The KLOE-2 experiment

at DAΦNE upgraded in luminosity

Presented by

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On behalf of the KLOE-2 collaboration

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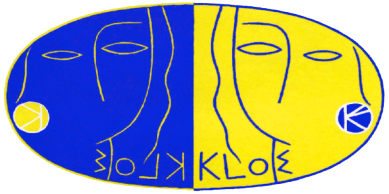
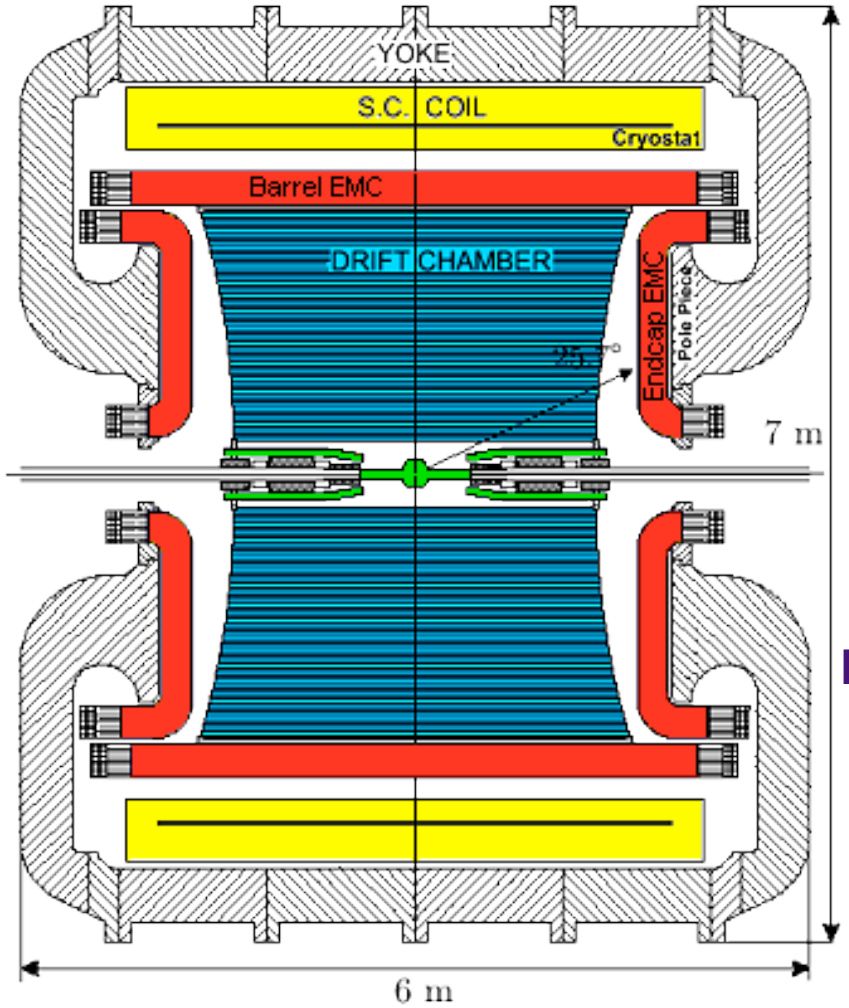


The old KLOE detector



The KLOE experiment collected an integrated luminosity of ~2.5 fb^{-1} at the DAΦNE collider at LNF.
It consists of a large volume drift chamber surrounded by an electromagnetic calorimeter and it operates in a magnetic field of 0.52T. The experiment achieved several precision results in:

Kaon physics: measurements of all significant branching ratios of K_S, K_L, K^+ , K^-.

Hadron physics: study of the properties of scalar and pseudoscalar mesons and measurement of the $e^+e^- \rightarrow \pi^+\pi^-$ cross section giving the main contribution to the error of muon anomaly.

KLOE-2 physics programme

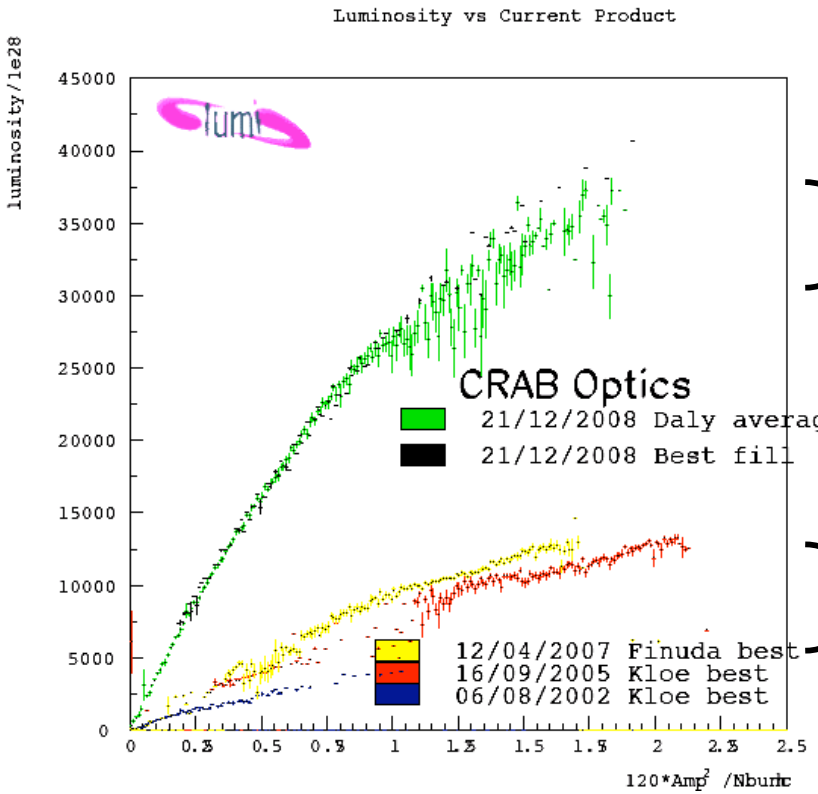
The programme, discussed in arXiv:1003.3868 (to be published by EPJC) includes the improvement of several KLOE measurements and

- the study of $\gamma\gamma$ physics based on a sample tagged by a new system for the detection of $e^{\pm}$ from the process $e^+e^- \rightarrow e^+e^- X$;
- the search for particles from a hidden sector which could explain the dark matter problem;
- precise measurements of the hadronic cross section near threshold and if the upgrade in energy of the collider is approved in the region from 1.02 GeV to 2.3 GeV.

