Status of KLOE-2

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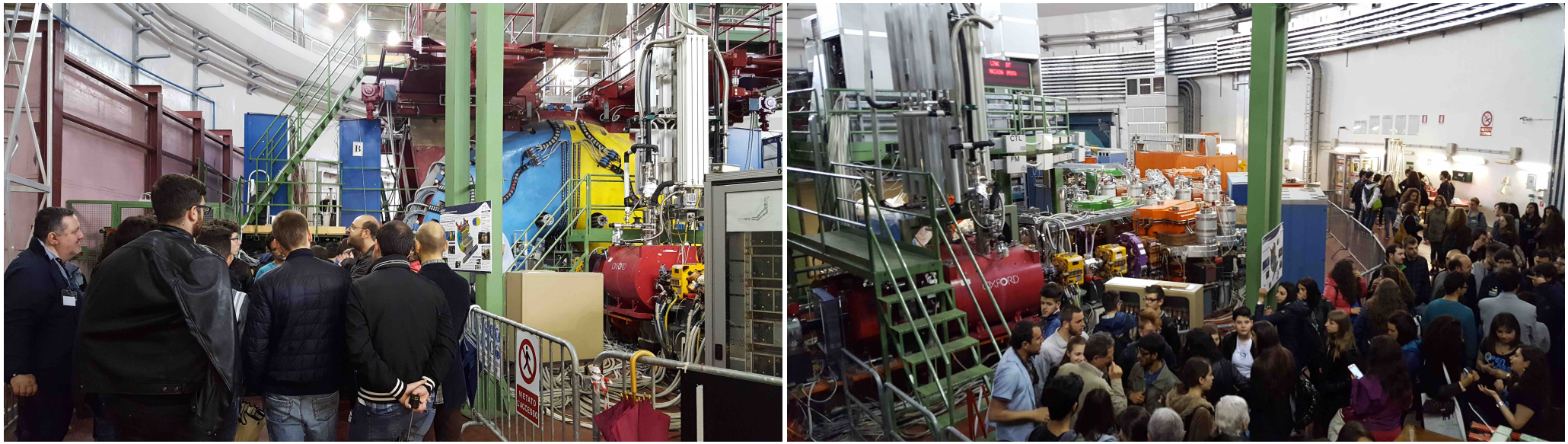
on behalf of the KLOE-2 collaboration



LNF Scientific Committee meeting – closed session
Frascati, 24 May 2016

KLOE-2 physics program discussed in several occasions in the past with different luminosity scenarios.
(reminder: KLOE program for interferometry and eps'/eps based on 10 fb-1)

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THE EUROPEAN PHYSICAL JOURNAL C

Review

In this paper

Step 0 : 5 fb-1
Step 1 : 20 fb-1

Physics with the KLOE-2 experiment at the upgraded DAΦNE

G. Amelino-Camelia[1,2], F. Archilli[3,4], D. Babusci[5], D. Badoni[4], G. Bencivenni[5], J. Bernabeu[6], R.A. Bertlmann[7], D.R. Boito[8], C. Bini[1,2], C. Bloise[5,a], V. Bocci[2], F. Bossi[5], P. Branchini[9], A. Budano[9], S.A. Bulychjev[10], P. Campana[5], G. Capon[5], F. Ceradini[9,11], P. Ciambrone[5], E. Czerwinski[5], H. Czyz[12], G. D'Ambrosio[13], E. Dané[5], E. De Lucia[5], G. De Robertis[14], A. De Santis[1,2], P. De Simone[5], G. De Zorzi[1,2], A. Di Domenico[1,2], C. Di Donato[13], B. Di Micco[9,11,39], D. Domenici[5], S.I. Eidelman[15], O. Erriquez[14,16], R. Escribano[8], R. Essig[17], G.V. Fedotovich[15], G. Felici[5], S. Fiore[1,2], P. Franzini[1,2], P. Gauzzi[1,2], F. Giacosa[18], S. Giovannella[5], F. Gonnella[3,4], E. Graziani[9], F. Happacher[5], B.C. Hiesmayr[7,19], B. Höistad[20], E. Iarocci[5,21], S. Ivashyn[12,22], M. Jacewicz[5], F. Jegerlehner[23], T. Johansson[20], J. Lee-Franzini[5], W. Kluge[24], V.V. Kulikov[10], A. Kupsc[20], R. Lehnert[25], F. Loddo[14], P. Lukin[15], M.A. Martemianov[10], M. Martini[5,21], M.A. Matsyuk[10], N.E. Mavromatos[26], F. Mescia[27], R. Messi[3,4], S. Miscetti[5], G. Morello[28,29], D. Moricciani[4], P. Moskal[30], S. Müller[5,40], F. Nguyen[9], E. Passemar[6,31], M. Passera[32], A. Passeri[9], V. Patera[5,21], M.R. Pennington[33], J. Prades[34], L. Quintieri[5], A. Ranieri[14], M. Reece[35], P. Santangelo[5], S. Sarkar[26], I. Sarra[5], M. Schioppa[28,29], P.C. Schuster[17], B. Sciascia[5], A. Sciubba[5,21], M. Silarski[30], C. Taccini[9,11], N. Toro[36], L. Tortora[9], G. Venanzoni[5], R. Versaci[5,39], L.-T. Wang[37], W. Wislicki[38], M. Wolke[20], J. Zdebik[30]

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THE EUROPEAN PHYSICAL JOURNAL C

Review

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Physics with the KLOE-2 experiment at the upgraded DAΦNE

Contents

1 Introduction

This report results from discussion started at the workshop held at the Frascati Laboratory of INFN to review the major topics of interest for investigation at the upgraded ϕ factory DAΦNE . The scientific program with a high-performance detector such as KLOE covers several fields in particle physics: from measurements of interest for the development of the Effective Field Theory (EFT) in quark-confinement regime to fundamental tests of Quantum Mechanics (QM) and CPT invariance. It includes precision measurements to probe lepton universality, CKM unitarity and settle the hadronic vacuum polarization contribution to the anomalous magnetic moment of the muon and to the fine structure constant at the M_Z scale.

During year 2008 the Accelerator Division of the Frascati Laboratory has tested a new interaction scheme on the DAΦNE ϕ-factory collider, with the goal of reaching a peak luminosity of 5×10^{32} cm $^{-2}$s $^{-1}$, a factor of three larger than what previously obtained. The test has been successful and presently DAΦNE is delivering up to 15 pb $^{-1}$/day, with solid hopes to reach soon 20 pb $^{-1}$/day [1,2]. Following these achievements, the data-taking campaign of the KLOE detector on the improved machine that was proposed in 2006 [3], will start in 2010.

KLOE is a multipurpose detector, mainly consisting of a large cylindrical drift chamber with an internal radius of 25 cm and an external one of 2 m, surrounded

Contents

- CKM unitarity and lepton universality
- CPT symmetry and Quantum Mechanics
- Low energy QCD
- Physics in the continuum: σ_{hadr}
- Physics in the continuum: $\gamma\gamma$ processes
- Hidden WIMP dark matter

Physics program with 5 fb^{-1}

The KLOE-2 physics program is under revision taking into account the quality of the data and the new detector performance

- **QM, CPT and Lorentz invariance tests** with neutral kaons, sensitive to effects at the Planck scale (10^{19} GeV)
- SM test with **precision measurements of the V_{us}** element of the CKM mixing matrix
- **Low-energy QCD** with radiative kaon, η, and η' decays and **low-mass scalars** with the study of scalar-KK coupling
- **$\gamma\gamma$ physics** with the measurements of the π^0 width and $\pi^0 \rightarrow \gamma\gamma^*$ transition form factor in the space-like region
- **Search for new light bosons** from dark sector

Physics program with 5 fb^{-1}

Decay mode	Physics case	Physics reach
Kaon physics - $\varphi \to K_S K_L$		
$\pi^+\pi^-\pi^+\pi^-$	QM, CPT and Lorentz invariance tests	Factor 4 improvement in sensitivity
$K_S \to 3\pi^0$	CP violation, best limit: BR<2.6 × 10^{-8} @ 90% C.L.	< 1 × 10^{-8}
$K_S \to \pi e \nu$	CP, CPT test A_S=(1.5 ± 11)×10^{-3}	± 2.7 × 10^{-3} (CP viol. A_S=3.3× 10^{-3}) (CPT : A_S-A_L=0)
Hadron physics – Transition Form Factors		
$\varphi \to \eta\mu^+\mu^-$	BR < 9.4×10^{-6} (PDG)	BR and TFF slope
$\varphi \to \eta\pi^+\pi^-$	BR < 1.8×10^{-5} (PDG)	BR and TFF slope
$e^+e^- \to \omega\gamma_{ISR}$, $\omega \to \pi^0 l^+ l^-$	NA60 discrepancy with VMD in $\omega \to \pi^0\mu^+\mu^-$	~ 10^4 $\omega \to \pi^0 e^+e^-$ evts ~ 10^3 $\omega \to \pi^0\mu^+\mu^-$ evts
Hadron physics		
$\eta \to \pi^0\gamma\gamma$	test of ChPT at O(p^6) recent meas by A2@MAMI	~ 10^4 evts expected Meas γγ invariant mass spectrum
$\varphi \to [f_0(980)+a_0(980)]\gamma$ $\to K_S K_S \gamma$	f_0/a_0 interference; BR < 1.9×10^{-8}, @ 90% C.L.	With IT possible evidence at 3σ if tetraquark is allowed
η' decays	$\eta' \to \pi^+\pi^-\gamma$ (box anomaly) $\eta' \to \eta\pi\pi$ (f_0/a_0 contribution)	~ 10^6 η' expected

Physics program with 5 fb^{-1}

Decay mode	Physics case	Physics reach
$\gamma\gamma$ physics		
$e^+e^- \to e^+e^-\pi^o$ ($\gamma\gamma \to \pi^o$)	$\Gamma(\pi^o \to \gamma\gamma)$ PrimEx (2011) ⇒ 2% stat. unc.	HET - HET coincidence ~1% stat. accuracy
$\gamma^*\gamma \to \pi^o$	TFF $F_{\pi 0 \gamma^* \gamma}(q^2,0)$ at $\lvert q^2\rvert<0.1$ GeV^2	HET - EMC coincidence
$e^+e^- \to e^+e^-\pi\pi$ ($\gamma\gamma \to \pi\pi$)	study of $f_0(500)$	
Dark force searches		
Dark Higgs-strahlung		higher statistics + reduction of K charged bckg ⇒ at least a factor 2 in limits
B-boson $B \to \pi^o\gamma$	leptophobic vector boson coupling to quarks [S.Tulin PRD 89(2014)114008]	$\eta \to B\gamma \to \pi^o\gamma\gamma$ $\varphi \to \eta B \to \eta\pi^o\gamma$ (preliminary study on 2004-2005 data in progress)

Prospects for KLOE-2 at upgraded DAΦNE

Param.	Present best published measurement	KLOE-2 L=5 fb^{-1}	KLOE-2 L=10 fb^{-1}	KLOE-2 L=20 fb^{-1}
BR($K_S \to 3\pi^0$)	$< 2.6\times 10^{-8}$	$< 0.9\times 10^{-8}$	$< 4\times 10^{-9}$	$< 2\times 10^{-9}$ - seen
A_S	$(1.5 \pm 11) \times 10^{-3}$	$\pm 2.7 \times 10^{-3}$	$\pm 1.9 \times 10^{-3}$	$\pm 1.4 \times 10^{-3}$
A_L	$(332.2 \pm 5.8 \pm 4.7) \times 10^{-5}$	$\pm 8.9 \times 10^{-5}$	$\pm 6.3 \times 10^{-5}$	$\pm 4.5 \times 10^{-5}$
Re(ε'/ε)	$(1.92 \pm 0.21) \times 10^{-3}$	$\pm 0.72 \times 10^{-3}$	$\pm 0.51 \times 10^{-3}$	$\pm 0.36 \times 10^{-3}$
Im(ε'/ε)	$(-1.72 \pm 2.02) \times 10^{-3}$	$\pm 9.4 \times 10^{-3}$	$\pm 6.7 \times 10^{-3}$	$\pm 4.7 \times 10^{-3}$
Re(δ)+Re(x_-)	Re(δ) = $(0.29 \pm 0.27) \times 10^{-3}$ Re(x_-) = $(-0.8 \pm 2.5) \times 10^{-3}$	$\pm 0.7 \times 10^{-3}$	$\pm 0.5 \times 10^{-3}$	$\pm 0.4 \times 10^{-3}$
Im(δ)+Im(x_+)	Im(δ) = $(-0.6 \pm 1.9) \times 10^{-5}$ (*) Im(x_+) = $(0.2 \pm 2.2) \times 10^{-3}$ (**)	$\pm 9 \times 10^{-3}$	$\pm 7 \times 10^{-3}$	$\pm 5 \times 10^{-3}$
Δm	$(5.2797 \pm 0.0195) \times 10^9$ s^{-1}	$\pm 0.096 \times 10^9$ s^{-1}	$\pm 0.068 \times 10^9$ s^{-1}	$\pm 0.048 \times 10^9$ s^{-1}

(*) = using Bell-Steinberger rel. (**) = KLOE-CPLEAR combined fit

2 fb^{-1} (old KLOE) + 6-7 fb^{-1} (KLOE-2) ~ O(10 fb^{-1})

Semileptonic asymmetry of KS (CP and CPT test)

eps'/eps (CP test)

KL lifetime

etc…

Focus on $\phi \rightarrow K_S K_L \rightarrow \pi^+\pi^- \pi^+\pi^-$

CPT violation: standard picture

CP violation:

$$\varepsilon_{S,L} = \varepsilon \pm \delta$$

T violation:

$$\varepsilon = \frac{H_{12} - H_{21}}{2\left(\lambda_S - \lambda_L\right)} = \frac{-i\Im M_{12} - \Im\Gamma_{12}/2}{\Delta m + i\Delta\Gamma/2}$$

CPT violation:

$$\delta = \frac{H_{11} - H_{22}}{2\left(\lambda_S - \lambda_L\right)} = \frac{1}{2}\frac{\left(m_{\overline{K}^0} - m_{K^0}\right) - \left(i/2\right)\left(\Gamma_{\overline{K}^0} - \Gamma_{K^0}\right)}{\Delta m + i\Delta\Gamma/2}$$

- $\delta \neq 0$ implies CPT violation
- $\varepsilon \neq 0$ implies T violation
- $\varepsilon \neq 0$ or $\delta \neq 0$ implies CP violation

(with a phase convention $\Im\Gamma_{12} = 0$)

$$\Delta m = m_L - m_S \quad , \quad \Delta\Gamma = \Gamma_S - \Gamma_L$$

$$\Delta m = 3.5 \times 10^{-15}\ \text{GeV}$$

$$\Delta\Gamma \approx \Gamma_S \approx 2\Delta m = 7 \times 10^{-15}\ \text{GeV}$$

CPT violation: standard picture

CP violation:

$$\varepsilon_{S,L} = \varepsilon \pm \delta$$

T violation:

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CPT violation:

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$$\Delta\Gamma \approx \Gamma_S \approx 2\Delta m = 7 \times 10^{-15}\ \text{GeV}$$

neutral kaons vs other oscillating meson systems

	<m> (GeV)	Δm (GeV)	<Γ> (GeV)	ΔΓ/2 (GeV)
K^0	0.5	3×10^{-15}	3×10^{-15}	3×10^{-15}
D^0	1.9	6×10^{-15}	2×10^{-12}	1×10^{-14}
B^0_d	5.3	3×10^{-13}	4×10^{-13}	$O(10^{-15})$ (SM prediction)
B^0_s	5.4	1×10^{-11}	4×10^{-13}	3×10^{-14}

Decoherence and CPT violation

S. Hawking (1975)

Possible decoherence due quantum gravity effects (BH evaporation) (apparent loss of unitarity):
Black hole information loss paradox =>
Possible decoherence near a black hole.

