DVCS collaboration meeting

16 January 2017

Calorimeter π^0 calibration update

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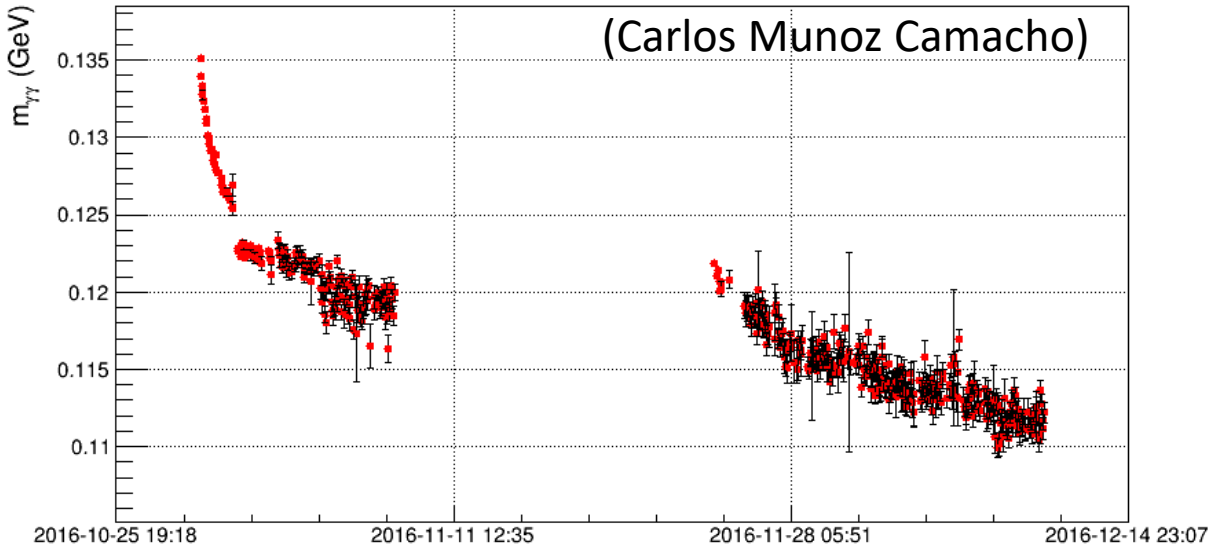
Reminder

- Monitors fast darkening of the calorimeter
- Can be done very often (~once a day) to update correction coefficients
- Uses π^0 produced during production run (no dedicated run needed)



Reminder – calibration process

- Compute energy correction coefficients to optimize mean value and resolution of π^0 invariant mass reconstruction by computing extremum of:

$$F = \sum_{i=1}^{N} (m_i^2 - m_0^2)^2 + 2\lambda \sum_{i=1}^{N} (m_i^2 - m_0^2)$$

m_i : reconstructed invariant mass

m_0 : π^0 mass

λ Lagrange multiplier

$\sum_{i=1}^{N} (m_i^2 - m_0^2)^2$ Measures the width of the reconstructed mass peak

$2\lambda \sum_{i=1}^{N} (m_i^2 - m_0^2)$ Embodies the constraint $\langle m_i^2 \rangle = m_0^2$

Reminder – calibration process

- The gains of each blocks are corrected by correction coefficients ε_k:

$$E_{ji}^{(k)} \rightarrow E'^{(k)}_{ji} = (1 + \varepsilon_k) E_{ji}^{(k)}$$

k: block number

j: shower number

i: event number

$E_{ji}^{(k)}$: energy of block k, involved in shower j, event I

- Compute ε_k by computing $\dfrac{\partial F'}{\partial \varepsilon_k} = 0$

Reminder – calibration process

$$\frac{\partial F'}{\partial \varepsilon_k} = 2\sum_{i=1}^{N}(m_i'^2 - m_0^2)\frac{\partial m_i'^2}{\partial \varepsilon_k} + 2\lambda\sum_{i=1}^{N}\frac{\partial m_i'^2}{\partial \varepsilon_k}$$
$$= 2\sum_{i=1}^{N}\left(m_i^2 - m_0^2 + \lambda + \sum_{k'}\varepsilon_{k'}\frac{\partial m_i'^2}{\partial \varepsilon_{k'}}\right)\frac{\partial m_i'^2}{\partial \varepsilon_k}$$
$$= 0$$

Solution:

$$\varepsilon_k = [C^{-1}]_{kk'}(D - \lambda L)_{k'}$$

$$C_{kk'} = \sum_{i=1}^{N}\left(\frac{\partial m_i'^2}{\partial \varepsilon_k}\frac{\partial m_i'^2}{\partial \varepsilon_{k'}}\right)$$

$$D_k = -\sum_{i=1}^{N}\left((m_i^2 - m_0^2)\frac{\partial m_i'^2}{\partial \varepsilon_k}\right)$$

$$L_k = \sum_{i=1}^{N}\frac{\partial m_i'^2}{\partial \varepsilon_k}$$

$$B = \sum_{i=1}^{N}(m_i^2 - m_0^2)$$

$$\lambda = \frac{B + L^{\mathrm{T}}C^{-1}D}{L^{\mathrm{T}}C^{-1}L}$$

$$\frac{\partial m_i'^2}{\partial \varepsilon_k} \simeq m_i^2\frac{E_{ji}^{(k)}}{s_j}$$

s_{ji} = shower energy

Reminder – calibration process

- Iterative process
- Computation stops when $\varepsilon_k \rightarrow 0$
- In reality, you choose the number n of iterations:
  - Minimum: 4 computation iterations
  - Recommended: 8 computation iterations
- Finally: Correction coefficients are $(1+\varepsilon_k(\text{iteration1})) * (1+\varepsilon_k(\text{iteration2})) *\ldots ...*(1+\varepsilon_k(\text{iteration n}))$

