

TOF calibration

AMS-TOF Group

presented by Lucio Quadrani

CERN, March 2012

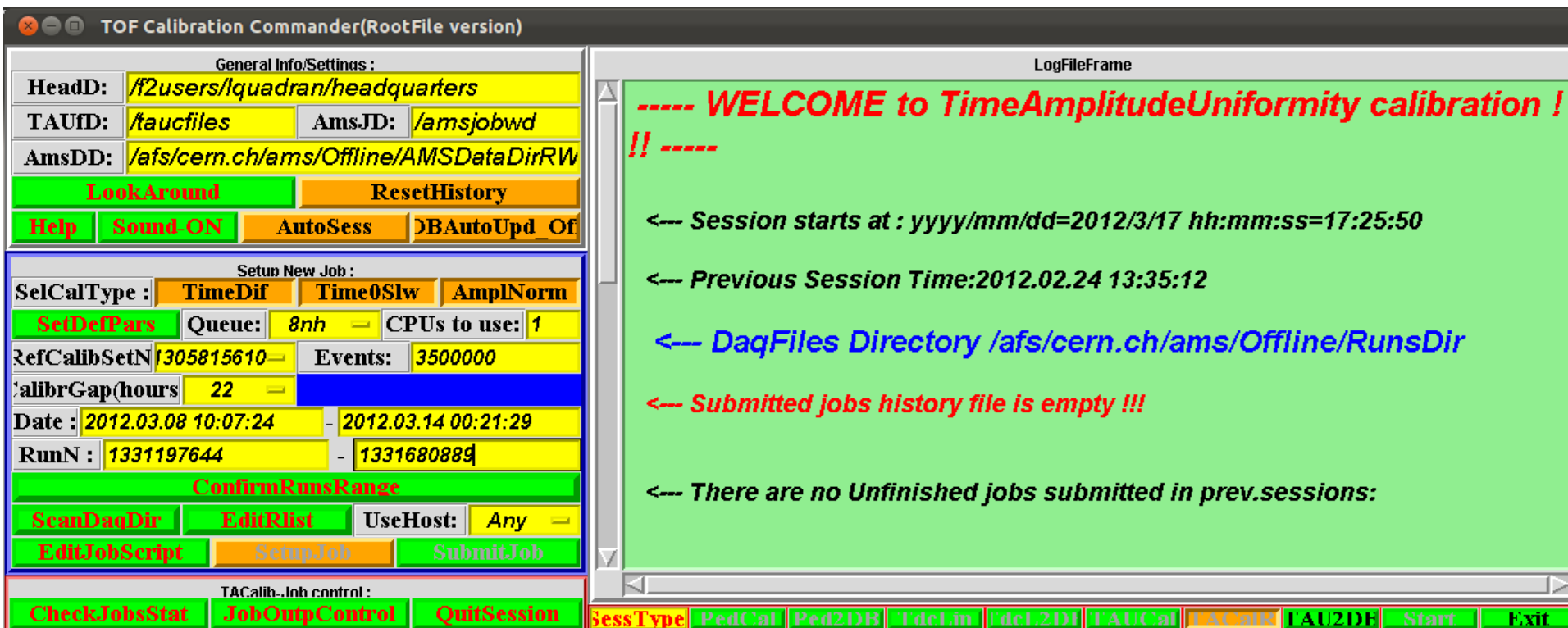
1. Time calibrations:

- slewing-time zero calibration
- velocity-time delay calibration

2. Charge calibrations:

- anode and dynode amplitude calibration

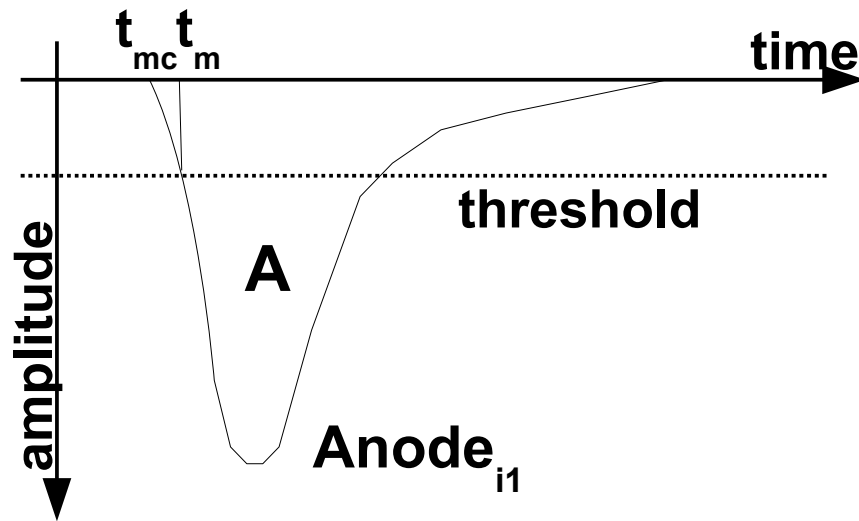
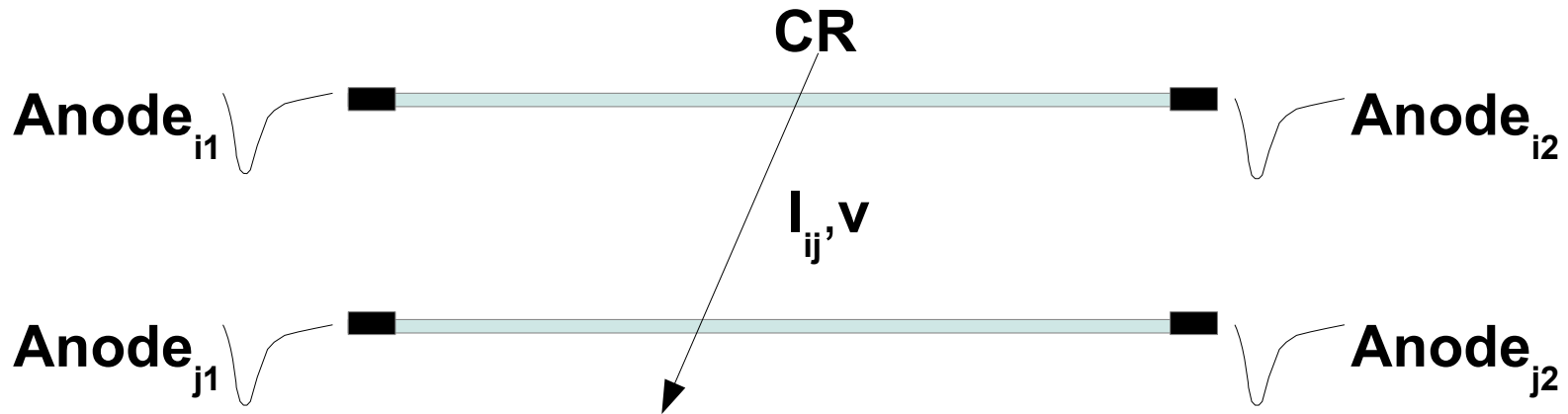
TOF Calibration Commander (software developed by E.Choumilov).



Each calibration is performed daily, using $3.5 \cdot 10^6$ triggers randomly chosen on two hours of data. 22 hours gap between 2 calibrations.

Particles used: protons from top of AMS.

All TOF calibrations are stored into the AMS DataBase (details in the Twiki).



$$t_{mc} = t_m + s/\sqrt{A}$$

Considering two different counters from different layers:

$$\left(\frac{t_{m_1} + \frac{s_{1i}}{\sqrt{A_1}} + t_{m_2} + \frac{s_{2i}}{\sqrt{A_2}}}{2} \right)_i - \left(\frac{t_{m_1} + \frac{s_{1j}}{\sqrt{A_1}} + t_{m_2} + \frac{s_{2j}}{\sqrt{A_2}}}{2} \right)_j + \frac{l_{ij}}{v} + T0_i - T0_j = 0$$

Where:

- $t_{m1(2)}$ = measured time in counter side1(2)
- $A_{1(2)}$ = charge amplitude in counter side1(2)
- $s_{1(2)i(j)}$ = slewing parameter in counter i(j) side1(2)
- l_{ij} = particle track length between counters i and j (from Tracker)
- v = particle velocity (calculated using momentum and mass)
- $T0_{i(j)}$ = time-zero constant for counter i(j)

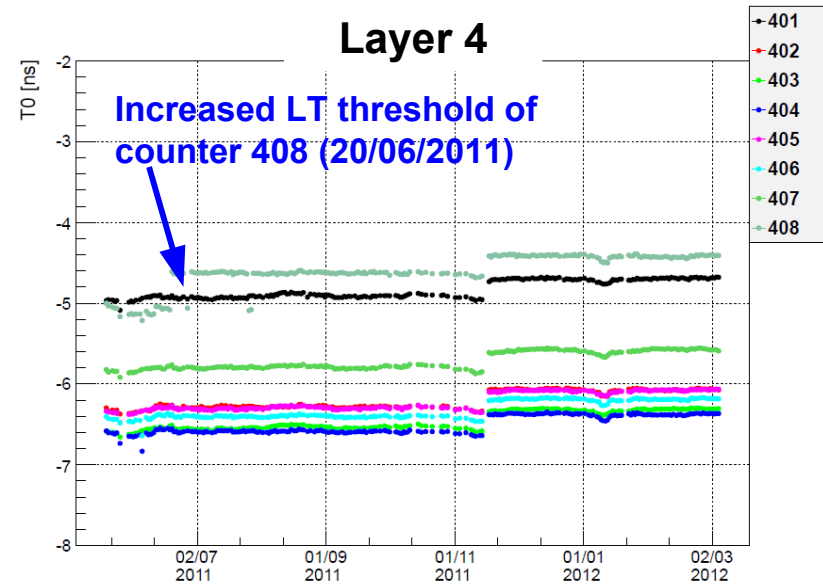
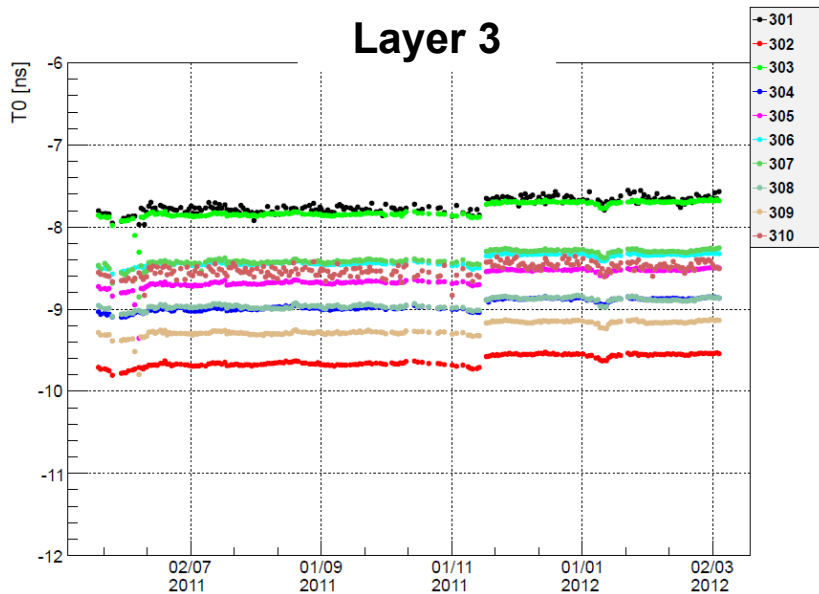
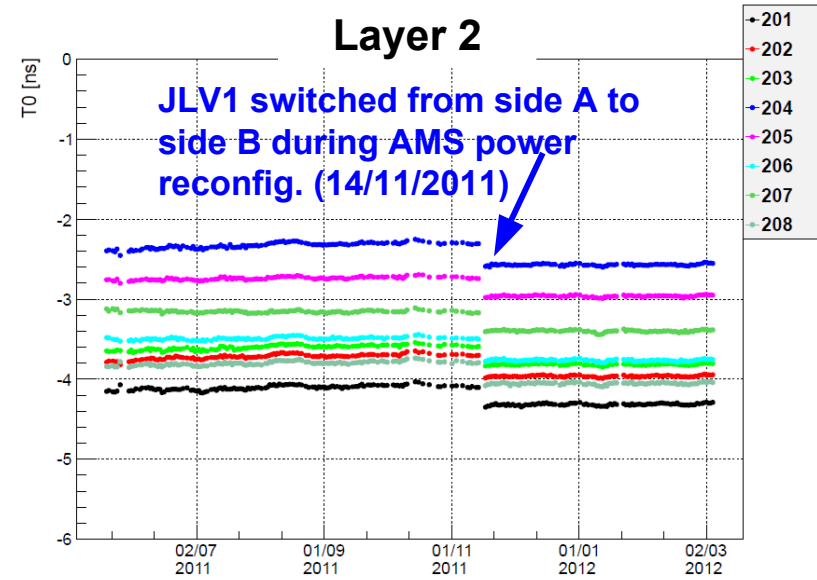
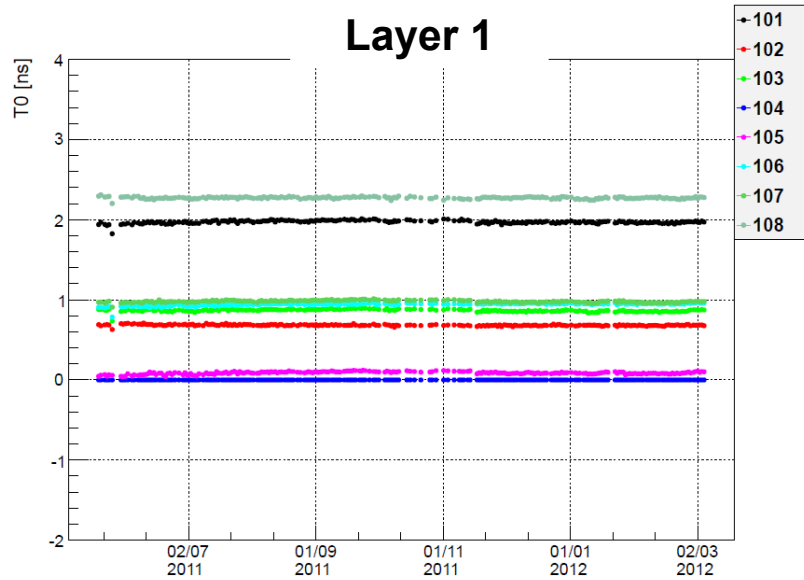
N.B. i,j are counters from different layers.

