KLOE-2 news from CSN1

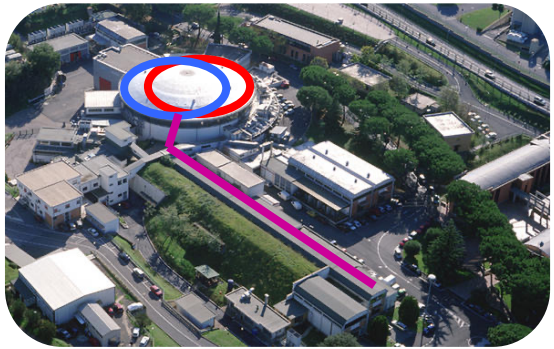
Erika De Lucia
on behalf of KLOE-2 Collaboration

DAφNE & KLOE-2

- DAφNE Frascati φ-factory: an e^+e^- collider @ $\sqrt{s}$ =1019.4 MeV = M_φ and with crab-waist sextuples configuration

  Best performance in 2018:

  - $L_{peak} = 2.28 \times 10^{32}\ cm^{-2}s^{-1}$
  - $\int Ldt = 14.3\ pb^{-1}$/day delivered

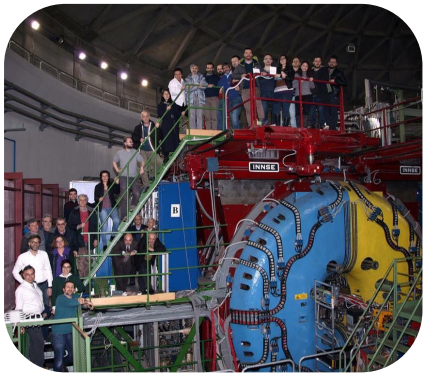


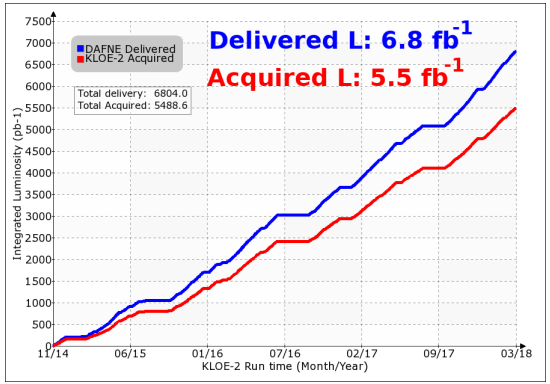
- KLOE-2 integrated 5.5 fb^{-1} @ $\sqrt{s}=M_\varphi$ (2014-18)

Physics with the KLOE-2 experiment at the upgraded DAΦNE [EPJC 68 (2010)]

- Ks, η rare decays & hadron physics
- Interferometry & Symmetries
- Dark photon search

KLOE+KLOE-2 data set largest sample ever collected at ϕ-meson peak





KLOE-2 Collaboration and Chart

- KLOE-2 is a small collaboration among Italian – Polish – Swedish and Russian research institutes & universities
- Physics WG convenorship and Analysis Board & Offline responsibilities are shared between Italian (INFN/not-INFN) and non-Italian colleagues

The KLOE-2 collaboration

D. Babusci,[c] M. Berlowski,[u] C. Bloise,[c] F. Bossi,[c] P. Branchini,[r] A. Budano,[q,r] B. Cao,[t] F. Ceradini,[q,r] P. Ciambrone,[c] F. Curciarello,[i,j] E. Czerwiński,[b] G. D'Agostini,[m,n] R. D'Amico,[m,n] E. Danè,[c] V. De Leo,[m,n] E. De Lucia,[c] A. De Santis,[c] P. De Simone,[c] A. Di Cicco,[q,r] A. Di Domenico,[m,n,1,2] E. Diociaiuti,[c] D. Domenici,[c] A. D'Uffizi,[c] A. Fantini,[o,p] G. Fantini,[m,n] P. Fermani,[c] S. Fiore,[s,n] A. Gajos,[b] P. Gauzzi,[m,n] S. Giovannella,[c] E. Graziani,[r] V.L. Ivanov,[f,g] T. Johansson,[t] X. Kang,[c,v] D. Kisielewska-Kamińska,[b] E.A. Kozyrev,[f,g] W. Krzemien,[u] A. Kupsc,[t] P.A. Lukin,[f,g] G. Mandaglio,[e,a] M. Martini,[c,l] R. Messi,[o,p] S. Miscetti,[c] D. Moricciani,[c] P. Moskal,[b] A. Passeri,[r] V. Patera,[k,n] E. Perez del Rio,[m,n] P. Santangelo,[c] M. Schioppa,[i,j] A. Selce,[q,r] M. Silarski,[b] F. Sirghi,[c,d] E.P. Solodov,[f,g] L. Tortora,[r] G. Venanzoni,[h] W. Wiślicki[u] and M. Wolke[t]

