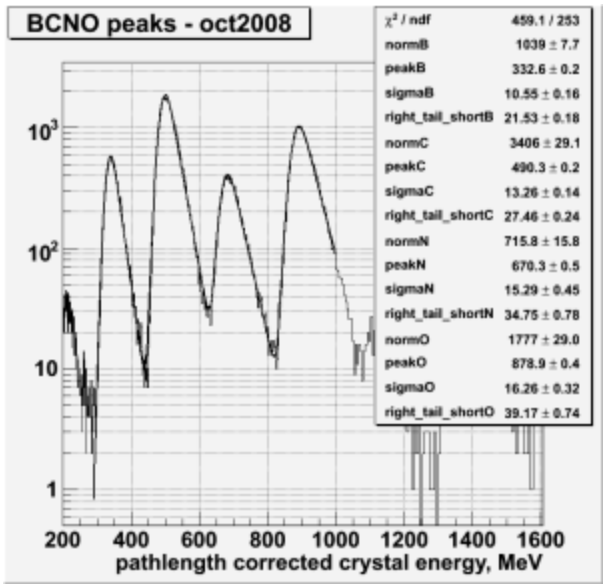
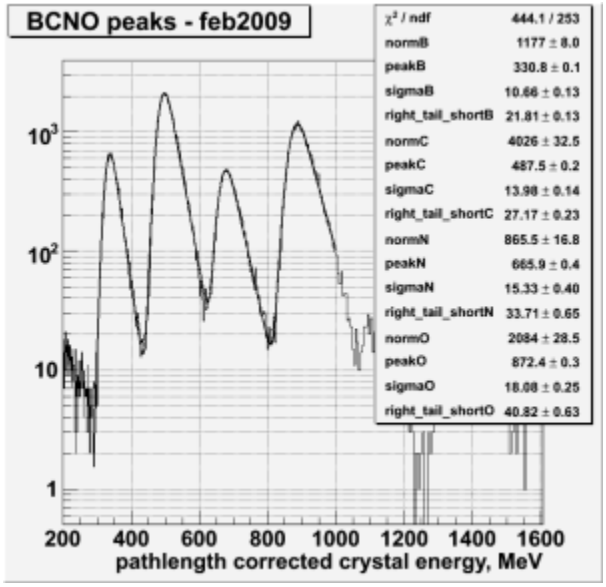
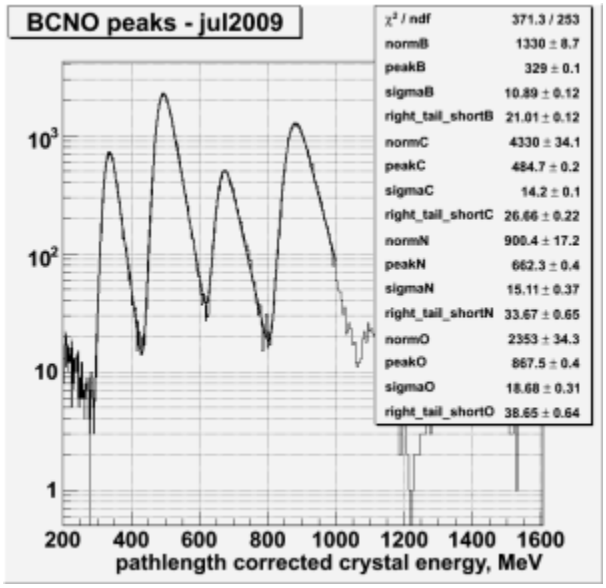
Long term variation of calorimeter energy scale.

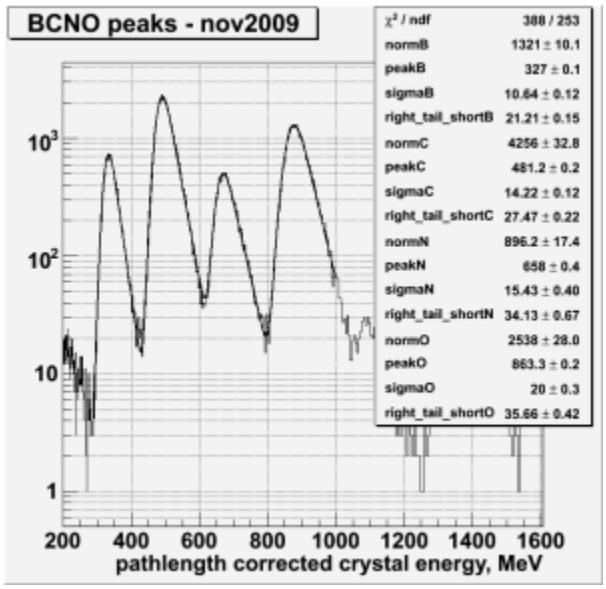
I've made a fit of the histograms of pathlength corrected crystal energies of four biggest GCR peaks(B, C,N and O) for 5 time periods with distance ~4 month between periods (oct 2008, feb2009, jul2009, nov2009, mar2010).

