



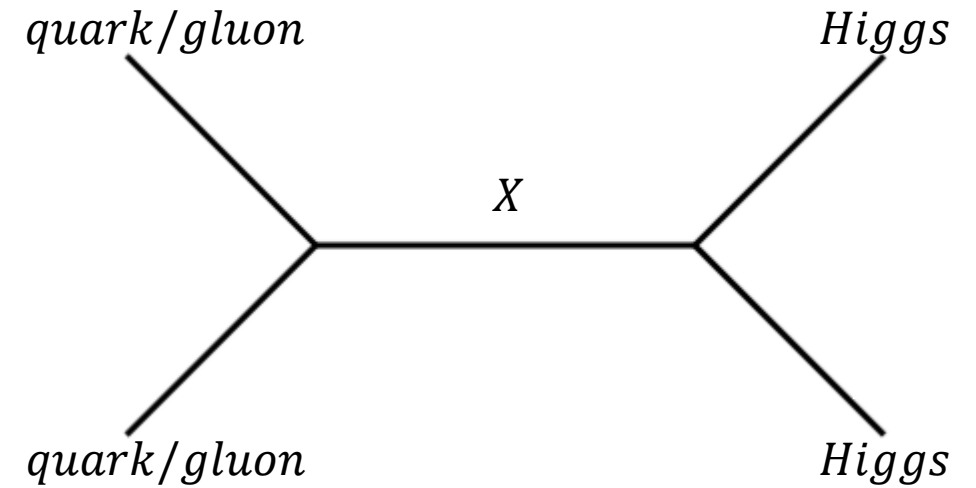
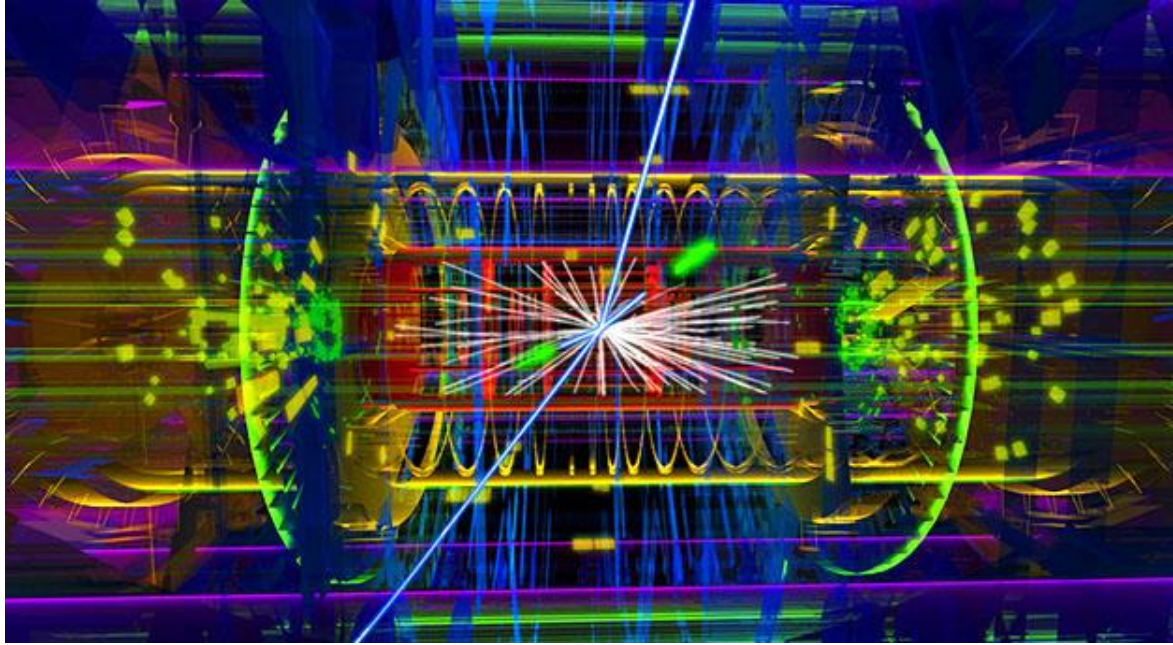
# Search for Radion/Graviton $\rightarrow$ 2H $\rightarrow$ 4b Decays in 2 and 3 Jet Events

