Fast and reliable dark matter inference for Euclid strong lenses

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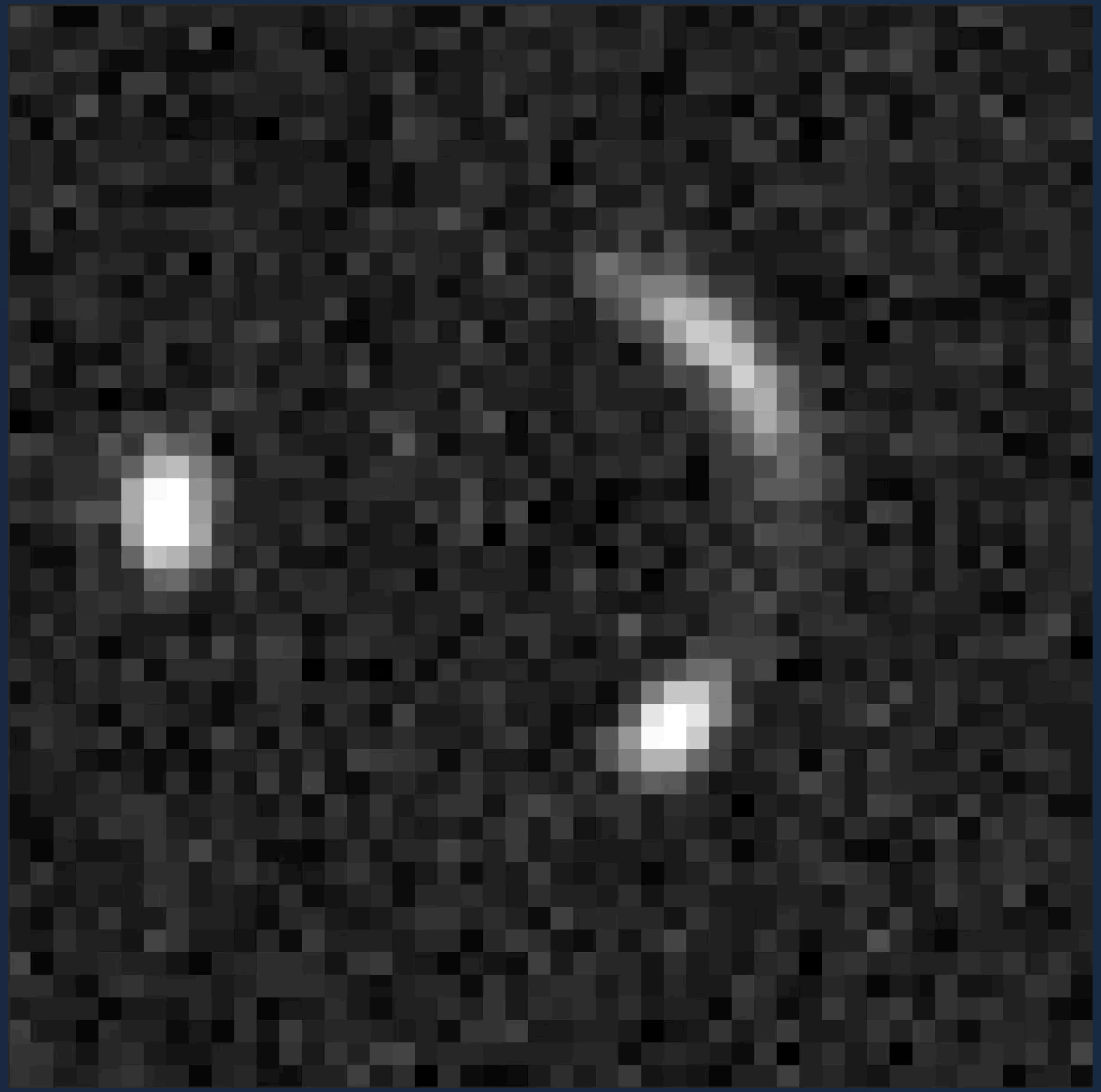
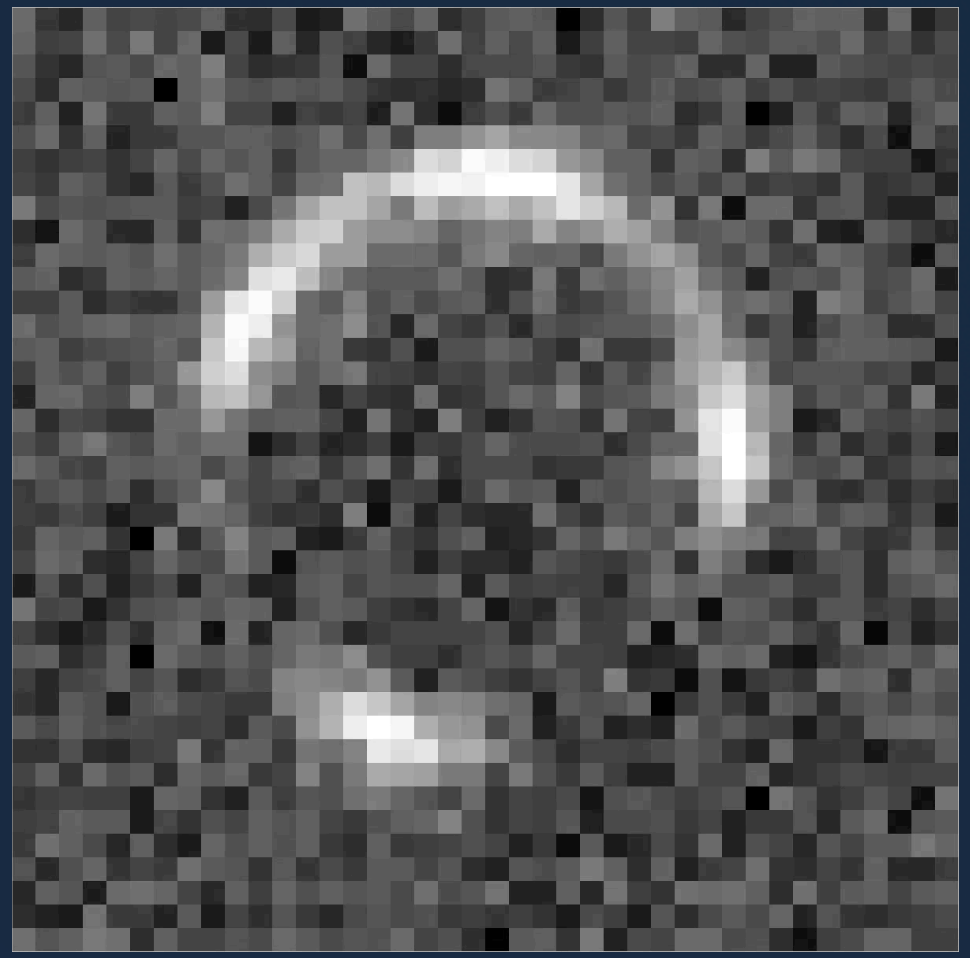
FOR ASTROPHYSICS

