The WASA-FRS project at FAIR Phase 0 and beyond

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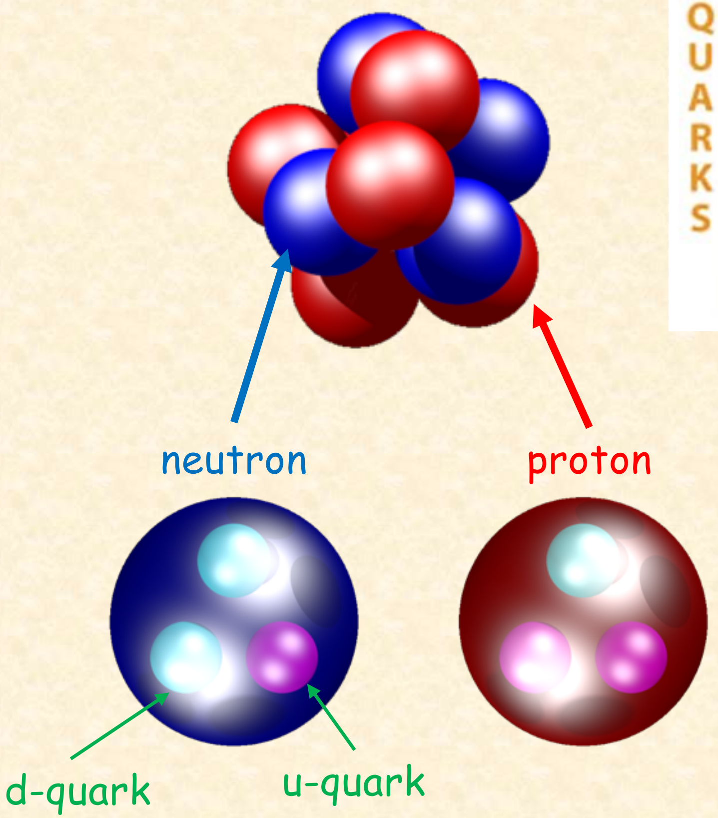
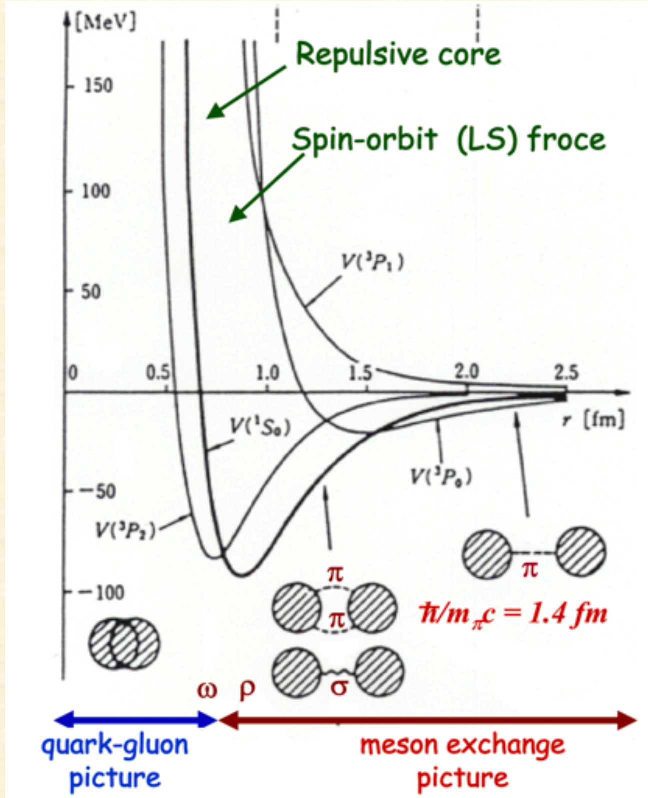
Outline

- Very brief introduction of hypernuclear physics
- Motivations of the WASA-FRS project at FAIR Phase 0 (GSI)
  - Hypernuclear production with heavy ion beams
  - The HypHI Phase 0 experiments and two puzzles
- The WASA-FRS project at FAIR Phase 0
- Our perspective
  - Hypernuclear project at HIAF in China
  - Overall scanning of nuclear emulsion with machine learning

Quarks and sub-atomic nuclei

Sub-atomic nucleus

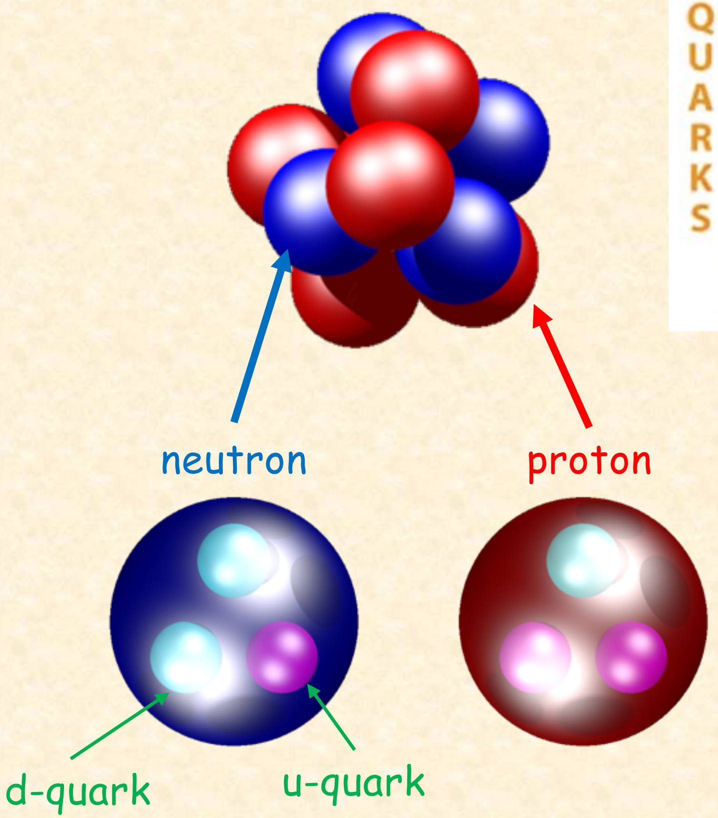




There are many identical quarks

Quarks and sub-atomic nuclei

Sub-atomic nucleus



There are many identical quarks

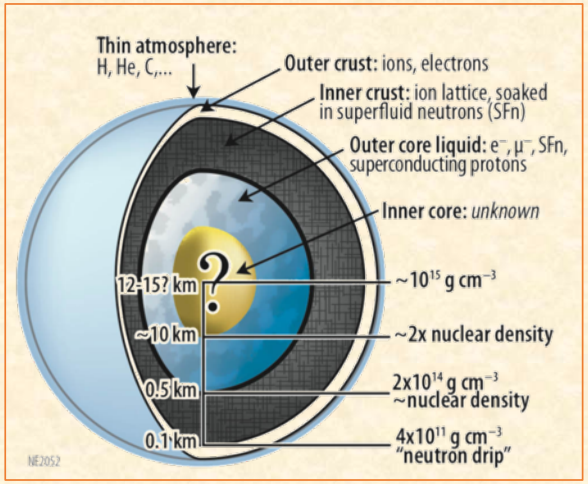
Hyperon	Quarks	I(J^P)	Mass (MeV)
Λ	uds	0(1/2$^+$)	1115
Σ^+	uus	1(1/2$^+$)	1189
Σ^0	uds	1(1/2$^+$)	1193
Σ^-	dds	1(1/2$^+$)	1197
Ξ^0	uss	1/2(1/2$^+$)	1315
Ξ^-	dss	1/2(1/2$^+$)	1321
Ω^-	sss	0(3/2$^+$)	1672

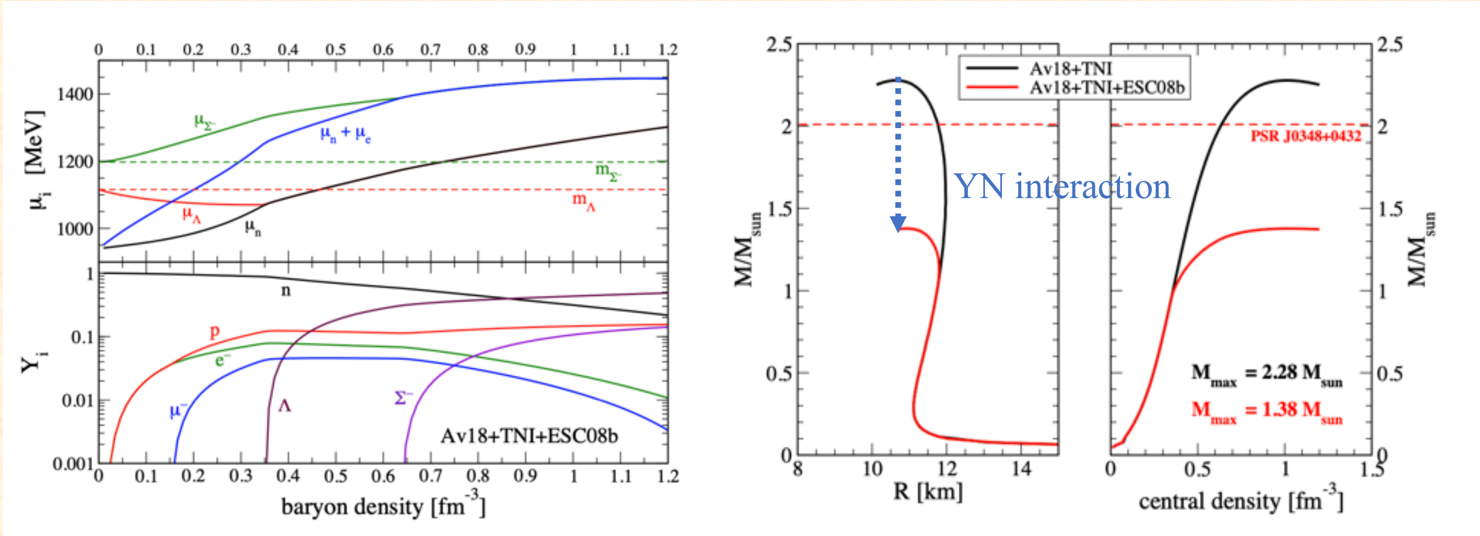
hyperon (Λ)

Lifetime: 10^{-10} ps

s-quark: distinguishable from u- and d-quarks

Neutron stars and dense nuclear matter

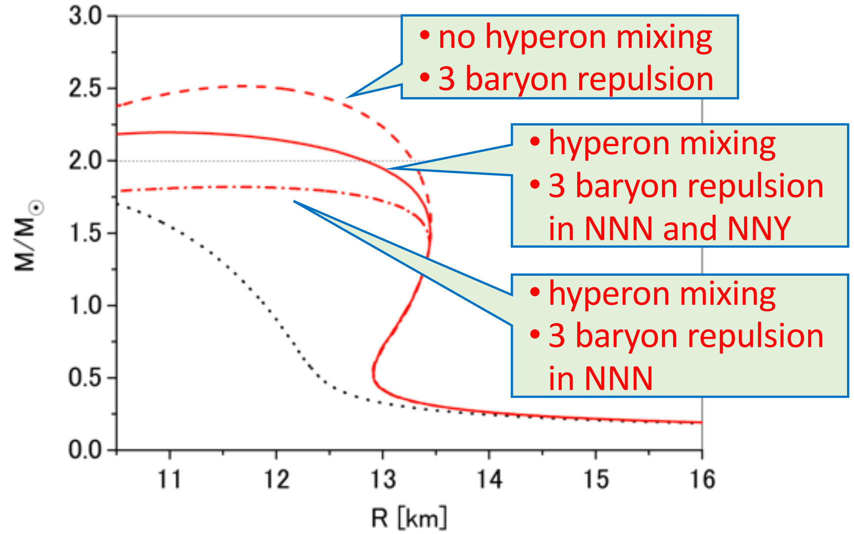




Baryon interaction

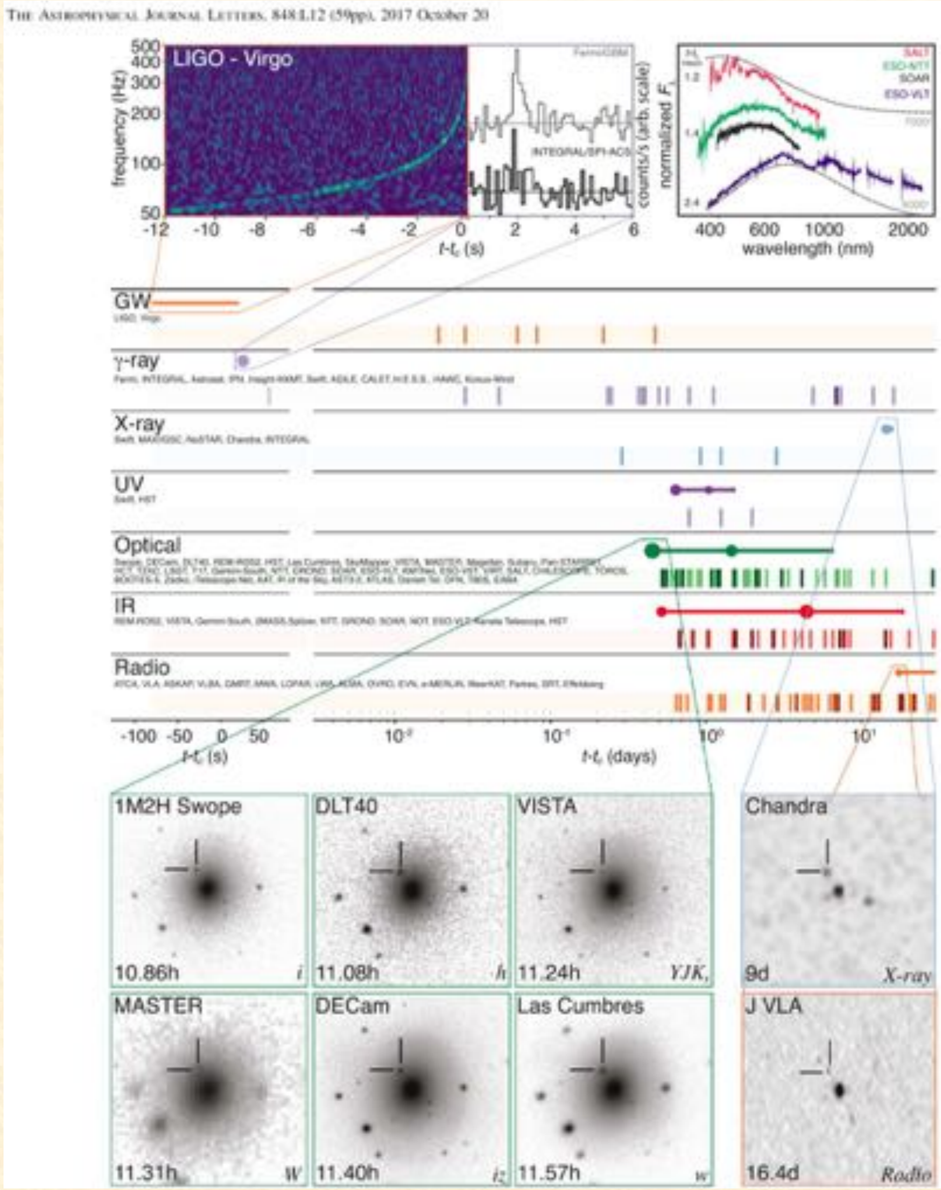
- N−N
- Λ−N
- **Σ−N**
- **Λ−Λ, Σ−Σ, Λ−Σ**
- **Ξ−N**
- **Ξ−Λ, Ξ−Σ**
- **Ξ−Ξ**

Y. Yamamoto, T. Furumoto, N. Yasutake, Th.A. Rijken, Phys. Rev. C90 045805 (2014)



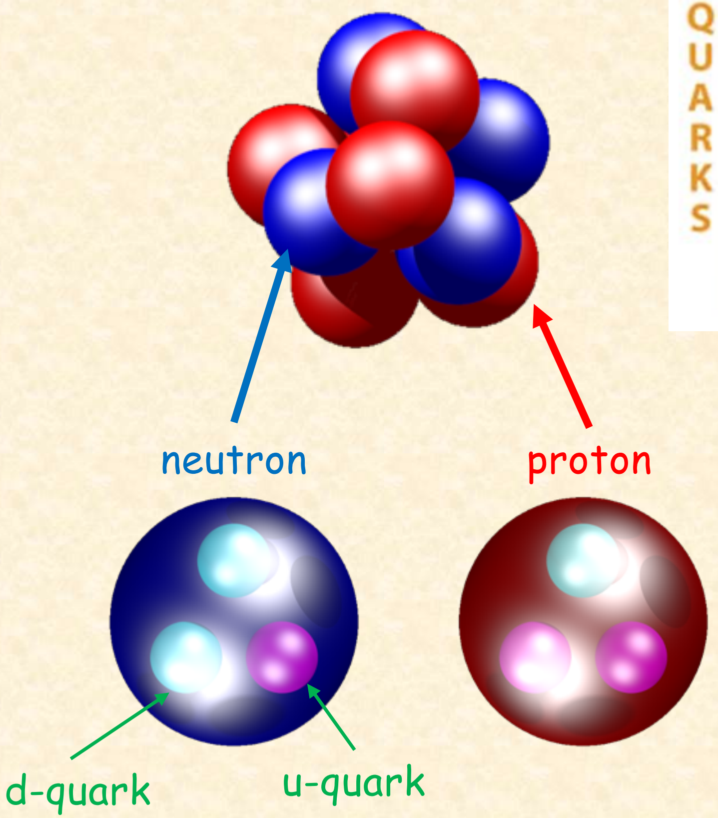
Neutron star merger: August 17th, 2017

- GW170817 detected by LIGO and Virgo
- First multi-messenger observations of a binary neutron star merger
- Constraints in radius, ...
- Awaiting the information of the baryonic interaction with strangeness



Quarks and sub-atomic nuclei

Sub-atomic nucleus



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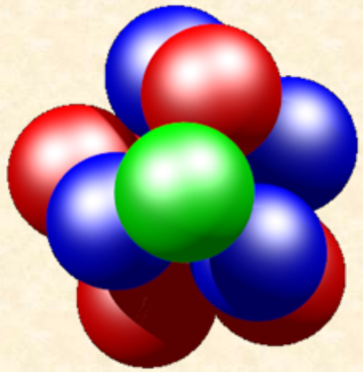
hyperon (Λ)

Lifetime: 10^{-10} ps

s-quark: distinguishable from u- and d-quarks

hypernucleus

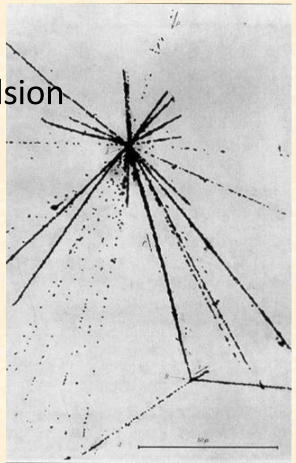


Micro-laboratory to study baryonic-interactions

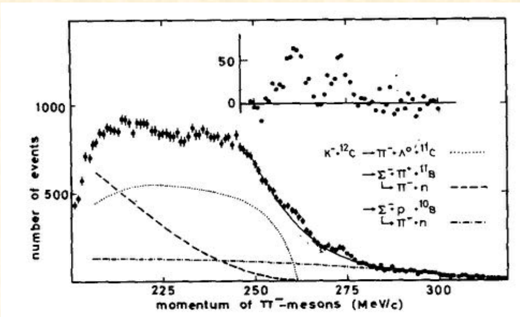
History of hypernuclear Experiments (only a major part)

1953 – 1970
With nuclear emulsion

Marian Danysz (left) and Jerzy Pniewski, who first observed a hypernucleus.



