# Exotic Searches at ATLAS

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On behalf of the ATLAS Collaboration

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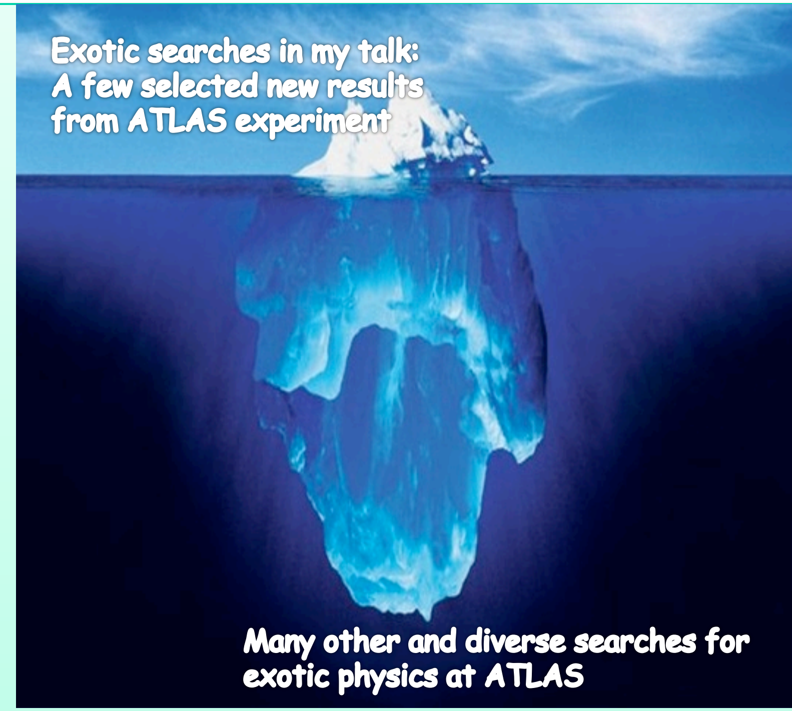
# Introduction and Outline

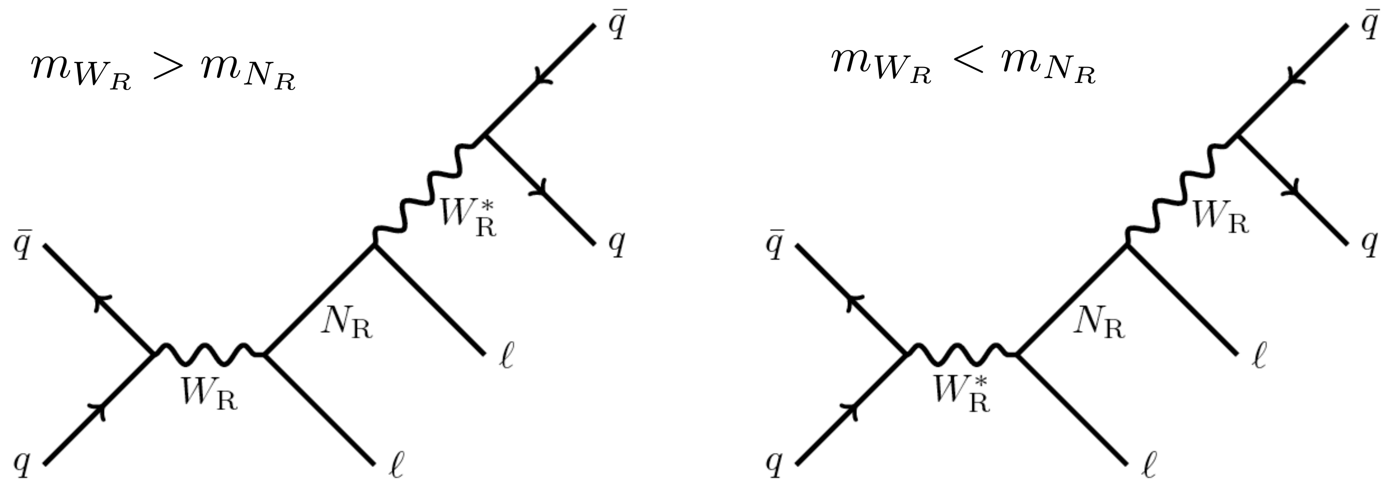
- Exotic physics at ATLAS:
  - ✓ Searches for new physics (NP) beyond the SM: Many well motived theories
  - ✓ Many diverse & broad topics
    - Large overlap with SYSY searches




- Only a few selected results from ATLAS Analyses after summer 2018
  - ✓ Heavy neutrio + right-handed W
    - arXiv: 1809.11105 [hep-ex]
  - ✓ 4 Top production
    - arXiv: 1811.02305 [hep-ex]
  - ✓ Single Long-lived neutral particle
    - arXiv: 1811.02542 [hep-ex]
  - ✓ All based on 36.1fb$^{-1}$ data at 13TeV pp collisions (149fb$^{-1}$ recorded)
  - ✓ Not include SUSY, dark matter searches & BSM Higgs, Eg:
    - Invisible Higgs decays, arXiv: 1809.06682 [hep-ex]
    - BSM H->hh arXiv:1811.04671 [hep-ex]

