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Search for HH resonant production in the 4b final state with the CMS experiment at $\sqrt{s}$=13 TeV

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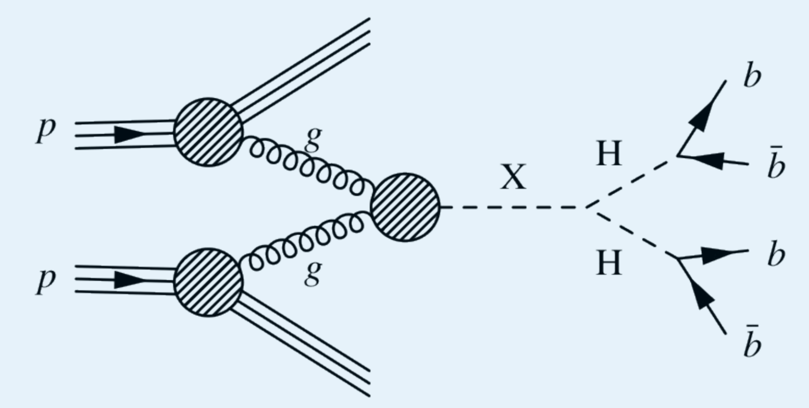
HH resonant production

- HH resonant production predicted within several New Physics scenarios (SUSY, Extra Dimensions, Scalar-singlet models, etc.)
- Common signature: a narrow resonance decaying to HH pairs
- Searches performed in a model independent way
- Gluon-gluon fusion production mode assumed
- Spin-0 and Spin-2 hypotheses tretated separately due the different acceptance

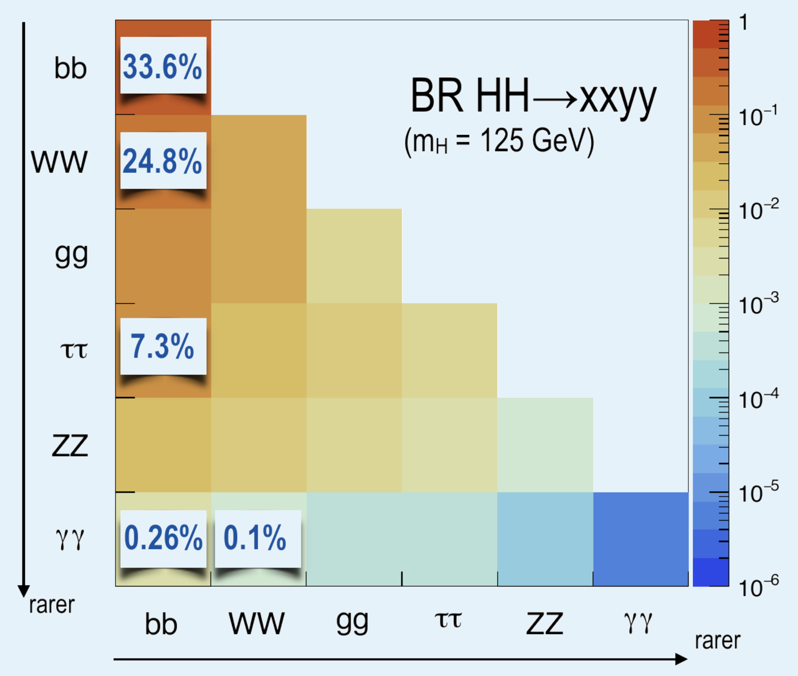


$gg \rightarrow X \rightarrow HH$ not predicted in the SM – direct search for new physics