1970 - 1985
Kaon beams at CERN



1985 - 2005
Kaon and pion beams at AGS/BNL and PS/KEK

FINUDA

From 21st century
Kaon beams at J-PARC and electron beams at JLab

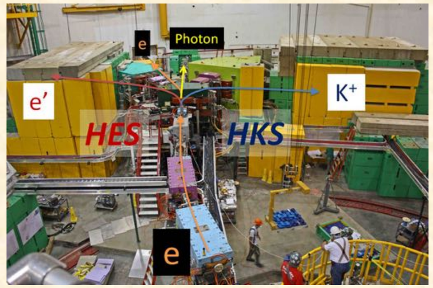


Chart of ordinary nuclei

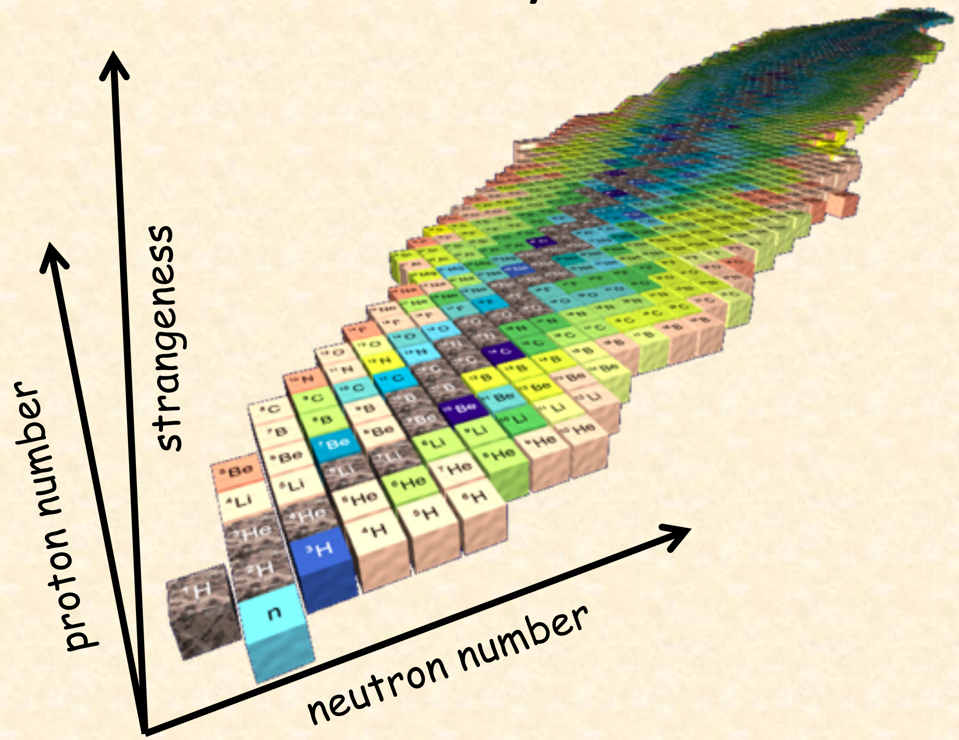


Chart of single-strangeness hypernuclei

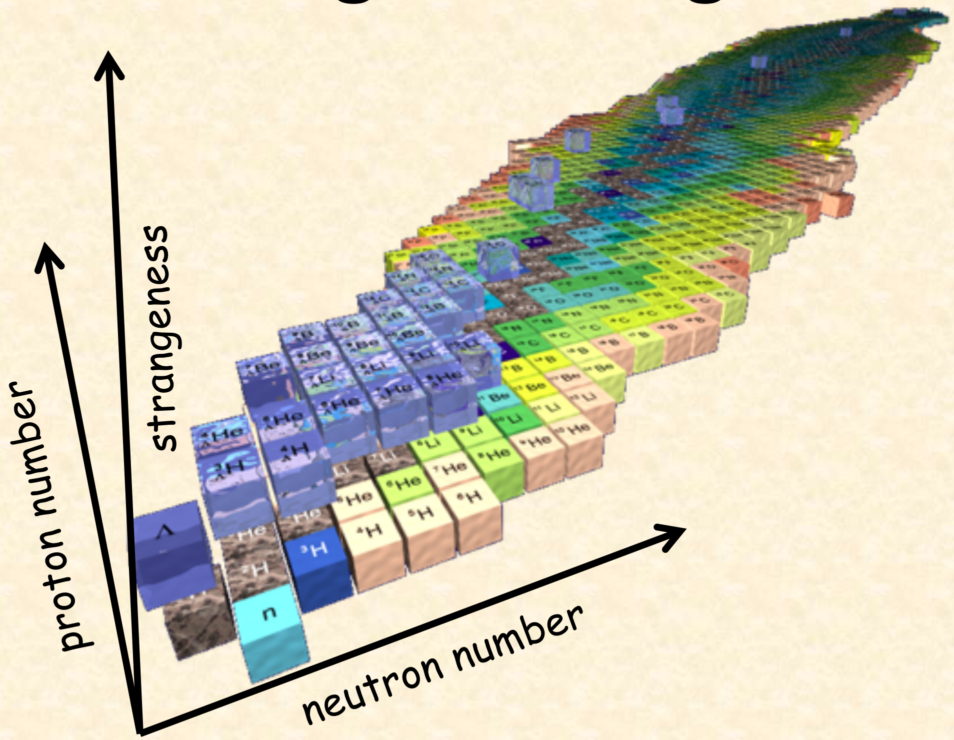


Chart of double-strangeness hypernuclei

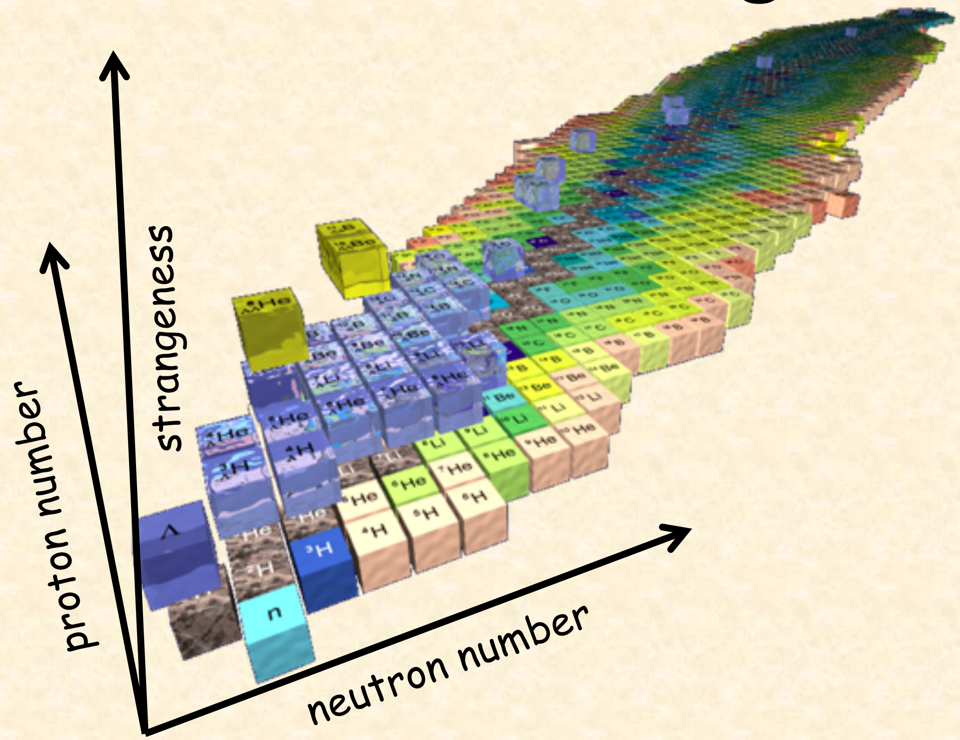
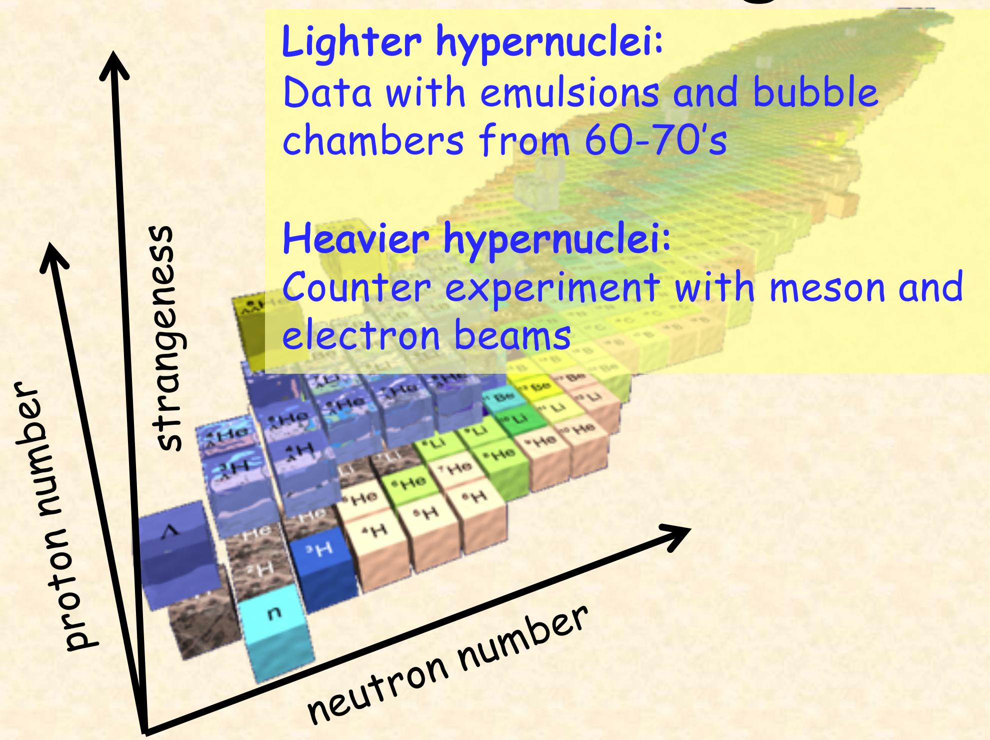


Chart of double-strangeness hypernuclei



Lighter hypernuclei:
Data with emulsions and bubble chambers from 60-70's

Heavier hypernuclei:
Counter experiment with meson and electron beams

Hypernuclear spectroscoy with **H**eavy **I**on Beam

Advantage
- Precise spectroscopy
  - Structure in detail
- Clean experiment

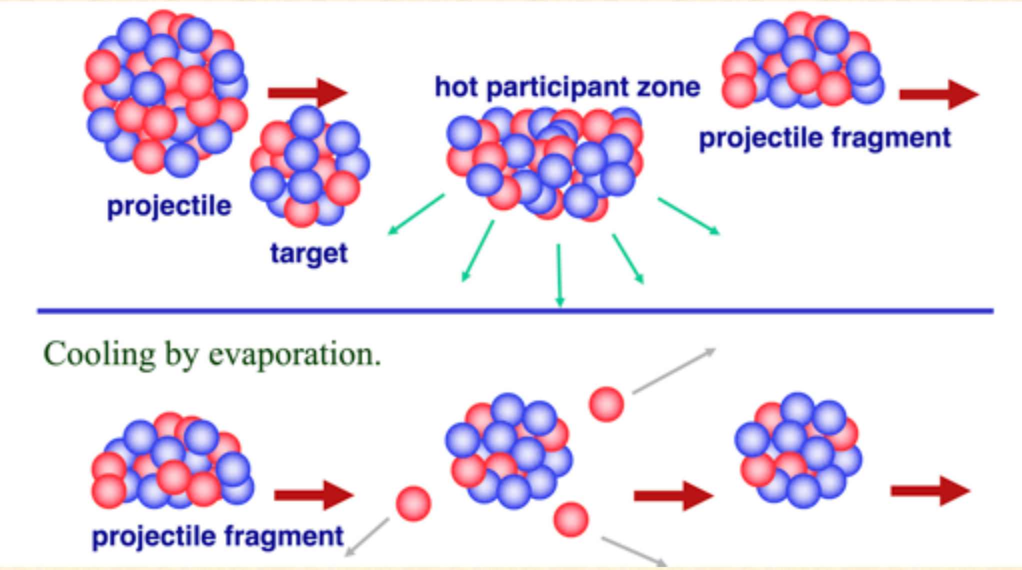
Difficulties
- Limited isospin
- Small momentum transfer to separate hypernuclei
- Difficulties on decay studies
- Only up to double-strangeness

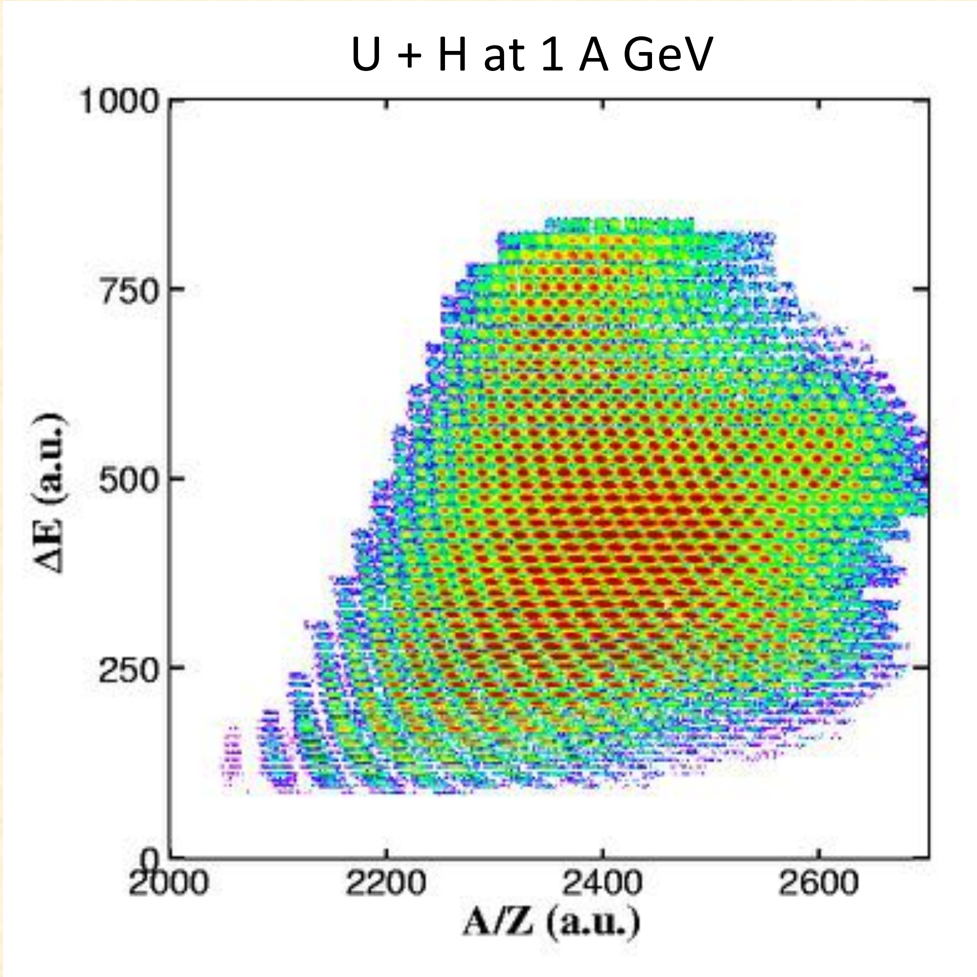
Hypernuclear spectroscopy with heavy ion beams

HypHI project, started in 2005

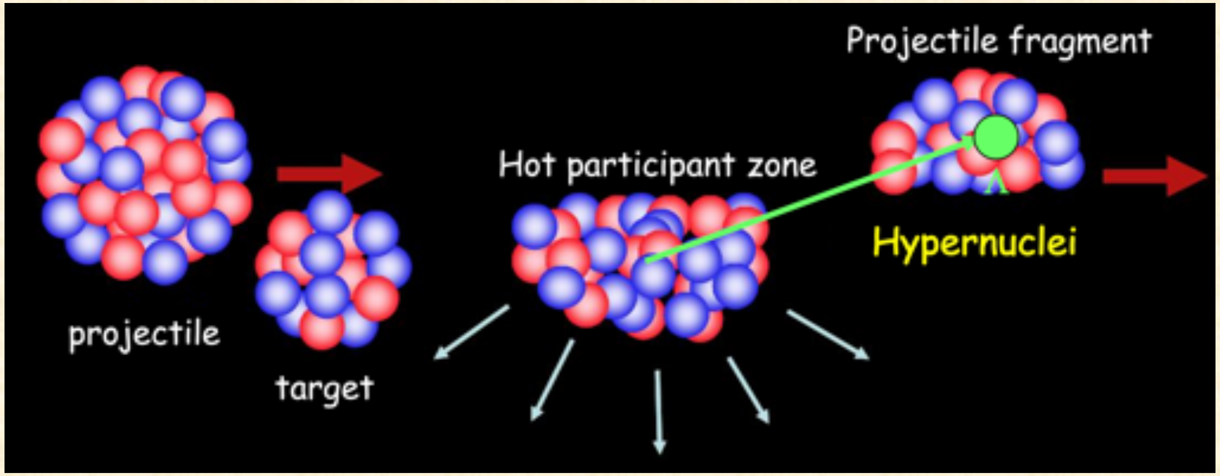
The way to produce hypernuclei with HypHI

