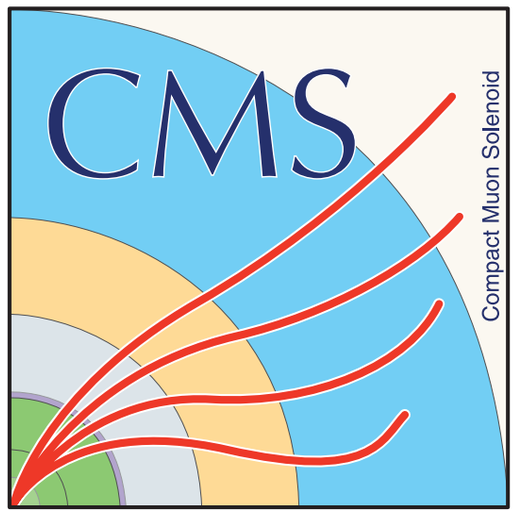
Tagging electroweak processes with machine learning

IIHE annual meeting

Hugues Evard, Andrea Malara, Laurent Thomas, Pascal Vanlaer

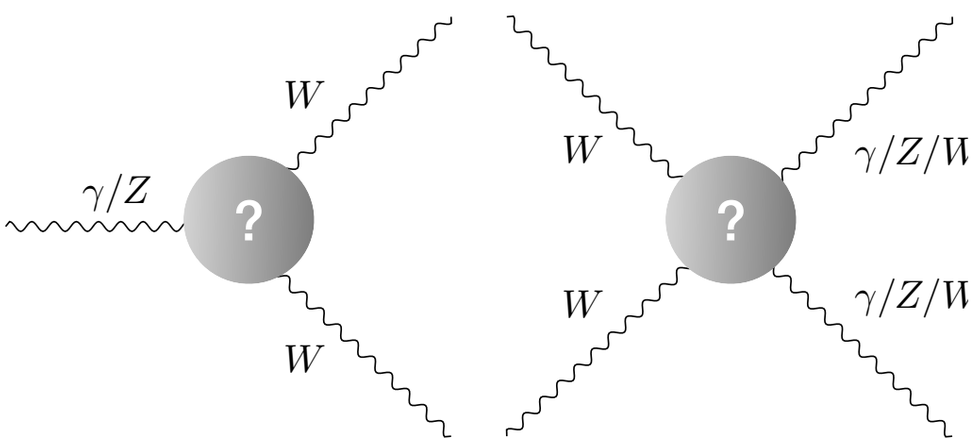
Université Libre de Bruxelles

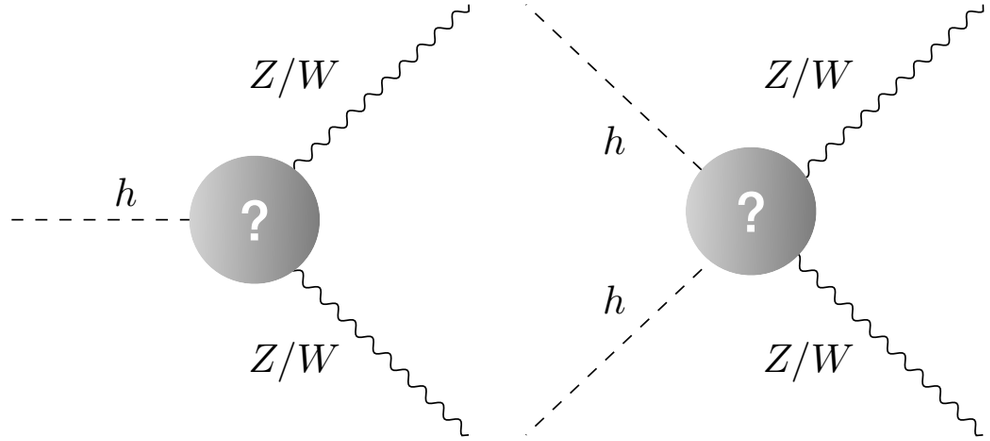
15 November 2023



Motivation for VBF/VBS measurements

- Probe multi-boson interactions, both in the Standard Model and beyond
  - trilinear and quartic gauge couplings
  - Higgs couplings with vector bosons
- Suppress background and study rare decays ($H \to \mu\mu$, $H \to invisible$)





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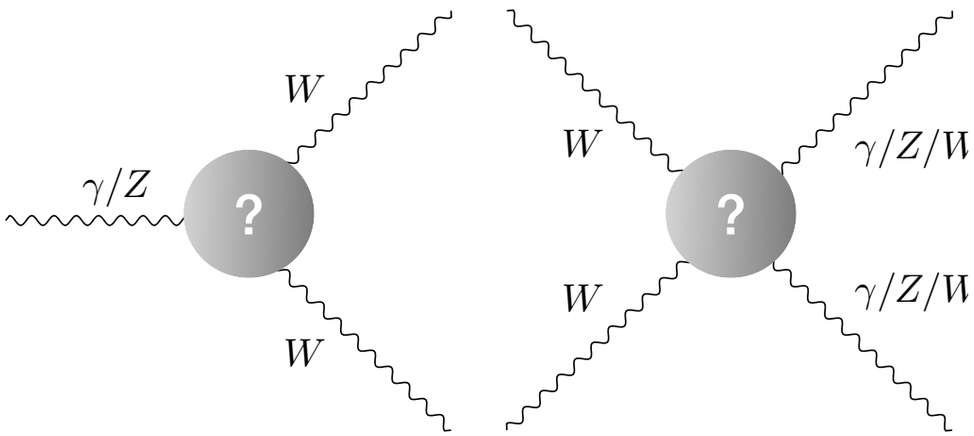
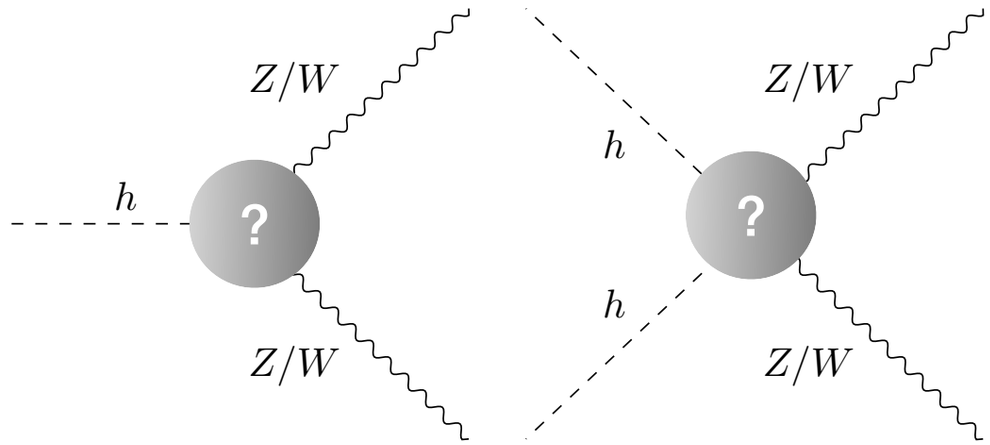
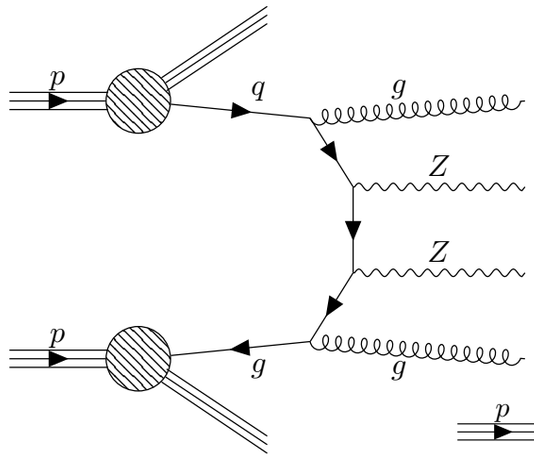
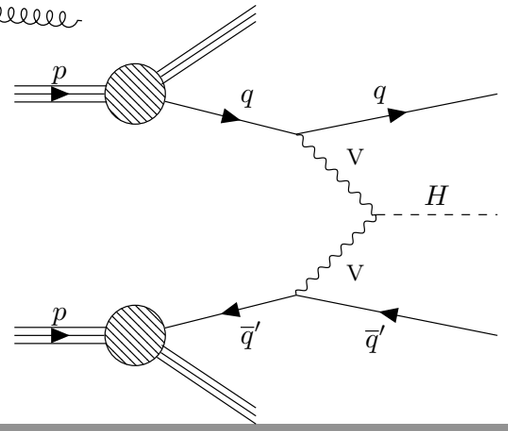




- At the LHC
  - Strong production (mix of α_s and α_{EW})
  - Electroweak production (powers of α_{EW})
- Measure of electroweak production:
  - Vector Boson Fusion (VBF)
  - Vector Boson Scattering (VBS)
  - Higgs and di-Higgs production



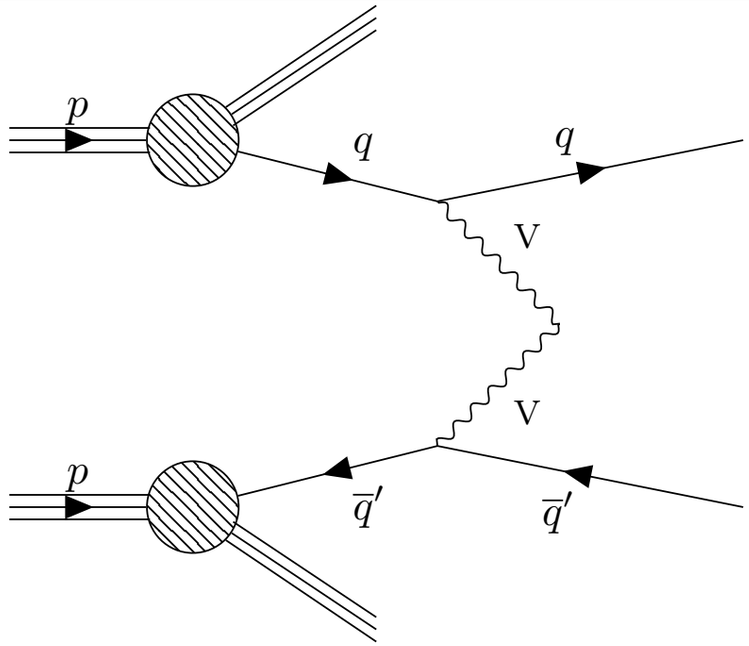
QCD ZZjj



VBF Higgs

Experimental signatures

- Characteristic signature:
  - 2 quarks (reconstructed as “jets”)



