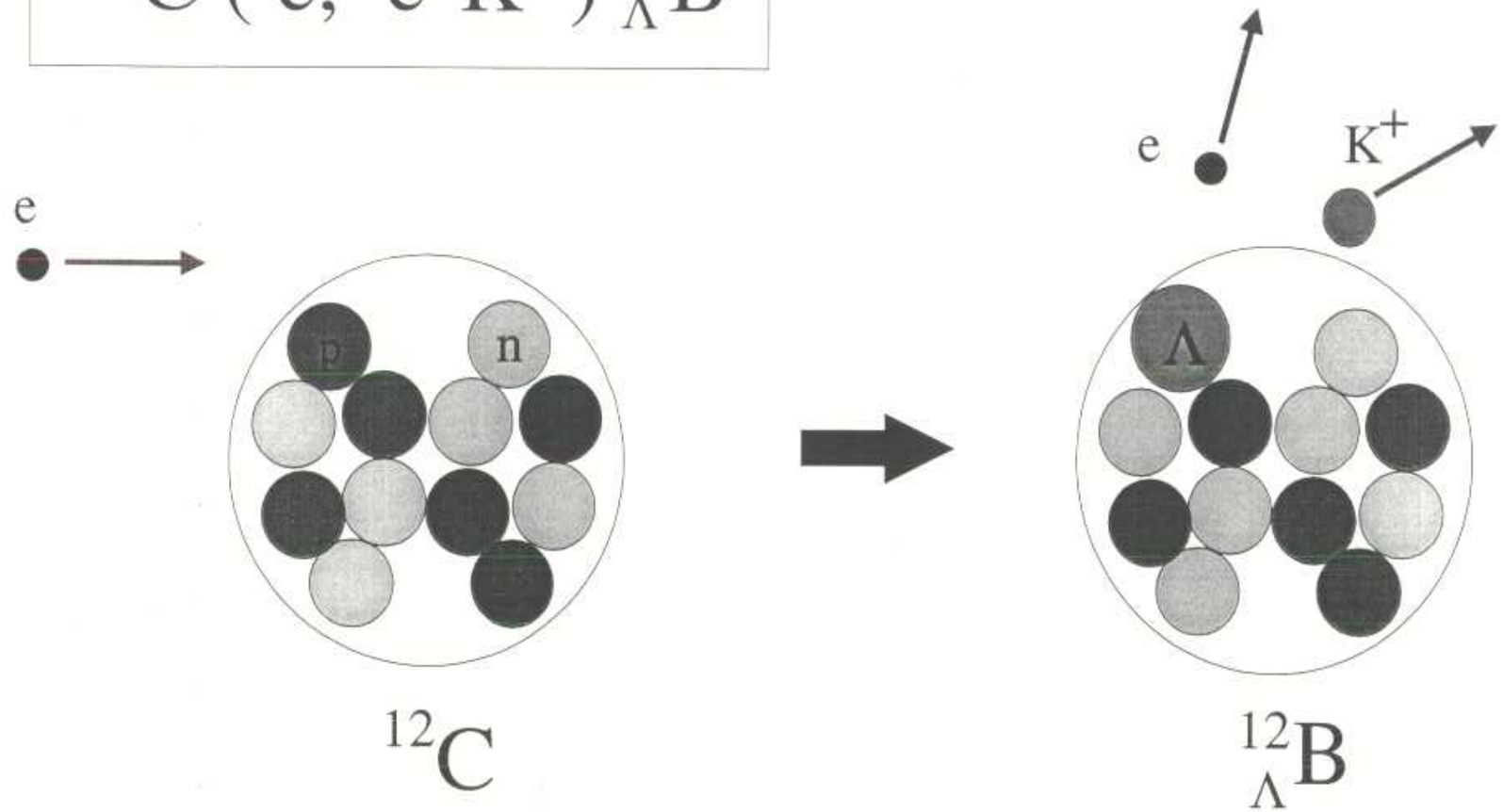
$$^{12}C\,(e,\ e'K^{+})\,^{12}_{\Lambda}B$$



$$\gamma^{*} + p \longrightarrow \Lambda + K^{+}$$

Juan

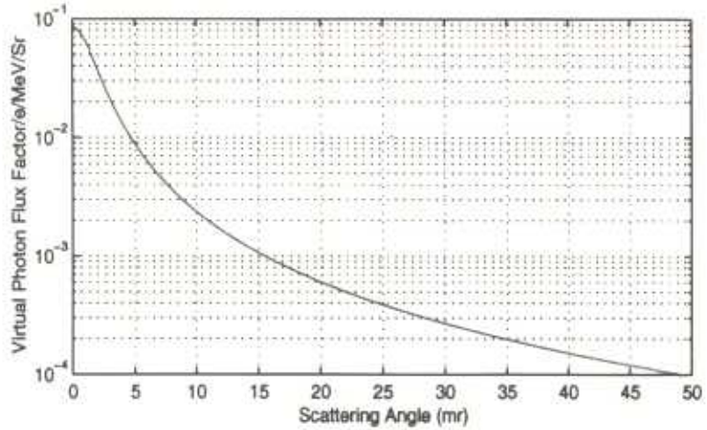
Experimental Goal of E89009

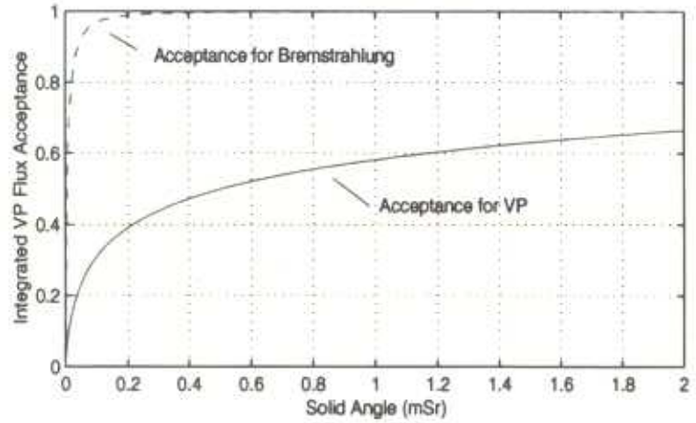
- High resolution
  - High resolution hypernulear spectrum is the key to extract information about spin-dependent interaction of Λ-core
  - Use Λ as impurity to probe interior structure of nuclei
  - Cebaf primary electron beam with high enery stability (10^{-4}) and high duty factor

