Polca

- Apparatus
- Principle
- Potential for comparison with Tpol Lpol
- Analysis
- Future prospect

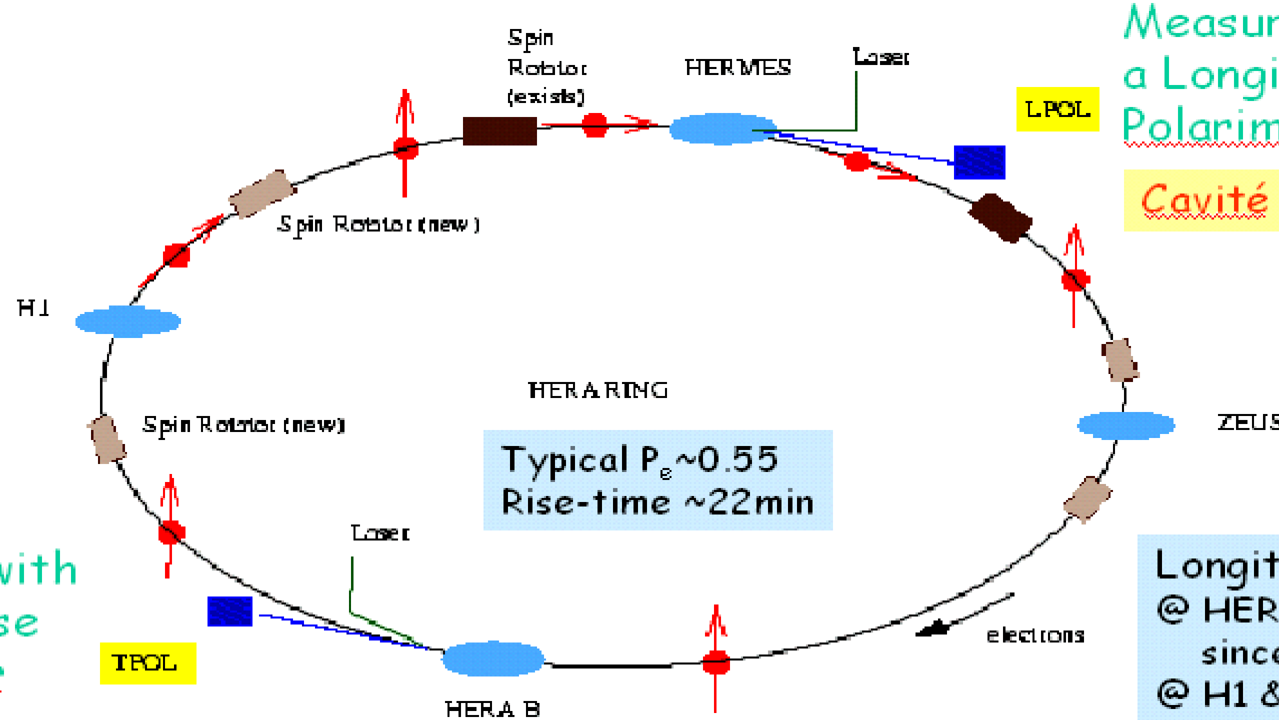
Hera and the three polarimeters

Sokolov-Ternov Effect

Natural transverse polarization → Spin Rotator → Longitudinal polarizatior

Measured with a Longitudinal Polarimeter

Cavité LPOL

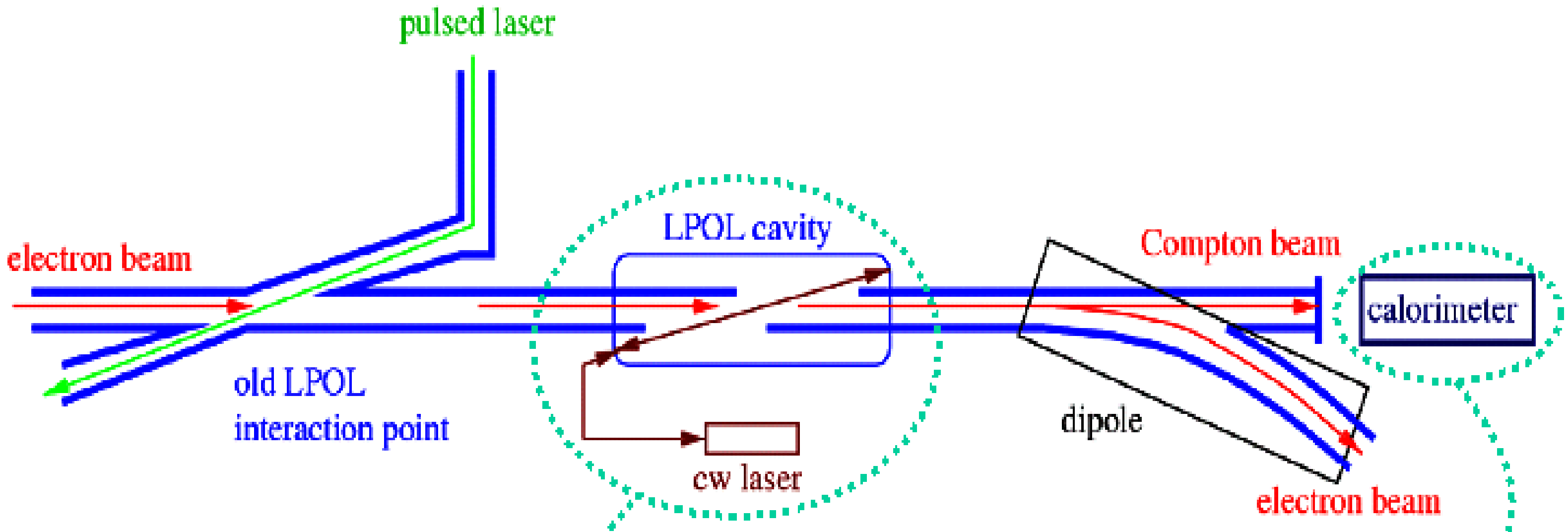


Typical P_e~0.55
Rise-time ~22min

Measured with a Transverse Polarimeter

Longitudinal P_e
@ HERMES since 1995
@ H1 & ZEUS after upgr

Polca setup



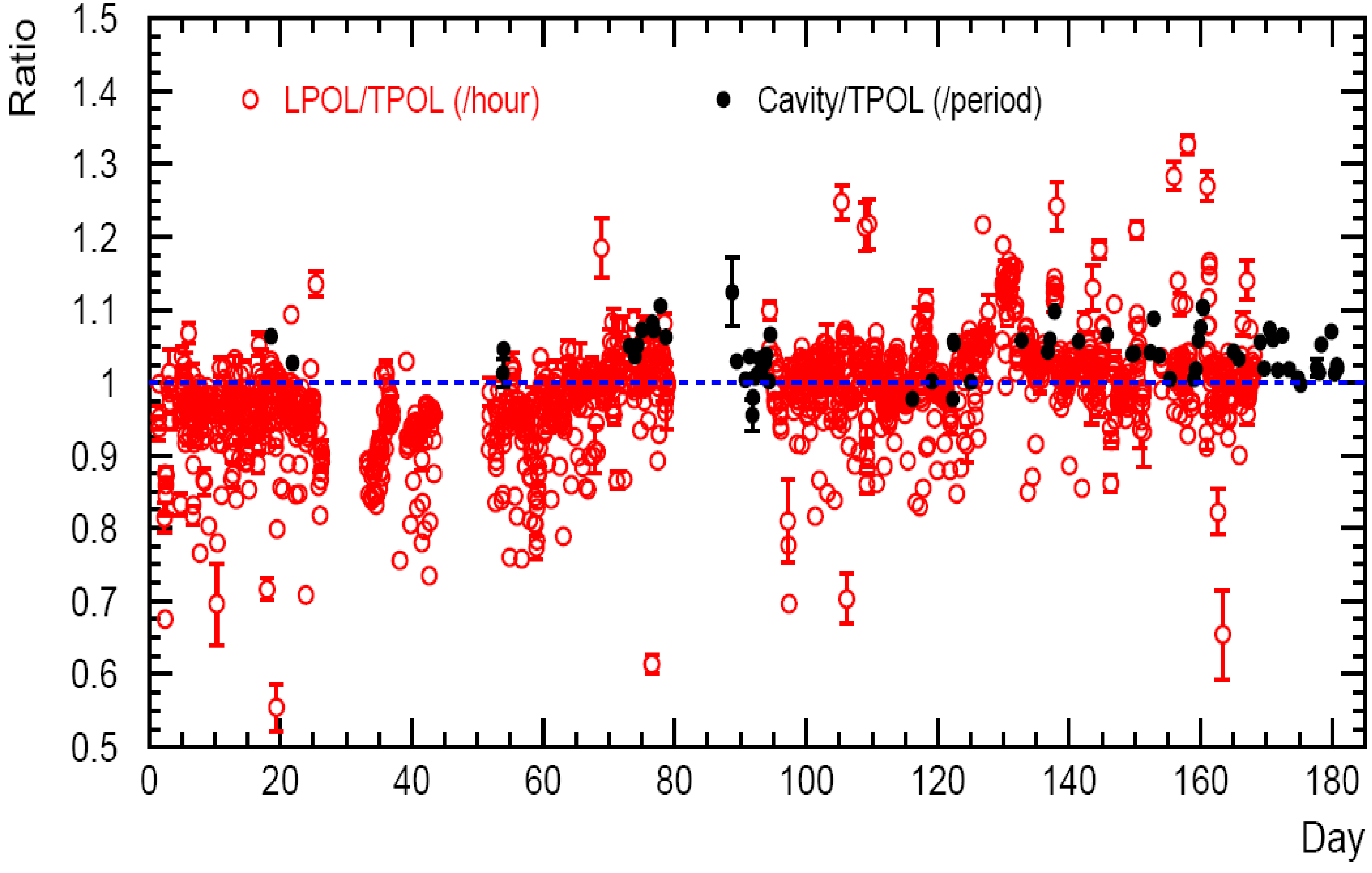
→ **Two key elements:**

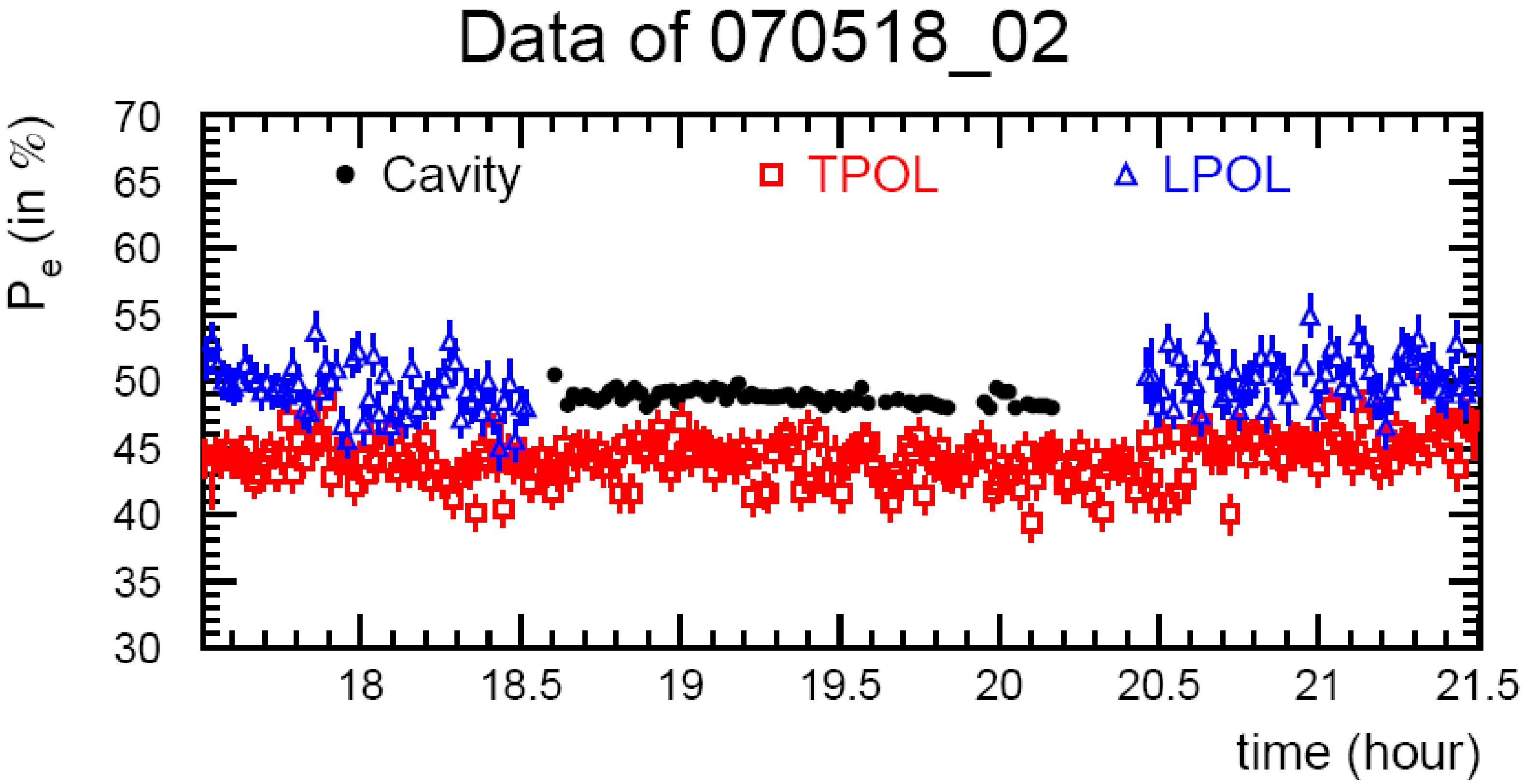
- Fabry-Pérot cavity (to increase the laser power by >10^3)
- Sandwich or fiber calorimeter (to measure E_γ of the scattered photon)

