Workshop of Electro- and Photoproduction of Hypernuclei and Related Topics 2022

Current status of hypertriton binding energy measurement at MAMI

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for the A1 collaboration

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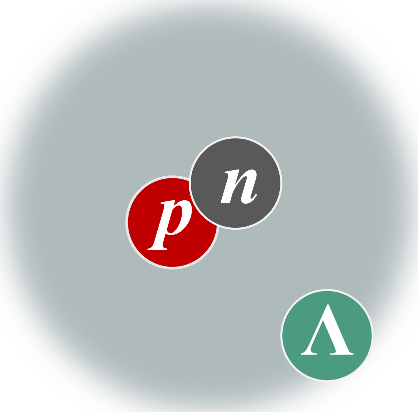
Contents

Λ Binding Energy of Hypertriton

Hypertriton
d-Λ binding system

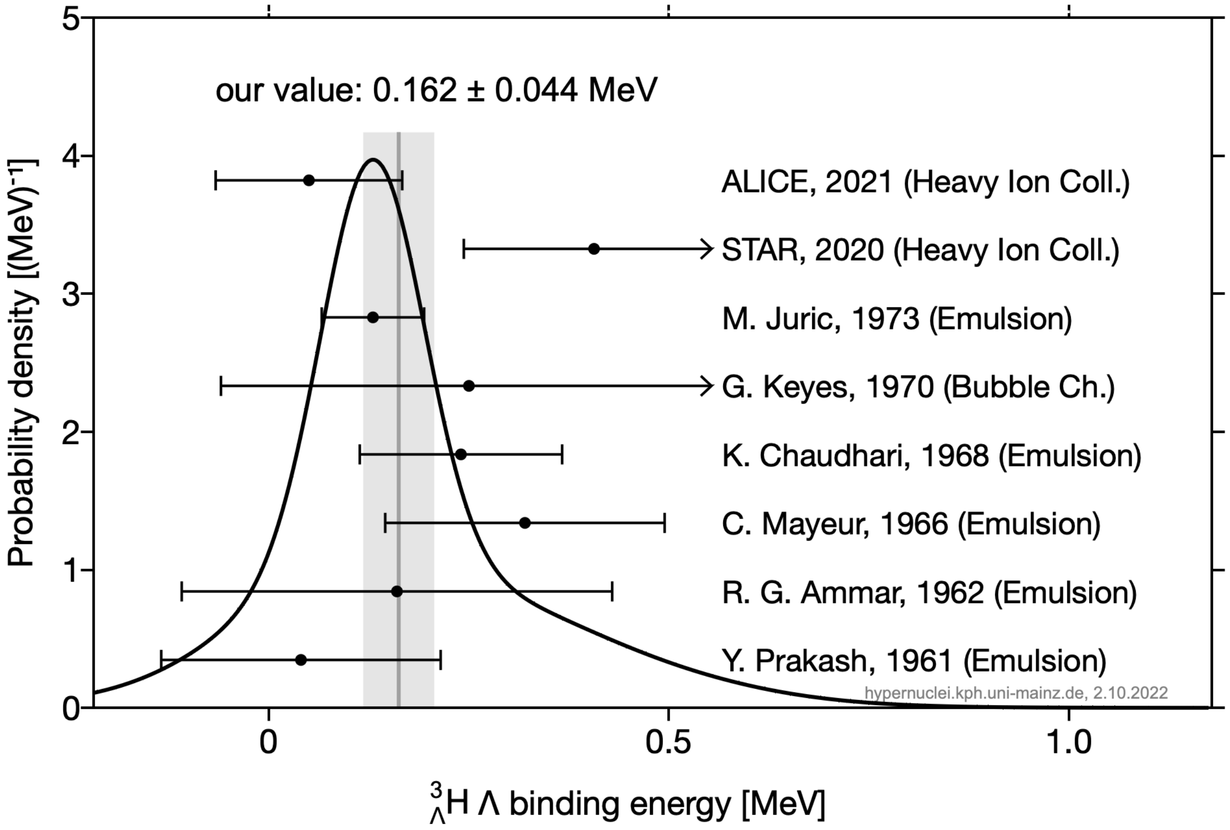


- Still large experimental uncertainties:
  STAR 2020 : $0.406 \pm 0.120_{(stat.)} \pm 0.110_{(syst.)}$ MeV
  ALICE 2021 : $0.050 \pm 0.060_{(stat.)} \pm 0.100_{(syst.)}$ MeV

