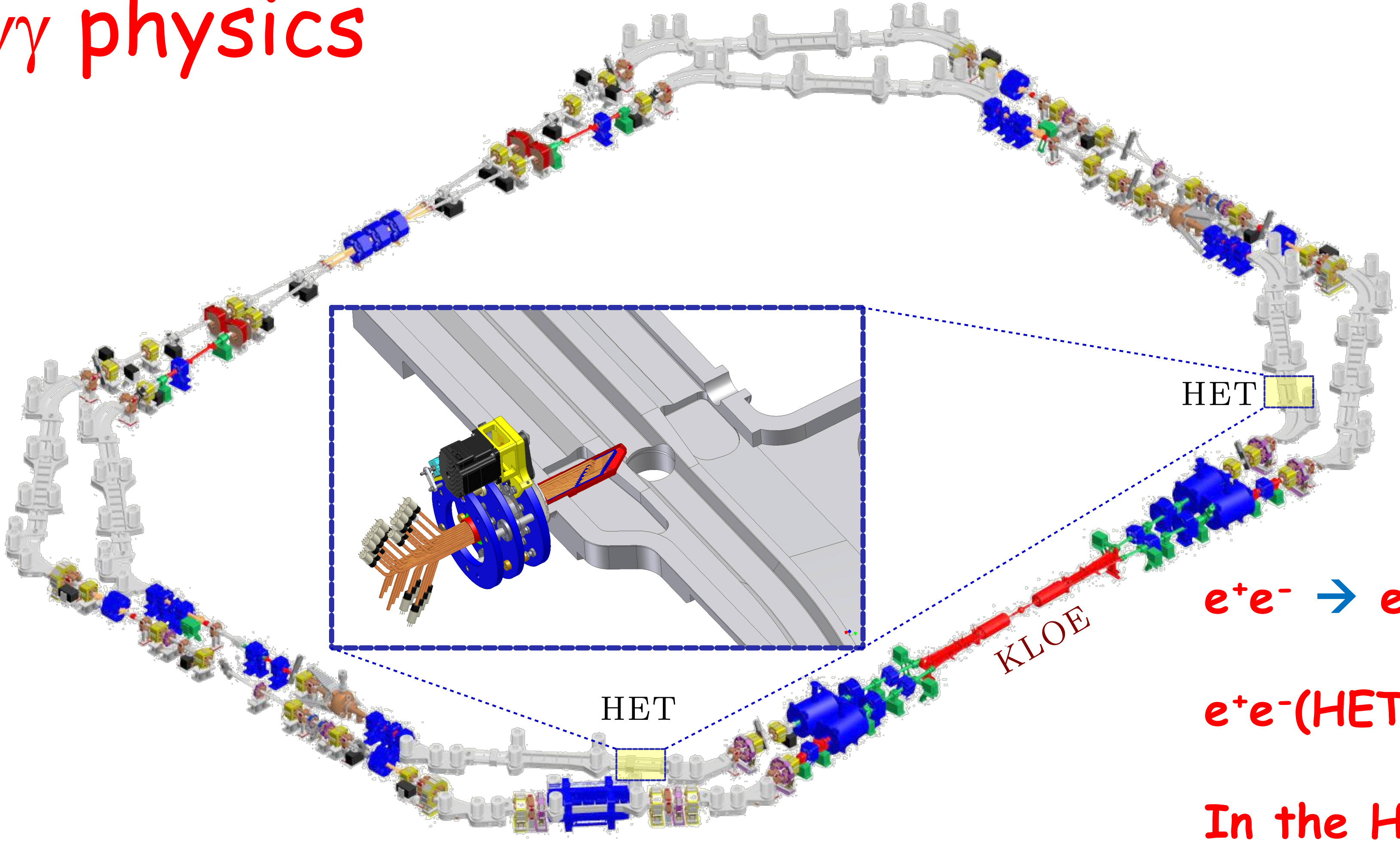
Status of the KLOE-2 high energy taggers

D. Moricciani on behalf of KLOE-2 collaboration

Summary

- Physics motivation
- HET detector
- HET performance
- HET counting rate
- π^0 preliminary analysis
- Conclusion

$\gamma\gamma$ physics



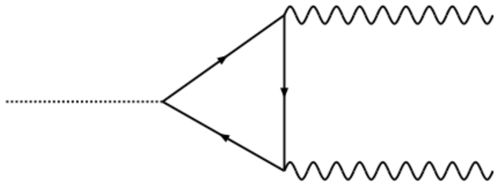
$e^+e^- \rightarrow e^+e^- \gamma\gamma \rightarrow e^+e^- X$

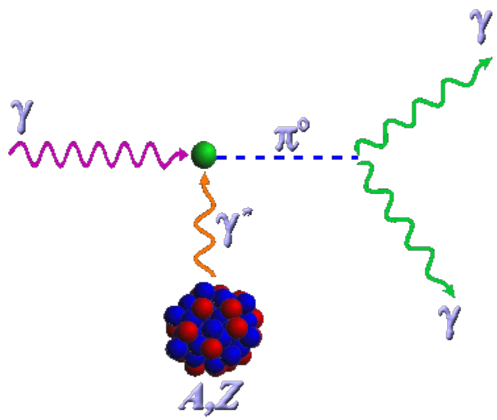
e^+e^-(HET) and X(KLOE)

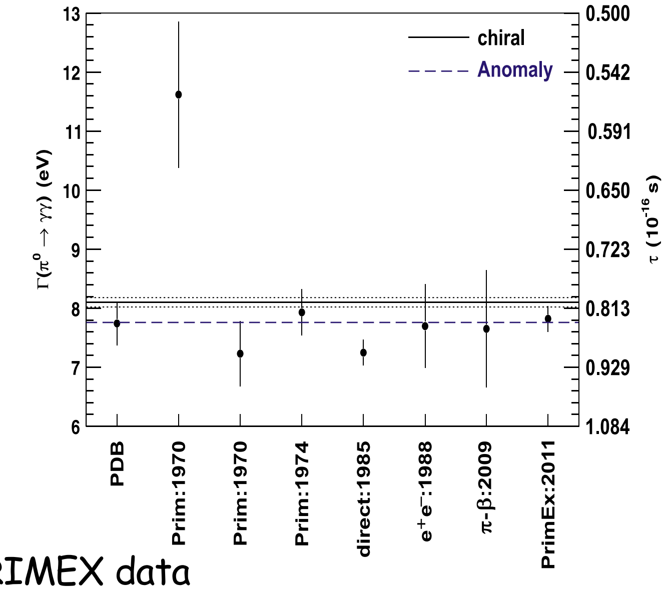
In the HET case $X = \pi^0$

Physics Goal : $\pi^0 \rightarrow \gamma\gamma$ case

- Chiral (massless) version of QCD predict $A_{\pi\gamma\gamma}=0$
- Adler, Bell, Jackiw (1968) discover the axial chiral anomaly







PRIMEX data

- $A_{\pi\gamma\gamma} = \alpha/\pi F_\pi$
- $\Gamma(\pi^o \rightarrow \gamma\gamma) = (\alpha m_\pi{}^3 F_\pi/64\pi^2)$

$$\boxed{\Gamma^{\text{theor}}_{\pi^0\rightarrow\gamma\gamma} = 8.09 \pm 0.11 \text{ eV}}$$

(1.4 %)

Target	$\Gamma(\pi^0 \rightarrow \gamma\gamma)$ [eV]	
^{12}C	7.79±0.18	2.3 %
^{208}Pb	7.85±0.23	2.9 %

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Physics Goal ($\mathscr{L}_{int}$=5fb^{-1})

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THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Theoretical Physics

