Hints of BSM Physics in ATLAS

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On behalf of the ATLAS Collaboration

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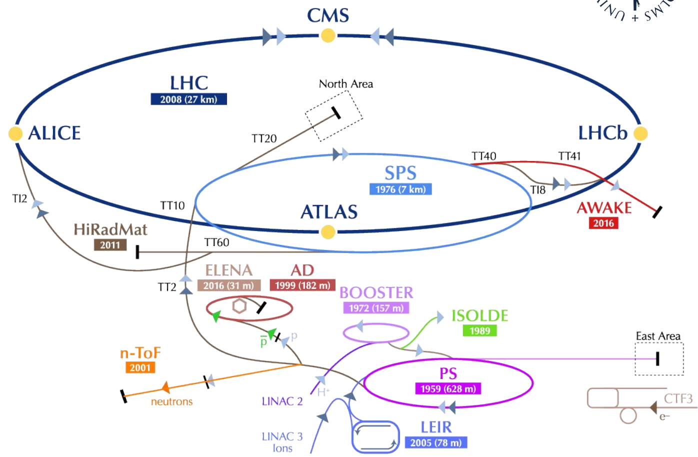
Introduction

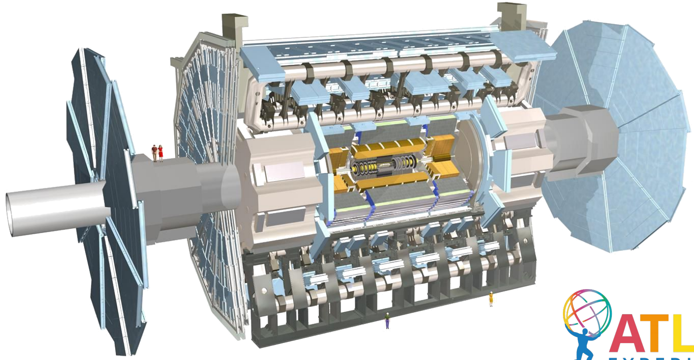
- So far haven’t discovered any Beyond the SM Physics yet
- ATLAS analyses showed a couple of small excesses
- Expected as O(100) searches on same data set
    - Need more statistics - but for small excesses Run3 data set only brings small improvement to significance
    - Future and already ongoing analyses need to make use of new techniques/ideas
- Can only present small subset of results - some covered (in depth) later on:
    - S. Solomon - Electroweak measurements (VBS) at the LHC
    - D. Rousso - Search for Long-Lived particles in ATLAS with Displaced Vertex Signatures in Multi-Jet-Triggered events
    - S. Sinha - Not a jet all the way: a search for semi-visible jets in non- resonant production mode in ATLAS
    - T. Park - EFT at the LHC

ATLAS detector and the Large Hadron Collider

Run 2 2015 – 2018

- completed very sucessfully
- delivered total 156 fb-1 of proton – proton collisions at √s = 13 TeV
  - up to 2748 bunches circulating
  - each bunch contains ~ 1011 protons
  - bunches collide at interaction points every 25 ns
- peak luminosity: 2.1e34 cm-2s-1
- average number of interactions per buch crossing: 33.7
- 'good for physics' data set 139 fb-1

