Modification
(Hall-A → Hall-C)

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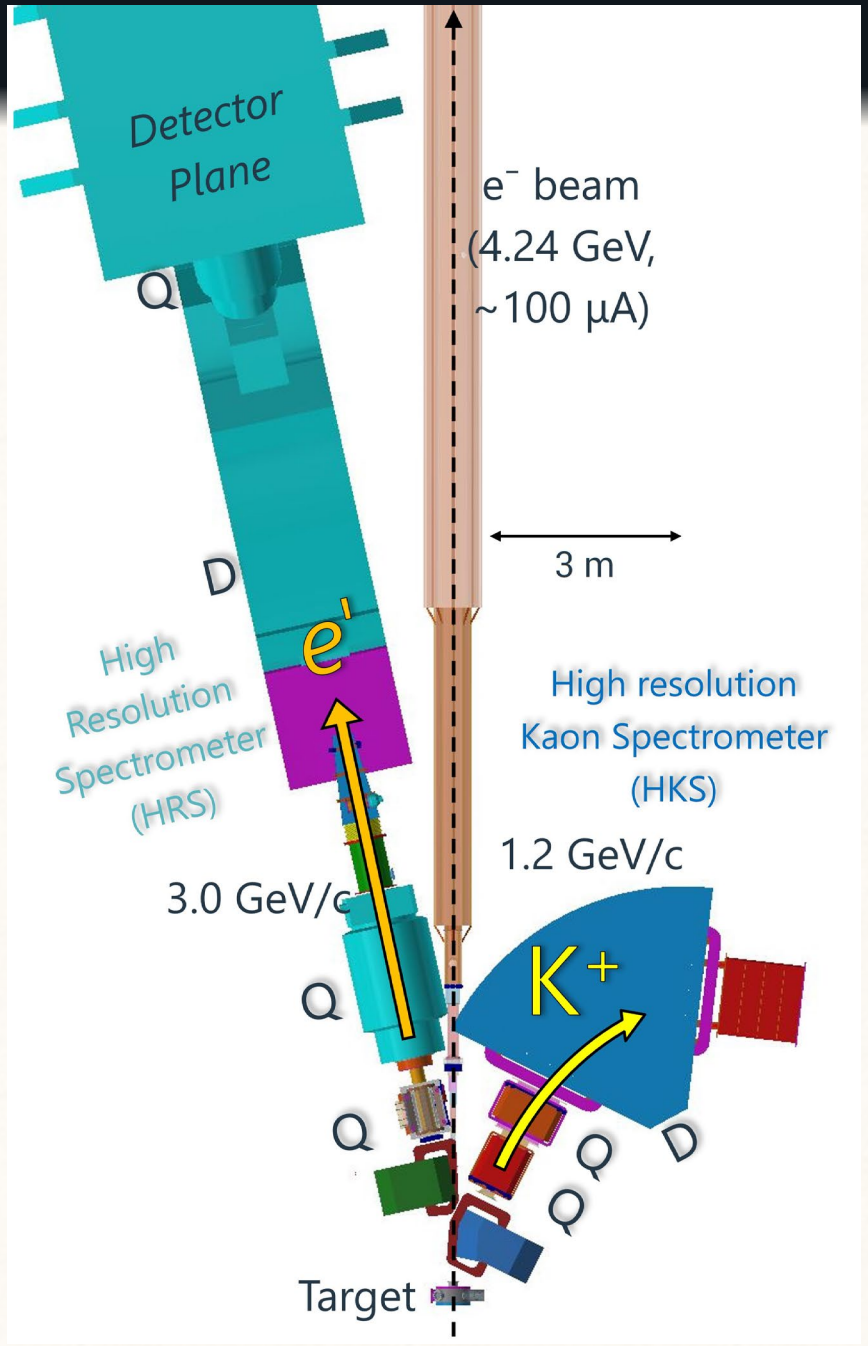
Contents

- Setup plan of original proposal and Hall-C exp.
- Modifications
- Update of Yield, Resolution, Background estimation
- Summary

Original Setup (Hall-A)

