Long-lived particle searches in ATLAS and CMS

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On behalf of the ATLAS and CMS Collaborations
Large Hadron Collider Physics 2016
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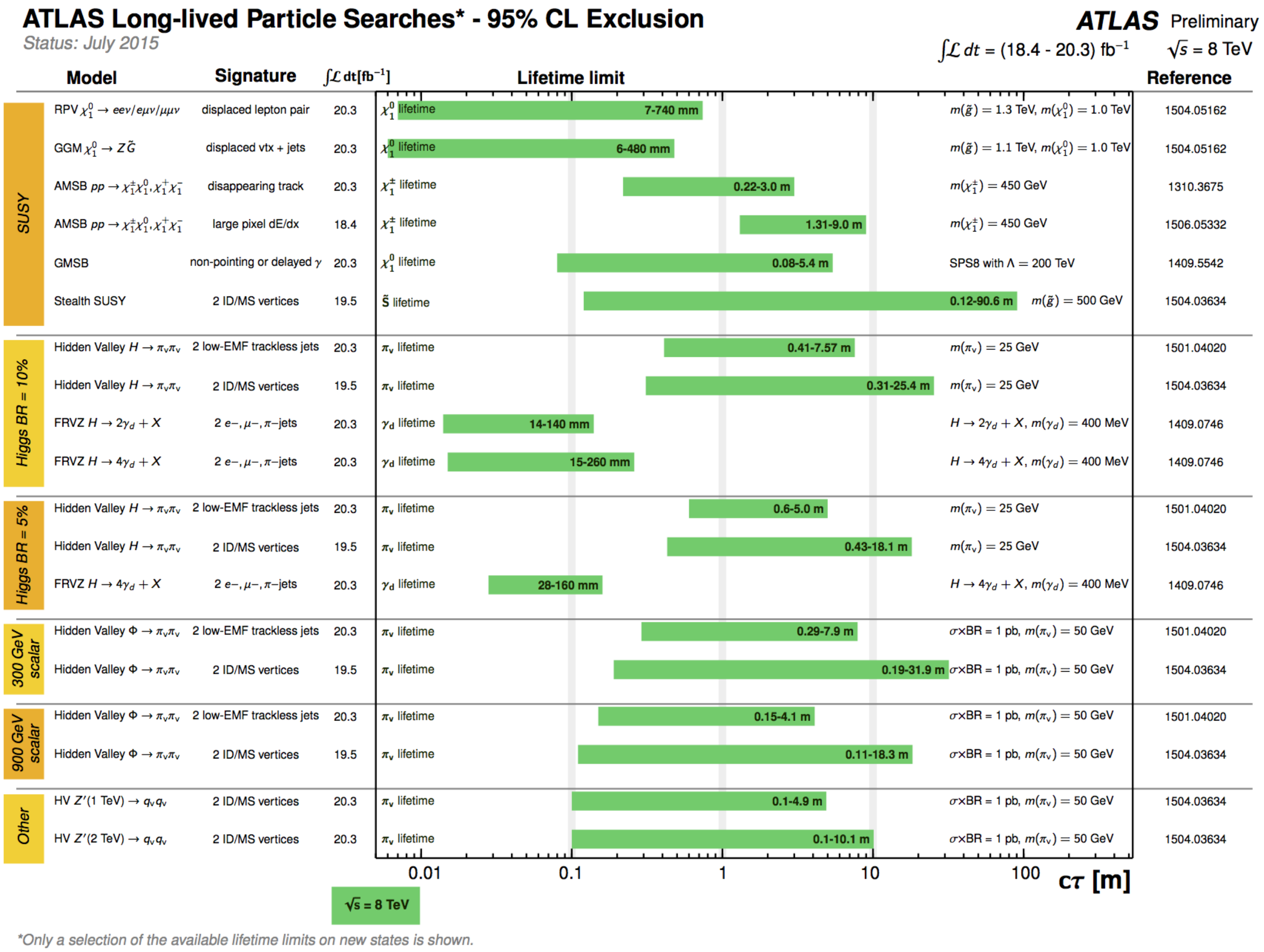
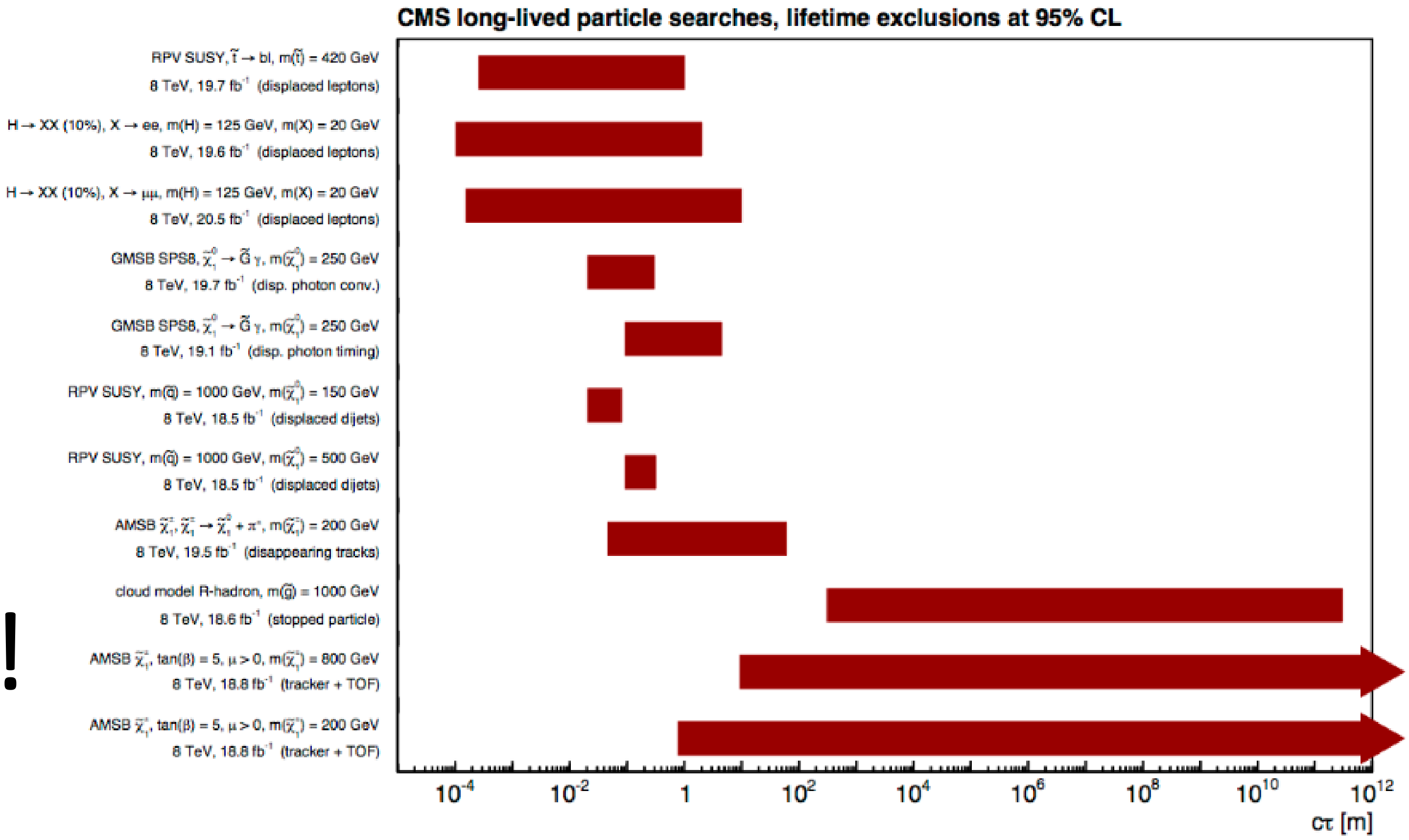
Introduction