LPOL Cavity statistics

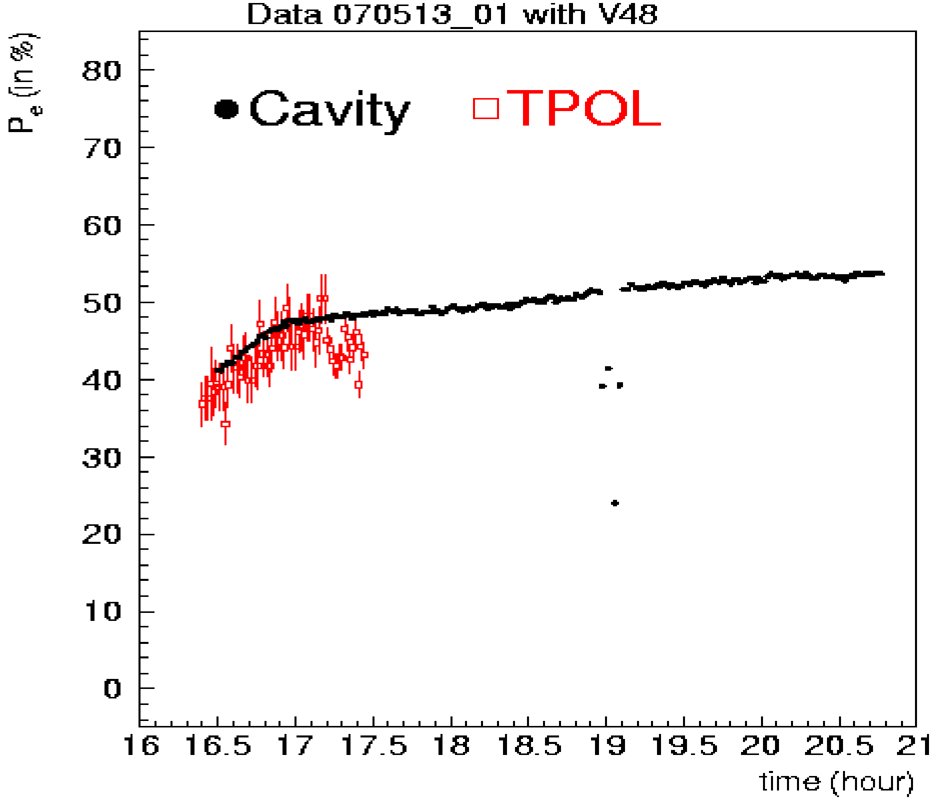
- Efficient running during about 300 hours (from 6 oct 2006 to end)
- Calo energy : 7 Tera measurements
- Brems : 2 Tera
- Comptons : 900 Giga (~ energy stored in one Hera bunch)
- Left and Right laser polarization differ by 60 Giga
- Systematics dominated

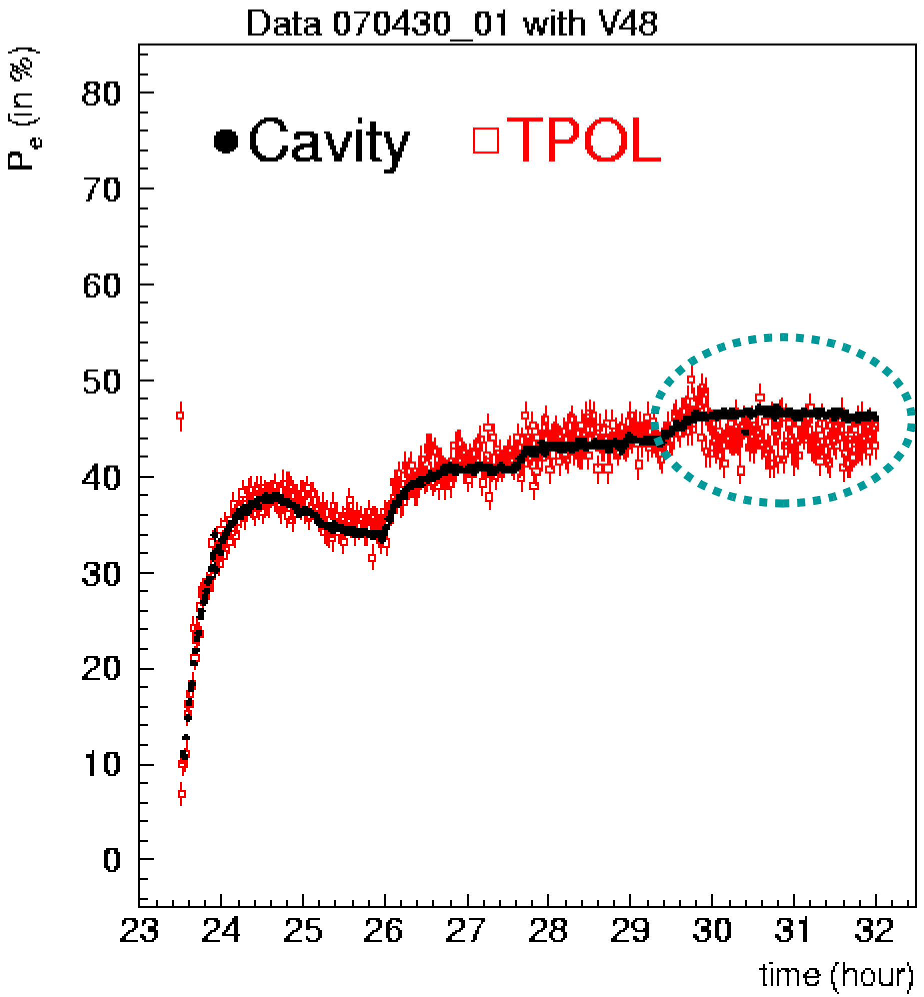
Comparison with Tpol Lpol




Data of 070518_02
Cavity
TPOL
LPOL
P_e (in %)
70
65
60
55
50
45
40
35
30
18
18.5
19
19.5
20
20.5
21
21.5
time (hour)

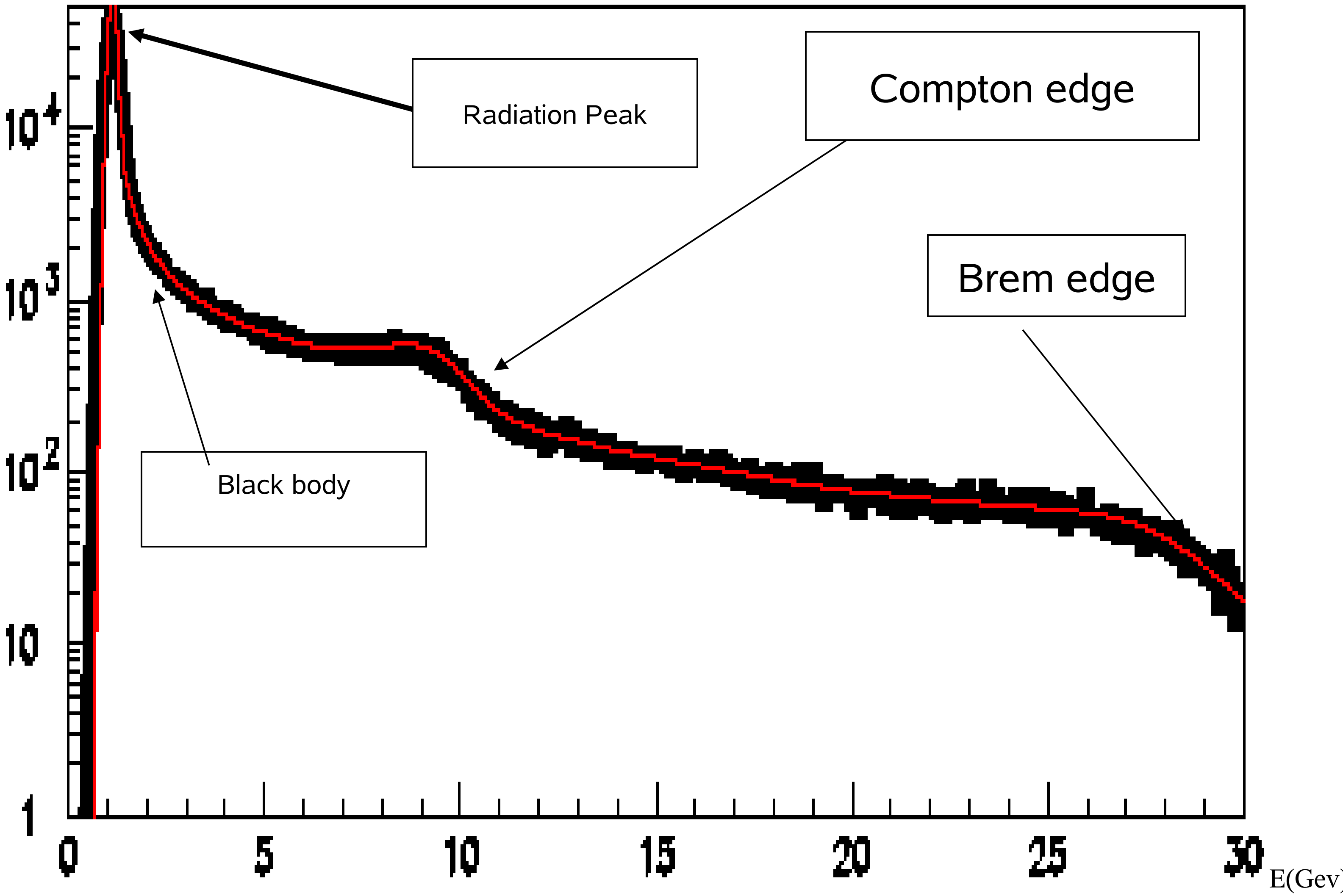
One good example to show only cavity measurements are available



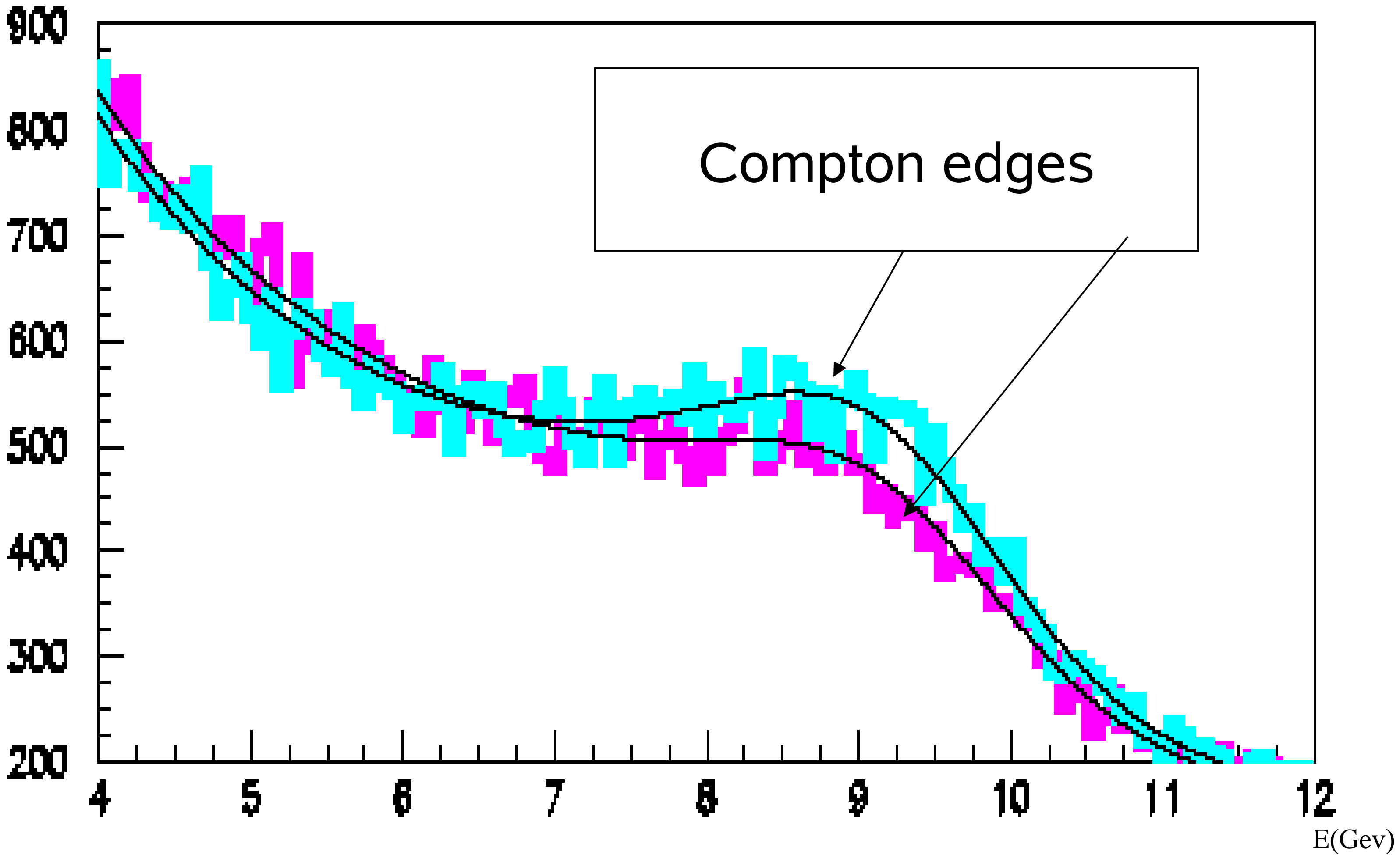


Data 070430_01 with V48
P_e (in %)
80
70
60
50
40
30
20
10
0
Cavity
TPOL
23
24
25
26
27
28
29
30
31
32
time (hour)

