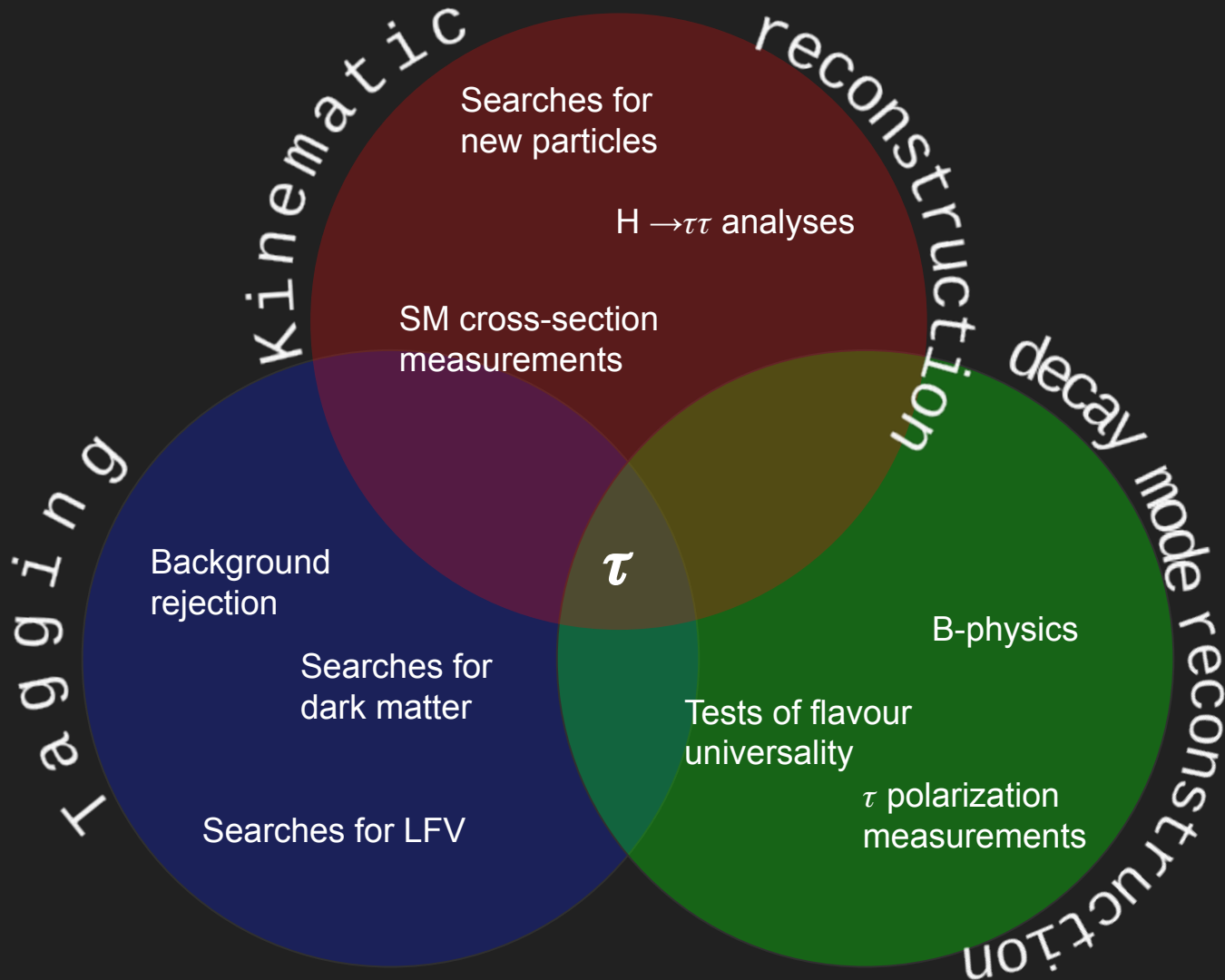


FUTURE
CIRCULAR
COLLIDER

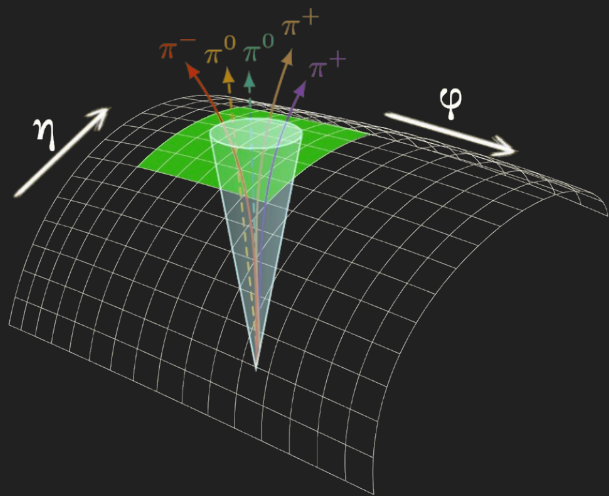
ML based τ_h reconstruction & identification