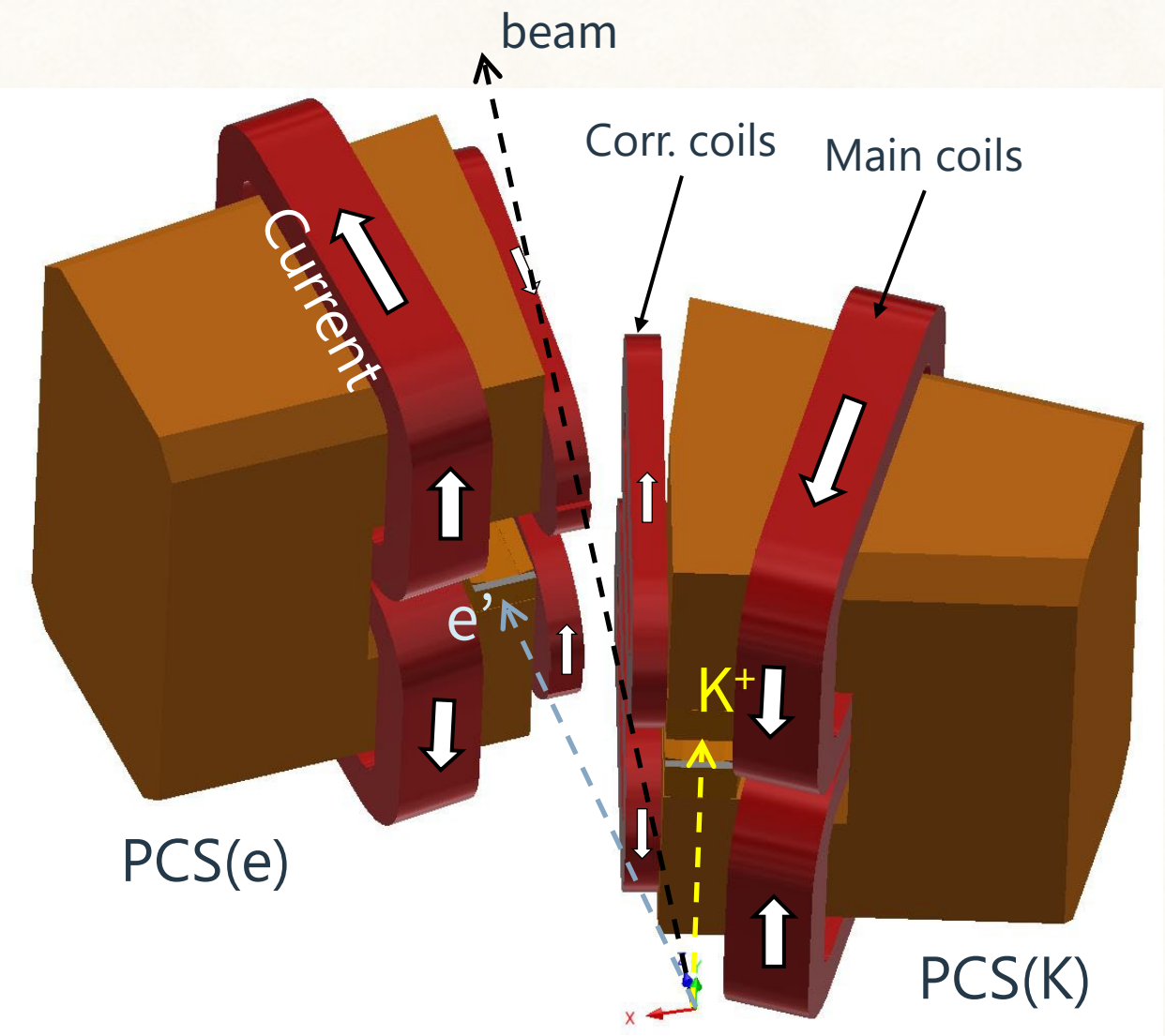


Beam Energy	4.24 GeV (2-pass)
Beam Intensity	50 / 25 μA for ^{40,48}Ca / ^{208}Pb
Beamtime	21 / 20 PAC days for ^{40,48}Ca / ^{208}Pb

	Scattered Electron	Associated Kaon
Momentum	2.74 GeV/c	1.2 GeV/c
Spectrometer	PCS(e') + HRS	PCS(K^+) + HKS
Angle	6.5 deg	14 deg
$\Delta p/p$	1×10^{-4}	3×10^{-4}
Solid Angle	5 msr	8 msr
Bending	Vertical	Horizontal
Δz (rms)	1 cm	N/D

