

Kraków, 27 May 2002

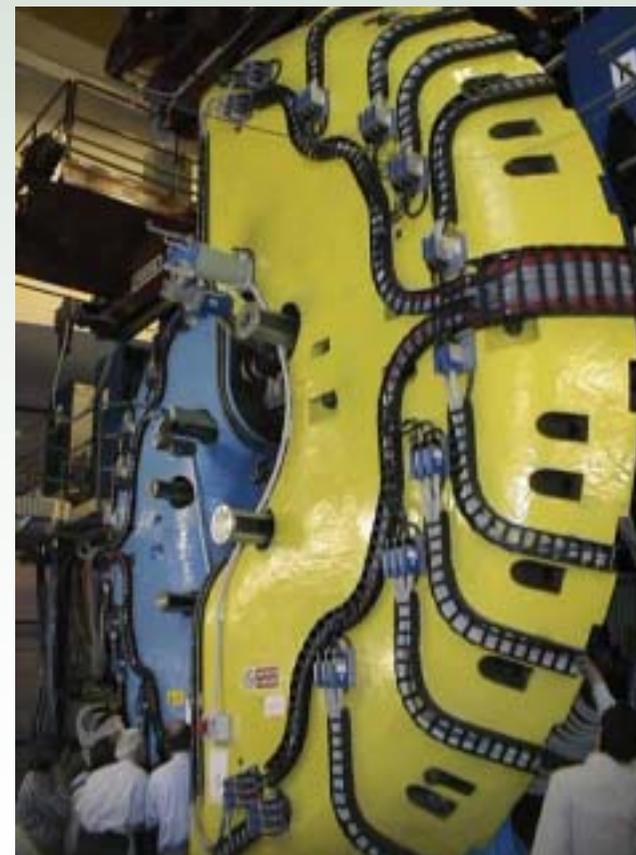


Recent results from the KLOE experiment at the DAΦNE ϕ -factory

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**on behalf of the KLOE Collaboration*

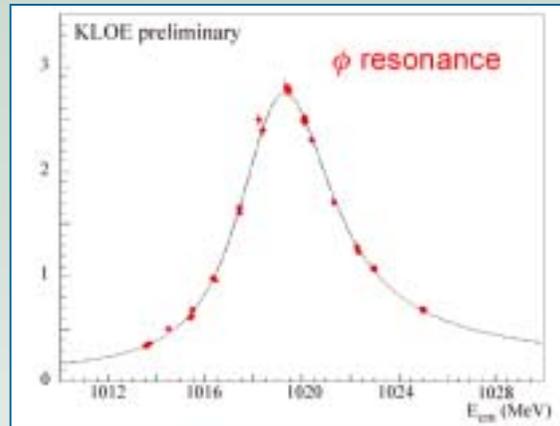


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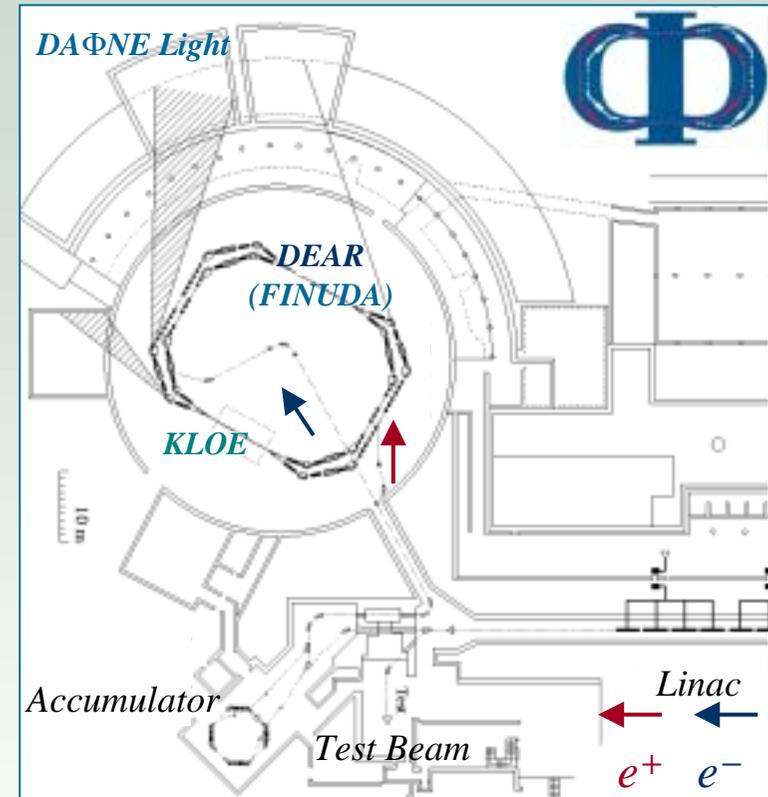
DAΦNE: the Frascati ϕ -factory

$$\sqrt{S} = 1020 \text{ MeV} \approx M_{\phi}, J^{PC} = 1^{--}$$



(today \rightarrow design)

- Number of bunches: 45 \rightarrow 120
- Bunch spacing: 5.4 ns \rightarrow 2.7 ns
- Bunch current: 20 mA \rightarrow 40 mA



- Single bunch luminosity: $1 \cdot 10^{30} \text{ cm}^{-2} \text{ s}^{-1} \rightarrow 4 \cdot 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$
- Peak luminosity: $5 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1} \rightarrow 5 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
- Daily luminosity: 3 pb^{-1}



$\phi \rightarrow K_S K_L$

KLOE detector

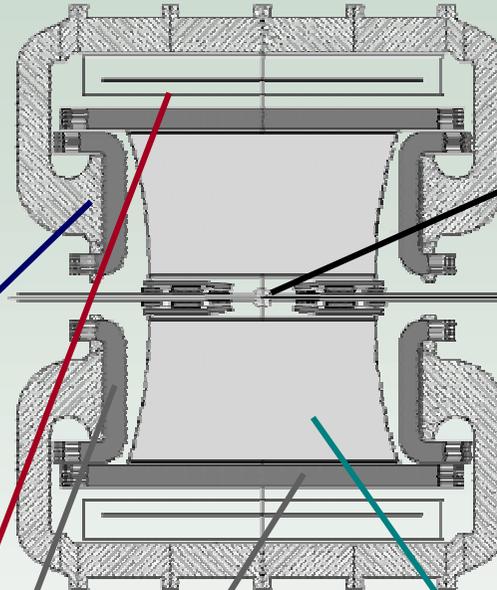
Kaon beams, pure and monochromatic:
 $p_K \approx 110 \text{ MeV/c}$

$\lambda(K_S) = 6 \text{ mm}$ ($\tau=90 \text{ ps}$)
• drives IP surroundings

$\lambda(K_L) = 3.5 \text{ m}$ ($\tau=51.7 \text{ ns}$)
• drives detector size

$\lambda(K^\pm) = 95 \text{ cm}$ ($\tau=12.4 \text{ ns}$)

Iron Yoke *SC Coil*
5.2 kG



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

He based
Drift chamber



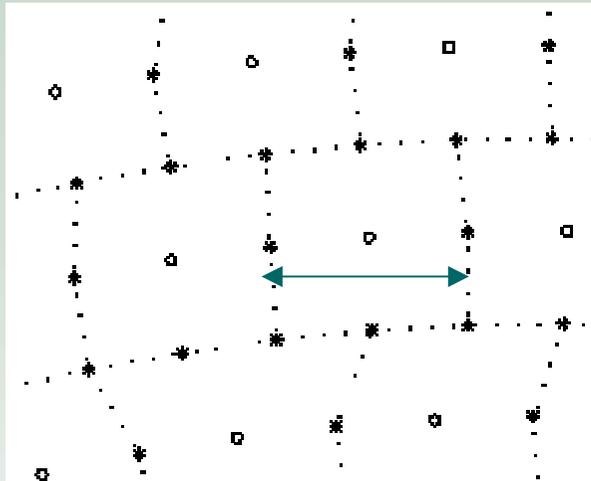
Pb-SciFi
Calorimeter
(barrel+endcap)



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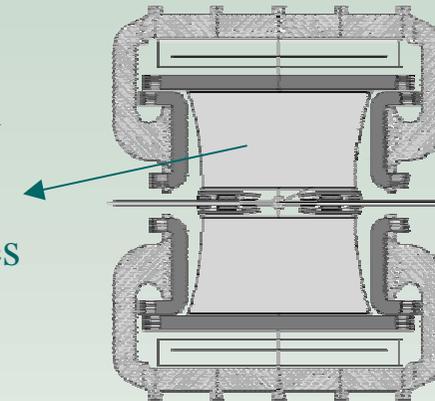


KLOE detector: drift chamber



3 cm (2 cm for the 12 innermost layers)

4 m diameter \times 3.3 m length
 90% He-10% iC_4H_{10}
 12582/52140 sense/total wires
All-stereo geometry

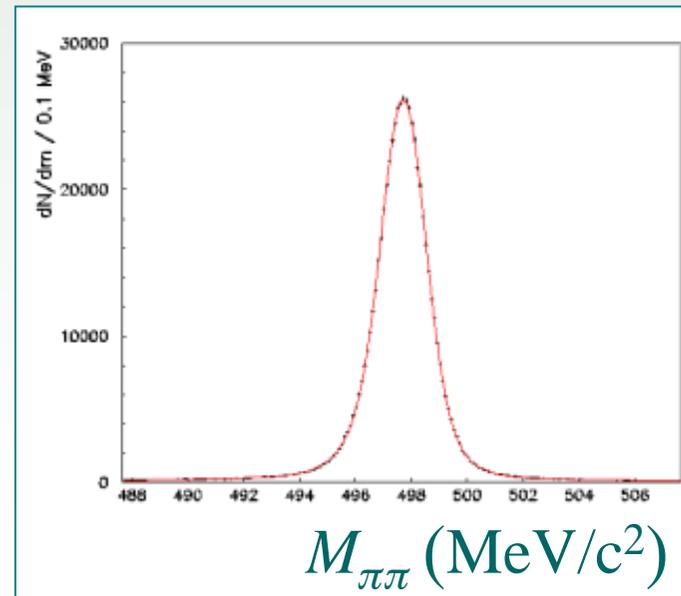


$$\sigma_p/p = 0.4 \% \text{ (for } 90^\circ \text{ tracks)}$$

$$\sigma_{r\phi} = 150 \mu\text{m}$$

$$\sigma_z = 2 \text{ mm}$$

Nucl. Instr. Meth. **A**, in print



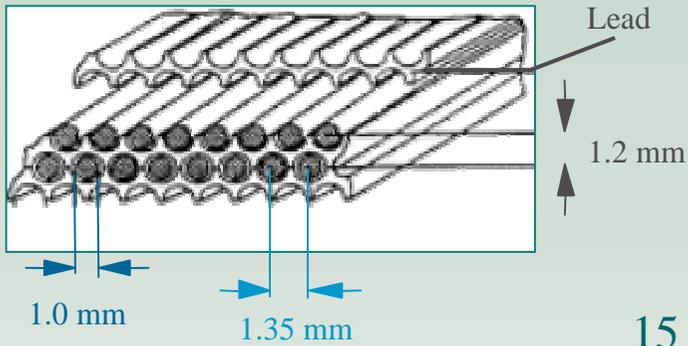
$$M_{\pi\pi} = 497.7 \text{ MeV}/c^2$$

$$\sigma_M = 1 \text{ MeV}/c^2$$

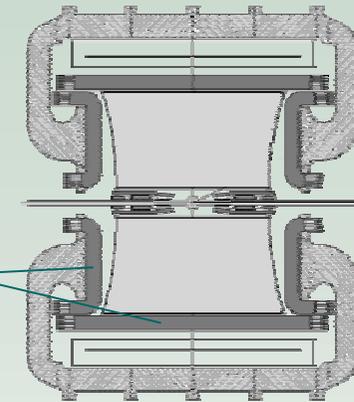
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KLOE detector: calorimeter



Lead/scintillating fiber
4880 PMTs
98% coverage of solid angle
15 X_0 depth (5×4.4 cm granularity)
Provides 1st level trigger



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

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

(finite bunch-length contribution subtracted)

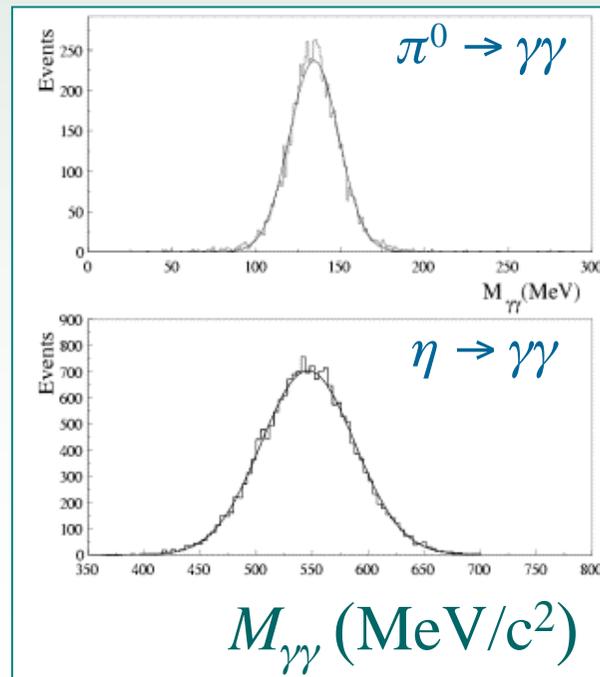
$$\sigma_{xy} = 1.2 \text{ cm}$$

$$\sigma_z = 1.2/\sqrt{E(\text{GeV})}$$

Nucl. Instr. Meth. **A482** (2002) 364

Nucl. Instr. Meth. **A483** (2002) 649

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$$M_{\gamma\gamma} = 135 \text{ MeV}/c^2$$

