SEARCH FOR RPV AND LONG-LIVED SUSY PARTICLES

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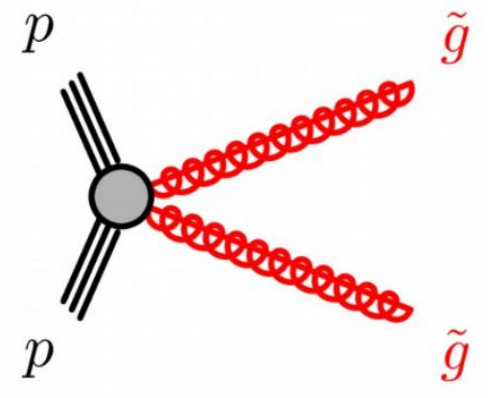
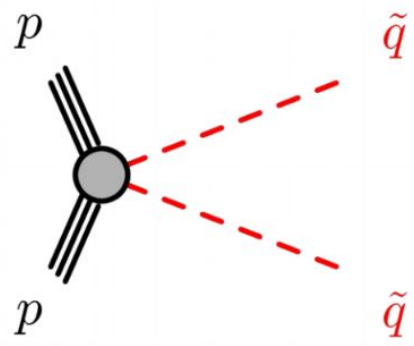
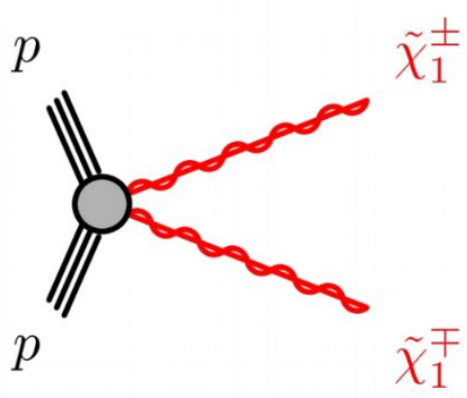
UNIQUE FINAL STATE SEARCHES

Diverse searches for unique SUSY final states when standard assumptions are broken:

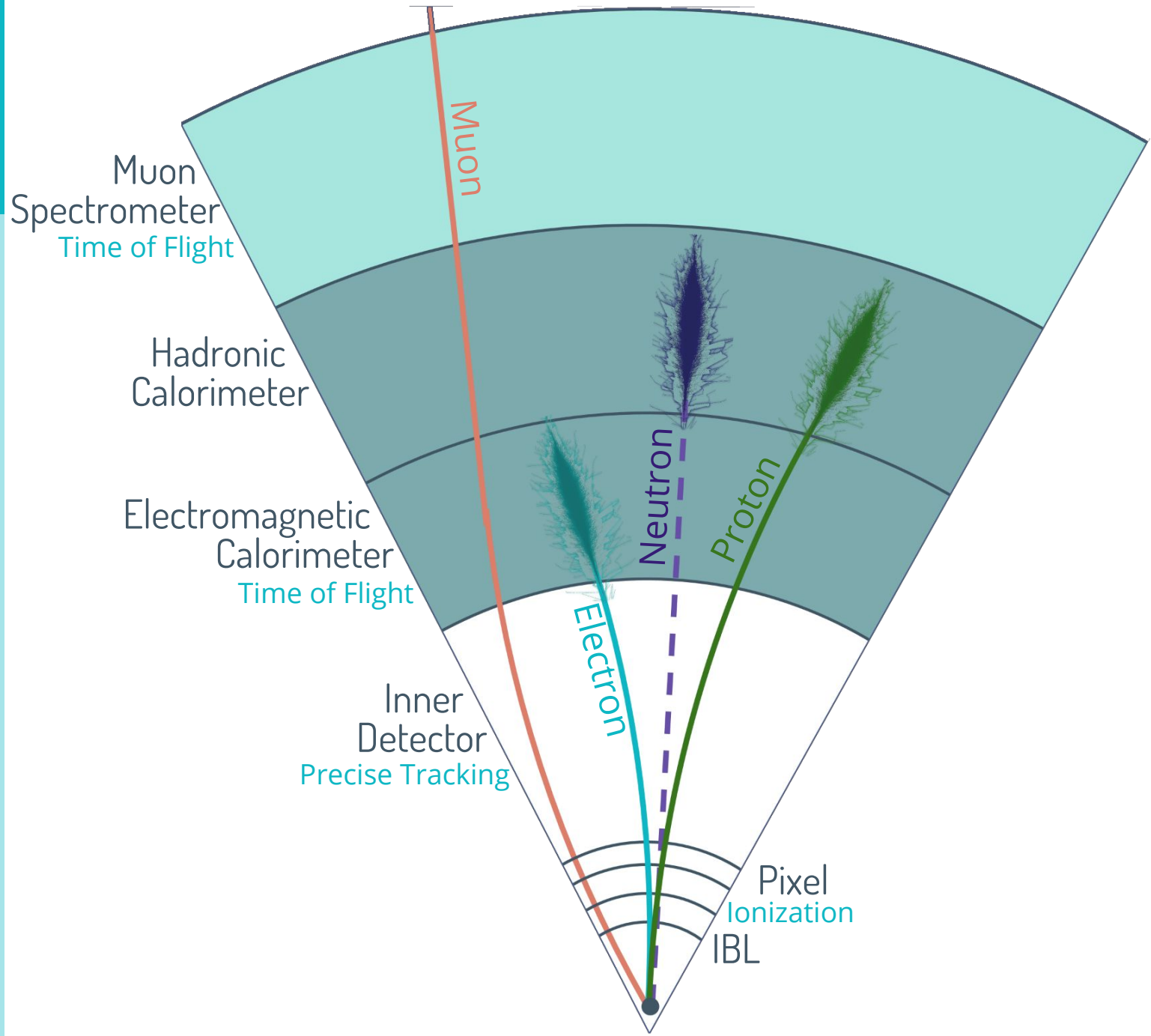
- ~~R-Parity Conservation~~
  - search without missing energy (E_T^{MISS}) for R-Parity Violating (RPV) models
- ~~Prompt Decays~~
  - search for long-lived particles
  - unique signatures target specific lifetime ranges
  - combined, searches cover everything from prompt to stable particles