Training data



→ ResNet-50 → $P(\mathrm{sub} \mid d)$

Sensitivity images

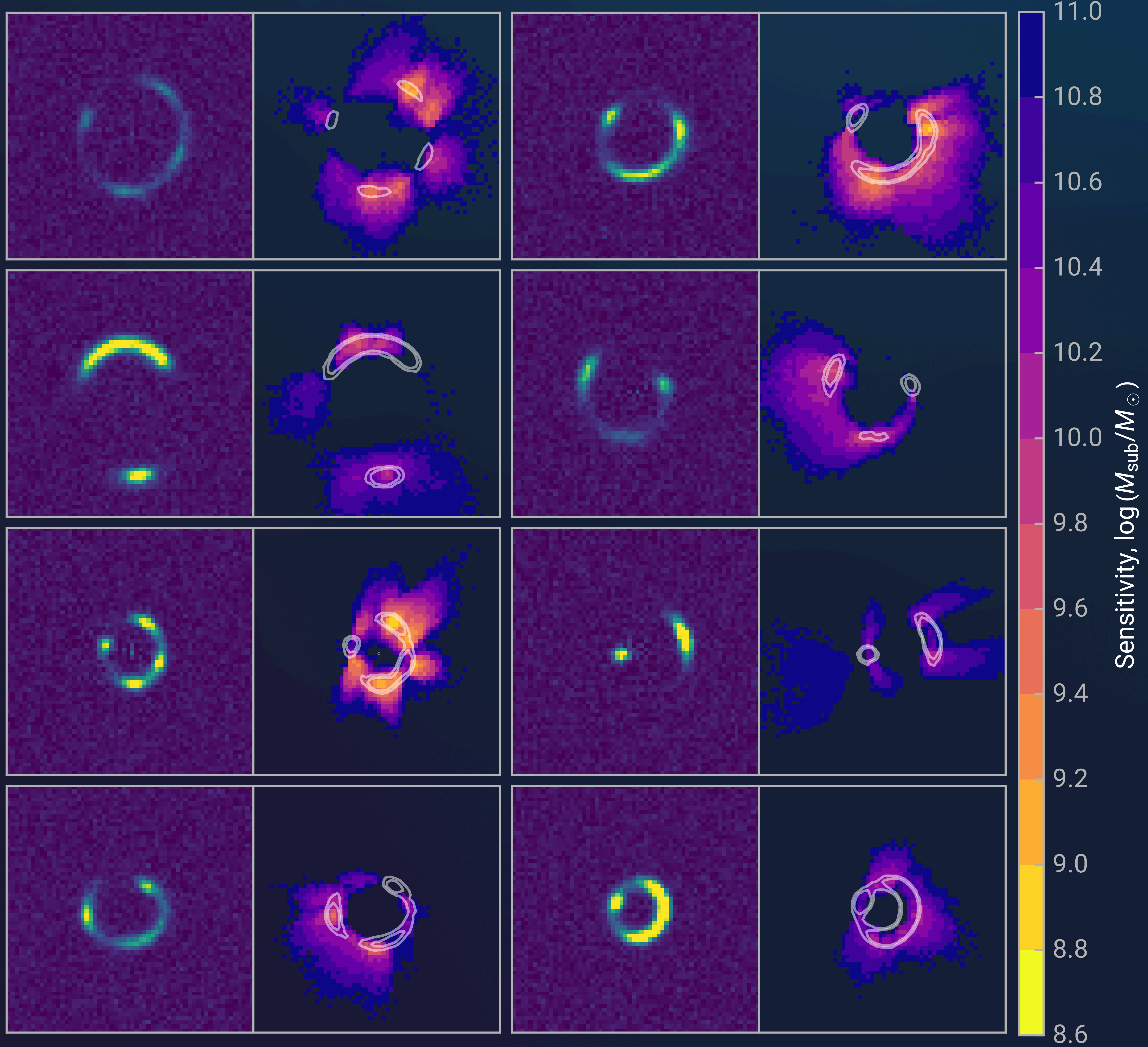


↑ ResNet-50

$P(\mathrm{sub} \mid d)$ ↓

Sensitivity map

Smallest detectable mass in every pixel



Predictions for *Euclid*

1 in 70

lenses yield a detection

1 in 3

in the best lenses

2500

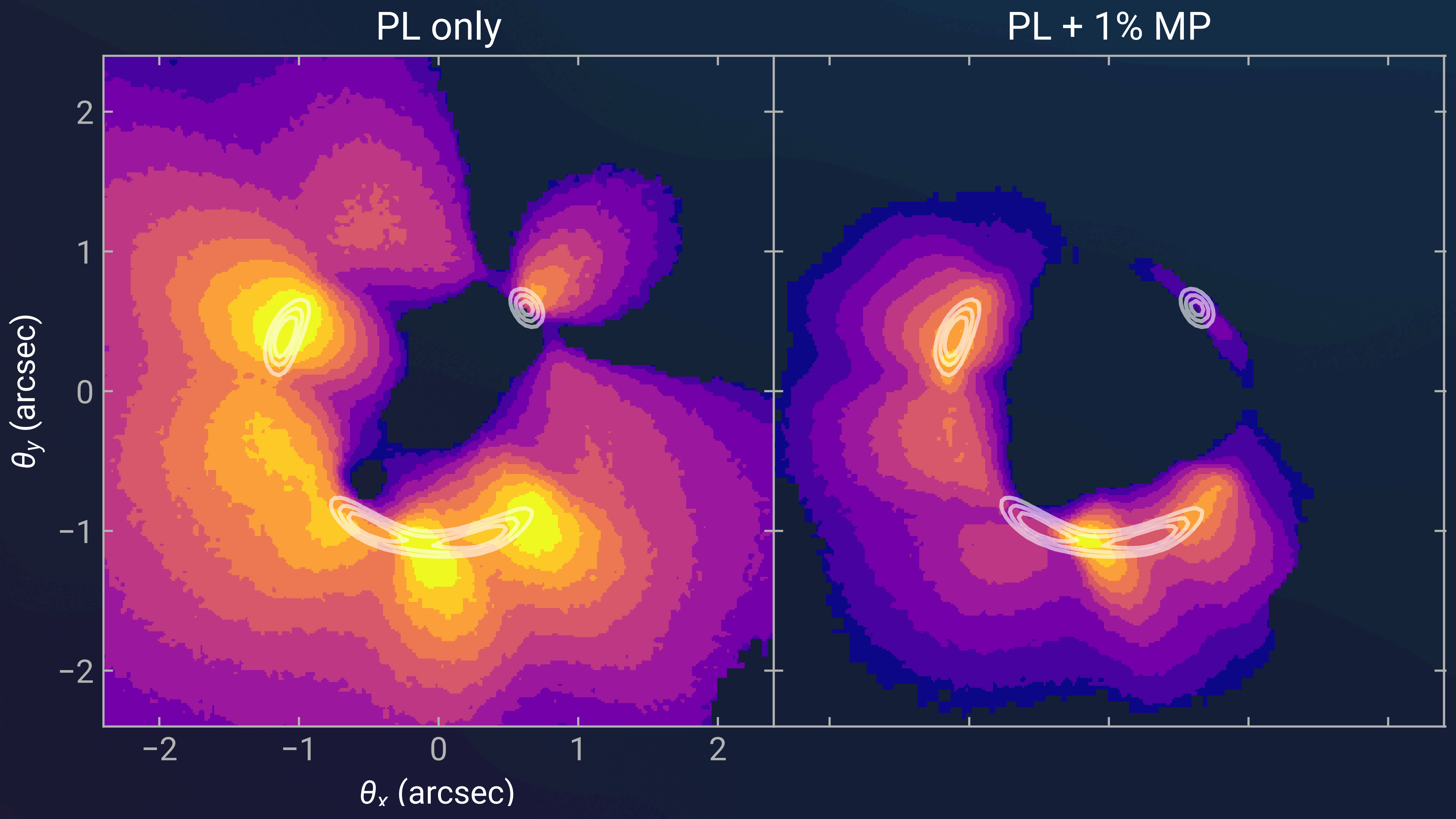
new subhalo detections

$10^{8.8}\,M_\odot$

smallest detectable object*

*real *Euclid* lenses agree

Testing systematics



Allowing for 1% angular perturbations in the lens means…

80%

loss in sensitive area

0.25 dex

loss in sensitivity depth

Dark matter science in *Euclid*

Now: *the first 100s of lenses*

- First dark substructure detections
- Measuring multipoles in large lens sample