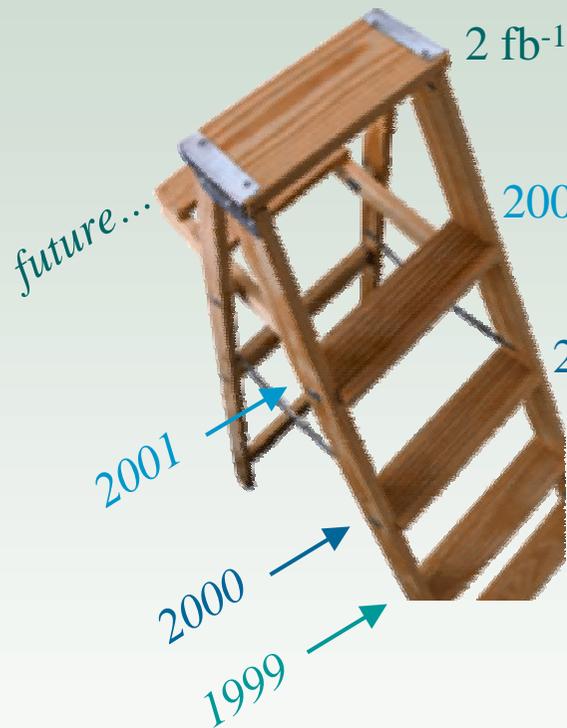
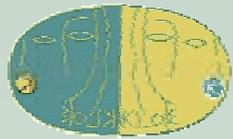
$$\sigma_M = 15 \text{ MeV}/c^2$$

$$M_{\gamma\gamma} = 546 \text{ MeV}/c^2$$

$$\sigma_M = 42 \text{ MeV}/c^2$$



KLOE physics program



ϵ'/ϵ with double ratio

Semileptonic asymmetry (CPT test)
 $K_L K_S$ Interferometry

2 fb⁻¹

K_L form factors, rare K_S , $K_L \rightarrow 2\pi, K_L \rightarrow \gamma\gamma, K^\pm$ decays
 $\sigma(e^+e^- \rightarrow \pi^+\pi^-)$ to < 1 % (stat)

200 pb⁻¹

Ongoing analysis...

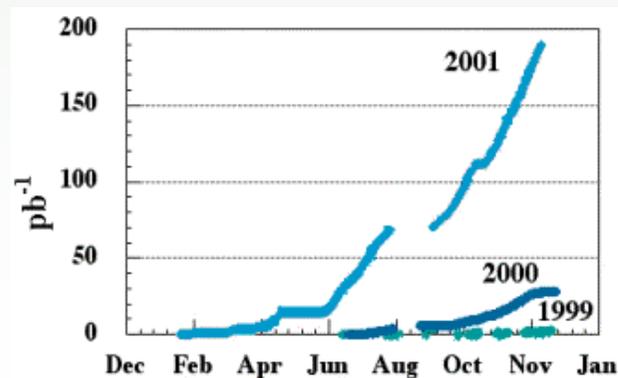
20 pb⁻¹

K_S physics: $BR(K_S \rightarrow \pi^+\pi^-)/BR(K_S \rightarrow \pi^0\pi^0)$,
 $BR(K_S \rightarrow \pi e\nu)$
 ϕ radiative decays: $\phi \rightarrow f_0\gamma, a_0\gamma, \phi \rightarrow \eta'\gamma, \eta\gamma$

Papers in print...

2 pb⁻¹

Engineering run

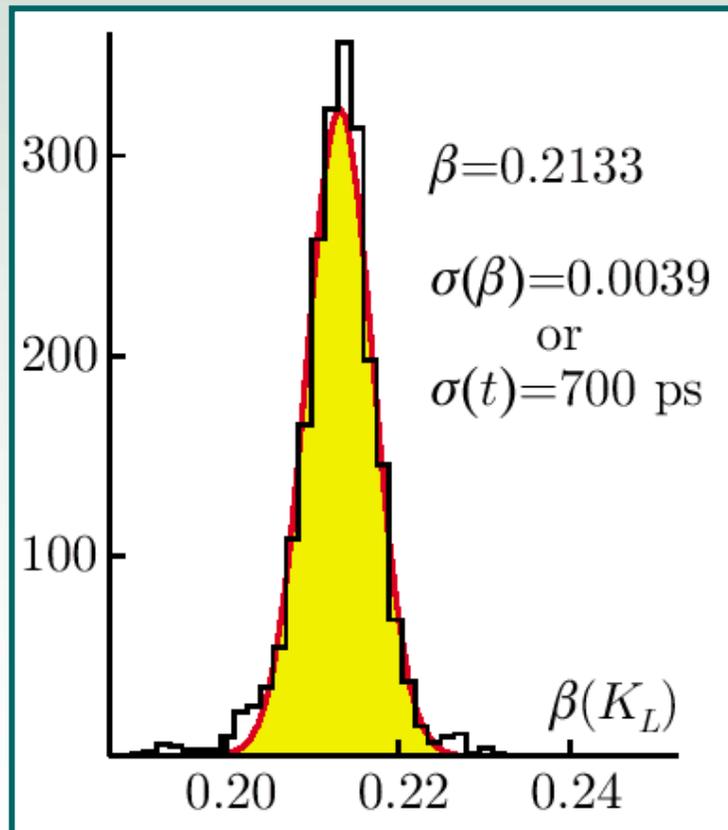
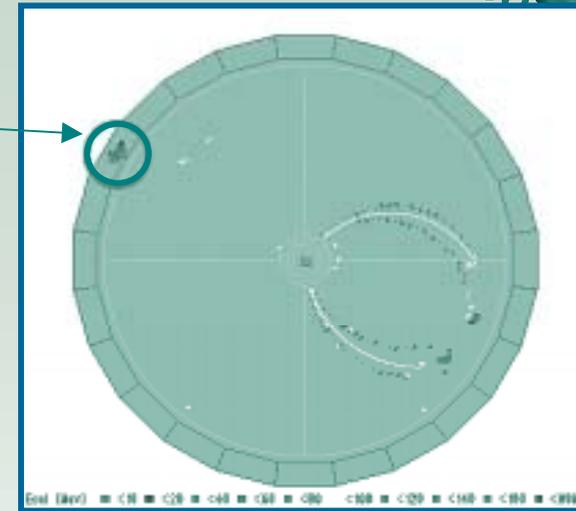




K_S tagging: K_L interactions

- Clean K_S tagging by time-of-flight identification of K_L interactions in the calorimeter:

β^* (= K_L velocity in the ϕ rest frame) \cong 0.218





Beam energy

$\delta\beta = 0.0039$ translates into an error in the machine energy W :

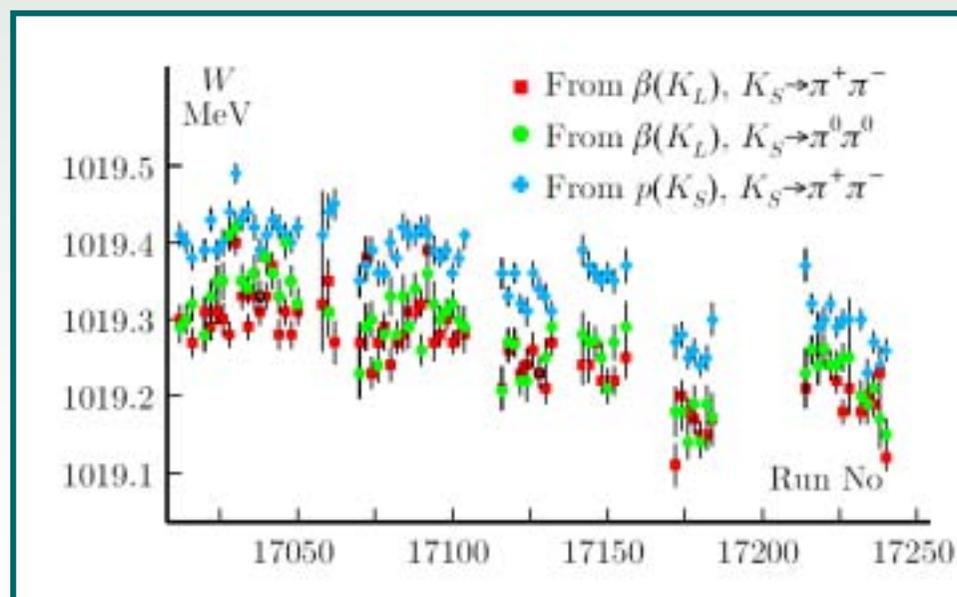
$$\delta W(K_L) \sim 0.8 \text{ MeV from one event}$$

... but of course we have another **independent** estimate of machine energy W , using charged tracks in $K_S \rightarrow \pi\pi$:

$$\delta p(K_S) \sim 0.4 \text{ MeV from one event}$$

$$W = 2m_K \gamma(\beta)$$

$$\bullet E_K = \gamma \cdot m_K \rightarrow \delta E_K = E_K \cdot \beta \gamma^2 \cdot \delta\beta$$

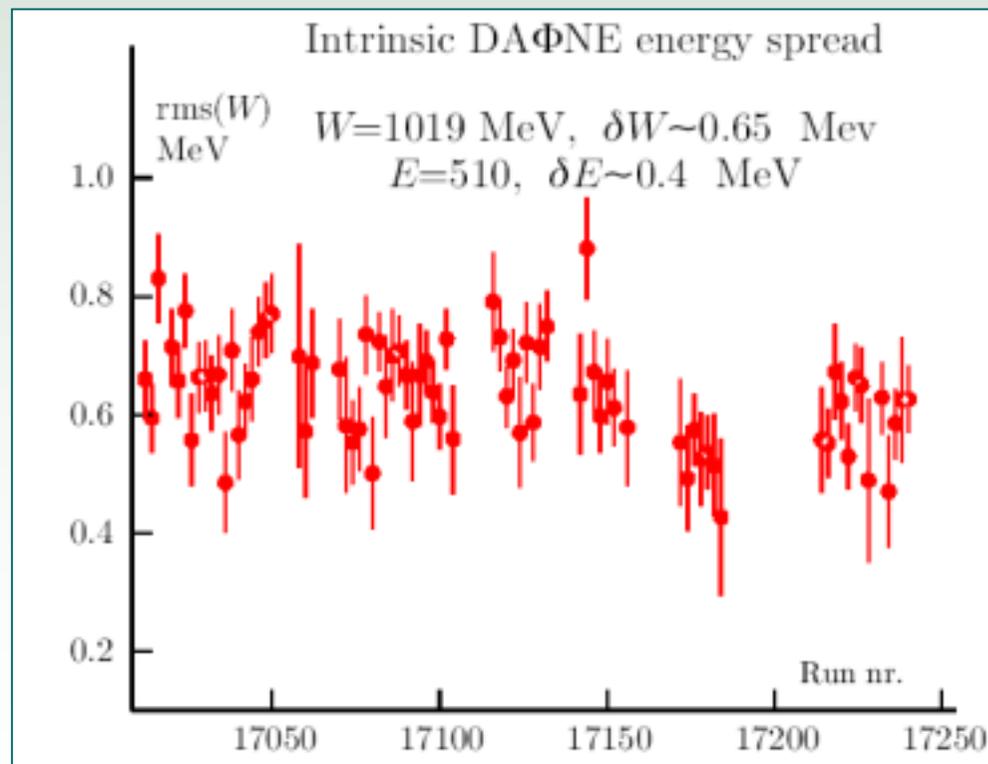




Beam energy spread

- Get beam energy spread by comparing $W_S + W_L$ and $W_S - W_L$ distributions:

$$\sigma^2 = \sigma_{\text{beam}}^2 + \sigma_{\text{detector}}^2 \qquad \sigma^2 = \sigma_{\text{detector}}^2$$



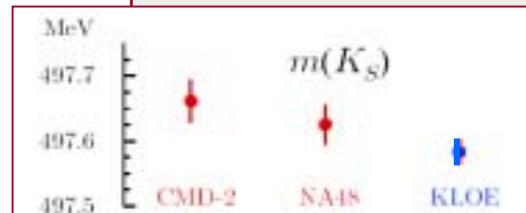
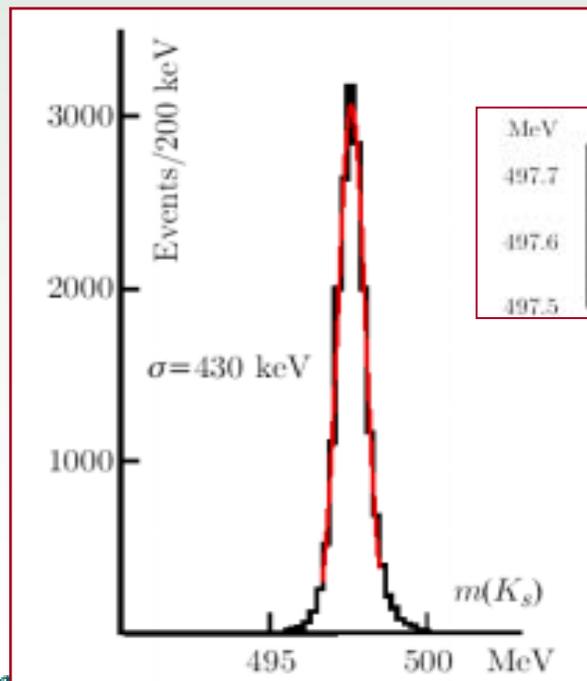


