Target Meeting
(JLab Hypernuclear Experiments)

Graduate School of Science, Kyoto University
Toshiyuki Gogami

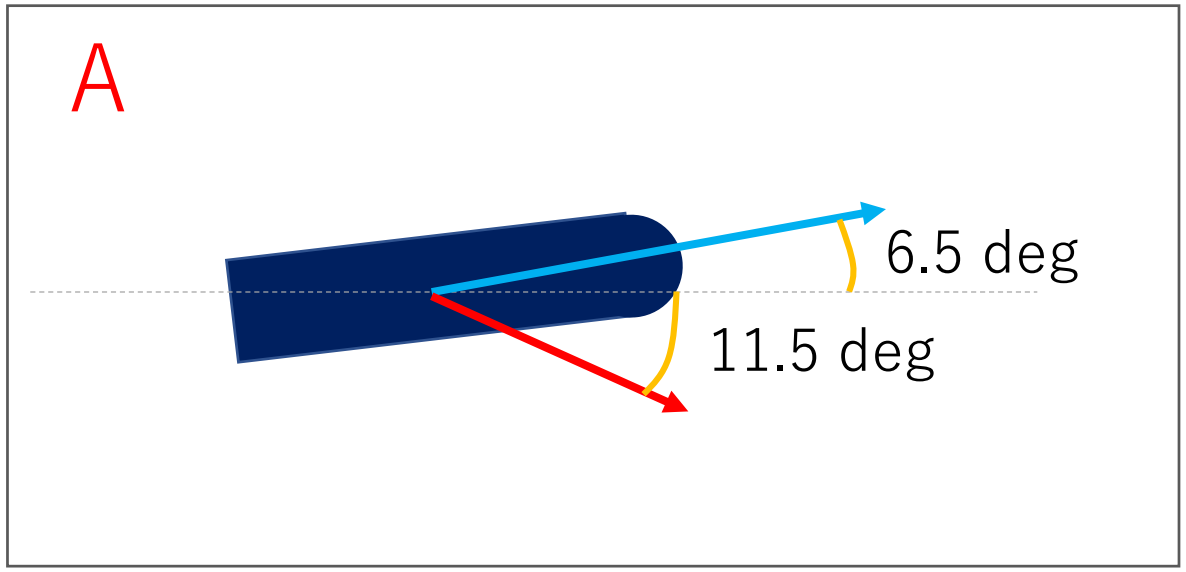
January 8, 2021

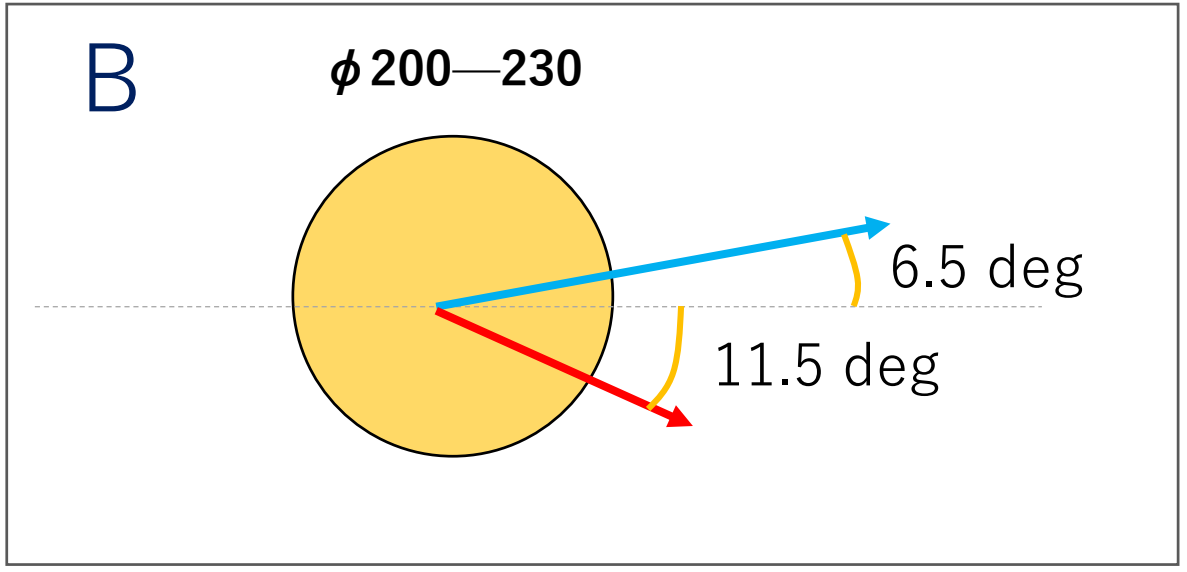
京都大学
KYOTO UNIVERSITY

科研費
KAKENHI

SPIRITS
SUPPORTING PROGRAM FOR INTERACTION-BASED INITIATIVE TEAM STUDIES

