Status Report for HKS: Hypernuclear Spectroscopy Experiment

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Hall C January Meeting

Jan. 6th, 2005

E01011 (HKS) Collaboration: Spectroscopy Study of Lambda Hypernuclei up to Medium-heavy Mass Region Through (e,e'K) Reaction

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- S. Kato (Yamagata U)
- T. Takahashi, Y. Sato, H. Noumi (KEK)
- T. Motoba (Osaka EC)
- L. Tang (Spokesperson), O.K. Baker, M. Christy, L. Cole, P. Gueye, C. Keppel, L. Yuan (Hampton U)
- J. Reinhold (Spokesperson), P. Markowitz, B. Beckford, S. Gullon, C. Vega (FlU)
- Ed.V. Hungerford, K. Lan, N. Elhayari, N. Klantrains, Y. Li,S. Radeniya , V. Rodrigues(Houston)
- R. Carlini, R. Ent, H. Fenker, T. Horn, D. Mack, G. Smith, W. Vulcan, S.A. Wood, C. Yan (JLab)
- N. Simicevic, S. Wells (Louisiana Tech)
- L. Gan (North Carolina, Wilmington)
- A. Ahmidouch, S. Danagoulian, A. Gasparian (North Carolina A&T)
- D. Dehnhard (Minnesota)
- M. Elaasar(New Orleans)
- R. Asaturyan, H. Mkrtchyan, A. Margaryan, S. Stepanyan, V. Tadevosyan (Yerevan)
- D. Androic, T. Petkovic, M. Planinic, M. Furic, T. Seva (Zagreb)
- T. Angelescu (Bucharest)
- V.P. Likhachev (Sao Paulo)
- M. Ahmed (Duke)

Timeline

Beam time: June to September, 2005

- June:
  - Beamline tuning
  - HKS spectrometer and detector commissioning, electronics, trigger and DAQ setup with F1 TDC

- July:
  - run condition and trigger optimization: grouping trigger setup with TUL
  - Spectrometer optical calibration

- August-Sept.: physics runing

  Targets(I uA): $^{28}Si(18)$, ^{6}Li, $^{7}Li(30)$ $^{9}Be(20)$ $^{10}B(26)$

  R&D: 51V, 89Y, 208Pb

  Calibration targets: 12C(30), CH_2

- Data analysis

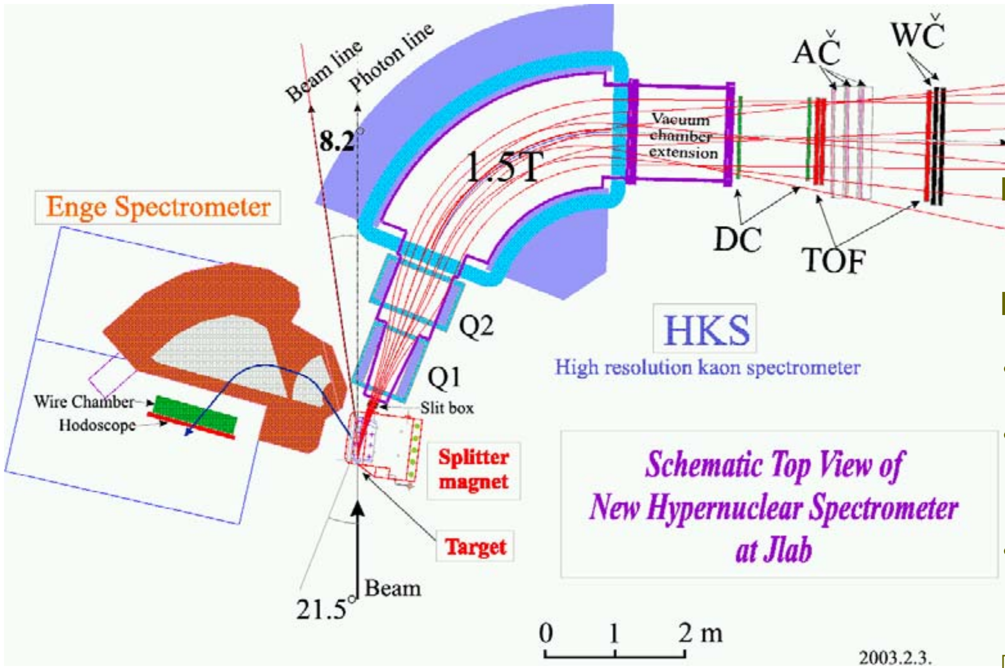
Physics Motivation

- Hyperon-nucleon(YN) interaction toward a unified understanding of baryon-baryon interaction

- New nuclear many body structure induced by strangeness; Properties of strangeness matter

- Advantages of (e,e'K) reaction:
  - New hypernuclear systems, $^{7}_{\Lambda}$He, $^{28}_{\Lambda}$Al, etc;
  - unnatural parity, high spin states
  - high resolution

HKS Experimental Setup



Momentum Resolution	2 x 10^{-4} (FWHM)
Solid Angle	30 msr (w/o Spl)
	16 msr (w/ Spl)
K^+ detection angle	1 ~ 13 degree
Momentum Acceptance	12.50%

- Enge tilted ~7.75 degree off-plane (up)
- Kinematics:
  - Beam energy Ee~1.83 GeV
  - e' momentum Ee'= 0.22 ~ 0.41 GeV
  - K+ central momentum 1.2 GeV/c
- Expected hypernuclear missing mass resolution ~400 MeV (FWHM)
- Estimated $^{12}{}_{\Lambda}B$ GS yield (30 uA beam): 45 /hour

Particle and Trigger Rate

HKS single arm particle rate at 30 uA (preliminary):

Target (100mg/cm^2)	p [kHz]	K [Hz]	π [kHz]	e+ [kHz]
^{12}C	21	~150	11	4
^{28}Si	32	130	11	11

Trigger rate

Target	Beam Current (uA)	HKS single(KHz)	Enge Single (MHz)	Coin (Hz)
^{12}C (100 mg/cm^2)	30	14.8	1.3	740
^{28}Si (65mg/cm^2)	18	15.3	1.6	910

- **Tilt Enge method works: Enge single arm e' rate ~100 times lower than E89009 (12C target at I=0.66 uA): ~100 MHz with 22 mg/cm^2**