- List of topics include:
  - CKM unitarity and lepton universality;
  - CPT symmetry and Quantum Mechanics;
  - Low-energy QCD;
  - Physics in the continuum: hadronic cross section;
  - Physics in the continuum: $\gamma\gamma$ processes;
  - Hidden WIMP dark matter.

DAΦNE upgrade

- A new collision scheme worked out with:
  - large crossing angle;
  - reduced beam size at the crossing point;
  - sextupole pairs for crab-waist configuration of beam interaction.



SIDDHARTA Run (2008/09)

$L = 4.5 \times 10^{32}\ cm^{-2}s^{-1}$

KLOE run (2002/05)

Project status and planning

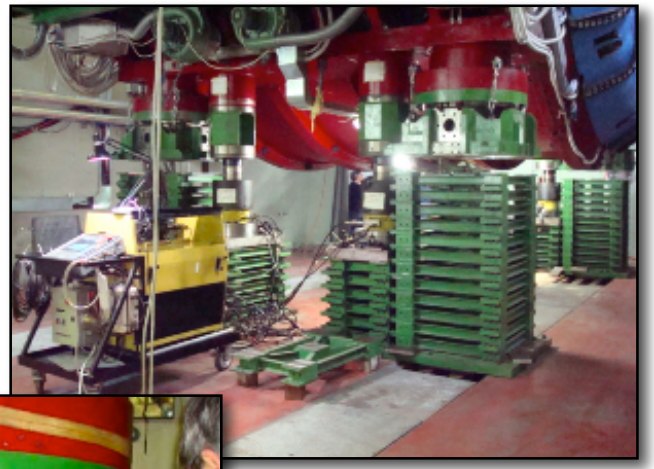
DAΦNE machine:

- The machine commissioning starts by the end of June;
- Three-months period scheduled for major tuning of the operation;
- Upgrade of the LINAC by the end of 2010.

KLOE detector:

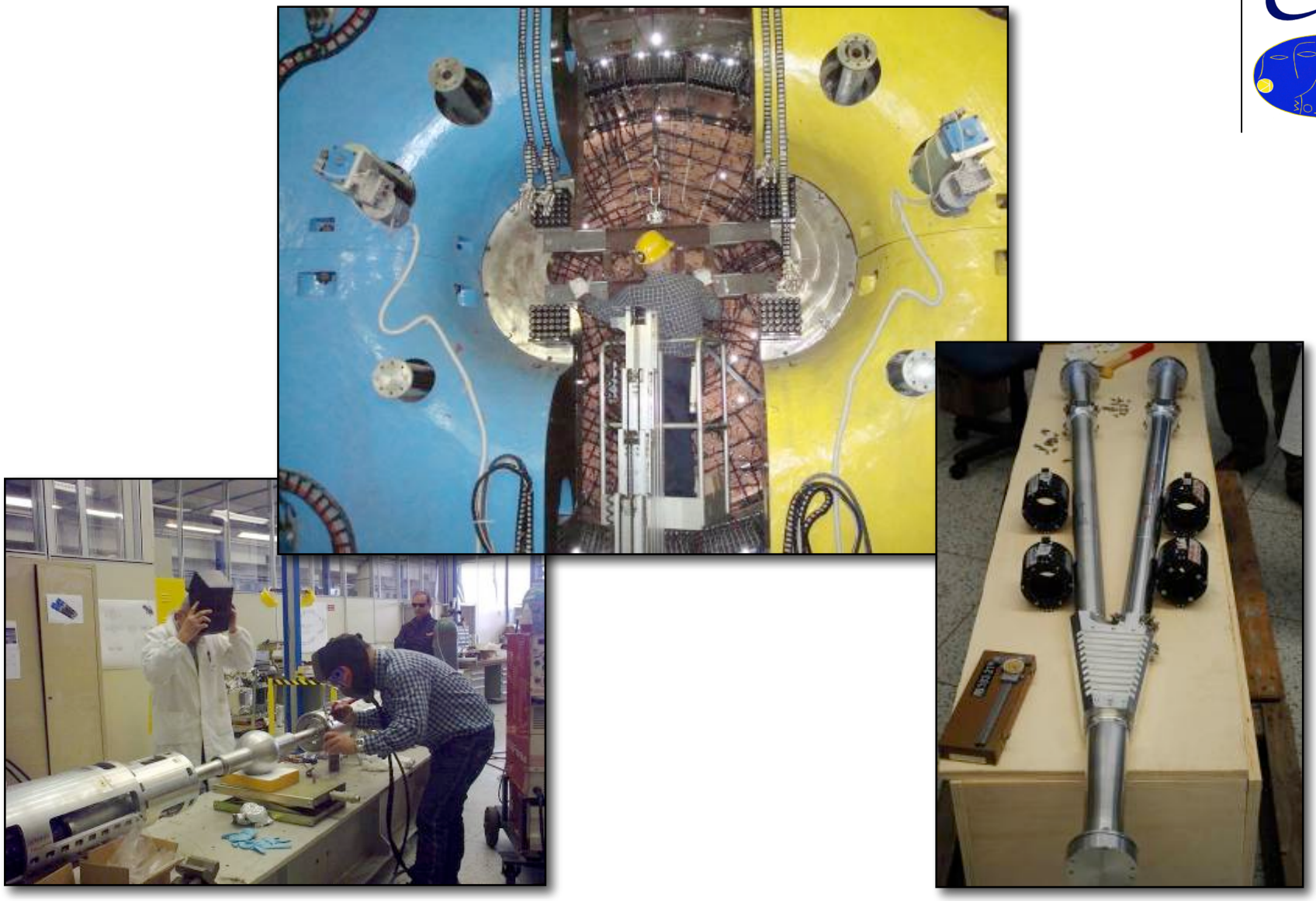
- STEP0: Lepton tagging system for $\gamma\gamma$ physics:
  - High Energy Tagger (HET);
  - Low Energy Tagger (LET);
- STEP1: 3 new detectors inside KLOE:
  - Inner Tracker (IT);
  - 2 new calorimeters: QCALT, CCALT.

