New measurement of the direct CP violation parameter ϵ'/ϵ by NA48 experiment at CERN

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March 18, 2000
XXXVth Rencontres de Moriond - QCD

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Plan of the presentation

- Physics motivation
- NA48 method
- Analysis of the 1998 data
- The world average
- Conclusions

Physics motivation

Strangeness eigenstates:

$$\mathrm{K}^0(\bar{\mathrm{s}}\mathrm{d}) \quad (S=+1)$$
$$\overline{\mathrm{K}^0}(\mathrm{s}\bar{\mathrm{d}}) \quad (S=-1)$$

CP eigenstates:

$$\mathrm{K}_1 = (\mathrm{K}^0 + \overline{\mathrm{K}^0})/\sqrt{2} \quad (CP=+1)$$
$$\mathrm{K}_2 = (\mathrm{K}^0 - \overline{\mathrm{K}^0})/\sqrt{2} \quad (CP=-1)$$
$$\pi^+\pi^-, \pi^0\pi^0 \quad (CP=+1)$$

Mass and Lifetime eigenstates:

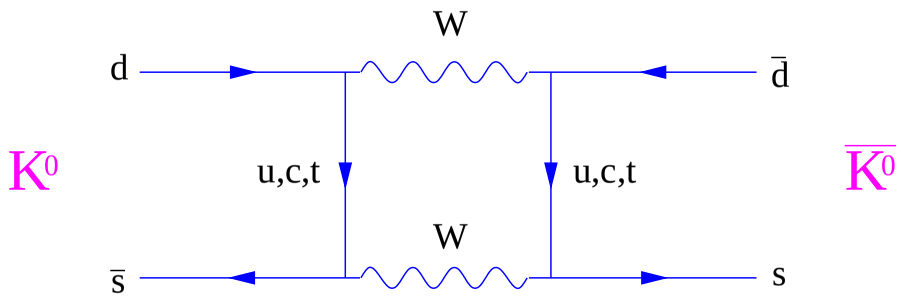
$$\mathrm{K_S} \simeq \mathrm{K}_1 + \varepsilon \mathrm{K}_2 \quad (\mathrm{c}\tau_\mathrm{S} = 2.67 \text{ cm})$$
$$\mathrm{K_L} \simeq \mathrm{K}_2 + \varepsilon \mathrm{K}_1 \quad (\mathrm{c}\tau_\mathrm{L} = 15.5 \text{ m})$$

$\mathrm{K_S}$		$\mathrm{K_L}$	
69 %	$\pi^+\pi^-$	21 %	$3\pi^0$
31 %	$\pi^0\pi^0$	13 %	$\pi^+\pi^-\pi^0$
		27 %	$\pi\mu\nu$
		39 %	$\pi e\nu$
		0.2 %	$\pi^+\pi^-$
		0.1 %	$\pi^0\pi^0$

$$\varepsilon = (2.28 \pm 0.02) \times 10^{-3}$$

Physics motivation, contd.

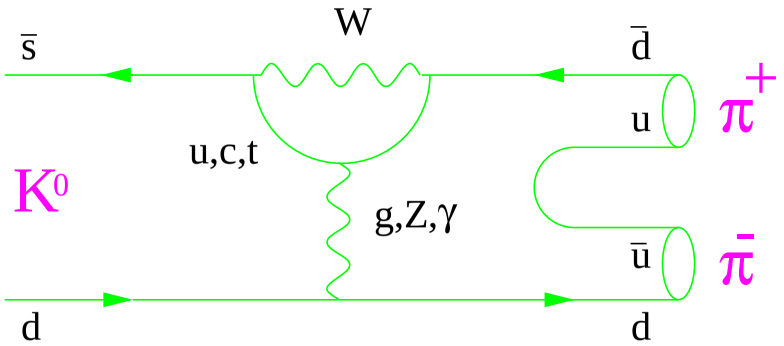
$\varepsilon \Rightarrow$ Indirect CP violation via $K^0/\overline{K^0}$ mixing



$$K_L = K_2^{-1} + \varepsilon\, K_1^{+1} \qquad \pi^+\pi^-,\ \pi^0\pi^0$$

CP = +1

$\varepsilon' \Rightarrow$ Direct CP violation:



$$\varepsilon' = \frac{i}{\sqrt{2}}\mathfrak{Im}\frac{A_2}{A_0}\exp(i(\delta_2 - \delta_0))$$

$$\mathrm{A}(\mathrm{K}^0 \rightarrow \pi\,\pi\,,\mathrm{I}) = \mathrm{A}_\mathrm{I}\exp(\mathrm{i}\delta_\mathrm{I})$$
$$\mathrm{A}(\overline{\mathrm{K}^0} \rightarrow \pi\,\pi\,,\mathrm{I}) = \mathrm{A}_\mathrm{I}^*\exp(\mathrm{i}\delta_\mathrm{I})$$

Double ratio technique

$$\eta_{+-} \equiv \frac{A(\mathrm{K_L}\to\pi^+\pi^-)}{A(\mathrm{K_S}\to\pi^+\pi^-)} \simeq \varepsilon + \varepsilon'$$

$$\eta_{00} \equiv \frac{A(\mathrm{K_L}\to\pi^0\pi^0)}{A(\mathrm{K_S}\to\pi^0\pi^0)} \simeq \varepsilon - 2\,\varepsilon'$$

$$\mathrm{Re}(\varepsilon'/\varepsilon) \simeq \frac{1}{6}\left\{1 - \frac{\frac{\Gamma(\mathrm{K_L}\to\pi^0\pi^0)}{\Gamma(\mathrm{K_S}\to\pi^0\pi^0)}}{\frac{\Gamma(\mathrm{K_L}\to\pi^+\pi^-)}{\Gamma(\mathrm{K_S}\to\pi^+\pi^-)}}\right\} = \frac{1}{6}\,(1-\mathrm{R})$$

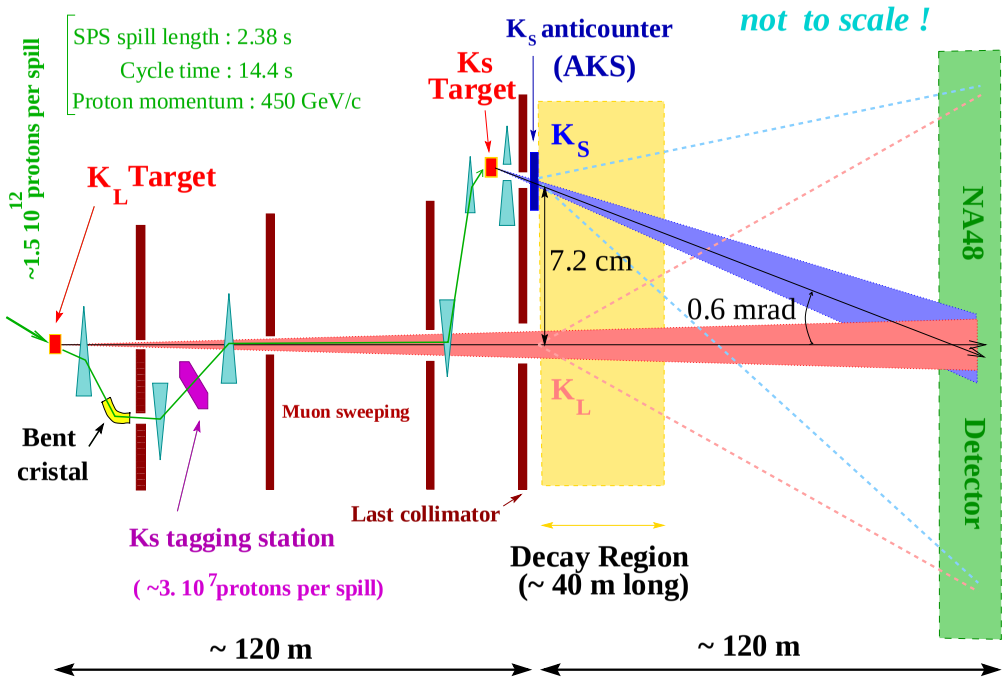
If at least $\mathrm{K_S}$ /$\mathrm{K_L}$ or $\pi^+\pi^-/\pi^0\pi^0$ are collected at the same time

$$\mathrm{R} = \frac{\mathrm{N_L^{00}}}{\mathrm{N_S^{00}}} \Big/ \frac{\mathrm{N_L^{+-}}}{\mathrm{N_S^{+-}}}$$

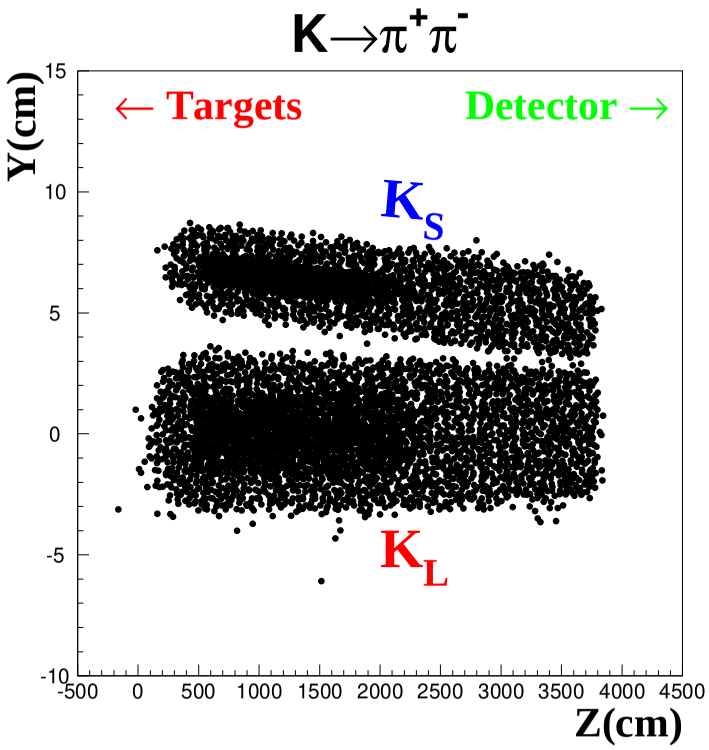
It is a counting experiment!

NA31	$(23.0 \pm 6.5) \times 10^{-4}$
E731	$(7.4 \pm 5.9) \times 10^{-4}$
KTEV	$(28.0 \pm 4.1) \times 10^{-4}$
NA48 97	$(18.5 \pm 7.3) \times 10^{-4}$
NA48 98	new

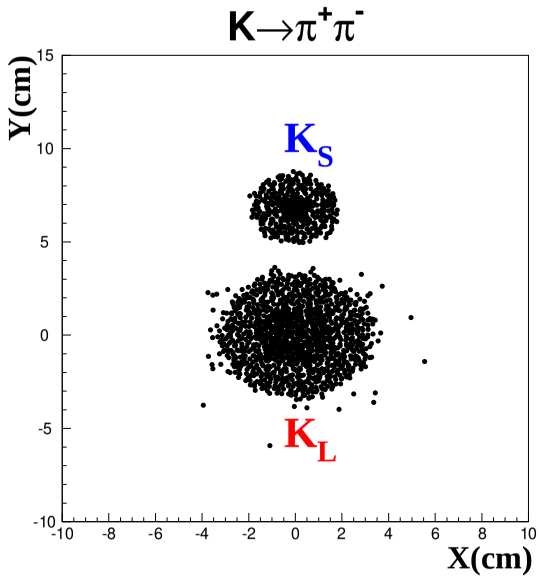
NA48: simultaneous K_L and K_S beams

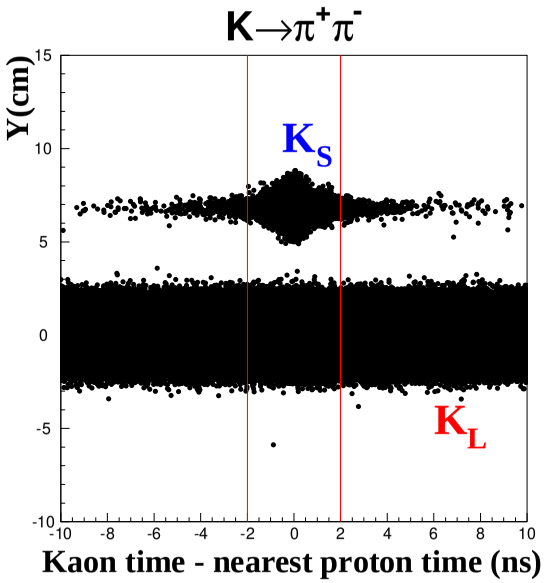


- K_S are distinguished from K_L by tagging the protons upstream of the K_S target
- All 4 modes $\Rightarrow$ same decay region



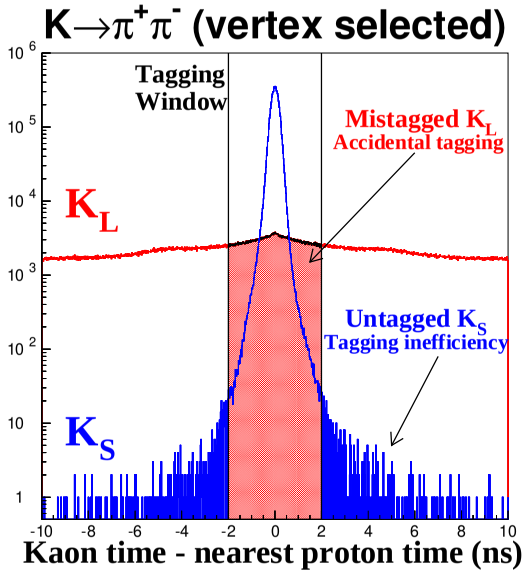
NA48: Tagging





Tagging inefficiency
$P(K_S \rightarrow K_L)$:
$\alpha_{SL}^{+-} = (1.97 \pm 0.05) 10^{-4}$

Accidental tagging
$P(K_L \rightarrow K_S)$:
$\alpha_{LS}^{+-} = (11.05 \pm 0.01)\%$



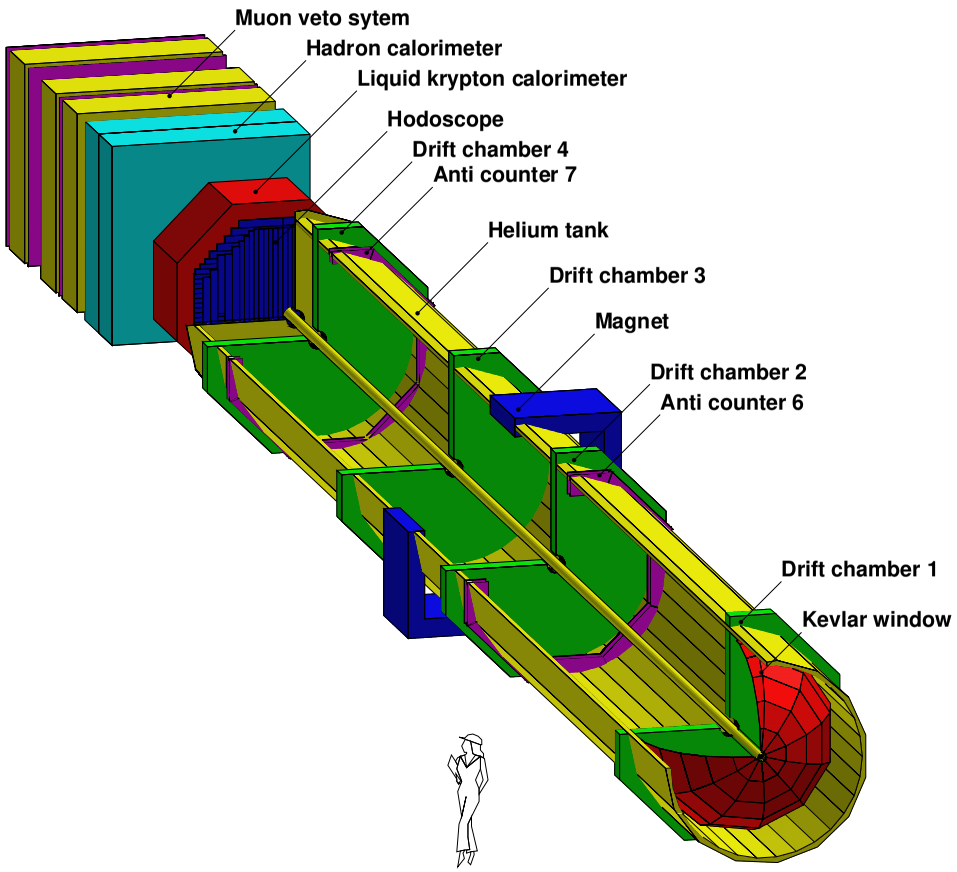
In $K \rightarrow \pi^0\pi^0$ indirect methods are used:

$$|\alpha_{SL}^{00} - \alpha_{SL}^{+-}| < 0.5 \times 10^{-4} \qquad \boxed{\Delta R < 3 \times 10^{-4}}$$

$$\alpha_{LS}^{00} - \alpha_{LS}^{+-} = (0.5 \pm 4) \times 10^{-4}$$

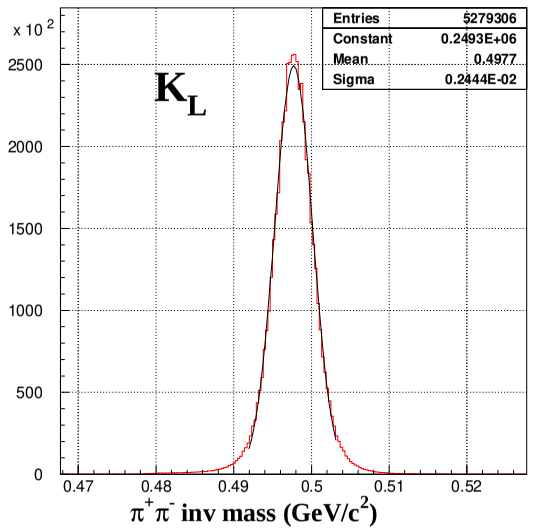
$$\boxed{\Delta R = (1 \pm 8) \times 10^{-4}}$$

