

# Resonant diboson production searches in the boosted topology at CMS

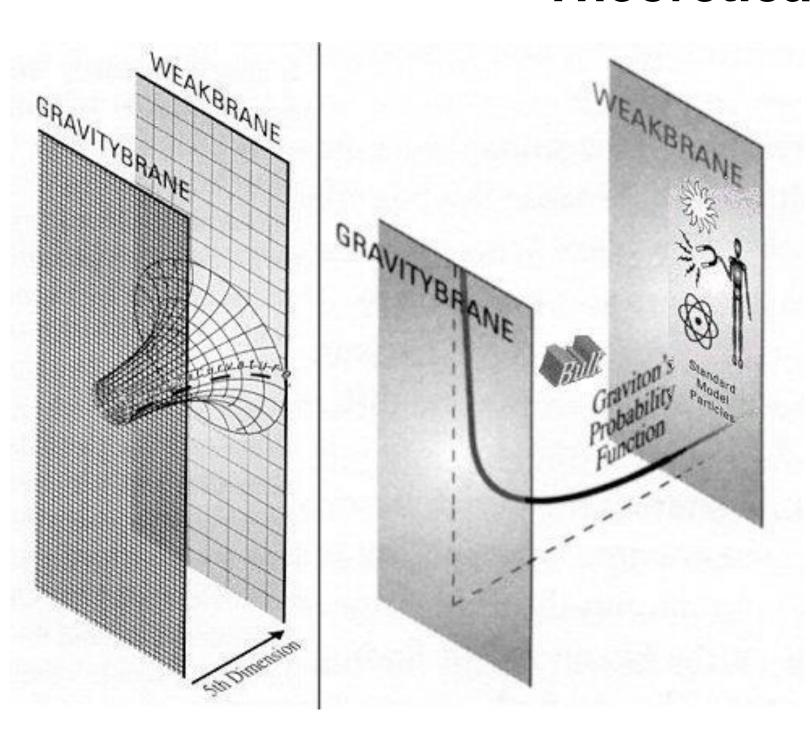
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### Theoretical motivation

Why is gravity much weaker than the weak force in nature?

This is one of the big unanswered questions of particle physics. New physics scenarios try to answer these questions. Some models attempt to explain this by increasing the number of spatial dimensions, e.g. warped dimensions, while others introduce new interactions, as in the case with extended gauge theories.



The existence of new neural particles, i.e. Kaluza-Klein excitations of both spin-0 (radion) and spin-2 (graviton), is predicted.

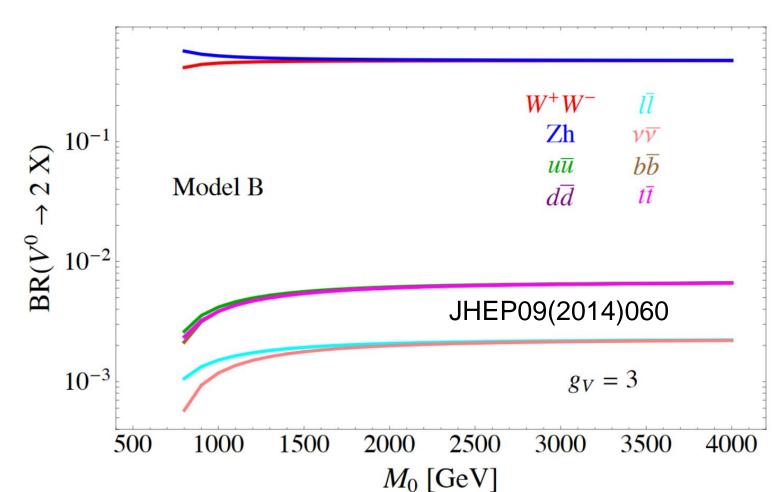
kL=35arXiv:1110.6452  $\mathsf{M}\phi$  (**GeV**)

V/H

Highly boosted

intermediate bosons

Composite and little Higgs theories predict new particles of spin-1 (V'): charged W' and neutral Z'.