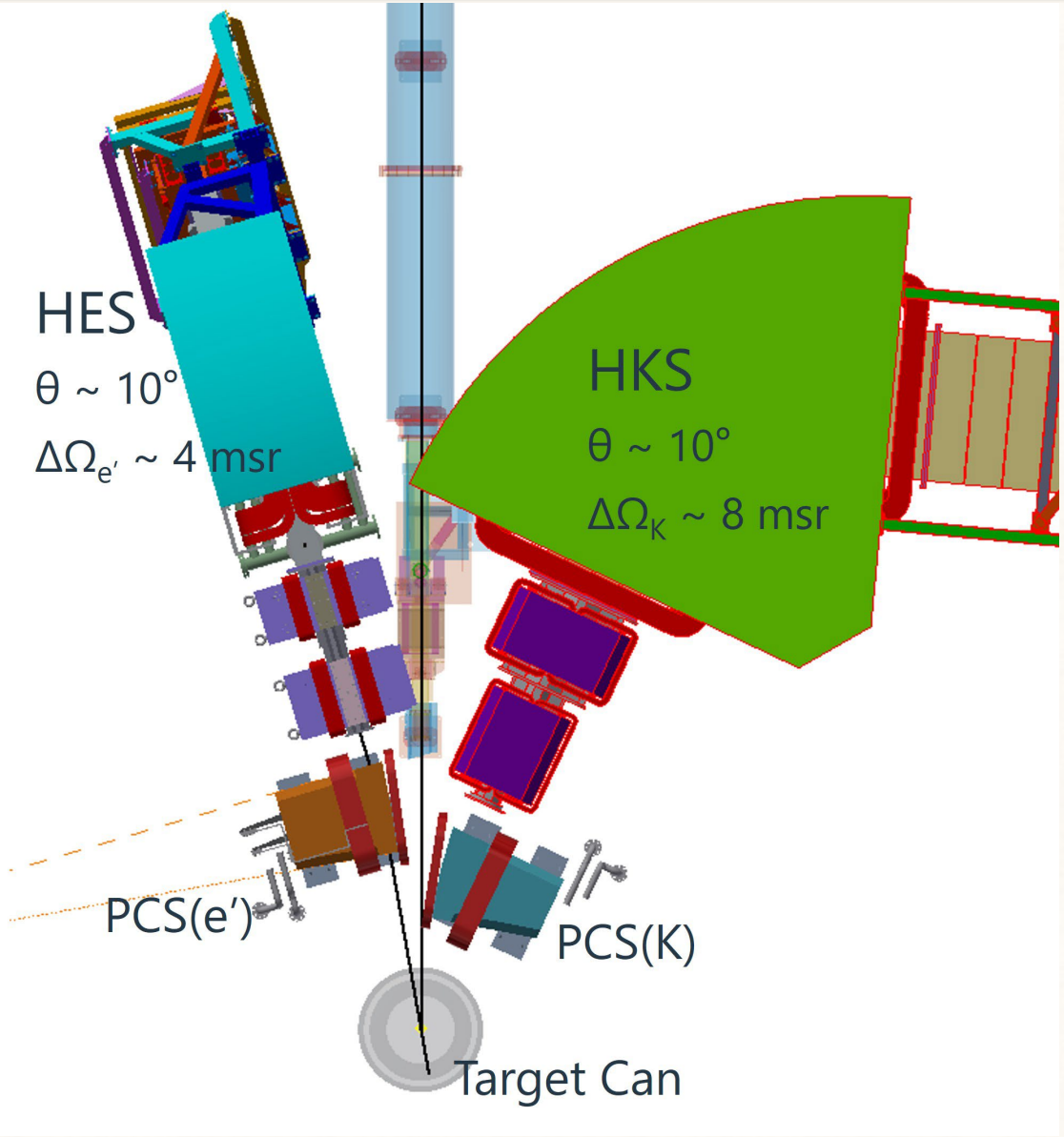
Mass resolution : 0.8 MeV/c^2

Particle Charge Separator (PCS)



		PCS(K)	PCS(e)
Weight		7.8 t	8.0 t
Max. Field		1.3 T	
Main Coil	Geometry	16×16 / Φ10	
	Turns	96 / coil	
	Current	1700 A	
	Voltage	106 V / each mag.	
	Δt	20°C	
Corr. Coil	Geometry	14×9 / 10×5	
	Turns	88 / coil	
	Current	1000 A	
	Voltage	97 V / each mag.	
	Δt	11°C	

New setup (Hall-C)