NA48: detectors



- $K_{L,S} \to \pi^+\pi^-$
  - magnetic spectrometer ($P_T{}^{kick} \sim 265\,\mathrm{MeV}/c$)
  - scintillators hodoscope
- $K_{L,S} \to \pi^0\pi^0$
  - quasi-homogeneous Liquid Krypton e.m. calorimeter
  - scintillating fibers hodoscope

NA48: $K^0 \rightarrow \pi^+ \pi^-$ reconstruction

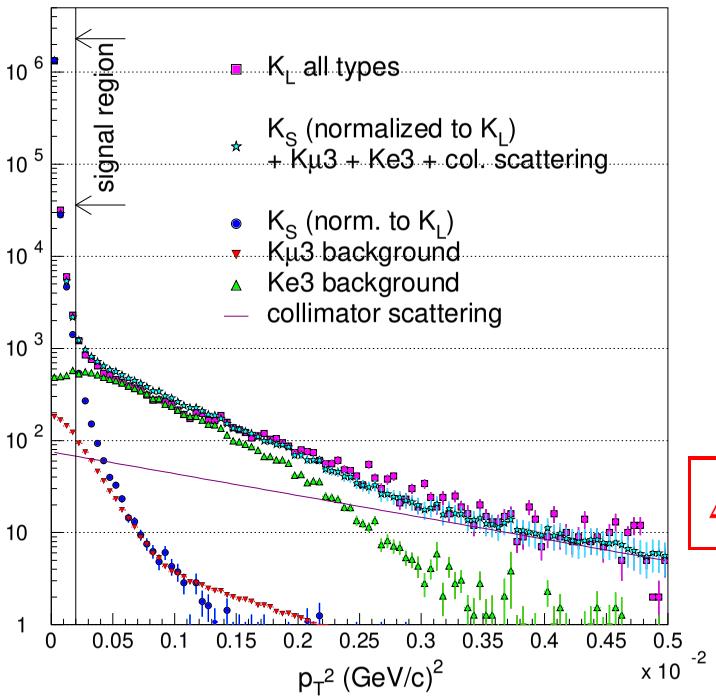


Kaon mass resolution

~ 2.5 MeV/c^2

$$\frac{\sigma(p)}{p} \simeq 0.5\% \oplus 0.009\, p\%$$

p in GeV/c



Background rejection:
No hits in the μ counters
$E/p < 0.8$

$$\Delta R = (+19 \pm 3) 10^{-4}$$

$\pi^+\pi^-$ energy: opening angle and tracks energy ratio

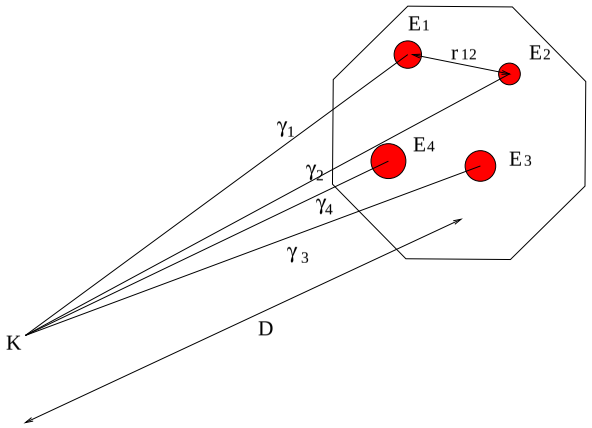
$E_K^2 = (C/\theta^2)\left\{m_K^2 - C\, m_\pi^2\right\}$

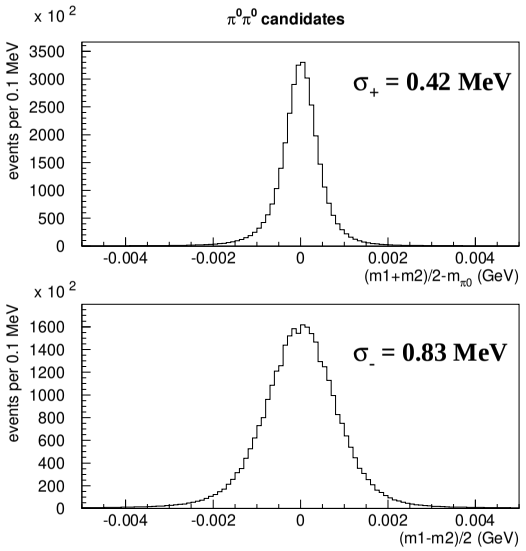
$C = 2 + E_{\pi 1}/E_{\pi 2} + E_{\pi 1}/E_{\pi 2}$

$\Rightarrow$ geometry of the drift chambers

NA48: $K^0 \rightarrow \pi^0\ \pi^0$ reconstruction

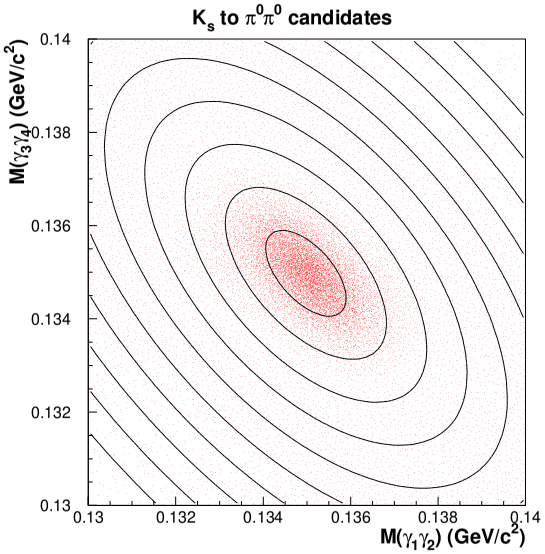
$K^0 \rightarrow 2\ \pi^0 \rightarrow 4\gamma$

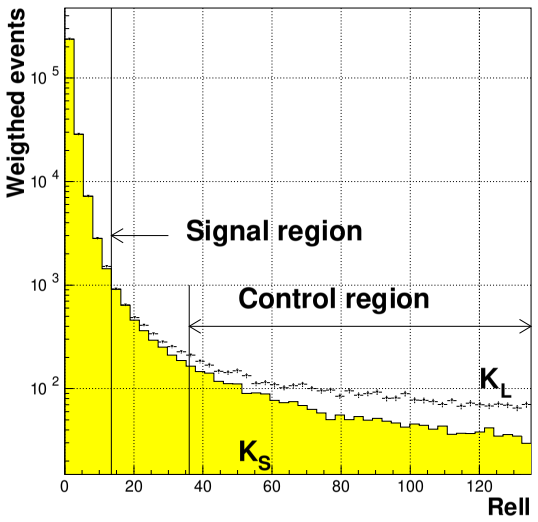




$$D = \frac{\sqrt{\sum E_i E_j \times (r_{ij})^2}}{M_K}$$

$$m_{ij} = \frac{\sqrt{E_i E_j}\ .\ r_{ij}}{D}$$



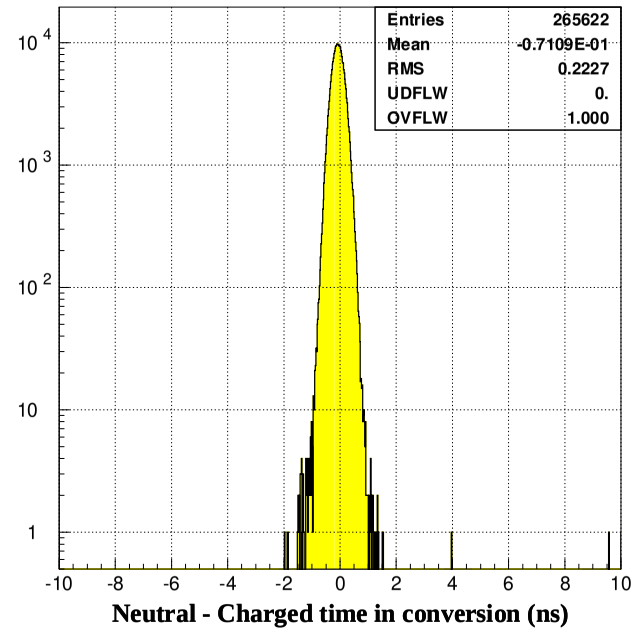


3 π^0 background rejection:

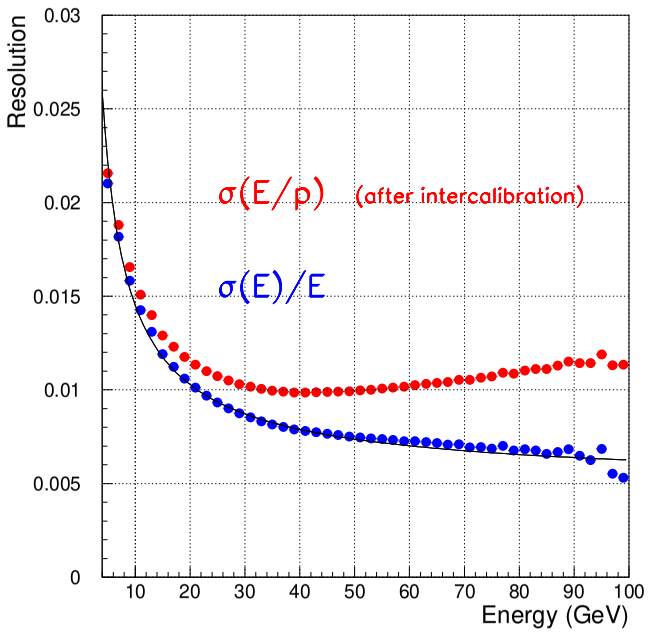
Cut on in-time extra photons ($\pm$ 3ns)

$$\Delta R = (-7 \pm 2) \times 10^{-4}$$

NA48: $\pi^+\pi^-/\pi^0\pi^0$ time and energy resolution



Comparison of LKr and scintillators hodoscope times in K_L and K_S events ($3\pi^0$ and $2\pi^0$) containing a photon conversion



Comparison of LKr energy and magnetic spectrometer momentum for electrons in K_{e3} decays

$$\frac{\sigma(E)}{E} = \frac{3.2\%}{\sqrt{E}} \oplus \frac{100MeV}{E} \oplus 0.5\%$$

NA48: $\pi^0\pi^0$ energy scale

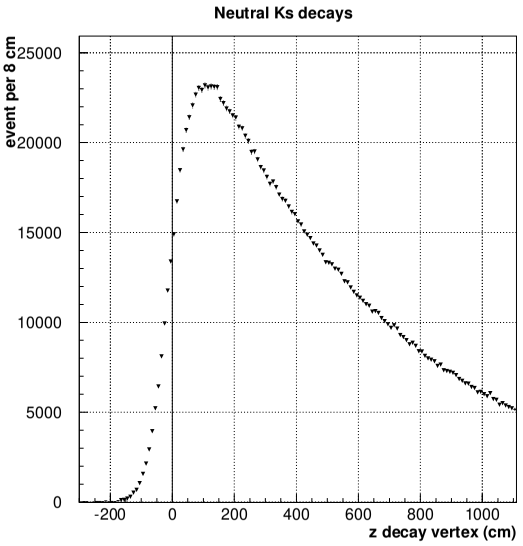
$$E_{\rm M} = (1+\alpha) \times E_{\rm T}$$

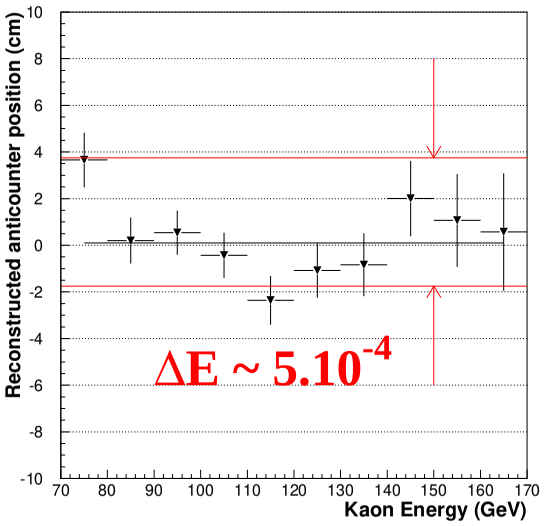
α = uncertainty on the $\pi^+\pi^-/\pi^0\pi^0$ energy scale

The beginning of the K_S decay region is defined by an anti-counter (AKS)

The energy of the $\pi^0\pi^0$ is determined by the Lkr
$\Rightarrow$ it relies on the calibration of the calorimeter

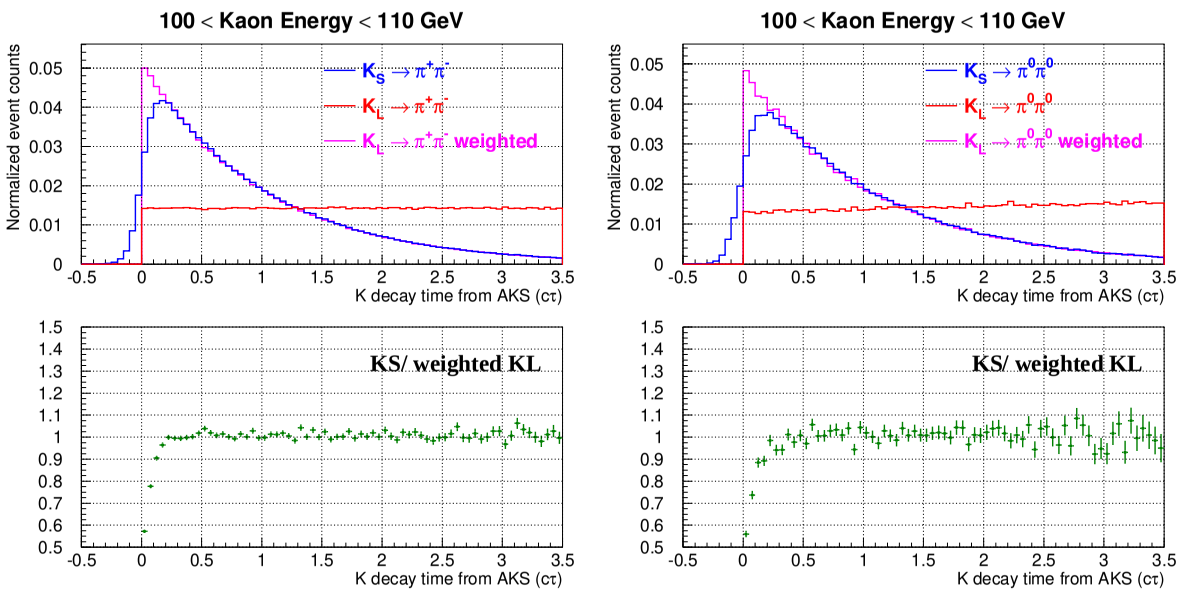
To set the overall distance/energy scale, the position of the K_S anti-counter is used as a reference in $K_S \rightarrow \pi^0\pi^0$ events



