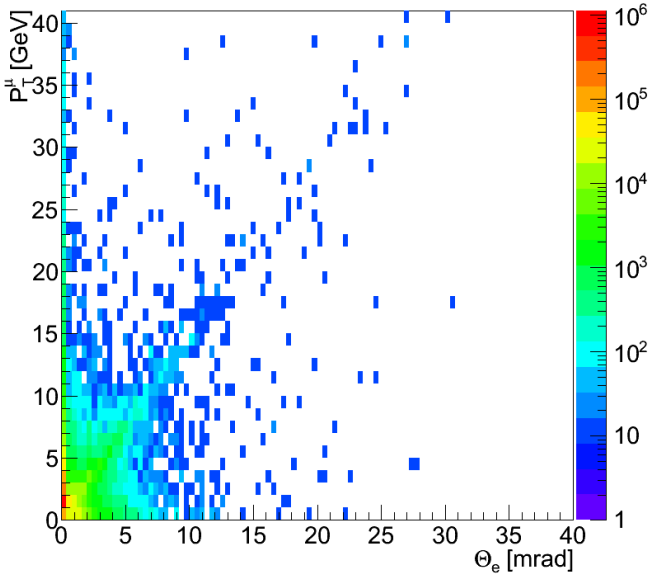


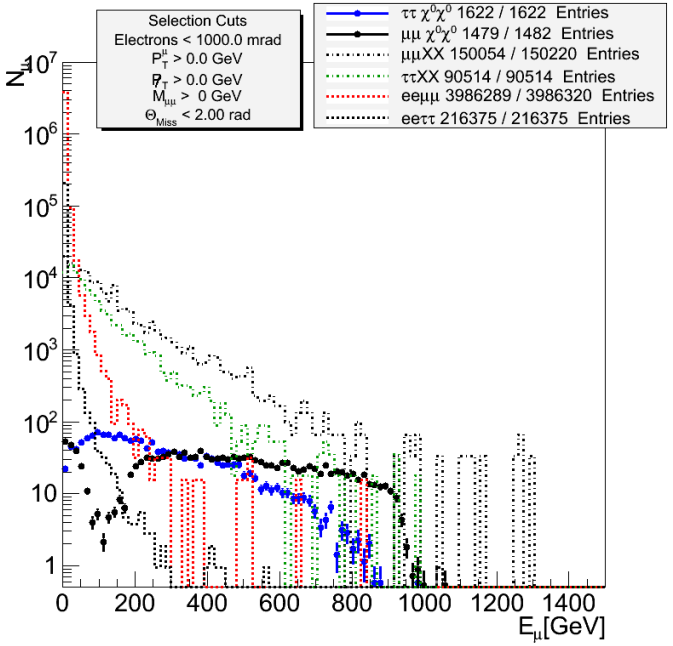
BeamCal

- BeamCal
  - 40 Layer Si-W
  - Inner Radius: 2.6 cm (8 mrad)
  - Outer Radius: 15 cm (47 mrad)
  - Number of Rings, Sectors and Pads not Changed
    - i.e. Pads are a little bit smaller than for ILD
  - Dead Area increased due to different crossing angle