- Many models of new physics predict long-lived (LL) particles through small/suppressed couplings or high mass scales, e.g.
  - Split/RPV/stealth SUSY, and symmetry-breaking mechanisms
  - Exotic Higgs
  - Hidden valley
  - Dark sector
- Depending on model and lifetime, particles measured with different parts of the detector: analyses focused on signatures
- This talk: small sample of searches at ATLAS and CMS
  - Mostly 8 TeV results; corresponding 13 TeV analyses in progress

First: rich program in ATLAS and CMS!



First: rich program in ATLAS and CMS!

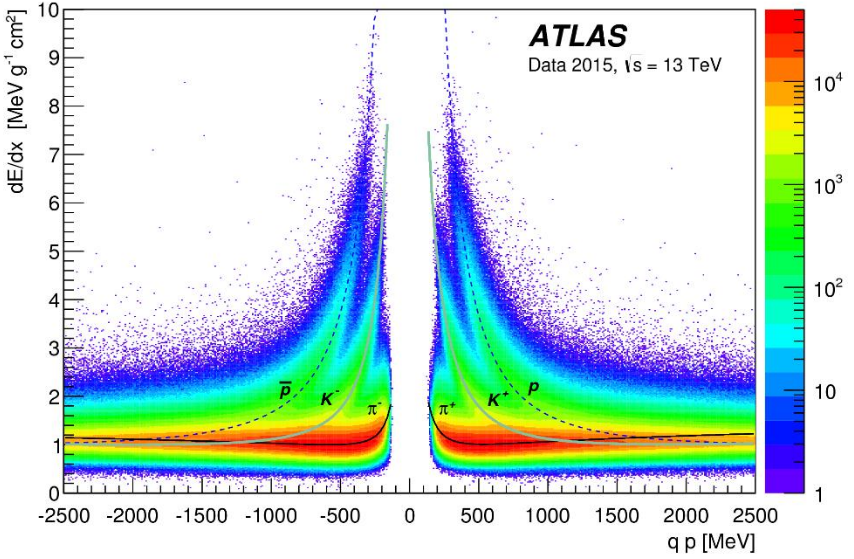


dE/dx in pixels

ATLAS, 13 TeV

SUSY-2016-03 arXiv:1604.04520

- Search for charged (meta)stable R-hadrons ($\tilde{g}$) decaying via $\tilde{g} \rightarrow q\bar{q}\tilde{\chi}^0$
- Trigger on calorimeter MET from $\tilde{\chi}^0$ or unbalanced ISR
- Look for high-p, high dE/dx track
- Reconstruct most probable value of dE/dx from pixel cluster charge info (now with IBL)
- Use parameterized Bethe-Bloch to estimate βγ → mass of particle



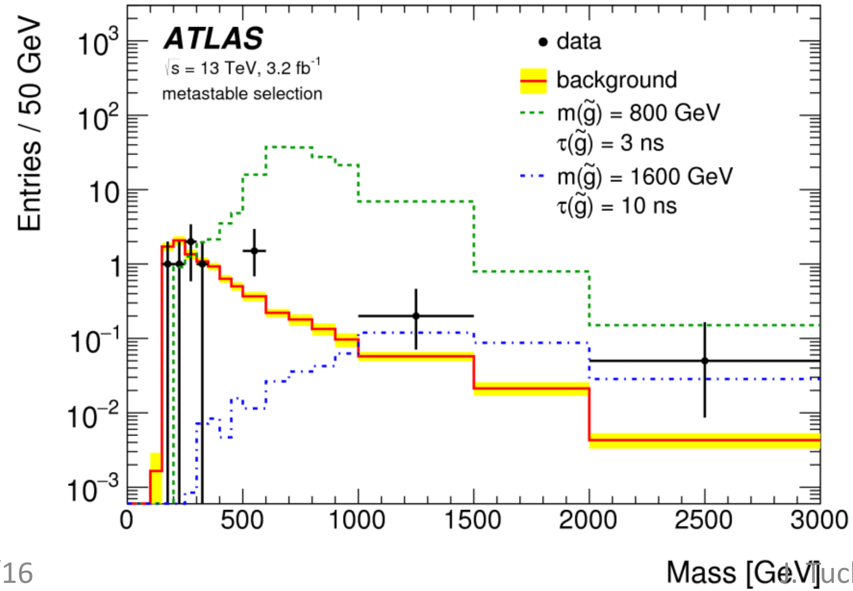
See talk from T. Lenz on Friday for more on dE/dx searches, including ATLAS 13 TeV dE/dx + TOF analysis