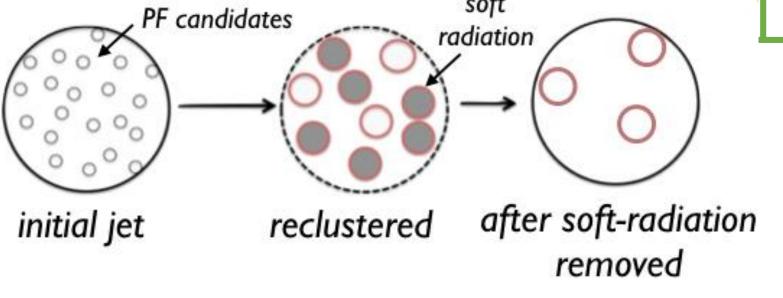


Predicted new particles have large couplings to bosons.

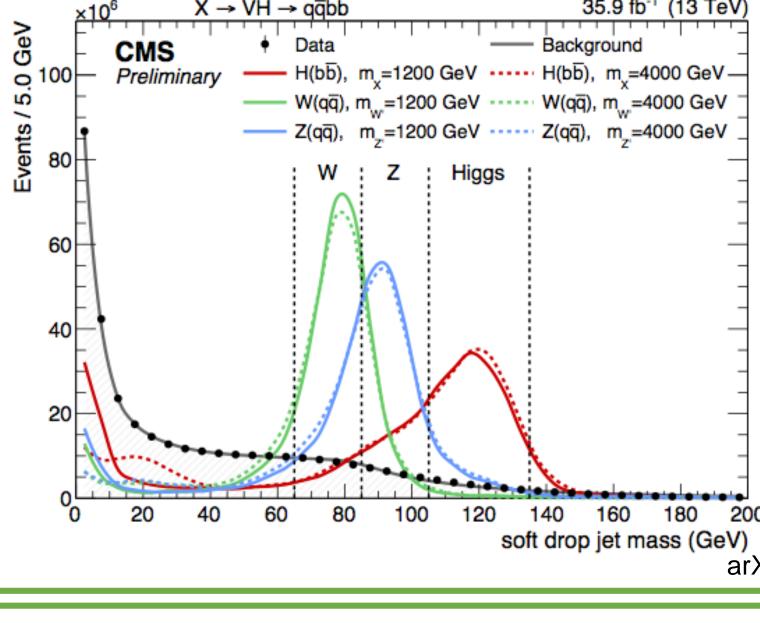
A large jet cone (R=0.8) is used in order to contain all the decay particles of the boson.

### Grooming

Grooming techniques distinguish between jets originating from single quarks/gluons or bosons by filtering out soft and large angle emissions in the jets.



