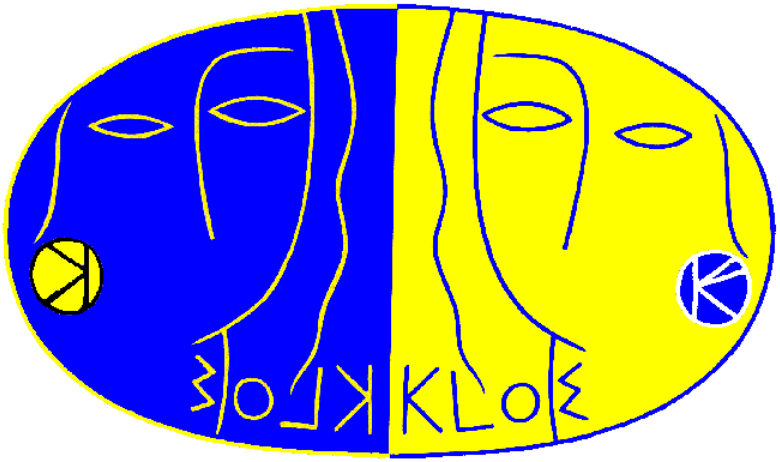
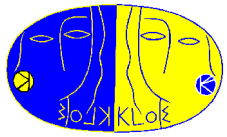
Charged Kaons Decays @ KLOE

Roberto Versaci on behalf of KLOE collaboration

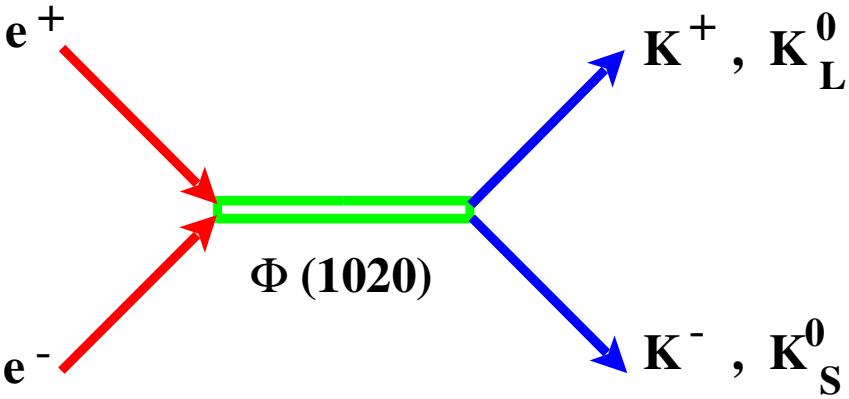
VIII LNF Spring School 'Bruno Touschek'

