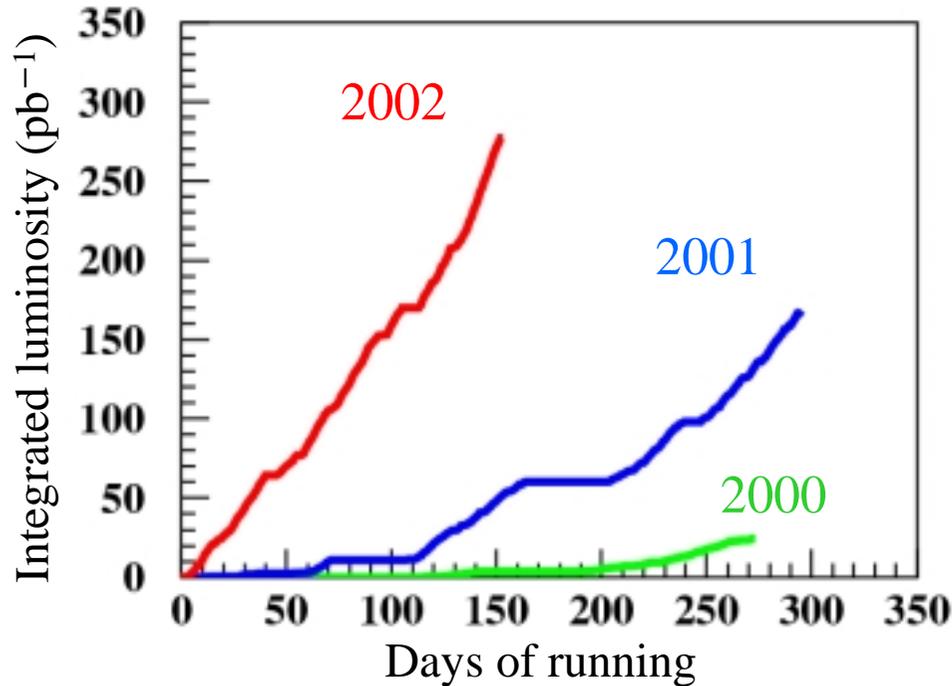
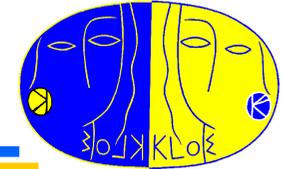




**M. Moulson, LNF
for the KLOE Collaboration**

**Commissione Scientifica Nazionale I
Lecce, 22 September 2003**

KLOE data taking: 2000-2002



2000: 25 pb⁻¹
80 · 10⁶ ϕ decays

*First
published
results*

2001: 176 pb⁻¹
550 · 10⁶ ϕ decays

*Analysis in
progress*

2002: 296 pb⁻¹
920 · 10⁶ ϕ decays

2002 KLOE data taking

3 May—30 September

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

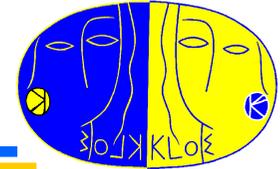
Best $\int L dt$ in one day: 4.5 pb^{-1}

A major effort for KLOE in 2003 was to upgrade our capabilities for data processing, MC, etc., in order to exploit the $\sim 450 \text{ pb}^{-1}$ of good data collected in 2001-2002. We are now using these tools to churn out physics results.

These tools will also allow us to capitalize on $\sim 2 \text{ fb}^{-1}$ of new data to be taken in 2004.

The main focus of the collaboration is currently to ensure that these tools are kept in working order and are well used.

Summary of KLOE results 2002-2003



5 papers published in *Phys. Lett.* in 2002

2 papers published in *Phys. Lett.* so far in 2003

+3 papers in preparation, contributed to EPS '03 and LP '03

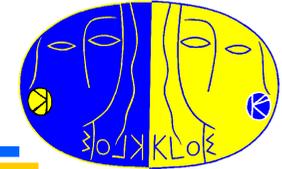
5 papers submitted to *Nucl. Instrum. Meth.*, 2002-2003

>70 presentations at conferences and seminars 2002-2003

11 KLOE measurements in PDG '03 web update

11 cases in which KLOE measurement is best

Milestones for 2003



<i>Q1</i>	1. Preparations for IR modifications
<i>Q1-4</i>	2. Maintenance of detector performance at 2002 levels
<i>Q1</i>	3. QCAL upgrade
<i>Q1</i>	4. Upgrades to raw-data filters
<i>Q1</i>	5. Reconstruction of all data
<i>Q1</i>	6. Preparation of DST's for analysis
<i>Q1-4</i>	7. MC production for 2002 analyses
<i>Q2-4</i>	8. BR's and cross section, $\phi \rightarrow K^+K^-$
<i>Q4</i>	9. Repeat 2002 analyses with full data set

*Milestones: 1. Preparations for IR modifications (Q1)
2. Maintenance of detector performance (Q1-4)*

Detector open from January to July for installation of new IR

DC	FEE maintenance: 60 channels repaired ADC gates widened Wire tension measurements Geometrical survey before/after new IR installed
EmC	HV distribution boards repaired 2 HV crates, 3 PMT's replaced EmC fully operational
QCAL	Complete FEE upgrade

-
-
- Milestones: 1. Preparations for IR modifications (Q1)
2. Maintenance of detector performance (Q1-4)*

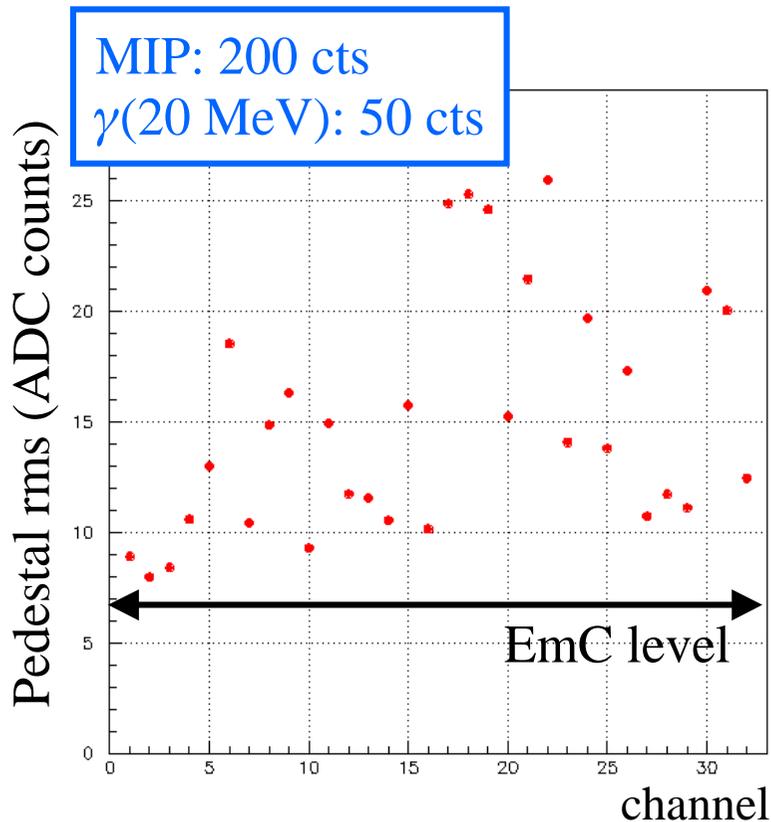
Current detector status

July	Water crisis impedes collection of cosmic-ray data with field on Debugging of cryogenic system after KLOE/FINUDA compensators connected to main He circuit
Sept	Machine operations starting up KLOE waiting to take test data with field on

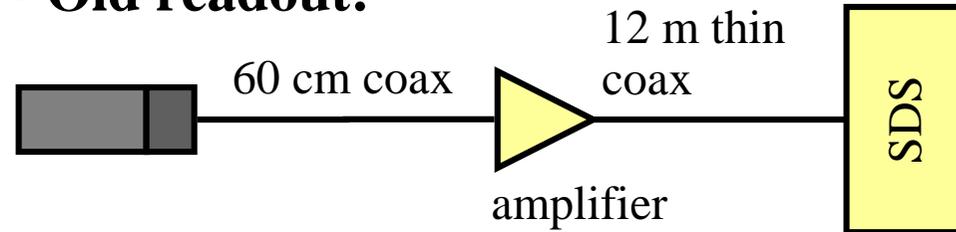
Milestones satisfied 100%

Milestone 3: QCAL upgrade (Q1)

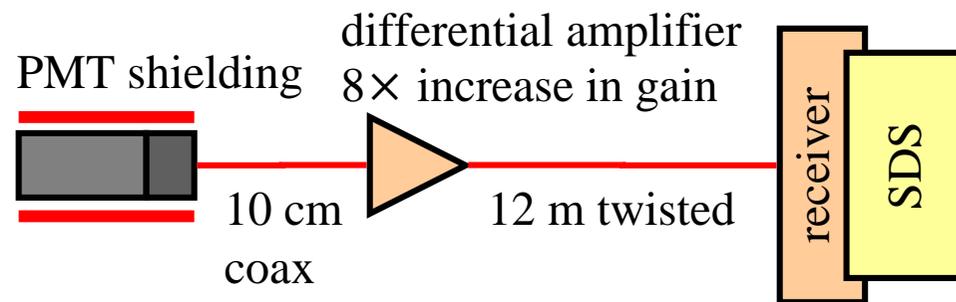
High level of high-frequency noise
Correlated with machine RF
Both TDC and ADC affected



• Old readout:



• New readout:



- **Worst 10 PMT's replaced**
- **Work completed**
- **Waiting for field-on and beam for final testing**

Milestone satisfied 100%

Milestone 4: Upgrades to raw-data filters (Q1)

2001 running

Avg. L : $2.1 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

Avg. T2: **2000 Hz**

500 Hz downscaled CR

2002 running

Avg. L : $5.4 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

Avg. T3: **1600 Hz**

0 Hz downscaled CR

Implementation of T3 for 2002 data taking eliminates need for downscaled CR sample and decreases DAQ load by 500 Hz

Status of offline software filters:

- **Currently reject ~60% of events before track reconstruction**
- **Upgrades to increase rejection/reduce bias under study**
- **Need restart of data taking for tuning of cuts, etc.**

Milestone satisfied 80%

Milestones: 5. Reconstruction of all data (Q1)
6. Preparation of DST's for analysis (Q1)

164 pb⁻¹ 2001 data: Re-reconstructed with 2002 code in early 2002

288 pb⁻¹ 2002 data: Reconstructed in “real time” during data taking

DST production following reconstruction for all streams except K^+K^-

K^+K^- stream re-reconstructed at DST stage (completed May 2003)

As of May, entire KLOE data set (452 pb⁻¹) available as DST's

Total space: 4.3 TB

MC DST's add ~2.9 TB



DST disk cache: 5.7 TB

Majority of DST's disk-accessed

Milestones satisfied 100%

Milestone 7: MC production for 2002 analyses (Q1-4)

Ambitious program for MC development and production

Simulated event samples statistically comparable to data

$\phi \rightarrow \text{all}$ 452 pb⁻¹ at 1:5 scale ~300M events

$\phi \rightarrow K_S K_L$ 452 pb⁻¹ at 1:1 scale ~500M events

Comprehensive upgrades

Both MC executable and production procedure affected:

- State-of-the-art detector simulation
- Inclusion of accidental activity from machine background
- MC DST's to provide transparent user interface

Each run in data set individually simulated

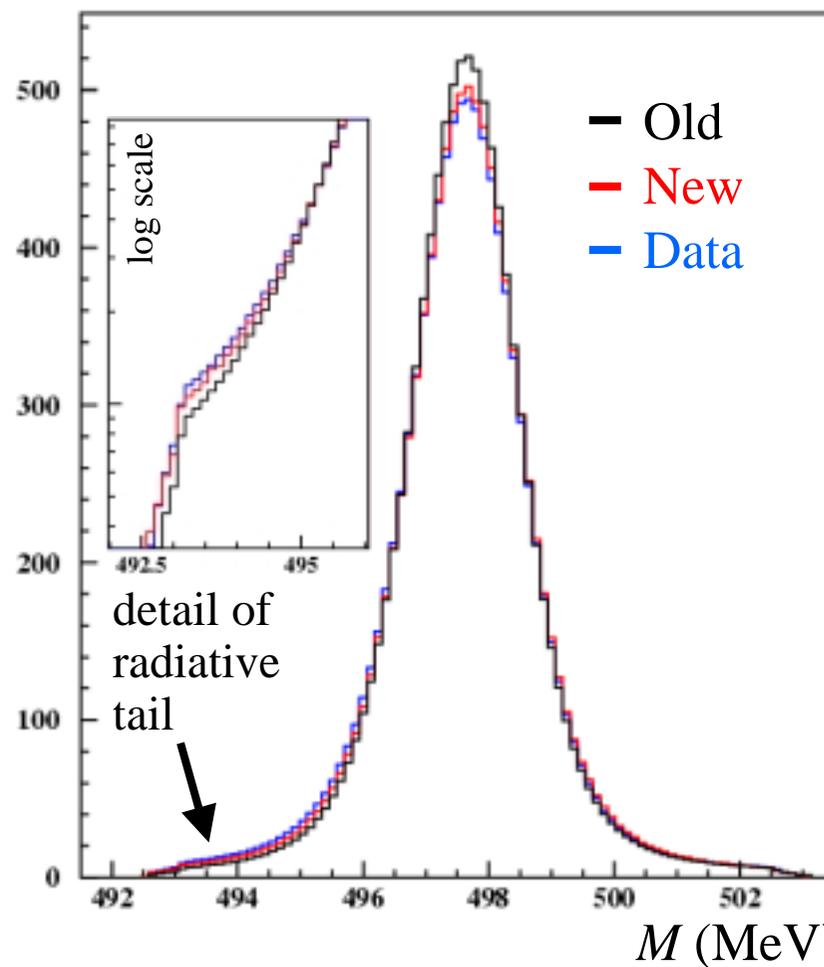
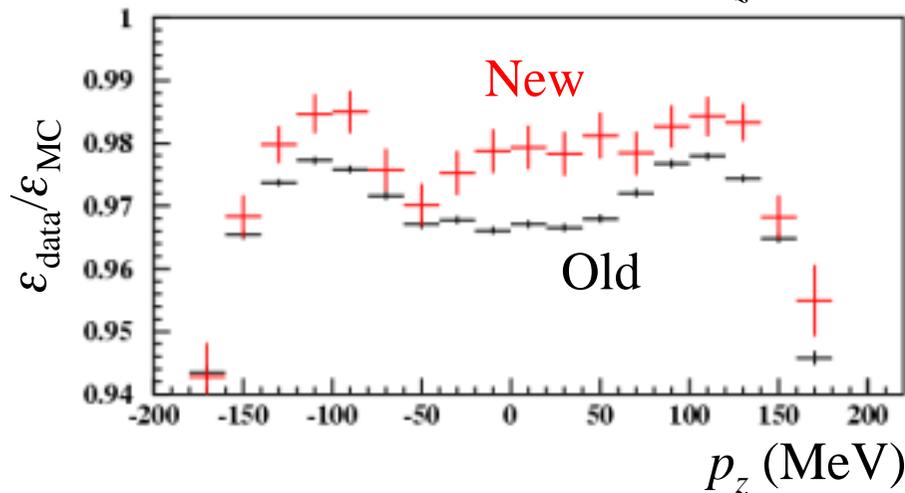
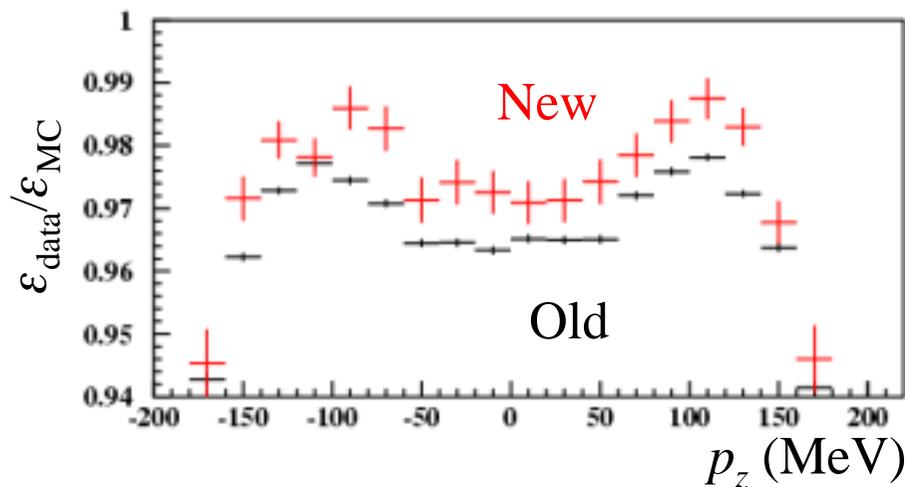
- \sqrt{s} , \mathbf{p}_ϕ , \mathbf{x}_ϕ , background, dead wires, trigger thresholds...

Milestone 7: MC production for 2002 analyses (Q1-4)

MC-data comparison: tracking

Efficiency: π from $K_S \rightarrow \pi^+\pi^-$

Resolution: $M(K_S \rightarrow \pi^+\pi^-)$



Milestone 7: MC production for 2002 analyses (Q1-4)

Background from $e^+e^- \rightarrow \gamma\gamma$ events

All DC hits (tracklets, etc.)

