Hyperon results from NA48/I

QCD 06

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On behalf of the NA48/I Collaboration

Out-line:

- The NA48 detector
- Data taking periods
- The Beam
- Summary of hyperon studies in NA48
- The Ξ^0 lifetime
- Decay asymmetry measurements:
  - $\Xi^0 \rightarrow \Lambda\pi^0$
  - $\Xi^0 \rightarrow \Lambda\gamma$
  - $\Xi^0 \rightarrow \Sigma^0\gamma$
- Ξ^0 semileptonic decays
  - Measurement of BR($\Xi^0 \rightarrow \Sigma^+ e^- \overline{\nu}_e$)
  - Measurement of BR($\Xi^0 \rightarrow \Sigma^+ \mu^- \overline{\nu}_\mu$)

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- The Ξ^0 lifetime NEW AND PRELIMINARY!
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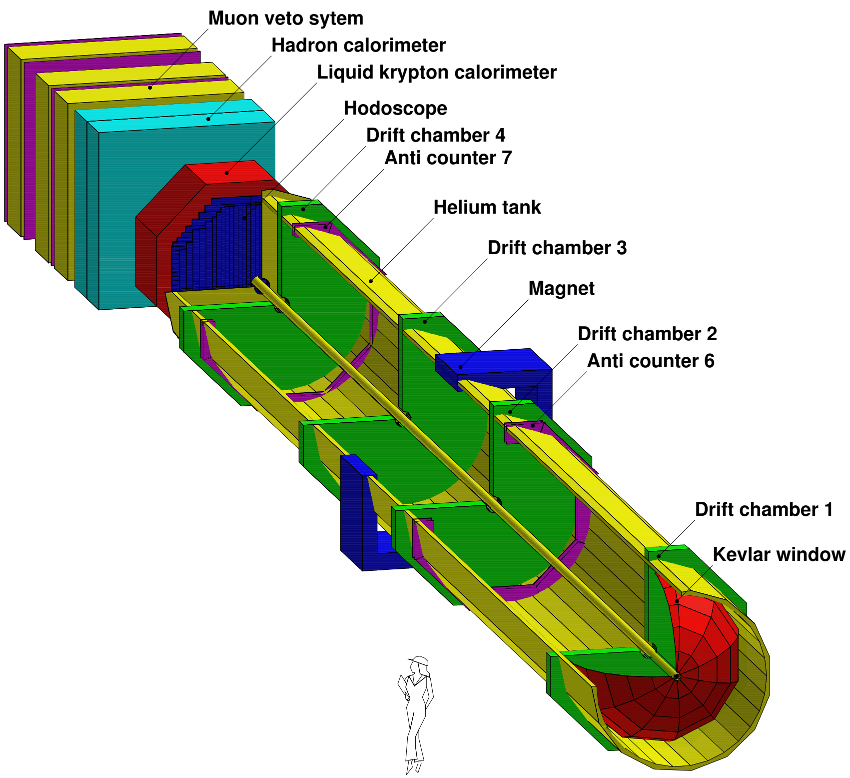
The NA48 detector



CHARGED DECAYS:

magn. spectrometer and scintillator hodoscope ($p_T^{kick} \simeq 265\ MeV/c$)

$$\frac{\sigma(p)}{p} \simeq 0.5\% \oplus 0.009\%\ p\ (GeV/c)$$

$$\sigma_{x,y}^{hit} \simeq 90\ \mu m$$

$$\sigma_{x,y}^{vtx} \simeq 2\ mm$$

$$\sigma_t \simeq\ 200\ ps$$

NEUTRAL DECAYS:

Quasi homogeneous Liquid Krypton electromagnetic calorimeter (LKr)

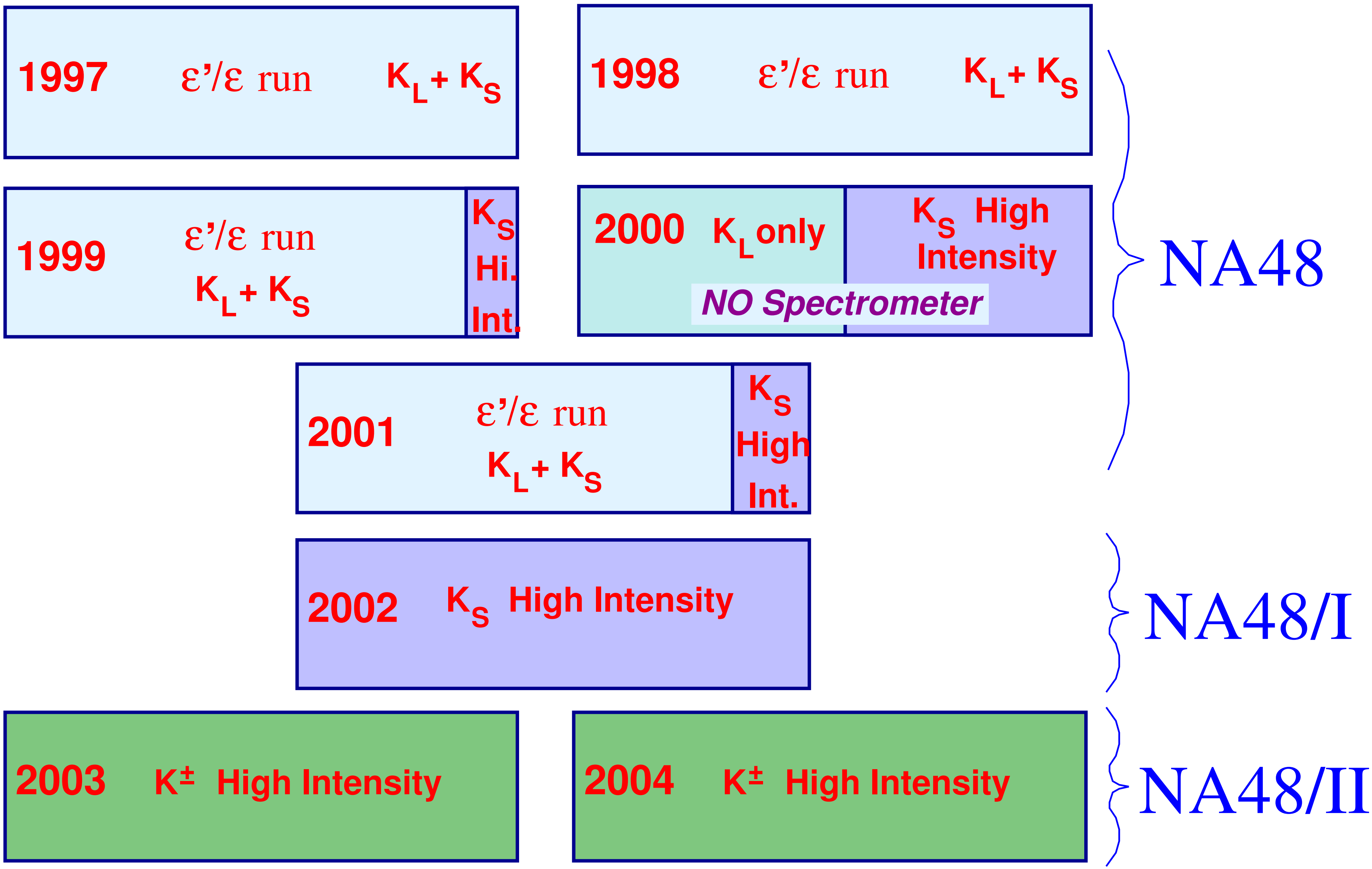
$$\frac{\sigma(E)}{E} = \frac{3.2\%}{\sqrt{E}} \oplus \frac{0.10}{E} \oplus 0.5\%\ (E\ in\ GeV)$$