Minimum statistics needed

- Estimation using π^0 simulation with ~kin48_2 parameters:
  - ~1/4 day of data with 15 μA beam (2 million CODA events ~ 4k π^0 events):
    - ±4% error for “central” blocks
    - ±10-15% error for blocks “close” to the edges
  - ~1/2 day of data with 15 μA beam (4 million CODA events ~ 8k π^0 events):
    - ±2-3% error for “central” blocks
    - ±6-8% error for blocks “close” to the edges
  - ~1 day of data with 15 μA beam (8 million CODA events ~ 16k π^0 events):
    - ±1-2% error for “central” blocks
    - ±4-5% error for blocks “close” to the edges
- Experience from Fall 2016:
  - Simulation may be too optimistic (π^0 distribution across calorimeter surface, background, very dark blocks, etc…)

Time consumption issue

- Several concatenated “for” loops + 8 iterations + huge statistics needed = Very long to run
  - Longer than allowed time on computation farm.
- Acceleration by pre-selecting π^0 events candidates (millions → a few 10k events).
  - ~1h to run pre-selection + 20min for calibration process
- However: pre-selection + statistics need = issue with blocks joining the dark side.

The Dark block problem

- Dark block = few events (energy deposit cut)

→ not enough statistics for the calibration

- At computation iteration 2: new (temporary) correction coefficient $(1+\varepsilon_k)$ should increase the gain.

→ more statistics

BUT: because of pre-selection, number of π^0 events already limited

→ not enough statistics → calibration fails

- Need to do {pre-selection+calibration} a 2nd time, starting with coefficients from 1st time.
- May need a 3rd time if block very dark.
- Still faster than if no pre-selection at all.

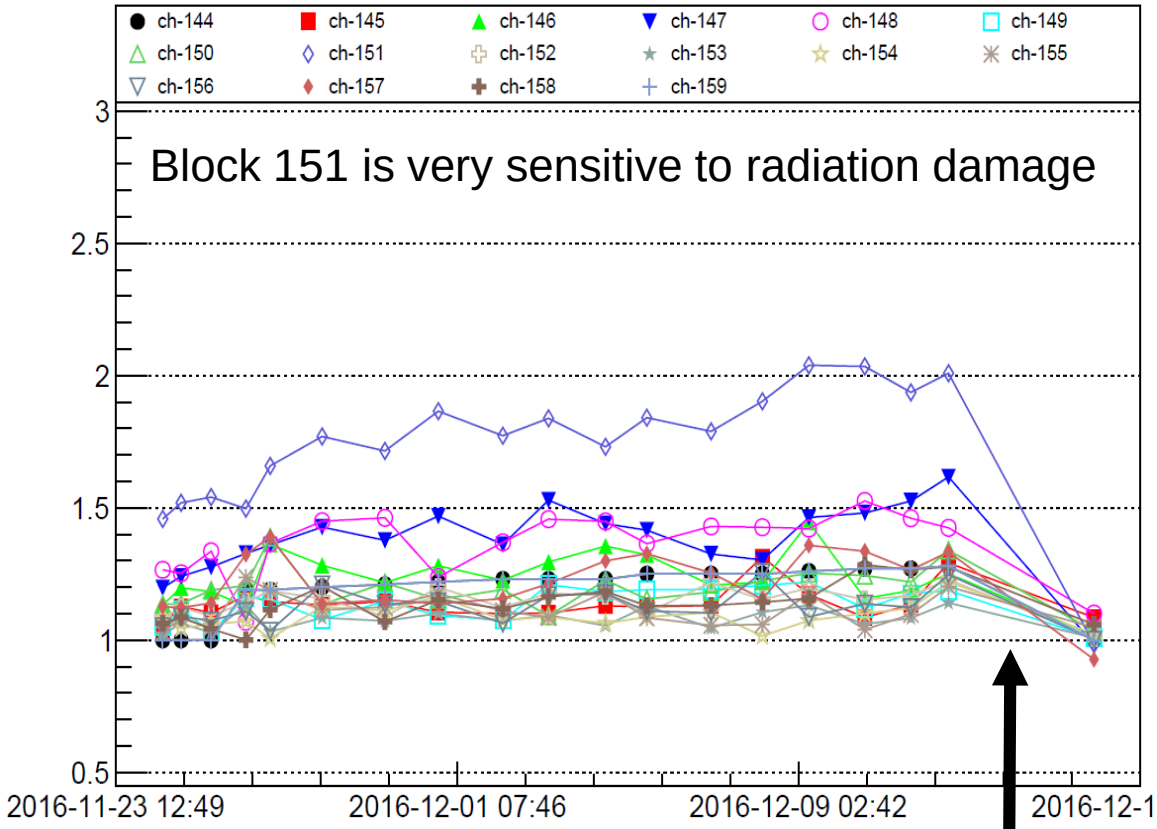
(caution)

