
# Pile up – possible cause of bad longitudinal position measurement in calorimeter.

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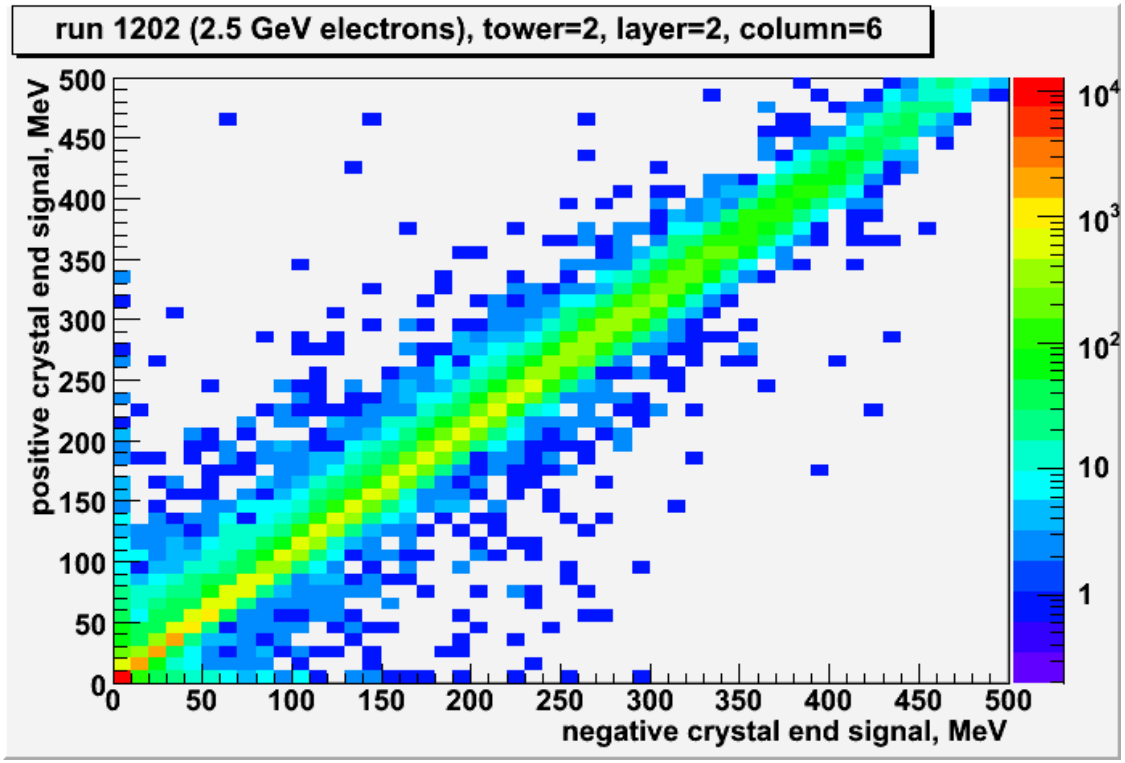
# Situation with bad longitudinal position measurement

- Philippe noticed some runs with high fraction of events (up to 10% in run 1202- 2.5 GeV electrons) with longitudinal position = 163 mm (at one crystal end) at least for one crystal
  - This means that Epos/Eneg for this crystal is out of range defined by light attenuation in full length of crystal (it should be between 0.65 and 1.5)
  - Possible physical effect producing this situation – direct energy deposition in one of the diodes
    - But this happens when beam is in the center of tower – it's hard to imagine that we have significant energy depositions near the diodes
    - In Monte Carlo the rate of bad position measurement is negligible, while the direct energy deposition in diodes is included in the simulation
      - Diodes are active detectors and producing hits
      - The energy deposited in a diode is properly weighted and added to crystal energy
        - » Energy in diode first converted to the number of electrons (dividing by 3.6 eV per electron)
        - » then converted to equivalent energy in crystal dividing by 5000 electrons per MeV
        - » this number is taken from old requirements – it should be replaced by 6500 e/MeV – actual average light yield – so the effect of direct energy deposition is overestimated now.
  - I tried to search for other mechanisms (possibly related to electronics) capable to produce bad longitudinal position measurement