K_S mass

- $m_\phi - 2m_{K_S} = 26$ MeV is small... $W = E_{K_S} + E_{K_L}$
- $m_K^2 = (W/2)^2 - p_{K_S}^2$
- W from e^+e^- invariant mass, p_{K_S} from $K_S \rightarrow \pi^+\pi^-$
- absolute scale from ϕ resonance scan
(normalized to m_ϕ Novosibirsk with resonant depolarization)
- take into account radiative corrections

- $E_K^2 = m_K^2 + p_K^2 \rightarrow \delta E_K = \beta \cdot \delta p_K$
- $m_K^2 = E_K^2 - (\mathbf{p}_{\pi^+} + \mathbf{p}_{\pi^-})^2 \rightarrow \delta m_K \cong 2\beta \cdot \delta p_K$

- $\delta m_K \sim 0.4\%$ with **one event**



$$m(K_S) = 497.583 \pm 0.005_{\text{stat}} \pm 0.020_{\text{syst}} \text{ MeV}/c^2$$



K_S physics

- $\Gamma(K_S \rightarrow \pi^+\pi^-) / \Gamma(K_S \rightarrow \pi^0\pi^0)$

1. It is the first part of the double ratio

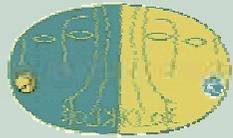
Experiments measure *double ratio* at 0.1% but the *single ratio* only at 1%; KLOE aims to measure each *single ratio* (K_L and K_S) at 0.1%

2. It allows the extraction of isospin amplitudes and phases when the soft γ 's in $K_S \rightarrow \pi^+\pi^-\gamma$ are consistently treated

- $\Gamma(K_S \rightarrow \pi e \nu) / \Gamma(K_S \rightarrow \pi^0\pi^0)$

If **CPT is OK** and $\Delta S = \Delta Q$ is at work: $\Gamma(K_S \rightarrow \pi e \nu) = \Gamma(K_L \rightarrow \pi e \nu)$

- *DAΦNE provides a pure K_S beam \rightarrow unique opportunity*



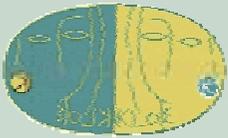
$K_S \rightarrow \pi^+\pi^- / K_S \rightarrow \pi^0\pi^0$: selection

• K_S tagging

- 2 tracks from IP
- acceptance and loose p cuts, efficiency **from MC**
- single-track reconstruction efficiency **from data** ($K_S \rightarrow \pi^+\pi^-$ subsamples), used to scale MC

- ≥ 3 neutral prompt clusters
- energy and time cuts ($\pi^0 \rightarrow \gamma e^+ e^-$ included), efficiency **from MC**
- photon detection efficiency **from data** ($\phi \rightarrow \pi^+\pi^-\pi^0$ sample), used to scale MC

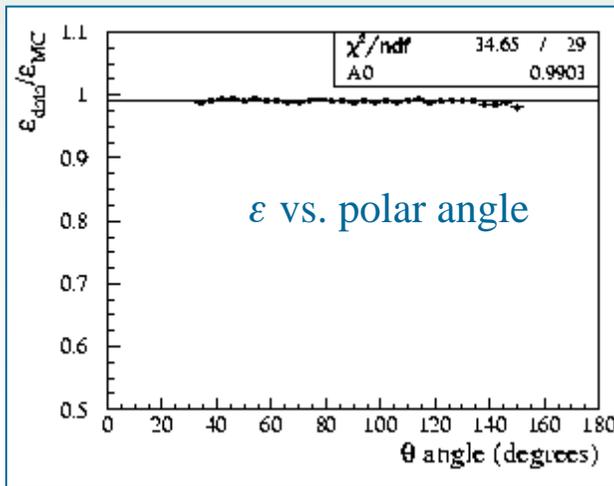
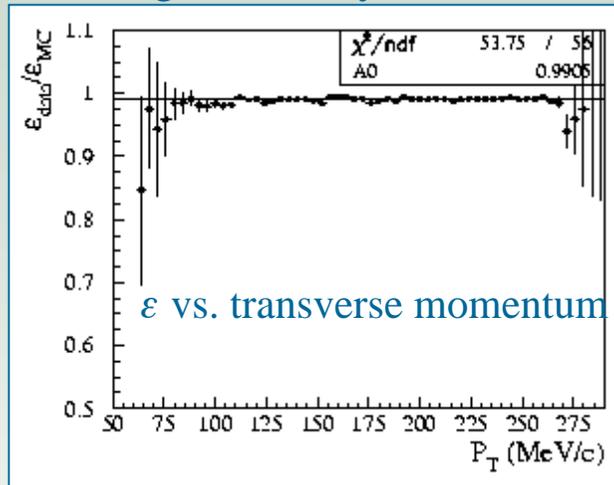
- Single-particle t_0 and trigger efficiencies **from data** plugged into MC ($K_S \rightarrow \pi^+\pi^-$ but also $K_L \rightarrow \pi^+\pi^-\pi^0$, $\phi \rightarrow \pi^+\pi^-\pi^0$)



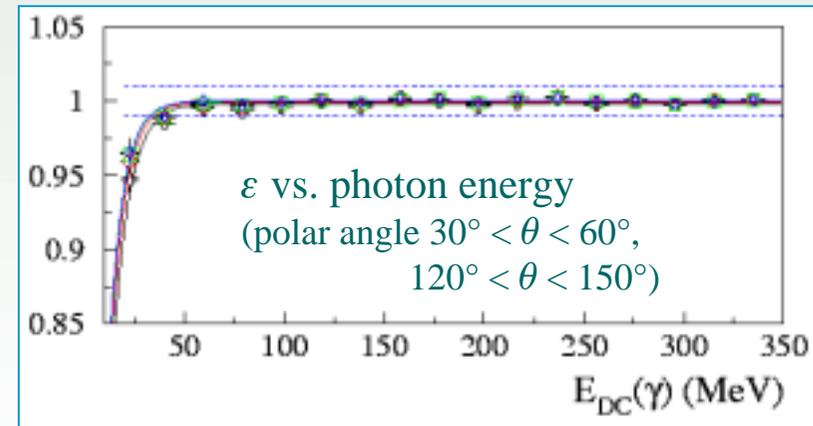
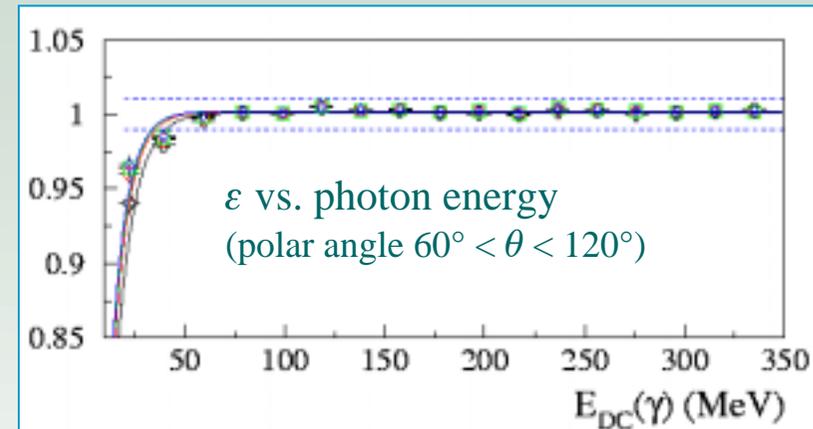
$K_S \rightarrow \pi^+ \pi^- / K_S \rightarrow \pi^0 \pi^0$: efficiencies

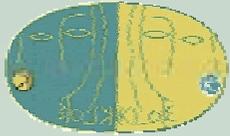


Tracking efficiency: **Data/MC ratio**



Photon detection efficiency: **Data/MC ratio**

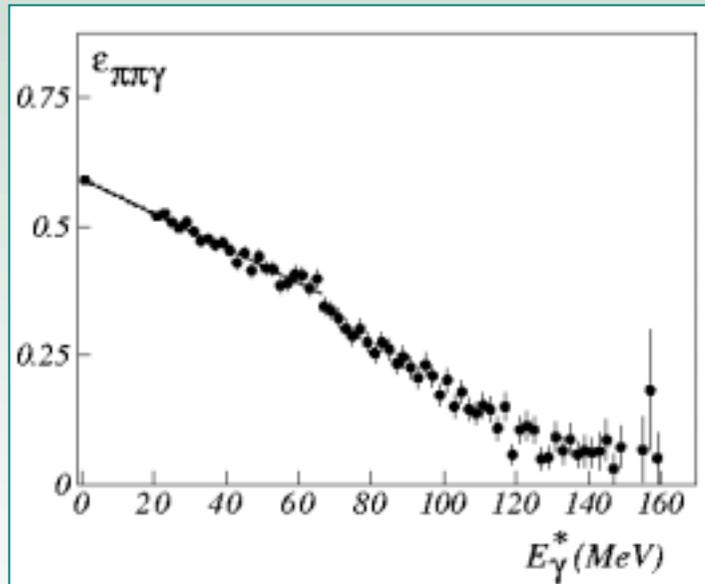




$K_S \rightarrow \pi^+\pi^- / K_S \rightarrow \pi^0\pi^0$: results

Fully inclusive measurement:

$\varepsilon_{\pi\pi\gamma}(E_\gamma^*)$ from MC and folded into theoretical γ spectrum
[Cirigliano, Donoghue, Golowich 2000]



Contribution to systematic error	%
$K_S \rightarrow \pi^0\pi^0 / K_S \rightarrow \pi^+\pi^-$ tag	0.55
photon counting	0.20
trigger and t_0	0.23
tracking	0.26
Overall systematic error	0.68

Nota bene: efficiencies estimated using *data control samples* (statistically limited)

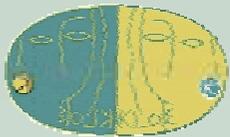
Goal: reach 0.1% systematic uncertainty [$1.7 \cdot 10^{-4}$ on $\text{Re}(\varepsilon'/\varepsilon)$]

• KLOE 2000 data:

$$2.236 \pm 0.003_{\text{stat}} \pm 0.015_{\text{syst}}$$

(PDG: 2.197 ± 0.026 , without clear indication of E_γ^* cut)

Accepted by Phys. Lett. B
hep-ex/0204024



$K_S \rightarrow \pi e \nu$: selection

- K_S tagging
- charged vertex at IP: $r < 8\text{cm}$, $|z| < 10\text{cm}$
- 2 tracks with associated calorimeter clusters
- Preselection on $M_{\pi e}$ and K_S momentum
- Time of flight e/ π identification cut on:
 $\delta t(\text{m}) = t_{\text{measured}} - t.o.f.(\text{hypotesis m})$
- Kinematic closure of event...

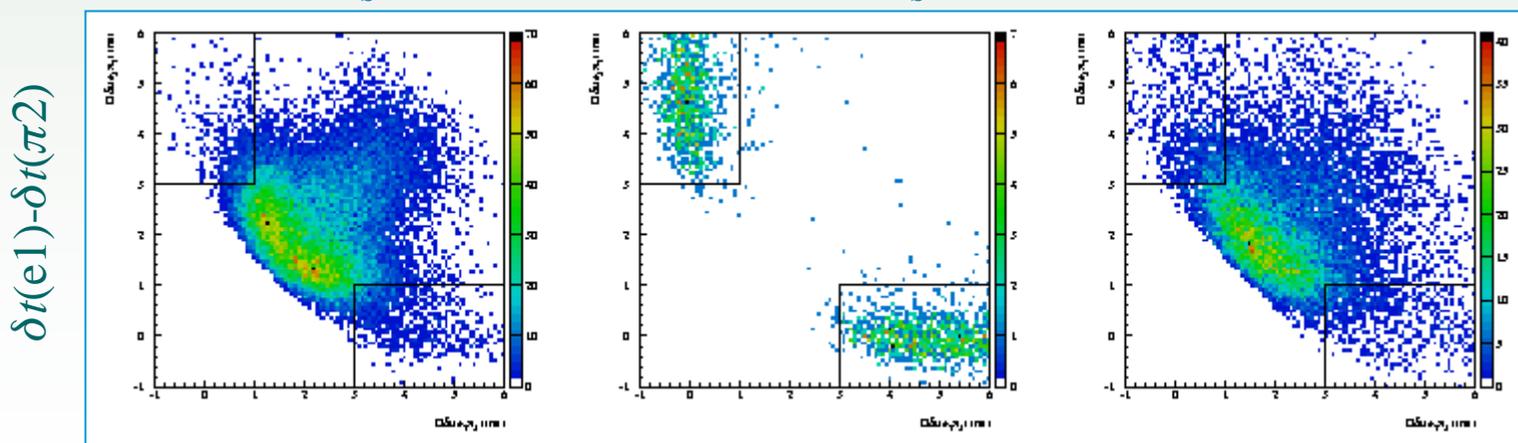
acceptance and selection efficiency **from MC**
 Tracking, track/cluster association efficiencies
from data (several control samples)

efficiency **from data**: $K_L \rightarrow \pi e \nu$ early decays

Monte Carlo $K_S \rightarrow \pi^+ \pi^-$

Monte Carlo $K_S \rightarrow \pi e \nu$

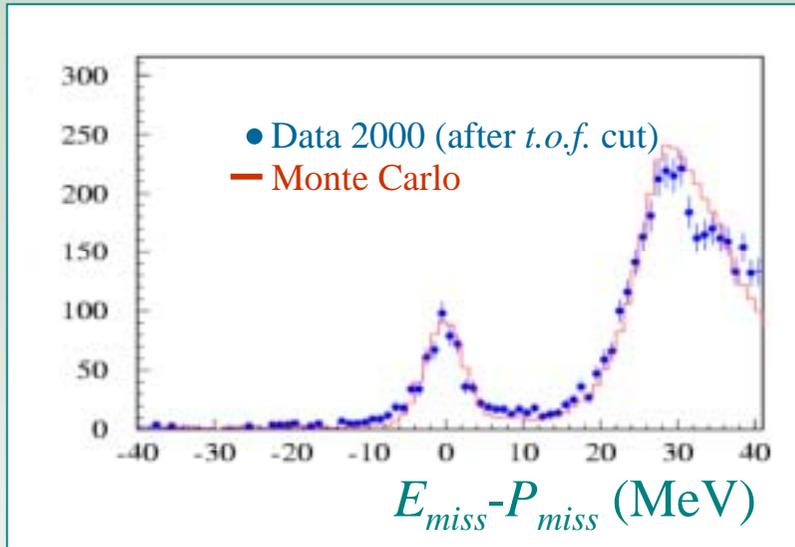
Data 2000





$K_S \rightarrow \pi e \nu$: results

... kinematically close the event using p_K to get p_ν :

