

# Search for VLQ $Wq+X$ at ATLAS detector

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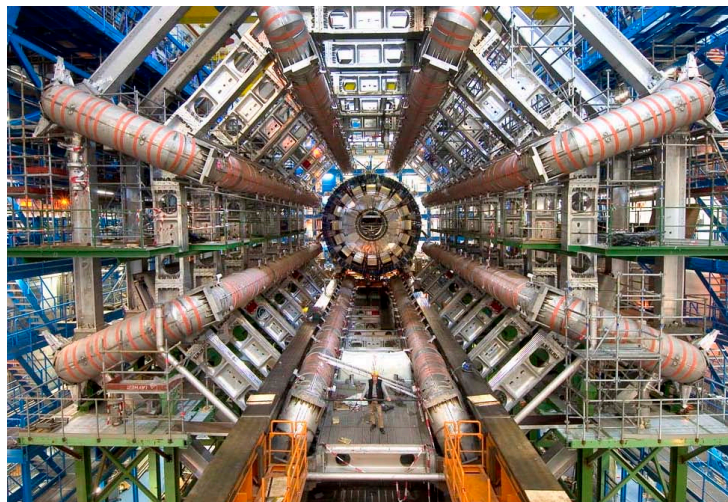
06/12/22

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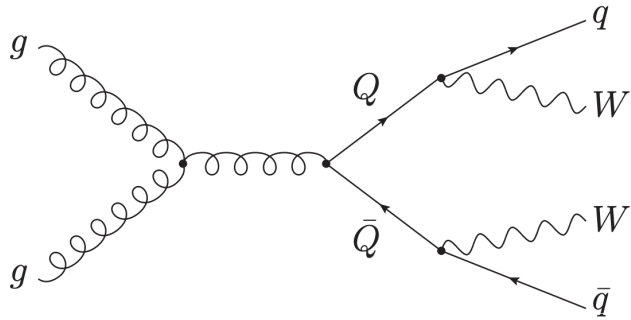
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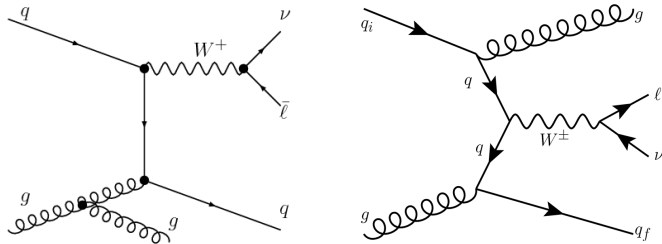


# Vector-like quarks

VLQ signal



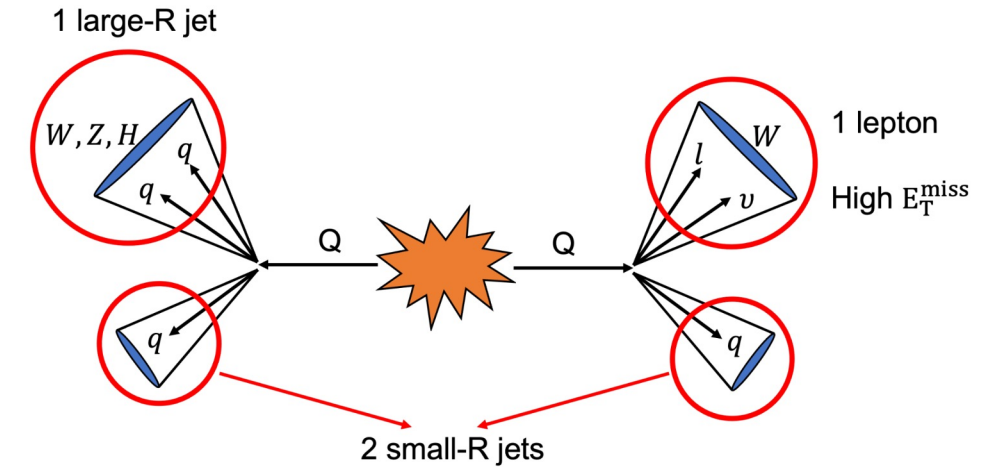
W+jets



- Vector-like quarks (VLQ) are hypothetical particles that appear in some extensions of the Standard Model.
- VLQs have quantum mechanical mixing with the SM quarks
  - Allowing them to decay to SM quarks and either a  $W$ ,  $Z$ , or Higgs boson
  - Exact nature of the coupling depends on the model.
- If such quarks exist they are expected to be produced in pairs
- Main background from SM  $W$ +jets