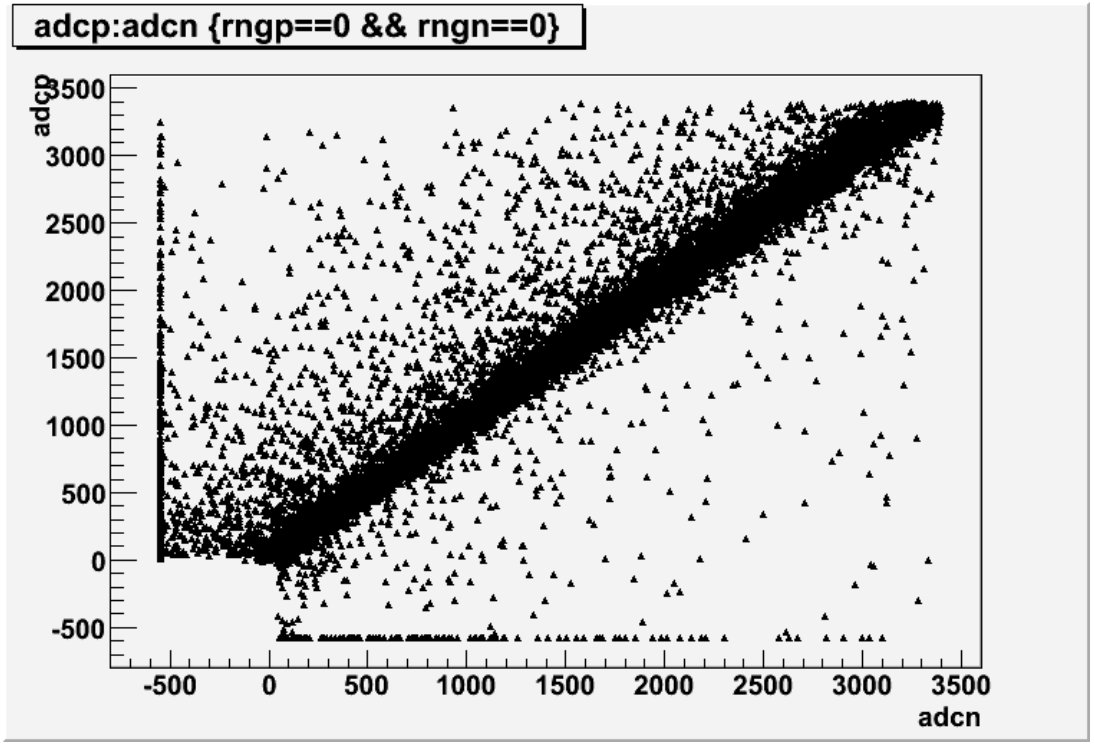
# Positive end versus negative end

- 2d histogram of signals at two opposite ends of the same crystal contains significant population biased from the main line by ~100 MeV
- Probability doesn't depend on the energy in the crystal, only on the deviation from the main line (enePos = eneNeg)




- Significant fraction of these events produce bad position measurement, especially at energies below 100 MeV
- Another way to look at low left corner – to plot pedestal subtracted LEX8 adc values
  - 1 MeV = 30 LEX8 adc units

