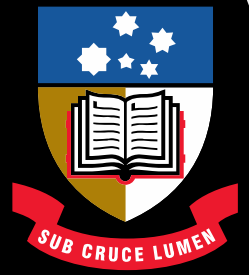
# Searches for Long-Lived Particles using Displaced Vertices and Missing Transverse Energy at the ATLAS Detector




Emily Filmer, University of Adelaide
on behalf of the DV + MET Analysis Team
AIP, 12th December 2022

ATLAS EXPERIMENT

# Overview

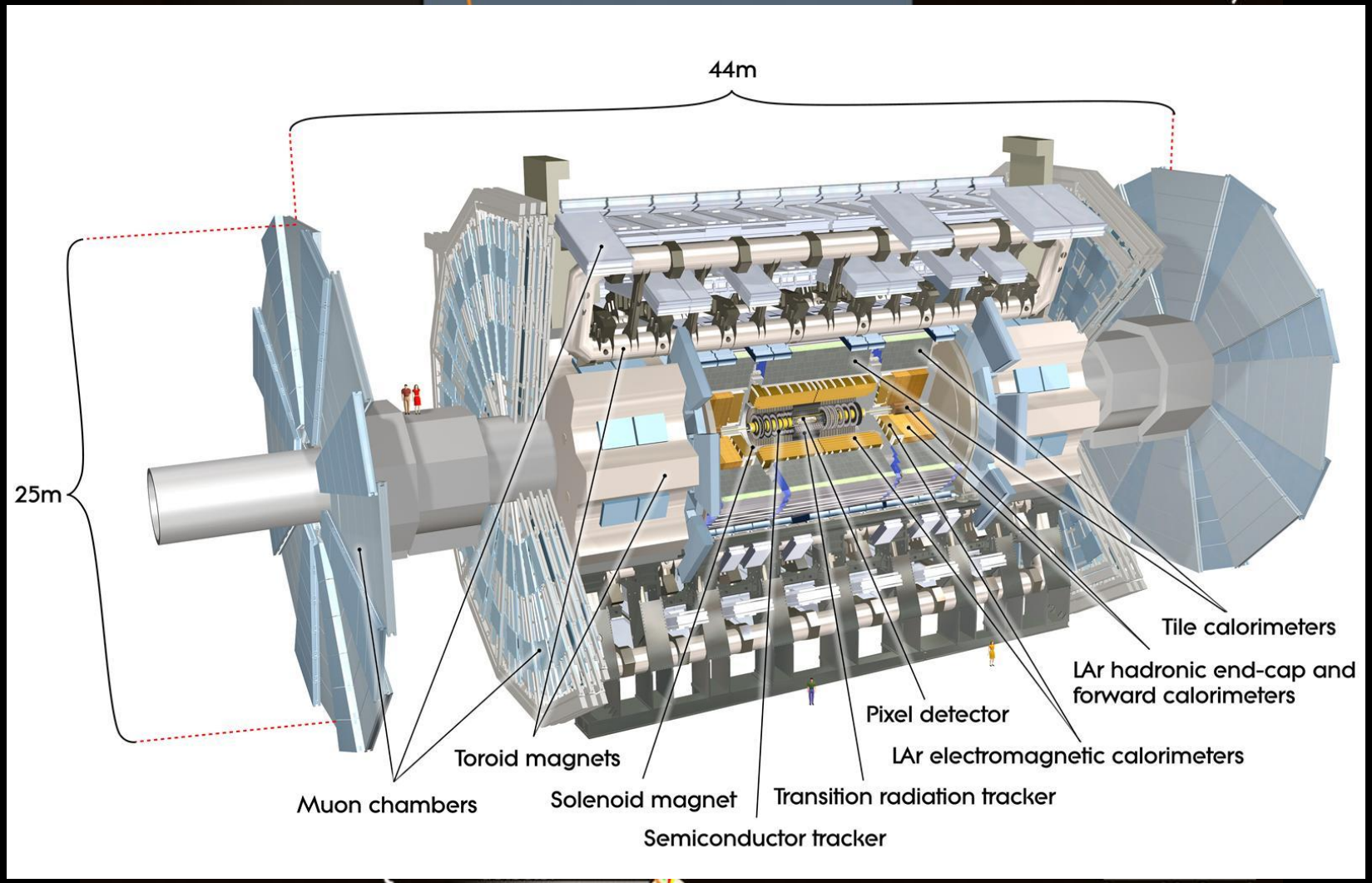
What
is a displaced vertex?

Why
are we looking for them?

How
will we look for them?