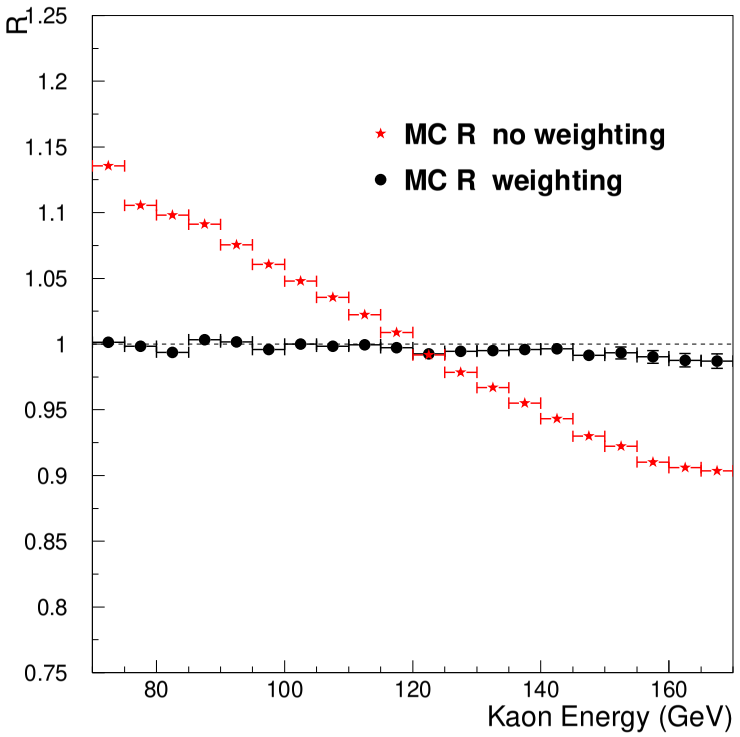


$$\Delta R < 10 \times 10^{-4}$$

NA48: K_L proper time weighting



K_L are weighted with the K_S proper time

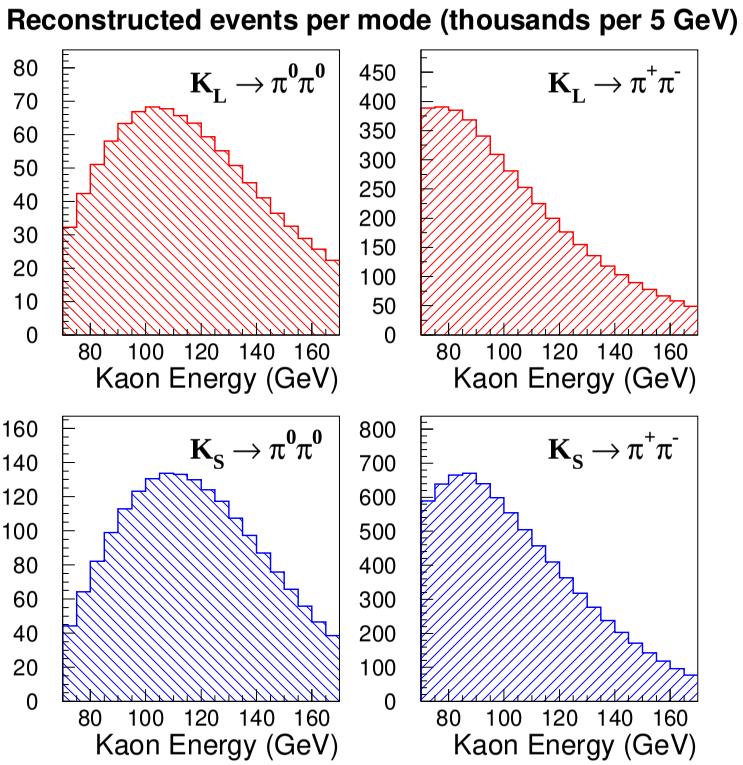


The increase of the statistical error due to weighting is 35%

$$\Delta R = (+31 \pm 6(stat) \pm 6(syst)) \times 10^{-4}$$

NA48: Analysis cuts

- $70 < E_{\mathrm{K}} < 170$ GeV
- Centre of Gravity $(R_{\mathrm{cog}}) < 10\,\mathrm{cm}$
- Decay region: $0 < t < 3.5\,\tau_{\mathrm{S}}$



- Charged dead time (<5 % from charged trigger and $\approx$ 25 % from DCH read out) is applied to neutrals.
- All corrections are applied in bins of energy, to account for the slight difference in the spectra of $\mathrm{K_S}$ and $\mathrm{K_L}$

NA48: accidental activity

Accidental activity can induces asymmetric losses or gains in K_S and K_L

We overlay events collected proportionally to the beam intensity to $\pi^+\pi^-$ and $\pi^0\pi^0$ events and evaluate the gain and losses induced by the analysis cuts

$$\Delta R = (2 \pm 6) \times 10^{-4}$$

The K_S /K_L ratio is constant with a R.M.S. of 10% but:

- the difference in accidental activity seen by K_S and K_L events is ≈ 1 %
- The asymmetric losses on $\pi^+\pi^-$ and $\pi^0\pi^0$ induced by the noise in the DCH read out are $< 2.5\%$
- the noise in the detector does not change by more than a factor of two as a function of time

$$\Delta R < 10 \times 10^{-4}$$

NA48: Data sample

- 1997: 89 days, 1×10^{12} ppp on K_L target

  $\Rightarrow$ 0.49 million of $K_L \to \pi^0\pi^0$

  PUBLISHED Phys. Lett. B 465 (1999)

  $$\mathrm{Re}(\varepsilon'/\varepsilon) = (18.5 \pm 4.5 \pm 5.8) \times 10^{-4}$$

- 1998: 135 days, $\sim 1.4 \times 10^{12}$ ppp on K_L target

  Main improvements :

  - LKr High Voltage 1500 $\to$ 3000 V
  - Charged trigger efficiency 91.3 $\to$ 97.7 %
  - Carbon fibre pipe $\to$ less showers in the detectors
  - New data acquisition system (PC farm) + 30 % rate

  $\Rightarrow$ 1.14 million of $K_L \to \pi^0\pi^0$
  $\Rightarrow$ four-fold increase of $\pi^+\pi^-$

- 1999: 128 days, $\sim 1.4 \times 10^{12}$ ppp on K_L target

  Further improvements :

  - DCh read-out, dead time, DAQ efficiency, spill length

  $\Rightarrow$ Around 2 million of $K_L \to \pi^0\pi^0$

  ANALYSIS in progress...

NA48: triggers

$\pi^0\pi^0$ trigger

- Fully pipelined system using LKr cell information to compute energy, centre of gravity and proper time
- Output rate $\sim$ 2 kHz
- Negligible dead time
- Efficiency : 99.93 ± 0.02 %
- Control trigger provided by SCIFI hodoscope embedded in LKr

$\pi^+\pi^-$ trigger

- Level 1 :

	Efficiency
+ Energy in calorimeters	99.49 ± 0.03 %
+ Two track topology	99.95 ± 0.01 %
+ Two track multiplicity	> 99.99 %

- Level2 : on-line processing of vertices and $\pi\pi$ invariant mass
  - Latency : $< 102\ \mu s$
  - Rejection $\sim 45 \rightarrow$ 2 kHz output
  - Dead Time : $< 5\%$ monitored and applied to $\pi^0\pi^0$
  - Efficiency: 97.75 ± 0.05 %

$$\Delta R = (-1 \pm 11) \times 10^{-4}$$

NA48: 1998 Result

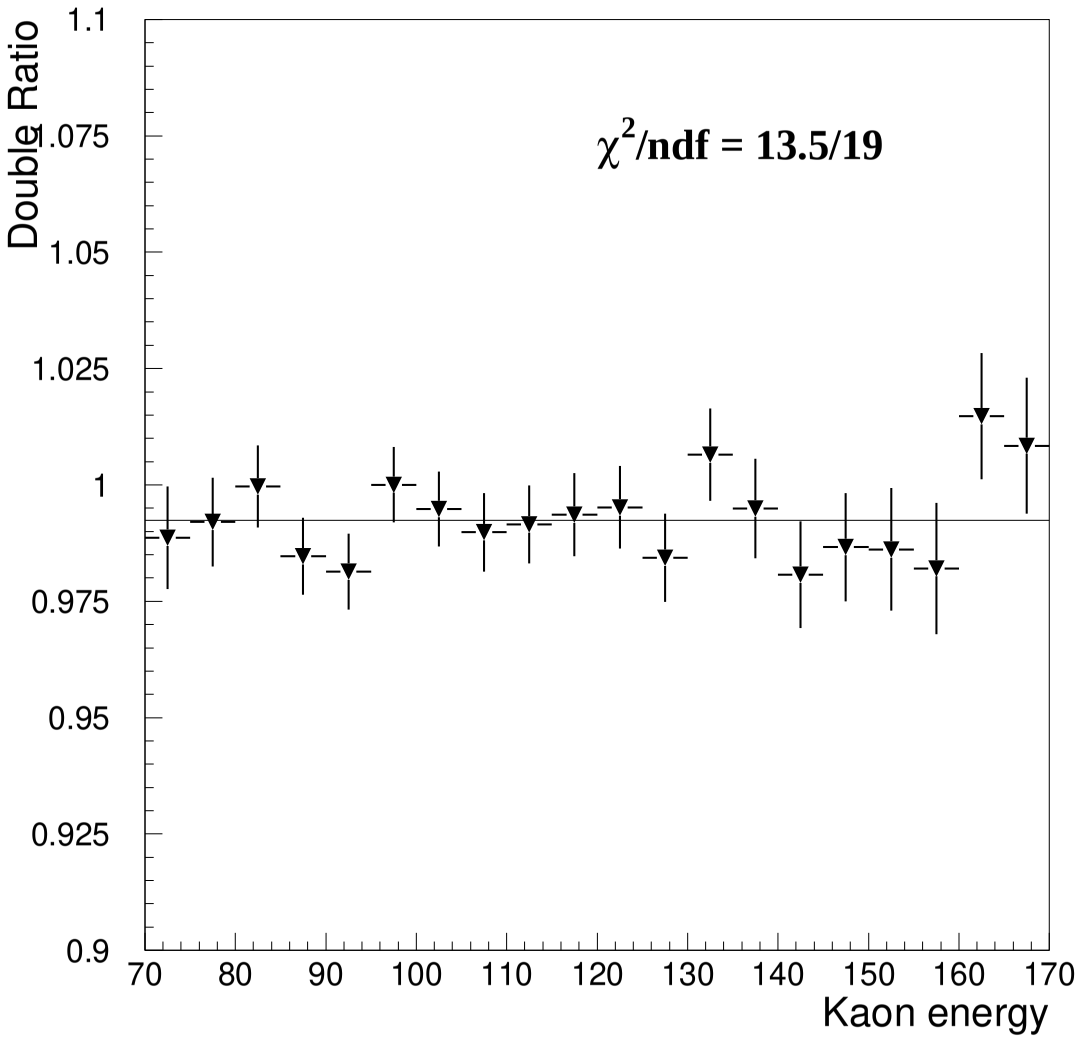
Statistics (millions) 1998			
$K_S \to \pi^+\pi^-$	7.46	$K_L \to \pi^+\pi^-$	4.87
$K_S \to \pi^0\pi^0$	1.80	$K_L \to \pi^0\pi^0$	1.14

Corrections and systematic uncertainties on R (Units = 10^{-4})		
Source	1998 sample	
Charged trigger	−1	± 11
Mistagging probability	+1	± 8
Tagging efficiency	−	± 3
Neutral scale	−	± 10
Charged vertex	+2	± 2
Acceptance and AKS eff.	+31	± 9
Neutral BG	−7	± 2
Charged BG	+19	± 3
Beam scattering	−10	± 3
Accid. activity and in-time BG	+2	± 12
Total	+37	± 24

$$R = 0.99267 \pm 0.00173(stat.) \pm 0.00238(syst.)$$

NA48: 1998 Result

PRELIMINARY RESULT ON 1998 DATA



$$\mathrm{Re}(\varepsilon'/\varepsilon) = (12.2 \pm 2.9\,(\mathrm{stat.}) \pm 4.0\,(\mathrm{syst.})) \times 10^{-4}$$

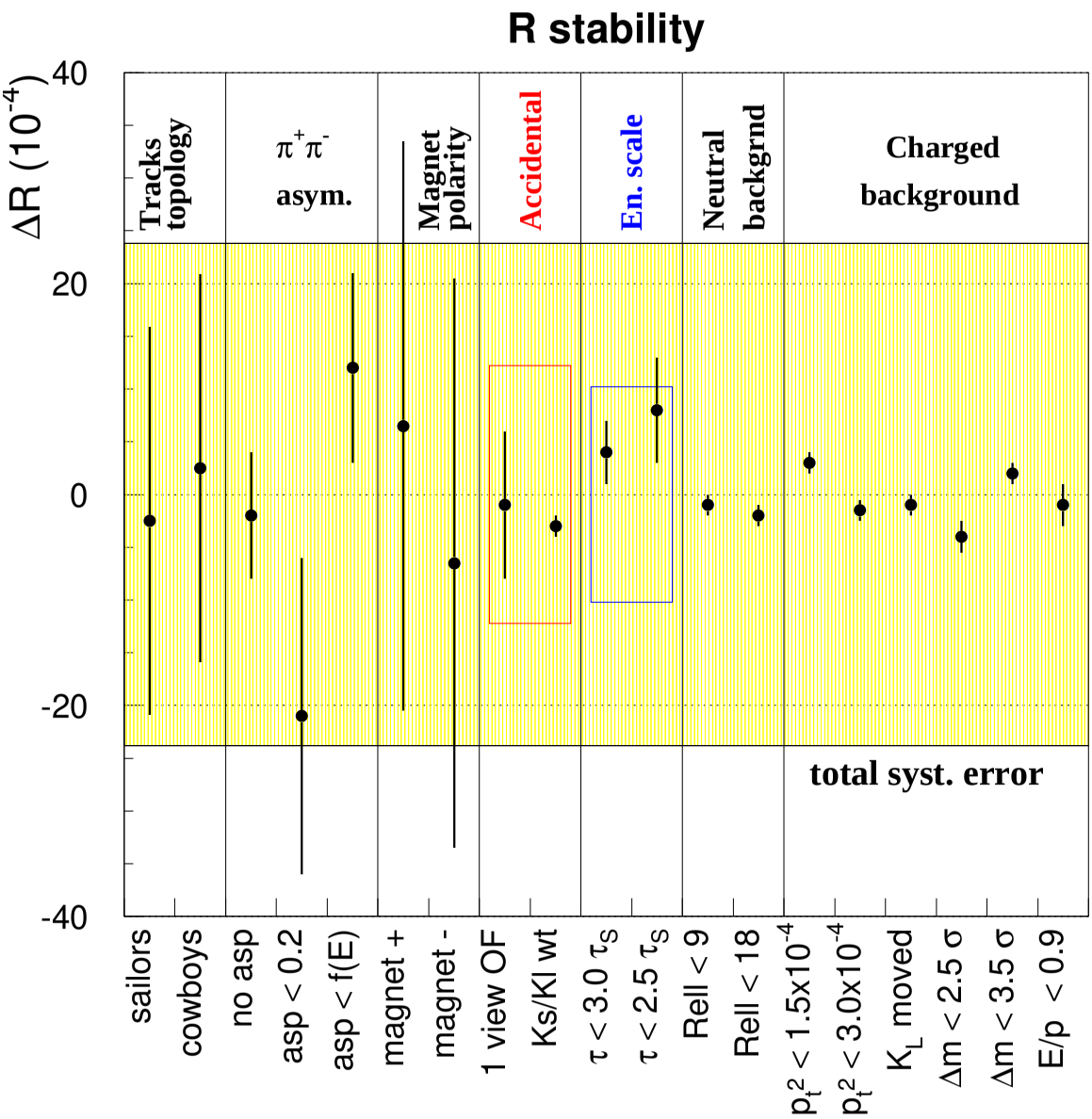
$$\mathrm{Re}(\varepsilon'/\varepsilon) = (12.2 \pm 4.9) \times 10^{-4}$$

This result is preliminary. The systematic uncertainty is partly of statistical nature

Combined 1997 and preliminary 1998

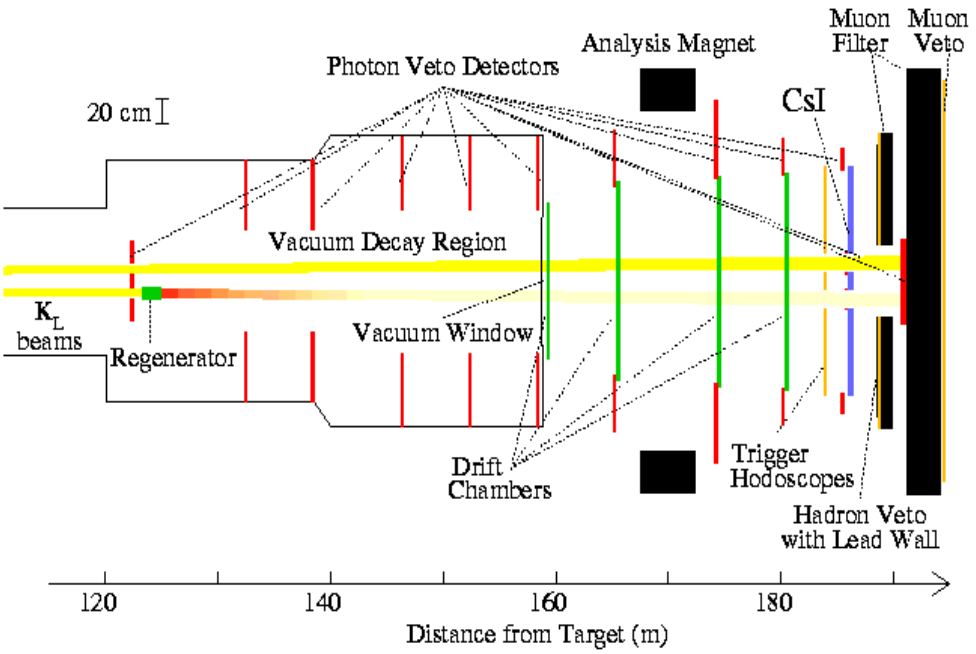
$$\mathrm{Re}(\varepsilon'/\varepsilon) = (14.0 \pm 4.3) \times 10^{-4}$$

NA48: Checks


R stability
ΔR (10^-4)
40
20
0
-20
-40
Tracks topology
π+π- asym.
Magnet polarity
Accidental
En. scale
Neutral backgrnd
Charged background
total syst. error
sailors
cowboys
no asp
asp < 0.2
asp < f(E)
magnet +
magnet -
1 view OF
Ks/Kl wt
τ < 3.0 τS
τ < 2.5 τS
Rell < 9
Rell < 18
pt2 < 1.5x10-4
pt2 < 3.0x10-4
KL moved
Δm < 2.5 σ
Δm < 3.5 σ
E/p < 0.9