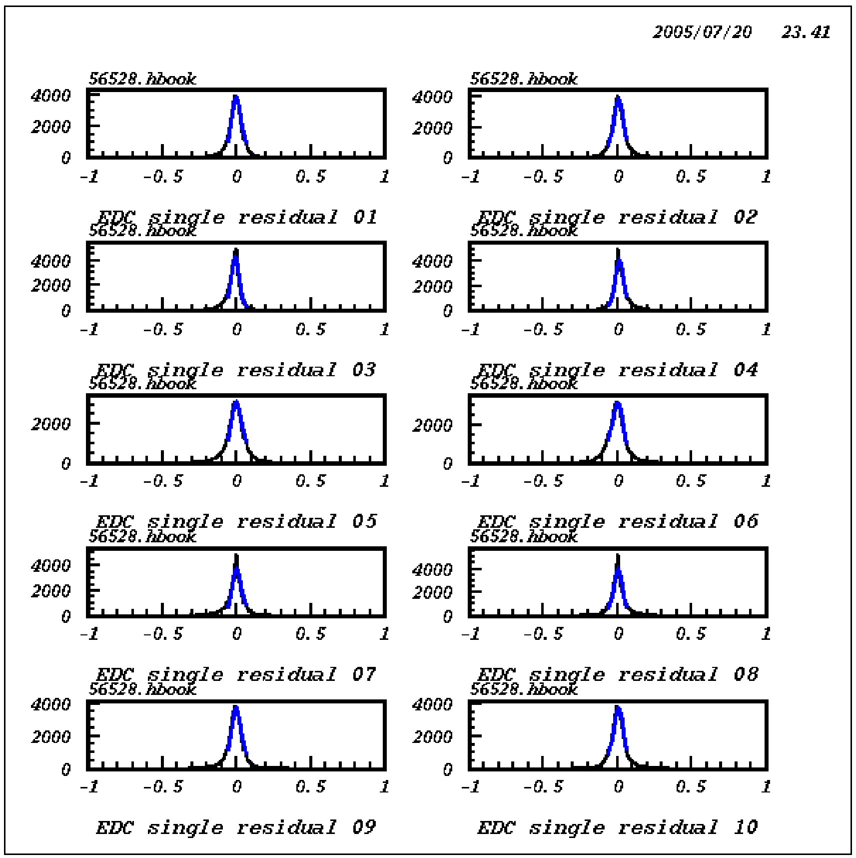
HKS and Enge Drift Chamber

- HKS DCs:
  - 2 sets of SOS DC type of chamber with uu'xx'vv' wire configuration
  - Average plane detection efficiency at particle rate of several MHz: ~98%
  - Average plane resolution (σ): 220 um

- Enge Honeycomb DC:
  - Layer configuration: xx'uu'xx'vv'xx' with honeycomb cell structure to detect large angle scattering e'
  - Average plane detection efficiency >97%
  - Average plane resolution (σ): 390 um.

Enge and HKS DC Tracking Residues

Enge DC tracking residues
(12C, 28 uA, Vth=5 v)



HKS DC tracking residues
(12C, 10 uA, Vth=3.4 v)

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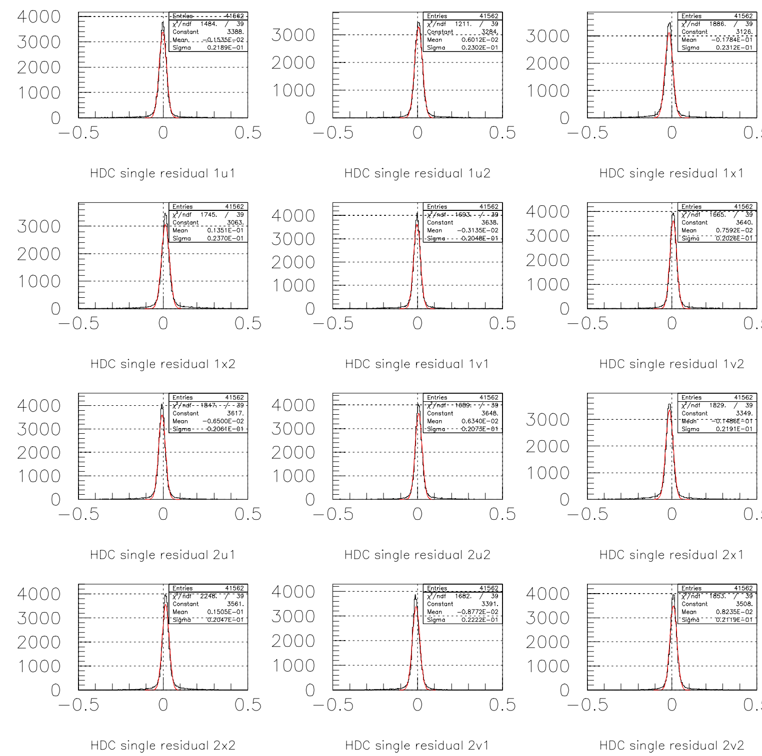
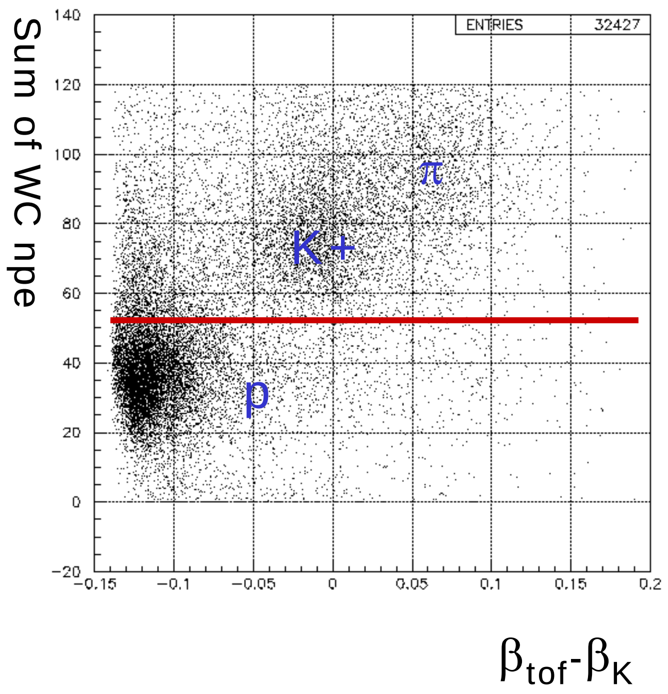


