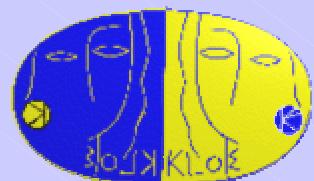


# KLOE perspectives in $K_{l3}$ decays

Workshop on the CKM Unitarity Triangle

13-16 February 2002

- ⇒ Contributions to  $\Delta V_{us}$
- ⇒ Experimental status of K semileptonic decays
- ⇒ KLOE perspectives on  $K_{l3}$  decays
- ⇒ Conclusions and Outlook



# $V_{us}$ from $K_{l3}$ decays

$$\Gamma(K_{e3}) = \frac{G_F^2 m_K^5}{192\pi^3} C_K^2 |V_{us}|^2 |f_+^{K\pi}(0)|^2 I_K(m_K^2, m_\pi^2, m_\ell^2, \tilde{f}_+^{K\pi}(q^2))$$

$\Rightarrow V_{us} = 0.2196 \pm 0.0023$

$$\tau_{K^+} = (1.2386 \pm 0.0024) \cdot 10^{-8} \text{ sec}$$

$\Rightarrow$  Observable:  $|V_{us}| |f_+(0)|$

$$\frac{\Delta \tau_+}{\tau_+} = 0.2\%$$

3 M

$\Rightarrow$  Measurement of:  $\Gamma(K_{l3}) = BR(K_{l3})/\tau_K$

$$\tau_{K_L} = (5.15 \pm 0.04) \cdot 10^{-8} \text{ sec}$$

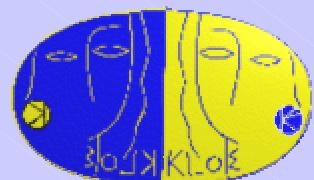
$\Rightarrow$  Measurement of the evolution of form factors:

$$\frac{\Delta \tau_L}{\tau_L} = 0.8\%$$

400 k

$$f_x^{K\pi}(q^2) = f_x^{K\pi}(0) \cdot \left( 1 + \frac{\lambda_+^{K\pi}}{m_\pi^2} q^2 \right)$$

$\Rightarrow$  Knowledge, provided by theory, of the form factors at  $q^2=0$ :  $|f_+(0)|$



# Experimental status of $K^0_{e3}$ decays

$$BR_{K^0_{e3}} = (38.78 \pm 0.28)\%$$

$$\frac{\Delta BR}{BR} = 0.7\%$$

No direct measurement

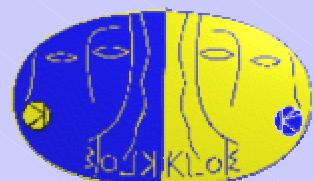
$$\lambda_+^{K^0_{e3}} = 0.0288 \pm 0.0015$$

$$\frac{\Delta \lambda}{\lambda} = 5\%$$

365 k

$$0.0245 \pm 0.0012_{stat} \pm 0.0022_{syst}$$

A. Apostolakis *et al.*, Phys. Lett. B473, 186 (2000) (CPLEAR)



# Experimental status of $K^0_{\mu 3}$ decays

$$BR_{K^0_{\mu 3}} = (27.18 \pm 0.25)\%$$

$$\frac{\Delta BR}{BR} = 1.3\%$$

No direct measurement

$$\lambda_+^{K^0_{\mu 3}} = 0.034 \pm 0.005$$

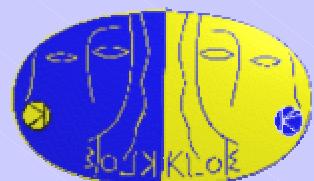
$$\frac{\Delta \lambda}{\lambda} = 15\%$$

10k - 1.6M

$$\lambda_0^{K^0_{\mu 3}} = 0.025 \pm 0.006$$

$$\frac{\Delta \lambda}{\lambda} = 24\%$$

10k - 1.6M



# Experimental status of $K_{e3}^+$ decays

$$BR_{K_{e3}^+} = (4.85 \pm 0.09)\%$$

$$\frac{\Delta BR}{BR} = 1.8\%$$

3516

$$(4.86 \pm 0.08_{stat} \pm 0.06_{syst})\%$$

$E_\gamma^{cut} \approx 50$  MeV  
(Chiang '72)

$$\lambda_+^{K_{e3}^+} = 0.0278 \pm 0.0019$$

$$\frac{\Delta \lambda}{\lambda} = 6.8\%$$

$$0.0293 \pm 0.0015_{stat} \pm 0.002_{syst}$$

130 k

(ISTRAP+)

$$0.0278 \pm 0.0017_{stat} \pm 0.0015_{syst}$$

100 k

(KEK-E246)