Electron Tagging

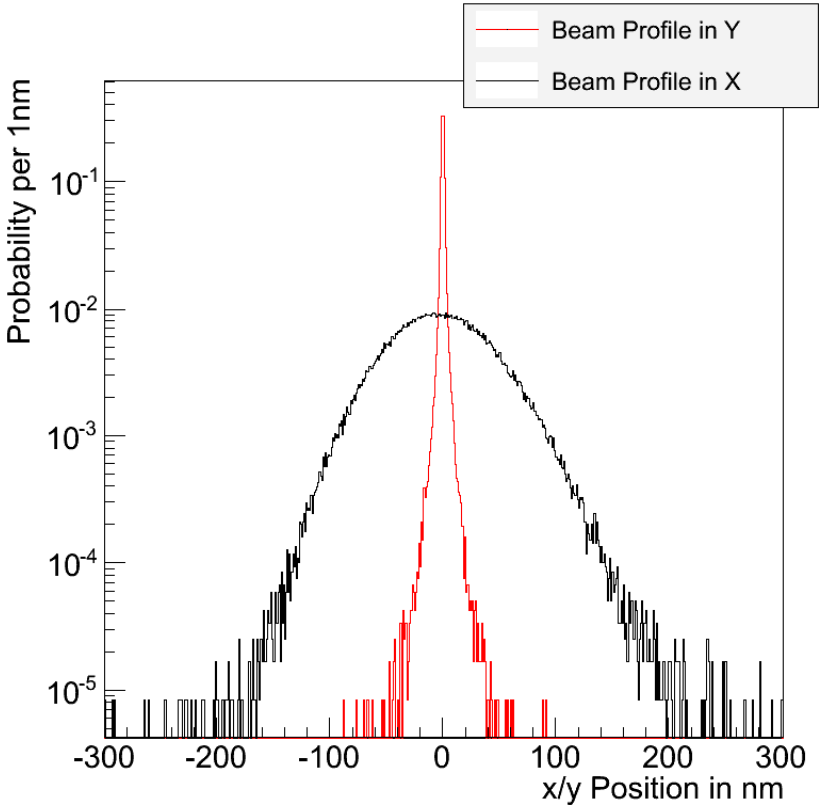
- eeττ and eeμμ are Background for corresponding slepton production
  - Generated with BDK (M. Battaglia)
  - Cross-sections (Full Angle):
    - eeτ τ: 280fb
    - eeμμ: 4700fb
- For CLIC
  - Almost all are down the beam pipe
  - Try to tag as many as possible with BeamCal
- Beam-Beam-Effect/ Luminosity Spectrum not included yet





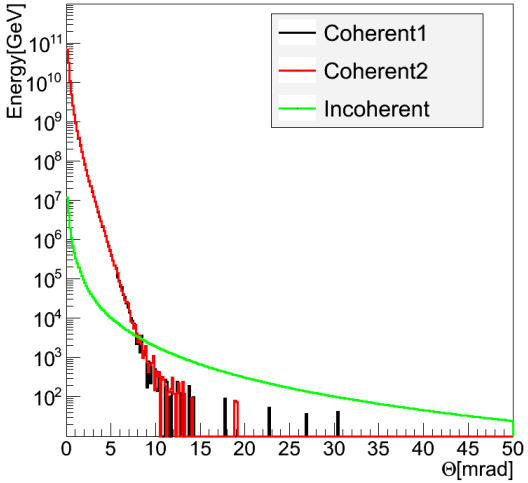
Beam-Beam-Background at CLIC

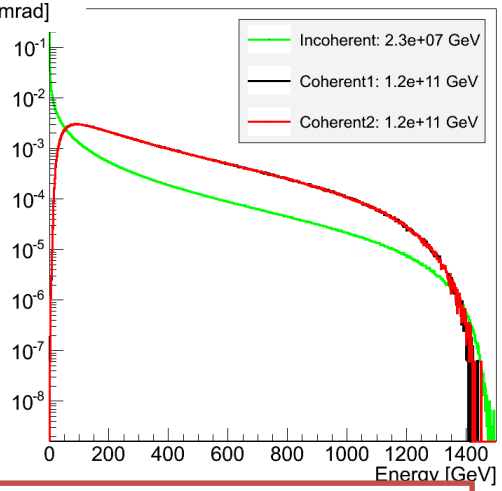
- Produced by GuineaPig
  - Using Beam Particle Distribution from Accelerator/BDS simulation
  - Fluctuation limited, because initial distribution does not change
- Incoherent Pairs
  - $3*10^5$ Particles/BX
- Coherent Pairs
  - $3.8*10^8$ Particles/BX
  - Very small angles (<10mrad)
  - Will be ignored in this analysis