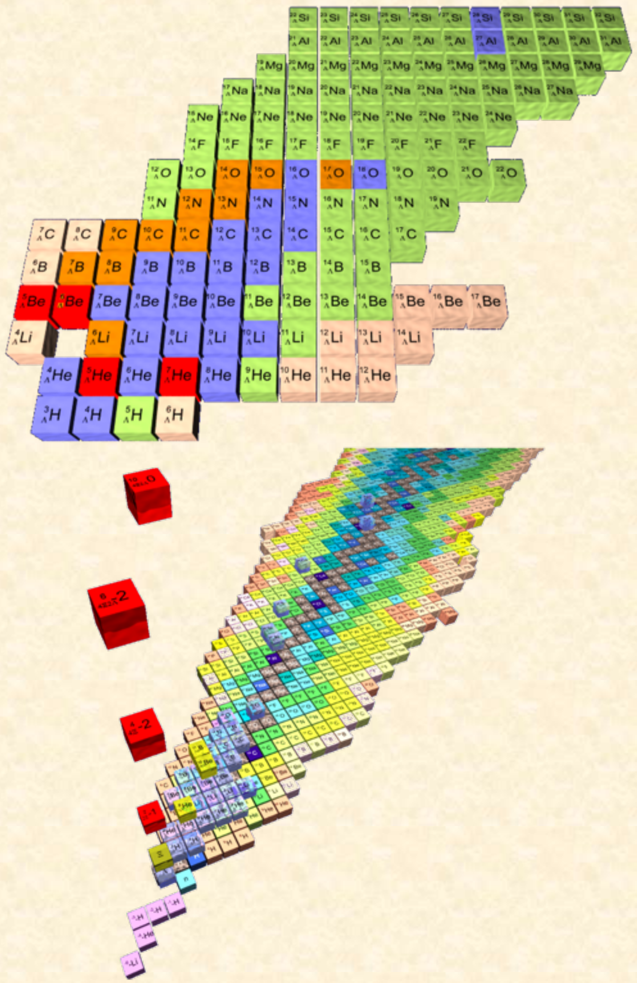
Projectile fragmentation reaction

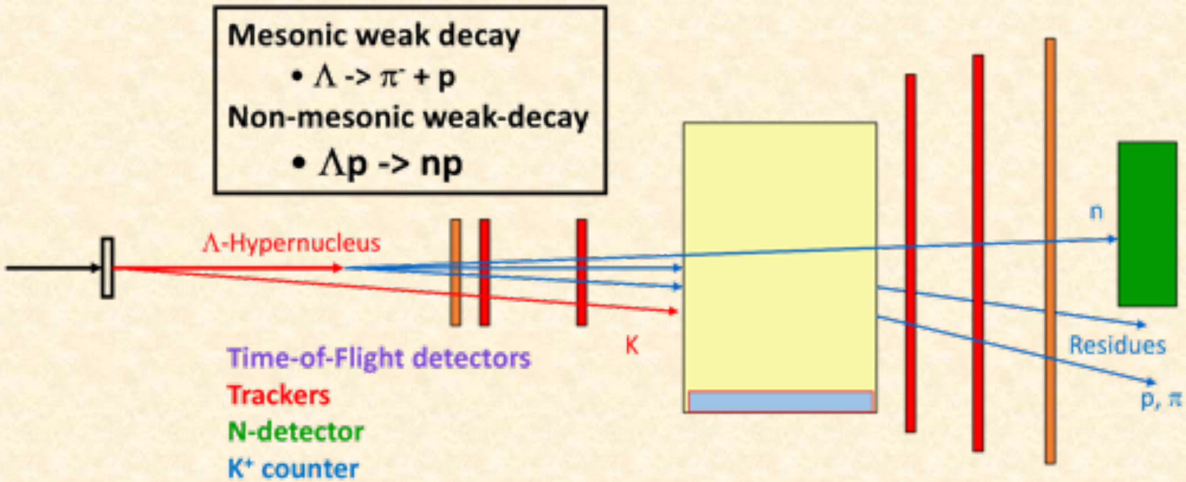




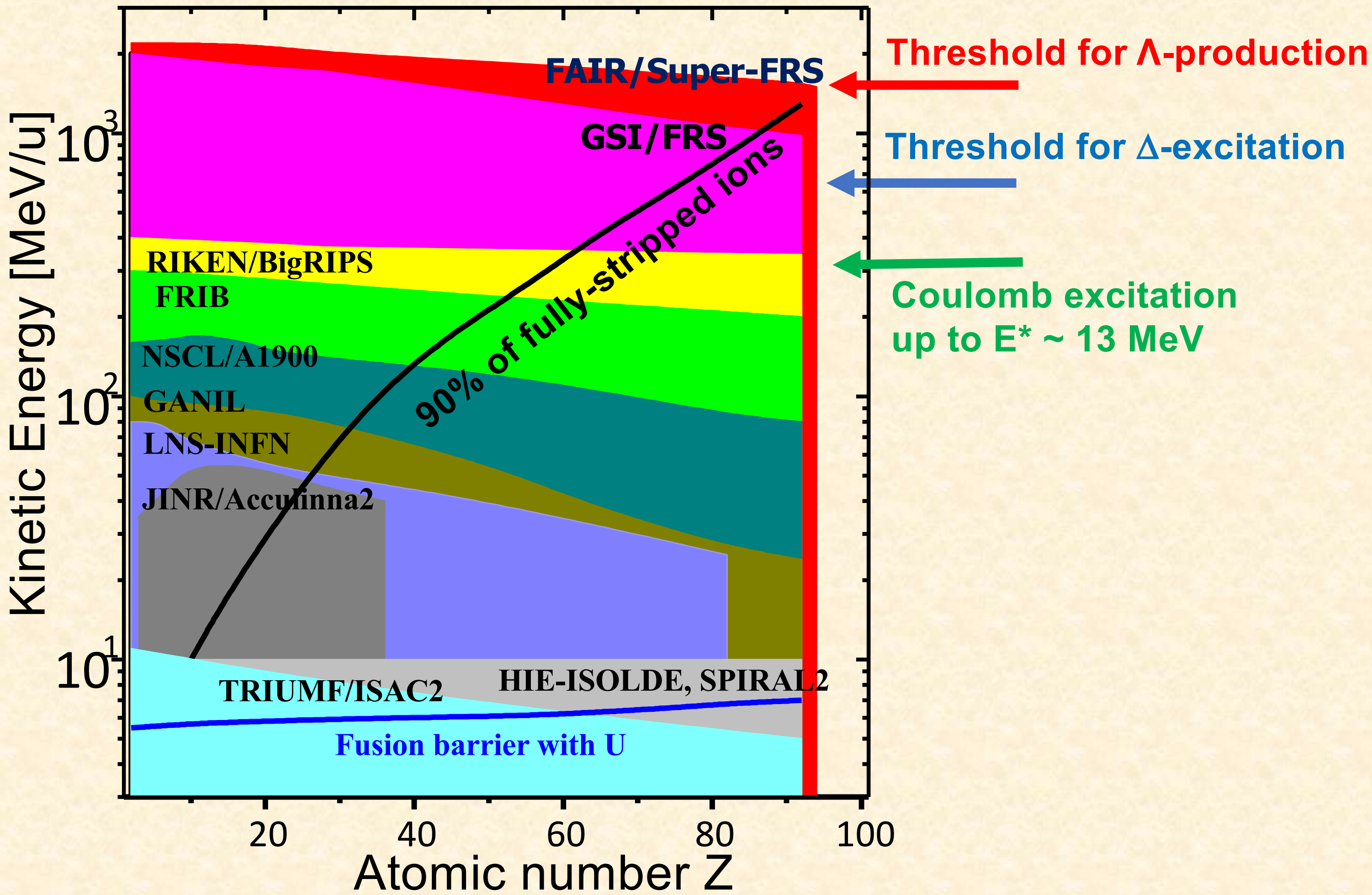
The way to produce hypernuclei with HypHI





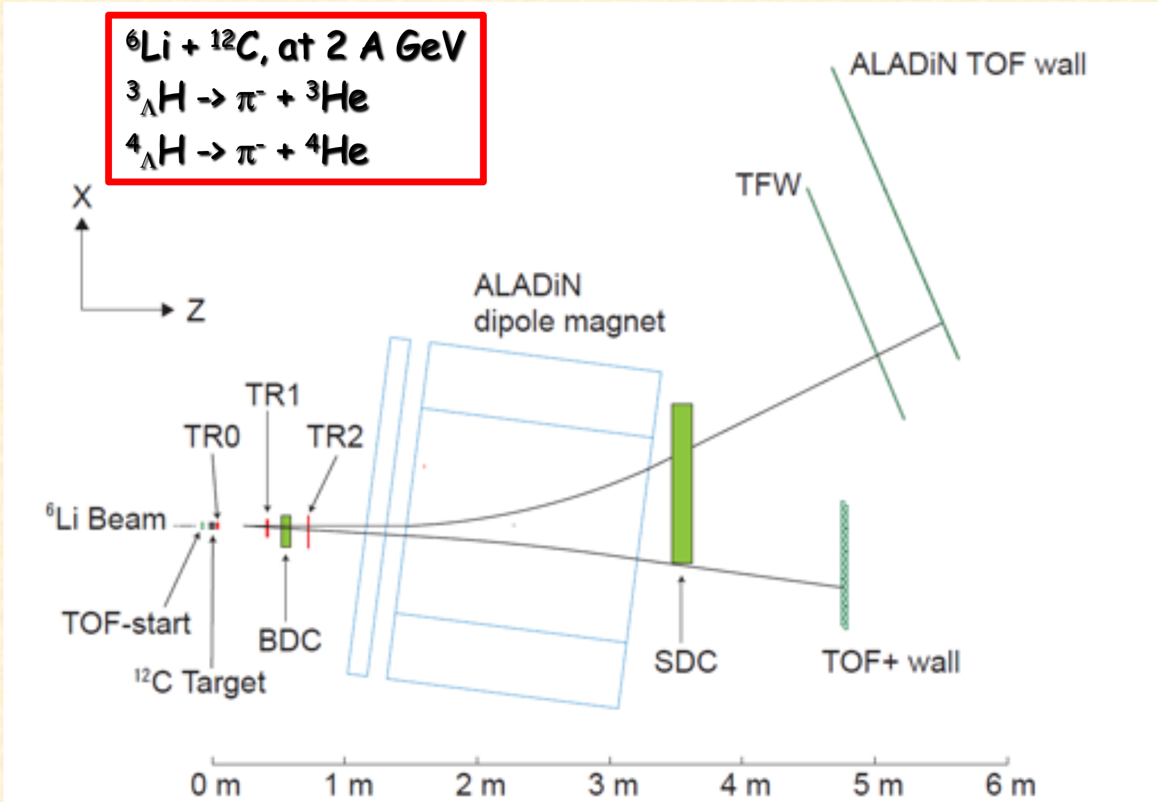


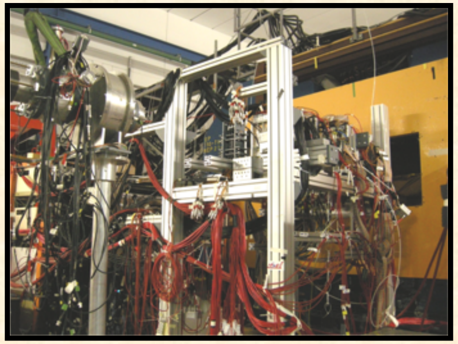
Hypernuclear production with Rare-Isotope beams

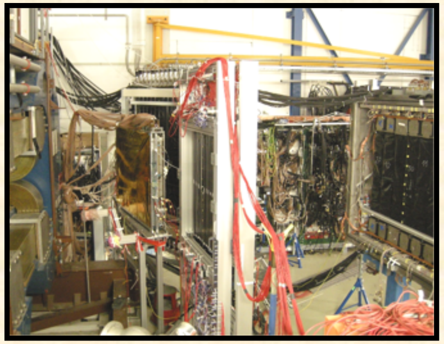


HypHI Phase 0 experiment (2006 – 2012)

- To demonstrate the feasibility of precise hypernuclear spectroscopy with ^{6}Li primary beams at 2 A GeV on a carbon target







Results of HypHI Phase 0

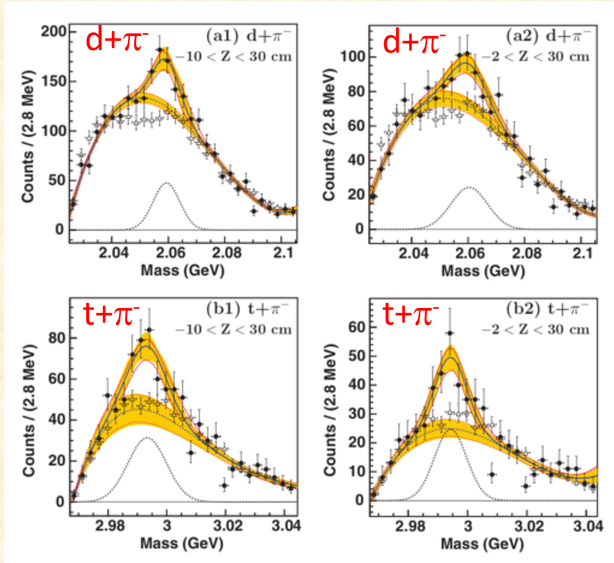
- **Observations of $^{3}_{\Lambda}H$, $^{4}_{\Lambda}H$ and Λ-hyperon**
  - Nucl. Phys. A 913 (2013) 170
- **Short lifetime of $^{3}_{\Lambda}H$ and $^{4}_{\Lambda}H$**
  - Nucl. Phys. A 913 (2013) 170
  - Phys. Lett. B 728 (2014) 543
- **Indications of the nnΛ bound state**
  - Phys. Rev. C 88 (2013) 041001-1-6(R)
- **Production cross section of $^{3}_{\Lambda}H$, $^{4}_{\Lambda}H$ and Λ-hyperon with $^{6}Li+^{12}C$ at 2 A GeV**
  - Phys. Lett. B 747 (2014) 129
- **Summary paper**
  - Nucl. Phys. A 954 (2016) 199

Two puzzles from HypHI

Signals indicating nnΛ bound state

<u>All theoretical calculations are negative</u>

- E. Hiyama et al., Phys. Rev. C89 (2014) 061302(R)
- A. Gal et al., Phys. Lett. B736 (2014) 93
- H. Garcilazo et al., Phys. Rev. C89 (2014) 057001



C. Rappold et al., PRC 88 (2013) 041001

Short lifetime of $^{3}_{\Lambda}$H C. Rappold et al., Nucl. Phys. A 913 (2013) 170

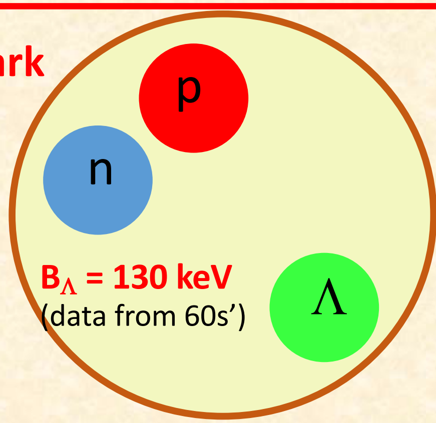
- HypHI Phase 0: 183^{+42}_{-32} ps
- STAR at RHIC: ~~155^{+25}_{-22} ps~~ **142^{+24}_{-21}**
- ALICE at LHC: ~~181^{+54}_{-39} ps~~ **237^{+33}_{-36}**

STAR Collaboration, Phys. Rev. C 97 (2018) 054909

ALICE Collaboration, Phys. Lett. B 797 (2019) 134905

<u>No theories to reproduce the short lifetime</u>

Benchmark



τ($^{3}_{\Lambda}$H) should be equal to τ(Λ, 263 ps)

Hot topics in hypernuclear and few-body physics

New results on hypertriton

NATURE PHYSICS | VOL 16 | APRIL 2020 | 409–412 | www.nature.com/naturephysics

nature physics LETTERS

https://doi.org/10.1038/s41567-020-0799-7

Check for updates

Measurement of the mass difference and the binding energy of the hypertriton and antihypertriton

The STAR Collaboration*

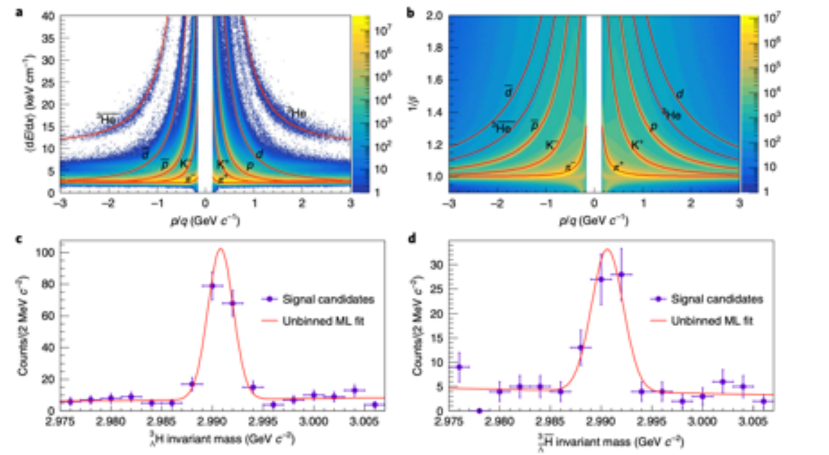


Fig. 2 | Particle identification and the invariant mass distributions for $^3_\Lambda$H and $^3_\Lambda\overline{\text{H}}$ reconstruction. a,b, ⟨dE/dx⟩ (mean energy loss per unit track length in the gas of the TPC) versus p/q (where p is the momentum and q is the electric charge in units of the elementary charge e) (**a**) and $1/\beta$ (where β is the speed of a particle in units of the speed of light) versus p/q (**b**). ⟨dE/dx⟩ is measured by the TPC and $1/\beta$ is measured by the TOF detector in conjunction with the TPC. In both cases, the coloured bands show the measured data for each species of charged particle, while the red curves show the expected values. Charged particles are identified by comparing the observed ⟨dE/dx⟩ and $1/\beta$ with the expected values. **c,d**, Utilizing both 2-body and 3-body decay channels, the invariant mass distributions of $^3_\Lambda$H (**c**) and $^3_\Lambda\overline{\text{H}}$ (**d**) are shown. The error bars represent statistical uncertainties (s.d.). The red curves represent a fit with a Gaussian function plus a linear background, using the unbinned maximum likelihood (ML) method.

The Λ binding energy, B_Λ, for $^3_\Lambda$H and $^3_\Lambda\overline{\text{H}}$ is calculated using the mass measurement shown in equation (1). We obtain

$$B_\Lambda = 0.41 \pm 0.12(\text{stat.}) \pm 0.11(\text{syst.})\ \text{MeV} \qquad (3)$$

Former value by emulsion (data from 60's)
0.13 ± 0.05 MeV

average value of 0.13 ± 0.05(stat.) MeV. When applied to our value of 0.41 ± 0.12(stat.) MeV it yields a significantly smaller value of $7.90^{+1.71}_{-0.93}$ fm. The larger B_Λ and shorter effective scattering length suggest a stronger YN interaction between the Λ and the relatively low-density nuclear core of the $^3_\Lambda$H (ref. [36]). This, in certain models, requires SU(3) symmetry breaking and a more repulsive YN interaction at high density, consistent with implications from the range of masses observed for neutron stars[5].