Two ideas for target cell





Configuration	Path length in cell	Uniformity
A. Cigar 0.3 mm + 6.5 deg tilt	e' : 0.3 mm K^+: 0.97 mm	△ (?)
B. Tuna 1.5 mm	e': 1.5 mm K^+: 1.5 mm	○ (?)

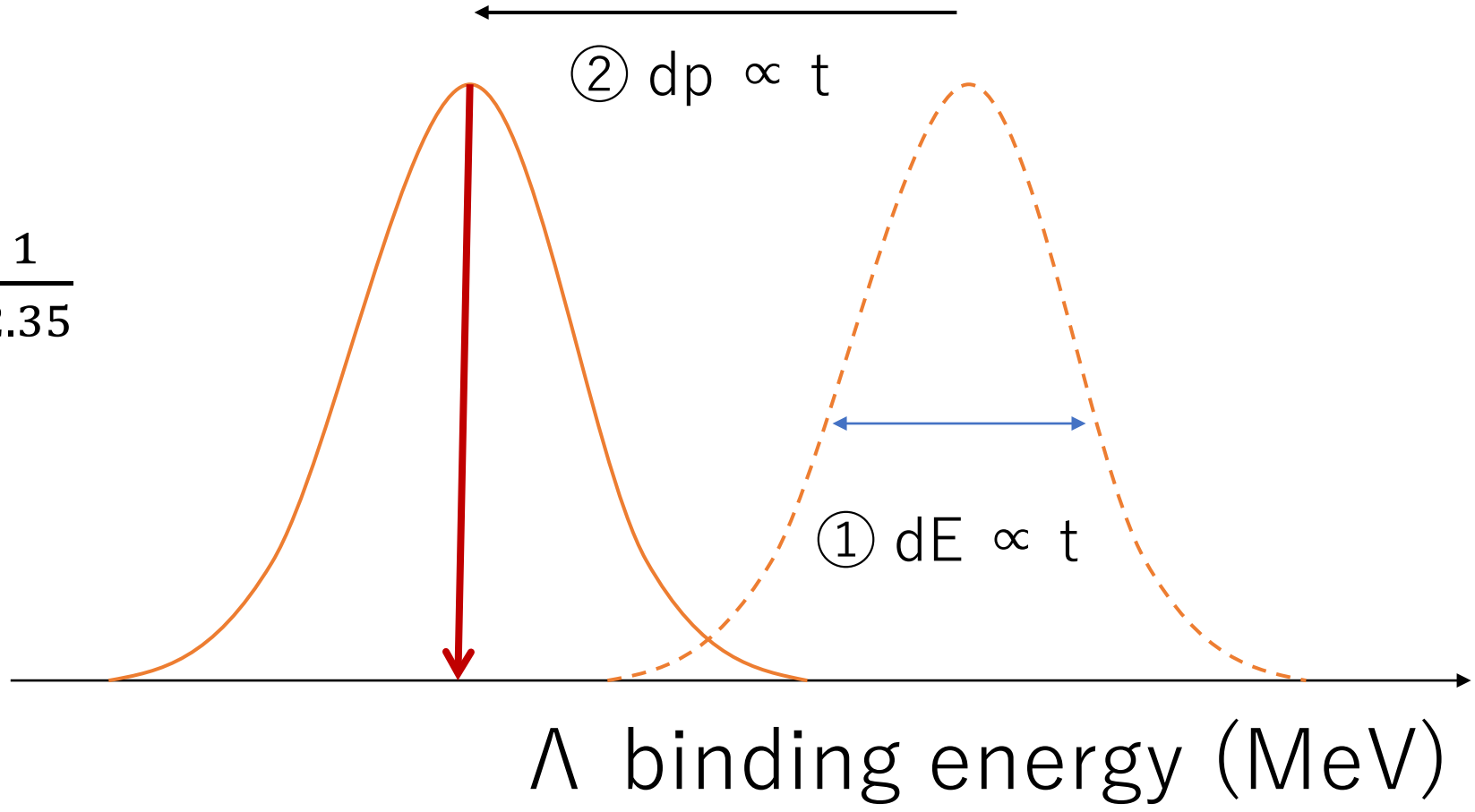
How target material impact a physics result