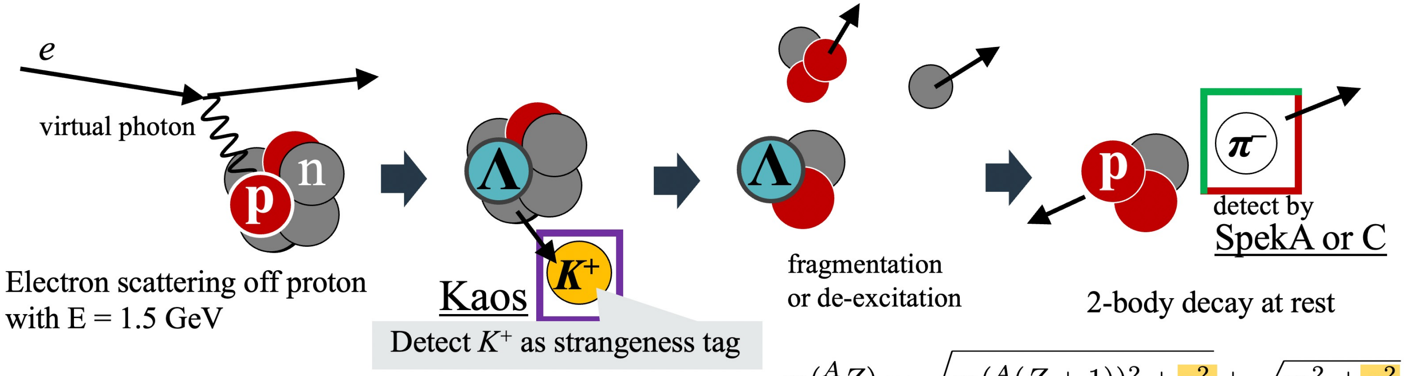
- Value still dominated by Emulsion data – 77 %

Precise measurement is needed!

