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Searches for New Phenomena at the LHC

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On behalf of the ATLAS and CMS Collaborations

ATLAS EXPERIMENT

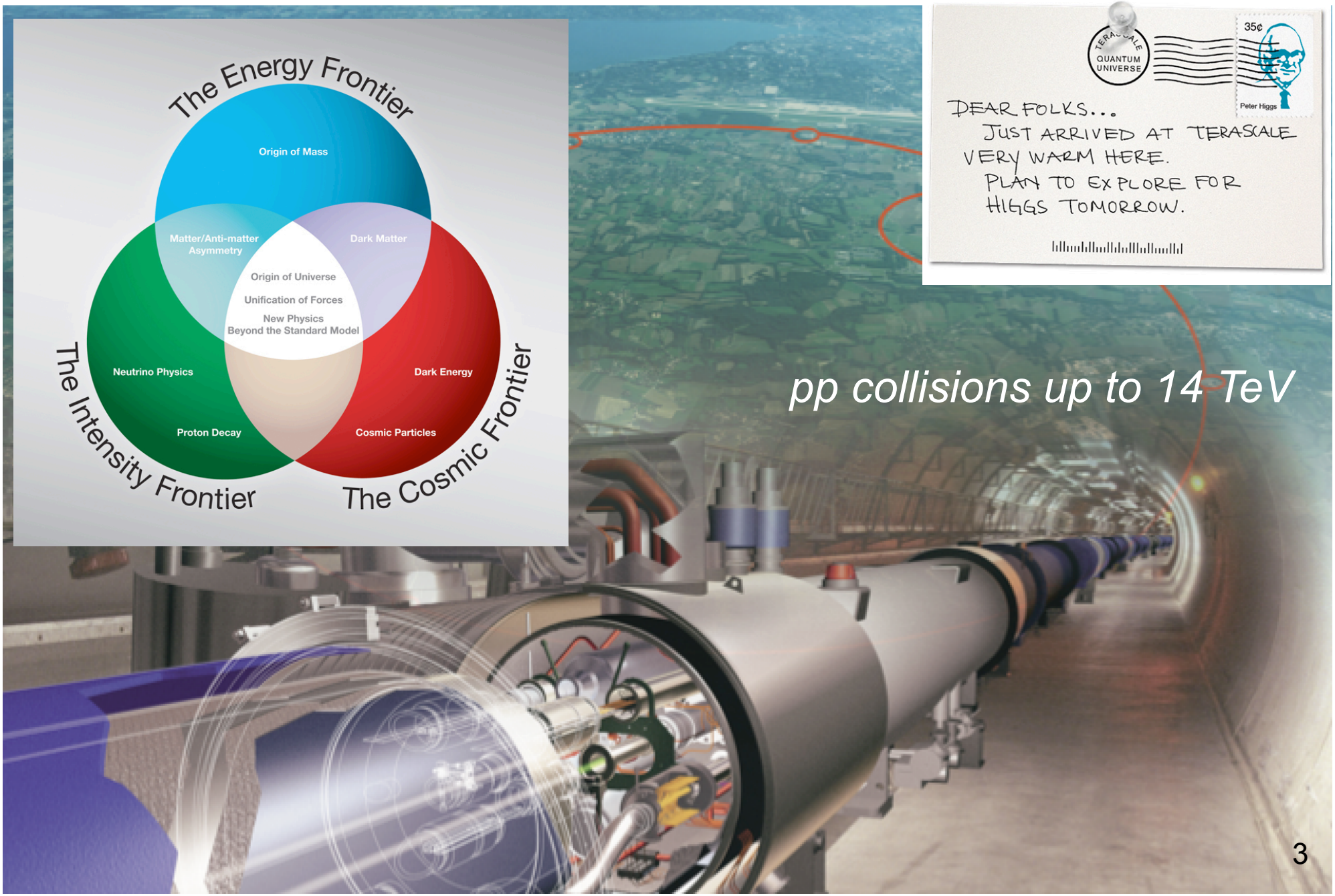
CMS

Outline

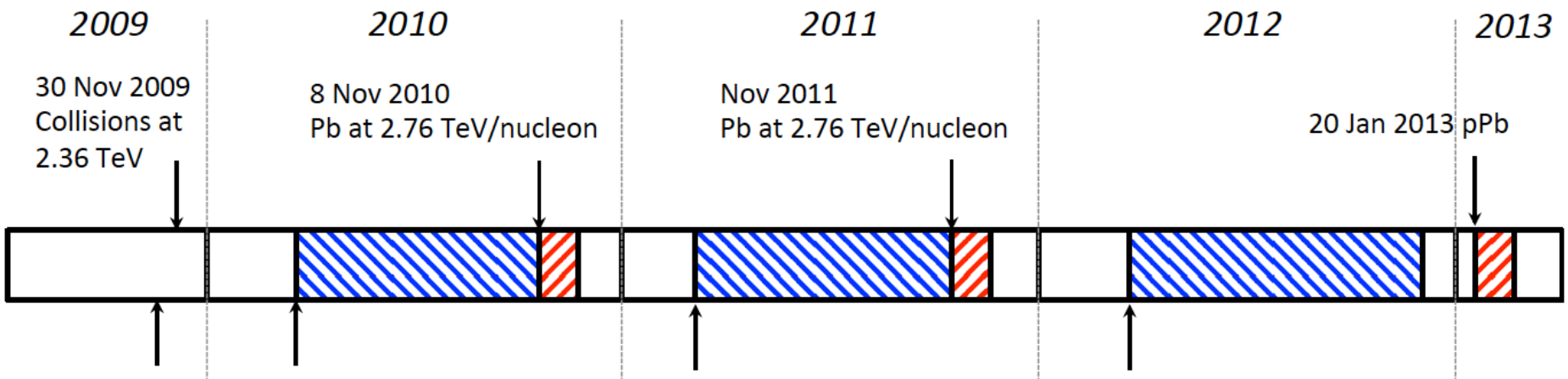
- Introduction
- Overview of recent results (*)
  - Supersymmetry searches
  - Exotics searches (vector-like quarks, dark matter, new heavy resonances)
- Summary and outlook

(*) Focused on 13 TeV data. Just a few selected results shown.

The LHC and the Energy Frontier



The LHC Run 1



0.05 fb^{-1} at 7 TeV

O(2) Pile-up events

~ 5 fb^{-1} at 7 TeV

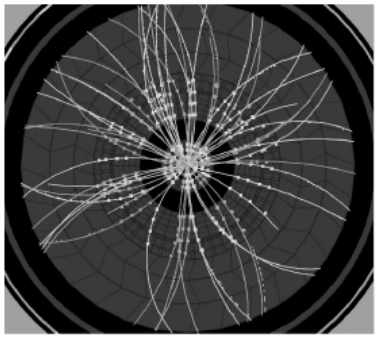
O(10) Pile-up events

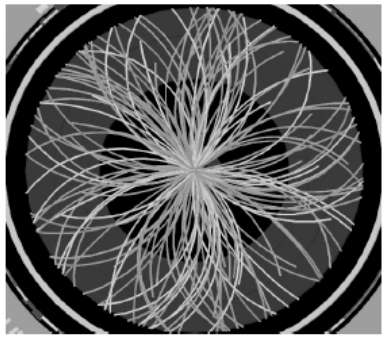
50 ns inter-bunch spacing

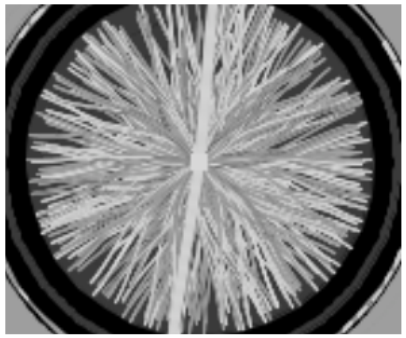
~ 20 fb^{-1} at 8 TeV

O(30) Pile-up events

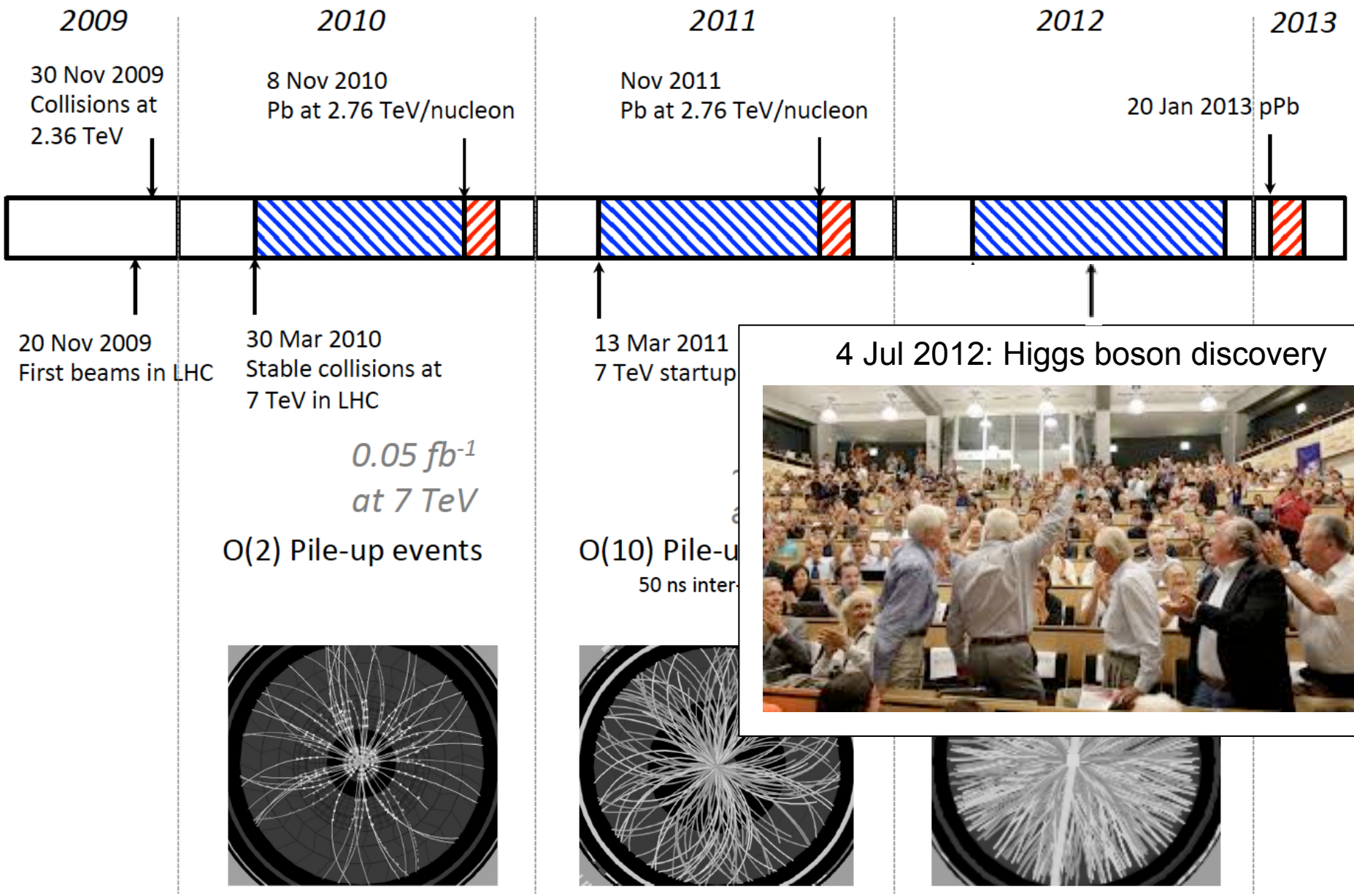
50 ns inter-bunch spacing





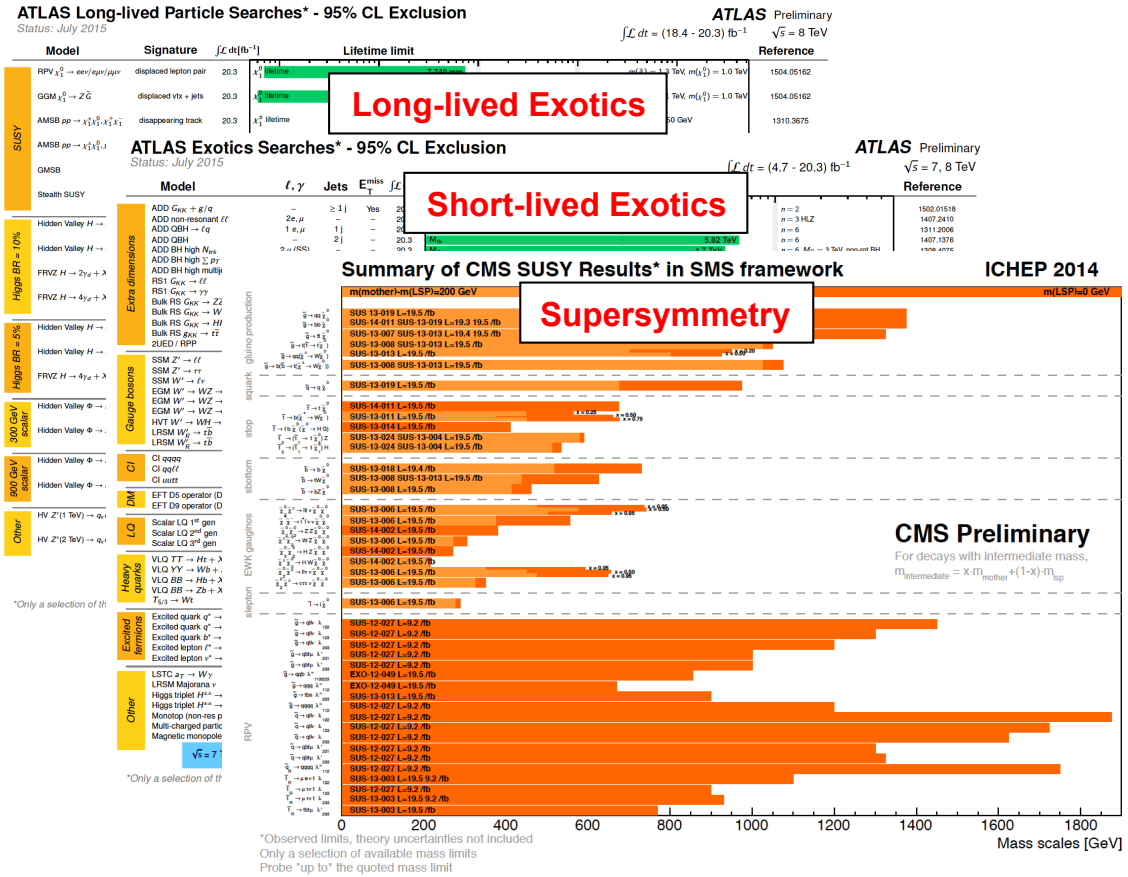


The LHC Run 1

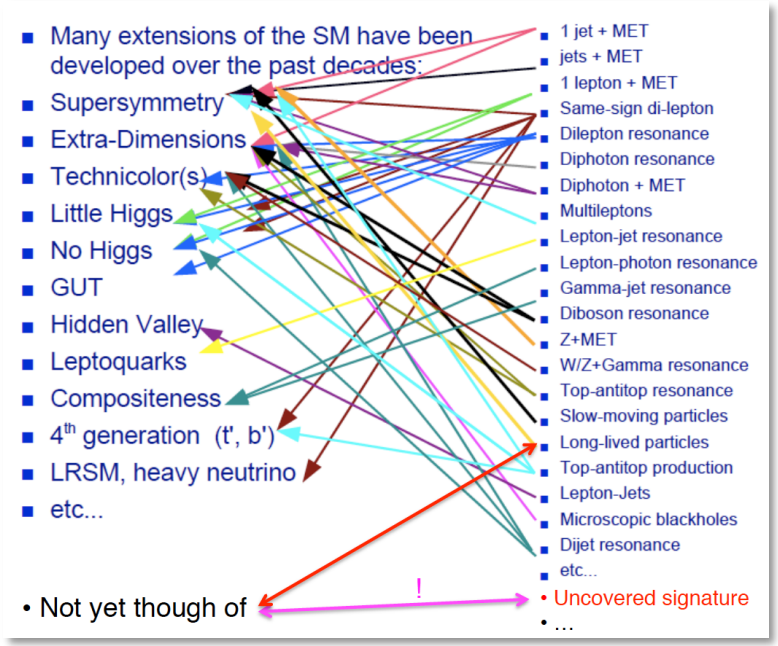

2009
2010
2011
2012
2013
30 Nov 2009
Collisions at
2.36 TeV
8 Nov 2010
Pb at 2.76 TeV/nucleon
Nov 2011
Pb at 2.76 TeV/nucleon
20 Jan 2013 pPb
20 Nov 2009
First beams in LHC
30 Mar 2010
Stable collisions at
7 TeV in LHC
13 Mar 2011
7 TeV startup
0.05 fb-1
at 7 TeV
O(2) Pile-up events
O(10) Pile-u
50 ns inter-
4 Jul 2012: Higgs boson discovery

LHC Run 1 Recap

- No clear indications of physics beyond the SM.
  ➔ useful constraints on the parameter space of many new physics models.
- Moving forward need to continue to:
  - cast as wide as possible net, even with some theoretical guidance.
  - cover broad phase spaces: many detector signatures, large range of masses, large span in production rates,…



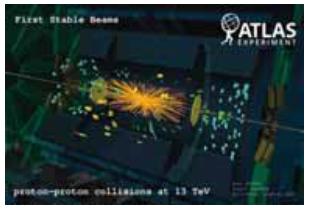
Signature-driven searches

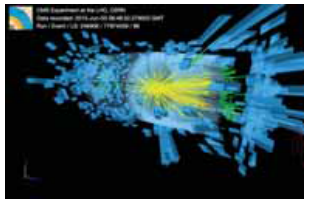


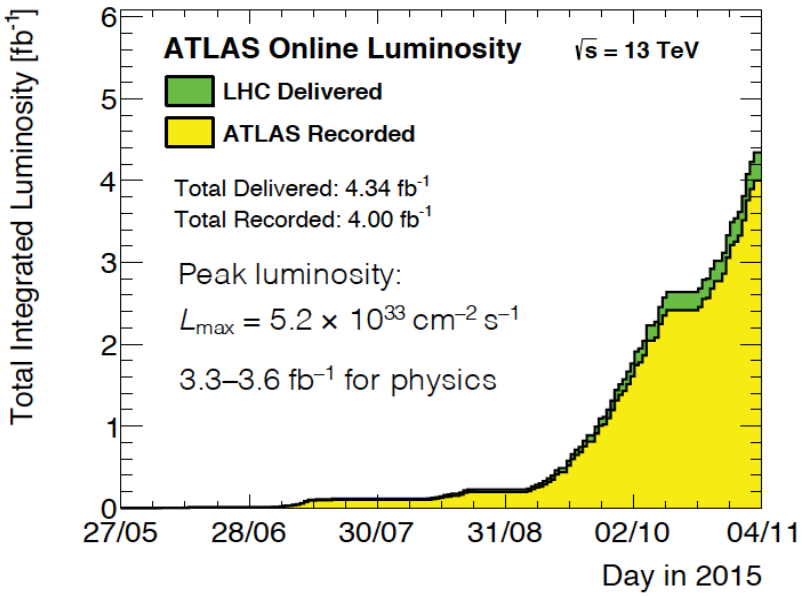
On to Run 2!

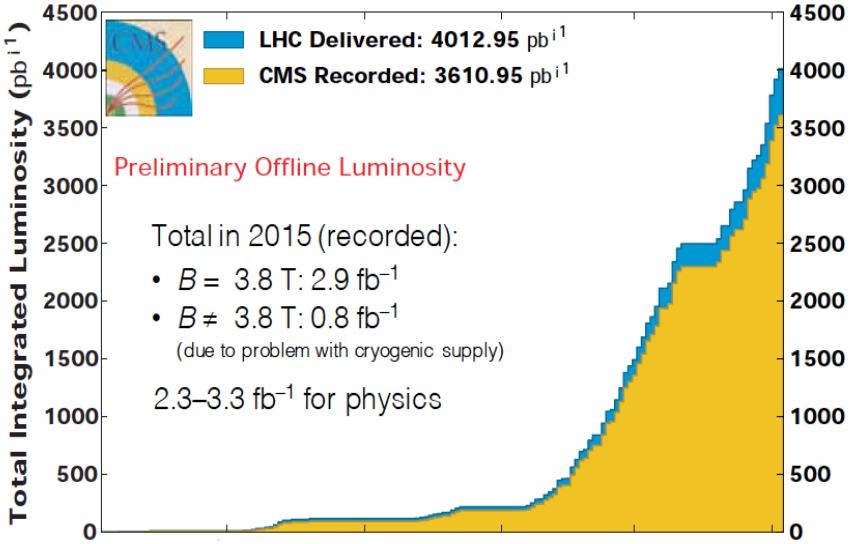
June 3, 2015:

Run 2 starts!



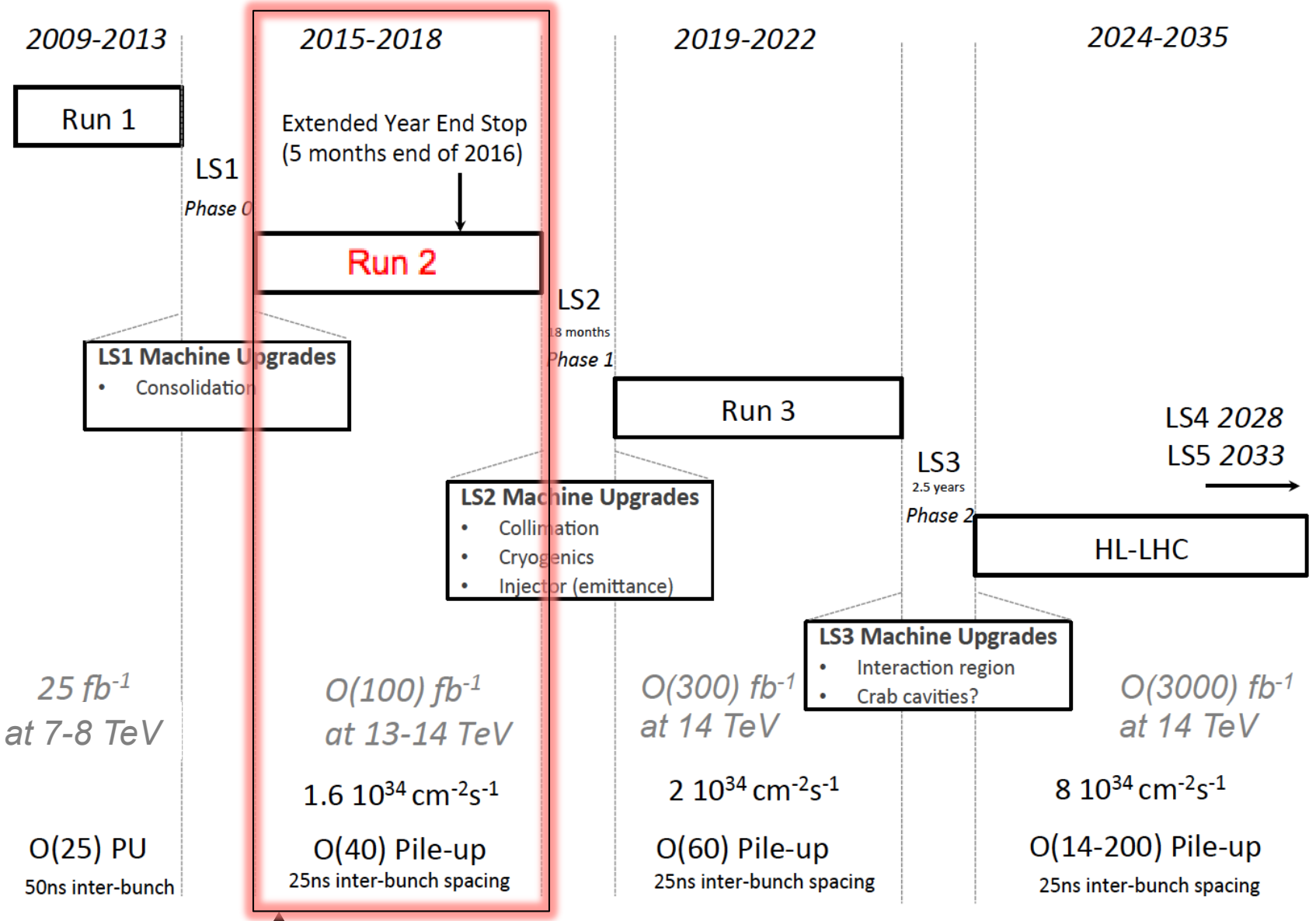






- **Tentative plan for 2016:**
  - Collisions restart on April 25, 2016.
  - Expect L_{max}=10^{34} cm^{-2}s^{-1} and L_{int}~25 fb^{-1} by end of year.

The LHC Run 2 and Beyond

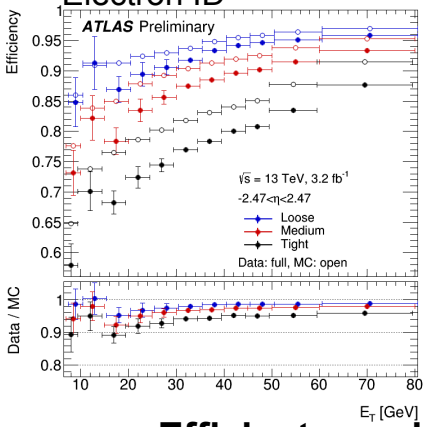


We are at the beginning of a ~20 year program!

