The KLOE-2 detector upgrade at DAΦNE

Dario Moricciani INFN Roma "Tor Vergata"
on behalf of the KLOE-2 collaboration

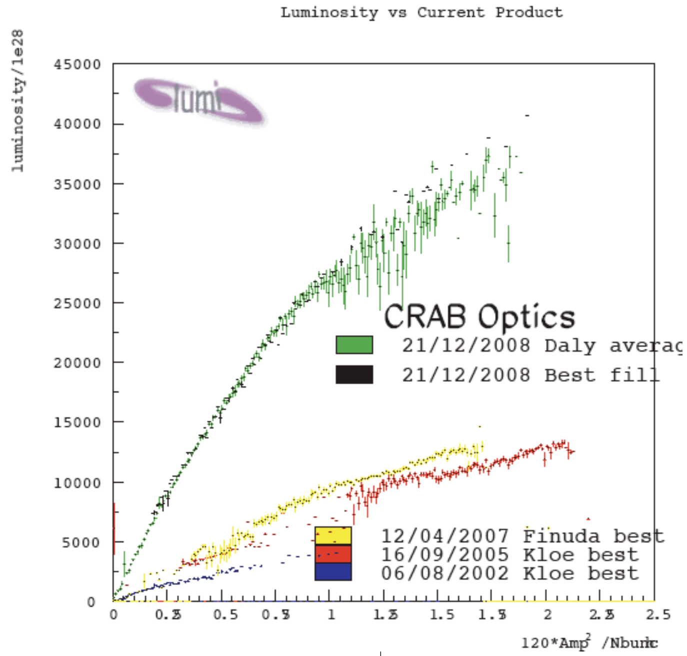
KLOE@DAΦNE and new Interaction scheme

- Frascati ϕ-factory :

e^+e^- collider @ $\sqrt{s} \approx 1020$ MeV $\approx M_\phi$;

- Best performances in 2005:
  - $L_{peak} = 1.4 \times 10^{32}$ cm^{-2}s^{-1}
  - $\int Ldt = 8.5$ pb^{-1}/day

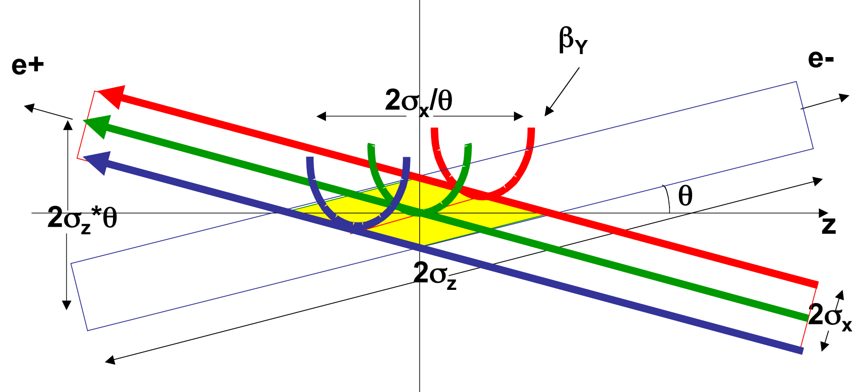
- KLOE: 2.5 fb^{-1} @ $\sqrt{s}=M_\phi$ and
  + 250 pb^{-1} off-peak @ $\sqrt{s}=1$ GeV



- New interaction scheme implemented : large beam crossing angle + crabbed waist sextupoles

Luminosity increase factor ~ 3

$\int Ldt \approx 1$ pb^{-1}/hour



$\mathcal{L}$=5x 10^{32} cm^{-2}s^{-1}

KLOE-2 Physics Program and new detectors

- $\gamma\gamma$ physics
  - Study of $\Gamma(S/PS\rightarrow\gamma\gamma)$, test of χPT, existence and properties of $\sigma(600)$ meson, PS Transition Form Factor

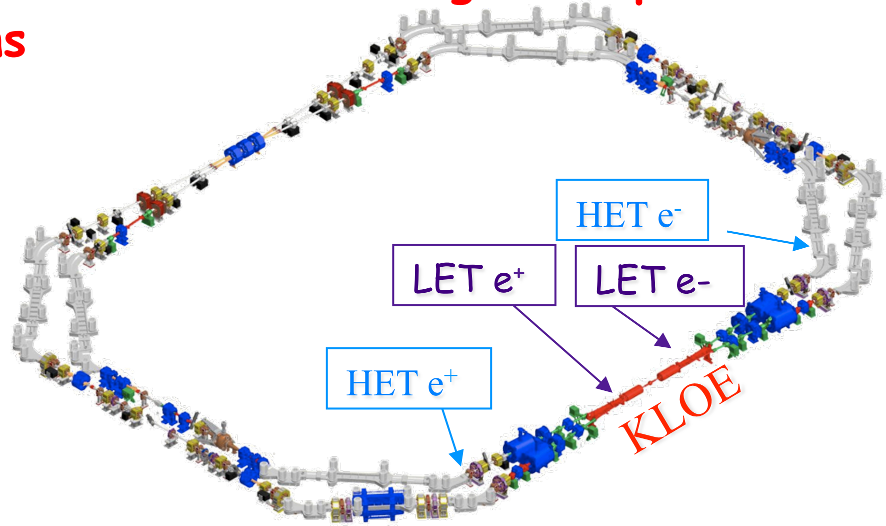
  New detectors needed are the $\gamma\gamma$ taggers : LET-HET
- Kaon Physics
  - Test of CPT (and QM) in correlated kaon decays
  - Test of CPT in K_S semileptonic decays
  - Test of SM (CKM unitarity, lepton universality)
  - Test of χPT (K_S decays)
- Spectroscopy of light mesons
  - η, η', f_0, a_0, σ in ϕ radiative decays
- Dark Matter searches (light bosons at O(1 GeV))

  New detectors for improving on tracking and photon acceptance : IT-QCALT-CCALT

References : KLOE-2 Collaboration *EPJC* ***68***, *(2010), 619*

γγ taggers – step0

Tagger for γγ physics: to detect off-momentum leptons for studying $e^+e^- \rightarrow e^+e^-\gamma\gamma \rightarrow e^+e^-X$. Where the e^+e^- are detected in the forward γγ taggers and the hadronic state X in KLOE. **We use the same magnet of DAΦNE as magnetic spectrometer foe the off-energy leptons**

