New measurement of direct CP violation in two pion decays of neutral kaons by experiment NA48 at CERN

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Plan of the presentation

We present a new measurement of the $\mathrm{Re}(\varepsilon'/\varepsilon)$ parameter based on data collected by NA48 during the 1998 SPS run. The statistics have increased by 2.5 times with respect to the result already published by NA48

- Physics motivation
- NA48 method
  - beams
  - detectors
- Analysis of the 1998 data
  - Data sample
  - Tagging efficiency
  - Mistagging probability
  - Background subtraction
  - Relative energy scale
  - K_L proper time weighting
  - Accidentals
- Result and checks
- Perspectives

This result is preliminary

Physics motivation

Strangeness eigenstates:

$$\mathrm{K}^0(\bar{\mathrm{s}}\mathrm{d})$$
$$\overline{\mathrm{K}^0}(\mathrm{s}\bar{\mathrm{d}})$$

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 eigenstates:

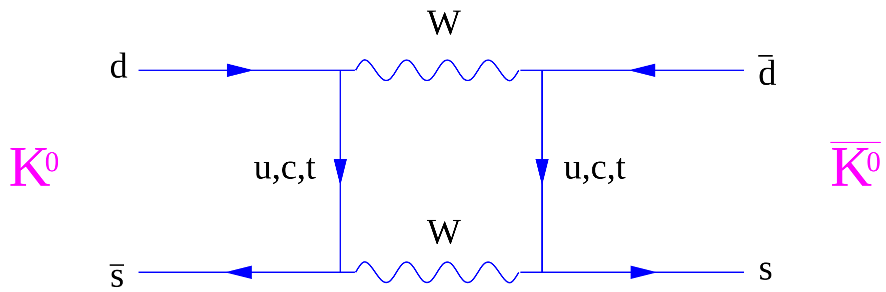
$\mathrm{K_S} \simeq$	$\mathrm{K}_1 +$	$\varepsilon \mathrm{K}_2$	$\mathrm{K_L} \simeq$	$\mathrm{K}_2 +$	$\varepsilon \mathrm{K}_1$
69 %	$\pi^+\pi^-$		21 %	$3\pi^0$	
31 %	$\pi^0\pi^0$		13 %	$\pi^+\pi^-\pi^0$	
			27 %	$\pi\mu\nu$	
			39 %	$\pi e\nu$	
			0.2 %		$\pi^+\pi^-$
			0.1 %		$\pi^0\pi^0$

$c\tau_\mathrm{S} = 2.67$ cm $\qquad$ $c\tau_\mathrm{L} = 15.5$ m

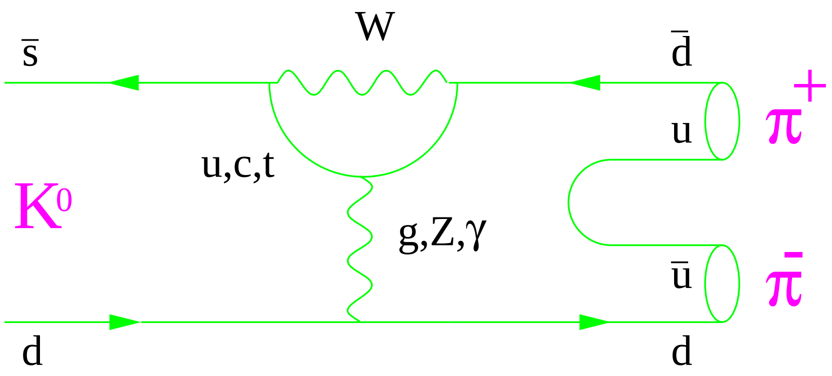
$$\boxed{\varepsilon = (2.28 \pm 0.02) \times 10^{-3}}$$

Physics motivation, contd.

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



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



Direct CP violation:

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

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

Double ratio technique

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

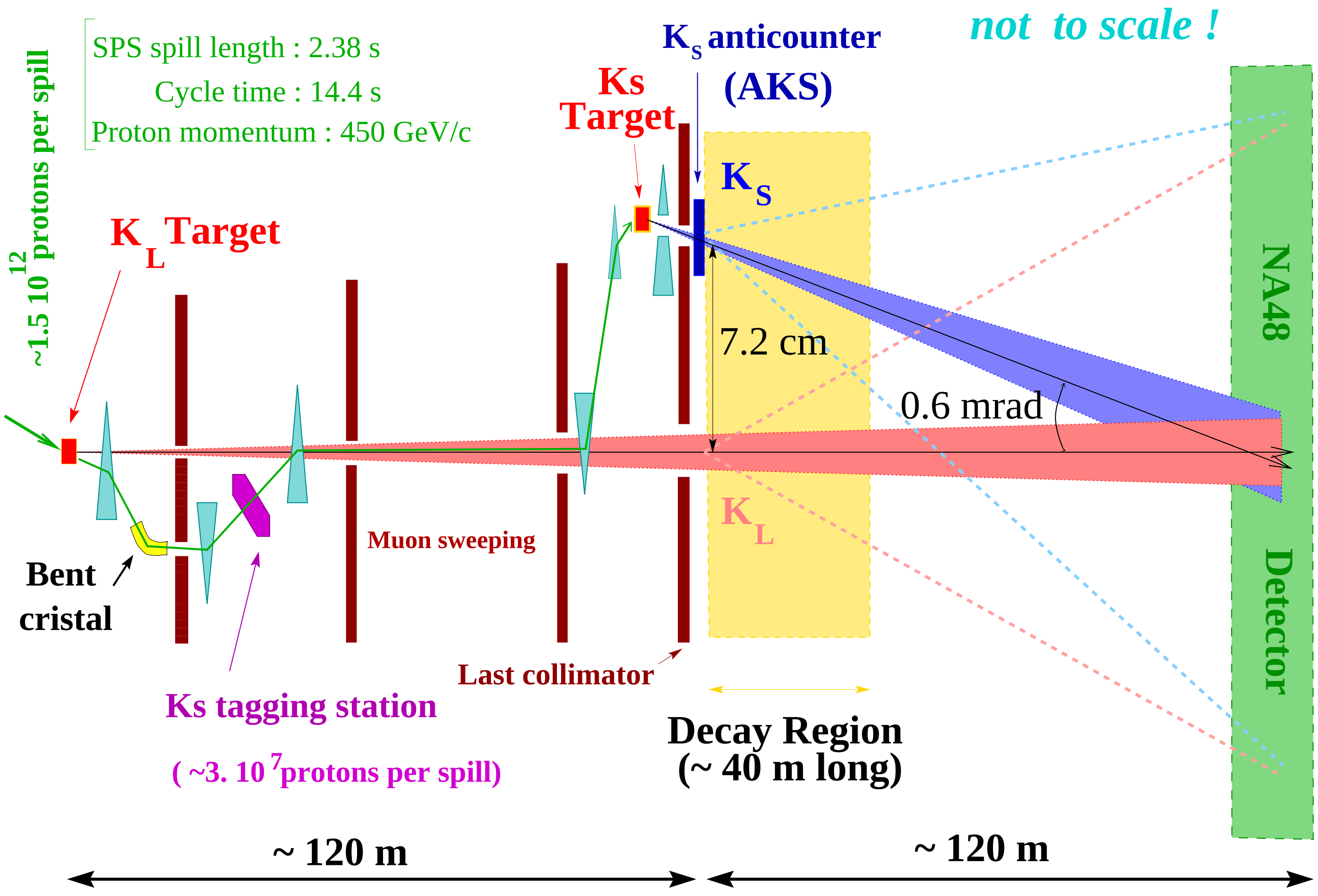
$$\eta_{00} \equiv \frac{A(K_L \to \pi^0\pi^0)}{A(K_S \to \pi^0\pi^0)} \simeq \varepsilon - 2\,\varepsilon'$$

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

$R = \frac{N_L^{00}}{N_S^{00}} / \frac{N_L^{+-}}{N_S^{+-}}$ Provided at least K_S / K_L or $\pi^+\pi^- / \pi^0\pi^0$ are collected at the same time

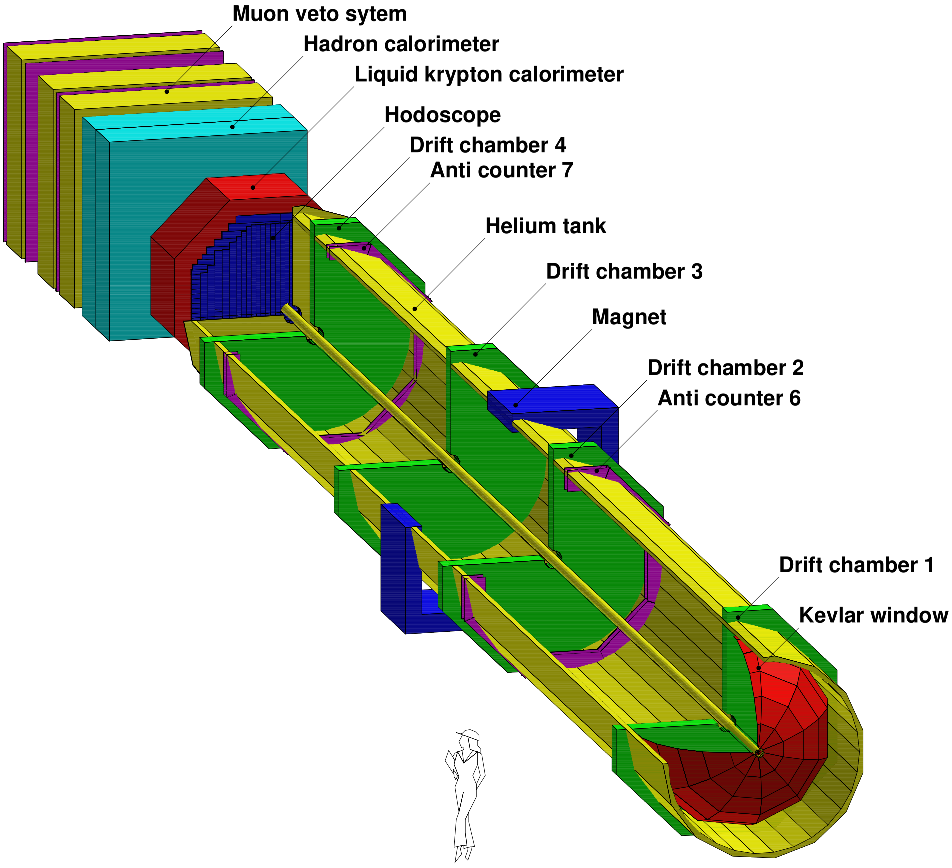
NA31	$(23.0 \pm 6.5) \times 10^{-4}$
E731	$(7.4 \pm 5.9) \times 10^{-4}$
KTEV	$(28.0 \pm 4.1) \times 10^{-4}$
NA48 97	$(18.5 \pm 7.3) \times 10^{-4}$
NA48 98	today!

NA48 method: simultaneous K_L and K_S beams



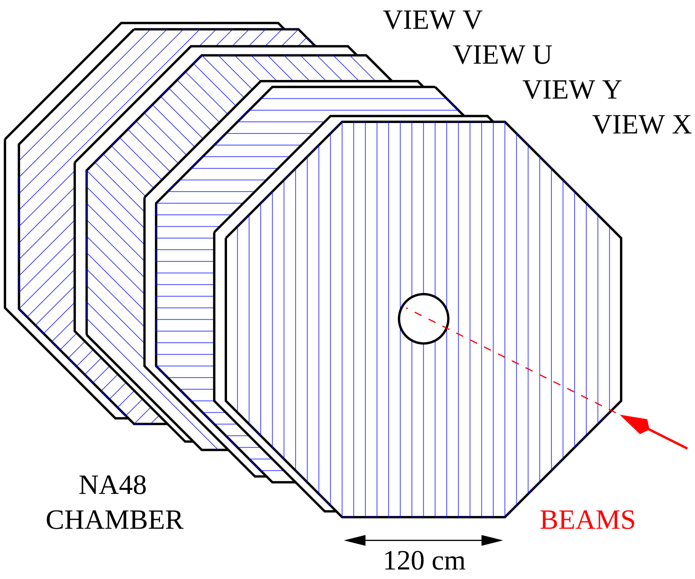
- K_S are distinguished from K_L by tagging the protons upstream of the K_S target
- NA48 detects all four modes from the same decay region

NA48 method: detectors



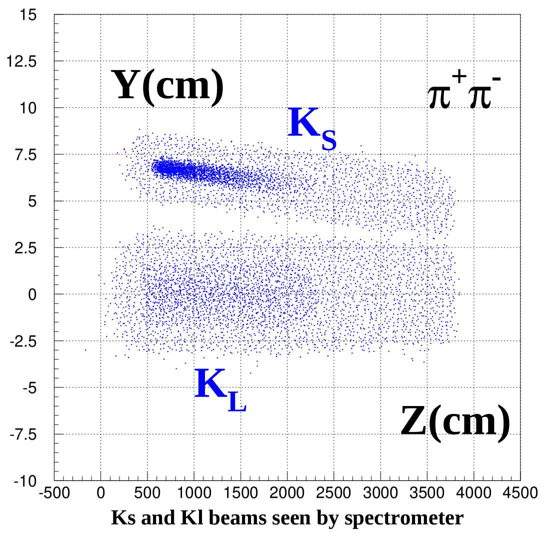
- $K_{L,S} \rightarrow \pi^+\pi^-$
  - magnetic spectrometer ($P_T{}^{kick} \sim 265\mathrm{MeV}/c$)
- $K_{L,S} \rightarrow \pi^0\pi^0$
  - quasi-homogeneous Liquid Krypton e.m. calorimeter :
    - high granularity (13212 2×2 cm^2 cells)
    - projective geometry

NA48 magnet spectrometer

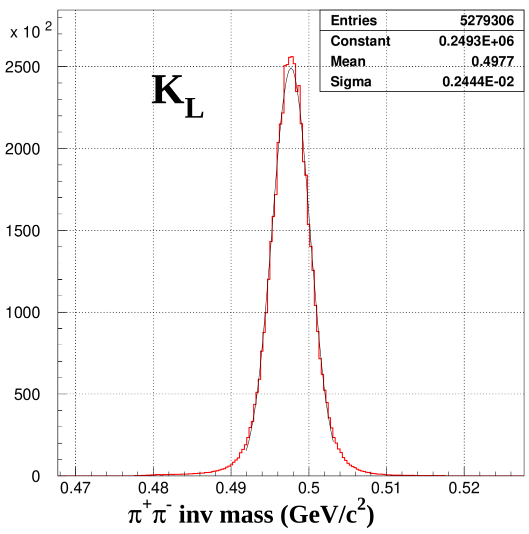


Per Chamber:

- 8 planes of 256 wires
- Positioning of wires to $\leq 100\mu$m/m
- Argon/Ethane
- Gain $\sim 8.10^4$



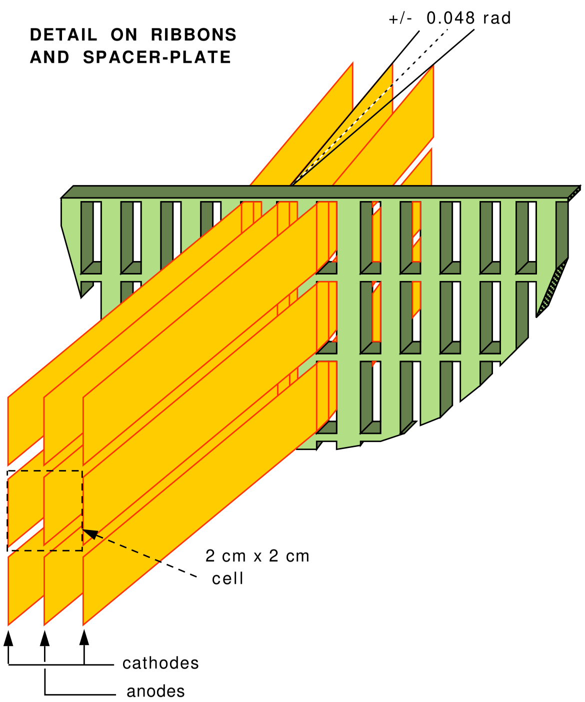
Vertex reconstruction allows beam separation



