MANCHESTER 1824
The University of Manchester

UKRI Science and Technology Facilities Council

Funded by the European Union

erc European Research Council
Established by the European Commission

A Year as a SMARTHEP - adjacent Student

Danielle Wilson-Edwards

ATLAS EXPERIMENT

Supervisor: Prof. Caterina Doglioni

Co-Supervisor: Prof. Mike Seymour

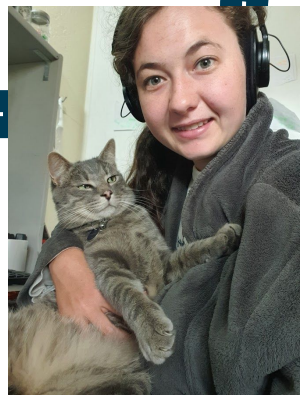
Introduction

Worked with pythia 8 - The Lund Monte Carlo!

Undergrad + Honours

Explored the QCD deadcone effect using Lund Planes

1



2

Masters

Constraining dark sector jet models, using measurements stored in rivet

Qualification Task:

Pile Up Jet Tagging in Real-TIme

Trigger Whitepaper

PhD (2022 - 2026?)

3

Attended and presented at Workshops, attended the STFC summer school and a C++ School

Analysis

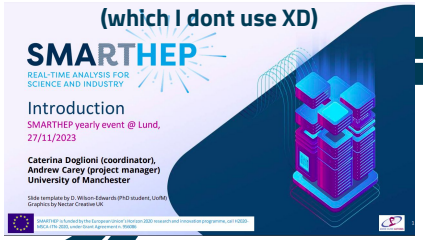
Search for Dark Jet Resonances with ATLAS

Long-Term Attachment @ CERN

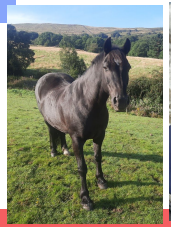
Control room shifts + in-person analysis meetings

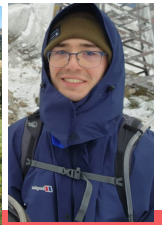
Made SMARTHEP slide template

(which I dont use XD)



Made two new friends named Max





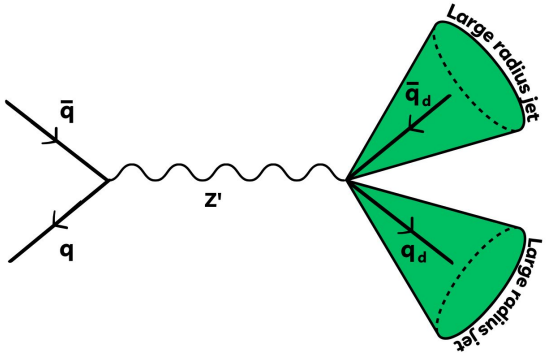
Made my cats world-travellers

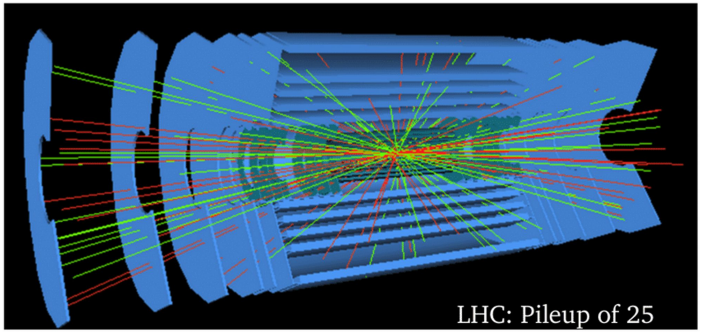
Research Motivation

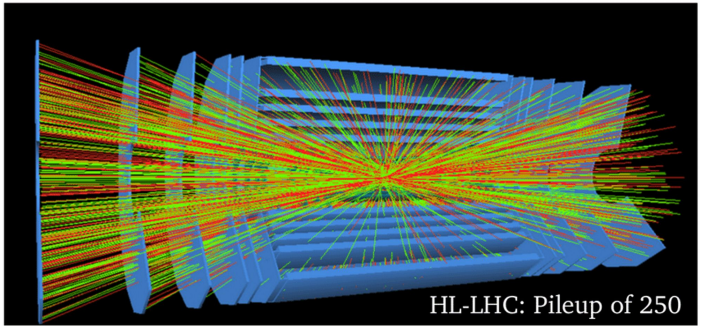
- As LHC pushes the energy frontier
  - no signs of new physics => searching for new **rare processes**
    - for example, **dark matter**
- To observe these rare processes:

