$K_L \rightarrow K_S$ regeneration in the KLOE detector

Fabio Bellini
Università Roma Tre

on behalf of the KLOE collaboration

Motivation

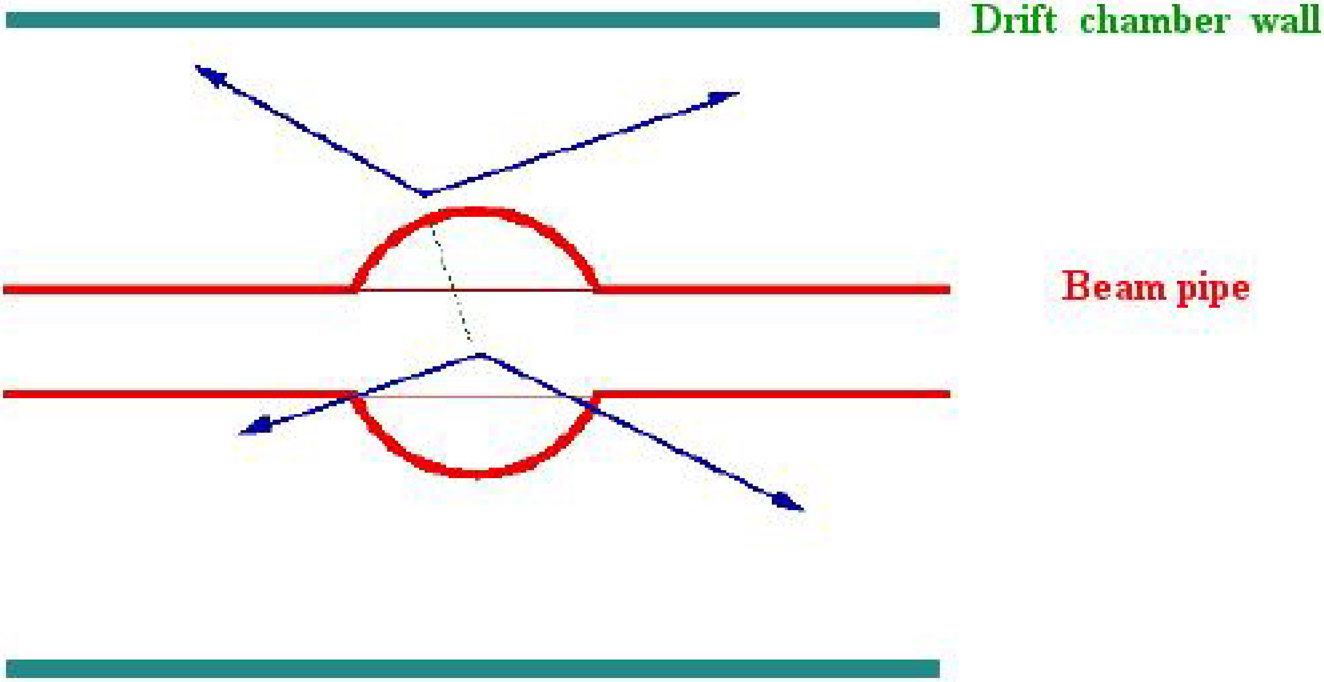
- source of background for
  K_L CP violating decay to $\pi\pi$
- regeneration process interesting in itself:

  study of amplitude of low energy kaon interactions with nuclei

- no low energy K beams exist

  very little theoretical predictions and very little experimental data

Regenerators in KLOE



50 μm Be **500 μm Be 60 % -Al 40 % alloy**

750 μm C 60 % fiber - 40 % epoxy **150 μm Al shield**

Small thickness of regenerators ($t < \lambda_{K_S}$) implies dominance of incoherent regeneration.

i.e. Elastic process

Data sample

- Analysis based on 2.4 pb^{-1} collected during 1999.