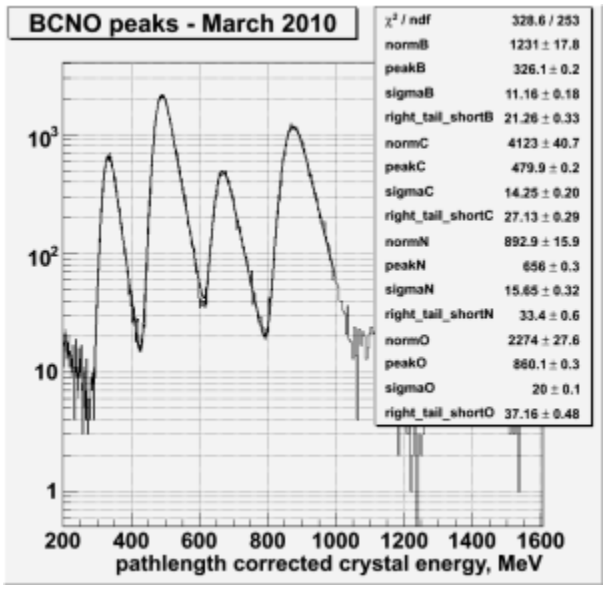
The histograms with fits are shown on the following plots:





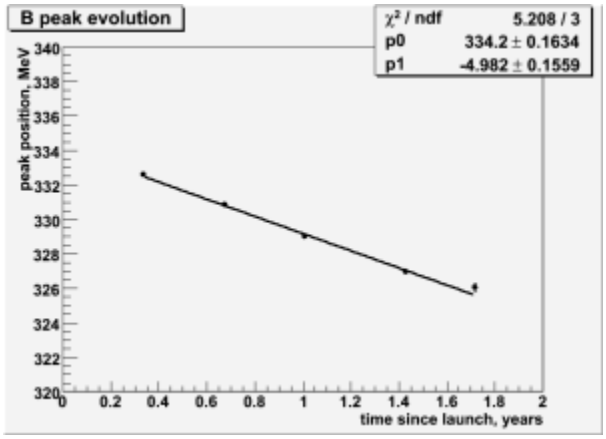

BCNO peaks - jul2009
χ² / ndf 371.3 / 253
normB 1330 ± 8.7
peakB 329 ± 0.1
sigmaB 10.89 ± 0.12
right_tail_shortB 21.01 ± 0.12
normC 4330 ± 34.1
peakC 484.7 ± 0.2
sigmaC 14.2 ± 0.1
right_tail_shortC 26.66 ± 0.22
normN 900.4 ± 17.2
peakN 662.3 ± 0.4
sigmaN 15.11 ± 0.37
right_tail_shortN 33.67 ± 0.65
normO 2353 ± 34.3
peakO 867.5 ± 0.4
sigmaO 18.68 ± 0.31
right_tail_shortO 38.65 ± 0.64
10³
10²
10
1
200 400 600 800 1000 1200 1400 1600
pathlength corrected crystal energy, MeV

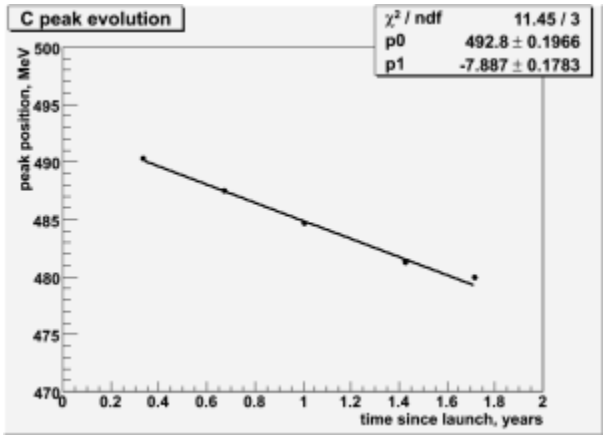

BCNO peaks - nov2009
χ² / ndf 388 / 253
normB 1321 ± 10.1
peakB 327 ± 0.1
sigmaB 10.64 ± 0.12
right_tail_shortB 21.21 ± 0.15
normC 4256 ± 32.8
peakC 481.2 ± 0.2
sigmaC 14.22 ± 0.12
right_tail_shortC 27.47 ± 0.22
normN 896.2 ± 17.4
peakN 658 ± 0.4
sigmaN 15.43 ± 0.40
right_tail_shortN 34.13 ± 0.67
normO 2538 ± 28.0
peakO 863.3 ± 0.2
sigmaO 20 ± 0.3
right_tail_shortO 35.66 ± 0.42
10³
10²
10
1
200 400 600 800 1000 1200 1400 1600
pathlength corrected crystal energy, MeV