- 100s of non-detections would be in tension with CDM

Soon: *the first 1000 lenses and beyond*

- First constraints on f_{sub}
- Constraints on LOS mass function
- ML sensitivity mapping at large scales

EuCAIFCon 2024

Weak supervision for quark/gluon tagging in CMS Open Data

(Poster #81)

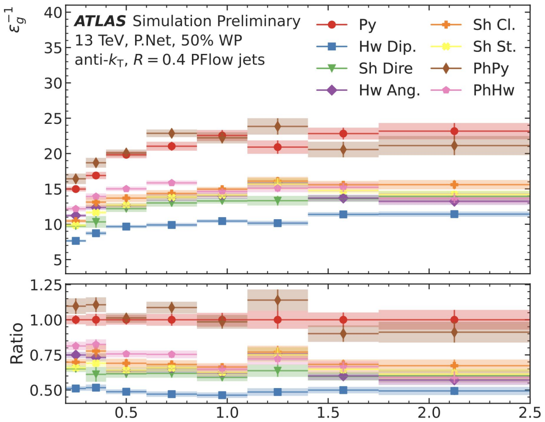
Ayodele Ore

In collaboration with Matthew J. Dolan and John Gargalionis

Weakly-supervised quark/gluon tagging

- At LHC, High-energy quarks and gluons both lead to ***jets.***
- Neural networks are good classifiers, but full supervision inherits large theory uncertainty from simulation.
- Weak supervision allows models to be trained directly on data, using **mixed quark/gluon** samples.

