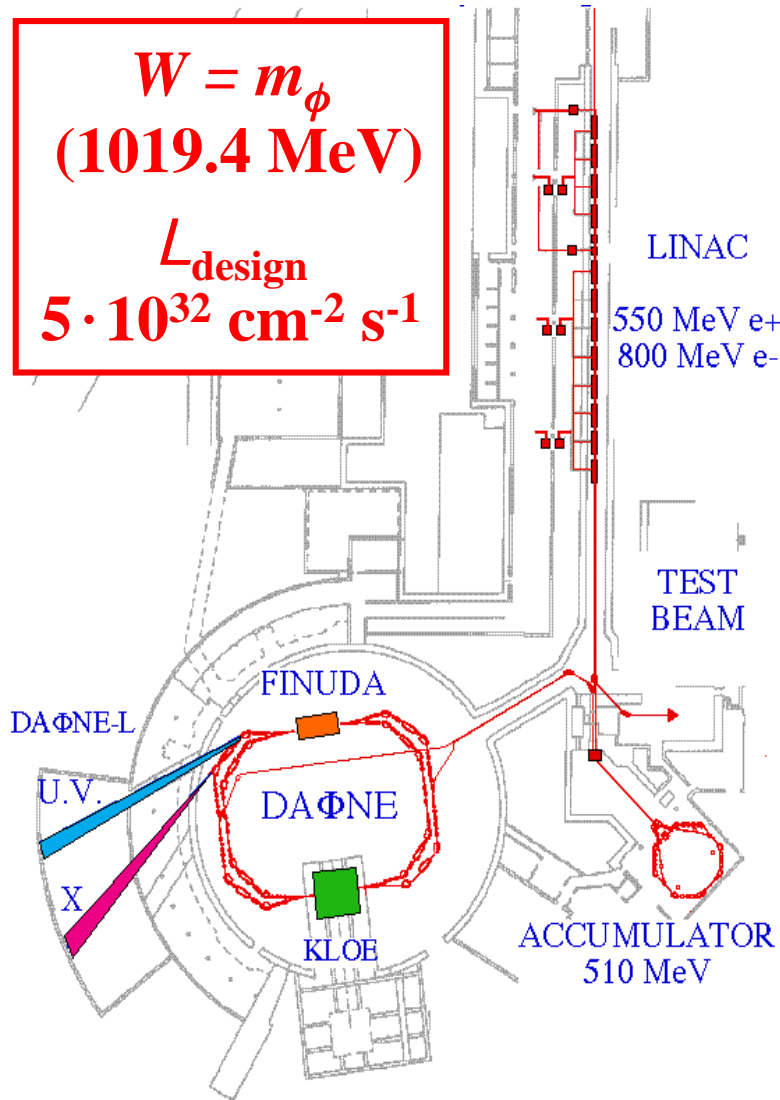
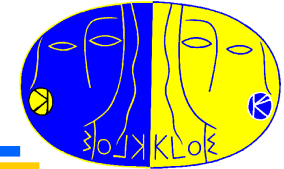


Recent results from KLOE at DAΦNE

**M. Moulson, INFN/Frascati,
for the KLOE collaboration**

**Conference on the Intersections of Particle and Nuclear Physics
New York, 22 May 2003**

DAΦNE: the Frascati ϕ factory

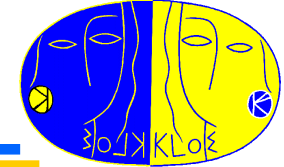


$W = m_\phi$
 (1019.4 MeV)
 L_{design}
 $5 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$

- Two interaction regions
- Separate e^+ , e^- rings minimize beam-beam interactions
- Beams cross at 12.5 mrad angle
- Injection during data-taking

DAΦNE parameters	Design	2002
Max. bunches	120	51
Lifetime (mins)	120	40
Bunch current (mA)	40	20
L , single bunch ($\text{cm}^{-2}\text{s}^{-1}$)	$4.4 \cdot 10^{30}$	$1.5 \cdot 10^{30}$
L , peak ($\text{cm}^{-2}\text{s}^{-1}$)	$5.3 \cdot 10^{32}$	$0.75 \cdot 10^{32}$
ϕ per year (10^9)	15	0.9

Physics opportunities at DAΦNE



$$\sigma(e^+e^- \rightarrow \phi) \approx 3 \mu\text{b}$$

$K_S K_L$ ($K^+ K^-$) produced in pure $J^{PC} = 1^{--}$ state

Principal ϕ decays

$K^+ K^-$	49.1%
-----------	-------

$K_S K_L$	34.3%
-----------	-------

$\rho\pi$	15.4%
-----------	-------

$\eta\gamma$	1.3%
--------------	------

$$K_S, K^+ \longleftarrow \phi \longrightarrow K_L, K^-$$

$$\frac{1}{\sqrt{2}} (|K_L, \mathbf{p}\rangle |K_S, -\mathbf{p}\rangle - |K_L, -\mathbf{p}\rangle |K_S, \mathbf{p}\rangle)$$

Observation of $K_{S,L}$ signals presence of $K_{L,S}$

Allows precision measurement of absolute BR's

Allows interference measurements of $K_S K_L$ system

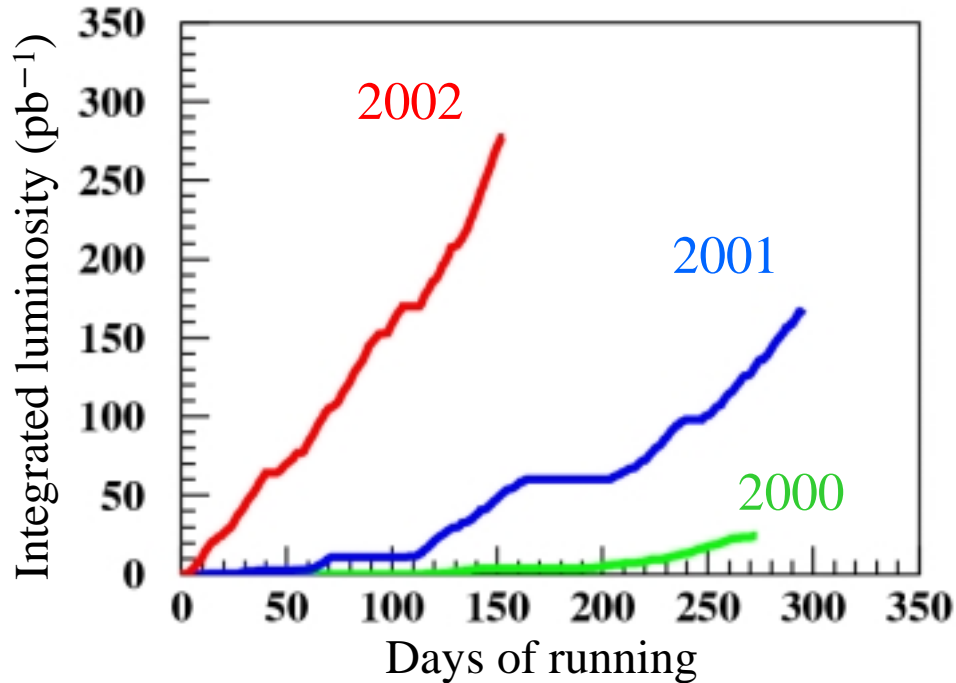
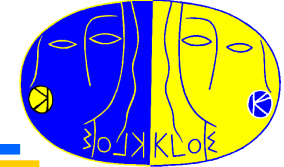
$$p_{L,S} = 110 \text{ MeV}$$

$$\beta_{L,S} = 0.22$$

$\lambda_S = 6 \text{ mm}$: K_S decays near interaction point

$\lambda_L = 3.4 \text{ m}$: Appreciable acceptance for K_L
($\sim 0.5\lambda_L$)

KLOE data taking: 2000-2002



2000 run: 25 pb⁻¹
80 · 10⁶ ϕ decays

*First
published
results*

2001 run: 170 pb⁻¹
530 · 10⁶ ϕ decays

*Analysis in
progress*

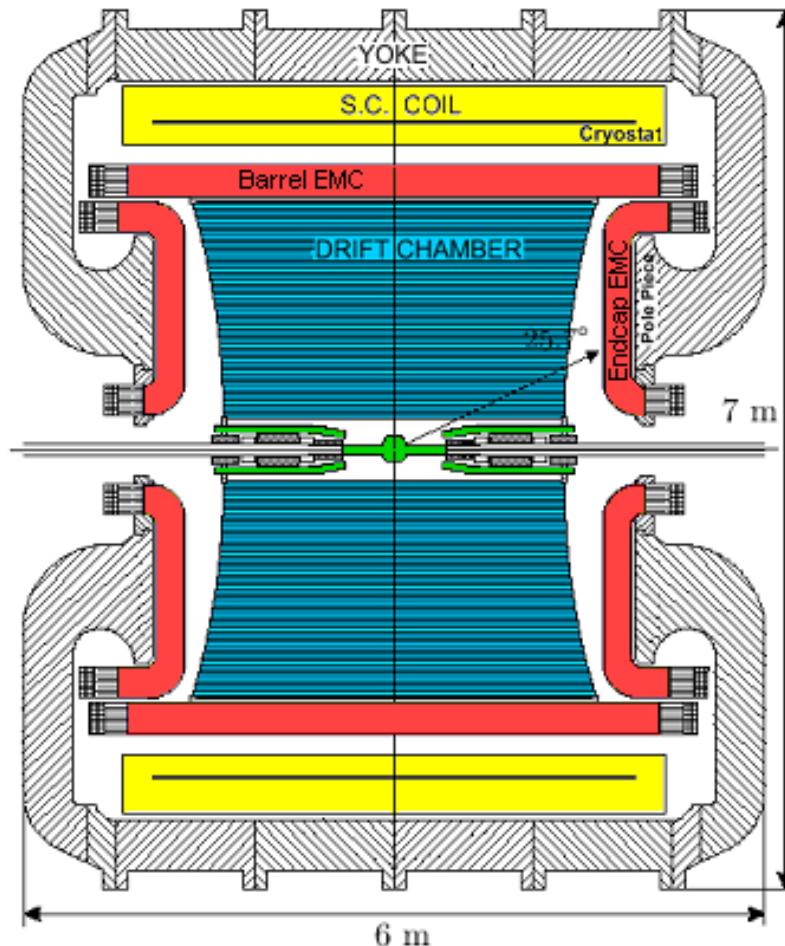
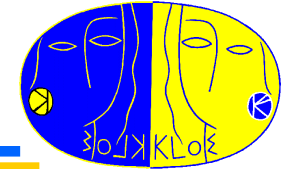
2002 run: 280 pb⁻¹
870 · 10⁶ ϕ decays

5 months of KLOE data taking in 2002:

Best value of L_{peak} : $7.8 \cdot 10^{31} \text{ cm}^{-2}\text{s}^{-1}$

Best $\int L dt$ in one day: 4.5 pb^{-1}

The KLOE experiment



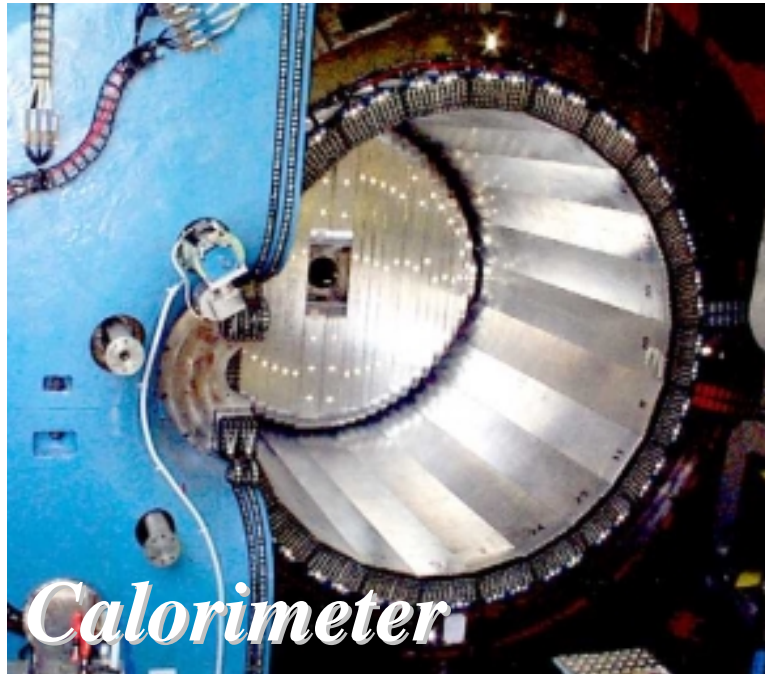
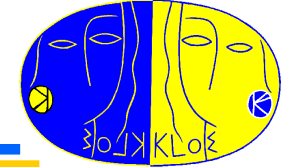
Be beam pipe (0.5 mm thick)
Instrumented permanent magnet quadrupoles (32 PMT's)

