Recent results from NA48 experiment

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on behalf of NA48 collaboration

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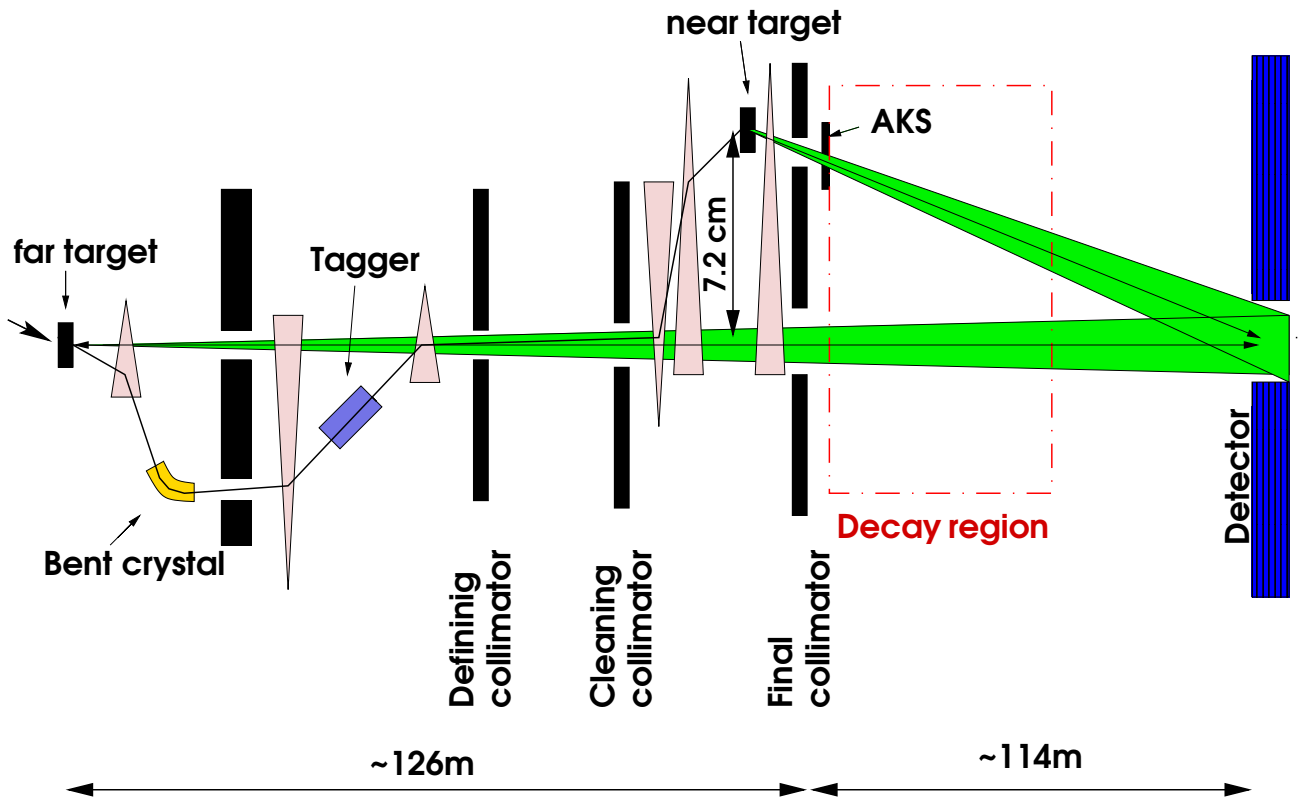
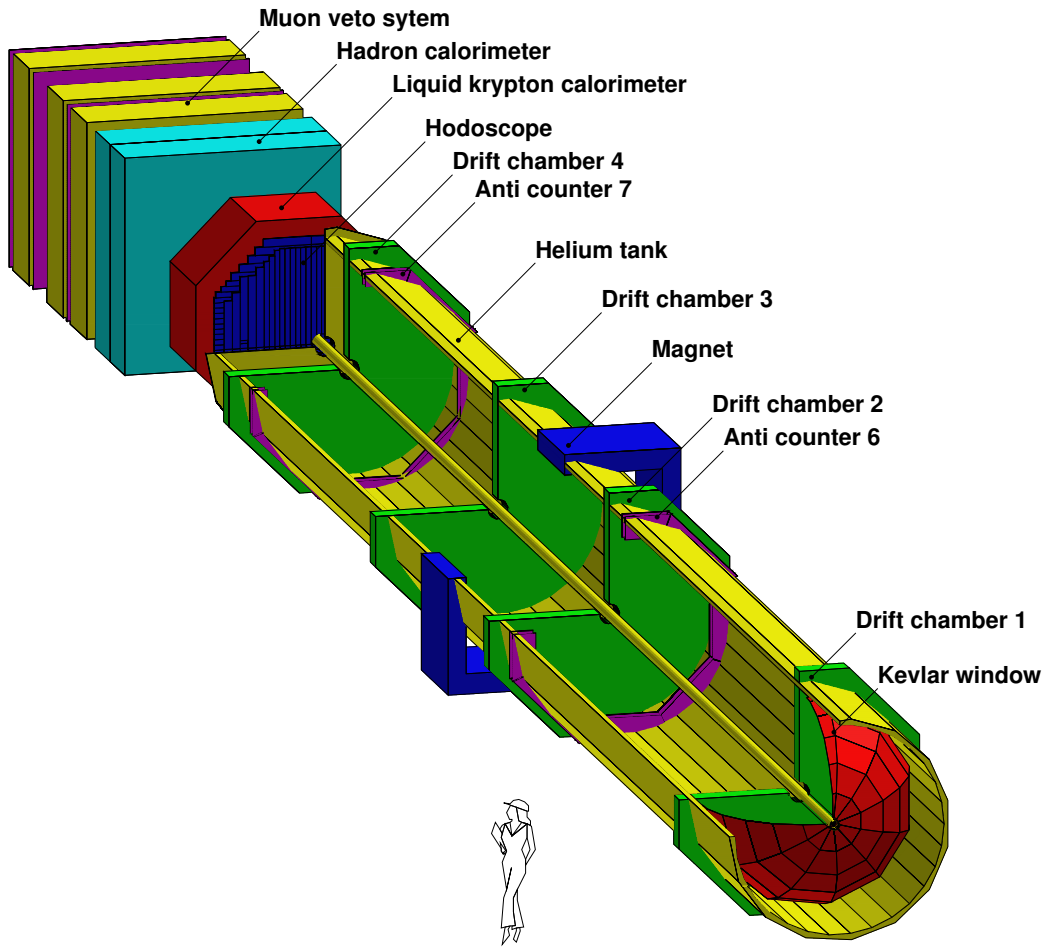
Chiral Perturbation Theory tests

