Hyperon Static Properties

Hyperon99 Peter S. Cooper Fermilab September 28, 1999

Outline

- Introduction
- CPT Tests with a new result from E761
- Magnetic Moments
- Lifetime
- Mass with a preliminary result from NA48
- Radii /polarizablilties CF:H Kruger's talk yesterday
- Conclusions

Introduction

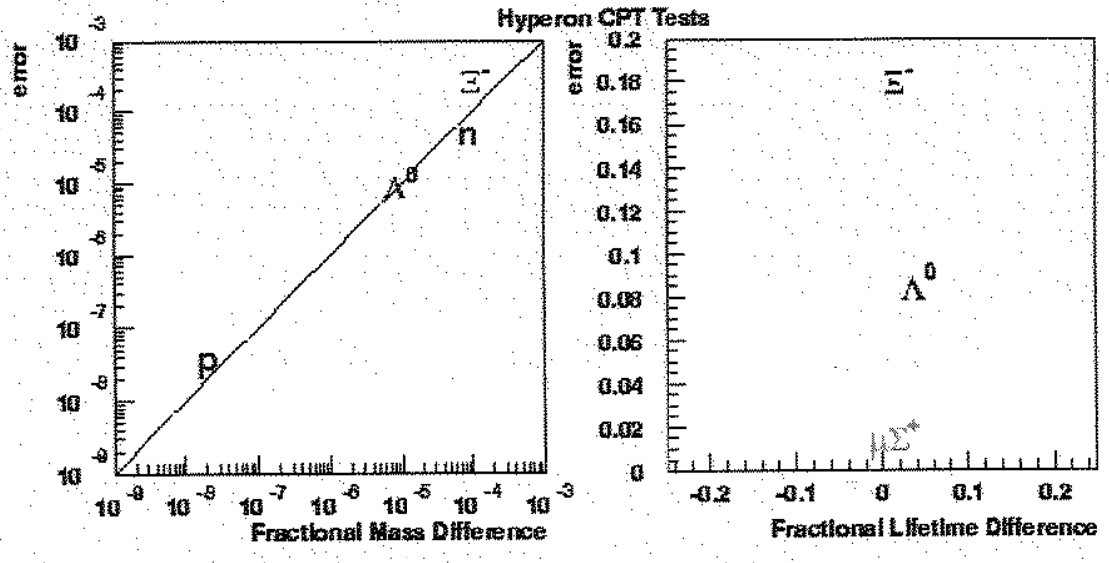
- This will largely be a review of hyperon measurements from the PDG.
- Little is new - only 2 new papers in the PDG since 1995
- Some new work is ongoing or can be expected from the present experiments.
  (I'll show 2 new results.)
- Question - Where can new or improved measurements can have a significant physics impact?

CPT Tests

All Static properties: Mass, Lifetime and Magnetic moment have invarient magnitudes under CPT

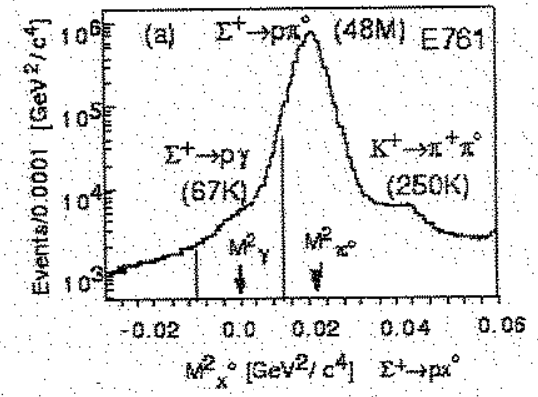
If masses of particle and anti-particle are different then the lifetime will differ due to phase space.

