Radiative Hyperon Decays an Overview

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Short Introduction

Hara 1964: Asymmetries in radiative decays of Σ^+ and Ξ^- vanish in the SU(3) limit. *But* …

- First measurements for $\Sigma^+ \rightarrow p\gamma$ coming from bubble chambers
  - BR(Σ^+ -> p γ)=(1.91 $\pm$ 0.4) x 10^{-3}
  - And: first evidence for large negative asymmetry
  - $\alpha_\gamma = -1.03\ ^{+0.54}_{-0.42}$

- Most precise measurement so far: E761 at Fermilab (1994):
  - High statistics (~ 30000 events)
  - negative asymmetry
  - BR(Σ^+ -> p γ) = (2.32 $\pm$ 0.11 $\pm$ 0.10) x 10^{-3}
  - $\alpha_\gamma = -0.72 \pm 0.086 \pm 0.045$

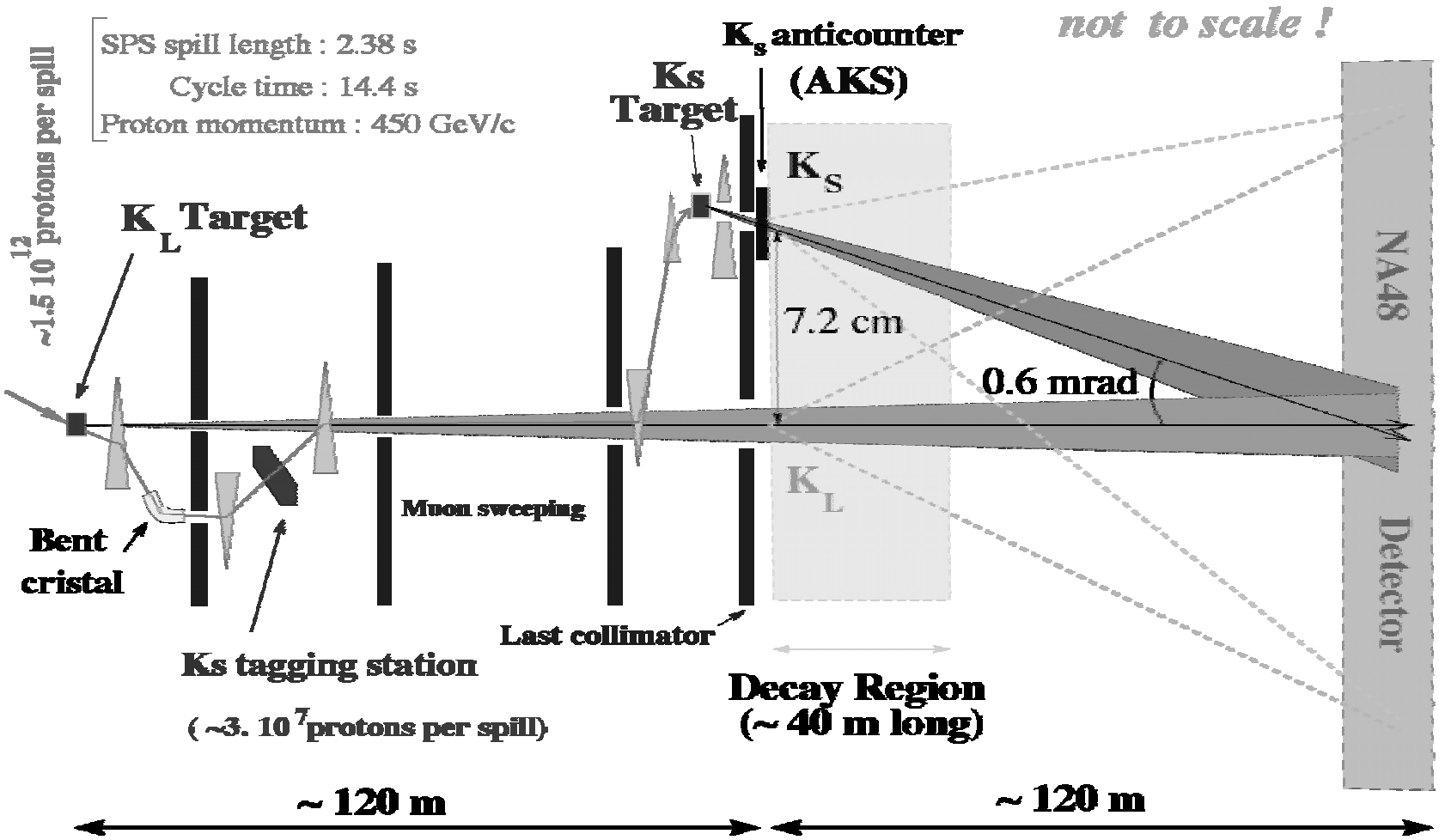
Experimental Results till 1998

No. of events	Branching ratio (10^{-3})	Asymmetry parameter	Laboratory	Reference, Year
		$\Sigma^+ \to p\gamma$		
24	1.91 ± 0.41		BNL	Bazin [7] (1965)
31(61)	1.42 ± 0.26	$-1.03^{+0.54}_{-0.42}$	Berkeley	Gershwin [2] (1969)
45	1.08 ± 0.15		CERN	Ang [6] (1969)
30(46)	1.09 ± 0.20	$-0.53^{+0.38}_{-0.36}$	CERN	Manz [3] (1980)
155	$1.27^{+0.15}_{-0.18}$		CERN	Biagi [9] (1985)
190	1.30 ± 0.15	$-0.86 \pm 0.13 \pm 0.04$	KEK	Kobayashi [4] (1987)
408	$1.45 \pm 0.20^{+0.11}_{-0.22}$		BNL	Hessey [8] (1989)
(34754)		$-0.720 \pm 0.086 \pm 0.045$	Fermilab	Foucher[a] [13] (1992)
31901	$1.20 \pm 0.06 \pm 0.05$		Fermilab	This result[a]
		$\Xi^- \to \Sigma^-\gamma$		
11	0.23 ± 0.10		CERN	Biagi [14] (1987)
211	$0.122 \pm 0.023 \pm 0.006$	1.0 ± 1.3	Fermilab	Dubbs[a] [11] (1994)
		$\Xi^0 \to \Sigma^0\gamma$		
85	$3.56 \pm 0.42 \pm 0.10$	$0.20 \pm 0.32 \pm 0.05$	Fermilab	Teige [15] (1989)
		$\Xi^0 \to \Lambda\gamma$		
116(87)	$1.06 \pm 0.12 \pm 0.11$	0.43 ± 0.44	Fermilab	James [16] (1990)
		$\Lambda \to n\gamma$		
24	1.02 ± 0.33		CERN	Biagi [17] (1986)
287	$1.78 \pm 0.24 \pm 0.15$		BNL	Noble [18] (1992)
1816	1.75 ± 0.15		BNL	Larson [19] (1993)
		$\Omega^- \to \Xi^-\gamma$ Limits at 90% C.L.		
	<2.2		CERN	Bourquin [20] (1984)
	<0.46		Fermilab	Albuquerque[a] [12] (1994)