Laurits Tani

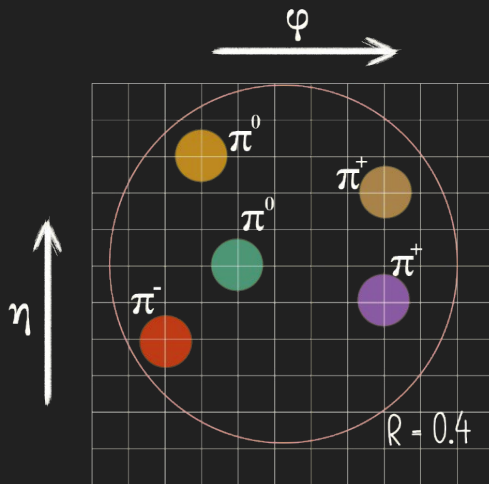
16. January 2025



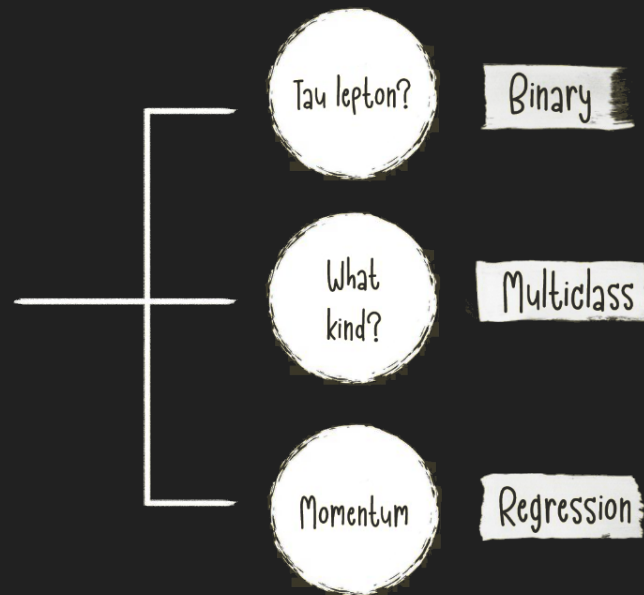
Idea



Jet Reconstruction



Machine Learning



FUTURE DATASET

dataset with full detector simulation for the development and training of τ_h identification and reconstruction algorithms.



UNOFFICIAL

CLICdet setup [CLICdb Collaboration](#)

Pythia8 [Christian Bierlich et al.](#)

Geant4 [Geant4 Collaboration](#)

Marlin reconstruction [Gaede et. al](#)

