$BR(K_S \to \pi^+\pi^-)/BR(K_S \to \pi^0\pi^0)$

F. Bossi, *P. Valente*

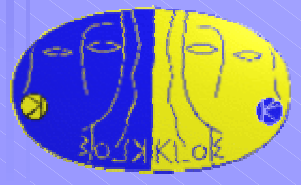
INFN LNF

M. Palutan

Università & INFN Roma II

T. Spadaro

Università & INFN Roma I



Analysis overview

- K_S tag (K_L interaction)
  - Tag efficiency from data

$\pi^+\pi^-$

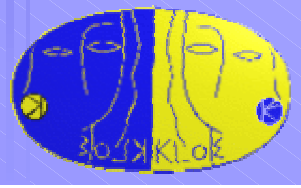
- 2 tracks coming from the IP
- Acceptance and loose p cuts

- Acceptance from Monte Carlo
- Tracking efficiency from data
- t0 and trigger efficiencies:
  - Single particle efficiencies from data ($K_S \to \pi^+\pi^-$, $K_L \to \pi e \nu$) plugged in MC

$\pi^0\pi^0$

- 4 prompt clusters by TOF
- Acceptance and E cuts

- Acceptance from Monte Carlo
- Photon detection efficiency from data using $\phi \to \pi^+ \pi^- \pi^0$ control samples
- Trigger efficiency:
  - probability of having 0,1 triggering clusters from data



Conclusions at Elba Workshop (May 2001)

Systematics

- ❑ Track efficiency: DATA/MC = 98.5%
- ❑ t_0 and trigger: Check convolution
- ❑ Tag efficiency: ≈1%
- ✓ Cluster counting: ≈1%

β^* spectra deviation

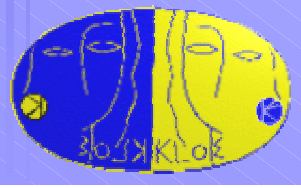
Method 1 (2 tracks)

- ✓ Reasonable results, with respect to 1999 and PDG
- ❑ Stability to be checked on whole year 2000 statistics

Method 2 (Double + single tag)

Improvements

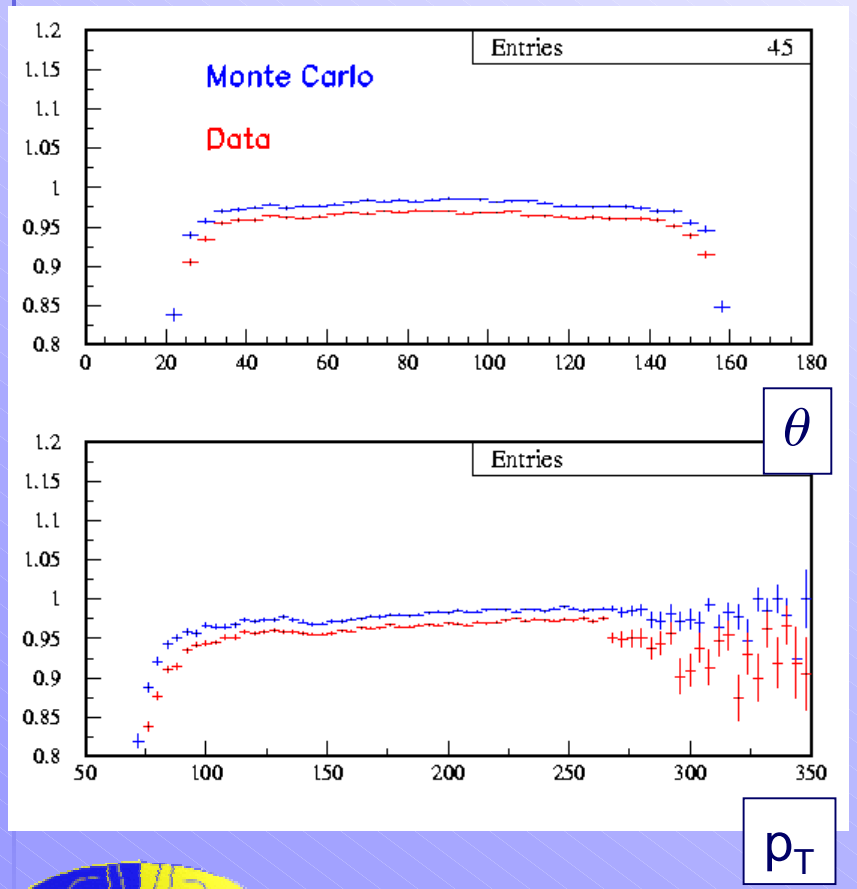
- ❑ Use $K_L \to \pi^+\pi^-\pi^0$ events for rephasing and t_0
- ❑ Ideas for $dN(\pi+\pi-\gamma)/dE_\gamma$

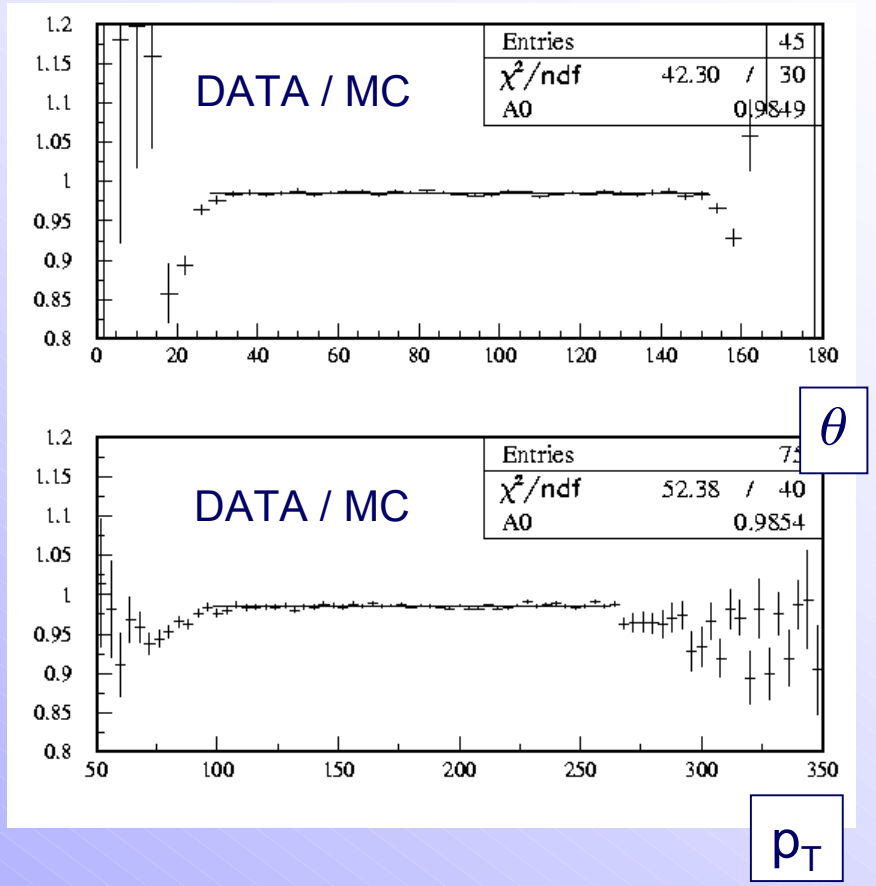


Track efficiency: DATA vs. MC (May 2001)

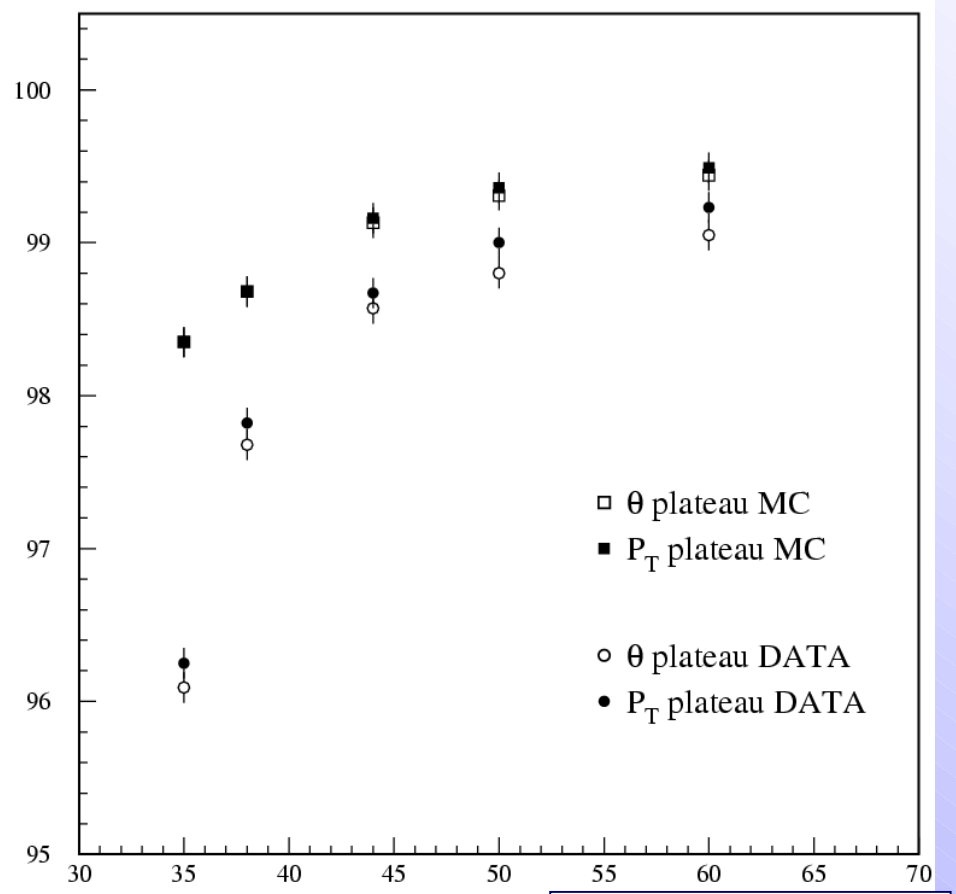
- track efficiency vs. θ and p_T

DATA/MC = 98.5 %





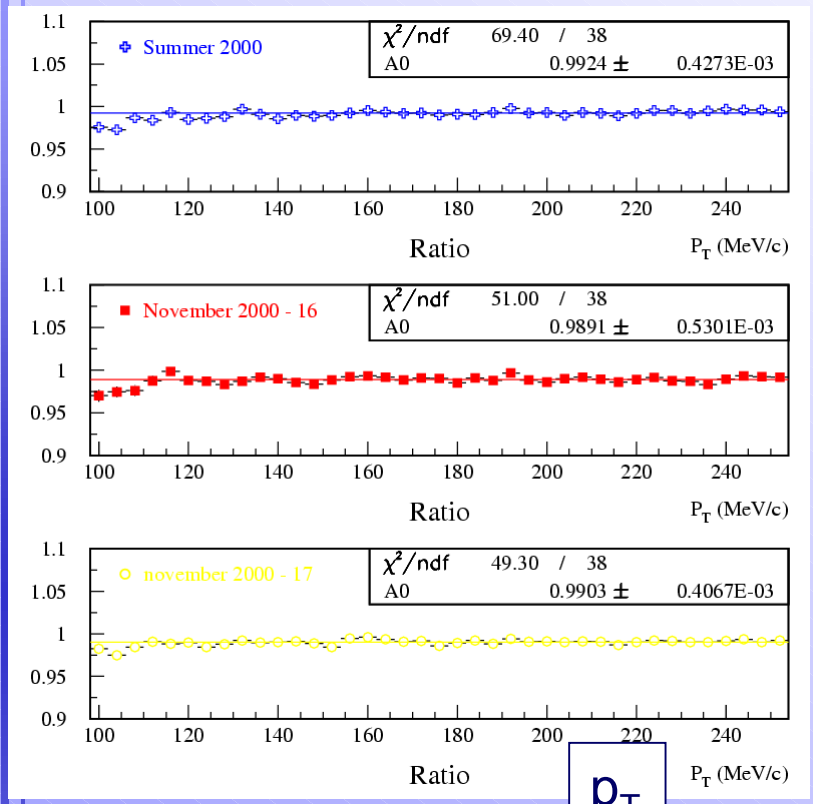
Track efficiency: DATA and MC



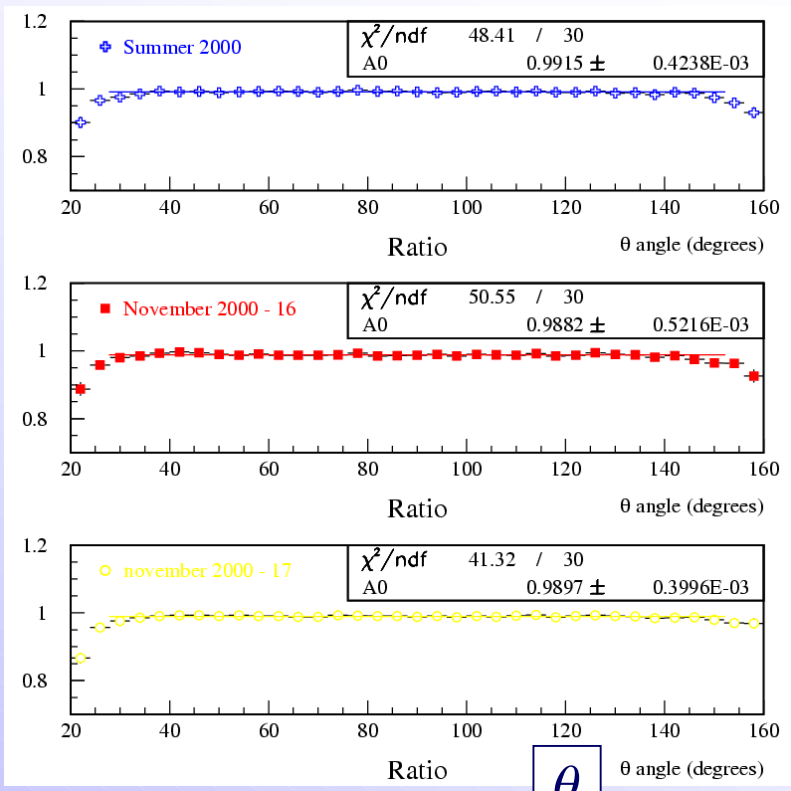
Tracks are searched requiring the first hit to be in a cylinder of $r_{\perp} = R_{first}$ centered in the origin

