

# Status of BSM searches at ATLAS

## & some future prospects at HL-LHC

Caterina Vernieri on behalf of the ATLAS collaboration  
[caterina@slac.stanford.edu](mailto:caterina@slac.stanford.edu)

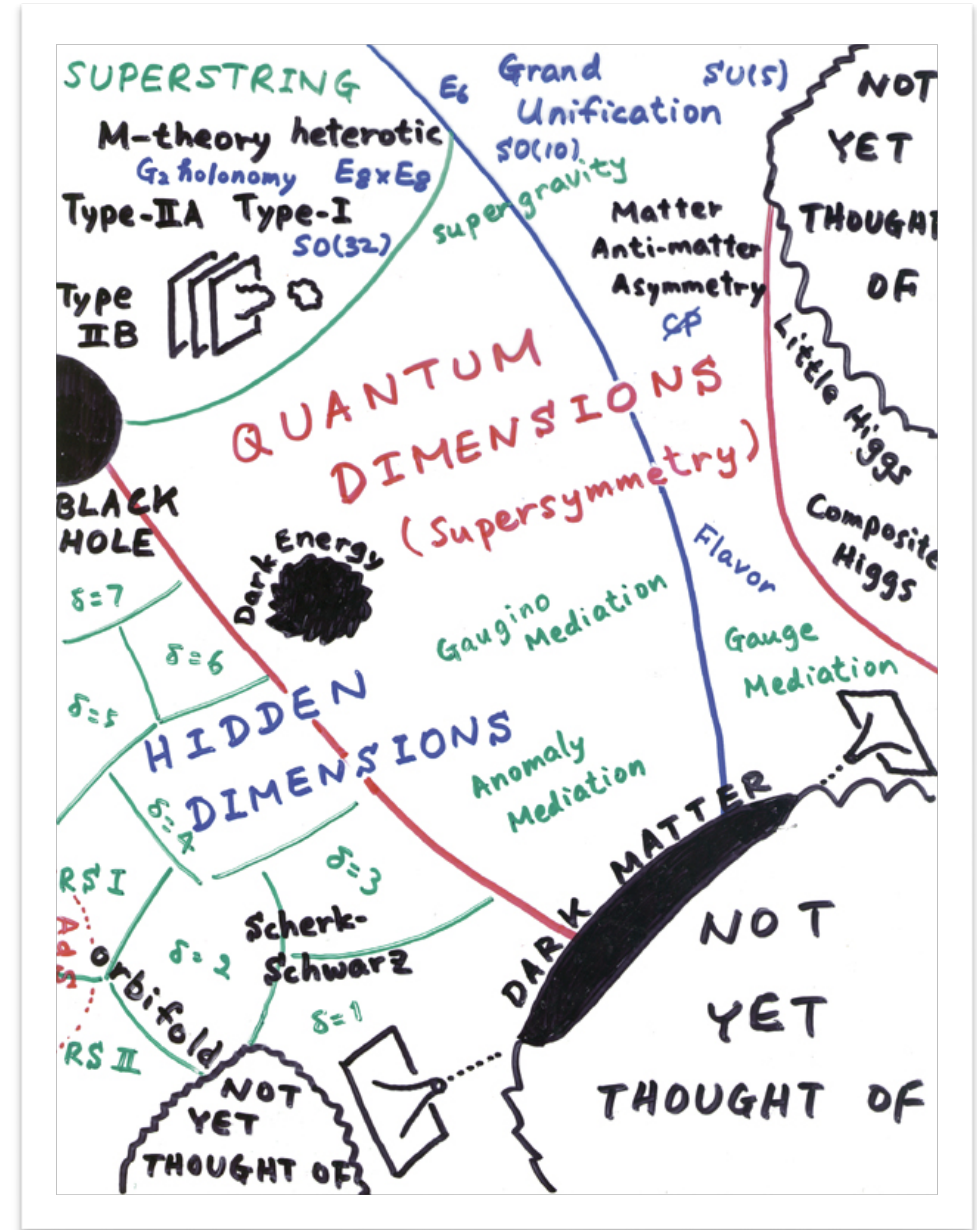
# Where is new physics?

*We don't know*

*Exploring the unknown*

- signature-based generic searches
- model-driven targeted searches

*New technique to explore new ground*



# Where is new physics?

*We don't know*

*Exploring the unknown*

**Warped Extra Dimension:**  
Integration of gravity in SM and  
solution to the hierarchy problem

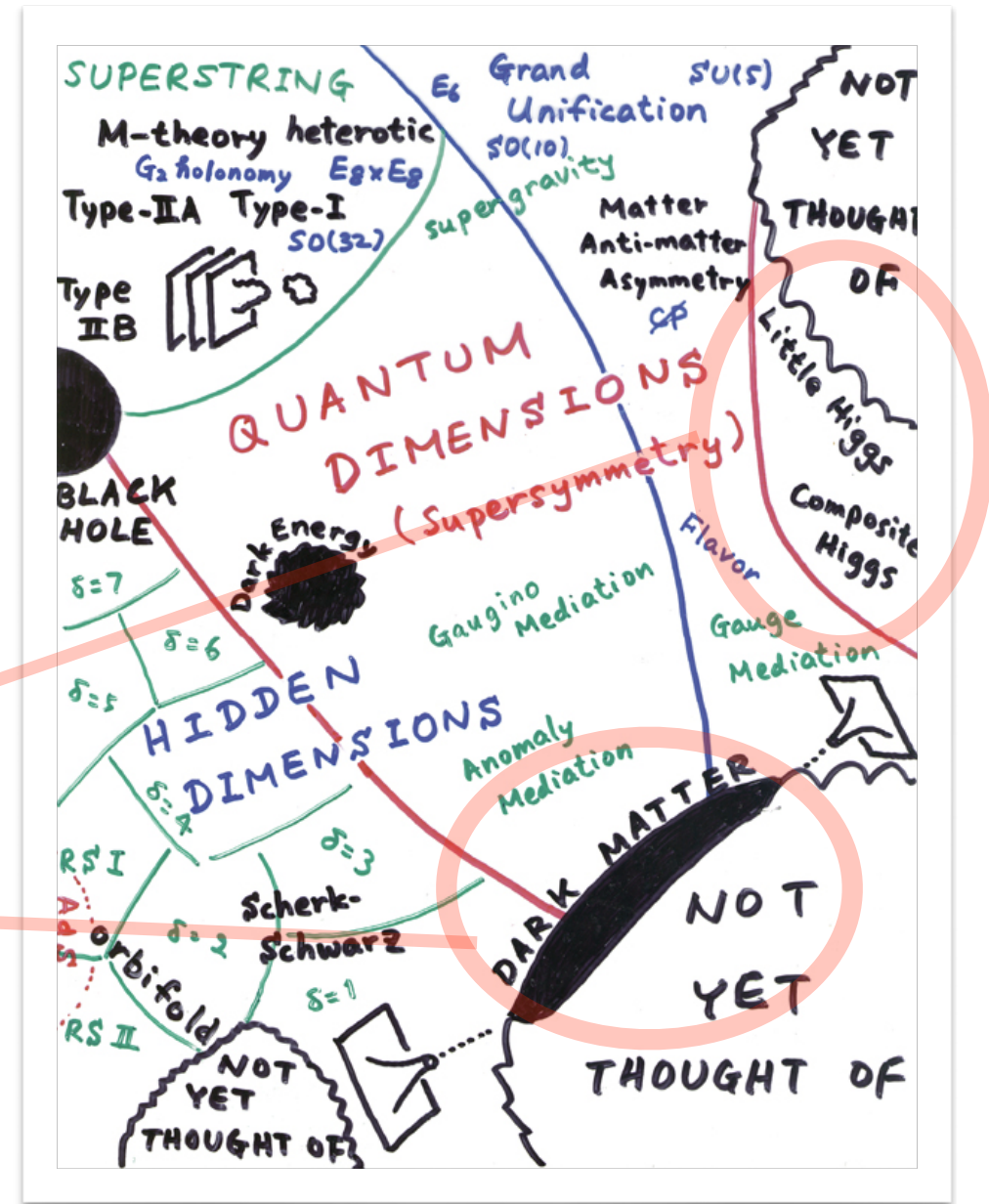


# Where is new physics?

*We don't know*

*Exploring the unknown*

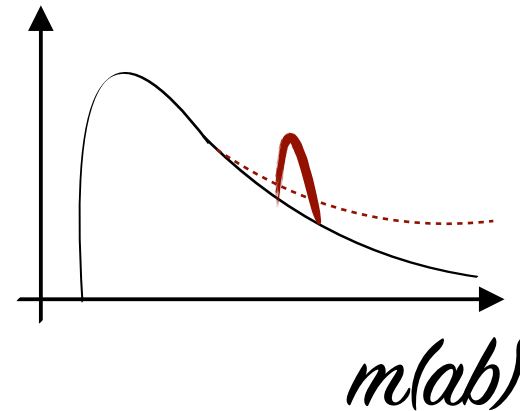
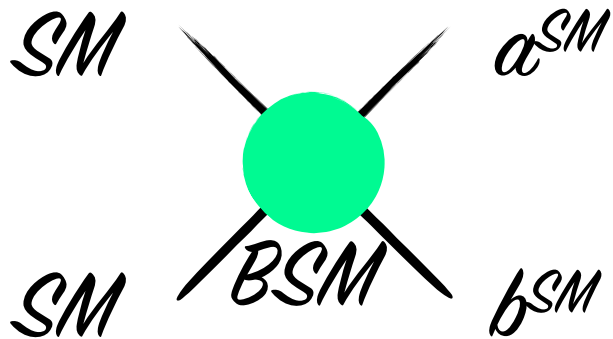
**New gauge bosons: Z/W-like  
Z' as Dark Matter mediator**

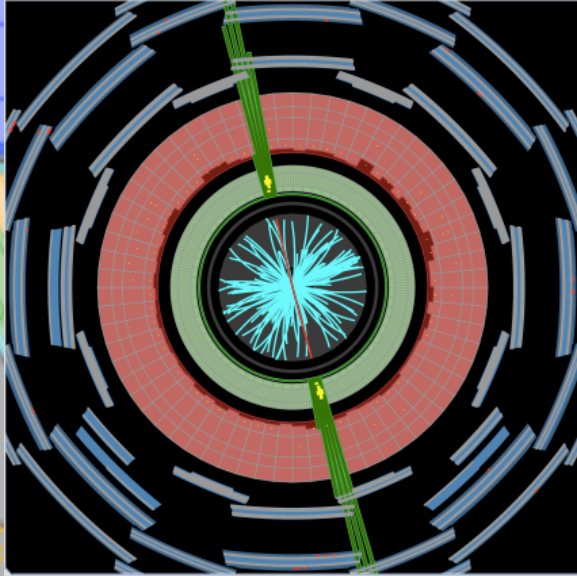
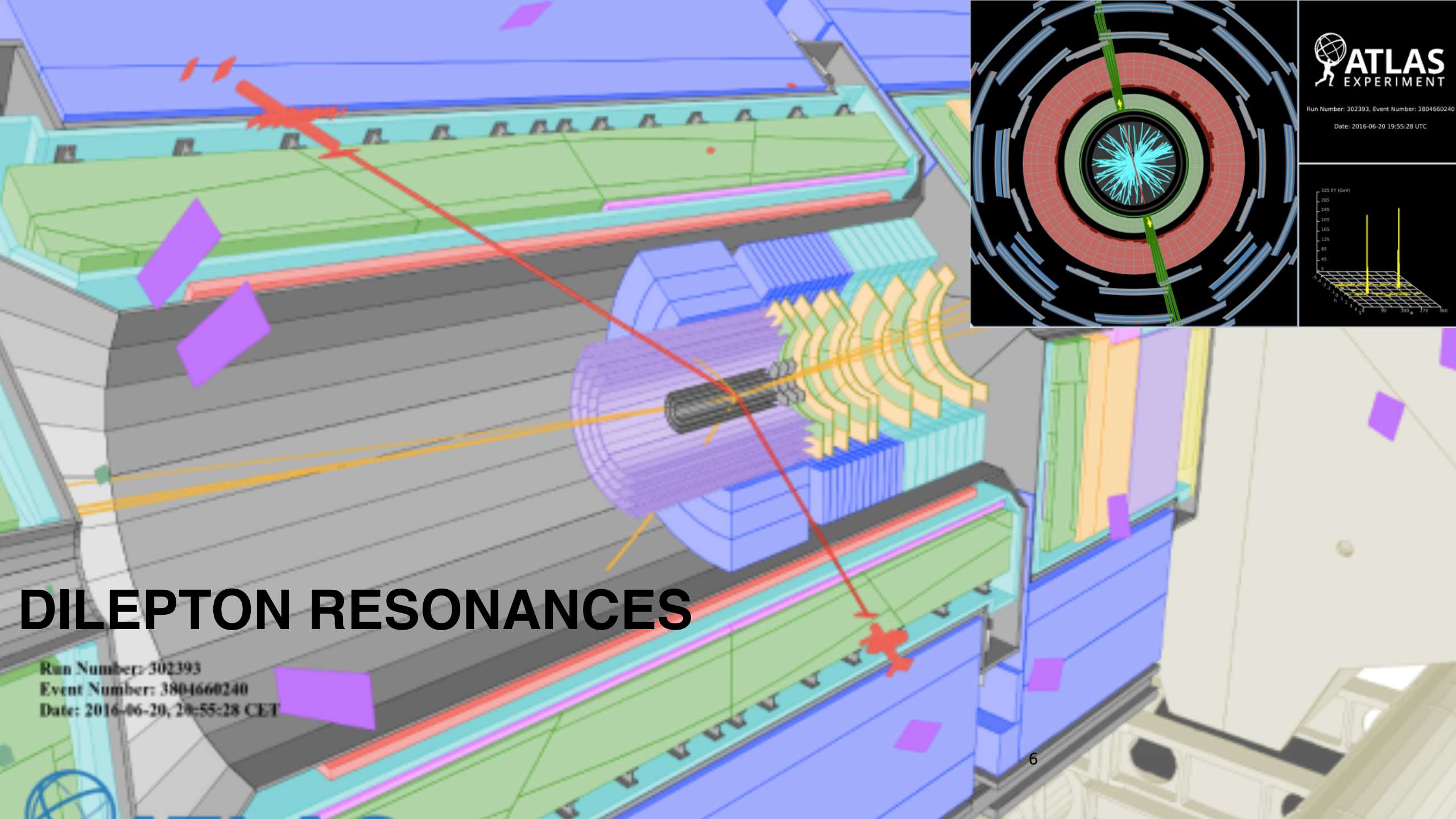