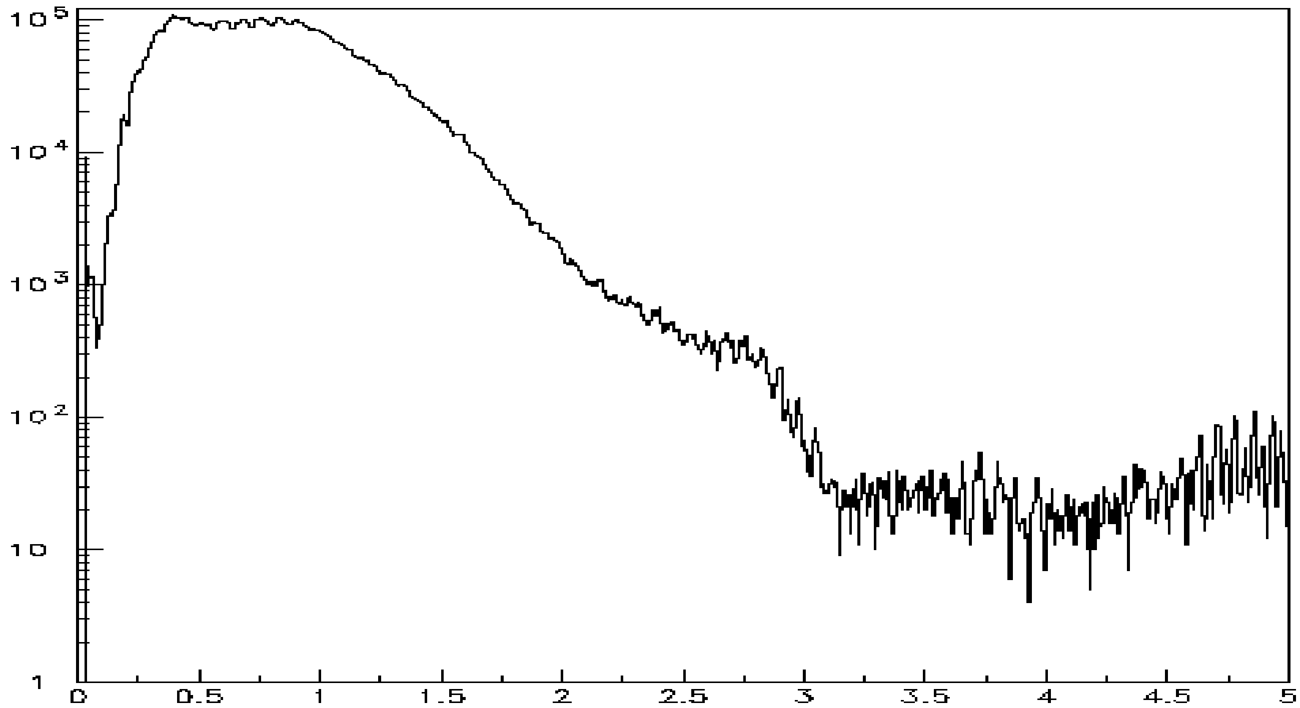
Measurement example



Measurement example

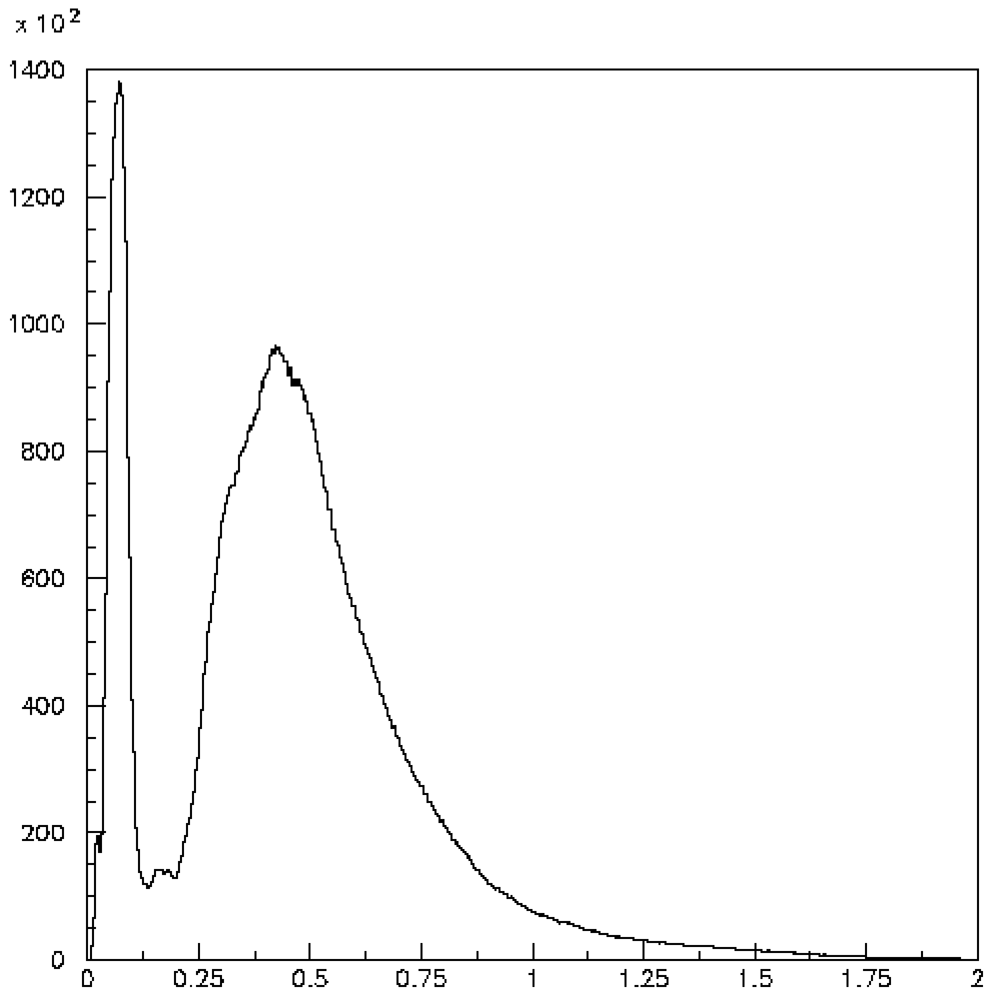


Rads peak energy

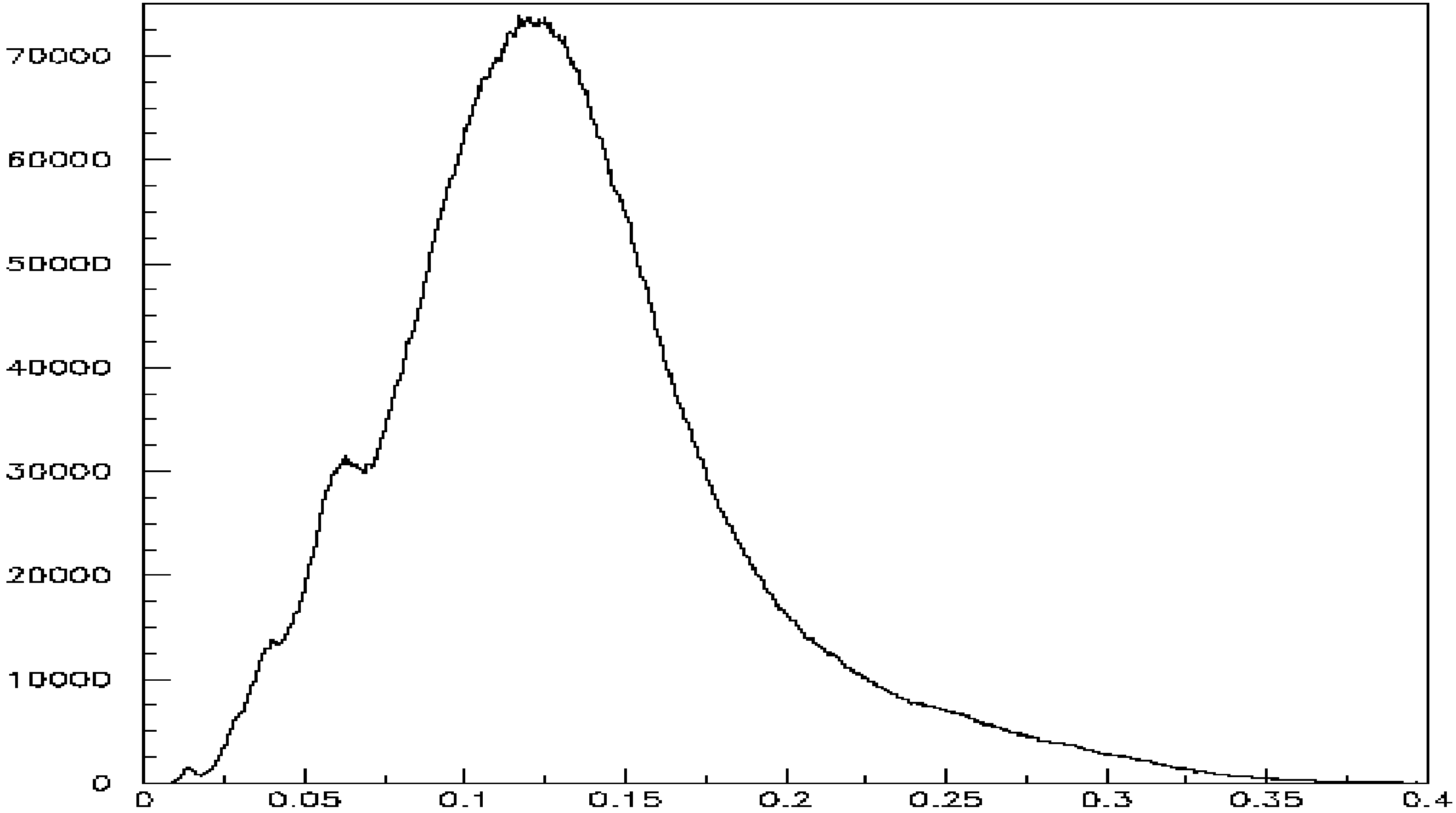


E (GeV)

Distribution of number of brem



Distribution of number of Compton



Analysis method

- Simulation

Cross section: (Brem,Compton,Black) or Energy (synchrotron peak)

Calo simulation: Rad peak $\sigma_r^2 = aE$ photon $\sigma_\gamma^2 = aE+bE^2$

$E=\alpha x$ x following a χ^2 distribution

E to ADC conversion: five alternate models such as A=cE(1+d/E+E*s)

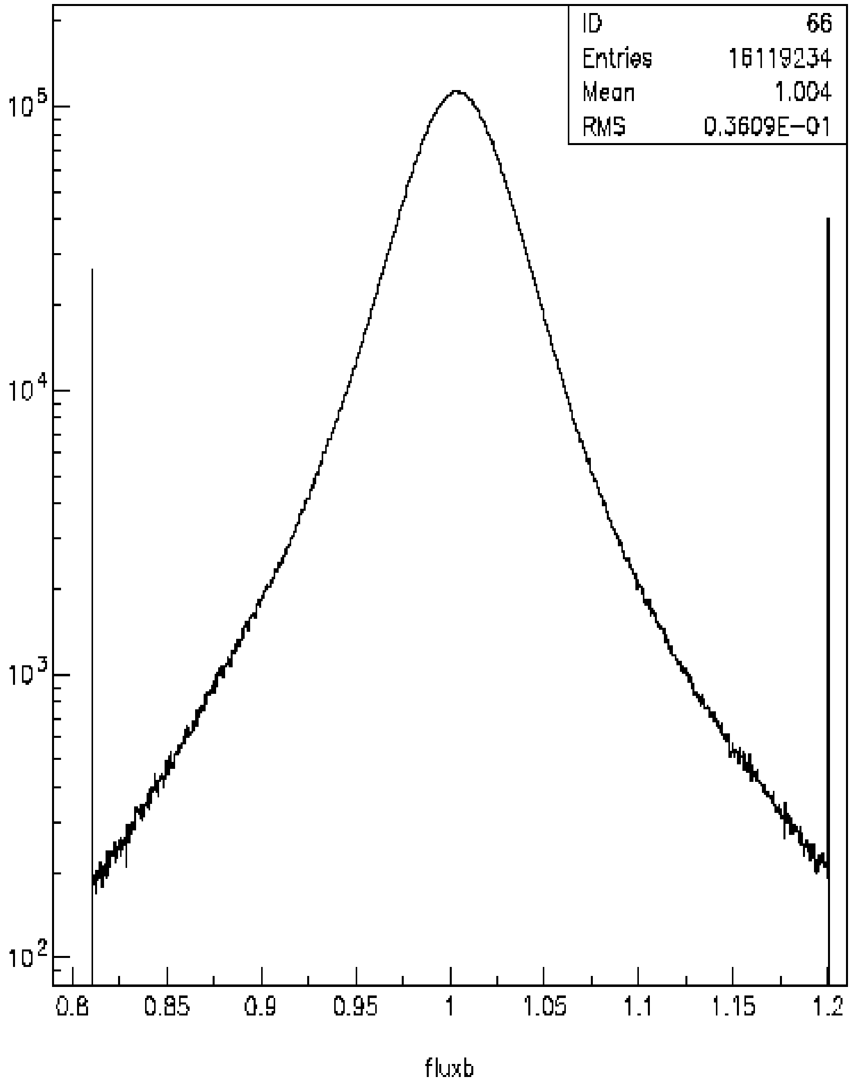
Electronic noise: Gaussian

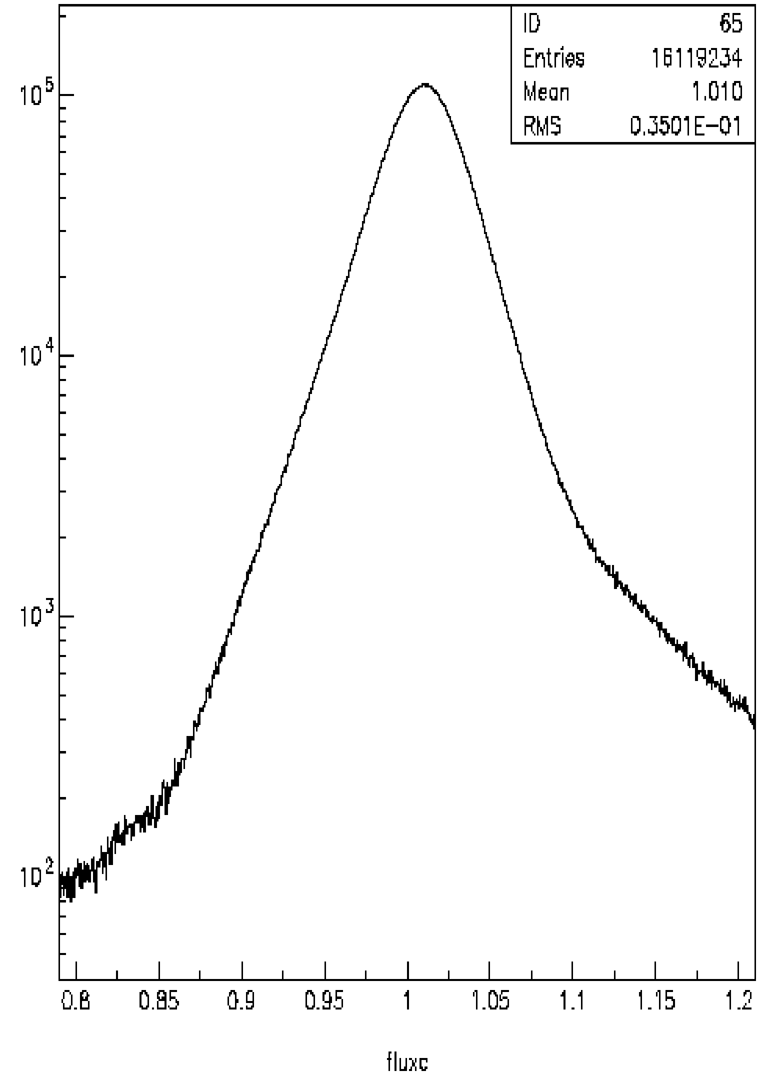
- Likelihood to compare simulation and histogram

  Obtain Erads Brem Black Compton polar (and fluxes)