- Electroproduction of Hypernulei by (e, e'K^+)
  First experiment in the world to produce hypernuclei with electron beam

- Produce mirror nuclei
  Convert Proton to Λ ($^{12}{}_{\Lambda}B$) compared with (π^+, K^+) and (K^-,π^-) reaction ($^{12}{}_{\Lambda}C$)

Experiment Technique: Tagging 0 Degree Scattering Electrons

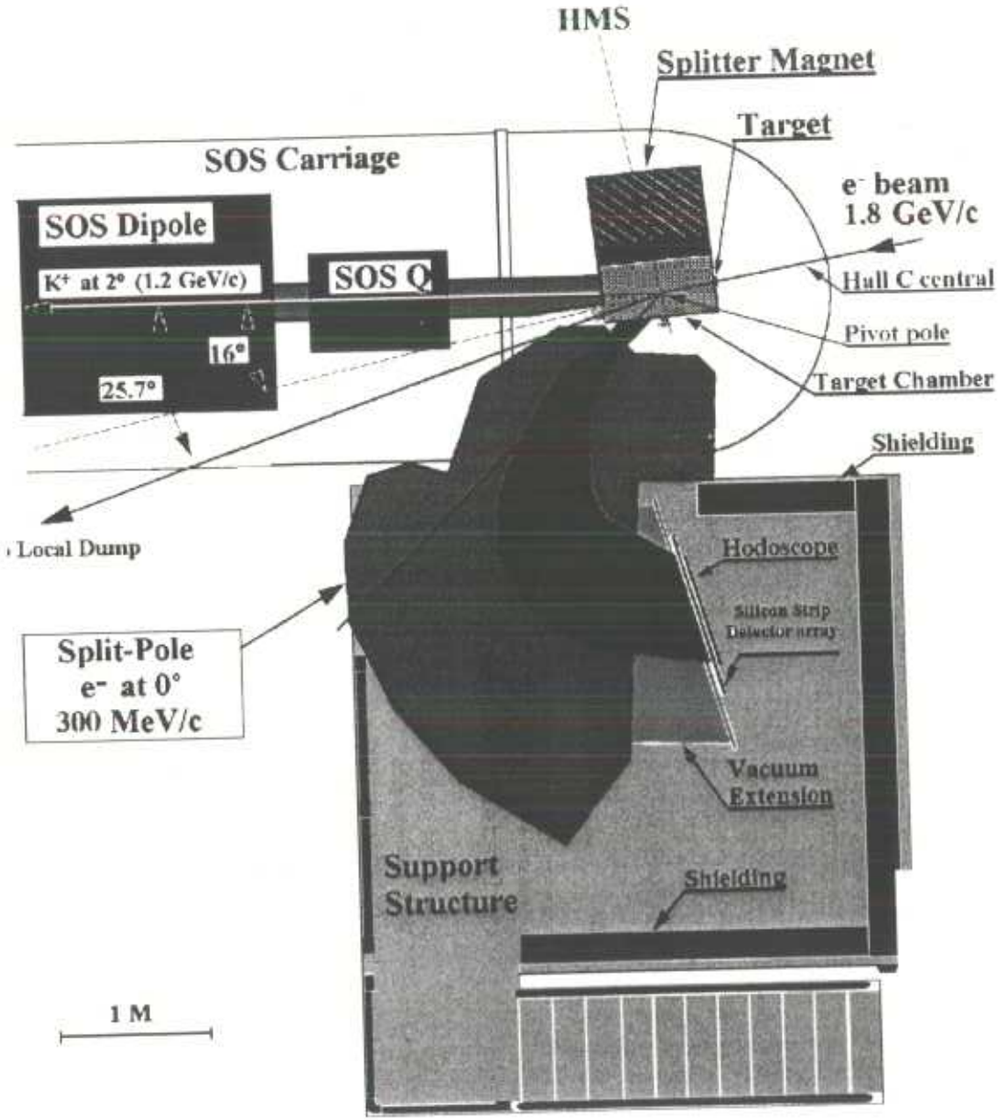




- Advantage:
  - Maximize virtual photon acceptance
  - K^+ also detected at very forward angles (0°–4°) to increase production cross section
  - Extreme condition: gaining experience for future forward angle e' scattering experiment
- Disadvantage:
  - Overwhelmed by 0°Bremstrahlung electrons(100 Mhz for the entire Enge focal plane at 0.6 μA). High accidental rate restricts beam current
  - Low statistics and yield

Experimental setup

TOP VIEW OF EXP89-009 APPARATUS



Coincident measurement of e' (0°) and K^+(1.85°

0° tagging method

Maximize the virtual photon flux

Beam

Energy 1.864 / 1.721 GeV

Current 0.2 – 1.5 μA

Energy fluctuation ($< 2 \times 10^{-4}$)

Splitter magnet

SOS spectrometer to measure kaon

Drift chamber (0.5 mm pitch 12 planes)

TOF hodoscope (σ_T~100 ps)

Aerogel Cerenkov counter

Lucite Cerenkov counter

Gas Cerenkov counter

ENGE split–pole spectrometer

High rate capability up to 200 MHz

SSD (0.5mm pitch,1440 ch)