Drift chamber (4 m \varnothing \times 3.3 m)
90% He + 10% IsoB, CF frame
12582 stereo sense wires

Electromagnetic calorimeter
Lead/scintillating fibers
4880 PMT's

Superconducting coil (5 m bore)
 $B = 0.52 \text{ T}$ ($\int B dl = 2 \text{ T}\cdot\text{m}$)

KLOE detector specifications



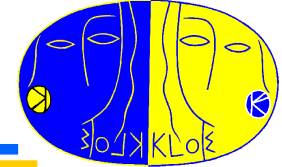
$$\sigma_E/E \quad \mathbf{5.7\% \sqrt{E}(\text{GeV})}$$
$$\sigma_t \quad \mathbf{54 \text{ ps} \sqrt{E}(\text{GeV}) \oplus 50 \text{ ps}}$$

(relative time between clusters)

$$\sigma_L(\gamma\gamma) \quad \mathbf{\sim 1.5 \text{ cm}} \quad (\pi^0 \text{ from } K_L \rightarrow \pi^+\pi^-\pi^0)$$

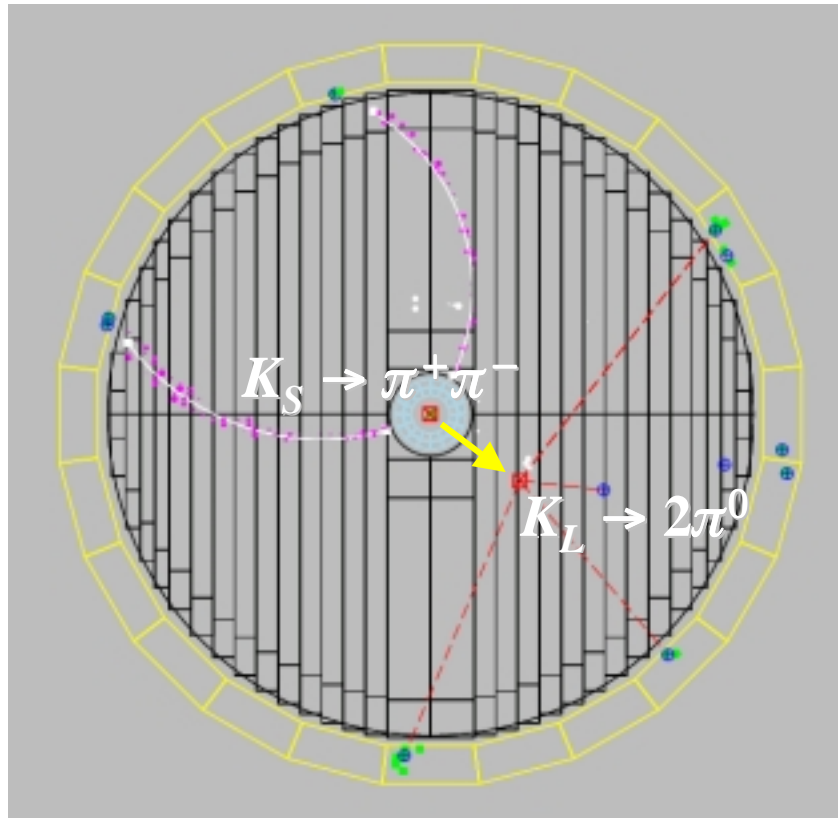
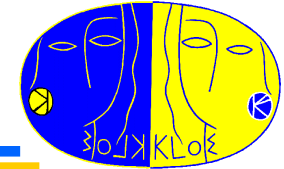
$$\sigma_p/p \quad \mathbf{0.4\%} \quad (\text{tracks with } \theta > 45^\circ)$$
$$\sigma_x^{\text{hit}} \quad \mathbf{150 \mu\text{m} (xy), 2 \text{ mm} (z)}$$
$$\sigma_x^{\text{vertex}} \quad \mathbf{\sim 1 \text{ mm}}$$

Kaon physics at KLOE

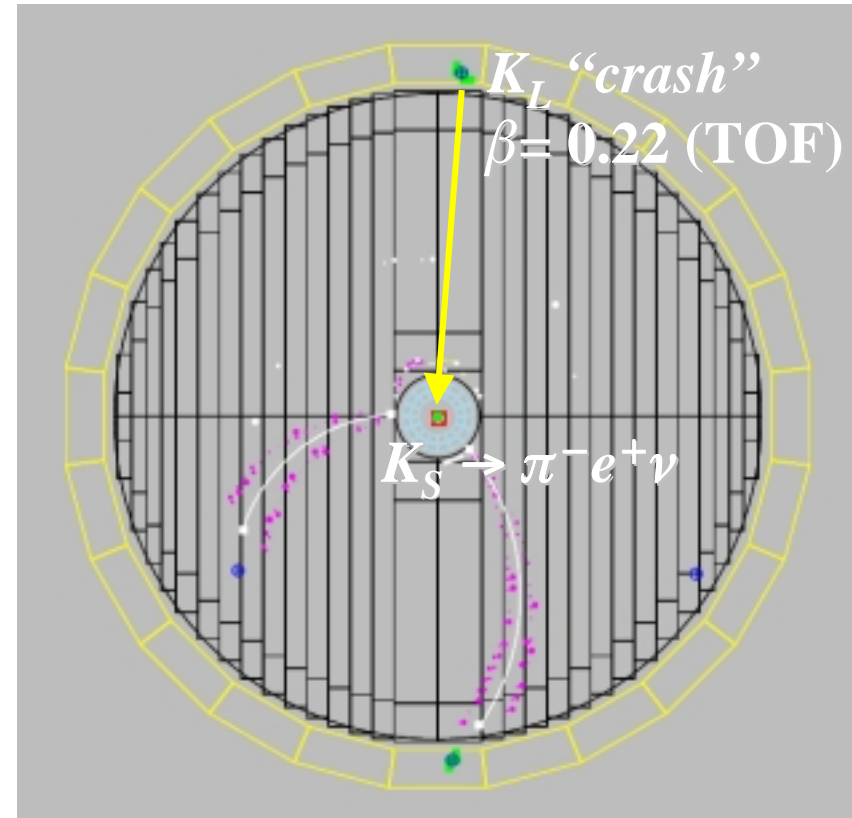


$K_S \rightarrow \pi^+\pi^-(\gamma)$ $K_S \rightarrow \pi^0\pi^0$	Phys. Lett. B538 , 21 (2002)
$K_S \rightarrow \pi e \nu$	Phys. Lett. B537 , 21 (2002) Preliminary update with 2001 data
K_S mass	KLOE Note 181 (http://www.lnf.infn.it/kloe)
$K_L \rightarrow \gamma\gamma / K_L \rightarrow 3\pi^0$	Submitted to Phys. Lett. (hep-ex/0305035)
$K_L \rightarrow$ charged	Preliminary results
CP violation & interference	Prospects & preliminary results
$K^+ \rightarrow \pi^+\pi^0\pi^0$	Preliminary results
V_{us}	Prospects & preliminary results

Tagged K_L and K_S “beams”

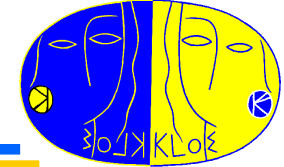


K_L tagged by $K_S \rightarrow \pi^+\pi^-$ vertex at IP
Efficiency $\sim 70\%$ (mainly geometrical)
 K_L angular resolution: $\sim 1^\circ$
 K_L momentum resolution: ~ 2 MeV



K_S tagged by K_L interaction in EmC
Efficiency $\sim 30\%$ (largely geometrical)
 K_S angular resolution: $\sim 1^\circ$ (0.3° in ϕ)
 K_S momentum resolution: ~ 2 MeV

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

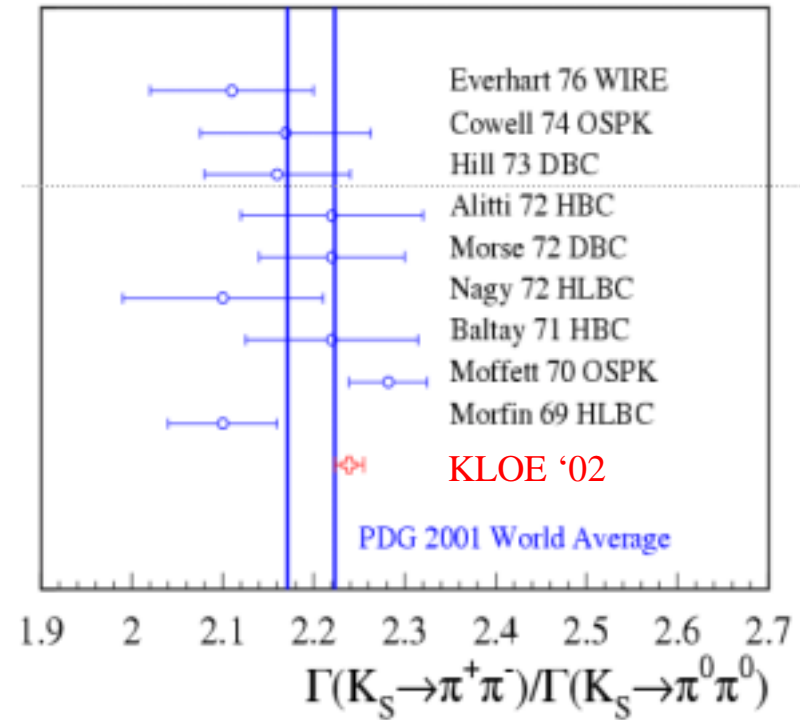
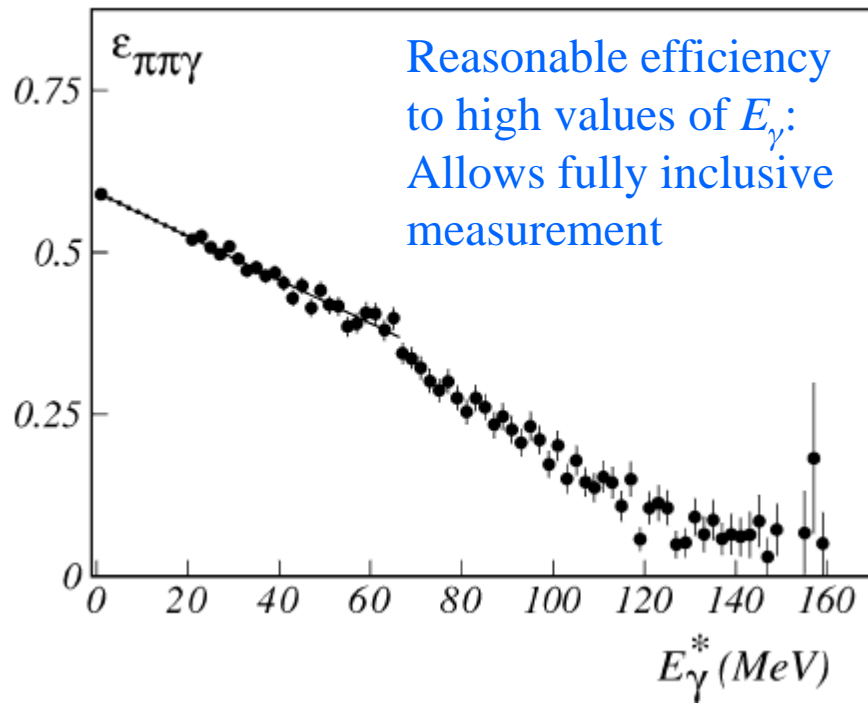


- First part of double ratio for $\text{Re } \varepsilon'/\varepsilon$
- Provides information on EM isospin breaking in $K \rightarrow \pi\pi$ decays
- Can extract $\delta_0 - \delta_2$ if effective E_γ cutoff known for $\pi\pi\gamma$ channel

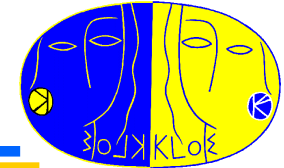
PDG '02 2.197 ± 0.026 (avg.)