The 4b final state

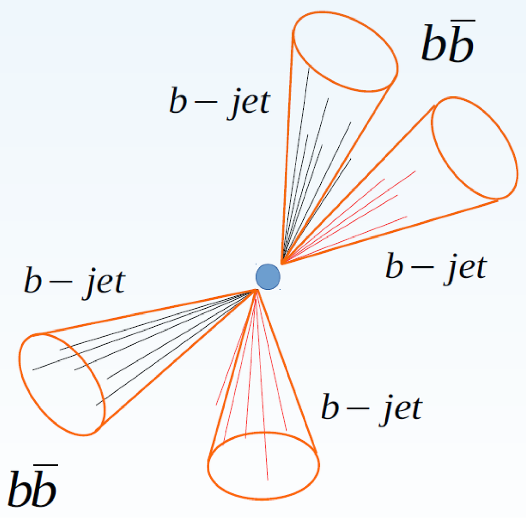
Each of the two H can decay to different particles pairs

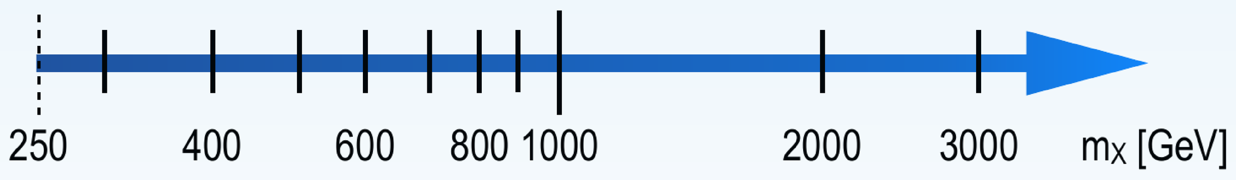
- Analyses divided by final states
- 4b (largest BR), $b\bar{b}\gamma\gamma$, $b\bar{b}\tau\tau$, $b\bar{b}WW$ all covered by CMS
- the 4b benefits from the highest SM branching ratio (33%)
- expected to be the most sensitive channel in a broad mass range
- b-tagging crucial to remove QCD background also at trigger level



Mass Coverage

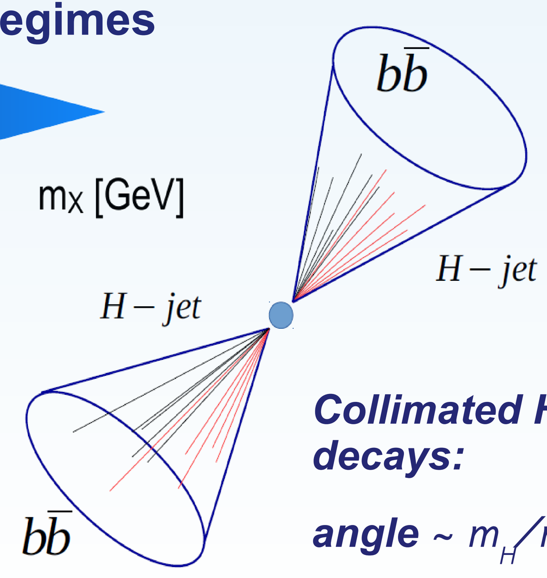
- A broad mass spectrum is covered (starting from 250 GeV up to ~3 TeV)
- Heavy resonances (m_X > 1TeV) produce high momentum Higgs Bosons whose decay products can be very collimated and the H→$b\bar{b}$ decay can be detected as a single jet
- The 4b analysis is split into two main kinematic regimes





Resolved Regime
4 b-jets signature

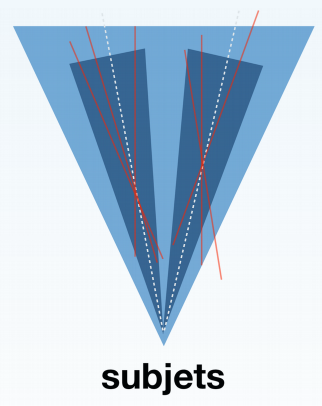
Boosted Regime
2 $b\bar{b}$ fatjets signature

