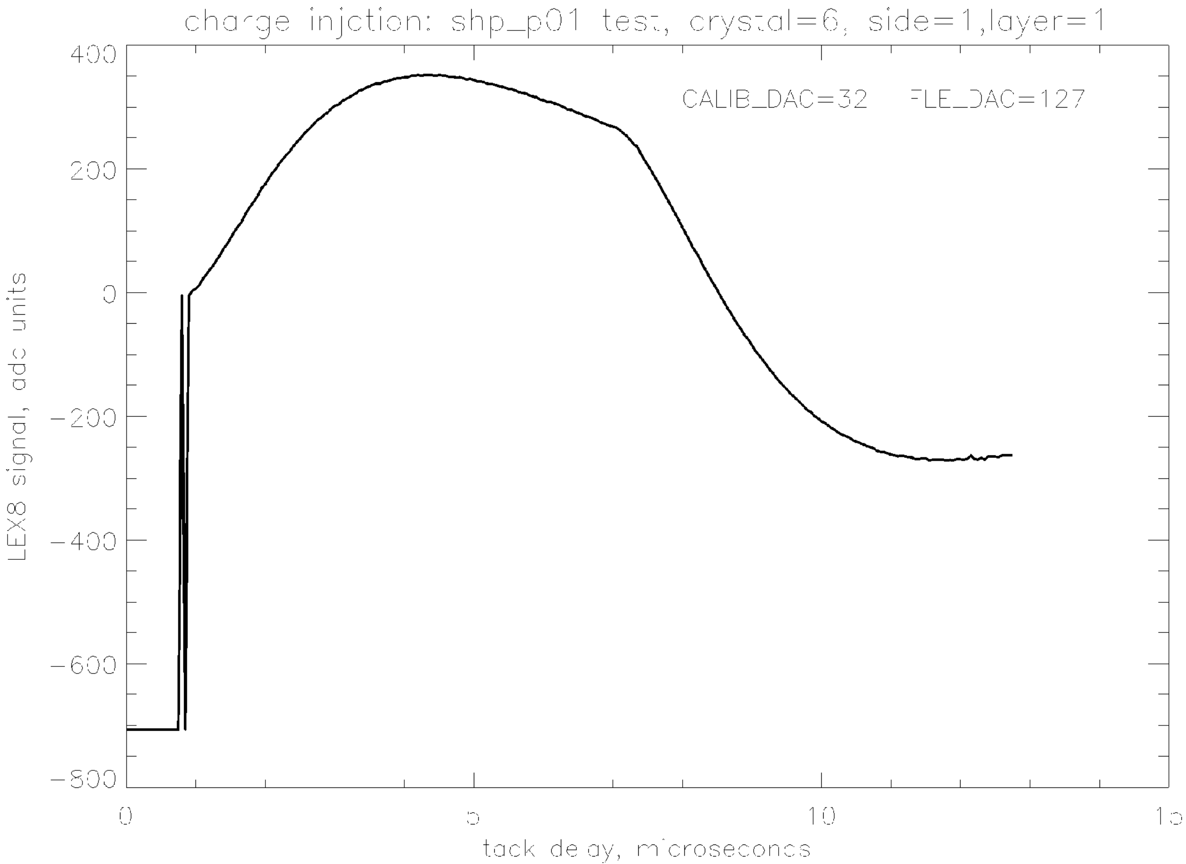
CAL crosstalk issues and their implications

Alexandre Chekhtman
NRL/GMU

How we can study signal pulse shape ?

