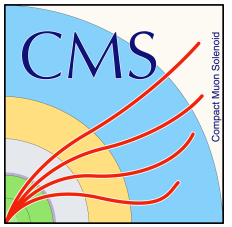

Model-agnostic search for dijet resonances with the CMS detector

Results to appear on CDS [link]

Louis Moureaux on behalf of the CMS Collaboration
cms-pag-conveners-exo@cern.ch

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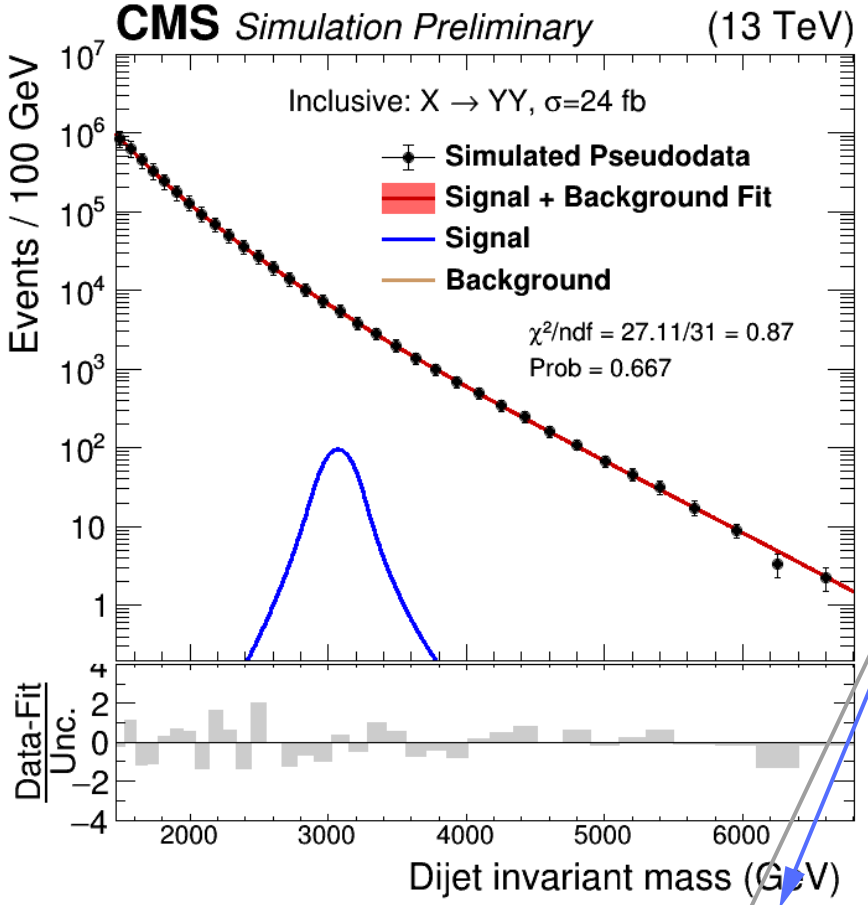
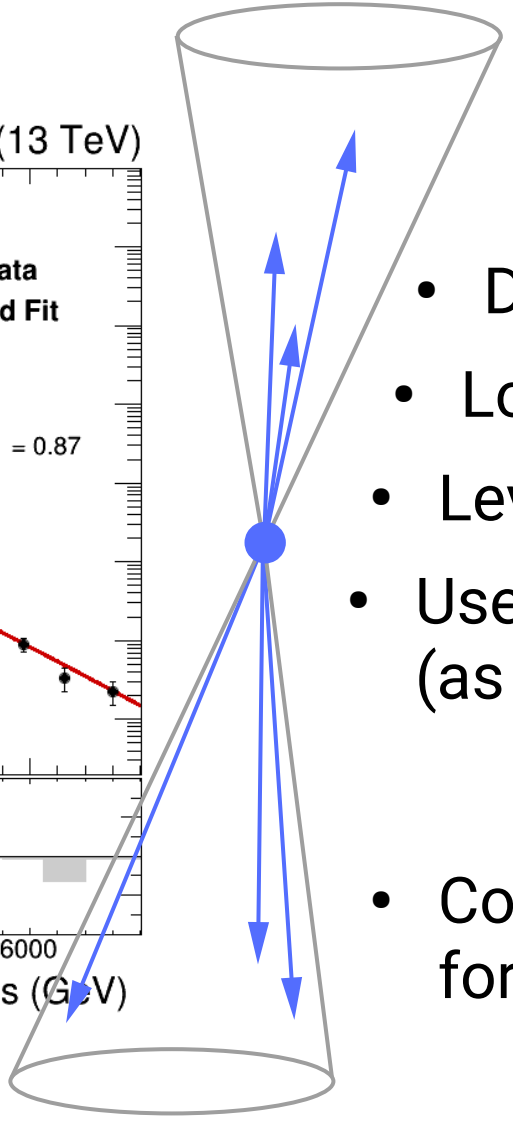