Track efficiency turns out to be sensitive to this cut, due to spurious hits (noise and machine background) in the very first layers of the chamber

Track efficiency: DATA/MC



p_T



θ

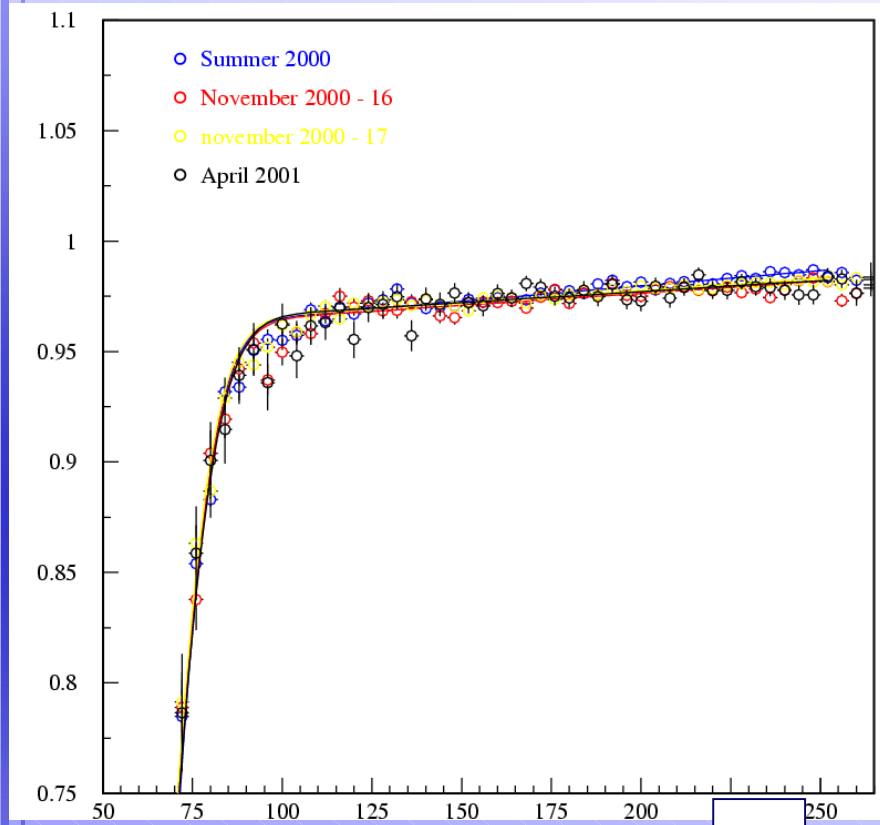
- Almost flat in the accepted range:

  $120<p_T<300$ MeV/c; $30°<\theta<150°$

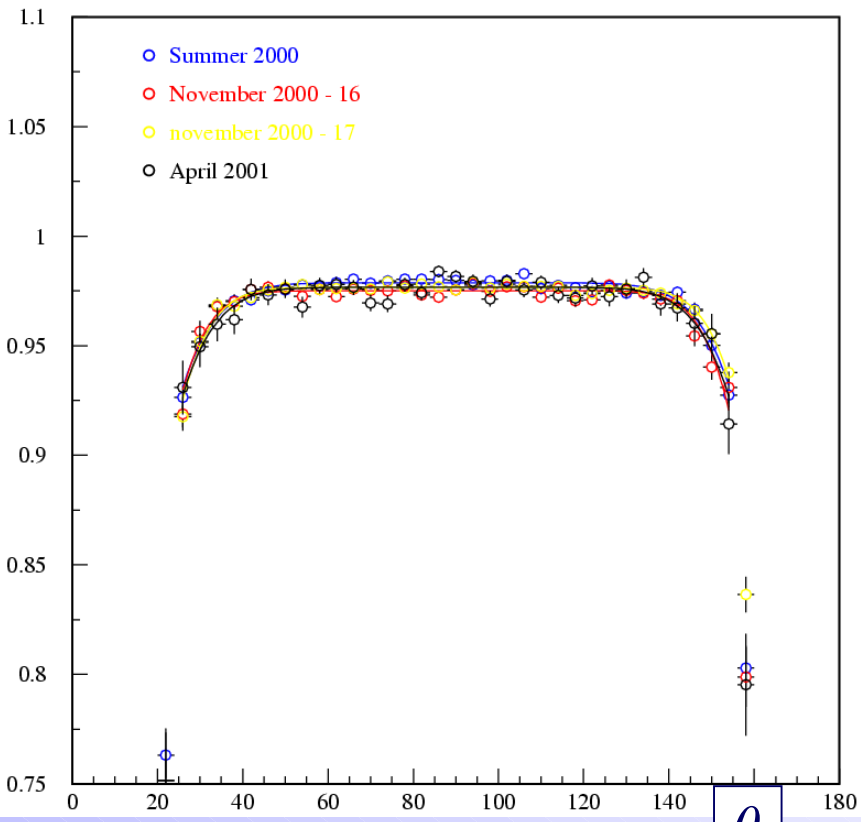
- Systematic error from ε vs. p_T and θ differences in the different samples:

  $\approx 1‰$

Track efficiency stability



p_T



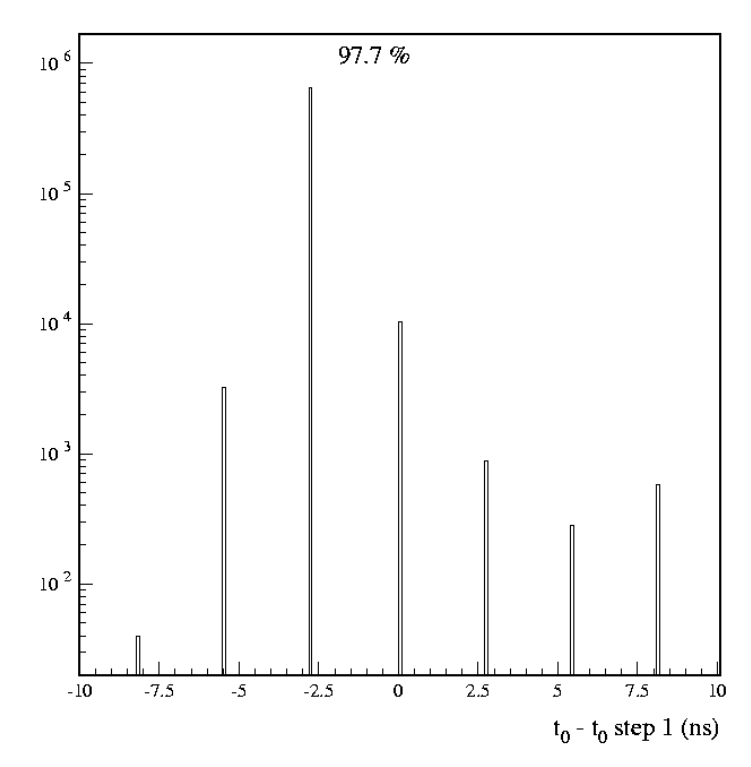
θ

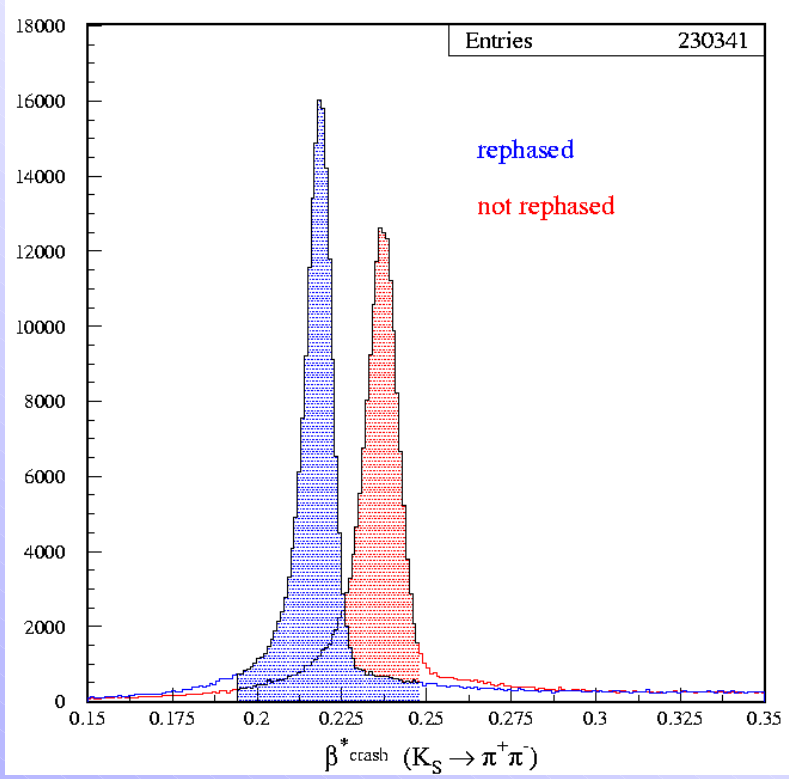
Absolute tracking efficiency is stable in the different running periods

Tag efficiency ratio

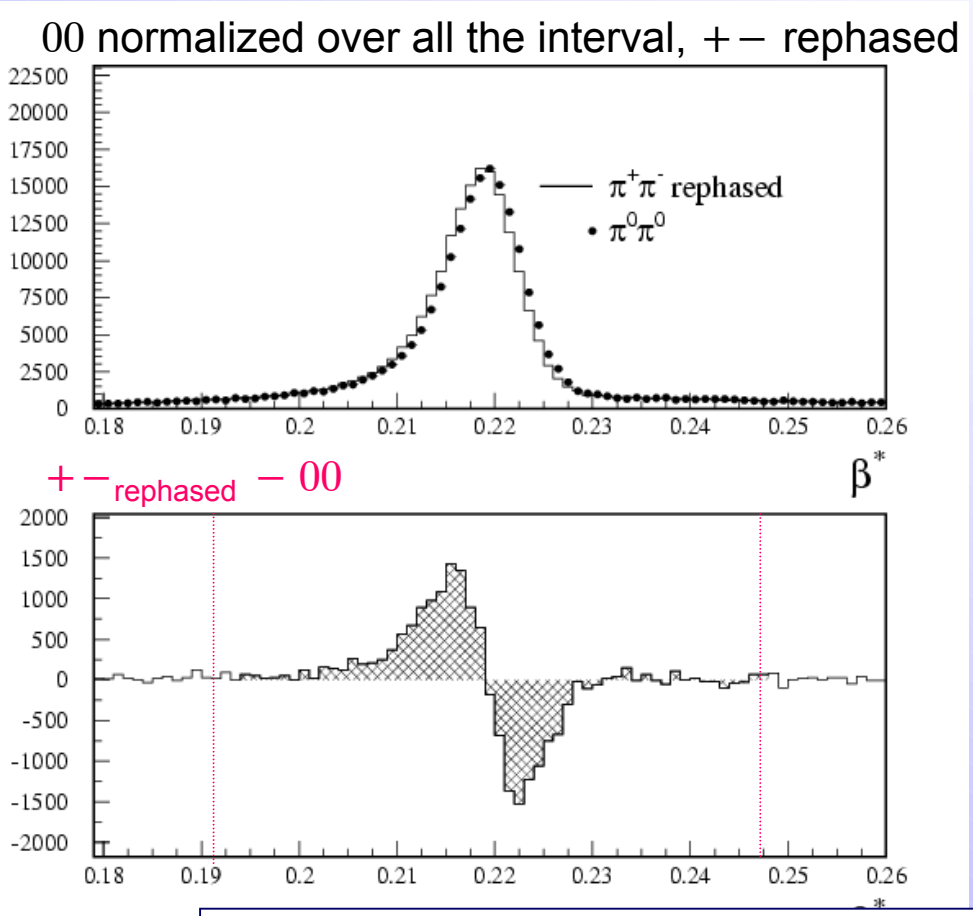
$K_S \to \pi^+\pi^-$ sample (2 track + inv. mass cut):
comparison between β^* spectra before and after T0STEP1 correction

ε (events in window) = (96.5 $\pm$ 0.5) %





Tag efficiency ratio (May 2001)

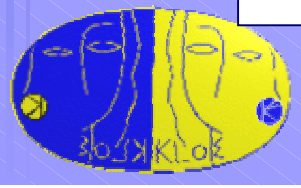


Systematics from comparison between β^* spectra of:

$(K_S \to \pi^+\pi^-)_{\text{rephased}}$ and
$(K_S \to \pi^0\pi^0)$

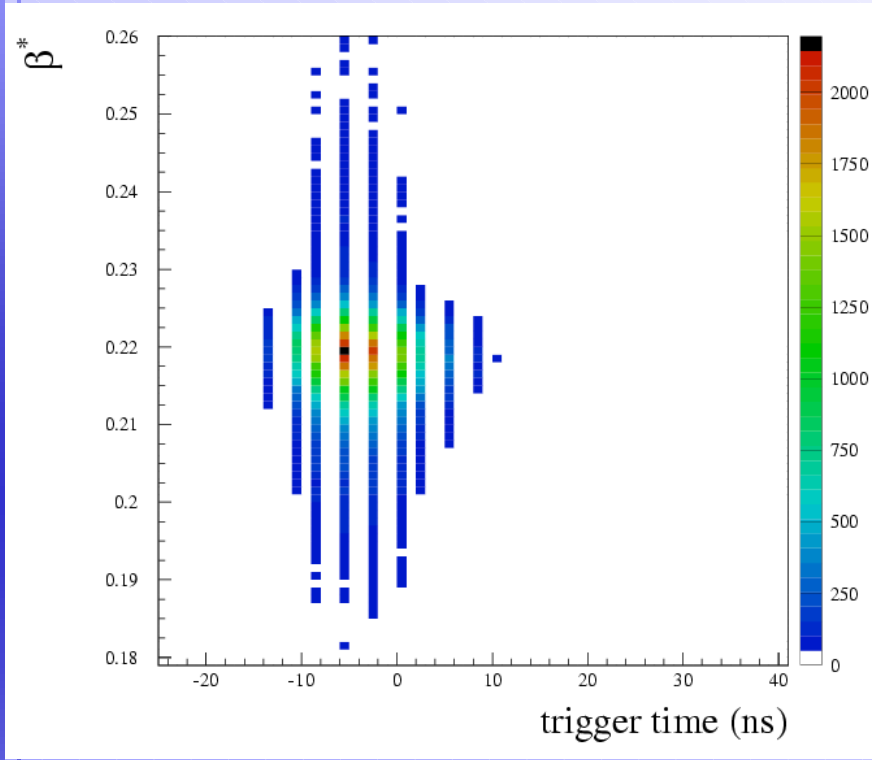
2 problems:

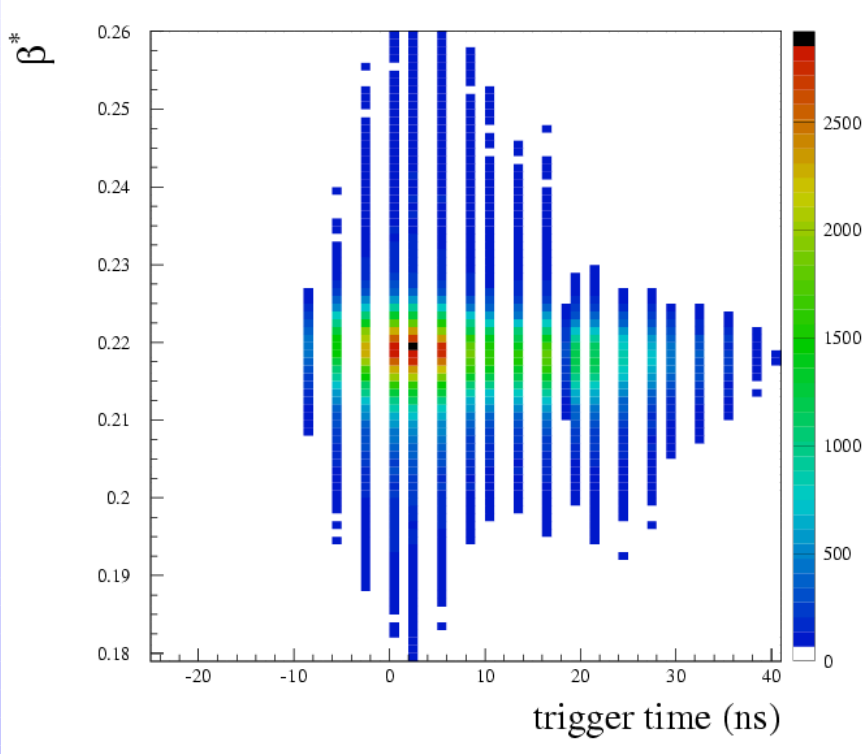
- The +− rephased distribution is shifted wrt 00 one
- +− rephased normalization is sensitive to the tails



β^* shift (time scale correction I)

Look at β^* distribution as a function of the trigger time:



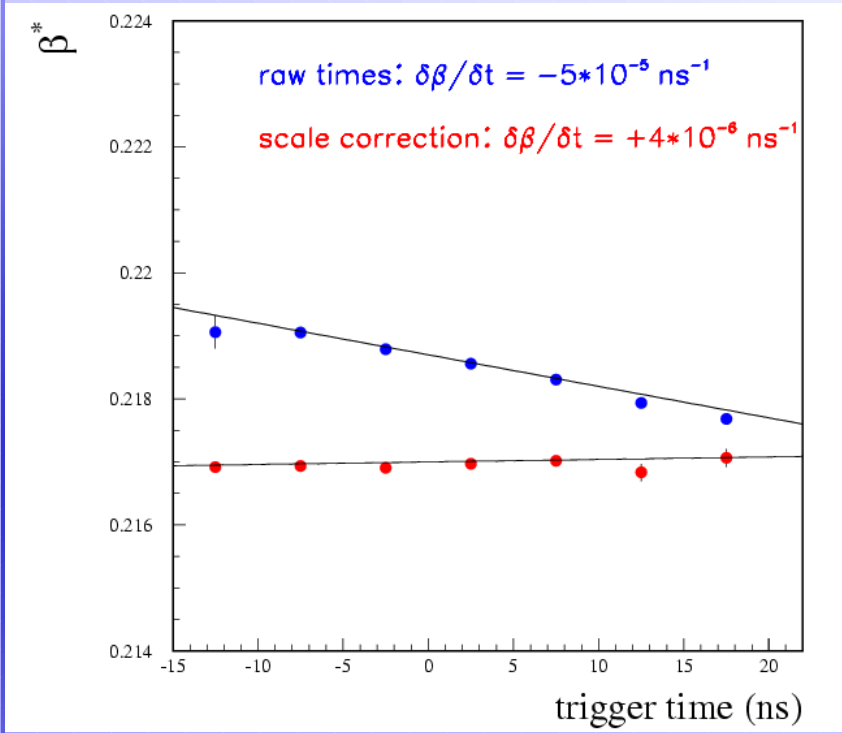


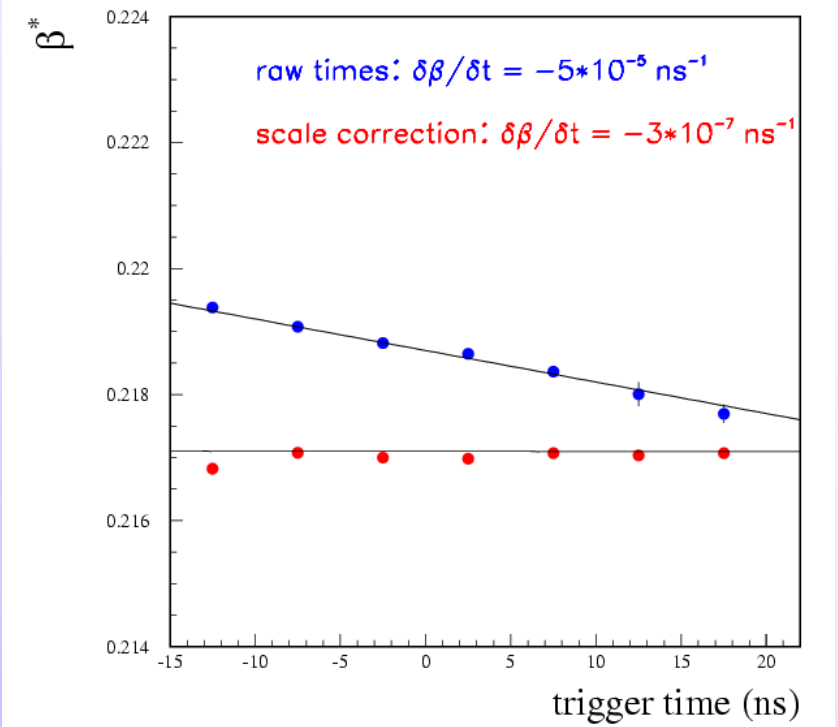
$K_S \to \pi^0\pi^0$ $K_S \to \pi^+\pi^-$

$$t_{trigger} = \mathrm{NINT}([\Delta_{cable} - t_{raw} + t_{TOF}] / t_{bunch}) \bullet t_{bunch}$$

β^* shift (time scale correction II)

β^* vs. trigger time profile without and with time scale correction:



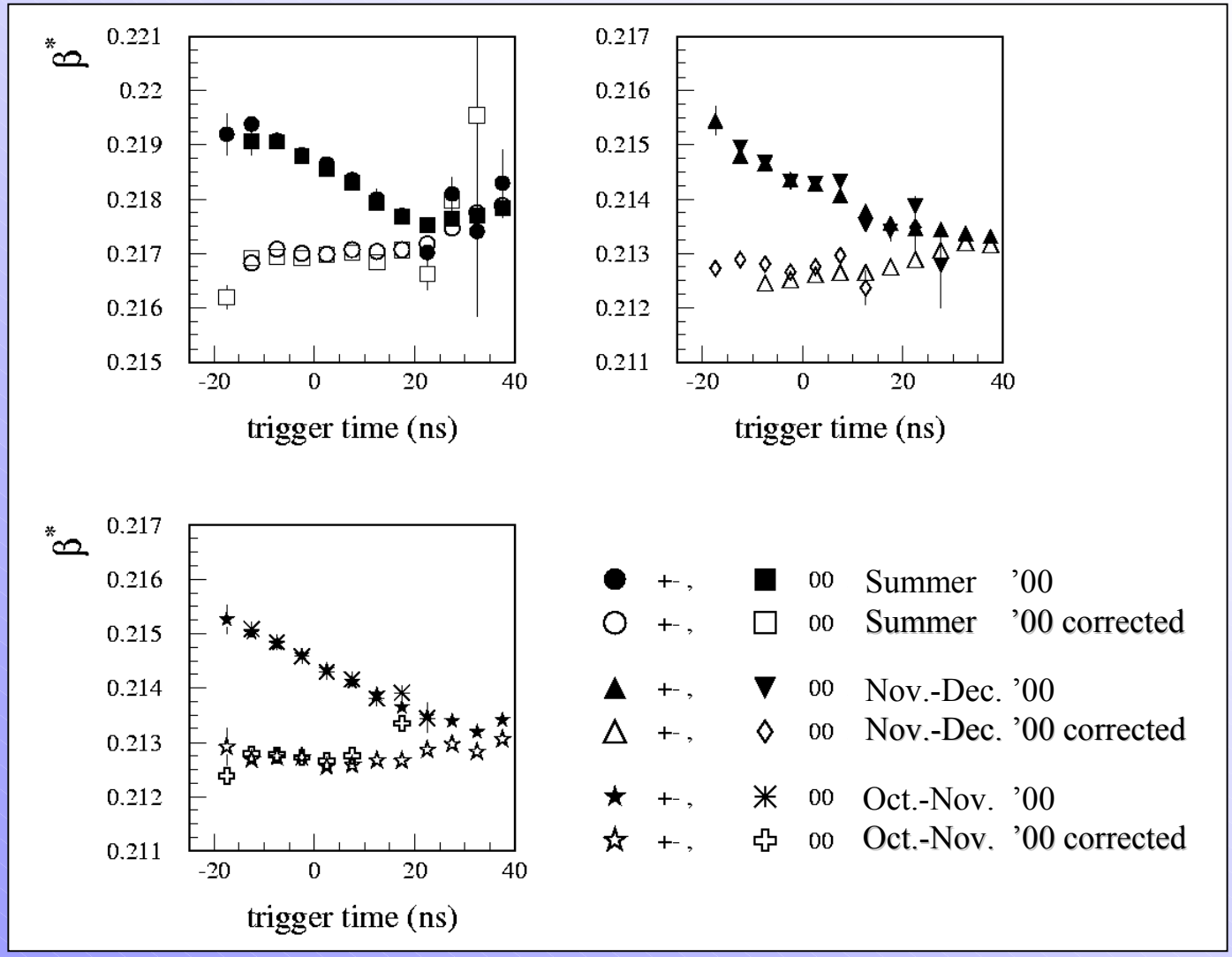


$K_S \to \pi^0\pi^0$

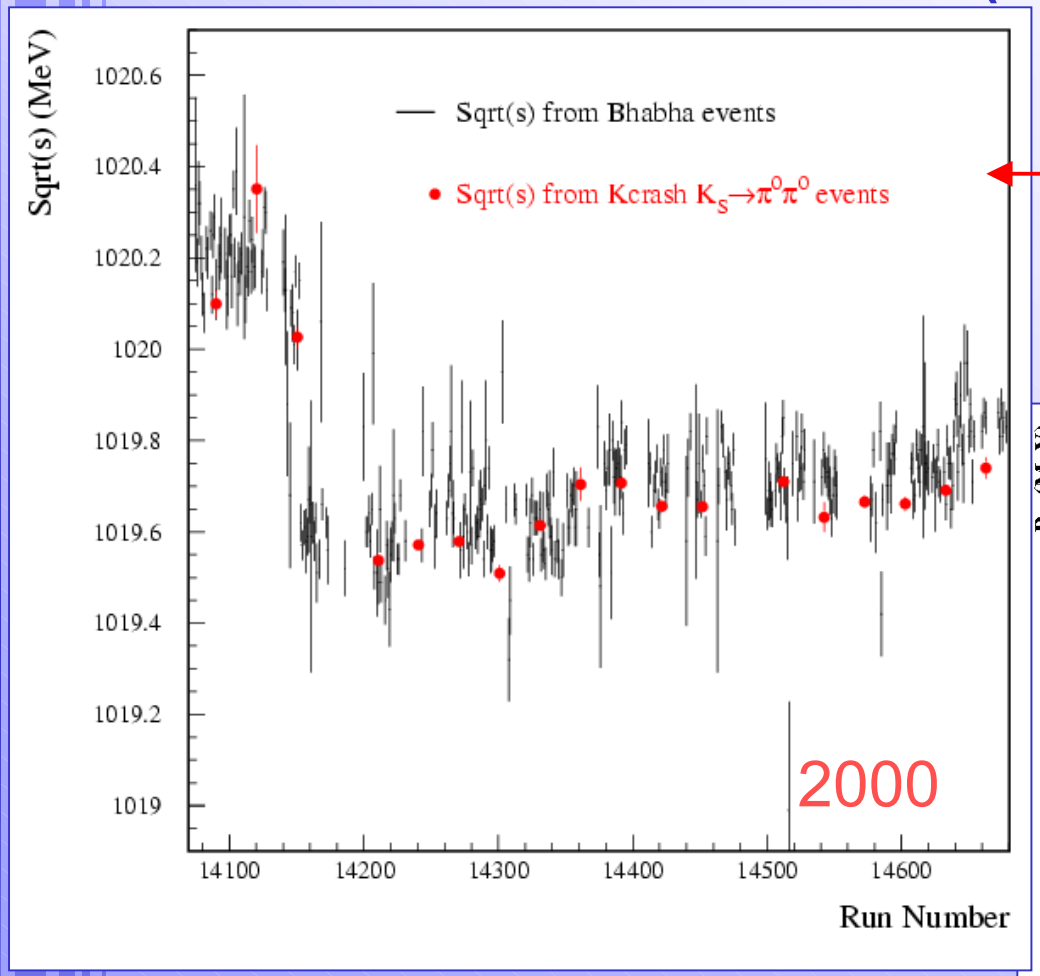
$K_S \to \pi^+\pi^-$

time scale correction from $e^+e^- \to \gamma\gamma$ events

Time scale correction stability

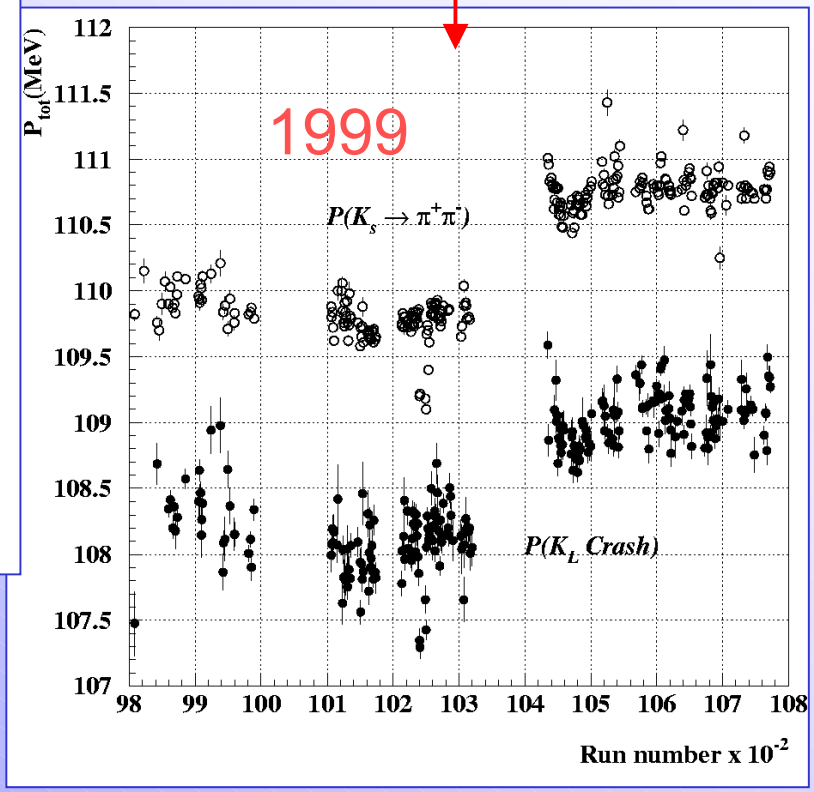


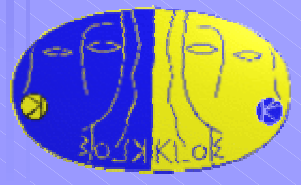
Time scale correction (√S from K crash)



$$\sqrt{S} = 2M_K \cdot [1-(\beta^*)^2]^{-1/2}$$

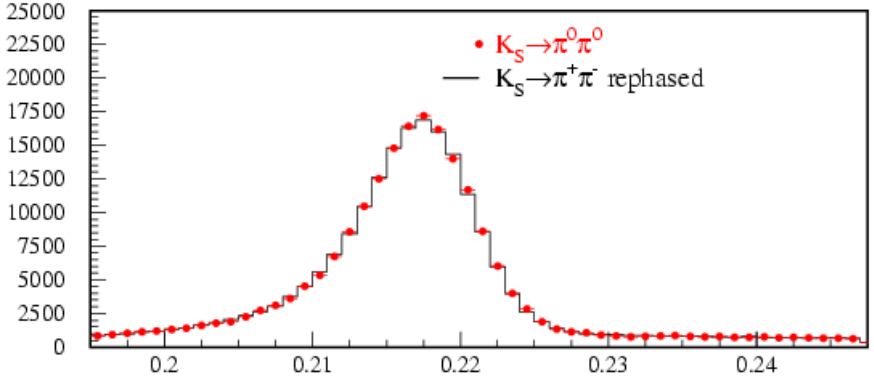
$$p^*_K = M_K \cdot \beta^* [1-(\beta^*)^2]^{-1/2}$$



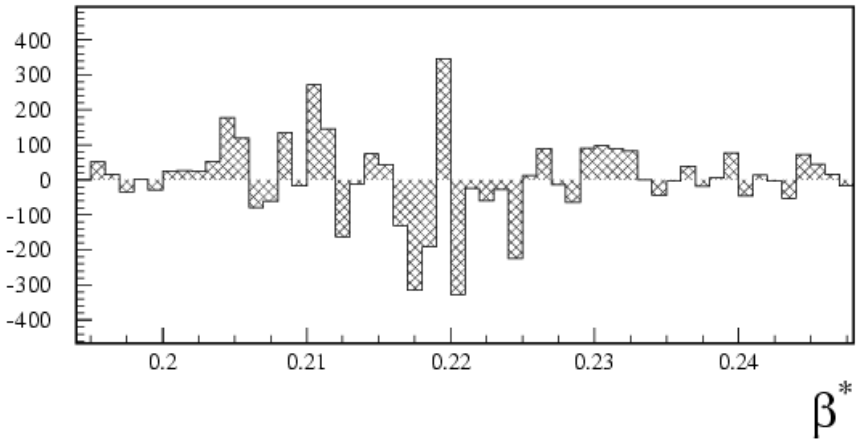


β^* spectra (after t correction)

00 normalized over all the interval, +− rephased

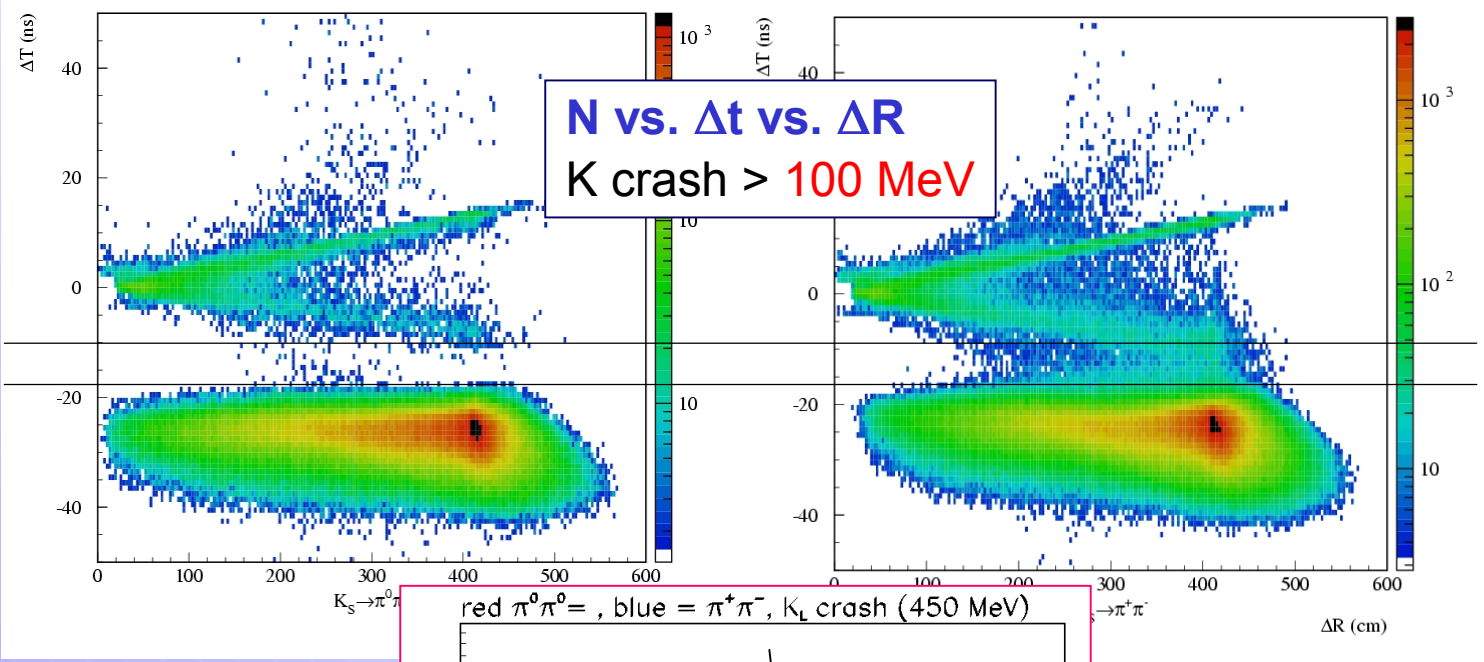


+− rephased − 00



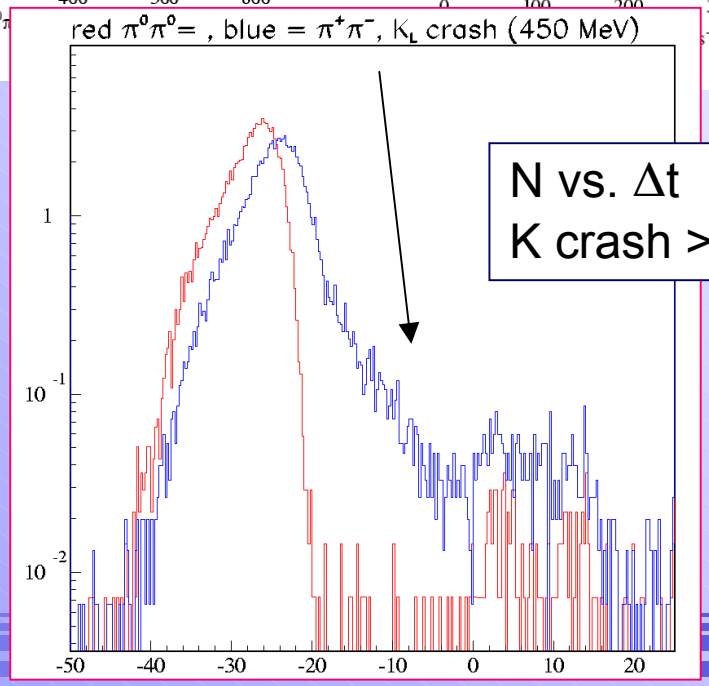
- After correction +− rephased is no longer shifted wrt 00
- There is still the systematic effect due to the tails…

β^* distribution tails (where do they come from?)