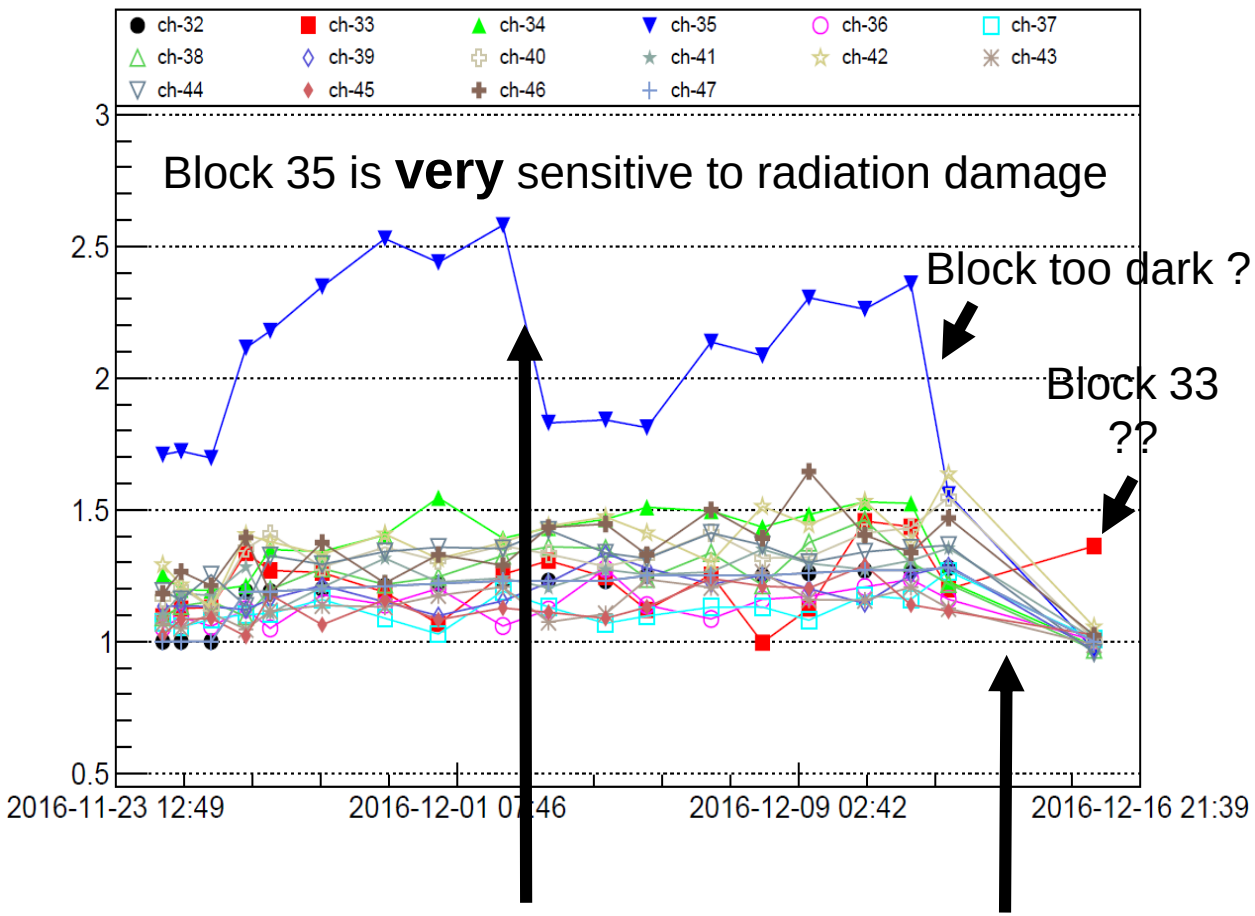
- Do not confuse:
  - {pre-selection+calibration} iteration
  - computation iteration
- calibration process computes correction coefficients using several computation iterations (minimum: 4, recommended: 8)
- We need several (2 or maybe 3) {pre-selection+calibration} iterations to get “correct” values for the correction coefficients.

Limitations with the calorimeter edges

- π^0 calibration does not work for the edges of the calorimeter (may lead to infinite or negative coefficients)
- Artificially lock correction coefficients of blocks at the edges at a fixed value:
  - 1
  - Mean value of all the other coefficients
    - From previous set of runs used
    - From previous {pre-selection+calibration} iteration
- Blocks near blocks on the edges: less reliable results.