- Calo optimization

Fluxes for the second histoset

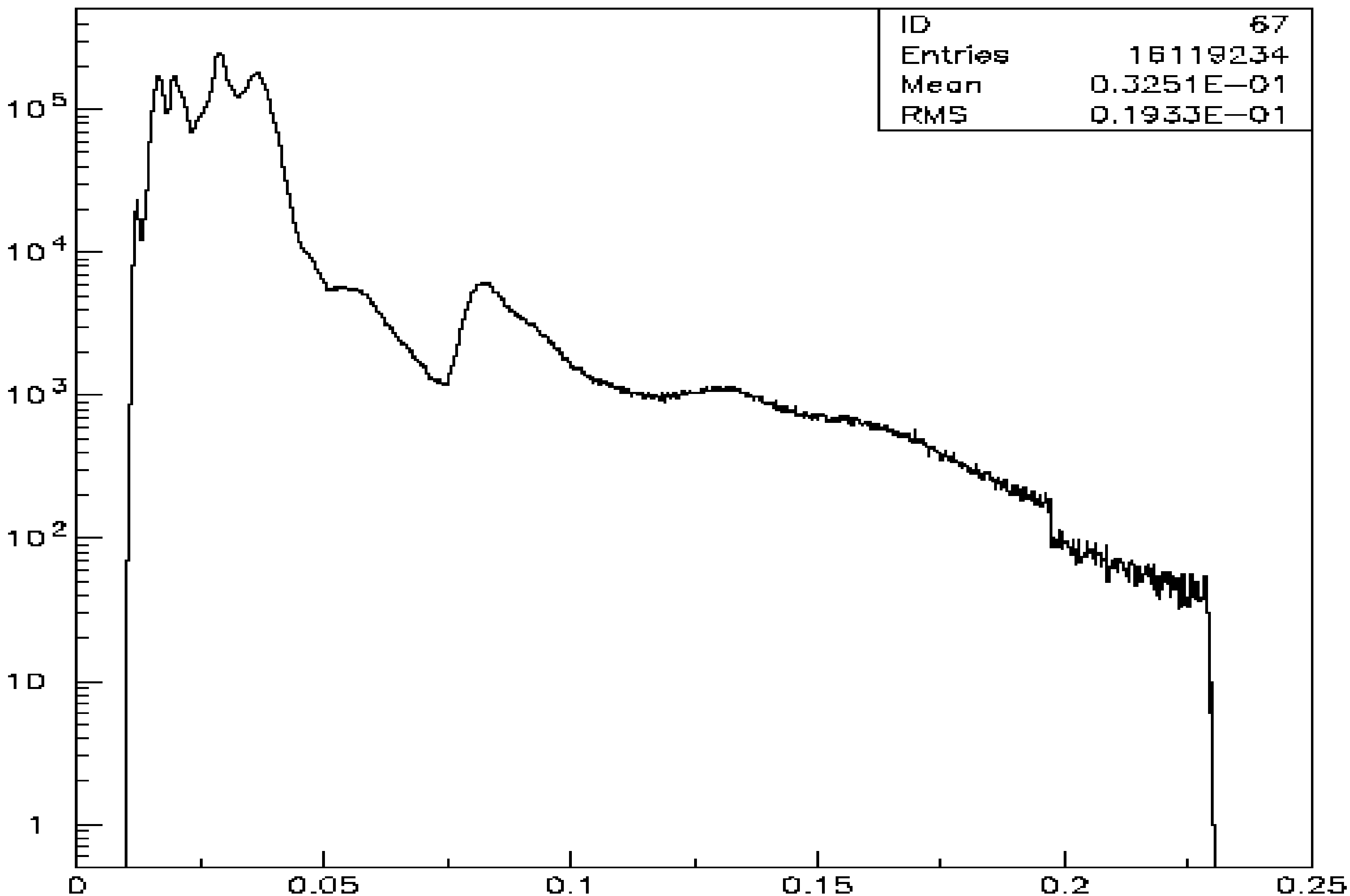




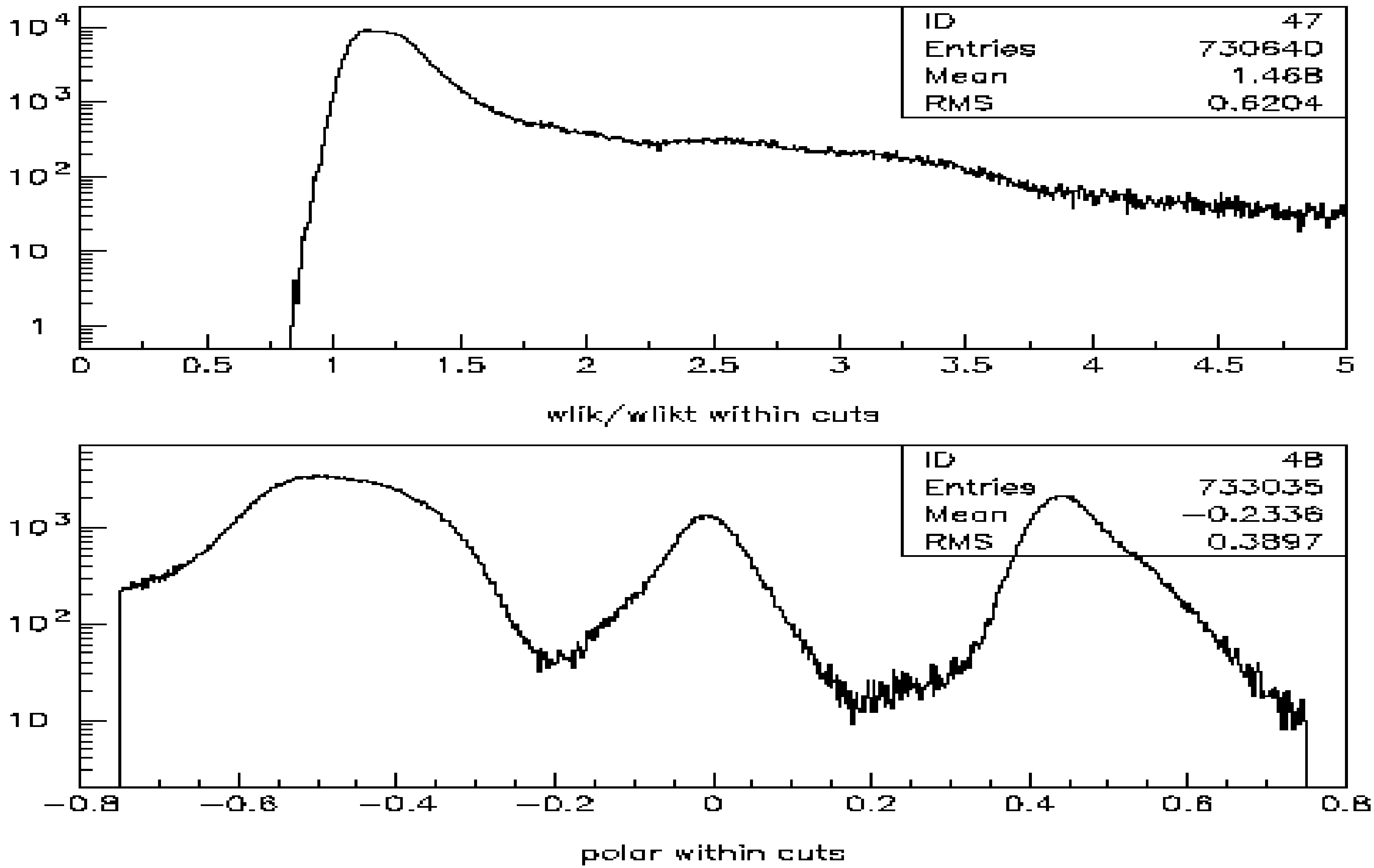
Errors determination

- Produce all the doublets
- Subdivide whole sample in ~80 sub periods
- Discriminate on rads brem compton and Tpol flatness
- For each error source choose a smaller sub sample (10,6,2) and vary conditions
- Run detector parameter measurements every 25 doublets
- Run polarization measurements
- Make plots comparison

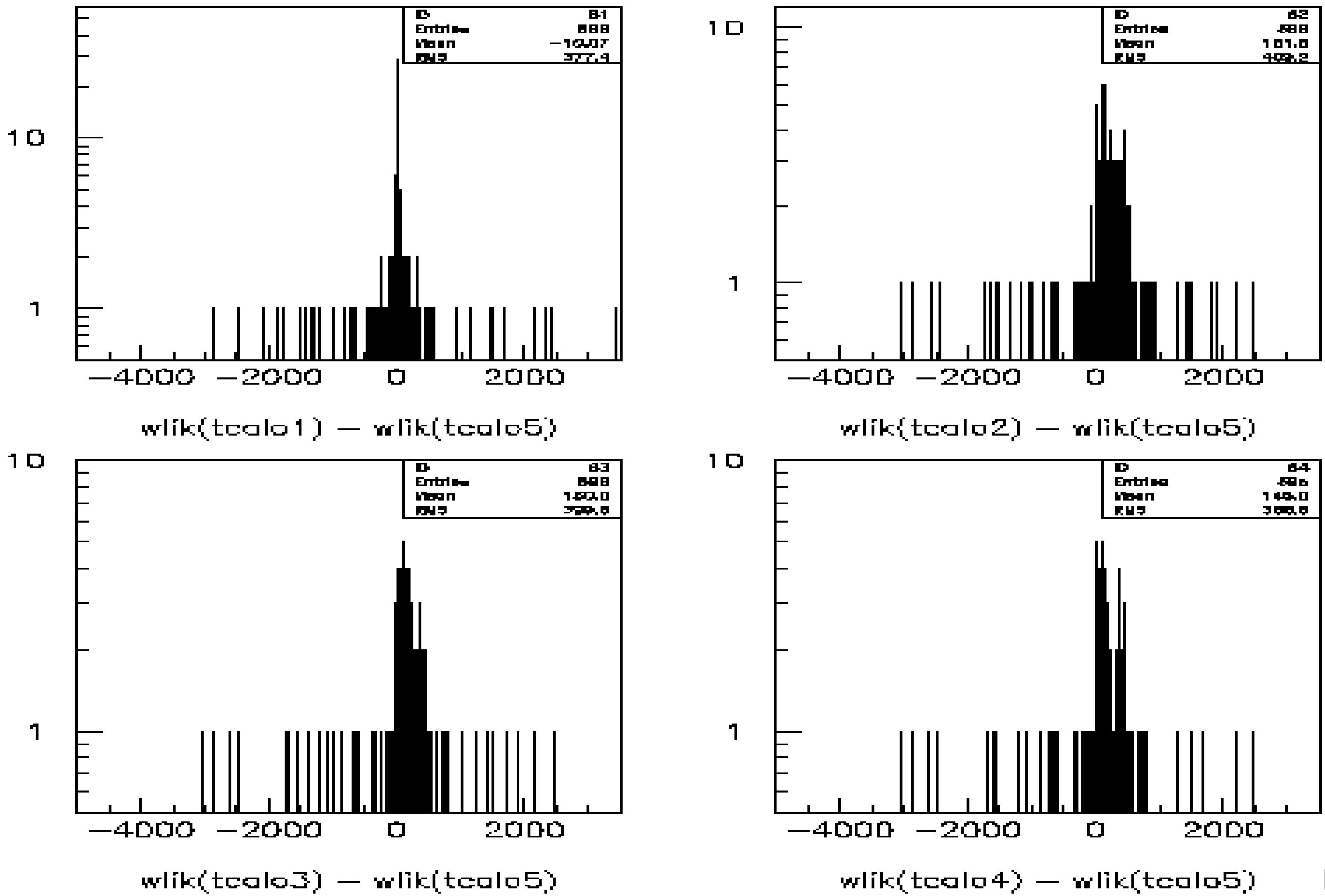
Error distribution for one bunch per 10 s