$$\sigma_{m_{\pi^0}} \simeq 1\ MeV/c^2$$

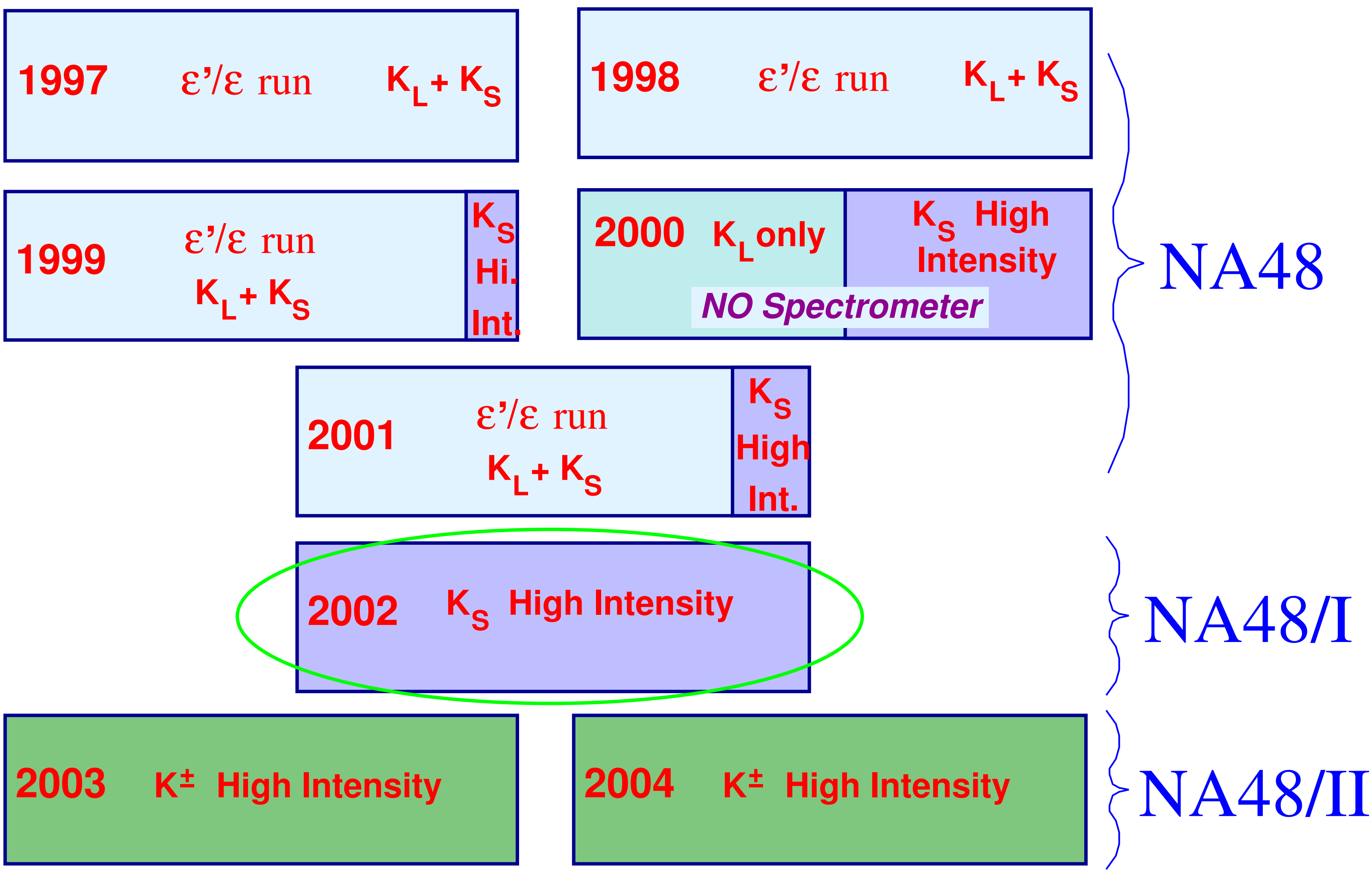
$$\sigma_{x,y} <\ 1.3\ mm$$

$$\sigma_t <\ 300\ ps\ above\ 20\ GeV$$

Data taking periods

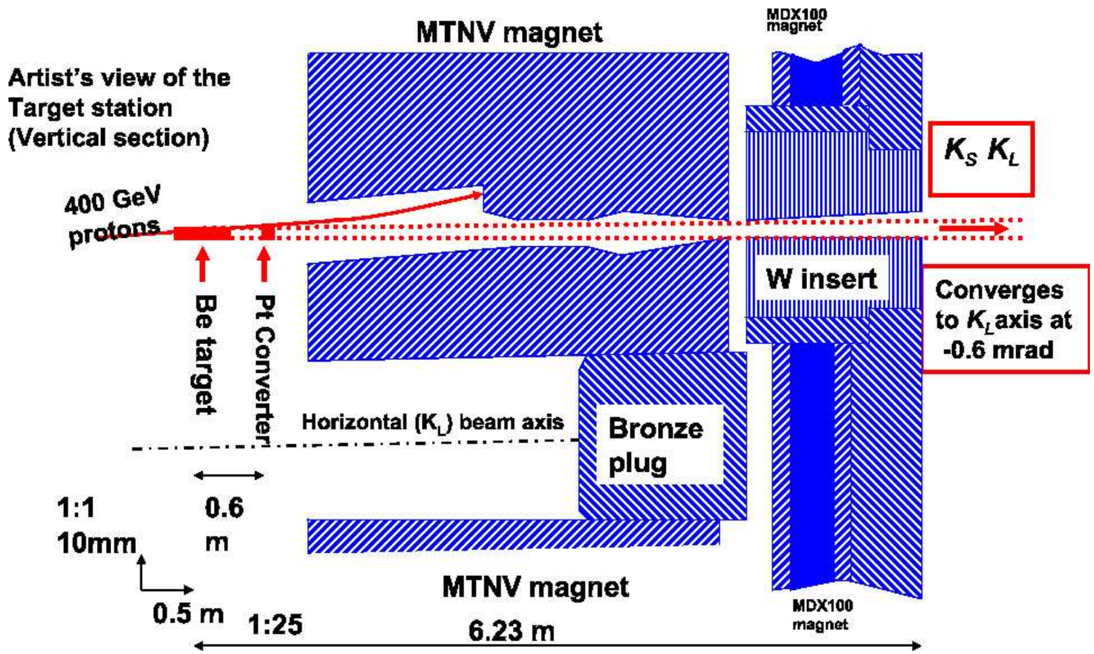


Data taking periods



The NA48 beam

DETAIL OF THE K_S TARGET STATION (2002 conf.)



SPS proton momentum	400 GeV/c
Duty Cycle	4.8 s/16.8 s
Protons per pulse on target	$\sim 5 \cdot 10^{10}$
Production angle	-4.2 $mRad$ Polarized hyperons!