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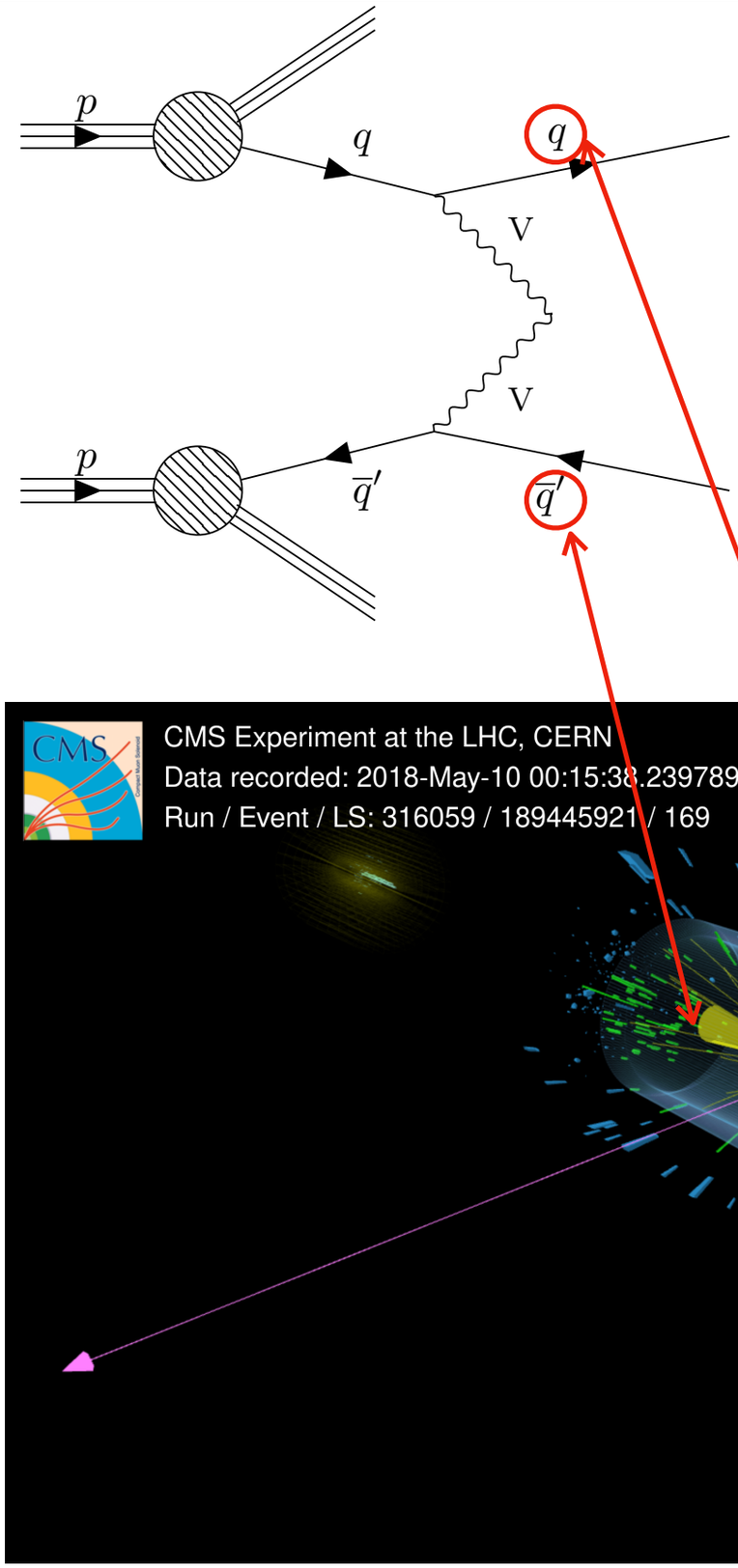

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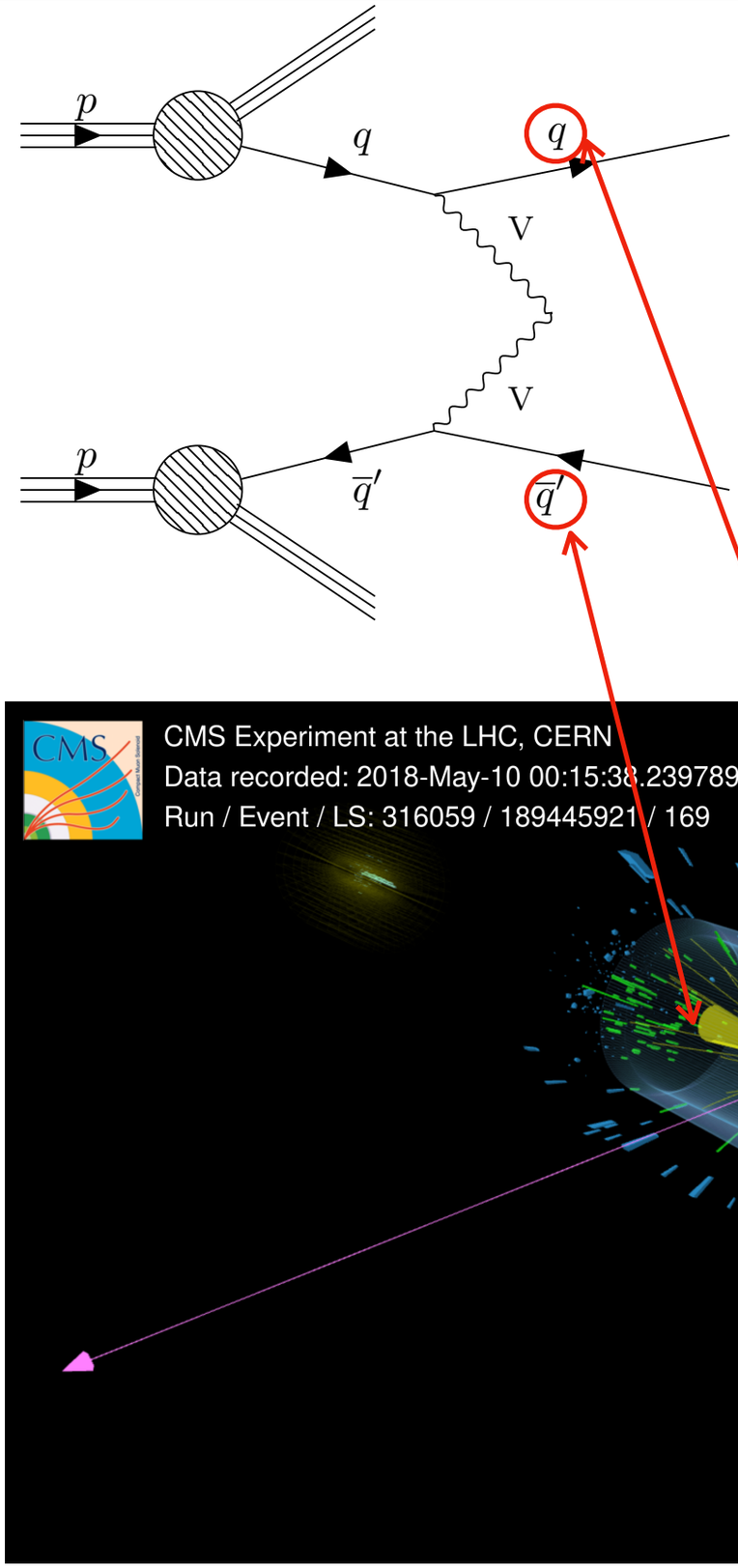
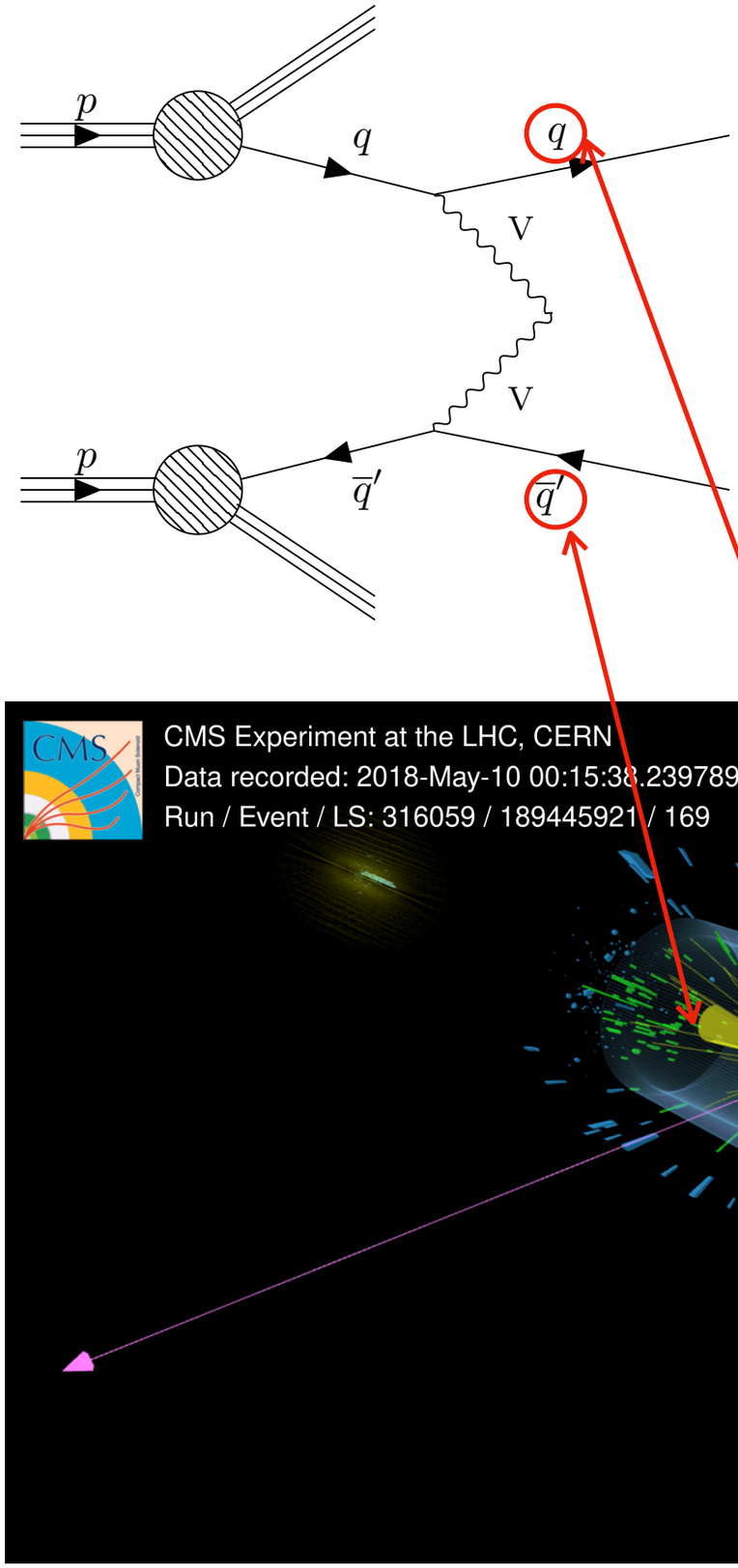
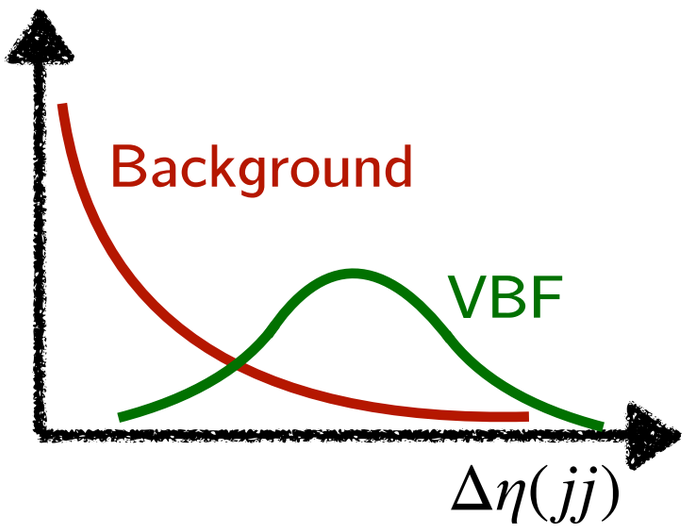
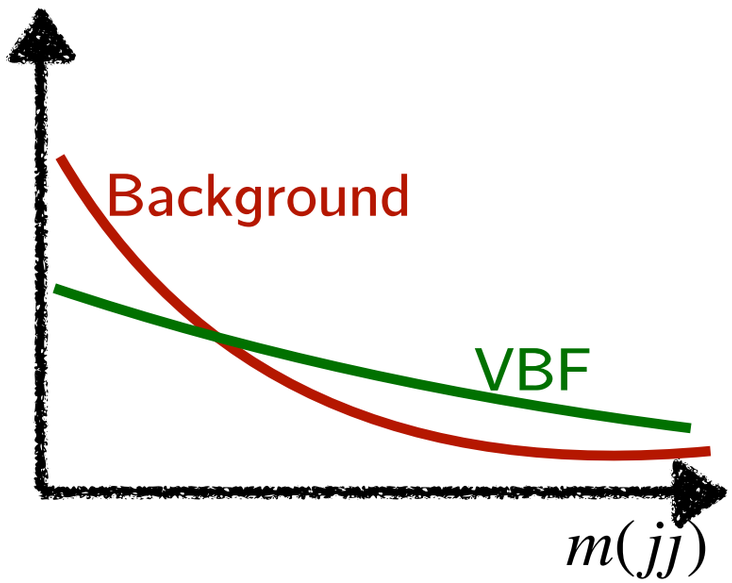