- Starting sample is the *$K_S K_L$ stream:*

$K_S \to \pi^+\pi^-$

$\rho_{vtx} < 4$ cm $|z|_{vtx} < 8$ cm

$400 < M_{inv} < 600$ MeV $50 < P_{tot} < 170$ MeV

$K_S \to \pi^0\pi^0$

prompt calorimeter neutral clusters $\beta \approx 1$

K_L crash

calorimeter neutral cluster $\beta \approx 0.2$

$K_L \to$ charged

$30 < \rho_{vtx} < 190$ cm

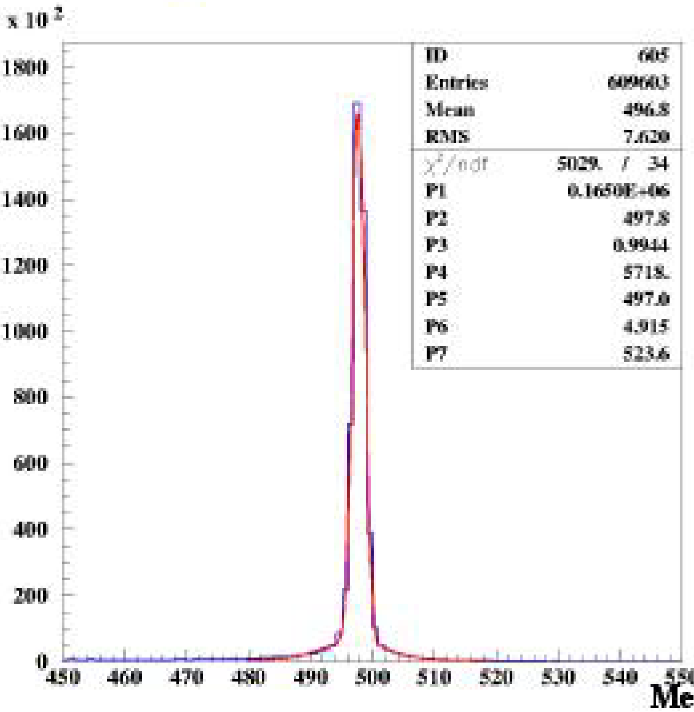
$140 < |z|_{vtx} < 160$ cm

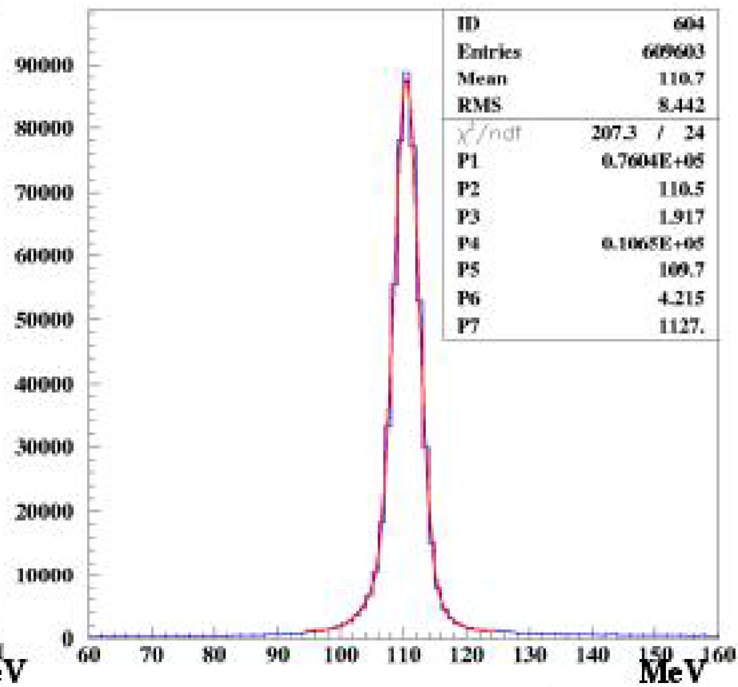
- ≥ 2 vertices required formed by 2 unlike sign tracks

$\Rightarrow$ obtain $4.2 \cdot 10^6$ events

K_S reconstruction

• Require 1 vertex at $r < 6\ cm$: obtain





• Cut on p_{vtx} and M_{inv} : $$\left(\frac{M-\langle M\rangle}{\sigma_M}\right)^2 + \left(\frac{p-\langle p\rangle}{\sigma_p}\right)^2 < 4^2$$

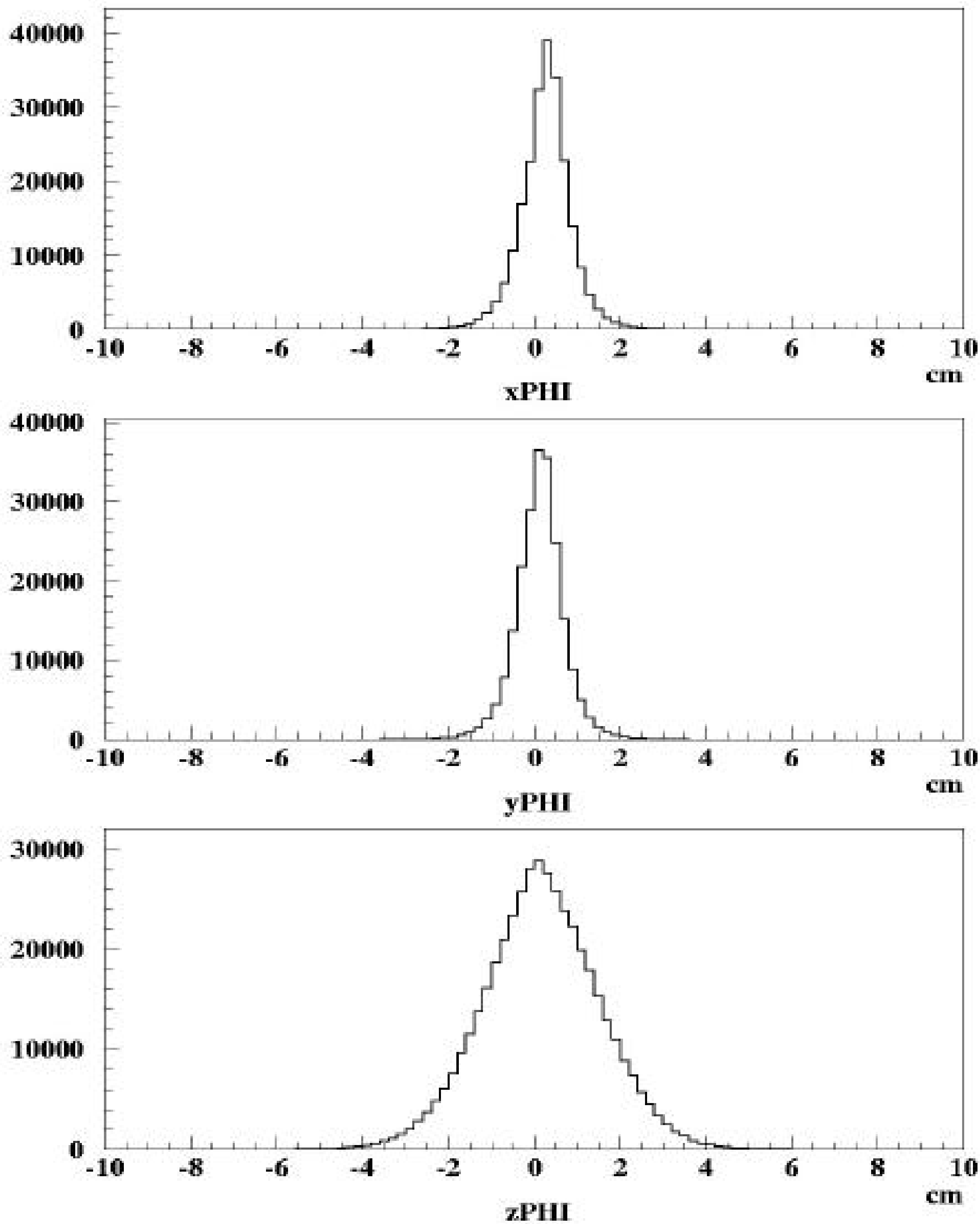
(σ_M = 1 MeV, σ_p = 1.9 MeV)

• reconstruct φ decay vertex evaluating the point of minimal approach between K_s direction and z axis