- Focus on basic search strategy without too much technical details

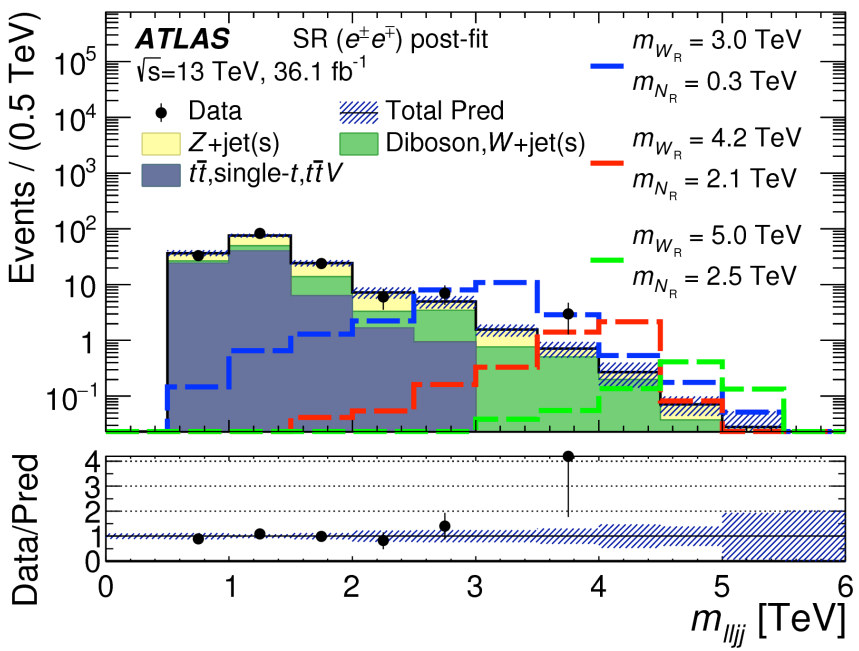
# Heavy Neutrino and Right Handed W

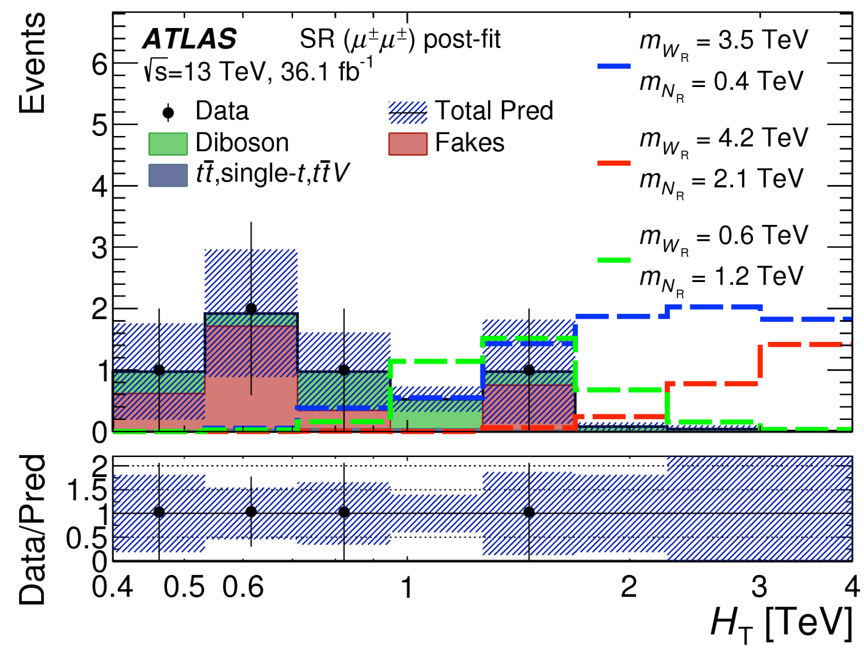



- Left-right symmetric models: Keung-Senjanovic (KS) process
  - ✓ Assuming no mixing between flavors: two same flavor leptons (e,μ) + 2 jets final states
  - ✓ Heavy Dirac neutrino $N_R$: opposite signed leptons
  - ✓ Heavy Majorana neutrino $N_R$: 50% same (SS) and 50% opposite (OS) signed leptons
- Background in OS final state:
  - ✓ Dominated by SM top & Z+jets: estimated using MC
  - ✓ Small contribution from diboson and W+jets
- Background in SS final state:
  - ✓ SM diboson and SM Z+jets (for ee only due to charge misidentification)
    - Charge misidentification from control sample
  - ✓ Largest bg from fake leptons (~60%)
    - estimated using fake factors from data

# Heavy Neutrino and Right Handed W

- Defined signal (SR) and control (CR) region:
  - ✓ Events in CR to constrain the background estimation
- Signal extraction: Simultaneous binned likelihood fits to various kinematic variables of selected events in the signal and control regions
  - ✓ Simultaneous fit to SS and OS events for Majorana neutrino senario
- Systematic uncertainties taken into account as nuisance parameters in fits

