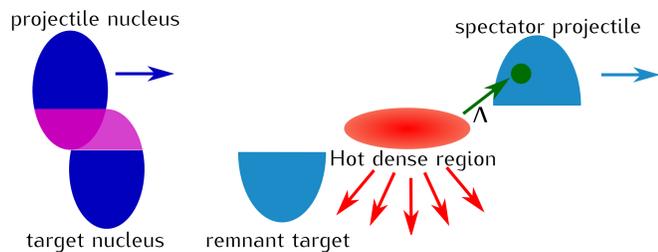


HypHI project: Final results of the study of hypernuclei in the reaction ${}^6\text{Li} + {}^{12}\text{C}$ at 2 A GeV

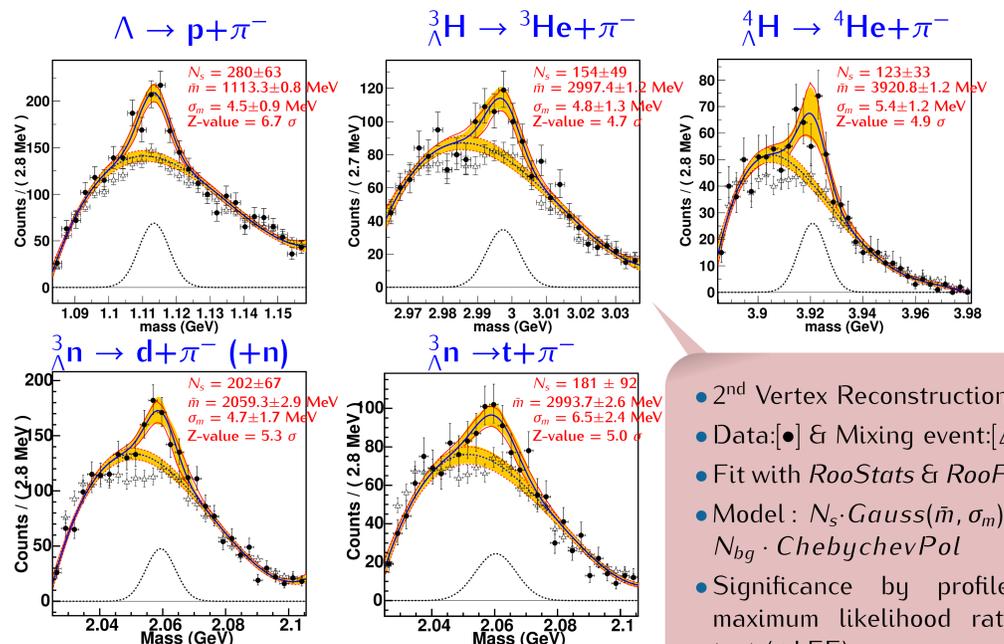
Production mechanism



- $NN \rightarrow \Lambda KN$ Energy threshold ~ 1.6 GeV.
- Beam energy $> E_{th}$: available at GSI (2 A GeV)
- Coalescence of Λ or (π^+, K^+) reaction in spectator fragment.
⇒ same velocity than projectile: *Lorentz Boosted*
- Effective lifetime longer:
→ 200 ps → 600 ps ($\gamma \sim 3$) at GSI: $c\tau \sim 15$ to 20 cm.
⇒ study Hypernuclei in flight
→ Lifetime measurement via decay vertex reconstruction.

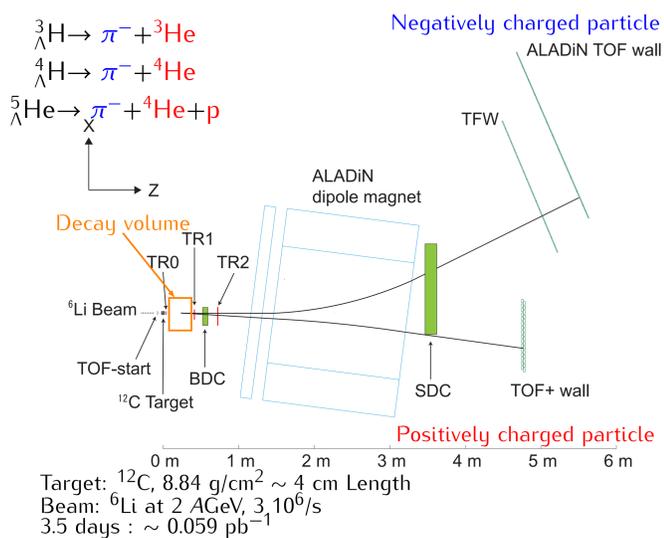
To demonstrate the feasibility of hypernuclear spectroscopy with HI [1].

Experimental Results: Invariant Masses



- 2nd Vertex Reconstruction
- Data: [●] & Mixing event: [Δ]
- Fit with *RooStats* & *RooFit*
- Model: $N_s \cdot \text{Gauss}(\bar{m}, \sigma_m) + N_{bg} \cdot \text{ChebychevPol}$
- Significance by profiled maximum likelihood ratio test (+LEE)
- More details in [2] & [3].

