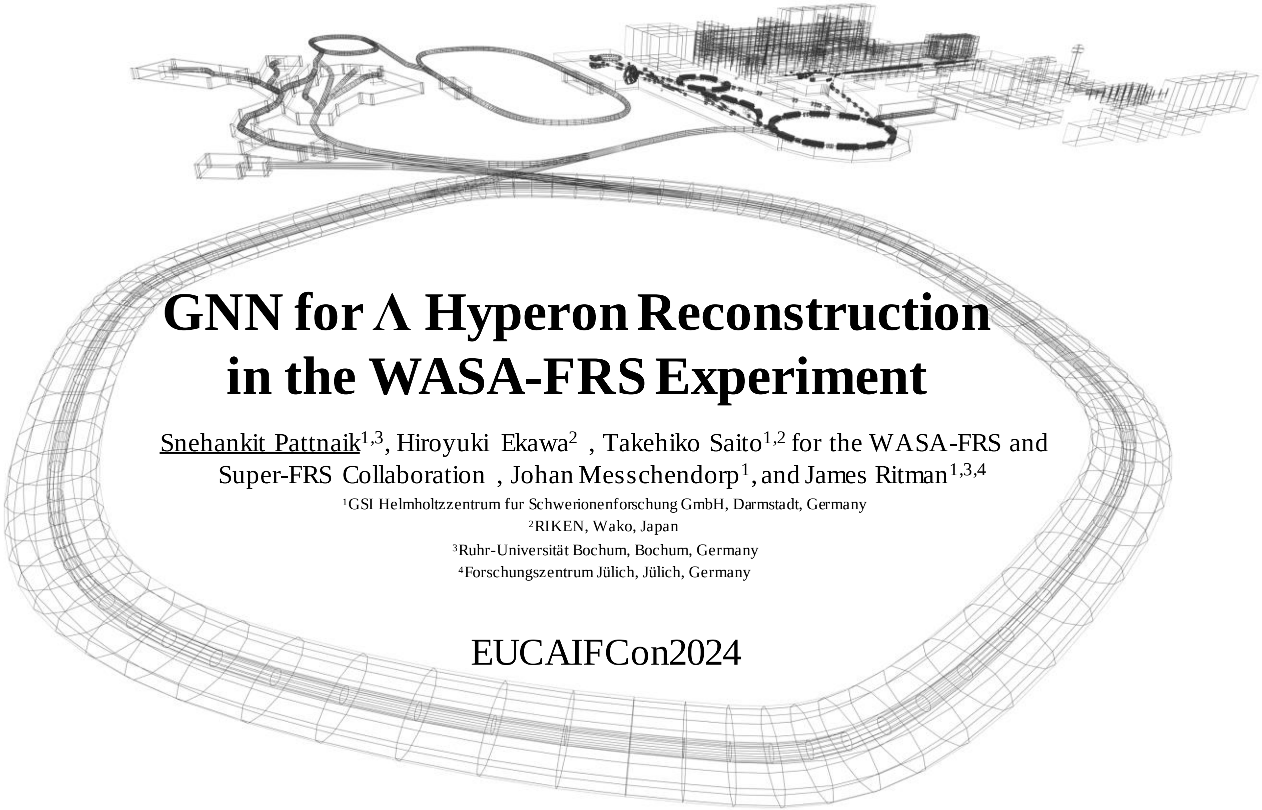

GNN for Λ Hyperon Reconstruction in the WASA-FRS Experiment

Snehankit Pattnaik[1,3], Hiroyuki Ekawa[2] , Takehiko Saito[1,2] for the WASA-FRS and Super-FRS Collaboration , Johan Messchendorp[1], and James Ritman[1,3,4]

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[2]RIKEN, Wako, Japan

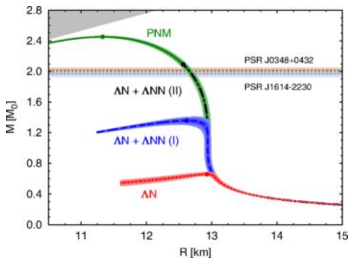
[3]Ruhr-Universität Bochum, Bochum, Germany