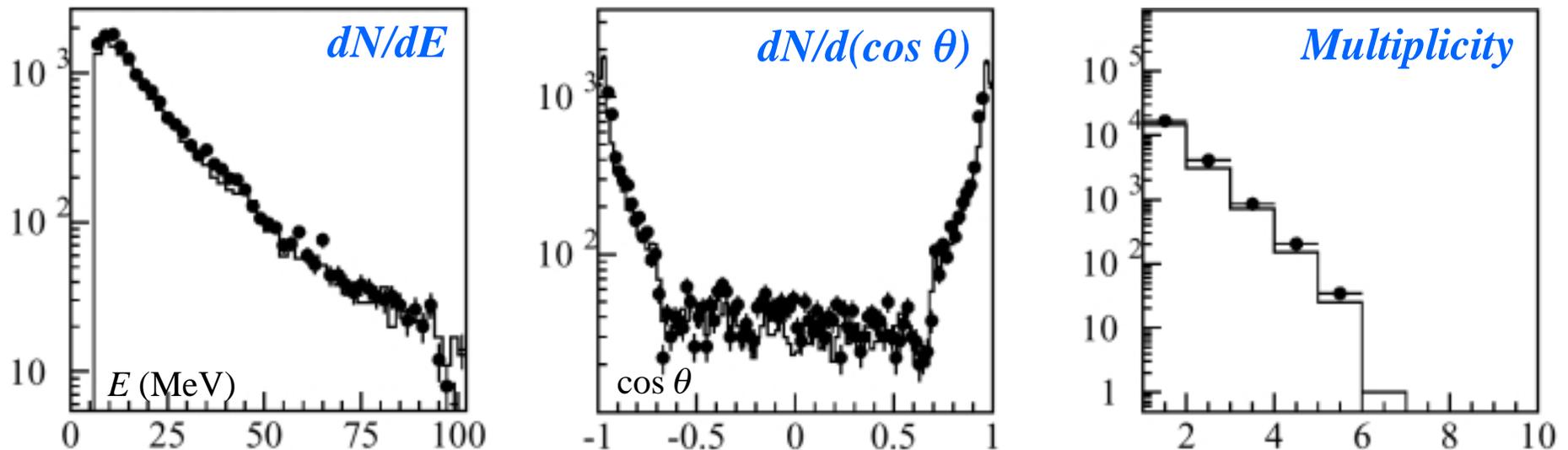
All EmC clusters except $\gamma\gamma$
($\gamma\gamma$ isolated by $\Delta r, \Delta t$)

New reconstruction stream

One background file per raw data file
77,000 files, 8 GB total

Selection of background clusters on EmC

- Selected clusters
- Out-of-time clusters in data



Background hits (DC and EmC) inserted in MC events with timing preserved

Milestone 7: MC production for 2002 analyses (Q1-4)

Generation	Events requested	Elapsed days (60 CPU's)	Completed
$\phi \rightarrow \text{all}$	255M 452 pb ⁻¹ , 1:5	26	100%
$\phi \rightarrow \pi\pi\gamma$ PHOKHARA 1.0	40M 140 pb ⁻¹ , 5:1	6	100%
$\phi \rightarrow \pi\pi\gamma$ PHOKHARA 3.0	40M 140 pb ⁻¹ , 5:1	6	100%
$\phi \rightarrow K_S K_L$	475M 452 pb ⁻¹ , 1:1	43 (est.)	20%

Total output size: 17.6 TB + 2.9 TB DST at program completion

430M/810M events completed
10M/day generation+reconstruction

Milestone satisfied 90%

Milestone 8: BR's and cross section, $\phi \rightarrow K^+K^-$ (Q2-4)

DST's for K^+K^- events newly available in early 2003

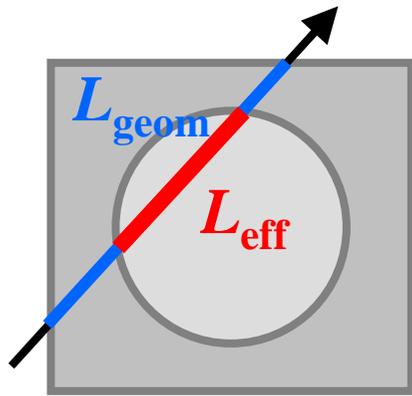
K^+K^- events re-reconstructed during DST production

- Dedicated energy-loss treatment ($m = m_K$) in track fit
- Refined treatment of multiple-scattering correlation matrix
- Improved merging of split kaon tracks
- Dedicated algorithm for global t_0 determination
- Kaon time-of-flight corrections to drift distances
- dE/dx reconstruction from DC ADC's introduced

Milestone 8: BR's and cross section, $\phi \rightarrow K^+K^-$ (Q2-4)

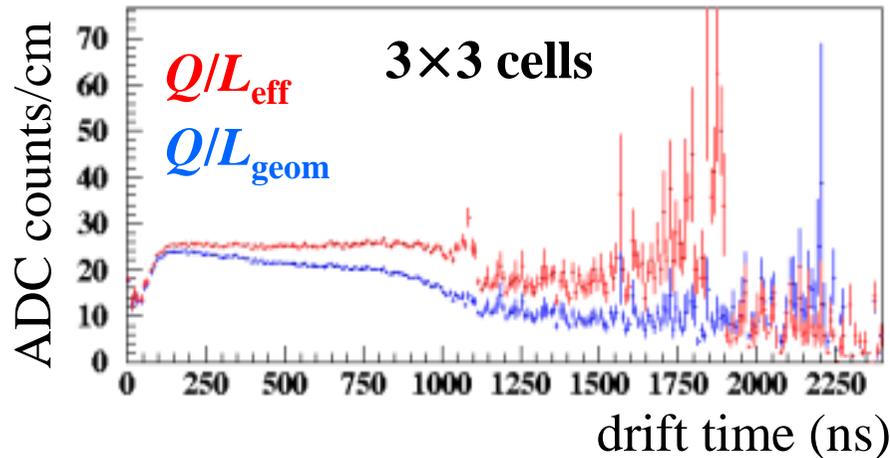
dE/dx measurement

ADC gates aligned with respect to T1

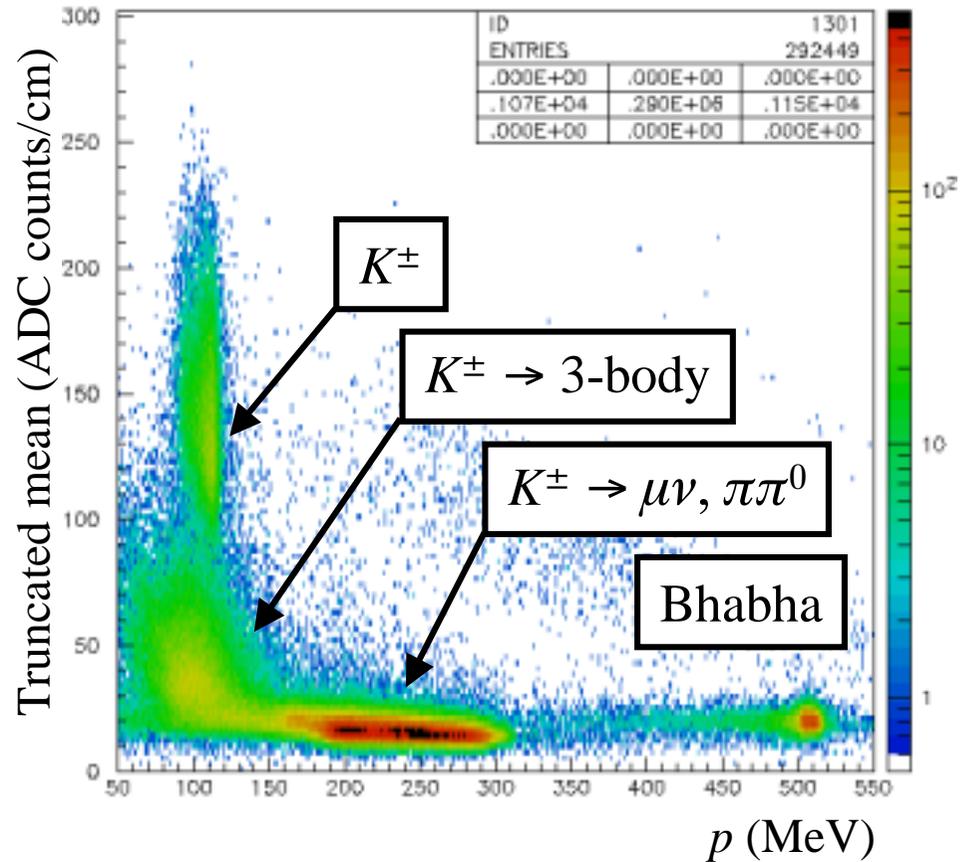


1.8 μs gate too short
 Charge lost at large t_{drift}
 Lengthened to 3.3 μs

For 2002 data, calculate
effective length for dE/dx

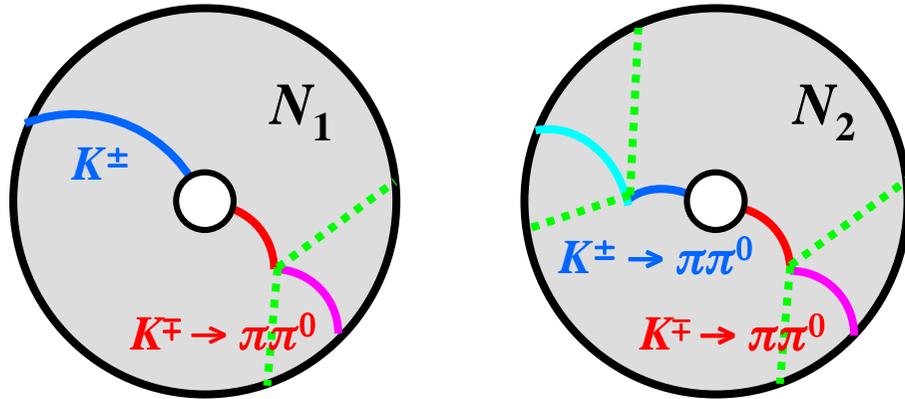


Software implementation



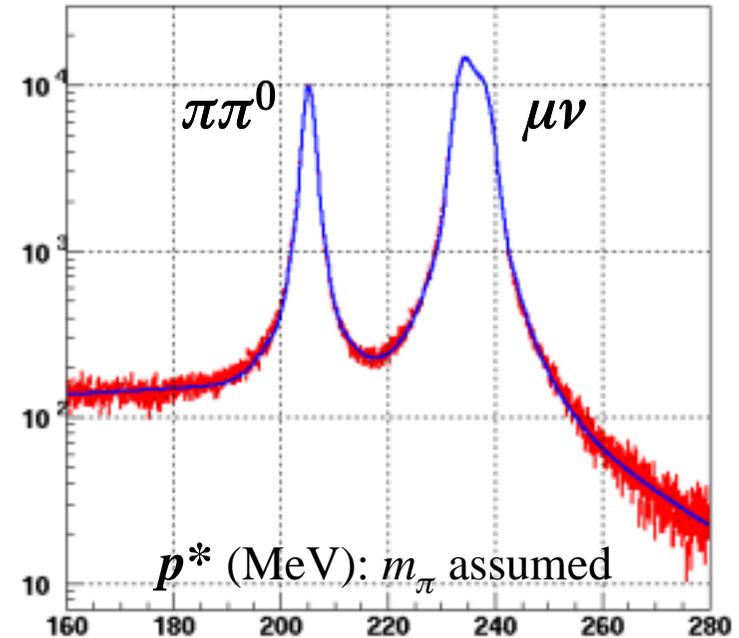
Goal to use unambiguous K PID as tag
 K^+K^- DST's a platform for dE/dx software

Milestone 8: BR's and cross section, $\phi \rightarrow K^+K^-$ (Q2-4)



From N_1 and N_2 obtain ϵ_{sel} and N_{KK}
 $\pi\pi^0$ decay auto-triggers EmC: ϵ_{sel} includes ϵ_{trig}

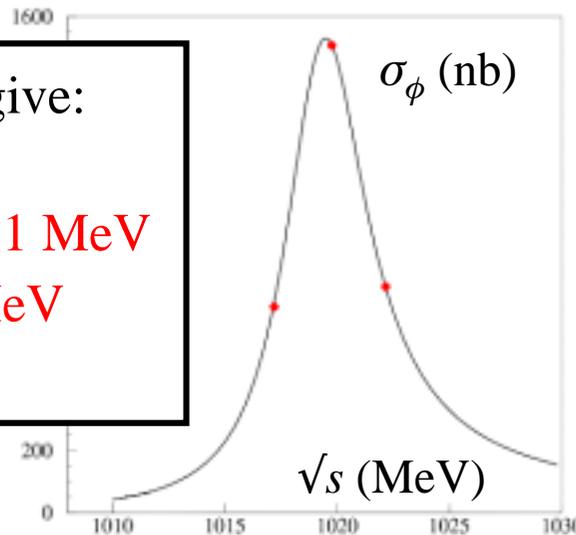
Identification of 2-body decays



$\text{BR}(\pi\pi^0)/\text{BR}(\mu\nu)$: 281 pb^{-1} '02 data
 $0.3300 \pm 0.0003 \pm 0.0025$

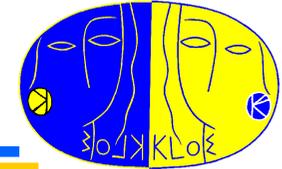
Systematics still under evaluation

3 pts of '02 scan give:
 $\sigma_\phi = 2105 \pm 65$ nb
 $m_\phi = 1019.45 \pm 0.11$ MeV
 $\Gamma_\phi = 4.07 \pm 0.21$ MeV
 Stat. error only



Milestone satisfied 70%

CPU available for data processing



60 to 74 B80 CPU's for reconstruction
on current farm (reallocatable)

	2002	2004 est.
Avg. L ($\text{cm}^{-2} \text{s}^{-1}$)	5.4×10^{31}	2.0×10^{32}
Avg T3 (Hz)	1600 Hz	4100
Reconstruction time (ms/ev)	19	25
CPU's needed to match T3	30	100

2004 working estimate is:

Optimistic in terms of L

Pessimistic in terms of

- MB rate
- MB rejection capability

→ **Maximum reasonable load assumption**

Must also add

- **MC generation + reconstruction** ($\phi \rightarrow$ all: 370 ms/ev, 1M events = 5 CPU days)
- **DST production**

Results of 3rd KLOE call for tenders (June 2003):

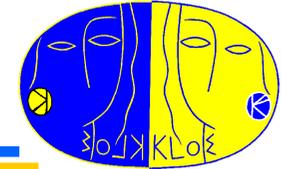
10 IBM 7028-6C4 p630 4×1.45 GHz
POWER4 servers

Doubles CPU power of offline farm
~70 → 150 B80 CPU equivalents

18.6 TB disk space, SAN/FC interface
3× increase of offline disk space

To be added to DST cache and AFS cell

Tape library: status and upgrade plans



Current usage (TB)

Raw	100.9
Reconstructed	51.2
DST	4.1
Old MC	4.9
New MC	9.5
MC DST	1.6
Total	172.3

Capacity (TB)

Before reversal	200
Current	300

Space crisis averted by reversal to high-density cartridges (40 → 60 GB)

Final decision on new library by end of year

New IBM Magstar technology: 3494-L12

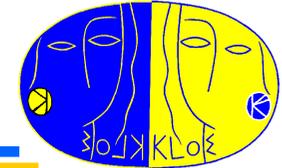
- 300 GB/cartridge (roadmap for 1 TB)

Proposed initial installation:

- 1000 cartridges installed (300 TB)
- Space for 3600 cartridges (1080 PB)
- 2 robots, 6 drives (40 MB/s each)
- Placed in LNF computer center
- Remotely attached to the KLOE servers via FiberChannel/SAN
- **7 months of raw+reconstructed data at $200 \mu\text{b}^{-1}/\text{s}$ with 1600 Hz MB**

Milestone 9:
Repeat 2002 analyses with full data set

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



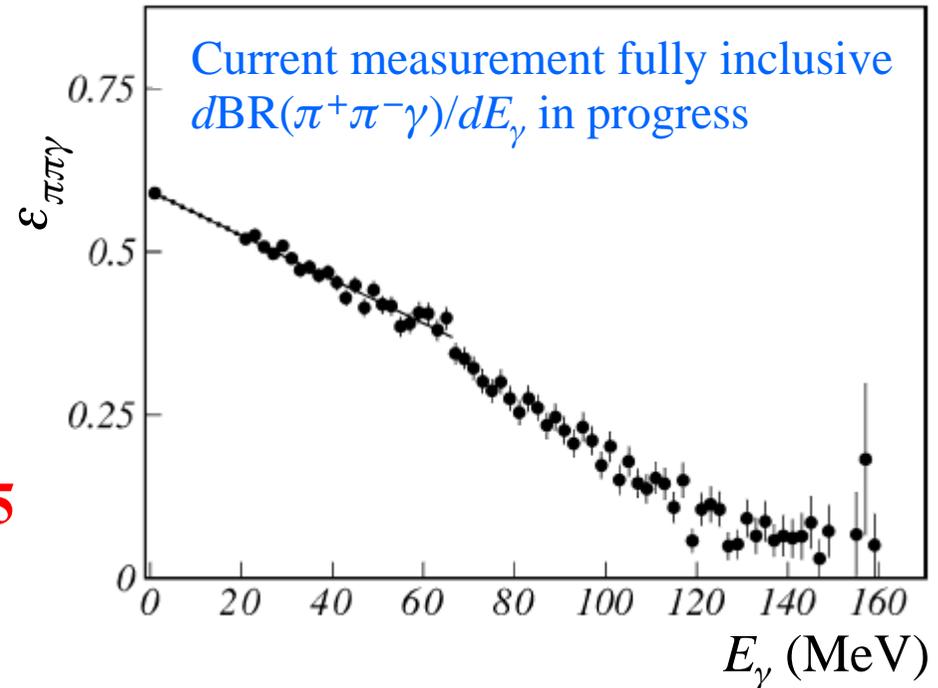
- First part of double ratio for $\text{Re } \varepsilon'/\varepsilon$
- Provides information on EM isospin breaking in $K \rightarrow \pi\pi$ decays
- Can extract $\delta_0 - \delta_2$ if effective E_γ cutoff known for $\pi\pi\gamma$ channel

PDG '02 **2.197 ± 0.026 (avg.)**

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

17 pb^{-1} '00 data, *Phys. Lett.* **B538 21**

Error will be reduced to 0.1%



$\chi_0 - \chi_2$

$\delta_0 - \delta_2$

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

Cirigliano et al. '01

$(45 \pm 6)^\circ$

χ PT estimate

Gasser & Meissner, '91

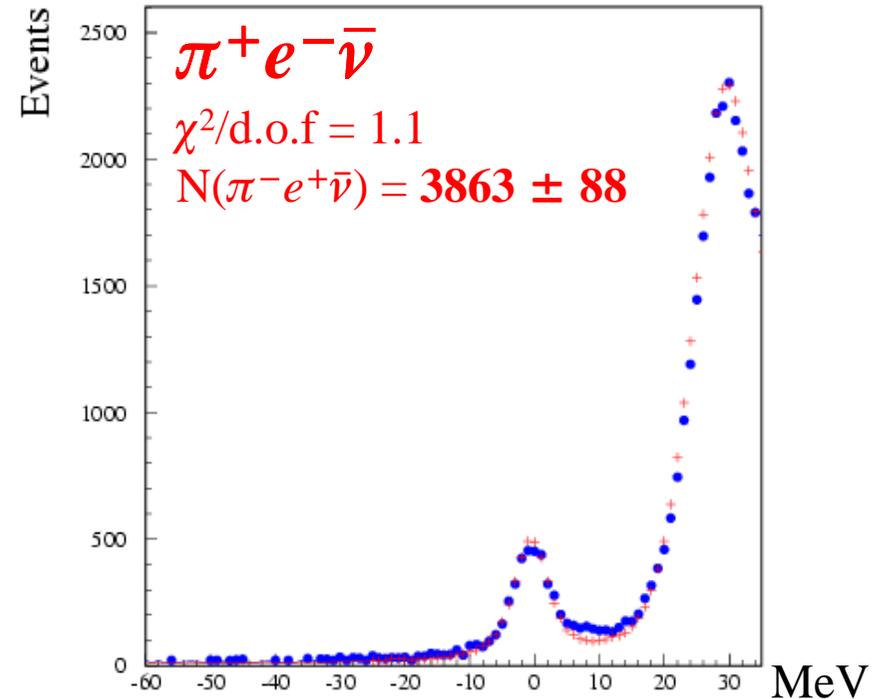
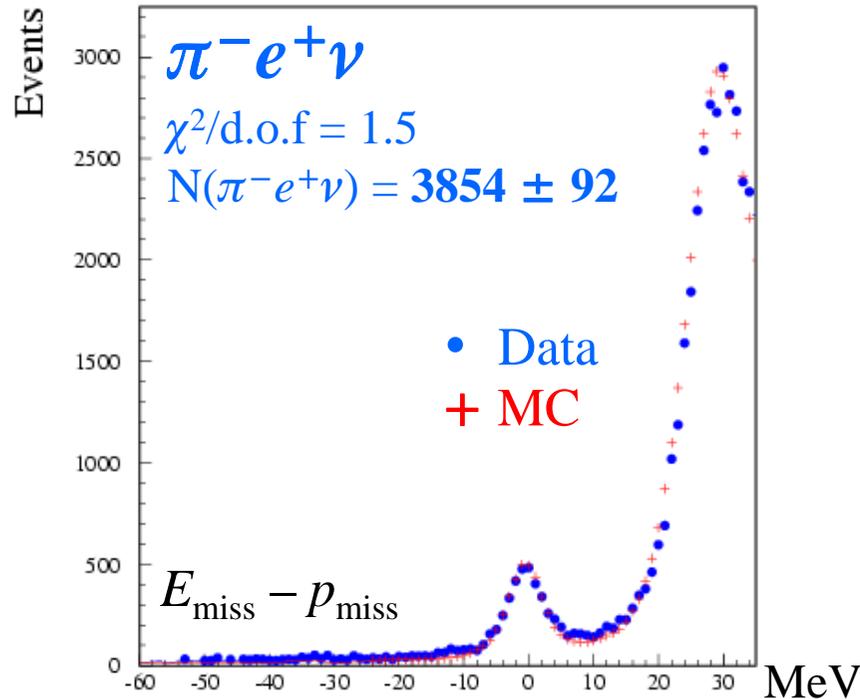
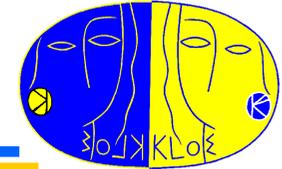
KLOE '02 value for
 $\Gamma(\pi^+\pi^-)/\Gamma(\pi^0\pi^0)$ **$(48 \pm 3)^\circ$**

$(47.7 \pm 1.5)^\circ$

$\pi\pi$ scattering

Colangelo et al. '01

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

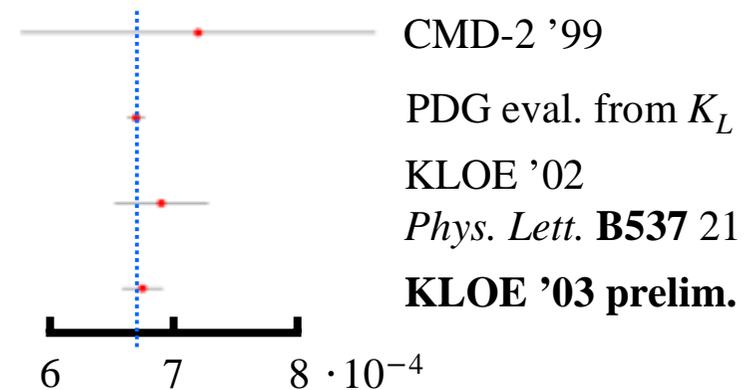


KLOE preliminary (170 pb⁻¹ '01 data)

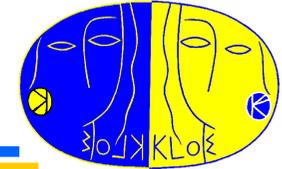
$$\text{BR}(\pi^- e^+ \nu) = (3.46 \pm 0.09 \pm 0.06) \cdot 10^{-4}$$

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

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



$K_S \rightarrow \pi e \nu$: *CPT* and $\Delta S = \Delta Q$



$$A \equiv \frac{\Gamma(\pi^- e^+ \nu) - \Gamma(\pi^+ e^- \bar{\nu})}{\Gamma(\pi^- e^+ \nu) + \Gamma(\pi^+ e^- \bar{\nu})}$$

$A_S - A_L \neq 0$ implies *CPT* viol.