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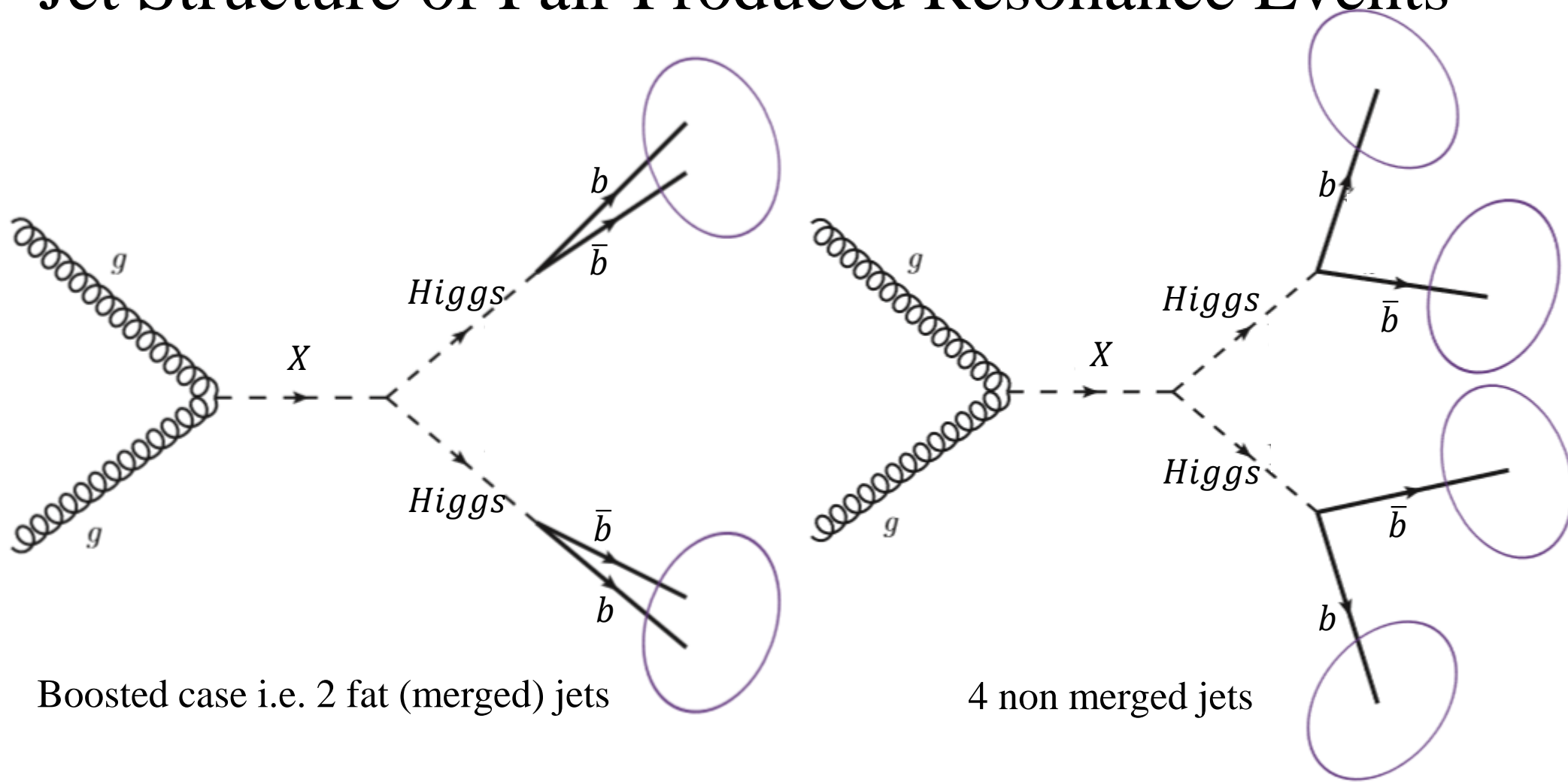