# The ATLAS Detector

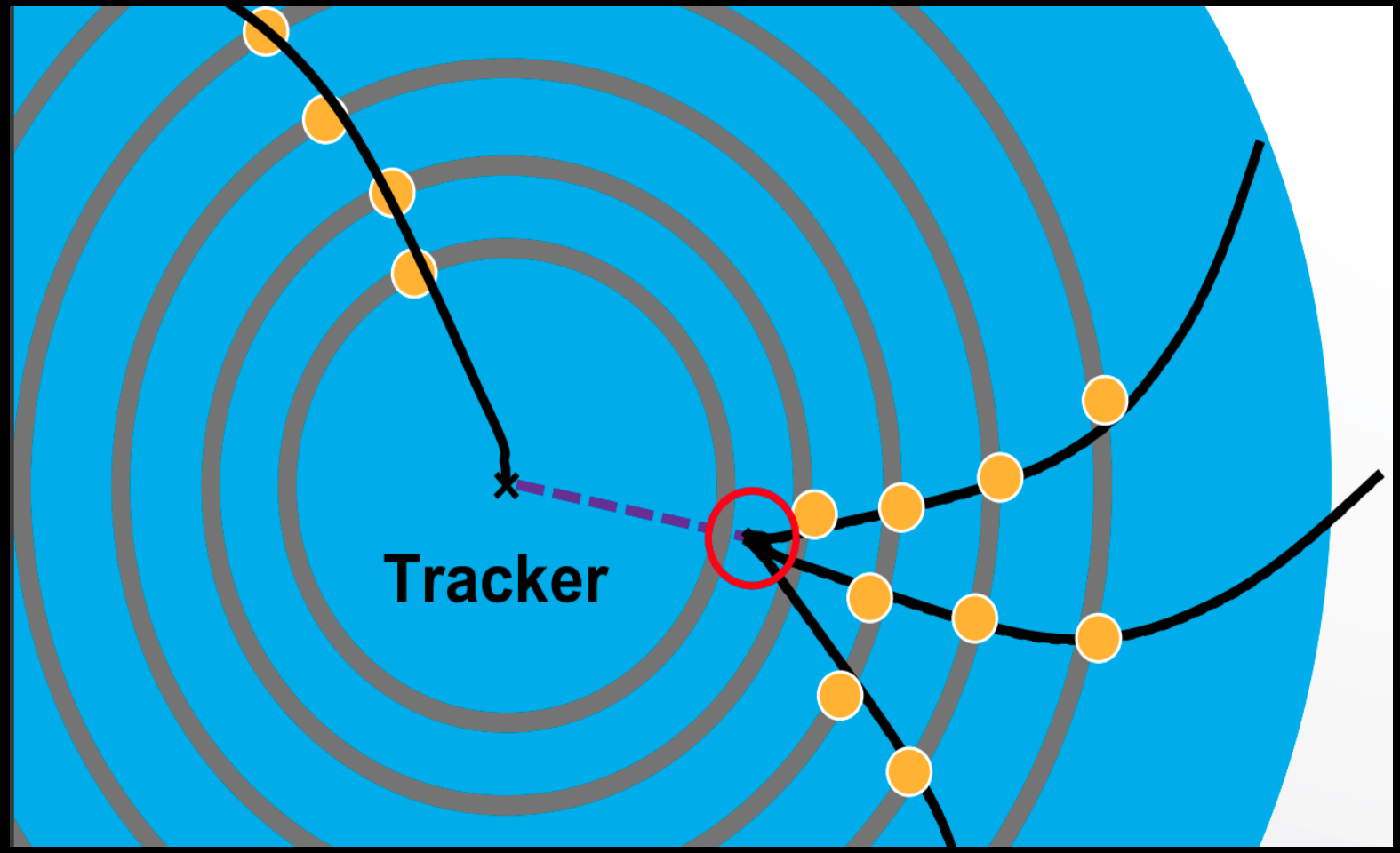
- General purpose detector on the Large Hadron Collider
- Comprised of concentric subsystems
- Designed to look for Higgs boson (SM particles)
- Protons are complex, we don't know beamline momentum
  - Recreate events in the transverse plane




