WASA@FRS HypHI Experiment

Study of light hypernuclei

10-19/3/2022, GSI (Germany)

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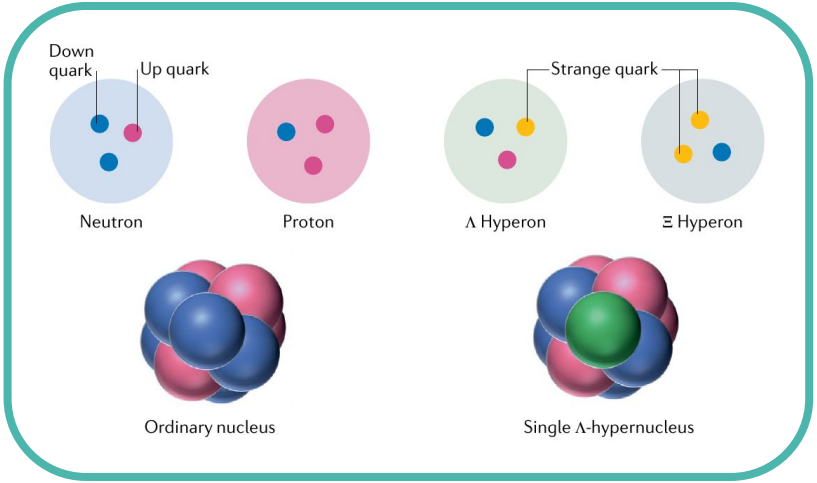
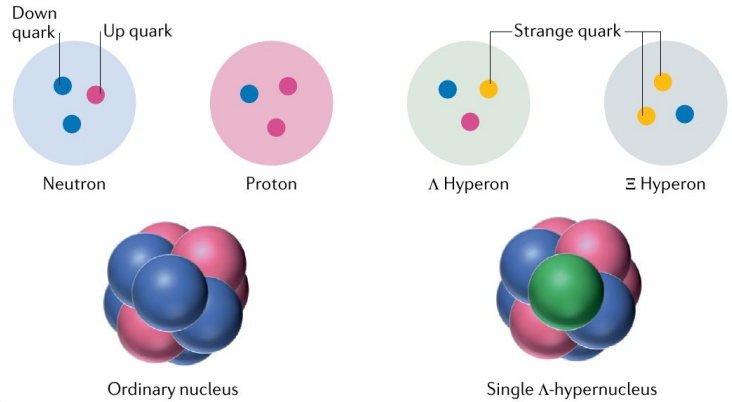
Introduction to hypernuclei



[T.R. Saito *et al.*, Nature Reviews Physics **3** (2021) 803-813]

Introduction to hypernuclei

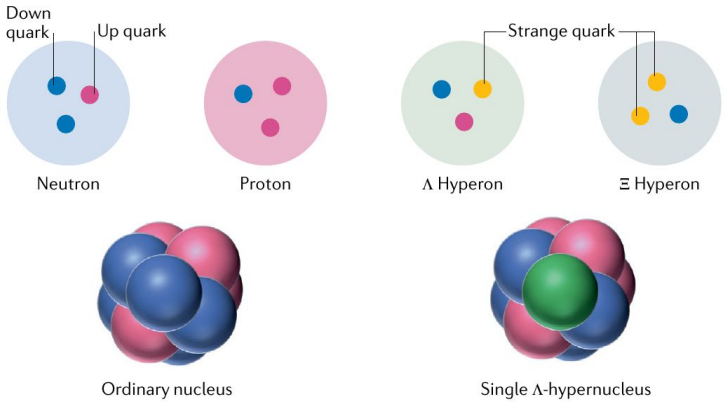


[T.R. Saito *et al.*, Nature Reviews Physics **3** (2021) 803-813]

Study Y-N and Y-Y interaction:

- Difficult to get scattering data
  - Short lifetime
- Analyse Charge Symmetry Breaking (CSB)
  - Difference Y-p and Y-n
- Describe hypernuclei
- Modelize high-density environments
  - Neutron stars cores

Introduction to hypernuclei



[T.R. Saito *et al.*, Nature Reviews Physics **3** (2021) 803-813]