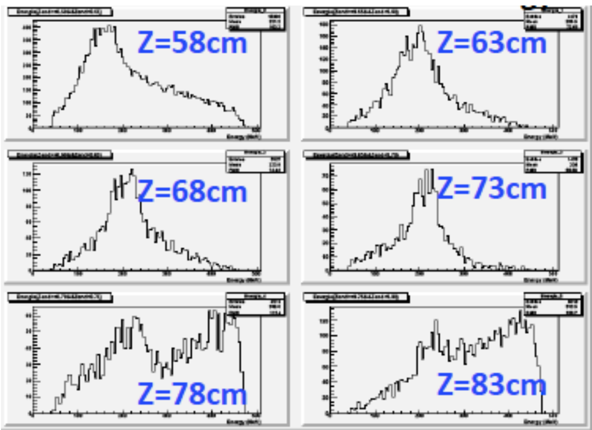


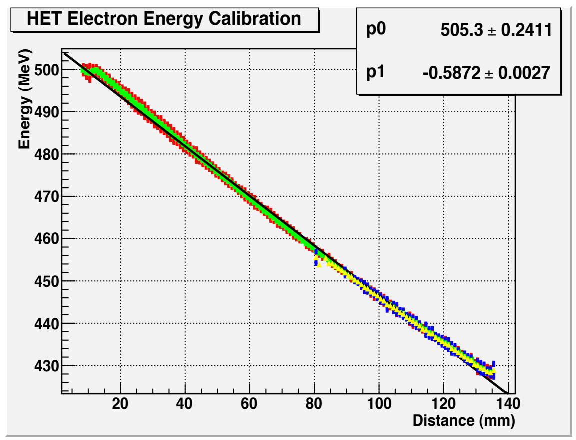
We locate two possible detector location :

1) Inside KLOE ~ 1 m from the IP : LET
2) After the first bending magnet ~ 11 m from IP : HET

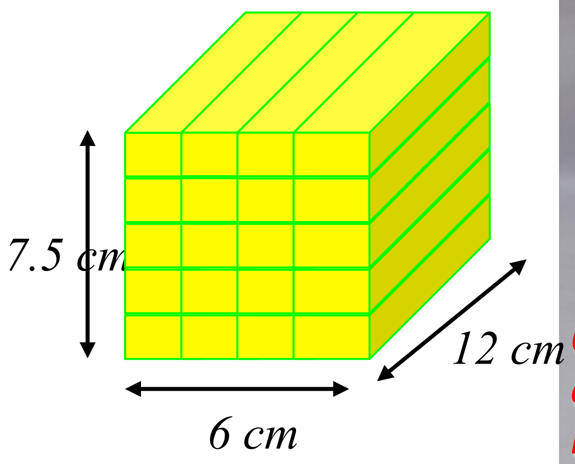
LET is a calorimeter
HET is a position detector