On the possibility to measure the $\pi^0 \to \gamma\gamma$ decay width and the $\gamma^*\gamma \to \pi^0$ transition form factor with the KLOE-2 experiment

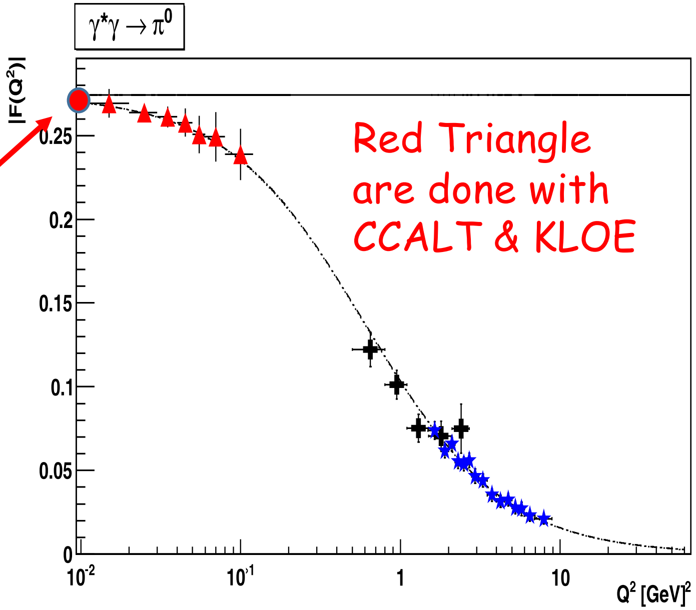
$a_\mu = (g-2)_\mu/2$

$a_\mu^{Exp}-a_\mu^{Theo} \approx (27.6 \pm 8.7) \times 10^{-10} \sim 3.4\ \sigma$

$8.7 \approx 5_{HLO} \oplus 3_{LbL} \oplus 6_{Exp}$

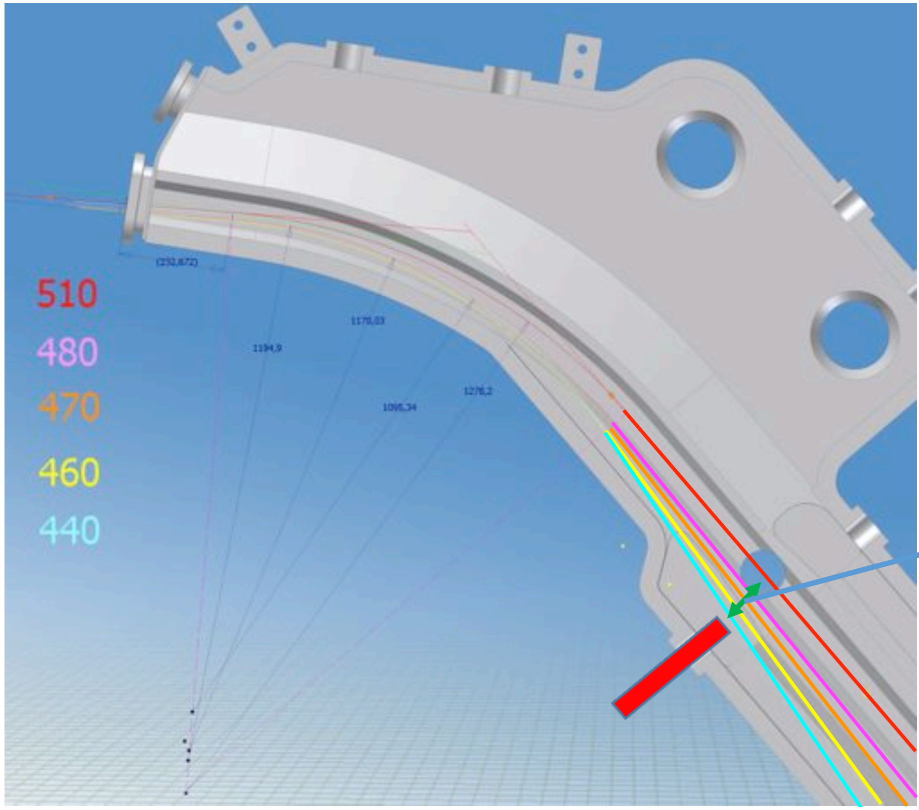
	T_1
No Trigger	13873
	63 %
CALO Barrel	8178
	37 %

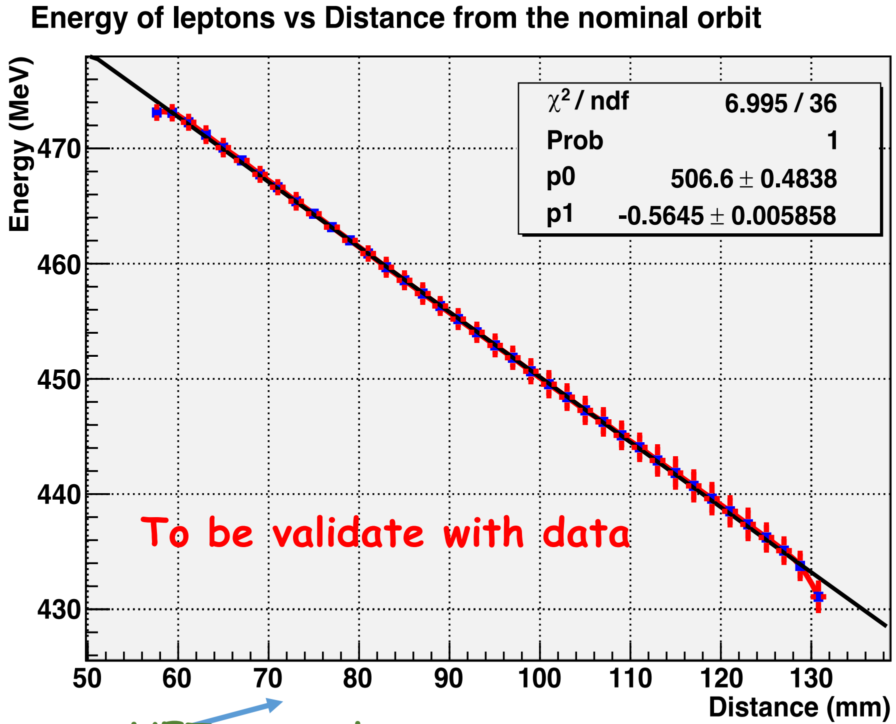
(1 % level)



Model	Data	$\chi^2/d.o.f.$	$a_\mu^{LbyL;\pi} \times 10^{11}$
VMD	A0	6.6/19	$(57.2 \pm 4.0)_{JN}$
VMD	A1	6.6/19	$(57.7 \pm 2.1)_{JN}$
VMD	A2	7.5/27	$(57.3 \pm 1.1)_{JN}$
LMD+V, $h_1 = 0$	A0	6.5/19	$(72.3 \pm 3.5)_{JN}$ * $(79.8 \pm 4.2)_{MV}$
LMD+V, $h_1 = 0$	A1	6.6/19	$(73.0 \pm 1.7)_{JN}$ * $(80.5 \pm 2.0)_{MV}$
LMD+V, $h_1 = 0$	A2	7.5/27	$(72.5 \pm 0.8)_{JN}$ * $(80.0 \pm 0.8)_{MV}$
LMD+V, $h_1 \neq 0$	A0	6.5/18	$(72.4 \pm 3.8)_{JN}$ *
LMD+V, $h_1 \neq 0$	A1	6.5/18	$(72.9 \pm 2.1)_{JN}$ *
LMD+V, $h_1 \neq 0$	A2	7.5/26	$(72.4 \pm 1.5)_{JN}$ *
LMD+V, $h_1 \neq 0$	B0	18/35	$(71.9 \pm 3.4)_{JN}$ *
LMD+V, $h_1 \neq 0$	B1	18/35	$(72.4 \pm 1.6)_{JN}$ *
LMD+V, $h_1 \neq 0$	B2	19/43	$(71.8 \pm 0.7)_{JN}$ *