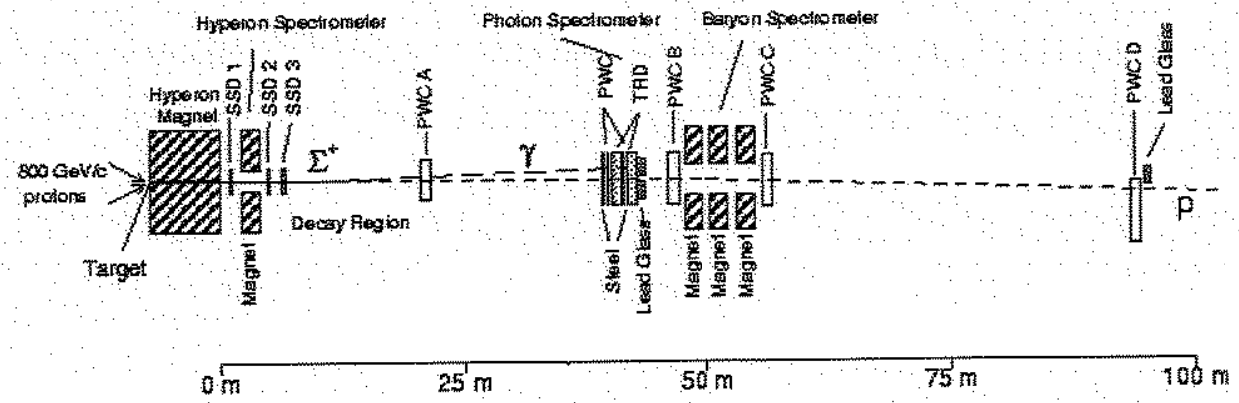
There are no real models for CPT violation. The K^0 system is probably most sensitive place to look for such violations.



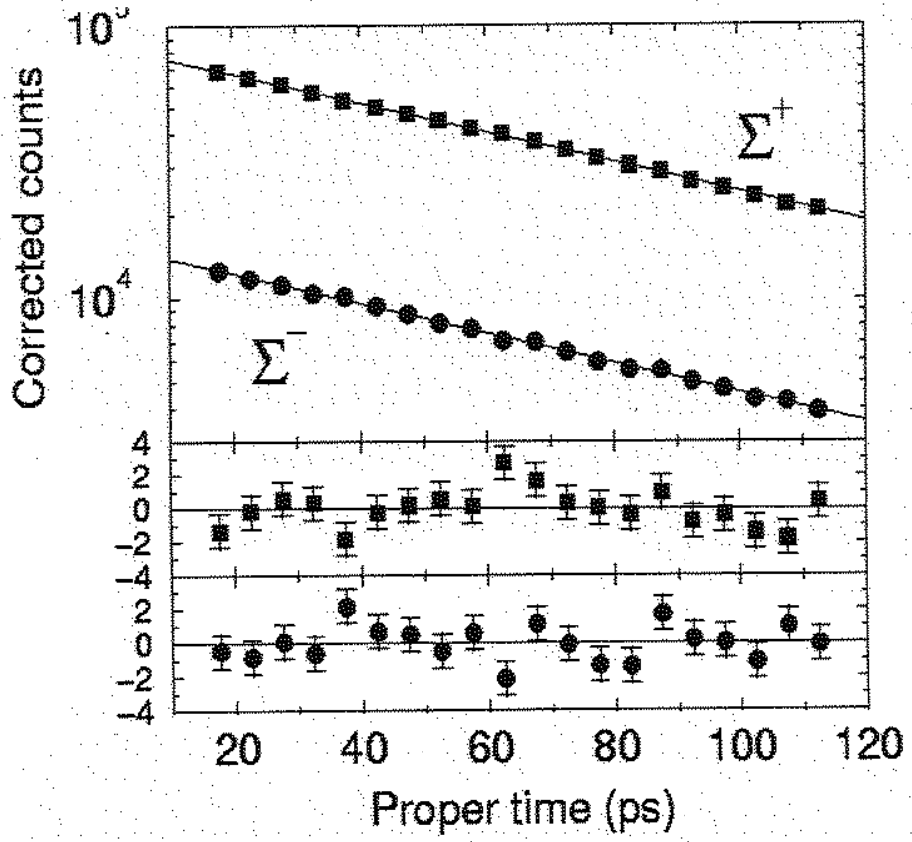
CPT Tests New Σ^+ and $\bar{\Sigma}^-$ Lifetimes from E761

- E761 Data in the 1990 fixed target run in PC4
- Physics goals :Br and α_γ for $\Sigma^+ \rightarrow p\,\gamma$, $\Xi^- \rightarrow \Sigma^-\,\gamma$
- This new result is the *last* E761 paper (?)
  R.F. Barbosa *et.al.* - To be submitted to PRL

