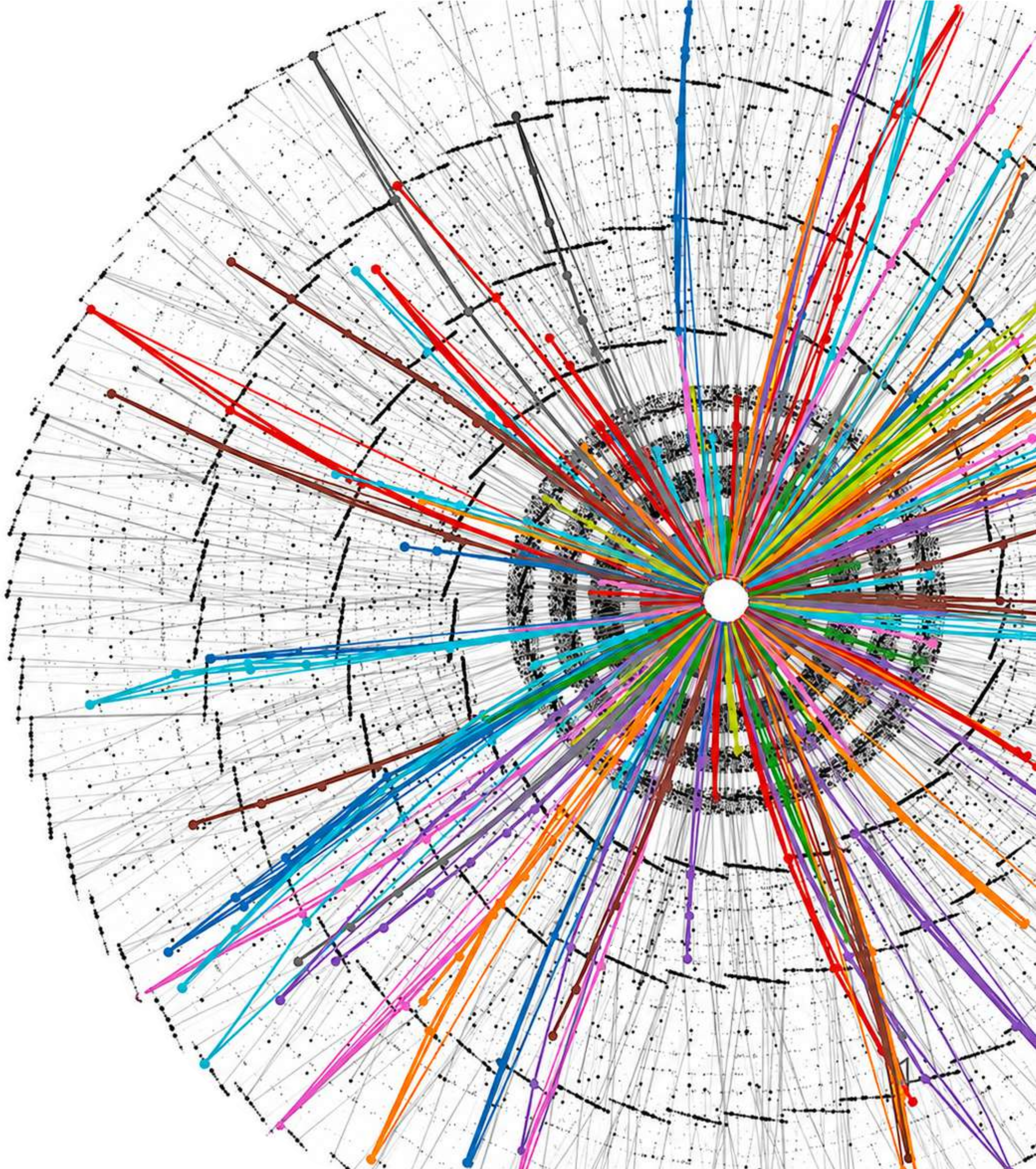
GNN applied to streaming readout in EICrecon