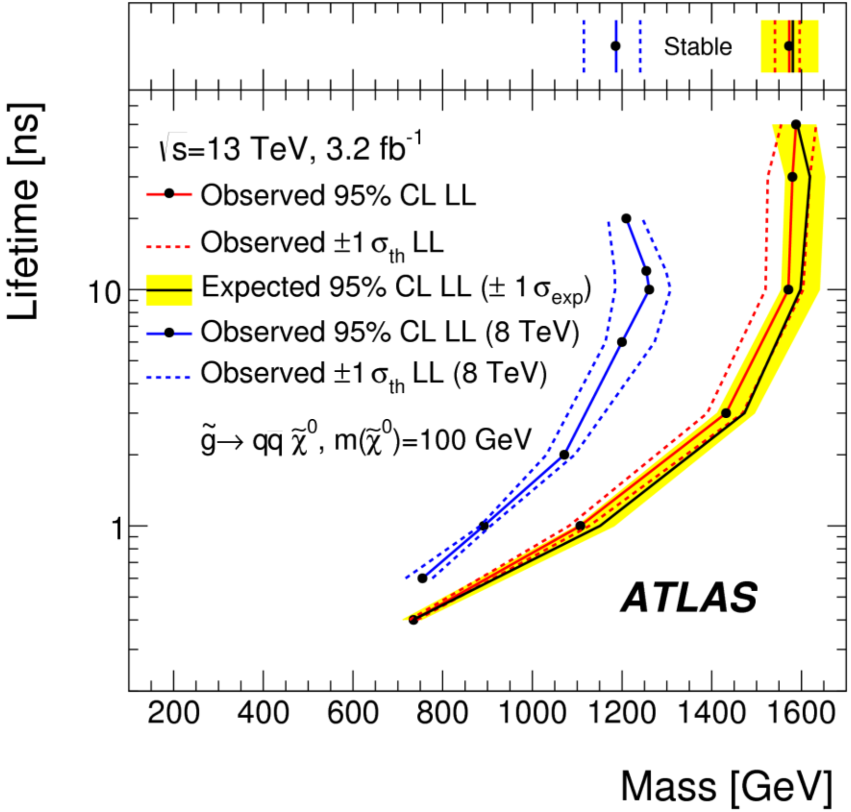
dE/dx in pixels

ATLAS, 13 TeV

SUSY-2016-03 arXiv:1604.04520

- Background estimated using control regions with tracks failing dE/dx, MET cuts
- Set improved limits as function of $\tilde{g}$ lifetime and mass



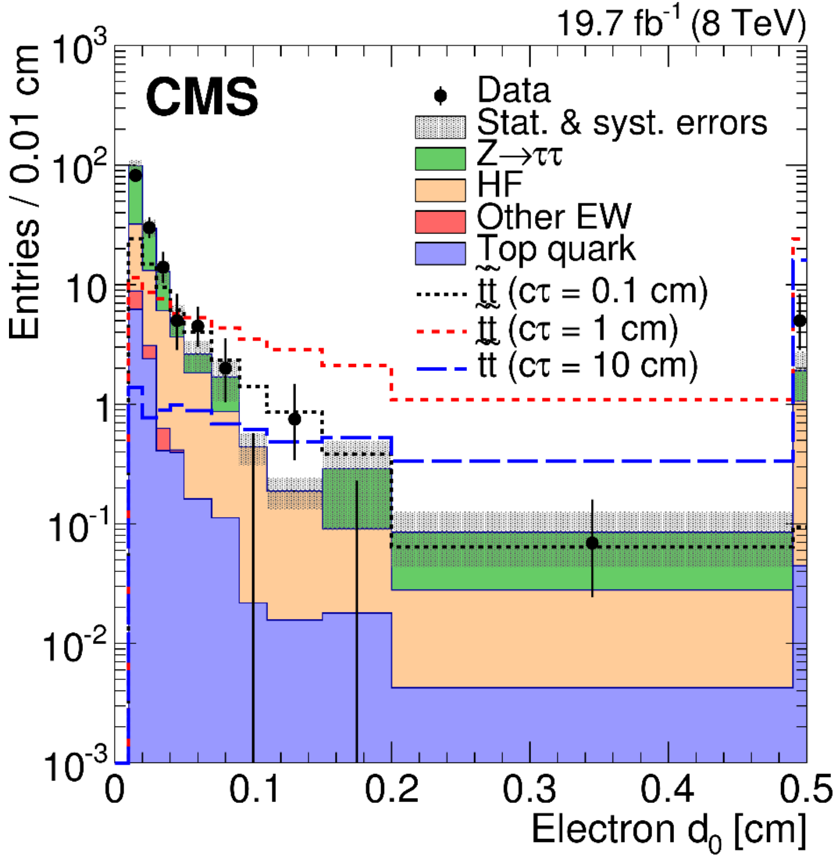


Displaced e + μ

CMS, 8 TeV

Phys. Rev. Lett. 114, 061801 (2015)

- Pair-produced $\tilde{t} \rightarrow bl$ with small RPV coupling
- Select events with isolated, oppositely-charged e + μ
- Three exclusive signal regions in 2D plane of leptons' transverse impact parameter: $0.02 < d_0 < 2$ cm
- Main SM background is heavy flavor (HF), estimated from data using non-isolated, same-sign samples (ABCD)