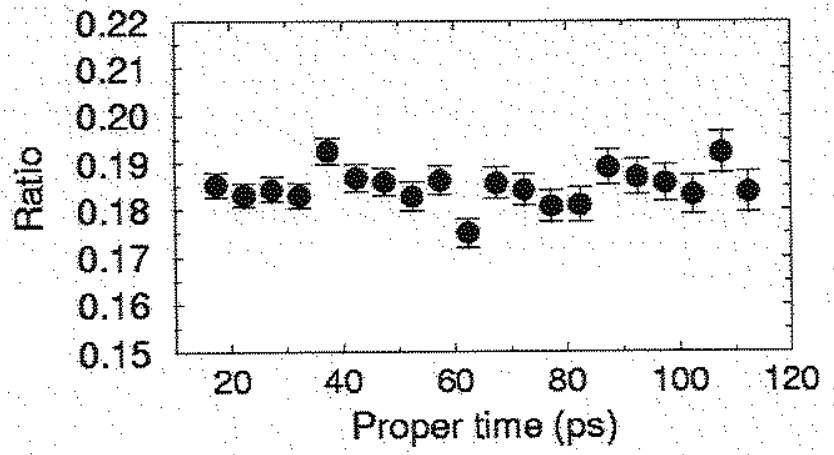




- Data sets used are 375 GeV/c Σ's produced by 800 GeV/c protons on Cu
  - 132K $\Sigma^- \rightarrow p\pi^0$ after cuts
  - 640K $\Sigma^+ \rightarrow p\pi^0$ after cuts - small subset of total data sample
  - Both data sets taken with same apparatus geometry - just sign reversal
- Acceptance corrections with a full GEANT simulation



- Results
  - $\tau[\Sigma^+] = 80.38 \pm 0.40 \pm 0.14$ psec
  - $\tau[\Sigma^-] = 80.43 \pm 0.80 \pm 0.14$ psec
  - $\Delta\tau/\langle\tau\rangle = -0.06 \pm 1.12\%$
- Best baryon lifetime CPT test
  - Λ^0 4.4 ± 8.5 %, Ξ^- 2 ± 18 %



Magnetic Moments

- All the Hyperon magnetic moments are now measured with high precision (<~1%).
- The SU6 quark model fits the data to ~5-10%. The deviations are all very well measured (~10σ)
- ~100 papers latter no other model does much better!
- We're done until theory builds a better baryon.

Hyperon magnetic moments [NM]

Hyperon	Moment	Quark Model	Difference
p	+2.792847	fixed	___
n	-1.913043	fixed	___
Λ°	-0.613(04)	fixed	___
$\Sigma+$	+2.458(10)	+2.67	-0.210(10)
$\Sigma^\circ \rightarrow \Lambda^\circ$	-1.610(80)	-1.63	+0.020(80)
$\Sigma-$	-1.160(25)	-1.09	-0.070(25)
Ξ°	-1.250(14)	-1.43	+0.177(14)
$\Xi-$	-0.6517(25)	-0.47	-0.161(03)
$\Omega-$	-2.024(56)	-1.84	-0.184(56)

Review from the 1998 PDG

BARYON MAGNETIC MOMENTS

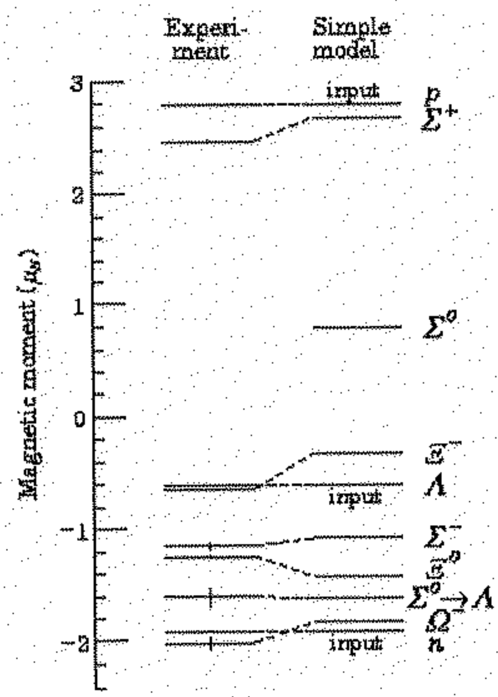
Written 1994 by C.G. Wohl (LBNL).