# Search for Physics Beyond the SM



- Candidates for the heavy resonance  $X$  are the Radion ( $S=0$ ), the massive Kaluza Klein theory Graviton ( $S=2$ ) etc.
- Challenge in these searches posed by large QCD multijet background
- Develop techniques for distinguishing pair produced resonance events from the background

# Jet Structure of Pair Produced Resonance Events



Boosted case i.e. 2 fat (merged) jets

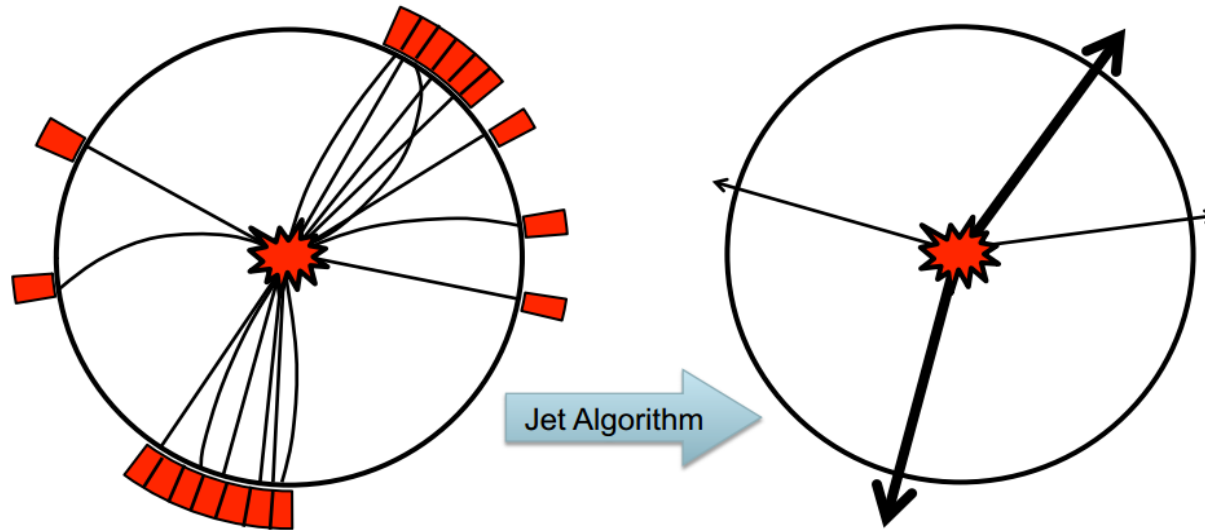
4 non merged jets

✚ Intermediate case with 3 jets

- Jet number is specified by the dimensionless boost factor  $r_M = \frac{M_x}{2M_{Higgs}}$

# Jet Reconstruction Algorithms

- Why are they useful?



