

**First Results**  
**from  $\phi \rightarrow K_L K_S$  Decays**  
**with the KLOE detector**

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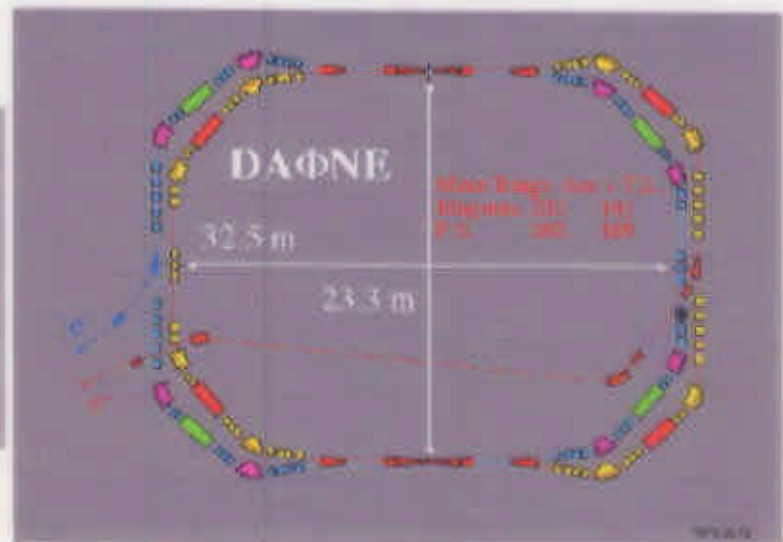
**on behalf of the KLOE collaboration**

XXX International Conference on High energy Physics  
Parallel session PA-06  
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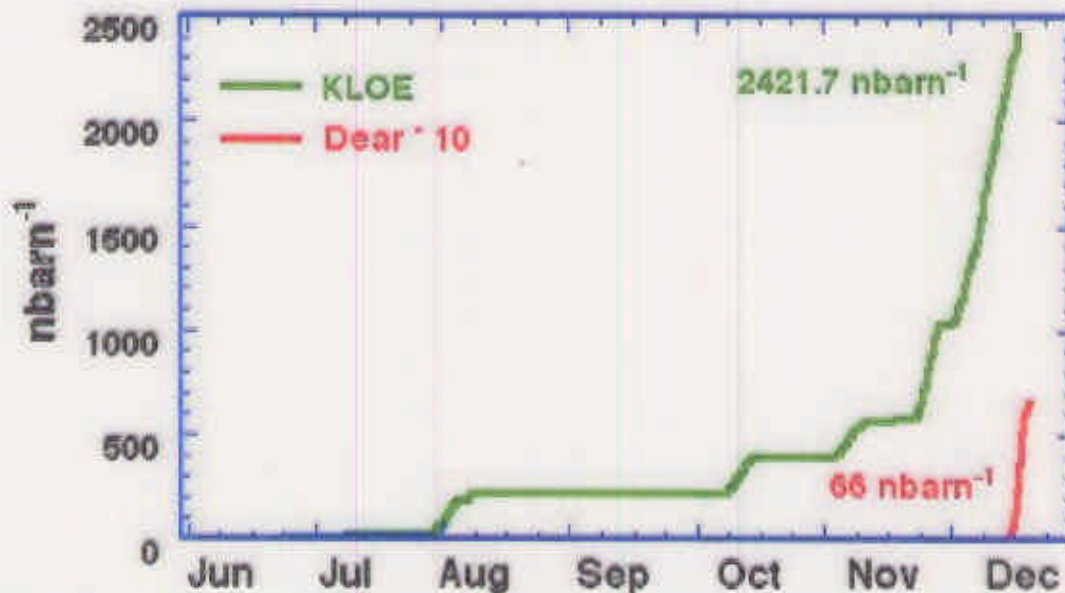


**DAΦNE  $\phi$ -factory came into operation in april 1999 and delivered  $\sim 2.4 \text{ pb}^{-1}$  to the KLOE experiment during its commissioning**

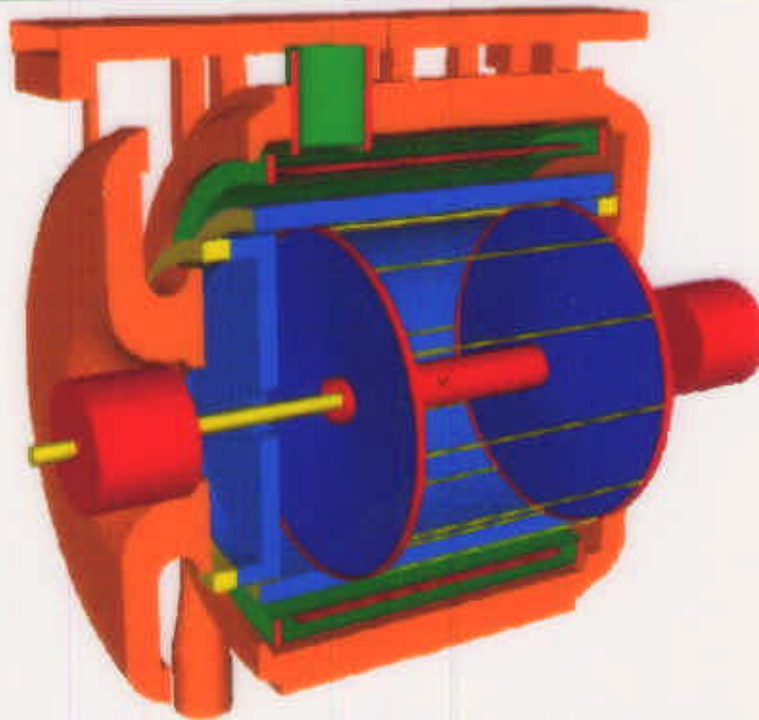
20 + 20 bunches  
 300 mA per beam  
 $\mathcal{L} \sim 2 \cdot 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$   
 $\sim 30 \text{ min}$  lifetime  
 $\phi$  boosted by  $\sim 12 \text{ MeV}$



