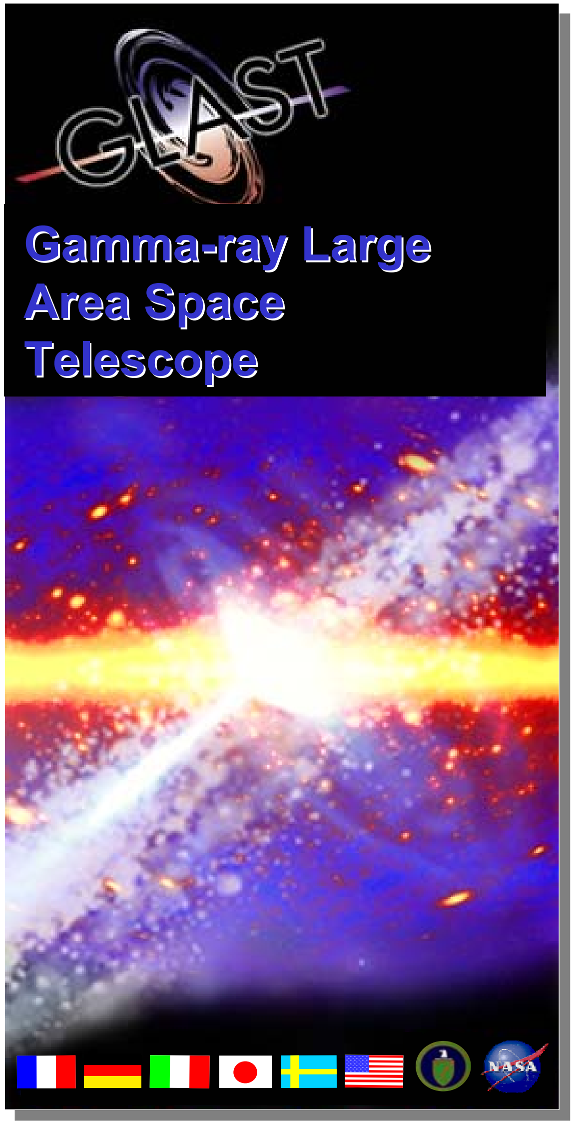


Status of CAL calibration.

Alexandre Chekhtman
NRL/GMU

Outline

- Calorimeter calibration procedure
- Known problems with CAL calibration
- Possible explanations
- What to do ?

Crystal energy reconstruction

- Input: ADC values for positive and negative end of crystal
- Output: energy in MeV
- Algorithm:
  - Pedestal subtraction:
    - ADC_PED = ADC – PED
  - Conversion to the units of charge injection DAC:
    - DAC = adc2dac(ADC_PED)
  - calculation of geometric mean of two ends of crystal:
    - DAC_mean = sqrt(DAC_pos*DAC_neg)
  - Conversion to MeV:
    - Ene = MeVperDAC*DAC_mean
- Calibration data needed:
  - Pedestal – one constant for each range
  - Adc2dac – spline function for each range
  - MeVperDAC – one constant for crystal and diode size(big/small)

