

Updates on November 2015 BTF ECAL analysis

PADME General meeting

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01 Mar 2016

Test beam summary

Date: 16-30 November 2015

To test

- Calorimeter: 2x 9 BGO crystals (APD and PMT)
- Active target: 2x2cm 50 μ m thick diamond with 19 1mm horizontal and vertical “sensitive” strips

Study performed with e^+ produced by e^+ or e^- impinging on a target. Depending on the primary beam, secondary e^+ shows a little different behavior.

Runs summary

PMT		APD	
E [MeV]	# run	E [MeV]	# run
150	304	150	313
297	305	295.6	311
431	302	448	312
range [V]		range [V]	
[-1,0]		[0,1]	
channels		channels	
[0,9]		[16,25]	
board		board	
0		0	

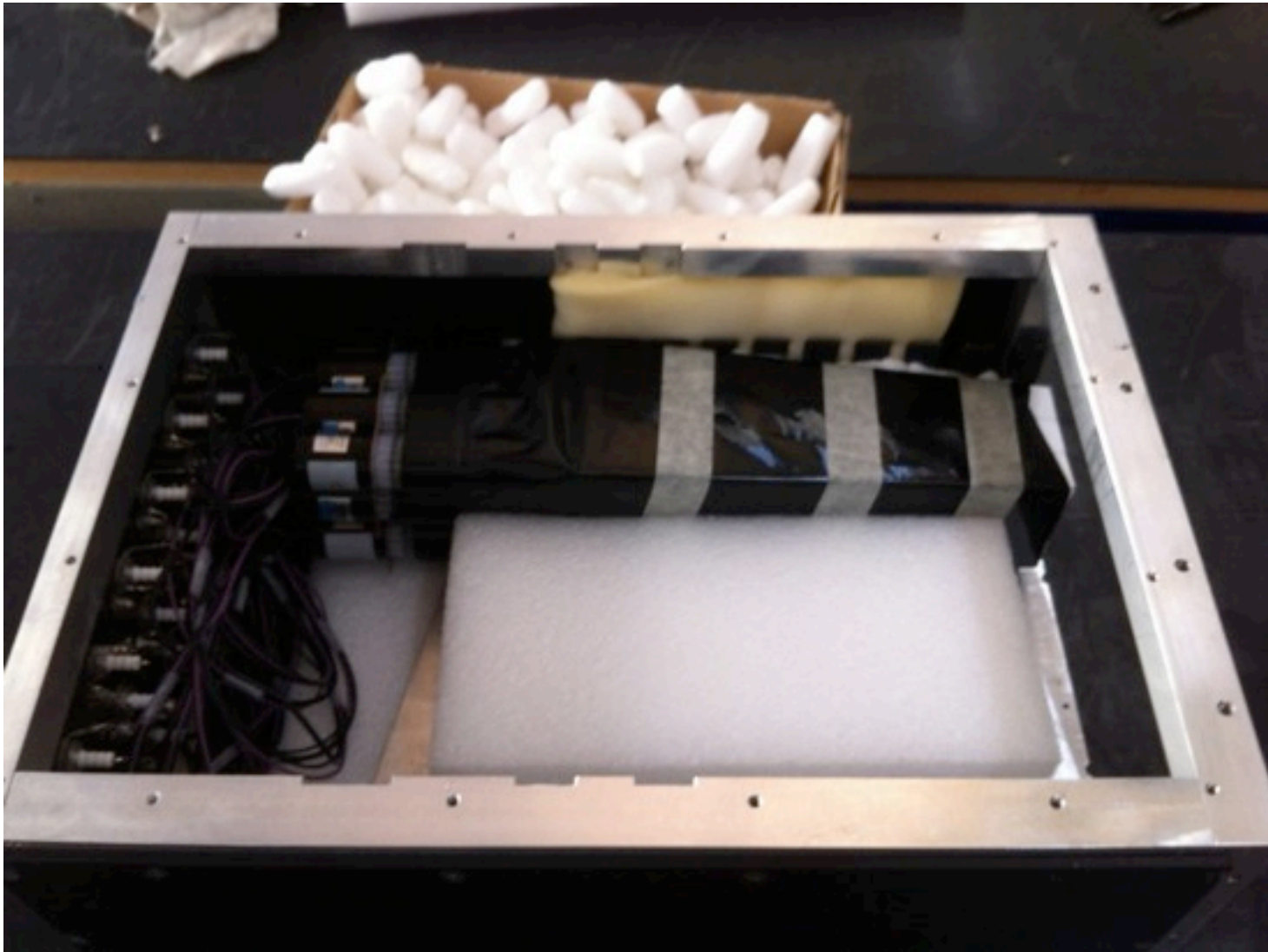
Runs summary

Considered for the present analysis

PMT		APD	
E [MeV]	# run	E [MeV]	# run
150	304	150	313
297	305	295.6	311
431	302	448	312
range [V]		range [V]	
[-1,0]		[0,1]	
channels		channels	
[0,9]		[16,25]	
board		board	
0		0	

PMT setup

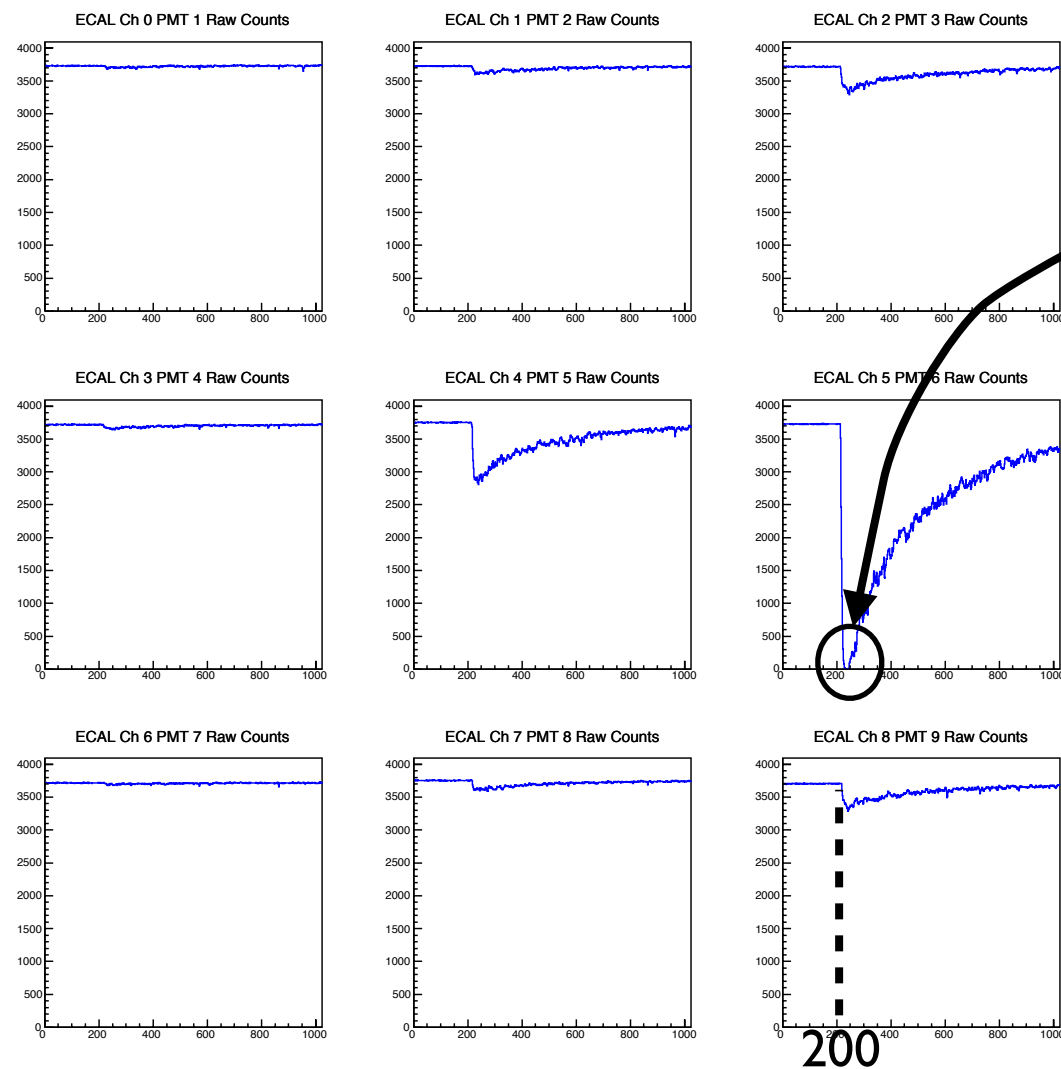
- 1" Hamamatsu R22-38 PMT
- 9 truncated pyramid original L3 BGO crystals (24cm length, $2.2 \times 2.2 \text{ cm}^2$ small face, $3 \times 3 \text{ cm}^2$ large face)
- teflon painting
- stable structure
- PMT not touching BGO
- PMT gains $\approx 10^5$ (central one $\approx 20\%$ smaller)



Raw signals

Signals registered with a VI742 CAEN board:

- 1024 samples
- 1 GHz sampling frequency (1 ms window)
- 1 V full scale (PMT ↘: [-1,0]V, APD ↗: [0,1]V)
- 12-bit resolution (4096 counts, 0.24mV/count)



Example of a non-centered and saturated event (PMT 431 MeV)
y-scale: [0,4096]counts

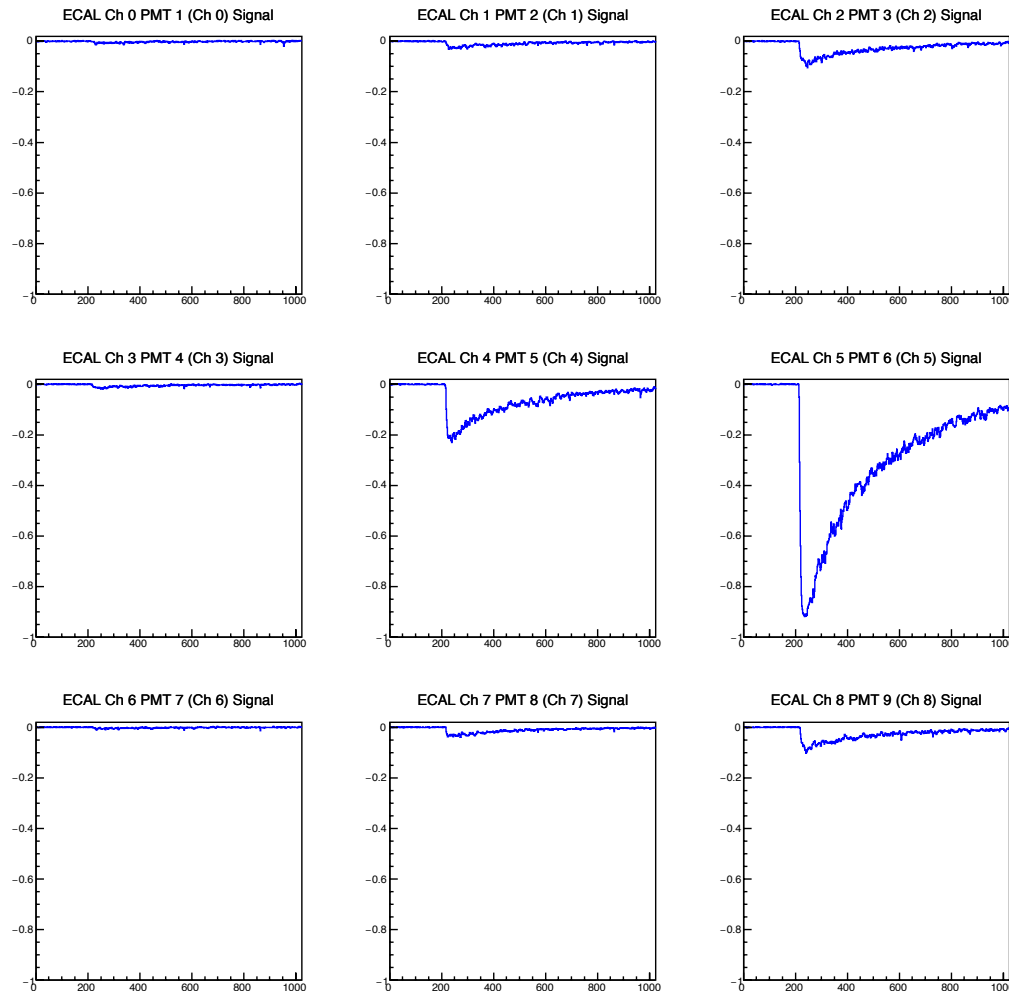
Not complete recover (theoretically visible starting from 8 MeV)

mV signals (old method)