Incoherent and Coherent Pairs at 3 TeV

- →BeamCal inner Radius limited by Coherent Pairs
- Very low statistics for large angles
  - Plot on the right is from 1000 GuineaPig++ runs scaled to 1 BX
- For 10 mrad: 2 times more energy from Incoherent than from Coherent Pairs per Side

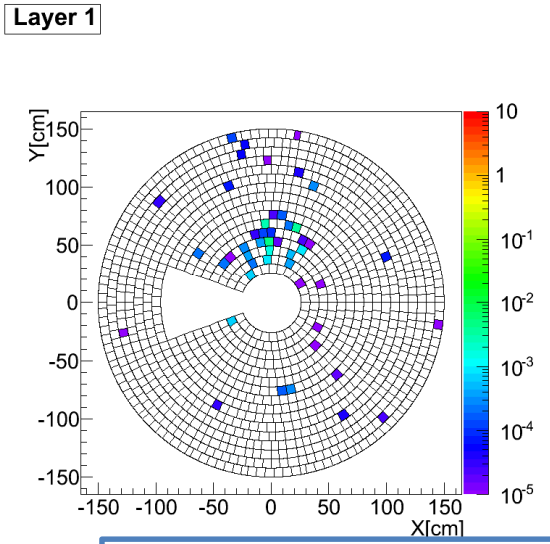


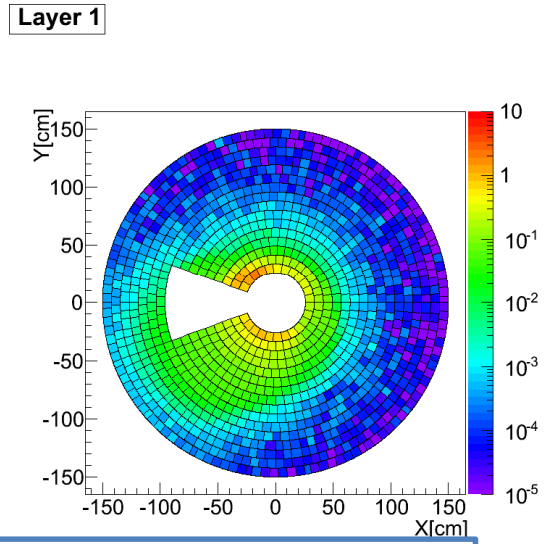


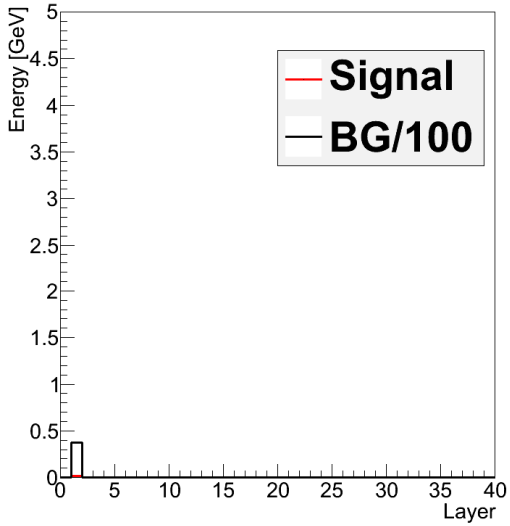
Coherent1/2 are for Positron and Electron bunch, incoherent is for both sides

Simulation

- Background
  - 10 BX of incoherent Pairs
- Signal:
  - 1.5 TeV Electrons
  - Along “12 O'clock” of BeamCal