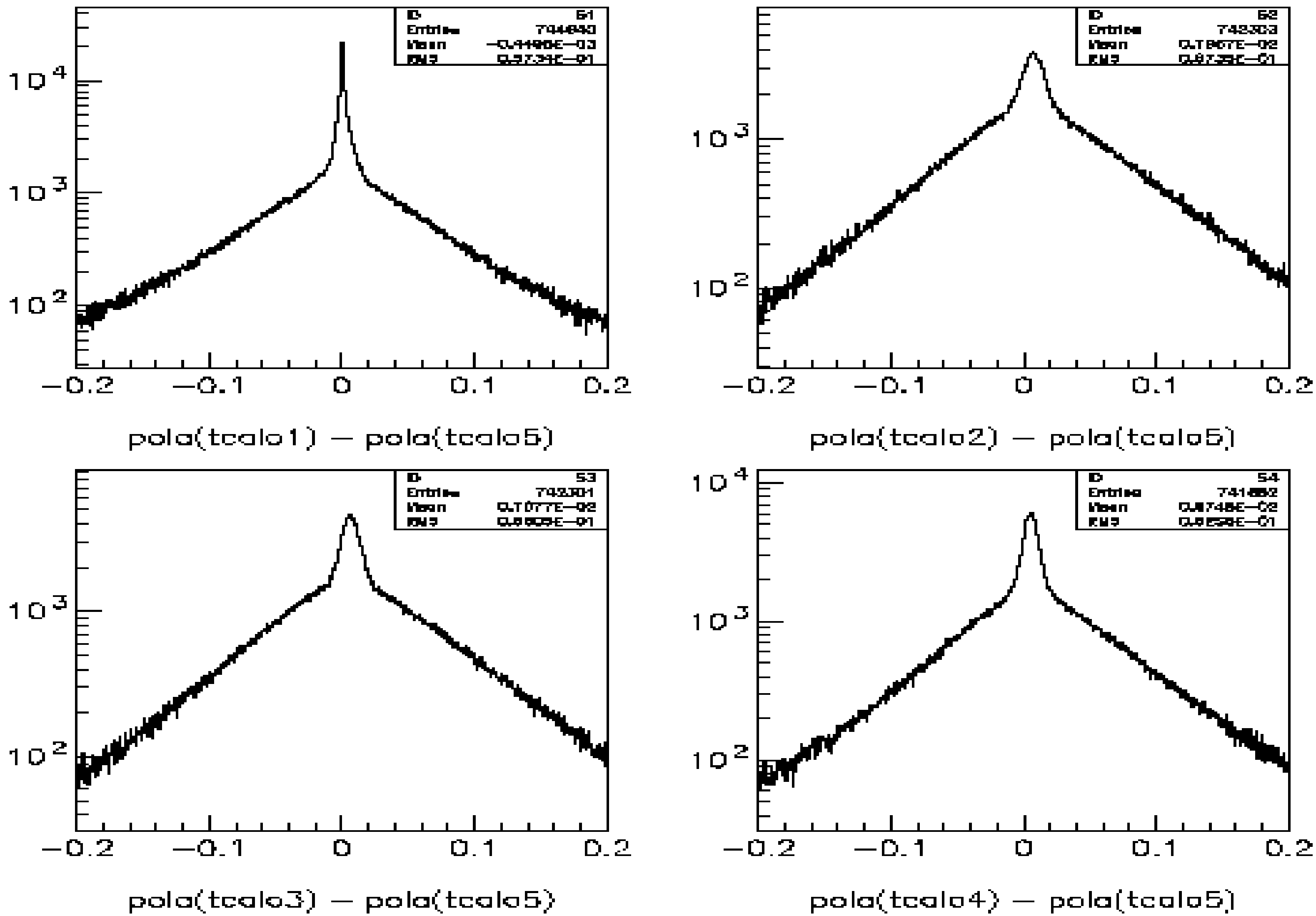
Detector analytical representation



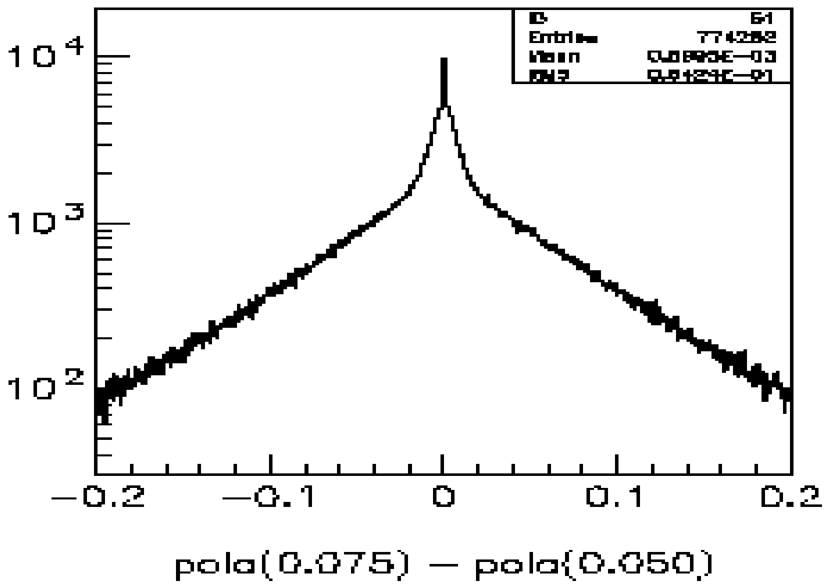
Detector analytical representation

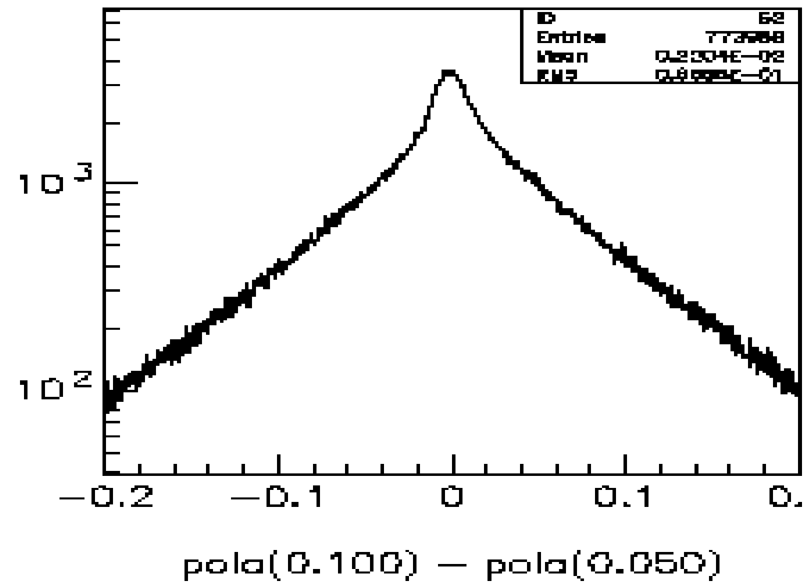


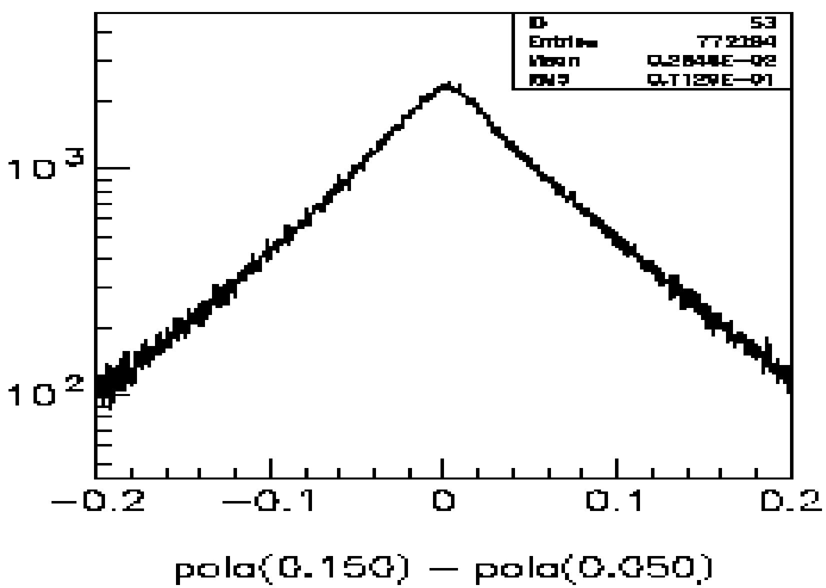
Detector analytical representation



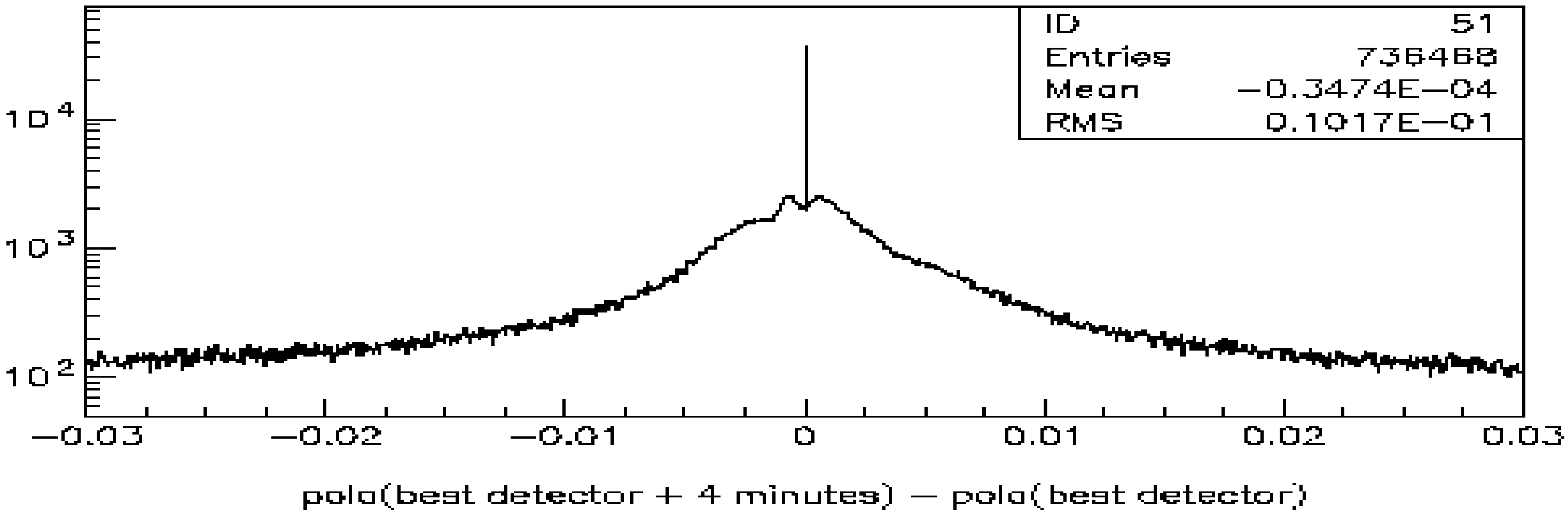
Radiation peak cut study

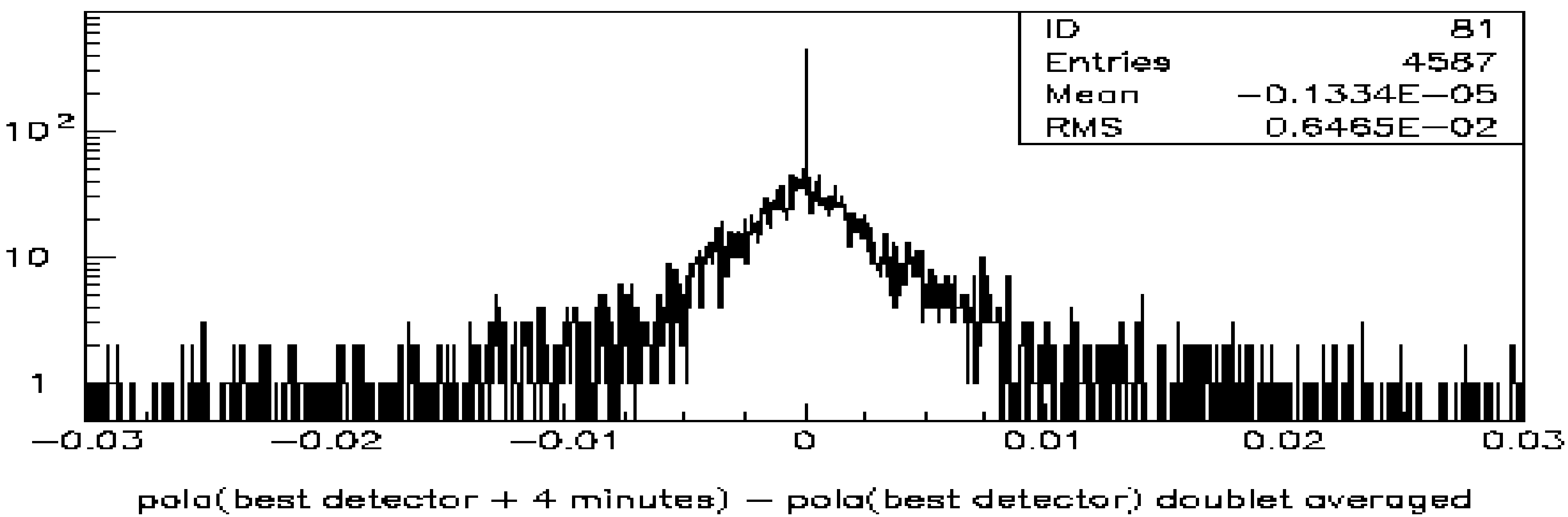




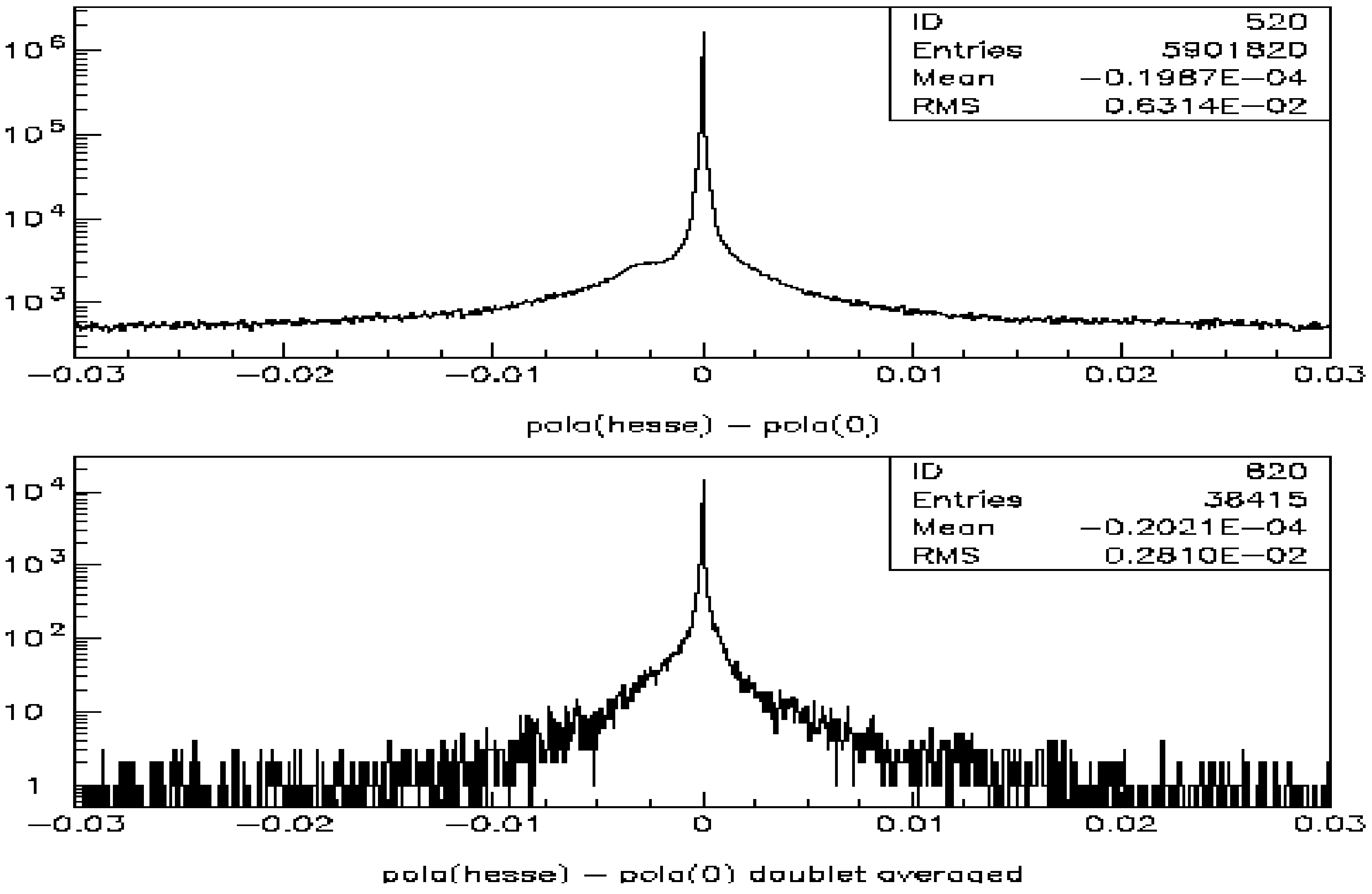


Detector fluctuation method 1

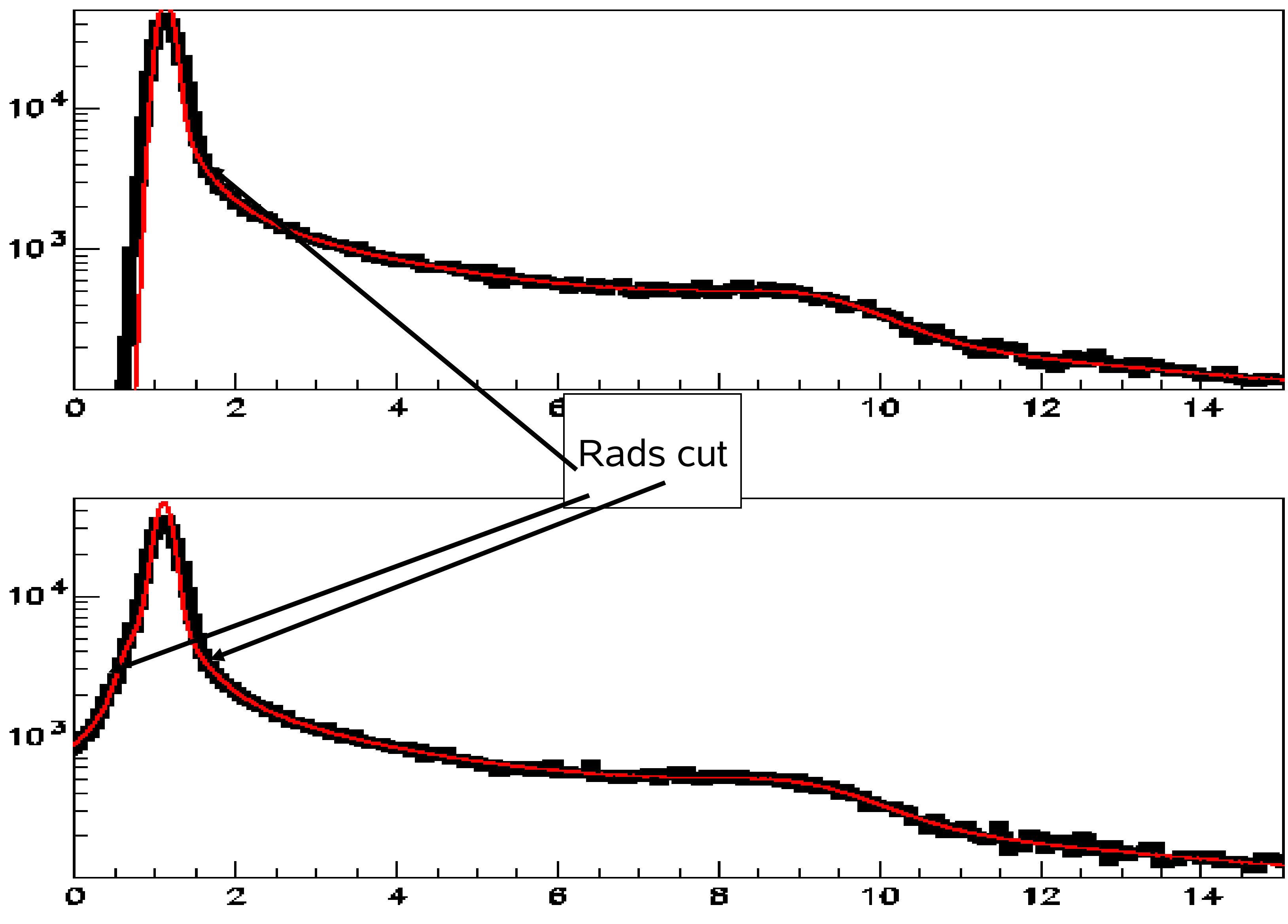




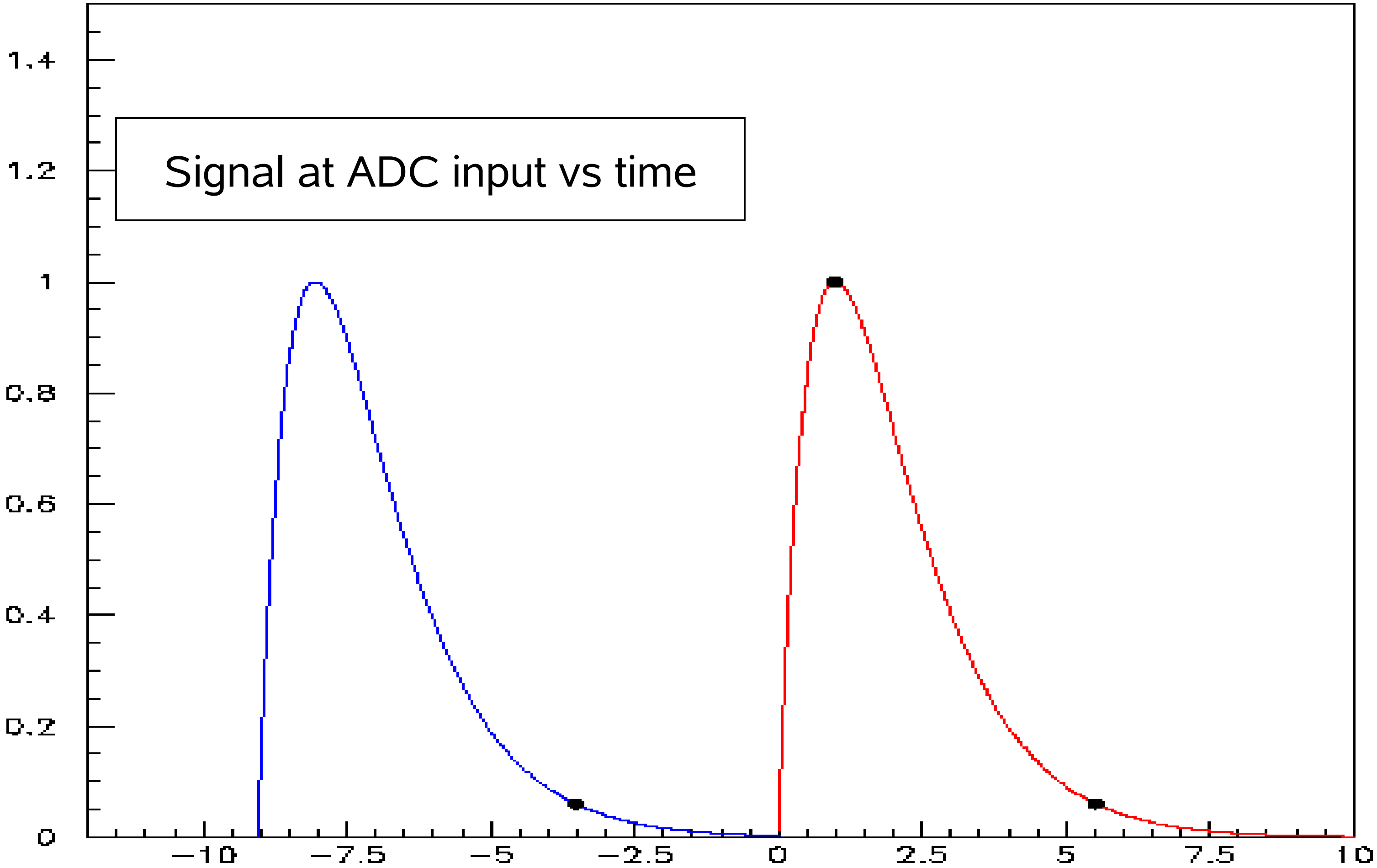