- Hypernuclear database

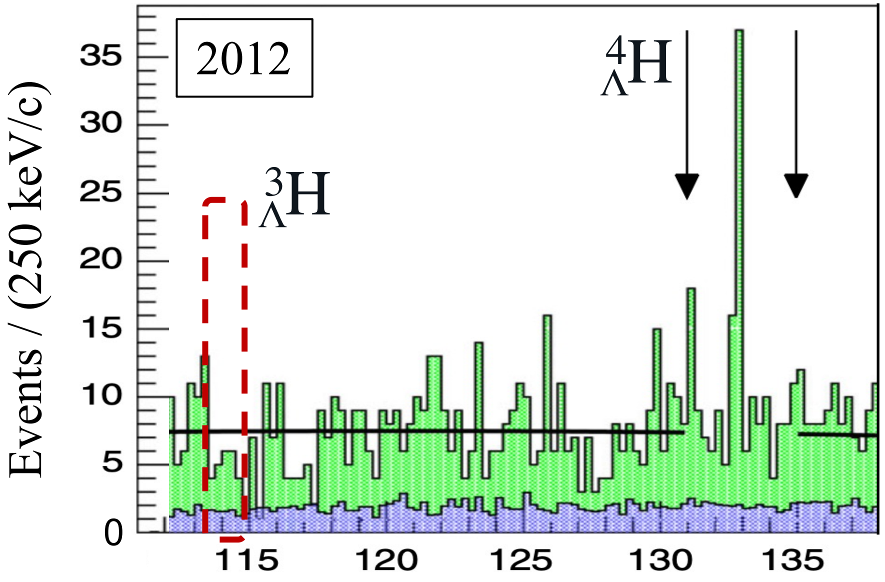


Decay-pion spectroscopy at MAMI

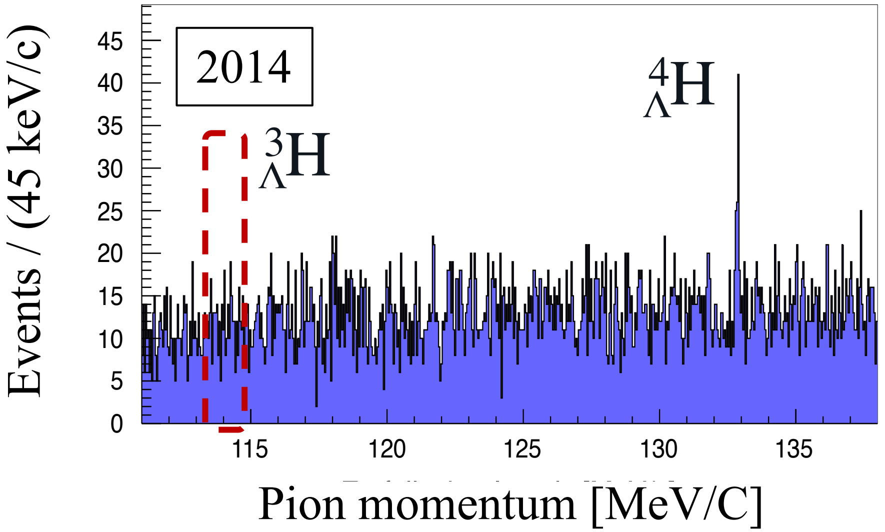


$$m({}^{A}_{\Lambda}Z) = \sqrt{m({}^{A}(Z+1))^2 + p_\pi^2} + \sqrt{m_\pi^2 + p_\pi^2}$$

A. Esser, S. Nagao *et al.*, PRL 114 (2015) 232501.



F. Schulz, Doctoral thesis, J.G. Univ. of Mainz (2015)



${}^{4}_{\Lambda}$H: $B_\Lambda = 2.12 \pm 0.01$ (stat.) ± 0.09 (syst.) MeV (2012)

$B_\Lambda = 2.157 \pm 0.005$ (stat.) ± 0.077 (syst.) MeV (2014)

the new experiment

- Suppression of systematic errors
- Ensuring the yield of ${}^{3}_{\Lambda}$H

Setup for the experiment

Magnetic spectrometer A & C

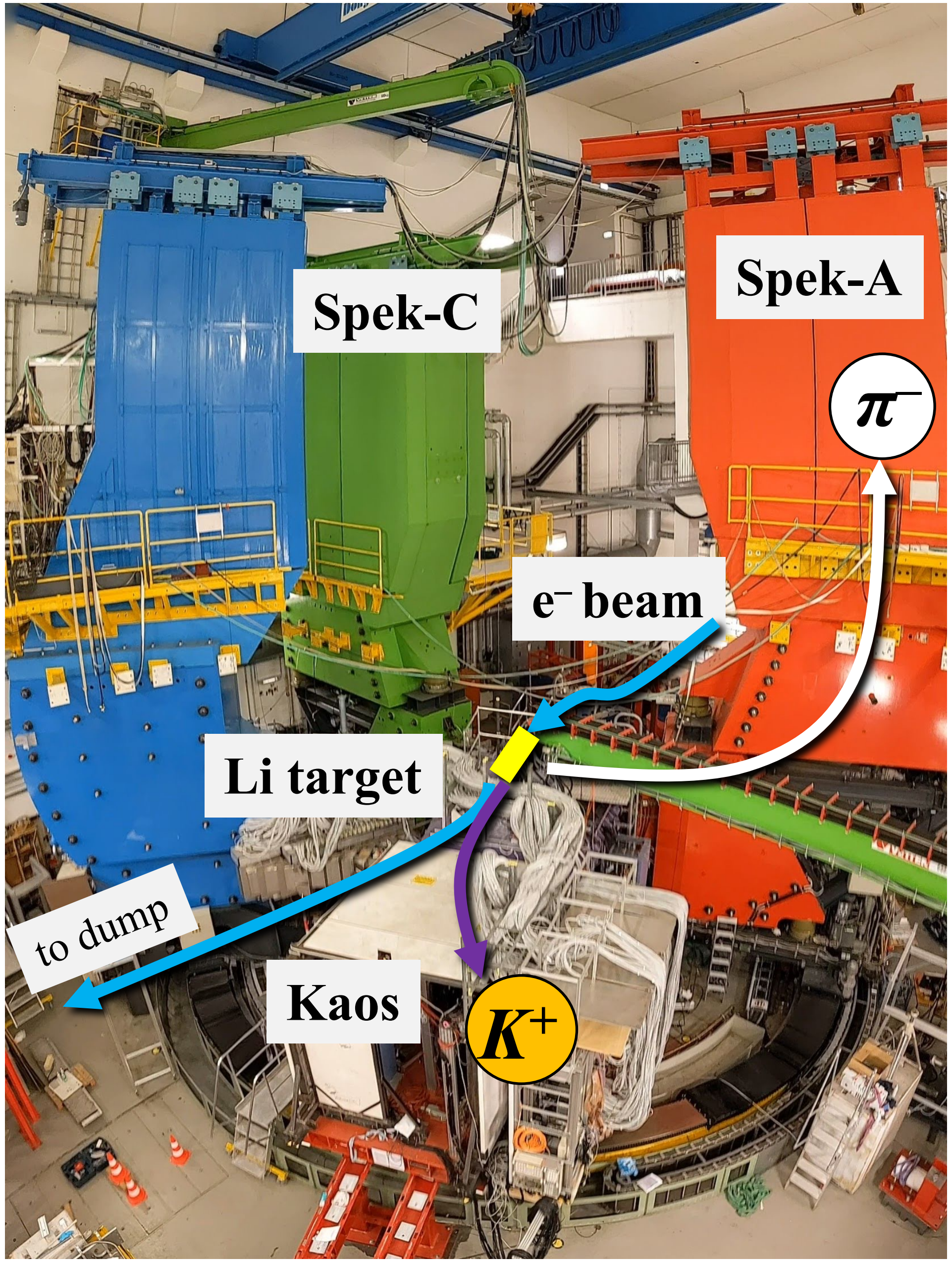
- Offer high momentum resolution of ~10^{-4}
- calibration limited to 10^{-4} by MAMI energy

