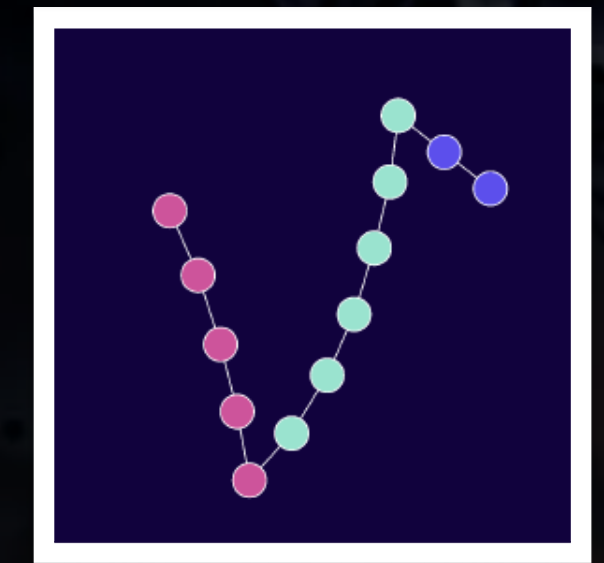


Current state of NuGraph3 on DuneVD simulated data

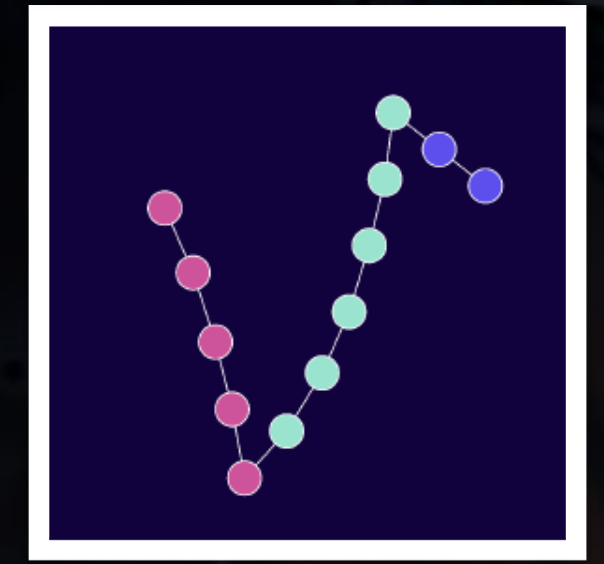
L. Zappacosta, 9/3/2026

What is NuGraph?