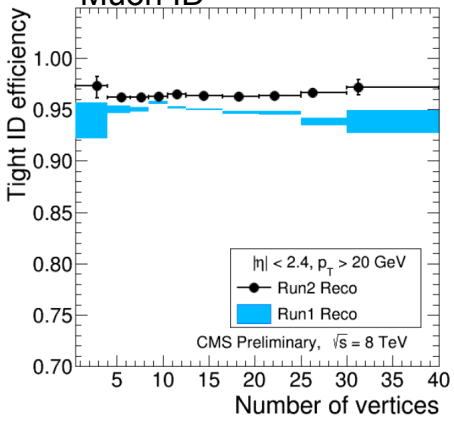
Physics Objects at 13 TeV

- In general performance of object reconstruction comparable or better than in Run 1. Further improvements expected (also on uncertainties) with further studies.

Electron ID

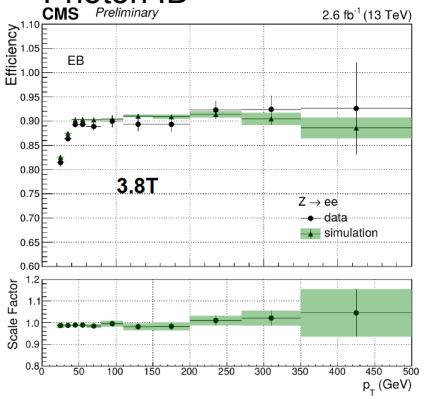


Muon ID

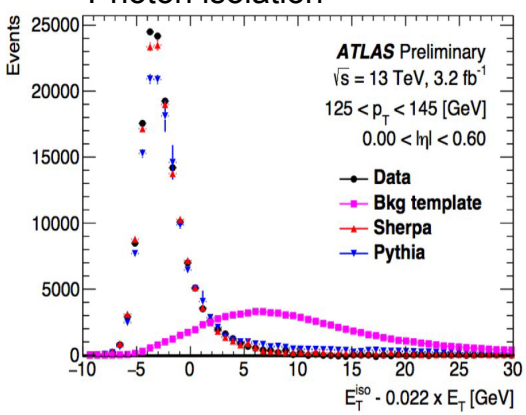


Efficient e and μ identification

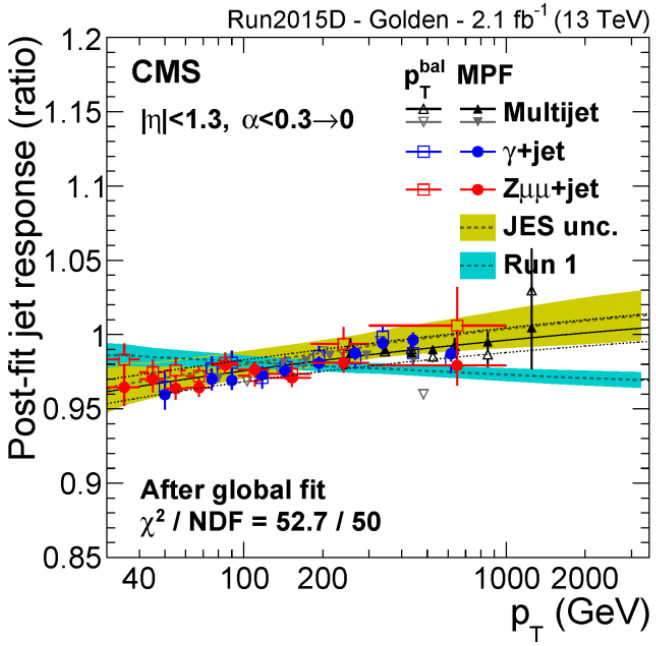
Photon ID



Photon isolation

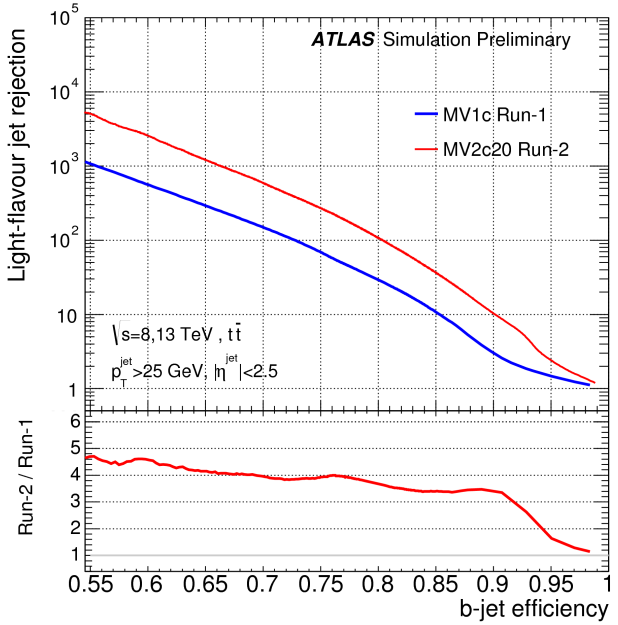


Efficient γ identification



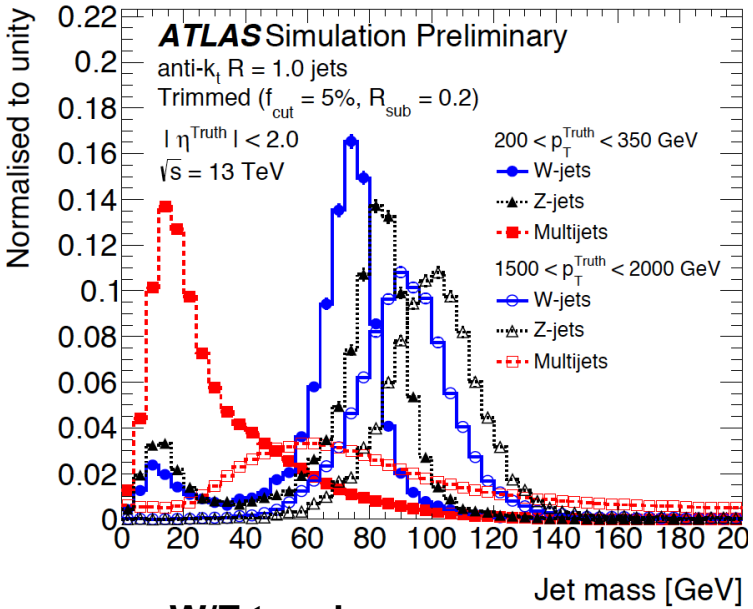
Well-understood jet energy calibration

Improved b-jet identification



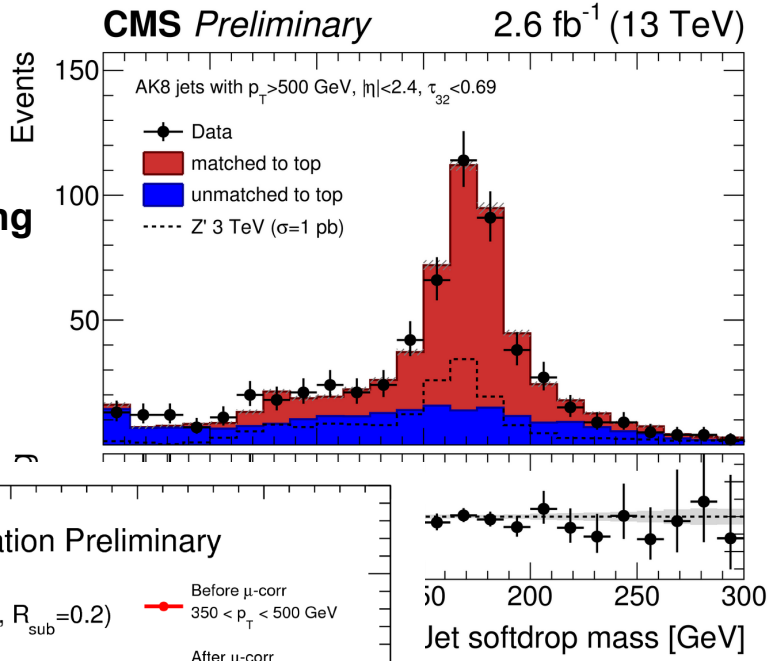
Physics Objects at 13 TeV

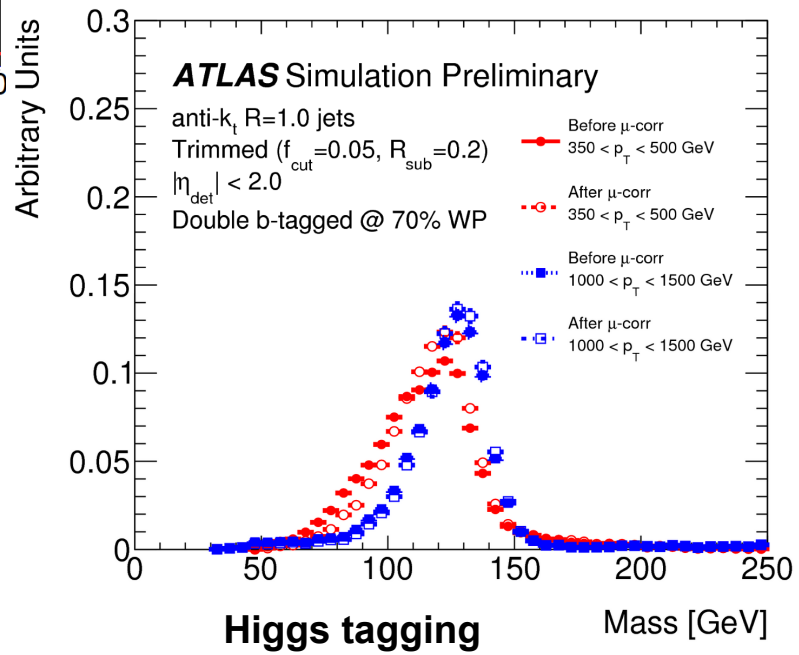
- In general performance of object reconstruction comparable or better than in Run 1. Further improvements expected (also on uncertainties) with further studies.



W/Z tagging

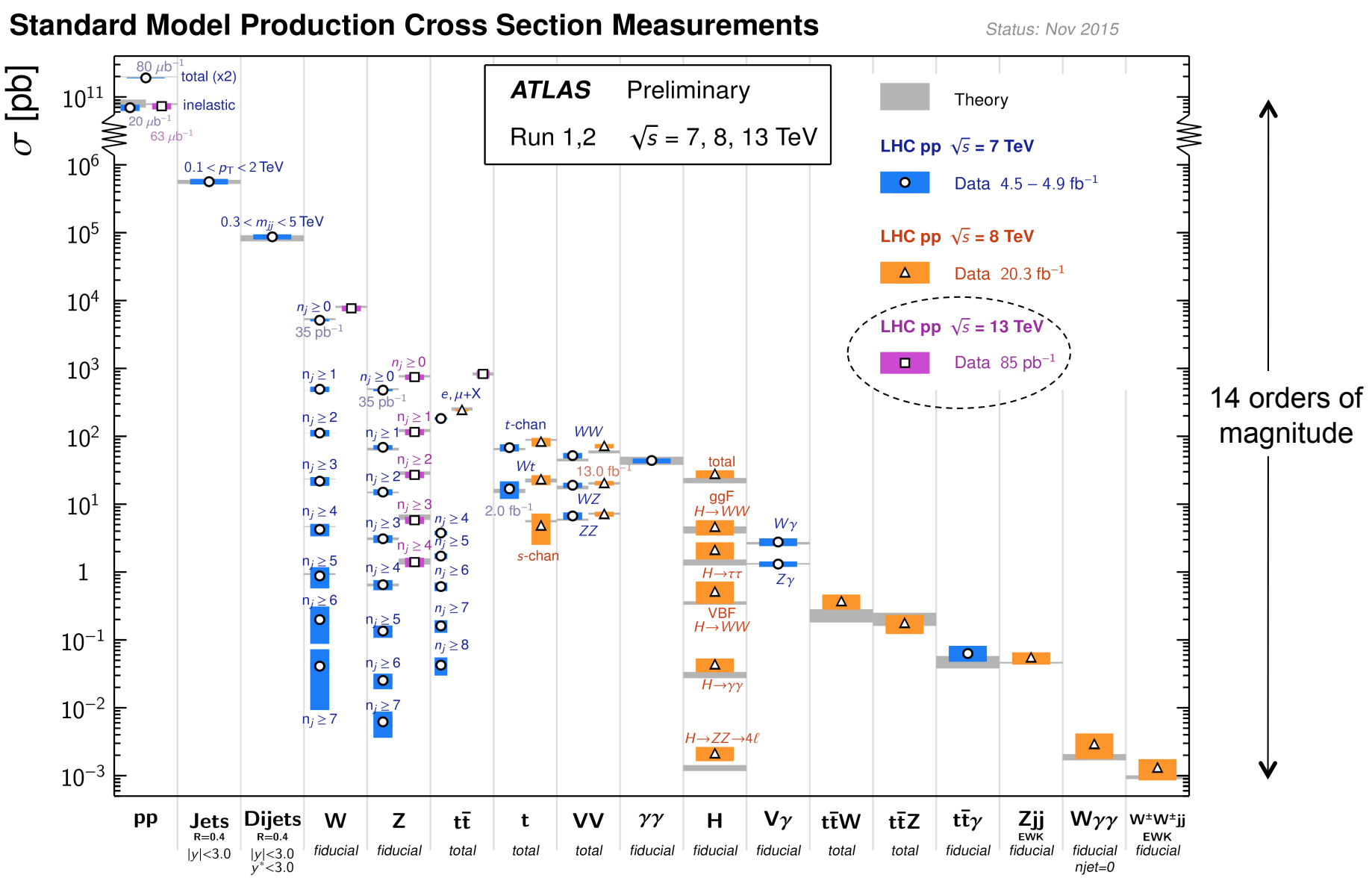
Top tagging





Higgs tagging

Standard Model Measurements

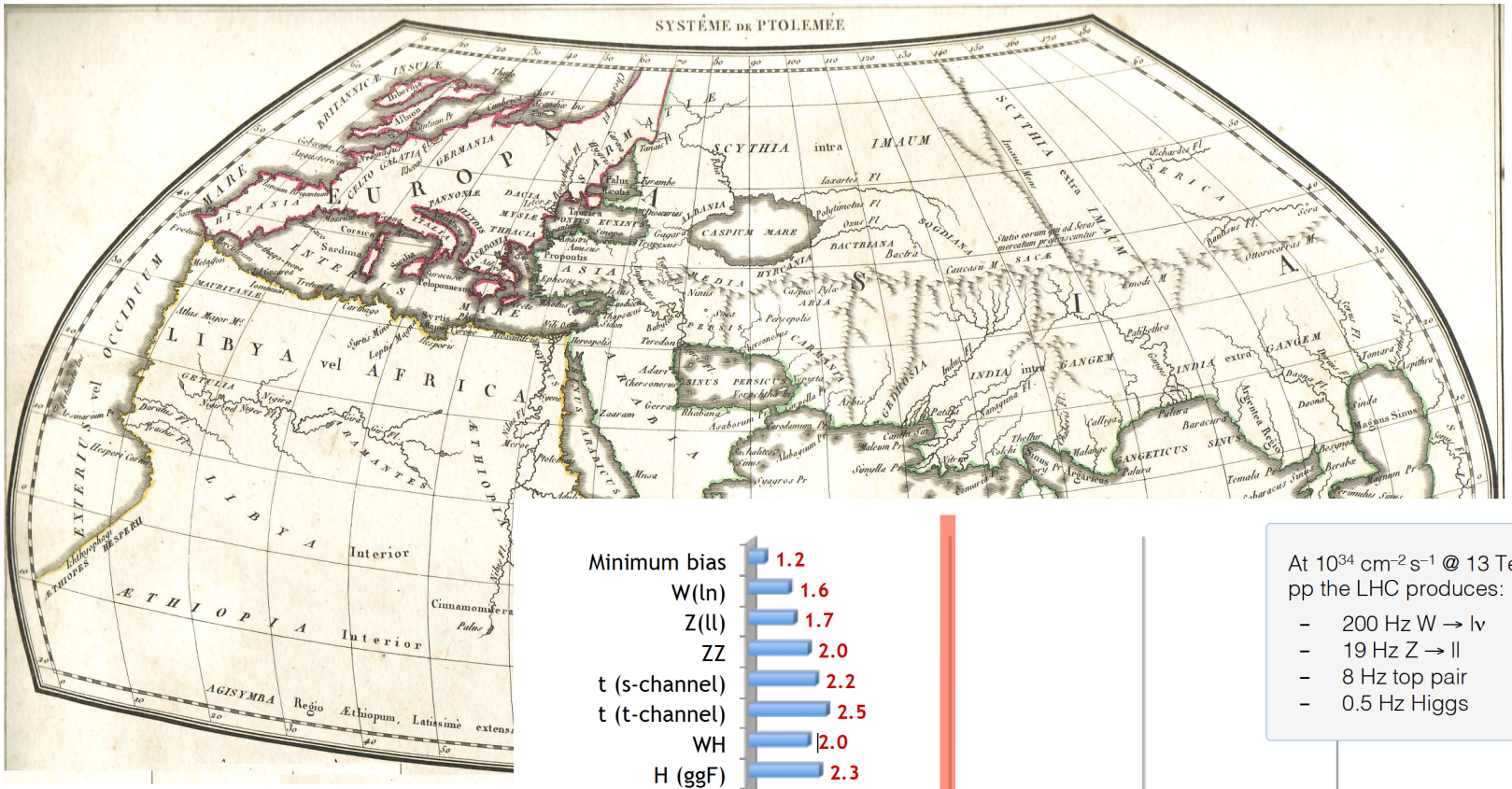


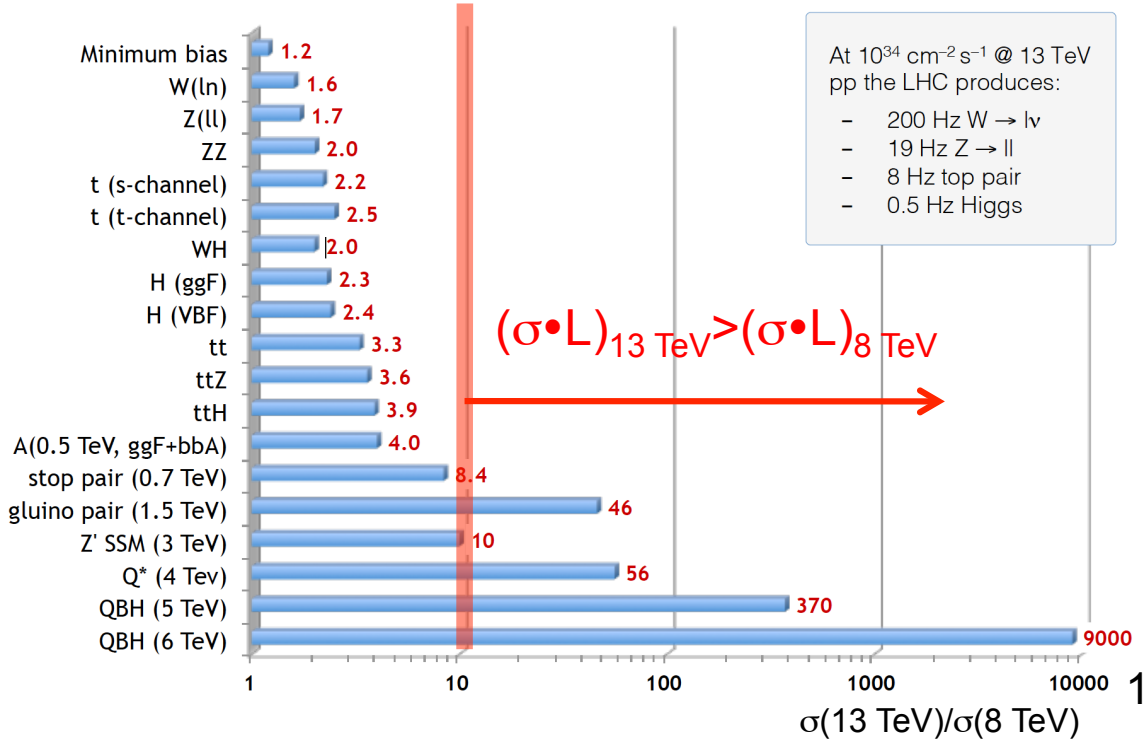
14 orders of magnitude

Stunning achievement, both from experiment and theory.

Also a necessary step to confidently search for new physics.

Searches for New Phenomena



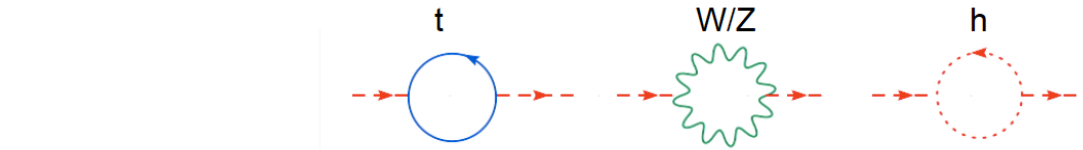


Terra Incognita

With great expectations!

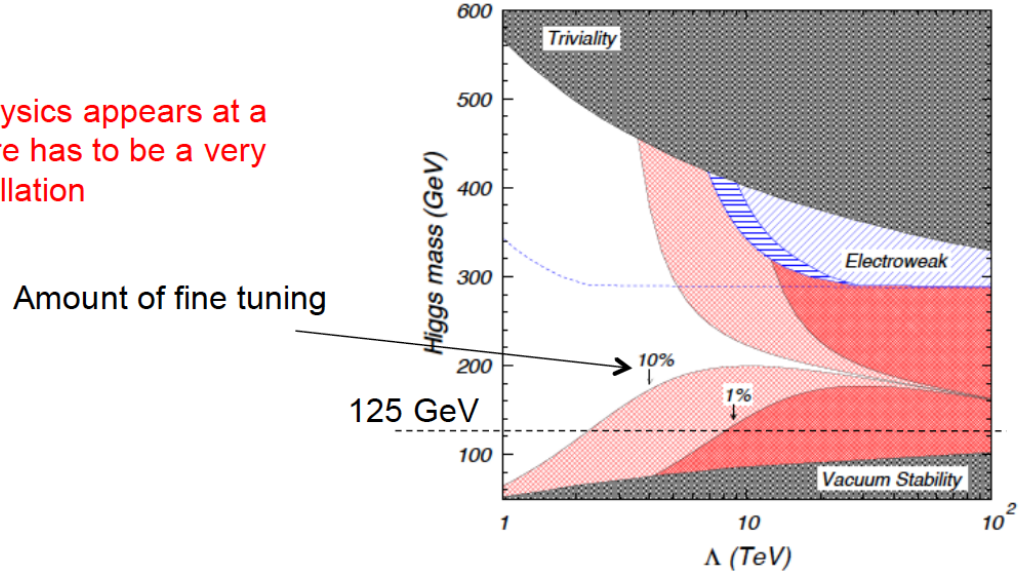
In some cases may exceed Run 1 sensitivity with <2 fb^{-1} at 13 TeV!

Implications from Higgs Discovery



$$(125\,\mathrm{GeV})^2 = m_{H0}^2 + \left[-(2\,\mathrm{TeV})^2 + (700\,\mathrm{GeV})^2 + (500\,\mathrm{GeV})^2\right]\left(\frac{\Lambda}{10\mathrm{TeV}}\right)^2$$

Either New Physics appears at a scale Λ or there has to be a very delicate cancellation

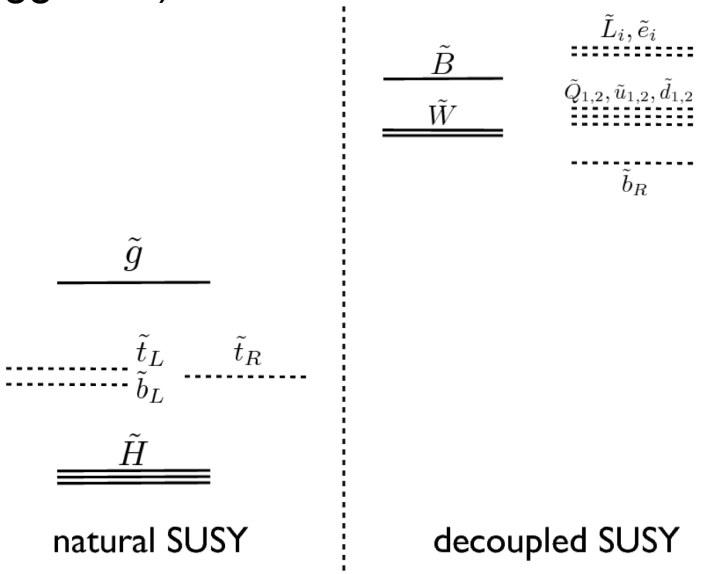


- "Natural" solutions by postulating new states at ~1 TeV curing Higgs boson quantum instabilities (SUSY, new strong dynamics) or that fundamental Planck mass at the electroweak scale (extra dimensions).