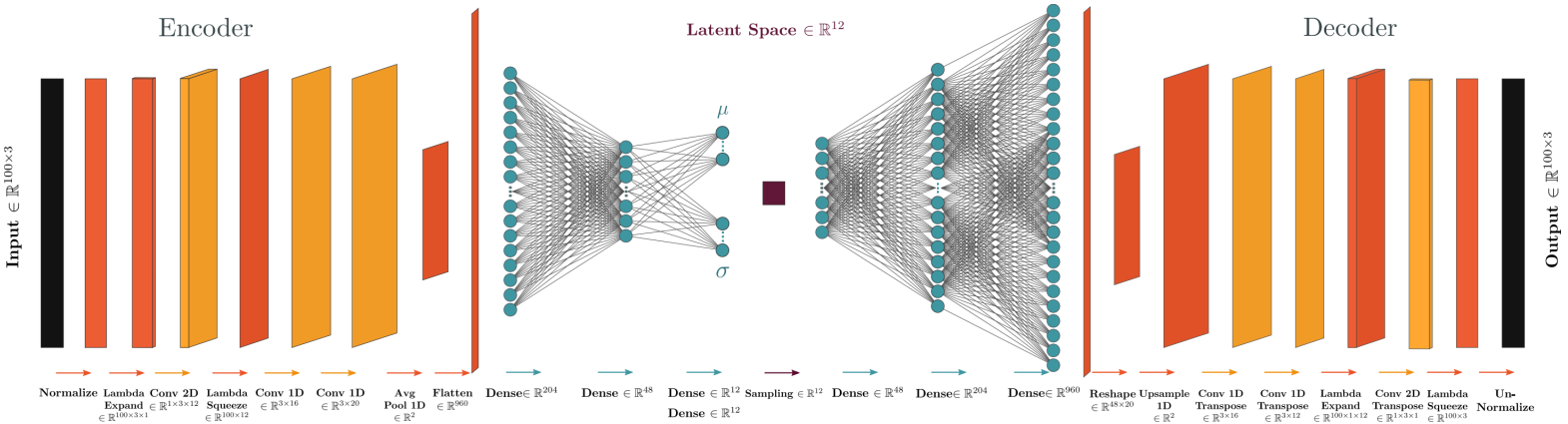


Overview

- Dijet events (anti-k_T, R = 0.8)
- Look for a narrow resonance
- Leverage substructure
- Use state-of-the-art AD methods (as of two years ago)

- Compare **5** techniques for anomaly detection

Methods: **Variational Autoencoder**



- Encodes up to 100 PF* constituents per jet
- Trained with jets from a QCD-dominated sideband ($\Delta\eta > 1.4$)
- Final score: lowest reconstruction loss of the two jets
- Background sculpting controlled with quantile regression

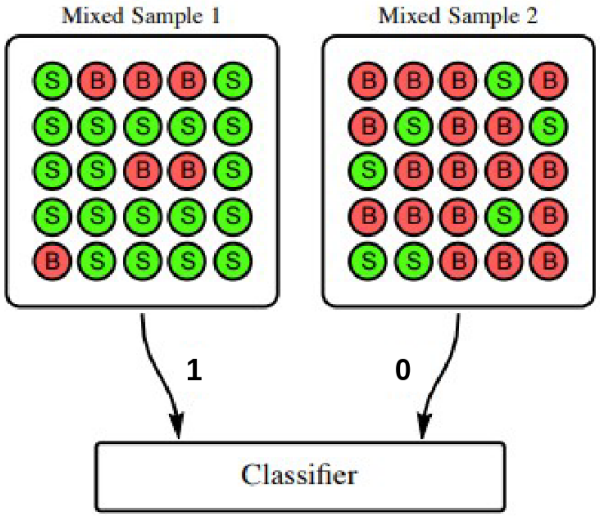
* Particle Flow

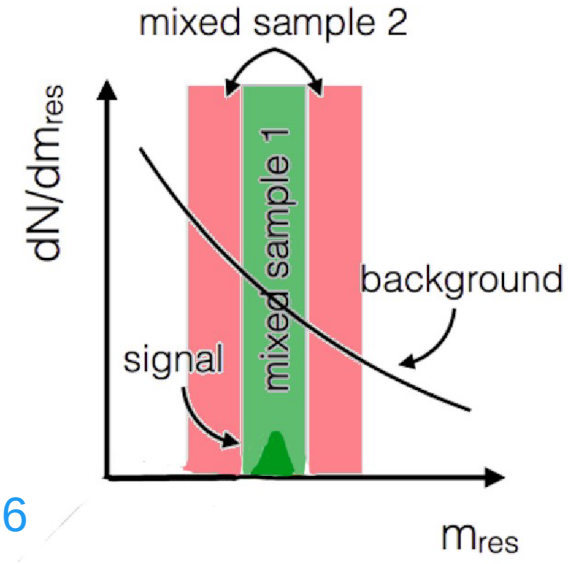
Methods: **Weak Supervision**

Train a classifier between data and a background-like sample

- **CWoLa:** background taken from sidebands
- **CATHODE:** background interpolated from sidebands
- **Tag N' Train:** autoencoder preselection, targets events with **two** anomalous jets