Number of Events = Cross-section x Luminosity

- Higher luminosity => more simultaneous proton-proton collisions = **PILEUP**
  - Additional pileup particles complicate searches:
    - can bury signals in high-rate backgrounds
    - can make it difficult to correctly **detect and reconstruct** unusual jet signatures







Pile-Up Jet Tagging

The Jet Vertex Tagger

ATLAS-CONF-2014-018

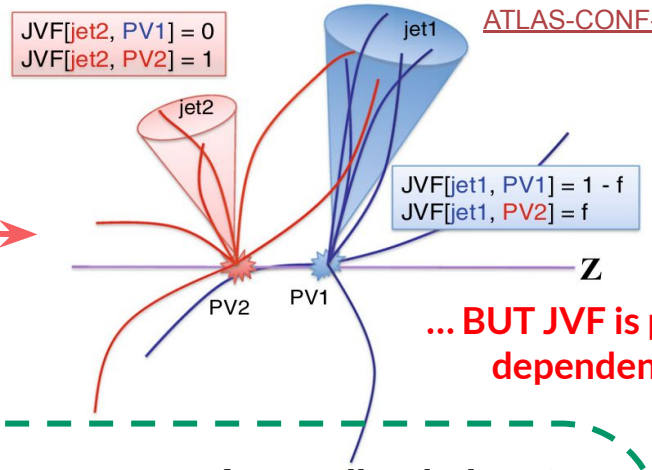
"fake jets" are reconstructed from pileup interactions, instead from processes of interest

Solution:

Suppress pileup jets using tracks associated to the jet

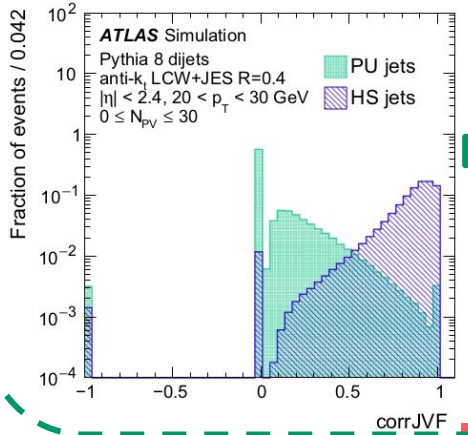
Previously, ATLAS used the JVF…

ATLAS-CONF-2011-073

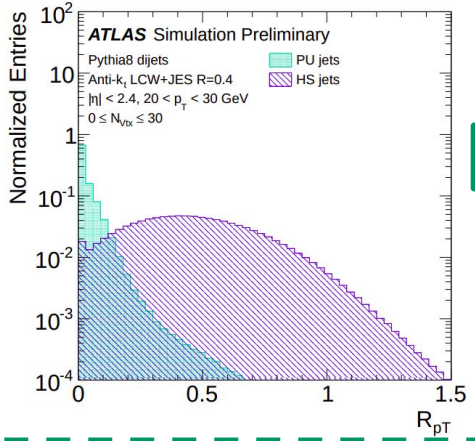


… BUT JVF is pileup dependent!

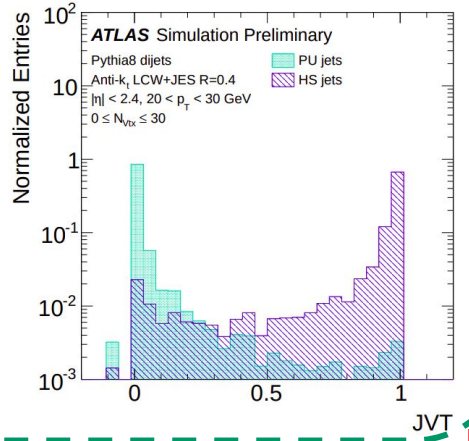
corrJVF: JVF corrected for its pileup dependence



RpT: ratio of the primary vertex track sum to the jet pT



A new discriminant *the jet vertex tagger (JVT)*



Towards a Real-time Optimised JVT

- Major improvements to track and vertex reconstruction efficiencies for Run-3 **=> New and improved offline JVT implemented**
  - BUT **High-Level Trigger (HLT, or online) jets** saw approximately four times less pile up rejection