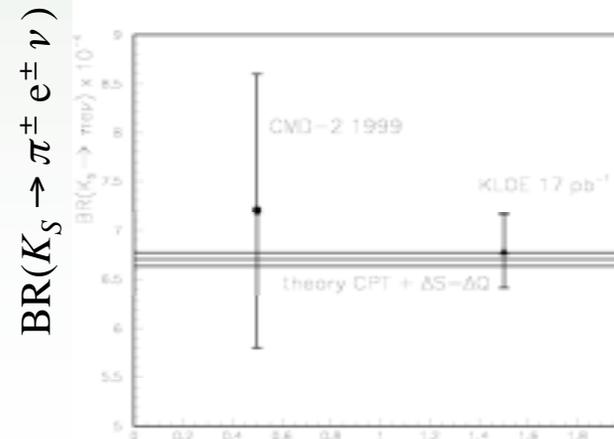


Contributions to total error	%
Statistics	4.9
Tracking + vertex efficiency	2.0
Cluster, t_0 , trigger	0.9
TOF selection efficiency	0.8
Tag efficiency	0.6
Total	5.9

• **KLOE 2000:** $(6.91 \pm 0.34_{\text{stat}} \pm 0.15_{\text{syst}}) \cdot 10^{-4}$

❖ Fit Signal+Background MC shape:
 624 ± 30 events

❖ Correct for efficiencies



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Phys. Lett. **B 535** (2002), 37
(Dedicated to the memory of L. Paoluzzi)



Scalar and pseudoscalar mesons

$$\phi \rightarrow P(0^{-+})\gamma, S(0^{++})\gamma$$

$$J^{PC} = 0^{-+}$$

According to quark model:

$$\pi^0 = (|u\bar{u}\rangle - |d\bar{d}\rangle)/\sqrt{2}$$

$$\eta = \cos\alpha_P (|u\bar{u}\rangle + |d\bar{d}\rangle)/\sqrt{2} + \sin\alpha_P |s\bar{s}\rangle$$

$$\eta' = -\sin\alpha_P (|u\bar{u}\rangle + |d\bar{d}\rangle)/\sqrt{2} + \cos\alpha_P |s\bar{s}\rangle$$

$$\phi = |s\bar{s}\rangle (\alpha_V = 0)$$



- no other content, (gluonic)?

$$X_\eta |(u,d)\rangle + Y_\eta |s\bar{s}\rangle + Z_\eta |\text{Gluonium}\rangle$$

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$$J^{PC} = 0^{++}$$

According to quark model:

$$a_0 = (|u\bar{u}\rangle - |d\bar{d}\rangle)/\sqrt{2}$$

$$\sigma = (|u\bar{u}\rangle + |d\bar{d}\rangle)/\sqrt{2}$$

$$f_0 = |s\bar{s}\rangle$$



f_0, a_0 are not easily interpreted as $q\bar{q}$ states...

3 different possibilities:

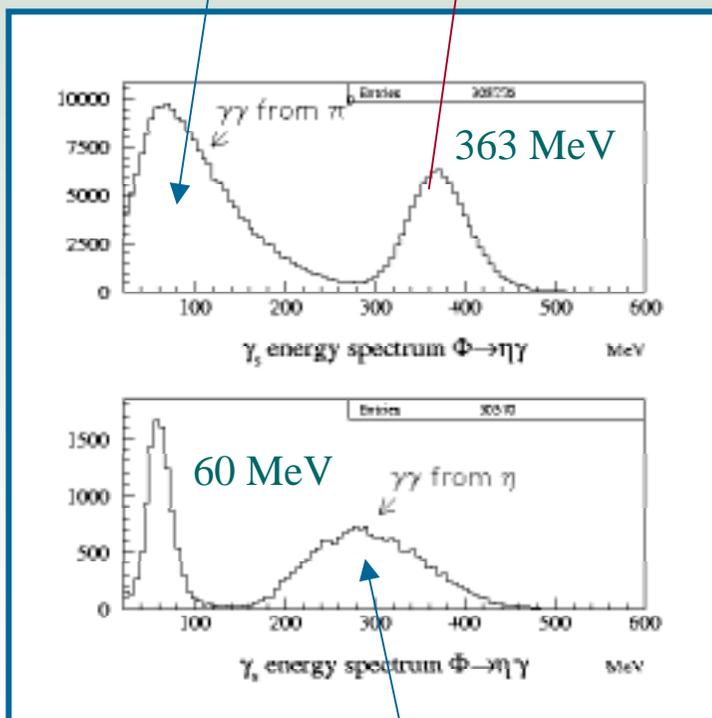
- $q\bar{q}q\bar{q}$ states (lower mass) [Jaffe 1977]
- $K\bar{K}$ molecule ($M(f_0, a_0) \sim 2M_K$) [Weinstein, Isgur 1990]
- $f_0(980), a_0(980), \sigma \rightarrow q\bar{q}$ nonet [Tornqvist 1999]



$\phi \rightarrow \text{pseudoscalars} + \gamma$

η factory!

$\pi^0 \rightarrow \gamma\gamma (\eta)$



$\eta \rightarrow \gamma\gamma$

$$\phi \rightarrow \eta \gamma$$

$$\downarrow \pi^+ \pi^- \pi^0$$

$$\downarrow \gamma\gamma$$

$$\phi \rightarrow \eta' \gamma$$

$$\downarrow \eta \pi^+ \pi^-$$

$$\downarrow \gamma\gamma$$

2 tracks + 3 γ

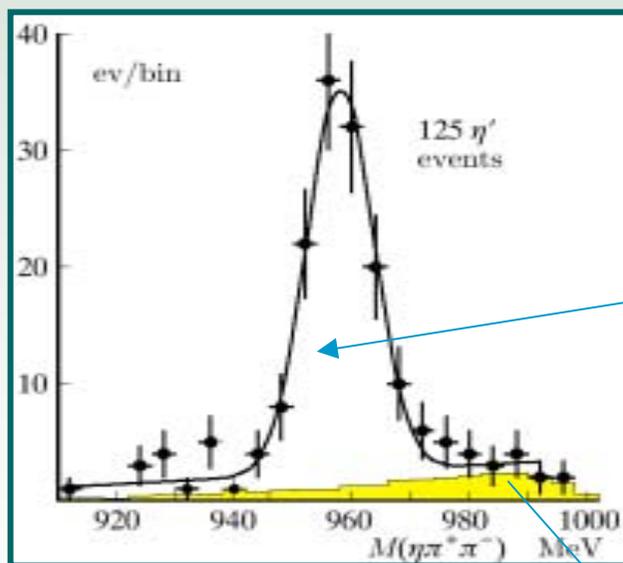
Background from $\phi \rightarrow \pi^+ \pi^- \pi^0$ and $K_S K_L$



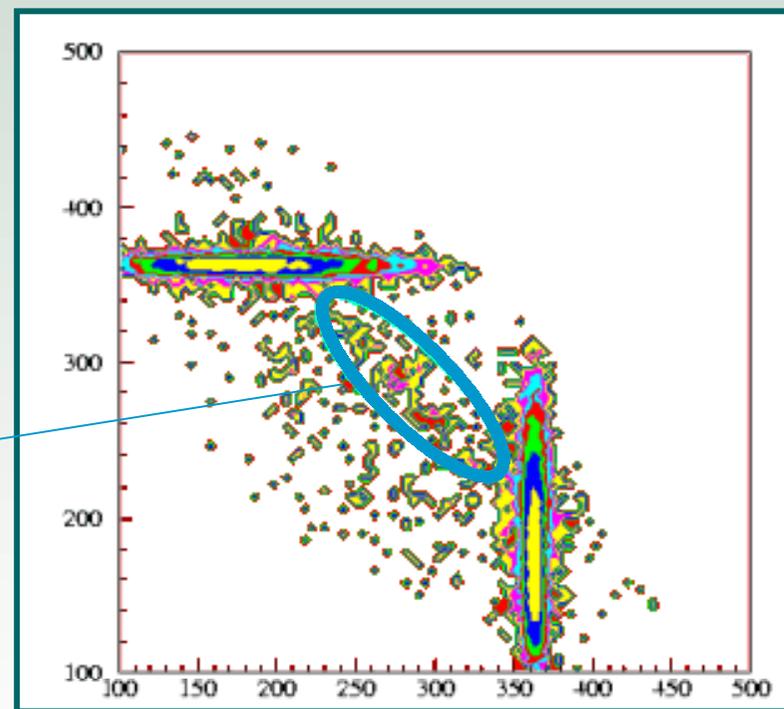
$$\phi \rightarrow \eta' \gamma$$



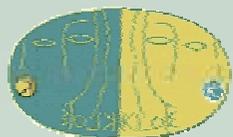
- Cut on $E_{\pi^+} + E_{\pi^-}$ to reject $\phi \rightarrow \pi^+ \pi^- \pi^0$ background
- Kinematic fit (with global 4-momentum conservation, no mass constraints)
- Cut in E_{γ_1} vs. E_{γ_2} (2 hardest photons)



E_{γ_2}



E_{γ_1}



$$\phi \rightarrow \eta' \gamma / \phi \rightarrow \eta \gamma$$

$$\text{BR}(\phi \rightarrow \eta' \gamma) / \text{BR}(\phi \rightarrow \eta \gamma) = (5.3 \pm 0.5_{\text{stat}} \pm 0.3_{\text{syst}}) \cdot 10^{-3}$$

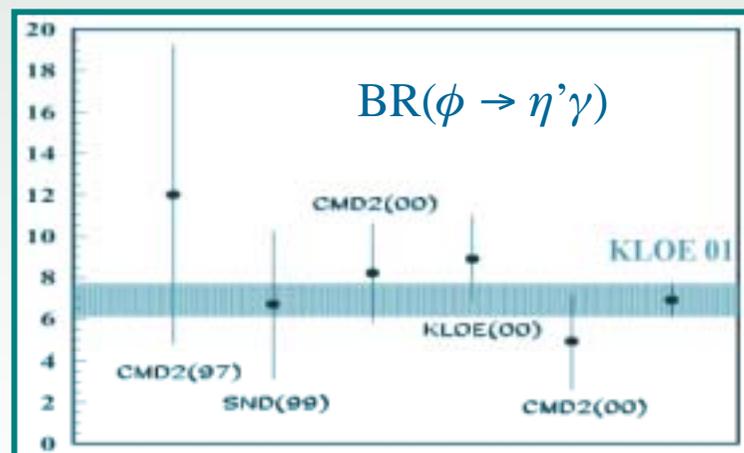
$$= \cot^2(\alpha_P) \cdot (p_{\eta'}^3 / p_{\eta}^3) \quad \text{assuming } \phi = |\bar{s}s\rangle$$

$$\alpha_P = (40.0^{+1.7}_{-1.5})^\circ \quad (\text{flavor basis})$$

$$\phi_P = (14.7^{+1.7}_{-1.5})^\circ \quad (\text{octet-singlet basis})$$

Using PDG value for $\text{BR}(\phi \rightarrow \eta \gamma)$:

$$\text{BR}(\phi \rightarrow \eta' \gamma) = (6.8 \pm 0.6_{\text{stat}} \pm 0.5_{\text{syst}}) \cdot 10^{-5}$$