[4]Forschungszentrum Jülich, Jülich, Germany

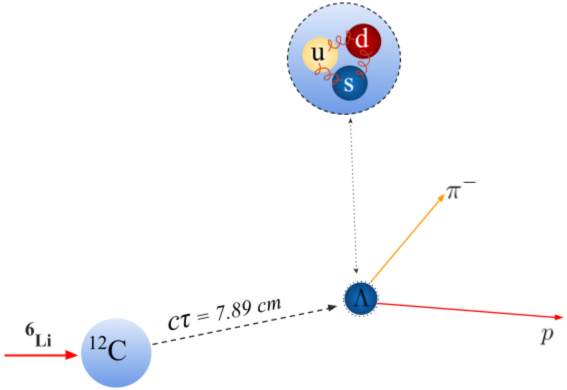
EUCAIFCon2024

Search for Hyperons and Hypernuclei

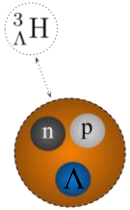
- The hyperon-nucleon interactions holds detailed information especially to describe the core of neutron stars.
- Hypertriton, $^{3}_{\Lambda}H$, a hypernucleus containing a proton, neutron, and Λ hyperon.
- Λ hyperon will serve as a calibration for the hypertriton reconstruction.
- The WASA-FRS detector was installed at GSI-FAIR, Darmstadt in 2022.
- The setup involves a ^{6}Li beam at 1.96 A GeV to a fixed ^{12}C target.
- Limitations: Track finding efficiency with conventional method about 60%.
- Objective: Track finding and fitting with momentum estimation based on GNN leading up to Λ reconstruction with the WASA-FRS detector.

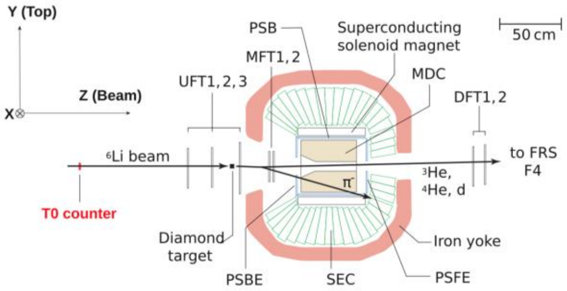


PRL114, 092301 (2015)



Strangeness Production in the WASA-FRS

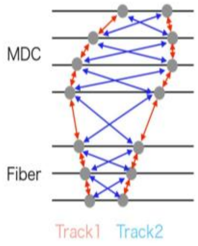


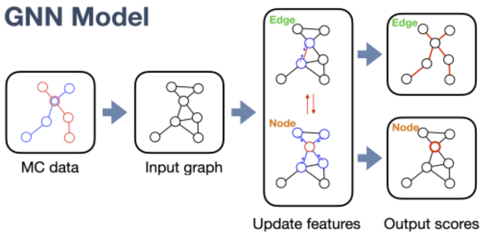


T.R. Saito et al., Nature Reviews Physics 3, 803 (2021)

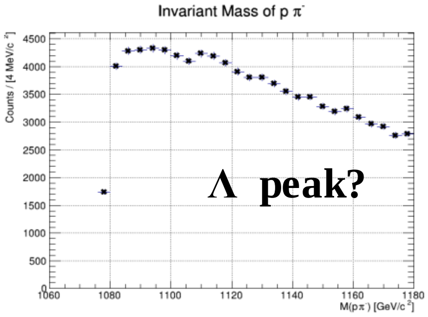
Track Finding with GNN

- Tracking based on graph neural networks
  - Create a graph data with different hit combinations for training from Monte Carlo simulations.
  - Binary classification for edge connections.
  - Testing with actual experimental data.
- Charged tracks efficiency about 88 % - 91 %.

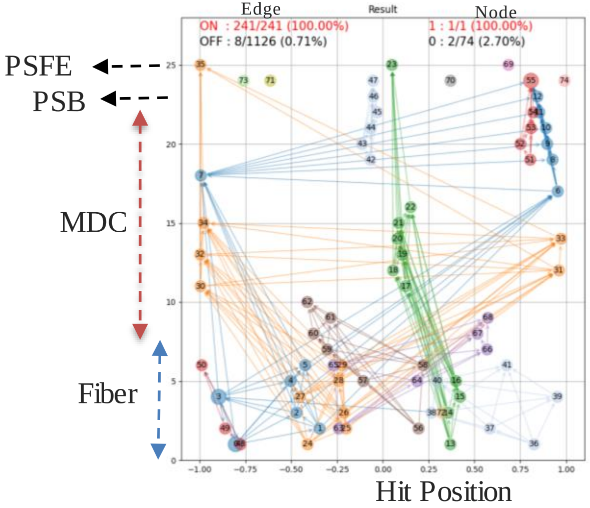




H. Ekawa et al., Eur. Phys. J. A 59 103 (2023)



Results



Can we see Λ hyperon using GNN?

Hope to see you at the poster!