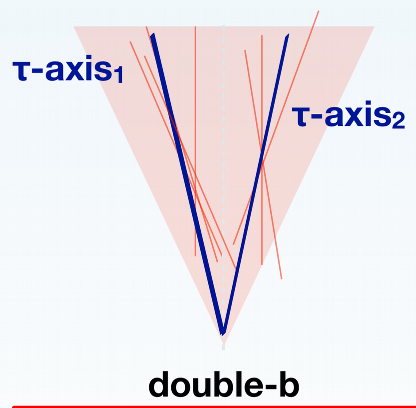


Collimated H→ $b\bar{b}$ decays:
angle ~ m_H/m_X

b-Tagging

- Analysis sensitivity strongly depends on b-tagging performances (4 tags per event)
- b-tagging used also at trigger level in the resolved regime
- Two tagging algorithms available for fatjets (ΔR=0.8) in the boosted regime: subjet and double b-tagging



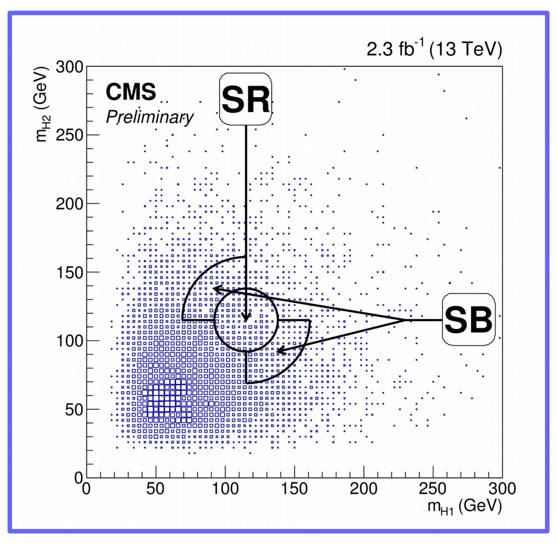


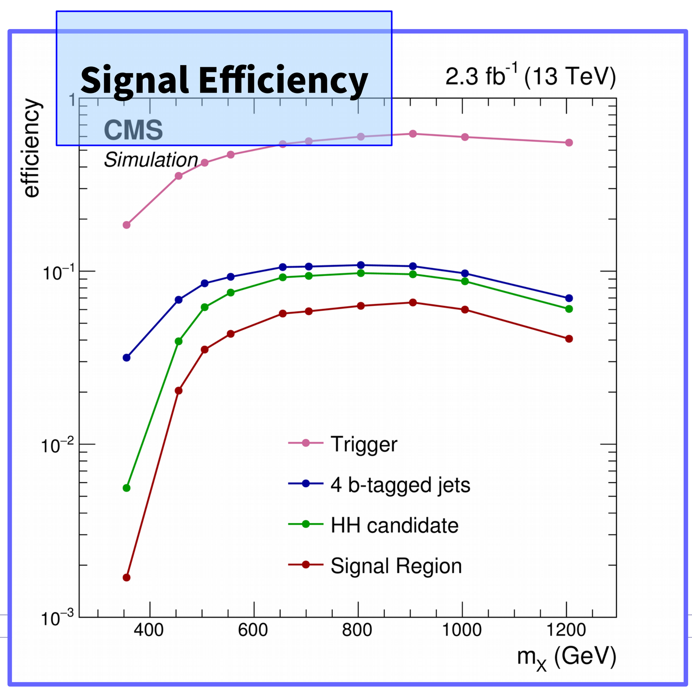
Subjet b-tagger: uses subjets (ΔR=0.3) inside fatjets (ΔR=0.8)