KTeV '02 result for A_L

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

KLOE preliminary

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

First measurement of A_S !

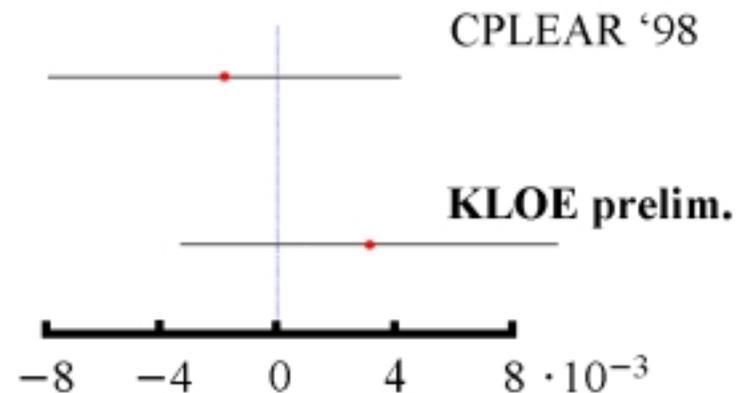
$$\text{Re } x_+ = \frac{1}{2} \frac{\text{BR}_S(\pi e \nu)/\tau_S - \text{BR}_L(\pi e \nu)/\tau_L}{\text{BR}_S(\pi e \nu)/\tau_S + \text{BR}_L(\pi e \nu)/\tau_L}$$

KLOE preliminary

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

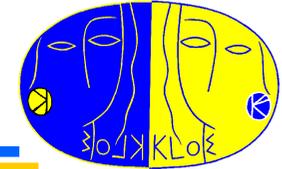
Compare to CPLEAR '98

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



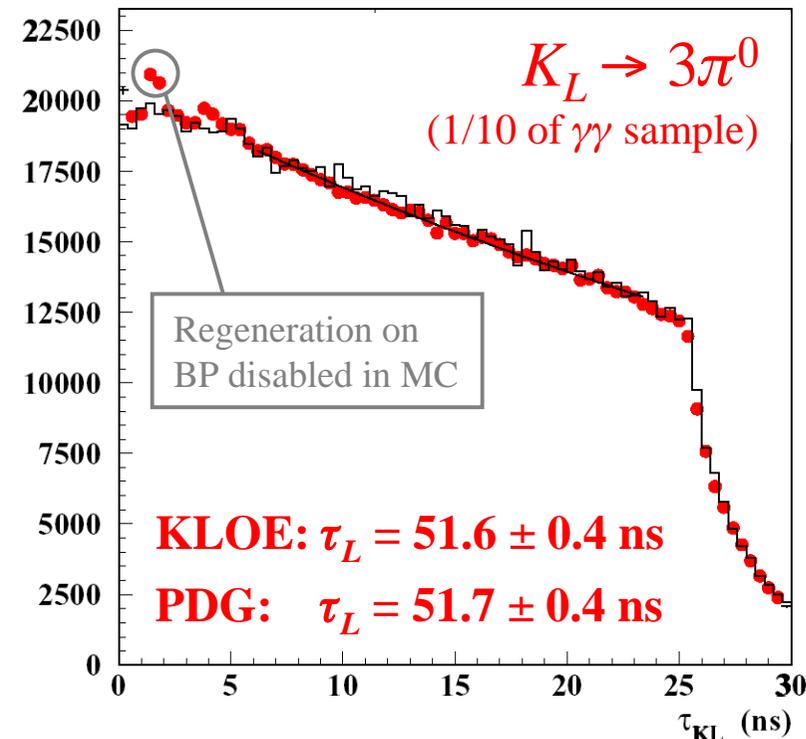
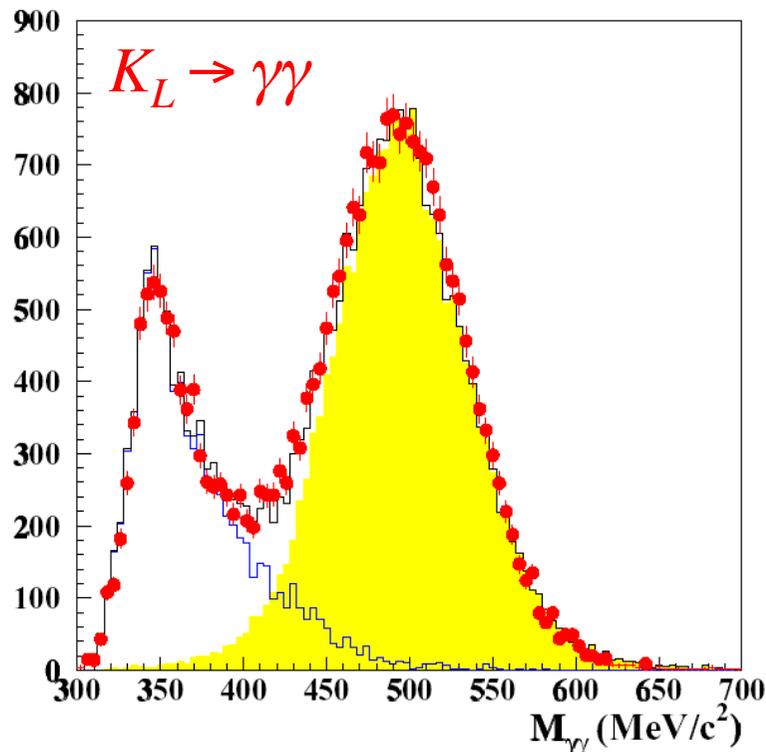
280 pb⁻¹ from '02 running +
KLOE measurements of τ_L ,
BR($K_L \rightarrow \pi e \nu$) on the way

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



- Dominated by long-distance contribution (π^0, η, η')
 χ PT calculation of BR sensitive to θ_p
- Dominates long-distance contribution to $K_L \rightarrow \mu^+\mu^-$

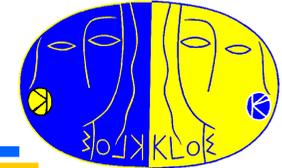
Exploits performance of EmC for reconstruction of photon vertex



KLOE '03: $(2.793 \pm 0.022 \pm 0.024) \times 10^{-3}$
362 pb⁻¹ '01+'02 data, *Phys. Lett. B566* 61

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

$K_L \rightarrow \text{charged particles}$



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

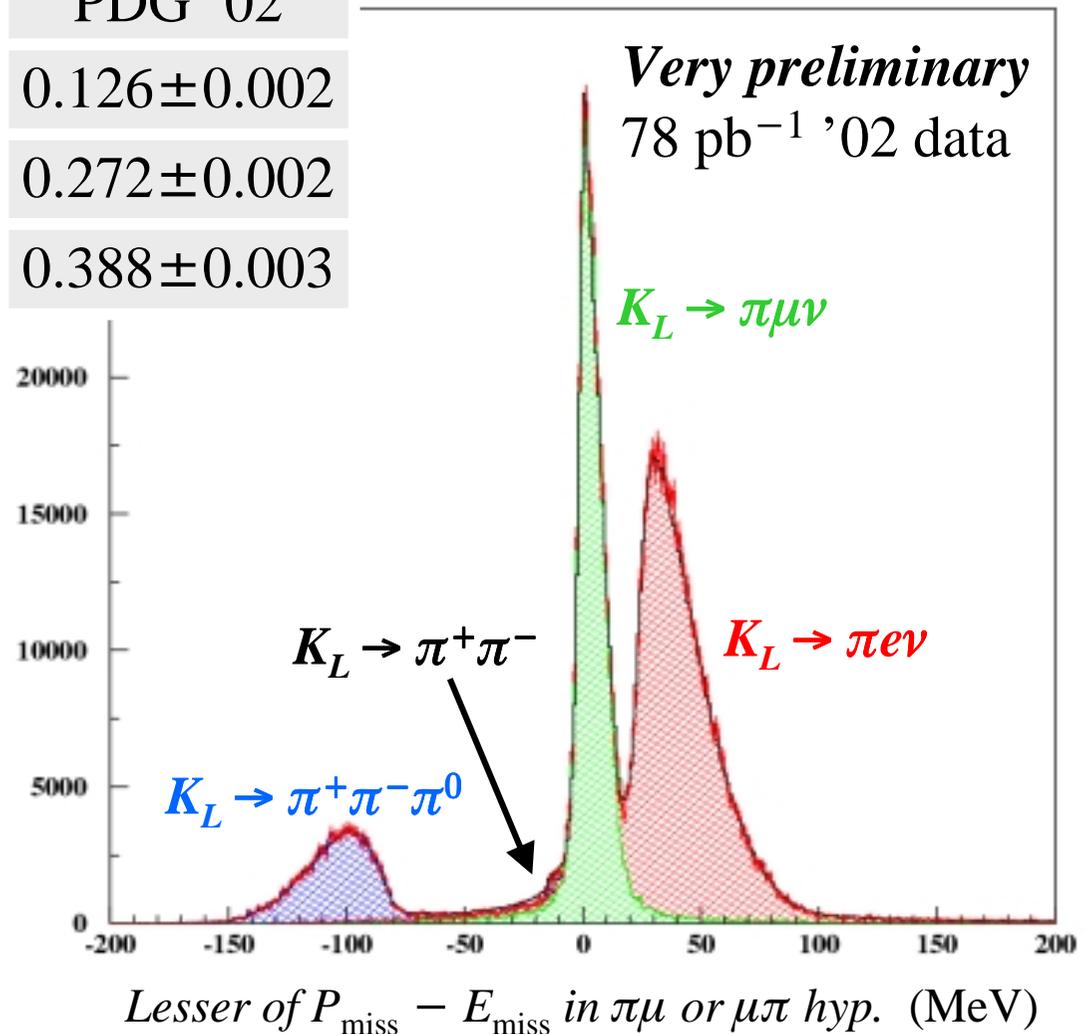
$K_L \rightarrow \pi^+\pi^-$ contribution fixed

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

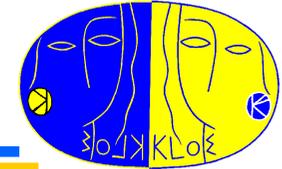
KLOE $(2.04 \pm 0.04) \times 10^{-3}$

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

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 ($\sim 400 \text{ pb}^{-1}$)

K_L

Statistical error: $\sim 1.5\%$

Systematic error: $\sim 2\%$, *in progress*

$\pi^+\pi^-$

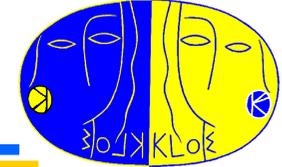
- Momentum reconstruction/resolution, including DC occupancy effects
- Effect of $K\ell 3\gamma$ decays on background determination

$\pi^0\pi^0$

- Separation of overlapping clusters
- Regeneration

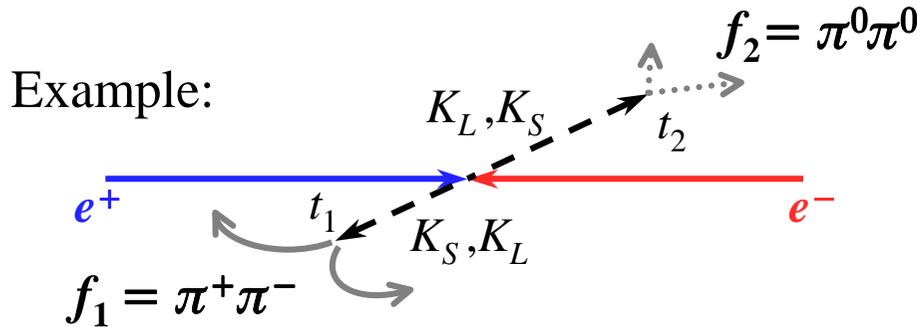
Need at least 10× more data to reach the 10^{-4} regime

CP/CPT studies: longer term prospects

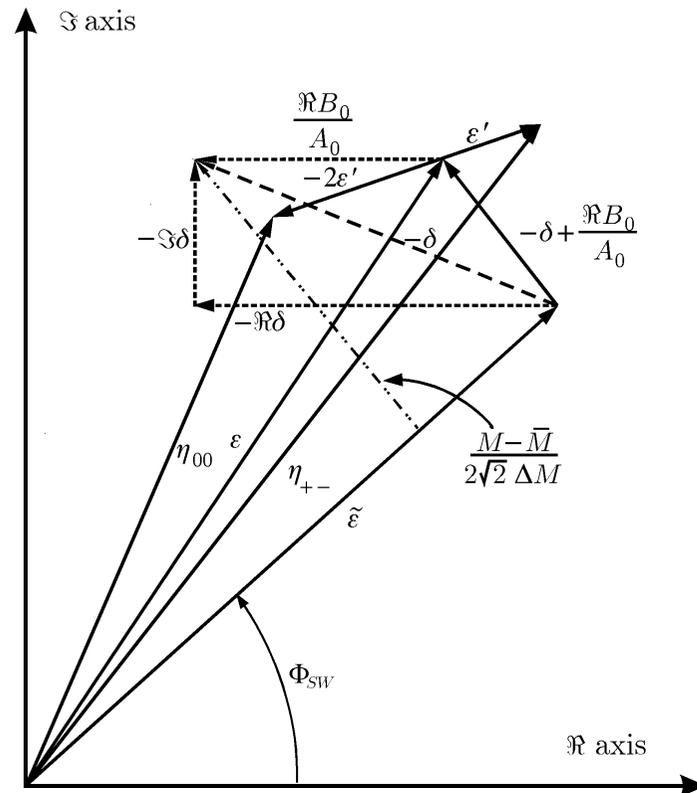


Interference term in $I(\Delta t | f_1, f_2) \propto -2|\eta_1||\eta_2|e^{-\frac{\Gamma\Delta t}{2}} \cos(\Delta m\Delta t + \phi_2 - \phi_1)$

$$\eta_f = |\eta_f| e^{i\phi_f} = \frac{A(K_L \rightarrow f)}{A(K_S \rightarrow f)}$$

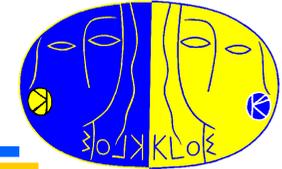


$$\begin{array}{l} \eta_1 \longrightarrow \eta_{+-} \approx \varepsilon + \varepsilon' \\ \eta_2 \longrightarrow \eta_{00} \approx \varepsilon - 2\varepsilon' \\ \phi_1 - \phi_2 \longrightarrow \phi_{+-} - \phi_{00} \approx 3 \operatorname{Im} \varepsilon'/\varepsilon \end{array}$$



With sufficient L , KLOE can use both absolute BR measurements and interferometry to measure many CP & CPT violation parameters of $K_S K_L$ system

A first glance at interference



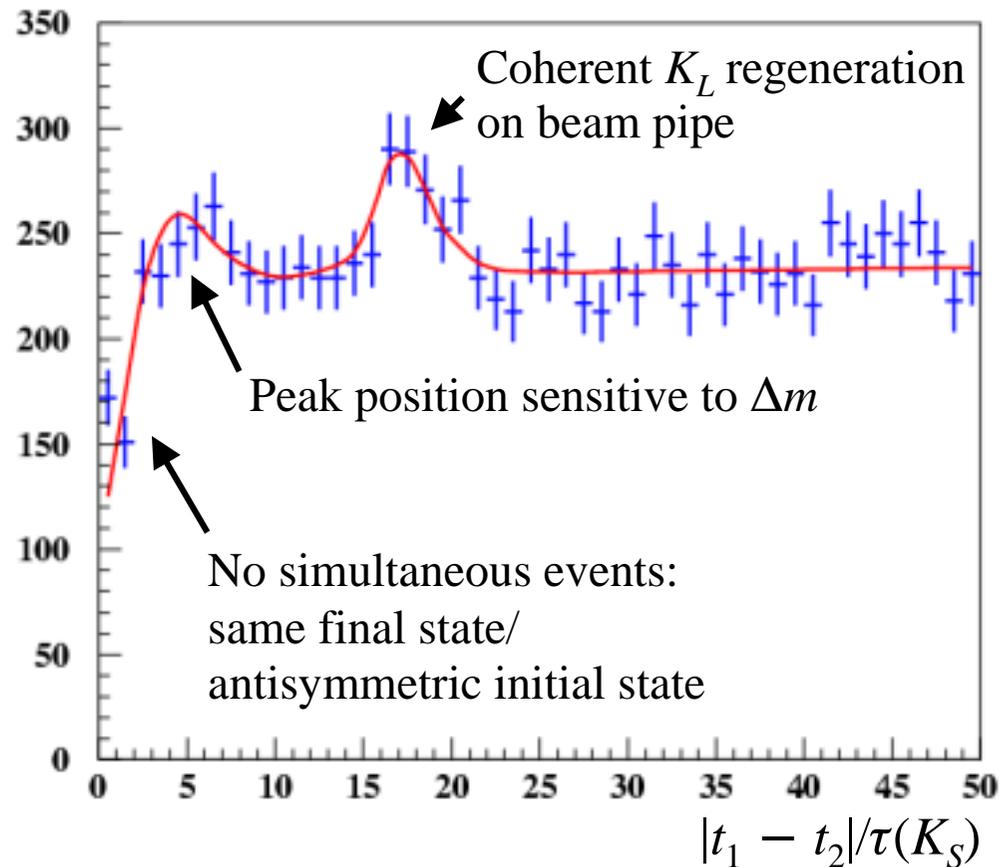
$$K_S K_L \rightarrow \pi^+ \pi^- \pi^+ \pi^-: \quad |A(\Delta t)|^2 \propto e^{-\Gamma_L |\Delta t|} + e^{-\Gamma_S |\Delta t|} - 2e^{-(\Gamma_S + \Gamma_L)|\Delta t|/2} \cos(\Delta m \Delta t)$$

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

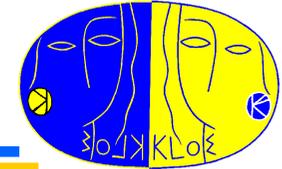
Fit with PDG values for Γ_S, Γ_L
 $\chi^2/\text{d.o.f.} = 43.7/47$

$\Delta m = (5.64 \pm 0.37) \times 10^{-11} \hbar \text{ s}^{-1}$
PDG '02: $(5.301 \pm 0.016) \times 10^{-11} \hbar \text{ s}^{-1}$