New theoretical calculation

Revisiting the hypertriton lifetime puzzle

A. Pérez-Obiol,[1] D. Gazda,[2] E. Friedman,[3] and A. Gal[3,*]

[1]*Laboratory of Physics, Kochi University of Technology, Kami, Kochi 782-8502, Japan*
[2]*Nuclear Physics Institute, 25068 Řež, Czech Republic*
[3]*Racah Institute of Physics, The Hebrew University, Jerusalem 91904, Israel*

(Dated: July 9, 2020)

Concluding remarks. Reported in this work is a new microscopic three-body calculation of the ${}^3_\Lambda$H pionic two-body decay rate $\Gamma({}^3_\Lambda\mathrm{H} \to {}^3\mathrm{He}+\pi^-)$. Using the $\Delta I = \frac{1}{2}$ rule and a branching ratio taken from experiment to connect to additional pionic decay rates, the lifetime $\tau({}^3_\Lambda\mathrm{H})$ was deduced. As emphasized here $\tau({}^3_\Lambda\mathrm{H})$ varies strongly with the small, rather poorly known Λ separation energy $B_\Lambda({}^3_\Lambda\mathrm{H})$; it proves possible then to correlate each one of the three distinct RHI experimentally reported values $\tau_{\mathrm{exp}}({}^3_\Lambda\mathrm{H})$ with a theoretical value $\tau_{\mathrm{th}}({}^3_\Lambda\mathrm{H})$ that corresponds to its own underlying $B_\Lambda({}^3_\Lambda\mathrm{H})$ value. The $B_\Lambda({}^3_\Lambda\mathrm{H})$ intervals thereby correlated with these experiments are roughly $B_\Lambda \lesssim 0.1$ MeV, $0.1 \lesssim B_\Lambda \lesssim 0.2$ MeV and $B_\Lambda \gtrsim 0.2$ MeV for ALICE, HypHI and STAR, respectively. New experiments proposed at MAMI on Li target [39] and at JLab, J-PARC and ELPH on ^{3}He target [40] will hopefully pin down precisely $B_\Lambda({}^3_\Lambda\mathrm{H})$ to better than perhaps 50 keV, thereby leading to a unique resolution of the 'hypertriton lifetime puzzle'.

STAR, HypHI, ALICE: **from 121 to 270 ps**

Urgent issues

Hypertriton
Lifetime (HypHI,STAR,ALICE): **121 ~ 270 ps**
Binding Energy: **130 ± 50 keV (Very old emulsion)**
410 ± 120 ± 110 keV (STAR 2020)

nnΛ
Does it exist?

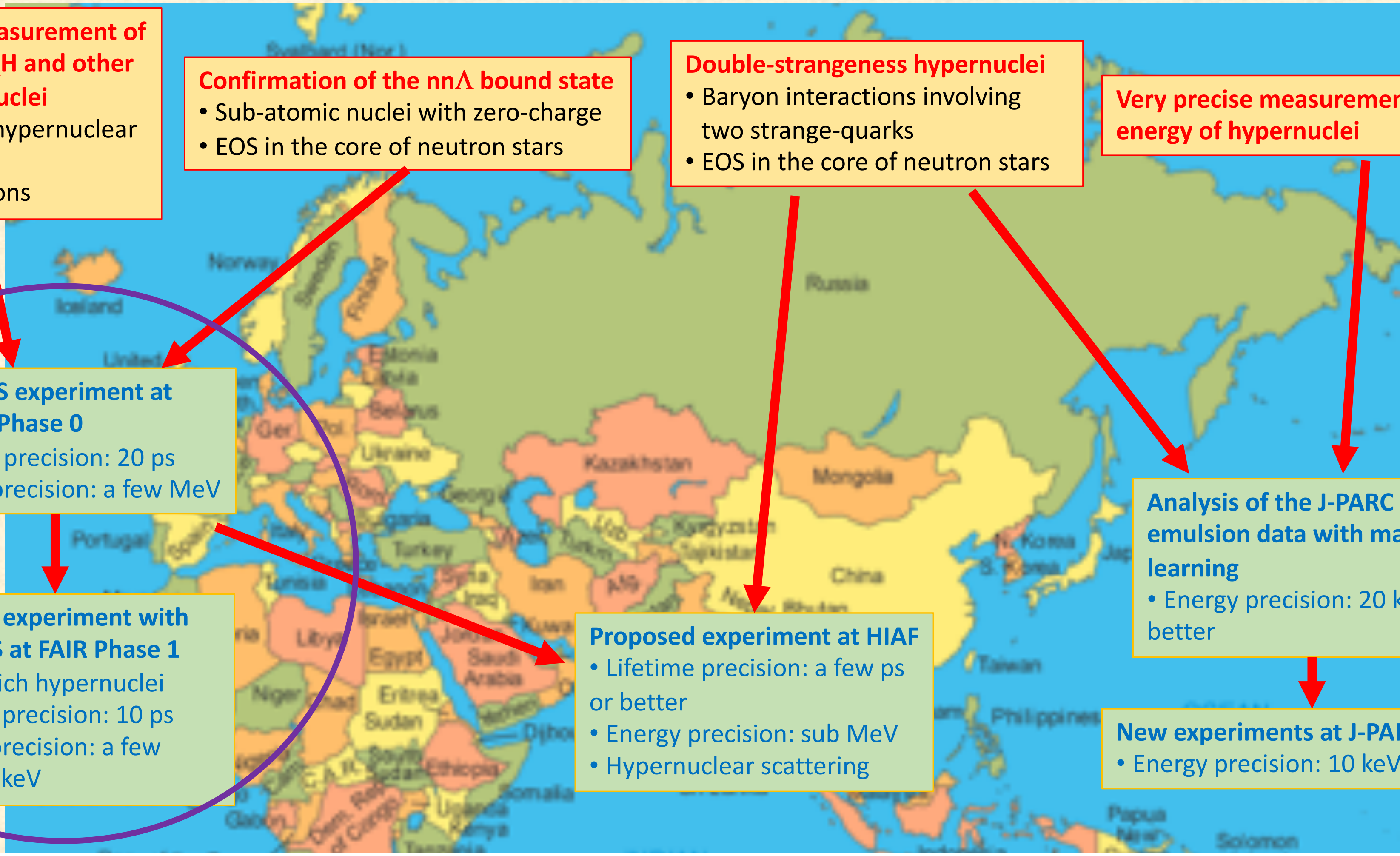
Very precise measurements for hypertriton on
- **Lifetime**
- **Binding energy**

Confirmation of nnΛ with large statistics

And, much more information for double-strangeness hypernuclei

Our strategy for very urgent important issues

on Nuclear physics, Hadron physics and Astrophysics



Very precise measurement of lifetime τ_Λ for $^3_\Lambda$H and other single-Λ hypernuclei

- Benchmark in hypernuclear physics
- B_Λ-τ_Λ correlations

Confirmation of the nnΛ bound state

- Sub-atomic nuclei with zero-charge
- EOS in the core of neutron stars

Double-strangeness hypernuclei

- Baryon interactions involving two strange-quarks
- EOS in the core of neutron stars

Very precise measurement of binding energy of hypernuclei

WASA-FRS experiment at GSI/FAIR Phase 0

- Lifetime precision: 20 ps
- Energy precision: a few MeV

Proposed experiment with Super-FRS at FAIR Phase 1

- Proton rich hypernuclei
- Lifetime precision: 10 ps
- Energy precision: a few hundreds keV

Proposed experiment at HIAF

- Lifetime precision: a few ps or better
- Energy precision: sub MeV
- Hypernuclear scattering

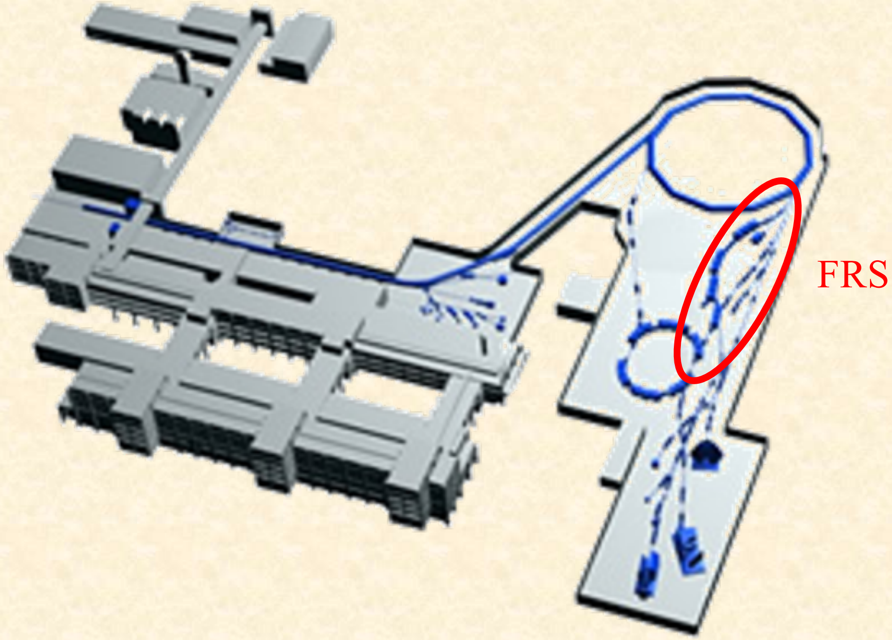
Analysis of the J-PARC E07 emulsion data with machine learning

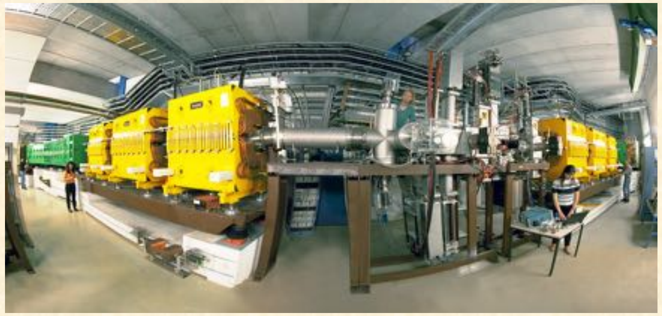
- Energy precision: 20 keV or better

New experiments at J-PARC

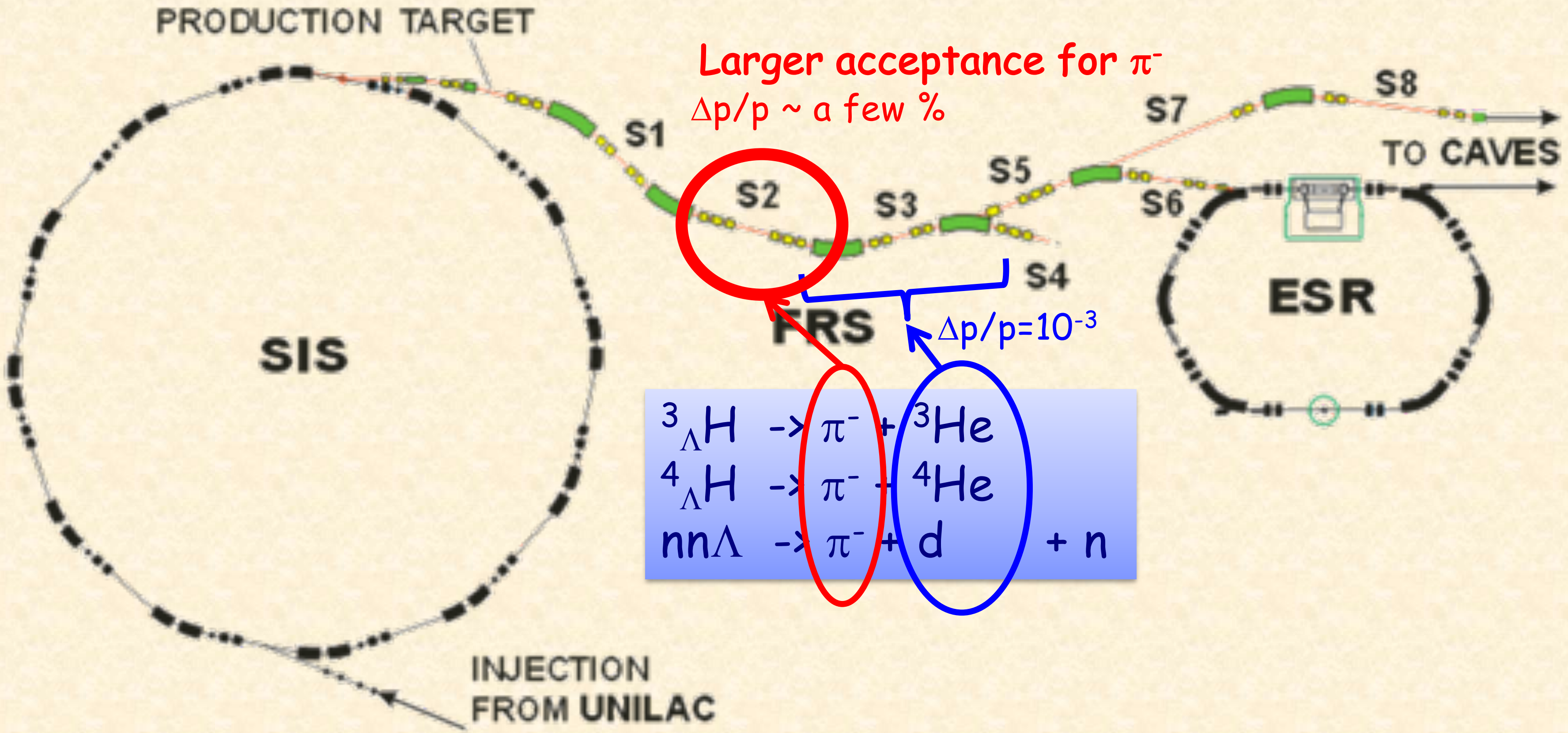
- Energy precision: 10 keV or better

The WASA-FRS experiment at GSI in Germany





The WASA-FRS experiment at FAIR Phase 0 (GSI)



The WASA-FRS experiment at FAIR Phase 0 (GSI)

C. Bargholtz et al. / Nuclear Instruments a

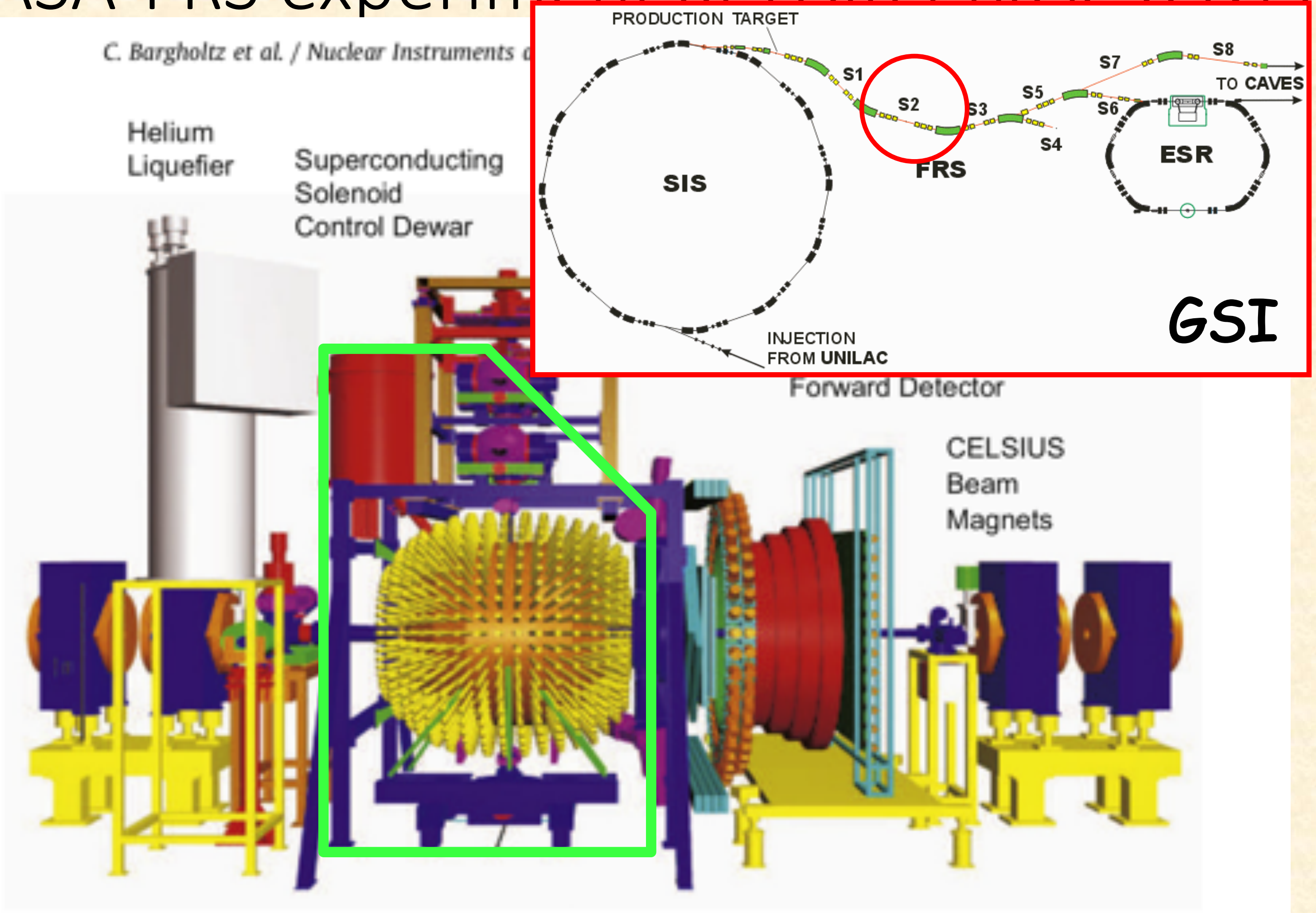
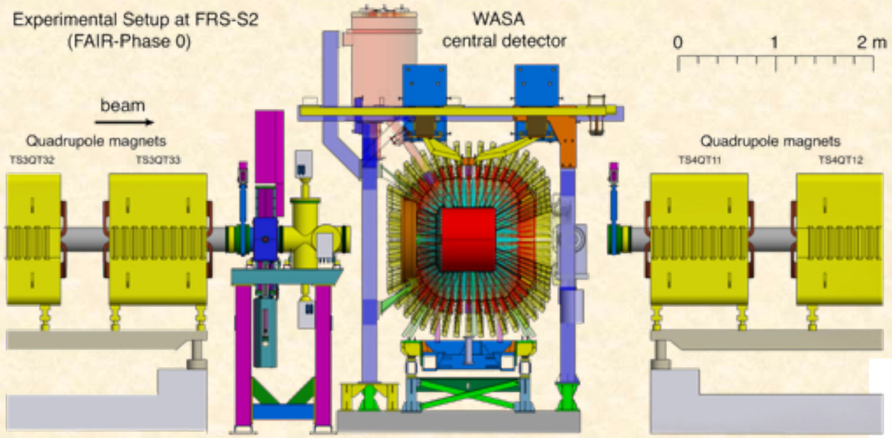


Fig. 1. CAD view of the WASA detector facility. The zero-degree spectrometer is located further downstream to the right.

