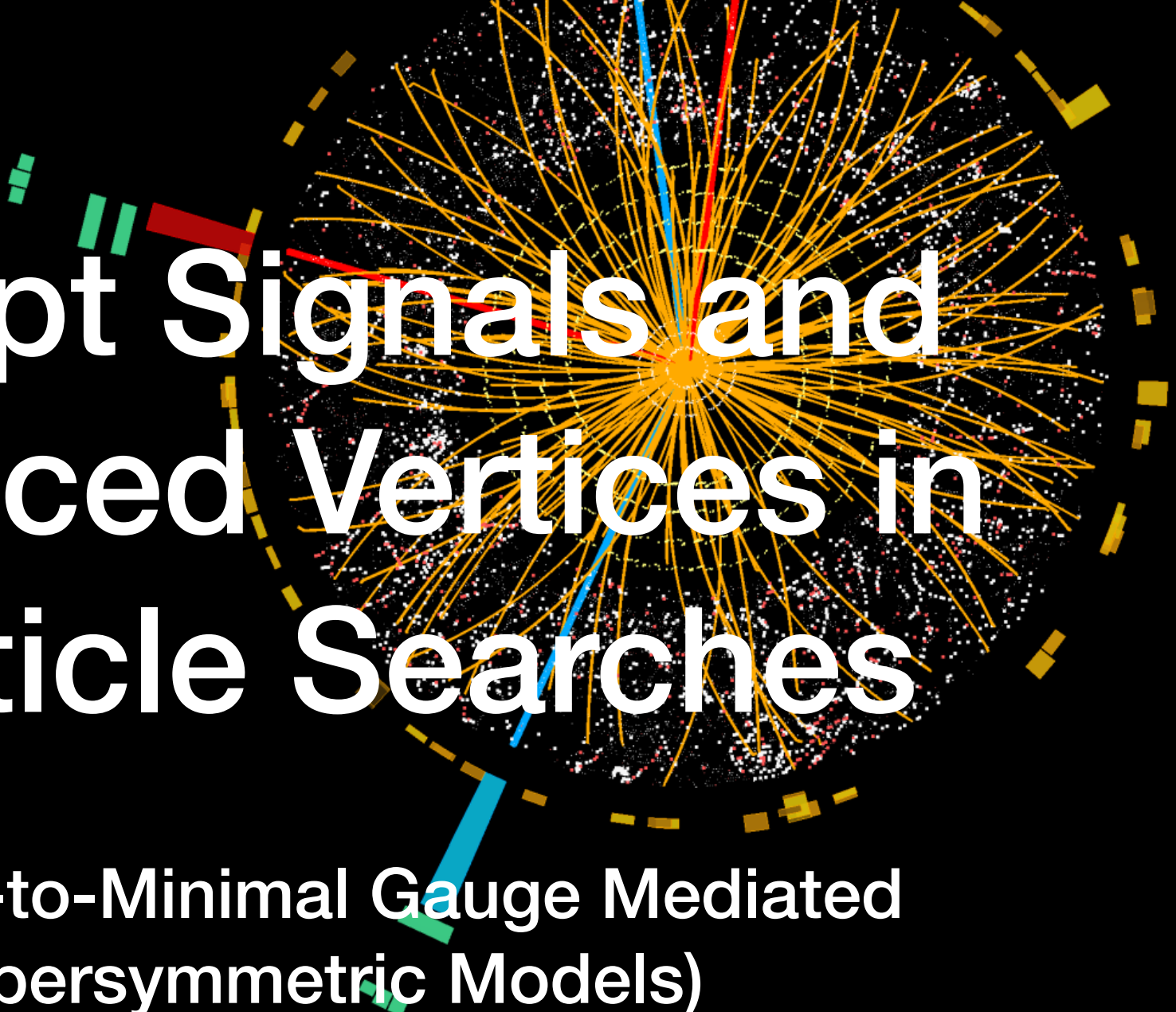


A particle detector event visualization showing a central vertex with numerous tracks radiating outwards. The tracks are colored in yellow, blue, and red, and are surrounded by a dense cloud of small white and red dots. The background is black.

Prompt Signals and Displaced Vertices in Sparticle Searches

(for Next-to-Minimal Gauge Mediated Supersymmetric Models)

