Search for the X → HY→bbbb decay in the boosted regime at CMS with 13 TeV Run-2 data

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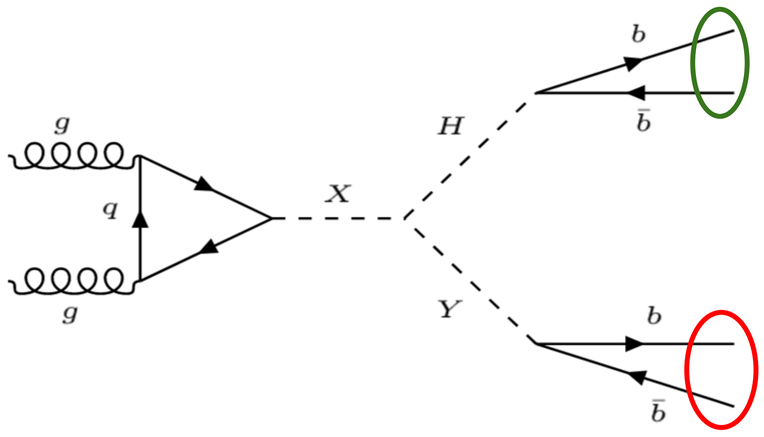
Introduction

- X and Y are massive scalar particles
- Foreseen in Next-to-Minimal Supersymmetric Standard Model (NMSSM)[1][2]
- Other BSM also predict this, for example, the "Two real scalar singlet extension"[3]

Searching for new physics in X→HY→bbbb **boosted** topology



Search range:
$0.9 < M_X < 4$ TeV
$60 < M_Y < 600$ GeV

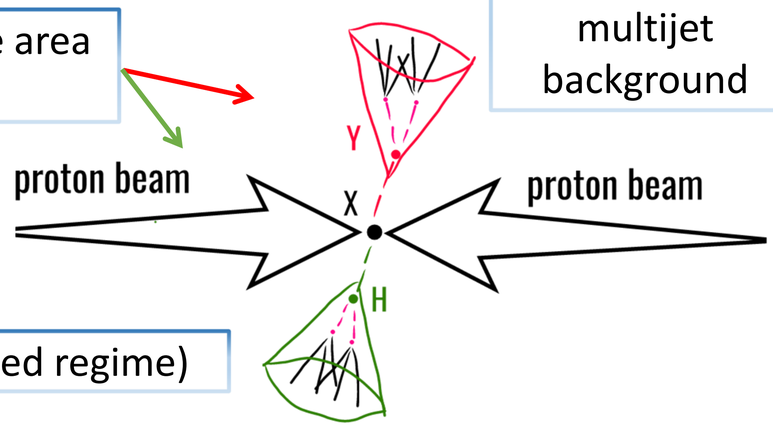
Boosted topology:
$M_X >> M_Y, M_H$
Merged **H-** and **Y-** jets

Event topology and selection

Y-candidate jet:
Mass > 60 GeV

Two central, large area jets

|Δη(H,Y)|<1.3 suppresses multijet background



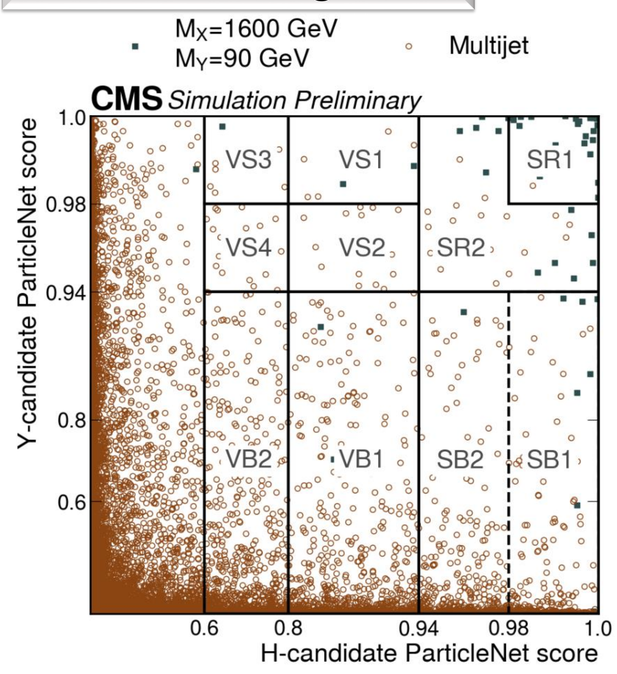
High jet p_T (boosted regime)

