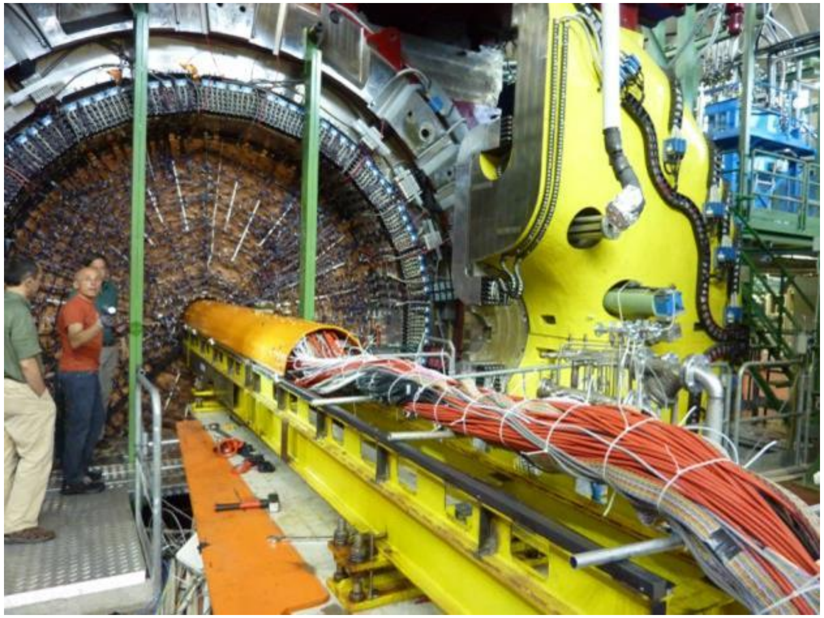
The KLOE-2 Experiment at DAΦNE



A.Passeri on behalf of the KLOE-2 Collaboration

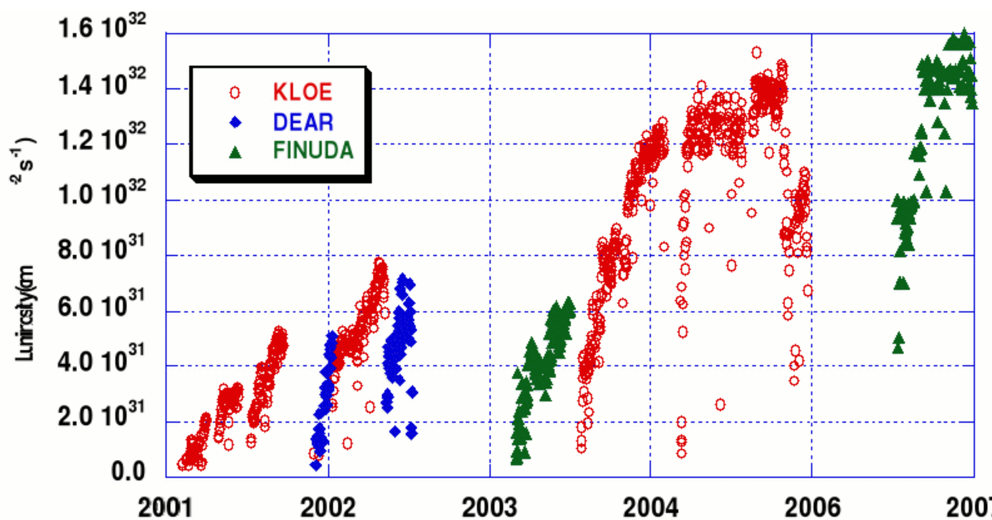
KAON 2016 Conference – September 14-17 - University of Birmingham

The DAΦNE phi-factory

DAΦNE has first worked in 2000-2007 at Frascati National Labs of INFN

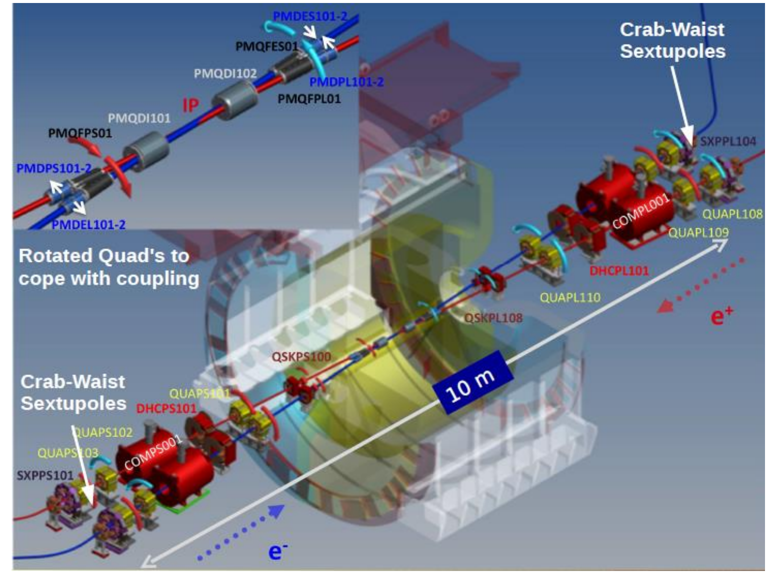
$\sqrt{s}$ = 1020 MeV
TRF = 2.7 ns, up to 120 bunches
15 mrad crossing angle
Topping-up injection

Max peak lumi: $1.6\ 10^{32}$ cm^{-1}s^{-1}
Best daily int. lumi: ~10 pb^{-1}

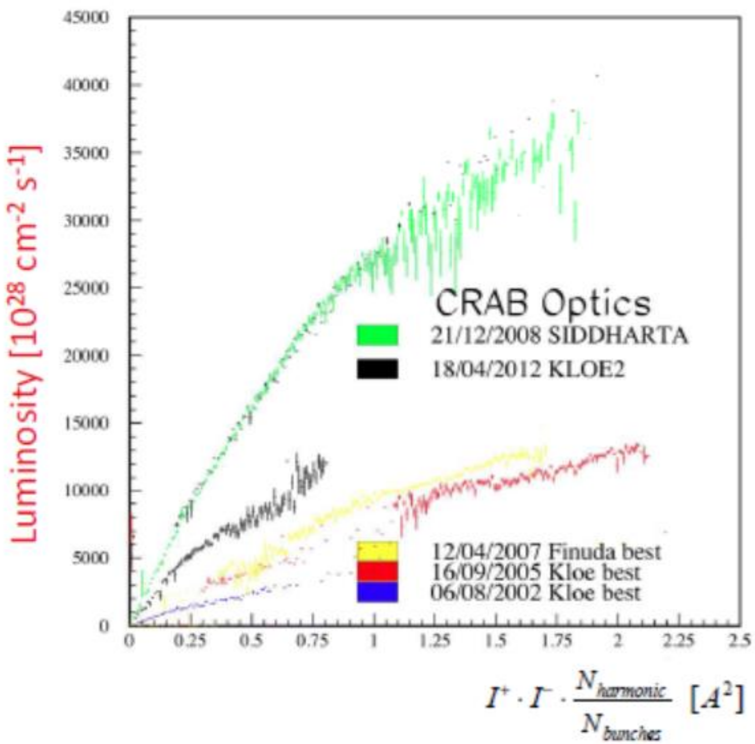


DAΦNE upgrade

Crab waist scheme, proposed by P.Raimondi, requires beam crossing at larger angle (50 mrad) and a sextupole correction stage to grant a factor of 3 higher luminosity.



Crab waist implemented in DAΦNE in 2008, with a complete redesign of IR.



The upgrade was successfully tested in 2008 with the Siddharta experiment.

Insertion of KLOE and its 0.5 T solenoid required specific tuning of the optics and a careful control of the backgrounds.
Still the crab-waist scheme provides a significant luminosity gain.