① Energy resolution

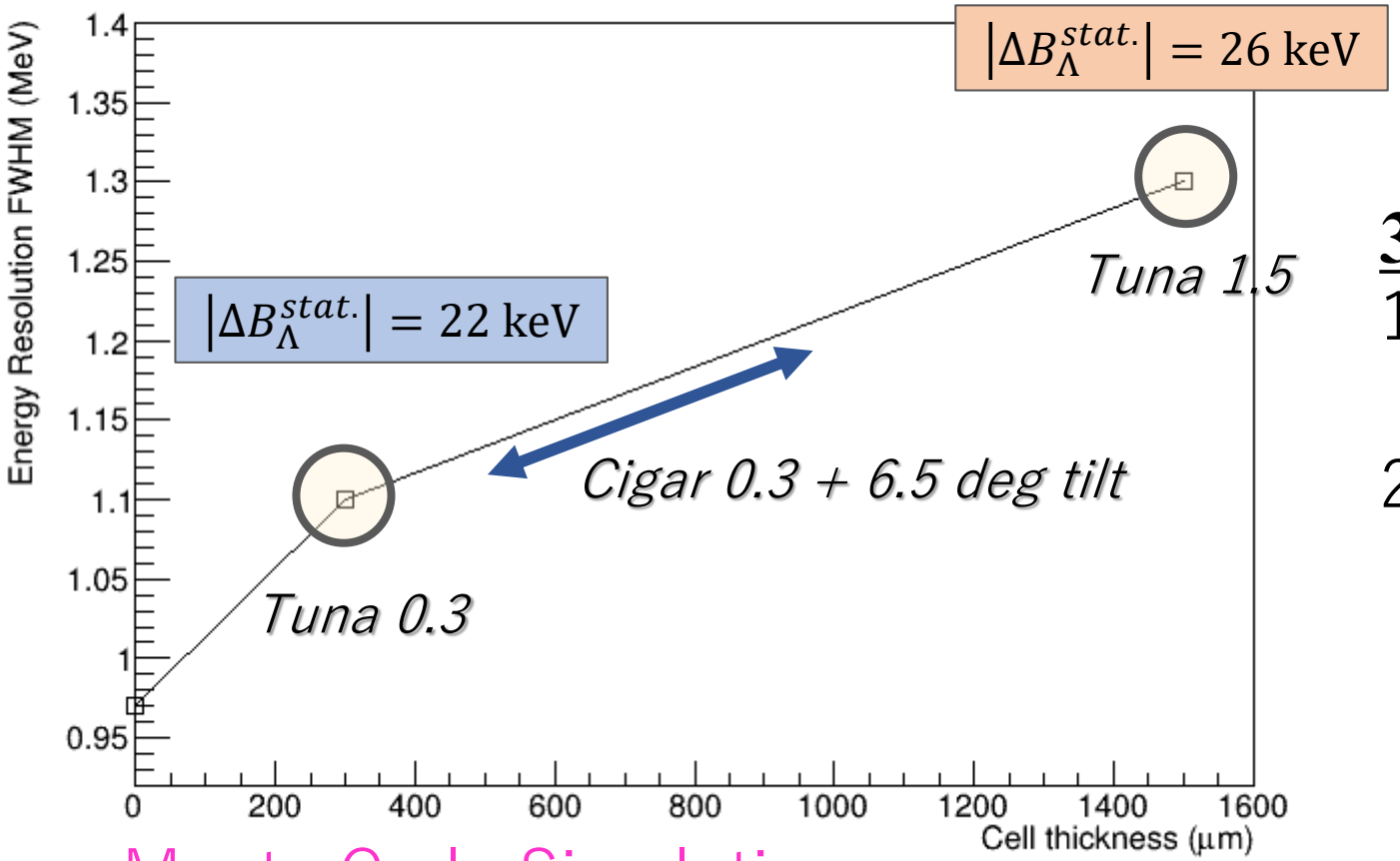
→ $\left|\Delta B_{\Lambda}^{stat.}\right| = \frac{FWHM}{\sqrt{N}} \times \frac{1}{2.35}$