Counts to mV:

$$\text{signal(mV)} = (\text{signal(counts)} - \text{avg}) / 4096$$

↑ average baseline evaluated
w/ the firsts 180 samples



Same event of previous slide

y-scale: [-1, 0.02]V
(to accommodate the baseline
oscillations around 0)

mV signal to charge:

$$Q(\text{pC}) = \sum \text{weight} \times \text{signal(mV)} \times 50(\text{Ohm}) \times 10^{-9}(\text{s}) / 10^{-12}$$

weight(Central channel PMT) = 1.21

weight(all other channels) = 1

To pass from
C to pC



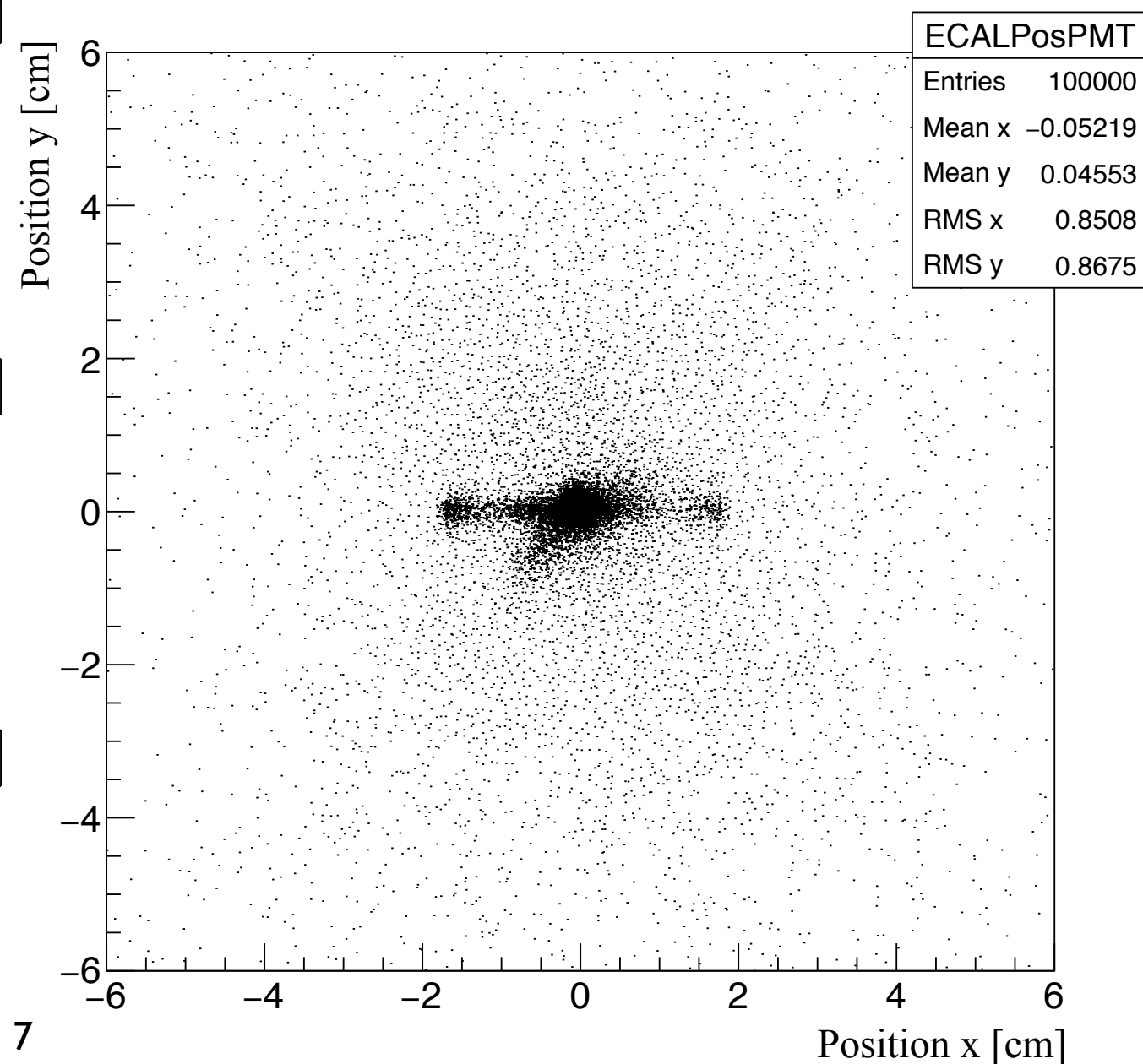
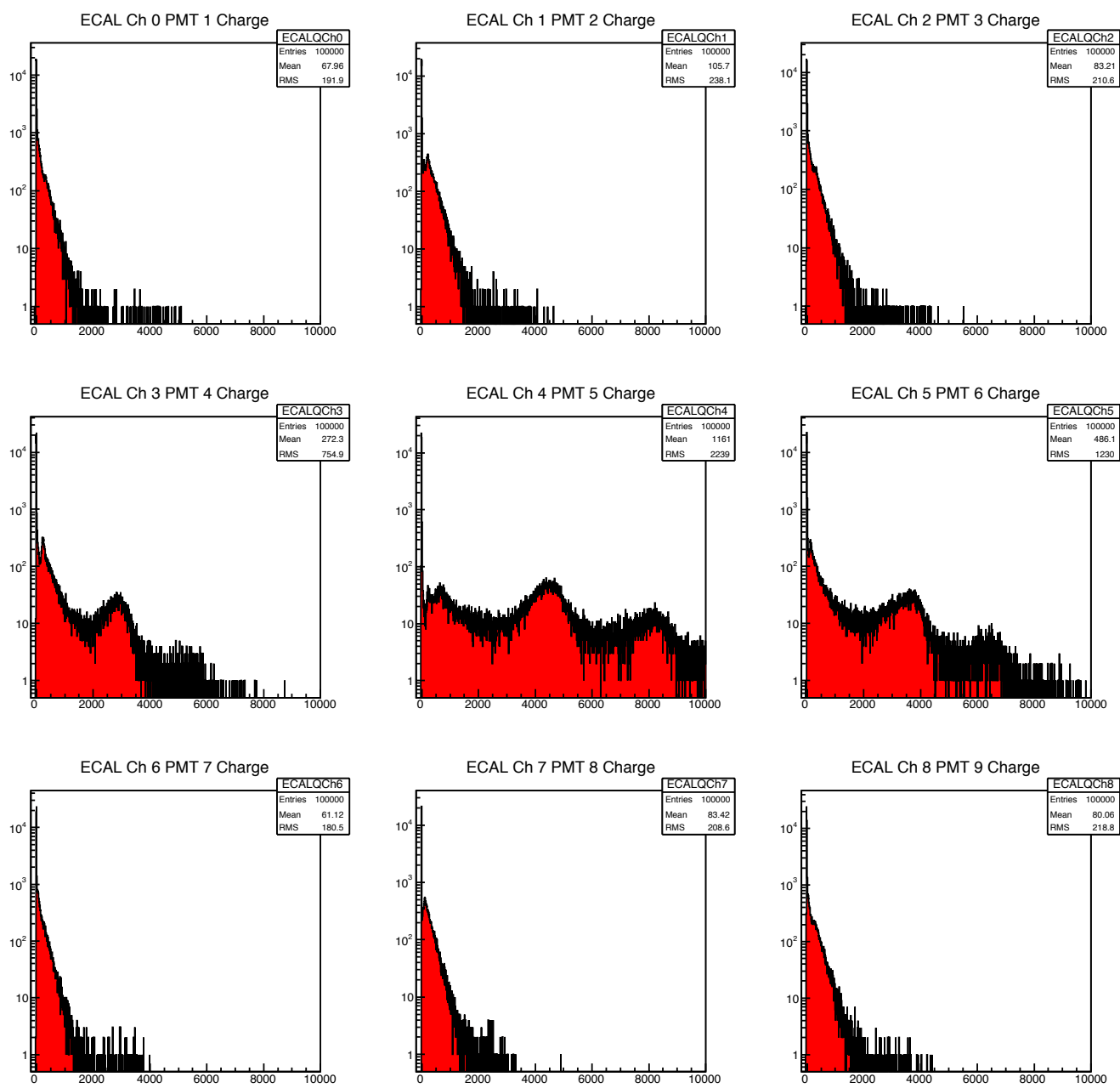
PMT run 305 (I)

$E = 297\text{MeV}$

Single channel spectra
(bin = 5 pC)

Interaction position

ECAL - Position run 305

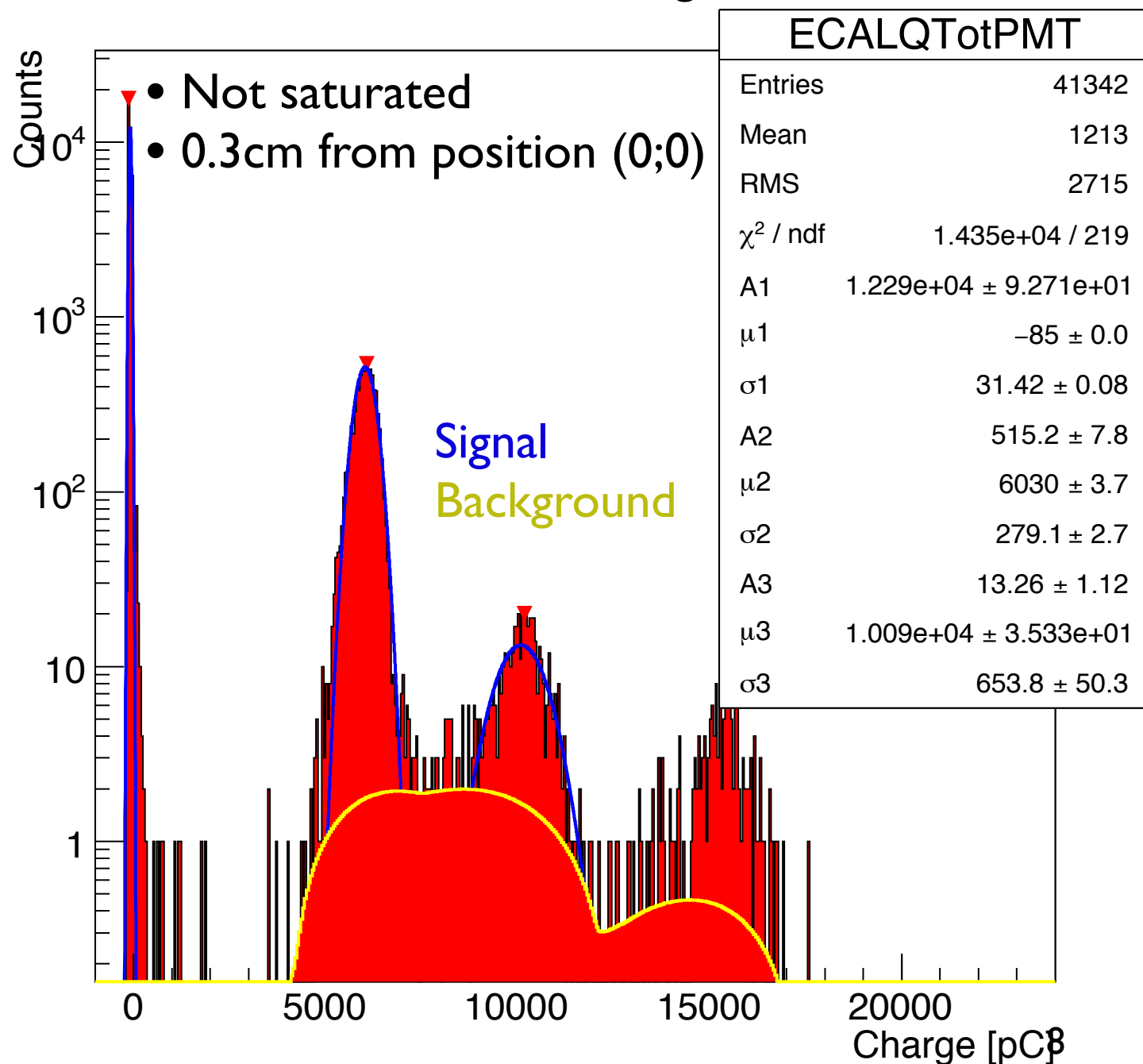


PMT run 305 (2)