KLOE '02 $2.236 \pm 0.003 \pm 0.015$

17 pb^{-1} '00 data: $1.1 \cdot 10^6 K_S \rightarrow \pi^+\pi^-$
 $0.8 \cdot 10^6 K_S \rightarrow \pi^0\pi^0$



Extraction of $\delta_0 - \delta_2$



Conventional extraction of strong phase shifts from $K_S, K^+ \rightarrow \pi\pi$ decays:

$$A_{+-} = \sqrt{\frac{2}{3}} A_0 e^{i\delta_0} + \sqrt{\frac{1}{3}} A_2 e^{i\delta_2}$$

$$A_{00} = -\sqrt{\frac{1}{3}} A_0 e^{i\delta_0} + \sqrt{\frac{2}{3}} A_2 e^{i\delta_2}$$

$$A_{+0} = \sqrt{\frac{3}{4}} A_2 e^{i\delta_2}$$

- Extraction of $K \rightarrow \pi\pi$ amplitudes from measured widths must take into account effective cutoff for processes with γ in final state

- Including isospin-breaking EM effects:**

$$A_I e^{i\delta_I} \rightarrow (A_I + \delta A_I) e^{i\chi_I}$$

$$\chi_I \equiv \delta_I + \gamma_I \quad \gamma_I = \text{EM phase shift}$$

$K \rightarrow \pi\pi$ decays actually measure $\chi_0 - \chi_2$

For $\delta_0 - \delta_2$, need theoretical input ($\gamma_0 - \gamma_2$)

$\chi_0 - \chi_2$

$\delta_0 - \delta_2$

PDG widths **$(56 \pm 8)^\circ$**

Cirigliano et al. '01

$(45 \pm 6)^\circ$

χ PT estimate

Gasser & Meissner, '91

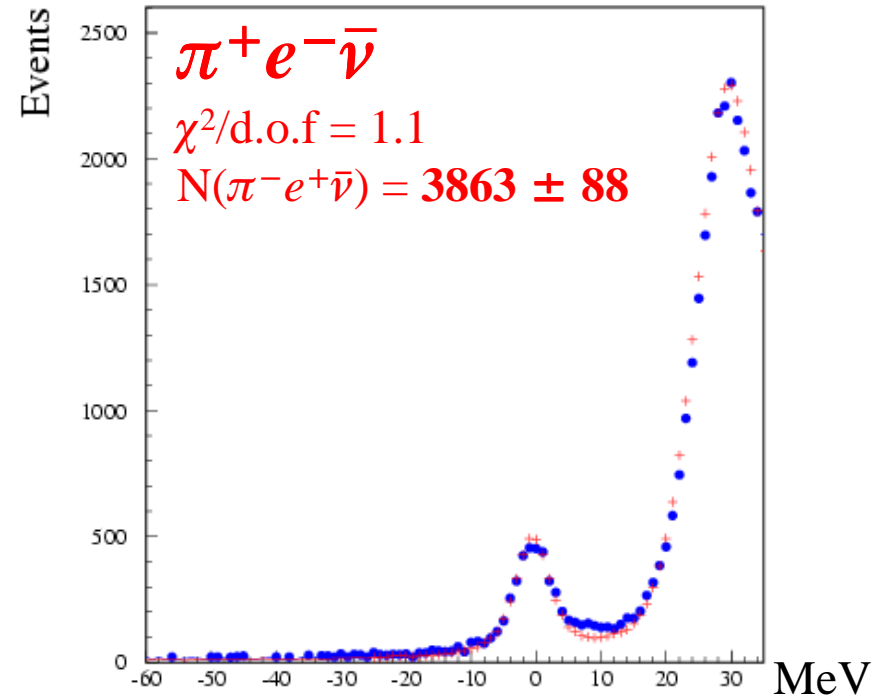
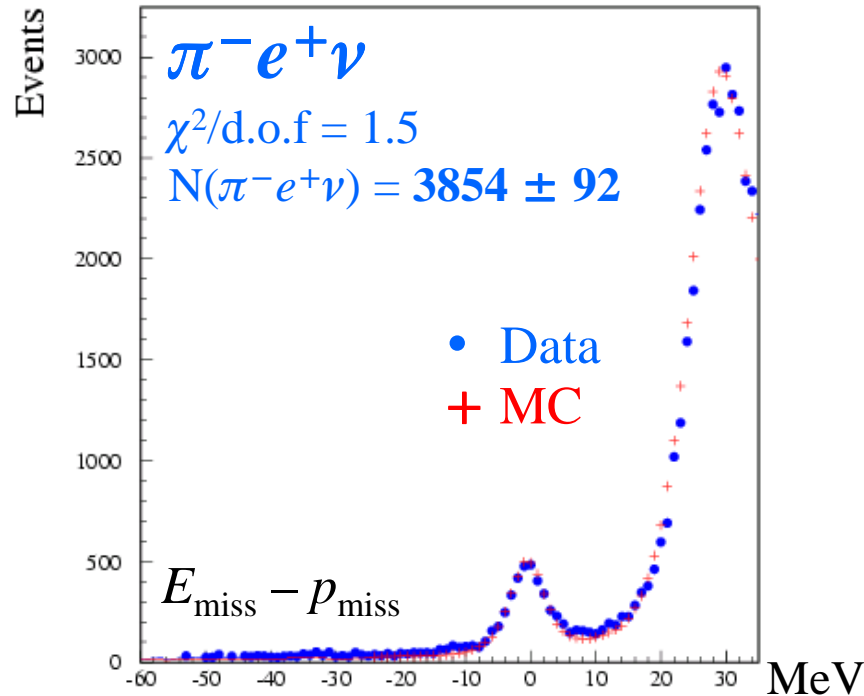
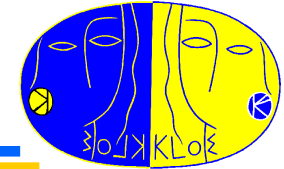
KLOE '02 value for $\Gamma(\pi^+\pi^-)/\Gamma(\pi^0\pi^0)$ $(48 \pm 3)^\circ$

$(47.7 \pm 1.5)^\circ$

$\pi\pi$ scattering

Colangelo et al. '01

$K_S \rightarrow \pi^- e^+ \nu, \pi^+ e^- \bar{\nu}$

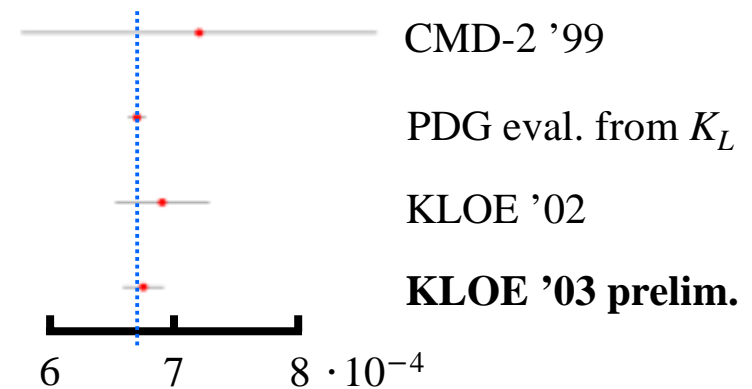


KLOE preliminary (170 pb⁻¹ '01 data)

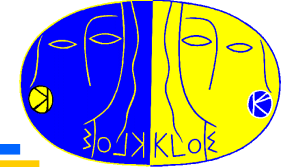
$$\text{BR}(\pi^- e^+ \nu) = (3.46 \pm 0.09 \pm 0.06) \cdot 10^{-4}$$

$$\text{BR}(\pi^+ e^- \bar{\nu}) = (3.33 \pm 0.08 \pm 0.05) \cdot 10^{-4}$$

$$\text{BR}(\pi^\mp e^\pm \nu) = (6.81 \pm 0.12 \pm 0.10) \cdot 10^{-4}$$



$K^0 \rightarrow \pi e \nu$ decays and CPT



$$\langle \pi^- e^+ \nu \mid H_W \mid K^0 \rangle = a + b$$

$$\langle \pi^+ e^- \bar{\nu} \mid H_W \mid \bar{K}^0 \rangle = a^* - b^*$$

$$\langle \pi^+ e^- \bar{\nu} \mid H_W \mid K^0 \rangle = c + d$$

$$\langle \pi^- e^+ \nu \mid H_W \mid \bar{K}^0 \rangle = c^* - d^*$$

T	$Im a = Im b = Im c = Im d = 0$
CP	$Im a = Re b = Im c = Re d = 0$
CPT	$b = d = 0$
$\Delta S = \Delta Q$	$c = d = 0$

$$A \equiv \frac{\Gamma(\pi^- e^+ \nu) - \Gamma(\pi^+ e^- \bar{\nu})}{\Gamma(\pi^- e^+ \nu) + \Gamma(\pi^+ e^- \bar{\nu})} \begin{cases} A_S = 2(\text{Re } \varepsilon_K + \text{Re } \delta_K + \text{Re } b/a - \text{Re } d^*/a) \\ A_L = 2(\text{Re } \varepsilon_K - \text{Re } \delta_K + \text{Re } b/a + \text{Re } d^*/a) \end{cases}$$

$A_S - A_L \neq 0$ implies CPT

\cancel{CP}

\cancel{CPT} in
mixing

\cancel{CPT} in
decay

$\Delta S \neq \Delta Q$
and \cancel{CPT}

KLOE preliminary

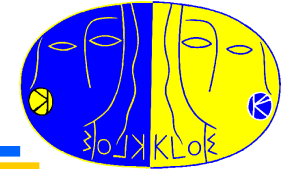
$$A_S = (19 \pm 17 \pm 6) \cdot 10^{-3}$$

First measurement of A_S !

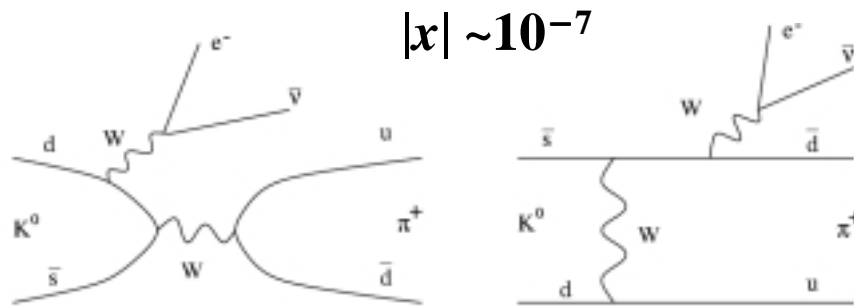
Compare to KTeV '02 result for A_L

$$A_L = (3.322 \pm 0.058 \pm 0.047) \cdot 10^{-3}$$

$K^0 \rightarrow \pi e \nu$ decays and $\Delta S = \Delta Q$



No $\Delta S \neq \Delta Q$ transitions at lowest order
 ($\Delta S \neq \Delta Q$ in higher order transitions)



$$\text{Re } x_+ = \frac{1}{2} \frac{\text{BR}_S(\pi e \nu)/\tau_S - \text{BR}_L(\pi e \nu)/\tau_L}{\text{BR}_S(\pi e \nu)/\tau_S + \text{BR}_L(\pi e \nu)/\tau_L}$$