AI Flash Talk
Oliver Partridge - 16/07/2026

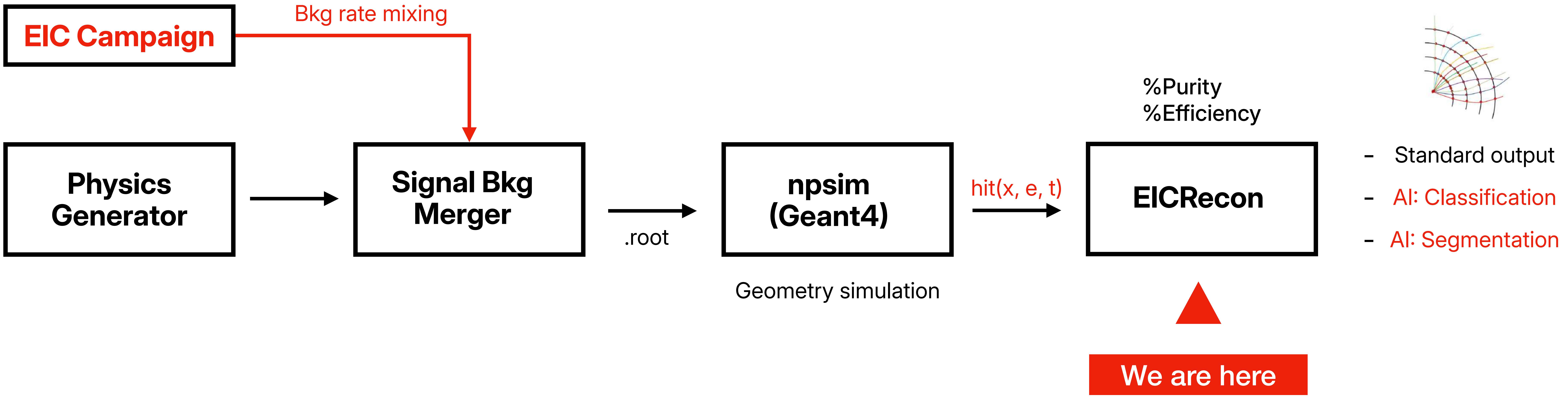


Img from DANIEL MURNANE

Introduction

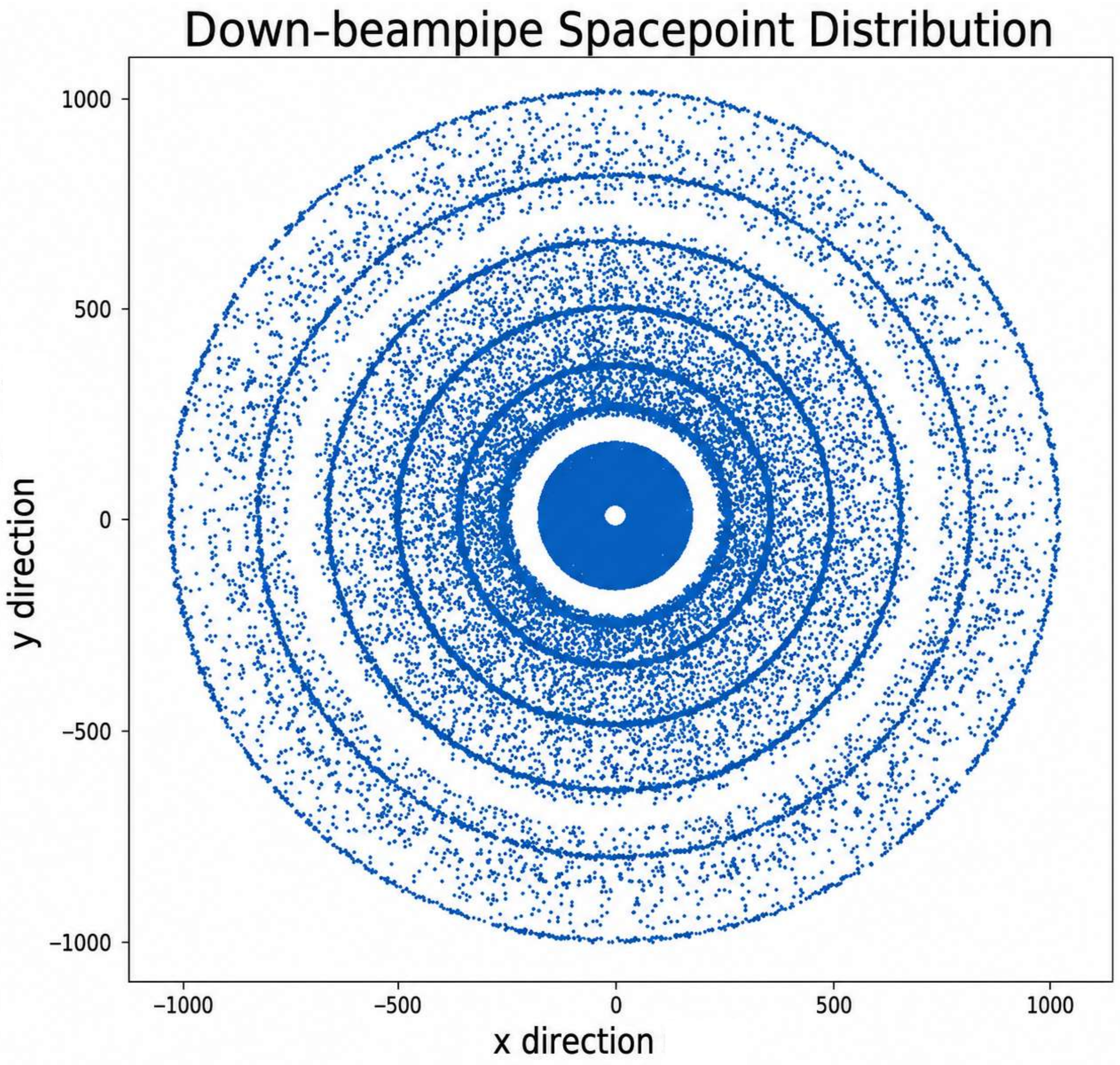
Quick self presentation

- Oliver Partridge (Engineering student in France)
  Air France, Thales, CNRS, Tokyo City University
- Supervised by Marco Meyer-Conde (TCU)
- My Work: GNN machine learning for pre-filtering streaming readout in EICrecon



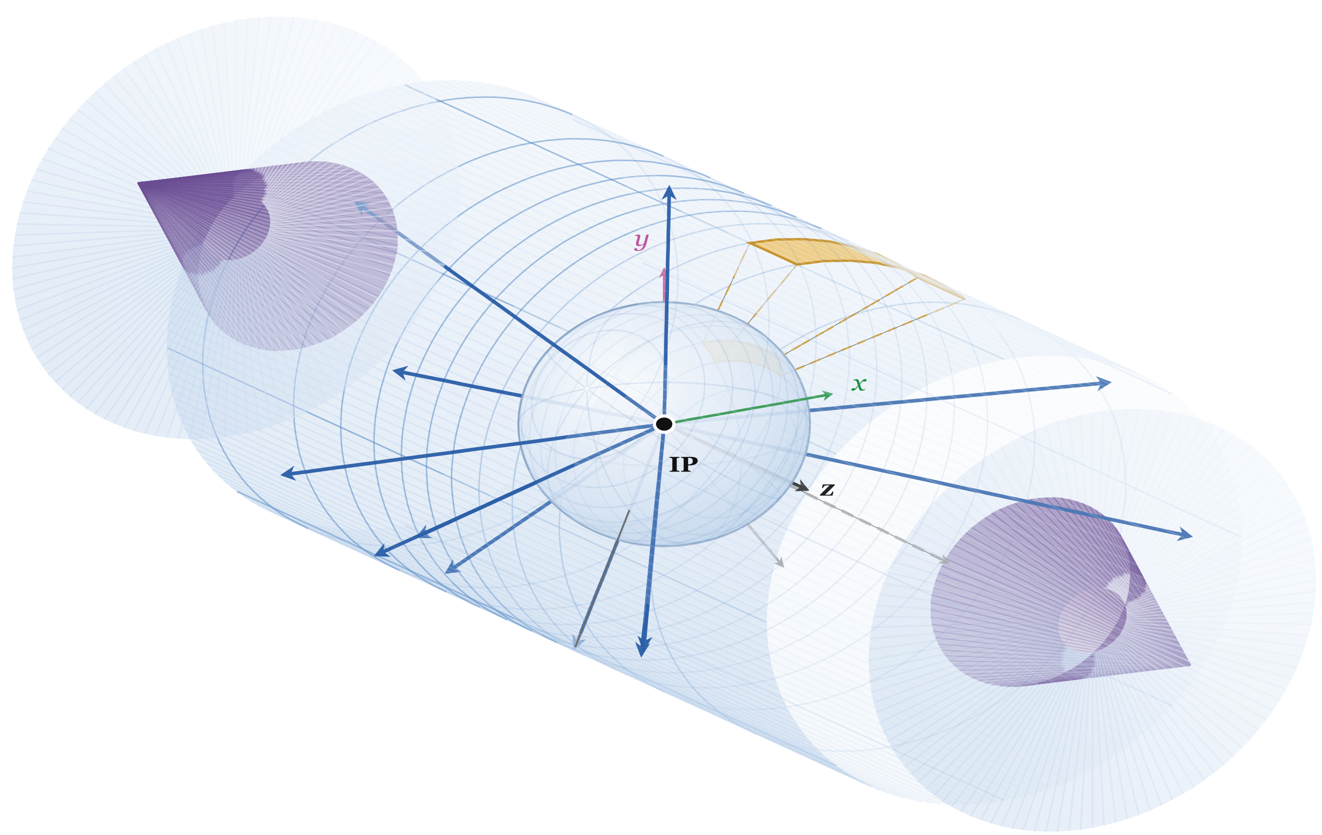
The problem

Hits in a detector are mainly back ground noise.



Event Builder: Time Frame To physics Event

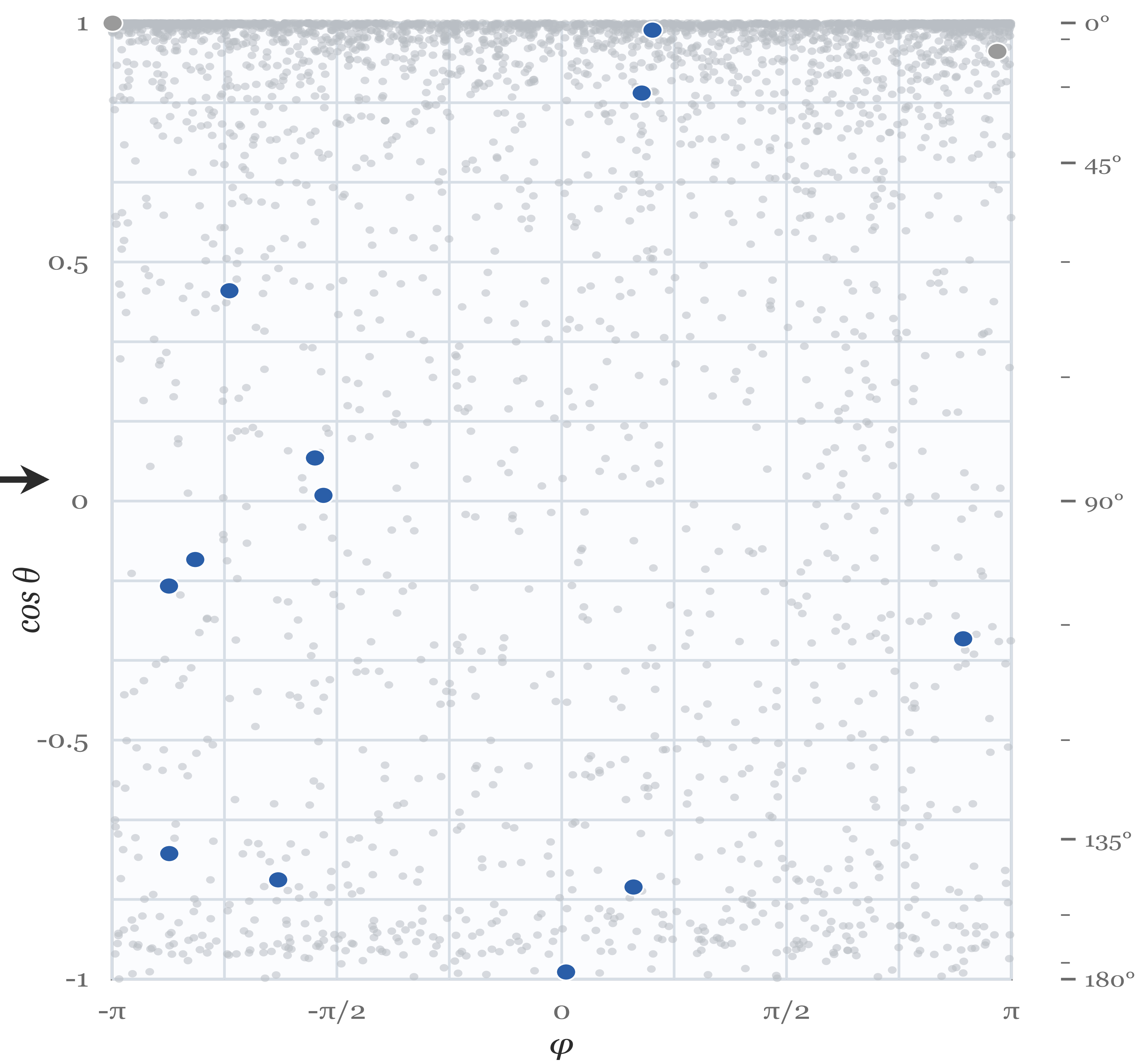
Point cloud model = Raw hit in all the detectors