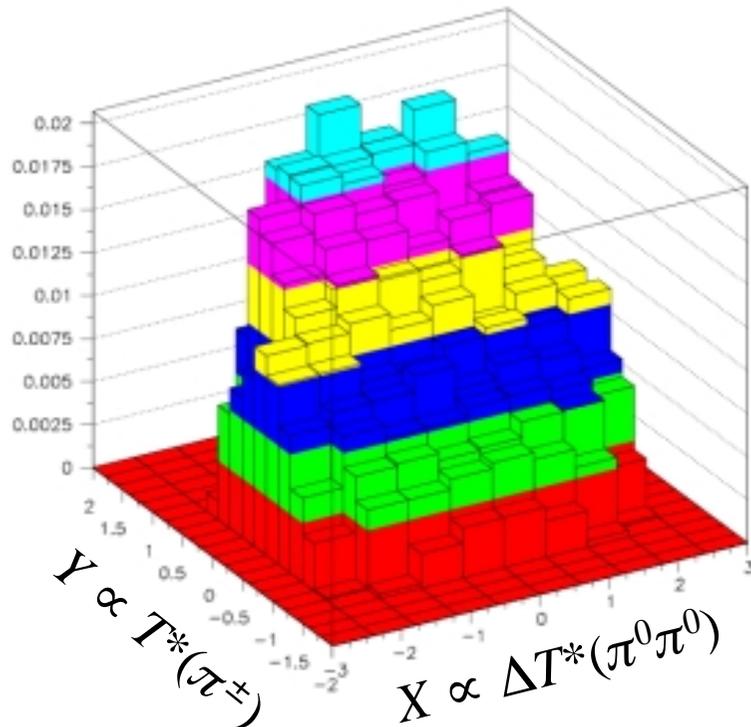
First observation of quantum interference in relative decay-time distribution of K_S, K_L



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



- Asymmetries in K^\pm rates ($\sim 10^{-8}$) and Dalitz slopes ($\sim 10^{-5}$) signal direct CP viol.
- Dalitz slopes give information on $\Delta I = 1/2, 3/2$ amplitudes for $K \rightarrow 3\pi$ decays



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

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

KLOE preliminary hep-ex/0307054

441 pb^{-1} '01+'02 data

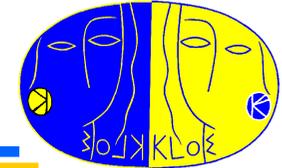
187 pb^{-1} counted as signal

$(1.781 \pm 0.013 \pm 0.016)\%$

Preliminary fit to Dalitz plot
 $F(X,Y) = 1 + gY + hY^2 + kX^2$

	KLOE	PDG
g	$0.586 \pm 0.010 \pm 0.012$	0.652 ± 0.031
h	$0.030 \pm 0.010 \pm 0.013$	0.057 ± 0.018
k	$0.0055 \pm 0.0026 \pm 0.0018$	0.0197 ± 0.0054

$K^\pm \rightarrow \pi^0 \pi^0 e^\pm \nu$ (K_{e4}')



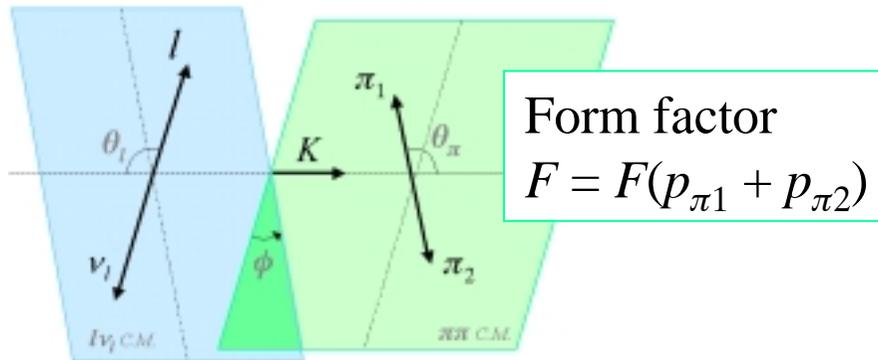
Assuming $\Delta I = 1/2$:

$$\Gamma(K_{\ell 4}^\pm) = 2\Gamma(K_{\ell 4}') = 1/2\Gamma(K_{\ell 4}^0)$$

$$|F(K_{\ell 4}^\pm)| = |F(K_{\ell 4}')|$$

$$\text{For } K_{\ell 4}', m_\ell = 0: \Gamma = C_F |F|^2 |V_{us}|^2$$

Angular distribution in θ_ℓ, ϕ plane allows determination of $\delta_0^0 - \delta_1^1$



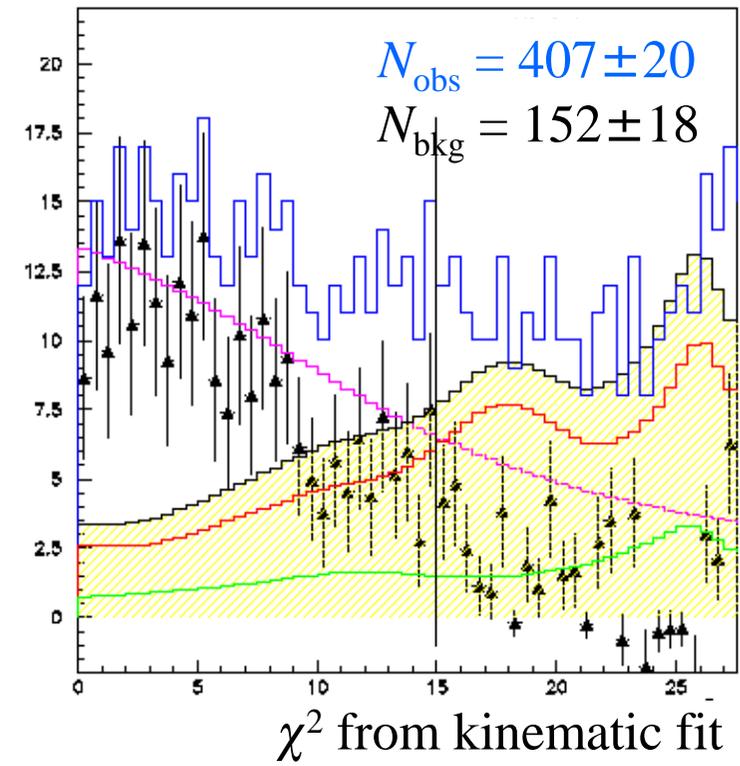
KLOE preliminary (441 pb⁻¹ '01 + '02 data)

$$\text{BR}(K_{e4}') = (2.43 \pm 0.20 \pm 0.22) \times 10^{-5}$$

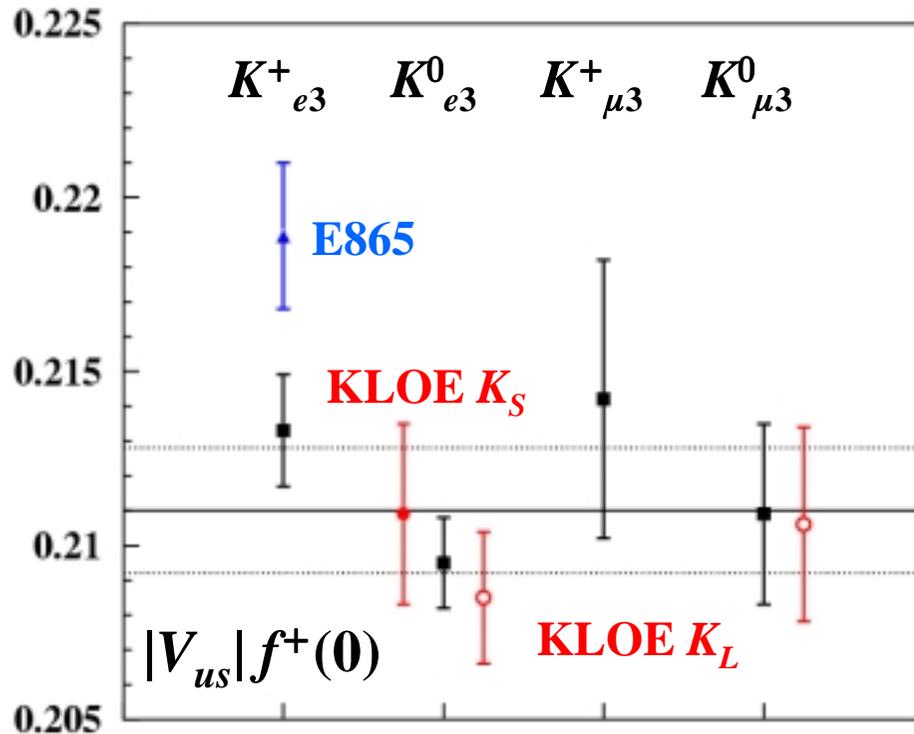
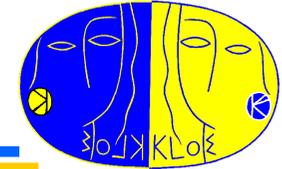
$$\text{PDG fit: } (2.1 \pm 0.4) \times 10^{-5}$$

$$\text{Best measurement: } (2.54 \pm 0.89) \times 10^{-5}$$

$K_{\ell 4}^\pm$	$K^\pm \rightarrow \pi^+ \pi^- \ell^\pm \nu$
$K_{\ell 4}'$	$K^\pm \rightarrow \pi^0 \pi^0 \ell^\pm \nu$
$K_{\ell 4}^0$	$K_L \rightarrow \pi^0 \pi^\mp \ell^\pm \nu$



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



Old data (Chiang '72) or PDG fit values
Inclusiveness for $K_{e3}\gamma$?

New E865 measurement, agrees better with current values of V_{ud}

KLOE preliminary $K_S \rightarrow \pi e \nu$ 170 pb^{-1}
Consistent with previous measurements

KLOE preliminary $K_L \rightarrow \pi \ell \nu$ 78 pb^{-1}
Also confirms previous measurements

For K_{e3} modes:

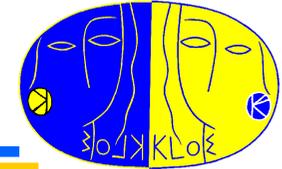
$$\frac{\delta |V_{us}|}{|V_{us}|} = \underbrace{\frac{1}{2} \left(\frac{\delta \text{BR}}{\text{BR}} \right) \oplus \frac{1}{2} \left(\frac{\delta \tau}{\tau} \right) \oplus \frac{1}{20} \left(\frac{\delta \lambda_+}{\lambda_+} \right)}_{\text{exp}} \oplus \underbrace{\frac{\delta f_+(0)}{f_+(0)}}_{\text{th}}$$

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

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

KLOE will measure *all BR's* to *0.1% level* and can also significantly improve $\lambda_+, \lambda_0, \tau_L$

Parameters of the ϕ meson



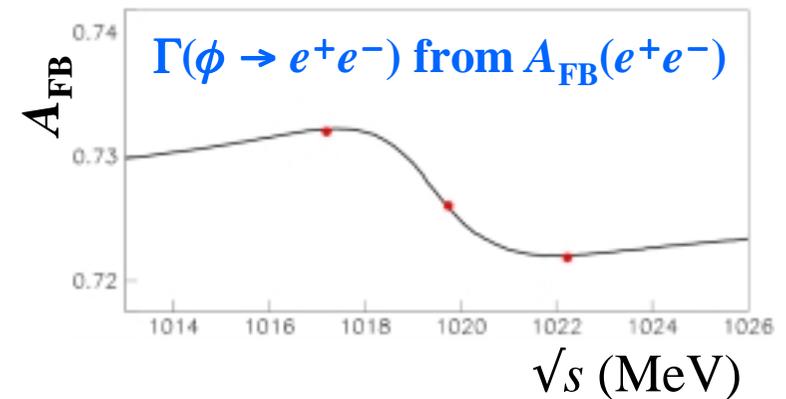
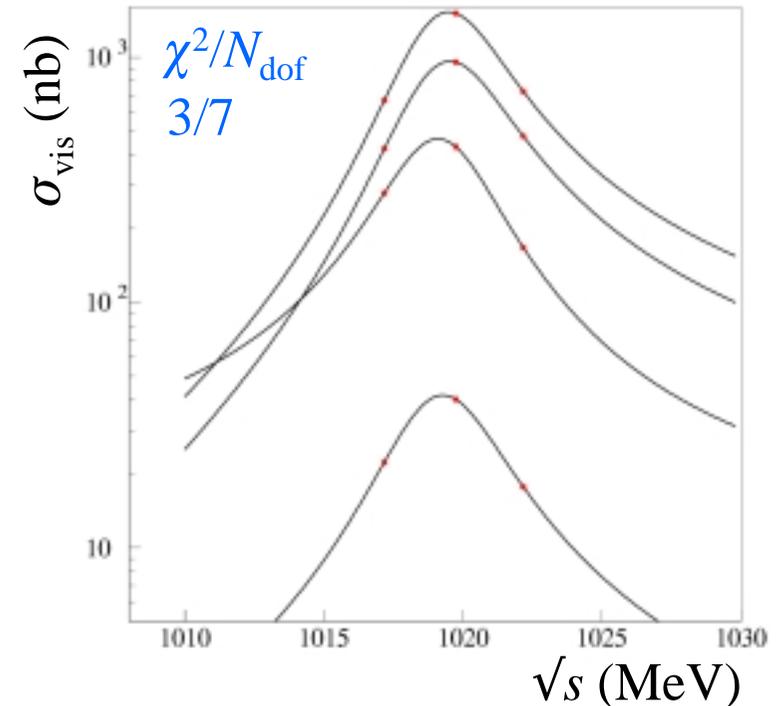
2002 scan: 3 points ($m_\phi, m_\phi \pm \Gamma_\phi/2$)
 $\sim 7 \text{ pb}^{-1}$ each

Preliminary – stat errors only

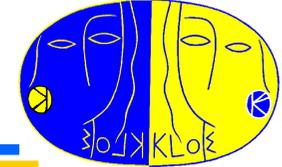
Decay	Method	σ_0 (nb)
K^+K^-	$\pi\pi^0$ double tag	2080\pm42
K_LK_S	$K_S \rightarrow \pi^+\pi^-$, K_L in EmC	1344\pm12
$\rho\pi$	Kinematic selection	693\pm8
$\eta\gamma$	3γ selection	58\pm1

*Mass scale from CMD-2 resonance
 depolarization measurement*

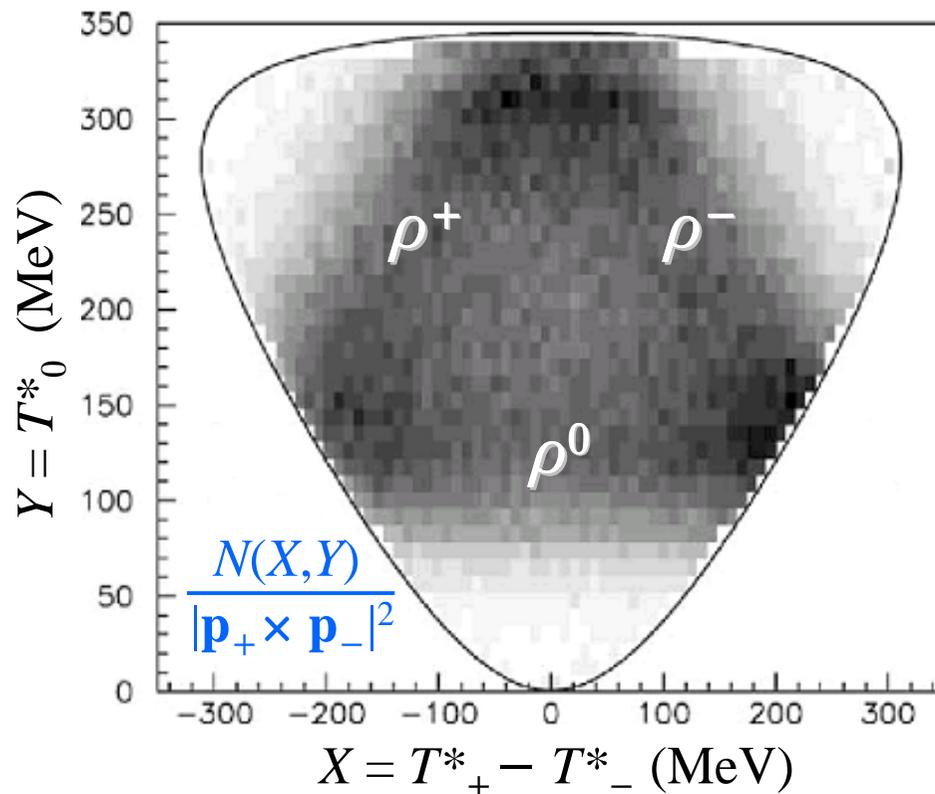
$$\Gamma_\phi = 4.19 \pm 0.04 \text{ MeV}$$



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



KLOE '03: *Phys. Lett.* B561 55
17 pb⁻¹ '00 data, 2M 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

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

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

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

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

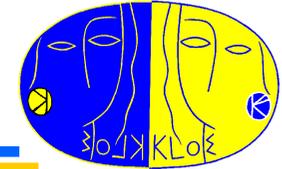
Relative decay intensities from
 integration of $|A|^2$ over Dalitz plot

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

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

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

$$\eta \rightarrow \pi^+ \pi^- \pi^0$$



Study of Dalitz plot gives u - d quark mass difference and sheds light on isospin-breaking mechanisms

Fit with a, b, d free parameters,
 c, d fixed to zero

$$\chi^2/N_{\text{dof}} = 33/38$$

Stat. errors only

	PDG	KLOE
a	-1.08 ± 0.014	-1.05 ± 0.01
b	0.034 ± 0.027	0.20 ± 0.03
d	0.046 ± 0.031	0.05 ± 0.03

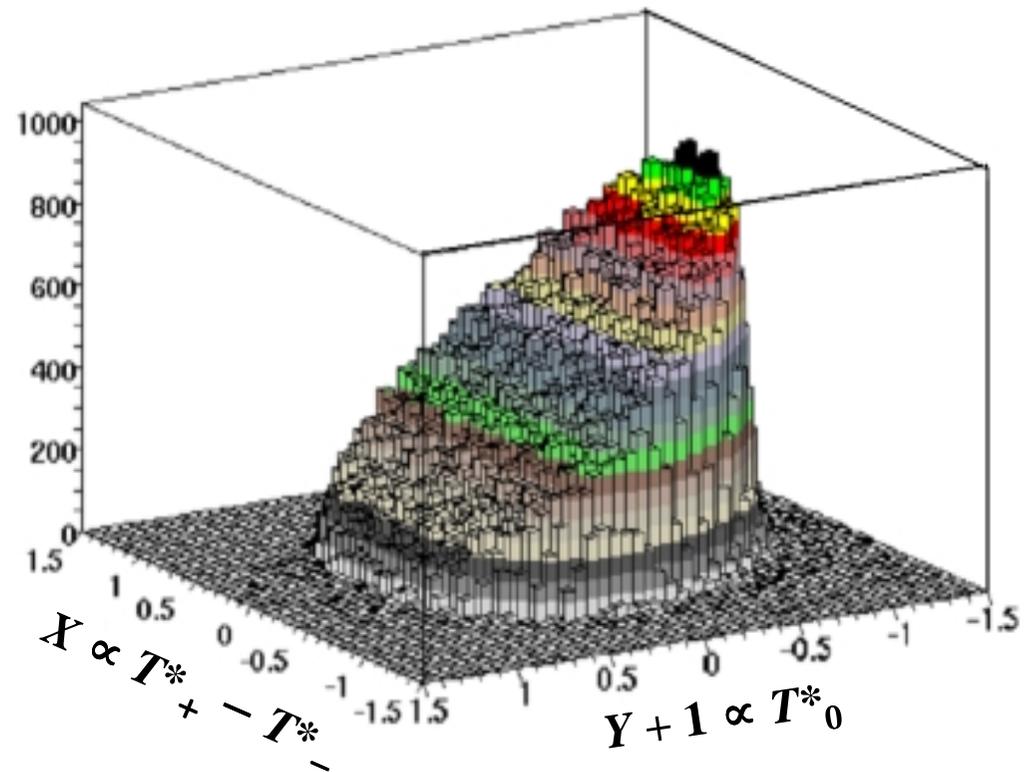
When treated as free parameters:

$$c = -0.008 \pm 0.010$$

$$d = 0.01 \pm 0.03$$

Will limit C violation in $\eta \rightarrow 3\pi$

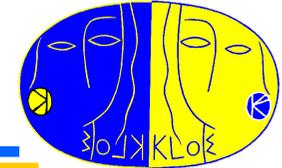
**KLOE preliminary, $\sim 100 \text{ pb}^{-1}$
352K $\eta \rightarrow \pi^+ \pi^- \pi^0$ events**