$E = 297\text{MeV}$

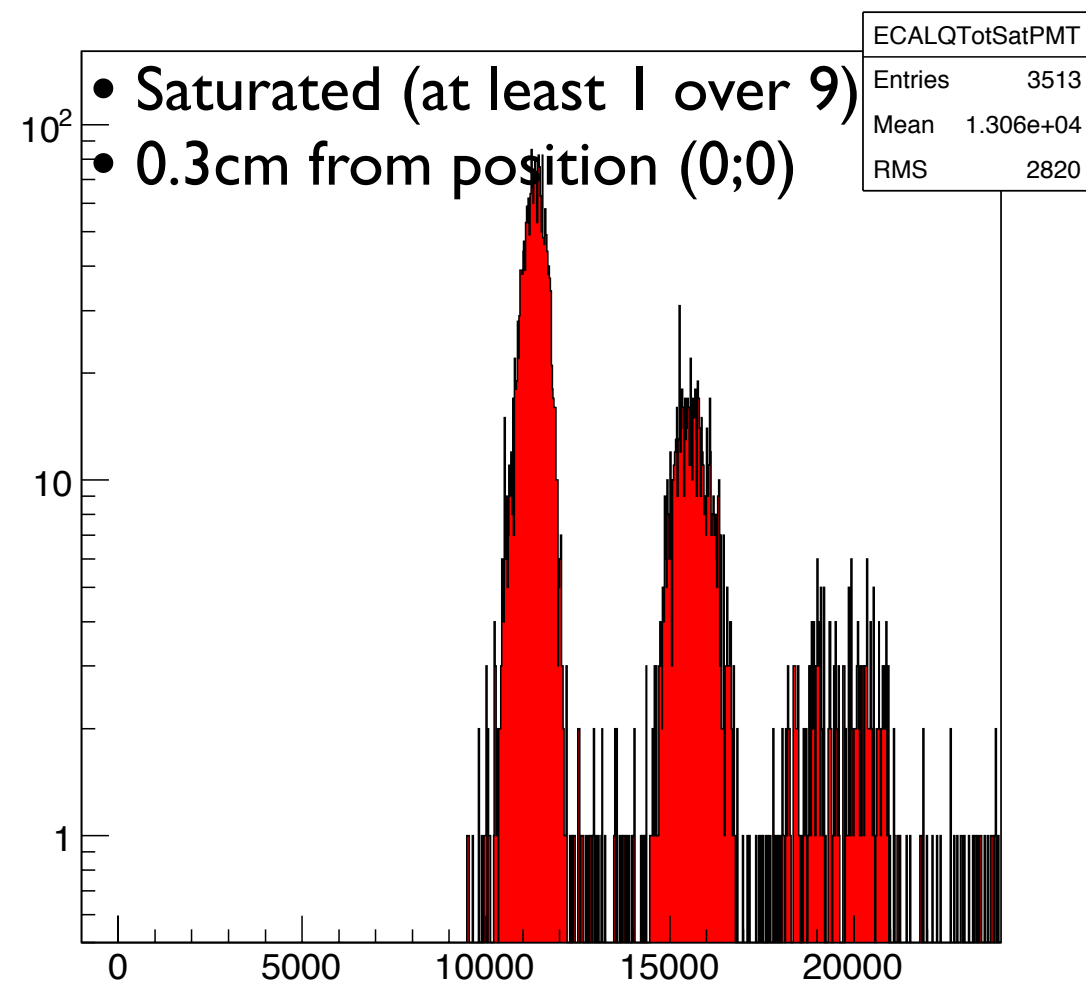
Charge spectrum (bin = 25 pC)

ECAL - Total Charge run 305



Charge spectrum of voltage saturated events (bin = 25 pC)

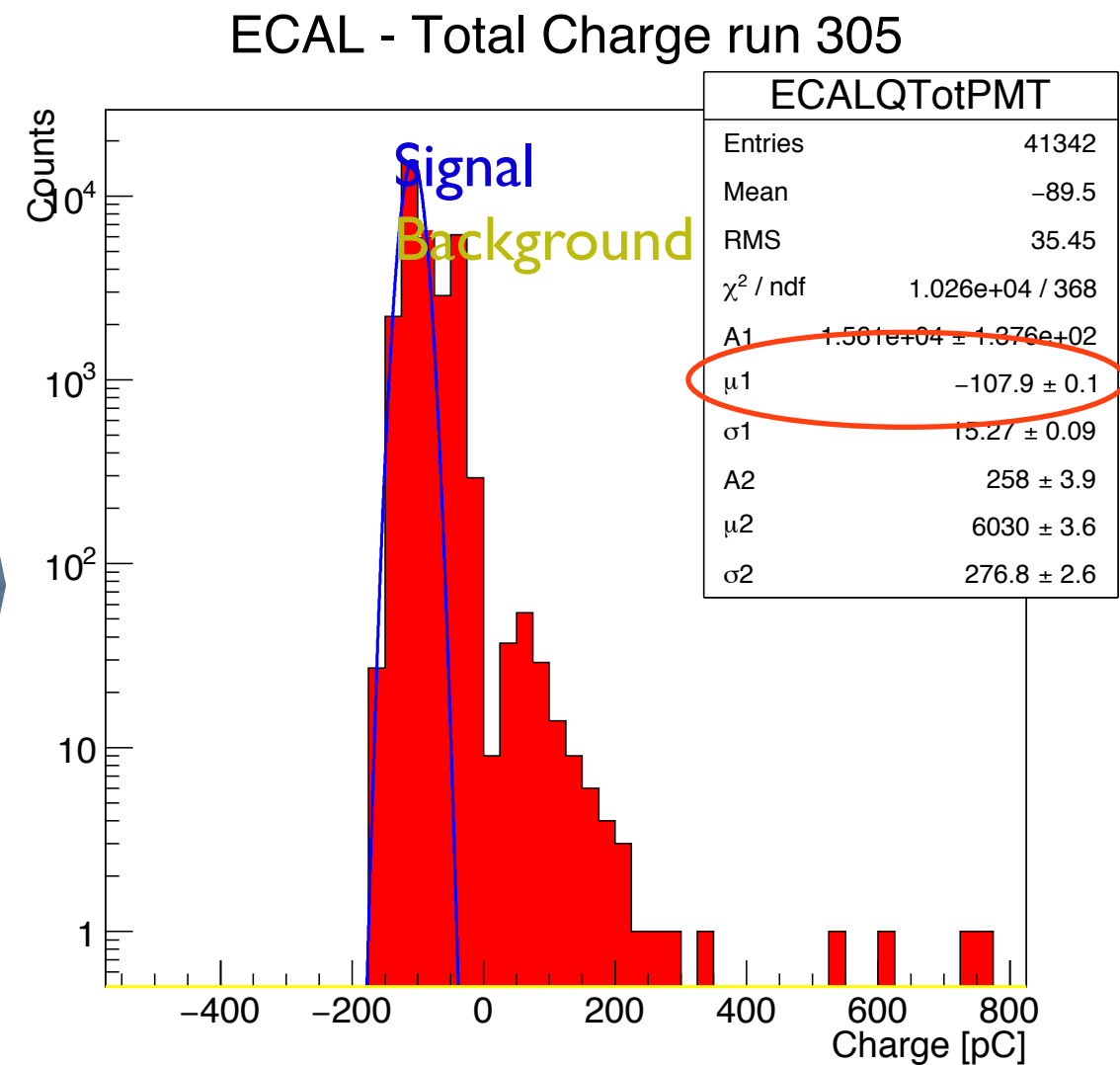
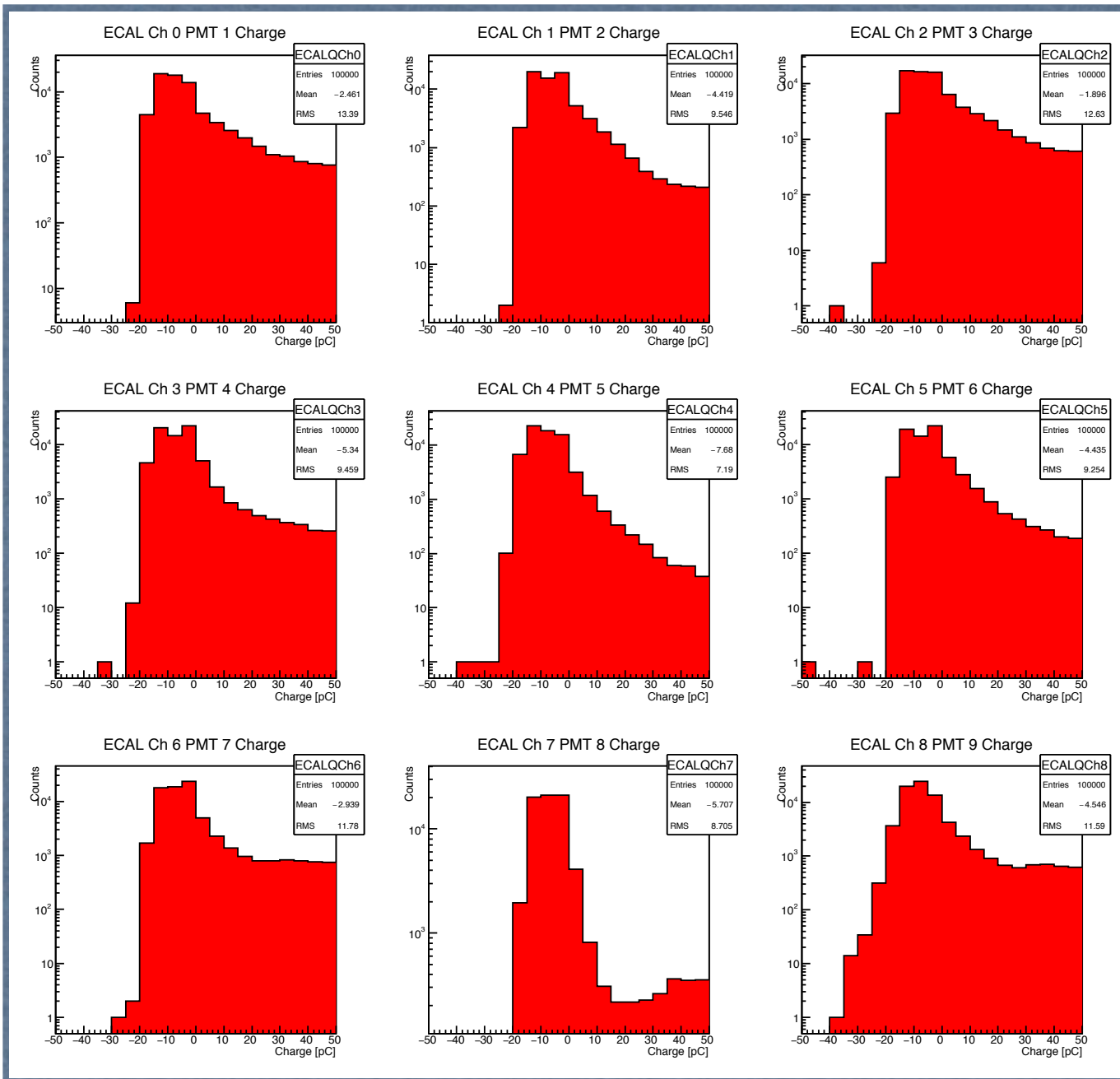
ECAL - Total Charge Saturated run 305



Charge pedestal problem

Single channel spectrum pedestals (bin = 5 pC)

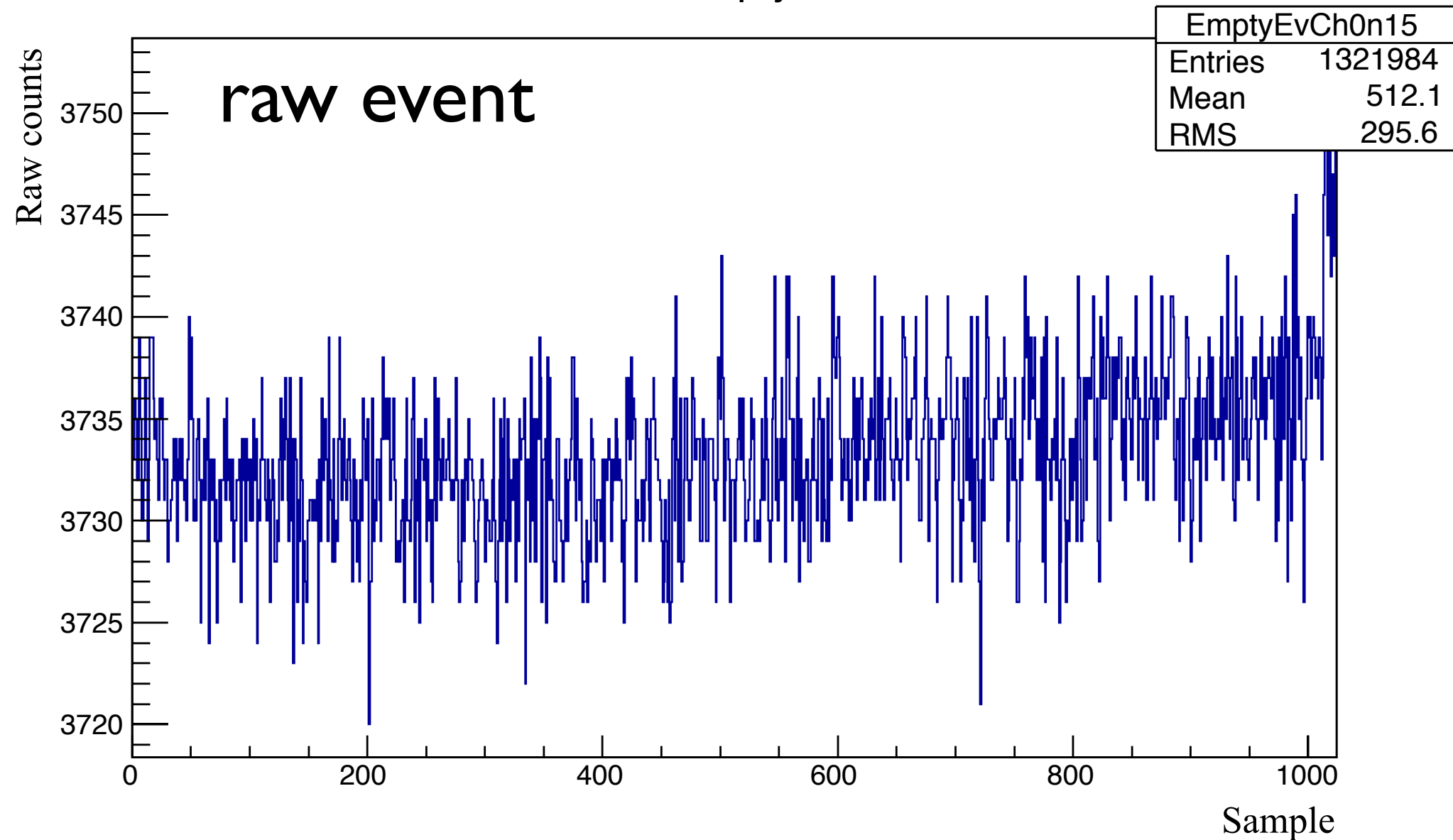
Global spectrum pedestal (bin = 25 pC)