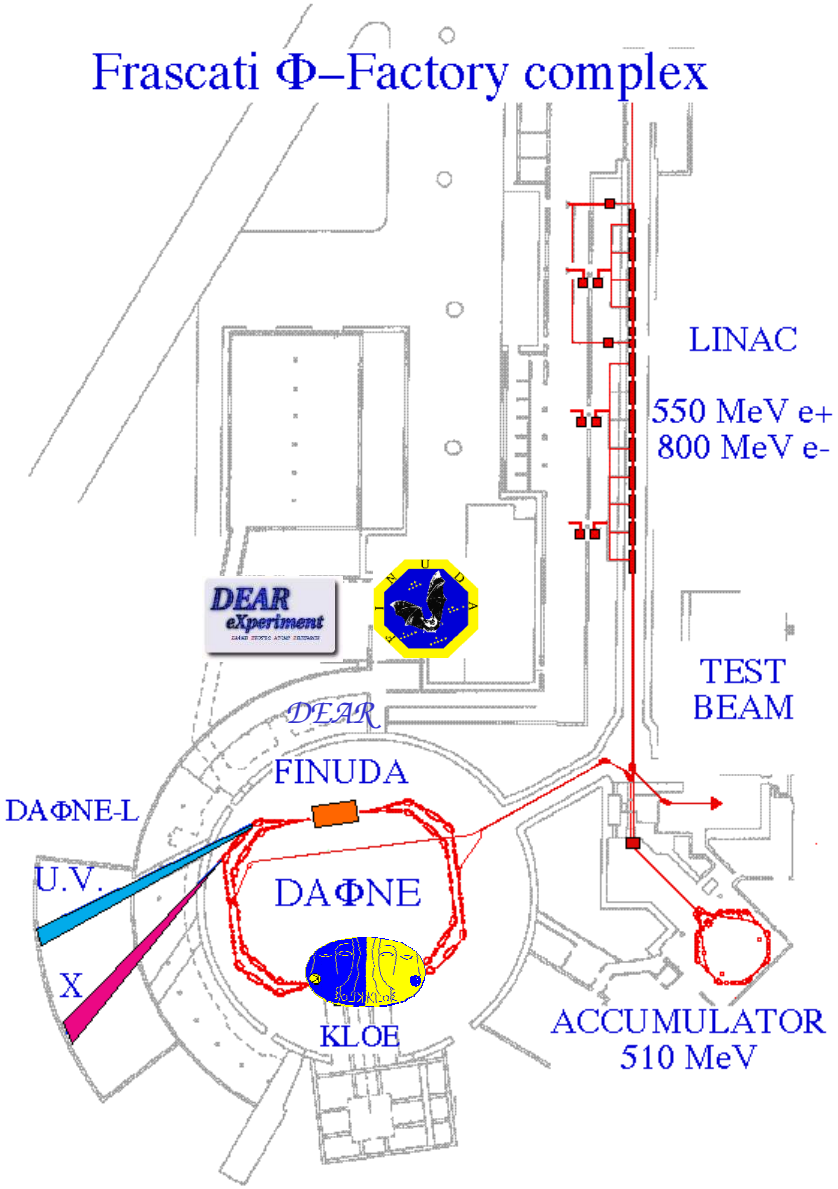




DAΦNE

Double Annular
Φ-factory for
Nice Experiments





$BR(\phi \to K^+K^-)$ $(49.2 \pm 0.7)\%$

$BR(\phi \to K^0_L K^0_S)$ $(33.8 \pm 0.6)\%$

$BR(\phi \to \rho\pi + \pi^+\pi^-\pi^0)$ $(15.5 \pm 0.6)\%$

DAΦNE performance

- **2000 run**: **25 pb^{-1}** **7.5 x 10^{7}** ϕ *first published results*
- **2001 run**: **190 pb^{-1}** **5.7 x 10^{8}** ϕ *analysis in progress*
- **2002 run**: **300 pb^{-1}** **9.0 x 10^{8}** ϕ *analysis in progress*