Transverse Plane

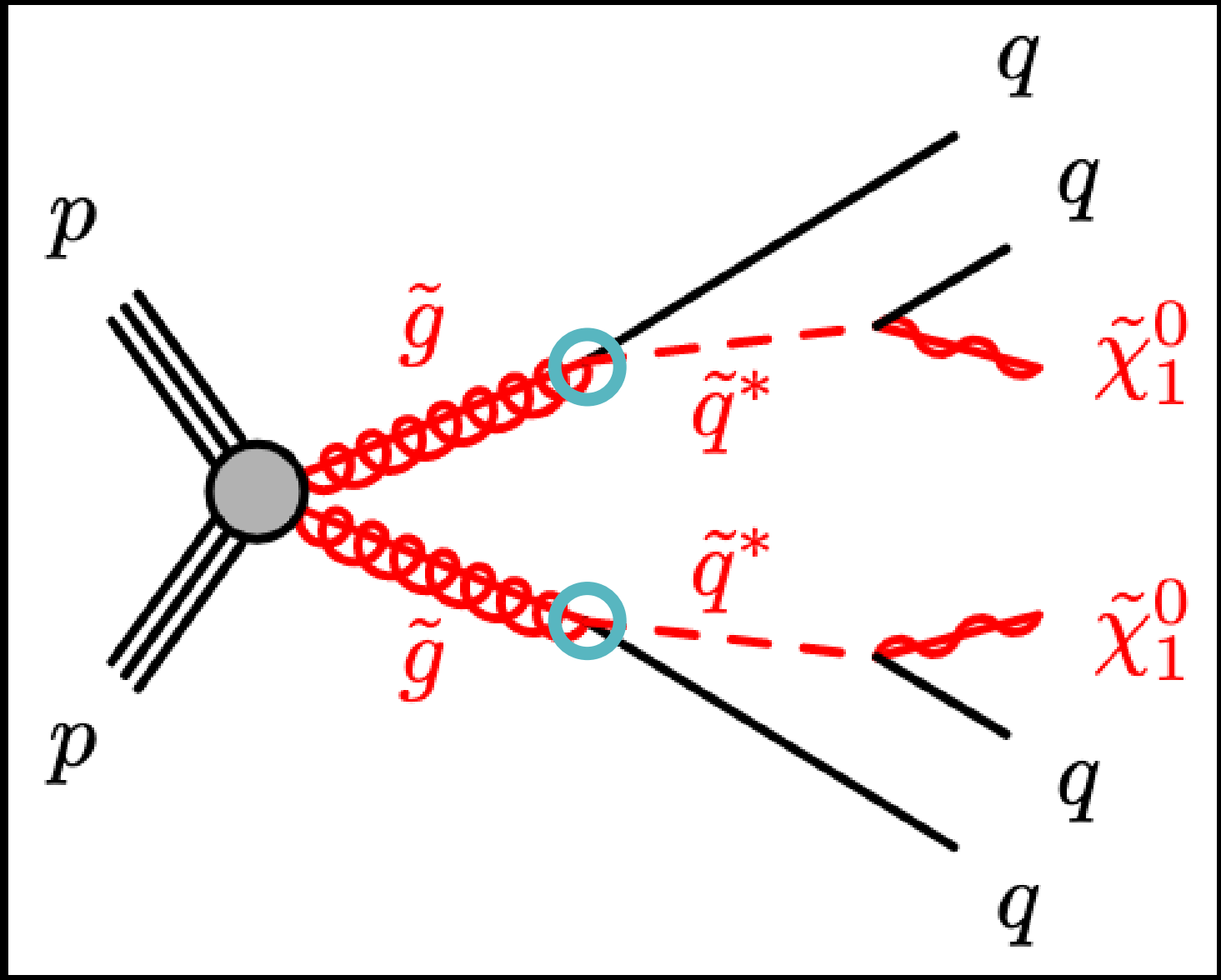
# Displaced Vertices

- One kind of long-lived particles
- Decays that have some time of flight from the primary vertex (p-p) ~1 ns / 0.3 m
- Decays to many charged tracks in the Inner Detector



# Why Look for Displaced Vertices?

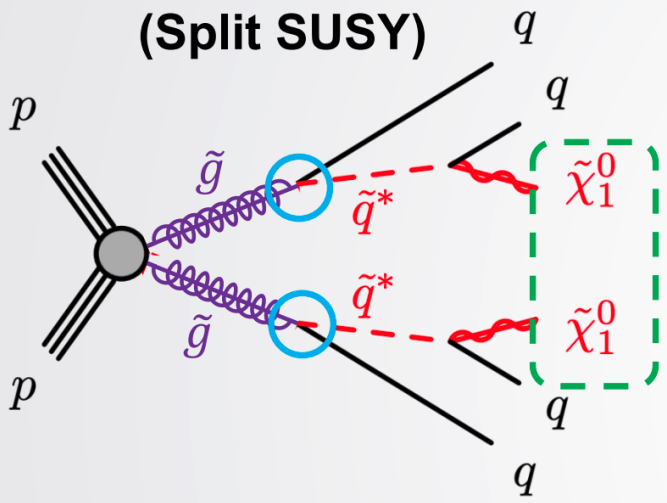
- Often predicted by Beyond Standard Model Physics
- We want to look for BSM physics
- This would be difficult to see without a dedicated search