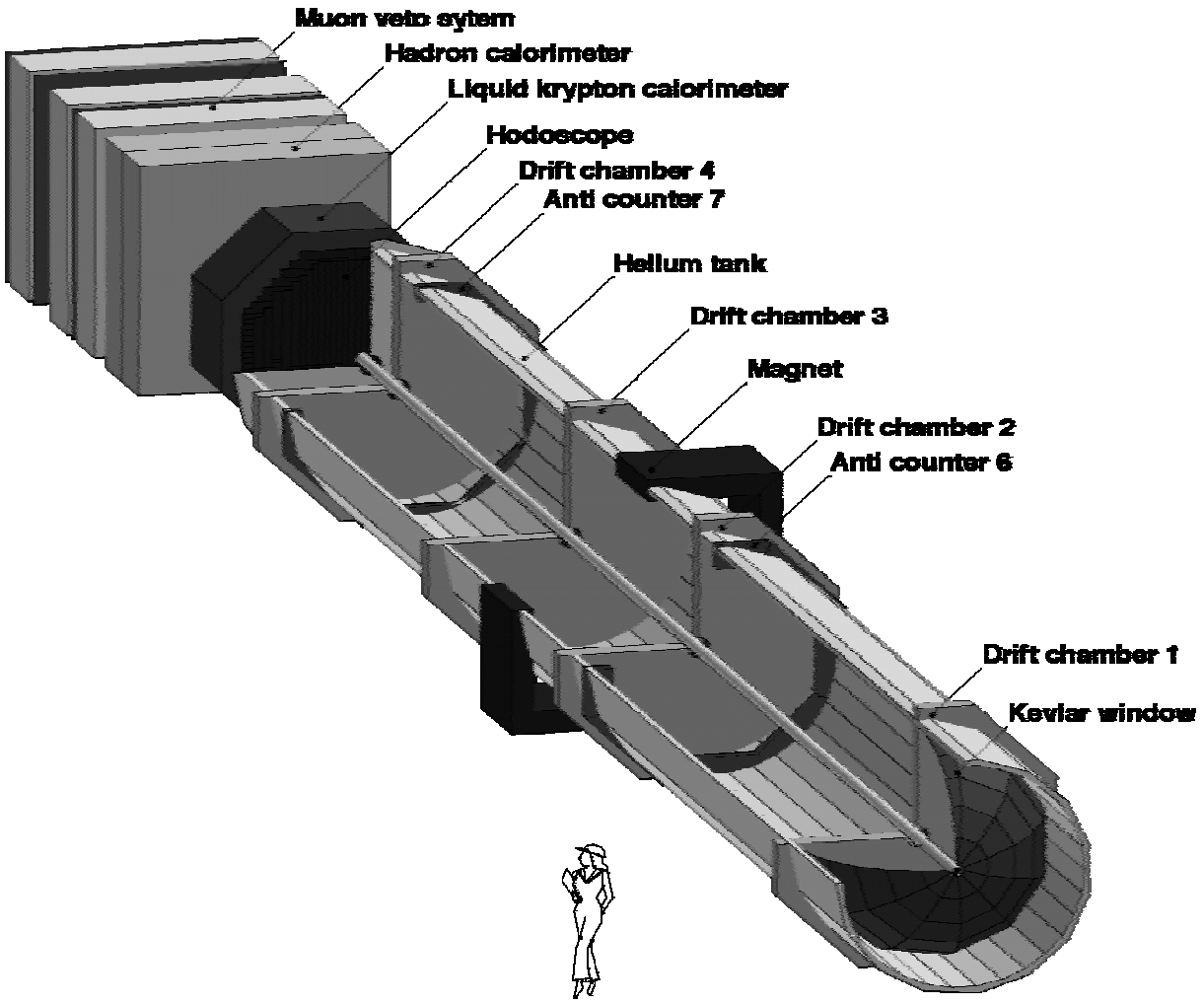
NA48 - Experiment

- main goal: measurement of $Re(\varepsilon`/\varepsilon)$
- 2 collinear beams for K_S and K_L Mesons
- Lifetimes for K_S Meson and Hyperons in same range ($\sim 10^{-10}$s)
- => Hyperons from Ks Target
- Spectrometer, excellent mass and vertex resolution
- Liquid Krypton calorimeter with excellent energy resolution

NA48 - The Beam Lines

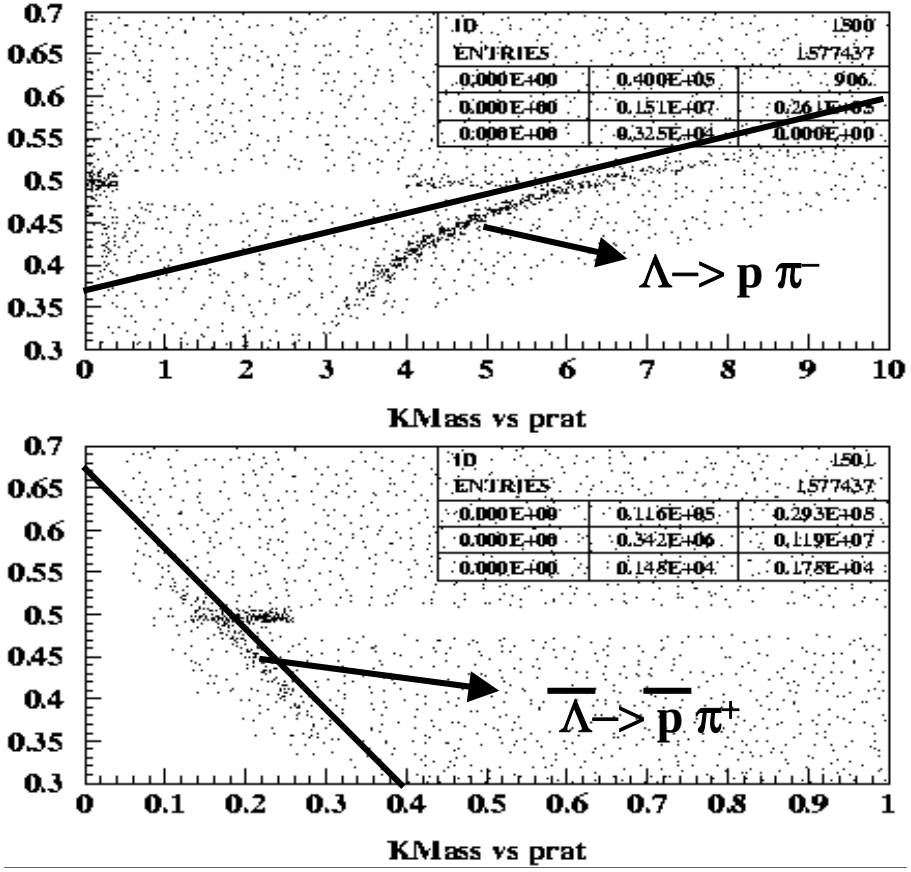


NA48 - The Detector



NA48 - Hyperon Selection

- Select Λ by 2 dim cut in p(+)/p(-) vs. $m_{\pi\pi}$ plane
- 1.113 GeV < m(p π) <1.118 GeV
- free clusters (not related to a track)
- Analysed decay modes: $\Xi^- \to \Lambda\pi^0$, $\Xi^- \to \Lambda\gamma$, $\Xi^- \to \Sigma^0\gamma$