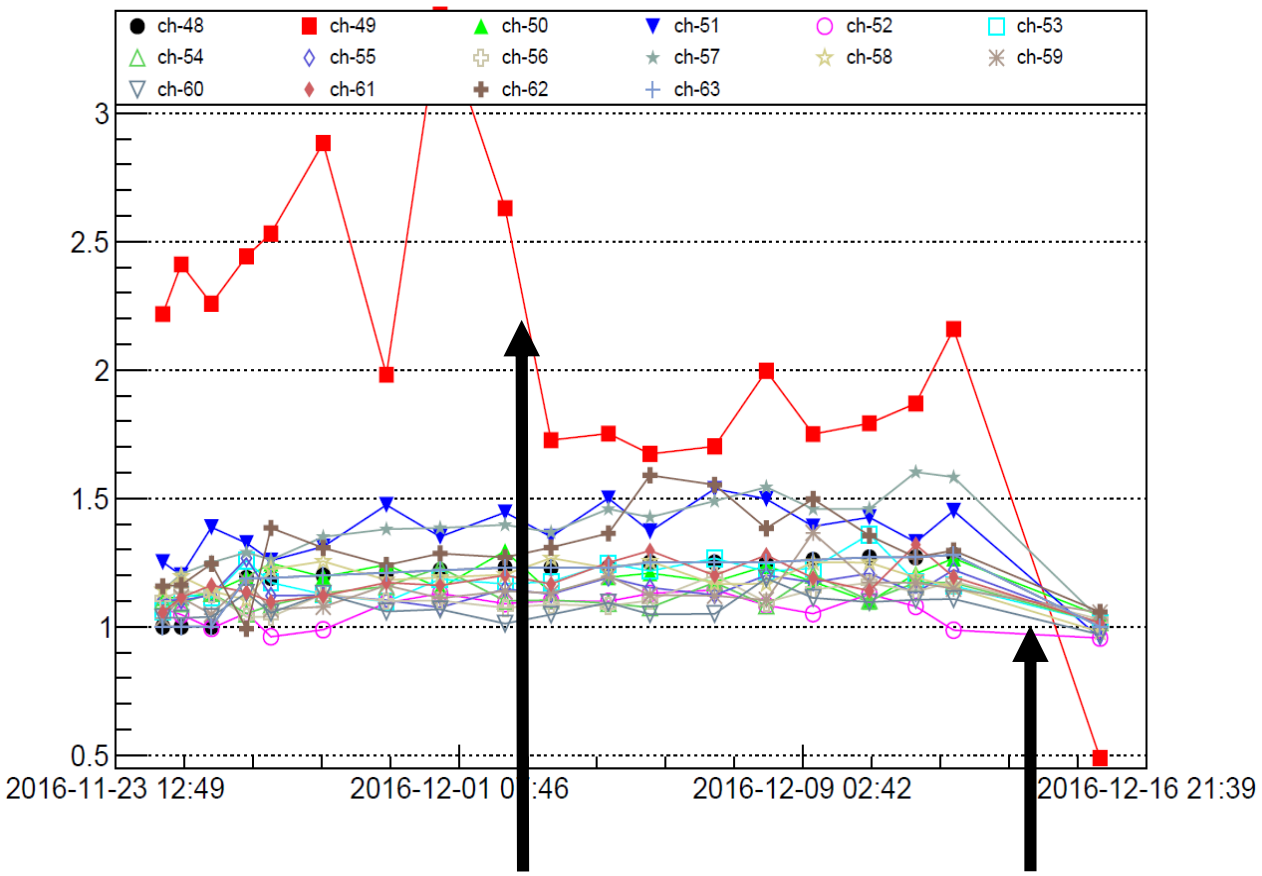
Some results from Fall 2016





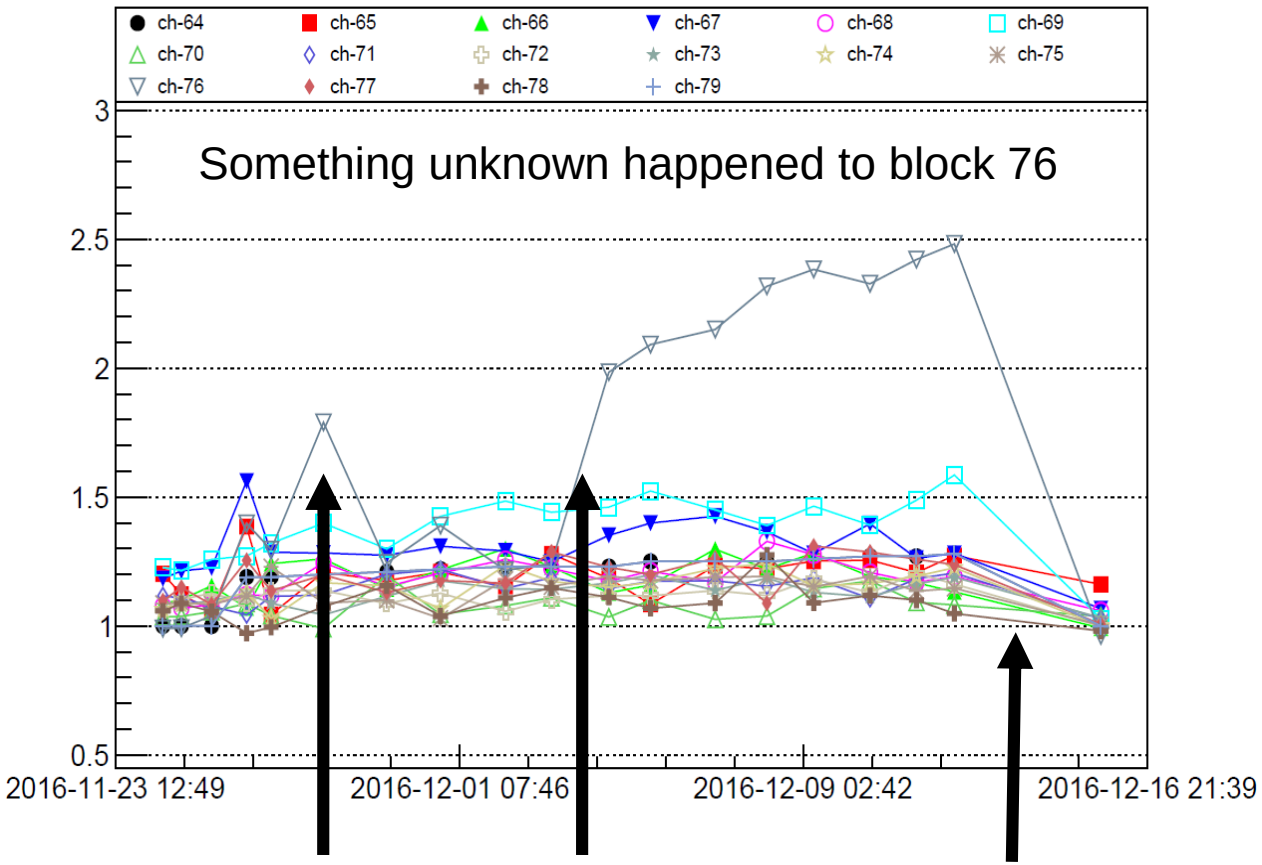
Some results from Fall 2016

Block 49 is so dark that the calibration