("like candy rolling on the tongue" by J. Wheeler)

Hawking [1] suggested that at a microscopic level, in a quantum gravity picture, non-trivial space-time fluctuations (generically space-time foam) could give rise to decoherence effects, **which would necessarily entail a violation of CPT** [2].

Modified Liouville – von Neumann equation for the density matrix of the kaon system with 3 new CPTV parameters α,β,γ [3]:

$$\dot{\rho}(t) = \underbrace{-iH\rho + i\rho H^{+}}_{\text{QM}} + L(\rho;\alpha,\beta,\gamma)$$

at most:

$$\alpha,\beta,\gamma = O\left(\frac{M_K^{\,2}}{M_{PLANCK}}\right) \approx 2\times 10^{-20}\ \text{GeV}$$

[1] Hawking, Comm.Math.Phys.87 (1982) 395; [2] Wald, PR D21 (1980) 2742;[3] Ellis et. al, NP B241 (1984) 381; Ellis, Mavromatos et al. PRD53 (1996)3846; Handbook on kaon interferometry [hep-ph/0607322], M. Arzano PRD90 (2014) 024016

$\phi \rightarrow K_S K_L \rightarrow \pi^+\pi^- \pi^+\pi^-$: decoherence and CPT violation

Study of time evolution of **single kaons** decaying in $\pi^+\pi^-$ and semileptonic final state

CPLEAR **PLB 364, 239 (1999)**

$$\alpha = (-0.5 \pm 2.8) \times 10^{-17} \text{ GeV}$$
$$\beta = (2.5 \pm 2.3) \times 10^{-19} \text{ GeV}$$
$$\gamma = (1.1 \pm 2.5) \times 10^{-21} \text{ GeV}$$

single kaons

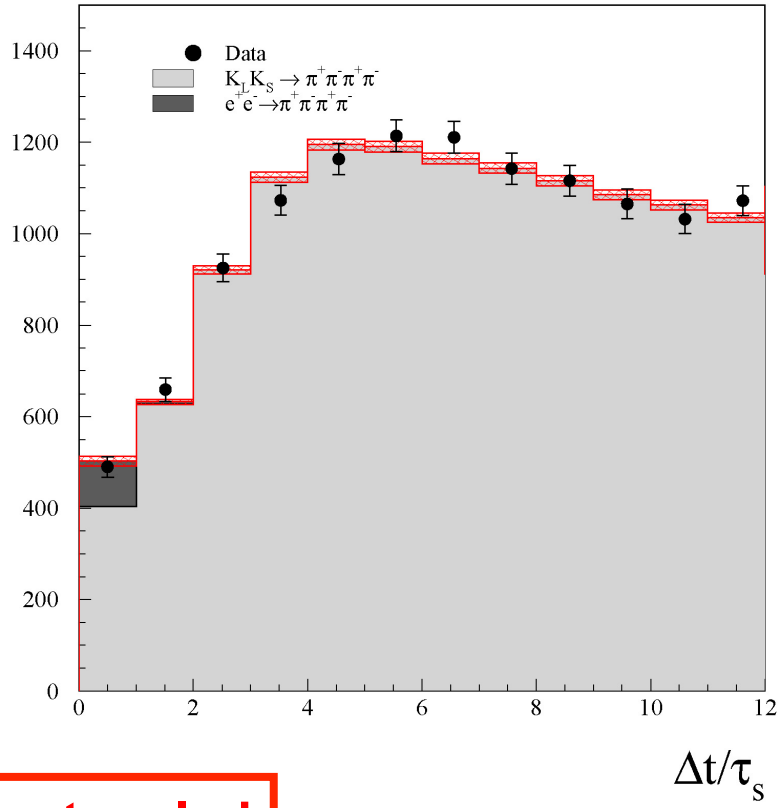
In the complete positivity hypothesis
$\alpha = \gamma$, $\beta = 0$
=> only one independent parameter: γ

The fit with $I(\pi^+\pi^-,\pi^+\pi^-;\Delta t,\gamma)$ gives:

KLOE result L=1.5 fb^{-1}

$$\gamma = (0.7 \pm 1.2_{STAT} \pm 0.3_{SYST}) \times 10^{-21} \text{ GeV}$$

PLB 642(2006) 315
Found. Phys. 40 (2010) 852



entangled kaons

Prospects for KLOE-2 KSKL->pi+pi-pi+pi-

Param.	Present best published measurement	KLOE-2 (IT) L=5 fb^{-1} (stat.)	KLOE-2 (IT) L=10 fb^{-1} (stat.)
ζ_{00}	$(0.1 \pm 1.0) \times 10^{-6}$	$\pm 0.26 \times 10^{-6}$	$\pm 0.18 \times 10^{-6}$
ζ_{SL}	$(0.3 \pm 1.9) \times 10^{-2}$	$\pm 0.49 \times 10^{-2}$	$\pm 0.35 \times 10^{-2}$
α	$(-0.5 \pm 2.8) \times 10^{-17}$ GeV	$\pm 5.0 \times 10^{-17}$ GeV	$\pm 3.5 \times 10^{-17}$ GeV
β	$(2.5 \pm 2.3) \times 10^{-19}$ GeV	$\pm 0.50 \times 10^{-19}$ GeV	$\pm 0.35 \times 10^{-19}$ GeV
γ	$(1.1 \pm 2.5) \times 10^{-21}$ GeV compl. pos. hyp. $(0.7 \pm 1.2) \times 10^{-21}$ GeV	$\pm 0.75 \times 10^{-21}$ GeV compl. pos. hyp. $\pm 0.33 \times 10^{-21}$ GeV	$\pm 0.53 \times 10^{-21}$ GeV compl. pos. hyp. $\pm 0.23 \times 10^{-21}$ GeV
$Re(\omega)$	$(-1.6 \pm 2.6) \times 10^{-4}$	$\pm 0.70 \times 10^{-4}$	$\pm 0.49 \times 10^{-4}$
$Im(\omega)$	$(-1.7 \pm 3.4) \times 10^{-4}$	$\pm 0.86 \times 10^{-4}$	$\pm 0.61 \times 10^{-4}$
Δa_0	$(-6.0 \pm 8.3) \times 10^{-18}$ GeV	$\pm 2.2 \times 10^{-18}$ GeV	$\pm 1.6 \times 10^{-18}$ GeV
Δa_Z	$(3.1 \pm 1.8) \times 10^{-18}$ GeV	$\pm 0.50 \times 10^{-18}$ GeV	$\pm 0.35 \times 10^{-18}$ GeV
Δa_X	$(0.9 \pm 1.6) \times 10^{-18}$ GeV	$\pm 0.44 \times 10^{-18}$ GeV	$\pm 0.31 \times 10^{-18}$ GeV
Δa_Y	$(-2.0 \pm 1.6) \times 10^{-18}$ GeV	$\pm 0.44 \times 10^{-18}$ GeV	$\pm 0.31 \times 10^{-18}$ GeV

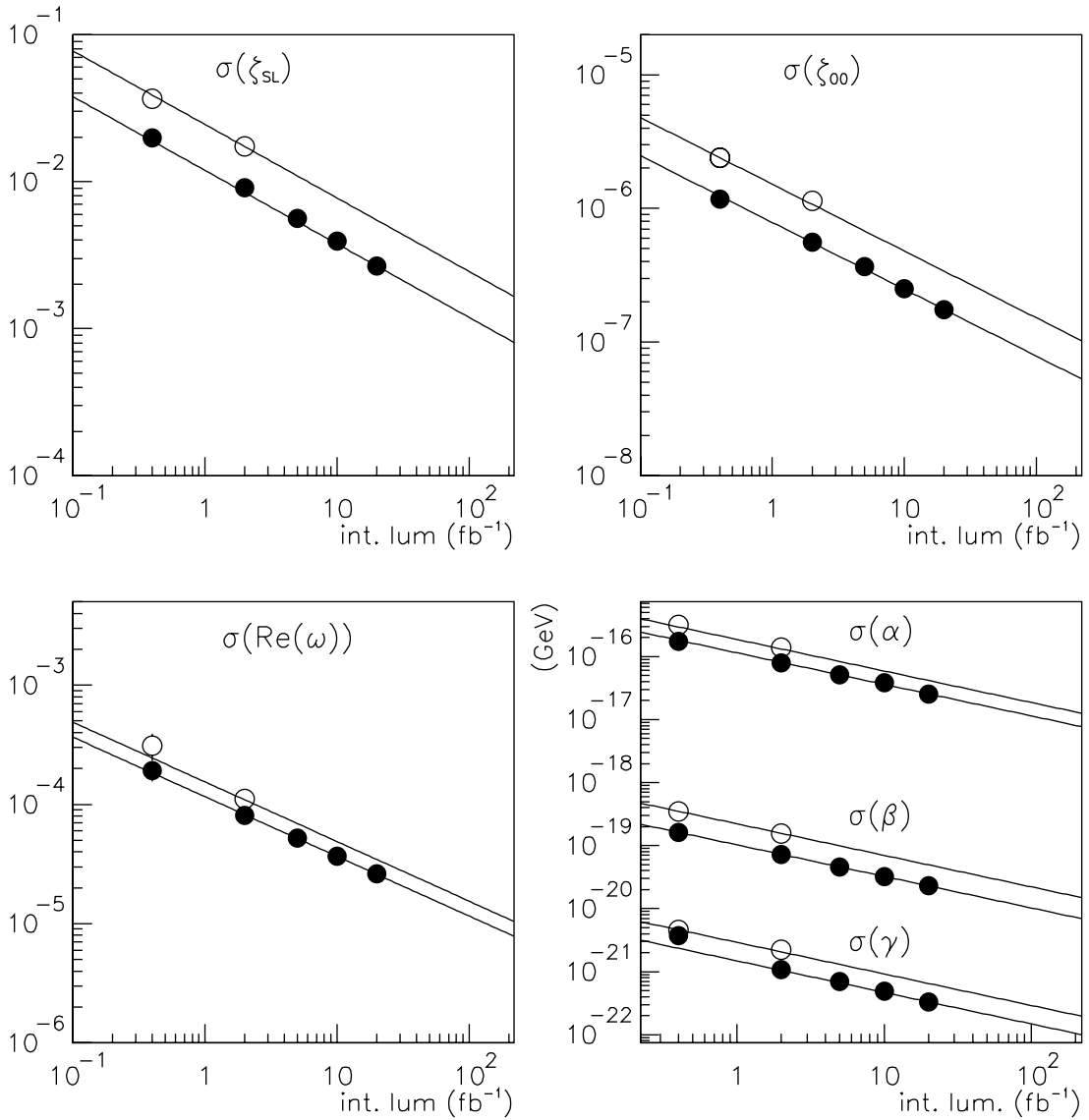
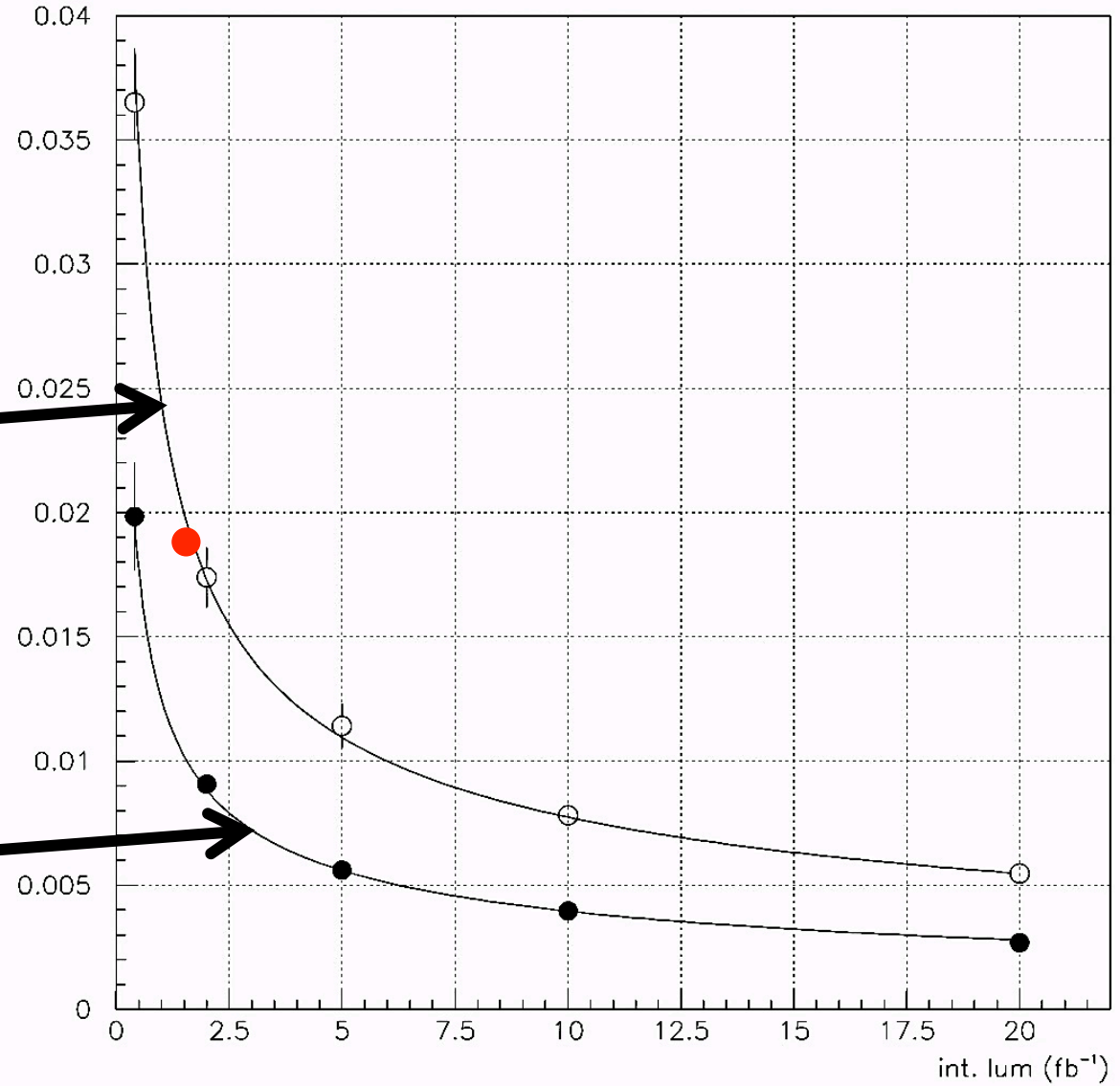


