מכון ויצמן למדע

WEIZMANN INSTITUTE OF SCIENCE

Set2Tree

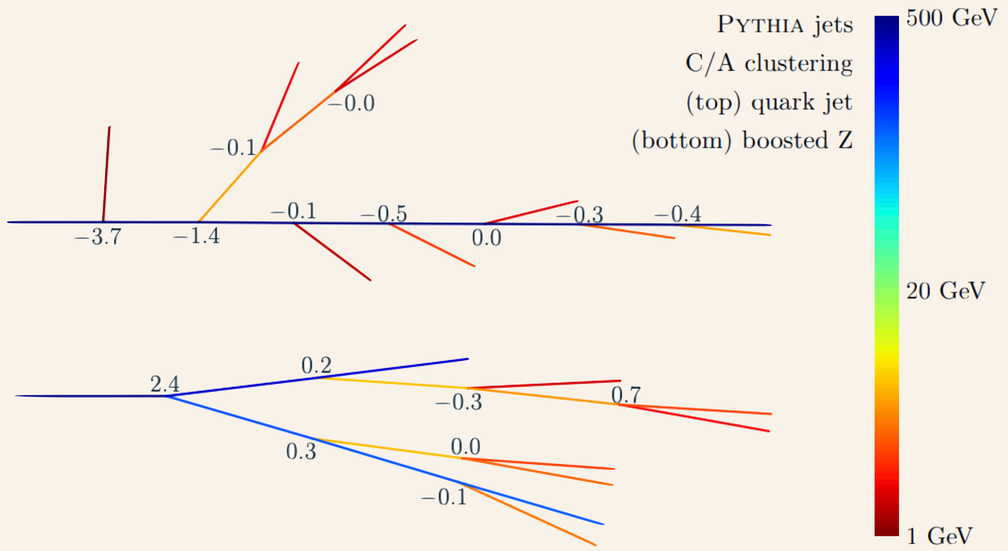
Particle decay reconstruction via GNN

E. Dreyer, E. Gross, D. Kobylianskii,
J. Lu, S. Liang, S. Lu

ML4Jets 2023

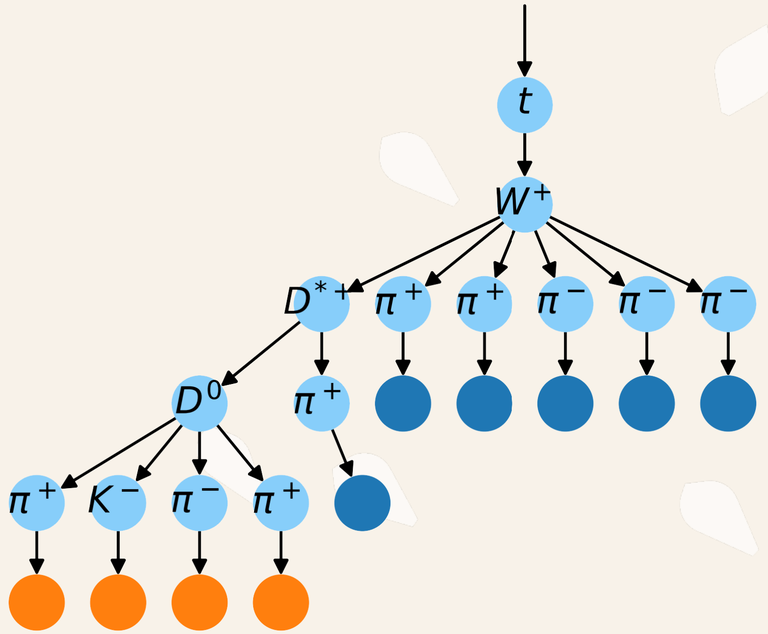
WEIZMANN INSTITUTE OF SCIENCE

Trees in HEP



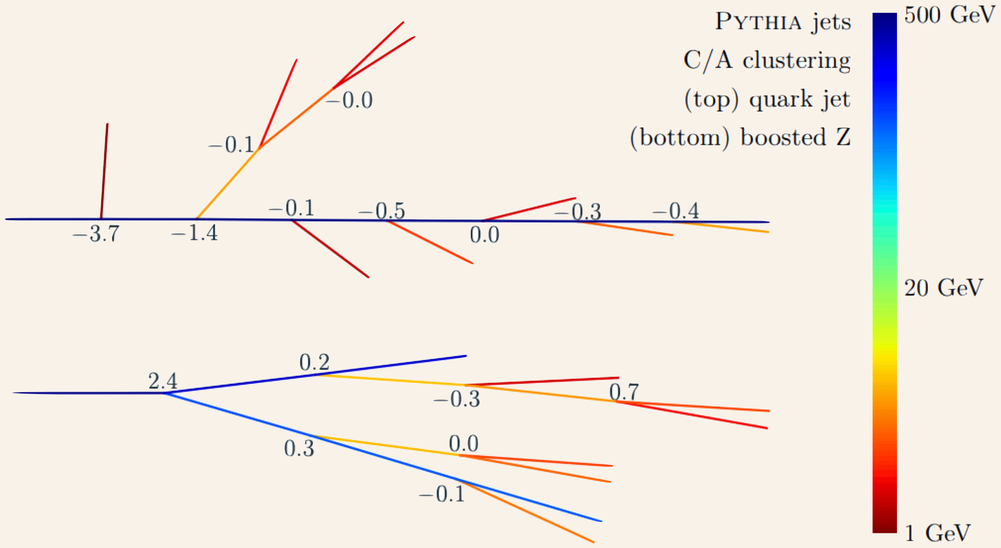
Jet clustering

(JUNIPR, arXiv:1804.09720)