KLOE rolled in successfully



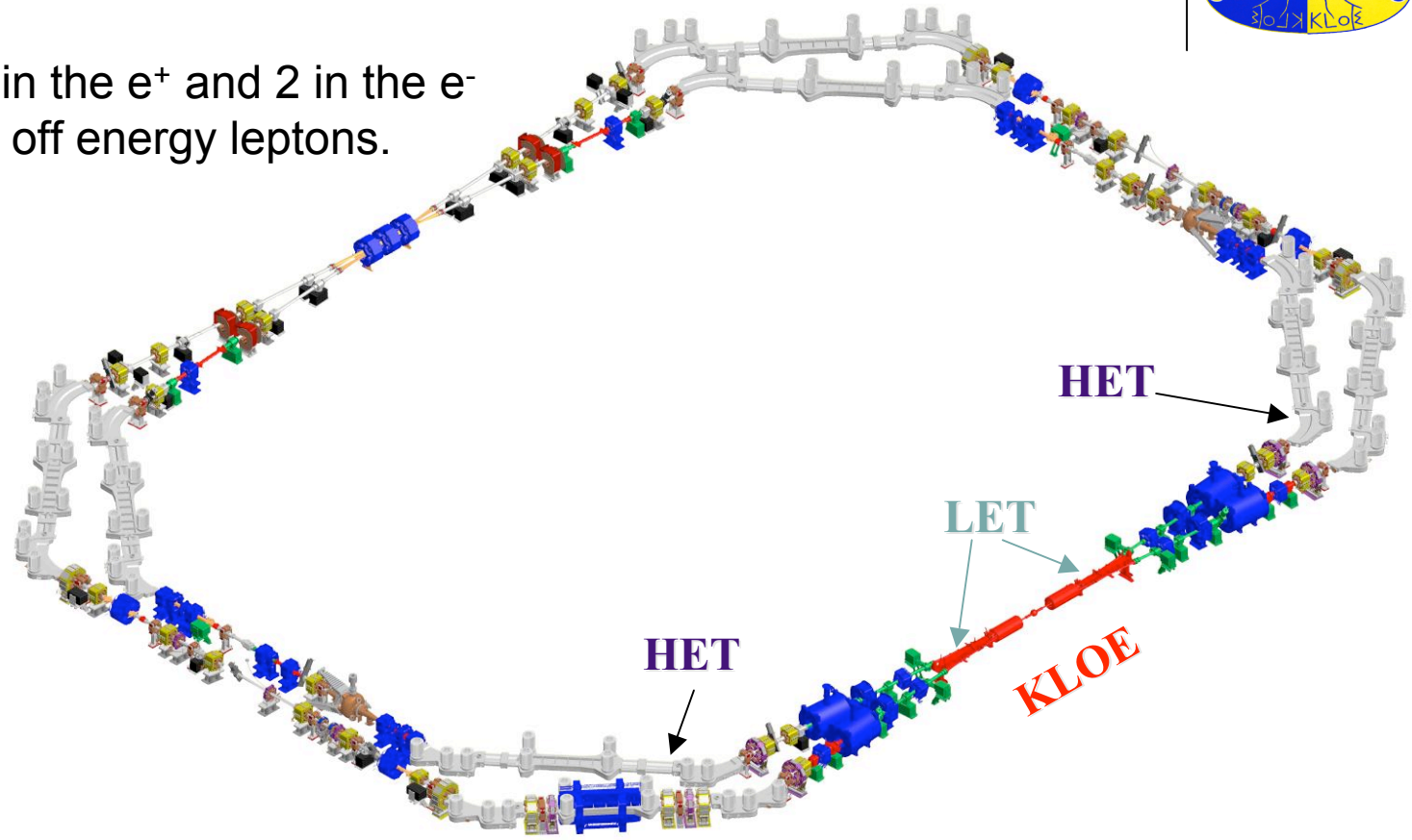
Detector closed and ready for data taking!!

New beam pipe installed!



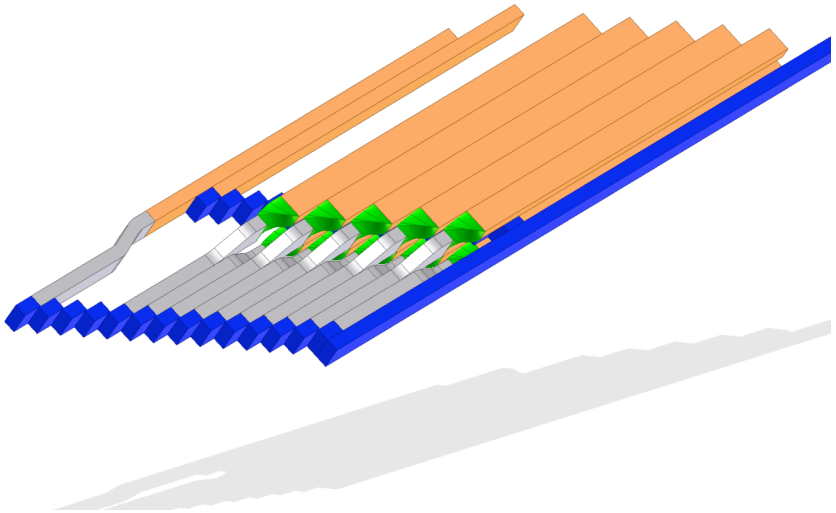
The electron tagging system

4 new detectors, 2 in the e^+ and 2 in the e^- arm, for measuring off energy leptons.



