V. Andreev
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Offline Luminosity estimation

V. Andreev

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Introduction

- The luminosity measurement is based on Bethe-Heitler reaction (BH)

$$ep \rightarrow e\gamma p$$

- An integrated luminosity for the given data sample can be determinated as

$$L = \frac{N^{ep}_{BH}(E_\gamma > E_{min})}{\sigma_{BH}(E_\gamma > E_{min})} = \frac{\frac{\sum\limits_i (W_i(E_{min}) - W_i^{bgr}(E_{min}))}{\varepsilon_{trig}(E_{min})}(1-\delta_{n\gamma}(L, E_{min}))}{\sigma_{BH}(E_{min}) A_\gamma(\theta_x, \theta_y)}$$

where $W_i = P_i N_i$ represent the total and background number of events in run i from the sample, after accounting for the prescaling factor P_i;

A_γ - geometrical acceptance;

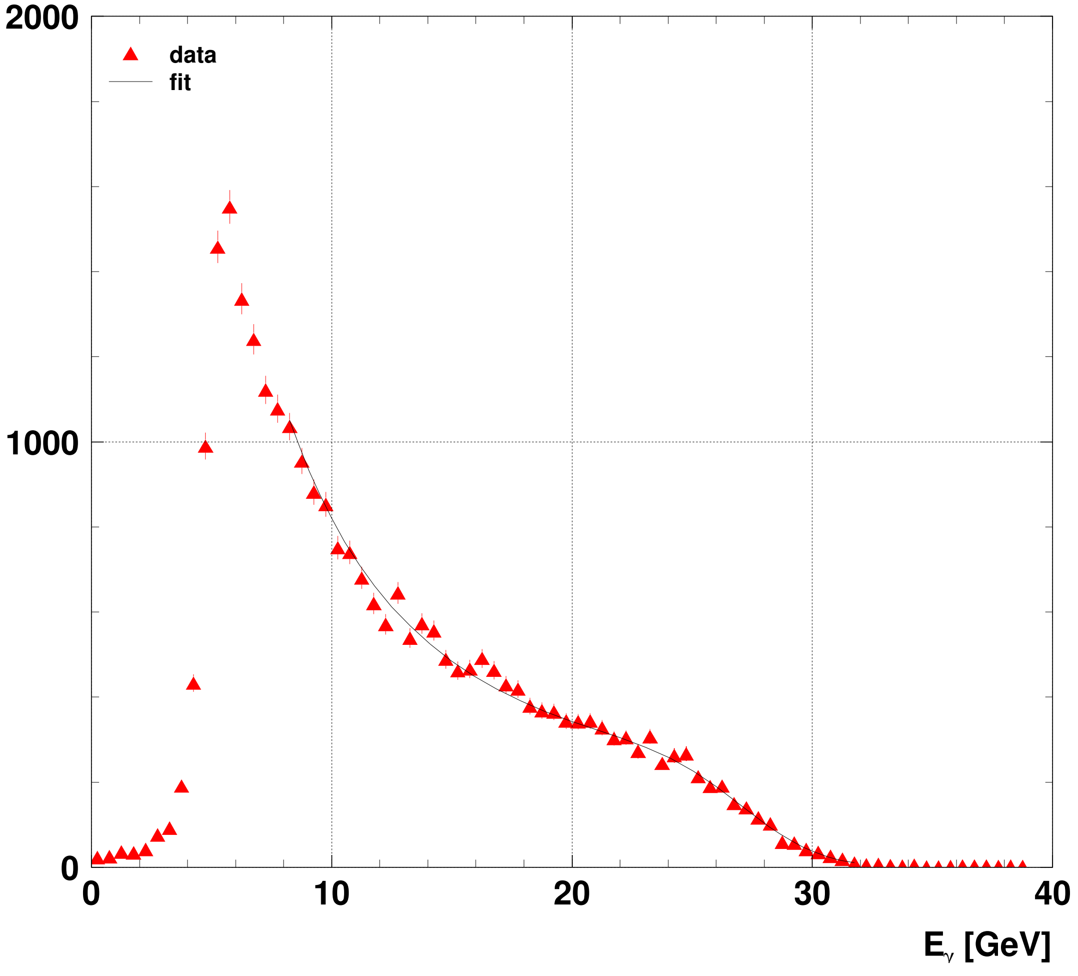
θ_x and θ_y lepton tilt in the interaction point;