⇒ cut at 3 σ of φ vertex position distributions

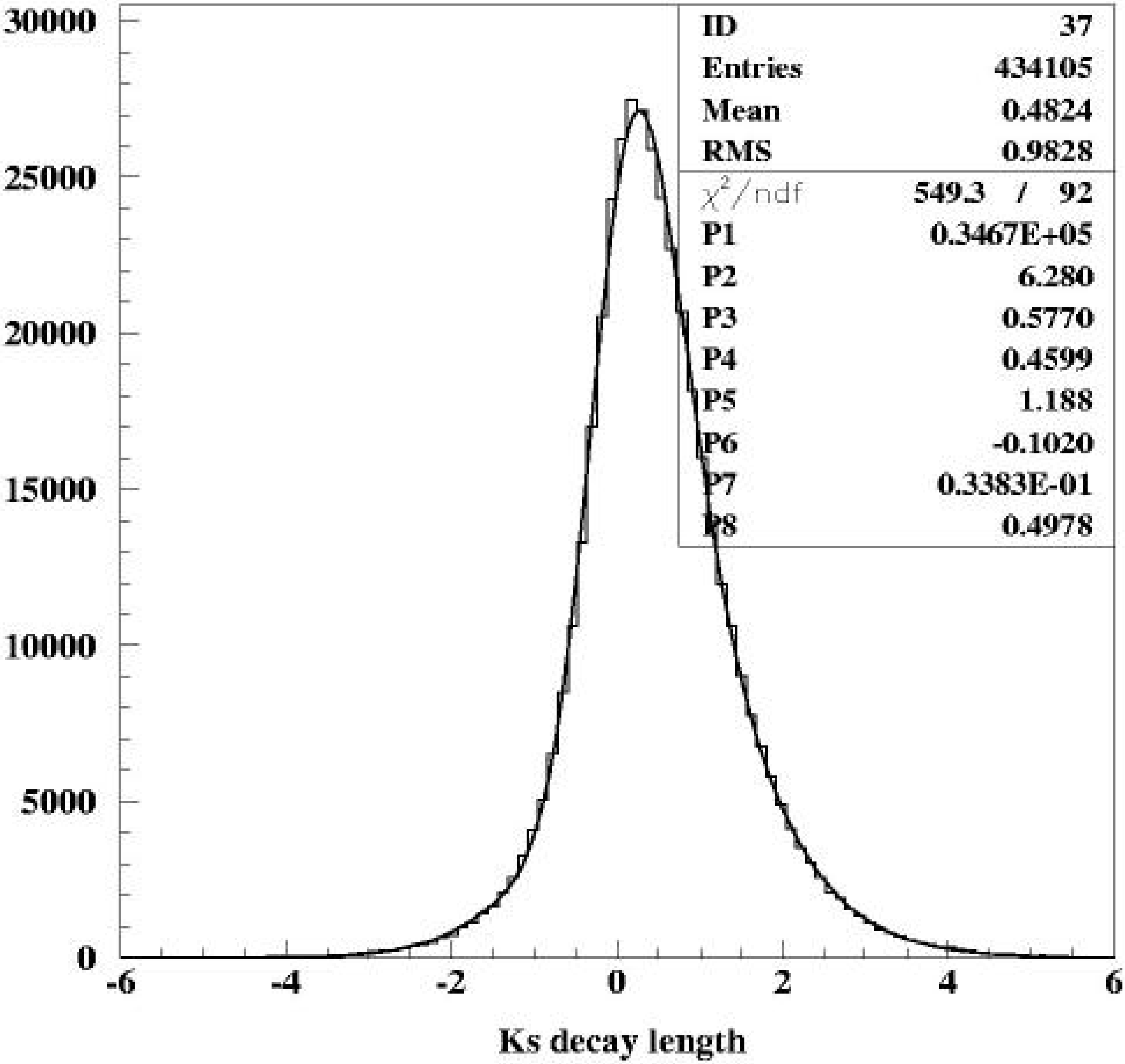
end up with 434105 K_s candidates

φ vertex



40000
30000
20000
10000
0
-10
-8
-6
-4
-2
0
2
4
6
8
10
cm
xPHI
40000
30000
20000
10000
0
-10
-8
-6
-4
-2
0
2
4
6
8
10
cm
yPHI
30000
20000
10000
0
-10
-8
-6
-4
-2
0
2
4
6
8
10
cm
zPHI

K_S decay length



$\lambda_{Ks} = 5.77 \pm 0.11$ mm (in c.m. reference)

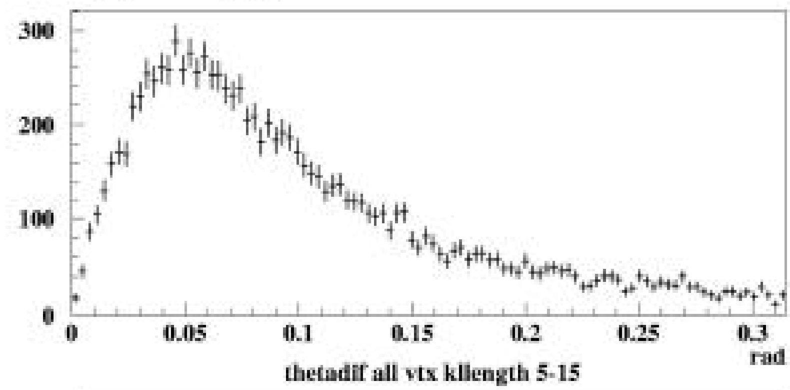
K_l reconstruction

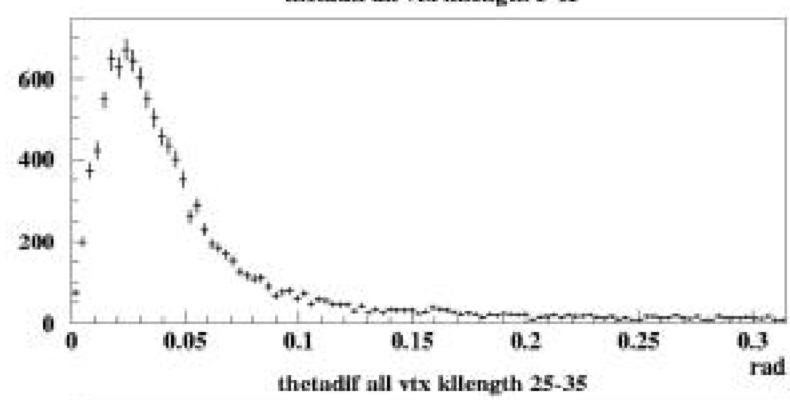
Look for a vertex inside a cone of aperture α around K_L direction:

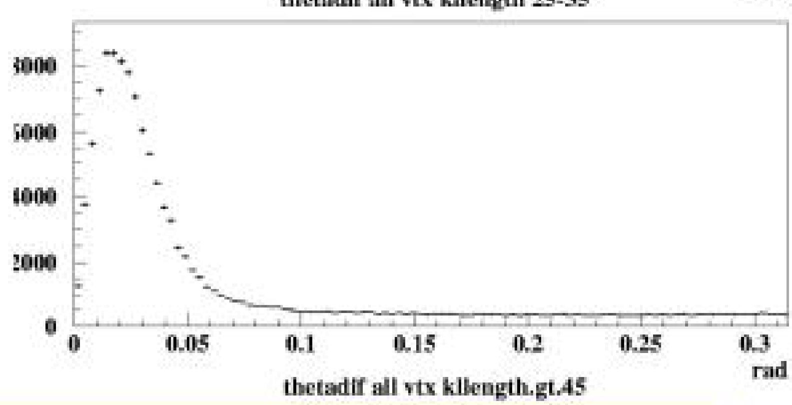
$$\alpha = 4\left[\sigma_\alpha^2 + \left(\frac{\sigma_\perp}{d}\right)^2\right]^{1/2}$$

$\sigma_\alpha = 0.025$ rad

$\sigma_\perp = 0.5$ cm







End up with

138755

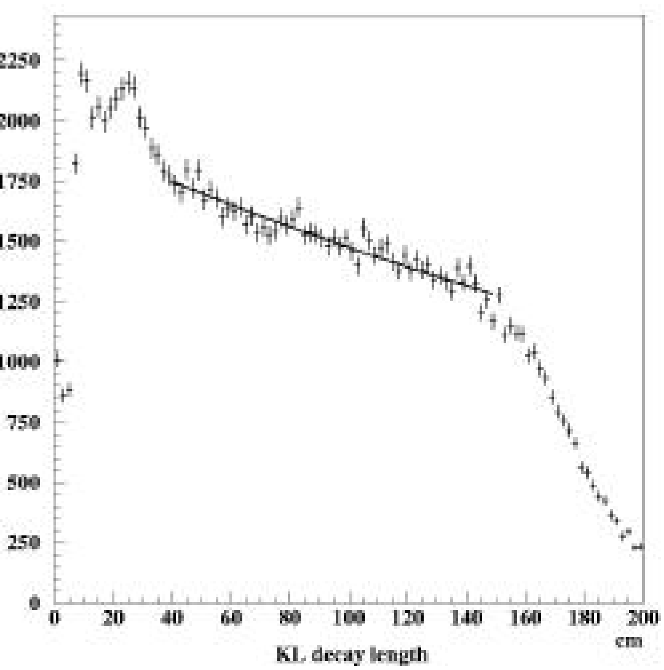
K_L candidates

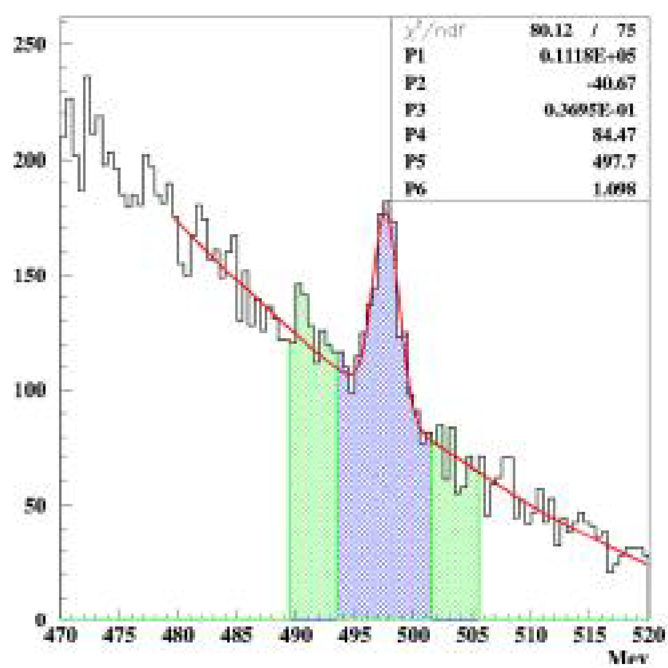
•Fit to K_L decay length: λ_{Kl}=352 ± 13 cm