KTEV

KTeV Detector, E832 Configuration



PUBLISHED Phys. Rev. Lett. 83 (1999)

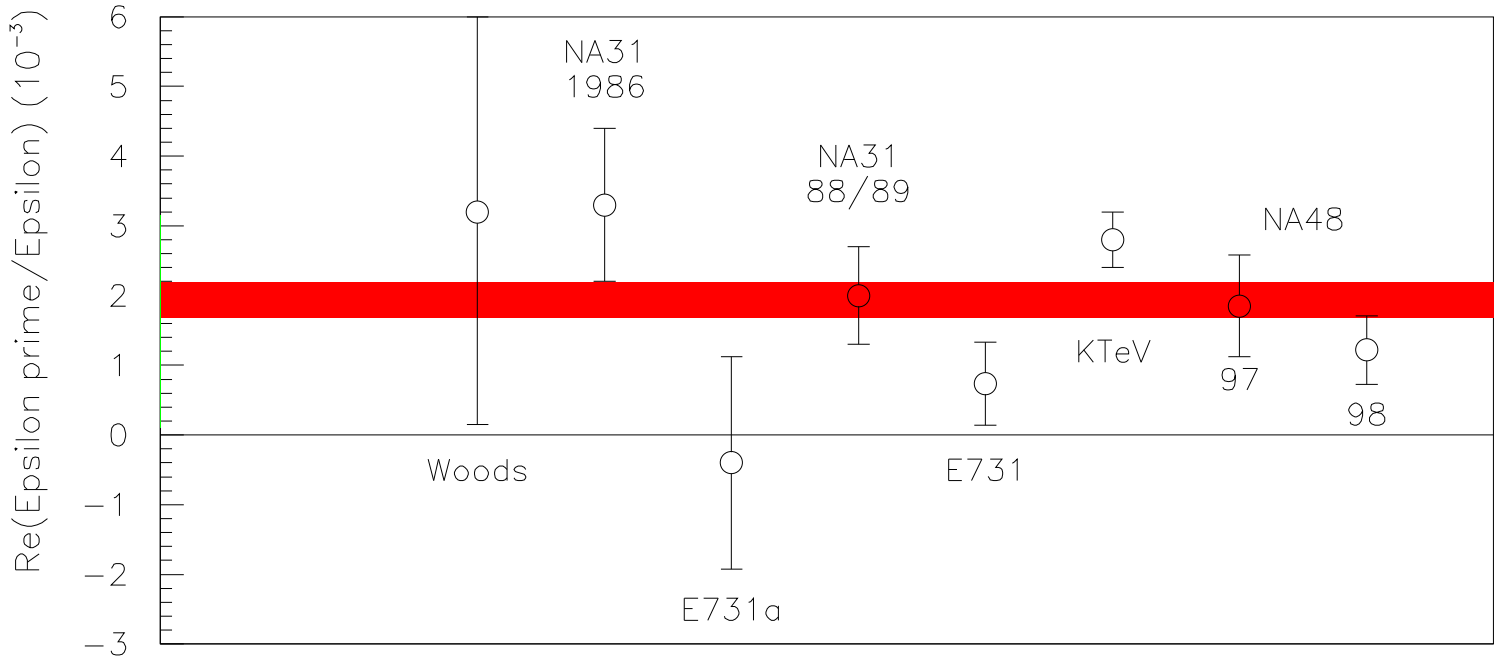
$$\mathrm{Re}(\varepsilon'/\varepsilon) = (28.0 \pm 3.0(stat.) \pm 2.8(syst.)) \times 10^{-4}$$

$$\boxed{\mathrm{Re}(\varepsilon'/\varepsilon) = (28.0 \pm 4.1) \times 10^{-4}}$$

KTEV-NA48 comparison

	NA48	KTEV
K_S production	2nd target	regenerator
K_S identification	Time (proton t.o.f.)	Space (C.O.G.)
Simult. K_S & K_L	Yes	Yes
Simult. $\pi^+\pi^-$ & $\pi^0\pi^0$	Yes	Yes(not yet)
K_S K_L beams distance	7.2 cm $\rightarrow$ 0	30 cm
Acceptance (correction)	ctau weight (small)	MC*** (large)
Calorimeter	Liquid Kripton	CsI crystals
Magnetic Spectrometer	Yes	Yes
Evacuated decay region	Yes	Yes
K_S decay region begin.	Sharp (Veto)	Sharp (Veto)
Data taking years	1997-98	1996($\pi^0\pi^0$)-97($\pi^+\pi^-$)
Selected kaon energy	70-170 GeV	40-160 GeV
K_{l3} BG in $K_L \rightarrow \pi^+\pi^-$	0.19%	0.07%
$3\pi^0$ BG in $K_L \rightarrow \pi^0\pi^0$	0.07%	0.27%
Scatt.BG in $K_{L(S)} \rightarrow \pi^+\pi^-$	-	0.014% (0.086%)
Scatt.BG in $K_{L(S)} \rightarrow \pi^0\pi^0$	0.10%	0.46% (1.21%)
K_S /K_L ratio	const. $\pm$10%	const.

New world average

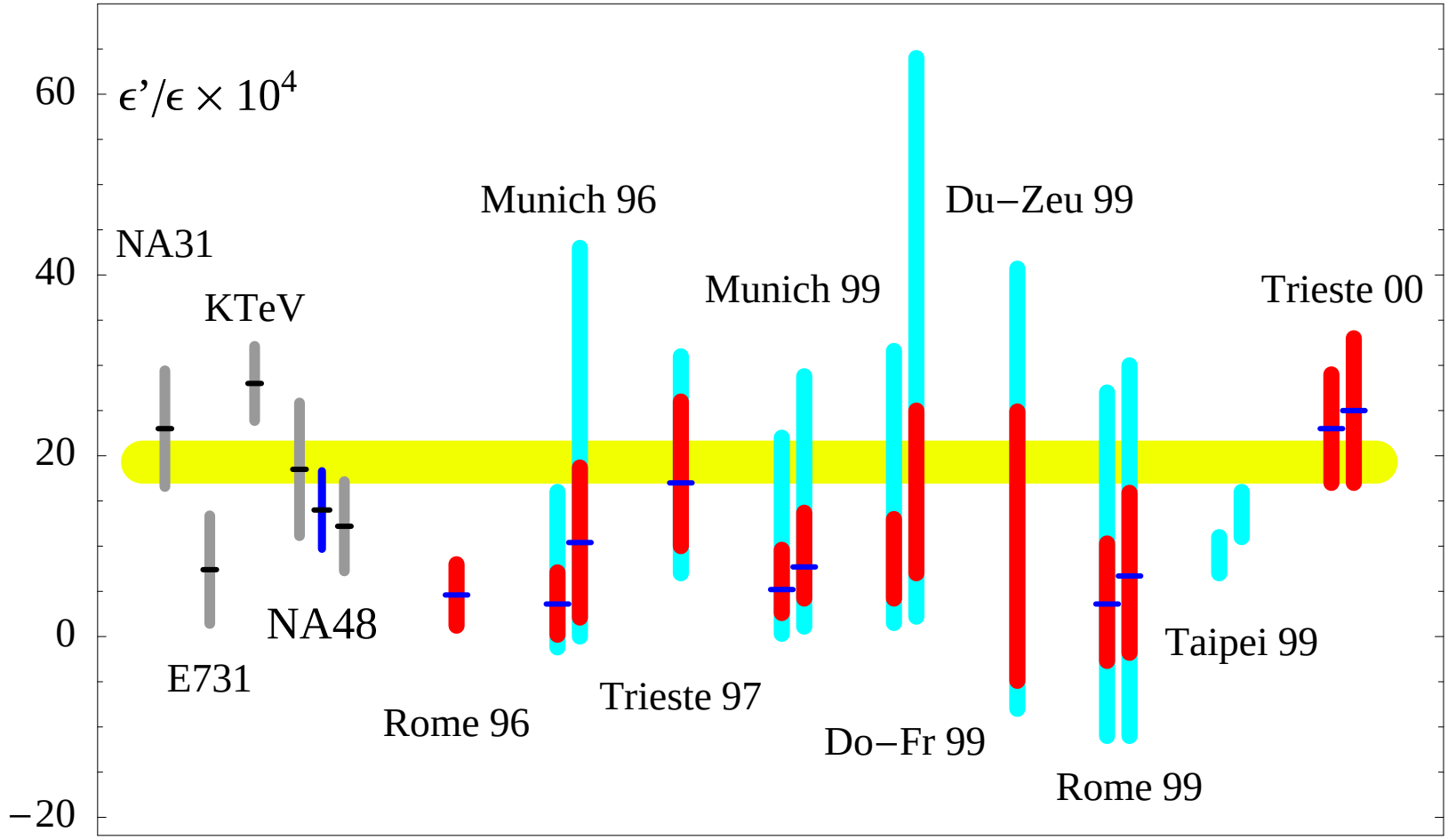


New world average:

$$\boxed{\mathrm{Re}(\varepsilon'/\varepsilon) \;=\; (19.3 \pm 2.4) \times 10^{-4}}$$

$$(\chi^2/ndf = 11.1/5)$$

Experiment vs. Theory



Experiments versus Theory

Conclusions

- NA48 has presented a new preliminary measurement of $\mathrm{Re}(\varepsilon'/\varepsilon)$ based on the 1998 data sample:

$$\mathrm{Re}(\varepsilon'/\varepsilon) = (12.2 \pm 4.9) \times 10^{-4}$$

- Combining this result with the NA48 published data and taking into account the (small) correlated systematics, we obtain:

$$\mathrm{Re}(\varepsilon'/\varepsilon) = (14.0 \pm 4.3) \times 10^{-4}$$

- The result confirms a non-zero, positive value for $\mathrm{Re}(\varepsilon'/\varepsilon)$

- Improvement on systematics expected. 1999 data analysis in progress

- New results are expected from KTEV (FNAL) and KLOE (DAΦNE)

Spare material

The following slides are kept as spare material in case of questions

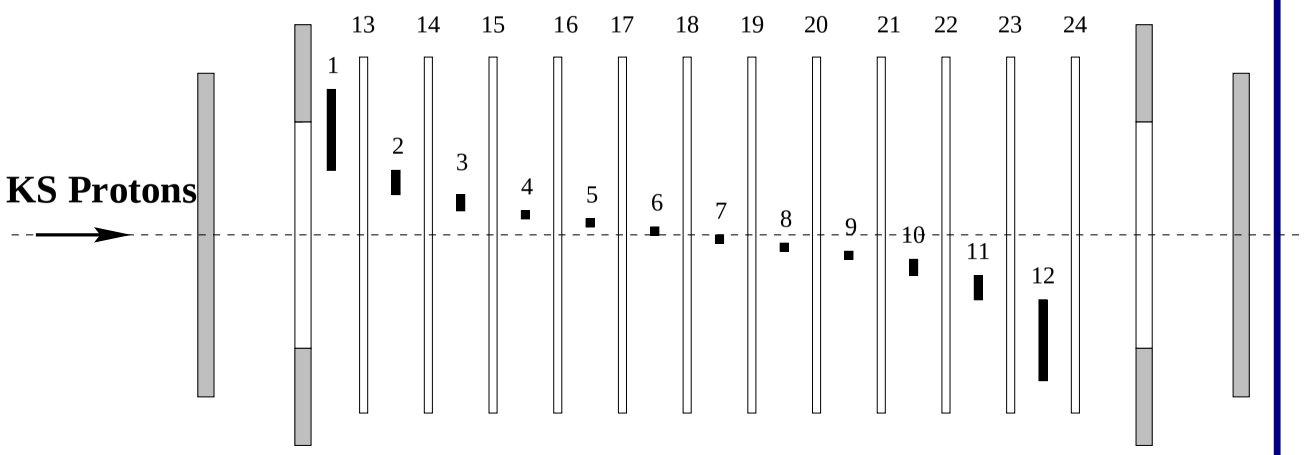
NA48: K_S tagger

T.O.F. between a reconstructed Kaon decay and the tagger:

$|t_K - t_{tagger}| < 2ns \Rightarrow K_S$

$|t_K - t_{tagger}| > 2ns \Rightarrow K_L$

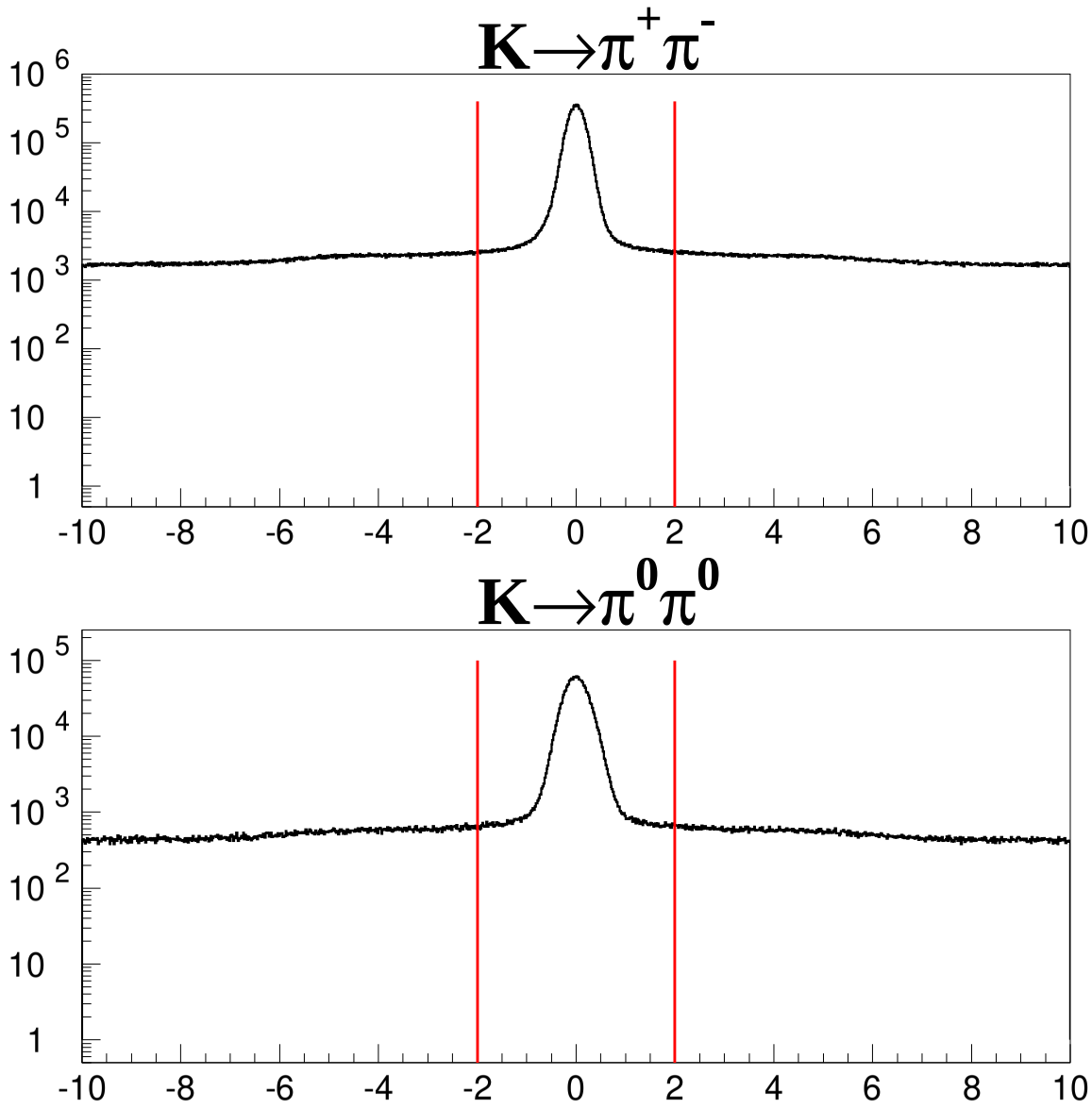
Tagger from side view



: Vertical ladder : Horizontal ladder

- 8-bit 960MHz FADC read-out
- 200ps time resolution per counter
- 4ns double pulse separation