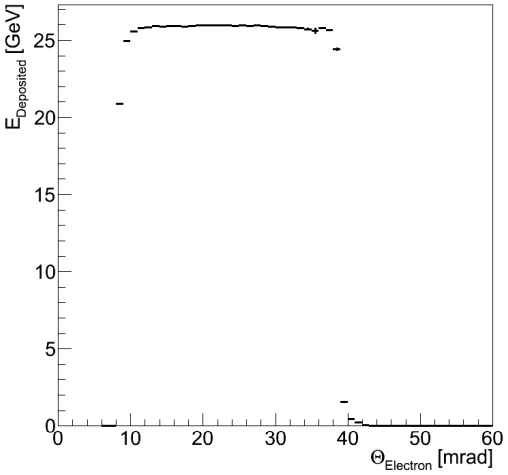


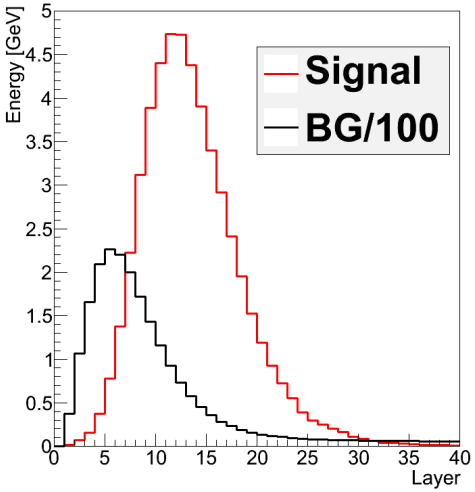


1. 5 TeV Electron at ≈15 mrad, 1BX average BG

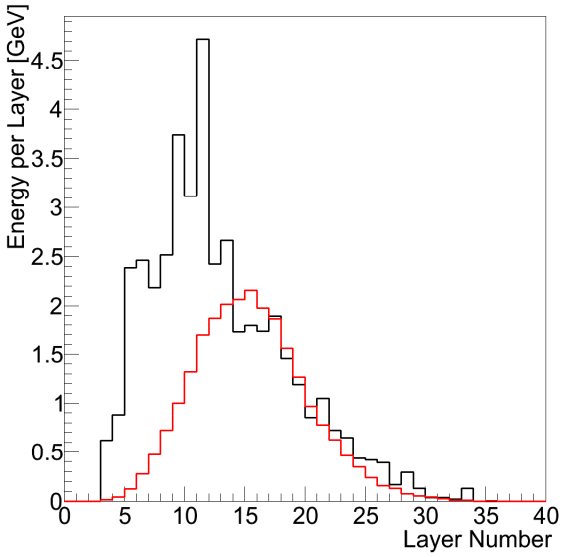
Deposited Energy

- 26 GeV Deposited by fully contained Electrons
- Signal: Peaks in Layer 12
- BG: Peaks in Layer 6