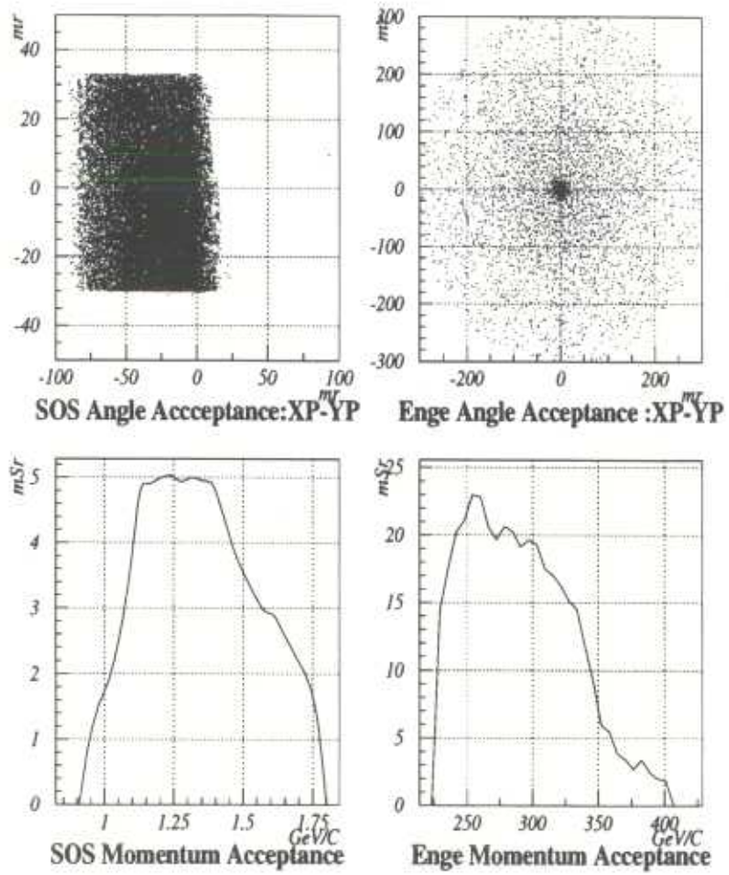
Scintillation hodoscope (σ_T~200 ps)

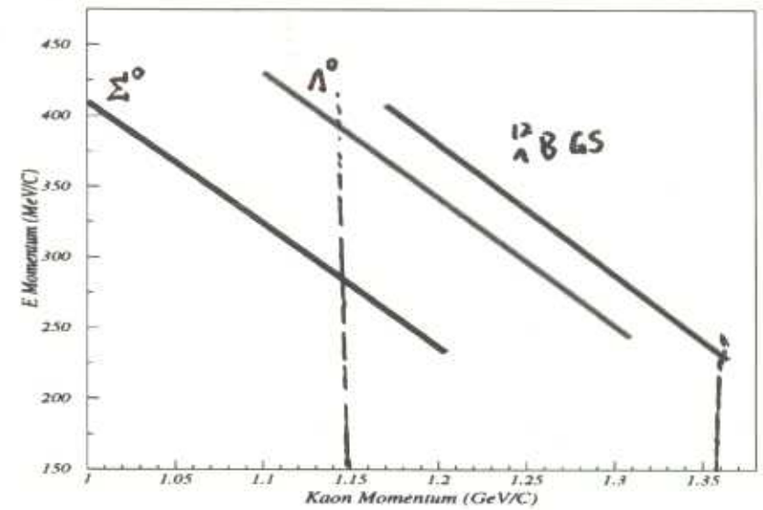
Target

^{12}C (22 mg/cm^2, enriched)

CH_2 (9.2 mg/cm^2)

HNSS Solid Angle and Momentum Acceptance



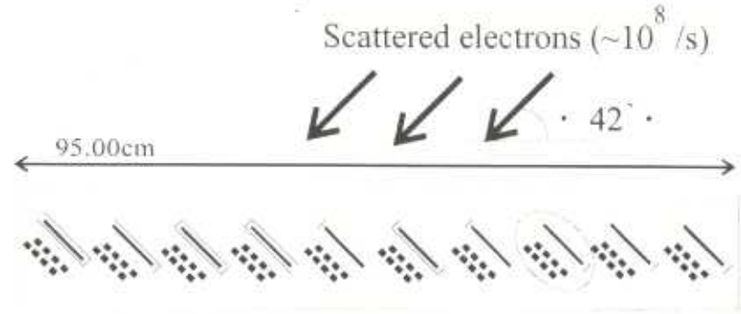


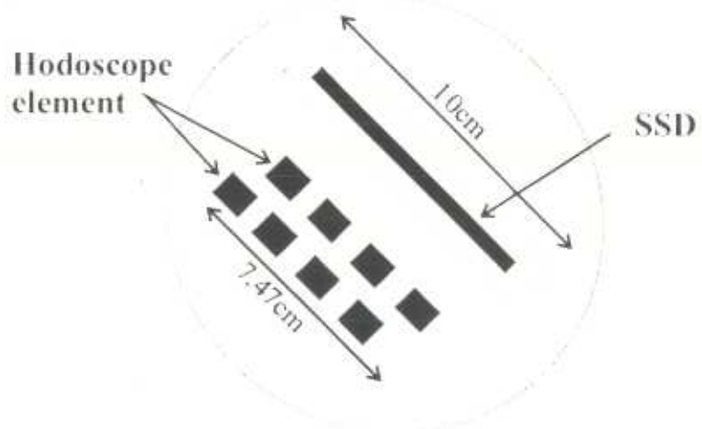
- Kaon arm at forward angle;E' arm at 0 degreee
- Centers at $^{12}_{\Lambda}B$ gs, including Λ and Σ for calibration

e' arm (Enge Spectrometer)

Newly installed to Hall-C

$\Delta\Omega$:	6 msr
$\delta p/p$:	5×10^{-4}(FWHM)
Momentum bite: ±20%	





Focal plane detector

SSD (Tohoku+Houston)