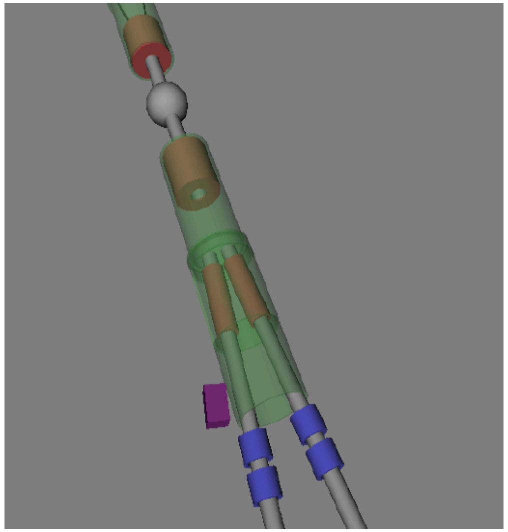
Data taking start next autumn

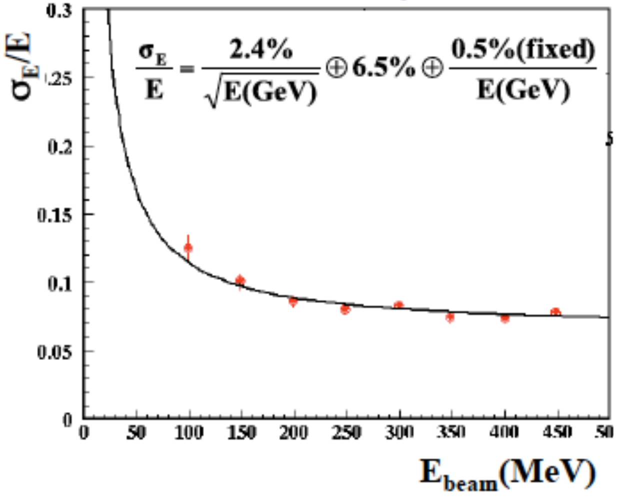


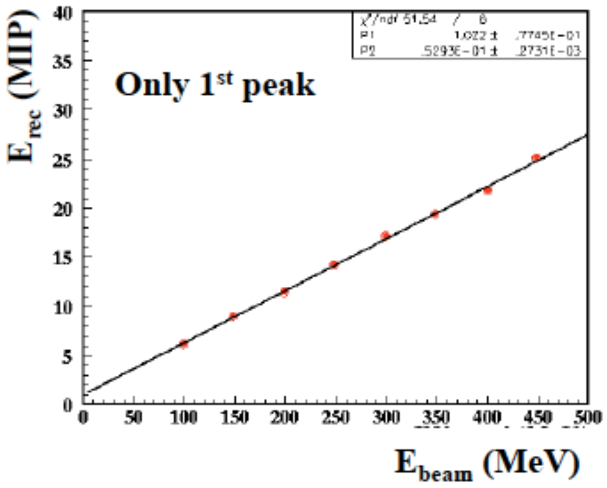


LET Characteristics and Performances

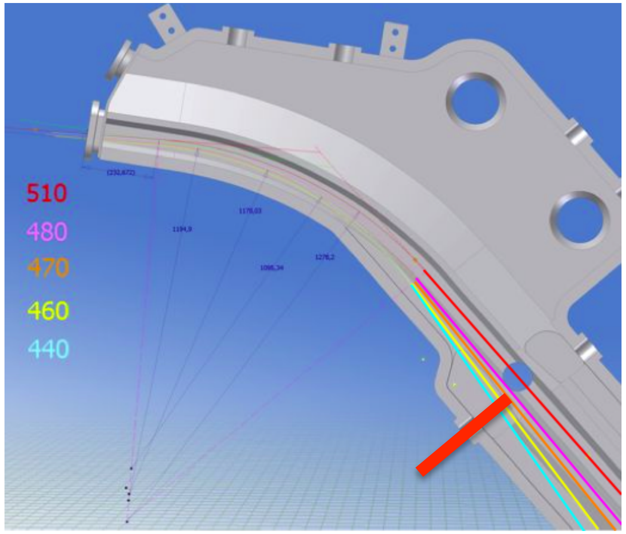


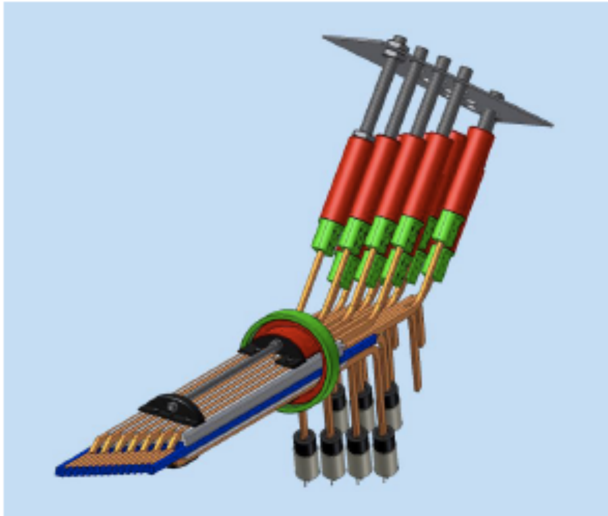






HET Characteristics and Performances

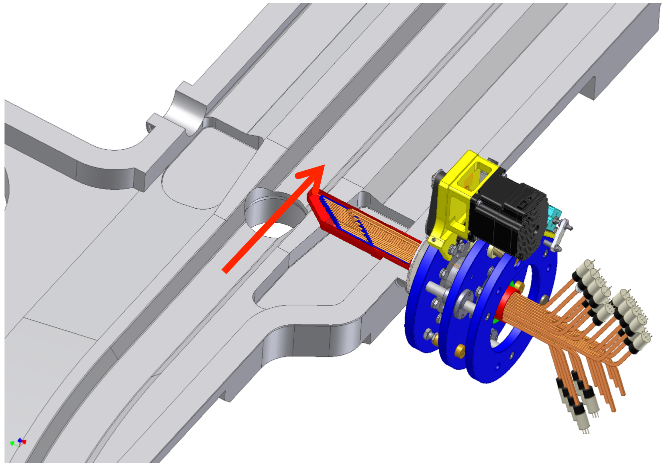




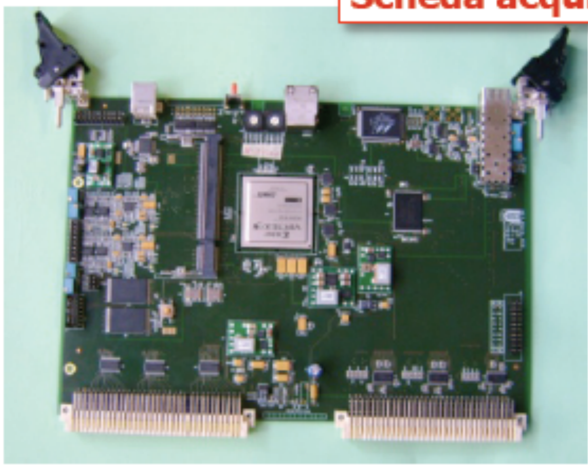
Should have the option to acquire data hit-pattern for every bunch crossing ~ 368 MHz :

Time Res. ~ 150 ps (fast scint. + high QE PMT)

New DAQ module (V5) has been developped

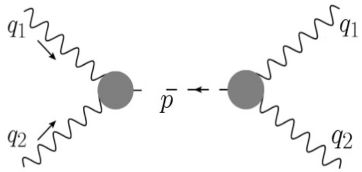


Scheda acquisizione HET (6U)



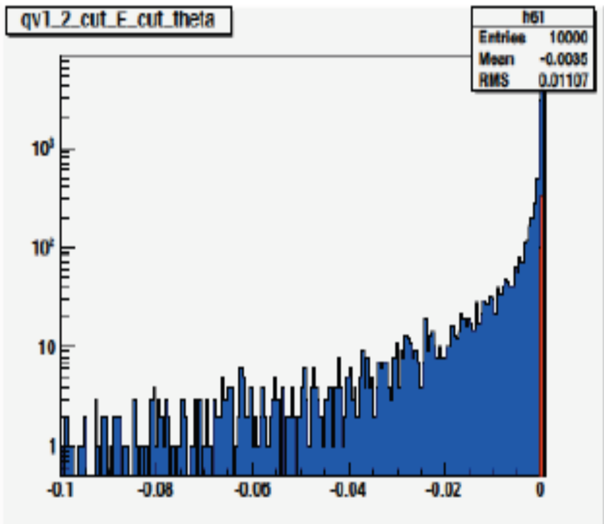
Physics item studied …

$\Gamma(\pi^o \rightarrow \gamma\gamma)$



$$\mathcal{F}^2_{\pi^0\gamma\gamma}(m^2_{\pi^0},0,0) = \frac{1}{(4\pi\alpha)^2}\frac{64\pi\Gamma(\pi^0\rightarrow\gamma\gamma)}{M^3_{\pi^0}}$$

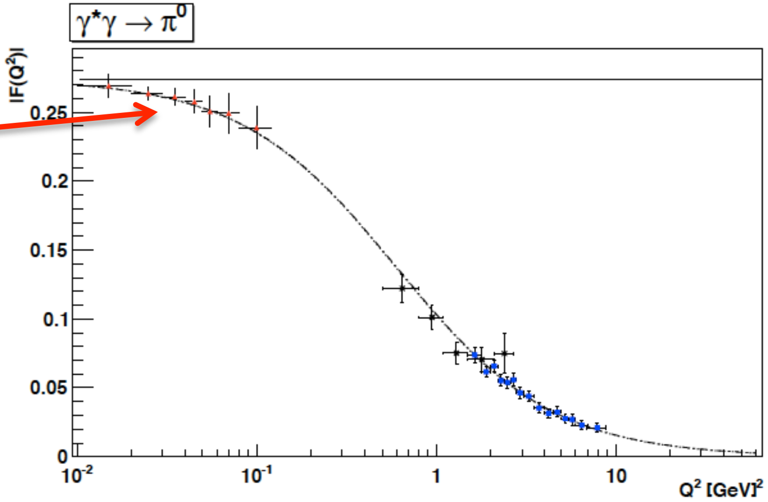
$\sigma \approx \Gamma(\gamma^*\gamma^* \rightarrow \pi^o)\Gamma(\pi^o \rightarrow \gamma\gamma) = \Gamma^2(\pi^o \rightarrow \gamma\gamma)$