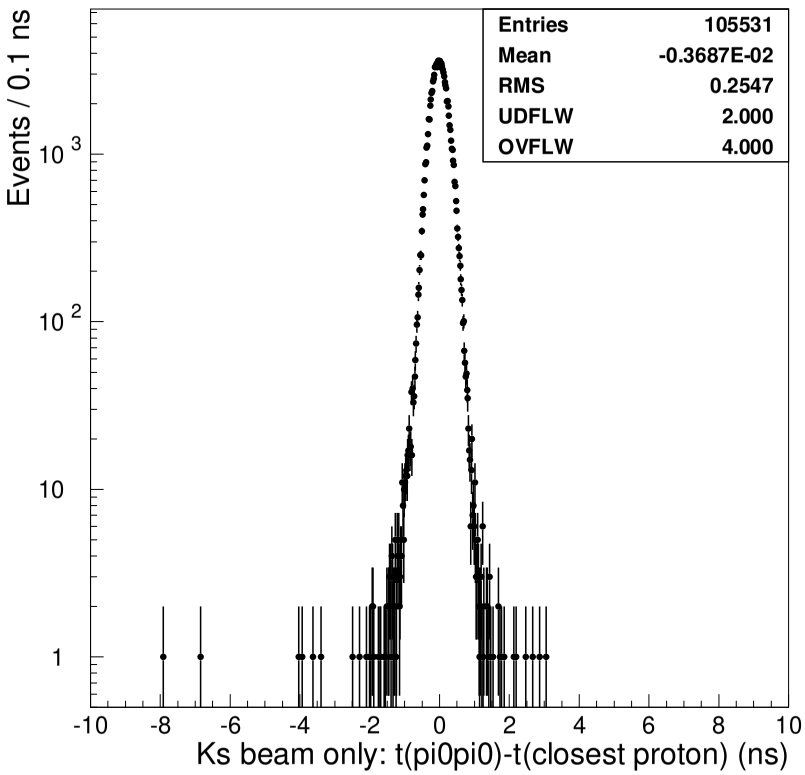
NA48: Tagging



NA48: Efficiency for $\pi^0\pi^0$ tagging

The tagging efficiency for $\pi^0\pi^0$ is verified with 3 methods:

1. K_S only runs (the K_L beam is stopped)



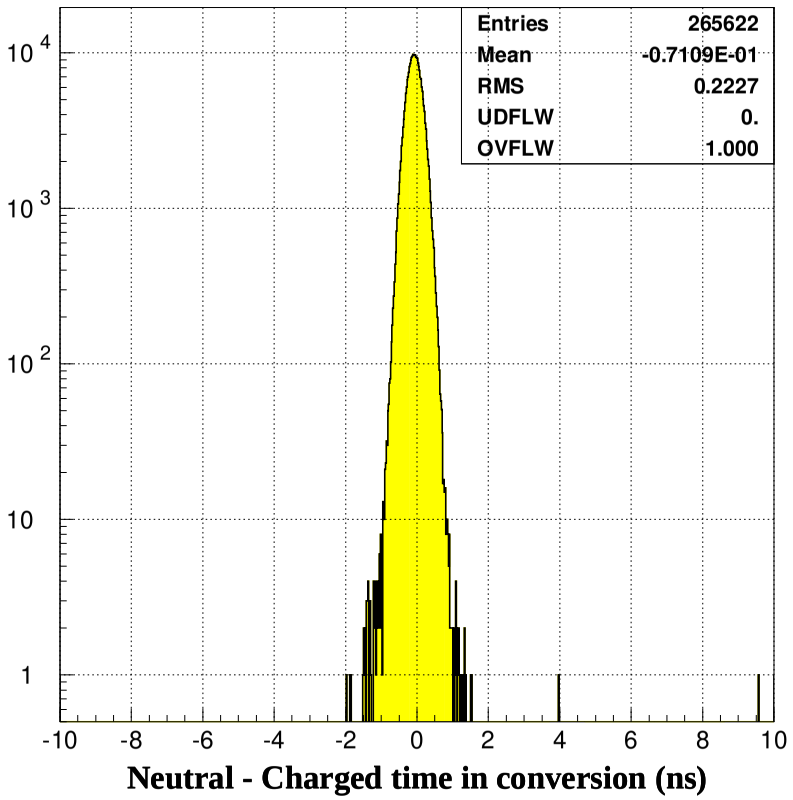
   - After subtraction of the K_L beam which punches through the beam stopper: $\alpha_{SL}^{00} = (1.3 \pm 0.5) \times 10^{-4}$
   - During these dedicated runs we measured, for comparison: $\alpha_{SL}^{+-} = (1.4 \pm 0.2) \times 10^{-4}$

2. $K_S \rightarrow \pi^0 e^+ e^- \gamma$ events

NA48: Efficiency for $\pi^0\pi^0$ tagging

3. Comparison of hodoscope and LKr times in K_L and K_S events ($3\pi^0$ and $2\pi^0$) containing a conversion

- The *Tagger* contribution dominates the inefficiency and is symmetric for $\pi^0\pi^0/\pi^+\pi^-$
- neutral time: the calorimeter (γ's)
- charged time: the hodoscope (e^+e^-)



$$|\alpha_{SL}^{+-} - \alpha_{SL}^{00}| < 0.5 \times 10^{-4}$$

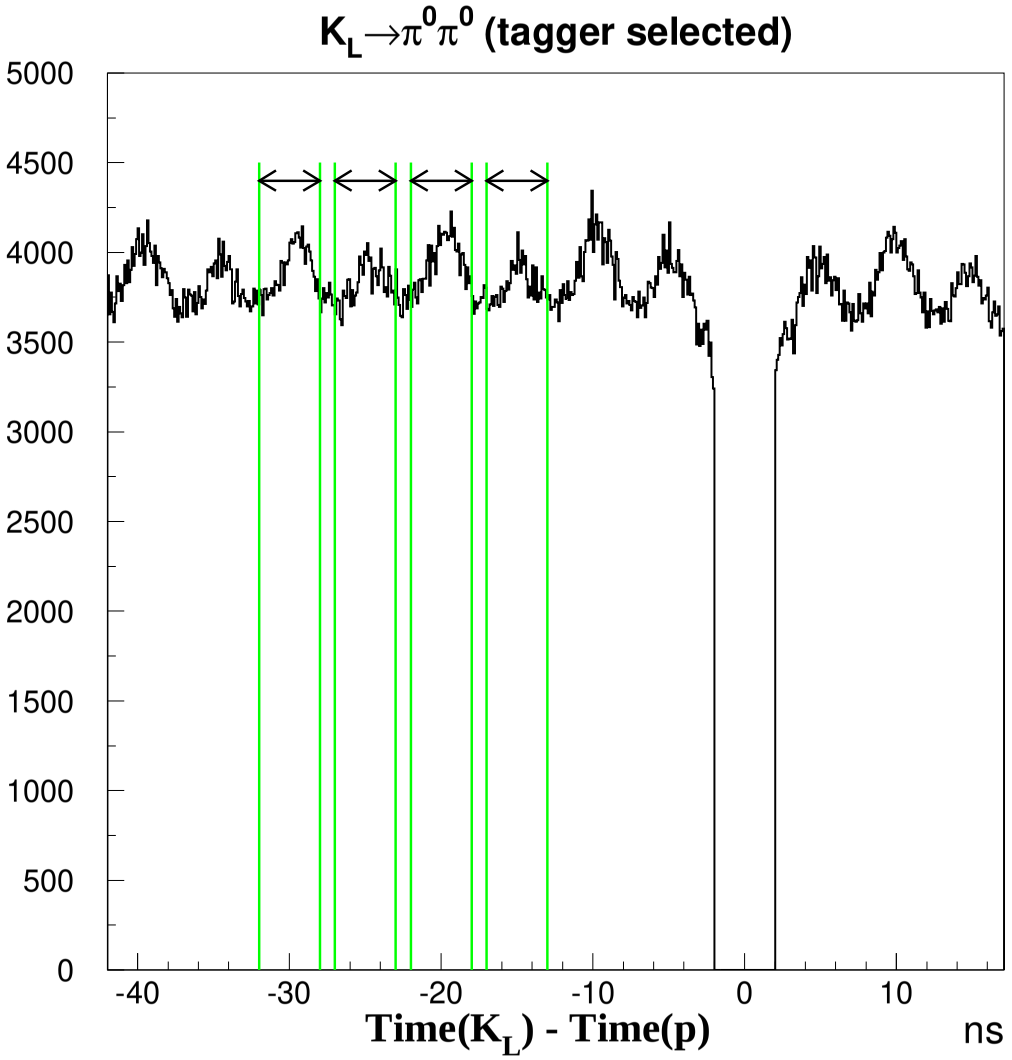
$$\Delta R < 3 \times 10^{-4}$$

NA48: Mistagging probability

$$\Delta\alpha_{\rm LS} = \Delta\beta_{\rm tag} + \Delta {\rm W}$$

$\Delta\beta_{\rm tag}$ is the difference of tagging probability in the side bands for $\pi^0\pi^0$ and $\pi^+\pi^-$ untagged $\rm K_L$

$$\Delta\beta_{\rm tag} = \beta^{00}_{\rm tag} - \beta^{+-}_{\rm tag}$$



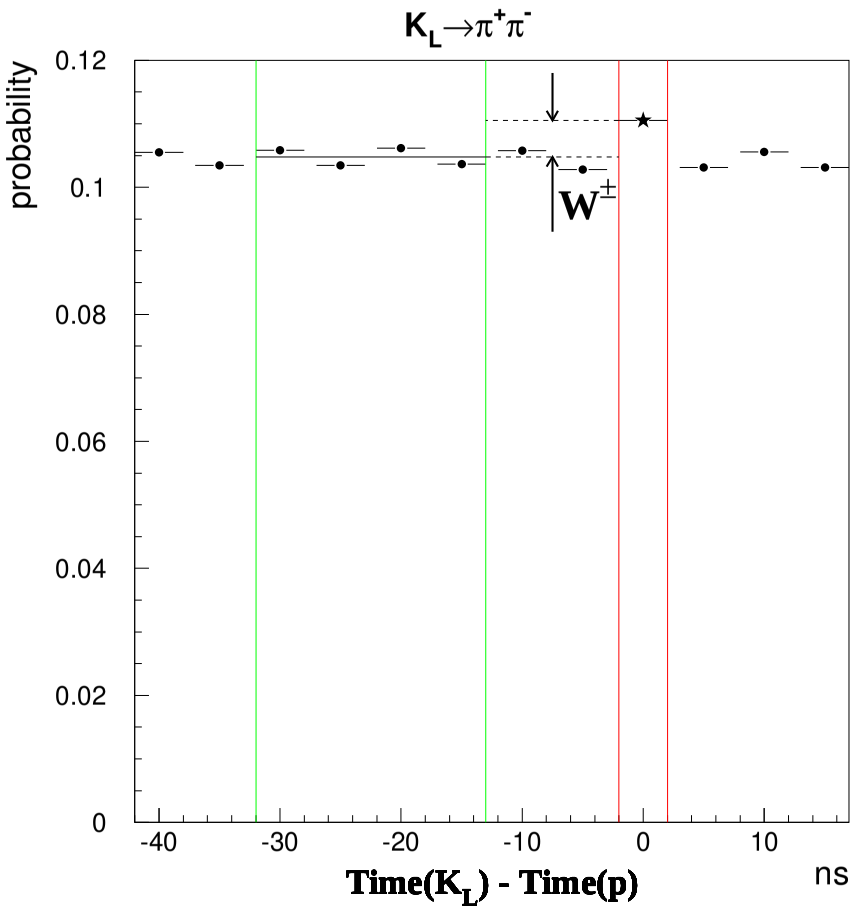
$$\Delta\beta_{\rm tag} = (5.3 \pm 1.6) \times 10^{-4}$$

NA48: Mistagging probability

ΔW is the difference in tagging probability for K_L in the tagging window and untagged K_L in the side bands: $W = \alpha_{LS} - \beta_{tag}$

$K_L \rightarrow 3\pi^0$ are used for the neutral detector.

$$\Delta W = W^{00} - W^{+-} \simeq W^{000} - W^{+-}$$

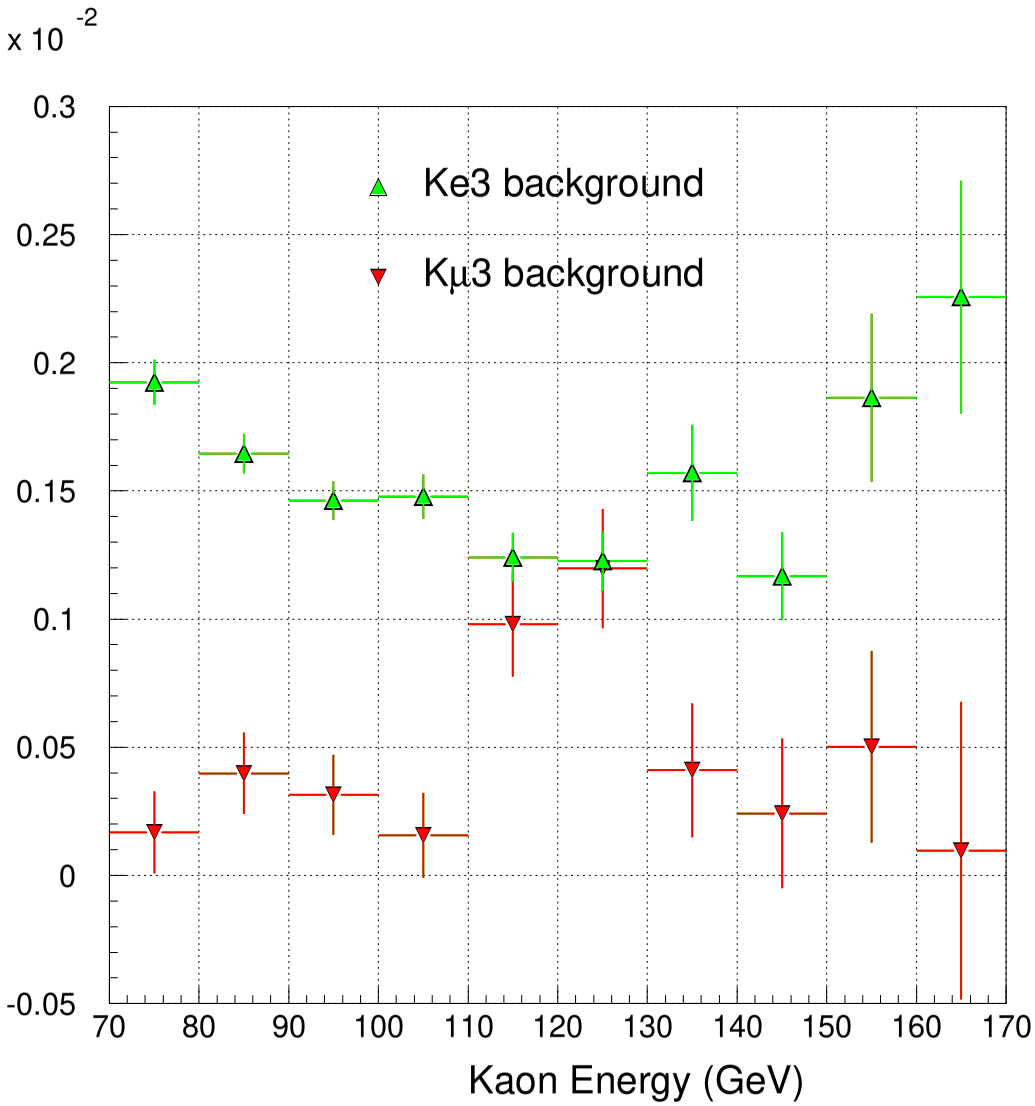


$$\Delta W = (-5.0 \pm 3.9) \times 10^{-4}$$

Limited for now by the statistics of reprocessed $3\pi^0$

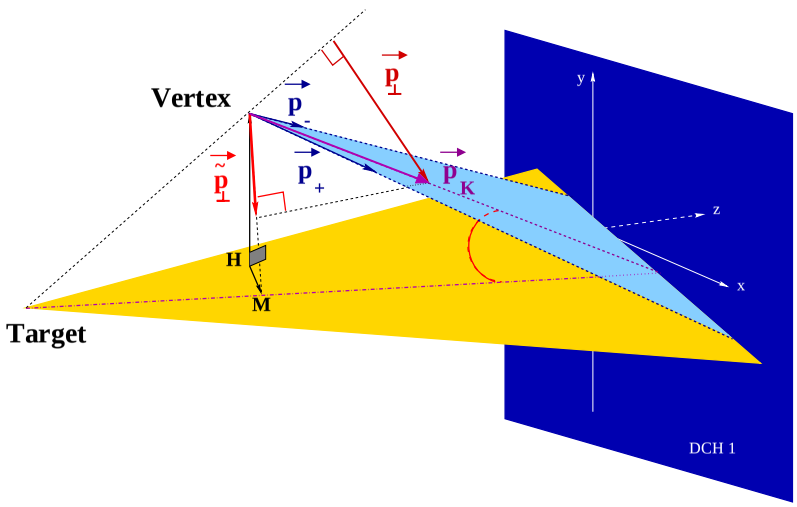
$$\Delta R = (1 \pm 8) \times 10^{-4}$$

NA48: Charged background



NA48: Background

- $\pi^+\pi^-$
  - $p_T'^2 < 2 \times 10^{-4} (\mathrm{GeV/c})^2$

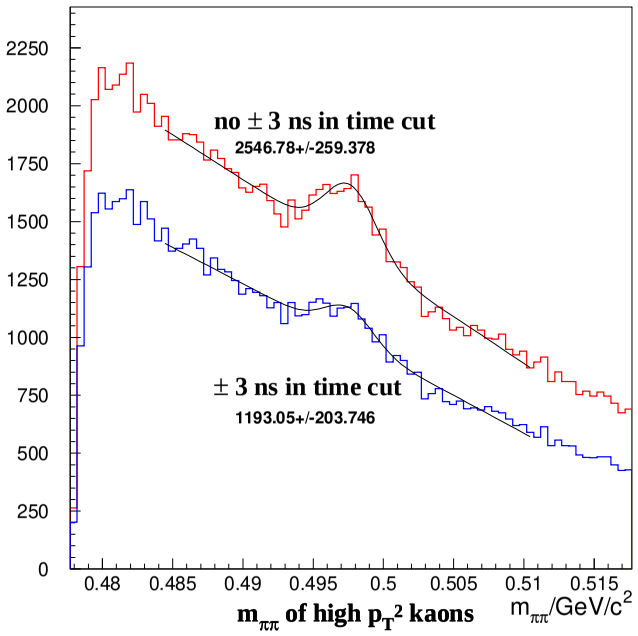


  - $\pm 3\sigma$ $m_{\pi^+\pi^-}$ mass cut

- $\pi^0\pi^0$
  - $R_{ell} \equiv \left\{ \left(\frac{\frac{m_1+m_2}{2} - m_{\pi^0}}{\sigma_{\frac{m_1+m2}{2}}} \right)^2 + \left(\frac{\frac{m_1-m_2}{2}}{\sigma_{\frac{m_1-m2}{2}}} \right)^2 \right\}$
  - Signal: $R_{\mathrm{ell}} < 13.5$