# In this talk, focus on...

Many Beyond SM theories predict new resonances at the TeV mass scale  
This talk focuses on recent BSM results with full 13 TeV dataset

- *Dilepton*
- *Dijet*
- *Diboson  $\rightarrow$  Di-scalar*

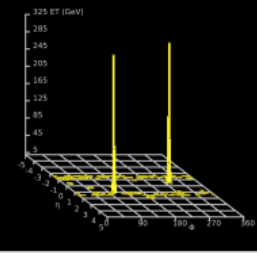




**ATLAS**  
EXPERIMENT

Run Number: 302393, Event Number: 3804660240

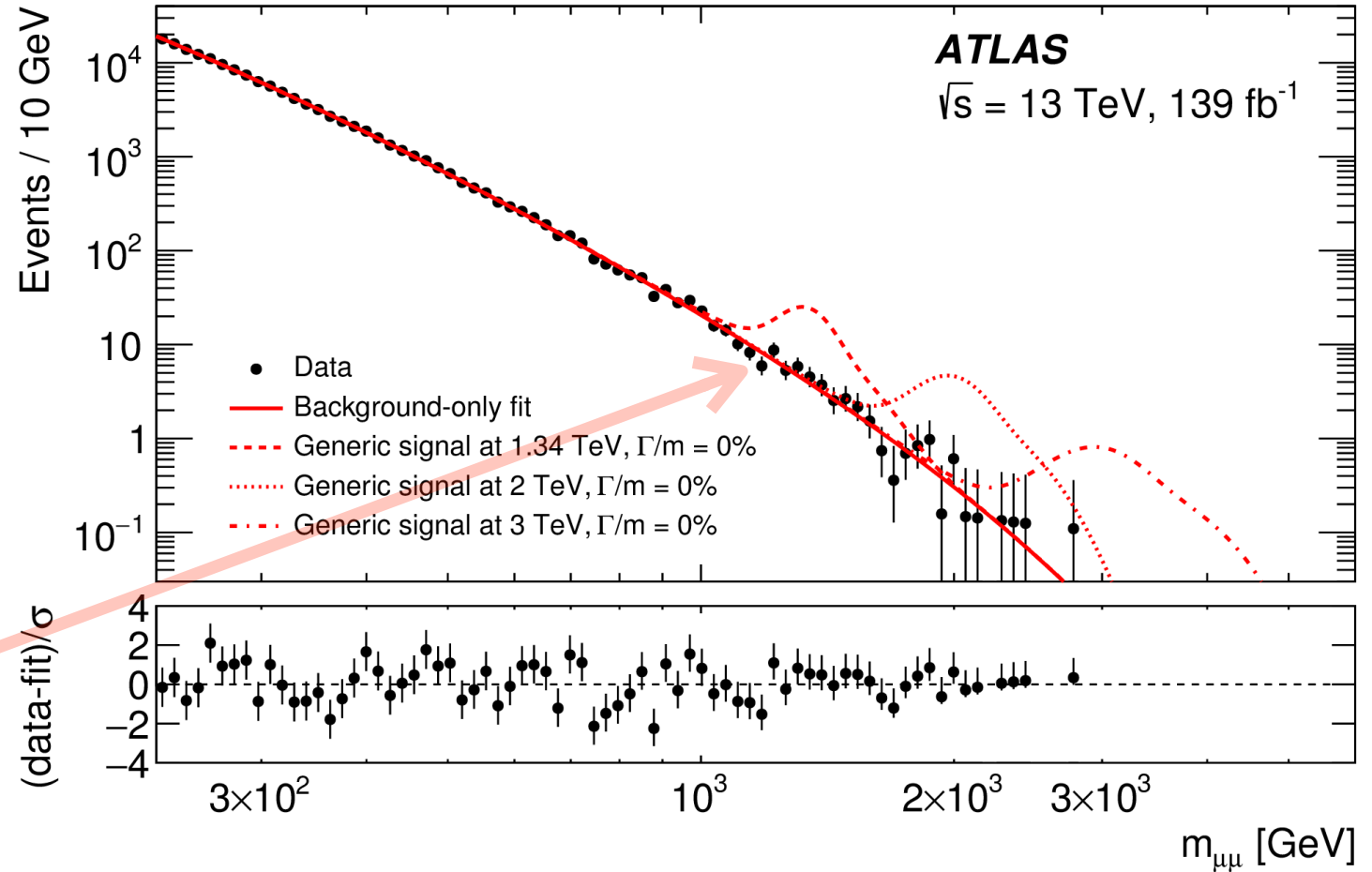
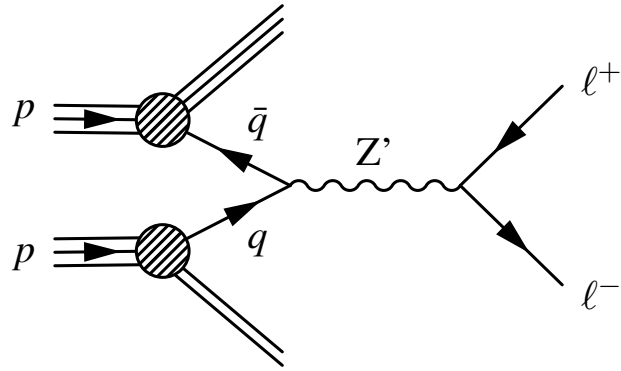
Date: 2016-06-20 19:55:28 UTC



# DILEPTON RESONANCES

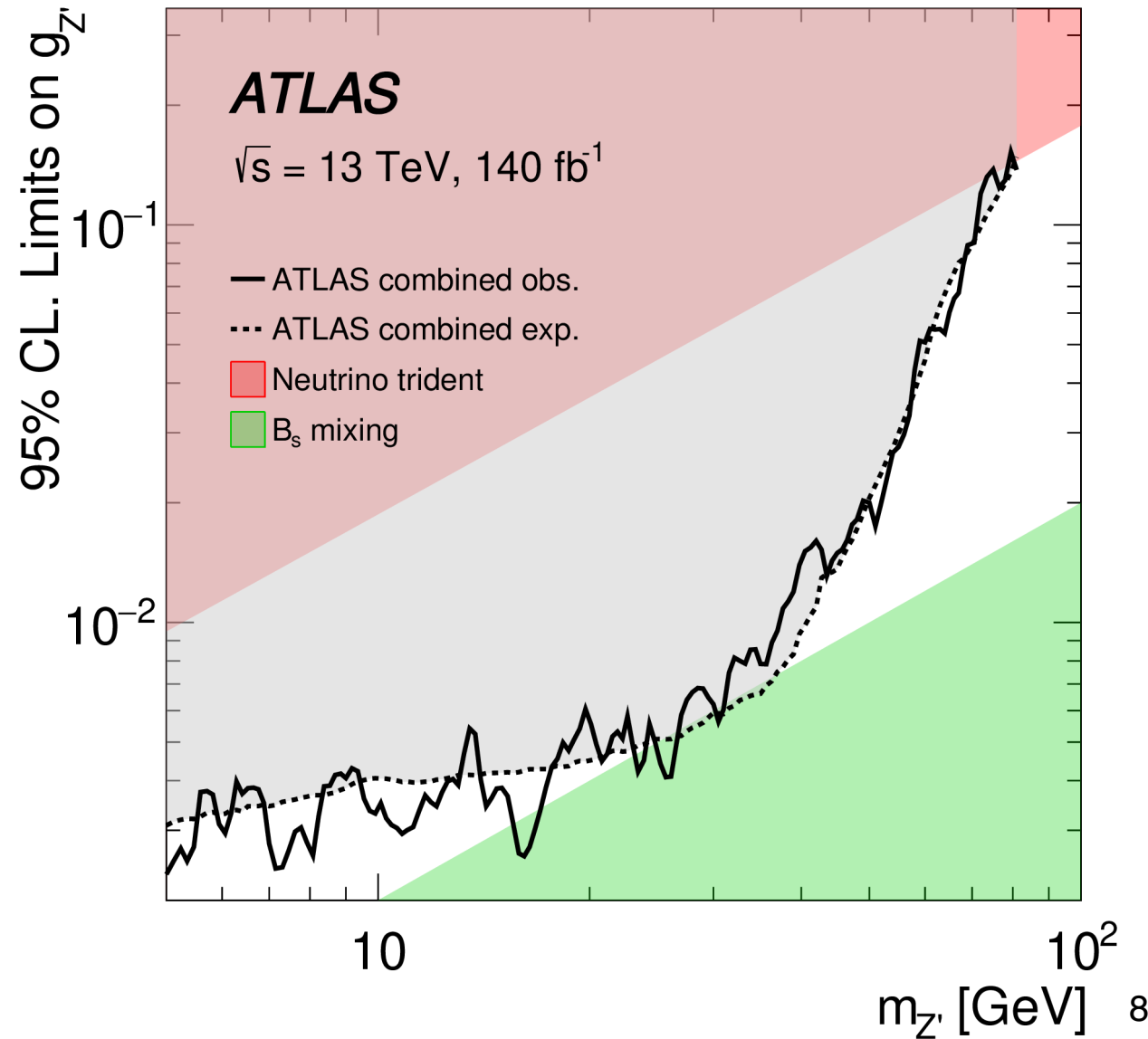
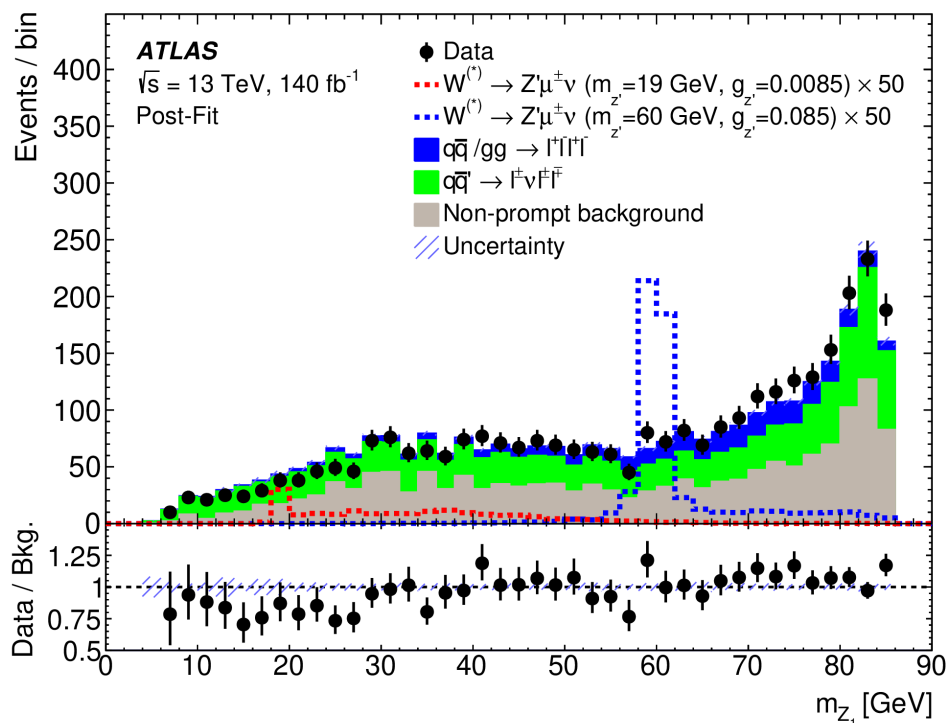
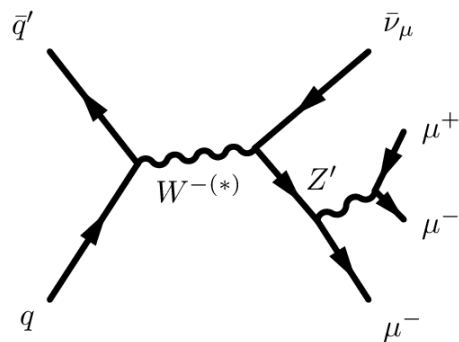
Run Number: 302393  
Event Number: 3804660240  
Date: 2016-06-20, 20:55:28 CET