Spokesman	A. Di Domenico (Sapienza Univ.)
Responsabile Nazionale	P. Gauzzi (LNF-INFN)
Analysis Board	P. Gauzzi (Sapienza Univ.-INFN) A. Kupsc (Uppsala Univ.)
Kaon Physics WG	E. De Lucia (LNF-INFN) E. Czerwinski (Jagiellonian Univ.)
Hadron Physics WG	F. Curciarello (CS-INFN) E. Graziani (RM3-INFN) G. Mandaglio (Univ. di Messina)
Offline WG	E. Perez del Rio (Jagiellonian Univ.) P. Gauzzi (Sapienza Univ.)

KLOE-2 Recent Achievements (I)

Precision tests of Quantum Mechanics and CPT Symmetry with Entangled Neutral Kaons at KLOE	**JHEP 04 (2022) 059** Most precise test of quantum coherence in an entangled system
Measurement of the KSe3 Branching Fraction with the KLOE experiment	Final result @ ICHEP2022 **Paper submitted to JHEP**
$\gamma^*\gamma^* \rightarrow \pi^0$ search with 3 fb^{-1} KLOE-2 data	Result @ ICHEP2022 Finalizing analysis =>6.5% precision
Direct test of T, CP, CPT Symmetries in Transitions of Neutral K mesons with the KLOE detector	Result @ ICHEP2022 - **Draft ready** First direct T test & CPT model independent test
B-boson search: Upper limit on $B \rightarrow \pi 0\ \gamma$ using $\phi \rightarrow \eta\ \pi 0\ \gamma$ final state with KLOE data	Result @ ICHEP2022
χPT Golden mode – $O(p^6)$ dominates: $BR(\eta \rightarrow \pi 0\ \gamma\gamma)$ with 1.7 fb^{-1} KLOE data	Final Result @ ICHEP2022
$e+e- \rightarrow \pi^+\pi^-\pi^0\gamma_{ISR}$: $Br(\omega \rightarrow e+e-) \times Br(\omega \rightarrow \pi+\pi-\pi 0)$ and cross-section @ $\omega(782)$ for (g-2) Hadronic Vacuum Polarization	Preliminary @ ICHEP2022

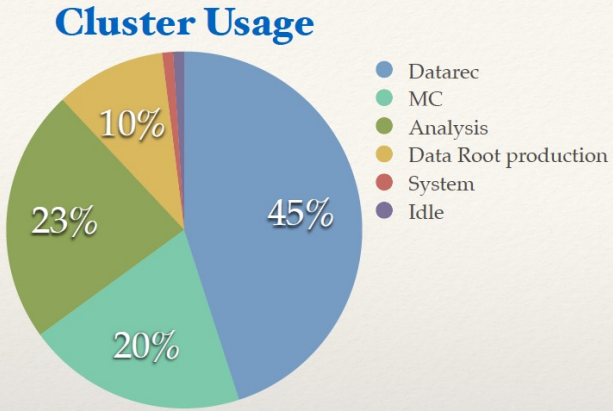
Italian contribution to all ongoing analysis: either as main author or as internal referee

KLOE-2 Recent Achievements (II)

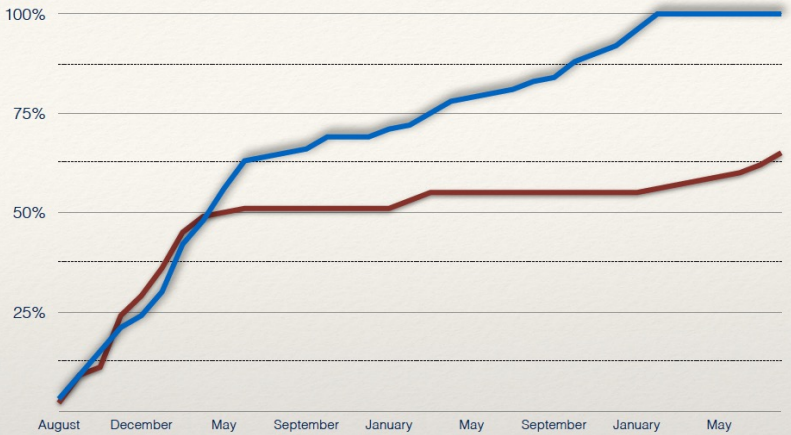
- 2nd round of Data Reconstruction completed with 5.1 fb^{-1}
- MC massive production completed with luminosity scale factor 1
- Root Output for Data Preservation
  - 3.5 fb^{-1} KLOE-2 Data available & to be completed by '22
  - ~ 8 compression factor DATAREC/ROOT (depending on run conditions)
  - Next: produce MC KLOE-2 root output files and then both KLOE Data-MC
  - 350-400 TB estimated for both KLOE and KLOE-2 root output
  - Plans: Keep root output files on disk to improve accessibility for future analysis within the collaboration and in view of Open Data
- Data Consolidation: migration from old to new IBM library completed