H-candidate jet: 110< Mass < 140 GeV

ParticleNet

- ❑ State-of-the-art graph convolutional neural network based tagging algorithm
- ❑ Identifies H→bb or Y→ bb decays against a background of other jets

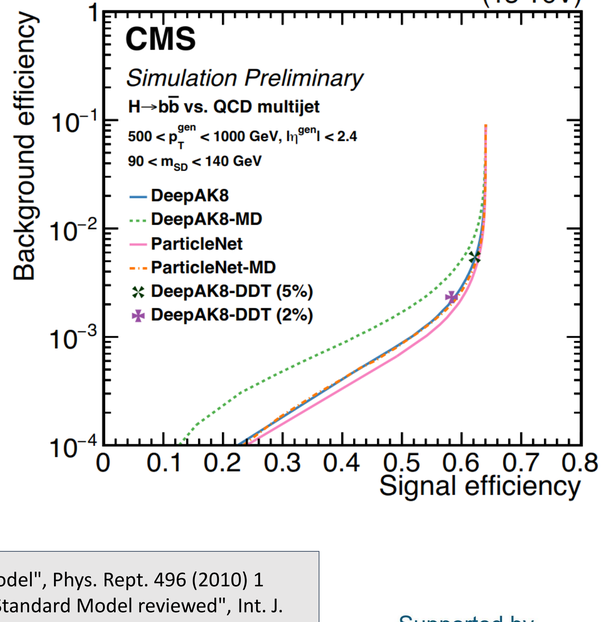
ParticleNet regions



Signal regions (SR)
Used to search for signal

Sideband (SB) regions
Help estimate multijet background

ParticleNet performance[4]



[1] U. Ellwanger et al, "The Next-to-Minimal Supersymmetric Standard Model", Phys. Rept. 496 (2010) 1
[2] M. Maniatis, "The Next-to-Minimal Supersymmetric extension of the Standard Model reviewed", Int. J. Mod. Phys. A 25 (2010) 3505
[3] T. Robens, et al, "Two-real-scalar-singlet extension of the SM LHC phenomenology and benchmark scenarios", Eur. Phys. J. C 80 (2020), no. 2, 151
[4] CMS Collaboration, "Identification of highly Lorentz-boosted heavy particles using graph neural networks and new mass decorrelation techniques", CMS Detector Performance Note, 2020.

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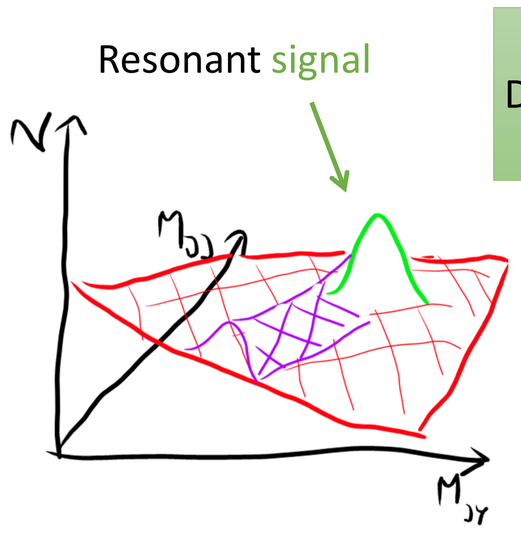
Search strategy



Search in 2D plane
Defined by mass of the Y-candidate mass (M_{JY}) and dijet invariant mass (M_{JJ})

Multijet background

Multijet SB shape estimated from data

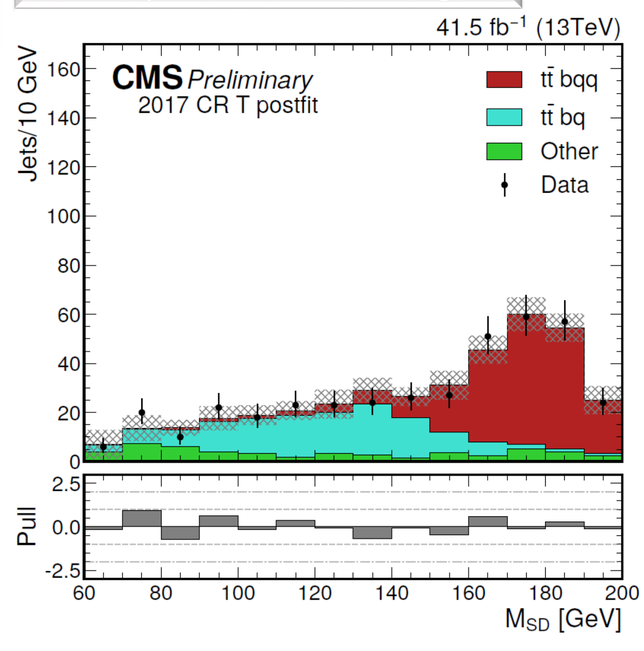
$$N^{SR}_{multijet} = N^{SB}_{multijet} \times R_{P/F}$$