DAΦNE run with KLOE-2

After upgrade of several accelerator components, DAΦNE started a stable run with KLOE-2 in novembre 2014, delivering up to now 3.0 fb^{-1} (2.4 acquired)

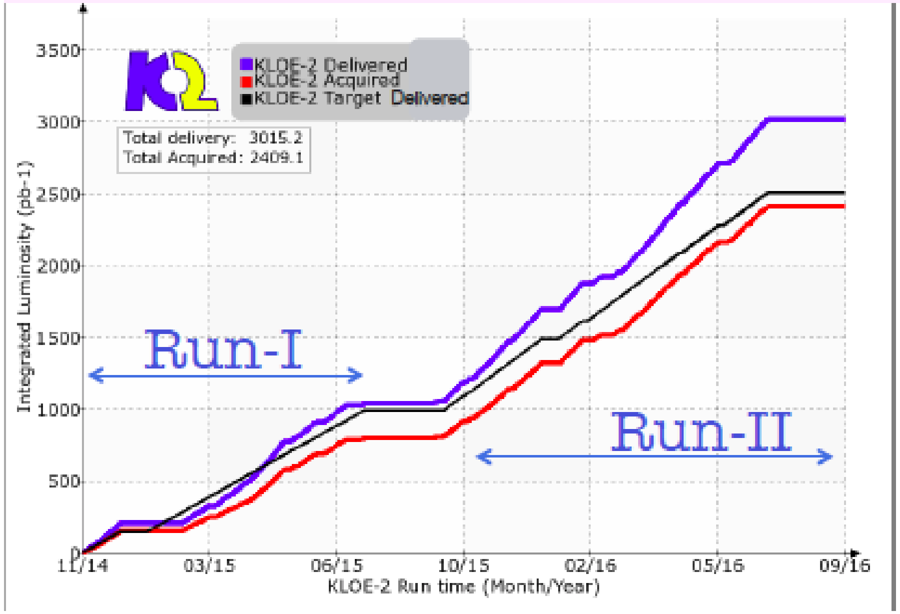
Peak Luminosity: 2.2 x 10^{32} cm^{-2} s^{-1}

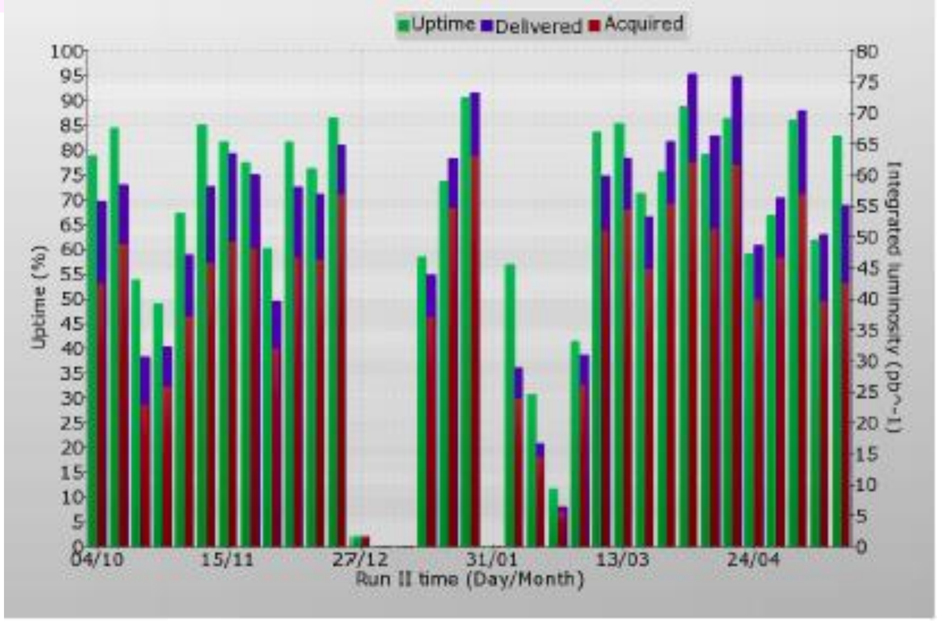
Best daily delivered integrated lumi: 13 pb^{-1} (11 acquired)

Average up-time : 80%

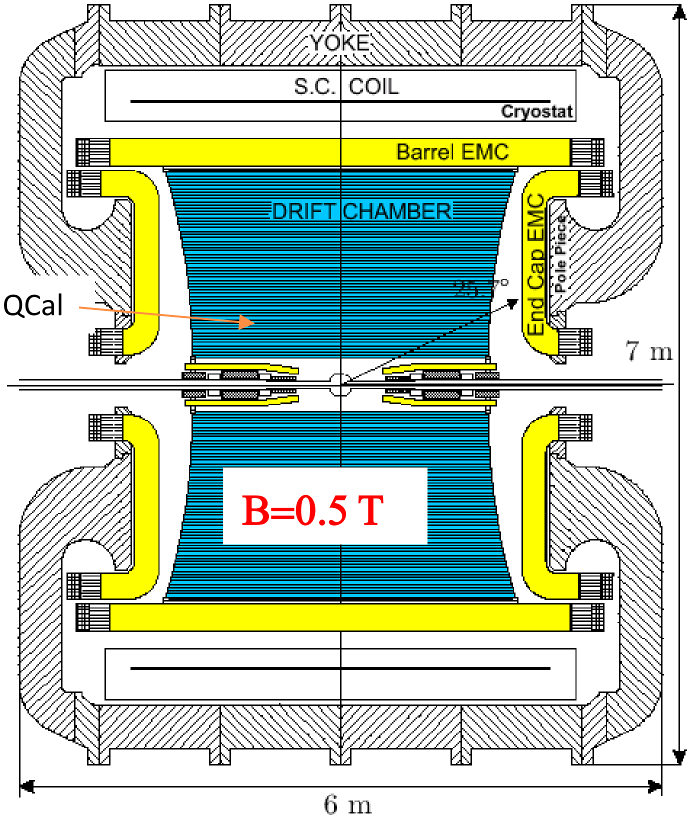
Expect to deliver another 3fb^{-1} by end of 2017.

Still room for improvement





The KLOE-1 detector



Large volume Drift Chamber (13K cells, He gas mixt.) :

4m-∅, 3.75m-length, all-stereo

$\sigma_p/p = 0.4\ \%$ (tracks with $\theta > 45°$)

$\sigma_x^{hit} = 150\ \mu m$ (xy), 2 mm (z)

σ_x^{vertex} ~1 mm $\sigma_{M\pi\pi}$ ~ 1 MeV

Pb-SciFi Calorimeter (barrel + endcap, 15 X_0 depth, 98% solid angle coverage) :

$\sigma_E/E = 5.7\% / \sqrt{E(GeV)}$

$\sigma_T = 54\ ps / \sqrt{E(GeV)} \oplus 50\ ps$

- PID capabilities mostly from TOF

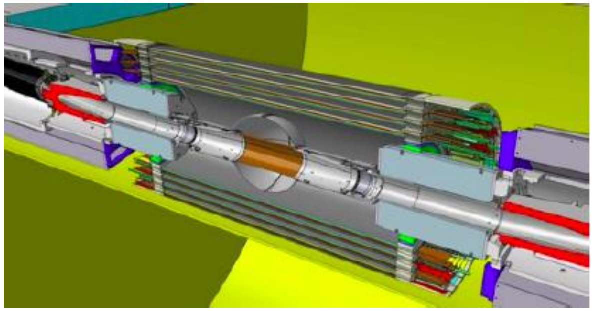
Interaction region:
Instrument quadrupoles,
Al-Be spherical beam pipe

KLOE upgrade philosophy

Improve vertex and tracking close to IP:

KLOE-1 had no detector between the beam pipe and the DC to avoid regeneration.

Vertex efficiency and resolution can gain a lot from few more tracking points with ~200 μm resolution, very low material budget and high rate tolerance.



Add γγ events tagging stations:

γγ events cannot be distinguished from the dominant ϕ decay with same signature (KLOE-1 studied them only off-peak).