Ξ^0 decays: summary

The K_S target is also a source of hyperons

We essentially study Ξ^0 decays:

- $\Xi^0 \to \Sigma^+ e^- \overline{\nu}_e$, $\Sigma^+ \to p\pi^0$ (BR, Form factors)
- $\Xi^0 \to \Sigma^+ \mu^- \overline{\nu}_\mu$, $\Sigma^+ \to p\pi^0$ (BR)

- $\Xi^0 \to \Lambda\pi^0$, $\Lambda \to p\pi^-$ (Asymmetry, Ξ^0 mass, Ξ^0 lifetime)
- $\Xi^0 \to \Lambda\gamma$, $\Lambda \to p\pi^-$(Asymmetry, BR)
- $\Xi^0 \to \Sigma^0\gamma$,$\Sigma^0 \to \Lambda\gamma$, $\Lambda \to p\pi^-$(Asymmetry, BR)

- $\Xi^0 \to \Lambda e^+ e^-$, $\Lambda \to p\pi^-$ (Search, BR)

- $\Xi^0 \to p\pi^-$ (ΔS=2) (Search)

The Ξ^0 nonleptonic decay

For the measurement of lifetime and fluxes we use the nonleptonic Ξ^0 decay:

$$\Xi^0 \to \Lambda\pi^0 \qquad (\overline{\Xi^0} \to \overline{\Lambda}\pi^0)$$

$BR = 99.522 \pm 0.032$

$\Rightarrow$ High statistics

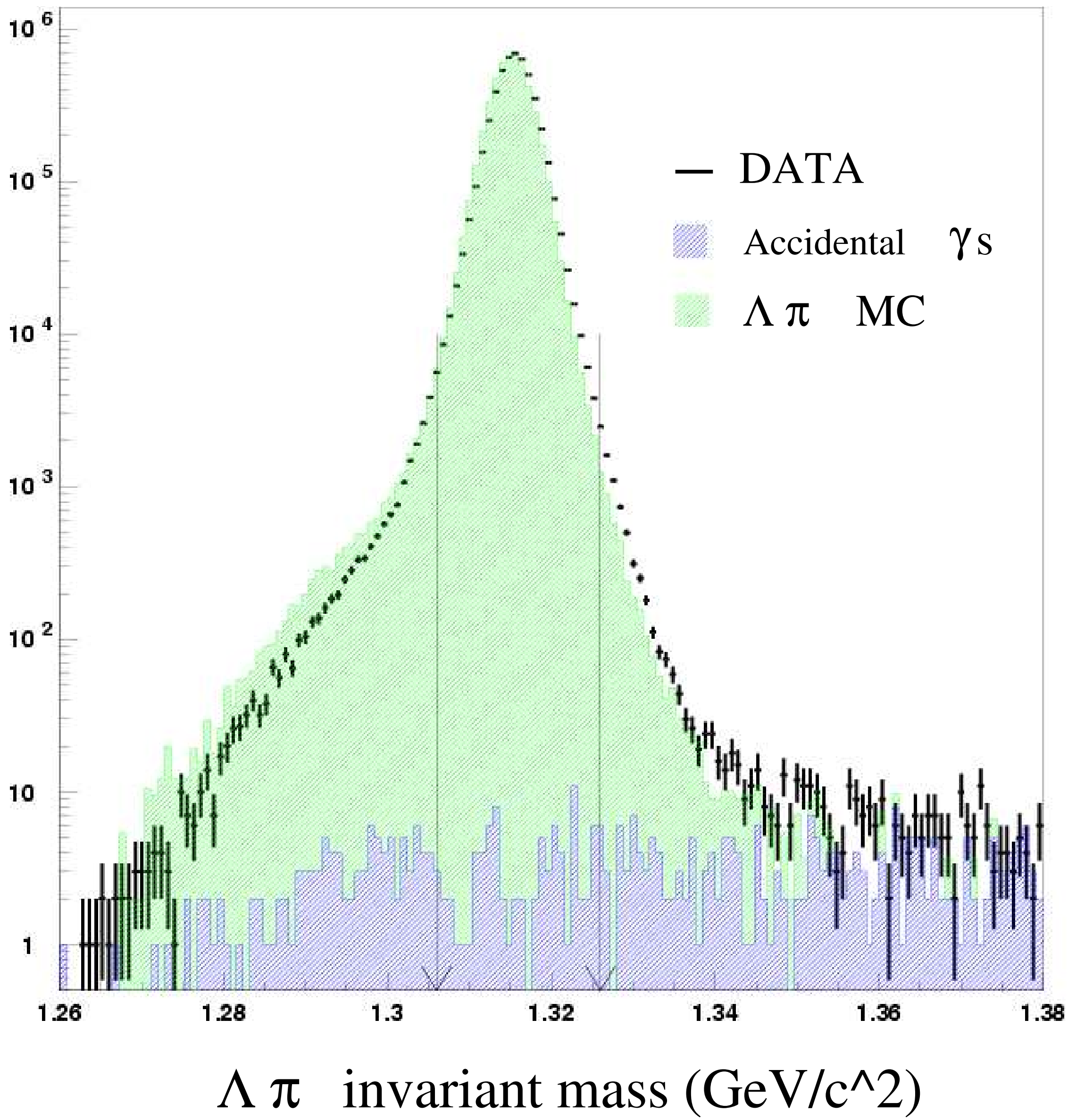
Strong signature coming from the possibility to reconstruct both the Ξ^0 and the Λ mass