Fewer features for CATHODE than CWoLa/TNT

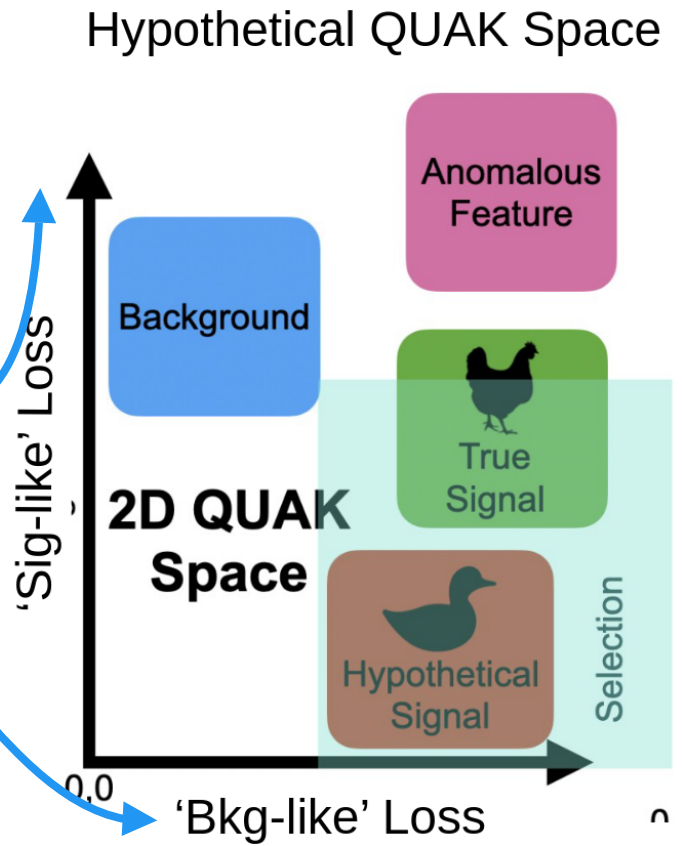




CWoLa: 1902.02634 / CATHODE: 2109.00546 / TNT: 2002.12376

Methods: **QUAK**

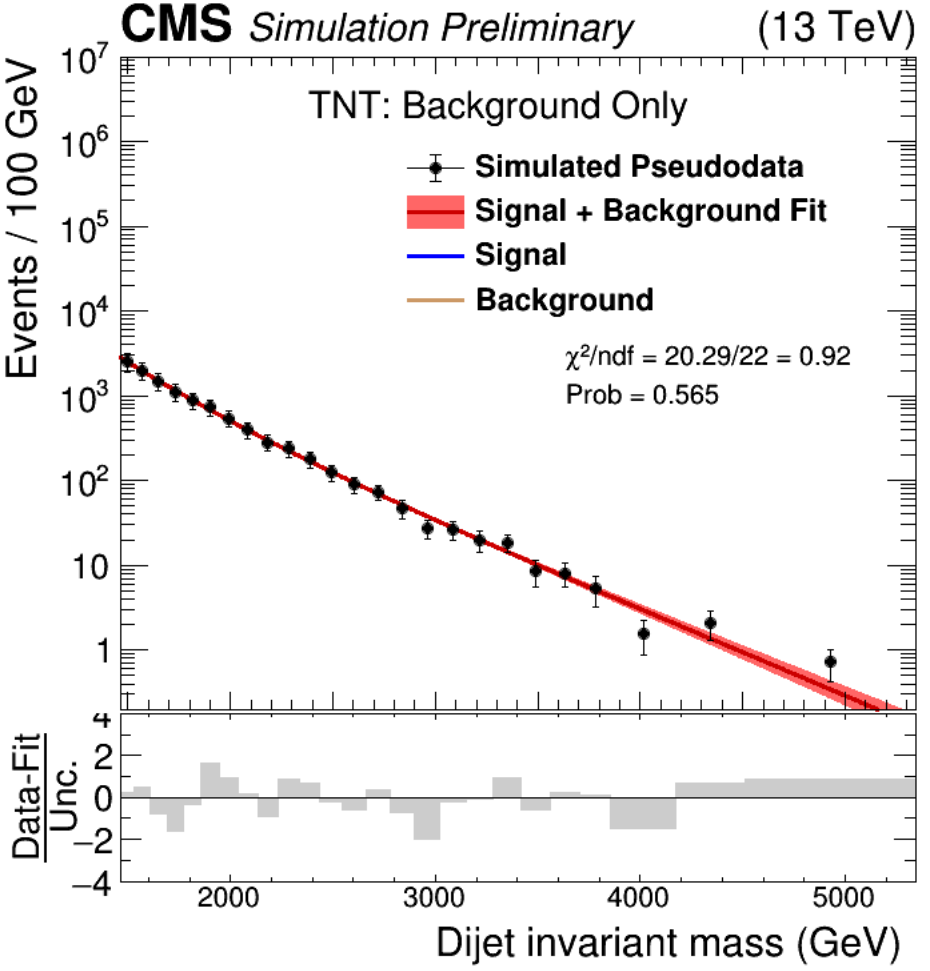
- Hybrid approach, encoding a **prior** on signal-like features
- Train two normalizing flows:
  - On a mixture of signal MCs
  - On background MC
- The losses define a **2D QUAK space**
- The signal is somewhere in that space...



