Search for the decay $K_s \to e^+e^-$

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on behalf of the KLOE collaboration

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KLOE experiment

Large cylindrical drift chamber:

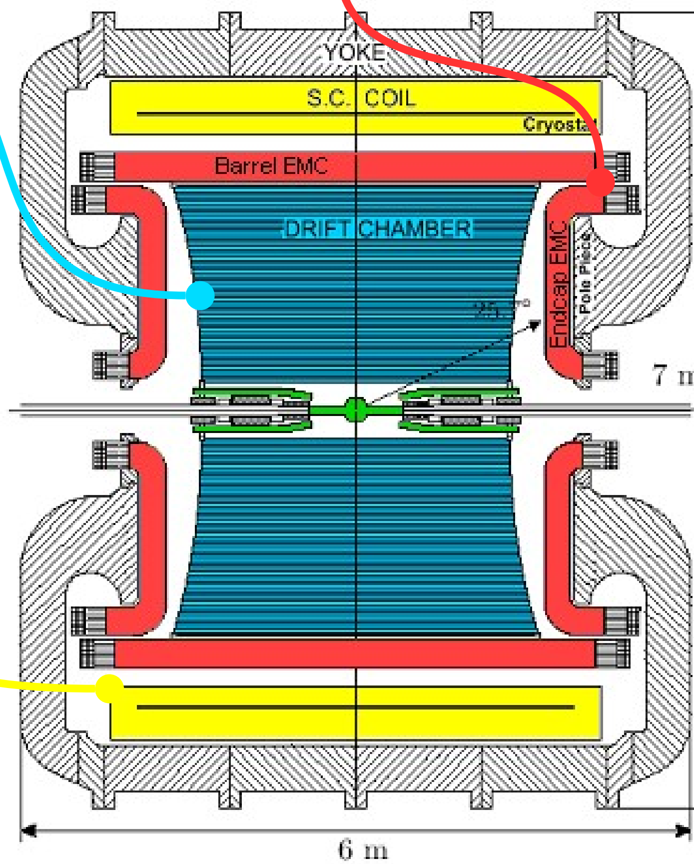
- 4 m diameter – 3.7 m length, carbon-fiber, gas: 90% He – 10% IsoC_4H_{10}
- σ_p/p = 0.4 % (track with $\theta > 45°$)
- σ_{xy}^{hit} = 150 μm, σ_z^{hit} = 2 mm, σ_{vtx} ~ 1 mm
- σ_M ~ 1 MeV

Lead/scintillating-fiber calorimeter:

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

Superconducting coil:

- $\langle B \rangle$ = 0.52 T



KLOE has collected ~ 2.2 fb^{-1} during 2001–2005 at DAΦNE collider.

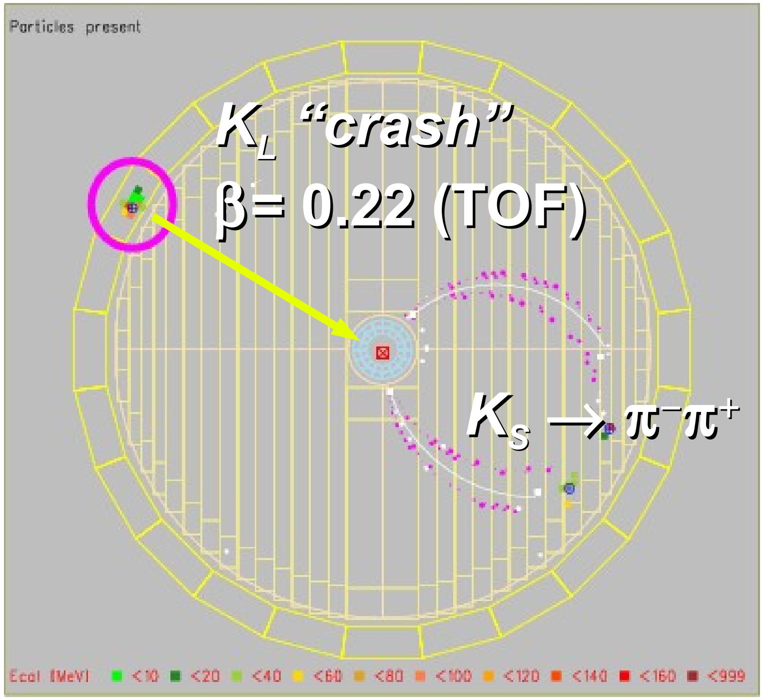
Tagging of K_S beam

DAΦNE collider produces ϕ almost at rest. The ϕ decay provides monochromatic and pure beam of kaons.