$\Rightarrow$ The background is negligible

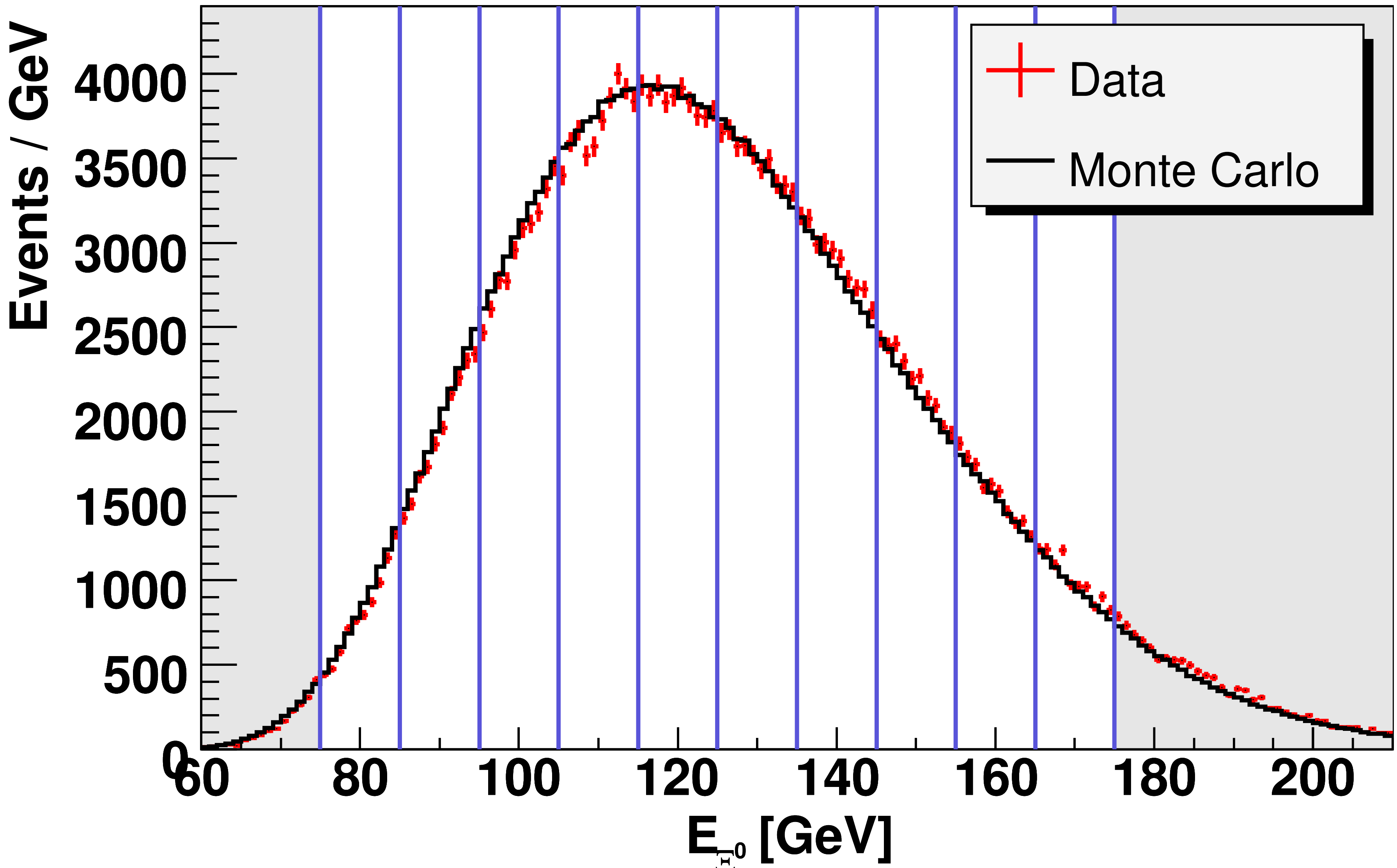
To reduce the bias coming from trigger inefficiencies we only consider events acquired directly after LV1 (DOWNSCALING=35)