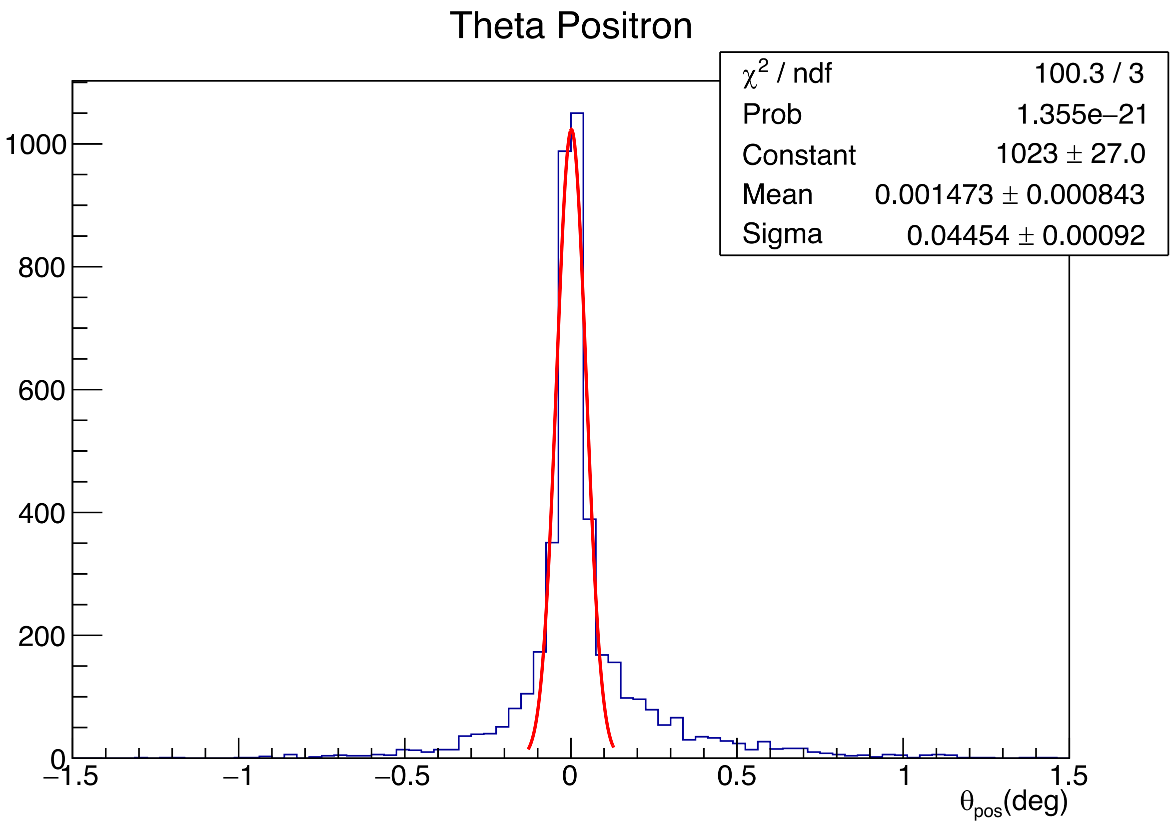
HET Acceptance

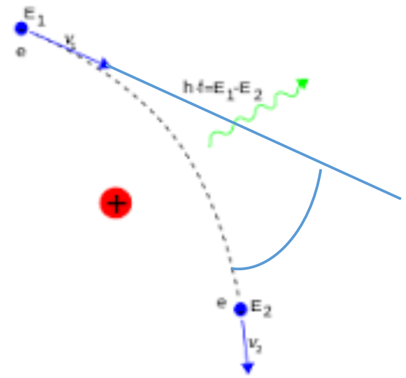




- HET tagged energy cover range between 430 and 480 for leptons : photon energy from 30 to 80 MeV
- Two photons cover the range from 60 up 160 MeV which cover the physics case of the π^0 at rest
- HET energy resolution is of the order of 0.5 MeV/mm

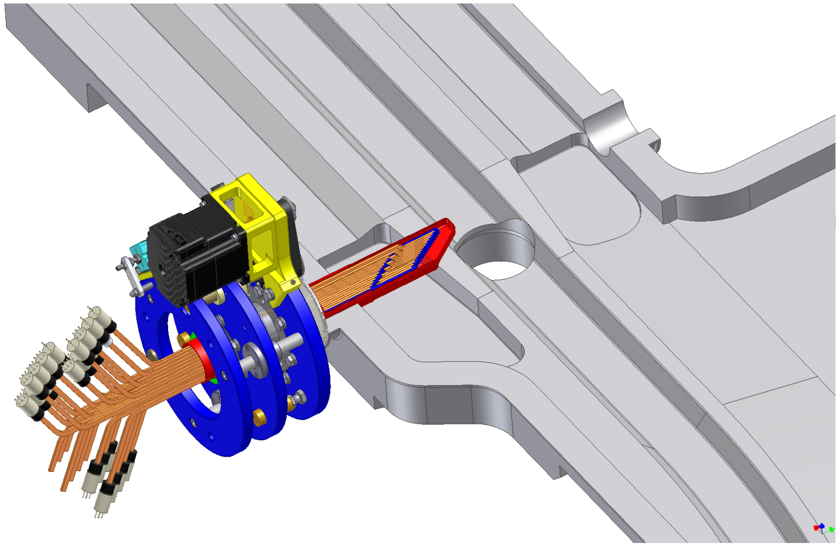
HETs angular acceptance



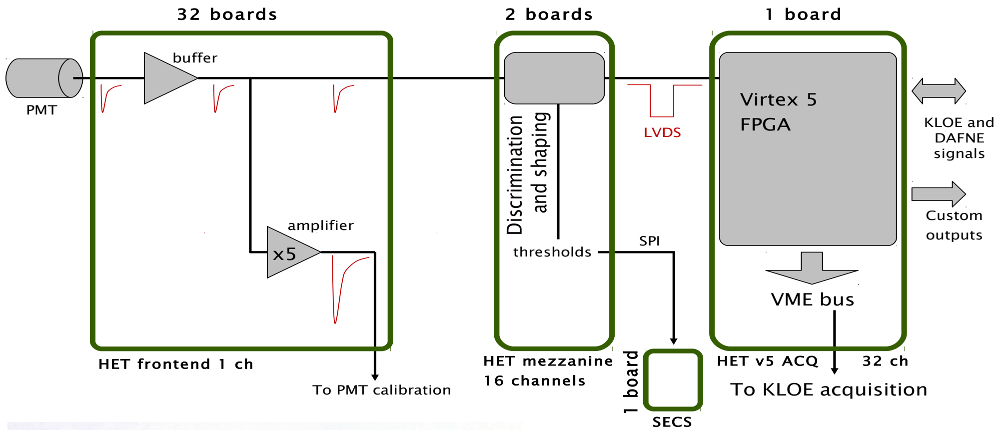


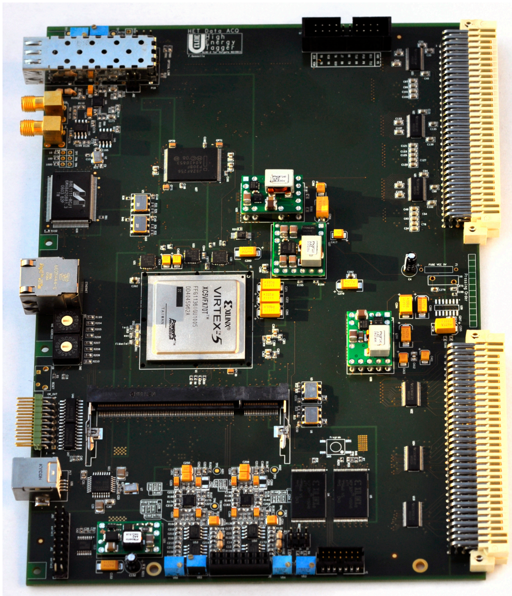
The HET angular acceptance is of the order of 3*Sigma ~ 2.5 mrad