Experimental signatures

- Characteristic signature:
  - 2 quarks (reconstructed as “jets”)
  - large angular separation (“forward”)
  - large invariant mass

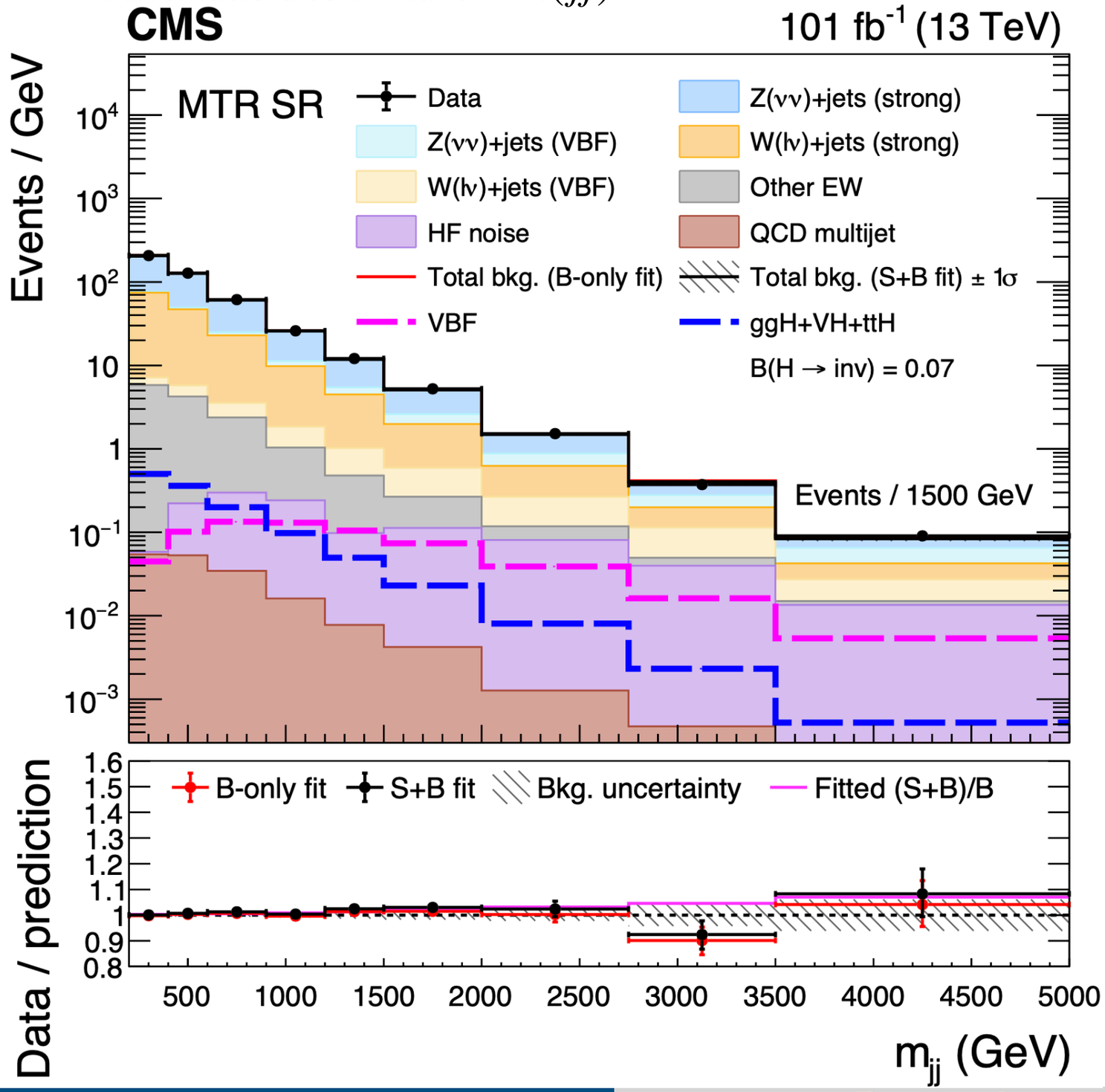






Experimental techniques

- Techniques:
  - Kinematic discriminant -- $m(jj)$



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- Techniques:
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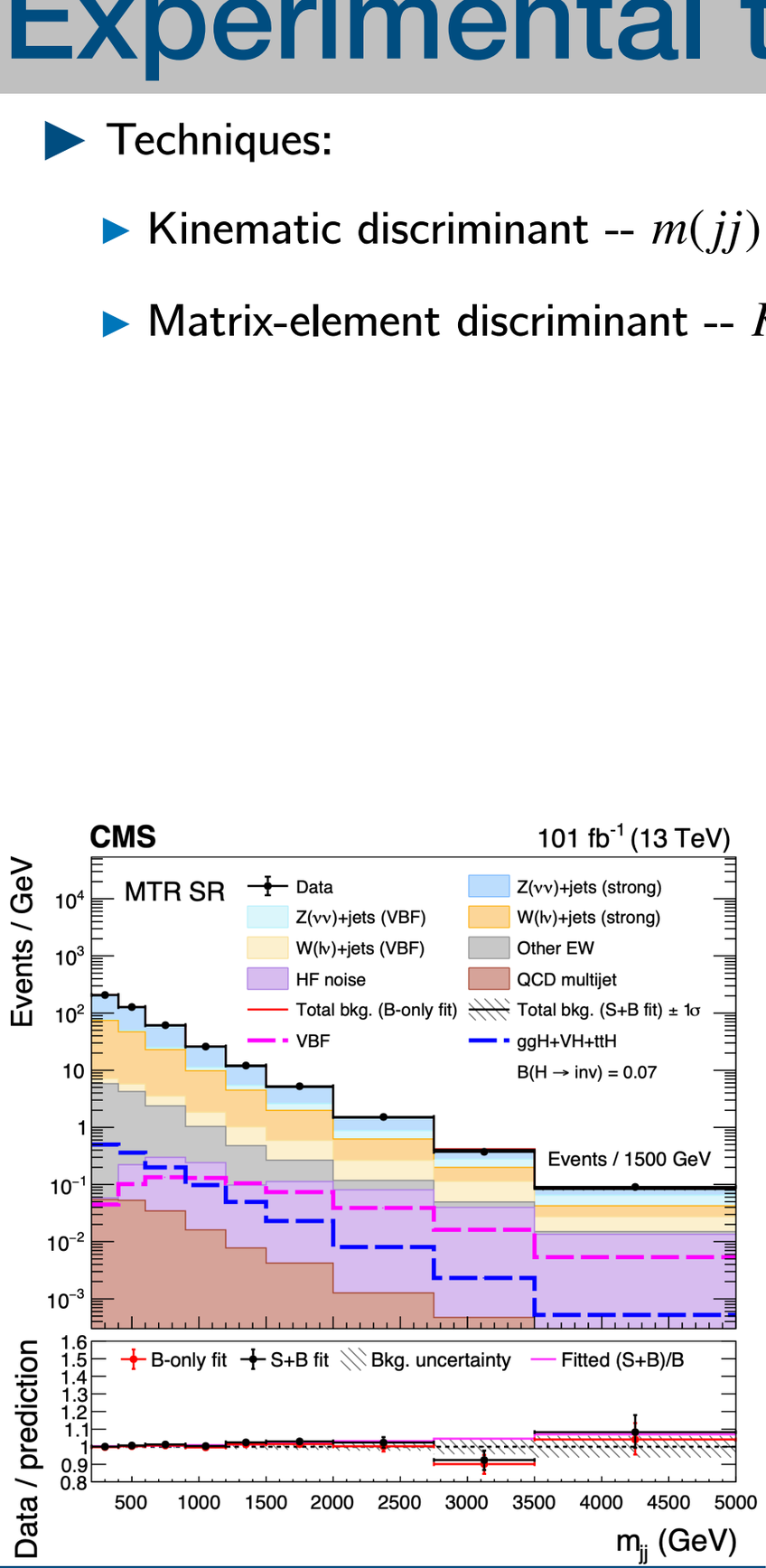