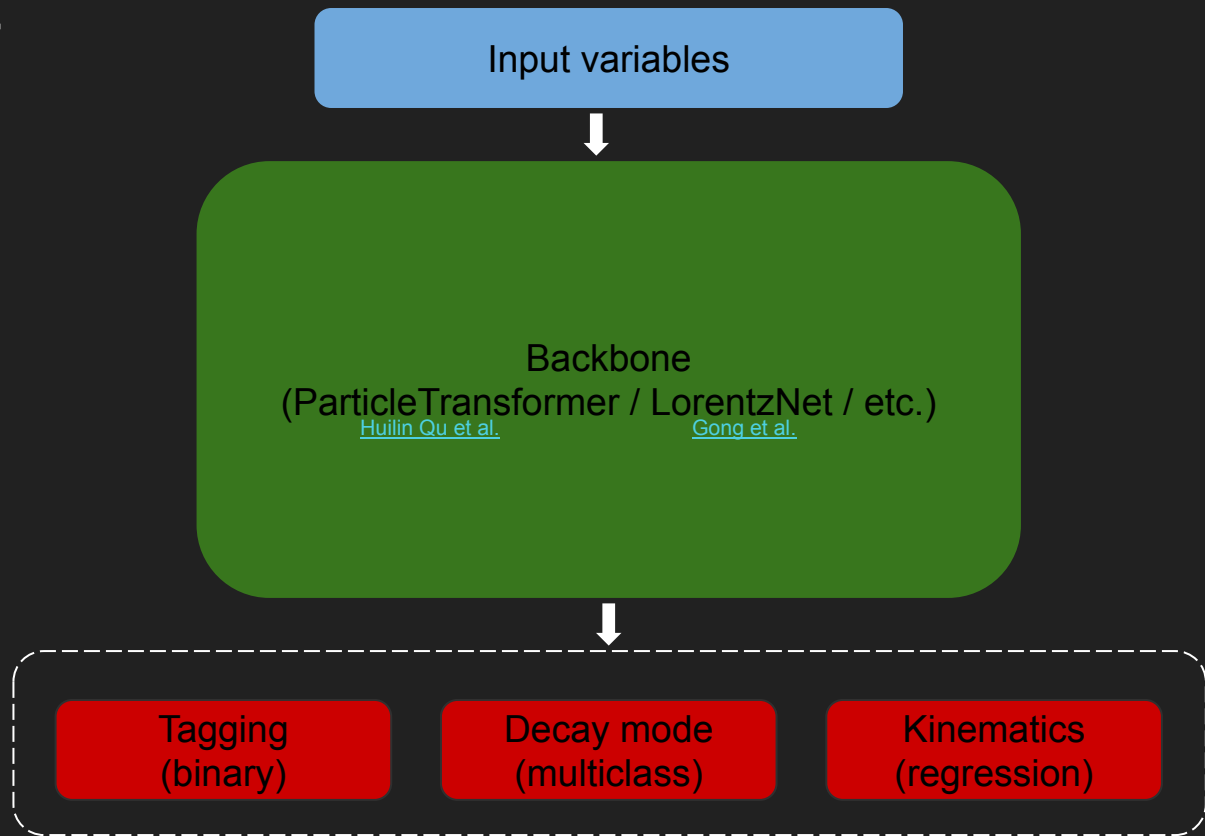
PandoraPF [Marshall et al.](#)

Key4HEP software [Gerardo Ganis et al.](#)

EDM4HEP format [Gaede et al.](#)