HET Detector



28 plastic scintillator : 5x6x3 mm^3
1 Long Plastic for coincidence
HAMATSU PMT R9880U-110 SEL
Quantum efficiency ~ 35 %

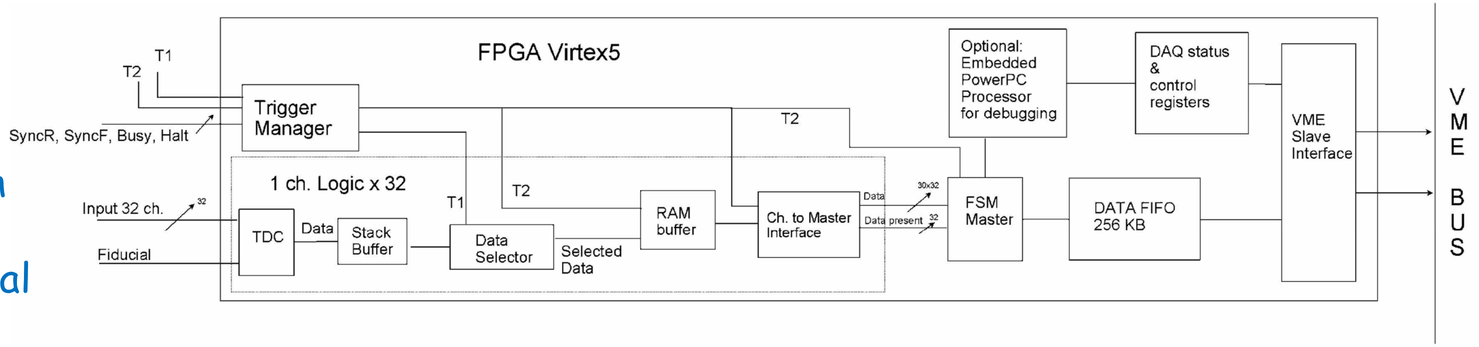


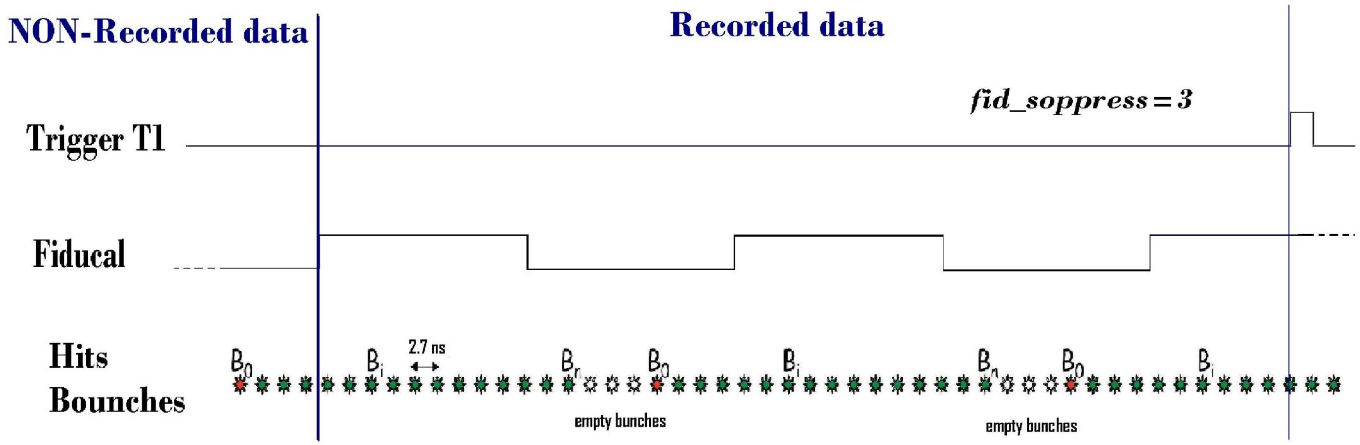


- Discriminator should provide output signal with a width ~ 2 ns in order to distinguish 2 consecutive bunches in DAΦNE (2.7 ns)
- TDCV5 use custom logic in order to manage signals from HET-DAΦNE-KLOE

HET DAQ : TDCV5

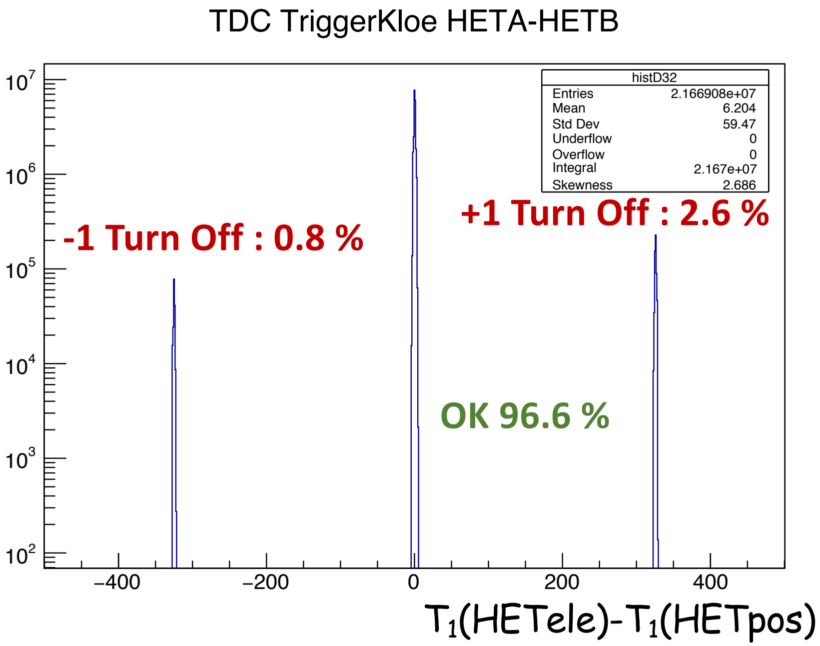
- Usually DAΦNE is filled with 100 bunches over 120
- We use the "Fiducial", a signal provided by DAΦNE as TDC common start. By definition it is in phase with respect to the first bunch circulating in DAΦNE
- the HET stores information corresponding to N turns of DAΦNE only when KLOE provides the trigger (T_1 and T_2)
- The two DAQ systems (HET and KLOE) are asynchronous

