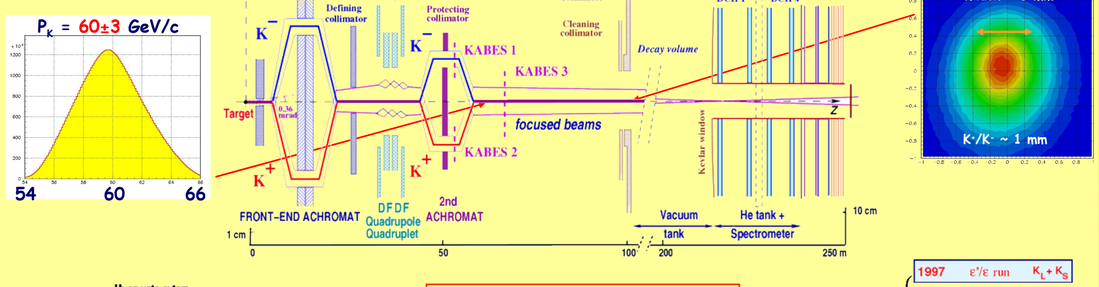
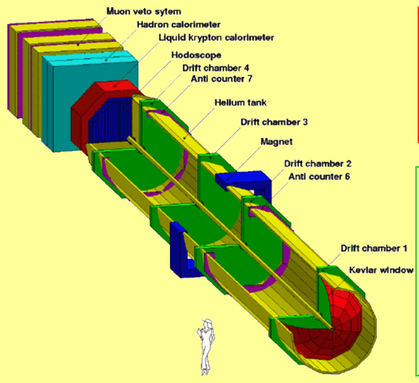
Precision Measurements of Kaon Radiative Decays at NA48/2

NA48/2

Simultaneous K^+ and K^- beams:
Flux ratio: K^+/K^- ~ 1.8





LKr EM calorimeter

$$\frac{\sigma(E)}{E} = \frac{3.2\%}{\sqrt{E}} \oplus \frac{0.1}{E} \oplus 0.5\%$$

$$\sigma_{x,y} < 1.3mm$$

Spectrometer

- 4 Drift Chambers
- Magnet

$$\frac{\sigma(p)}{p} = 1.0\% \oplus 0.044 \times p(GeV)$$

$$\sigma^{x,y}_{VTX} \sim 2mm$$

NA48	1997	ε'/ε run	$K_L + K_S$
	1998	ε'/ε run	$K_L + K_S$
	1999	ε'/ε run	$K_L + K_S$ / K_S Hi Int
	2000	K_L only / NO Spectrometer	K_S High Intensity
	2001	ε'/ε run	$K_L + K_S$ / K_S High Int.
NA48/1	2002	K_S High Intensity	
NA48/2	2003	$K^\pm$ High Intensity	
	2004	$K^\pm$ High Intensity	

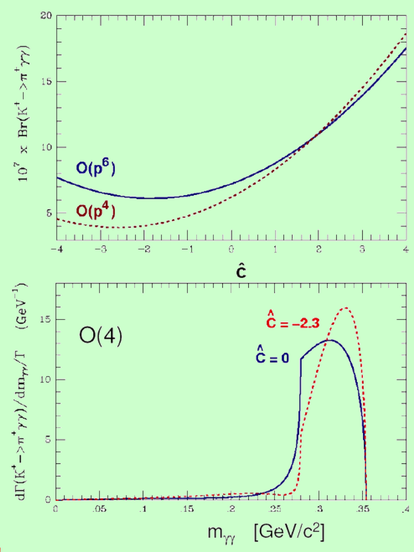
$K^\pm \to \pi^\pm\gamma\gamma$

$$z = \frac{(q_1+q_2)^2}{m_{K^+}^2} = \frac{m_{\gamma\gamma}^2}{m_{K^+}^2} \qquad y = \frac{p\cdot(q_1-q_2)}{m_{K^+}^2}$$

$$\frac{\partial^2\Gamma}{\partial y \partial z} = \frac{m_{K^+}}{(8\pi)^3}\left[z^2(|A+B|^2 + |C|^2) + \left(y^2 - \frac{1}{4}\lambda(1, r_\pi^2, z)\right)^2 (|B|^2 + |D|^2)\right]$$