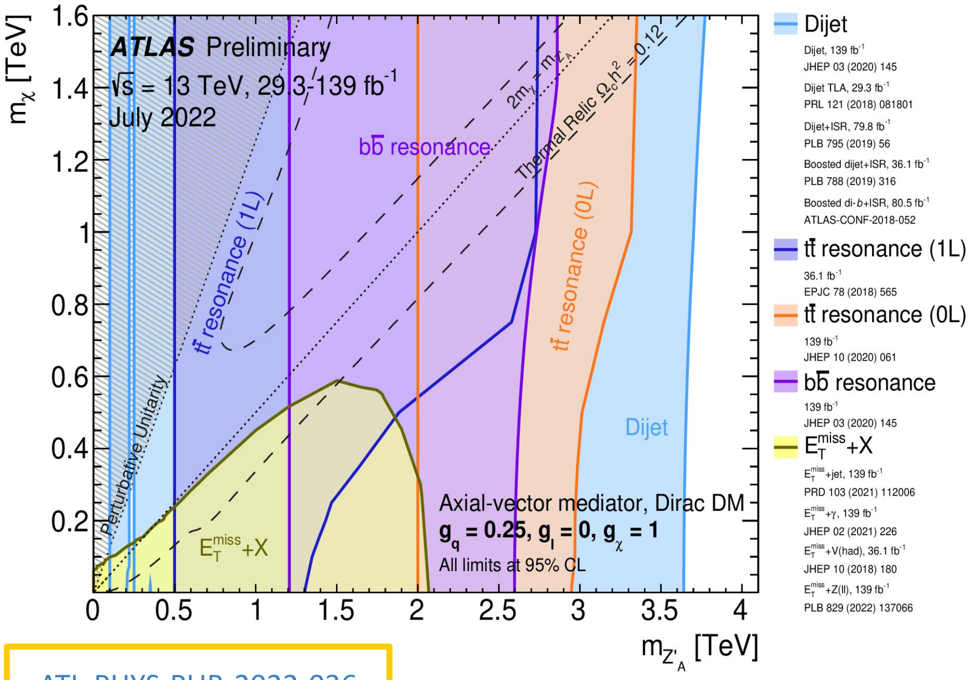


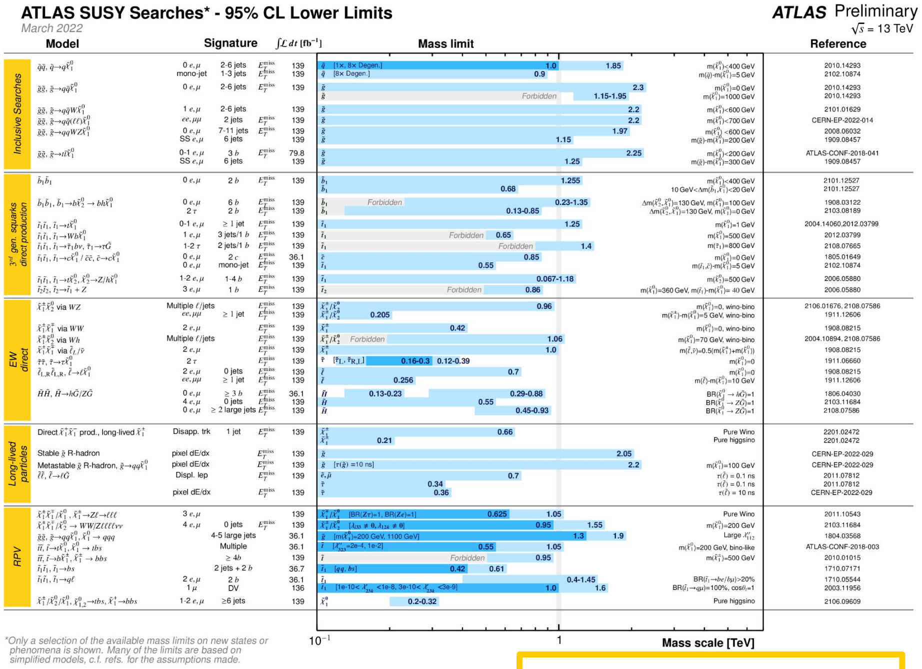


Large multi-purpose detector

- Complete azimuthal coverage of interaction point
- consist of tracking systems – calorimeters– muon systems – strong magnetic fields
- different design and technologies used to CMS ⟶ able to verify results with two independent experiments
- Large range of physic research program, from precision SM measurements to BSM searches