② Energy loss correction

→ $\left|\Delta B_{\Lambda}^{sys.}\right|$



$|\Delta B_{\Lambda}^{stat.}|$ deterioration due to a thicker cell wall (Tuna 0.3 → 1.5 mm)



Monte Carlo Simulation

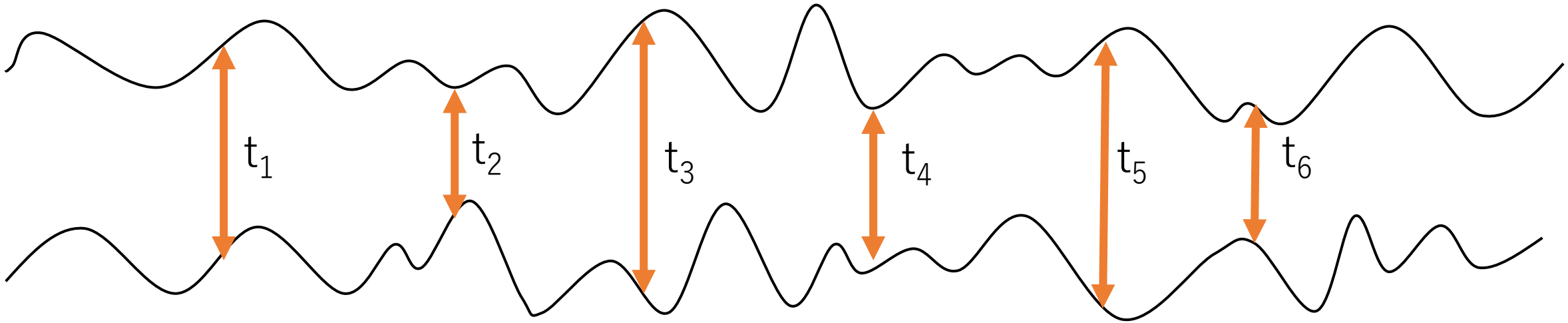
based on K.N. Suzuki's (Kyoto Univ.) Geant4 simulation
(https://www-nh.scphys.kyoto-u.ac.jp/~gogami/e12-17-003/meeting/analysis/src/JLabMeeting_20210107_suzuki.pdf)

300 μm thick → 1500 μm thick:

1. MM resolution
   - 1.1 → 1.3 MeV
2. Statistical error $|\Delta B_{\Lambda}^{stat.}|$
   - 22 → 26 keV

Negligibly small impact

Thickness uncertainty → $|B_{\Lambda}^{dp:sys.}|$



Average of measurements: $\overline{t_m} = \frac{1}{N}\sum_{i=1}^{N} t_i$

vs.