Relevant only @ low $m_{\gamma\gamma}$

Previous measurement E787:
BR=(1.1±0.32)·10⁻⁶ ĉ=1.8±0.6
Based on 31 events 5 BG events



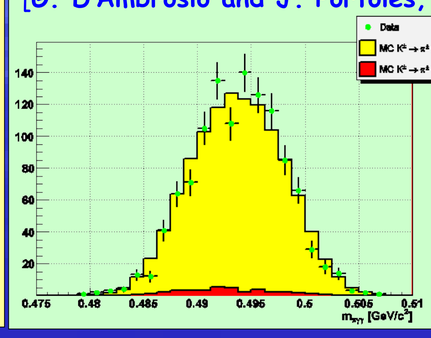
$O(p^4)$ in χPT: B=D=0; A: loop diagrams contribution,
C: WZW anomaly (10%)

$$\Gamma(K^\pm \to \pi^\pm\gamma\gamma) = \Gamma_{loop} + \Gamma_{WZW}$$

$$\Gamma_{loop} = (2.80 + 0.87\cdot\hat{c} + 0.17\cdot\hat{c}^2)\cdot 10^{-23} GeV$$

$$\Gamma_{WZW} = 0.26\cdot 10^{-23} GeV$$

$O(p^6)$ χPT: unitarity corrections can increase BR by 30-40 %
[G. D'Ambrosio and J. Portoles, Nucl., Phys. B386 (1996), 403]



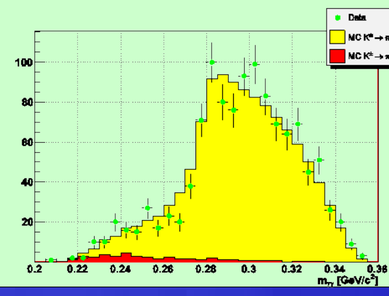
2003+2004 data: 4155 cand.

Preliminary:

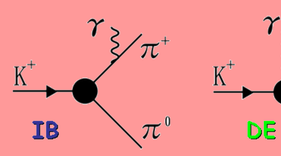
$\hat{C} = 1.67 \pm 0.07_{sta} \pm 0.34_{sys}$