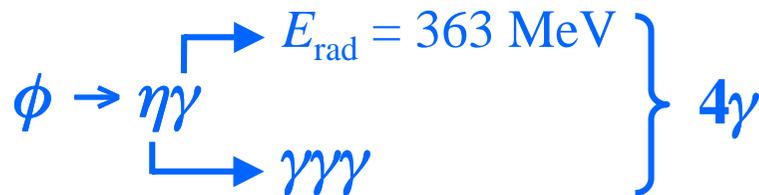
Expansion of Dalitz plot:

$$A(X, Y) \propto 1 + aY + bY^2 + cX + dX^2 + eXY$$

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



Violates C $\left\{ \begin{array}{ll} 5 \times 10^{-4} \text{ 95\% CL} & \text{PDG '02 (GAMS2000)} \\ 1.8 \times 10^{-5} \text{ 90\% CL} & \text{Crystal Ball '02 prelim} \end{array} \right.$



Require 4γ with fiducial cuts on E, θ

Reclustering to eliminate 3γ background

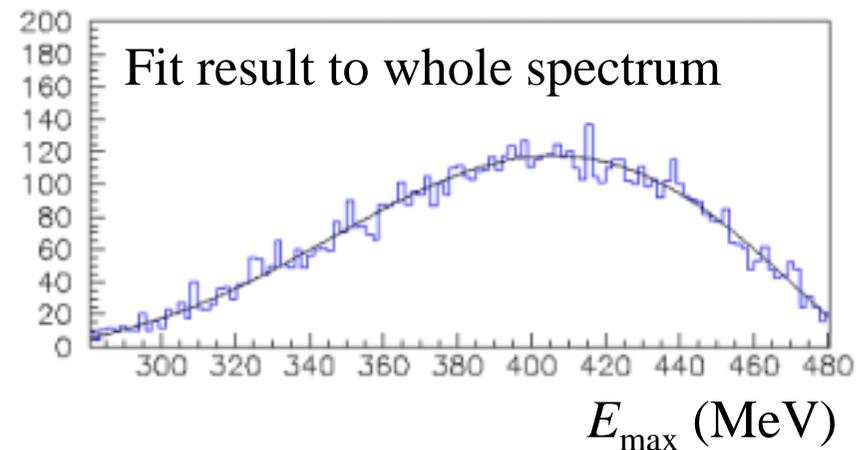
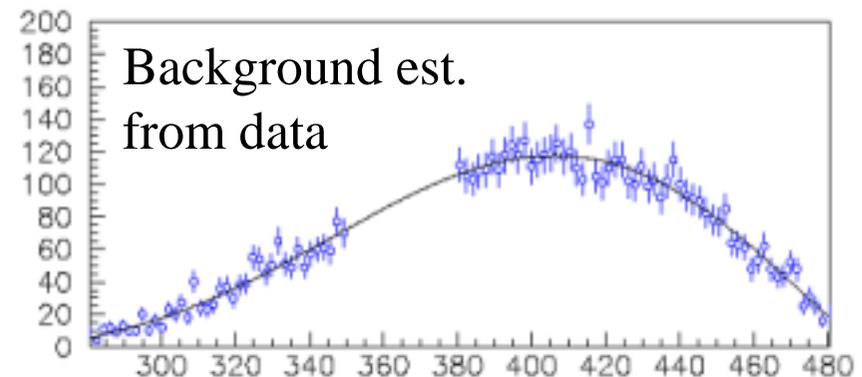
Kinematic fit

$m(\pi^0)$ veto eliminates $e^+e^- \rightarrow \omega\pi^0$ and 5γ background

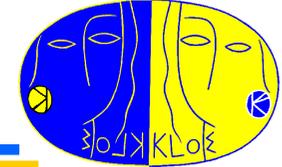
KLOE preliminary hep-ex/0307042

410 pb^{-1} '01 + '02 data

$\text{BR}(\eta \rightarrow 3\gamma) \leq 1.6 \times 10^{-5}$ 95% CL

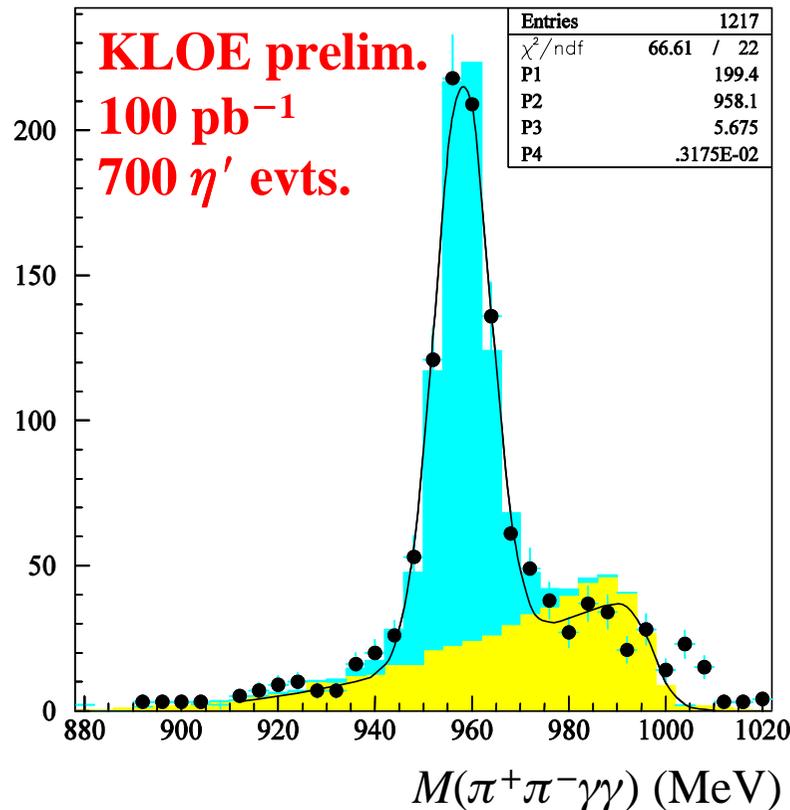


$\phi \rightarrow \eta' \gamma, \eta \gamma$



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

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



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

KLOE '02:

17 pb⁻¹ '00 data, *Phys. Lett. B541 45*

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

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

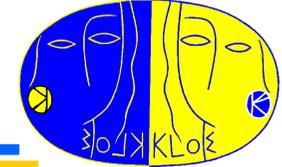
$$(Z')^2 = 0.06_{-0.06}^{+0.09}$$

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

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

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

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



Scalar mesons f_0 and a_0 not easily interpreted as $q\bar{q}$ states

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

	BR($\phi \rightarrow f_0\gamma$)	BR($\phi \rightarrow a_0\gamma$)
$q\bar{q}$	$5 \cdot 10^{-5}$	$2 \cdot 10^{-5}$
$q\bar{q}q\bar{q}$	$3 \cdot 10^{-4}$	$2 \cdot 10^{-4}$
$K\bar{K}$	10^{-5}	10^{-5}

KLOE '02

17 pb⁻¹ '00 data

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

$(1.09 \pm 0.03 \pm 0.05) \times 10^{-4}$

Phys. Lett. **B537** 21

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

$\eta \rightarrow \gamma\gamma$

$(8.51 \pm 0.51 \pm 0.57) \times 10^{-5}$

$\eta \rightarrow \pi^+\pi^-\pi^0$

$(7.96 \pm 0.60 \pm 0.40) \times 10^{-5}$

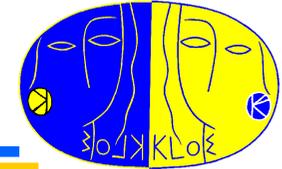
Phys. Lett. **B536** 209

PDG '02

$(1.08 \pm 0.19) \times 10^{-4}$

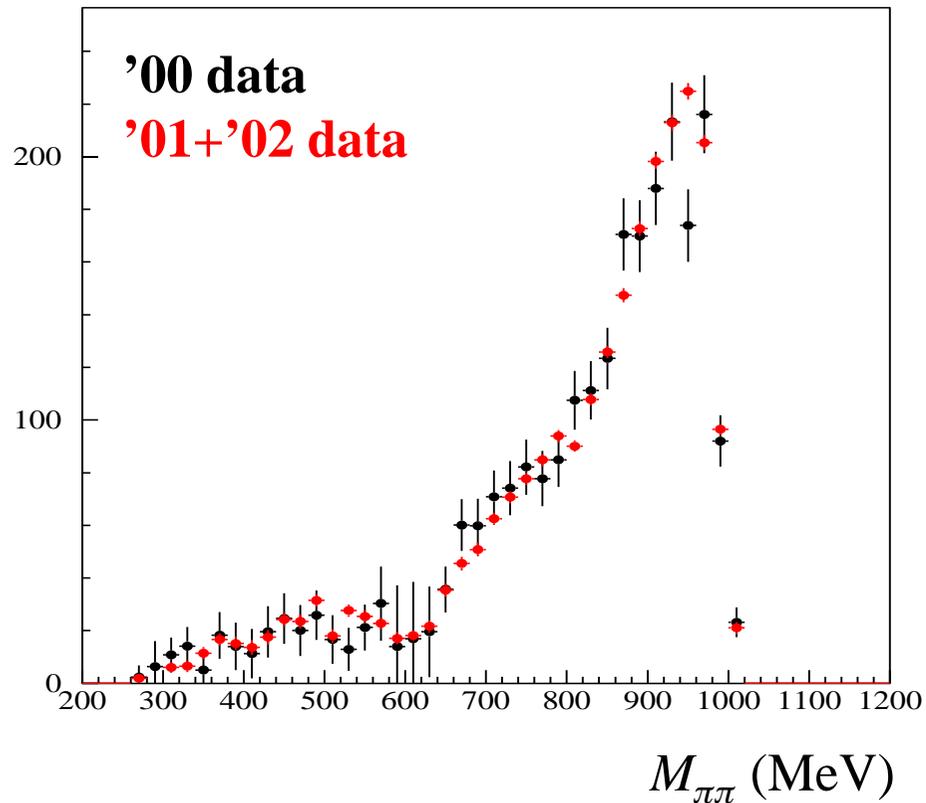
$(8.9 \pm 1.4) \times 10^{-5}$

$\phi \rightarrow \pi^0\pi^0\gamma, \eta\pi^0\gamma$: updated spectra

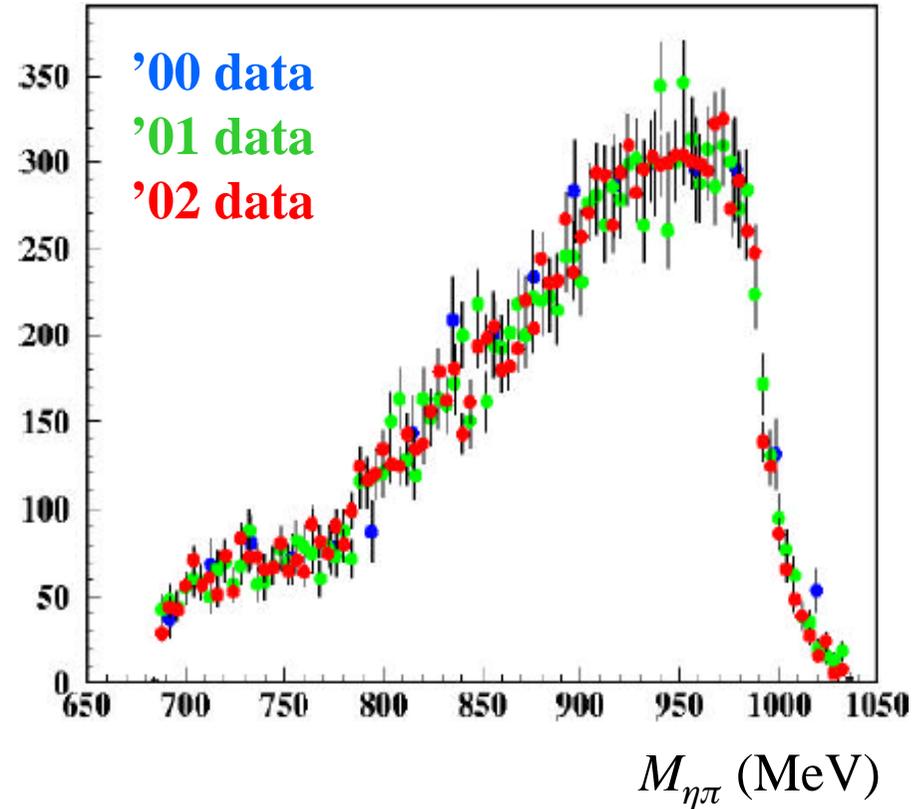


KLOE preliminary: $\sim 400 \text{ pb}^{-1}$ '01 + '02 data

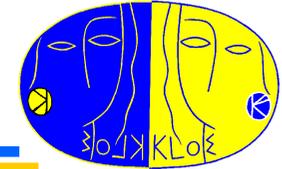
$$\phi \rightarrow \pi^0\pi^0\gamma$$



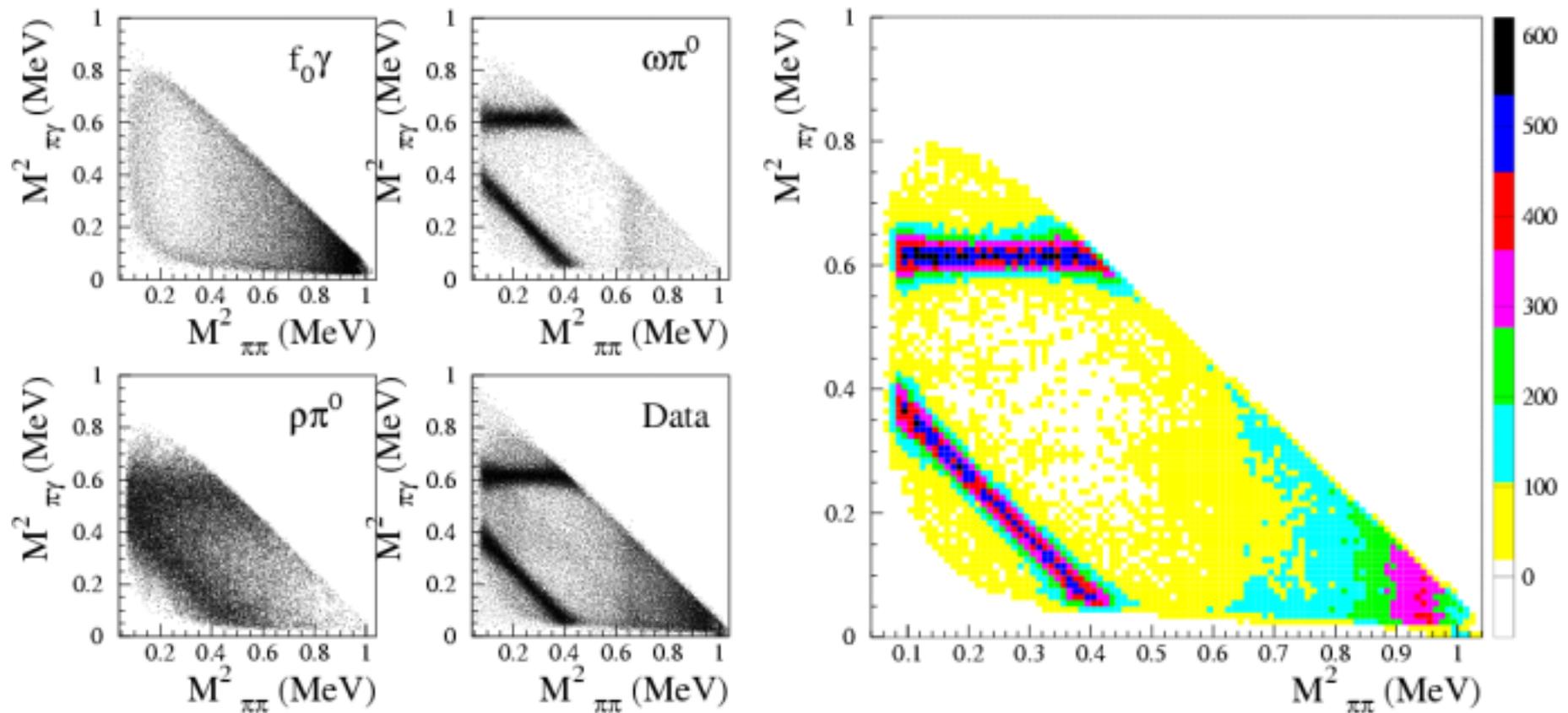
$$\phi \rightarrow \eta\pi^0\gamma \rightarrow 5\gamma$$



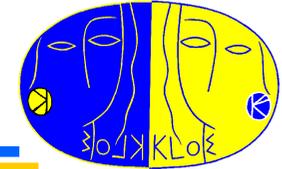
$\phi \rightarrow \pi^0\pi^0\gamma$: Dalitz plot



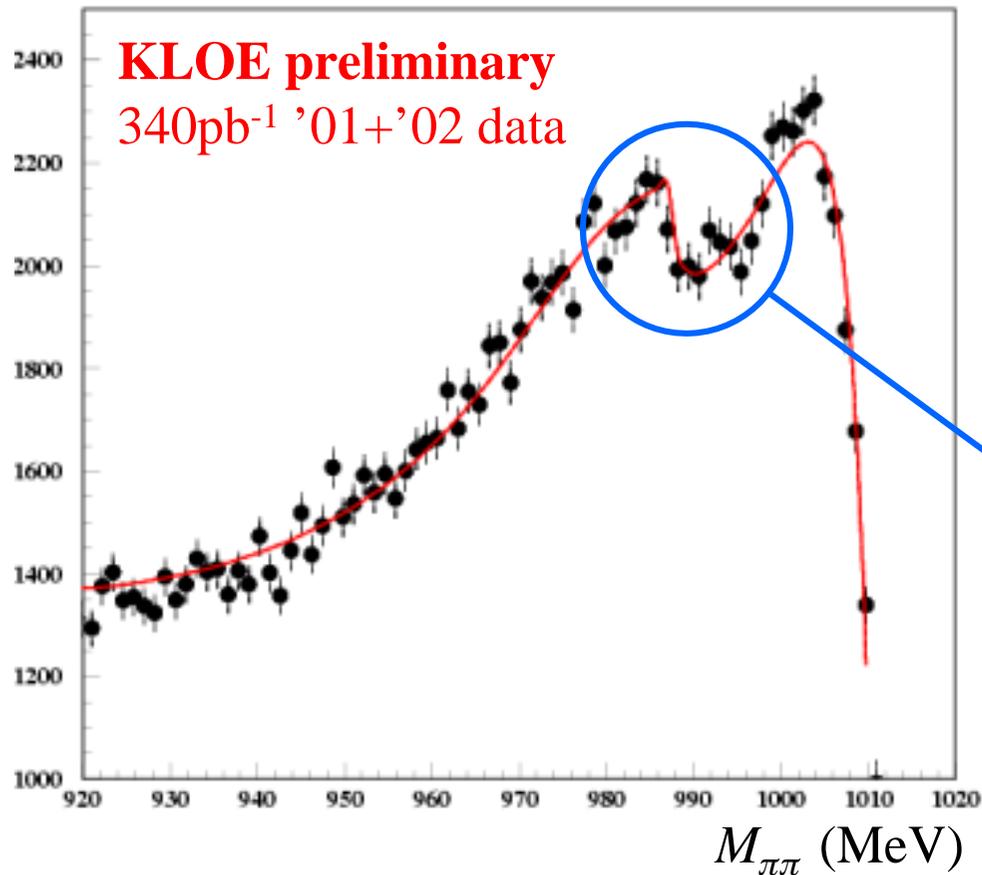
Statistics of '01-'02 data set allow interference between $f_0\gamma$, $\omega\pi^0$, $\rho\pi^0$ contributions to be studied in a model-independent way



Search for $f_0 \rightarrow \pi^+\pi^-$



Completely dominated by $e^+e^- \rightarrow \pi^+\pi^-\gamma$ with γ from initial state (ISR)



Fit to $M_{\pi\pi}$ spectrum with:

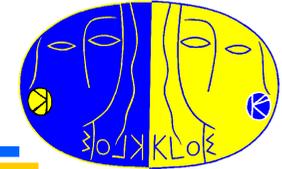
- $\pi\pi\gamma$ continuum
 γ from both ISR and FSR
- Signal (f_0)
- f_0 -FSR interference