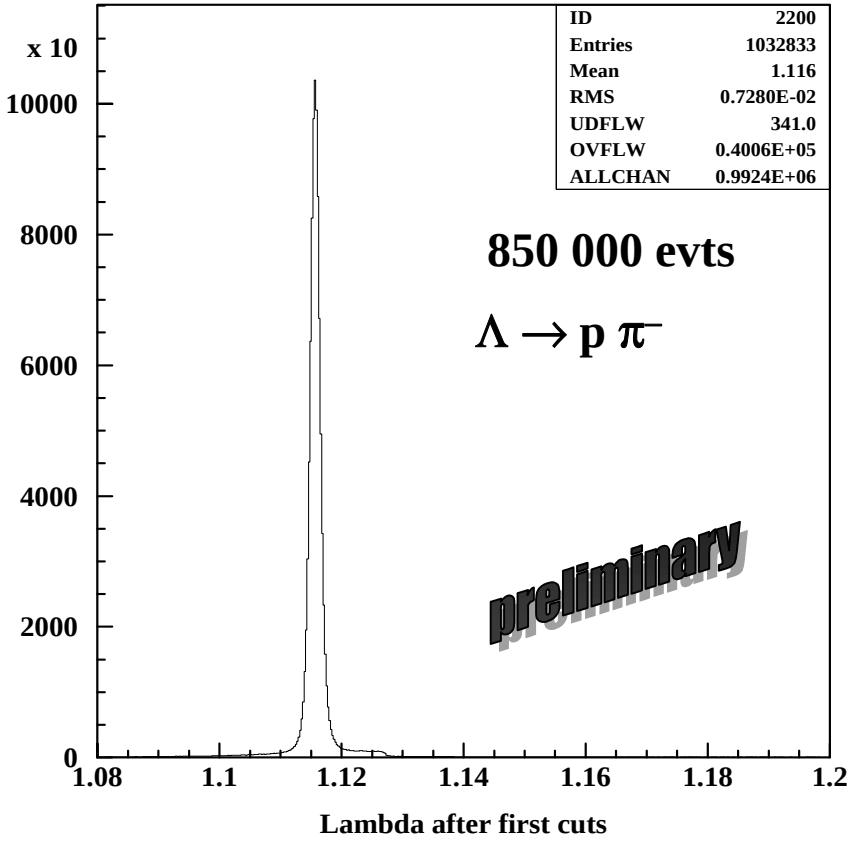
NA48 - Results from 1997 Data

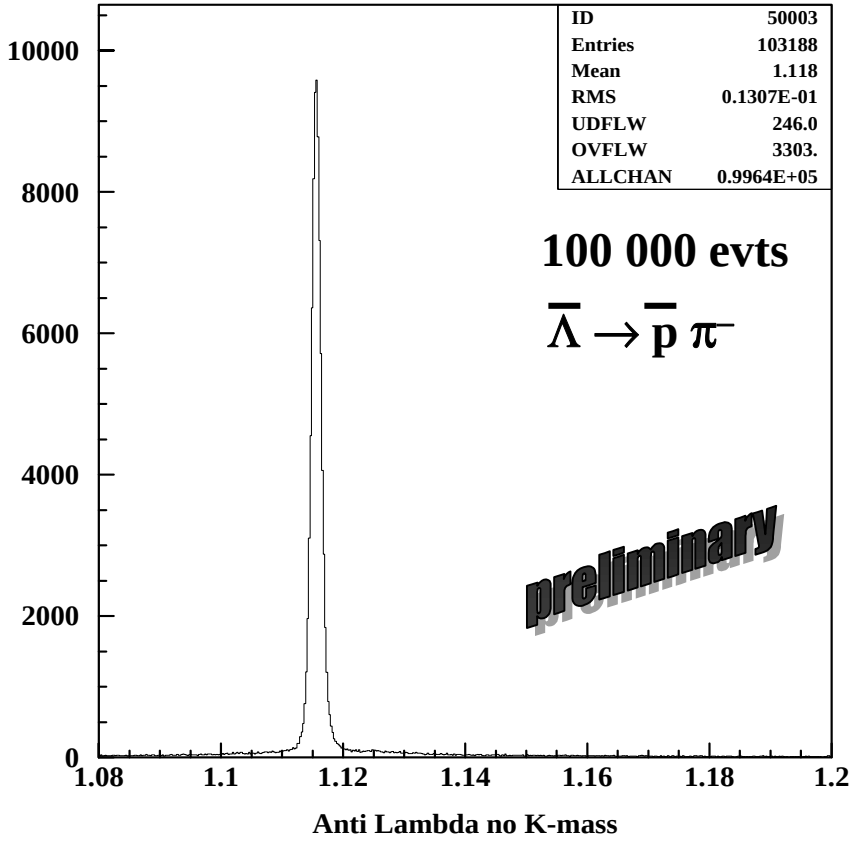
- **Significant improvement for M_{Ξ} from decay $\Xi \rightarrow \Lambda\pi^0$: $M_{\Xi} = (1314.82 \pm 0.06 \pm 0.2)$MeV**
- **BR($\Xi^0 \rightarrow \Lambda\gamma$) = $(1.90 \pm 0.34 \pm 0.19) \times 10^{-3}$ (31 events)**
- **BR($\Xi^0 \rightarrow \Sigma^0\gamma$) = $(3.14 \pm 0.76 \pm 0.32) \times 10^{-3}$ (17 events)**
- **Total statistics for 1997, 1998 and 1999: ~10 times more.**

NA48 - High Intensity K_S (K_S Test 1999)