I. V. Ajinenko *et al.*, hep-ph/0112023 (2001)

A. S. Levchenko, *et al.*, hep-ph/0111048 (2001)

F.Bossi L.Passalacqua B.Sciascia

Workshop on the CKM Unitarity Triangle-CERN 13Feb2002

# Experimental status of $K^+ \mu_3$ decays

$$BR_{K_{\mu 3}^+} = (3.18 \pm 0.08)\%$$

$$\frac{\Delta BR}{BR} = 2.5\%$$

2345

$E_\gamma^{\text{cut}} \approx 50 \text{ MeV}$   
(Chiang '72)

$$(3.33 \pm 0.07_{\text{stat}} \pm 0.14_{\text{syst}})\%$$

$$\lambda_+^{K_{\mu 3}^0} = 0.031 \pm 0.008$$

$$\frac{\Delta \lambda}{\lambda} = 25\%$$

112 k

$$0.0321 \pm 0.004_{\text{stat}} \pm 0.002_{\text{syst}} \quad (\text{ISTRAP})$$

$$\lambda_0^{K_{\mu 3}^0} = 0.006 \pm 0.007$$

$$\frac{\Delta \lambda}{\lambda} = 24\%$$

$$0.0209 \pm 0.004_{\text{stat}} \pm 0.002_{\text{syst}} \quad (\text{ISTRAP})$$

$$0.022 \pm 0.005_{\text{stat}} \pm 0.004_{\text{syst}} \quad (\text{KEK-E246})$$

I. V. Ajinenko *et al.*, hep-ph/0202061 (2002)

A. S. Levchenko, *et al.*, hep-ph/0106006 (2001)

F.Bossi L.Passalacqua B.Sciascia

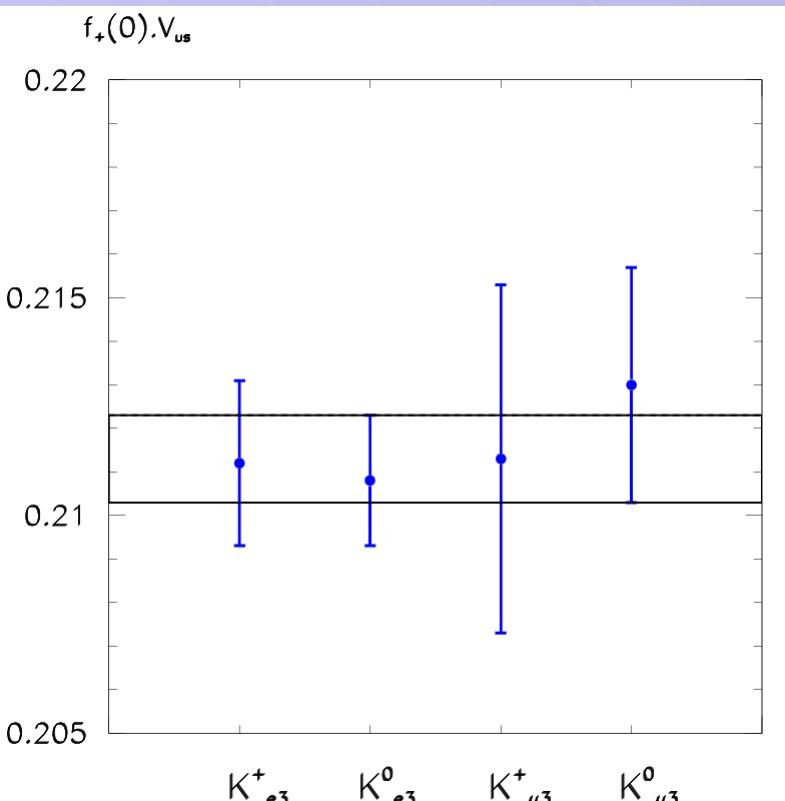
Workshop on the CKM Unitarity Triangle-CERN 13Feb2002

41 k

6

# $V_{us}$ with $K^+_{e3}$ decays

$$\Gamma(K^\pm \rightarrow \pi^0 e^\pm \nu) = \frac{BR(K_{e3}^\pm)}{\tau(K^+)} = \frac{1}{384\pi^3} G_\mu^2 m_K^5 |V_{us}|^2 |f_+(0)|^2 \cdot I \cdot (1 + \delta_{RC}).$$