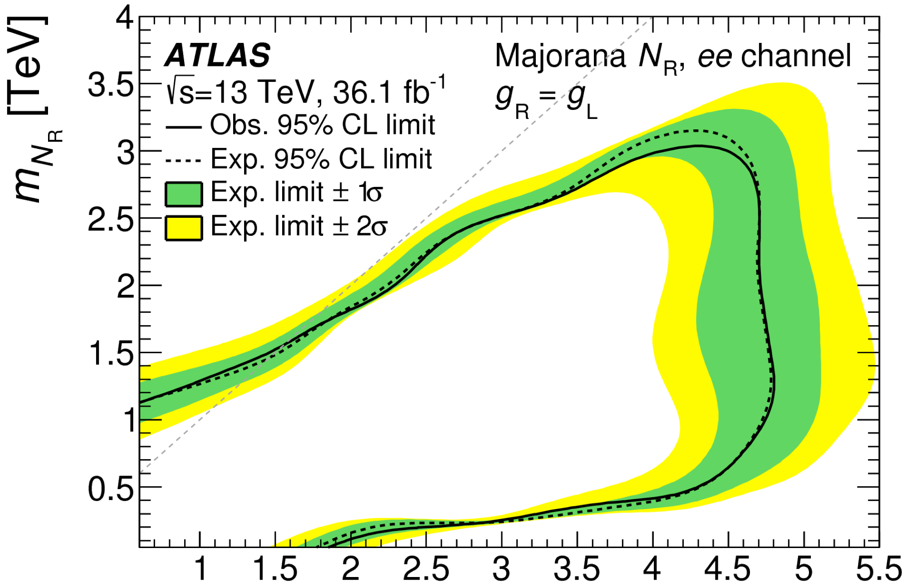


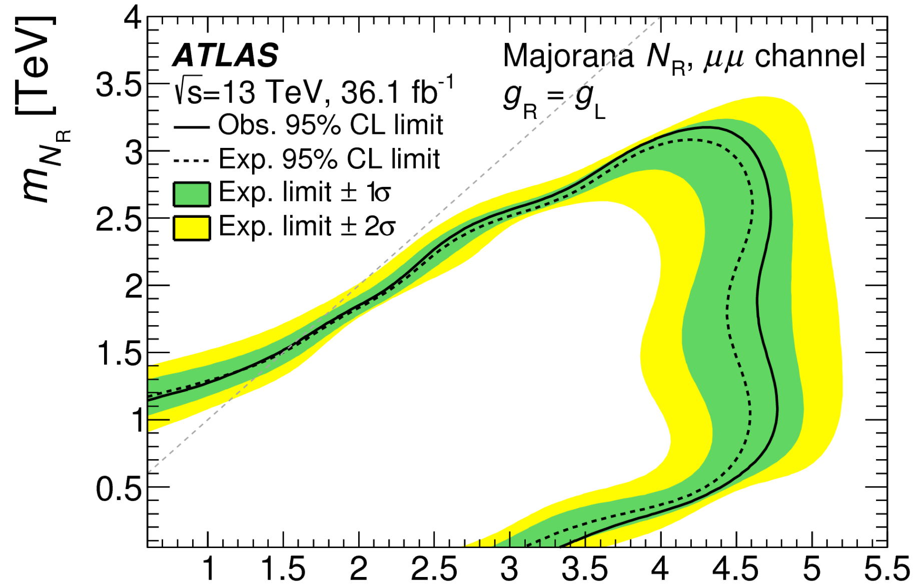



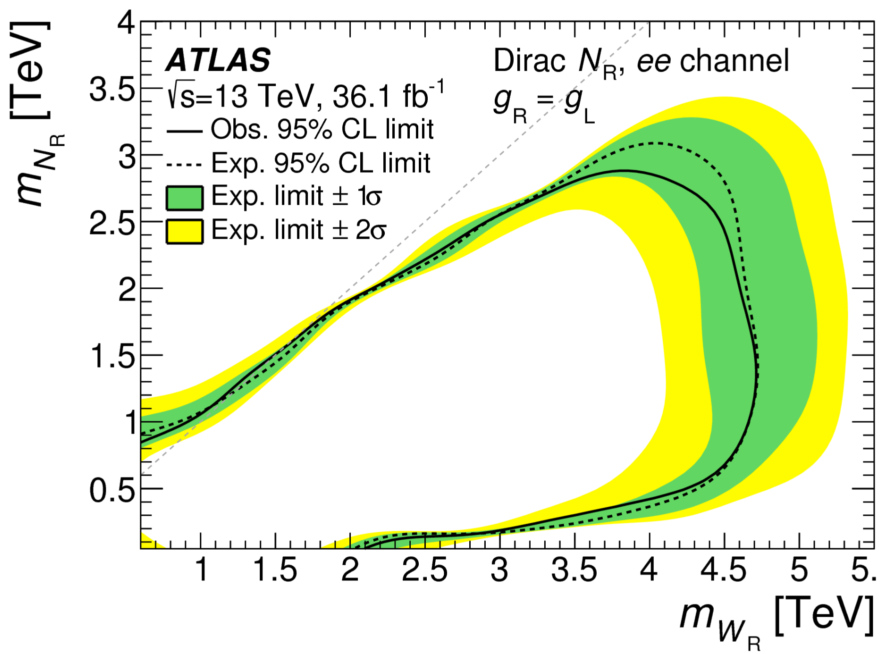

[Ref] arXiv:1809.11105 [hep/ex]

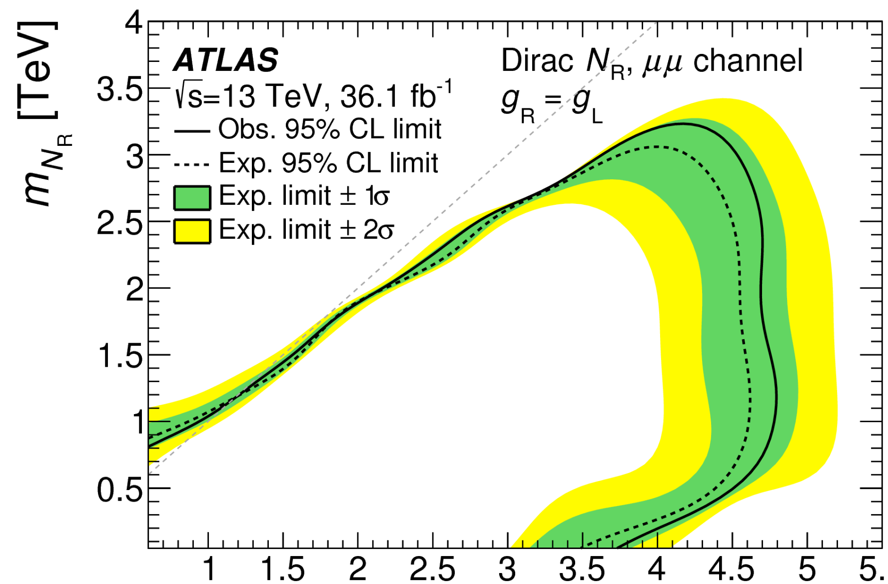
$H_T$: scalar sum of $p_T$ of selected lepton pairs and two most energetic jets