Water and Aerogel Cerenkov

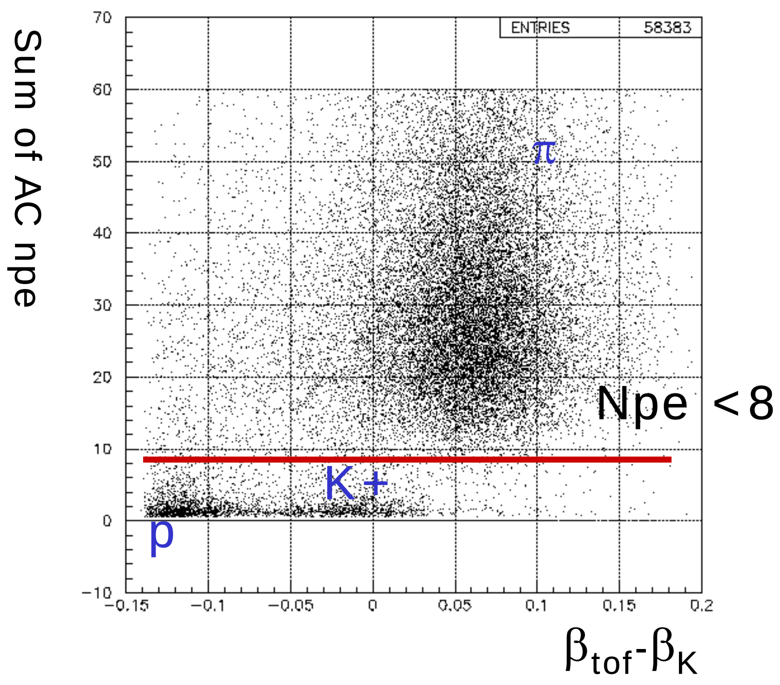
Water Cerenkov:

Npe >50 for K^+ ~1.2 GeV/C



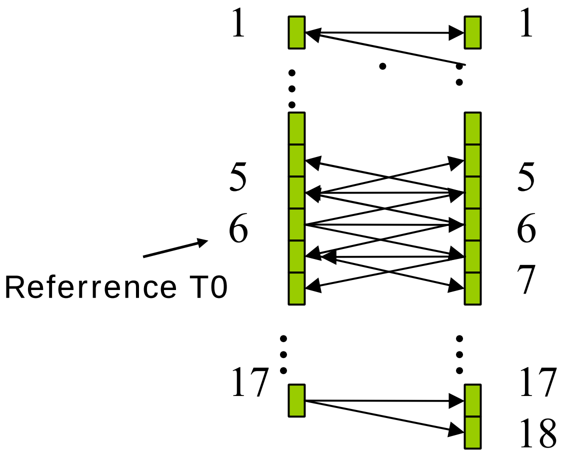
Aerogel Cerenkov:

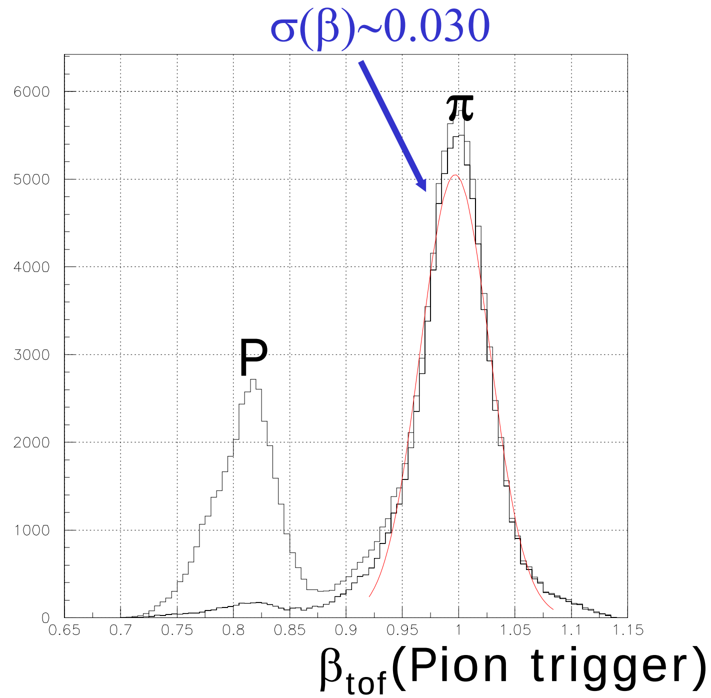
- Bucking coil around PMT were used to actively cancel the leaking field from HKS Dipole.



HKS Hodoscope and TOF Calibration

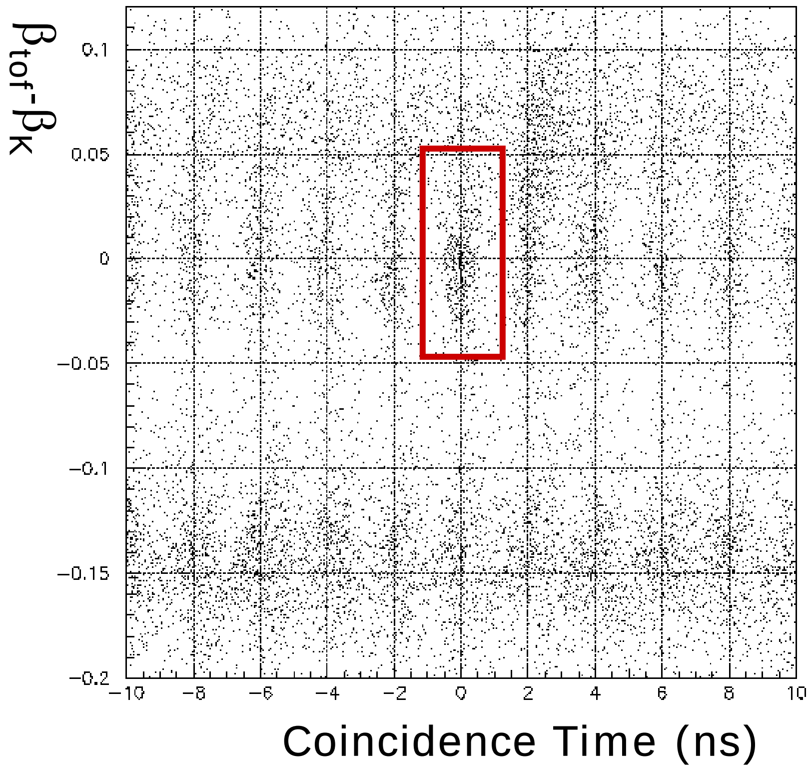
- 3 layers: 1X,1Y,2X
- Average TOF resolution from 2 layers: TOF = T1x – T2x, σ_{tof}=180 ps
- TOF calibration by a "shoe string" algorithm from 1X and 2X