Overview exclusion reach



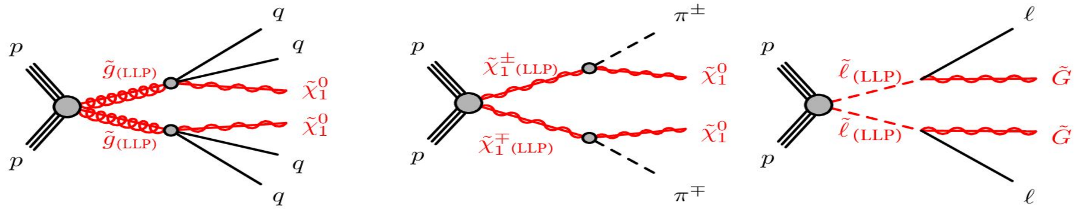


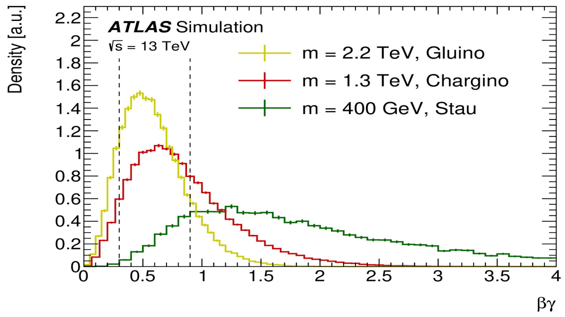
ATL-PHYS-PUB-2022-036

ATL-PHYS-PUB-2022-013

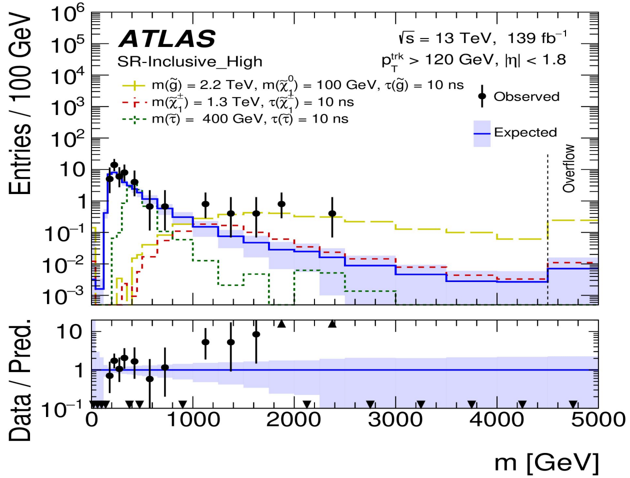
Long Lived Particles - Pixel dE/dx

SUSY-2018-42





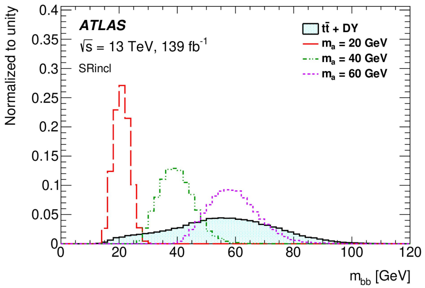
- Long lived, charged particle search inspired by SUSY models with β <<1, high pT and dE/dx
- Relying on Inner Detector information
- Significance of 3.6σ local at [1100,2800] GeV (3.3σ global)
  - Corresponding to 1.4 TeV in long lifetime regime
- Follow up analysis under way including additional detector information