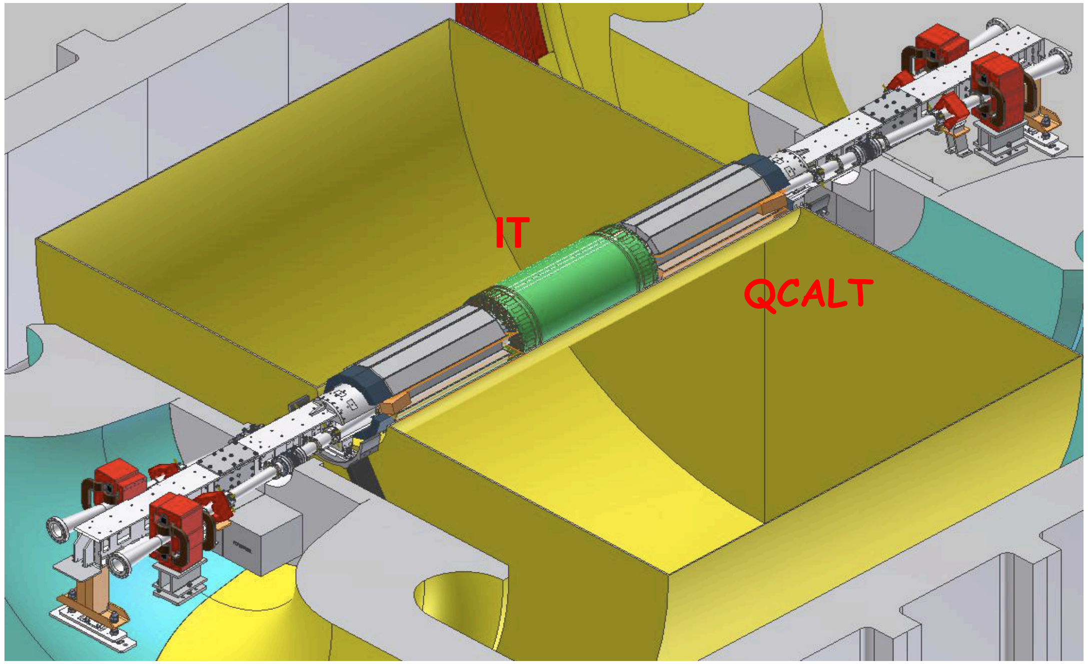
$\sigma_{tot}(1020\ MeV) = 0.28\ nb$ $\sigma_{exp}=\sigma_{tot}$*1.9% $(H_e{}^*H_e)$

$N_{ev}=\sigma_{exp}\mathscr{L}_{ee}\varepsilon_K$ $(\varepsilon_K=37\%)$ **N_{ev}=10000/(5 fb^{-1})**

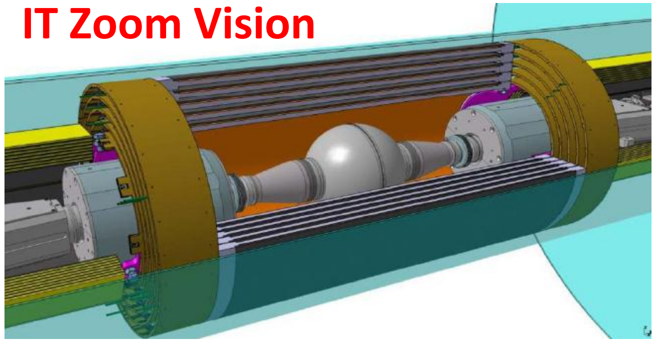
We can fill the low q^2 region up to 0.1 GeV^2 of the $\gamma\gamma^* \rightarrow \pi^o$ transition from factor in order to improve the actual knowledge of the Light-by-Light contribution to muon anomaly

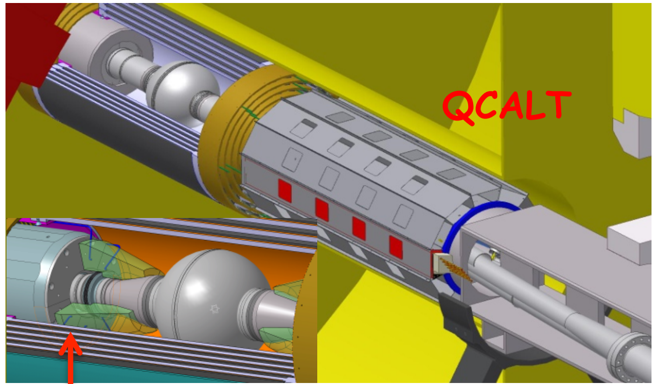


New Detectors for step1



IT Zoom Vision





CCALT

Inner Tracker located between the beam pipe and the DC: 4 layers of cylindrical triple GEM:

Improve vertex reconstruction near the IP

QCALT: W + Scint. Tiles readout by SiPM via WLS fibers

To Reject secondary photons and increase the efficiency of Kaon decay

CCAL: LYSO crystals + SiPM; close to IP

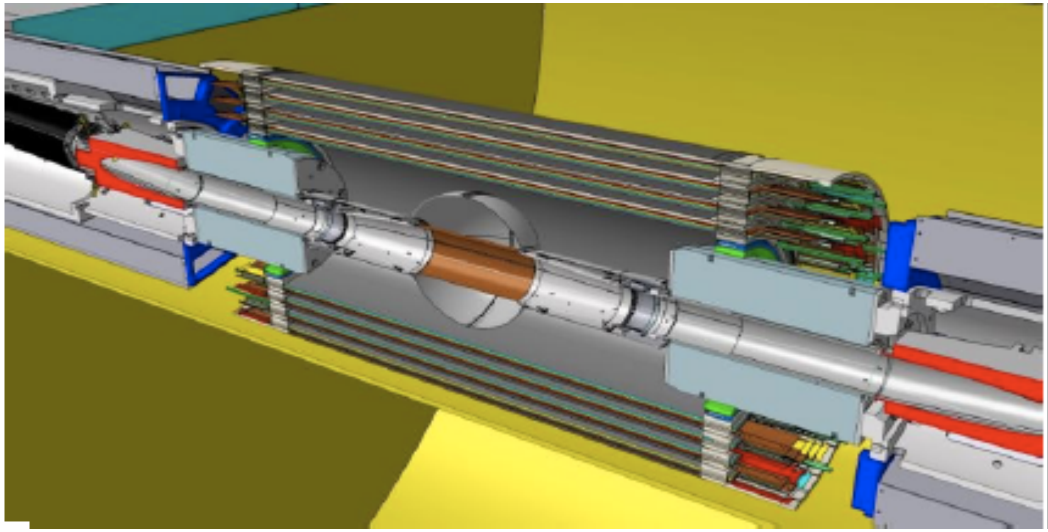
To increase acceptance for photons coming from the IP (min. angle: 21°→ 9°)