1999 DAFNE Integrated Luminosity



## The KLOE detector



**B=0.56 T**

- **Drift chamber:**  $25 < \rho < 195$  cm ;  $|z| < 160$  cm  
90%He-10%Isobutane      12582 drift cells

$$\sigma_{R\phi} = 140 \mu\text{m} \quad \Delta p/p = 0.3\% \text{ at } 500 \text{ MeV}$$

- **Calorimeter:** Pb-SciFi       $15 x_0$

$$\sigma_E/E = 5.7\% / \sqrt{E} \oplus 0.6\%$$

$$\sigma_t = 50 \text{ ps} / \sqrt{E} \oplus 60 \text{ ps}$$

- **Trigger:**  $\geq 2$  emc deposits    barr-barr or barr-ecap

$\varepsilon \approx 90\%$  (geom included) for most  $\phi$  decays

(see P.Branchini talk in session PA12)



- $\phi$  meson decays 34% of the times in a pure  $K_S K_L$  state. Kaon momentum is  $110 \text{ MeV}/c$  ( $\beta \sim 0.21$ ).
- $K_S \rightarrow \pi^+ \pi^-$  decays are easily reconstructed by requiring a good vertex at  $\rho < 4 \text{ cm}$  and  $|z| < 8 \text{ cm}$ . Also:  $400 < M_{\pi\pi} < 600 \text{ MeV}$  and  $50 < p_{\pi\pi} < 120 \text{ MeV}$

### **$K_S$ lifetime measurement:**

- The primary vertex position is reconstructed on average (run by run) using Bhabha events. Resolution is:  $\sigma_x \sim 70 \mu\text{m}$ ,  $\sigma_y \sim 70 \mu\text{m}$ ,  $\sigma_z \sim 150 \mu\text{m}$ .
- A better  $K_S$  definition is required:  
 $493 < M_s < 497 \text{ MeV}/c^2$ ;  $105 < p_s < 114 \text{ MeV}/c$
- angular cuts:  
 $45^\circ < \theta_s < 135^\circ$ ;  $|\cot \theta_\pi| < 1$  (both pions)
- decay length in lab frame (projected on  $K_S$  direct.) is fitted. Result is then corrected using measured  $\phi$  boost.



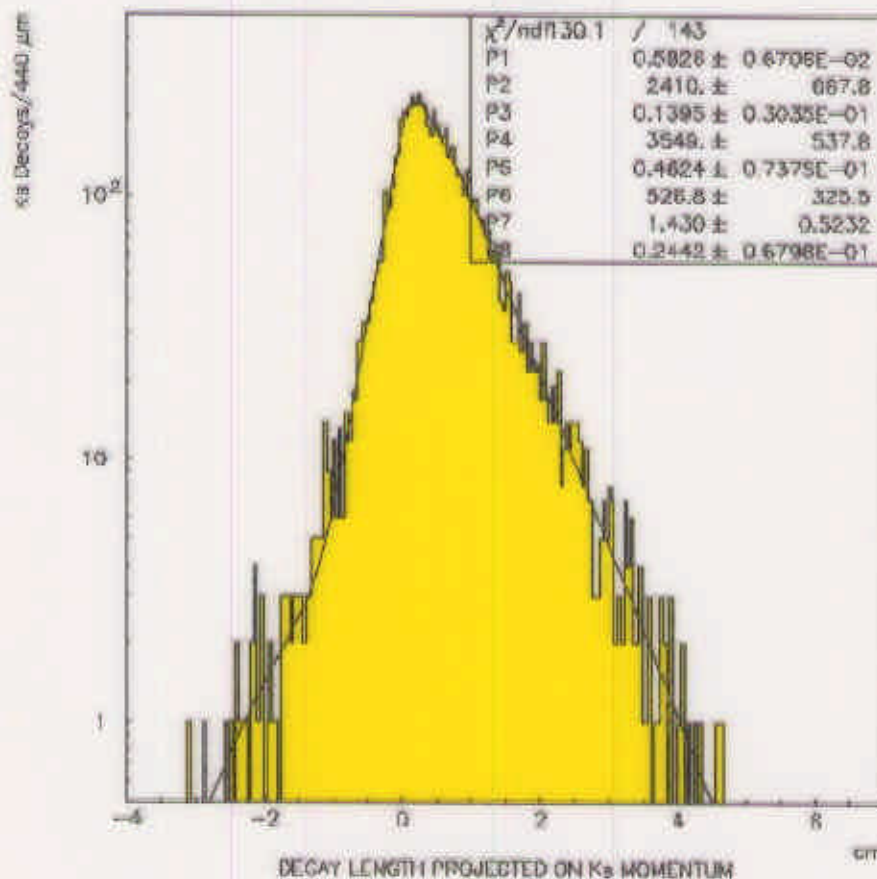
• **Only a subsample of full statistics used**