Detector fluctuation method 2



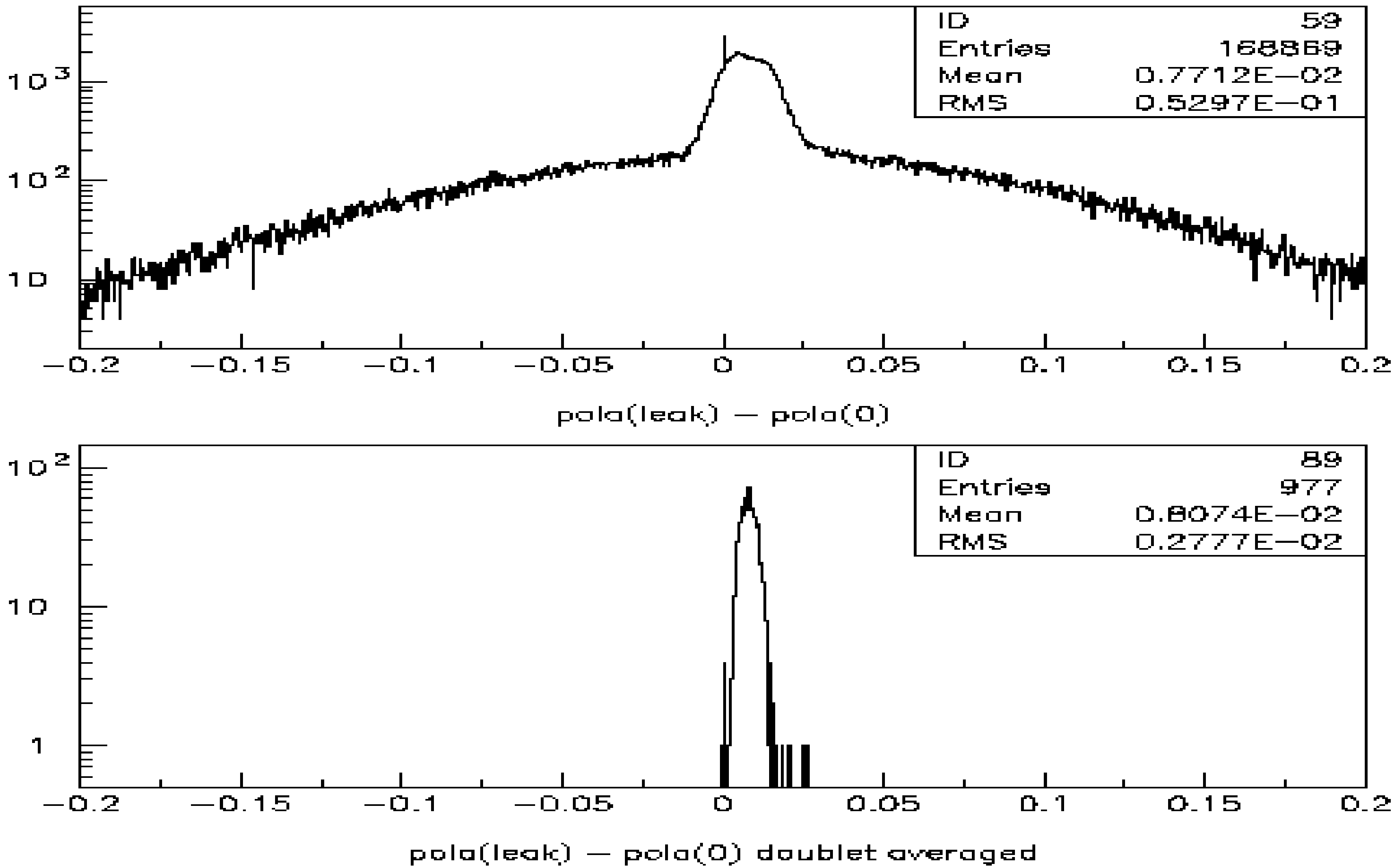
Leak effect



Leak effect and its systematic



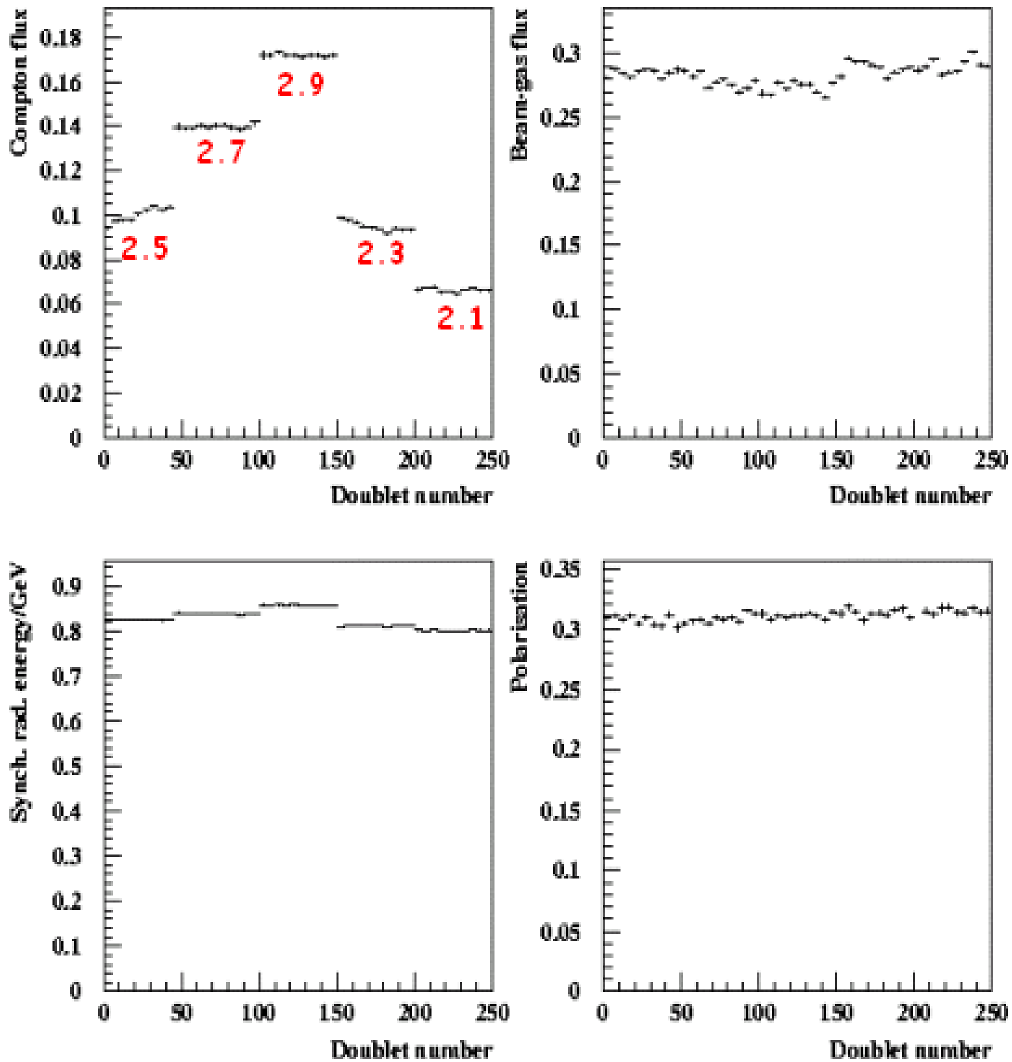
Leak


ID 59
Entries 168869
Mean 0.7712E−02
RMS 0.5297E−01
10^3
10^2
10
−0.2 −0.15 −0.1 −0.05 0 0.05 0.1 0.15 0.2
pola(leak) − pola(0)
ID 89
Entries 977
Mean 0.8074E−02
RMS 0.2777E−02
10^2
10
1
−0.2 −0.15 −0.1 −0.05 0 0.05 0.1 0.15 0.2
pola(leak) − pola(0) doublet averaged

Beam position

Position (mm)	$\langle P_e \rangle$ (%)
2.5	30.98 ± 0.06
2.7	31.03 ± 0.05
2.9	31.20 ± 0.04
2.3	31.45 ± 0.07
2.1	31.77 ± 0.09