Kaos

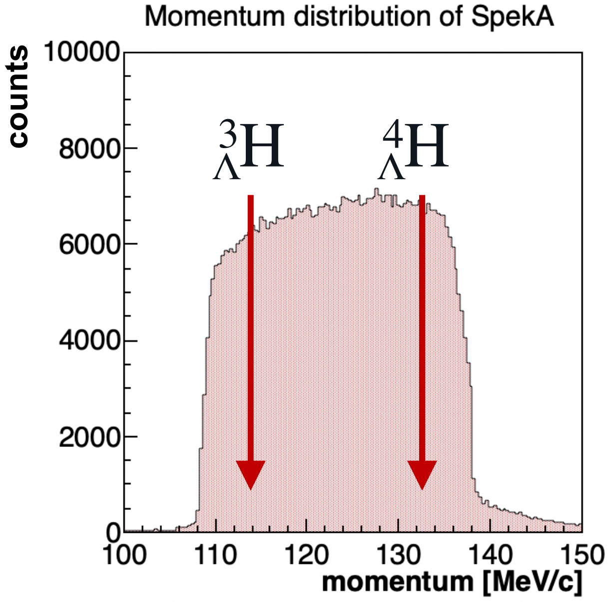
Detection of kaons
→ Identify hyperon production events

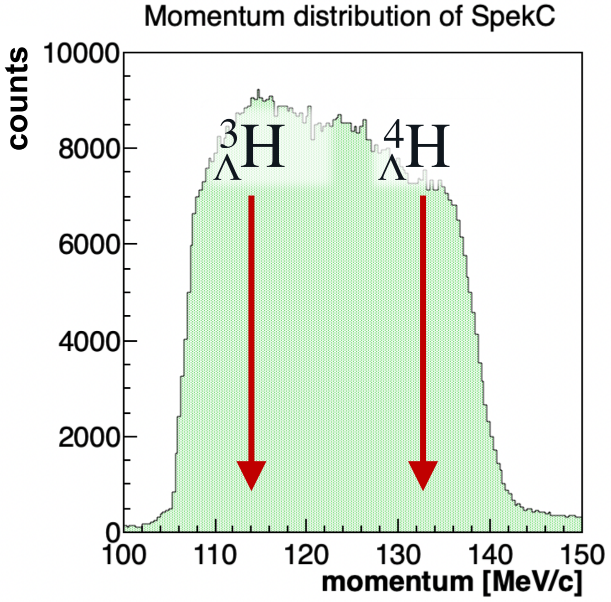
- Short central orbital length (~ 6.4 m)
  → Suitable for short-live kaons ($c\tau$ ~ 3.7 m)
- Wide momentum acceptance
  → High yield of kaons