The slewing constants are the only parameters determined once for a long period of time (at least three months).

This is due to the fact that:

- a. the slewing effect is mainly determined by electronics (i.e. it is not affected by external variables like temperatures).
- b. lot of data is needed for the calibration (see following talk);

Time calibration – time zero constants



Counter 104 is taken as reference ($T0=0$)

Considering one counter:

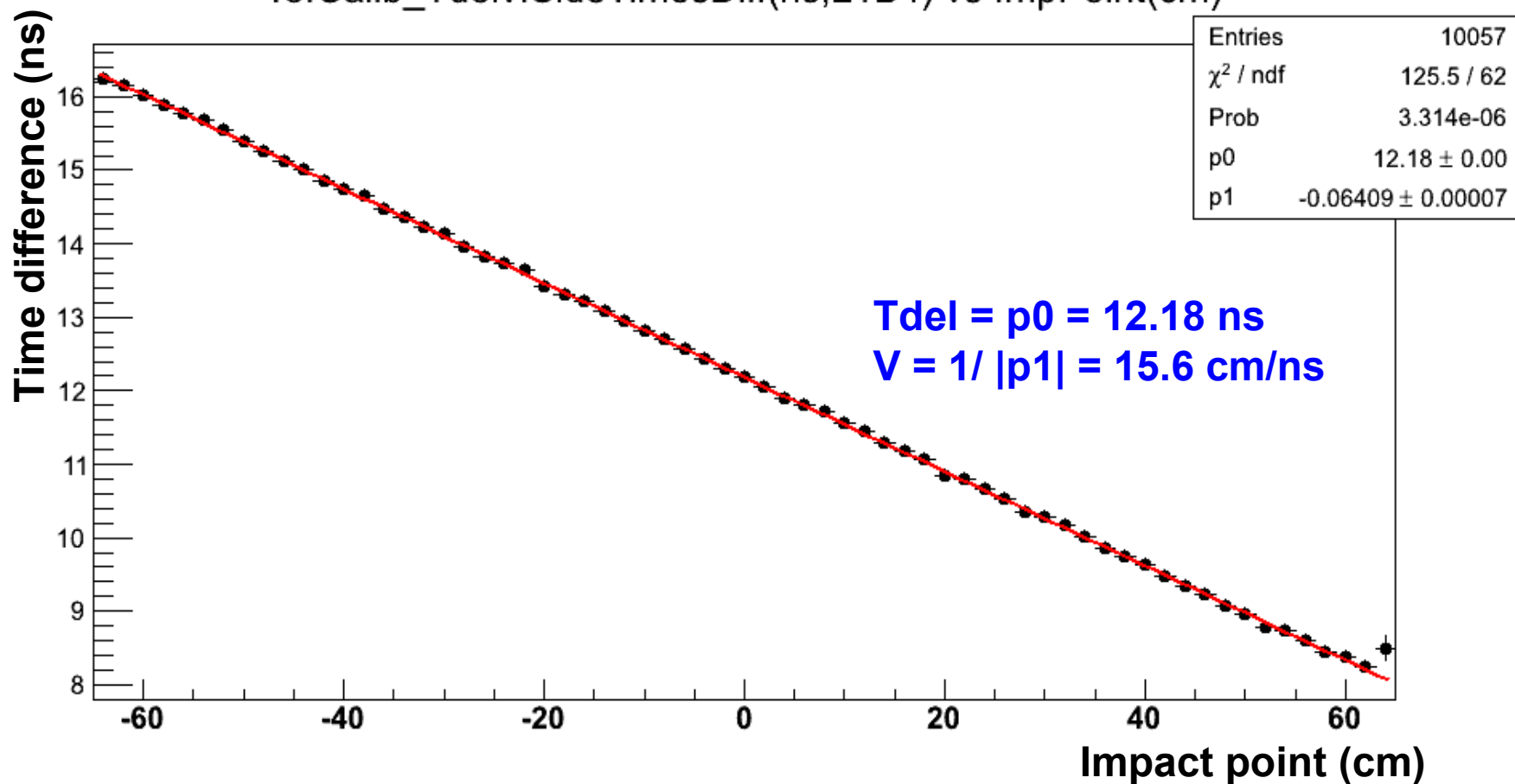
$$x = V \left(\frac{t_{m1} + \frac{s_1}{\sqrt{A_1}} - t_{m2} - \frac{s_2}{\sqrt{A_2}}}{2} + t_{del} \right)$$

Where:

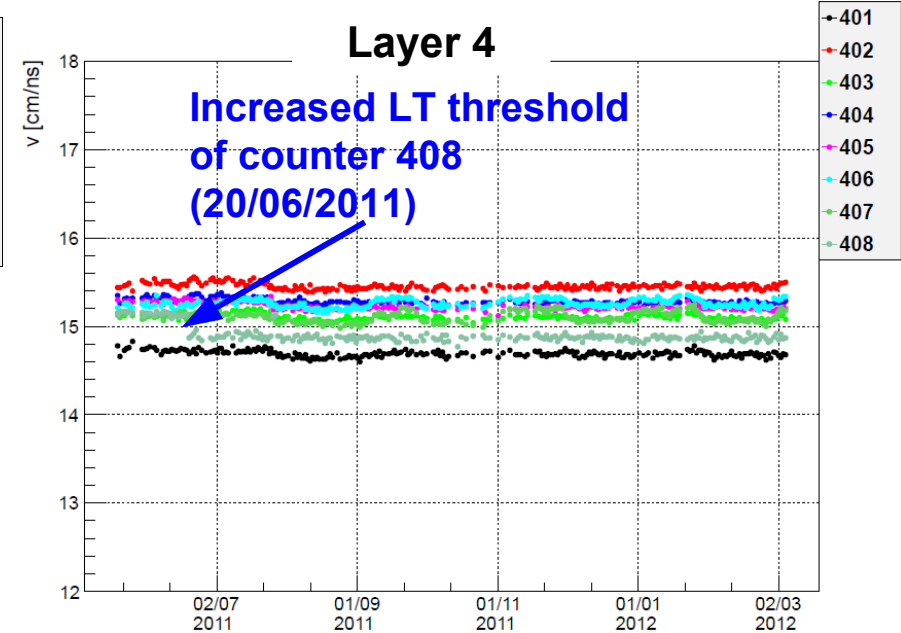
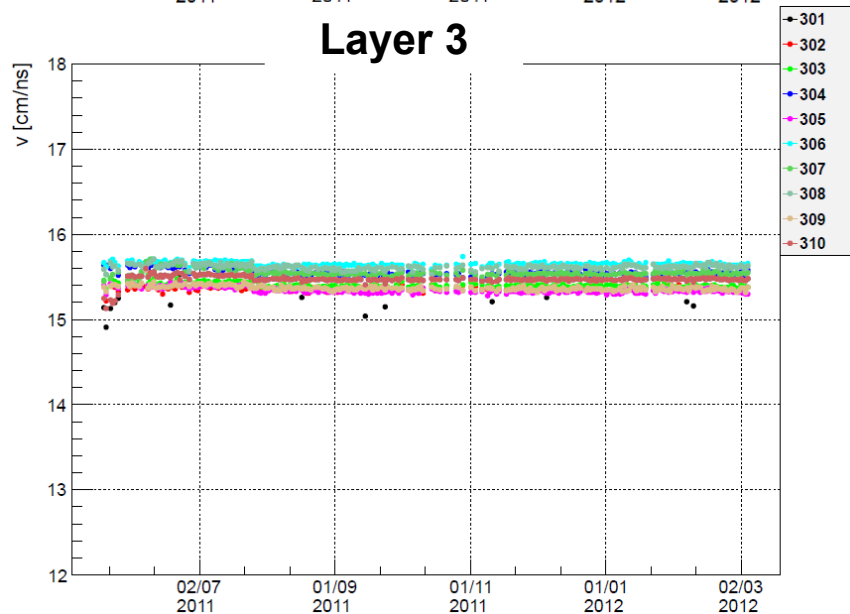
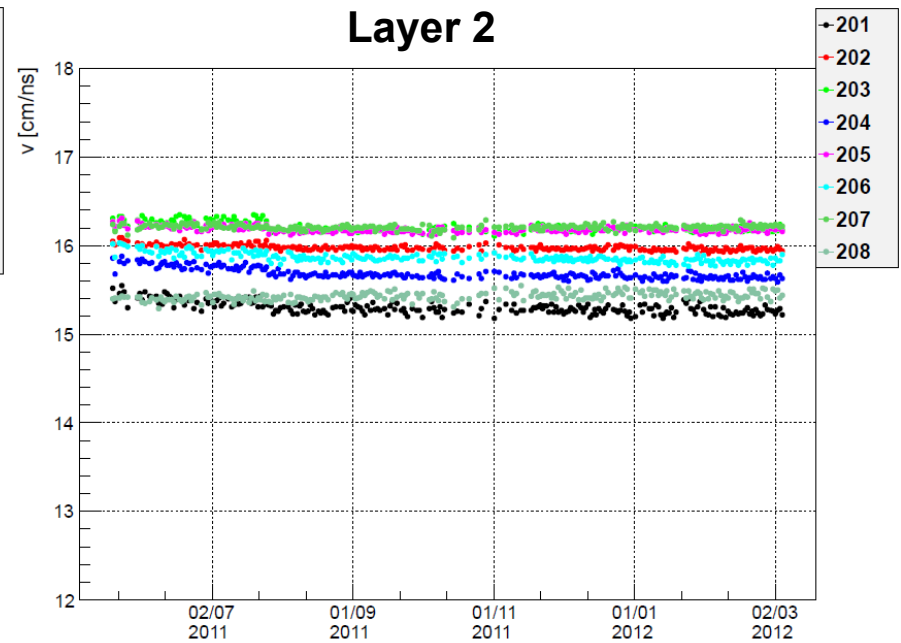
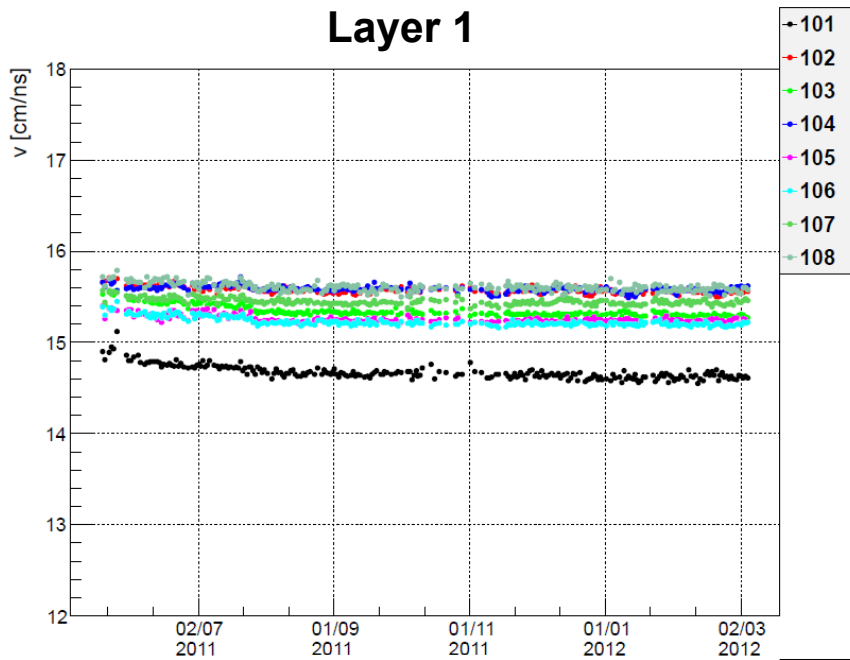
- $t_{m1(2)}$ = measured time in counter side1(2)
- $A_{1(2)}$ = charge amplitude in counter side1(2)
- $s_{1(2)}$ = slewing parameter in counter side1(2)
- x = coordinate along the counter (defined by Tracker track)
- V = light velocity along the counter
- t_{del} = counter time delay