$$K_S \longleftarrow \phi \longrightarrow K_L$$

Pure $J^{PC} = 1^{--}$ state

$$\frac{1}{\sqrt{2}}\left(|K_L, p\rangle|K_S, -p\rangle - |K_L, -p\rangle|K_S, p\rangle\right)$$



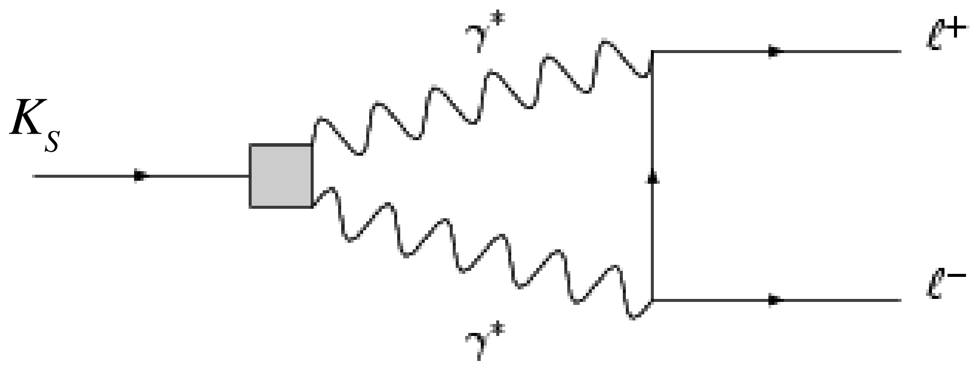
Tagging: observation of K_L (interacting with calorimeter) signals presence of K_S :

- K_S beam tagging with ~30% efficiency
- Kaon momentum is measured with 1 MeV resolution ($p(K_S) = p(\phi) - p(K_L)$)

K_SK_L
$10^6/pb^{-1}$
$p^* = 110$ MeV/c
$\lambda_S = 6$mm; $\lambda_L = 3.4$ m

Introduction

The $K_S \to e^+e^-$ decay is a flavour-changing neutral current process, suppressed in the SM. Decay amplitude is dominated by two photon intermediate state.



Using χPT $O(p^4)$ we obtain the SM prediction for the branching ratio:

$$BR(K_S \to e^+e^-) \approx 2 \times 10^{-14}$$

The best experimental limit to date has been given by CPLEAR and it is equal to 1.4×10^{-7}

SM prediction is so low leaving room for possible new physics effects to be detected

Data sample and preselection

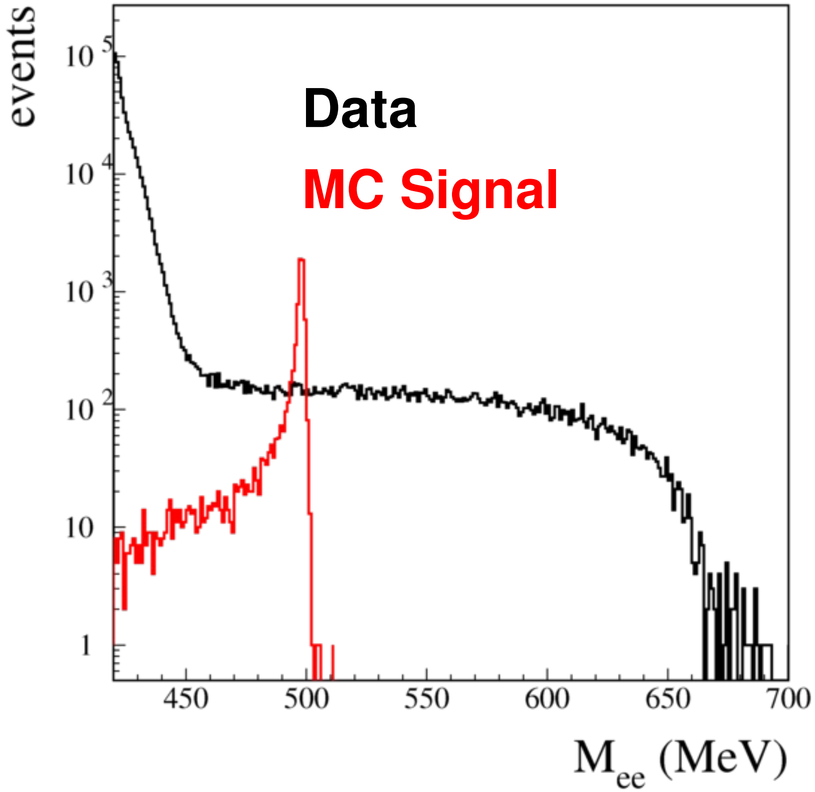
For this analysis 1.9 fb^{-1} of integrated luminosity has been used.