Before: Complicated Event  
with many particles

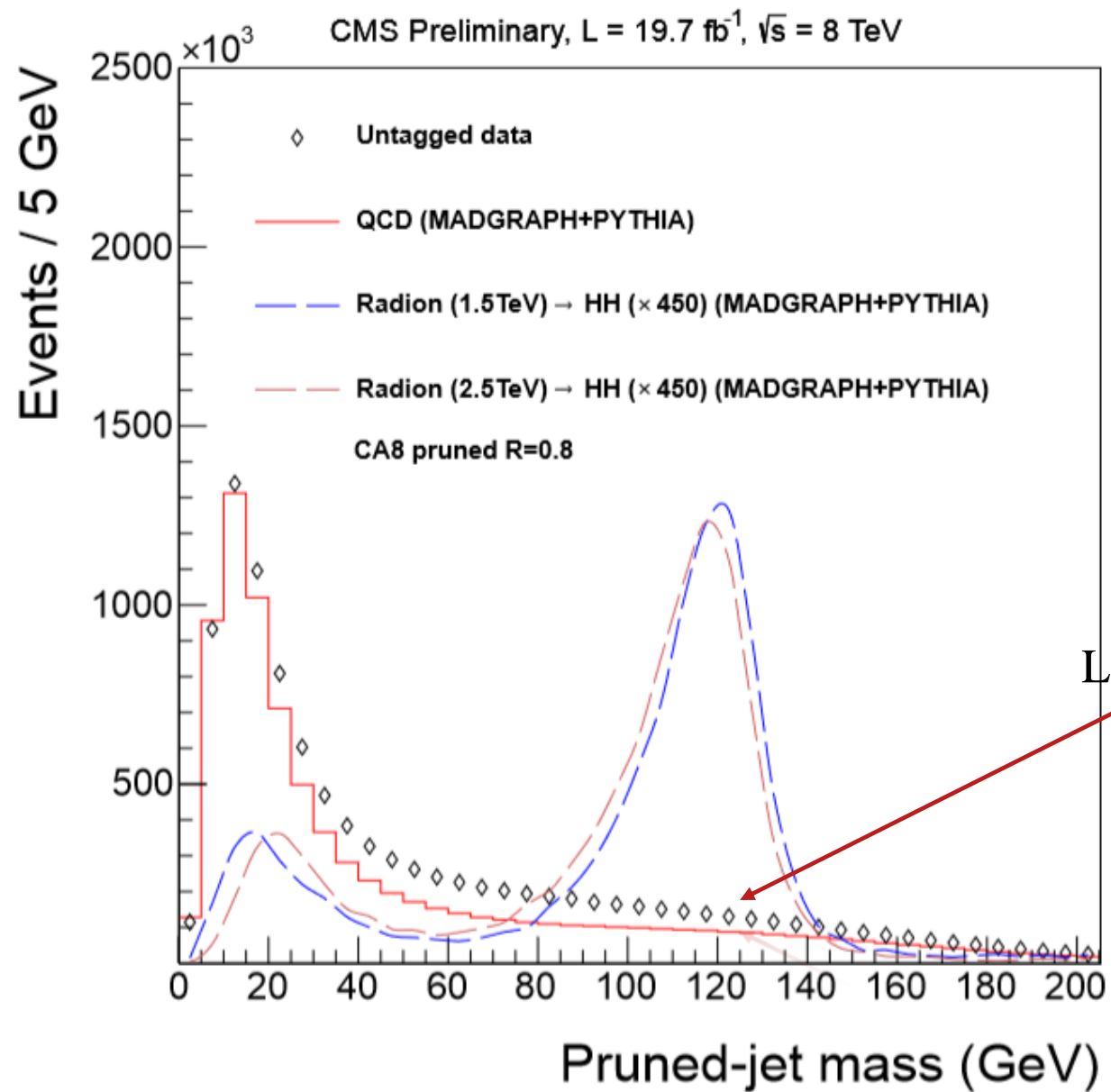
After: Multijet structure  
easily identifiable

- Propose algorithm for smooth interpolation between boosted ( $r_M \rightarrow \infty$ ) and fully resolved ( $r_M \ll 1$ ) regimes
- Cambridge Aachen (CA) algorithm used for fat jets and Anti  $k_T$  (AK) algorithm used for non merged jets

# Some Useful Definitions

- $\eta$ : Pseudorapidity defined by  $\eta = -\ln \left[ \tan \left( \frac{\theta}{2} \right) \right]$  where  $\theta$  is the angle between the jet axis and the beam axis
- $R$ : jet radius in pseudorapidity-azimuthal angle plane;  $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$
- CA8 jet: fat jet reconstructed using the Cambridge Aachen Algorithm with  $R = 0.8$
- AK5 jet: non fat jet reconstructed using the Anti  $k_T$  Algorithm with  $R = 0.5$
- CSV: Combined Secondary Vertex reconstructed by detectors associated with large lifetimes of  $b$  quarks (crucial in signal/background distinction)
- Jet Pruning: Lowest  $p_T$  (soft) particles are removed from the jet
- Higgs Mass Tagged 2 AK5 jets:  $M_{invariant} \in [110,150] GeV$
- Higgs Mass Tagged 2 pruned AK5 jets:  $M_{invariant} \in [100,135] GeV$

# Importance of pruning for background elimination





# 2 and 3 Jet Signal Distinction from Background

Select events with more than 1 fat CA8 jet

Check for 2 jet signal events

Look for highest  $p_T$  pruned AK5 jet pointing away from the CA8 jet ( $\Delta\phi > 90^\circ$ )