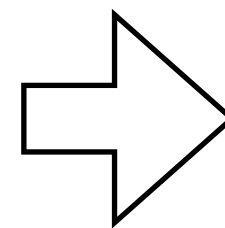
- Not saturated
- 0.3cm from position (0;0)

Pedestal position origin

Ch 0 PMT 1 empty events n.15



- Baseline non-null slope
- flat fit on first (70-180) samples



$$Q(\text{pedestal}) \neq 0$$

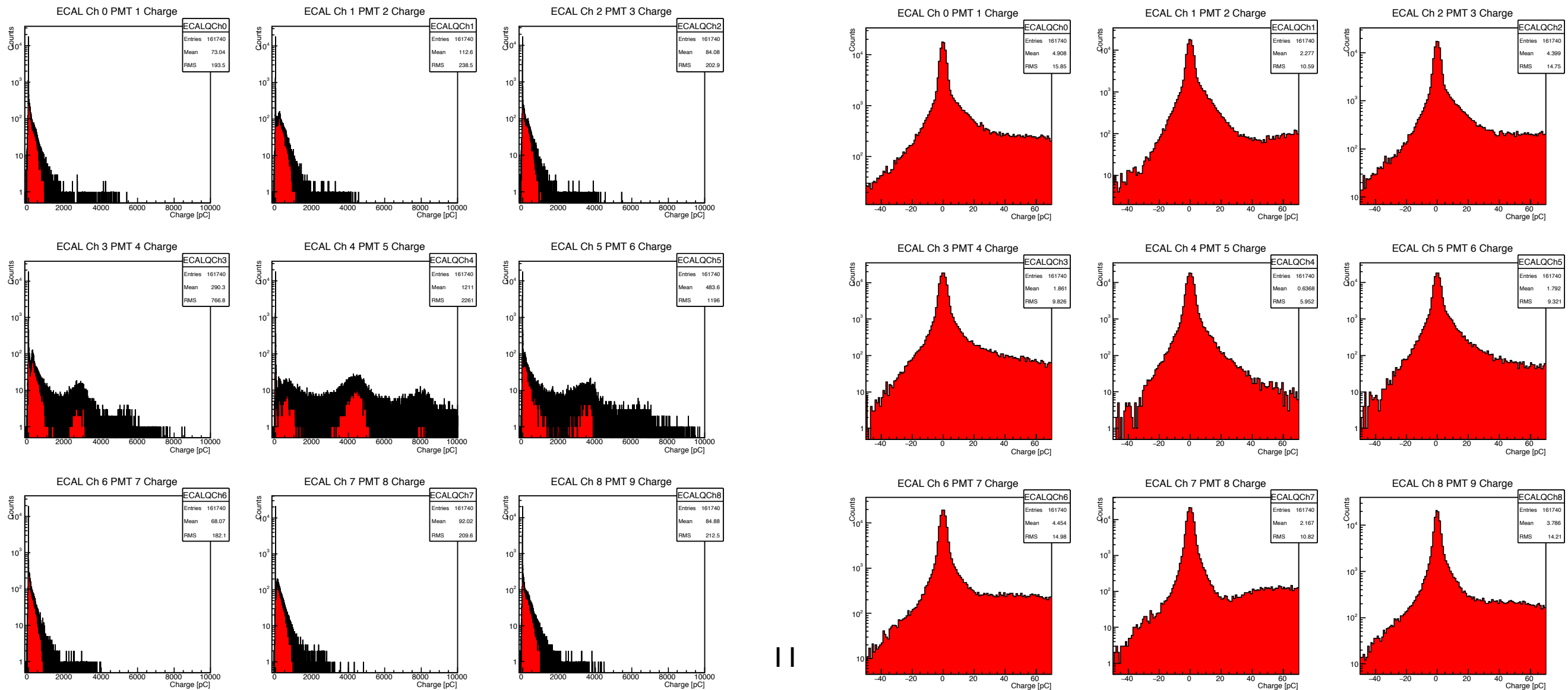
Baseline linear fit

Linear fit to last empty event up to sample 980 (to exclude last problematic samples) to:

- evaluate the charge (by subtraction)
- verify the presence of a pulse (3 consecutive pts > 2 bsl RMS)

bin = 1 pC

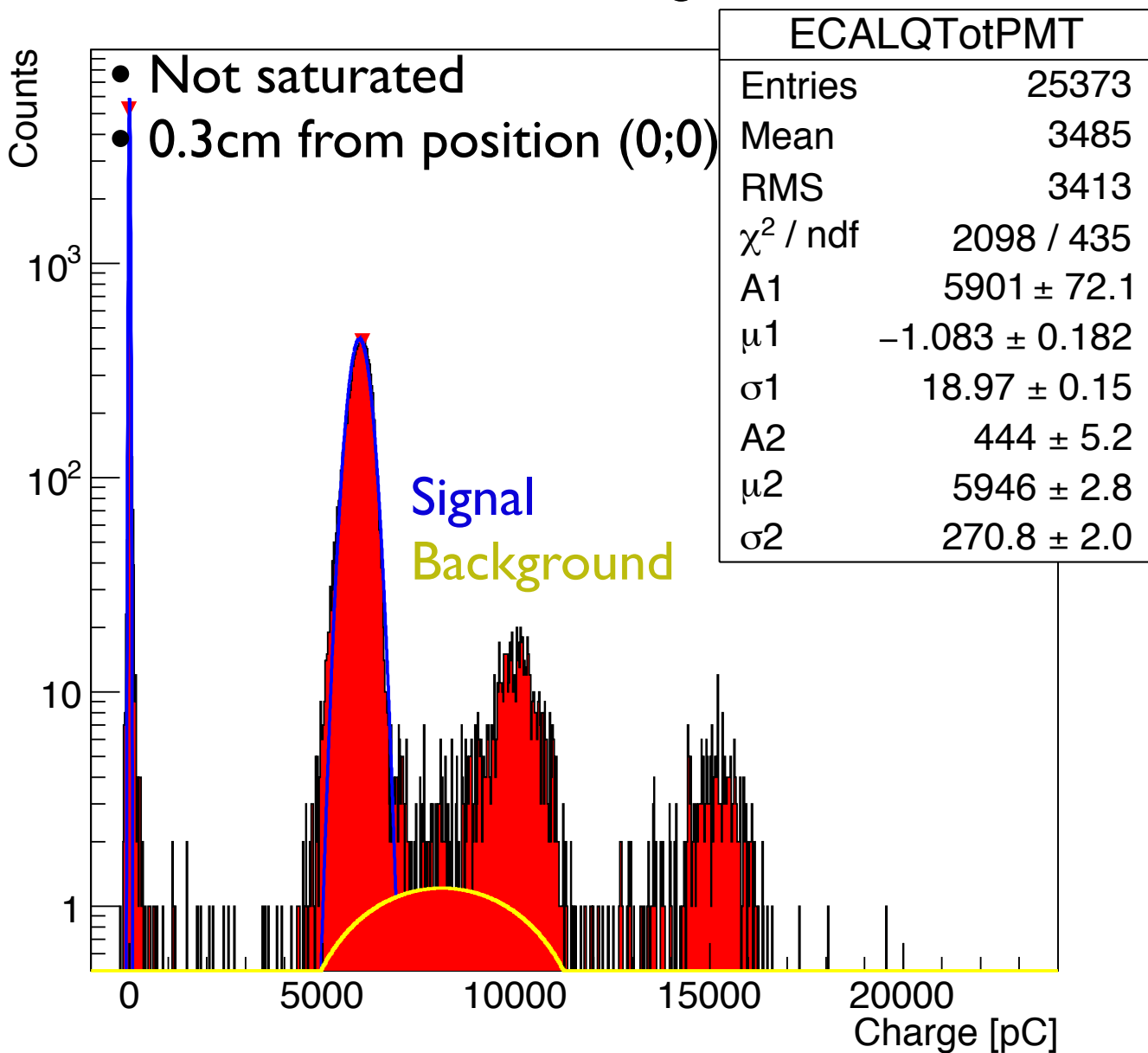
bin = 1 pC



Baseline linear fit global spectrum

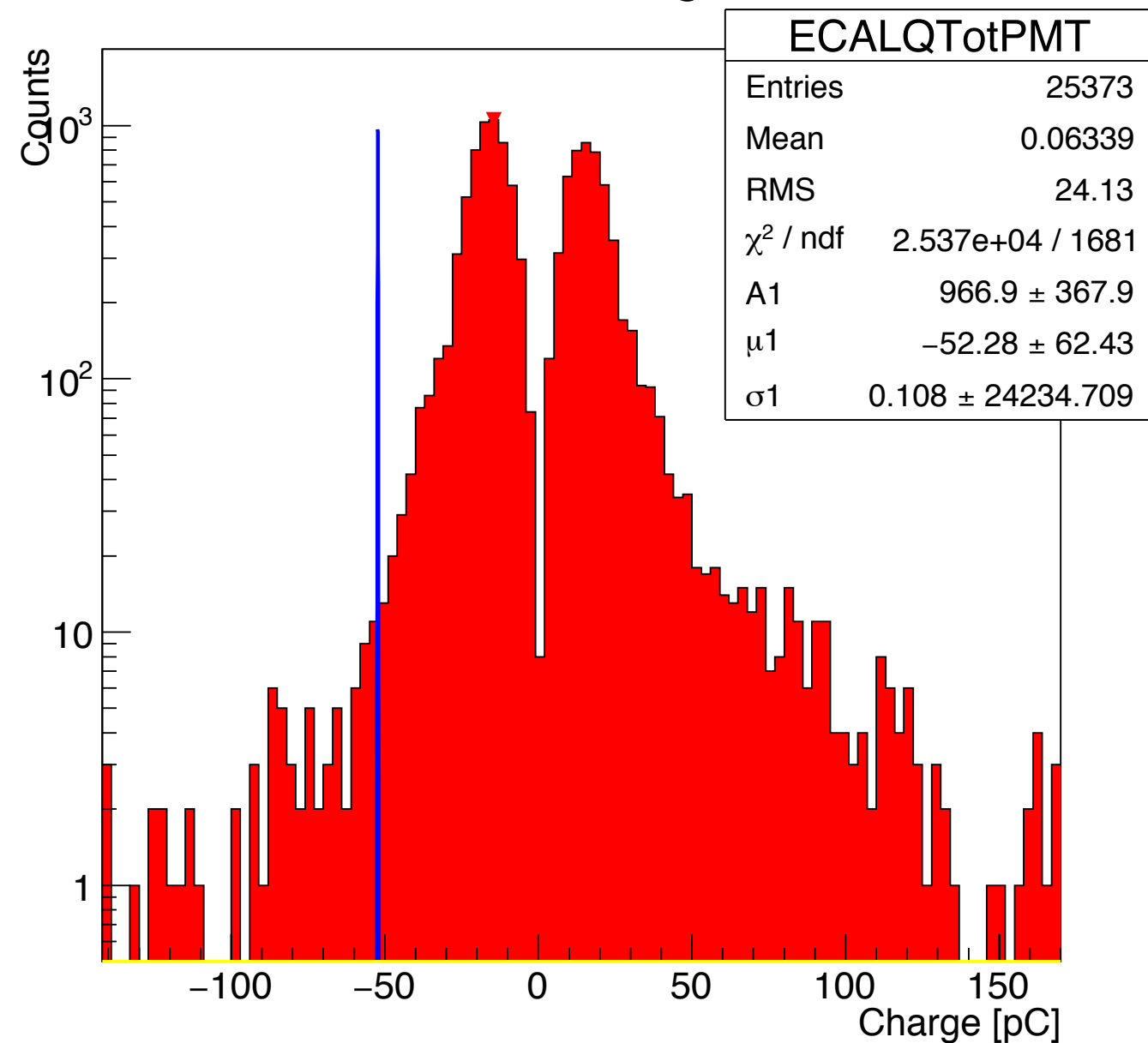
Charge spectrum
(bin = 25 pC)

ECAL - Total Charge run 305



Global spectrum
pedestal (bin = 3 pC)

