THE STANDARD MODEL AND VECTOR-LIKE LEPTONS

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THE STANDARD MODEL

- Elementary particles
- Force carriers
- What makes up everything



Three Generations of Matter

http://inspirehep.net/record/853601/plots

OUR PROJECT

- Investigate the existence of a heavier lepton
- Determine sensitive mass ranges and ways to find it
- "vector-like"
- Data collected from ATLAS Project at the LHC under CERN



Three Generations of Matter

GOALS

- Investigate the possibility of τ' decaying to jets
- Rule out masses below 500 GeV
- Find our expected signal and background as a function of mass



https://en.wikipedia.org/wiki/Color_confinement

DATA IN HIGH ENERGY PHYSICS $N = L * \sigma$ Luminosity: Cross-section; Number Amount of how likely of Events something Data (b^{-1}) to happen (b)

 $Barn = 10^{-28} m^2$



PREVIOUS WORK DONE

- Probability of producing the particle decreases as mass increases
- Singlet- no neutrino for the τ'
- Doublet- neutrino's for both
- Greater than 100 GeV (1990)



N. Kumar and S. Martin. "Vector-like Leptons at the Large Hadron Collider," *Cornell University Library*.



SIGNIFICANCE (Z)

- Measured in standard deviations
- Corresponds to how likely the measured signal is actually there
- ► 3 ways to increase it
 - Increase signal relative to background
 - Increase total data taken
 - Decrease uncertainty on background
- ► Z = 2:95% confidence level (CL)
- ► Z = 3: evidence
- ► Z = 5: discovery



BOOSTED DECISION TREE (BDT)

- Machine learning technique
- Shown both background and signal events
- Several variables are weighted and evaluated
- Program then assigns a score to events based on how likely something is to be signal

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OUR BDT

- Looks at:
 - Mass
 - Flavor
 - Transverse momentum (PT)
 - Charge
 - Hadronic E/EM E
 - Δη
 - Δφ
 - # of Jets
 - Time component
- Trained for the 500 GeV mass point

TMVA overtraining check for classifier: BDTG





CUTS

- Throwing out events based on criteria
- Allows us to raise signal relative to background
- ▶ Jet cuts- at least 1 jet
- Distance cuts- jets must be at least a certain distance apart
- B-jet cuts- at least 4 b-jets
- BDT cut- BDT score for the jet must be above a certain threshold

Significance v. TP Mass R4



MOVING FORWARD

Apply techniques used here to lepton-based searches

Much lower backgrounds allow more sensitivity

Refine cuts to optimize significances at higher mass points

▶ Try to set a 95% CL beyond the 500 GeV mass point

QUESTIONS?