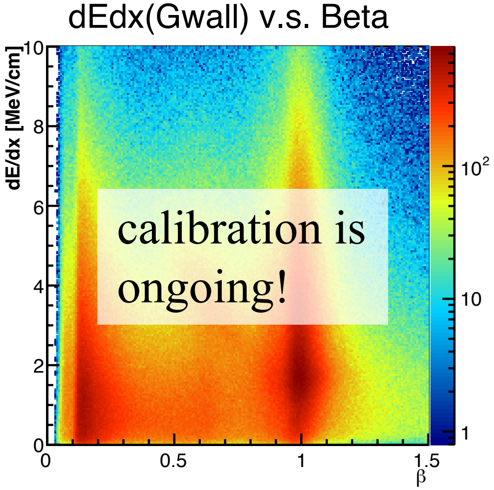
Coincidence events: Kaos and (A or C)



Setup for the experiment

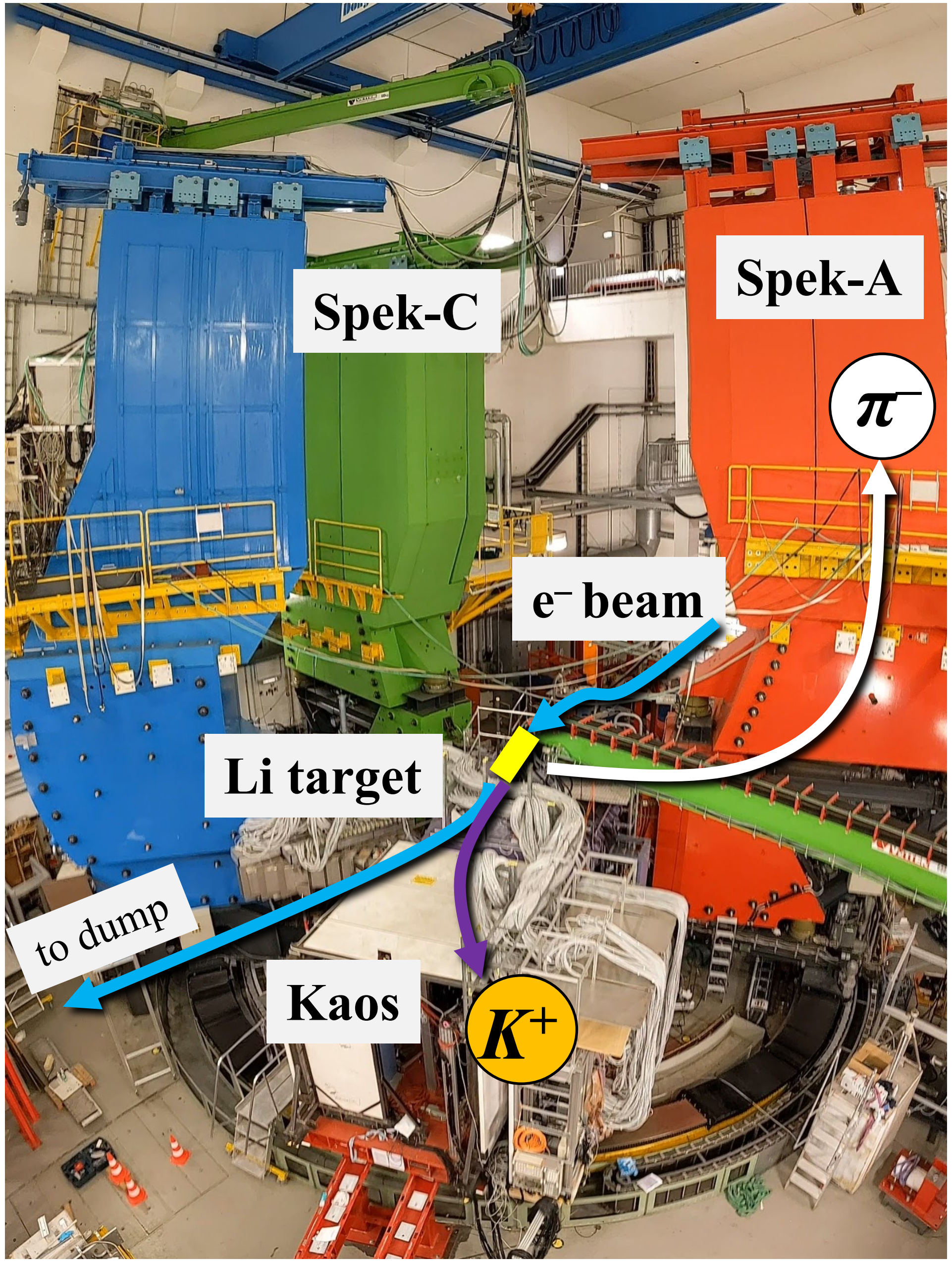






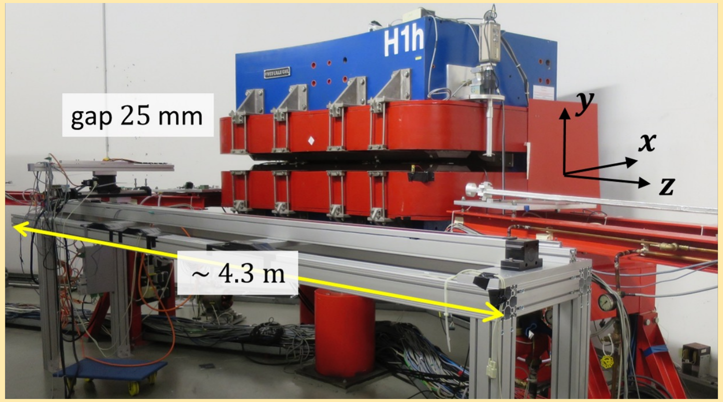
▲Both of spectrometers covering momentum range