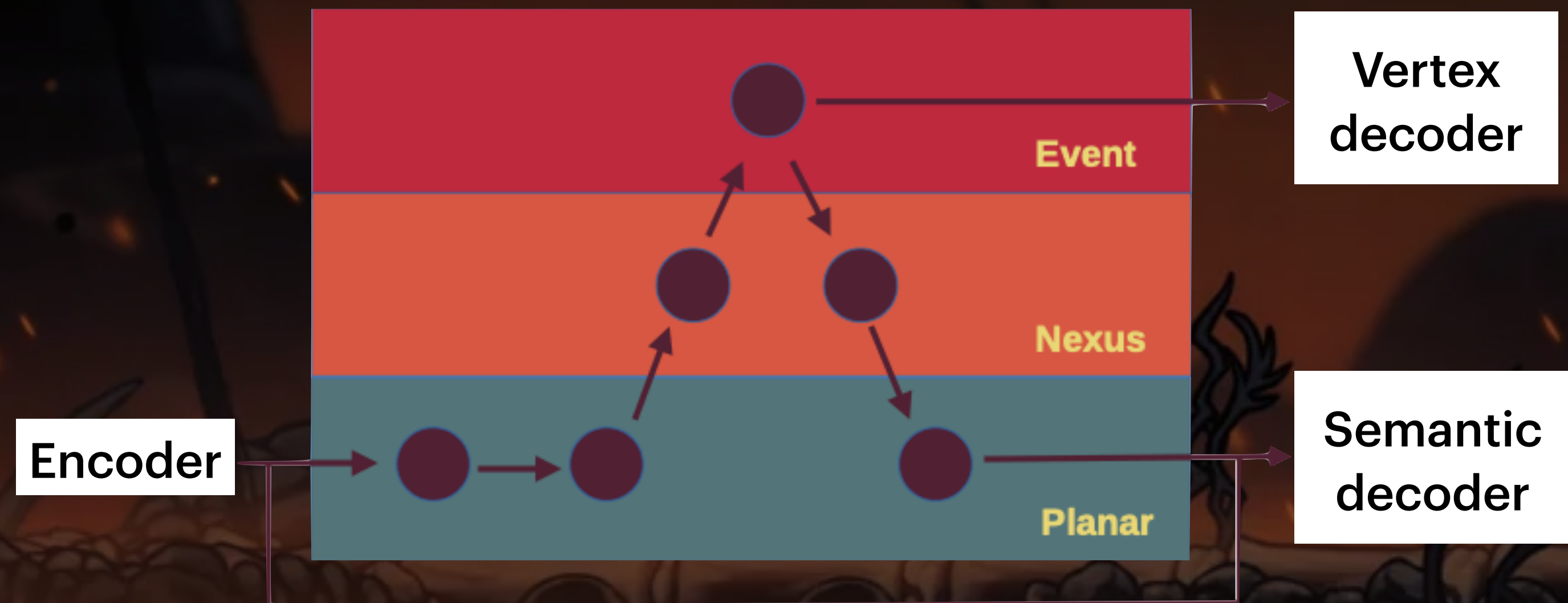


- Hierarchical graph neural network tailor-made for neutrino physics
- Each event is read as a graph, hits are nodes carrying information (position, energy deposited, ...)
- The neural network learns to correctly identify each hit as noise or signal, and to assign a semantic label to it (type of particle)
- Graphs are more efficient than images in carrying information: better performances than classic CNNs
- Some readings:
 - <https://arxiv.org/pdf/2403.11872>
 - <https://indico.phys.ethz.ch/event/113/contributions/836/attachments/516/1110/aurisanoNuGraph3NPML.pdf>

NuGraph3



- NuGraph3 expands on NuGraph2 by adding a new layer: event layer
- Allows for event type identification and vertex reconstruction



Why use NuGraph

- Can help tackling event and track reconstruction
- All-in-one: neutrino flavor prediction, background discrimination, particle and track reconstruction and interaction vertex reconstruction.
- All is handled in parallel, only one big training needed
- Little pre-analysis needed, skips Pandora clustering process, informations taken directly from hits