- χPT describes low energy processes where QCD is non-perturbative
- It is based on perturbative expansion of momenta and masses: $\frac{p^2}{(4\pi F_\pi)^2}, \frac{m^2}{(4\pi F_\pi)^2}$ where $(4\pi F_\pi) \sim 1.2$ GeV
- Two experimental tests of the theory will be presented
  - $K_S \to \gamma\gamma$
  - $K_S \to \pi^0\gamma\gamma$
- They all have $\mathcal{O}(p^2) = 0$ and $\mathcal{O}(p^4)$ precisely predicted

The beam


near target
AKS
7.2 cm
far target
Tagger
Bent crystal
Definig collimator
Cleaning collimator
Final collimator
Decay region
Detector
~126m
~114m

The detector



NA48 data taking periods

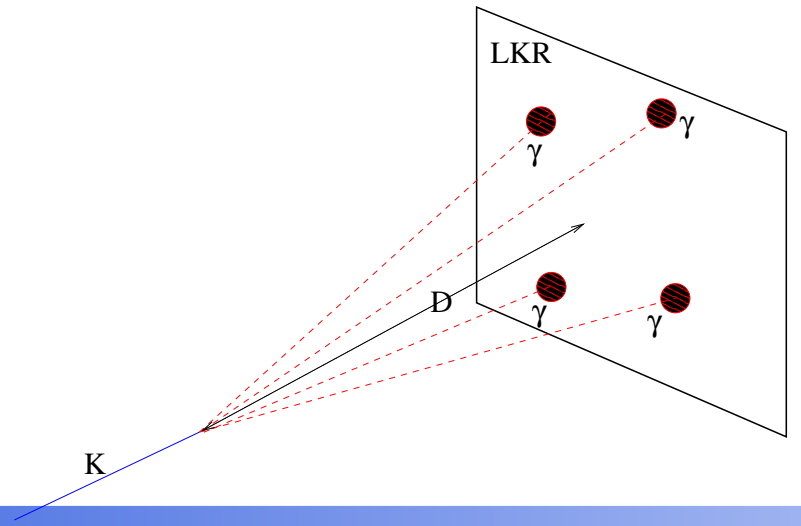
Year	Beam type	Physics program
1997	$\mathrm{K_L} + \mathrm{K_S}$	ε'/ε
1998	$\mathrm{K_L} + \mathrm{K_S}$	ε'/ε, $\mathrm{K_S}$ lifetime, $\mathrm{K_L} \to \pi^0\gamma\gamma$, ...
1999	$\mathrm{K_L} + \mathrm{K_S}$	ε'/ε, $\mathrm{K_L} \to \pi^0\gamma\gamma$, ...
2000 No spectrometer	$\mathrm{K_L}$ only	K^0 mass, $\mathrm{K_L} \to \gamma\gamma$, ε'/ε checks
	η run	η mass
	$\mathrm{K_S}$ high intensity	$\mathrm{K_S} \to \gamma\gamma$, ...
2001	$\mathrm{K_L} + \mathrm{K_S}$	ε'/ε
2002	$\mathrm{K_S}$ high intensity	Hyperon physics, $\mathrm{K_S}$ rare decays
2003	$\mathrm{K^+}, \mathrm{K^-}$	$\mathcal{CP}$ violation in charged Kaons

The z_{vertex} reconstruction

$$z_{vertex} = z_{LKR} - \frac{1}{m_{K_0}} \sqrt{\sum_{i,j<i} E_i E_j [(x_i - x_j)^2 + (y_i - y_j)^2]}$$

Requirements for Kaon decay vertex reconstruction

- Good cluster energy resolution
- Good impact point resolution



$$\frac{\sigma(E)}{E} = \frac{0.09}{E} \oplus \frac{0.032}{\sqrt{E}} \oplus 0.0042$$

