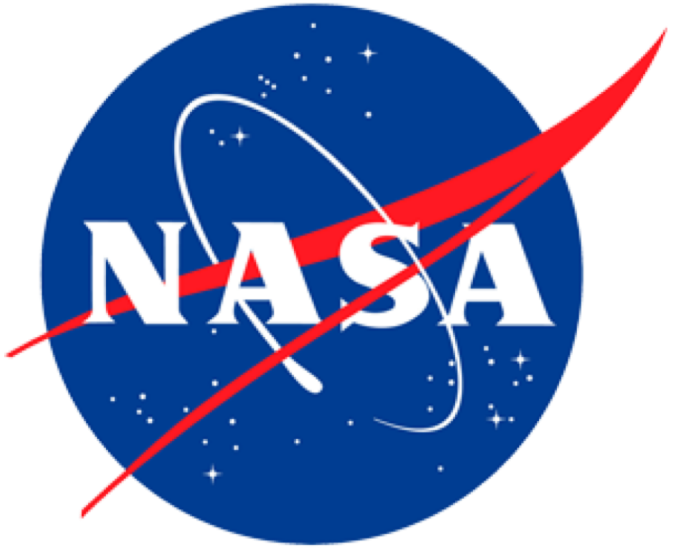

Machine Learning in High Energy Physics: the Search for Vector-Like Quarks

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Dr. Erich Varnes UA High Energy Physics Group, ATLAS Experiment

April 14, 2018 | NASA Space Grant Symposium | Tucson, AZ

Terminology

Vector-Like Quarks (VLQ)