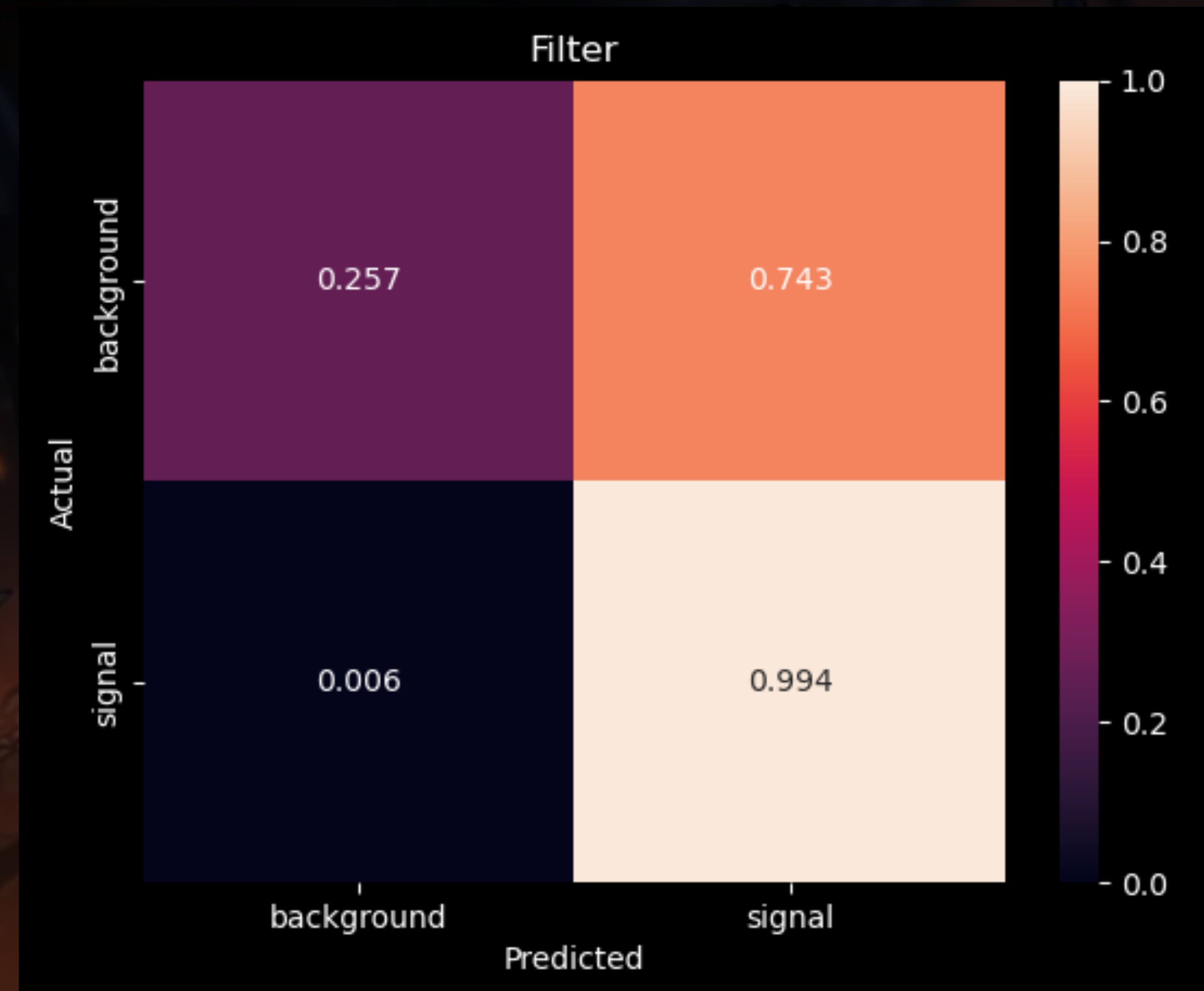
Our test setup

- Trained on 872 nu_mu events total (784 train / 44 test / 44 validation)
- Trained on IN2P3 resources at Lyon (Tesla V100-SXM2-32GB, CUDA 12.1)
- Total time required for this training: roughly 100 minutes

Preliminary results (filter)

Considering the small training sample, there is still some results to talk about:

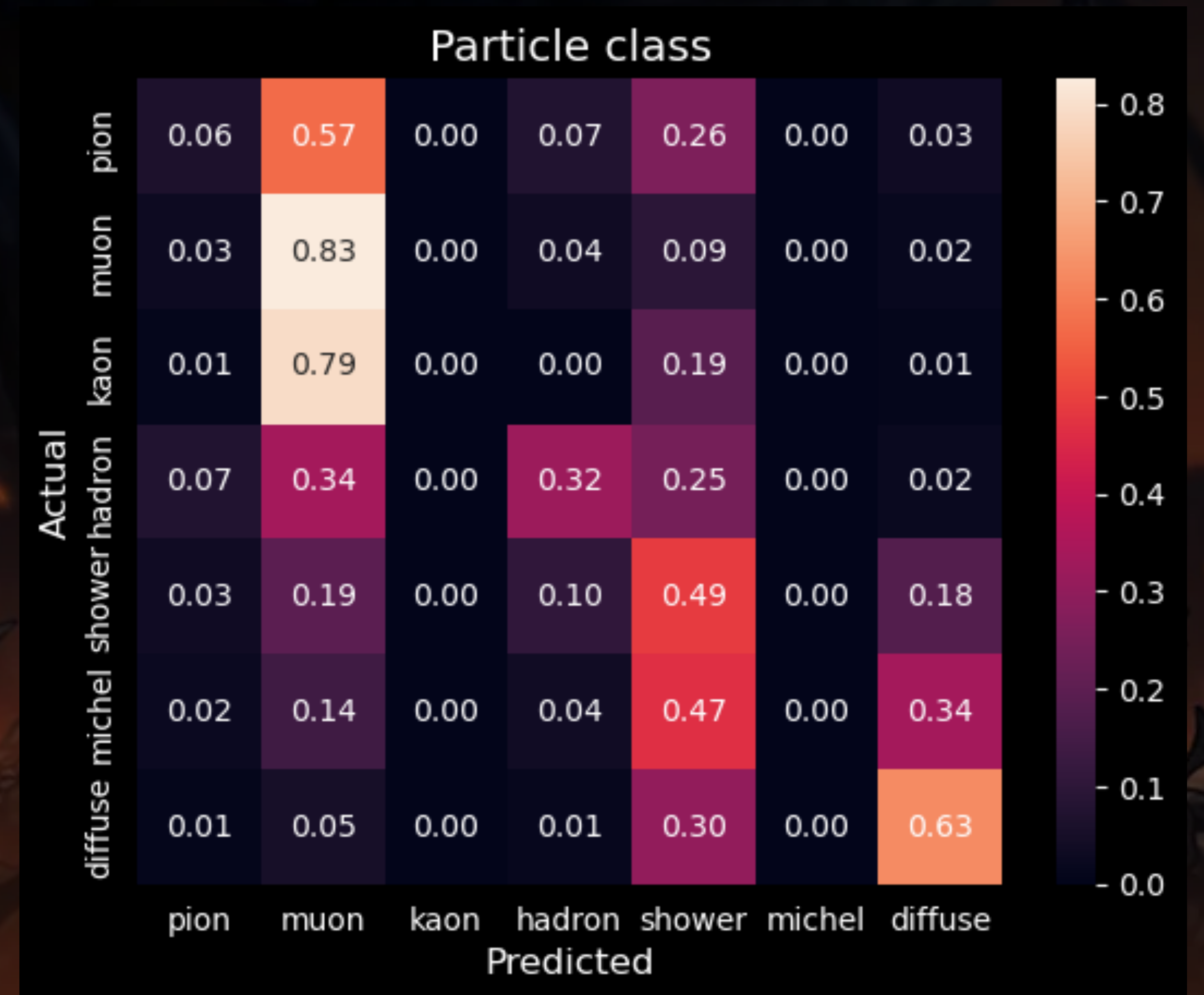
- **Filter:** recall 99.4%, precision 97.9%. Low background counts skews training towards false positives, more training can compensate for that.



Preliminary results (particle)