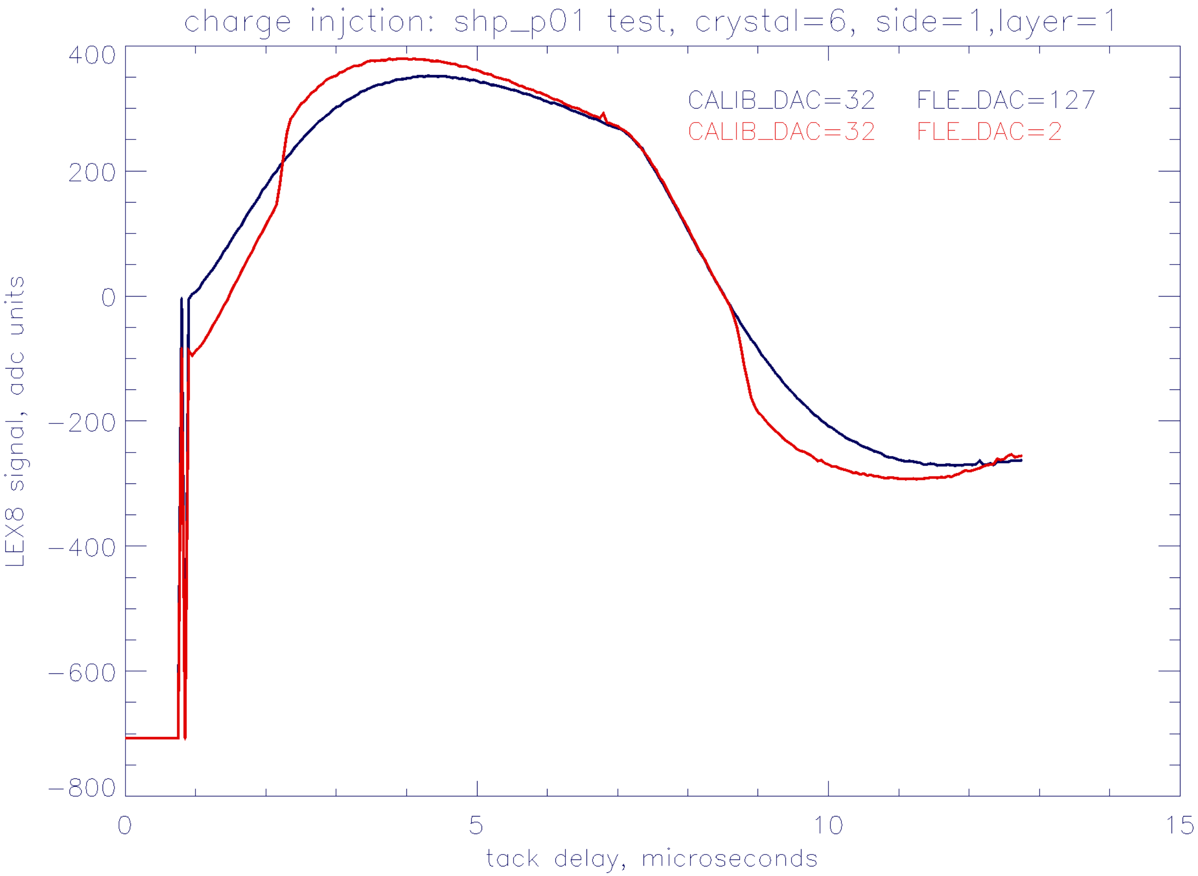
- Shp_p01 test measures the CAL response to the same injected charge, but setting different "tack" (trigger acknowledgement) delay

- Plot shows the result of pulse shape measurement for the following conditions:
  - the signal amplitude close to the muon signal
  - "Fast shaper Low Energy" (FLE) discriminator threshold set to maximum possible value FLE=127 – discriminator never fired.



What happens for nominal FLE threshold ?

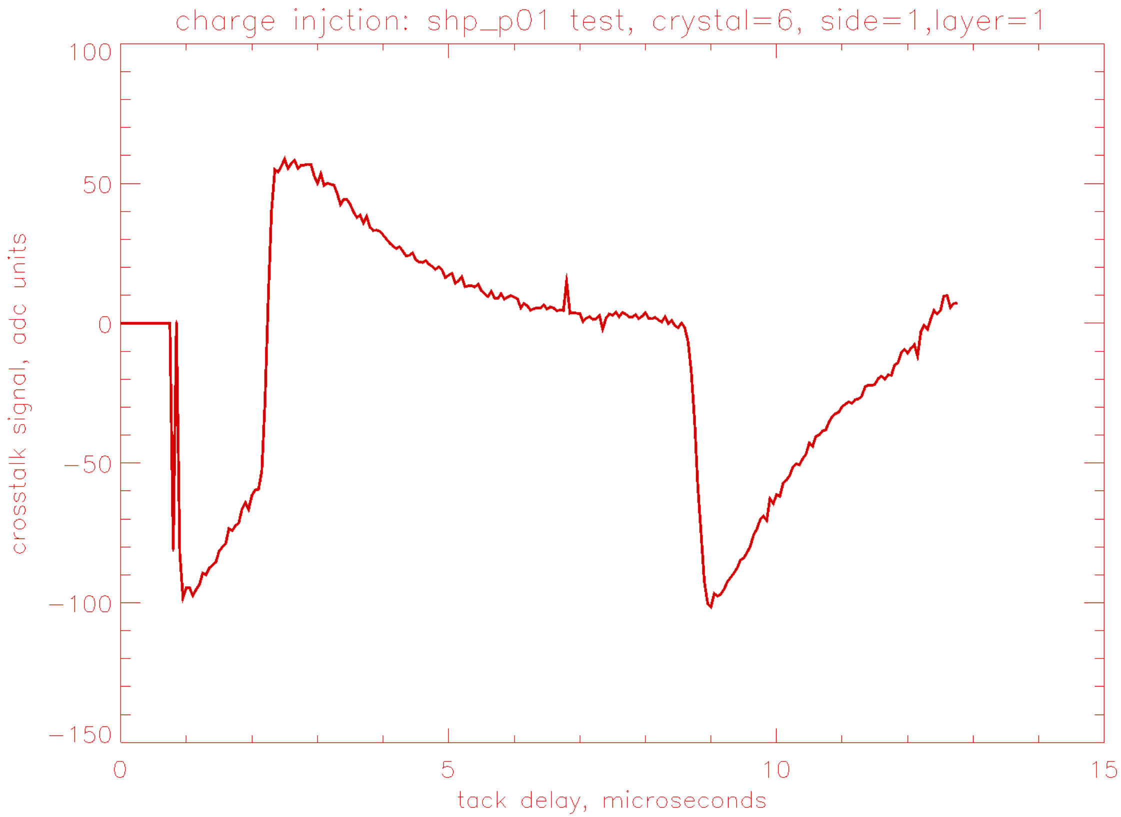
- Pulse shape for lower FLE threshold (red curve) superimposed on normal pulse shape