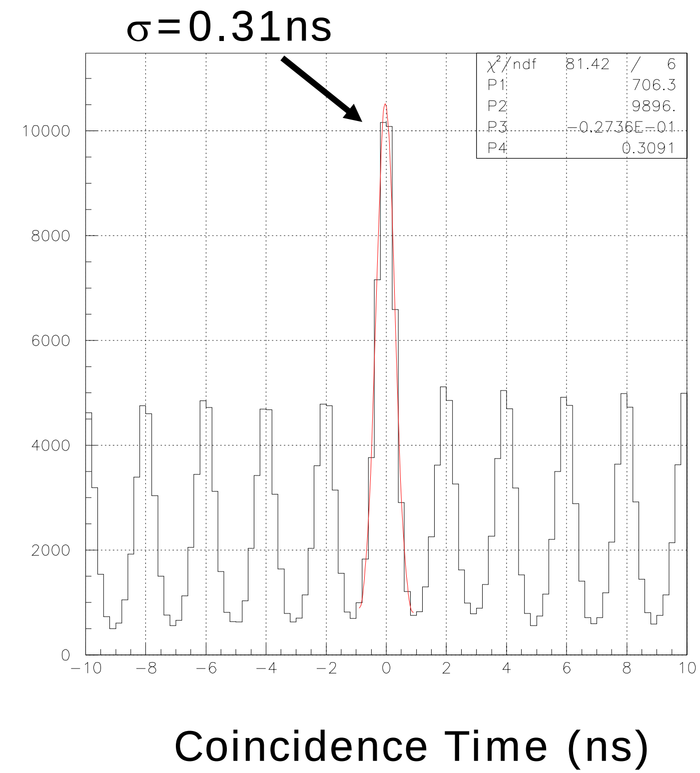




Real Coincidence Kaons

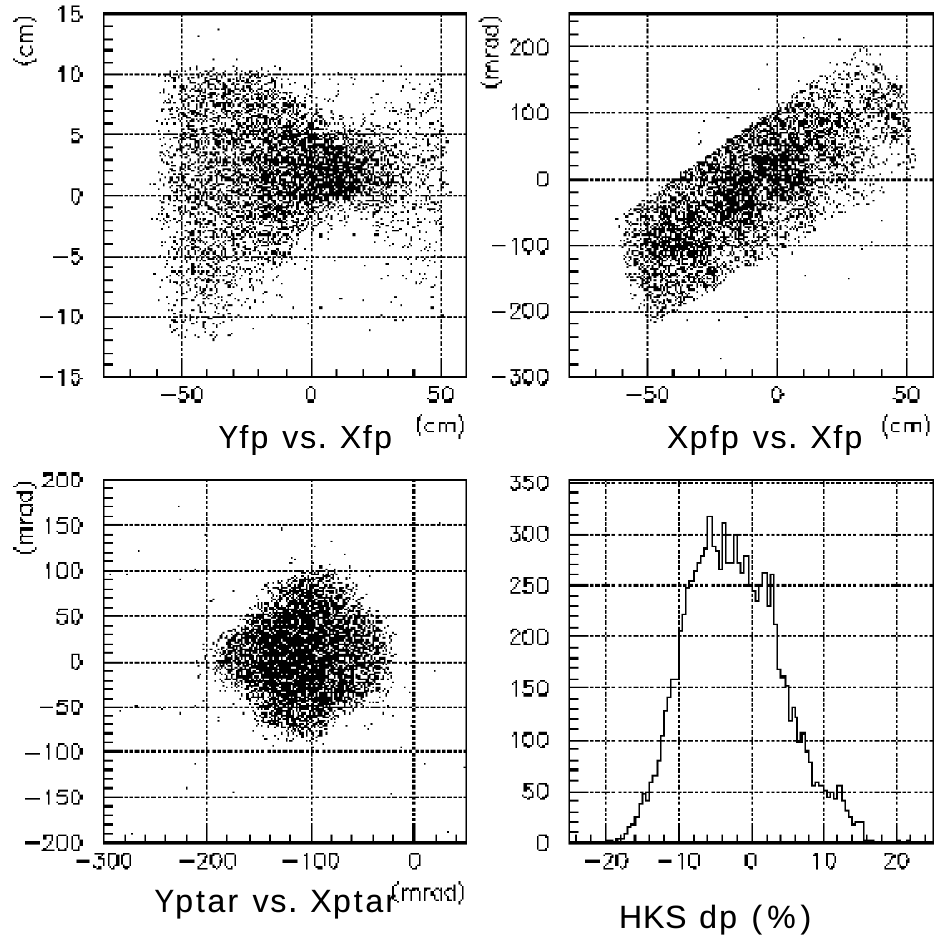
- Select 2ns real coin time window
- Signal/accidental ratio: 12C (24 uA):~0.76