- Predicted particle in many new physics theories

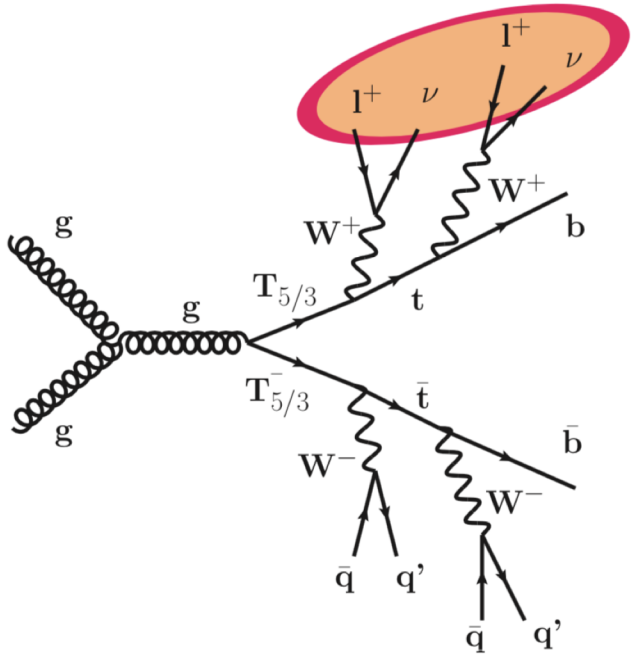


Fig 1: Feynman diagram of VLQ pair production

Machine Learning

- Algorithmic “learning” from patterns and structures within datasets

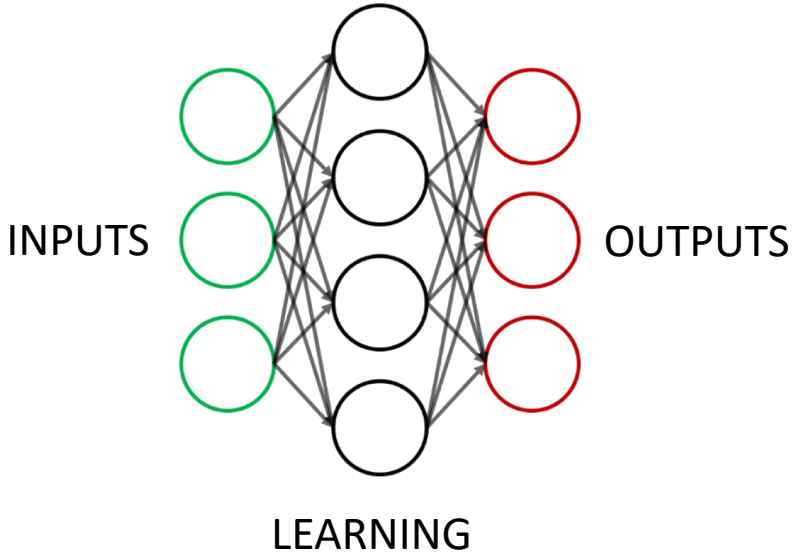


Fig 2: Neural Network learning model

Background:
Searching for Particles

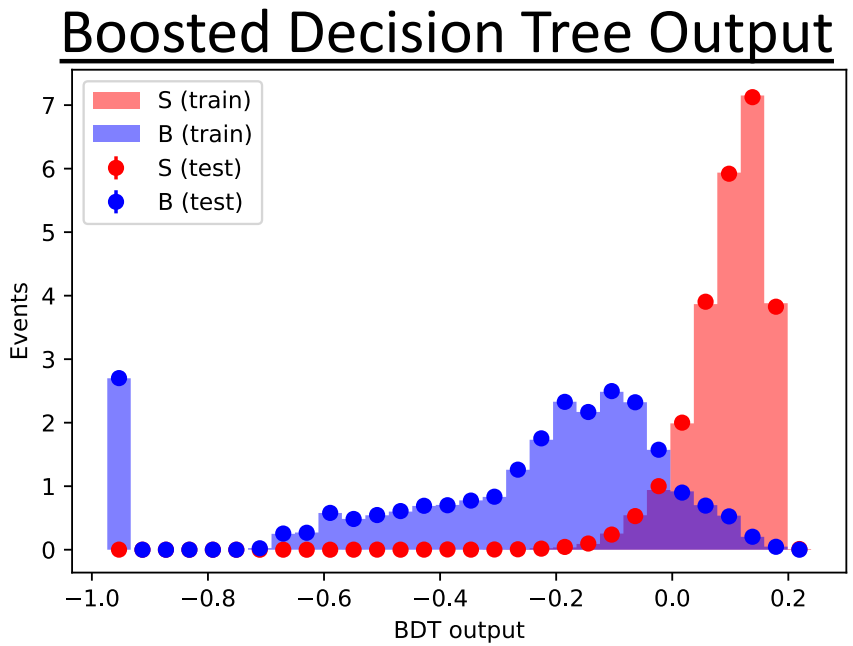
The ATLAS Detector *at the* Large Hadron Collider

1 billion collisions(events)/sec → 200 interesting events/sec

Source: ATLAS Outreach

Research Question

How much can generalized **machine learning algorithms** improve **sensitivity** in **VLQ detection?**

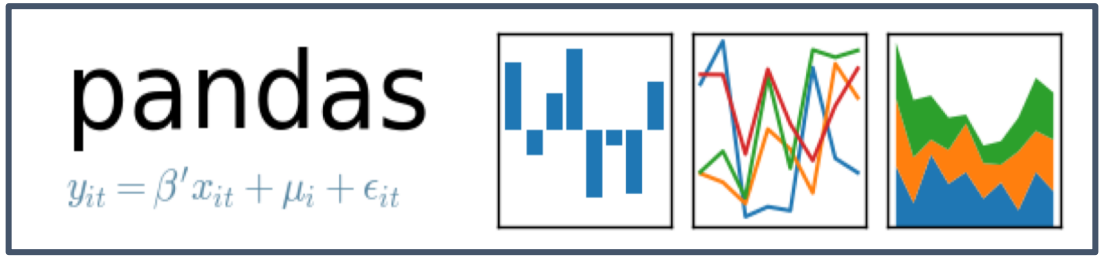


How can we separate VLQ **(signal)** from all other physics events **(background)**?