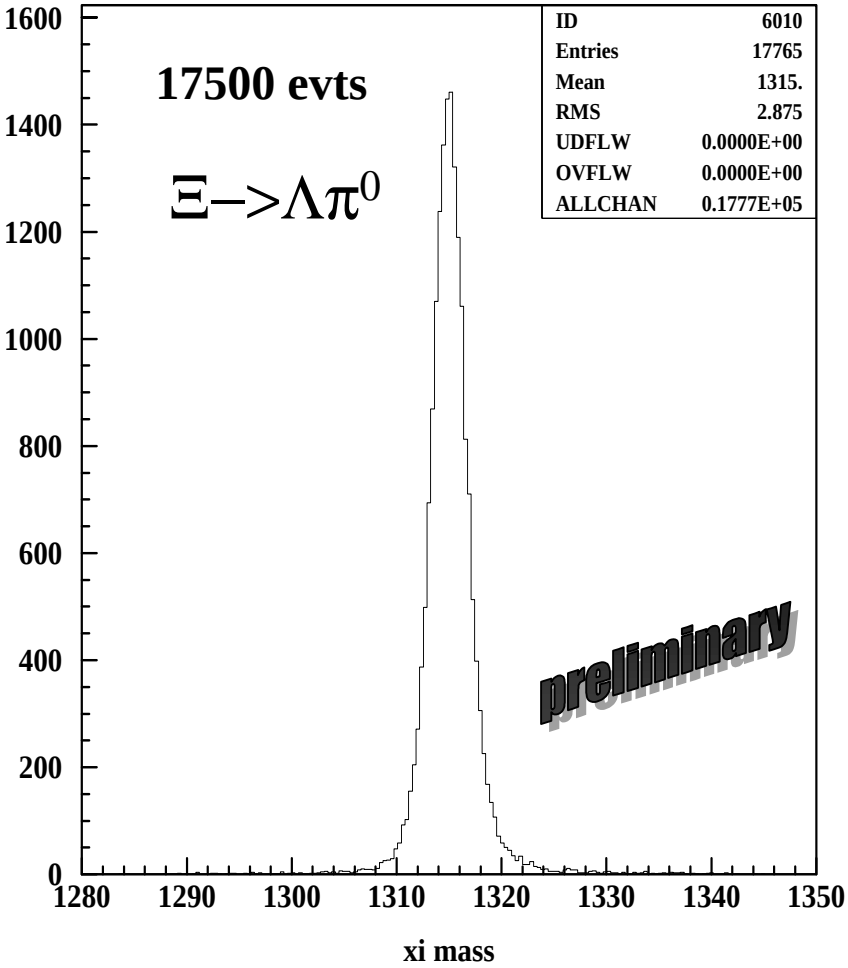
- First 8 hours test this year in August
- Beam intensity: 4 x 10^9 protons / pulse (200 x ε´ data taking)
- Trigger downscaling by a factor of 10
- 20 - 30 days run foreseen next year

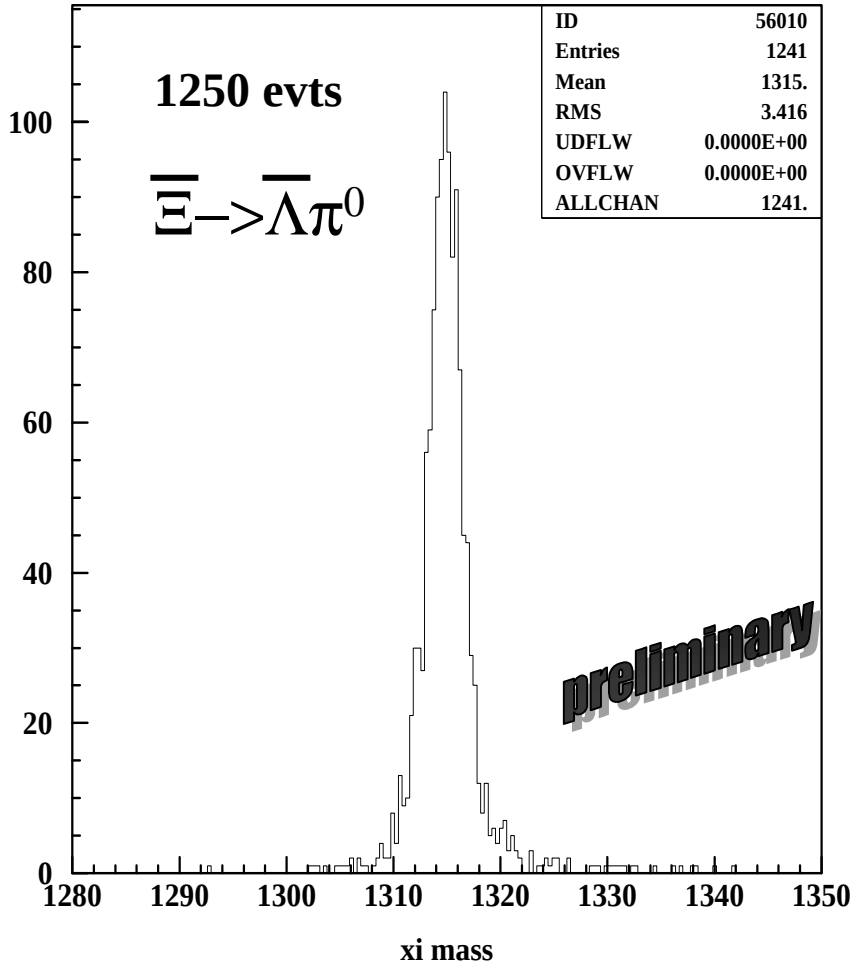
Λ and $\overline{\Lambda}$ (High Intensity K_S Test 1999)