Metodiev et al.
JHEP10(2017)174



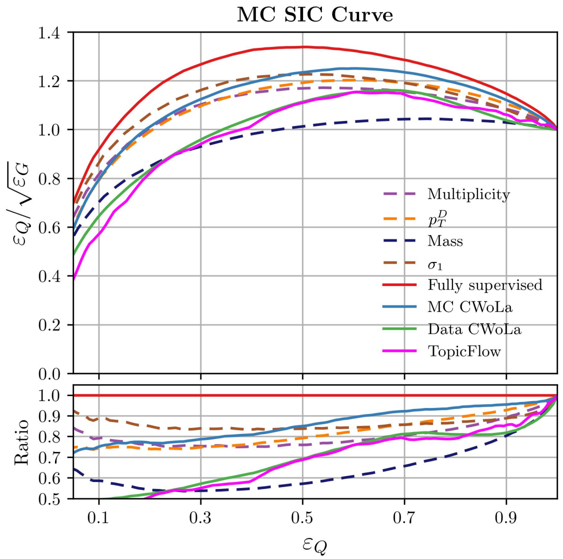
ATL-PHYS-PUB-2023-032

Full supervision		Weak supervision	
(Quark jets)	QQQQQ	QQQGG	(Z + jet events)
	VS	VS	
(Gluon jets)	GGGGG	QGGGG	(Dijet events)

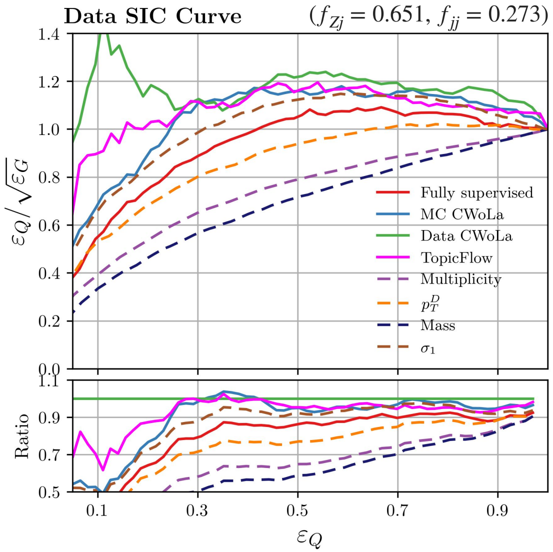
Can isolate in data

Our study: How do models rank on real data?

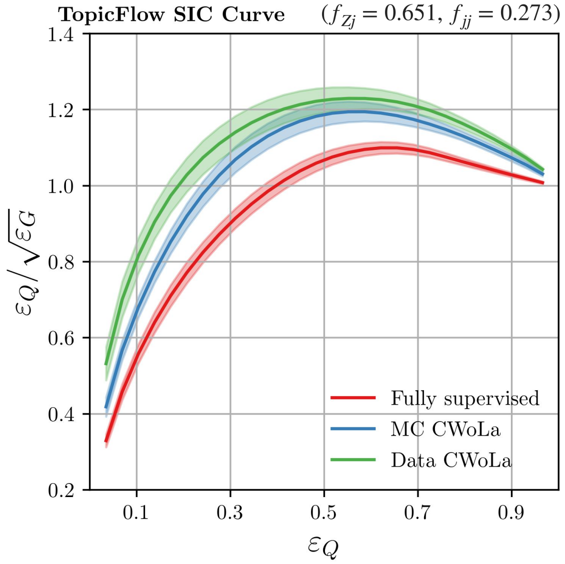
1. Estimate mixture fractions
2. Train TopicFlow



Simulation



Data



Generative model

EUROPEAN AI FOR FUNDAMENTAL PHYSICS CONFERENCE
EuCAIFCon 2024

A fast convolutional neural network for online particle track recognition

N.V. Biesuz[2], R. Bolzonella[1,2], P. Cardarelli[2], E. Calore[2], **V. Cavallini**[1,2], M. Fiorini[1,2], S.F. Schifano[1,2], R. Zese[1]

1 – University of Ferrara, Italy
2 – Istituto Nazionale di Fisica Nucleare (INFN), Italy