- $\lambda_S$  resolution parameterized with 2 or 3 gaussians
- fit differences due to choice of resolution function considered as systematic error

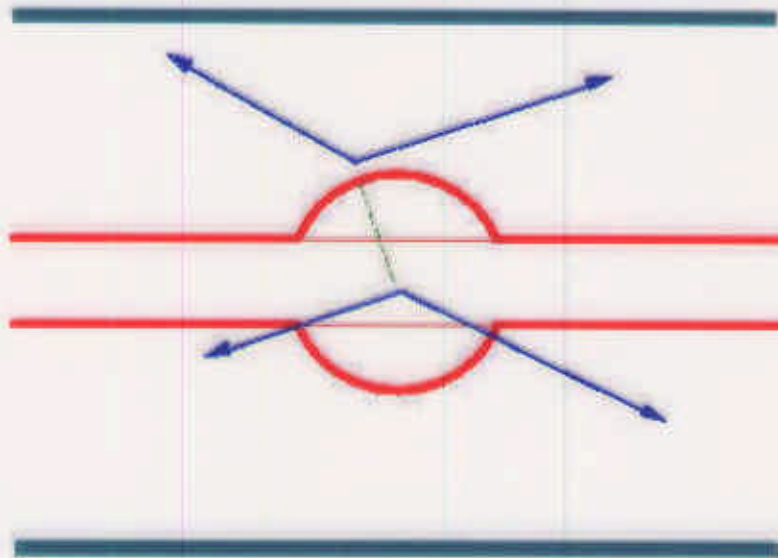
$$\lambda_S = 5.78 \pm 0.08 \pm 0.10 \text{ mm}$$

KLOE preliminary

corresponds to  $\tau_S = (0.871 \pm 0.019) 10^{-10} \text{ s}$



## Regeneration in KLOE



**Beam pipe:** sphere  $r=10$  cm     $500 \mu\text{m}$  thick  
 made of AlBeMet: 39% Al - 61% Be

**D.C. wall :** cylinder  $\rho = 25$  cm  
 $750 \mu\text{m}$  Carbon +  $200 \mu\text{m}$  Al

- regeneration is a background to  $K_L \rightarrow \pi^+ \pi^-$  events
- few experimental data available
- expect mainly incoherent regeneration due to  $K$  momenta and small regenerator thickness:  
 $\Rightarrow$  elastic process

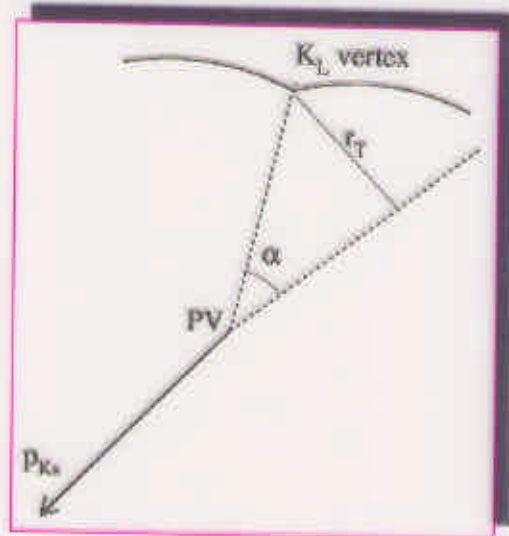


•  **$K_S$  selection:**  $M_{\pi\pi} \in (M_K \pm 4 \text{ MeV})$ ;  $p_{\pi\pi} \in (110 \pm 7.6 \text{ MeV})$

• **extrapolation resolution to  $K_L$  vertex:**

$$\alpha < 4 \left[ \sigma_\alpha^2 + \left( \frac{\delta r_T}{d} \right)^2 \right]^{1/2}$$

