USING MACHINE LEARNING TO SEARCH FOR MSSM HIGGS BOSONS

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Introduction

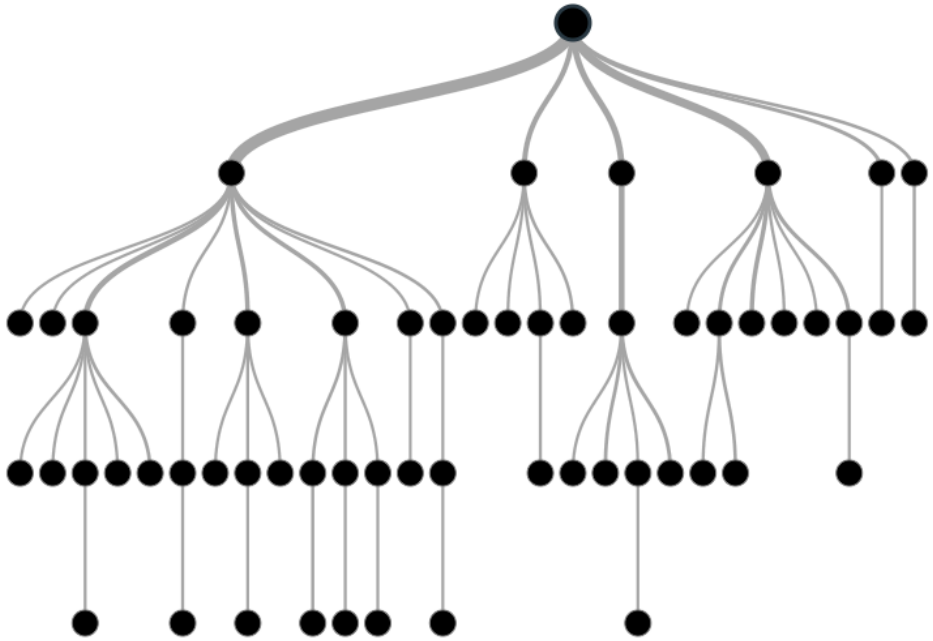
- Working with the CMS collaboration
- Focus on MSSM Higgs to Tau Tau decays
- Using simulated data to evaluate sensitivity to multiple MSSM Higgs masses

How does machine learning perform relative to typical cuts?

How can we use this information to improve the analysis?

Boosted Decision Trees

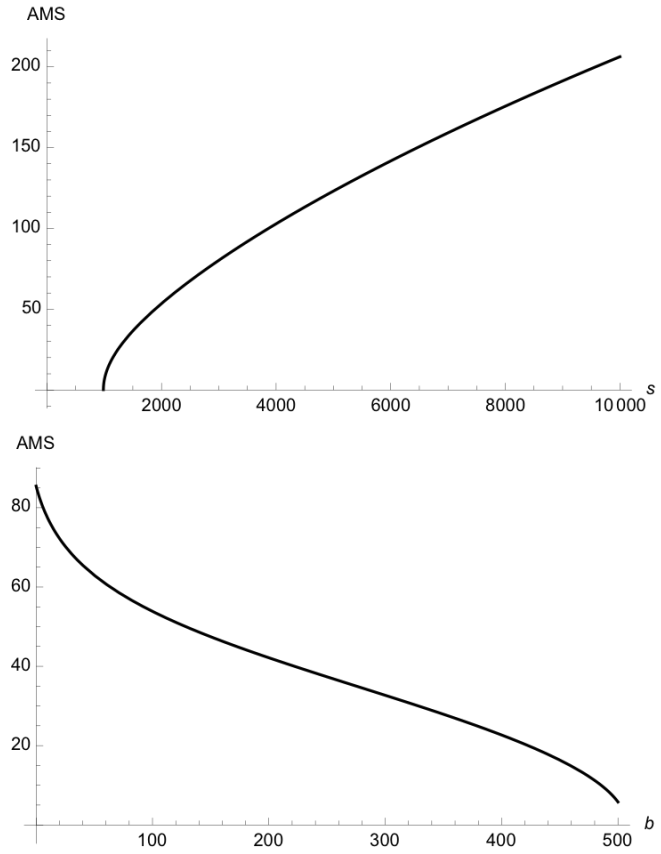
- Two algorithms to optimize:
  - *scikit-learn*
  - *XG Boost*
- XG Boost tends to perform slightly better.