KLOE preliminary

$$\text{Re } x_+ = (3.3 \pm 5.2 \pm 3.5) \cdot 10^{-3}$$

Compare to CPLEAR '98

$$\text{Re } x_+ = (-1.8 \pm 4.1 \pm 4.5) \cdot 10^{-3}$$

$$x = (c^* - d^*)/(a + b)$$

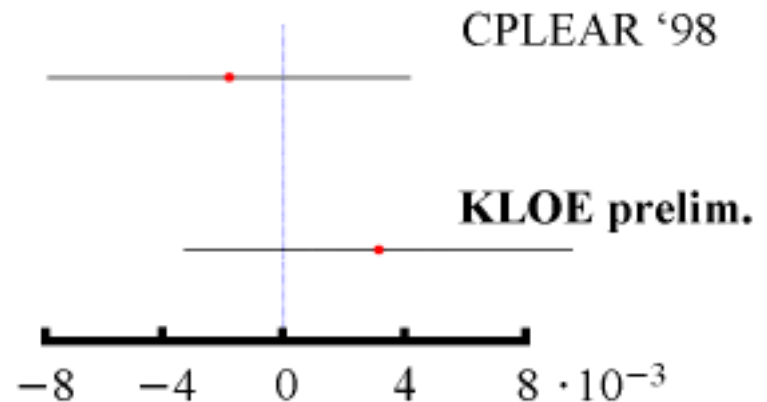
$\Delta S \neq \Delta Q$ in \bar{K}^0 decay to e^+

$$\bar{x} = (c + d)/(a^* - b^*)$$

$\Delta S \neq \Delta Q$ in K^0 decay to e^-

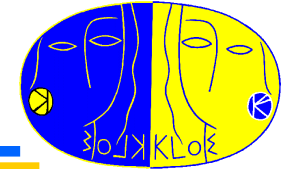
$$x_+ = (x + \bar{x})/2 \approx c^*/a$$

$\Delta S \neq \Delta Q$ if *CPT* conserved



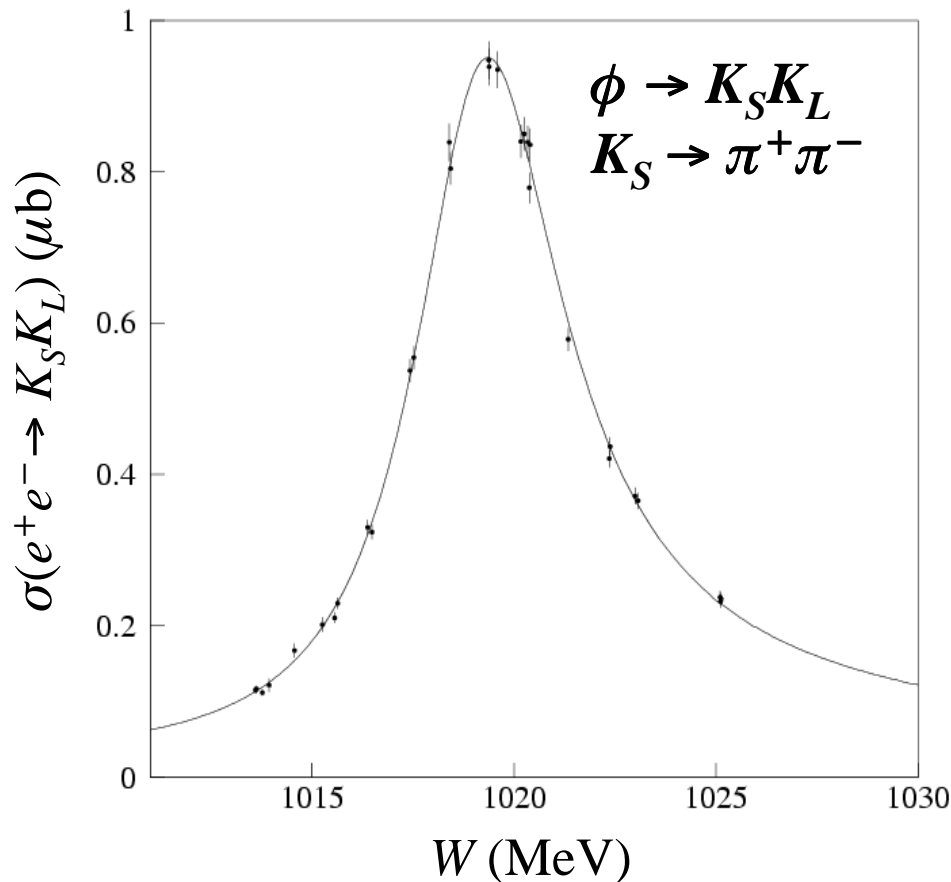
280 pb⁻¹ from '02 running +
 KLOE measurements of τ_L ,
 BR($K_L \rightarrow \pi e \nu$) on the way

Measurement of K_S mass



2001 ϕ peak scan: 29 pts, 0.5 pb^{-1}

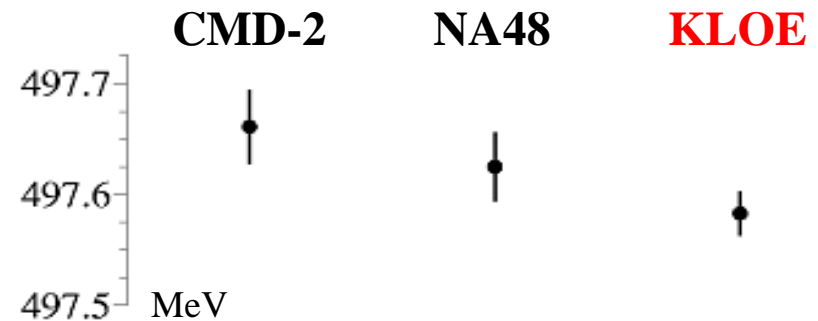
Momentum scale calibrated to CMD-2 '01
 $m(\phi) = 1019.483 \pm 0.011 \pm 0.025 \text{ MeV}$



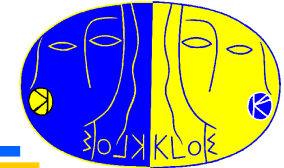
$$W = M(e^+e^-)$$
$$P = \mathbf{p}(\pi^+) + \mathbf{p}(\pi^-)$$

$$m(K_S) = W^2/4 - P^2$$
$$\delta m/m \approx 0.05(\delta P/P)$$

$m(K_S)$ KLOE preliminary
 $497.583 \pm 0.005 \pm 0.020 \text{ MeV}$

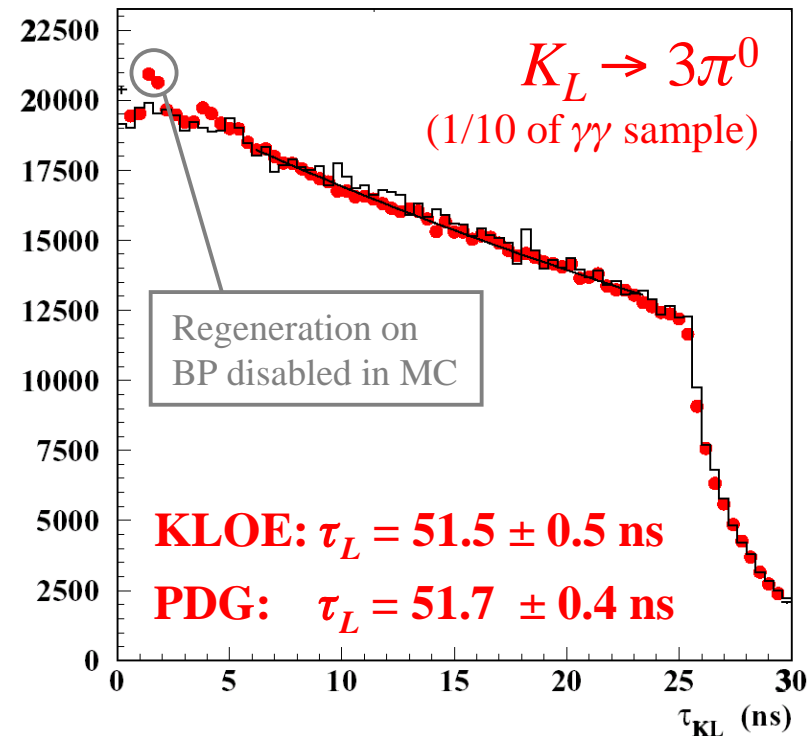
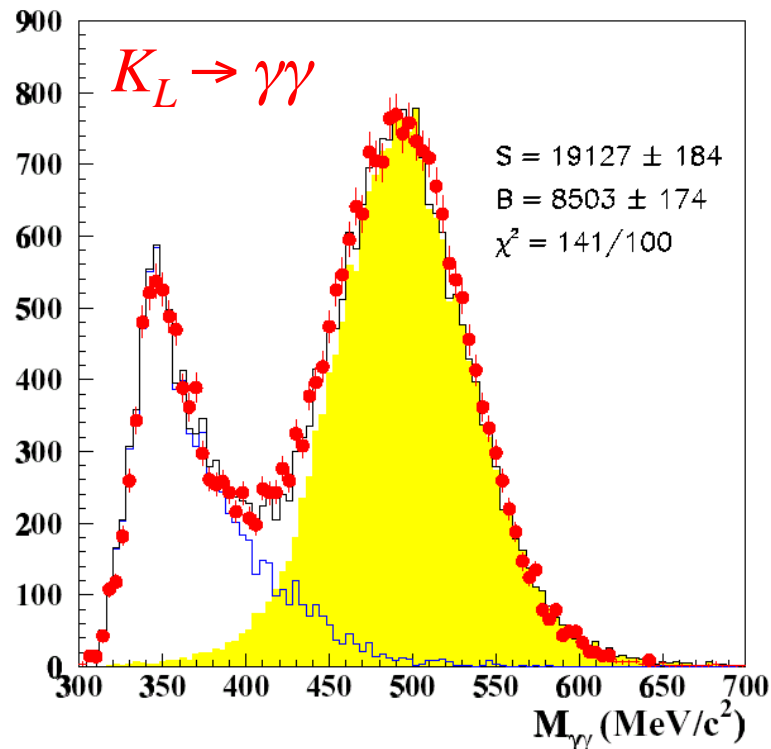


$\Gamma(K_L \rightarrow \gamma\gamma) / \Gamma(K_L \rightarrow \pi^0\pi^0\pi^0)$



- Dominated by long-distance contribution (π^0, η, η')
Can be calculated in χ PT, sensitive to θ_P
- Dominates long-distance contribution to $K_L \rightarrow \mu^+\mu^-$

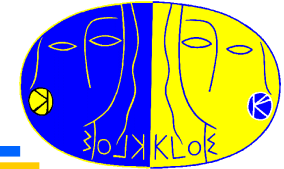
Exploits performance of EmC for reconstruction of photon vertex



KLOE '03: $(2.793 \pm 0.022 \pm 0.024) \cdot 10^{-3}$
312 pb⁻¹ '01 + '02 data

NA48 '02: $(2.81 \pm 0.01 \pm 0.02) \cdot 10^{-3}$
PDG '02: $(2.82 \pm 0.08) \cdot 10^{-3}$

$K_L \rightarrow \text{charged particles}$



BR	KLOE	PDG '02
$K_L \rightarrow \pi^+\pi^-\pi^0$	0.132 ± 0.002	0.126 ± 0.002
$K_L \rightarrow \pi\mu\nu$	0.271 ± 0.002	0.272 ± 0.002
$K_L \rightarrow \pi e\nu$	0.384 ± 0.002	0.388 ± 0.003

Errors are statistical only!
(including MC statistics)

Systematic errors also ~1-2%
but not yet fully evaluated

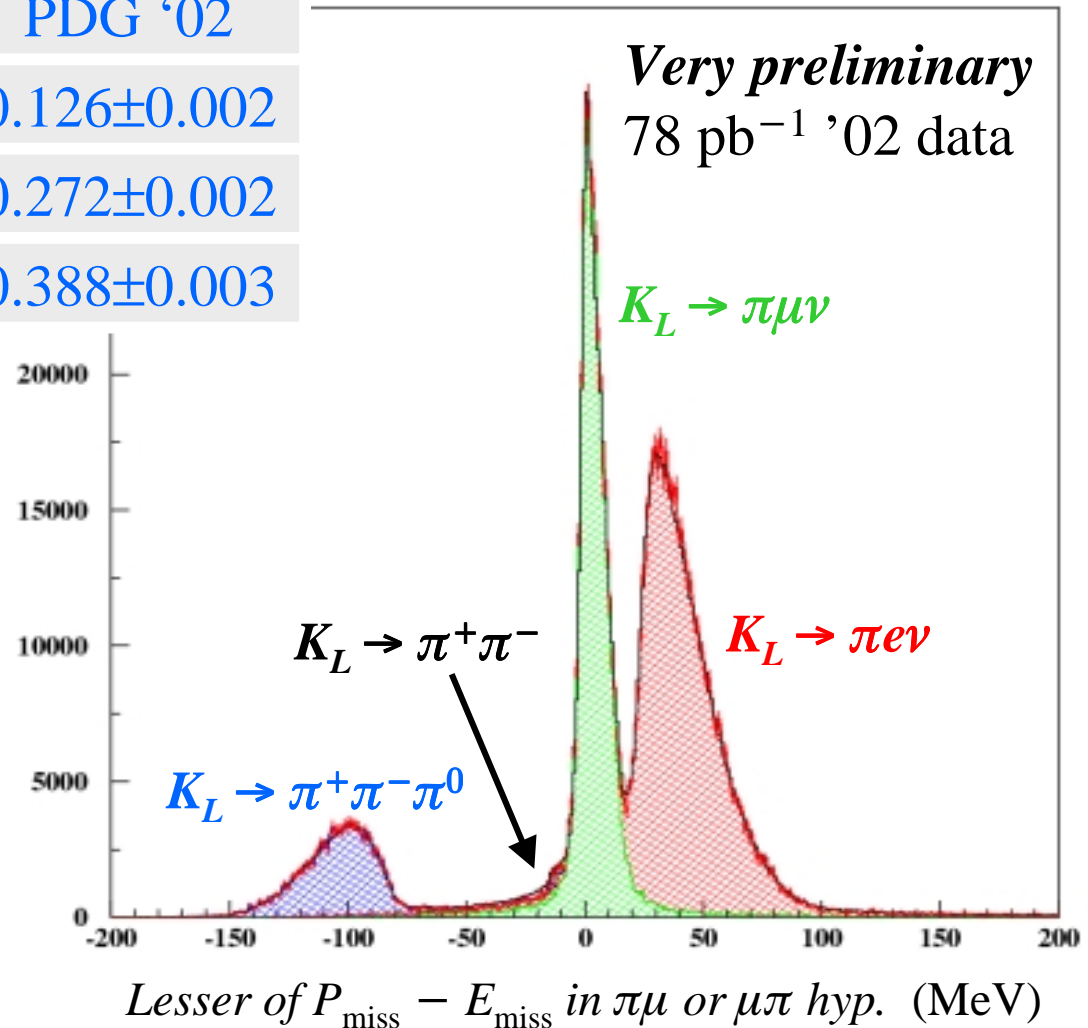
$K_L \rightarrow \pi^+\pi^-$ contribution fixed

BR($K_L \rightarrow \pi^+\pi^-$), similar analysis:

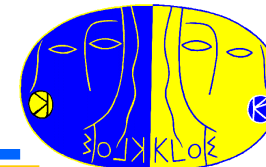
KLOE $(2.04 \pm 0.04) \cdot 10^{-3}$

PDG '02 $(2.084 \pm 0.032) \cdot 10^{-3}$

Very preliminary!