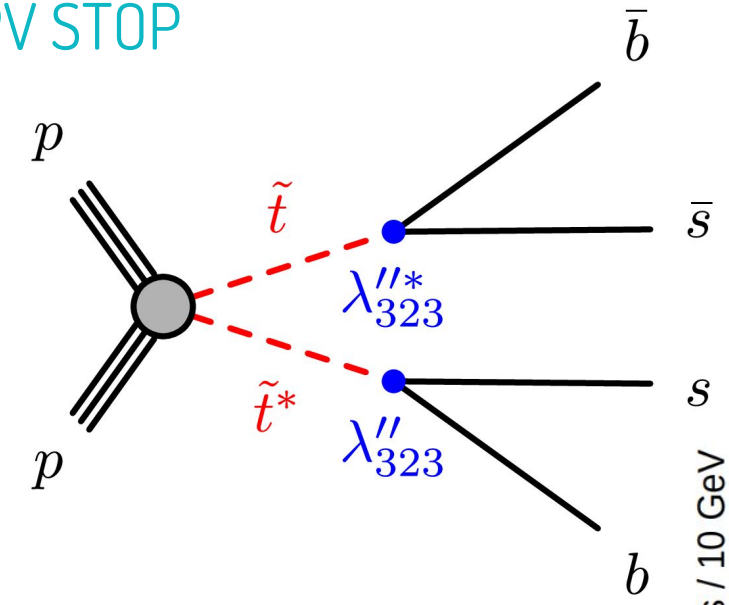




ATLAS DETECTOR



RPV STOP



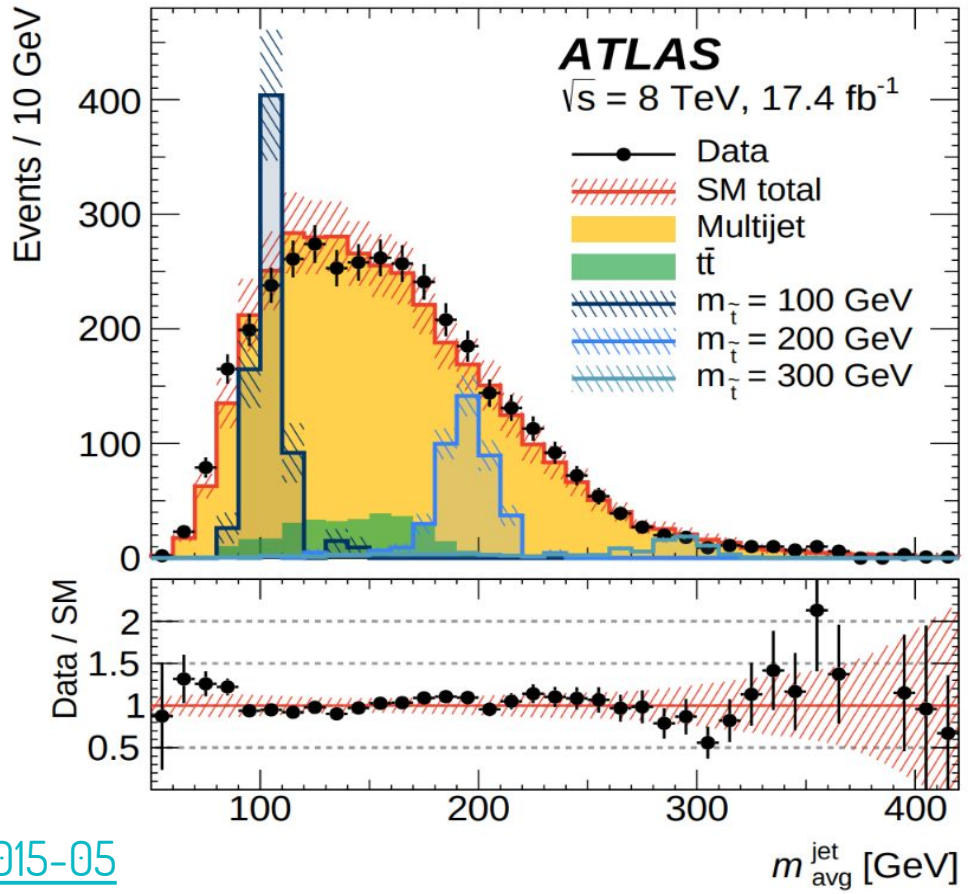
- No E_T^{MISS} to discriminate from QCD background

Strategy

- For low m_{stop} (100-300 GeV), each squark has a significant boost
- Jets of the two products merge, with characteristic jet substructure variables

Results - Run 1

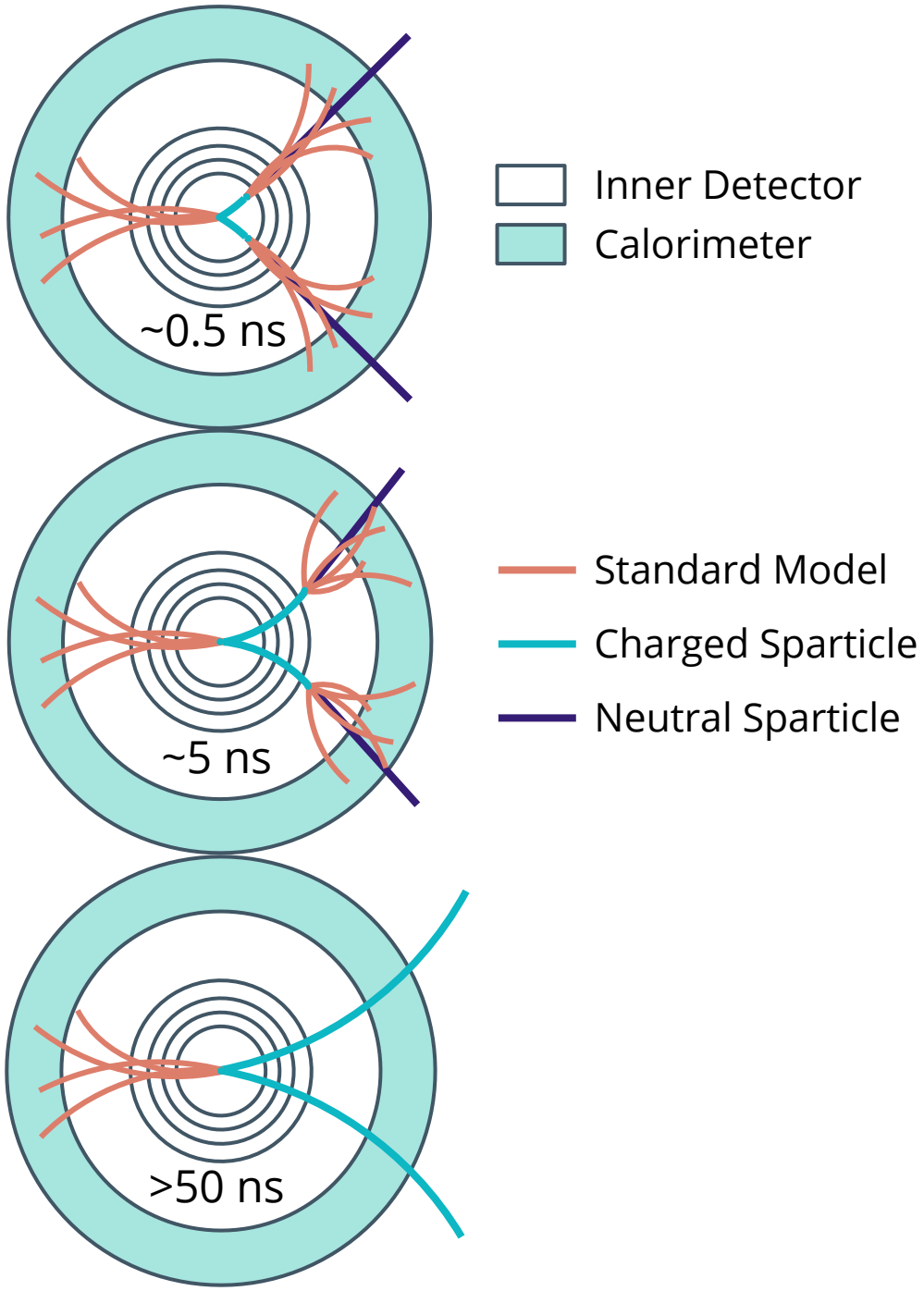
- Top squarks excluded between 100 and 300 GeV