Methodology

Data Acquisition
(or Monte Carlo modeling)

Data Storage + analysis



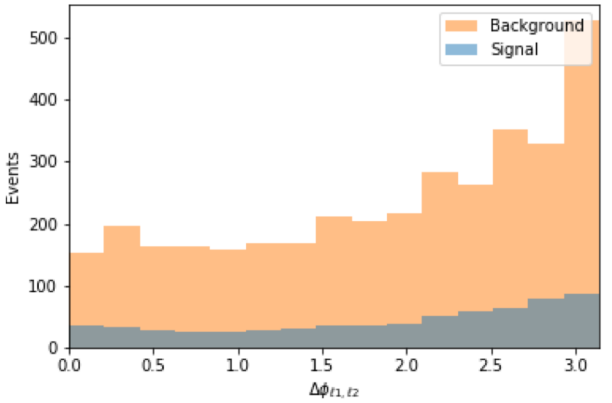
Data Cleaning

Model development+ testing

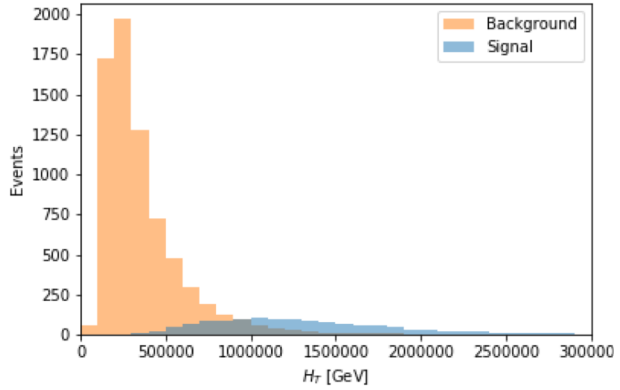
Feature Selection

Past experiments and current theories inform specific **independent variables (features)** to use **(“feed”)** in our models to best predict VLQ events