The WASA-FRS experiment at FAIR Phase 0 (GSI)



WASA-FRS collaboration
with Super-FRS Experiment Collaboration

- **hypernuclei**
- **η'-nucleus**

Table 2: Summary of the channels of interest, magnetic rigidity setup of FRS, requested shifts for each setup and corresponding expected signal integrals after the event reconstructions.

Channel of interest	FRS rigidity [Tm]	Duration of beams on target	Estimated signal integral
$d+\pi^-$	16.675	24 shifts (8 days)	4.0×10^3
${}^3_\Lambda$H→^{3}He+π^-	12.623	9 shifts (3 days)	1.5×10^3
${}^4_\Lambda$H→^{4}He+π^-	16.675	together with $d+\pi^-$	5.0×10^3

10 ~ 40 times more

Already approved by the GSI PAC (highest priority)
2017 and 2020

- **6 days commissioning**
- **9 days for hypernuclear physics run**

At least 2 times better resolution

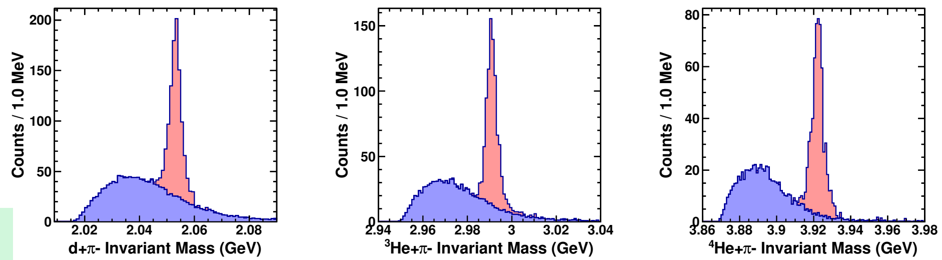


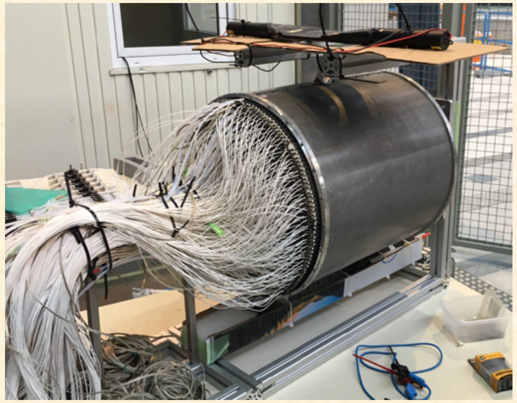
Figure 8: Expected invariant mass distributions of d+π^- from ${}^3_\Lambda$n, 3He+π^- from ${}^3_\Lambda$H and 4He+π^- from ${}^4_\Lambda$H, together with signals (red) and backgrounds (blue).

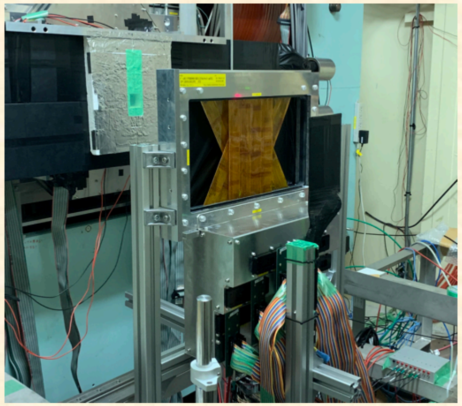
The WASA-FRS experiment at FAIR Phase 0 (GSI)

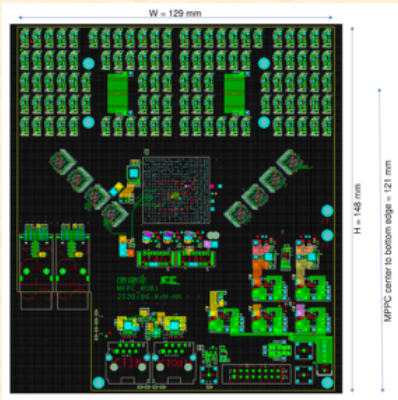
WASA already at GSI since March 2019

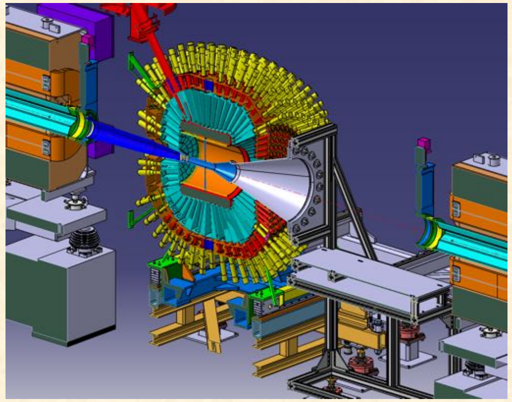
The WASA-FRS experiment at FAIR Phase 0 (GSI)

- Commissioning of
  - Mini drift chamber: **DONE**
  - Superconducting magnet: **already ay 4 K**
- Upgrading of
  - Time-of-Flight Barrel: in progress, **by end of 2020**
- Development and construction of
  - Large Scintillating fiber detectors: **mass production done**, **commissioning in progress**
  - Mini fiber detector inside the iron yoke: **in production**
  - Electronics for fiber detectors: in progress, **by end of 2020**
  - New holding structures: in progress, **by end 2020**







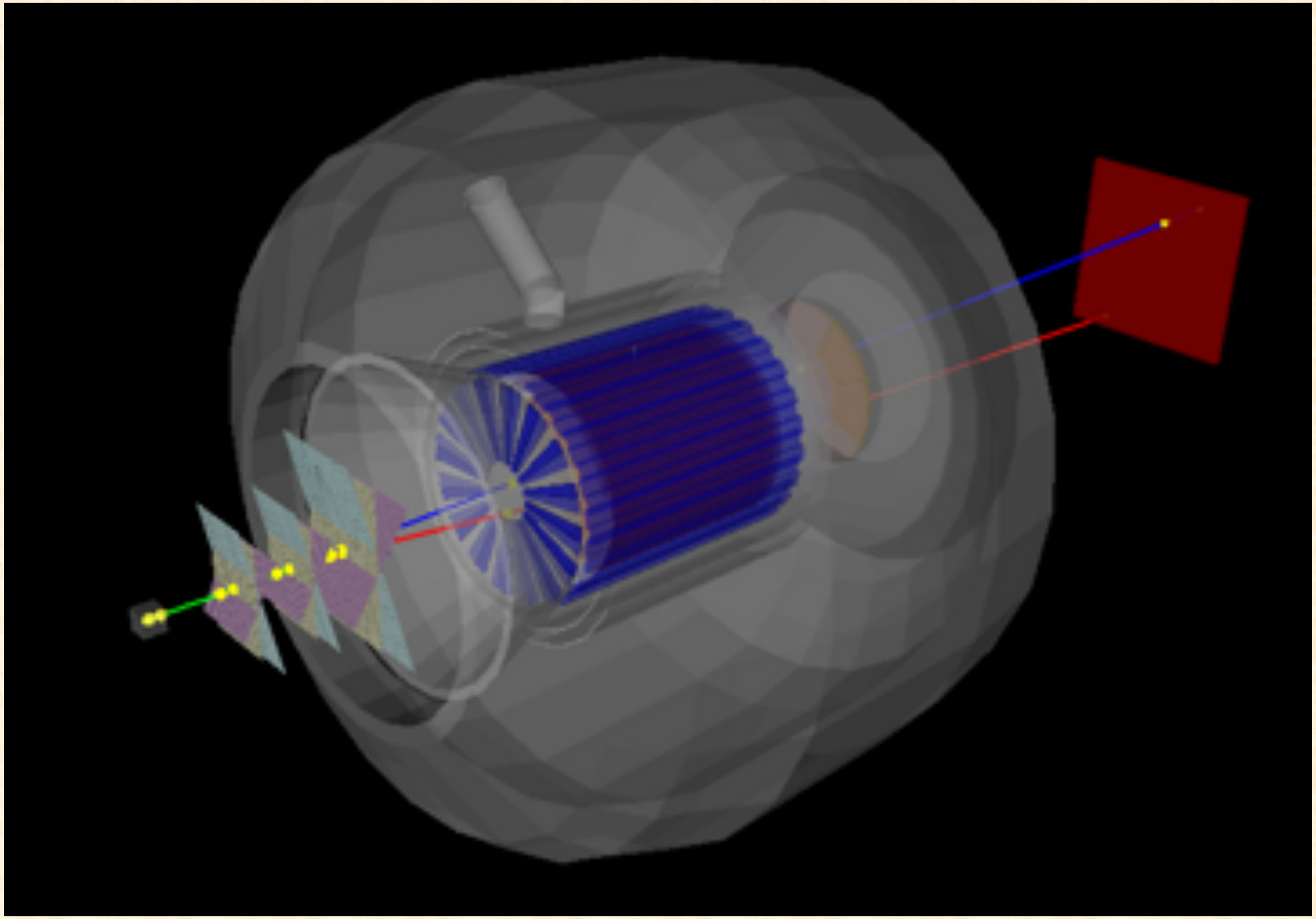


The WASA-FRS experiment at FAIR Phase 0 (GSI)

Test experiment at FRS with proton beams: June 5th – 8th, 2020

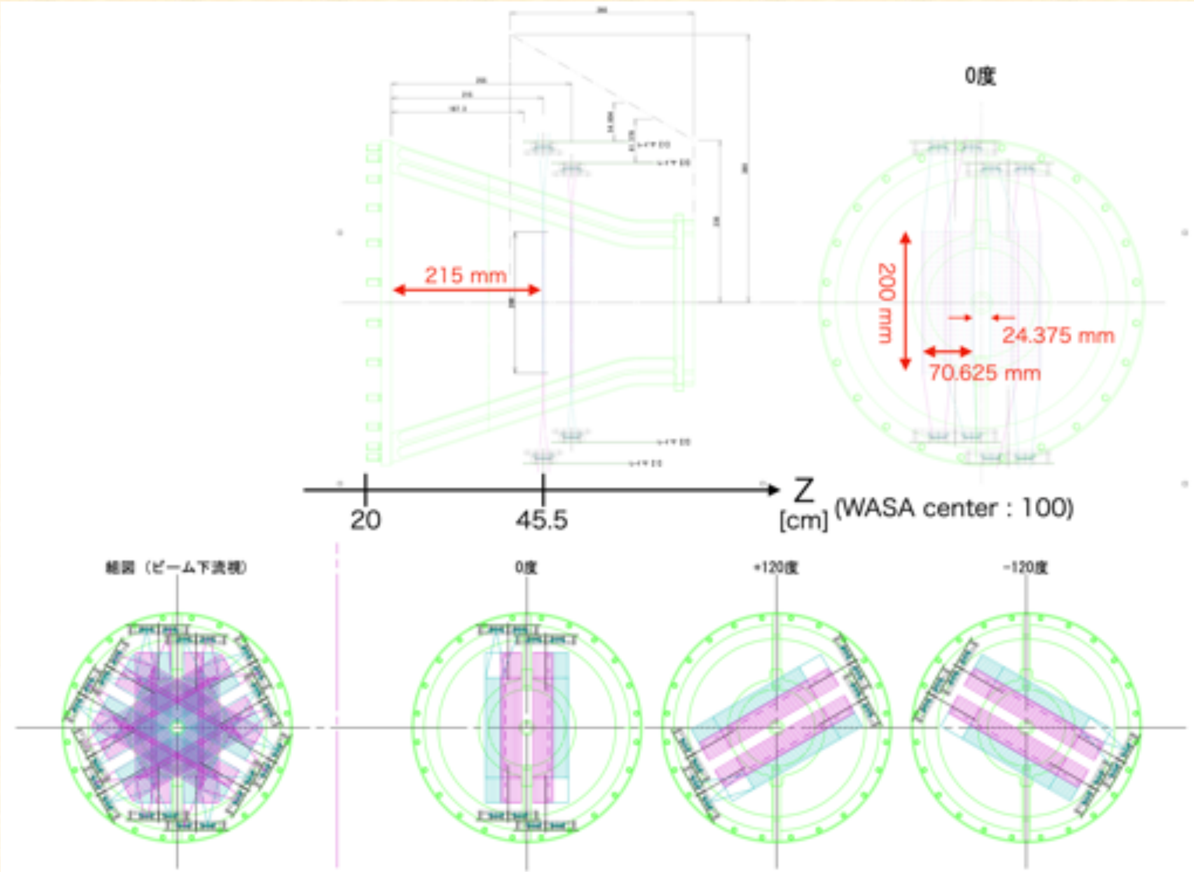
DAQ trigger rate	✓ < 1 kHz
PID in FRS (S3-S4)	✓ Contamination$<10^{-3}$
Single count rate in WASA	✓PSB count rate < 100 kHz
Radiation safety in FRS	✓< 1 μSv/h
Overall feasibility	✓Fulfilled

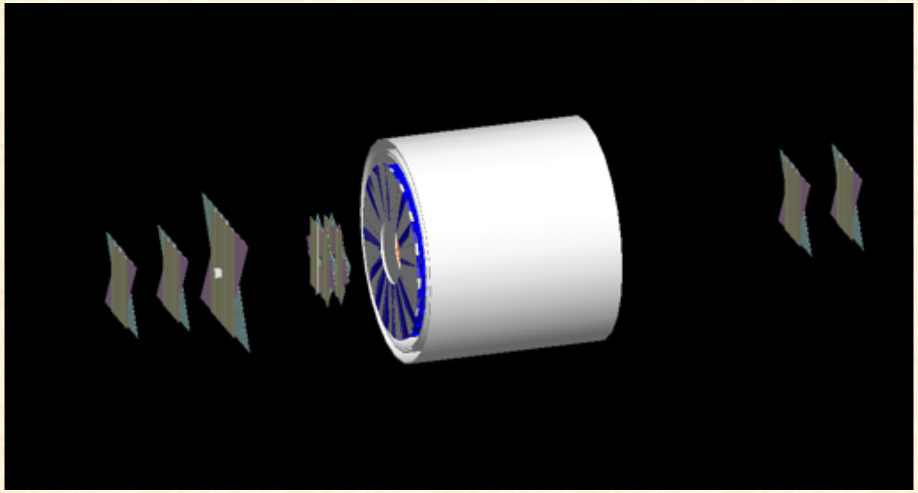
The WASA-FRS experiment at FAIR Phase 0 (GSI)



The WASA-FRS experiment at FAIR Phase 0 (GSI)

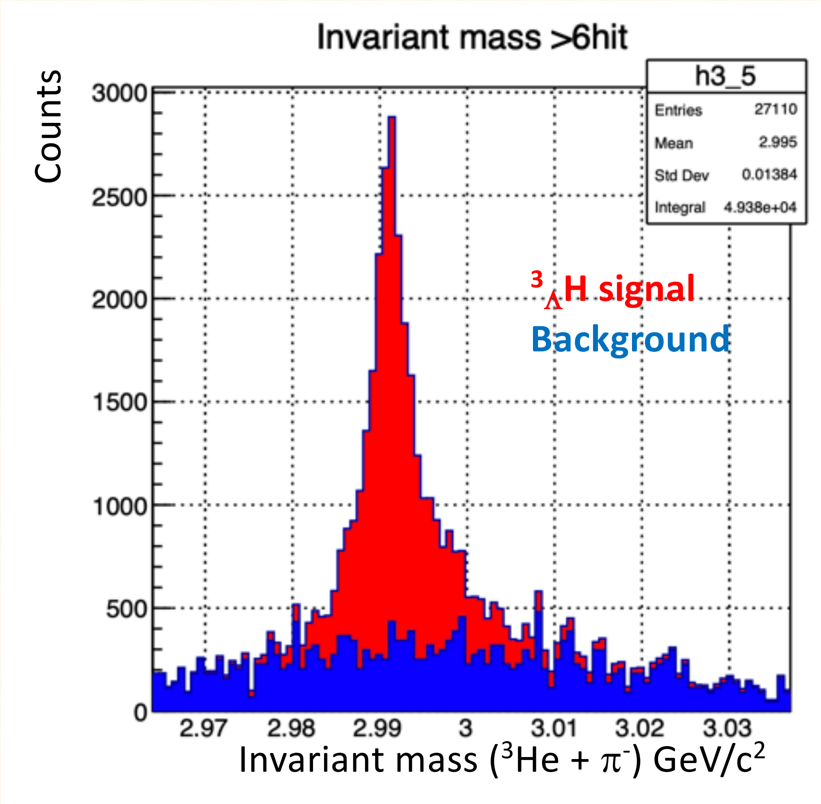
Mini fiber detector



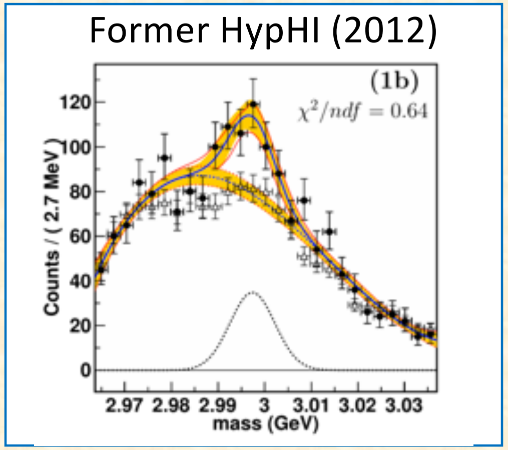


The WASA-FRS experiment at FAIR Phase 0 (GSI)

Updated Monte Carlo simulations



6.8 days measurement



target position: z=25 cm
vertex z cut: 35 – 50 cm
#layer(MDC): > 6
cldst cut: < 0.3 cm

Mass resolution:

- 2.6 MeV/c^2 (1 T field)
- 1.8 times better than HypHI

Statistics

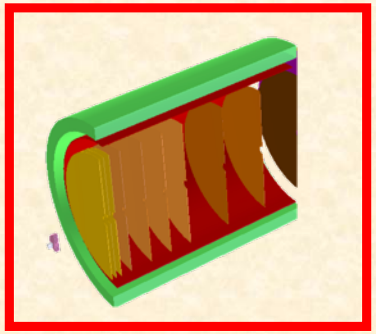
- About 16000 in the peak for 4.5 days
- 100 times more than HypHI