Strip width 0.5 mm

~ 100 keV/c

Efficiency : 97%

Radiation damage : negligible

Time measurement

Hodoscope w/ 3 stage boosters

Time resolution σ=250 ps

Singles rate

50^8 Hz/72 cm

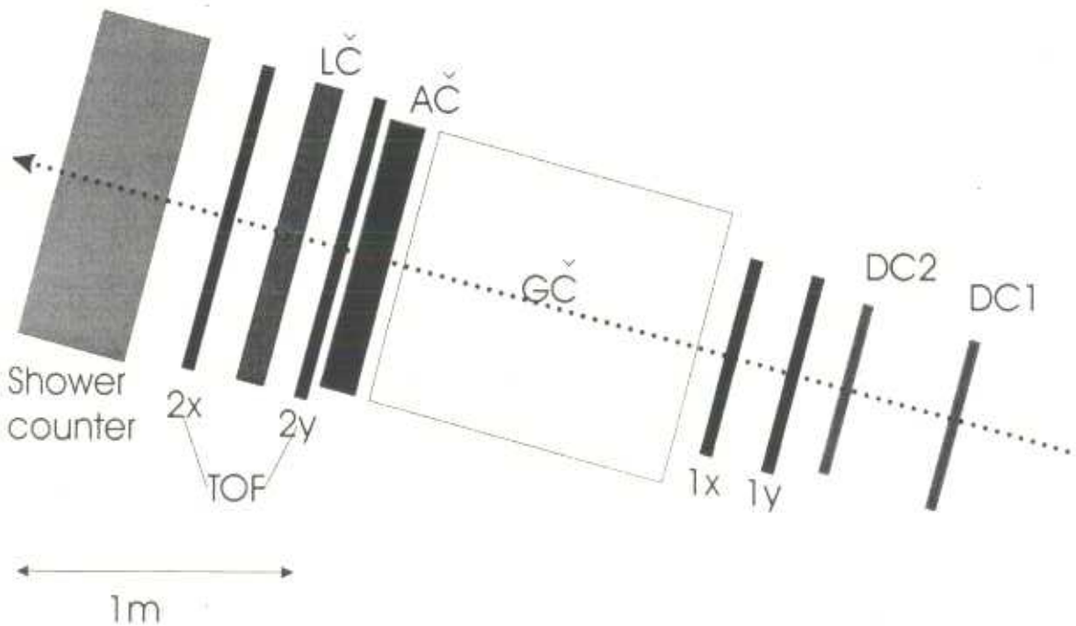
1.8 MHz/ Hodoscope

100 kHz/SSD strip

K^+ arm (SOS : Short Orbit Spectrometer)

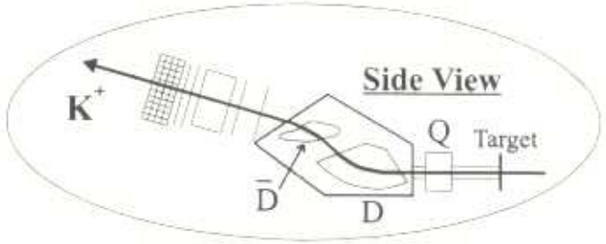
Standard equipment of Hall-C
2 DCs, 4 TOF walls, GC, AC, LC, and SC

$\Delta\Omega$:	6 msr
$\delta p/p$:	5×10^{-4}(FWHM)
Momentum bite:	$\pm20\%$
Flight path:	7.4 m

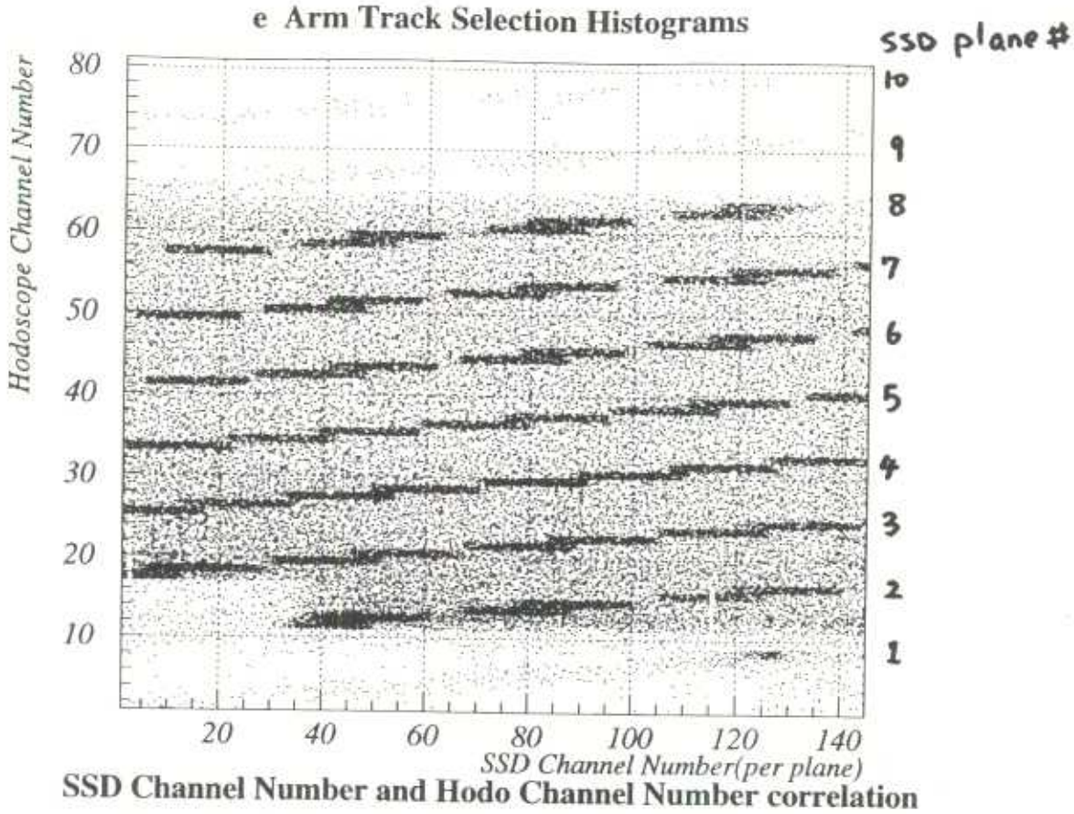


Measured singles rates
(C 22mg/cm^2, 0.47μA)