Fig. 7 The sensitivity to the ζ_{SL}, $\zeta_{00\bar{0}}$, Re ω and α, β, γ parameters with the present KLOE resolution $\sigma_{\Delta t} \approx \tau_S$ (*open circles*), and with the improved resolution $\sigma_{\Delta t} \approx 0.3\,\tau_S$ expected with the IT at KLOE-2 (*full circles*)

(the plot is for ζ – almost identical for γ) $\sigma(\zeta_{SL})$ only stat.err. (MC)



no IT

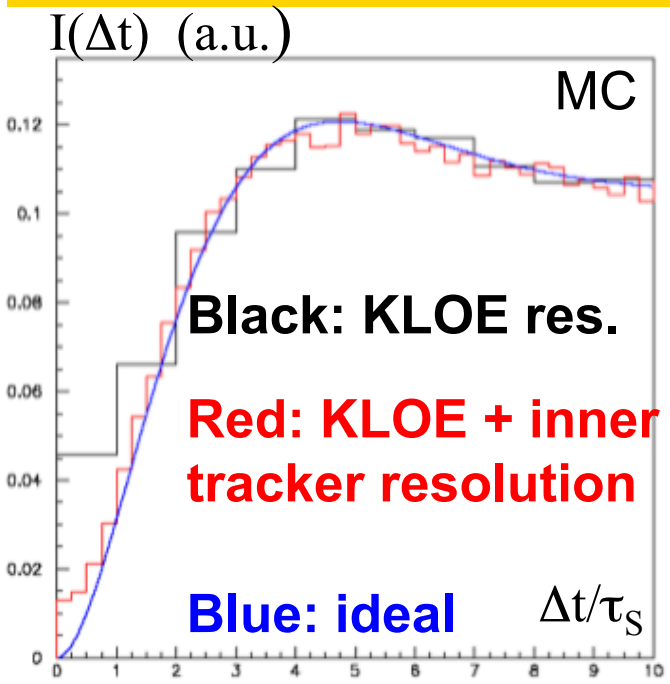
KLOE FINAL 2004-05 L=1.5 fb-1

$$\zeta_{SL} = \left(0.3 \pm 1.8_{\mathrm{STAT}} \pm 0.6_{\mathrm{SYST}}\right) \times 10^{-2}$$

Sensitivity gain due to IT ~ x 2

with IT

Systematic error depends from resolution and can be reduced with IT



Improvement in resolution x 3 (x 4)
⇒ Sensitivity x1.5 (x 2)

Statistics x 4 ($1.5fb^{-1}$ x 4 = $6fb^{-1}$)

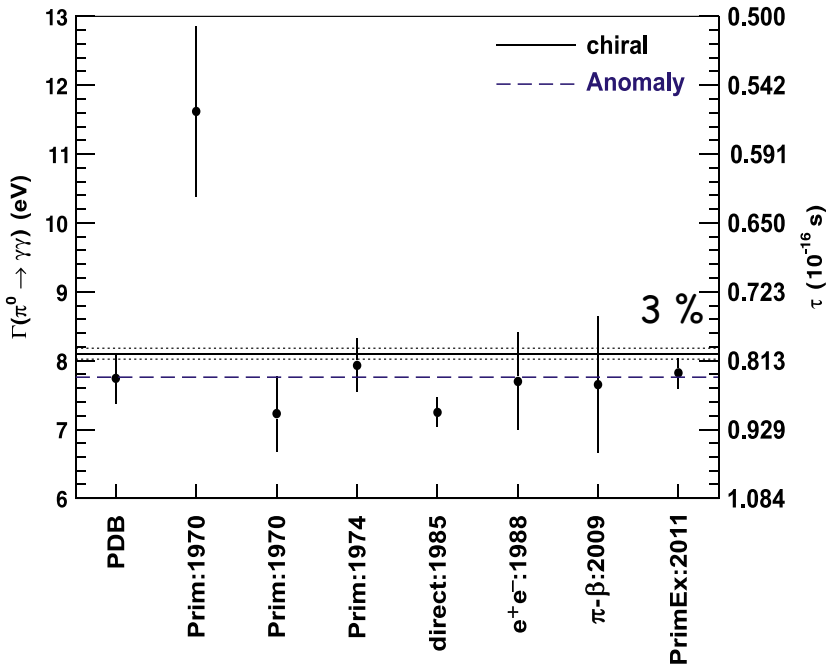
⇒ Overall improvement in precision
1.5 (2) x 2 = 3 (4)

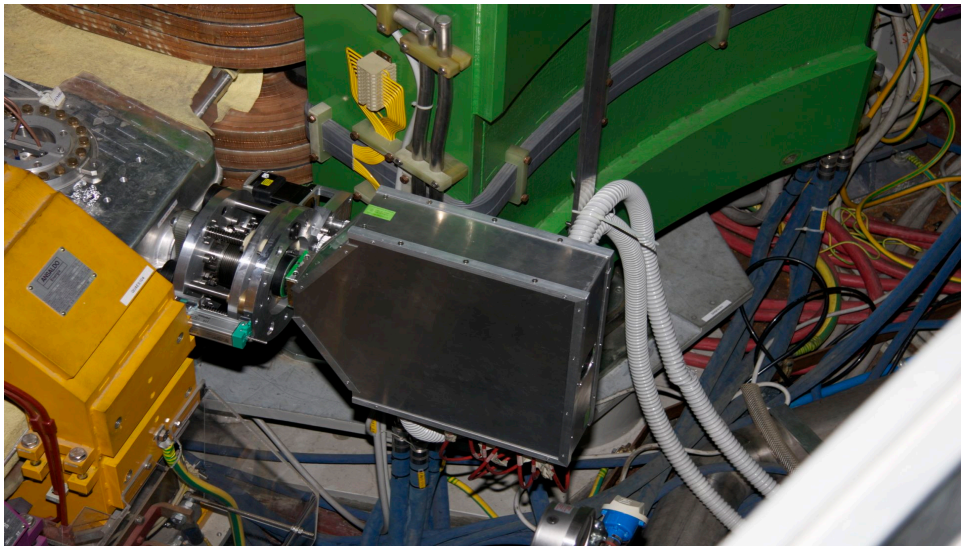
KLOE Δt resolution ~ 1 τ_S

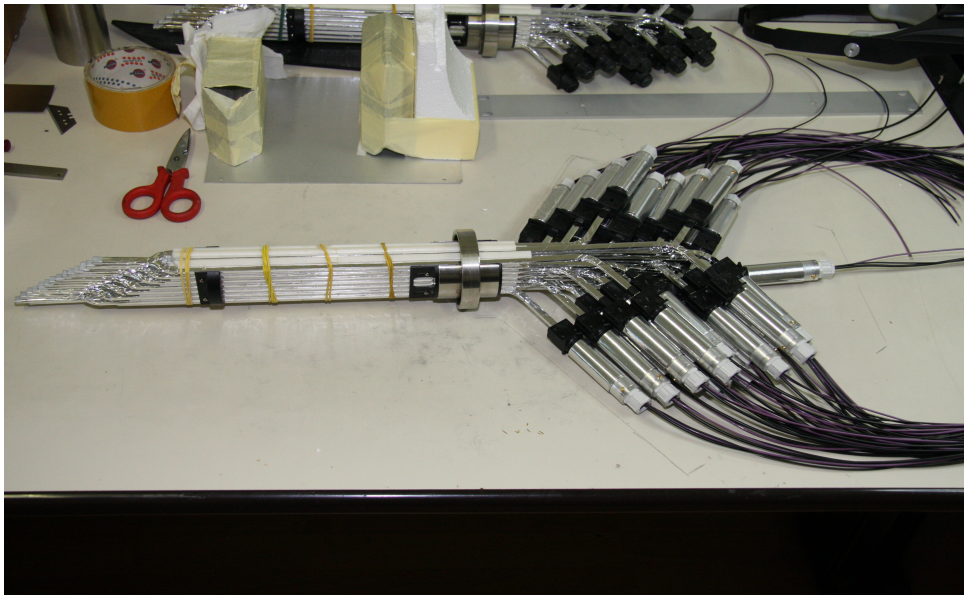
KLOE-2 with IT ~ 1/3 τ_S

HET taggers for $\gamma\gamma$ physics

- Main goal is the precision measurement of the π^0 width
- 10^4 π^0 expected with $\mathcal{L}_{int}$=5 fb^{-1} (~1% stat)
- The HET stations are installed after the bending dipoles, 11 m from the IP
- 28+1 scintillators of different length
- Operational since the very beginning of the KLOE-2 data taking
- Energy acceptance from 425-490 MeV. MC validation is needed



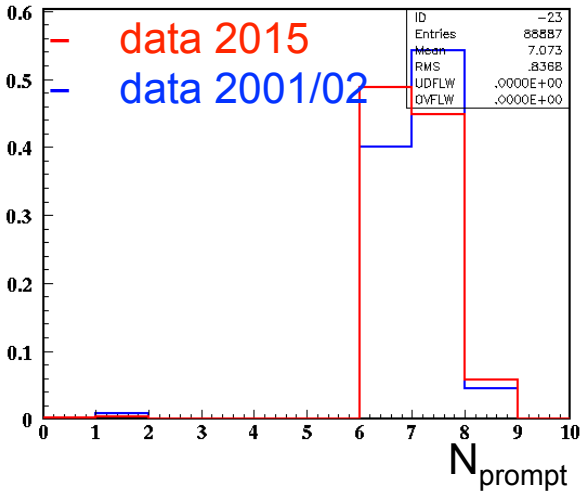


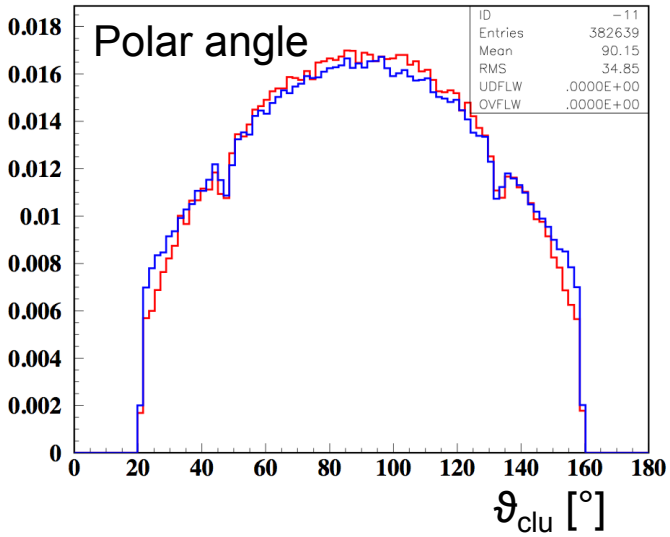


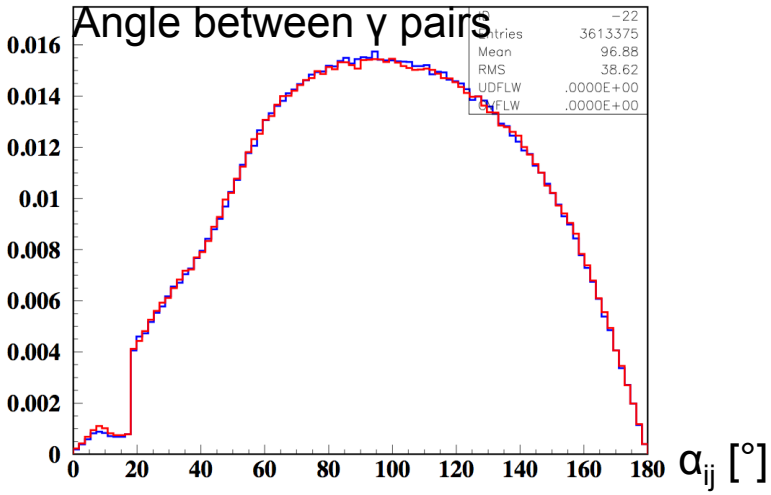
Data quality monitor

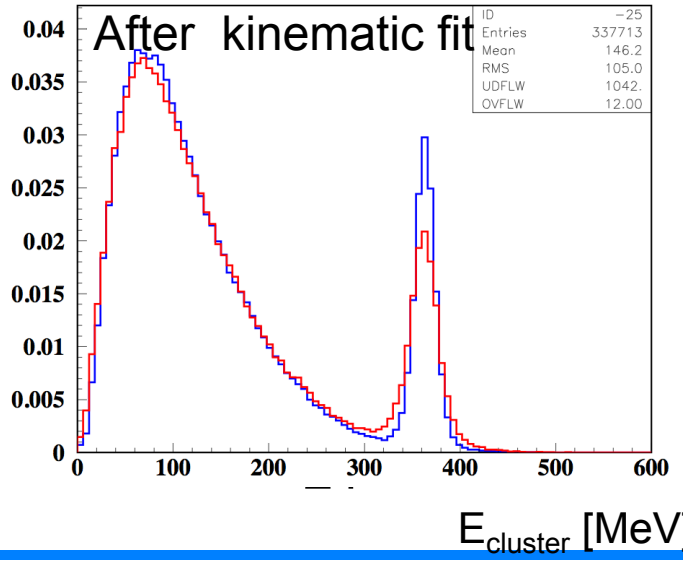
Data quality benchmark (1): $\phi \rightarrow \eta\gamma$ with $\eta \rightarrow 3\pi^0$

- Neutral rad w/ N_{prompt} > 5 clusters
- To select $\phi \rightarrow \eta\gamma$ with $\eta \rightarrow 3\pi^0$ (recoil $\gamma \Rightarrow$ 363 MeV)