Detector geometry projection

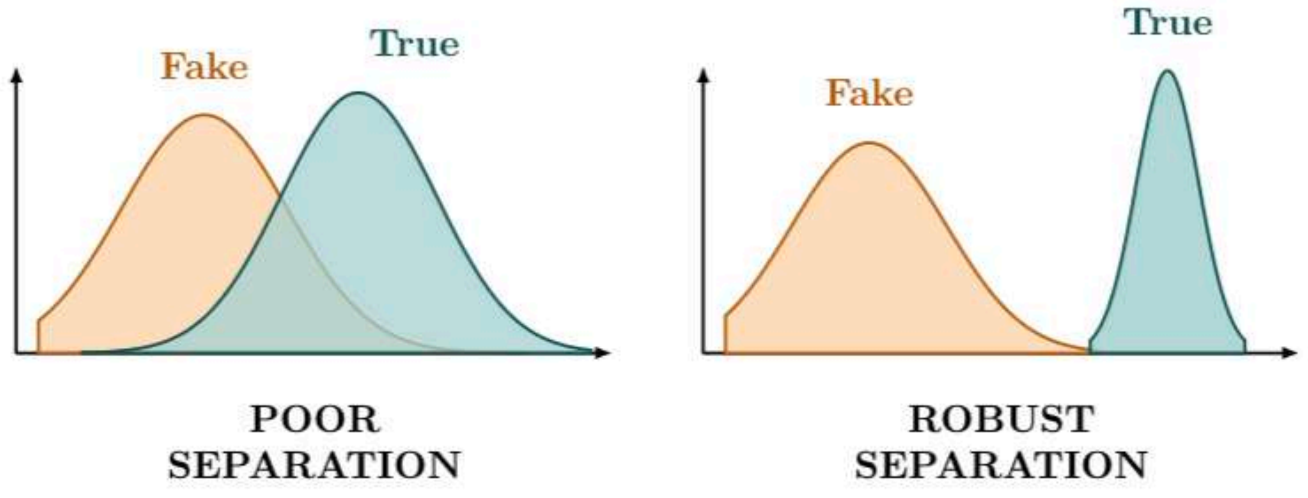
project to

$(\varphi, \cos\theta)$



Hits (BKG+SIGNAL) from TOF + MPGD simulation in a time window ΔT

For each cell, we compute an event significance score and estimate the probability of a true or fake event.

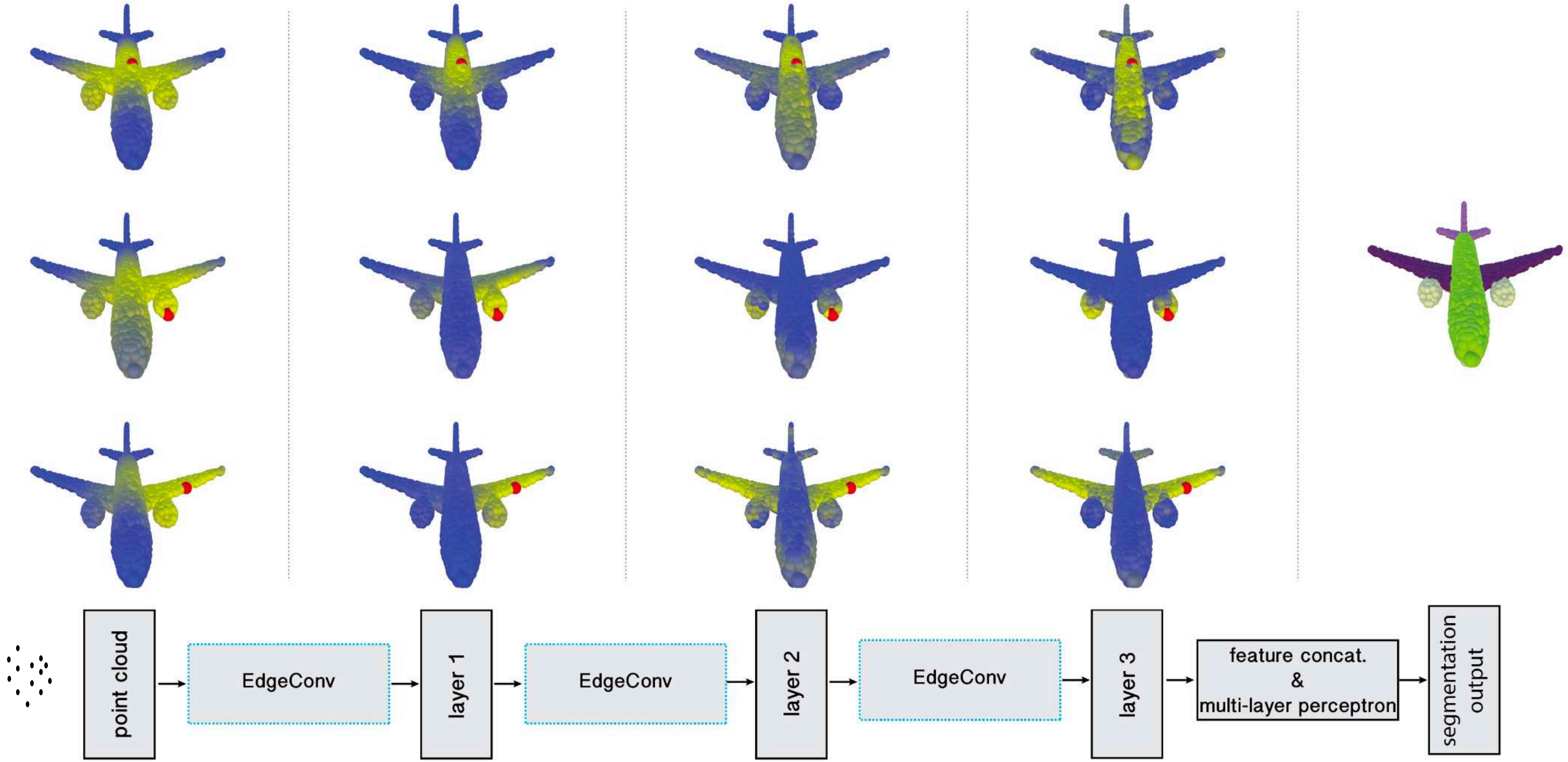


AI added value

Classical filtering

GNN Model

Our architecture is based on the GNN architecture proposed by Wang et al. (2019)