$^{3}_{\Lambda}H$: $(p + n + \Lambda) \rightarrow {}^{3}He + \pi^{-}$

$^{4}_{\Lambda}H$: $(p + n + n + \Lambda) \rightarrow {}^{4}He + \pi^{-}$

$nn\Lambda$: $(n + n + \Lambda) \rightarrow d + n + \pi^{-}$

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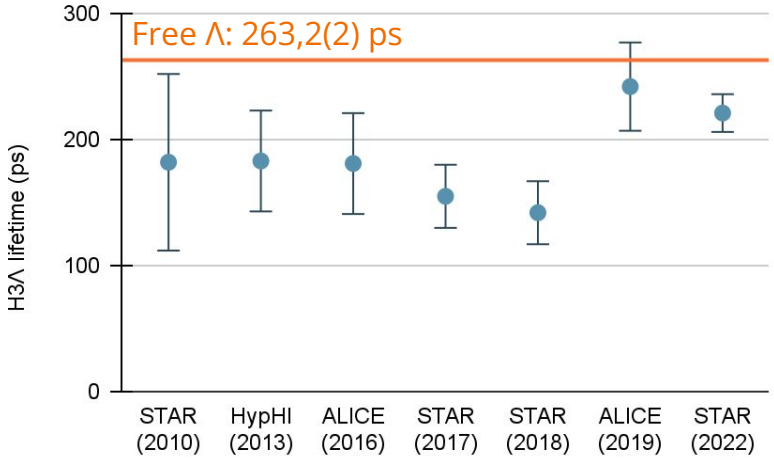
Experimental goals

- Short lifetime of the hypertriton
  - Small binding energy d-Λ (B = 0.13 ± 0.05 MeV)



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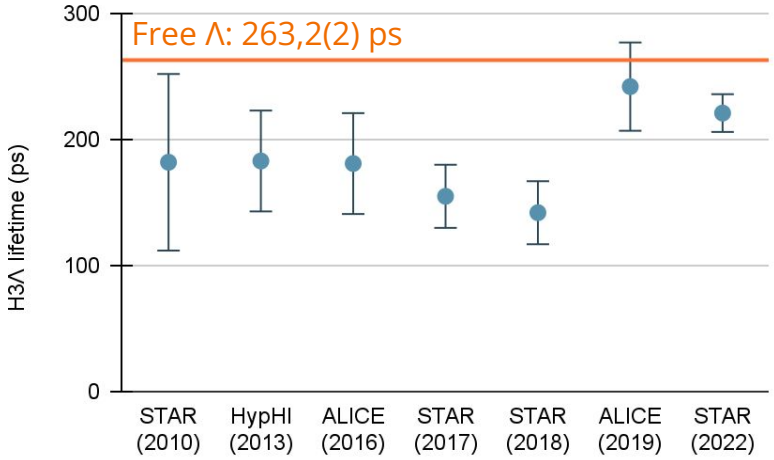
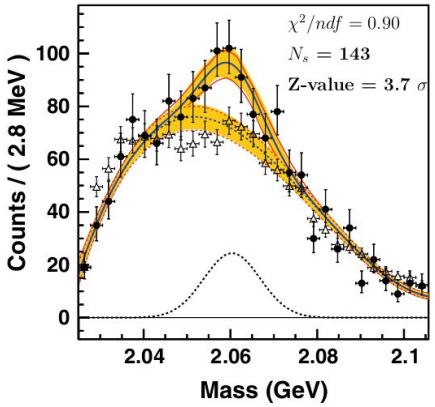
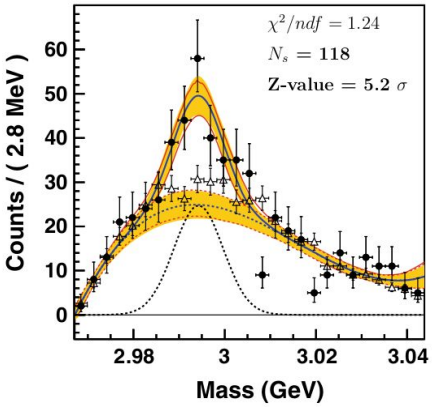


- Signal suggesting the existence of a bound state nnΛ
  - All the models provide a negative indication