$t\bar{t}$ decay tree

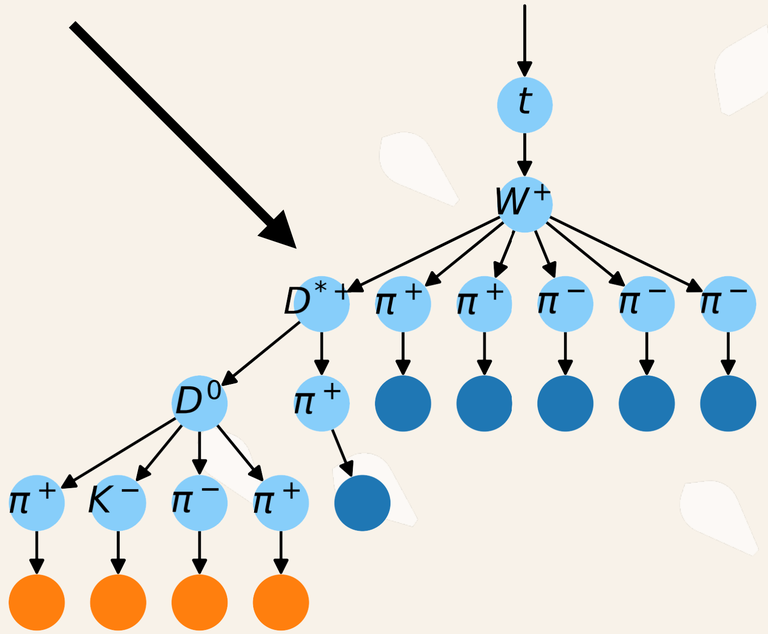
Trees in HEP



Jet clustering

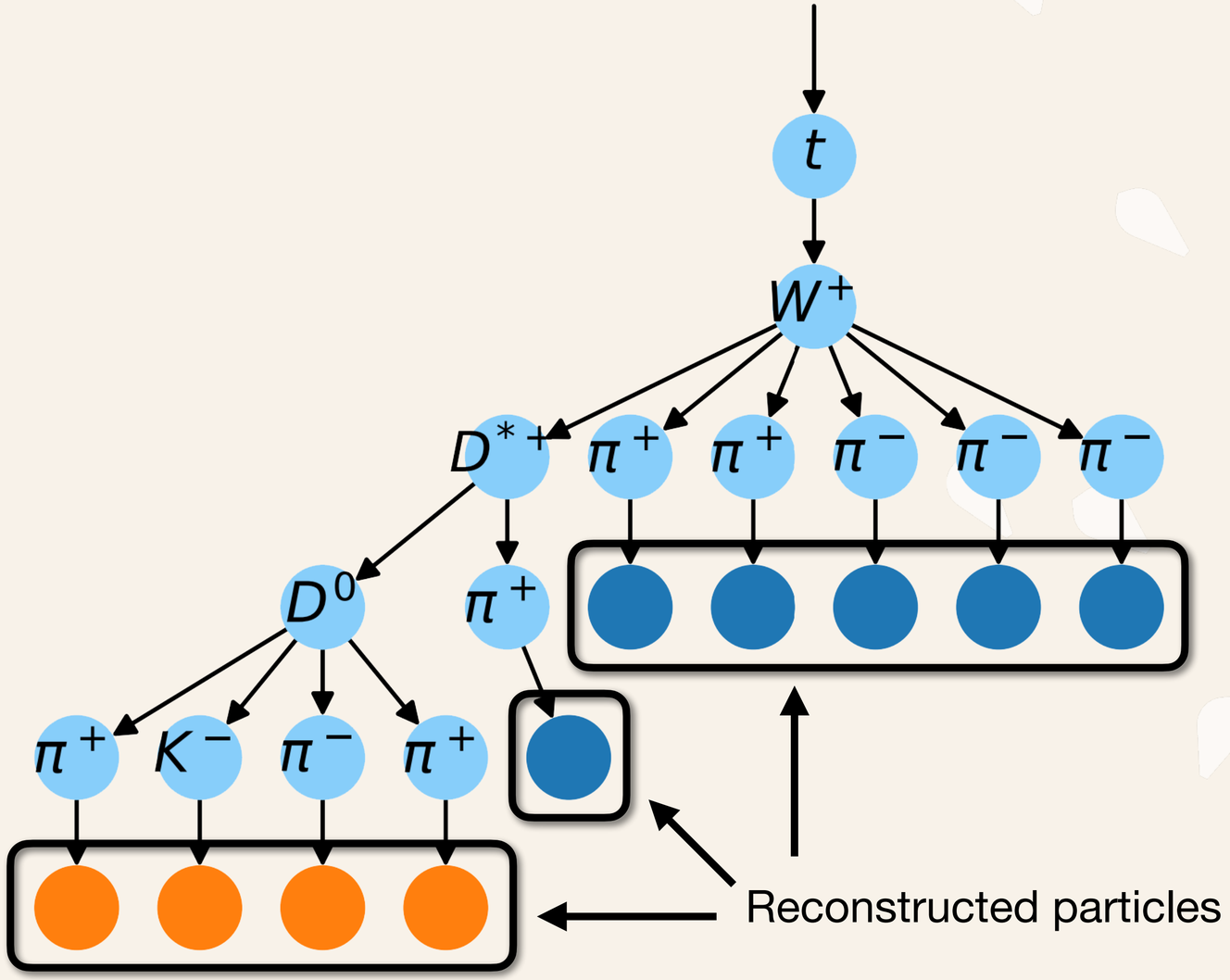
(JUNIPR, arXiv:1804.09720)