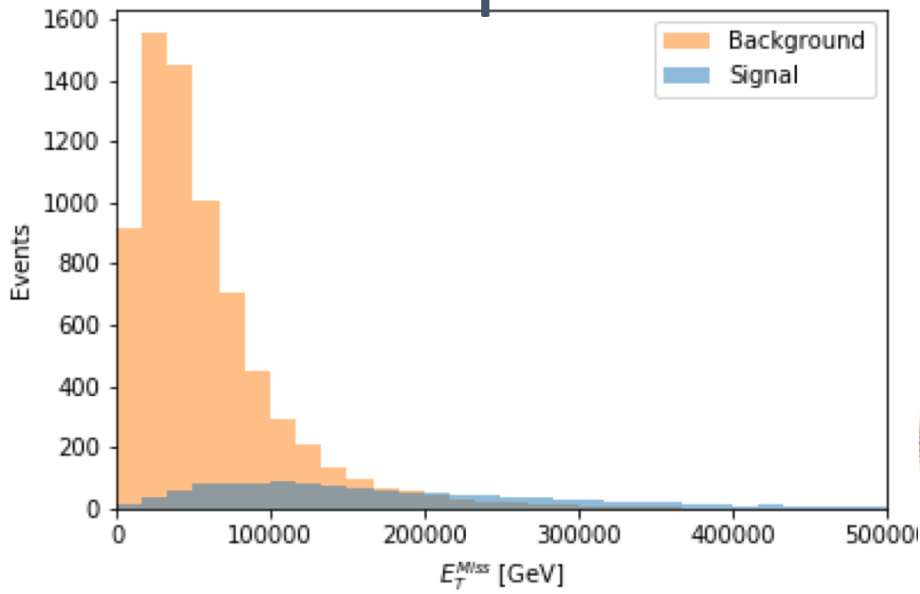
$\Delta\phi_{\ell 1, \ell 2}$

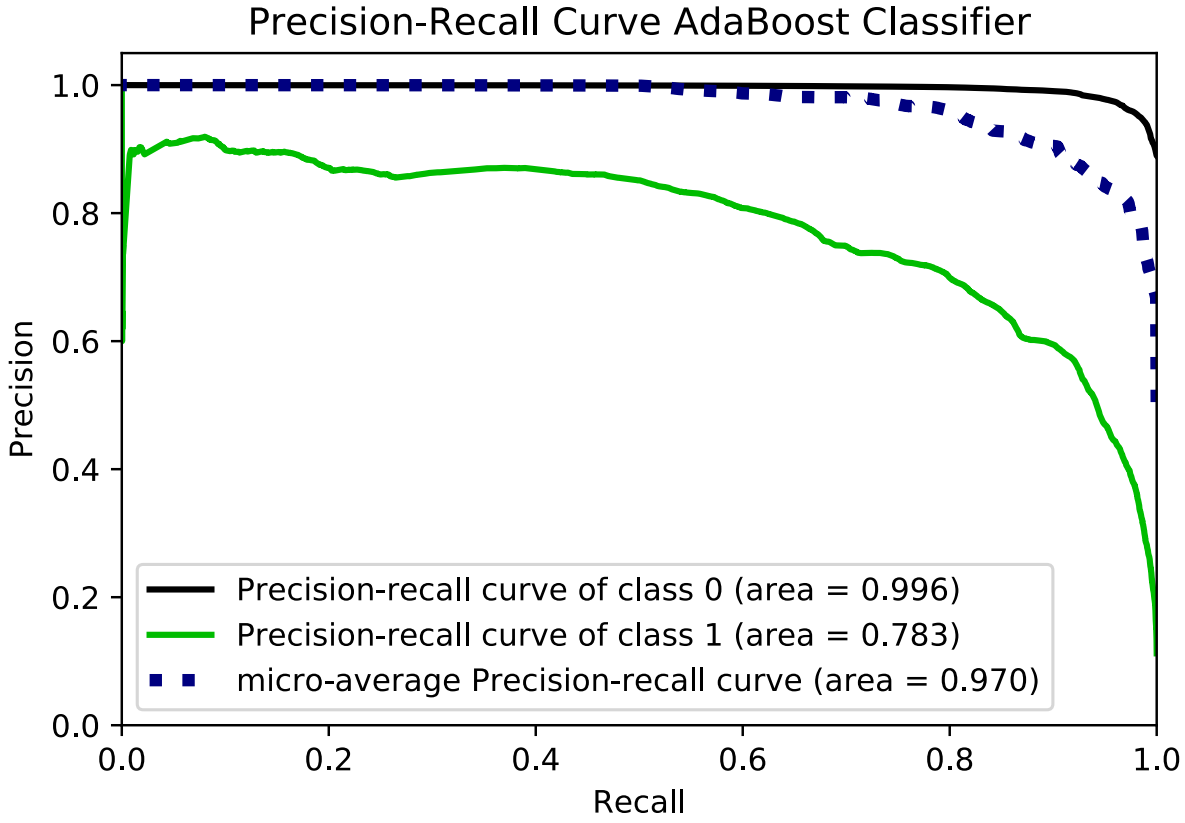


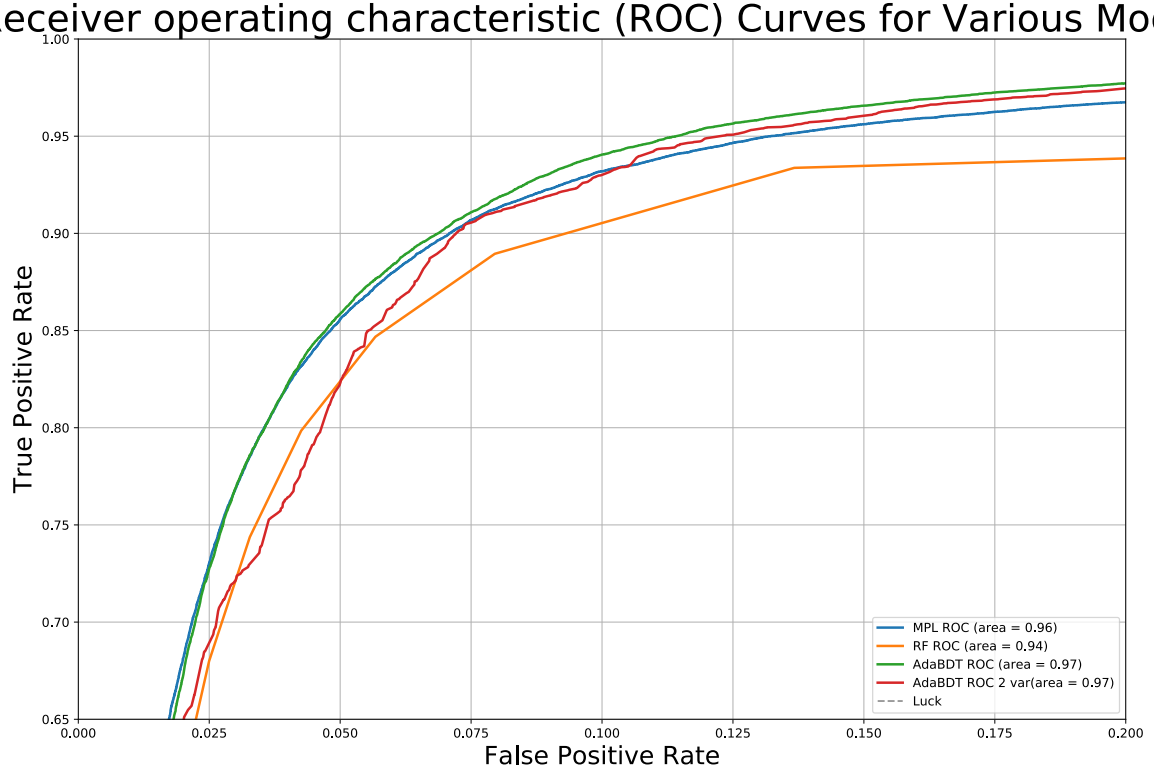
H_T



E_T^{Miss}







Evaluating ML Performance

Next Steps and Future Efforts