Prospects for ε'/ε



$$1 - 6 \operatorname{Re} \varepsilon'/\varepsilon = \frac{BR(K_S \rightarrow \pi^+\pi^-)}{BR(K_S \rightarrow \pi^0\pi^0)} \cdot \frac{BR(K_L \rightarrow \pi^0\pi^0)}{BR(K_L \rightarrow \pi^+\pi^-)}$$

K_S

Statistical error: negligible

Systematic error:

<u>Source</u>	<u>Error (%)</u>
Tagging	0.55 ('00 data) → ~0.1 ('01-02 data)
γ counting	0.20
Trigger/ t_0	0.23
Tracking	0.26

Total error: 0.7% → 0.4%

Should scale down to 0.1% on full data set (~400 pb⁻¹)

K_L

Statistical error: ~1.5%

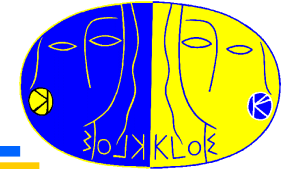
Systematic error: ~2%

Work in progress on:

- Momentum reconstruction/resolution, including DC occupancy effects
- Effect of $K\ell 3\gamma$ decays on background determination
- Separation of overlapping clusters
- Regeneration

Need at least 10× more data to reach the 10⁻⁴ regime

A first glance at interference



K_S, K_L initially in pure quantum state:
Relative time distribution for decay to two given final states shows interference



Measure $\Gamma_S, \Gamma_L, \Delta m,$
 $\varepsilon'/\varepsilon, \eta_{\pi\pi}, \delta_K,$ etc.

$$K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-: \quad |A(\Delta t)|^2 \propto e^{-\Gamma_L |\Delta t|} + e^{-\Gamma_S |\Delta t|} - 2e^{-(\Gamma_S + \Gamma_L) |\Delta t| / 2} \cos(\Delta m \Delta t)$$

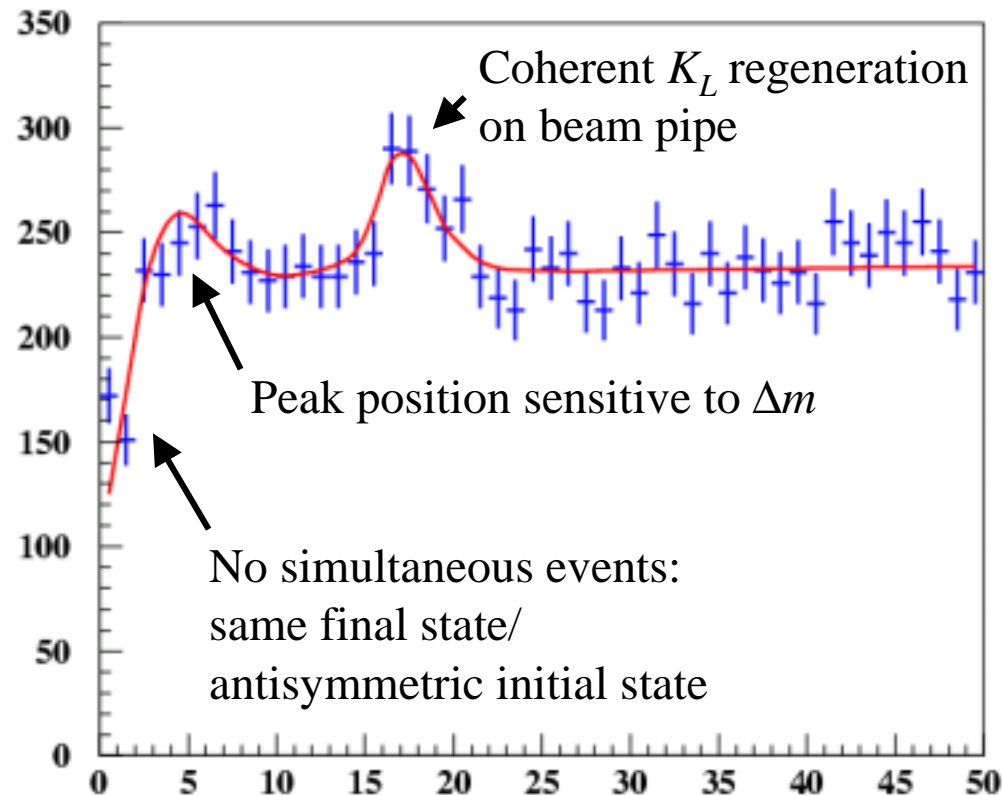
KLOE preliminary
340 pb⁻¹ '01 + '02 data

Fit with PDG values for Γ_S, Γ_L
 $\chi^2/\text{d.o.f.} = 43.7/47$

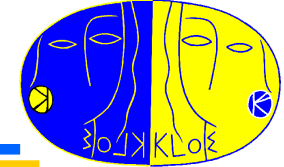
$$\Delta m = (5.64 \pm 0.37) \cdot 10^{-11} \hbar \text{ s}^{-1}$$

PDG '02: $(5.301 \pm 0.016) \cdot 10^{-11} \hbar \text{ s}^{-1}$

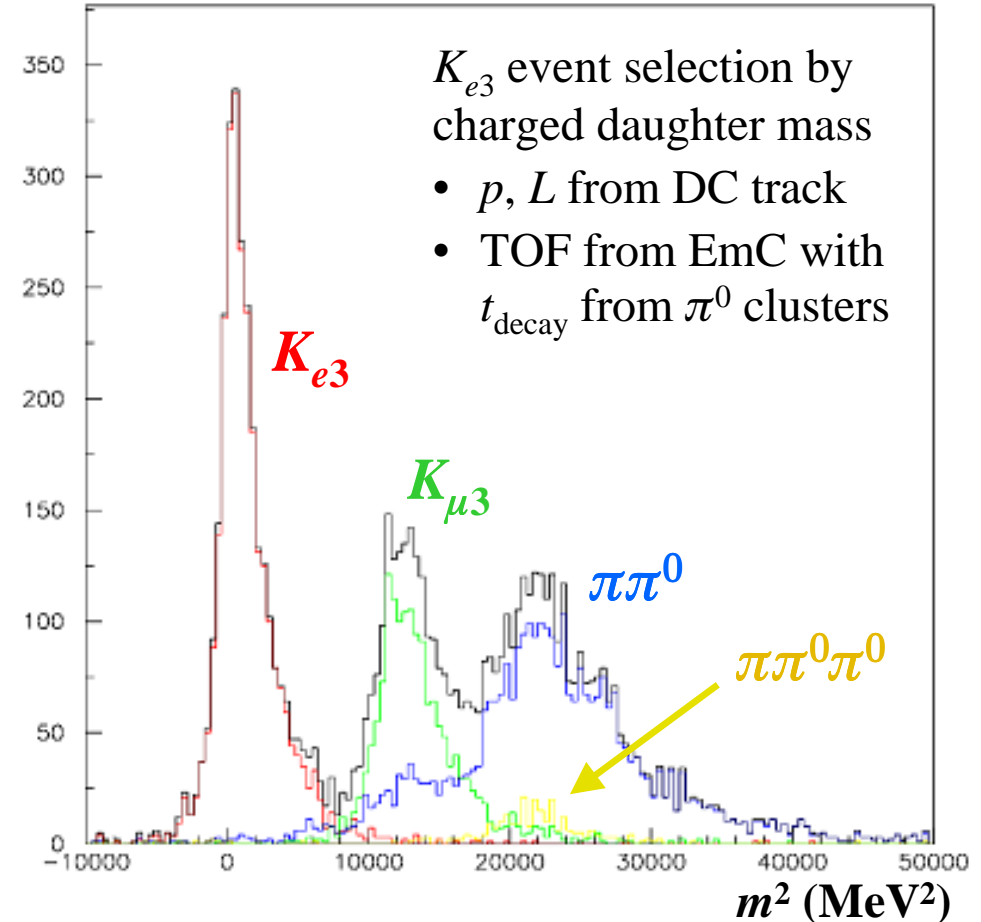
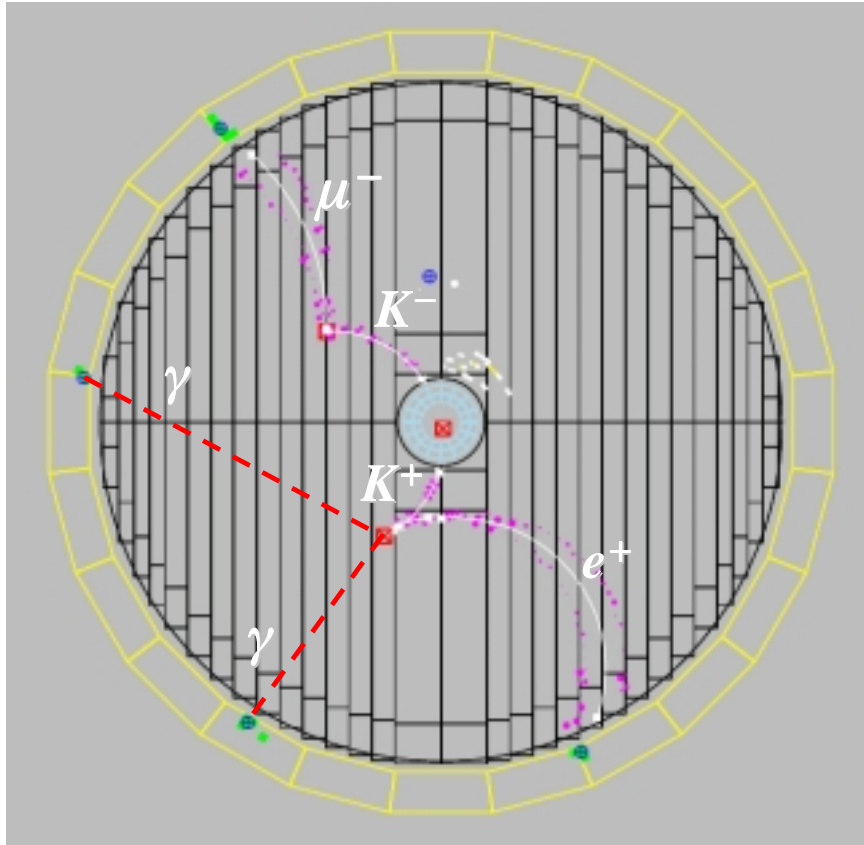
First observation of quantum interference in relative decay-time distribution of K_S, K_L



Charged kaon decays



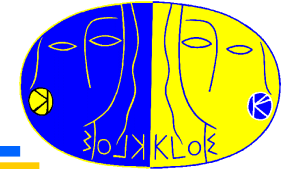
Tagging via $K \rightarrow \mu\nu$ or $K \rightarrow \pi\pi^0$: $6 \cdot 10^5$ tags/pb $^{-1}$ for measurement of **absolute BR's**