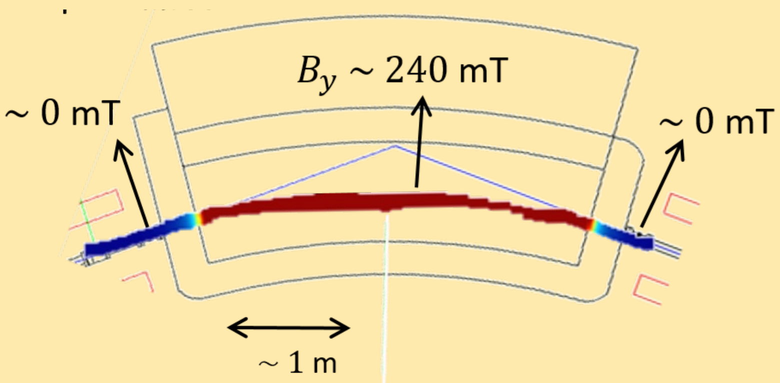
◀ Kaos can see protons & pions presice calibration is needed to see Kaons



Suppression of systematic errors

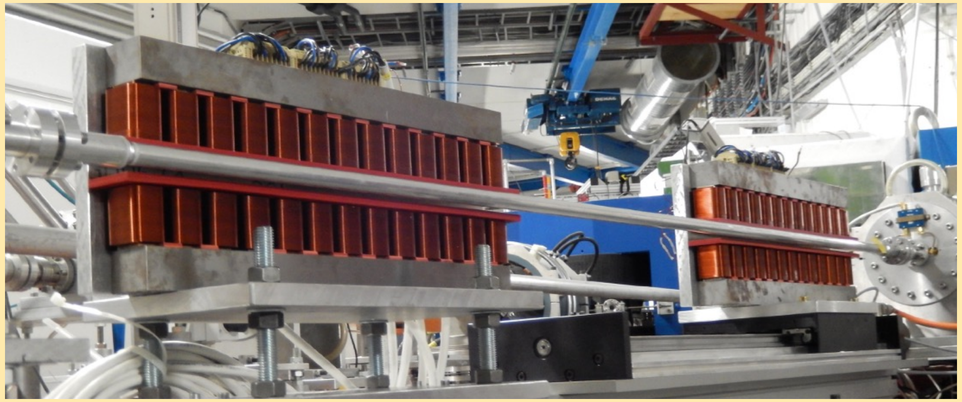
Precise field measurement of an Acc. dipole magnet