$BR_{(O(p6),z>0.24)}$=

$(0.963 \pm 0.019_{sta} \pm 0.052_{sys})\cdot 10^{-6}$



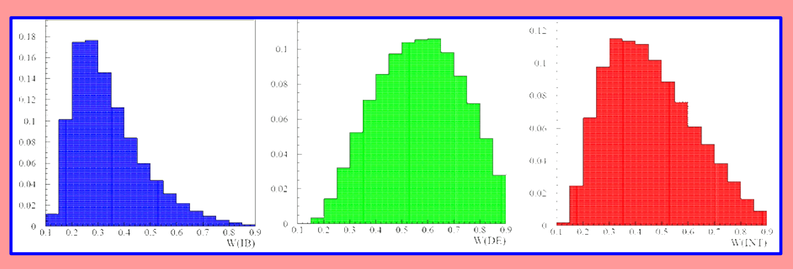
$K^\pm \to \pi^\pm\pi^0\gamma$



$$W^2 = \frac{(P_K^*\cdot P_\gamma^*)(P_\pi^*\cdot P_\gamma^*)}{m_K m_\pi}$$

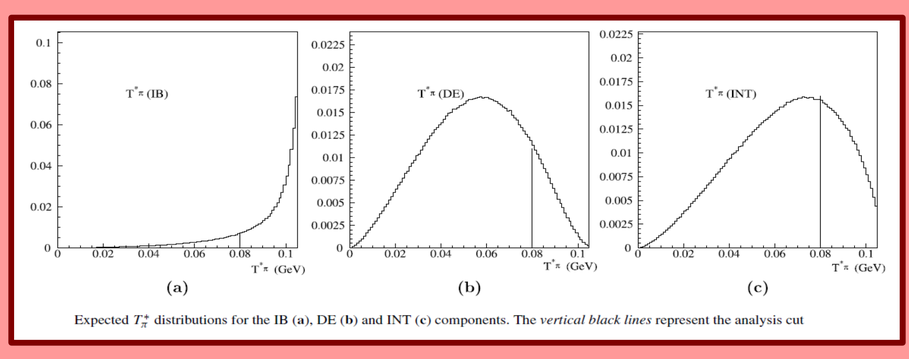
$$\frac{d\Gamma^\pm}{dW} \cong \left(\frac{d\Gamma^\pm}{dW}\right)_{IB}\left[1 + 2\left(\frac{m_\pi}{m_K}\right)^2 W^2 |E|\cos((\delta_1-\delta_0)\pm\phi) + \left(\frac{m_\pi}{m_K}\right)^4 W^4(|E|^2+|M|^2)\right]$$

IB — INT — DE

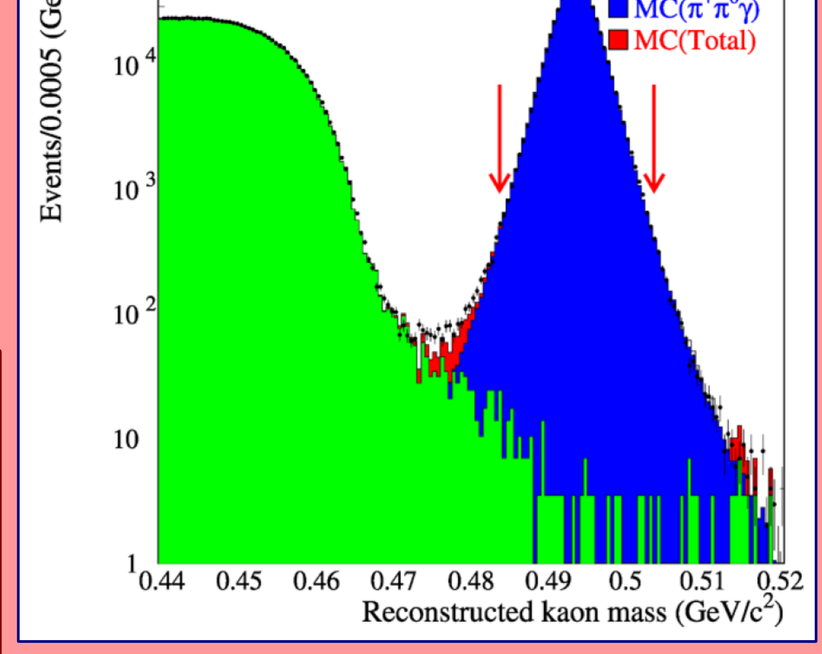


Events selection

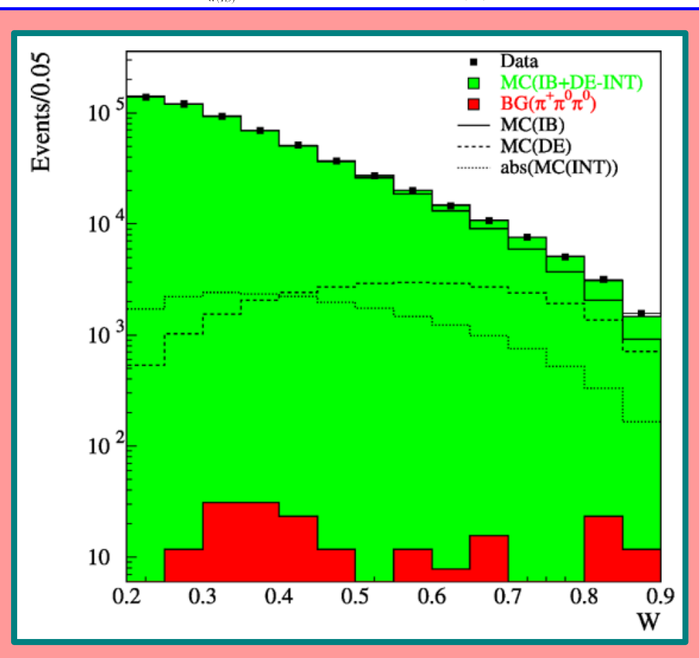
- 1 track with P>10 GeV/c, E/p<0.85, in time
- 3 LKr clusters with E>3 GeV, in time
- Distance between track and cluster at Lkr > 35 cm
- Distance between clusters > 10 cm
- Zch: from CDA between the track and beam axis
- π^0 pair: closest to PDG π^0 mass from Zch
- ($Z\pi^0$ — Zch) < 400 cm
- No MUV hits
- 54 < Ekaon < 66 GeV