N vs. Δt vs. ΔR
K crash > 100 MeV

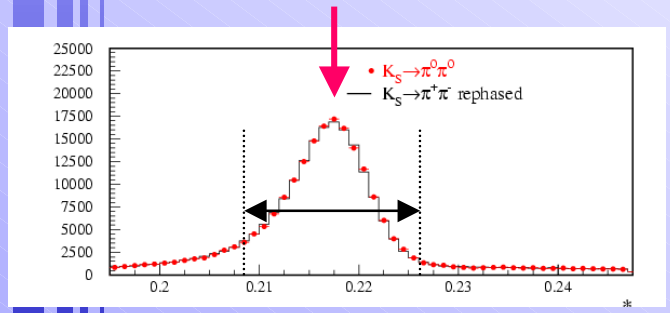
Clusters ≠ K crash cluster



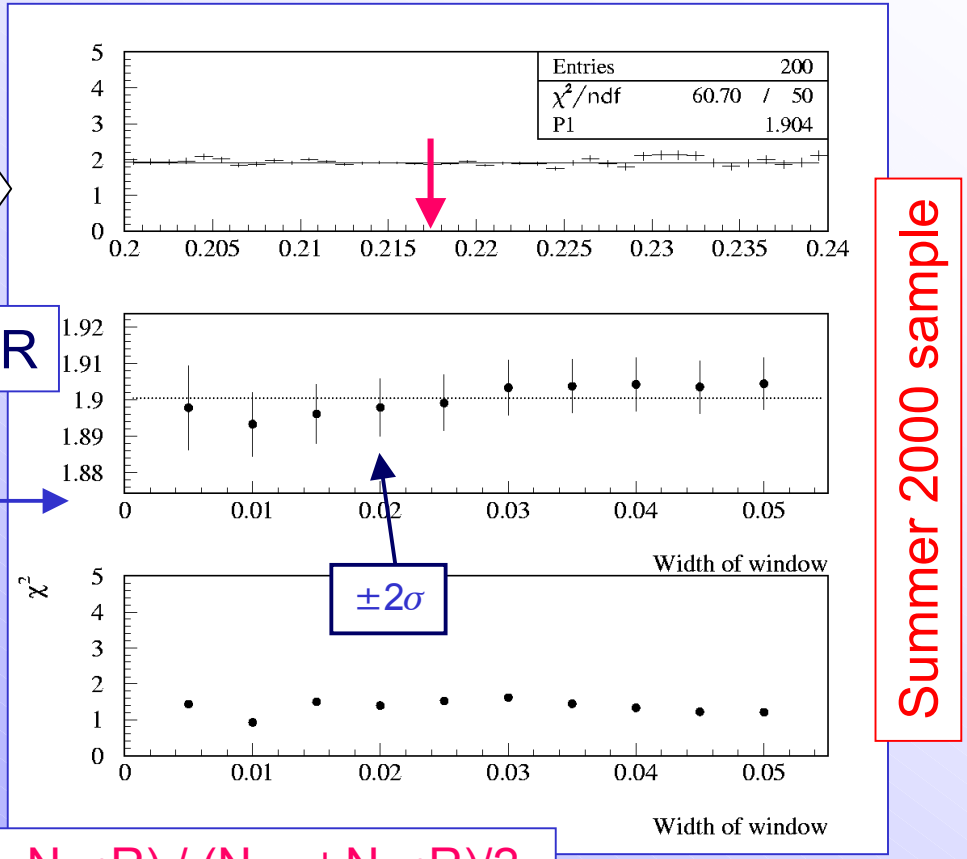
N vs. Δt
K crash > 450 MeV

Tails in β^* ($+-_{reph}$ vs. 00 comparison I)

- Residual differences evaluated by comparing the 2 distributions bin to bin
- Fit R=+− rephased/00 with a constant in different windows around the β^* peak



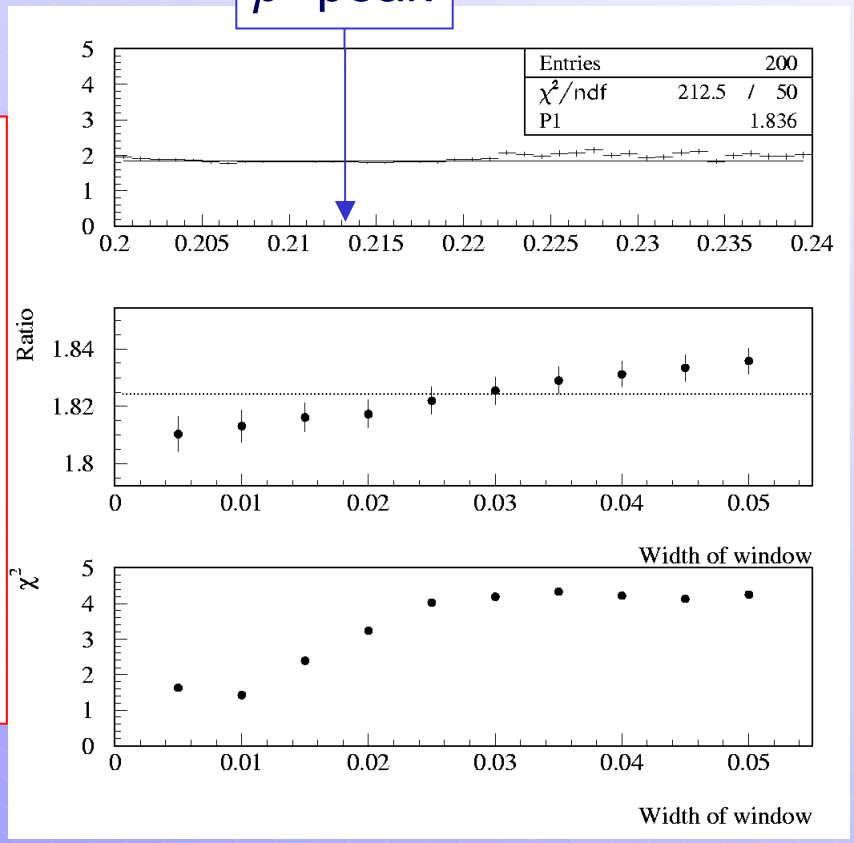
Ratio



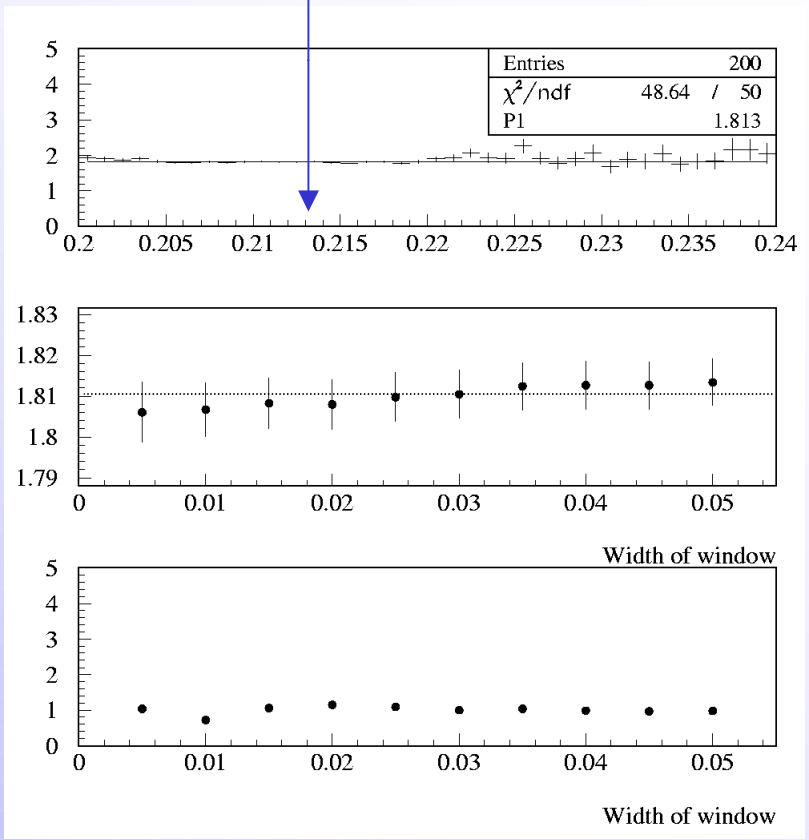
- Evaluate systematics from $(N_{+-} - N_{00} \cdot R) / (N_{+-} + N_{00} \cdot R)/2$
- Statistical error on R calculated from fit

Tails in β^* ($+-_{reph}$ vs. 00 comparison II)