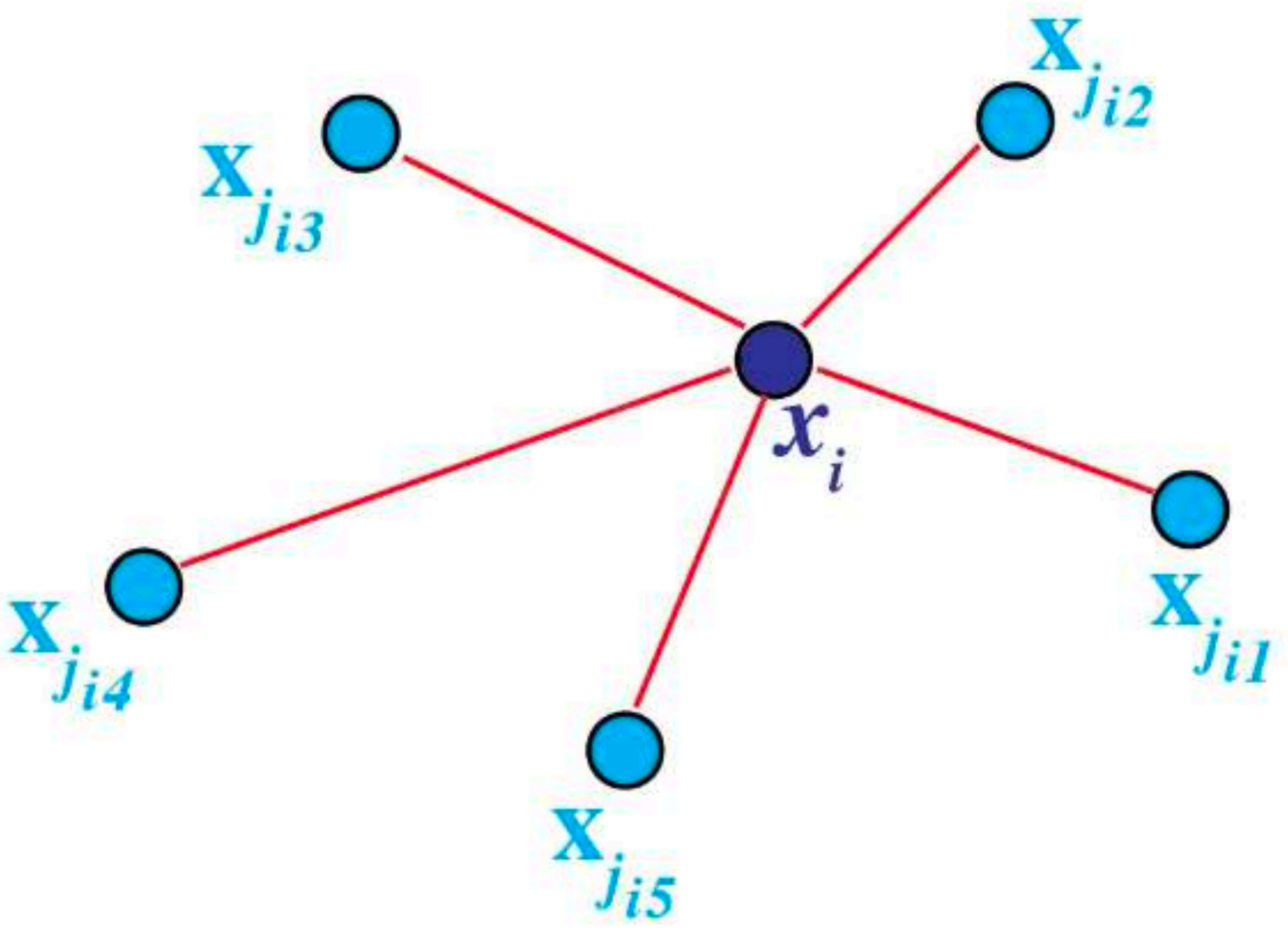


GNN Model

What is EdgeConv and K-Nearest Neighbors (KNN)