Beam Energy **2.24 GeV** (1-pass) *

Beam Intensity 50 / 25 μA for ^{40,48}Ca / ^{208}Pb *

* To be updated

	Scattered Electron	**Associated Kaon**
Momentum	**0.74 GeV/c** **	1.2 GeV/c
Spectrometer	PCS(e') + **HES**	PCS(K^+) + HKS
Angle	**10 deg**	10 deg
$\Delta p/p$	5×10^{-4}	3×10^{-4}
Solid Angle	4 msr	8 msr
Bending	Vertical	Horizontal
Δz (rms)	2-3 cm	N/D

** HES central momentum could be adjusted up to 0.85 MeV/c.
This corresponds to ~2.35 GeV of beam energy.

Mass resolution : 0.6 MeV/c^2

What to be modified

- **Yield, Resolution, Background**

  At least one spectrometer HRS must be changed. Expected hypernuclear yield, peak resolution, background condition will be change.

- **Vertical Bending Spectrometer**

  Z position reconstruction is very important to measure hypernuclear peaks with good resolution. Vertical bending spectrometer provides z information.

- **Connection of PCS(e')**

  PCS(e') was designed to connect with HRS. PCS vacuum and sieve collimators must be updated. Optics of e' arm also must be updated.

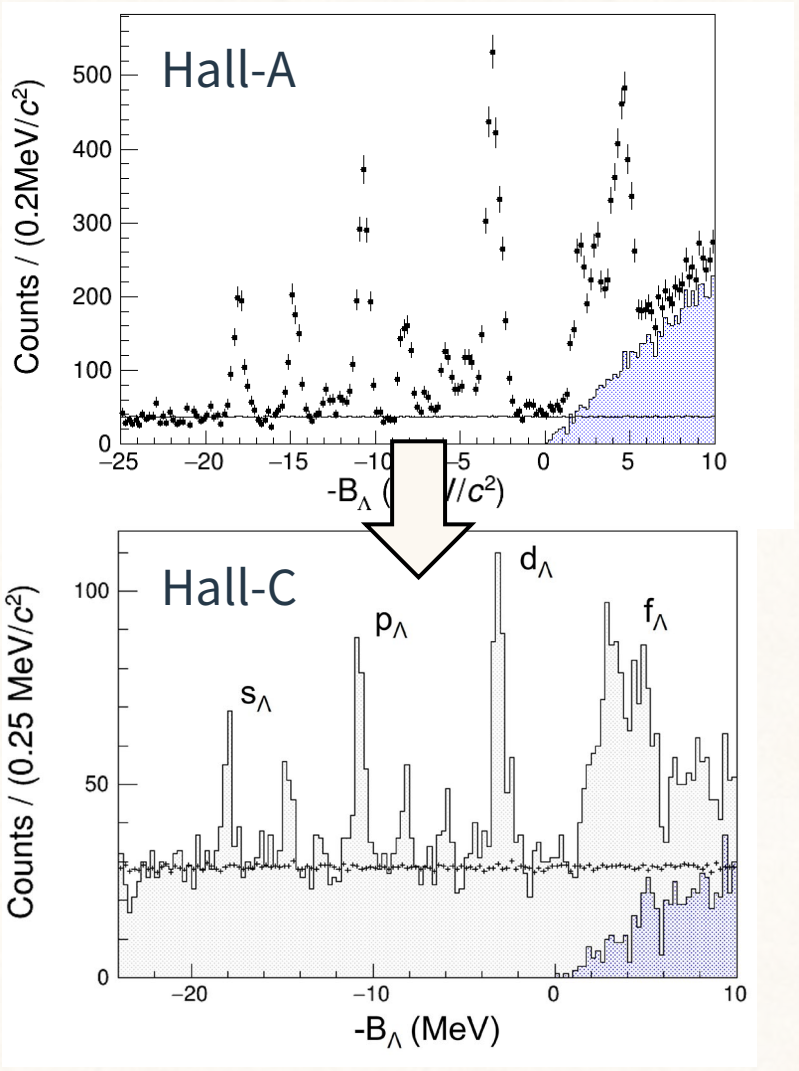
- **PCS Power Supply**

  PCS powers which are 1700 A / 120 V for Main coils and 1000 A / 110 V for collection coils. SBS power supply was planned in the Hall-A experiment.

- **Target Can**

  Target mounter system is necessary. This part doesn't change a lot with the Hall-A experiment.