We will focus on this



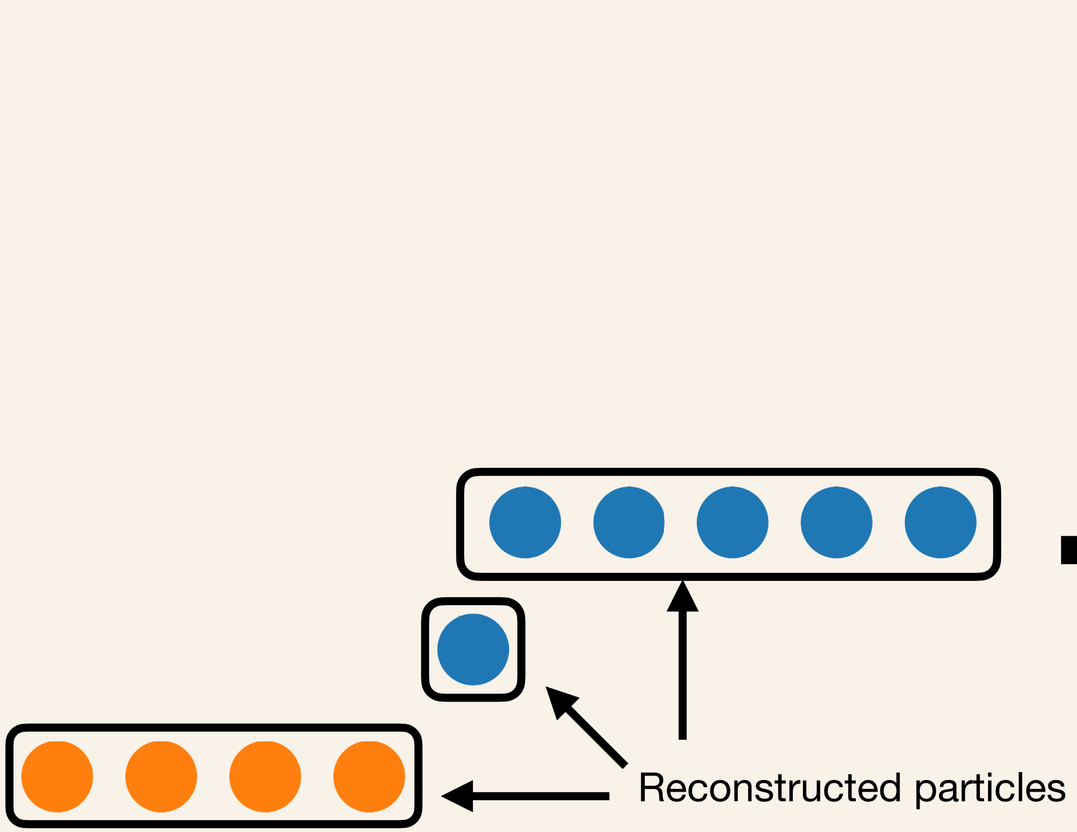
$t\bar{t}$ decay tree

Trees in HEP

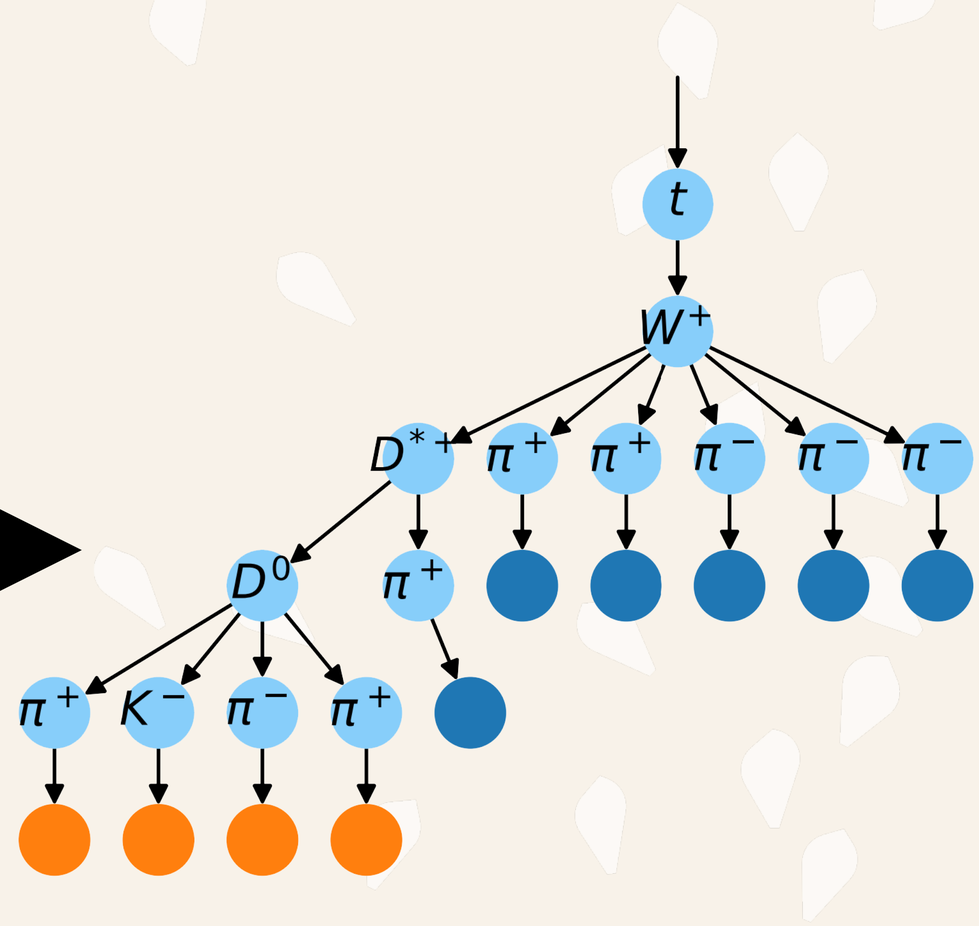


WEIZMANN INSTITUTE OF SCIENCE

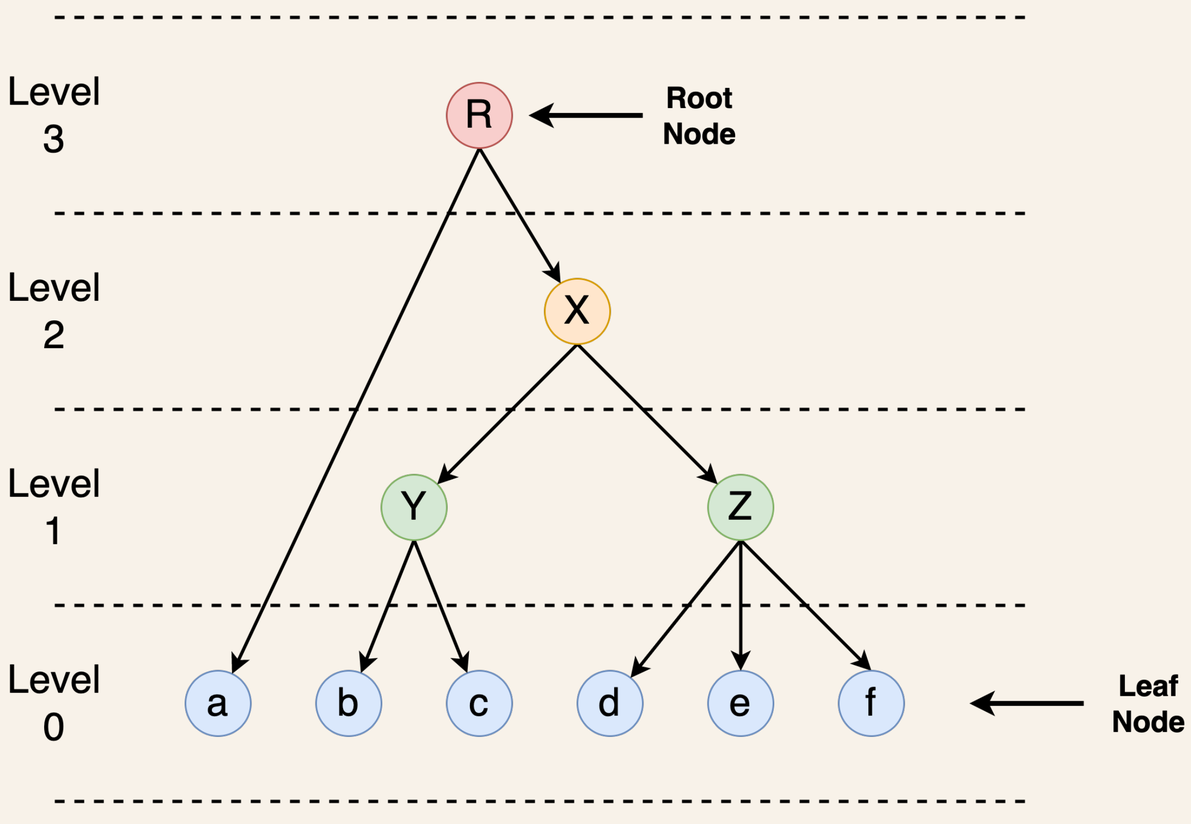
Our goal



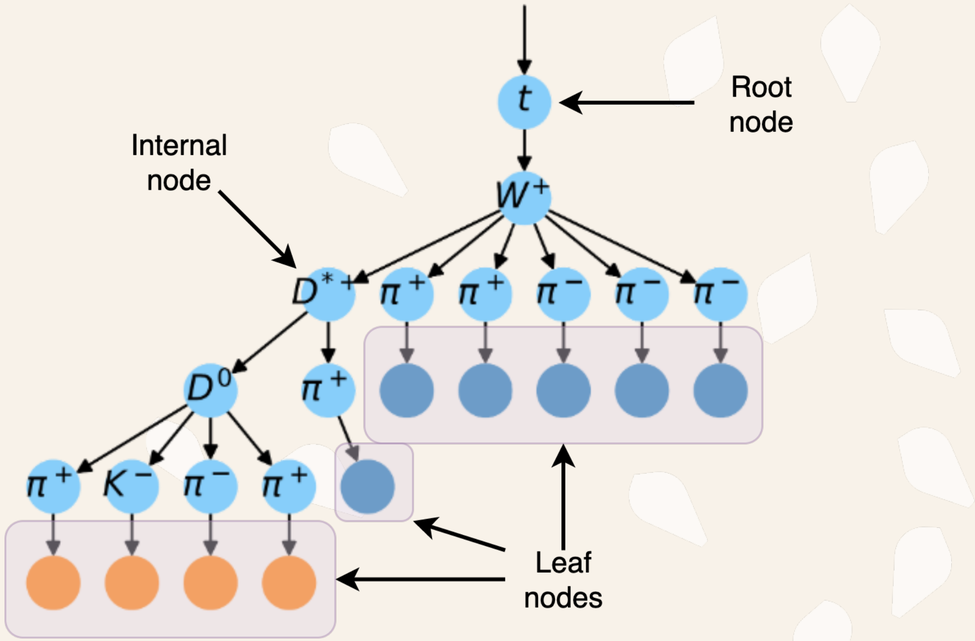
Produce!