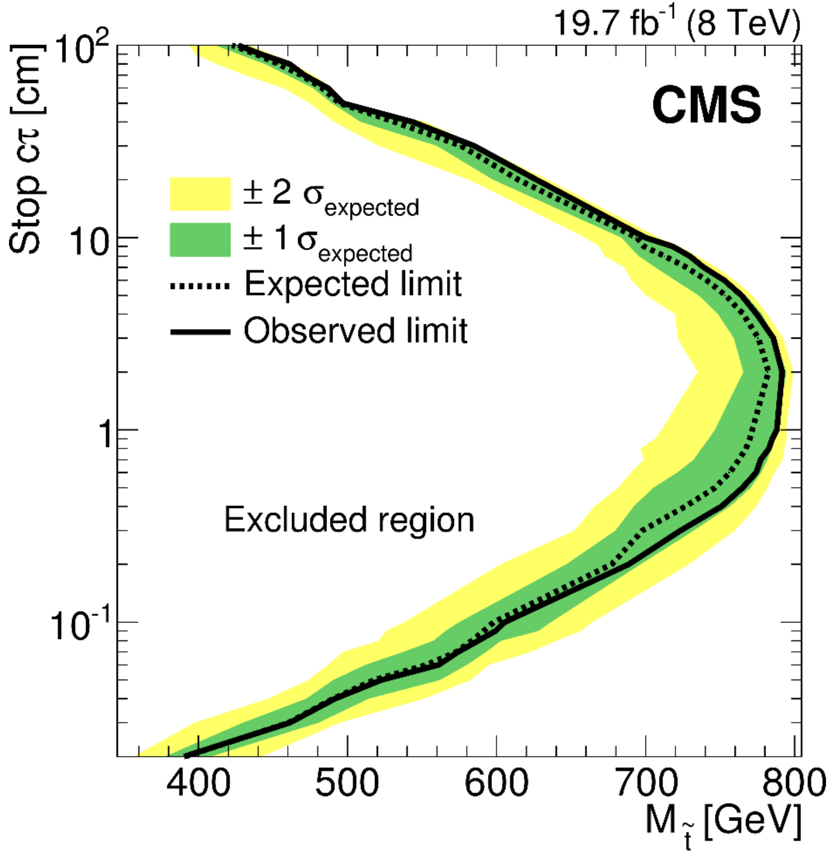


Displaced e + μ

CMS, 8 TeV

Phys. Rev. Lett. 114, 061801 (2015)

- In tightest signal region:
  - background prediction 0.05 ± 0.01 events;
  - >1 event expected for $\tilde{t}$ with M = 500 GeV and cτ = 1 mm;
  - 0 events observed.
- 95% CL limits set as function of cτ and M of $\tilde{t}$
- Inclusive requirements → sensitive to other models with oppositely-charged e + μ

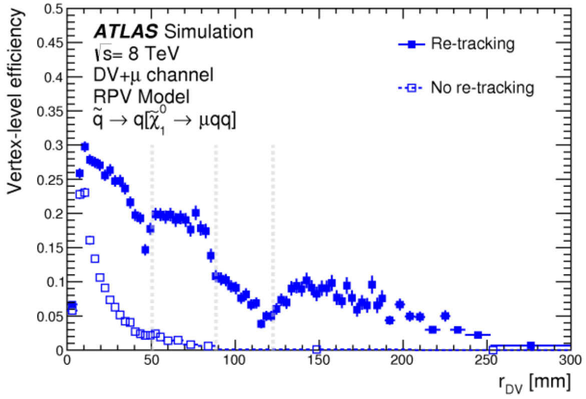


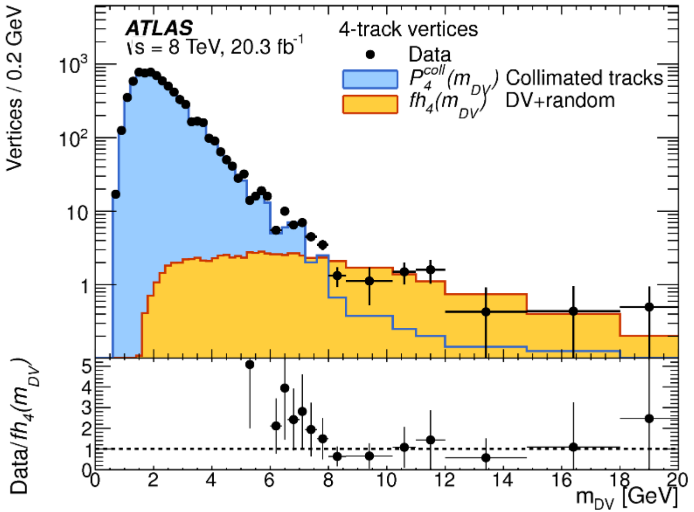
Displaced vertices + X

ATLAS, 8 TeV

Phys. Rev. D 92, 072004 (2015)

- X = e, μ, jets, or MET; X used to trigger
- "Re-tracking" to recover tracks with large d_0
- Reconstruct vertices starting from pairs of tracks, merge iteratively
- Veto vertices in detector material
- Discriminant: vertex mass and number of tracks
- Background from accidental track crossings and merged vertices: estimate from data