Coincidence with tagged scattered electrons will kill the ϕ background

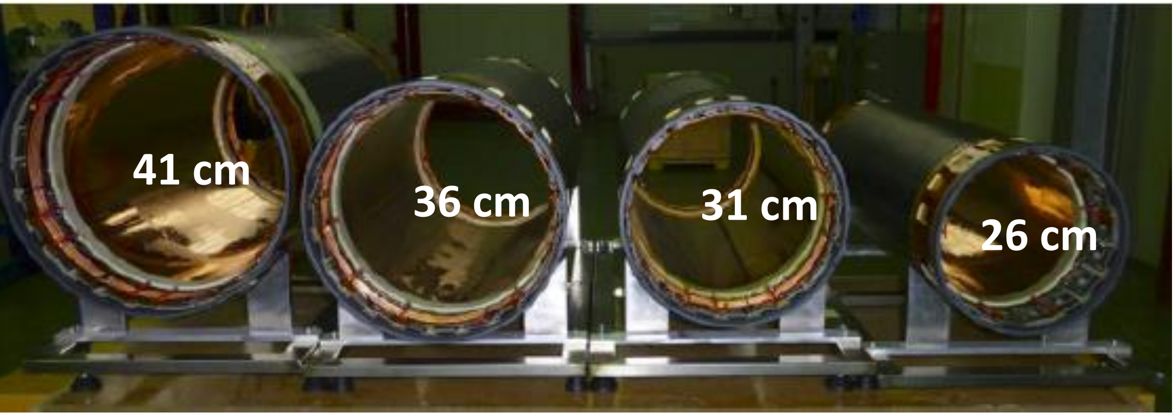
Provide photon veto and energy measurement at low angle:

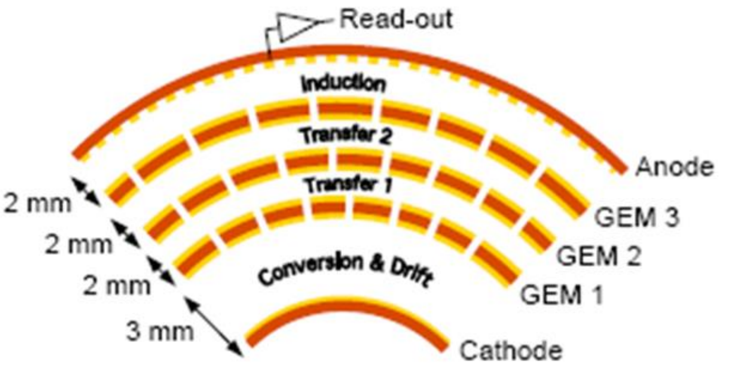
Photons escaping detection at low angle are one of the worst limiting factor both for rare decay search and for precision BR measurement.

The KLOE-2 Inner Tracker

The first cylindrical GEM detector ever built and operated:
4 coaxial layers of cylindrical triple GEMs
70 cm active length, 130-205 mm radia
X-V stereo readout
2% X_0 total material budget

- **Large GEM foils produced at CERN with single-mask technique.**
- **Wrapping and insertion technique developed at Frascati.**
- **1600 HV channels, to reduce energy of discharges.**
- **Operated with Ar-Iso 90-10% gas mixture at a nominal gain of 12000**
- **1k X-strips + 1M V-pads with <0.5% dead area**





Inner Tracker operation and reconstruction

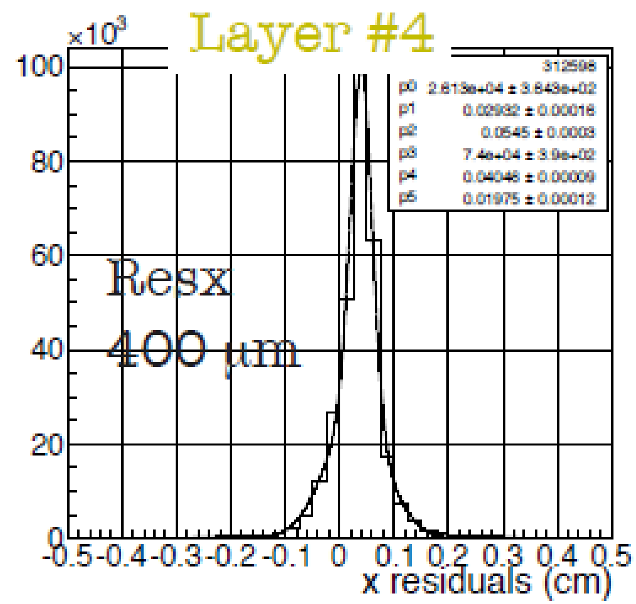
A dedicated cooling system was designed to compensate for 2 important heat sources: the on-detector FEE (100 W per side) and the Beam Pipe.
Temperature monitor in all detector zones is also provided.

IT is very sensitive to machine background, and to beam injections. HV distribution design is critical to minimize discharges. Controlled detector trip during injections has been implemented.

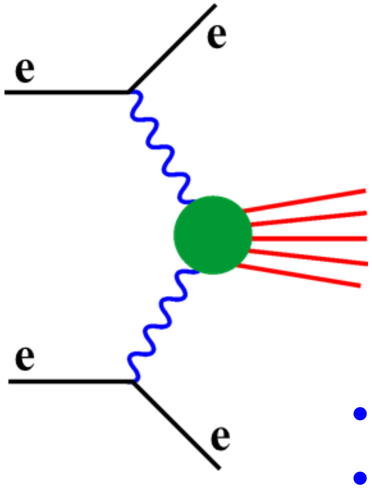
Tracking corrections are calculated from cosmic rays and Bhabha events to account for 2 effects :

- B field is perpendicular to C-GEM E field
- non-radial tracks

KLOE drift chamber used as reference.
Combined tracking and vertexing to be released soon



DC-IT tracks residuals in Bhabhas

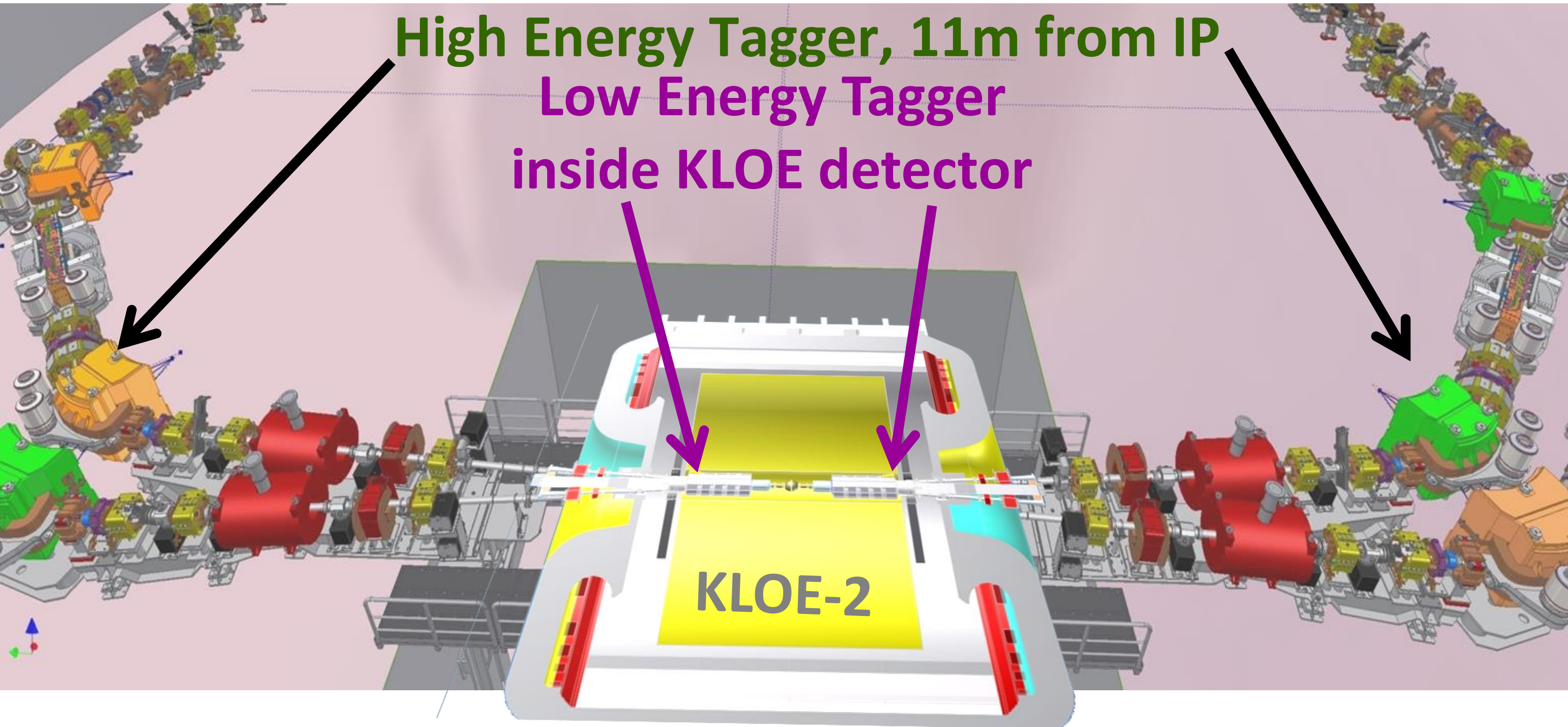


γγ taggers

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

inside KLOE-2
to Tagger

- Use DAFNE magnets as a spectrometer to select FS $e^{\pm}$ momentum
- Kill background coming from ϕ decays and close kinematics