# Heavy Neutrino and Right Handed W



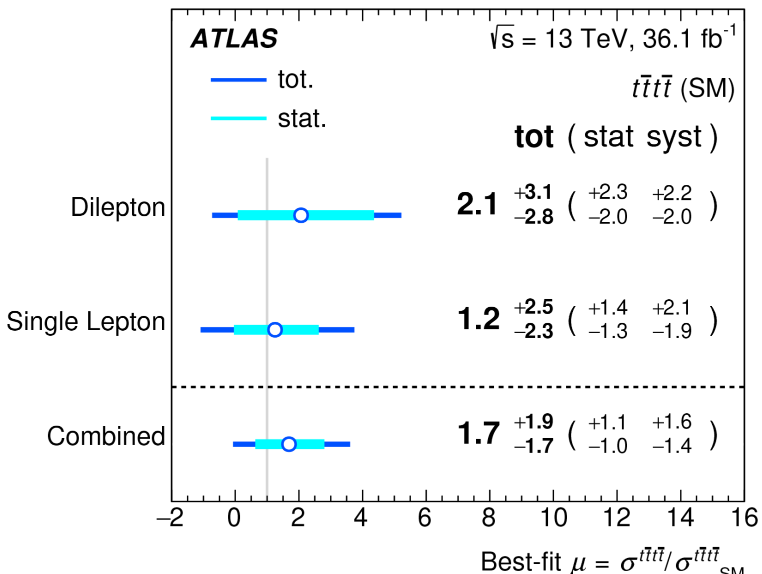



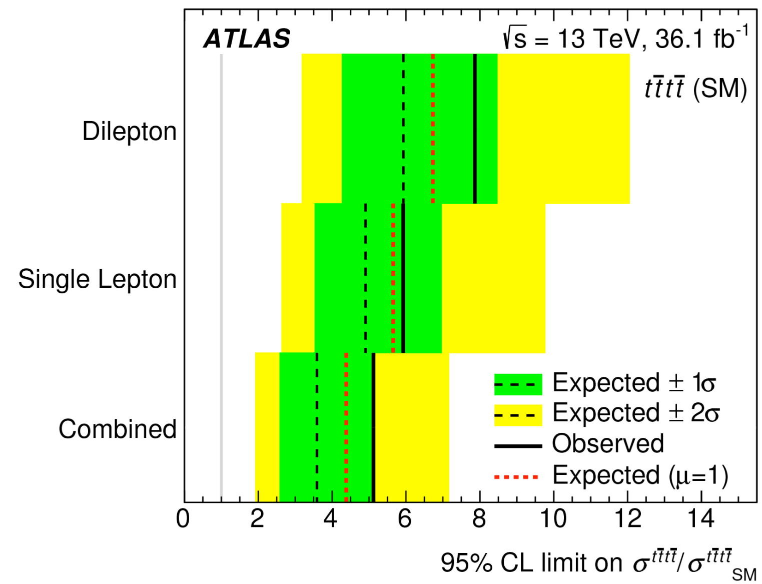




[Ref] arXiv:1809.11105 [hep/ex]

# Four Top Quark Production

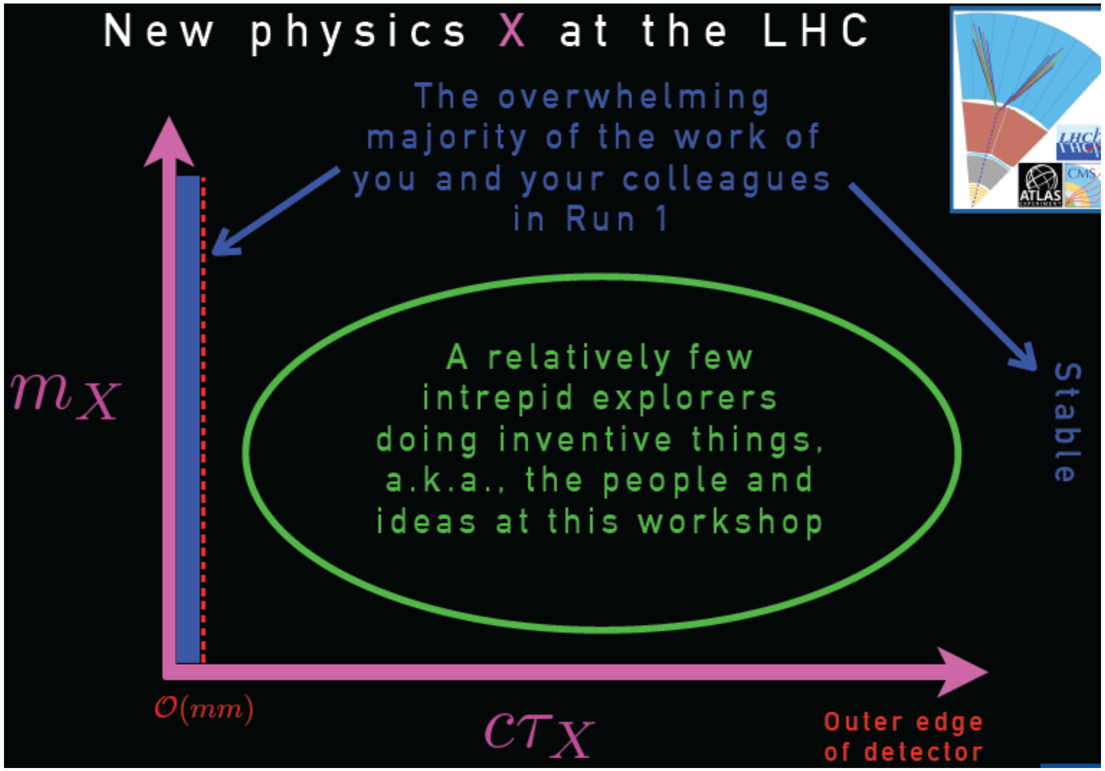
- SM 4 quark production (σ~9.2fb), can be significantly enhanced by NP
- Final state: 1 or 2 W boson decay leptonically
  - ✓ Single or dilepton + MET
  - ✓ high multiplicity of jets & b-jets
  - ✓ Hadronic top candidates tagged with large-R jets
- Dominated by SM top+jets production
  - ✓ Based on b-jet fake probability: assuming no correlation with jet multiplicity
- Distinguish signal from background using $H_T$
  - ✓ $H_T$: scalar sum of the jet $P_T$
- See talk by Leonid Serkin at this workshop for details