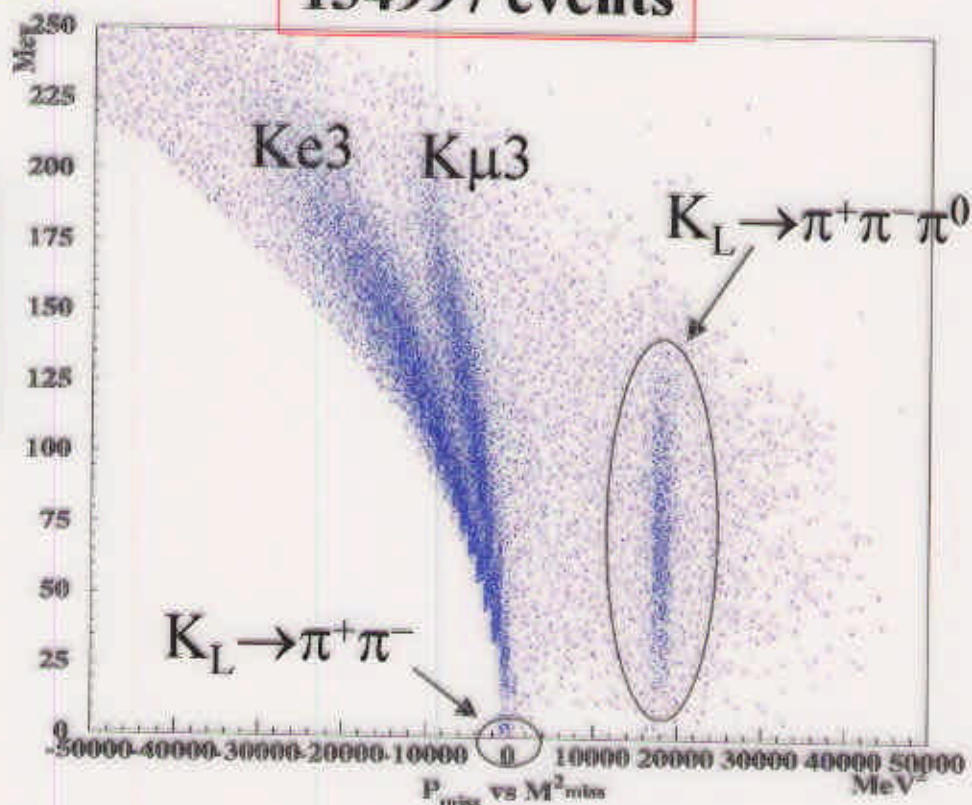
from real data:  $\sigma_\alpha = 18 \text{ mrad}$   
 $\delta r_T = 0.56 \text{ cm}$