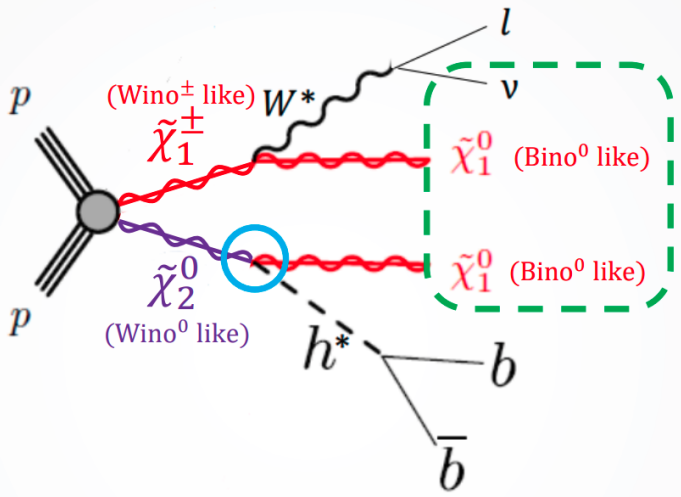
# Signal Models

- ≥ 5 tracks
- DV invariant mass ≥ 10 GeV
- DV lifetime between 0.1 ns - 10 ns

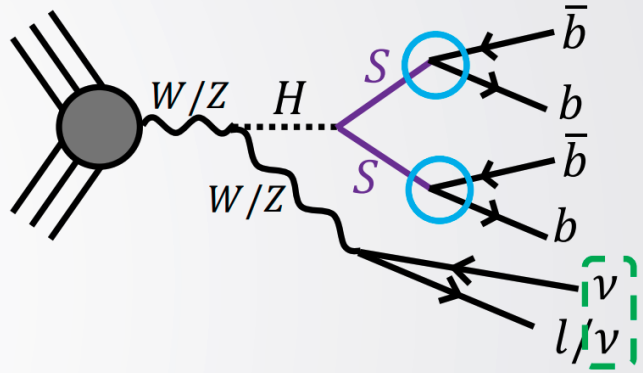
**Gluino R-Hadron (Split SUSY)**




**Wino-Bino**



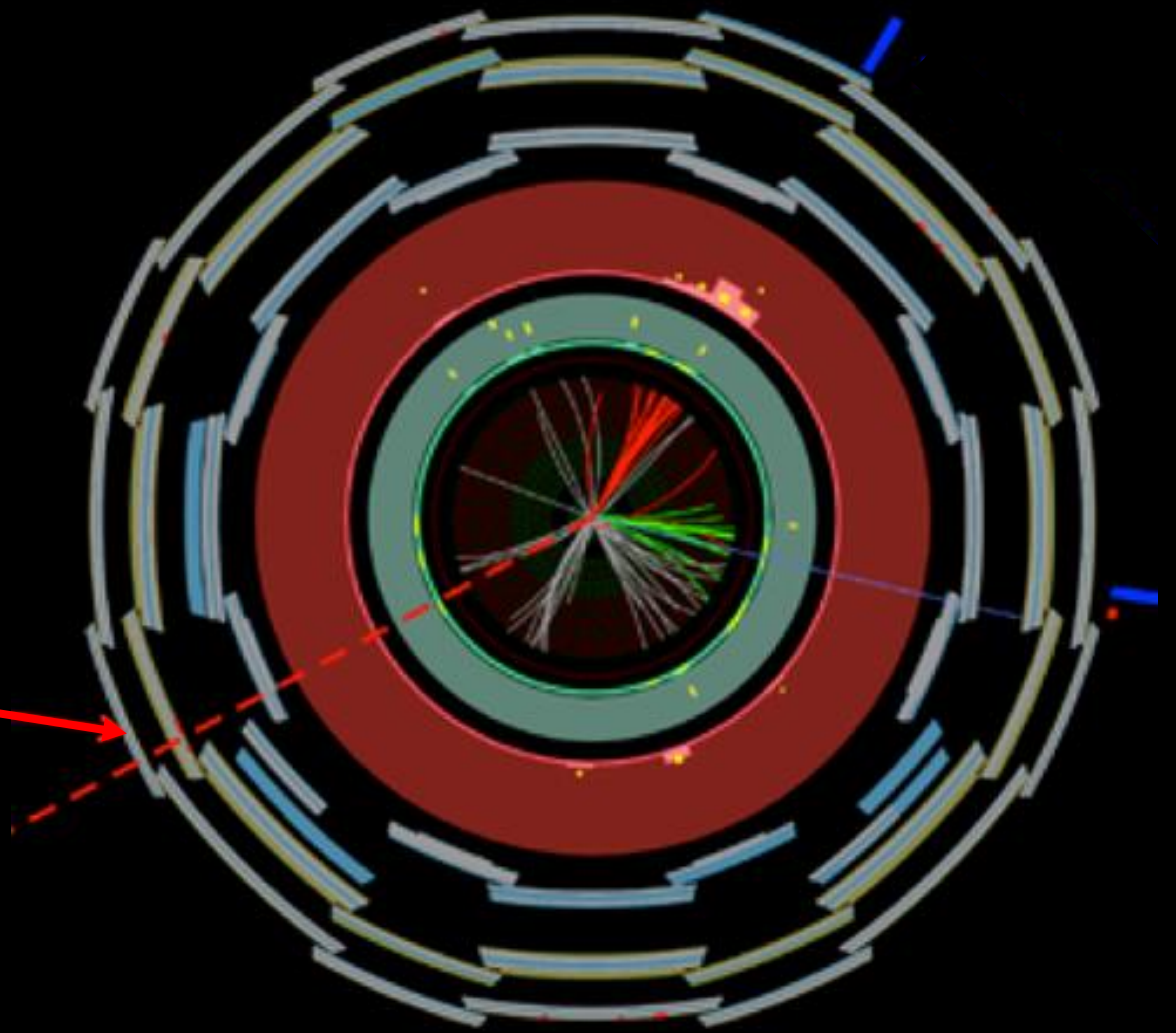

**Higgs Portal**




**(+other Higgs prod.)**

# Missing Energy

- “Leftover” energy in transverse plane
  - Reconstruction
  - Neutrinos
  - BSM particles
- Need to trigger our detector on some event parameter
- ~ 250 GeV