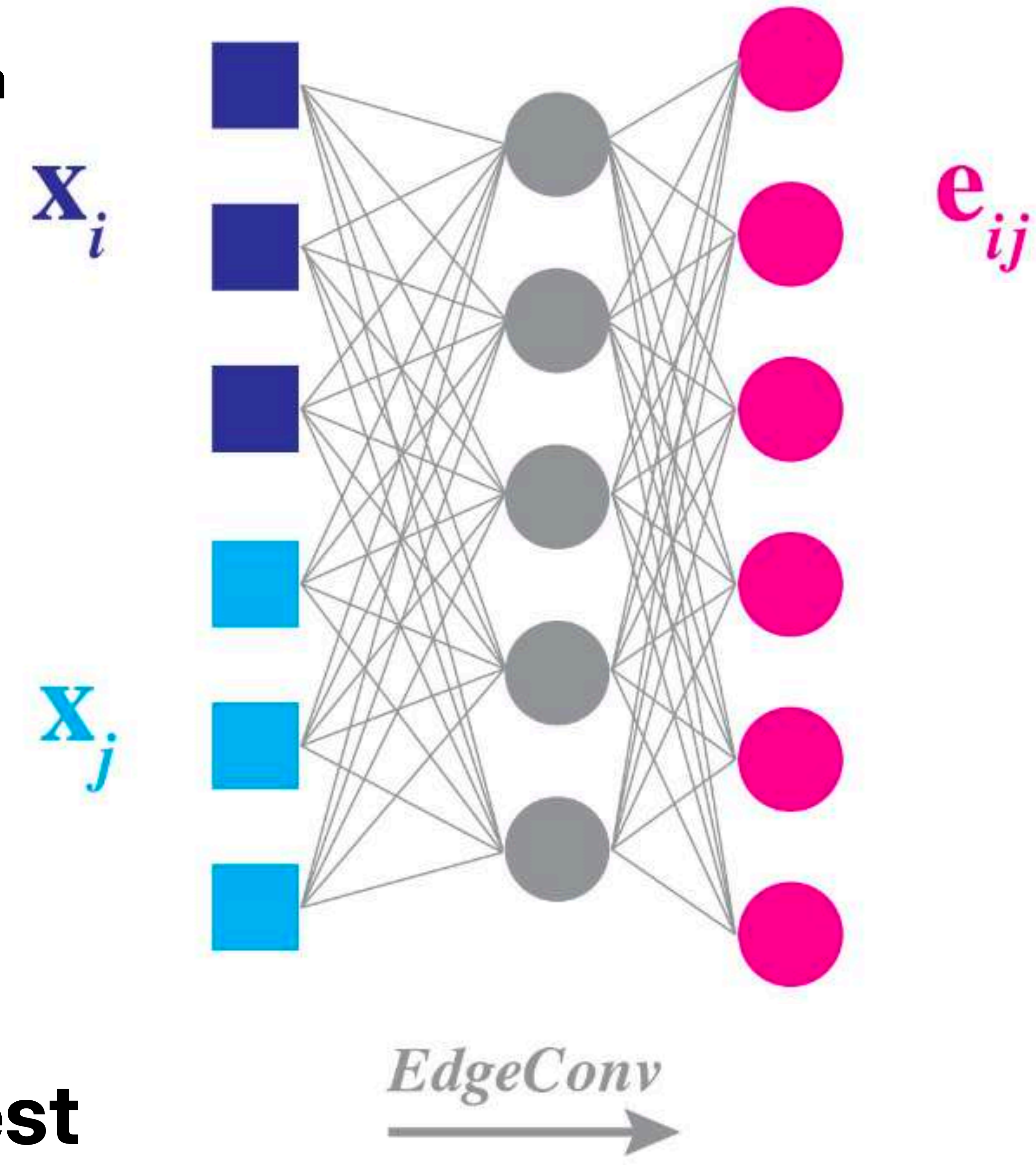
Dynamic KNN

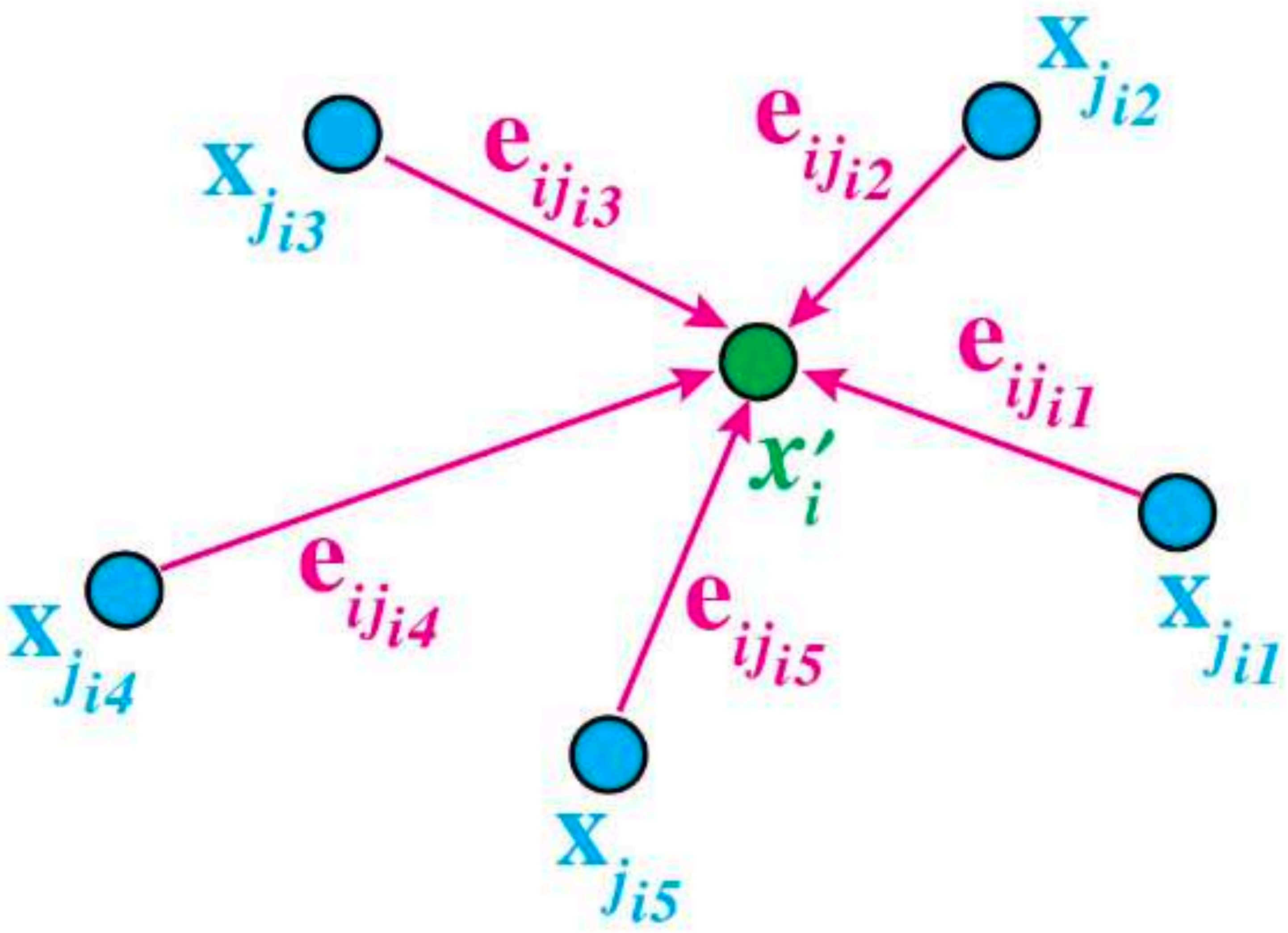
Using nanoflann



Draw relations with nearest neighbours

Static graph





Represent each hit by its interaction with KNN

GNN Architecture

Data

~8000 simulated collisions events split into 75/15/15 training, validation and test

Optimization

Epochs 20-200
Optimizer Adam
Batch size

Loss function

Cross-entropy loss

Stability

Curriculum strategy
Dropout, weight decay, gradient clipping

Hardware/compute

Training runs on a 4-GPU workstation (NVIDIA Blackwell)

Hyperparameter selection

3-4 layer depth
Graduated width 64, 64, 128, 256

Goal

2 heads:
- Classification
- Multiplicity

Model dimensionning

GNN Training

Curriculum learning

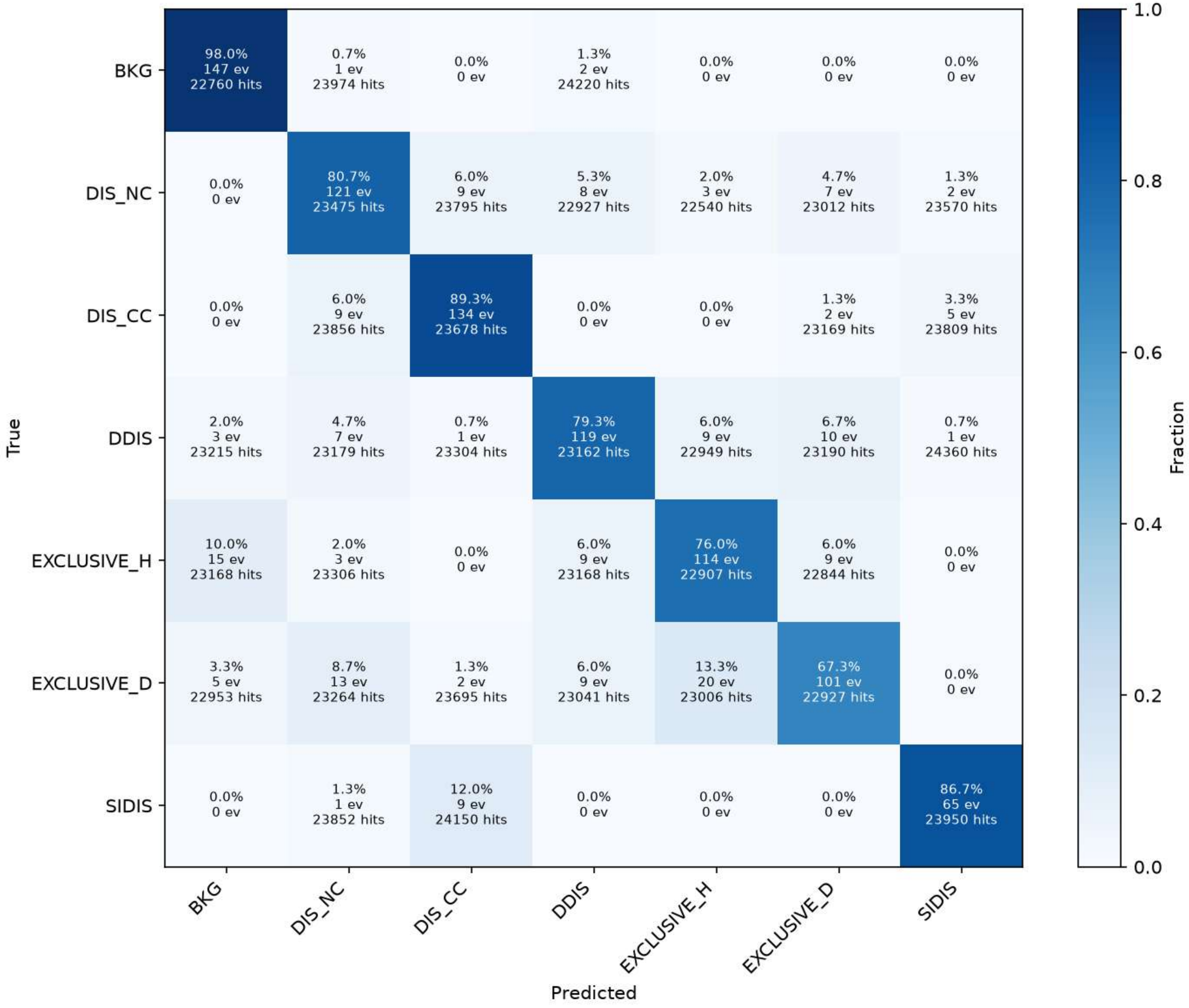
The model is trained on increasing level of noise.