KLOE-2 Computing (I)

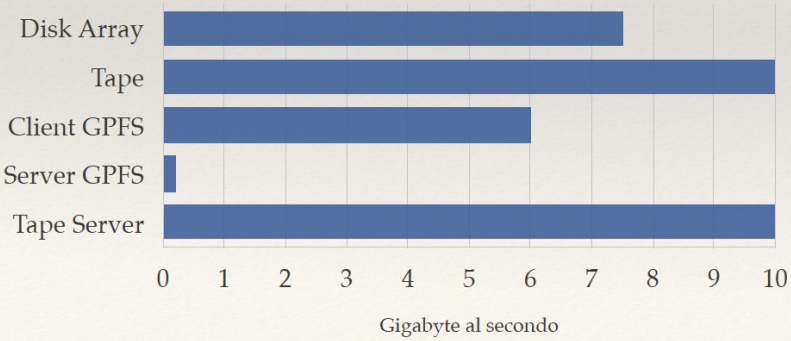
Situazione elaborazioni sul cluster KLOE



Status of Data Migration



Picco spostamento dati in Gygabyte/s su SAN

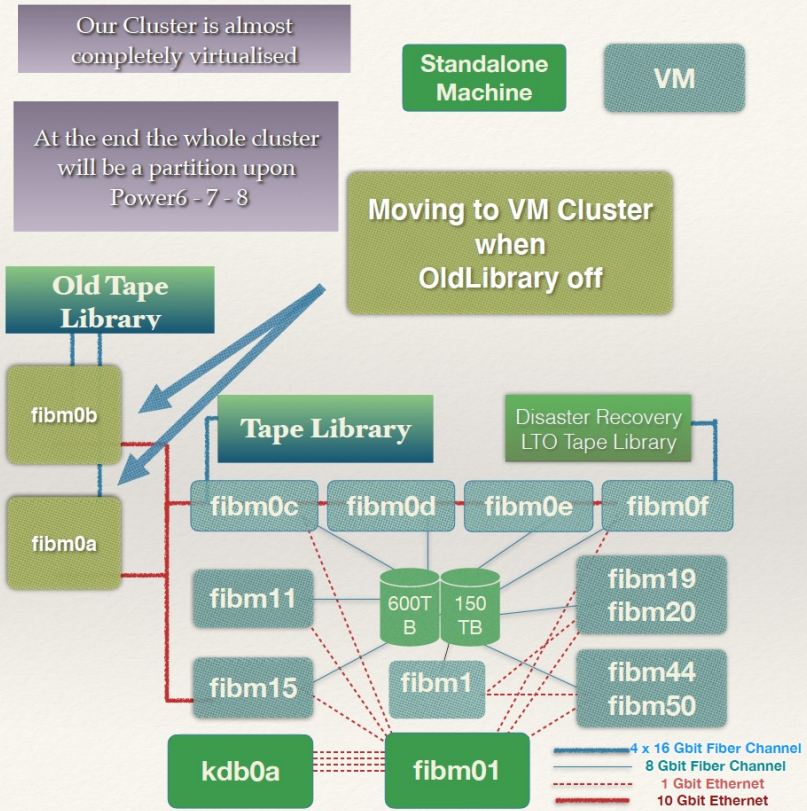


Data Preservation

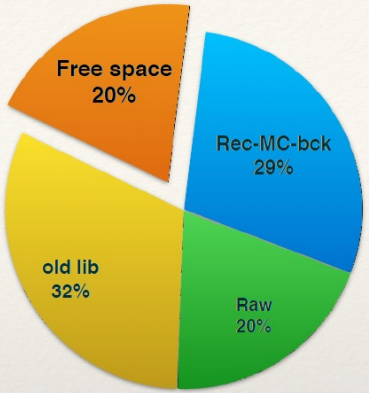
Data Migration

KLOE-2 Computing (II)