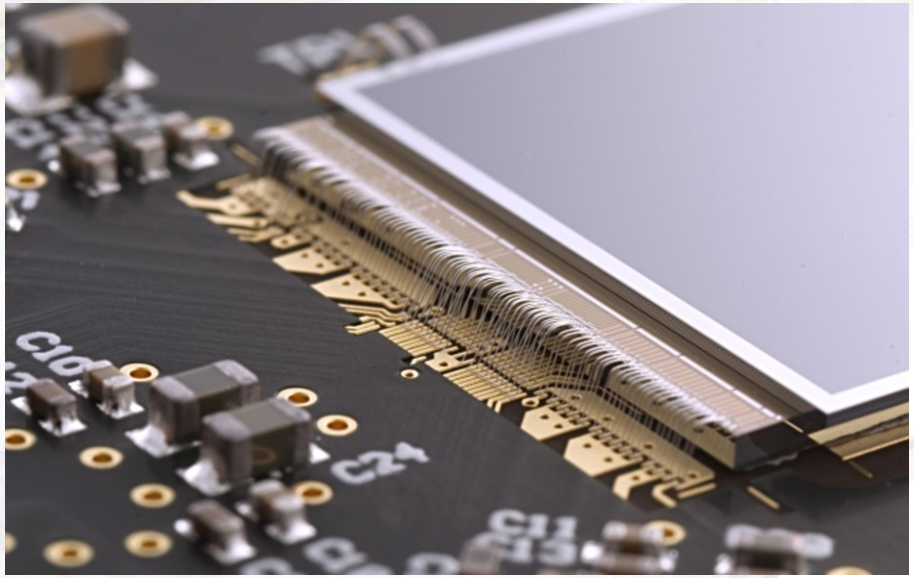
Poster Board 83

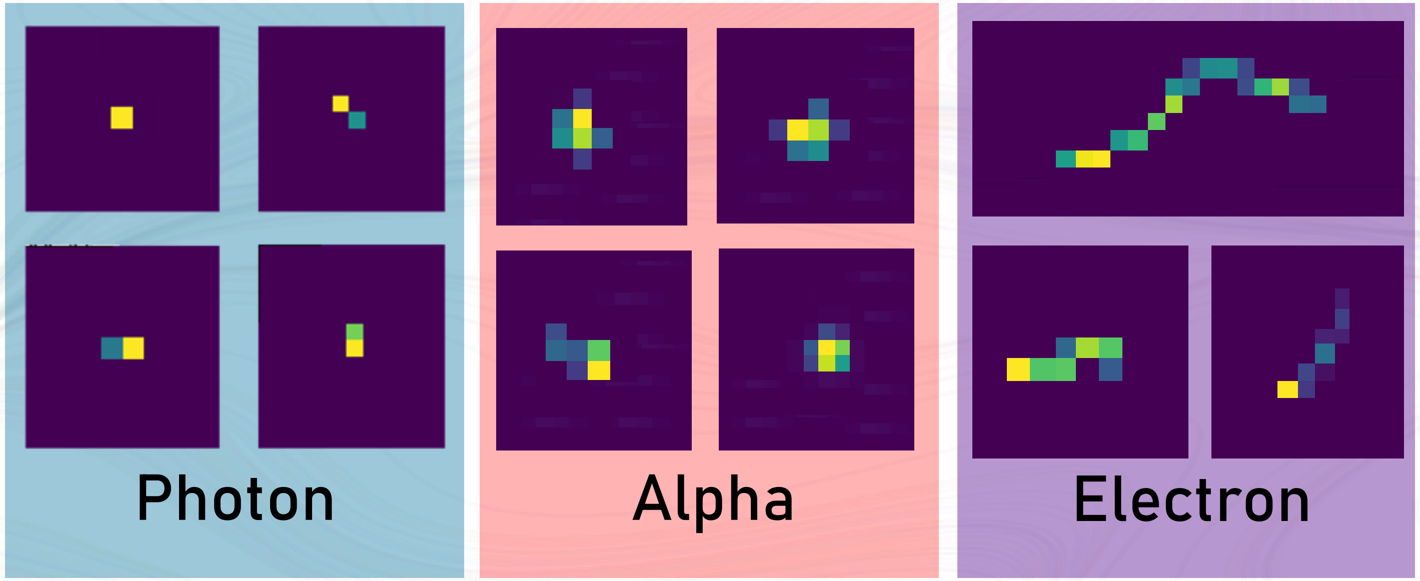
Timepix4 and particle dataset

Poster Board 83

Timepix4 is a **hybrid pixel detector readout** ASIC developed by the **Medipix4 Collaboration** (CERN).

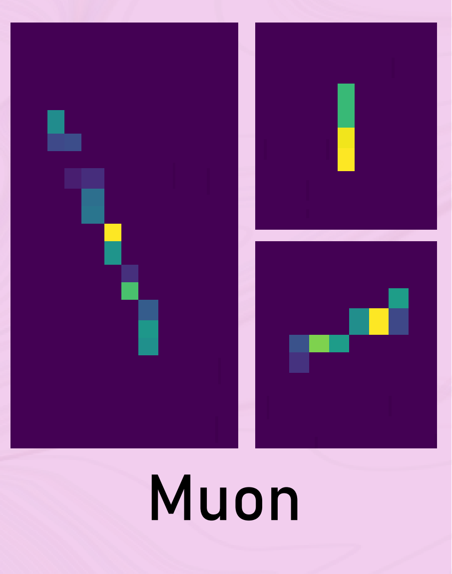
It consists of a **matrix of ~230k pixels** with 55 µm pitch. Each can measure **time-of-arrival** and **time-over-threshold** when hit.



