Exotic searches with the ATLAS detector

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HIGH ENERGY PHYSICS BRANCH OF CPS

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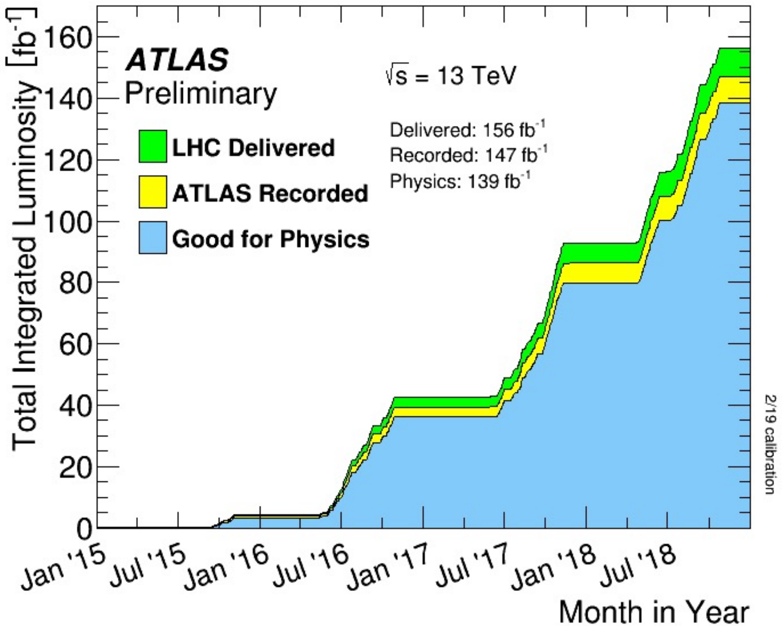
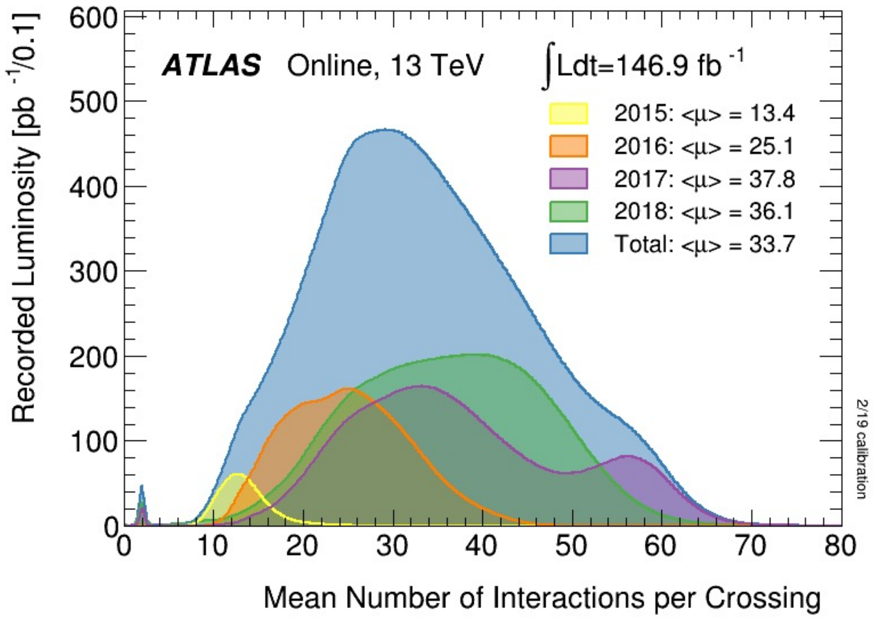
Introduction

So far, the **Standard Model (SM)** is our best description of the elementary particles and their interactions in our universe. However, it fails to:

- describe the gravity;
- provides dark matter and dark energy candidates;
- explain the matter-antimatter asymmetry;
- … …

You may find in this talk: a very brief summary of the latest non-SUSY searches for exotic decays using **139 fb^{-1}** of proton-proton collision data collected with a centre-of-mass energy of 13 TeV with the ATLAS detector.