Similarities with CS

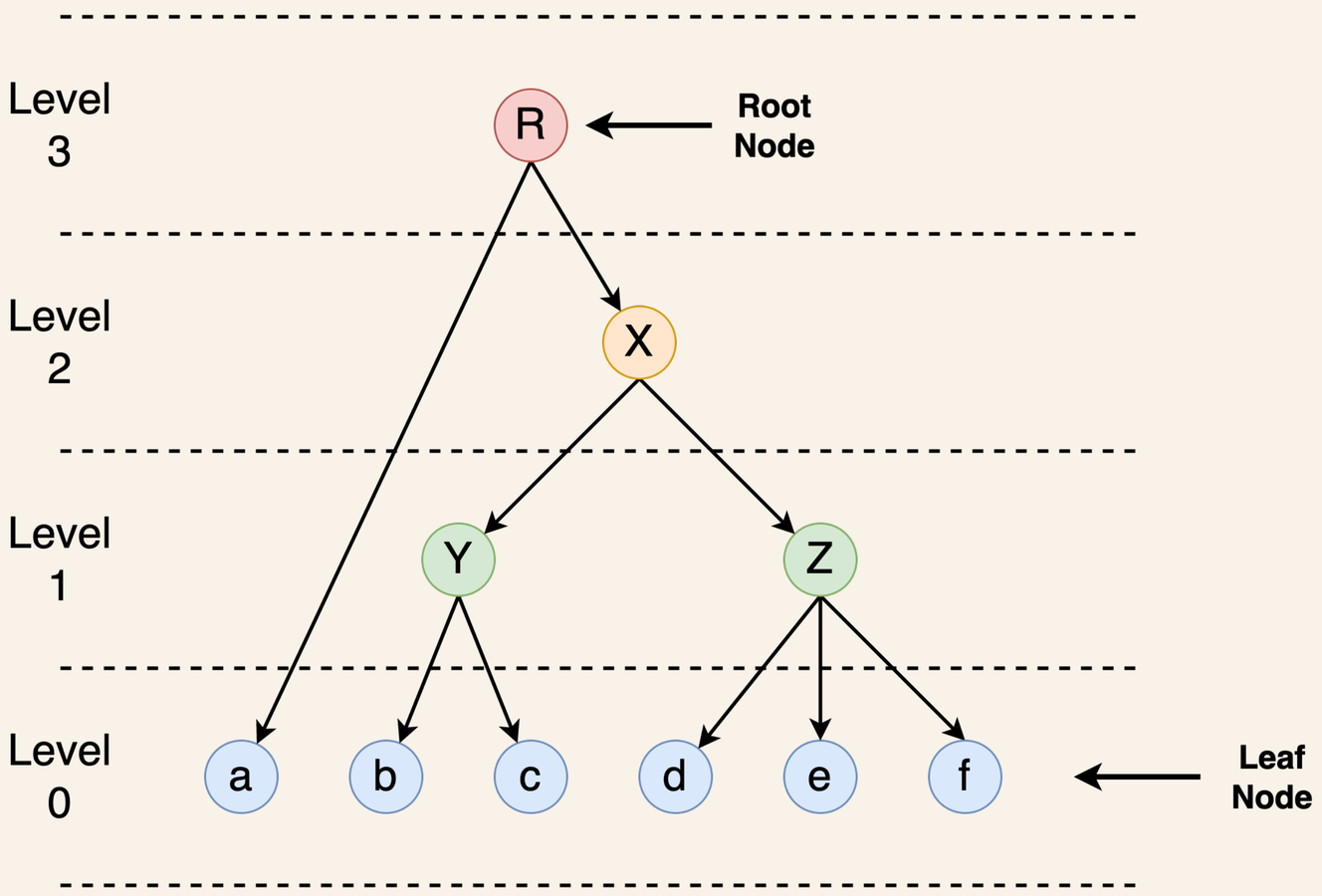


Tree (graph theory)



Tree (particle physics)

Nice representation

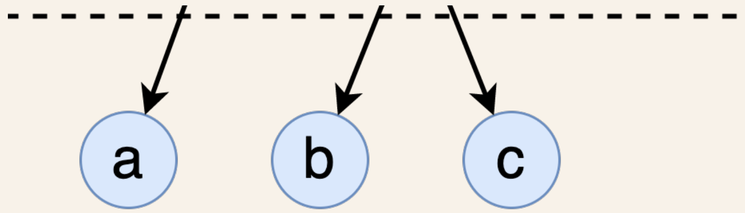


	a	b	c	d	e	f
a	0	3	3	3	3	3
b	3	0	1	2	2	2
c	3	1	0	2	2	2
d	3	2	2	0	1	1
e	3	2	2	1	0	1
f	3	2	2	1	1	0

LCAG

Learning Tree Structures from Leaves For Particle Decay Reconstruction, arXiv:2208.14924

Task reformulation

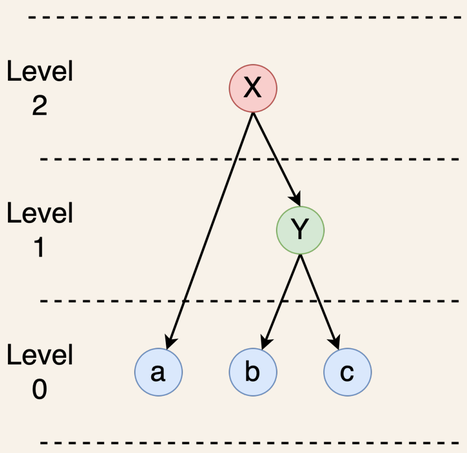


Leaf nodes

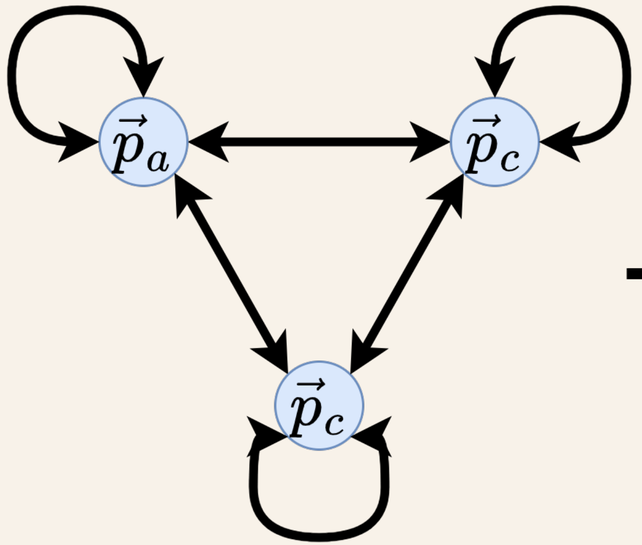
Produce!