NA48: Scattered Events in the K_L beam

There are some $K \to \pi^+\pi^-$ with large $p_T'^2$ mainly originating from the K_L final collimator and with a typical K_S decay distribution



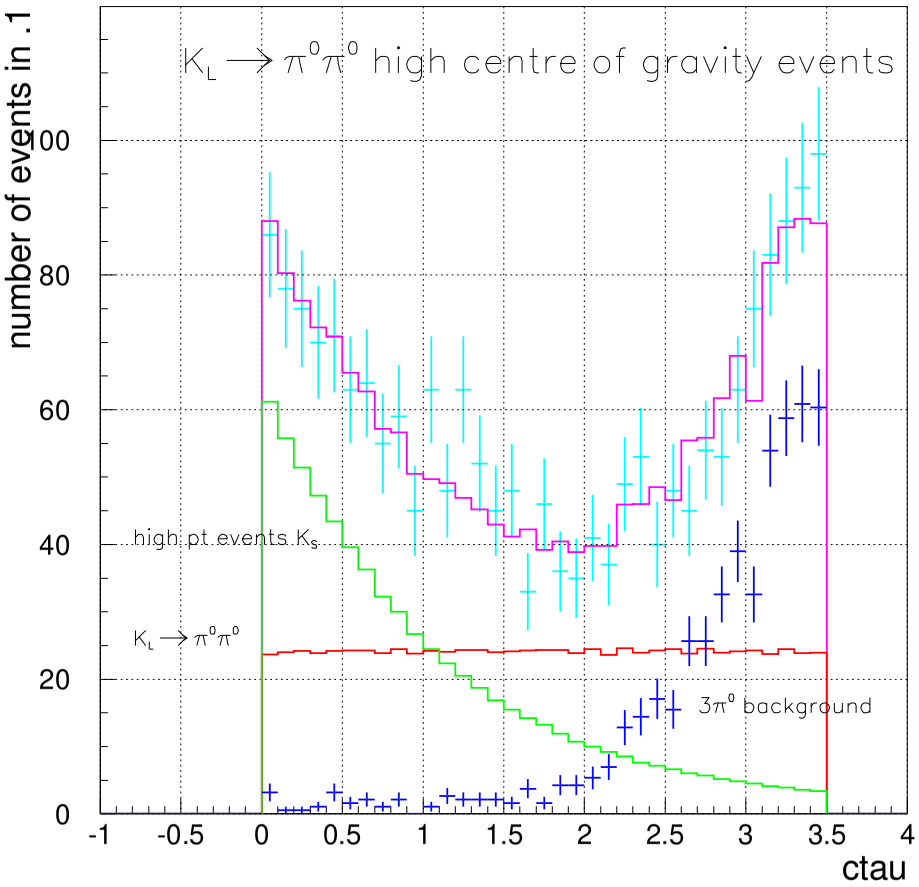
Rejected by the $p_T'^2$ cut applied to $\pi^+\pi^-$ but not to $\pi^0\pi^0$

- They can be identified in the $\pi^0\pi^0$ sample requiring a large centre of gravity (R_{cog})
- The amount of scattered kaons found in $\pi^0\pi^0$ and $\pi^+\pi^-$ agrees once the ± 3ns in-time cut is applied to the $\pi^+\pi^-$
- This is a very small effect only visible because amplified by the $1/|\eta_\pm|^2$ factor!

$$\Delta R = (-10 \pm 3) \times 10^{-4}$$

NA48: Scattered Events in the K_L beam

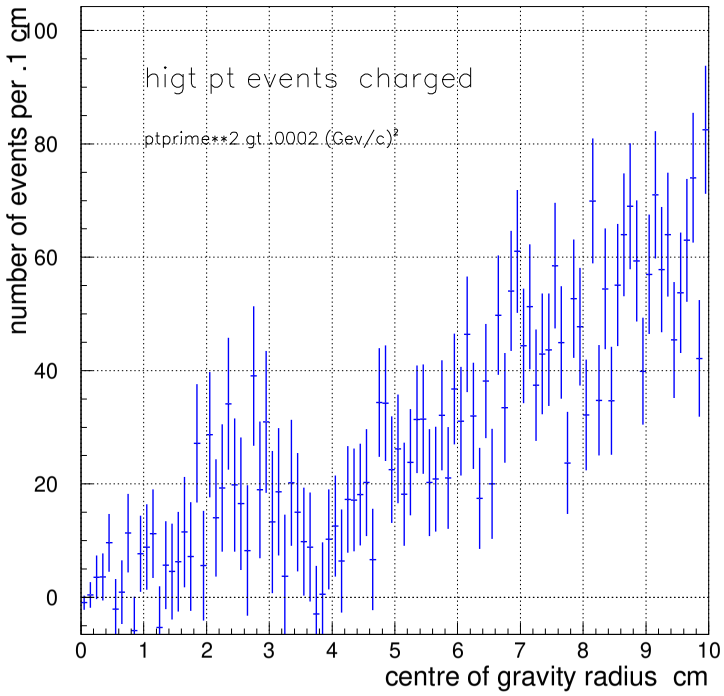
- They can be identified in the $\pi^0\pi^0$ sample requiring a large centre of gravity (R_{cog})

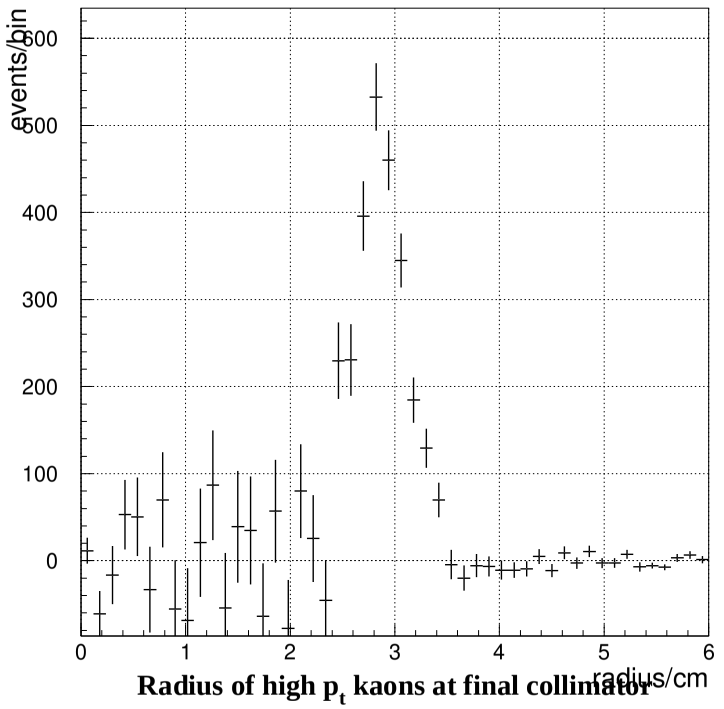


- The amount of scattered kaons found in $\pi^0\pi^0$ and $\pi^+\pi^-$ agrees once the ± 3ns in-time cut is applied to the $\pi^+\pi^-$
- This is a very small effect only visible because amplified by the $1/|\eta_\pm|^2$ factor!

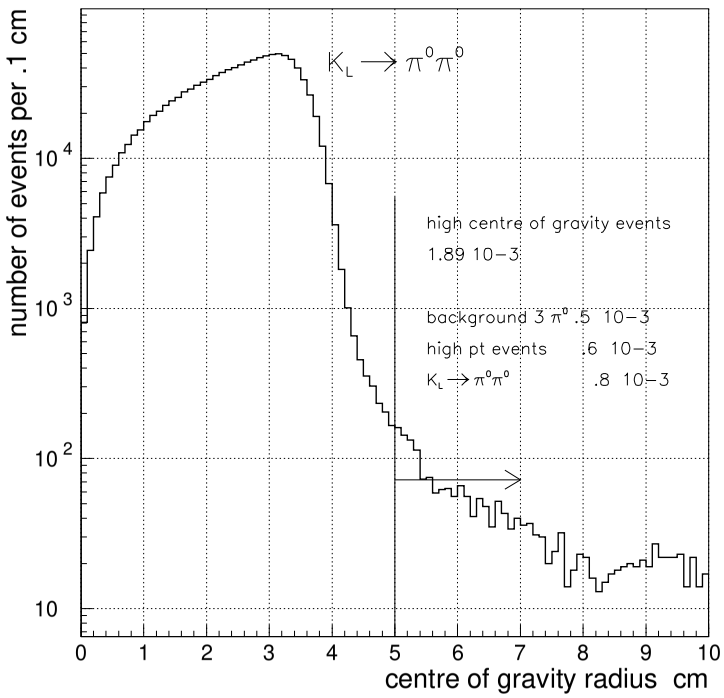
$$\Delta R = (-10 \pm 3) \times 10^{-4}$$

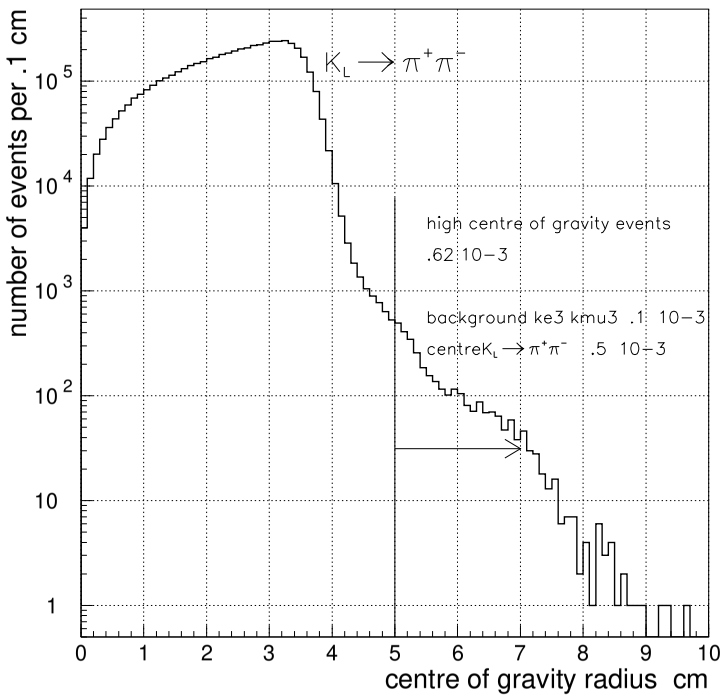
NA48: Scattered Events in the K_L beam





NA48: Centre of gravity distribution





NA48: energy scale

$$E_{\rm M} = (1+\alpha) \times E_{\rm T}$$

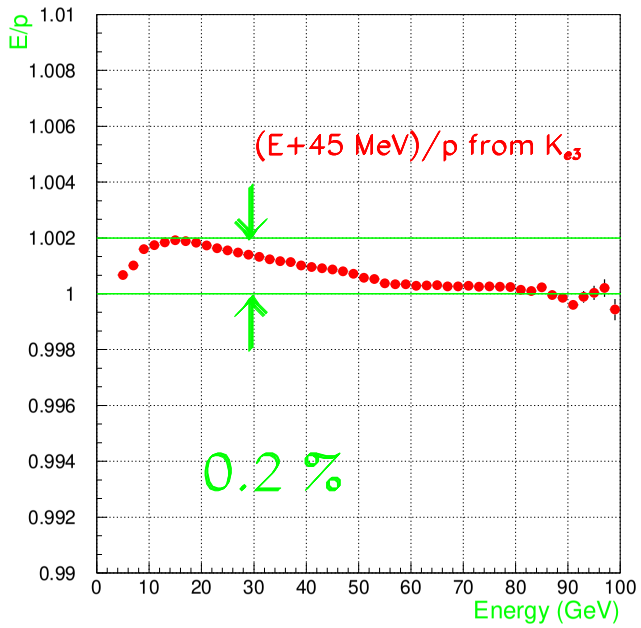
α = uncertainty on the $\pi^+\pi^-/\pi^0\pi^0$ energy scale

The uncertainty introduced on R is small if the beginning of the K_S decay region is defined by an anti-counter (AKS)

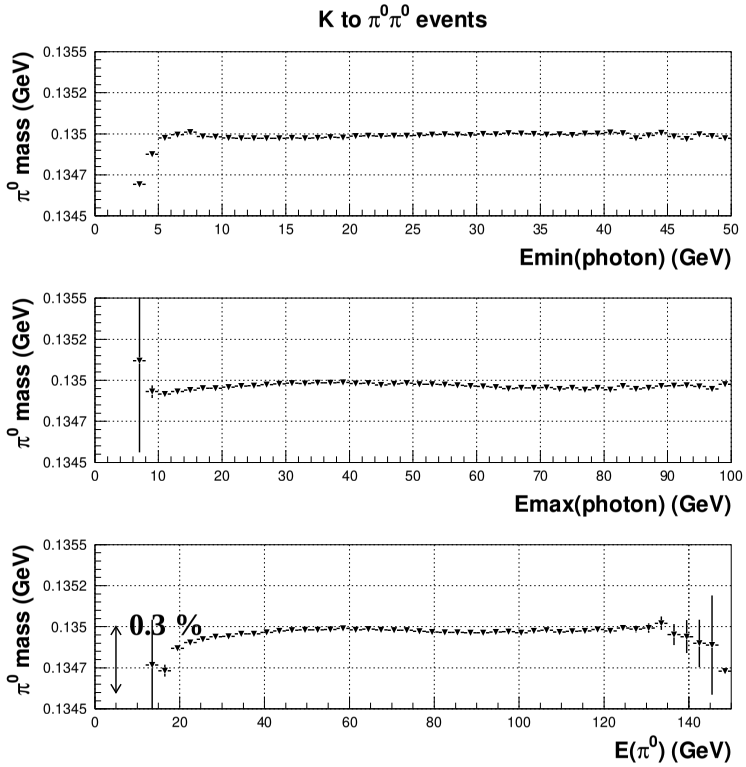
Example: for $E_{\rm K} = 100$GeV and flat acceptance:

AKS	Δ R
NO	$\simeq 20 \times \alpha$
YES	$\simeq \frac{\exp(-3.5 c\tau_S)}{1-\exp(-3.5 c\tau_S)} \times 20 \times \alpha = 0.6 \times \alpha$

NA48: Linearity



$$\frac{E}{P} = \frac{\text{Energy from LKr}}{\text{Momentum from spectrometer}}$$ for Ke3 electrons as a function of the energy



Stability of m_{π^0} in $K \rightarrow 2\pi^0$ decays

NA48: Neutral systematics

Neutral reconstruction systematics	
Source	ΔR (units 10^{-4})
Non linearity	$\pm$ 5
Non Gaussian tails in σ_E	$\pm$ 5
Transverse scale	$\pm$ 3
Intercalibration	$\pm$ 3
Distance/Energy scale	$\pm$ 3
Other sources	$\pm$ 4

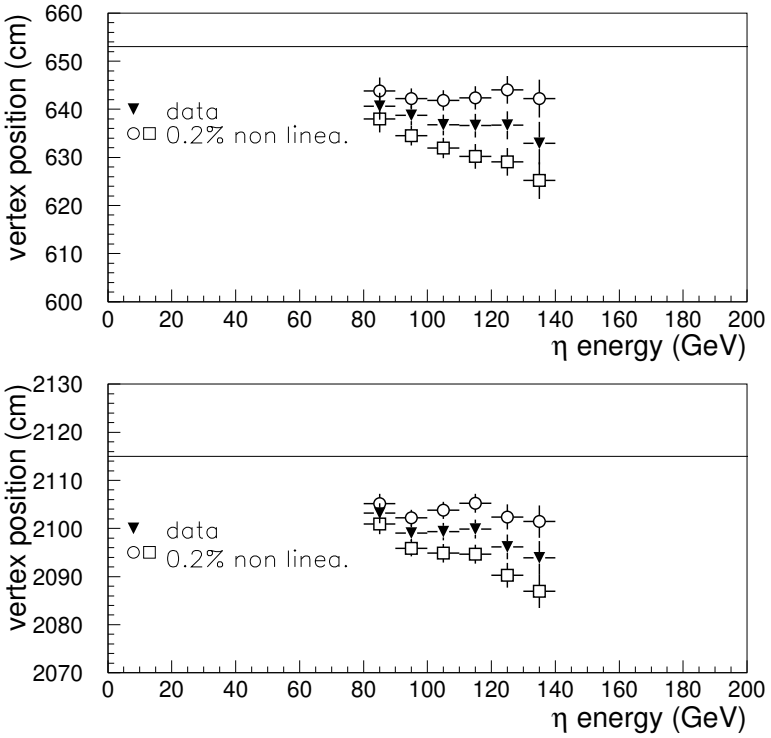
- We employ a π^- beam and two 3.5cm thick polyethylene targets, to produce $\eta, \pi^0 \to \gamma\gamma$ decays to cross check the distance scale using the published π^0 and η masses.
- A discrepancy at the level of 2 σ is found reconstructing the vertex for $\eta \to \gamma\gamma$