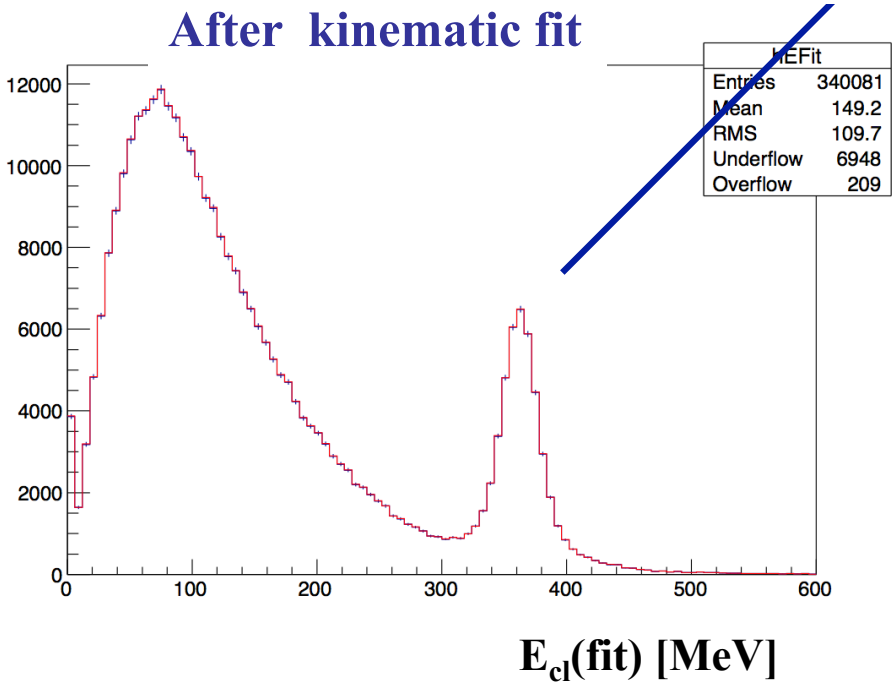




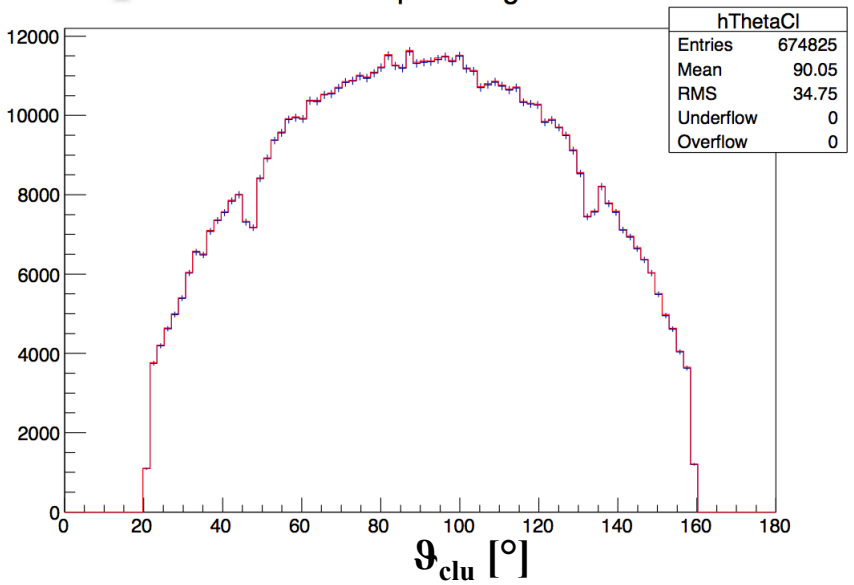
Neutral rad w/ $N_{prompt} > 5$ clusters

January 2016

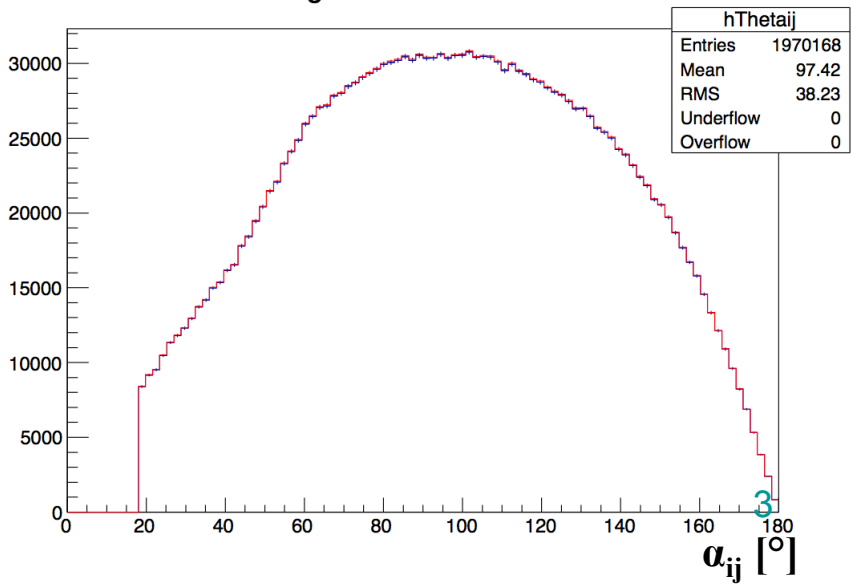
After kinematic fit



Cluster polar angle



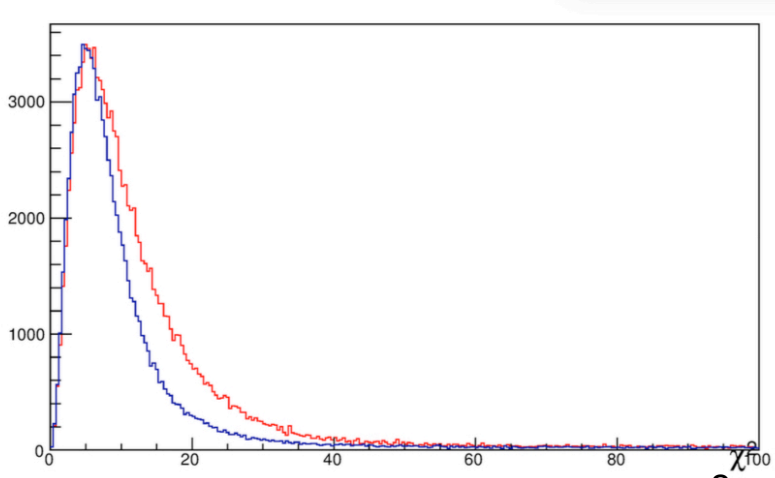
Angle between clusters

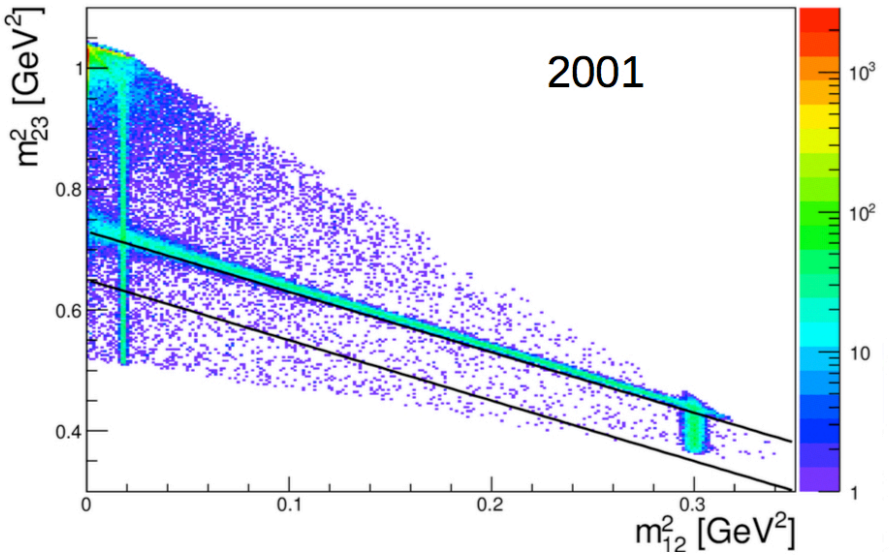


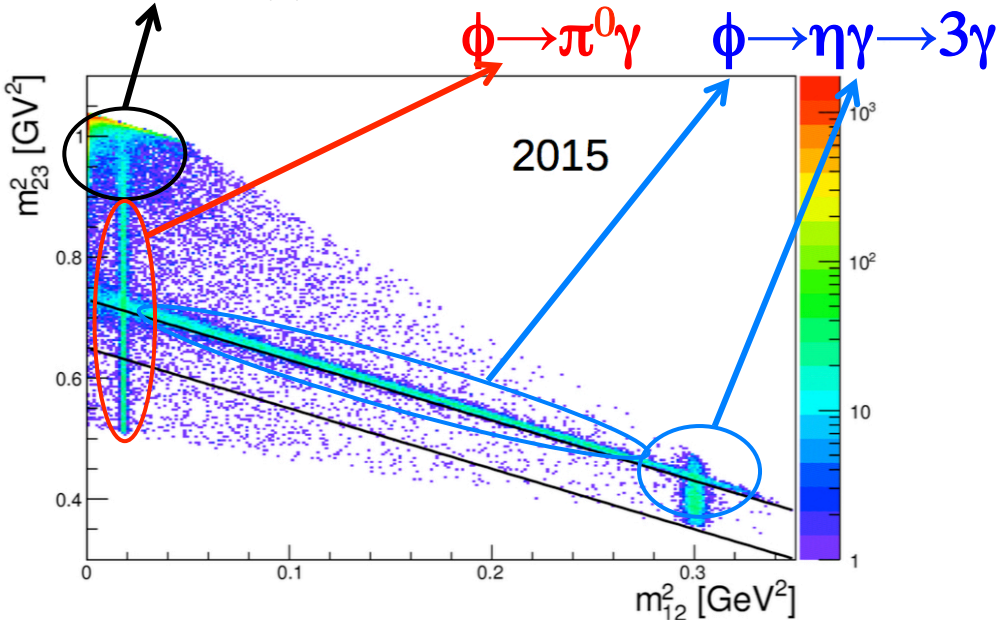
Data quality benchmark (2): $\phi \to \eta\gamma$ with $\eta \to \gamma\gamma$

Work in progress

- E1 < E2 < E3
- Kinfit $\chi^2 < 35$
- Cuts to select eta and pion peaks



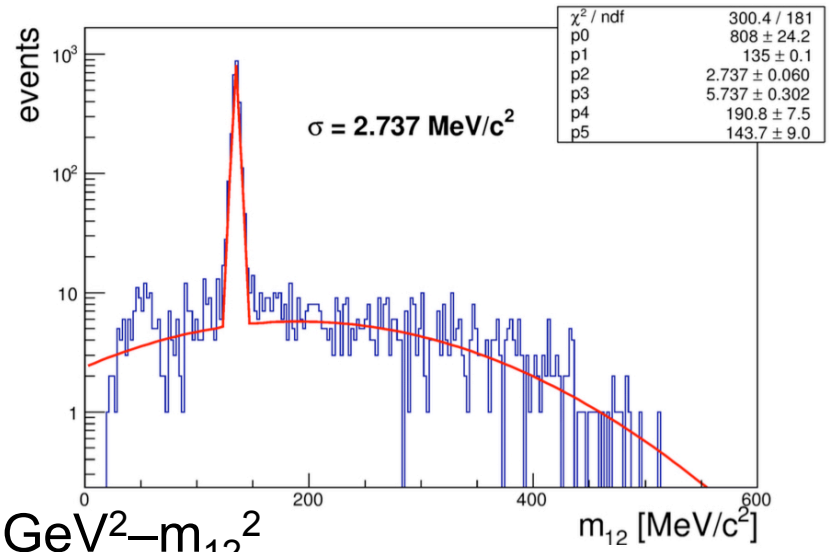




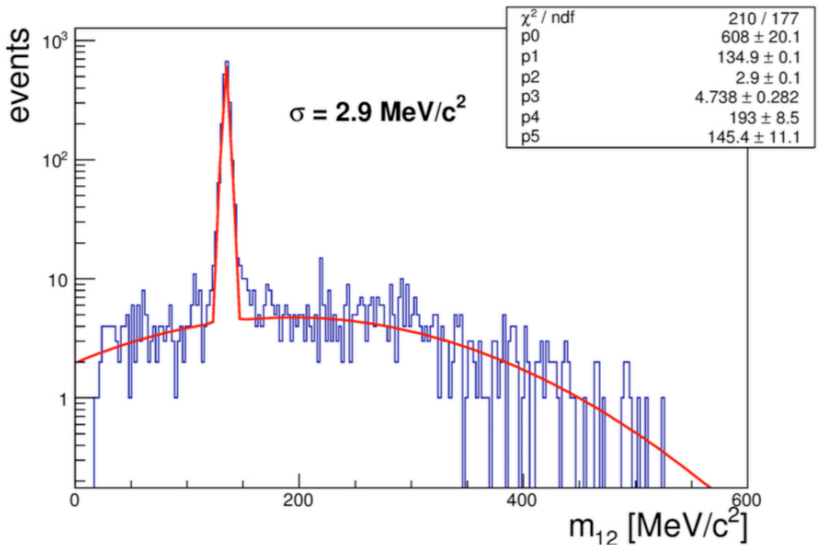
Data quality benchmark (2): $\phi \to \eta\gamma$ with $\eta \to \gamma\gamma$