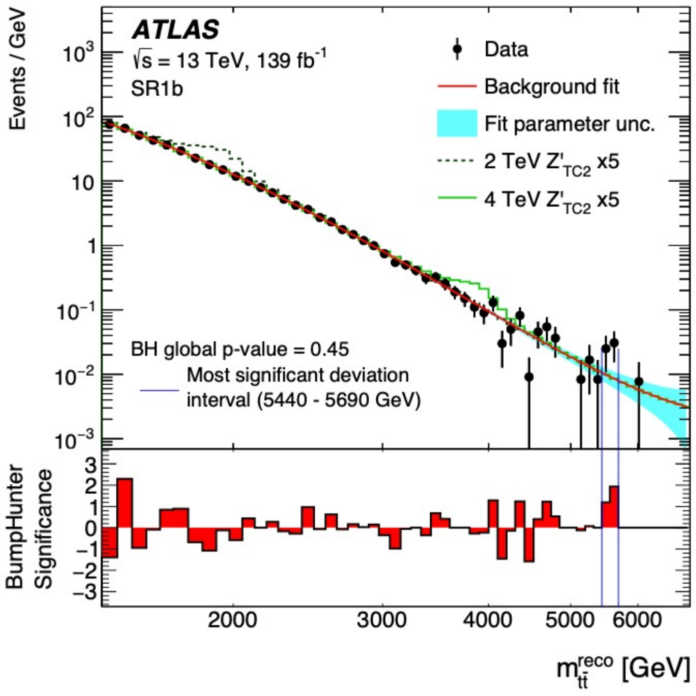


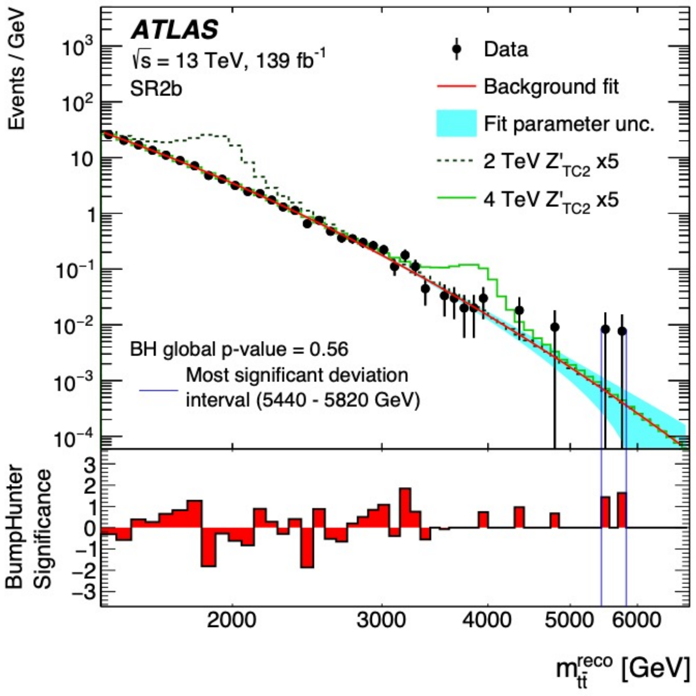


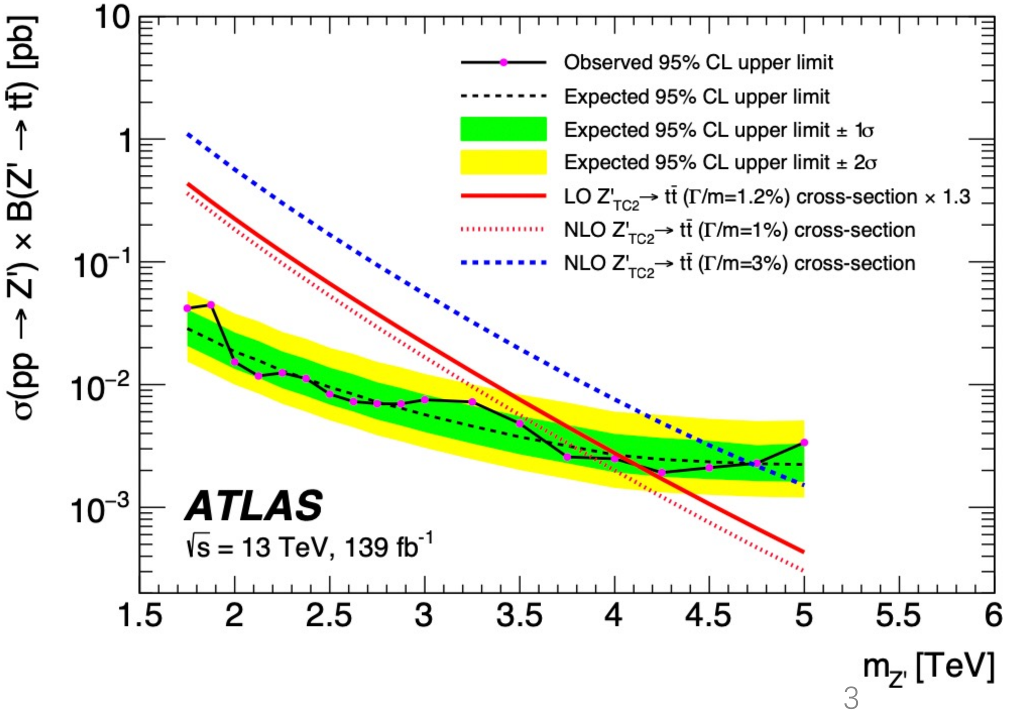
Heavy resonances – dijet search

Submitted to JHEP
arxiv: 2005.05138

- **Dijet channel: large production cross-section and smoothly falling background; excellent for extremely high masses.**
- Search for $t\bar{t}$ resonances above 1.4 TeV with subsequent decay into a fully hadronic final state.
- using a dedicated multivariate technique with jet substructure to identify hadronically decaying top quarks using large-radius (large-R) jets.
- Largest deviation found at Z'_{TC2} = 1.88 TeV: 1.6σ local p-value.