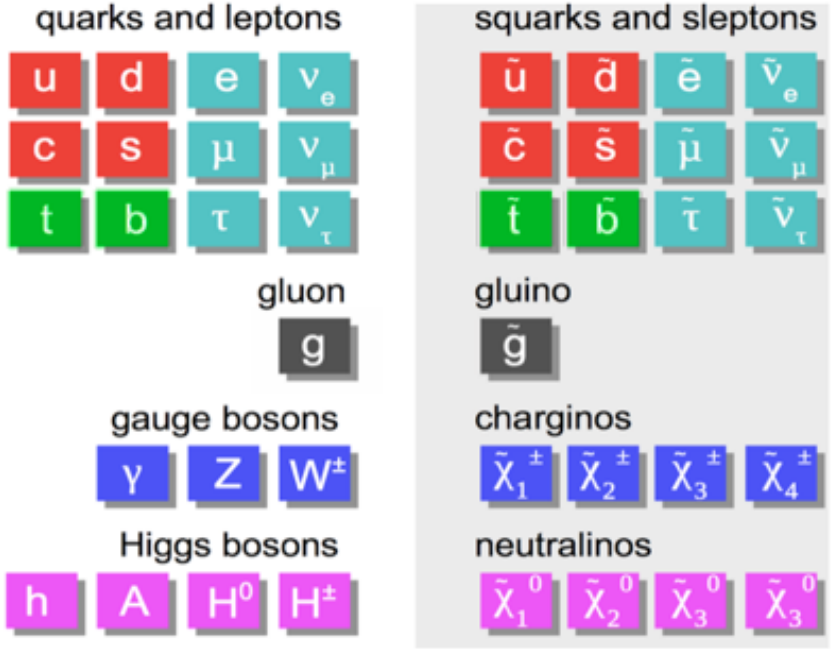
  ➔ Precision Higgs couplings and direct searches for new states are complementary.
- However, no "no loose" theorem anymore. [Cosmological relaxation of the EW scale?]
- Searches relatively agnostic but do often focus on models that address naturalness problem and/or have a dark matter candidate.

Supersymmetry

- Many features make it one of the strongest candidates to extend the SM:
  - Solves the hierarchy problem
  - Can provide a dark-matter candidate: if R-parity is conserved, lightest SUSY particle (LSP, neutralino) is stable
  - Predicts gauge coupling unification
  - …
- In typical “Natural SUSY” scenarios the 3rd generation squarks (stop/sbottom) and the gluino can be relatively light (also the Higgsinos).



Global symmetry between fermions & bosons:
all SM particles have SUSY partners



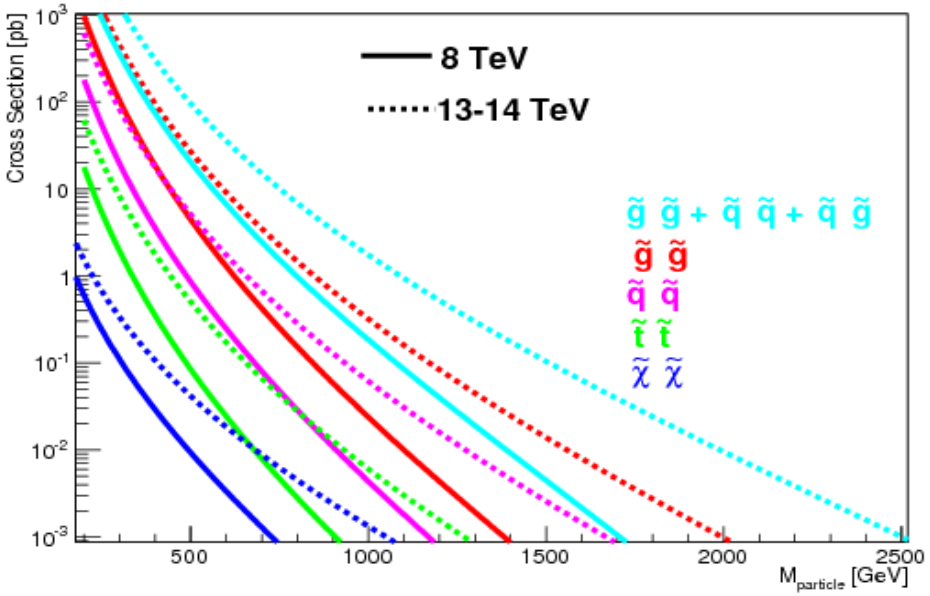
$Q|\text{fermion}\rangle = |\text{boson}\rangle$

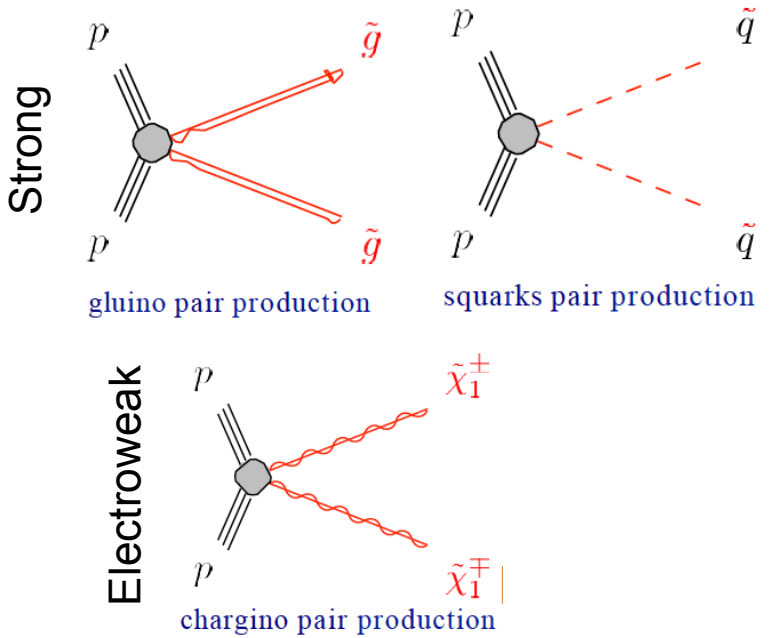
$Q|\text{boson}\rangle = |\text{fermion}\rangle$

$s_{SUSY} = s_{SM} - 1/2$

$R = (-1)^{2s}(-1)^{3B}(-1)^{L}$

Classification of SUSY Searches





- **Large increase in cross section from 8 to 13 TeV!**
- **Inclusive searches for squarks/gluinos**
  - Large cross sections
  - Rich final states in the case of $\tilde{g}\tilde{g}$
- **Dedicated searches for lightest stop/sbottom**
  - Moderate cross sections
  - Final states closer to SM background
- **Searches for charginos/neutralinos**
  - Low cross sections
  - Multilepton final states with low SM background
- Searches for long-lived particles and RPV SUSY

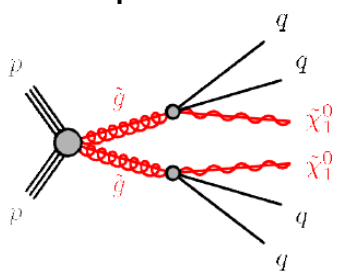
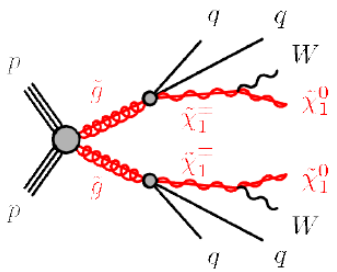
Focus on searches for gluino and 3rd generation squarks with 2015 data ➔ discovery potential beyond Run-1 limits even with 3 fb^{-1} of 13 TeV data

Discovery potential of beyond Run-1 limits will be reached with 2016 data

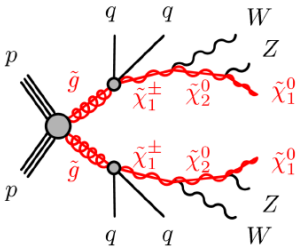
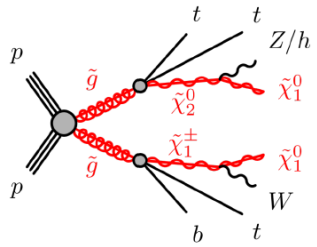
Natural SUSY: Gluino

- Strong production of gluino pairs one of the most promising search channels with early Run 2 data: σ(13 TeV)/σ(8 TeV)~46 for gluino mass of 1.5 TeV.

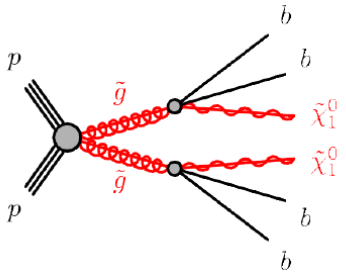
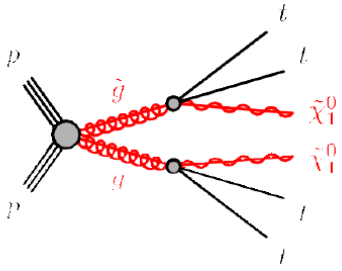
- Many search regions needed to cover a large number of possible decay chains.
  For example:

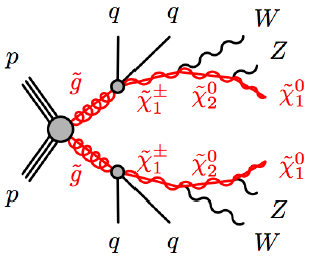
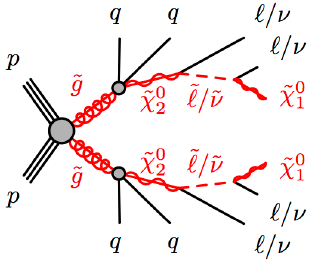
2-6 jets+E_T^{miss}

7-10 jets+E_T^{miss}

multi b-jets+E_T^{miss}

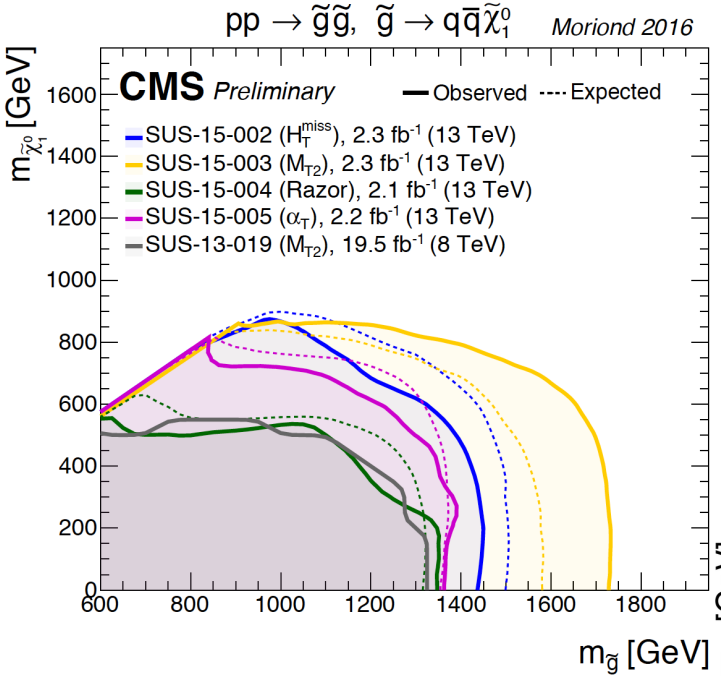



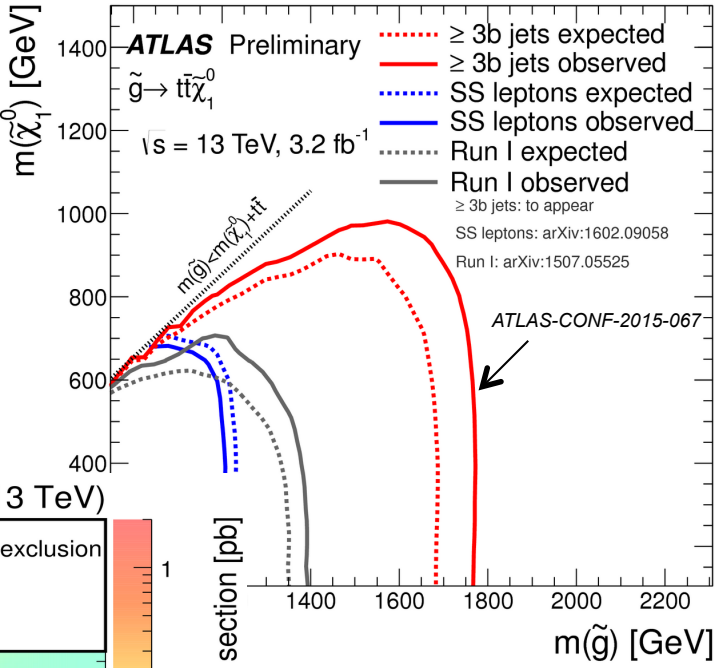
SS dilepton/trileptons+E_T^{miss}

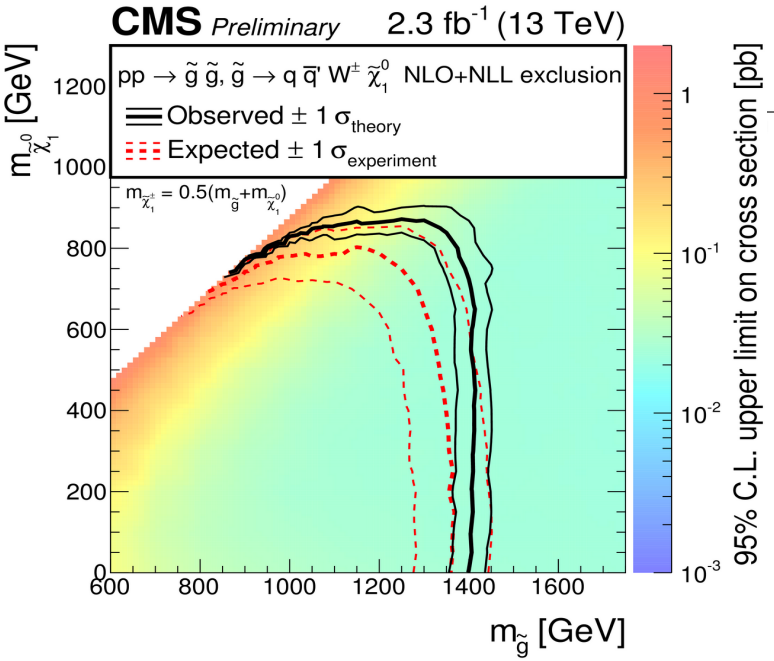
...

Natural SUSY: Gluino

- About a dozen searches performed in several final states (without and with leptons).
- Significantly extending Run 1 reach. No significant excess observed.



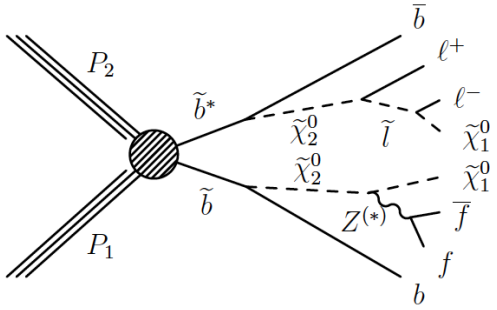




Highest mass limits for gluino reaching ~1.8 TeV

Natural SUSY: Gluino

- Checks of Run 1 excesses in opposite-sign dileptons+jets+E_T^{miss} final states.



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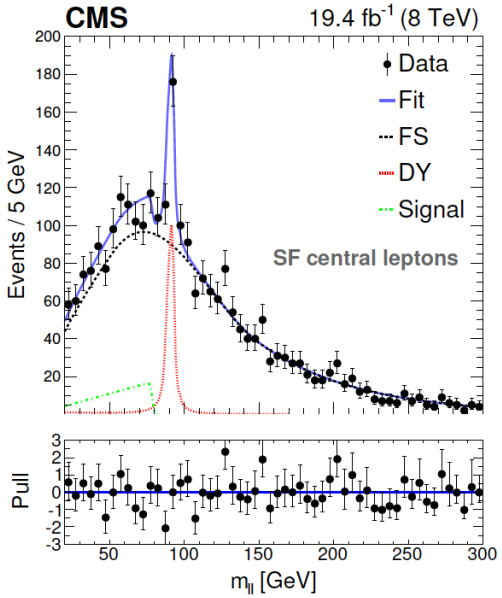
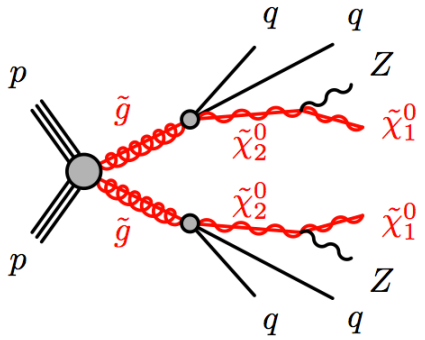


Run 1



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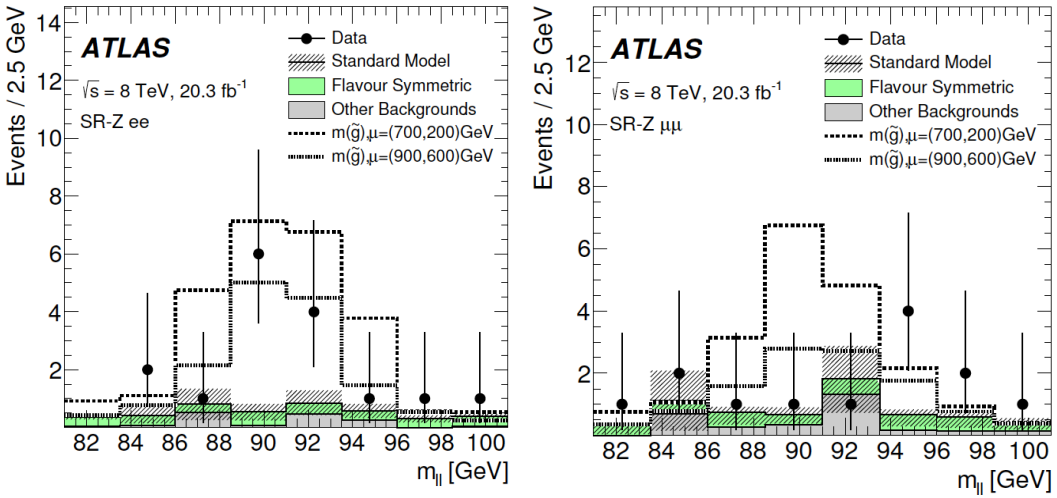
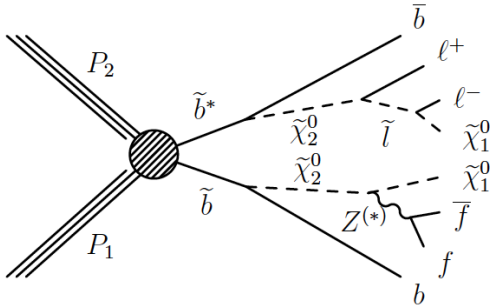


- 2.6σ excess of off-Z events
- Consistent with “edge” expected from off-shell Z boson or slepton decays
- Not observed by ATLAS

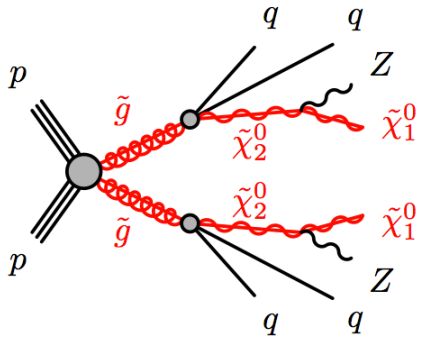
- 3.0σ excess of on-Z events
- Larger neutralino mass difference ➔ more on-Z events
- Not observed by CMS

Natural SUSY: Gluino

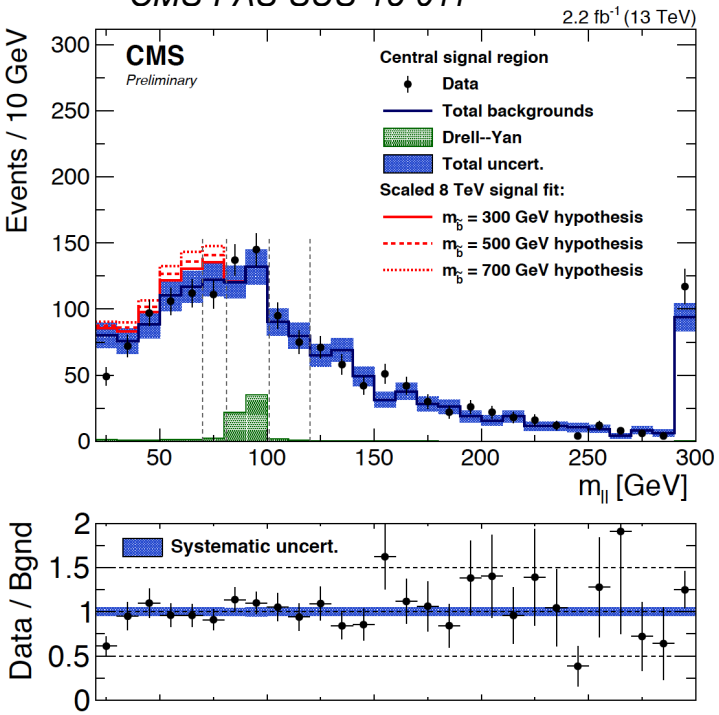
- Checks of Run 1 excesses in opposite-sign dileptons+jets+E_T^{miss} final states.



Early Run 2

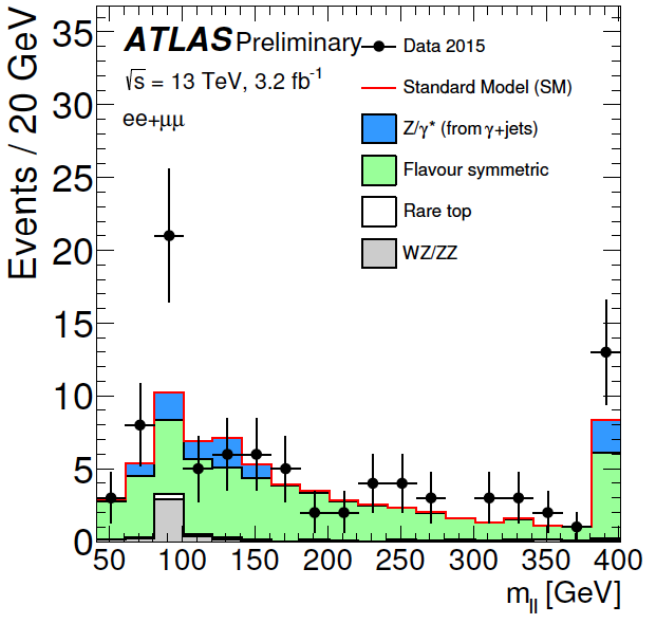


CMS-PAS-SUS-15-011



- Run 1 excess not confirmed

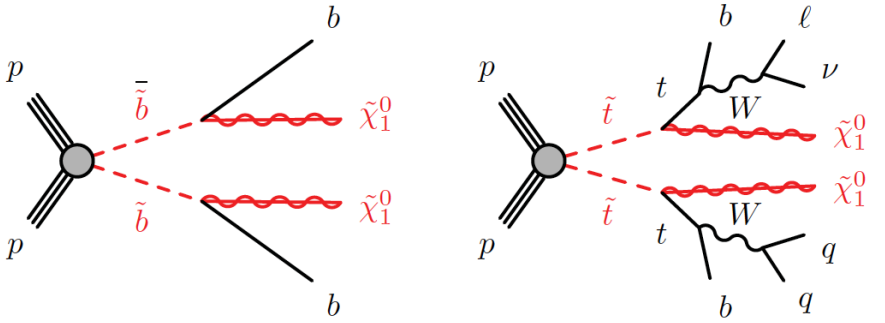
ATLAS-CONF-2015-082



- Again, 2.2σ excess of on-Z events
- Not observed by CMS

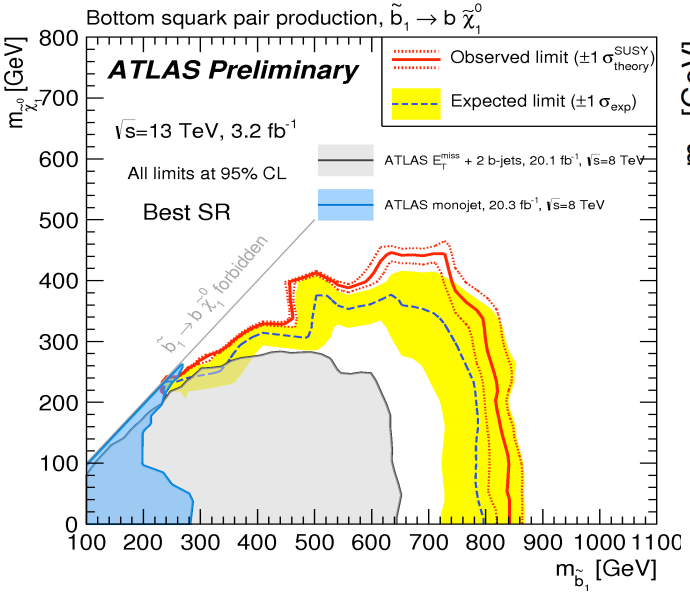
Natural SUSY: 3rd Generation Squarks

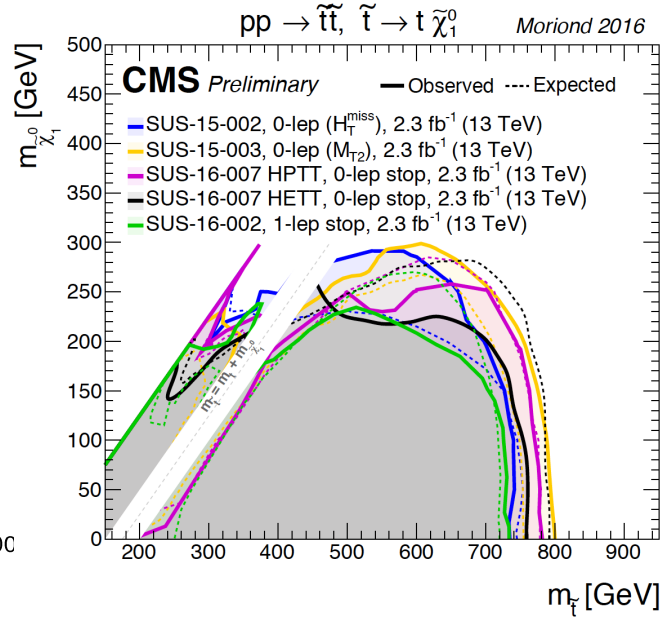
- Smaller cross section increase:
  $\sigma(13\ \text{TeV})/\sigma(8\ \text{TeV})\sim 8.4$ for $m(\tilde{t})=700$ GeV
  so current Run 2 luminosity not high enough yet to significantly exceed Run 1 sensitivity in all cases.