"Real" mean thickness: $\overline{t_r}$

Thickness uncertainty → $|B_\Lambda^{dp:sys.}|$

Ex.) In the tritium ($nn\Lambda$) experiment (2018):

- T_2: $\frac{\sigma}{t_m} = 9\% \rightarrow |B_\Lambda^{dp:sys.}| \sim 130\ \mathrm{keV}$
- H_2: $\frac{\sigma}{t_m} = 24\% \rightarrow |B_\Lambda^{dp:sys.}| \sim 400\ \mathrm{keV}$

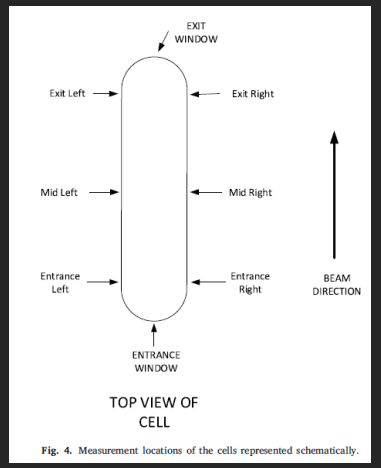


Fig. 4. Measurement locations of the cells represented schematically.

Table 2
Cell wall thickness measurements for different cells as measured by a Hall effect thickness gauge.

Location	^{40}Ar/Empty cell thickness (mm)	^{3}H Cell thickness (mm)	^{1}H Cell thickness (mm)	^{2}H Cell thick (mm)	^{3}He Cell thickness (mm)
Entrance	0.254 ± 0.005	0.253 ± 0.004	0.311 ± 0.001	0.215 ± 0.004	0.203 ± 0.007
Exit	0.279 ± 0.005	0.343 ± 0.047	0.330 ± 0.063	0.294 ± 0.056	0.328 ± 0.041
Exit left	0.406 ± 0.005	0.379 ± 0.007	0.240 ± 0.019	0.422 ± 0.003	0.438 ± 0.010
Exit right	0.421 ± 0.005	0.406 ± 0.004	0.519 ± 0.009	0.361 ± 0.013	0.385 ± 0.016
Mid left	0.457 ± 0.005	0.435 ± 0.001	0.374 ± 0.004	0.447 ± 0.009	0.487 ± 0.060
Mid right	0.432 ± 0.005	0.447 ± 0.004	0.503 ± 0.005	0.371 ± 0.012	0.478 ± 0.007
Entrance left	0.508 ± 0.005	0.473 ± 0.003	0.456 ± 0.010	0.442 ± 0.005	0.504 ± 0.003
Entrance right	0.424 ± 0.005	0.425 ± 0.003	0.457 ± 0.006	0.332 ± 0.011	0.477 ± 0.011

Nuclear Inst. and Methods in Physics Research, A 940 (2019) 351–358

Thickness Uniformity vs. Total Energy Error

$$\left|\Delta B_{\Lambda}^{sys.}\right| \cong \sqrt{\left(\Delta B_{\Lambda}^{dp:sys.}\right)^2 + \left(\Delta B_{\Lambda}^{calib:sys.}\right)^2}, \text{ where } \left|\Delta B_{\Lambda}^{calib:sys.}\right| = 50\ \mathbf{keV}.$$

$$\left|\Delta B_{\Lambda}^{tot.}\right| \cong \sqrt{\left(\Delta B_{\Lambda}^{sys.}\right)^2 + \left(\Delta B_{\Lambda}^{stat.}\right)^2}$$

Unit: keV

Δ t/t	3%	5%	10%	20%
A. Cigar 0.3 mm + 6.5 deg tilt	20 ($\left\|\Delta B_{\Lambda}^{tot.}\right\|$=70)	30 (64)	60 (82)	120 (134)
Tuna 1.5	43 (70)	70 (90)	140 (150)	270 (276)
Tuna 1.0	38 (68)	46 (73)	90 (106)	180 (189)

Summary

Requirement:

- Cigar 0.3 mm + 6.5 deg tilt ($\Delta t/t \leqq 10\%$)
- Tuna 1.5 mm ($\Delta t/t \leqq 5\%$)
- Tuna 1.0 mm ($\Delta t/t \leqq 8\%$)

Another option:

- Thickness mapping by nondestructive measurement