Review of applications done and on-going with the Laser(I)

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Outline

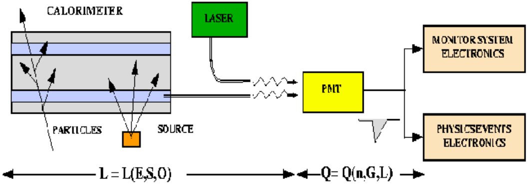
We try to list and summarize the work done with the laser(I) up to now; two main aspects are under investigation:

- PMT gain monitoring (the Pisa or statistical method)
  - idea of the method
  - some results
- the laser in the gap
  - the idea
  - MBTS studies
  - gap-and-crack scintillator studies

PMT gain monitoring using a statistical method

The Laser system

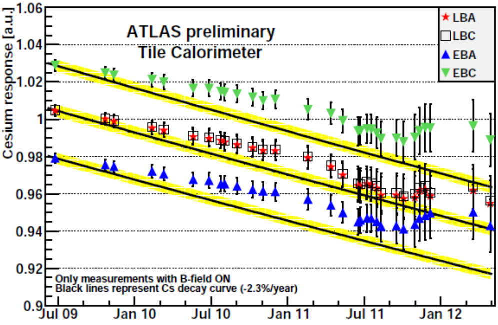
- the TileCal Laser system is used to calibrate part of the read-out chain
- Nino and Vincent pointed out a way to monitor the PMT gain



- pros:
  - the method depends on PMT mainly
  - the laser amplitude is reconstructed in pC, so the method is independent of Cesium constants
  - the laser depends on the CIS constants, but we use a workaround.
- cons:
  - sensible to everything between Coimbra-Box and the PMTs
  - our laser is not a 100% coherent light source
  - gain is sensible to bias in the fit method
  - it's very hard to extract the laser light properties

Cesium calibration and decay curve

Laser results can be compared with the Cesium response:



- Cesium response is affected by the Cesium decay curve
- Sasha already showed deviations from the expected theoretical behaviour
- when comparing gain with the Laser to gain with the Cesium, we subtracted for the Cs decay effect
- remaining deviations can be checked with the Laser

Statistical method

The PMT gain is related to the optical properties of the light in input and to the charge distribution in output:

$$G = \frac{1}{e}\left(\frac{Var(q)}{\bar{q} \cdot f} - \bar{q} \cdot \kappa\right)$$

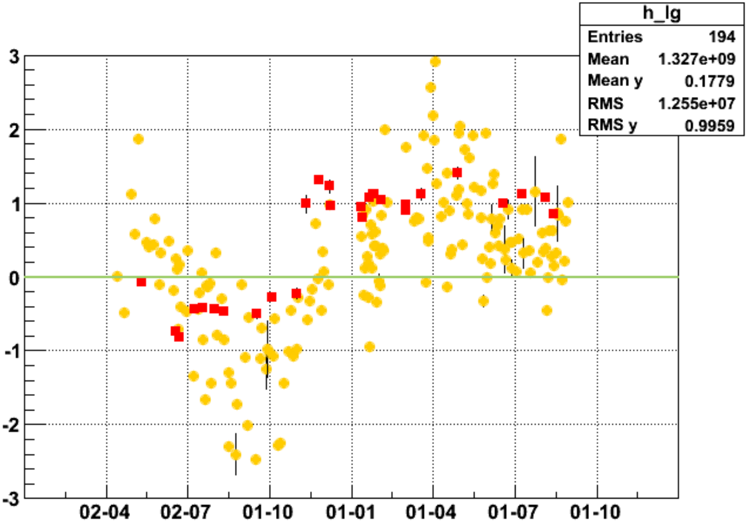
- e: electron charge
- $\bar{q}$: charge distribution mean value
- $Var(q)$: charge distribution variance
- f: eccess noise factor; the multiplication process is not a pure Poissonian process
- κ: incoming light statistical properties

- this formula is slightly different from what we were using before; this takes into account a further correction
- see this page for more information on the statistical method