HKS Acceptance

- HKS accetance consistent with expectation

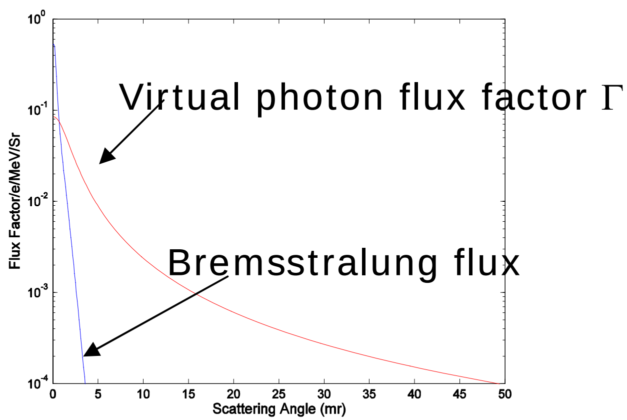


Enge Acceptance

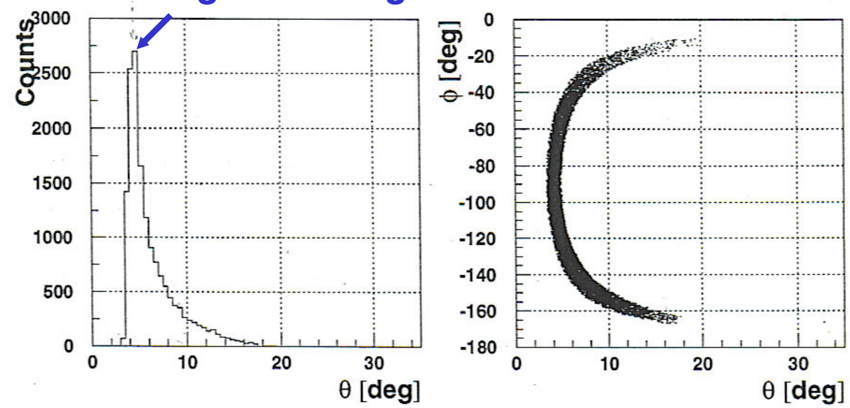
- *Integrated Virtual Photon acceptance (physics yield) reduced (factor of 5-8?) due to mismatch of field setting of Enge and Splitter.*

- *Original design: Splitter 1.546 T, Enge 1.45 T*

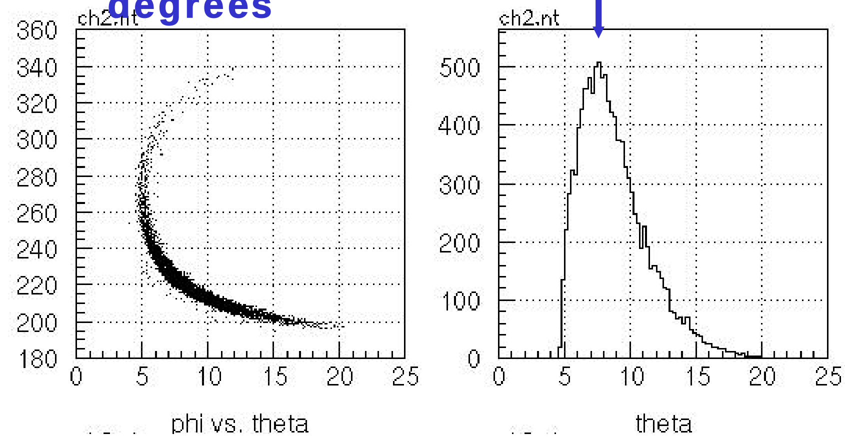
- *Reality: Enge 1.5685 T(8% up), Splitter field at midpoint of e' central: 1.55 T, Hall Probe reading:* 1.672 T (8% up)