# $Z' \rightarrow \mu\mu$



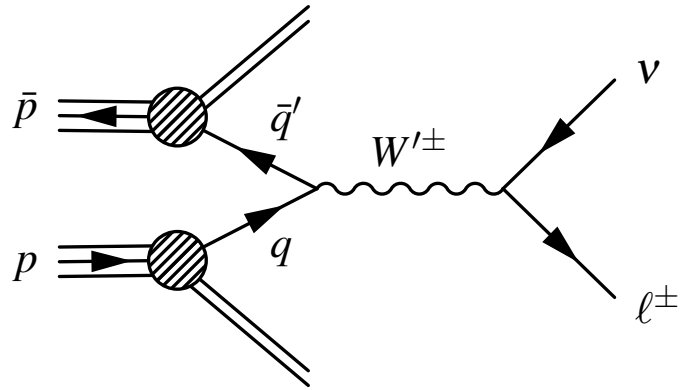
Look for a peak on top of the SM background

# Lower $Z'$ mass searches





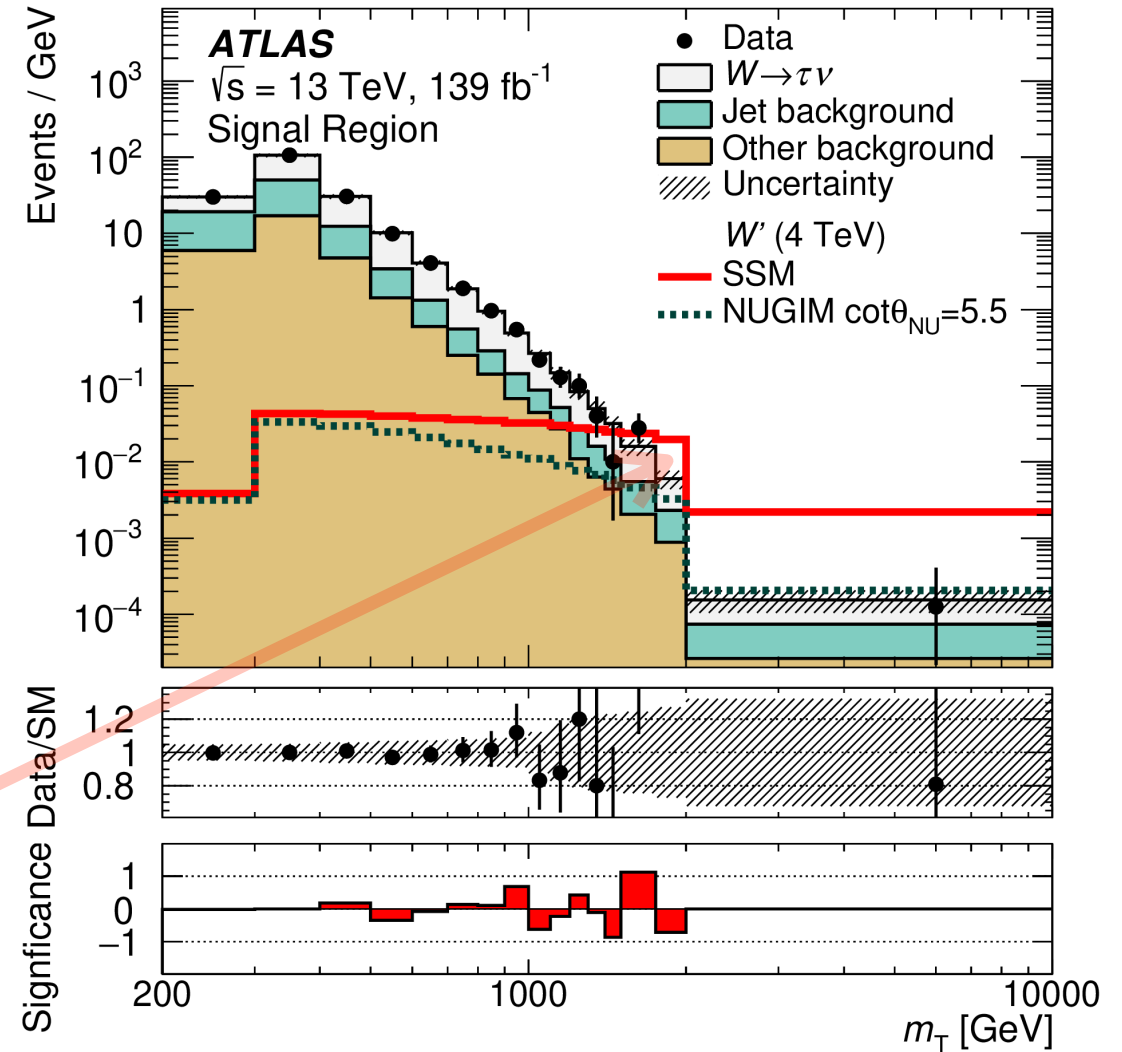
# $W' \rightarrow \tau \nu$



Neutrinos are partially reconstructed assuming momentum conservation in the transverse plane

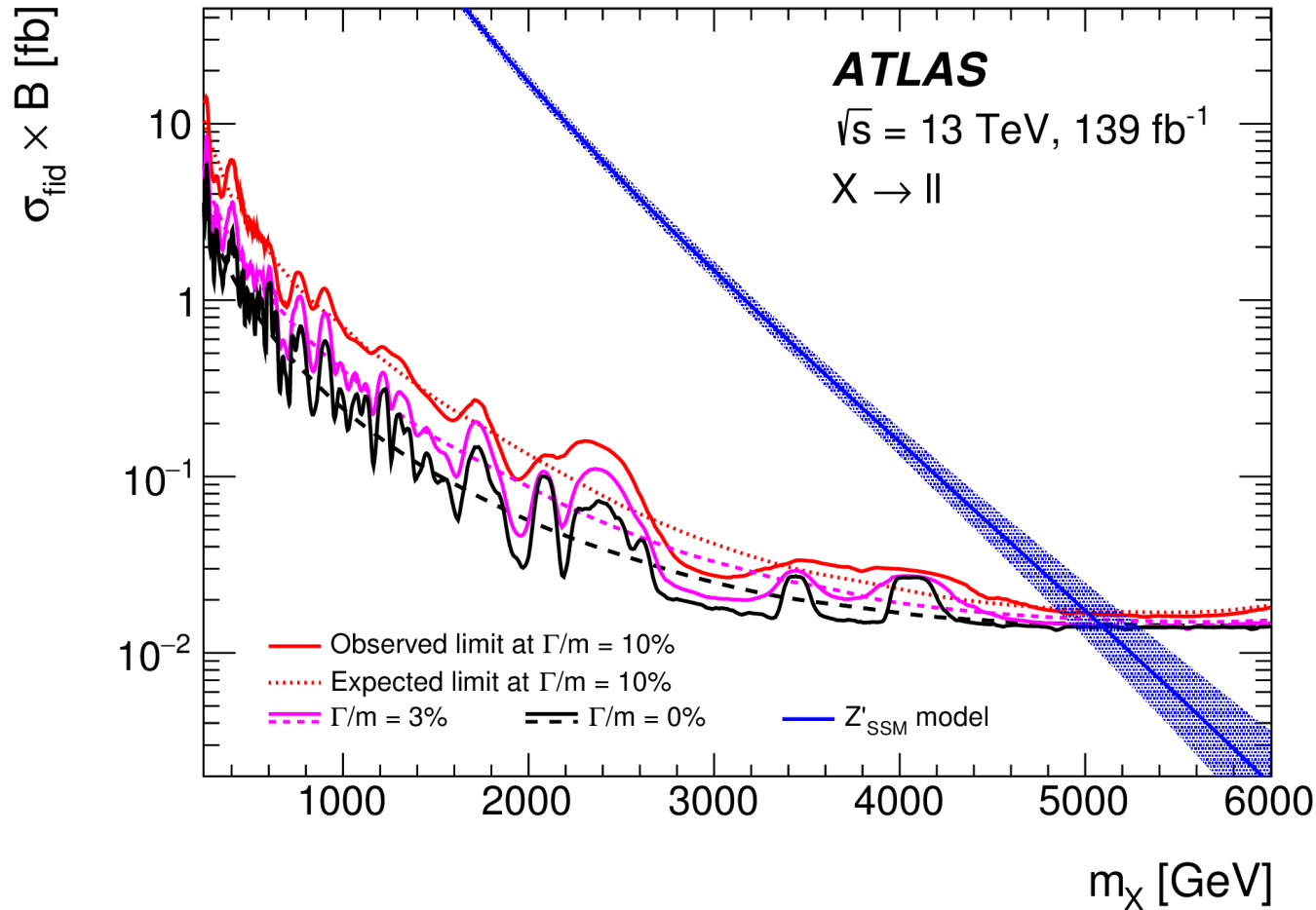
MET+lepton **transverse mass** used to extract the signal

$$M_T = \sqrt{2p_T^l E_T^{\text{miss}} (1 - \cos[\Delta\phi(\vec{p}_T^l, \vec{p}_T^{\text{miss}})])}$$