2011.03550

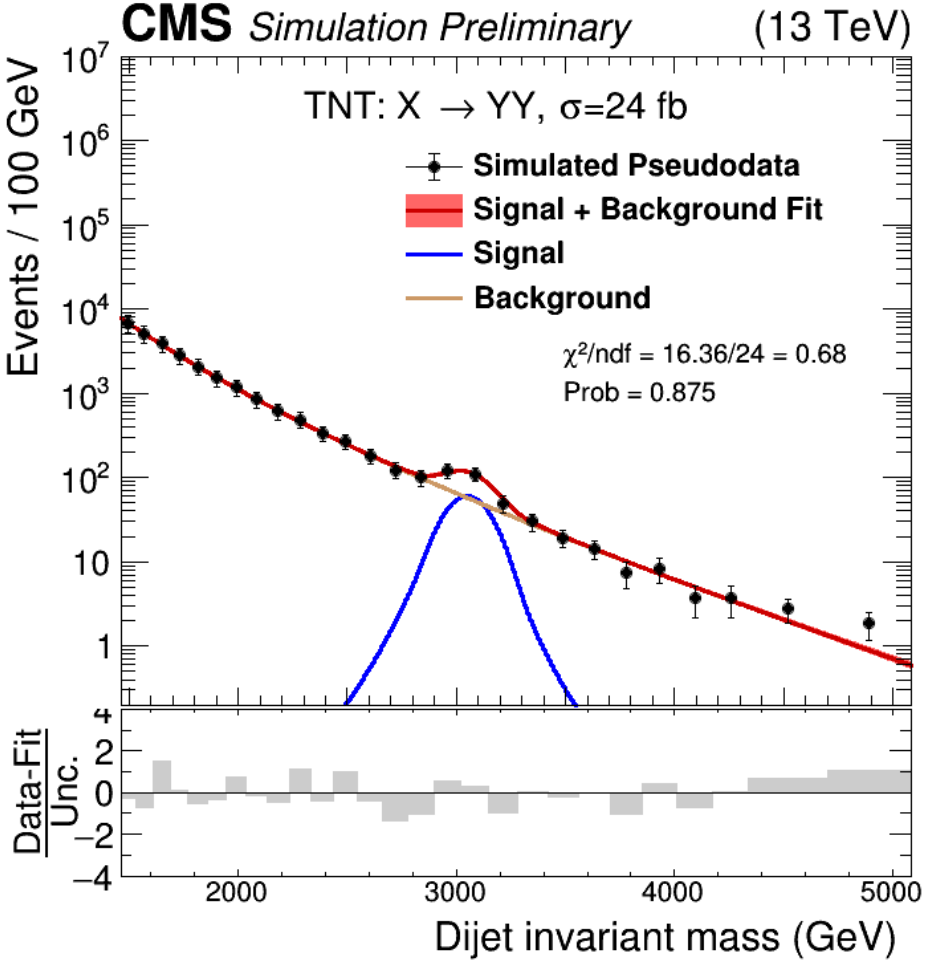
After Tagging

- Choose a working point
- Select events
- Look at m_{jj} spectrum
- Fit with analytic functions



After Tagging

- Choose a working point
- Select events
- Look at m_{jj} spectrum
- Fit with analytic functions
- Find a bump (maybe)
- Derive a *p*-value



We use everything

Compression	VAE/TNT
Regression	QR for VAE
Classification	CWoLa et al.
Density estimation	CATHODE/QUAK
Event generation	CATHODE
Hand-crafted analytical function	Final m_{jj} fit

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... except data ...

Complementarity

Do all methods find
the same events?