- Fired FLE discriminator produces significant distortion of the pulse shape

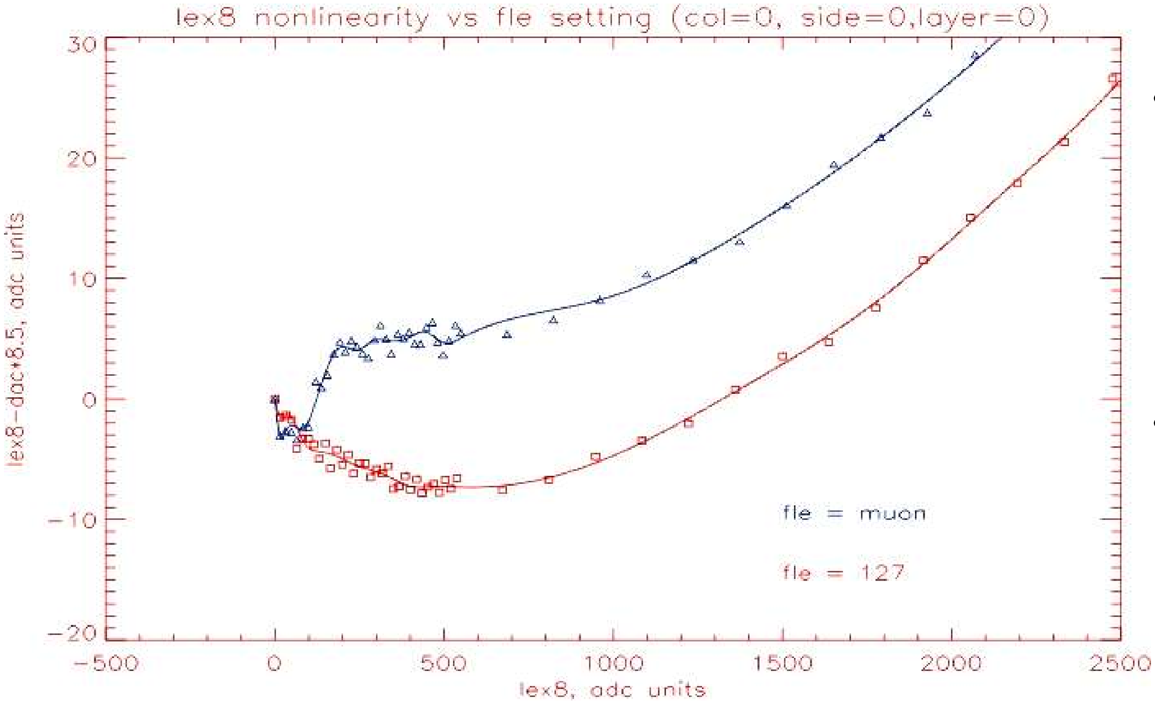
FLE crosstalk shape

- By subtracting normal curve from distorted curve we can find the shape of crosstalk



- Amplitude of this effect is rather big ~100 adc units (4MeV)
- Fortunately, we are making energy measurement at tack=5μs, where effect is small
- If FLE is fired asynchronously by noise or other scintillation, the crosstalk could introduce significant positive or negative bias
  - Could result in pedestal bias and/or broadening