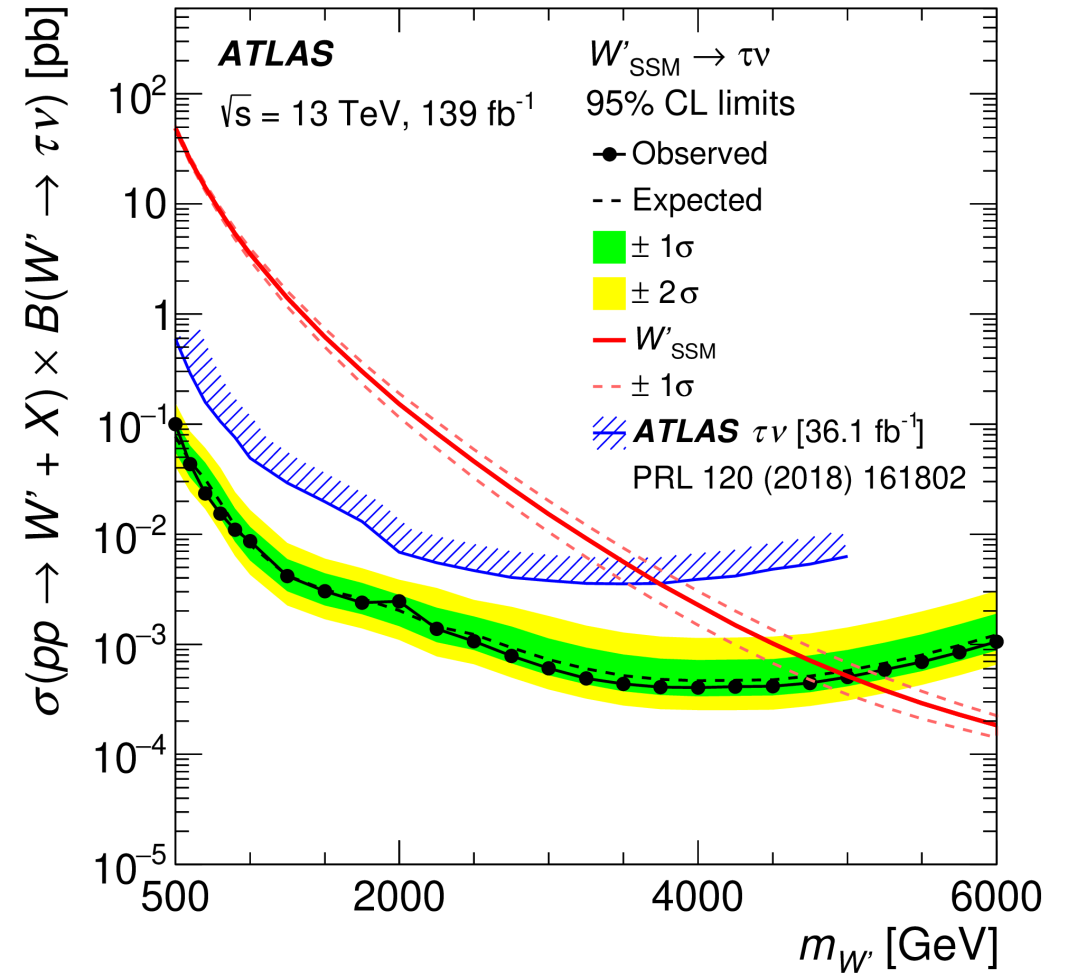


# Results

$Z' \rightarrow \mu\mu$

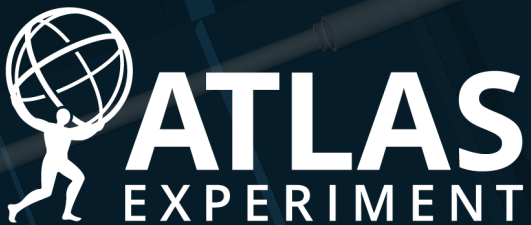


$W' \rightarrow \tau\nu$





**Dijet mass  
8.12 TeV**



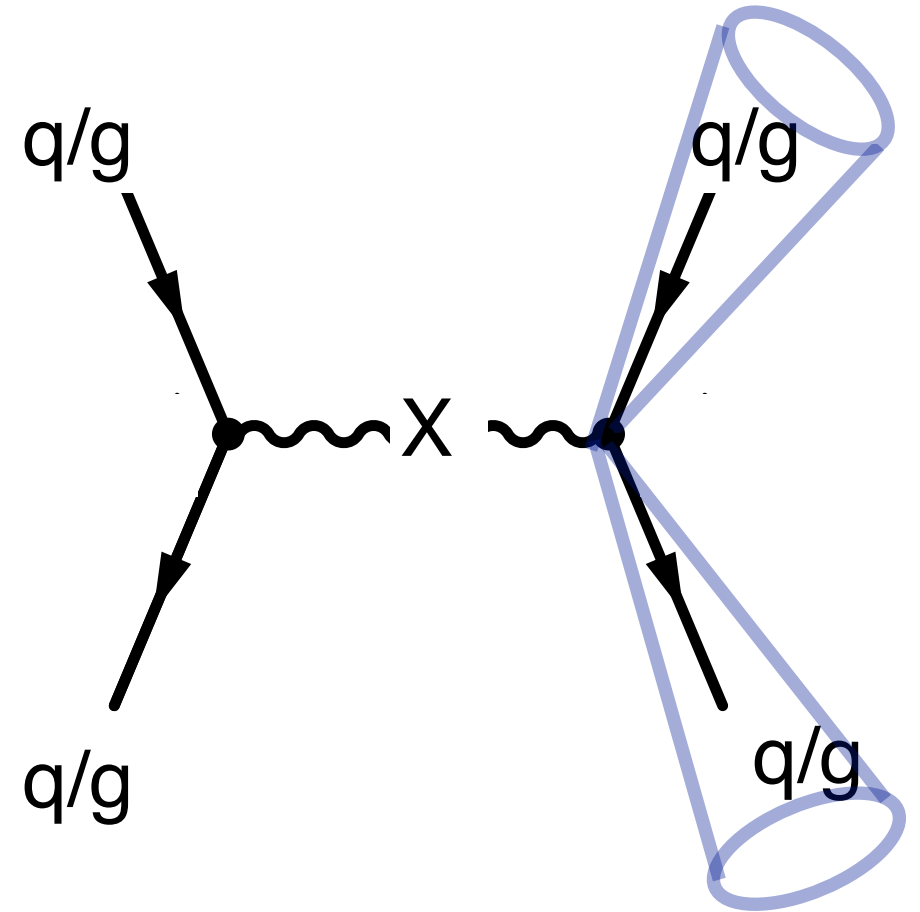
Run: 305777

Event: 4144227629

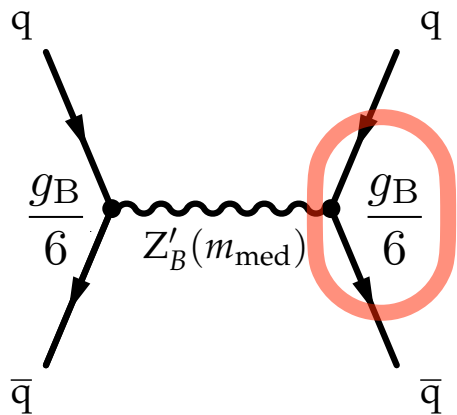
**DIJET RESONANCES**

# Dijet resonances

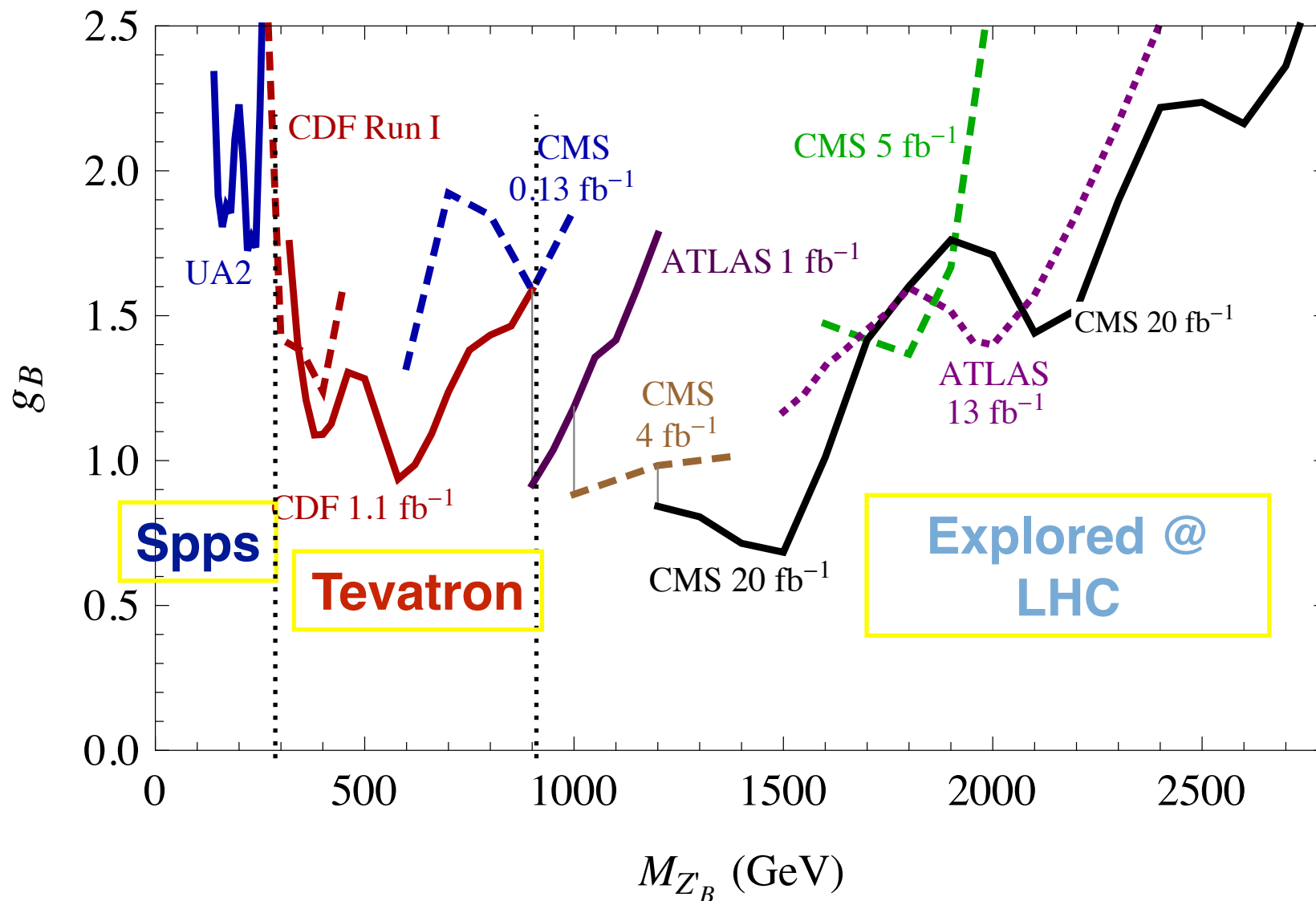
- A classic program at hadron colliders
- Sensitive to several scenarios
  - excited quarks, strings, new bosons, gravitons, DM