# adcPos versus adcNeg for the same crystal

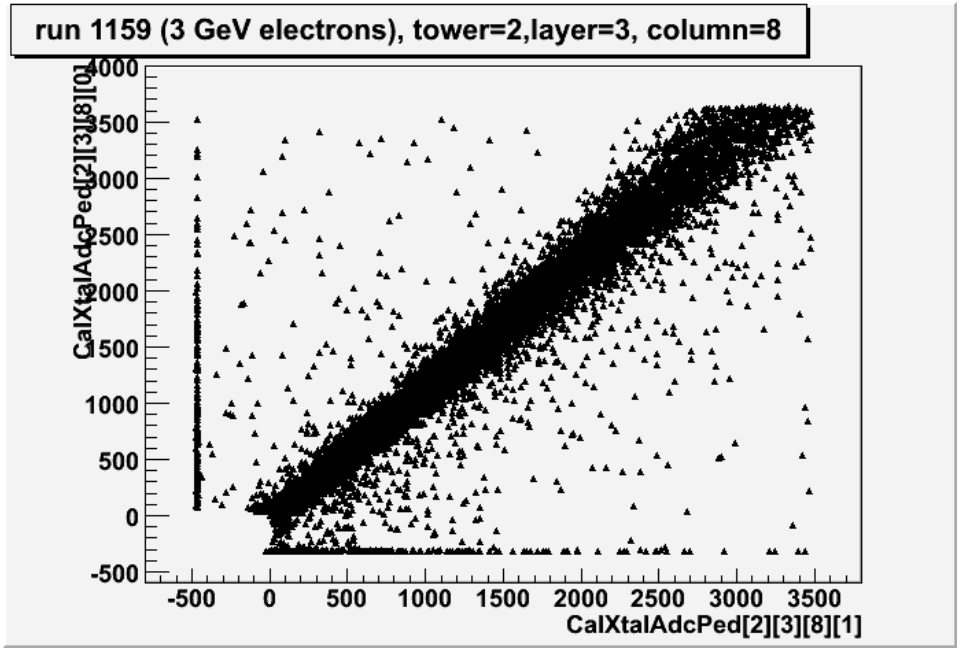


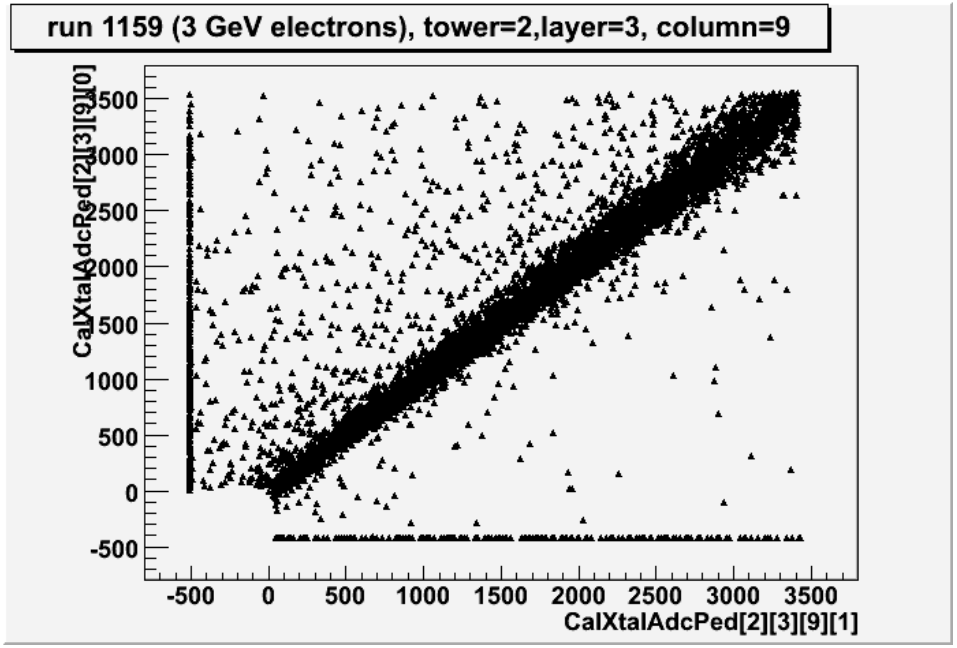

- This is pedestal subtracted adc values from CalTuple
  - LEX8 pedestal for this crystal ~600 adc units
  - Square "shadow" at low signals is produced by LAC threshold discriminators:
    - Signal should be above 60 adc units (2 MeV) at least at one end to enable the crystal readout
    - We see the events with adcp=60 adc units (2 MeV), but with negative adcn =-600 adc units(-20 MeV)

- While normal scintillation signals are equal at both ends, there are additional NEGATIVE signals, which are significantly bigger at negative crystal end than at positive crystal end (for this crystal)