Based on EPJC (2016) 76:482

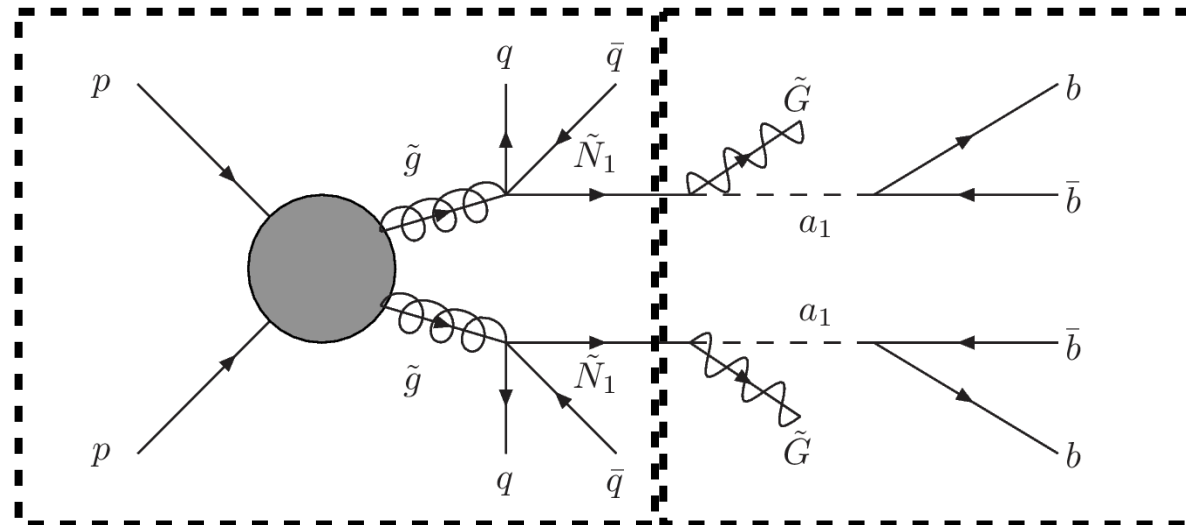
Nishita Desai; LUPM, Montpellier

Collaborators: B. Allanach, M. Badziak, G. Cottin, C. Hugonie, R. Ziegler



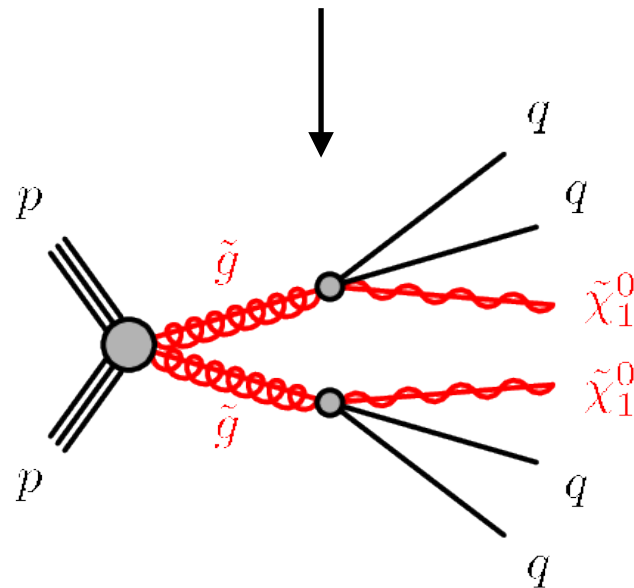
SUSY 2017; TIFR, Mumbai

NMSSM: Long Lived Neutral Particles



Same as
standard SUSY

New decay

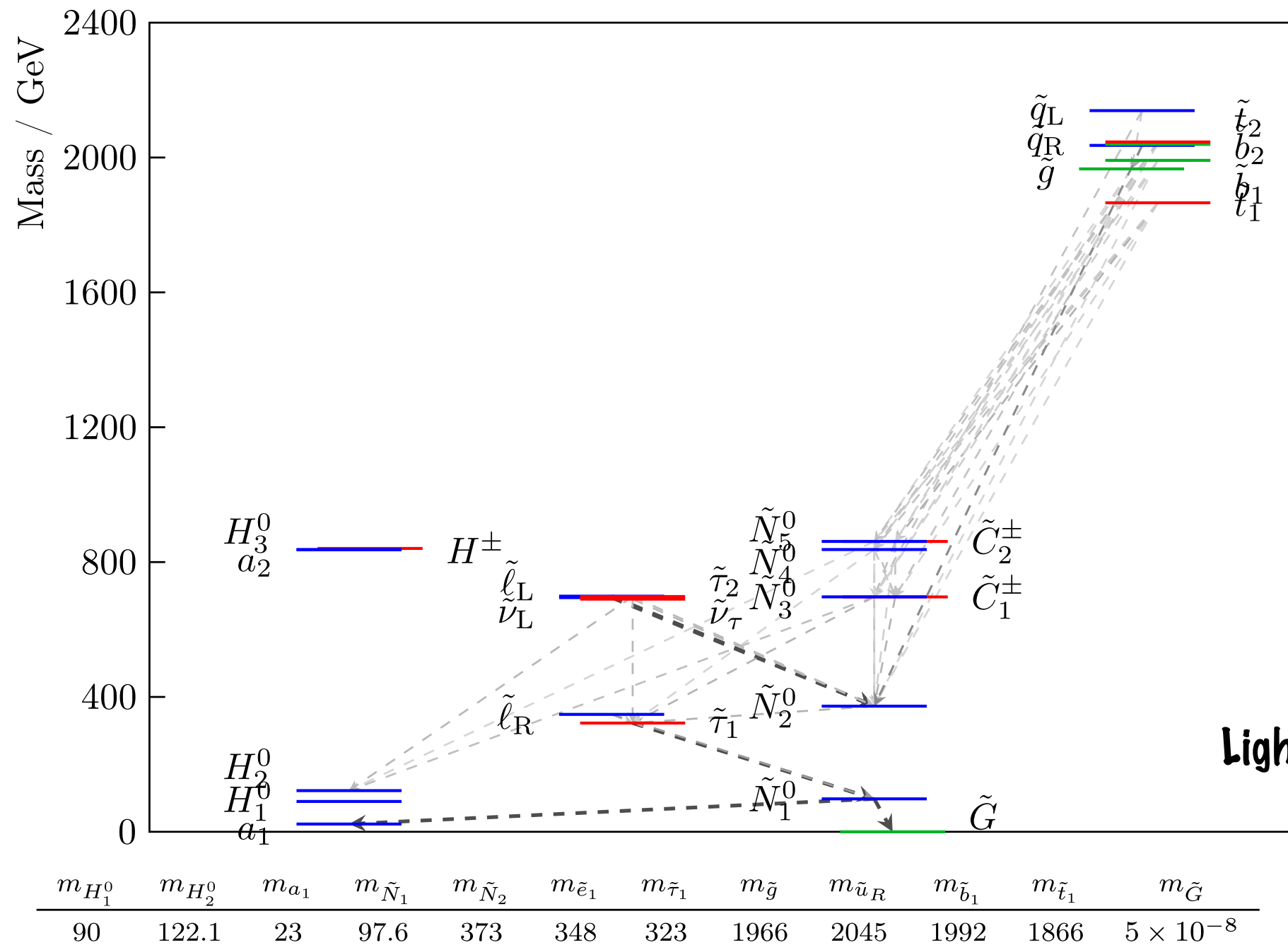


Questions:

1. Can ordinary SUSY searches find this scenario?
2. What are the effects of the extra pseudo scalar

- Supersymmetry with extra singlino & gauge mediation