Look for highest  $p_T$  pruned AK5 jet pointing inside a cone with  $\Delta R < 1.3$  around the first AK5 jet

Look for highest  $p_T$  AK5 jet pointing inside a cone with  $\Delta R < 1.3$  around the first AK5 jet

If there is exactly 1 Higgs mass tagged CA8 jet

Look for highest  $p_T$  AK5 jet pointing away from the CA8 jet ( $\Delta\phi > 90^\circ$ )

Look for highest CSV discriminator AK5 jet pointing inside a cone with  $\Delta R < 1.3$  around the first AK5 jet

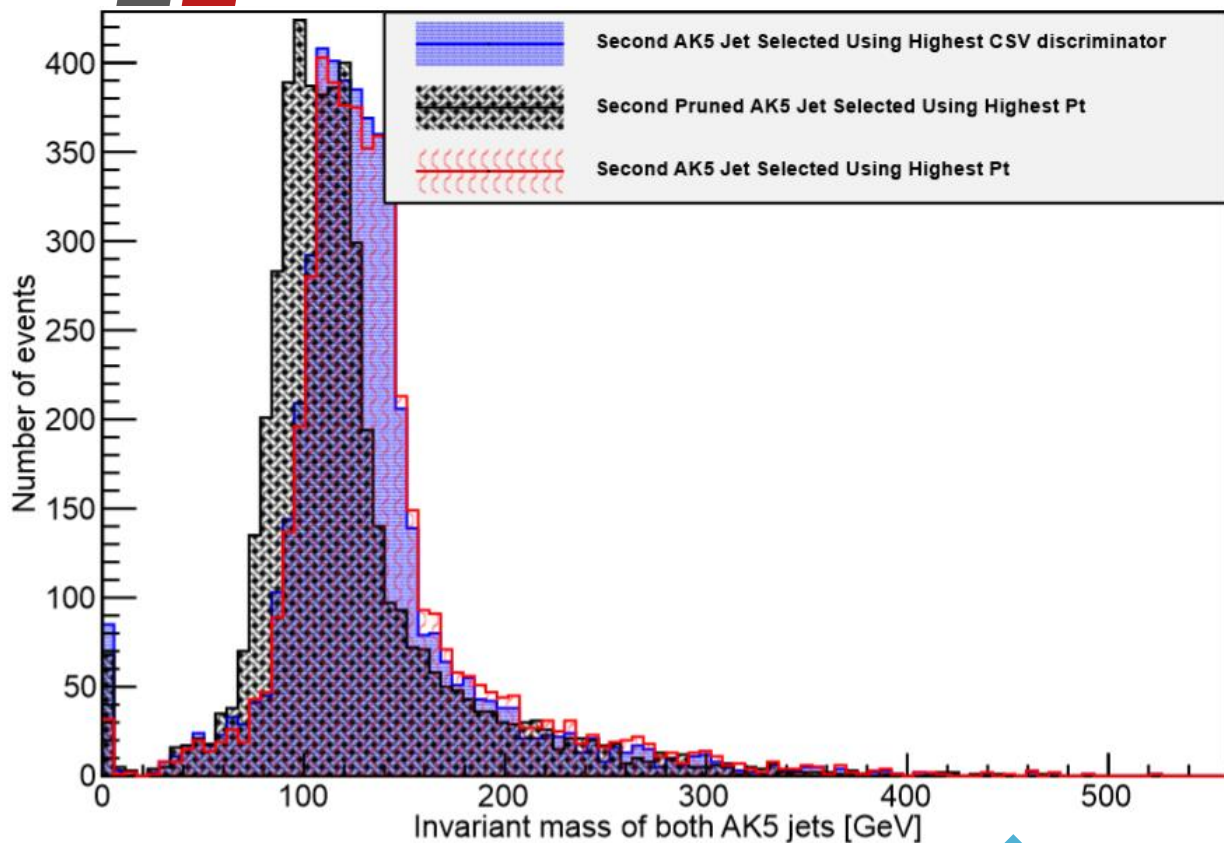
3 jet events are treated as signal only if their combined invariant mass is Higgs tagged!