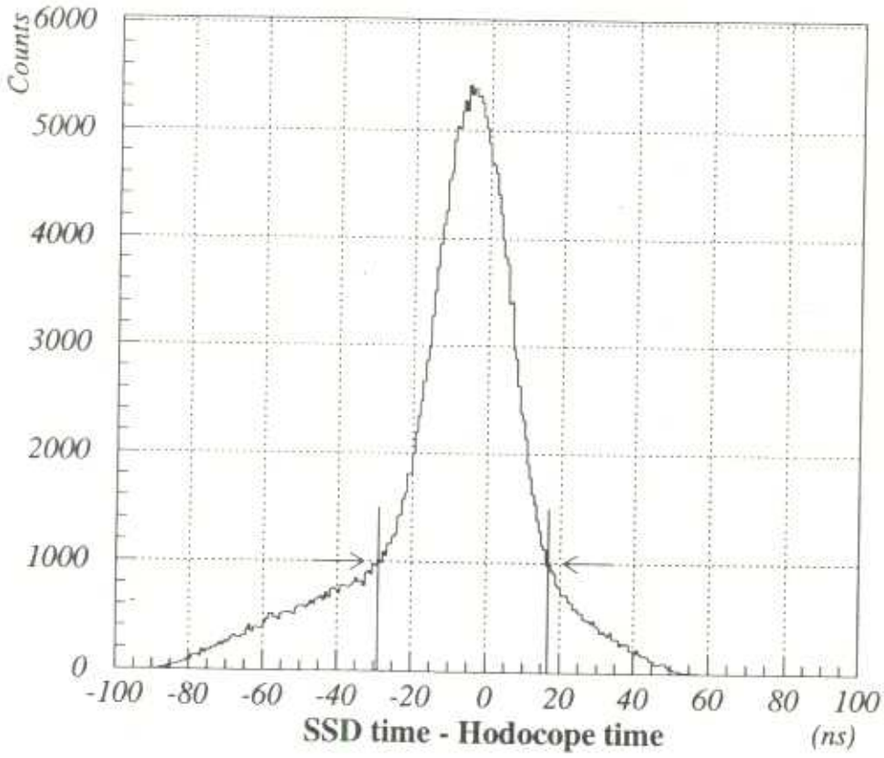
e^+	100 kHz
π^+	750 Hz
p	180 Hz
K^+	0.2 Hz