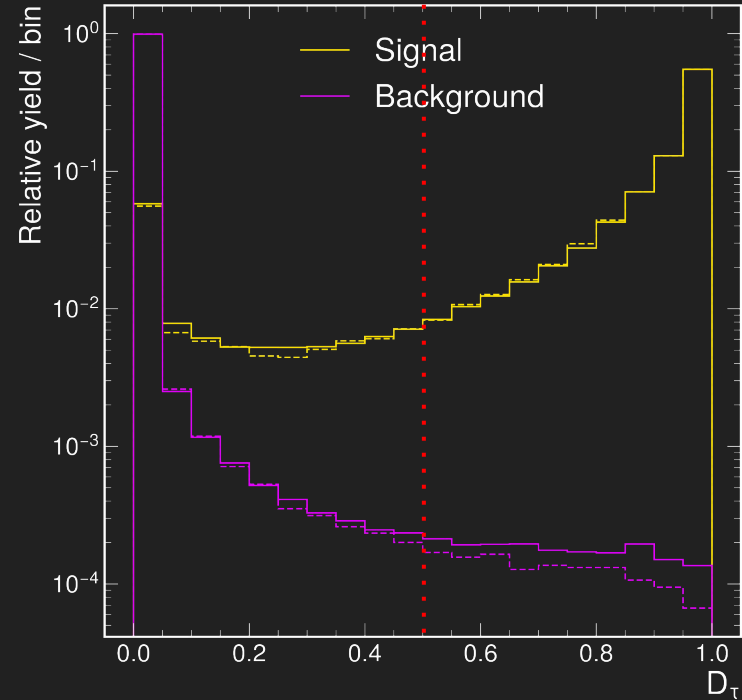
Why end-to-end ML

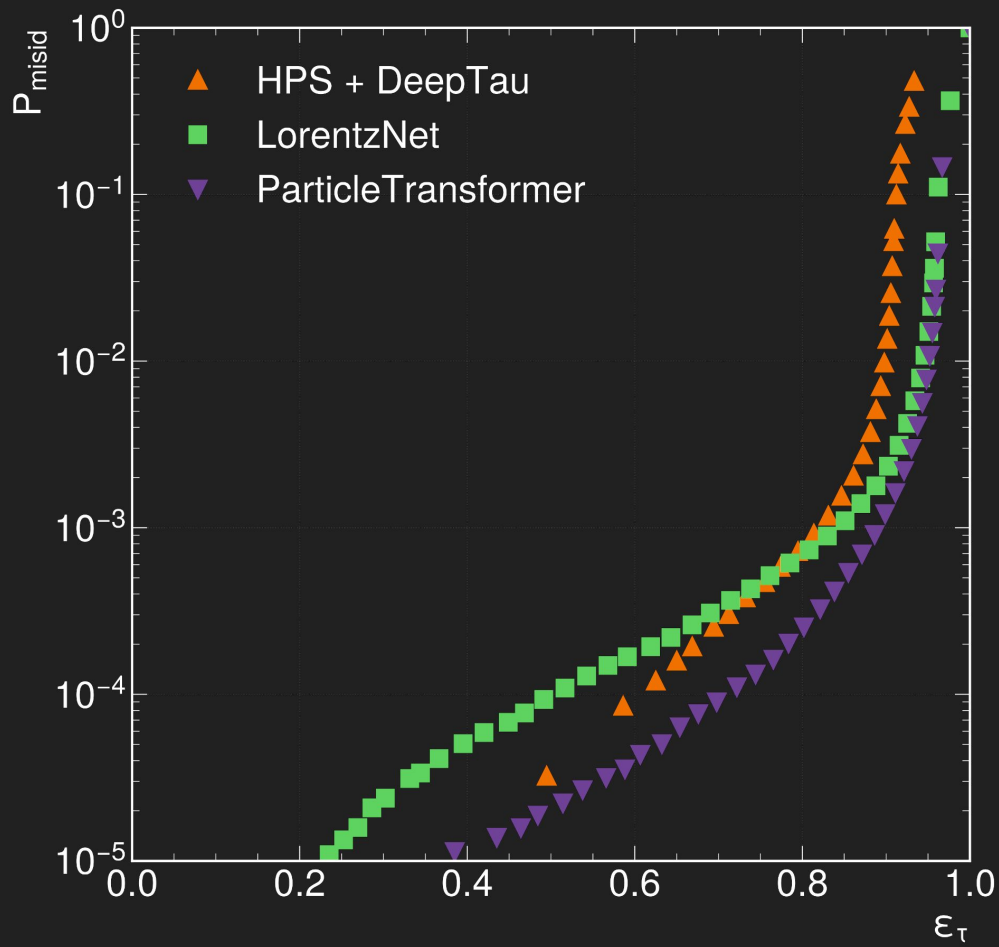
- ✓ Very flexible for retrainings
- ✓ Easier to optimize