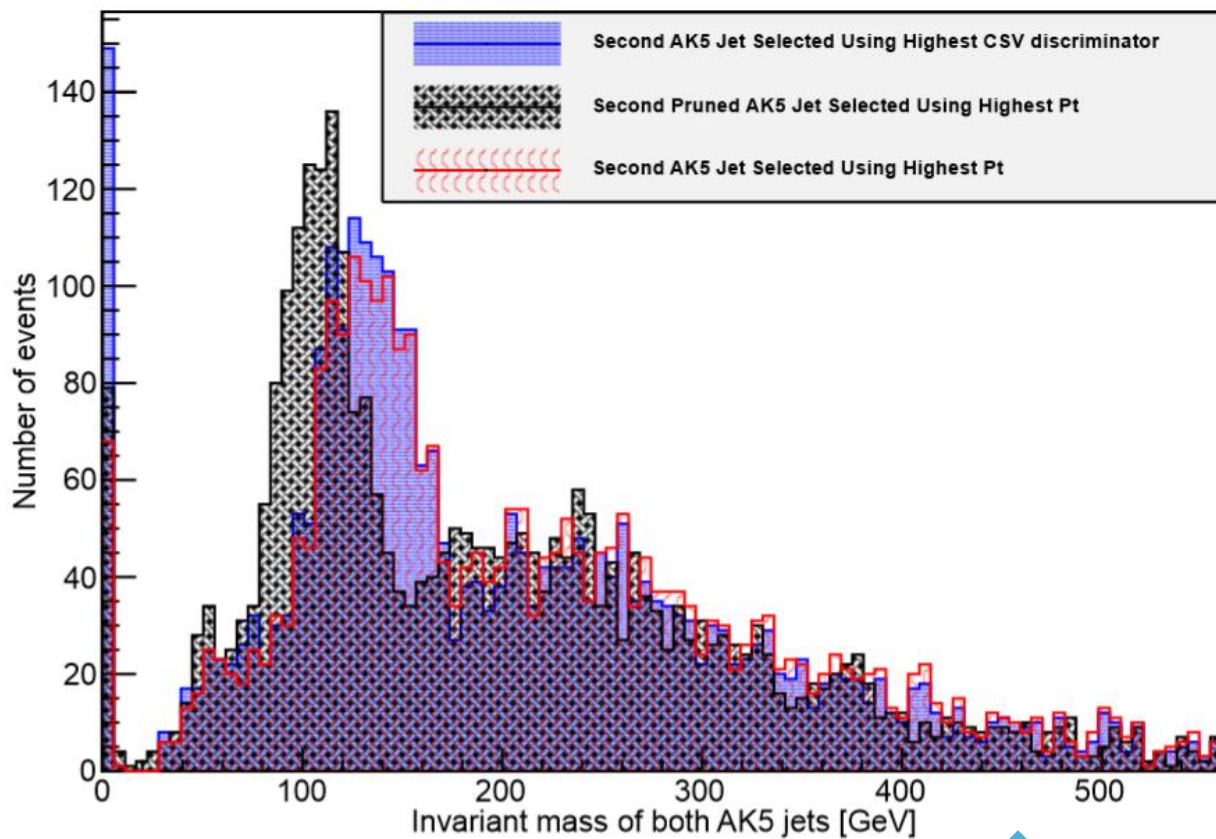


# Comparison of Different Jet Reconstruction Methods

Reconstructed Invariant Mass of Both AK5 Jets in 3 Jet Events with 1 Fat CA8 Higgs Mass Tagged Jet