For each TOF counter:

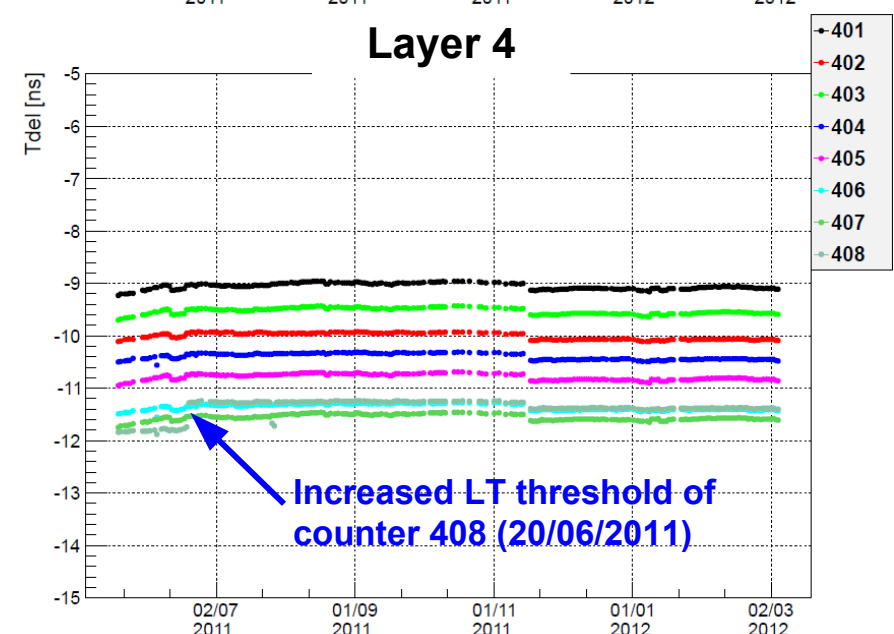
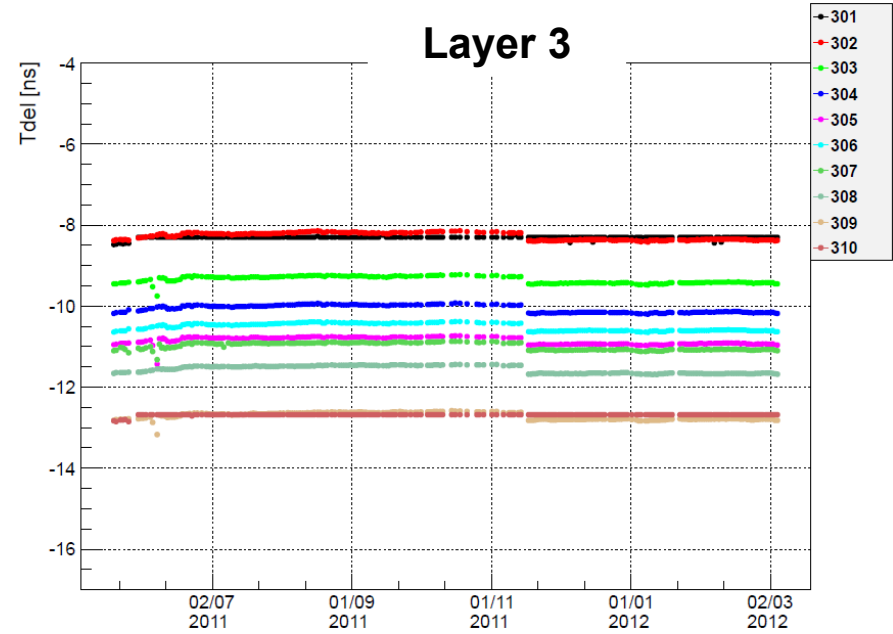
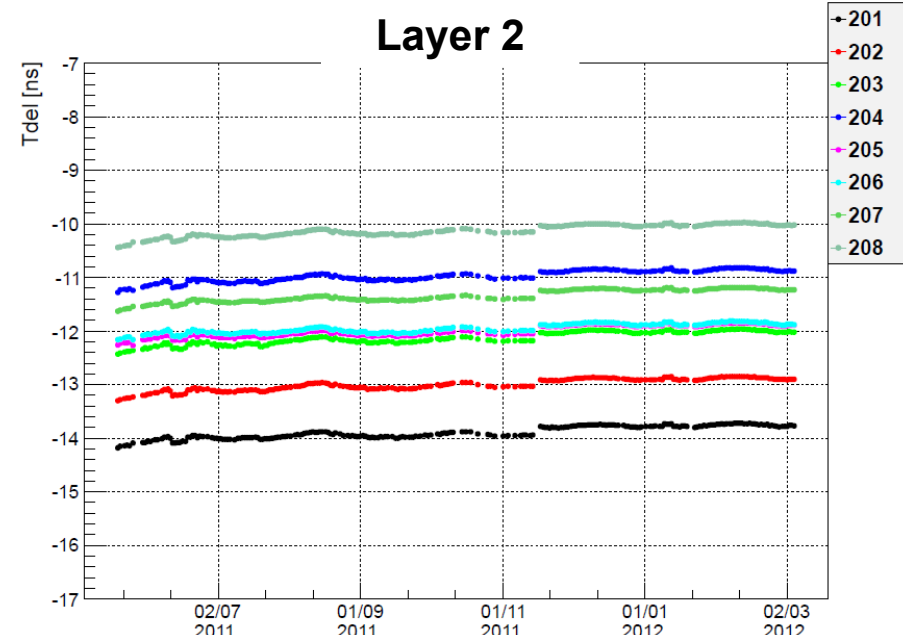
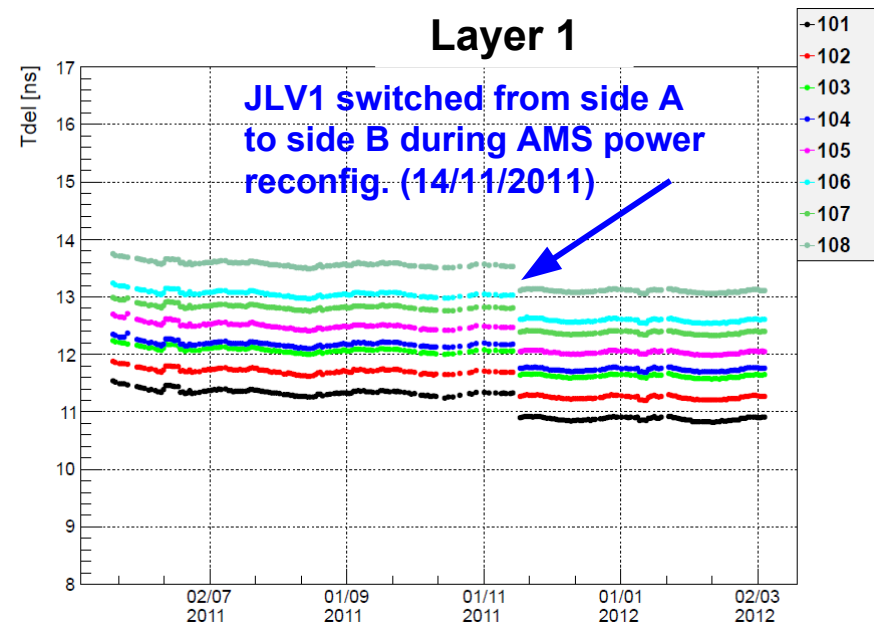
TofCalib_Tdelv:SideTimesDiff(ns,L1B4) vs ImpPoint(cm)



Time calibration – light velocity



Time calibration – time delay



Anode ADC channels are corrected for attenuation along the counter and equalized to give 1.65 MeV energy deposit at the peak for a minimum ionizing particle traversing perpendicularly 1 cm of scintillator.

Counters are of different sizes. 11 reference counters (101, 105, 401, 404, 201, 202, 204, 301, 302, 303, 305) are chosen one for each counter size.

All the other counters are calibrated relative to these reference counters.