- ✓ No need for handcrafted rules
- ✓ Accelerator friendly
- ✗ Needs a lot of labeled data (*)



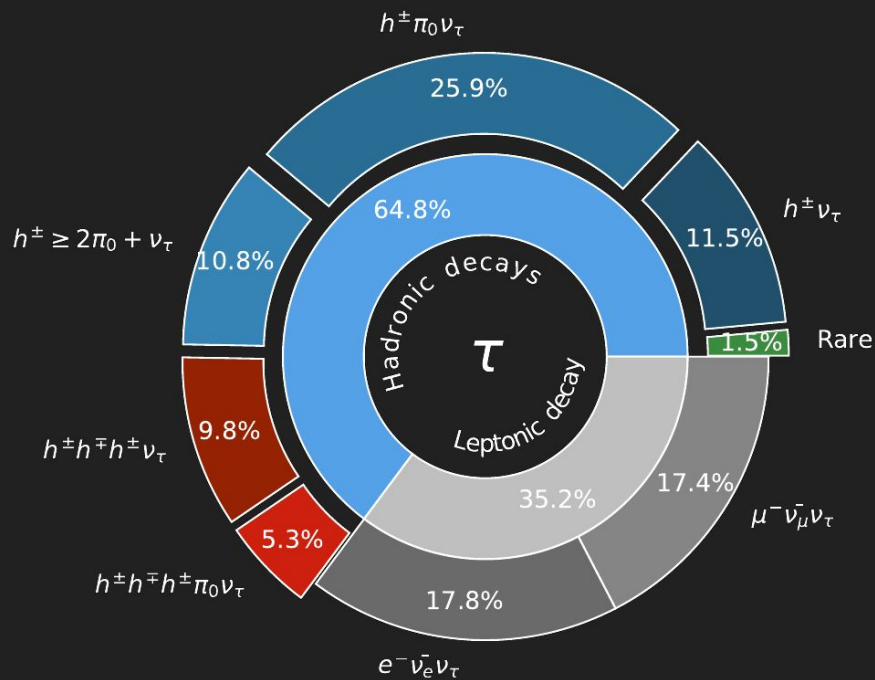
τ -tagging [binary classification]