nnΛ → n + d + π⁻

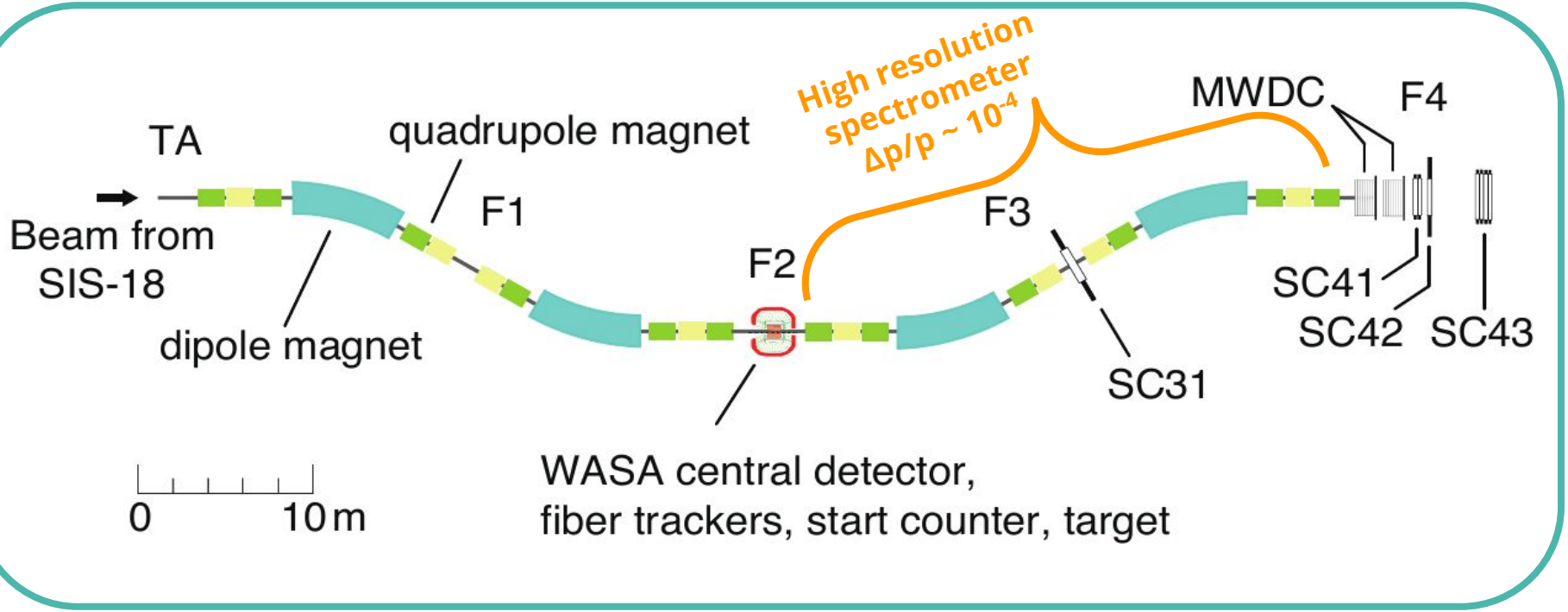


nnΛ → t + π⁻