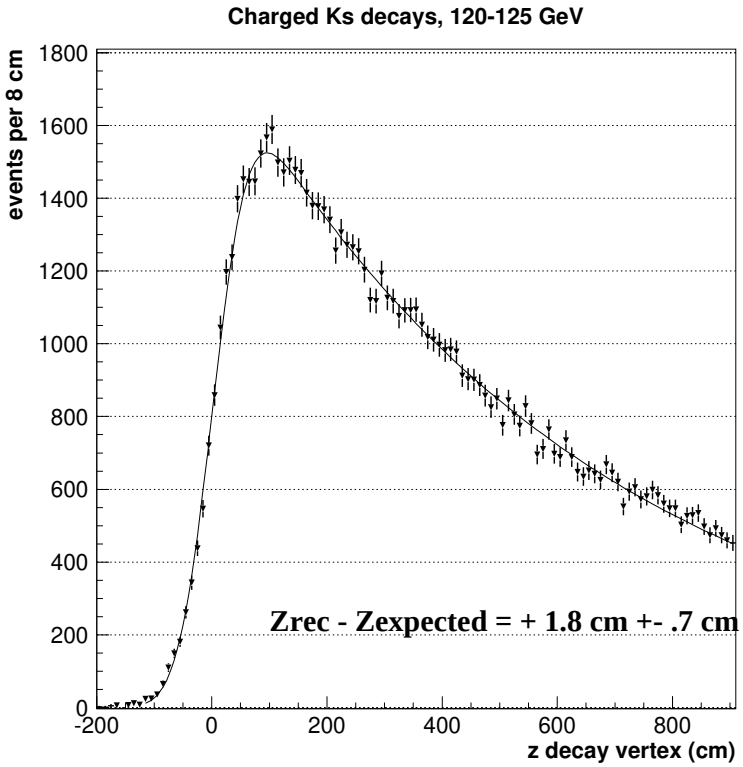
A dedicated η run will take place later this year to verify the effect

For the time being, we have increased the scale and/or the non linearity error to also cover the $\eta \to \gamma\gamma$ result.

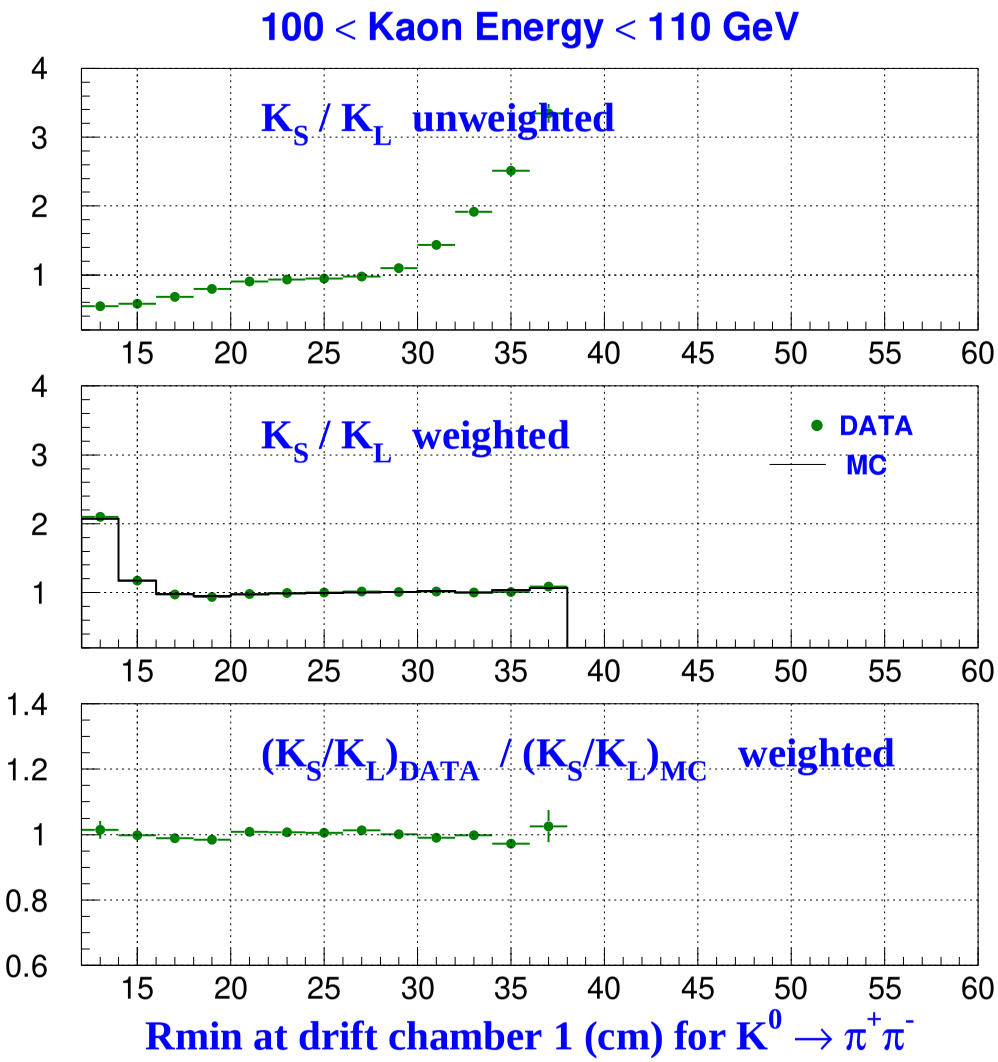
$$\Delta R < 10 \times 10^{-4}$$

NA48: Relative momentum scale

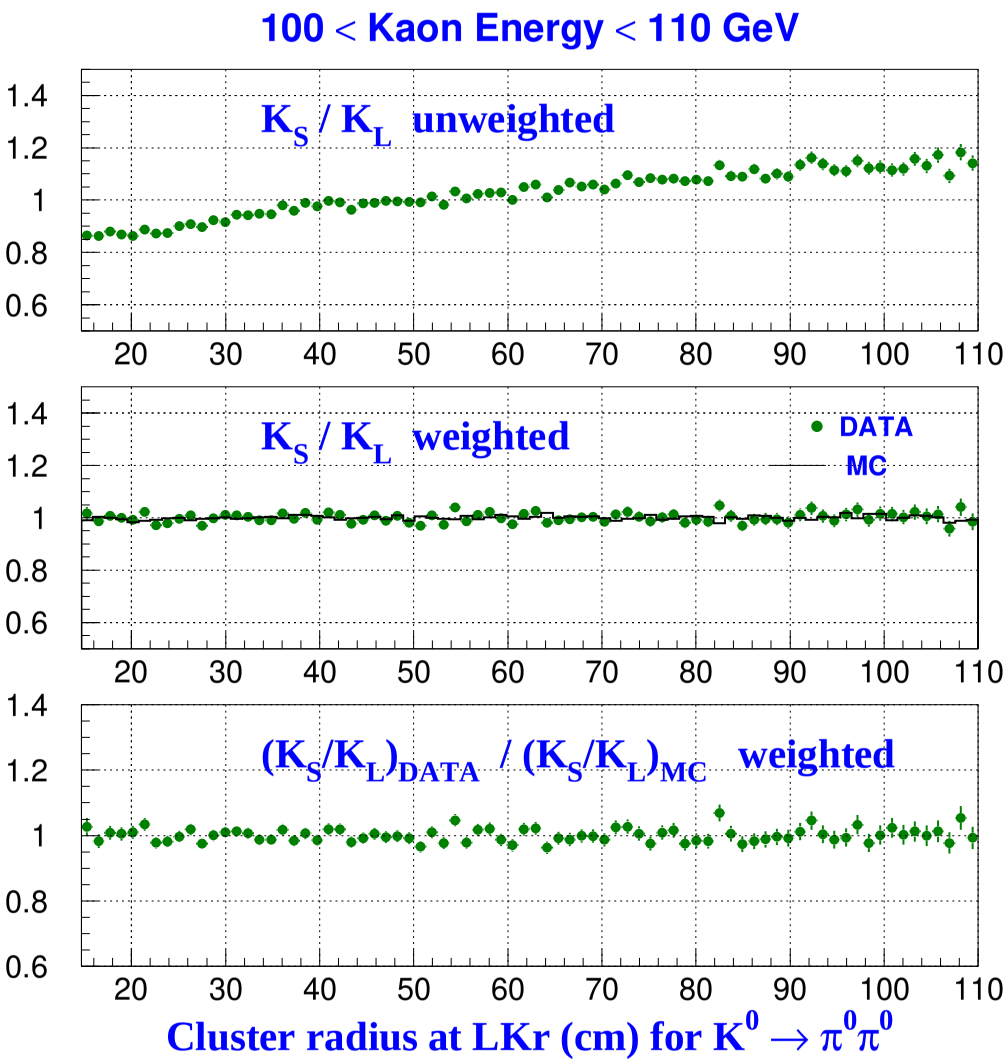




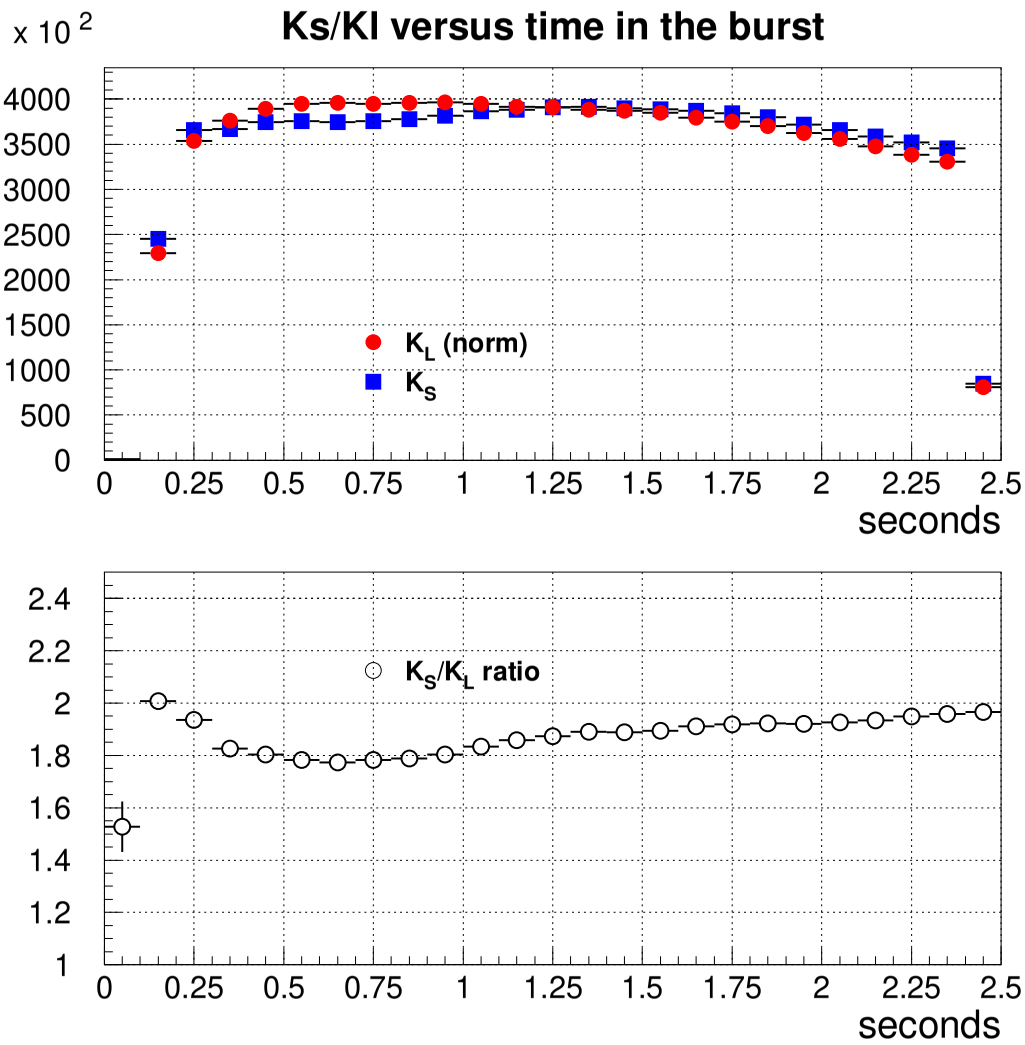
NA48: DATA/MC $\pi^+\pi^-$



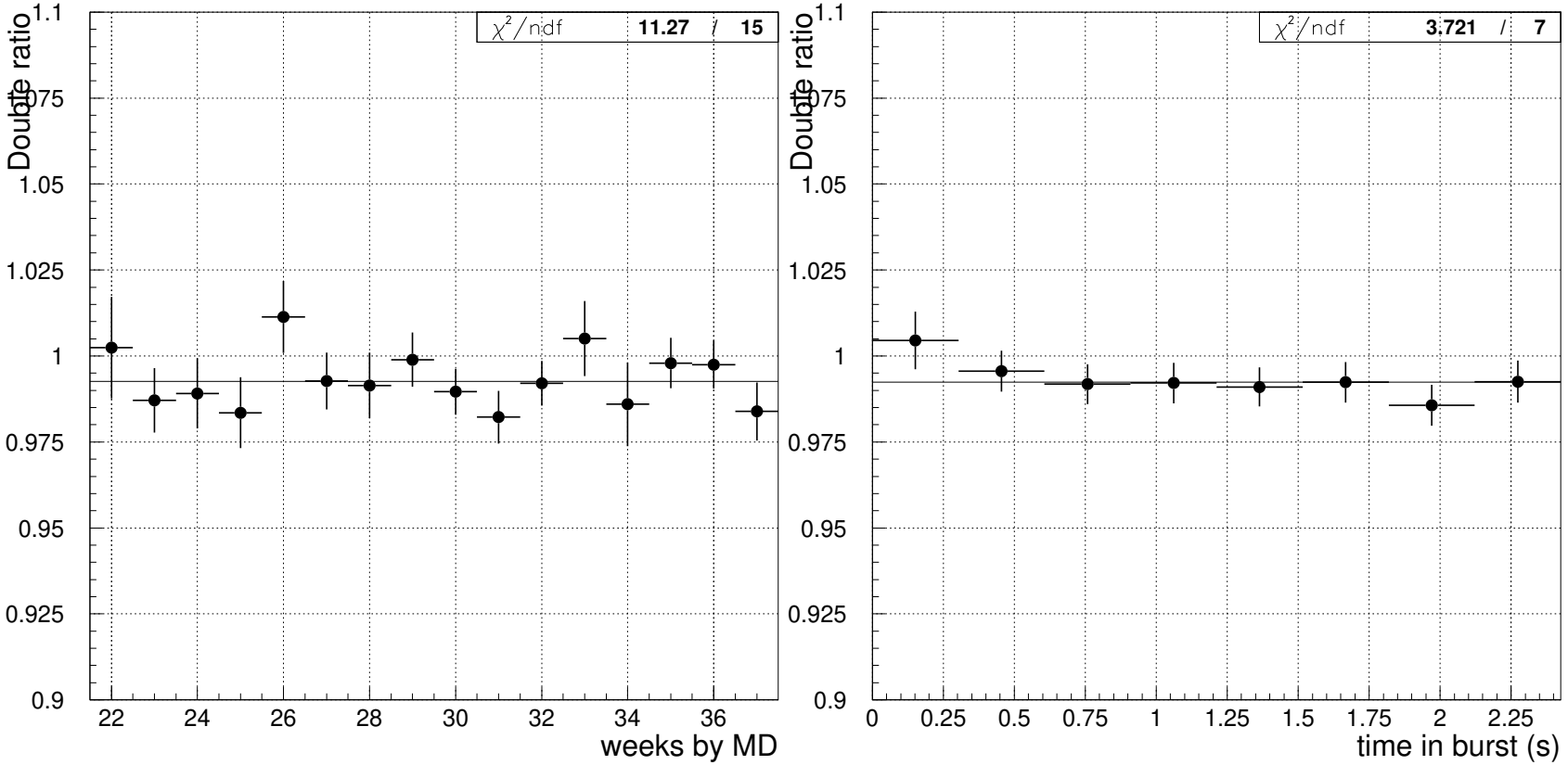
NA48: DATA/MC $\pi^0\pi^0$



NA48: K_S /K_L over during the spill



NA48: checking R vs time



NA48: Perspective

- The systematic error of the 1998 result should be reduced in the future
- The analysis of the 1999 data is in progress
- The implosion of the carbon fibre beam tube on November 1999 has damaged all four drift chambers
- NA48 has obtained approval to repair the chambers in order to bring to a proper completion the $\mathrm{Re}(\varepsilon'/\varepsilon)$ measurement
- We plan to collect more data in 2000 and 2001 to reduce the systematic errors