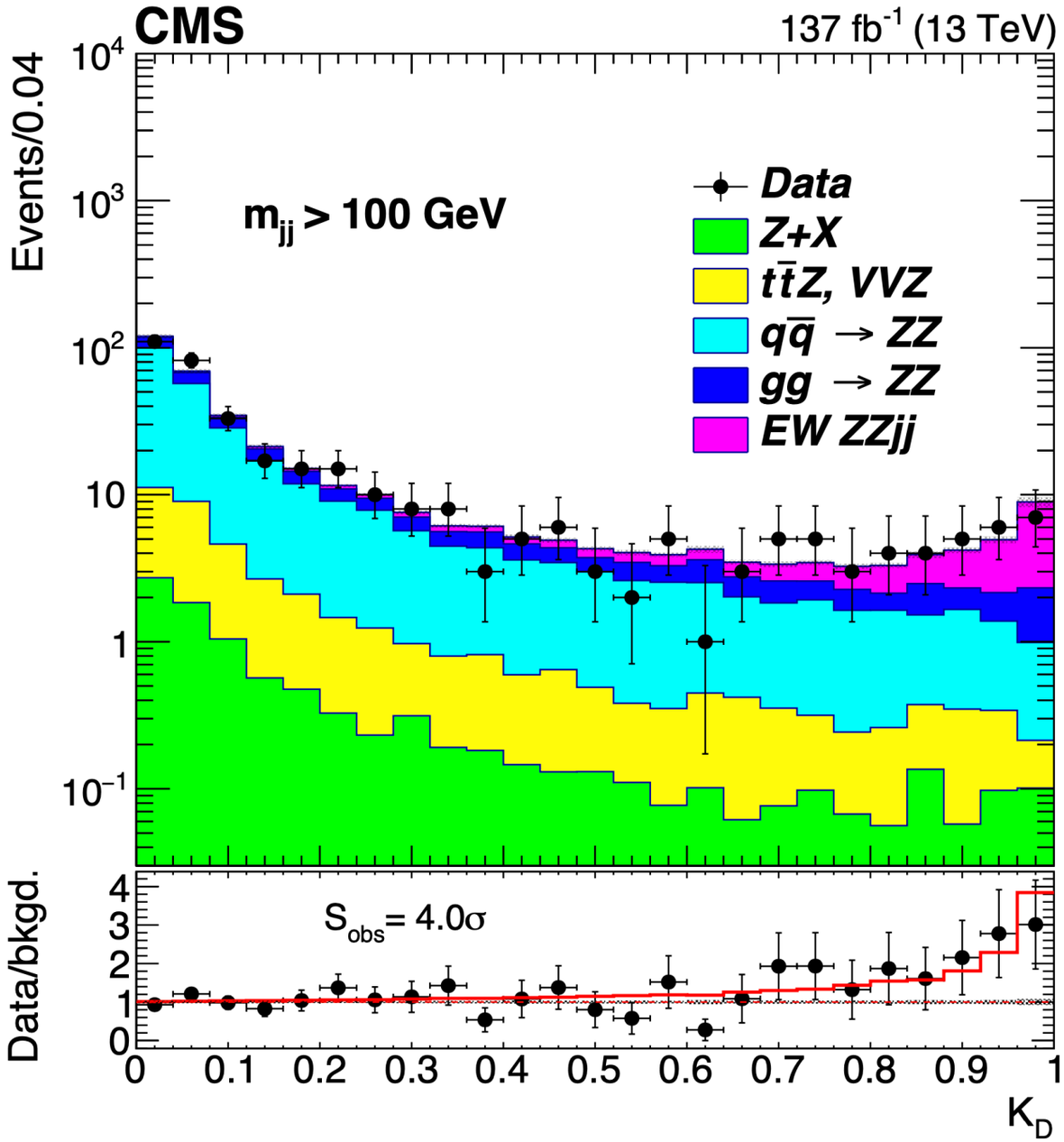

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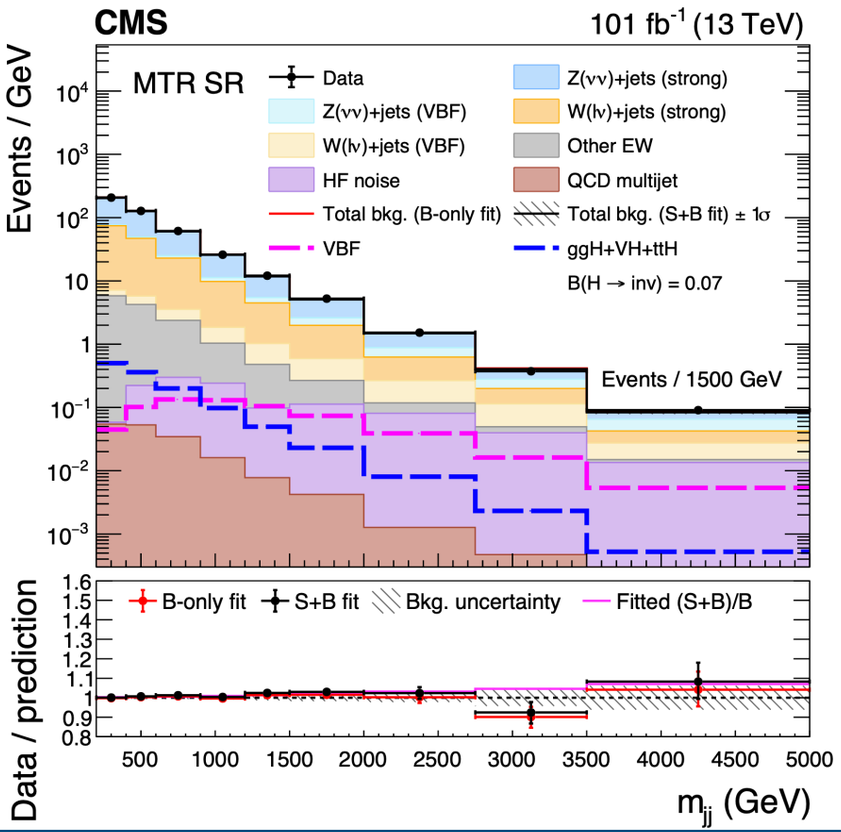

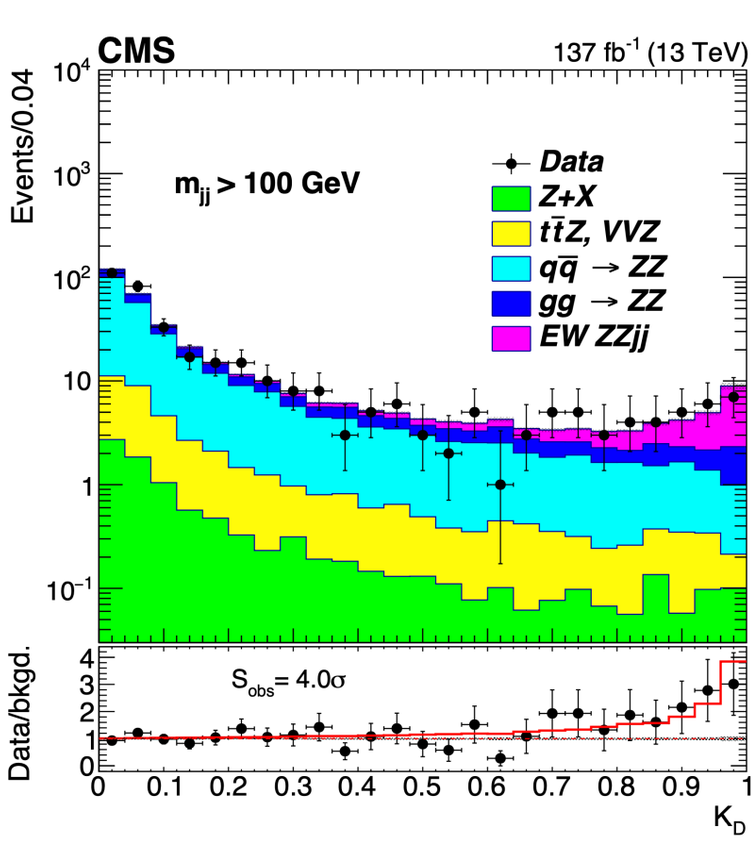

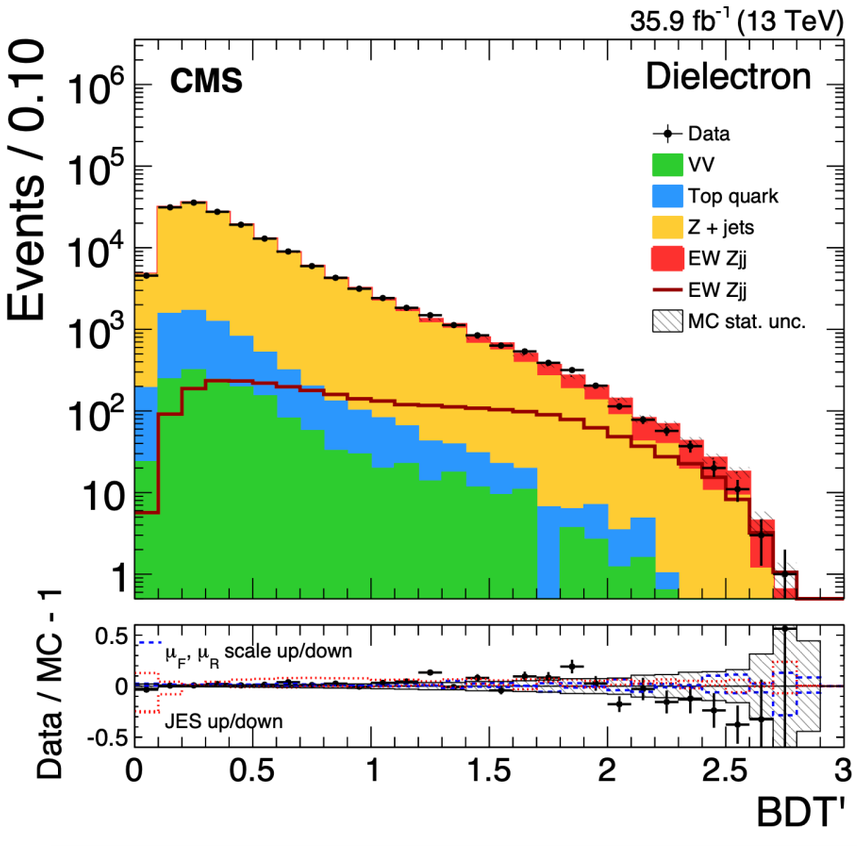

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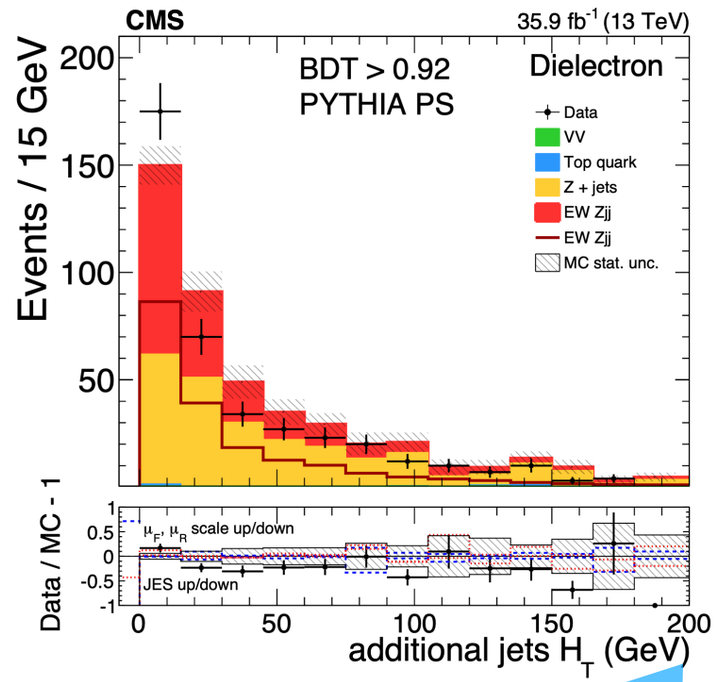