Preliminary results

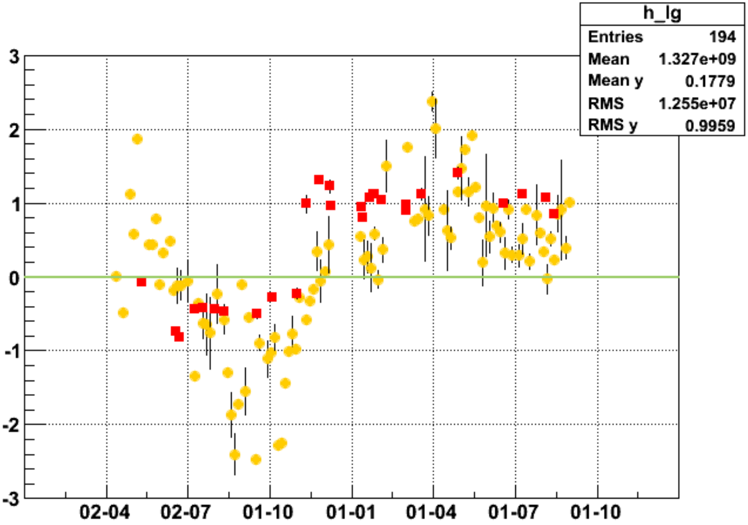
- the gain variations have been evaluated for a single channel, integrated over 5 modules, during time
- the same for Cesium runs
- starting period: April 2011
- end period: a few weeks ago (August 2012)
- both Laser and Cesium are normalized to the first run (first point)
- other methods: Clermont-Ferrand
  - normalize PMT gain to another PMT
  - unpredictable results in case of reference PMT condition variations
  - very precise, but without statistical errors
  - they need to split the runs in periods and normalize each time to the Cesium