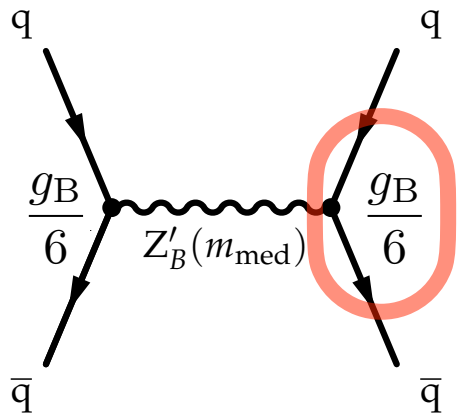


**two small radius jets**

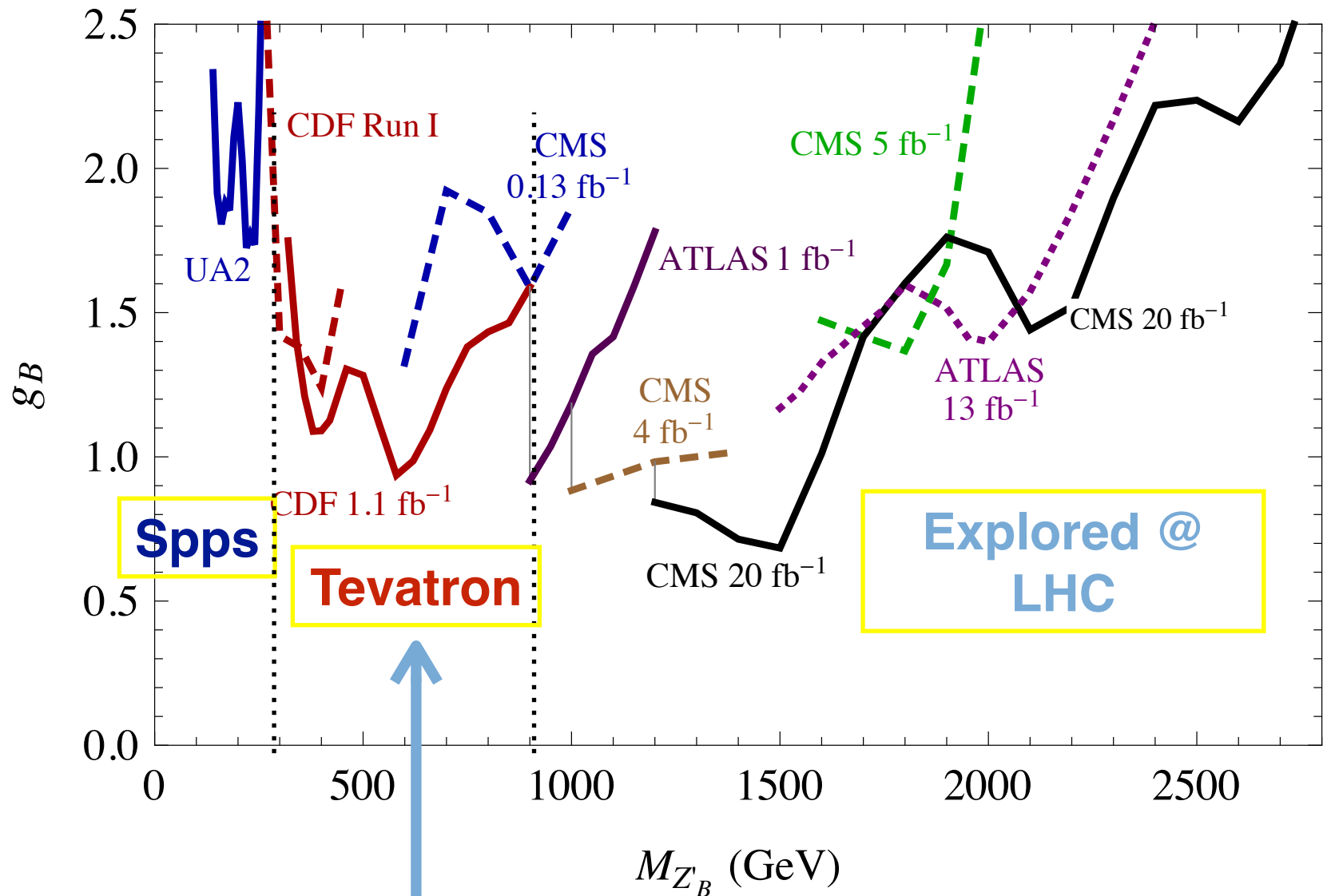


universal quark coupling  
to leptophobic  $Z'_B$





universal quark coupling  
to leptophobic  $Z'_B$



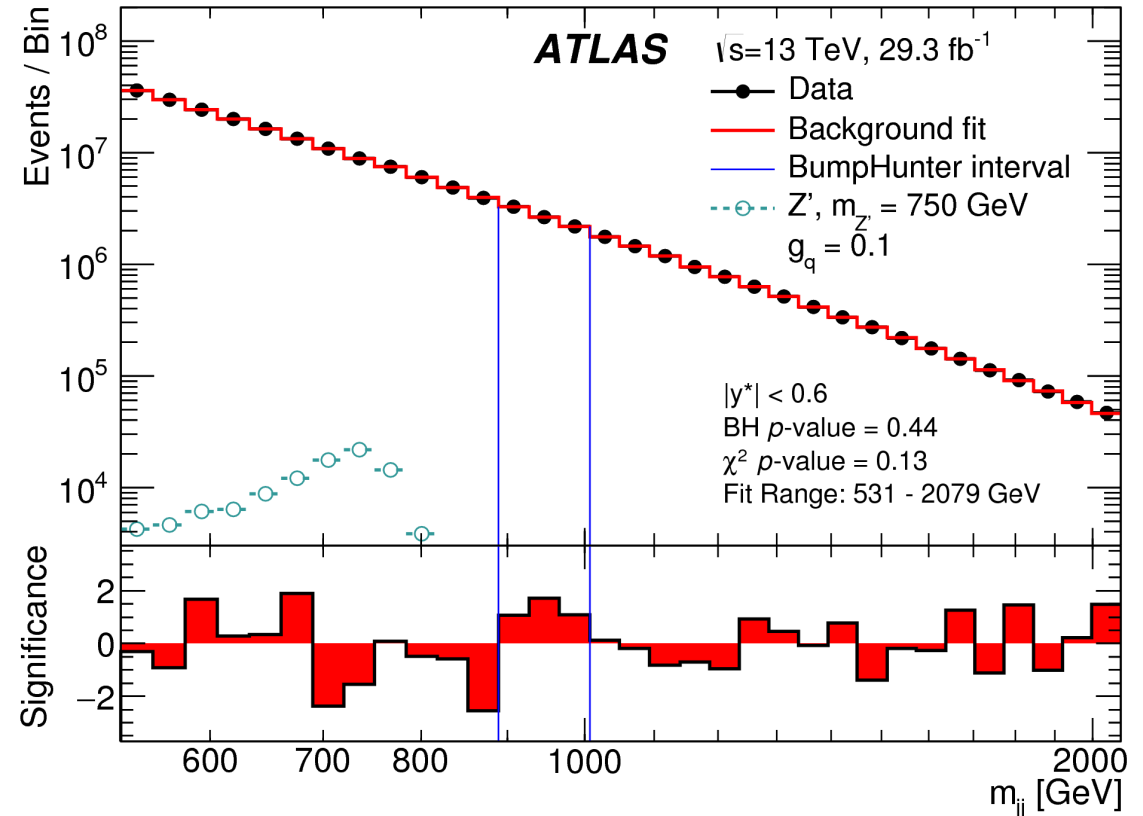
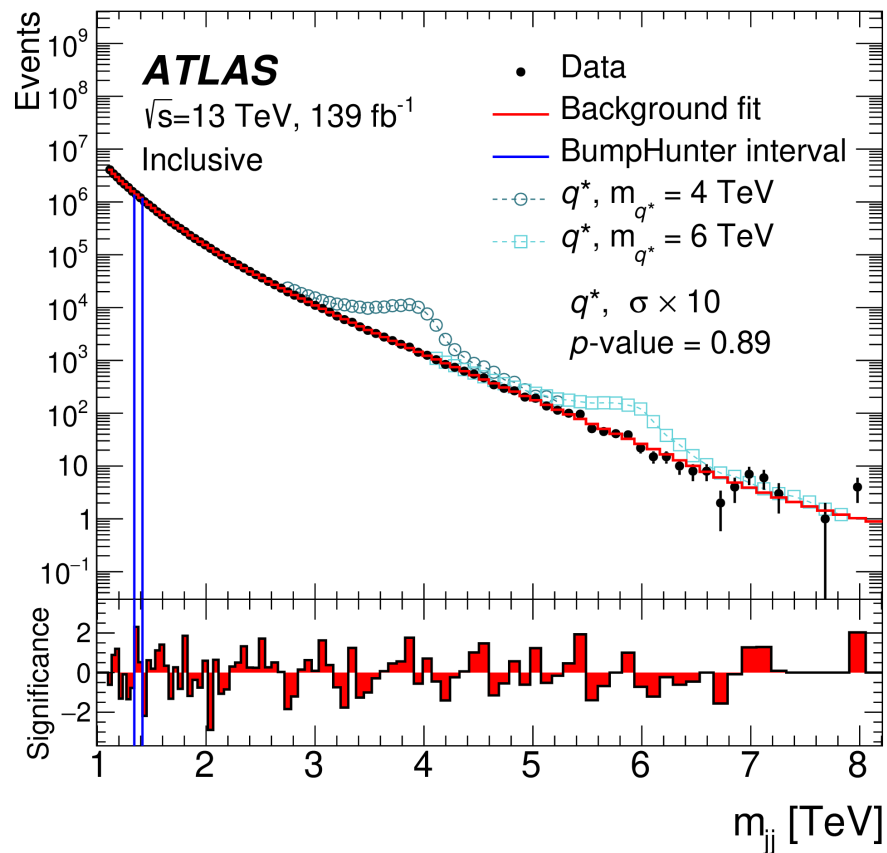
*trigger limited @LHC, but...*

# Classic dijet search

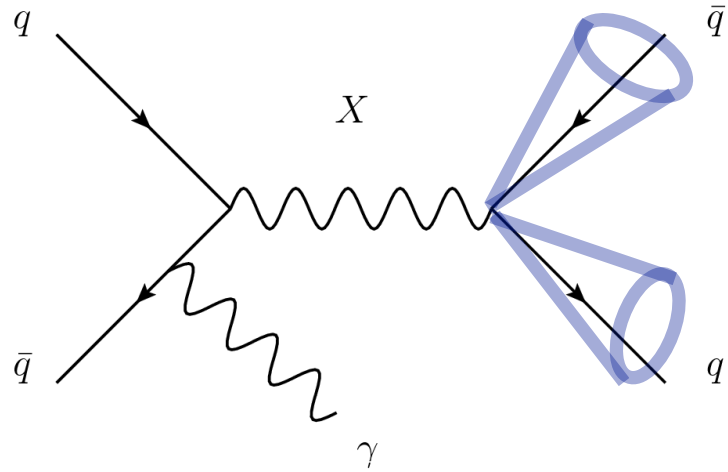
**Classic** resonance search for  $M_{jj}$  in the range 1.1–8 TeV

**Low mass** analysis for 450-1800 GeV (Trigger Limited Analysis)

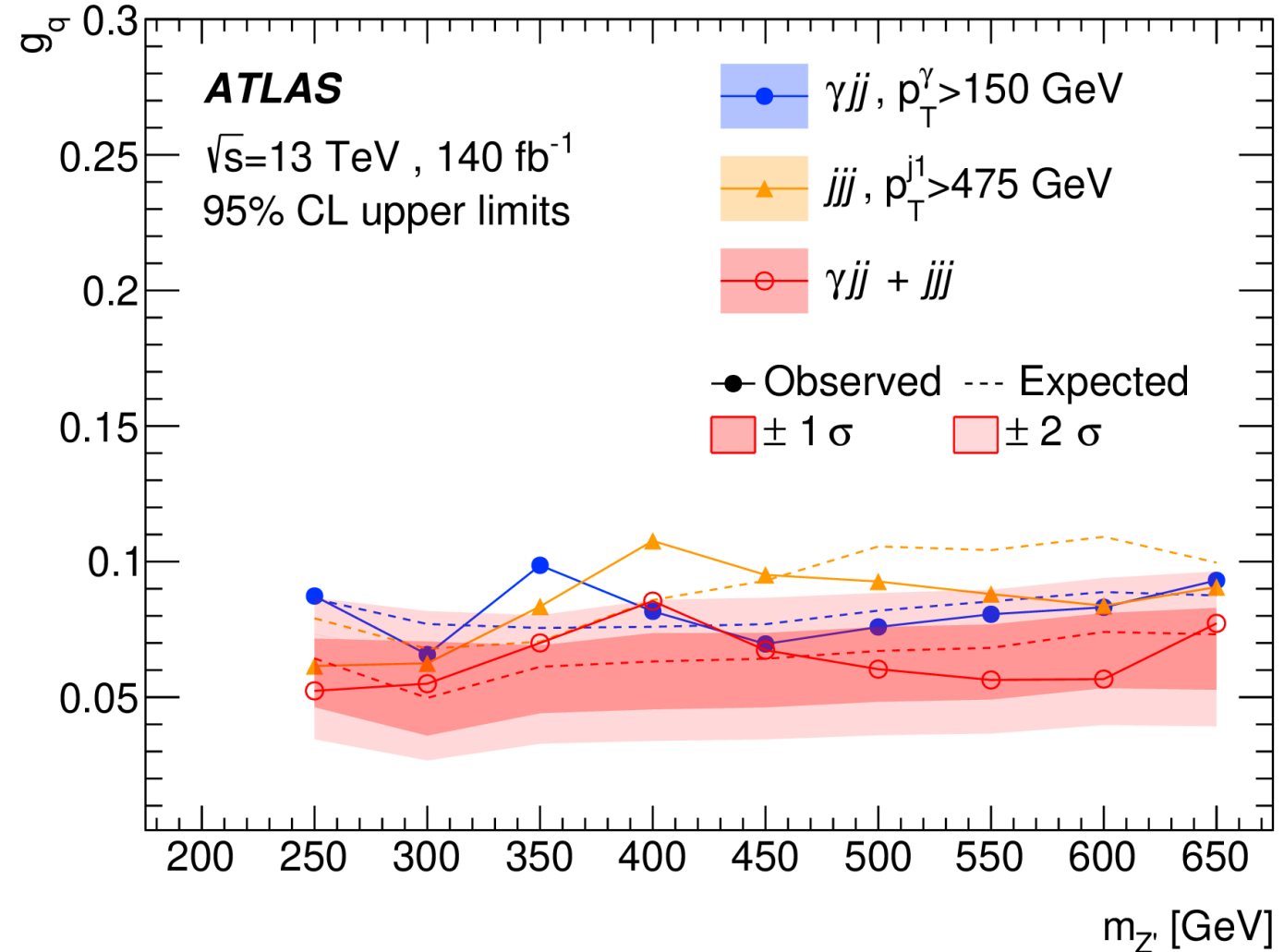
- lower trigger thresholds by recording only information necessary to perform analysis