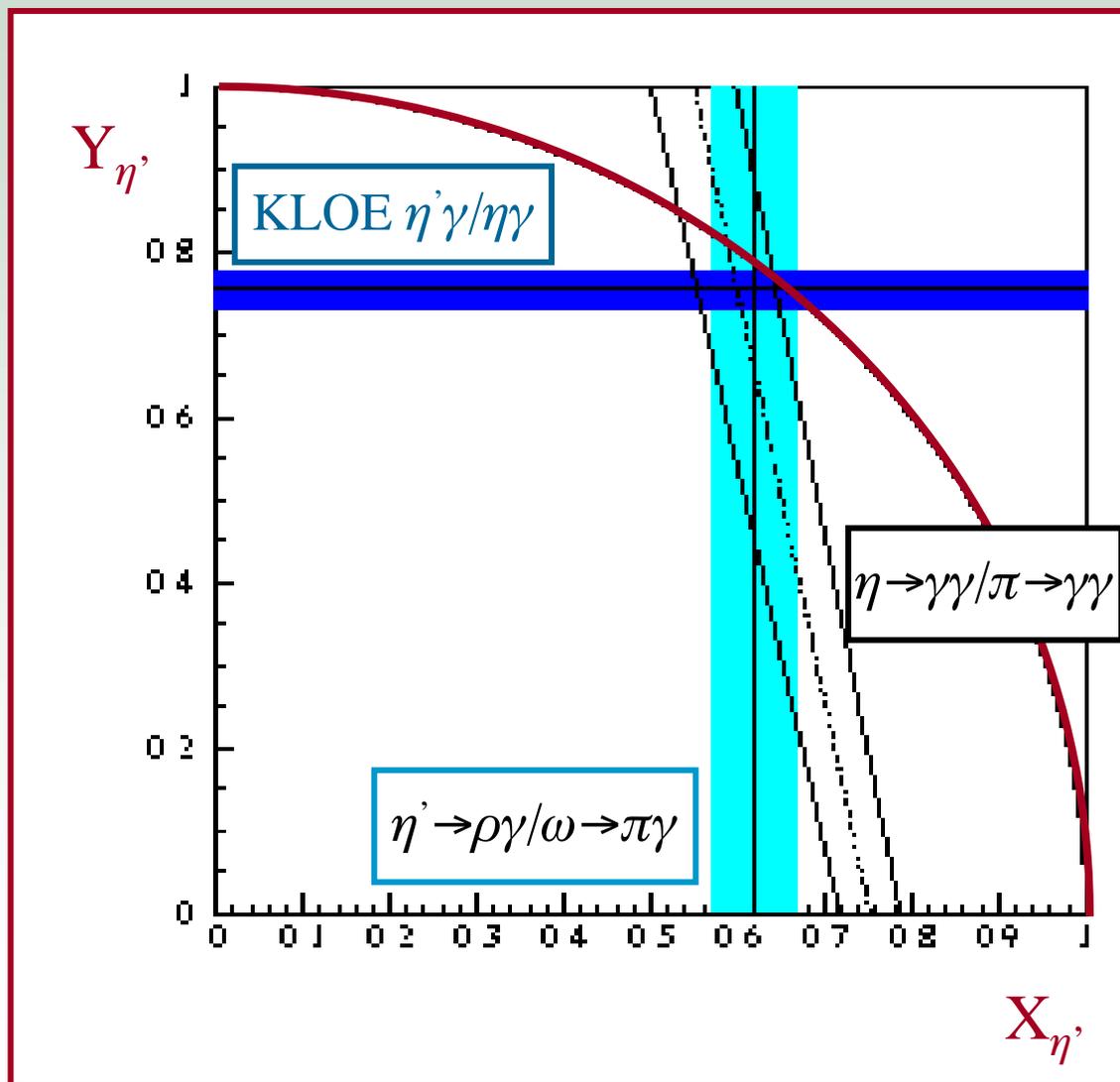


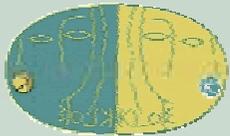
hep-ex/0107022



$$\phi \rightarrow \eta' \gamma / \phi \rightarrow \eta \gamma$$

Low gluonium content for the η'





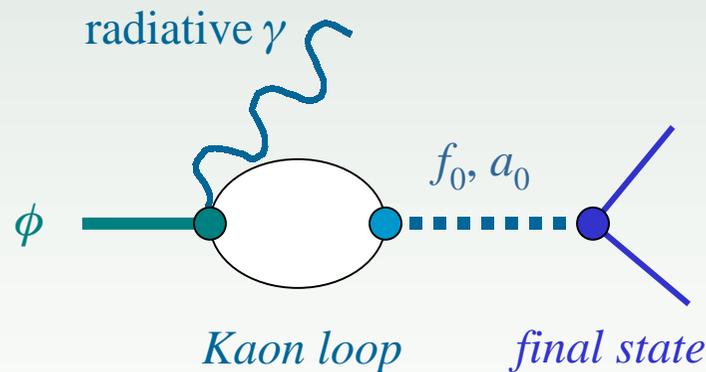
$\phi \rightarrow \text{scalars} + \gamma$

Motivations:

$\phi \rightarrow f_0 \gamma, \phi \rightarrow a_0 \gamma$ decays are sensitive to $f_0(980)$ (I=0) and $a_0(980)$ (I=1) nature

Phenomenological framework (**kaon loop** model) \rightarrow coupling constants

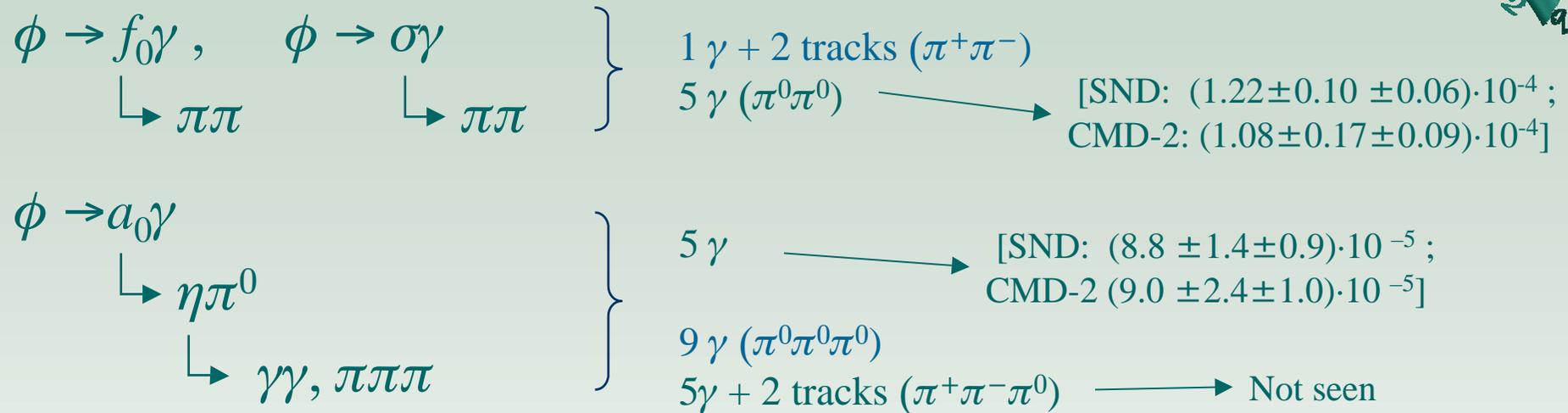
[Achasov, Ivanchenko, Nucl. Phys. **B315** (1989) 465]



- $g(\phi KK)$
 - $g(f_0 KK) \quad g(a_0 KK)$
 - $g(f_0 \pi\pi) \quad g(a_0 \eta\pi)$ } f_0, a_0 model
- from $\Gamma(\phi \rightarrow K^+ K^-)$
- from $M(\pi^0 \pi^0), M(\eta \pi^0)$ spectra



$\phi \rightarrow \text{scalars} + \gamma$



- 5 γ , 1st kinematic fit + γ pairings + 2nd fit (η/π mass)
- Background: from 5 γ processes, mainly $\omega\pi^0$;
3/7 γ from $\eta\gamma$;
 $\pi^0\pi^0\gamma$ main background to $\eta\pi^0\gamma$.
- 5 γ + 2 tracks, kinematic fit + $M_{\pi^+\pi^-}$ cut + 2nd fit (η/π mass)
- Background: same topology (very low);
2 tracks+4/6 γ from $\omega\pi^0$ or K_S +early K_L .



$$\phi \rightarrow \pi^0 \pi^0 \gamma$$

$$\text{BR}(\phi \rightarrow \pi^0 \pi^0 \gamma) = (1.09 \pm 0.03_{\text{stat}} \pm 0.05_{\text{syst}}) \cdot 10^{-4}$$

Fit to the $M(\pi^0 \pi^0)$ spectrum (kaon loop):

contributions from: $\phi \rightarrow f_0 \gamma$, $\phi \rightarrow \sigma \gamma$

+ “strong” negative interference

(Contribution from $\phi \rightarrow \rho^0 \pi^0 \rightarrow \pi^0 \pi^0 \gamma$ not considered)

Fit results:

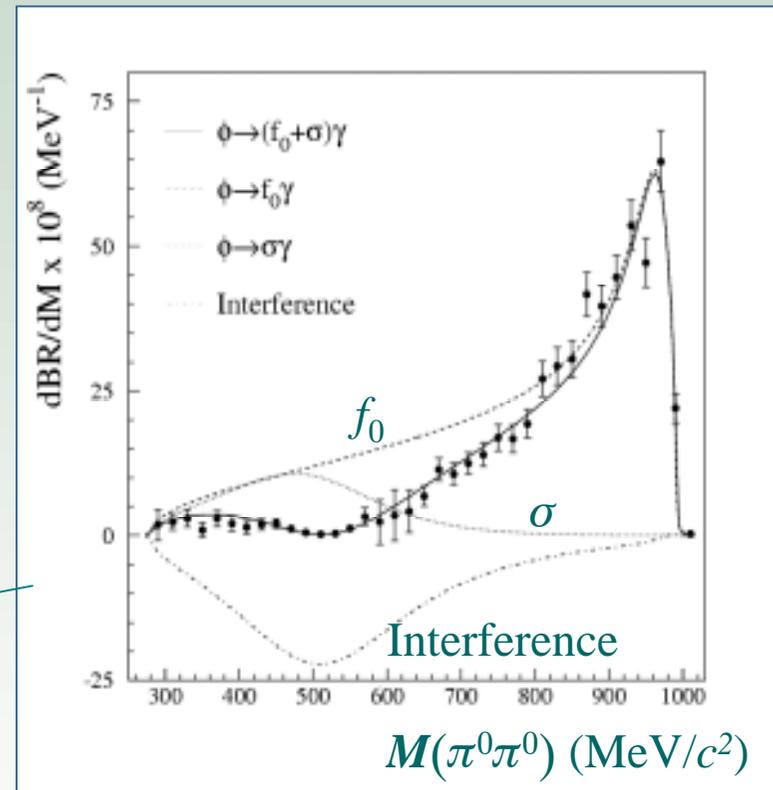
$$M(f_0) = 973 \pm 1 \text{ MeV}$$

$$g^2(f_0 KK)/4\pi = 2.79 \pm 0.12 \text{ GeV}^2$$

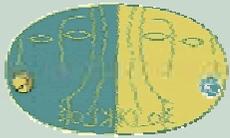
$$g(f_0 \pi \pi) / g(f_0 KK) = 0.50 \pm 0.01$$

$$g(\phi \sigma \gamma) = 0.060 \pm 0.008$$

$$\text{BR}(\phi \rightarrow f_0 \gamma \rightarrow \pi^0 \pi^0 \gamma) = (1.49 \pm 0.07) \cdot 10^{-4}$$



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$\phi \rightarrow \eta\pi^0\gamma$

$$\begin{aligned} \text{BR}(\phi \rightarrow a_0\gamma \rightarrow \eta\pi^0\gamma) &= (8.5 \pm 0.5_{\text{stat}} \pm 0.6_{\text{syst}}) \cdot 10^{-5} (5\gamma) \\ &= (8.0 \pm 0.6_{\text{stat}} \pm 0.5_{\text{syst}}) \cdot 10^{-5} (5\gamma+2t) \end{aligned}$$

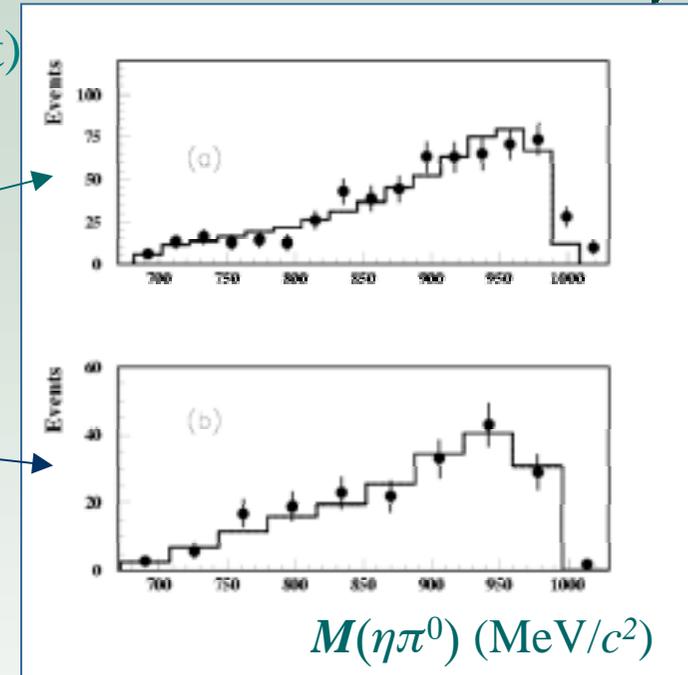
Fit to the $M(\eta\pi^0)$ spectrum:

2 samples: $\eta \rightarrow \gamma\gamma$ (5 γ)

$\eta \rightarrow \pi^+\pi^-\pi^0$ (5 γ +2 tracks)

contribution from $\phi \rightarrow a_0\gamma$

(negligible contribution from $\phi \rightarrow \rho^0\pi^0 \rightarrow \eta\pi^0\gamma$)



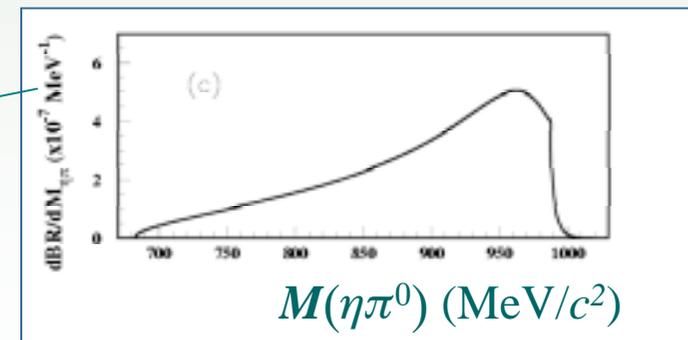
Fit results:

$$g^2(a_0KK)/4\pi = 0.40 \pm 0.04 \text{ GeV}^2$$

$$g(a_0\eta\pi) / g(a_0KK) = 1.35 \pm 0.09$$

$$M(a_0) = 984.8 \text{ MeV}/c^2 \text{ (PDG)}$$

$$\text{BR}(\phi \rightarrow a_0\gamma \rightarrow \eta\pi^0\gamma) = (7.4 \pm 0.7) \cdot 10^{-5}$$