The figure shows the measured magnetic moments of the stable baryons. It also shows the predictions of the simplest quark model, using the measured p, n, and Λ moments as input. In this model, the moments are [illegible]

$$\mu_p = (4\mu_u - \mu_d)/3 \qquad \mu_n = (4\mu_d - \mu_u)/3$$
$$\mu_{\Sigma^+} = (4\mu_u - \mu_s)/3 \qquad \mu_{\Sigma^-} = (4\mu_d - \mu_s)/3$$
$$\mu_{\Xi^0} = (4\mu_s - \mu_u)/3 \qquad \mu_{\Xi^-} = (4\mu_s - \mu_d)/3$$
$$\mu_\Lambda = \mu_s \qquad \mu_{\Sigma^0} = (2\mu_u + 2\mu_d - \mu_s)/3$$
$$\mu_\Omega = 3\mu_s$$

and the $\Sigma^0 \to \Lambda$ transition moment is

$$\mu_{\Sigma^0\Lambda} = (\mu_d - \mu_u)/\sqrt{3}\,.$$

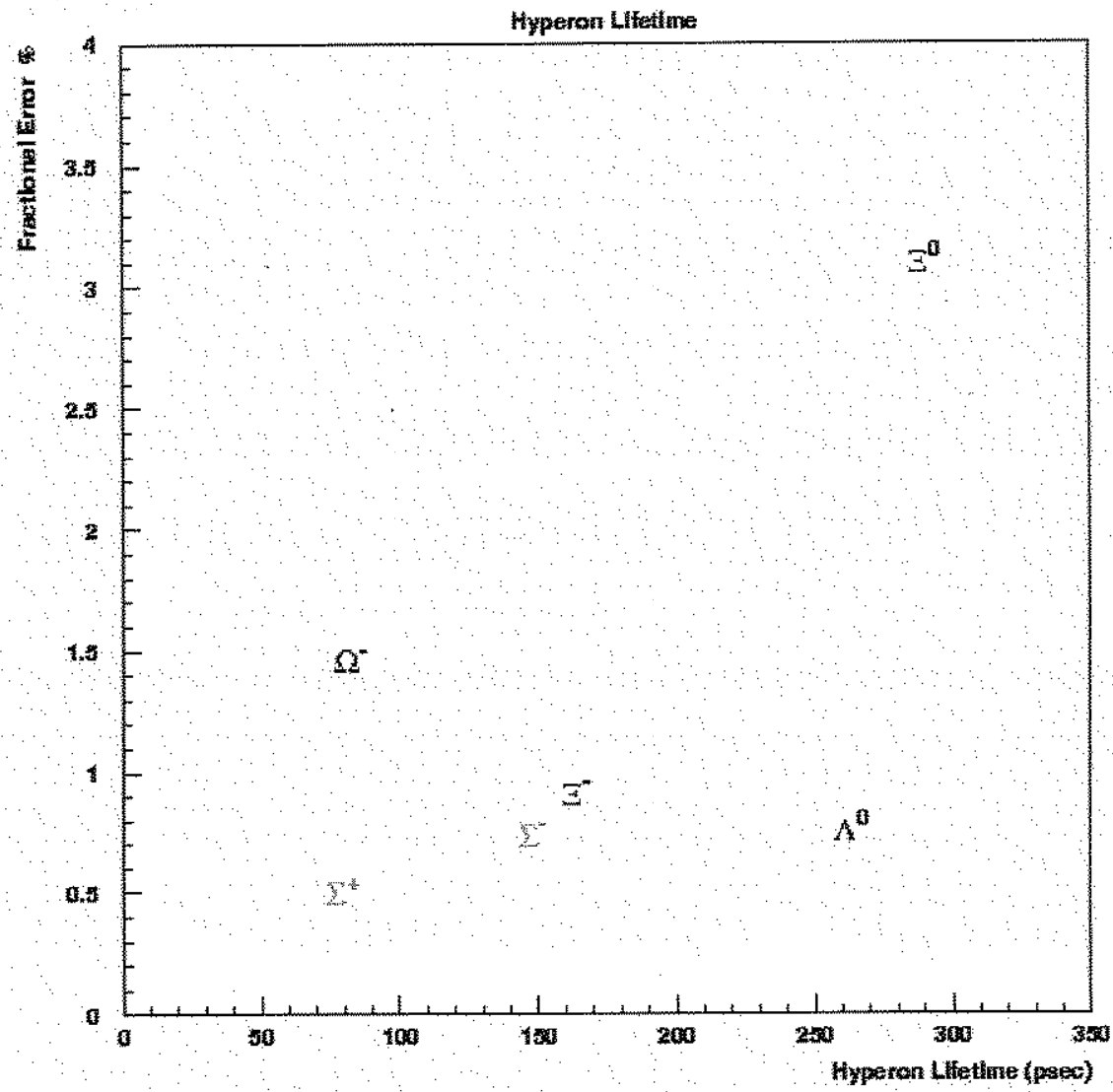


The quark moments that result from this model are $\mu_u = 1.852\,\mu_N$, $\mu_d = -0.972\,\mu_N$, and $\mu_s = -0.613\,\mu_N$. The

Lifetime

- All are measured to 1% or better except τ_{Ξ^0} and τ_{Ω^-}
- A combination of NA48, KTeV and HyperCP should be able to measure these two lifetimes to the 1% level.
- The lifetime uncertainty folds directly into the semi-leptonic decay rates in Cabibbo fits since $Br = \Gamma\tau$