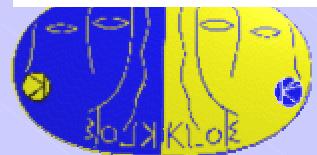


$$f_+(0) = 0.9874 \pm 0.0084$$

$$\frac{\Delta|V_{us}|}{|V_{us}|} = 0.5 \left( \frac{\Delta BR_{K_{e3}}}{BR_{K_{e3}}} \pm \frac{\Delta \tau_+}{\tau_+} \right) \pm 0.05 \frac{\Delta \lambda_+}{\lambda_+} \pm \frac{\Delta f_+(0)}{f_+(0)}$$

$$\frac{\Delta|V_{us}|}{|V_{us}|} = 0.59\% \pm 0.37\% \pm 0.86\%$$

G. Calderón and G. López Castro, hep-ph/0111272 (2001)



# $V_{us}$ with $K^+ e_3$ decays (new)

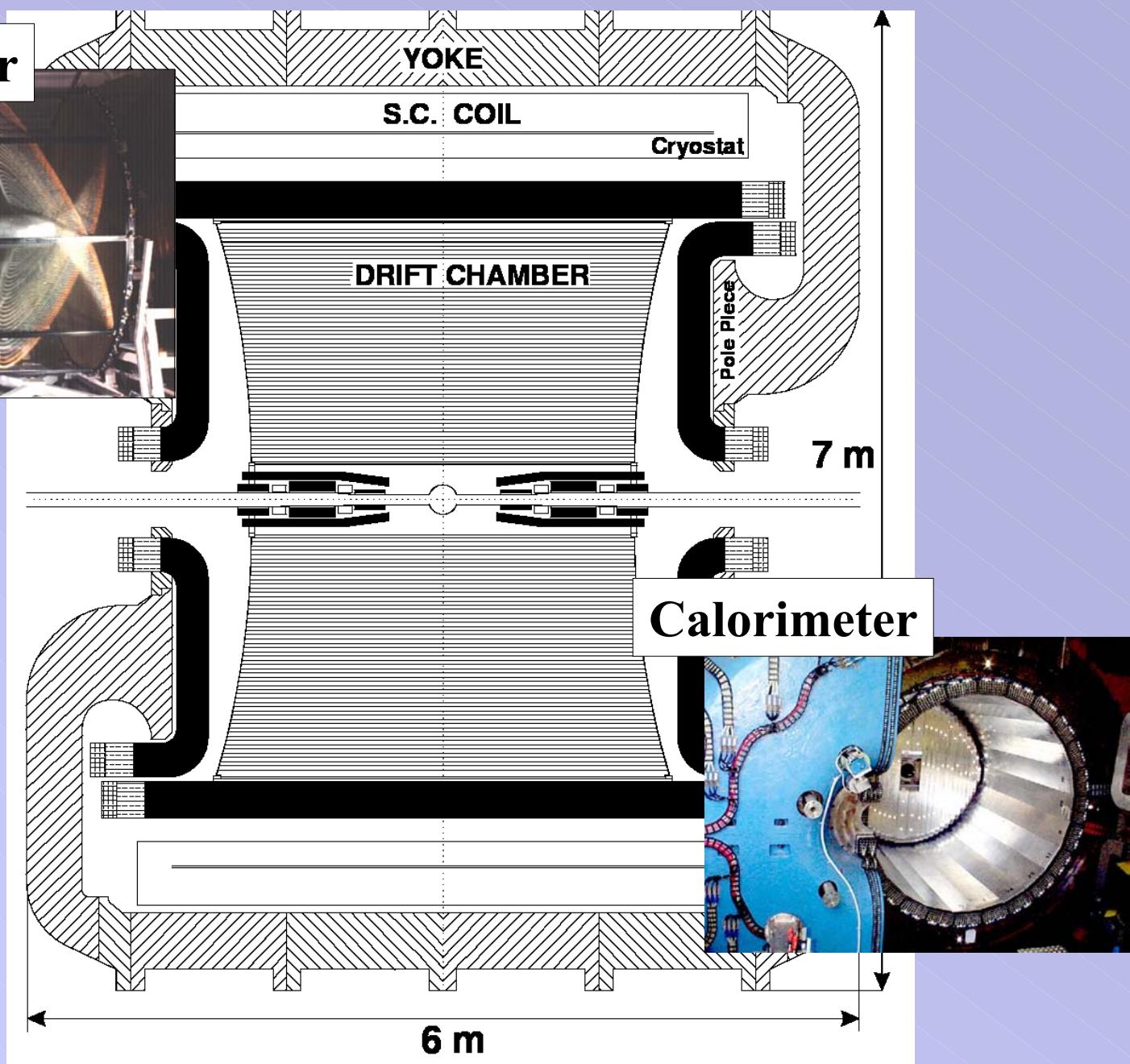
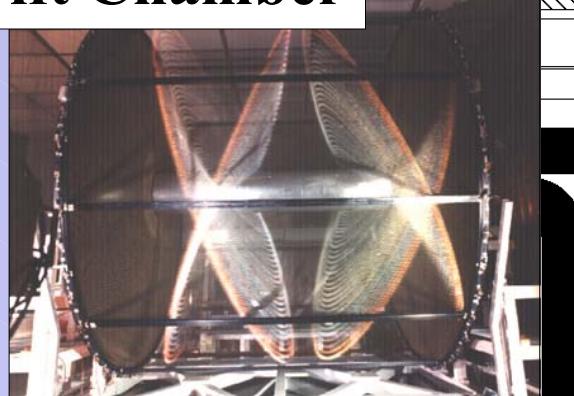
$\frac{\Delta BR}{BR}(\%)$	$\frac{\Delta \tau}{\tau}(\%)$	$\frac{\Delta \Gamma}{\Gamma}(\%)$	$\frac{\Delta \lambda_+}{\lambda_+}(\%)$	$\frac{\Delta \lambda_0}{\lambda_0}(\%)$
$K^+_e{}^3$				
1.2	0.2	1.22	4.5	-
$K^+_{\mu}{}^3$				
2.5	0.2	2.5	12.2	19.7
$K^0_{e}{}^3$				
0.7	0.8	1.06	4.7	-
$K^0_{\mu}{}^3$				
0.9	0.8	1.20	14.7	24.0