Tagged K_S : 650 $\times$ 10^6 events

~45000 events produced for MC signal

Preselection:

- 2 tracks with opposite charge from IP and momentum 120 < |p| < 350 MeV
- invariant mass in electron hypothesis Mee > 420 MeV



$$\epsilon_{sig} = \epsilon(tag)\epsilon(presel|tag) = 0.3 \times 0.534$$

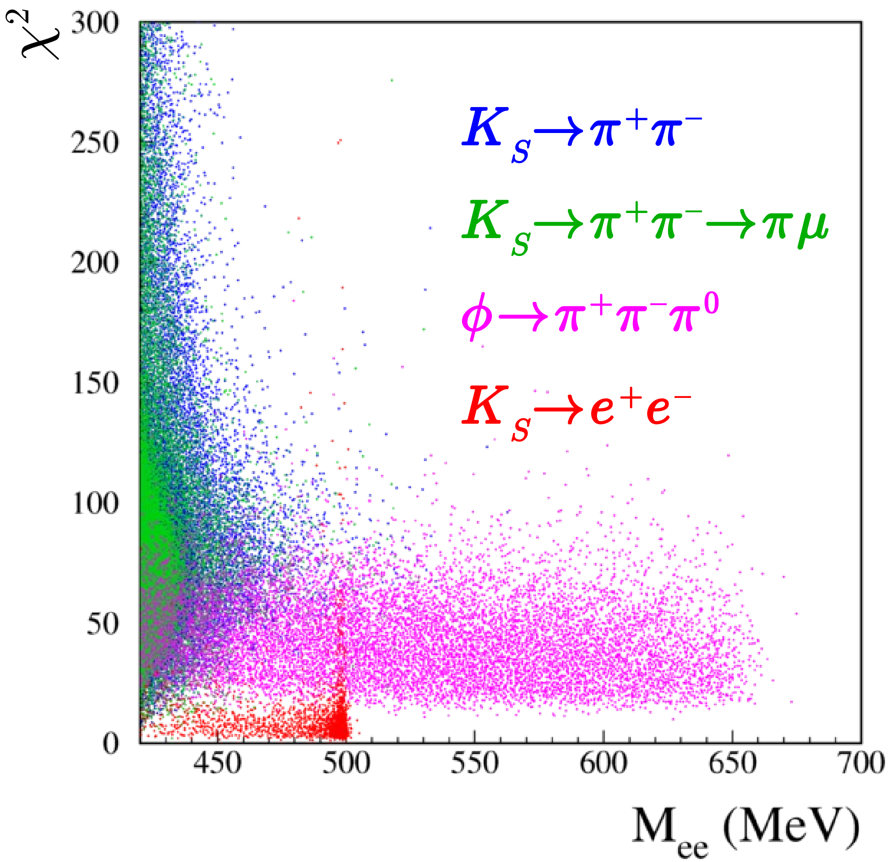
After preselection:

N_{obs} = 523 028

Calorimeter PID and bkg composition

For signal identification all cluster information are been collected into a χ^2-like variable, based on:

- TOF
- E/p
- distance between cluster and impact point of the track on calorimeter.