Kaon mass resolution $\sim$ 2.5 MeV/c^2

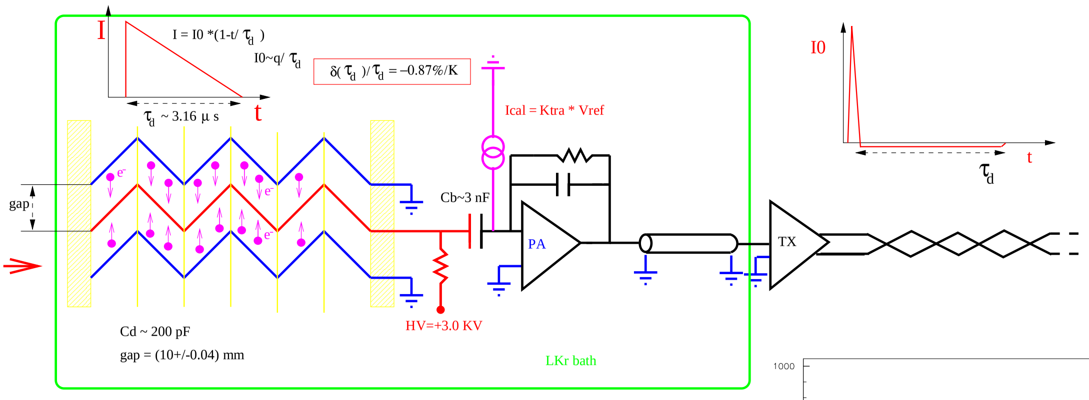
$$\sigma(p)/p \simeq 0.5\,\% \oplus 0.009\,p[\mathrm{GeV/c}]\,\%$$

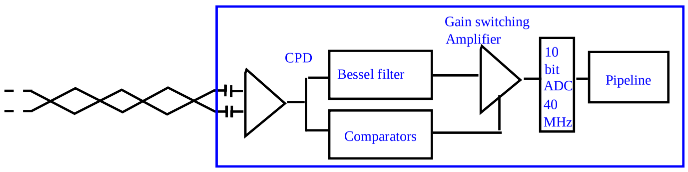
NA48 Liquid Krypton calorimeter

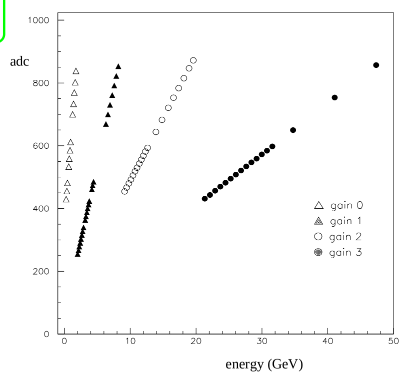


- Made of $\approx 9m^3$ LKr
- Cu-Be electrodes
- bias HV: +3 KV/cm
- 2cm×2cm×127cm
- Five Spacer plates
- Electrodes: ± 48mrad zig-zag in each spacer
- Geometry controlled to ≈0.2mm/1m

LKr read out and calibration



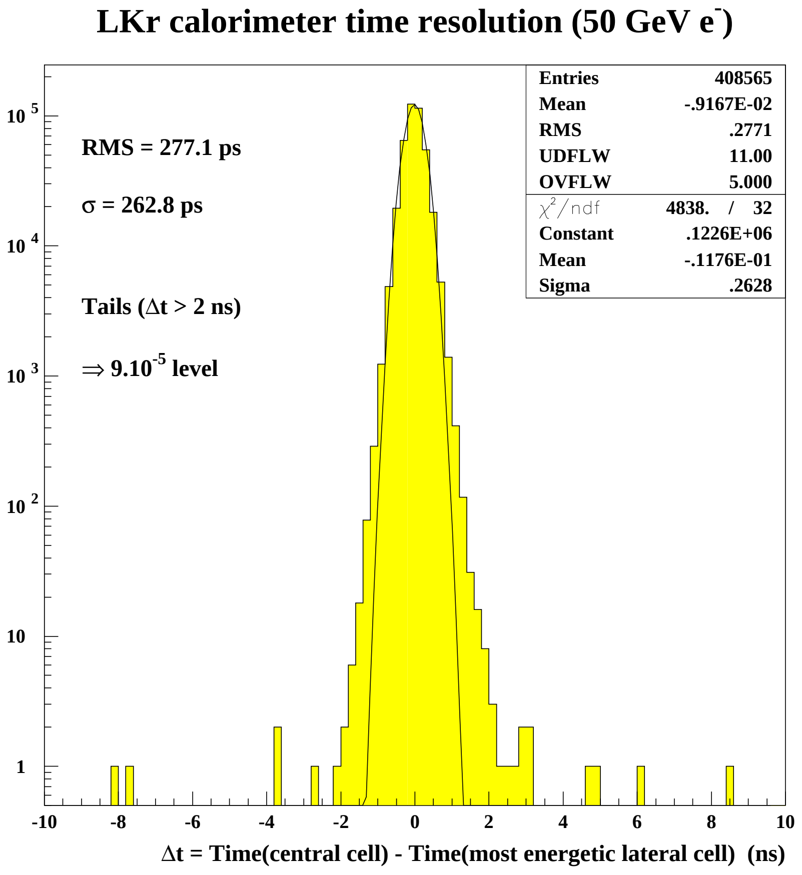


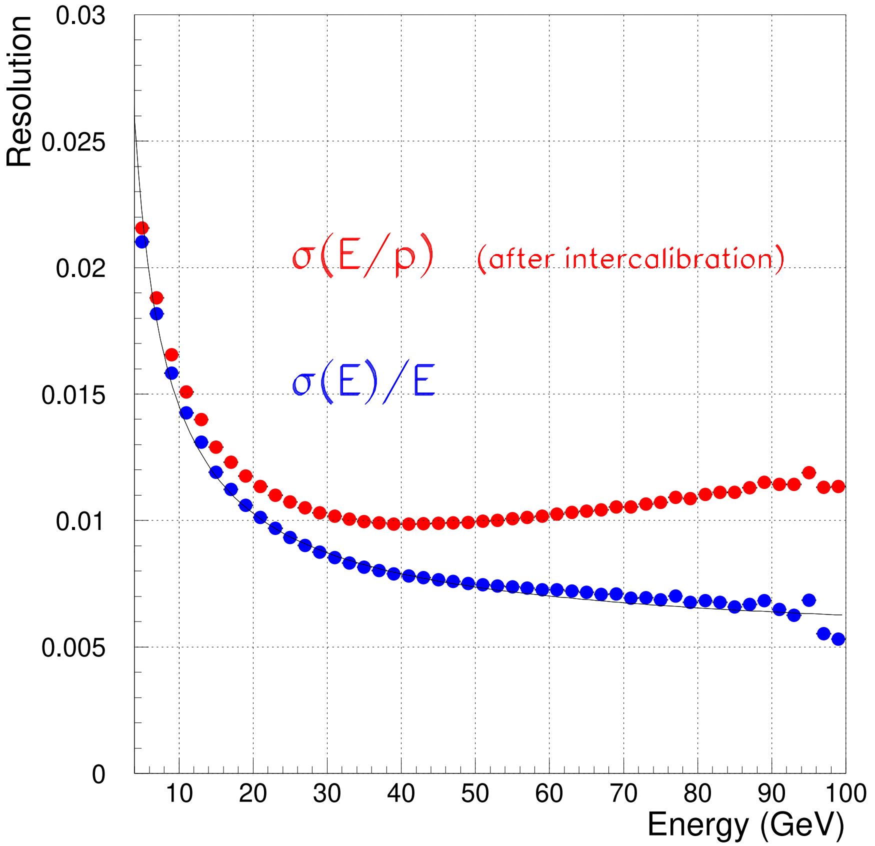


- In cold: Signal pre-amplification
- On feedthroughs: amplify and reshape the signal
- CPD: Shaping, 4 Gains $\times$ 10 bit FADC (dynamic range from $\approx$3.5MeV to $\approx$50GeV per cell), asynchronous 40MHz sampling

- Regular calibration during data taking to check offset and gain stability to $\approx 0.1\%$
- Time offsets calculated using Physics events (photons)

Time and energy resolution of LKr





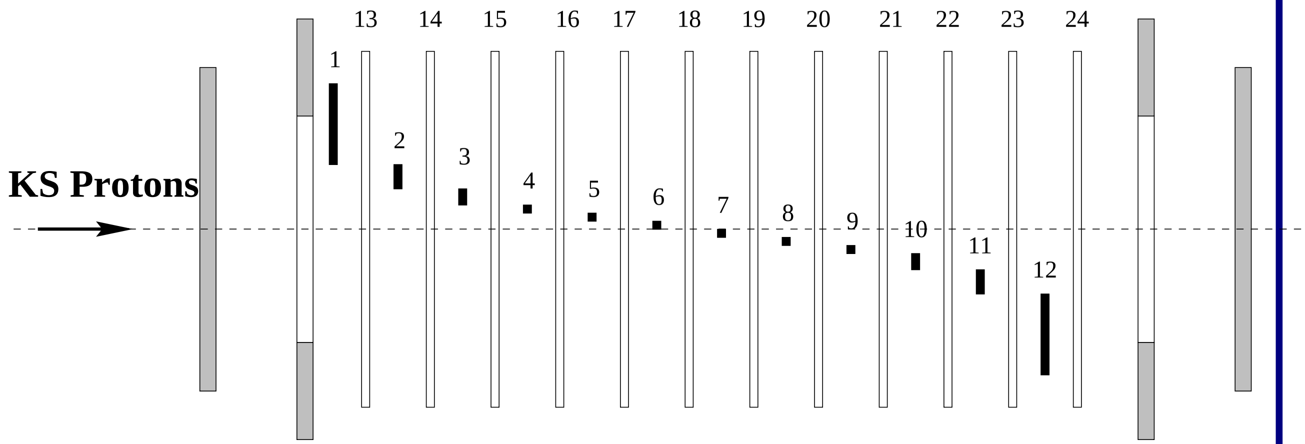
$$\frac{\sigma(E)}{E} = \frac{3.2\%}{\sqrt{E}} \oplus \frac{100MeV}{E} \oplus 0.5\%$$

NA48 method: K_S tagger

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

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

Tagger from side view



: Vertical ladder   : Horizontal ladder

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

Data sample

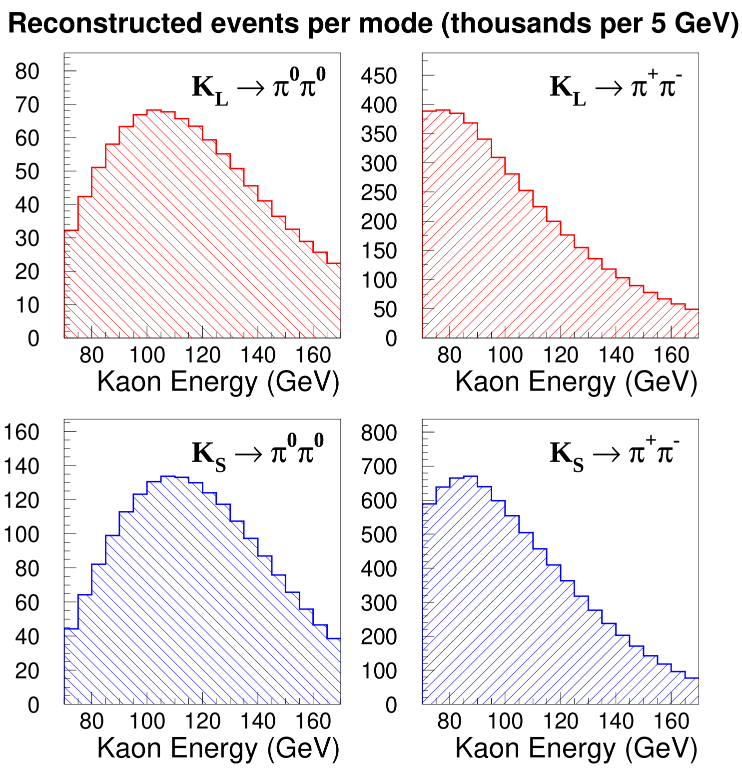
- 1997 : 89 days, 1×10^{12} ppp on $\mathrm{K_L}$ target
  $\Rightarrow$ 0.49 million of $K_L \to \pi^0\pi^0$
  PUBLISHED Phys. Lett. B 465 (1999)
  $$\mathrm{Re}(\varepsilon'/\varepsilon) = (18.5 \pm 4.5 \pm 5.8) \times 10^{-4}$$
- 1998 : 135 days, $\sim 1.4 \times 10^{12}$ ppp on $\mathrm{K_L}$ target
  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 $\mathrm{K_L}$ 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...