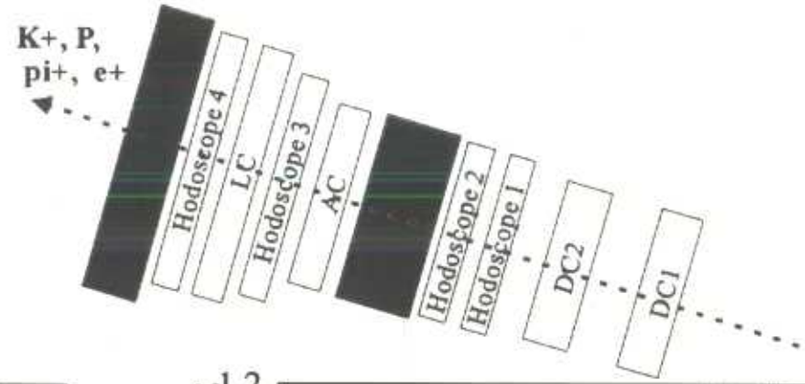
e Arm Track Selection Histograms

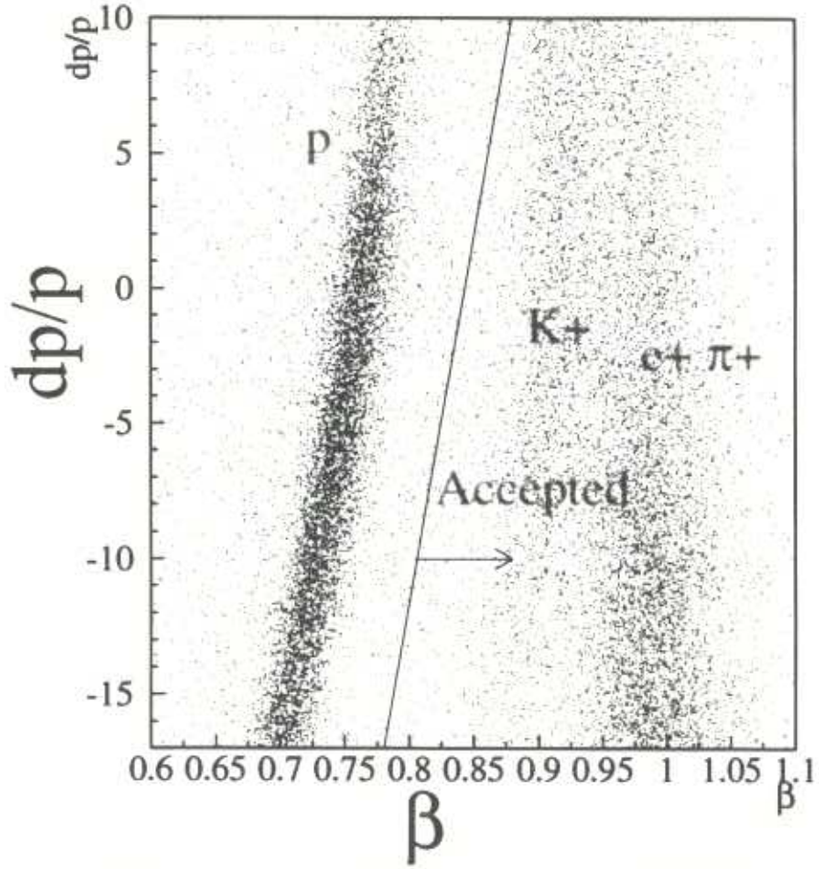


SSD Channel Number and Hodo Channel Number correlation

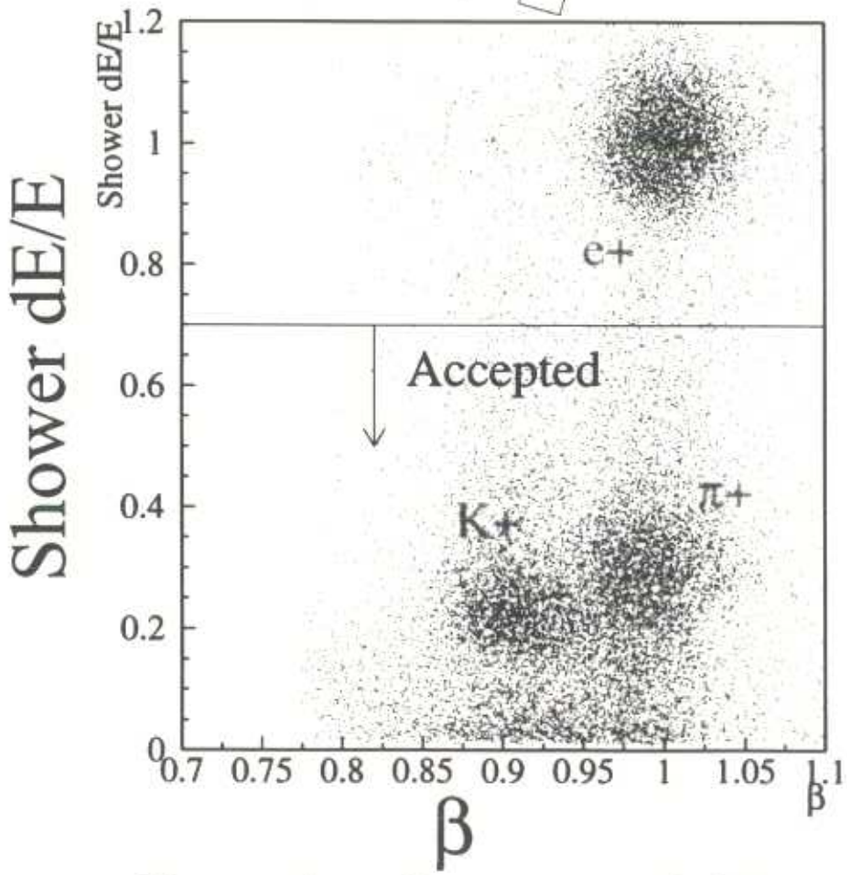


proton and positron cut



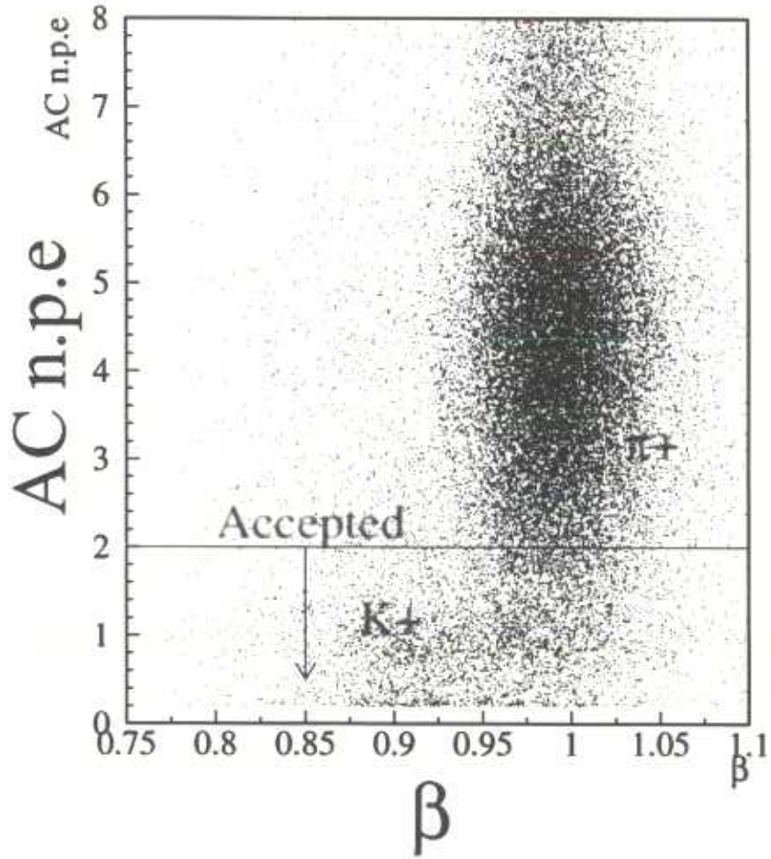


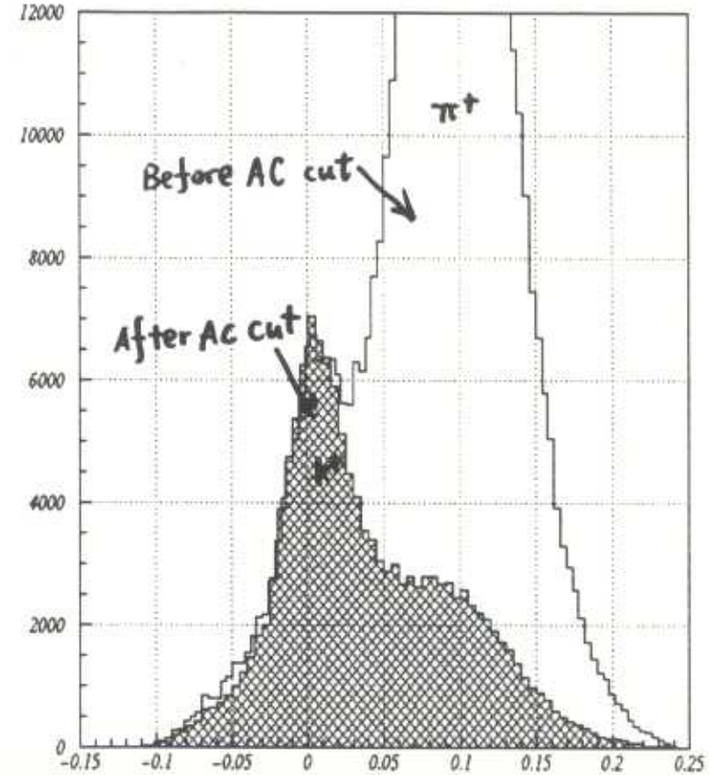