KLOE CED



Cartridges Status



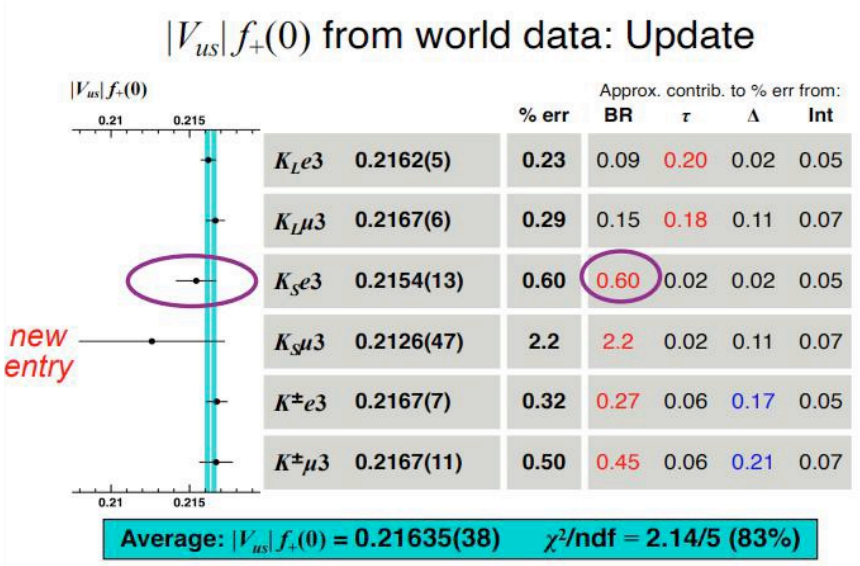
Overall reconstruction compression level 42 %

Free Space 2.2 Petabyte

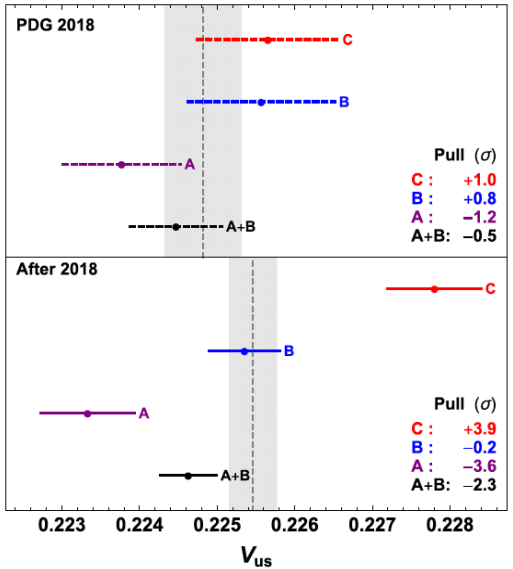
Tape Library Usage

Measurement of the KSe3 Branching Fraction with the KLOE experiment	Final result @ ICHEP2022 **Paper submitted to JHEP**

KSe3 decay and V_{us} extraction



M.Moulson and E.Passemar @ CKM 2021



EPJC80(2020)149

Possible deviation from unitarity of the CKM matrix 1st raw
[EPJC80(2020)113, EPJC80(2020)149]

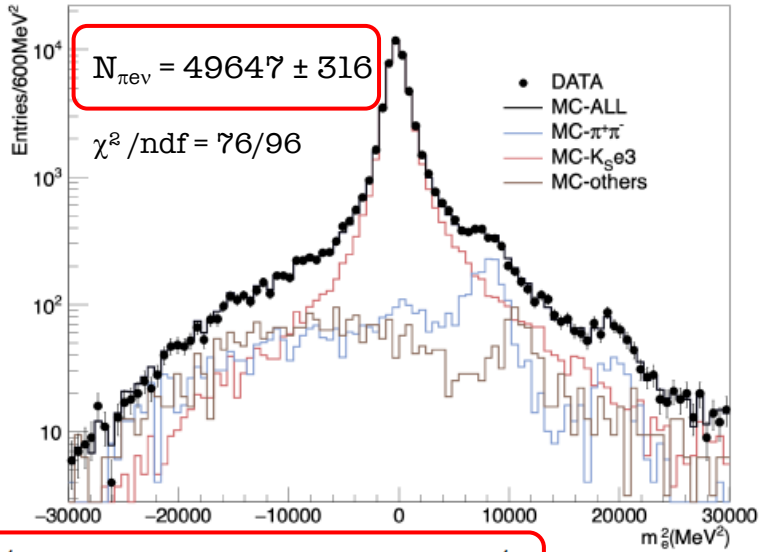
- Unique possibility to select pure K_S beam
- Present BR(KSe3) value dominated by the KLOE measurement with 0.4 fb^{-1} [PLB 636 (2006) 173]