Noise ladder	Bkg rate
vanilla	0 Hz
gold-coating	1.3 GHz
vacuum	3.3 GHz

Physics classes

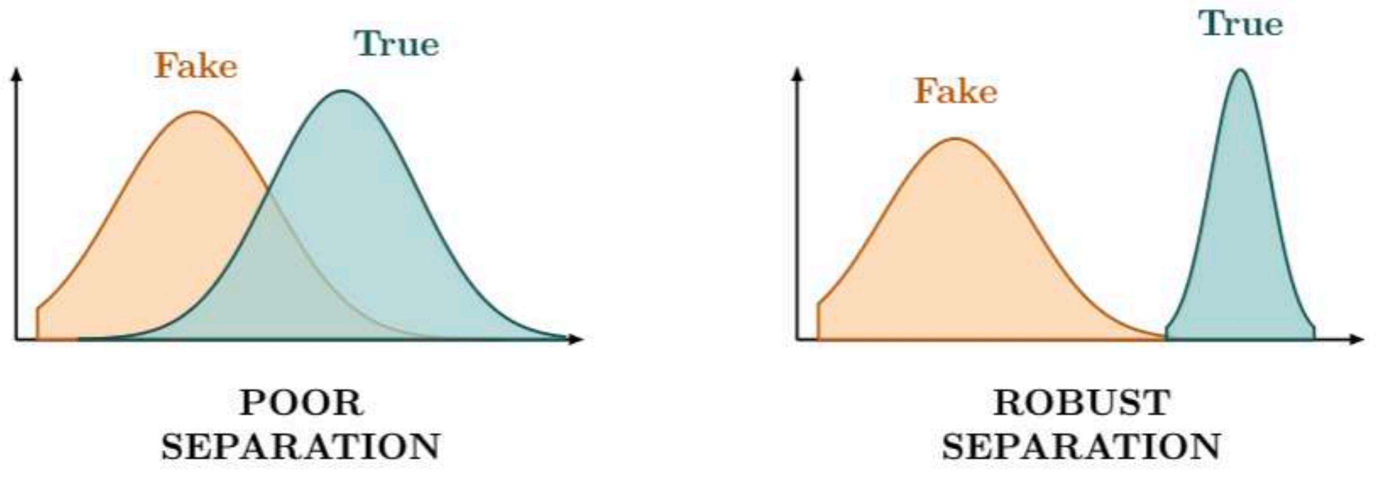
#	Class	Description
0	BKG	Machine backgrounds (SynRad, Touschek, Coulomb, BeamGas, Brems)
1	DIS_NC	DIS neutral current (scattered e^- visible in backward ECal)
2	DIS_CC	DIS charged current (forward jets + missing-E)
3	DDIS	Diffractive DIS (rapidity gap + intact proton in RPs)
4	EXCLUSIVE_H	Hard exclusive non-diffractive (DVCS, DVMP, DEMP, TCS)
5	EXCLUSIVE_D	Diffractive vector-meson (J/Ψ, ρ, ϕ; 2-body decay)
6	SIDIS	Semi-inclusive DIS (D^0, Λ, Λ_c, dijets)

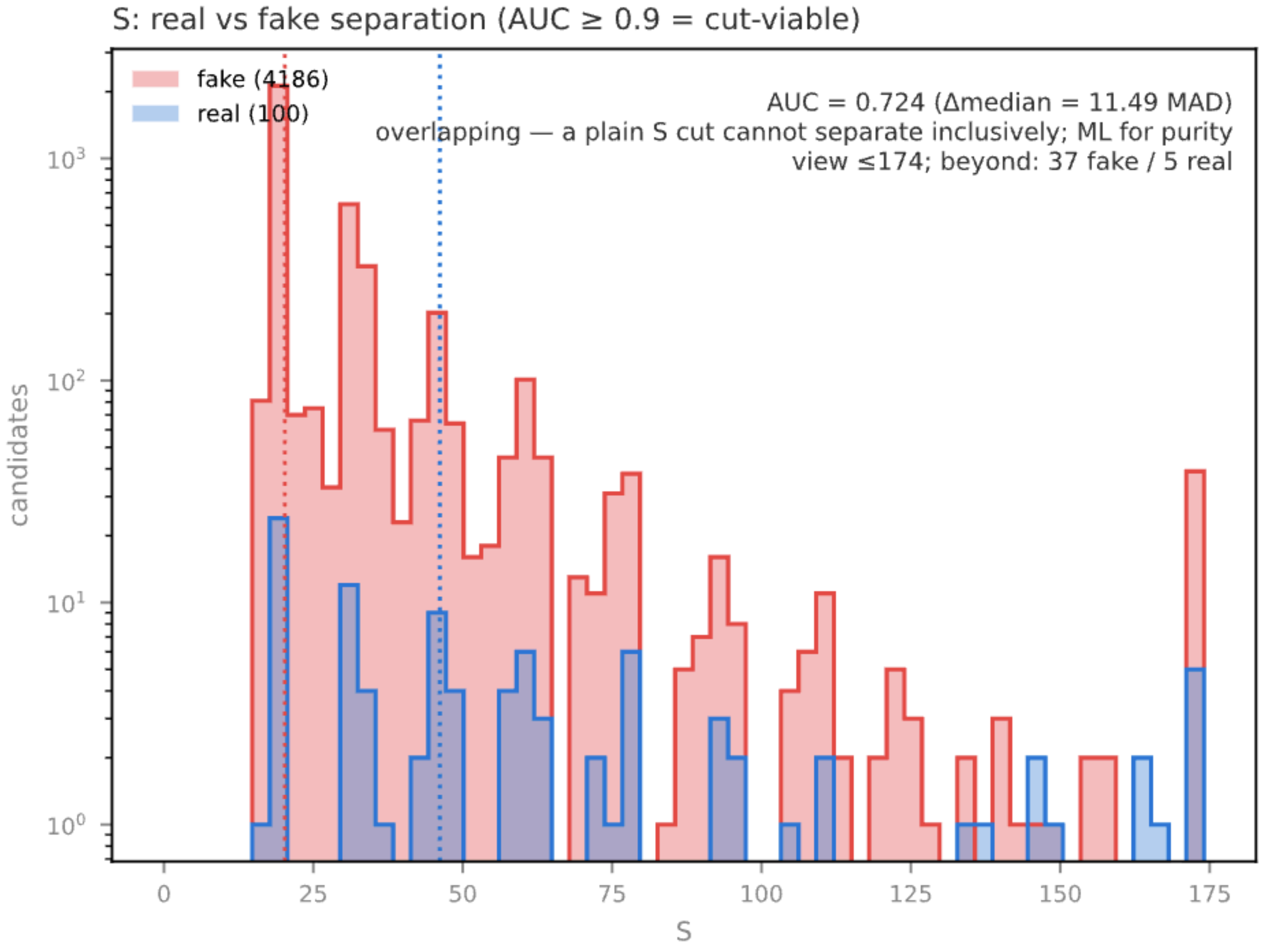
Confusion matrix

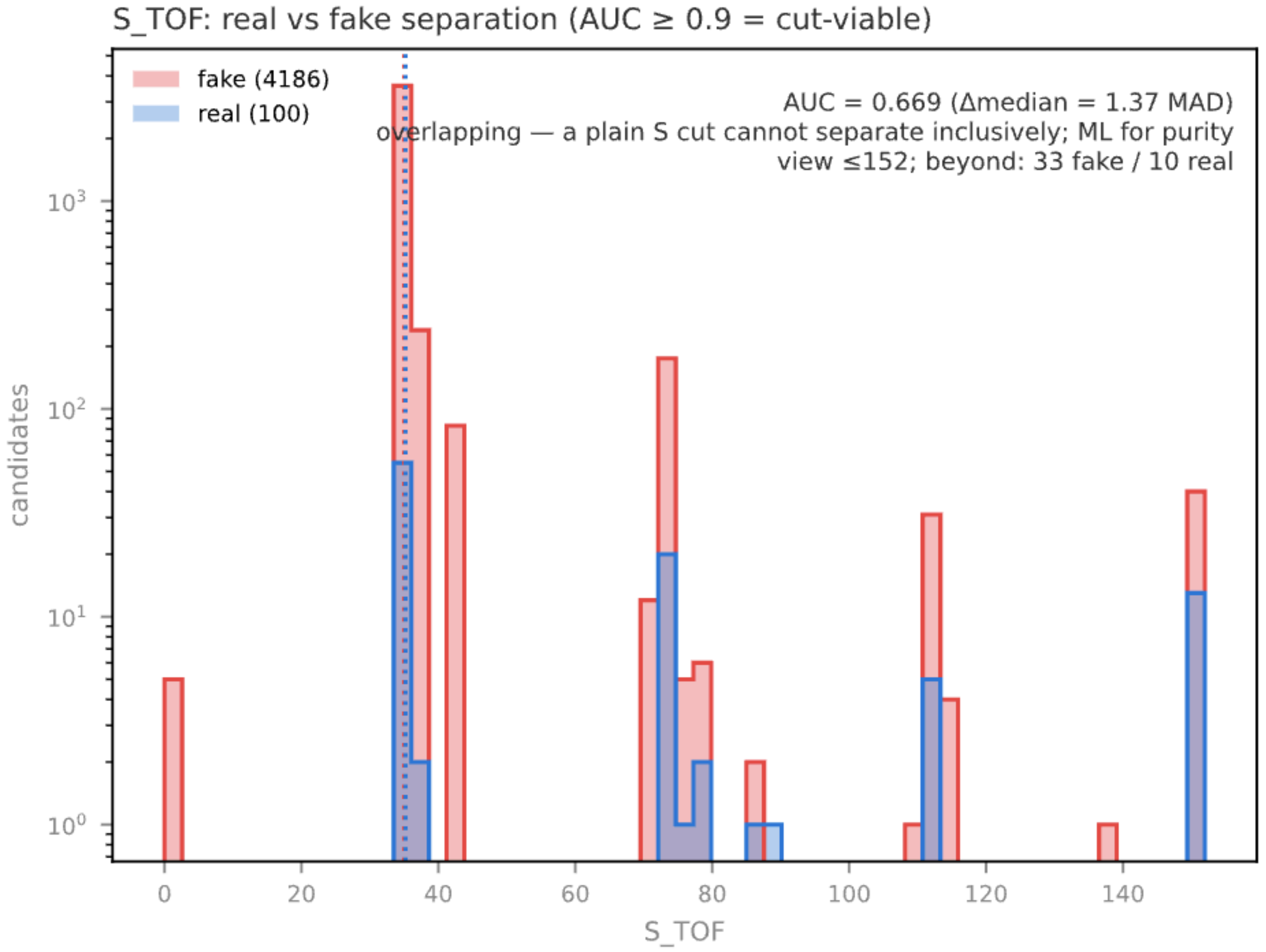


What support or collaboration could help move it forward?