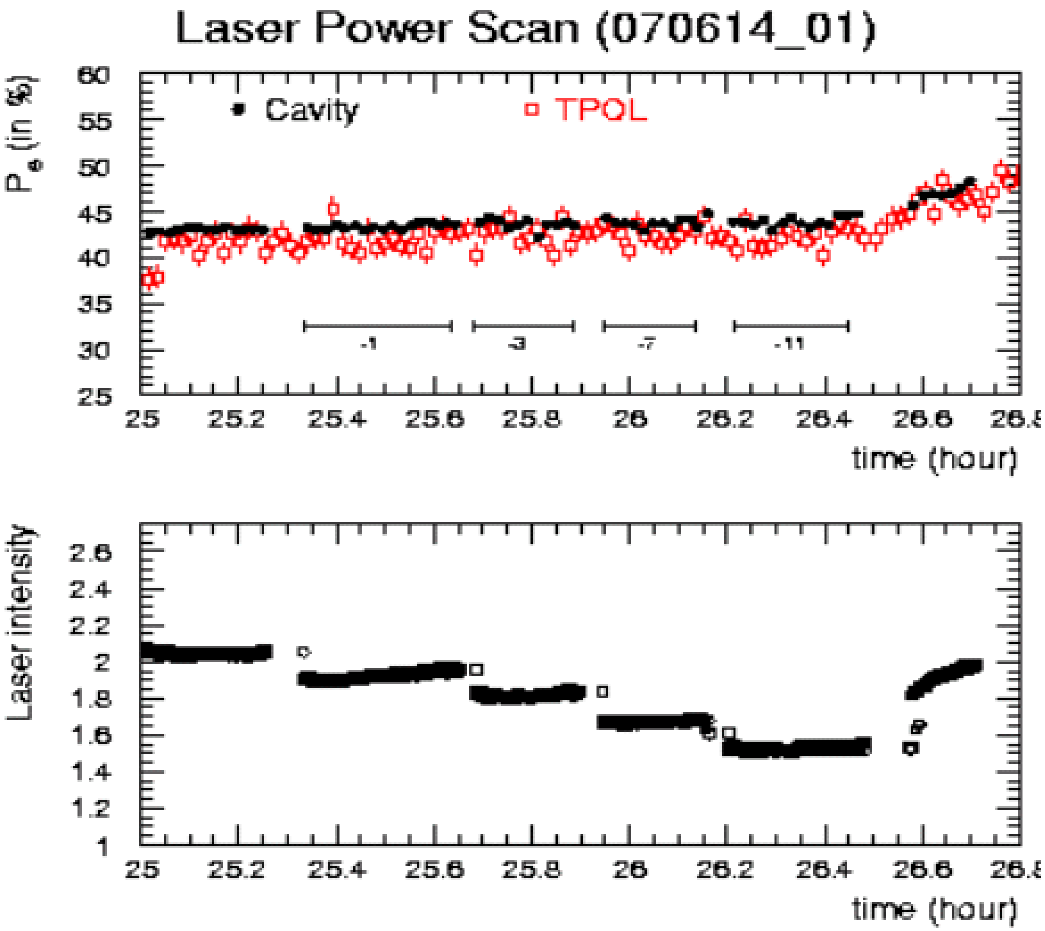
➔ $\delta P_e \leq 0.32\%$



Laser power

Power	$\langle P_e \rangle$ (%)
Standard	43.44 ± 0.05
-1	43.70 ± 0.04
-3	44.07 ± 0.05
-7	44.09 ± 0.05
-11	44.21 ± 0.05

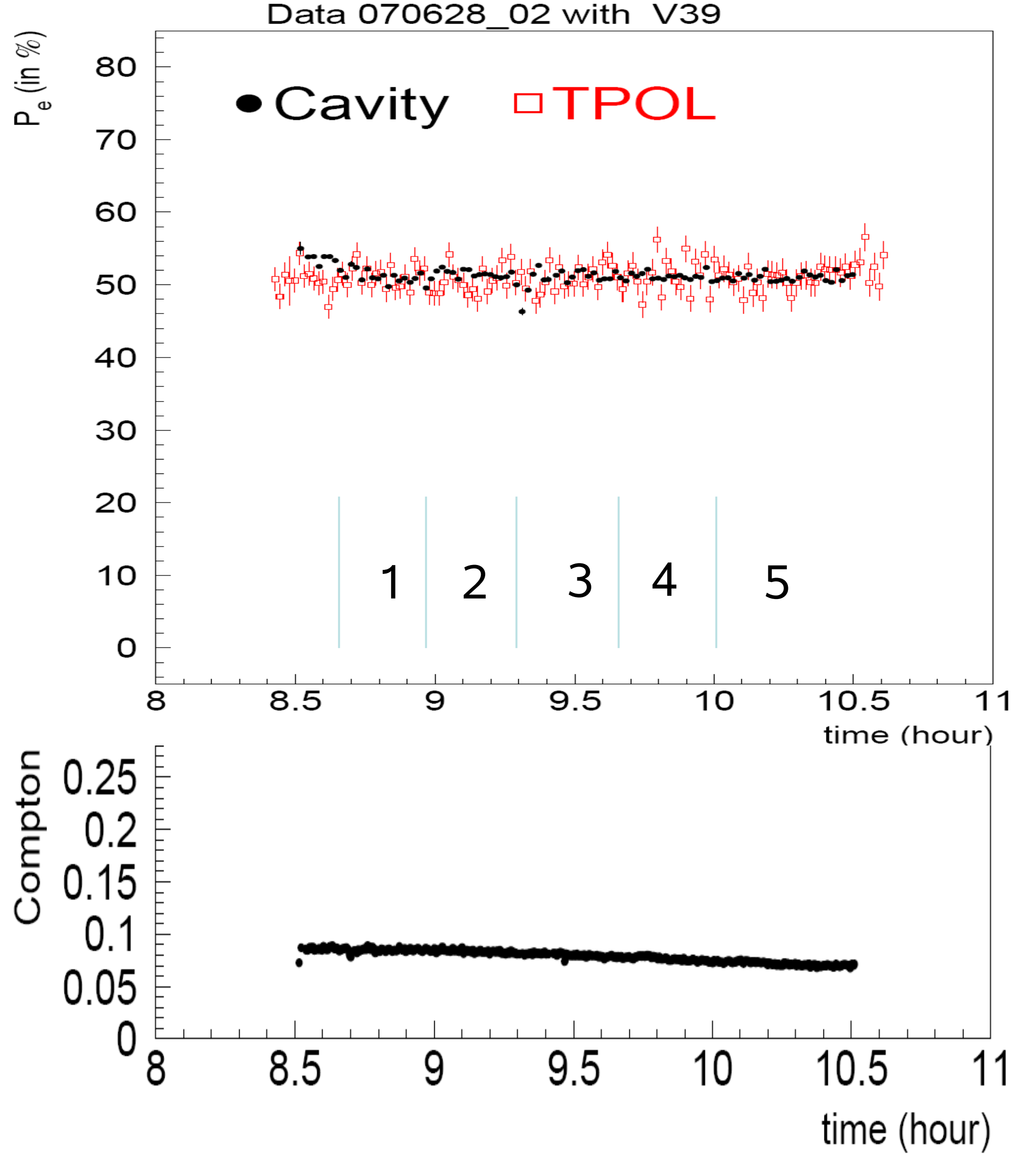
➔ $\delta P_e \leq 0.37\%$



MOCO Position Scan

Position (S_γ)	$\langle P_e \rangle$ (%)
1 (0.9936/-0.9834)	51.48 ± 0.09
2 (0.9936/-0.9909)	51.67 ± 0.08
3 (0.9973/-0.9968)	51.12 ± 0.08
4 (0.9842/-0.9968)	51.45 ± 0.08
5(default) (0.9957/-0.9950)	51.23 ± 0.06

➔ $\delta P_e \leq 0.44\%$



Statistical uncertainties

- Pola error per bunch and for 10s : 3%
- From detector parameters (*) : 0.5 % (fully bunches and doublet correlated during 6mn)

Systematic uncertainties

- From Hera : 0.70%
- From Laser : 0.75%
- From detector: 0.10%
- -----------------------------------
- Total 1. %

Future prospect

Everything done so far once but needs to be improved before final result

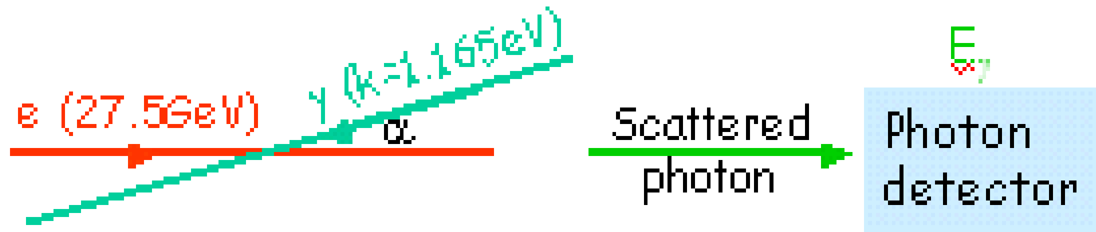
- Optimize detector parameters finding (done)
- Choose between tcalo1 and tcalo5 .Eventually run tcalo15 (one parameter more in widening technique $E=\alpha x^{\mu}$)
- Revisit systematic issues with test sub periods
- Run detector parameters finding on all periods
- Run polar extraction on all periods
- Extend to earlier 16 bits daq output and check quality (these go back to October 2006)

THE END

Polarimeter principle

Compton Scattering:

$e+\gamma \rightarrow e+\gamma$



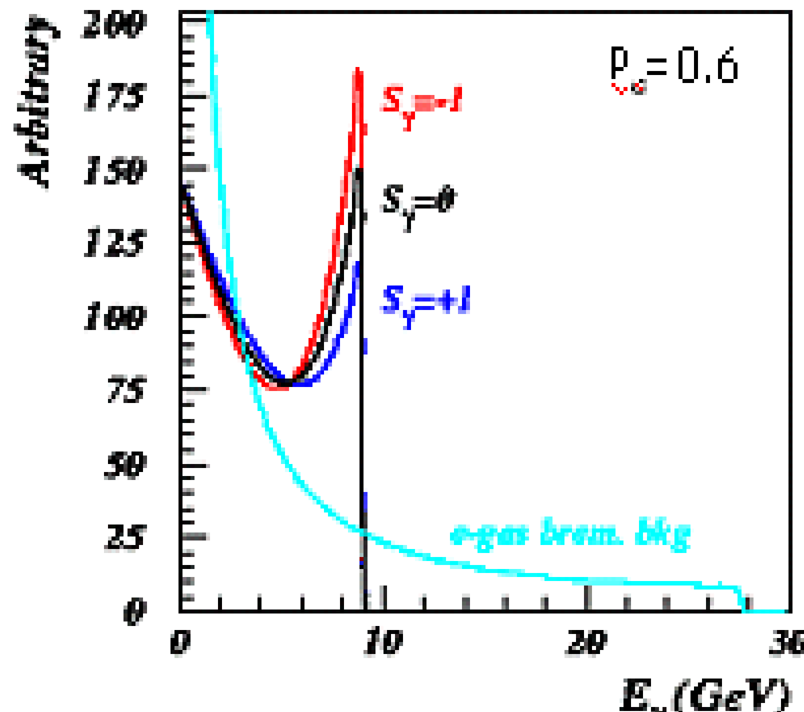
Cross Section:

$d\sigma/dE_\gamma = \sigma_0(E_\gamma) - P_e S_\gamma \sigma_1(E_\gamma)$

σ_0, σ_1: known (QED)

P_e: Polarization of the **e beam** to be measured

S_γ: Circular polarization (+-1) of the **laser beam**



Luminosity (electron-laser):

$$L \propto \frac{P_L I_e}{k\,\alpha\sqrt{\sigma^2_{e,y}+\sigma^2_{\gamma,y}}}$$

I_e: e beam intensity

P_L: Laser beam power

Previous systematics

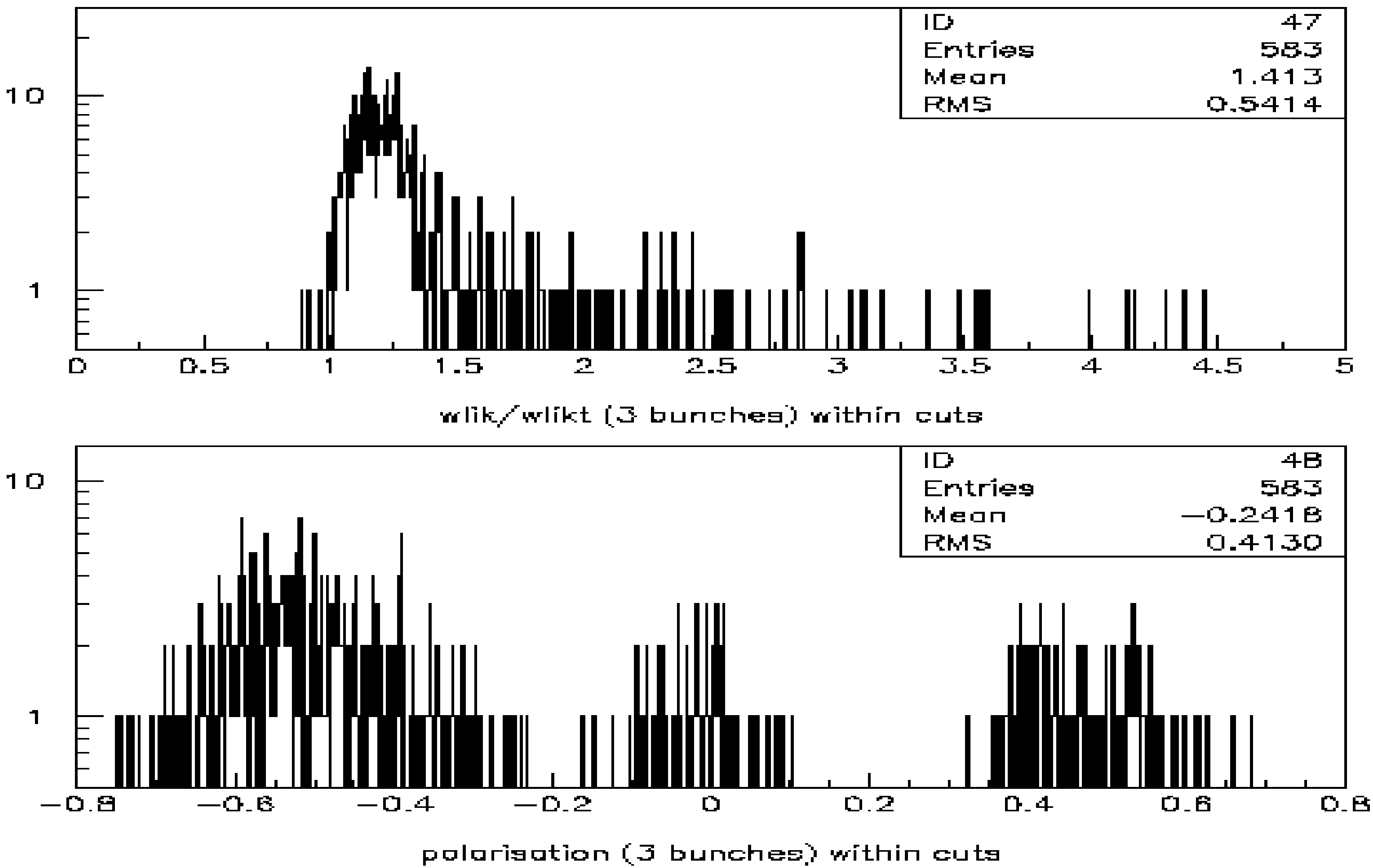
Source	δP_e (%)
Laser polarization uncertainty	$\lesssim 0.50$
Laser circularity [MOCO position scan]	$\lesssim 0.44$
Laser power variation	$\lesssim 0.37$
Electronic Noise [C_empty (1.43-1.35)]	0.20
Detector parameters [$\pm 1\sigma$]	0.12
Dead material in front of calorimeter?	0.17
Calorimeter position scan in x & y	$\lesssim 0.58$
Synchrotron radiation cut [0.05→0.01-0.1]	0.29
Blackbody temperature [300K→500K]	0.29
Beam position scan	$\lesssim 0.32$
e beam energy uncertainty (27.6GeV→27.5GeV)	0.21
Total	$\lesssim 1.2$

Most of the errors are conservatively estimated.