Technical Design Report of the $\gamma\gamma$ tagger system for the KLOE-2 experiment - **LNF:10-14(P)**

The HET and the LET detectors

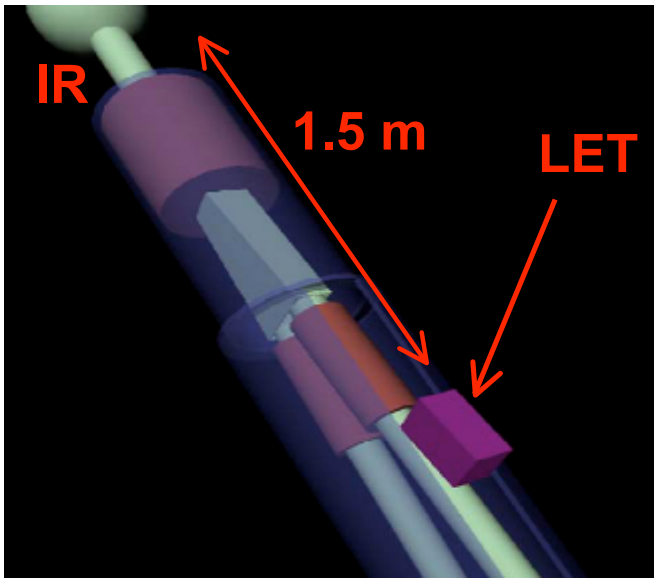


The **HET** is a position detector made of:

- Fast plastic scintillators;
- Clear light guides;
- Photomultipliers.

The **LET** is a calorimeter composed of:

LYSO crystal matrix with SiPM readout

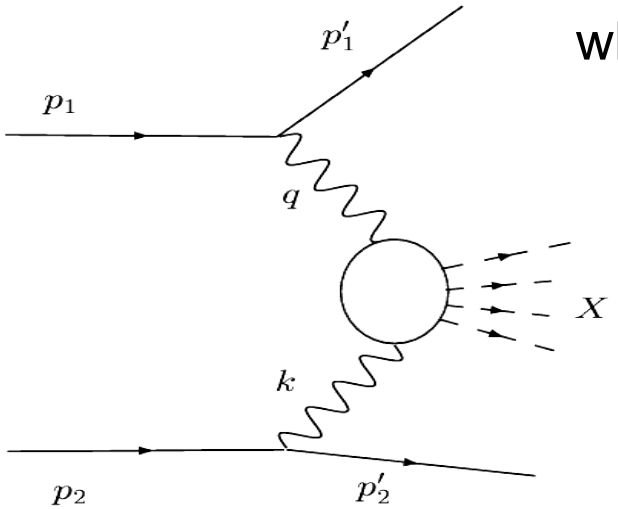


130-230 MeV/c e^+ or e^- tagged in this position.

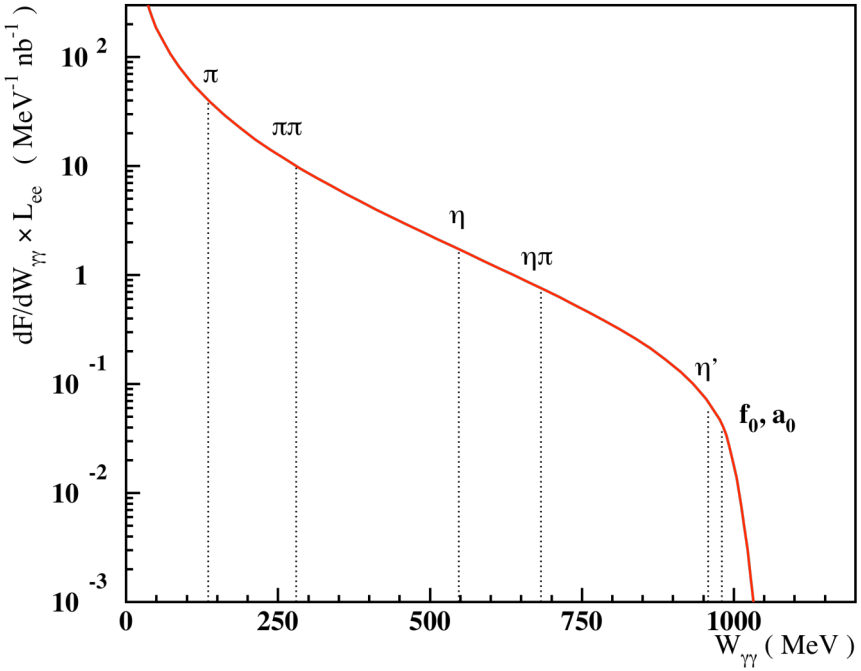
γγ physics

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

where $X = \{ \pi\pi, \pi^0, \eta \}$



$$\frac{dN_X}{dW_{\gamma\gamma}} = L_{ee} \frac{dL}{dW_{\gamma\gamma}} \sigma(\gamma\gamma \rightarrow X)$$