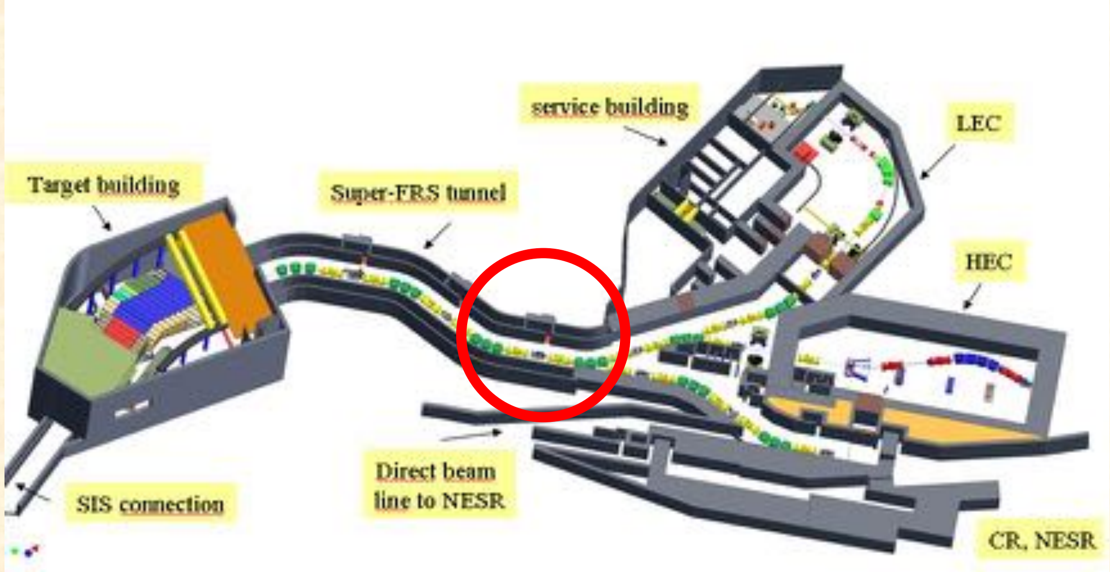
Expected Lifetime accuracy

- 10 ps
- 4 times better than HypHI

To be performed in February – March, 2022

Further steps at FAIR in Germany

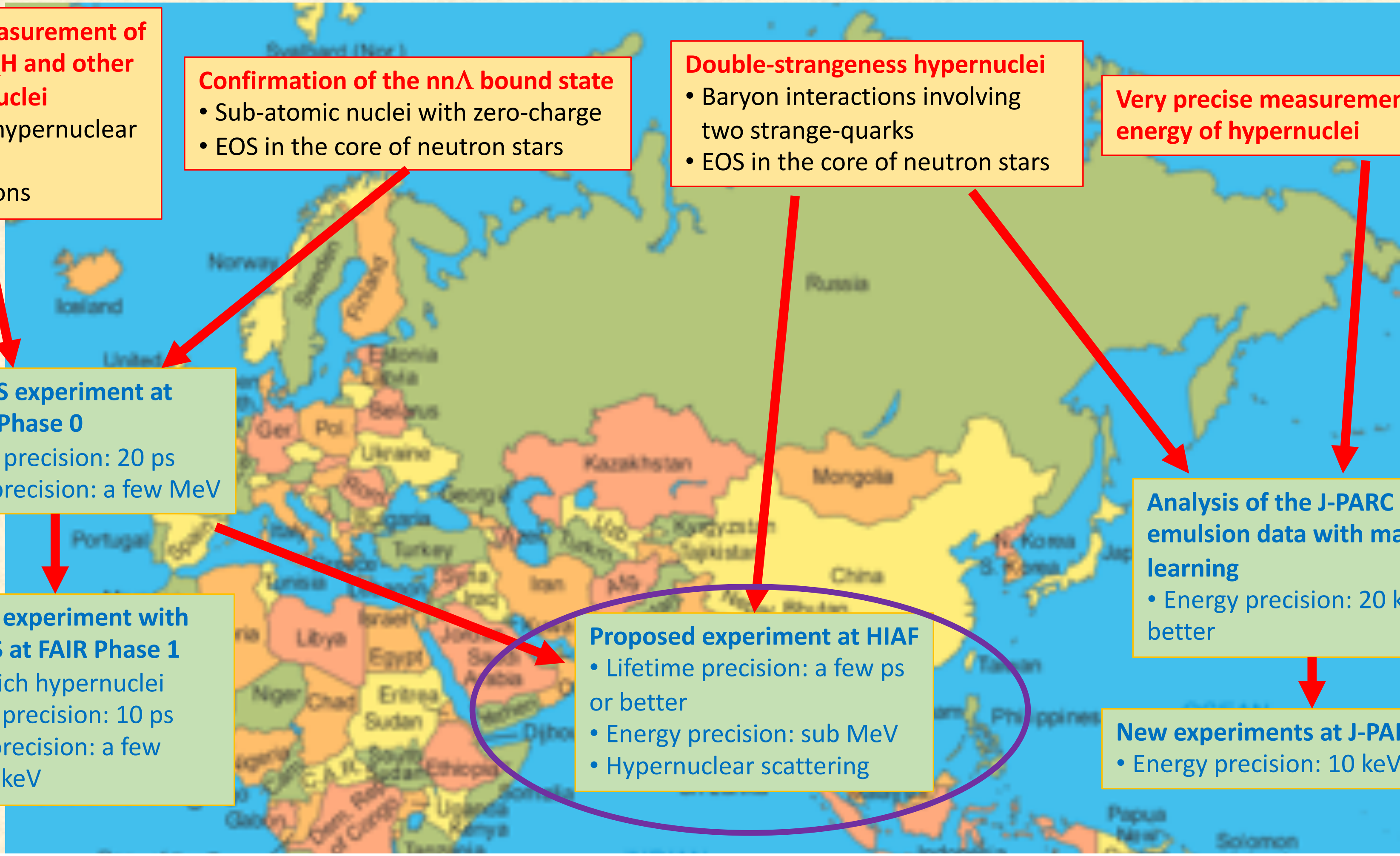




Precise spectroscopy with RI-beams

Our strategy for very urgent important issues

on Nuclear physics, Hadron physics and Astrophysics



Very precise measurement of lifetime τ_Λ for $^3_\Lambda$H and other single-Λ hypernuclei
- Benchmark in hypernuclear physics
- B_Λ-τ_Λ correlations

Confirmation of the nnΛ bound state
- Sub-atomic nuclei with zero-charge
- EOS in the core of neutron stars

Double-strangeness hypernuclei
- Baryon interactions involving two strange-quarks
- EOS in the core of neutron stars

Very precise measurement of binding energy of hypernuclei

WASA-FRS experiment at GSI/FAIR Phase 0
- Lifetime precision: 20 ps
- Energy precision: a few MeV

Proposed experiment with Super-FRS at FAIR Phase 1
- Proton rich hypernuclei
- Lifetime precision: 10 ps
- Energy precision: a few hundreds keV

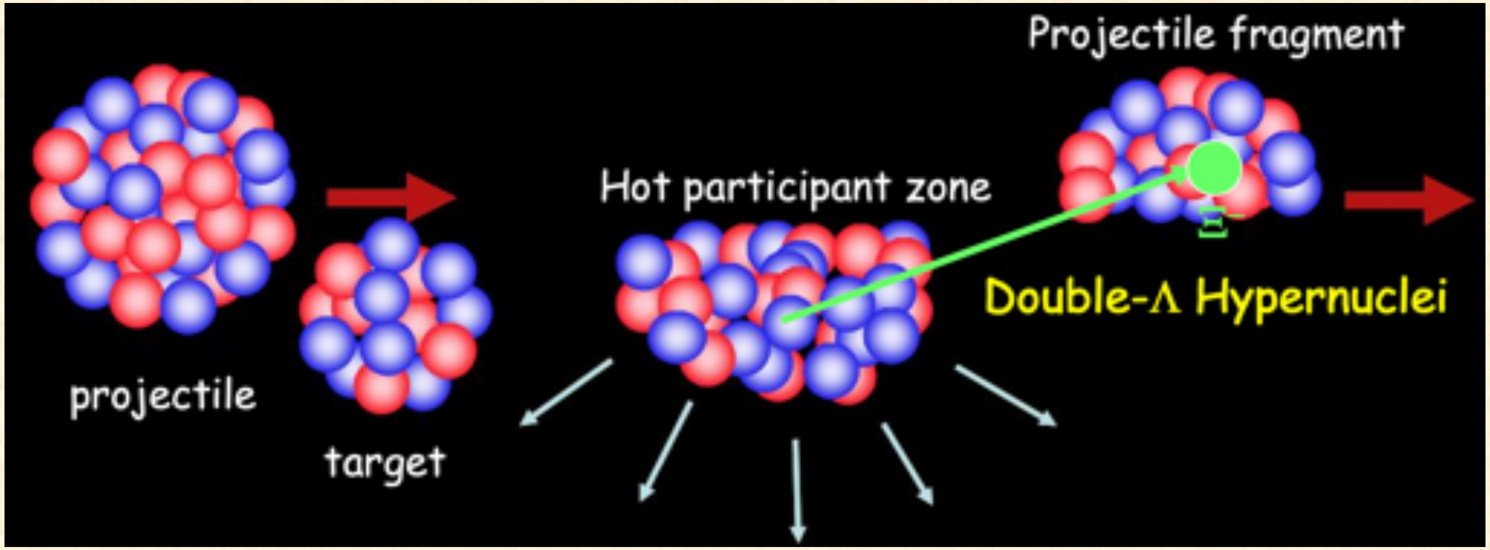
Proposed experiment at HIAF
- Lifetime precision: a few ps or better
- Energy precision: sub MeV
- Hypernuclear scattering

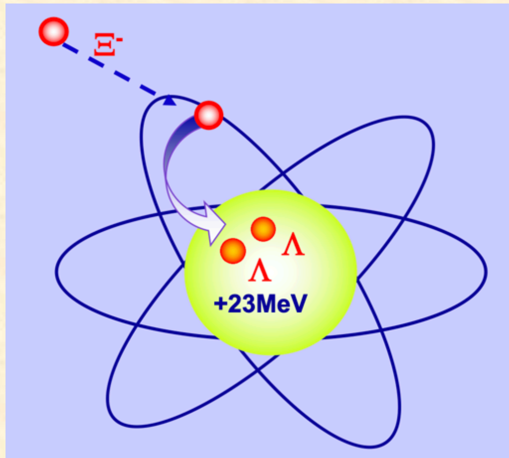
Analysis of the J-PARC E07 emulsion data with machine learning
- Energy precision: 20 keV or better

New experiments at J-PARC
- Energy precision: 10 keV or better

Hypernuclear project at HIAF in China

Towards double-strangeness hypernuclei: E > 3.75 A GeV





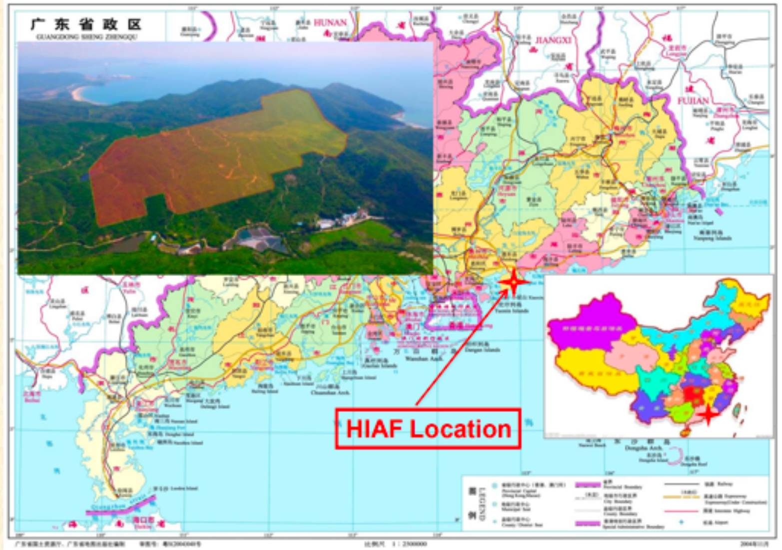
Huge variety of
- Λ hypernuclei
- Σ hypernuclei
- Ξ hypernuclei
- Double-Λ hypernuclei

Hypernuclear project at HIAF in China

HIAF (High Intensity heavy ion Accelerator Facility)

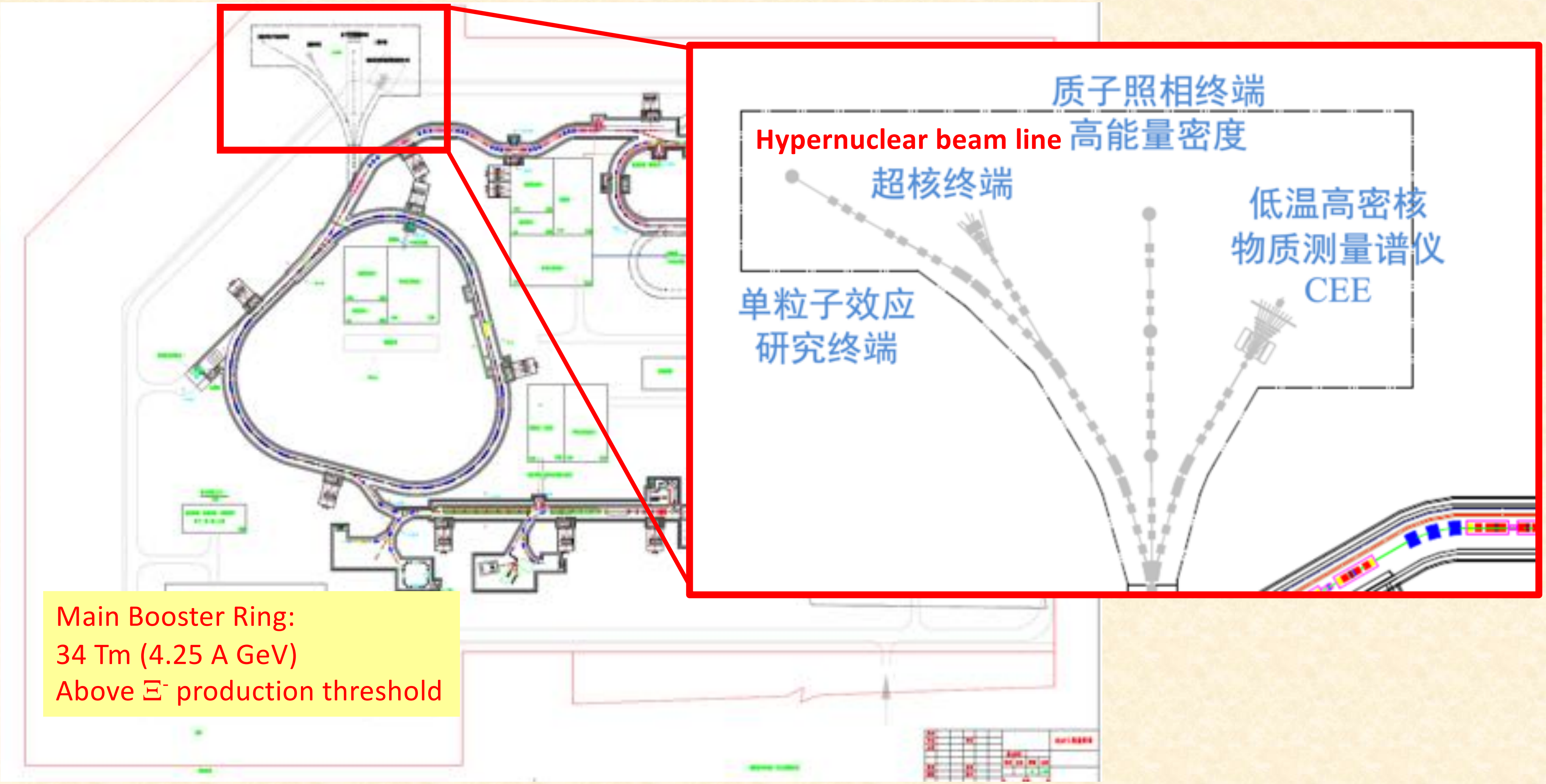
- To be operational in 2025

T.S. is leading the new hypernuclear project since 2016



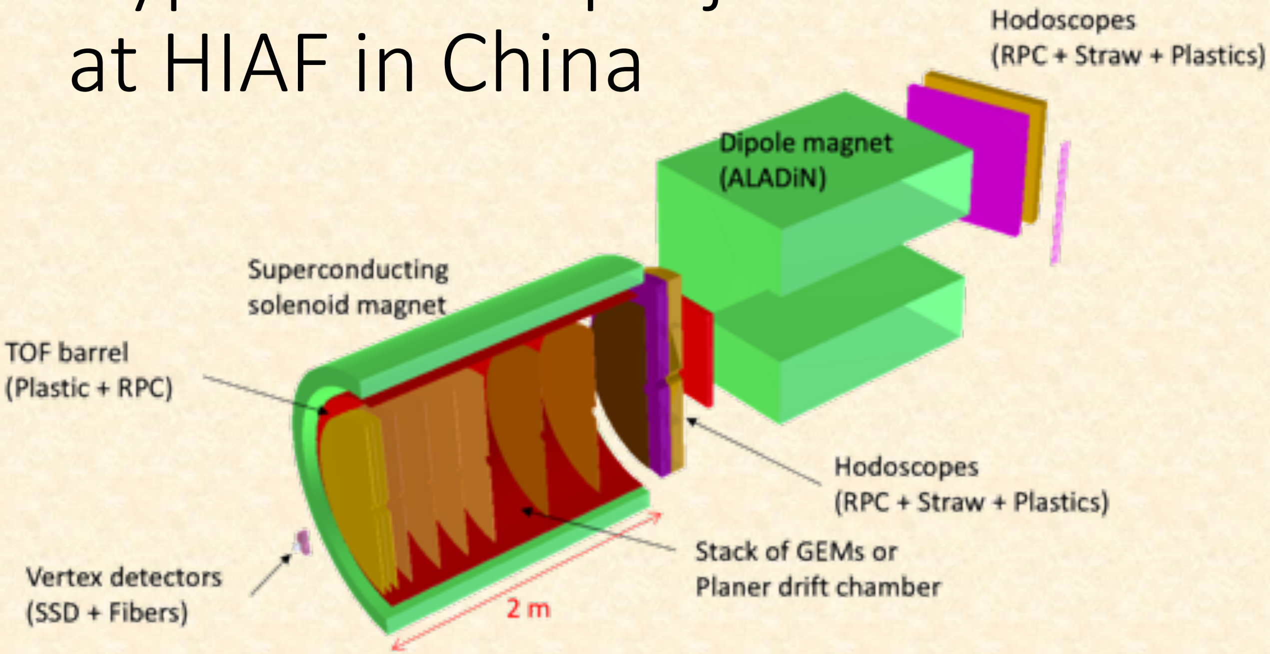
New institute to be built in Huizhou

Hypernuclear project at HIAF in China



Main Booster Ring:
34 Tm (4.25 A GeV)
Above Ξ^- production threshold

Hypernuclear project at HIAF in China



$d + \Xi^- \rightarrow {}^{3}_{\Xi^-}n \rightarrow n\Lambda\Lambda$

$t + \Xi^- \rightarrow {}^{4}_{\Xi^-}n \rightarrow nn\Lambda\Lambda$

${}^{3}He + \Xi^- \rightarrow {}^{4}_{\Xi^-}H \rightarrow {}^{4}_{\Lambda\Lambda}H$