Work in progress

2001

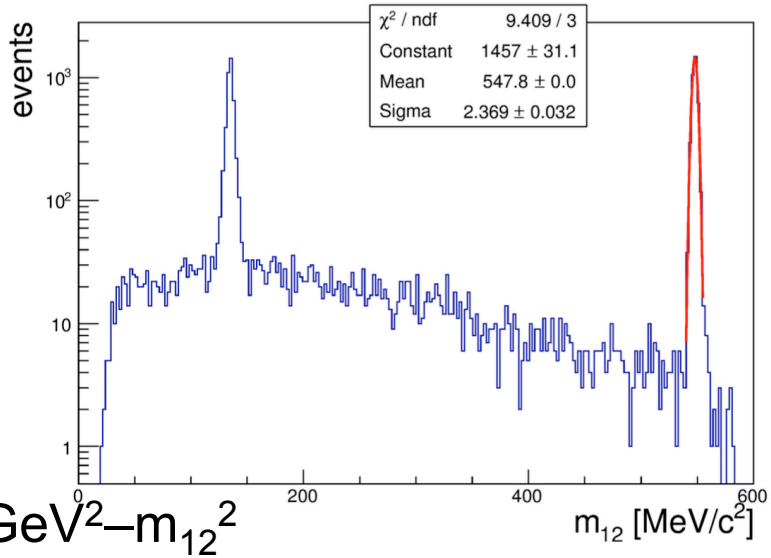


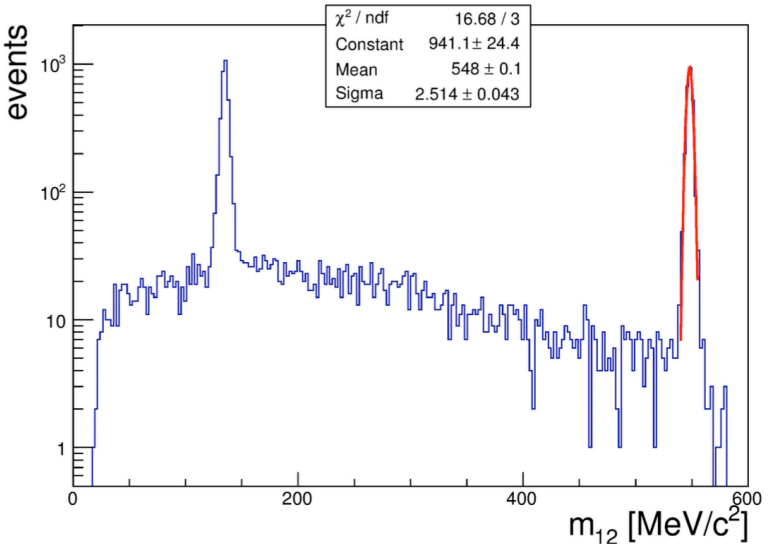
2015



π^0 peak

$m_{23}^2 < 0.65\ \text{GeV}^2 - m_{12}^2$





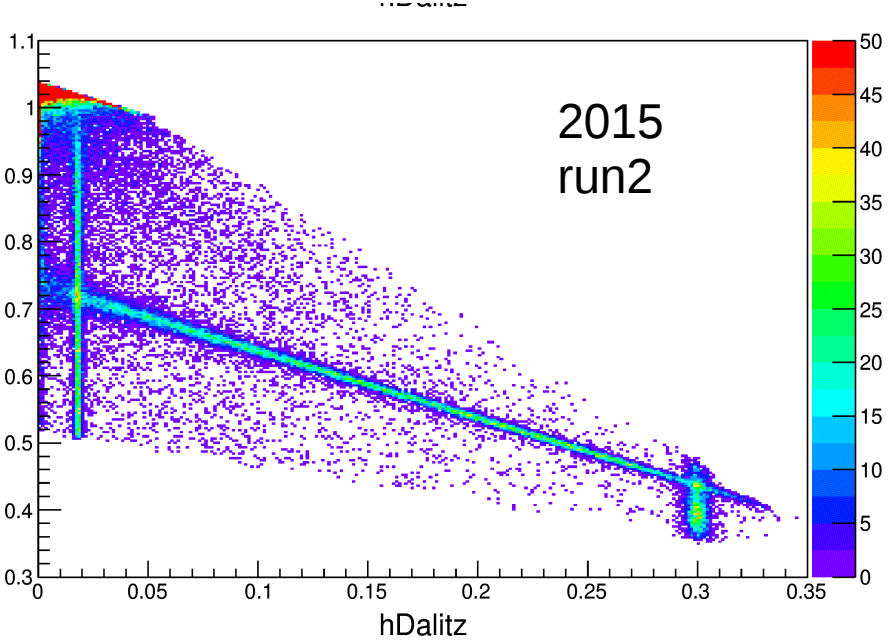
η peak

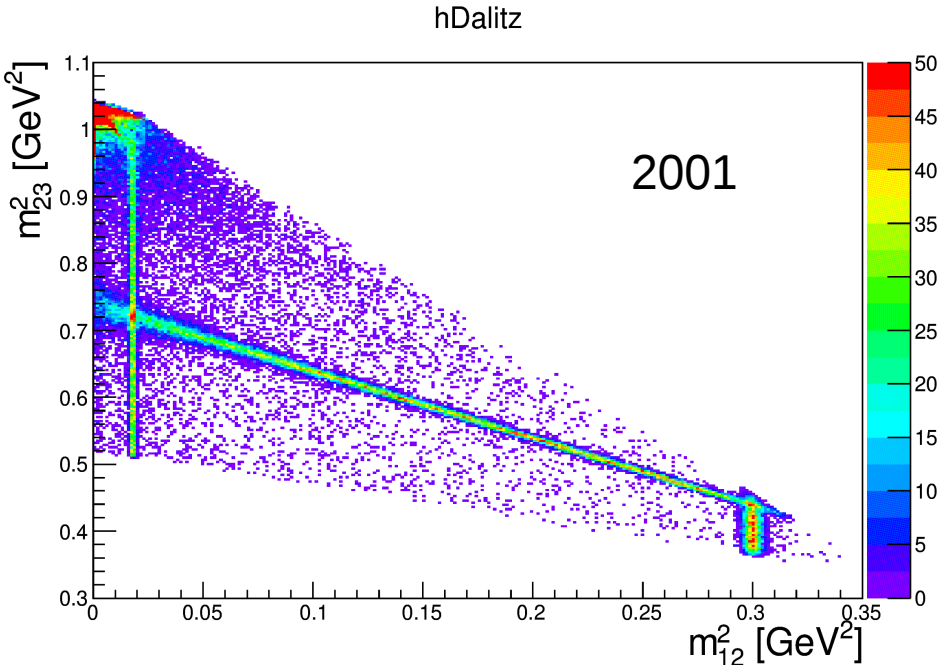
$m_{23}^2 < 0.73\ \text{GeV}^2 - m_{12}^2$

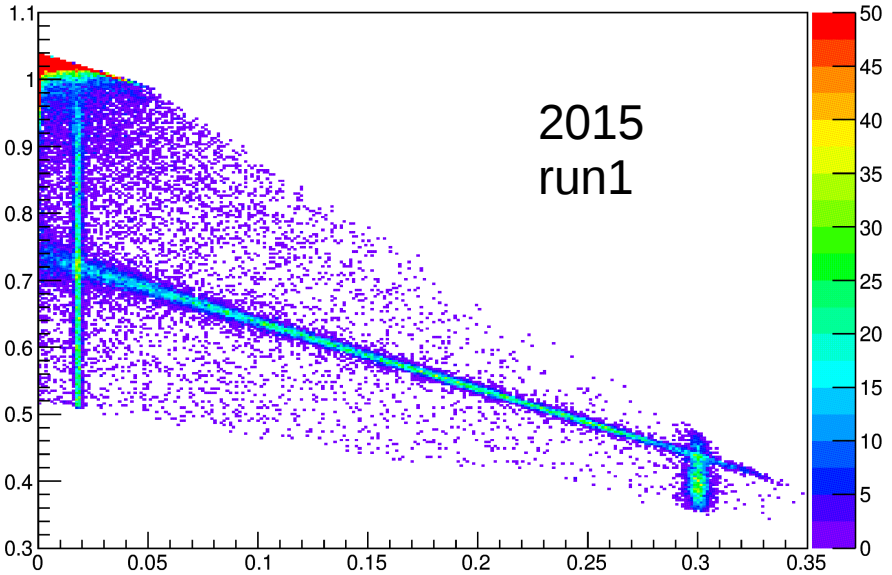
Data quality benchmark (2): $\phi \to \eta\gamma$ with $\eta \to \gamma\gamma$

- E1 < E2 < E3
- Kinfit χ^2 < 35

  (as in km333)
- Cuts to select eta and pion peaks

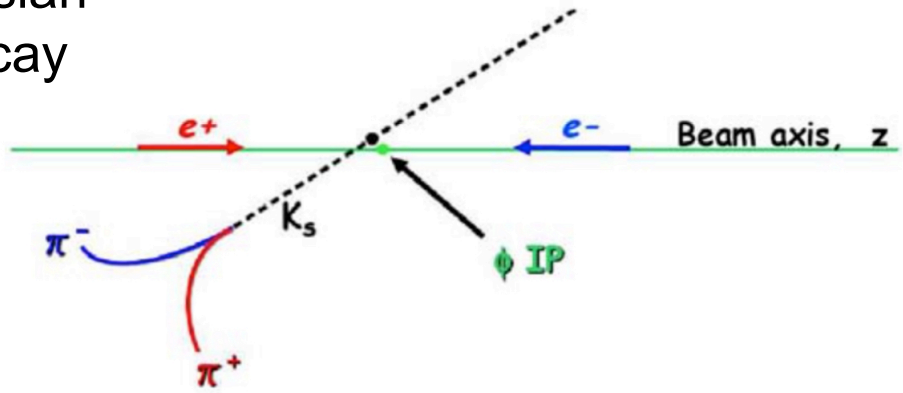


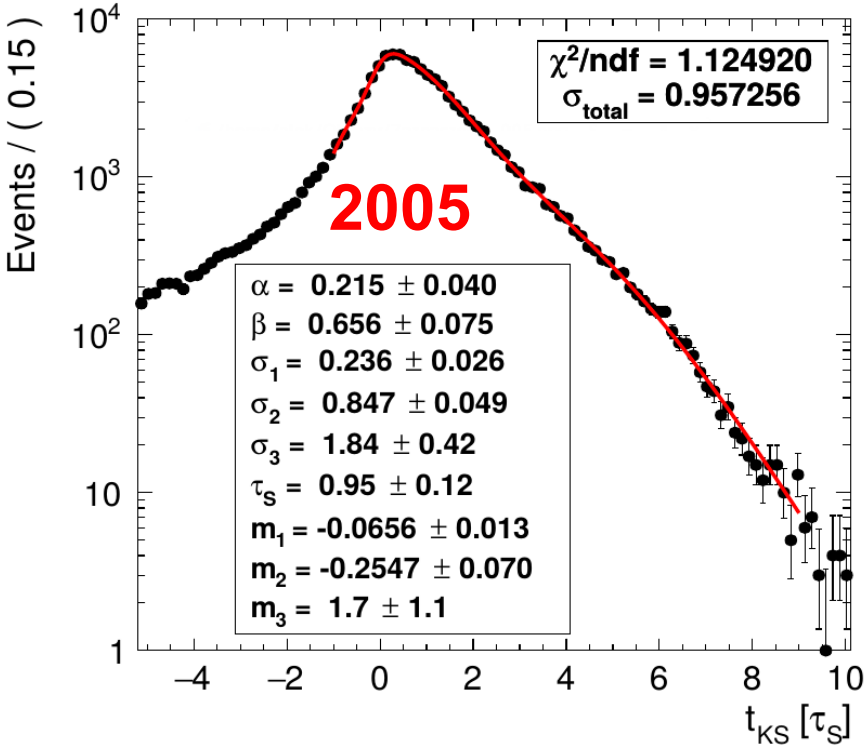


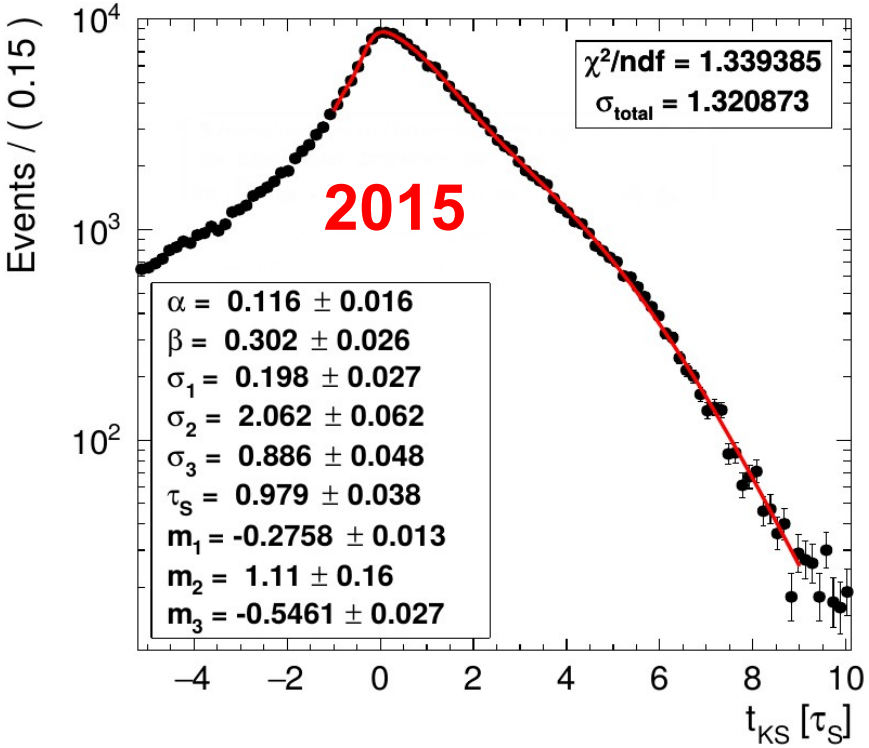


Data quality benchmark (3): K_S lifetime with $K_S \to \pi^+\pi^-$

- Exponential function folded with a triple gaussian
- Time calculated from the projection of the decay length on the KS momentum direction (negative tail due to resolution)
- Better resolution and efficiency expected from IT tracking