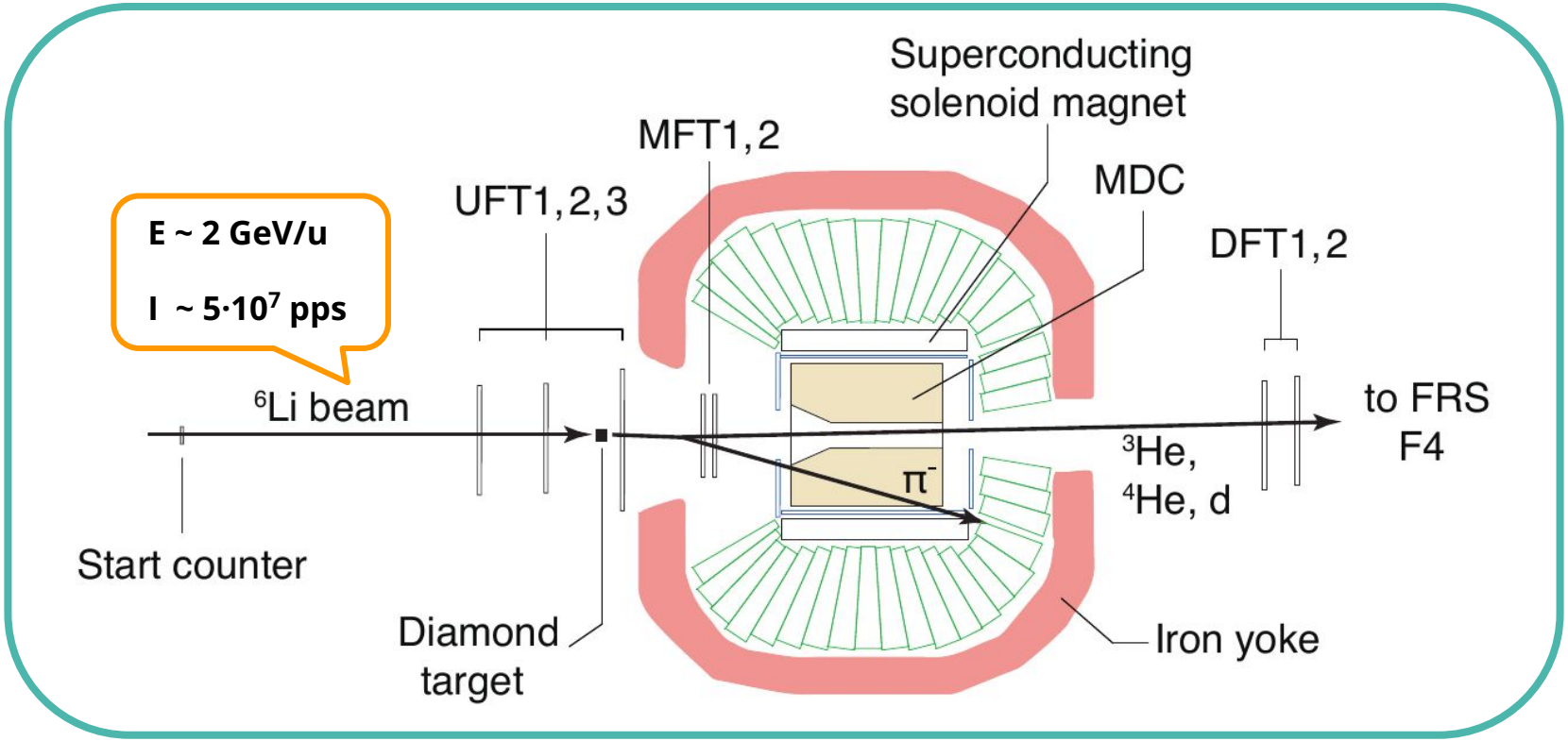


[C. Rappold *et al.*, Phys. Rev. C **88** (2013), 0401001(R)]