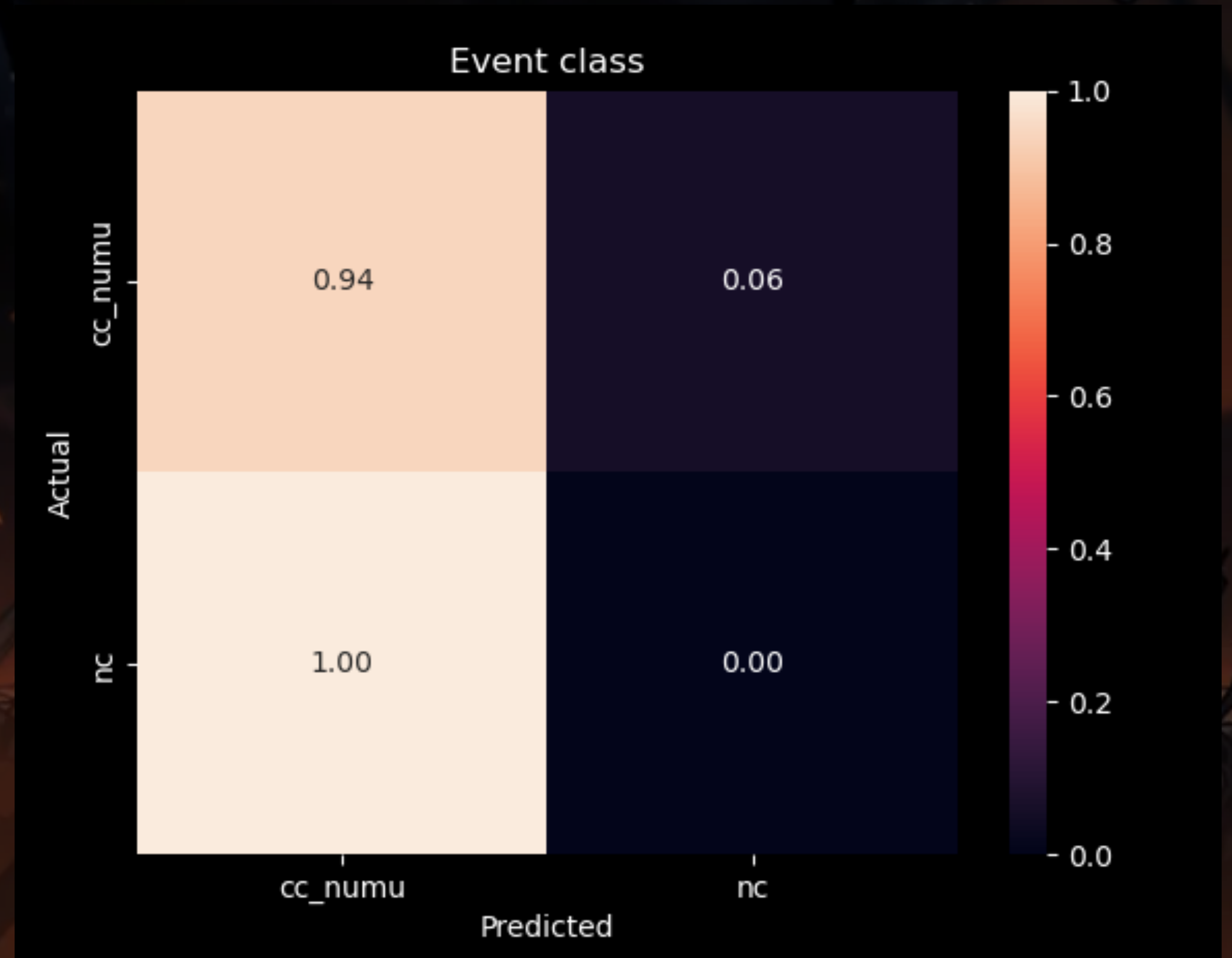
Semantic (particles):

- Good performances on muon track recognition, however also a lot of false positives to muon (over-representation).
- Michel and kaon most hard to recognize, due to low hit counts. More training will fix it.