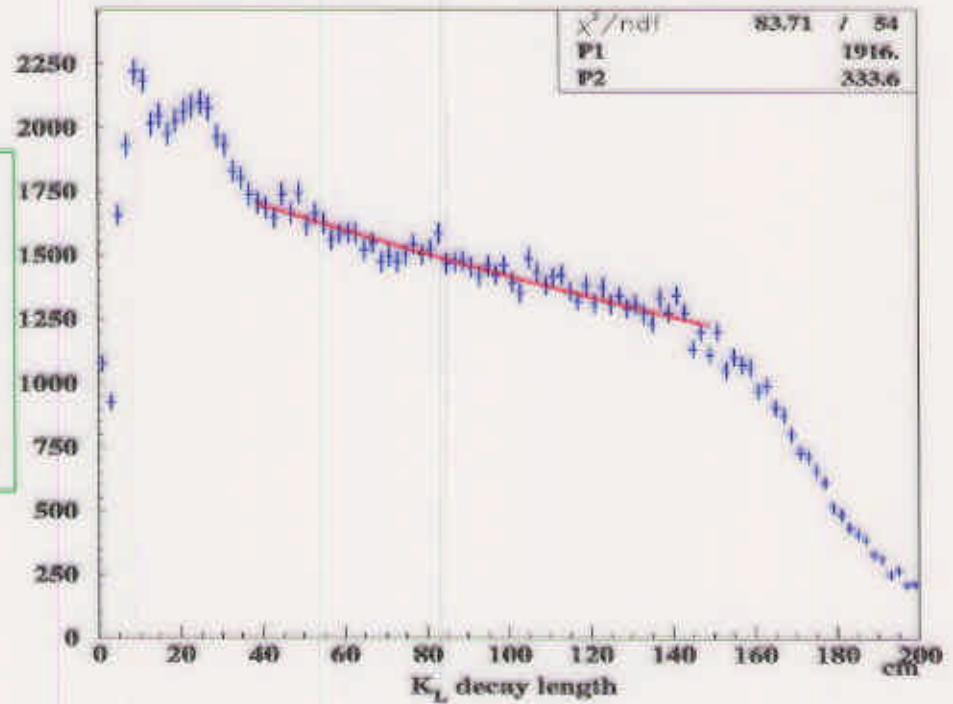
**$K_L$  candidates:**

134997 events

Pion mass hypothesis for both tracks



**Expected:**  
 $\lambda_{K_L} = 343 \text{ cm}$   
**Fitted:**  
 $\lambda_{K_L} = 333 \pm 12 \text{ cm}$



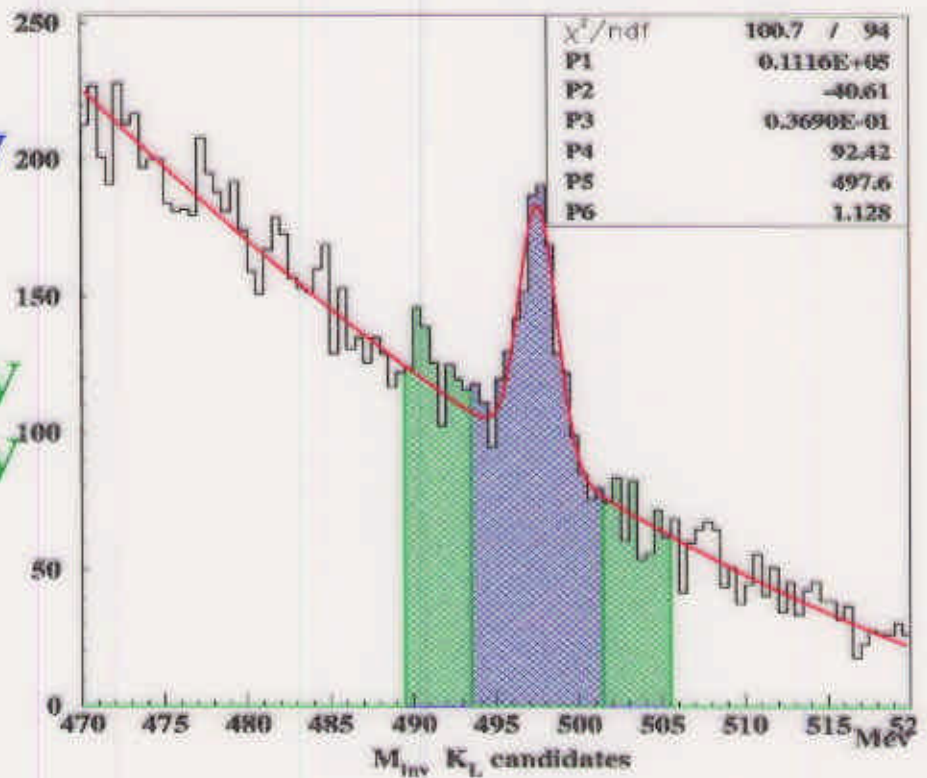
**Signal:**

$M_{K_L} \pm 4 \text{ MeV}$

**Sidebands:**

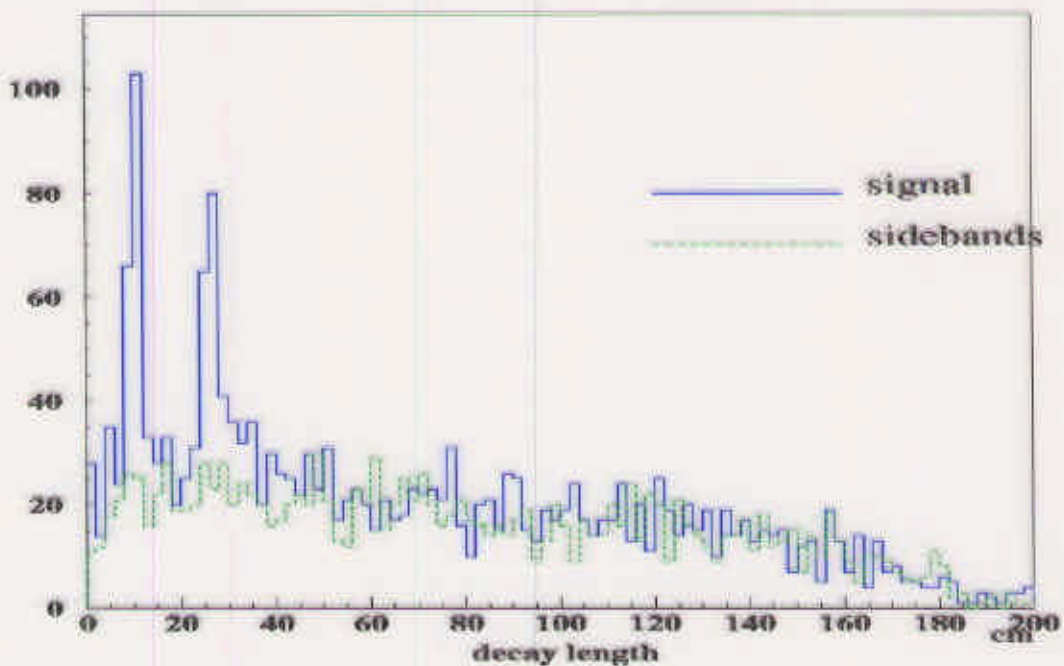