Phase 0 experiment @ GSI:

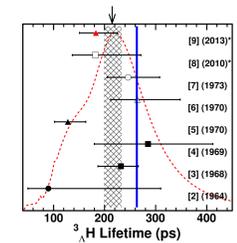


Target: ${}^{12}\text{C}$, 8.84 g/cm² ~ 4 cm Length
Beam: ${}^6\text{Li}$ at 2 A GeV, $3 \cdot 10^{10}$ /s
3.5 days : ~ 0.059 pb⁻¹

Next: Lifetimes & Cross sections

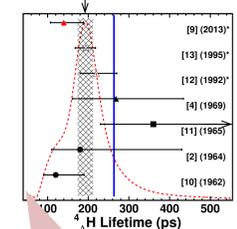
- Unbinned Maximum Likelihood method
- S+B: $[\bar{m} \pm 2\sigma]$
- B-only: 2σ Sidebands
- Goodness-of-Fit test: (S+B) binned data vs. $S_{\text{model}} + (B)$ binned data
- More details in [2] & [3]

	extracted Lifetime
Λ	$\tau = 262^{+56}_{-43} \pm 45$ ps
${}^3_\Lambda\text{H}$	$\tau = 183^{+42}_{-32} \pm 37$ ps
${}^4_\Lambda\text{H}$	$\tau = 140^{+48}_{-33} \pm 35$ ps
$d + \pi^-$	$\tau = 181^{+30}_{-24} \pm 25$ ps
$t + \pi^-$	$\tau = 190^{+47}_{-35} \pm 36$ ps



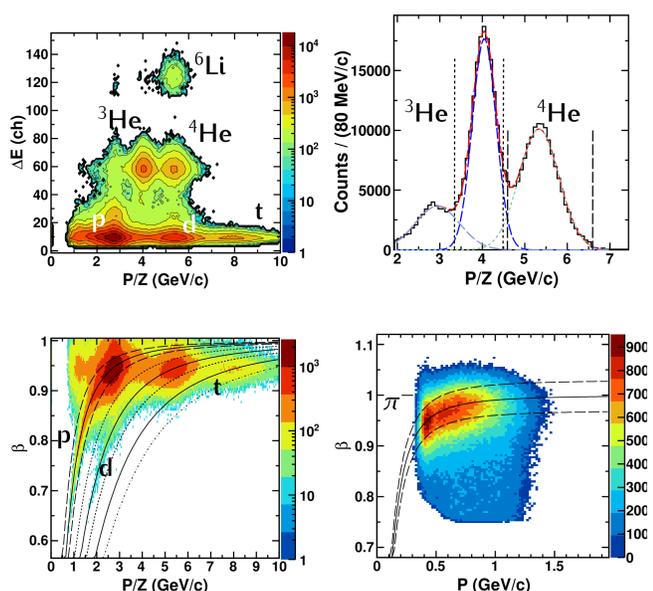
- Draft to be submitted
- Bayesian inference → combined all systematics
- From the raw yield

	Cross section
Λ	$\sigma_{\text{prod}} \sim 1.5$ mb
${}^3_\Lambda\text{H}$	$\sigma_{\text{prod}} \sim 4$ μb
${}^4_\Lambda\text{H}$	$\sigma_{\text{prod}} \sim 3$ μb
${}^3_\Lambda n$	$\sigma_{\text{prod}} \sim 30$ μb
$t + \pi^- / d + \pi^-$	Ratio ~ 0.5



- World data analysis as PDG: Details in [4]
- ${}^3_\Lambda\text{H}$: 216^{+19}_{-16} ps & ${}^4_\Lambda\text{H}$: 192^{+20}_{-18} ps

Tracking performance: PID

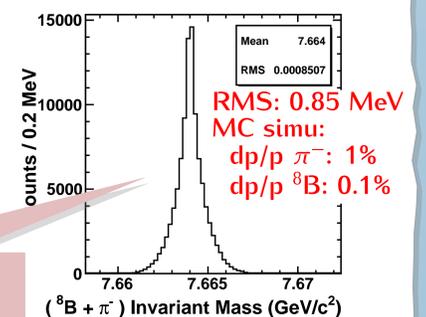


Tracking across the magnet with Kalman Filter (P/Z) + time-of-flight measurement (β) + energy deposit TOF walls (ΔE)
Details in [2]

Future plans @ FAIR

- Future phase of the HypHI project :
Exotic hypernuclei / strangeness cluster: Use heavy ion and RI beam to study @ FRS & SuperFRS
- Hypernuclei toward the proton and neutron drip-lines with Exotic beam.
 - Forward spectrometer : Exclusive experiment
 - highly precise measurement for forward fragments: Improve Invariant Mass resolution

- ${}^{12}\text{C}$ primary beam on ${}^9\text{Be}$ target: RI beam prod.
- ${}^9\text{C}$ secondary beam on ${}^{12}\text{C}$ target: Hypernuclear prod.
- ${}^8_\Lambda\text{Be} \rightarrow {}^8\text{B} + \pi^-$: ${}^8\text{B}$ analyzed by last SuperFRS stages



References

- [1] T. Saito *et al.*, Letter of Intent (2006).
- [2] C. Rappold *et al.* (HypHI Collaboration), Nucl. Phys. A. 913, 170 (2013).
- [3] C. Rappold *et al.* (HypHI Collaboration), Phys. Rev. C 88, 041001 (2013).
- [4] C. Rappold *et al.*, Phys. Lett. B 728, 543 (2014).