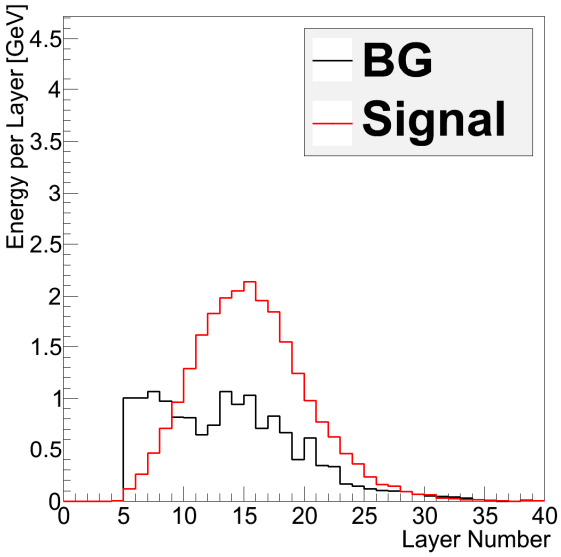




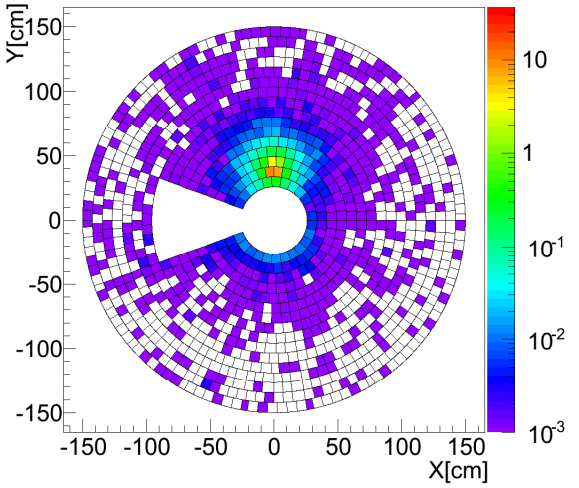
Total (significant) Energy



Energy above Fluctuation



1500 GeV Electron at 12 mrad



Simple Electron ID (I)

- Can't use sophisticated approach (yet)
  - Fluctuation for Background is not very realistic
  - Full Simulation takes a lot of time
- Get an idea how well BeamCal works at 3 TeV CLIC:
  - How much energy from Electrons is deposited above fluctuation from Background → Estimate BeamCal coverage: What is the minimal angle electrons can be tagged

Simple Electron ID (II)

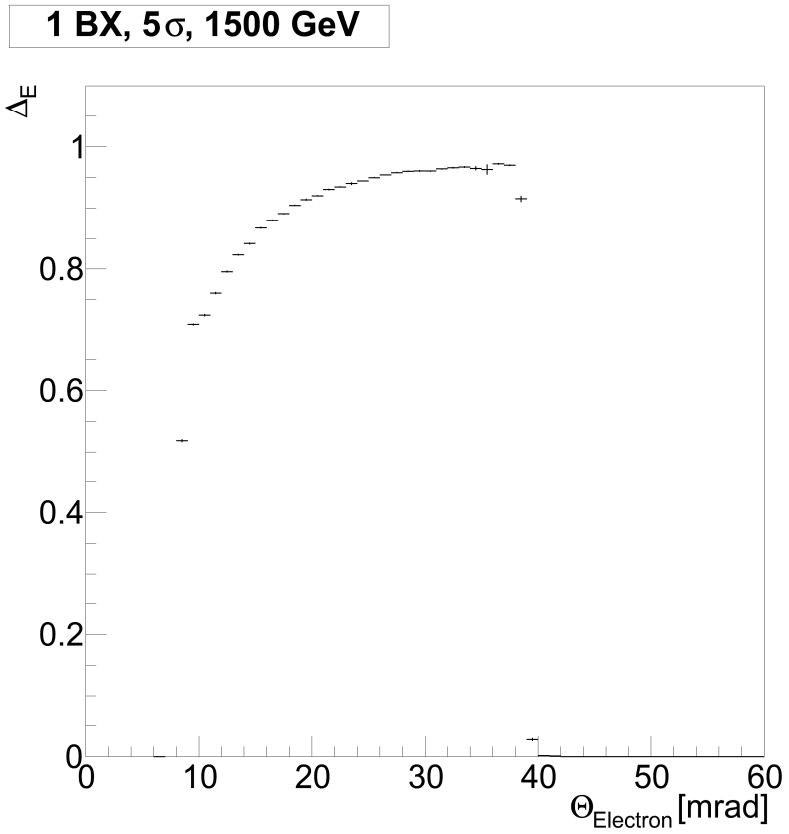
- For each Pad of BeamCal get
  - Deposited Energy from Electrons E_{Signal}
  - Deposited Energy from Background E_{BG}
  - Standard Deviation from Background σ_{BG}
  - Add energy of Pads with $E_{Signal} > \sigma_{BG}$

- "Figure of Merit": $\Delta E = \sum_{\text{Pads i}}^{\text{E}>\sigma} \left(E^{i}_{\text{Signal}} - \sigma^{i}_{\text{BG}} \right) / 26\text{GeV}$