2002 *peak luminosity:*

$0.75 \times 10^{32}\, cm^{-2}\, s^{-1}$

$\sigma(e^+ e^- \to \Phi) \simeq 3\,\mu b$

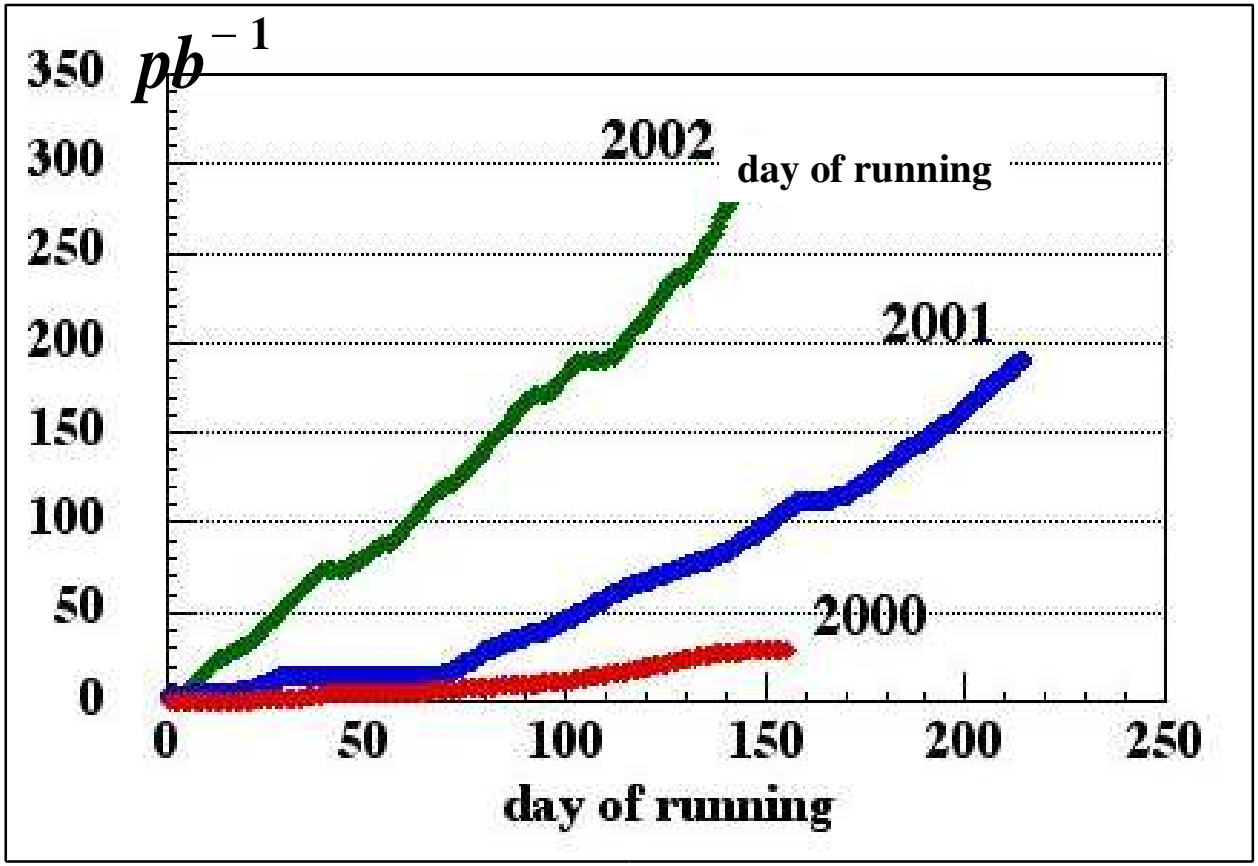
$\downarrow$

$1.5 \times 10^{6}\ K^+ K^-$

$10^{6}\ K_S K_L$

per pb^{-1}

$400\, pb^{-1}$ *available*



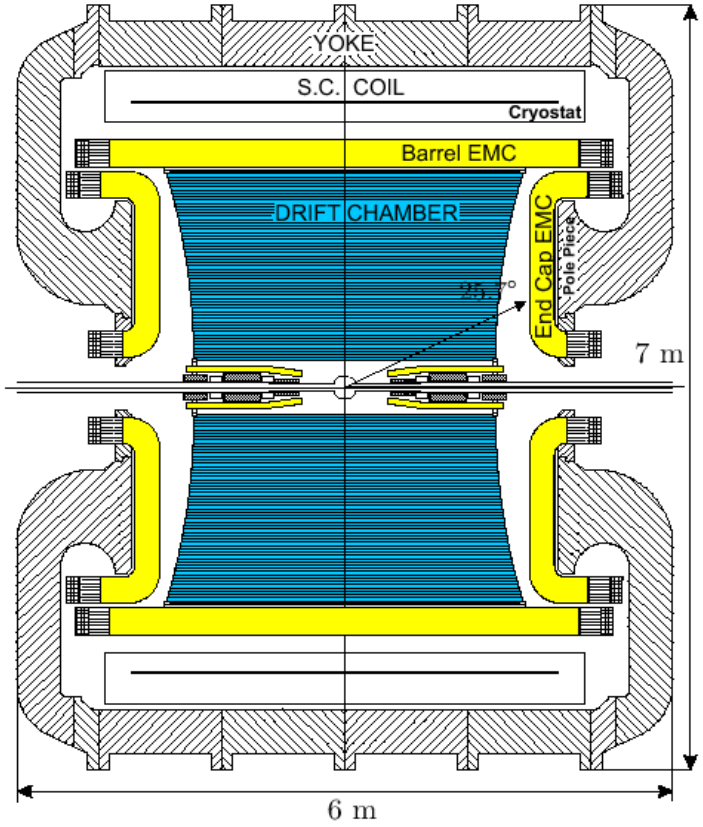
The detector

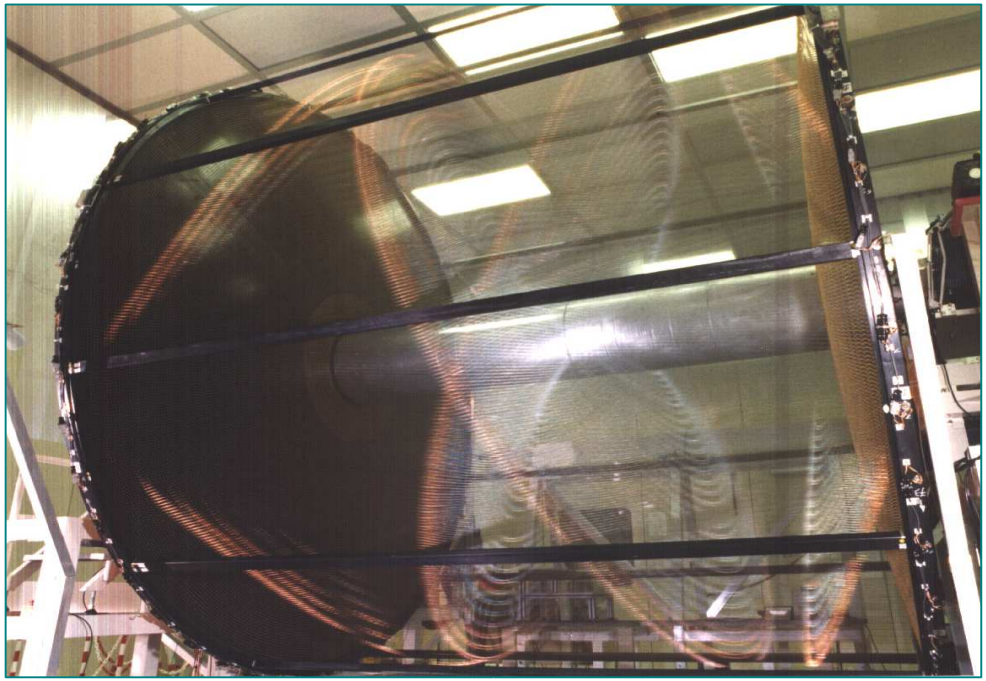
Drift Chamber

$\lambda_S = 0.6\ cm$
$\lambda_L = 340\ cm$
$\lambda_{\pm} = 90\ cm$

$\sigma_r = 160\ \mu m$
$\sigma_z = 2\ mm$
$\sigma_V = 3\ mm$
$\sigma_p / p = 0.4\ \%$