End-to-End Object Reconstruction in a Sampling Calorimeter using YOLO

Shashi Dugad, Gagan Mohanty, Pruthvi Suryadevara
(pruthvi.suryadevara@tifr.res.in)

First European AI for Fundamental Physics Conference (EuCAIFCon)

Motivation

Constantly improving object detection frameworks, e.g., YOLO

Increasing granularity of sampling calorimeters using silicon, e.g., CMS high granularity calorimeter

+

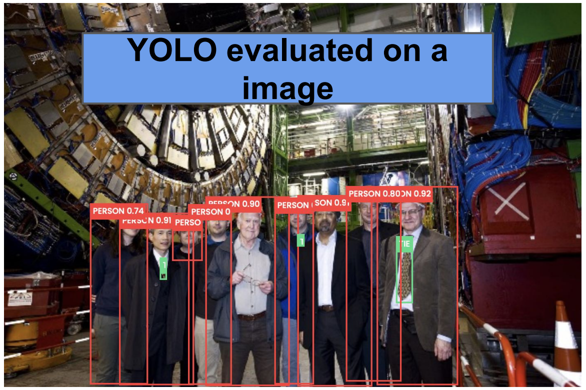
Novel idea of interpreting the layers in sampling calorimeter as colours of image

→

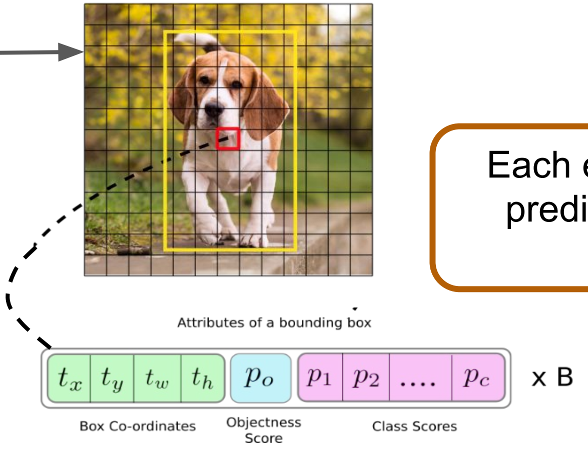
Efficient way to reconstruct physics objects, e.g., electrons, muons, etc.

YOLO working

<u>You Only Look Once</u> (YOLO) is a highly popular object detection framework extensively used in computer vision to identify objects of different types such as animals, person, automobile, etc.



Input image → Convolutional neural network with skips connections and effective stride of 32 → Feature grid

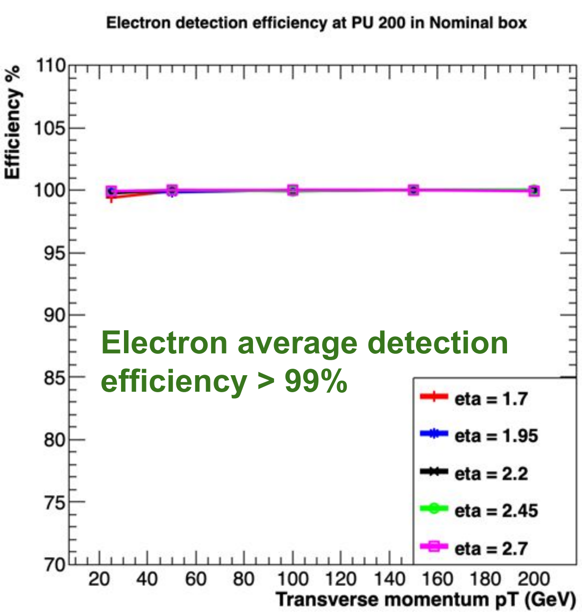


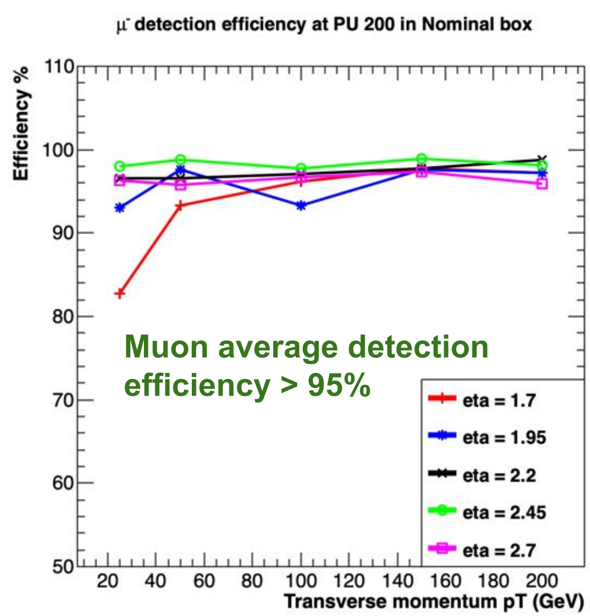
Each element in feature grid is trained to predict the bounding-box and class for objects of interest