SUSY-2015-05

LONG-LIVED PARTICLES

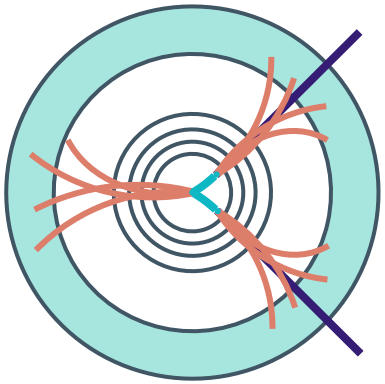
Unique detector signatures to cover range of lifetimes



DISPLACED VERTICES

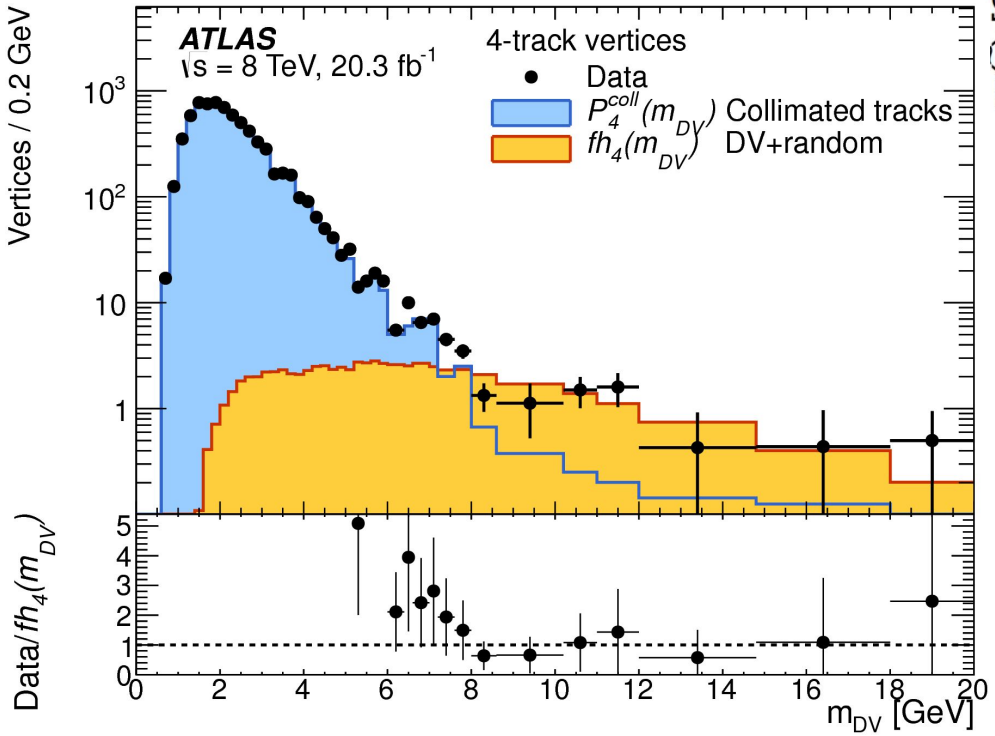
Reconstruct vertices for particles that decay after travelling for O(cm)