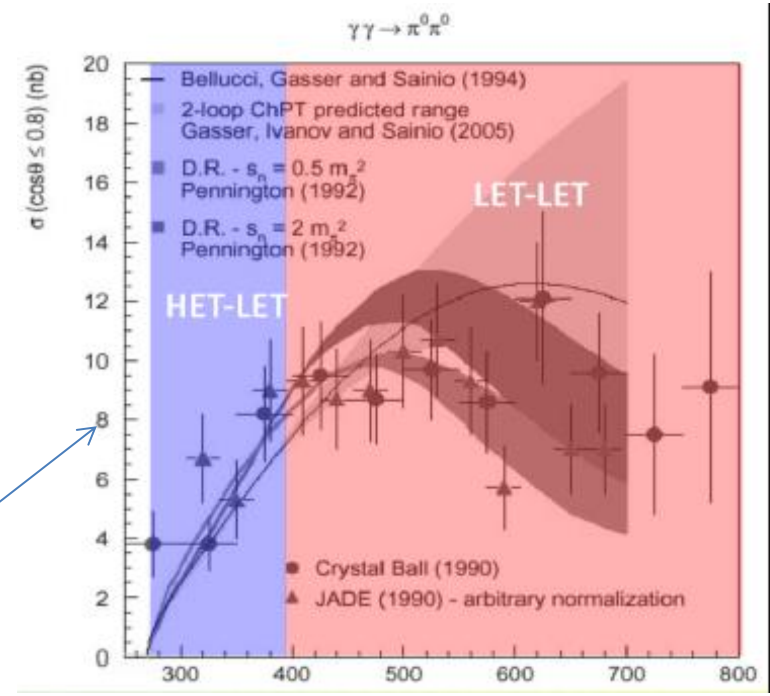


Low Energy Tagger (LET):

Energy range 150-400 MeV

- 2 stations at ±1 m from IP
- 20 LYSO crystals with SIPM readout
- $\sigma_E/E < 10\%$ for E>150 MeV

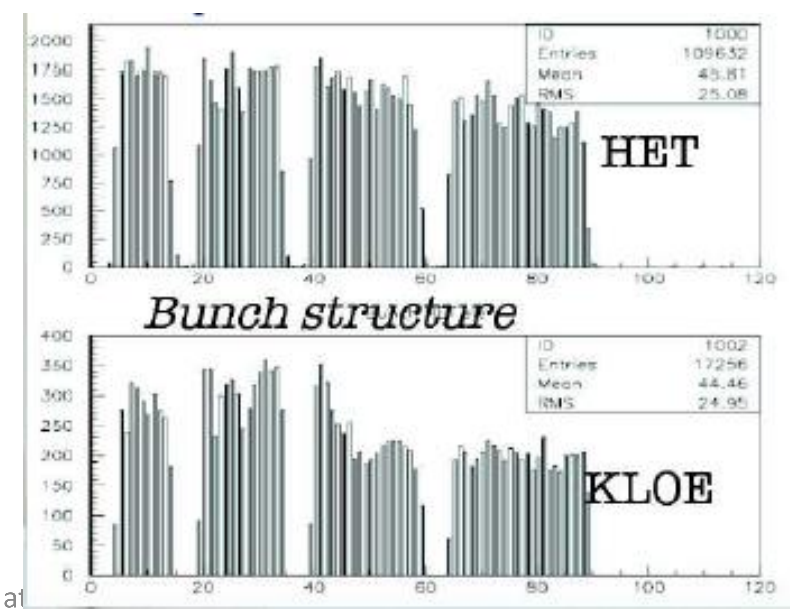
Search for 2 π^0 resonance profits of LET tagging



High Energy Tagger (HET):

Energy range > 400 MeV

- 2 stations after first dipoles
- Plastic scintillator hodoscopes with PMT readout
- Excellent time resolution to resolve RF structure and syncronize with KLOE trigger

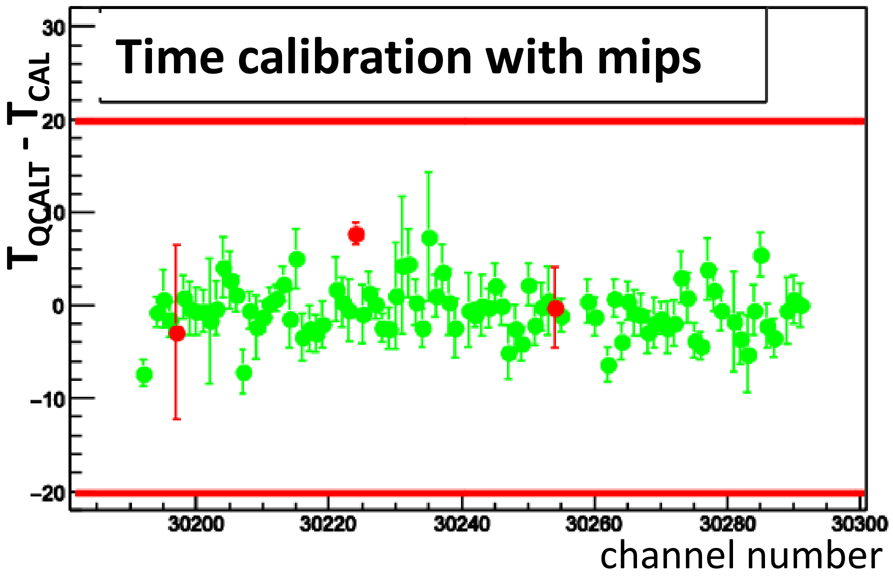


HET is essential to look for single π^0 production

QCALT: Quadrupole CALorimeter with Tiles

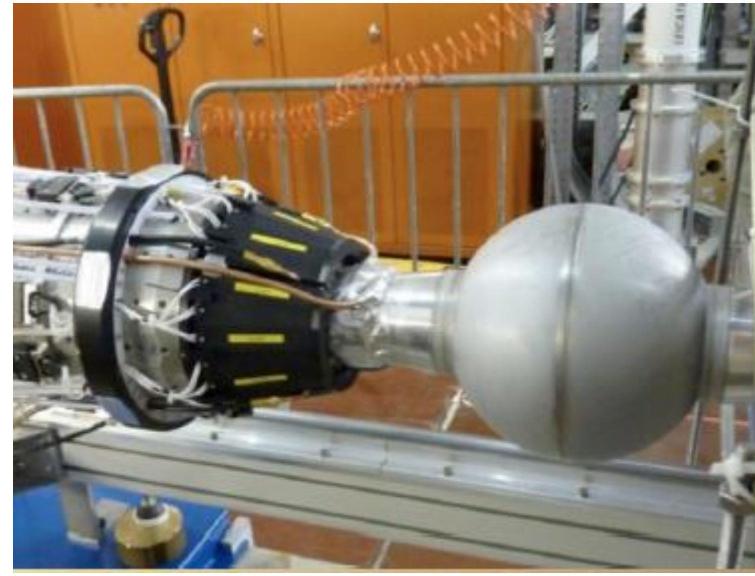
- 12 prism structures surronding the beam pipe
- Each prism filled by scintillator tiles and tugsten absorbers
- Tiles are individually readout with fibers and SiPM

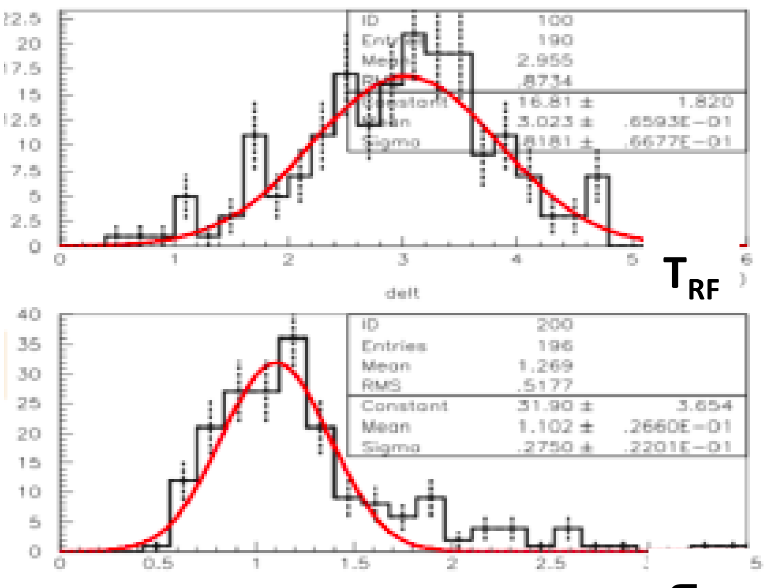
Close detector hermeticity at low angle
Specially aimed to catch photons from KL neutral decays
Provides time and shower profile measurement