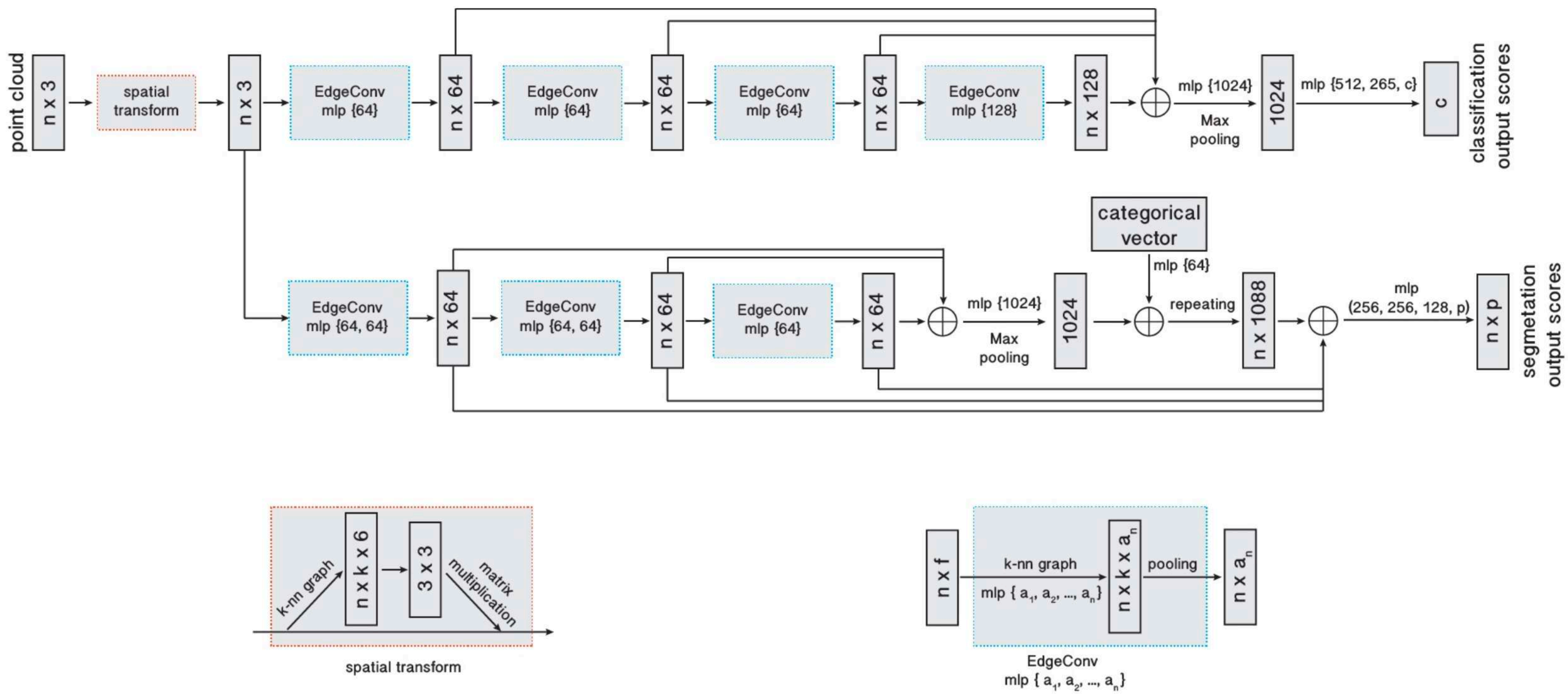
Advising for more realistic data → the current bkg noise is not time structured.