November 2000 sample

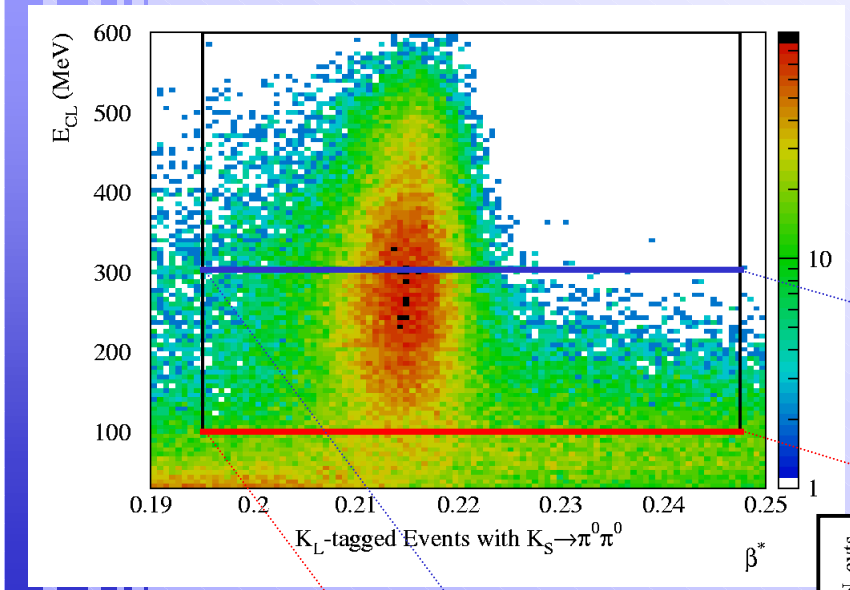


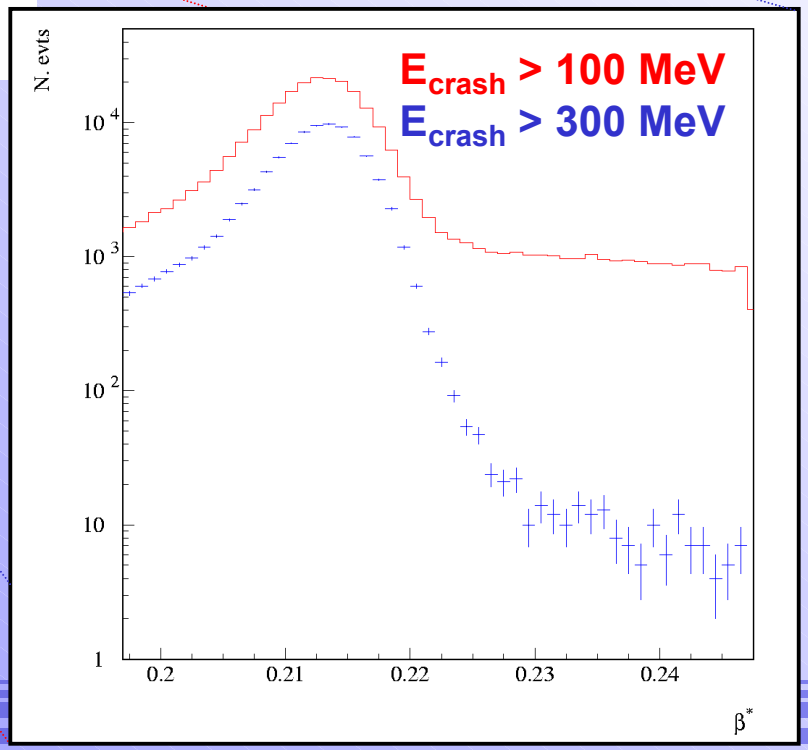
100 MeV cut



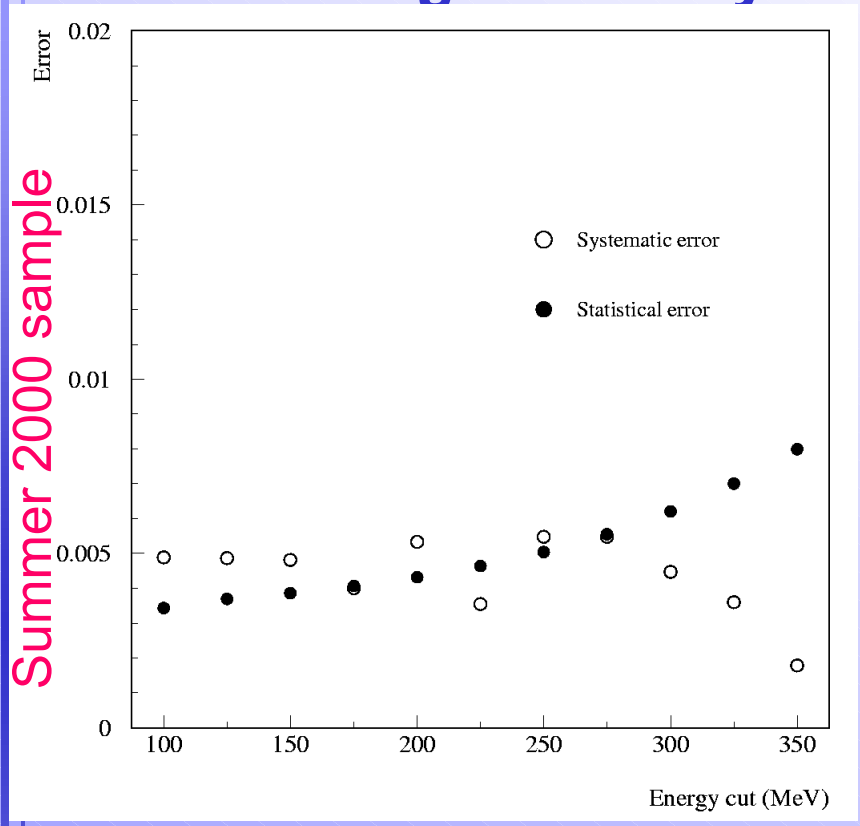
200 MeV cut

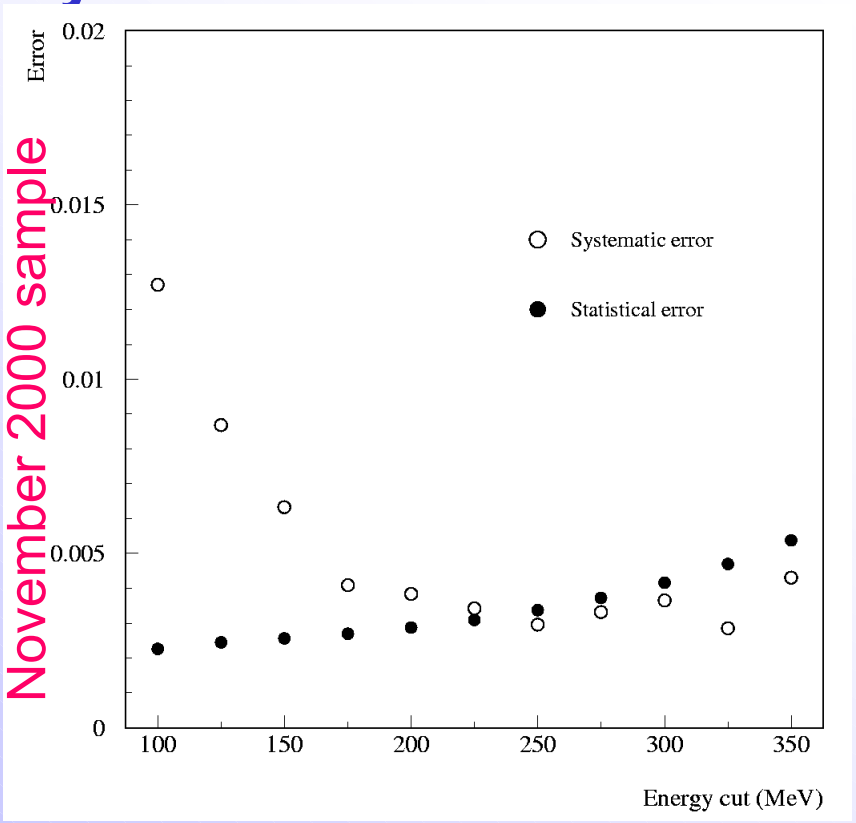
β^* spectra vs. E_{crash}





Tag efficiency ratio systematics



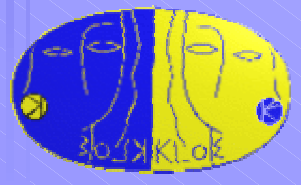


The contribution to the systematic error due to the tag can be reduced increasing the K crash energy cut (at the cost of some increase in the statistical error)

K crash energy cut tuning

Sample	Runs	Period	Luminosity
14k	14075-14678	15/07/2000 05/08/2000	3.37 pb^{-1}
16k	16211-16712	30/10/2000 15/11/2000	6.15 pb^{-1}
16k bis	16713-17010	15/11/2000 24/11/2000	3.90 pb^{-1}
17k	17011-17249	24/11/2000 06/12/2000	3.92 pb^{-1}

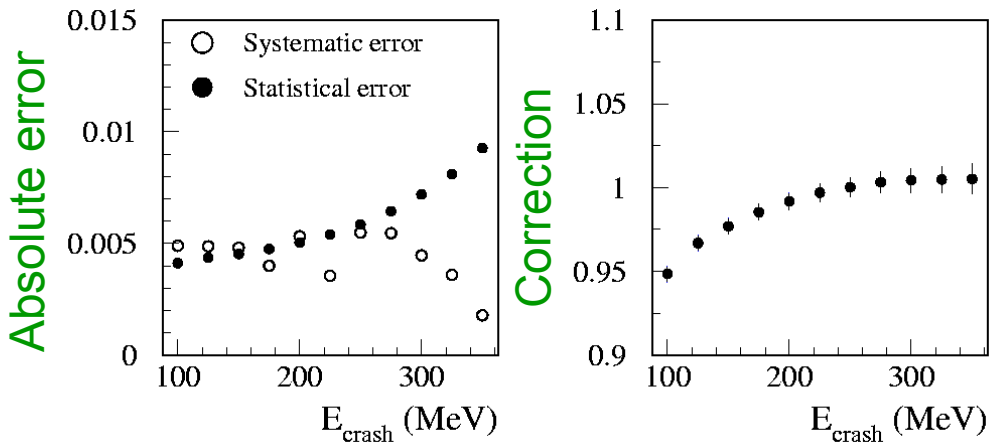
The **4** main corrections to the final ratio have been considered, together with their errors changing the K crash energy cut…



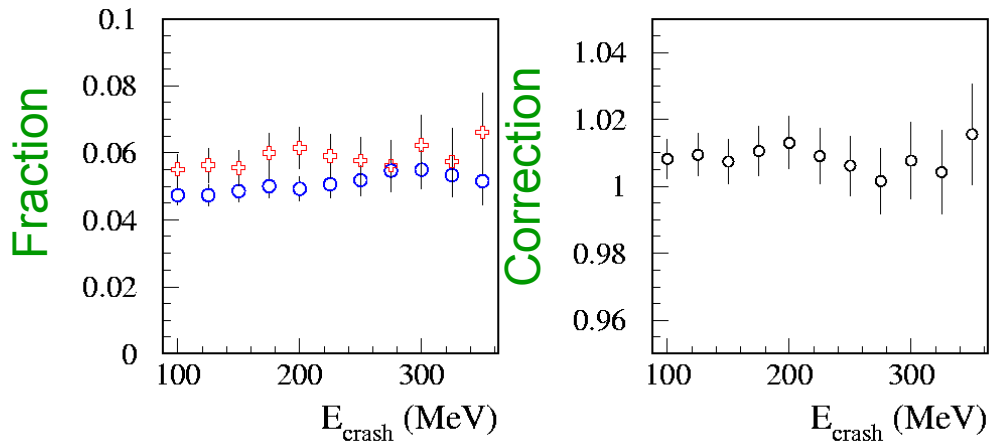
Efficiencies vs. E_{crash} cut I

14k sample

Tag ratio: +−/00



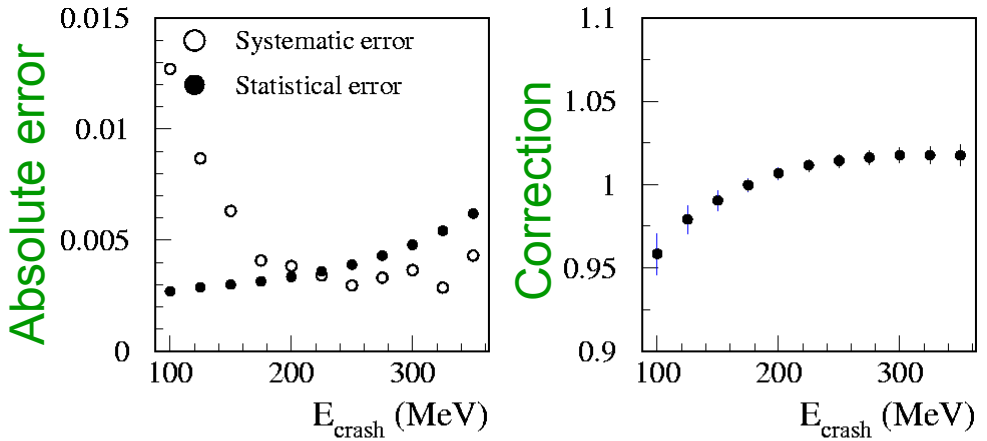
Cosmic veto +− & 00



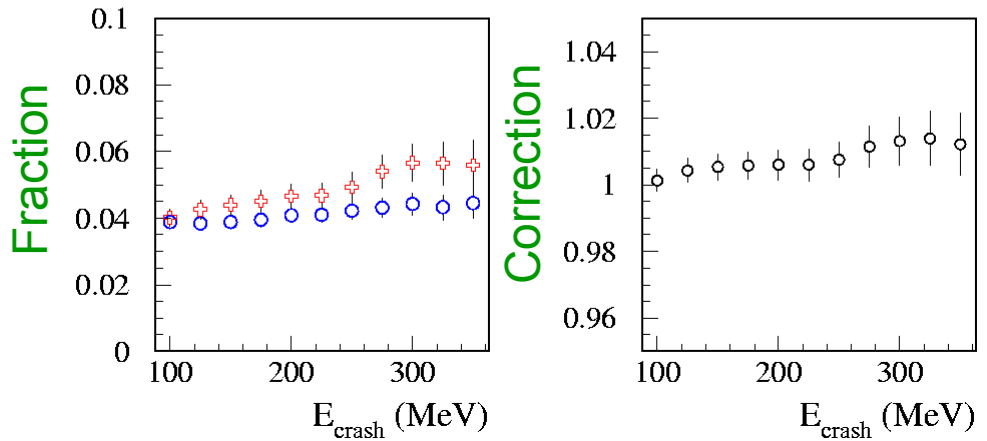
Efficiencies vs. E_{crash} cut II

16k sample

Tag ratio: +−/00



Cosmic veto +− & 00



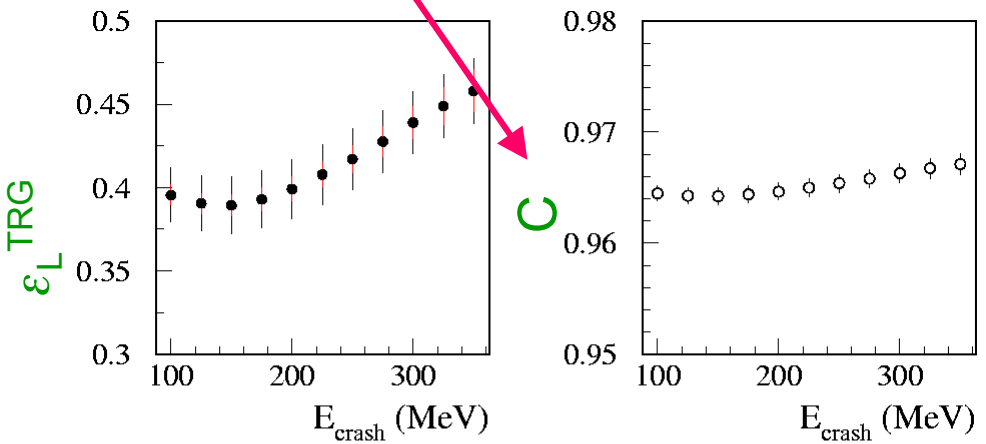
Efficiencies vs. E_{crash} cut III

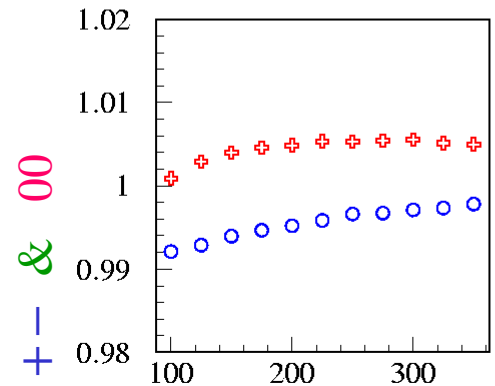
TRG/t0 correction:

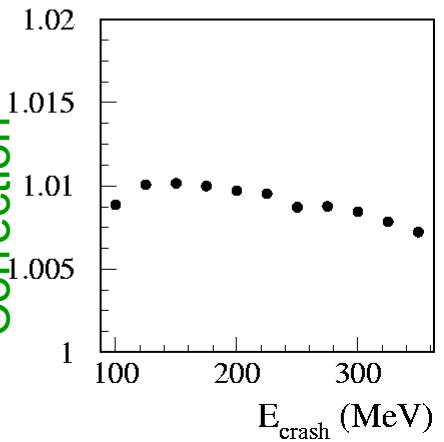
$$\varepsilon_L^{TRG} \times \varepsilon_S^{t0} + (1-\varepsilon_L^{TRG}) \times \varepsilon_S^{TRG \cdot t0} = C$$

TRG/t0

Time scale (streaming)