•select signal requiring $M_{inv} \in 497.7 \pm 4$ MeV

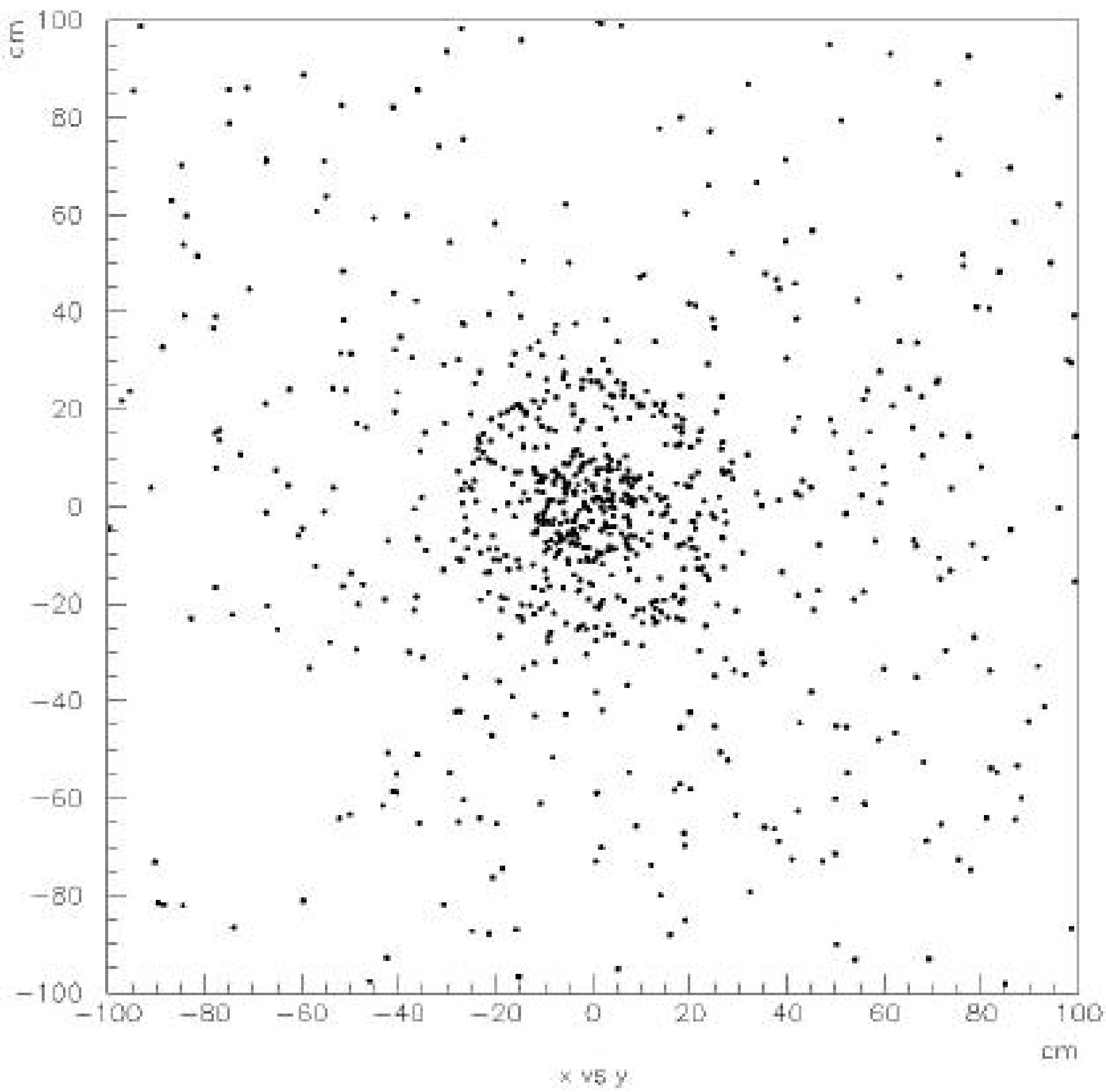
only regenerated K_s, $K_L \rightarrow \pi^+\pi^-$ survive, and a small background from semileptonic decays

•background studied using events in M_{inv} sidebands





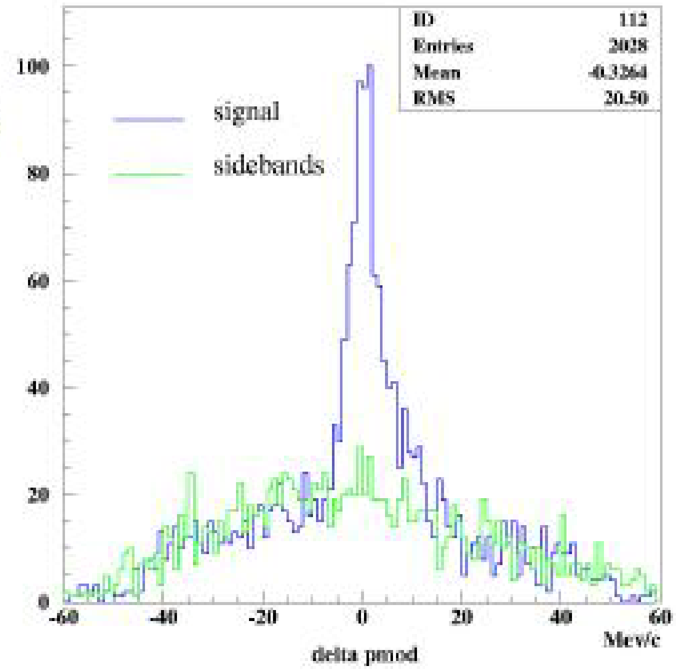
Regenerator shape well visible after M_{inv} cut:



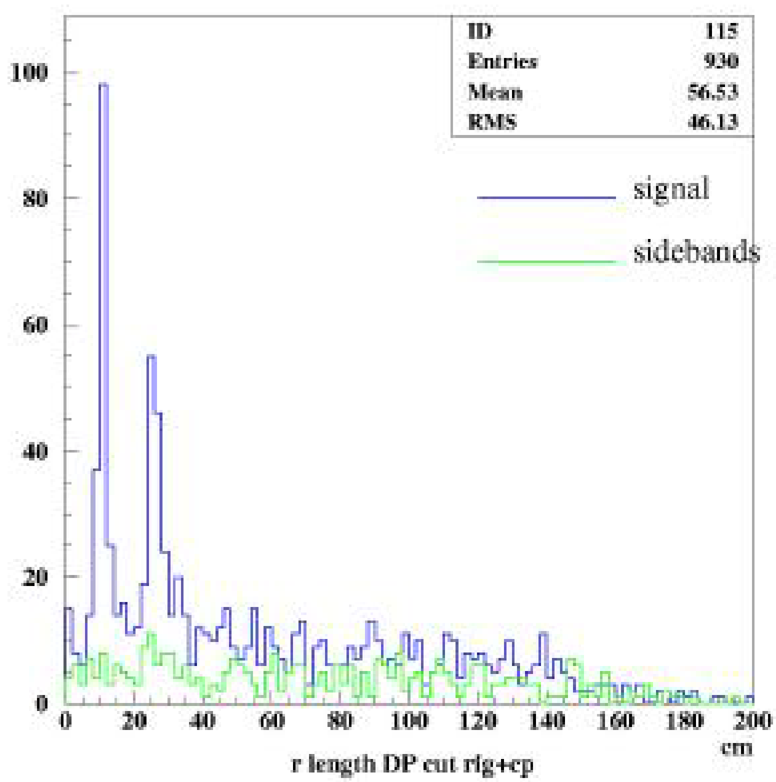
elastic selection:

To reduce semileptonic background, require:

$$-6 < |p_{vtx}| - |p^{estim}| < 12$$



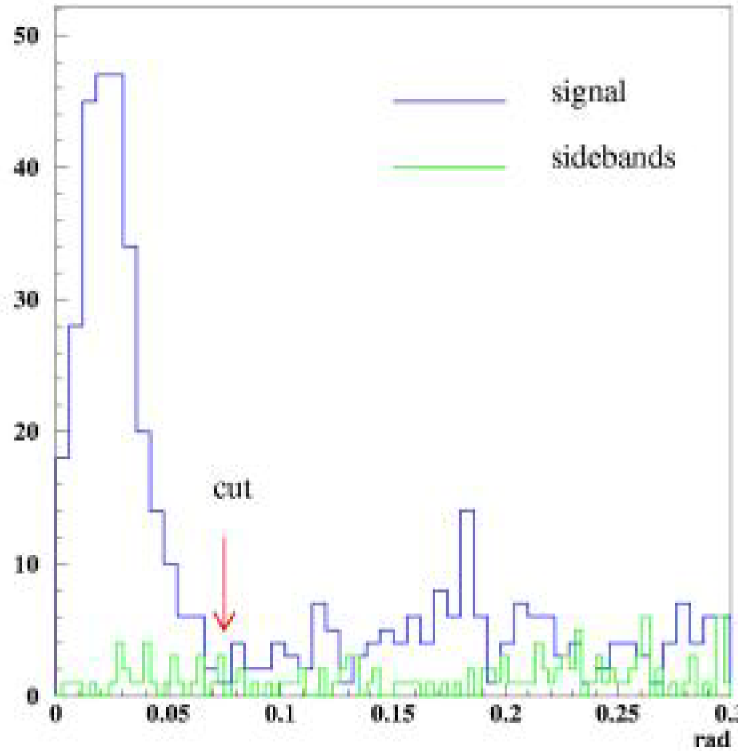
Obtain 930 events:



Rejection of $K_L \to \pi^+\pi^-$

Angle between p_{vtx} and p^{estim} small for $K_L \to \pi^+\pi^-$

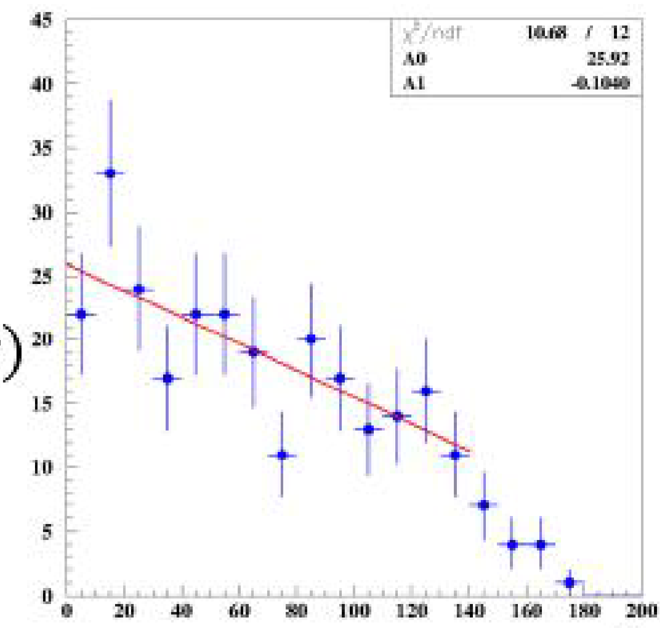
$\Rightarrow$ regenerated >0.075 rad



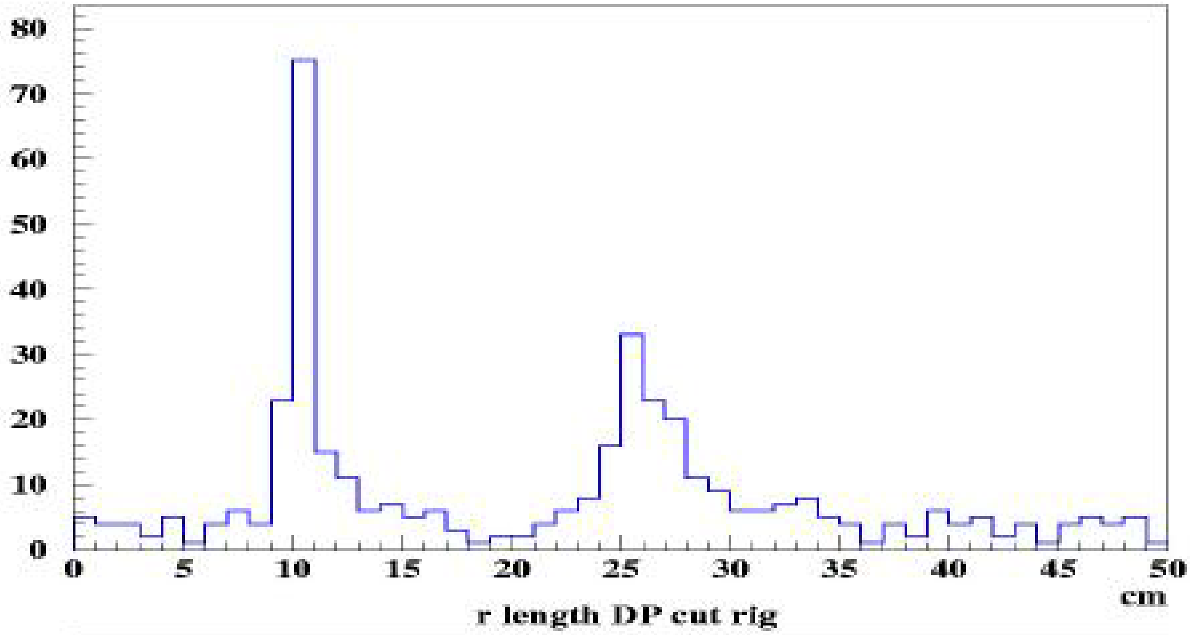
CP viol decay length used to evaluate efficiency as a function of the distance:

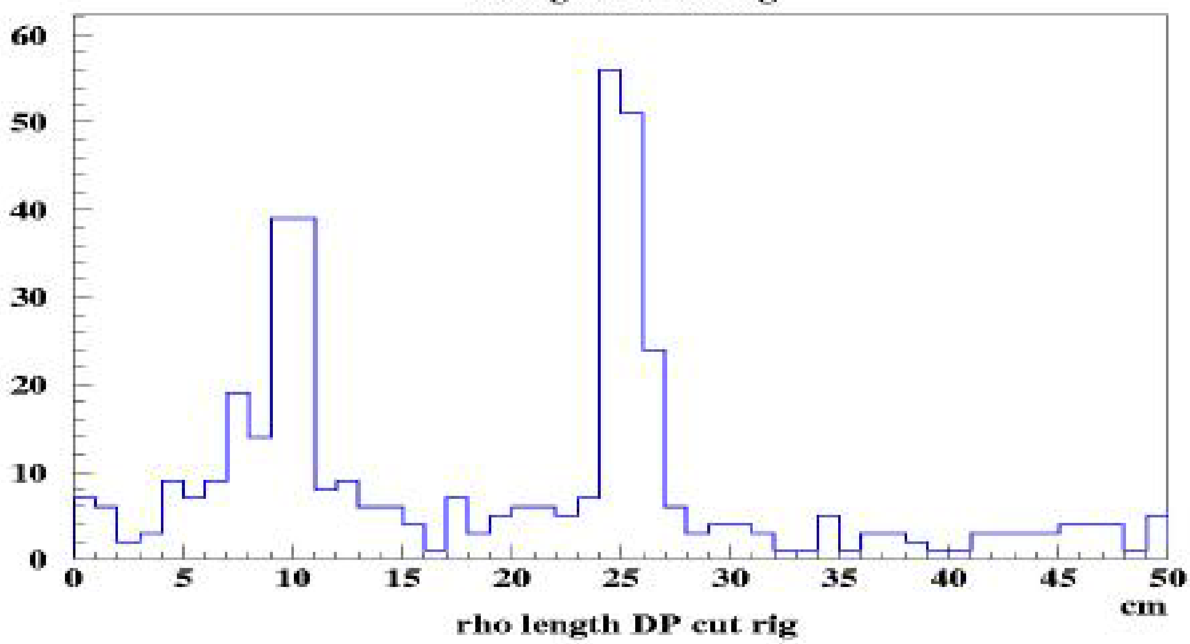
$$\frac{N_L B_{K_L \to \pi^+\pi^-}}{\lambda_{K_L}} e^{-x/\lambda}\varepsilon(x) = \frac{dN}{dx}(x)$$

n(x) obtained with a linear fit to $K_L \to \pi^+\pi^-$ dec length



$\langle\varepsilon\rangle \approx 50$ %





- Define: beam pipe: $9 < r < 13$ cm
  dc wall: $23 < \rho < 27$ cm

- events: $N_{bp} = 130 - 17 = 113 \pm 12$
  $N_{dc} = 144 - 13 = 131 \pm 13$

cross section

$$\boxed{N_{kl} e^{-x/\lambda} B_{KS\rightarrow\pi+\pi-}\ \varepsilon\ \sigma_{reg} \langle nt \rangle = N_{event}}$$

$$(nt) = N_A \Box \frac{\rho}{A} f$$

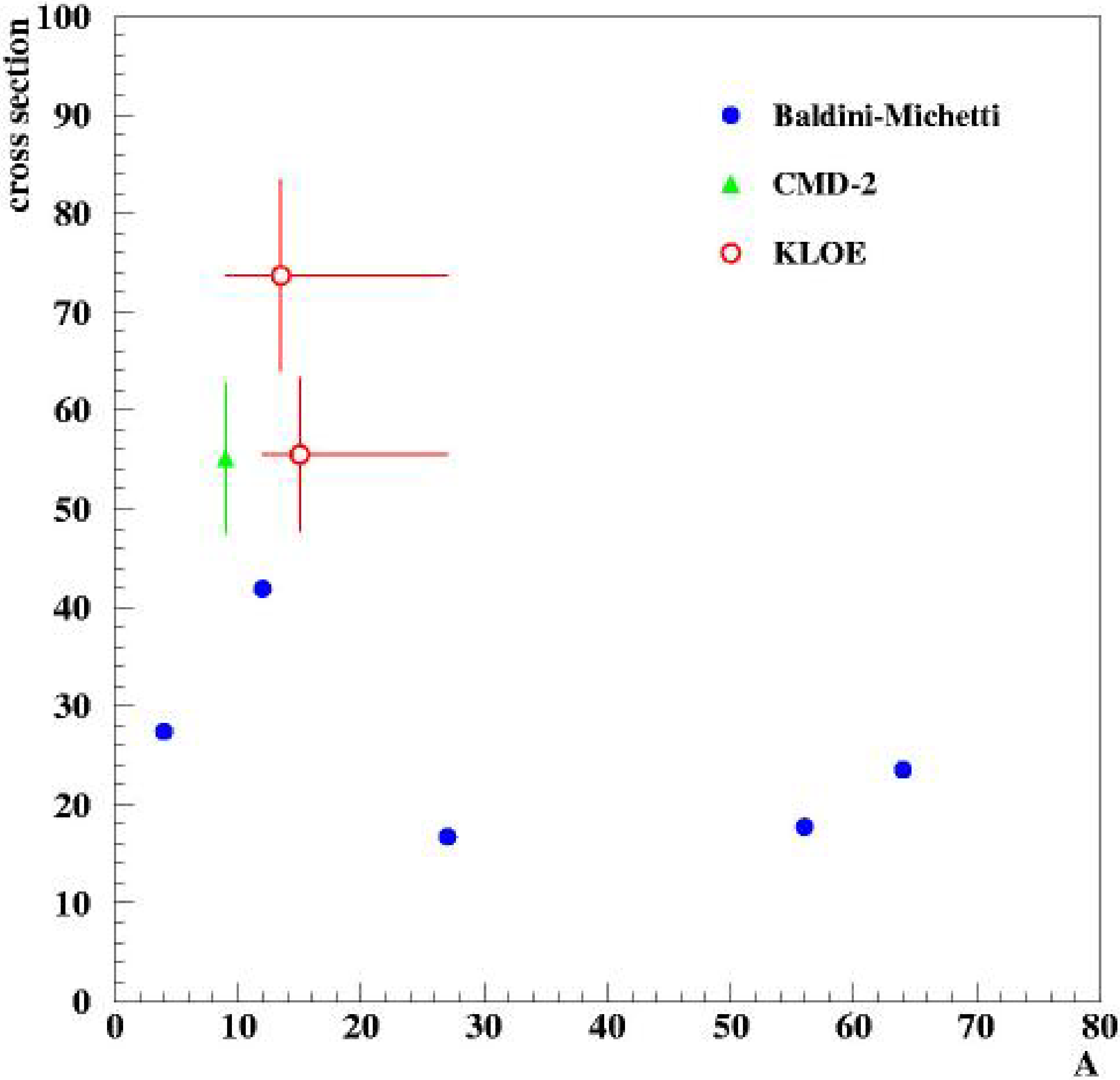
$$(nt)^{bp} = 4.92\ ?10^{-21} \qquad (nt)^{dc} = 6.67\ ?10^{-21}$$

$$\sigma = \frac{N_{even}}{\langle nt \rangle} ? \frac{B_{KL \blacklozenge \pi\pi}}{B_{KS \blacklozenge \pi\pi}} ? \frac{1}{\lambda ? \left.\frac{dN}{dx}\right|_{dc,bp}}$$