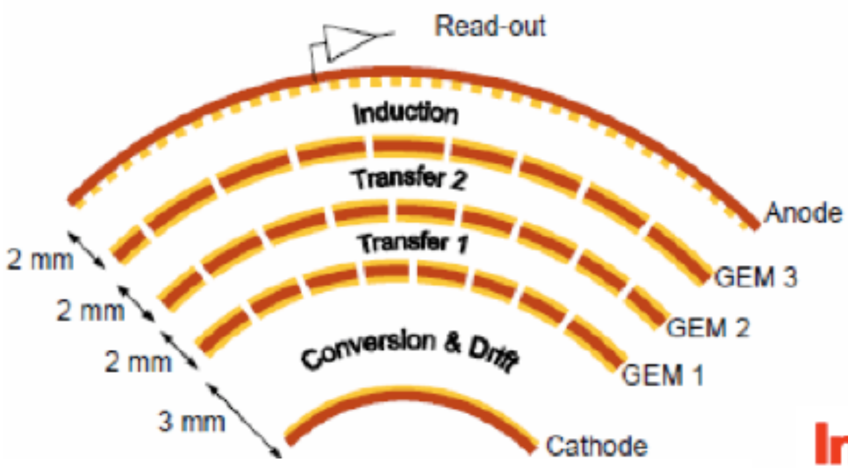
Installation scheduled next summer

IT characteristics

Improve of the decay vertex reconstruction requirements :
$\sigma_{r\phi} \sim 200\ \mu m$ and $\sigma_z \sim 500\ \mu m$
Low Material budget < $0.02\ X_o$
High Rate capability 5 kHz/cm^2

→ GEM detector should be used





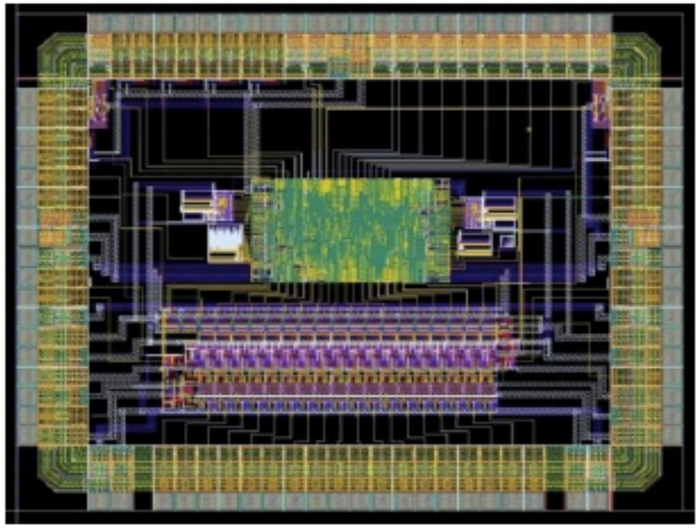
- 4 layer of cylindrical GEM with radii from 13 to 23 cm
- 700 mm active length
- X-V strips-pads readout
- 1.5 Xo radiation length with the carbon fibers supports

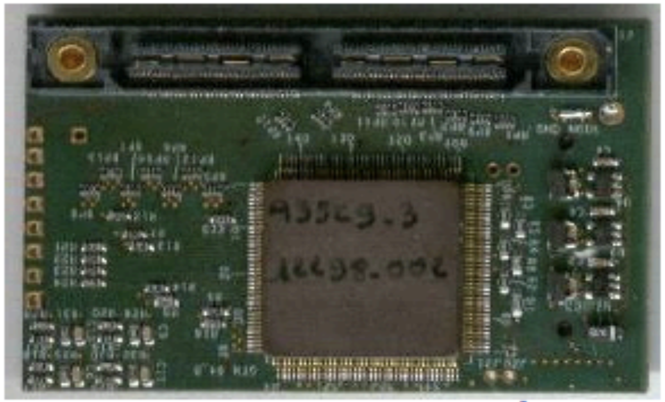
Improvement of about a factor 3 on the $K_s \rightarrow \pi\ \pi$ vertex resolution

IT dedicated Front-End CHIP

Sensitivity (pF)	20 mV/fC
Z_{IN}	400 Ω (low frequency)
C_{DET}	1 - 50 pF
Peaking time	90 - 200 ns (1-50 pF)
Noise (erms)	800 e- + 40 e-/pF
Channels/chip	64
Readout	LVDS/Serial

- Mixed analog-digital circuit
- Low input equivalent noise, low power consumption and high integrated chip
- 4 blocks:
  - charge sensitive amplifier
  - shaper
  - leading-edge discriminator (programmable threshold)
  - monostable (stretch digital signal for trigger)