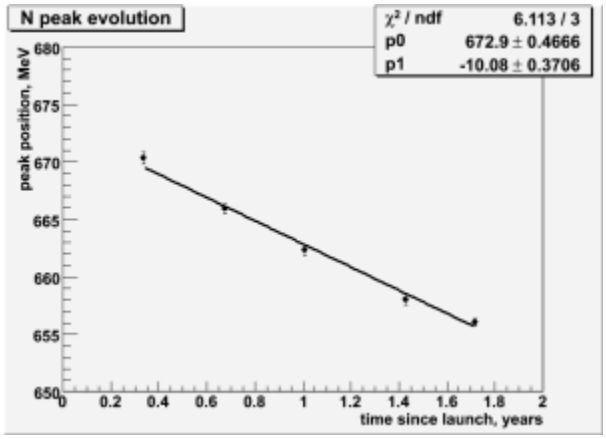

BCNO peaks - March 2010
χ² / ndf 328.6 / 253
normB 1231 ± 17.8
peakB 326.1 ± 0.2
sigmaB 11.16 ± 0.18
right_tail_shortB 21.26 ± 0.33
normC 4123 ± 40.7
peakC 479.9 ± 0.2
sigmaC 14.25 ± 0.20
right_tail_shortC 27.13 ± 0.29
normN 892.9 ± 15.9
peakN 656 ± 0.3
sigmaN 15.65 ± 0.32
right_tail_shortN 33.4 ± 0.6
normO 2274 ± 27.6
peakO 860.1 ± 0.3
sigmaO 20 ± 0.1
right_tail_shortO 37.16 ± 0.48
10³
10²
10
1
200 400 600 800 1000 1200 1400 1600
pathlength corrected crystal energy, MeV

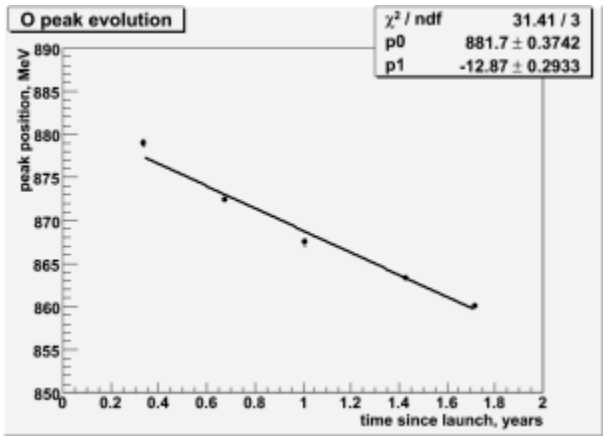
The fitting function contains for each peak a gaussian convolved with two exponential tails (the slope of left tail was fixed during fitting).

The following plot show the time evolution of peak positions for B, C, N and O peaks:





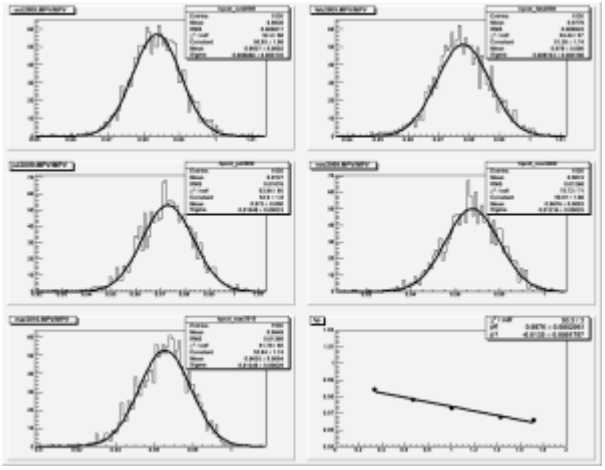




All four peaks show linear decrease with very close relative slope:

- B: 1.49+-0.05% per year
- C: 1.60+-0.04% per year
- N: 1.50+-0.06% per year
- O: 1.46+-0.03% per year
  This signal decrease is probably explained by radiation damage to CsI crystals and has the value consistent with pre-launch expectations ~1% per year

I've done the proton calibration of individual crystals for the same time periods and compared the results with the initial on-orbit calibration done on June 28, 2008 and used of reconstruction so far.