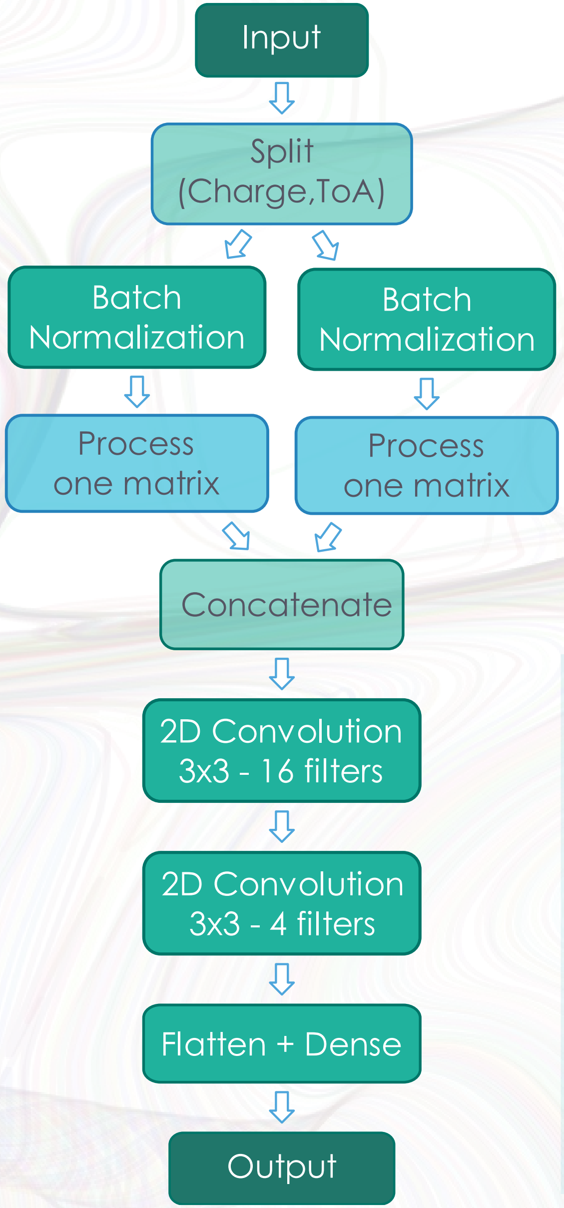


Natural radioactivity dataset acquired with Timepix4 bump-bonded to a **500 µm** thick **Silicon sensor**.

Dataset size: 4000 Clusters

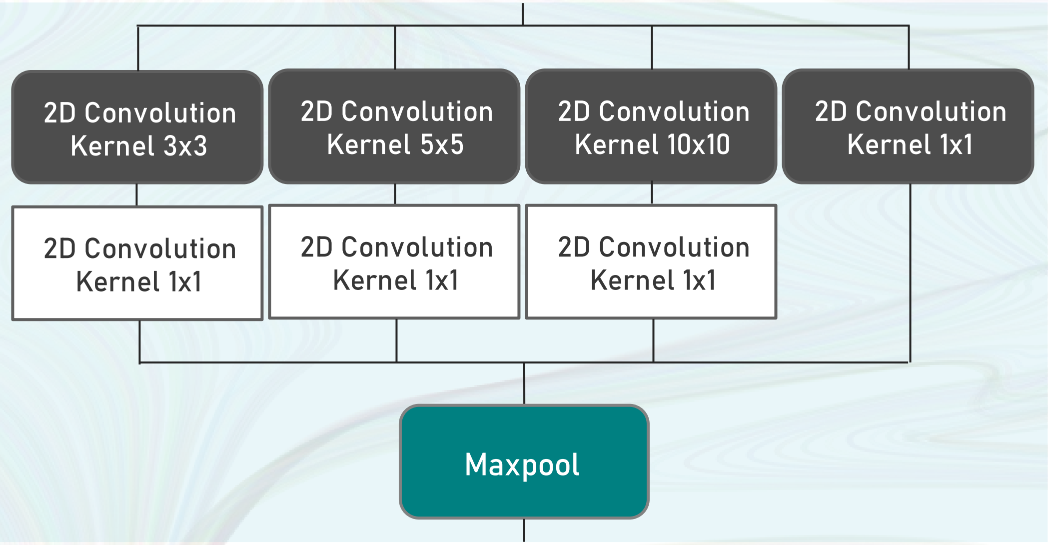


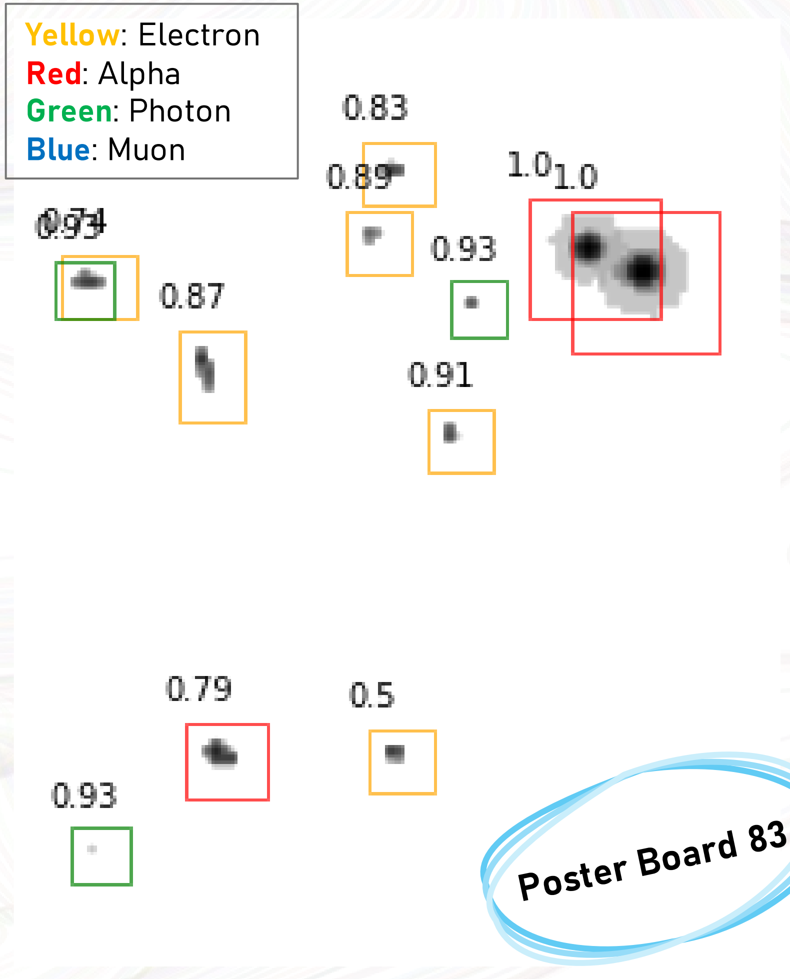
Network structure and performance



The network takes as input a 50x50x2 matrix, that is split into **two 50x50 matrices**: **ToA + Charge**.