$$\frac{\Delta |V_{us}|}{|V_{us}|} = 0.59\% \pm 0.22\% \pm 0.86\%$$



# The KLOE detector

## Drift Chamber



F.Bossi L.Passalacqua B.Sciascia

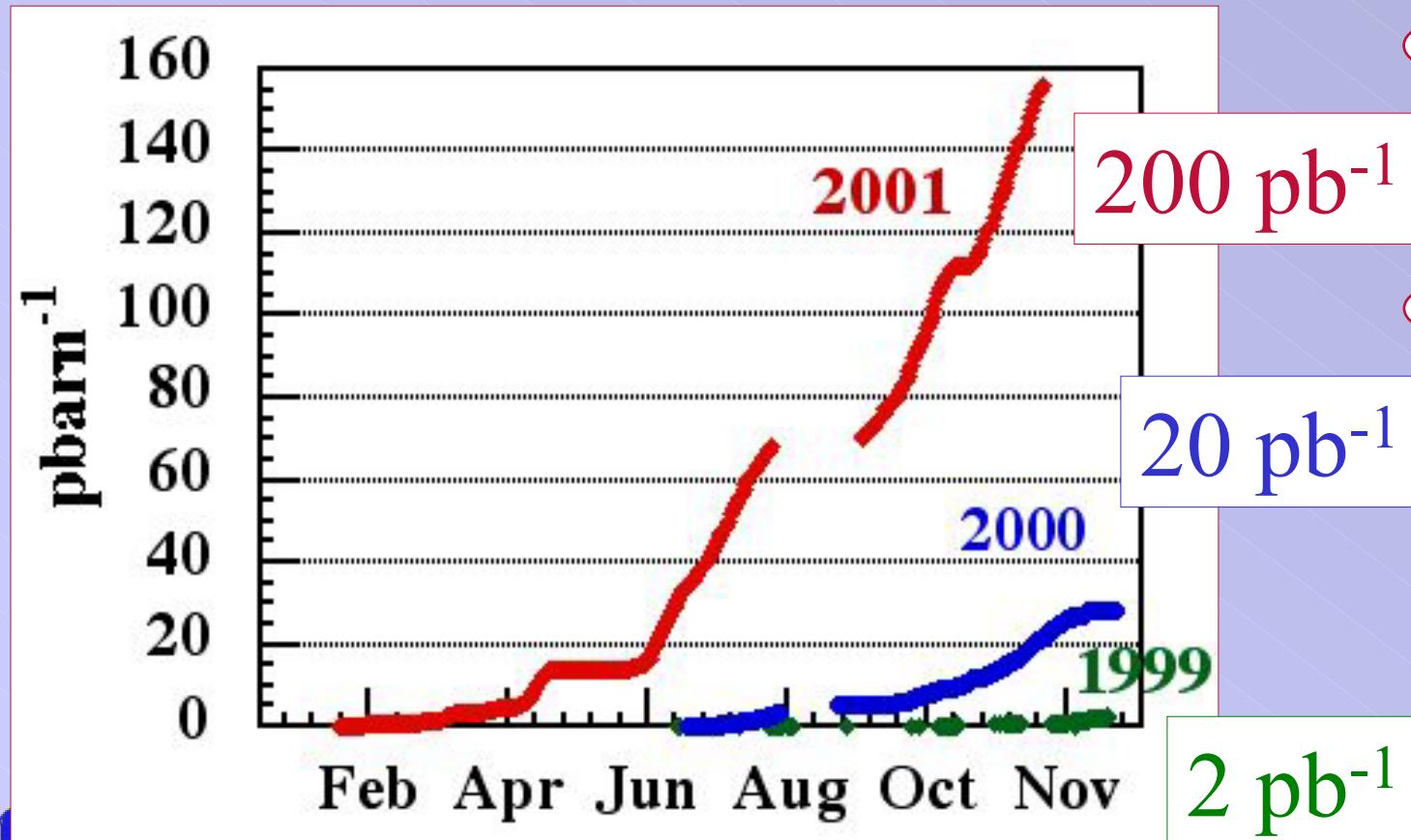
Workshop on the CKM Unitarity Triangle-CERN 13Feb2002