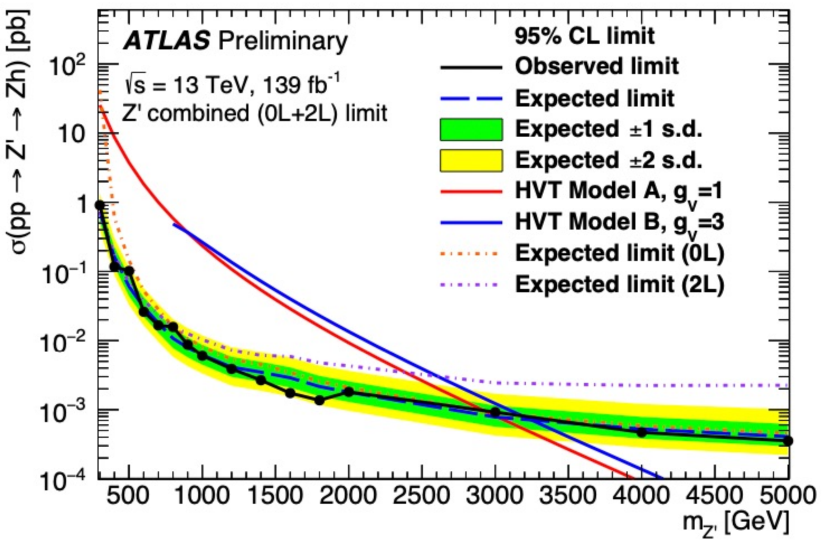


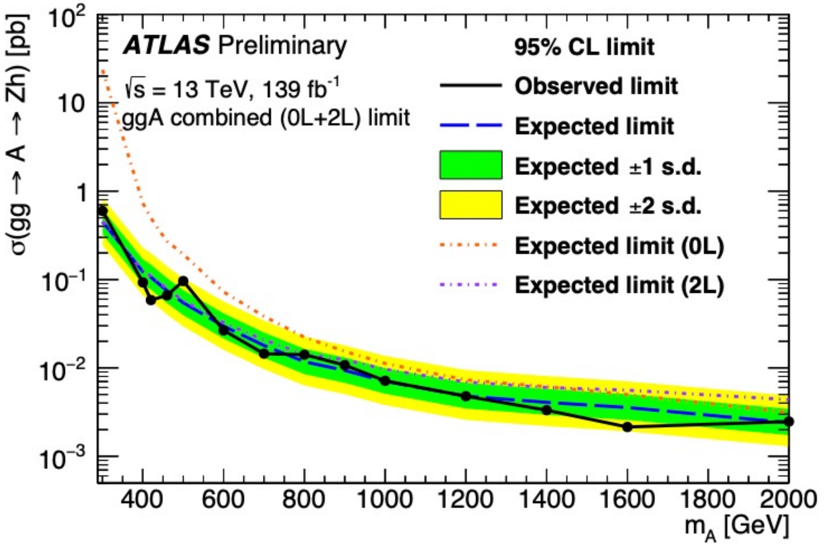
Heavy resonances – diboson search

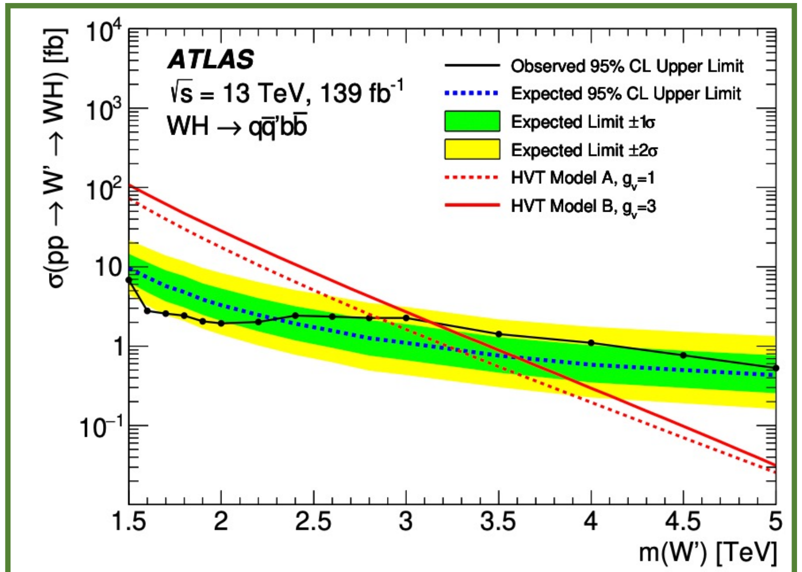
[leptonic] ATLAS-CONF-2020-043

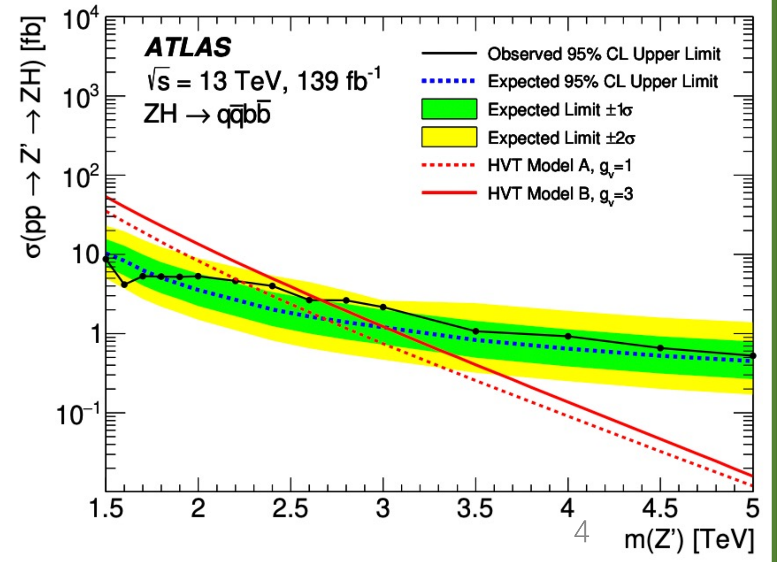
[hadronic] PRD, arxiv: 2007.05293

- Many extensions of SM predict new resonances decaying to a Z/W and a Higgs boson.
- Diboson channel:
  - 0-lepton and 2-lepton final state: $W/Z \to \nu\bar{\nu}$ *or* $l^{+}l^{-}$ (where $l = e^{\pm}/\mu^{\pm}$) *and* $H \to b\bar{b}$
  - Fully hadronic final state: $W/Z \to q\bar{q}$ *and* $H \to b\bar{b}$
  - V and H produced with high transverse momentum resulting in large-R jets.