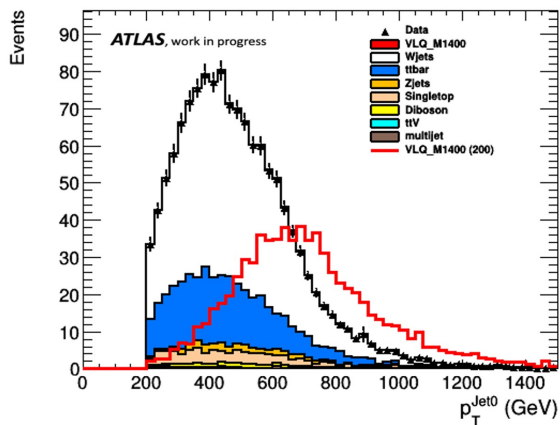
# What are we looking for?

- Searching for events with two very heavy quarks
- Leptonic VLQ decay (right)
  - Neutrino  $\rightarrow$  High missing momentum
  - Lepton  $\rightarrow$  electron/muon
  - Quark  $\rightarrow$  jet  $\rightarrow$  Small-R jet
- Hadronic VLQ decay (left)
  - Quark  $\rightarrow$  jet  $\rightarrow$  Small-R jet
  - Hadronically decaying  $W \rightarrow$  Large-R jet



# Project goals

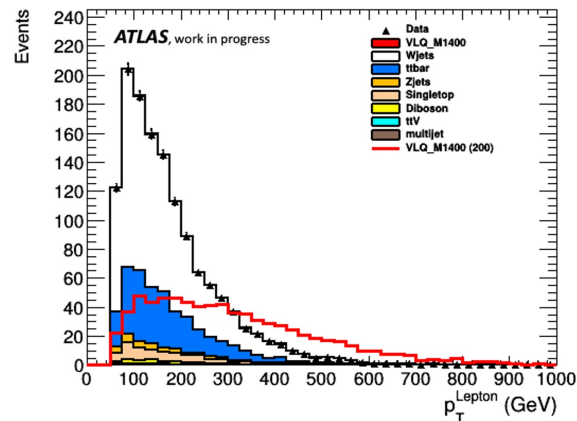
- Goal is to reduce background and keep as many signal events as possible
  - Apply selection criteria (cuts) to each event
- Scanned potential cuts values
  - Leading Jet  $p_T$ 
    - Starting from 200 GeV – 600 GeV
  - Lepton  $p_T$ 
    - Starting from 60 GeV – 120 GeV
- Check the sensitivity vs number the of signal events
  - The higher number of sensitivity and signal events the better
- Use VLQ mass 1400 GeV
- Background
  - W+jets
  - ttbar
  - Z+jets
  - Single top
  - Diboson
  - Multijet events