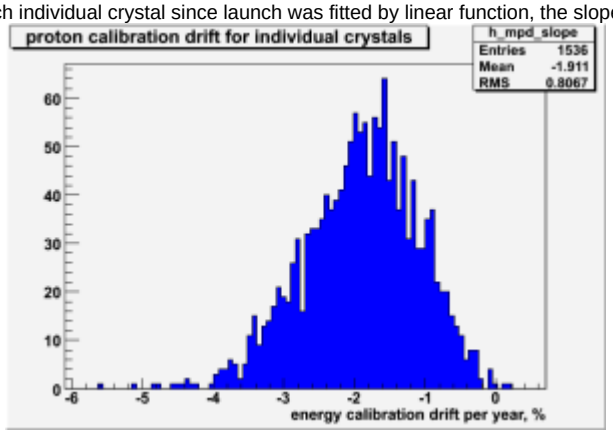
The results are shown on the following plot:
Each histogram shows the histogram of ratios of calibration coeffient of each crystal at some time period to its initial value on June 28, 2008.

Last plot shows the evolution of the mean value of the histograms and has the linear decrease of 1.35+-0.02% per year, consistent with the slope determined form GCR peaks.

We have to correct this calibration change by using new calibration made recently and by recalibrating the CAL every 6 month.

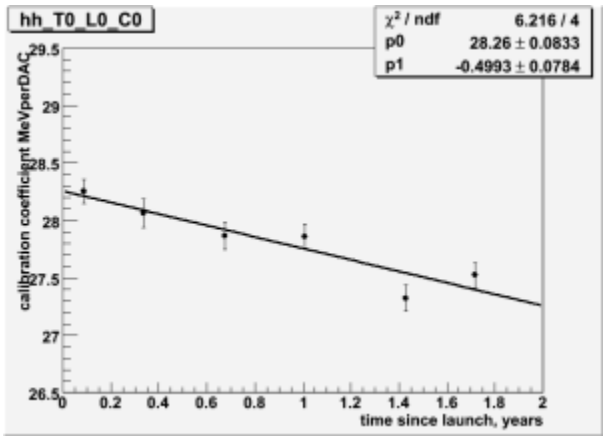
To correct the data already processed possible solution is to introduce energy correction to reconstructed energies linear with time.

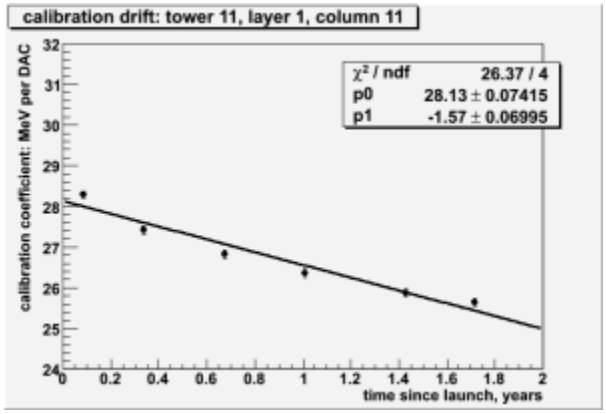
The evolution of calibration coefficients for each individual crystal since launch was fitted by linear function, the slopes obtained from these fits for all crystals are shown on the following histogram:

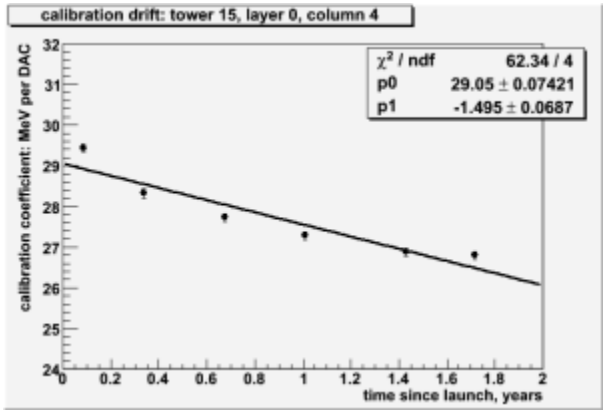


As one can see, the spread of these slopes are very substantial and much bigger than the staistical error (~0.2%).

The time eveolution of the calibration coefficient for typical channel (tower=0, layer=0, col=0) and two channels from the "left tail" of the histogram (tower=11, layer=1, col=11 and tower=15, layer=0, col=4) are show below:







It is evident that for the crystals with big change in calibration the evolution is not linear with time.

The fact that the calibration coefficients evolve differently for different crystals and in general not linearly with time requires that we use up-to-date set of calibration coefficients for pipeline processing.