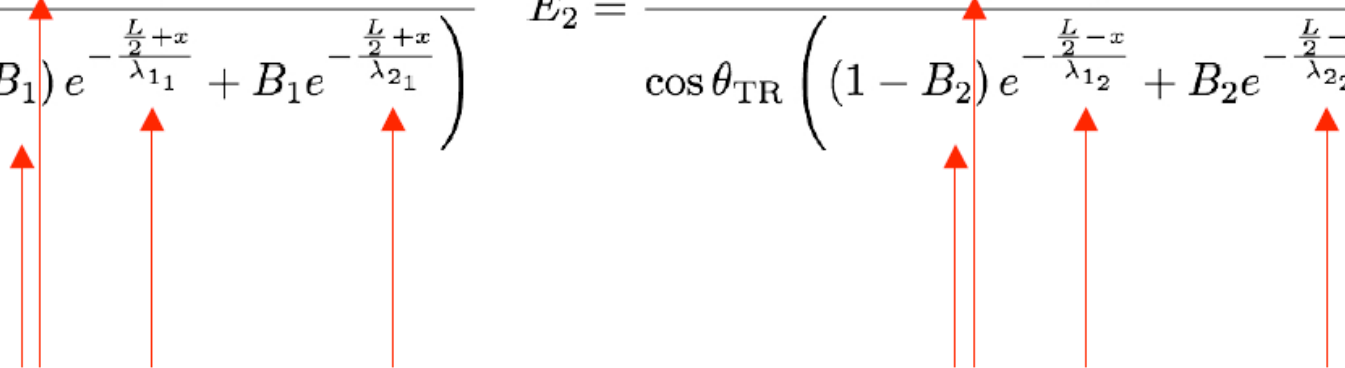
For the reference counters the amplitude calibration finds:

1. anode attenuation parameters depending on the track impact point;
2. absolute charge normalization (conversion factor from ADC to MeV);

Charge calibration – anode attenuation

1. Anode attenuation parameters (along the counter).
 For each reference counter side:

$$E_1 = \frac{A_1 \text{ADC}_1}{\cos \theta_{\text{TR}} \left((1 - B_1) e^{-\frac{\frac{L}{2} + x}{\lambda_{11}}} + B_1 e^{-\frac{\frac{L}{2} + x}{\lambda_{21}}} \right)}$$

$$E_2 = \frac{A_2 \text{ADC}_2}{\cos \theta_{\text{TR}} \left((1 - B_2) e^{-\frac{\frac{L}{2} - x}{\lambda_{12}}} + B_2 e^{-\frac{\frac{L}{2} - x}{\lambda_{22}}} \right)}$$


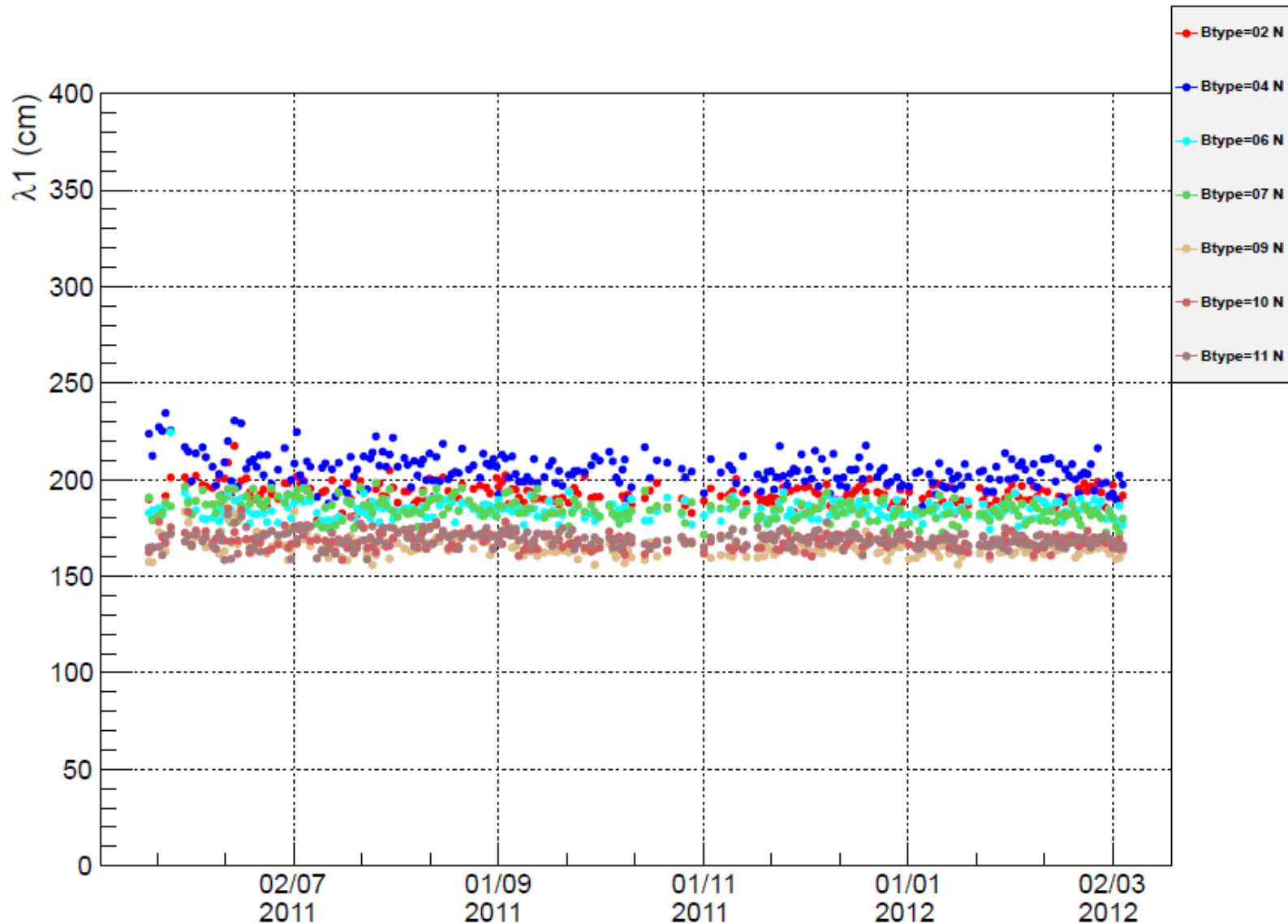
Calibration constants
 (4 per counter side)

ADC_i = amplitude (ADC ch.) (pedestal subtracted)

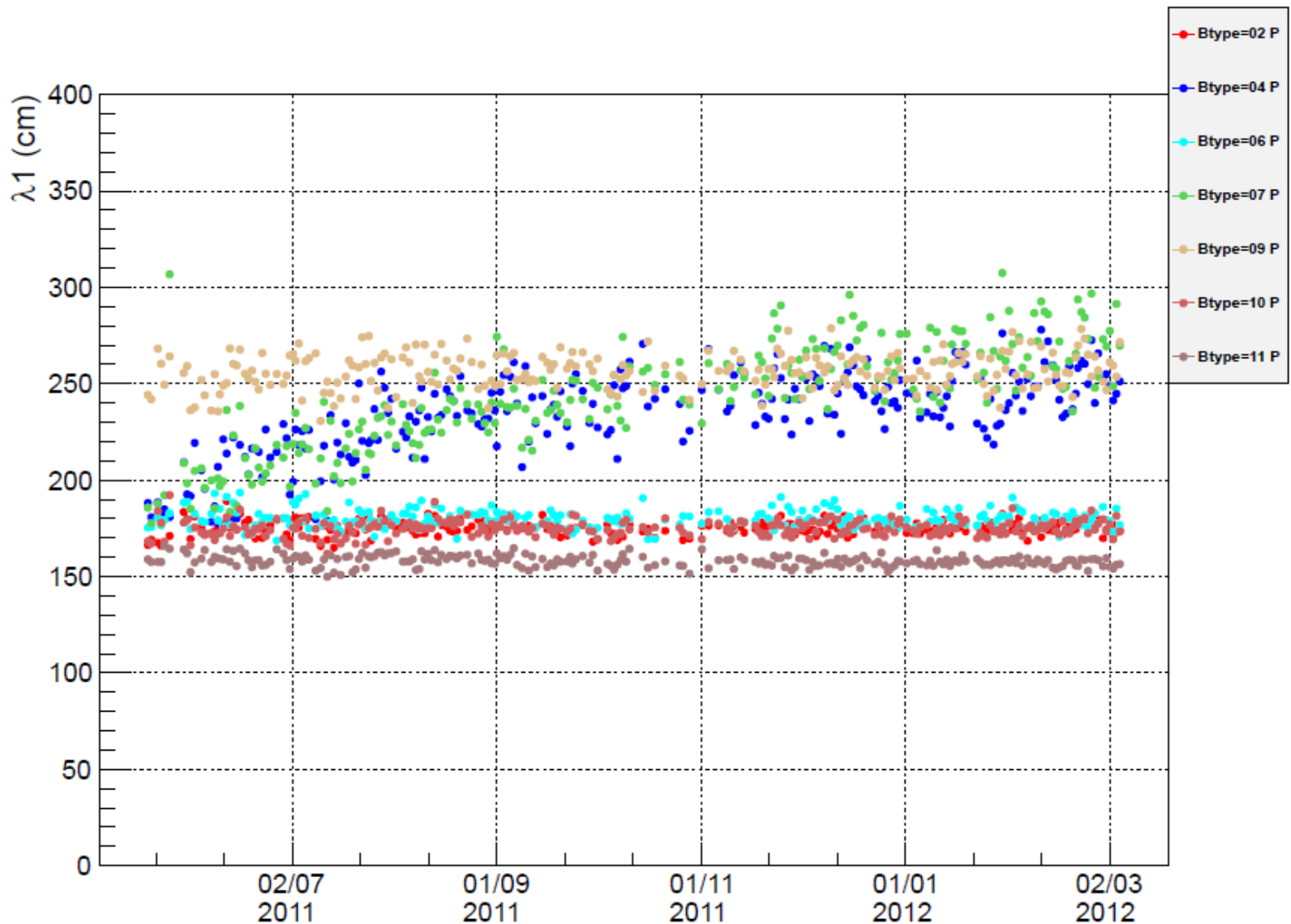
L = counter length

x = particle impact point along the counter

θ_{TR} = track inclination w.r.t. z-axis

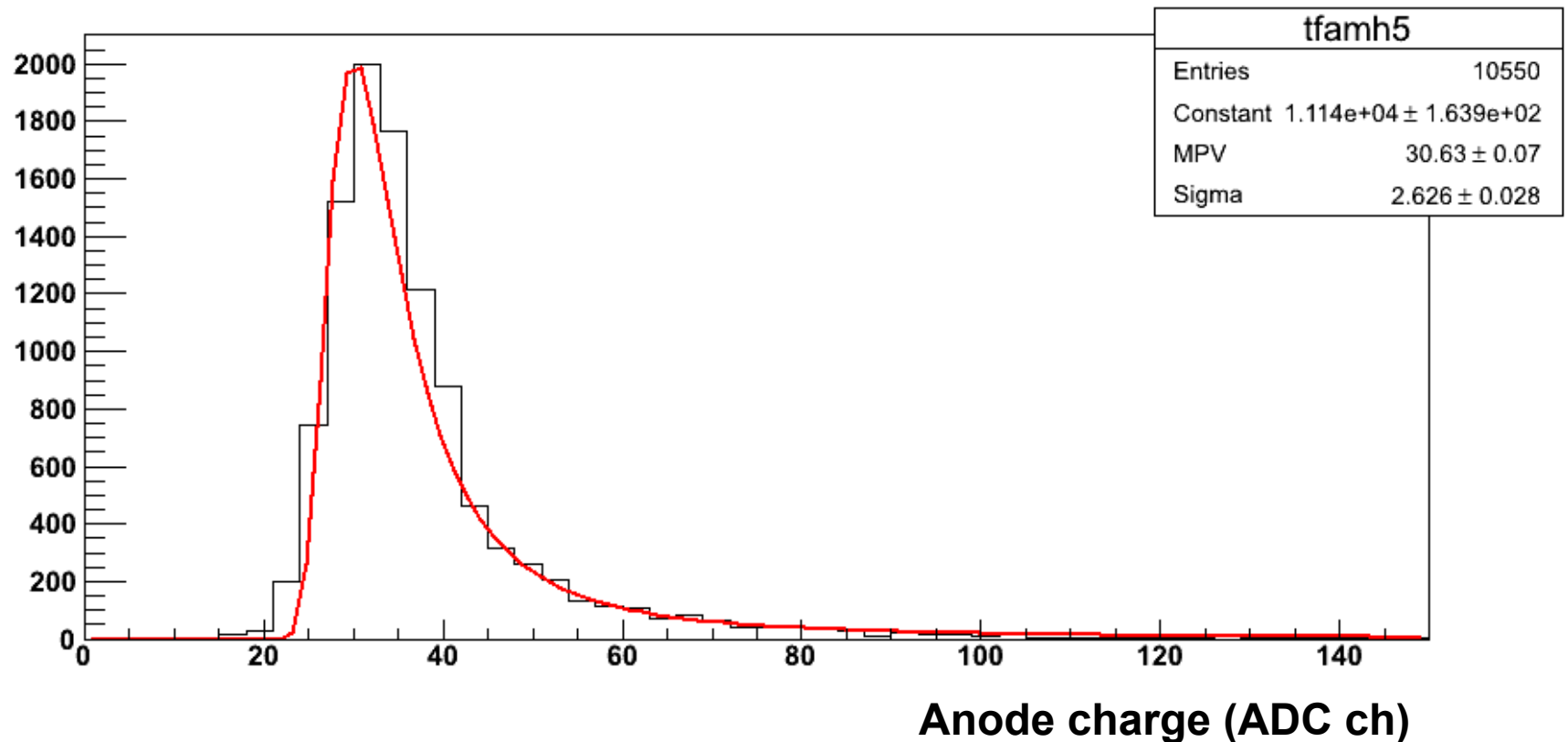


11 ref. counters: BT1=101, BT2=105, BT3=401, BT4=404, BT5=201, BT6=202, BT7=204, BT8=301, BT9=302, BT10=303, BT11=305