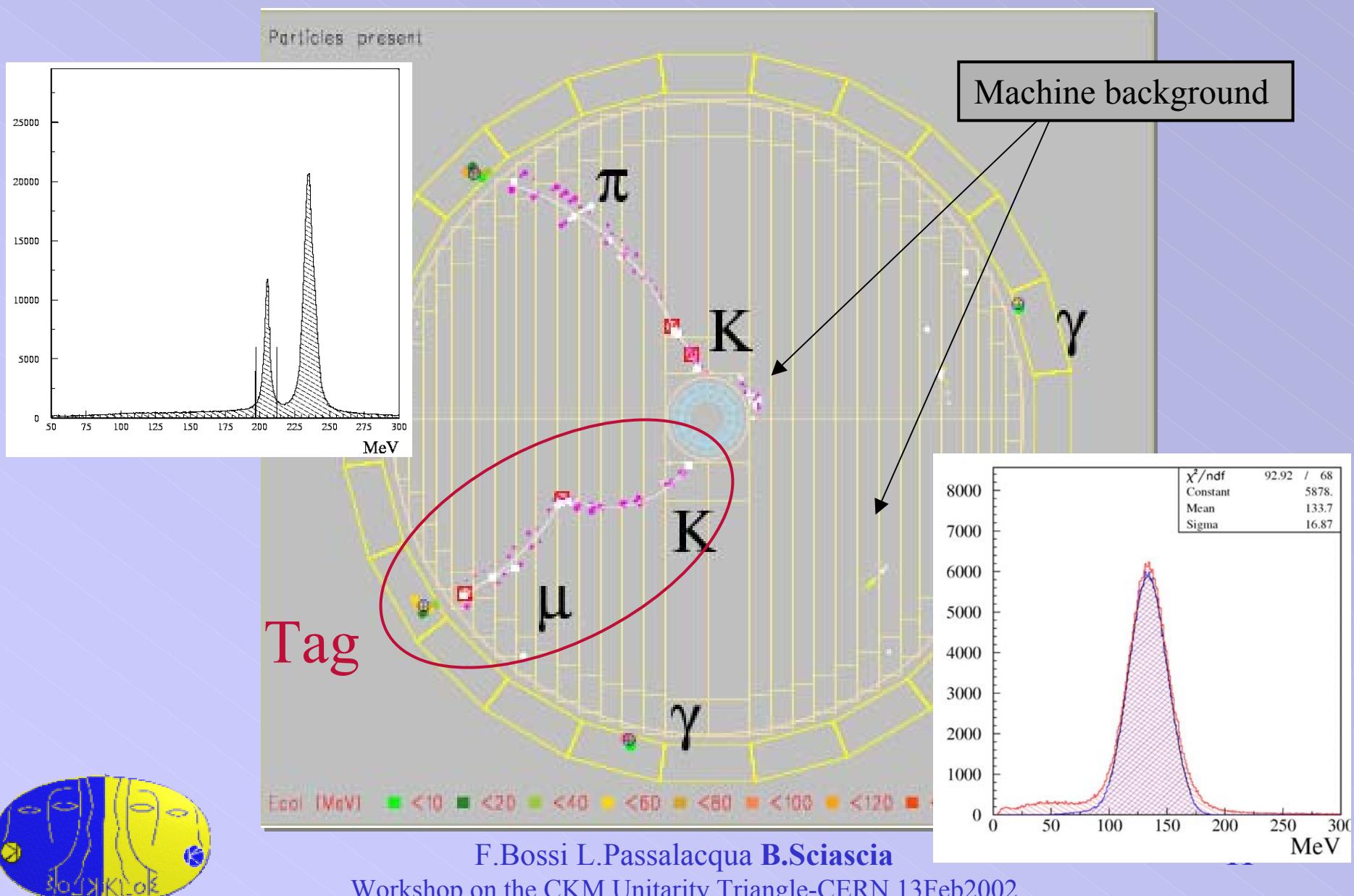
# KLOE data taking

2002:  
 $\geq 200 \text{ pb}^{-1}$  more

$$\sigma(e^+e^- \rightarrow \phi) \cong 3 \mu\text{b} \quad \left\{ \begin{array}{l} 1.5 \times 10^6 K^+K^- \text{ per } pb^{-1} \\ 10^6 K_L K_S \text{ per } pb^{-1} \end{array} \right.$$



# Tagging



# Tagging efficiency

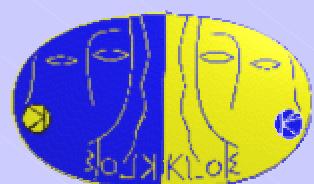
⇒ Tagging decays ( $K \rightarrow \mu\nu$ ,  $K \rightarrow \pi\pi^0$ ) selected using only Drift Chamber information.

$$\Rightarrow \mathcal{E}_{\mu\nu}^{TAG} \approx \mathcal{E}_{\pi\pi^0}^{TAG}$$

⇒ From MC:  $\mathcal{E}_{\mu\nu}^{TAG} \approx 55\%$

⇒  $\mathcal{E}_{\mu\nu}^{TAG}$  can be estimated directly from Data using the redundant calorimetric information ( $N_\gamma=0$ )

$$\Rightarrow 200 \text{ pb}^{-1} \Rightarrow \frac{\Delta \mathcal{E}_{TAG}}{\mathcal{E}_{TAG}} \propto \frac{1}{\sqrt{N_{\mu\nu}}} \approx 0.1\%$$