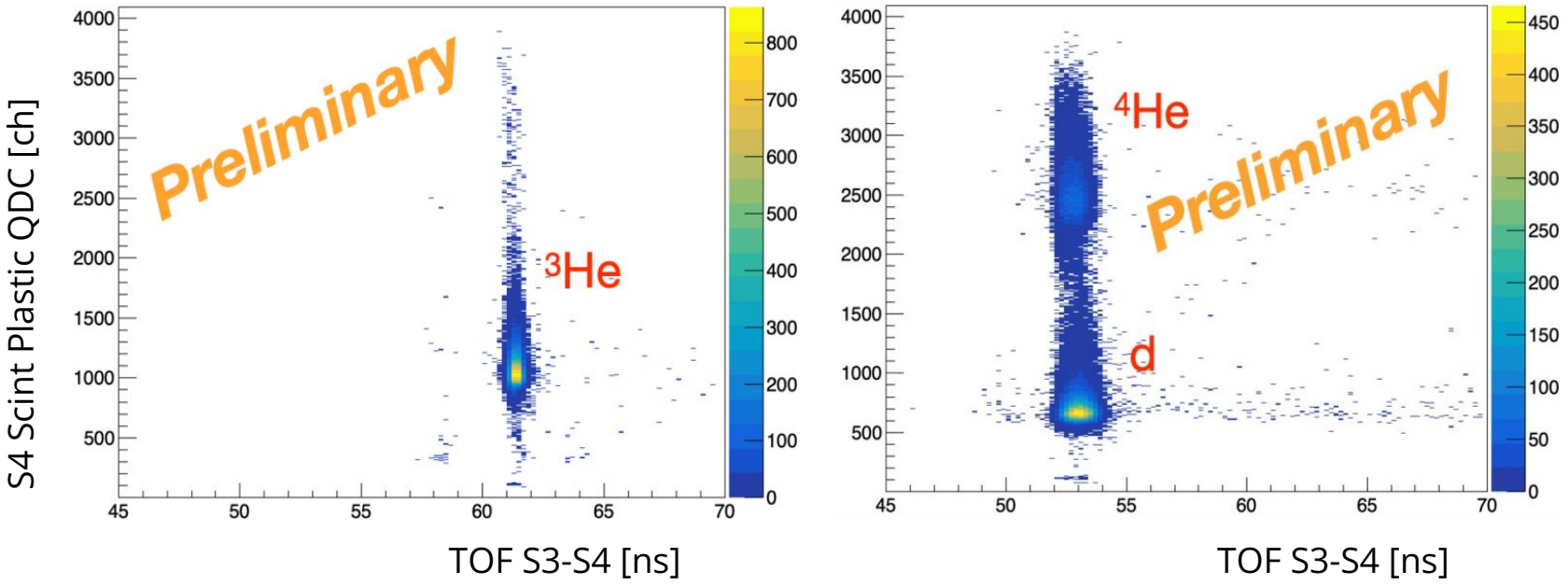
Experimental setup: FRS



Experimental setup: WASA



Preliminary data analysis: fragments