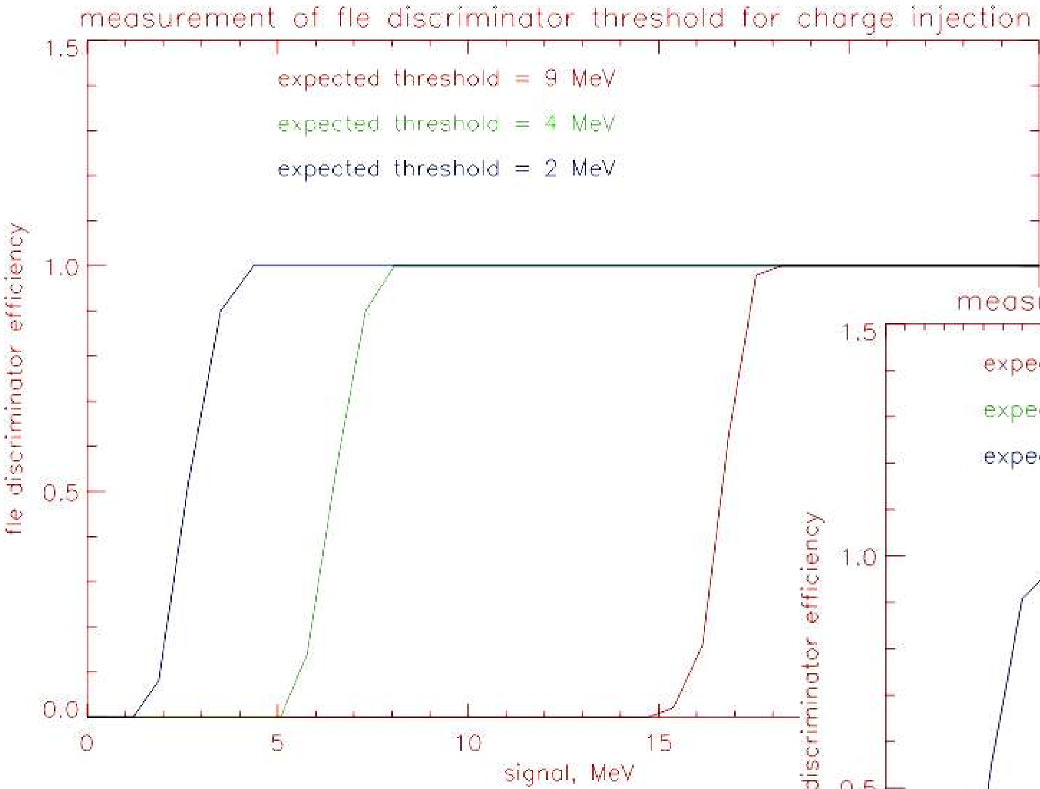
Example of charge injection curves



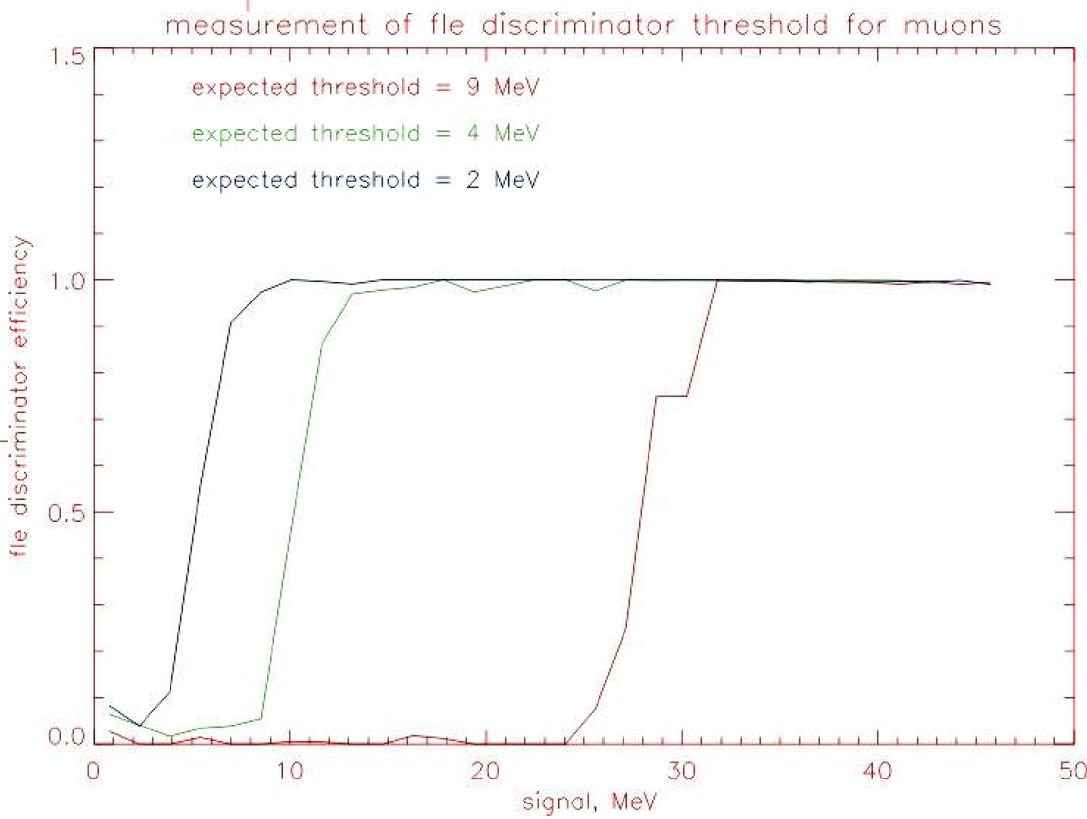
- Difference between curves explained by crosstalk from fast shaper discriminator to the input of LEX8 preamplifier
- Charge injection should be done with exactly the same settings as real data we want to correct for non-linearity

- Points (triangles, squares) – charge injection calibration data
- Curves – spline fit
- Red curve+squares: highest possible fast shaper discriminator threshold - above lex8 range
- Blue curve+triangles: fast shaper discriminator threshold used for muon data collection