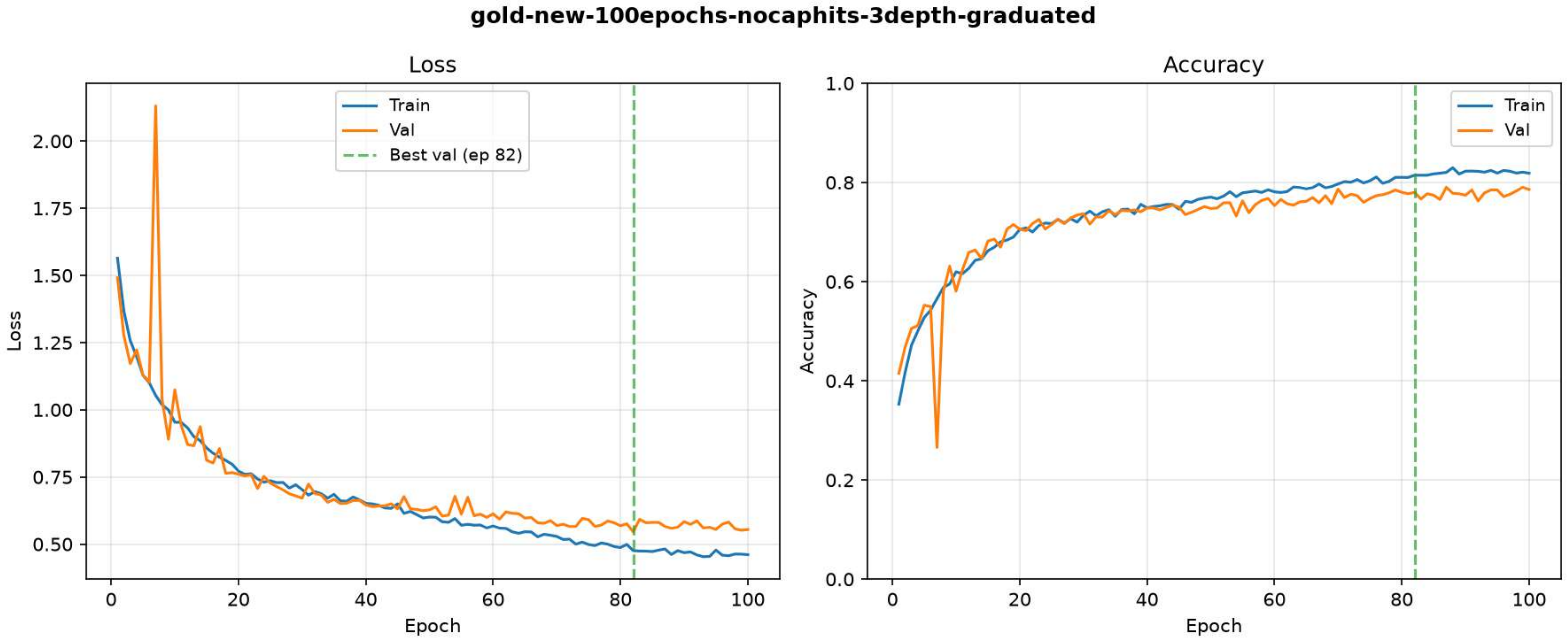




A1 Model architecture

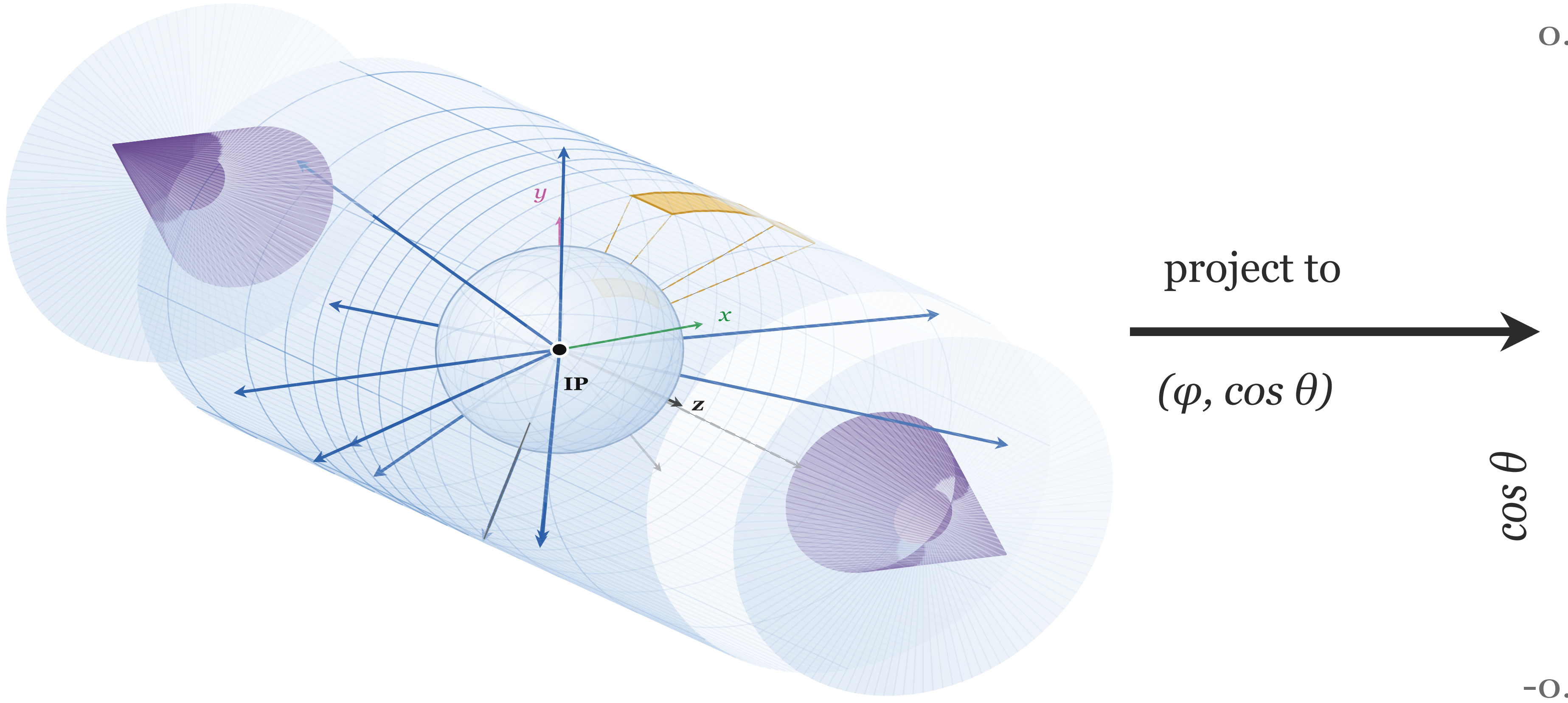


A2 Loss and accuracy

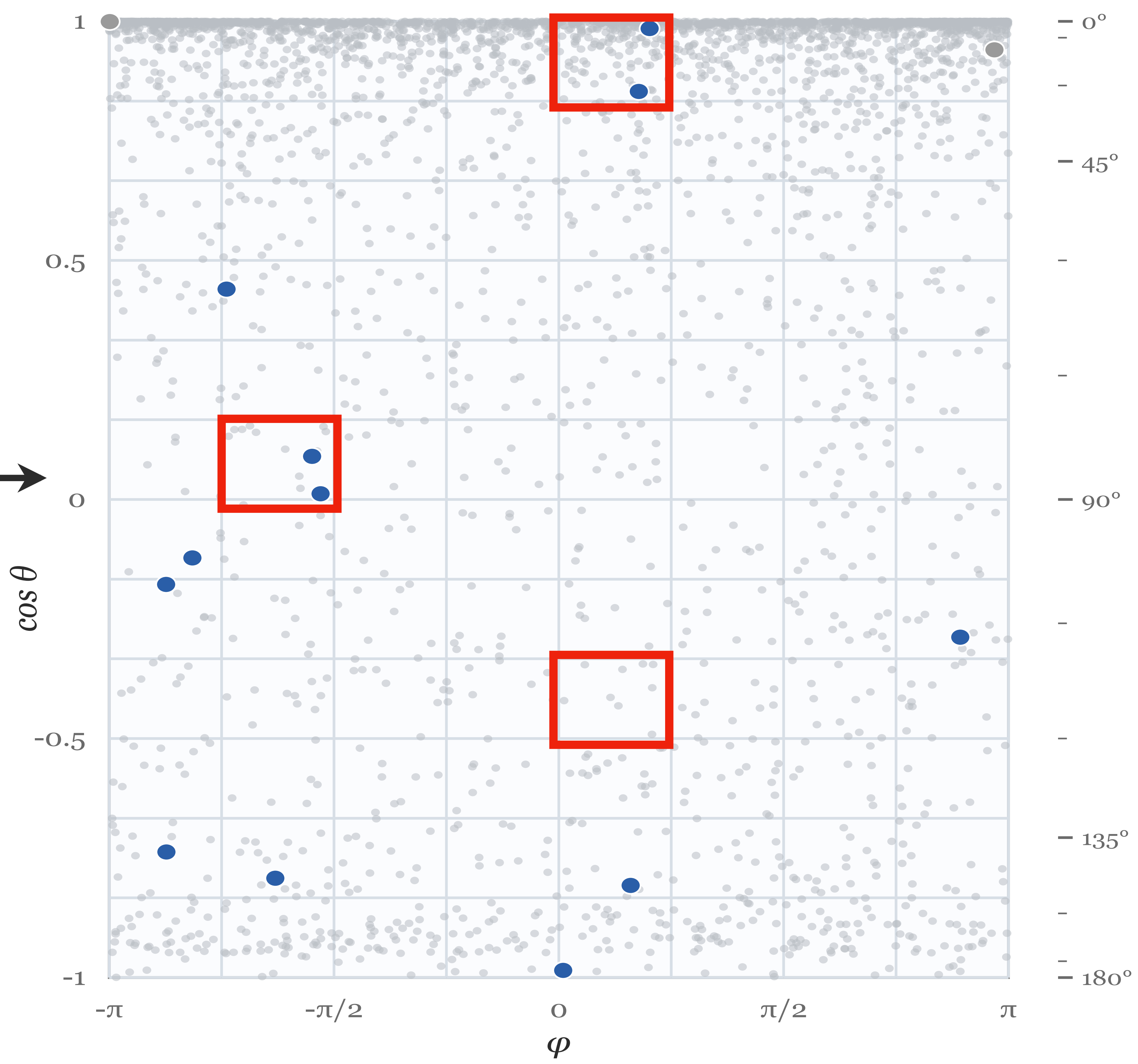


A3 Probability

Point cloud model = Raw hit in all the detectors



Detector geometry projection



Hits (BKG+SIGNAL) from TOF + MPGD simulation

For each cell we define:

$C_{\max}$ Peak cell occupancy

$$\mu = \frac{N \cdot \Delta t}{N_{\text{cell}} \cdot \Delta T}$$

Mean occupancy

$$S = \frac{C_{\max}}{\mu}$$

Significance

A3 Probability

CITY UNIV.

Point cloud model = Raw hit in all the detectors

H0: Observed hits are entirely consistent with accidental bkg fluctuations.
No genuine physics event is present in the considered time window and angular cell

Background model under the null hypothesis H_0:

$$X \sim \text{Poisson}(\mu)$$

Per-event false-alarm criterion:

$$P(X \geq k \mid \mu) < p_{\text{FALSE}}$$

Significance from the p-value:

$$S = -10 \log_{10}(p\text{-value})$$

Detection criterion in terms of significance:

$$\text{SNR}(S_i, \mu) \gg 1$$

Large-μ (Gaussian) limit of the Poisson significance test:

$$\mu \gg 1 \iff \chi^2_{N_{\text{dof}}} \sim 1$$

For each cell we define:

$C_{\max}$ Peak cell occupancy

$$\mu = \frac{N \cdot \Delta t}{N_{\text{cell}} \cdot \Delta T}$$

Mean occupancy

$$S = \frac{C_{\max}}{\mu}$$

Significance

time coincidence (threshold κ)

$|t - t_i| < 3\,\sigma_{\text{MPGD}}$ **MPGD + TOF**