ε_{trig} - trigger efficiency;

$\delta_{n\gamma}(L, E_{min})$ - correction factor connects with a pile-up effect (the probability to detect more than just one photon in the same bunch crossing).

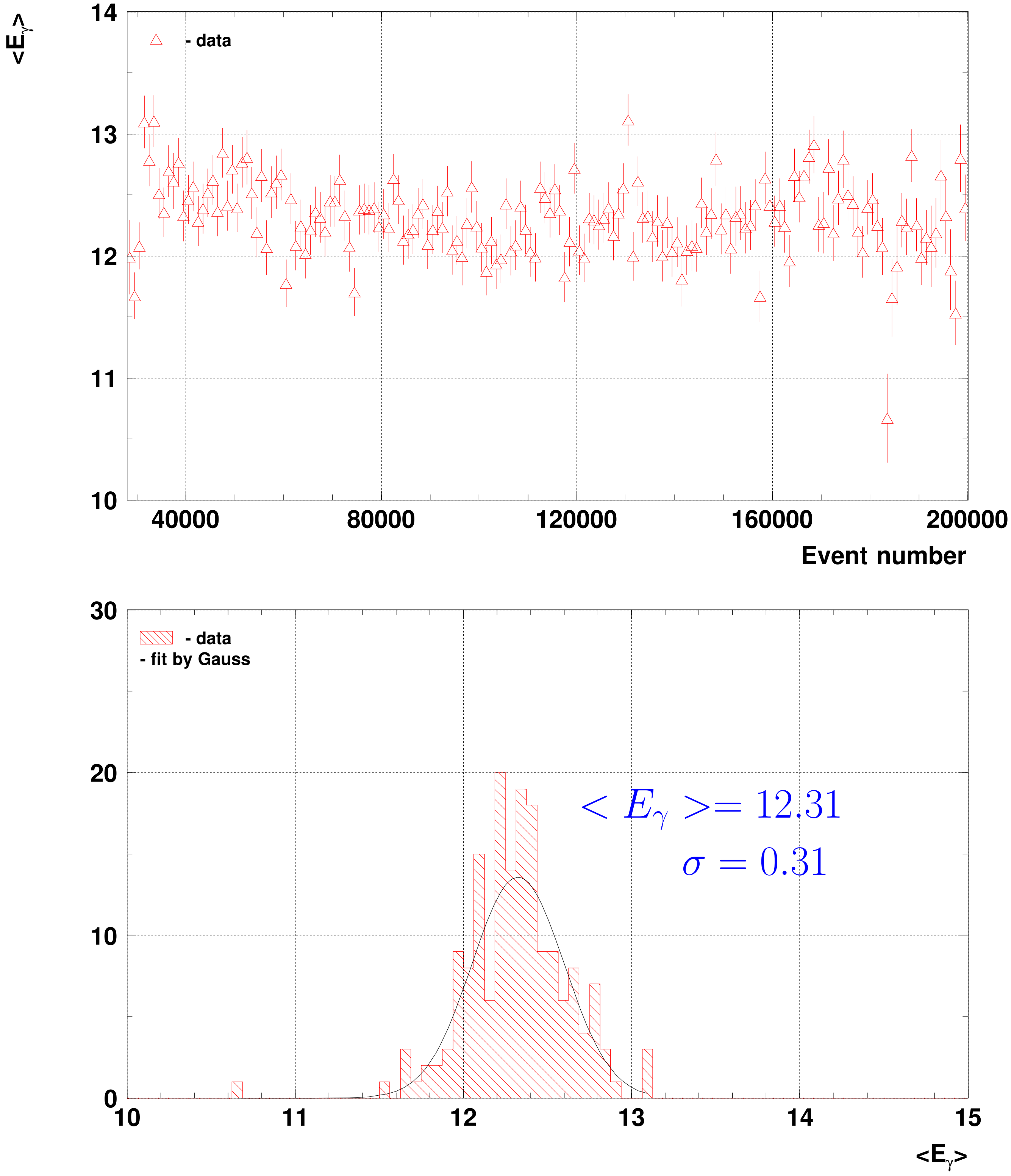
PD calibration procedure

- Using special PD scan data ⇒ equalize individual channel response
- Final determination of energy scale from the fit PD energy spectrum by the Bethe-Heitler