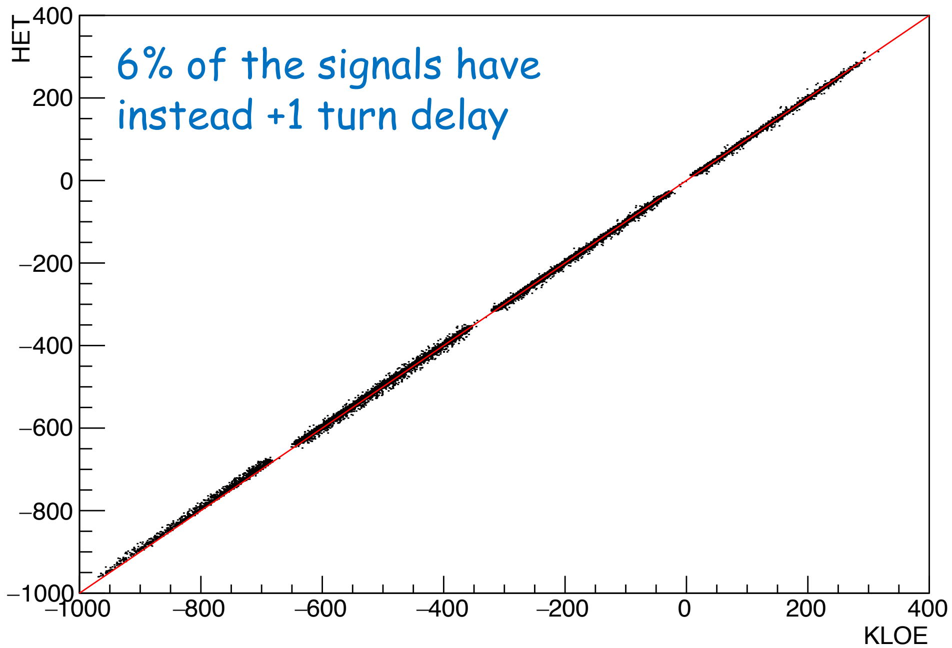




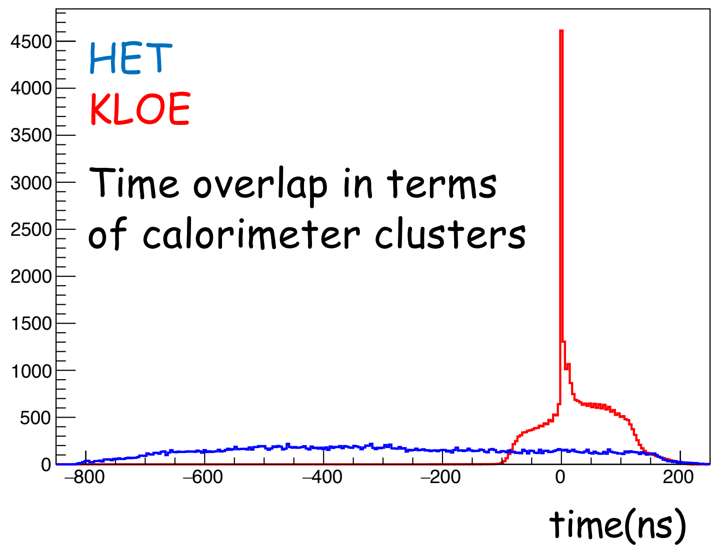
Time Synchronization HETs - KLOE

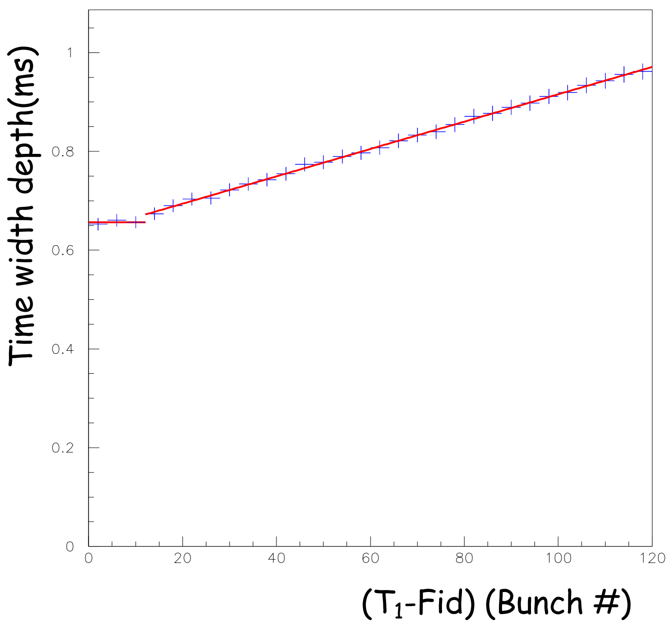
- KLOE Trigger T_1 allows us to synchronize both HETs stations
- HETs Long plastic signal allow to synchronize HETs with respect to KLOE