1 channel, 1 day



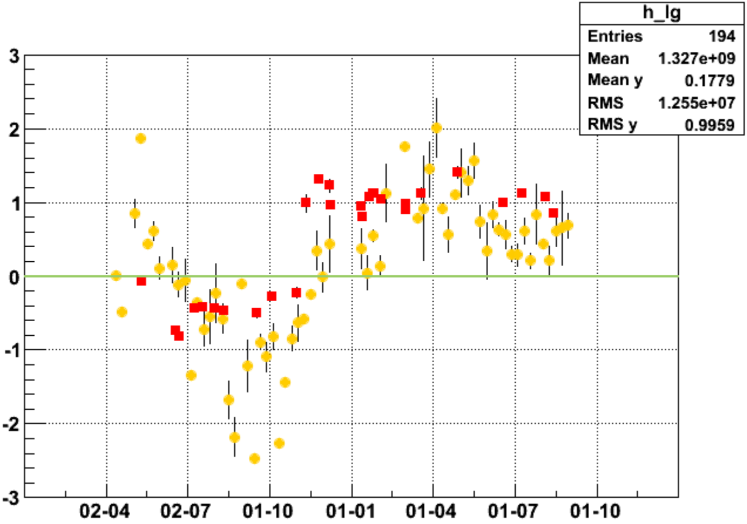
LBA01, pmt 5

1 channel, 4 days



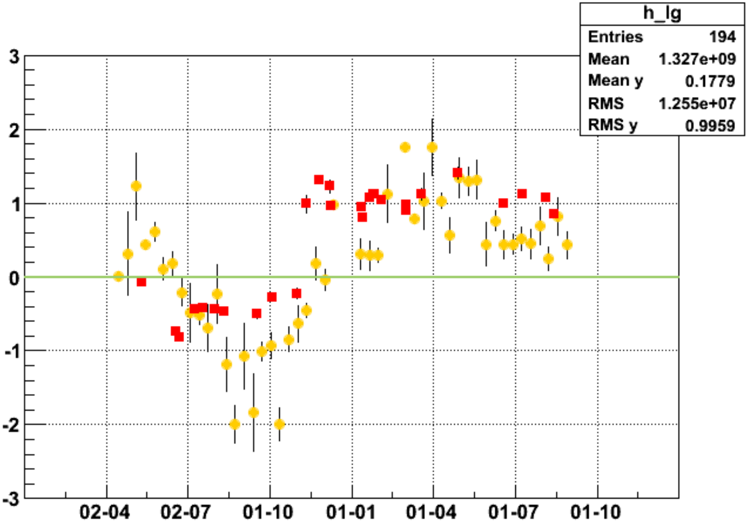
LBA01, pmt 5

1 channel, 7 days



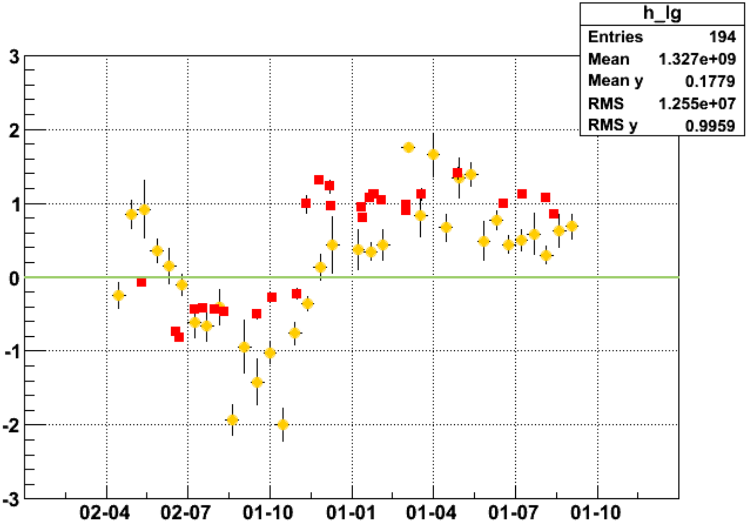
LBA01, pmt 5

1 channel, 10 days



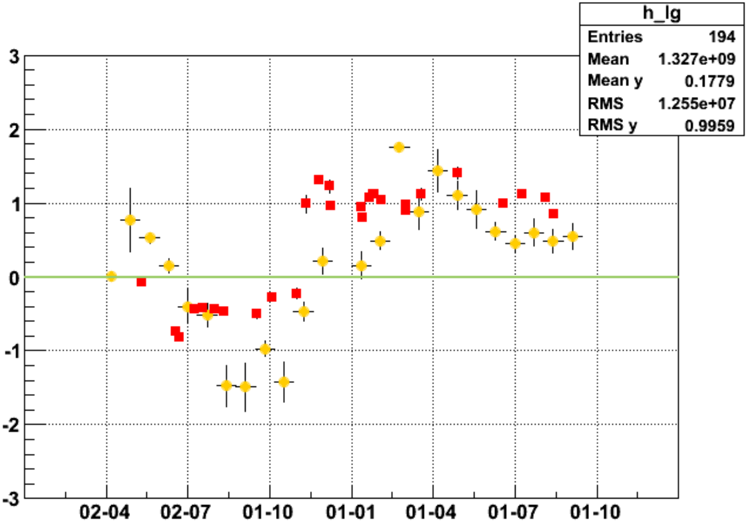
LBA01, pmt 5

1 channel, 14 days



LBA01, pmt 5

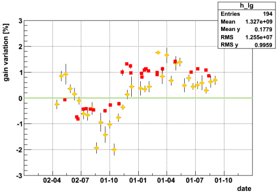
1 channel, 21 days

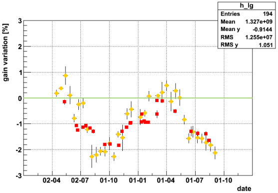


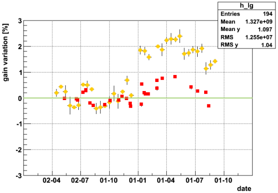
LBA01, pmt 5.

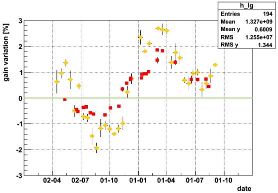
Statistical fluctuactions are reduced integrating over time

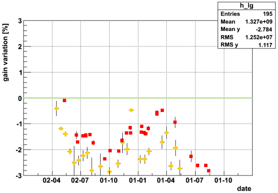
5 channels, 1 day (I)





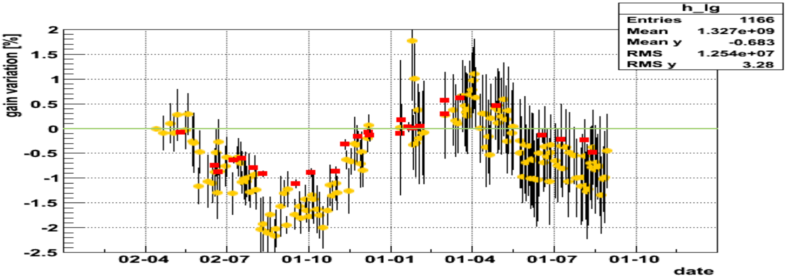


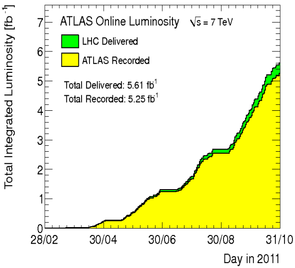


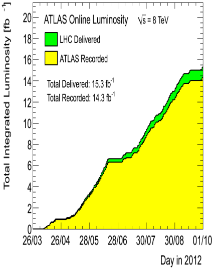


LBA01, LBA02, LBA03, LBA04, LBA07, pmt 5.
What if putting all together?

5 channels, 1 day (II)







Next steps

- compare with other channels
- comparison with Clermont-Ferrand method
- correctly estimate errors

Laser in the gap

InterBunch: ideas for analysis

During data-taking, it is possible to fire the Laser in the PMTs in empty bunches. If the event is accepted by the L1 trigger, all the Tile PMTs are illuminated.