- Recognize jets originating from hadronically decaying τ -leptons:
 - Signal: $Z \rightarrow \tau\tau$
 - Background: $Z \rightarrow qq$

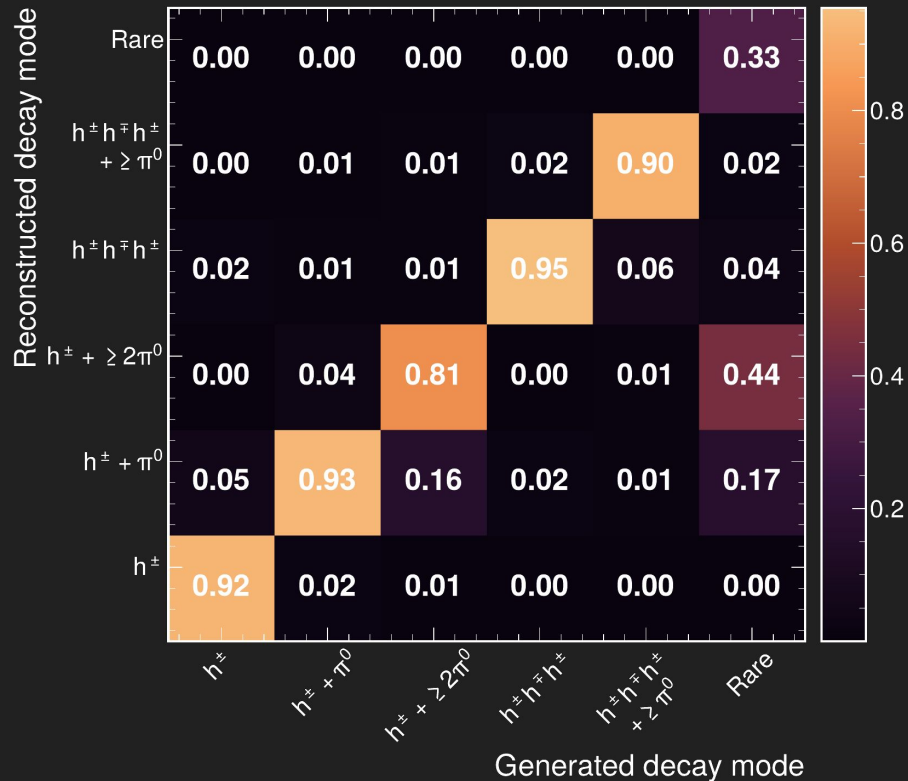


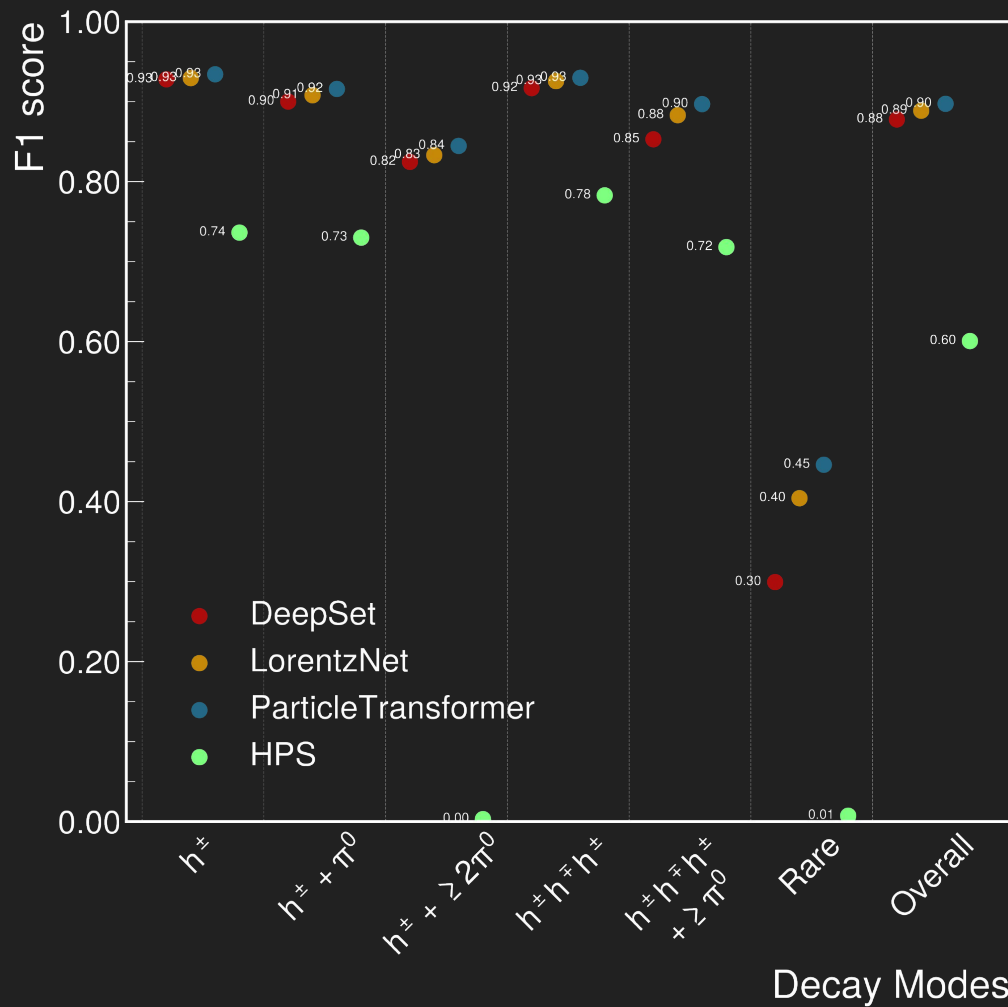


Decay mode reconstruction [multiclass classification]