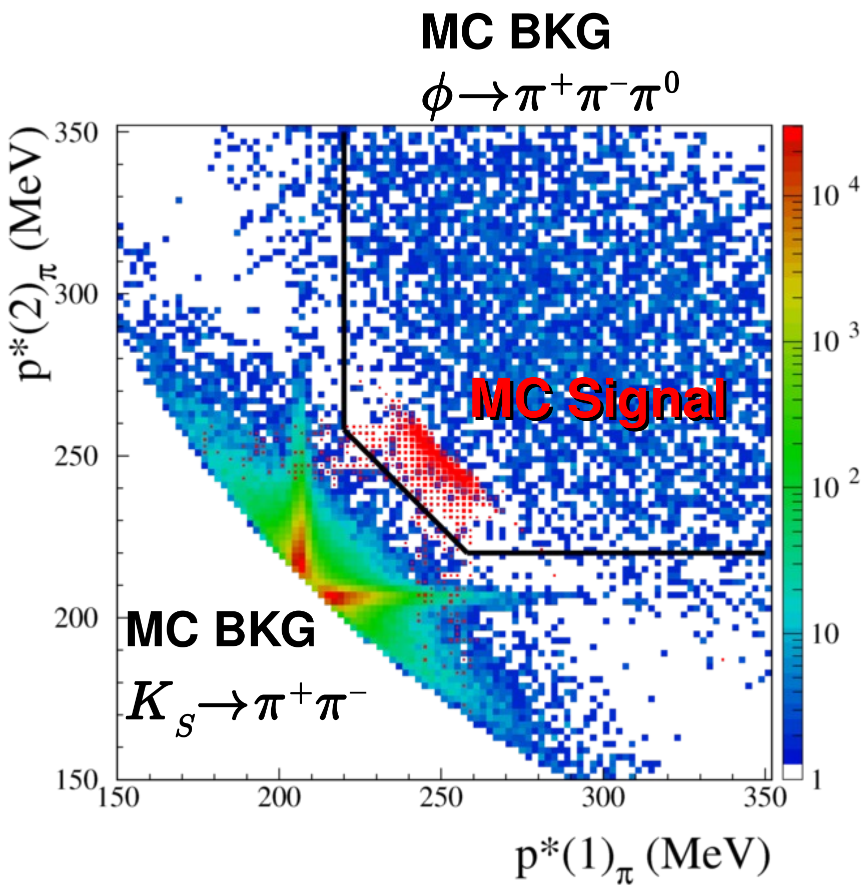
- $K_S \to \pi^+\pi^-$ events enter preselection because of tracks resolution
- $\phi \to \pi^+\pi^-\pi^0$ are selected by tagging algorithm with a fake K_L interaction