Analysis cuts

- $70 < E_{\mathrm{K}} < 170$ GeV
- Centre of Gravity (R_{cog}) < 10cm
- Decay region: $0 < t < 3.5\tau_{\mathrm{S}}$. For $\mathrm{K_S}$ the upstream cut (t >0) is done requiring no hits in the anti-counter placed on the $\mathrm{K_S}$ beam



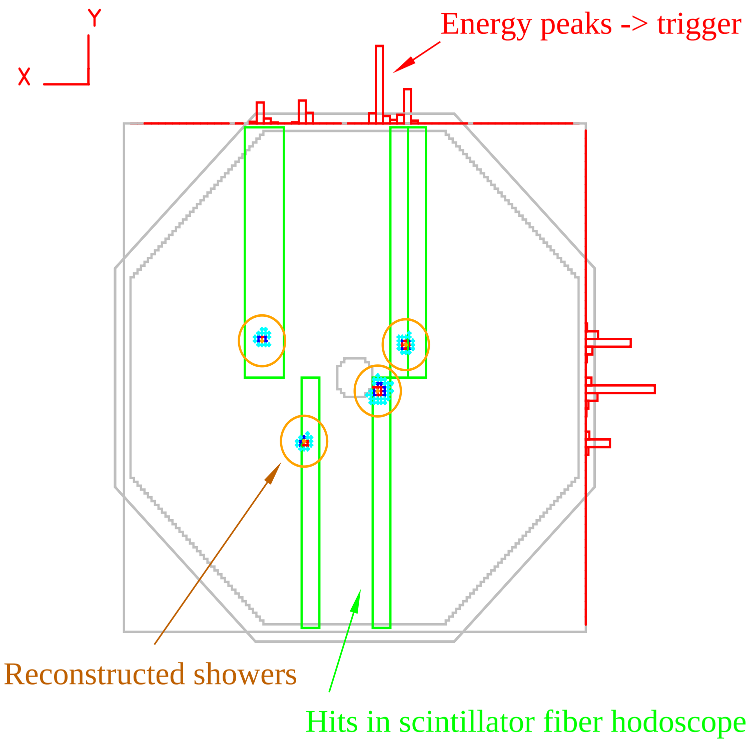
- Cut on dead time (<5 % from charged trigger and $\approx$ 25 % from DCH read out)
- All corrections are applied in bins of energy, to account for the slight difference in the spectra of $\mathrm{K_S}$ and $\mathrm{K_L}$

Trigger $\pi^0\pi^0$

- 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 :

$$99.93 \pm 0.02\ \%$$

Control trigger provided by SCIFI hodoscope embedded in LKr



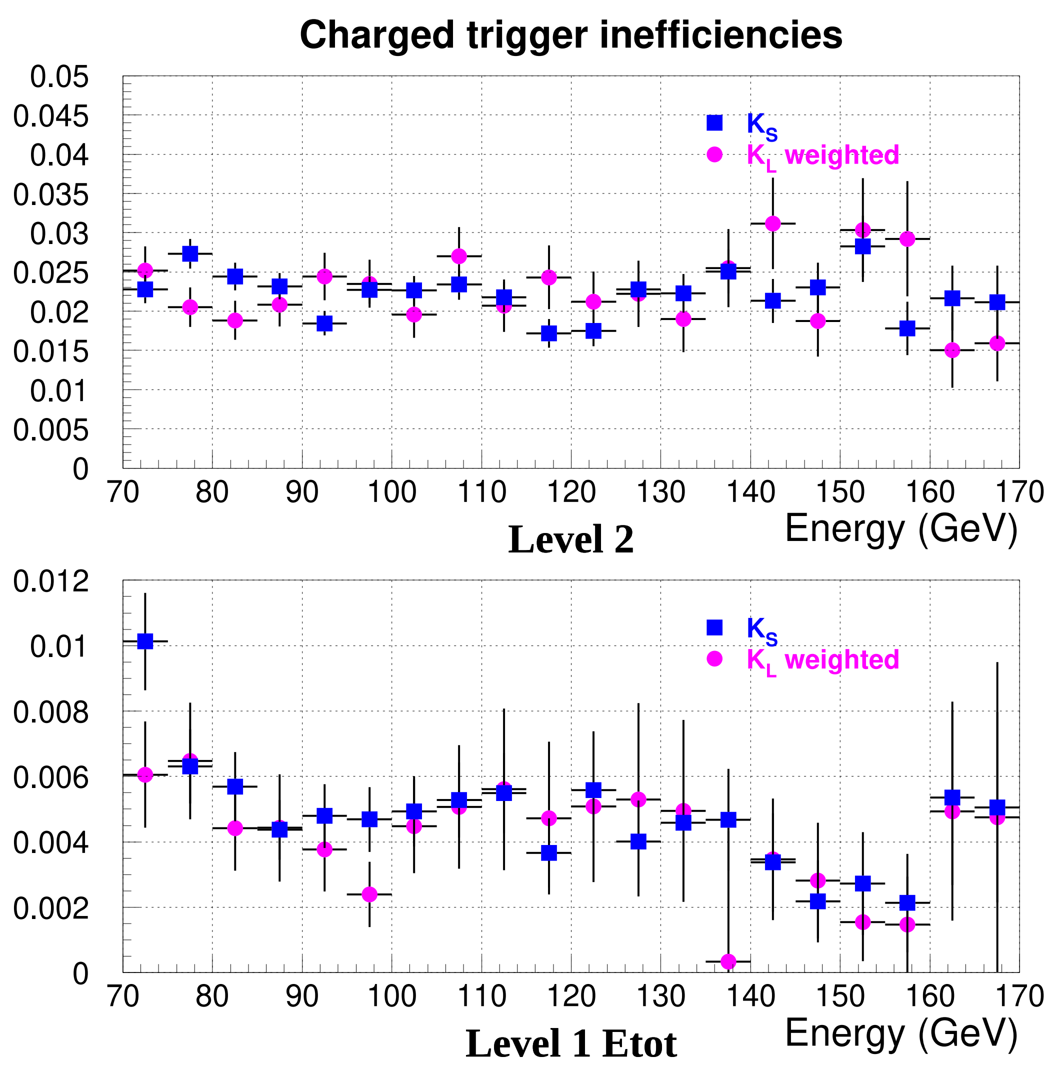
Trigger $\pi^+\pi^-$

- Level 1 :

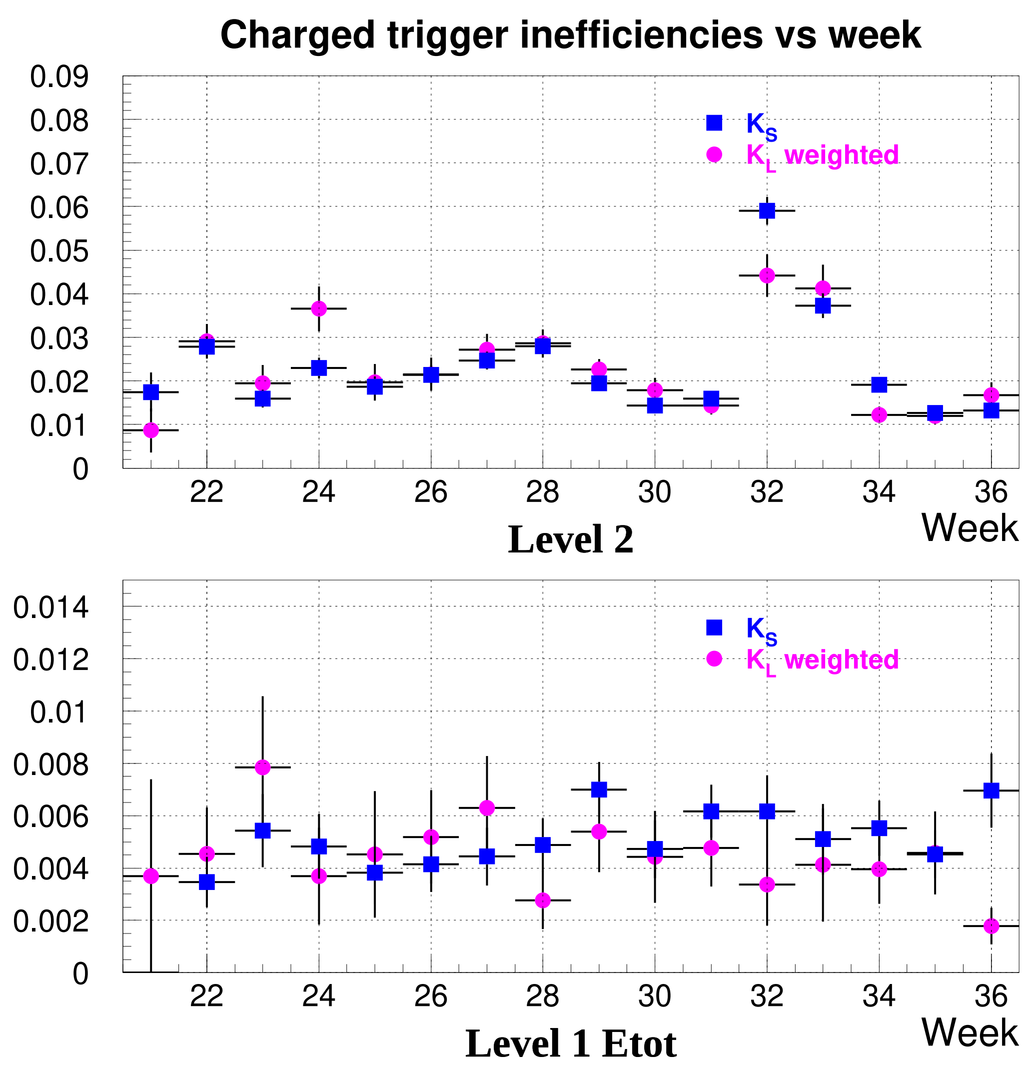
	Efficiency
+ Energy in calorimeters > 35 GeV	99.49 ± 0.03 %
+ Two track topology in hodoscope	99.95 ± 0.01 %
+ Two track multiplicity in chamber 1	> 99.99 %

- level2 : on-line processing of vertices and $\pi\pi$ invariant mass
  - Latency : $< 102\ \mu s$
  - Rejection ~ 45
    $\longrightarrow$ 2 kHz output
  - Dead Time : $< 5\%$ monitored and applied to $\pi^0\pi^0$
  - Efficiency $\simeq 97.75 \pm 0.05$

Trigger efficiency $\pi^+\pi^-$



Trigger efficiency $\pi^+\pi^-$, contd.



Remainder

$$\boxed{\mathrm{Re}(\varepsilon'/\varepsilon) \; = \frac{1}{6} \times (1 - R)}$$

In the following we will quote corrections and uncertainties on the double ratio. We will divide by 6 at the end!!

Tagging principle

- Proton tagging allows us to distinguish $\mathrm{K_S}$ from $\mathrm{K_L} \to 2\pi^0$ decays
- to preserve the symmetry in the double ratio, it must be used for $\pi^+\pi^-$ events as well

- tagging inefficiency: α_{SL}
  A tagging inefficiency transforms a $\mathrm{K_S}$ into $\mathrm{K_L}$. The sensitivity comes from asymmetric tails in the detector time distributions:

$$\Delta \mathrm{R} \simeq 6 \times \left(\alpha_{SL}^{00} - \alpha_{SL}^{+-}\right) = 6 \times \Delta\alpha_{\mathrm{SL}}$$

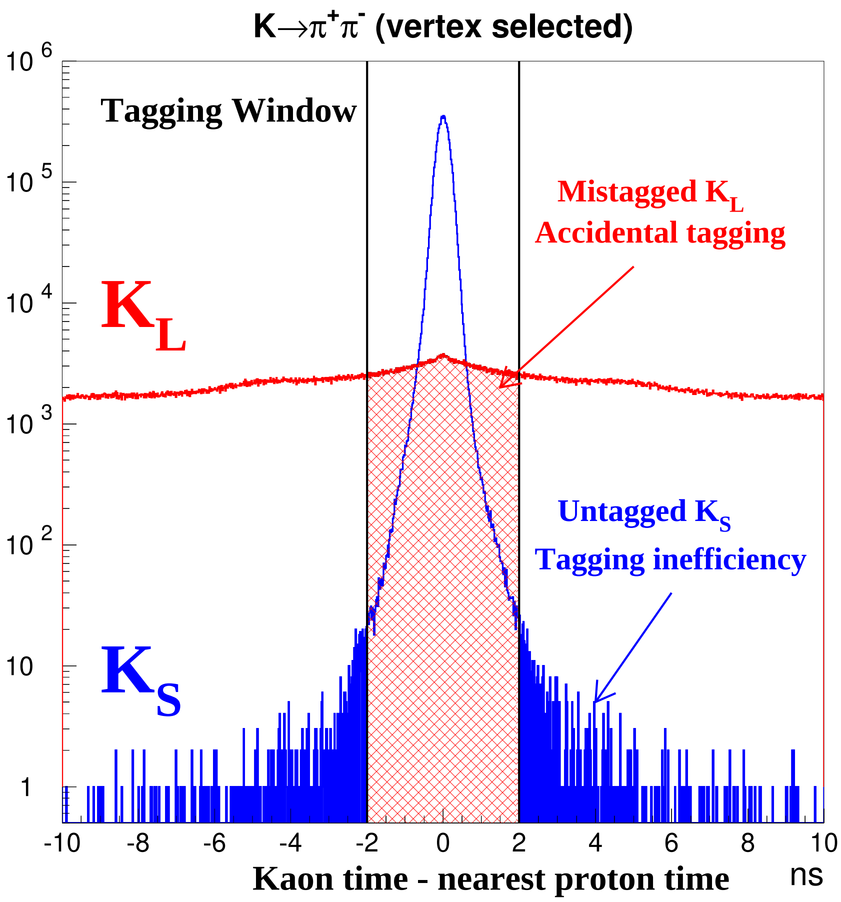
- mistagging probability: α_{LS}
  A true $\mathrm{K_L}$ is counted as $\mathrm{K_S}$ if an accidental proton is found in the ± 2 ns tagging window:

  - It dilutes $\mathrm{Re}(\varepsilon'/\varepsilon)$
  - A $\pi^+\pi^+/\pi^0\pi^0$ asymmetry sensitive to intensity may lead to a bias:

$$\Delta \mathrm{R} \simeq 2 \times \left(\alpha_{LS}^{00} - \alpha_{LS}^{+-}\right) = 2 \times \Delta\alpha_{\mathrm{LS}}$$

Tagging for $\pi^+\pi^-$

$\alpha_{\rm SL}^{+-}$ and $\alpha_{\rm LS}^{+-}$ are measured distinguishing K_S and K_L from the vertical position of the decay vertex



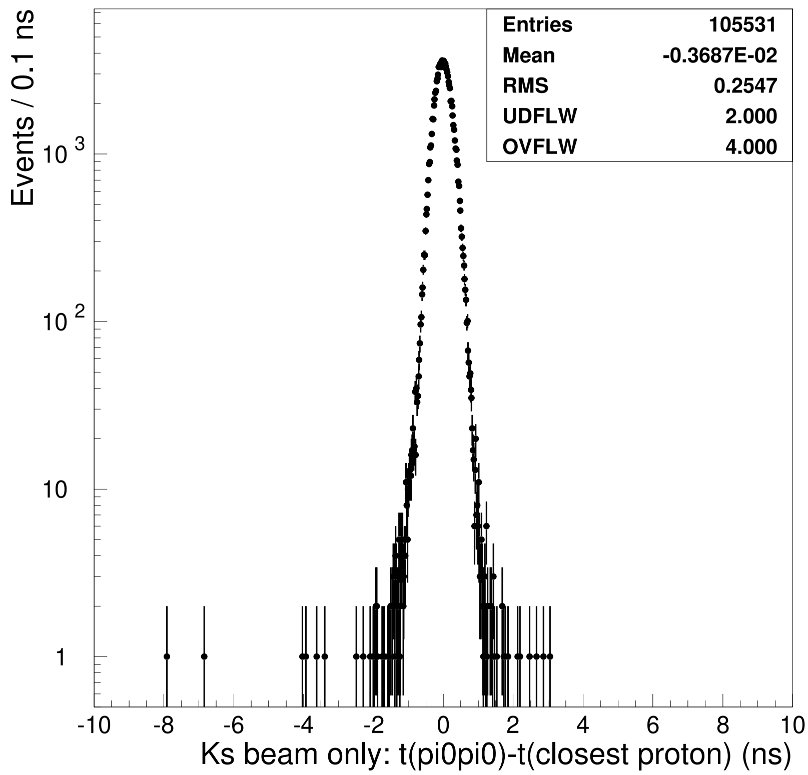
Inefficiency: $\alpha_{SL}^{+-} = (1.97 \pm 0.05) \times 10^{-4}$

Mistags: $\alpha_{LS}^{+-} = (11.05 \pm 0.01)\%$

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: $\alpha_{SL}^{00} = (1.3 \pm 0.5) \times 10^{-4}$

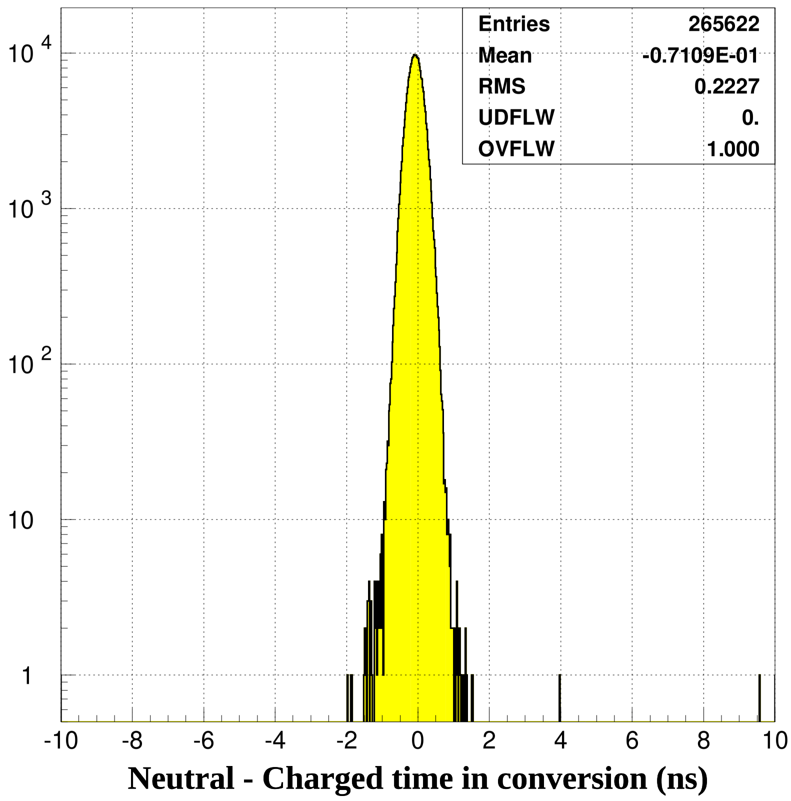
   – During these dedicated runs we measured, for comparison: $\alpha_{SL}^{+-} = (1.4 \pm 0.2) \times 10^{-4}$

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

Efficiency for $\pi^0\pi^0$ tagging, contd.