Selection criteria for  
Lepton  $p_T$  60 GeV

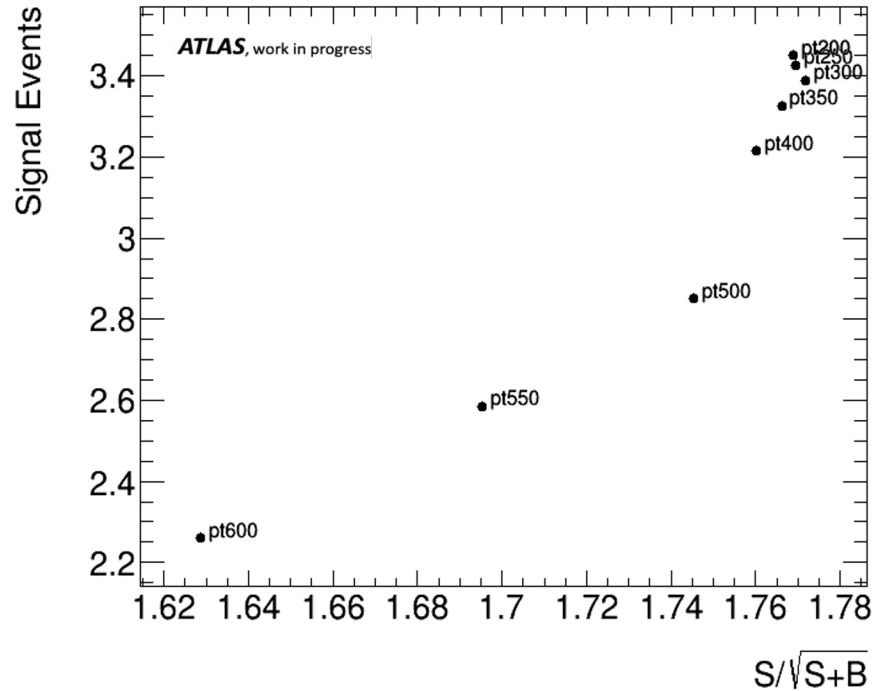


Selection criteria for  
Leading Jet  $p_T$  200 GeV



# Results Leading Jet pT scan

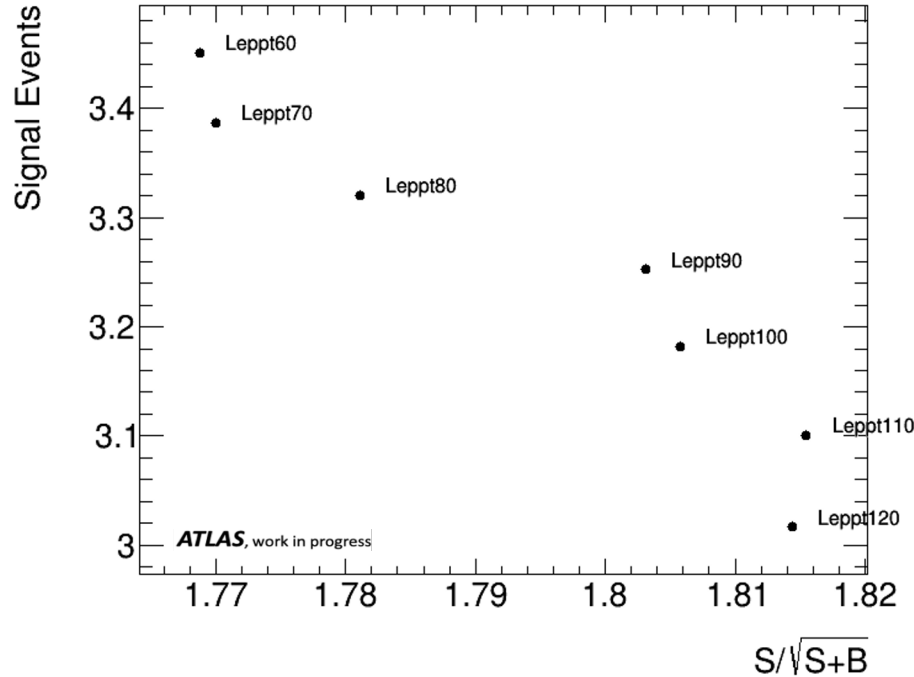
- Significance plots for Leading Jet pT 200 – 600 GeV/Lep pT < 60 GeV
- Each point is the cuts made for the Leading jet pT
  - From 200 GeV – 600 GeV in steps of 50



- As the Leading jet increases the energy, it loses events
- Best cut is between 200 – 300 GeV

# Results Lepton pT scan

- Significance plots for Leading Jet  $p_T < 200$  GeV / Lep  $p_T < 60 - 120$  GeV
- Each point is the cuts made for the Lepton  $p_T$ 
  - From 60 GeV – 120 GeV in steps of 10



- As the Lepton  $p_T$  increases, it has more sensitivity, but it loses a lot of events
- The loss sensitivity is very small compared to the loss of events, due to multivariable analysis the Lepton  $p_T$  60 GeV is the best cut

# Conclusion

- We are looking for  $QQ \rightarrow WqWq \rightarrow l\nu jj$
- Goal is reduce background and keep as much signal events as possible
- Optimization results
  - Leading jet  $p_T > 200$  GeV
  - Lepton  $p_T > 60$  GeV
- Final selection will use multivariable analysis
  - Looking into using a deep neural network (Tensorflow), or boosted decision tree (TMVA)
  - Requires “mini trees” with final selected events
  - In parallel, I helped developed the framework with postdoc to create the “mini trees”
- Future plans
  - Investigate multivariables techniques



# Thanks



- Thanks to OSU team
  - Evan R. Van De Wall
  - Vallary Shashikant Bhopatkar
  - Joe Haley
- NSF, DOE and ATLAS SUPER Program for giving me this opportunity and having an amazing learning experience