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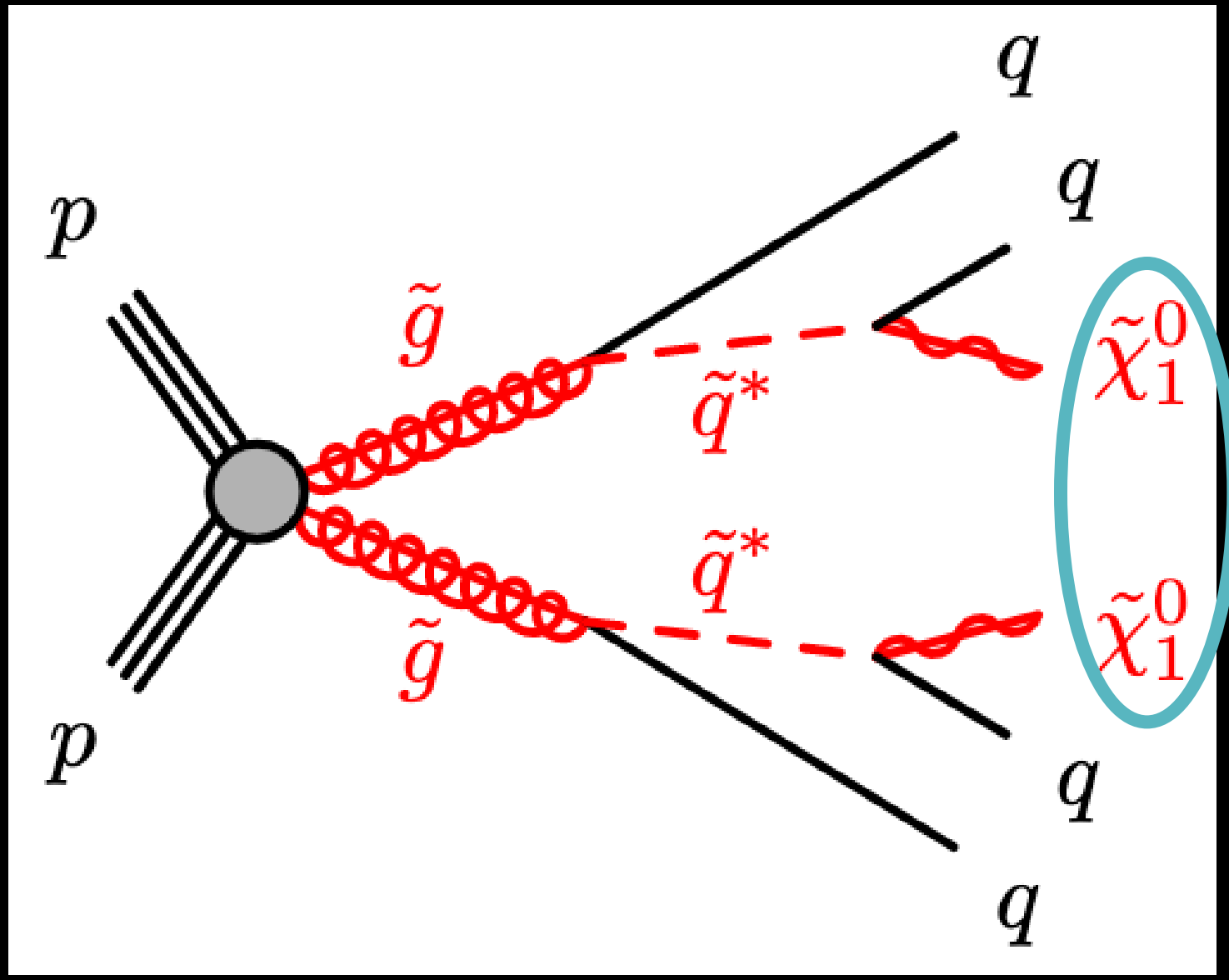