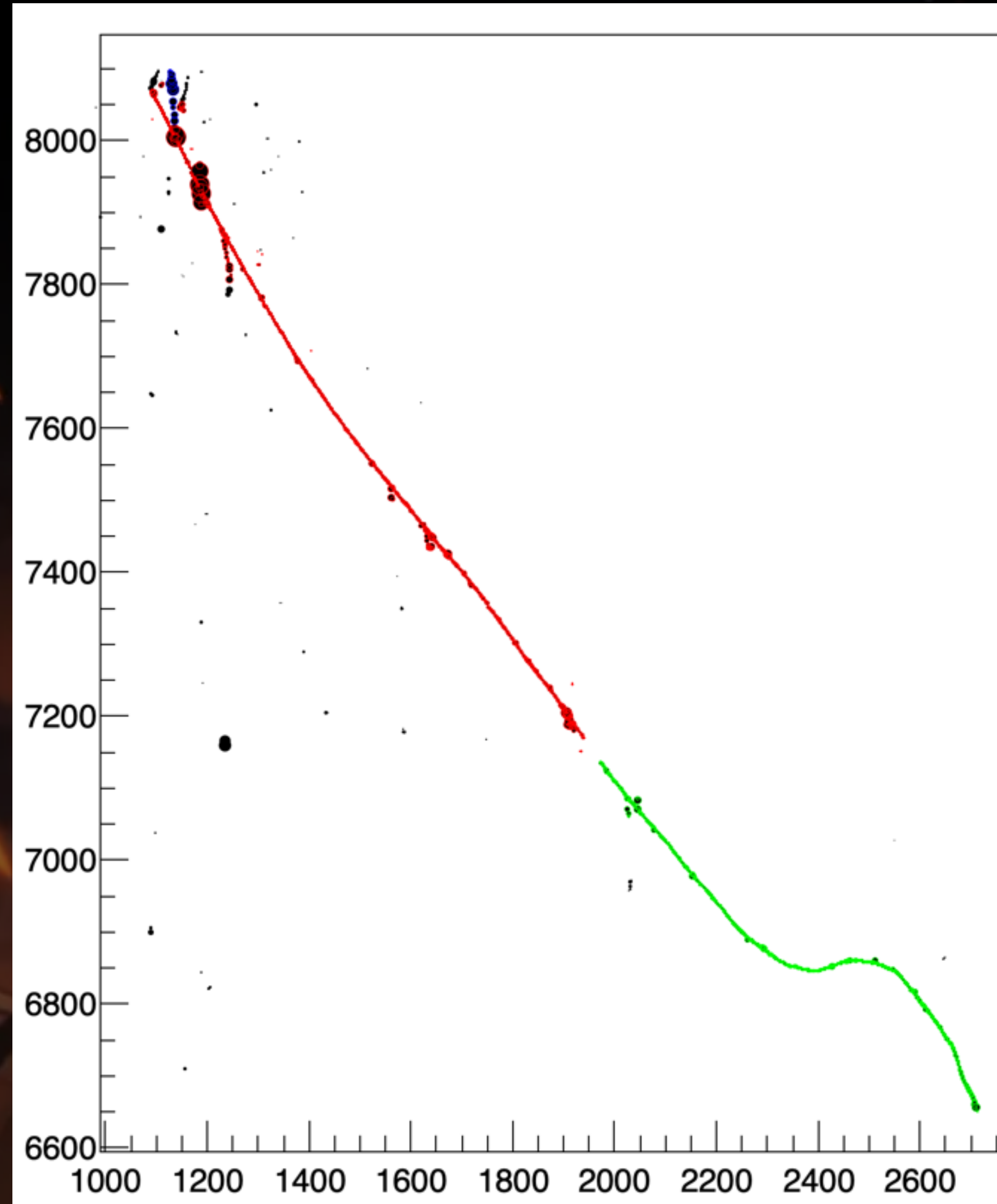
Preliminary results (event)

Events simulated are only from nu_mu, a beam-like production sample is needed to properly assess event labeling