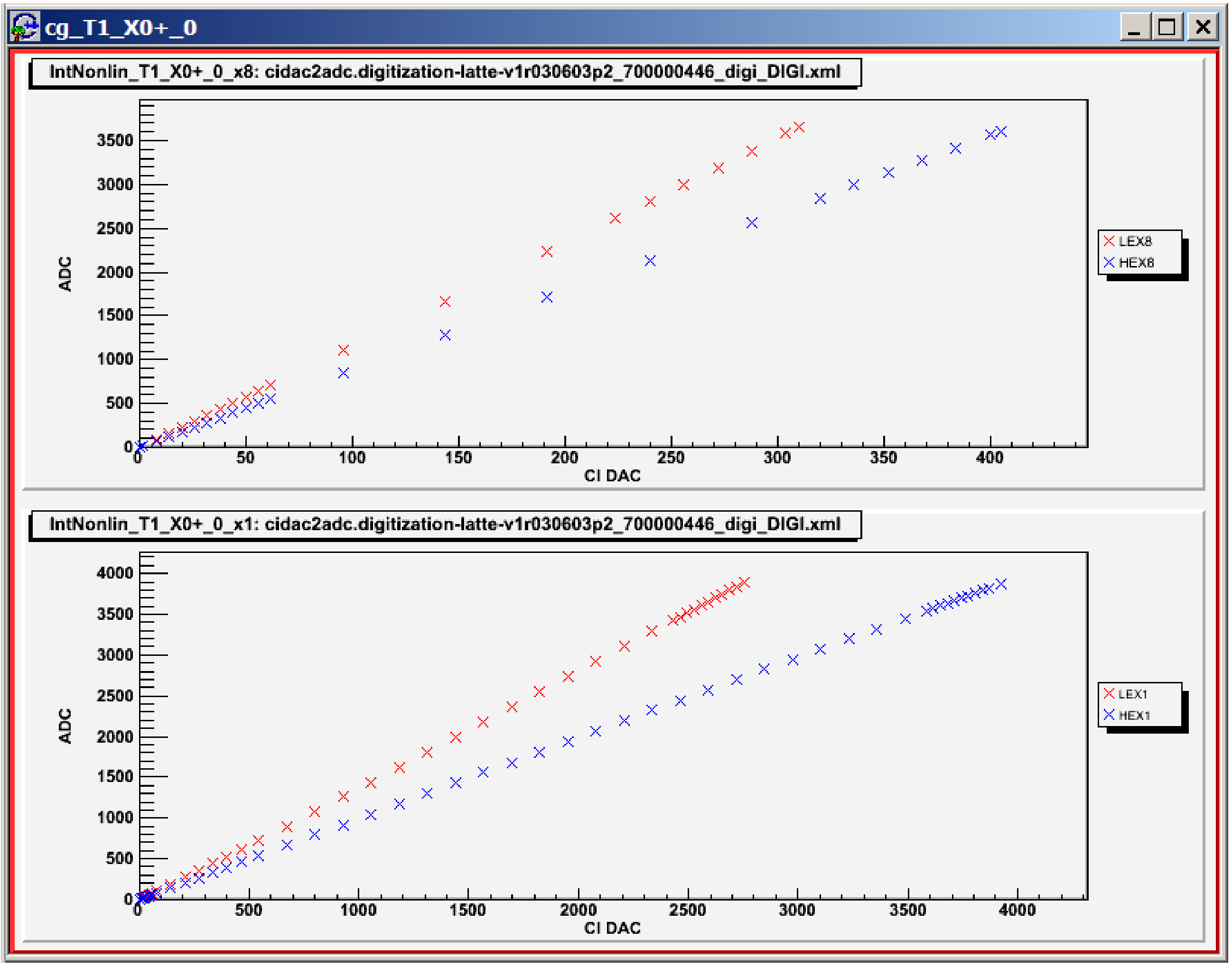
Meaning of calibration constants

- adc2dac (integral nonlinearity) – relationship between measured signal (in ADC units) and the charge injected to the preamplifier input
  - Should take care of different preamplifier gain
- MeVPerDAC – relationship between deposited energy in a crystal and the charge (in DAC units) injected to the preamplifier input
  - Should NOT depend on preamplifier gain