Evaluating Performance:
AMS

$$AMS = \sqrt{2((s + b + b_r)\log\left(\frac{s}{b + b_r}\right) - s)}$$

- s = true positive rate
- b = false positive rate
- b_r = regularization term (set to 10)

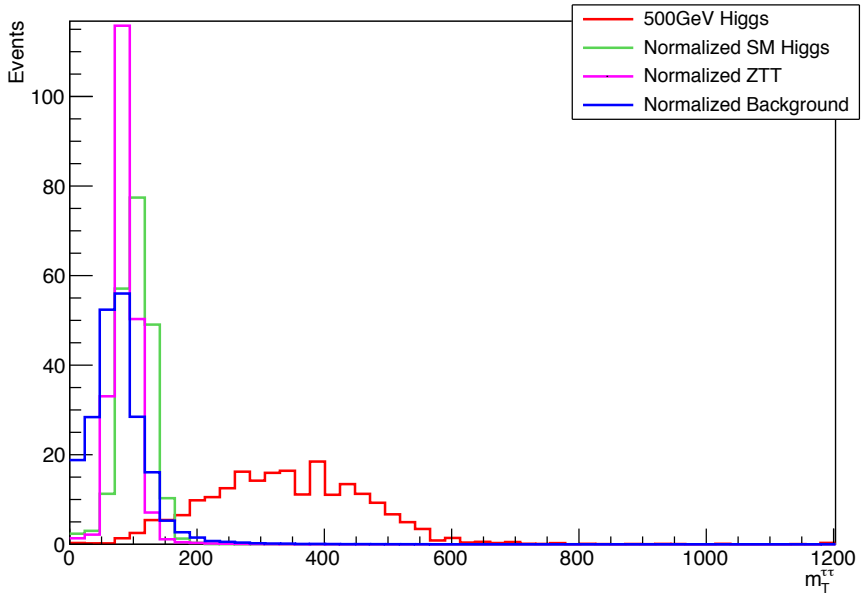


Training Variables

- m_T
- N jets
- me_T p_T
- p_T higgs
- VBF m_{jj}
- VBF deta
- VBF N central
- L2 p_T
- L1 p_T
- SVFIT mass
- SVFIT transverse mass
- delta phi L1 L2
- delta eta L1 L2
- m_T leg 2
- delta phi L2 me_T
- delta phi L1 me_T
- m_{vis}
- m_T total

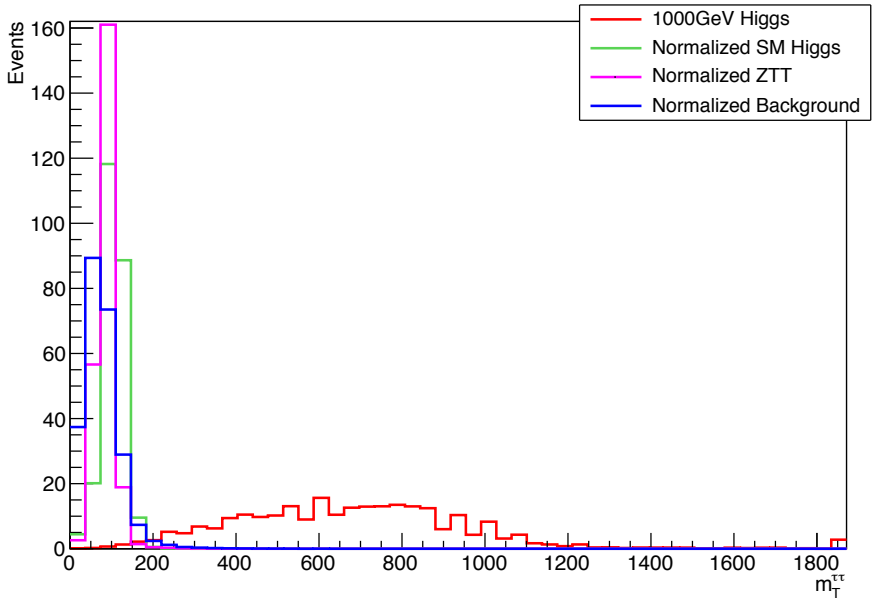
Simple Cuts:
SVFIT Transverse Mass

500 GeV Higgs



AMS: **3.40** (310 GeV)
AMS w/ m_T < 40 cut: **4.11** (310 GeV)