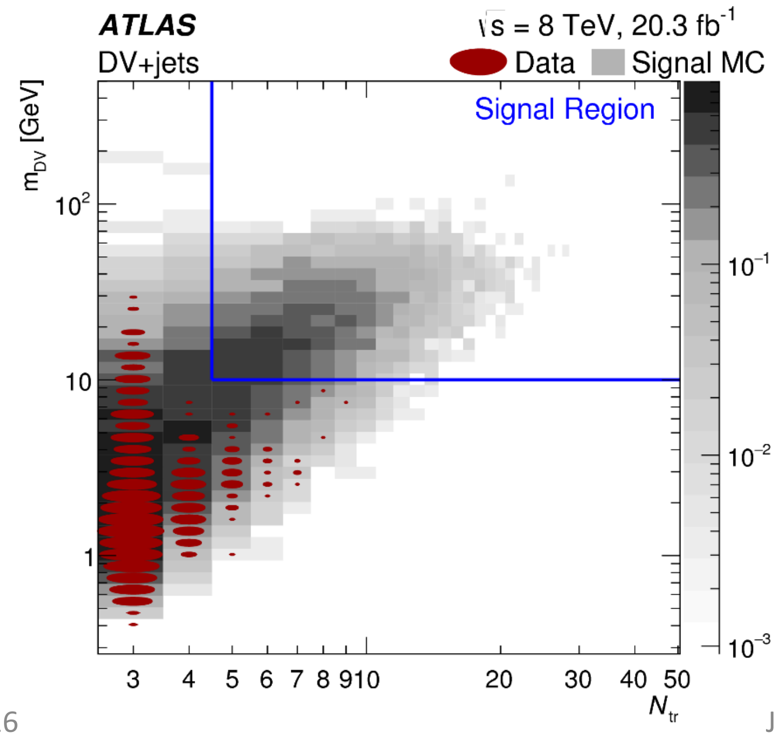


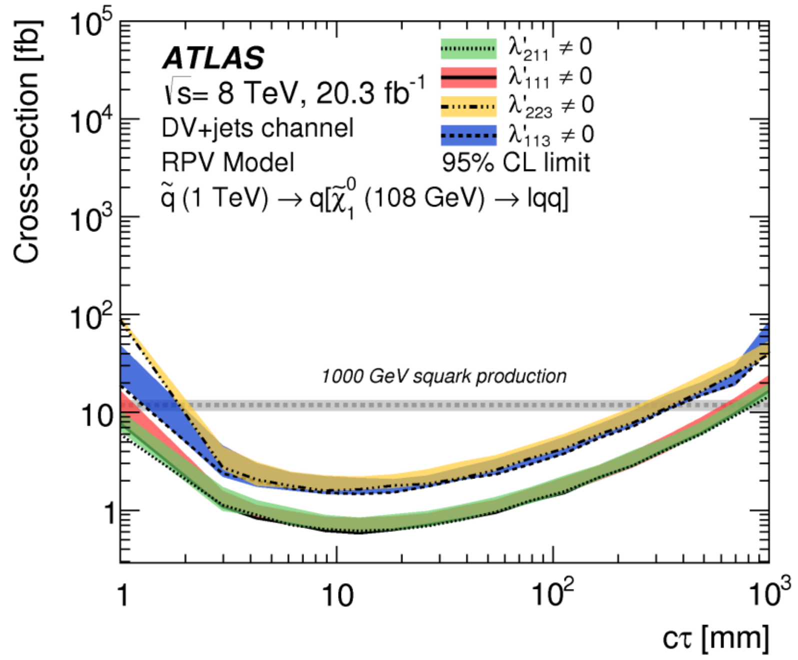


Displaced vertices + X

ATLAS, 8 TeV
Phys. Rev. D 92, 072004 (2015)

- Signal region: background prediction <1 event in all channels; 0 observed
- Interpreted in the context of many models: example RPV $\tilde{\chi}^0$ model



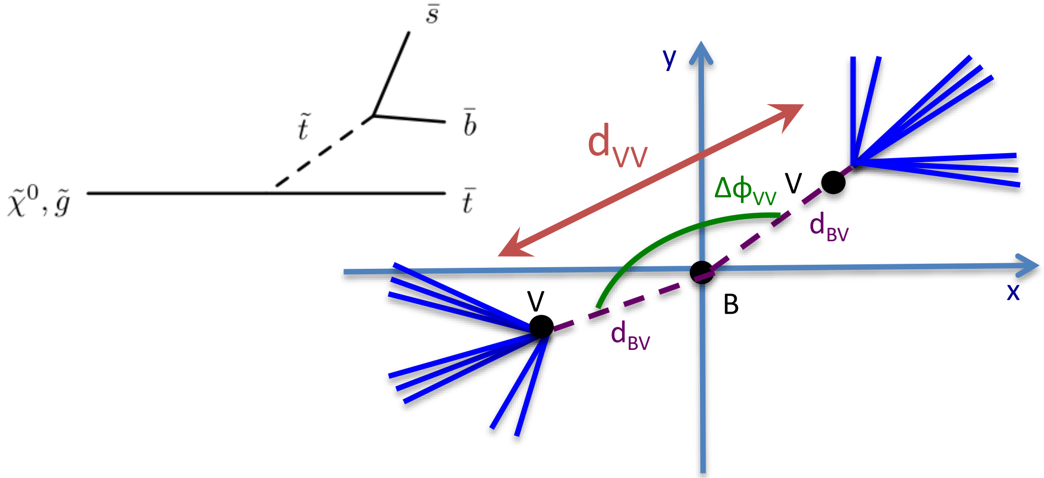


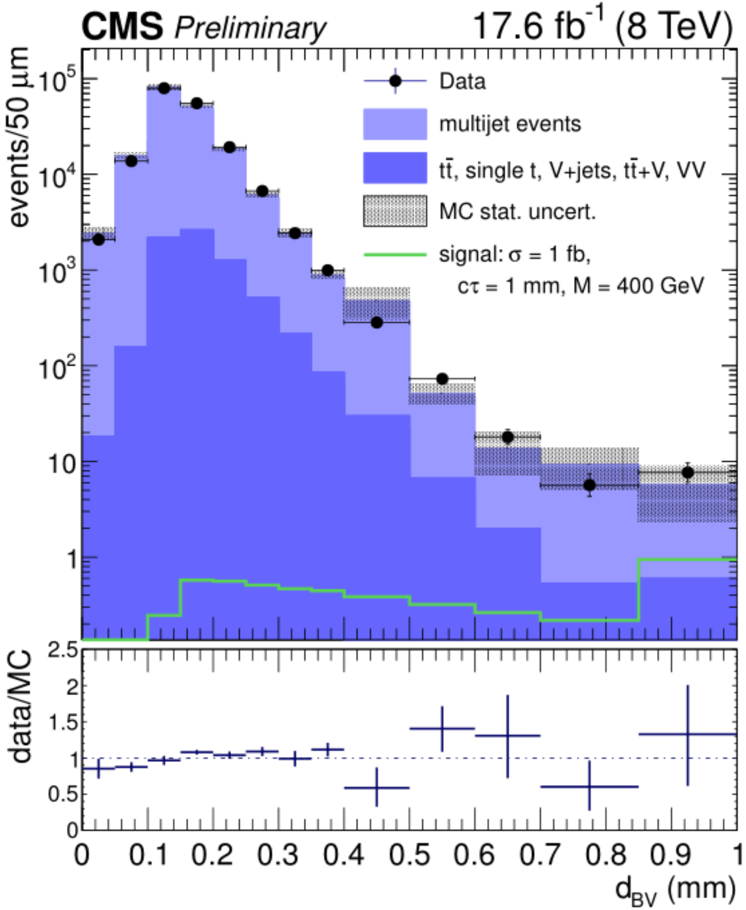
Displaced multi-jet vertices

CMS, 8 TeV

CMS-PAS-SUS-14-020

- Pair-prod. $\tilde{g} \rightarrow tbs$: 2 displaced multi-jet vertices
- Focus on intermediate lifetimes down to 300 μm
- Background from mis-reconstruction, b quark jets
- Discriminant d_{VV}: x-y distance between vertices
- Estimate background using distances, angles in one-vertex sideband