	a	b	c
a	0	2	2
b	2	0	1
c	2	1	0

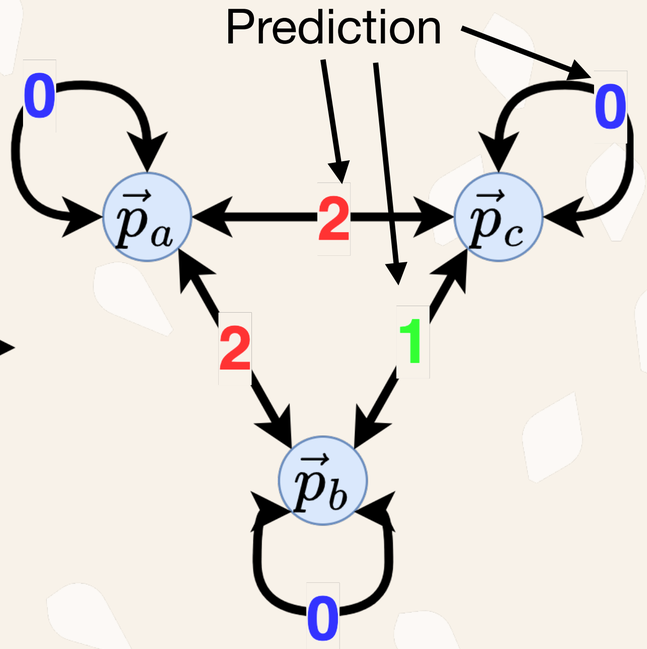
LCAG

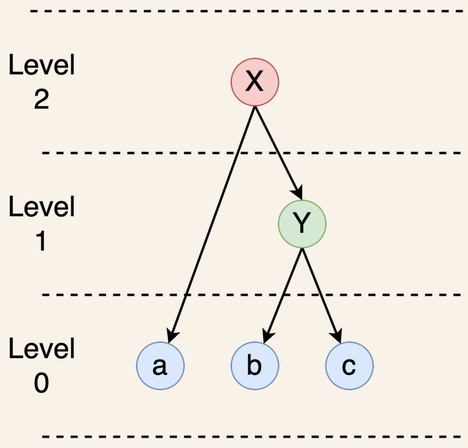


Solution



GNN





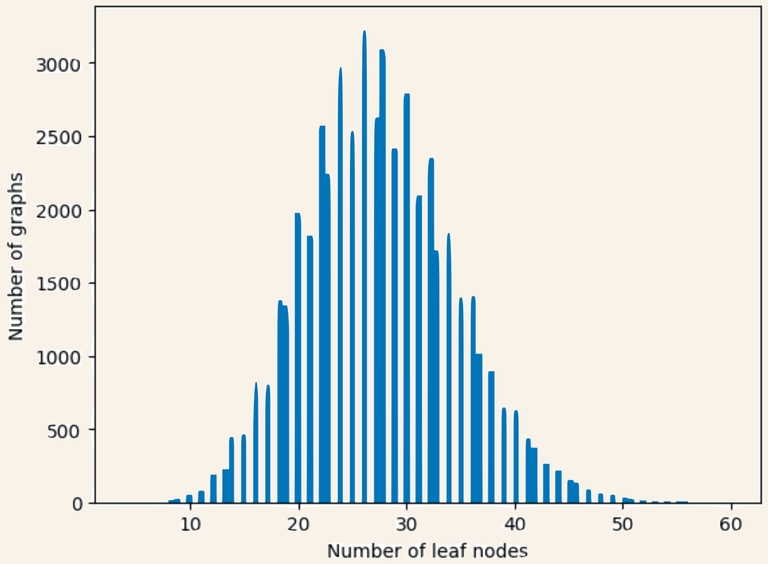
	a	b	c
a	0	2	2
b	2	0	1
c	2	1	0

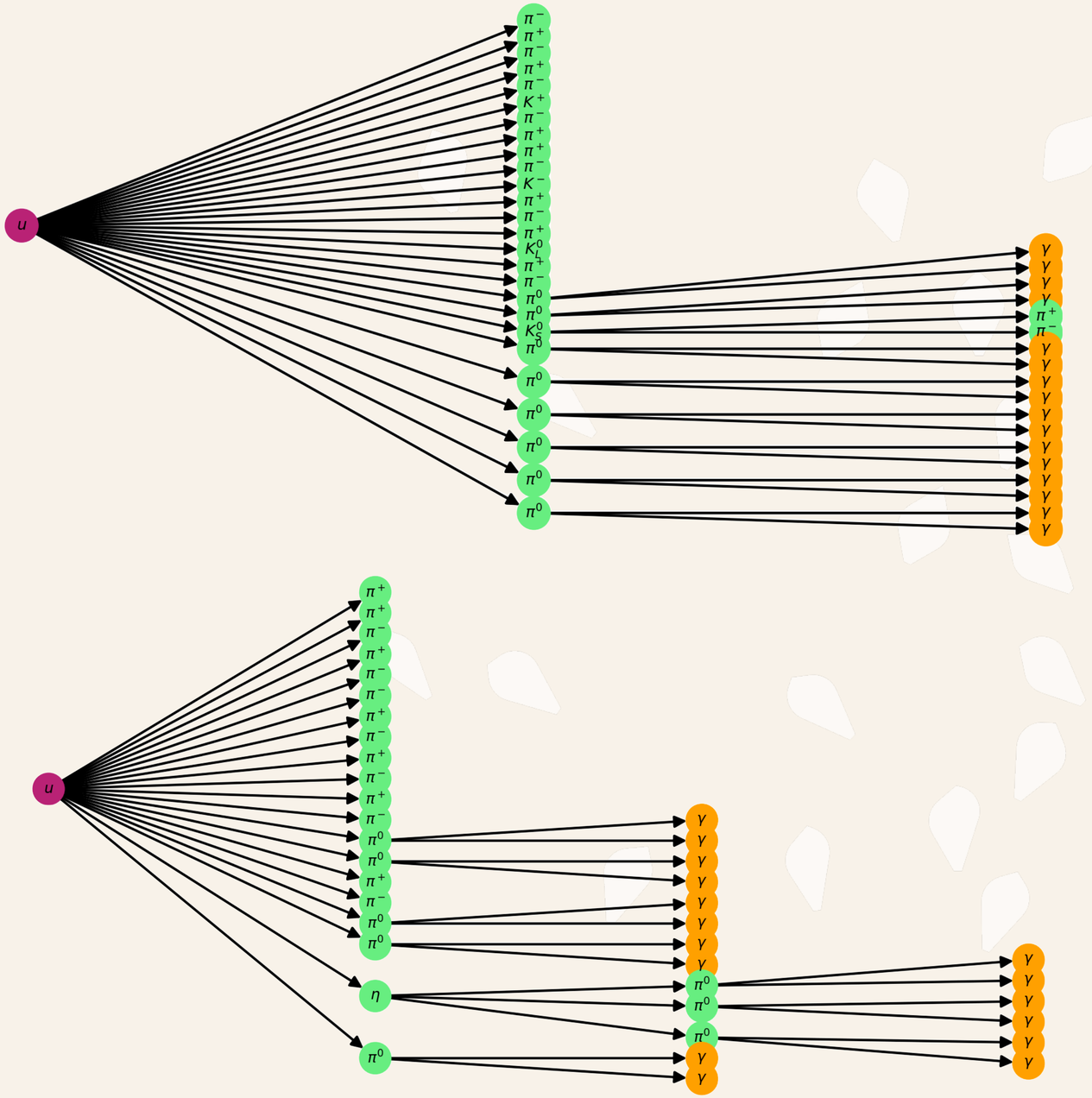
LCAG

WEIZMANN INSTITUTE OF SCIENCE

Dataset

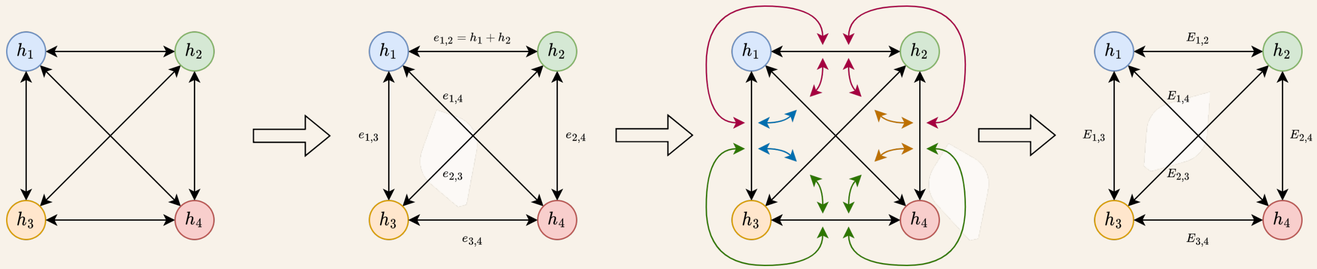
- Pythia 8 simulation
- u-quark decay
- 800k events
- m, p_T, η, ϕ as input features