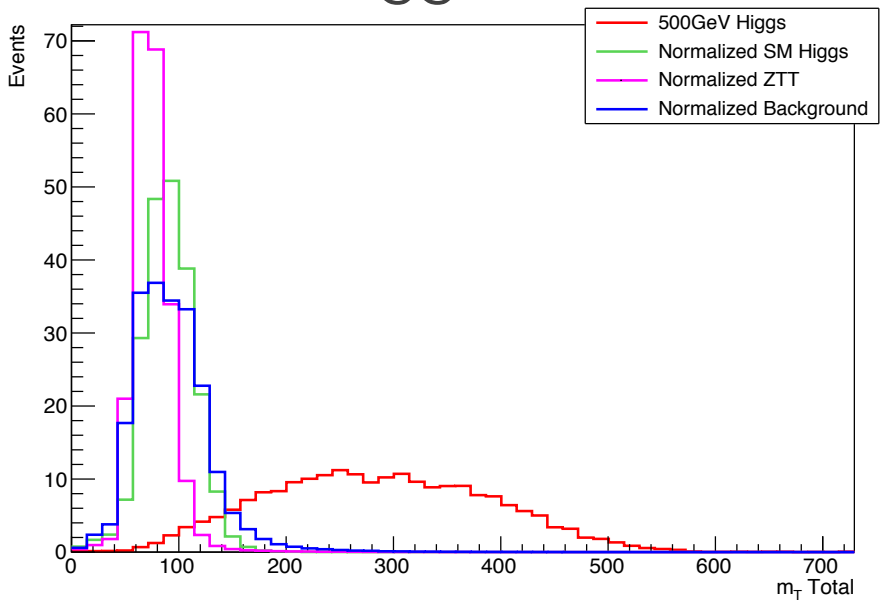
1000 GeV Higgs



AMS: **3.33** (540 GeV)
AMS w/ m_T < 40 cut: **2.69** (410 GeV)

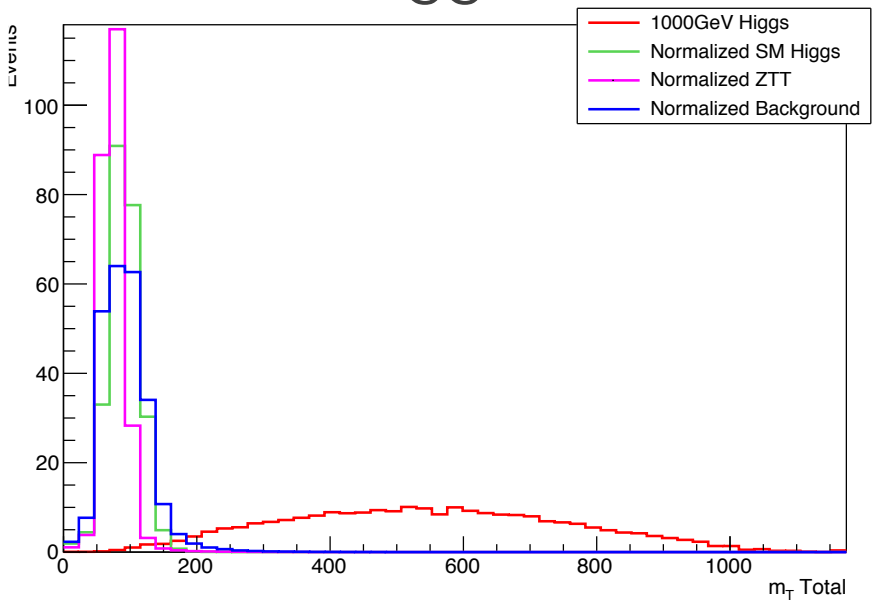
Simple Cuts:
m_T total

500 GeV Higgs



AMS: **3.15** (290 GeV)
AMS with $m_T < 40$ cut: **4.01** (280 GeV)

1000 GeV Higgs



AMS: **3.56** (450 GeV)
AMS with $m_T < 40$ cut: **2.72** (390 GeV)