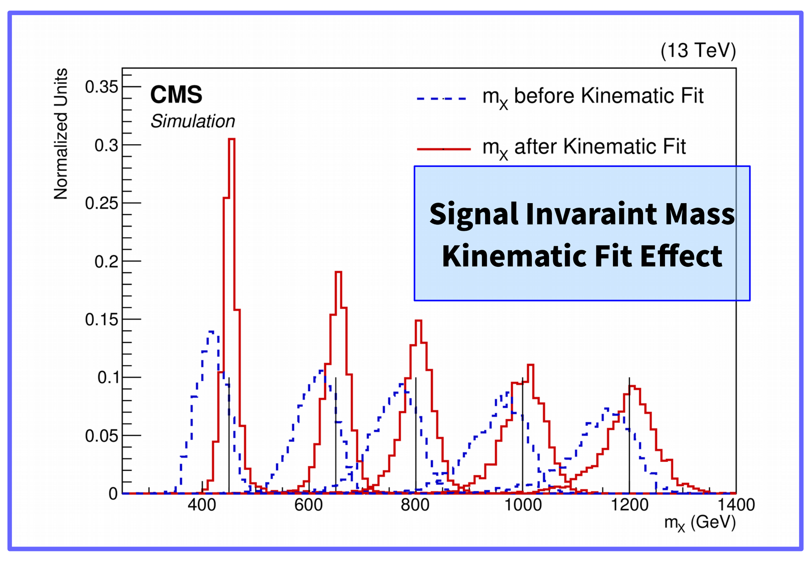
Double b-tagger: full fatjet tagger targeting the H→bb system specifically

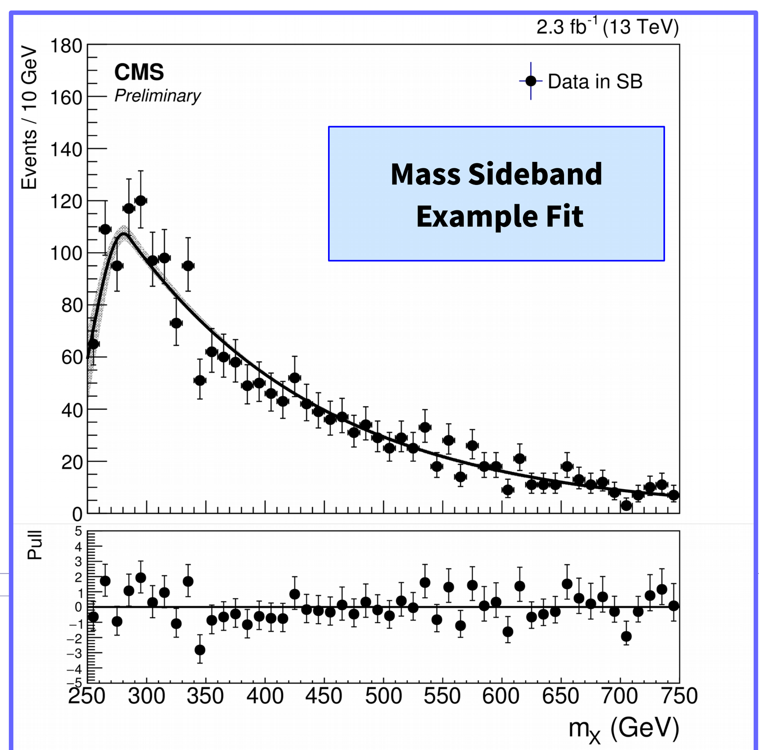
HH → 4b *resolved*

- Di-Higgs reconstruction based on 4 b-tagged jets
- Largest backgrounds are QCD multijet and ttbar production
- Data driven background estimate based on mass sideband (SB)
- Kinematic fit to the known Higgs mass used to improve the resonance mass resolution