LV1 efficiency=$(99.56 \pm 0.02)\%$

$\Xi^0 \rightarrow \Lambda\pi^0$

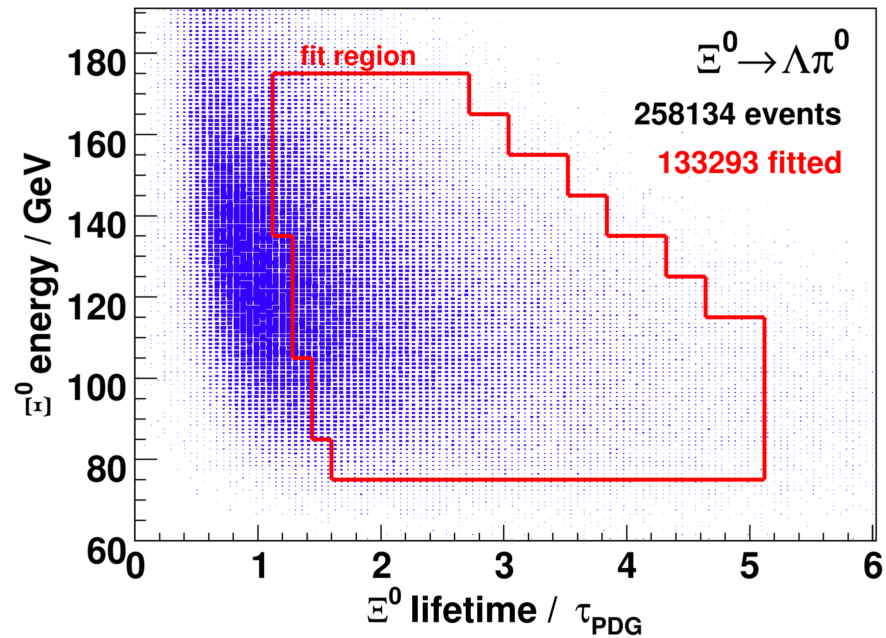


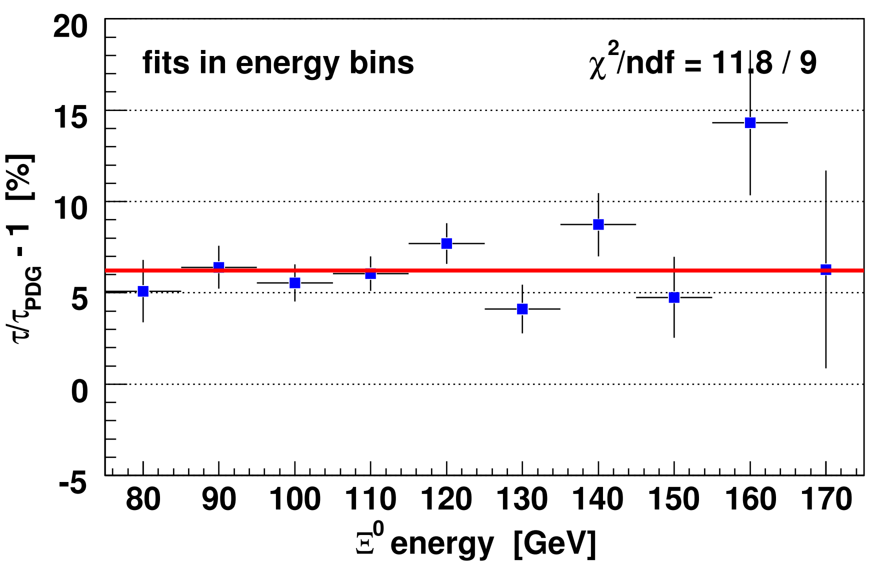
Ξ^0 spectrum



Measurement of the Ξ^0 lifetime

Lifetime is measured for Ξ^0 decaying well outside the final collimator





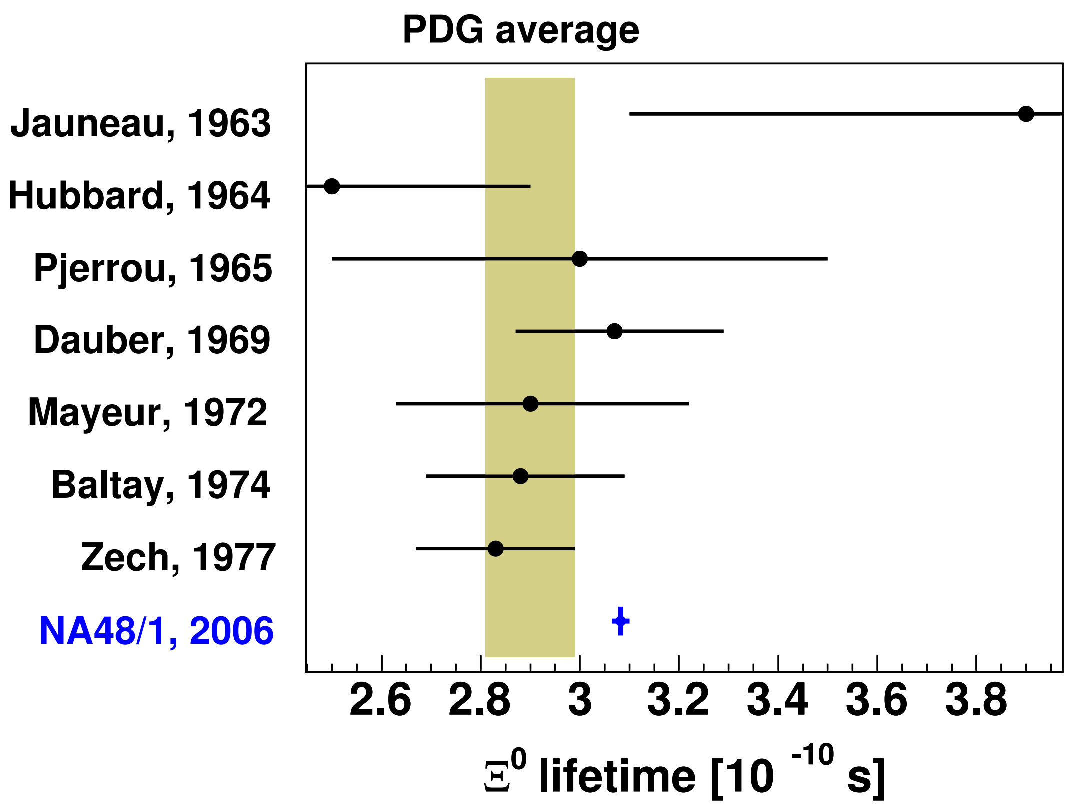
10 different fits depending from Ξ^0 energy

Ξ^0 lifetime, cont.

Source	$\delta_{\rm syst}/\tau$ (%)
Detector acceptance	± 0.30
Vertex resolution	± 0.08
Energy scale	± 0.14
Energy non-linearities	± 0.09
Ξ^0 polarization	± 0.15
Ξ^0 mass	± 0.20
Λ lifetime	± 0.04
Total systematics	± 0.43
Statistical uncertainty	± 0.44

Ξ^0 lifetime, cont.

$$\tau_{\mathrm{PDG}}^{\Xi^0} = (2.90 \pm 0.09) \times 10^{-10}\ \mathrm{s}$$



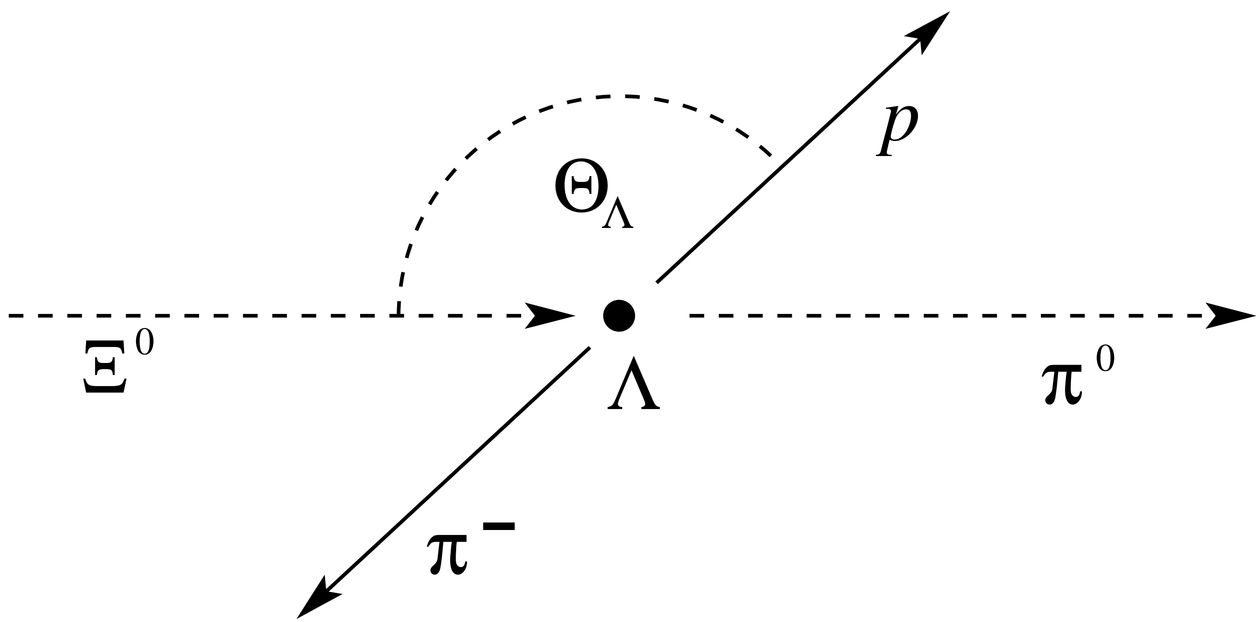
$$\tau_{\mathrm{PDG}}^{\Xi^0} / \tau_{\mathrm{NA48}}^{\Xi^0} = 1.0626 \pm 0.0044_{\mathrm{stat}} \pm 0.0043_{\mathrm{syst}}$$

$$\tau_{\mathrm{NA48}}^{\Xi^0} = 3.082 \pm 0.013_{\mathrm{stat}} \pm 0.0012_{\mathrm{syst}} \times 10^{-10}\ \mathrm{s}$$

Decay asymmetry for $\Xi^0 \to \Lambda\pi^0$

We test the method to measure the decay asymmetry in the decay $\Xi^0 \to \Lambda\pi^0$

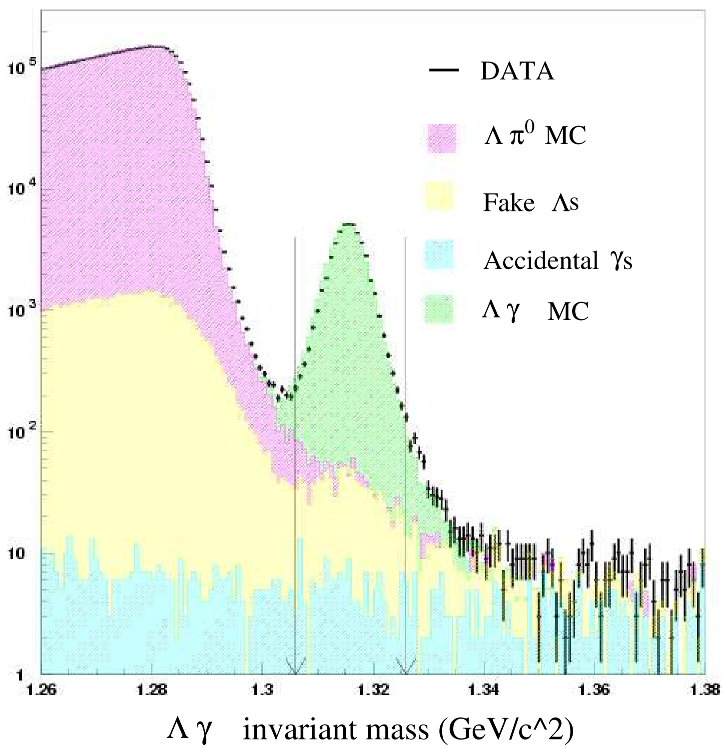
$$\frac{dN}{d(cos\Theta_\Lambda)} = N_0(1 + \alpha_{(\Xi^0\to\Lambda\pi^0)}\alpha_{(\Lambda\to p\pi^-)}cos\Theta_\Lambda)$$