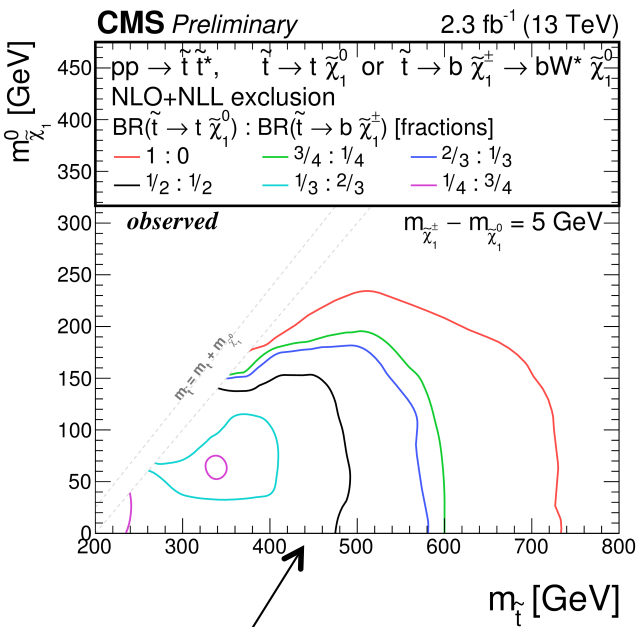
- A total of 10 Run 2 analyses available.
  No significant excess observed.

ATLAS-CONF-2015-066





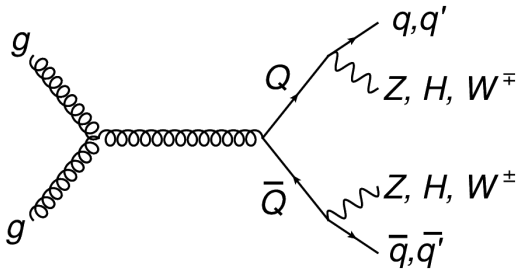
CMS-PAS-SUS-16-002



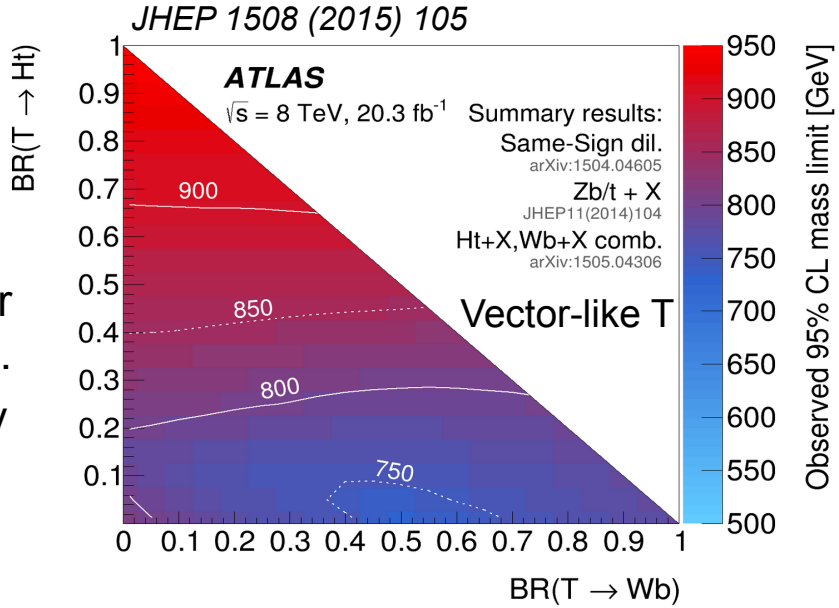
Highest mass limits for stop/sbottom ~800 GeV

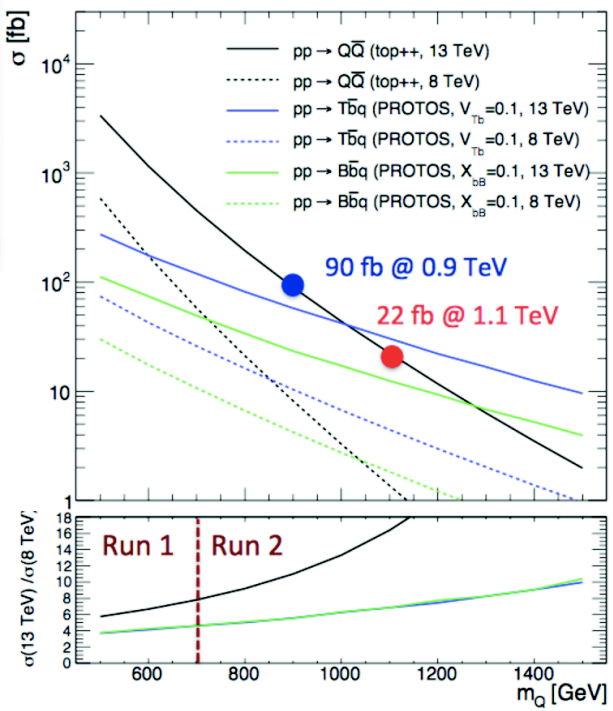
BUT beware of simplistic assumptions in simplified models!

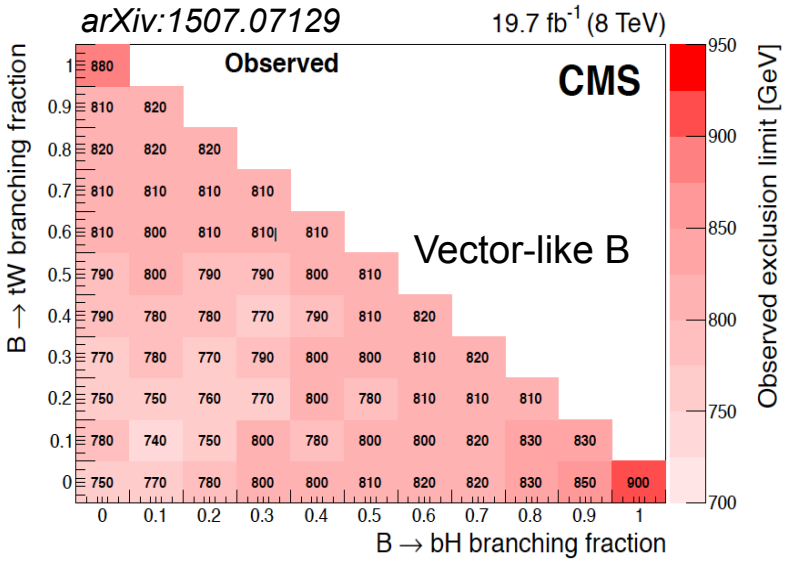
Natural Exotics: Vector-Like Quarks



- Vector-like top and bottom quarks naturally appear in composite Higgs and extra-dimensional models.
- Very rich phenomenology depending on the heavy quark mass and quantum numbers.
- Run 1 excluded masses below ~750 GeV.



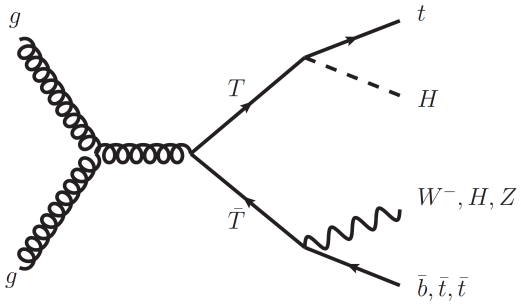


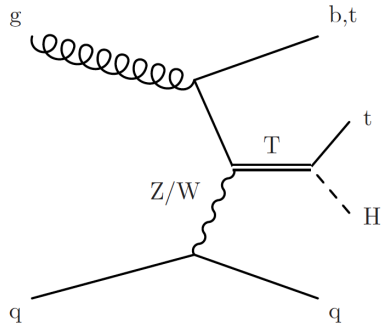


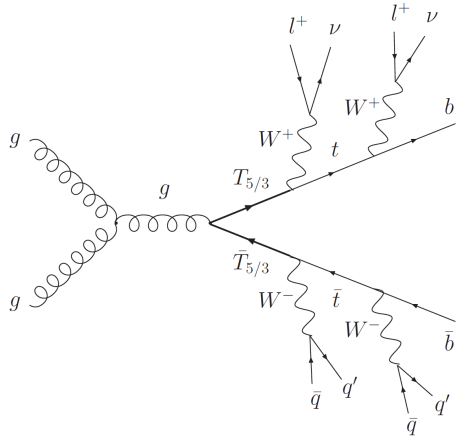
Great potential for discovery in Run 2!

Natural Exotics: Vector-Like Quarks

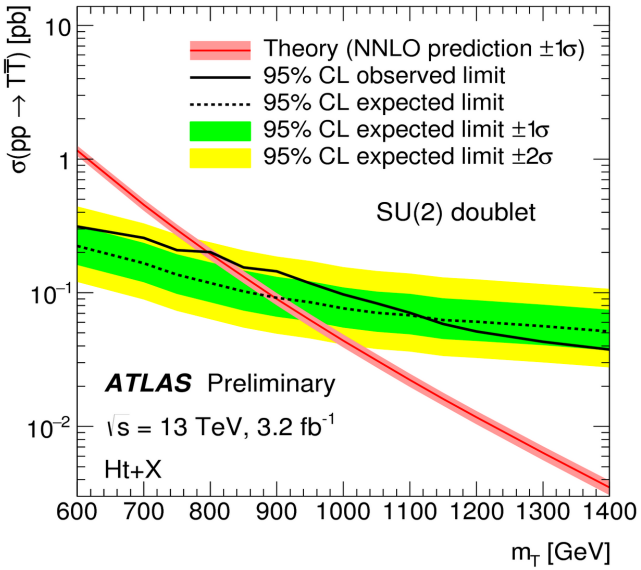
- Early 13 TeV searches for pair production matching or exceeding Run 1 sensitivity in particular corners or parameter space.
- Single production starting to be exploited for higher mass reach (dependent on assumed couplings to SM particles).



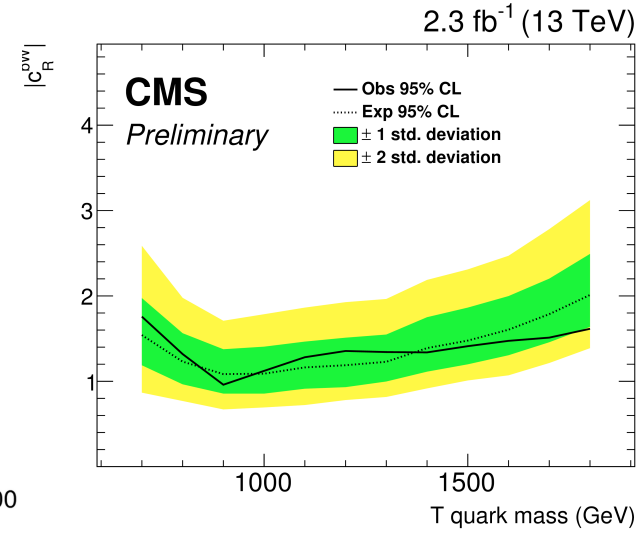




ATLAS-CONF-2016-013

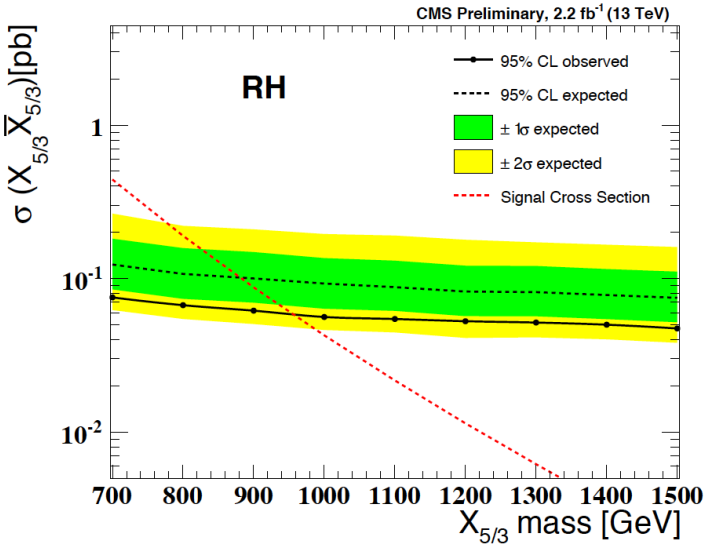


CMS-PAS-B2G-15-008



95% CL observed exclusion:
Doublet: m_T<800 GeV (Run 1: 820 GeV)

CMS-PAS-B2G-15-006



95% CL observed exclusion:
$m_{X5/3}$<960 GeV (Run 1: 800 GeV)

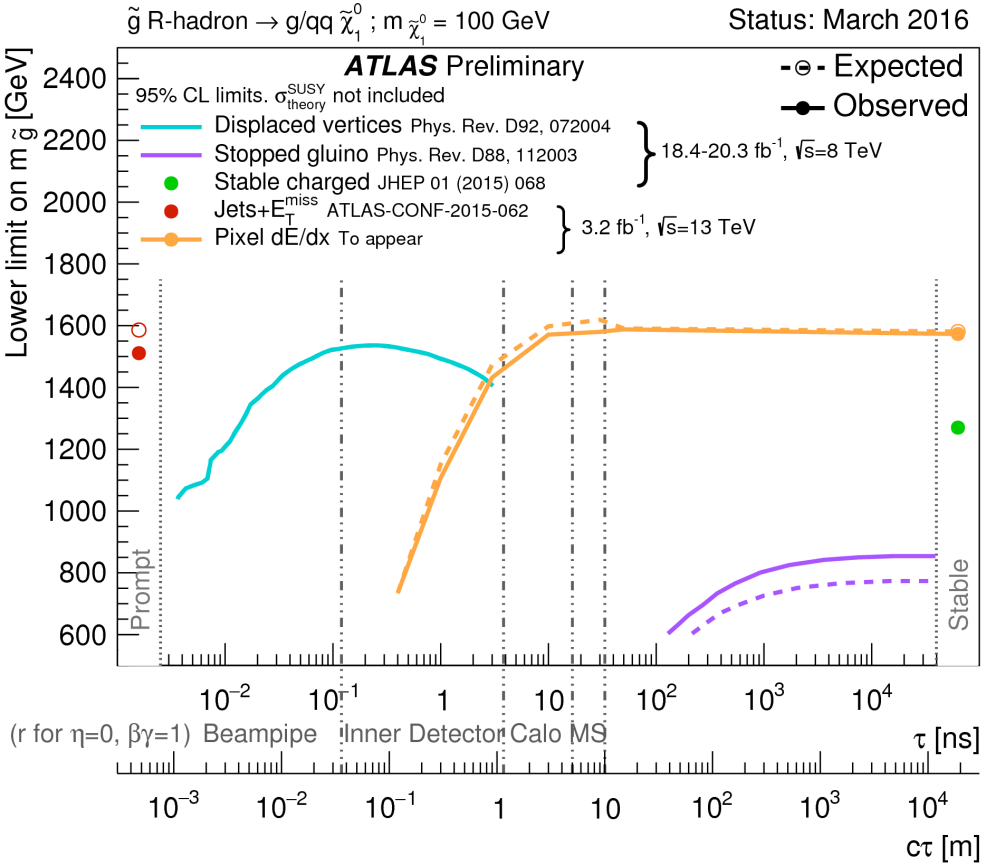
Searches in Unconventional Final States

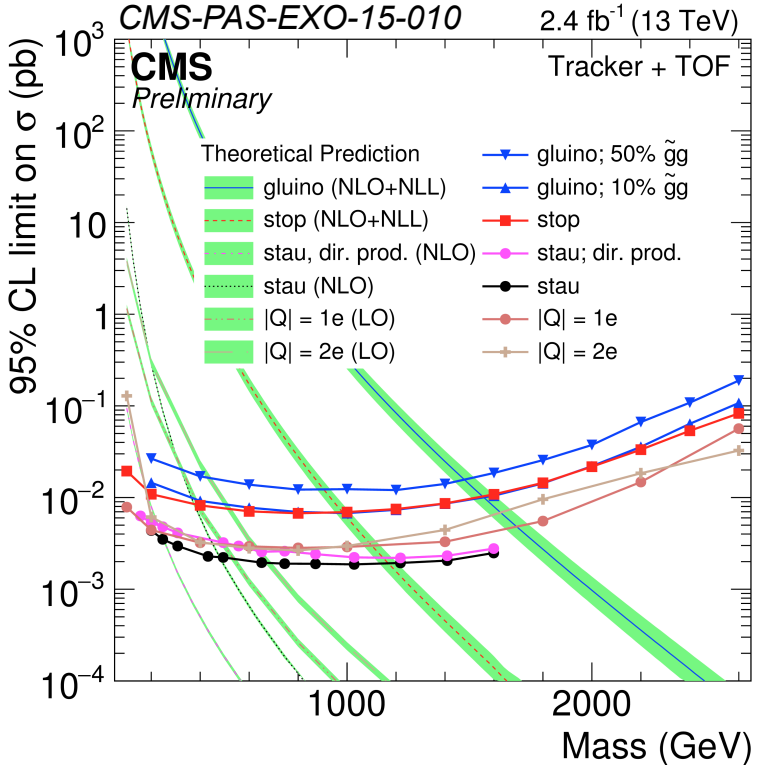
- Many BSM scenarios involve long-lived particles.
- New massive particles expected to be non-relativistic ($\beta<1$).

  If electrically charged, the new particle is expected to be highly ionizing.
- Unusual decay products can be produced (B-, L-violating, multiple jets, etc).

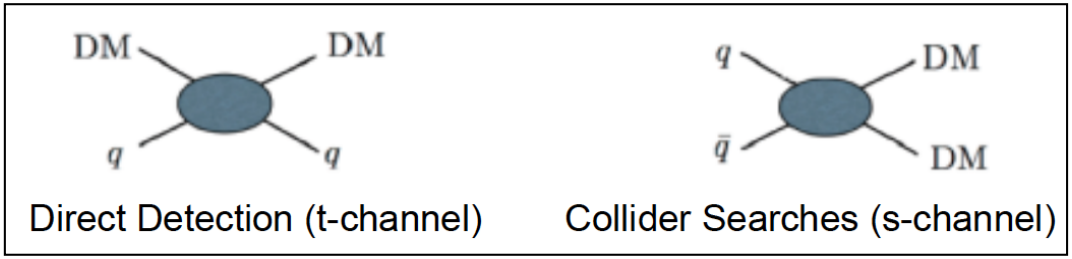
  ➔ Multitude of signatures, some requiring dedicated triggers, most requiring dedicated analysis strategies.

No excess found

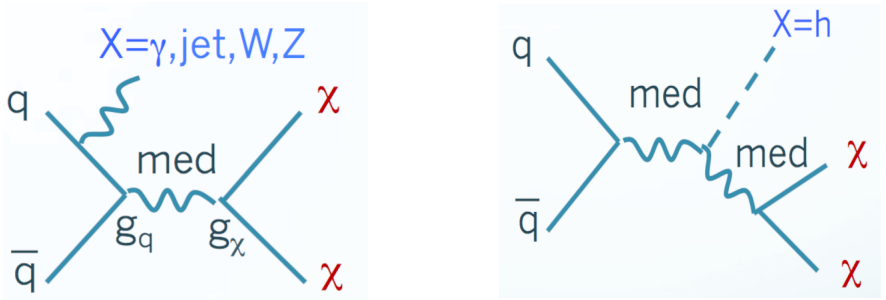




Dark Matter

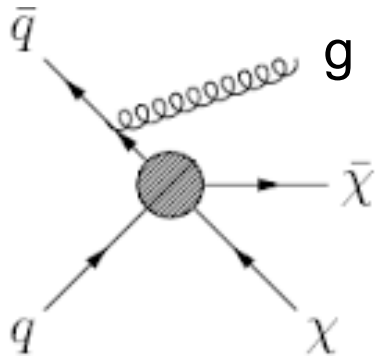


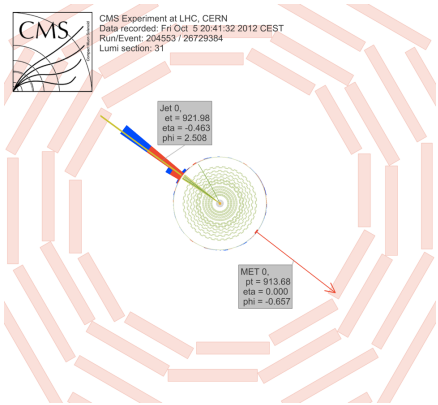
- Dark matter can also be produced at colliders.
- Being searched in association with SM particles, giving signatures of E_T^{miss}+X
  (X can be pretty much anything: q, g, V, h, top(s), b(s)) ➔ **"Mono-mania"**

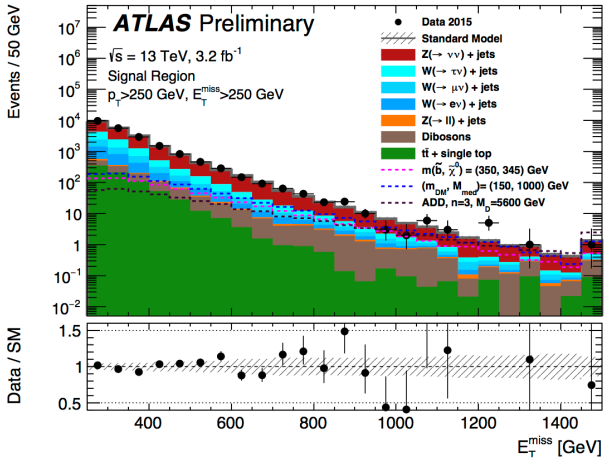


- Common "language" established last year with simplified models:
  ATLAS-CMS Dark Matter (DM) Forum (*arXiv:1507.00966*)
  - DM particle is a Dirac fermion χ
  - Mediator (med) exchanged in the s-channel
  - 5 parameters: M_{med}, m_χ, g_q, g_χ, Γ_{med}
  - Physics objects (X) produced in ISR (or radiated in case of h)
  - EFT models kept as benchmark (but with clear limitations and validity bounds)