$BR(K_S \to \pi e \nu) = (7.046 \pm 0.078 \pm 0.049) \times 10^{-4}$ 1.4% total uncertainty (1.1% stat ± 0.7% syst)

The Results

- Sample selected with BDT and TOF
- Signal count from fit to m_e^2 distribution

  $m_e^2 = (E_{KS} - E_\pi - p_{miss})^2 - p_e^2$ (E_{KS} and p_{KS} from KL-crash)



- Previous KLOE result: 0.4 fb^{-1} independent data sample

  [Phys. Lett. B 636 (2006) 173]

  $BR(K_S \to \pi e\nu) = (7.046 \pm 0.078 \pm 0.049) \times 10^{-4}$

  1.4% total uncertainty (1.1% stat ± 0.7% syst)

- New result with 1.63 fb^{-1}

$$\mathcal{B}(K_S \to \pi e\nu) = (7.211 \pm 0.046_{\text{stat}} \pm 0.052_{\text{syst}}) \times 10^{-4} = (7.211 \pm 0.069) \times 10^{-4}$$

arXiv.2208.04872

- Combination accounting for correlations:

$$\mathcal{B}(K_S \to \pi e\nu) = (7.153 \pm 0.037_{\text{stat}} \pm 0.043_{\text{syst}}) \times 10^{-4} = (7.153 \pm 0.057) \times 10^{-4}$$

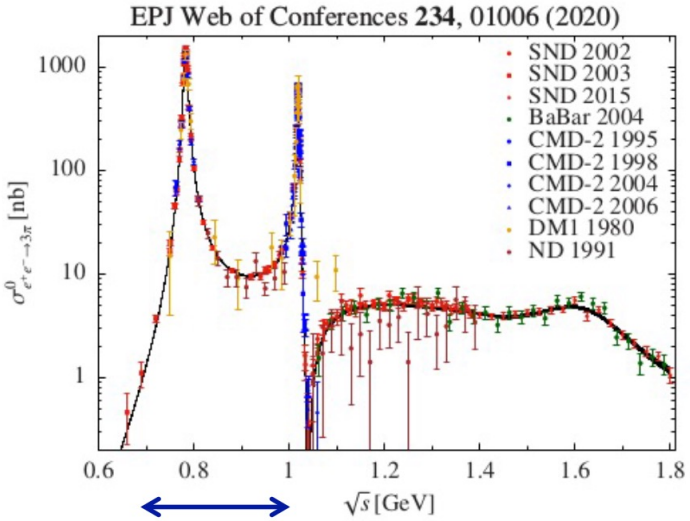
- Sizeable uncertainty reduction on: $f_+(0)|V_{us}| = 0.2170 \pm 0.0009$ 0.4% uncertainty

$e^+e^- \to \pi^+\pi^-\pi^0\gamma_{ISR}$: $Br(\omega \to e^+e^-) \times Br(\omega \to \pi^+\pi^-\pi^0)$ and cross-section @ ω(782) for (g-2) Hadronic Vacuum Polarization

Preliminary @ ICHEP2022

$e^+e^- \to \pi^+\pi^-\pi^0\gamma_{ISR}$

- $e^+e^- \to \pi^+\pi^-\pi^0$ is the second largest contribution to the calculation of the Hadronic Vacuum Polarization for $(g-2)_\mu$ and to its uncertainty
- Initial State Radiation (ISR) measurement at KLOE is complementary to energy scan in the range $\sqrt{s} < M_\phi$ (SND and CMD-2)



Goals:

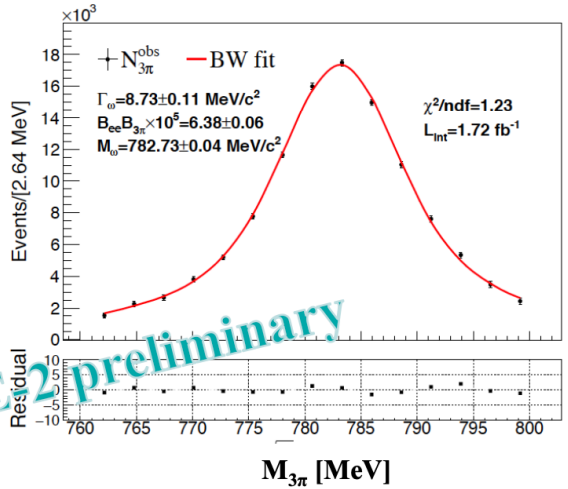
- Measure the cross section in the ω(782) region
- Evaluate the product $Br(\omega \to e^+e^-) \times Br(\omega \to \pi^+\pi^-\pi^0)$