B = 0.6 T

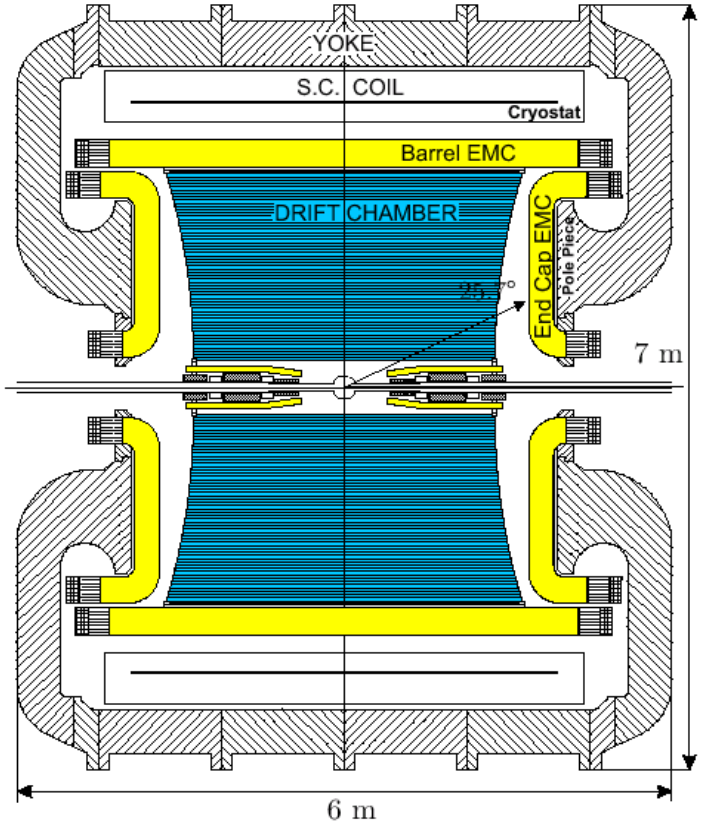


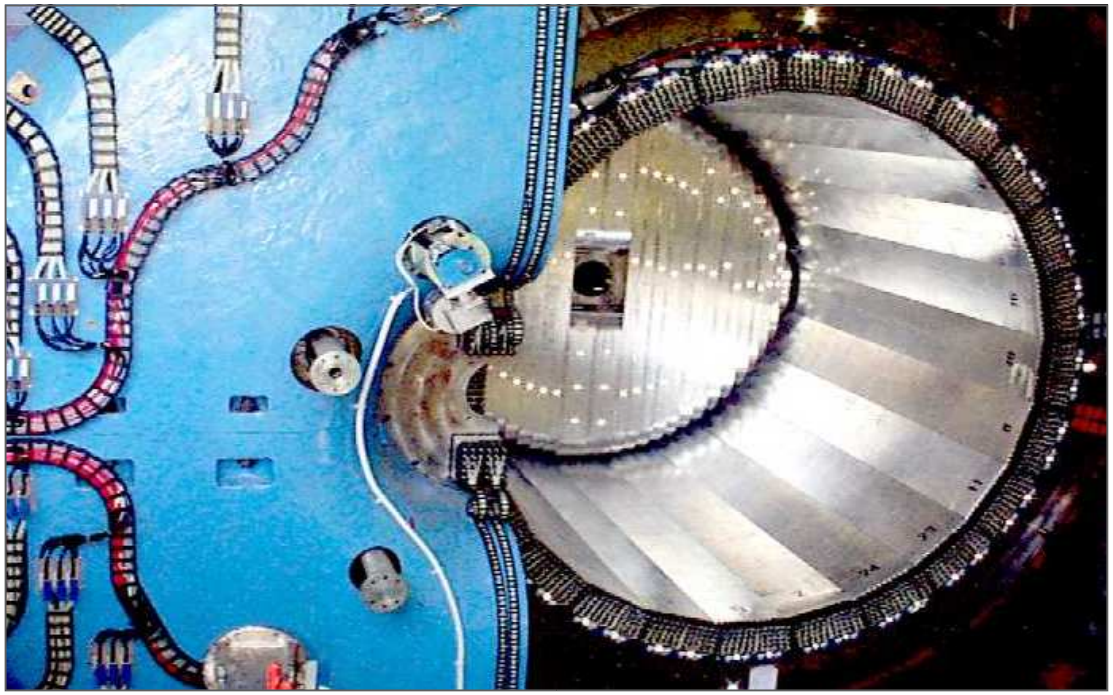


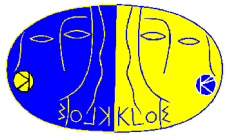
The detector

ElectroMagnetic Calorimeter

$$\sigma_E / E = 5.7\% / \sqrt{E\,(GeV)}$$
$$\sigma_t = 54\,ps / \sqrt{E\,(GeV)} \oplus 50\,ps$$







Why study charged kaons?

Decays	BR PDG 2002	Theoretical interest
$\mu^{\pm}\ \nu$	63.43 ± 0.17	f_K
$\pi^{\pm}\ \pi^0$	21.13 ± 0.14	χPT
$\pi^0\ e^{\pm}\ \nu$	4.87 ± 0.6	V_{us}, χPT
$\pi^0\ \mu^{\pm}\ \nu$	3.27 ± 0.6	V_{us}, χPT
$\pi^{\pm}\ \pi^0\ \pi^0$	1.73 ± 0.04	χPT
$\pi^{\pm}\ \pi^+\ \pi^-$	5.58 ± 0.03	χPT

V_{us} from $K^{\pm}_{13}$ decays

$$\frac{BR(K^{\pm}_{e3})}{\tau(K^{\pm})} = \frac{1}{384\pi^3} G^2 m_K^5 |V_{us}|^2 |f_+(0)|^2 I(\lambda_+)(1+\delta_{RC})$$

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

PDG 2002 $\boxed{|V_{us}| = 0.2196 \pm 0.0023}$

$BR(K^{\pm}_{e3}) = (4.87 \pm 0.09)\% \rightarrow error \simeq 0.9\%$ ← Mainly from Chiang et al. 1972 fixed target exp.