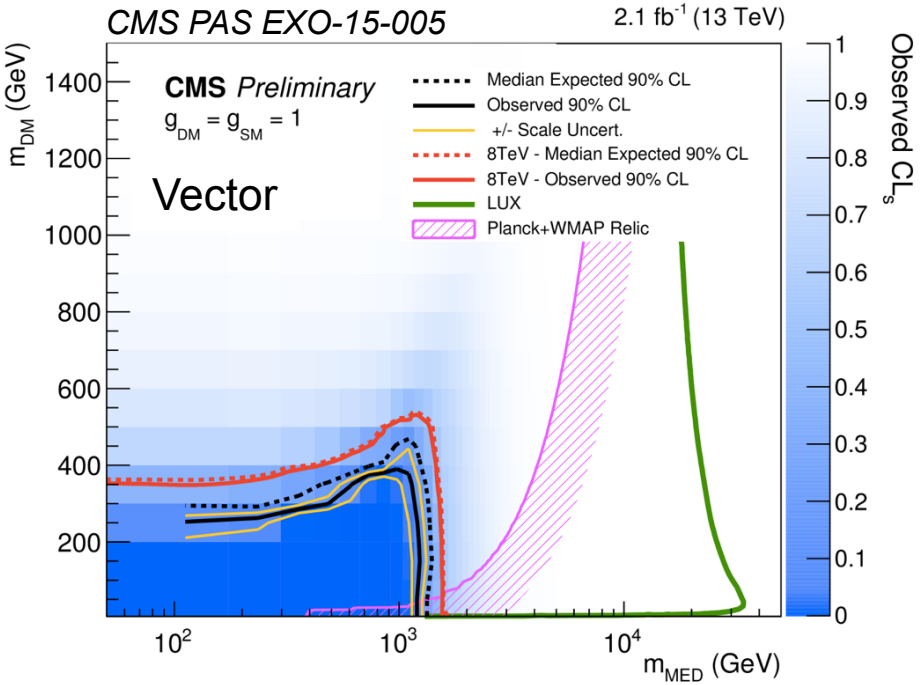
Dark Matter: Mono-jet

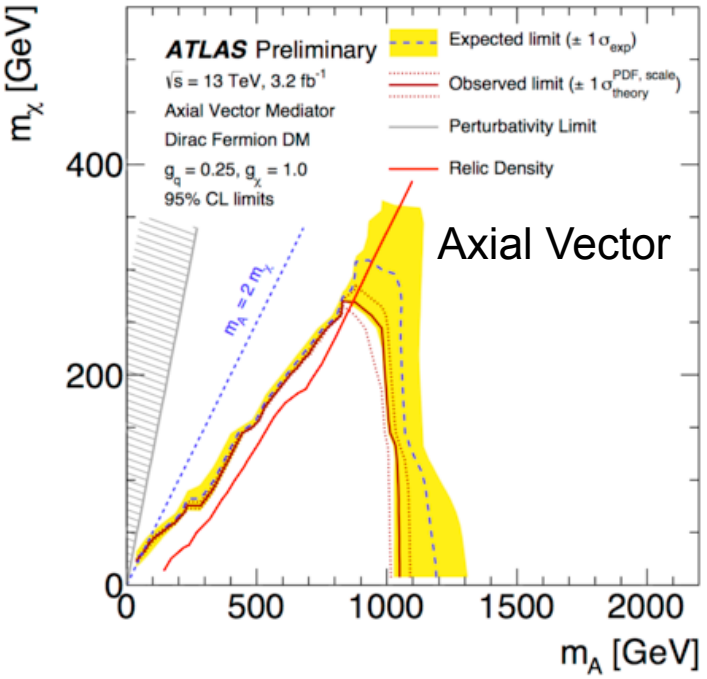




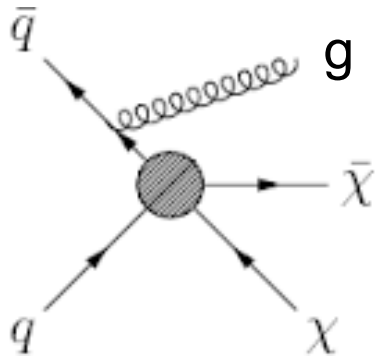


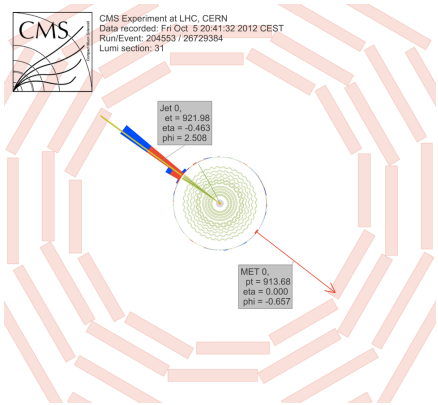
- High-p_T jet + large E_{Tmiss} (low jet multiplicity)
- Main backgrounds: Z(→νν)+jets, W(→lν)+jets
- **Most powerful and generic DM search**

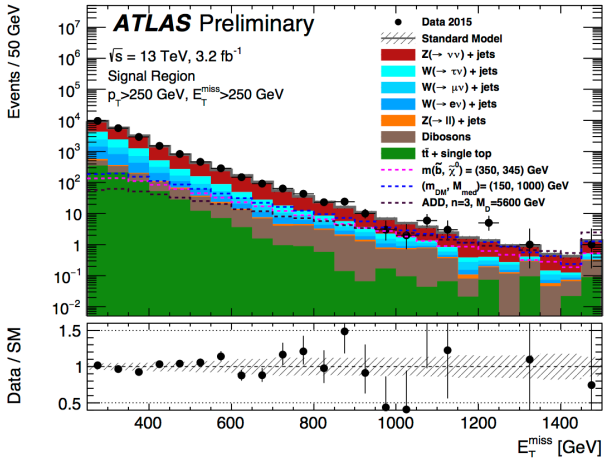




Dark Matter: Mono-jet

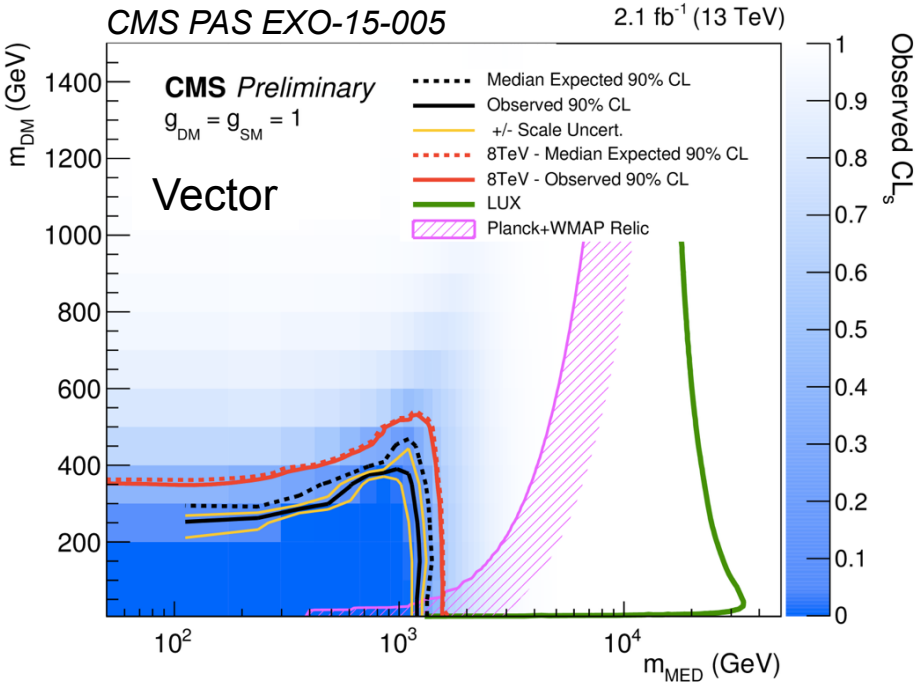


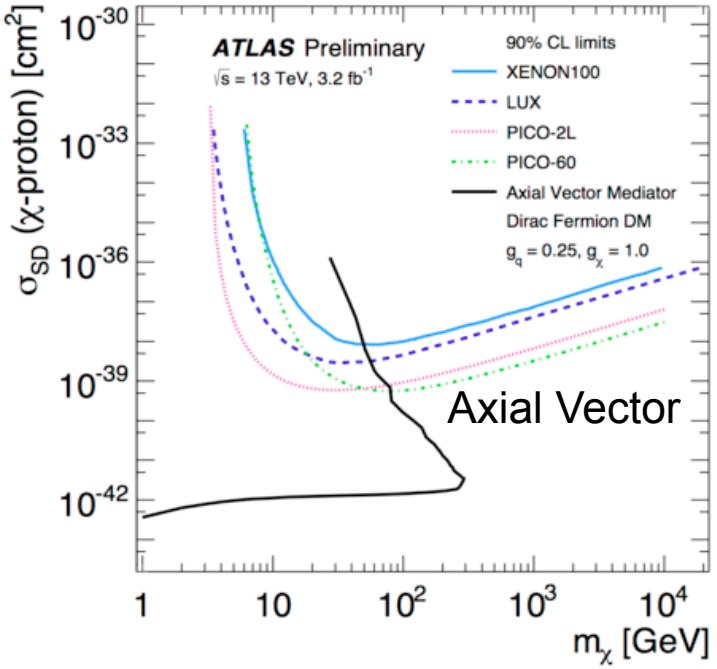




- High-p_T jet + large E_{Tmiss} (low jet multiplicity)
- Main backgrounds: Z(→νν)+jets, W(→lν)+jets
- **Most powerful and generic DM search**

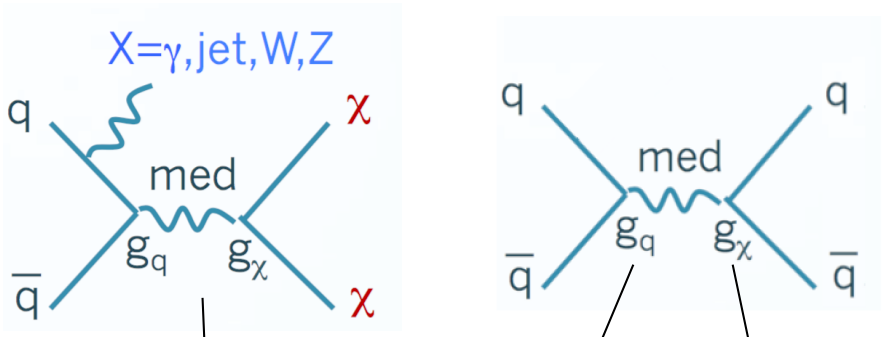
Translation into 90% CL exclusion limit on the spin-dependent χ-proton scattering σ (model dependent)





Mono-jet – Dijet Resonances Complementarity

- If the mediator is produced by $q\bar{q}$, it will also decay into $q\bar{q}$
  ➔ probed by dijet resonance searches!



Off-shell region:

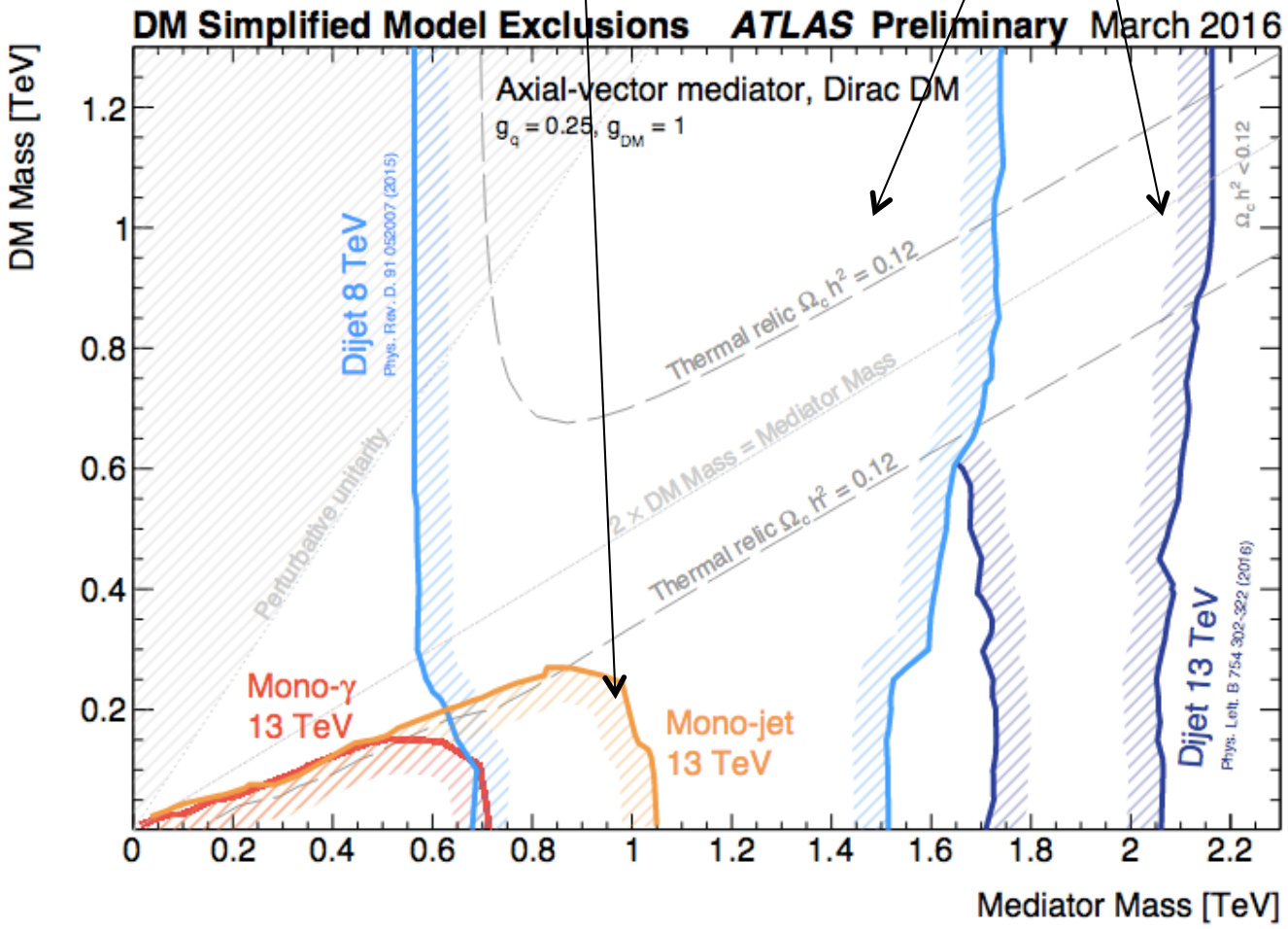
$M_{med}<2m_\chi$

The mediator can decay only to di-jet

On-shell region:

$M_{med}>2m_\chi$

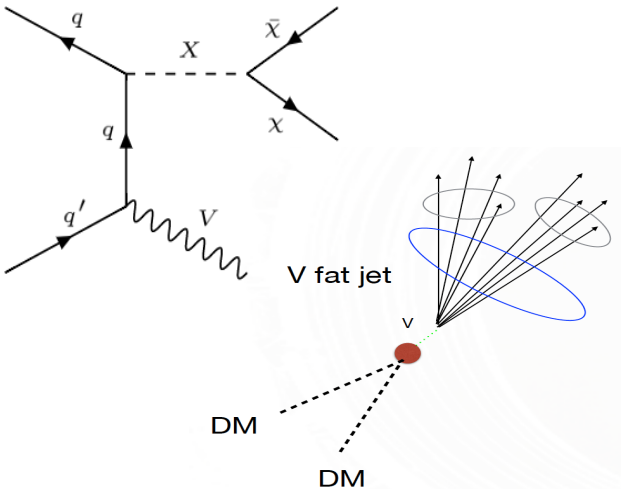
The mediator can decay also to DM

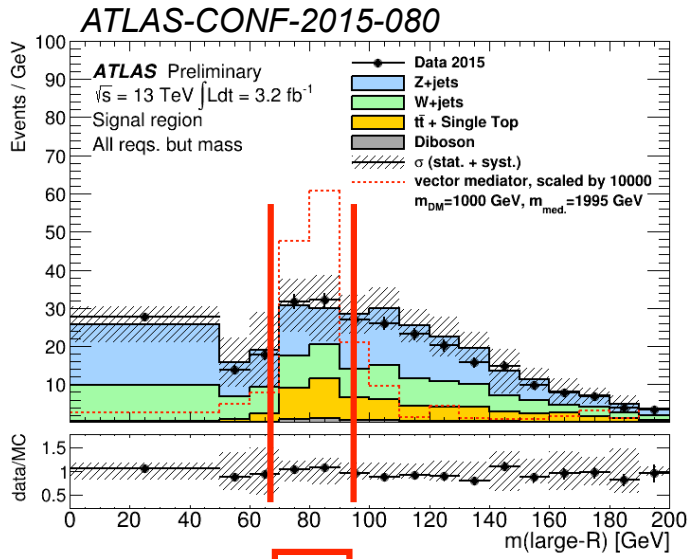


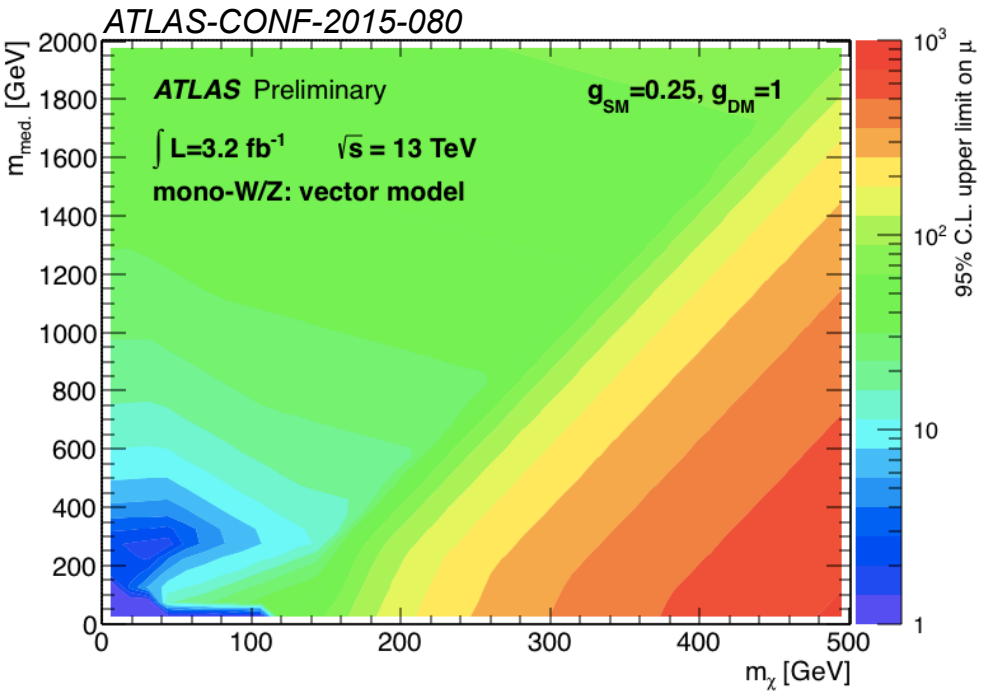
Dark Matter: Mono-W/Z

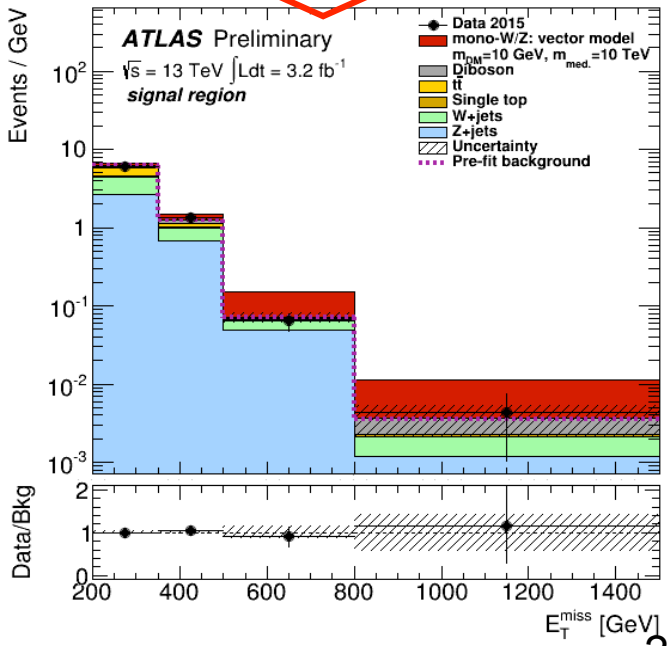
- Mono-W/Z production provides information on the couplings to u- and d-quarks, as well as on their relative sign.
- Most-sensitive search:

  boosted hadronically-decaying W/Z + E_T^{miss}









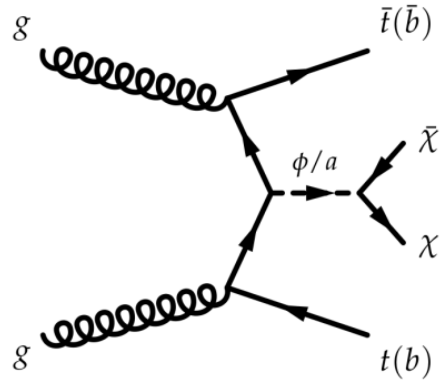
Strongest channel, together with mono-jet

Dark Matter: DM+Heavy-flavor

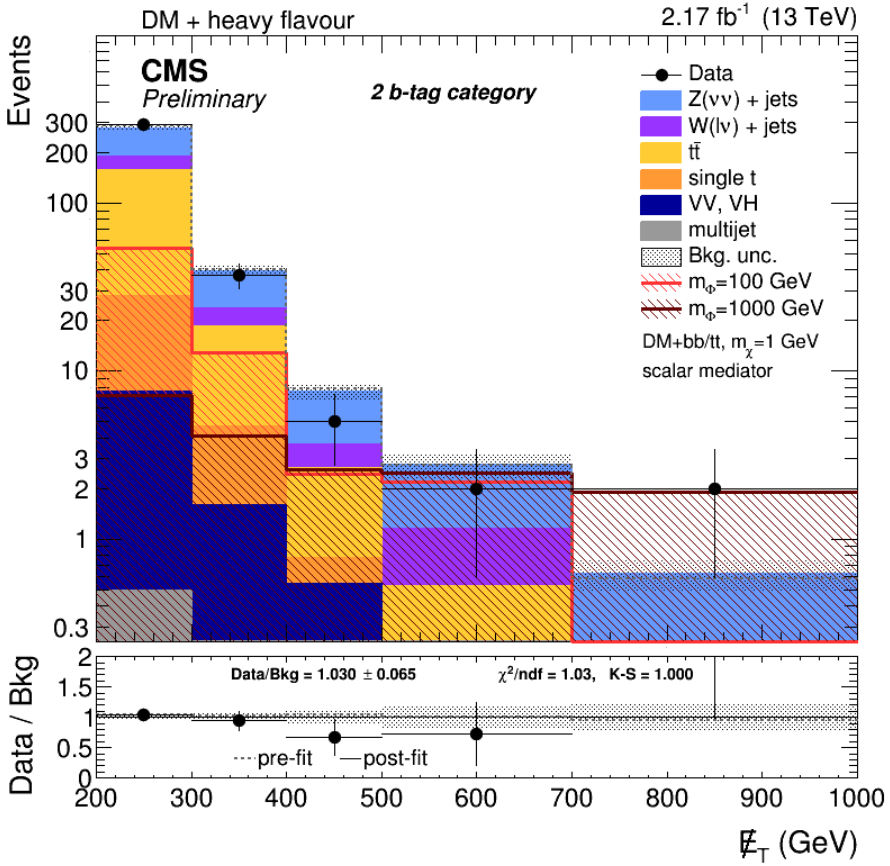
- Dark matter produced in association with bottom/top particularly sensitive to (pseudo-)scalar interactions:

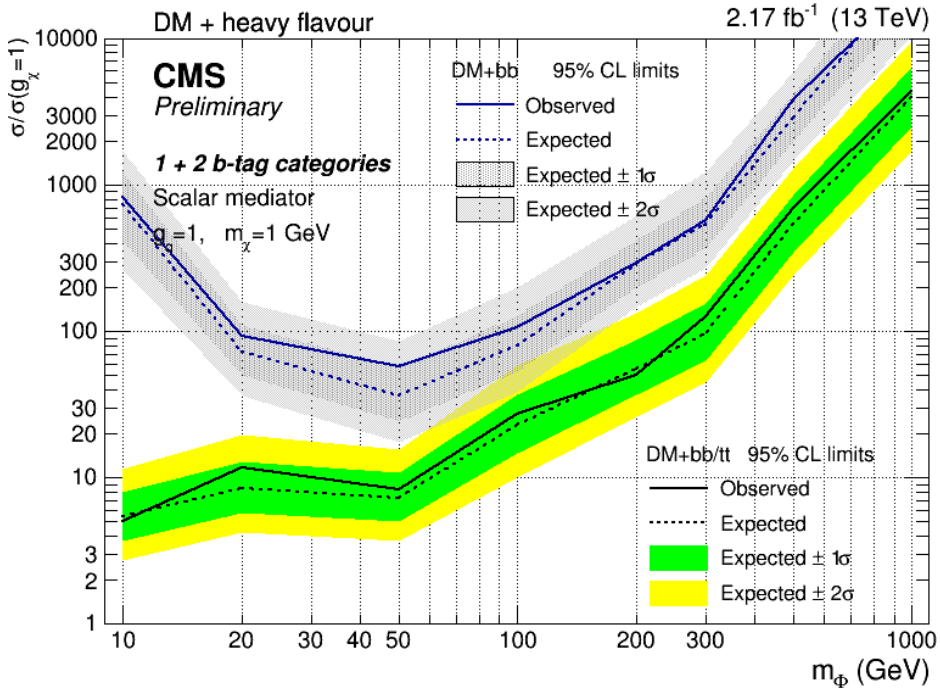
$$coupling \propto m_q$$

- Consider events with <3 jets and with 1 and 2 b-tags.
  - Still significant background from W/Z+jets.