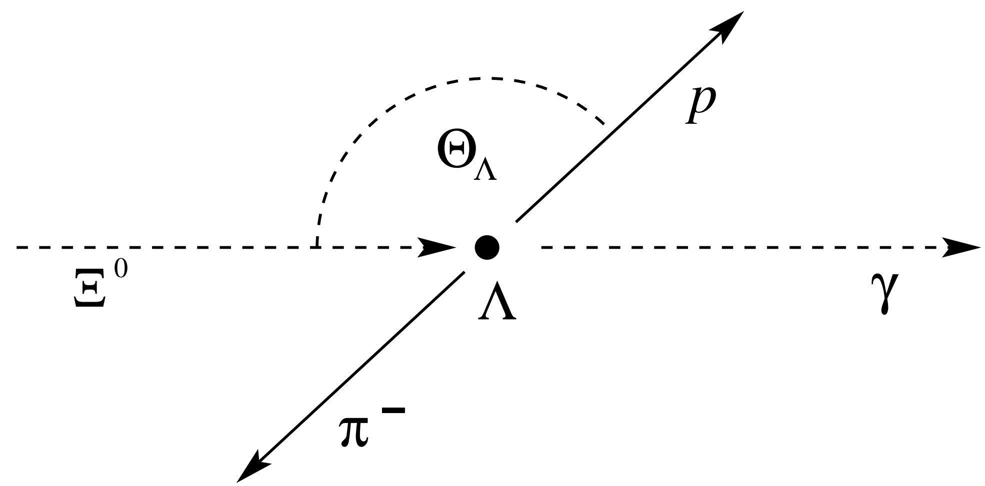


$$\alpha_{(\Xi^0\to\Lambda\pi^0)}\alpha_{(\Lambda\to p\pi^-)} = -0.282 \pm 0.003_{\text{stat}} \pm 0.028_{\text{syst}}$$

PDG: $\alpha_{(\Xi^0\to\Lambda\pi^0)}\alpha_{(\Lambda\to p\pi^-)} = -0.264 \pm 0.013$

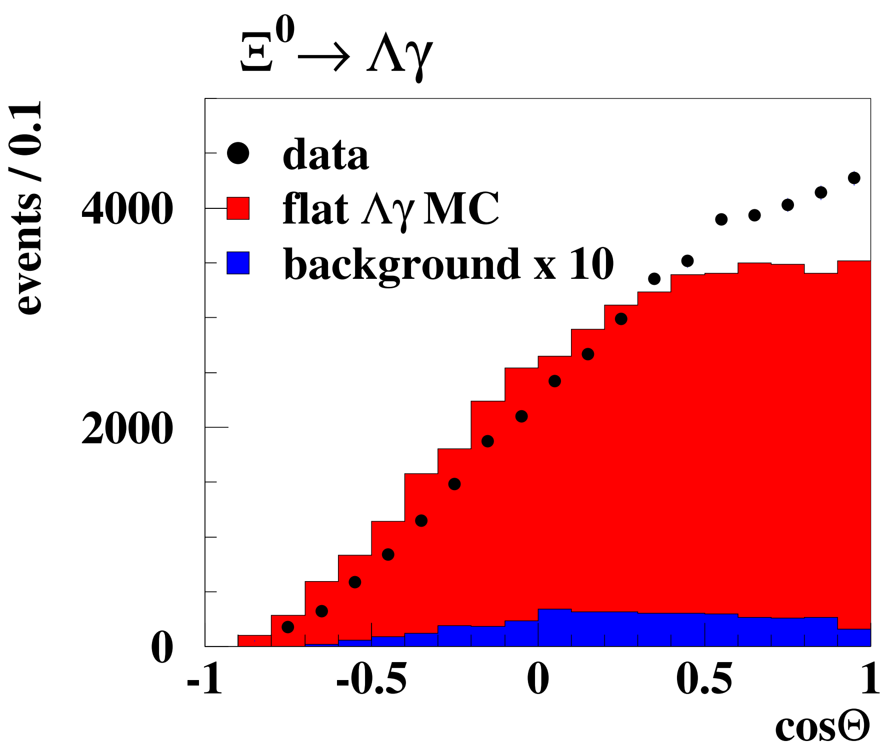
$\Xi^0 \to \Lambda\gamma$ decay asymmetry

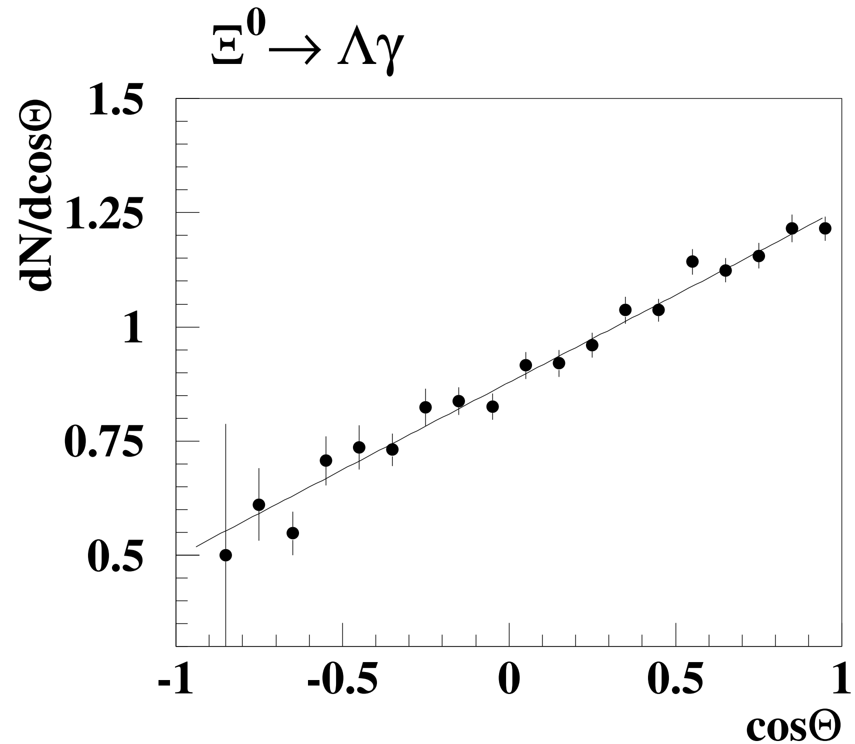




$$\frac{dN}{d(cos\Theta_\Lambda)} = N_0(1 + \alpha_{(\Xi^0\to\Lambda\gamma)}\alpha_{(\Lambda\to p\pi^-)}cos\Theta_\Lambda)$$

$\Xi^0 \rightarrow \Lambda\gamma$ decay asymmetry, cont.