3. Comparison of hodoscope and LKr times in $\mathrm{K_L}$ and $\mathrm{K_S}$ 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^-)



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

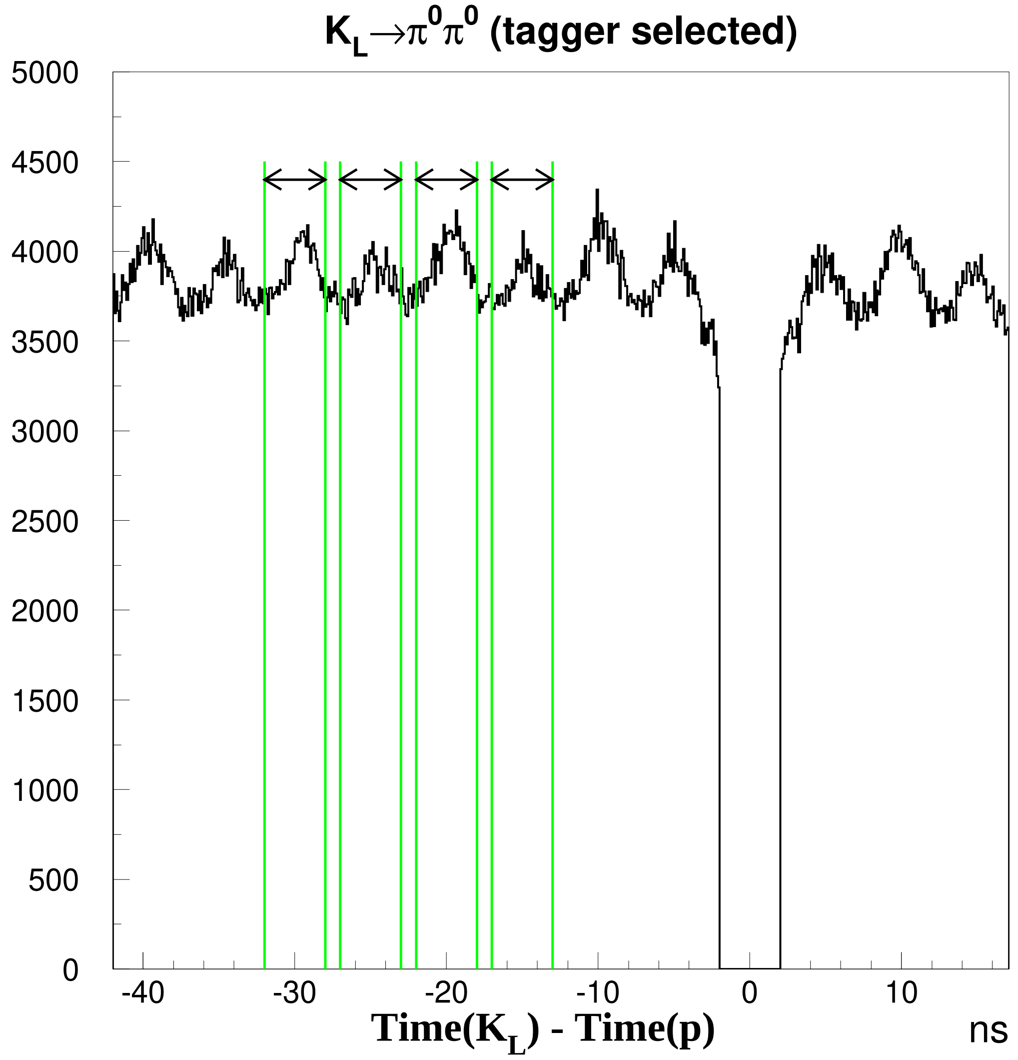
$$\boxed{\Delta R < 3 \times 10^{-4}}$$

Mistagging probability

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

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

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



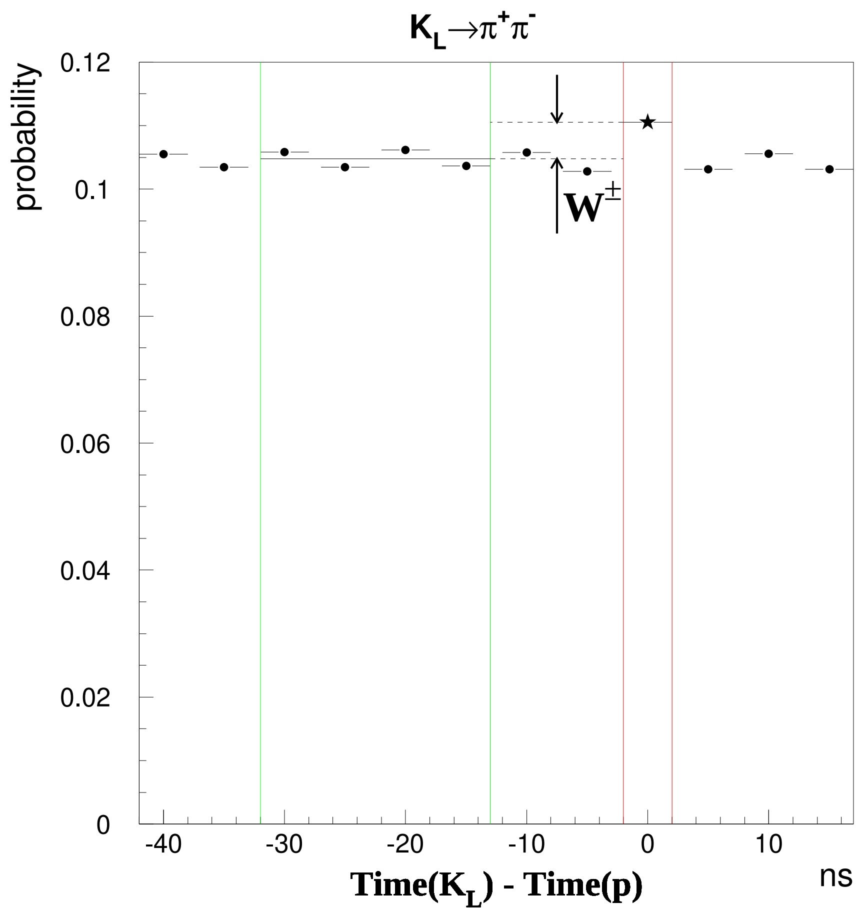
$$\Delta\beta_{\mathrm{tag}} = (5.3 \pm 1.6) \times 10^{-4}$$

Mistagging probability, contd.

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.

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



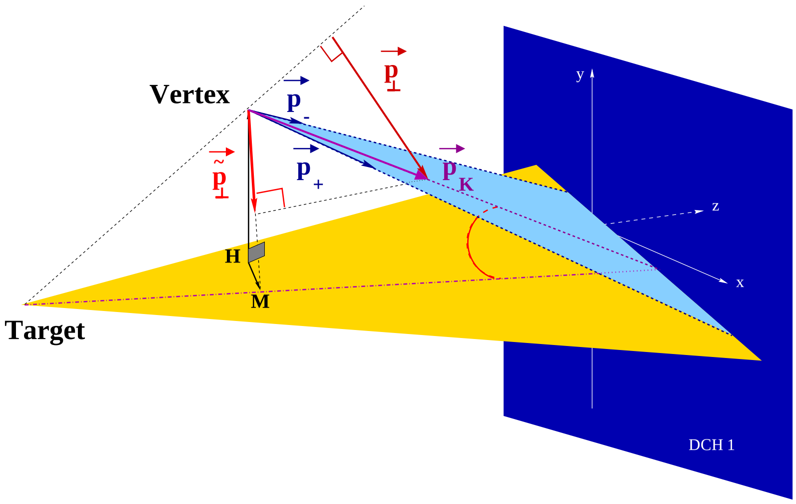
$$\Delta W = (-5.0 \pm 3.9) \times 10^{-4}$$

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

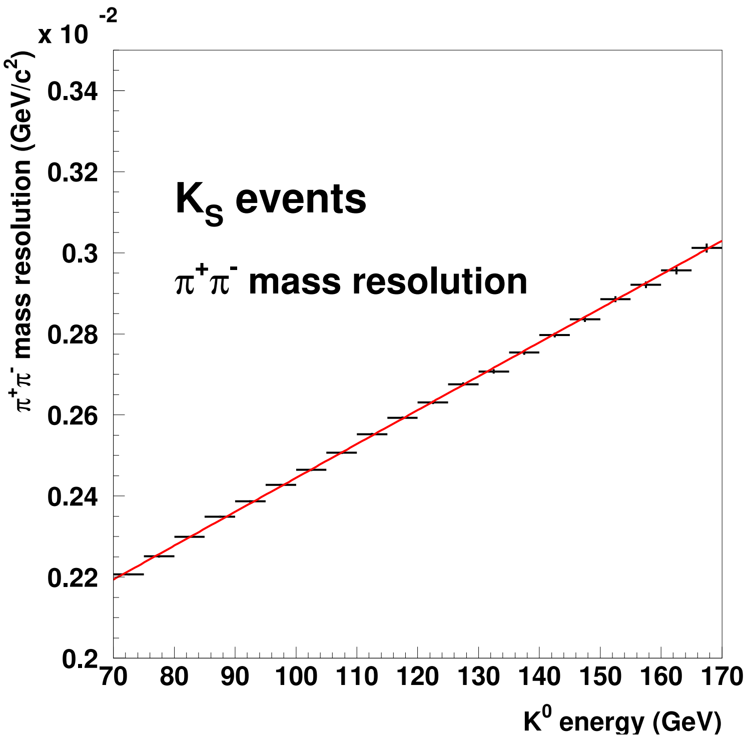
$$\boxed{\Delta R = (1 \pm 8) \times 10^{-4}}$$

Background to $\pi^+\pi^-$

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

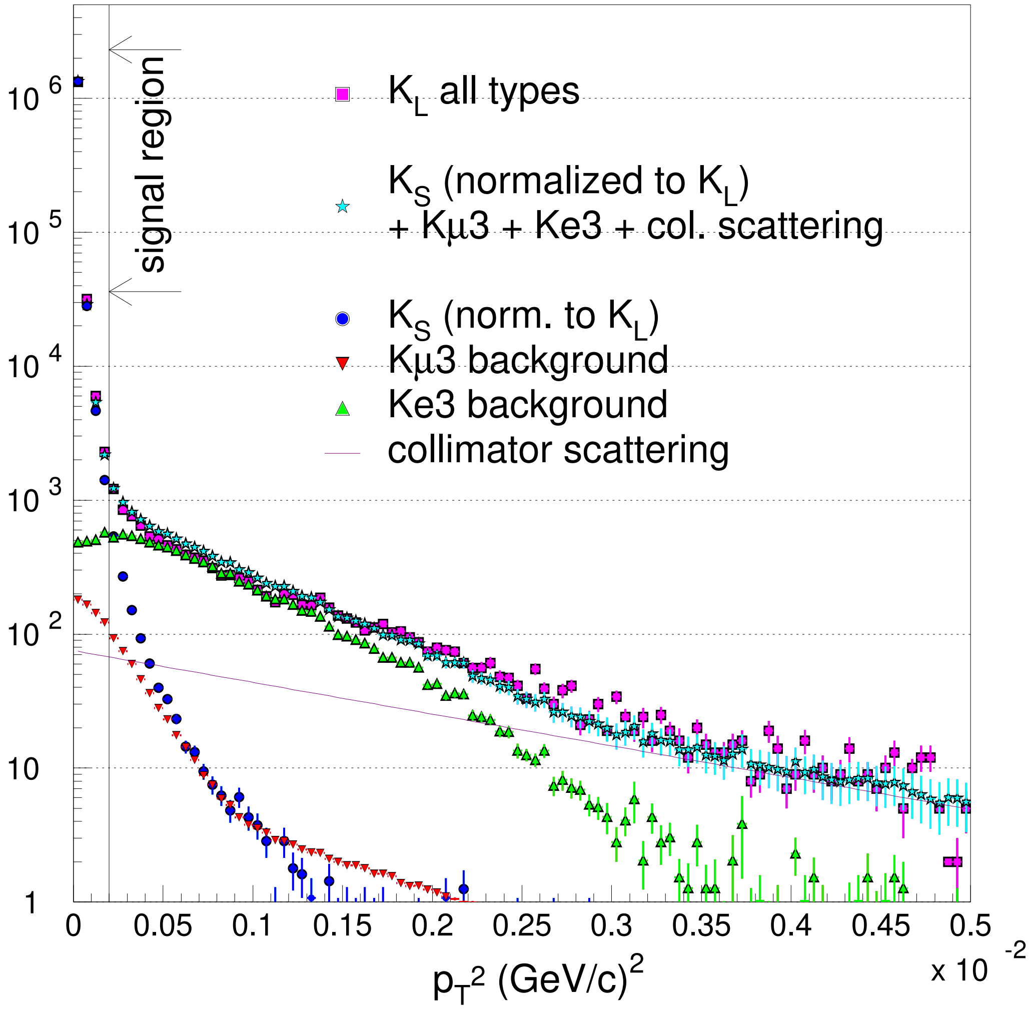


- $\pm 3\sigma \quad m_{\pi^+\pi^-}$ mass cut



Background to $\pi^+\pi^-$, cntd.