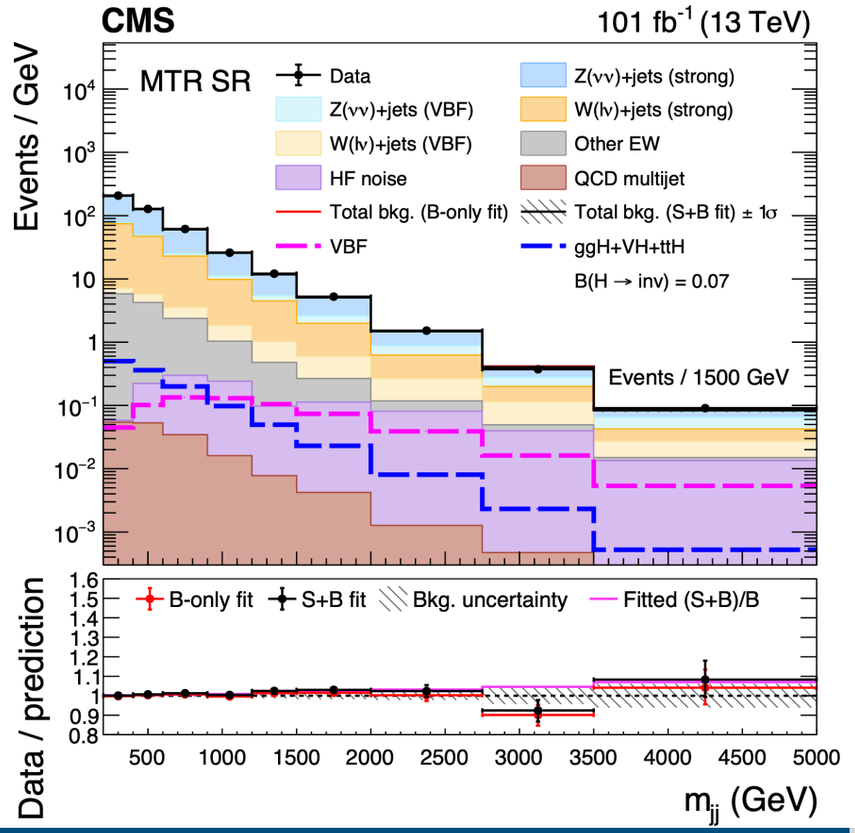

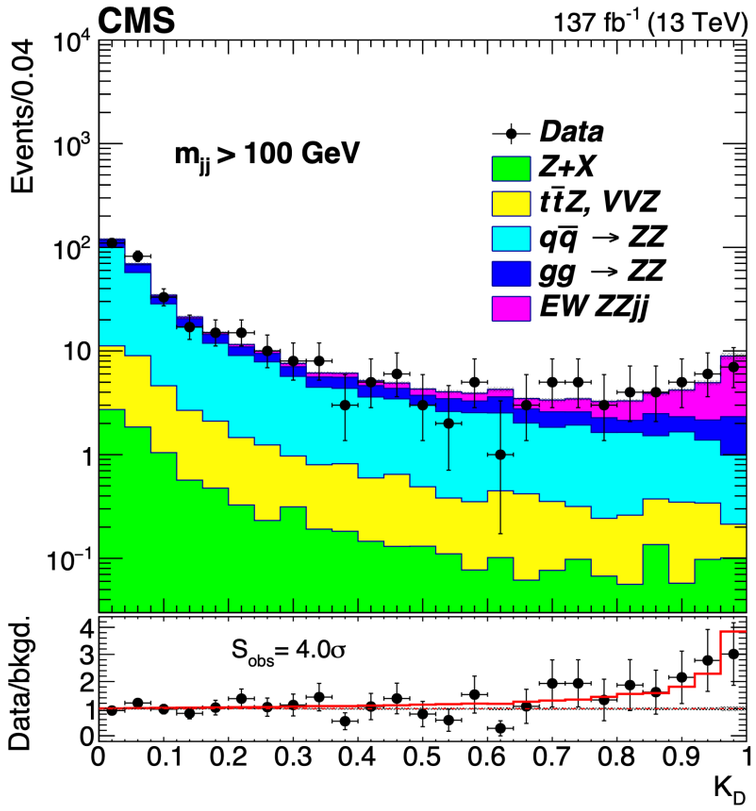

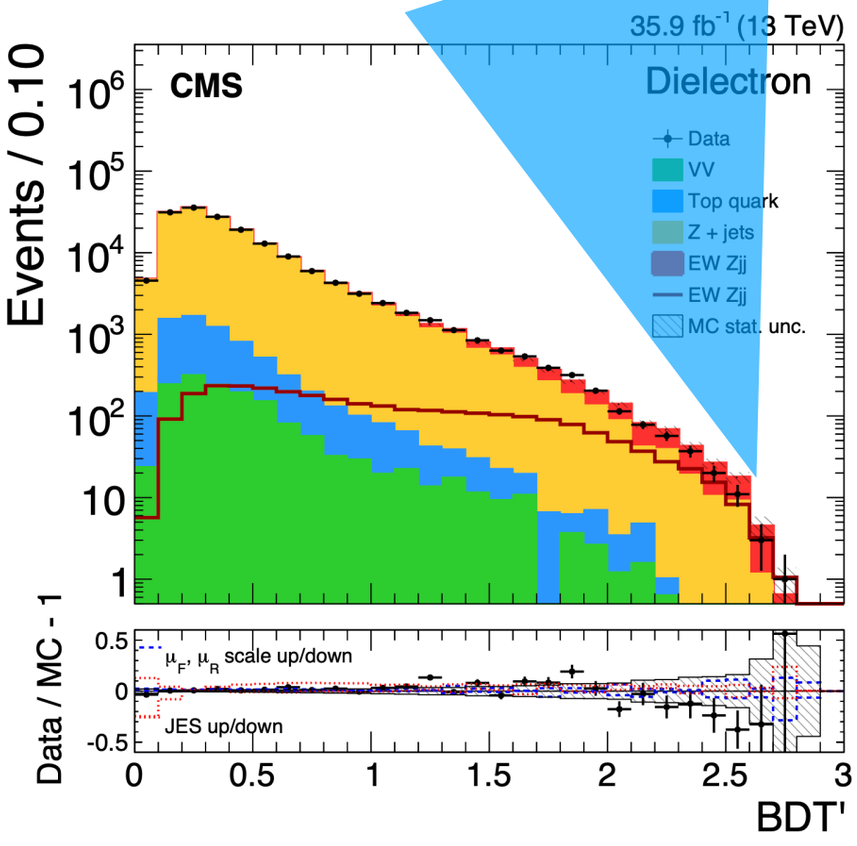

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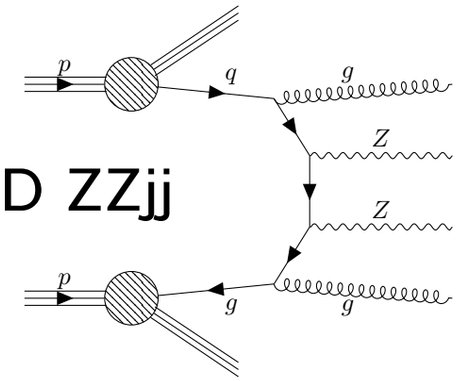
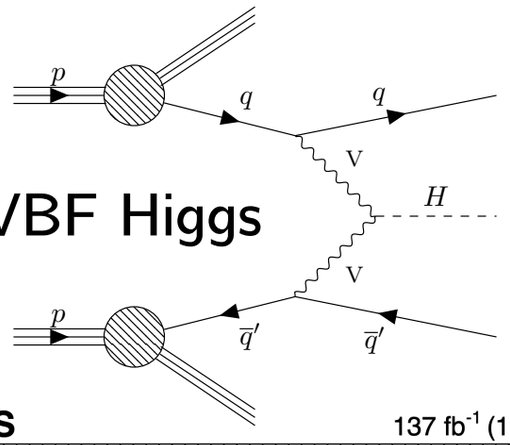
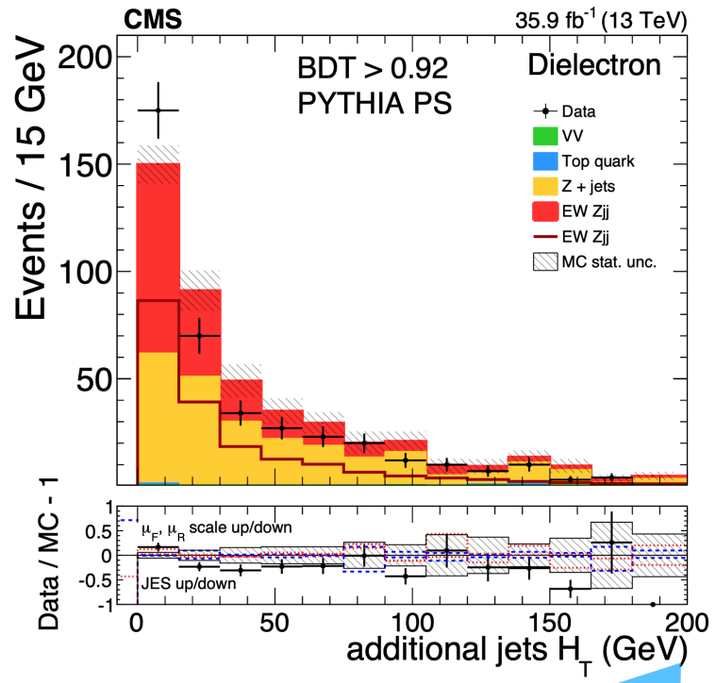
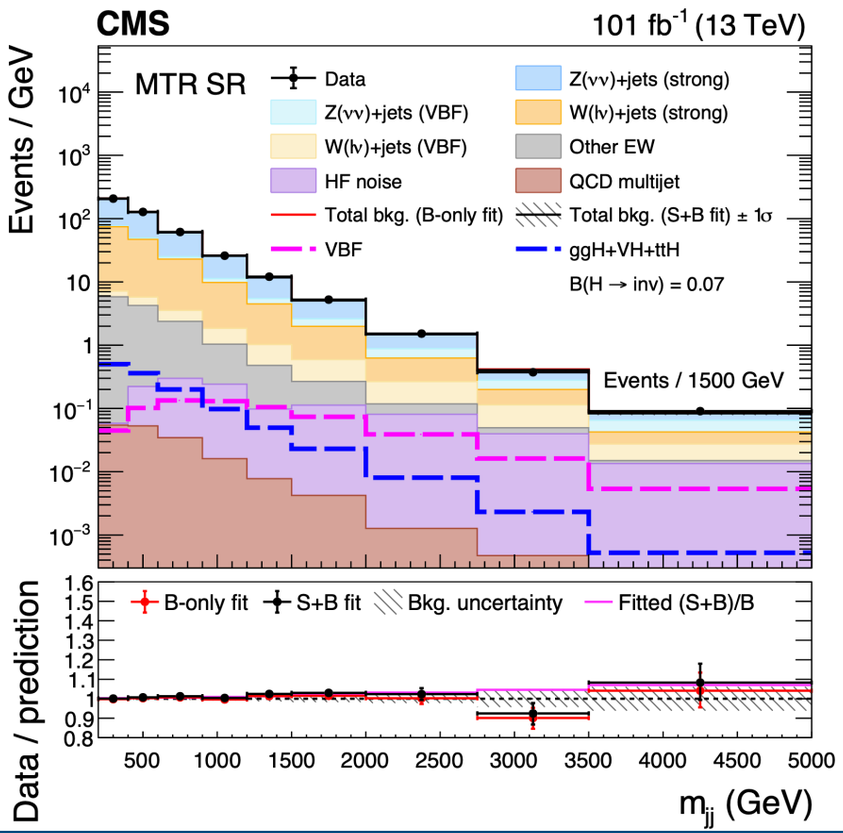
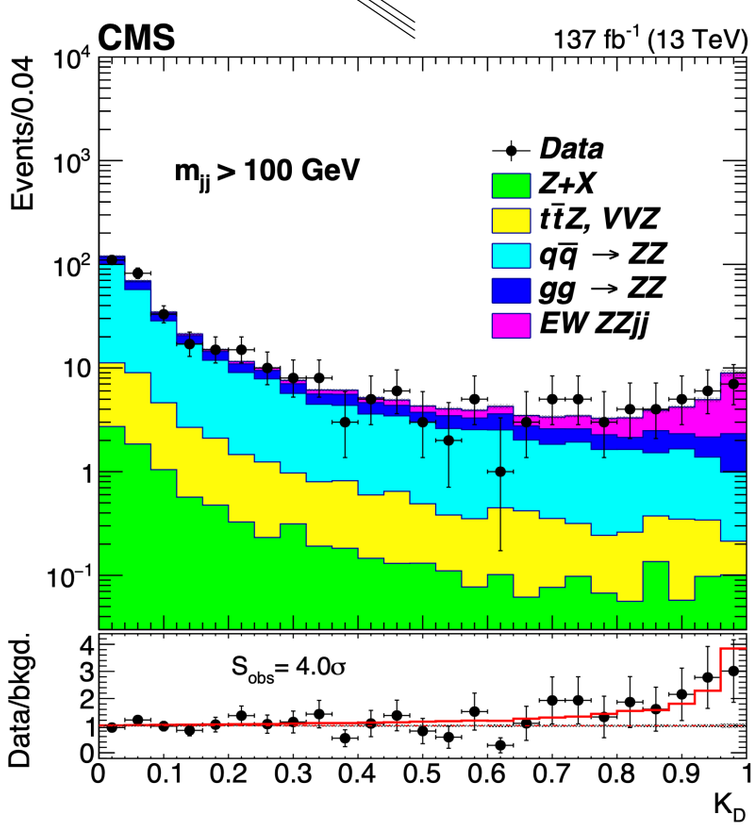