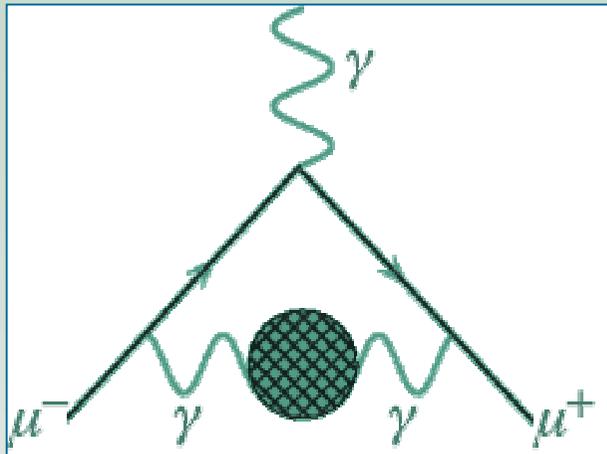
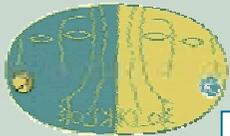
KLOE vs. models

Parameter	KLOE result	4q model
$g^2(f_0\text{KK})/4\pi$ (GeV ²)	2.79 ± 0.12	“super-allowed” (few GeV ²)
$g(f_0\pi\pi) / g(f_0\text{KK})$	0.50 ± 0.01	0.3-0.5
$g^2(a_0\text{KK})/4\pi$ (GeV ²)	0.40 ± 0.04	“super-allowed” (few GeV ²)
$g(a_0\eta\pi) / g(a_0\text{KK})$	1.35 ± 0.09	0.91

- 4q not compatible a_0 parameters;
- 4q compatible with f_0 parameters;



Hadronic cross section & $(g-2)_\mu$



- $d\sigma/dQ^2(e^+e^- \rightarrow \text{hadrons}+\gamma) = \sigma(e^+e^- \rightarrow \text{hadrons}, Q^2) \cdot H(Q^2, \cos\theta_0)$

- KLOE can measure $d\sigma/dQ^2(e^+e^- \rightarrow \text{hadrons}+\gamma)$ for

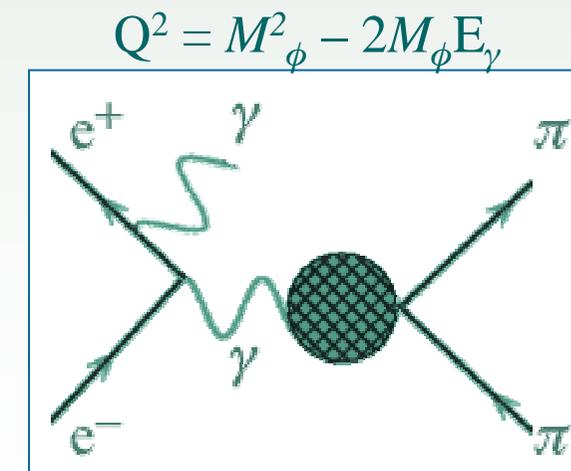
$$(2M_\pi)^2 < Q^2 < (M_\phi)^2$$

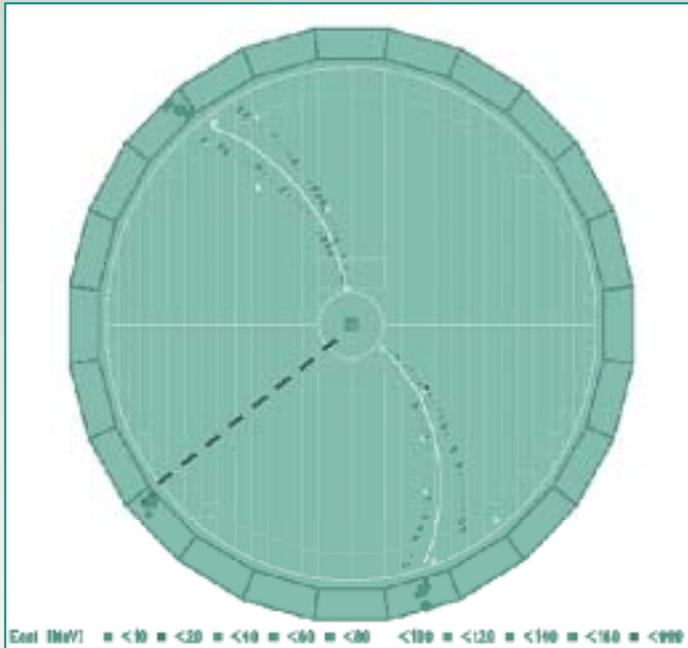
using $e^+e^- \rightarrow \pi^+\pi^-\gamma$ with a γ radiated in initial state (ISR)

(complementary approach to the standard energy scan

- $\sim 70\%$ of $\delta a_\mu^{\text{hadr}}$ ($5000 \cdot 10^{-11}$) comes from this interval in $M_{\pi\pi}$

[Jegerlehner; hep-ph/0104304]



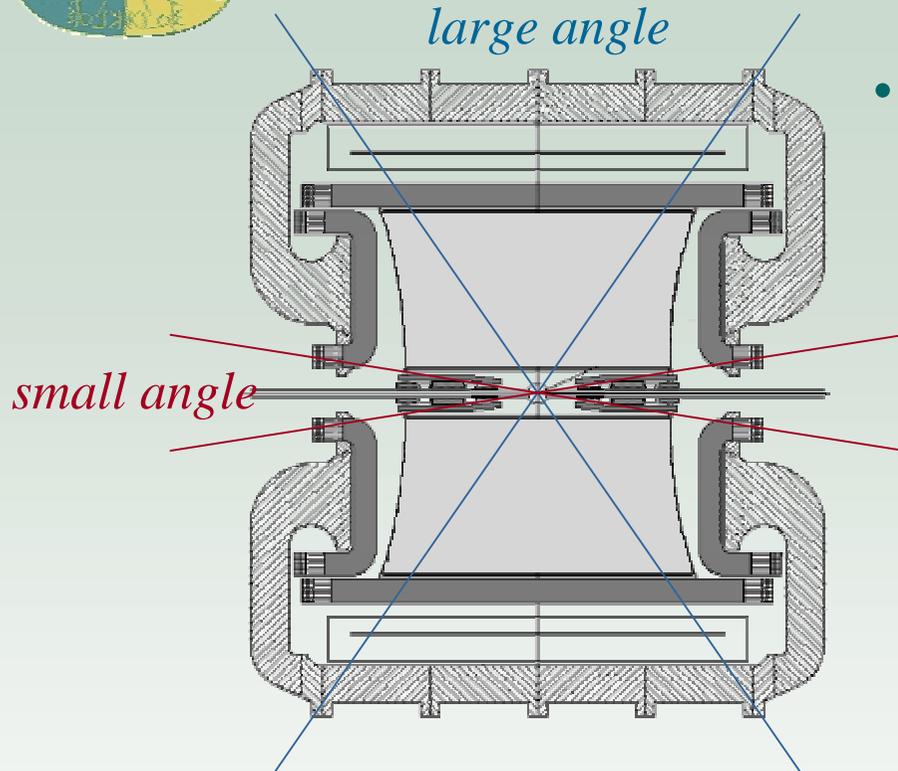
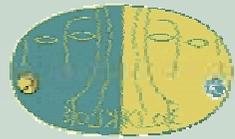
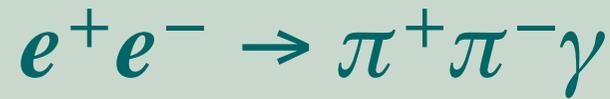


$$d\sigma/dM^2_{\pi\pi} = (N^{\text{obs}} - N^{\text{bkg}}) / \Delta M^2_{\pi\pi} \cdot (\epsilon L)^{-1}$$

Efficiency

Luminosity from Bhabha
(1% accuracy, cross-check with $\gamma\gamma$)

Precise knowledge of ISR and FSR are required, including *all* radiative corrections
KLOE can give a significant contribution, especially at low Q^2 (down to 0.6 GeV²)



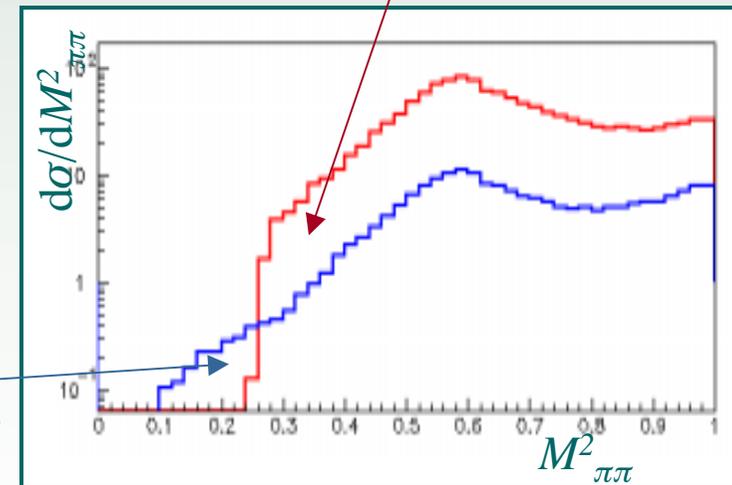
- 2 different samples are selected:

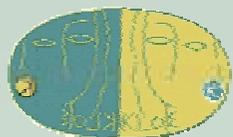
small angle: $\theta_{(\pi\pi)} < 15^\circ$ and $\theta_{(\pi\pi)} > 165^\circ$

- highest cross section;
- small background from $\pi\pi\pi$;
- no γ tagging available \rightarrow ρ resonance
- acceptance losses

large angle: $55^\circ < \theta_{(\pi\pi)} < 125^\circ$

- large background from $\pi\pi\pi$, especially at low Q^2 ;
- FSR contamination;
- require γ : possibility of using the calorimeter to discriminate \rightarrow $m_{\pi\pi}$ at threshold

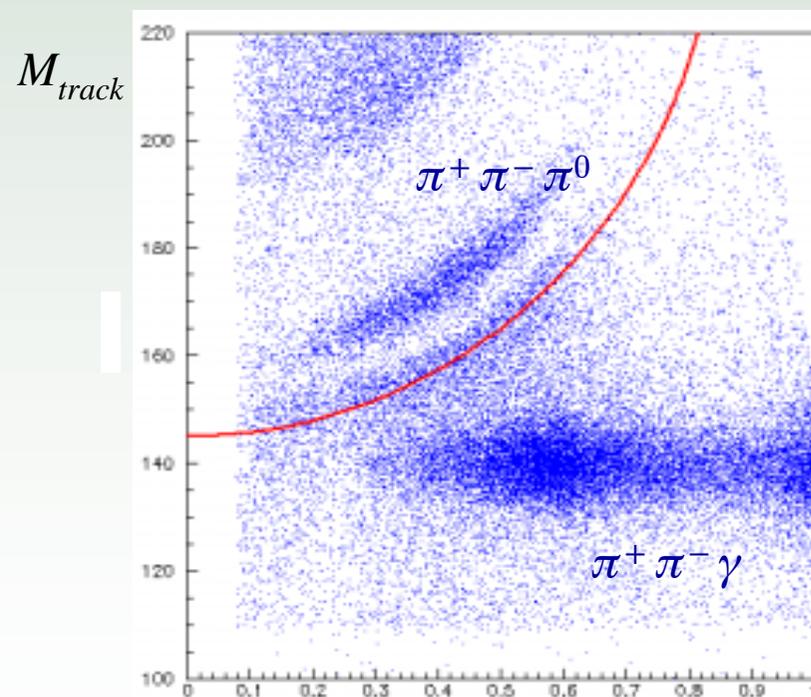
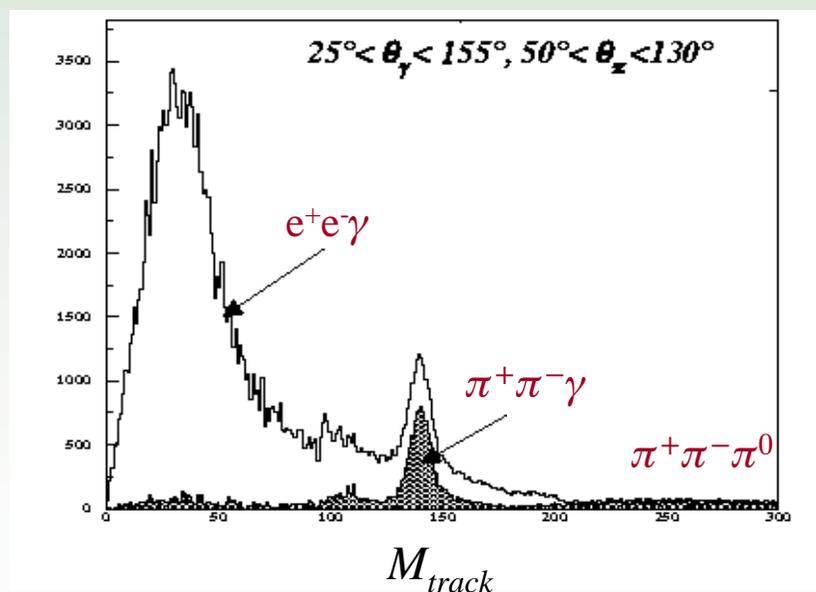




