

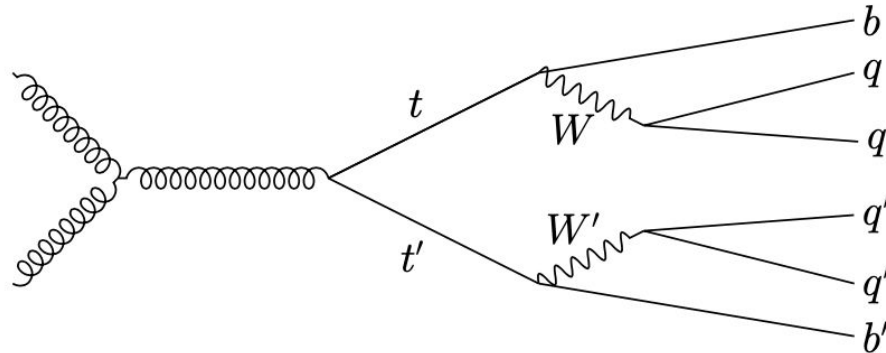
Top Quark Final States Reconstruction with SPANet

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SPANet

- Symmetry-Preserving Attention Networks
- Find assignments without evaluating all possible permutations
- Current permutation-based methods are severely computationally limited for higher luminosity upgrades coming to LHC
- SPANet improves partial event reconstruction



- Source: <https://arxiv.org/abs/2010.09206>

SPANet

- First paper: <https://arxiv.org/abs/2010.09206>
- Second paper (generalized): <https://arxiv.org/abs/2106.03898>
- Generalized SPANet opens up many topologies to study

Project

- I am training networks on several topologies, evaluating and analyzing their performance, and making currently intractable topologies tractable with SPANet
- Topologies:
 - $t t'$
 - $t t' b b'$
 - $t t' z$
 - $t t' H$
 - 4 top

SPANet Input

- Develop code infrastructure for several topologies for input data for SPANet
- Truth-matching assignments with