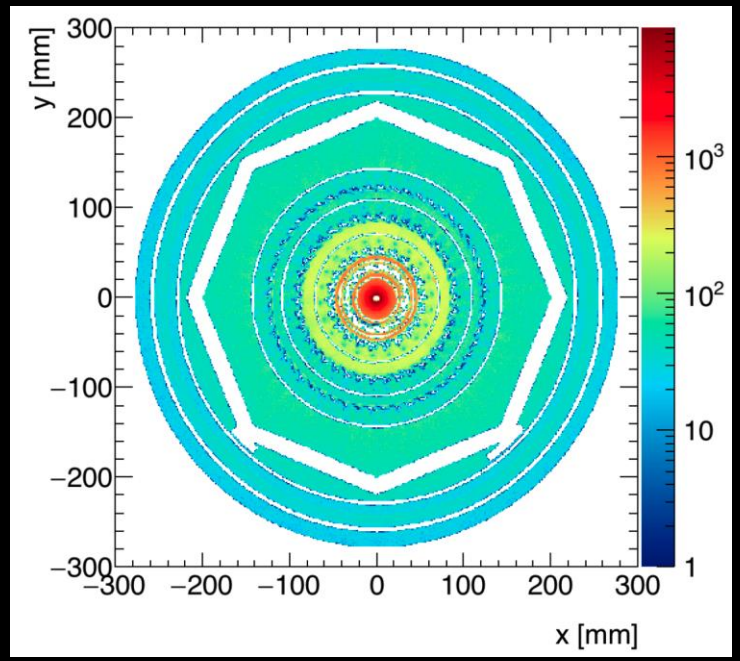
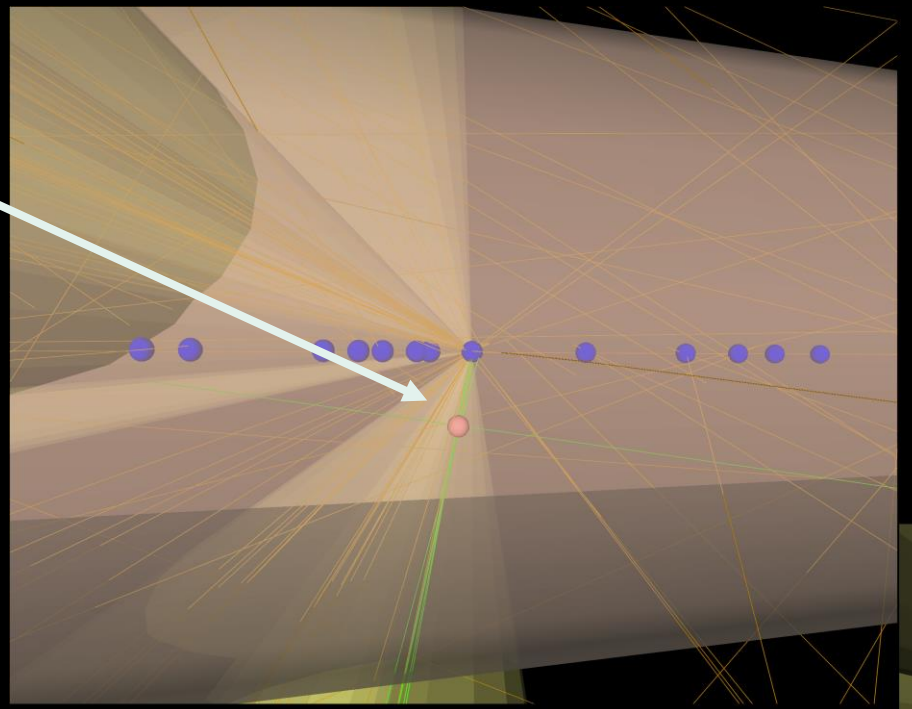
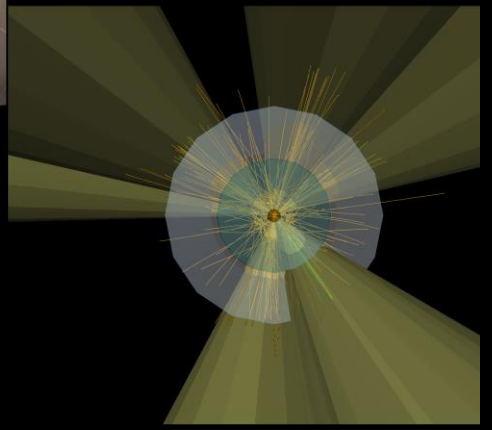