ZH Confusion Matrix

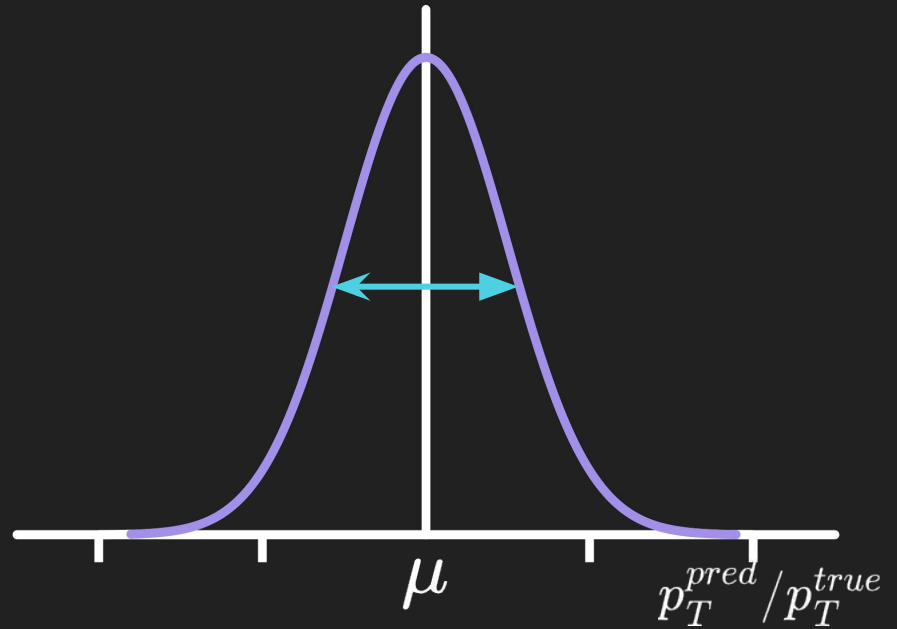


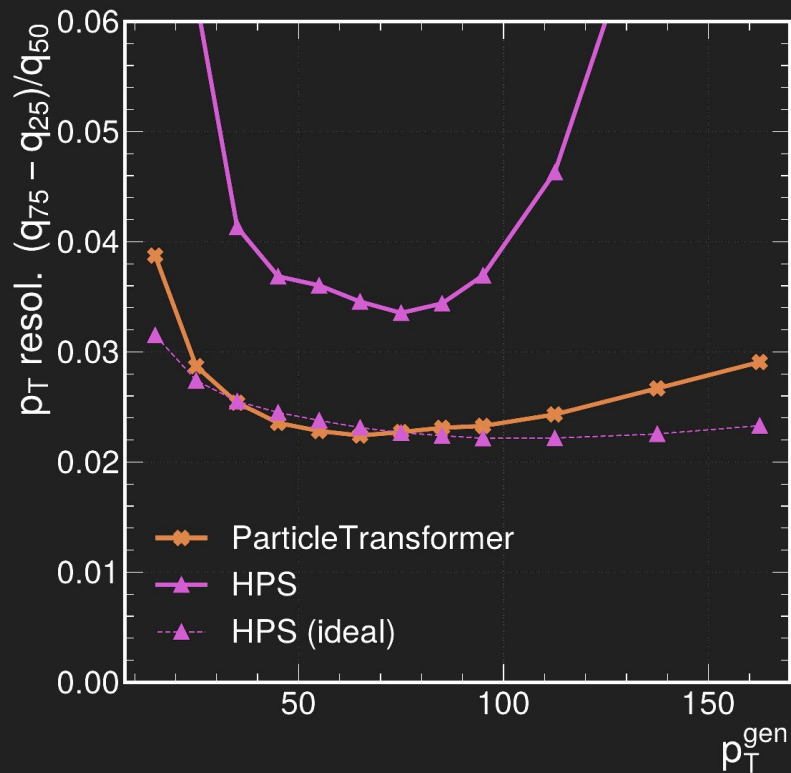
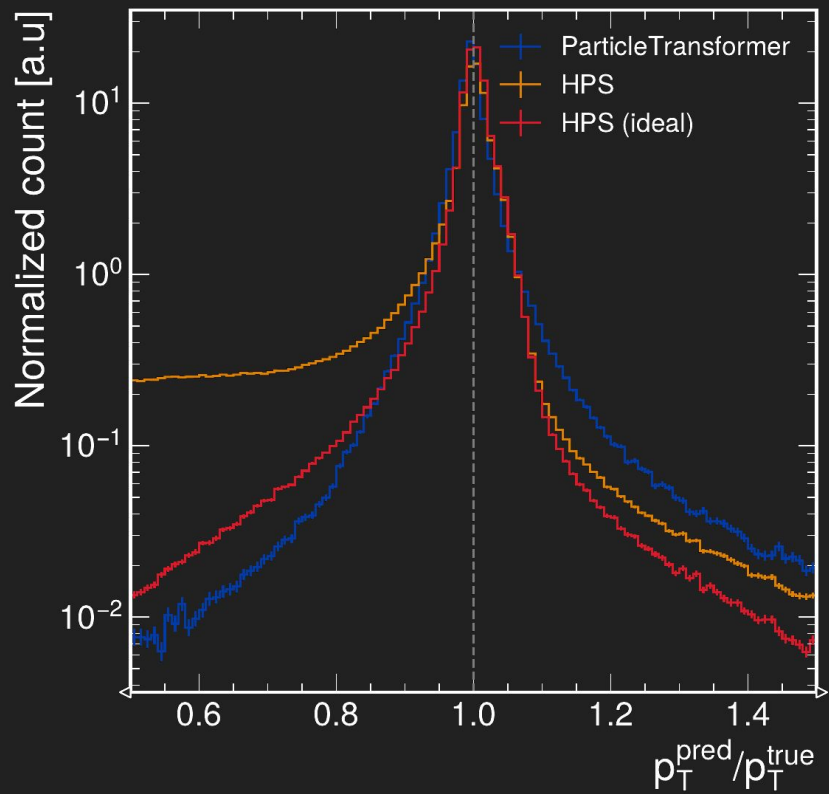