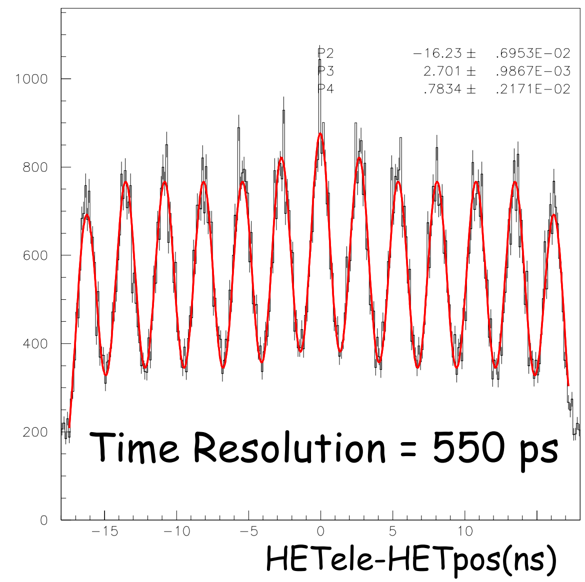




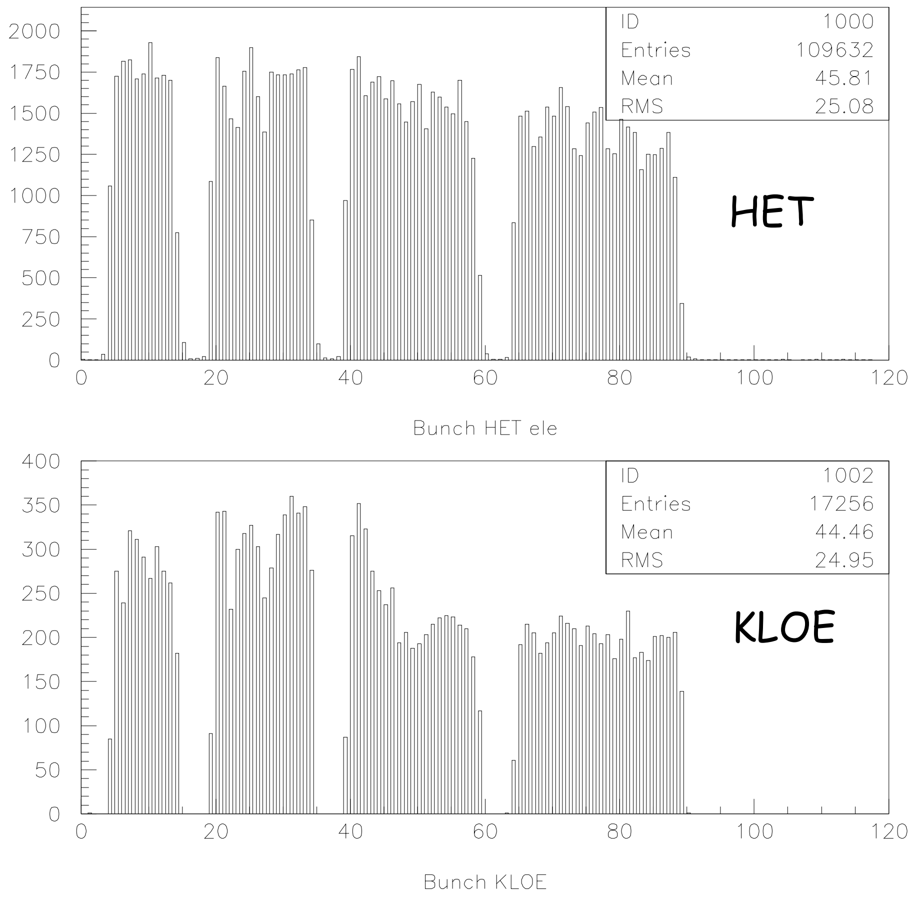
HET performance …

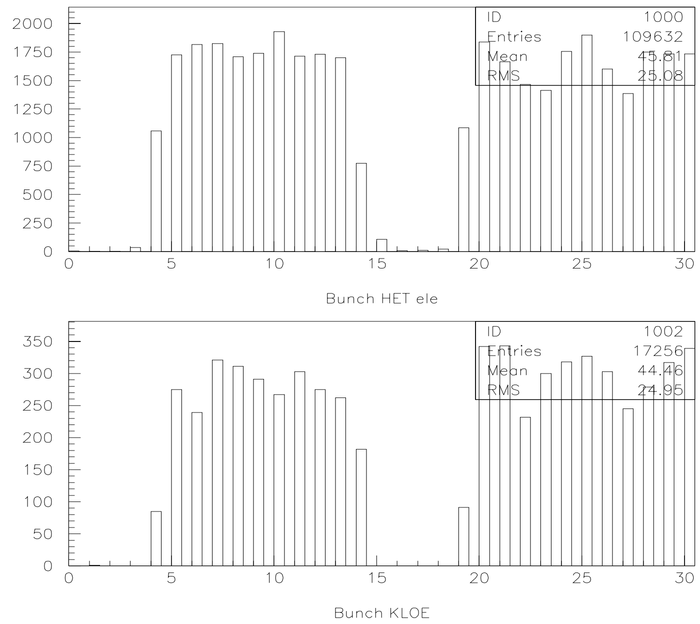






DAΦNE "bar-code"





- KLOE events after bhabha selection
- HET is noiseless : no beam = no hit

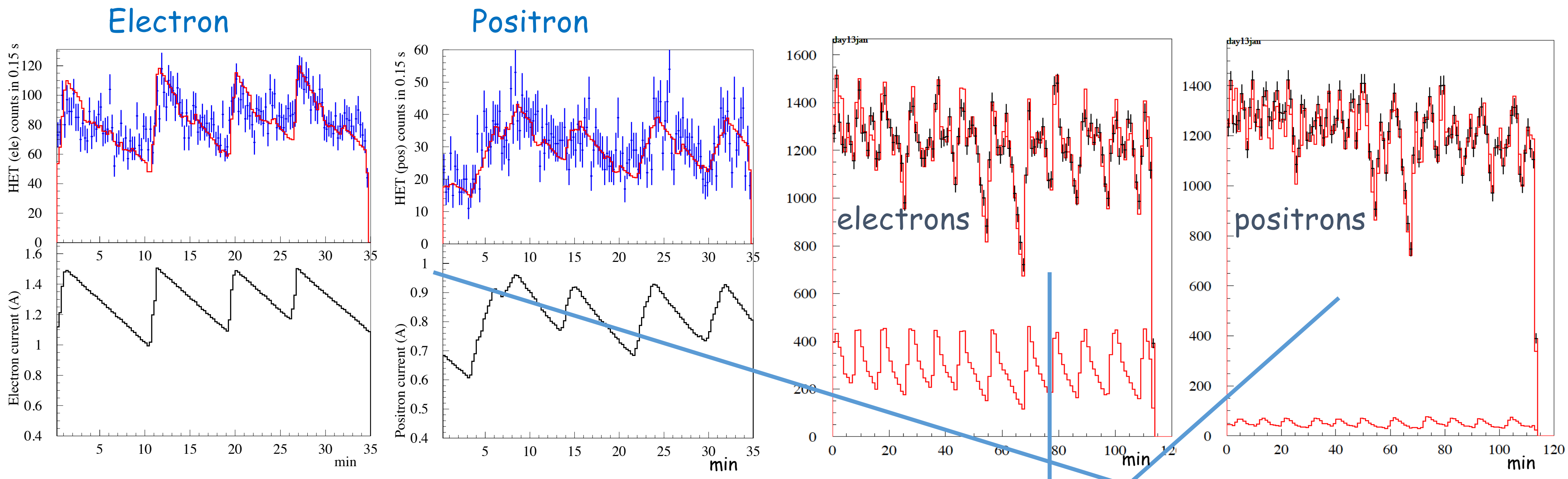
HET Counting Rate with beam …

In the HET events we clearly see only two contributions :

- The events due to background/Touschek (I^2) events
- The events due to Luminosity ($\mathcal{L}$) of DAΦNE

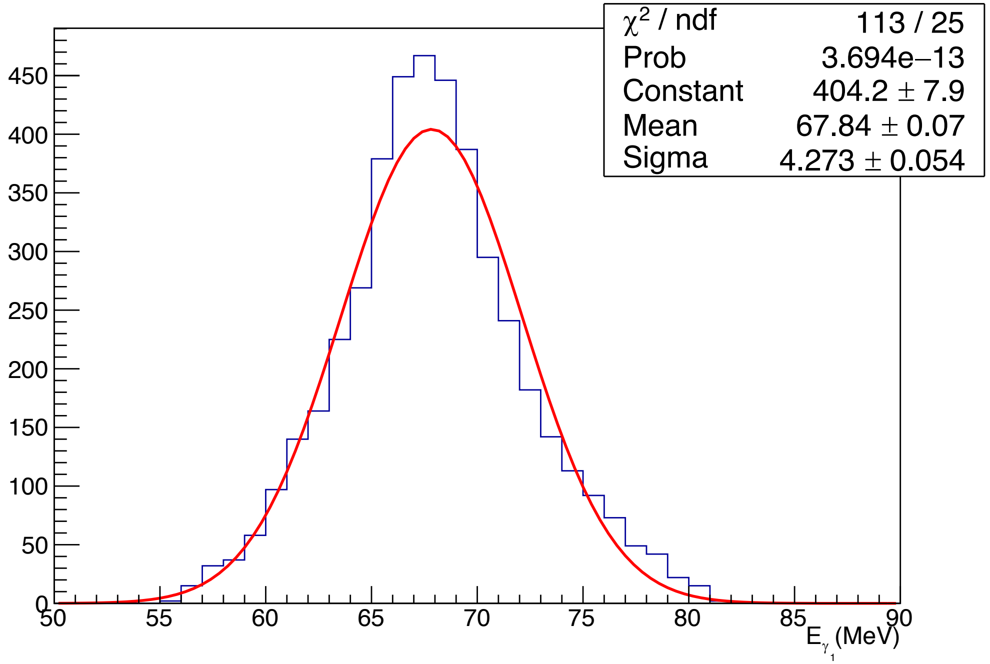
$$\text{HET-Rate} = \text{KLOE-Trigger-Rate} \times (\alpha_{ele/pos}\,\mathcal{L} + \beta_{ele/pos}\, I^2_{ele/pos})$$

No Collision and Collision run



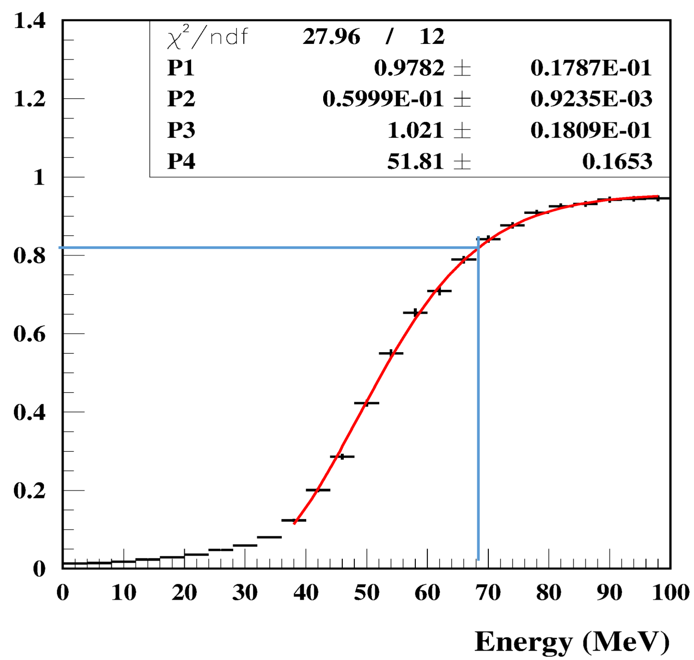
HET-Rate= KLOE-Trigger-Rate x $(\alpha_{ele/pos}\,\mathcal{L} + \beta_{ele/pos}\, I^2_{ele/pos})$

Criteria for data selection : signal events



Spectra of the photons from π^0 decay

How KLOE detect these photons :
Resolution and Trigger Efficiency ?