Expected T_π^* distributions for the IB (a), DE (b) and INT (c) components. The *vertical black lines* represent the analysis cut



600K $\pi\pi\gamma$ candidates whit negligible BG contribution



Fit performed with free INT term
Use extended ML for 0.2<W<0.9 range

Fit the W data spectrum using MC shapes:
$W_{dat} = (1-\alpha-\beta)W_{IB} + \alpha W_{DE} + \beta W_{INT}$
First evidence of non zero INT term!
Parameters are highly correlated ρ=-0.93

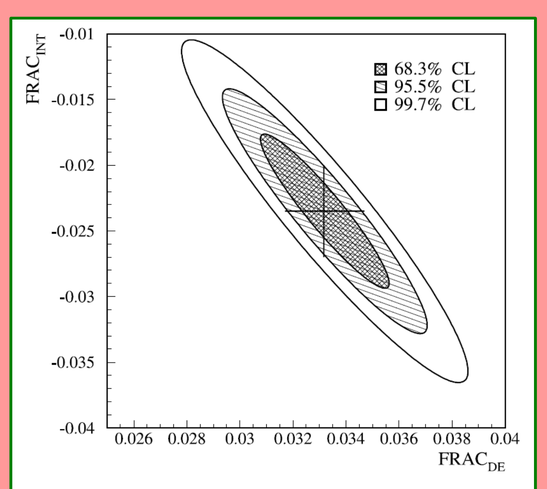
Final result, 2003+2004 data set:

$Frac(DE)_{0<T^*_\pi<80\ MeV} = (3.32 \pm 0.15_{stat} \pm 0.14_{syst})\%$

$Frac(INT)_{0<T^*_\pi<80\ MeV} = (-2.35 \pm 0.35_{stat} \pm 0.39_{syst})\%$

where T* is the kinetic energy of charged pion in the kaon rest frame.

Allows the measurement of electric and magnetic amplitudes: $X_E = -24 \pm 6\ GeV^{-4}$, $X_M = 254 \pm 9\ GeV^{-4}$



Contour plot for DE and INT terms. The cross shows the 1σ statistical uncertainties on the projections

CPV TESTS

1) Difference in K+ and K- decay rates:

$A_N = (N^+ - RN^-)/(N^+ + RN^-)$,
where $R(K^+/K^-)$ ratio = 1.7998 ± 0.0004 from $K_{3\pi}$

Result (systematics from trigger and kaon momentum distributions):

$A_N = -0.0 \pm 0.001_{stat} \pm 0.0006_{syst}$

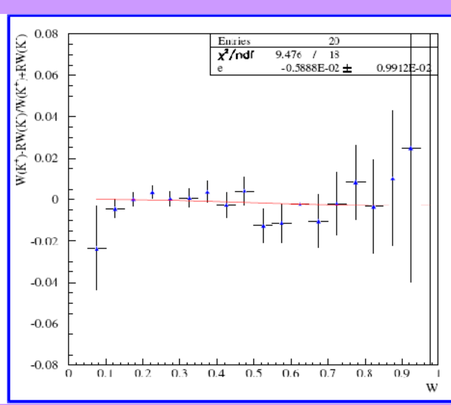
Corresponds to upper limit $|A_N| < 1.5 \times 10^{-3}$ at 90% CL

2) Difference in W spectra shapes:

$dAw/dW = (\Gamma^+ - \Gamma^-)/(\Gamma^+ + \Gamma^-) = eW^2(1+aW^2+bW^4)$,

e is a free parameter
Result (integrating):

$(I_{INT}/I_{IB})Aw = -0.0006 \pm 0.001_{stat}$



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