${}^{4}He + \Xi^- \rightarrow {}^{5}_{\Xi^-}H \rightarrow {}^{5}_{\Lambda\Lambda}H$

${}^{6}Li + \Xi^- \rightarrow {}^{7}_{\Xi^-}He \rightarrow {}^{7}_{\Lambda\Lambda}He$

${}^{6}Li + \Xi^- \rightarrow {}^{7}_{\Xi^-}He \rightarrow {}^{6}_{\Lambda\Lambda}He + n$

${}^{7}Li + \Xi^- \rightarrow {}^{8}_{\Xi^-}He \rightarrow {}^{8}_{\Lambda\Lambda}He$

${}^{9}Be + \Xi^- \rightarrow {}^{10}_{\Xi^-}Li \rightarrow {}^{10}_{\Lambda\Lambda}Li$

${}^{10}Be + \Xi^- \rightarrow {}^{11}_{\Xi^-}Li \rightarrow {}^{11}_{\Lambda\Lambda}Li$

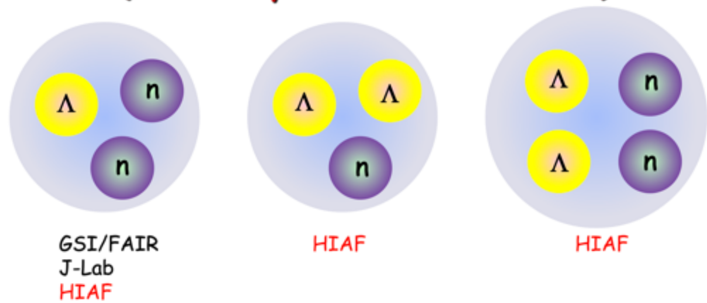
${}^{10}B + \Xi^- \rightarrow {}^{11}_{\Xi^-}Be \rightarrow {}^{11}_{\Lambda\Lambda}Be$

${}^{11}B + \Xi^- \rightarrow {}^{12}_{\Xi^-}Be \rightarrow {}^{12}_{\Lambda\Lambda}Be$

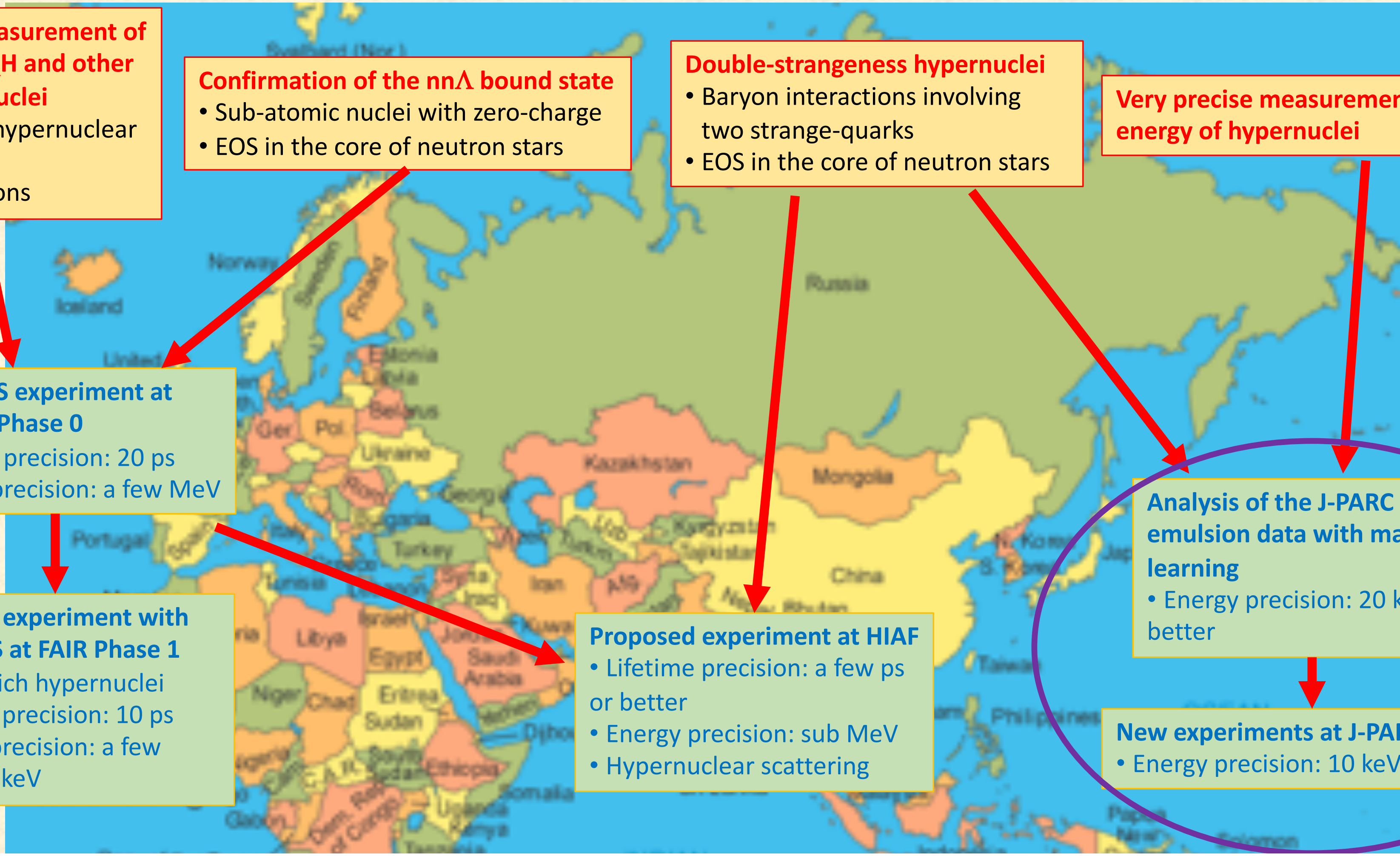
	Single-strangeness hypernuclei	Double-strangeness hypernuclei
Observation per week	6 X 10^6	6 X 10^2
Lifetime accuracy	**~ 1 ps**	**~ 10 ps**
Binding energy accuracy	~ 100 keV	Sub MeV

Hypernuclear scattering experiment feasible

Femto Neutron Stars
(named by Josef Pochodzalla)



Our strategy for very urgent important issues
on Nuclear physics, Hadron physics and Astrophysics



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- Energy precision: 20 keV or better

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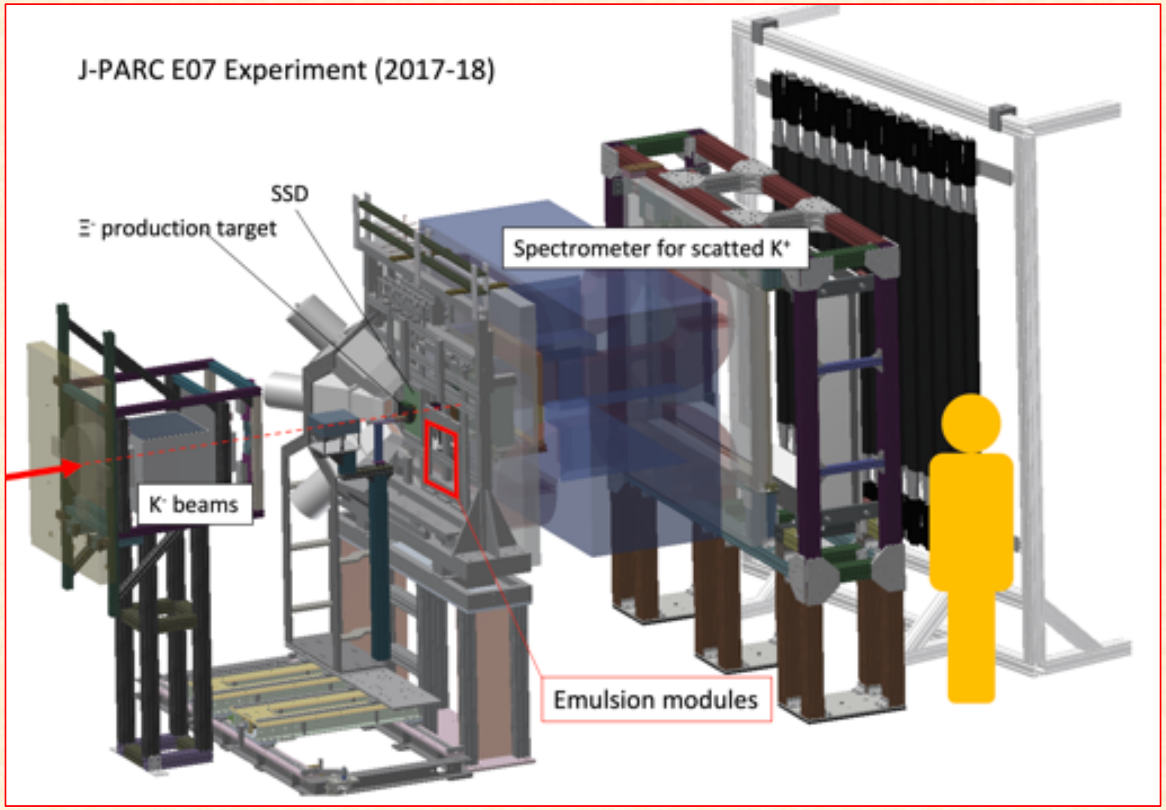
- Energy precision: 10 keV or better

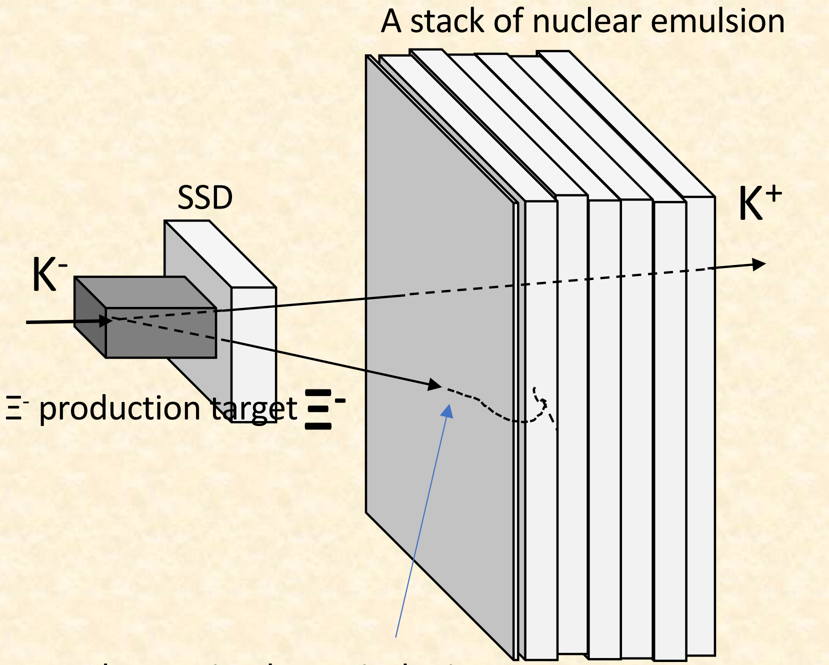
Analysis of J-PARC E07 data with Machine Learning at RIKEN

Conventional way to study double-strangeness hypernuclei

- <u>Hybrid methods (J-PARC E07 experiment)</u>

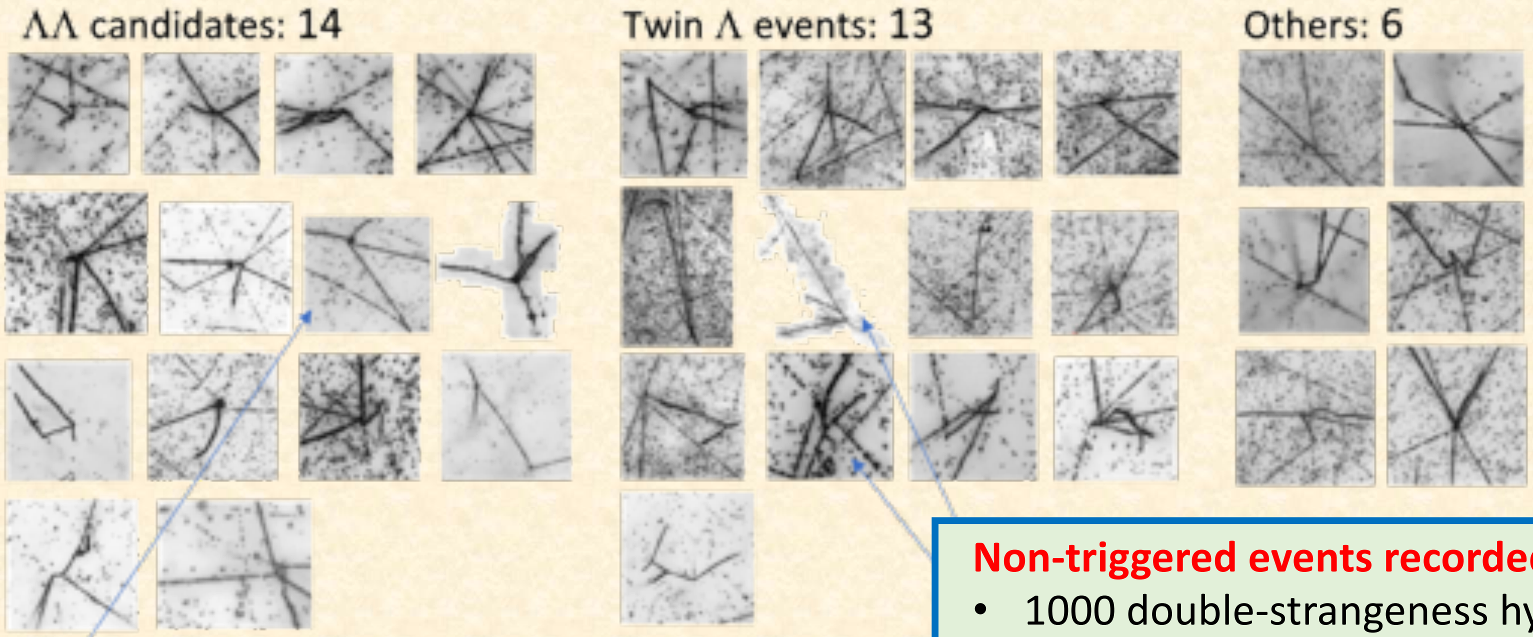


Triggers by the observation of (K-, K+) reactions



Analysis of J-PARC E07 data with Machine Learning at RIKEN

Outcome of the E07 experiments



${}_{\Lambda\Lambda}$Be

H. Ekawa et al., Prog. Theor. Exp. Phys. 2019, 021D02

Non-triggered events recorded in 1000 emulsions sheets

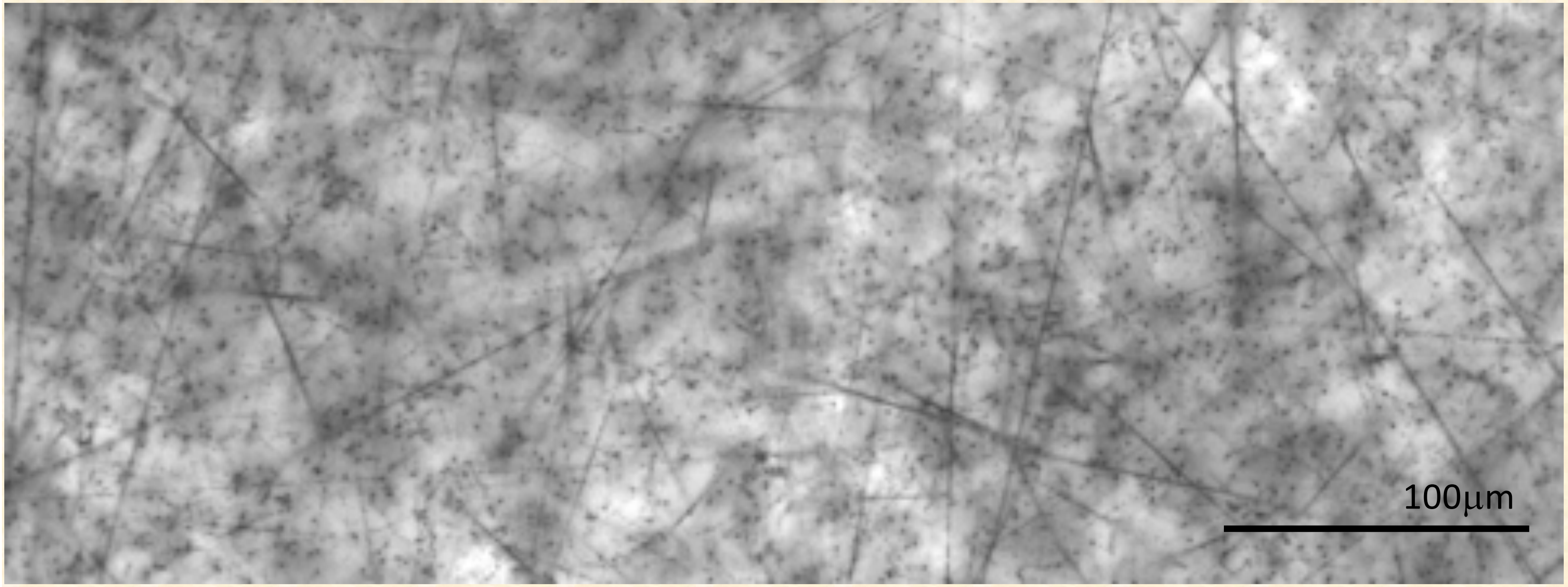
- 1000 double-strangeness hypernuclear events
- Millions of single-strangeness hypernuclear events

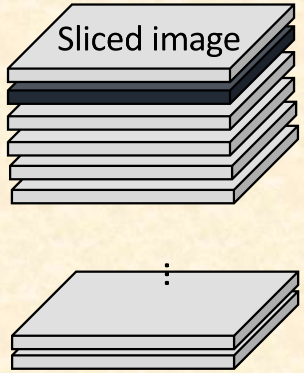
Overall scanning of all emulsion sheets

(35 X 35 cm^2 X 1000)