- RPV models, Split SUSY
- Very generic search with 7 signal regions

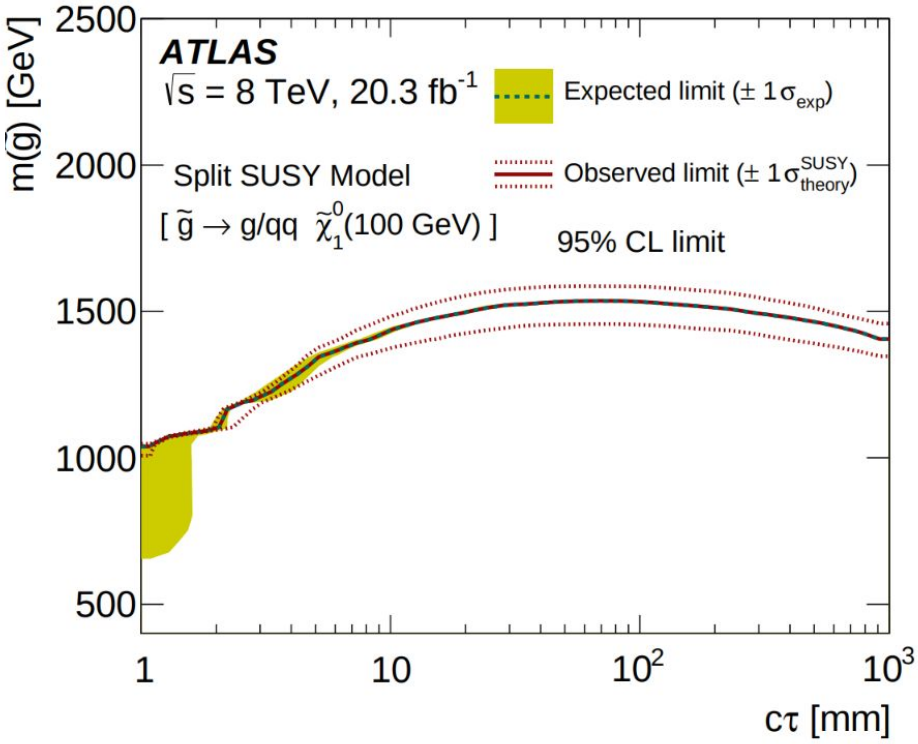


Strategy

- Main discriminant: mass of particles associated to the vertex



Results - Run 1

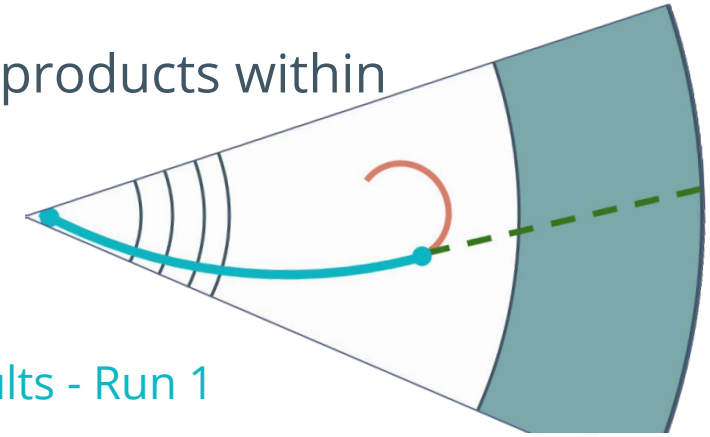


SUSY-2014-02

DISAPPEARING TRACKS

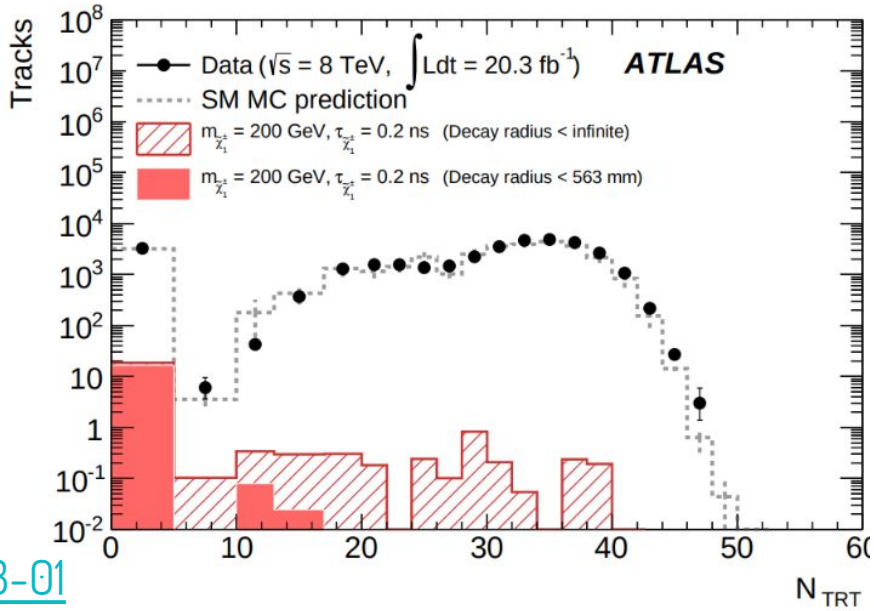
Charged particles decay to undetected products within the inner detector

- $\tilde{\chi}^{\pm} \rightarrow \tilde{\chi}^{0}\pi^{\pm}, m_{\tilde{\chi}^{\pm}} \approx m_{\tilde{\chi}^{0}}$

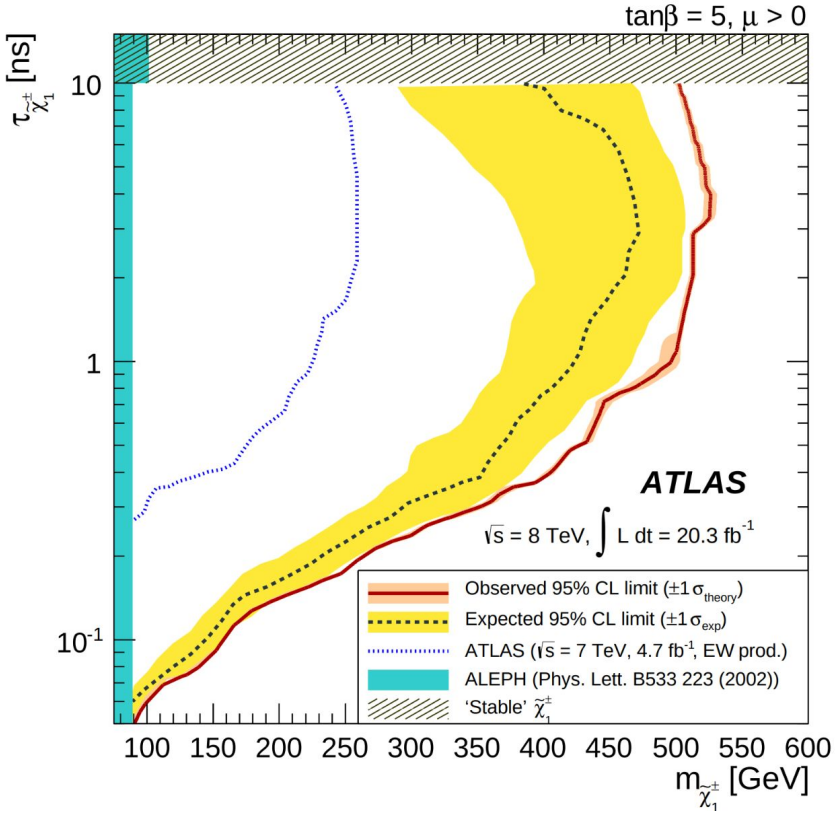


Strategy

- Require that a track does not extend fully to the TRT, calorimeter, or muon system
- Use track p_T as final discriminant



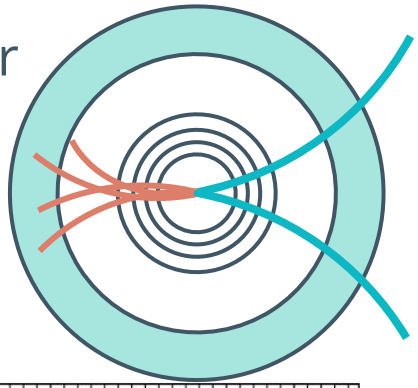
Results - Run 1



SUSY-2013-01

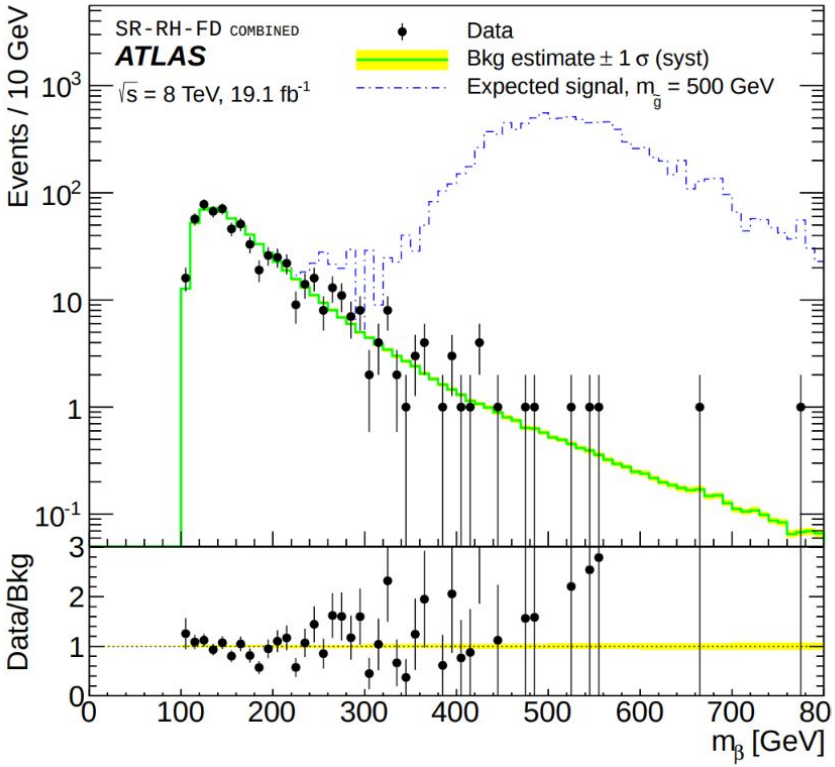
STABLE CHARGED

Particles which propagate through the entire detector can be identified by dE/dx and time of flight