Groomed jet mass

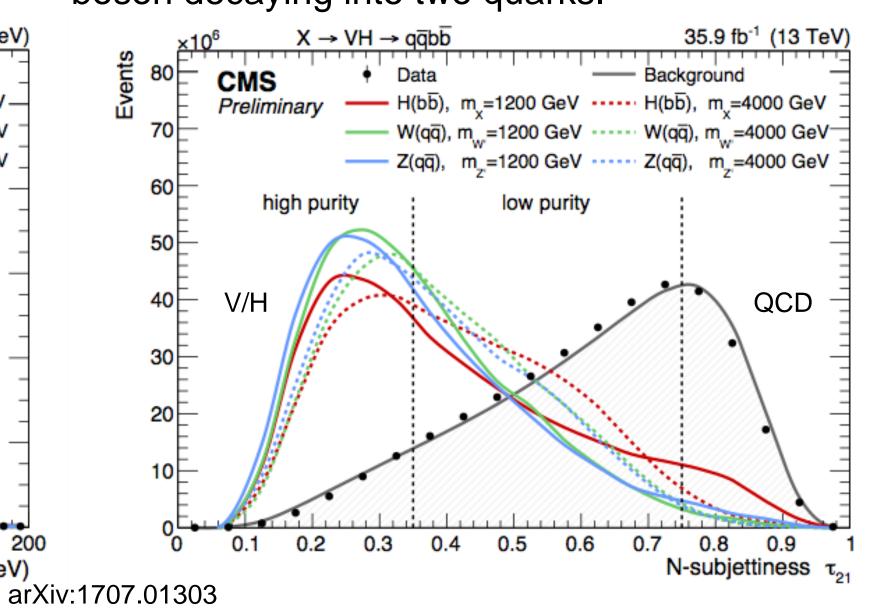


Resolving jet substructure  $\tau_{21}$ : The ratio  $\tau_2/\tau_1$  is a measure of how 2- versus 1-prong like a jet is, allowing the discrimination between jets originating from single quark/gluon and those originating from the decay of a V/H boson decaying into two quarks.