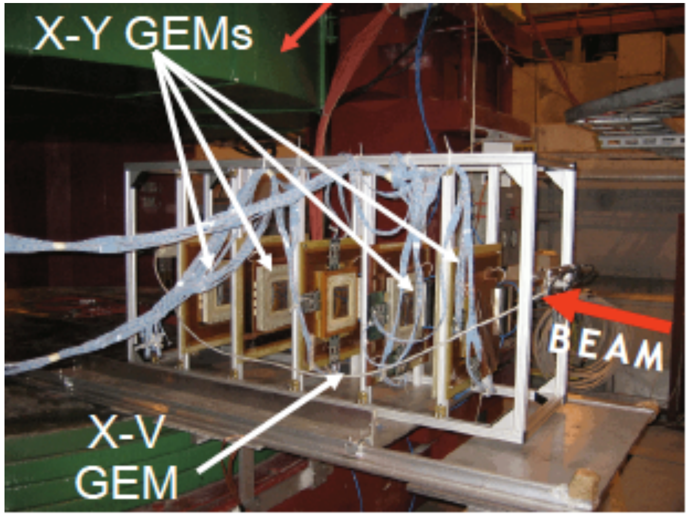




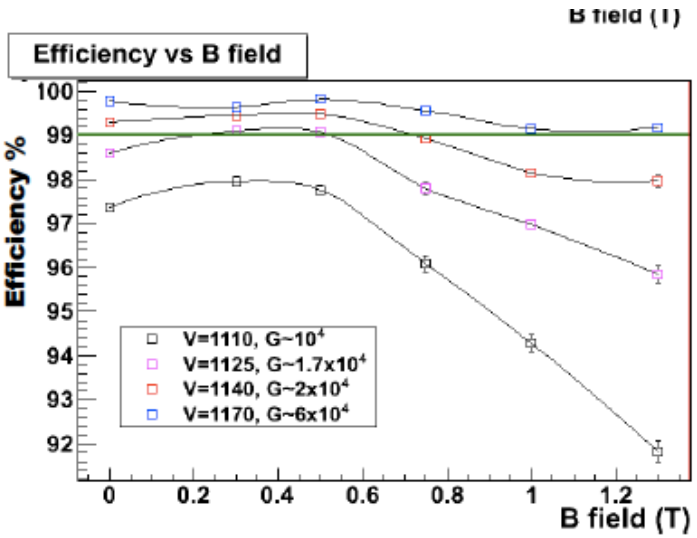
GASTONE 64 ch

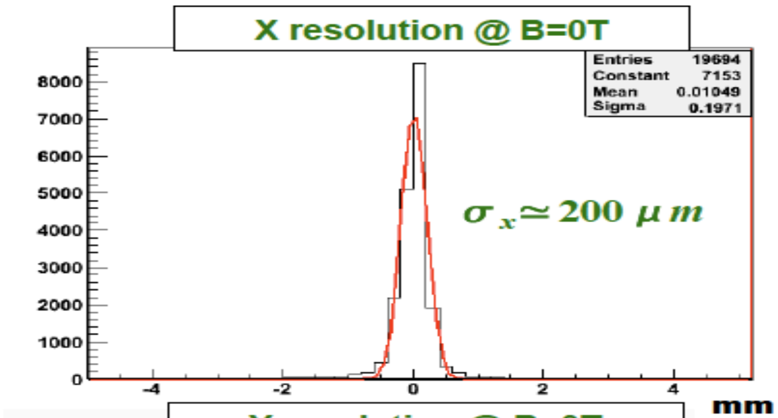
TOTAL POWER CONSUMPTION for the 30000 chs ~ 200 W

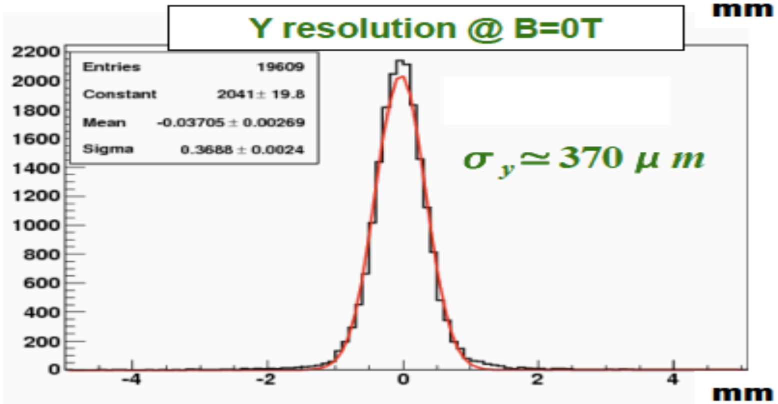
IT Test Beam in magnetic field



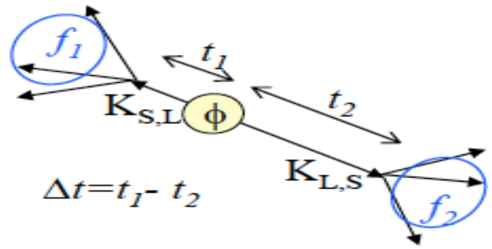
- H4 (RD51 facility) at CERN-SPS with 150 GeV pion
- The magnetic field was provided by GOLIATH dipole magnet up to 1.5 T in a volume of 3x1x1 m^3