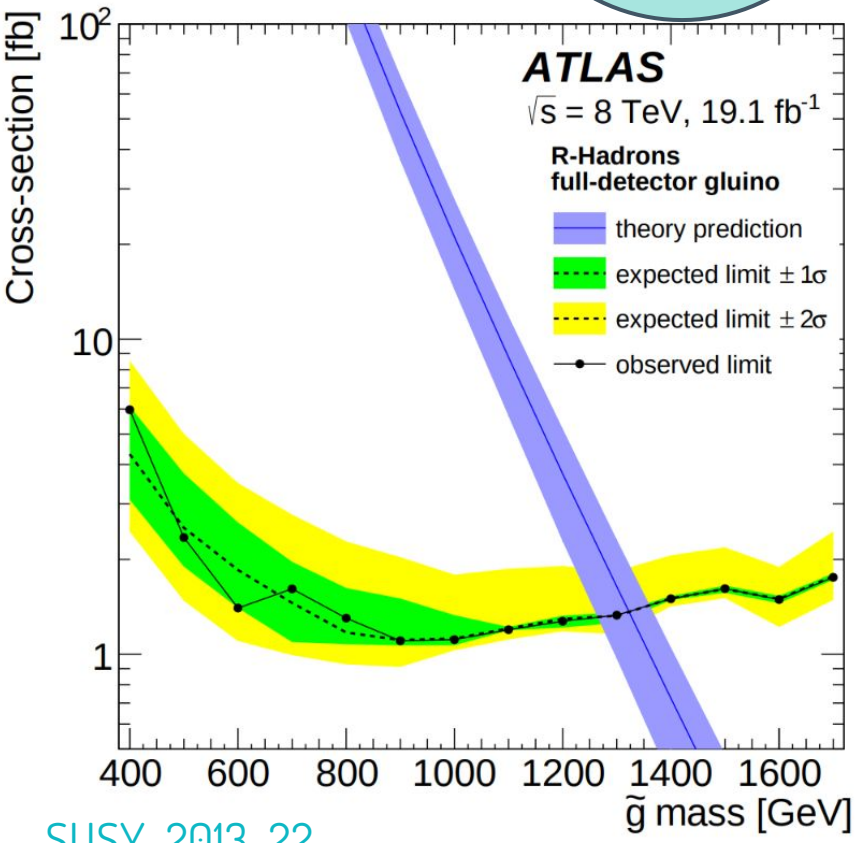


Strategy

- Check consistency between multiple measurements of velocity ($\beta = v/c$)
- $m_\beta = p/\beta\gamma$



Results - Run 1

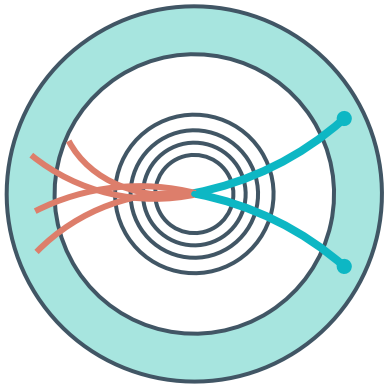


SUSY-2013-22

STOPPED R-HADRONS

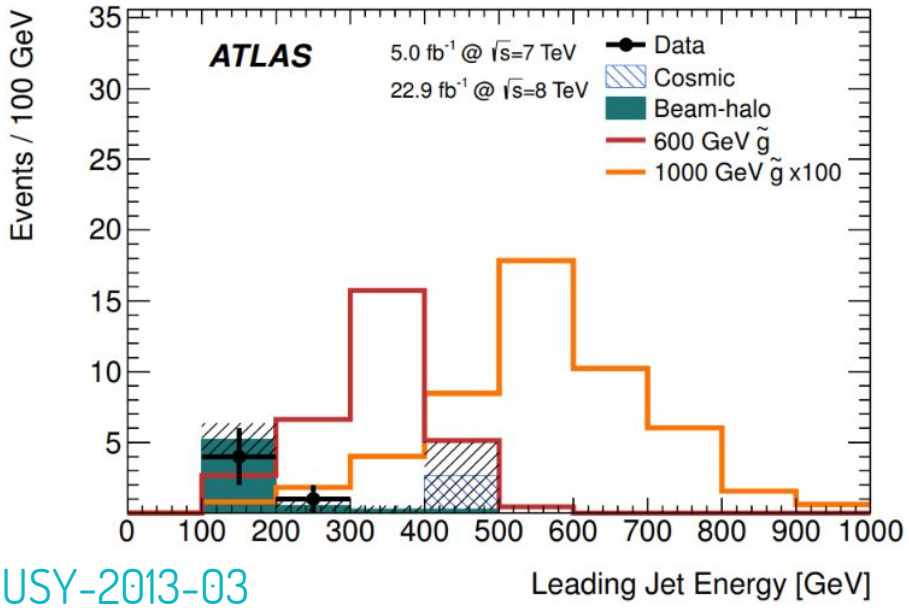
R-Hadrons with very long lifetimes may come to rest in the calorimeters and decay after a delay

- Activity occurs when beams aren't colliding

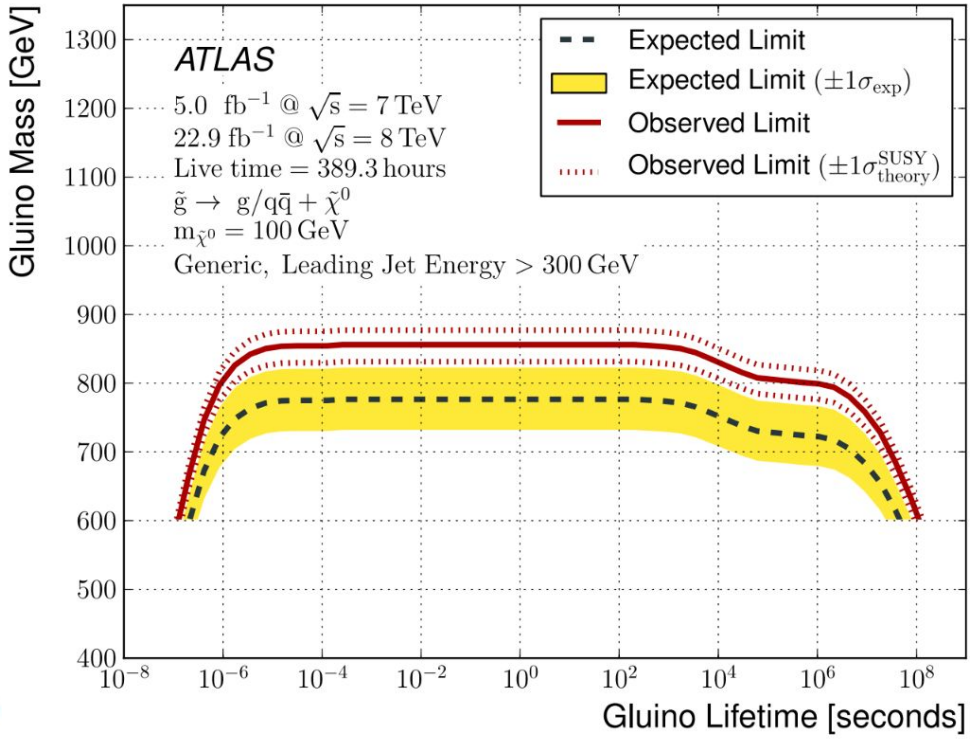


Strategy

- Look for calorimeter activity during empty bunch crossings
- Check for extra, energetic jets from R-Hadron decays