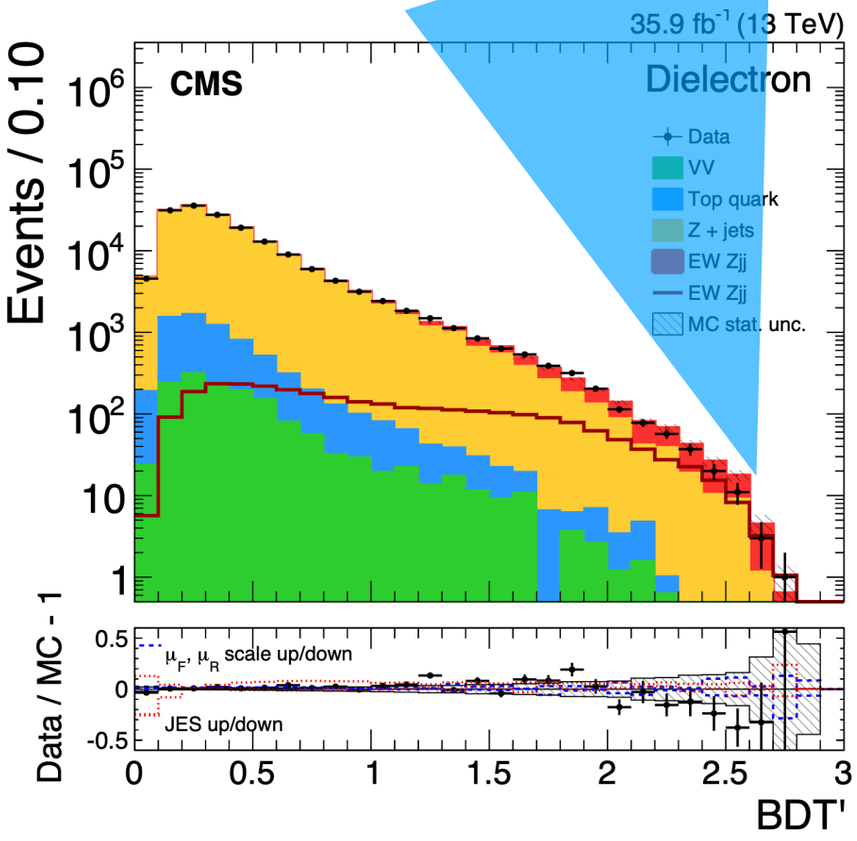
VBF Higgs





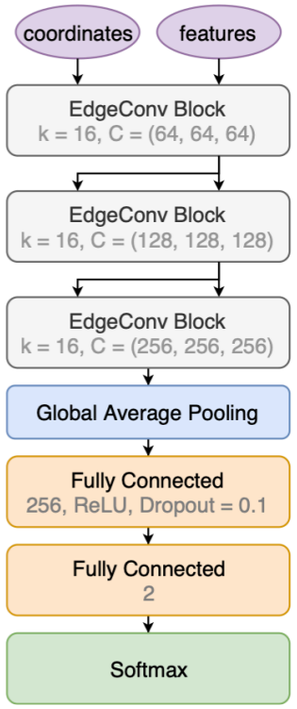


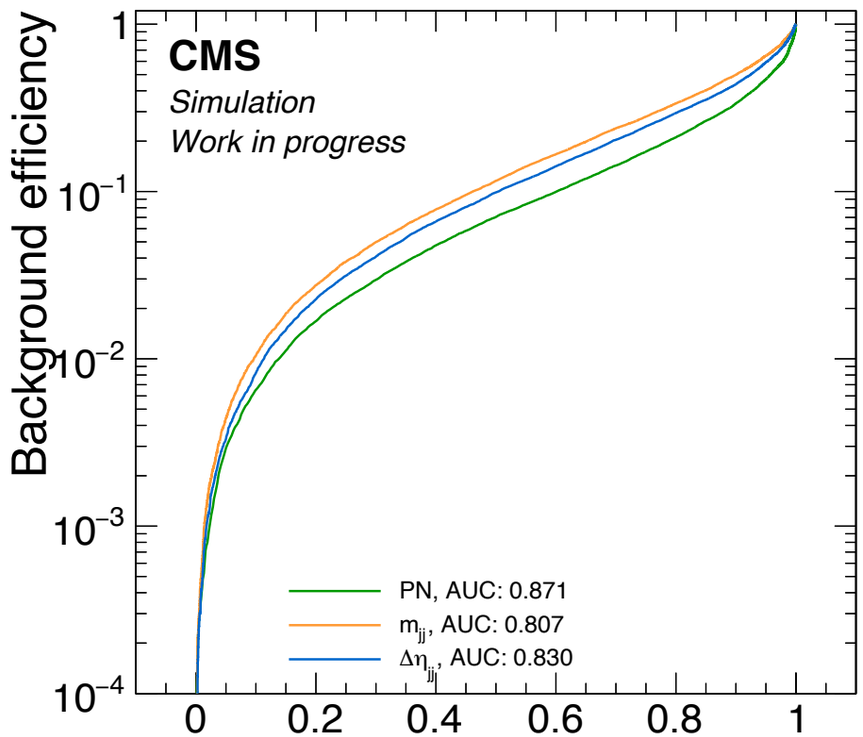


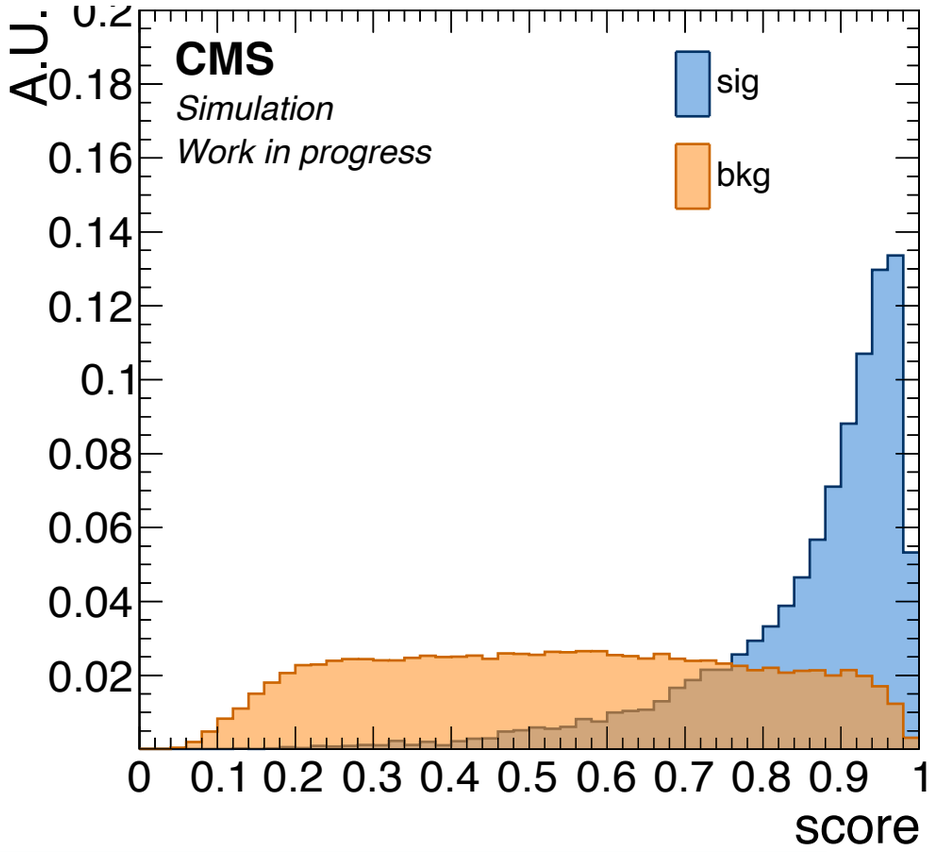


Tagging with machine learning

- Discriminate production modes (ggH vs VBF)
- Establish correlations on a multi-dim phase-space
- Focus on O(100-1000) particles generated during pp collisions
- State-of-the-art machine learning techniques
  - Dynamic Graph Convolutional Neural Network