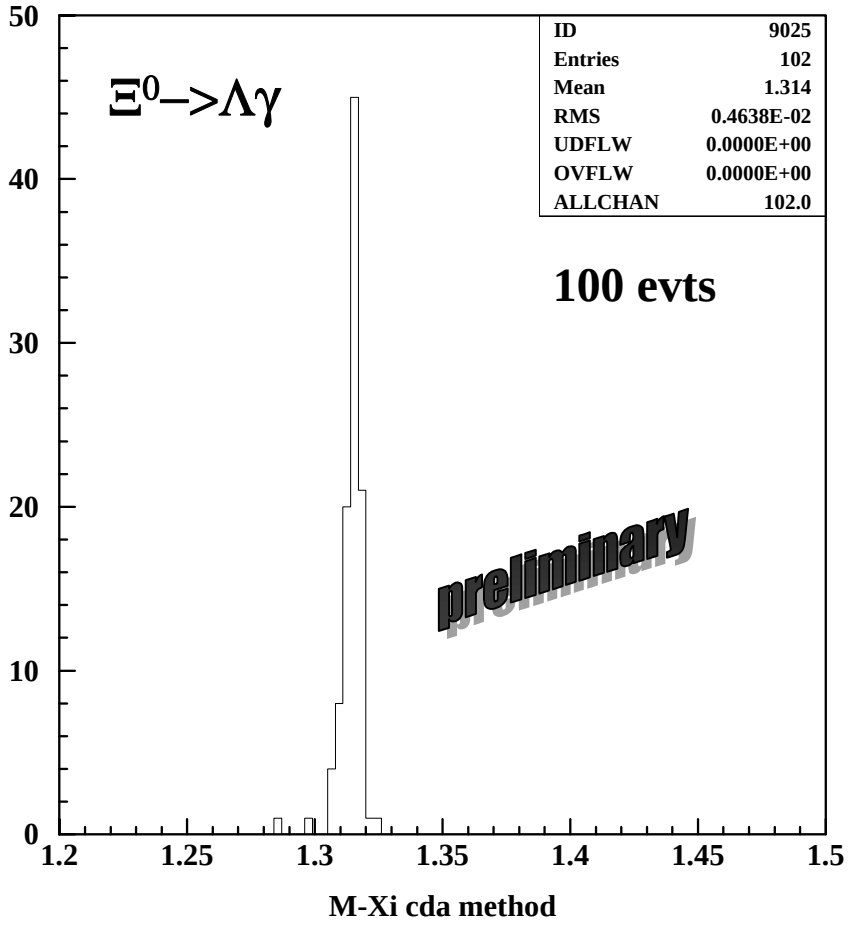


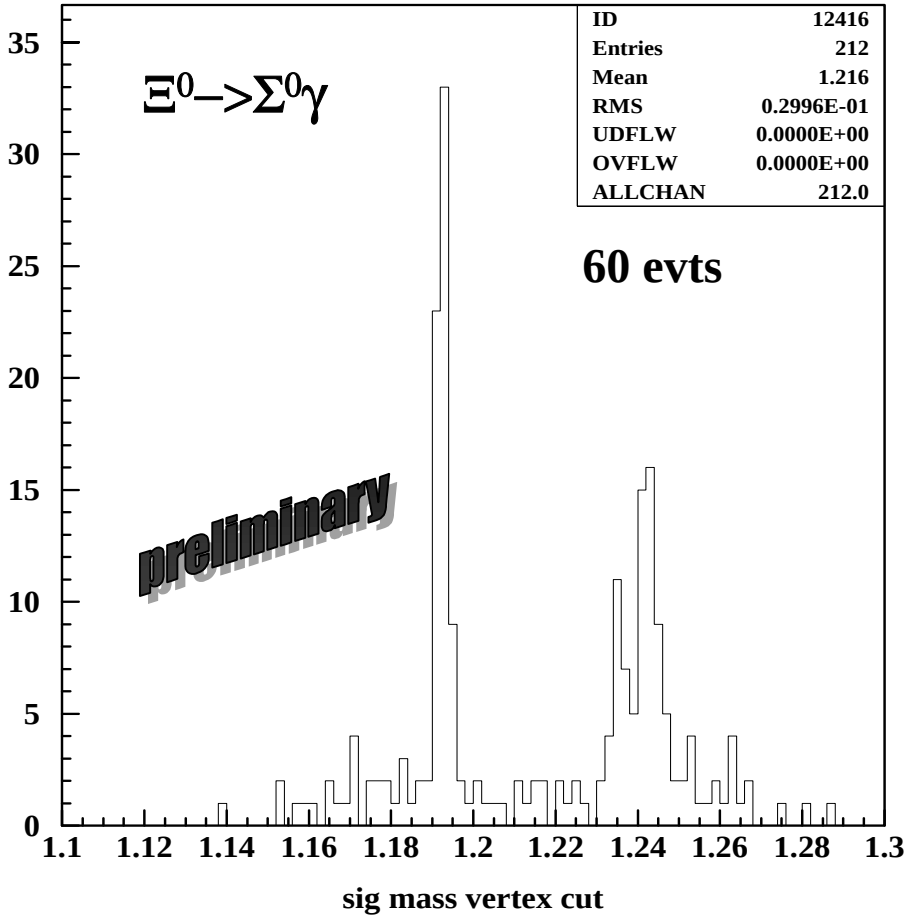
$\Xi^- \to \Lambda\pi^0$ and $\overline{\Xi}^+ \to \overline{\Lambda}\pi^0$ decays (High Intensity K_S Test 1999)





Radiative Ξ decays (High Intensity K_S Test 1999)