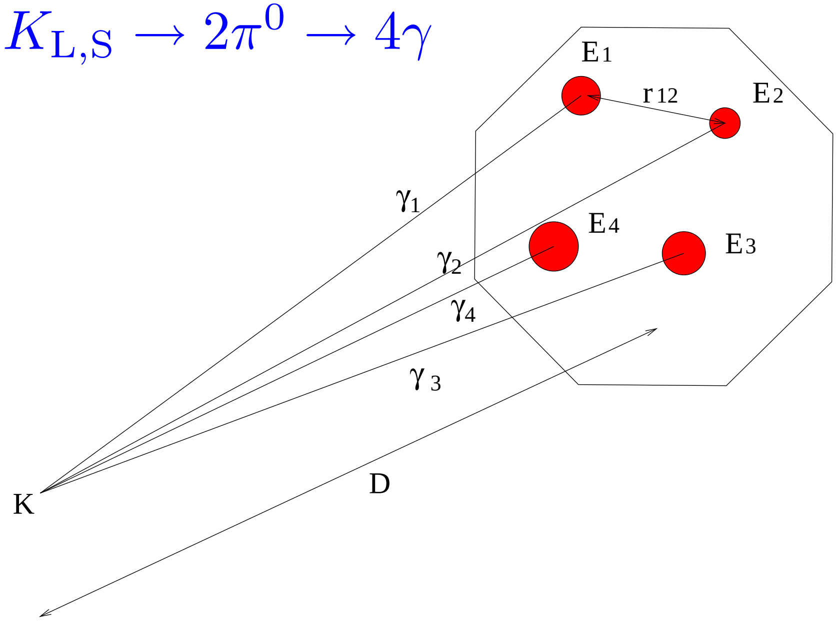
- No hits in the μ counters
- $E/p < 0.8$

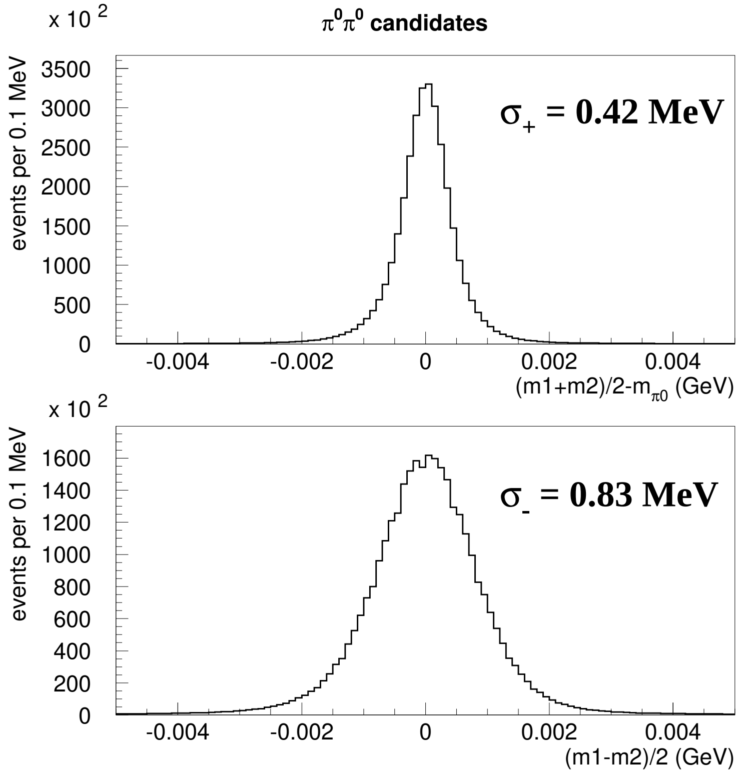


$$\Delta \mathrm{R} = (+19 \pm 3) \times 10^{-4}$$

$K^0 \to \pi^0\pi^0$ identification

$K_{L,S} \to 2\pi^0 \to 4\gamma$



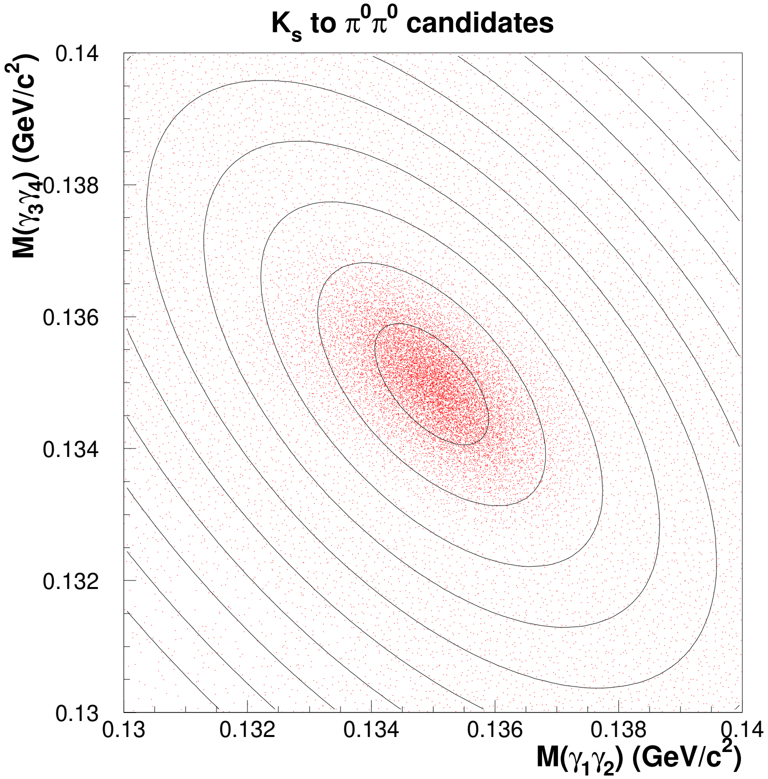


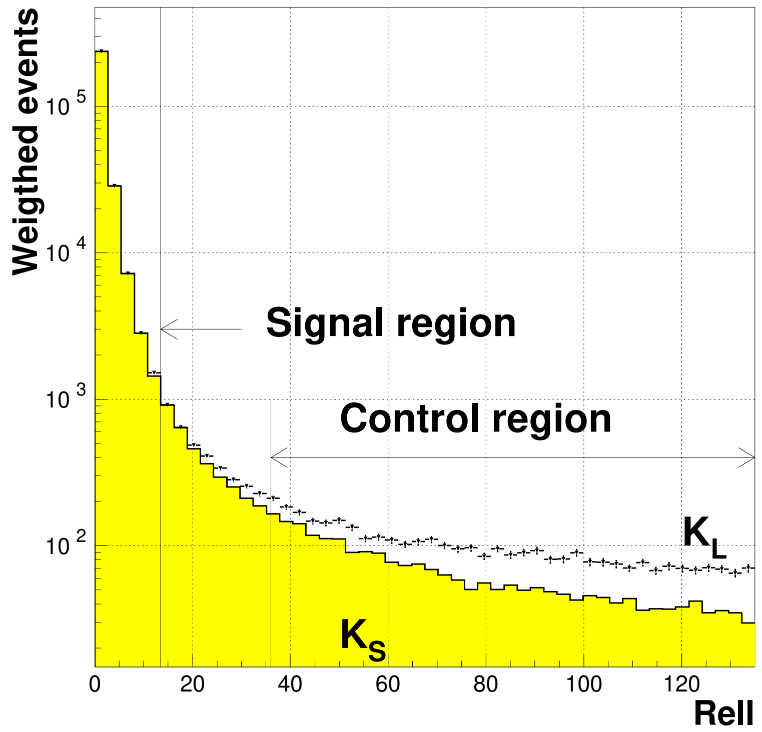
$$D = \sqrt{\sum E_i E_j \times (r_{ij})^2} \; / M_K$$

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

$3\ \pi^0$ background

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



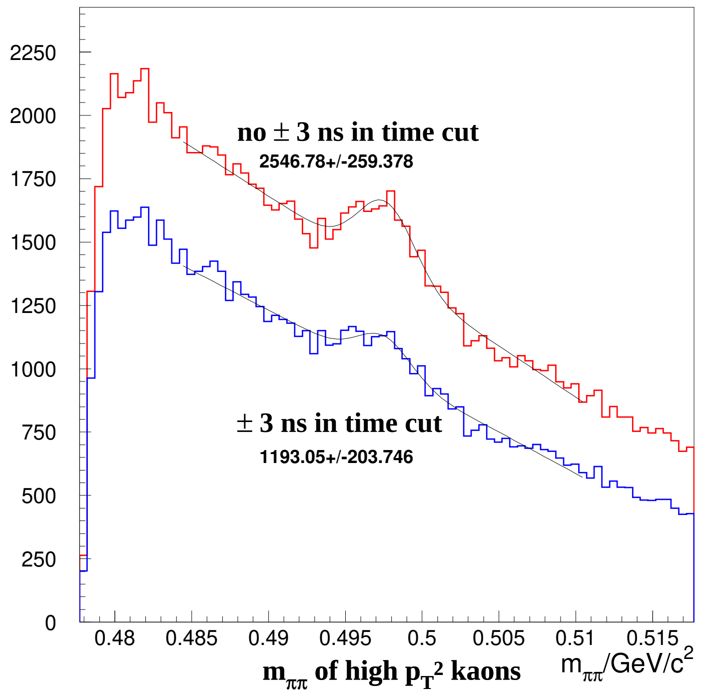


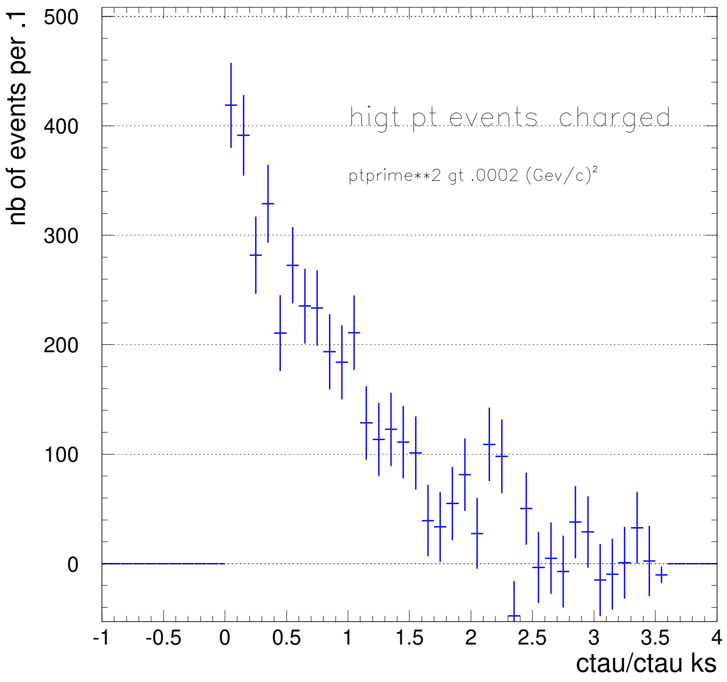
- Cut on in-time extra photons ($\pm$ 3ns)

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

Scattered Events in the K_L beam

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

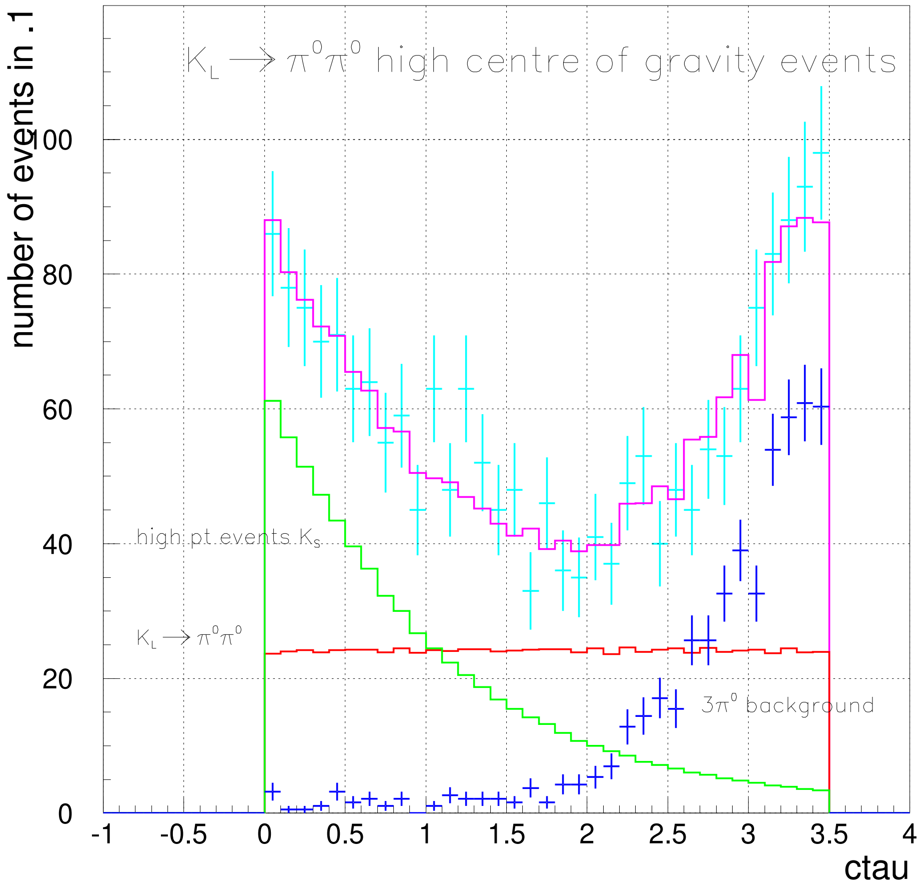




- They are rejected by the $p_T'^2$ cut applied to $\pi^+\pi^-$ but not to $\pi^0\pi^0$

Scattered Events in the K_L beam, contd.

- 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!

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

$\pi^+\pi^-/\pi^0\pi^0$ energy scale

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

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

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

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

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

- The energy for a $\pi^+\pi^-$ is determined from the opening angle and the ratio of the energy of the two tracks:

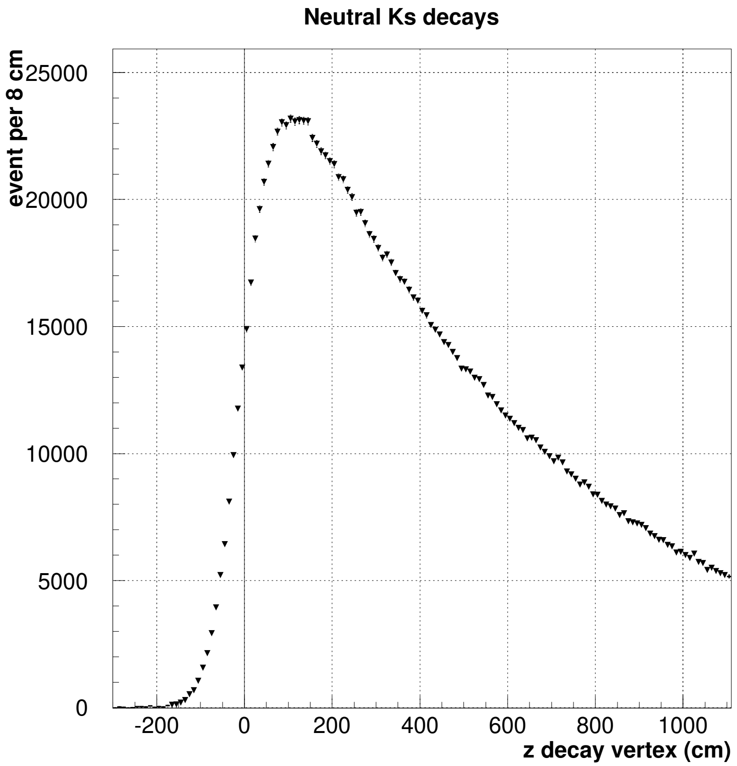
  $$E_K^2 = (C/\theta^2)\left\{m_K^2 - C\ m_\pi^2\right\}$$
  $$C = 2 + E_{\pi 1}/E_{\pi 2} + E_{\pi 2}/E_{\pi 1}$$