Measurement of calibration constants

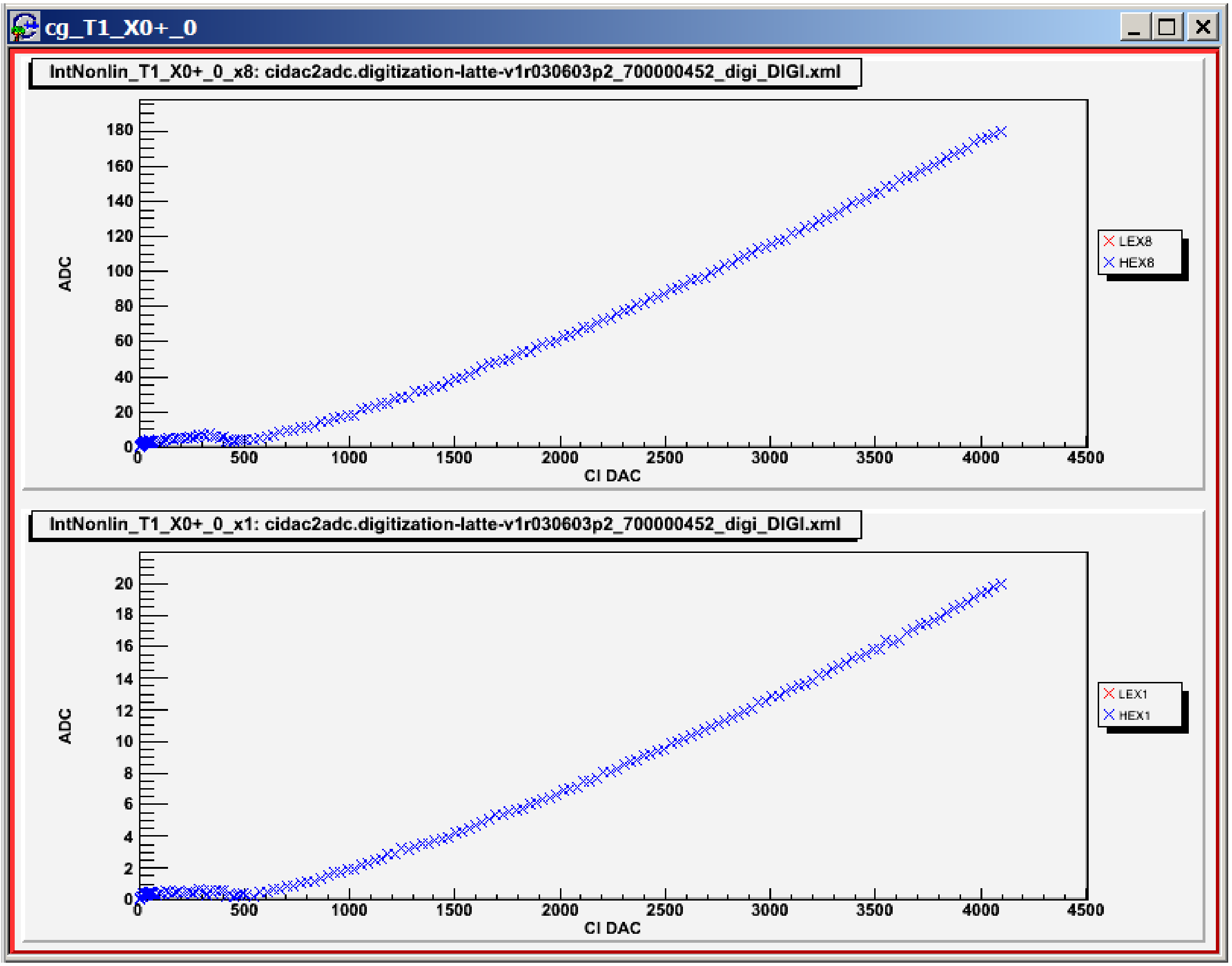
- Pedestals:
  - From CPT pedestal runs
  - From periodic trigger events during normal data taking
- Adc2dac:
  - calibGen charge injection script - measures adc2dac for different combinations of configuration parameters:
    - In each run only one diode pulsed at each crystal end
      - Both diodes are read out – allows the crosstalk measurement
    - Two different gain settings for small diode: flight gain and muon gain (used for muon calibration of small diode)
    - Two values of charge injection capacitor
      - Allows to find the crosstalk for realistic signal ratio between big and small diodes
- MeVperDAC:
  - For big diode – from calibration with cosmic muons
  - For small diode – from small/big diode ratio