$\tau(K^{\pm}) = (1.2386 \pm 0.0024) \times 10^{-8}\ s \rightarrow error \simeq 0.1\%$

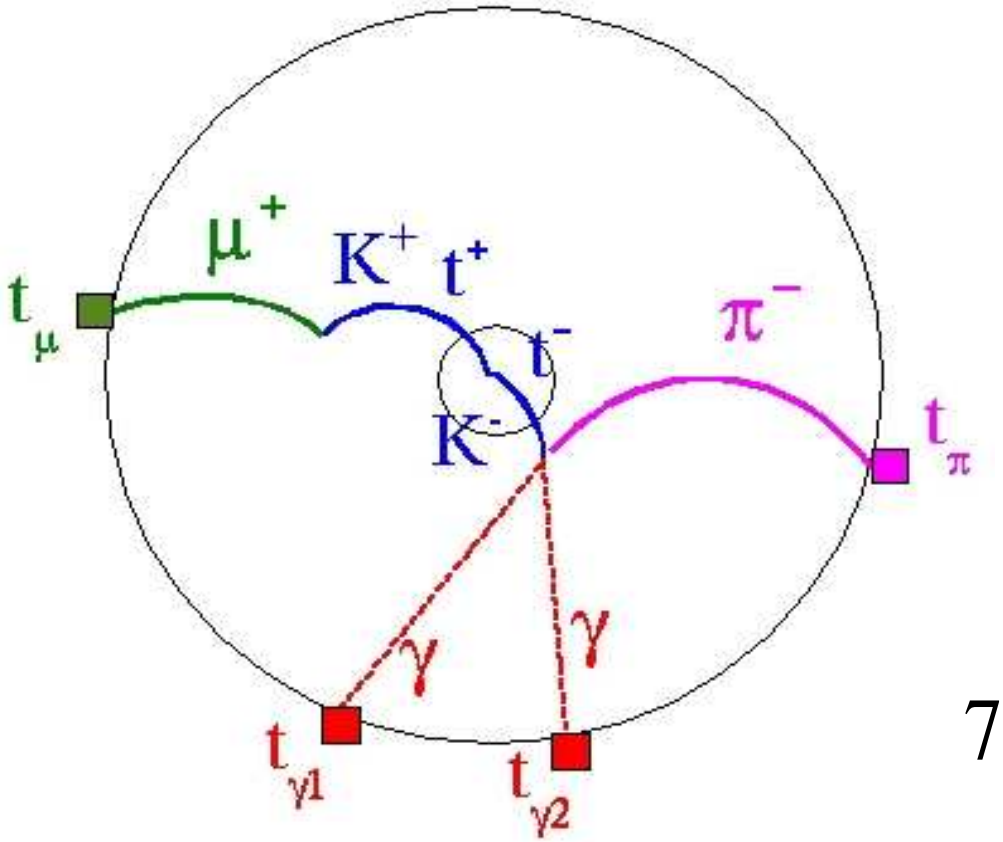
CKM Workshop 2002 →

$|f_+(0)| = 0.982 \pm 0.008 \rightarrow error \simeq 0.8\%$

$\lambda_+ = 0.0278 \pm 0.0019 \rightarrow error \simeq 0.4\%$

Charged kaons @ KLOE

Charged kaons have small β, about 0.2 (p ≈ 100 MeV),
so multiple scattering affects strongly track reconstruction