ECAL - Total Charge run 305

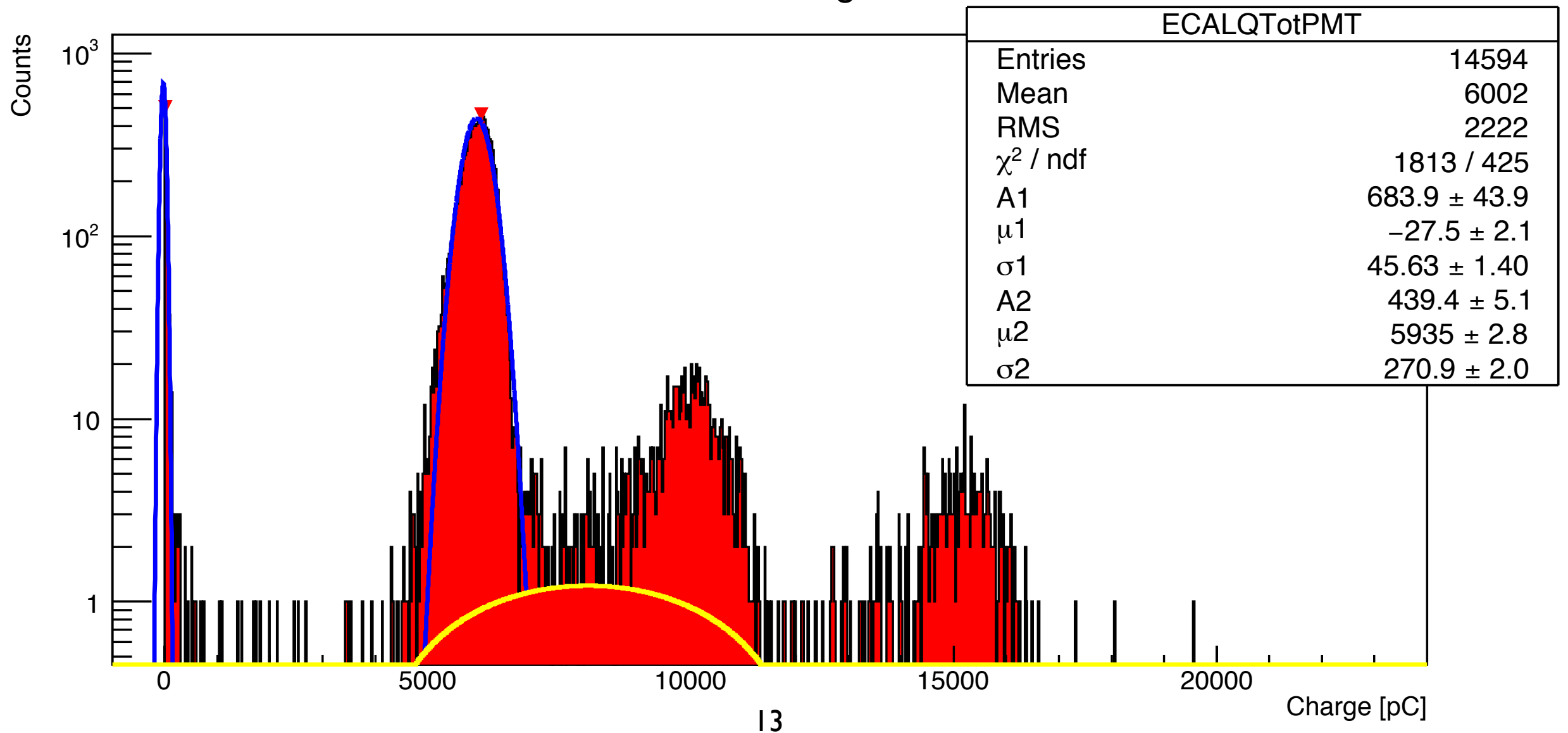


“Final” spectrum v.1

- Fit subtraction
- Zero-suppression
- $Q = 0$ & $IsPulse = false$ if $(Q < 0 \ || \ IsPulse = false)$

⇒ $IsPulse$ [bool] = true if there is a pulse (3 consecutive pts > 2 bsl RMS)

ECAL - Total Charge run 305

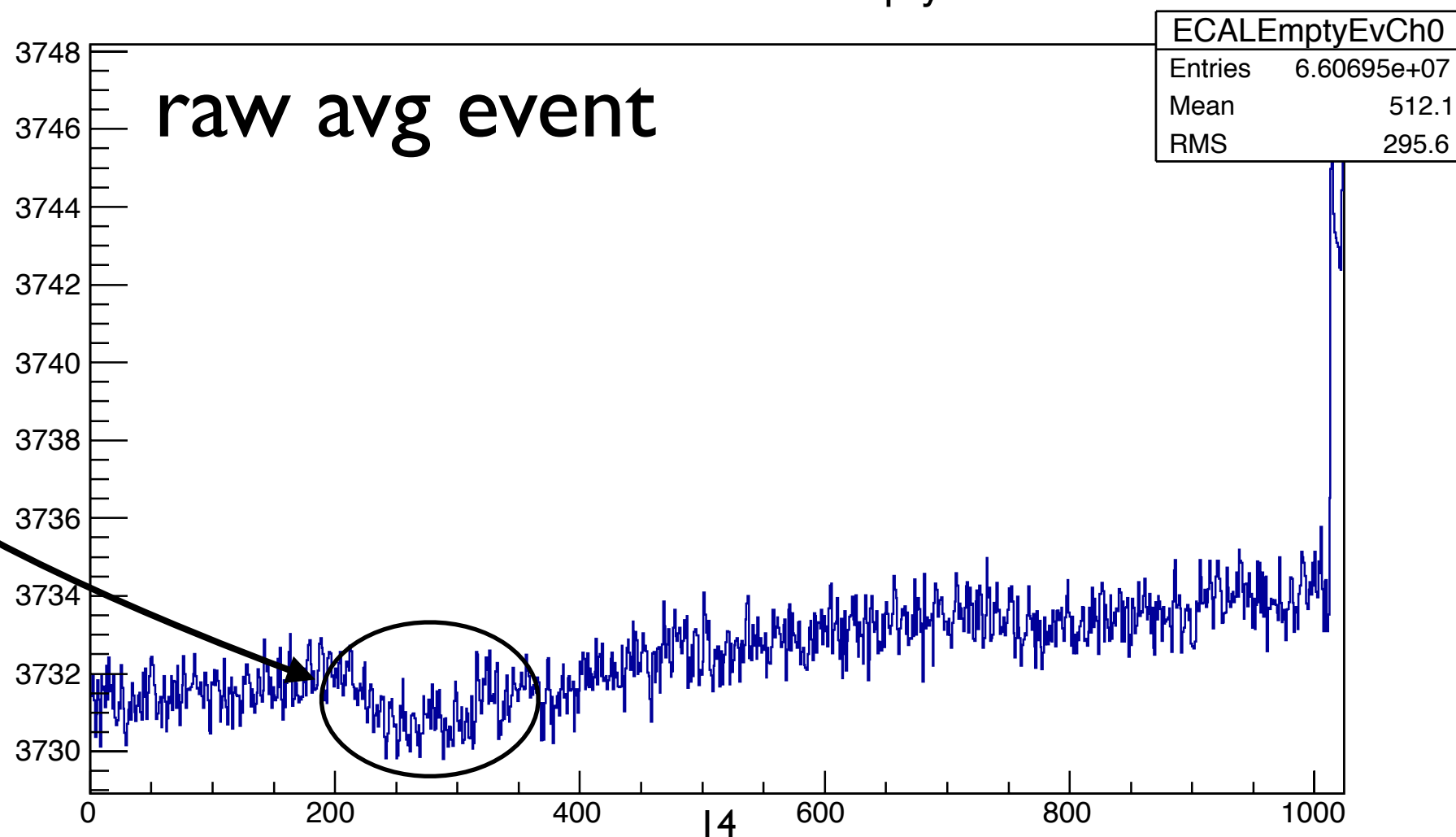


Average empty pulse subtraction

50 empty events to built the average empty pulse (1 per channel). Used to:

- evaluate the charge (by subtraction)
- not to verify the presence of pulse (due to a small bump at the peak position)