NA48: 1997 and 1998 results

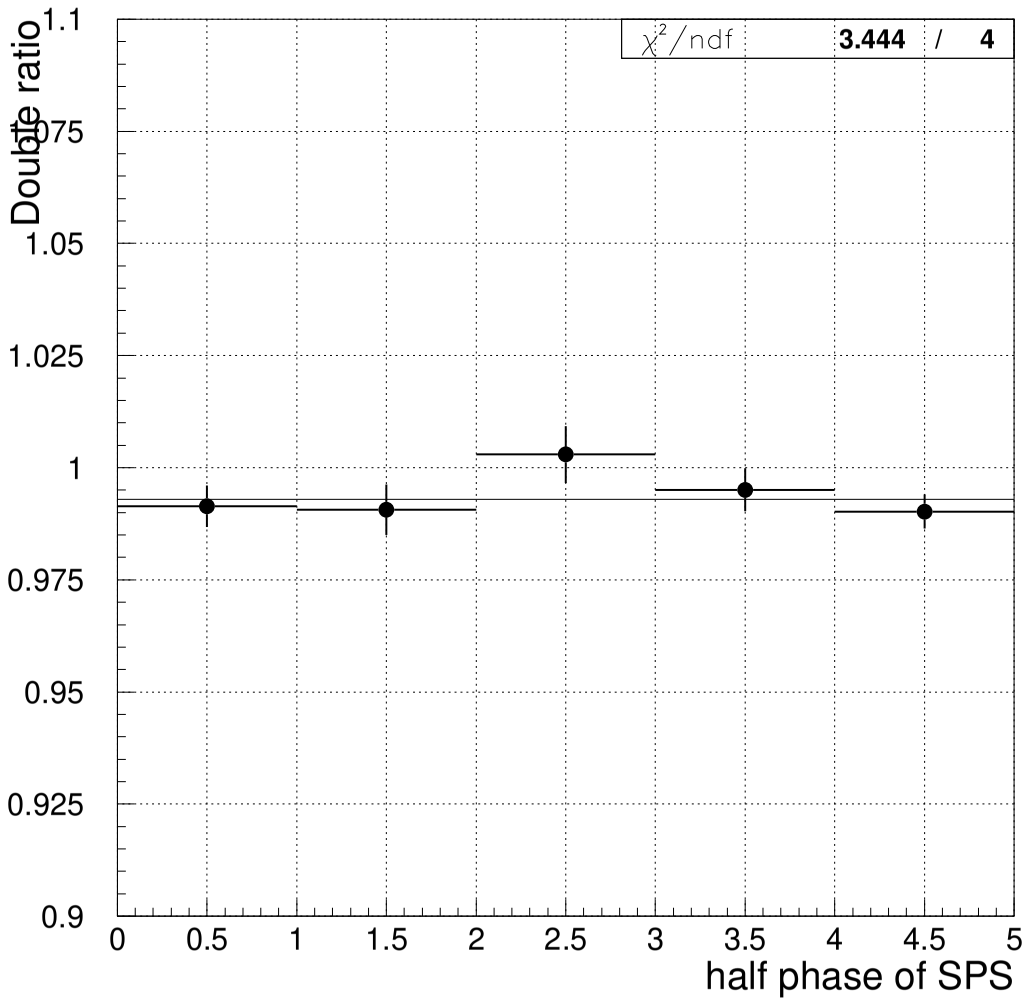
Corrections and syst. uncertainties on R (Units = 10^{-4})				
Source	1997 sample		1998 sample	
Charged trigger	+9	± 23	–1	± 11
Mistagging prob.	+18	±9	+1	±8
Tagging efficiency	–	±6	–	± 3
Neutral scale	–	±12	–	±10
Charged vertex	–	±5	+2	±2
Acceptance	+29	±12	+31	±9
Neutral BG	–8	±2	–7	±2
Charged BG	+23	±4	+19	±3
Beam scattering	–12	±3	–10	±3
Accid. activity	–2	±14	+2	±12
Total	+57	±35	+37	±24

- 1997
  $\mathrm{Re}(\varepsilon'/\varepsilon) = (18.5 \pm 4.5(stat.) \pm 5.8(syst.)) \times 10^{-4}$
- 1998
  $\mathrm{Re}(\varepsilon'/\varepsilon) = (12.2 \pm 2.9(stat.) \pm 4.0(syst.)) \times 10^{-4}$

Combined 1997 and preliminary 1998

$$\mathrm{Re}(\varepsilon'/\varepsilon) = (14.0 \pm 4.3) \times 10^{-4}$$

NA48: R vs SPS phase



NA48: accidental activity

To account for the geometric difference of the K_S and K_L beams, we overlay events collected proportionally to the beam intensity (*randoms*) to $\pi^+\pi^-$ and $\pi^0\pi^0$ events and evaluate the gain and losses induced by the analysis cuts

$$\Delta R = (2 \pm 6) \times 10^{-4}$$

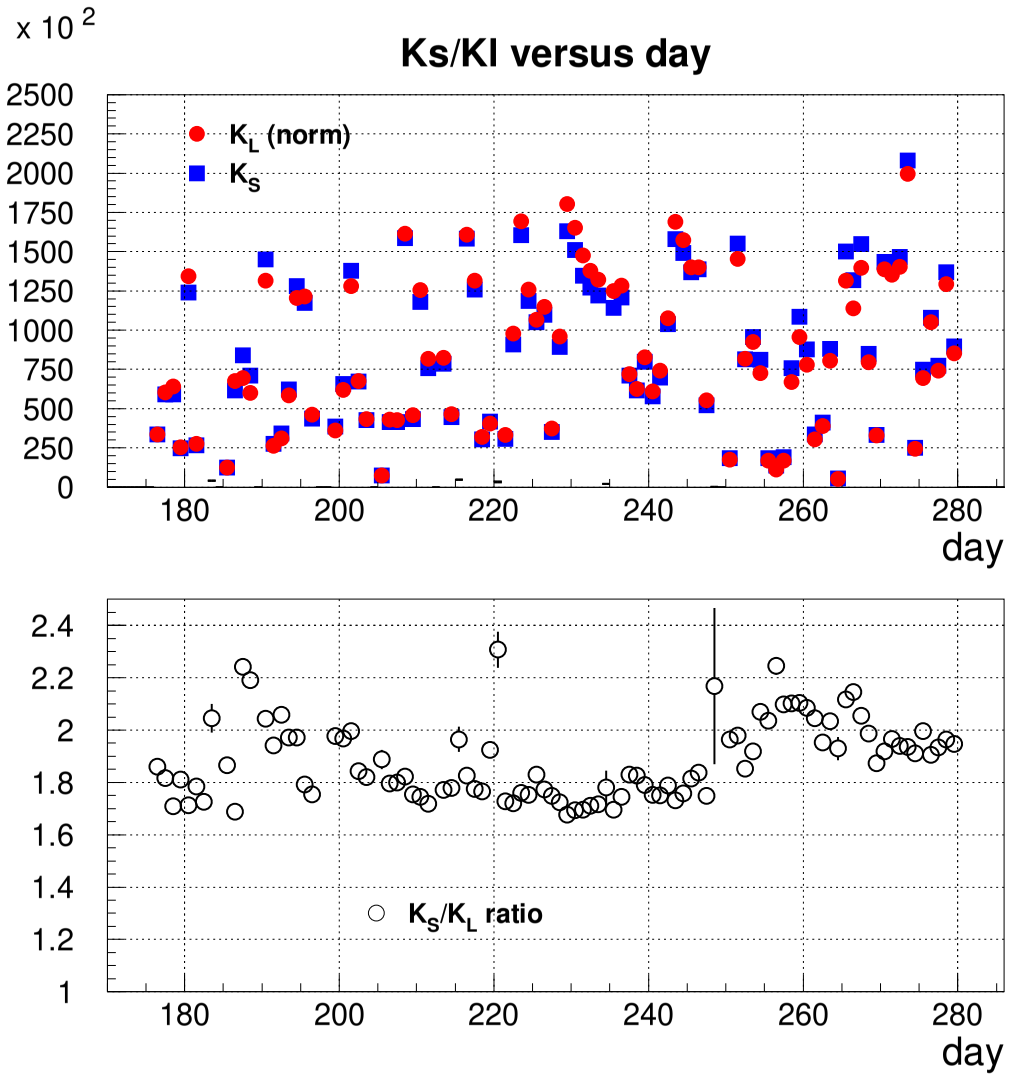
To put bounds on the effects related to the variation of the K_S / K_L ratio (R.M.S. 10 %) and the effects which are not related to the K_L accidental activity, we use the following inputs:

- the difference in accidental activity seen by K_S and K_L events is ≈ 1 %
- The asymmetric losses on $\pi^+\pi^-$ and $\pi^0\pi^0$ induced by the noise in the DCH read out are $< 2.5\%$
- the noise in the detector does not change by more than a factor of two as a function of time

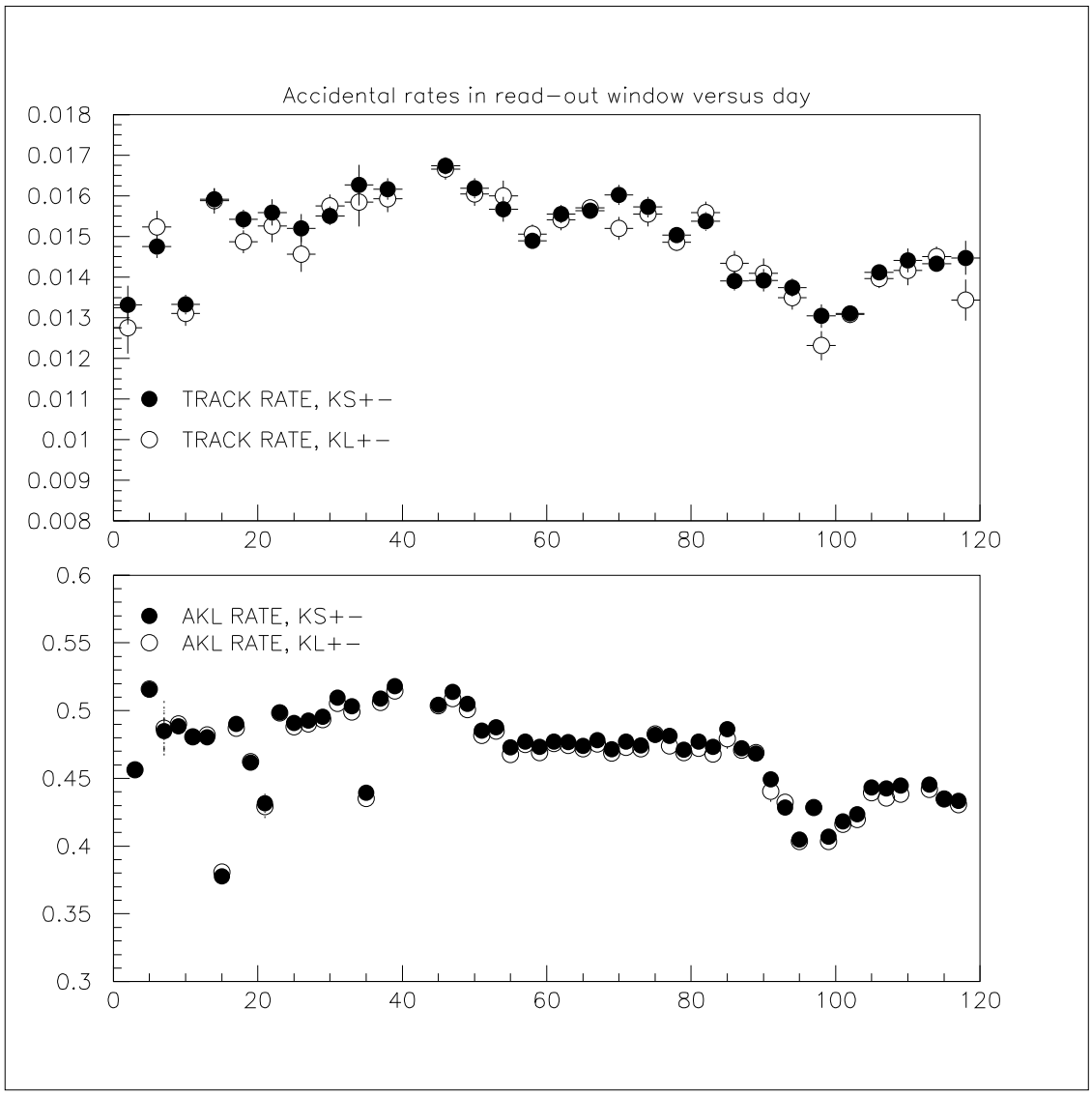
$$\Delta R < 10 \times 10^{-4}$$

In the future, we will overlay the randoms to the MC data to reduce the effect of doubling the noise.

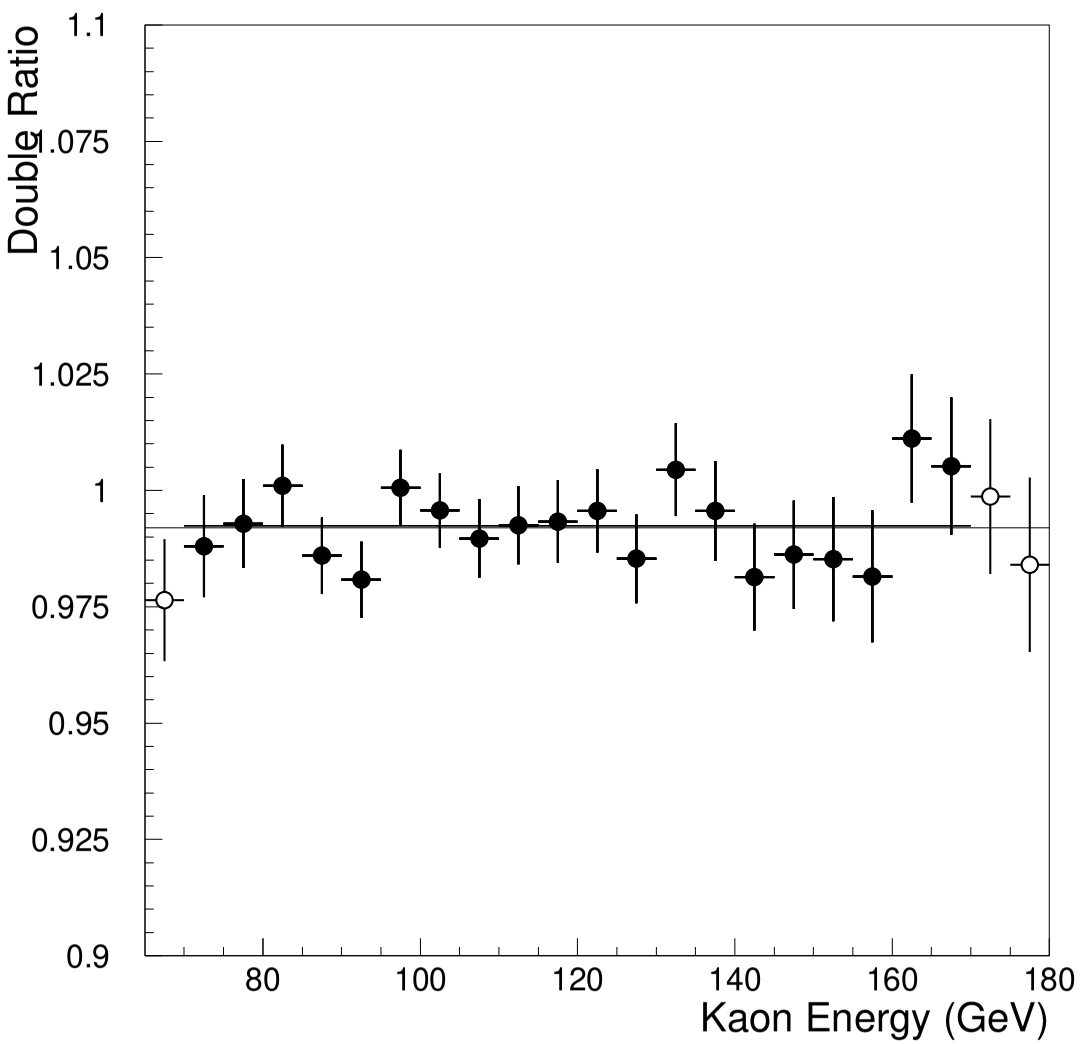
NA48: K_S /K_L over during the run



NA48: Accidental rate in K_S and K_L



NA48: extended energy range



NA48: running in 2000 and 2001

- Year 2000 With no DCH available we will focus on the neutral decays.
  - We want to measure the difference in mistagging probability for $\pi^0\pi^0$
  - We want to improve on the distance/momentum scale and non linearity of the LKr using dedicated runs with the negative π beam to produce large amount of $\eta \to \gamma\gamma$ and $\eta \to 3\pi^0$
- Year 2001 We plan to collect data with the restored drift chambers. The aim is to address in particular the systematic errors related to the beam intensity variation