As example I considered special ρ^o - meson run data collected in February 2003
(H1runs 340212-340972, 9.02.-11.02.2003)

- Stability Photon Detector response and calibration procedure is illustrated on the next picture



For the chosen sample the additional fit of photon spectrum is done and it gives $\Delta E = 0.110 GeV$ (0.4 $\%$) energy error for the high edge of the photon spectrum.

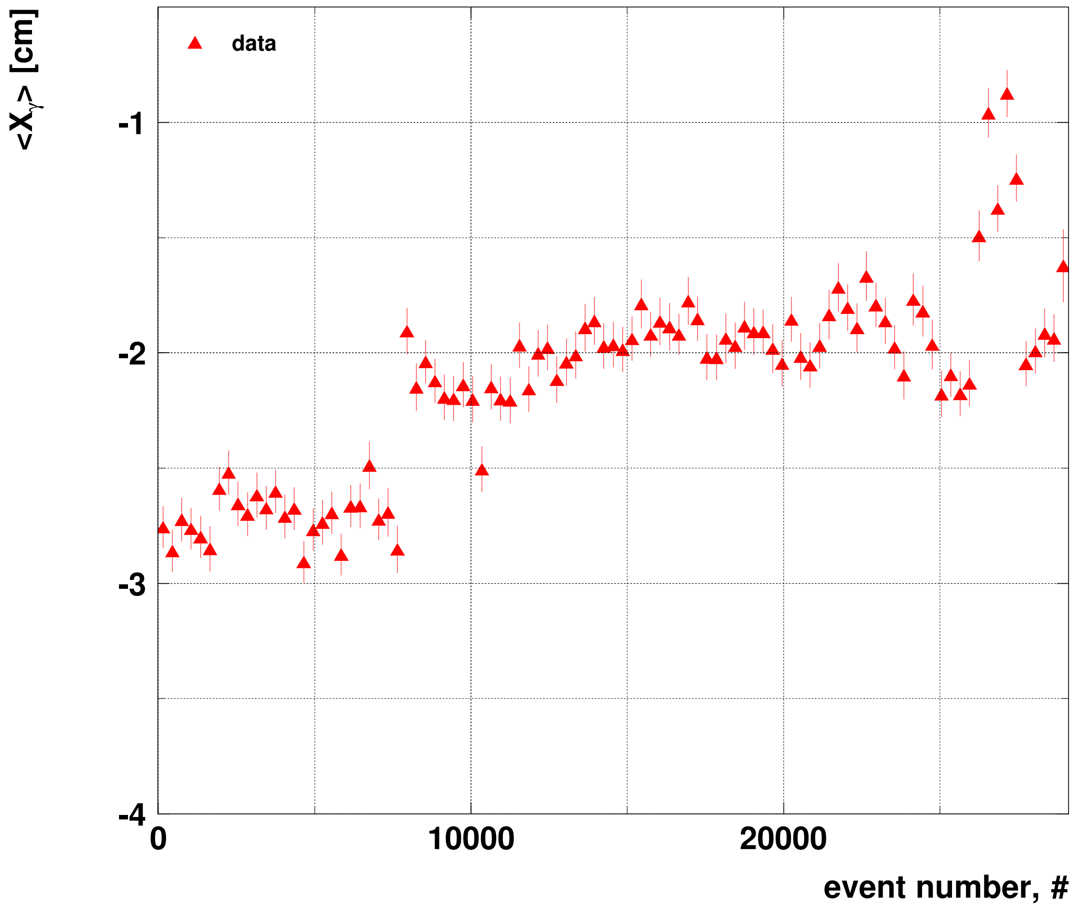
I supppose that this error is also valid E_γ = 10 GeV.