$$\sqrt{\Delta\eta^2 + \Delta\phi^2} < 0.4$$

- SPANet is given a description of the topology, so it knows what particles and features (pt, eta, phi, etc.) will be given
- Symmetries between particles and jets
- Symmetries between jets
- B-tag WPs
- leptag for leptonic decays

```
[SOURCE]
FEATURE_1 = FEATURE_OPTION
FEATURE_2 = FEATURE_OPTION
FEATURE_3 = FEATURE_OPTION
...

[EVENT]
particles = (PARTICLE_1, PARTICLE_2, ...)
permutations = EVENT_SYMMETRY_GROUP

[PARTICLE_1]
jets = (JET_1, JET_2, ...)
permutations = JET_SYMMETRY_GROUP

[PARTICLE_2]
jets = (JET_1, JET_2, ...)
permutations = JET_SYMMETRY_GROUP

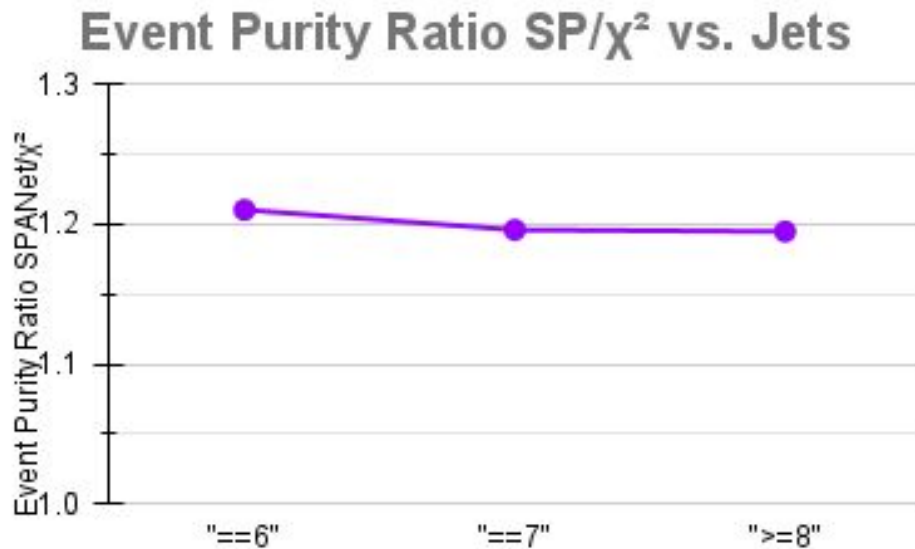
...
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Performance

- Train and evaluate on partial events
- Event Purity: fraction of correctly reconstructed events
- After training, networks predict the assignments and outputs them to be analyzed

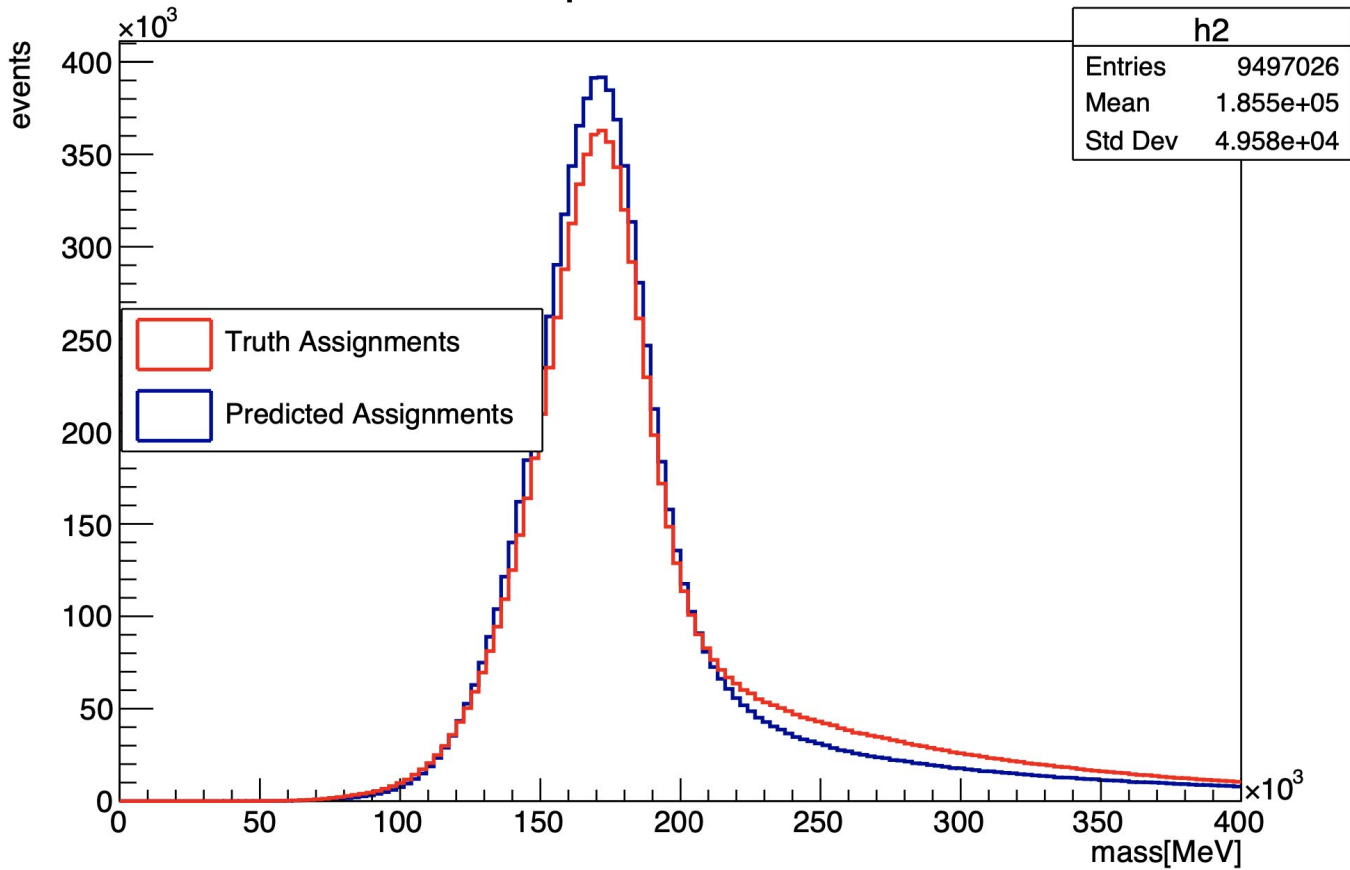
t t'

- All-hadronic channel
- Symmetries
- Performance will compare to the χ^2 minimisation performance described in the SPANet paper: <https://arxiv.org/abs/2106.03898>
- 0.06-0.1 increase in event purity
- Event Purity Ratio – SPANet is consistently performing better than χ^2 , ~20% increase



t t'

Reco Top Quark Invar Mass



Obstacles

- CUDA Driver on the HPC I work on is incompatible with SPANet's PyTorch version
- The Monte Carlo data I was receiving was delayed due to some complications with the truth-matching information

Future Work

- Train and Evaluate networks on more topologies
- Build a trigger using SPANet to improve data acquisition
 - Less computational cost and fast network inference

Conclusion

- SPANet outperforms permutation-based assignment techniques on most topologies that quickly become computationally limited at higher jet-mi
- SPANet can make previously intractable topologies tractable
- SPANet's evaluation time per event may allow for the creation of an improved trigger

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