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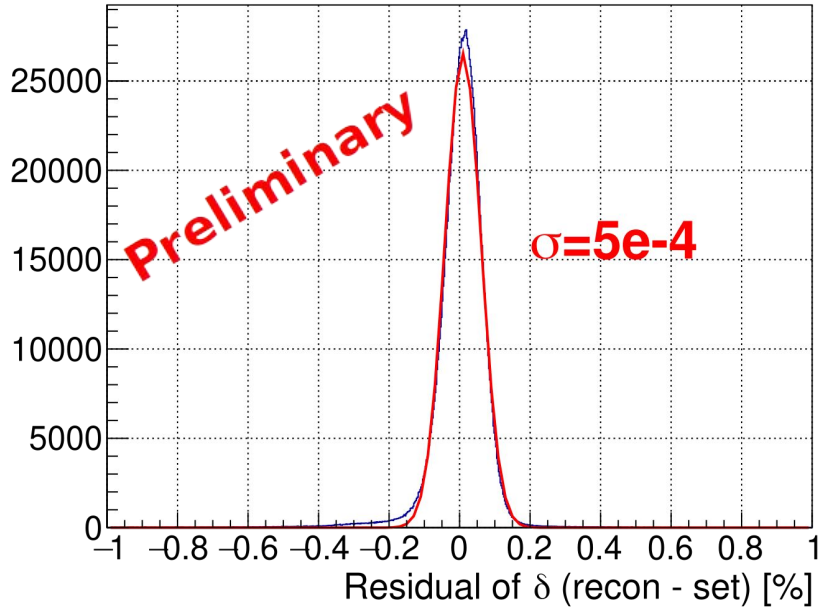
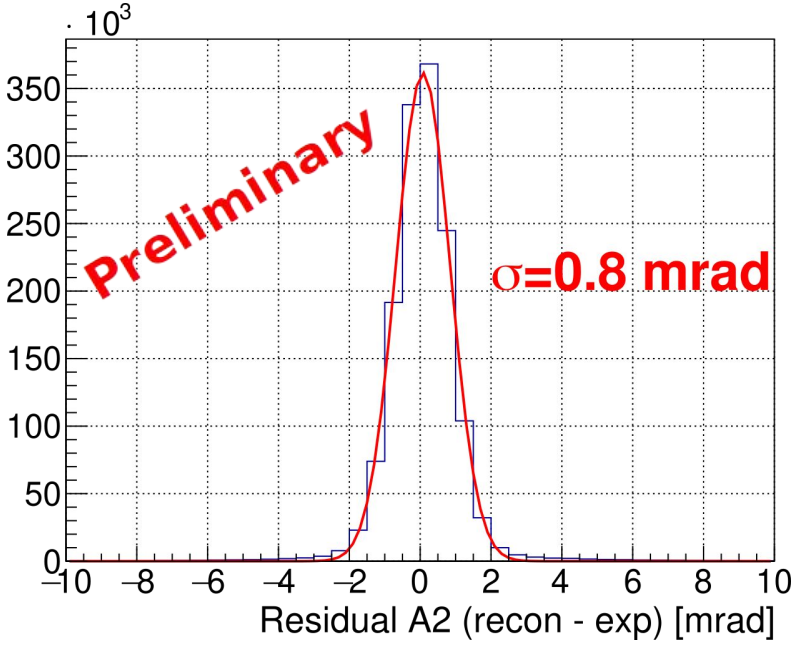
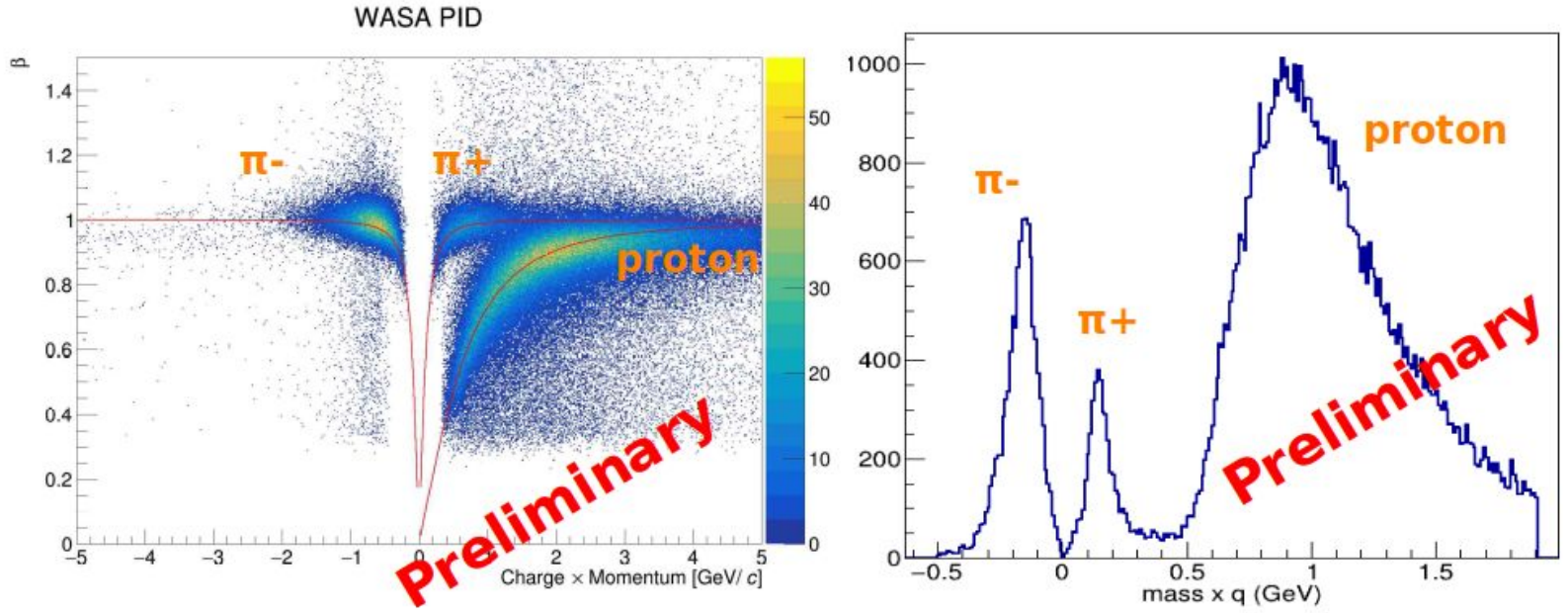