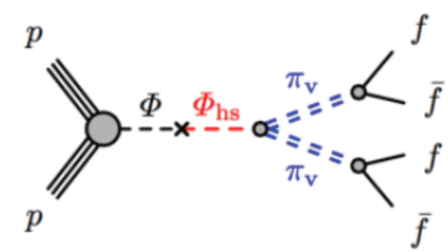


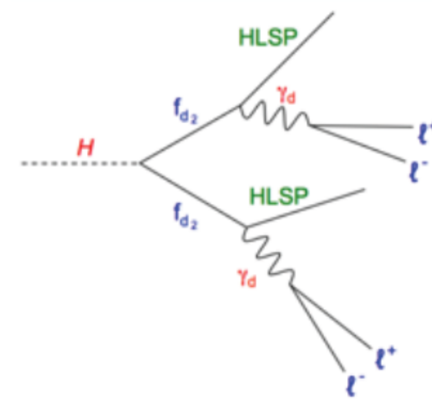




[Ref] arXiv:1811.02305[hep/ex]

# Long-lived Neutral Particles (LLP)

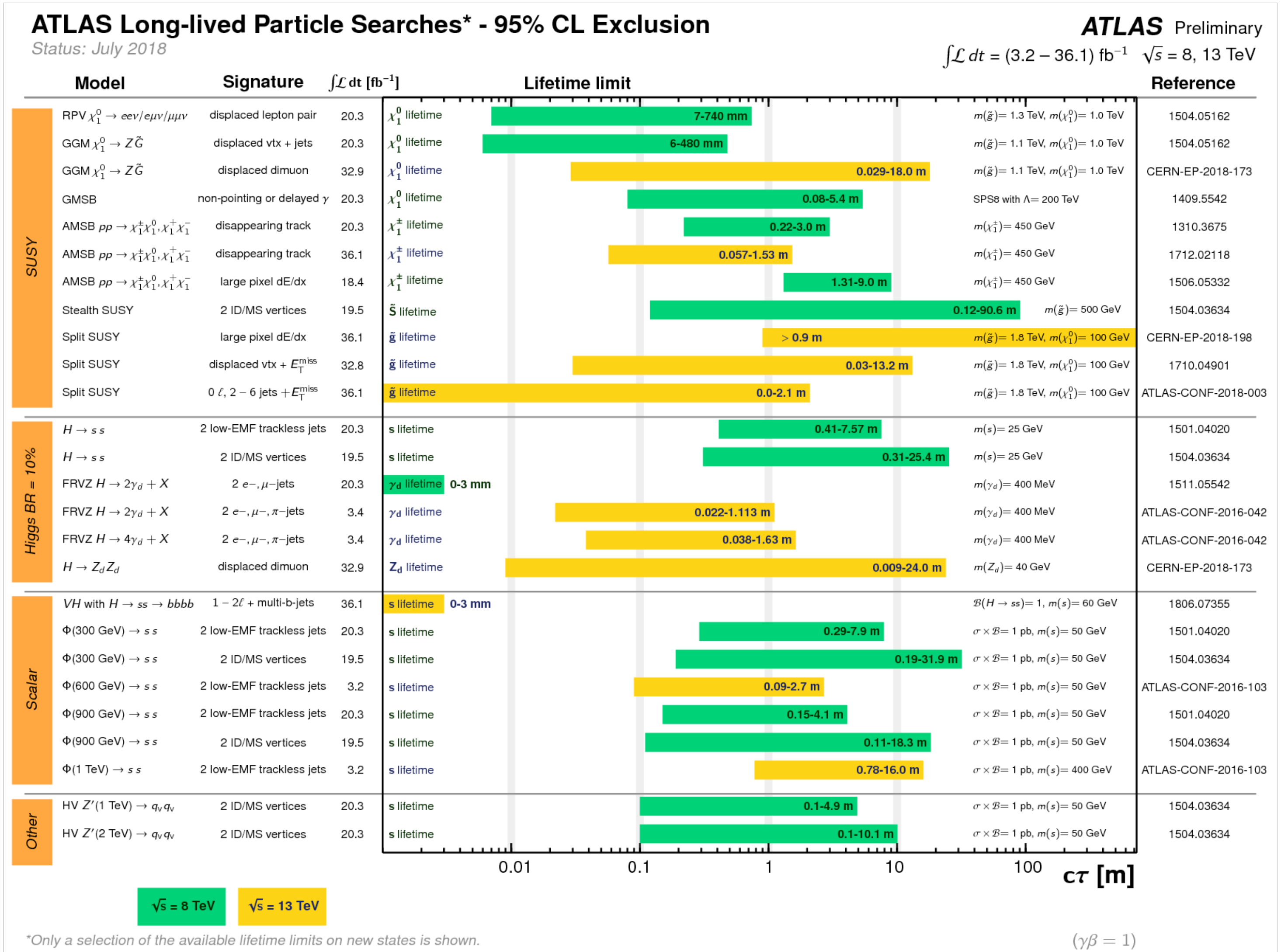


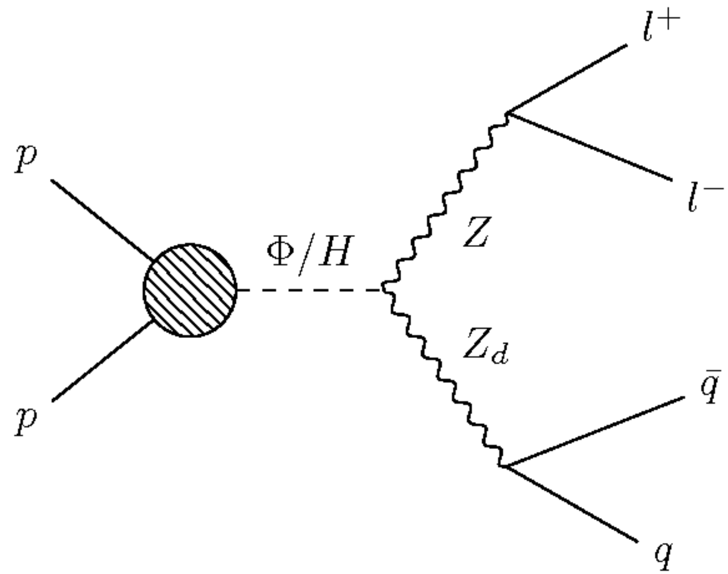

- Long lived neutral particles predicted by NP: Hidden/Dark sectors, SUSY ……
- Very unconventional experimental signatures, Eg:
  - Jets associated with vertice significant away from the collision point
  - Narrow jets with little energy deposition in the EM calorimeter, and no inner detector tracks
  - Lepton jet: collinear jet-like structure containing leptons/pions