CCALT: Crystal CALorimeter with Timing capabilities

- Specially shaped LYSO crystals
- SiPM light readout
- 48 crystals per side
- Extend photon acceptance down to 11^0
- Shared with DAFNE for fast luminosity monitoring





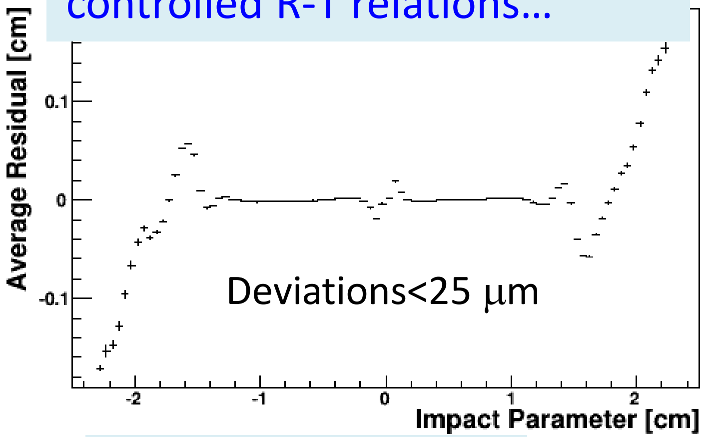
After time calibration with CR RF period well reconstructed with average 1 ns resolution

La vieille garde: KLOE drift chamber and calorimeter

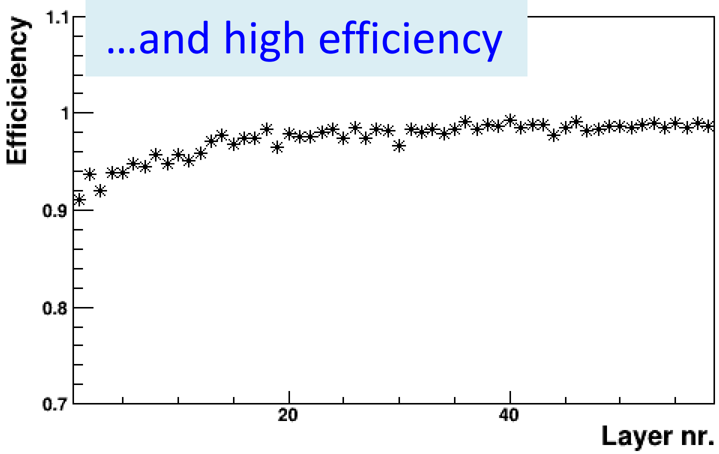
After 18 years of operation the old KLOE detector is still healthly and efficient

Old electronics requires careful babysitting and suffers from lack of spare components

DC smoothly working with well controlled R-T relations…

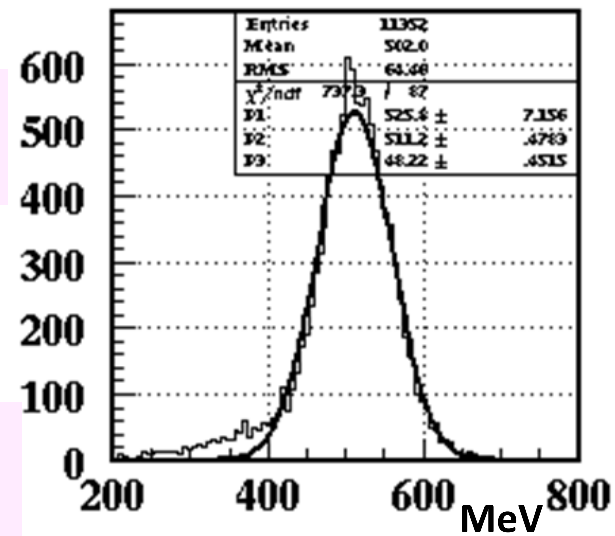


…and high efficiency

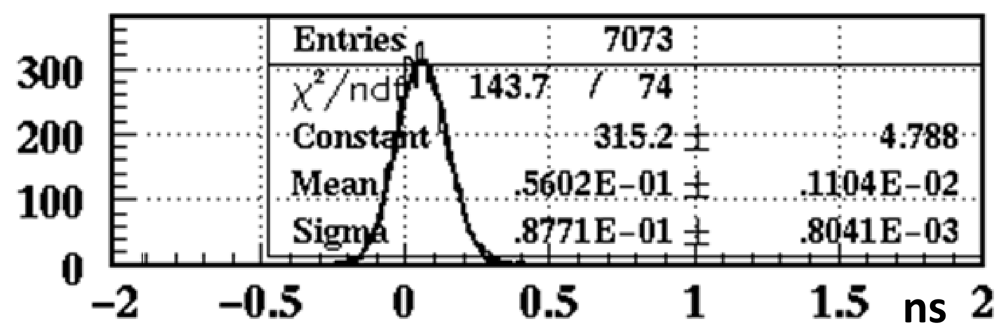


Calo keeping is performances:

σ_E = 45 MeV for γ's@510 MeV



Intrinsic σ_t<90 ps @ 510 MeV



KLOE-2 running

Average values at run time:

I^- ~ 1.2÷1.4 A

I^+ ~ 0.7÷1.0 A

$\mathscr{L}$ ~ 1.4÷1.8 x10^{32} $cm^{-2}s^{-1}$

Severe background conditions !
Data are acquired only if:

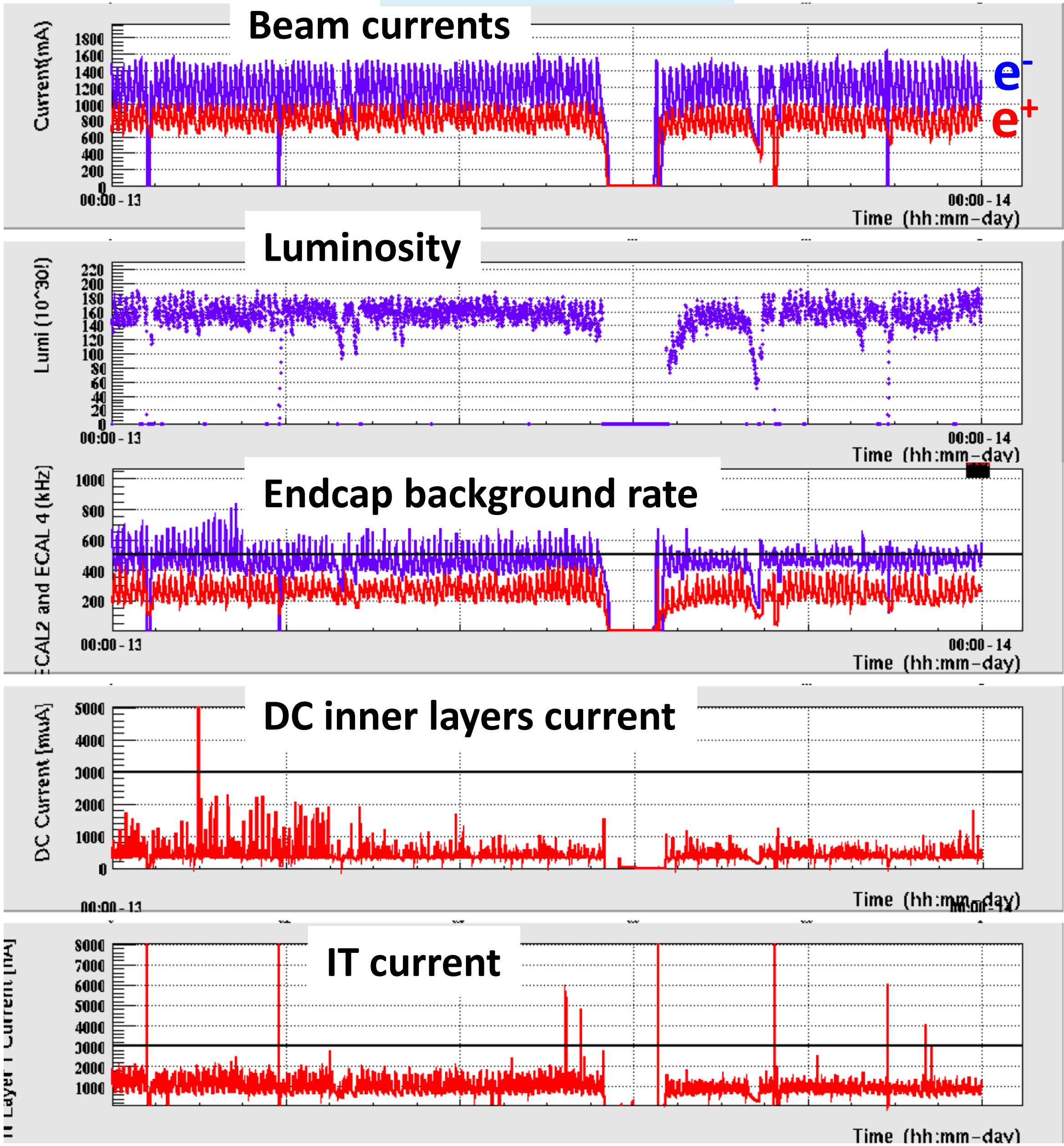
ECAP bckgr < 500 kHz

DC current < 3000 μA

IT current < 3000 nA

Current spikes related to injections cured with specific veto logic

a typical day



Energy scan

Scan performed by DAFNE shifting central RF: $$\frac{\Delta p}{p} = -\frac{1}{\alpha_c}\frac{\Delta \nu_{RF}}{\nu_{RF}}$$

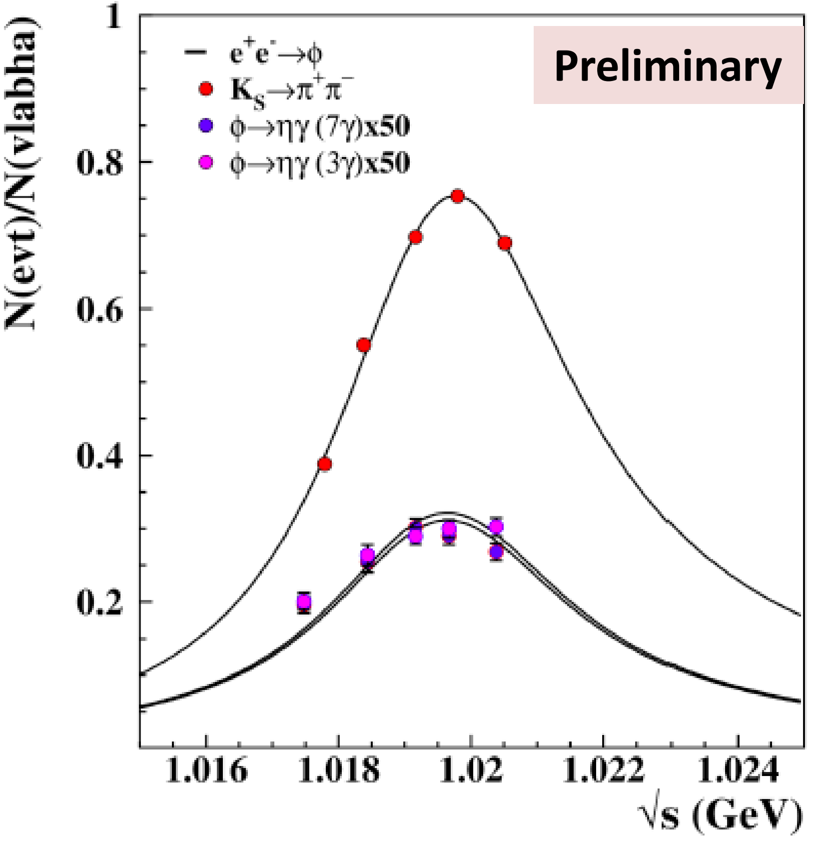
Count events:

- $\phi \rightarrow K_S K_L$, with $K_S \rightarrow \pi^+\pi^-$
- $\phi \rightarrow \eta\gamma$, with $\eta \rightarrow \gamma\gamma$, $\eta \rightarrow 3\pi^0$

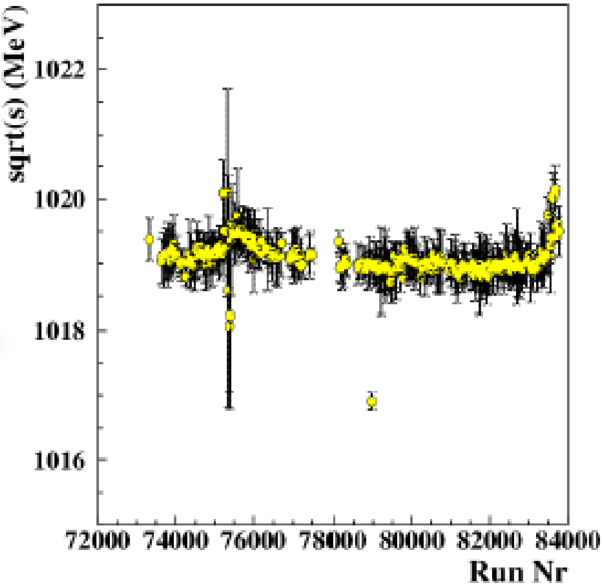
Events are normalized to large angle Bhabhas

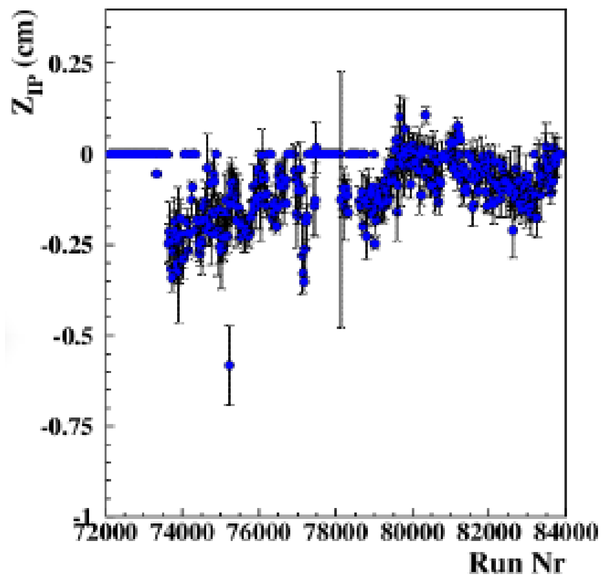
Fit includes the full line shape energy dependence, radiative corrections and beam energy spread (300 KeV)