V/H

Large resonance

masses



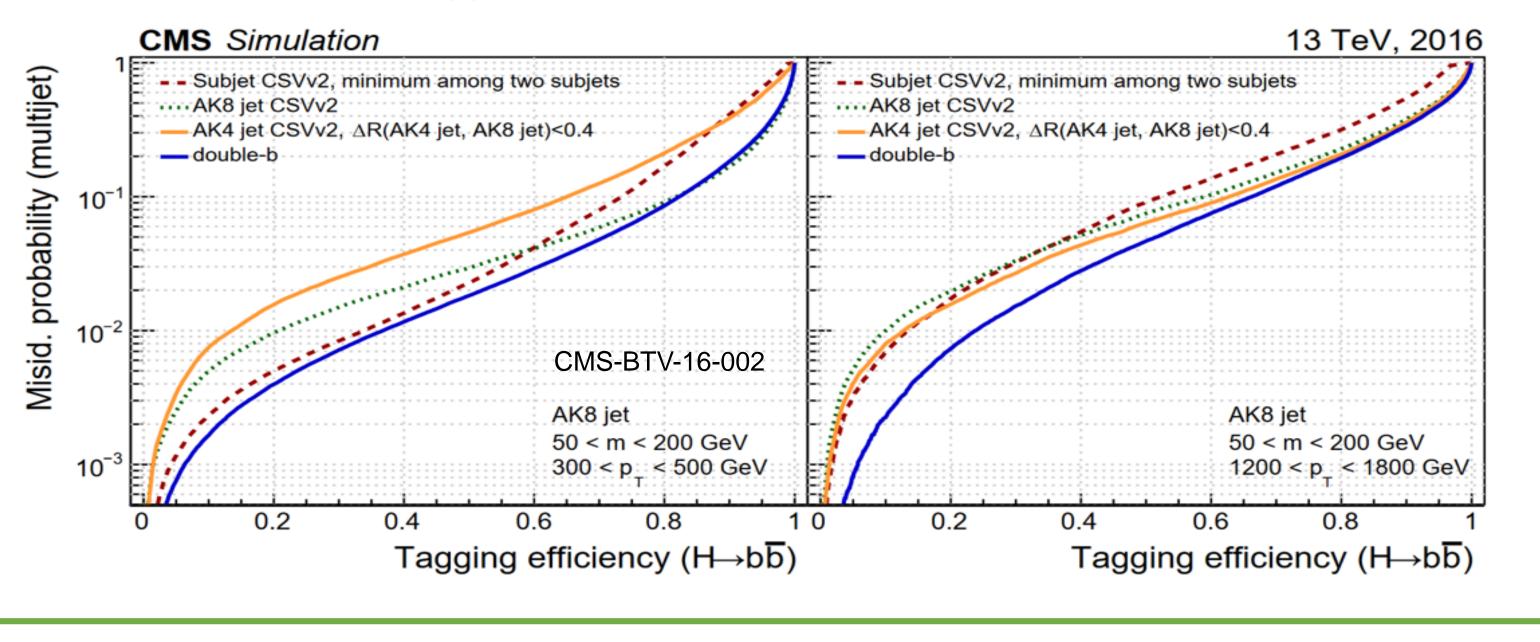
heavy-flavour

JINST 13 (2018) P05011

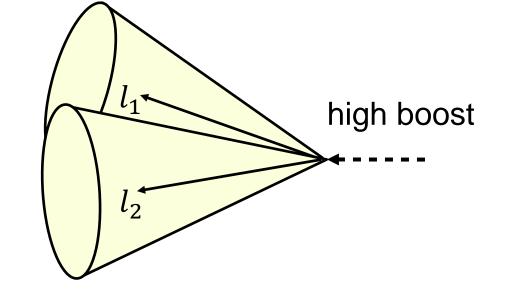
## bb

Jets originating from b quark hadronization can be identified by a secondary vertex due to the longer lifetime of the B hadrons.

For jets originating from the Higgs boson decay to b quarks either the large-cone jet or the subjets can be b tagged.



If the vector bosons are highly boosted, the leptons are very close to one another.



In this case, the lepton isolation has to be modified in order to remove unwanted particles stemming from the background, without removing the other lepton from the V/H decay.

23%

(13 TeV)

MVA iso VLoose

### $\tau\tau$

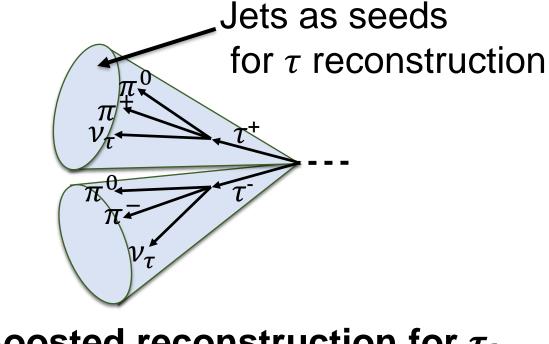
The reconstruction of tau leptons is challenging due to the plethora of possible final states, like  $e\nu_e\nu_\tau$ ,  $\mu\nu_\mu\nu_\tau$ ,  $h^\pm\nu_\tau$ ,  $h^\pm\pi^0\nu_\tau$  and  $3h^\pm\pi^0\nu_\tau$ .