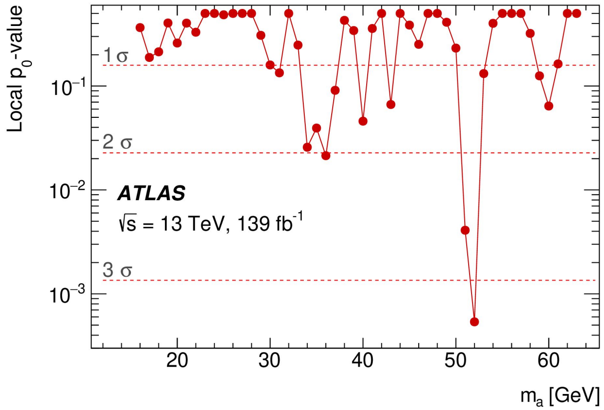


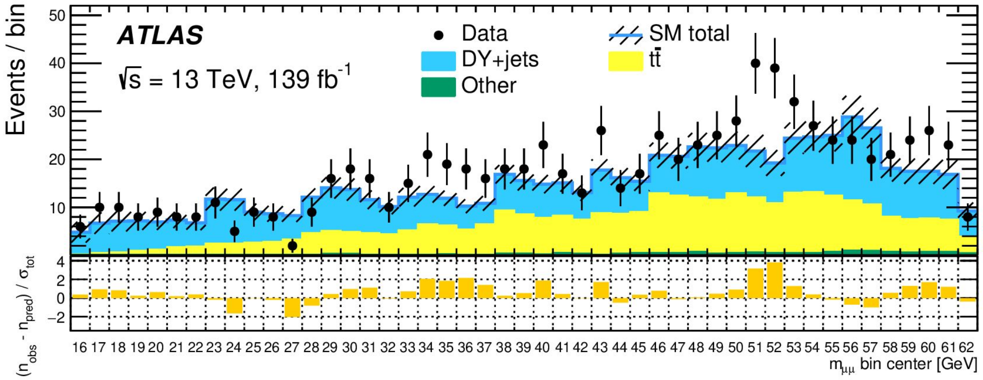
H→aa→μμbb

HDBS-2021-03

- Search for narrow di-muon resonance - $m_{\mu\mu}$ [16,62] GeV
- Very good mass resolution due to the muons plus high BR (bb)
- Making use of BDT to separate signal and standard model background (Z+jets, ttbar)
- Several excesses, largest:
- 3.3σ local (1.7σ global) in $m_{\mu\mu}$= 52 GeV