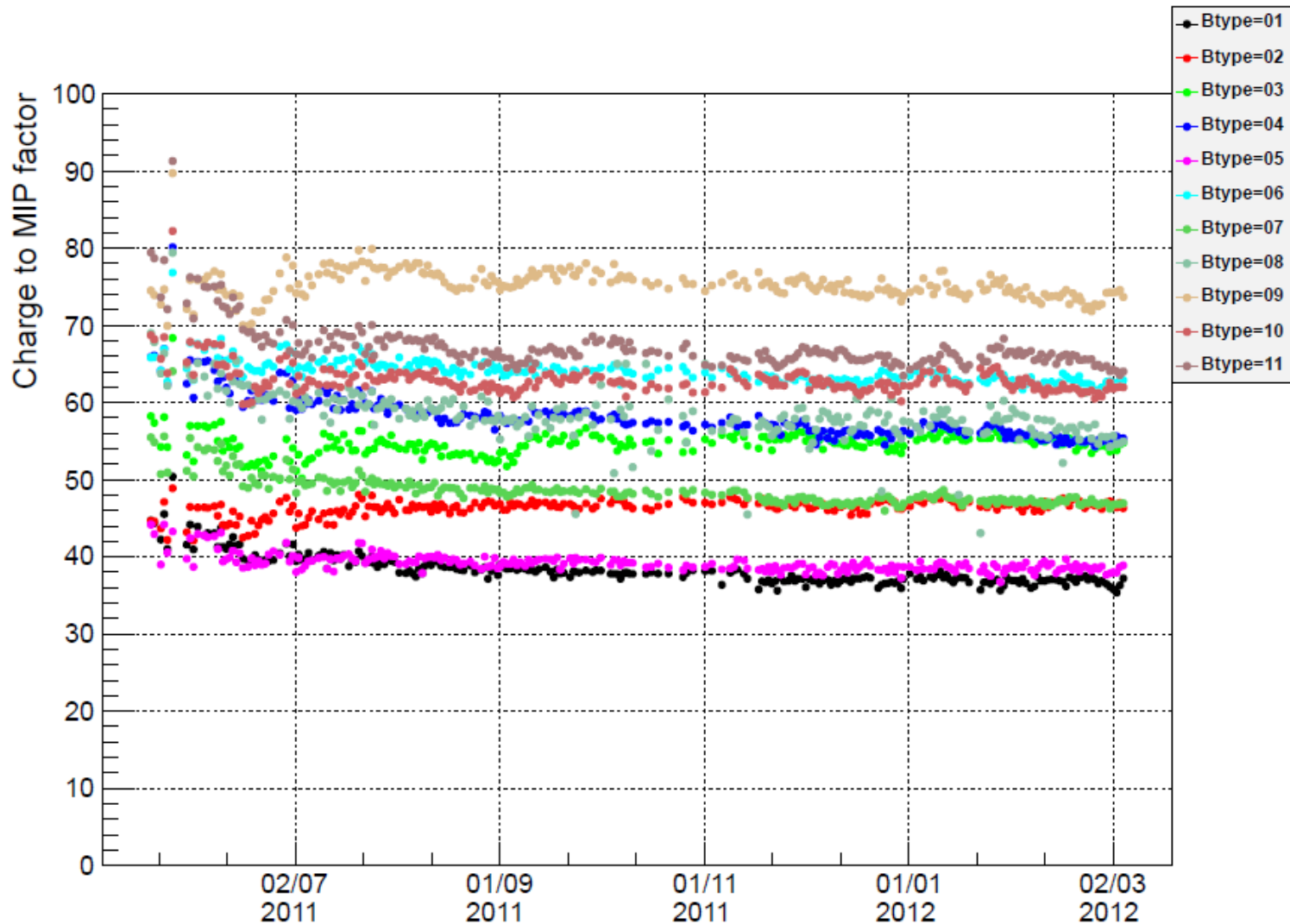


11 ref. counters: BT1=101, BT2=105, BT3=401, BT4=404, BT5=201, BT6=202, BT7=204, BT8=301, BT9=302, BT10=303, BT11=305

2. Absolute charge normalization for reference counters.
Considering the central part of each counter, the anode amplitude distribution is fitted with a Landau function.



The absolute charge normalization factor is obtained equalizing the anode peak to 1.65MeV for the MIP.

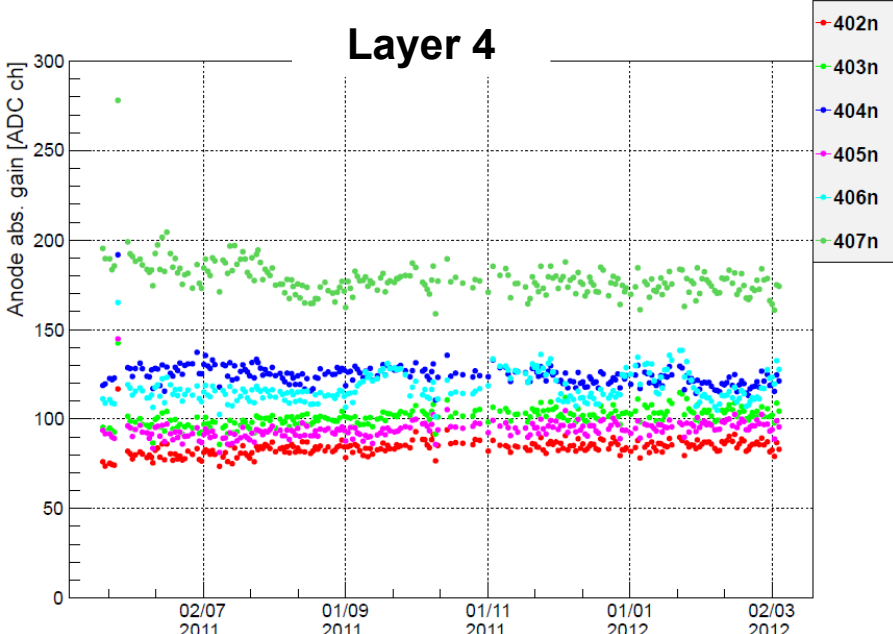
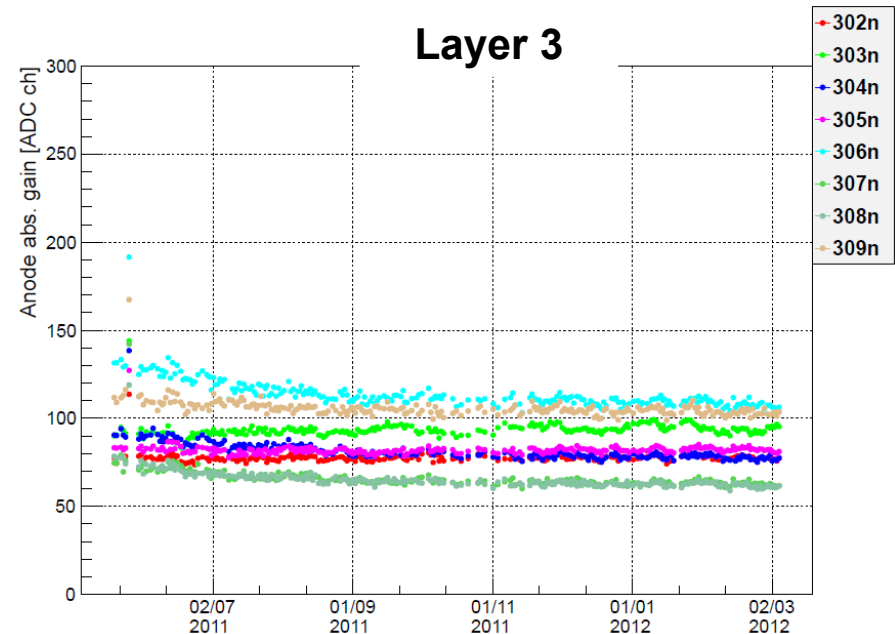
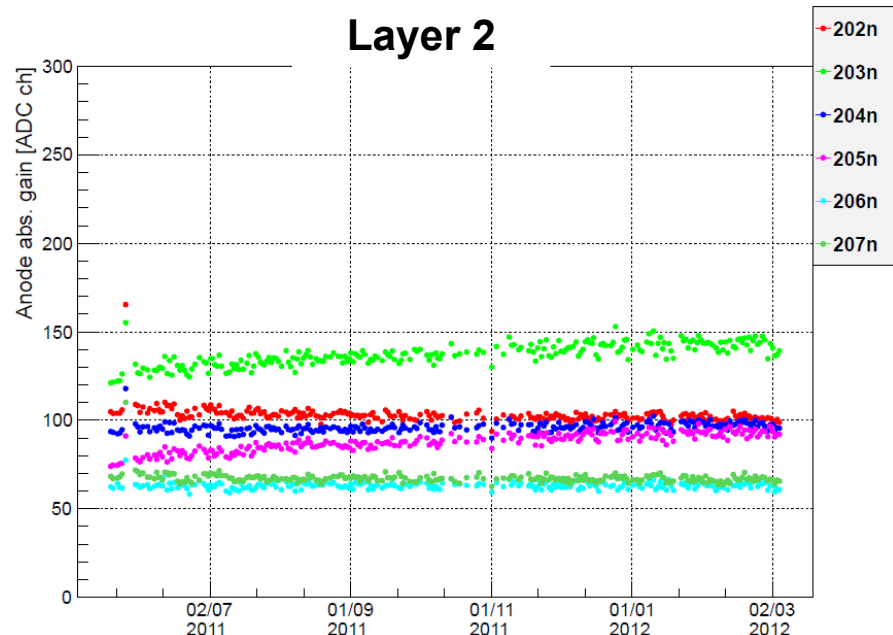
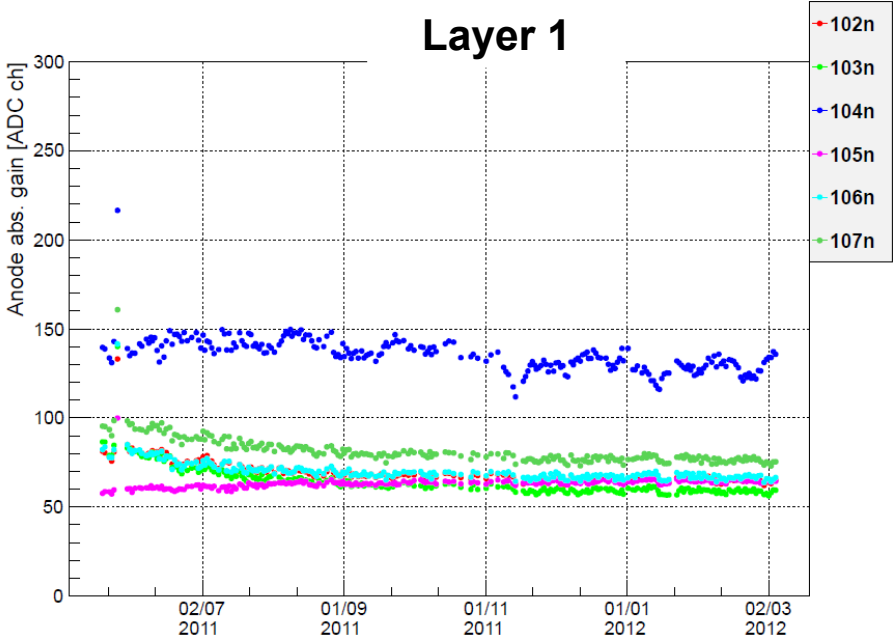