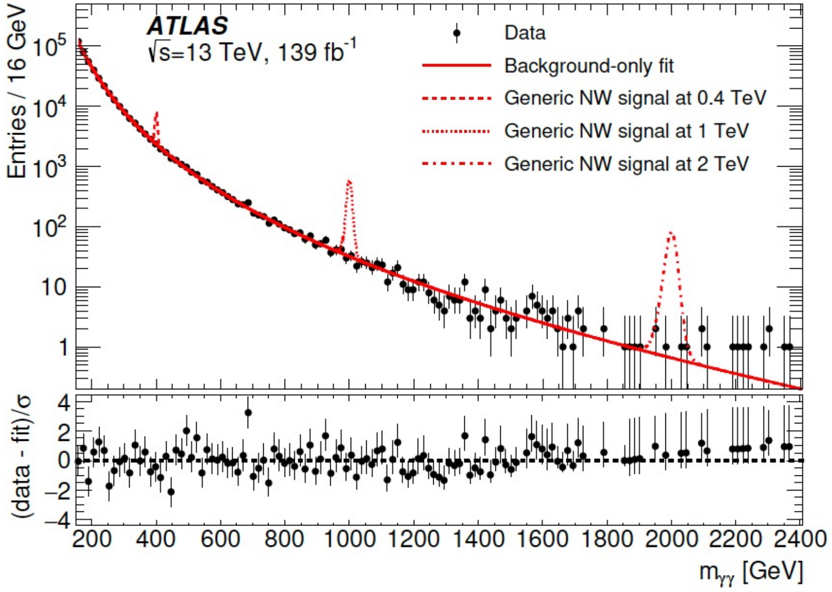


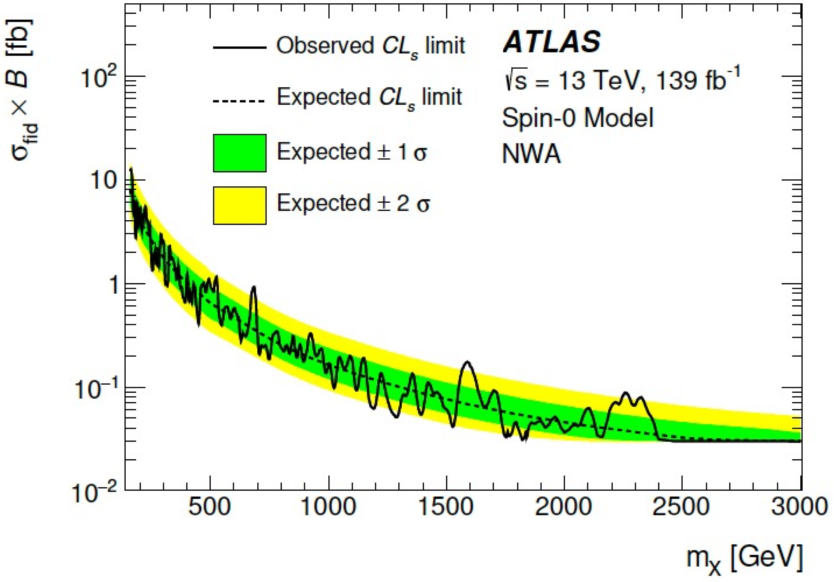


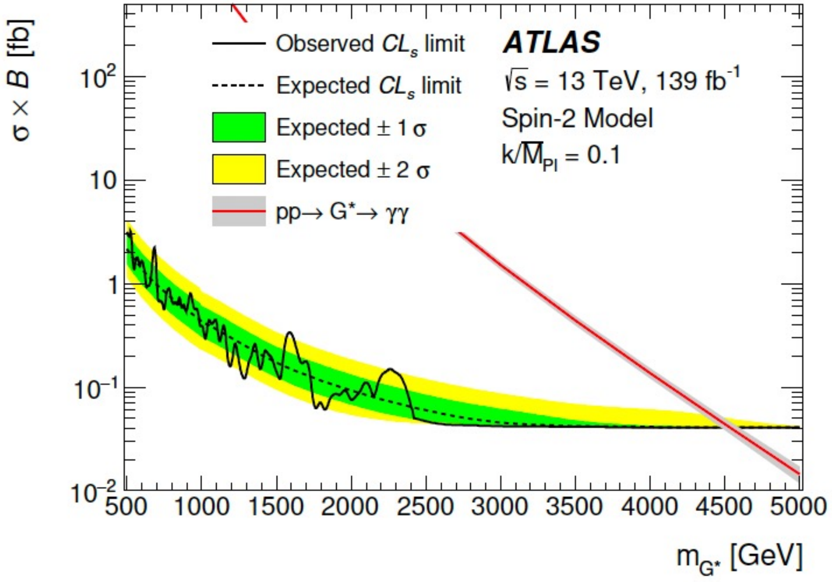
Heavy resonances – diphoton search

Submitted to PLB
arxiv: 2102.13405

- **Diphoton channel: excellent mass resolution and smoothly falling background.**
- Searches for a generic resonance using two benchmark signal models:
  - ➢ a spin-0 resonant state (models with extensions to the Higgs sector)
  - ➢ a spin-2 graviton (RS1 model)
- Fit data with analytical functions that model the background and signal shapes.
- Largest deviation found at m_X = 684 GeV (NWA, $k/\overline{M_{pl}}$ = 0.01): 3.29σ local, ~1.3σ global significance considering look-elsewhere effect.