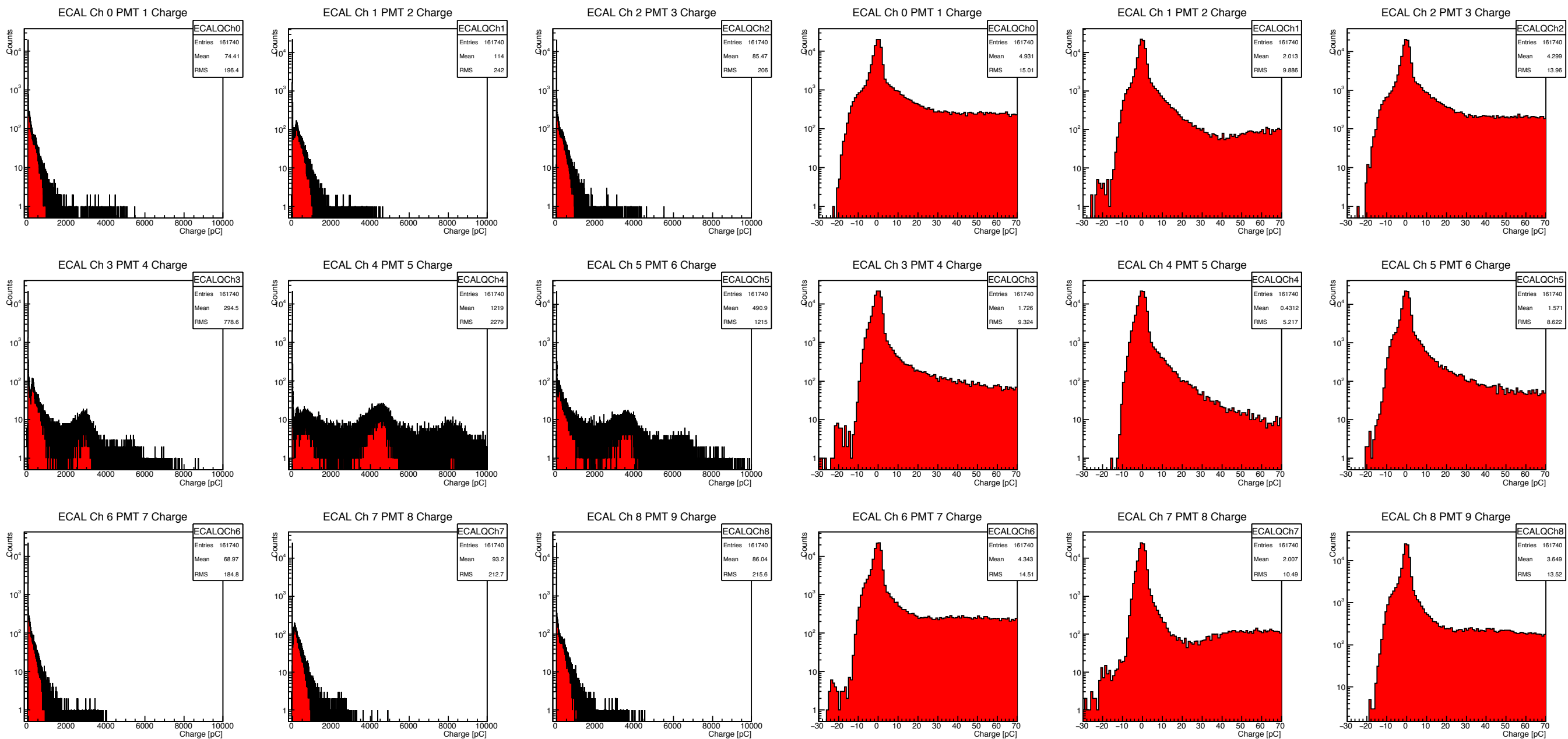
ECAL Ch 0 PMT 1 last empty event



Avg empty pulse sub. spectra

bin = 1 pC

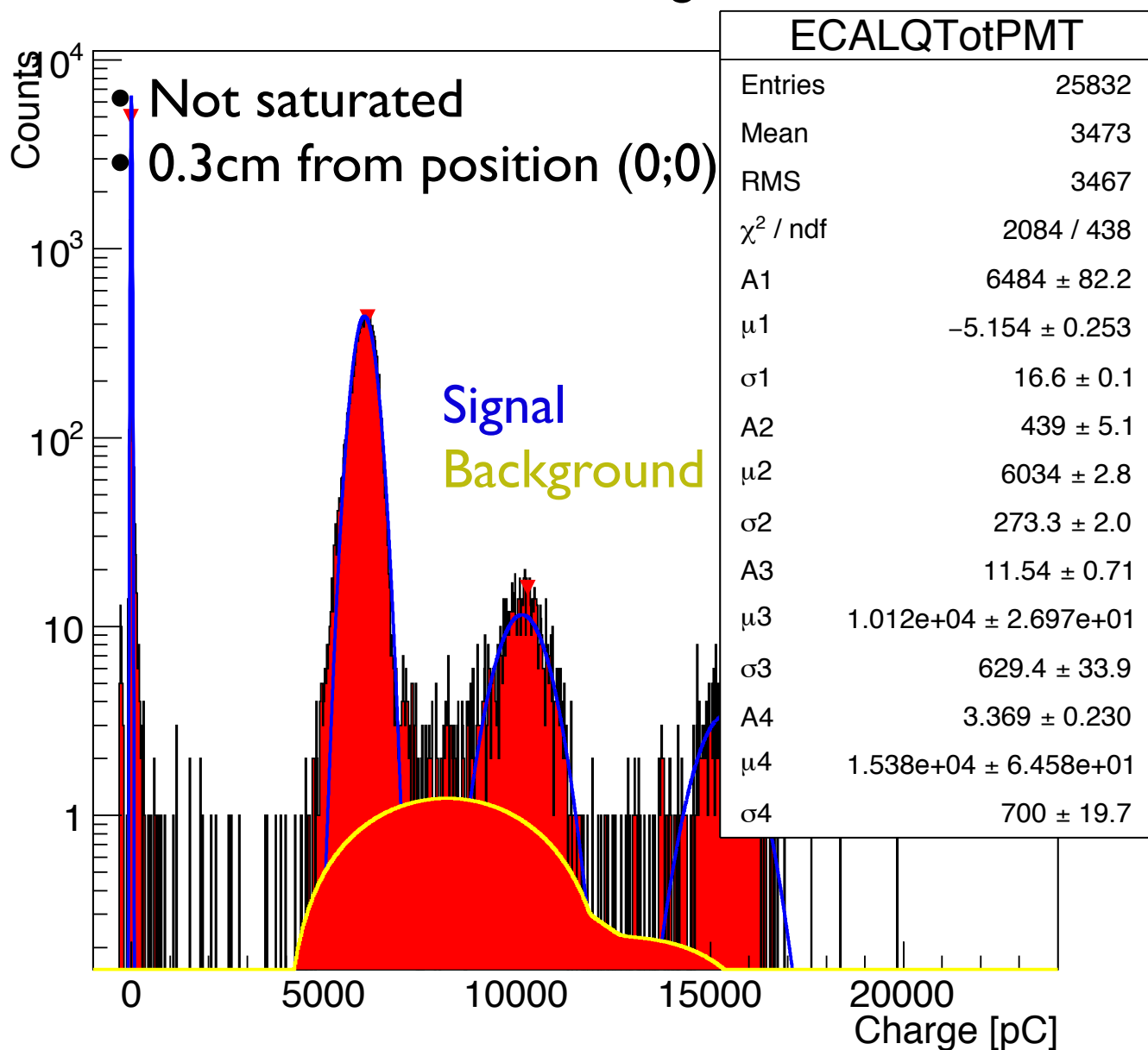
bin = 1 pC



Avg empty pulse sub. global spectrum

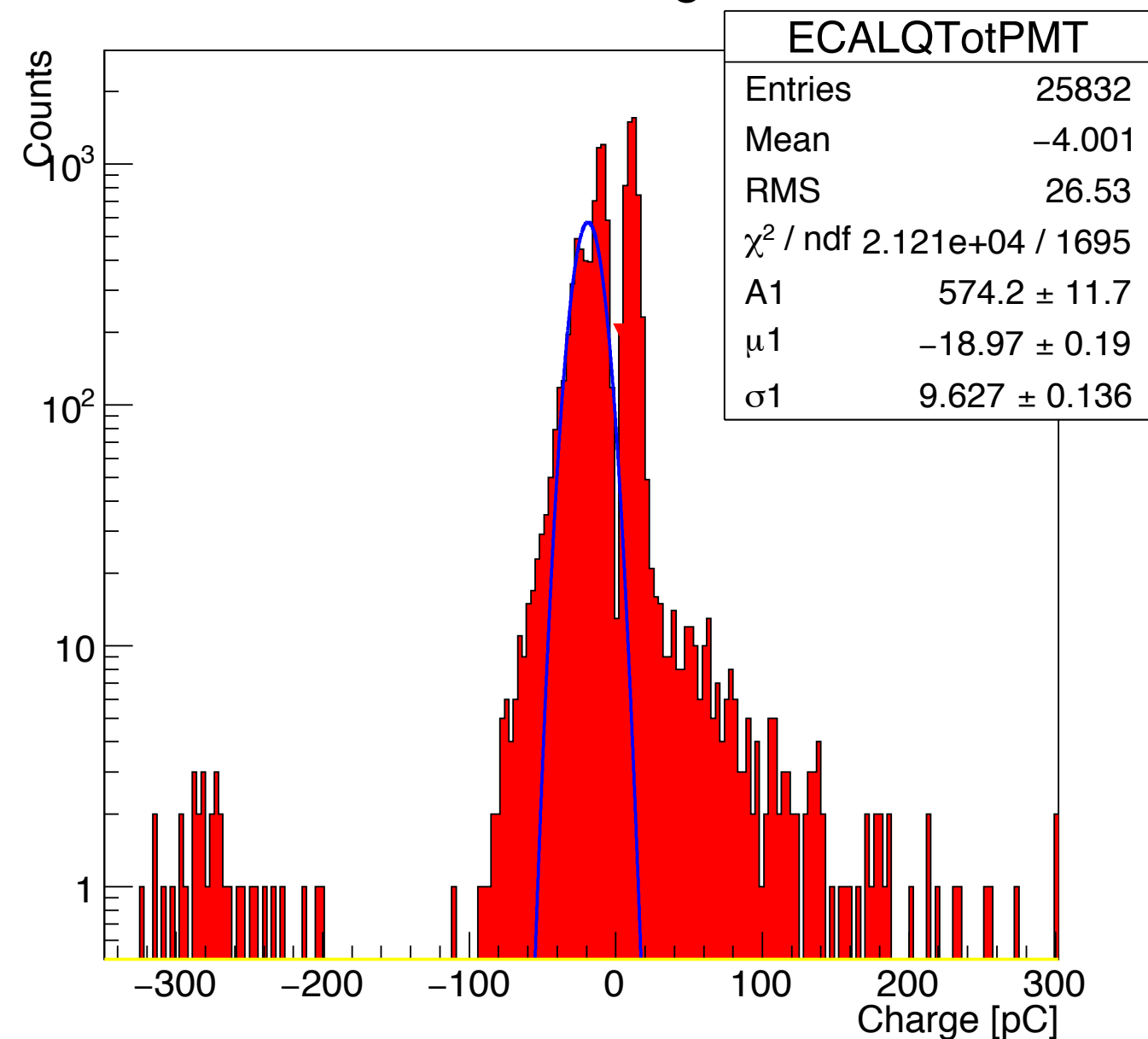
Charge spectrum
(bin = 25 pC)

ECAL - Total Charge run 305



Global spectrum
pedestal (bin = 3 pC)

ECAL - Total Charge run 305

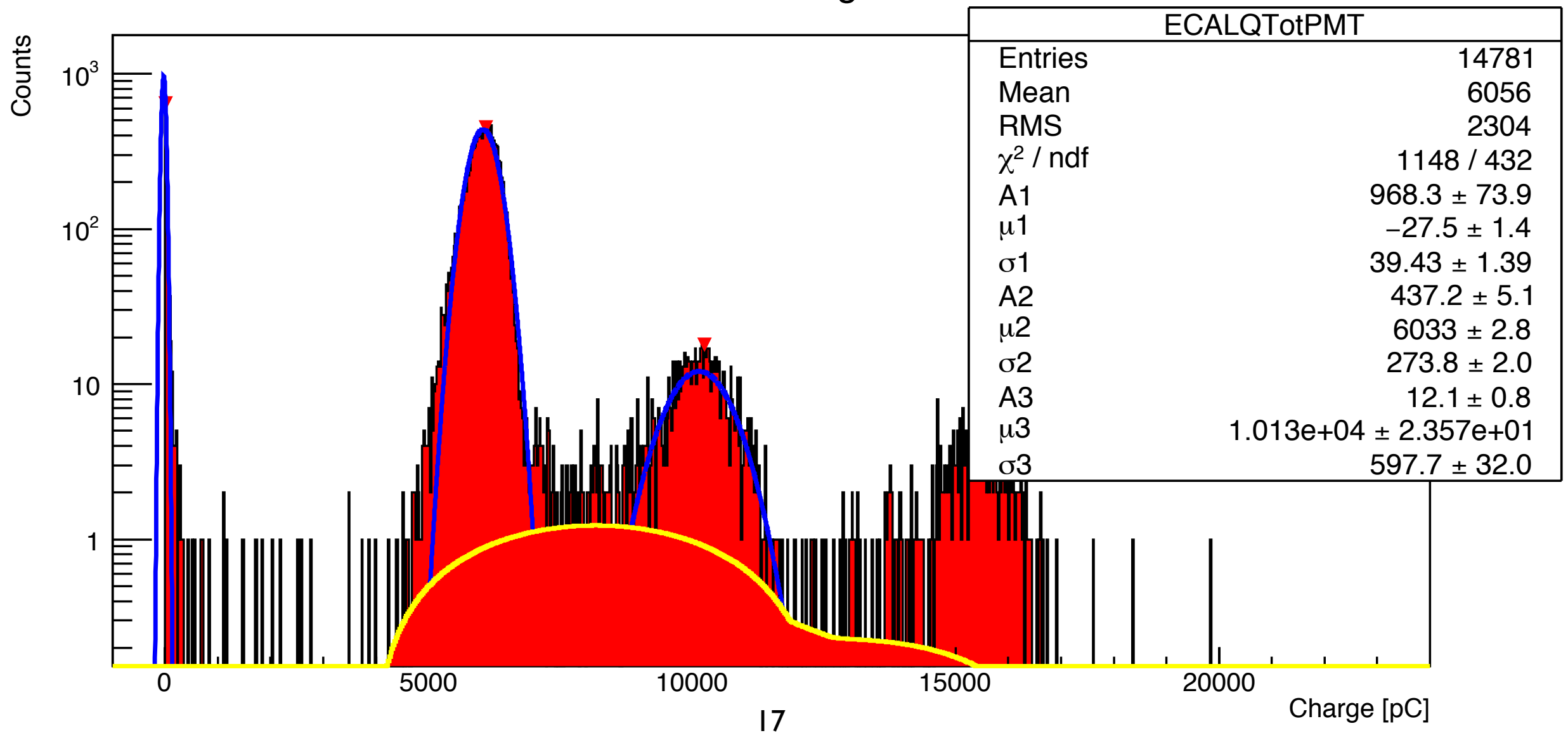


“Final” spectrum v.2

- Avg empty pulse subtraction
- Zero-suppression
- $Q = 0$ & $IsPulse = false$ if $(Q < 0 \ || \ IsPulse = false)$

⇒ $IsPulse$ [bool] = true if there is a pulse (3 consecutive pts > 2 bsl RMS)

ECAL - Total Charge run 305



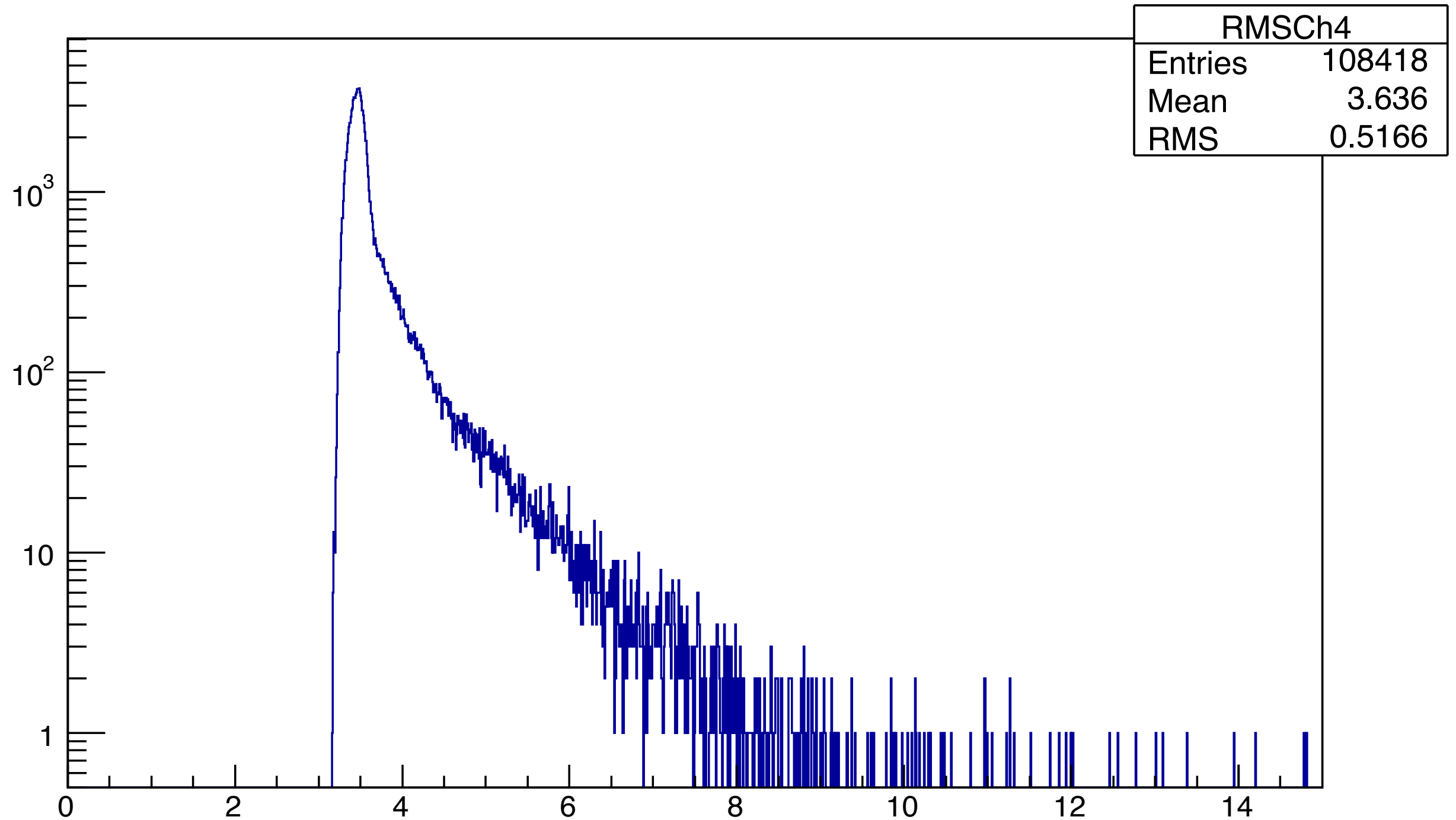
Resolutions comparison

	“Original”	Fit subtraction	Avg subtraction	Fit subtraction + zero- suppression	Avg subtraction + zero- suppression
Reso @1 GeV [%]	2.46	2.48	2.47	2.47	2.46
Pedestal position [pC]	-108	2 peaks: ± 15	2 peaks: ± 10	0 (by definition)	0 (by definition)