Goal:

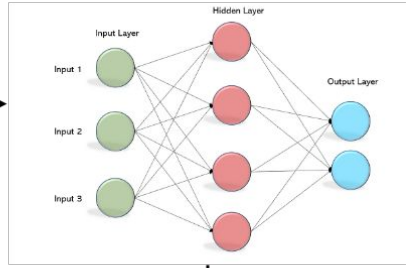
Improve online pileup suppression by augmenting a **neural network** with new track-based input information

Example Feature List

```
['pt', 'eta', 'Timing',
'RPtTrkPt500_vx0',
'RPtTrkPt500_vx1',
'MaxRPtTrkPt500',
'DMaxRPtTrkPt500_vx0',
'TrackWidthPt1000_vx0',
'DMaxTrackWidthPt1000_vx0']
```

Preprocessing

Multi-Layer Perceptron



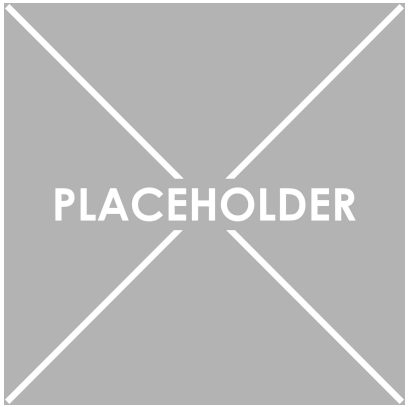
Prediction score, between 0 and 1

-> 0 = Pileup
-> 1 = Hardscatter

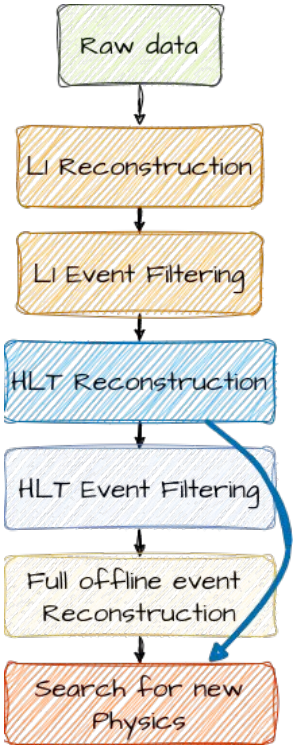
```
vertex i, sorted in order
of sum pT^2
Width from tracks from
vertex i above 1 GeV
RpT from tracks from
vertex i above 0,5 GeV
Difference w.r.t to
Max value
```

Results so far:

Pending sign-off and public approval :)



HLT events are **~0.5% the size** of full event => more data can be saved to probe rare processes!