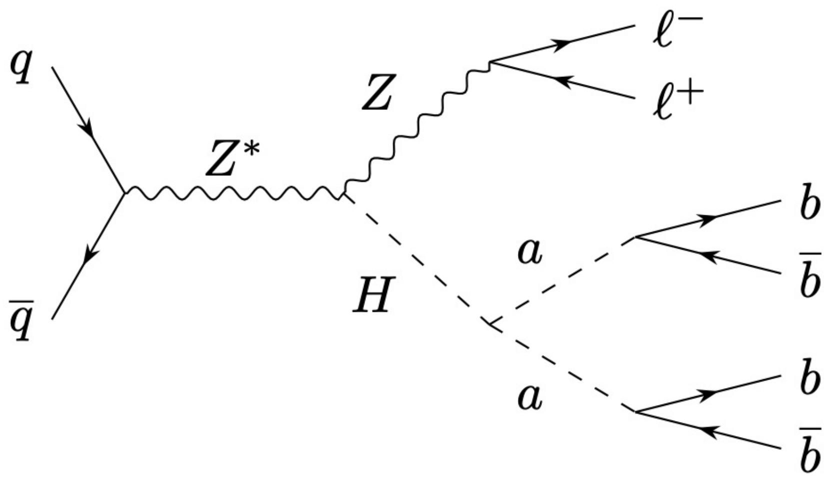




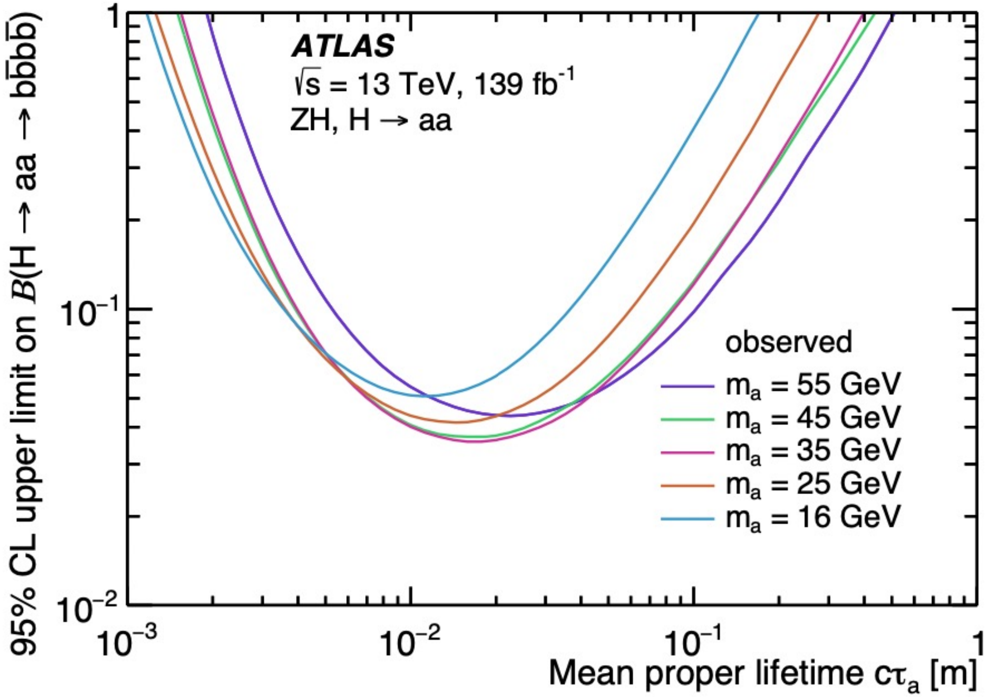
Long-lived particles

Submitted to JHEP
arixiv: 2107.06092

- Decays of the Higgs boson into particles with macroscopic mean proper lifetimes (>100 μm), known as long-lived particles (LLPs).
- **Seen in several different topologies in detectors:** displaced vertexes, jets, leptons; delayed photons; stable charged particles, etc.
- **e.g., pairs of long-lived neutral particles, each decaying into a bottom quark pair.**
  - reconstructed from inner-detector tracks as displaced vertices (at least two) with high mass and track multiplicity relative to SM processes.



Assume a is neutral, decays exclusively into bb.
Sensitivity to LLPs with $2\ \mathrm{mm} \leq c\tau_a \leq 0.2\ m$ is obtained.



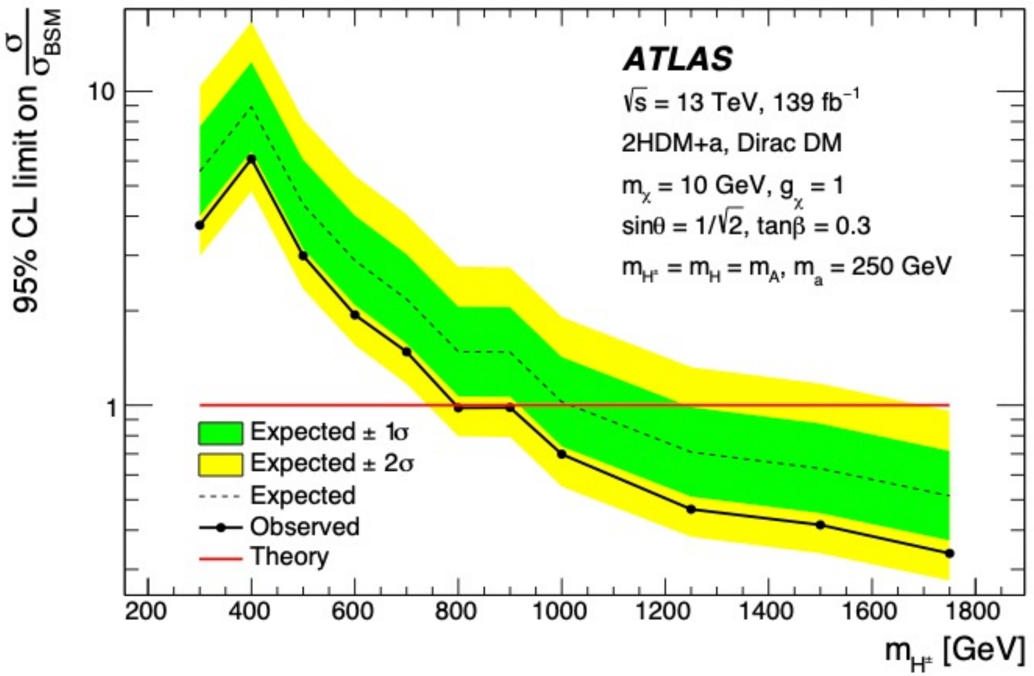
Dark matter (DM)