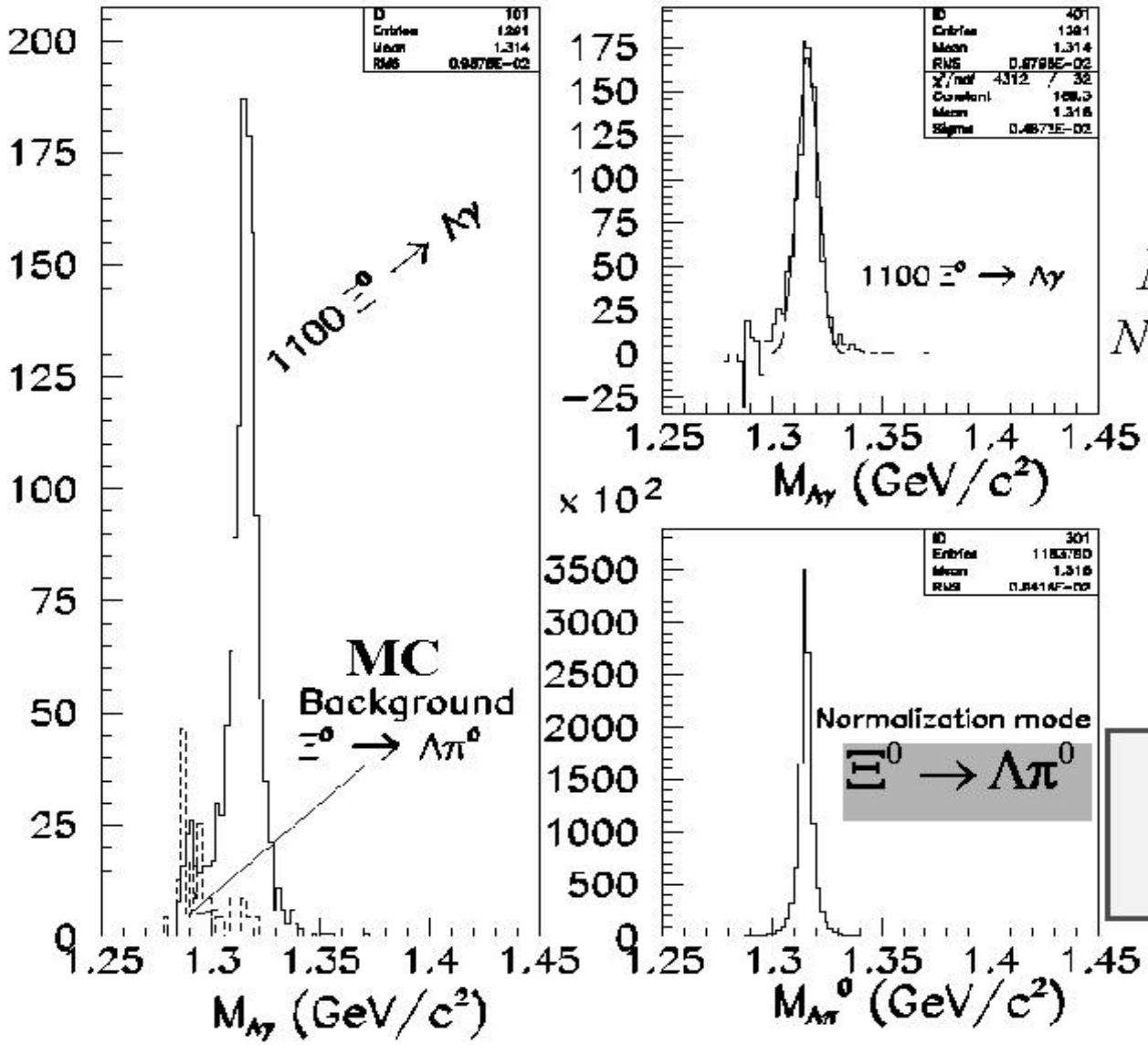
NA48 - High Intensity K_S Run

	measured rates 1999		expected rates 2000		
	8 hours, downscaling 10		24 hours downscaling 1		30 days
Decay modes	total	burst	total	burst	total
$\Lambda \rightarrow p\,\pi$	8,50E+05	425,00	2,13E+07	4250,00	6,38E+08
$\bar{\Lambda} \rightarrow \bar{p}\,\pi^+$	1,00E+05	50,00	2,50E+06	500,00	7,50E+07
$\Xi \rightarrow \Lambda\pi^0$	1,70E+04	8,50	4,25E+05	85,00	1,28E+07
$\Xi \rightarrow \Lambda\gamma$	1,00E+02	0,05	2,50E+03	0,50	7,50E+04
$\Xi \rightarrow \Sigma\gamma$	6,00E+01	0,03	1,50E+03	0,30	4,50E+04
$\bar{\Xi} \rightarrow \bar{\Lambda}\,\pi^0$	1,20E+03	0,60	3,00E+04	6,00	9,00E+05

KTeV - Expeted Results from 1997 Data

- **Measurement of Branching Ratio for $\Xi \rightarrow \Lambda\gamma$ (~1000 evts)**
- **Measurement of Branching Ratio for $\Xi \rightarrow \Sigma^0\gamma$ (~5000 evts)**
- **Measurement of Asymmetry for $\Xi \rightarrow \Sigma^0\gamma$ (~5000 evts)**
- **Measurement of Decay mode $\Lambda \rightarrow p\ \pi^-\ \gamma$**
- **Σ^0 physics from $\Xi \rightarrow \Sigma^0\gamma$**

BR calculation of $\Xi^0 \longrightarrow \Lambda\gamma$



Winter'97 data

$$\frac{\alpha cc(\Lambda\gamma)}{\alpha cc(\Lambda\pi^0)} = 1.04$$

$$N(\Lambda\gamma) = 1{,}100 \pm 33 \text{ evts}$$

$$N(\Lambda\pi^0) = 1{,}130{,}000 \pm 1063 \text{evts}$$

Preliminary

$$\frac{BR(\Lambda\gamma)}{BR(\Lambda\pi^o)} = (0.94 \pm 0.04)\text{(stat)}\text{x}10^{-3}$$

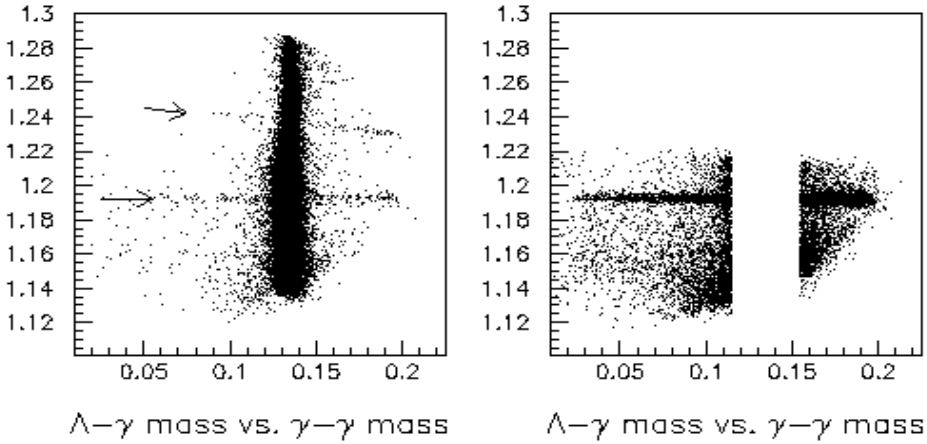
$$BR_{PDG} = [1.06 \pm 0.16]\text{x}10^{-3}$$

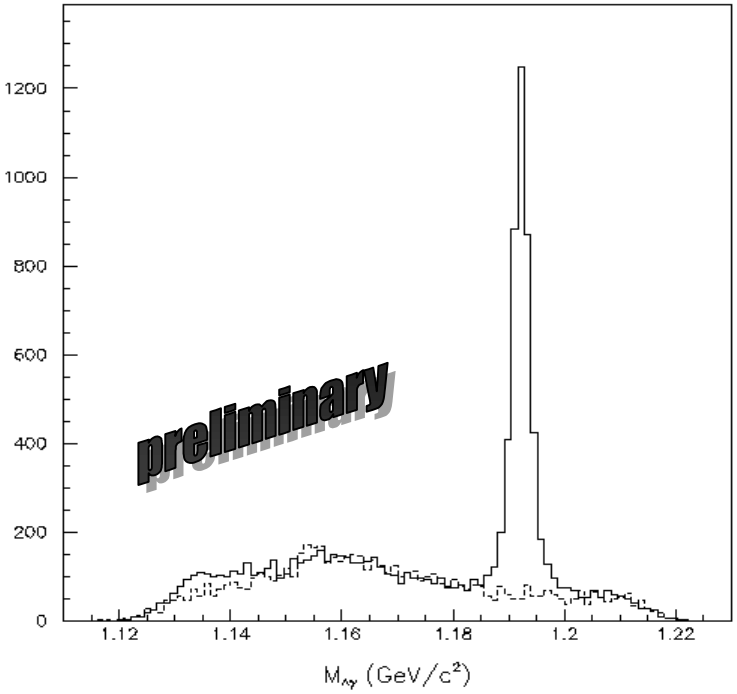
KTeV - BR(

Same final state as the decay mode
$\Xi \rightarrow \Lambda \pi^0$ (99.95 %)

can be distinguished by $\Lambda\gamma$ and $\gamma\gamma$ mass

use $\Xi \rightarrow \Lambda \pi^0$ for normalization





Preliminary:

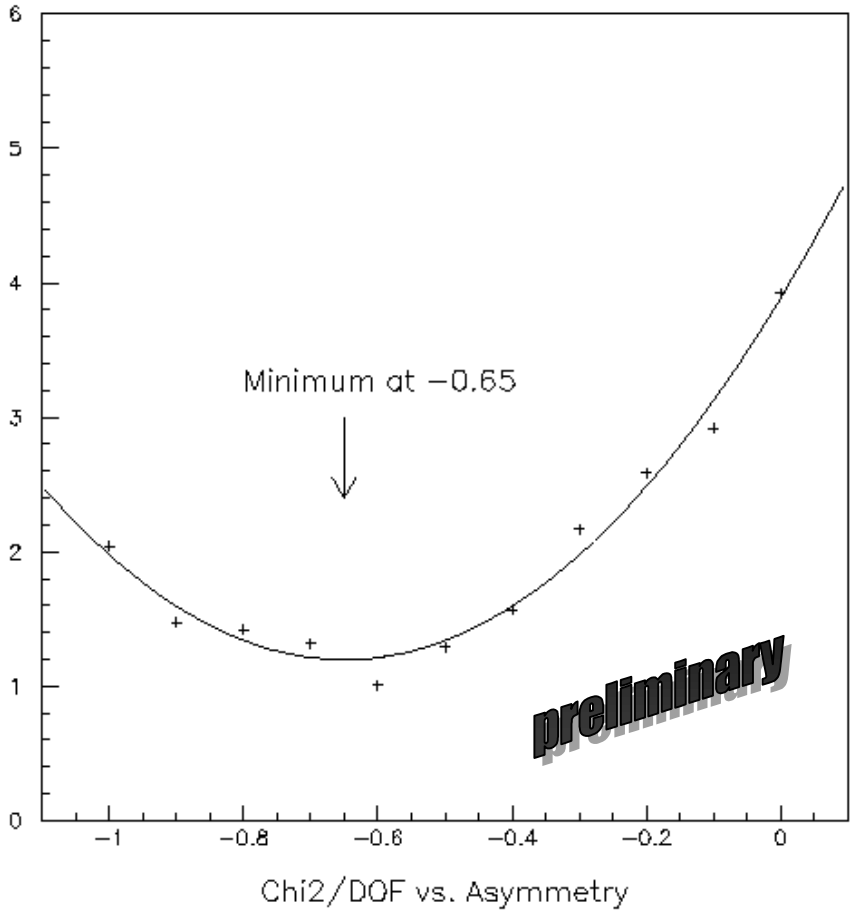
$BR(\Xi \rightarrow \Sigma^0 \gamma) = (3.0 \pm 0.05 \pm 0.2) * 10^{-3}$

KTeV - Ξ ->

3 stages of decay have to be taken into account

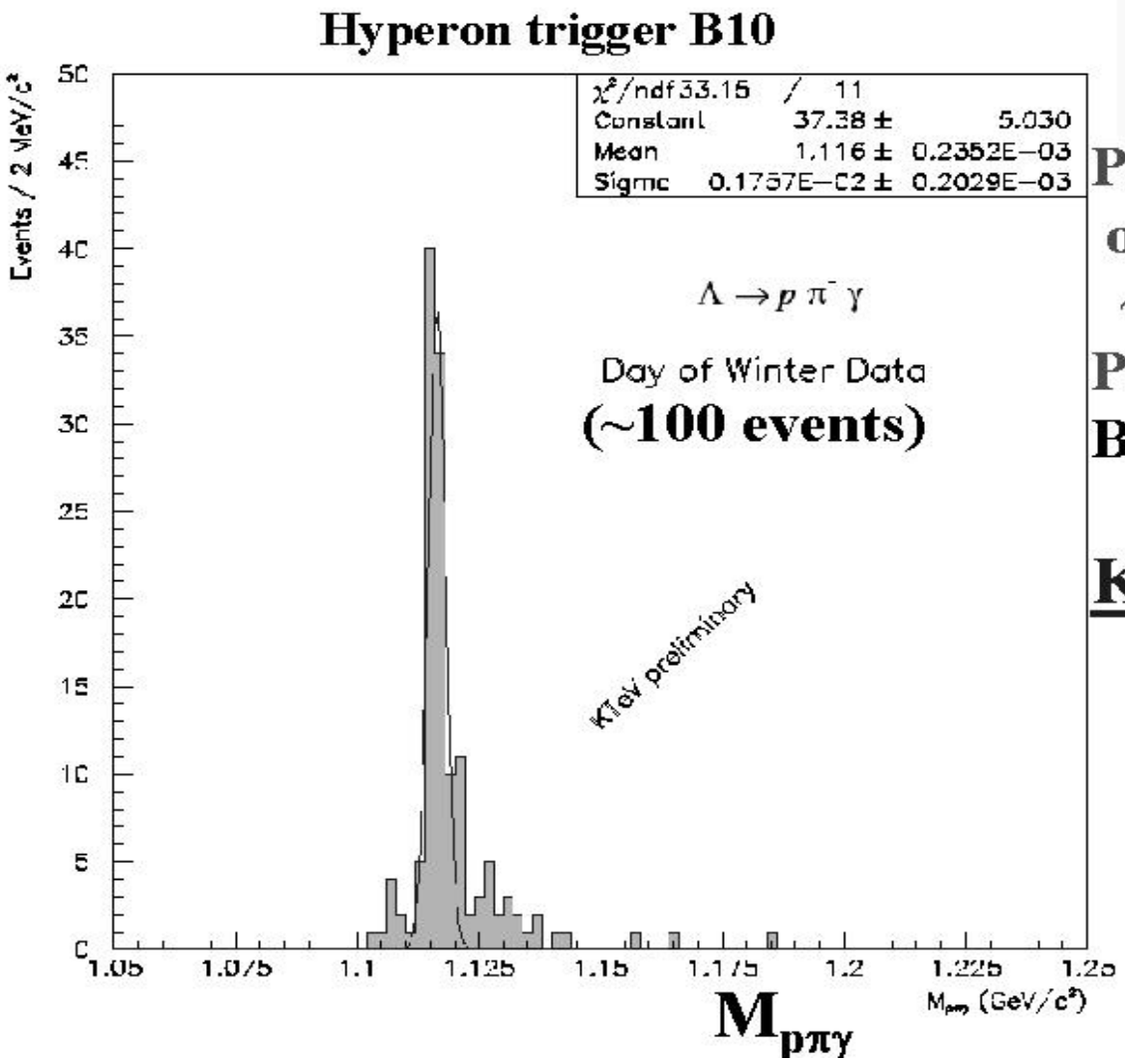
2 dimensional cosine distribution of the data has been compared to 10 sets of MC data ranging from $\alpha = 0$ to $\alpha = -1$

The X^2/DOF comarison for each of this cases is shown in the right figure



Preliminary Result:
$\alpha_\gamma = -0.65 \pm 0.13$

3-body Hyperon Radiative decay



$\Lambda \rightarrow p\pi^{-}\gamma$

Previous measurement of BR was based on ~72 events

PRL 42B (1972) 379

BR=$(8.4 \pm 1.4)\times10^{-4}$

KTeV collected ~5,000

Σ^0 – Physics at KTeV

Σ^0 Physics at KTeV

Can we do Σ^0 Physics with the KTeV detector?