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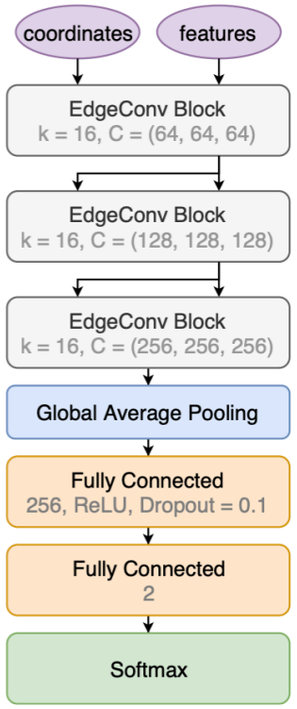
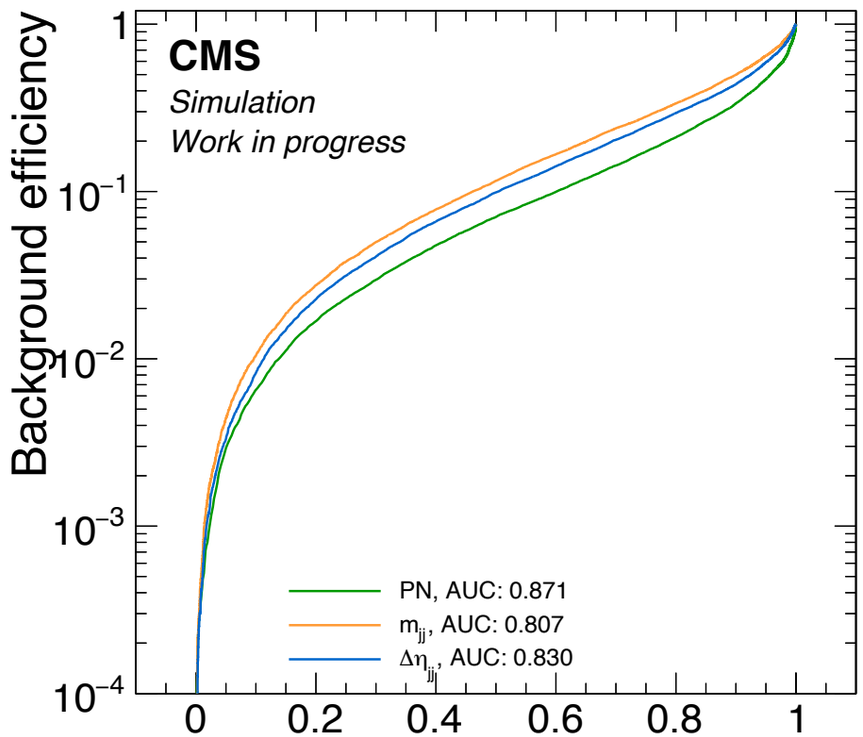
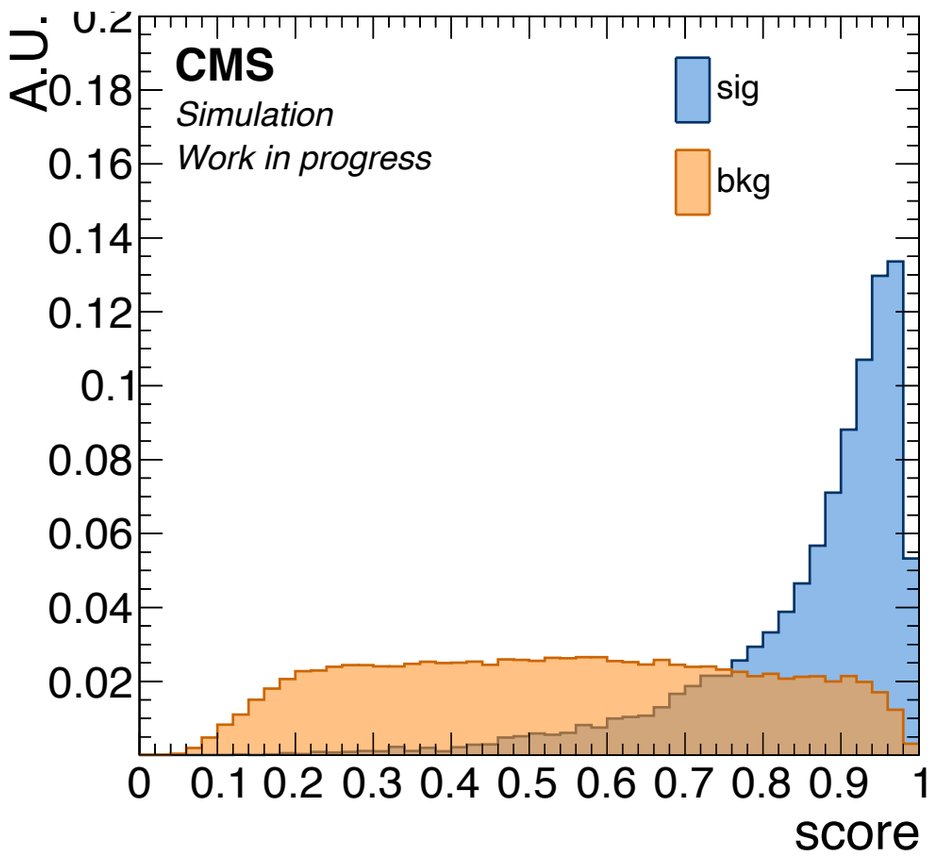
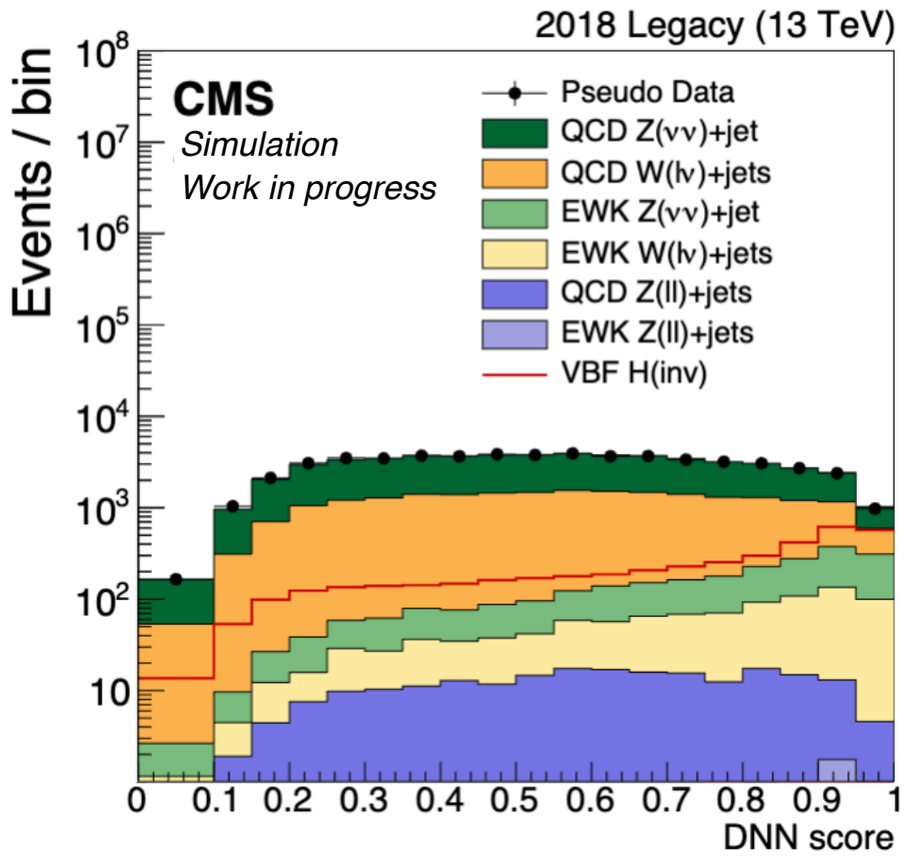
  - Dynamic Graph Convolutional Neural Network
- Independent on the final states
  - Can be applied to several analyses