has trouble working



Increased HV of block 49

elastic calibration

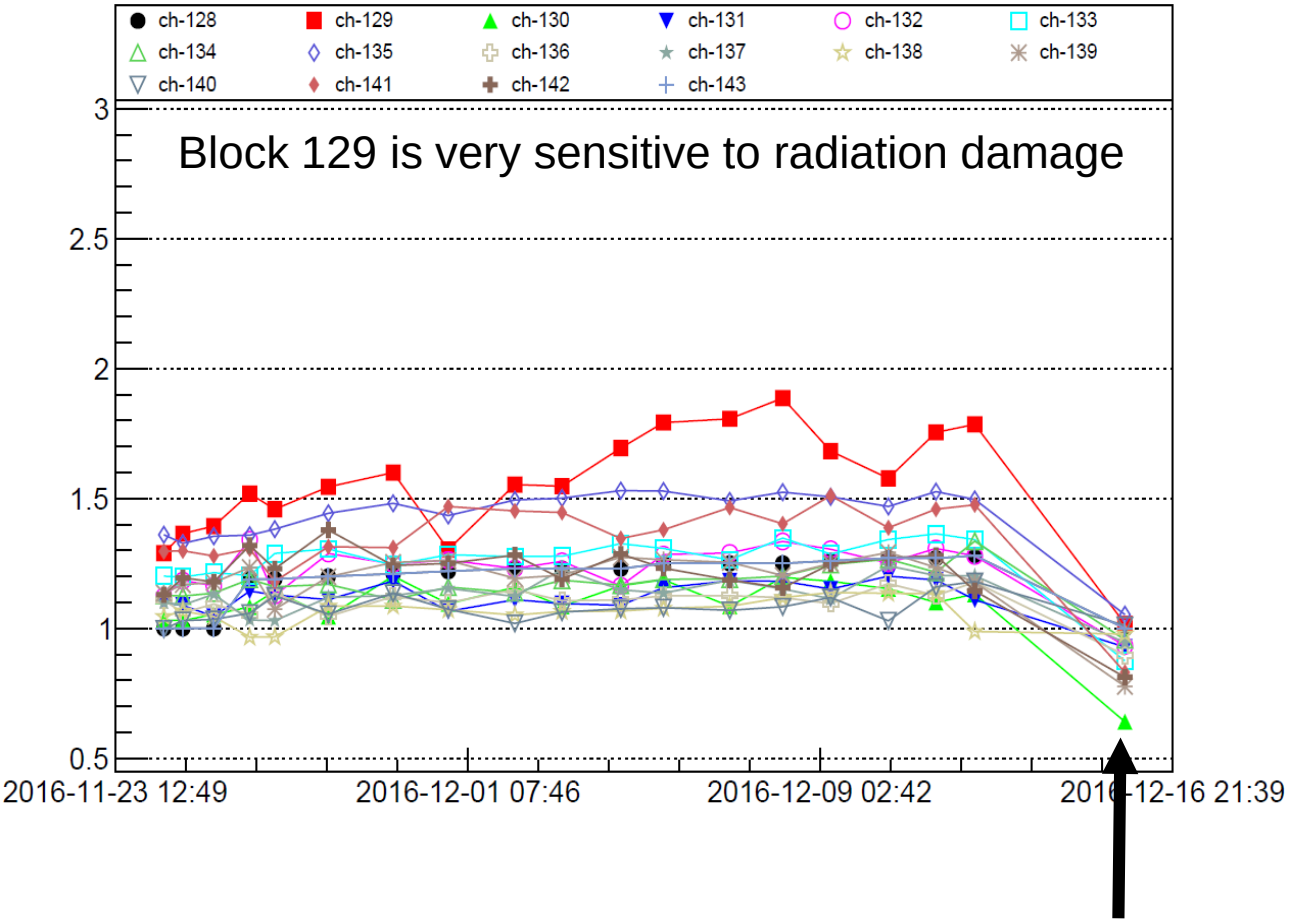


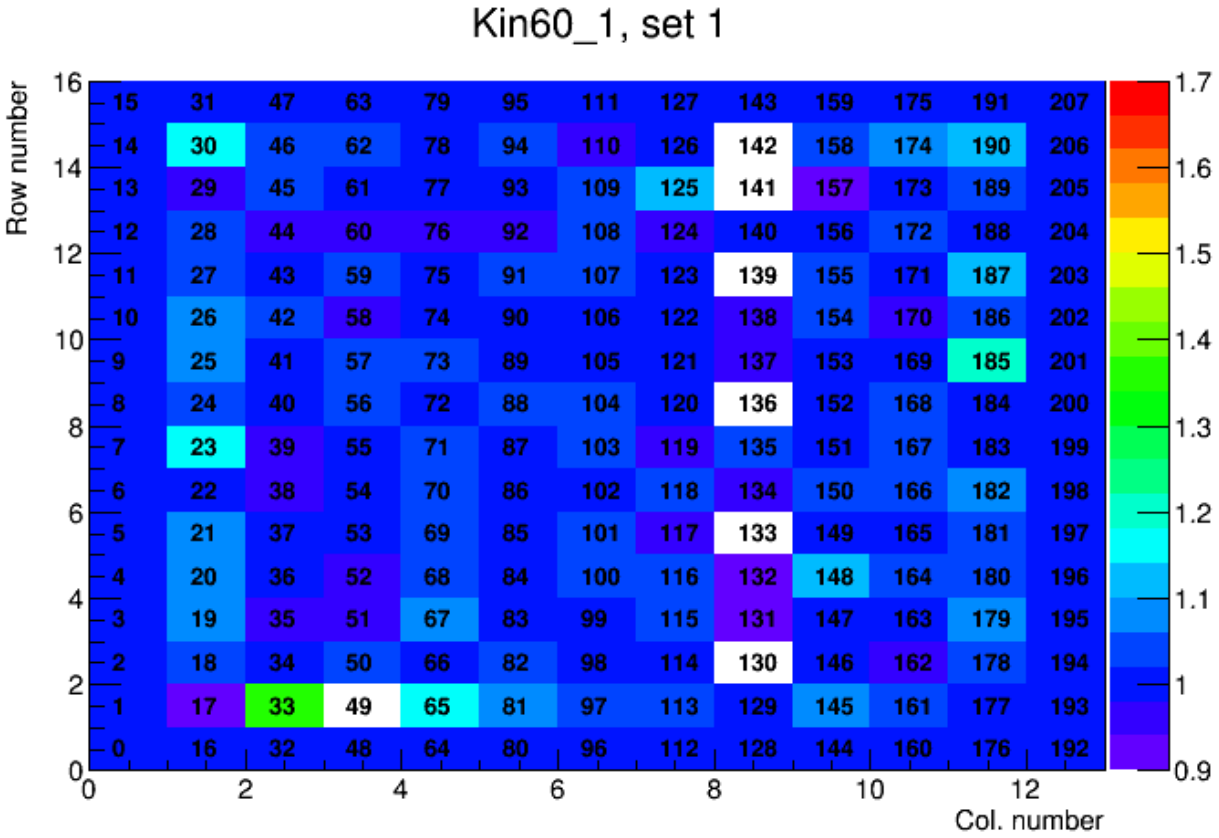
calibration error ?