Kaon selection

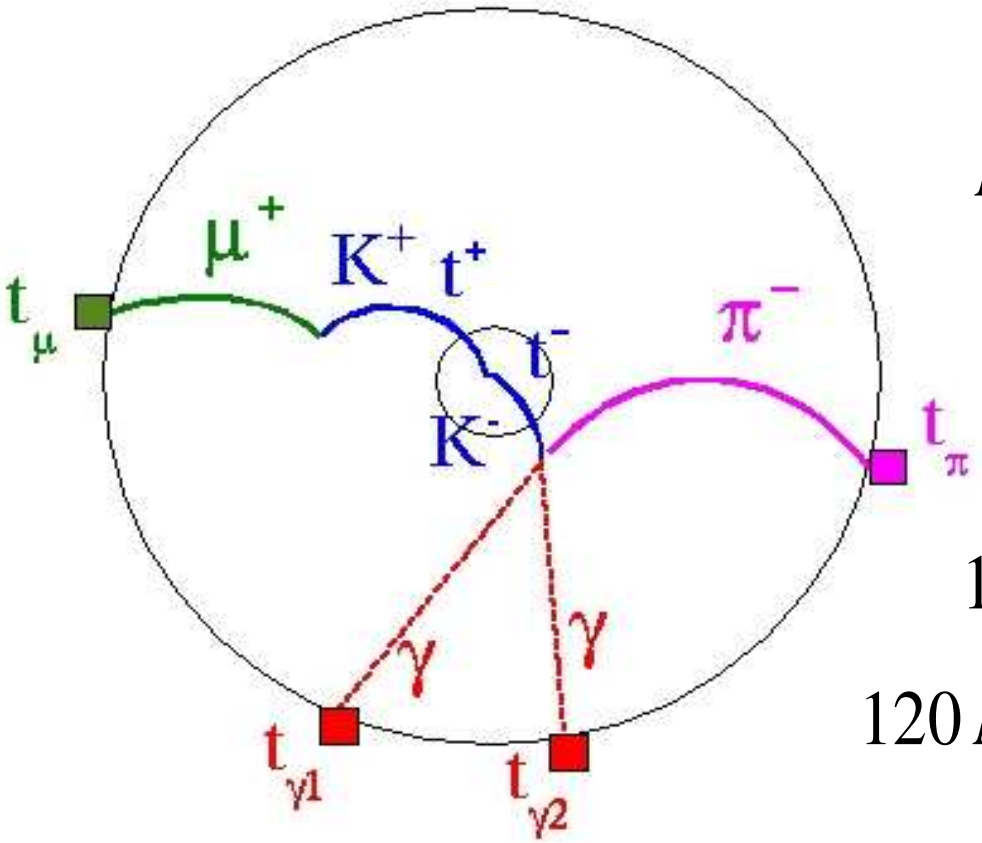
$$R_{xy} < 10\ cm$$

$$|z| < 20\ cm$$

$$dE/dx$$

$$70\ Mev/c < P < 130\ Mev/c$$

Charged kaons @ KLOE



Secondary vertex selection

$$Number\ of\ tracks\ at\ vertex = 2$$

$$same\ charge$$

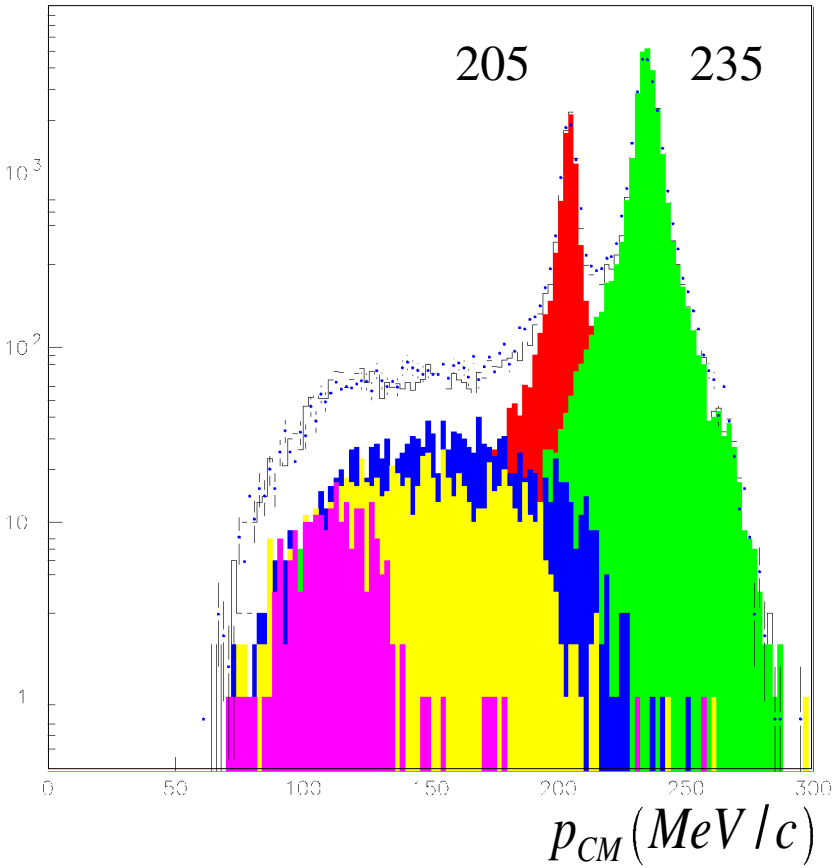
$$40\,cm < R_{xy} < 150\,cm$$

$$180\,Mev/c < P^{*} < 270\,Mev/c$$

$$120\,MeV/c < \left|P_K - p_{sec}\right| < 320\,MeV/c$$

Charged kaons @ KLOE

Two body decays dominate the spectrum



$K^{\pm} \to \mu^{\pm} \nu$

$K^{\pm} \to \pi^{\pm} \pi^0$

$K^{\pm} \to \pi^0 \mu^{\pm} \nu$

$K^{\pm} \to \pi^0 e^{\pm} \nu$

$K^{\pm} \to \pi^{\pm} \pi^0 \pi^0$

Analysis: BR measurement strategy

- Based on the tagging:

  given an identified 2 body $K^{\pm}$ decay on one emisphere (tag)
  then we look for $K^{\mp}$ decay on the other side (signal)

- The tagged decay is self-triggered so $\epsilon_{Trigger}$ and ϵ_{ID} cancel out

- The 2 γ s coming from the decay of the π^0 from $K_{\pi^{\pm}\pi^0}$ are used for self-triggering,with an high efficiency (90%)

- The μ cluster of the $K_{\mu\nu}$ decay triggers firing with good efficiency (30%)