# Another run, more crystals …

- Similar plots for another run 1159 and two adjacent crystals in columns 8 and 9 of layer 3
- In column 8 the negative signals happens more often at positive crystal end
  - Left bottom plot - Population below diogonal
- In column 9 the negative signals happens more often at negative crystal end
  - Right top plot – population above diogonal



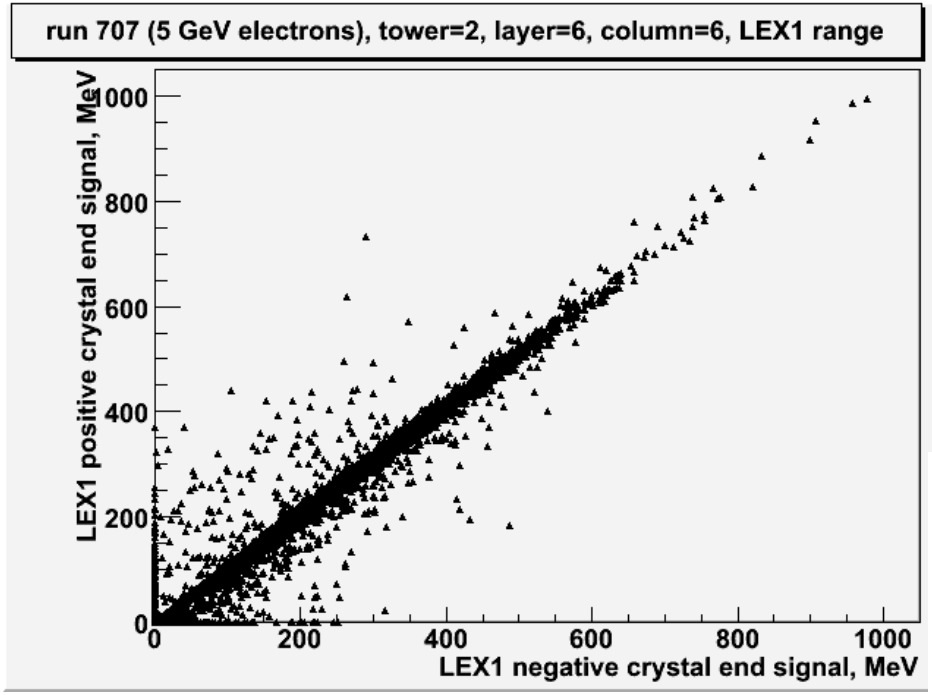



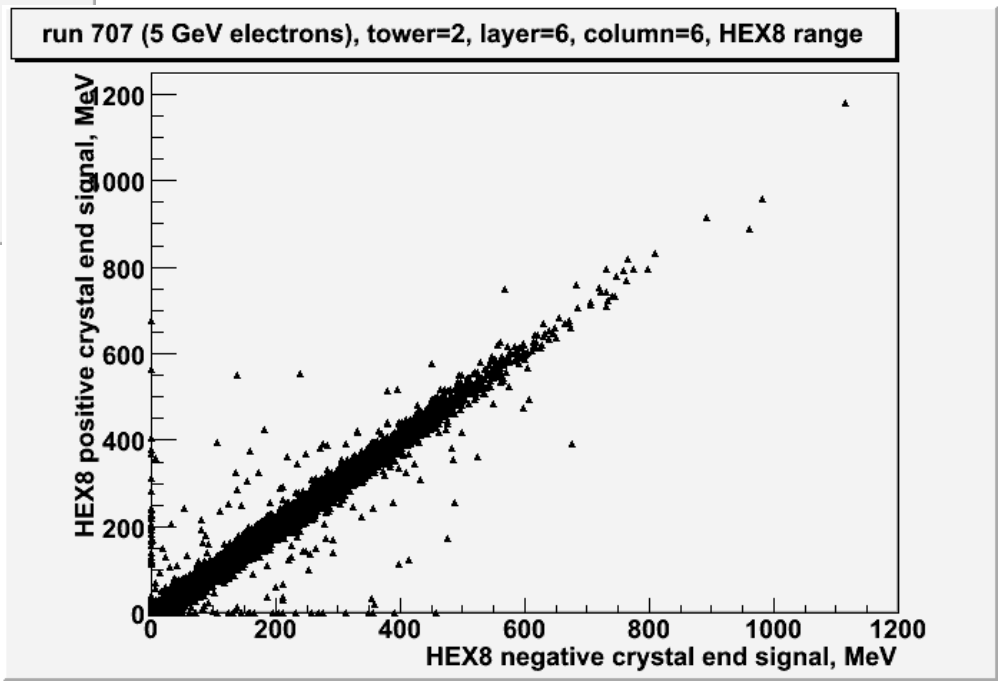

- These two plots confirm that:
  - This effect is NOT related to digital noise which is most pronounced in columns 5 and 6, close to digital data transmission lines on front-end board
  - This effect in NOT related to energy deposition in diodes, because if the asymmetry in signal was due different particle flux at two surfaces of the tower, the asymmetry should be the same for two adjacent crystals

# Pile up – possible source of big negative signals

- Preamplifier output signal has fast rise time ~1 μs (defined by scintillation timing) and slow exponential discharge with time constant ~100 μs
- calorimeter signal after shaper has peaking time ~4 μs, pulse width ~10 μs and negative exponential tail with amplitude ~0.1 of main pulse and time constant ~100 μs
- Each preamplifier has special preamp reset circuit (see http://heseweb.nrl.navy.mil/glast/CM/spec/GCFE_DESIGN_V9-LAT-SS-01972-01.pdf, page 12 ), which is activated if preamplifier signal exceeds the threshold equal to ~250 MeV (~ $\frac{1}{4}$ of full range of LEX1 range). In 10 μs after the threshold is reached this circuit starts the quick