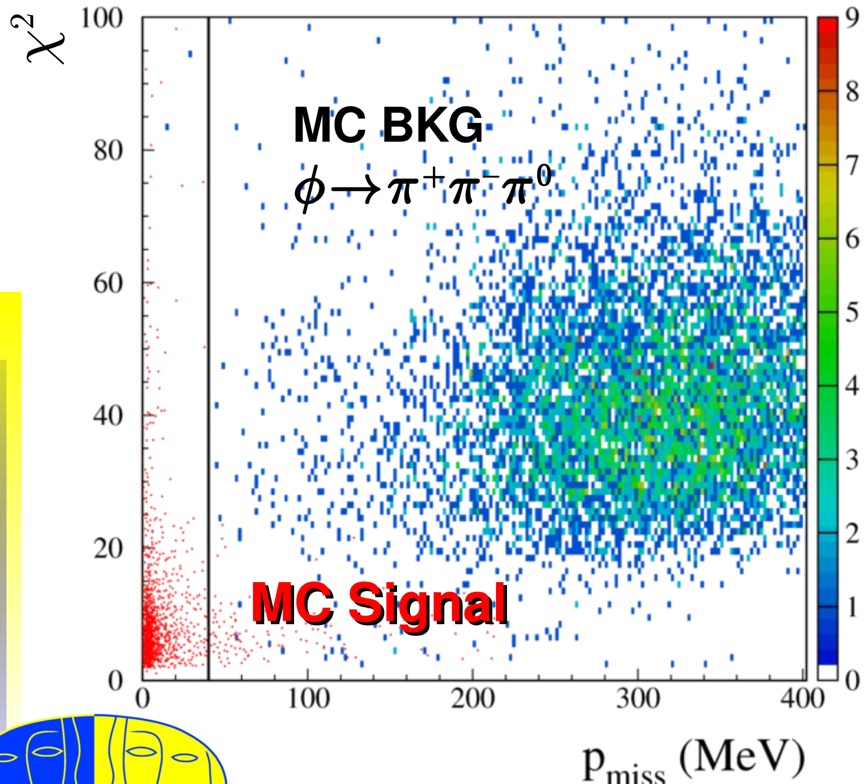
Background Rejection

Distribution of the track momenta in K_S rest frame (pion hypothesis) allow to reject most of $\pi^+\pi^-$ and $\pi\mu$ BKG events.

$$p^*_\pi > 220 MeV/c$$

$$p^*_\pi(1) + p^*_\pi(2) > 478 MeV/c$$



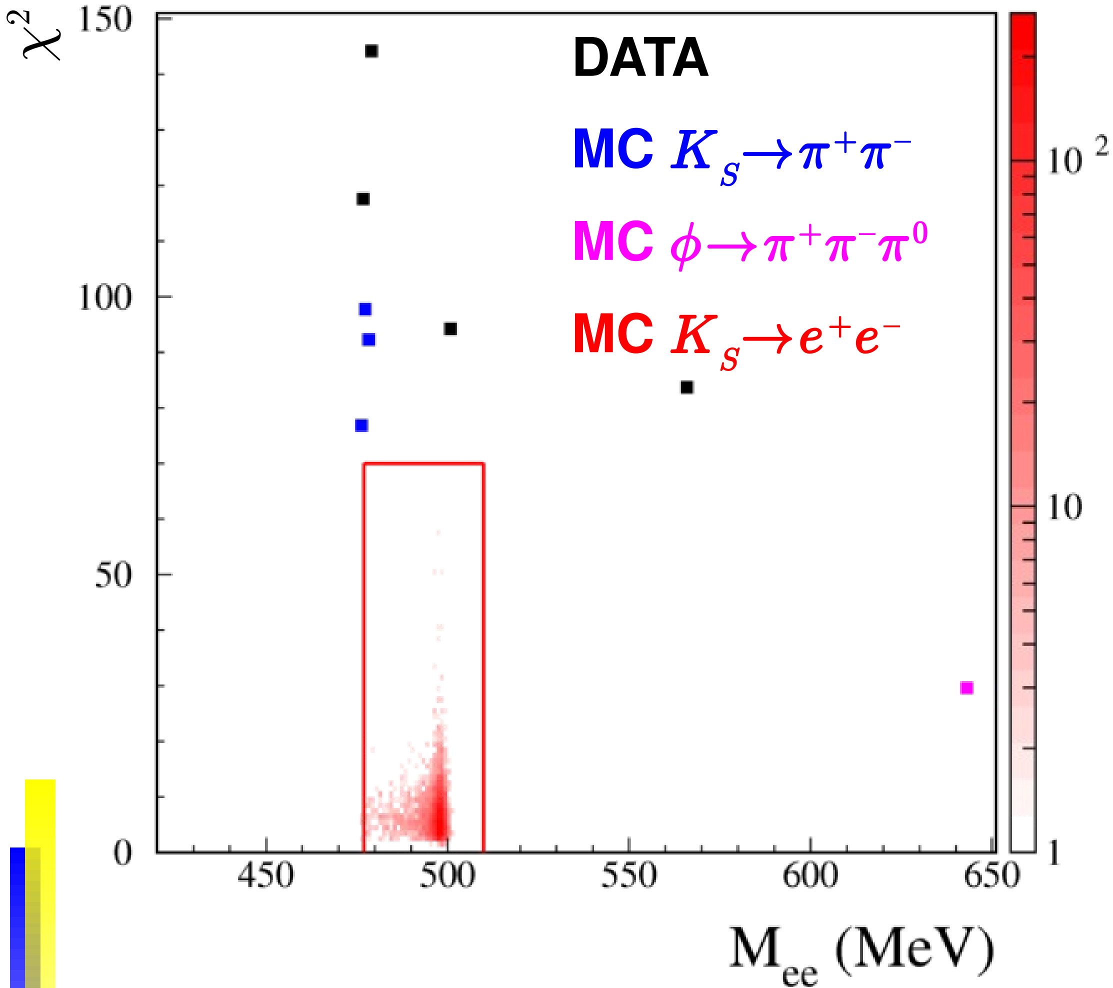


To reject $\phi \to \pi^+\pi^-\pi^0$ background events a cut on p_{miss} variable has been applied.