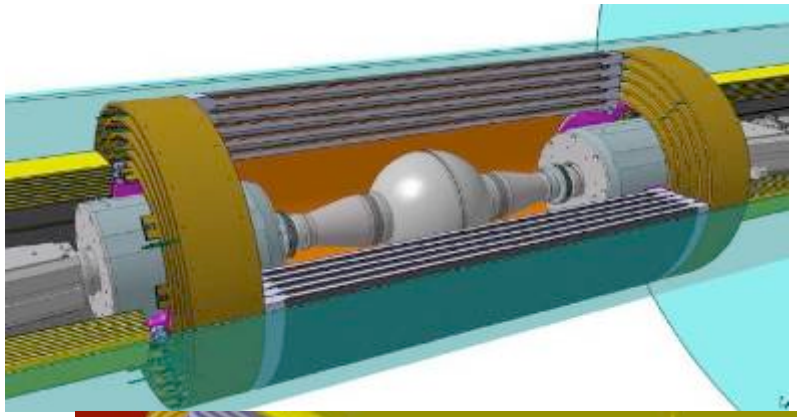
- $J^{PC}(X) = 0^{\pm+}, 2^{\pm+}$
  ($J^{PC} = 1^{--}$ for single γ case)
- $\sigma \propto \alpha^4 \ln^2(s)$
  (α^2/s for single γ case)
- Similar to bremsstrahlung
  $N_X \propto 1/E\gamma \rightarrow$ low M_X

KLOE detector upgrade

Major detector upgrades (late 2011) for second KLOE-2 run:

INNER TRACKER

- 4 layers of cylindrical triple GEM;
- Better vertex reconstruction near IP;
- Larger acceptance for low p_t tracks.

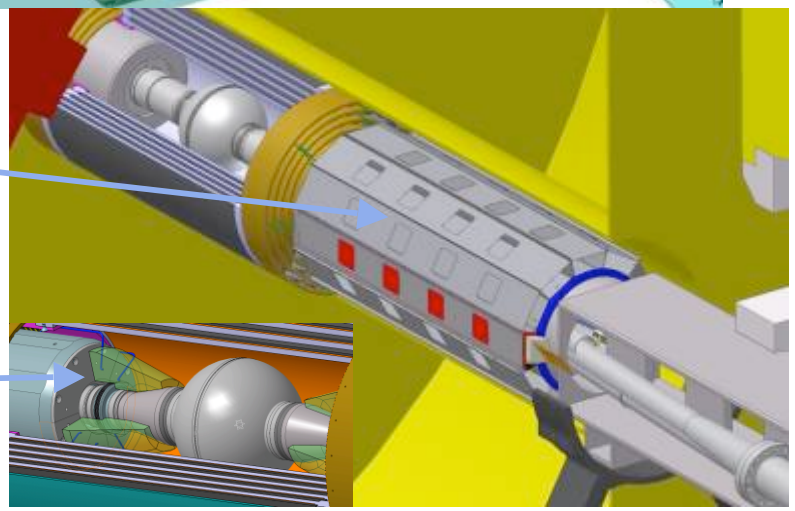


QCALT

- W + scintillator tiles + SiPM/WLS
- QUADS instrumentation for K_L decays

CCALT

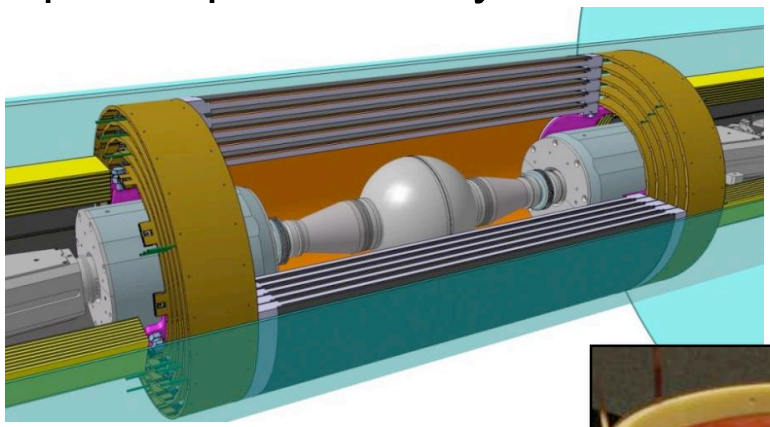
- LYSO + APD
- Increase acceptance for γ's from IP (21°→8°)



The Inner Tracker

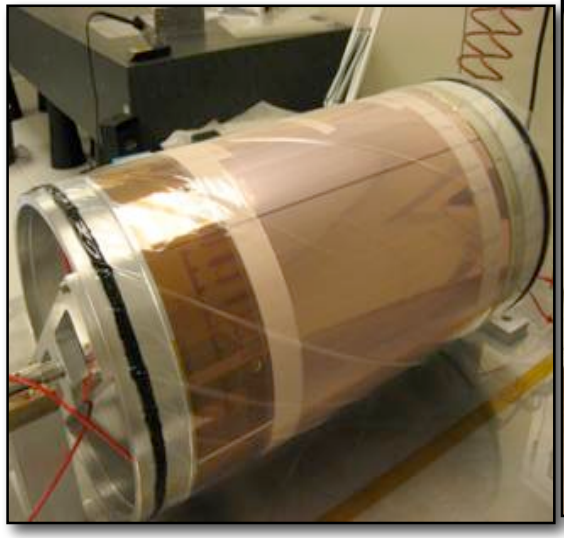
For fine vertex reconstruction of K_s , η and η' rare decays and K_s- K_L interference measurements:

- $\sigma_{r\varphi}$ ~ 200 μm and σ_z ~ 500μm;
- low material budget:<2%X_0
- 5 kHz/cm^2 rate capability.



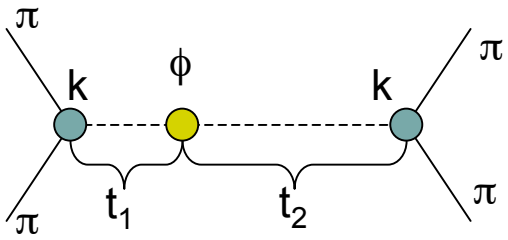
Cylindrical GEM detector

- 4 CGEM layers with radii from 13 to 23 cm from IP and before DC Inner Wall;
- 700 mm active length;
- XV strips-pads readout (40° stereo angle);
- 1.5% X_0 total radiation length in the active region with Carbon Fiber supports.