PMT dying ?

elastic calibration

Some results from Fall 2016

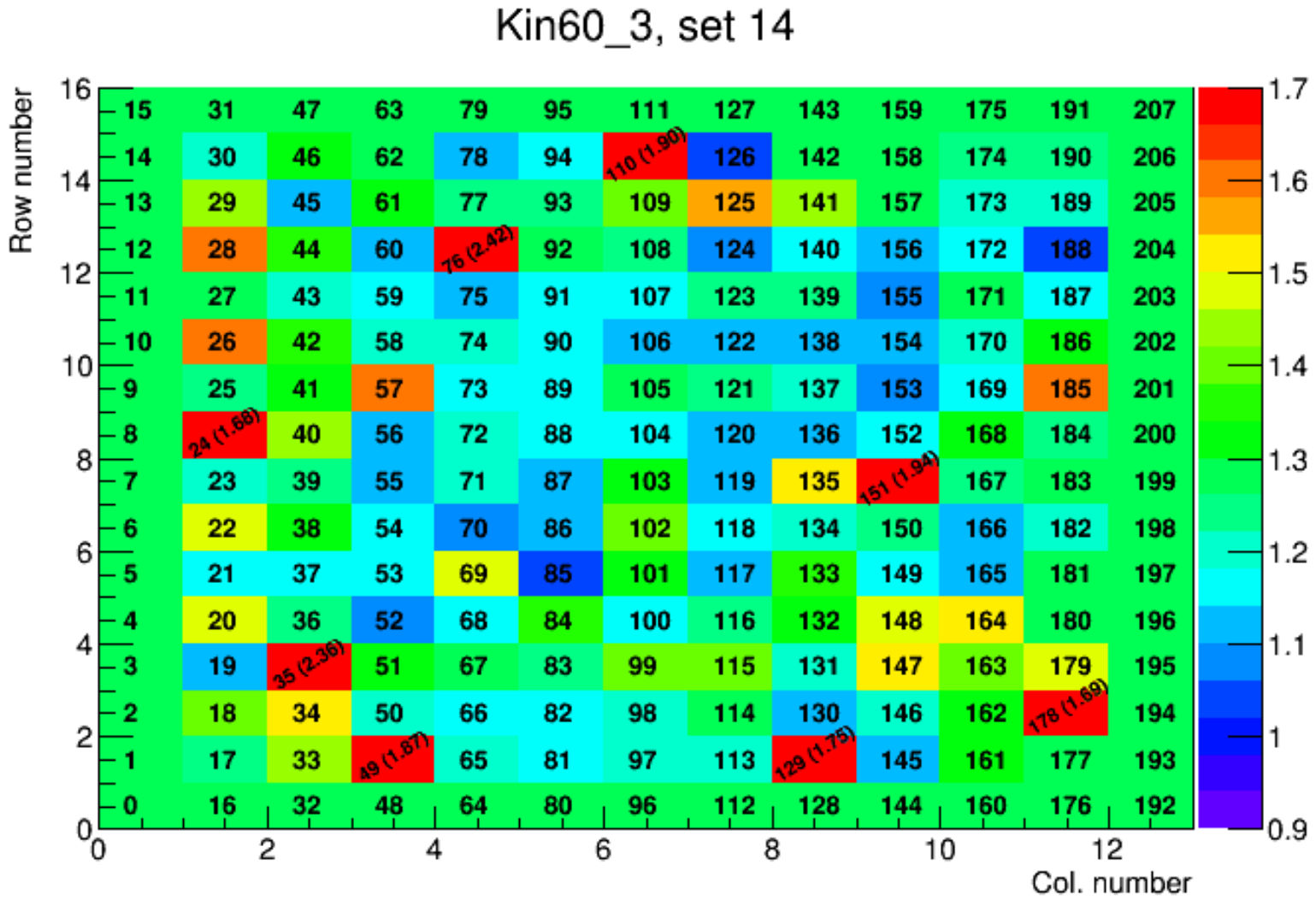




Issue with elastic calibration ?