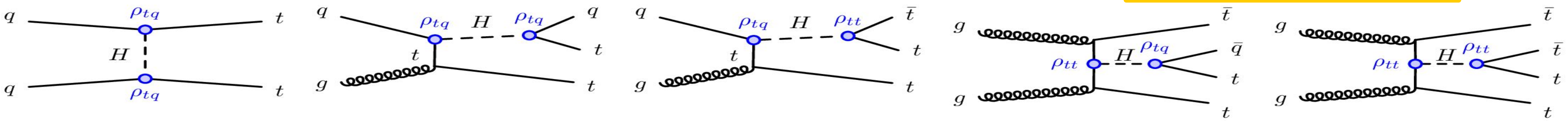




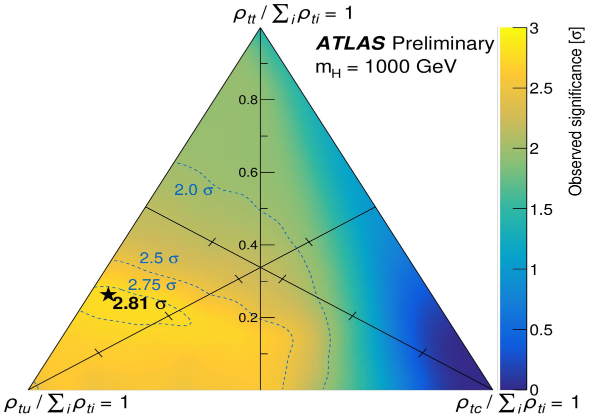


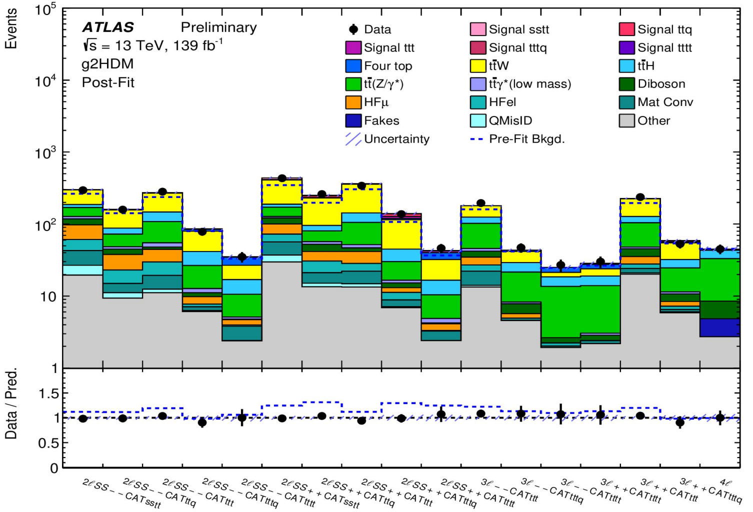
g2HDM

ATLAS-CONF-2022-039



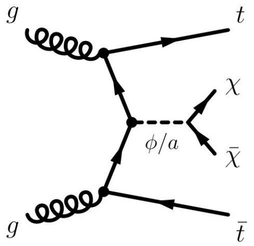
- First ATLAS analysis to probe g2HDM
  - Search for heavy Higgs boson in multilepton plus b-jets final state
- Using DNN to separate signal and background (ttbar+X, VV)
- SRs characterised by lepton multiplicity, charge and DNN score
- Largest excess: 2.81σ and H(1000)

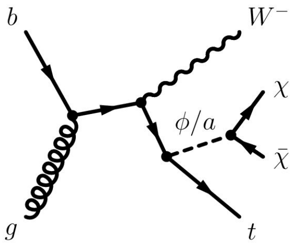


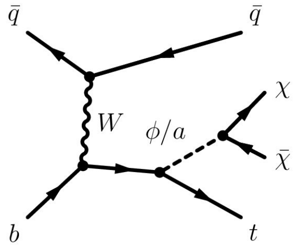


DM+ttbar combination

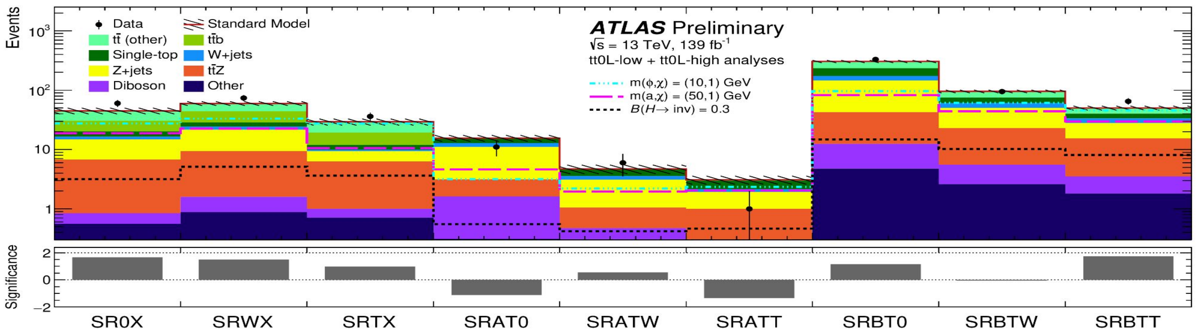
ATLAS-CONF-2022-007

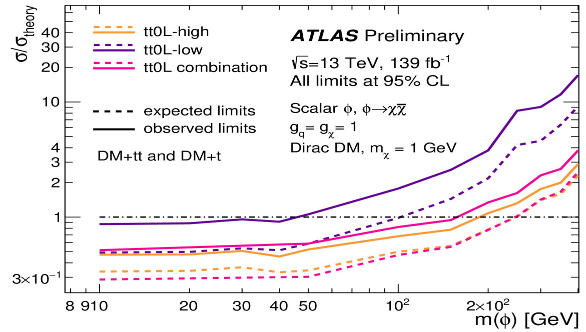


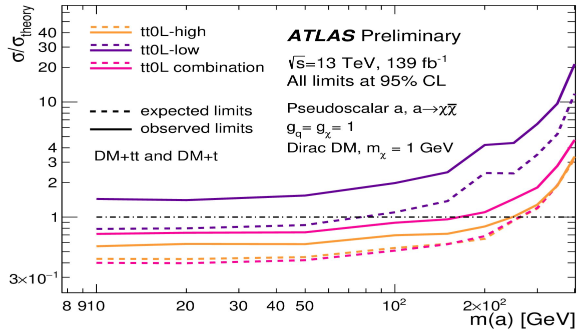




- Combination of analyses with ttbar + lepton + X final states
- Interpretation in spin-0 DM mediators
- Also upper limit on invisible SM Higgs branching ratio