And such uncertainty in the energy scale gives $\sim 1.4\%$ in the number of events behind threshold .

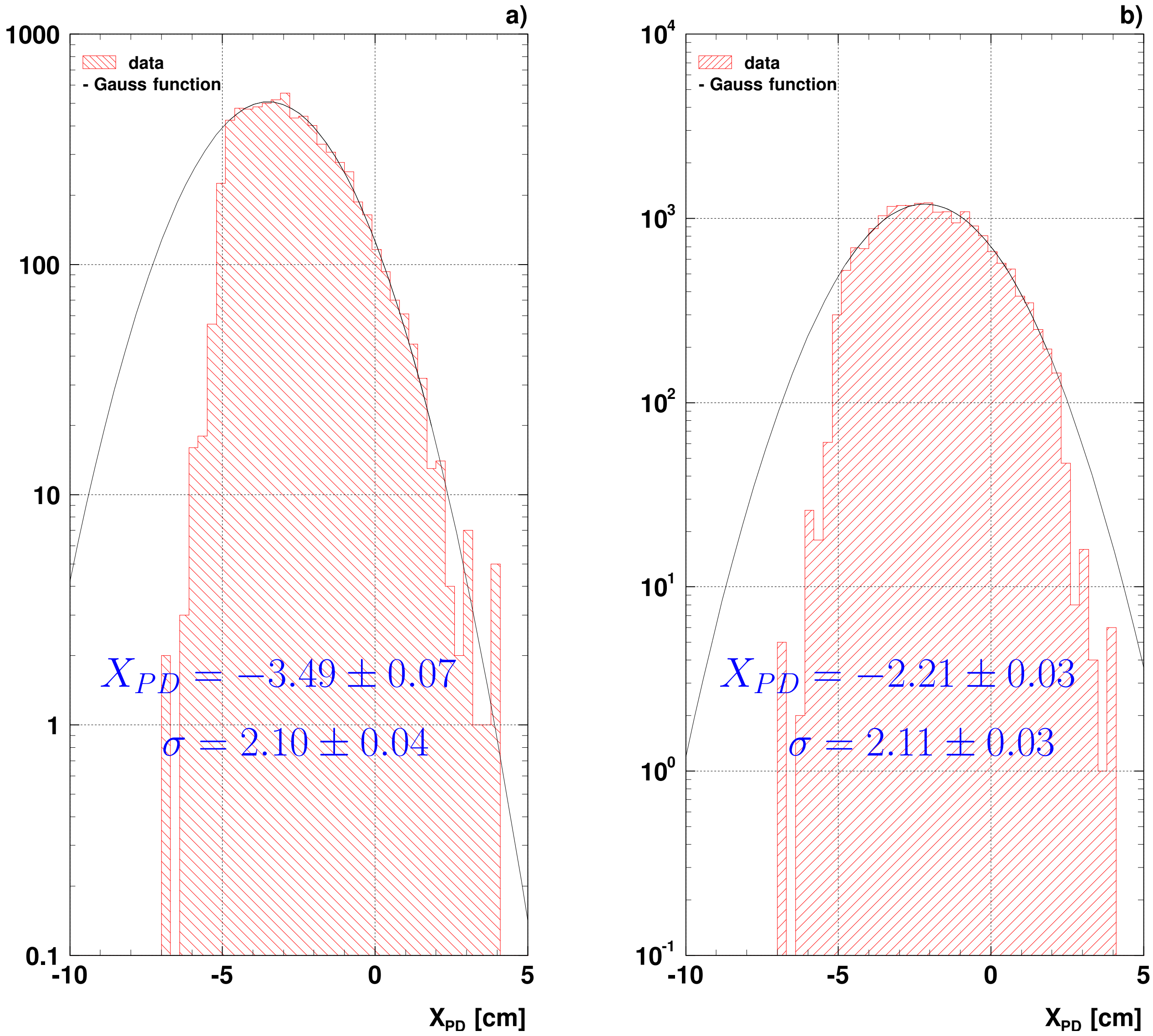
Acceptance of Photon Detector

- Acceptance of PD depends on the next main sources :
  - θ_x and θ_y tilt of the lepton beam in the interaction point (these values are measured using X_γ and Y_γ on PD)
  - X_{vertex} and Y_{vertex} position of primary vertex in IP (could be extracted from measurements)