Lifetime Present PDG values



Mass

- The mass spectrum of the baryons is an enduring subject. The Coleman-Glashow relation(1961) is

  $M_n - M_p + M_{\Xi^-} - M_{\Xi^0} + M_{\Sigma^+} - M_{\Sigma^-} = 0 \quad = -0.37 \pm 0.62$

  dominated by the experimental uncertainty on M_{Ξ^0} .
- More recent theoretical works includes:
  - J. Rosner hep-ph/9707473v4
  - E. Jenkins hep-ph/9893349
- Improvements on M_{Ξ^0} can be expected from NA48 and perhaps KTeV. With the NA48 preliminary results the CG relation becomes -0.30 ± 0.25
- The next biggest uncertainty is in M_{Ξ^-} which HyperCP should be able to improve. Beyond this (0.1 MeV) the precision should limited by theory.
- The other sum rules predicted involve decuplet, charm or beauty state masses.

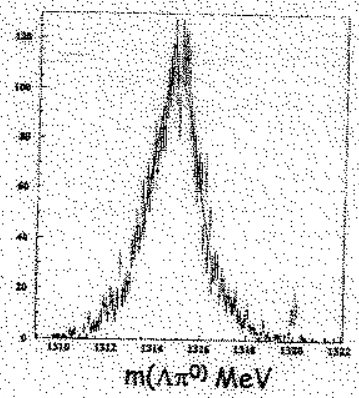
Mass

New Preliminary Result from NA48 from Lutz Kopke talk @ KAON99

Precision Ξ^0-mass

Precise tracking and small uncertainty in momentum scale

- select $\Xi^0 \rightarrow \Lambda\pi^0$
- use π^0-vertex
- use nominal π^0 and Λ masses as constraints