$e^+e^- \to \pi^+\pi^-\pi^0\gamma_{ISR}$

- $L = 1.7\ fb^{-1}$ at ϕ peak

Selection:

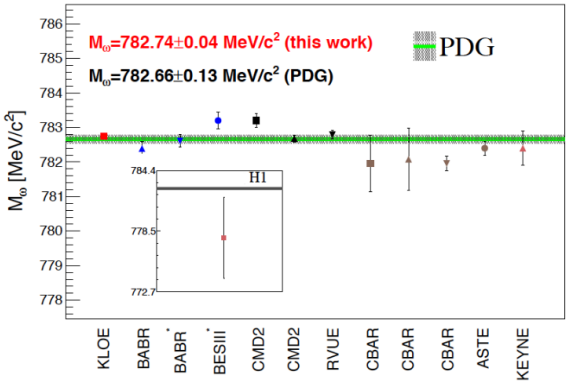
- At least 2 tracks with opposite curvature
- 3 neutral clusters
- Kinematic fit
- Fit with Breit-Wigner convoluted with smearing matrix
- ISR correction factor taken into account



KLOE results* compared with PDG

	M_ω [MeV/c²]	Γ_ω [MeV]	$\mathcal{B}_{ee}\times\mathcal{B}_{3\pi}$ [10^{-5}]
KLOE	782.73 ± 0.04	8.73 ± 0.11	6.38 ± 0.06
PDG	782.66 ± 0.13	8.68 ± 0.13	6.60 ± 0.16

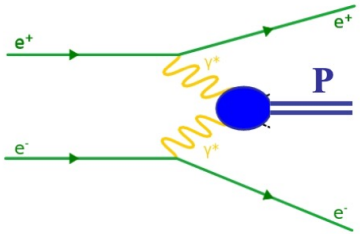
* Only stat. uncertainty



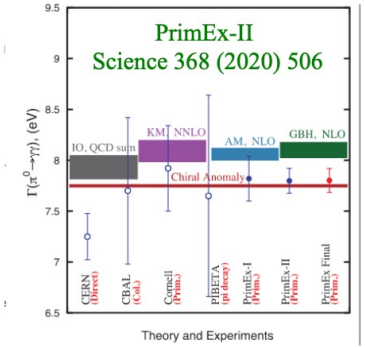
$\gamma^*\gamma^* \rightarrow \pi^0$ search with 3 fb^{-1} KLOE-2 data	Result @ ICHEP2022 Finalizing analysis =>6.5% precision

$\gamma^*\gamma^* \to \pi^0$

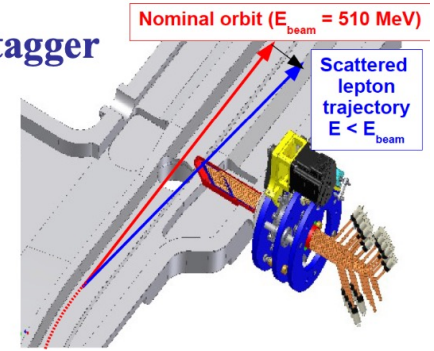
$$e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^-\mathbf{P} \quad [\mathbf{C(P) = +1}]$$



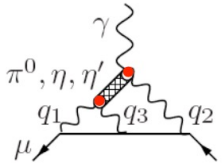
Goal: measurement of $\Gamma(\pi^0 \to \gamma\gamma)$ @ few % level



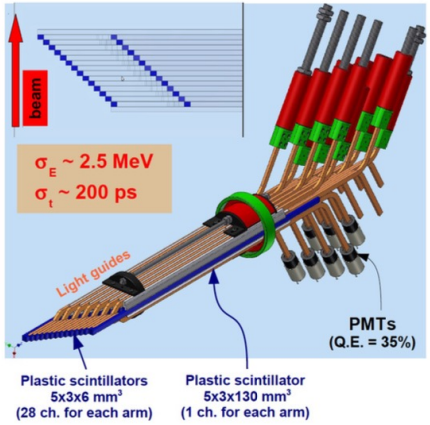
HET: e^+/e^- tagger



- **Transition Form Factor $\mathcal{F}_{\pi\gamma\gamma^*}(q^2,0)$ at space-like q^2 ($|q^2| < 0.1$ GeV^2), relevant for the Light-by-Light scattering contribution to $(g-2)_\mu$**