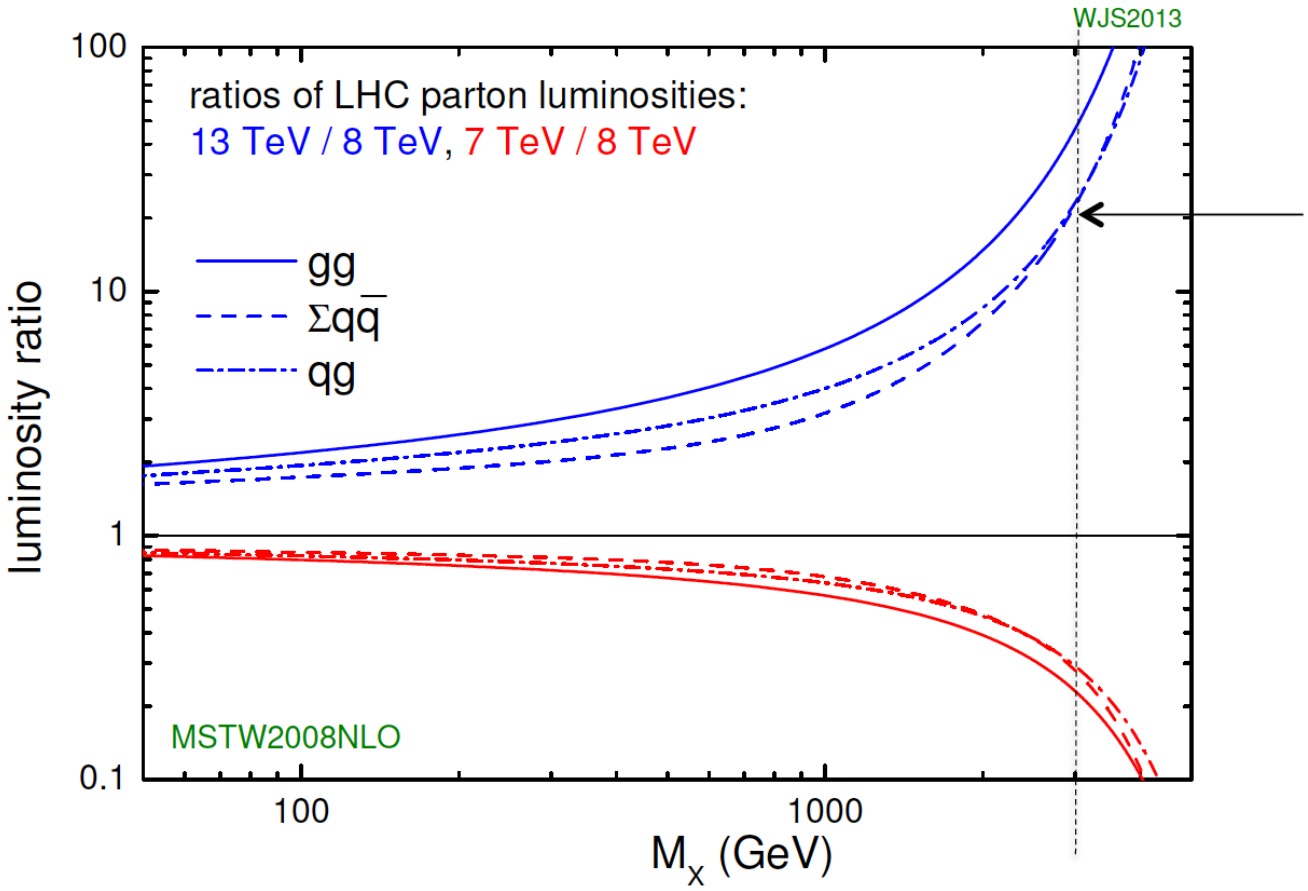
CMS PAS B2G-12-007





Limits on $b\bar{b}$+DM only and combined $b\bar{b}/t\bar{t}$+DM

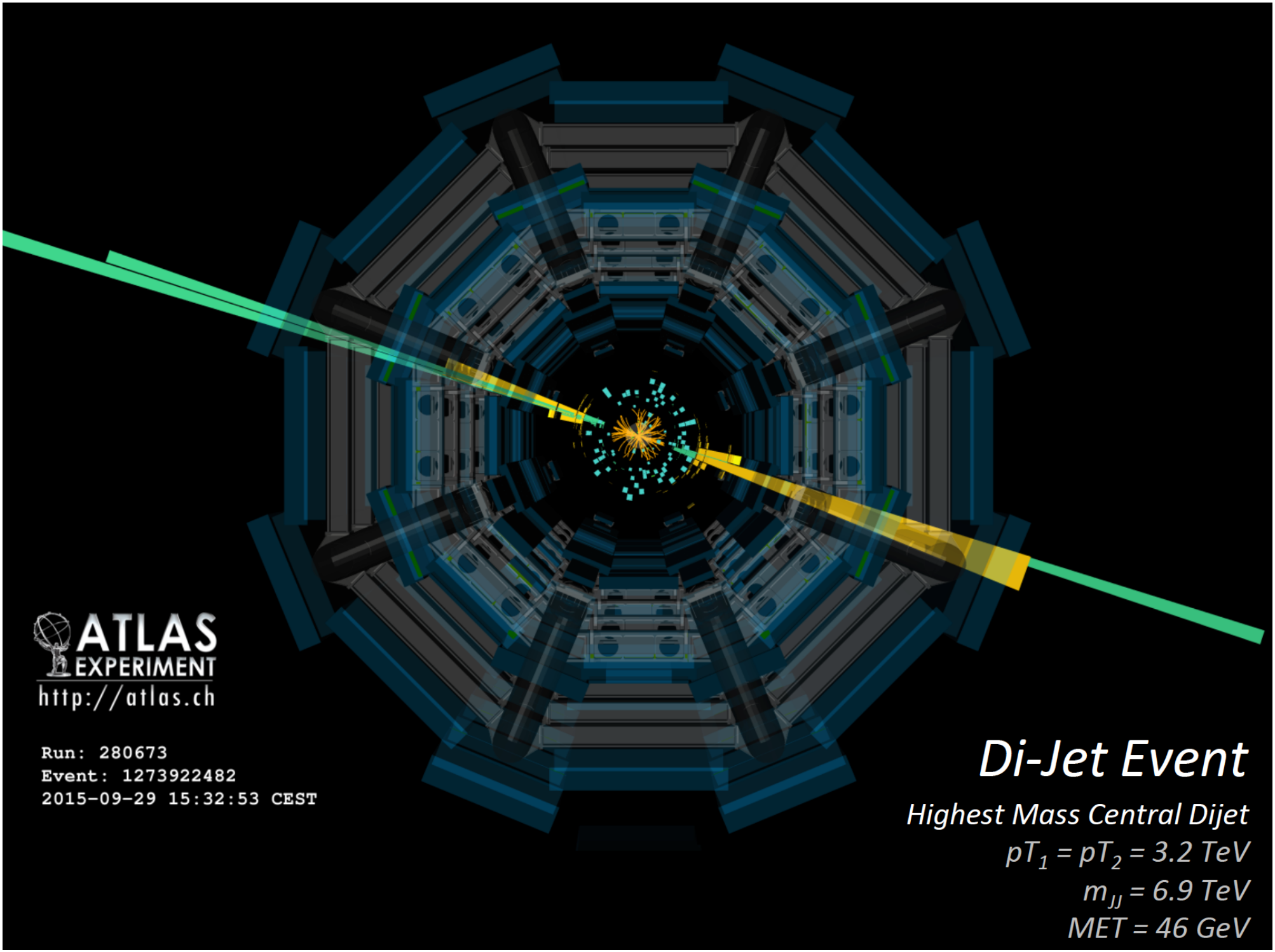
Early Searches for New Phenomena



Ratio of 13 TeV / 8 TeV
Cross sections:

- Z' at 3 TeV: **20**
- q* at 4 TeV: **56**
- QBH at 5 TeV: **370**
- QBH at 6 TeV: **9000**

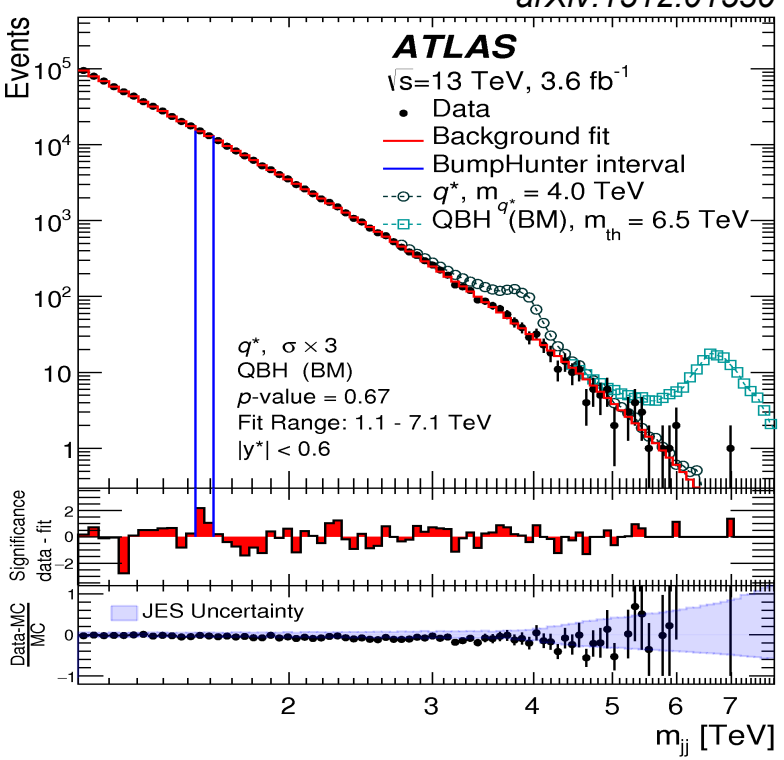
Many, many searches. Just some highlights shown here.


ATLAS
EXPERIMENT
http://atlas.ch
Run: 280673
Event: 1273922482
2015-09-29 15:32:53 CEST
Di-Jet Event
Highest Mass Central Dijet
$pT_1 = pT_2 = 3.2$ TeV
$m_{JJ} = 6.9$ TeV
MET = 46 GeV

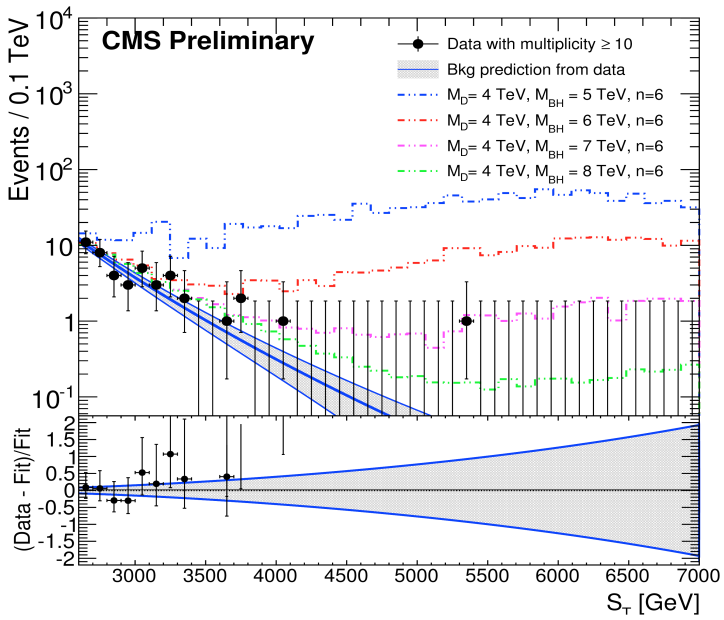
Resonances in High-p_T Multijet Final States

- Early searches at 13 TeV focusing on processes with large cross sections ➔ sensitive to highest New Physics scales.
- Many searches!
  - Dijet resonances and angular distributions
  - Photon+jet resonances
  - High-p_T multijets and lepton+jets produced e.g. by strong gravity
  - Second generation scalar leptoquark pair production (μq-μq final state, excl. <1.2 TeV)

arXiv:1512.01530

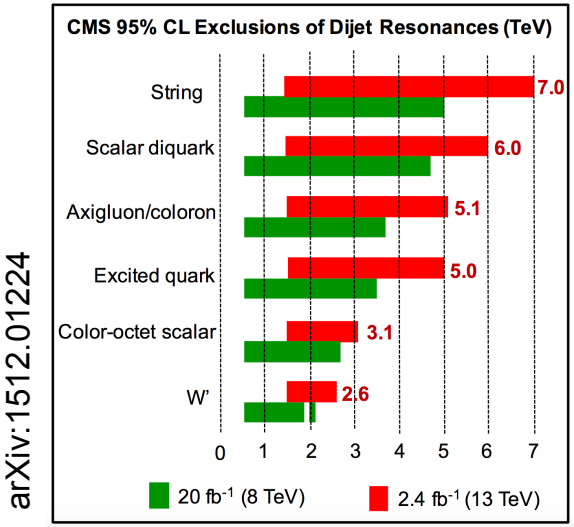


CMS-EXO-15-007 2.2 fb^{-1} (13 TeV)



No excess found

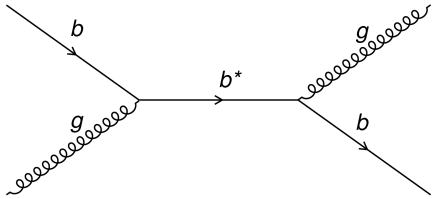
Significantly extended limits compared to Run 1

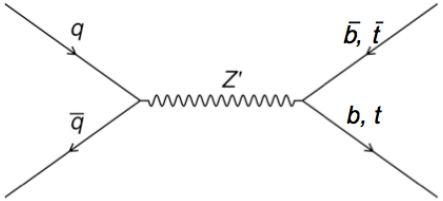


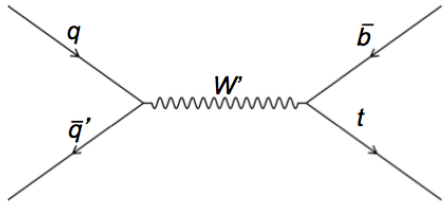
arXiv:1512.01224

Resonances in High-p_T Multijet Final States

- Also searches for resonances decaying into 3rd generation quarks.

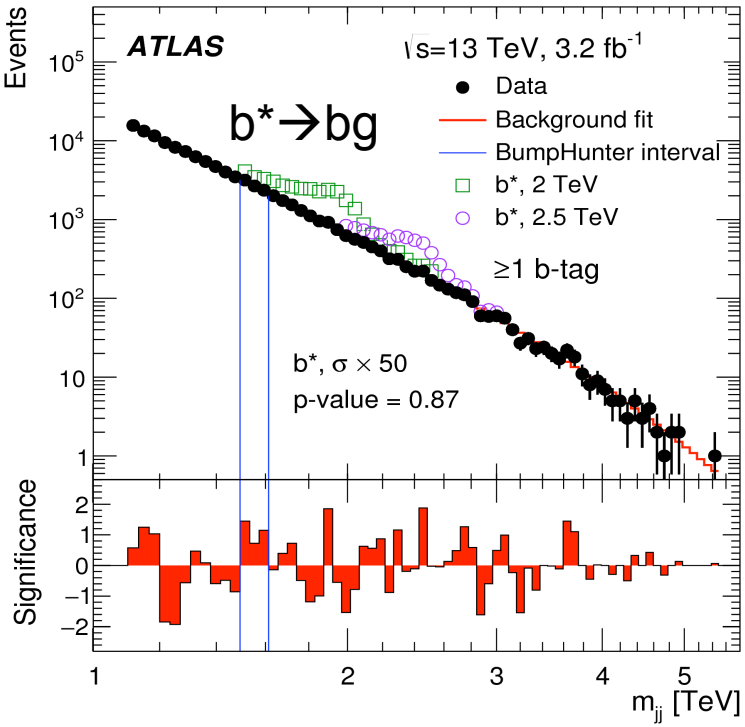




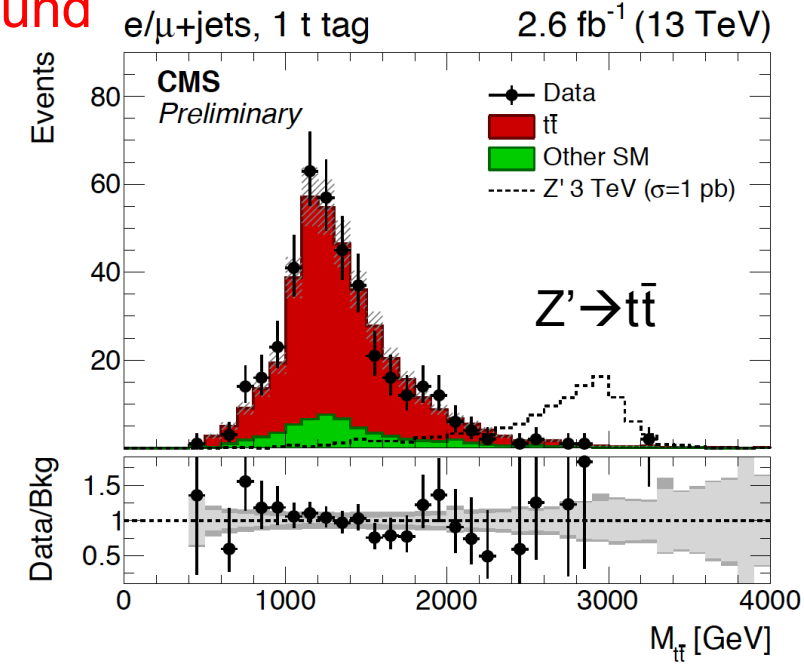


No excess found

arXiv:1603.08791

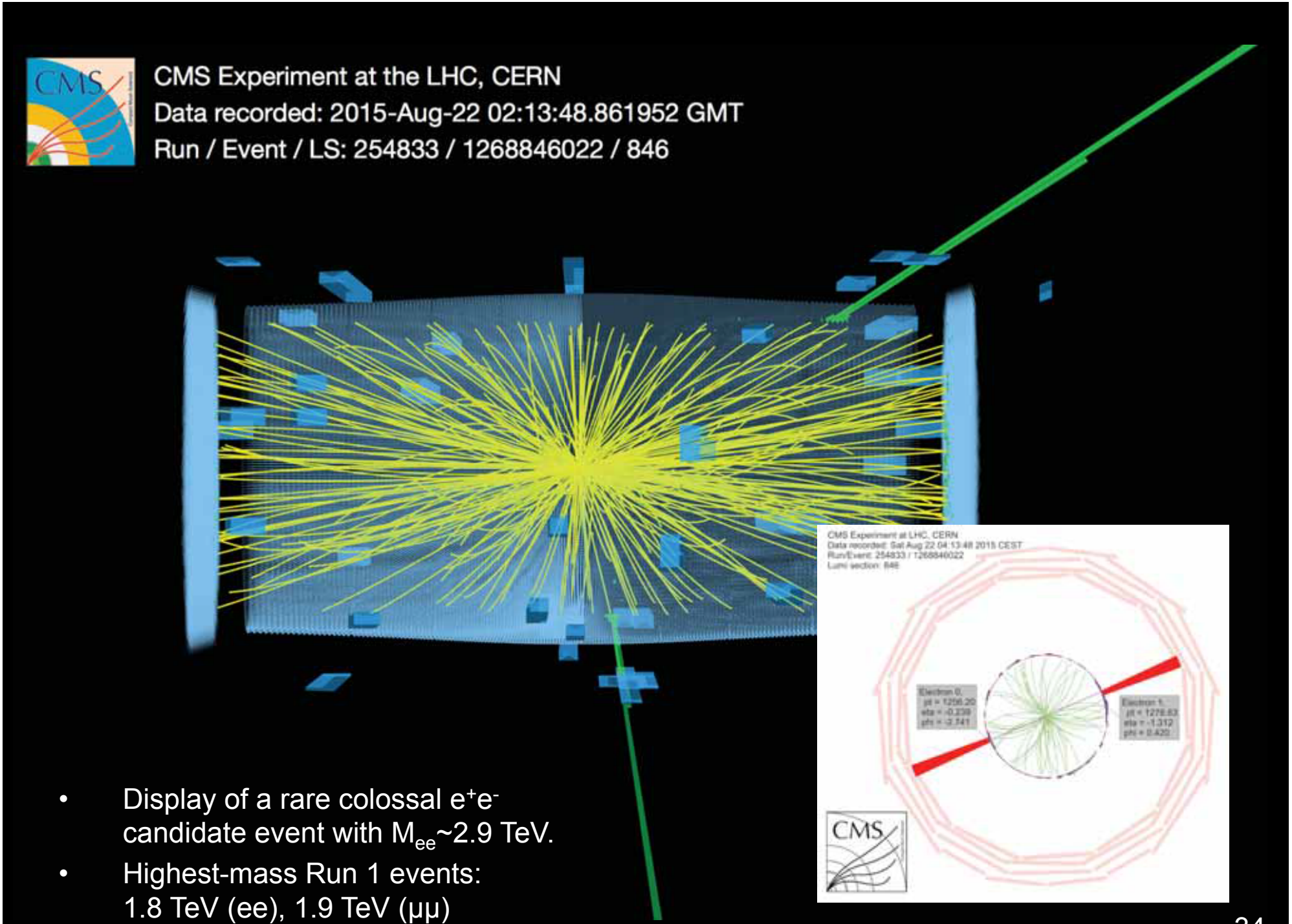


95% CL exclusions:
Excited b quark: $1.1<m_{q^*}<2.1$ TeV
SSM Z': $1.1<m_{Z'}<1.5$ TeV



95% CL exclusions:
TC2 Z' : $0.7<m_{Z'}<2.0$ TeV
KK gluon: $0.5<m_{gKK}<2.9$ TeV
W'$_R$: $m_{W'}<2.4$ TeV

ATLAS-CONF-2016-014
CMS-PAS-B2G-15-002
CMS-PAS-B2G-15-004

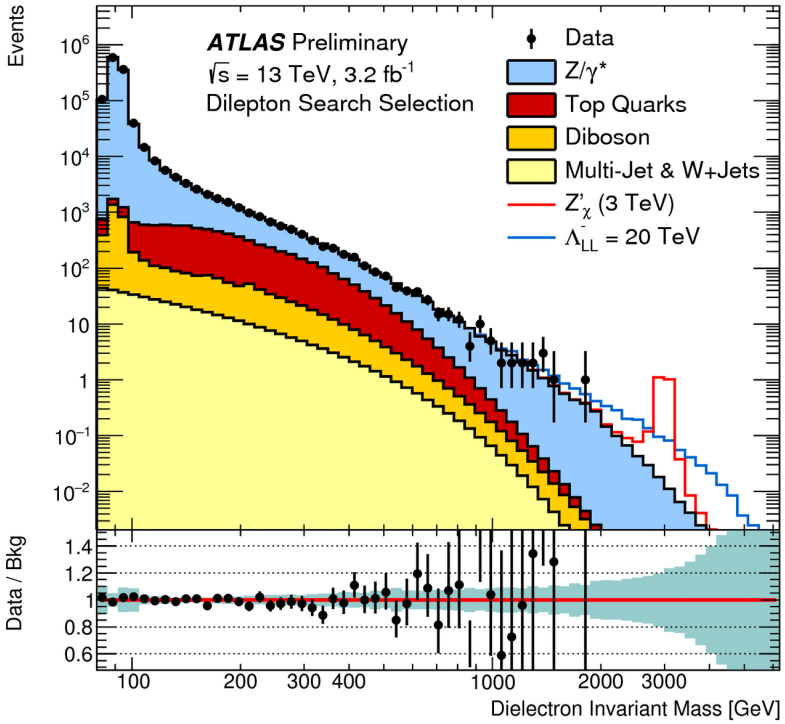


- Display of a rare colossal e^+e^- candidate event with M_{ee}~2.9 TeV.
- Highest-mass Run 1 events: 1.8 TeV (ee), 1.9 TeV (μμ)

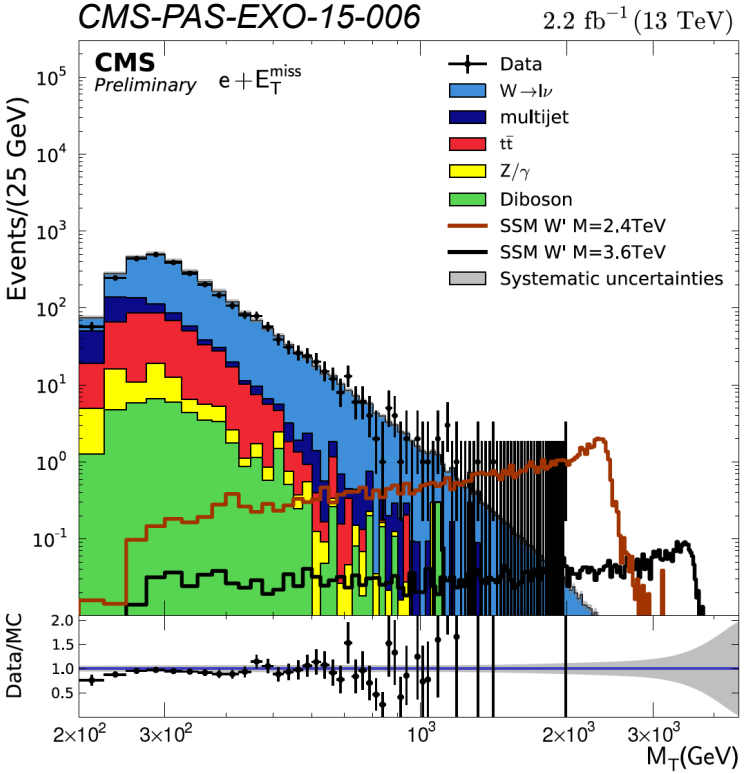
Resonances in Leptonic Final States

- Early 13 TeV searches for resonant production of Z'→ee, μμ, eμ and W'→eν, μν.