  - exact knowledge of the dead material in front of PD (beam-line elements, Beryllium filter and lead window)

Dependence average X_γ^{hit} PD vs time for the special ρ^o runs



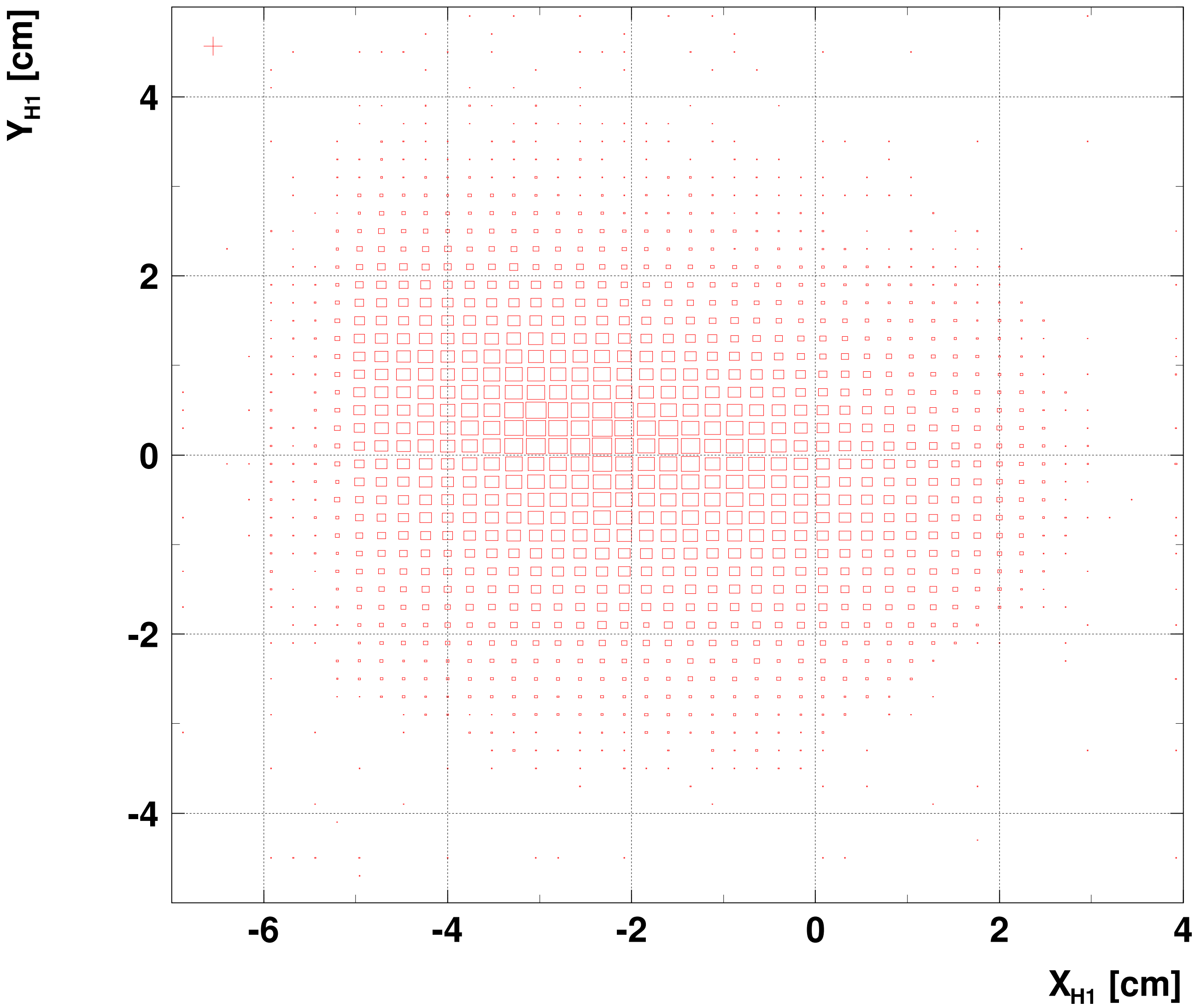
- Acceptance determination using data
  - total sample was devided on 2 sub-samples with "stable" $< X_\gamma >$ position
  - X-distribution was fitted by Gaussian function for each sub-sample
  - ratio determines PD acceptance