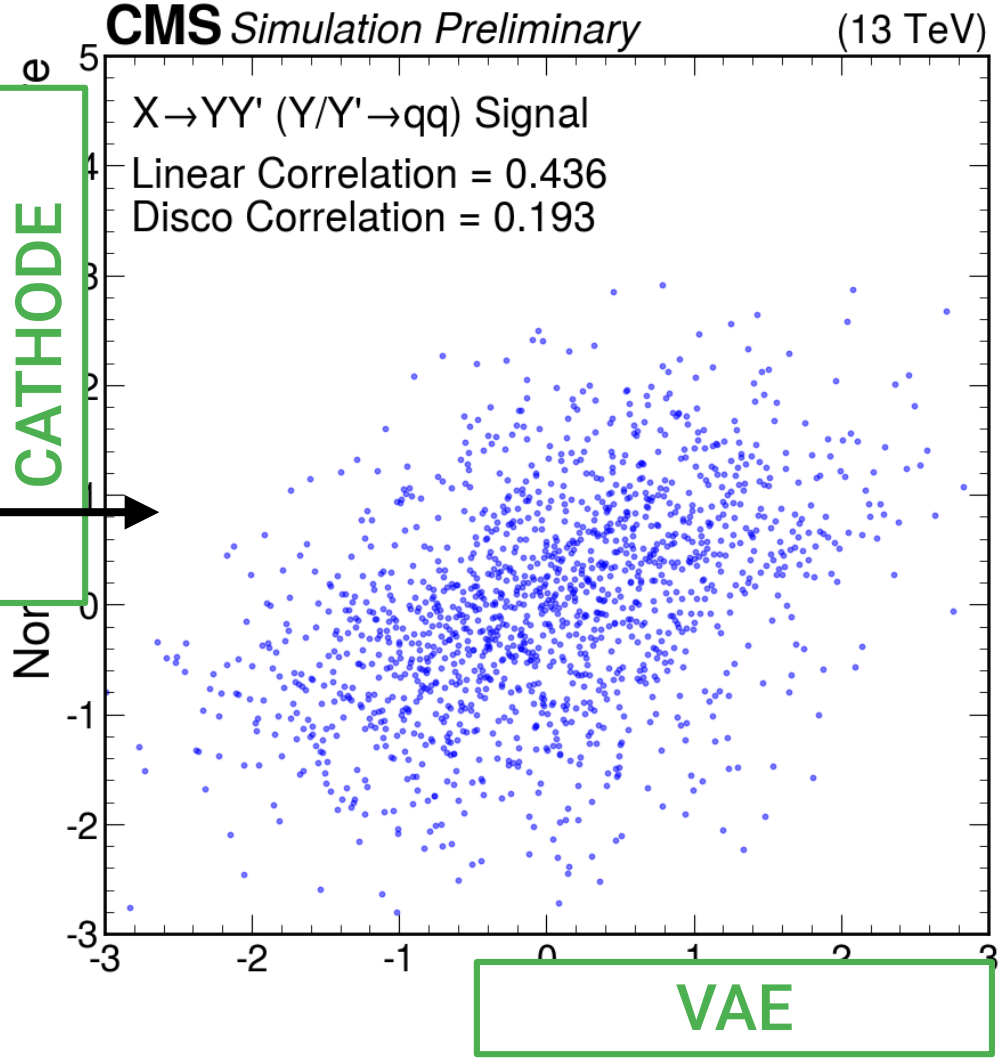
Complementarity

Do all methods find the same events?

Check correlation between scores

≃LHCO R&D dataset

Signal:
X(3000) → YY' → qq qq



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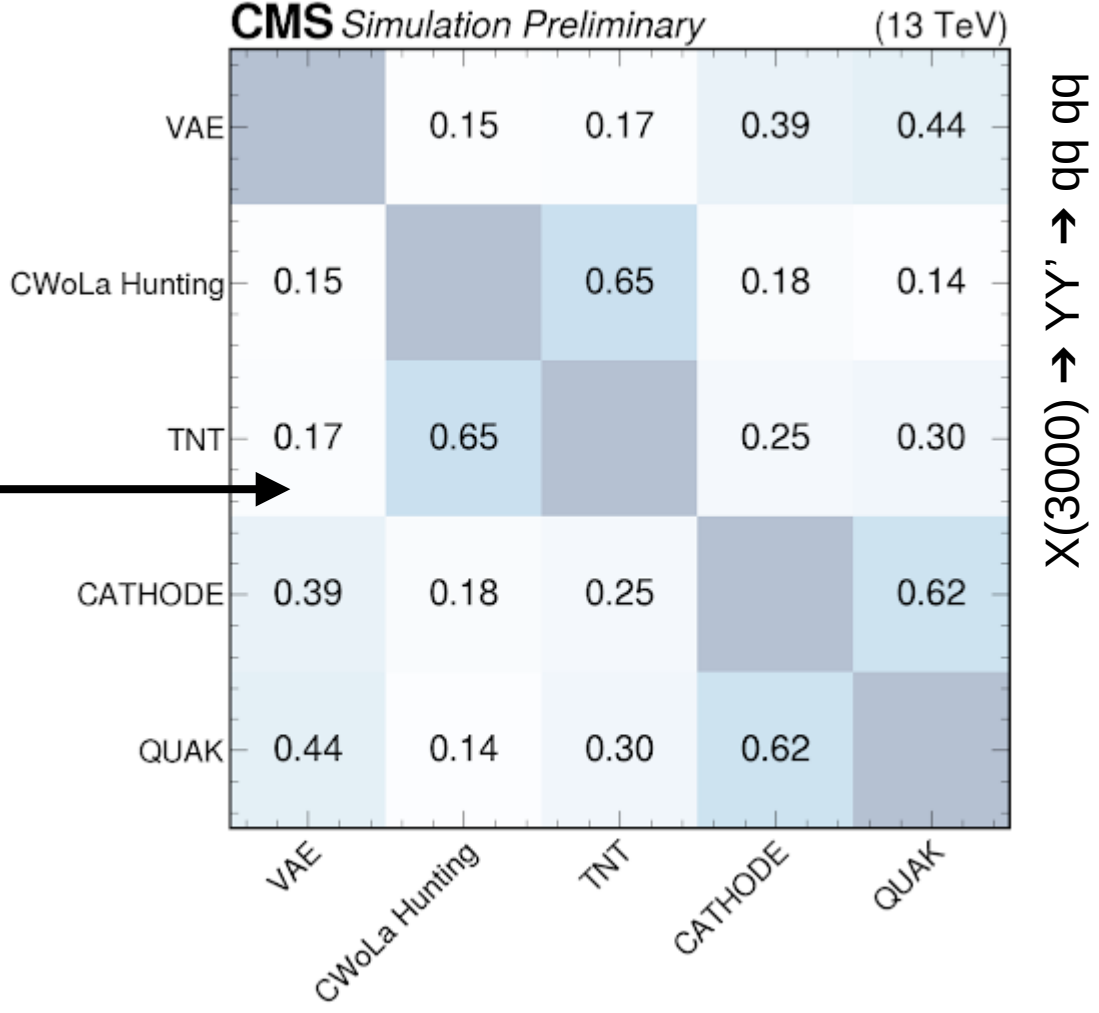


