

Accelerating the search for mass bumps using the Data-Directed Paradigm

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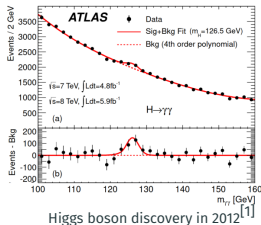


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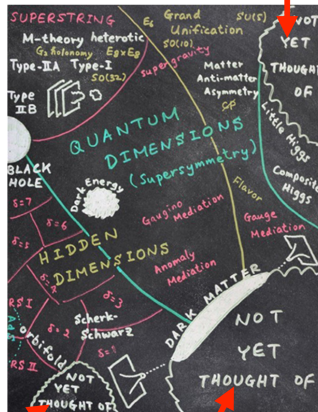
Search for anomalies at the LHC

- No physics beyond the Standard Model (BSM) has been observed at the LHC yet
- Resonant new physics naturally clusters in the data as bumps in invariant mass histograms



- **Data Directed Paradigm:** search strategy to efficiently identify regions of interest in the data. It requires two ingredients:
 - 1) Property of the SM
 - 2) Tool to scan the data in search for deviations

Artistic view of the landscape of BSM models



Crédit: H. Murayama

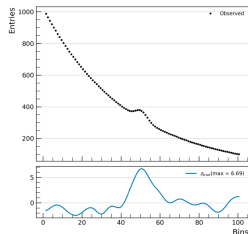
[1] ATLAS Collaboration, Physics Letters B 716, 1–29 (2012), arXiv:1207.7214 [hep-ex]

Bump search with the Data-Directed Paradigm

What? Train a neural network to **identify mass bumps in real data** without the need of simulation or analytical fit to estimate the background

How? Mapping **invariant mass** distribution to **statistical significance for bumps**

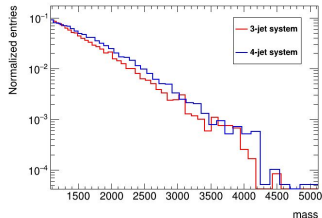
- **Input:** vector of bin entries from invariant mass histogram
- **Target:** vector of statistical significance Z from likelihood-ratio test



➤ Mass histograms of **all possible combinations** of objects in as **many final states** as possible

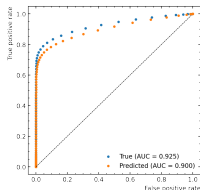
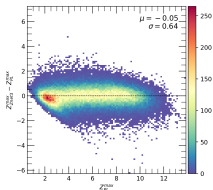
Electron	Leptonic Z
Muon	Boosted hadronic W/Z
Photon	Boosted top
Jet	High mass jet ($m > 200$ GeV)

➤ **Binning** that reflects the detector resolution so narrow signals appear in just a few bins



- Used the **Dark Machines** dataset^[2] designed to test anomaly detection techniques

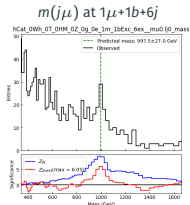
- Trained model **accurately predicts maximum significance**
- Excellent discriminating performance** of signal and background



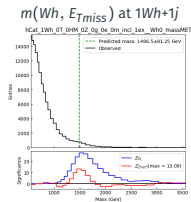
- Tested over **simulated BSM signals** added to the Dark Machines background

- Successfully finds an excess at the expected mass

Q RPV stop $\rightarrow b\ell$



Q $W' \rightarrow WZ$



[2] T. Aarrestad et al., SciPost Phys. 12, 043 (2022), arXiv:2105.14027 [hep-ph]

Thank you!