ATLAS-CONF-2015-063



CMS-PAS-EXO-15-006



No excess found

95% CL exclusions:

$Z'_\chi \rightarrow ee/\mu\mu$: $m_{Z'} < 2.8$ TeV (Run 1: 2.5 TeV)

ATLAS-CONF-2015-063

SSM $Z' \rightarrow ee/\mu\mu$: $m_{Z'} < 3.2$ TeV (Run 1: 2.9 TeV)

CMS-PAS-EXO-15-005

SSM $Z' \rightarrow e\mu$: $m_{Z'} < 3.0$ TeV

ATLAS-CONF-2015-072

95% CL exclusions:

SSM W': $m_{Z'} < 4.1$ TeV (Run 1: 3.2 TeV)

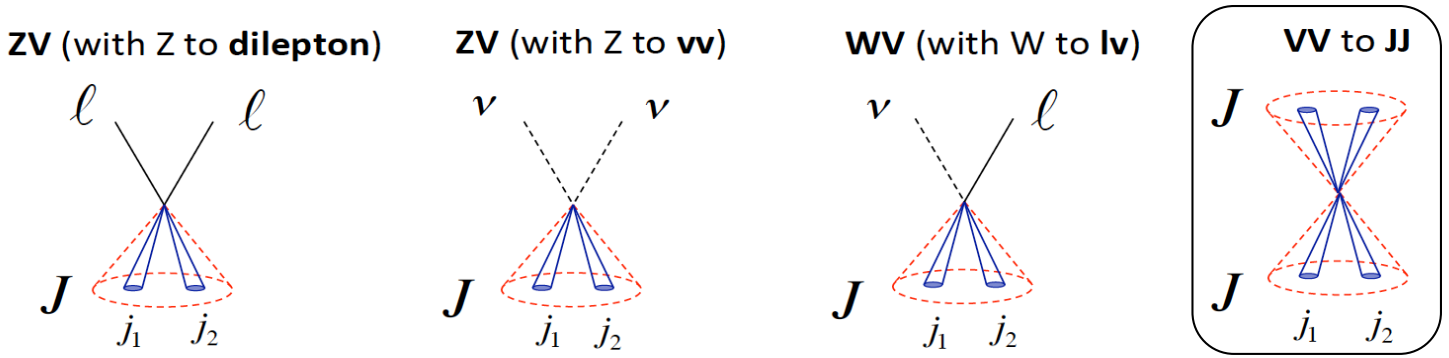
ATLAS-CONF-2015-063

$m_{Z'} < 4.3$ TeV (Run 1: 3.3 TeV)

CMS-PAS-EXO-15-006

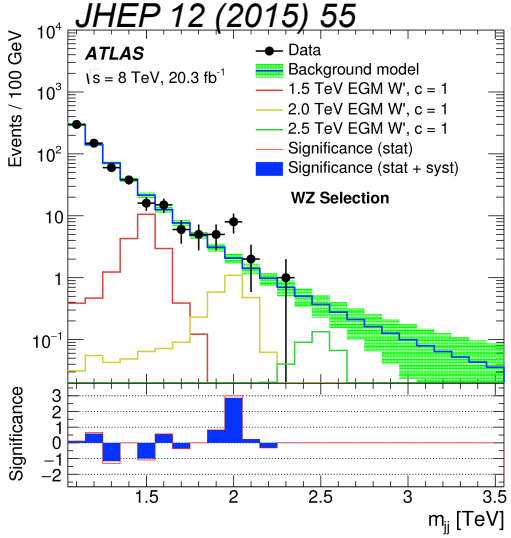
Diboson Resonances (VV)

- Many BSM theories predict heavy gauge bosons decaying into diboson final states.
- Fast turnaround of 13 TeV analyses. Many final state signatures explored.
  Here just showing one particularly popular example.



Run 1

JHEP 12 (2015) 55

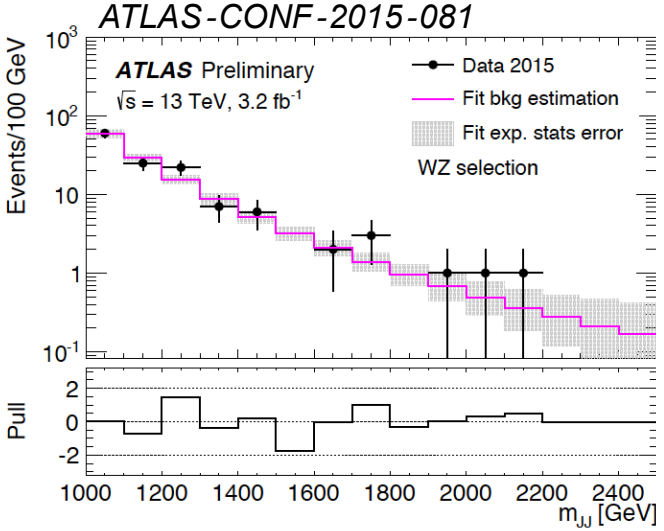


Modest excess at ~2 TeV:
3.4σ local/2.5σ global

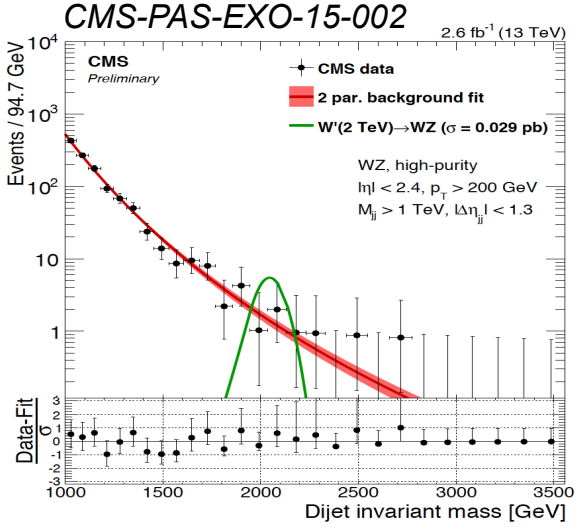
VS

Early Run 2

ATLAS-CONF-2015-081



CMS-PAS-EXO-15-002



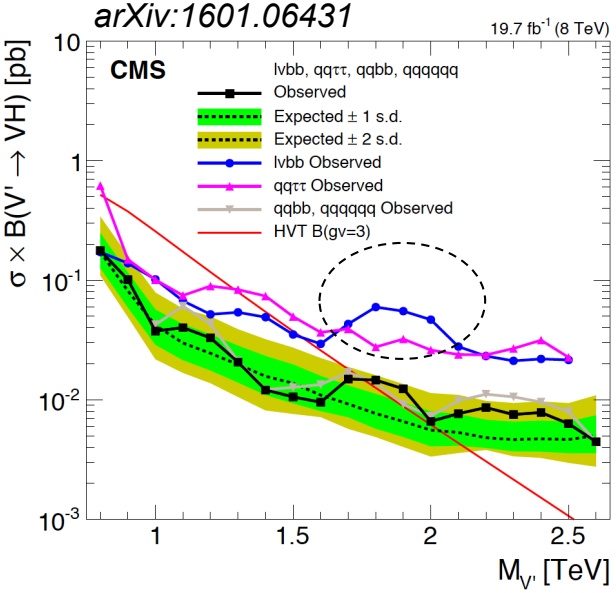
Excess not confirmed!

Diboson Resonances (Vh)

- Several searches for W'→Wh and Z'→Zh performed in Run 1 and early Run 2.

Run 1

arXiv:1601.06431



Modest excess in lνbb search (only electron channel) at $M_{W'}$~1.8 TeV: 2.9σ local/1.9σ global

95% CL exclusions:

Little Higgs: $m_{W'}$<1.4 TeV

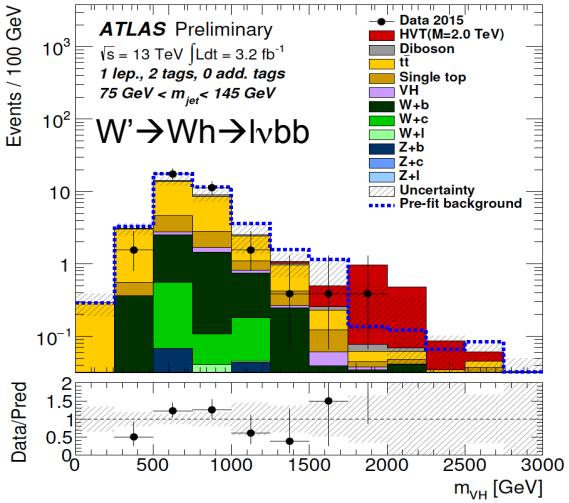
HVT B model: $m_{W'}$<1.5 TeV

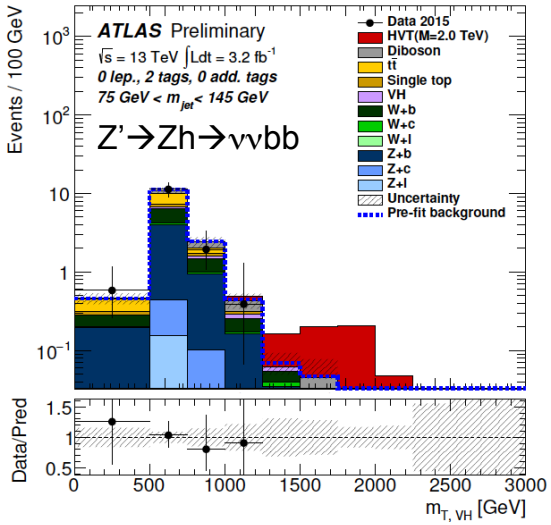
$m_{W'}$<1.8 TeV (comb.)

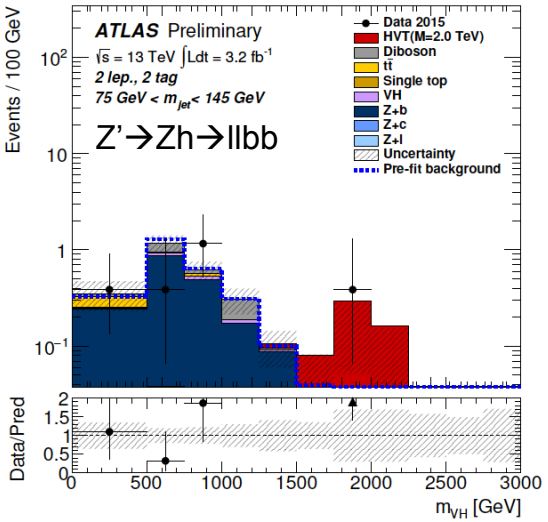
VS

Early Run 2

ATLAS-CONF-2015-074





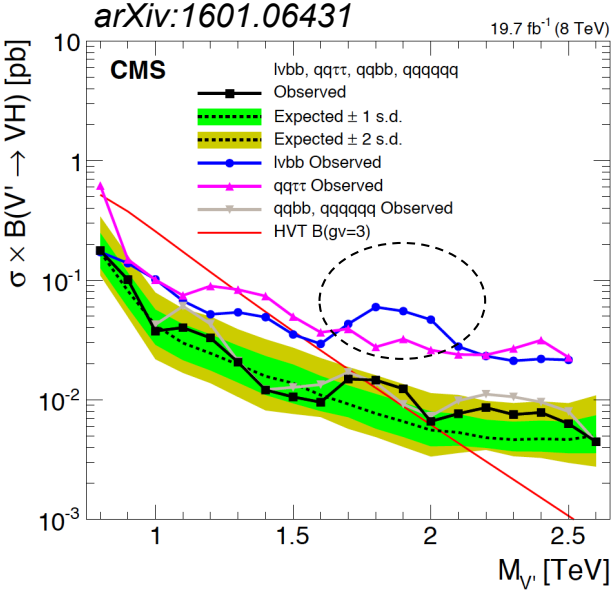


Diboson Resonances (Vh)

- Several searches for W'→Wh and Z'→Zh performed in Run 1 and early Run 2.

Run 1

arXiv:1601.06431



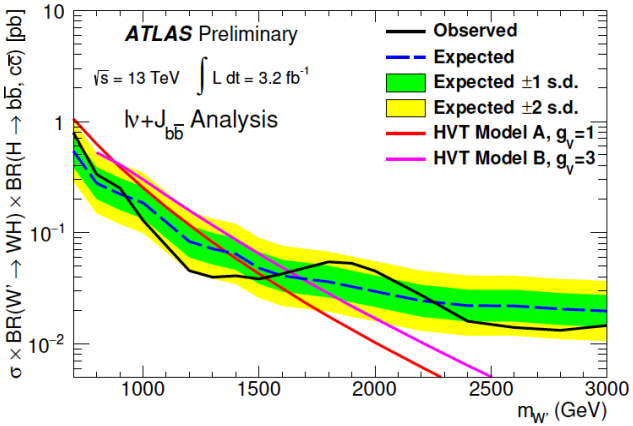
Modest excess in lνbb search (only electron channel) at $M_{W'}$~1.8 TeV: 2.9σ local/1.9σ global

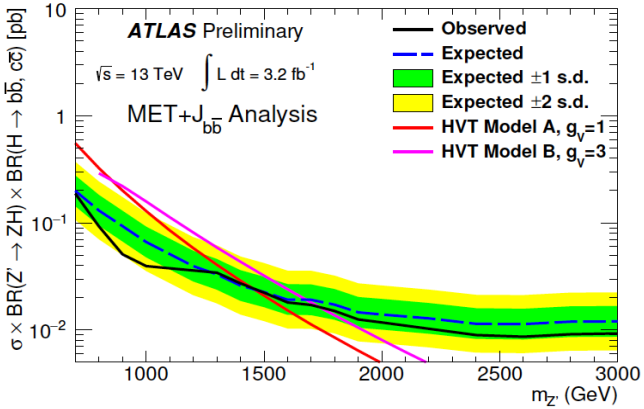
95% CL exclusions:
Little Higgs: $m_{W'}$<1.4 TeV
HVT B model: $m_{W'}$<1.5 TeV
$m_{W'}$<1.8 TeV (comb.)

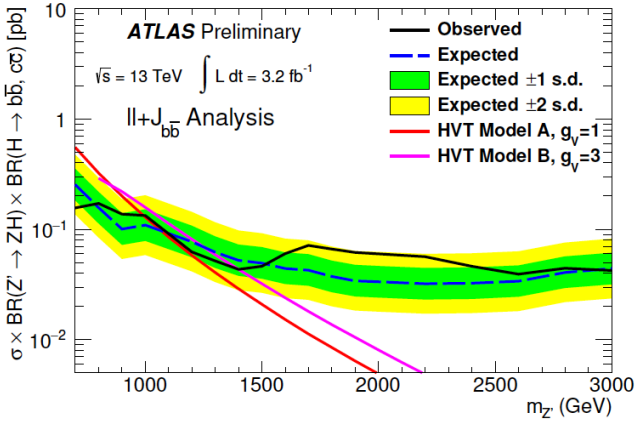
VS

Early Run 2

ATLAS-CONF-2015-074







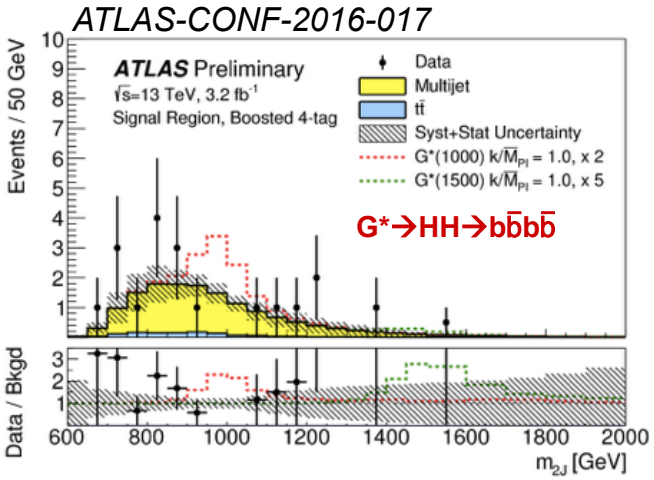
95% CL exclusions:
HVT B model: $m_{W'}$<1.6 TeV, $m_{Z'}$<1.8 TeV

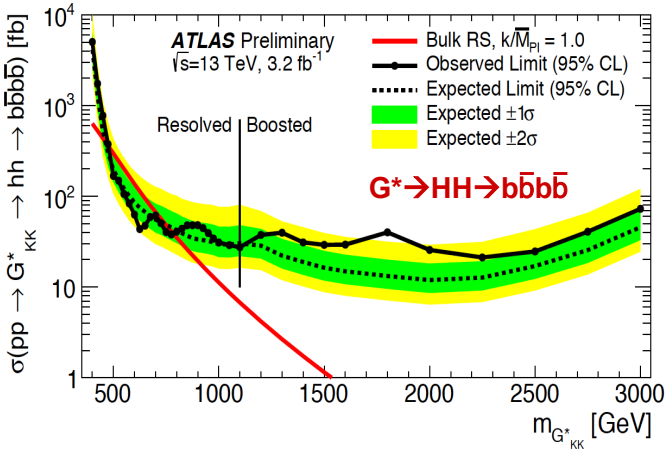
Diboson Resonances (hh)

- Searches for X→hh→bb̄bb̄ in resolved and boosted regimes (here focusing on the latter).
- Basic selection: 2 large-R jets and ≥3 b-tags (ATLAS), ≥2 b-tags (CMS), Higgs tagging.
- Main backgrounds from dijets and tt̄ estimated via data-driven techniques.
- Several signal regions considered.

Early Run 2

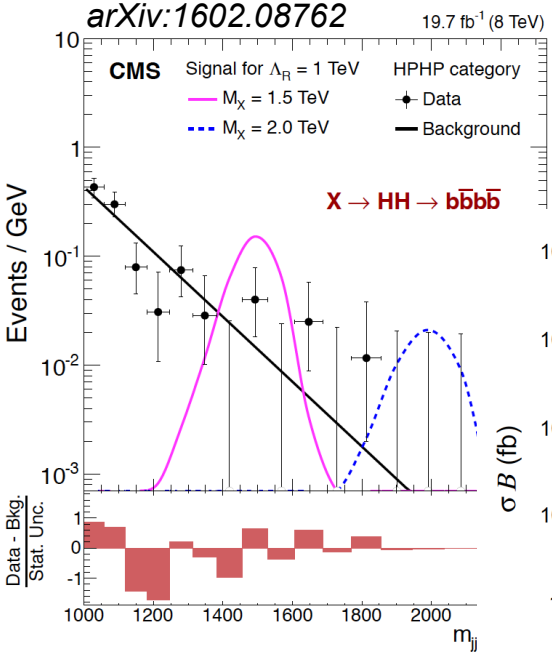
ATLAS-CONF-2016-017

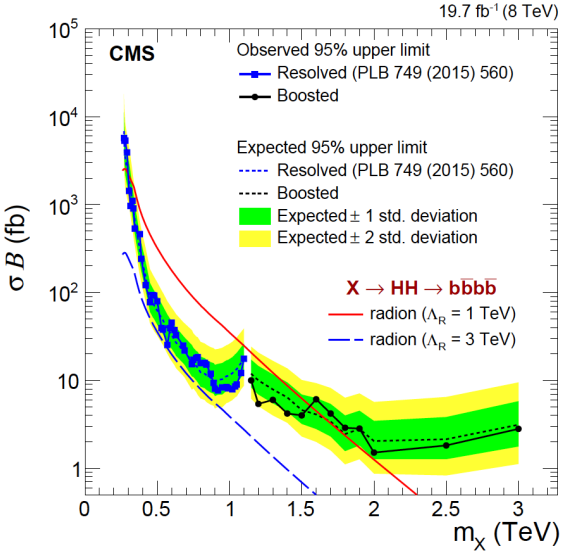




Run 1

arXiv:1602.08762





95% CL exclusions:

RS Graviton ($k/\bar{M}_{Pl}$=1): $475 < m_{G^*} < 785$ GeV

ATLAS-CONF-2016-017

WED Radion (Λ_R=1 TeV): $0.3 < m_X < 1.55$ TeV

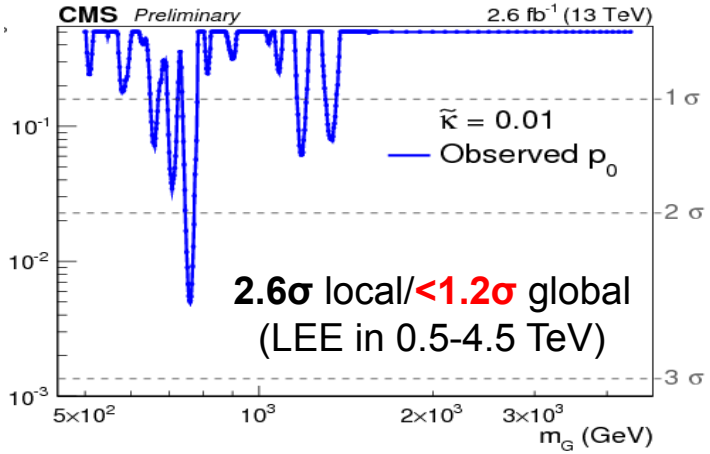
arXiv:1602.08762

Diphoton Resonances

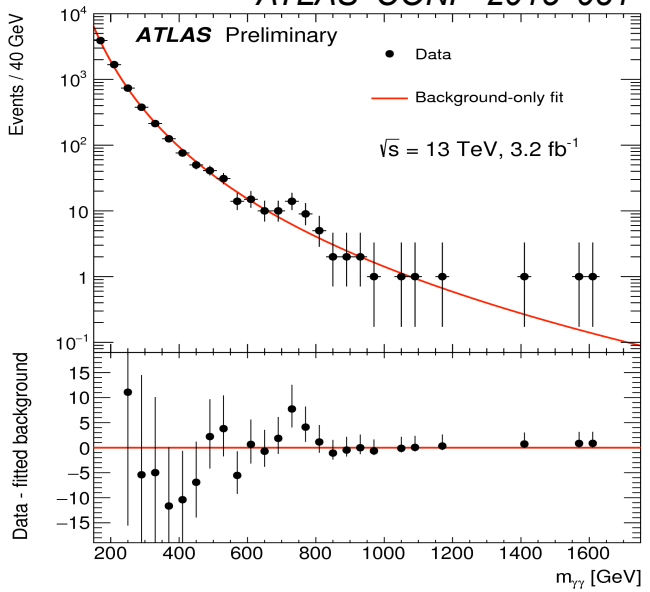
- High mass diphoton resonances appear in several BSM scenarios:
  - Spin 0: extended Higgs sectors
  - Spin 2: extra dimensions
- Very clean final state, “simple” analysis:
  - Two high-p_T isolated photons
  - Signature of resonant production:

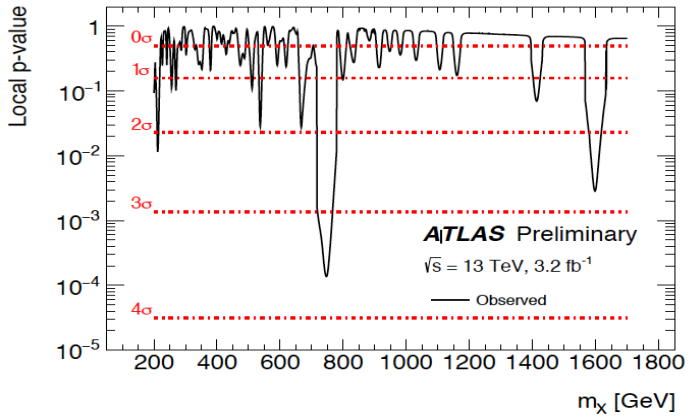
    ➔ localized excess of events in the diphoton invariant mass spectrum
- **First 13 TeV results shown at the Dec 15th, 2015 LHC Jamboree**:
  - Modest excess found at a mass of ~750 GeV

CMS-PAS-EXO-15-004



ATLAS-CONF-2015-081





Narrow-width: **3.6σ** local/**2.0σ** global

(LEE in 0.2-2.0 TeV mass range)

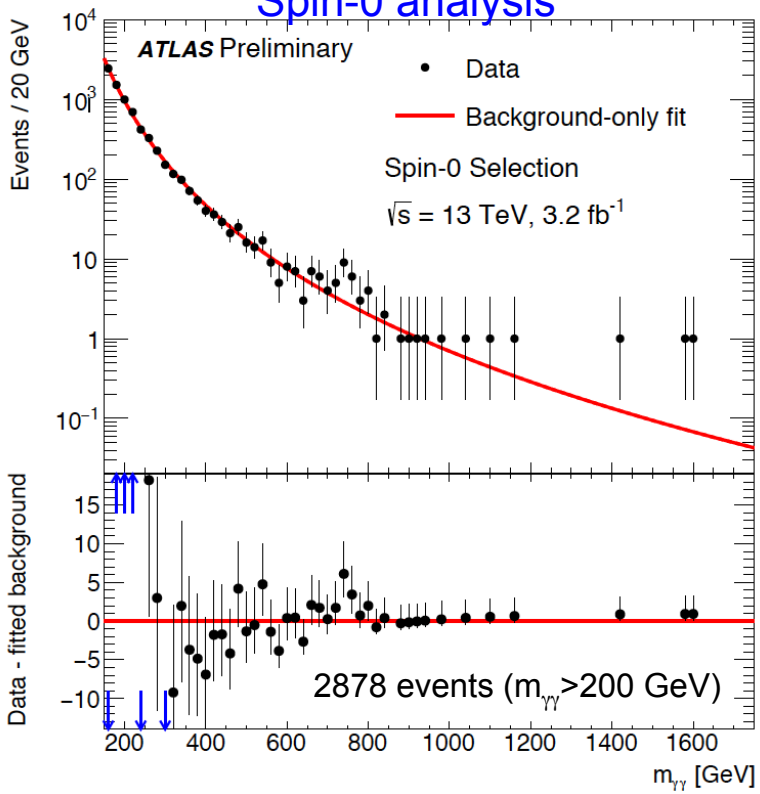
Large width (Γ/M~6%): **3.9σ** local/**2.3σ** global