Each 2D matrix is **individually processed** by a series of **inception blocks** and the results are **concatenated** together.





Poster Board 83

Accuracy on validation set: ~**81%**
Loss on validation set: ~ **0.86**

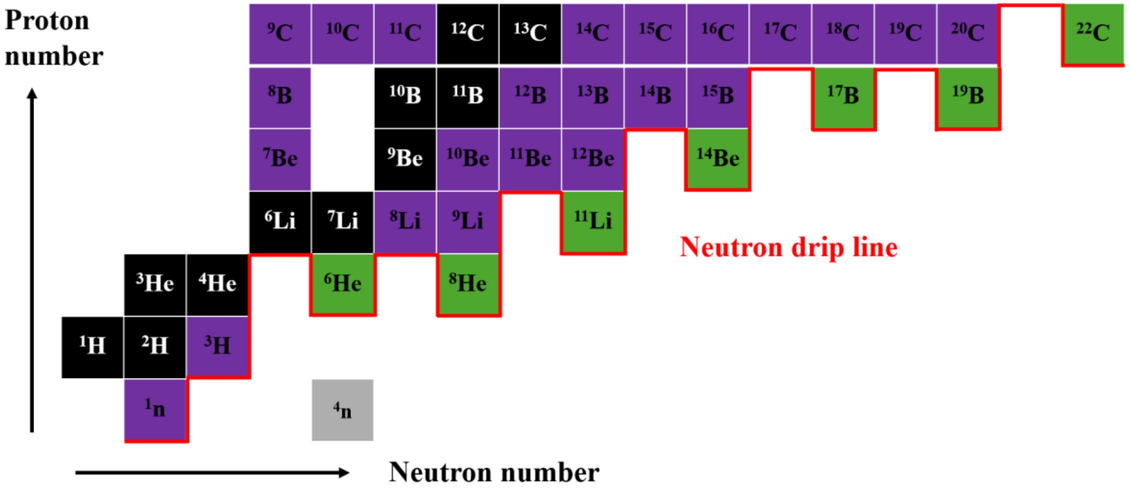
Improving Two-Neutron Detection Efficiency on the NEBULA Detector using XGBoost Algorithm

Y. Li[1,2], Z. Yang[3], Y. Kubota[1], T. Uesaka[1]

（On behalf of SAMURAI18 collaboration）

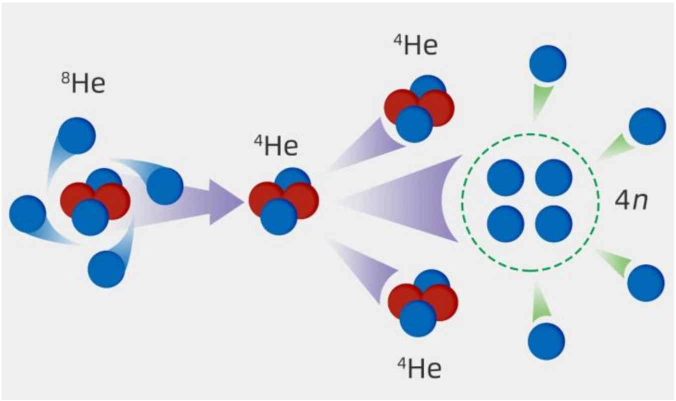
[1] RIKEN Nishina Center, Hirosawa 2-1, Wako, Saitama, Japan
[2] Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, China
[3] School of Physics, Peking University, Beijing, China

Background: multi-neutron detection is very important in nuclear physics

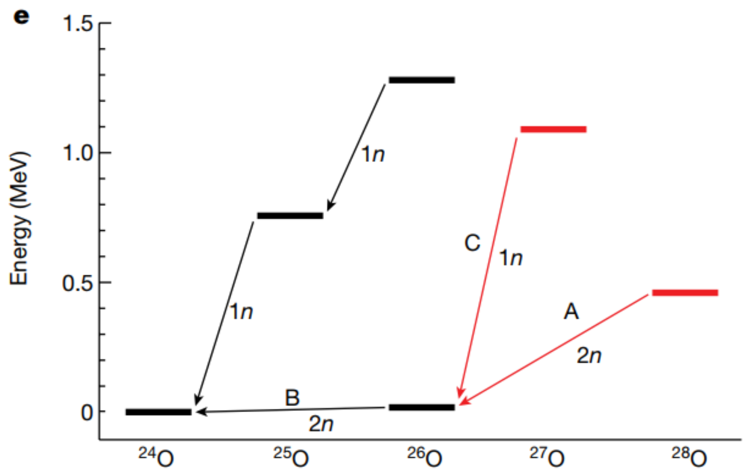


- In the field of nuclear physics, **multi-neutron detection** plays a critical role in revealing specific nuclear properties around neutron drip line
  - Neutron drip line: The boundary beyond which atomic nuclei are unbound
  - Invariant method: All decay products are required
  - Multi-neutron decay: Many drip line nuclei or resonances have more than one decay neutron