FLE thresholds for muons and charge injection



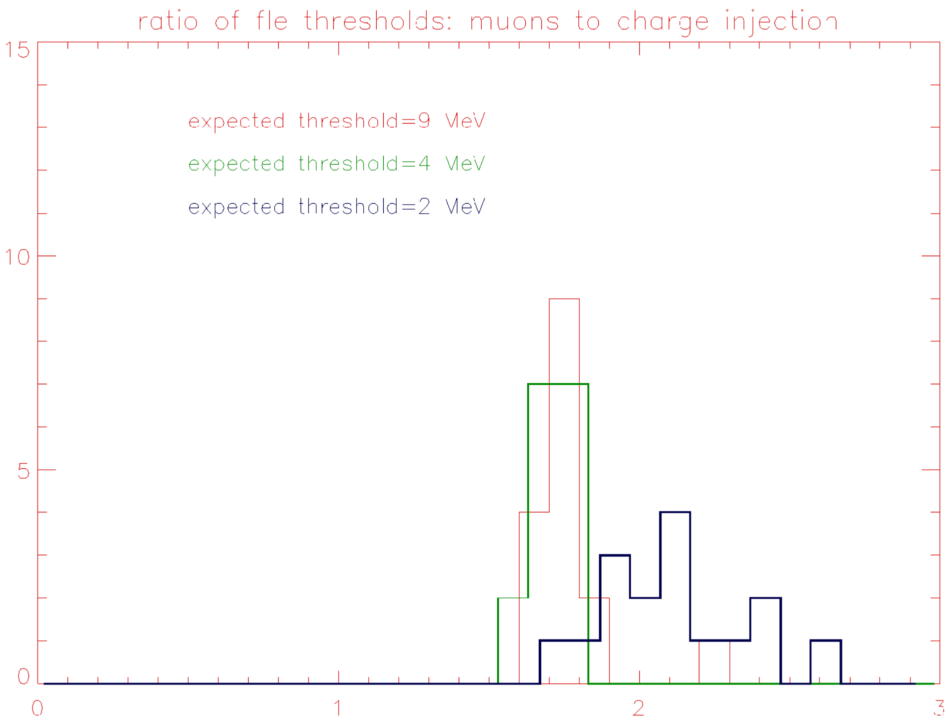
- Thresholds are measured using diagnostic bit for FLE discriminator



- Thersholds for muons are ~2 times higher than for charge injection due to longer rise time of scintillation pulse

FLE thersholds ratio muons to charge injection

- FLE discrimiator thersholds are different for muons and charge injection
  - we cannot directly apply to muons the nonlinearity correction, measured by charge injection, because it contains a component sensitive to FLE threshold position
  - We have to extract this crosstalk component, scale it according to muon/charge injection threshold ratio and add back to non-linearity correction.
  - Correction procedure is rather complex, we need some direct measurement of FLE crosstalk effect for muons to verify the procedure