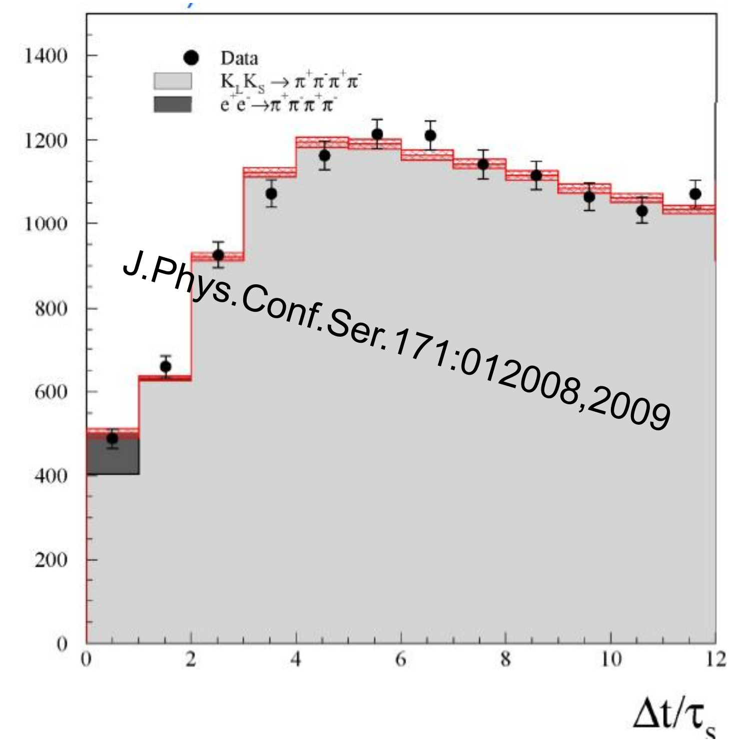


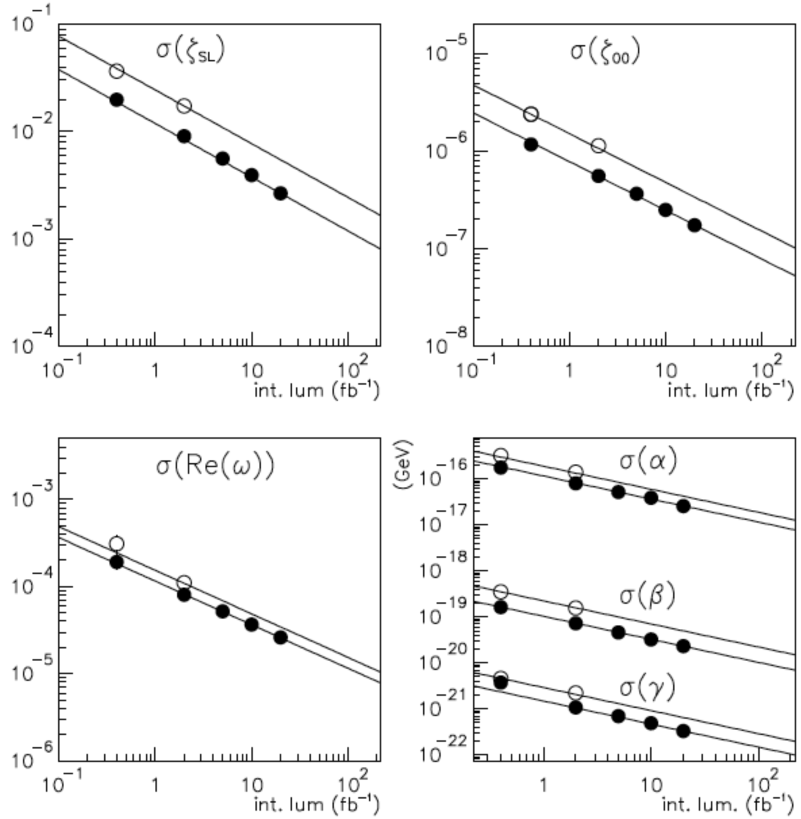
Physics item ..



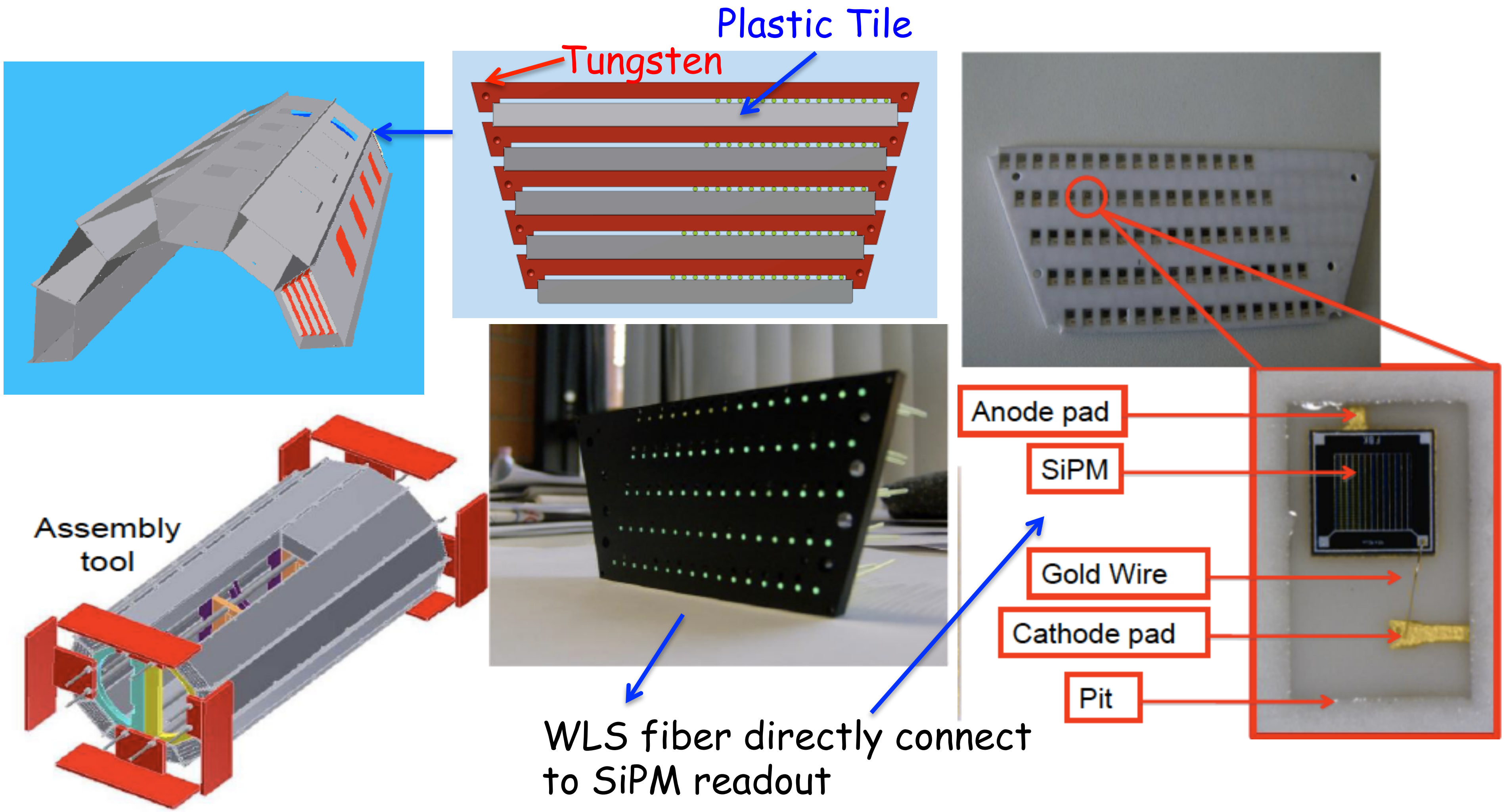
CPT and QM tests: $\phi \to K_S K_L \to \pi^+\pi^- \pi^+\pi^-$

$$I(\pi\pi,\pi\pi;|\Delta t|) \propto e^{-\Gamma_L|\Delta t|} + e^{-\Gamma_S|\Delta t|} - 2\cdot(1-\zeta_{00})\cdot e^{-(\Gamma_S+\Gamma_L)|\Delta t|/2}\cos(\Delta m|\Delta t|)$$