MVA Results:
Full 18 Variable Training

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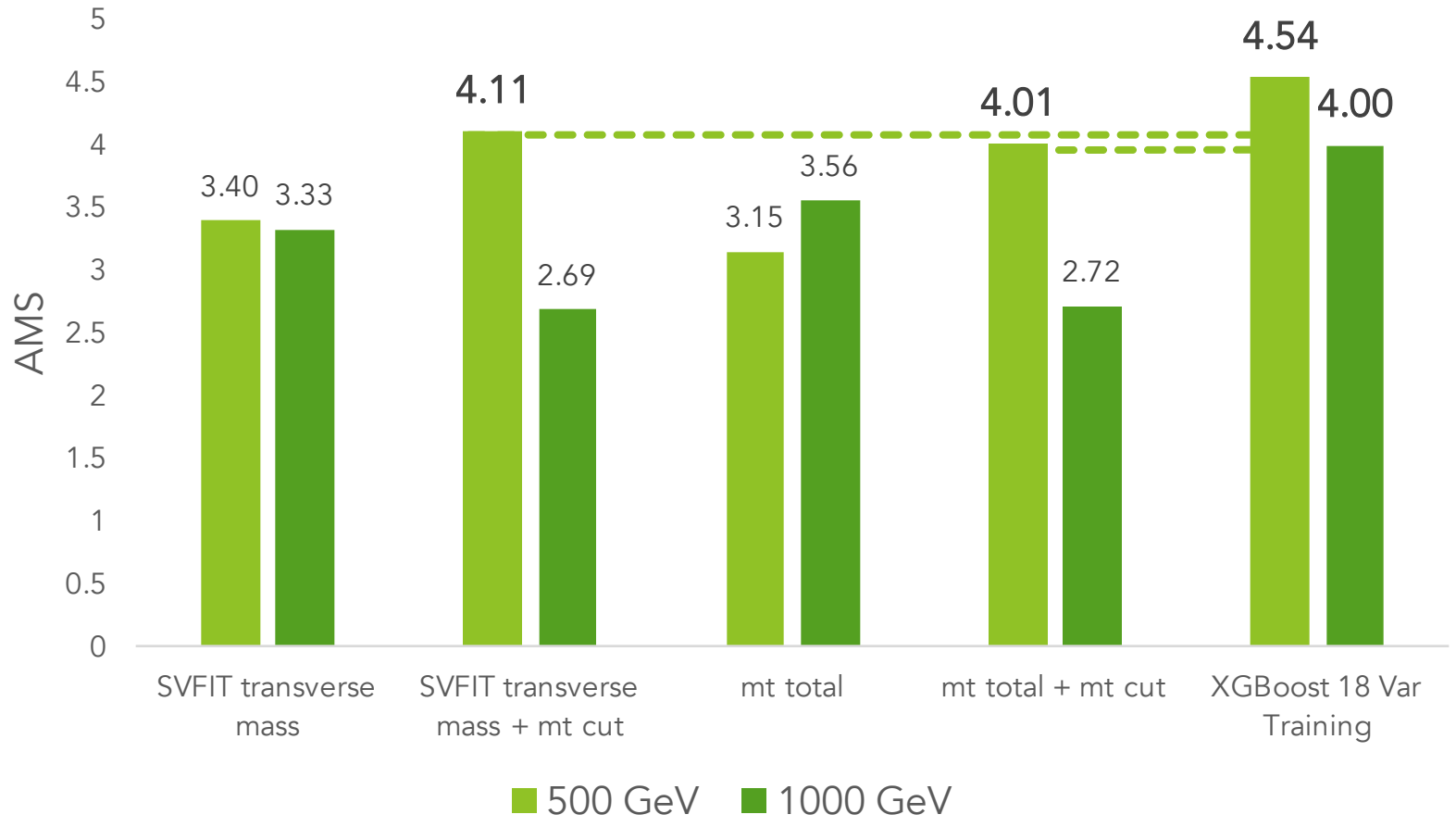
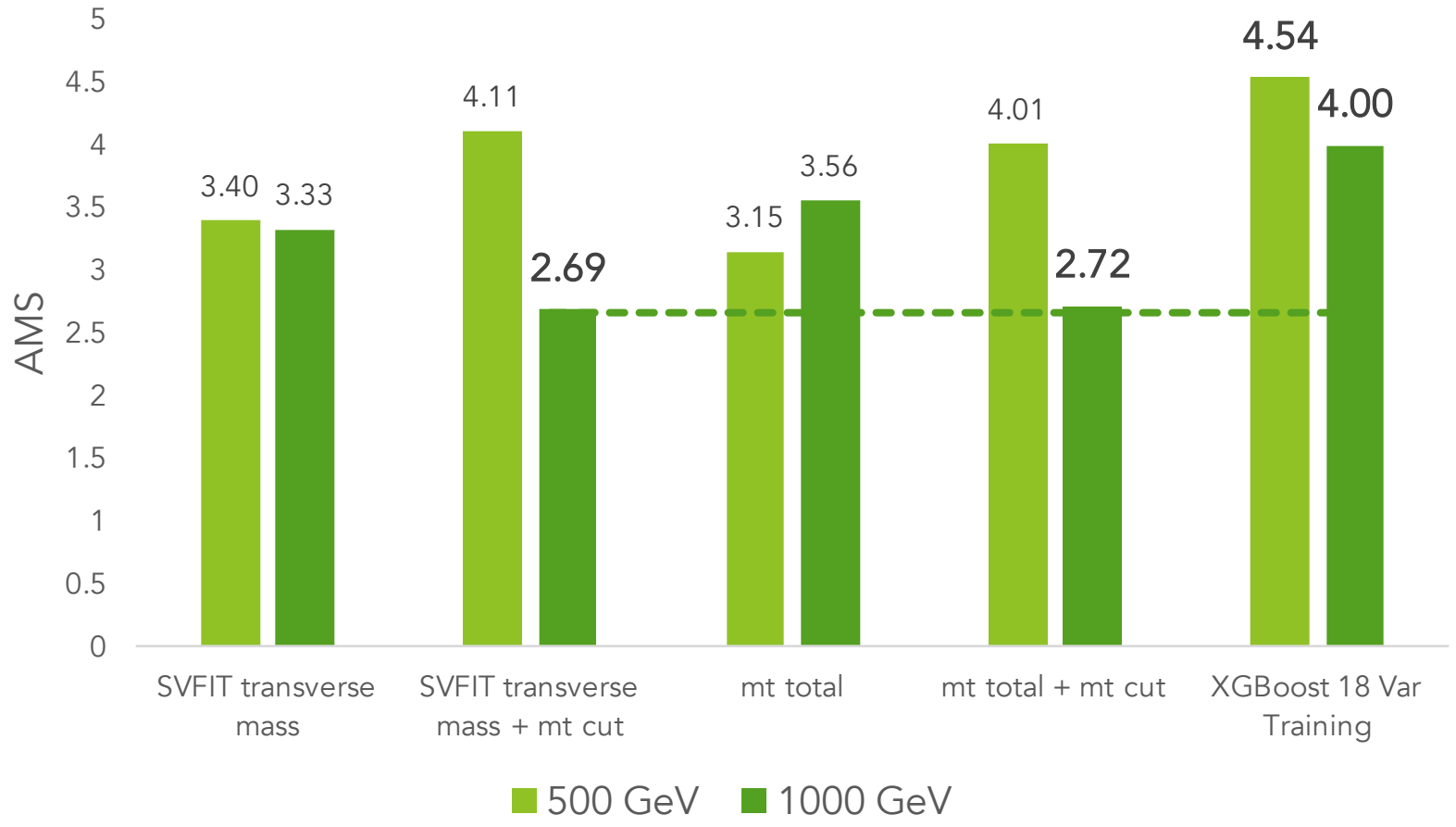
Full 18 Variable Training