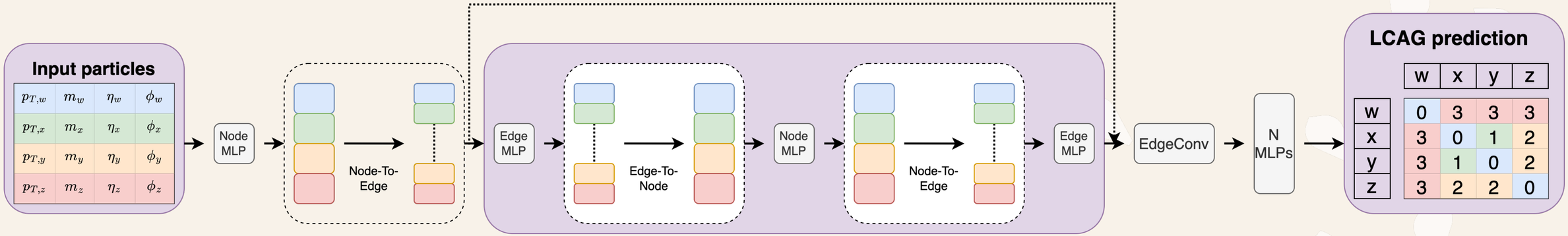




Architecture

- NRI architecture as a foundation;
- Improved by EdgeConv and factorized final MLP

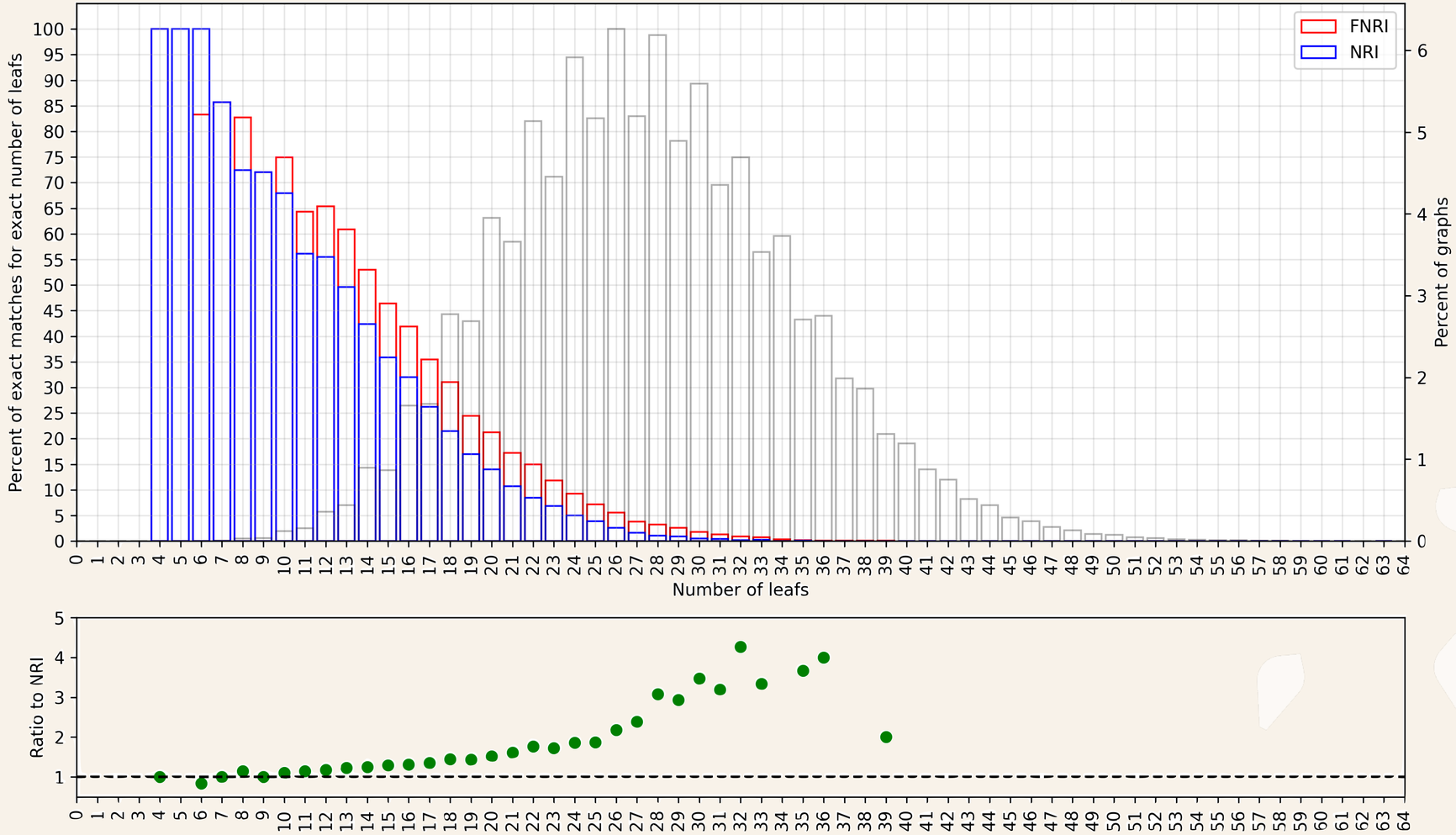




Learning Tree Structures from Leaves For Particle Decay Reconstruction, arXiv:2208.14924