All energy resolutions are compatible
irrespectively of the analysis approach

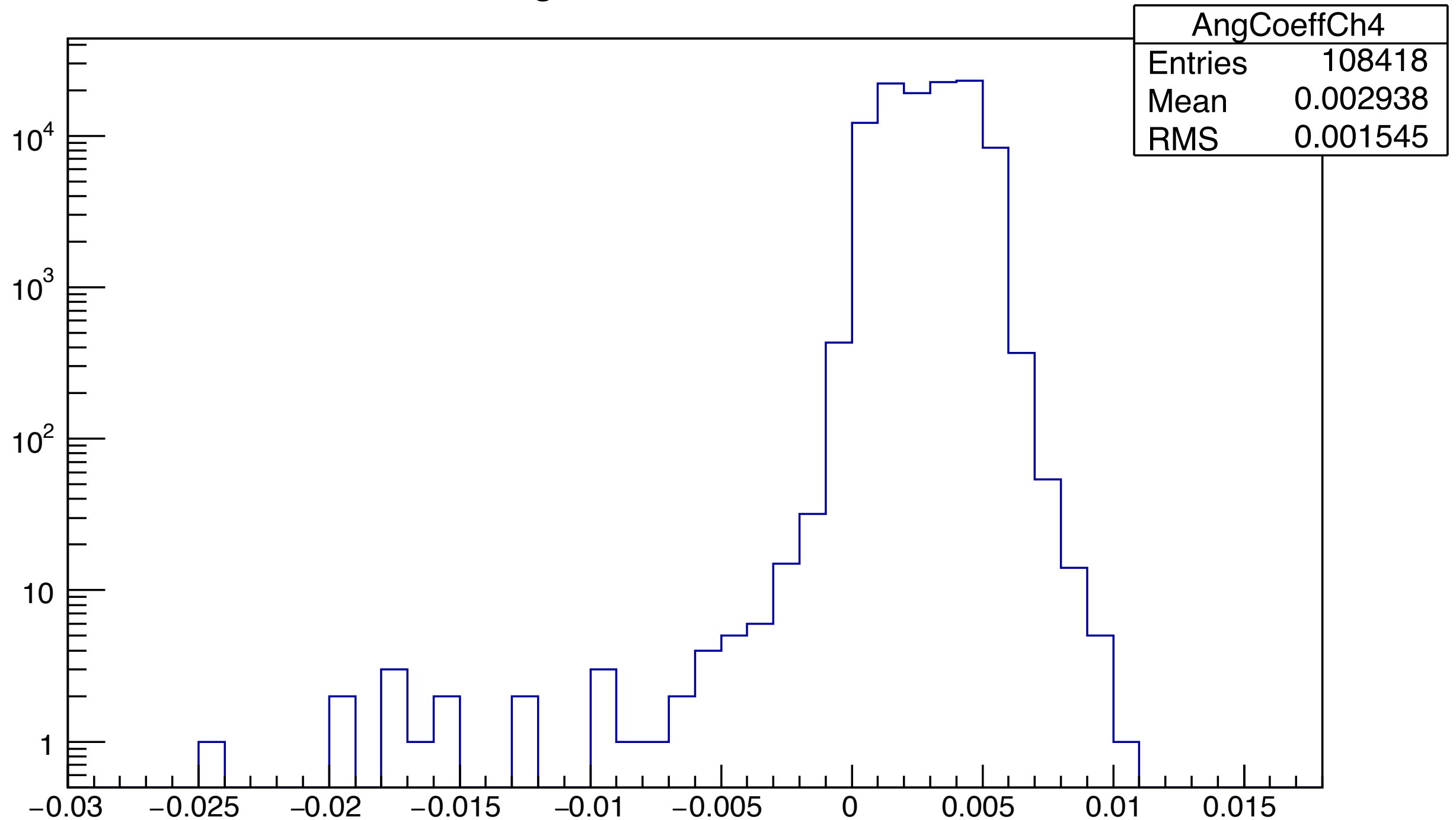
Baseline RMS

Linear fit RMS Ch 4 PMT 5



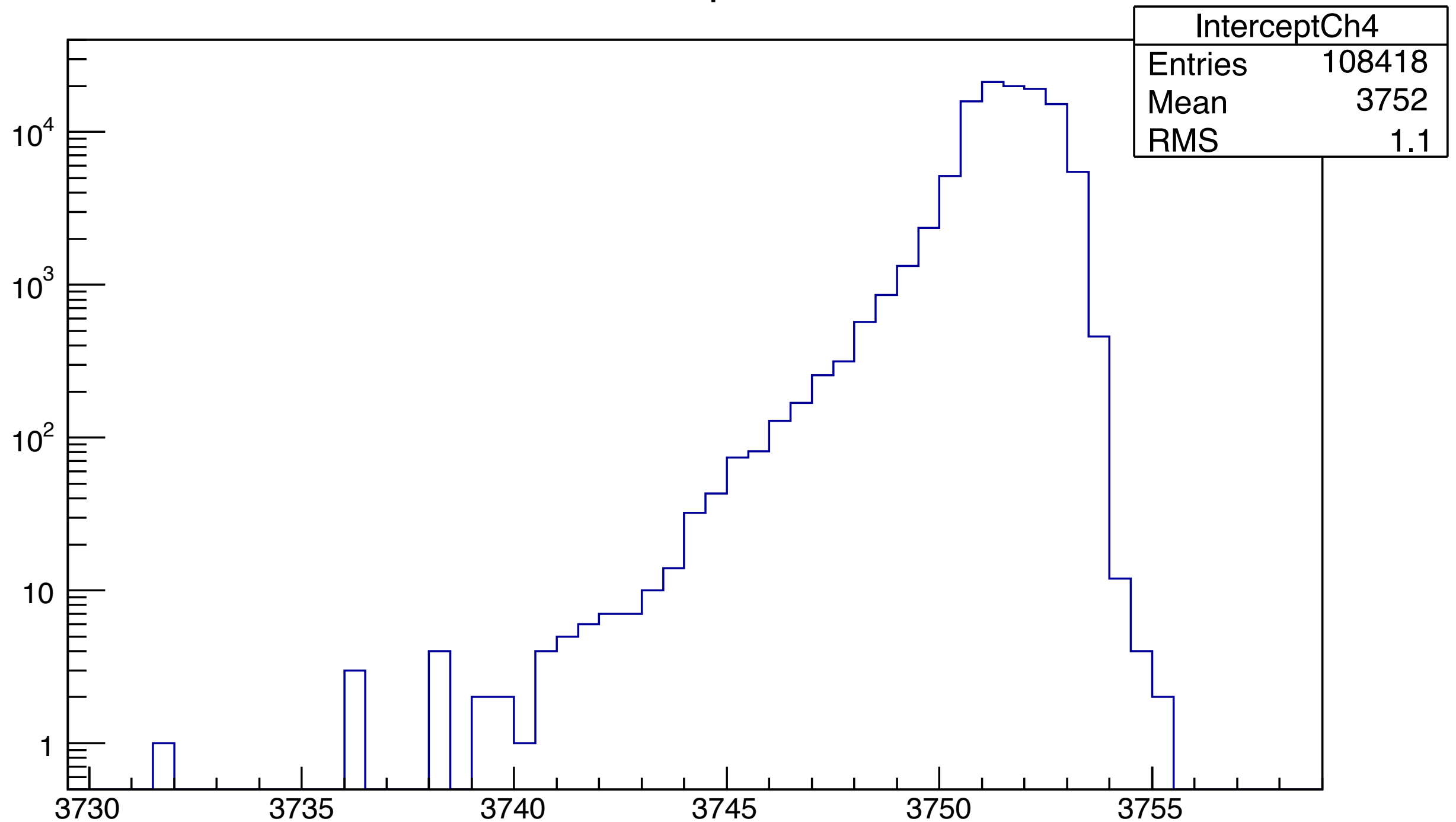
Linear fit angular coefficients

Linear fit angular coefficient Ch 4 PMT 5



Linear fit intercept

Linear fit intercept Ch 4 PMT 5



Position problem

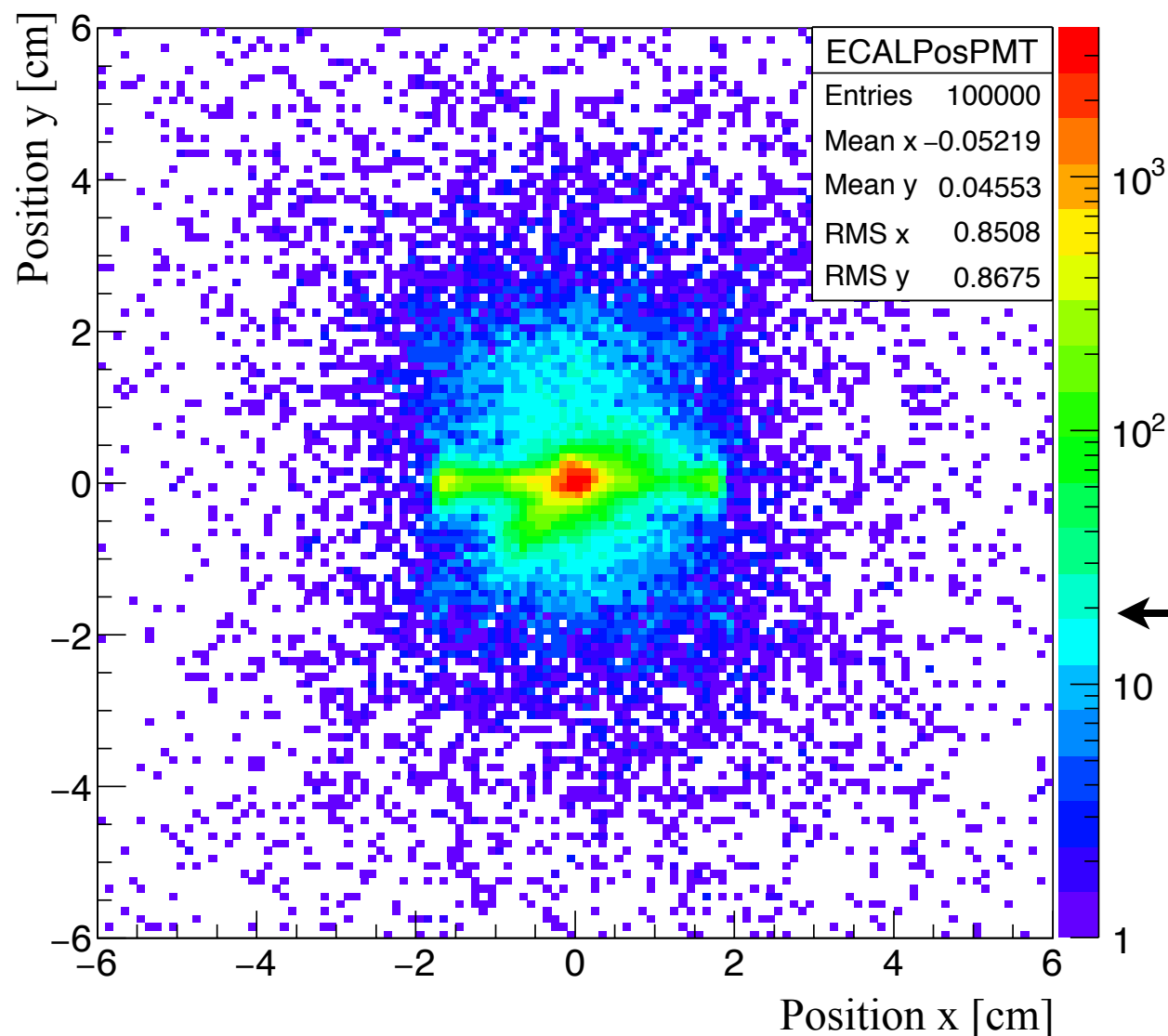
Interaction point by proportional weighting of the charge