Analysis of J-PARC E07 data with Machine Learning at RIKEN

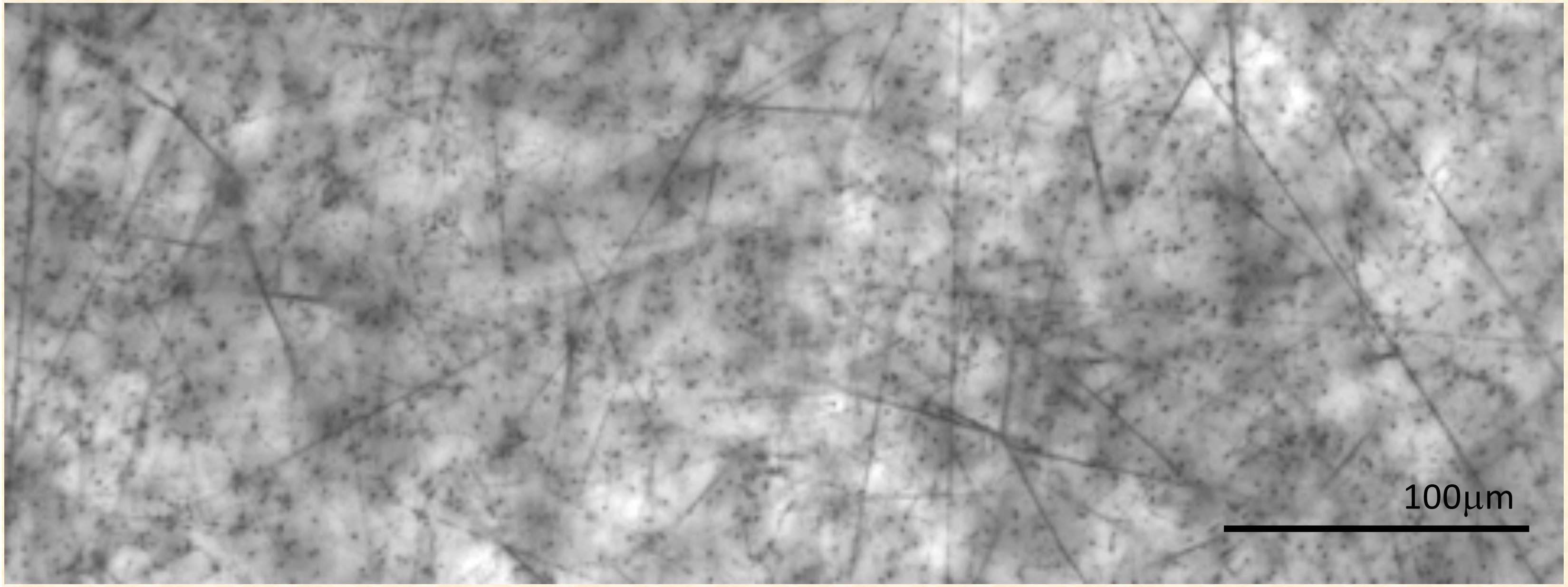
Overall scanning for E07 emulsions

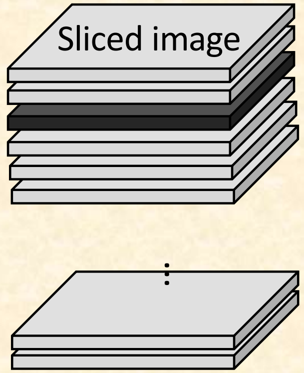




Analysis of J-PARC E07 data with Machine Learning at RIKEN

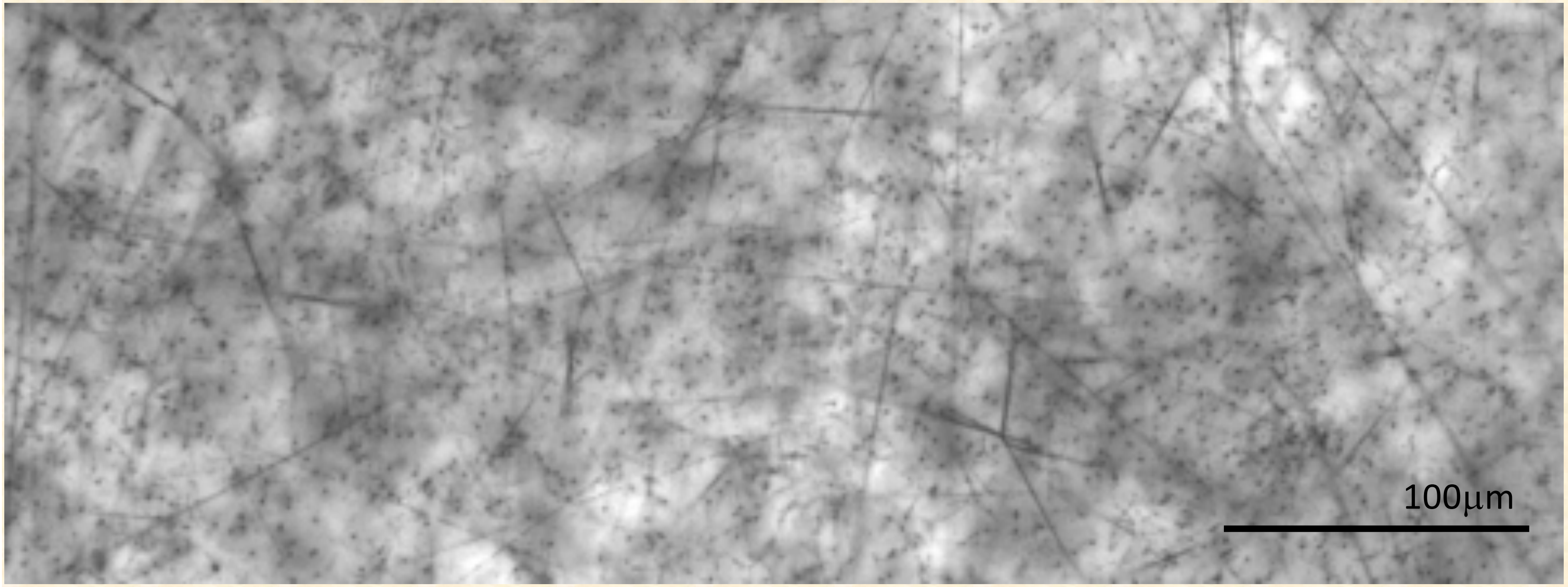
Overall scanning for E07 emulsions

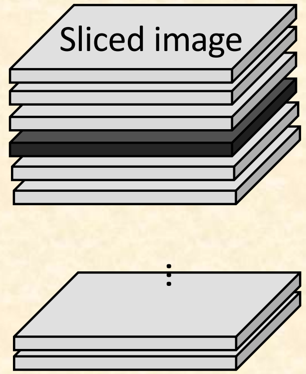




Analysis of J-PARC E07 data with Machine Learning at RIKEN

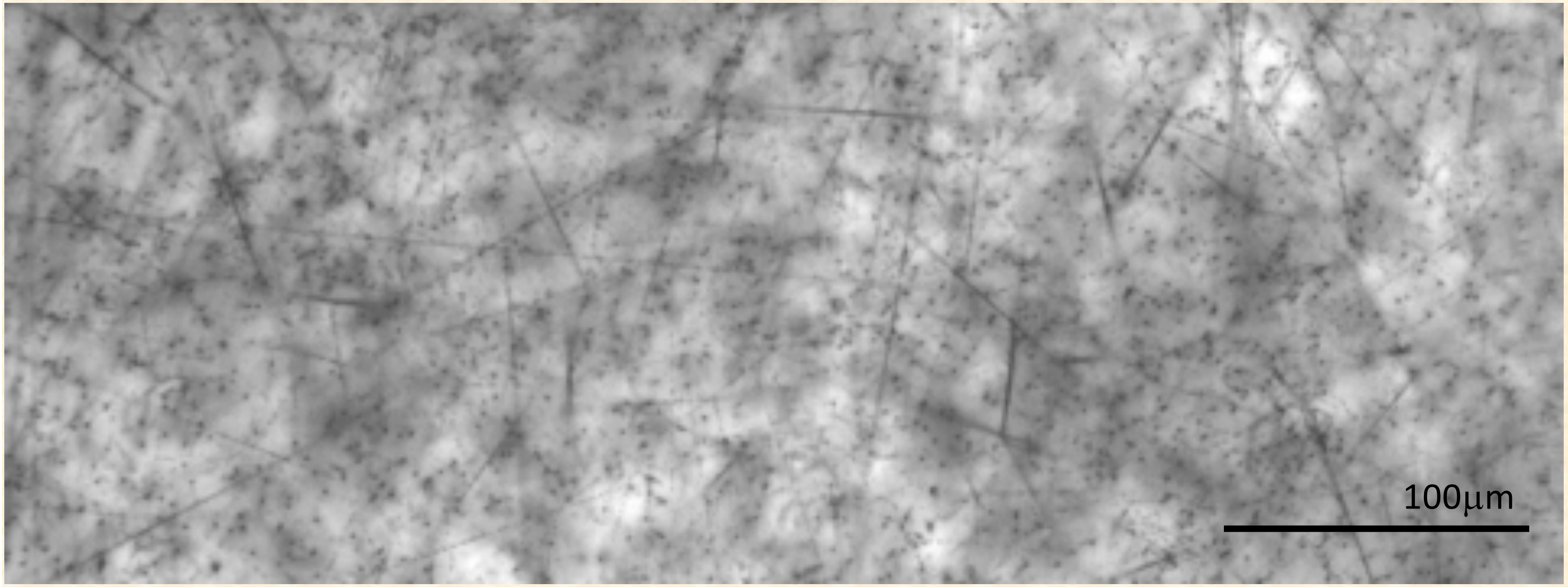
Overall scanning for E07 emulsions

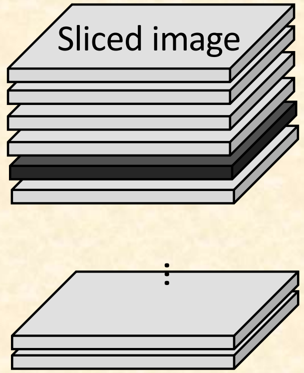




Analysis of J-PARC E07 data with Machine Learning at RIKEN

Overall scanning for E07 emulsions





Analysis of J-PARC E07 data with Machine Learning at RIKEN

Overall scanning for E07 emulsions

Data size:
- 10^7 images per emulsion (100 T Byte)
- 10^{10} images per 1000 emulsions (100 P Byte)

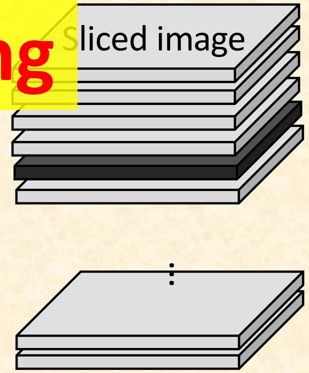
Number of background tracks:
- Beam tracks: 10^4/mm^2
- Nuclear fragmentations: 10^3/mm^2

Current equipments/techniques with visual inspections

750 years

100μm

Machine Learning



3 years

1000 double strangeness hypernuclei (formerly 8)

Analysis of J-PARC E07 data with Machine Learning

Double strangeness hypernuclei

New experiments at J-PARC

Development of the machine learning model (mask-R CNN) with training data produced by Monte Carlo simulations and GAN technique

In progress

Development of the Machine Learning model with Convolutional Neural Network (CNN)

Detecting α-decay events for calibrating the emulsion sheet (density, shrinkage, …)

Completed
J. Yoshida et al.,
arXiv:2009.05770 (September 2020)
In the revision process with NIM A

THEIA seminar
October 28th

Starting in April 2020

Challenge:
Training data produced with Monte Carlo simulations

Applications (in progress)

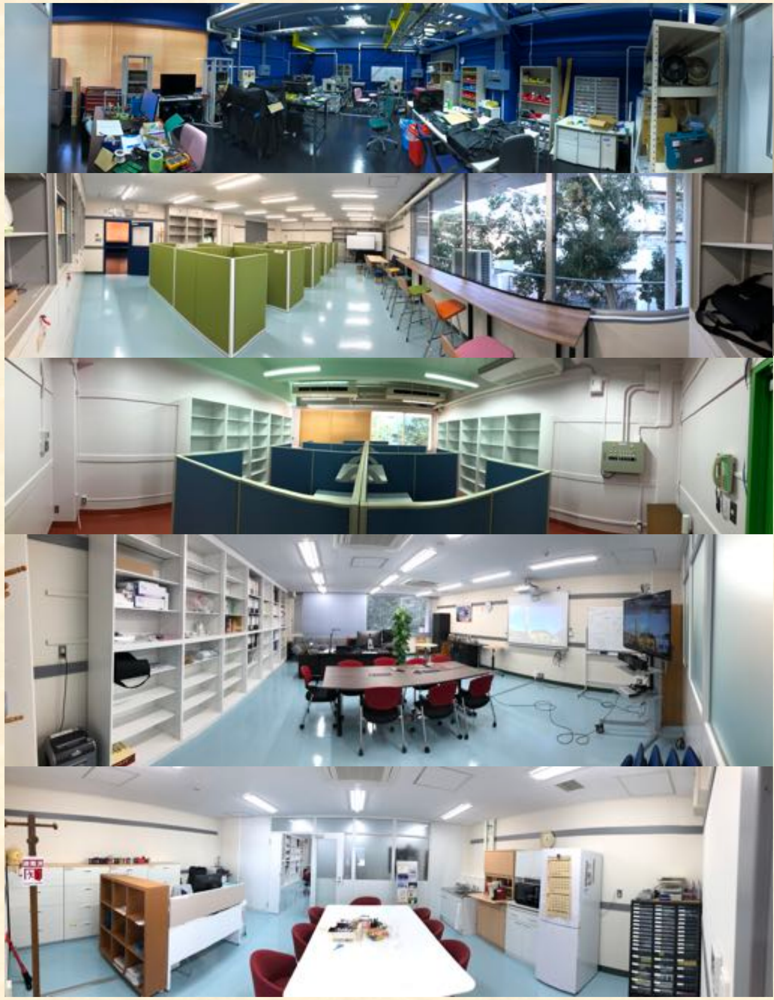
Very precise neutron imaging with emulsion

- Nondestructive inspection
  - ✓ Fuel cells
  - ✓ Semiconductor devices
  - ✓ Power transistors
  - ✓ Li batteries
- Medical applications
  - ✓ BNCT

Very precise g-ray imaging with emulsion

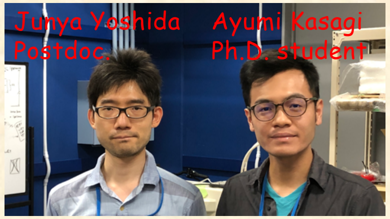
- Medical applications
  - ✓ Very precise PET (hybrid)

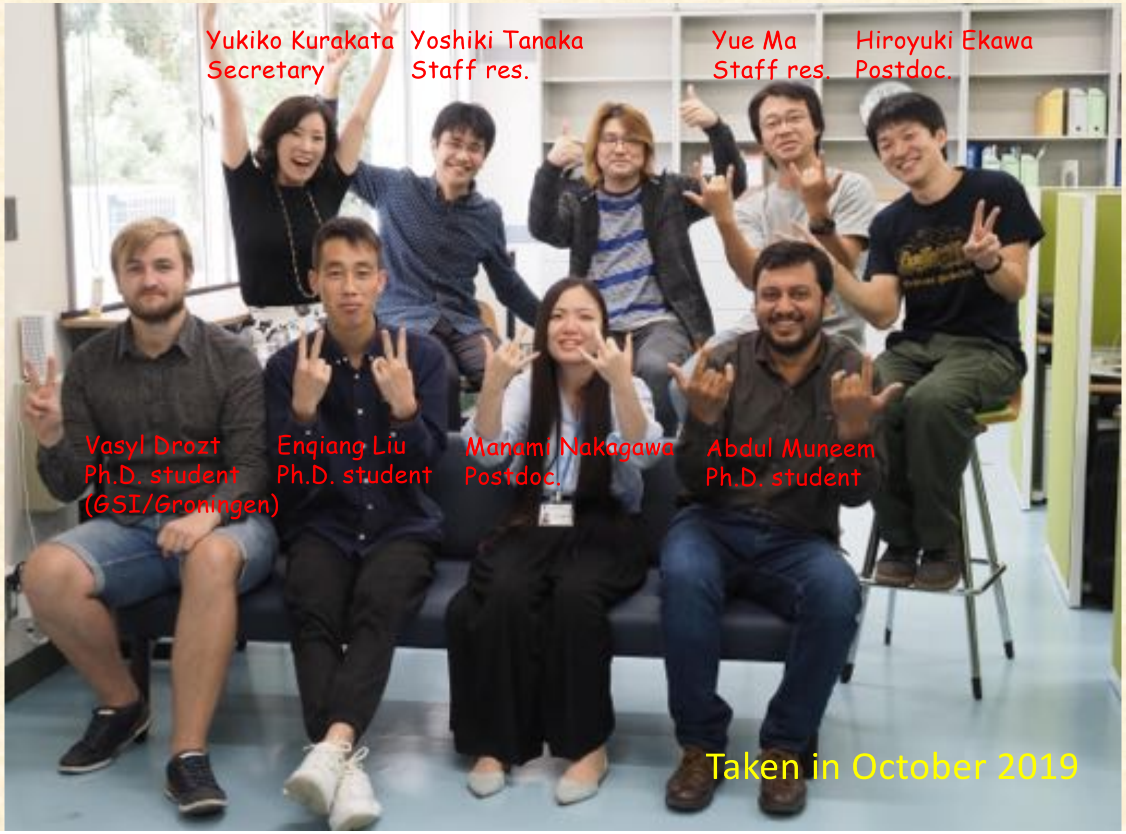
High Energy Nuclear Physics Lab at RIKEN (2019 -)



- ~ 1400 CPU cores
- 32 GPU boards (133376 CUDA cores)
- ~ 400 T Byte storage

High Energy Nuclear Physics Lab at RIKEN (2019 -)





Chief scientist:
- Take R. Saito

Secretary:
- Yukiko Kurakata

Permanent staff researchers:
- Yoshiki Tanaka
- He Wang
- Yue Ma

Senior researcher:
- Nami Saito

Postdocs:
- Hiroyuki Nakagawa
- Manami Nakagawa
- Junya Yoshida (Tohoku U)

Ph.D. students:
- Abdul Muneem
- Enqiang Liu
- Ayumi Kasagi

Master student:
- Wenbo Dou

Visiting researchers:
- Katsuya Hirota (Nagoya U)
- Kazuma Nakazawa (Gifu U)
- Masahiro Yoshimoto (Gifu U)

Hypernucl. Phys. Group, GSI

Leader:
- Take R. Saito

Engineers and technicians
- Tobias Weber
- H. Alfaki

Ph.D. students:
- V. Drozd
- Ryohei Sekiya

Hypernucl. Phys. Group, Lanzhou University

Leader and Professor:
- Take R. Saito

Secretary:
- Miao Yang

Professors:
- Bauyuan Sun
- TBA

Associate professors:
- Xiyu Qiu

Master student:
- Yan He