ADC vs DAC without crosstalk



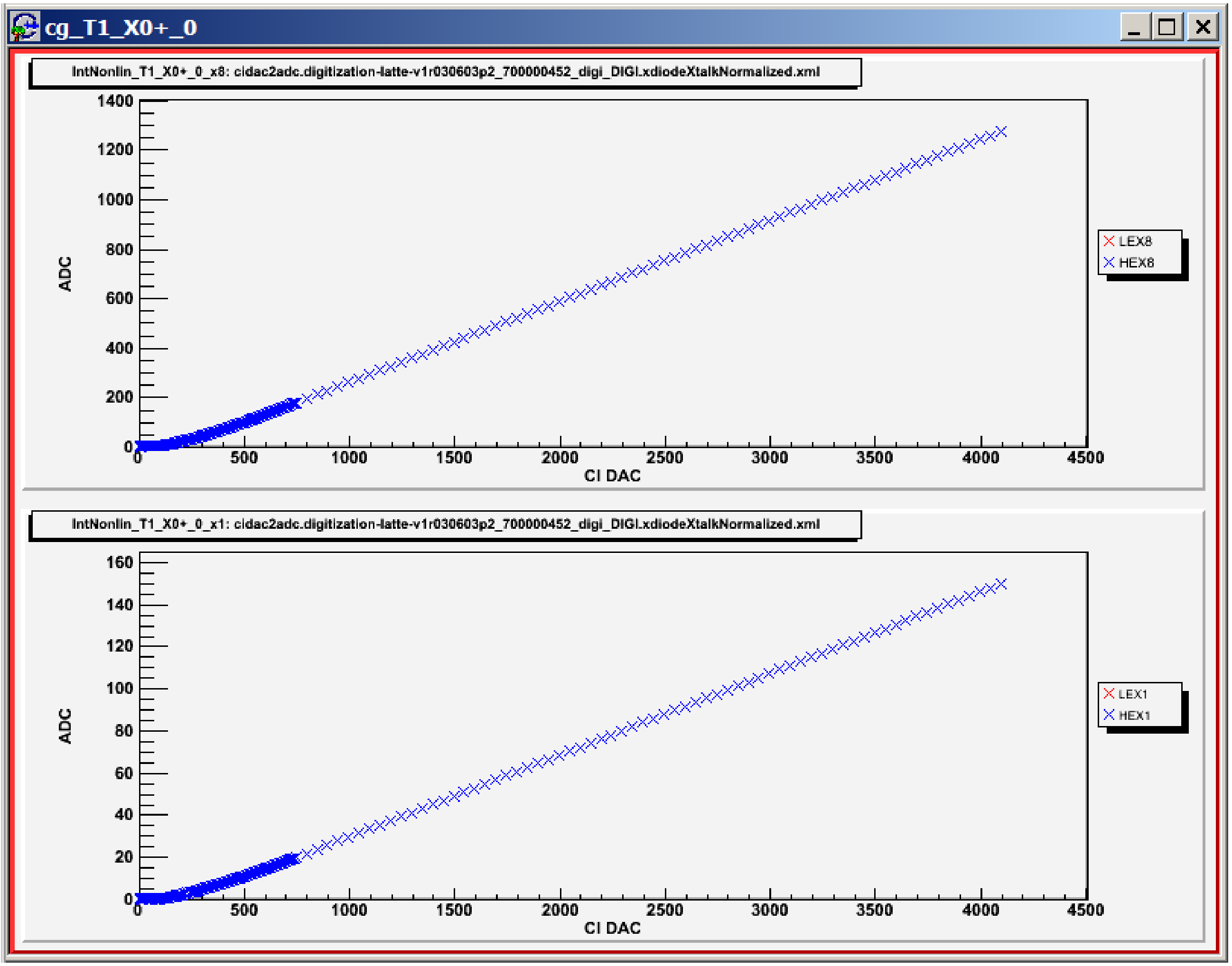
- Charge injection calibration for all 4 ranges of one crystal end
- Only one diode was pulsed in each run:
  - No crosstalk effect taken into account on this plot