Peaked at 4.5 degrees – forward angle for high VPF

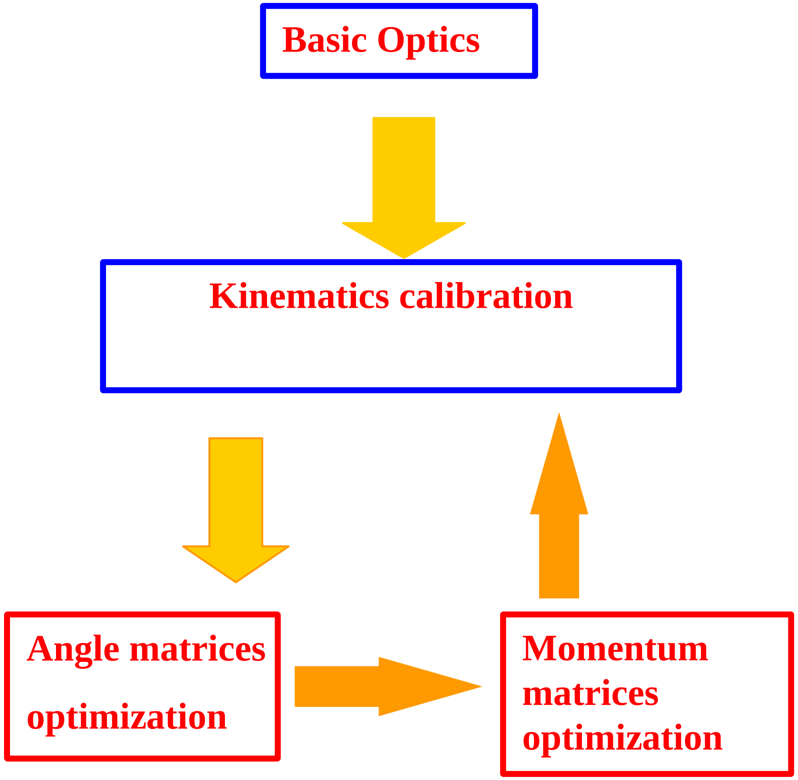


E' scattering angle centered at 7.5 degrees



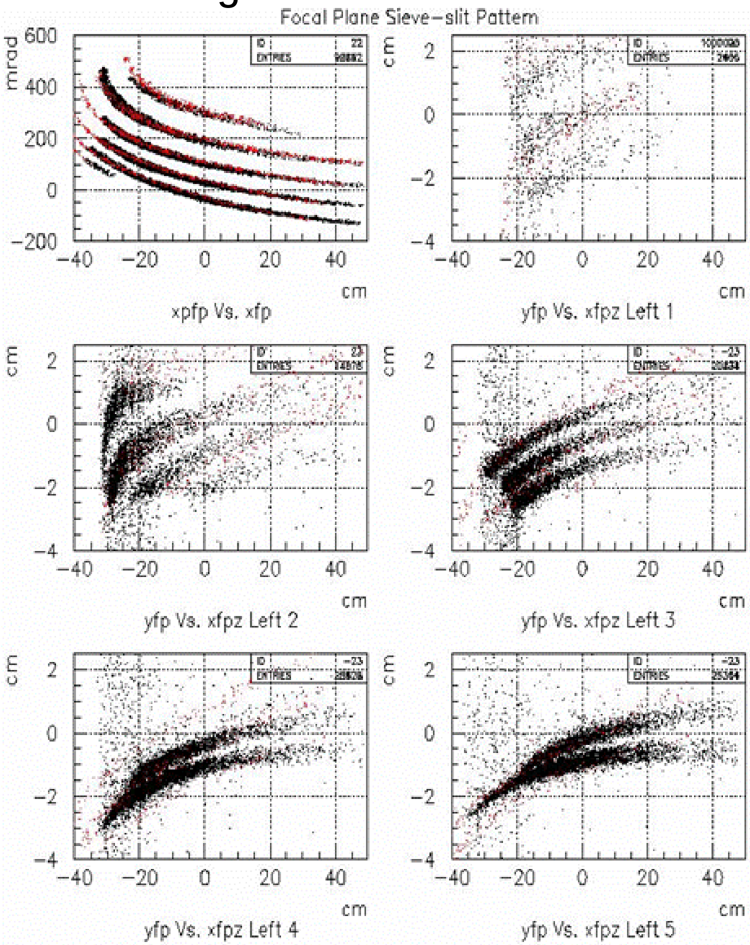
Spectrometer Calibration Procedure

- Find the basic optics through GEANT (for HKS) and Raytrace (for Enge) simulation
- Separate Enge and HKS Sieve Slit calibration: angle reconstruction matrices
- Kinematics calibration: beam energy, e' and K+ central momentum (including beam energy shift and energy loss corrections for CH2 data)
- Two arm momentum calibration using known masses of Λ,Σ from CH2 target and $^{12}{}_{\Lambda}$B gs.
- Iteration...

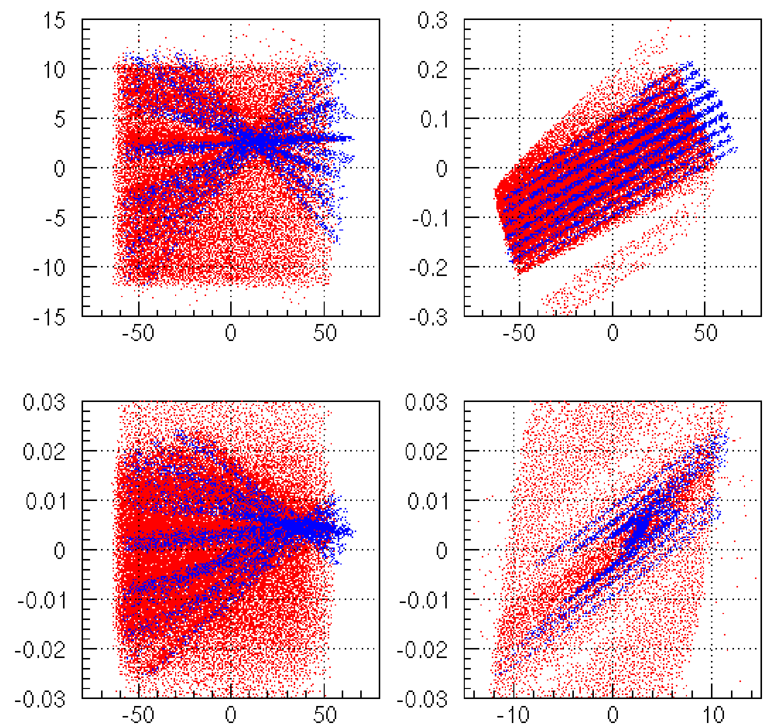


Comparison of Sieve Slit Patterns at FP

Enge Focal Plane Pattern



HKS Focal Plane Pattern

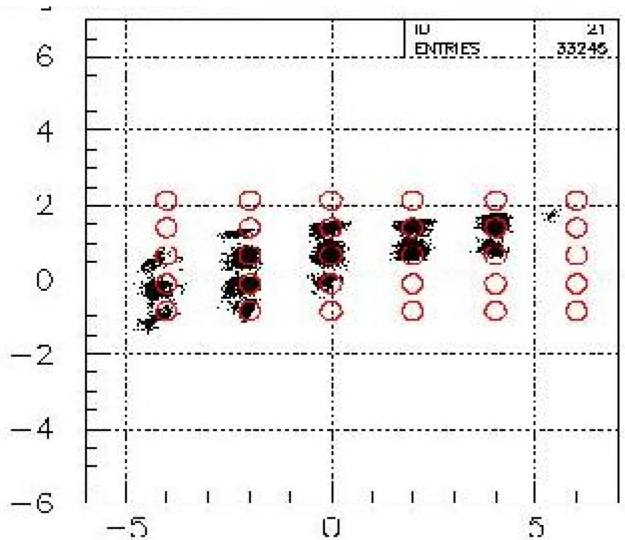


Sieve Slit Calibration

- Sieve slit angle selection depends on particle momentum and splitter field.

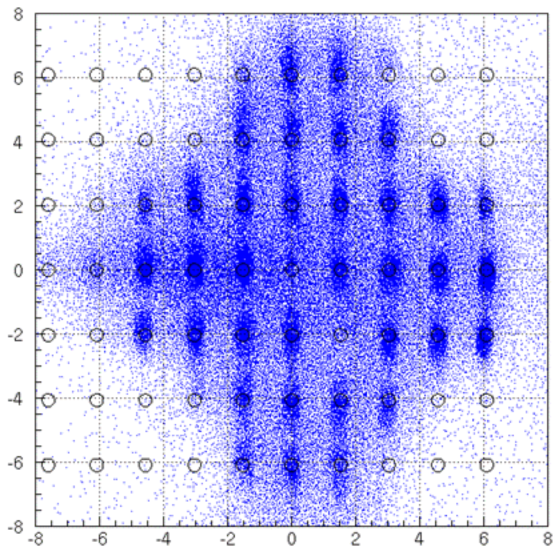
$$X'tar = F_{s2t}(dp, Xsv, Ysv)$$

Enge Sieve Slit Pattern



Y vs. X at ss plate (cm)

HKS Sieve Slit Pattern

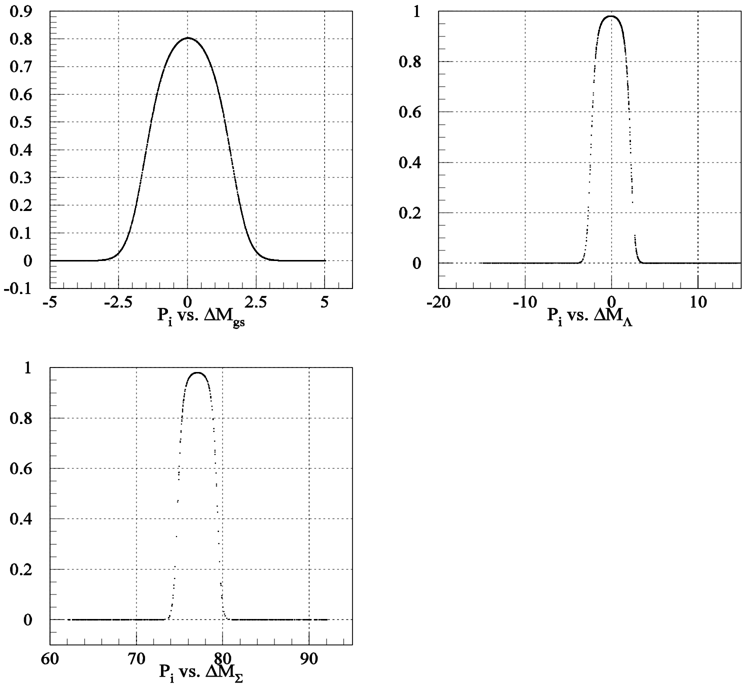


Y vs. X at ss plate (cm)