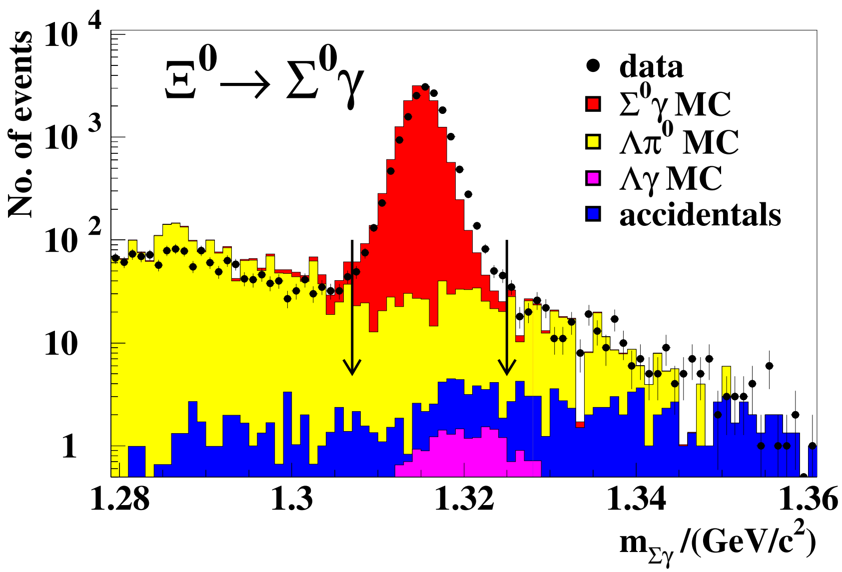




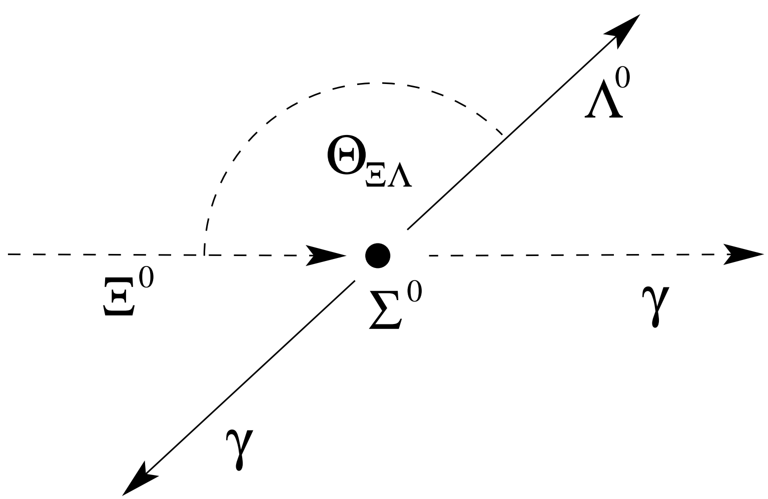
$$\alpha_{(\Xi^0\rightarrow\Lambda\gamma)}\alpha_{(\Lambda\rightarrow p\pi^-)} = -0.439 \pm 0.013_{\mathrm{stat}} \pm 0.038_{\mathrm{syst}}$$

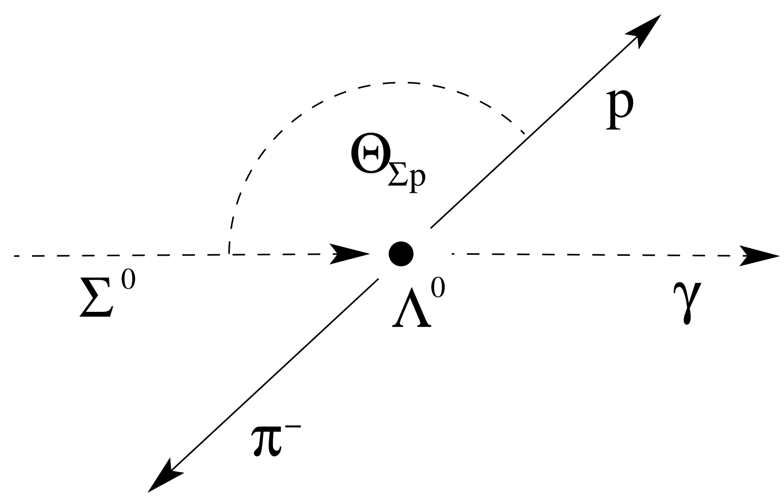
NA48 (1999): $\alpha_{(\Xi^0\rightarrow\Lambda\gamma)}\alpha_{(\Lambda\rightarrow p\pi^-)} = -0.50 \pm 0.13$

$\Xi^0 \rightarrow \Sigma^0\gamma$ decay asymmetry

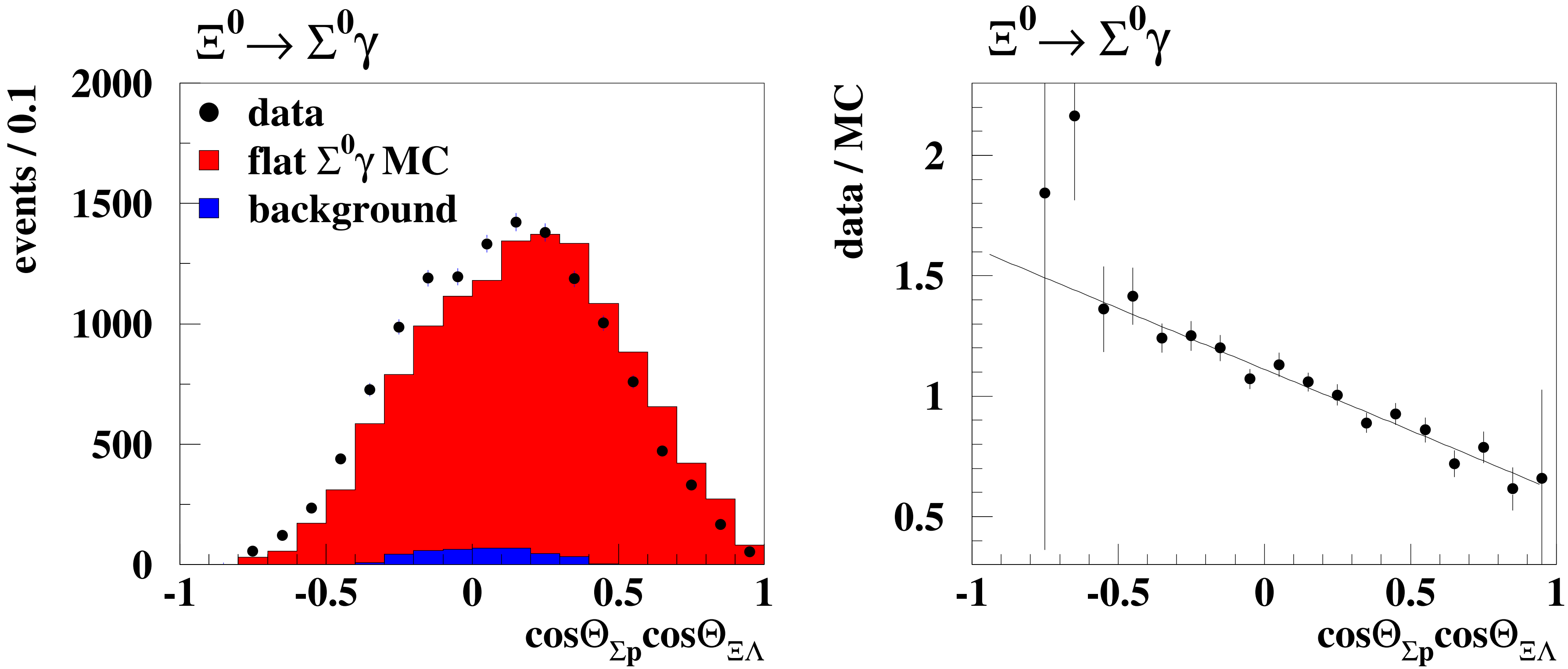


$$\frac{d^2N}{d(cos\Theta_{\Xi^0\Lambda})d(cos\Theta_{\Sigma^0 p})} = N_0(1 + \alpha_{(\Xi^0\rightarrow\Sigma^0\gamma)}\alpha_{(\Lambda\rightarrow p\pi^-)} \times \times cos(\Theta_{\Xi^0\Lambda})cos(\Theta_{\Sigma^0 p})$$