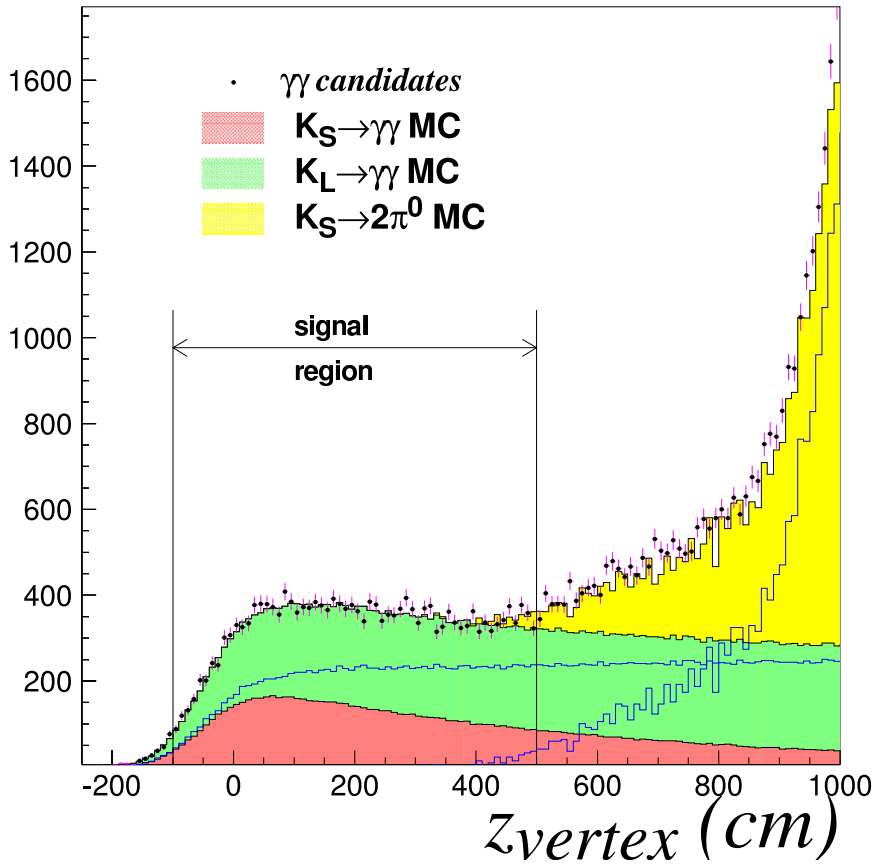
$$\sigma_{x,y} = 1.3 \text{ mm}$$

$$\sigma_t = 300 \text{ ps}$$

$\mathrm{K_S} \to \gamma\gamma$

- χPT at $\mathcal{O}(p^4)$ predicts BR $= 2.1 \times 10^{-6}$ (few % error)
  (D'Ambrosio-Espriu, J.L. Goity)
- Data from 2000 near-target run.
- Main background sources
  - $K_S \to \pi^0\pi^0$ with two showers in LKR:
    - overestimation of z_{rec} (> 9 meters)
    - decay region -1 m $< z_{vertex} < 5$ m
  - $K_L \to \gamma\gamma$ irreducible ($\sim 1.5\ \mathrm{K_S} \to \gamma\gamma$)
    - $K_L \to 3\pi^0$ to estimate K_L flux
    - "far-target" data used to measure $\frac{\Gamma(K_L \to \gamma\gamma)}{\Gamma(K_L \to 3\pi^0)}$

Background subtraction



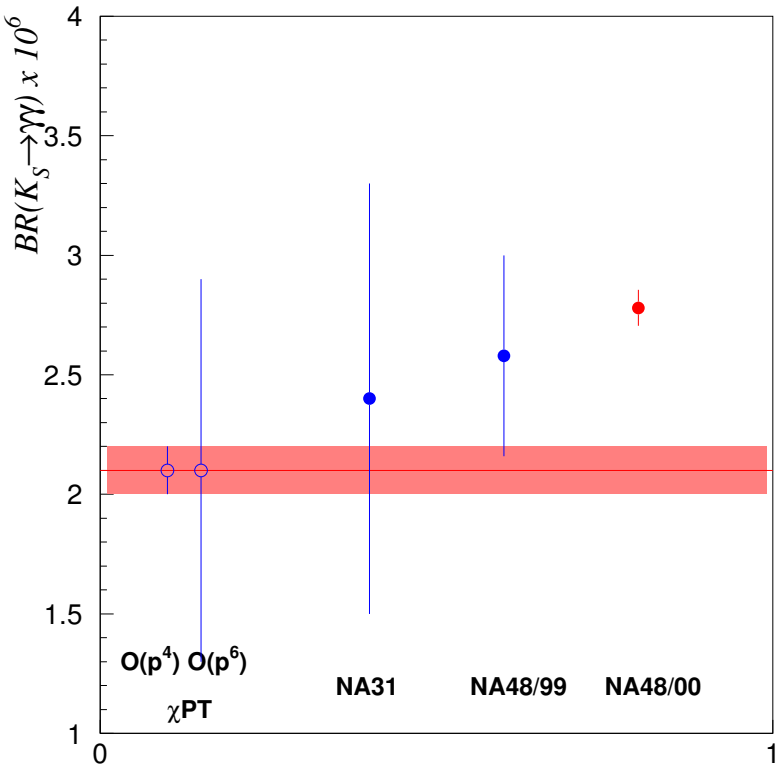
- Background from $\pi^0\pi^0$ subtracted using MC normalized to the fully reconstructed $\pi^0\pi^0$ events
- $K_L \to \gamma\gamma$ estimated from the "far-target" run because from PDG

$$\frac{\Gamma(K_L \to \gamma\gamma)}{\Gamma(K_L \to 3\pi^0)} = (2.77 \pm 0.08) \times 10^{-3}$$

Not enough precise !

$$\frac{\Gamma(K_L \to \gamma\gamma)}{\Gamma(K_L \to 3\pi^0)} = (2.81 \pm 0.01_{stat} \pm 0.02_{syst}) \times 10^{-3}$$