# Major Backgrounds

- Merged vertices
- Randomly crossing tracks
- Nuclear interactions with material of Inner Detector





ATLAS EXPERIMENT
Run: 331875
Event: 1897958208
2017-08-08 01:33:53 CEST

# Previous Analyses

- DV+MET 2017
  - 33 $fb^{-1}$
  - Only Split-SUSY Model

| Expected | Observed |
|---|---|
| 0.02 | 0 |

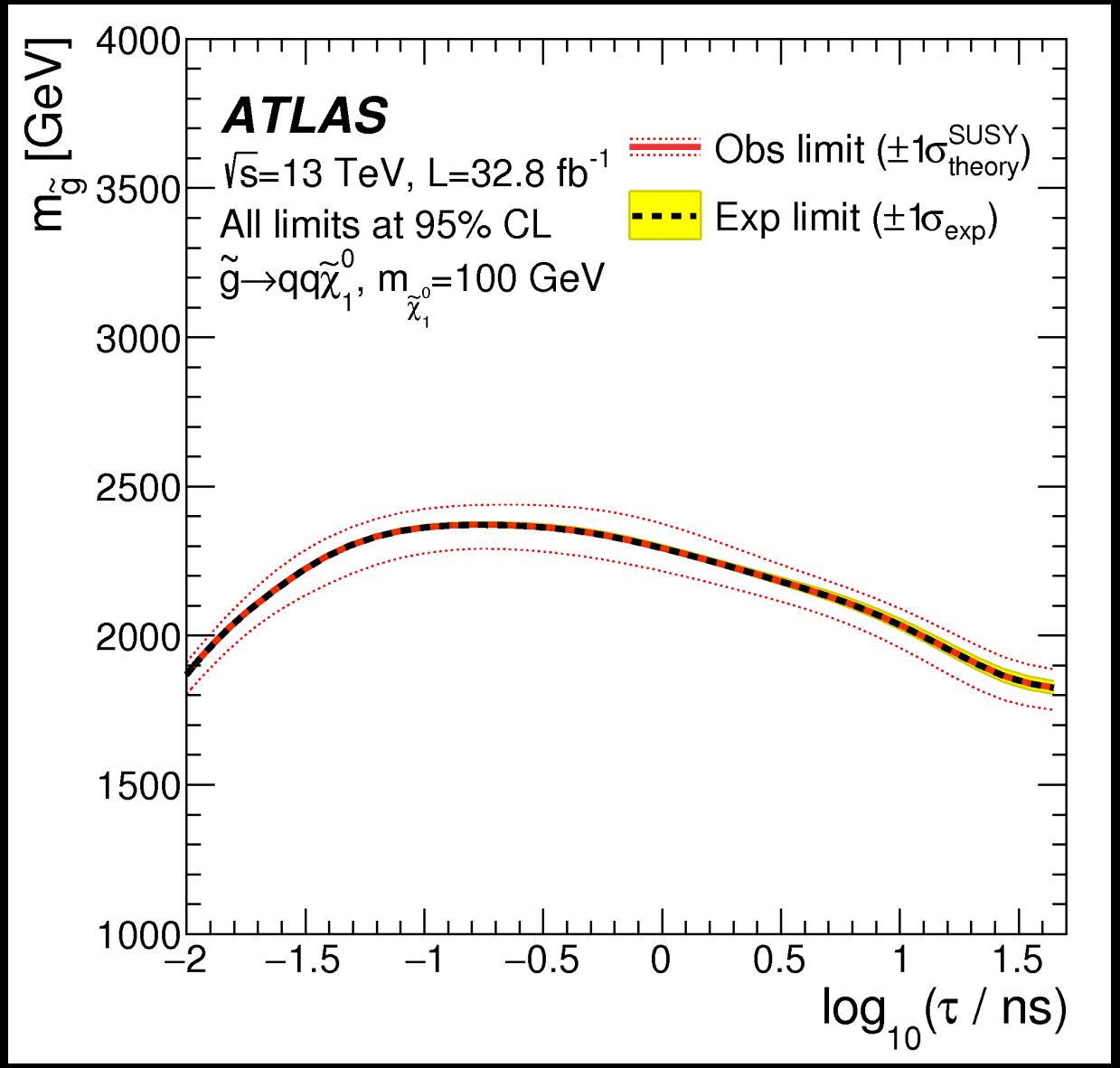
- DV+JETS 2022
  - 139 $fb^{-1}$
  - Great understanding of backgrounds

| Expected | Observed |
|---|---|
| 1 | 0 |

Clearly room for improvement!