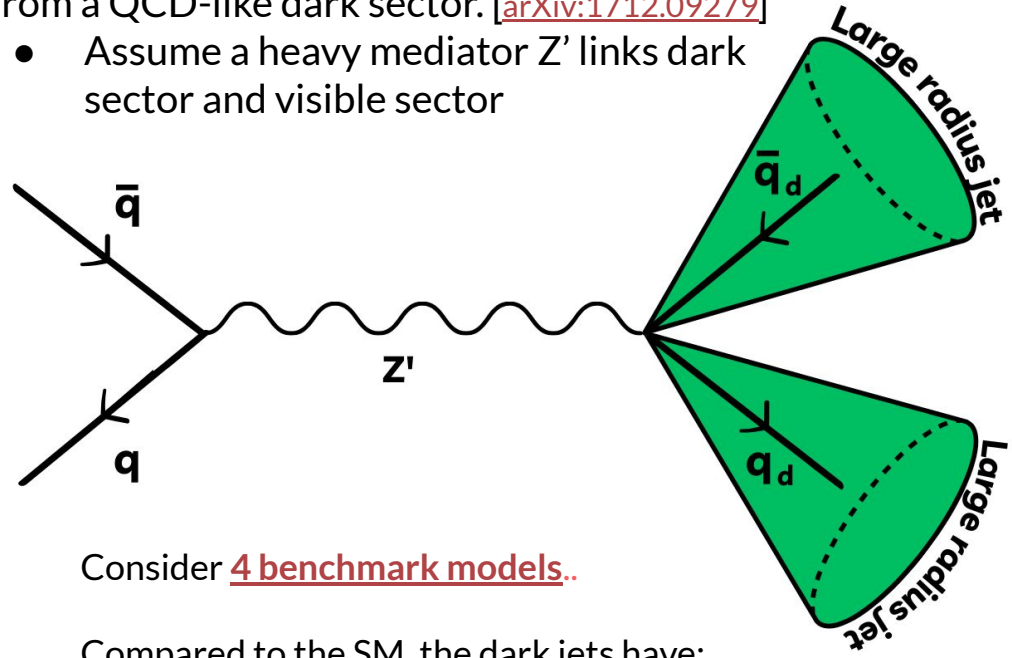


Dark Jet Resonance Search

Target Model

Unusual dijet signatures that could arise from a QCD-like dark sector. [arXiv:1712.09279]

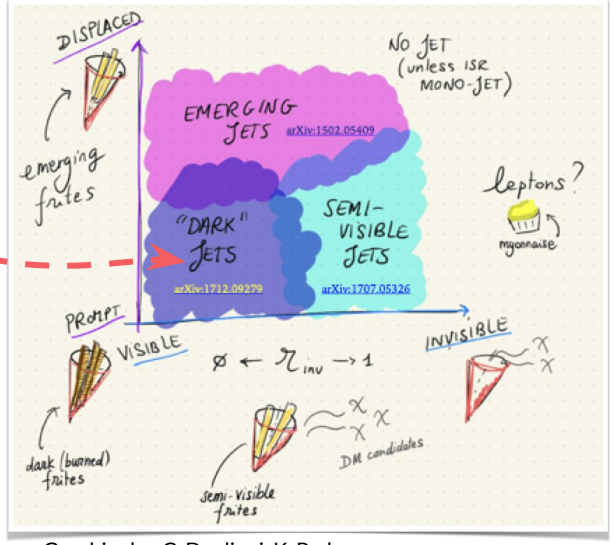
- Assume a heavy mediator Z' links dark sector and visible sector



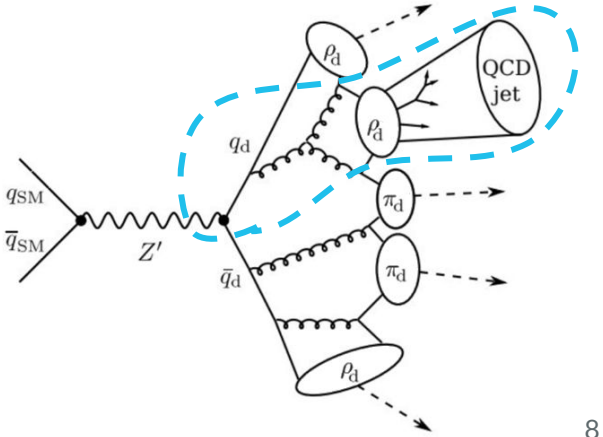
Consider 4 benchmark models..

Compared to the SM, the dark jets have:

- stronger running couplings
- more soft particles (=> more tracks)
- larger jets, due to **double hadronization**



Graphics by: C. Doglioni, K. Pedro



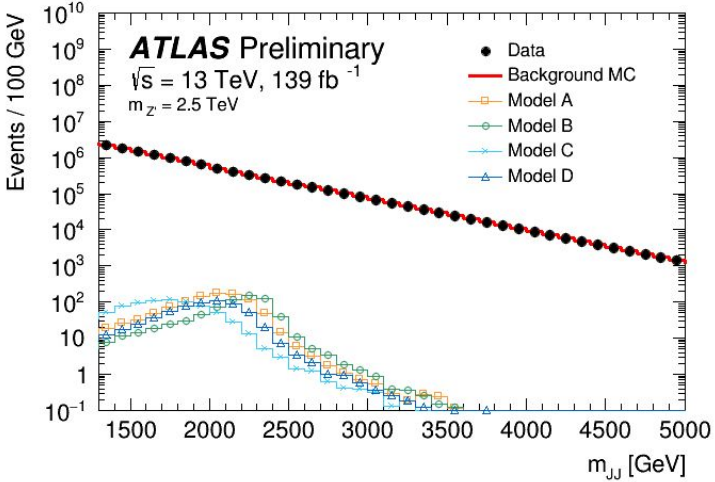
Dark Jet Resonance Search Analysis Strategy:

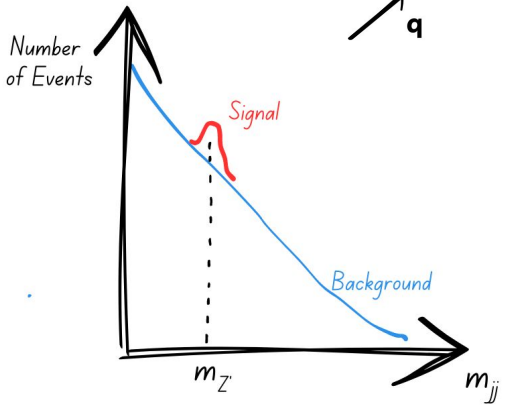
ATLAS-CONF-2023-047 arXiv:2311.03944

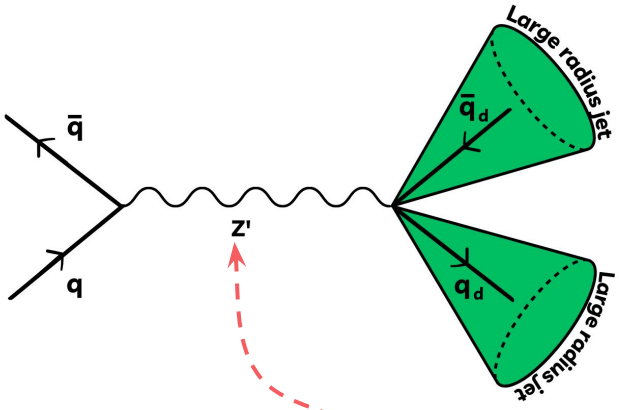
- **Reconstructed Objects:** Two Large radius jets (Trimmed LCTopo jets)
- **Trigger on Large-R jets**
- **Preselection cuts:** $|\eta(j_{1,2})| < 2.0 \quad p_{\mathrm{T}}(j_1) > 500\ \mathrm{GeV}\,, p_{\mathrm{T}}(j_2) > 400\ \mathrm{GeV} \quad m(j_{1,2}) > 50\ \mathrm{GeV} \quad m_{\mathrm{JJ}} > 1.3\ \mathrm{TeV}$

Signal scenario: Two dark jets

1) Tag them using substructure information
2) Look for a resonance over dijet background







Signal masses per model from mZ'=1.5 ->3.5 TeV in bins of 250 GeV, and bins of 500 GeV for higher masses

Bump Hunting

- To test the **statistical significance** of any localised excesses observed in the data, in a model-independent way:

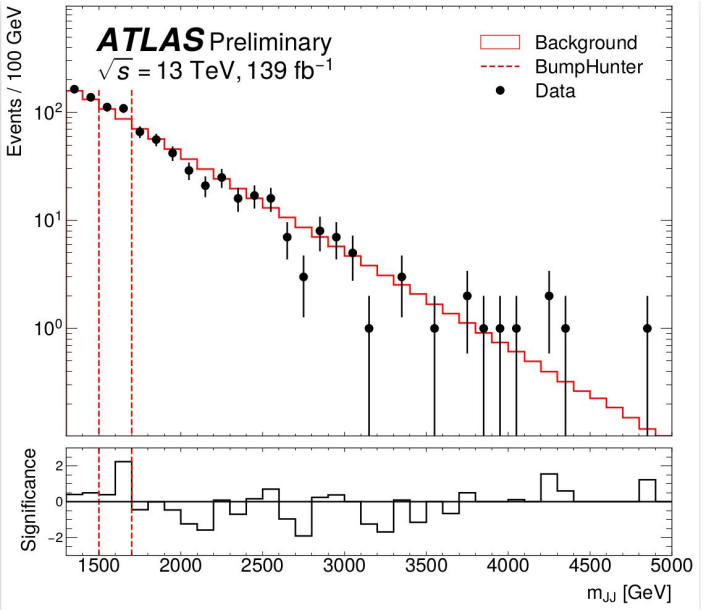
  a Bump Hunter test is performed

  (in addition to a full frequentist analysis)

- Scan the mjj distribution using a **sliding window of variable width**, and calculate the **local p-value** for each excess

  → the probability that the excess arises from the background only hypothesis

  - From the p-value, a significance and Bump-Hunter test statistic are calculated



Conclusion is the same as full statistical analysis:

No significant excesses observed!