Technical Design Report of the Inner Tracker for the KLOE-2 experiment - **arXiv:1002.2572**

Kaon interferometry



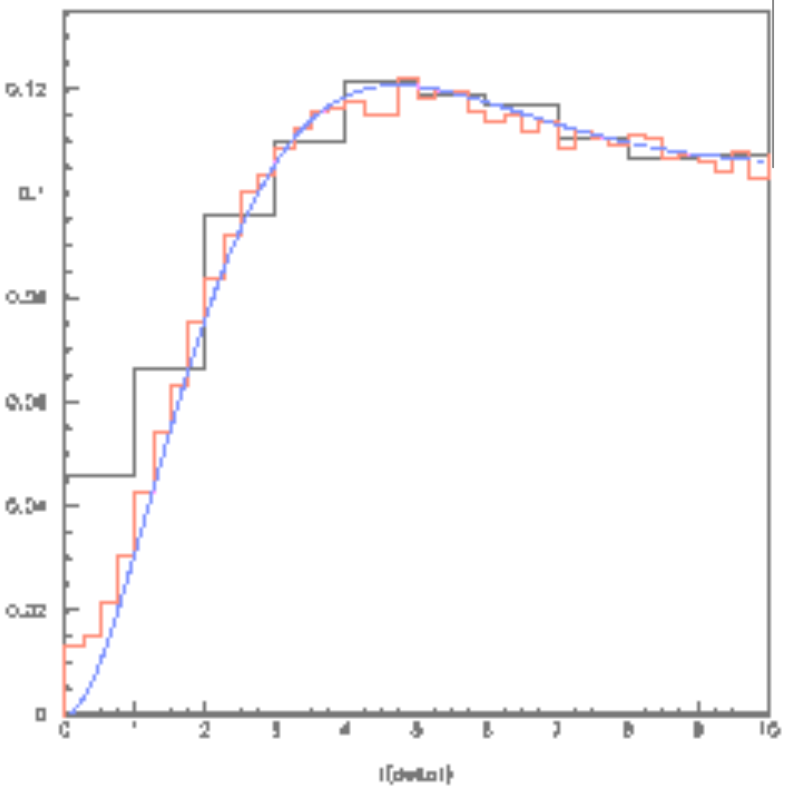
$$I(\pi^+\pi^-,\pi^+\pi^-;\Delta t) \propto$$

$$\propto [e^{-\Gamma_L \Delta t} + e^{-\Gamma_S \Delta t} +$$

$$-2(1-\zeta_{SL})e^{-(\zeta_S+\zeta_L)\frac{\Delta t}{2}} \cos(\Delta m \Delta t)]$$

ζ_{SL} = 0 Q.M.
ζ_{SL} = 0.003 ± 0.018 ± 0.006
Experimental sensitivity improved by a factor ~ 2 using the Inner Tracker.

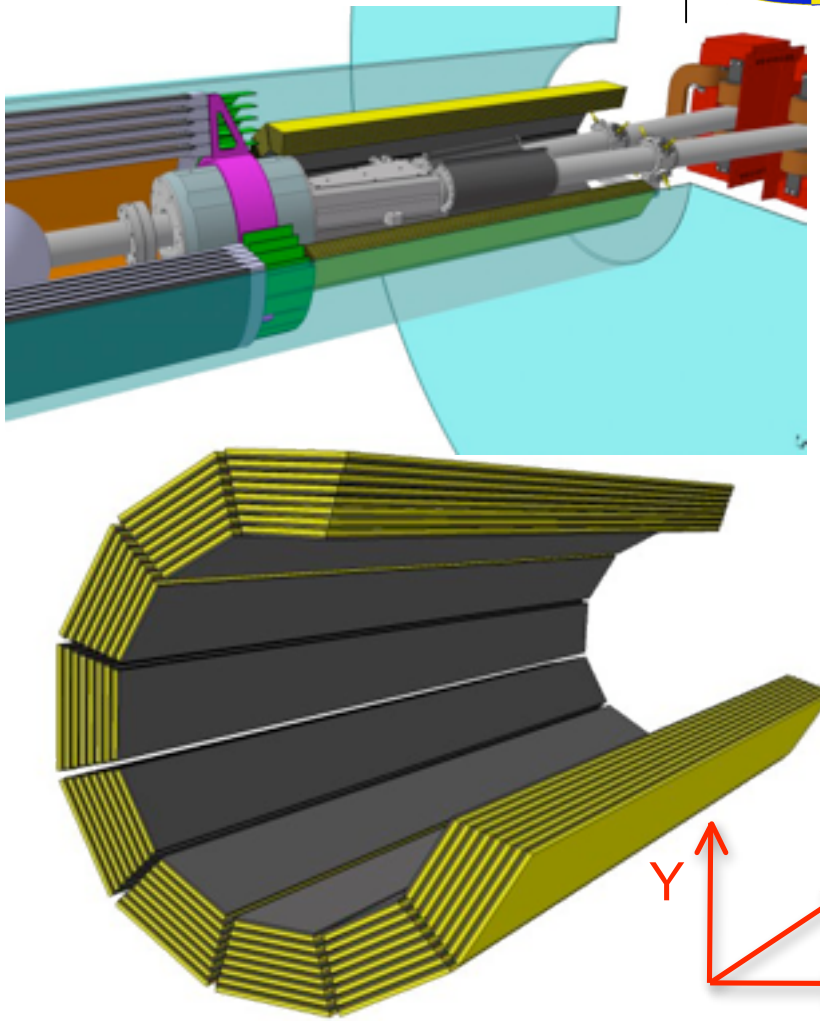
A. Di Domenico and KLOE Coll. J. Phys. Conf. Ser., 171, 012008, 2009



The I ($\pi^+ \pi^-$, $\pi^+\pi^-$; $|\Delta t|$) distribution as function of $|\Delta t|$ with the present KLOE resolution $\sigma_{|\Delta t|} \approx \tau S$ (wide bins), with $\sigma_{|\Delta t|} \sim 0.3\tau S$ (narrow bins) and the ideal case (blue line).