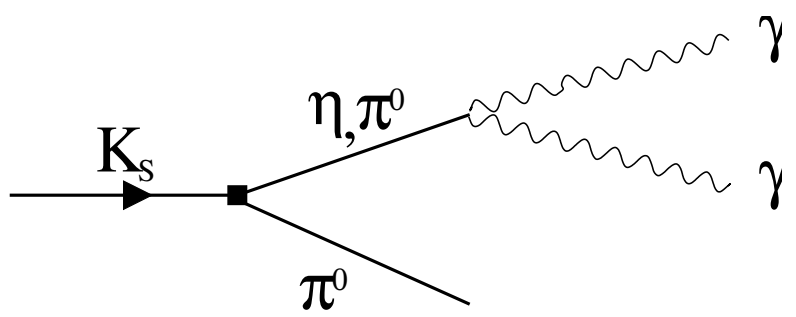
Experiment-theory comparison

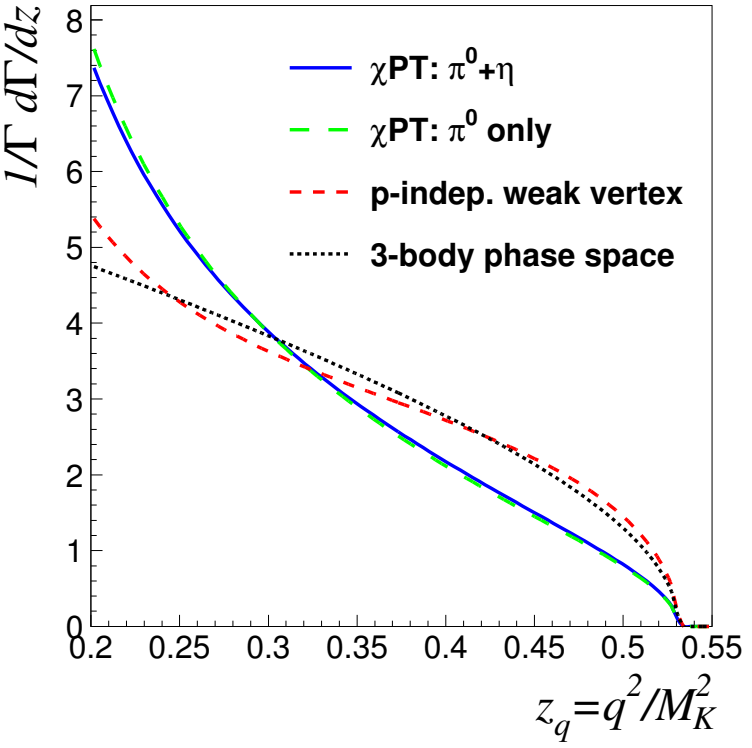


- Compatibility with previous measurements.
- NA48/00 differs by 30% from $\mathcal{O}(p^4)$ prediction of $\chi PT \implies$ Indication of a large $\mathcal{O}(p^6)$ contribution.

$$BR(K_S \to \gamma\gamma) = (2.78 \pm 0.06_{sys} \pm 0.03_{stat} \pm 0.02_{ext}) \times 10^{-6}$$