- **Bending dipoles of DAΦNE closer to IP act as spectrometers for the scattered e^+/e^- Strong correlation between E and trajectory**
- **Scintillator hodoscope + PMTs, inserted in Roman pots, pitch: 5 mm, ~ 11 m far from IP**



$\gamma^*\gamma^* \rightarrow \pi^0$

- HET is acquired asynchronously w.r.t. the KLOE-2 Trigger
- Synchronization with the "Fiducial" signal from DAΦNE (every 325 ns)
- HET signals corresponding to 2.5 DAΦNE revolutions are recorded for each KLOE trigger

$$\frac{\sigma_{\pi^0}}{\sigma_{\mathrm{Bha}}} = \frac{N^{\mathrm{meas}}_{\pi^0}}{\epsilon_{\mathrm{ana}}\, N^{\mathrm{meas}}_{\mathrm{Bha}}} \frac{A_{\mathrm{Bha}}}{A_{\pi^0}}$$

$$N^{\mathrm{meas}}_{\mathrm{Bha}} = \sigma^{\mathrm{meas}}_{\mathrm{Bha}} \int \mathrm{Ldt}$$

from KLOE online

measured at few % level

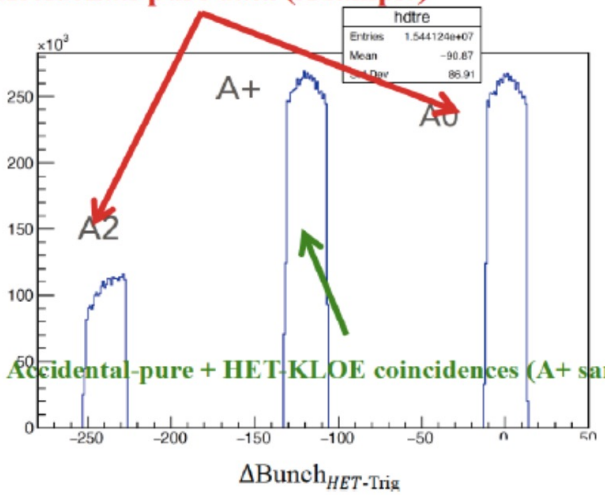
$N_{\pi 0}$ estimation:

Single arm selection (Luminosity = 3 fb^{-1})

- Two-clusters in the Barrel EMC
- Selected bunch crossing and HET signal in a time window of 40 ns around the KLOE Trigger
- Very loose kinematic cuts

Normalization to Radiative Bhabha at very small angle

Accidental-pure data (A sample)



Accidental-pure + HET-KLOE coincidences (A+ sample)

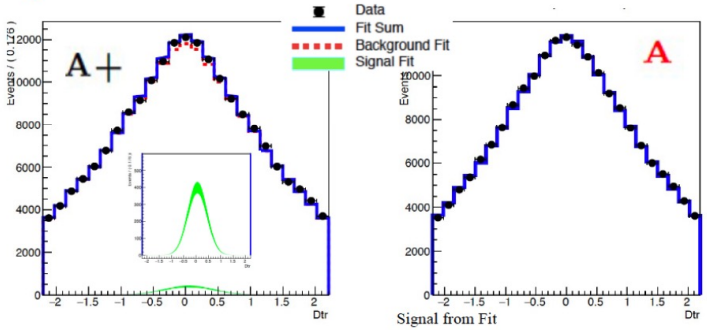
- Analysis based on "A+"/"A" comparison
- "A" sample used for background modelling
- Signal pdfs by MC (Ekhara) simulation, control samples and BDSIM transport MC

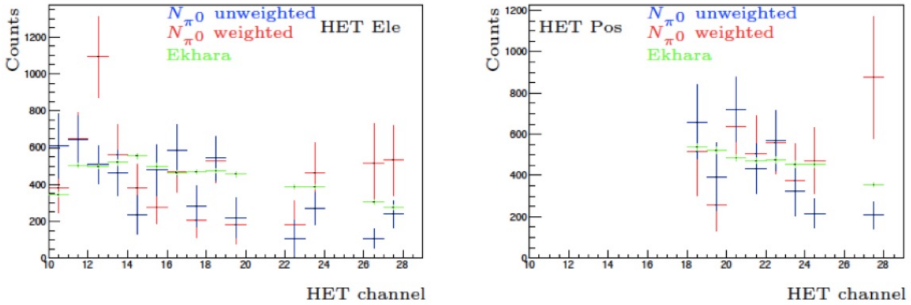
Simultaneous fits on several variables :