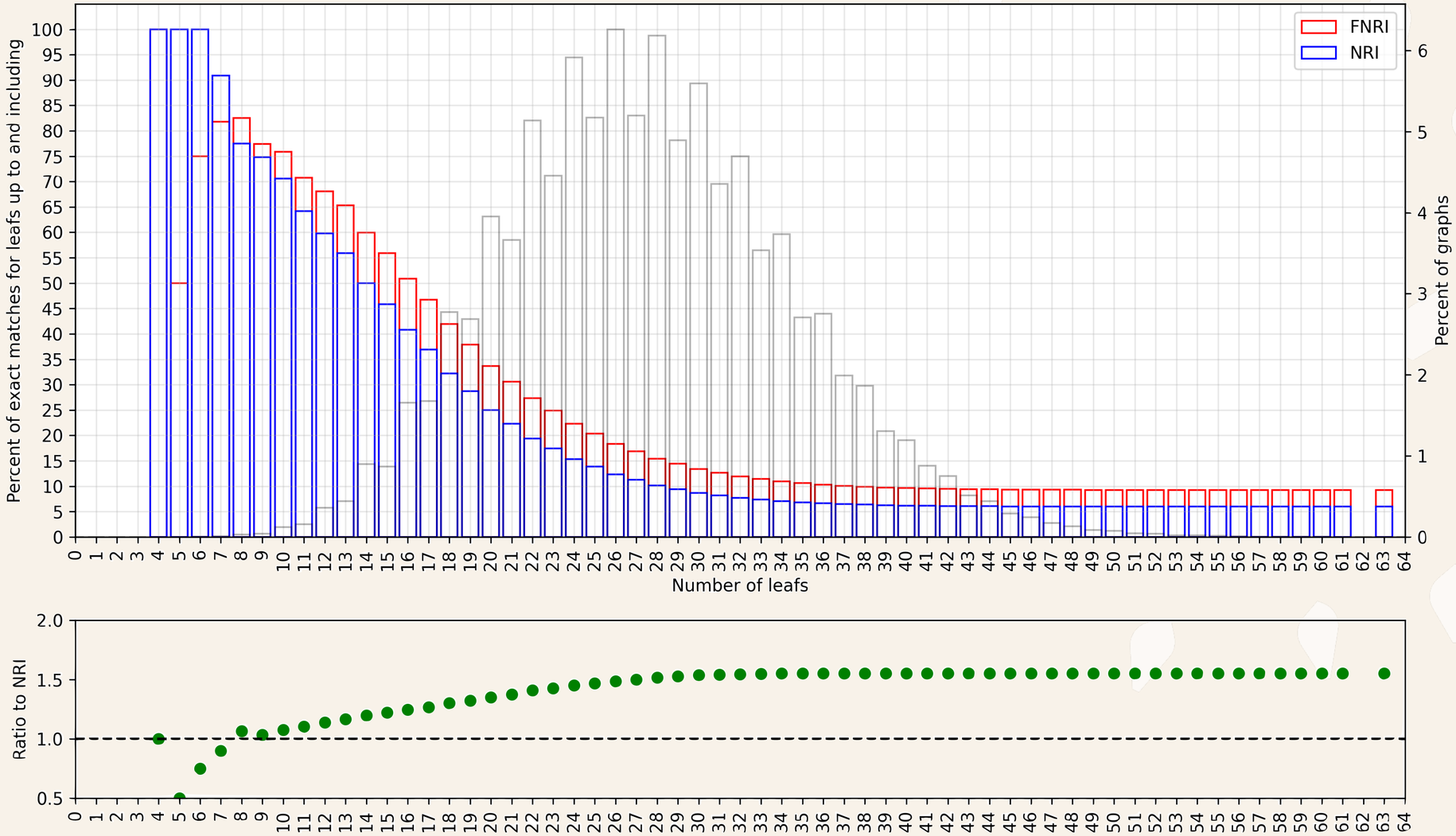
WEIZMANN INSTITUTE OF SCIENCE

Results: % of exact matches for n leafs



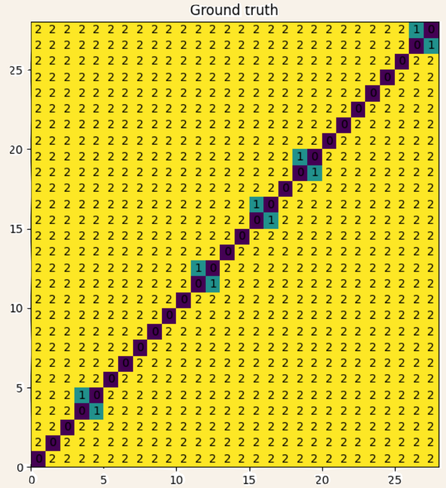
WEIZMANN INSTITUTE OF SCIENCE

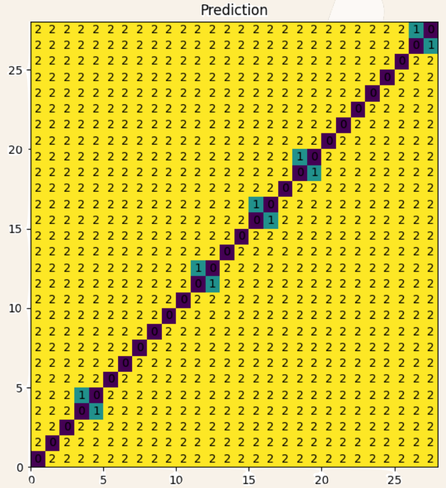
Results: % of exact matches for leafs up to and including