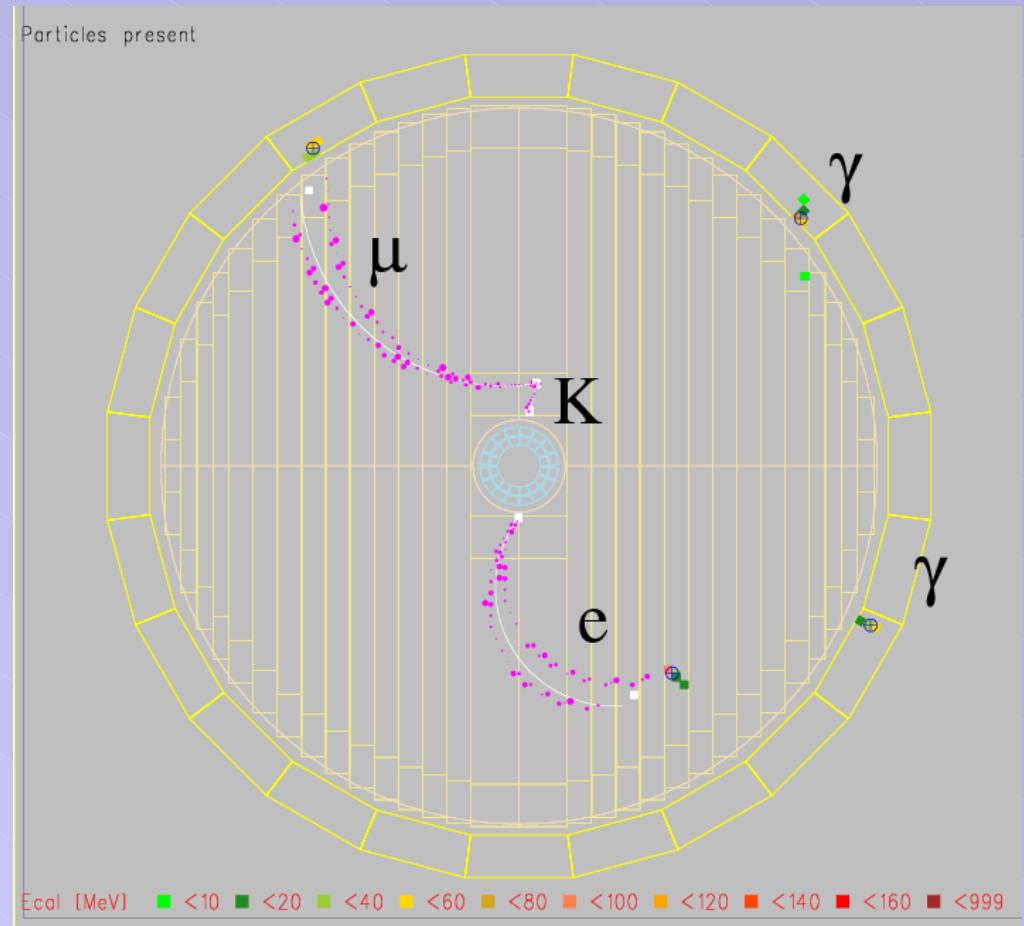
# Signal selection

- ⇒ Tag on one side
- ⇒ Vertex in DC
- ⇒ ToF selection
- ⇒  $\pi^0$  in EMC

20 pb<sup>-1</sup>

	$K_{e3}^\pm$ (yield)	$\varepsilon_{sele}(K_{e3}^\pm)(\%)$
$K_\mu^\pm$ TAC	21 662	$34.4 \pm 0.6$
$K_{\pi\pi^0}^\pm$ TAC	3 872	$32.7 \pm 1.3$