Measurement of the crosstalk from big to small diode



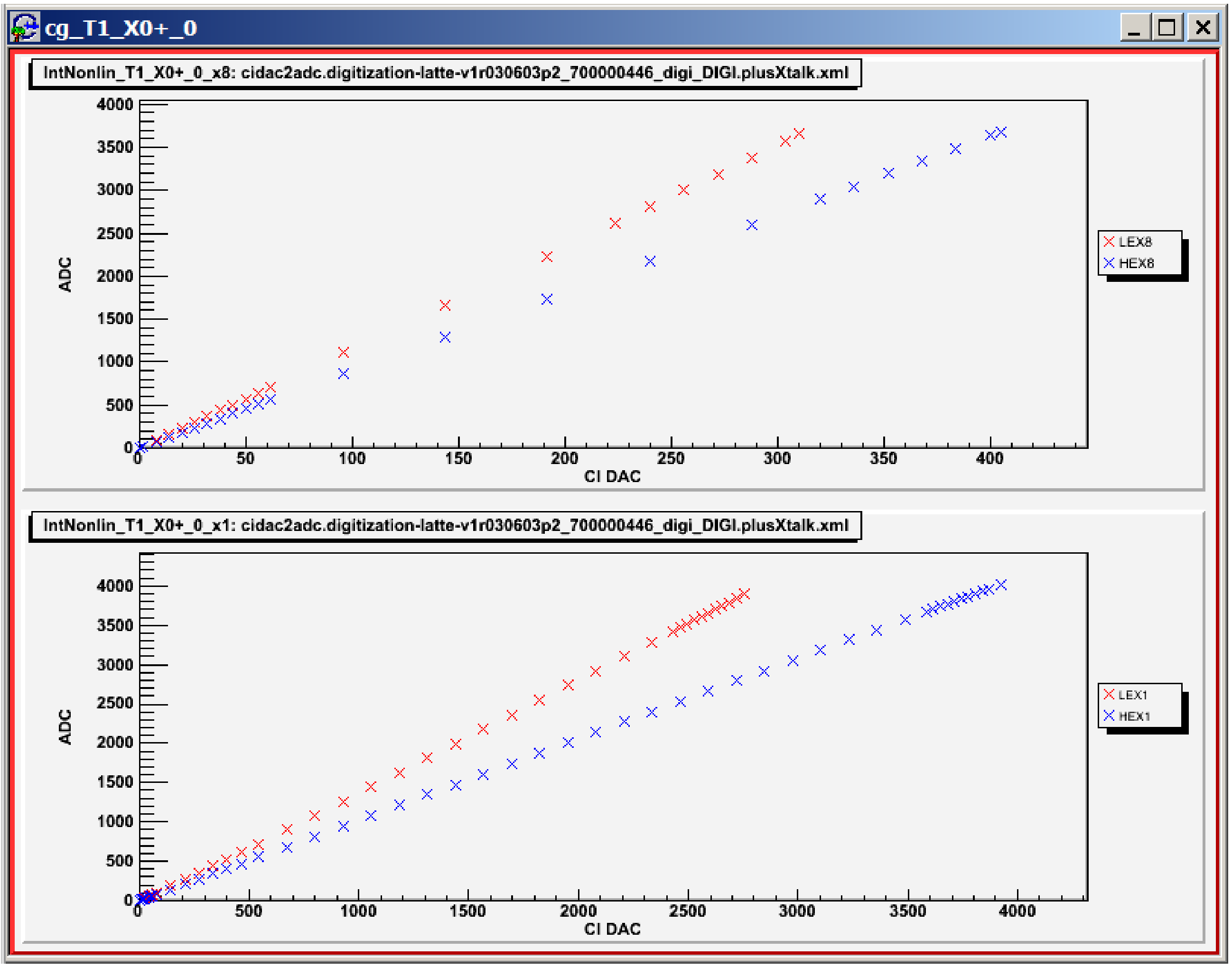
- Signal measured by HEX8 and HEX1 channels, when only LE diode was pulsed
- CALIBGAIN=OFF setting was used, to provide big signal on LE diode, (~10 times bigger than the saturation level)

Crosstalk vs signal at HE diode



- Horizontal axis value divided by factor 5.5 to convert to HE DAC scale
  - 5.5 - the ratio between big and small diode signals for real scintillation
- All measured points are below DAC~750
  - We do linear extrapolation of crosstalk for bigger signal
- From bottom plot the crosstalk is ~3% of HEX1 signal
- no real measurement for very big signals (DAC>750 or ene>15 GeV)

Nonlinearity curves corrected for crosstalk



- Scaled crosstalk measurement added to initial nonlinearity curve

Calibration process for high energy diode

- When high energy diode is calibrated with muons, preamplifier gain is set to the value 10 times bigger, than normal ("muon" gain)
- In this simplified model to take into account the different preamplifier gain setting we just have to use the appropriate adc2dac calibration (for flight gain or for muon gain)
- Real situation is more confusing: we also can change the charge corresponding to one DAC unit by switching charge injection capacitor (controlled by CALIBGAIN bit in the configuration word)
  - We use CALIBGAIN=OFF setting when doing charge injection calibration with muon gain, otherwise the step of charge injection calibration would be too big, compare to muon signal
    - This setting decrease the value of one DAC unit by factor ~9.3 (CALIBGAIN factor).
    - to take this into account, we have to multiply MeVPerDAC values by this CALIBGAIN factor, when reconstructing data collected with flight gain
    - CALIBGAIN factor is defined individually for each channel, by comparing charge injection calibrations done with CALIBGAIN=ON and CALIBGAIN=OFF
- Crosstalk correction is applied to the muon gain nonlinearity curve the same way as for flight gain
  - The only difference: to convert from LE DAC to HE DAC scale the DAC values are multiplied by 1.7 (=9.3/5.5)