Expected $^{40}_{\Lambda}$K spectrum



Yield Estimation

$$Y = N_e \times \int \Gamma(E,\theta) \times f(Q^2) \times \epsilon_{e'} \times N_t \times \frac{d\sigma}{d\Omega_K} \times \Delta\Omega_K \times \epsilon_K \times t$$

Geant4 (over $\Gamma(E,\theta)$) — HES / HRS

Geant4 (over $\Delta\Omega_K$) — HKS

Hypernuclear yield would be decreased by a factor of "1/3" due to the smaller VP flux.

$\Gamma(E, \theta) = (5.0 \times 10^{-6}) / (1.5 \times 10^{-5}) = 1/3$

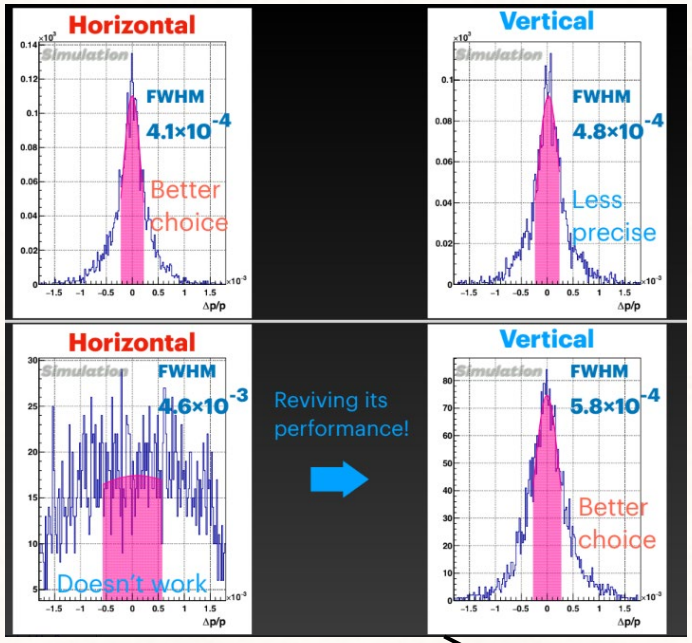
Beam energy effect: ×0.8
e' Angular effect: ×0.4

	$^{3}_{\Lambda}$H	$^{4}_{\Lambda}$H	$^{6}_{\Lambda}$He	$^{11}_{\Lambda}$Be	$^{12}_{\Lambda}$B	$^{40}_{\Lambda}$K	$^{48}_{\Lambda}$K	$^{208}_{\Lambda}$Tl
Target Thickness (mg/cm^2)	165	228	100			77.5		100
Beam Current (μA)	20	20	50					25
Beamtime (days)	25	5	1.2	1.2	1.5	9.6	11.7	20
g.s. Yield (Counts)	**260**	**220**	**20**	**10**	**120**	**100**	**100**	**40**

Hyper yields are less than the original values. Improvements are now studying...

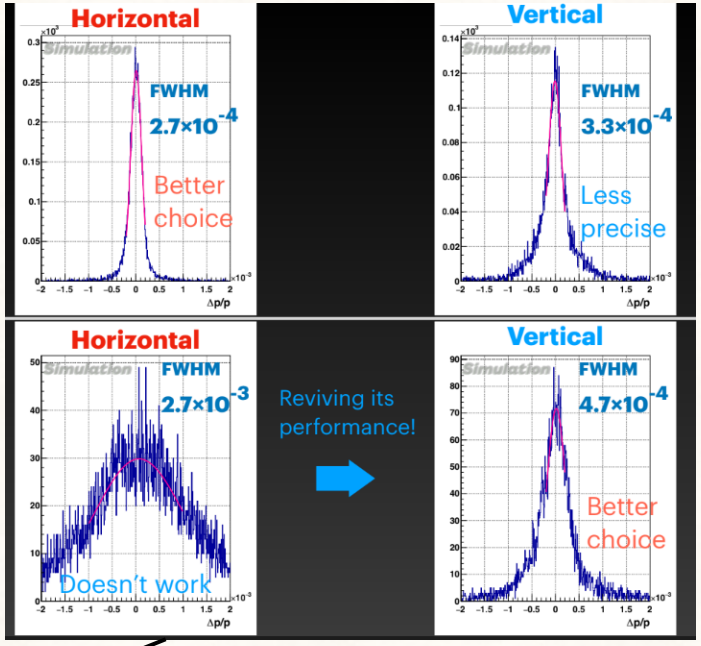
Resolution

HES momentum resolution



Ishige's talk Tomorrow

HKS momentum resolution



$$B_\Lambda = M_{\mathrm{core}} + M_\Lambda - \sqrt{(E_e + E_N - E_K - E_{e'})^2 - (\vec{p_e} - \vec{p_K} - \vec{p_{e'}})^2}$$

Missing Mass resolution could be estimated with Monte-Carlo simulation.