Momentum Calibration

- Iteratively re-weighted Least-square in the presence of high accidental background:

Sample assignment probability pi as functions of Δm_i

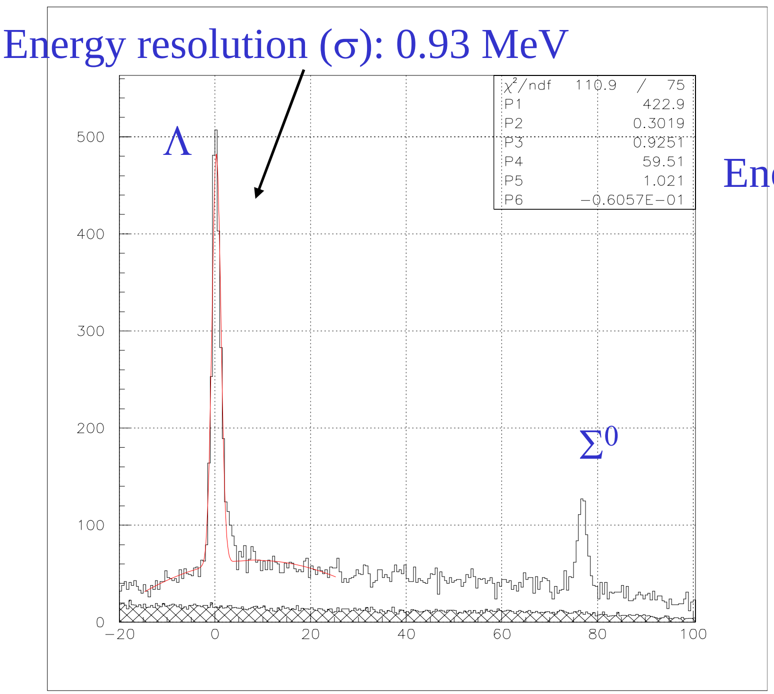


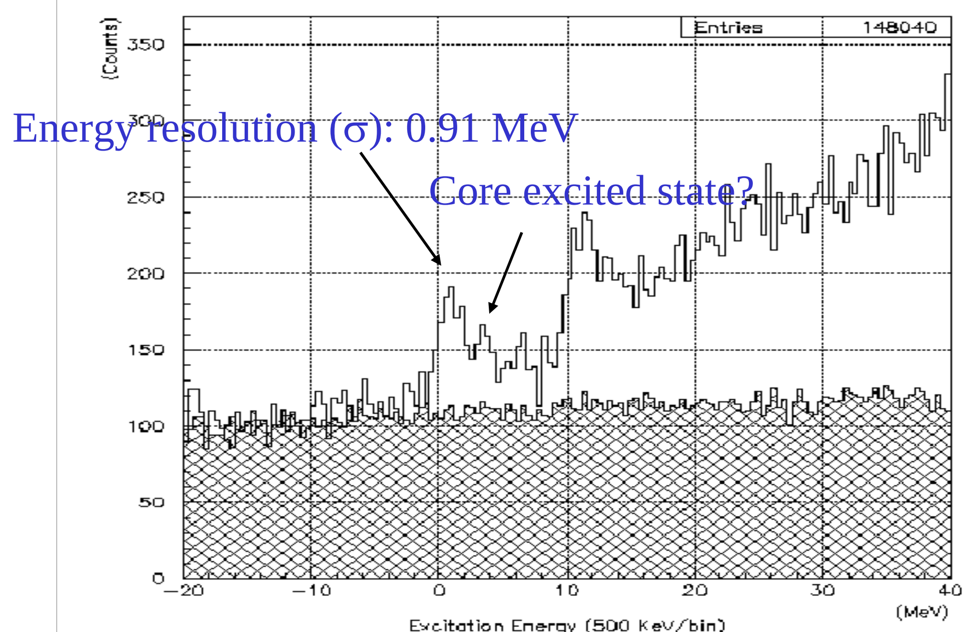
$$Chi^2 = \Sigma_i (w_i \Delta M_i^2 p_i')$$
$$= \Sigma_i [w_i(f(x_i, \{M_{dp}\}) - M^{PDB})^2 p_i']$$

P_i', the assignment probability, function of Δm_i, M_{dp}: matrix elements for δp

Current Λ,Σ^0 and ${}^{12}_{\Lambda}B$ Spectra

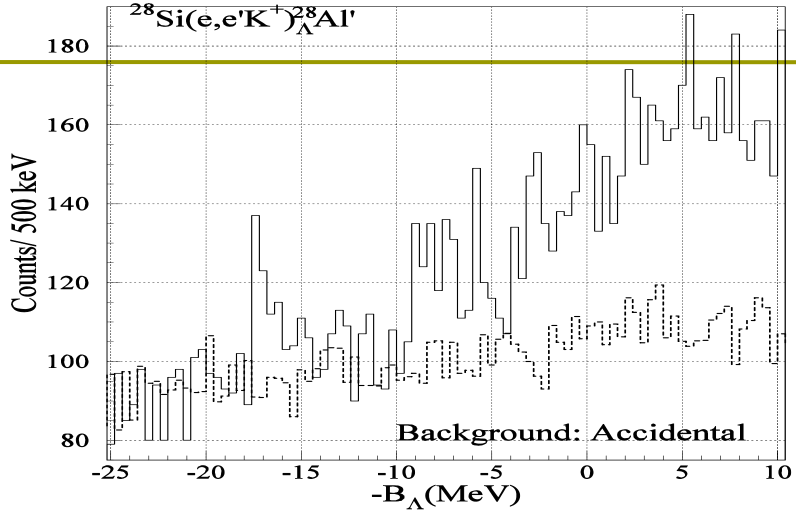
- 12C target: partial data (~90 hrs out of 110 hrs 30 uA equivalent)