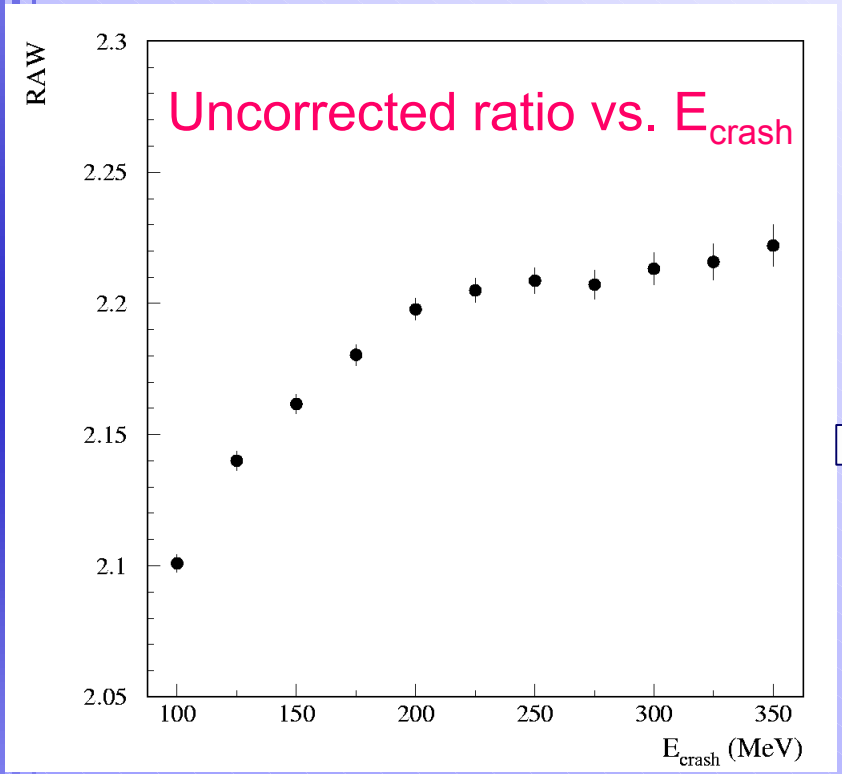


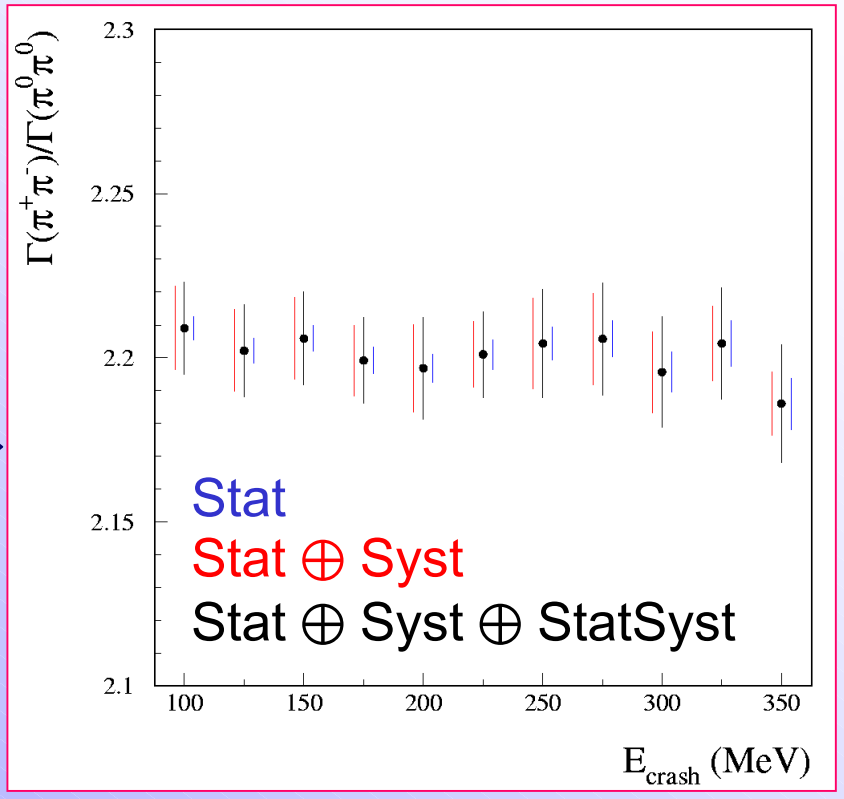


Corrections (+− & 00)
to account for streaming
without time scale correction

$\Gamma(K_S \to \pi^+\pi^-)/\Gamma(K_S \to \pi^0\pi^0)$ result (I)

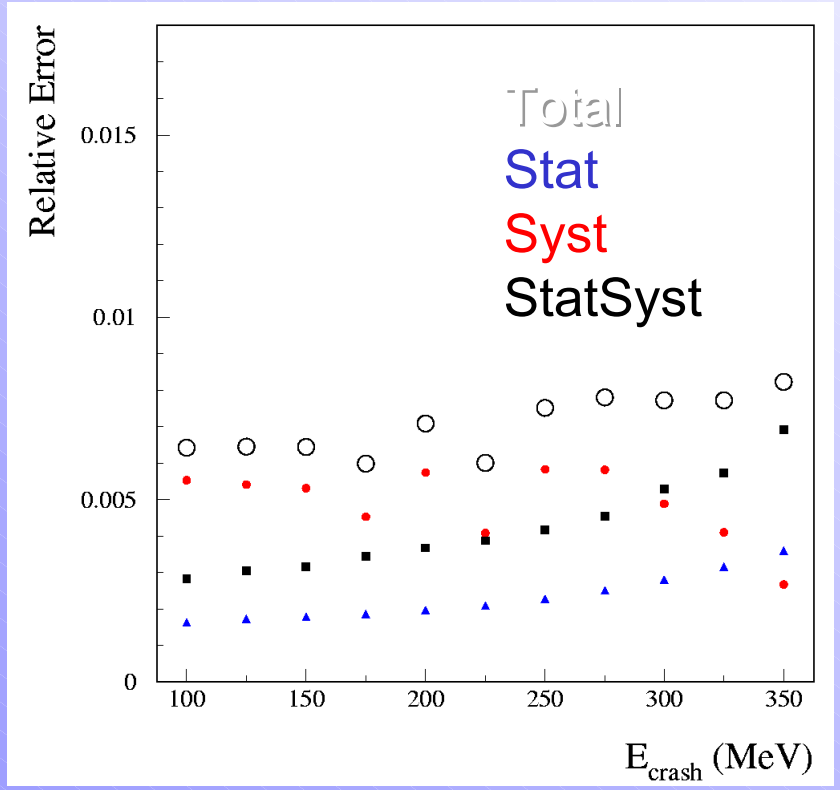
14k sample

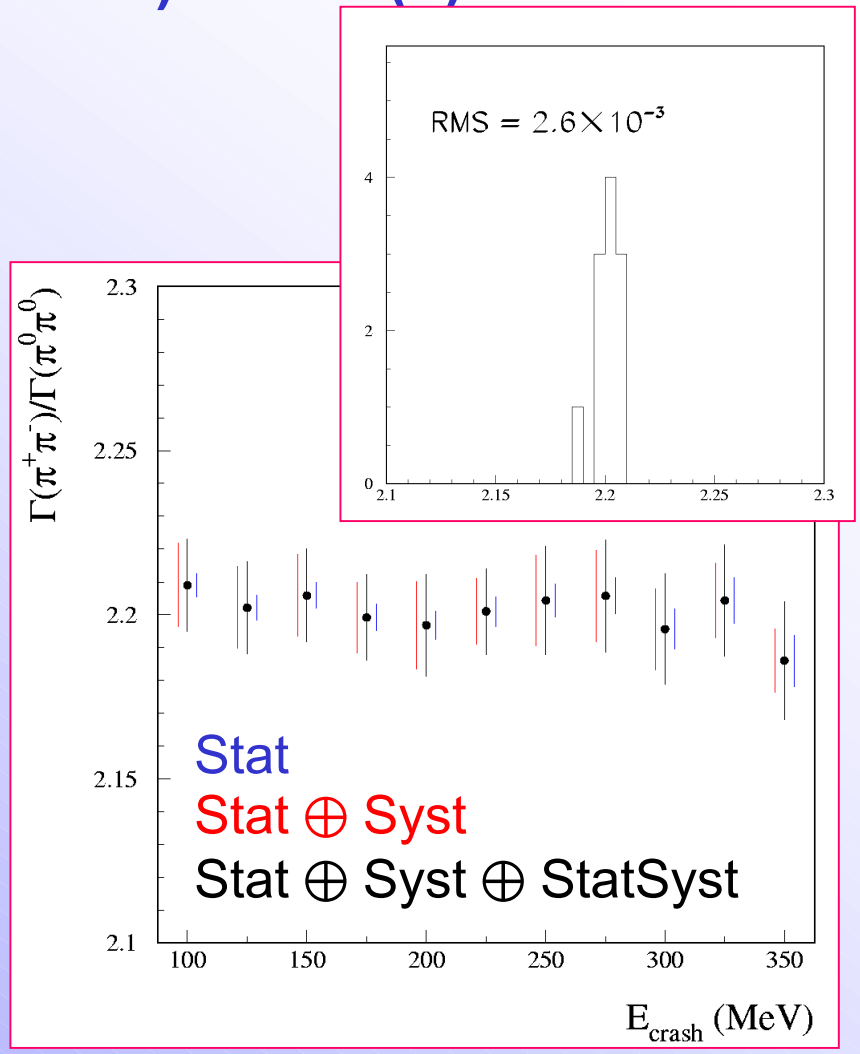




$\Gamma(K_S \to \pi^+\pi^-)/\Gamma(K_S \to \pi^0\pi^0)$ result (II)

14k sample

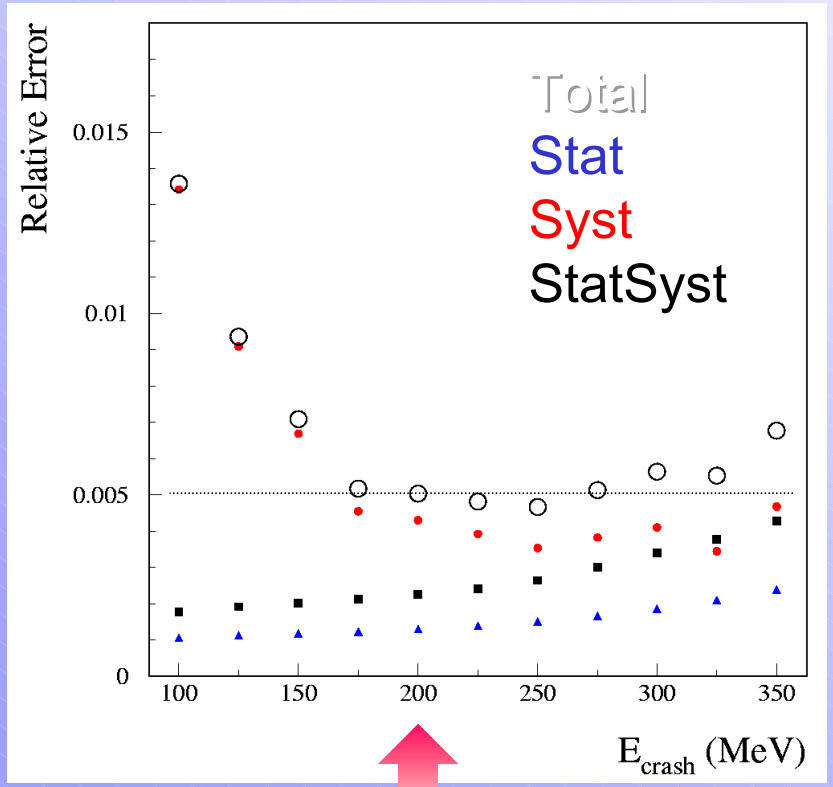


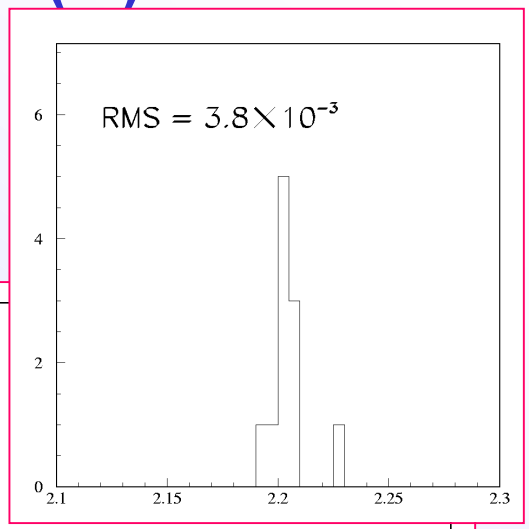


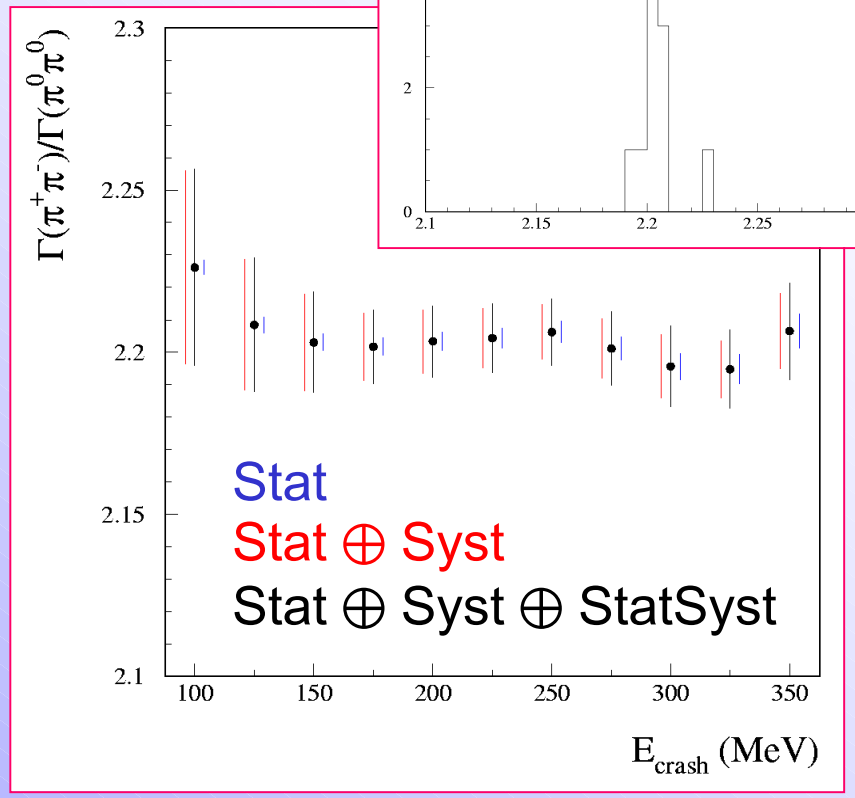
$\Gamma(K_S \to \pi^+\pi^-)/\Gamma(K_S \to \pi^0\pi^0)$ result (III)