Diphoton Resonances: ATLAS Updates

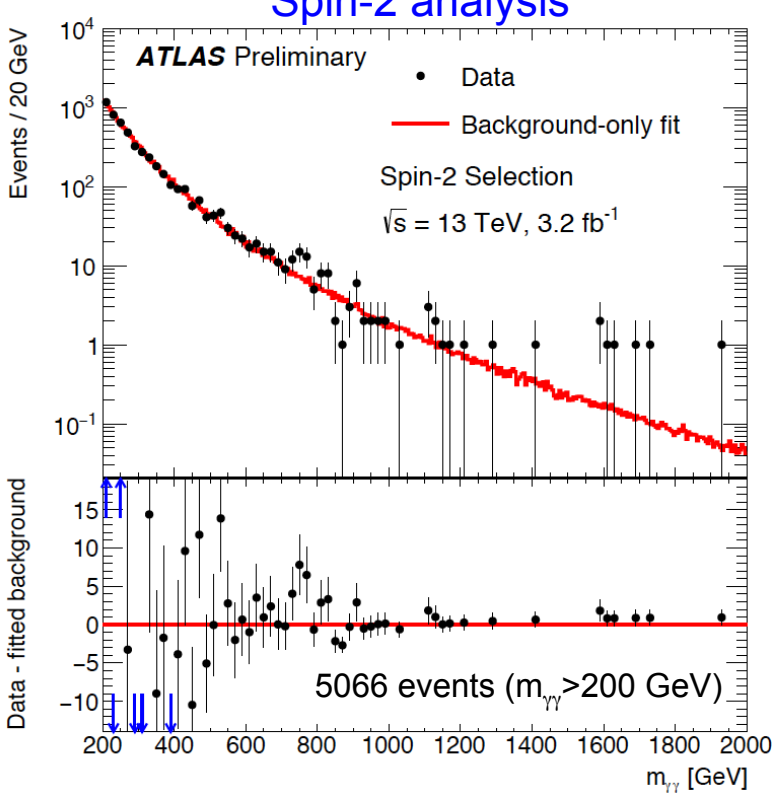
- Two dedicated searches, for spin-0 and spin-2, resonances:
  - Main difference is acceptance:
    spin-0: $E_T(\gamma_1)>0.4m_{\gamma\gamma}$, $E_T(\gamma_2)>0.3m_{\gamma\gamma}$; spin-2: $E_T(\gamma_{1,2})>55$ GeV
  - Photons are tightly identified and isolated (~94% $\gamma\gamma$ purity).
  - Background modeling:
    spin-0: empirical; spin-2 (mainly) theoretical (for high-mass search)

ATLAS-CONF-2016-018

Spin-0 analysis

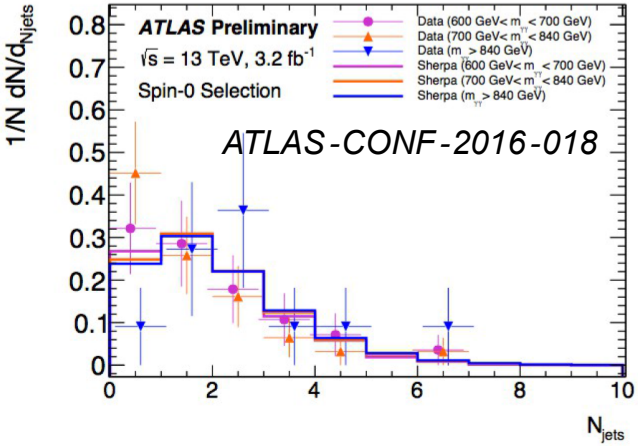


Spin-2 analysis



Diphoton Resonances: ATLAS Updates

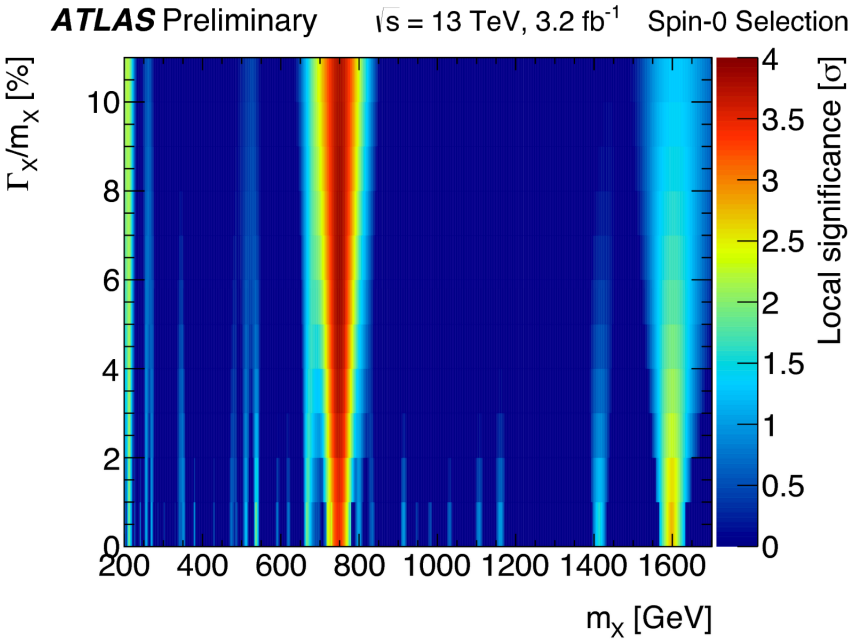
- Event properties in signal region statistically compatible with those in the sidebands.



- Background-only p-value vs resonance mass and width:

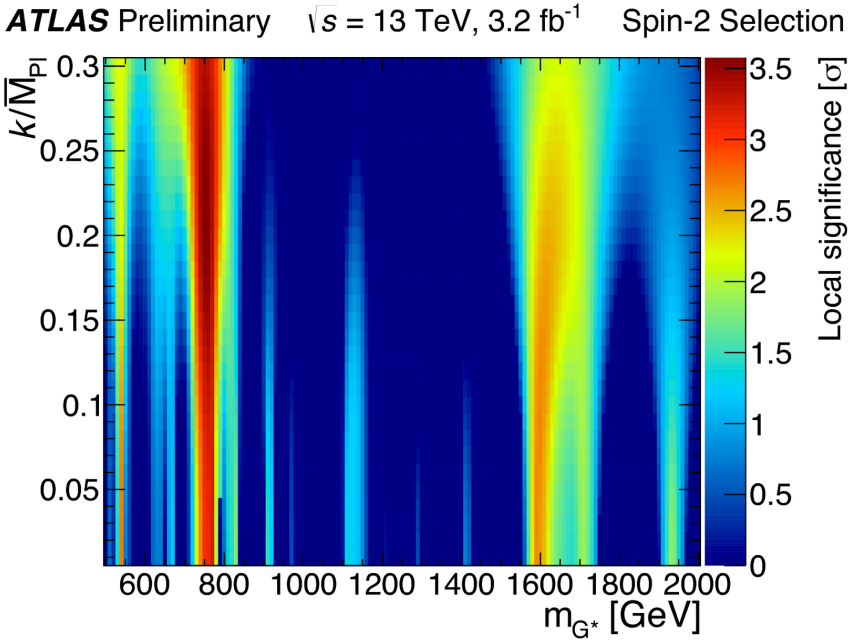
ATLAS-CONF-2016-018

Spin-0 analysis



Lowest p-value at ~750 GeV, Γ=45 GeV (6%)
3.9σ local/**2.0σ** global

Spin-2 analysis



Lowest p-value at ~750 GeV, Γ/M~7%
3.6σ local/**1.8σ** global

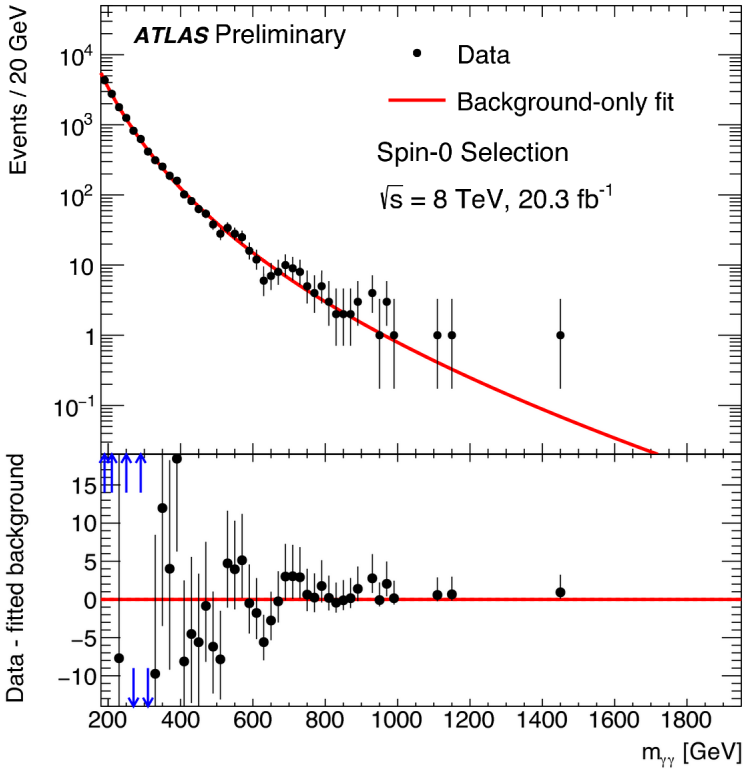
Global p-values derived with respect to scan planes

Diphoton Resonances: ATLAS Updates

- Compatibility with 8 TeV data (slight reanalysis: latest e/γ calibration, 13 TeV analysis method)

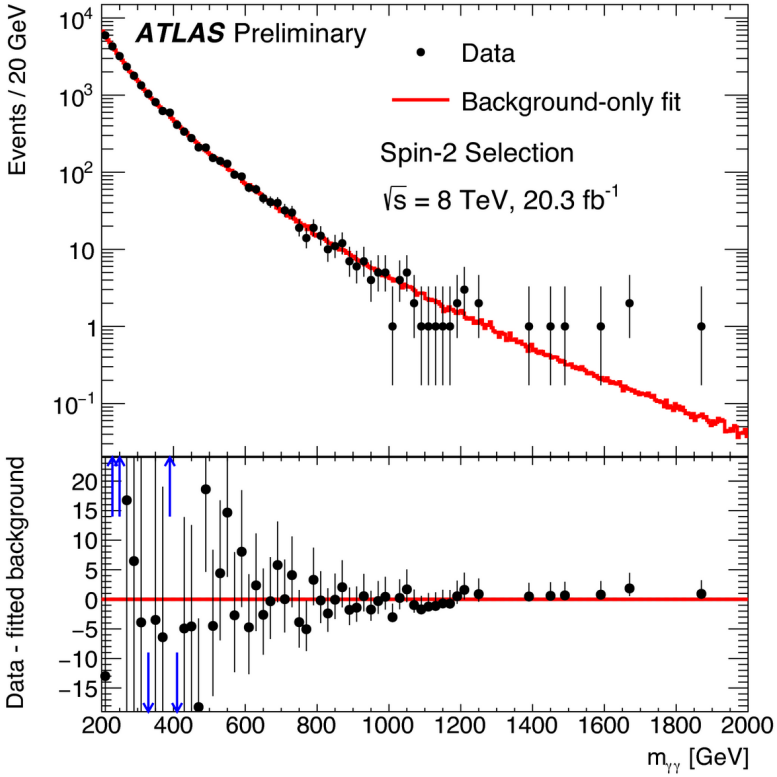
ATLAS-CONF-2016-018

Spin-0 analysis



1.9σ local at ~750 GeV, Γ/M=6%
Compatibility with 13 TeV excess:
gg (scaling: 4.7): 1.2σ
qq̄ (scaling: 2.7): 2.1σ

Spin-2 analysis

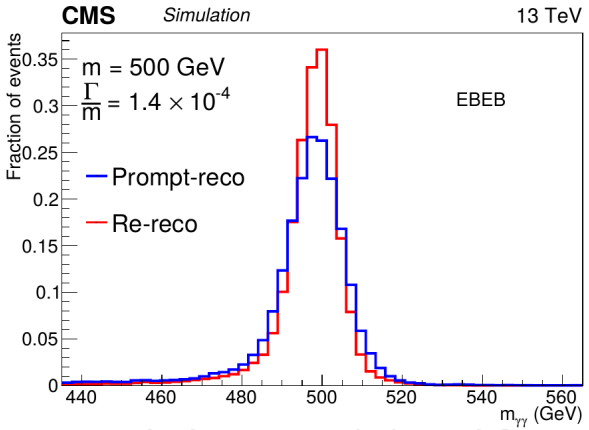


No significant excess
Compatibility with 13 TeV excess:
gg (scaling: 4.7): 2.7σ
qq̄ (scaling: 2.7): 3.3σ

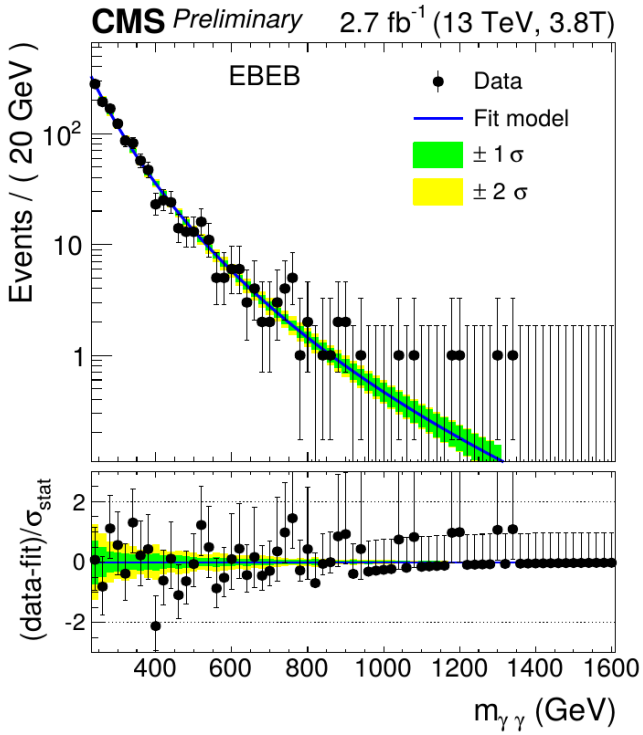
Diphoton Resonances: CMS Updates

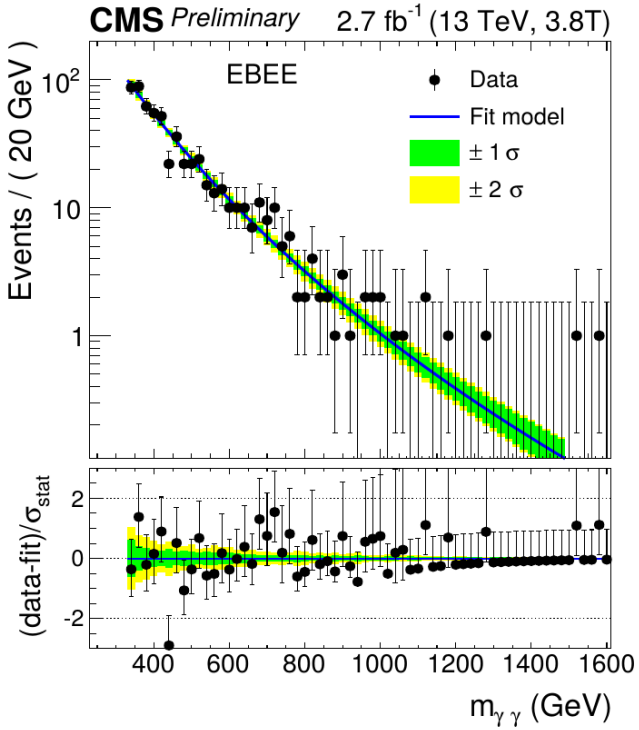
- Same search for spin-0 and spin-2 but both interpretations considered:
  - $E_T(\gamma_{1,2})$>75 GeV, ≥1 photon with |η|<1.44 (barrel); split EB-EB, EB-EE
- Re-reconstruction with new calibrations (30% improved resolution for $m_{\gamma\gamma}$>500 GeV ➔ 10% sensitivity increase).
- Add B-field off data (25% statistics increase ➔ another 10% sensitivity increase).

CMS-PAS-EXO-16-018



CMS-PAS-EXO-16-018





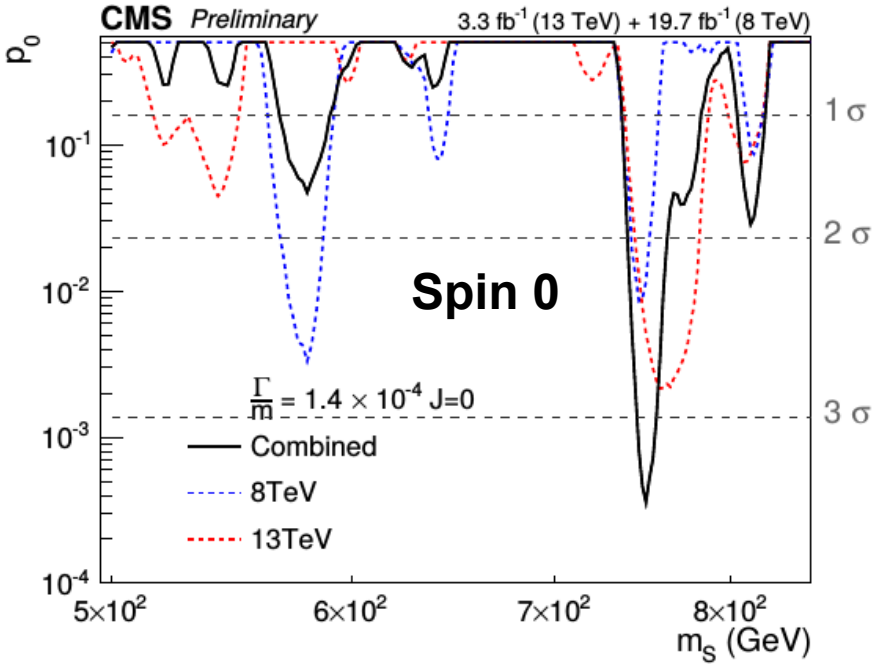
Empirical background modeling

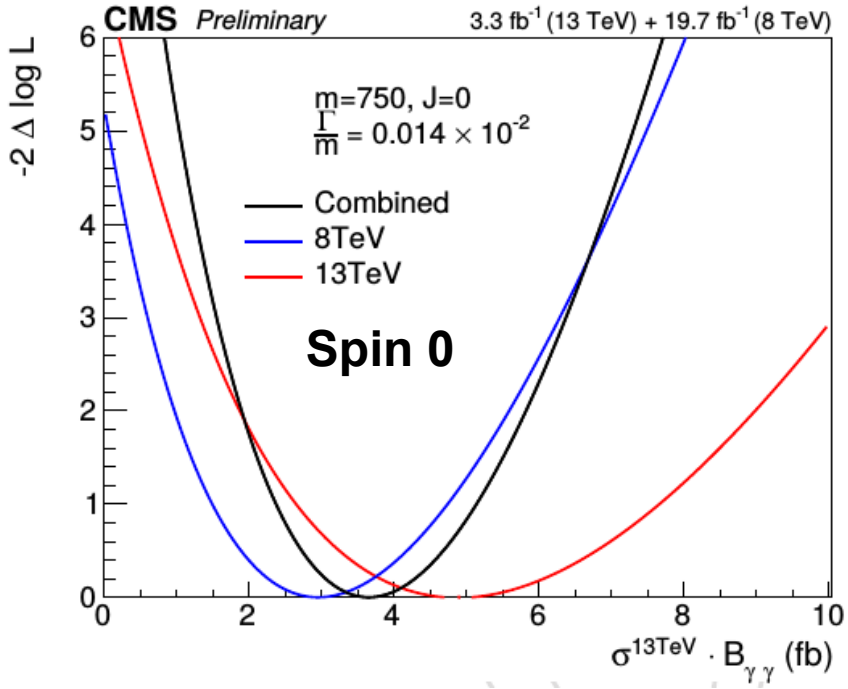
Diphoton Resonances: CMS Updates

- Event properties in signal region statistically compatible with those in the sidebands.
- Results at 13 TeV and 8 TeV found compatible ➔ combination.

- Largest excess observed for m_X=750 GeV and narrow width:
  - Local significance (8+13 TeV): **3.4σ**
  - Global significance (8+13 TeV): **1.6σ** (taking into account LEE over 0.5-3.5 TeV range and all signal hypotheses).

CMS-PAS-EXO-16-018





Similar picture for spin-2 hypothesis

Diphoton Resonances: Summary

L. Malgeri, Moriond QCD 2016, Exp. Summary

	spin 0 Local	spin 0 global	spin2 Local	spin 2 Global
Atlas (13 TeV only) - width 6%	3.9σ	2.0σ	3.6σ	1.8σ
CMS (13 TeV+8TeV) narrow width	3.4σ	1.6σ	~3.4σ	~1.5σ

Soon we shall know more!

Run 2

Wow, what a ride!

Summary and Outlook

- Status is good…
  - **LHC Run 2 has started.**
  - The ATLAS and CMS detectors have been successfully commissioned in Run 2 and once again showed exceptional performance.
  - A host of new results have been released with the full 2015 dataset at 13 TeV corresponding to **~3 fb^{-1}**.

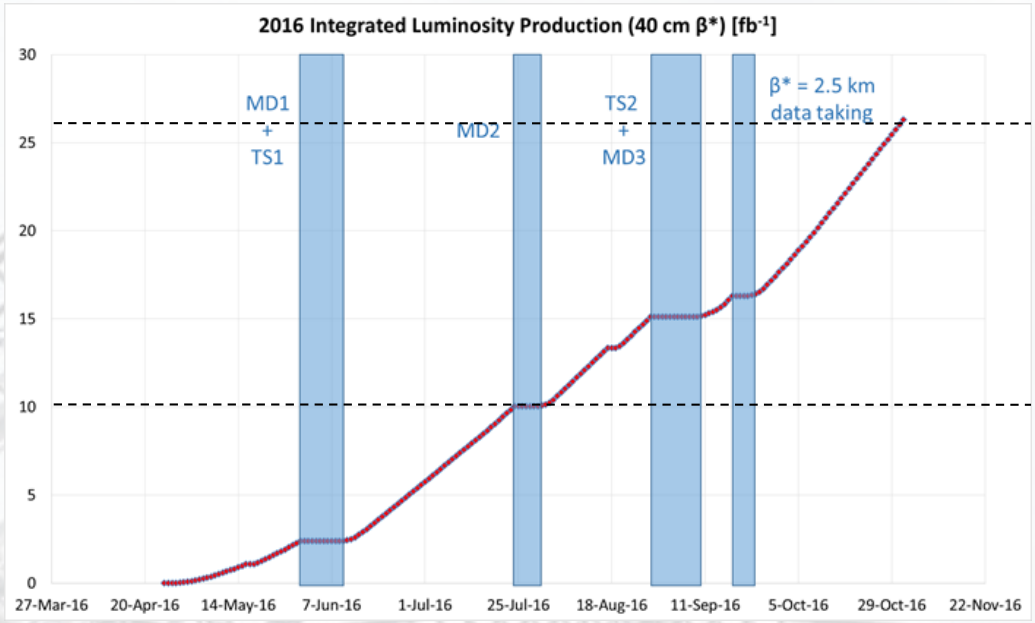
https://twiki.cern.ch/twiki/bin/view/AtlasPublic

http://cms.web.cern.ch/news/cms-physics-results

  - Many new physics searches **already exceeding Run 1 sensitivity**. **Some old and new moderate excesses begging for more data!**

Summary and Outlook

- Prospects are even better!



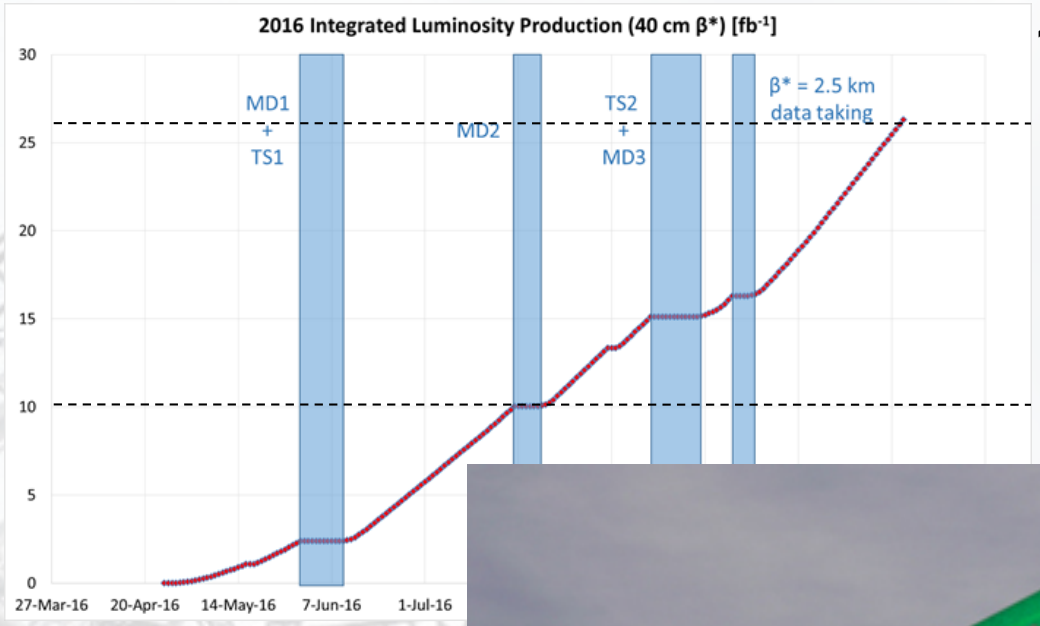
~100 fb^{-1} by Moriond 2019 (more beyond!)

~25 fb^{-1} by Moriond 2017

~10 fb^{-1} by ICHEP 2016

Summary and Outlook

- Prospects are even better!



~100 fb^{-1} by Moriond 2019 (more beyond!)

~25 fb^{-1} by Moriond 2017

~10 fb^{-1} by ICHEP 2016

Looking forward to new exciting discoveries!