Small correlations

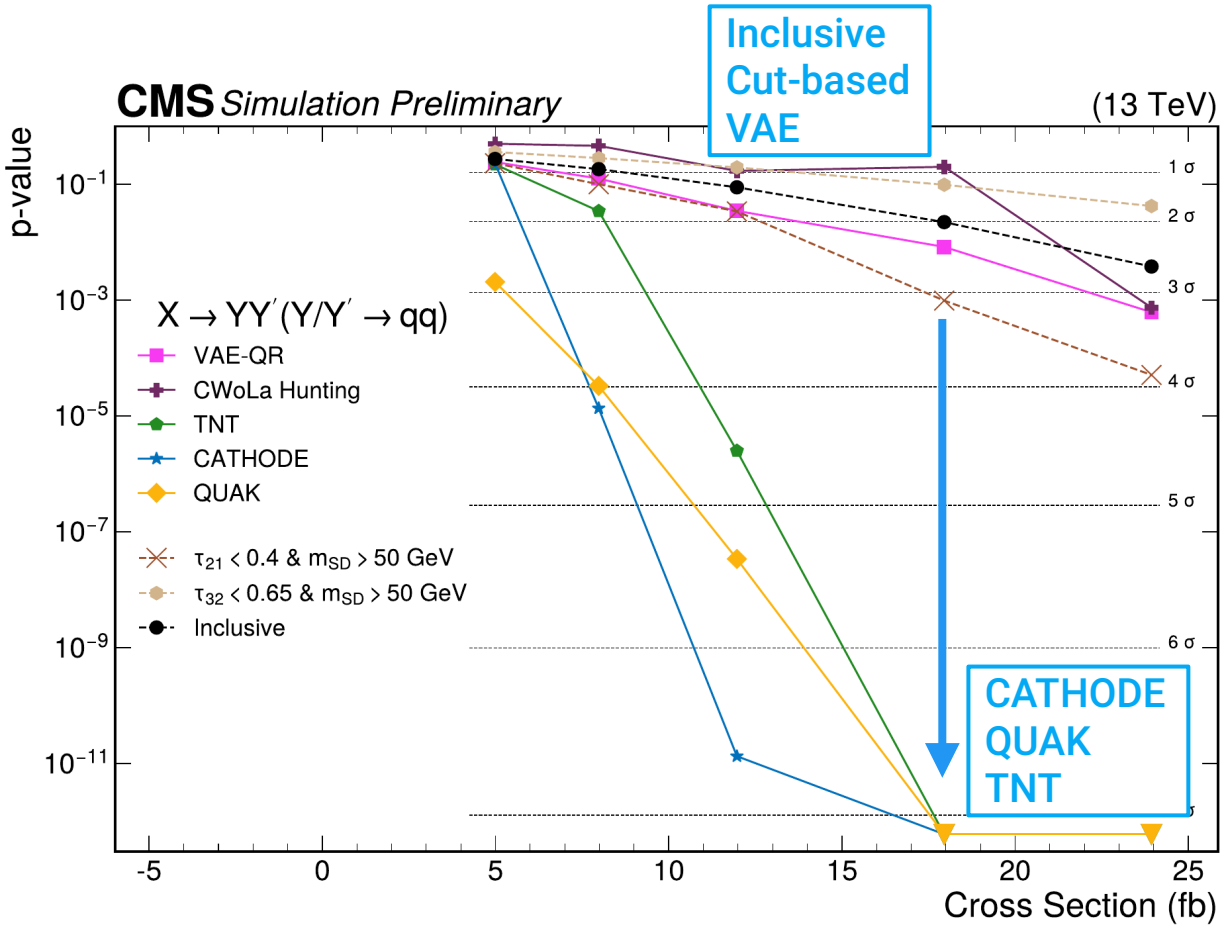
➡ **Complementarity**

Performance: 2 + 2

Testing performance on:

X(3000) → YY' → qq qq

≃LHCO R&D dataset

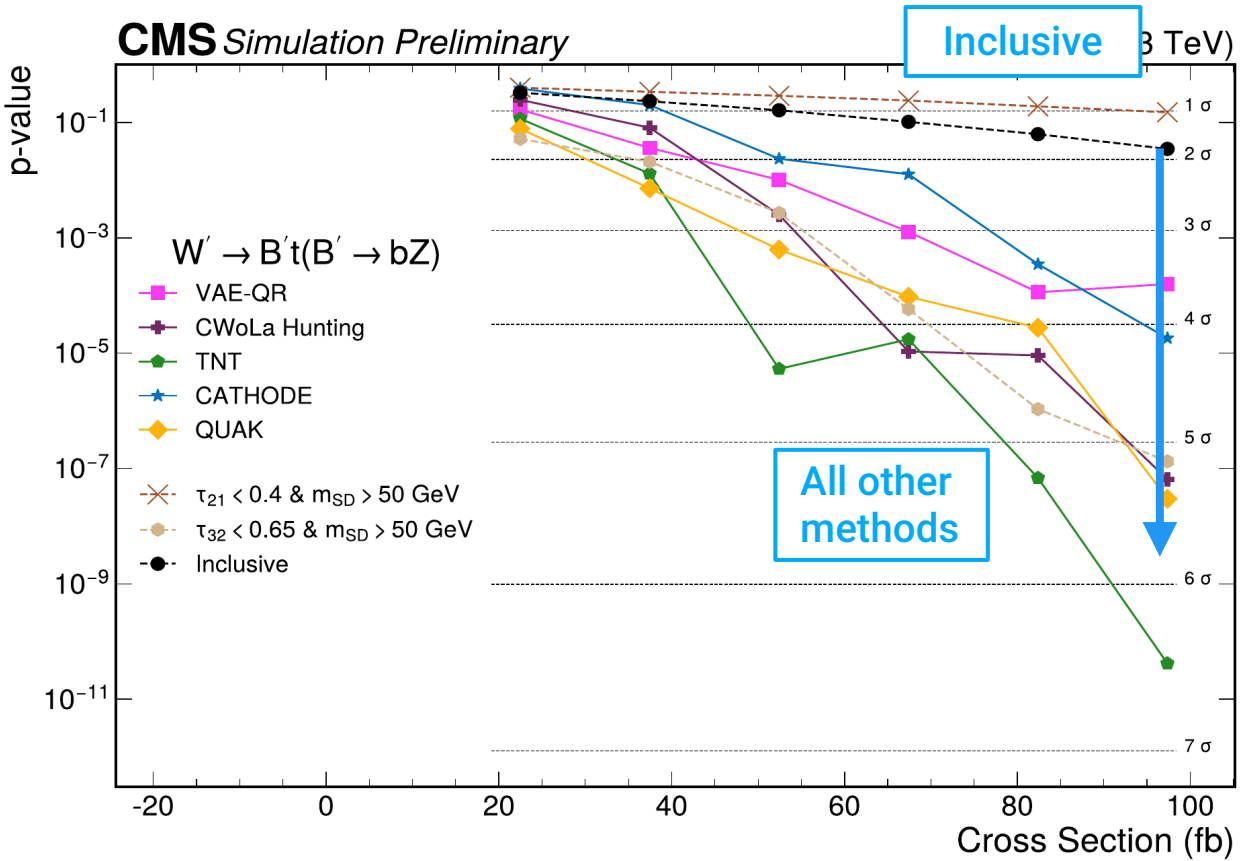


Performance: 3 + 3

Testing performance on:

W’ → B’t → qqq qqq

3 + 3



Performance: 3 + 3

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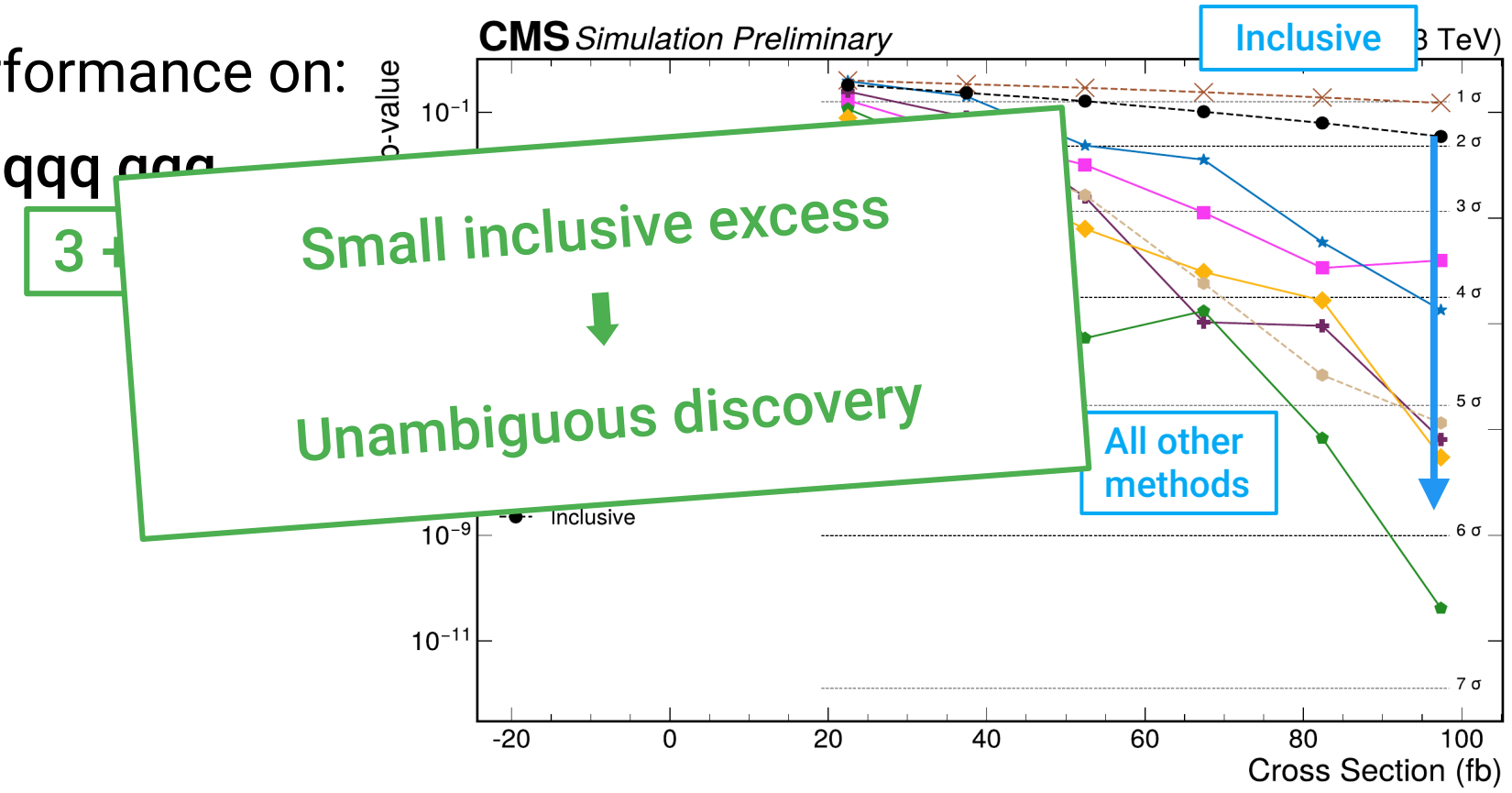