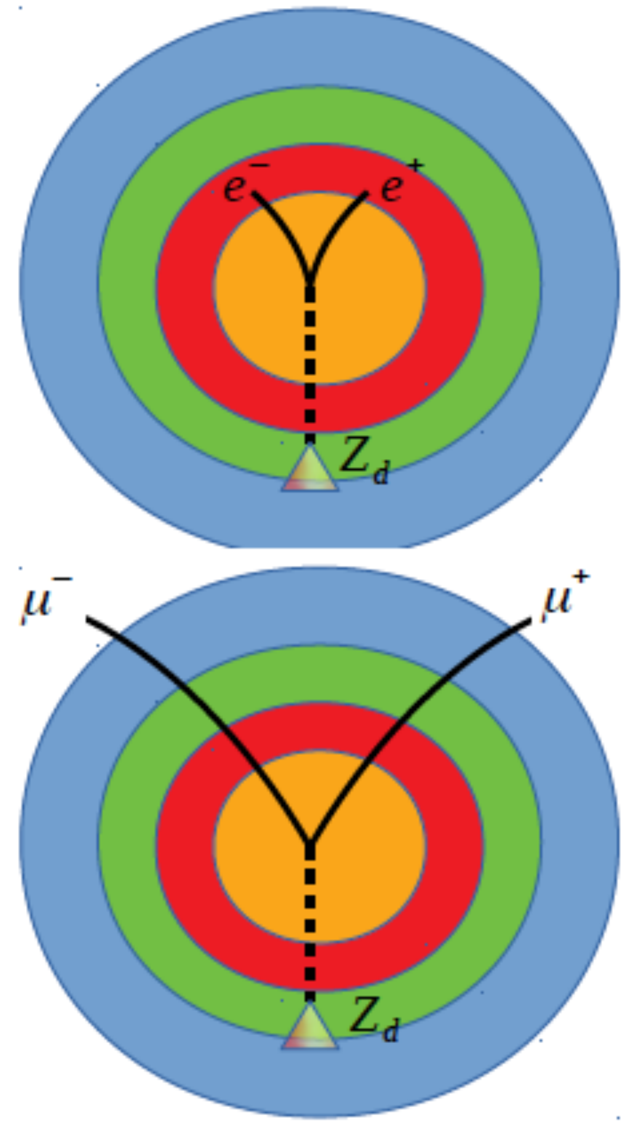
# Searches for LLP at ATLAS




All searches are for pair production of LLP so far

# Single LLP production with Z boson



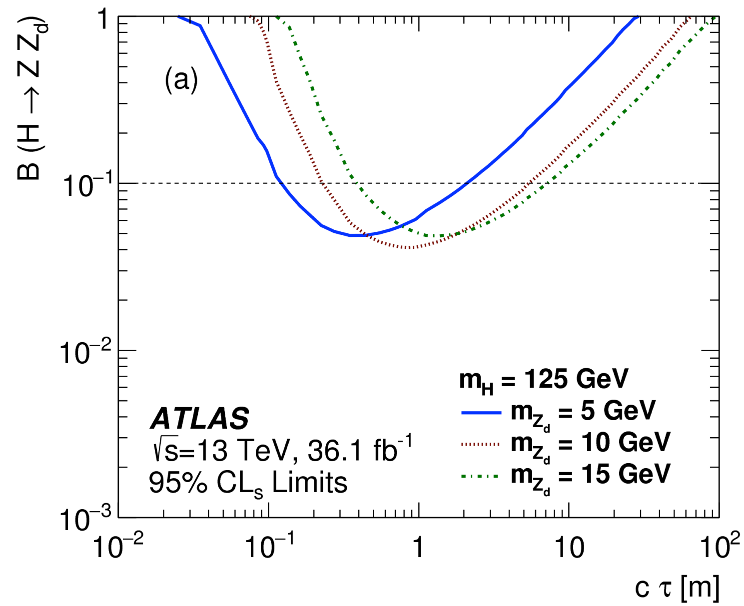



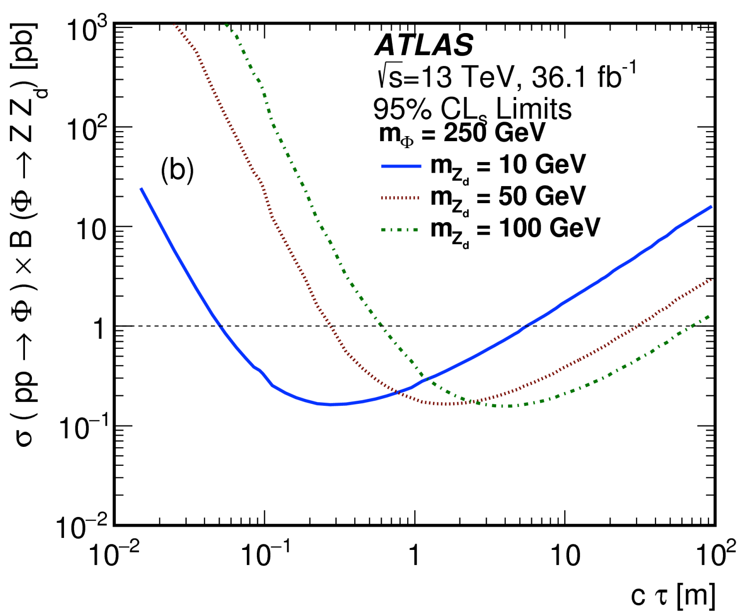

- Single production of LLP predicted in NP scenarios
- General search with a very unique experiment signature: Displaced jet
- Dominated bg from Z+jets (jet fakes LLP signal)
  - ✓ Data driven approach for bg estimate
  - ✓ Measuring fake jet fake probability using W+jets
- Counting experiment, different $E_T$ cut for $m_\Phi$
  - ✓ UL as a function of $m_{\Phi}$, $m_{Zd}$ and lifetime of Zd

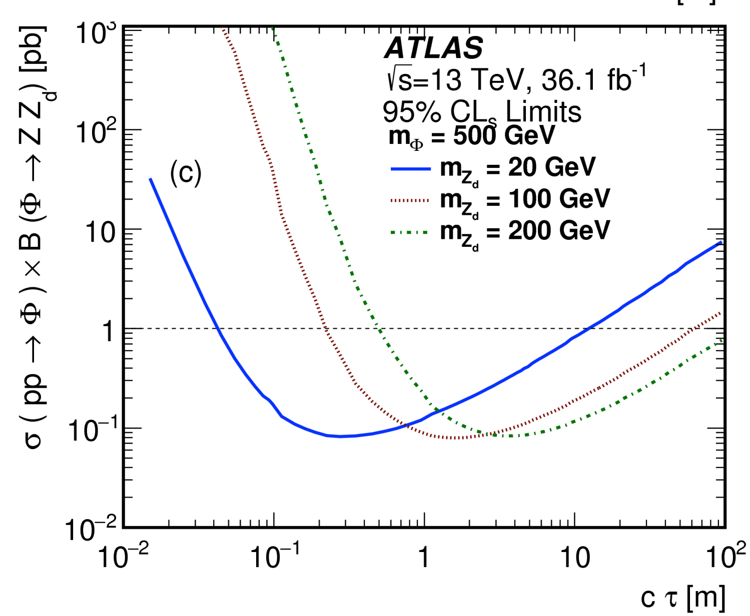
# Single LLP production with Z boson

| Minimum jet $E_T$ | 40 GeV | 60 GeV | 80 GeV |
|---|---|---|---|
| Background | 175 ±22 | 33.0 ±4.4 | 13.2 ±3.5 |
| Data | 158 | 35 | 16 |
| Expected UL | 65 | 17 | 10 |
| Observed UL | 50 | 18 | 13 |

[Ref] arXiv:1811.02542 [hep/ex]