Error comes from the limited statistic for each sample and accuracy of determination parameters from the fit sample a) $\boxed{A_{PD} = (79.44 \pm 1.61)\ \%}$ and

sample b) $\boxed{A_{PD} = (92.24 \pm 1.29)\ \%}$

Reconstructed photon hit points in PD for the events collected during January is shown on the picture (this illustrates available geometrical PD acceptance)



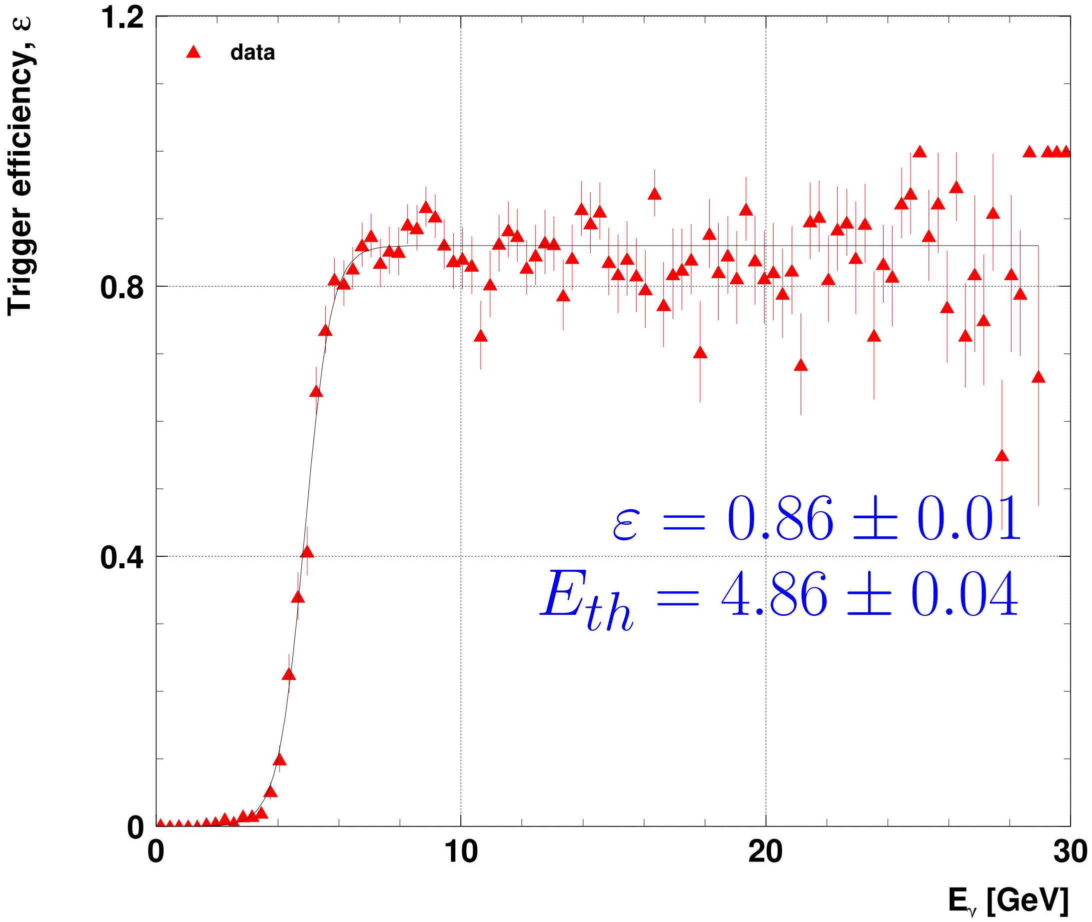
- Acceptance determination using MC
  - try to describe all material in front of PD with a good precision as possible (not always possible a lot of magnet elements)
  - using knowledge about X_{vx} and Y_{vx} of IP and distribution photon hit points on PD to calculate acceptance
  - for the error estimation use the fit result and error from the data and also possible deviation position of different beampipe elements from the nominal (as example position of lead window in front of Photon Detector).
- Result of MC calculation
  - take into account X_{vx} = 0.33 cm and Y_{vx} = 0.60 cm
  - θ_x = -0.343 $mrad$ and σ_{θ_x} = 0.206 $mrad$ for sample a) and
  - θ_x = -0.213 $mrad$ and σ_{θ_x} = 0.205 $mrad$ for sample b)
- Acceptance