11 ref. counters: $BT1=101$, $BT2=105$, $BT3=401$, $BT4=404$, $BT5=201$,
 $BT6=202$, $BT7=204$, $BT8=301$, $BT9=302$, $BT10=303$, $BT11=305$

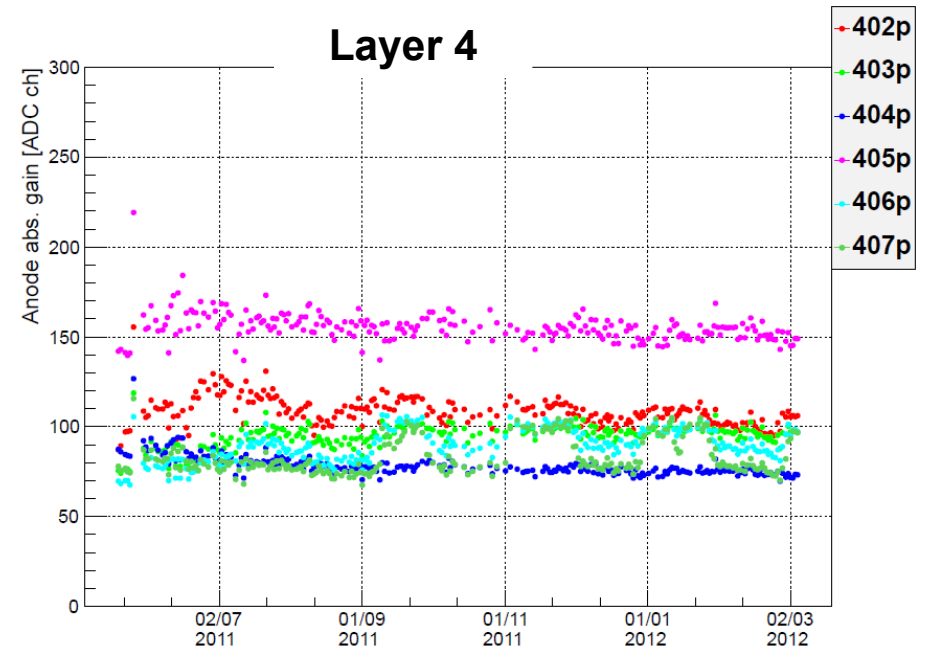
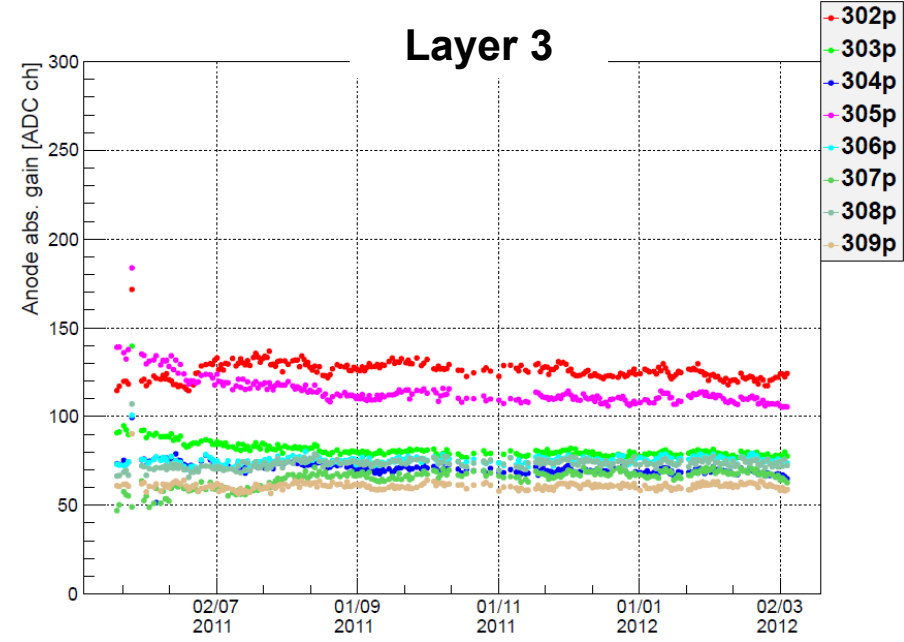
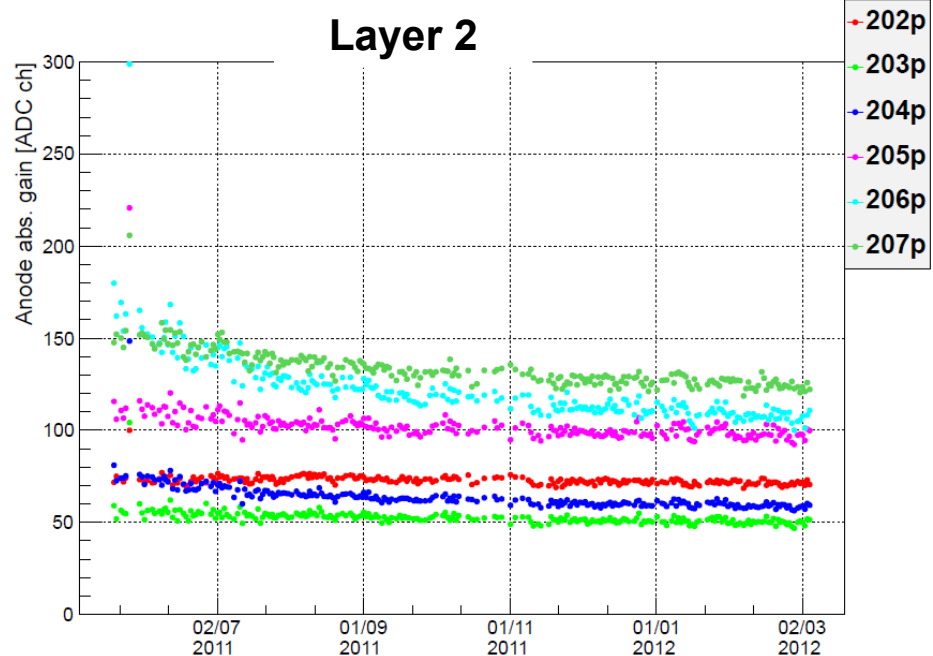
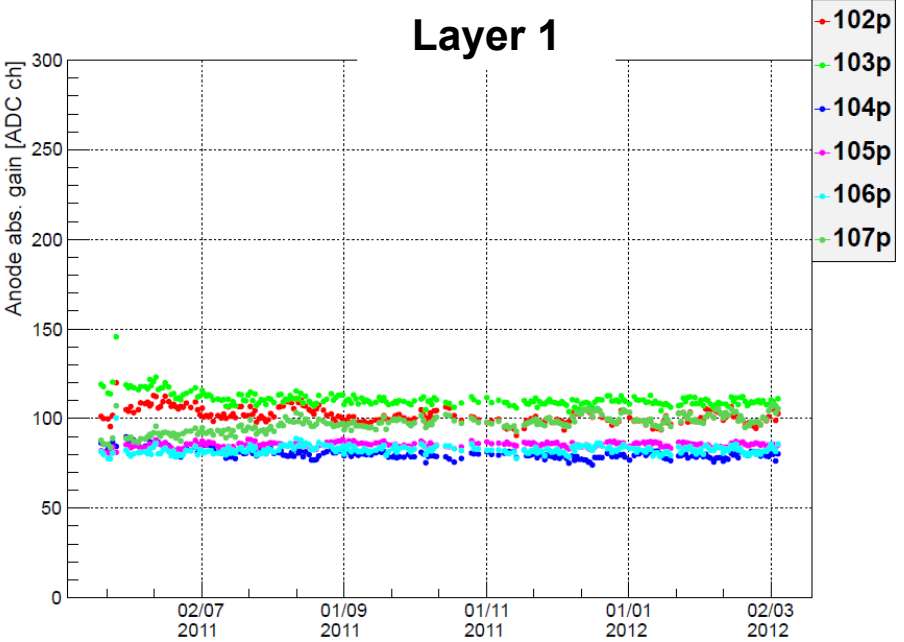
For all counters the amplitude calibration finds:

1. anode amplitude gain;
2. dynode relative amplitude;
3. anode/dynode amplitude ratio.

Charge calibration - anode absolute gain (side n)



Charge calibration - anode absolute gain (side p)



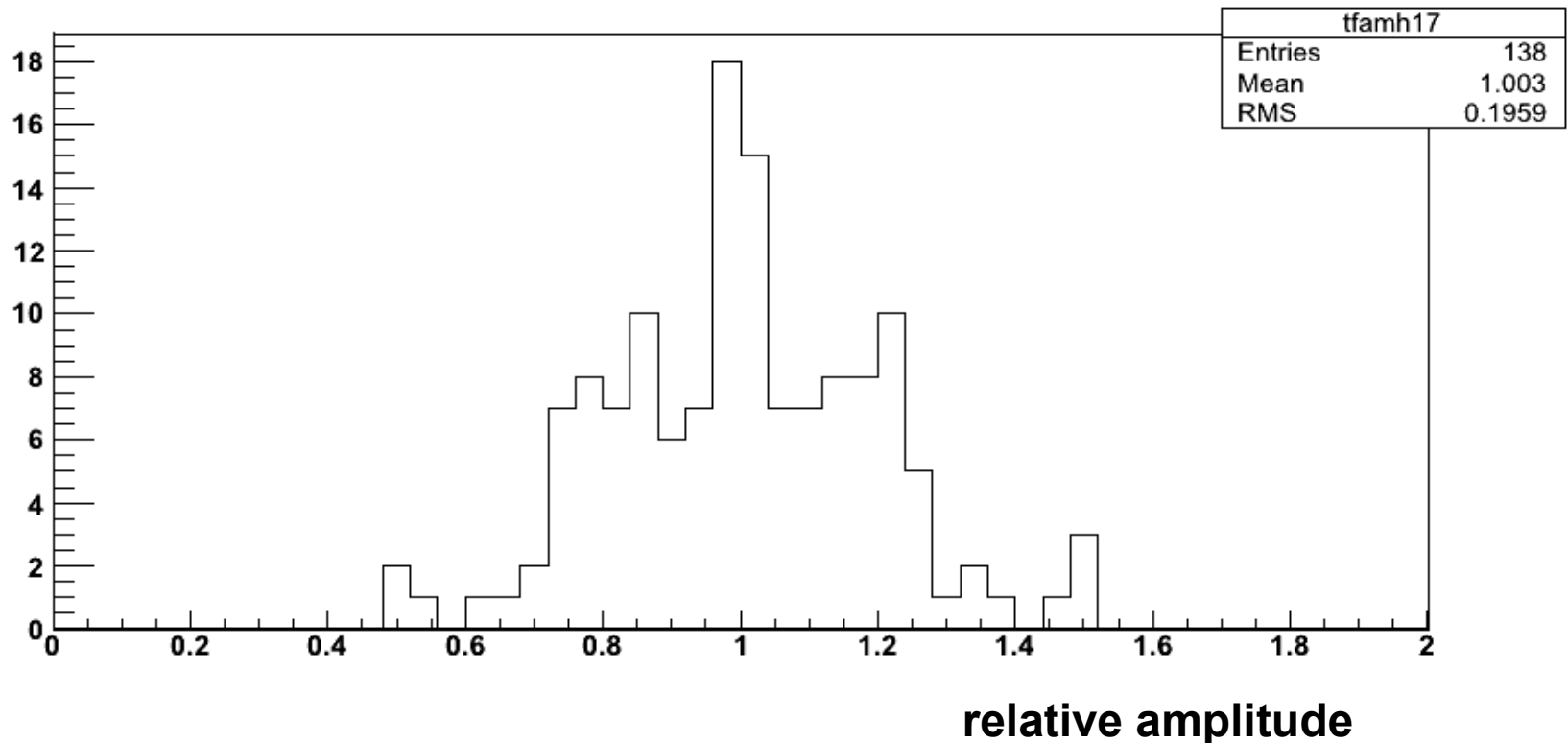
2. Dynode relative amplitude.