Typical mass resolution is expected to be 0.6 MeV/c^2 (solid targets), 1 MeV/c^2 (gas targets) in FWHM.

Background Estimation

$$N_{acc} = \underline{R_{e'}} \times \underline{R_K} \times T_{gate} \times t$$

2 ns

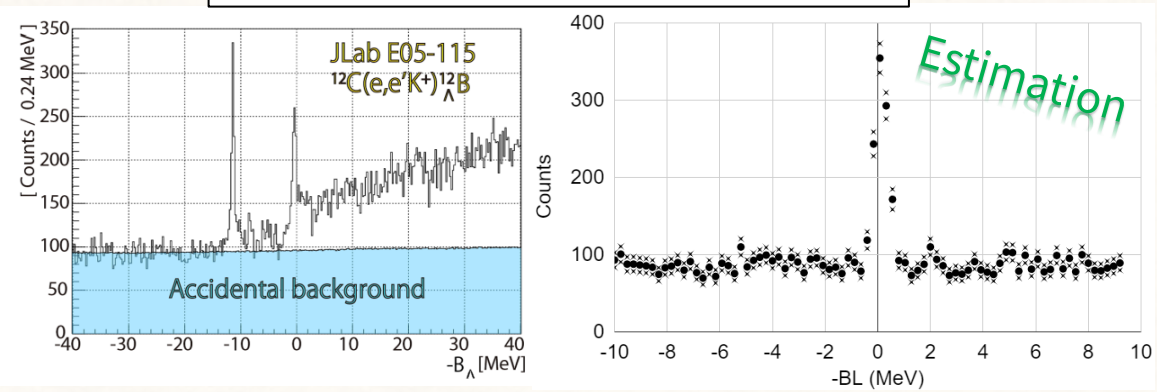
NOTE: "E05" superscripts mean $^{10}_{\Lambda}$Be results of E05-115.

$$R_{e'}^{E05} \times \underbrace{\frac{d\sigma_b(E_e, E_{e'}, \theta_{e'}) \times \Delta\Omega_{e'} \times I \times N_t}{[d\sigma_b(E_e, E_{e'}, \theta_{e'}) \times \Delta\Omega_{e'} \times I \times N_t]^{E05}}}_{\textbf{Scaling = 0.02}} \quad \sigma : \times 0.05,\ \Delta\Omega: \times 0.6$$

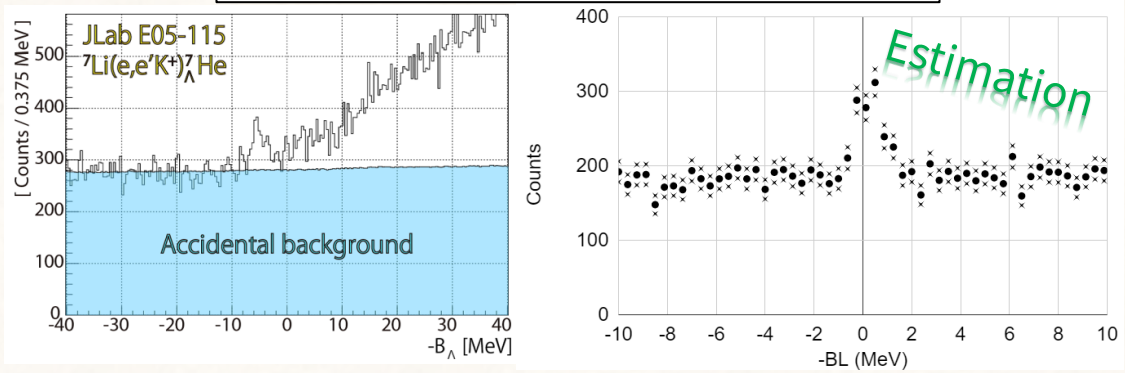
$$\underbrace{\left(\frac{R_K^{E05}}{\epsilon_{PID}^{E05}} - R_{e^+}^{E05}\right)}_{\pi^+, K^+, p \text{ rate}} \times \underbrace{\frac{\Delta\Omega_K \times I \times N_t}{[\Delta\Omega_K \times I \times N_t]^{E05}}}_{\text{Scaling} = 0.9} \times \underbrace{\epsilon_{PID}}_{0.9}$$

The procedure can reproduce single-rate, S/N etc. for other target results of E05-115 well (~30% precision).