m_T < 40 GeV cut performs well for 500 GeV Higgs

MVA Results:
Full 18 Variable Training

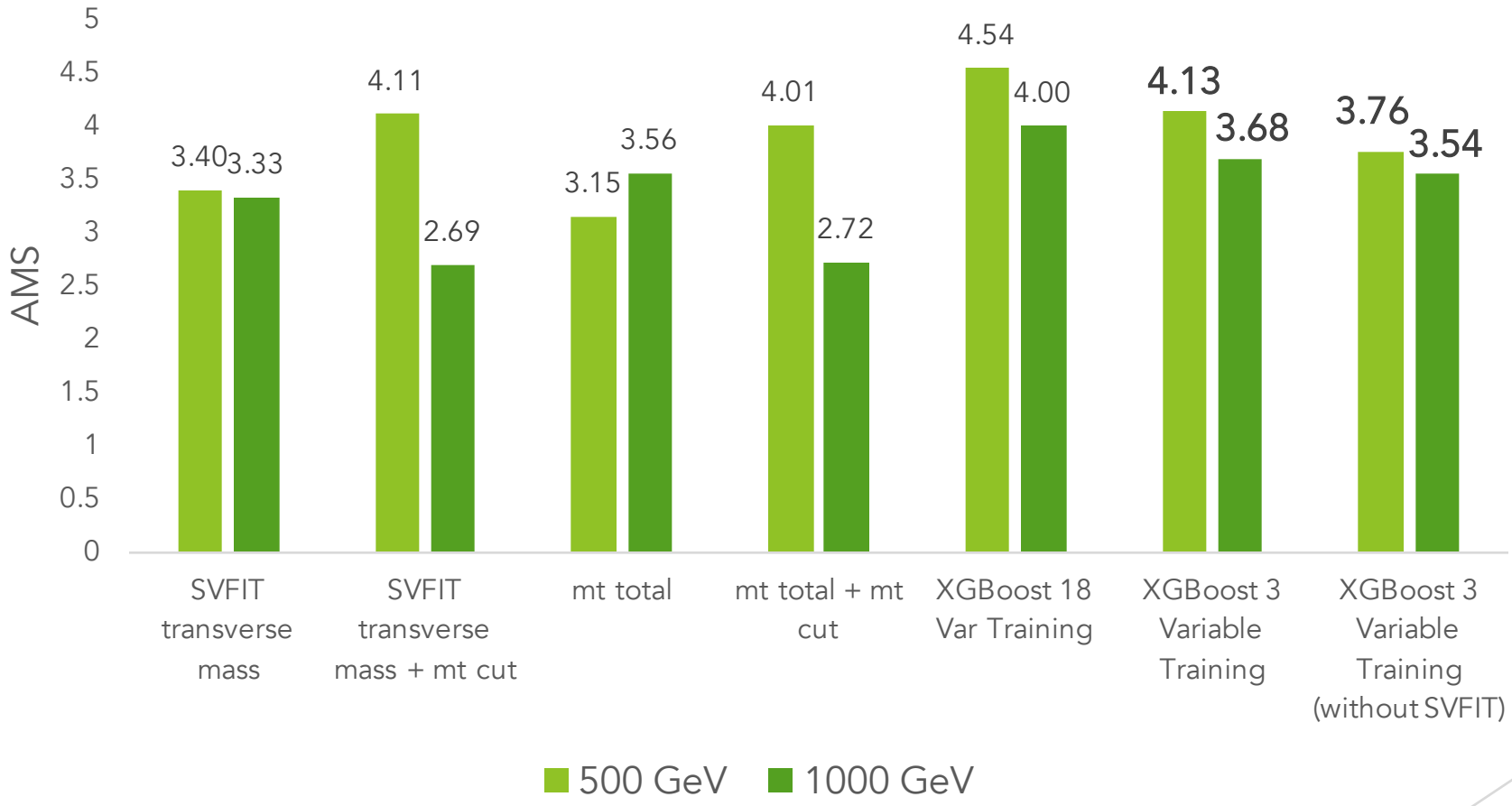


m_T < 40 GeV cut performs poorly for 1000 GeV Higgs

MVA Results
3 Variable Training

- Tested ~100 combinations of three training variables to find those that performed best
- Best combination: **m_T, L2 p_T, SVFIT mass**
- Best combination without an SVFIT variable: **m_T, m_{vis}, m_T total**

MVA Results
3 Variable Training



Summary

500 GeV Higgs

- Full 18 variable training performs better than cuts
- Three variable trainings perform comparably to a cut on SVFIT transverse mass with a cut on m_T
- Cuts on m_T tend to improve sensitivity

1000 GeV Higgs

- Full 18 variable training performs better than cuts
- Three variable trainings perform comparably to a single cut on m_T total
- Cuts on m_T consistently worsen sensitivity

How can we use this information to improve the analysis?

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