Each TOF counter side has 2 or 3 PMT dynode signals.

The relative dynode amplitude is computed considering the ratio:

$$R_i = \text{Dyn}_i / \langle \sum_i \text{Dyn}_i \rangle$$

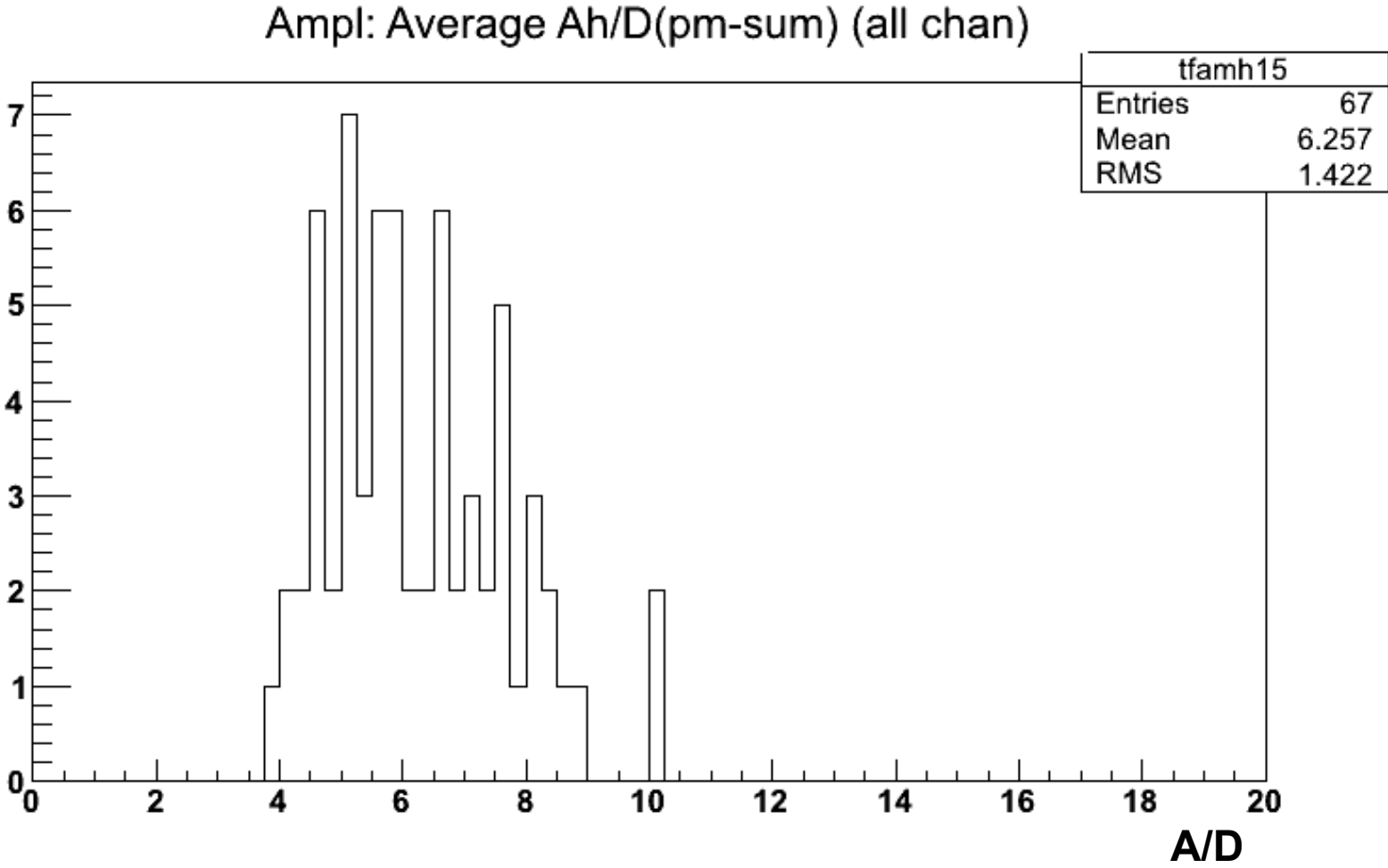
i = number of PMT (1, 2 or 3)



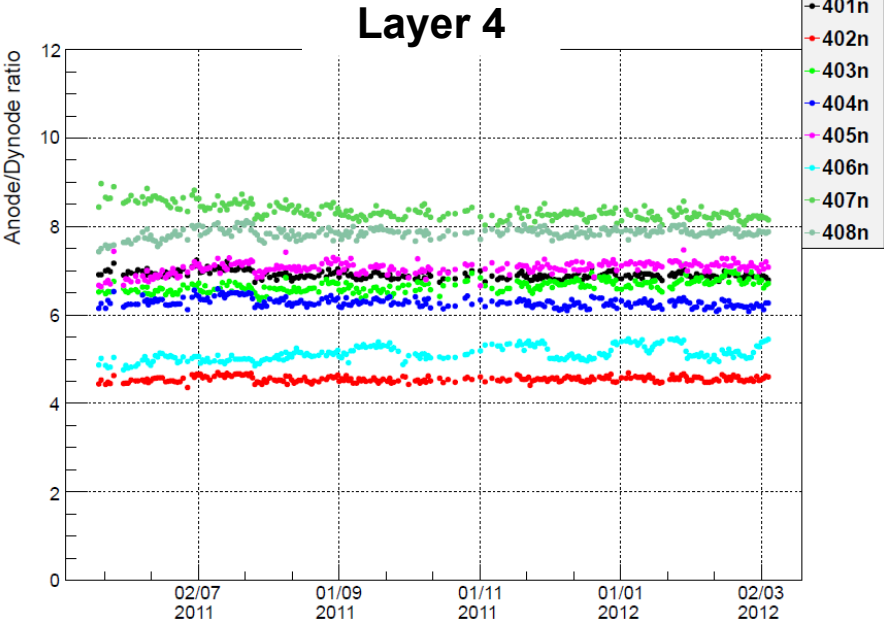
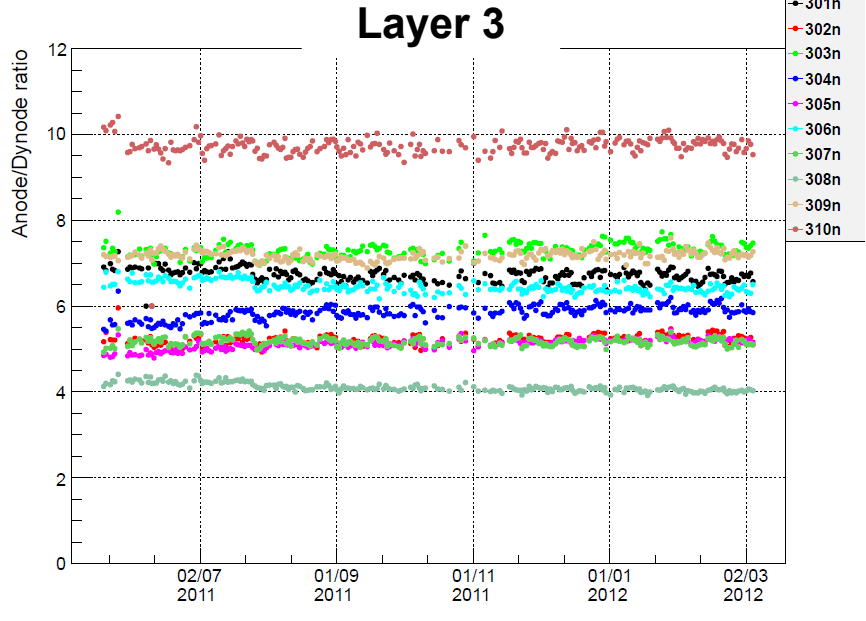
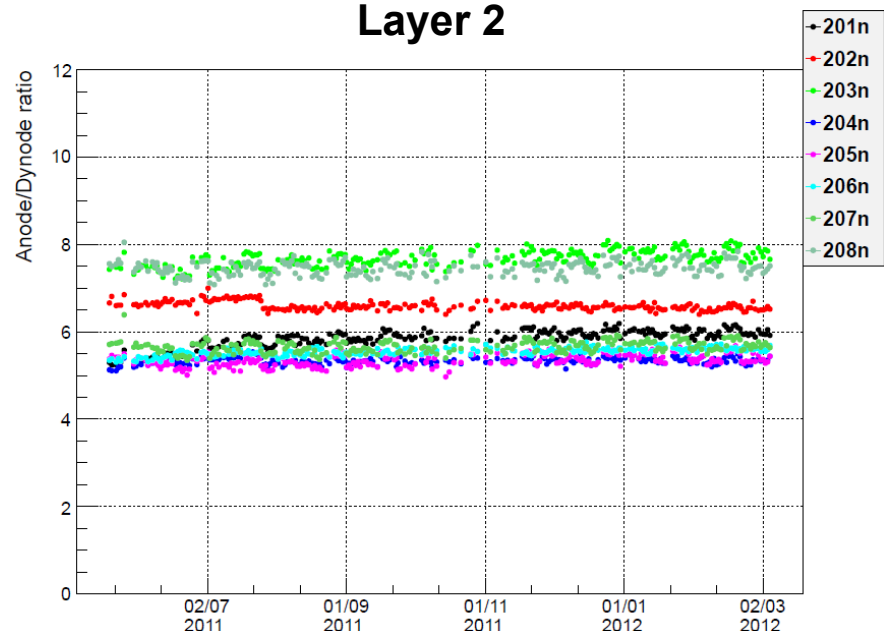
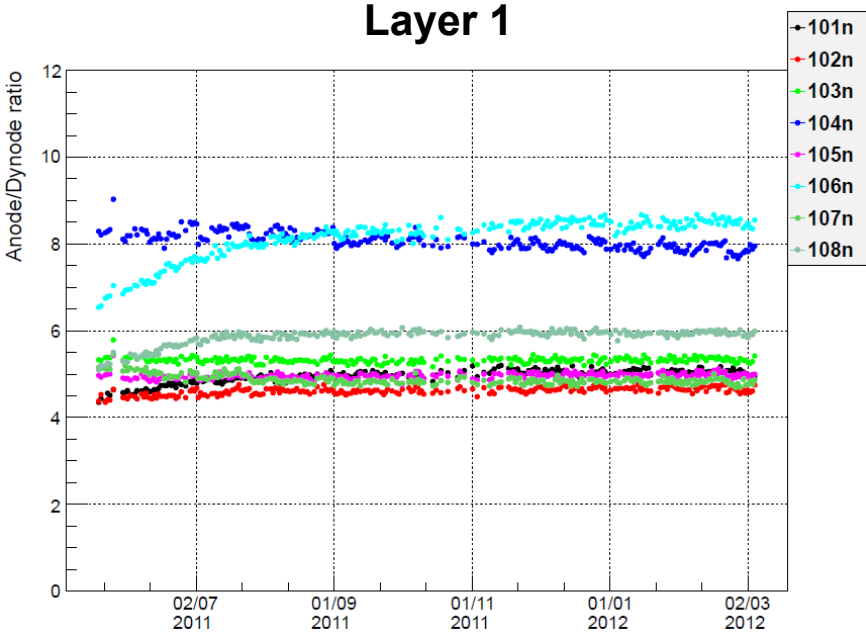
3. Anode/dynode amplitude ratio:

$$A/D = \text{Anode} / (\sum_i \text{Dyn}_i)$$

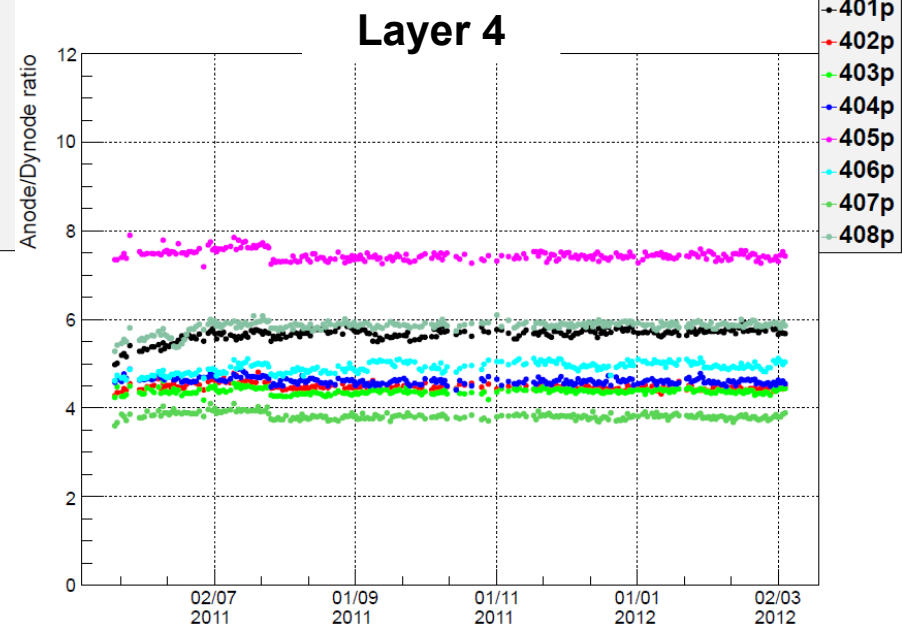
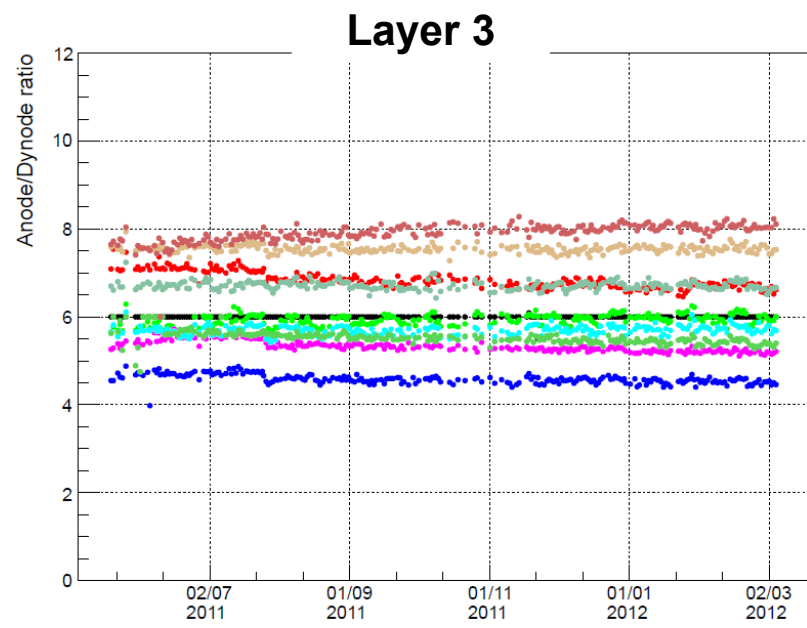
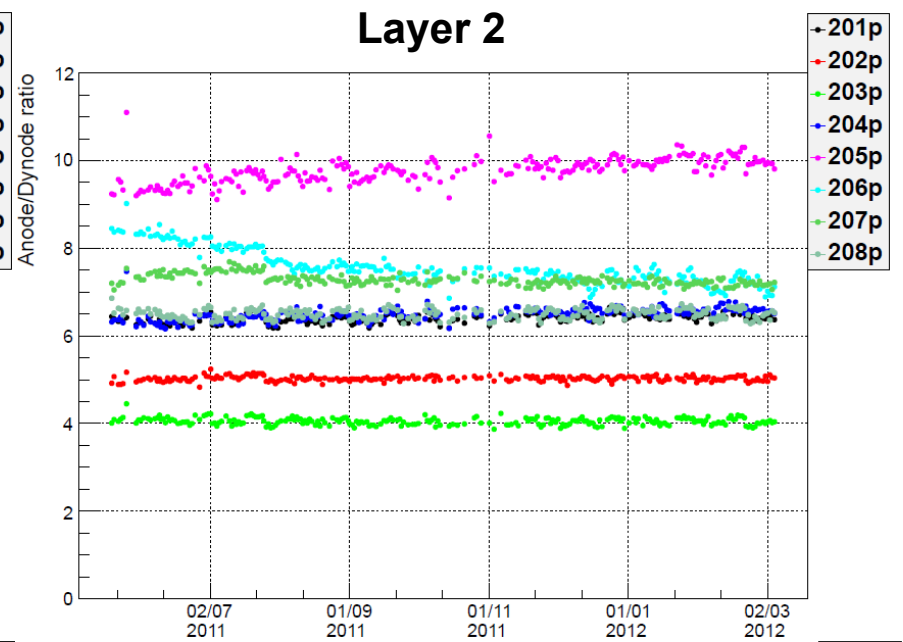
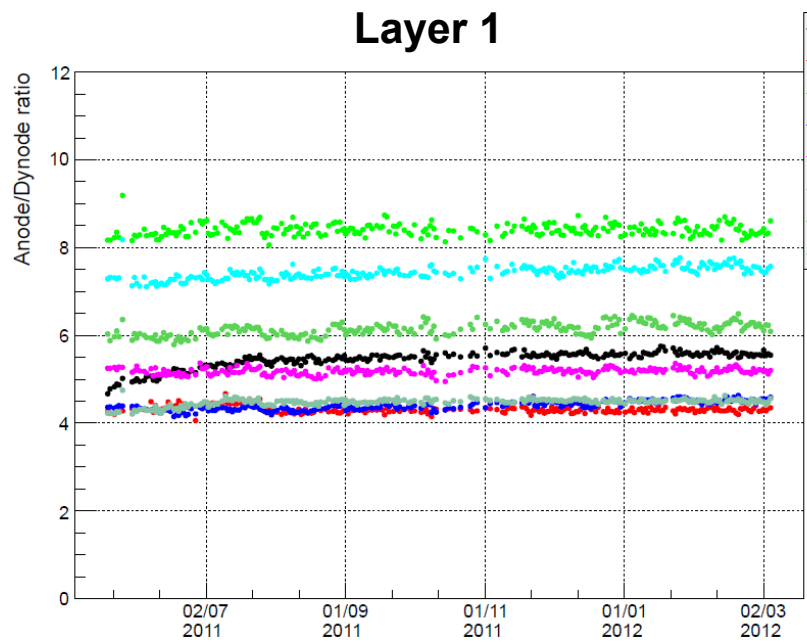
i = number of PMT (1, 2 or 3)



Charge calibration – anode/dynode amplitude ratio



Charge calibration – anode/dynode amplitude ratio



TOF calibration is a well tested and easy to apply procedure.

After an initial period of “stabilization” all calibration parameters are stable and variation are only do to external changes.

Temperature effects are included into the calibration constants, so there is no need for specific temperature corrections during analysis.



All TOF calibrations are stored into the AMS DataBase:

[/afs/cern.ch/ams/Offline/AMSDataDirRW/DataBase/Tofbarcal2/](https://afs.cern.ch/ams/Offline/AMSDataDirRW/DataBase/Tofbarcal2/)

Calibrations

- TOF
 - TofTdcCor
 - 1308112000 (15.06.11) / 12.31.2011 / 15.05.11 (Begin/End/Insert-times)
 - Tofbarcal2
 - set-1(2records): 1305805650 (19.05.11) / 2020 / 20.05.11- 1305828619 (19.05.11) / 2020 / 26.05.11
 - set-2: 1305849836 (20.05.11) / 2020 / 14.06.11- 1307982518 (13.06.11) / 2020 / 15.06.11 - 1308091936 (15.06.11) / 2020 / 15.06.11
 - set-3: 1308111586 (15.06.11) . 2020 / 23.06.11 13:57-1308755459 (22.06.11) / 2020 / 23.06.11 13:57
 - set-4(21records): 1308786328 (23.06.11) / 2020 / 29.06.11 15:52 - 1309230877 (28.06.11) / 2020 / 29.06.11 15:54
 - set-5(8records): 1309264222 (28.06.11) / 2020 / 6.07.11 15:00 - 1309874690 (05.07.11) / 2020 / 6.07.11 15:01
 - set-6(8records): 1310517754 (13.07.11) / 2020 / 22.07.11 13:45 - 1311223349 (21.07.11) / 2020 / 22.07.11 13:45
 - set-7(7records): 1311249135 (21.07.11) / 2020 / 27.07.11 11:03 - 1311757406 (27.07.11) / 2020 / 27.07.11 11:03
 - set-8(7records): 1311786564 (27.07.11) / 2020 / 05.08.11 13:03 - 1312312219 (02.08/11) / 2020 / 05.08.11 13:03
 -
 - set-32 (6 records): 1326920385 (18.01.12 h21:59) - 1327362021 (24.01.12 h00:40) - 25.01.12 h11:25
 - set-33 (7 records): 1327489395 (25.01.12 h12:03) - 1328000479 (31.01.12 h10:01) - 01.02.12 h14:54
 - set-34 (6 records): 1328043377 (31.01.12 h21:56) - 1328568397 (06.02.12 h23:46) - 08.02.12 h11:24
 - set-35 (8 records): 1328612717 (07.02.12 h12:05) - 1329219260 (14.02.12 h12:34) - 16.02.12 h10:37
 - set-36 (8 records): 1329262173 (15.02.12 h00:29) - 1329858888 (21.02.12 h22:14) - 22.02.12 h14:32
 - set-37 (8 records): 1329901752 (22.02.12 h10:09) - 1330516470 (29.02.12 h12:54) - 01.03.12 h09:48
 - set-38 (8 records): 1330558005 (01.03.12 h00:26) - 1331153340 (07.03.12 h21:49) - 08.03.12 h09:39
 - set-39 (5 records): 1331284890 (09.03.12 h10:21) - 1331633784 (13.03.12 h11:16) - 14.03.12 h10:06