The problem

Charge fluctuations become important near zero \Rightarrow position can go outside the $[-2,2]$ cm range in x and y

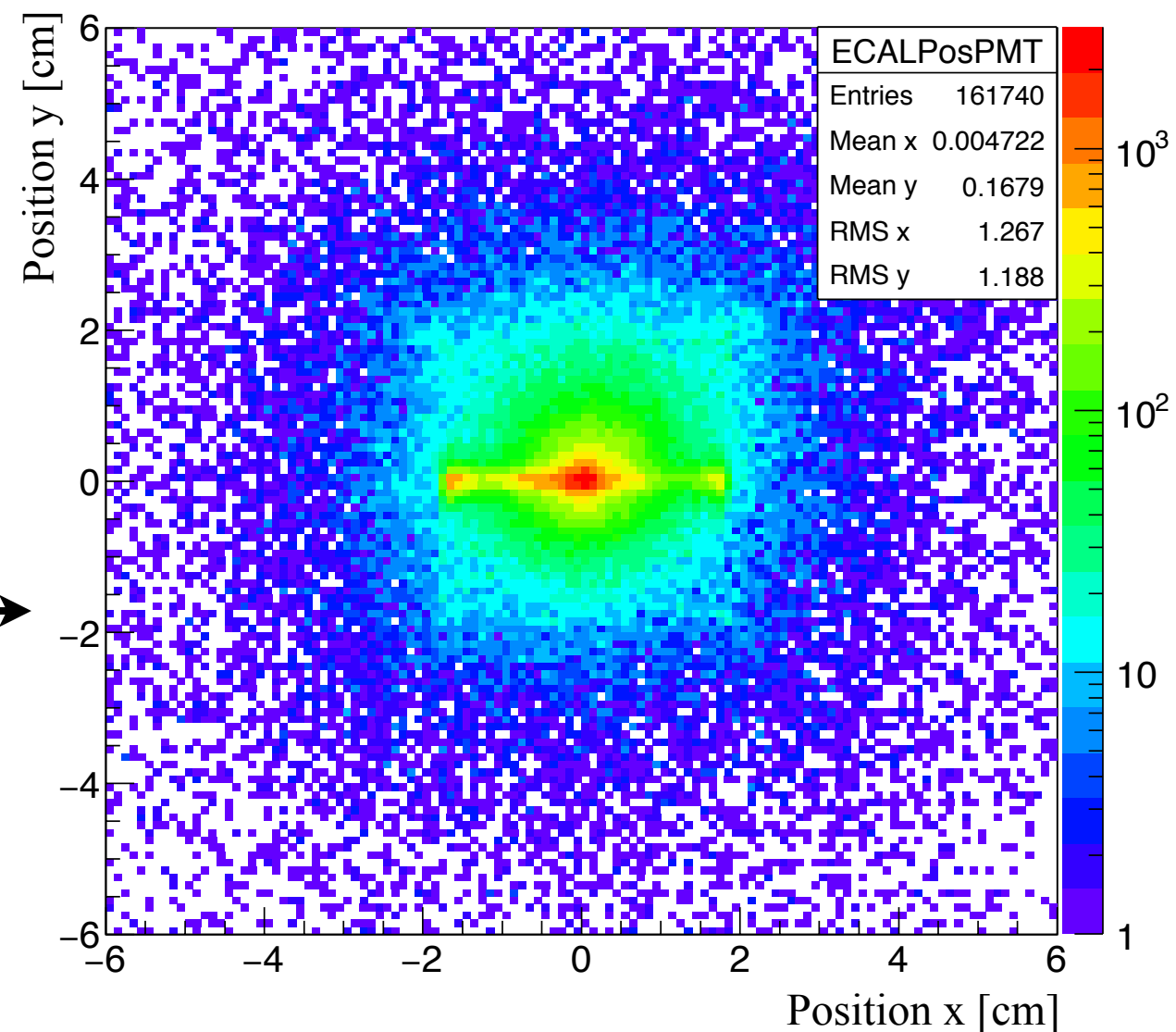
ECAL - Position run 305

ECAL - Position run 305



Two different code implementations

22

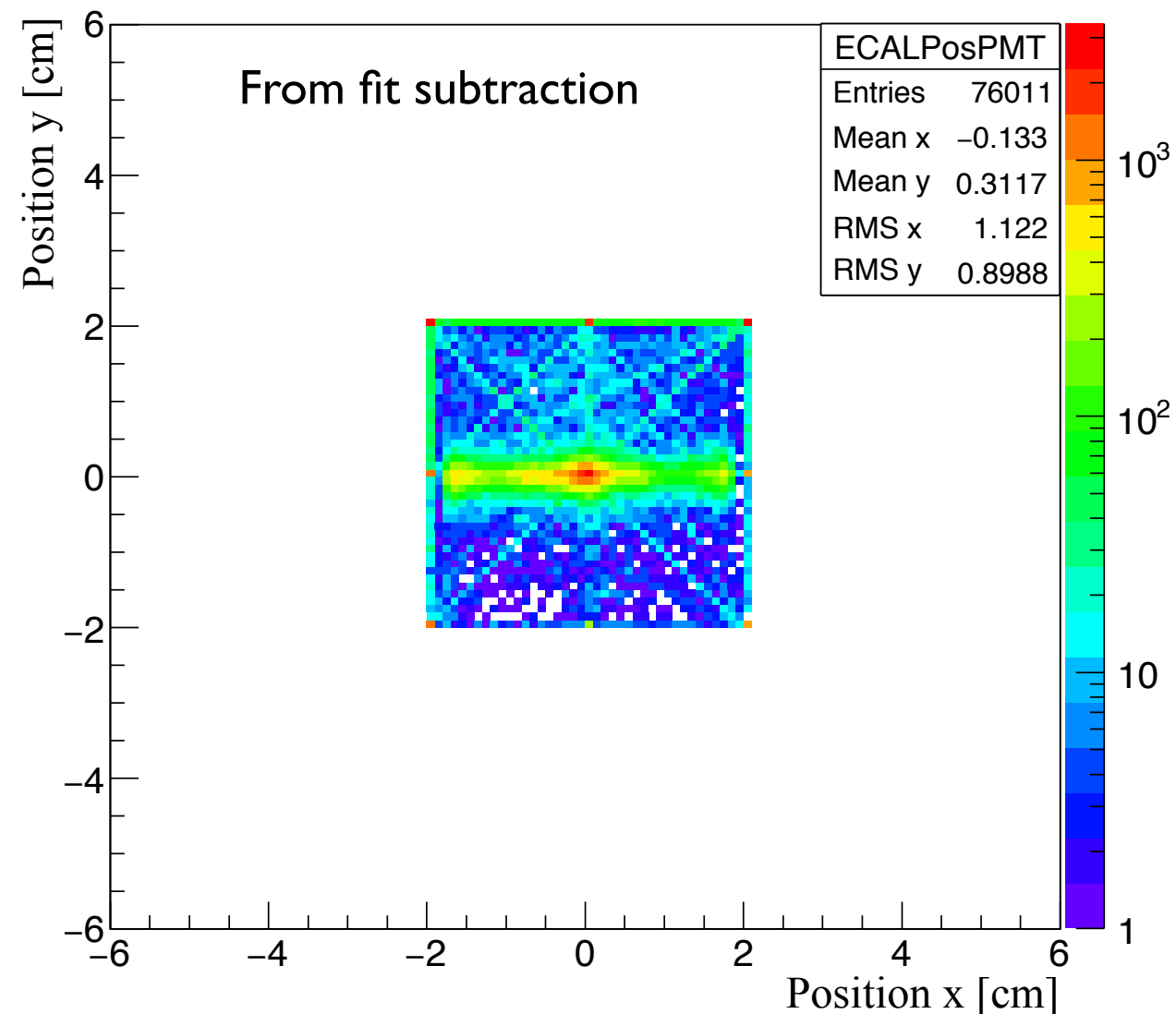
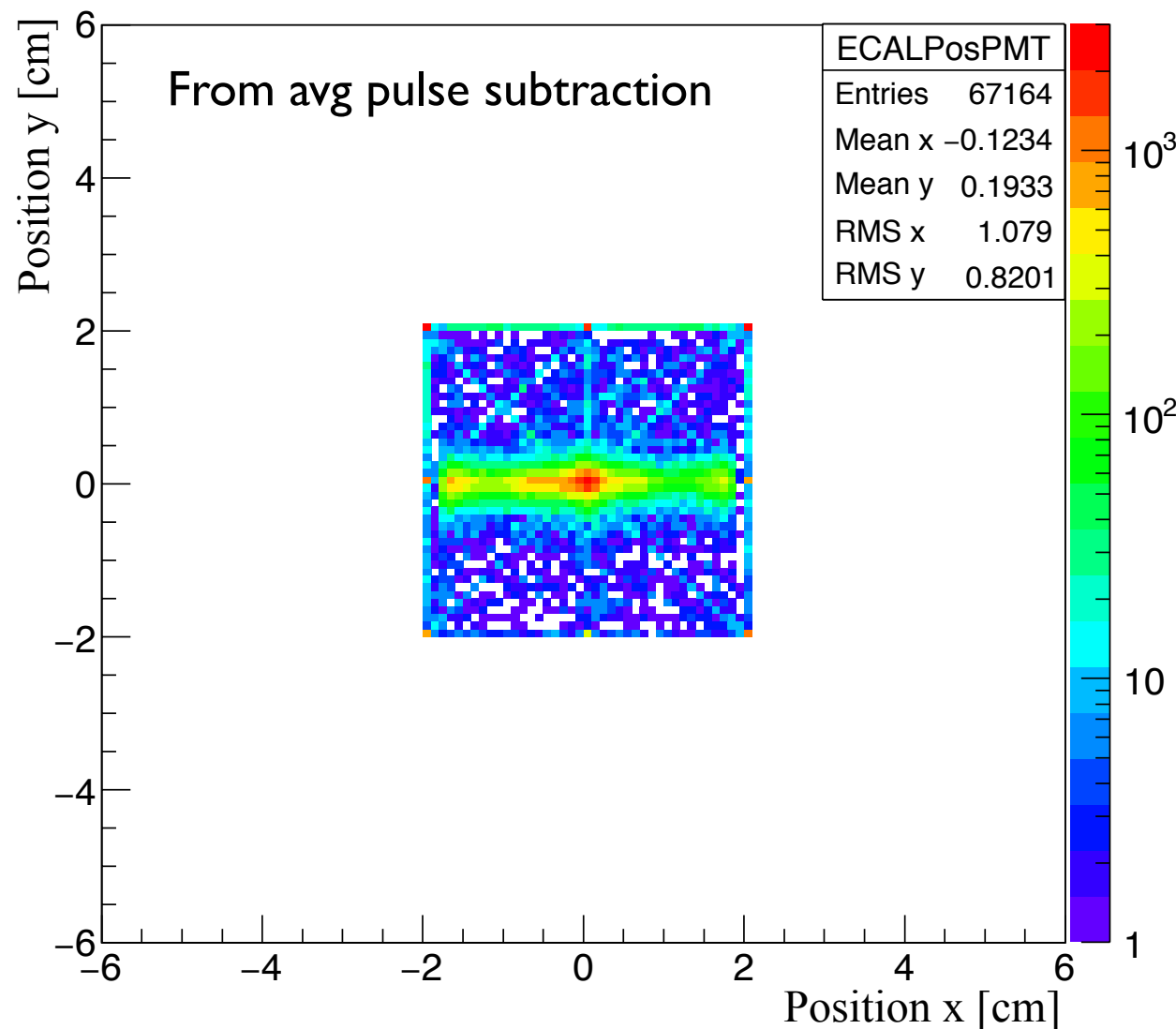


“Final” position

- Avg empty pulse subtraction
- Zero-suppression
- $Q = 0$ & $IsPulse = false$ if $(Q > 0 \ || \ IsPulse = false)$

ECAL - Position run 305

ECAL - Position run 305



Now position is in the correct range

Conclusions

- Last $\approx 10/15$ window samples are particularly problematic
- Baseline slope can be recovered by means of a linear fit or an avg empty pulse subtraction
- Avg pulse subtraction results can be improved w/ a trigger dedicated to collect empty events (lower threshold)
- Now position is in $[-2,2]$ cm range, both in x and y
- Position results can be improved w/ a non linear weighting (probably needed a larger ECAL for tests)
- Zero-suppression works fine
- Threshold < 1 MeV (20 pC) is achievable

Backup

APD setup

- $1 \times 1 \text{ cm}^2$ Hamamatsu S8664-1010 Si APD
- 9 $2 \times 2 \times 22 \text{ cm}^3$ L3 BGO crystals (cut and polished)
- teflon wrapping
- not stable and very homemade structure (e.g. BGO are leaning against the APD faces)
- APD equalized gains = 200