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



^{7}Li(e,e'K$^+$) $^{7}_{\Lambda}$He (High-rate run)

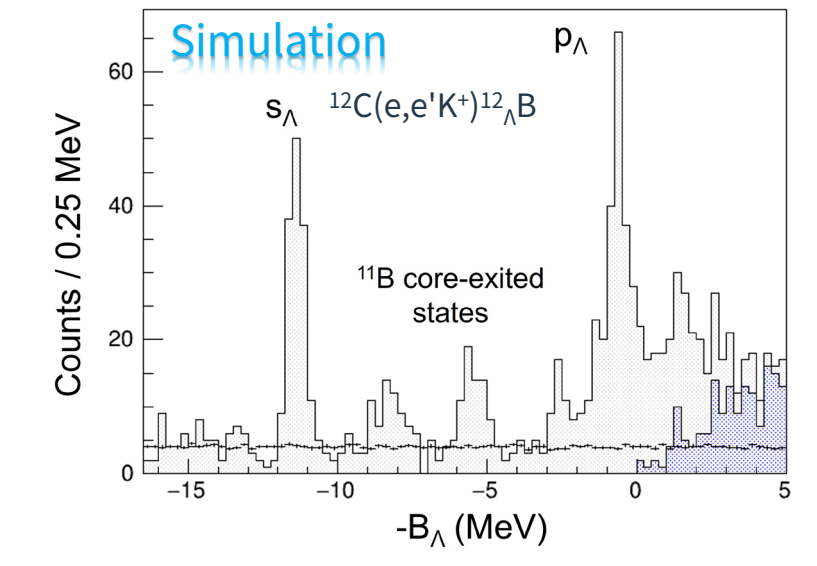


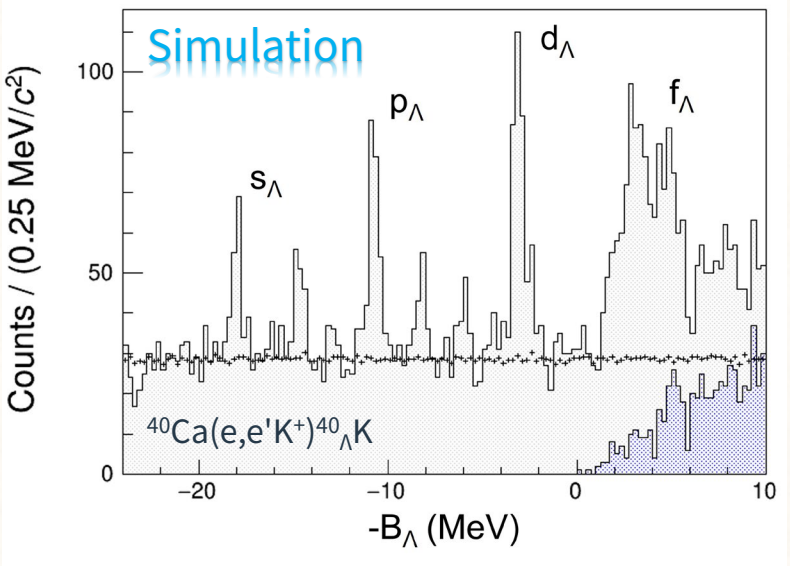
Expected Yield, Rate

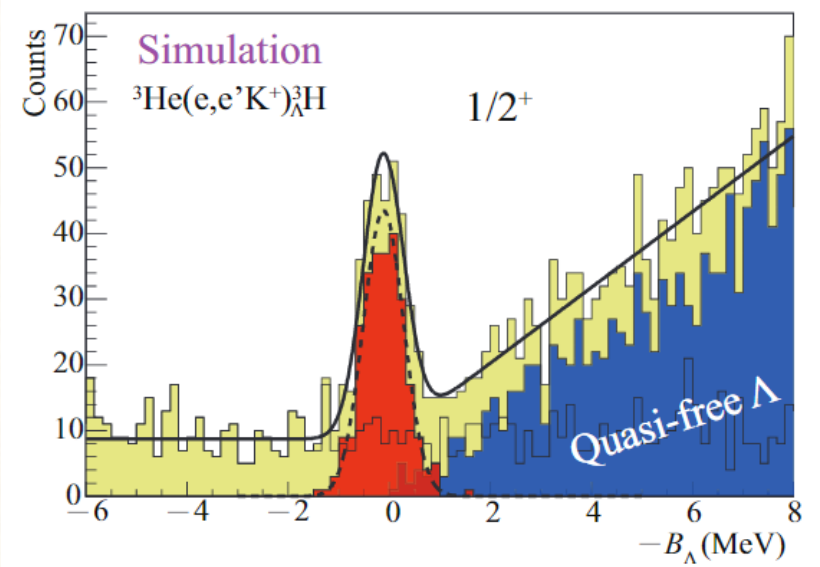
	^{3}He target	^{12}C target	^{40}Ca target	^{208}Pb target
Target Thickness (mg/cm2)	165	100	77.5	100
Beam Current (μA)	20	50	50	25
Beamtime (days)	25	1.5	9.6	20
Hypernuclear Yield (cts)	**260**	**120**	**100**	**40**
Mass Resolution (MeV/c^2)	**1**	**0.6**		
HES rate (kHz)	**600**	**100**	**240**	**460**
HKS rate (kHz)	**100**	**46**	**30**	**15**
Coin Trigger rate (Hz)	160	25	39	38
Peak Significance (S/√N)	7	7	4	2

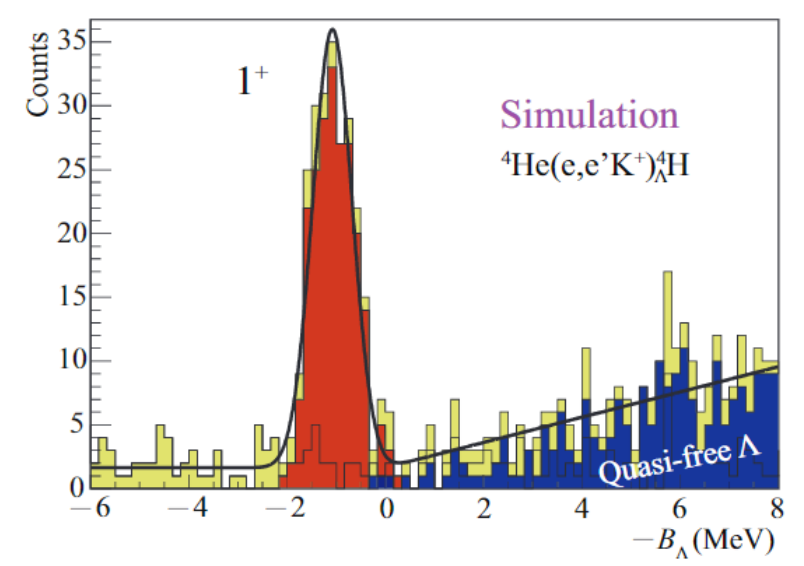
Single rates in both spectrometer would be much more relax than those of E05-115 (several MHz) thanks to larger e' opening angles and background separation with PCSs.

Expected Spectrum (Solid target)