Calorimeter design

- Dummy calorimeter with 47 layers of 200 μm Silicon segmented into 3.5 * 3.5 mm^2 cells as active material, with lead + copper-tungsten (stainless steel) as absorbers for electromagnetic (hadronic) sections.
- 10,000 electrons and muons with transverse-momentum pT∈ [20, 200] GeV and pseudo -rapidity η ∈ [1.6, 2.9] are simulated at three different average PU interactions (0, 50, 200) are used for training
- Every three consecutive layers are combined to create 736*736 image in eta-phi plane, creating a total of 16 coloured channels

Results





Fast evaluation independent of complexity (PU senario)

GPU NVIDIA RTX 3090 (RTX 4090) Batch size = 4				
Input Particle	PU	Pre processing (ms)	Inference (ms)	NMS (ms)
Electron or Muon	0	1.1	1.1	0.3
	50	1.1	1.1	0.3
	200	1.1	1.1	0.3

Thank You

Please drop by the poster on Thursday at location 89

Deep learning techniques in the study of the hypertriton puzzle

European AI for Fundamental Physics Conference 2024

30/04/2024

Christophe Rappold
IEM – CSIC, Madrid - Spain

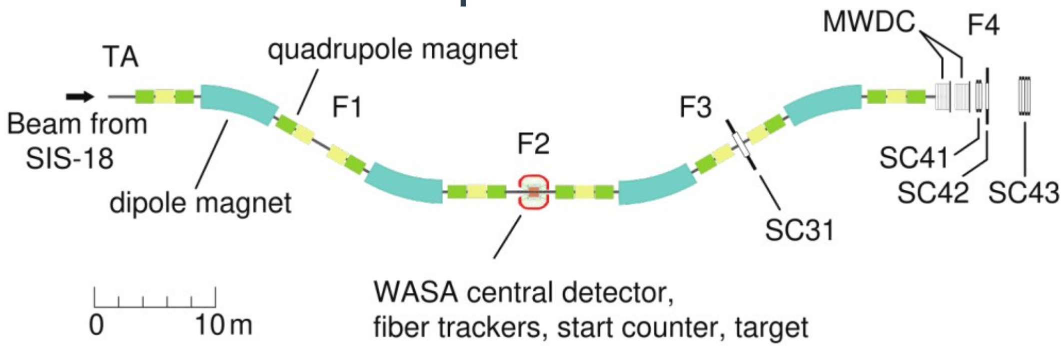
Emulsion-ML Collaboration & WASA-FRS / SuperFRS Experiment Collaboration

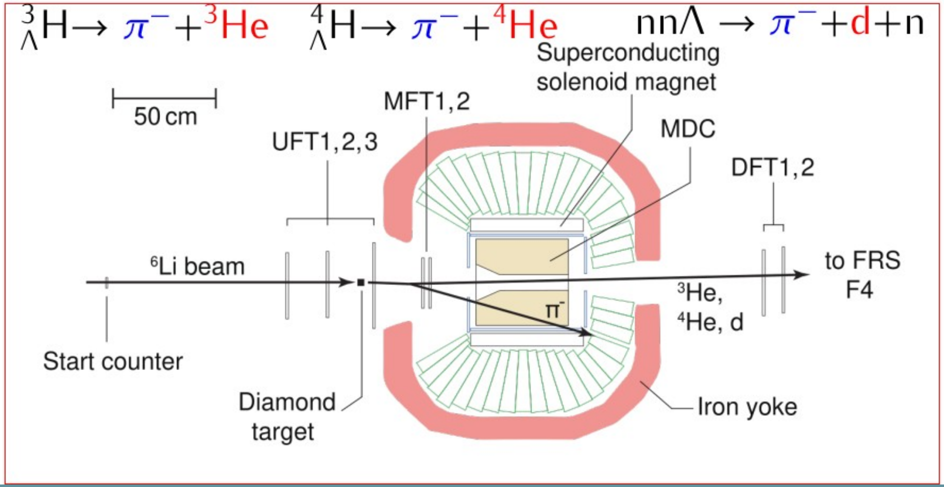
Deep learning in study of Hypertriton puzzle

- Our contributions to solve : 2 experiments to measure

→ Lifetime of $^{3}_{\Lambda}H$:

WASA-FRS experiment at GSI-FAIR

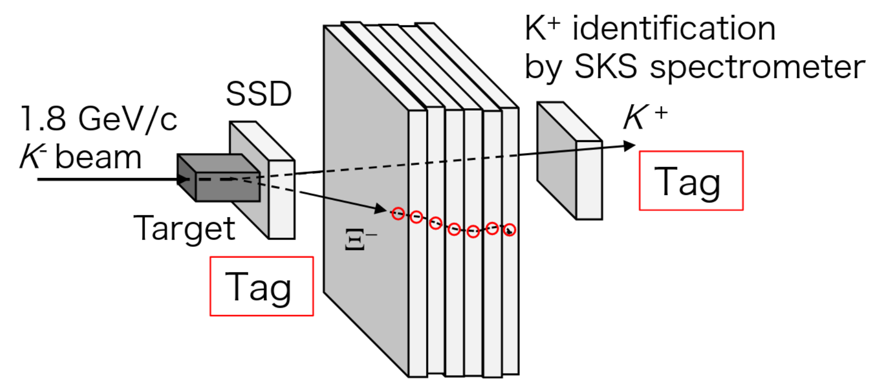


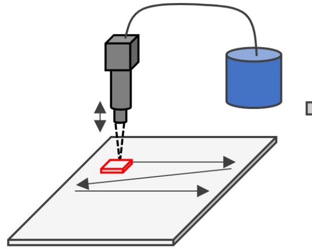


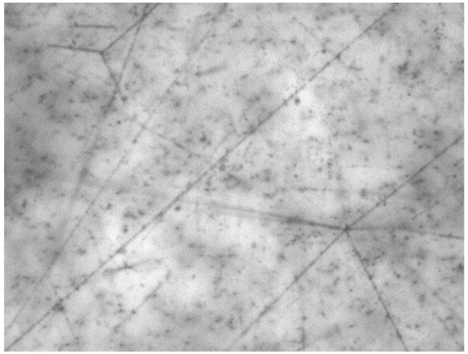
→ Binding energy $^{3}_{\Lambda}H$:

E07 experiment at JPARC

Emulsion-Counter hybrid method





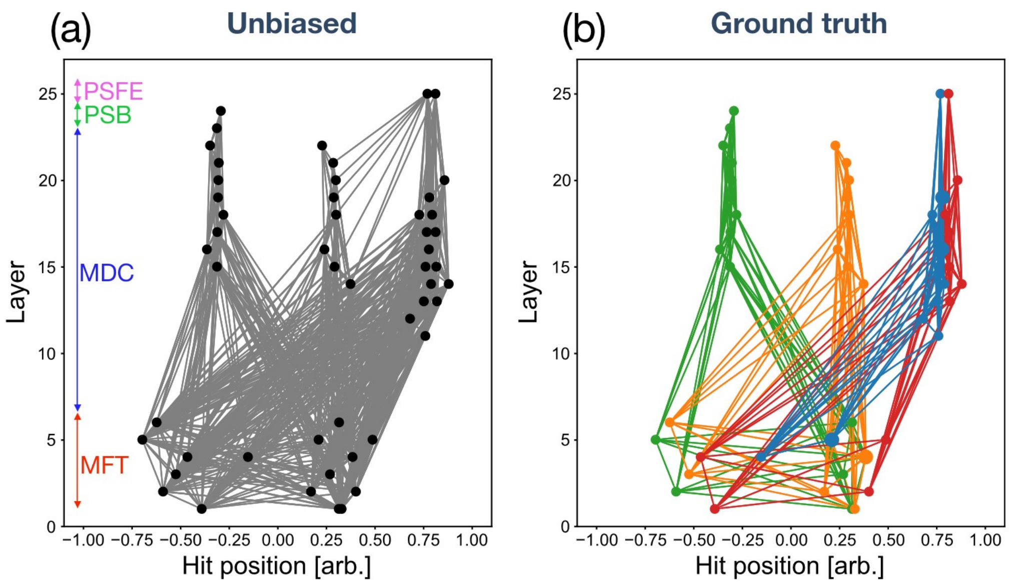


Deep learning in study of Hypertriton puzzle

- **WASA-FRS experiment:**

  Track finder: Graph Neural Network

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



- 98% π− & 97% others / Ghosts 0.04%
- + GNN model for track parameters:

  → finder + track estimator

- **E07 nuclear emulsions:** Hypernuclei Search via DL :
  - Geant4 + GAN → surrogate image of emulsions = Training data
  - Event Detection : Mask R-CNN
- First hypertriton found by non-human:

  T. Saito et al., Nat. Rev. Phys. 3, 803 (2021)