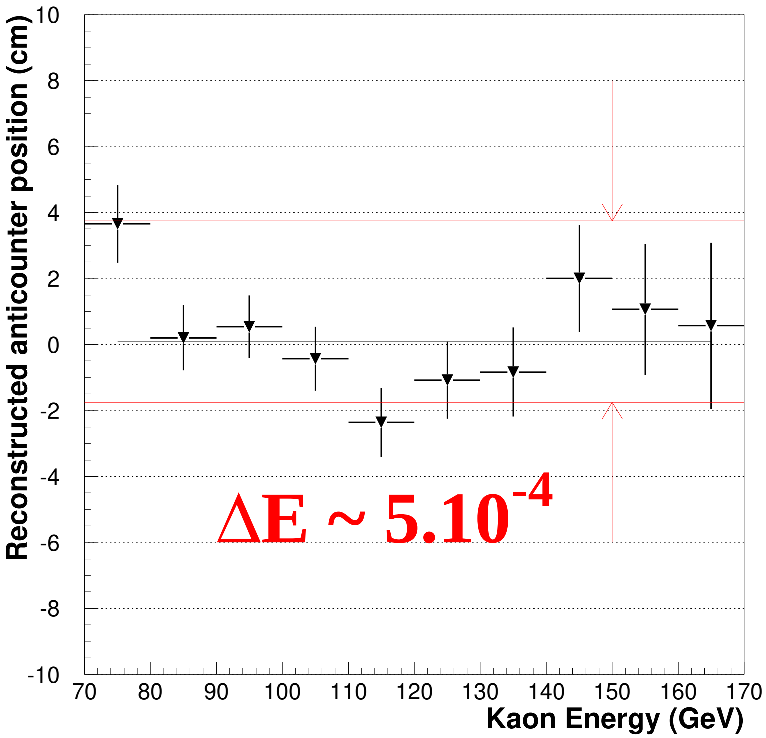
  $\Rightarrow$ defined by the geometry of the drift chambers

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

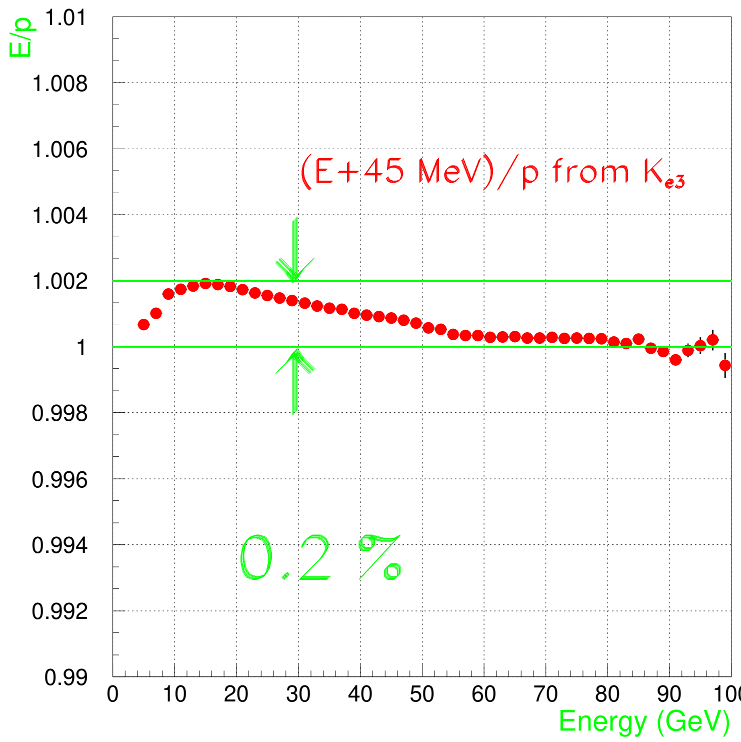
$\pi^0\pi^0$ distance/energy scale

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



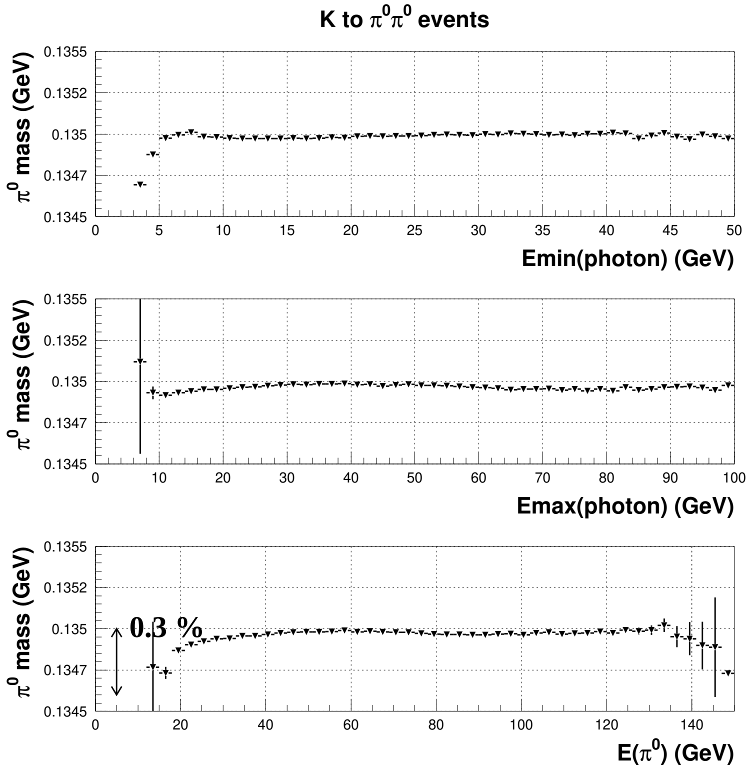


Linearity



$$\frac{E}{P} = \frac{\text{Energy from LKr}}{\text{Momentum from spectrometer}}$$

for Ke3 electrons as a function of the energy



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

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

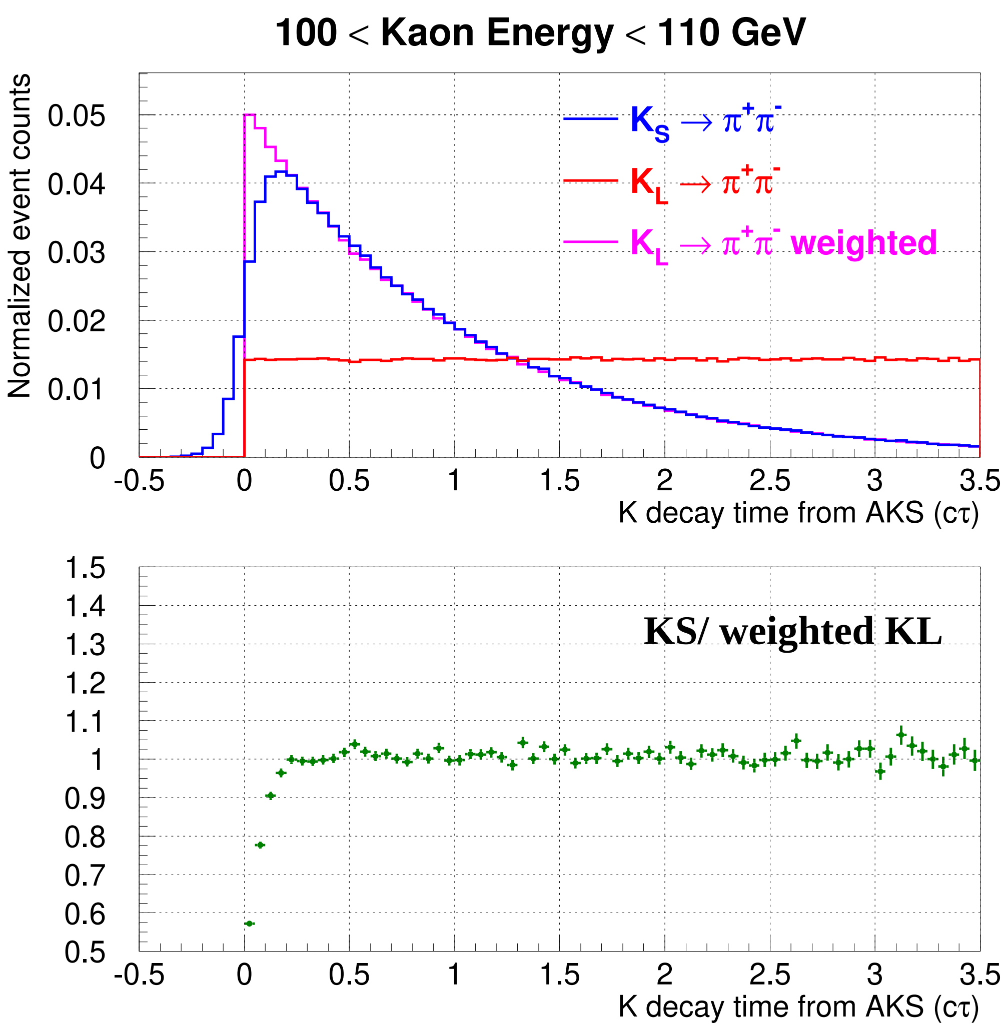
- We employ a π^- beam and two 3.5cm thick polyethylene targets, to produce $\eta, \pi^0 \rightarrow \gamma\gamma$ decays to cross check the distance scale using the published π^0 and η masses.
- A discrepancy at the level of 2 σ is found reconstructing the vertex for $\eta \rightarrow \gamma\gamma$

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 $\eta \rightarrow \gamma\gamma$ result.

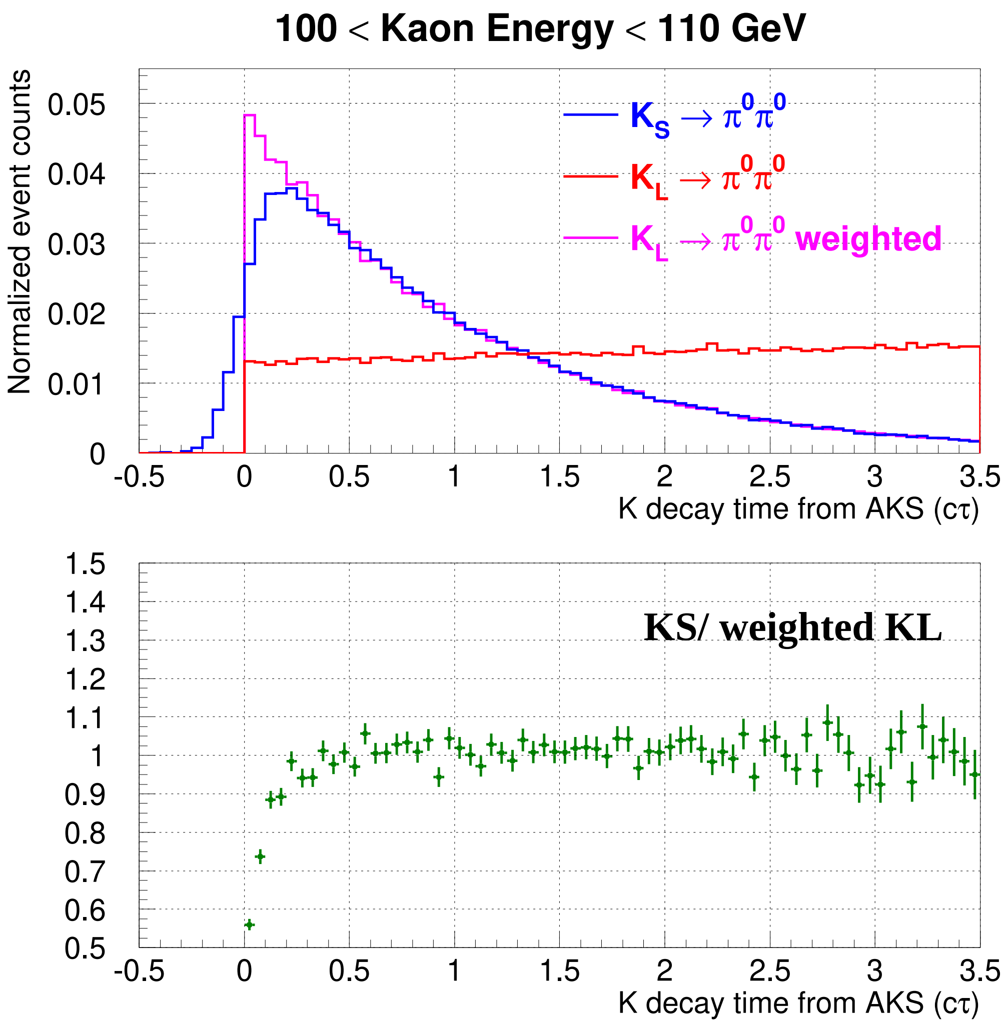
$$\boxed{\Delta R < 10 \times 10^{-4}}$$

Weighting $\pi^+\pi^-$

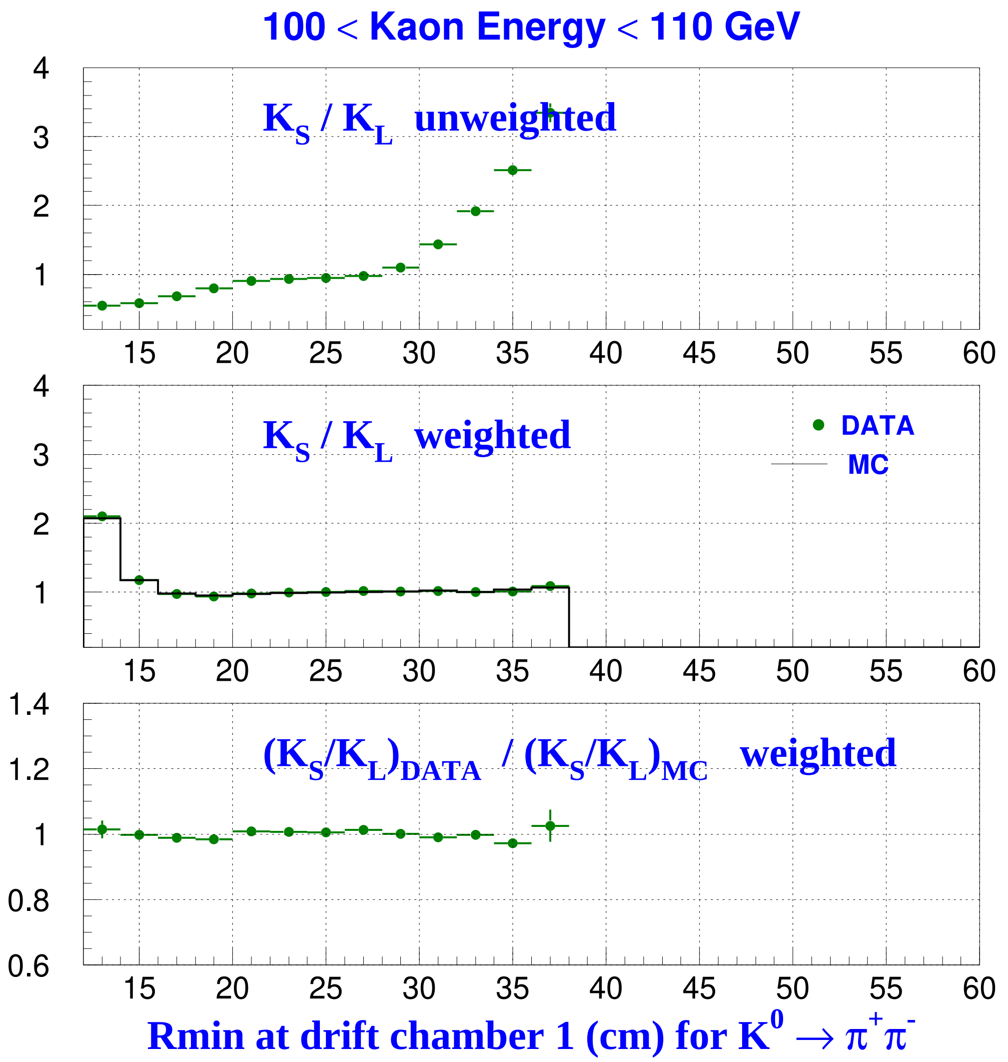


- The K_L events are weighted according to the ratio of the proper time distribution of K_S and K_L
- This reduces the acceptance correction to a few per mill