$K_S \to \pi^0\gamma\gamma$: theory





- Chiral structure of weak vertex is testable from the distribution of

$z_q = (m_{\gamma\gamma}/m_K)^2$

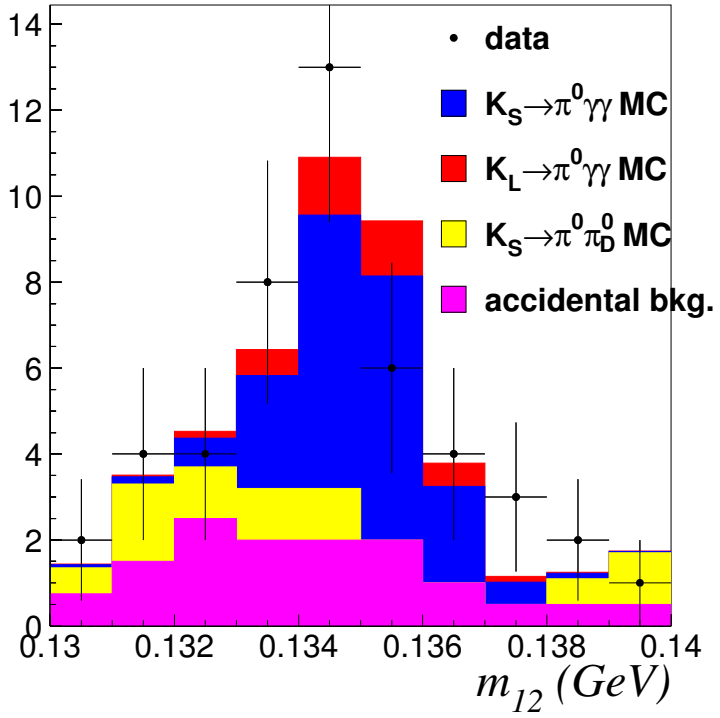
Ecker, Pitch and de Rafael: Phys. Lett B 189 (1987) 363

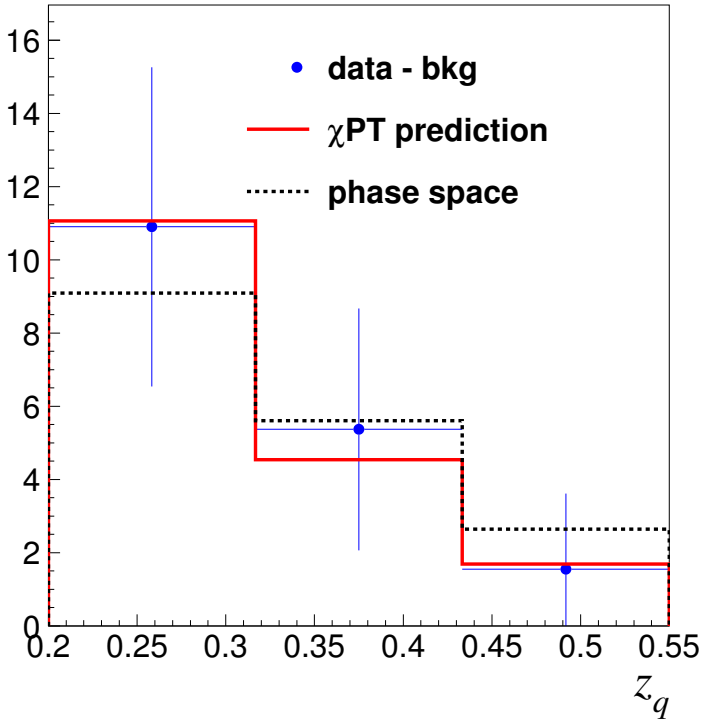
$$\mathrm{BR}(K_S \to \pi^0\gamma\gamma)_{z>0.2} = 3.8 \times 10^{-8}$$

Data analysis: preliminary

- Data sample from 2000 near-target data
- Normalization to $K_S \to 2\pi^0$
- Main background contributions
  - $K_S \to \pi^0\pi^0$, $K_S \to \pi^0\pi^0_D$: rejected by kinematic cuts
  - $K_L \to \pi^0\gamma\gamma$: irreducible
  - $\Xi^0 \to \Lambda\pi^0 \to n\pi^0\pi^0$
    - E_γ asymmetries cuts
    - Estimated using neutron shower profile distribution
  - Beam activity: rejected by time cuts + anticounters

Signal & Background





Preliminary result

$$\mathrm{BR}(K_S \to \pi^0\gamma\gamma)_{z>0.2} = (4.9 \pm 1.6_{stat} \pm 0.8_{syst}) \times 10^{-8}$$

Not enough statistics to test the chiral structure of the weak vertex.

Summary

- Two tests of the χPT performed by the analysis of the data collected by the NA48 experiment have been presented.
- The results show that
  - The $K_S \to \gamma\gamma$ can be described only invoking the $\mathcal{O}(p^6)$ terms of the theory
  - More statistics is needed to prove the chiral structure of the weak vertex in the $K_S \to \pi^0\gamma\gamma$