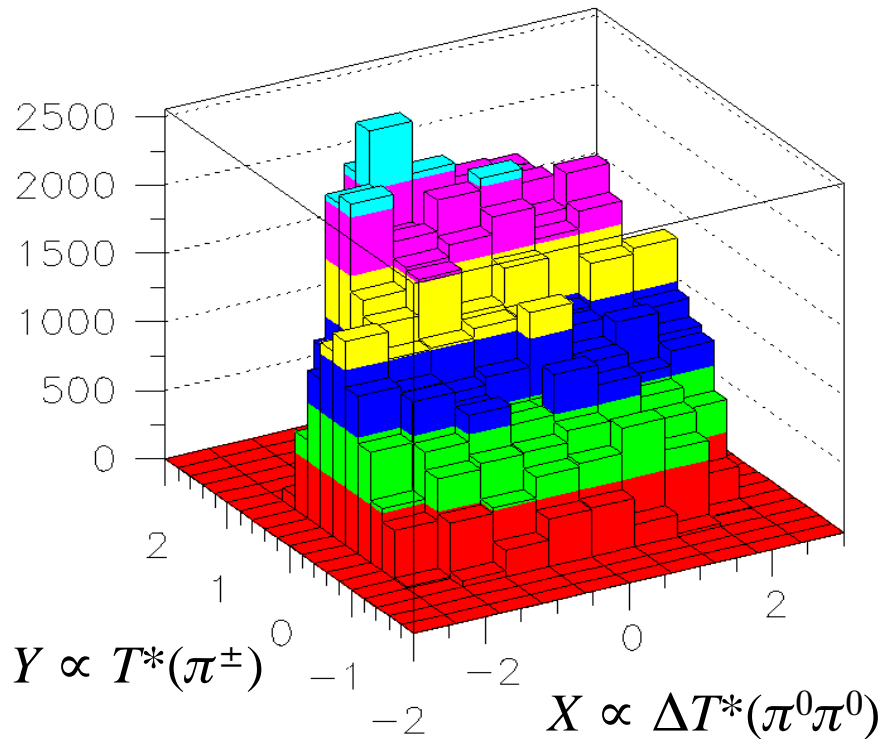
Recent reconstruction improvements:

- Second stage of tracking for identified K^\pm ($\beta \sim 0.2$) recently implemented
- '01 data reprocessed with event classification robust against machine background

$K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$



- Can extract isospin amplitudes and phase shifts for $K \rightarrow 3\pi$ decays (input to χ PT)
- Charge asymmetries in K^\pm rates ($\sim 10^{-7}$) and Dalitz plot slopes ($\sim 10^{-6}$) signal direct CP violation



BR($K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$)

PDG '02 fit $(1.73 \pm 0.04)\%$

KLOE preliminary

112 pb⁻¹ '02 data

$(1.807 \pm 0.008 \pm 0.018)\%$

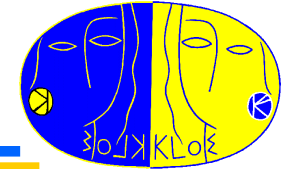
Preliminary fit to Dalitz plot

$$F(X, Y) = 1 + gY + hY^2 + kX^2$$

	KLOE 6.3 pb ⁻¹	PDG
g	0.607 ± 0.026	0.652 ± 0.031
h	0.026 ± 0.027	0.057 ± 0.018
k	0.0080 ± 0.0037	0.0197 ± 0.0054

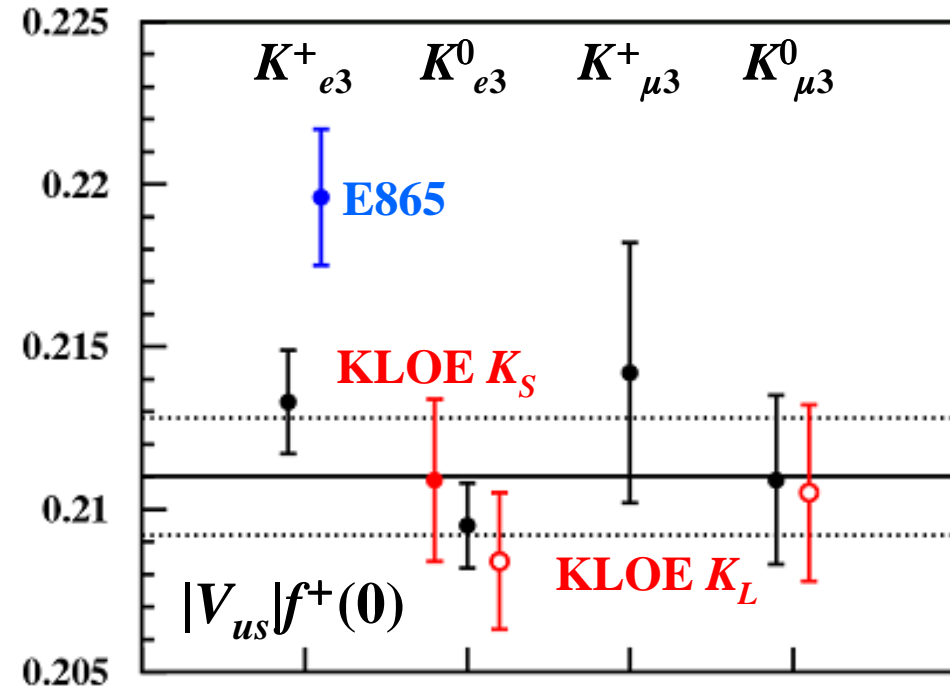
Errors are statistical only

V_{us} from $K_{\ell 3}$ decays



Experimental inputs to V_{us}			
Mode	BR(%)	$10^3 \lambda_+$	$10^3 \lambda_0$
K^+_{e3}	4.87 ± 0.06	27.8 ± 1.9	
K^0_{e3}	38.79 ± 0.27	29.1 ± 1.8	
$K^+_{\mu 3}$	3.27 ± 0.06	3.3 ± 1.0	4 ± 9
$K^0_{\mu 3}$	27.18 ± 0.25	3.3 ± 0.5	27 ± 6

$\tau_L = (5.17 \pm 0.04) \cdot 10^{-8} \text{ s}$
$\tau_S = (8.9598 \pm 0.0007) \cdot 10^{-11} \text{ s}$
$\tau_+ = (1.2384 \pm 0.0024) \cdot 10^{-8} \text{ s}$



For K_{e3} modes:

$$\frac{\delta |V_{us}|}{|V_{us}|} = \underbrace{\frac{1}{2} \left(\frac{\delta \text{BR}}{\text{BR}} \right) \oplus \frac{1}{2} \left(\frac{\delta \tau}{\tau} \right) \oplus \frac{1}{20} \left(\frac{\delta \lambda_+}{\lambda_+} \right)}_{\text{exp}} \oplus \underbrace{\frac{\delta f_+(0)}{f_+(0)}}_{\text{th}}$$

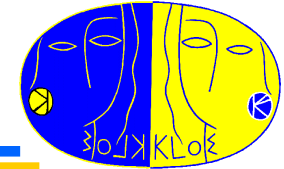
$$|V_{us}| = 0.2196 \pm 0.0019_{\text{exp}} \pm 0.0018_{\text{th}}$$

KLOE preliminary BR's confirm previous values for K^0_{e3} , $K^0_{\mu 3}$

KLOE will have BR(K^+_{e3}) soon

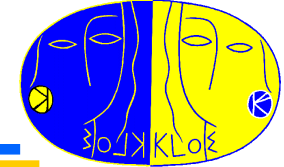
KLOE will measure all BR's to much better than 1% and can also significantly improve λ_+ , λ_0 , τ_L

ϕ and continuum physics at KLOE

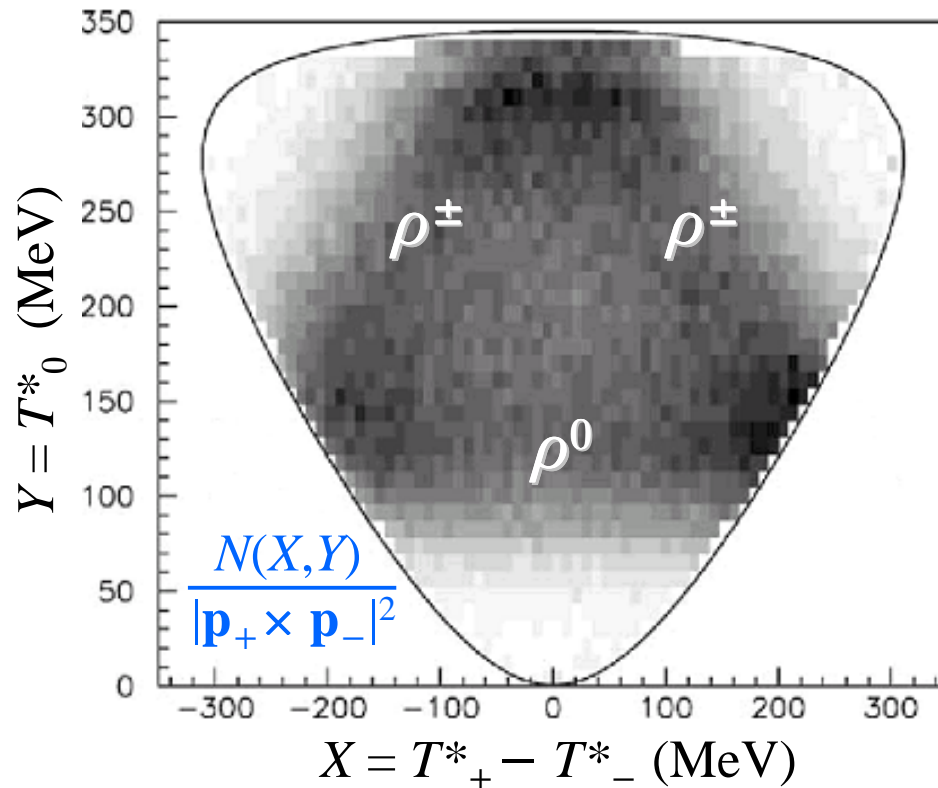


$\phi \rightarrow \pi^+\pi^-\pi^0$	Phys. Lett. B561 , 55 (2003)
$\phi \rightarrow \eta'\gamma$	Phys. Lett. B541 , 45 (2002) Preliminary update with 2001 data
$\phi \rightarrow f_0\gamma, a_0\gamma$	Phys. Lett. B536 , 209 Phys. Lett. B537 , 21 Preliminary update with 2001 data
$\sigma(e^+e^- \rightarrow \text{hadrons})$	Status and preliminary results

$\phi \rightarrow \rho\pi, \pi^+\pi^-\pi^0$



KLOE '03, 17 pb⁻¹ '00 data
2M $\pi^+\pi^-\pi^0$ events



$$F(X,Y) \propto |\mathbf{p}_+ \times \mathbf{p}_-|^2 |A_{\rho\pi} + A_{\text{dir}} + A_{\omega\pi}|^2$$

Fit parameters:

m_ρ, Γ_ρ	For ρ^+, ρ^-, ρ^0
$ A_{\text{dir}} , \phi_{\text{dir}}$	Amplitudes of direct,
$ A_{\omega\pi} , \phi_{\omega\pi}$	$\omega\pi$ contributions

$$m_\rho = 775.8 \pm 0.5 \pm 0.3 \text{ MeV}$$

$$\Gamma_\rho = 143.9 \pm 1.3 \pm 1.1 \text{ MeV}$$

$$m_0 - m_\pm = 0.4 \pm 0.7 \pm 0.6 \text{ MeV}$$

$$m_+ - m_- = 1.5 \pm 0.8 \pm 0.7 \text{ MeV}$$

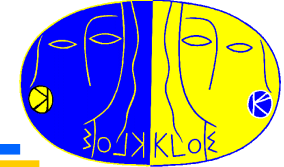
Relative decay intensities from
 integration of $|A|^2$ over Dalitz plot