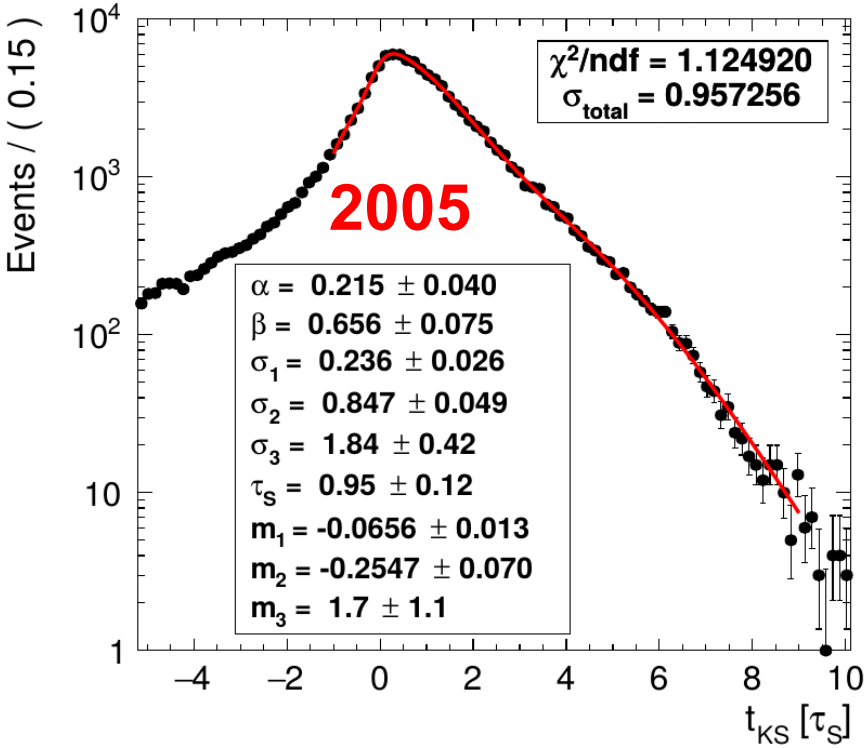


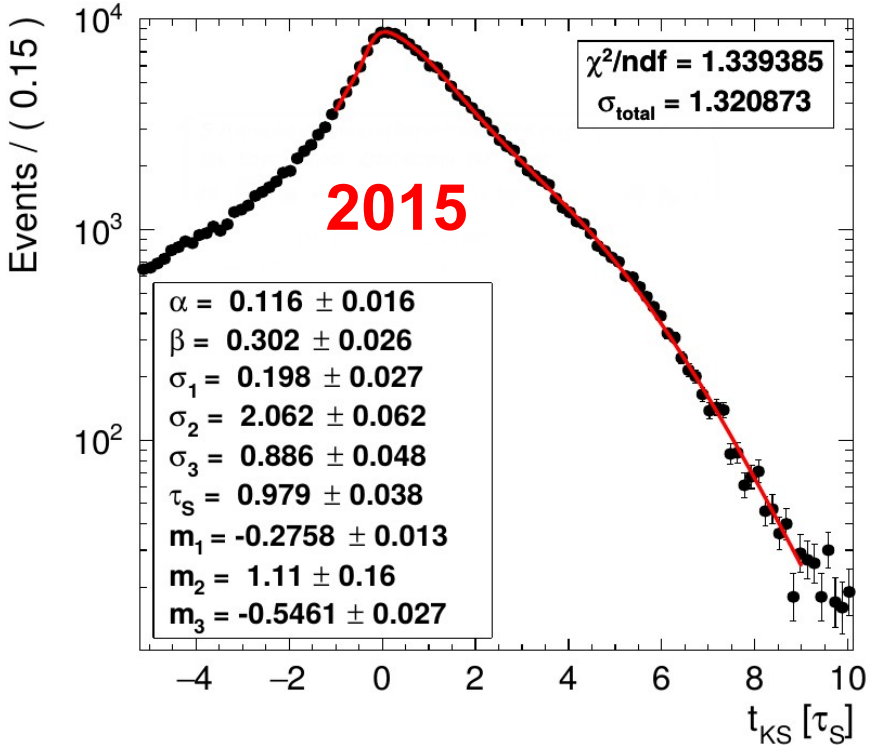




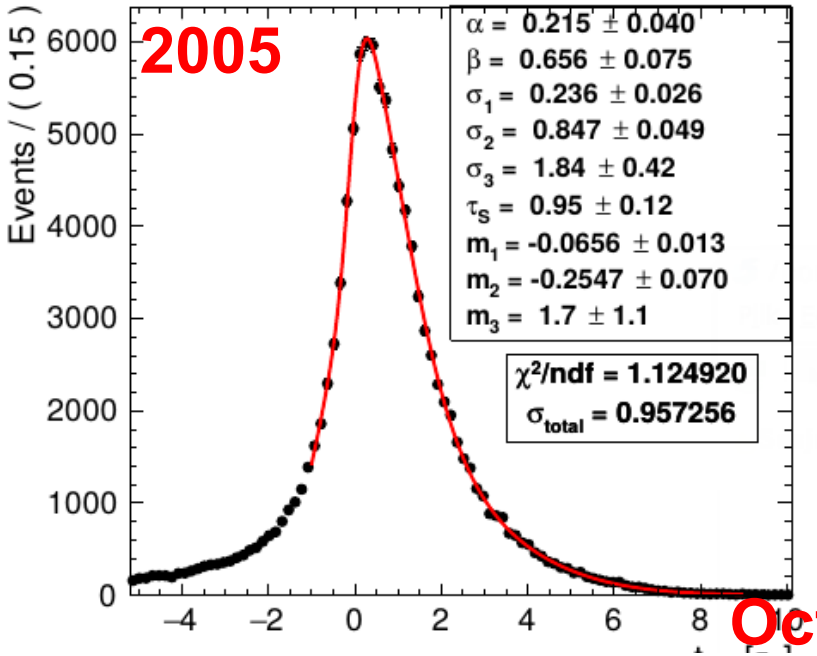
Data quality benchmark (3): K_S lifetime with $K_S \to \pi^+\pi^-$

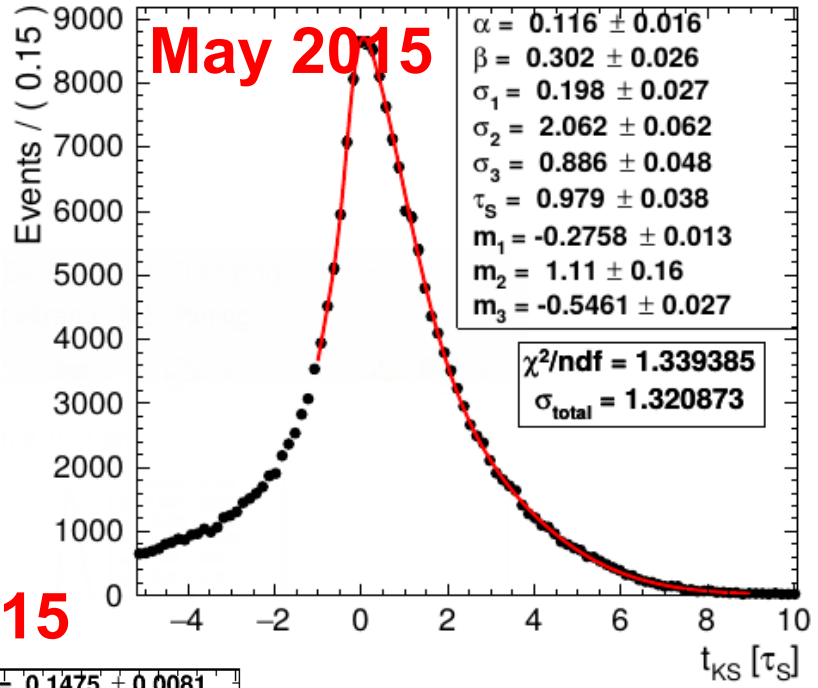
	2005	2015
χ^2/ndf	1.12	1.34
σ_{TOT} (τ_S)	0.96 ± 0.16	1.32 ± 0.05
K_S lifetime (τ_S)	0.95 ± 0.12	0.979 ± 0.038

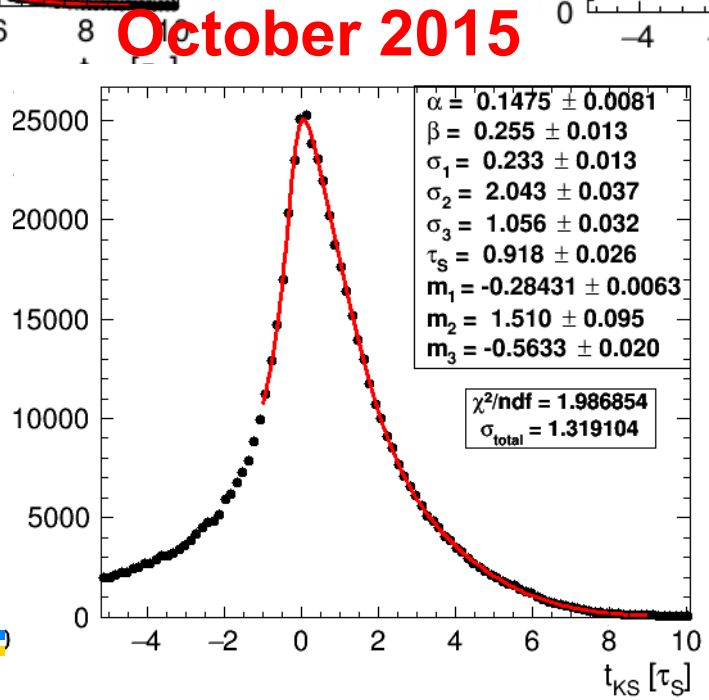




Data quality benchmark (3): K_S lifetime with $K_S \to \pi^+\pi^-$

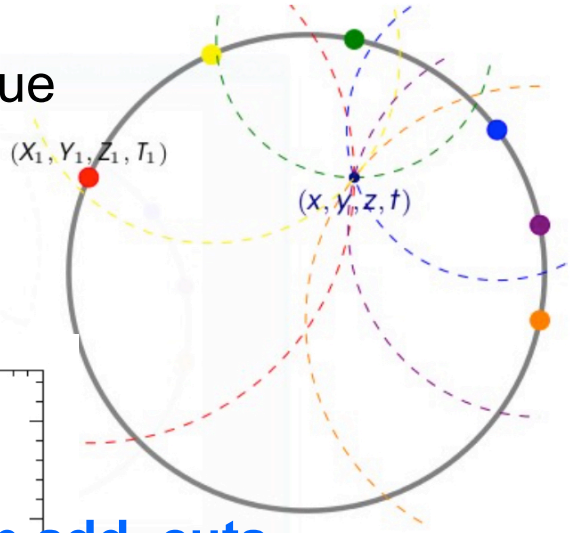


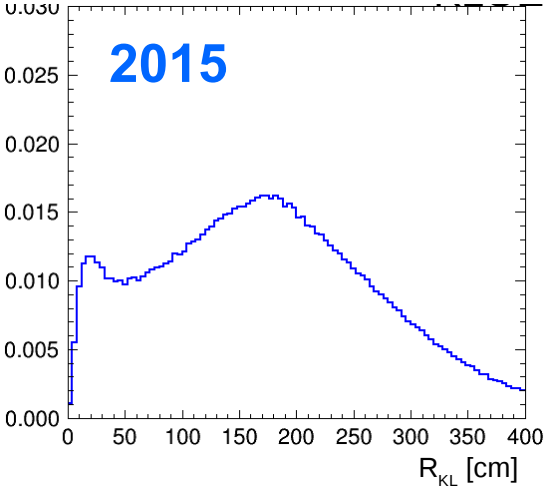


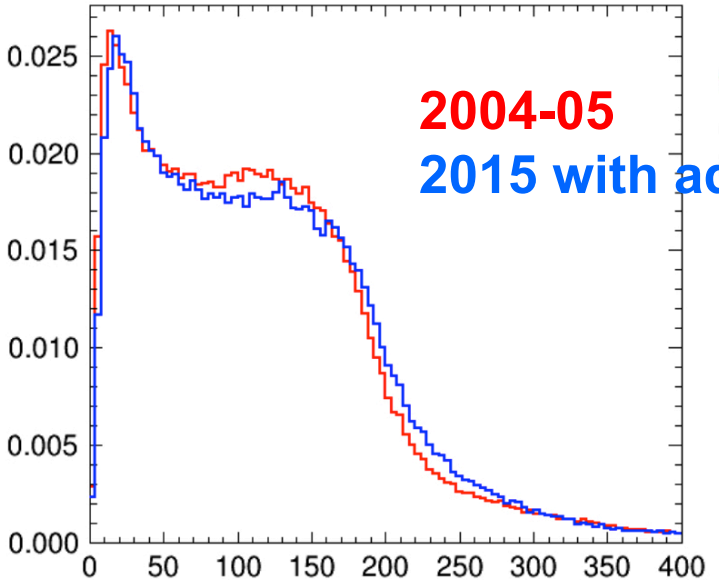


Data quality benchmark (4): $K_L \to 3\pi^0$

- New method to recostruct the $K_L \to 3\pi^0$ decay vertex inside the drift chamber volume by using a "GPS" technique (and without a K_L tag from $K_S \to \pi^+\pi^-$)
- Additional cuts to reject background:
  θ in [20,160] deg and t_{last}-t_{first} < 15 ns
- First step to select:
  $K_L \to 3\pi^0$, $K_S \to \pi l \nu$







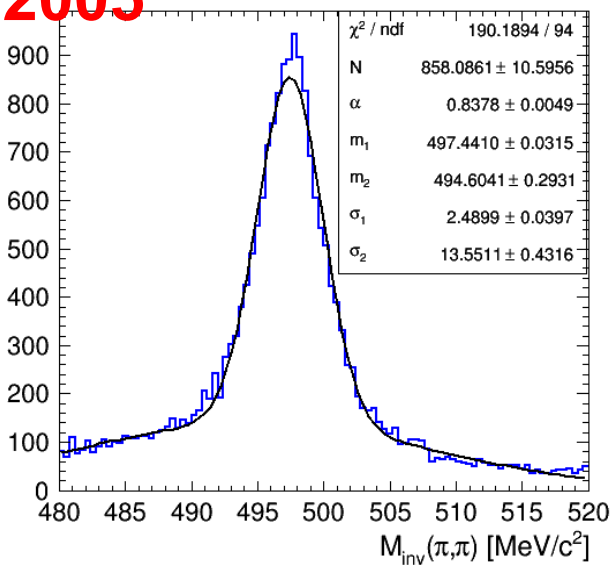
Work in progress

- This is a key ingredient for testing CPT symmetry in transition processes (never done before and possible only at KLOE)

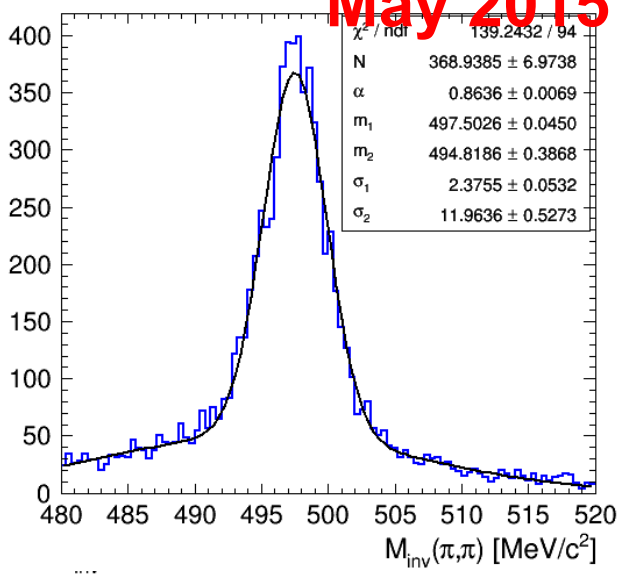
J. Bernabeu, A.D.D., P. Villanueva: JHEP 10 (2015) 139