Syst: dominated by tag (clustering **NOT** included)

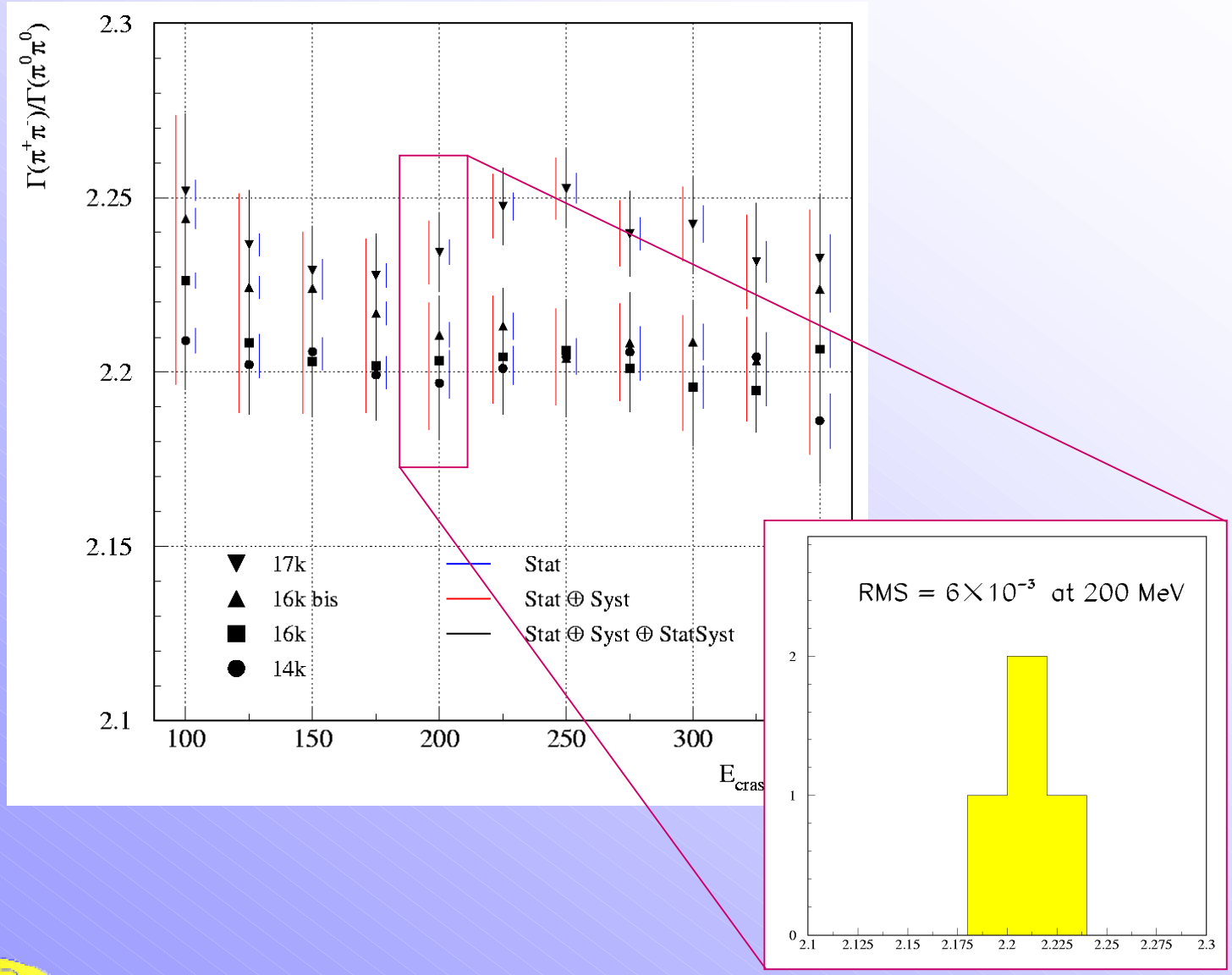
StatSyst: dominated by cosmic veto (downscaling)



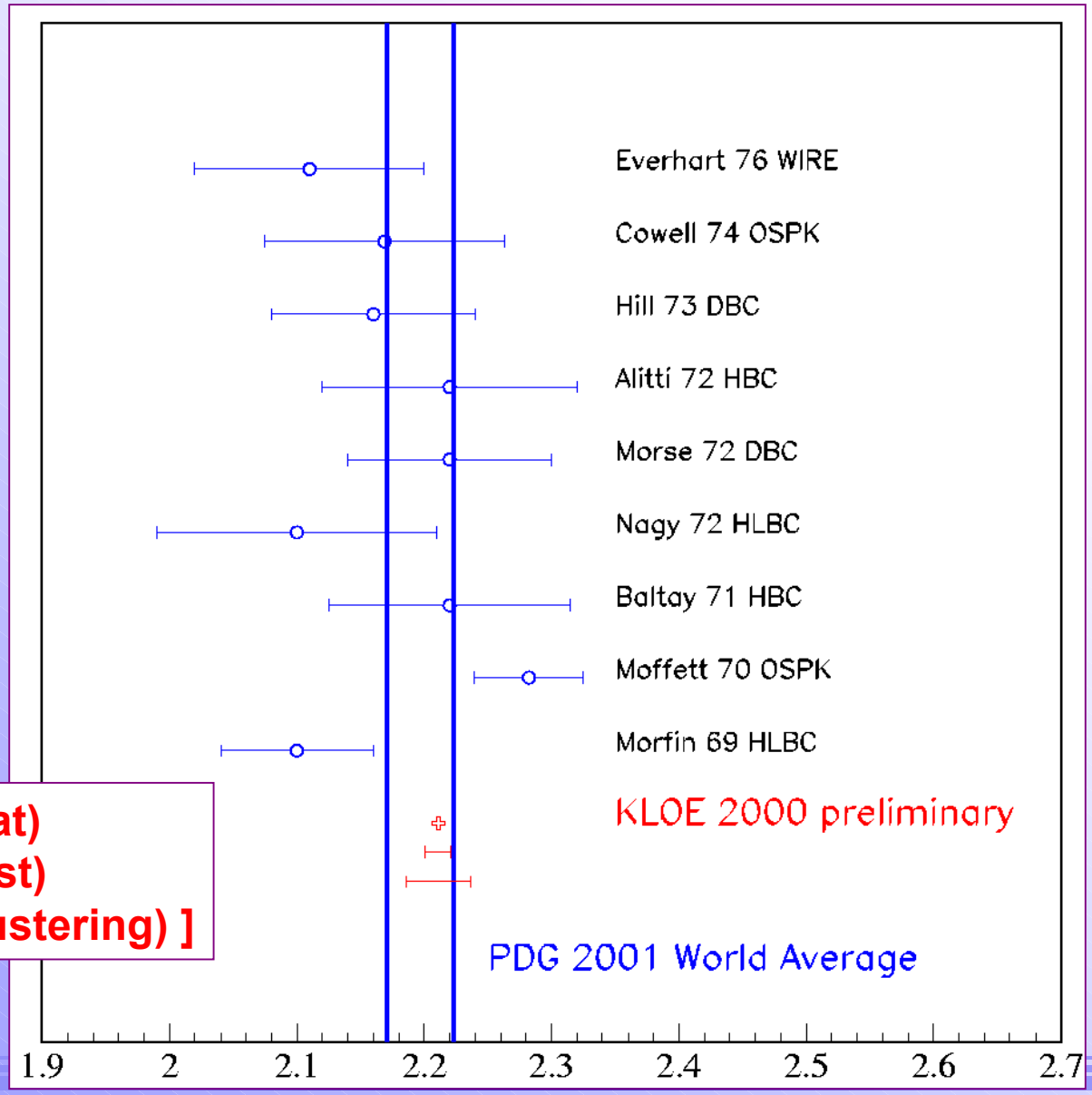




$\Gamma(K_S \to \pi^+\pi^-)/\Gamma(K_S \to \pi^0\pi^0)$ (All year '00 samples)



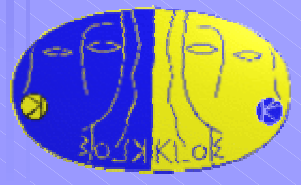
$\Gamma(K_S \to \pi^+\pi^-)/\Gamma(K_S \to \pi^0\pi^0)$ result at 200 MeV



2.211 × [1 ± 0.8‰ (stat)
± 6.8‰ (syst)
± 10.0‰ (clustering)]

Still-to-do list

- Get rephasing and t_0 and trigger efficiencies independently using $K_L \to \pi^+\pi^-\pi^0$ tag
  - work in progress
- Compute cluster efficiency systematics:
  - New Monte Carlo with accidental clusters soon (S. Miscetti)
- Measure $dN(\pi^+\pi^-\gamma)/dE_\gamma$

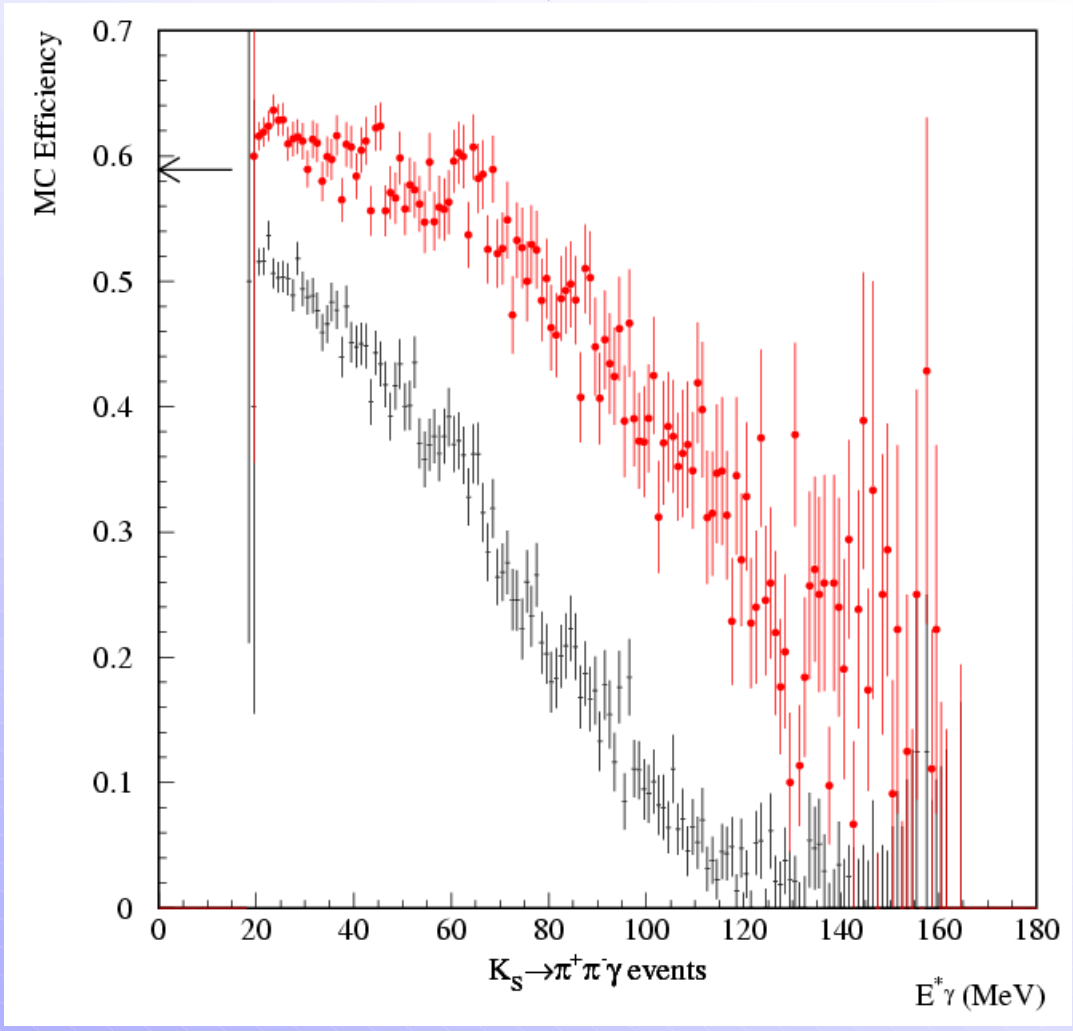


Ideas for dN($\pi^+\pi^-\gamma$)/dE$_\gamma$

- Present analysis (2 tracks on EMC)

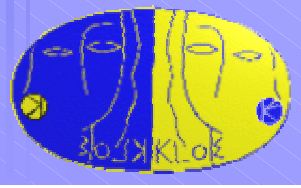
← Selection efficiency on Monte Carlo events with no radiative γ

- Require at least 1 track on EMC



Conclusions (I)

- The analysis is in good shape: total error going down towards 1% (and below); KLOE memo coming soon…
- Efficiency stability is good, systematic vs. statistical error can be optimized
- Systematic error can be further reduced improving the cluster counting understanding
- Work close to conclusion also for efficiencies checking with alternative tag
- Analysis to be slightly changed for $dN(\pi^+\pi^-\gamma)/dE_\gamma$ measurement



Conclusions (II)

- 2001 data-set: wider β^* window
  - ❑ easier to take into account streaming with a time scale not corrected
  - ❑ less sensitive to √S variations
- 2001 data-set: larger statistics
  - ❑ better evaluation of cosmic veto effect (reduce SystStat error)
  - ❑ possibility to study systematics on separate subsamples (avoid correlations)