$\Xi^0 \to \Lambda\gamma$ decay asymmetry, cont.



$$\alpha_{(\Xi^0\to\Sigma^0\gamma)}\alpha_{(\Lambda\to p\pi^-)} = -0.438 \pm 0.020_{\mathrm{stat}} \pm 0.041_{\mathrm{syst}}$$

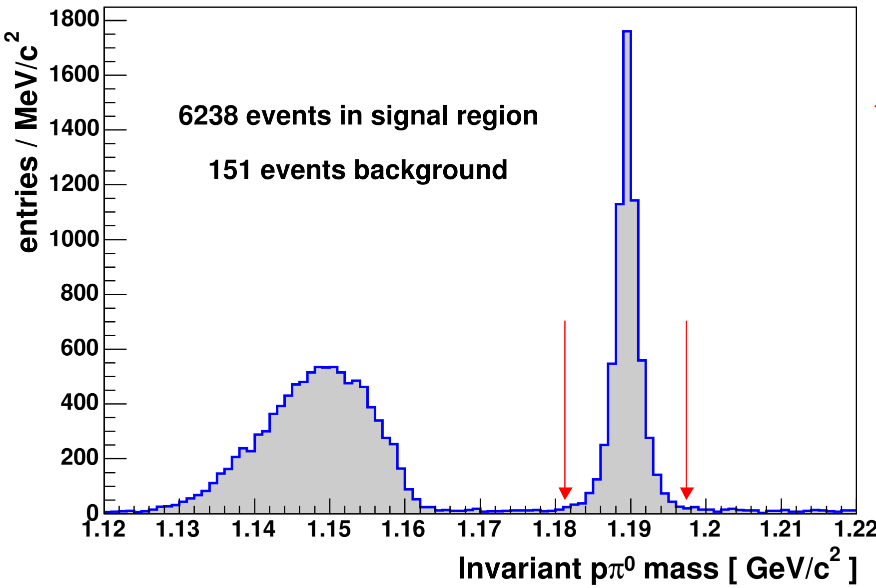
KTeV: $\alpha_{(\Xi^0\to\Sigma^0\gamma)} = -0.63 \pm 0.09$

$$\Rightarrow \alpha_{(\Xi^0\to\Sigma^0\gamma)}\alpha_{(\Lambda\to p\pi^-)} = -0.40 \pm 0.06$$

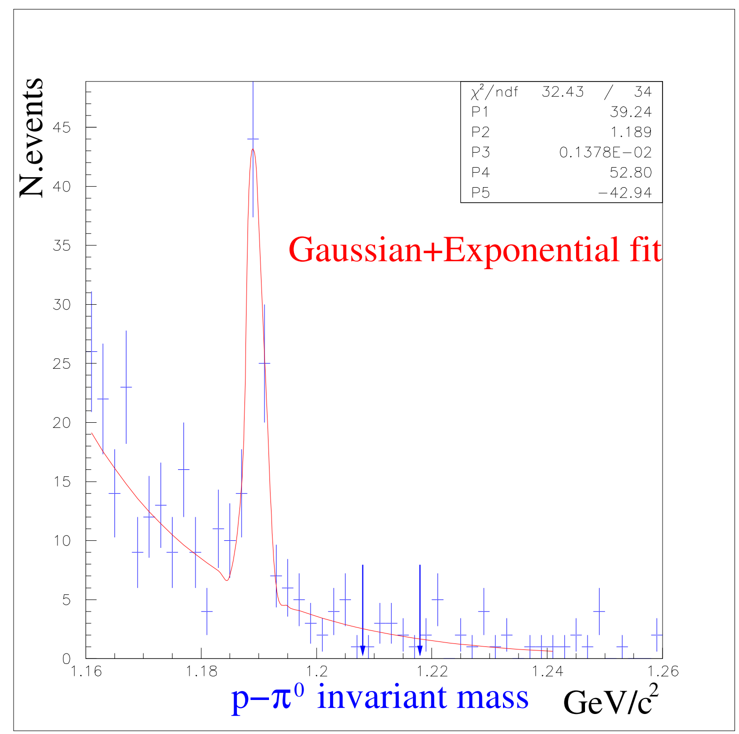
Summary of systematics

Source	$\Xi^0 \to \Lambda\pi^0$	$\Xi^0 \to \Lambda\gamma$	$\Xi^0 \to \Sigma^0\gamma$
Trigger efficiency	± 0.001	± 0.016	± 0.024
Ξ^0 polarization	± 0.002	-	-
Min. radius at DCH1	± 0.010	± 0.015	± 0.010
Cluster-track min. dist.	± 0.003	± 0.007	± 0.007
Min. z vertex	± 0.003	± 0.010	± 0.015
Min. γ energy	± 0.004	± 0.008	± 0.007
Ξ^0 energy	± 0.025	± 0.025	± 0.025
Ξ^0 mass	± 0.004	± 0.010	± 0.002
$\tau(\Xi^0)$ on MC	± 0.003	± 0.001	± 0.007
$\Xi^0)$ mass on MC	± 0.002	± 0.004	± 0.003
Total systematics	± 0.028	± 0.038	± 0.041
Statistical uncertainty	± 0.002	± 0.013	± 0.020

Ξ^0 semileptonic decays



$$BR(\Xi^0 \to \Sigma^+ e^- \overline{\nu_e}) =$$
$$(2.51 \pm 0.03_{\text{stat}} \pm 0.11_{\text{syst}}) \times 10^{-4}$$



$$BR(\Xi^0 \to \Sigma^+ \mu^- \overline{\nu}_\mu) =$$
$$(2.2 \pm 0.3_{\text{stat}} \pm 0.2_{\text{syst}}) \times 10^{-6}$$

Conclusions

Four new and preliminary results have been presented:

$\tau^{\Xi^0}_{\mathrm{NA48}} = 3.082 \pm 0.013_{\mathrm{stat}} \pm 0.0012_{\mathrm{syst}} \times 10^{-10}$ s

$\alpha_{(\Xi^0 \to \Lambda\pi^0)}\alpha_{(\Lambda \to p\pi^-)} = -0.282 \pm 0.003_{\mathrm{stat}} \pm 0.028_{\mathrm{syst}}$

$\alpha_{(\Xi^0 \to \Lambda\gamma)}\alpha_{(\Lambda \to p\pi^-)} = -0.439 \pm 0.013_{\mathrm{stat}} \pm 0.038_{\mathrm{syst}}$

$\alpha_{(\Xi^0 \to \Sigma^0\gamma)}\alpha_{(\Lambda \to p\pi^-)} = -0.438 \pm 0.020_{\mathrm{stat}} \pm 0.041_{\mathrm{syst}}$