- Also depends on Number of Integrated Bunch crossings
  - i.e. Time Stamping in BeamCal
  - CLIC: 312 BX per Train, 0.5 ns separation between BX

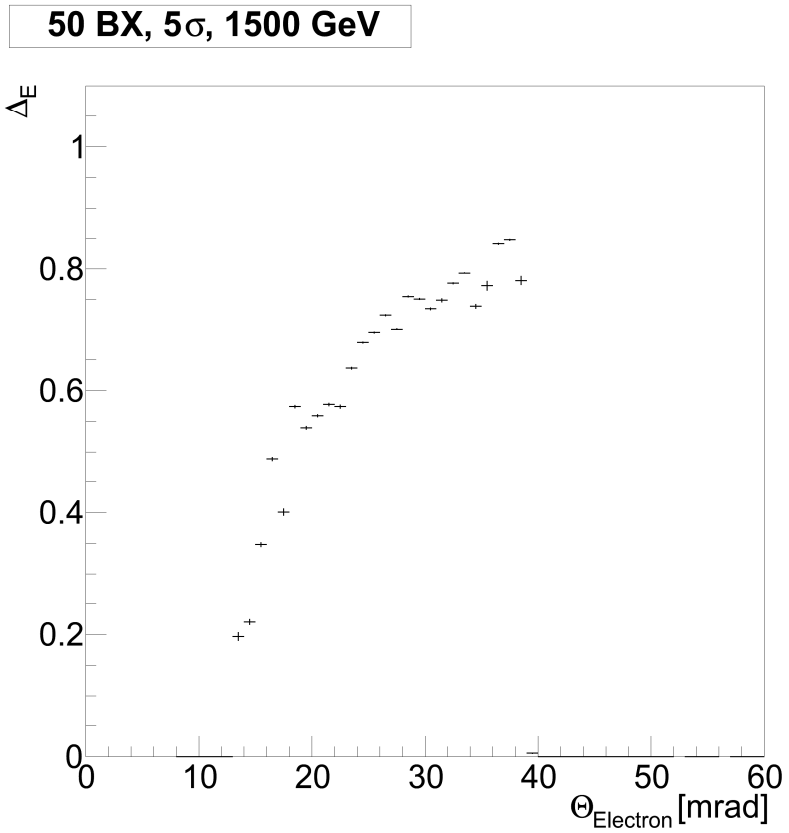
1 Bunch Crossing

- Using 5 Sigma separation
- Doesn't seem so bad, except for very small angles

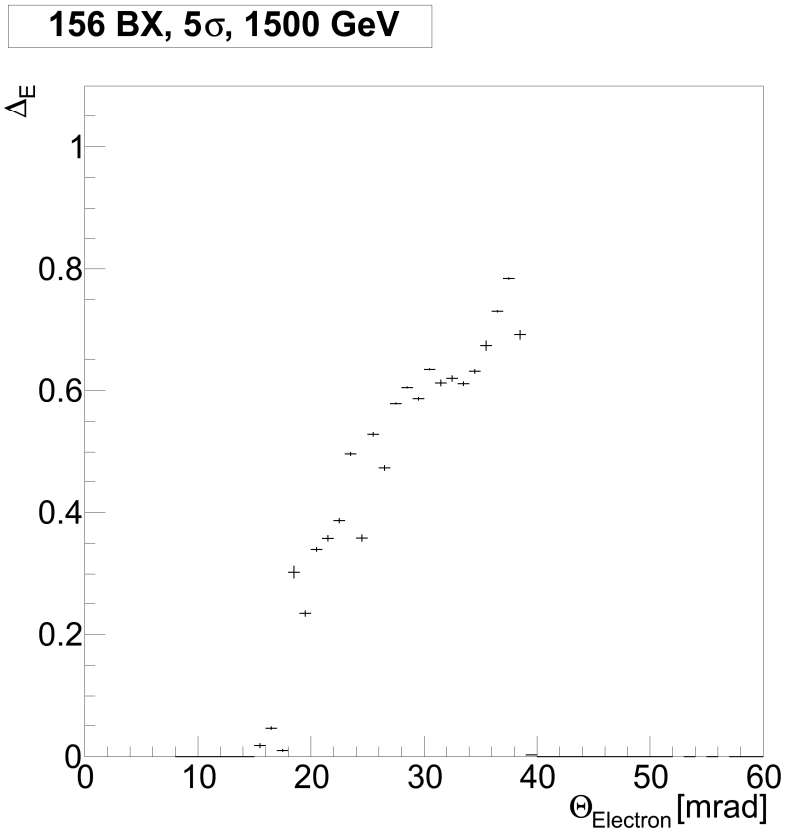


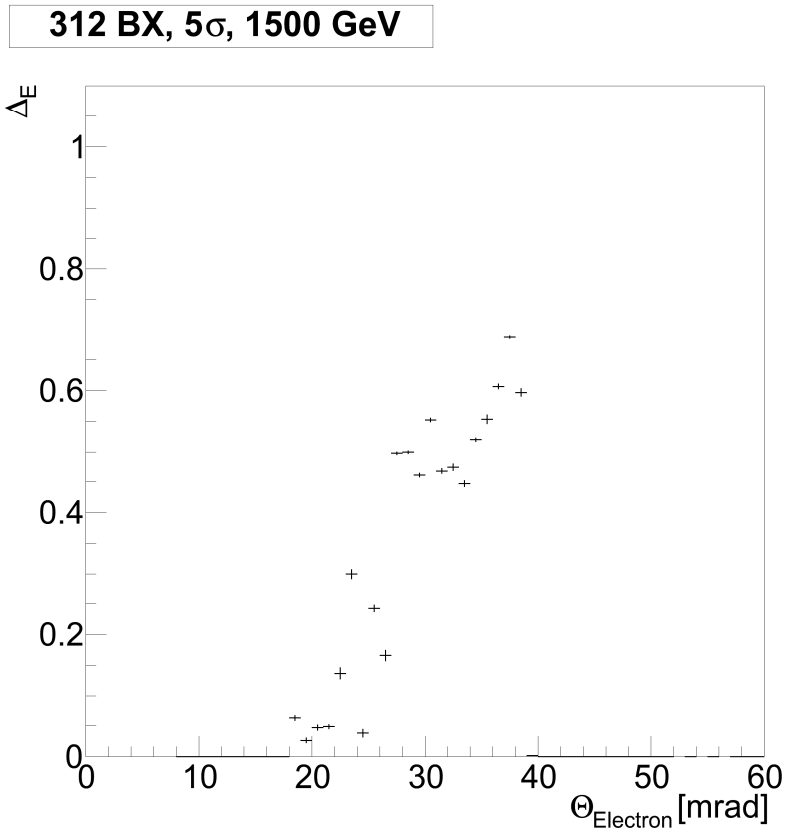
50 Bunch Crossings

- 25 ns Time Stamping
  - This is probably the goal for the rest of the Calorimeters due to γγ→Hadrons
- Nothing to see below 15 mrad



156 & 312 Bunch Crossings





Summary

- This was a very simple first look at BeamCal for CLIC
- Background in BeamCal is very high
- Clearly depending on Time Stamping
  - Fluctuations of Beam-Beam Background have to be better understood
  - Fluctuations for a full Bunch Train are not 312 times fluctuations for 1 Bunch Crossing

Conclusions

- More realistic Background has to be simulated
  - Bunch to Bunch fluctuations (offset, bunch shape)
- Newer BeamCal geometry (Inner Radius ~ 3.5 cm) should be looked at
- Include Coherent Pairs?
- Time Stamping for BeamCal has to be understood
  - Would the number of BX read out be always the same?
  - Investigate more sophisticated approach for electron tagging that does not rely on average Energy deposit?