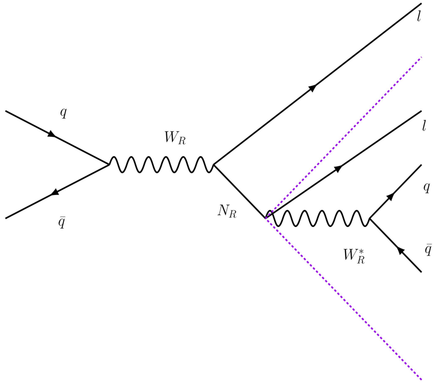


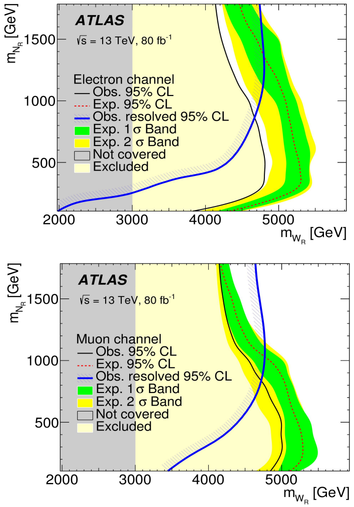


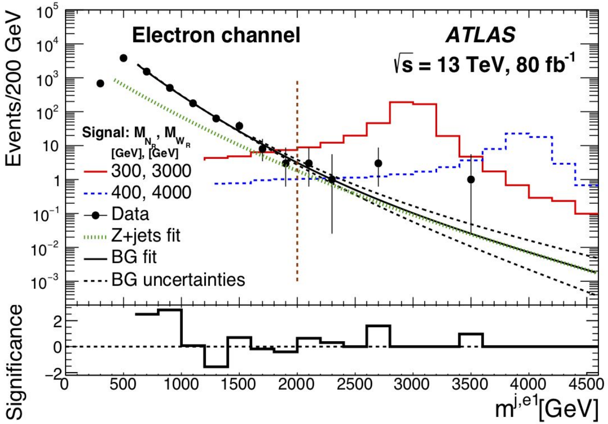


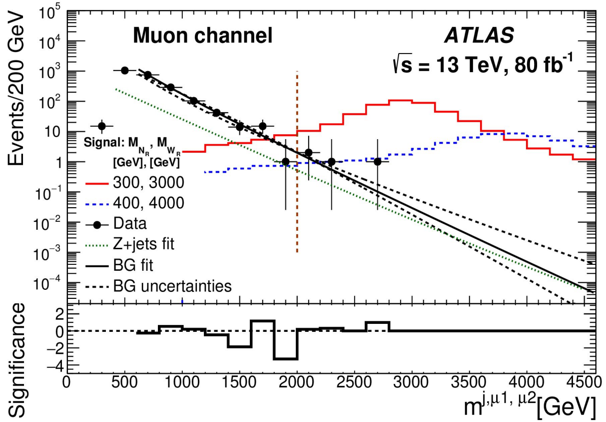
RH neutrinos

[EXOT-2018-15]