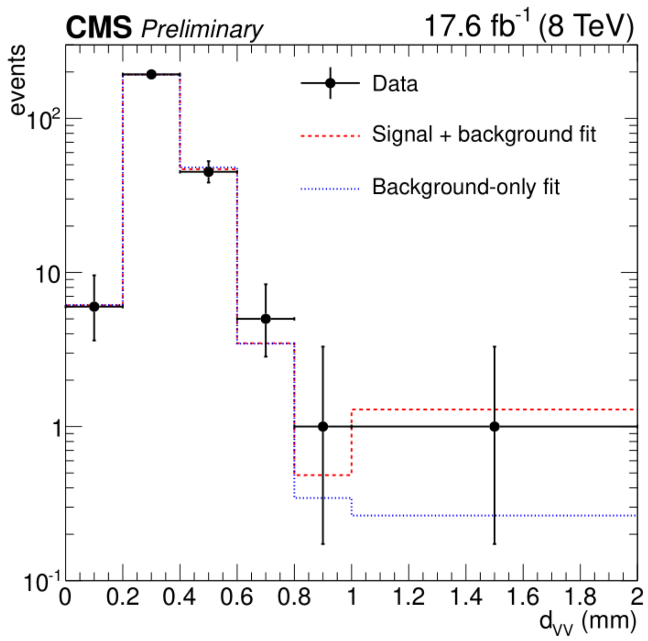


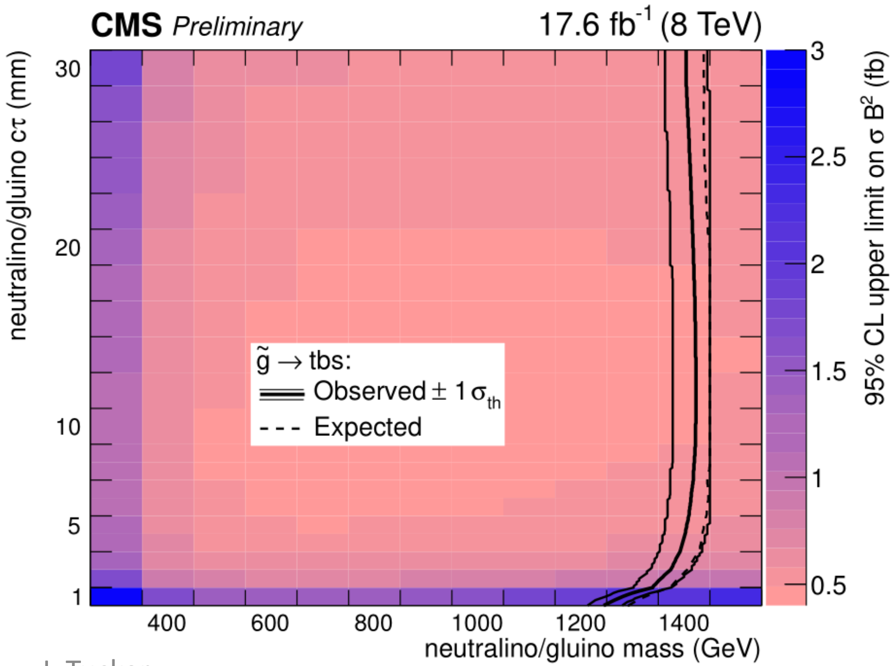
Displaced multi-jet vertices

CMS, 8 TeV

CMS-PAS-SUS-14-020

- Fit with signal template from MC, background from data
- Set 95% CL upper limits as function of lifetime and mass





Summary

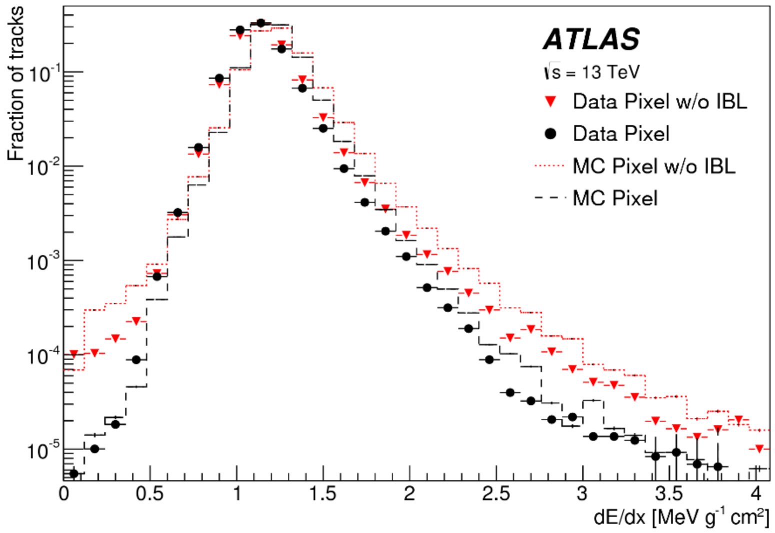
- Searches for long-lived particles are an active, rich program both w. theorists and at ATLAS + CMS
- Different decays and mass + lifetime ranges lend to different experimental techniques
  - Many analyses using different objects and targeting different models not described here!
- 8 TeV program set the stage for Run 2; many 13 TeV analyses underway!