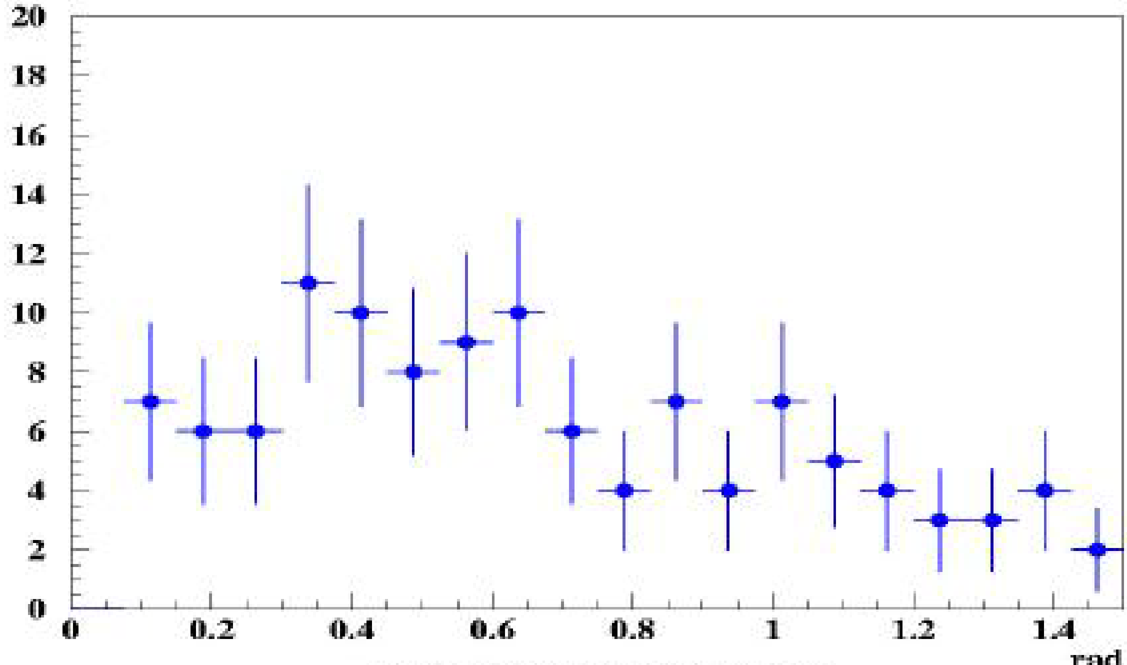
$$\boxed{\begin{array}{l} \sigma^{bp} = 73.7 \pm 9.7 \text{ mb} \\ \sigma^{dc} = 55.5 \pm 7.7 \text{ mb} \end{array}}$$

Only statisticalerrors computed

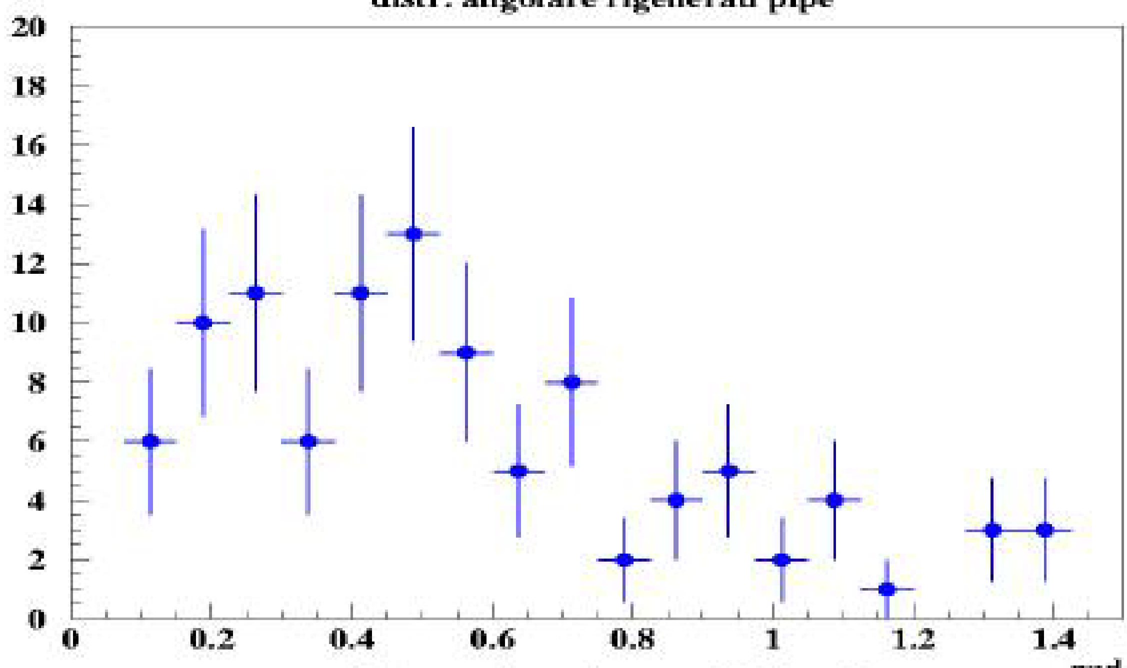
Comparison with calculations



Angular distributions of regenerated K_S



distr. angolare rigenerati pipe



distr. angolare rigenerati DC wall

Conclusions

- $K_L \rightarrow K_S$ regeneration observed on beam pipe and drift chamber wall

- cross section measured without use of MC corrections

- still some work to do to estimate systematic error due to the knowledge of regenerators

- agreement with theoretical calculations to be investigated