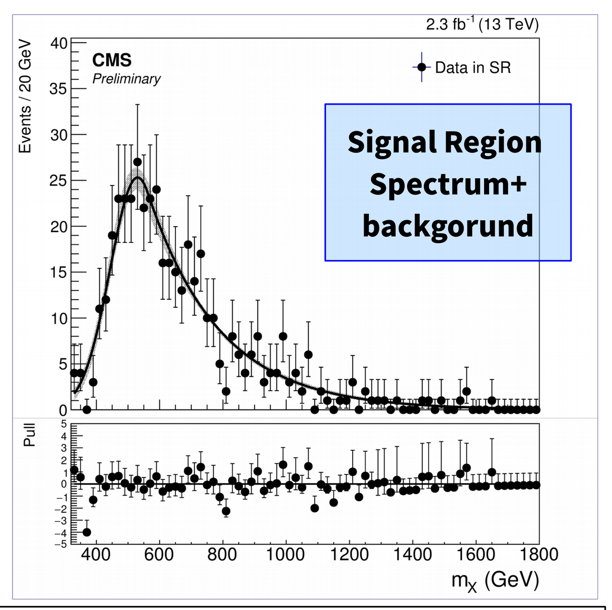


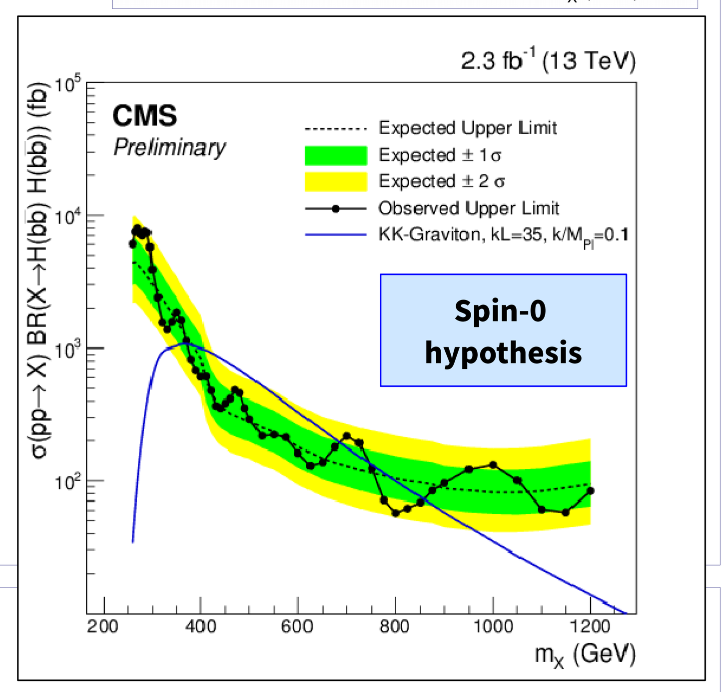




13 TeV results *resolved*

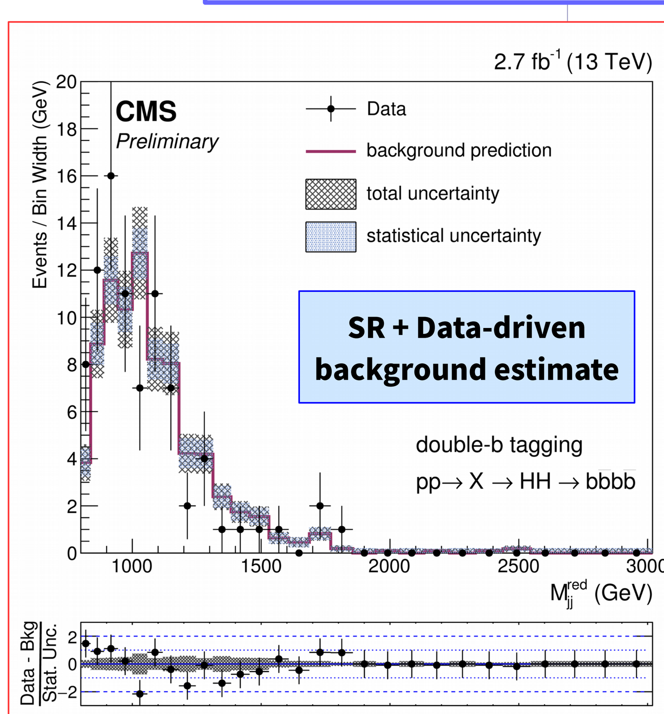
- 2.3 fb^{-1} analyzed
- Analysis is split into two mass regions with optimized selections
- Efficiency limited by trigger at low mass and by merging of jets at higher mass → boosted topology
- No significant excess observed