- Two self-triggering tag types with different topologies give us

  systematic checks

More about tags

Pion tag

$$|P - 205\,MeV/c| < 5\,MeV/c$$

$$E_\gamma > 25\,MeV$$

$$E_{\gamma 1} + E_{\gamma 2} > 100\,MeV$$

$$t_1 = t_{\gamma 1} - d_1/c$$

$$t_2 = t_{\gamma 2} - d_2/c$$

$$|t_1 - t_2| < 3\,ns$$

Muon tag

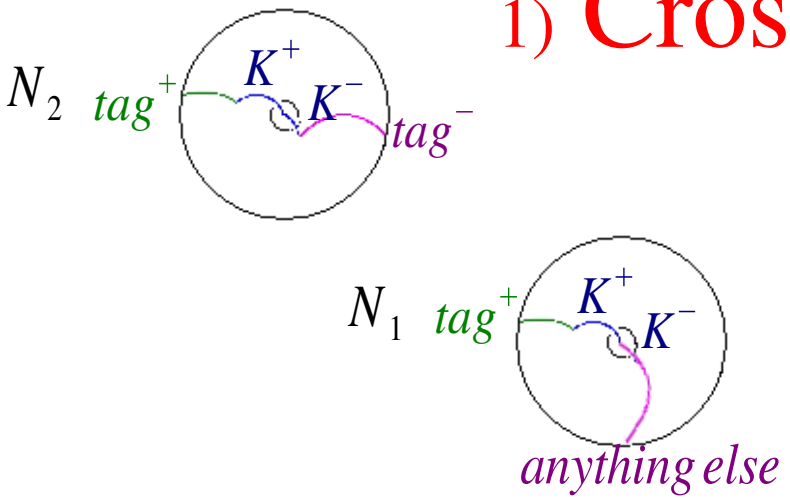
$$|P - 235\,MeV/c| < 5\,MeV/c$$

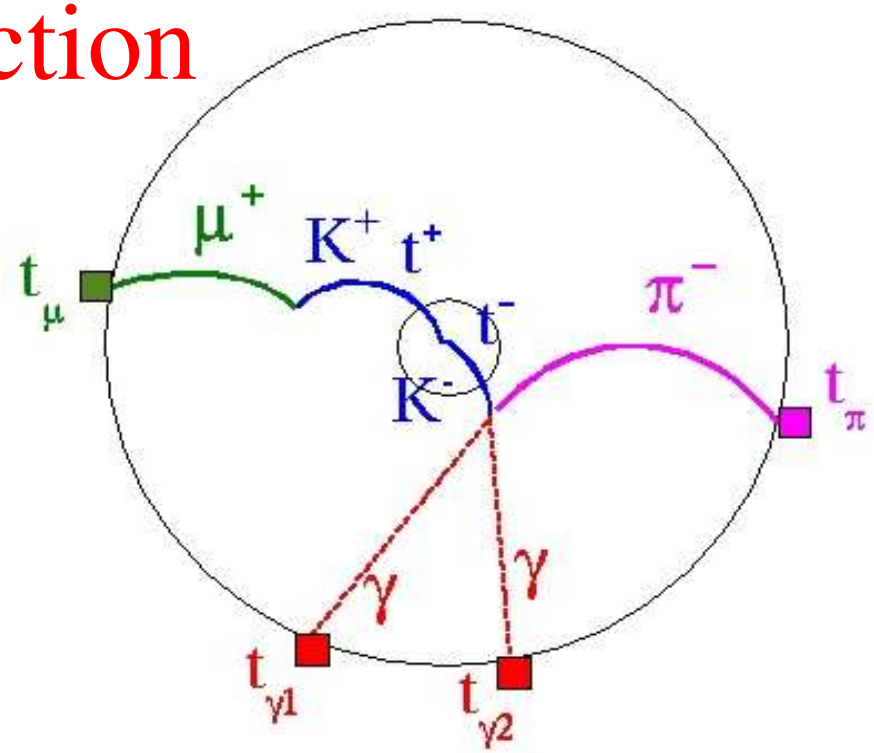
$$E_{cluster} > 100\,MeV$$

$$2\,cluster\ fired$$

First results **Preliminary**

1) Cross section





$$N_{KK} \simeq \frac{\epsilon_2}{\epsilon_1} \frac{(N_1 + 2N_2)^2}{4N_2}$$

$$\sigma_\phi = \frac{N_{KK}}{L \cdot BR_{\phi \to K^+K^-}}$$

It's only function of counting and geometrical acceptance

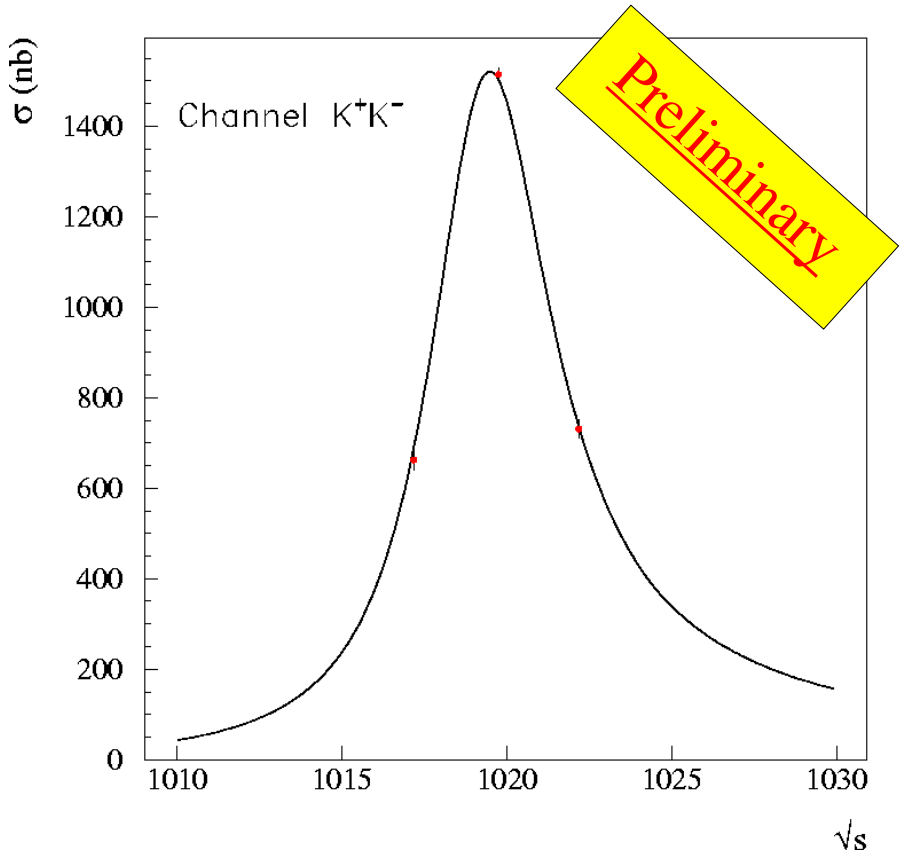
Doesn't depend on tag efficiency !