# Light dijet resonances: $Z'$ +ISR

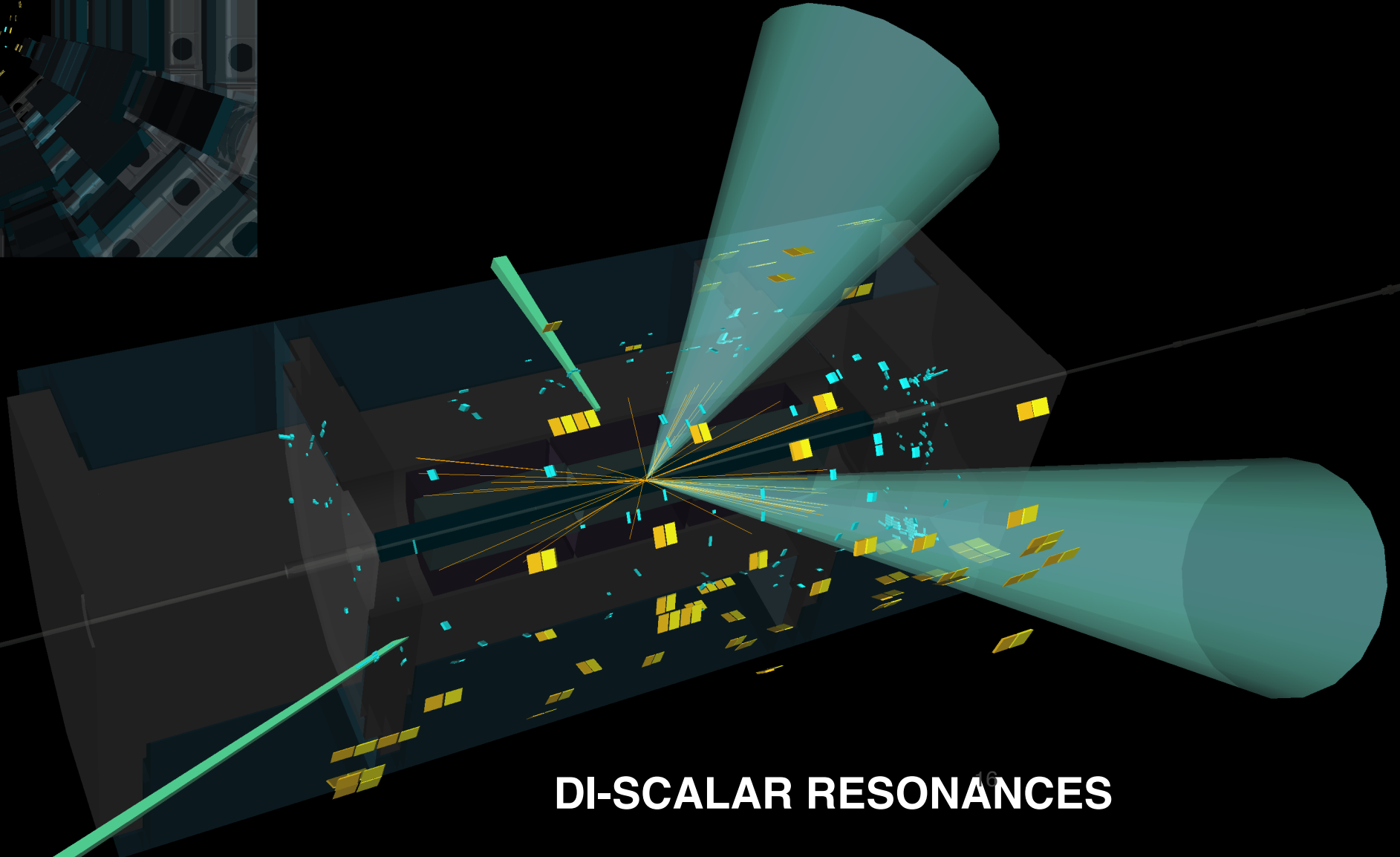
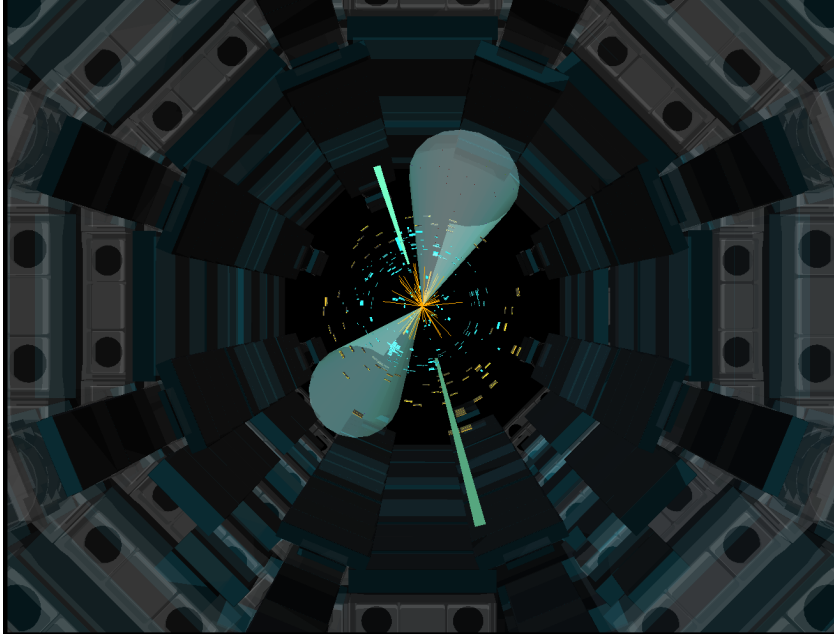


- ISR  $\gamma$  allows to lower jet  $p_T$  threshold
- The search is performed in the 250–650 GeV dijet mass range