Preliminary data analysis: WASA

Hit Collection → Calibration → Track Finder (GNN) → Track Fitter

[H. Ekawa *et al.*, Eur. Phys. J. A **59** (2023), 103]



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- Universidad de Santiago de Compostela, Spain:
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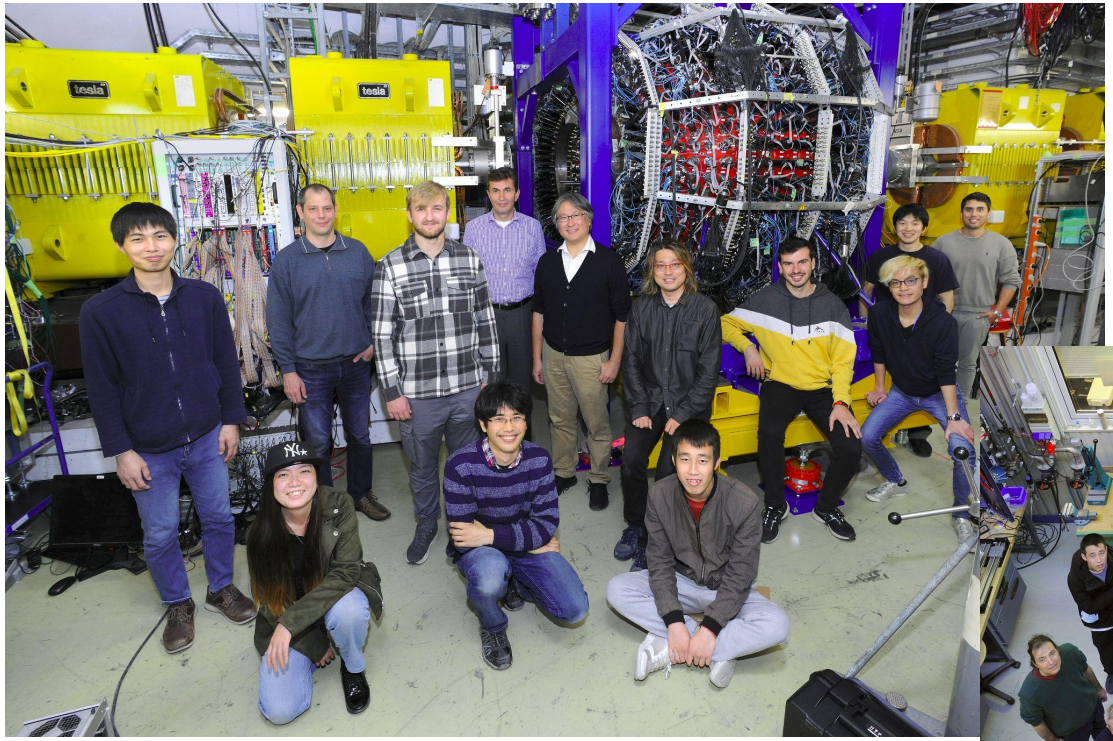
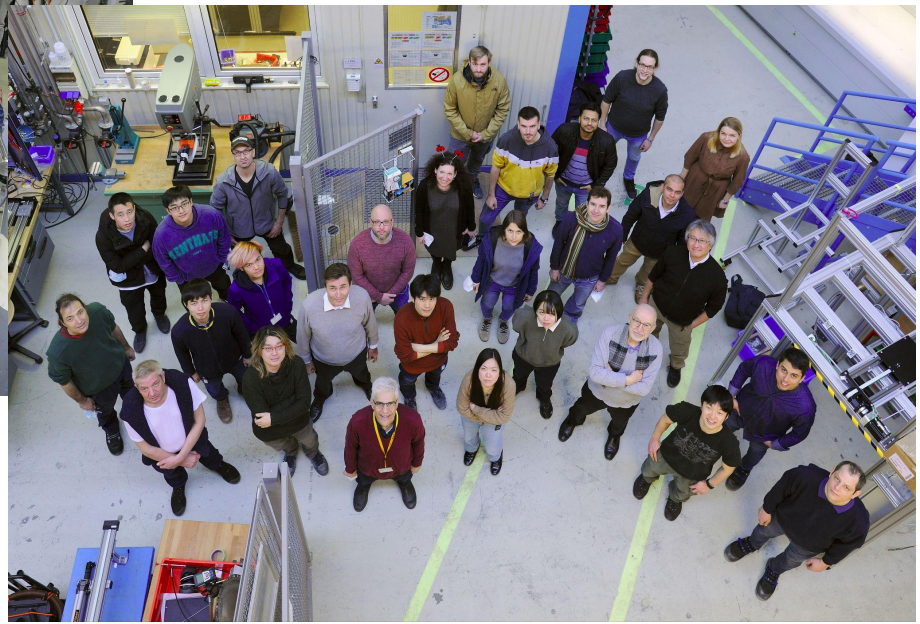




Thank you for your attention!