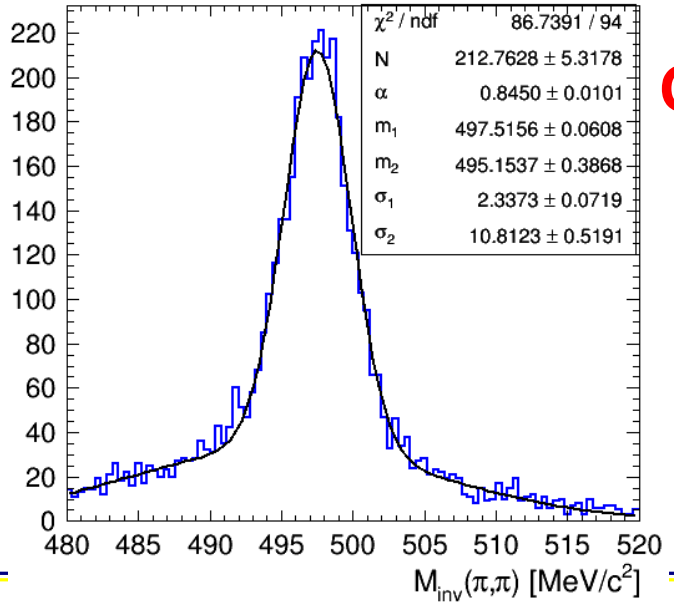
Data quality benchmark (5): $K_L \to \pi^+\pi^-$

2005



May 2015



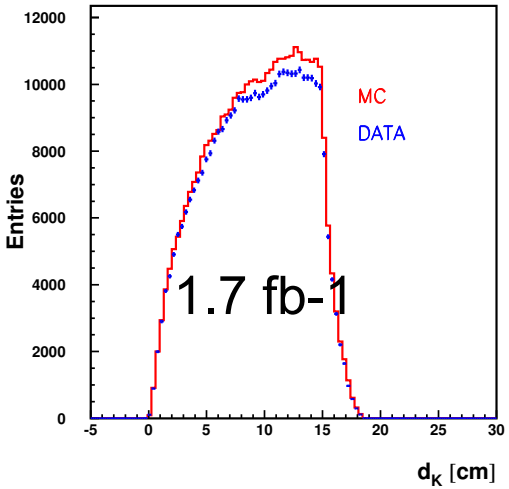


October 2015

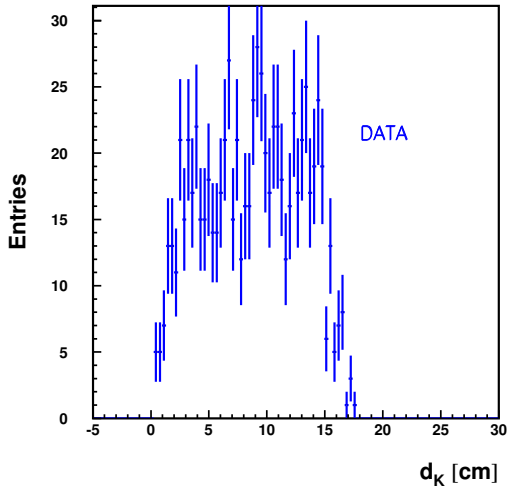
KLe3

$$\phi \rightarrow K_S K_L \rightarrow \pi^0 \pi^0 \pi e \nu$$

KL decay close to the IP

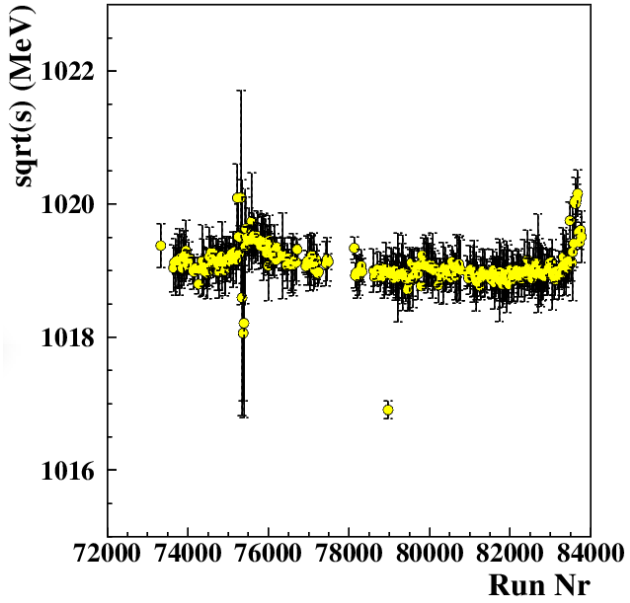


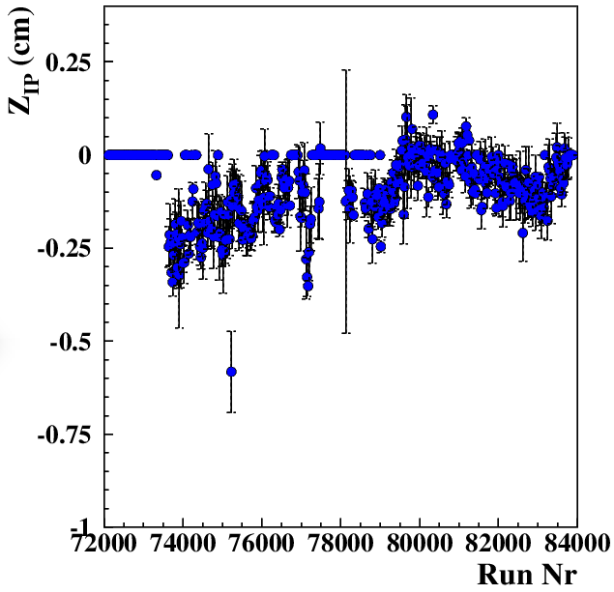
⇑ **KLe3 04-05**



⇑ **KLe3 2016**

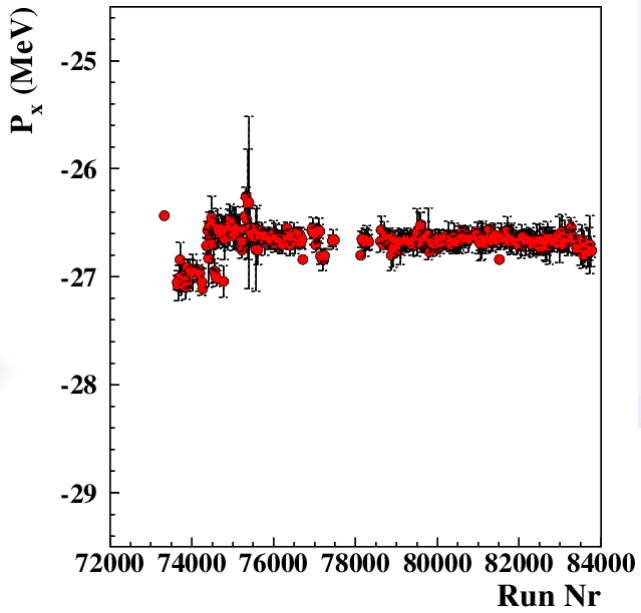
Data taking monitoring: few examples

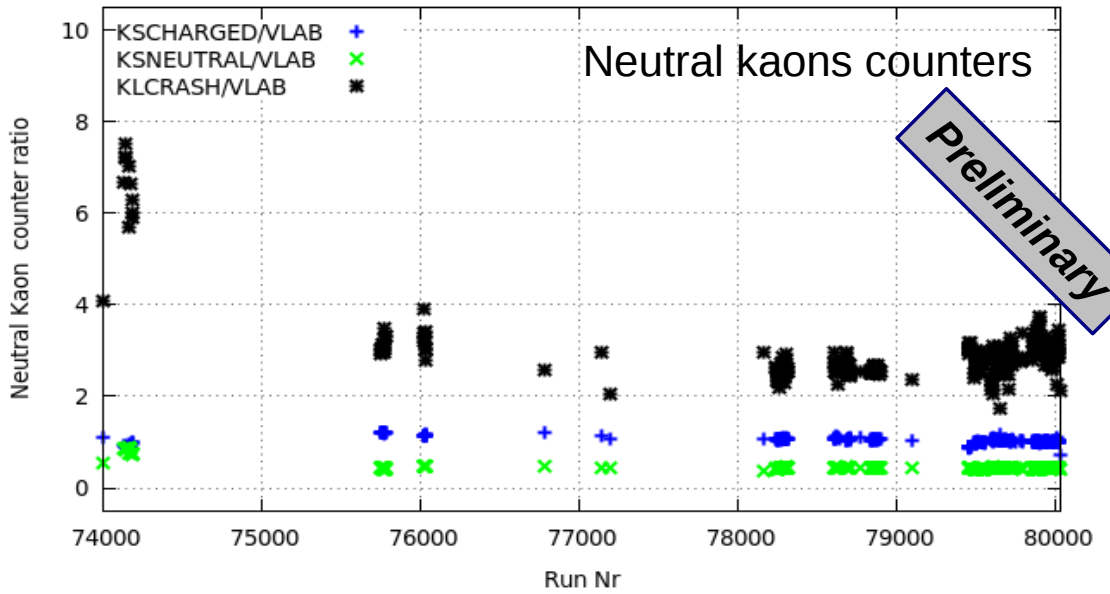




Beam parameters are constantly monitored also for DAFNE feedback

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





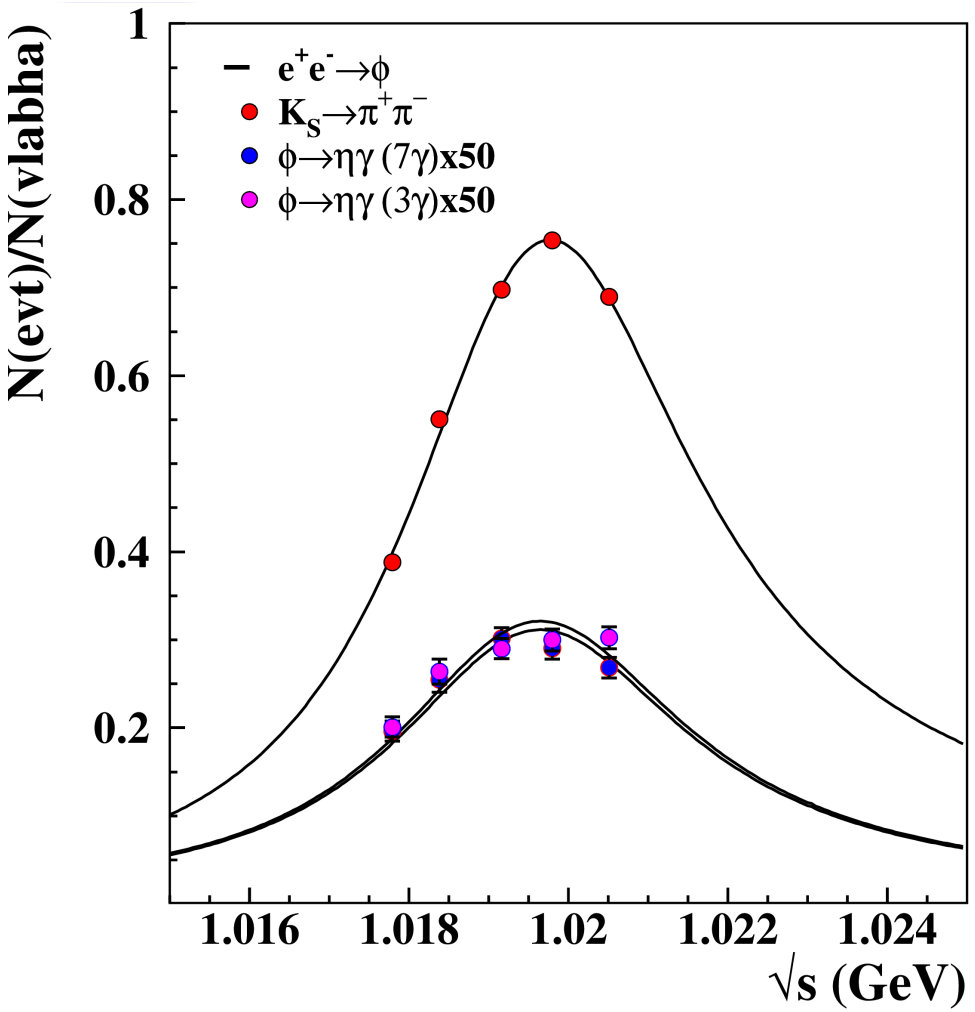
Data analysis: energy scan

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

Event counts normalized with very large angle Bhabha scattering events used to measure the luminosity.
Fit includes all the energy dependence in the line shape, radiative correction and beam energy spread (300 keV).
Free parameters: absolute normalization for each decay channel and the ϕ mass.

Conclusions:
KLOE absolute $\sqrt{s}$ fine calibration: -240 keV

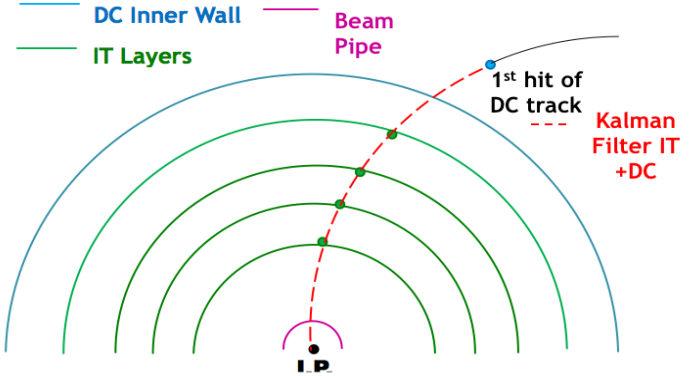
DAFNE: $\sqrt{s}$ has been shifted by +550 keV to run exactly on ϕ peak



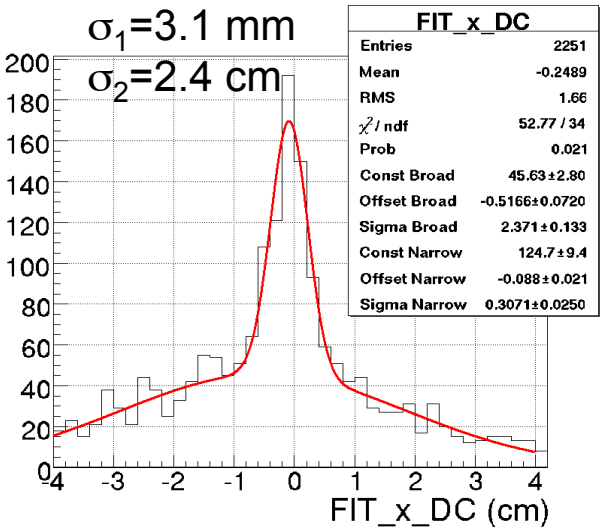
$$MAX(N(K_S \rightarrow \pi^+\pi^-))_{\phi LS} \Rightarrow \sqrt{s} = 1019.75\text{MeV}$$