# Current Analysis

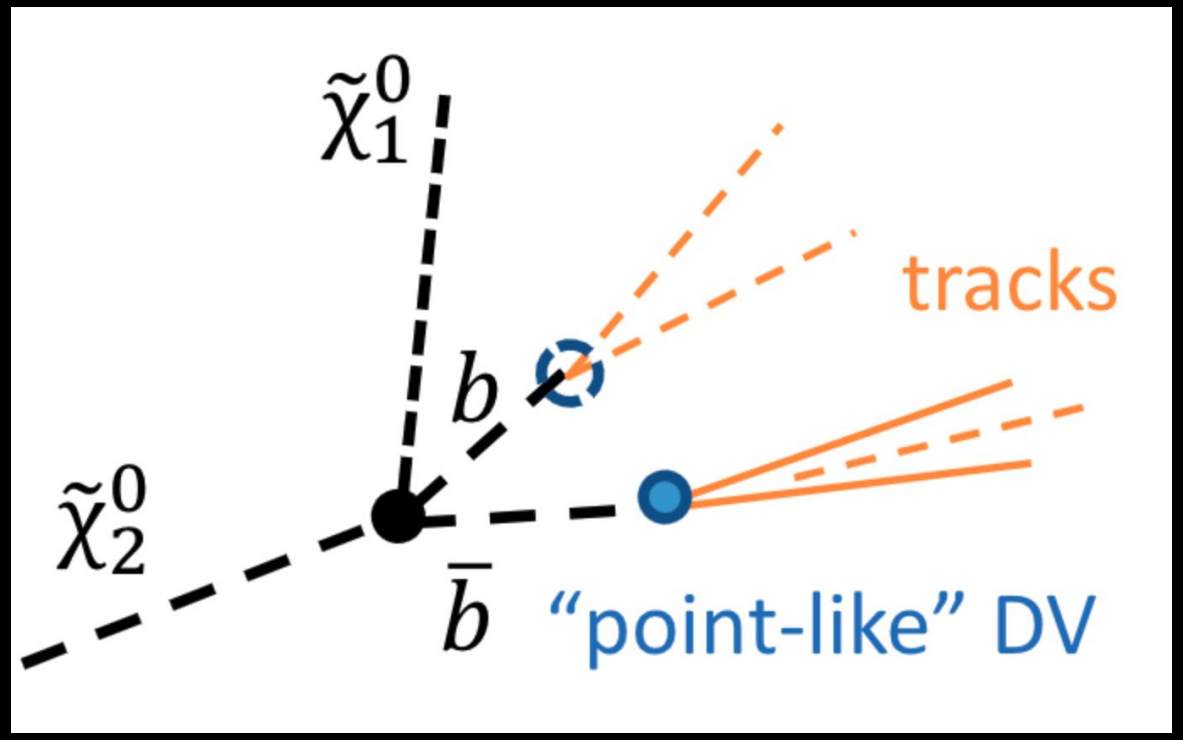
- Using full run 2 dataset
- Using Fuzzy vertexing
- Can improve existing limits

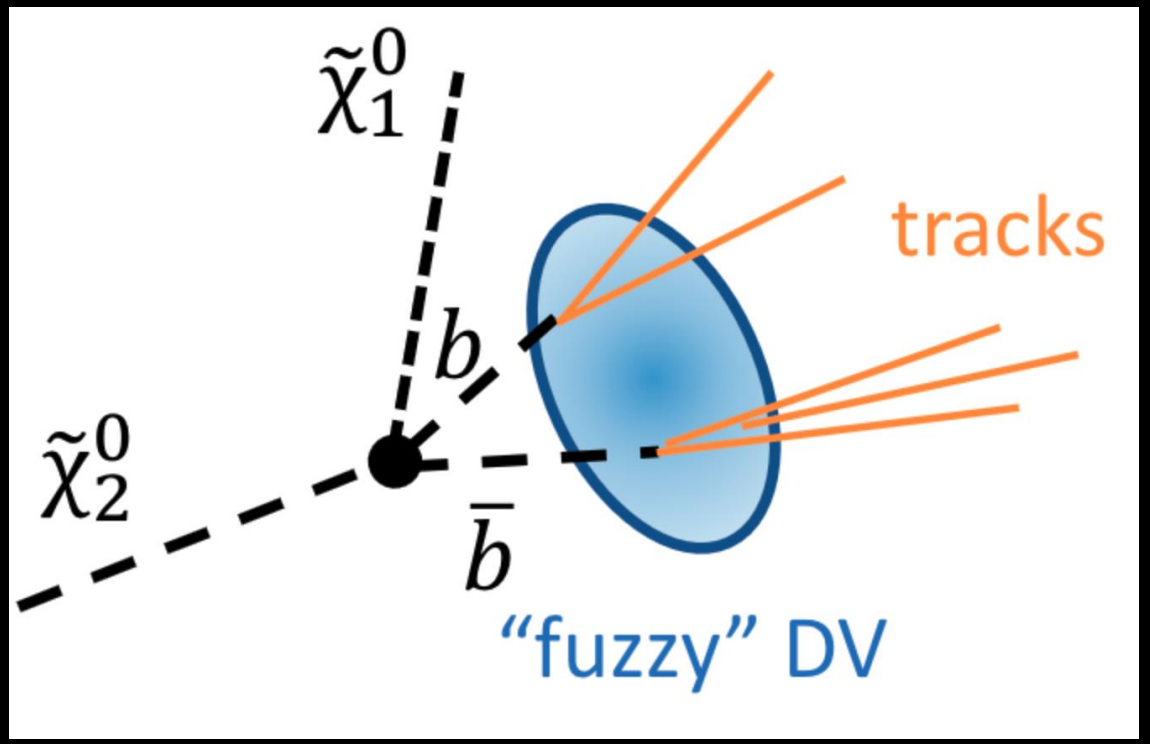



95% confidence limit from DV+MET 2017

# Fuzzy Vertexing – R Ushioda (Tokyo Tech)

- Usually assume that vertices are point-like
  - This will discount particles with decay of ~few mm
- Fuzzy Vertexing takes a 5σ volume around track using a seed merging procedure
- Sensitive to new models



# Summary

- Looking for Displaced Vertices
  - More data
  - New vertexing algorithm
- Hope to find BSM physics
- If not, refine cross section limits