Results - Run 1



SUSY-2013-03

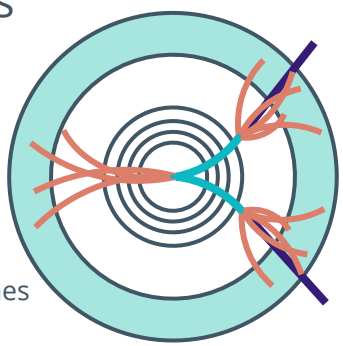
RUN-2 RESULTS

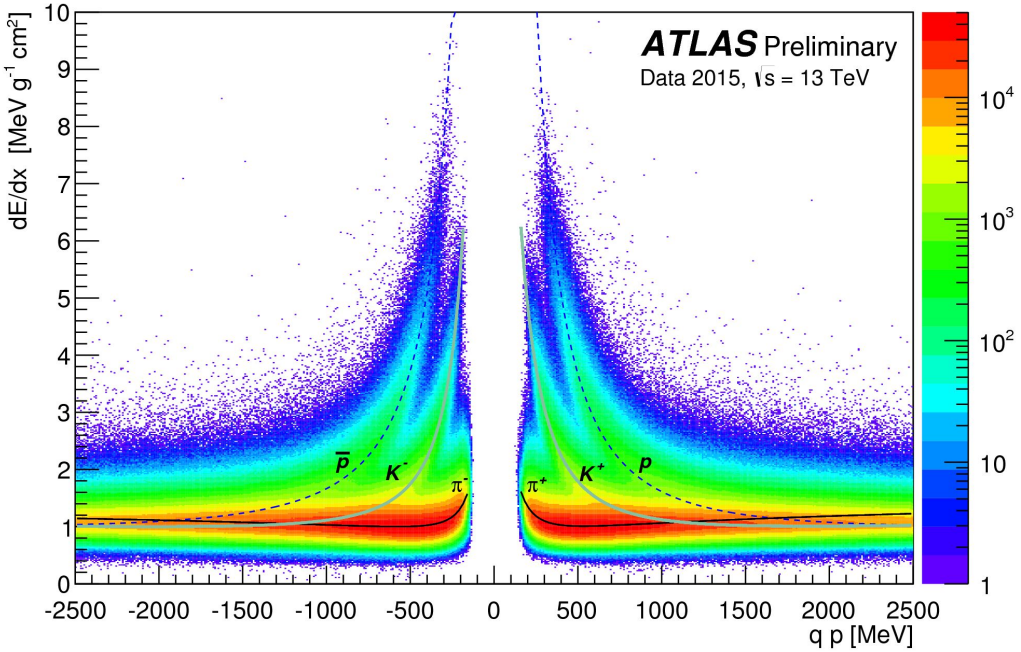
The dE/dx based metastable, heavy, charged particle search at 13 TeV

PIXEL DE/DX: TECHNIQUE

- Search for Heavy (TeV Scale), Long Lived ($\gtrsim$ 1 ns), Charged Particles
  - In events triggered with missing energy
  - Containing one high momentum, highly ionizing track
  - Rejecting standard model particles: electrons, jets, muons[+]

[+]Only for shorter lifetimes



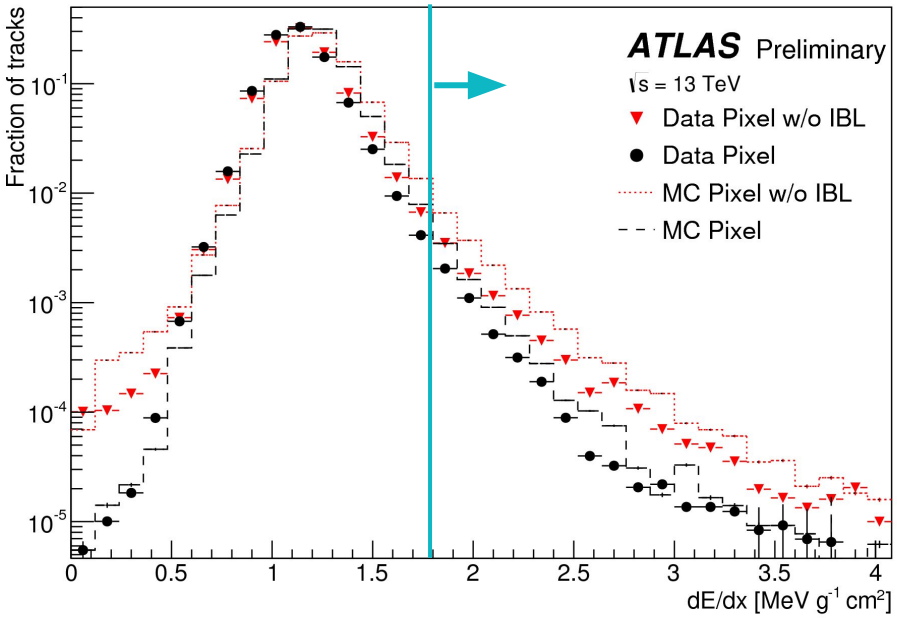


- Use dE/dx and momentum to estimate mass according to Bethe-Bloch function
  - Calibrated using low momentum hadrons in data

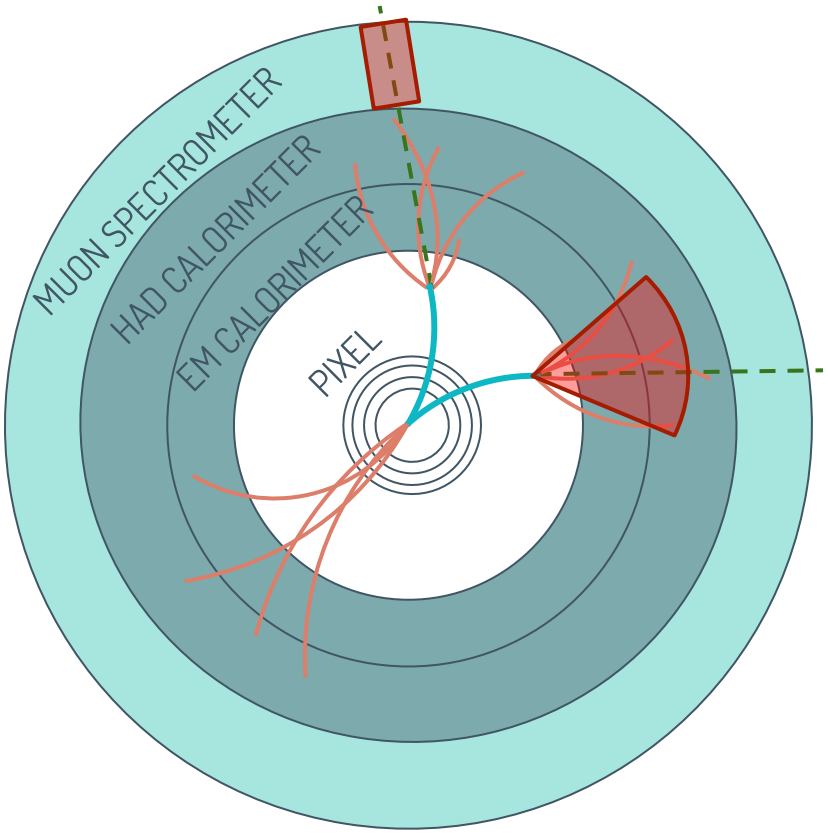
$$(\mathrm{d}E/\mathrm{d}x)_{\mathrm{MPV}}(\beta\gamma) = \frac{p_1}{\beta^{p_3}}\ln(1+[p_2\beta\gamma]^{p_5}) - p_4$$