Best results for destructive interference

Potentially study contribution from σ

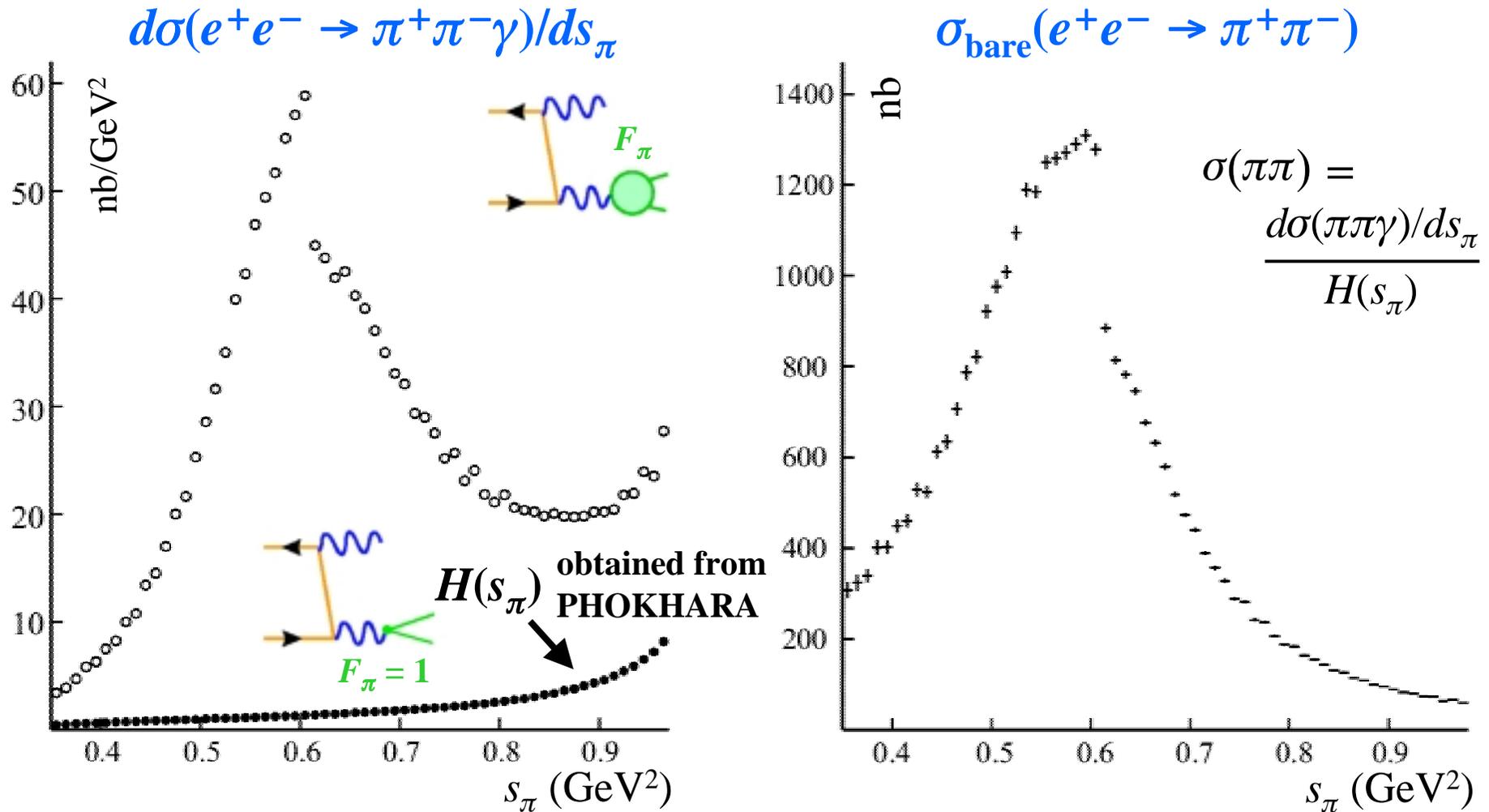
Analysis in progress

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

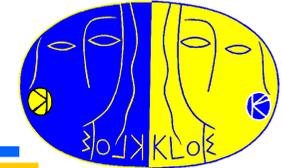


KLOE preliminary: 140 pb⁻¹ '01 data, 1.5M events

hep-ex/0307051

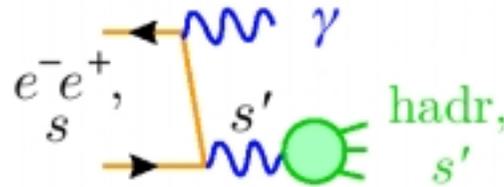


$\sigma(e^+e^- \rightarrow \text{hadrons})$



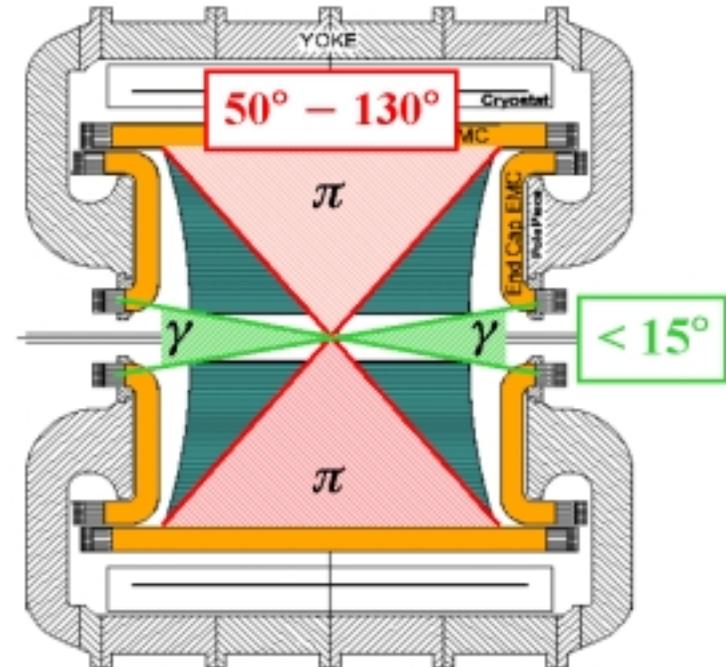
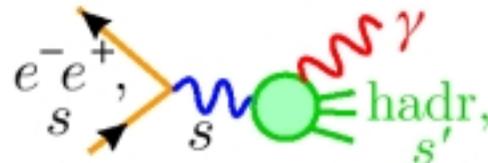
ISR:

$$M_{\pi\pi}^2 = s'$$



FSR:

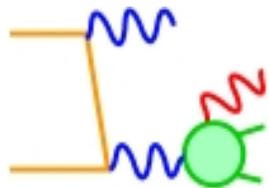
$$M_{\pi\pi}^2 = s \neq s'$$



Angular cuts ensure:

- High statistics for **ISR** events
- Very low contribution from **FSR-only** events
- Reduced background contamination

However, for a_μ , inclusive cross section is needed: $e^+e^- \rightarrow \pi^+\pi^-(\gamma), \gamma$ from FS

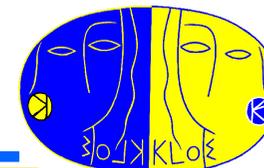


ISR+FSR events eliminated by kinematic cuts, must be resummed

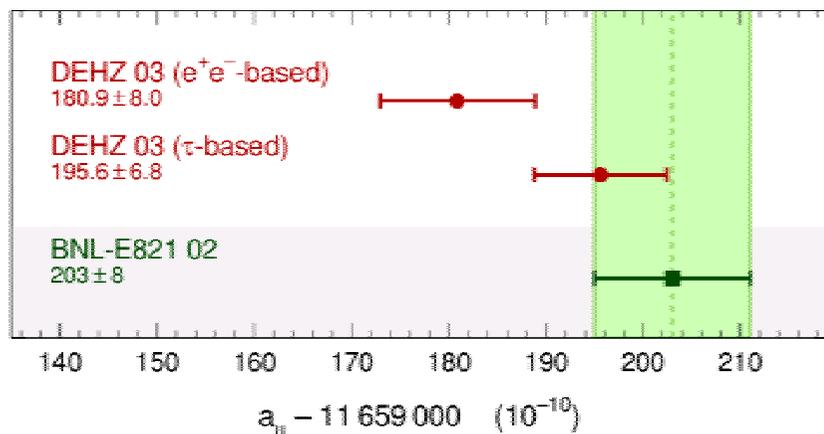
Now evaluating this correction with PHOKHARA v3.0

This correction not yet included: currently our largest error

Preliminary results for a_μ^{had}



Status of a_μ (Davier et al., Aug '03)



$\sim 70\%$ of a_μ^{had} from $s < m_\phi^2$

e^+e^- -based estimates dominated by CMD-2 (revised analysis Aug '03)

No comparable data set (until KLOE!)

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

$$a_\mu^{\pi\pi} \propto \int ds \sigma(e^+e^- \rightarrow \pi^+\pi^-) K(s)$$

$a_\mu^{\pi\pi} \times 10^{10}$ ($0.37 < s_\pi < 0.92 \text{ GeV}^2$):

CMD-2 $378.6 \pm 2.7_{\text{stat}} \pm 2.3_{\text{syst}}$

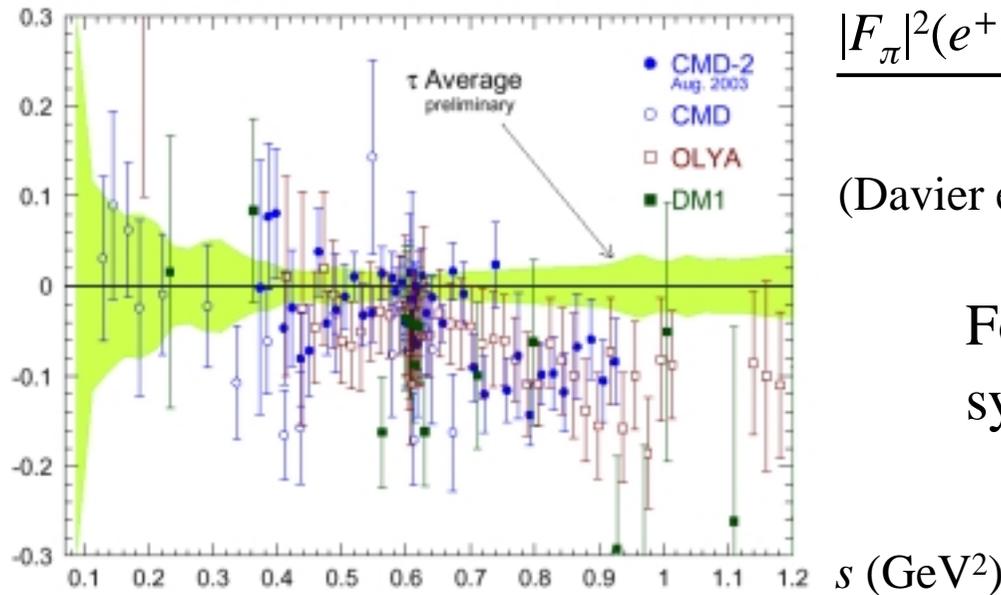
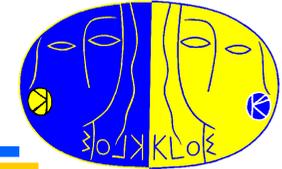
KLOE preliminary $374.1 \pm 1.1_{\text{stat}} \pm 5.2_{\text{syst}} \pm 3.0_{\text{th}} \left(\begin{smallmatrix} +7.5 \\ -0 \end{smallmatrix} \right)_{\text{FSR}}$

In progress: $1.4\% \rightarrow < 1\%$ $2.0\% \rightarrow < 1\%$

Results are compatible given systematic errors

Definitive comparison must await final FSR corrections

Preliminary results for $a_\mu^{\text{had}}: e^+e^-$ vs. τ



$$\frac{|F_\pi|^2(e^+e^-) - |F_\pi|^2(\tau)}{|F_\pi|^2(\tau)}$$

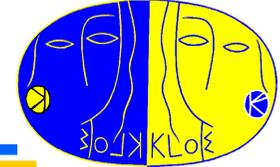
(Davier et al., Aug '03)

For $s > m_\rho^2$, $|F_\pi|^2$ from τ data systematically 10-15% higher

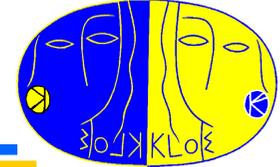
s_π (GeV ²)	$a_\mu^{\pi\pi} \times 10^{10}$ KLOE	$a_\mu^{\pi\pi} \times 10^{10}$ CMD-2
0.37-0.60	256.2 ± 4.1 (+5.1 ₋₀) _{FSR}	256.4 ± 2.5
0.60-0.92	117.9 ± 2.1 (+2.3 ₋₀) _{FSR}	123.3 ± 1.8

KLOE data confirm discrepancy between e^+e^- and τ data for $s > m_\rho^2$
 Point-by-point comparison must await final FSR corrections

Milestones for 2003: reprise



<i>Q1</i>	1. Preparations for IR modifications	100%
<i>Q1-4</i>	2. Maintenance of detector performance at 2002 levels	100%
<i>Q1</i>	3. QCAL upgrade	100%
<i>Q1</i>	4. Upgrades to raw-data filters	80%
<i>Q1</i>	5. Reconstruction of all data	100%
<i>Q1</i>	6. Preparation of DST's for analysis	100%
<i>Q1-4</i>	7. MC production for 2002 analyses	90%
<i>Q2-4</i>	8. BR's and cross section, $\phi \rightarrow K^+ K^-$	70%
<i>Q4</i>	9. Repeat 2002 analyses with full data set	80%



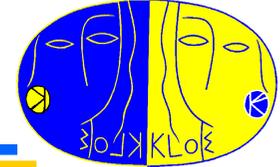
Expected DAΦNE performance

- Luminosity up to $2 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
- Lifetime $> 1 \text{ hr}$ (was 0.6 hr in 2002)
- $10 \text{ pb}^{-1}/\text{day}$, $200 \text{ pb}^{-1}/\text{month}$

DAΦNE run plans (from KLOE perspective)

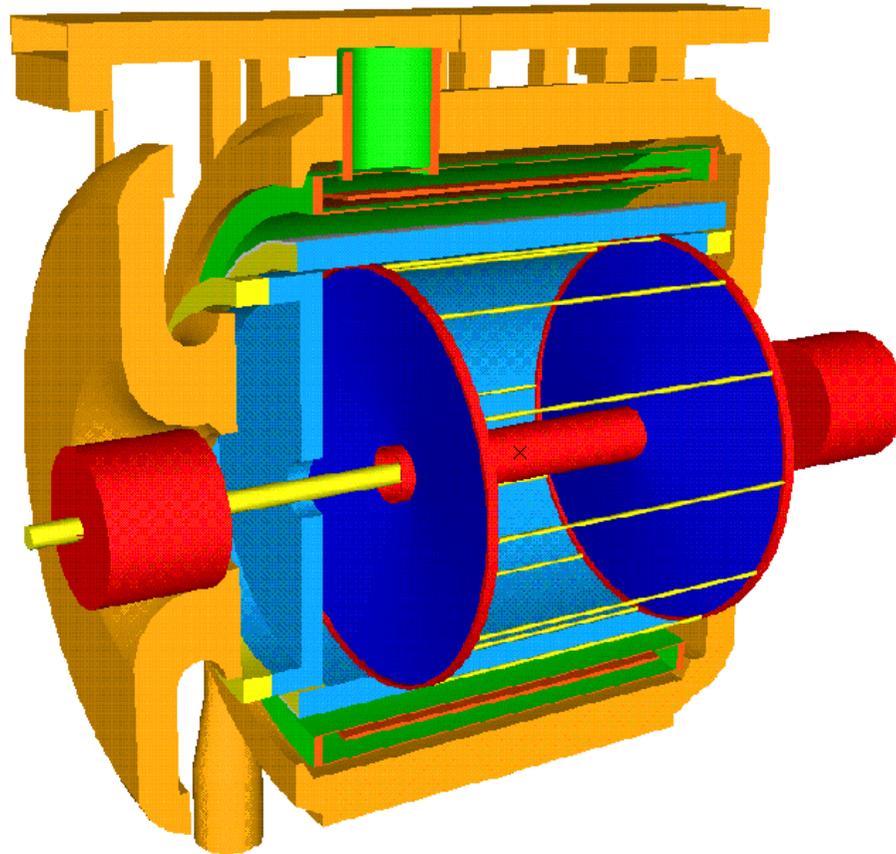
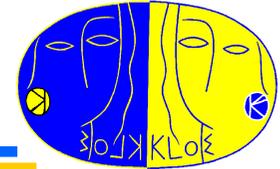
- Start FINUDA data taking A.S.A.P
- 250 pb^{-1} for FINUDA in ~ 2 months
- Realistically restart KLOE towards end of year
- Run **KLOE** for **~ 1 year** with goal of collecting **2 fb^{-1}**

Milestones for 2004

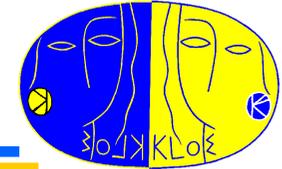


Q1-4	KLOE data taking and maintenance
Q1-4	Online reconstruction, all data
Q1-4	DST production quasi-online
Q2	Installation of new tape library
Q3	Introduction of level-4 filter
Q1-4	MC production for 2003/2004 data set
Q3-4	$BR(K_{e3}^{\pm})$ and V_{us}
Q3-4	Hadronic cross section down to threshold
Q4	$K_S \rightarrow \pi e \nu$ BR and semileptonic asymmetry to 0.4%
Q4	BR's for η, η' decays

Additional information

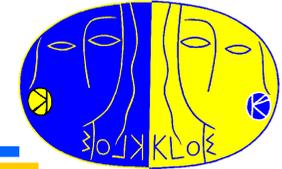


Operations: January-June 2003



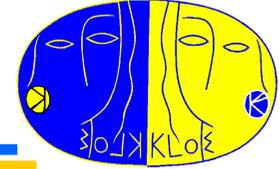
January February	Detector opened DC wire tension measurements DC FEE work: 60 channels repaired Geometrical survey HV boards for EmC repaired
March	IR dismantled Assembly of new IR started
April	DAQ on for tests of DC electronics
May	Gas flowing in DC DC ADC gates widened 2 EmC HV crates fail and are replaced
June	QCAL upgrade complete EmC: 3 PMT's replaced New IR installed DC + IR resurveyed

Operations: July 2003-present



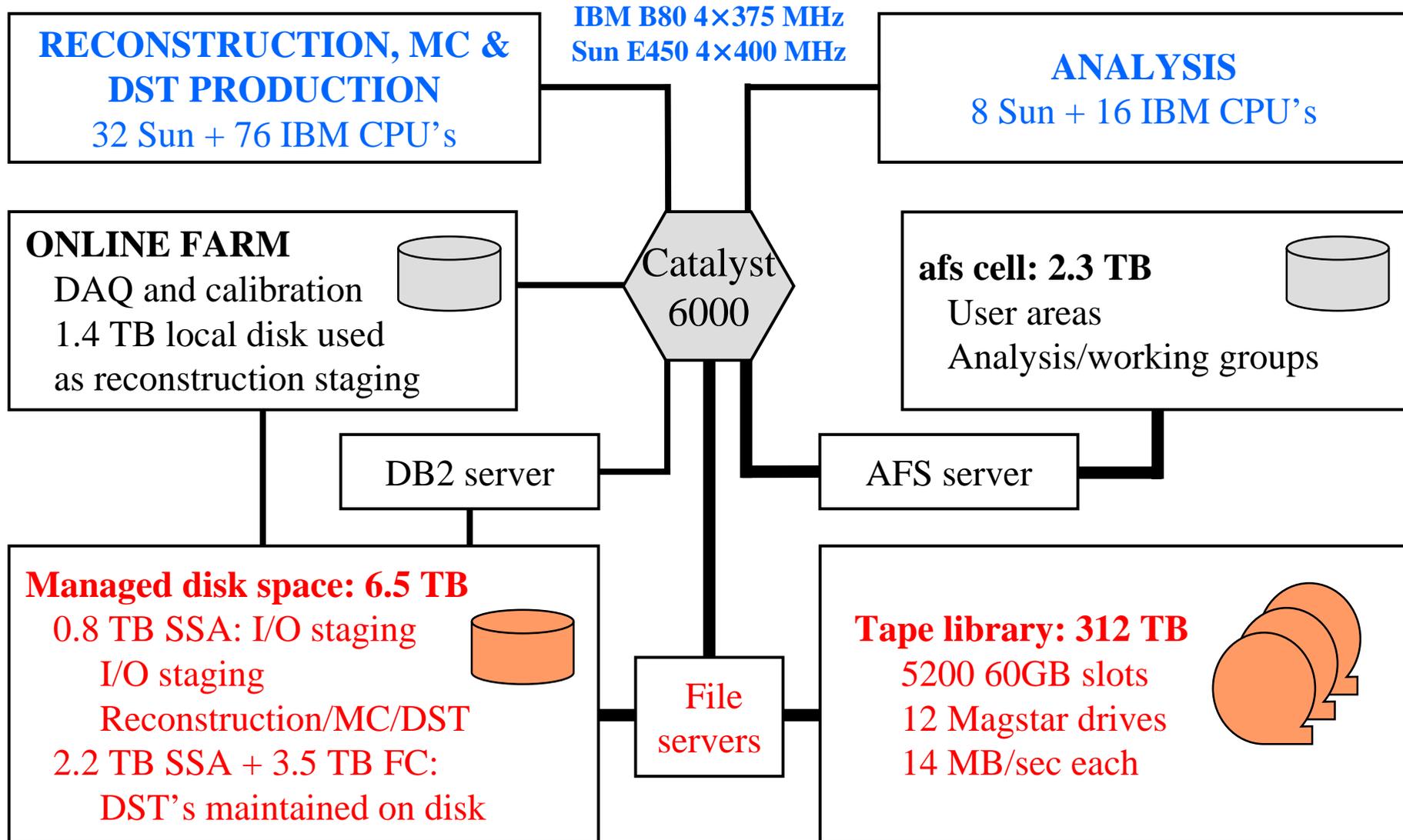
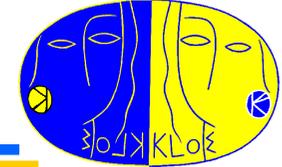
July	<p>Detector closed</p> <p>Field ramp cycles to test for deformations with new IR</p> <p>Final status of DC tested: 86 dead channels (preamps near IR)</p> <p>EmC fully operational: ~1 hr of field-on cosmic-ray data taken</p> <p>Water crisis impedes collection of cosmic-ray data with field on</p> <p>Debugging of cryogenic system after KLOE/FINUDA</p> <p>compensators connected to main He loop</p> <p>No running in sight: DC gas flow interrupted</p>
September	<p>Machine operations starting up</p> <p>KLOE still waiting to take test data with field on</p>