$I_{\rho\pi} = 0.937$	} Interference:	
$I_{\text{dir}} = 0.0085$		
$I_{\omega\pi} = 0.0002$		
		$I_{\rho\pi} + I_{\text{dir}} + I_{\omega\pi} \neq 1$

$$\sigma(e^+e^- \rightarrow \omega\pi^0 \rightarrow \pi^+\pi^-\pi^0) =$$

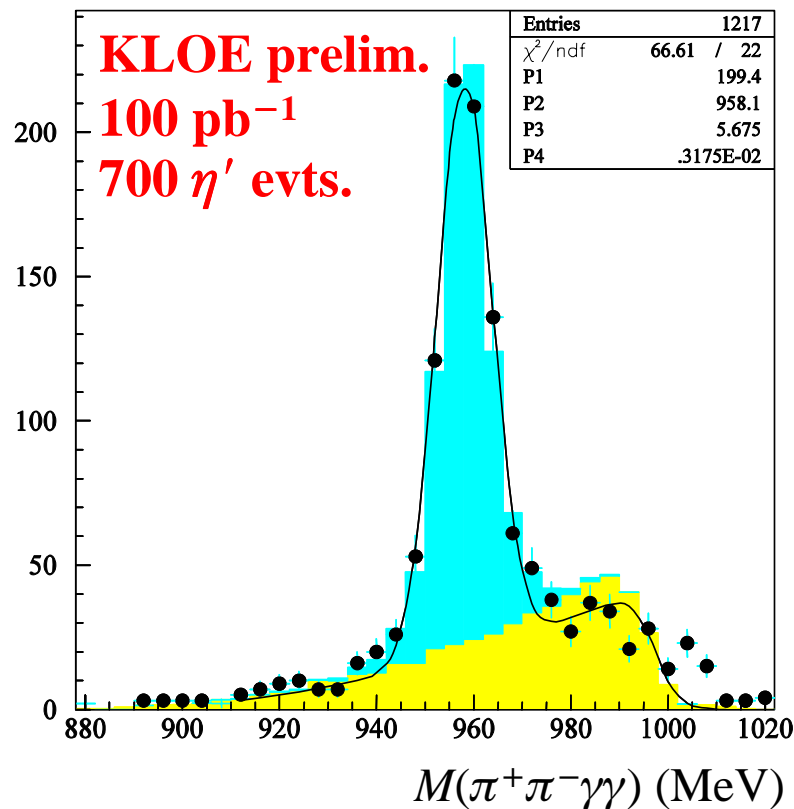
$$\mathbf{92 \pm 15 \text{ pb}}$$

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



$$R = \frac{\text{BR}(\phi \rightarrow \eta' \gamma)}{\text{BR}(\phi \rightarrow \eta \gamma)} \quad |\eta(\eta')\rangle = \frac{1}{\sqrt{2}} X^{(\prime)} |u\bar{u} + d\bar{d}\rangle + \frac{1}{\sqrt{2}} Y^{(\prime)} |s\bar{s}\rangle + Z^{(\prime)} |gg\rangle$$

Allows determination of $\eta-\eta'$ mixing angle (φ_P) and gg content of η' (Z')



$$\left. \begin{array}{l} \phi \rightarrow \eta' \gamma \rightarrow \pi^+ \pi^- \eta \gamma \\ \phi \rightarrow \eta \gamma \rightarrow \pi^+ \pi^- \pi^0 \gamma \end{array} \right\} R \text{ measured from } \pi^+ \pi^- 3\gamma \text{ final state}$$

KLOE '02, 17 pb⁻¹ '00 data

$$R = (4.70 \pm 0.47 \pm 0.31) \cdot 10^{-3}$$

$$\varphi_P = (41.8_{-1.6}^{+1.9})^\circ \quad \rightarrow \quad \theta_P = (12.9_{-1.6}^{+1.9})^\circ$$

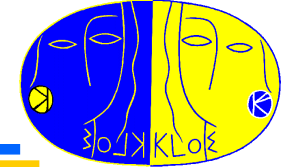
$$(Z')^2 = 0.06_{-0.06}^{+0.09}$$

BR($\phi \rightarrow \eta' \gamma$)

KLOE '02 $(6.10 \pm 0.61 \pm 0.43) \cdot 10^{-5}$

PDG '02 $(6.7 \pm 1.5) \cdot 10^{-5}$

$\phi \rightarrow \pi^0\pi^0\gamma$ ($f_0\gamma$) and $\phi \rightarrow \eta\pi^0\gamma$ ($a_0\gamma$)



Nature of f_0 and a_0 mesons uncertain

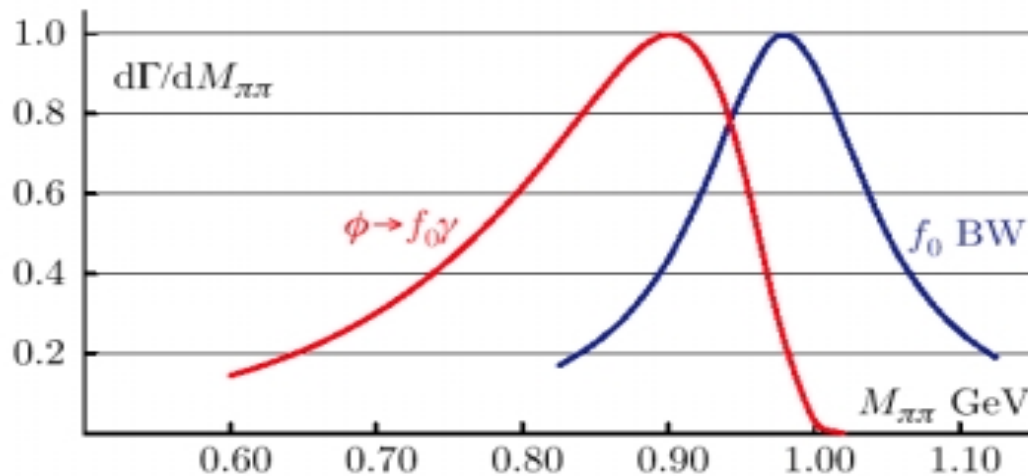
Precise measurements of BR's and $d\Gamma/dM$ may distinguish between various models:

$q\bar{q}q\bar{q}$, $K\bar{K}$, $q\bar{q}$, $s\bar{s}$, etc.

$$\phi \rightarrow f_0\gamma \rightarrow \pi^0\pi^0\gamma \rightarrow 5\gamma$$

$$\phi \rightarrow a_0\gamma \rightarrow \eta\pi^0\gamma \rightarrow \begin{cases} 5\gamma \\ \pi^+\pi^-5\gamma \end{cases}$$

Signal shape



$$d\Gamma/dM_{\pi\pi} \propto \text{BW} \times k^3 \times \text{Overlap}$$

Components of f_0 fit:

$$\phi \rightarrow f_0\gamma$$

$$\phi \rightarrow \rho^0\pi^0 \quad (\rho \rightarrow \pi^0\gamma)$$

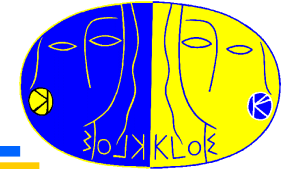
$$\phi \rightarrow \sigma\gamma$$

Components of a_0 fit:

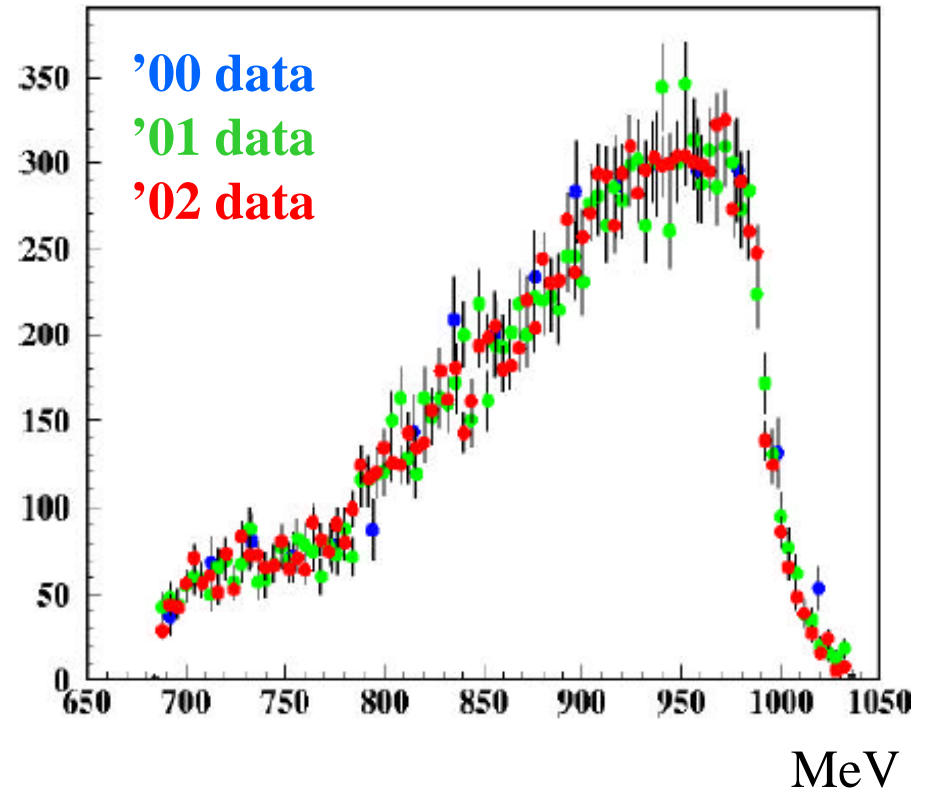
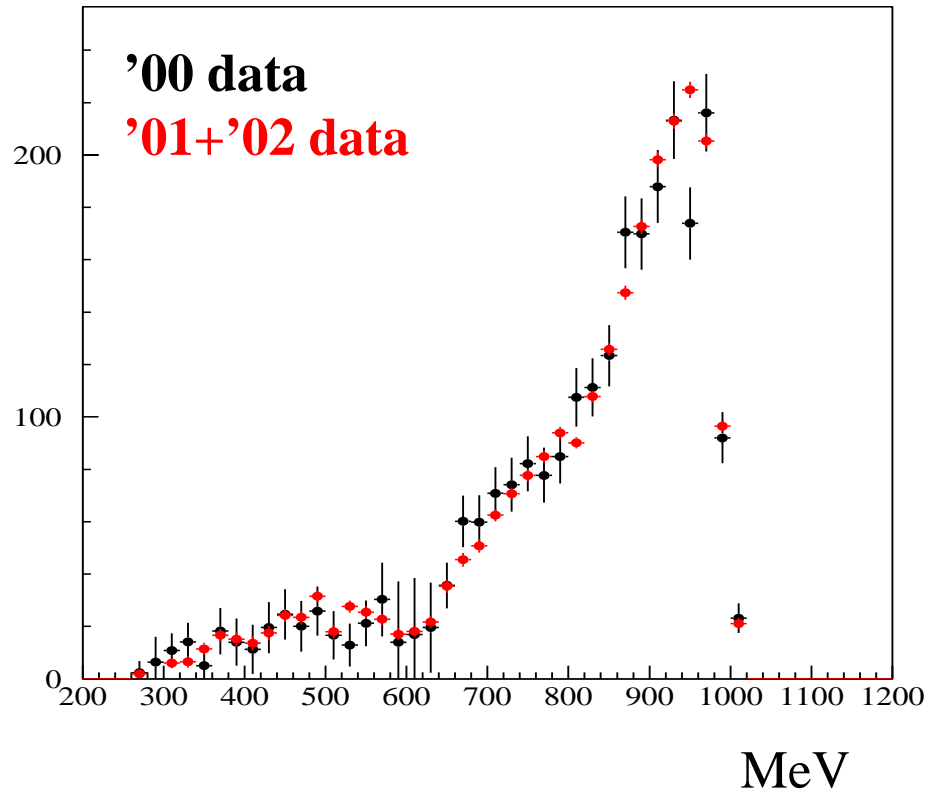
$$\phi \rightarrow a_0\gamma$$

$$\phi \rightarrow \rho^0\pi^0 \quad (\rho \rightarrow \eta\gamma)$$

$\phi \rightarrow \pi^0\pi^0\gamma$ ($f_0\gamma$) and $\phi \rightarrow \eta\pi^0\gamma$ ($a_0\gamma$)



KLOE preliminary: '01 + '02 data



BR($\phi \rightarrow \pi^0\pi^0\gamma$)

KLOE '02 $(1.09 \pm 0.03 \pm 0.05) \cdot 10^{-4}$

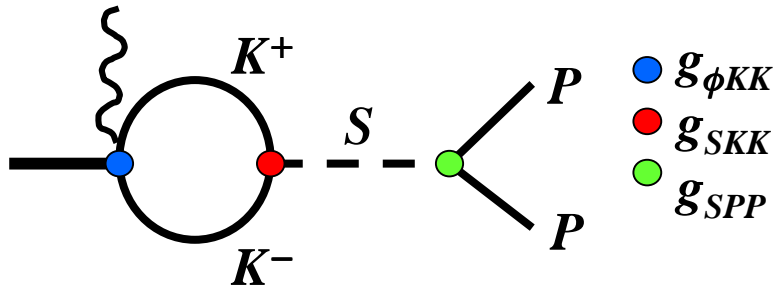
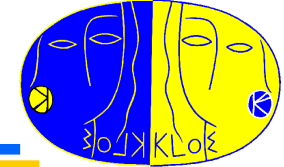
PDG '02 $(1.08 \pm 0.17 \pm 0.09) \cdot 10^{-4}$