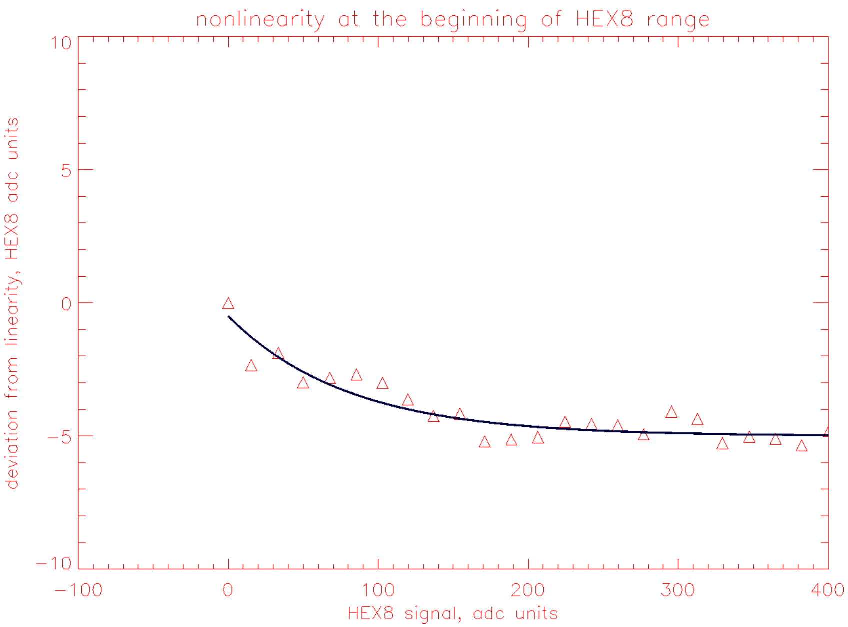


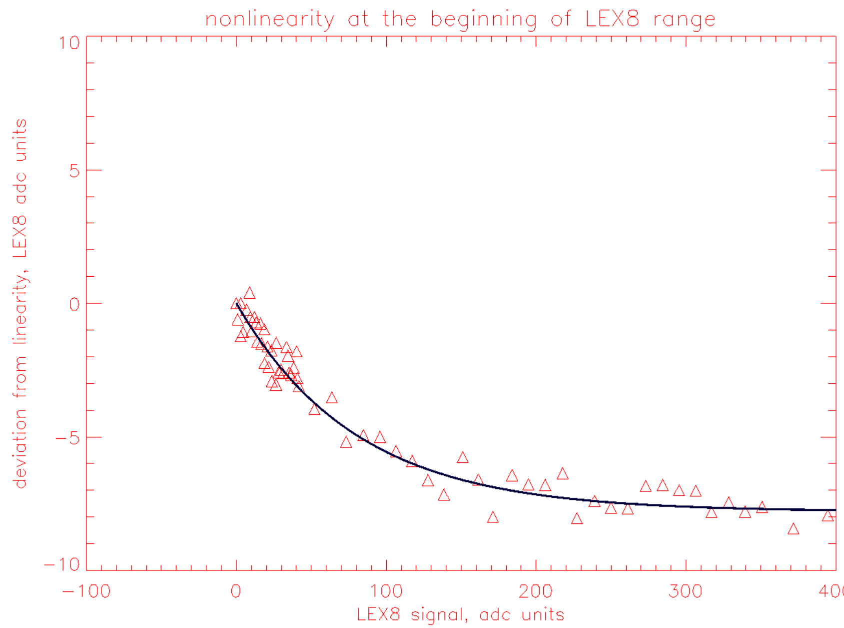
FLE crosstalk for muons

- It is possible to see FLE crosstalk for muons by looking at correlation of signals from LE and HE diodes (LEX8 and HEX8 ranges) when we use “muon gain” setting for HE diode, allowing to see muons signal
  - HE diode is not affected by this crosstalk because corresponding discriminator (FHE) set to 127 and is not fired
- We have to correct both signals (LEX8 and HEX8) for other nonlinearities, not related to FLE crosstalk and measured when FLE=127
- To calibrate nonlinearity of HEX8 range for small signals with muon gain we used special charge injection setting, decreasing injected charge by factor of 10 (using smaller capacitor).

Nonlinearity correction for small signals

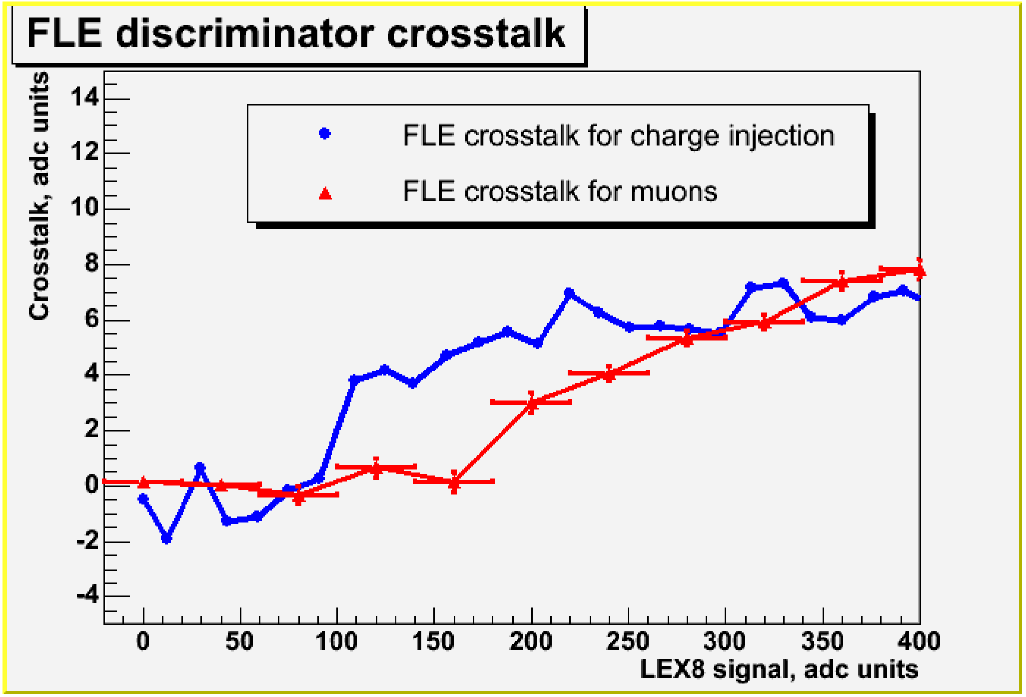
- Nonlineraity of LEX8 and HEX ranges was measured with FLE=127 and special setting providing small charge injection steps
- Results of the measurement were fitted with exponential functions and appropriate correction applied to muon signals





FLE crosstalk for muons - result

- Crosstalk for muons calculated as xtalk = lex8-k*hex8, where k is defined by hex8/lex8 gain ratio (for selected crystal=2 side=0 layer=5 this coefficient is k=4.68)