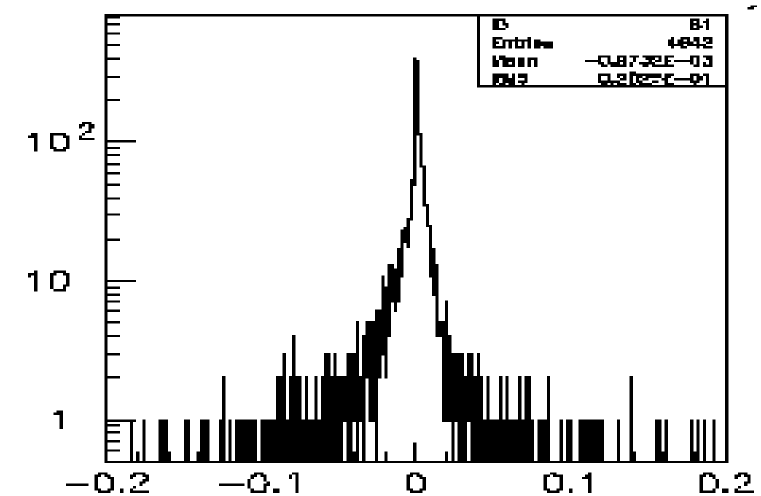
Some of the error sources are redundant (e.g. calo position scan with beam position scan).

Error reduction is expected in the future with improved fit program.

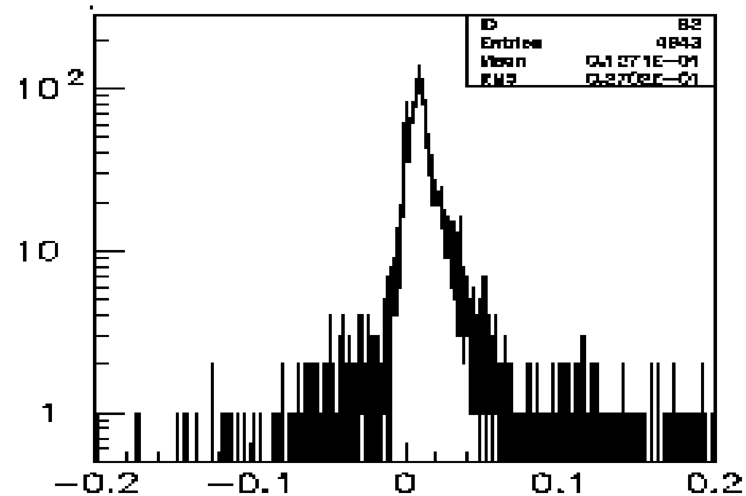
Detector analytical representation



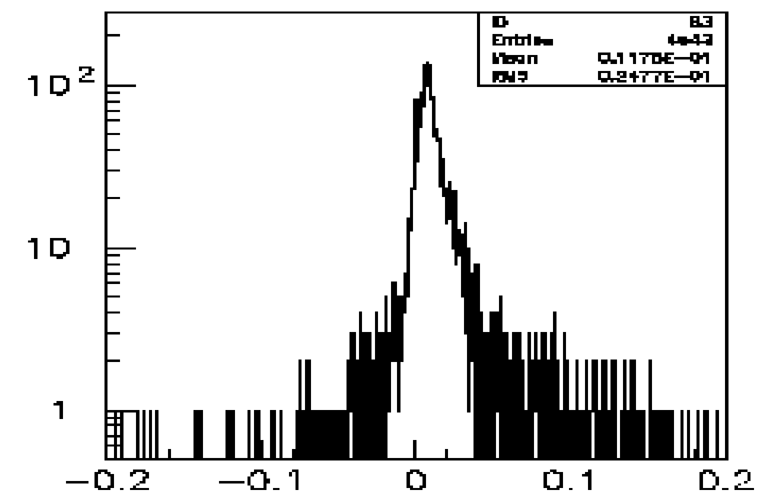
Detector analytical representation



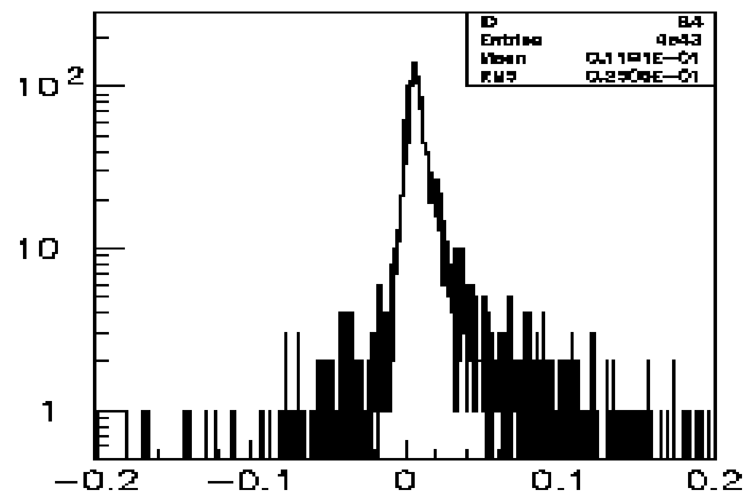
pola(tcalo1) - pola(tcalo5) doublet averaged



pola(tcalo2) - pola(tcalo5) doublet averaged

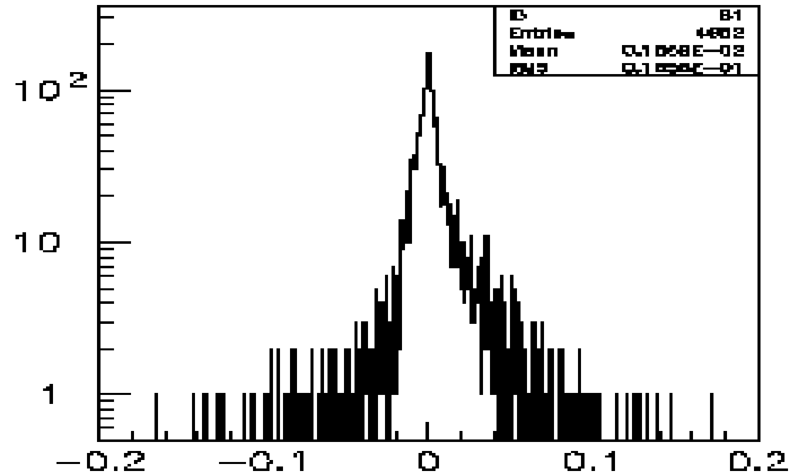


pola(tcalo3) - pola(tcalo5) doublet averaged

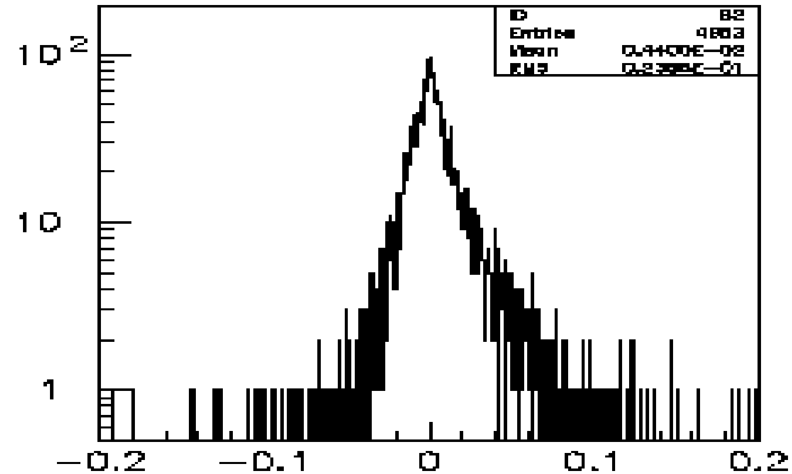


pola(tcalo4) - pola(tcalo5) doublet averaged

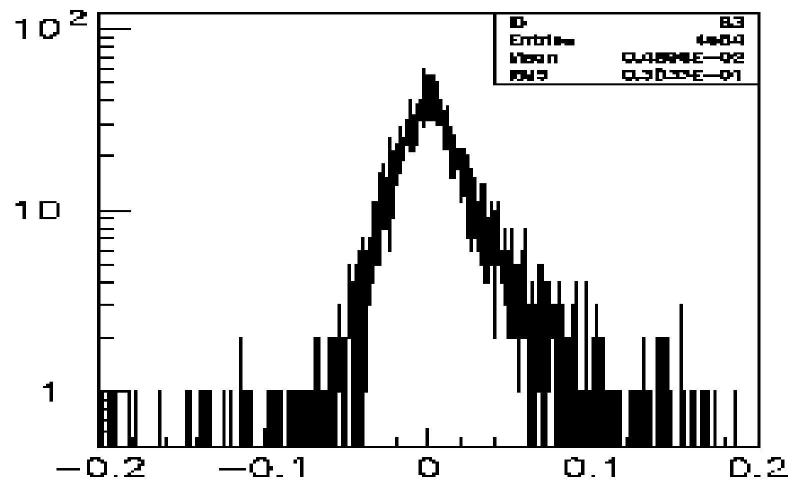
Radiation peak cut study



pola(0.075) − pola(0.050) doublet averaged

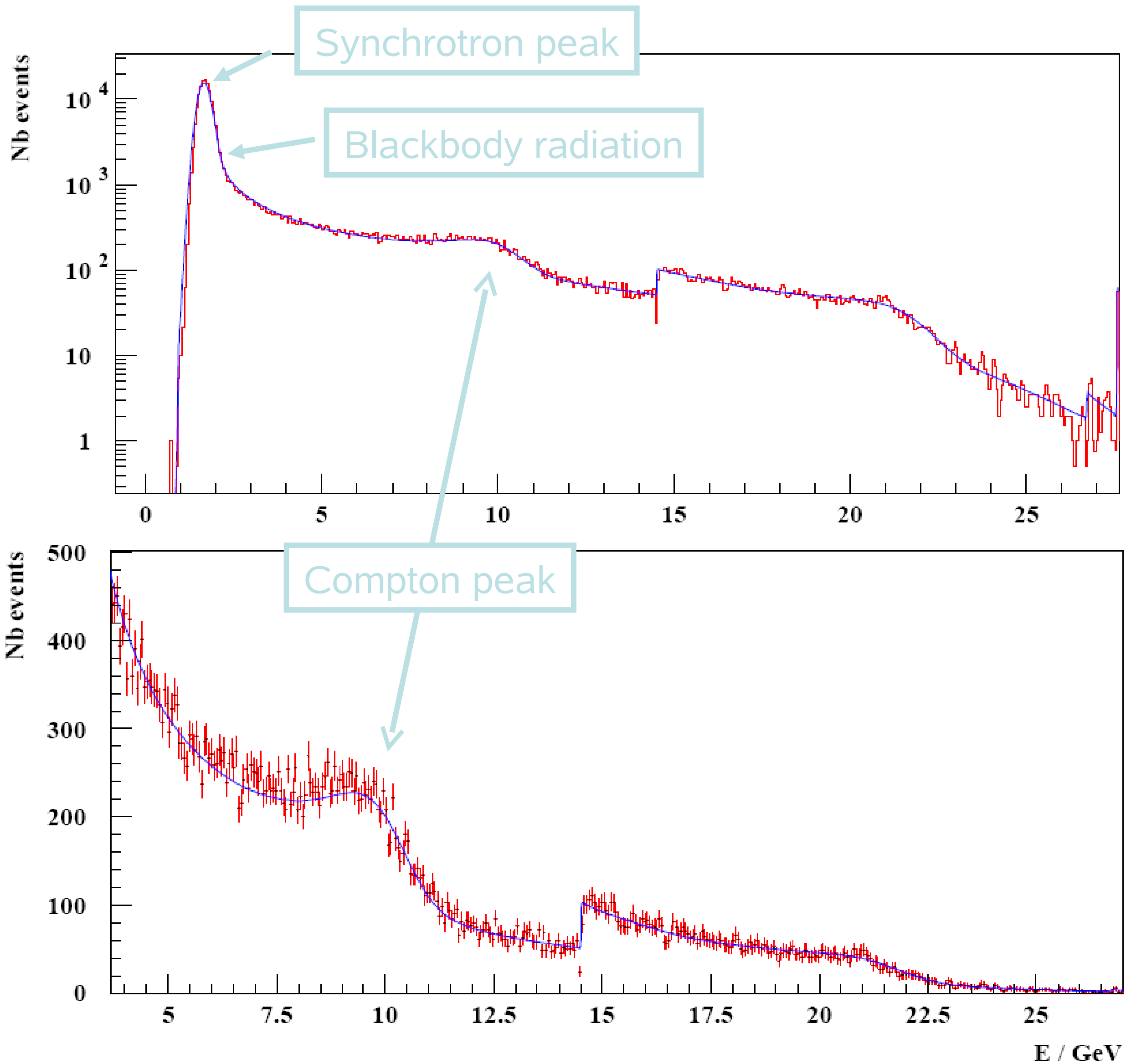


pola(0.100) − pola(0.050) doublet averaged



pola(0.150) − pola(0.050) doublet averaged

Measurement (varying bin histogram) vs Fit



An arbitrary example of one single bunch (~4s)
→ good description of the data (in red) by the fit (in blue)

New feature: varying histogram bins [finer (coarse) bins @ low (high) energies]
→ to have optimal gain vs available ADC dynamical range
→ provide a complete low energy spectrum

Cavity setup