Preliminary

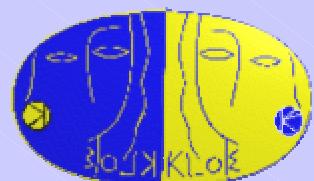


$$N_{K_{e3}^\pm} \approx 2000/\text{pb}^{-1} \Rightarrow 0.4 \times 10^6$$

F.Bossi L.Passalacqua B.Sciascia

Workshop on the CKM Unitarity Triangle-CERN 13Feb2002

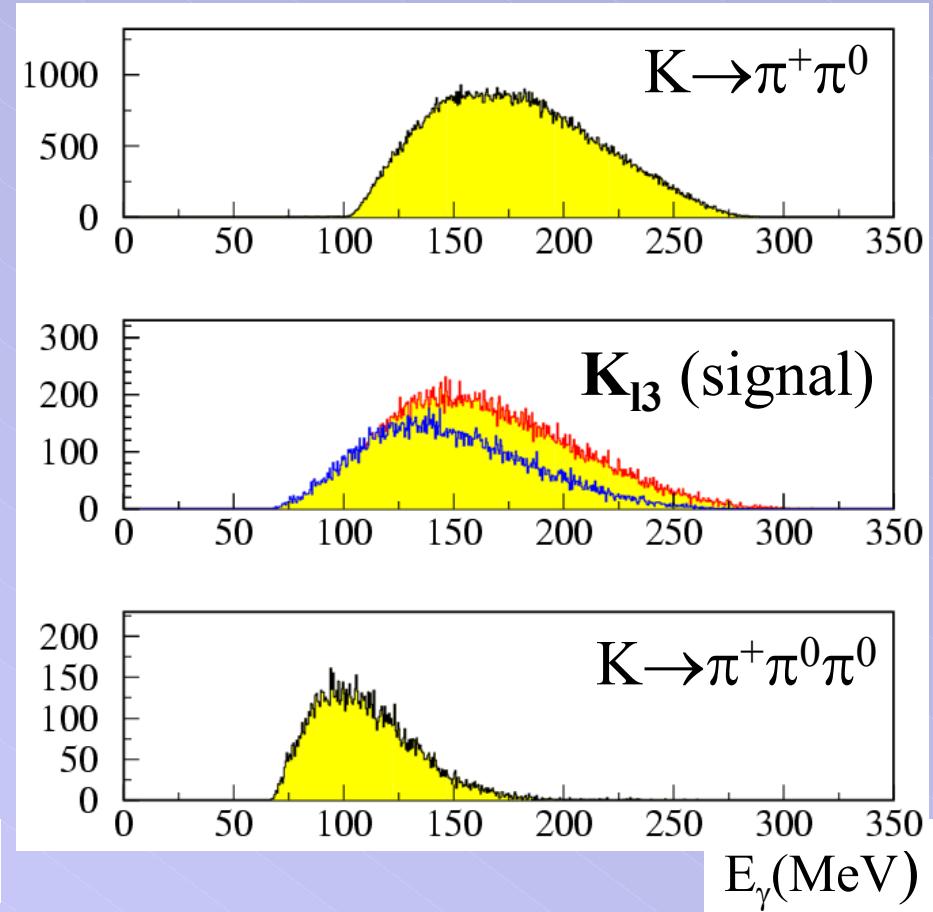
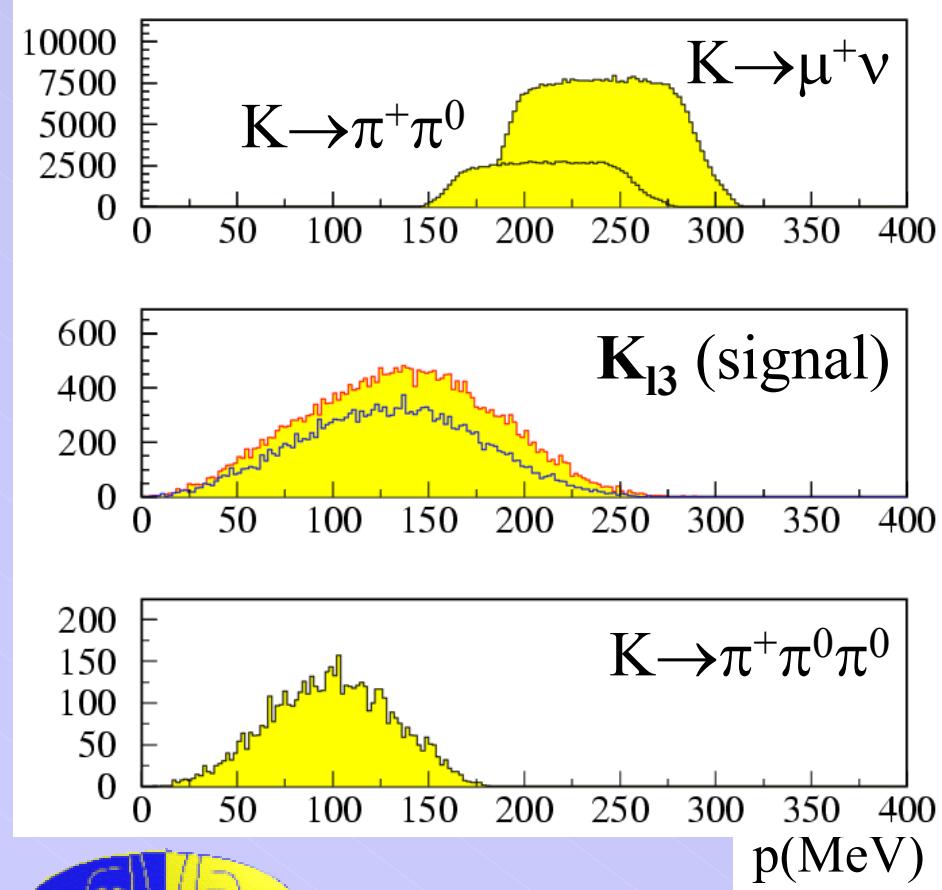
200 pb<sup>-1</sup>



# Signal efficiency

Track + Vertex fit

$\pi_0$



# Conclusions and Outlook

- ⇒ Next experimental improvement  $\Delta V_{us}$ :  $K_{l3}$  BR's
- ⇒ KLOE 2001 data taking:  $200 \text{ pb}^{-1}$  (more data coming)
- ⇒ Good experimental resolution
- ⇒ KLOE has the capability of measuring absolute BR's
- ⇒ stat ( $200 \text{ pb}^{-1}$ )  $\approx 0.5\%$
- ⇒ syst : to be determined