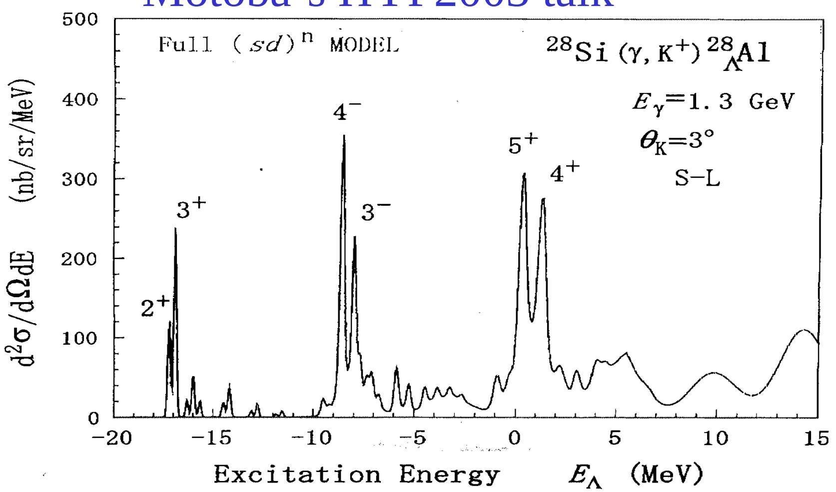


Current $^{28}{}_{\Lambda}$Al Spectrum

- Partial data: 170 hrs 13 uA equivalient (214 hrs total)

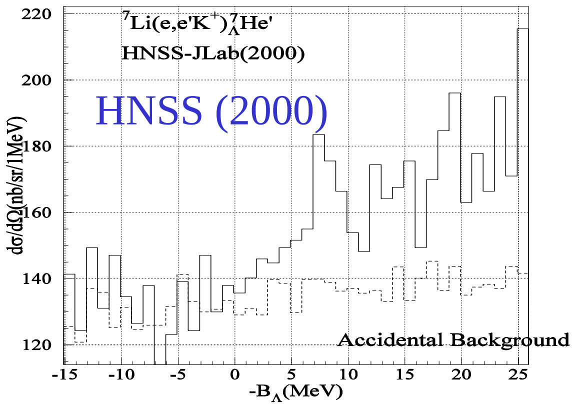


Motoba's HYP2003 talk

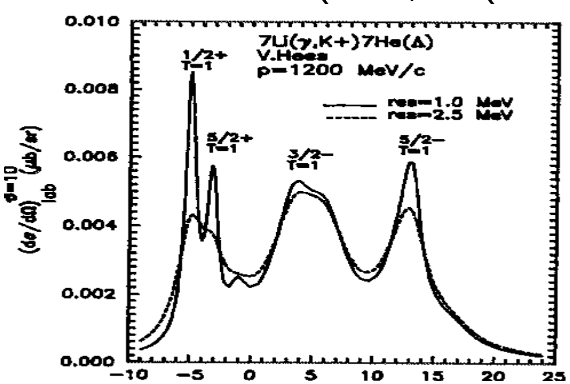


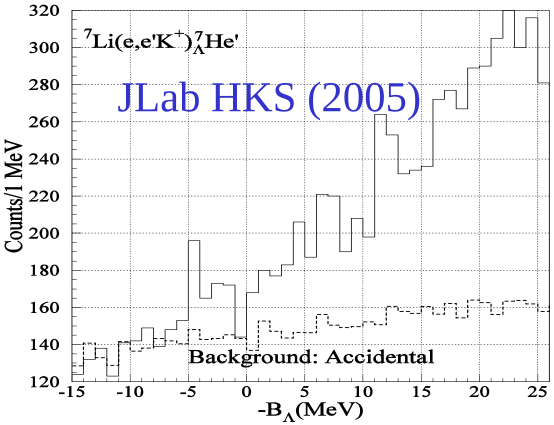
Current $^{7}_{\Lambda}$He spectrum

- Indication of $^{7}_{\Lambda}$He ground state at B_{Λ} = 5 MeV
- Peak structure at $-B_{\Lambda}$~7 MeV consistent with observation of HNSS spectrum



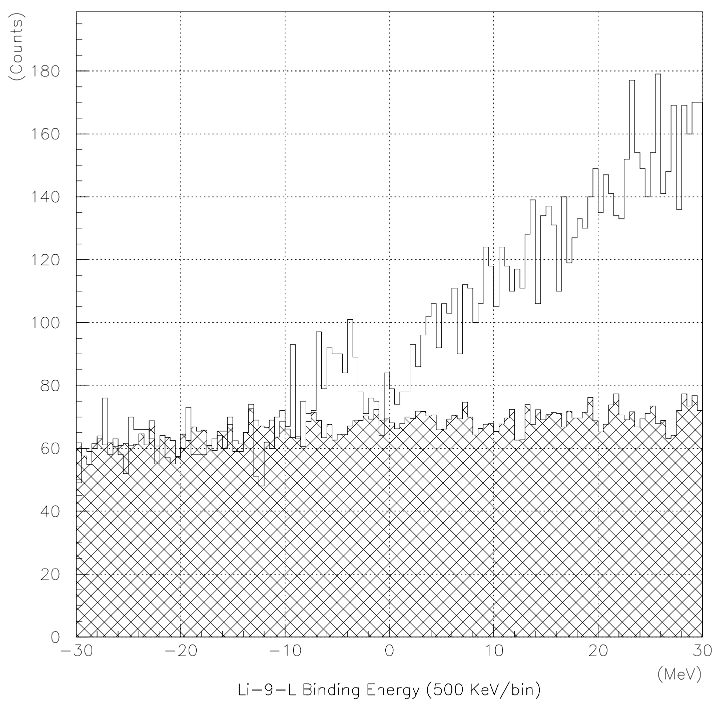
Richter's calculation (PRC, 43(2753))





Current $^{9}{}_{\Lambda}$Li Spectrum

- Indication of bound states



Future Work for Data Analysis

- Spectrometer calibration
- Yield study to determine the source of yield loss (Enge acceptance, detector efficiencies…)
- More detailed detector calibration