SUSY-2016-03

PIXEL DE/DX: RUN 2 IMPROVEMENTS



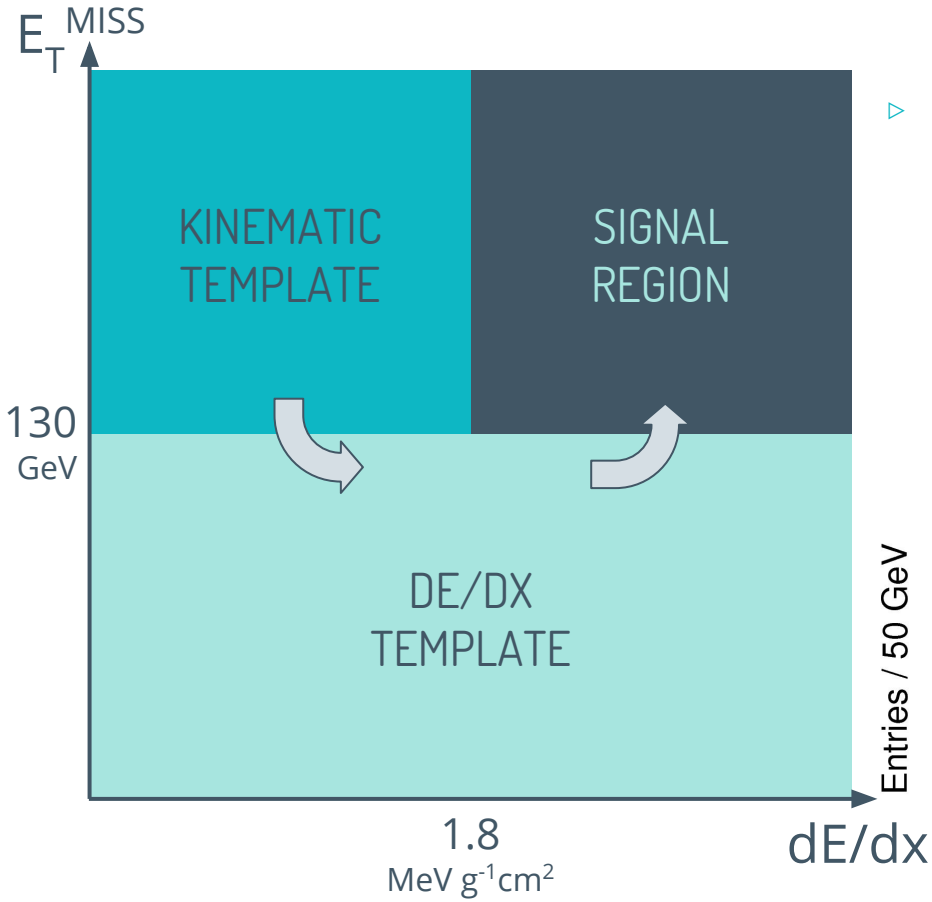
- Large cross section increase with √s at 13 TeV
- Newly inserted IBL improves truncated dE/dx measurement
- 50% reduction in tails



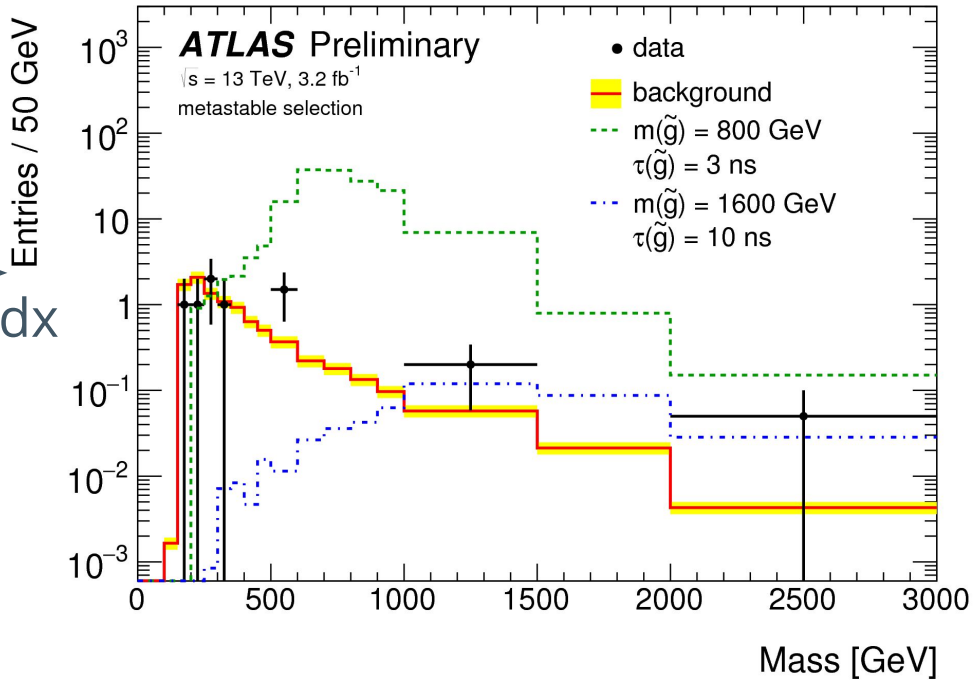
- Reject collimated tracks with new cluster-based isolation
- Reject standard model background with particle identification

SUSY-2016-03

PIXEL DE/DX: BACKGROUND



- Use templates measured in data control regions to estimate mass distribution
  - By generating random triplets of p, η, and dE/dx
  - For SM particles, ionization is not strongly dependent on momentum