S. Tomita, Master thesis, Tohoku Univ. (2016)

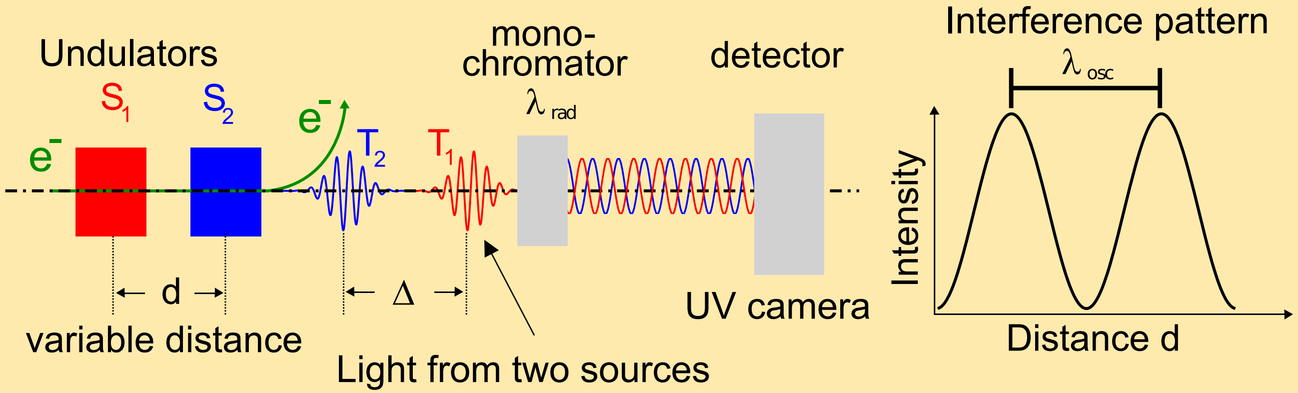
Interference of undulator radiation



Relativistic γ via undulator eq.:

$$\lambda_{osc} = 2\gamma^2 \lambda_{light}$$

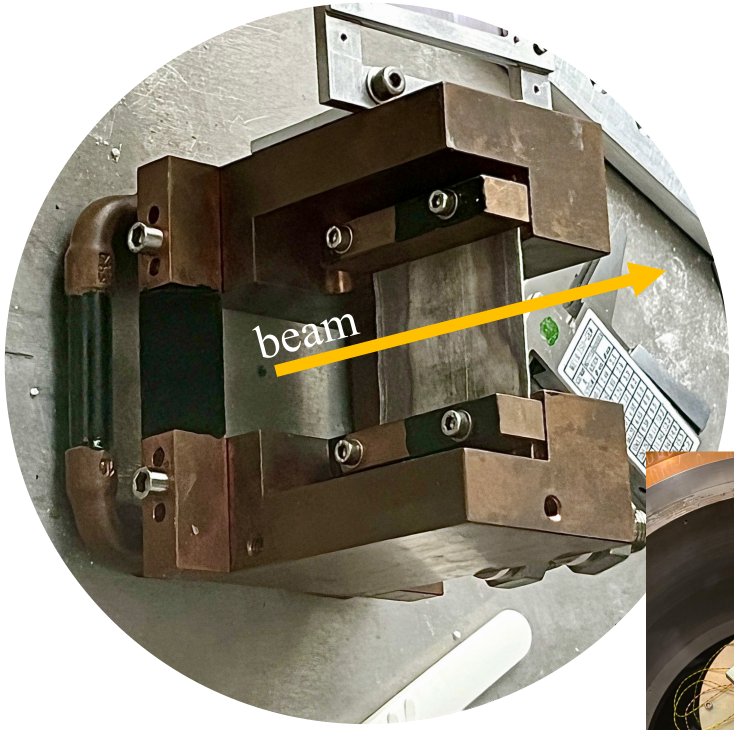
→ Precision of 18 keV possible

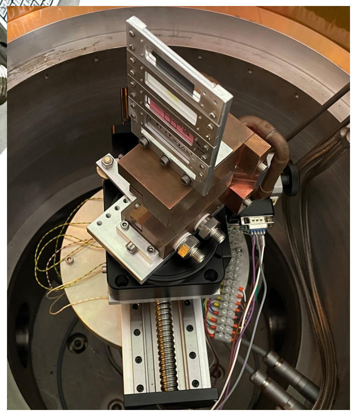


P. Klag *et al.*, NIM A 910 (2018) 147–156

Target design of ^{7}Li

^{9}Be 47mg/cm^2, 40 – 60 μA → ^{7}Li 2430 mg/cm^2, ~1 μA

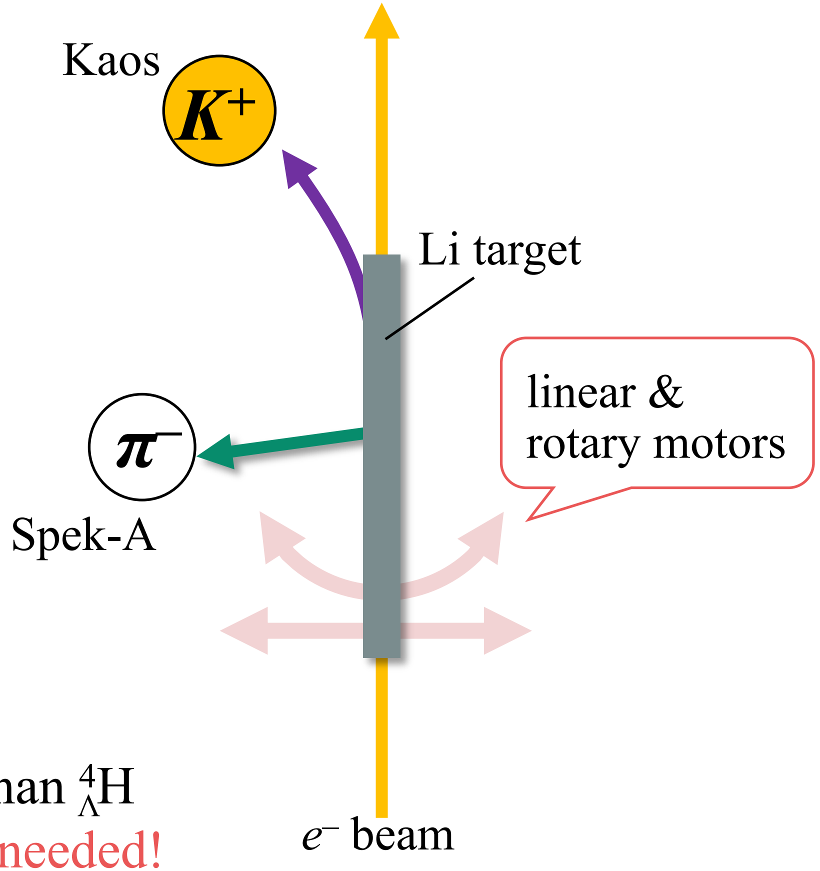




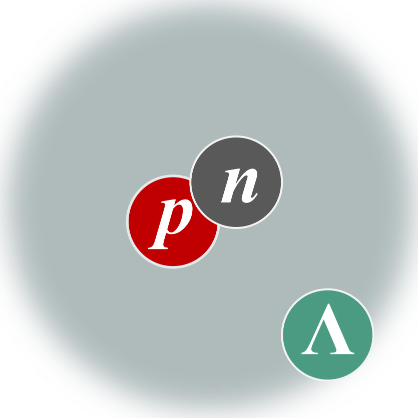
- Less background as ^{9}Be
  No heavy He with
  similar decay pion momenta:
  $^{7}_{\Lambda}$He: 115.7 $^{8}_{\Lambda}$He: 116.5 [MeV/c]
  ($^{3}_{\Lambda}$H: 114.3 MeV/c)

Yield estimate:
$^{3}_{\Lambda}$H factor of ~10 lower than $^{4}_{\Lambda}$H
→ Higher luminosity is needed!

- Beam direction – 45 mm long
  → Maximized rate of hypernuclei



Summary



- Beamtime schedule 2022

  July 11th – Aug. 1st : Commissioning run

  (Kaos started up again, confirmed coincidence peak)

  Sept. 16th – Oct. 17th : Physics run → **ongoing!**

  Apr. – May 2023 : Spectrometer calibration run

- Momentum setting to observe both of ${}^{3}_{\Lambda}\mathrm{H}$ and ${}^{4}_{\Lambda}\mathrm{H}$
- New target system → suppress BG & higher luminosity
- New calibration via undulator light interference → minimize syst. error

Our goal: total error of ± 20 keV in Λ binding energy