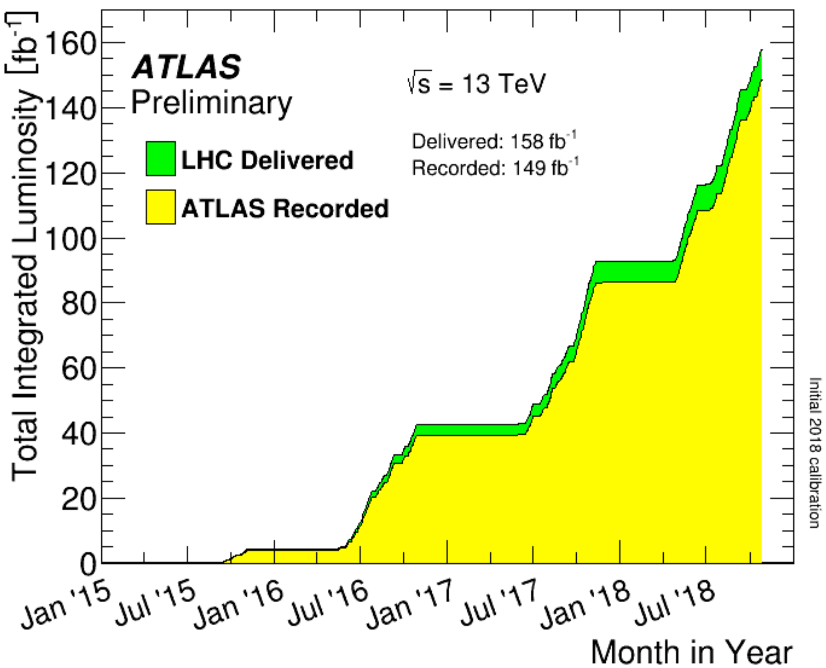


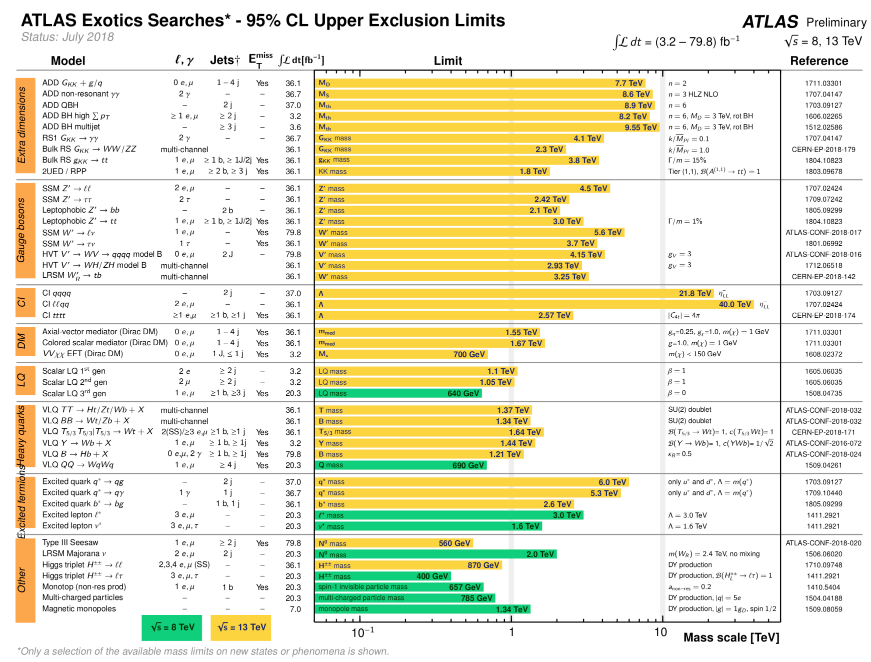



# Conclusion

- Very broad and rich exotic physics program at ATLAS
  - ✓ Only a few selected new results were reported here
  - ✓ Start to probe many possible new particles/NP scenario at TeV scale
  - ✓ Strong constraint for some NP scenario
- Current results still dominated by statistical limitation
  - ✓ Expect significantly better physics reach with more data (HL-LHC)