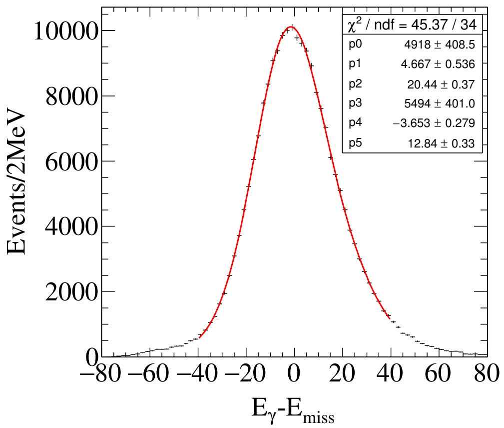
KLOE Trigger Efficiency ~ 82 %

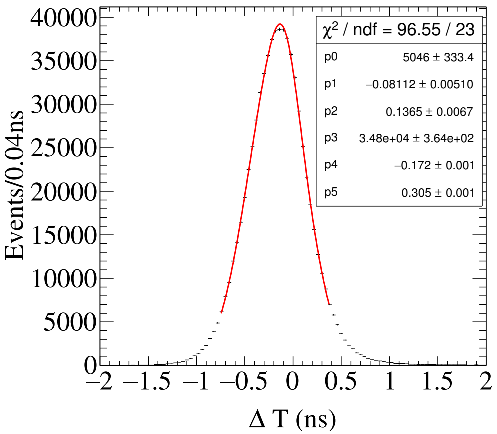
How KLOE detect low energy photon …

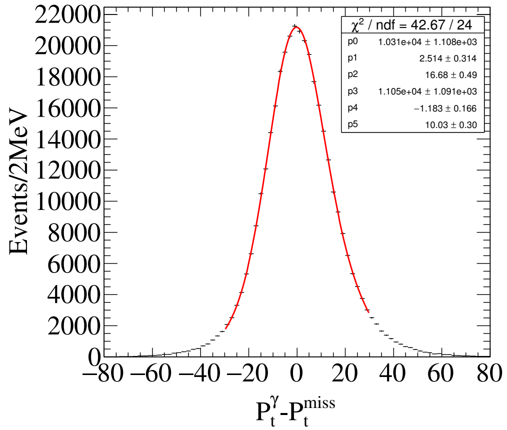
Radiative Bhabha scattering events in KLOE:

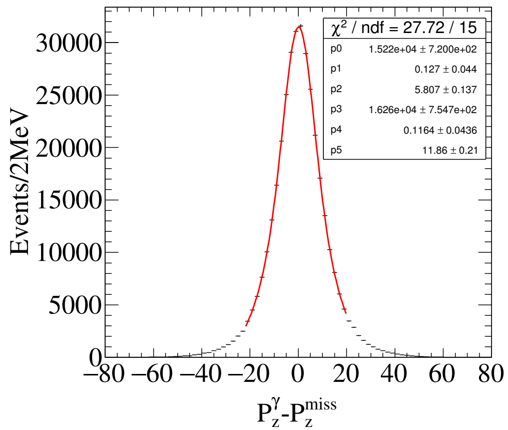
- 3-clusters, 2 energetic clusters with E > 350 MeV associated to electrons
- $Minv_{clus1,2}$ > 500 MeV
- 2 tracks with an associated vertex
- 250 MeV < $|P_{trk}|$ < 550 MeV
- $|P_{trk1,2}|$ > 500 MeV
- $|ClusterE_{1,2} - |P_{trk1,2}||$ < 60 MeV
- 60 < E_{miss} < 80 MeV
- $|\cos(\theta_{miss})|$ < 0.948
- $|\cos(p_{miss} - \gamma\ clus)|$ > 0.95