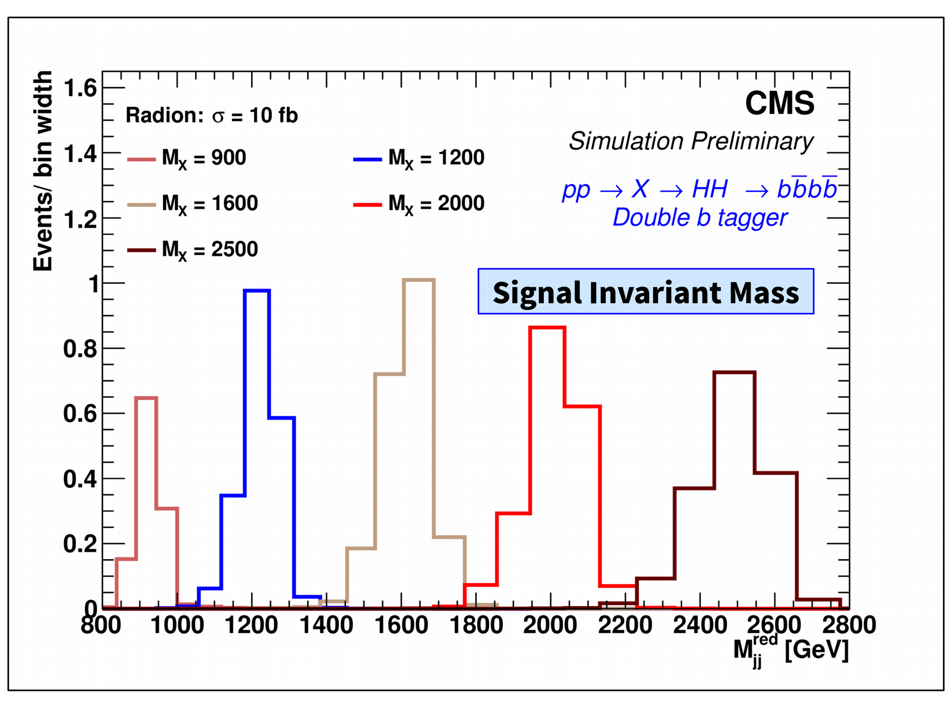


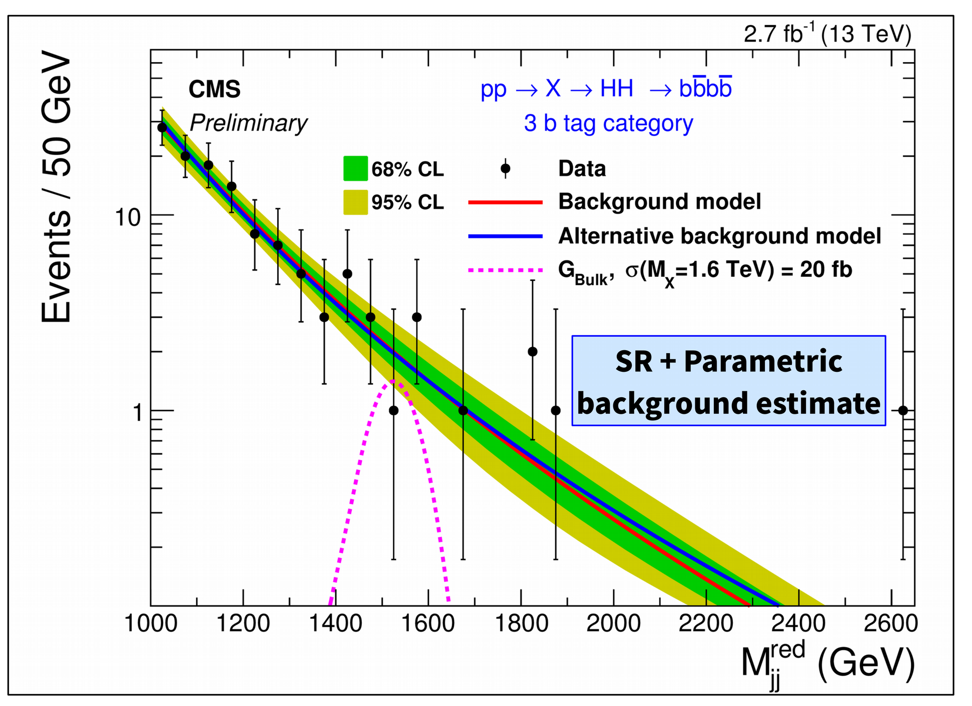


HH → 4b *boosted*

- Two complementary strategies each using different tagging and background estimate techniques
- Double-b tagging + data-driven background estimate based multiple control regions and mass sidebands
- Subjet b-tagging + parametric background estimate using a “levelled-exponential” function
- HH pair reconstruction with 2 tagged fatjets for the double-b tagging analysis
- Pruned mass window used to identify the Higgs fatjet