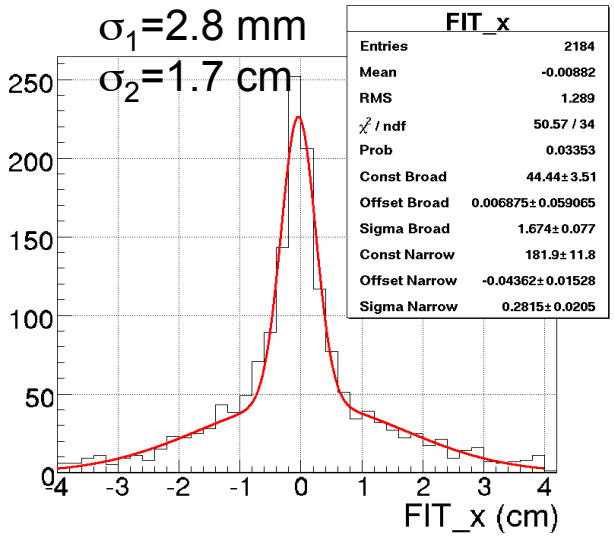
Integrated IT+DC tracking

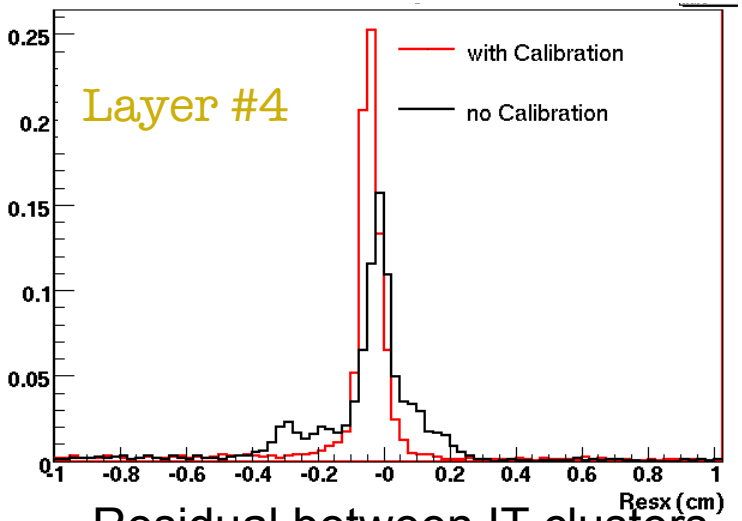
- Starting with DC tracks
- IT Clusters reconstructed are added
- IT+DC Kalman filter
- Updating track parameters
- Bhabha scattering events used as benchmark



- Using the first IT calibration, first comparison between IT+DC and DC vertex

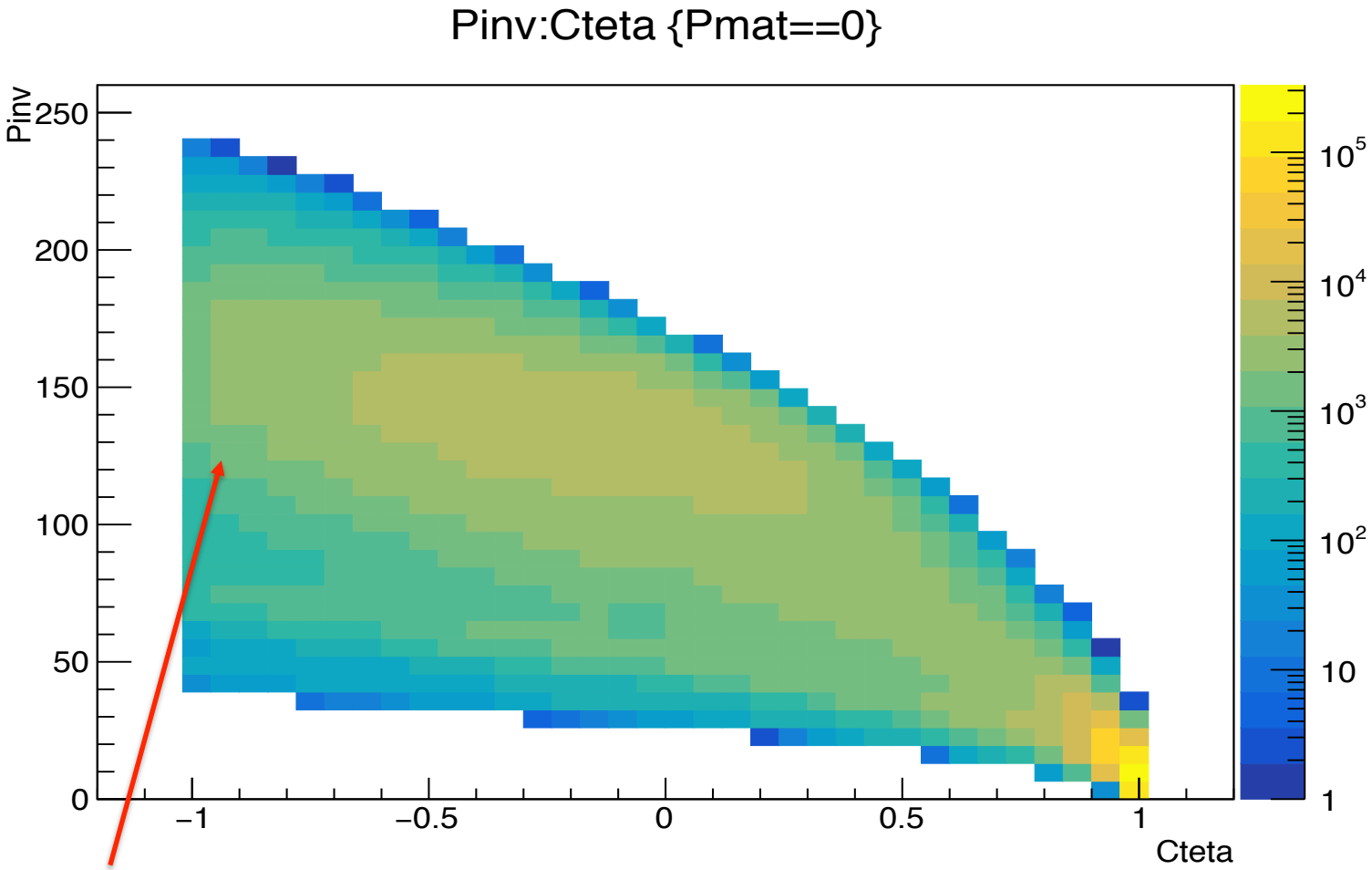






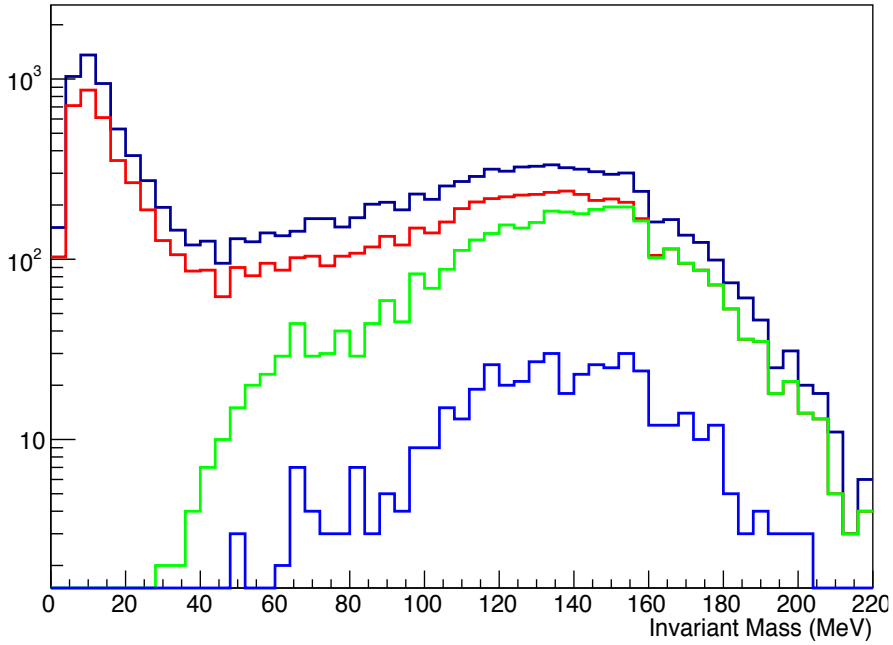
- Residual between IT clusters and expected position from Kalman w/wo Calibration

After rejection of Tracks …



We are interested at $\cos(\theta_{\gamma\gamma}) \sim -1$ which correspond to the decay of π^o at rest

Search for π^0 production – Double-Arm Tagging

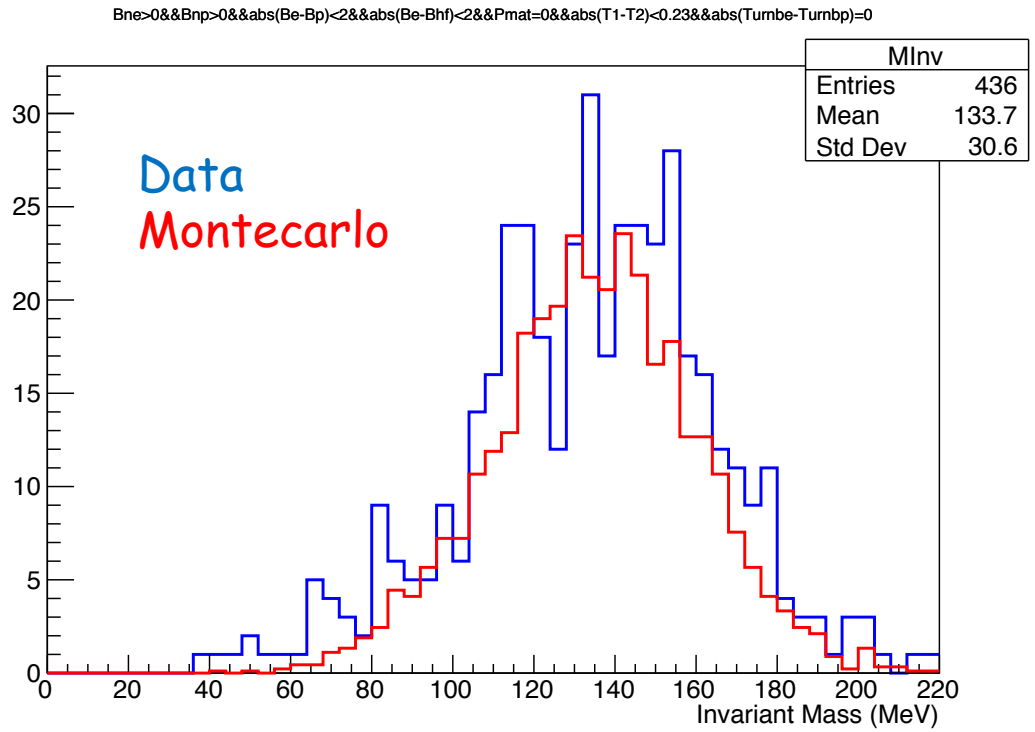


Cut Used :

ΔHET=1	: 12905 evs
No Tracks	: 8733 evs
$\cos(\theta_{12}) < 0$	: 3481
$\Delta(T_1-T_2) < 230$ ps	: 693

G. Rolandi question :
The last cut rejects π^0 decay far from IP:
first attempt to reject π^0 from K_L

First Attempt : Preliminary !!!



In this plot a preliminary attempt to reduce the K_S background is done

Reconstruction campaign could not have started before the arrival
of the new tape library (archiving data since 24th March 2016)
(new disk array in 2 weeks from now, necessary with 4 drives only)

Lesson from old KLOE (just to know…)
KLOE (04/05) started around March 04 with the same experimental setup as for the 01/02 data taking campaign.
KLOE (04/05) data online reconstruction started on April, 29 2004 with reconstruction version #19 ending on 26/04/2007 with the full reprocessing with reconstruction version #26. Meanwhile some MC was produced to study and compare the new data with some “controlled sample”.
First publication with 04/05 data: Jul 2007 (LP07 conference contributed papers) and Dec 2007 (JHEP KS->$\gamma\gamma$).

KLOE-2 new detectors have a level of complexity comparable to the “old” main detectors. The IT is the first detector of this kind in operation at a collider.

KLOE-2 internal milestones

Version: 8 August 2015
Revised: 23 November 2015
Revised:23 May 2015

KLOE-2 milestones

DATA QUALITY
Data quality benchmark
- (neutral channel) phi->(eta->3pi0) gamma (September 2015) done
- (charged channel) Ks->pi+pi- (September 2015) done
- continuous data quality monitor (all the run)

TAGGERS
- Preliminary calibration studies of HET with radiative Bhabha events (December 2015) done
- Preliminary study of e+e- -> e+e- X process with X=pi0 (June/July 2016)

DATA REDUCTION
Implementation of a filter based on bunch crossing identification to reject machine background
- Finalization of the studies (January 2016)
- Implementation of the filter (April 2016) lower priority

INNER TRACKER
- First alignment and calibration set with cosmic rays with magnetic field (November/December 2015) done
- First alignment and calibration set with Bhabha scattering events with integrated tracking DC+IT (February 2016) done
- Preliminary studies on vertices with integrated tracking DC+IT (March/April 2016) done
- Implement a first version of data reconstruction with IT (September 2016 at the restart of data taking after Summer shutdown)
- Measurement of the resolution of vertices close to IP; Ks--> pi+pi-; Phi--> pi+pi-pi0 etc (end of october 2016)

QCALT
- First calibration set with cosmic rays (December 2015) possible delay done

REVISION OF PHYSICS PROGRAM
- Establish DAFNE milestones in terms of delivered luminosity and allowed background (September 2015) done
- Preliminary prioritized plan of physics analyses (November 2015)
e.g. Preliminary results on e+e- -> e+e- pi0 with the first 2 fb-1 (December 2016)
e.g. Preliminary results on KSKL->pi+pi-pi+pi- with the first 2 fb-1 (February 2017)
- Organization of a KLOE-2 Physics workshop (March 2016) to be postponed in Summer 2016 fixed for 26-28 October 2016

COMPLETION OF ADVANCED ANALYSES WITH OLD KLOE DATA
- Dalitz plot of decay eta->pi+pi-pi0 (June 2016) published

- Ks -> pi e nu and semileptonic charge asymmetry (CPT test) (December 2016)
- Vacuum polarization contribution and running of alpha_QED with e+e-->mu+mu-gamma (December 2016)

FOCUS

- Implement a first version of data reconstruction with IT (September 2016 at the restart of data taking after summer shutdown)

- Measurement of the resolution of vertices close to IP; Ks--> pi+pi-; Phi--> pi+pi-pi0 etc (end of october 2016)

- Preliminary results on KSKL->pi+pi-pi+pi- with the first 2 fb-1 (February 2017)

- Preliminary study of e+e- -> e+e- X process with X=pi0 (June/July 2016)
- Preliminary results on e+e- -> e+e- pi0 with the first 2 fb-1 (December 2016)

Manpower issue

(difficulties due to next “concorso”)