- Laser light is emitted about 3 microseconds far from Physics, at 1 Hz nominal rate; recorded rate: ~ 0.2 Hz
- High Gain (signal spreads between 2 and 10 pC)
- very important: stuck bits may be neglected!!
- apart fibers and voltage problems, recontructed signals should be the same
- using Fit/OF2-Iter methods, so do not care about corrections and timing settings
- dedicated runs$\rightarrow$dedicated BCID, so it should be easy to check
- potentially, it is a very powerfull online monitor-profiler for TileCal

InterBunch: pros and cons

Pros:

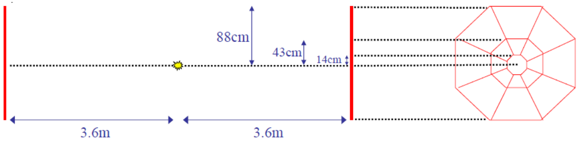
- online monitor for TileCal
- if TileCal has a problem, this should affect data and Laser runs
- Laser input light is (should be) under control
- it would be nice to have an online Laser tool (another one) for the shifter

Cons:

- low statistics: now gain monitoring with the Pisa method!
- rate is reduced by L1 acceptance by a factor ~ 5
- each time, we need databases access and so on...

Application for the MBTS

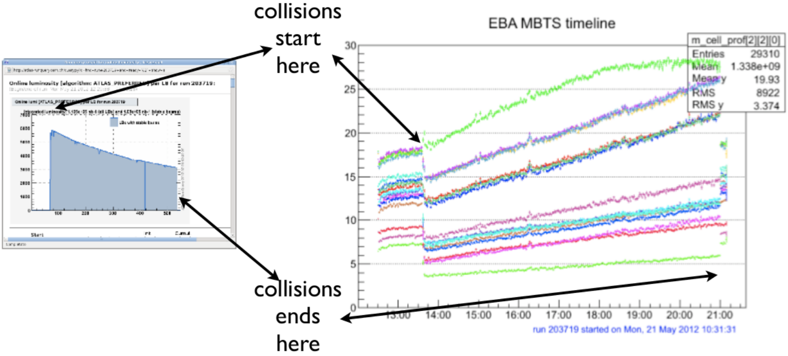
MBTS: Minimum-Bias Trigger Scintillator
32 scintillating plates mounted on LAr endcap cryostats.



- inner: $2.12 < |\eta| < 2.83$
- outer: $2.83 < |\eta| < 3.85$
- MIP deposit: 7 MeV

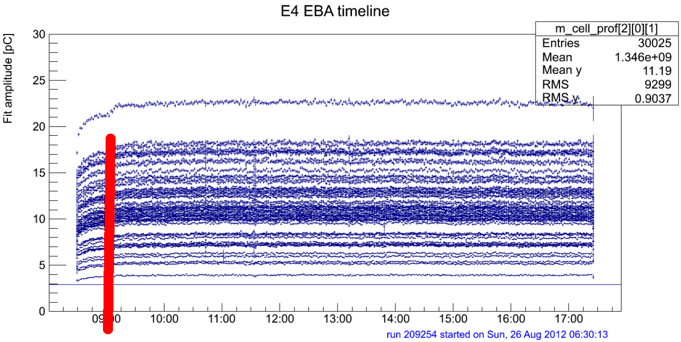
- high η: affected by high rate signals
- clear relation between Stable Beams condition and jumps in Laser amplitude for almost all 2012 runs with Stable Beams
- a jump in amplitude corresponds to a jump in pedestal
- spikes in Luminosity $\rightarrow$ spikes in Laser amplitudes
- tested both Fit and OF2-Iter methods; same results
- Laser and Physics have about 5 μs separation (raw estimate)
- no for normal cells
- something strange seen also in a 2011 run

Stable beam-MBTS



Other behaviours have been seen: MBTS response can have a different trend in different runs, but always related to the stable beam flag.

E4 behaviour



- red line: Stable Beam
- we start seeing the same problem in E3, E4 scintillators
- the response change is $\sim$ 1.5 pC over 20 pC, less than 10%
  - 20 pC corresponds rawly to 20 GeV in a scintillator: a huge amount of energy
  - a MIP in these cells releases $\sim$ 10 MeV
  - this may suggest that Physics is not affected
  - up to now, the question has no answer; the Egamma group does not see any effect

Conclusions

The Laser has been proved to be potentially a very interesting tool:

- calibration itself
- reprocessed Laser Calibration runs: PMT gain studies
- normal Laser Calibration runs: ramps, other studies (EM modules)
- Physics runs: Laser in the gap
- E3, E4: Physics seem ok, we are keeping an eye on these cells

Some points are very difficult to understand:

- systematics
- many things before Coimbra-box and the PMT are unknown
- for some studies, it is very difficult to find a reference
- Clermont-Ferrand people hold a lot of information, we should interact more

So we hope that Fabrizio will help on understanding the Laser system and improve the knowledge for the LaserII.