$$|\vec{p}_{miss}| = |\vec{p}_\phi - \vec{p}_S - \vec{p}_L|$$

$$|\vec{p}_{miss}| \leq 40\, MeV$$

Signal box



At the end of rejection algorithm we define a signal box on M_{ee} in order to include up to 20 MeV γ from IB.

$$477 \leq M_{ee} < 510 MeV$$

A cut on χ^2 is also applied to reject MC background events

$$\chi^2 < 70$$

Upper Limit evaluation

In data sample we find $N_{obs} = 0$ and 0 events in MC BKG sample.

The Upper limit for the number of signal events μ_{sig} is: UL(μ_{sig}) = 2.3 @ 90% CL

Using the following efficiencies:

$$\varepsilon_{sig}(sele|tag) = (0.534 \times 0.871) = 0.465(4)$$
$$\varepsilon_{\pi\pi}(sele|tag) = 0.6102(5)$$

Having normalized to:

$$N_{\pi\pi} = 217\,422\,768$$

we have:

$$UL(BR) = UL(\mu_{sig}) \times \frac{\epsilon_{\pi\pi}(sele|tag)}{\epsilon_{sig}(sele|tag)} \times \frac{BR_{\pi\pi}}{N_{\pi\pi}} = 9.3 \times 10^{-9} \,@\, 90\%\, CL$$

We improve by more than 1 order of magnitude on the present best limit.