$491.7 \pm 2 \text{ MeV}$

$503.7 \pm 2 \text{ MeV}$





**After mass cut :**



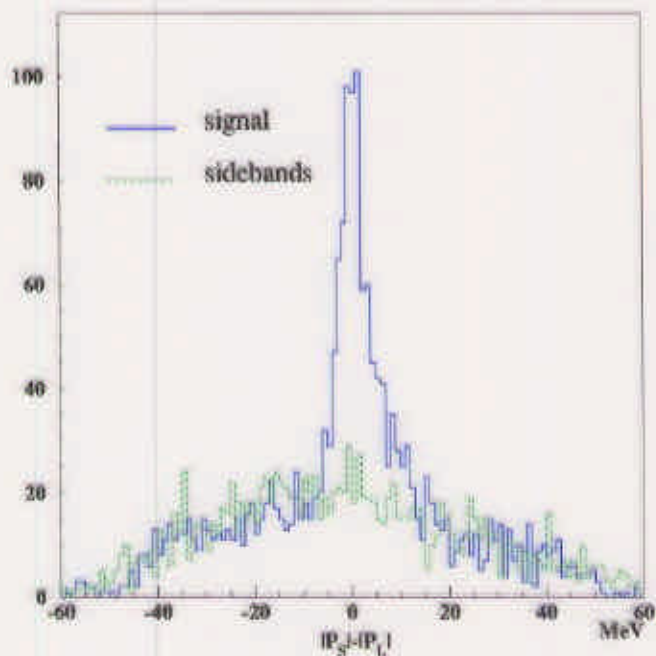
**Reject K13 background:**

incoherent regen is elastic

$$\Delta p = |p_S| - |p_L|$$

require

$$-6 < \Delta p < 12 \text{ MeV}$$

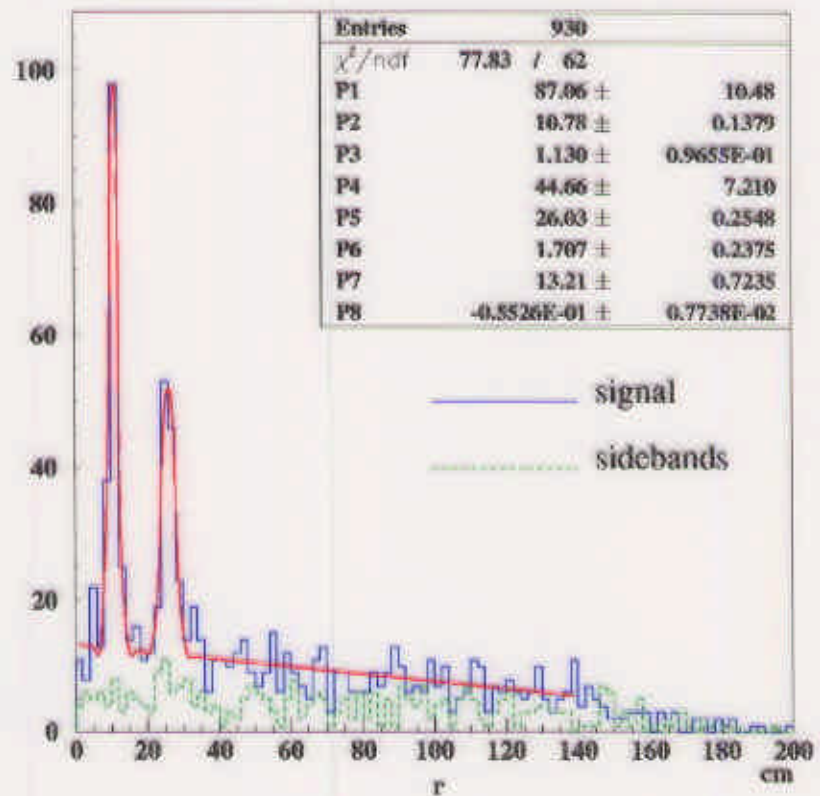


Event counting in  
regenerator region  
minus fitted linear  
background

Beam pipe:

$8 < r < 14$  cm

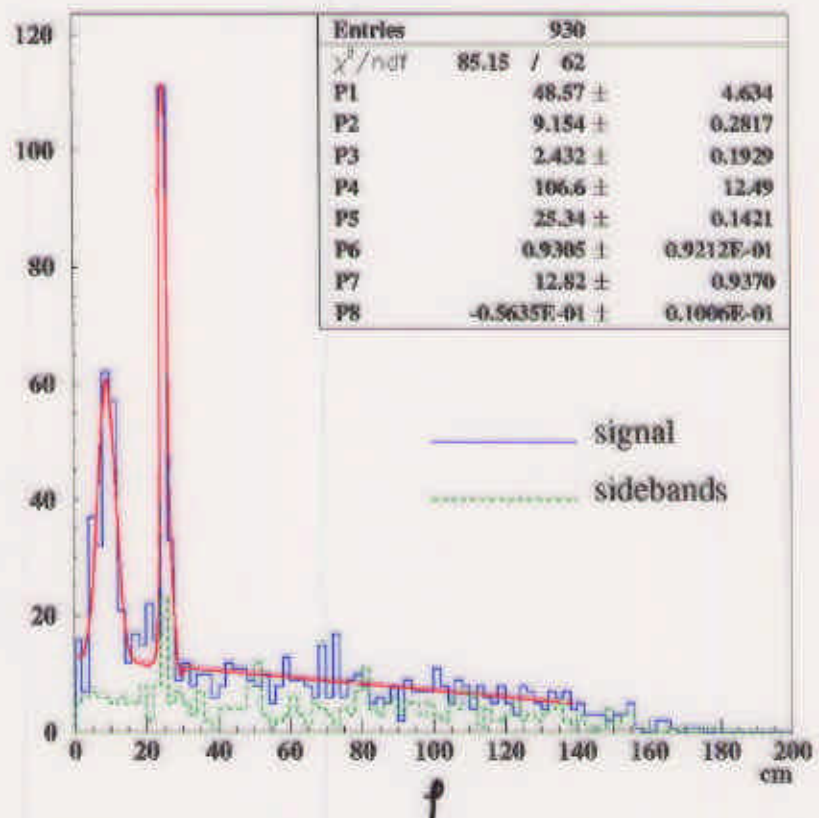
$N_{\text{reg}} = 123 \pm 13$



D.C. wall:

$23 < \rho < 29$  cm

$N_{\text{reg}} = 122 \pm 12$



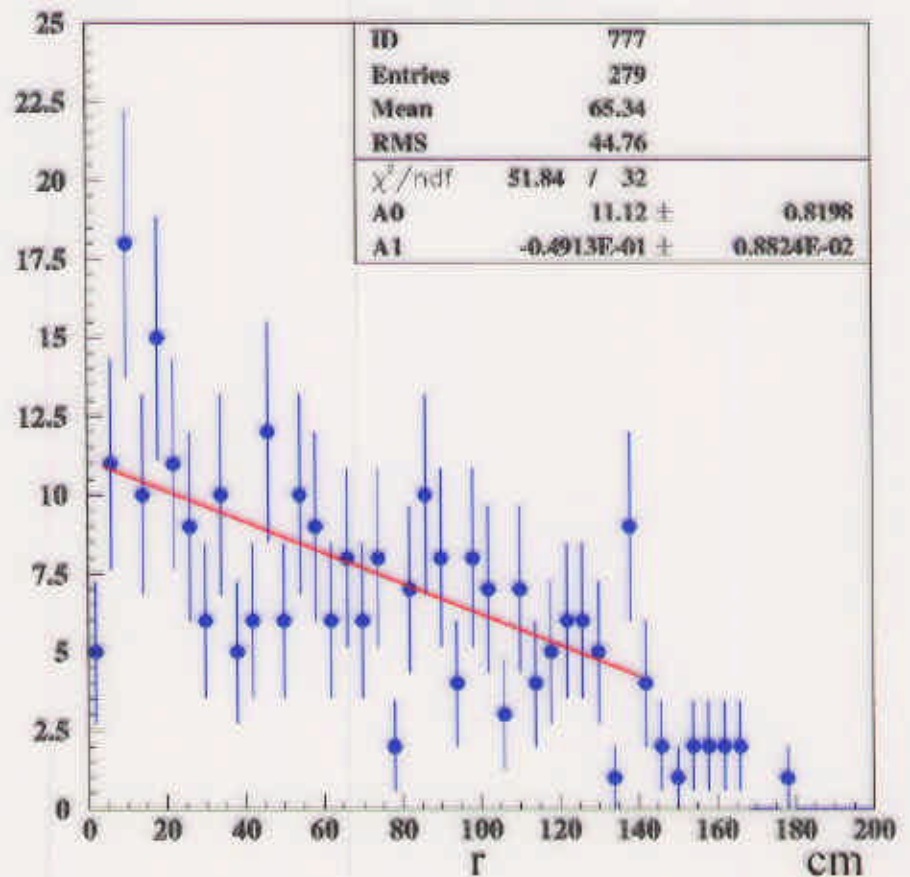
## Efficiency evaluation

- Assume regenerated  $K_S$  charged decays have same efficiency as  $K_L \rightarrow \pi^+ \pi^-$
- select  $K_L \rightarrow \pi^+ \pi^-$  requiring  $\alpha_{SL} < 75$  mrad  
→ MC shows  $K_{L3}$  contamination negligible
- fit with a straight line :

$$\frac{dN_{L\pi\pi}}{dr} = \frac{N_{K_S K_L} B_{L\pi\pi}}{\lambda_L} e^{-r/\lambda_L} \varepsilon(r)$$

$$(dN/dr)^{bp} = 2.65 \pm 0.19 \text{ cm}^{-1}$$

$$(dN/dr)^{dc} = 2.41 \pm 0.15 \text{ cm}^{-1}$$



## Results

**Using:**

$$\sigma_{reg} = \frac{B_{L\pi\pi}}{B_{S\pi\pi}} \frac{1}{\lambda_L (dN_{L\pi\pi} / dr)} \frac{N_{reg}}{\langle nt \rangle}$$

$$\langle nt \rangle^{bp} = 4.93 \cdot 10^{21} \text{ cm}^{-2} ; \langle nt \rangle^{dc} = 6.97 \cdot 10^{21} \text{ cm}^{-2}$$