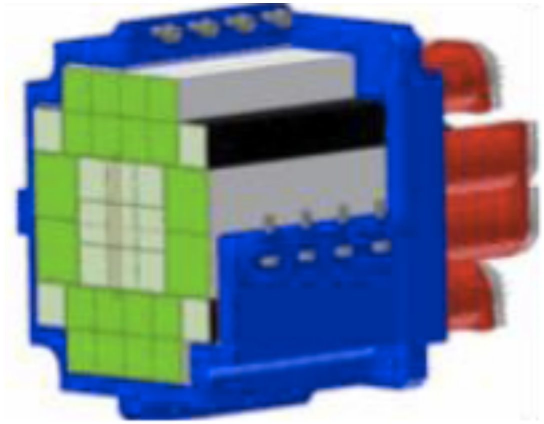


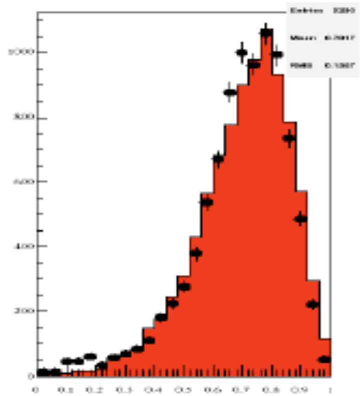
QCALT Characteristics



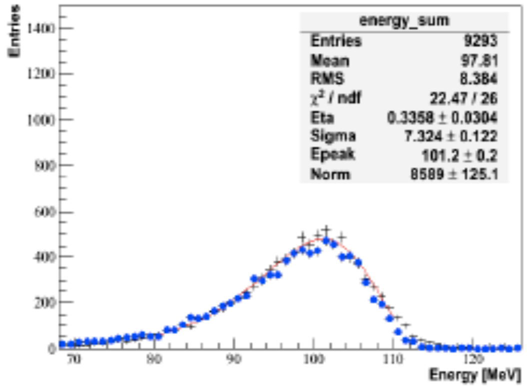
Common effort with CCALT and MAMI Best Beam

A crystal matrix prototype as been built and test at MAMI-A2 photon beam which provide a 1.5 GeV photon beam with an energy resolution of the order ~ 1 % (FWHM) and a rate of 10^8 γ/s

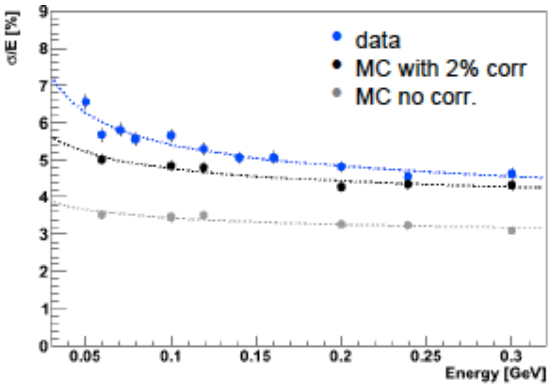


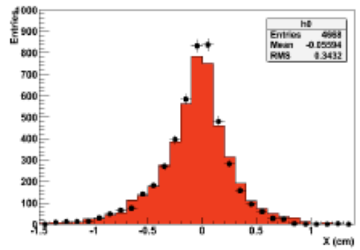


Energy deposited in the central tower Data-MC

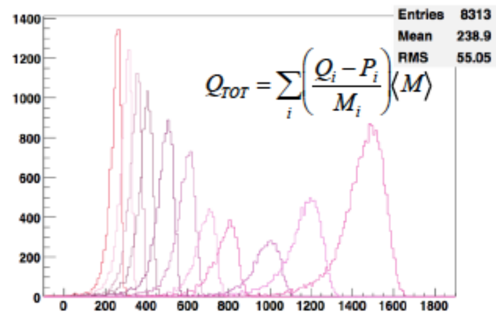


Energy sum Data-MC





Position resolution
~3mm

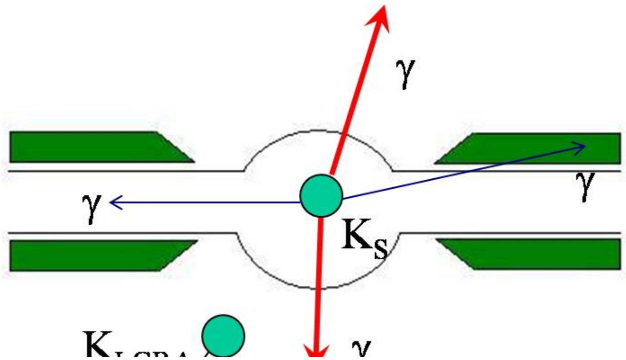


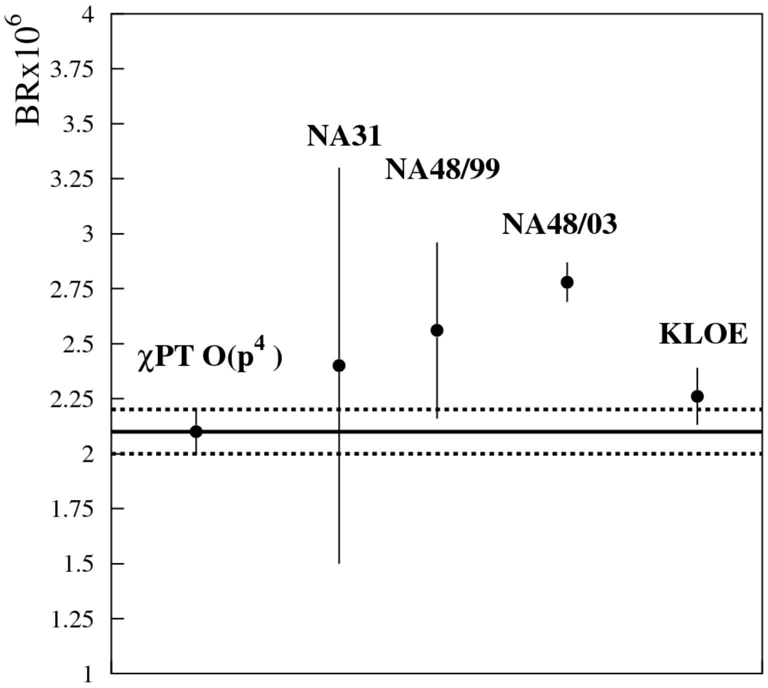
Energy
scan

Physics item … K_S decays

- $K_S \to \gamma\gamma$: χPT test ($\mathcal{O}(p^4)$)
- KLOE: (1.9 pb^{-1}) 2 prompt γ, with E >7 MeV and ϑ>21°
- Main bckg: $K_S \to \pi^0\pi^0$ with 2 γ lost
  $Br(K_S \to \gamma\gamma) = (2.26 \pm 0.12 \pm 0.06) \times 10^{-7}$
- Agreement with χPT
- 3σ discrepancy between KLOE and NA48

- KLOE-2 with 20 fb^{-1} , QCALT + CCAL
  γ acceptance $\to$ 9°
  Factor ~ 3 in background reduction
  $\delta Br(K_S \to \gamma\gamma)$ ~ 3%





Conclusion

- The KLOE-2 new detector as been presented together with (some) their related physics item
- Data taking for step0 (~ 5 fb^{-1}) start next autumn
- During 2012 summer shutdown IT+QCALT+CCALT detector should be installed
- From 2013 step1 data taking for an integrated luminosity of ~ 15 fb^{-1} start