Weighting $\pi^0\pi^0$

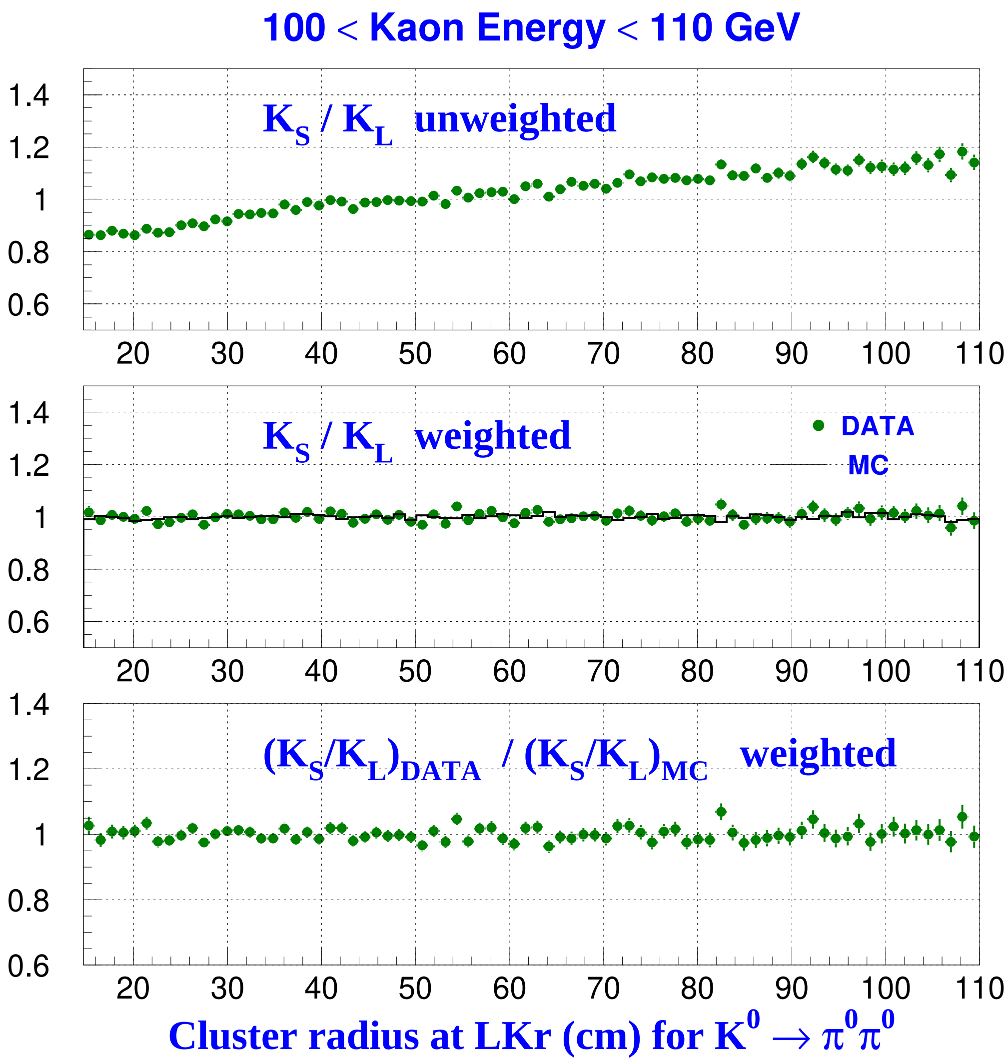


DATA/MC: $\pi^+\pi^-$



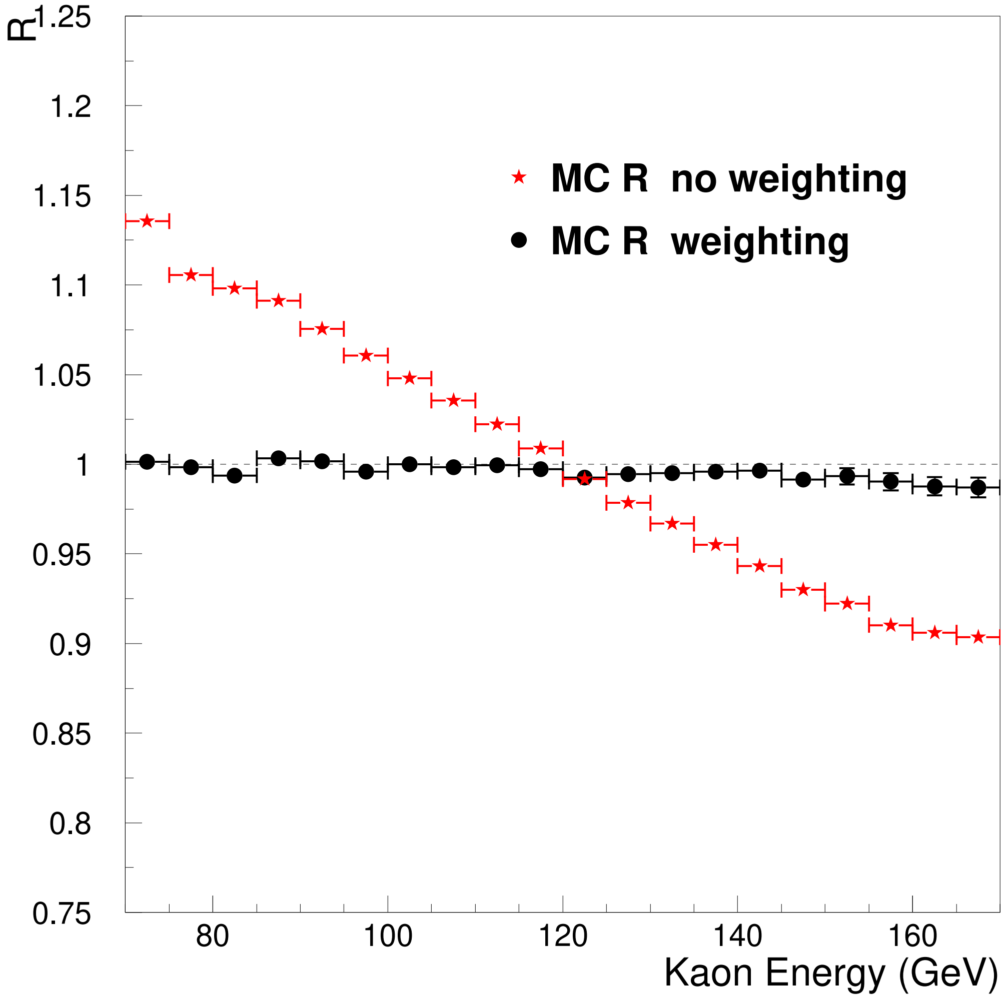
100 < Kaon Energy < 110 GeV
K_S / K_L unweighted
K_S / K_L weighted
DATA
MC
$(K_S/K_L)_{DATA} / (K_S/K_L)_{MC}$ weighted
Rmin at drift chamber 1 (cm) for $K^0 \rightarrow \pi^+\pi^-$

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



Acceptance

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



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

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

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

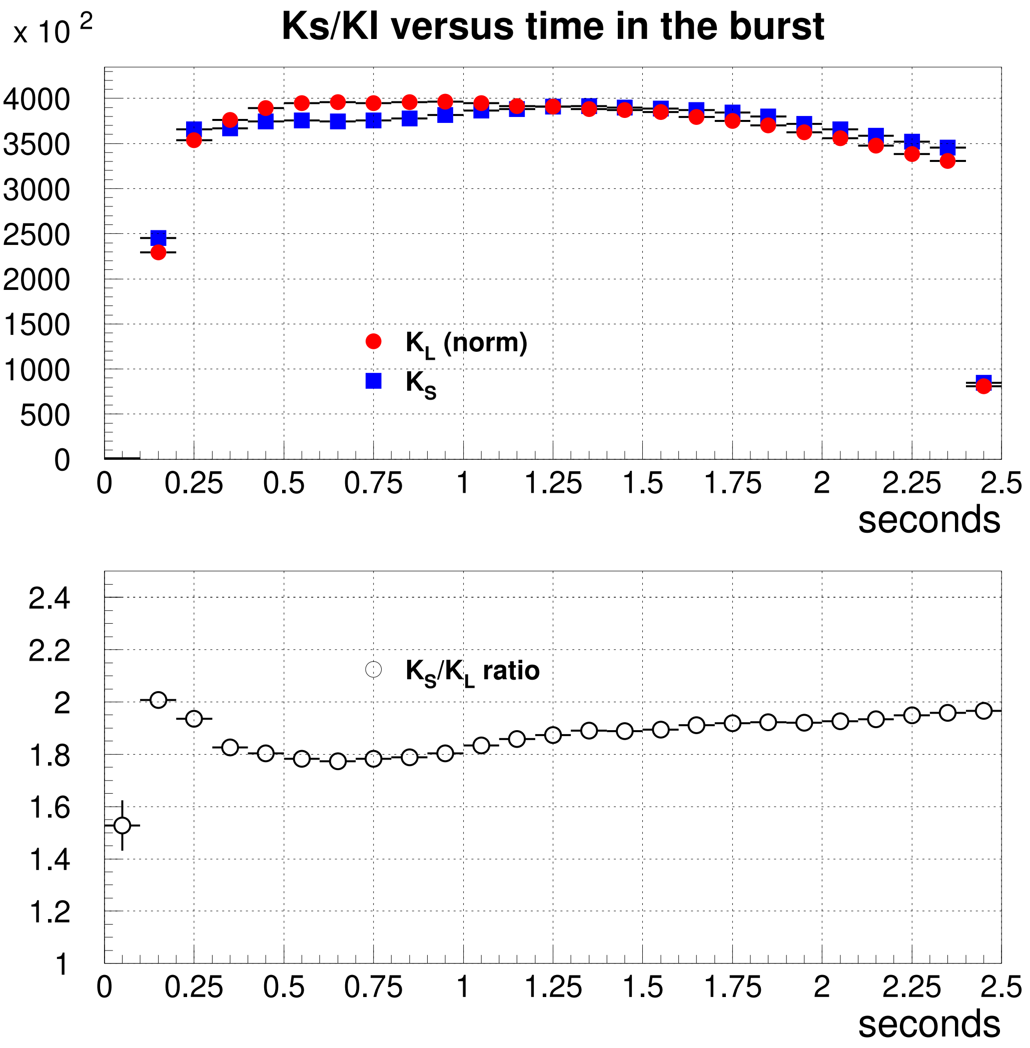
To put bounds on the effects related to the variation of the K_S / K_L ratio (R.M.S. 10 %) and the effects which are not related to the K_L accidental activity, we use the following inputs:

- 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

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

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

K_S /K_L over during the spill



Result 1998: statistics

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

Result 1998: $\mathrm{R}_{\mathrm{RAW}}$

Subtracting the mistagging probability and averaging in energy bins, the weighted result is:

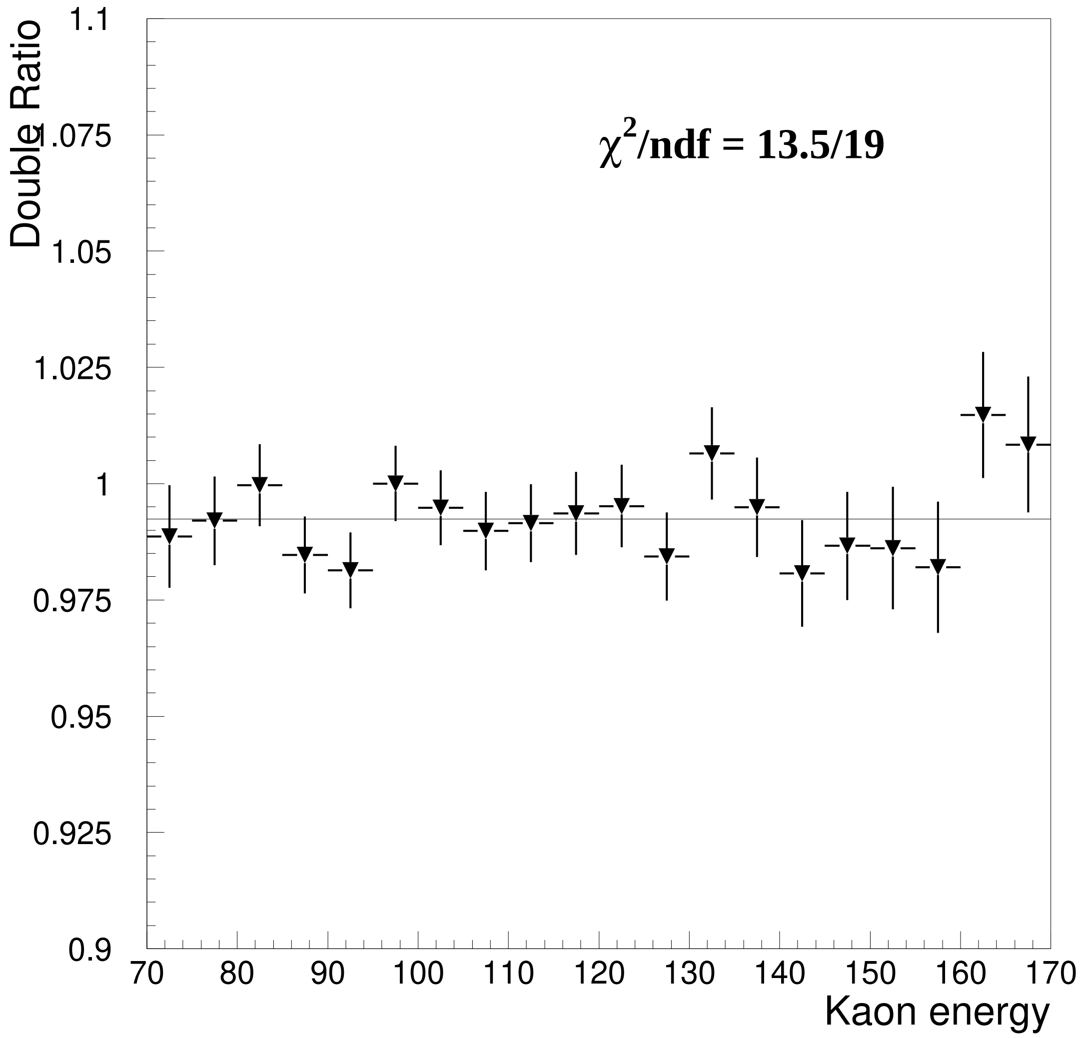
$$\mathrm{R}_{\mathrm{RAW}} = 0.98899 \pm 0.00173(stat)$$

Result 1998: systematic uncertainties

Corrections and systematic uncertainties on R (Units = 10^{-4})			
Source	1998 sample		Limitation
Charged trigger	–1	$\pm$ 11	(stat.)
Mistagging probability	+1	$\pm$8	(stat.)
Tagging efficiency	–	$\pm$ 3	
Neutral scale	–	$\pm$ 10	
Charged vertex	+2	$\pm$ 2	
Acceptance and K_S anti-counter	+31	$\pm$ 9	
Neutral and BG	–7	$\pm$ 2	
Charged BG	+19	$\pm$ 3	
Beam scattering	–10	$\pm$ 3	
Accid. activity and in-time BG	+2	$\pm$ 12	
Total	+37	$\pm$ 24	