Offline upgrades for 2003

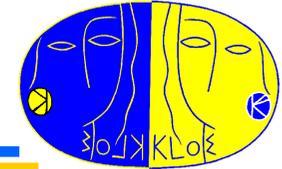


- **12 upgrade kits for Magstar drives in tape library**
 - 40 → 60 GB/cartridge
 - Total capacity 208 → 312 TB (5200 cartridges installed)
- **3.5 TB FiberChannel disk space for DST-access cache**
- **0.5 TB FiberChannel disk space for AFS cell (analysis)**
- **2 GB RAM for DB2 server (run/file database)**

Offline computing resources: 2003



2001-2002 trigger rates



2001 running

Avg. L : $2.1 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

Avg. T2: **2000 Hz**

- 700 Hz cosmic rays
- 500 Hz downscaled CR
- 200 Hz physics
- 600 Hz mach. bkg.

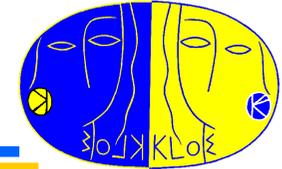
2002 running

Avg. L : $5.4 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

Avg. T3: **1600 Hz**

- 700 Hz cosmic rays
- **0 Hz downscaled CR**
- **500 Hz physics**
- **400 Hz mach. bkg.**

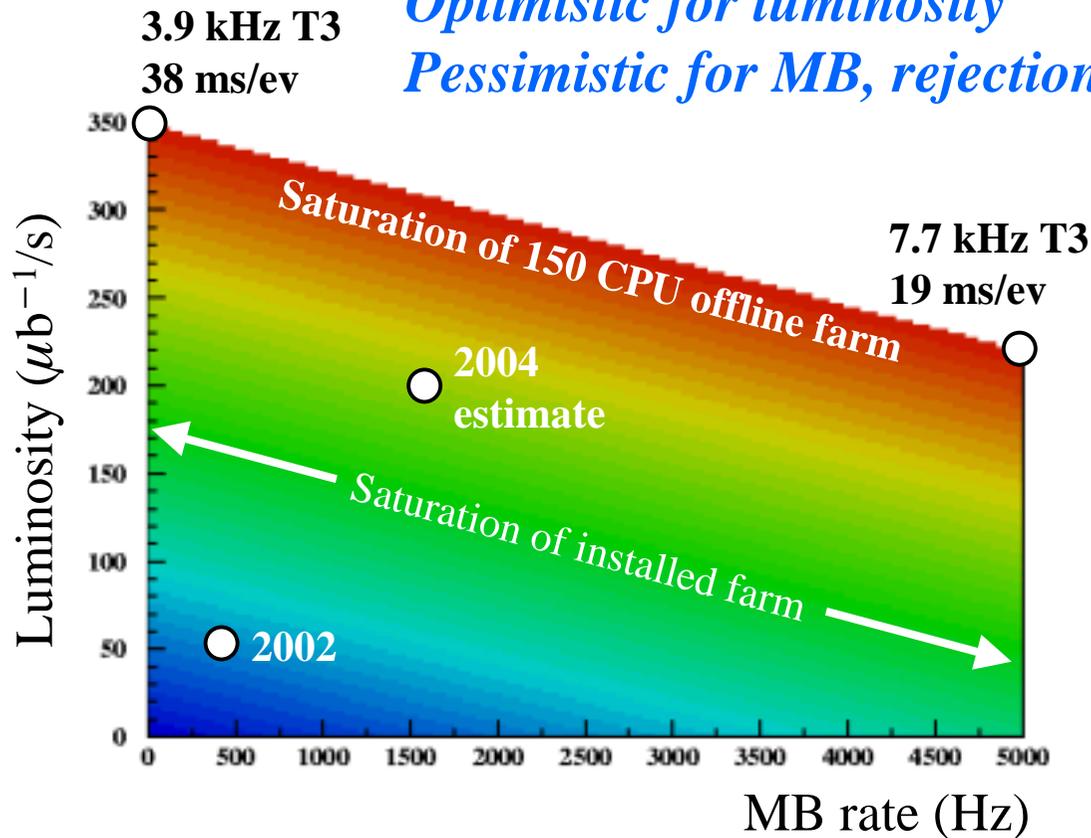
Reconstruction load scenarios



Assumptions: Standard B80 CPU's

- 5 ms/ev overhead
- +41 ms/ev to track ϕ /Bhabha events
- +17 ms/ev to track 50% of MB events

Optimistic for luminosity
Pessimistic for MB, rejection...



2002:

Avg. L : $5.4 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

Avg. T3: 1600 Hz

- 700 Hz cosmic rays
- 500 Hz physics
- 400 Hz MB

Reconstruction time 19 ms/ev

2004 working estimate:

Avg. L : $2.0 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$

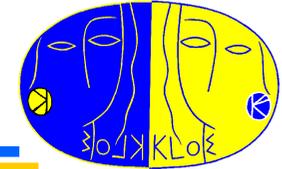
Avg. T3: 4100 Hz

- 700 Hz cosmic rays
- 1800 Hz physics
- 1600 Hz mach. bkg.

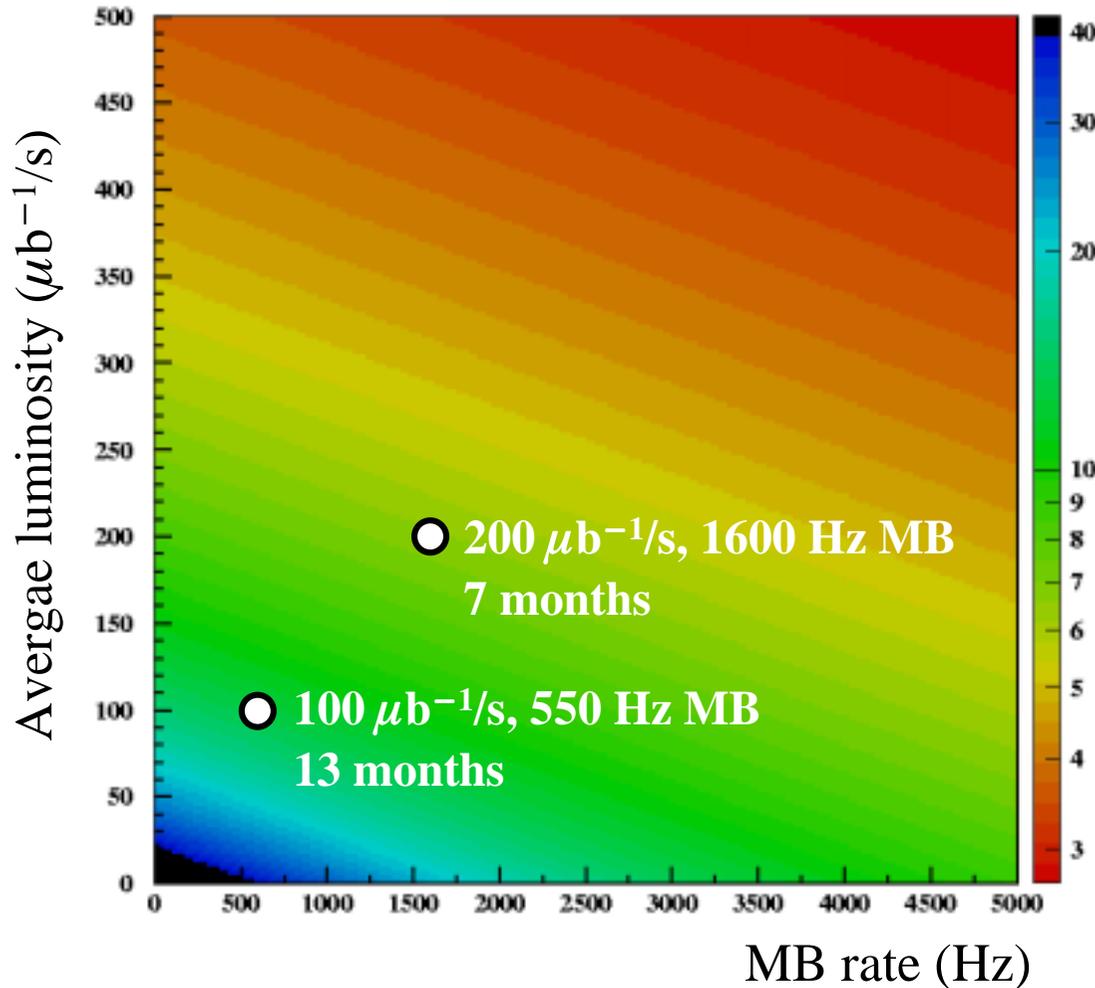
Reconstruction time 25 ms/ev

Load = 68%

Tape library scenarios



Duration of 350 TB library space, months



Raw and reconstructed data
Duration refers to 100% uptime
300+50 TB new+old libraries
80 TB reserved for MC, DST's...

Assumptions:

Current T3 configuration

Current event sizes

- Raw 2.6 KB
- Streamed ϕ decay 12.3 KB
- Streamed Bhabha 9.2 KB

Current event classification

- All ϕ events streamed
- No CR/MB events streamed

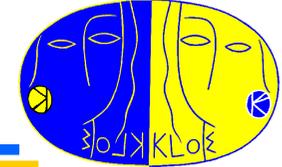
Except:

1:10 for Bhabhas $\theta < 45^\circ$

Optimistic luminosity

Pessimistic MB, rejection...

MC upgrades: detector simulation



DC

Geometry revised
Realistic wire sags from survey implemented
New s - t relations from simulated cosmic rays
Dead wire simulation (map a function of run number)

EmC

Geometry revised
 γ 's from $\pi^+\pi^-\pi^0$ events in data used to calibrate:

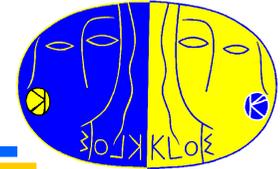
- sampling fraction
- energy response and resolution
- time response and resolution
- position dependence of above

Dead zones at module interfaces simulated
Variations in fiber attenuation length in endcaps simulated

Trigger

Thresholds adjusted in terms of reconstructed EmC/DC hits
Thresholds a function of run number

MC upgrades: event generators



New ϕ decay/ISR generator

Effective \sqrt{s} sampled before ϕ decay channel chosen
 ϕ BR from up-to-date cross-section measurements vs. \sqrt{s}

$K_L \rightarrow K_S$ regeneration updated

Regeneration on Al in DC wall enabled, nuclear recoil treated, angular distributions modified

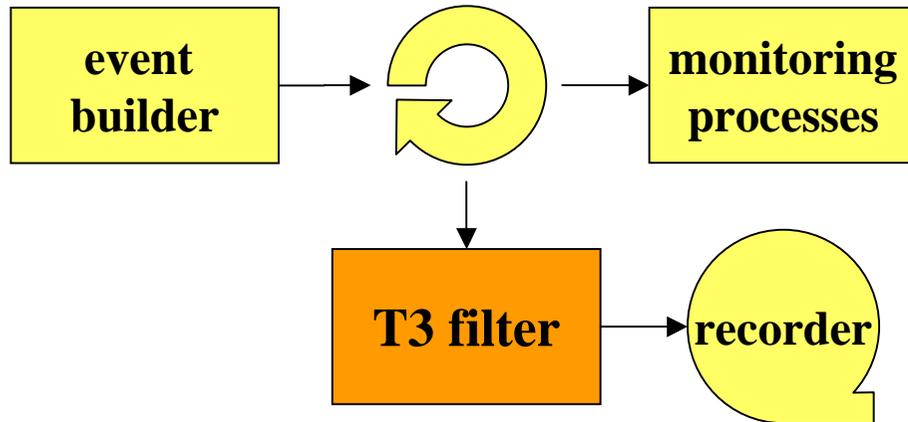
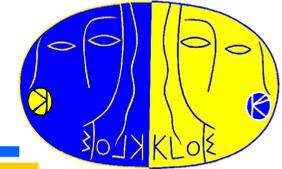
$\omega\pi^0, \eta\gamma, f_0\gamma, a_0\gamma$ generators updated

a_0 and f_0 mass spectra from fits to KLOE 2000 data

New generators for $K_S/K_L \rightarrow \pi^+\pi^-\gamma$ and $\pi^\pm\varepsilon^\mp\nu\gamma$

No cutoff at low E_γ

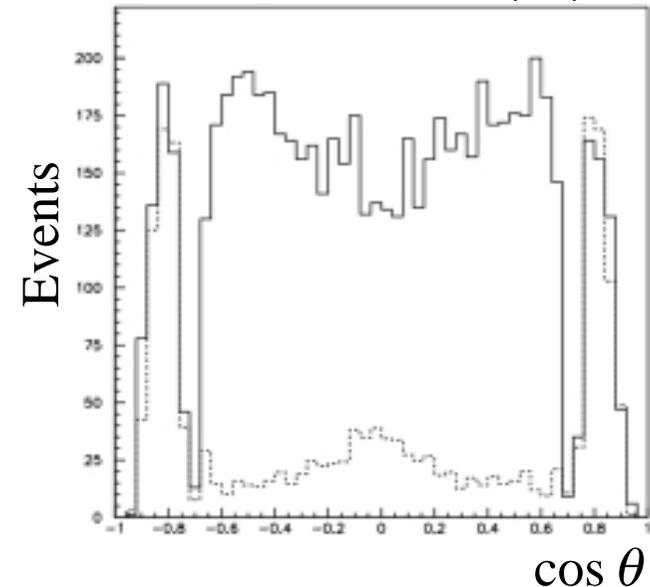
Level-3 DAQ filter



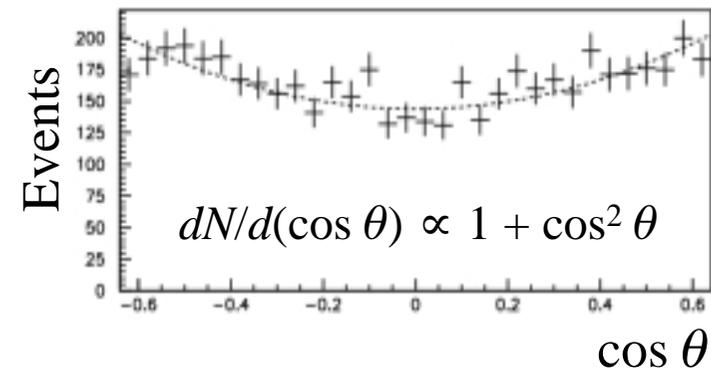
T3 filter installed before recorder to review and enforce cosmic-veto decision

- **Fast clustering**
Veto enforced if $\delta t_{12} = \text{cosmic ray TOF}$
- **Fast tracking on coarse lattice of DC wires**
Veto enforced if no activity near IR
- **Runs on online farm**
Can handle 1.9 KHz cosmic-veto rate

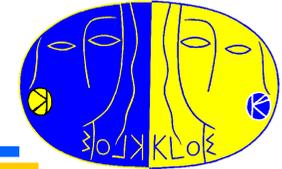
Recovery of $e^+e^- \rightarrow \mu^+\mu^-$



$e^+e^- \rightarrow \mu^+\mu^-$, barrel



Data-summary tapes



As of May, entire KLOE data set (452 pb⁻¹) available as DST's

DST type	Input size (GB)	Output size (GB)	Total time (days)
K^+K^-	5270	2070	50
$K_S K_L$	8900	1350	15
Neutral radiative	2920	130	10
Charged radiative		640	
$\rho\pi$ (80 pb ⁻¹)	250	60	1

Total space: 4.3 TB

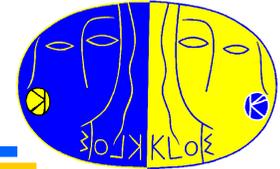
MC DST's add ~1.6 TB



DST disk cache: 5.7 TB

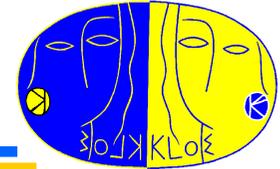
Vast majority of DST's disk-accessed

Kaon physics at KLOE



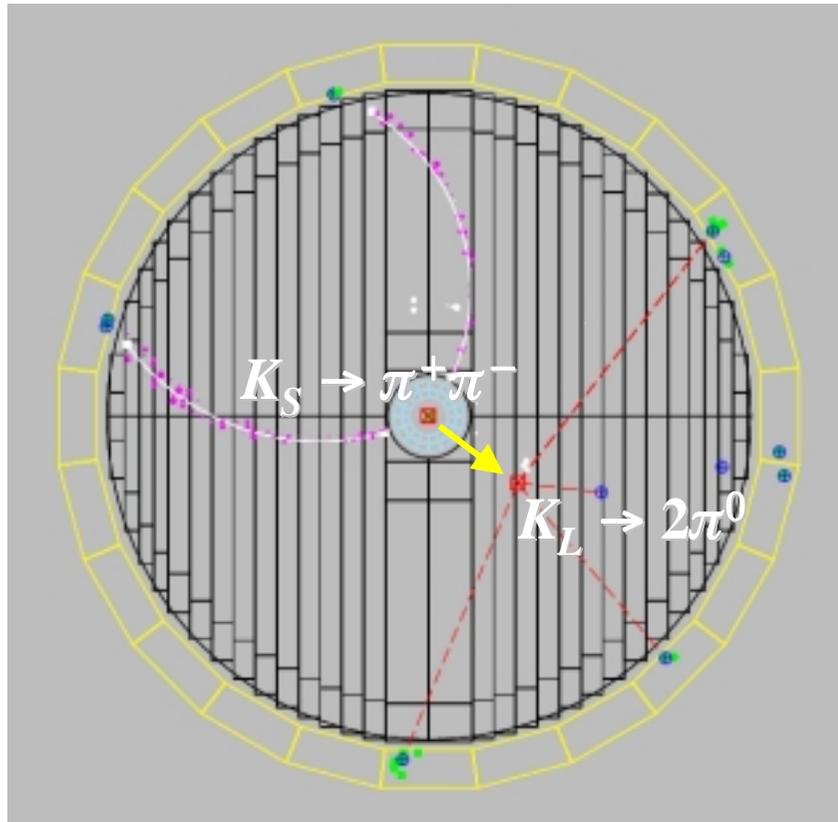
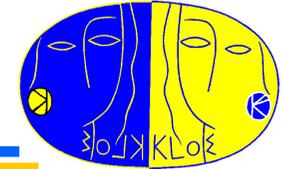
$K_S \rightarrow \pi^+\pi^-(\gamma)$ $K_S \rightarrow \pi^0\pi^0$	<i>Phys. Lett.</i> B538 21 (2002)
$K_S \rightarrow \pi e \nu$	<i>Phys. Lett.</i> B537 21 (2002) Preliminary update with 2001 data
K_S mass	KLOE Note 181 (http://www.lnf.infn.it/kloe)
$K_L \rightarrow \gamma\gamma / K_L \rightarrow 3\pi^0$	<i>Phys. Lett.</i> B566 61 (2003)
$K_L \rightarrow$ charged	Preliminary results
CP violation & interference	Prospects & preliminary results
$K^\pm \rightarrow \pi^\pm\pi^0\pi^0$	hep-ex/0307054, submitted to EPS'03, LP'03
$K^\pm \rightarrow \pi^0\pi^0 e^\pm \nu$	Preliminary results
V_{us}	Prospects & preliminary results