Back up

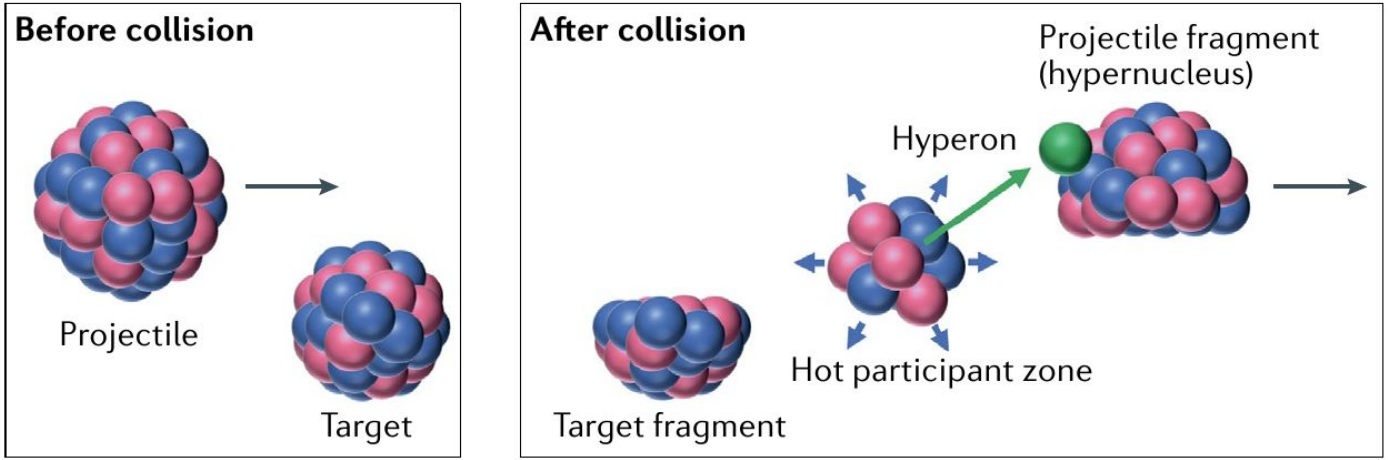
Production reaction

Beam: ^{6}Li

- E ~ 2 GeV/u
- I ~ $5 \cdot 10^{6}$ pps

Target: ^{12}C

- t ~ 10 g/cm^{2}

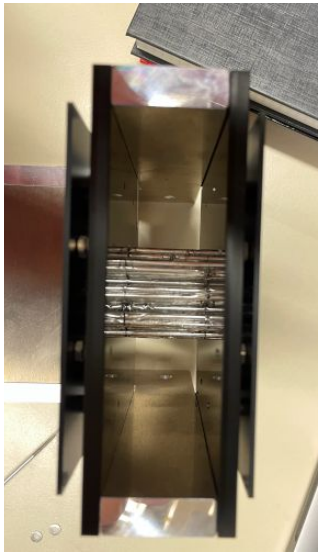


[T.R. Saito *et al.*, Nature Reviews Physics **3** (2021) 803-813]

Data taking

Beam	Fragment at S4	Amount	Time	Accepted trigger rate
6Li beam	^{3}He	3.3×10^{8}	40.9 hours	2.6 kHz
	^{4}He	0.9×10^{8}	43.9 hours	1.8 kHz
	d	1.8×10^{8}		
	p (mid-rap.)	5.3×10^{6}	3.2 hours	0.68 kHz
12C beam	^{3}He	1.0×10^{8}	13.5 hours	2.4 kHz
	^{9}C	2.4×10^{5}		

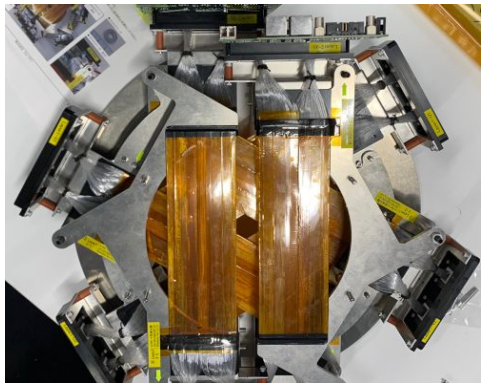
T0 Counter



T0 detector:

- 28 segments 1.5 x 1.5 mm^2 x 4.5 cm
- Total size 3.4 x 4.5 cm^2
- Start timing of the Time-of-Flight
- Time resolution: $\sigma \sim 40$ ps
- < 2MHz per segment → 2 10^7 total beam intensity
- NIMA paper to be submitted by E. Liu (PhD student)

Fiber Trackers



Fiber trackers: XUV layouts

- 512 or 768 fiber / layer : Fiber of 0.5 mm Xsection
- In total: 5760 channel readout
- Tracking charged particles
- Position resolution: σ ~ 0.25 mm
- Charge also measured via ToT
- UFT=DFT Eff : ~ 95% MFT : ~93%
- NIMA paper in preparation by V. Drozd (PhD Student)

Mini Drift Chamber (MDC)

MDC: Strawtubes drift chamber

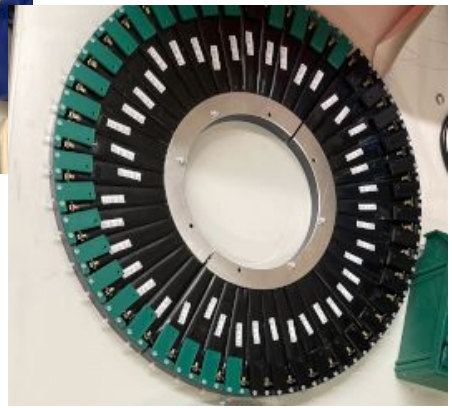
- 17 layers : Diameters : 4, 6 & 8 mm 9 // z axis + 8 stereos
- In total: 1738 channel readout
- Tracking charged hadrons : Momentum analysis
- Position resolution: $\sigma \sim 0.3 - 0.5$ mm
- Inner to outer layer eff. ~ 92% → 96%

Plastic Scintillator Barrel (PSB)

PSB: Plastic scintillator barrel

- 48 bars, size : 55 x 3.8 x 0.8 cm^3
- Stop ToF & final positions of charged hadrons
- Time & Position resolution: $\sigma_t \sim 85$ ps & $\sigma_z \sim 1$ cm
- R. Sekiya et al. NIMA **1034** (2022) 166745

Plastic Scintillator Back/Front Endcaps (PSB/FE)



PSBE - PSFE: Plastic scintillator Endcaps

- 38 & 44 bars, size : [10 & 8] x ~ 2 x 0.8 cm^3
- Position, Time measurements & increase acceptance
- Efficiency ~ 99%