Σ^0 decays EM, No direct Σ^0

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

$\Lambda\gamma$ *BR=100%*

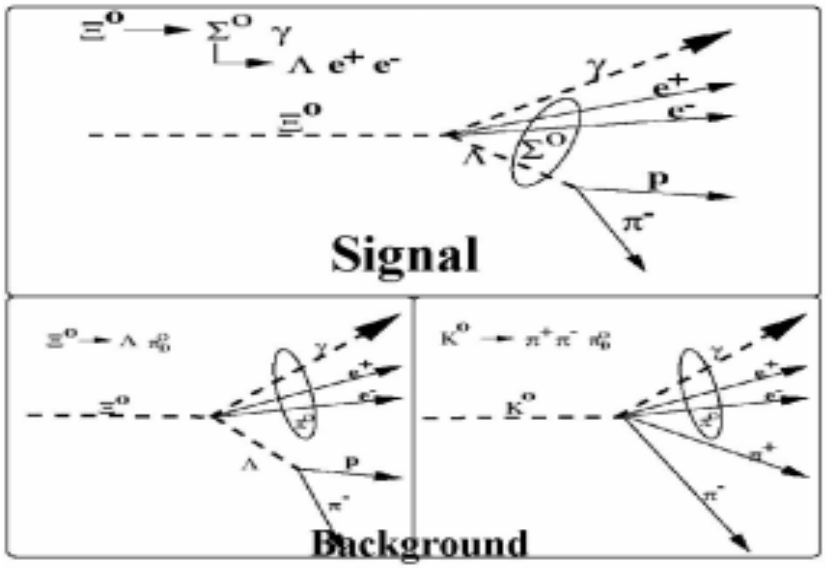
Λe^+e^- *BR ~ 0.5 - 0.6%, theory*

Not observed yet

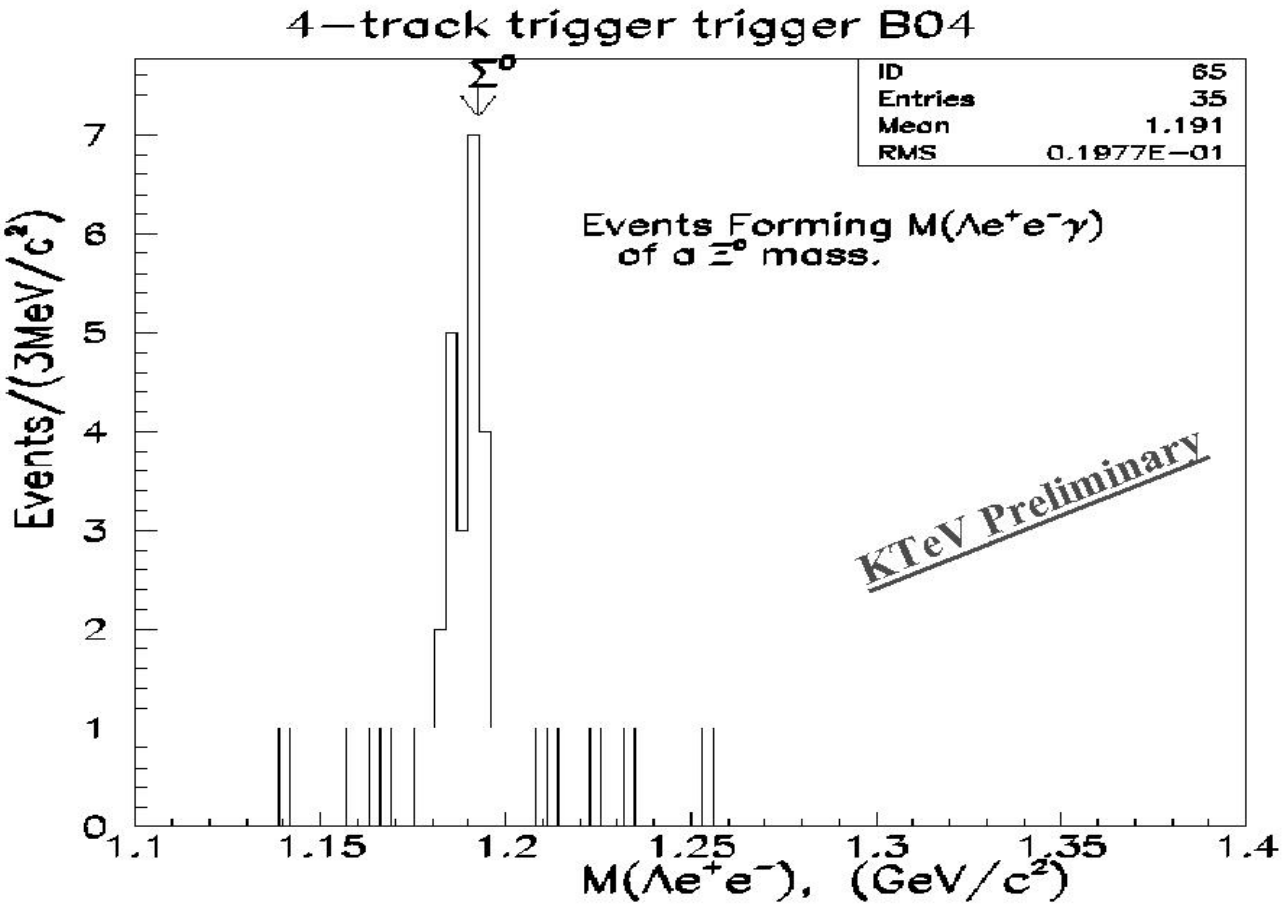
Measure relative parity of Σ^0, Λ

$\Lambda\gamma\gamma$ *BR < 3%, 1975 result*

BR~10^{-7}??? Theory



KTeV - Signal for $\Sigma^- \rightarrow \Lambda e^+e^-$



Summary

KTeV has very nice preliminary results for

$BR(\Xi^0 \to \Lambda\gamma) / BR(\Xi^0 \to \Lambda\pi^0) = (0.94 \pm 0.04) \times 10^{-3}$

$BR(\Xi^0 \to \Sigma^0\gamma) = (3.0 \pm 0.05 \pm 0.2) \times 10^{-3}$

$\alpha_\gamma(\Xi^0 \to \Sigma^0\gamma) = -0.65 \pm 0.13$

NA48 has results for

$BR(\Xi^0 \to \Lambda\gamma) = (1.90 \pm 0.34 \pm 0.19) \times 10^{-3}$ (31 events)

$BR(\Xi^0 \to \Sigma^0\gamma) = (3.14 \pm 0.76 \pm 0.32) \times 10^{-3}$ (17 events)

from 1997 Data with low statistics and promising event numbers from High Intensity K_S Test

Outlook

- KTeV: 1999 data to be analysed
- Result for Asymmetry for $\Xi \rightarrow \Lambda\gamma$ from 99 data
- NA48: extended K_S run (20 - 30 days) next year under optimised conditions
- Decay $\Omega^- \rightarrow \Xi^- \gamma$ still missing
- Better result for $\Xi^- \rightarrow \Sigma^- \gamma$?