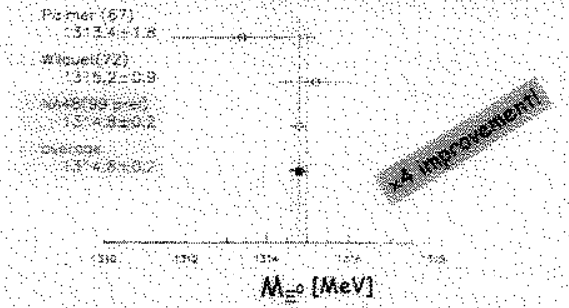


...Precision Ξ^0-mass

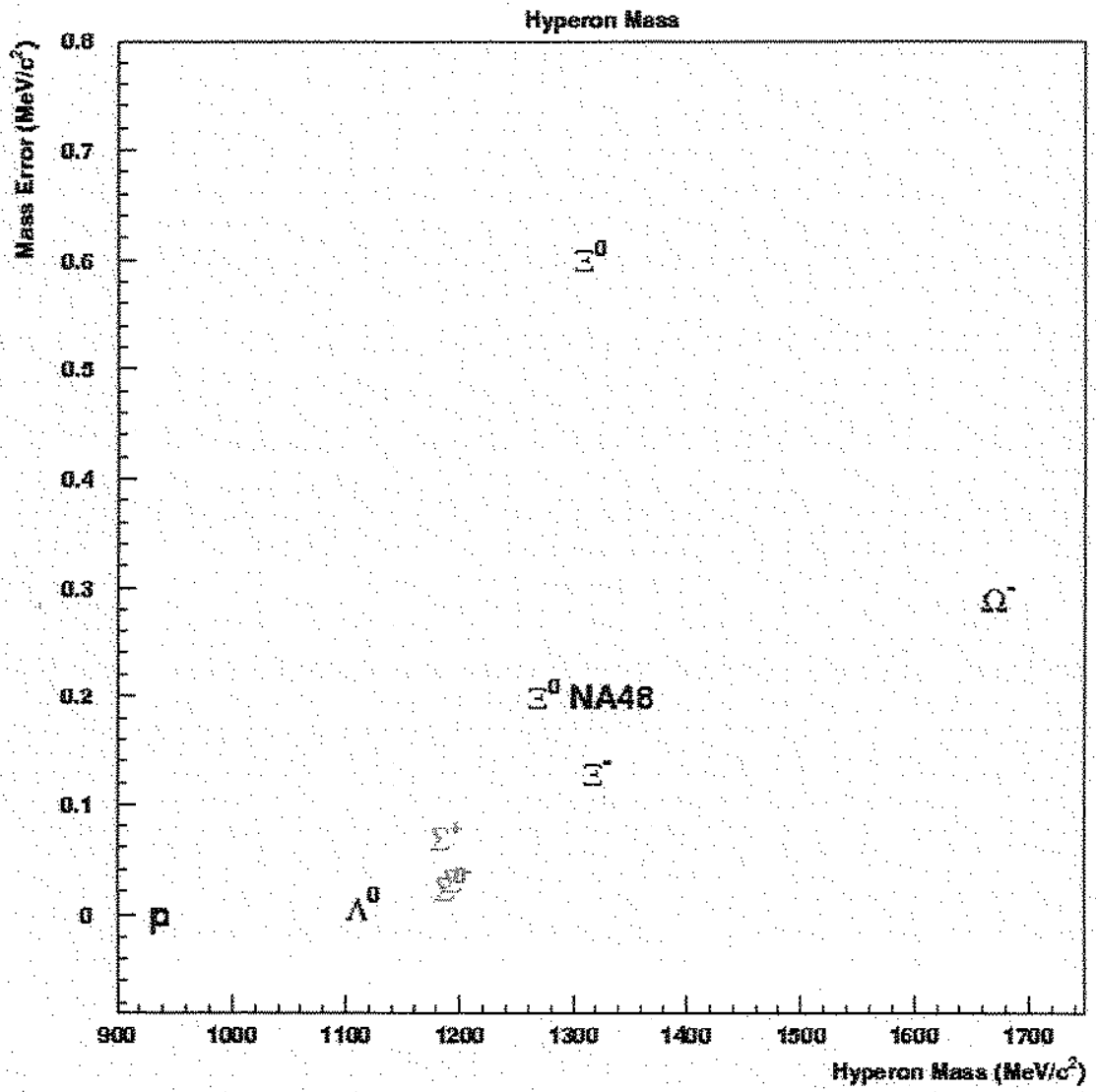
preliminary

$M_{\Xi^0} = 1314.83 \pm 0.06_{stat} \pm 0.20_{sys}$ MeV

systematic error mainly due to ± 50 cm uncertainty in vertex position



Mass Present PDG values



Conclusions

- With the anticipated new results from NA48, KTeV, HyperCP and perhaps some old experiments like E761 typical precisions on the static properties will approach
  - mass 0.1 MeV
  - lifetime 1%
  - magnetic moment 0.025 NM
- There does not appear to be a compelling reason to mount a new experiment to significantly improve any of these measurement at this time.
- Improved measurements of hyperon EM radii and/or polarizabilities require >500 GeV hyperons. Prospects are limited.
- This body of work is an operational definition of precision particle physics.