discharge of preamp feedback capacitor with time constant ~10 μs (this is my guess, but this parameter isn't well defined) and stops when signal drops down to 250 MeV threshold, then the discharge of feedback capacitor continues with standard ~100 μs time.
  - This fast discharge by reset circuit should produce big negative signal at the shaper output (with amplitude ~0.4 of main positive signal) which decreases exponentially with time constant ~10 μs and could last ~10-20 μs. After that the negative tail returns to its standard shape.
  - The parameters of the reset circuit (threshold, delay, discharge time constant) are not well defined by requirements, so they are not obliged to be the same for all channels. Eventually these parameters could be rather different for two ends of the same crystal
  - If the previous energy deposition (pile up signal) occurred within ~20 μs before the measured event, it could add big negative signals which are significantly different at opposite end of the same crystal.
- In order to produce big asymmetric negative signals the pile up pulse amplitude should exceed reset circuit threshold (~250 MeV)
- This could explains why bad position measurement effect
  - becomes smaller below 1 GeV - because energy per crystal is below 250 MeV and reset circuit is not triggered
  - Doesn't exist at 10 and 20 GeV – because we use mainly HEX8 range, where reset circuit threshold is much higher (1/4 of HEX1 range, i.e. ~20 GeV), and so it is not triggered.

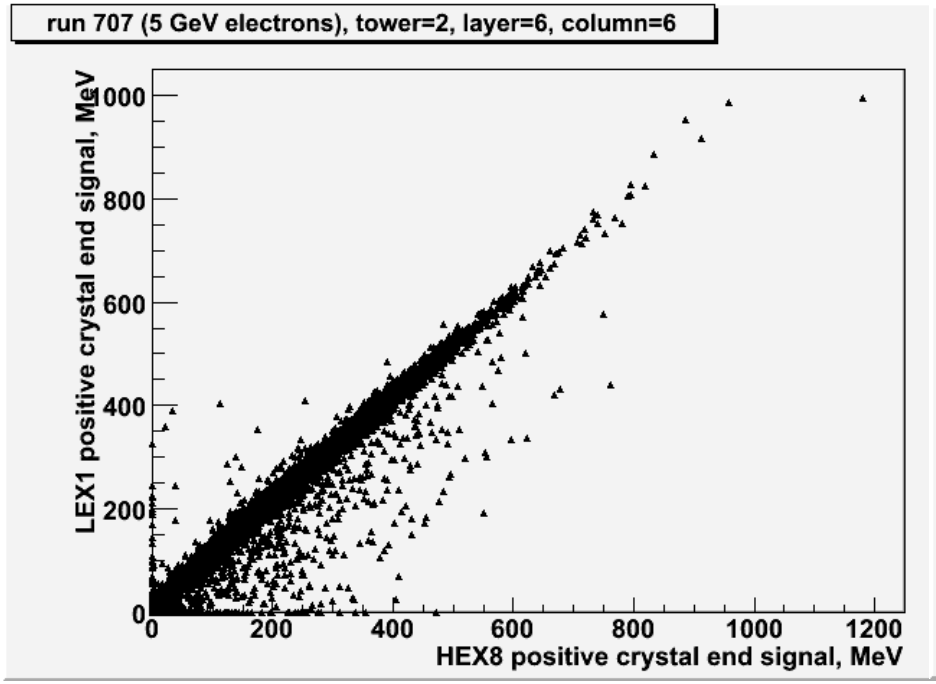
# Verification with 4 range readout run 707