Status for
VBF Higgs -> invisible

Backup

~~~ Additional Material ~~~

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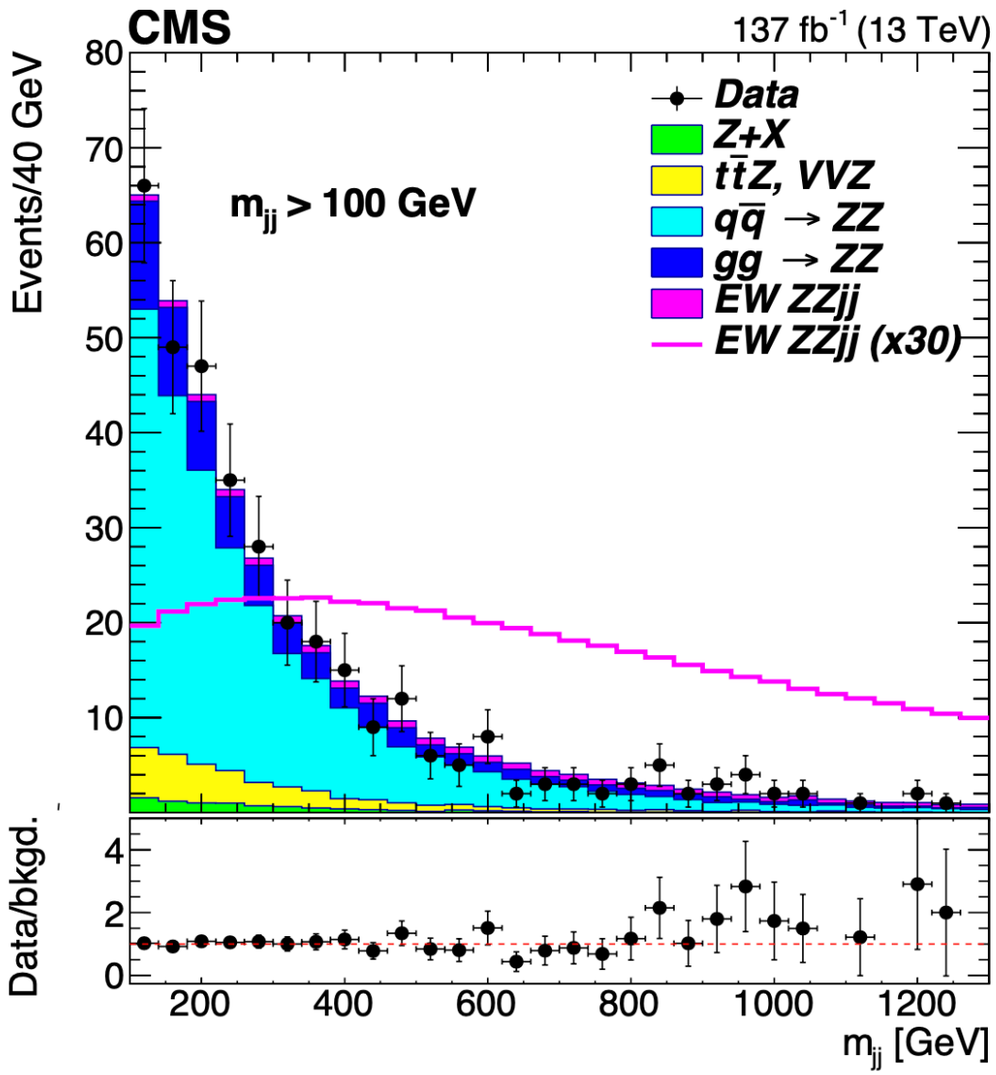
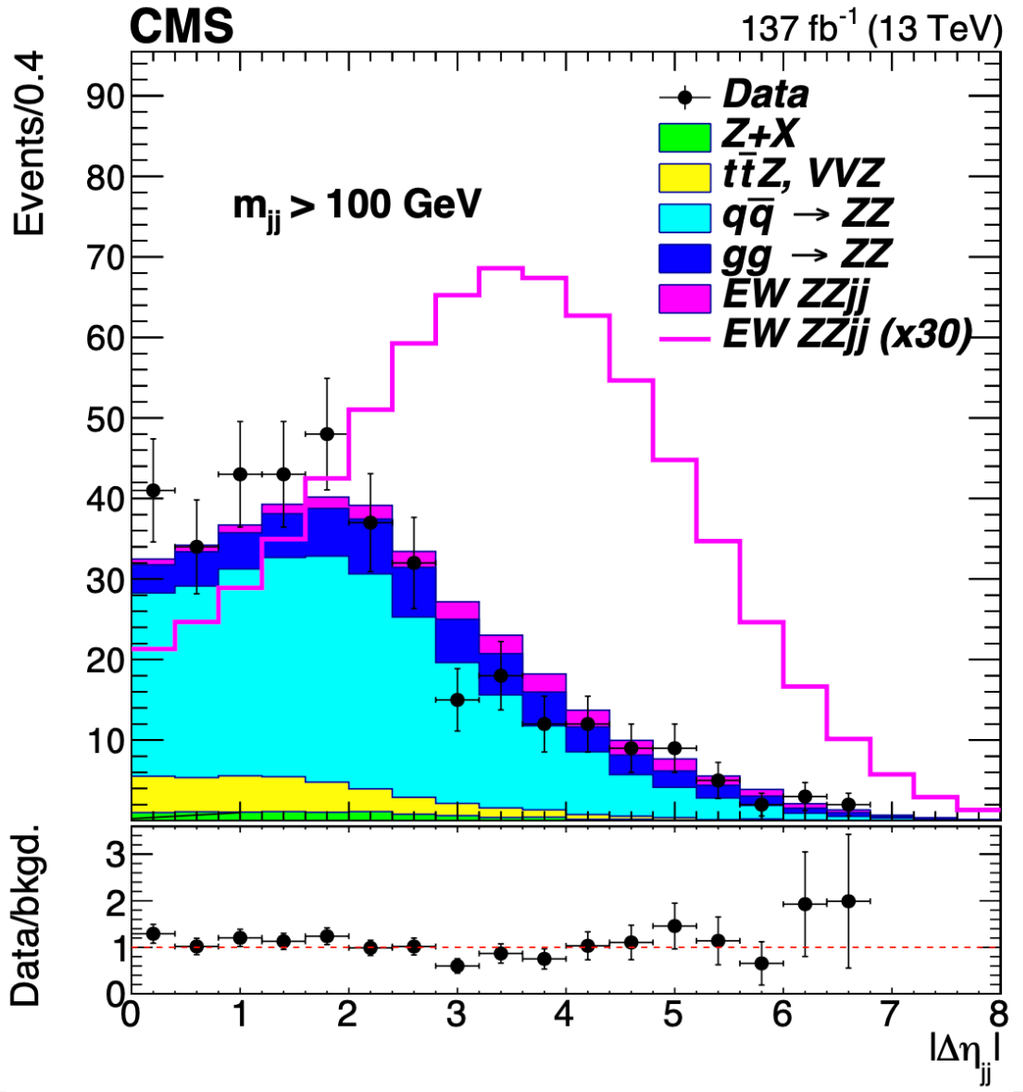
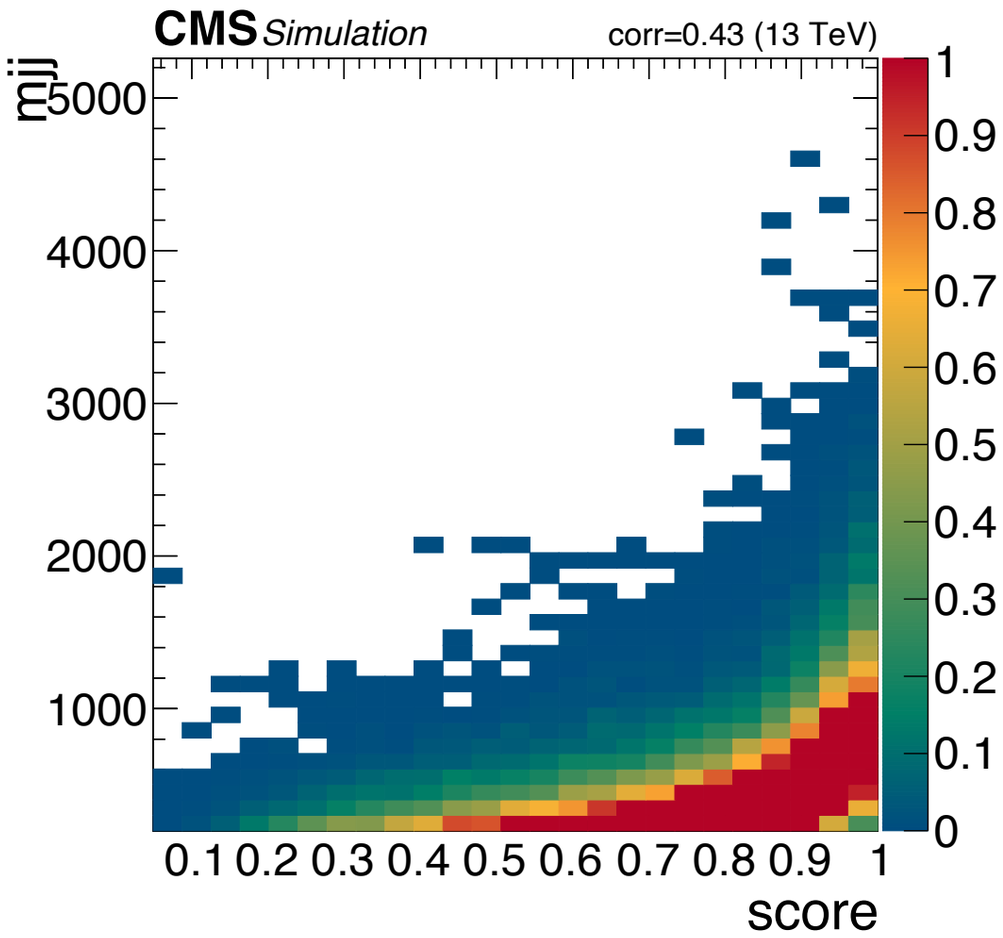
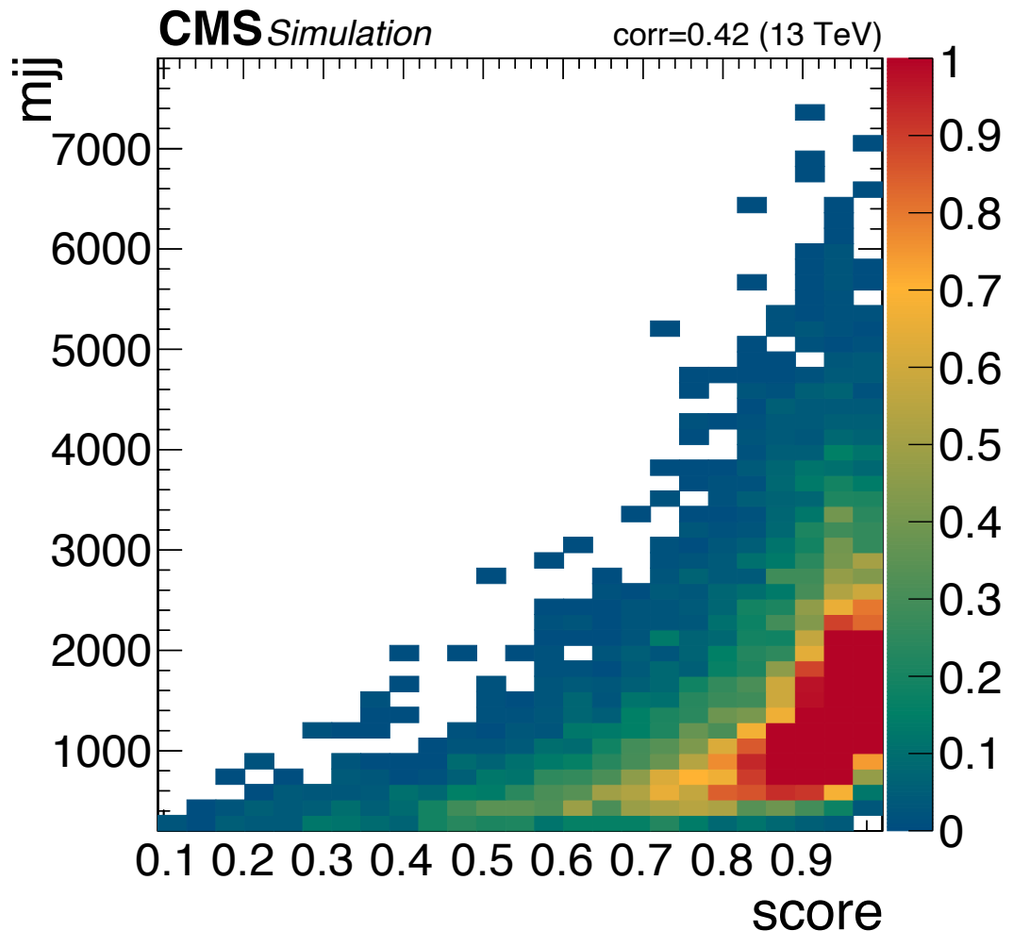
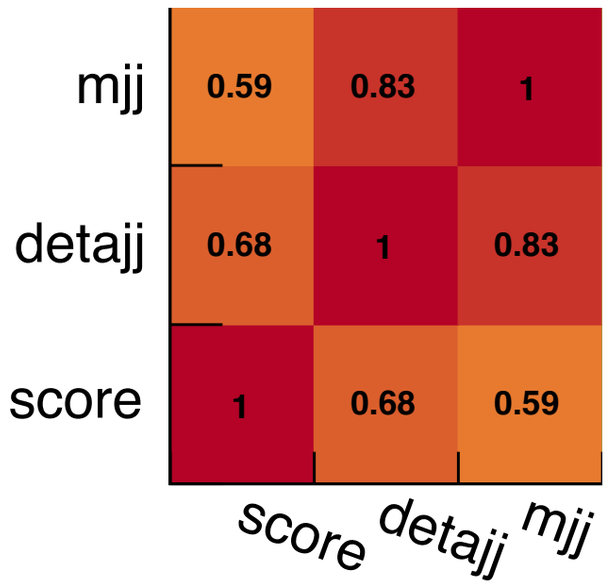




Correlation







Additional event variables