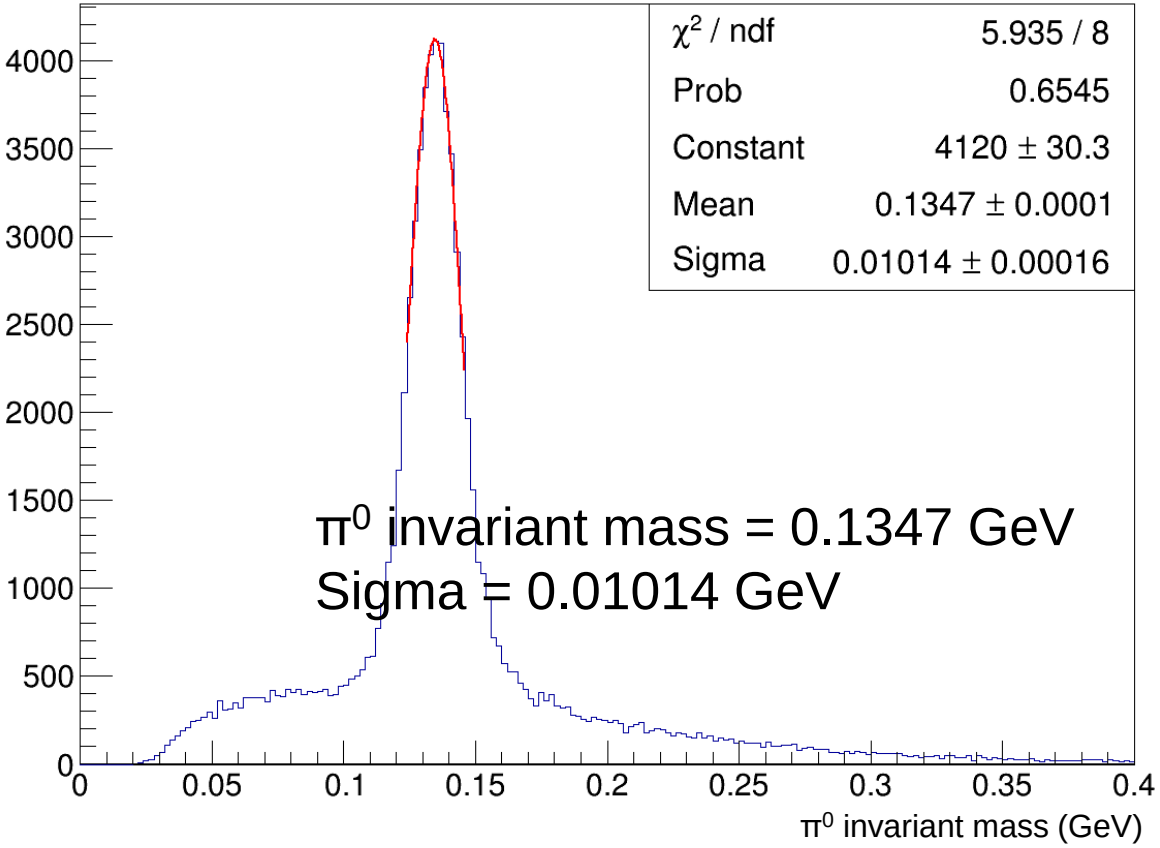
Some results from Fall 2016

Blocks with biggest issues: 24, 35, 49, 76, 110, 129, 151

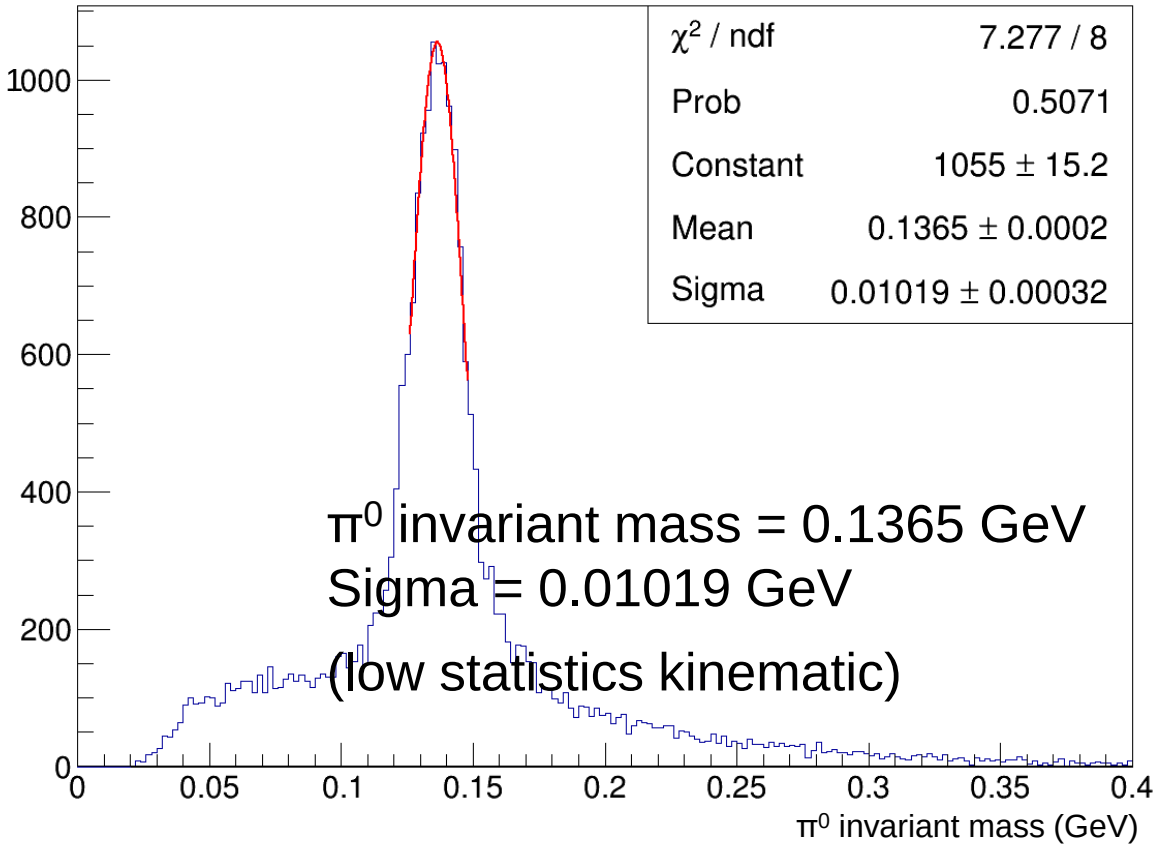


Some results from Fall 2016

November 24-25

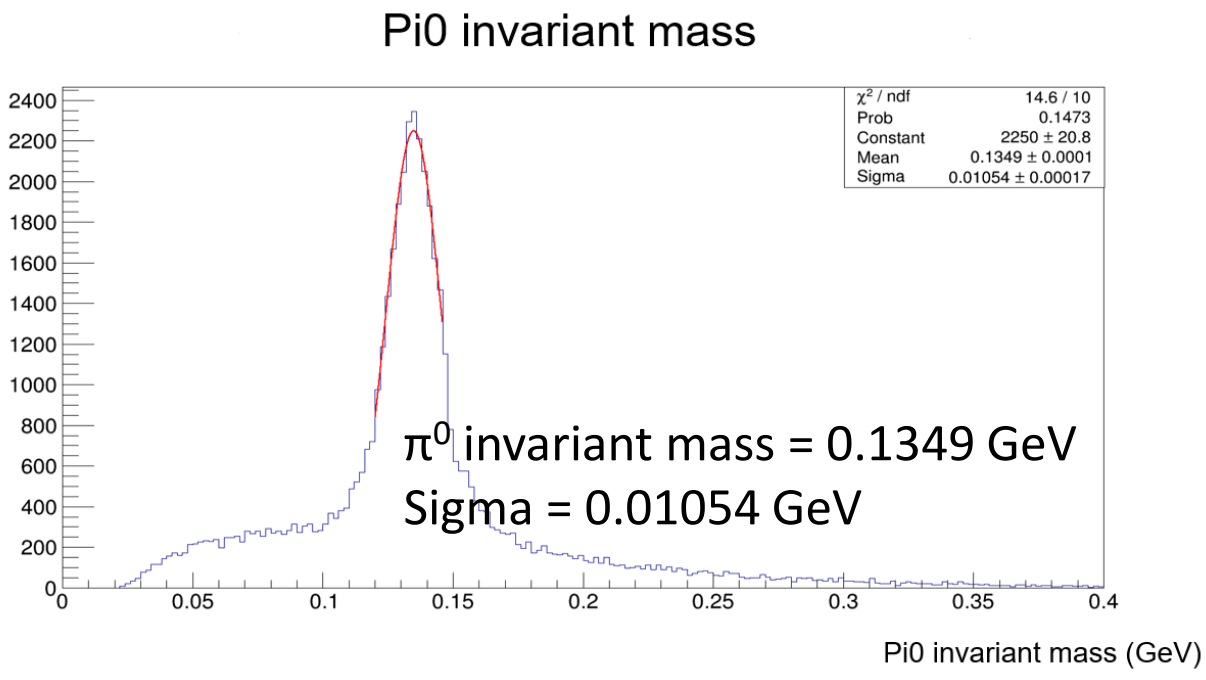


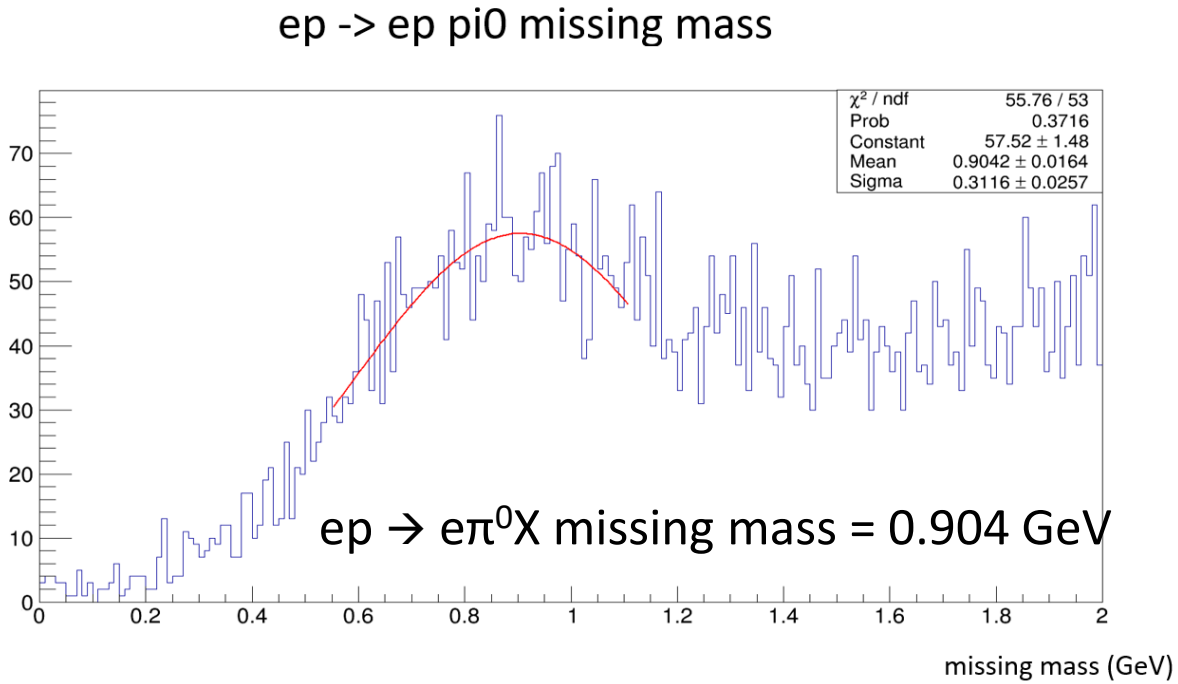
December 10-12



- π^0 calibration does work well despite limitations.

Some results from Fall 2016





Calibrations done a few days before elastic calibration (blocks loss of gain at its worse).

Status and outlook

- π^0 calibration working

- To do:
  - Fix Dark block issue (test 3rd {pre-selection+calibration} + use more statistics).
  - Test: use more statistics to improve precision / remove fluctuations.
  - Test: decrease energy deposit cuts even more to increase π^0 statistics
  - Make lists of sets of runs to use for the calibrations.
  - Macro for mass calibration of production runs almost ready: need to implement latest modifications from Fall 2016 (edges coefficients values, 2nd and maybe 3rd iteration of {pre-selection+calibration}).
  - (later) Copy output correction coefficients files to SQL database.