$\boxed{A_{PD} = (80.18 \pm 2.9)\%}$ for sample a)

$\boxed{A_{PD} = (91.45 \pm 1.9)\%}$ for sample b)

Trigger efficiency

- trigger efficiency is determined by the usual way using random sample for chosen period
- example of PD_{low} trigger element behaviour vs photon's energy is shown on the picture

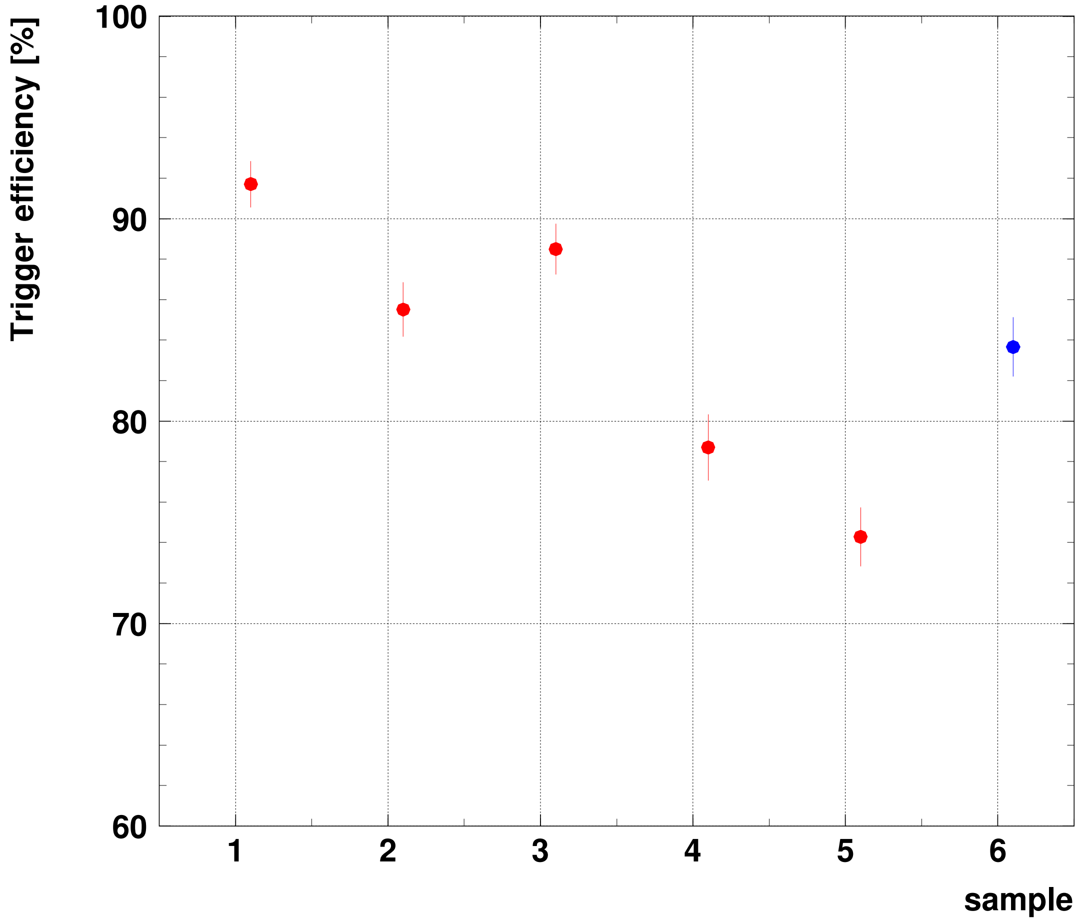


- integrated trigger efficiency for the "$\rho^o - meson$" run is

$$\boxed{\varepsilon_{tr} = (83.66 \pm 1.47)\ \%}$$

(error is only statistical)

- dependence integrated trigger efficiency (PD_{low}) on time illustrates below



- red points are data collected in January and blue one is for the "$\rho^o - meson$" run

Offline Luminosity

Online luminosity for the "$\rho^o - meson$" sample is

$$\boxed{\int_{online} L = 91.75 \pm 0.54\ ,\ nb^{-1}}$$

E_γ^{min}, GeV	$\sum_i W_i(E_{min})$	Stat.(*)	σ_{BH}	1-$\delta_{2\gamma}$	L_{off}, nb^{-1}
10.0	2.509$\cdot 10^9$	14455 - 31.	38.082	0.9818	88.58

Using the relation

$$L_{off} = \frac{\sum W_i (1-\delta_{2\gamma})\delta_{tr.screen}}{\sigma_{BH} A_\gamma \varepsilon_{tr}}$$

and the next values :

A_γ = 89.55 $\%$, $\delta_{tr.screen}$ = 1.026 , ε_{tr} = 83.66 $\%$

$$\Downarrow$$

$$\boxed{\Delta = (\frac{L_{off}}{L_{online}} - 1) \cdot 100\% = -3.44\ \%}$$

Errors summary

- Statictical error 0.7 %
- Uncertainty which connects with the photon energy scale 1.4 %
- acceptance determination gives 1.52 % from data and 2.4 % from MC
- trigger efficiency 1.76 % (only statistical error)

So the summary uncertainty for the luminosity measurement is

$$\boxed{\delta = 3.36\ \%}$$

CONCLUSION

1. First estimation offline luminosity for the some data sample is done.

2. Difference between online and offline luminosity calculation is small .

3. Achieved accuracy of the lumonosity measurement is δ = 3.36 $\%$.

Crucial points and possible improvements

- Photon Detector energy scale
  - add online monitoring of the PD channel response
  - online calibration of PD
- Photon Detector acceptance
  - put photon hot spot in the position of maximum acceptance
  - increase Photon Detector acceptance removing lead window
- Trigger efficiency
  - low absolute value of the trigger efficiency
  - non stable behaviour (at least for some time period)
  - check and monitoring this staff