Correction factor $\varepsilon > 0.99$



Correction factor $\varepsilon \sim 0.97$

Pion cut by AC and SOS β



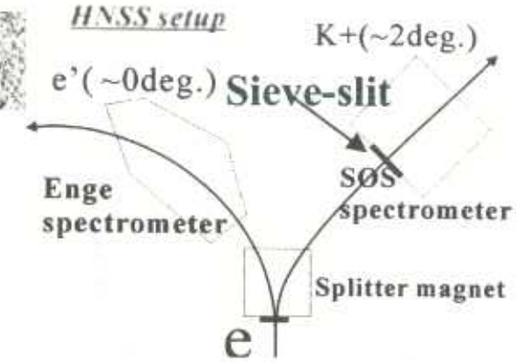


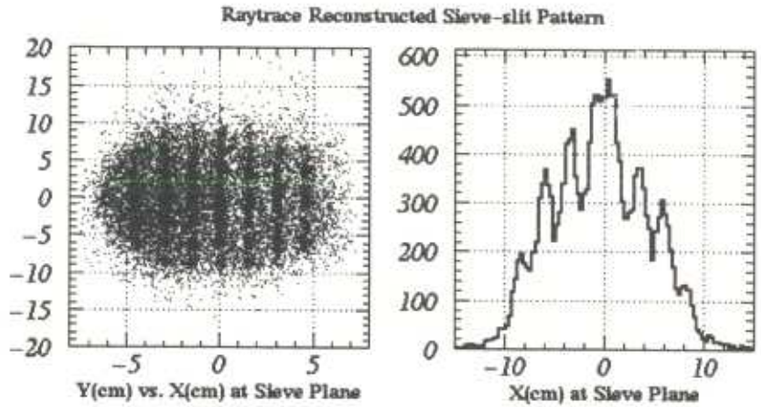
$\beta - \beta(K)$

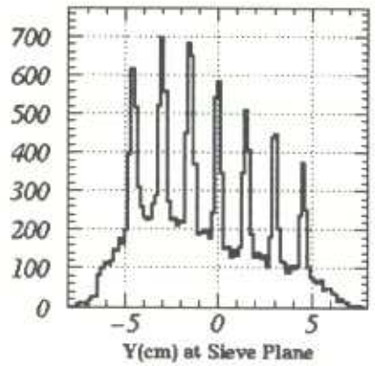
Correction factor 0.93 – 0.97
(rate dependent)