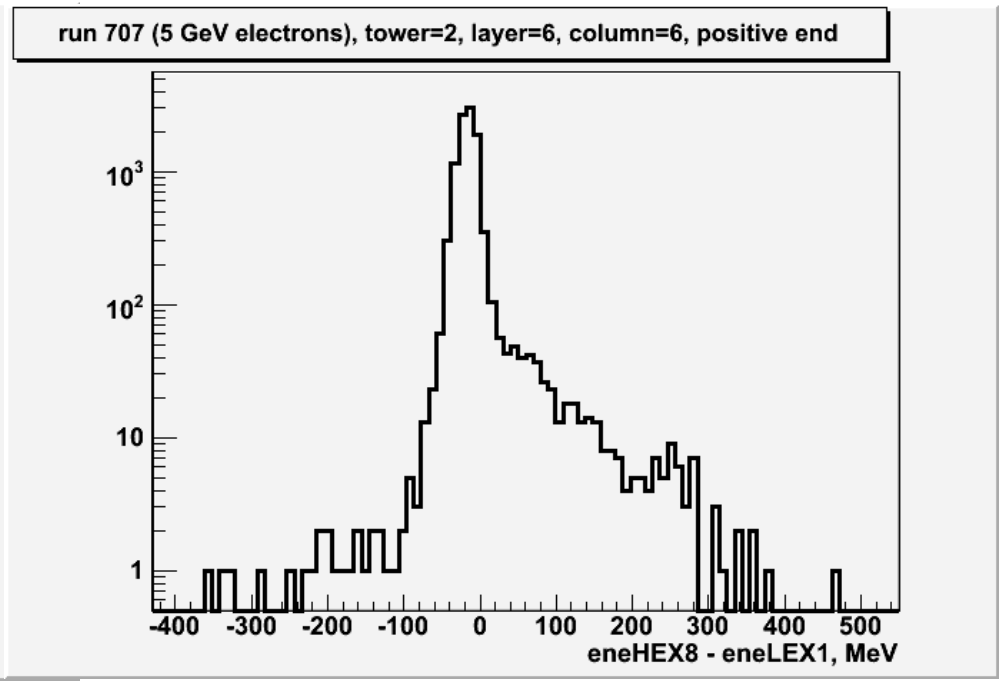



- Scatter plot enePos vs eneNeg for HEX8 range (bottom right) significantly less populated with biased events than the same plot for LEX1 range (top left)
- Not clear why HEX8 plot has some biased events – to be understood

# Verification with 4 range readout run 707 (cont.)




- LEX1 signal is always smaller than HEX8 (due to pile up)
- deviation has exponential distribution
- Maximum deviation is ~300 MeV – close to 40% of maximum signal in the crystal ( 800 MeV)

# Conclusion

- Pile up could possibly explain the bad position measurement effect
- Some addition verification should be done:
  - Effect of event rate
  - Estimate absolute probability
  - Look at similar effect in HEX8/HEX1 range at very high energies (>15 GeV per crystal)
  - Residual effect in HEX8 range at low energy – why ?