SPARES

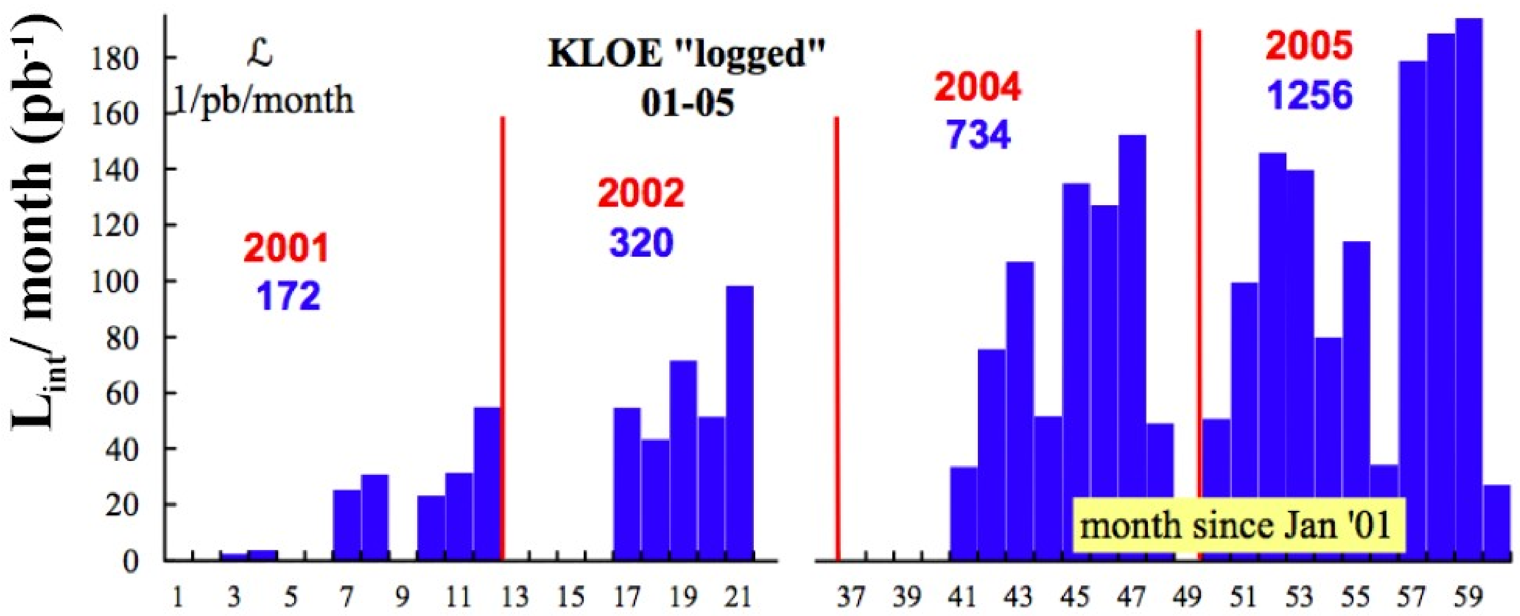
DAΦNE collider

DAΦNE is a e^+e^- collider that works at the peak energy of the ϕ mass:

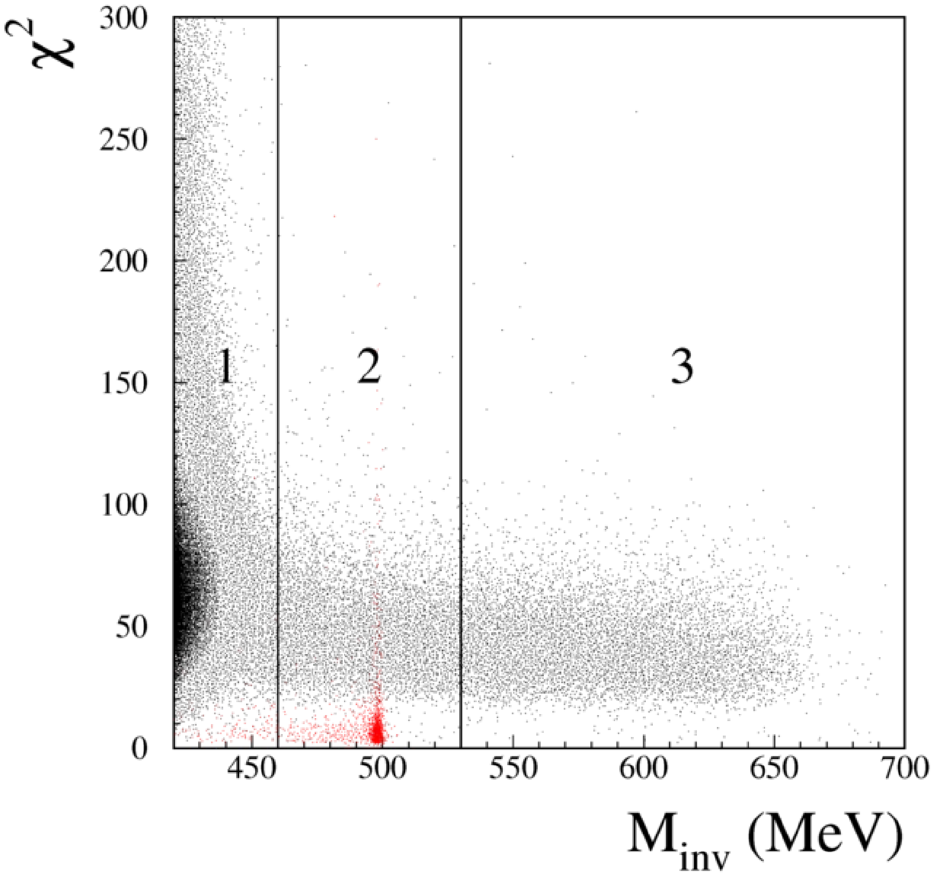
$\sqrt{s} \sim 1019.4$ MeV

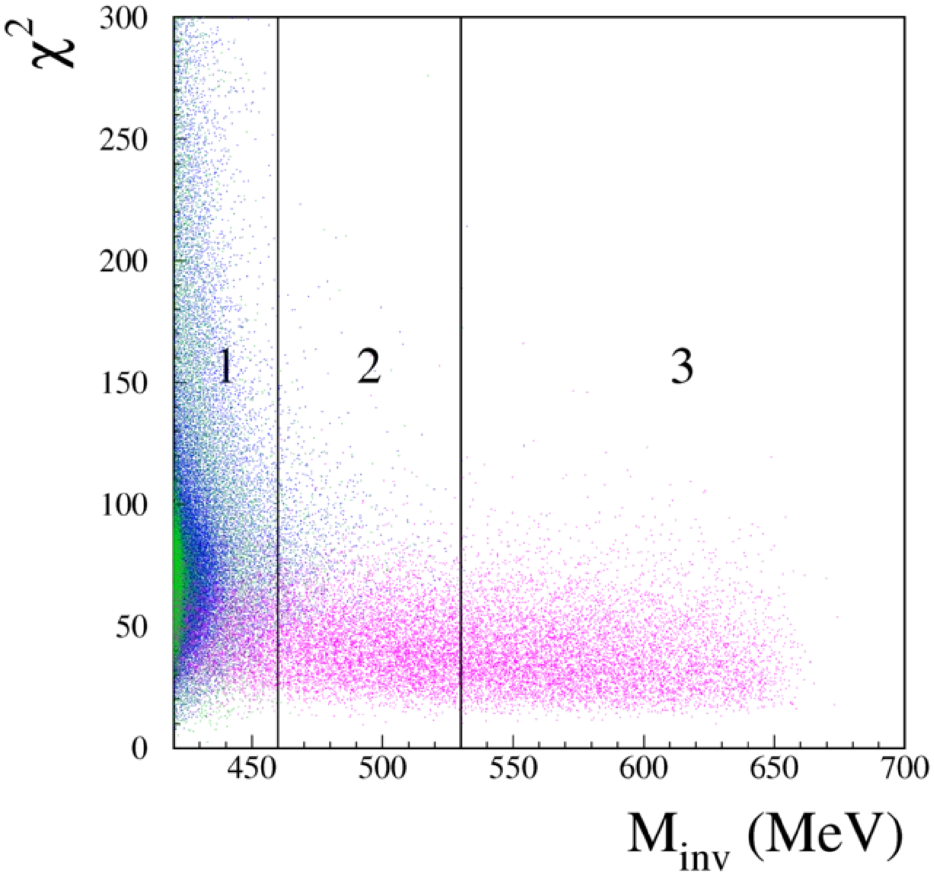
Cross section for ϕ production at peak is: $\sigma_{peak} \sim 3\mu b \rightarrow L_{peak} = 1.4 \times 10^{32} cm^{-2}s^{-1}$

2.5 fb^{-1} on tape @ $\sqrt{s} \sim M_\phi$ (~ 8 10^9 ϕ produced)



Signal and Background in $M_{ee} - \chi^2$ plane





	M_{ee} (MeV/c^2)	
REGION 1	420-460	Sideband
REGION 2	460-530	
REGION 3	530-700	Sideband

A) Green: $K_S \rightarrow \pi^+ \pi^- \rightarrow \pi \mu$

B) Blue: $K_S \rightarrow \pi^+ \pi^-$

C) Purple: $\phi \rightarrow \pi^+ \pi^- \pi^0$

DATA vs MC: Region 1 and 3

Check reliability of background normalization after each cut on M_{ee} sidebands

Region 1 ($420<M_{ee}<460$ MeV)

Cut	Data	MC BKG	$(\text{Data-MC})/\sigma_{DATA+MC}$
Preselection	**500314**	**501339±1249**	**-0.71**
p^*_π cut	**3738**	**3984±1021**	**-2.09**
$N_{prompt}\leqslant 1$	**1516**	**1716±59**	**-2.83**
$p_{miss}<40$ MeV	**0**	**0**	

Region 3 ($M_{ee}>530$ MeV)

Cut	Data	MC BKG	$(\text{Data-MC})/\sigma_{DATA+MC}$
Preselection	**12201**	**12214±233**	**-0.05**
p^*_π cut	**12107**	**12135±232**	**-0.11**
$N_{prompt}\leqslant 1$	**5041**	**5092±121**	**-0.36**
$p_{miss}<40$ MeV	**1**	**1 ev 3π x 1.75**	