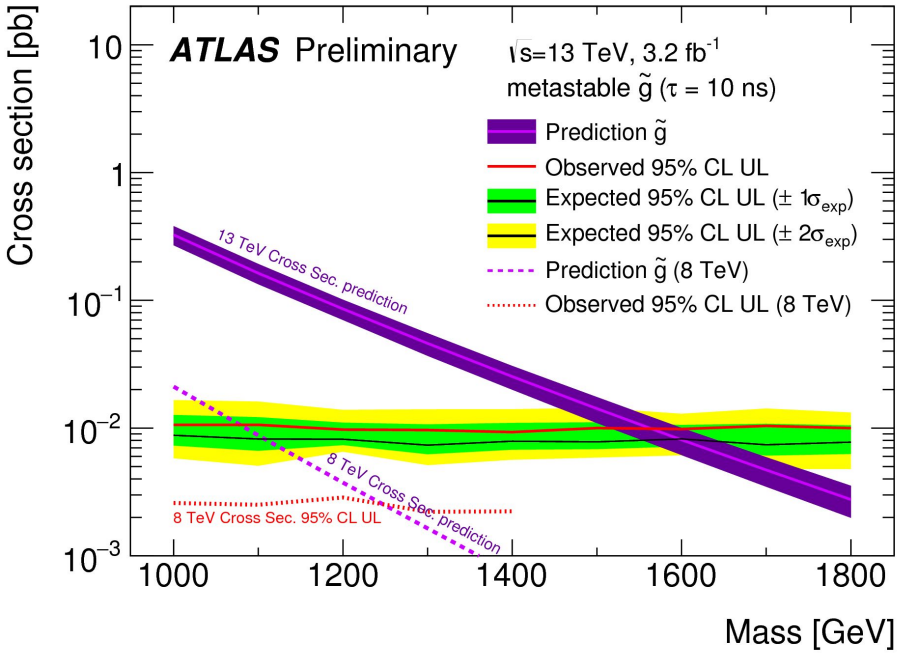


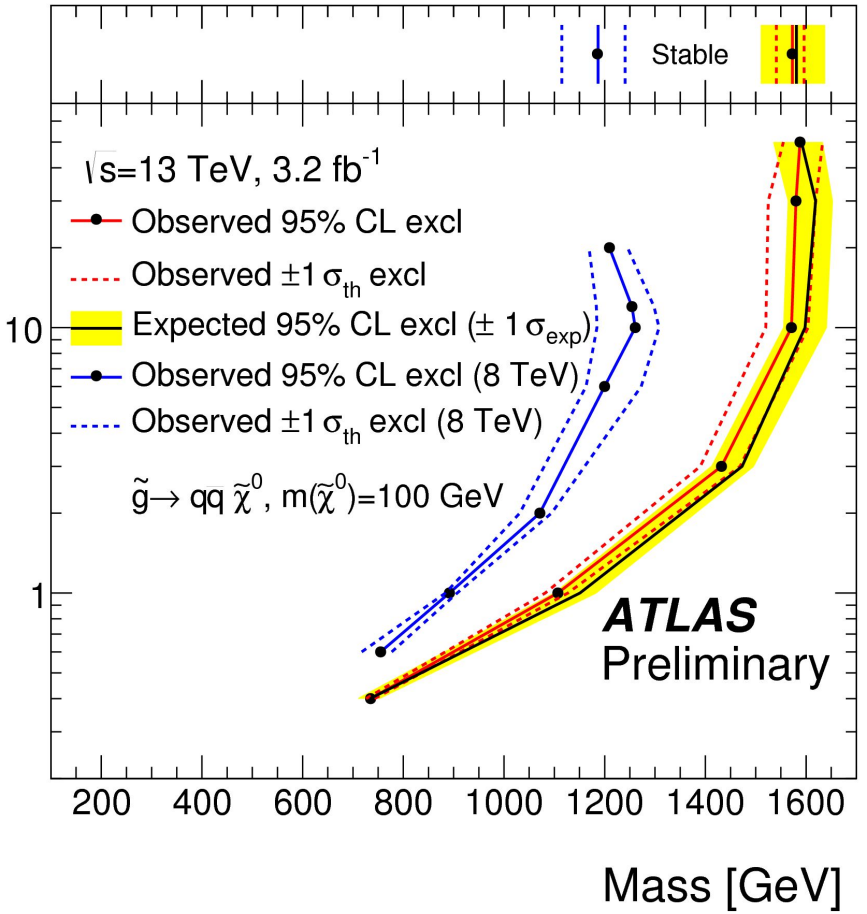
- Search for an excess in mass

SUSY-2016-03

PIXEL DE/DX: RESULTS

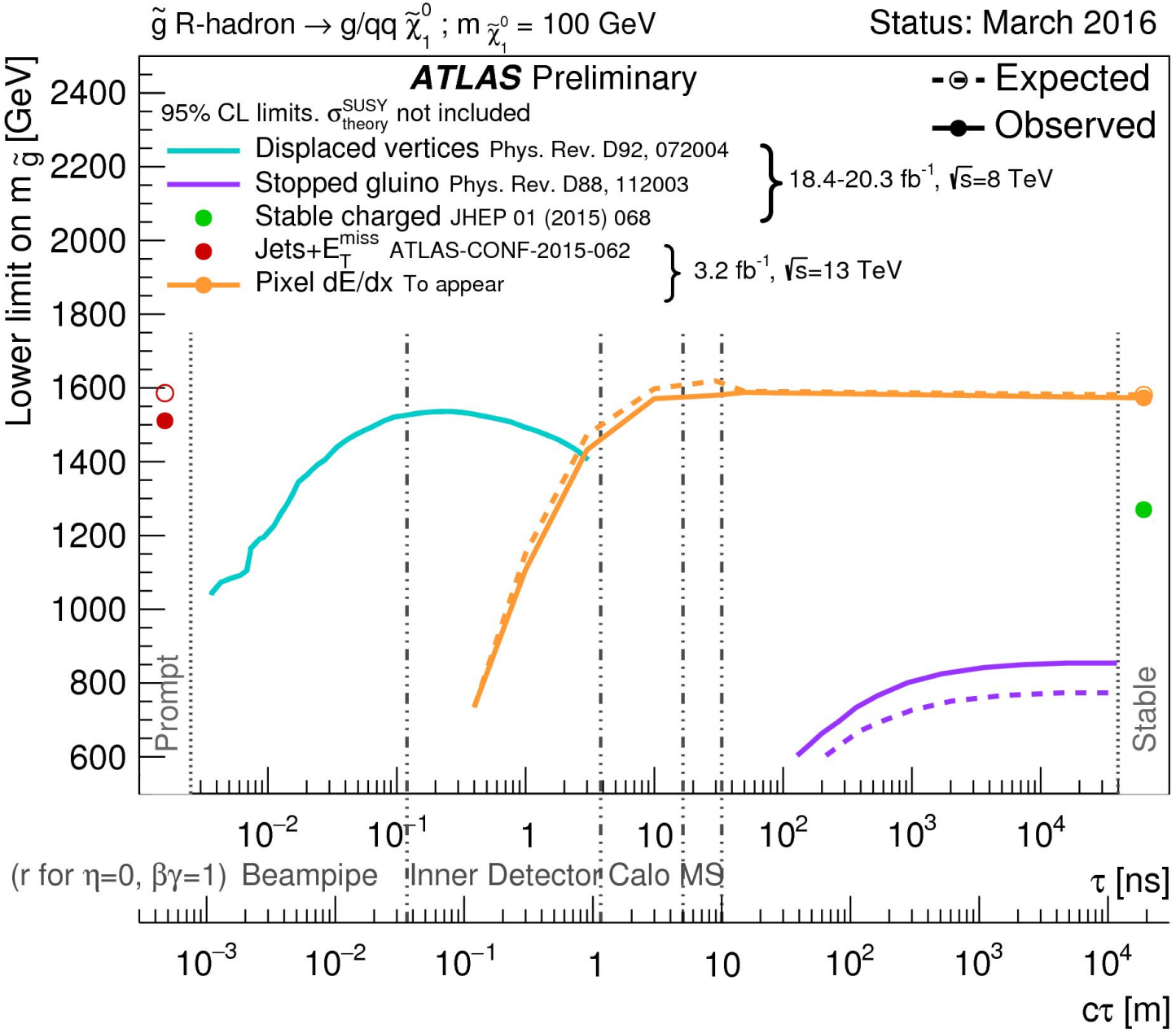
- No significant excess seen in 2015 data
  - R-Hadrons excluded
    - 1580 GeV between 10-30ns and 1570 GeV for long lifetimes
  - Significant improvement by 400 GeV over the Run 1 limit
  - Covers wide range of lifetimes





SUSY-2016-03

LONG-LIVED LIMIT SUMMARY



SUMMARY AND OUTLOOK

We've seen several searches which cover unique final states

- SUSY search without MET for RPV models
- SUSY searches for Long-lived particles
  - Unique detector signatures cover subset of final states
  - Cover all lifetimes from prompt decays to stable particles
- Starting to probe RPV and long-lived states at the TeV scale

Early Run 2 result: significant improvements from increase in energy and analysis refinement

- Pixel dE/dx search improves limit from 1200 to 1600 GeV
- Looking forward to Run-2 results this summer!