π^+ Contamination : 0.10 – 0.14

HNSS optics calibration

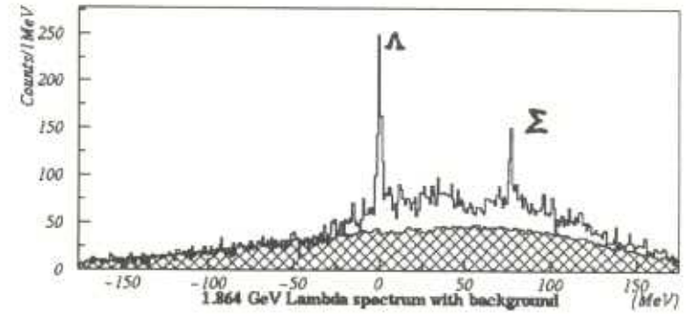


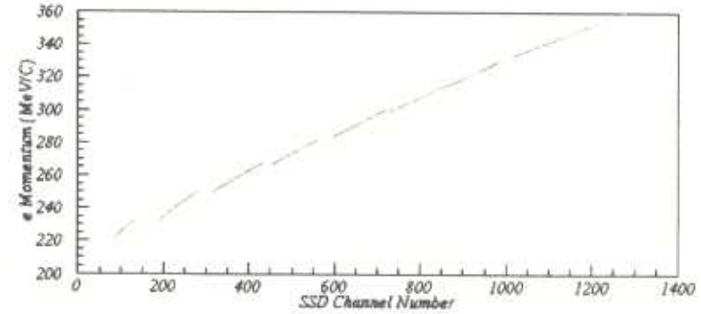




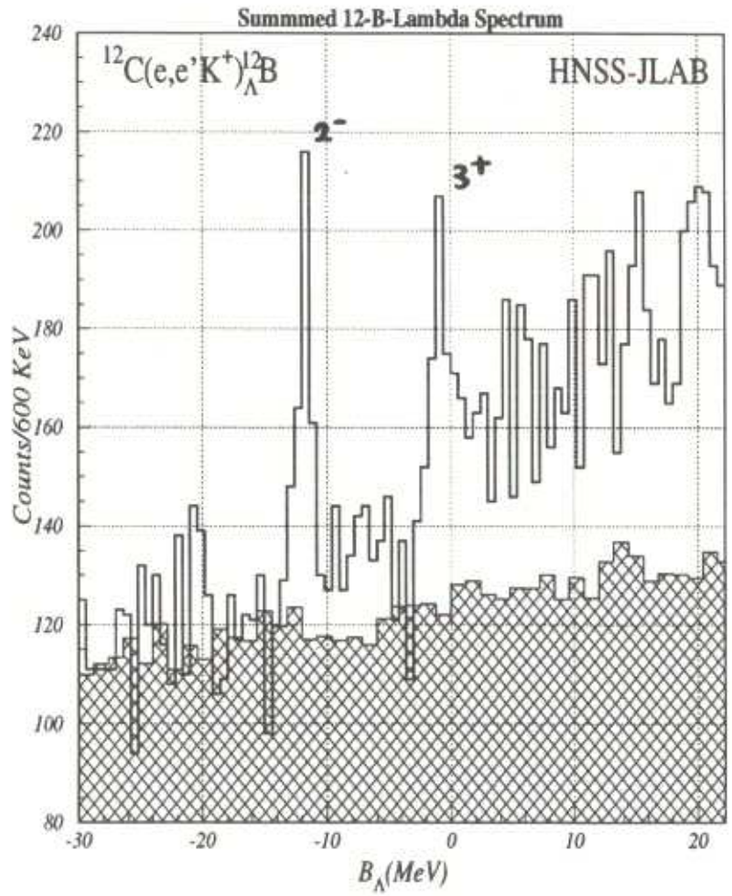
HNSS Resolution

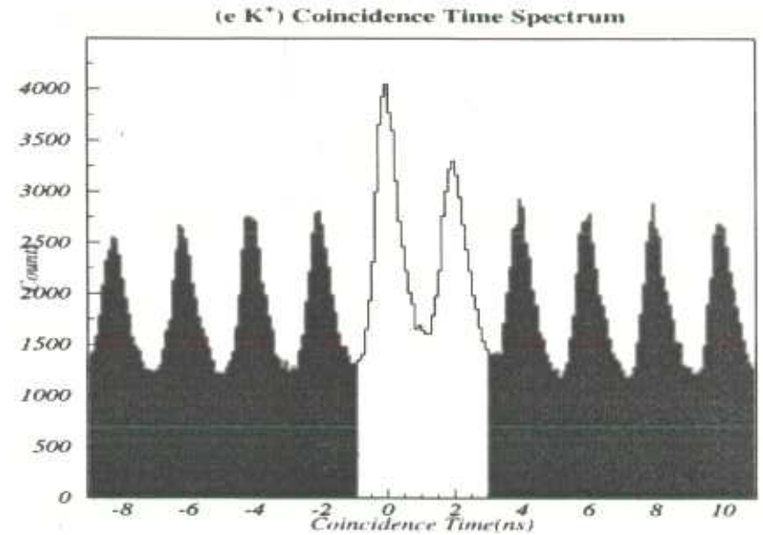
Beam Energy :	160 - 350 keV
splitter - split pole :	~100 keV
target :	~20 keV
Scattering Angle :	<200 keV
SOS :	~700 keV
Total :	~761 keV





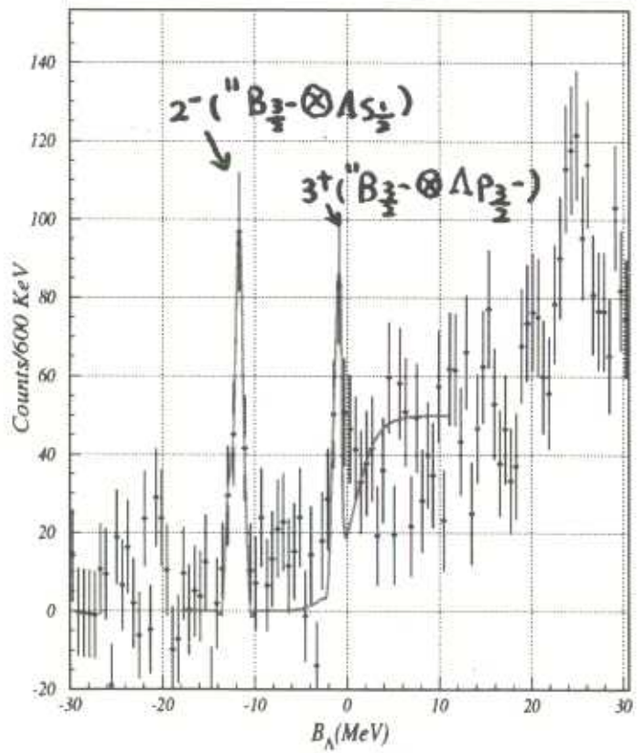
Summed $^{12}_{\Lambda}B$ Spectrum and Background Estimation



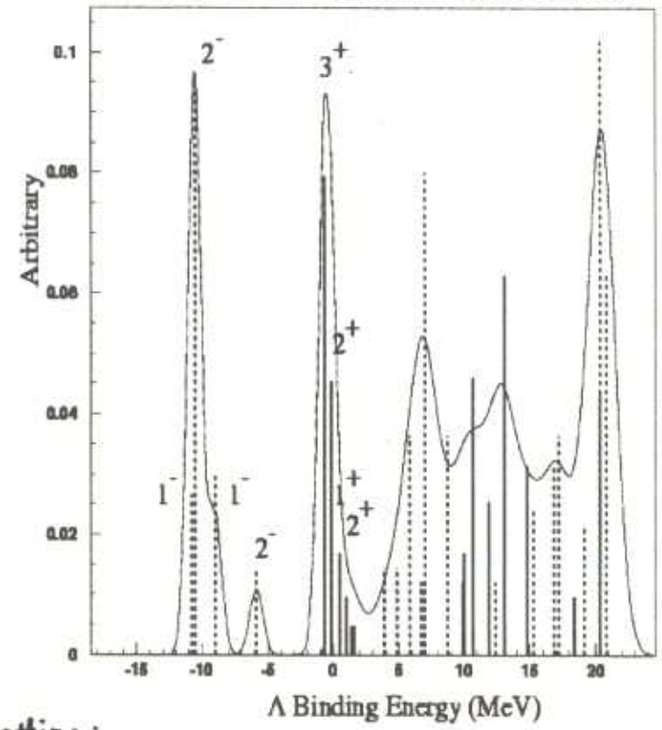


- Two peaks : $^{12}_{\Lambda}B$ Ground State and P shell Λ state. They are Λ spin flip states
- Background is estimated by averaging 8 accidental coincident peaks

Summed $^{12}_{\Lambda}B$ Spectrum Compared With Theory



T. Motoba, M. Sotona, and K. Itonaga, Prog. Theor. Phys. Suppl. No. 117(1994),123



Fitting:

$B_\Lambda(2^-) = -11.54$ MeV $\pm$ 0.06 MeV

$B_\Lambda(3^+) = -1.093$ MeV $\pm$ 0.07 MeV

Resolution: FWHM = 752 (MeV)

Summary

Jlab E89-009 (HNSS):

- First hypernuclear electroproduction experiment
- Successfully carried out 0 degree electron tagging technique; valuable experience learned for future hypernuclear experiment
- Acquired $^{12}{}_{\Lambda}B$ spectrum with better than 1 MeV energy resolution