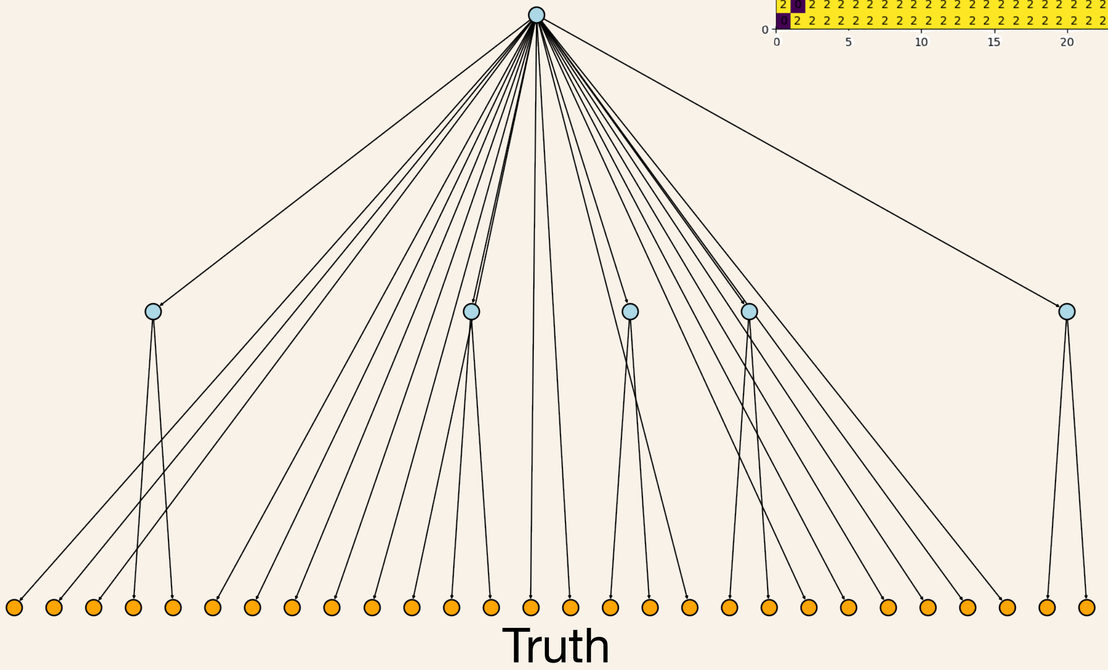


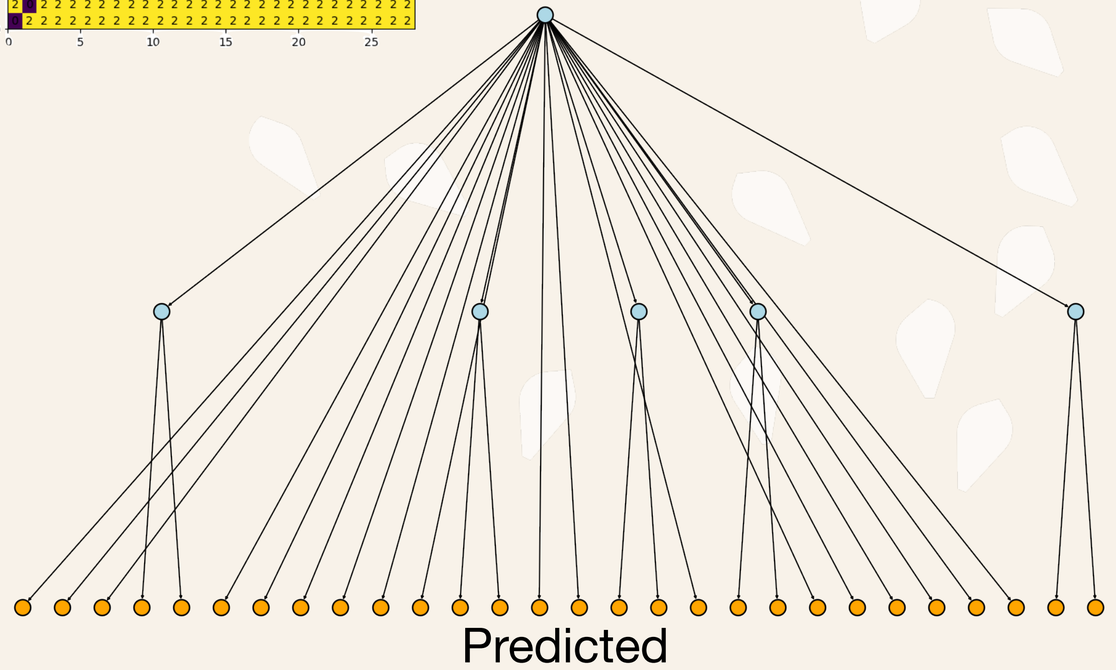
WEIZMANN INSTITUTE OF SCIENCE

Results: Good example



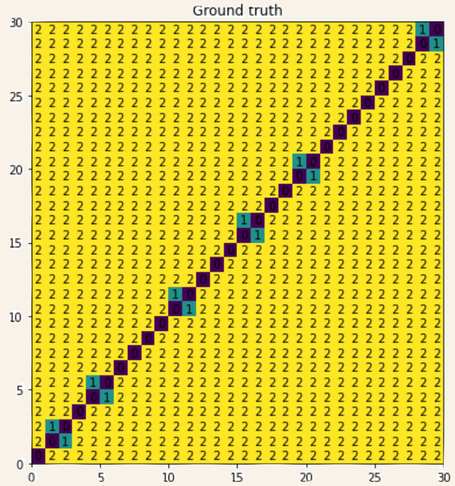


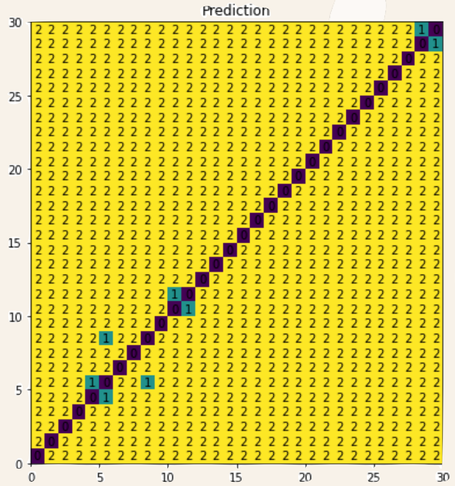


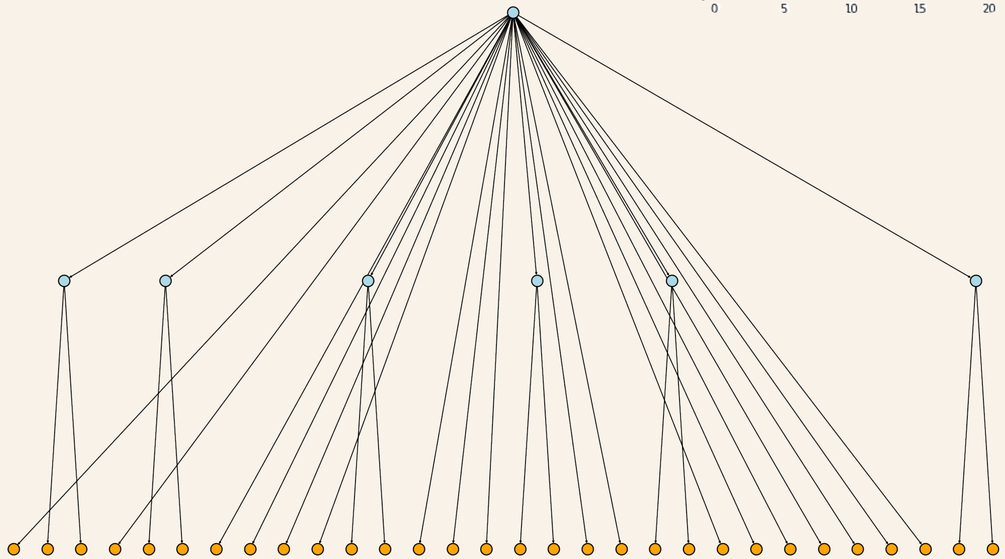


WEIZMANN INSTITUTE OF SCIENCE

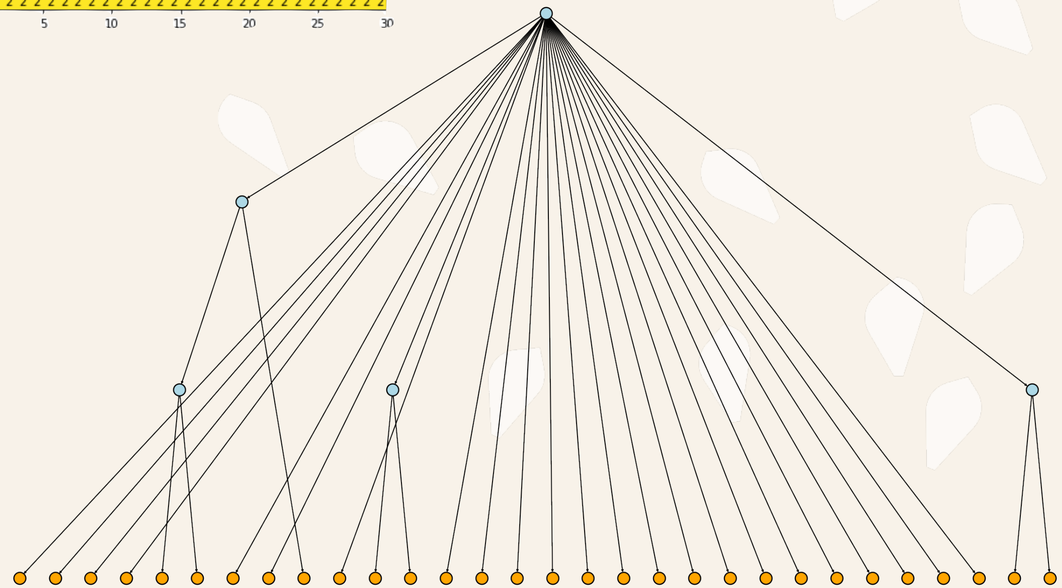
Results: Mistake example







Truth



Predicted

Summary

- Particle decay reconstruction can be solved for low number of leaf nodes. But this is left tail of distribution.
- Proposed model shows better performance than baseline in both metrics.
- `Exact` match metric is not good enough, need to invent another.