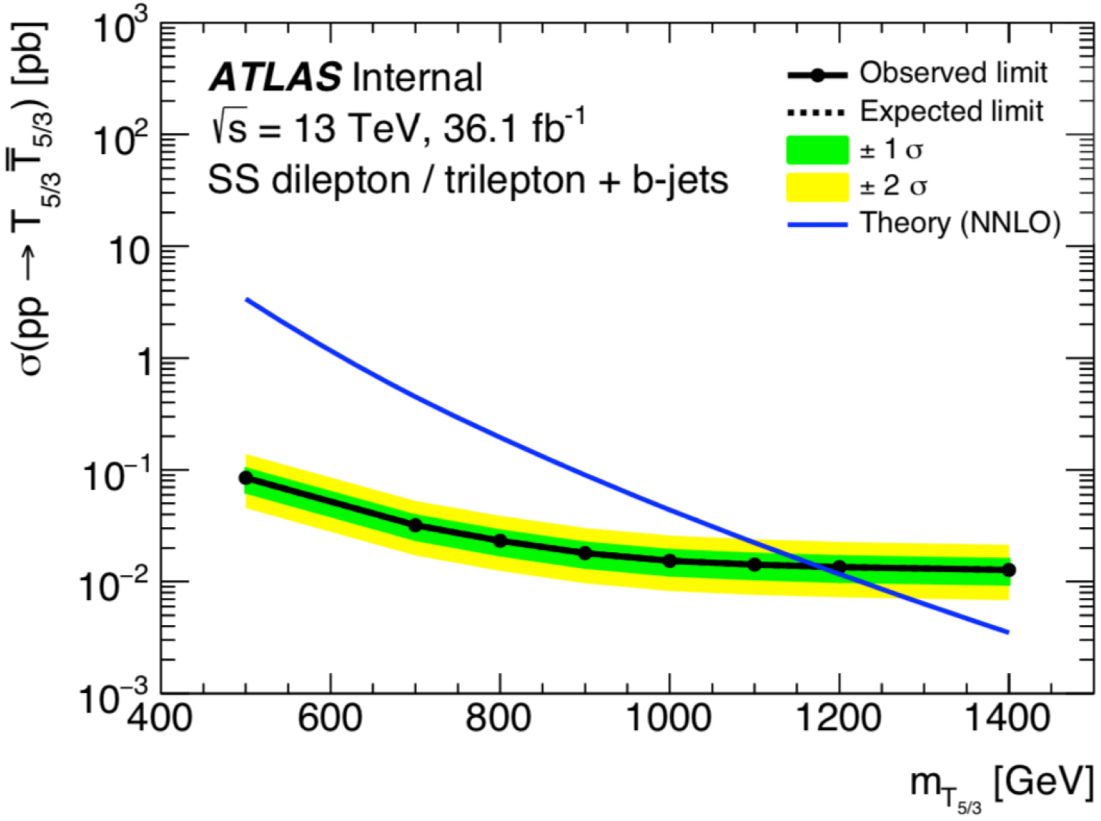


Fig 12: Current limits on VLQ mass (ATLAS Experiment)

- **Apply model to data to either find evidence for VLQ or put better limits on masses**
- **Continue to tune algorithms to improve ML performance (precision!)**

Thank you