1) Cross section

Using about $26\ pb^{-1}$

Summary table

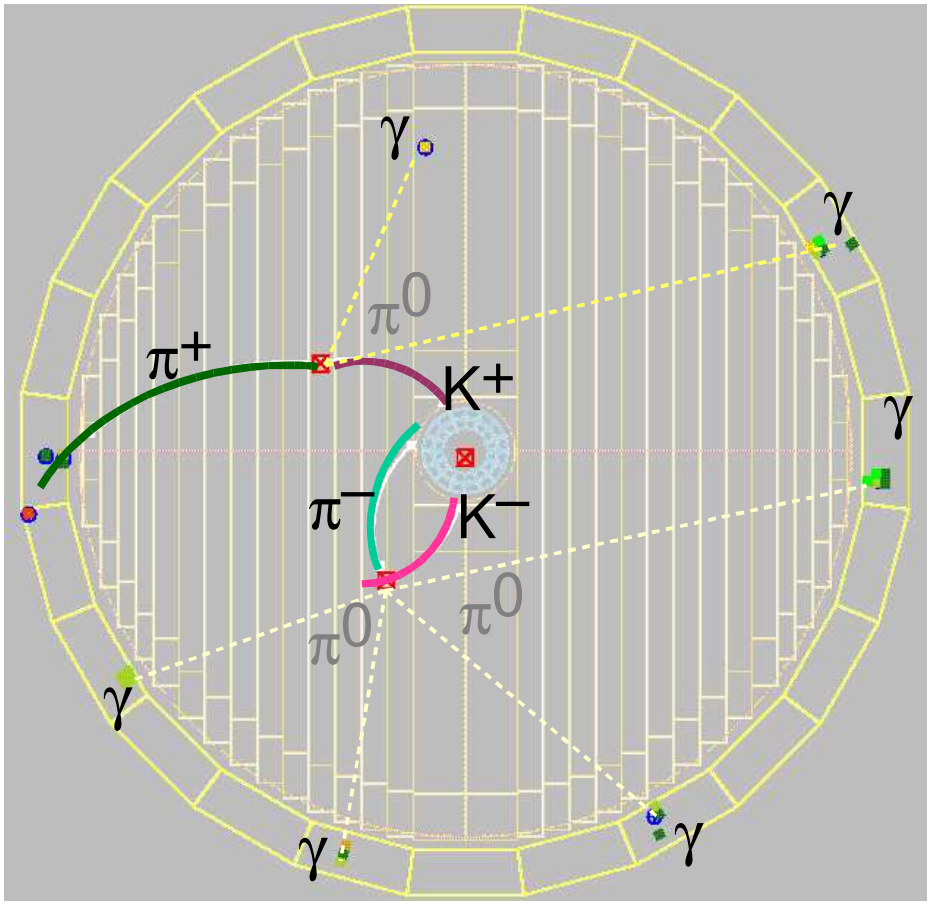
Energy (MeV)	σ (nb)	stat %	syst %
1017	662.2	0.9	3.2
1019	1514.2	0.3	1.3
1022	731.2	0.6	2.7



Using results from all ϕ decays it is found:

$$M_\phi = 1019.44 \pm 0.01\ MeV \qquad \Gamma_\phi = 4.29 \pm 0.01\ MeV$$

2) $K \to \pi^{\pm}\pi^0\pi^0$ decay



γ on-time condition requirement

$$\Delta t_{jk} = (t_j - t_k) - \frac{1}{c} \cdot \left(\left| \vec{r}_{Vj} \right| - \left| \vec{r}_{Vk} \right| \right)$$

$$\Delta t_{jk} < 4\,ns$$

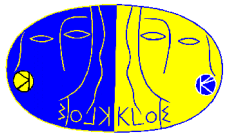
$$P^* < 135\,MeV/c$$

$$E_{tot} < 450\,MeV$$

$$Using \;\; 112\,pb^{-1}$$

Preliminary

$$BR(K^{\pm} \to \pi^{\pm}\pi^0\pi^0) = (1.807 \pm 0.008_{stat.} \pm 0.018_{syst.}) \cdot 10^{-2}$$



What about near future?

- Cross section with $K \to \mu \nu$ decay
- Ratio $BR(K \to \mu \nu) \,/\, BR(K \to \pi^{\pm} \pi^{0})$
- BR of all charged kaon decays
- V_{us} Measurement

"That's all Folks!"
Cartoon Songs From
MERRIE MELODIES & LOONEY TUNES