1000 GeV Resonance Mass



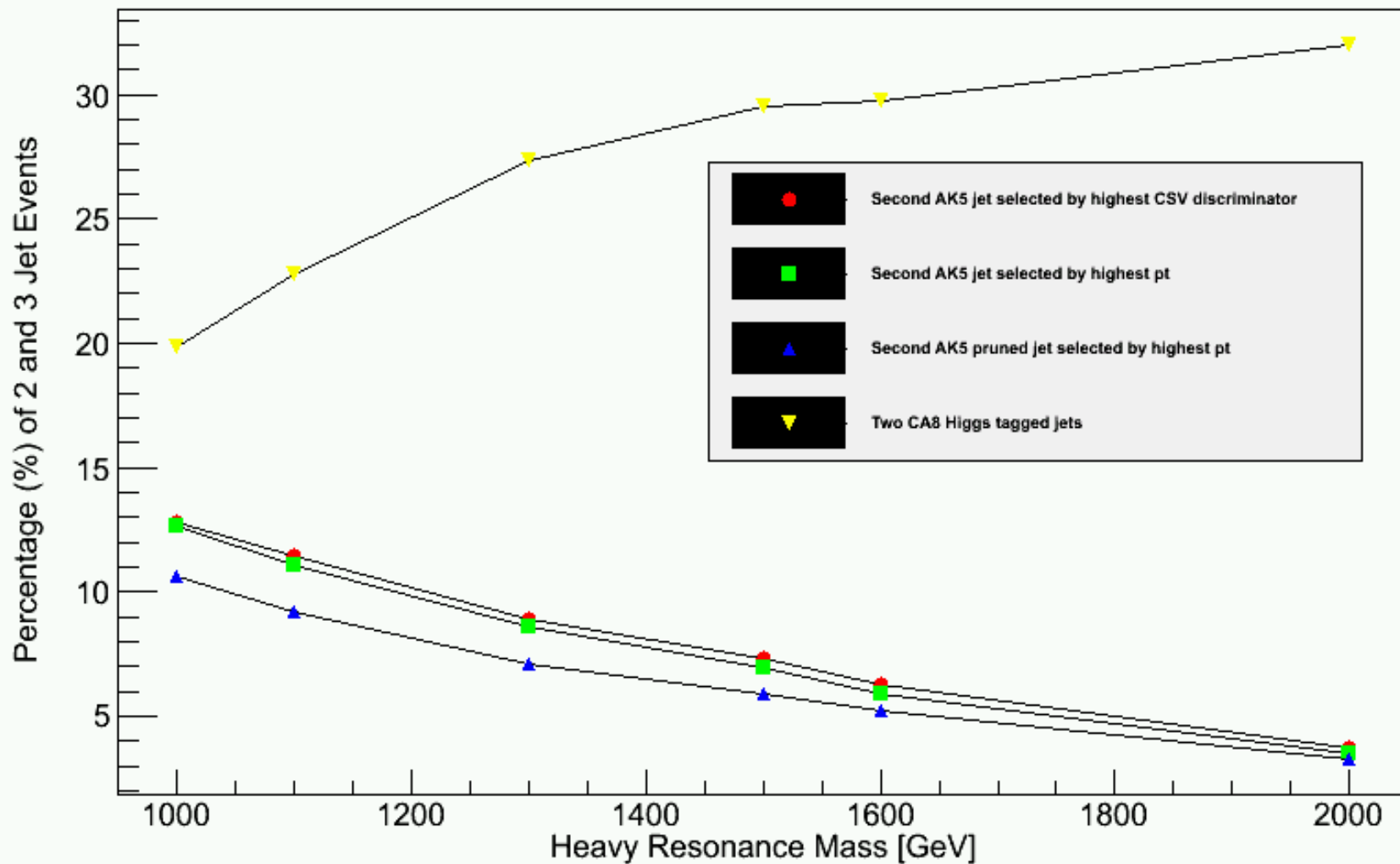
2000 GeV Resonance Mass





# Comparison of Different Jet Reconstruction Methods

Percentage of Reconstructed 2 and 3 Signal Jet Events as Function of Resonance Mass





# Summary and Outlook

- Characterize each of the 3 methods for 3 Jet Signal Reconstruction
- Finish  $b$  matching analysis by the end of next week
- Finish background analysis by the end of the last week
- Determine the most efficient method





Thank you for your attention!





## References

- [1] Gouzevitch, M., Oliveira, A., Rojo, J., Rosenfeld, R., Salam, G.P. and Sanz, V. (2013) ‘Scale-Invariant Resonance Tagging in Multijet Events and New Physics in Higgs Pair Production’, *Journal of High Energy Physics*
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