- **Four-neutron resonance states [1]**



- **First observation of ^{28}O [2]**

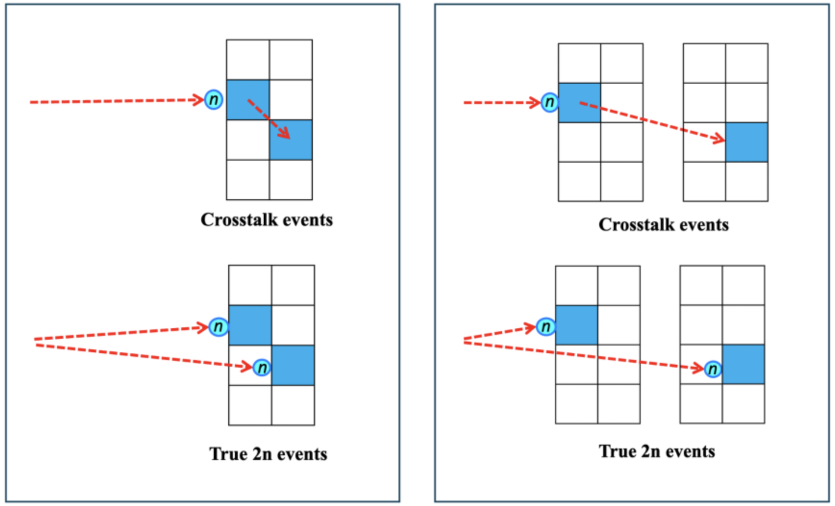


1) Duer, M., Aumann, T. et al. Nature 606, 678–682 (2022).
2) Kondo, Y., Achouri et al. Nature 620, 965–970 (2023).

CrossTalk events and XGBoost method

➢ CrossTalk events

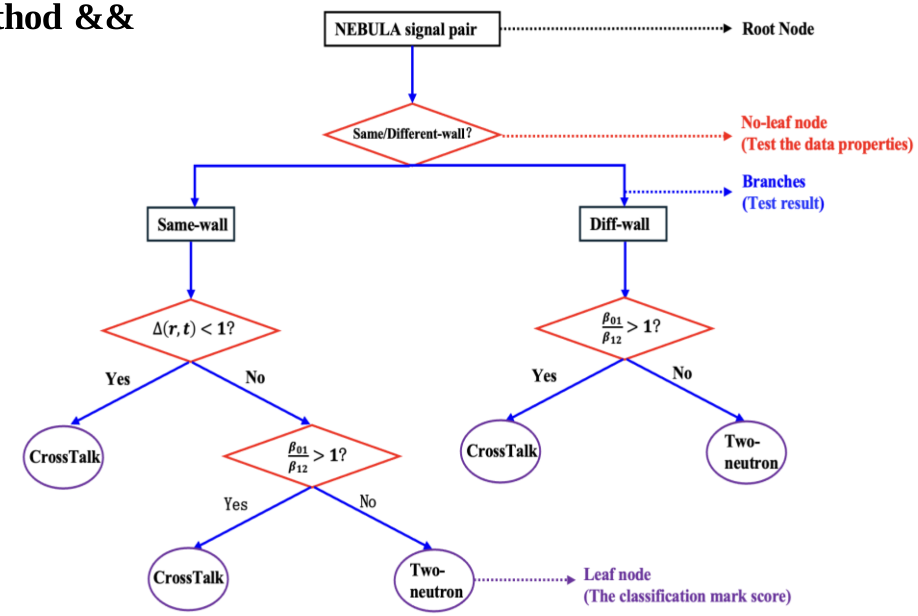
- Space-time separation
- Causality condition



Same-wall event

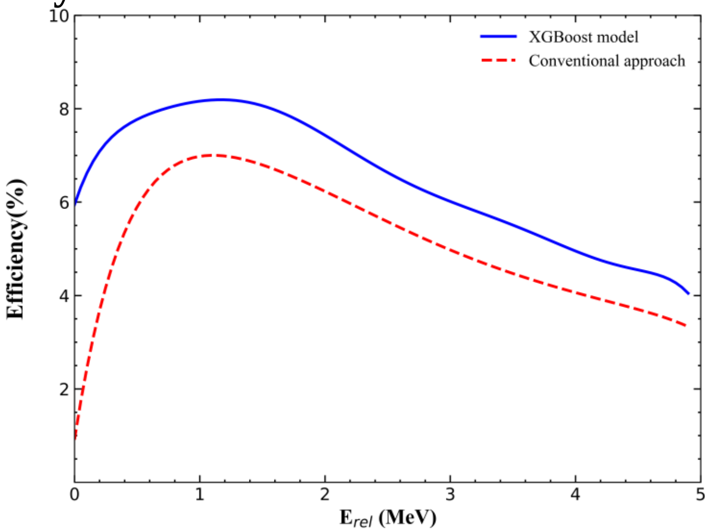
Different-wall event

➢ Conventional method && Decision tree



➢ Two-neutron Efficiency curve

- Within a smaller relative energy range, the detection efficiency for two-neutron is significantly improved.
- This performance is very helpful for enhancing the detection of multi neutrons.



➢ Different numbers of features

- Using the same number of features as conventional methods, XGBoost methods do not have obvious advantages.
- After adding other features including relative energy, XGBoost demonstrates its ability to classify in high-dimensional spaces..