# Backup

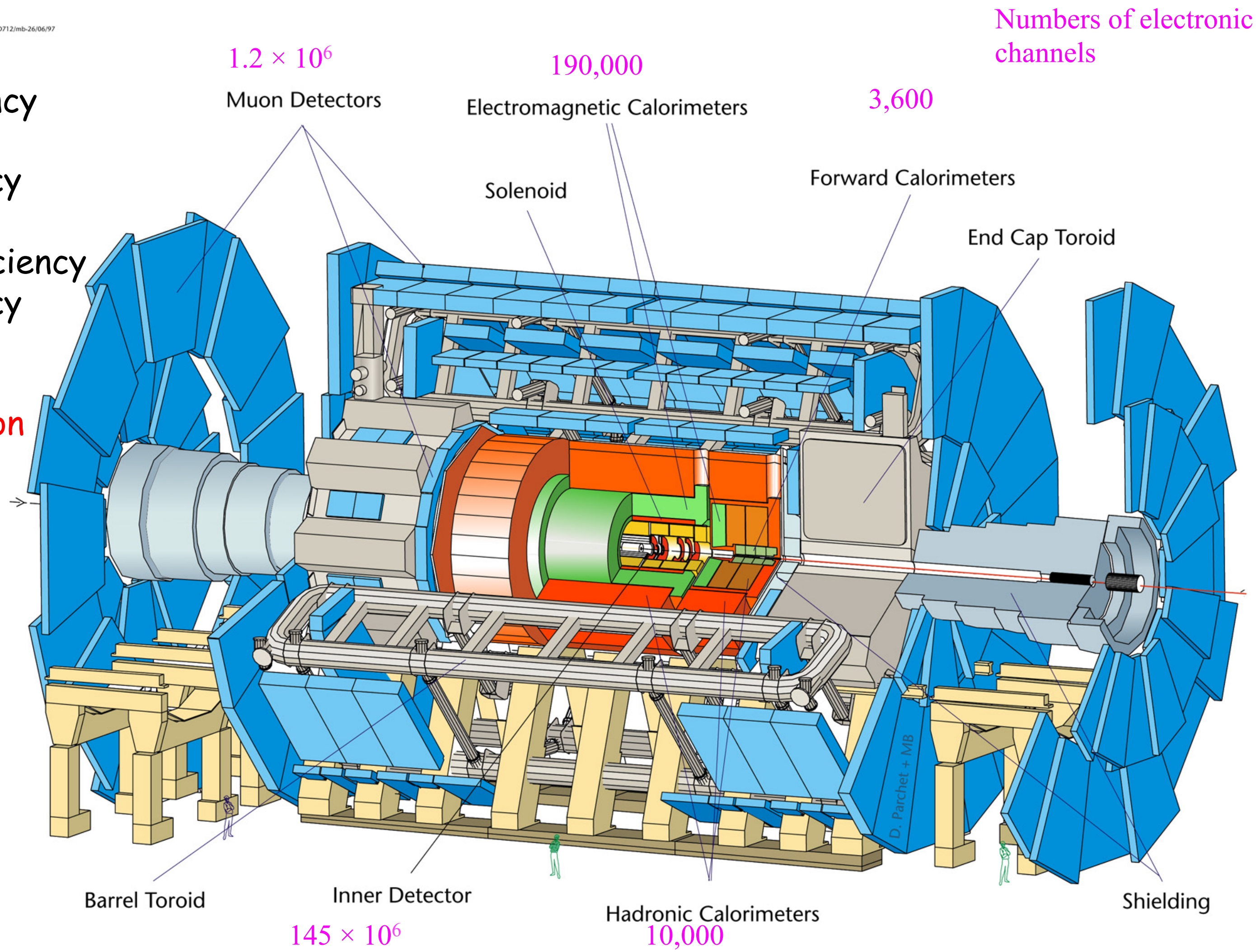
# The ATLAS Detector

e: ~75 – 90% efficiency

muon: ~90% efficiency

b tagging: ~57% efficiency
~ 0.2% fake efficiency
from light jets

Efficiency & resolution dependents on the selection criteria




46 m long, Overall weight: 7000 Tons

Excellent reconstruction efficiency and resolution:
Electron, muon, track, jets, b-tagging & missing transverse energy