The QCALT calorimeter

- Two tile calorimeters + Wavelength Shifter + SiPM readout around the new QUADs (2 times light yield, faster green fibers, 10 times improvements σ_z w.r.t old QCAL)
- Dodecagonal structure (1 m length)
- 5 layers of W (**3.5mm**) + tiles (**5mm**) + air gap (**1mm**) for a total of **5.5 X_0** (**4.75cm** depth)
- 20 cells/layer (100 SIPM/module) for a total of 2400 readout channels;
- Located after the Inner Tracker;
- Granularity of 5x5÷5x7.7 cm^2 tiles;
- Fast timing resolution (< 1 ns) .

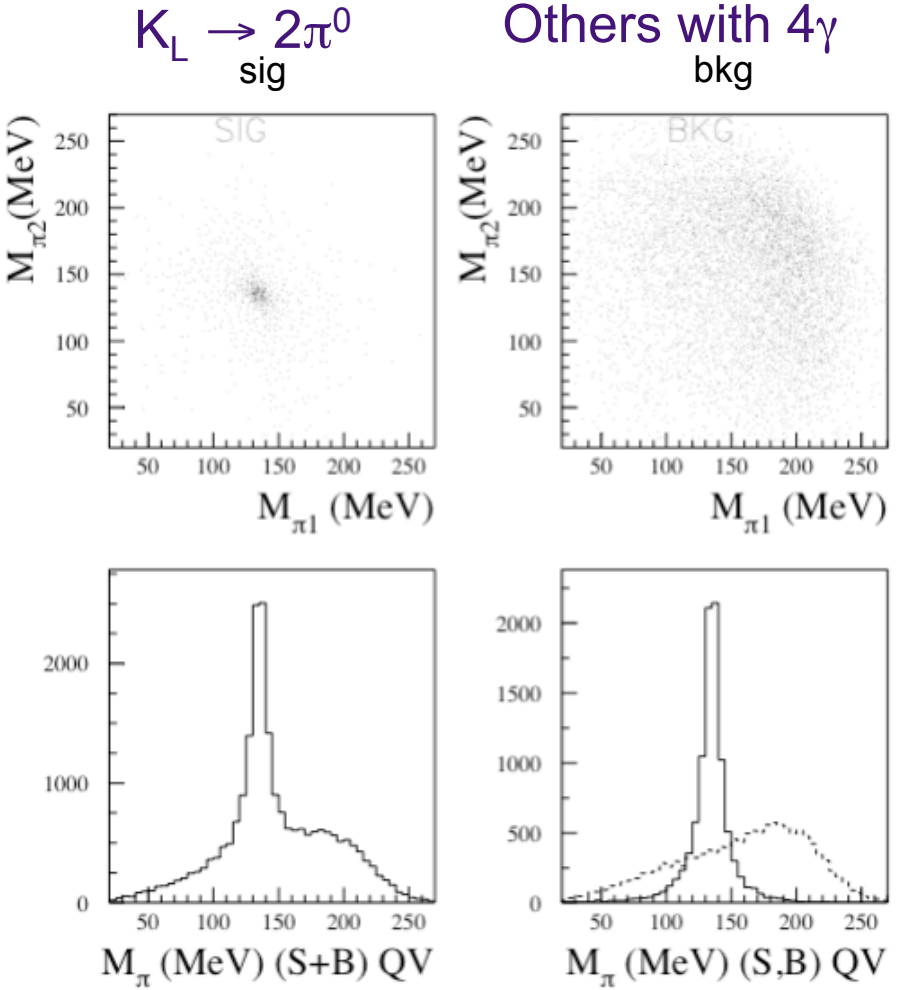


QCALT physics: $K_L \rightarrow 2\pi^0$

- KLOE has been designed to study the CP violation into the KKbar system through Re(ε'/ε) measurement.
- To reduce systematic errors we measure the double ratio:

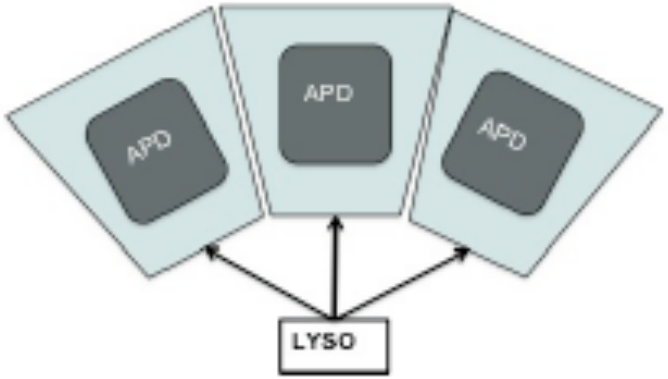
$$R = \frac{BR(K_L \rightarrow \pi^+\pi^-)/BR(K_L \rightarrow \pi^0\pi^0)}{BR(K_S \rightarrow \pi^+\pi^-)/BR(K_S \rightarrow \pi^0\pi^0)}$$

- The most important bg source in this measurement is $K_L \rightarrow 3\pi^0$;
- QCAL works well on rejecting background losing 1% of signal;
- **QCALT will increase the detection efficiency** and the high granularity will help on **reducing accidental losses**.