3 +

Small inclusive excess

⬇

Unambiguous discovery

All other methods

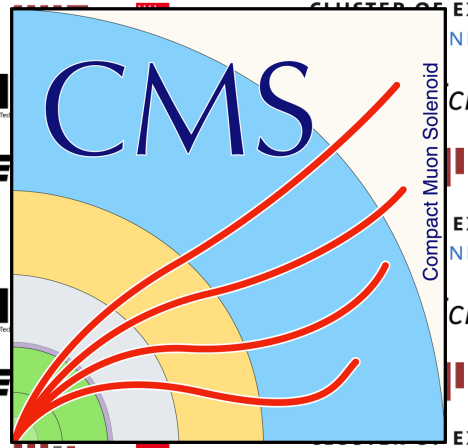
Summary

- CMS joining the anomaly detection party
- Looking for dijet resonances with **5** methods:

  VAE, CWoLa, CATHODE, Tag N' Train, QUAK
- Promising performance in simulation
- No method to rule them all

Results to appear on CDS [link]

Finalizing analysis in data: stay tuned


CMS
Compact Muon Solenoid

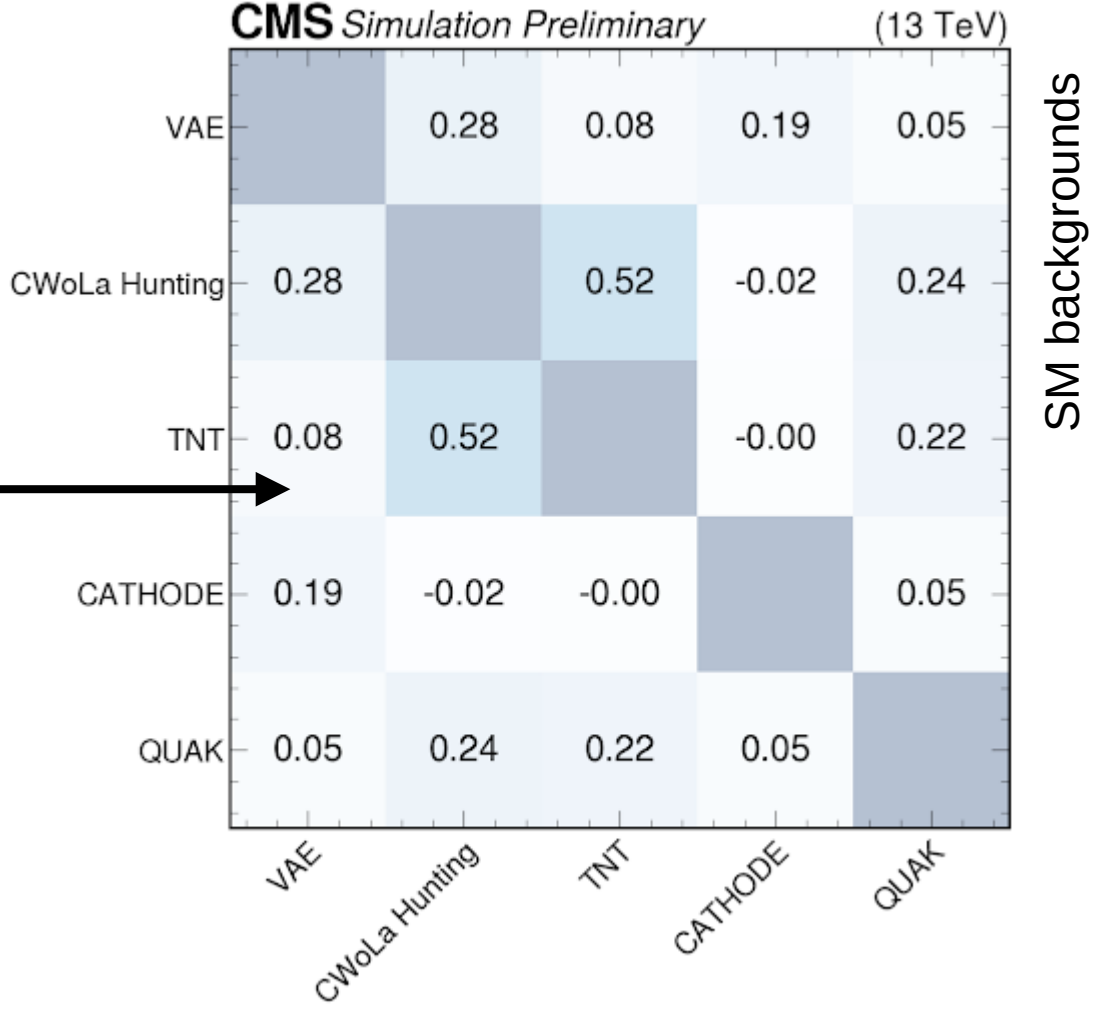
Input Features

- **VAE:** p_T, η, ϕ of leading 100 particle flow constituents (per jet)
- **CWoLa, TNT:** m_{SD}, τ_{21}, τ_{32}, τ_{43}, n_{PF}, LSF_3, b-tagging score (per jet)
- **CATHODE:** m_{SD1}, $m_{SD1} - m_{SD2}$, $\tau_{41,1}$, $\tau_{41,2}$ (per event)
- **QUAK:** m_{SD}, τ_{21}, τ_{32}, τ_{43}, $\sqrt{\tau_{21}/\tau_1}$, M/p_T (for each jet, per event)

Complementarity

Do all methods find the same events?

Check correlation between scores (background)



Small bg correlations