$\pi^+ \pi^- \gamma$ identification

$$q_\gamma^2 = \left(M_\phi - \sqrt{p_1^2 + M_{track}^2} - \sqrt{p_2^2 + M_{track}^2} \right)^2 = 0$$

Likelihood using t.o.f. and shower profile

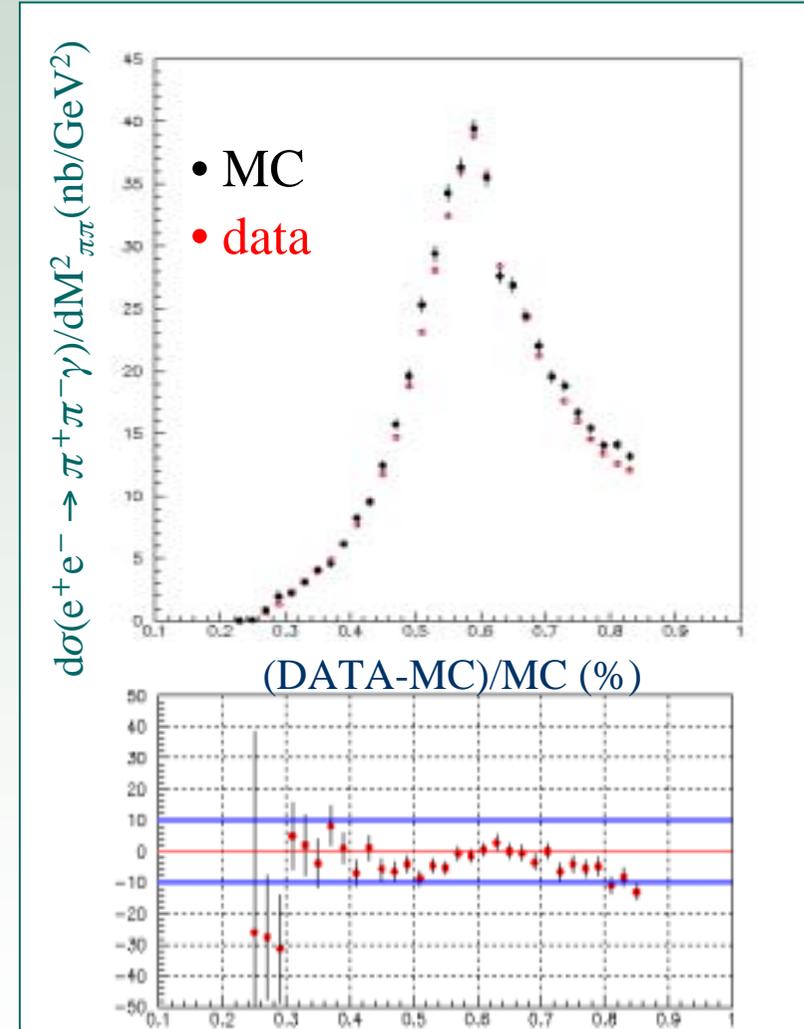
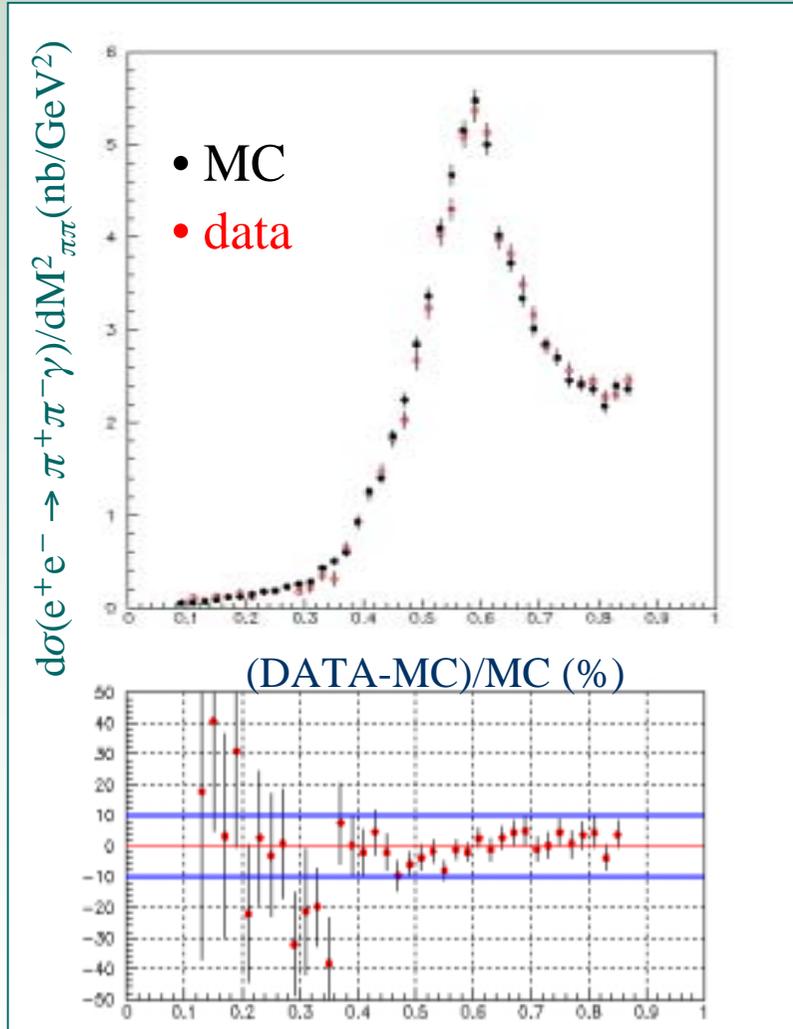




$$d\sigma/dQ^2(e^+e^- \rightarrow \pi^+\pi^-\gamma)$$

large angle (45kevents)

small angle (265 kevents)





$$d\sigma/dQ^2(e^+e^- \rightarrow \pi^+\pi^-\gamma)$$

- KLOE 2001 data (**175 pb⁻¹**) are enough to measure the hadronic cross-section $\sigma(e^+e^- \rightarrow \pi^+\pi^-)$ with a statistical uncertainty of \sim **0.15%** for **small angle sample** and \sim 0.3% for large angle sample.

- The new NLO generator from Kühn et al. improves the theoretical description of ISR.

The uncertainty from unaccounted higher order ISR is estimated to be around 0.5% [hep-ph/0112184]

- Expected improvement in the knowledge of the radiator function and in the luminosity measurement.



Analyses in progress

- ❖ Hadronic cross-section with radiative return

- ❖ Year 2000 results $\times 10$ statistics + improve systematic. In particular:
 - $\text{BR}(\text{K}_S \rightarrow \pi^\pm e^\pm \nu)$ down to 2%; first look at charge asymmetry
 - $\Gamma(\text{K}_S \rightarrow \pi^+ \pi^- (\gamma)) / \Gamma(\text{K}_S \rightarrow \pi^0 \pi^0)$ down to 0.1% (work on systematic)
 - High statistics a_0 spectrum

- ❖ $\text{K}_L \rightarrow \gamma\gamma / \text{K}_L \rightarrow 3\pi^0$
- ❖ Dynamics of the $\phi \rightarrow \pi^+ \pi^- \pi^0$ decay $\rightarrow \rho^+ \rho^- \rho^0$ parameters
- ❖ Upper limit on $\eta \rightarrow \gamma\gamma\gamma$
- ❖ Charged kaons: $0.6 \cdot 10^6$ tags/pb⁻¹, but sensitive to machine background conditions...



K_L physics

$K_L \rightarrow \gamma\gamma / K_L \rightarrow \pi^0\pi^0\pi^0$:

$K_L \rightarrow \pi^0\pi^0\pi^0$ well measured in all the fiducial volume:

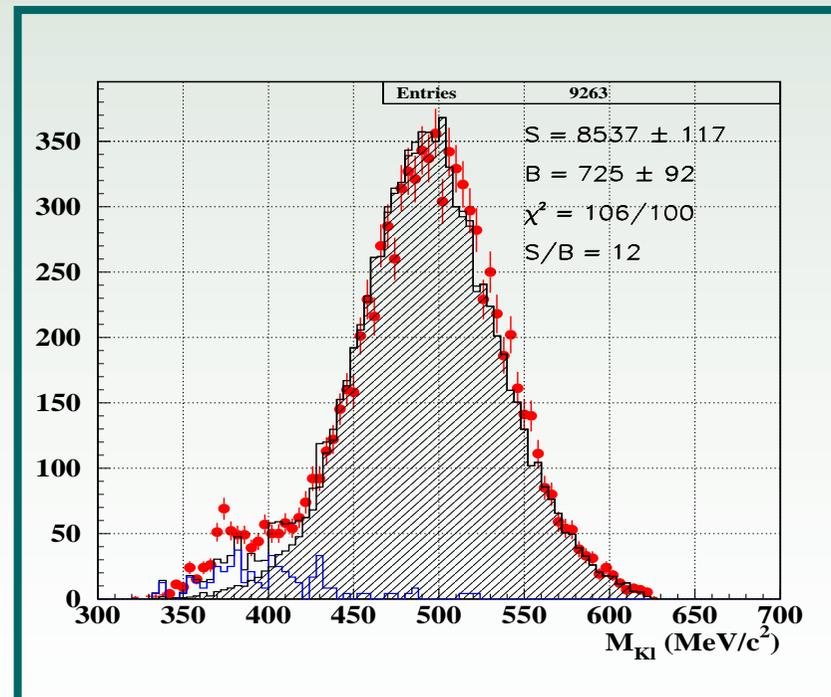
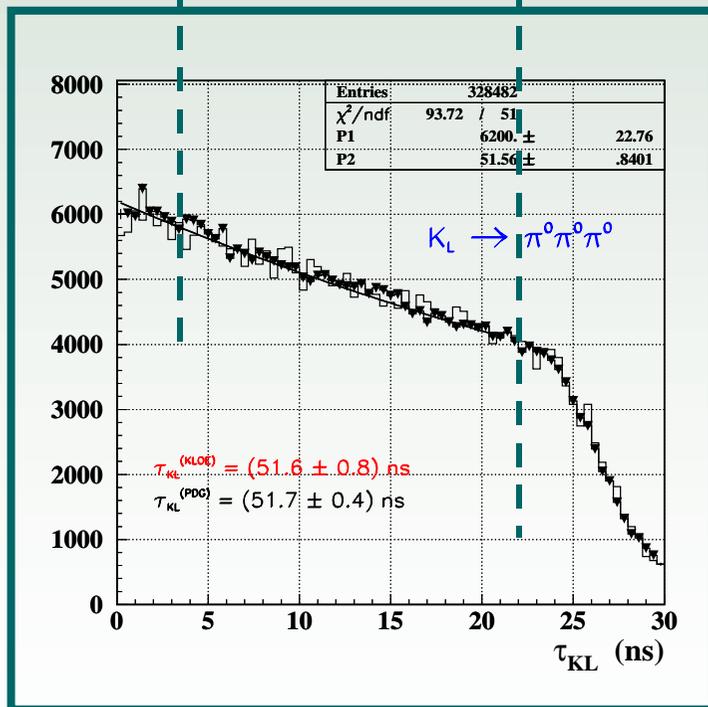
Measurement of τ_{K_L}

• Data

— MC signal

— MC background

Drift Chamber volume





Conclusions

- DAΦNE improved continuously during the first three years of KLOE data taking
- The KLOE detector is performing well
- From **2000 data** we measured:
 - $\text{BR}(K_S \rightarrow \pi^+\pi^-)/\text{BR}(K_S \rightarrow \pi^0\pi^0)$
 - $\text{BR}(K_S \rightarrow \pi e \nu)$
 - $\phi \rightarrow f_0 \gamma \rightarrow \pi^0 \pi^0 \gamma$
 - $\phi \rightarrow a_0 \gamma \rightarrow \eta \pi^0 \gamma$
 - $\phi \rightarrow \eta \gamma, \phi \rightarrow \eta' \gamma$

→ *First set of KLOE papers*
- From **2001 data**, we expect results from:
 - $K_L \rightarrow 2\pi, K^\pm$ decays, $K_L \rightarrow \gamma\gamma$ decays
 - Rare K_S decays ($\text{BR} \sim 10^{-5}$)
 - $\sigma(e^+e^- \rightarrow \pi^+\pi^-)$ by ISR to $< 1\%$ statistical error

→ *Next round of KLOE papers*
- Further improvements expected in 2002...



Conclusions II: what next?