**ℓ/**√/ℓ

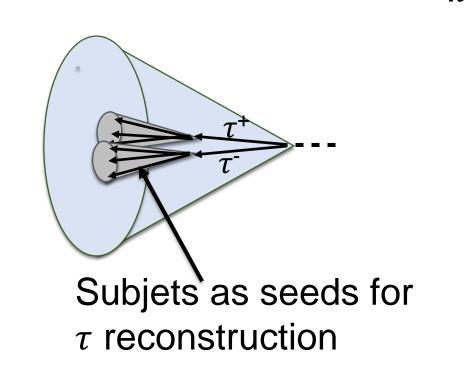
**l/v/v** 

## 41%, $\tau_h \tau_h$ 23%, τ<sub>h</sub>τ<sub>μ</sub> Standard reconstruction for $\tau_h$

τ<sub>κ</sub>τ<sub>κ</sub> channel



Boosted reconstruction for  $\tau_h$ 

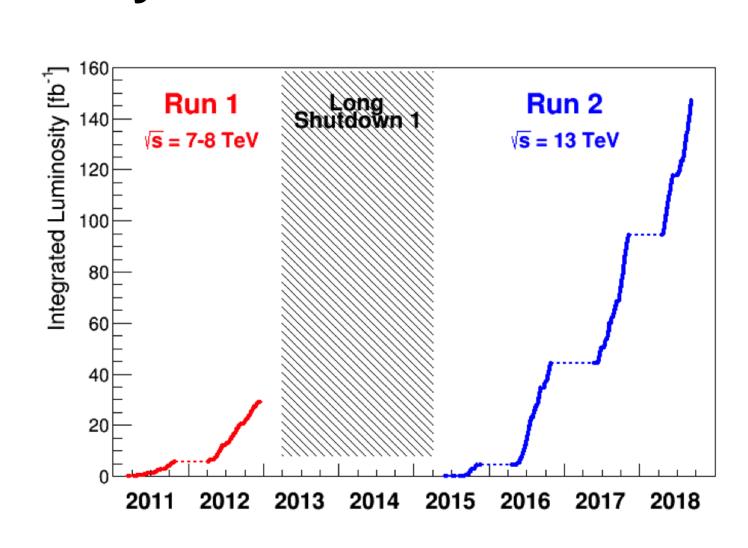


**→** Boosted T<sub>h</sub> reconstruction Standard T<sub>h</sub> reconstruction r<sub>h</sub> r identification CMS-TAU-16-003  $R \rightarrow HH \rightarrow b\bar{b}\tau\tau$ 600 Generated Higgs boson  $p_{\tau}$  (GeV)

### Summary

Analyses of Run 1 and Run 2 (2016) data showed no significant deviations with respect to the Standard Model expectations, and exclusion limits on the production cross section of these predicted new resonances were set.

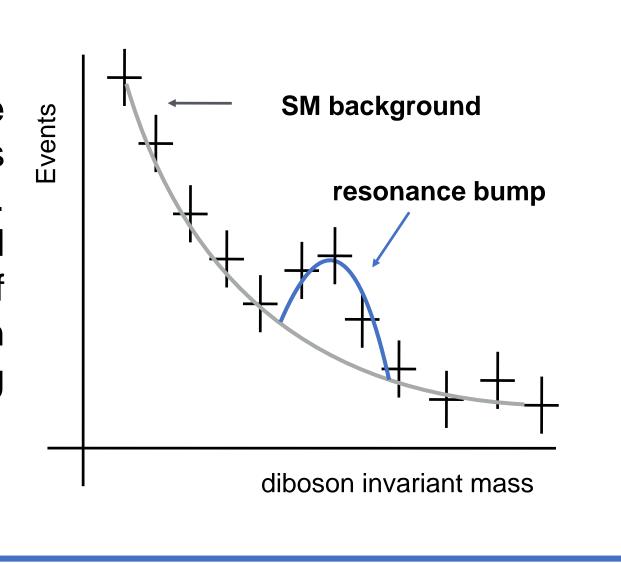
However, who knows what the remaining 60% of unanalyzed LHC data will reveal.



m<sub>w'</sub> [TeV]

### Search for resonance

After the two bosons are identified, the invariant mass of the system is reconstructed. The new resonance would manifest itself as an excess of events in a localized region on smoothly-falling top background spectrum.



### 35.9 fb<sup>-1</sup> (13 TeV) 35.9 fb<sup>-1</sup> (13 TeV) **ICHEP 2018 ICHEP 2018** HVT model B Bulk Graviton ( $\tilde{k} = 0.5$ ) — WH→2q2τ (CMS-PAS-B2G-17-006) — HH→2b2τ (CMS-PAS-B2G-17-006) — WZ→2q2l (arXiv:1803.10093) - ZZ→2l2v (JHEP 03 (2018) 003) 95% CL upper limits 95% CL upper limits Observed — WH→2q2b (EPJC 77 (2017) 636) 10 <del>−</del> Observed — HH→4b (CMS-PAS-B2G-17-019) ···· Median expected — WH→lv2b (CMS-PAS-B2G-17-004) ···· Median expected — ZZ→2q2l (arXiv:1803.10093) — WZ→2q2 $\nu$ (arXiv:1803.03838) — WW→4q (PRD 97 (2018) 072006) — WZ→2qlv (JHEP 05 (2018) 088) - ZZ→4q (PRD 97 (2018) 072006) [dd] [gd] - WZ→4q (PRD 97 (2018) 072006) — ZZ→2q2ν (arXiv:1803.03838) WW→2qlv (JHEP 05 (2018) 088) \_ \_\_01 ອີ \_10 گھ 10<sup>-2</sup> ≡ **CMS CMS** Preliminary Preliminary 2.5 m<sub>G<sub>Bulk</sub></sub> [TeV] 3.5

PhysicsResultsB2GDibosons