Low energy photon in KLOE …









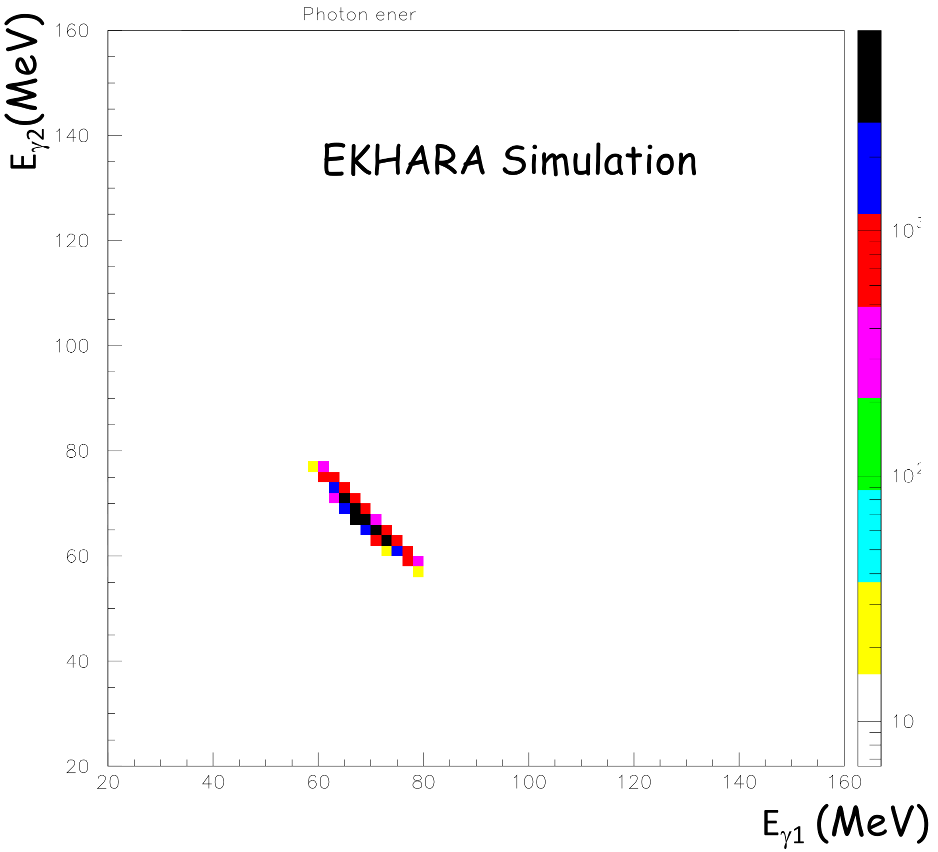
σ_E=16.4±0.2 MeV

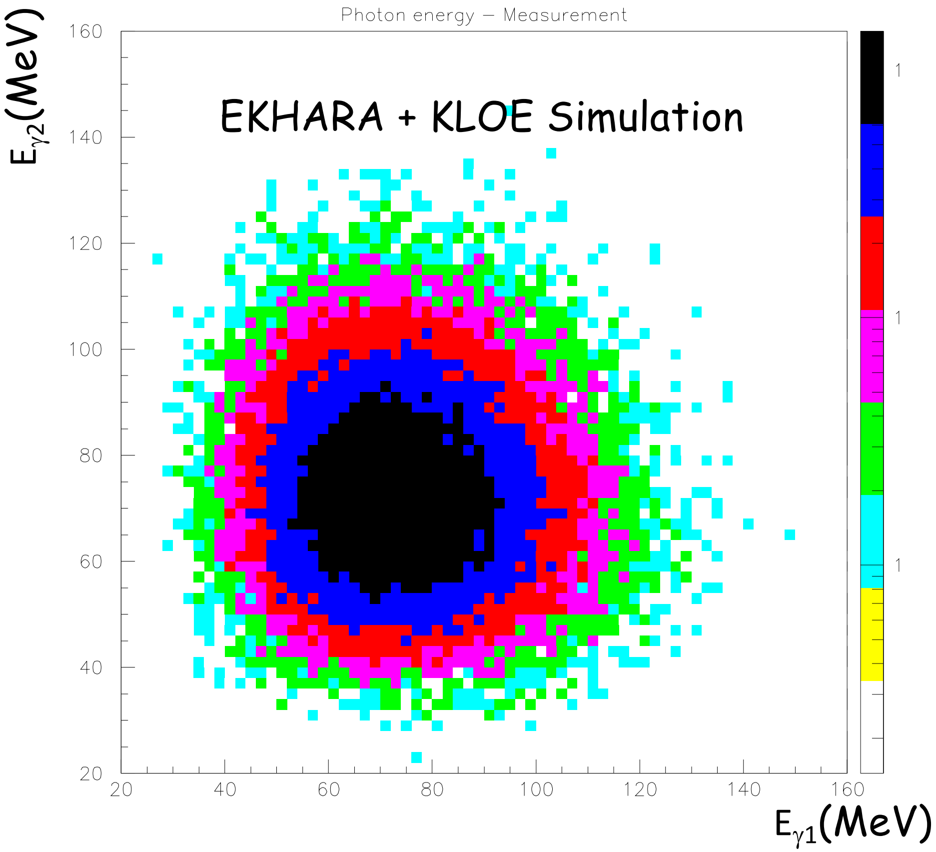
σ_T=283±1 ps

σ_{Pt}=13.2±0.3 MeV

σ_{Pz}=8.9±0.1 MeV

KLOE resolution and trigger effects on π^o photons





π^0 search : preselection

- About 500 pb^{-1} of integrated luminosity have been processed

Double Arm events :

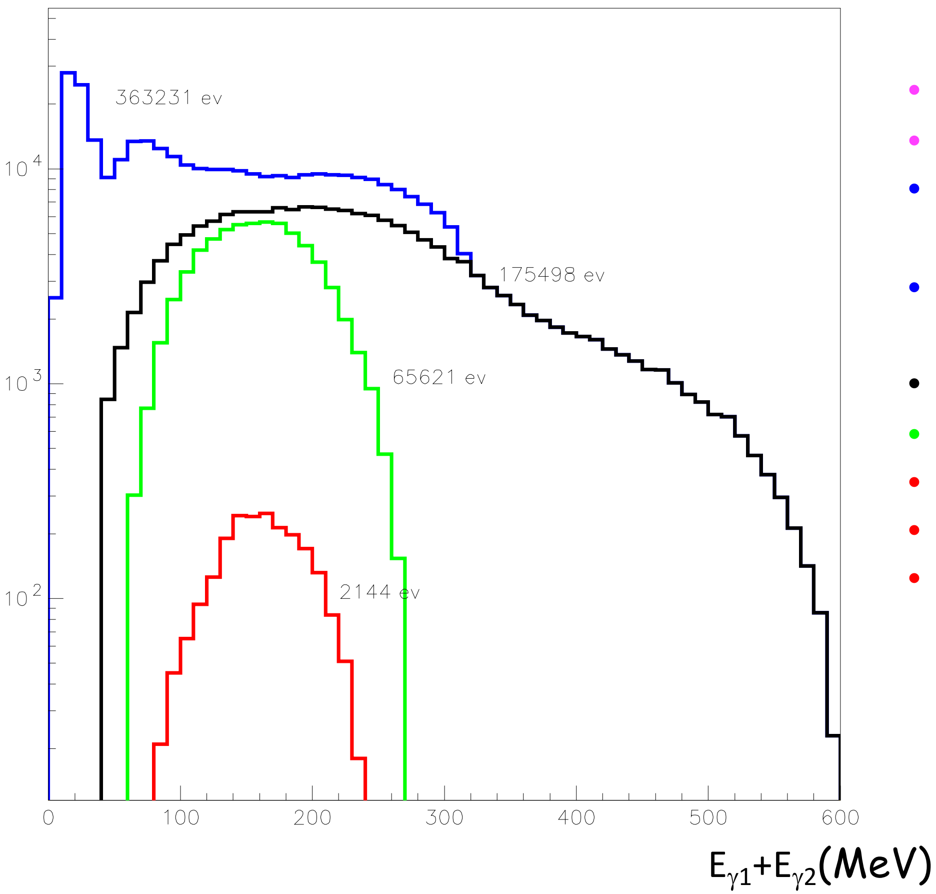
- coincidence between HET stations ($\pm$ 1 bunch expected from resolution studies, ΔT_{bunch} ~ 2.7ns , <1% of KLOE triggers)
- control sample of events with $-2 \leq \Delta T e^+e^- \leq 7$ bunches

Single Arm events :

- in time with KLOE trigger ($-3 \leq \Delta T_{tri-clu} \leq 8$ bunches)
- in time with a bunch with 2 cluster in the barrel 20 < Eclu < 300 MeV
- $|\Delta T_{KLOEclu-HET}| \leq 4$ bunches

- A sample of ~330 pb^{-1} of Double Arm events is being analyzed to search for π^0 production almost at rest.

π^o search : selections



- We start with 10^8 events
- From the simulation we expect to have ~ 350 events
- Coincidence between tagger hits : $|\Delta_{ep}|$ < 1 bunch and in time with the KLOE trigger
- 2 KLOE cluster associated with the same bunch with $\Delta T_{KLOEclu-HET} \leq \pm$ 4 bunches E_γ< 300 MeV
- E_γ> 20 MeV (events that can trigger the KLOE DAQ)
- 30<E_γ<135MeV
- $P_{(E\gamma1+E\gamma2)}$< 90 MeV
- $\cos\theta_{\gamma\gamma}$< -0.8
- 80 < $M_{\gamma\gamma}$< 230MeV and $|\Delta T - \Delta R/c|$ < 1.1 ns

Conclusion

- HET stations are completely noiseless
- The timeline of the counting rate for electron and positron stations shows only 2 visible contributions : from luminosity and from Touschek intra-bunch scattering particles
- Machine background reaches a maximal relative contribution of 45% for electron and 15% for positron beams
- The total rate dominated by bhabha scattering is at the level of 500-600 kHz. The measured effective cross section of 2 mb(ele) - 2.5 mb(pos) to be validate with montecarlo.
- The rate of uncorrelated time-coincidences between KLOE and HET requires full reconstruction of a large fraction of the KLOE triggers
- We have pre-filtered candidates of single-π^0 production from $\gamma\gamma$ scattering. A total of about 330 pb^{-1} are being analyzed
- Work in progress:
  - to optimize the signal selection
  - to accurately measure the background of random coincidences
  - to carry out the analysis of Single Arm events both for bhabha and π^0 events