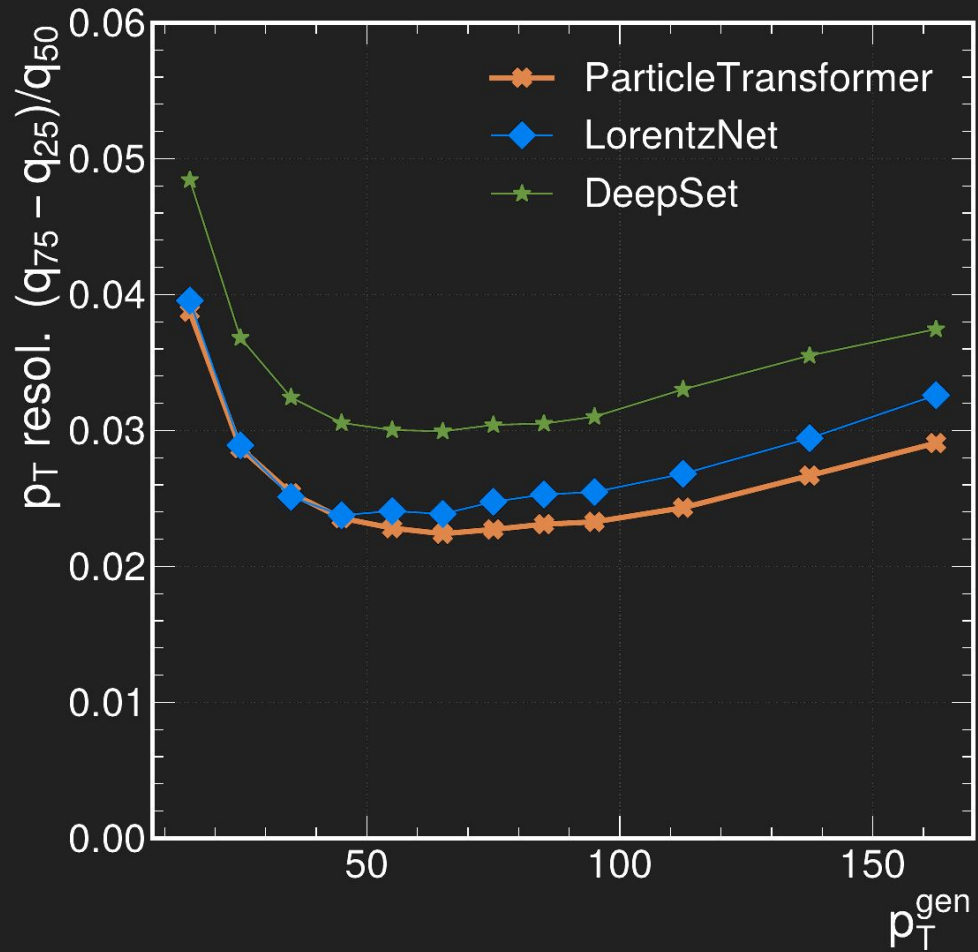
Decay Modes

Kinematic reconstruction [regression]

- Predict tau p_T
- Measures of interest:
 - scale/response: μ
 - resolution: $IQR = \frac{q_{75} - q_{25}}{q_{50}}$







Conclusions

OPEN TO COLLABORATION

- Created a new full-sim dataset for studying τ_h reconstruction and identification at future colliders
- Studied the performance of novel ML architectures for τ_h identification, decay mode classification and kinematic reconstruction
- E2E ML outperforms current state-of-the-art methods in all scenarios

Fin

References

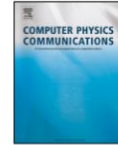
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- L. Tani et al. “A unified machine learning approach for reconstructing hadronically decaying tau leptons”. In: Comput. Phys. Commun. 307 (2025), p. 109399. doi: [10.1016/j.cpc.2024.109399](https://doi.org/10.1016/j.cpc.2024.109399). arXiv: [2407.06788](https://arxiv.org/abs/2407.06788) [hep-ex]
- L. Tani et al., Future - dataset for studies, development, and training of algorithms for reconstructing and identifying hadronically decaying tau leptons. [Online]. Available: <https://doi.org/10.5281/zenodo.12664634>



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Computational Physics

Tau lepton identification and reconstruction: A new frontier for jet-tagging ML algorithms [☆]

Torben Lange, Saswati Nandan, Joosep Pata, Laurits Tani ^{*}, Christian Veelken

National Institute of Chemical Physics and Biophysics (NICPB), R avala pst 10, 10143 Tallinn, Estonia



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journal homepage: www.elsevier.com/locate/cpc



Computational Physics

A unified machine learning approach for reconstructing hadronically decaying tau leptons [☆]

Laurits Tani ^{a,*}, Nalong-Norman Seeba ^a, Hardi Vanaveski ^{a,b}, Joosep Pata ^a, Torben Lange ^a

^a *National Institute Of Chemical Physics And Biophysics (NICPB), R avala pst. 10, 10143 Tallinn, Estonia*

^b *Tallinn University of Technology (TalTech), Ehitejate tee 5, 19086 Tallinn, Estonia*



Backup

FUTURE DATASET V.2

$Z \rightarrow \tau\tau$

4.35M jets
0.9 GB

$ZH, H \rightarrow \tau\tau$

5.34M jets
1 GB

$Z \rightarrow qq$

31.83M jets
7 GB

- Full detector simulation: Geant4
- CLIC like detector (CLICdet) setup
- Event reconstruction: Marlin reconstruction
- ParticleFlow candidates: PandoraPF
- Jet clustering: generalized k_t algorithm for ee ($p = -1; \Delta R = 0.4$)
- No $\gamma\gamma \rightarrow$ hadrons overlay