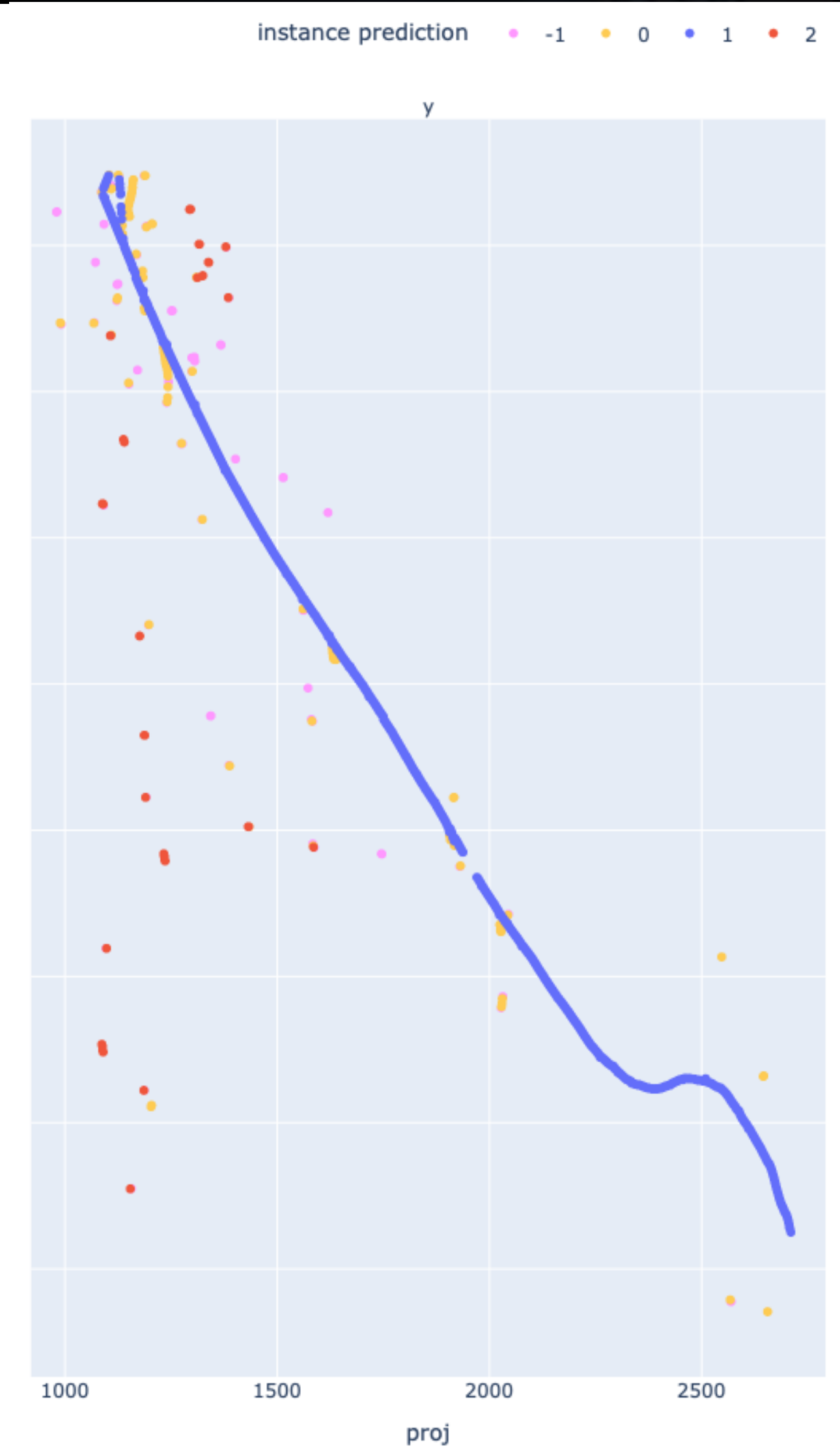


Track reconstruction improvements

NuGraph appears to be less prone to track splitting than Pandora, improving track reconstruction



Example of Pandora reconstruction (instance)



Same event on NuGraph (instance)

What's next?

- More statistic is surely needed: aim is 300k events for training dataset, meaning roughly 350k total production (counting also test-validation datasets)
- Too many events lost in preprocessing due to incomplete information (missing SpacePoints data) -> implemented filter for low edep events, simulation stopped before detsim level
- Proper event and vertex recognition will be implemented

Thank you