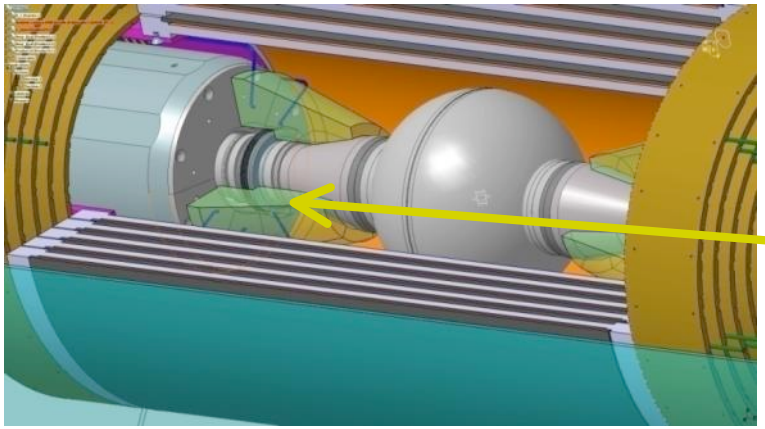


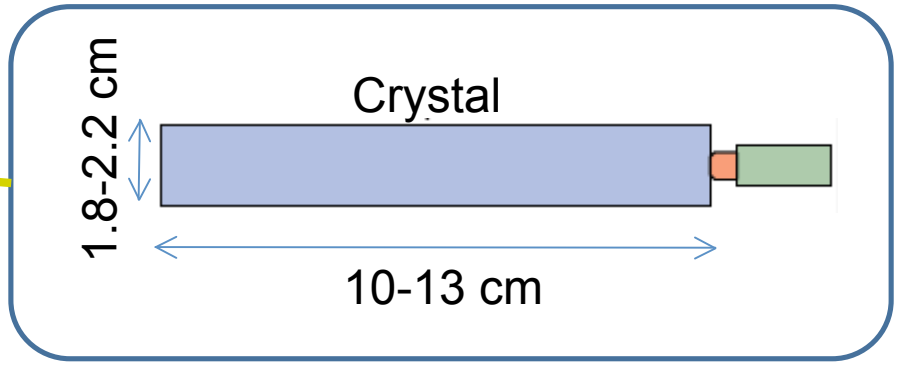
The CCALT calorimeter

Dodecagonal Barrel



2 small barrels of 24 crystals each, with a length of 10-13 cm and transversal area from 1.5x1.5 cm^2 to 2x2 cm^2

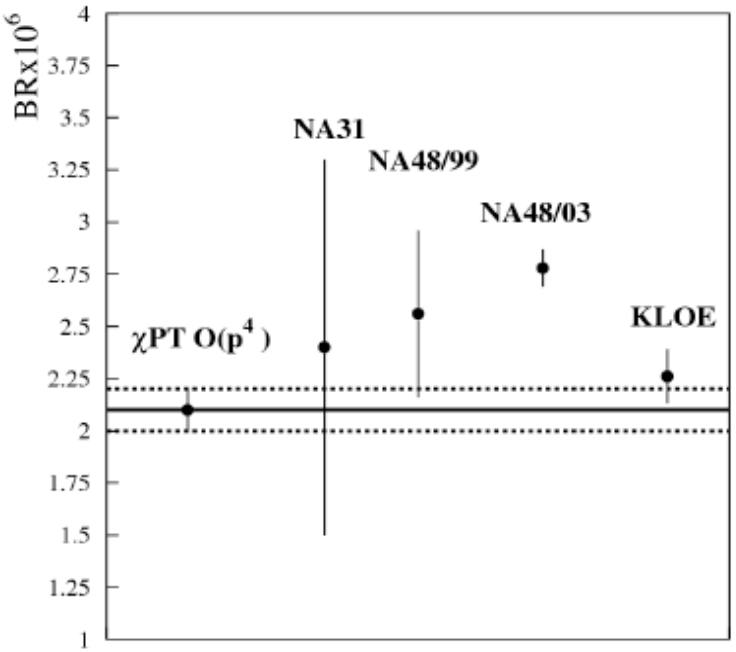




CCALT Physics: Ks →γγ

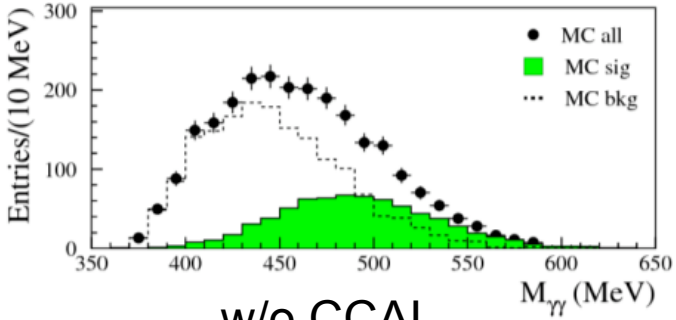
Last KLOE measurement on BR(Ks →γγ) (JHEP 0805:051,2008) differs by 3σ from NA48. A more precise measure is needed!

KLOE put a limits to O(p^6) prediction of ChPT.

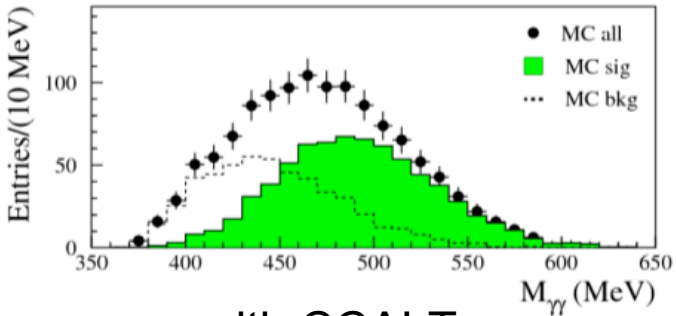


Major bkg:
Ks →π⁰π⁰
with 2 photons lost.
(beam pipe or QCAL inefficiency)

Ks →γγ **Ks →π⁰π⁰**



w/o CCAL



with CCALT

KLOE EMC covers down to 21°,
with the CCALT extension down to 8°!

Conclusions

- New **beampipe** ready and installed;
- The **KLOE** detector is up and running;
- **Magnet** has been switched ON;
- Electron tagging system:
  - **LET**: tested and installed;
  - **HET**: mechanics installed, detector on his way.;
- Work is in progress for detector upgrades (IT, QCALT and CCALT);
- DAΦNE commissioning is starting;
- DAΦNE High Energy Proposal.

Thanks for your attention.