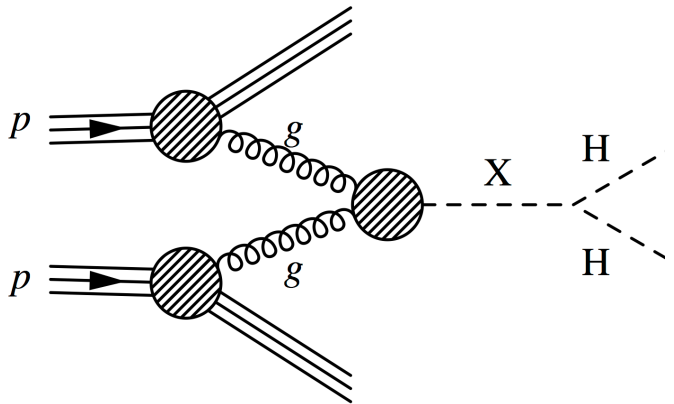


Run: 329869  
Event: 1512463585  
2017-07-16 14:42:56 CEST

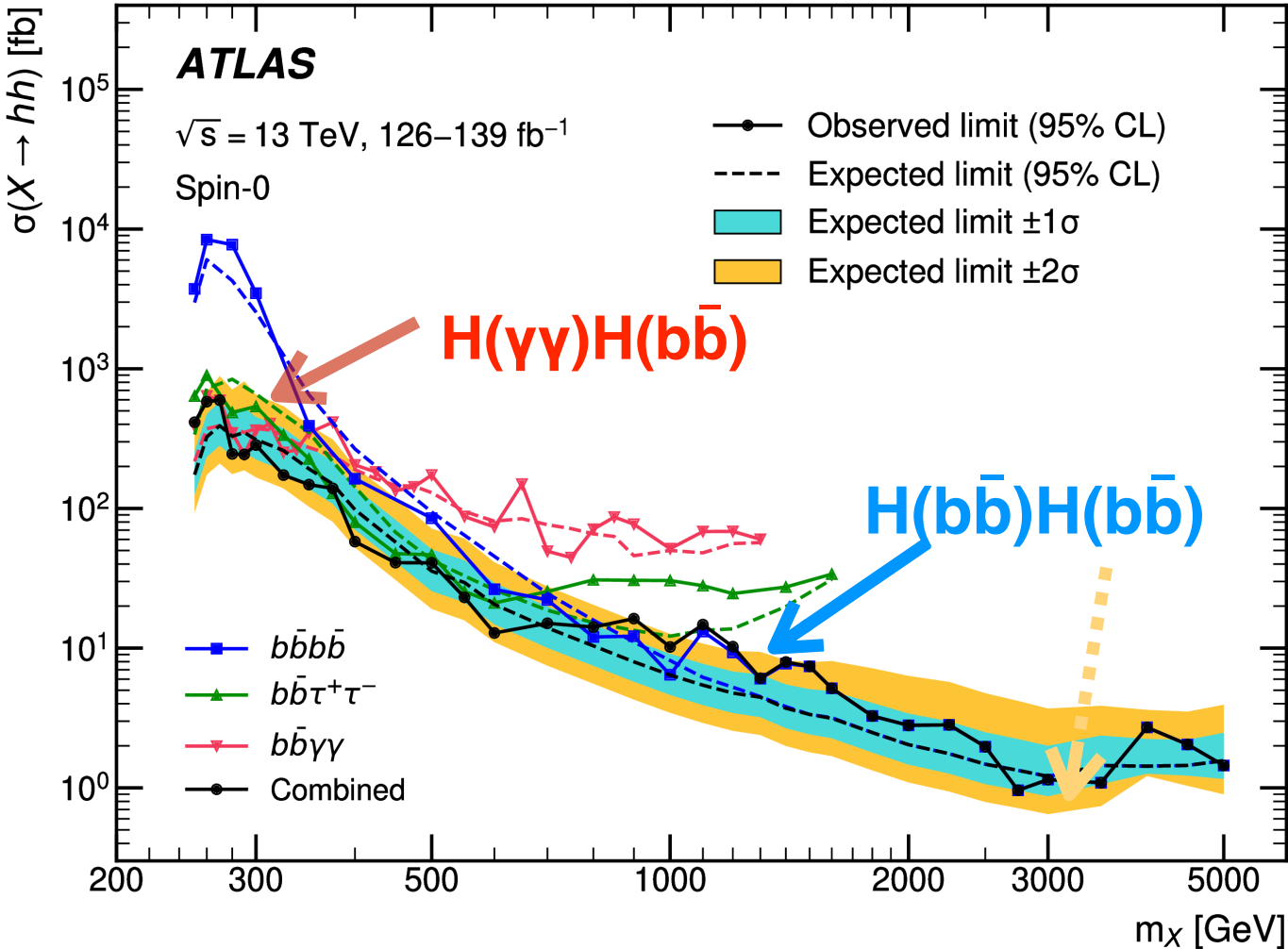


DI-SCALAR RESONANCES

# X → HH



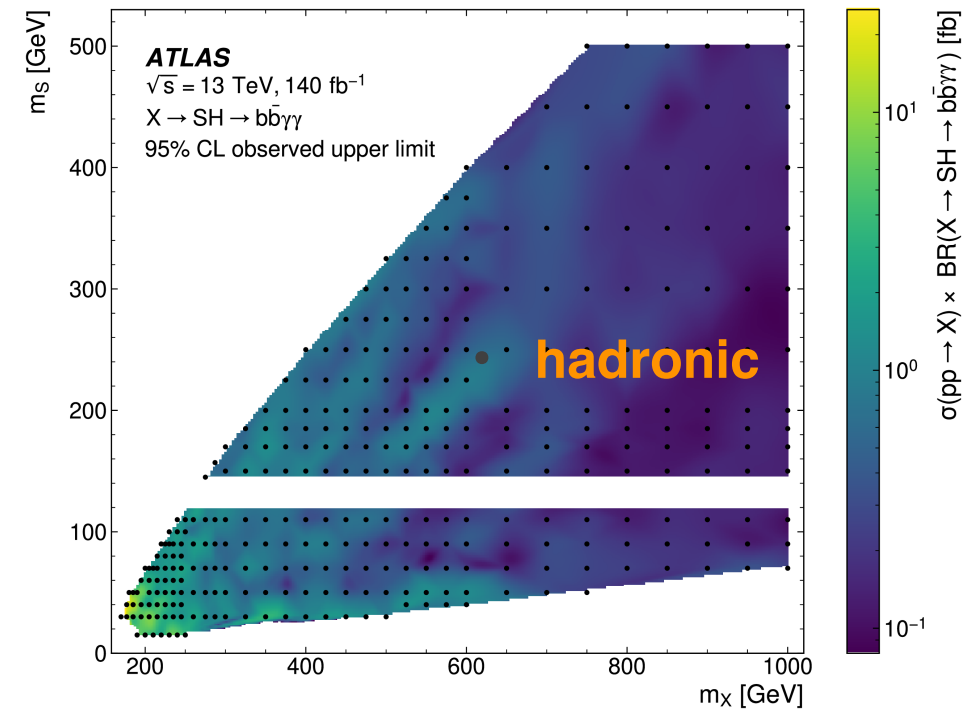
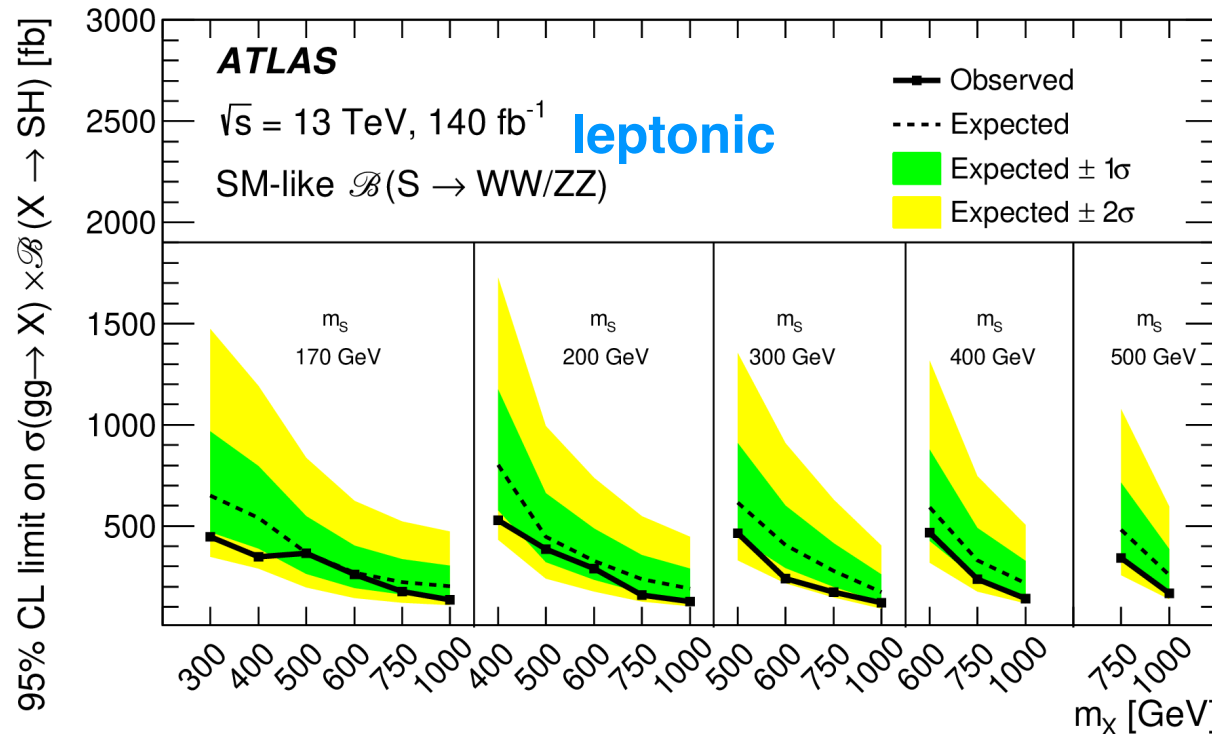
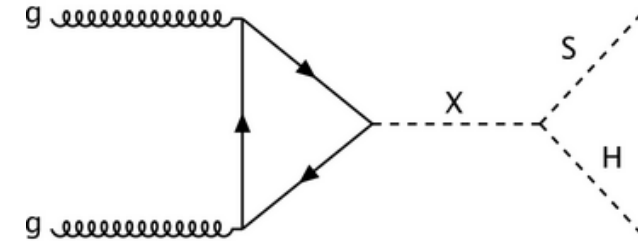
**H(b $\bar{b}$ )H(b $\bar{b}$ )** most sensitive channel for  $m_X > 400/500$  GeV  
**H( $\gamma\gamma$ )H(b $\bar{b}$ )** complement in the low mass



# $X \rightarrow SH(\gamma\gamma)$

Search for the production of **spin-0 resonances** with masses between 0.3 and 2.0 TeV

- both in the **leptonic** and **hadronic** final states



observed

Quarks



Vector Like Quarks

# Vector-Like Quarks

Vector-like quarks are extra family of quarks with symmetric “vector-like” couplings to W,Z

Production via

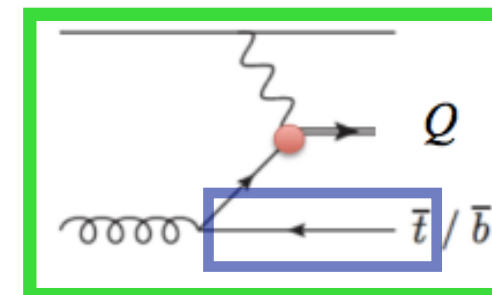
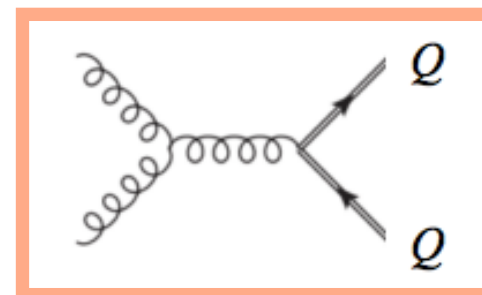
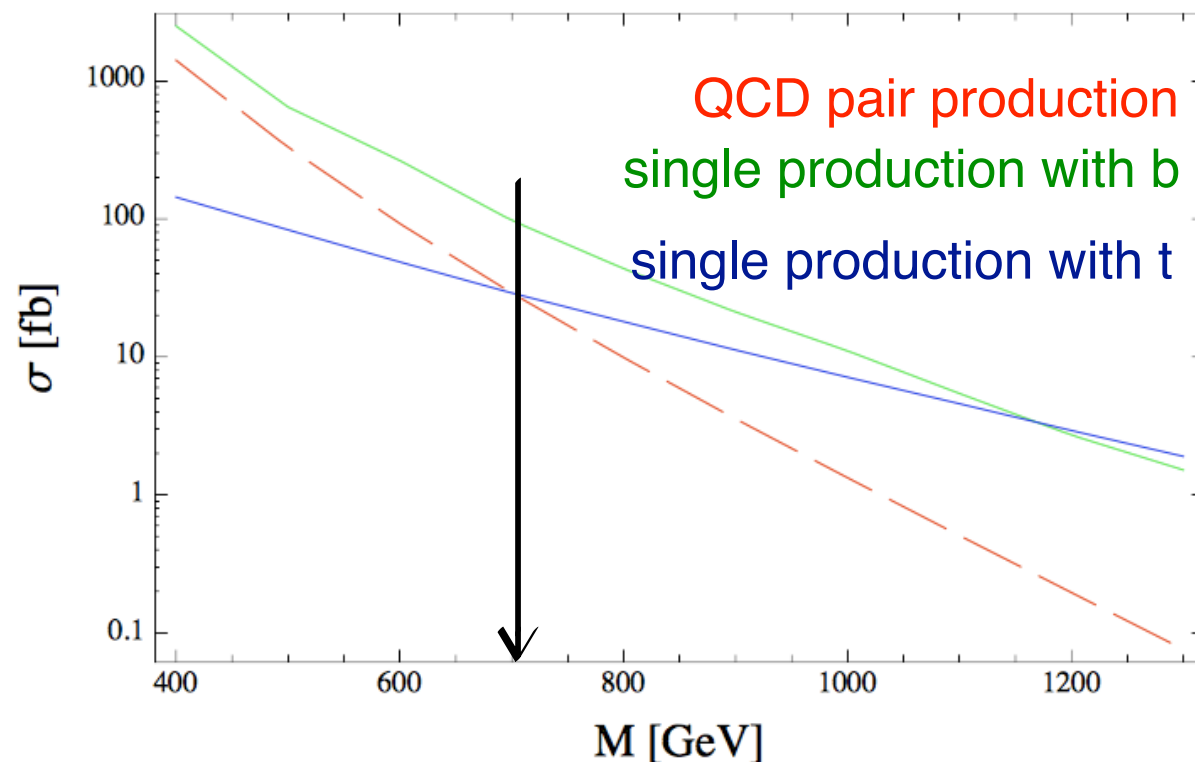
- QCD (pair) is model independent
- EW (single) interactions depends on the mixing with SM quarks

Both charged- and neutral-current decays are possible for B(-1/3) and T(2/3)