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

KLOE '02 $(0.85 \pm 0.05 \pm 0.06) \cdot 10^{-4}$

PDG '02 $(0.89 \pm 0.14) \cdot 10^{-4}$

f_0 and a_0 couplings



$$\frac{d\Gamma(\phi \rightarrow S\gamma \rightarrow PP\gamma)}{dM} = \frac{2M_{PP}^2}{\pi} \frac{\Gamma_{\phi S\gamma} \Gamma_{SPP}}{|D_S|^2}$$

$$\Gamma_{\phi S\gamma}(M) = \frac{(g_{S KK})^2 (g_{\phi KK})^2}{12\pi^2} \frac{|g(M)|^2}{m_\phi^2} \left(\frac{m_\phi^2 - M^2}{2m_\phi^2} \right)$$

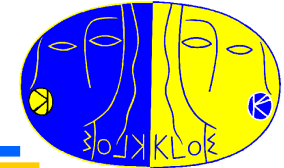
		KLOE	4q	q \bar{q}	s \bar{s}
f_0	$(g_{f_0 KK})^2/4\pi$ (GeV ²)	2.79 ± 0.12	~ 2.3	~ 0.15	~ 0.30
	$g_{f_0 \pi\pi}/g_{f_0 KK}$	0.50 ± 0.01	~ 0.35	~ 2	~ 0.5
a_0	$(g_{a_0 KK})^2/4\pi$ (GeV ²)	0.40 ± 0.04	~ 2.3	~ 0.15	—
	$g_{a_0 \eta\pi}/g_{a_0 KK}$	1.35 ± 0.09	~ 0.9	~ 1.5	—



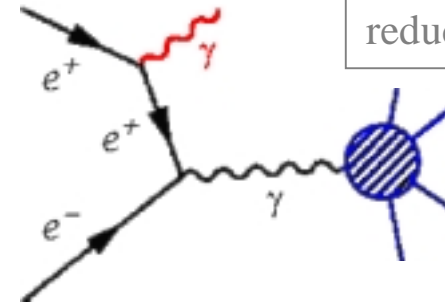
f_0 parameters compatible with 4q model

a_0 parameters not well described by the 4q model

$\sigma(e^+e^- \rightarrow \text{hadrons})$

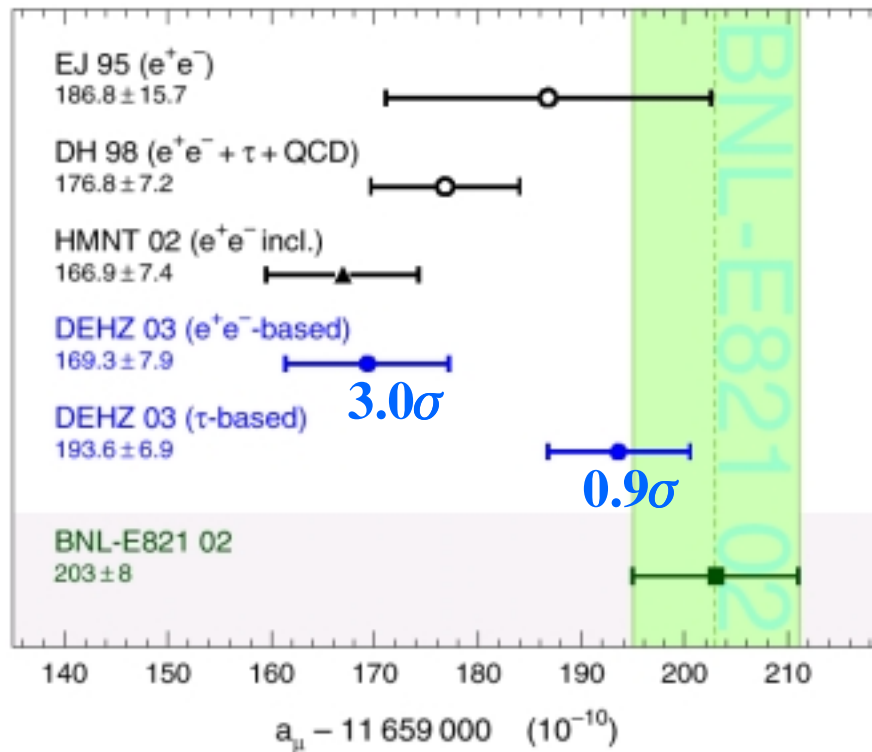


KLOE can measure $d\sigma/dM_{\pi\pi}^2(e^+e^- \rightarrow \pi^+\pi^-)$ for $2m_\pi < M_{\pi\pi} < m_\phi$ using $e^+e^- \rightarrow \pi^+\pi^-\gamma$ events with γ radiated in initial state



FSR complications reduced for $\theta_\gamma < 15^\circ$

Status of a_μ (Davier et al., '03)



$\sim 70\%$ of $\delta a_\mu^{\text{hadr}}$
 $\sim 15\%$ of $\delta \alpha(m_Z)^{\text{hadr}}$ } from $M < m_\phi$

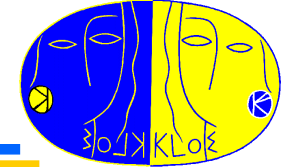
e^+e^- -based estimates dominated by CMD-2 data (0.6% error)

No comparable data set for cross checks

Use of τ data involves corrections for isospin breaking, etc.

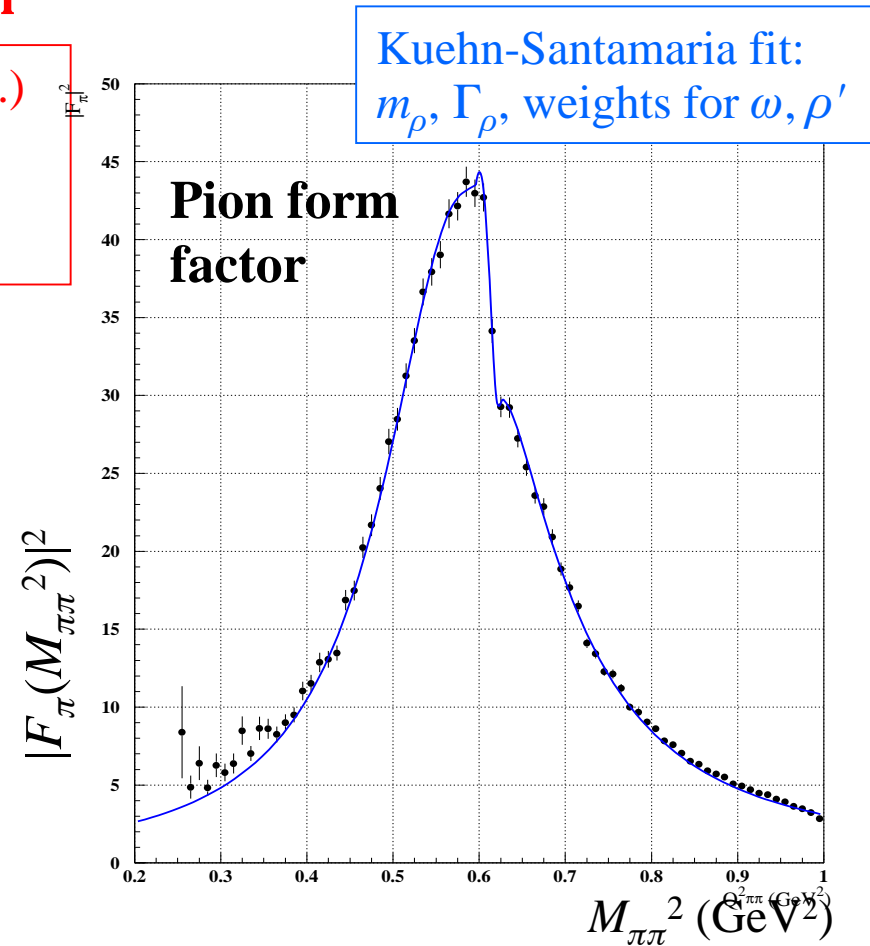
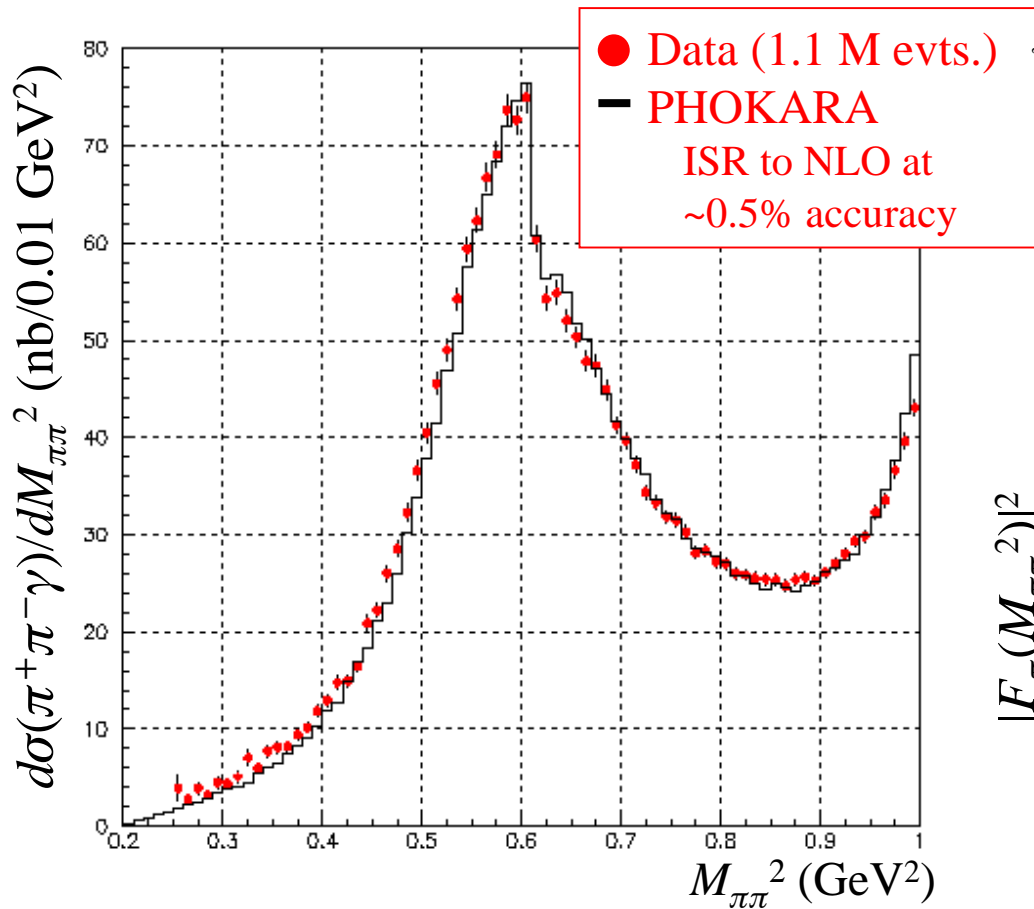
KLOE can complement $e^+e^- \rightarrow \pi^+\pi^-$ results and clarify situation

$\sigma(e^+e^- \rightarrow \text{hadrons})$

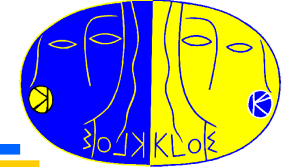


KLOE preliminary, 73 pb⁻¹ '01 data
Stat. error 1-2% in each bin near ρ peak
Working to reduce systematics to 1% level

$$|F_\pi(M_{\pi\pi}^2)|^2 = \frac{d\sigma_{\pi\pi\gamma}(M_{\pi\pi}^2)}{d\sigma_{\pi\pi\gamma, F_\pi=1}(M_{\pi\pi}^2)}$$



DAΦNE upgrades and 2003 running



New KLOE IR

- Rotation for low- β quads
- Decrease β_x and coupling
- Allow changes to KLOE field

Pole-shims on wigglers

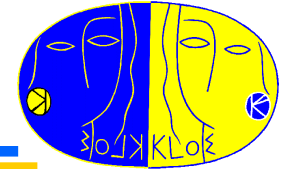
- Eliminate octopole terms



Run plans

- Increase peak luminosity and reach $1.5 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
- Restart by end of June with FINUDA first
- **Switch to KLOE in early fall and deliver $> 1 \text{ fb}^{-1}$ to KLOE**

Summary and outlook



KLOE is analyzing a unique data sample: 500 pb⁻¹ of ϕ decays

Extensions of previous KLOE analyses nearly ready:

$K_S \rightarrow \pi\pi$ BR's under control at per-mil level

K_S semileptonic asymmetry measured for first time

Many new analyses about to be finalized:

Measurement of $\sigma(e^+e^- \rightarrow \text{hadrons})$

Measurement of K_L , K^\pm BR's, V_{us}

Data collected will be used to demonstrate KLOE's capability for CP violation studies

KLOE expects to collect at least 1 fb⁻¹ in 2003