- Comparison with charge injection crosstalk (blue circles) confirms that
  - the amplitude of the crosstalk is the same
  - along horizontal axis the curve is scaled according to FLE threshold which bigger for muons than for charge injection

Muons collected with external trigger

- If external trigger (tracker or plastic scintillators) used for triggering and FLE thresholds set high to avoid firing of FLE discriminators, the FLE crosstalk effect should be absent
- It is possible to verify it the same way as described above, but more statistics needed (now – only one run ~200K triggers)
- I checked that muon peaks positions for nominal FLE thresholds for muon collection are higher by ~5-10 adc units than for muons collected with external trigger and FLE=127.
  - This also confirms the presence of FLE crosstalk

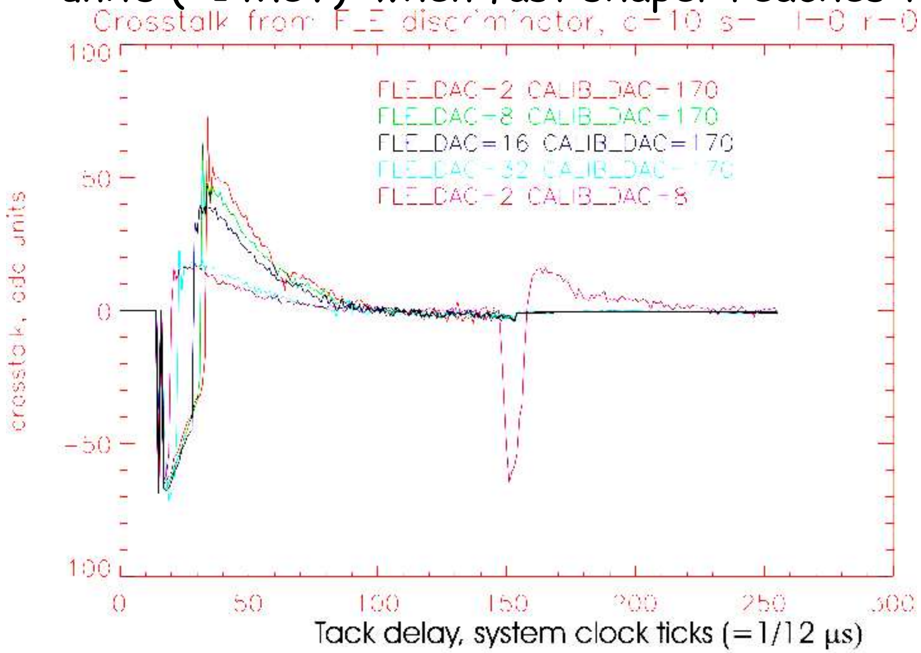
Conclusions

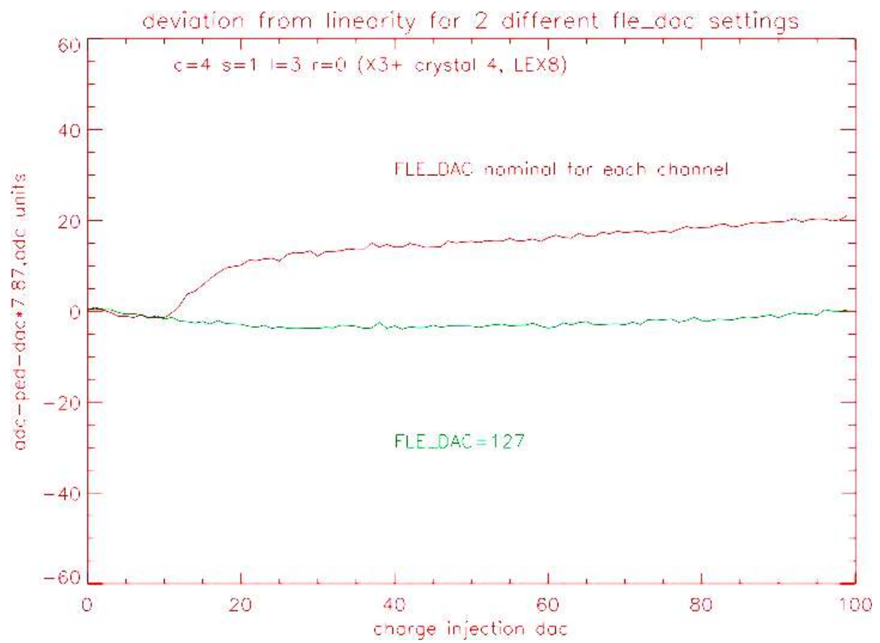
- The crosstalk from fast shaper discriminator to slow shaper output produce nonlinearity
- The effect depends on tack delay, gain and FLE threshold settings
  - For currently recommended gain=5, fle="2MeV"
    - the effect is ~10 adc units
    - muon peak is ~350 adc units
    - =>the effect is ~0.3 MeV
    - => 3% bias in muon calibration
- In some situations the crosstalk could produce much bigger error in energy measurement (~3MeV) - coincidence with noise or other particle.
- Due to the fact that thresholds for muons are ~2 times higher than for charge injection signals, the non-linearity function, measured with charge injection, should be scaled.
- Crosstalk effect for muons has be measured directly by using small diode (HEX8 range) as a reference