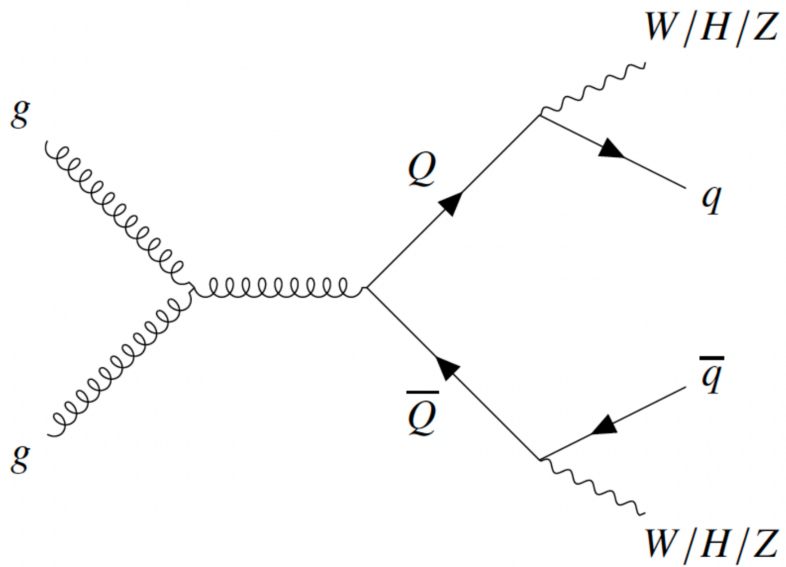
$$T \rightarrow bW, tZ, th$$

$$B \rightarrow bZ, bh, tW$$

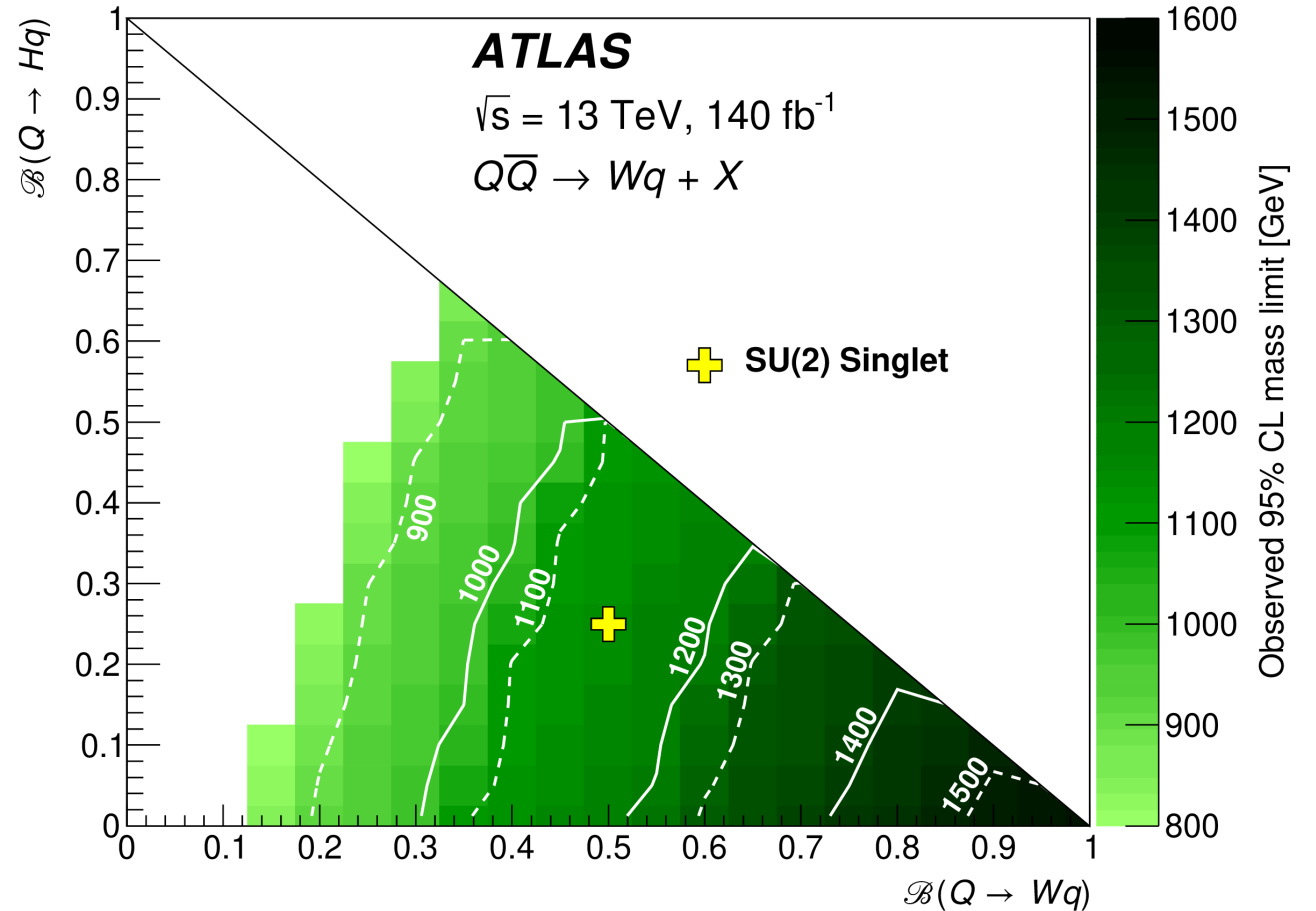
b-tagging in boosted topology leads to high sensitivity also in the fully hadronic final state



# $TT \rightarrow WqWq$

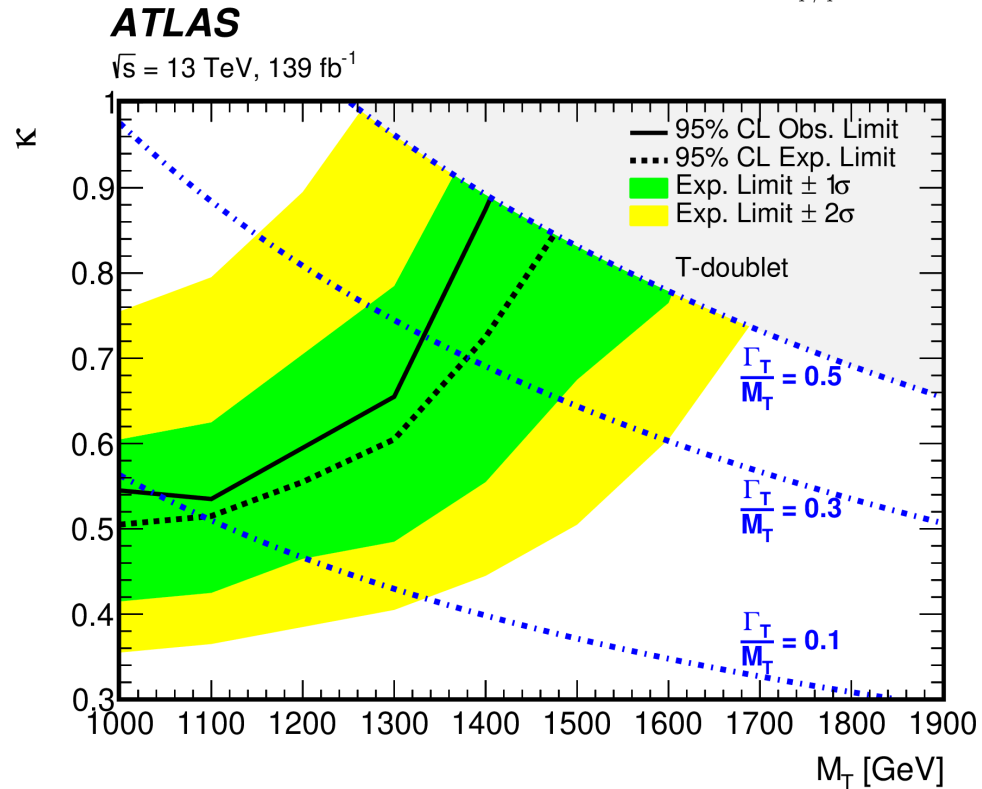
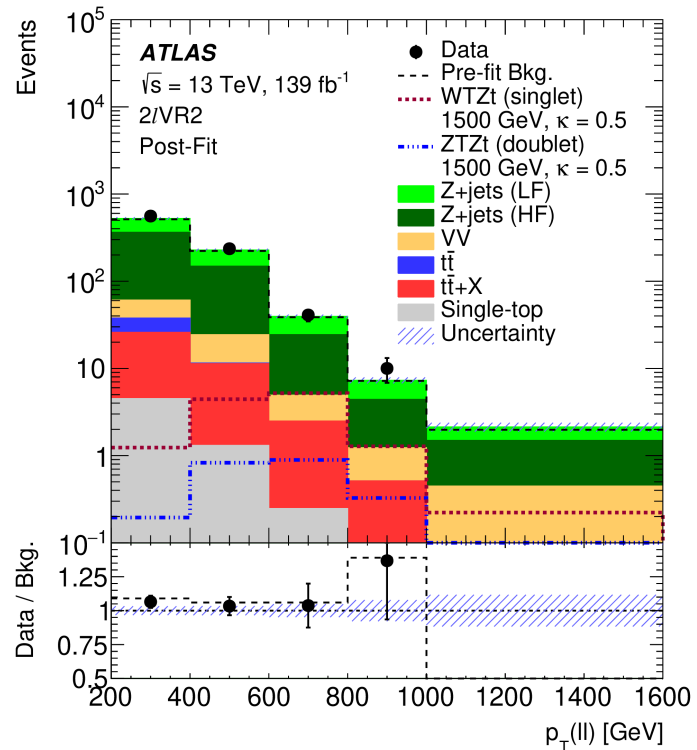
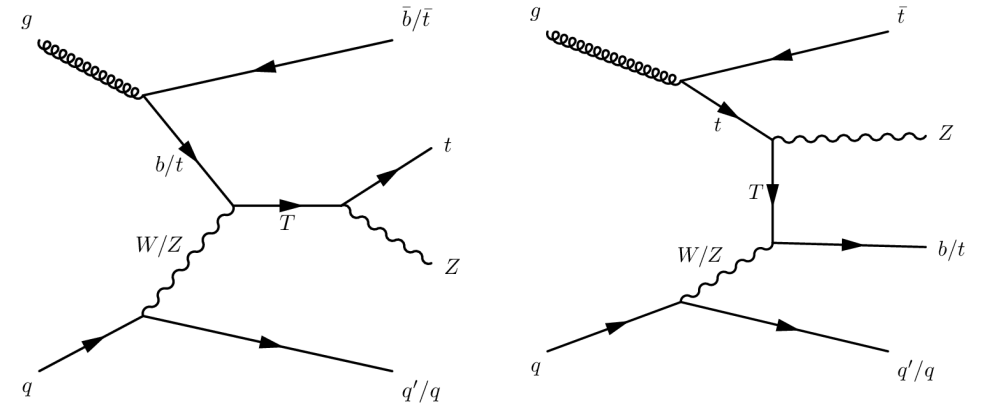


- Considering VLQ mixing with light quarks
- Limits as a function of  $BR(W/Z/Hq)$



# tZ(II)+X

- Both leptonic and hadronic top decay included
- Limits for singlet and doublet representations
- Strongest experimental limits for singlet case



# Conclusions & Perspectives

ATLAS has well-developed searches in place for new physics

The 13/13.6 TeV dataset should increase by a factor 2 by the end of Run 3 in 2025

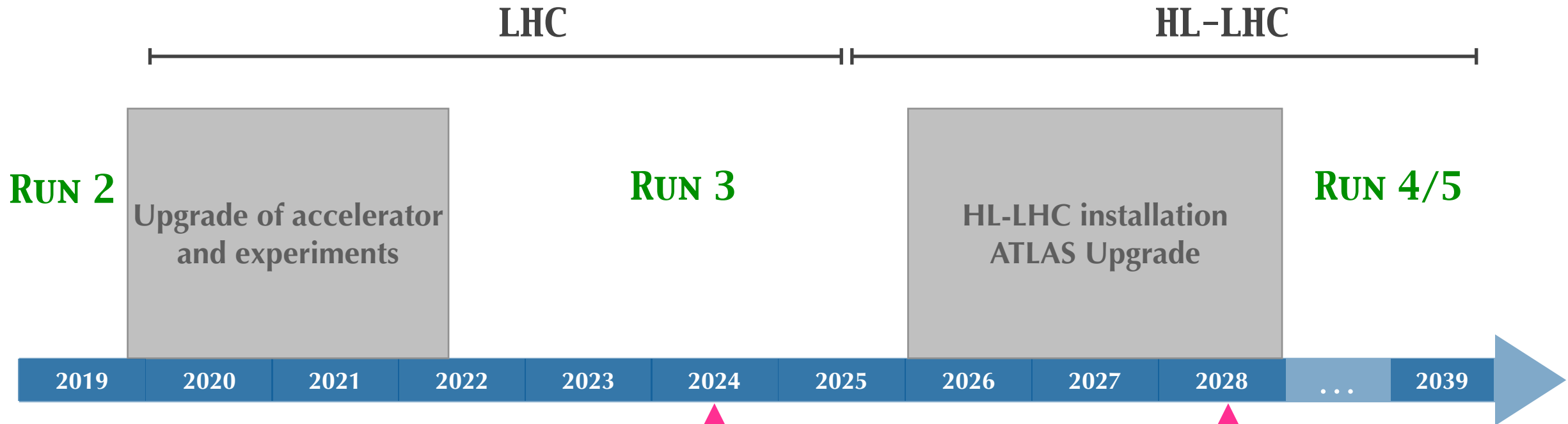
- LHC will probe ***smaller couplings with more data***

Improvements are also possible from :

- optimized events selection and improved object reconstruction
- include ***theory improvements*** on SM predictions
- ***new analysis techniques*** as the low-mass-dijet search

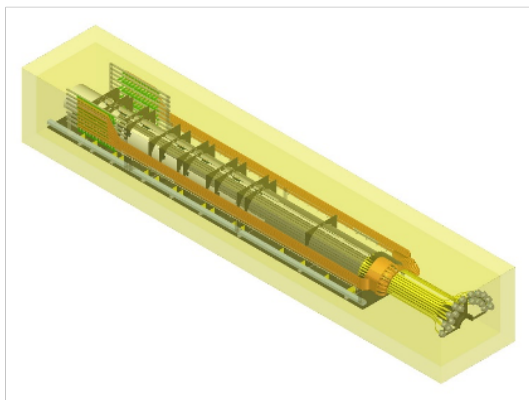
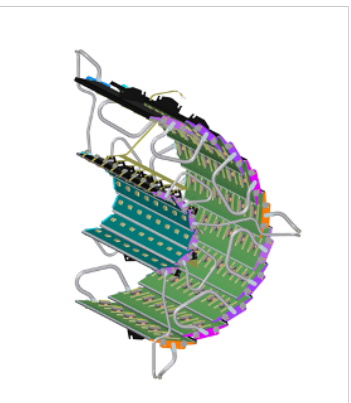
*Stay Tuned*





**TODAY**

**Phase-2 HL-LHC detector upgrades are being built**



# HL-LHC

- Increased tracking acceptance and granularity, and timing will be key to identify forward jets and preserve resolution
- Significant gains in rare BSM processes from x10 more luminosity
  - Long lived particle signatures will benefit from dedicated data streams and new detector capabilities