- Two categories in the subjet b-tagging analysis (4 tags+ 3 tags)



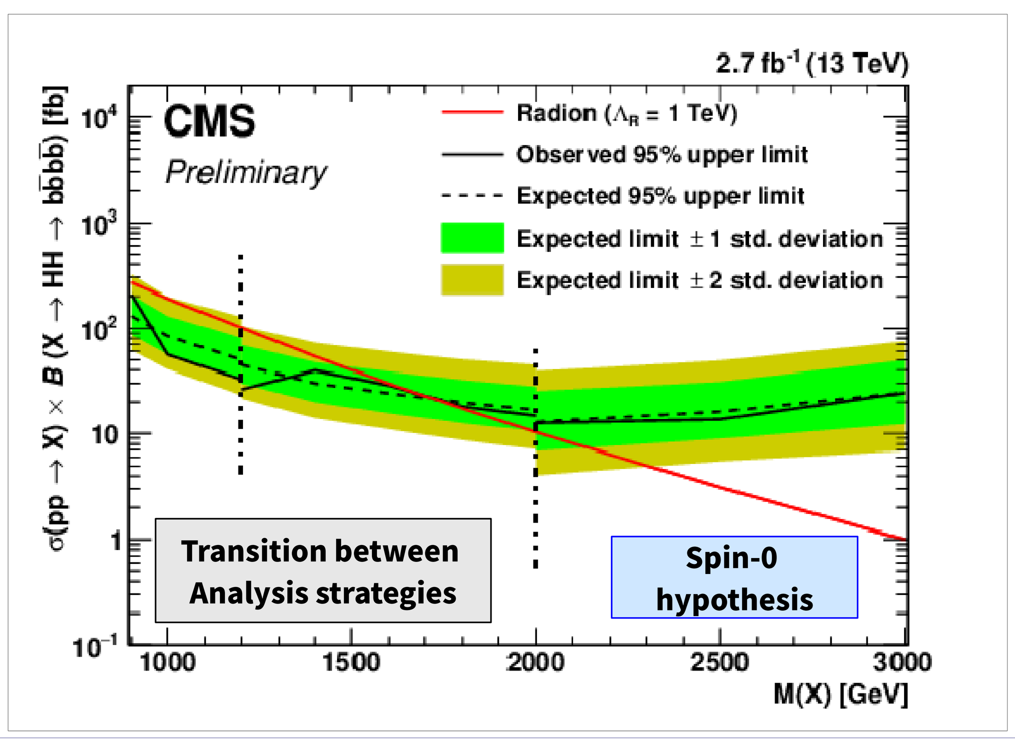




13 TeV results *boosted*

- Control region based background estimate allows to model the spectrum turn-on
- Double-b tagging robust at high-p_T
- Sensitivity limited by statistics at high mass
- No significant excess

- 2.7 fb^{-1} analyzed
- Comparable sensitivity for the two strategies employed



References:
CMS-PAS-BTV-15-002
CMS-PAS-B2G-16-008
CMS-PAS-HIG-16-002

Results soon to be updated using the full 2016 luminosity