Backup slides

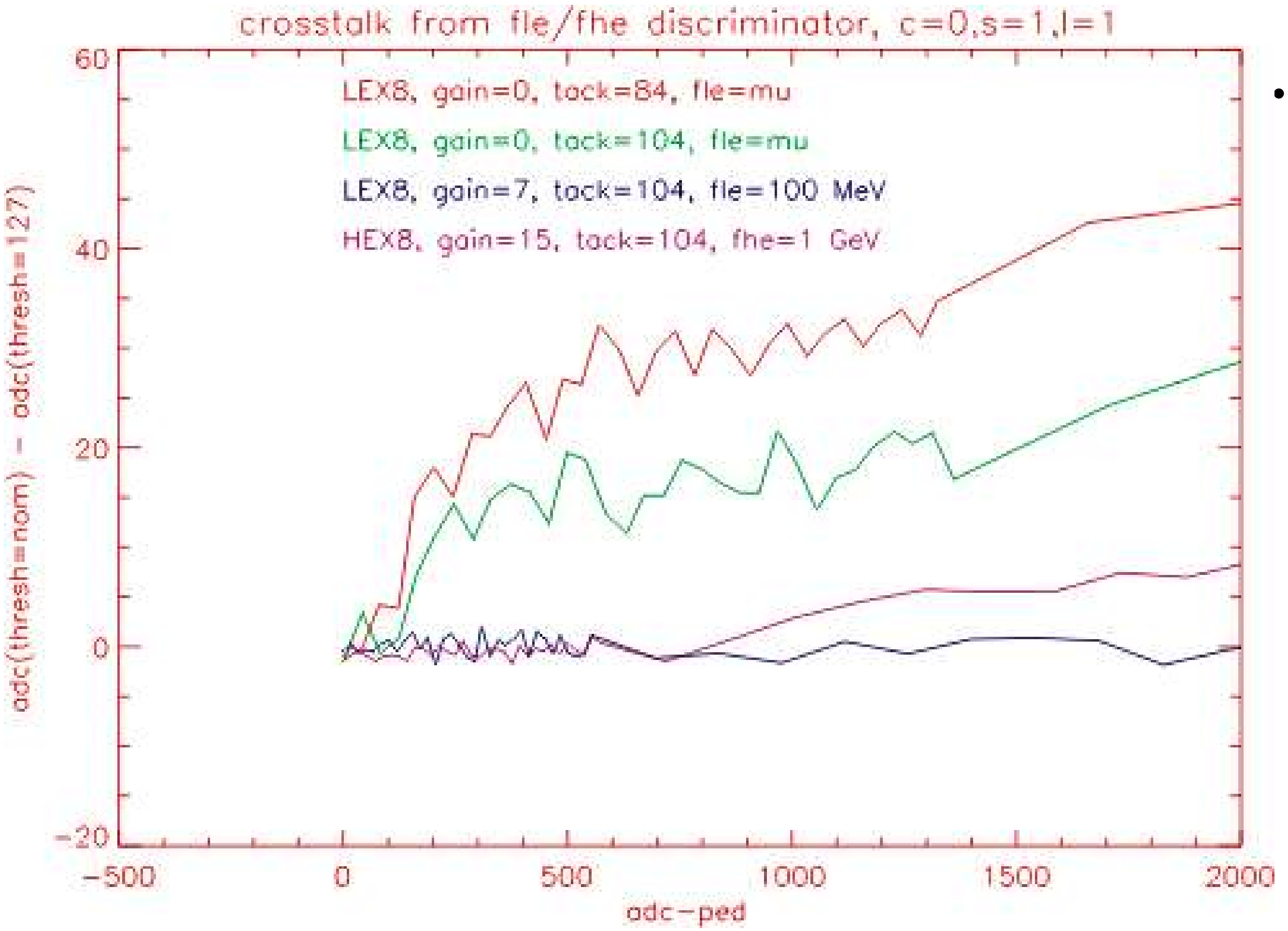
Nonlinearity from FLE discriminator crosstalk

- FLE (fast shaper low energy) discriminator receives signal from fast shaper and produces digital signal used by trigger.
- FLE discriminator threshold is defined by FLE_DAC
- Comparing the pulse shape at slow shaper for different FLE_DAC settings with pulse shape measured with high FLE threshold (FLE_DAC=127) one can see the effect of crosstalk from the fast shaper
- The same effect is seen in charge injection calibration as a positive step ~20 adc units (~1 MeV) when fast shaper reaches the threshold of discriminator.





Effect of FLE/FHE thresholds



- With thresholds FLE=100 MeV and FHE=1GeV used in GSI the effect on linearity becomes much smaller than with “muon” thresholds