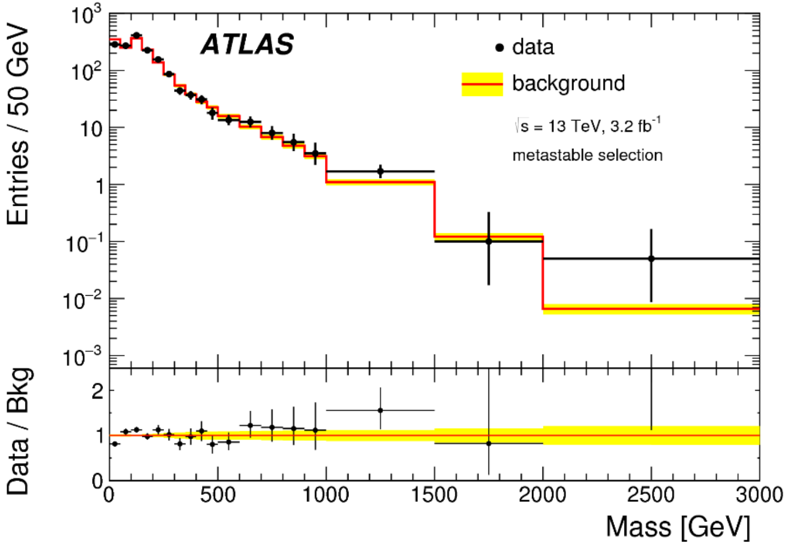
Supplementary material

dE/dx in pixels

ATLAS, 13 TeV

SUSY-2016-03 arXiv:1604.04520





Displaced e + μ

CMS, 8 TeV

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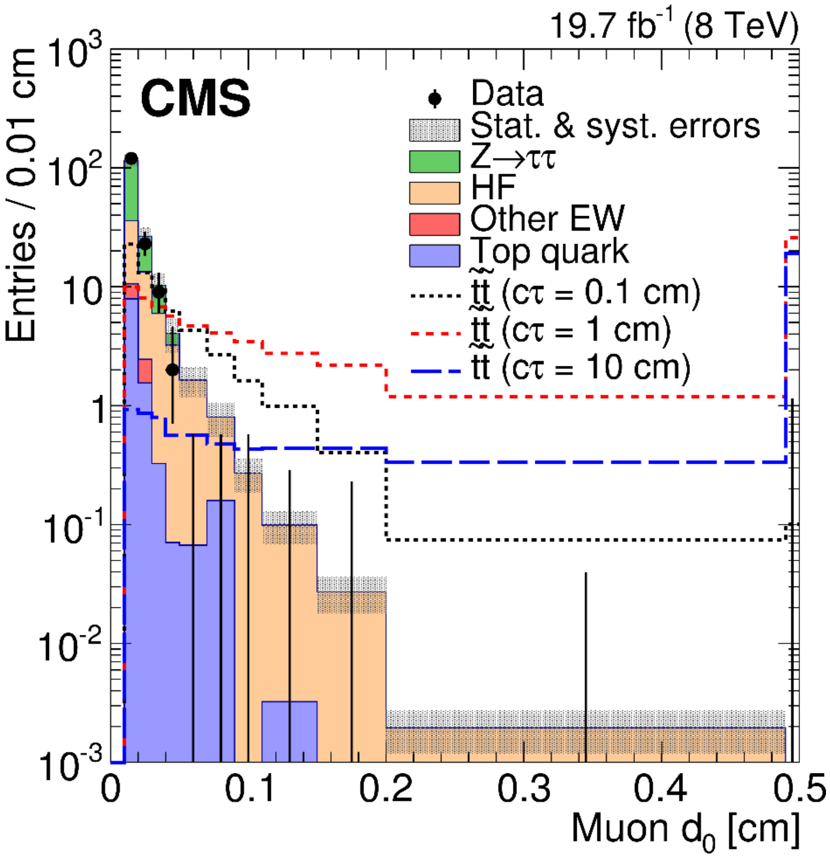