DAFNE √s value shifted by +550 KeV to run exactly on peak



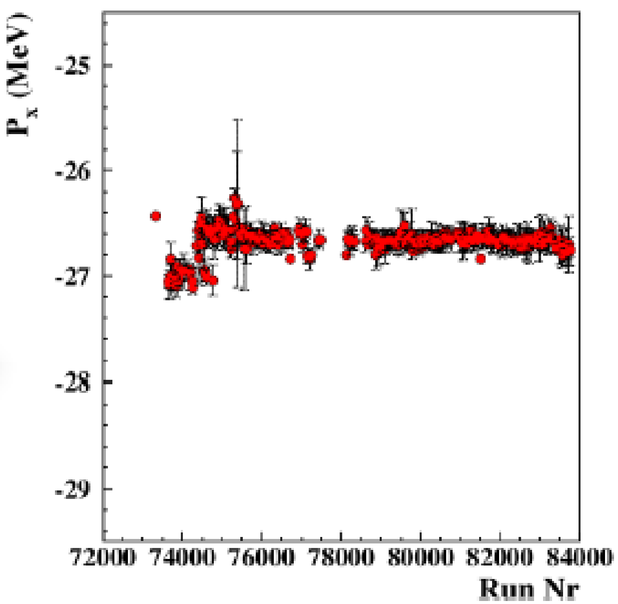
Data Quality monitor

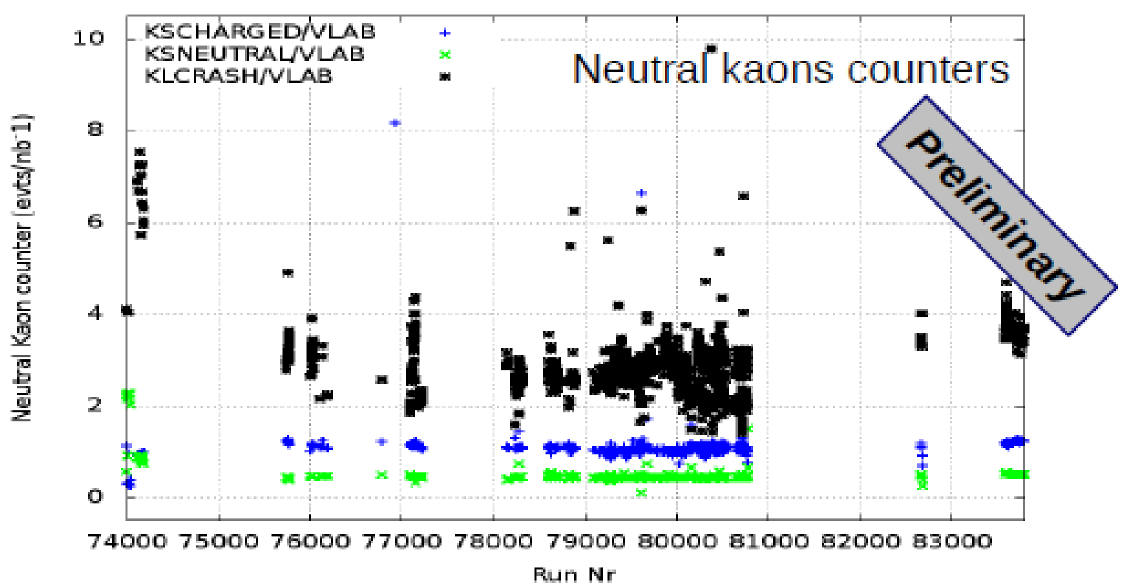




Beam parameters are constantly monitored also for DAFNE feedback

Event classification selection efficiency is constantly monitored to provide "fast" feedback to the detector experts.



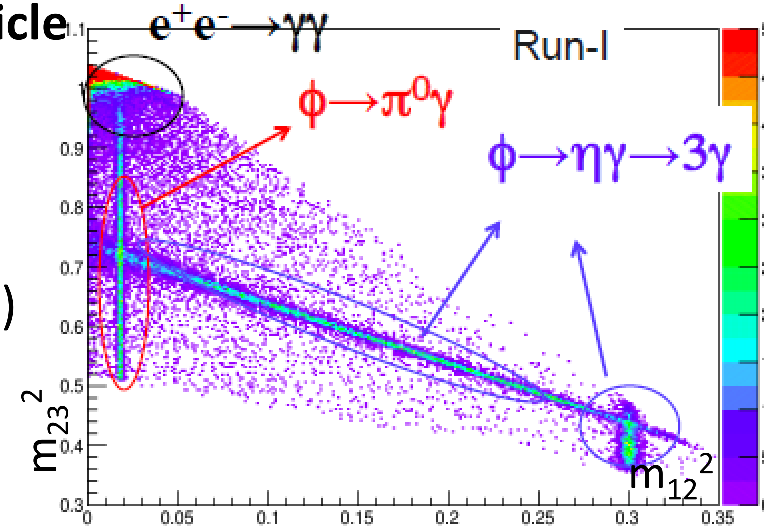


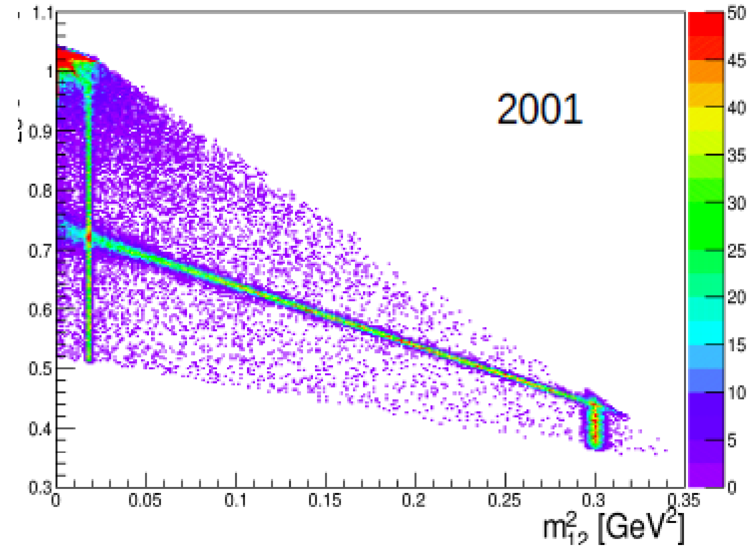
Benchmark channels

For neutral particle reconstruction:

$\phi \to \eta\gamma$, $\eta \to \gamma\gamma$

(but also $\eta \to 3\pi^0$)

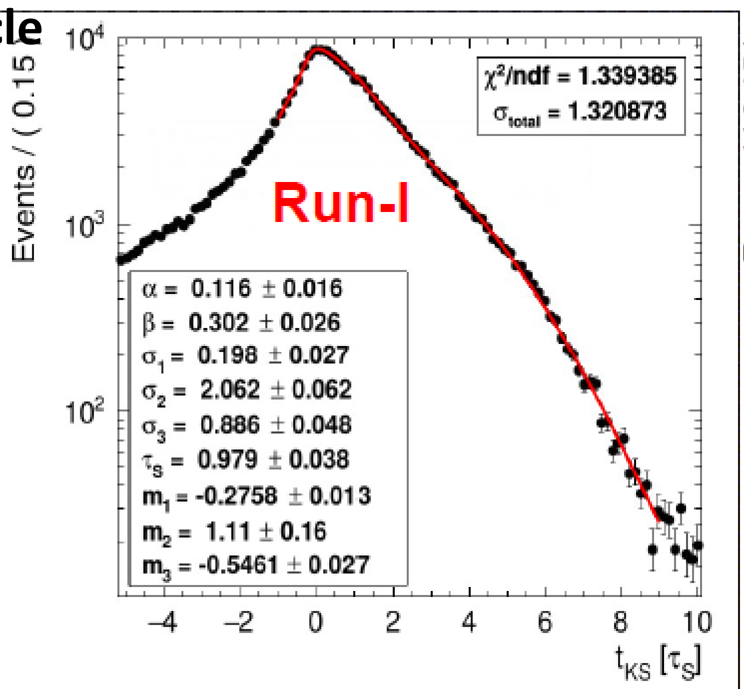


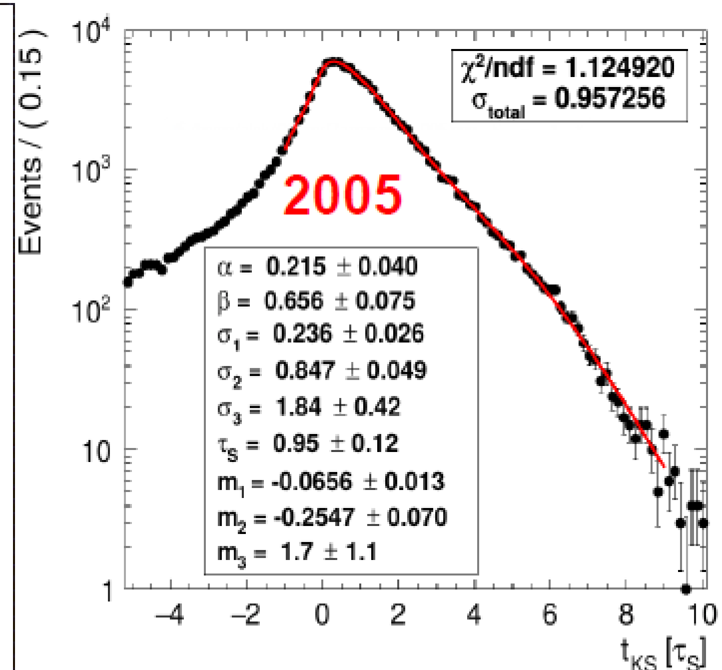


For charged particle reconstruction

$K_S \to \pi^+\pi^-$

(but also $K_L \to \pi^+\pi^-$)





Benchmark channels

For neutral particle reconstruction:

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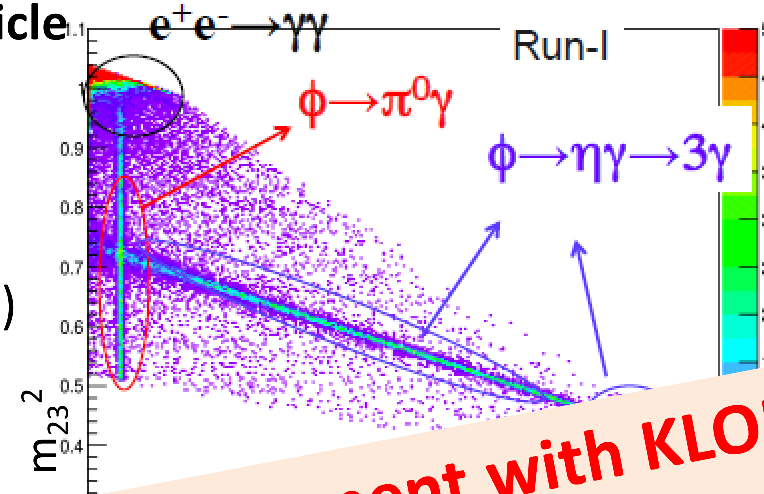
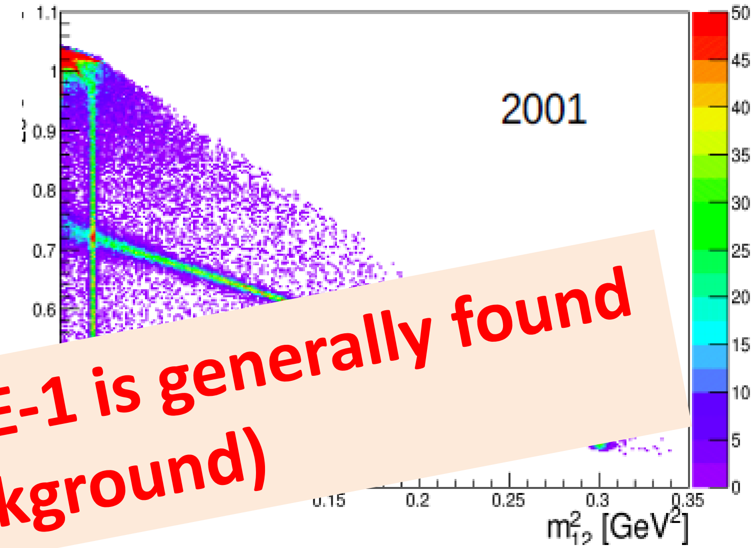


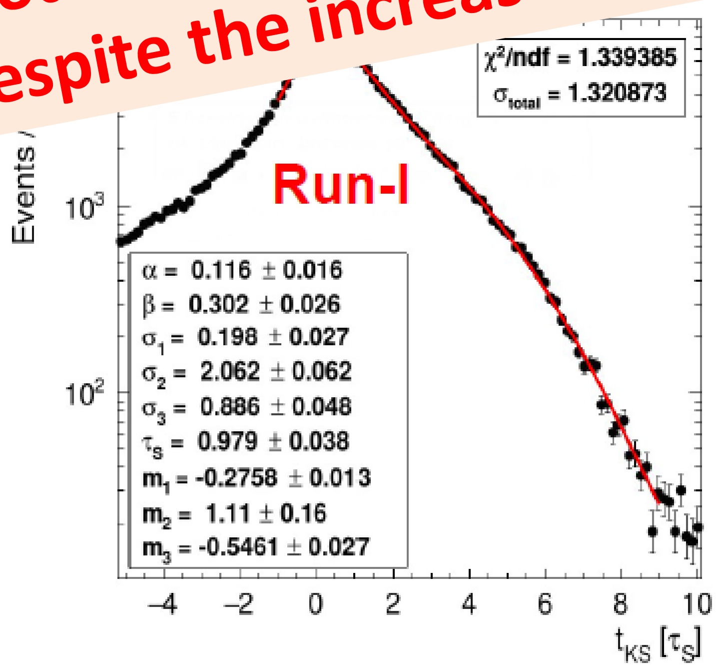


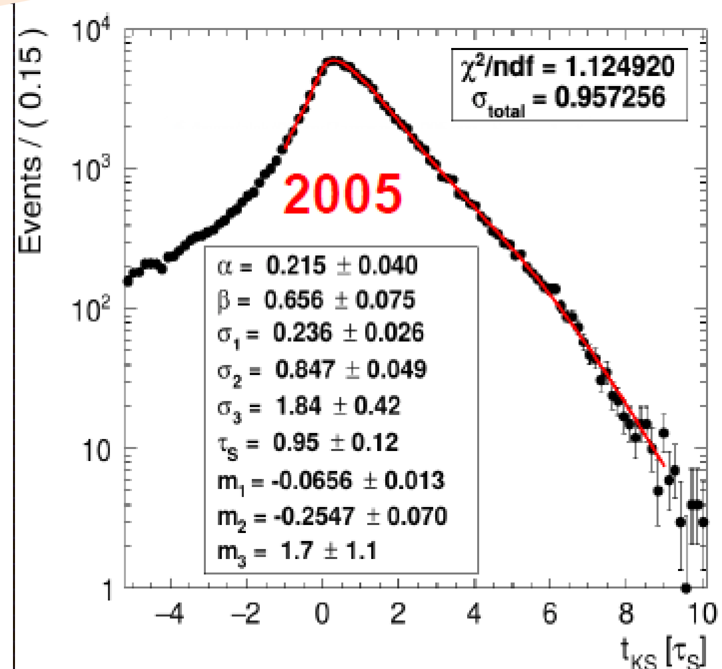
Good agreement with KLOE-1 is generally found (despite the increased background)

For charged particle reconstruction:

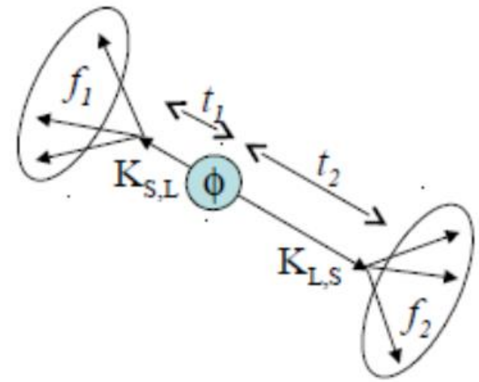
$K_S \to \pi^+\pi^-$

(but also $K_L \to \pi^+\pi^-$)



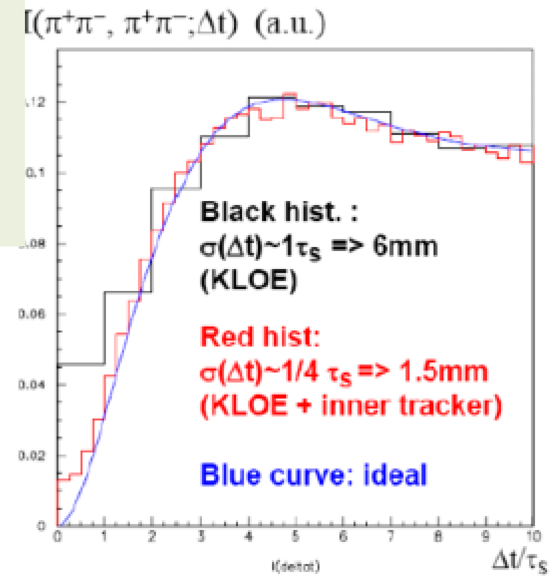


Physics analysis program/1



Neutral Kaon interferometry has a central place. KLOE-2 is a unique environment to test new physics models which predict violations of fundamental symmetries, of Lorentz invariance and possibly of quantum mechanics.

Such effects are enhanced in the entangled kaon system and are already being investigated with KLOE-1 data. KLOE-2 will not just double statistics, but profits of an improved central tracking and vertexing performance .



K_S decays can be studied in a very clean environment: with 5 fb^{-1} a total sample of $5x10^9$ K_S will be collected (to be added to the 2 billions of KLOE-1). Efficient tagging allow quality BR and asymmetry measurements.

Physics analysis program/2

$\gamma\gamma$ taggers will be exploited to look into low energy QCD processes:

$\pi^0\gamma\gamma$ form factor in the time-like region, 2 π^0 resonance below 1 GeV….

Dark photon searches in various channels (improving KLOE-1 limits and looking for new signatures)

Hadronic physics below 1 GeV, η and η' properties.

A workshop is being organized for end of october to review all possible measurements @ KLOE-2 :

https://agenda.infn.it/conferenceDisplay.py?confId=11722

Summary

DAΦNE phi-factory is steadely delivering luminosity at a rate > 10 pb^{-1}/day.

Already 3 fb^{-1} have been delivered since novembrer2014.

KLOE-2 experiment is fully operational and its new detectors are being successfully commissioned.

KLOE-2 first data are being analyzed with benchmark channels, and good agreement with previous KLOE performance is found.

Physics analysis is starting !