1) per single time period
2) per single channel

$\gamma^*\gamma^* \rightarrow \pi^0$

- **Example of fit on one HET readout channel**





Combining electron + positron sides
⇒ 6.5 % precision

$N_{\pi 0}$ counting: final checks on weights ongoing
ε_{ana}: Analysis efficiency evaluation completed
Luminosity measurement from KLOE online and cross-checks with $e^+e^- \rightarrow \gamma\gamma$

$\frac{A_{\mathrm{Bha}}}{A_{\pi^0}}$ **: evaluation of systematics in progress**

KLOE-2 2023 Activities

- Data reconstruction and preservation
  - Root output production
  - Data Preservation completing the disaster recovery copy

- Paper submissions:
  - Direct test of T, CP, CPT Symmetries in Transitions of Neutral K mesons with the KLOE detector
  - χPT Golden mode: $\eta \rightarrow \pi 0\, \gamma\gamma$
  - Dark forces: Leptophobic B-boson search with $\phi \rightarrow \eta\, \pi 0\, \gamma$ final state

- Complete ongoing analysis

Open Data Discussion

DRAFT
TO BE APPROVED BY THE KLOE-2 POLICY BOARD

KLOE-2 INTERNAL DISCUSSION OUTCOME ON OPENING KLOE AND KLOE-2 DATA TO PUBLIC

Following the suggestions of CSN1, the KLOE-2 collaboration investigated the possibility to open KLOE/KLOE-2 data and make them public. After some dedicated meetings and discussions on this topic, the conclusion of the collaboration is the following:

The collaboration recognizes the importance of having the opening of data to make the best use of this unique data sample, however this operation requires a strong effort to:

a) data organization in terms of physics streams and run conditions (luminosity, sqrt(s), background level etc.)
b) standard data certification (detector calibration, data quality)
c) standardize data format and procedures for external users, and uniformize KLOE and KLOE-2 data samples
d) make specific corrections based on control samples available to external users
e) grant access to virtual machines and data from outside users on our disk buffers at LNF (or CNAF)
f) write the documentation describing present procedures and software
g) develop "ad hoc" procedures, software, and user interface to access data and gather calibration and run condition information

So far, a huge effort has been carried out by the collaboration on points a)- c) of the above list and to provide an easily accessible format based on ROOT for the KLOE-2 data, to be extended to KLOE data at a later stage.
Some residual work is needed to complete point d) and e).
However, given the small size of the KLOE-2 collaboration and its commitments to data processing and analyses, there is no manpower available for the completion of points f)-g).

Therefore, the operation of making KLOE-2 data open to the generic public, even though it is very attractive, appears very difficult to be fully implemented.

Given the present situation, the KLOE-2 collaboration is anyhow willing to stimulate the collaboration with external people interested in specific analyses, as also recently suggested by the LNF scientific committee.To this purpose a special procedure has been approved by the collaboration.

KLOE-2 remains available to guide and supervise the operation of opening the data in case of interest and support from outside the collaboration, as for instance in terms of post-doc positions dedicated to this issue.

Document approved by KLOE-2 Spokesperson and Institution Board on 8 September 2022.

Comments from the Referees

KLOE-2

Referee Report
e
Proposta Assegnazioni per il 2023

CSN1, Arenzano, 12 settembre 2022

S. Giagu (RM1) - A. Perrotta (BO) - V. Vagnoni (BO)

Stato dell'esperimento

- Data reconstruction completata a gennaio 2022 (5.1 fb^{-1})
  - Data size: 1420 TB totale, 670 TB per i principali stream di analisi
- MC production completata: 4.7 fb^{-1}, corrispondente ai campioni di dati buoni per l'analisi
- Produzione dei files coi dati in formato root ongoing.
  - 3.5 fb^{-1} prodotti sinora, stima 350-400 TB per il campione totale (dati e MC, sia KLOE che KLOE2)
- Approvata una policy per la produzione di Open Data.
  - Ma manca il personpower per implementarla
  - **Ci vorrebbe un post-doc dedicato (PNRR?)**: analisi + lavoro tecnico…
- Risultati di fisica interessanti, presentati a ICHEP22 e/o in corso di pubblicazione: l'esperimento sta facendo buon uso dei dati raccolti!