Summary table

		Hall-A	Hall-C
Beam	Energy	**4.24 GeV**	**2.24 GeV**
	ΔE/E	1×10^{-4}	
e'	Spectrometer	**PCS(e') + HRS**	**PCS(e') + HES**
	p	**2.74 GeV/c**	**0.74 GeV/c**
	Δp/p	1×10^{-4}	5×10^{-4}
	ΔΩ	6 msr	4 msr
	Rate (^{40}Ca)	11 kHz	240 kHz
K^+	Spectrometer	PCS(K^+) + HKS	
	p	1.2 GeV/c	
	Δp/p	3×10^{-4}	
	ΔΩ	8 msr	
	Rate (^{40}Ca)	30 kHz	
Data	**Yield (^{40}Ca)**	**32 cts / day**	**10 cts / day**
	Acc. rate	**1.7 Hz**	**39 Hz**
	S/N	**23**	**0.37**
	Mass Resolution	**0.8 MeV/c^2**	**0.6 MeV/c^2**

Summary

- Setup plan of original proposal and Hall-C exp.

  HRS → vertical bending HES is really challenging.

- Modifications

  Simulation update, vertical bending HES support, connection of HES and PCS, Power supply, and Target design.

- Update of Yield, Resolution, Background estimation

  Yield will be 1/3.

  Resolution will be 20 % better.

  Background will be 10 times more than original proposal, 10 times less than E05-115.