Modifications to calibGenCAL to support flight and muon gain calibrations

- ciFit is able to process data for low energy diodes and high energy diodes separately
- ciFit for high energy diodes run 3 times with different runs from calibGen suite, producing 3 intnonlin files:
  1. Muon gain, CALIBGAIN=OFF (calibGen run 204)
  2. Flight gain, CALIBGAIN=ON (calibGen run 102)
  3. Flight gain, CALIBGAIN=OFF (calibGen run 104)
- Intnonlin file 1 is used in muon calibration procedure when producing MeVperDAC and Asymmetry files for muon gain
- Python script:
  - compares intnonlin files from 2 and 3 and generates the file with CALIBGAIN factors for all channels.
  - Generates MeVperDAC and Asymmetry files for flight gain
- We have to store in the calibration database two sets of calibration files for each time period (with different "flavor"):
  - For muon gain: intnonlin file 1 and MeVperDAC/Asymmetry for muon gain
  - For flight gain: intnonlin file 2 and MeVperDAC/Asymmetry for flight gain
- When running reconstruction we should select appropriate calibration flavor, depending on configuration used for data collection.

Known CAL calibration problems

- After calorimeter was calibrated according to described procedure, the intercalibration of ranges LEX1 and HEX8 with electron beam on PS and SPS showed the descrepancy of 5-10%.
  - This discrepancy is interpreted as an error in calibration of HEX8 range and corrected individually for each crystal
- Position measurement along the crystal based on asymmetry shows systematic deviations ~10-20 mm, depending on crystals and energy deposition
  - 10 mm position error corresponds to ~1% difference in calibration of two ends of the crystal
- Pedestals are moving depending on energy deposition rate and the time from previous event
  - Pedestal drift is significant, but not very big compare to the energy deposition in a crystal (~2-3%)
- There energy deposition in a crystal from high energy electron shower reconstructed from real data is upto 10-15% bigger than simulated by Geant4
  - Effect increases with energy
  - Effect decreases with layer number
  - Effect decreases with increasing theta angle of initial electron
  - Effect doesn't depend on event rate

Known CAL calibration problems (cont.)

- There are several crystals showing a change in the shape of LEX1 vs HEX8 inter-calibration curve
  - For example, tower=2, crystal=5 layer=6 has different range intercalibration curve in two runs with the same event rate and mean energy deposition in this crystal:
  - the only visible difference between two runs is the beam position:
    - Run 1794: beam hits crystal 4
    - Run 1796: beam hits crystal 6
  - The only explanation I could propose is that there is some crosstalk to crystal 5 from crystal 6, but no crosstalk from crystal 4.
    - We never saw such a crosstalk in charge injection, but
      - Charge injection shape is different (bipolar) from scintillation, may be it doesn't generate a crosstalk, while scintillation signal generates
      - Now we do the broadcast charge injection, so we can't measure the crosstalk between crystals
      - We never tried to measure crosstalk from very big signals well above saturation of LEX1 range

Discussion

- There was an attempt to explain the CAL calibration problems by the presence of afterglow with long time constant (milliseconds)
  - Main argument for this hypothesis was the absence of the pedestal drift when doing charge injection at high rate
    - But the charge injection signal is bipolar – the negative pulse arrives 10 us after the positive. So, charge injection definitely has the shape different from real scintillation at time scale >10 us
  - The "excessive energy" effect is not rate dependent – so most likely not related to afterglow
- The above mentioned difference in signal shape between scintillation and charge injection signal could cause the difference in nonlinearity curve
  - To verify this we need some independent measurement:
    - Calibration with LED coupled to the crystal ?
- Longitudinal position measurement with small diodes was calibrated by muon energy depositions only, i.e for very low signal. If nonlinearity for real scintillation is different from charge injection, this could cause the systematic errors in position measurement at high energy.

Discussion (cont.)

- possible way to verify the nature of calibration problems: measure charge injection curve when beam is on.
  - May be we can find time to run column-wise charge injection script with CALIBGAIN OFF – we'll be able to measure crosstalk between adjacent crystals, when LEX1 range is saturated.
- It is difficult to explain the dependency of "excessive energy" effect on the theta angle by CAL calibration – it is possibly the Monte Carlo problem in low energy particles simulation in tracker.
  - One way to verify it – compare data with simulation in tower 1 (without tracker in front)

Conclusion

- We have serious problems with CAL calibration
- It is more likely a mixture of different effects
- We definitely need to understand these problems because the energy measurement is completely dependent on CAL calibration procedure
  - GCR calibration is not really an alternative, because our measurement of quenching factors is based on CAL calibration with muons/protons and nonlinearity measurement with charge injection