Hadronic physics at KLOE

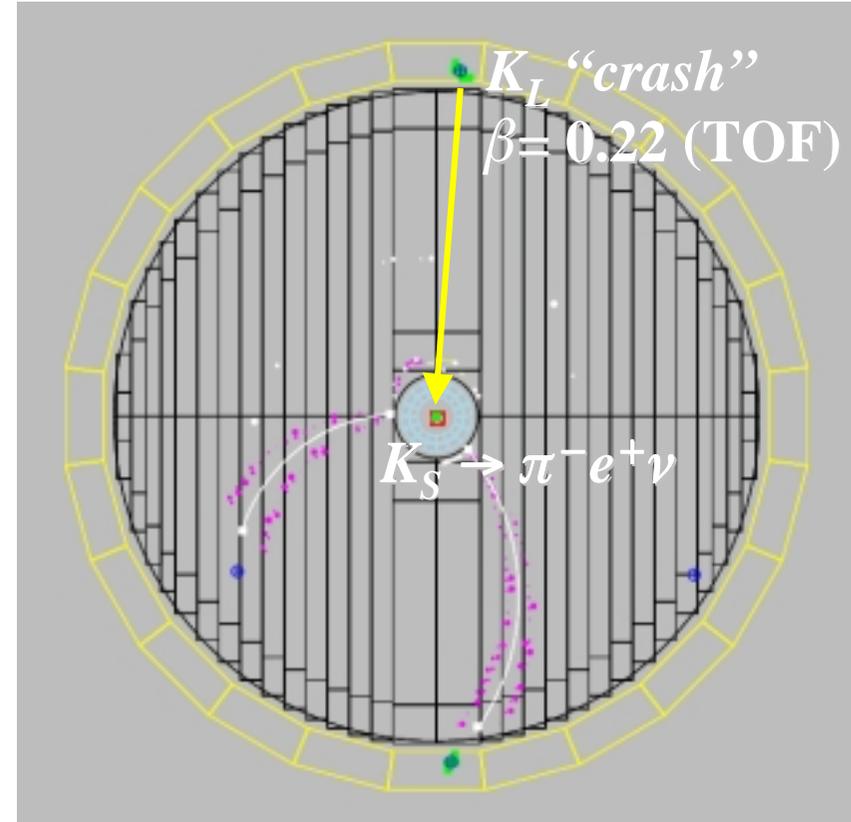


ϕ meson parameters	Preliminary results
$\phi \rightarrow \pi^+\pi^-\pi^0$	<i>Phys. Lett.</i> B561 55 (2003)
$\eta \rightarrow \pi^+\pi^-\pi^0$	Preliminary results
$\eta \rightarrow 3\gamma$	hep-ex/0307042 submitted to EPS'03, LP'03
$\phi \rightarrow \eta'\gamma$	<i>Phys. Lett.</i> B541 45 (2002) Preliminary update with 2001 data
$\phi \rightarrow f_0\gamma, a_0\gamma$	<i>Phys. Lett.</i> B536 209 (2002), B537 21 (2002) Preliminary update with 2001 data
$\sigma(e^+e^- \rightarrow \text{hadrons})$	hep-ex/0307051 submitted to EPS'03, LP'03

Tagged K_L and K_S “beams”

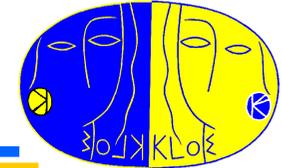


K_L tagged by $K_S \rightarrow \pi^+\pi^-$ vertex at IP
Efficiency $\sim 70\%$ (mainly geometrical)
 K_L angular resolution: $\sim 1^\circ$
 K_L momentum resolution: ~ 2 MeV



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

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

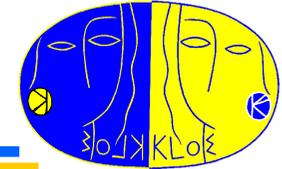
KLOE '02 value for **$(48 \pm 3)^\circ$**
 $\Gamma(\pi^+\pi^-)/\Gamma(\pi^0\pi^0)$

$(47.7 \pm 1.5)^\circ$

$\pi\pi$ scattering

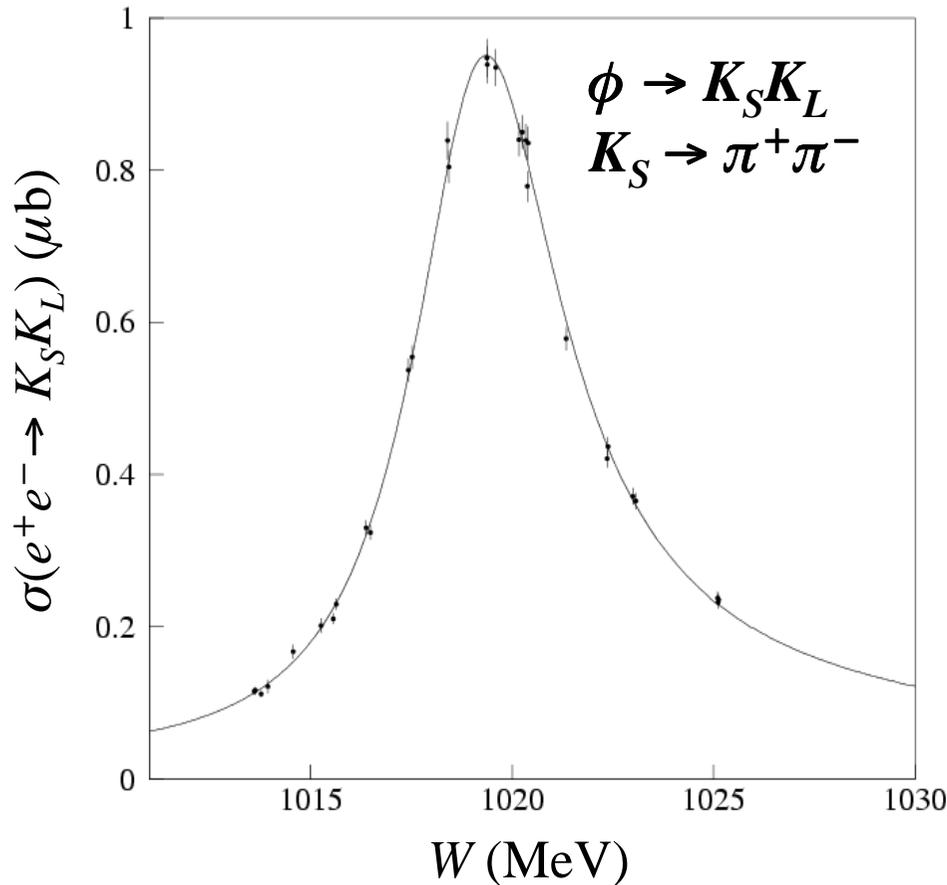
Colangelo et al. '01

Measurement of K_S mass



2001 ϕ peak scan: 29 pts, 0.5 pb^{-1}

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



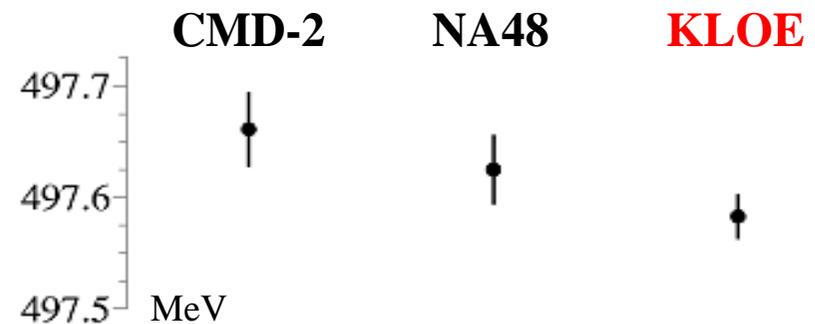
$$W = M(e^+ e^-)$$

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

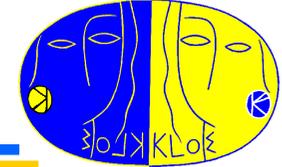
$$m(K_S) = W^2/4 - P^2$$

$$\delta m/m \approx 0.05(\delta P/P)$$

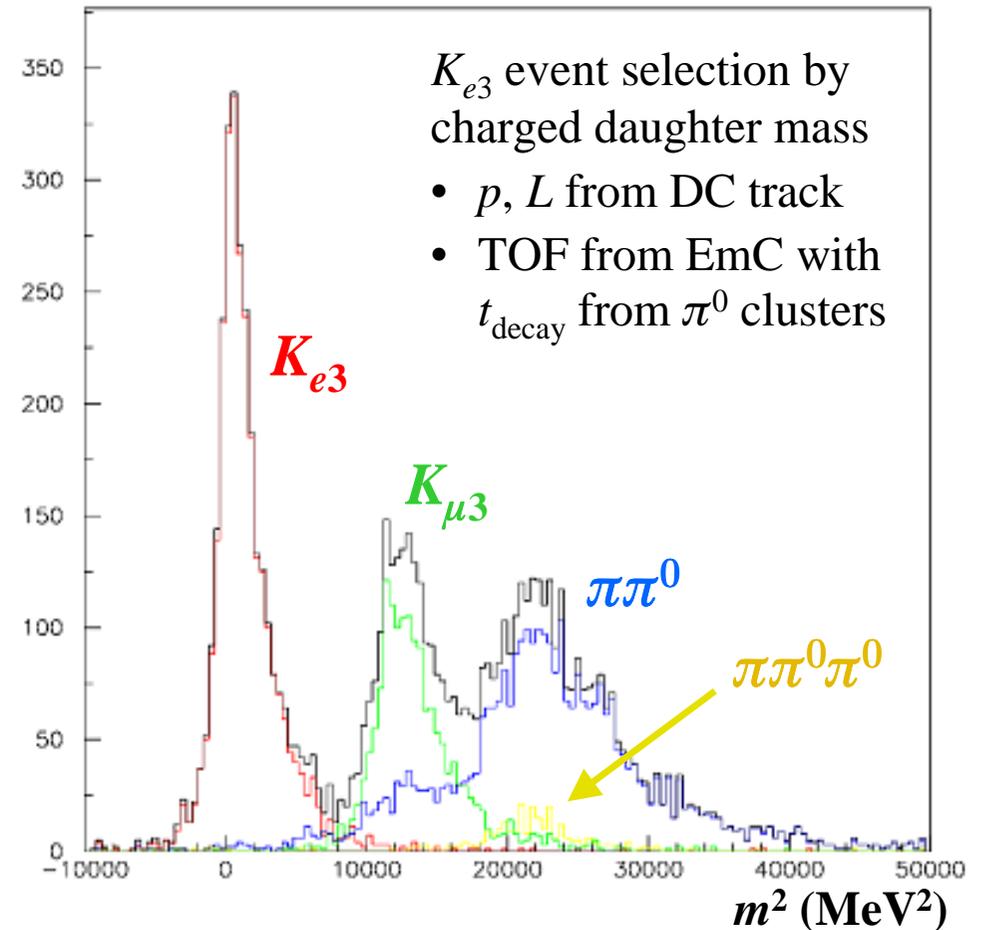
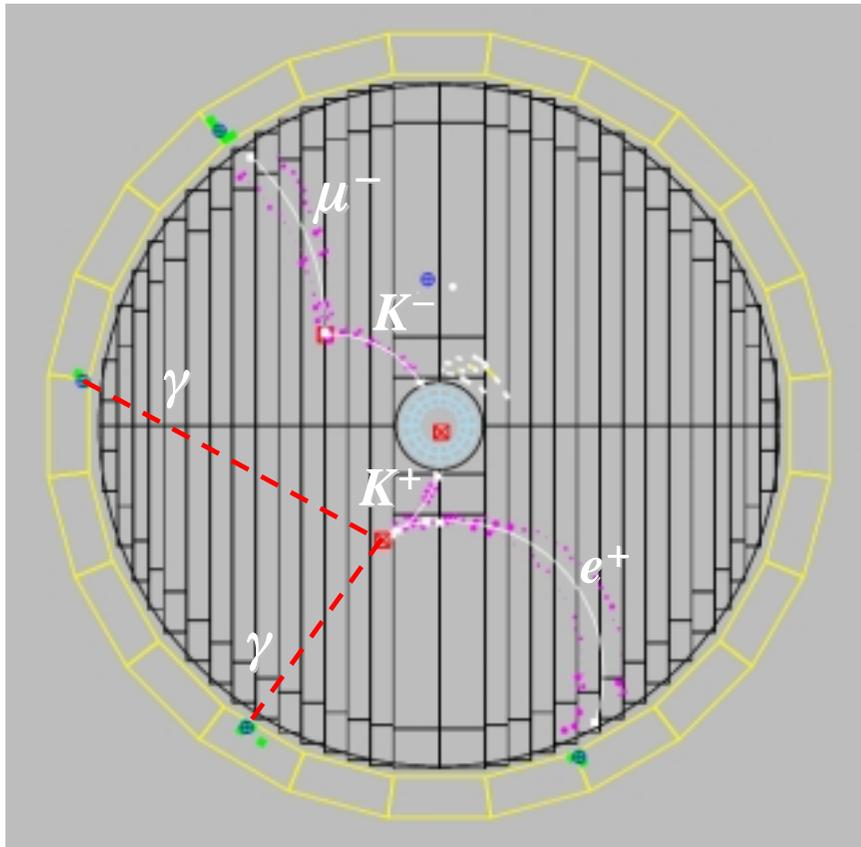
$m(K_S)$ KLOE preliminary
 $497.583 \pm 0.005 \pm 0.020 \text{ MeV}$
KLOE Note 181



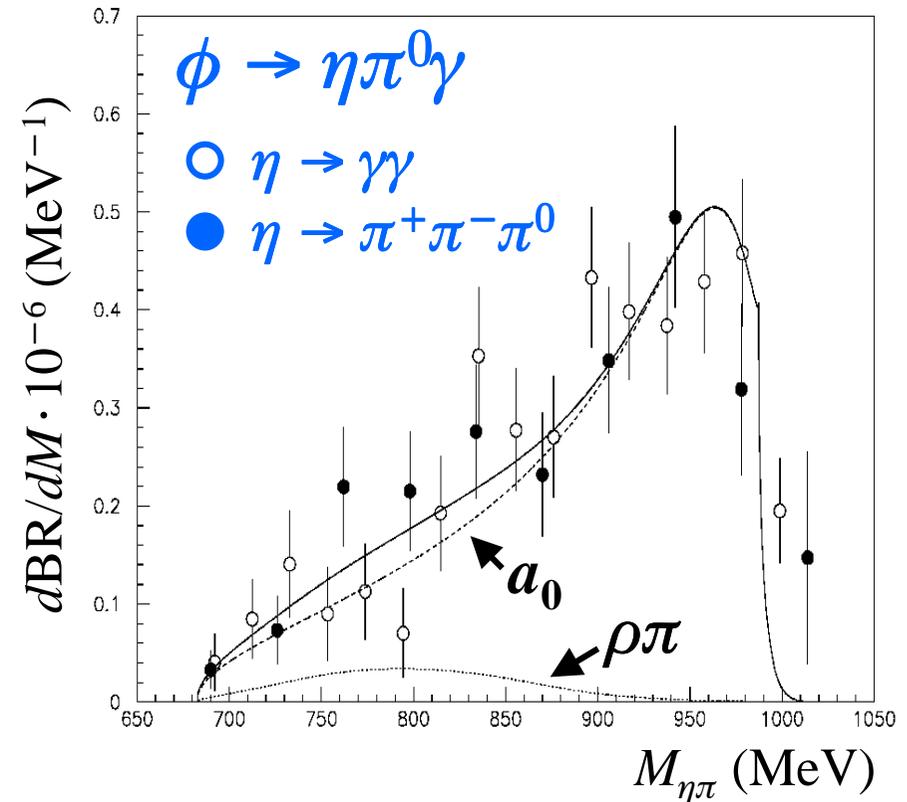
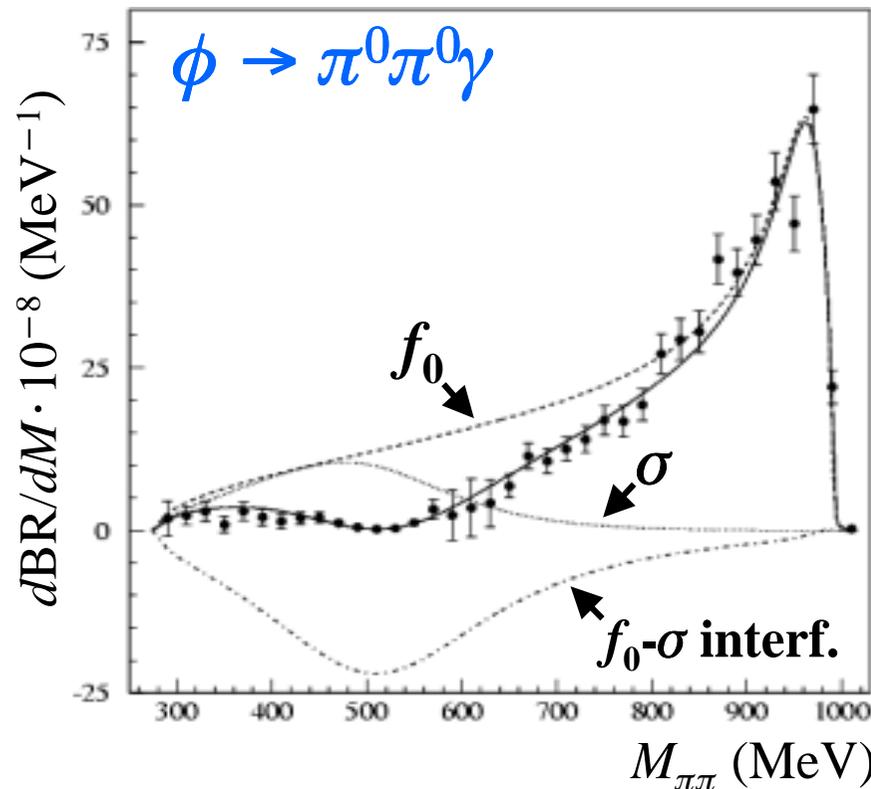
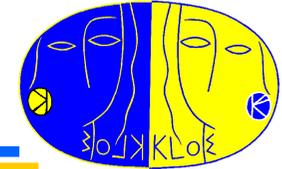
Charged kaon decays



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



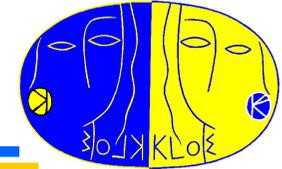
$\phi \rightarrow \pi^0\pi^0\gamma, \eta\pi^0\gamma$: mass spectra



Kaon-loop model for $\phi \rightarrow S\gamma$
 $\rho\pi$ contribution (VMD)
 Pointlike σ contribution for f_0

f_0 parameters compatible with $4q$ model
 a_0 parameters not well described

Systematic errors for a_μ^{had}



Theory	0.8%
Radiator function (H)	0.5%
Vacuum polarization	0.1%
Luminosity	0.6%
FSR corrections	2.0%
Experiment	1.4%
Acceptance	0.3%
Trigger efficiency	0.2%
Tracking efficiency	0.3%
Vertexing efficiency	1.0%
π/e identification	0.1%
Track mass cut	0.2%
Background subtraction	0.5%
Unfolding	0.6%