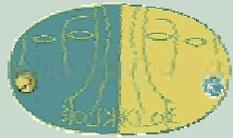
• **500 pb⁻¹ by the end of 2002** → *More results from KLOE...*

• **December 2002:** Start long shutdown ~ 6 months

New interaction region: quadrupole triplet → “tunable” doublet

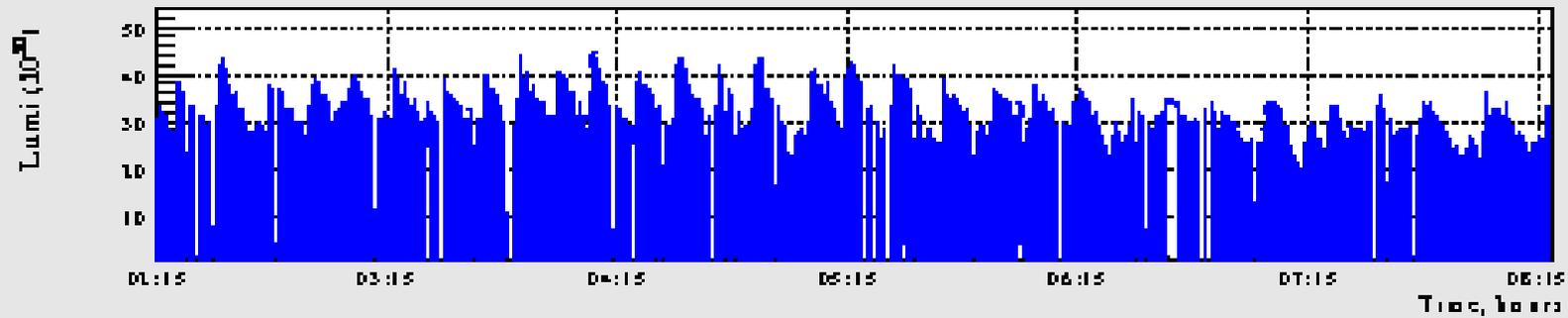
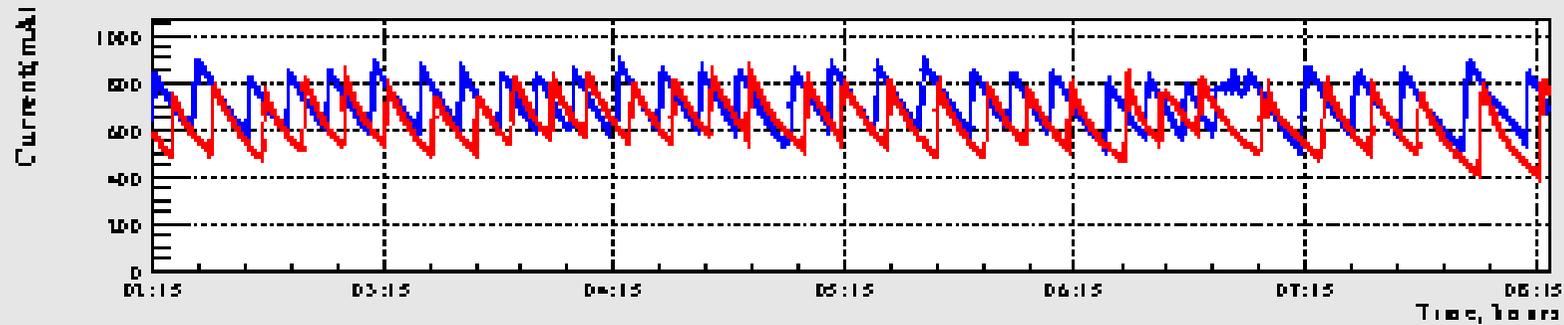
This was very effective in background reduction for IP2 (DEAR)

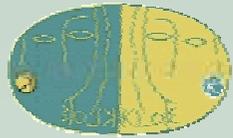
• **Goal peak luminosity: $5 \cdot 10^{32} \text{ cm}^2 \text{ s}^{-1}$** → *Here comes CP!*



2002 data taking

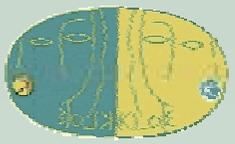
Kraków, 27 May 2002



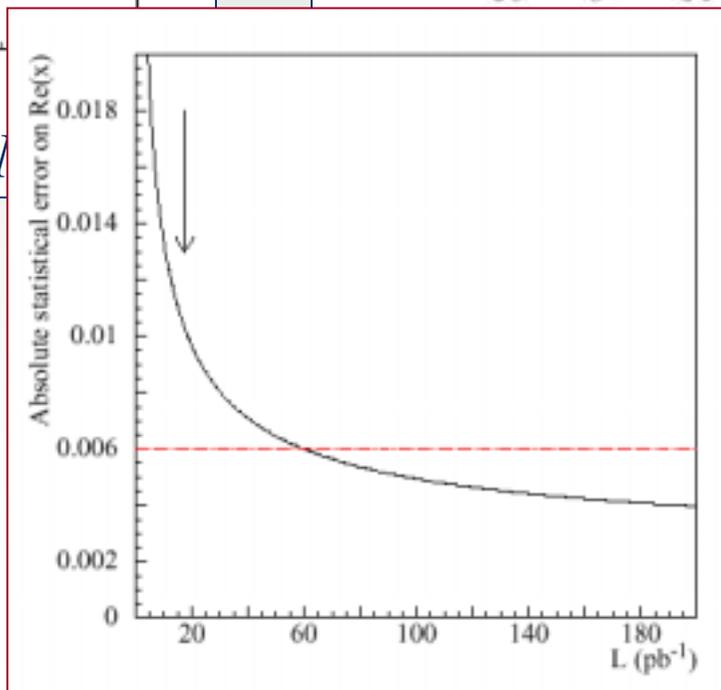
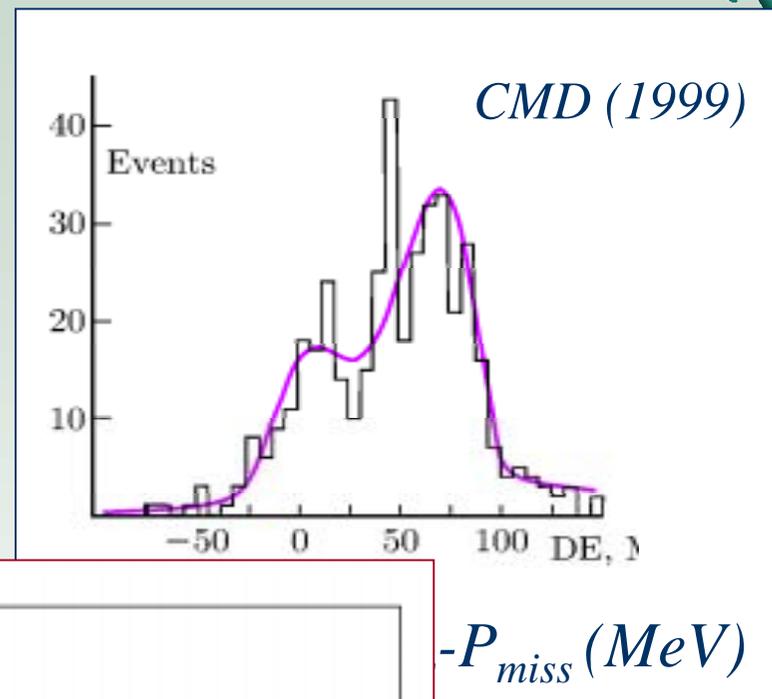
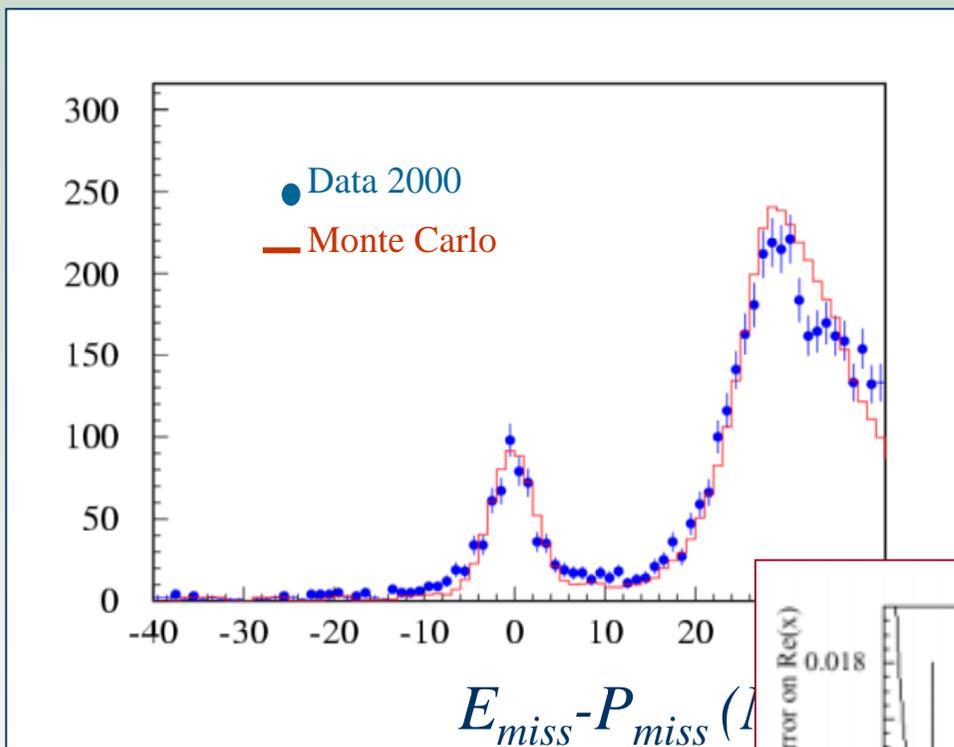


Event yield with 200 pb^{-1}

K_S	$2 \cdot 10^8$	$0.6 \cdot 10^8$ tagged (K_L visible interactions)	
	• $K_S \rightarrow \pi^+\pi^-$		$0.3 \cdot 10^8 \cdot \text{BR} \quad \sim 2 \times 10^7$
	• $K_S \rightarrow \pi^0\pi^0$		$0.3 \cdot 10^8 \cdot \text{BR} \quad \sim 1 \times 10^7$
	• $K_S \rightarrow \pi e \nu$		$0.9 \cdot 10^7 \cdot \text{BR} \quad \sim 6700$
	• $K_S \rightarrow \gamma\gamma$		$3.3 \cdot 10^7 \cdot \text{BR} \quad \sim 70$
	• $K_S \rightarrow \pi^0 e^+ e^-$ (Single Event Sensitivity)		$0.8\text{-}1.5 \cdot 10^{-7}$
	• $K_S \rightarrow \pi^0 \pi^0 \pi^0$ (Single Event Sensitivity)		$3 \cdot 10^{-8}$
K_L	$2 \cdot 10^8$	$0.9 \cdot 10^8$ tagged ($K_S \rightarrow \pi^+\pi^-$)	
	K_L Decay in FV (D.C.)		$2.5 \cdot 10^7$
	$K_L \rightarrow \pi^+\pi^-$		$\sim 2.7 \cdot 10^4$
	$K_L \rightarrow \pi^0\pi^0$		$\sim 1.0 \cdot 10^4$
	$K_L \rightarrow \gamma\gamma$		$\sim 0.5 \cdot 10^4$
$K^{+/-}$	$3 \cdot 10^8$	$0.7 \cdot 10^8$ tagged	
	Reconstructed K^+ (K^-)		$5 \cdot 10^7$



$K_S \rightarrow \pi e \nu$ result





Online calibration

- Detector calibrated on-line (run by run $\sim 0.1 \text{ pb}^{-1} \sim 1 \text{ hour}$), **before** starting quasi-online event reconstruction and classification:

Drift Chamber **s-t relations**

(*Bhabha*)

Drift Chamber momentum scale

($M_{\pi\pi}$ from $K_S \rightarrow \pi^+\pi^-$)

Calorimeter energy scale (0.1%)

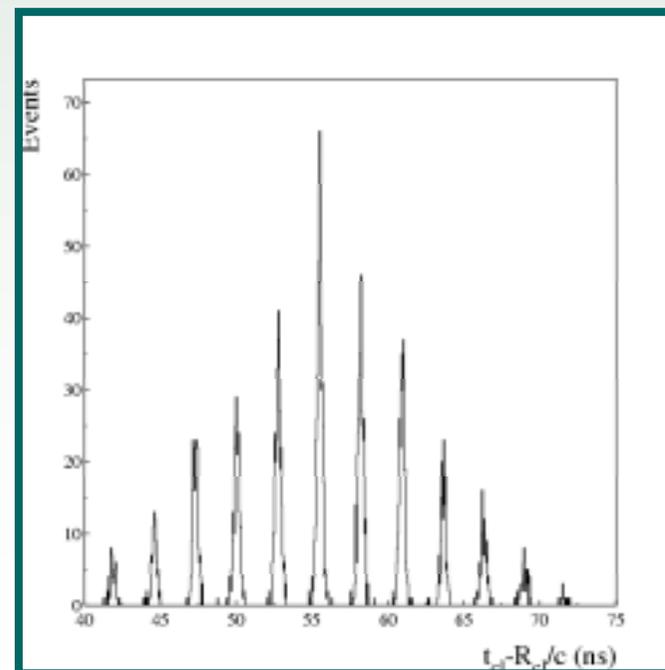
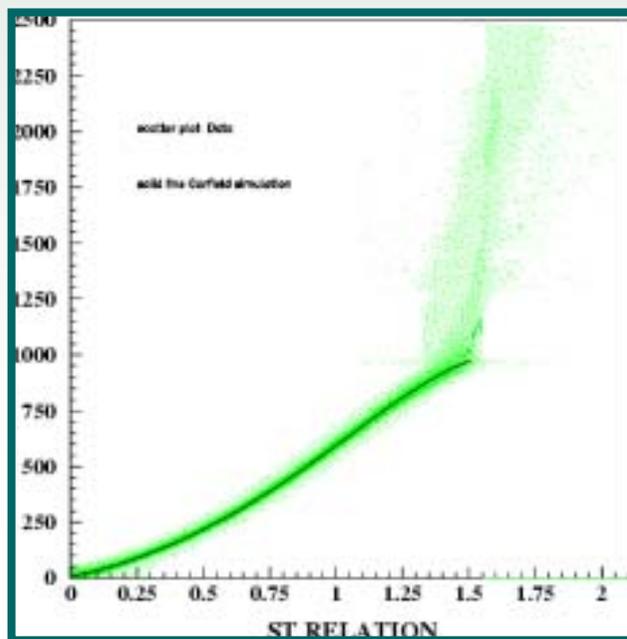
($e^+e^- \rightarrow \gamma\gamma$)

Calorimeter **time scale** (0.1%) + offset (20 ps)

“

\sqrt{S} and p_ϕ

(*Bhabha, K_S, K_L*)



Paolo Valente