Result 1998

PRELIMINARY RESULT ON 1998 DATA



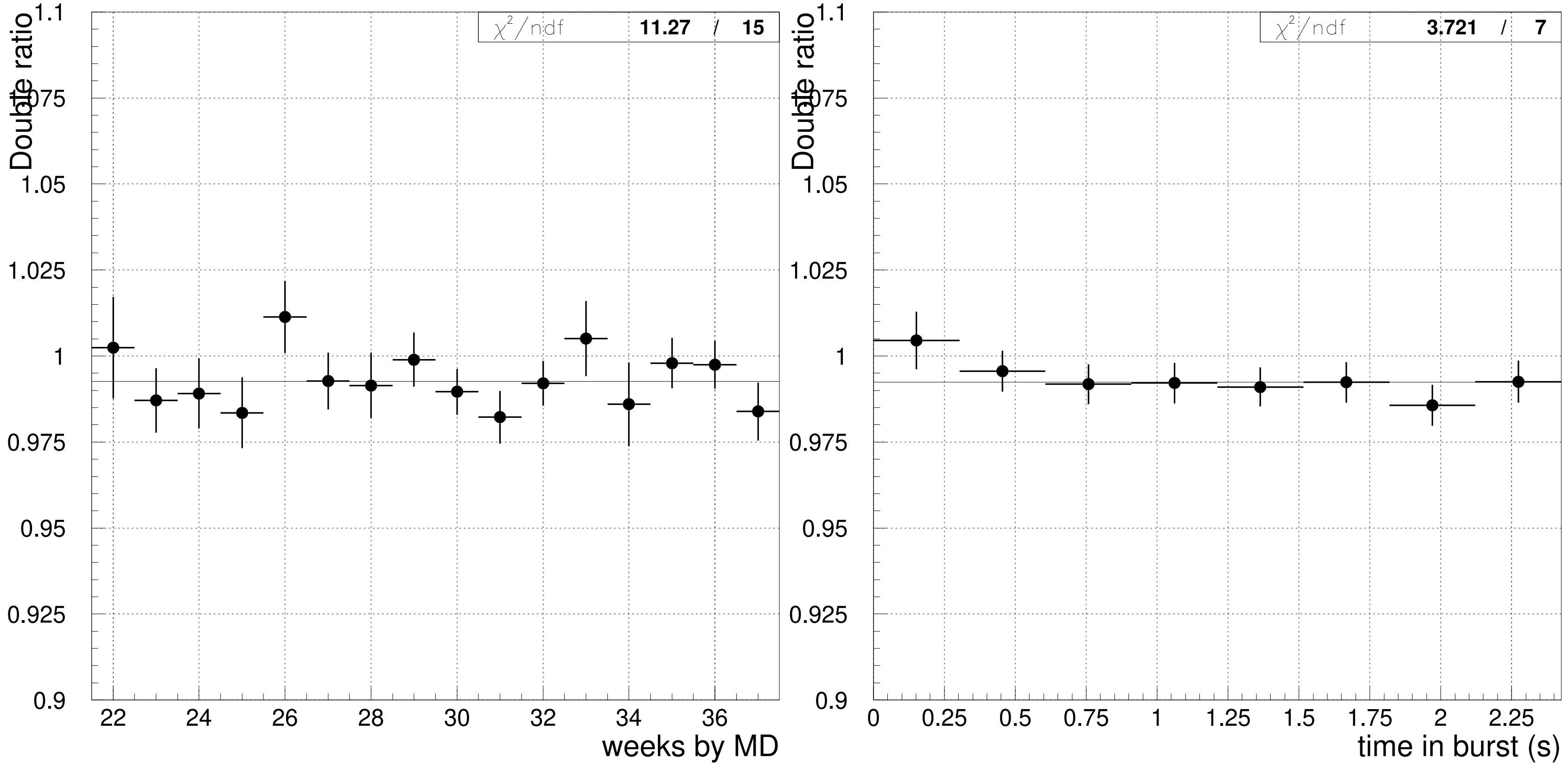
$$R = 0.99267 \pm 0.00173(stat.) \pm 0.00238(syst.)$$

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

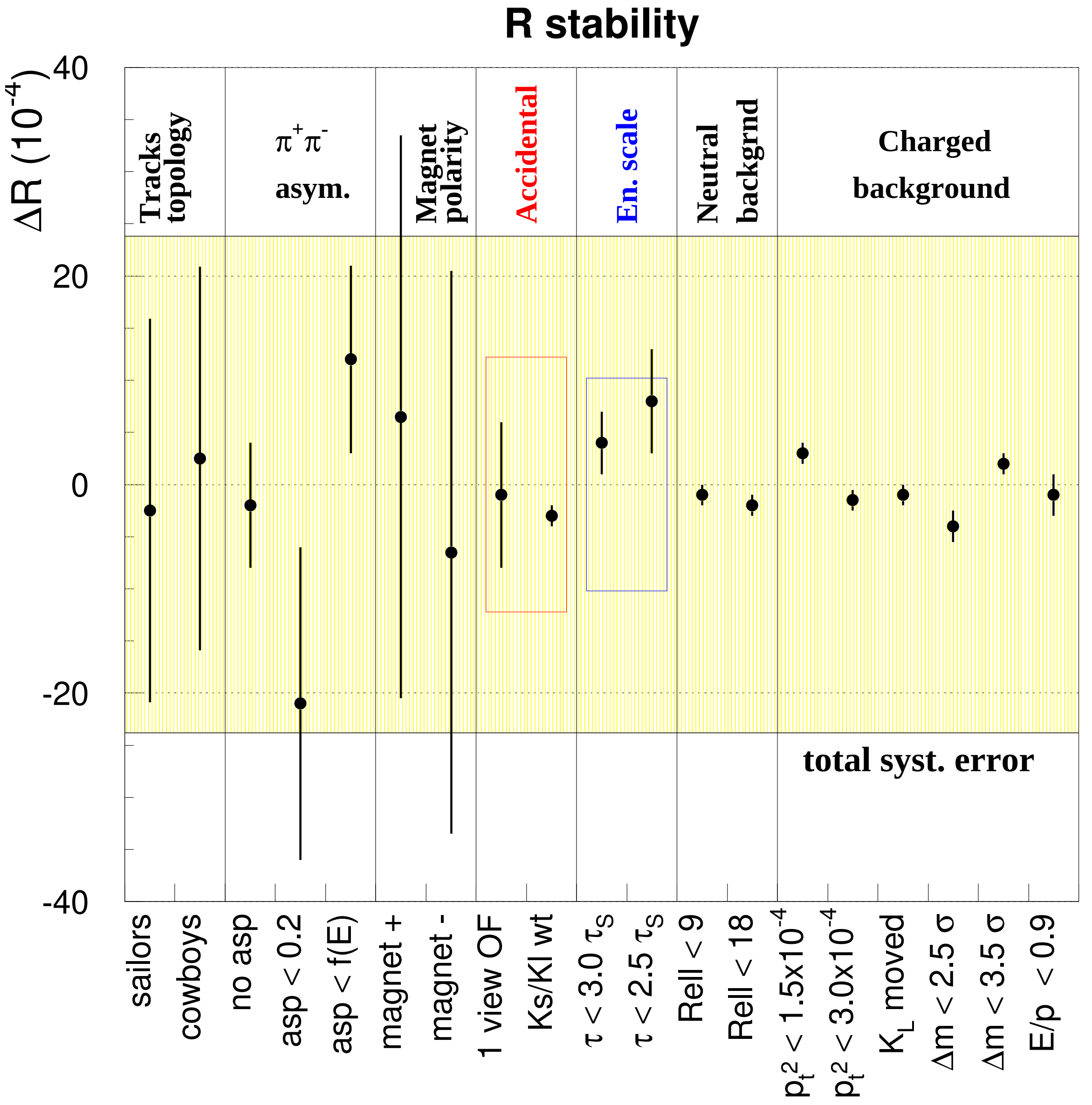
$$\boxed{\mathrm{Re}(\varepsilon'/\varepsilon) = (12.2 \pm 4.9) \times 10^{-4}}$$

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

Checks: R vs time



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

Comparison of the 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 probabilily	+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

Combined 1997 and 1998 result

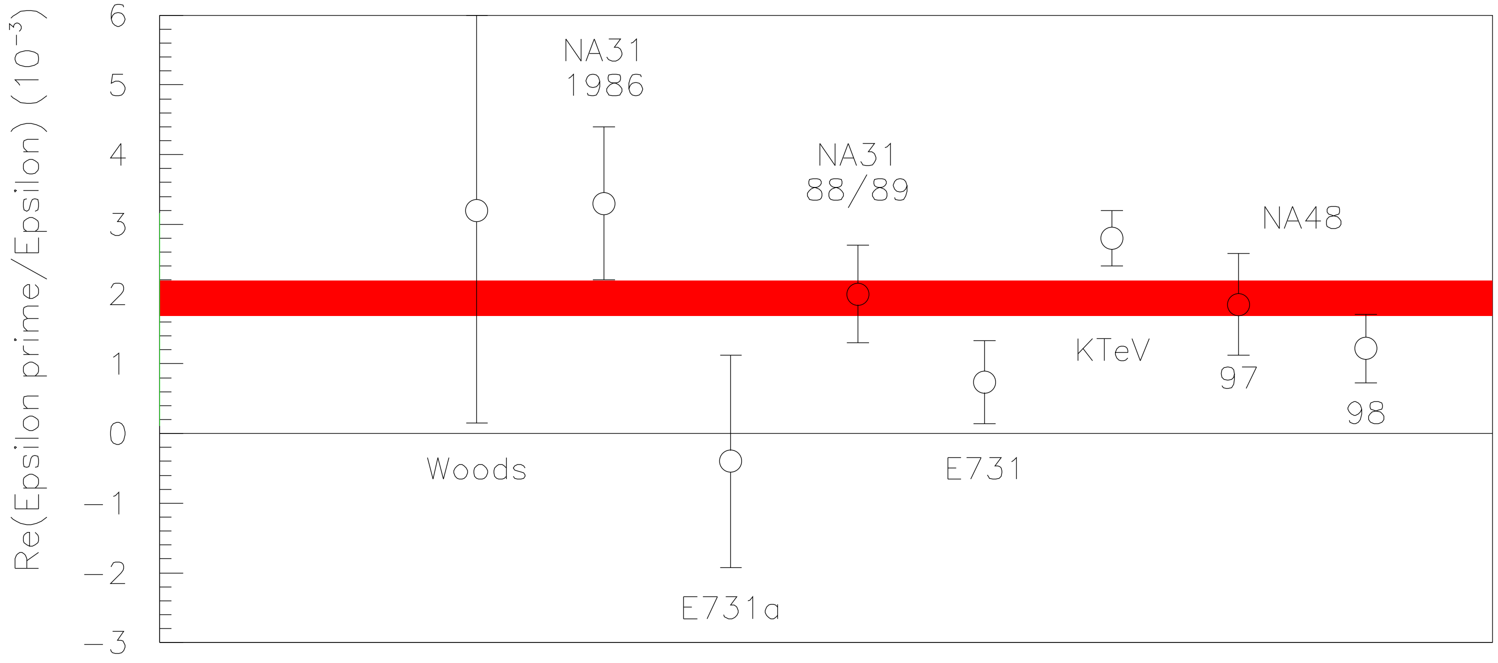
Combined 1997 and preliminary 1998 NA48 result

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

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

(taking into account the small correlated systematics)

New world average

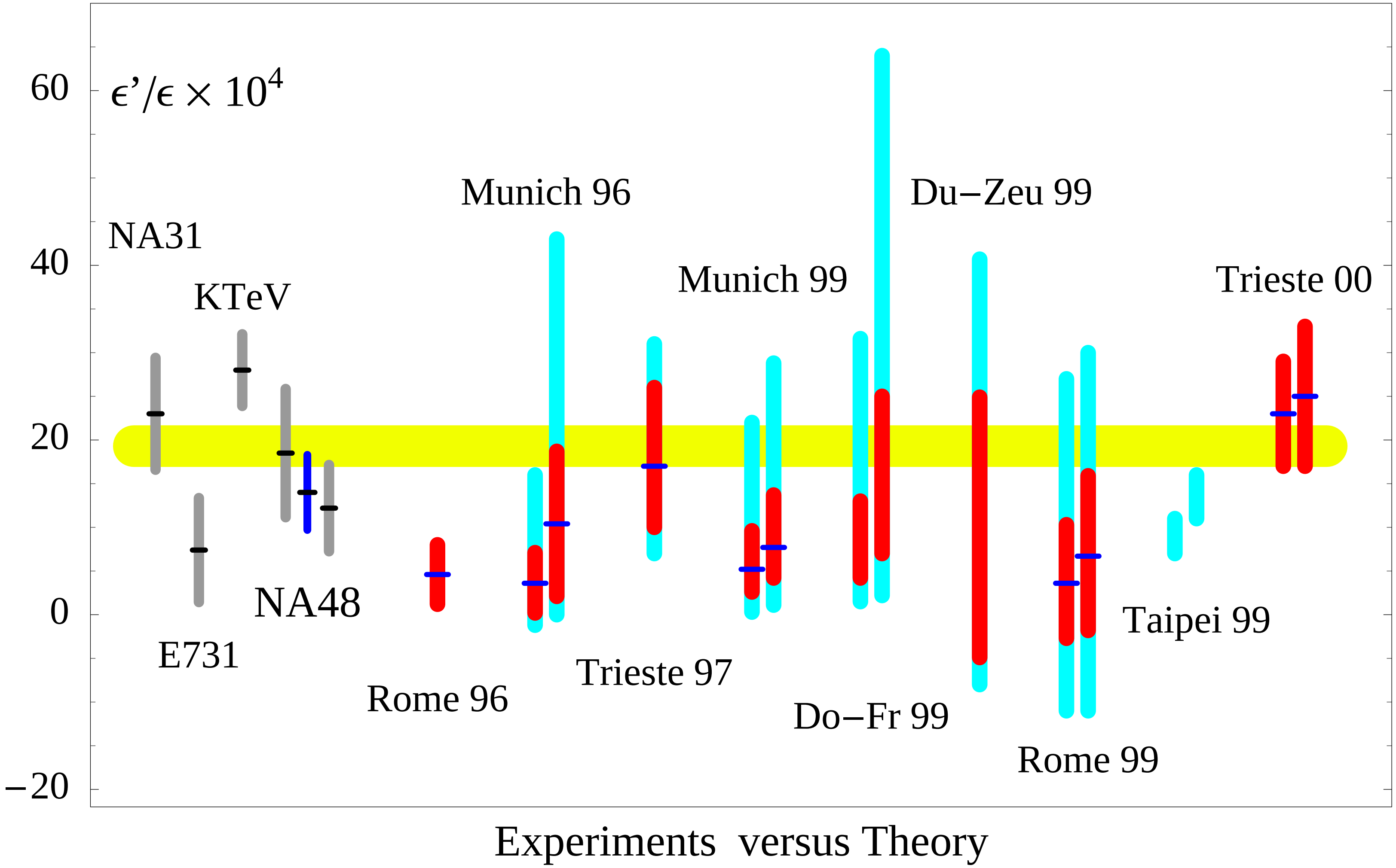


New world average:

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

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

Experiment vs. Theory



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

Conclusions

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

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

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

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

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

- It will be very interesting to compare this result with those expected from KTEV (FNAL) and KLOE (DAΦNE)