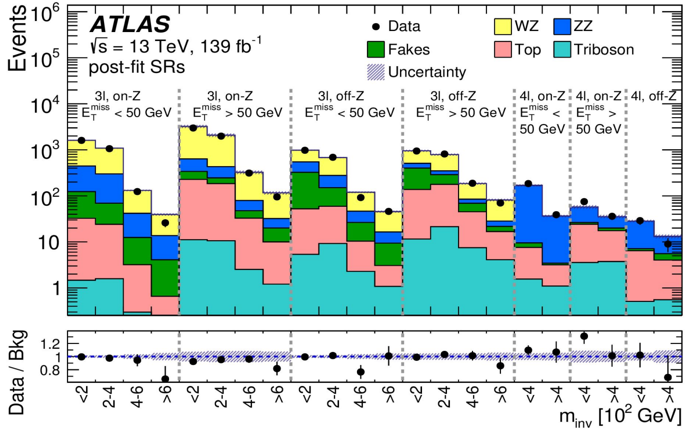


- Signal Model : righthanded W decaying to a lepton and boosted jet via heavy righthanded neutrino
  - Using 80 fb-1, analysis with full Run 2 dataset for boosted and resolved topology close to being published
- Large radius jet can be used to distinguish background and signal
- Small excess of 2.4σ in electron and 1.2σ in muon channel

Multilepton general

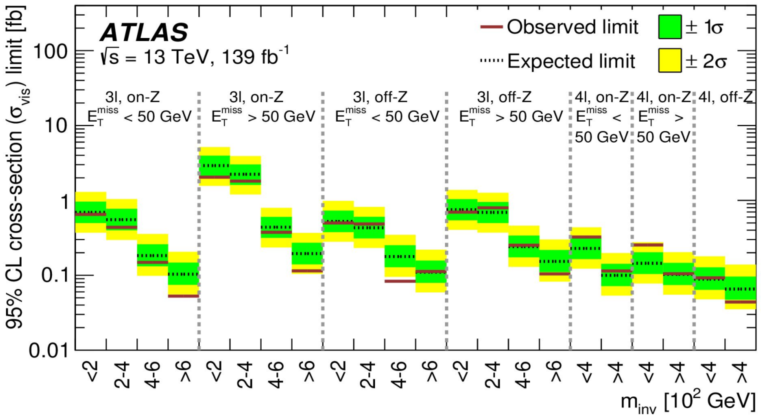
EXOT-2019-36

- Looking at 3l and 4l final states without ‘bias’ of specific model assumptions
  - also providing signal dependent interpretations
- SRs characterized by lepton multiplicity, E_T^{miss}, Z boson presence and m_{inv}
  - In total 22 SRs
- Results interpreted as limit on visible cross section of BSM signal
- 2 SRs with 4l show locally significant excess - largest 1.8σ
  - Largest significance for 4l, On-Z, E_T^{miss} < 50 GeV
  - Follow up analysis ongoing



SR	0–200 GeV	200–400 GeV	400–600 GeV	>600 GeV
3ℓ, On-Z, $E_T^{miss} < 50$ GeV	−0.2	−0.7	−0.6	−2.5
3ℓ, On-Z, $E_T^{miss} > 50$ GeV	−1.0	−0.5	−0.4	−1.6
3ℓ, Off-Z, $E_T^{miss} < 50$ GeV	−0.1	0.3	−2.7	0.1
3ℓ, Off-Z, $E_T^{miss} > 50$ GeV	−0.2	0.5	0.2	−1.2
SR		**0–400 GeV**		**>400 GeV**
4ℓ, On-Z, $E_T^{miss} < 50$ GeV		1.0		0.4
4ℓ, On-Z, $E_T^{miss} > 50$ GeV		1.8		0.1
4ℓ, Off-Z		0.1		−1.3

Local significance for indicated SR in bins of m_{inv}



Outlook

- Stay tuned for reinterpretations, combinations, less model dependent scans - many Run 2 analyses still going to be published and first Run 3 data at 13.6 TeV is coming in

- Large amount of analyses - only small fraction covered
  - See public SUSY, Exotics and HDBS pages for more results

- ATLAS wide effort to improve public materials that can be used for reinterpretations etc
  - Often pyhf workspaces of histfitter available in addition to simple simpleAnalysis implementation of SRs
  - Available files can be found on hepdata

- Small excesses in several places being followed up
  - Run 3 won't bring significant increase in statistics
  - Already started to dive into
    - more sophisticated analysis techniques
    - characterizing searches by final state instead of specific BSM model
    - new ideas being explored ●●●

- It stays interesting!