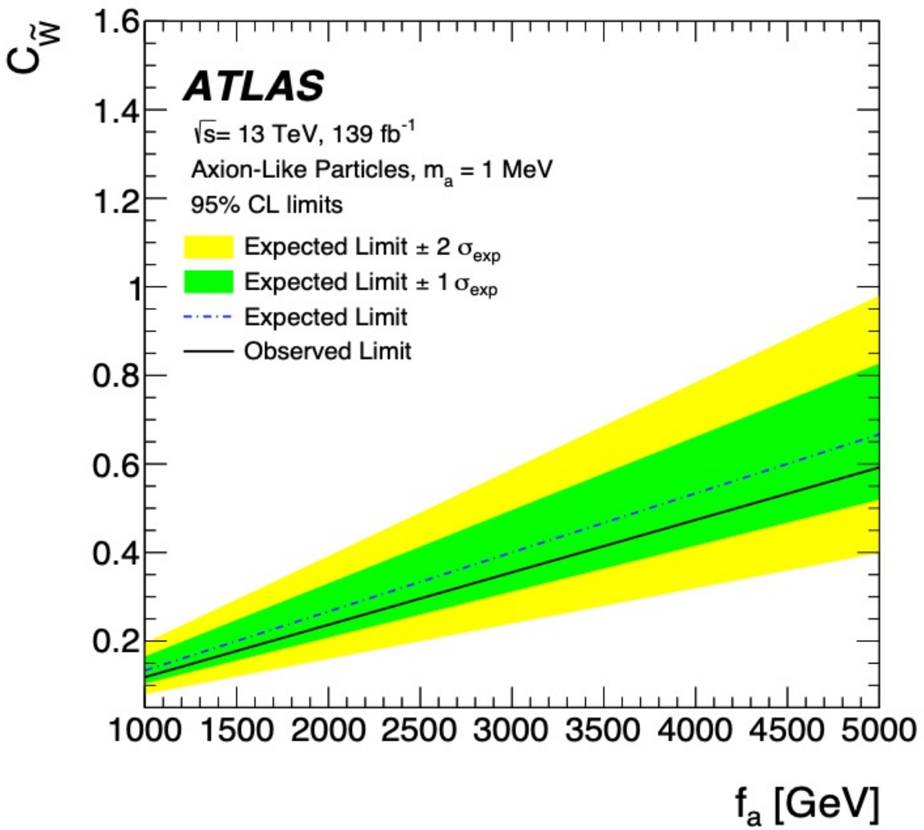
[top quark] submitted to EPJC

[energetic photon] JHEP

- Existence of DM proved by gravitational effects.
- At hadron colliders, DM searches rely on visible particles produced in association with (invisible) DM candidates.

- **Experimental signature: large missing energy. E.g.:**
  - DM in association with a single top quark
  - DM in association with an energetic photon
  - …





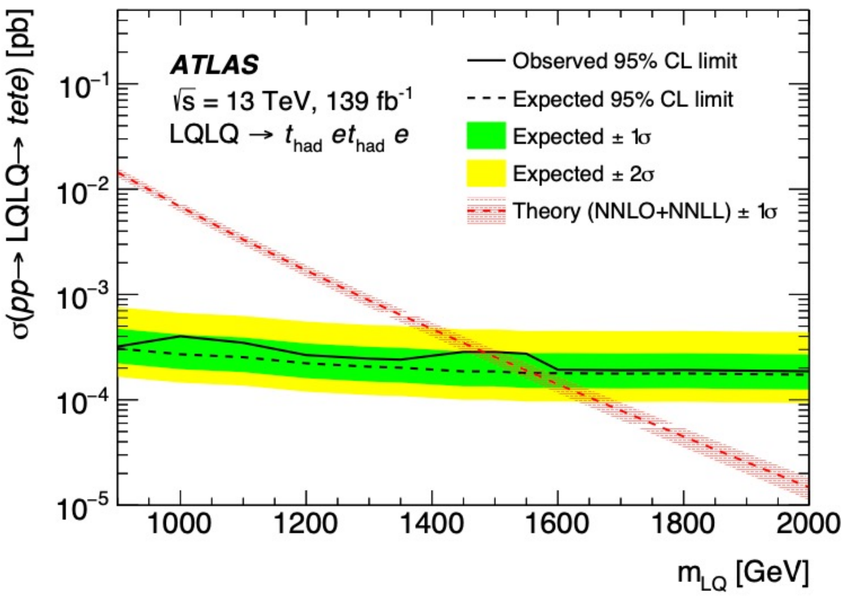
(interpreted in terms of limits on the parameters of the ALP model)

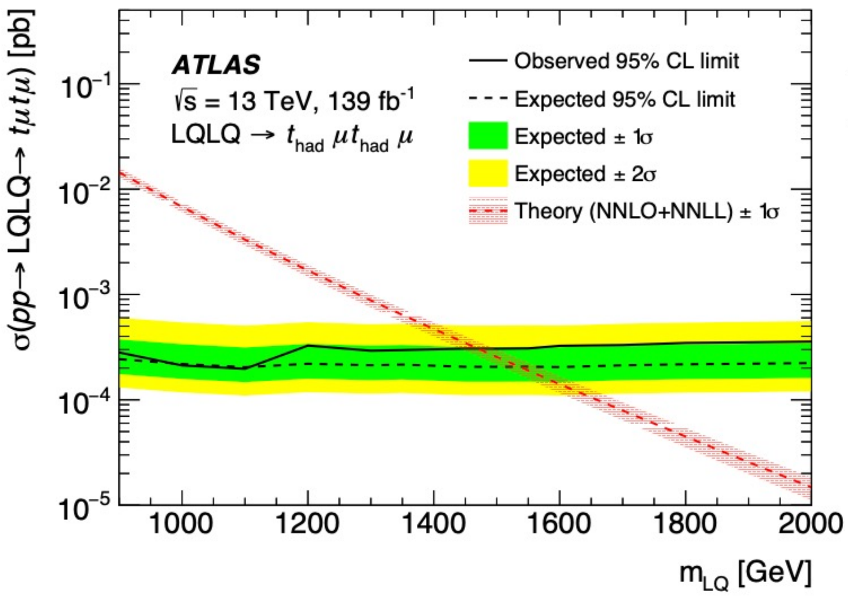
Leptoquarks (LQ)