**We get:**

$$(\sigma_{reg})^{bp} = 75.7 \pm 9.6 \pm 10.6 \text{ mb}$$

$$(\sigma_{reg})^{dc} = 51.9 \pm 6.2 \pm 5.3 \text{ mb}$$

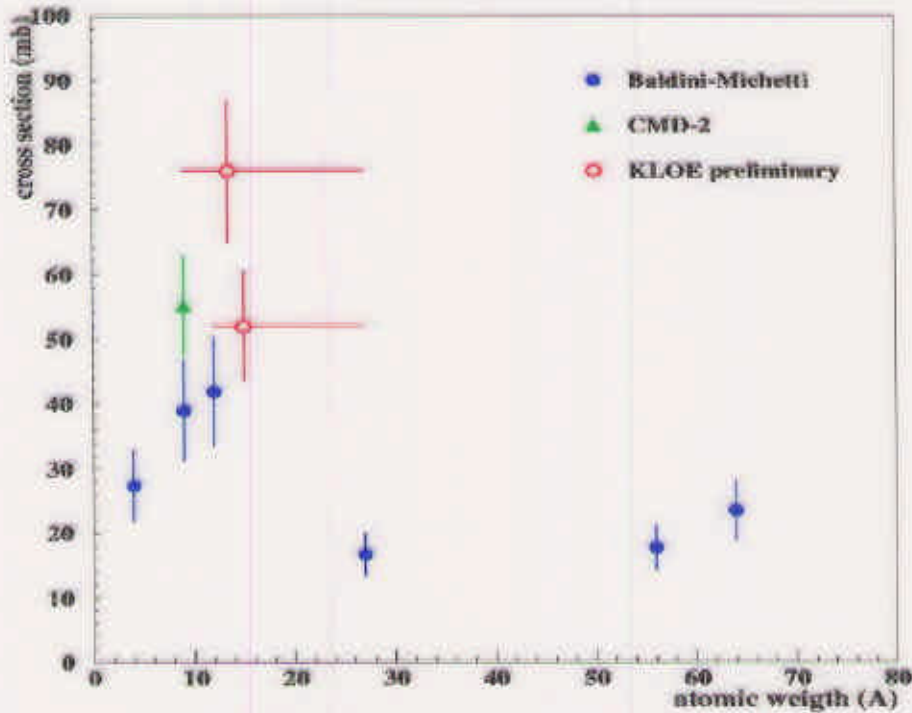
## Systematics:

error source	$\Delta\sigma^{Be-Al} \text{ (mb)}$	$\Delta\sigma^{C-Al} \text{ (mb)}$
r.o.i. limits	2.5	1.0
backgr. shape	2.0	0.4
$\epsilon_{op} \neq \epsilon_{reg}$	1.5	1.1
regen. contam. in $K_L \rightarrow \pi^+\pi^-$	6.5	3.7
regenerators thickness	7.6	3.5
total	10.6	5.3

Dominated by regenerators' thickness

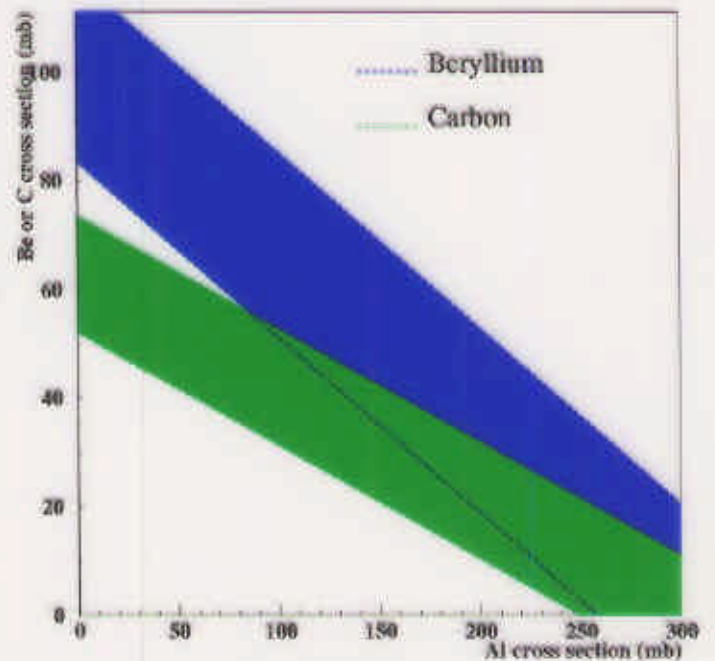


# Discussion:



Agreement with previous measurement (CMD-2) but not with available calculations (Baldini-Michetti) (using eikonal approximation)

Very hard to accommodate a low Al cross section



## Conclusions

- **The KLOE experiment has started analyzing data taken during DAΦNE commissioning**
- **$K_S K_L$  events are in good agreement with expectations in all respects**
- **KLOE detector data reconstruction is performing well**
- **$K_S$  lifetime and  $K_L \rightarrow K_S$  regeneration cross section have been measured**
- **first CP violating decays  $K_L \rightarrow \pi^+ \pi^-$  have been selected.....**