Displaced vertices + X

ATLAS, 8 TeV

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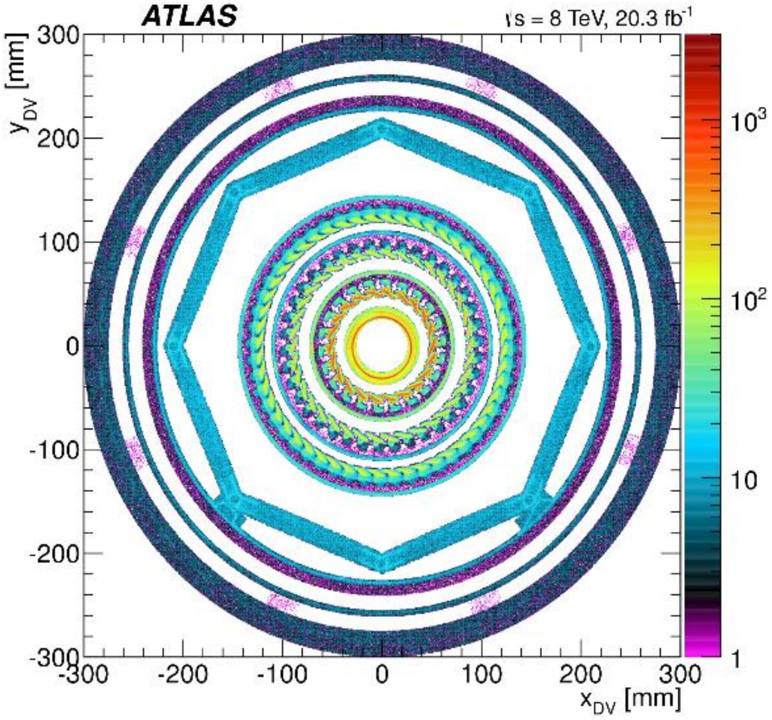
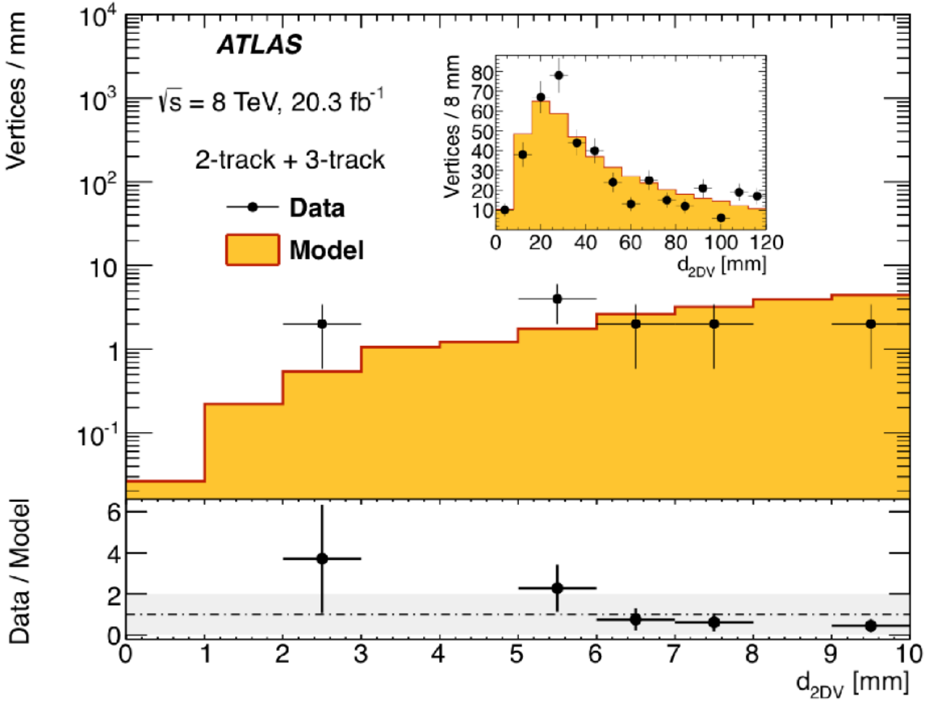
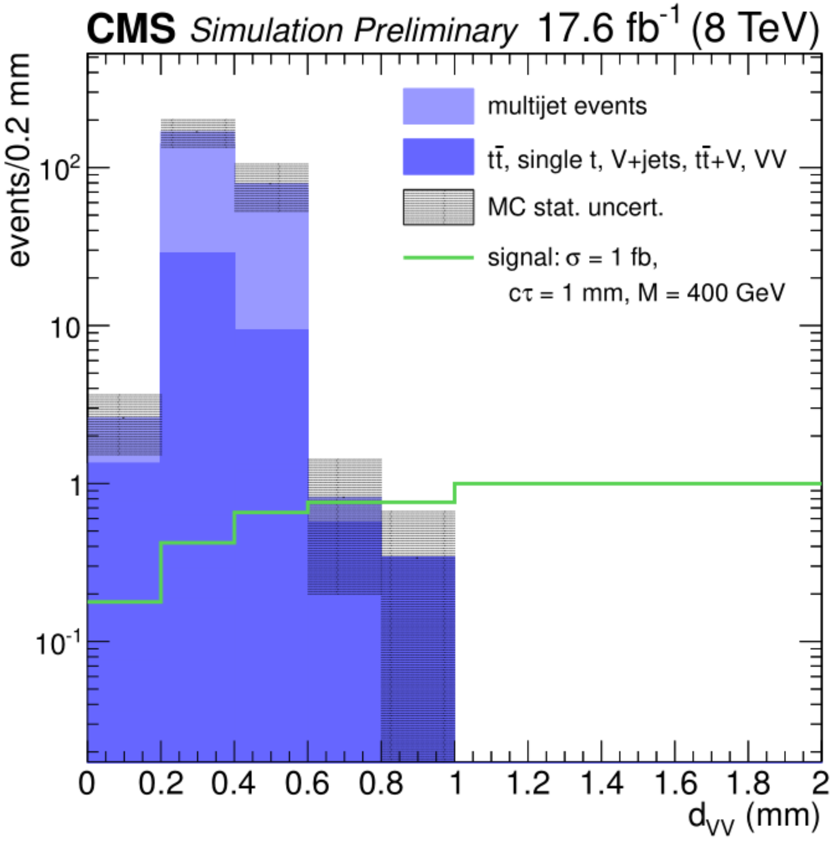


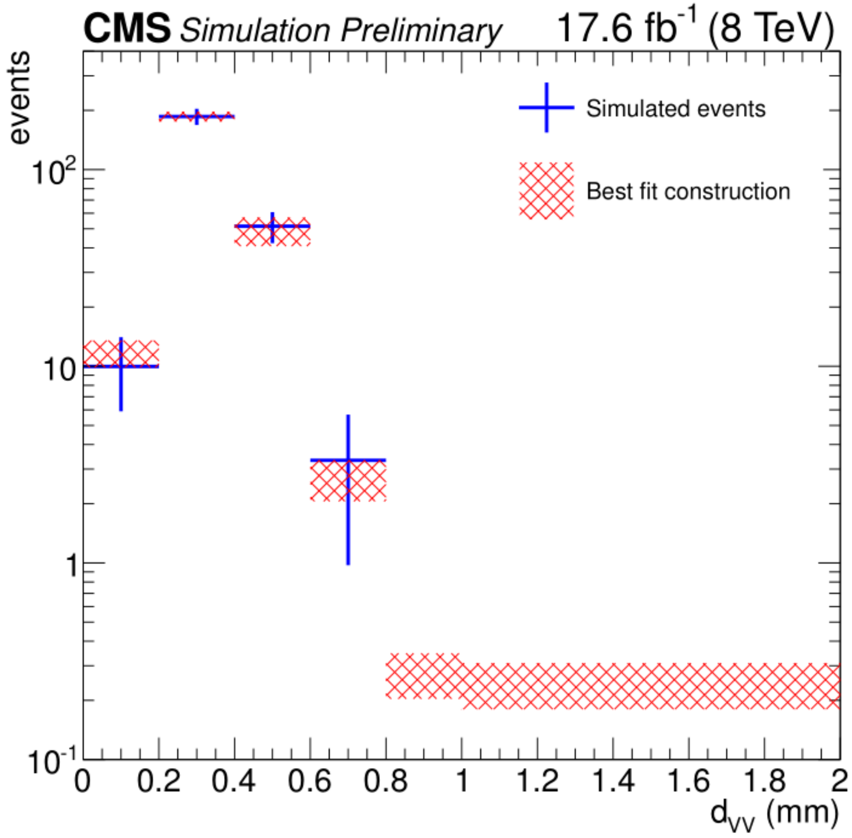


Displaced multi-jet vertices

CMS, 8 TeV

CMS-PAS-SUS-14-020





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CMS, 8 TeV

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