Transfer function determined during the fit

$t\bar{t}$ background

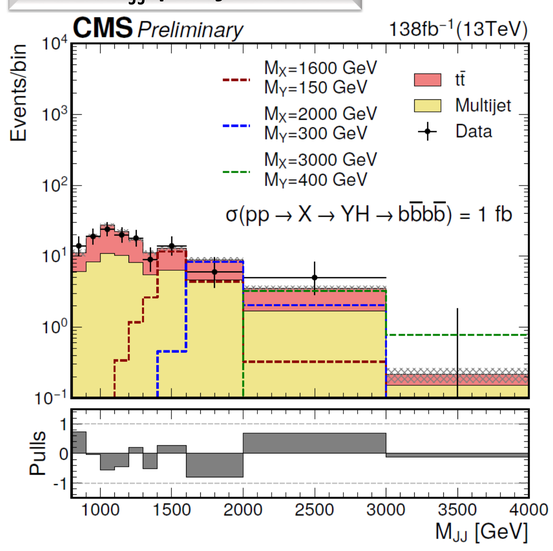
Estimated using simulation with **corrections** measured in semileptonic control regions

Semileptonic control region

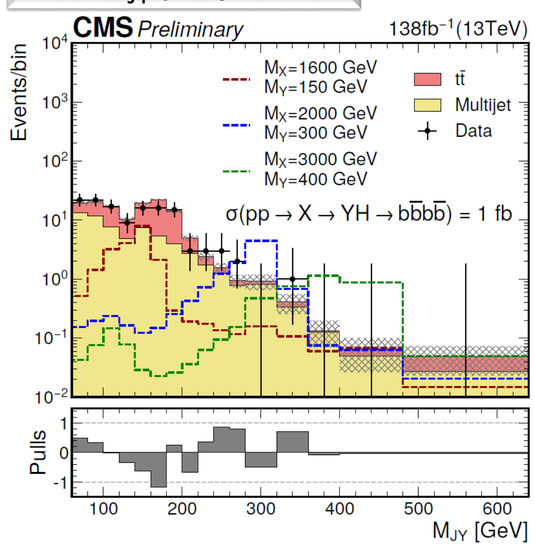


Postfit distributions

SR1 M_{JJ} projection



SR1 M_{JY} projection



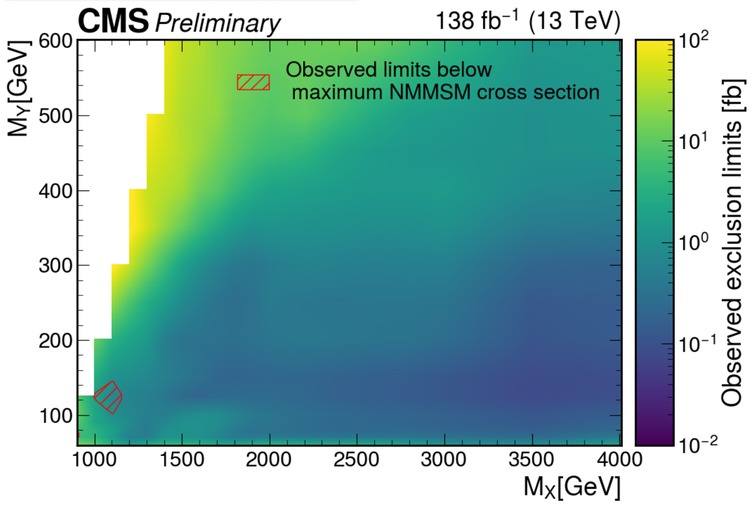
- ➢ Background estimate in good agreement with data

Setting exclusion limits on signal cross-section

Exclusion limits

- ➢ CL_s exclusion limits at 95% CI
- ➢ Most stringent limits on the cross-sections in the boosted regime

2D observed limits



1D exclusion limits