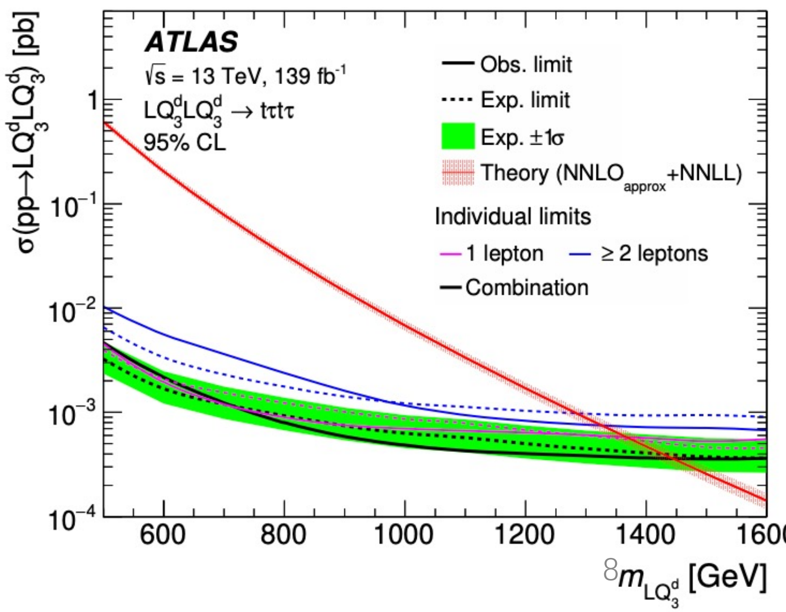
1^{st} & 2^{nd} generation: EPJC

3^{rd} generation: JHEP

- **Leptoquarks (LQ): new particles that carry both lepton and baryon number.**
- LQs explain the recent observed B meson anomalies. The quark–lepton–LQ coupling is determined by model parameter β and coupling parameter λ.
- Searches for pair production of scalar (less model dependent) LQ in two categories:
  - each LQ decaying into e/μ and a top quark.
    - Use binned BDTs in signal region and two control regions (Z+jets, $t\bar{t}$)
  - each LQ decaying into a τ and a top quark.
    - Six final states considered, each split into multiple event categories.







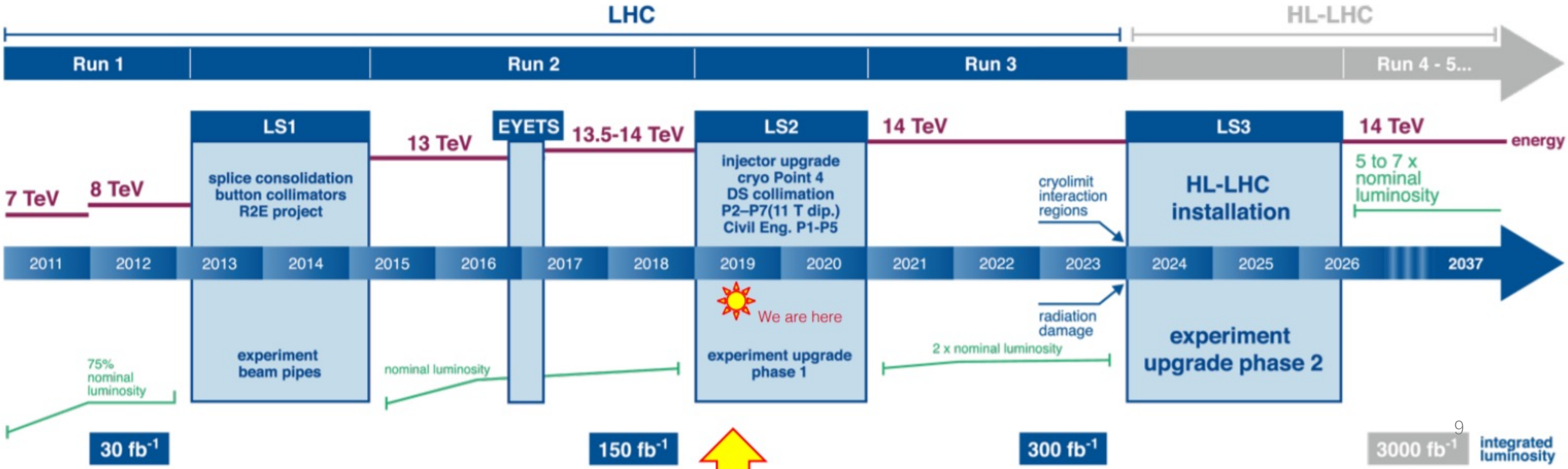
Conclusion

back

- **A selected snapshot of recent exotic searches with the ATLAS detector is given:**
  - New heavy resonances, long-lived particles, dark matter, leptoquarks

- Unfortunately, no significant excess observed above SM expectations.

- **Still a lot to expect in the future:** improvements for extremely high mass searches, low and intermediate mass searches, new approaches and techniques…



Thanks for your attention!