 - ✓ Predicts 125 GeV higgs mass
 - ✓ Doesn't violate low-scale observables
 - ✓ Predicts high masses of strongly charged SUSY partners
- Predicts a pseudo-scalar boson of mass ~ 30 GeV; all chains end in producing this boson
- This boson has a lifetime ~ 1 mm (due to boost, decays after traveling ~ 100 mm in the detector)

Spectrum of model



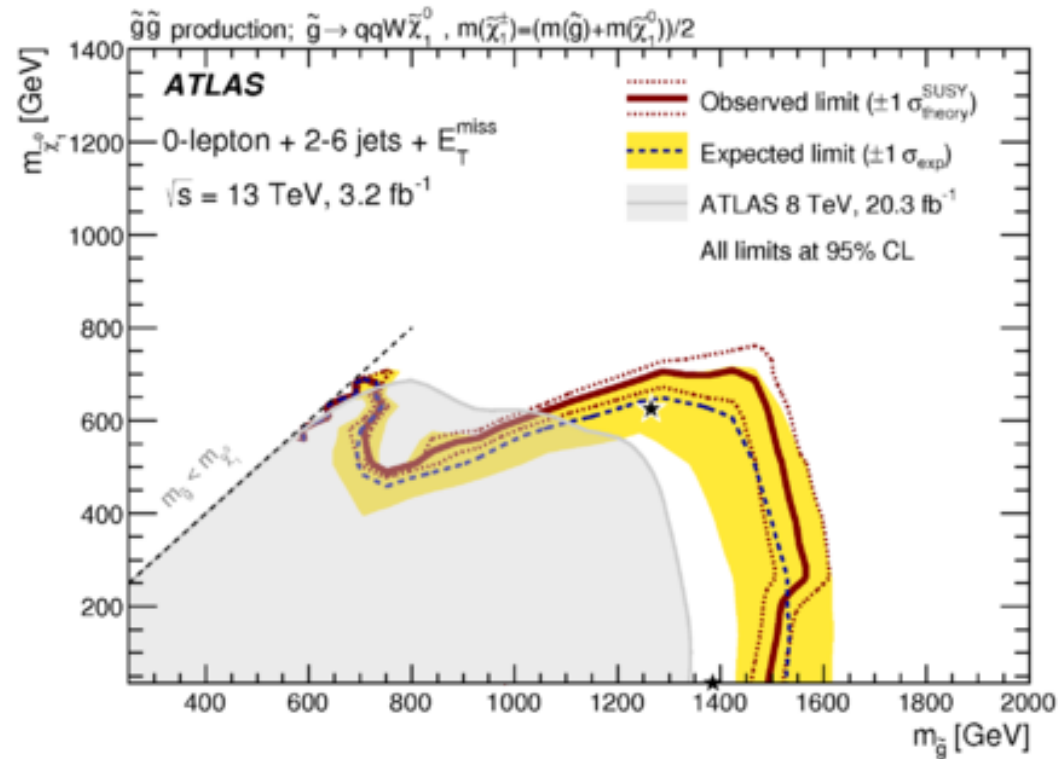
Naturally predicts heavy strong sector to get the right higgs mass

Lightest neutralino not stable

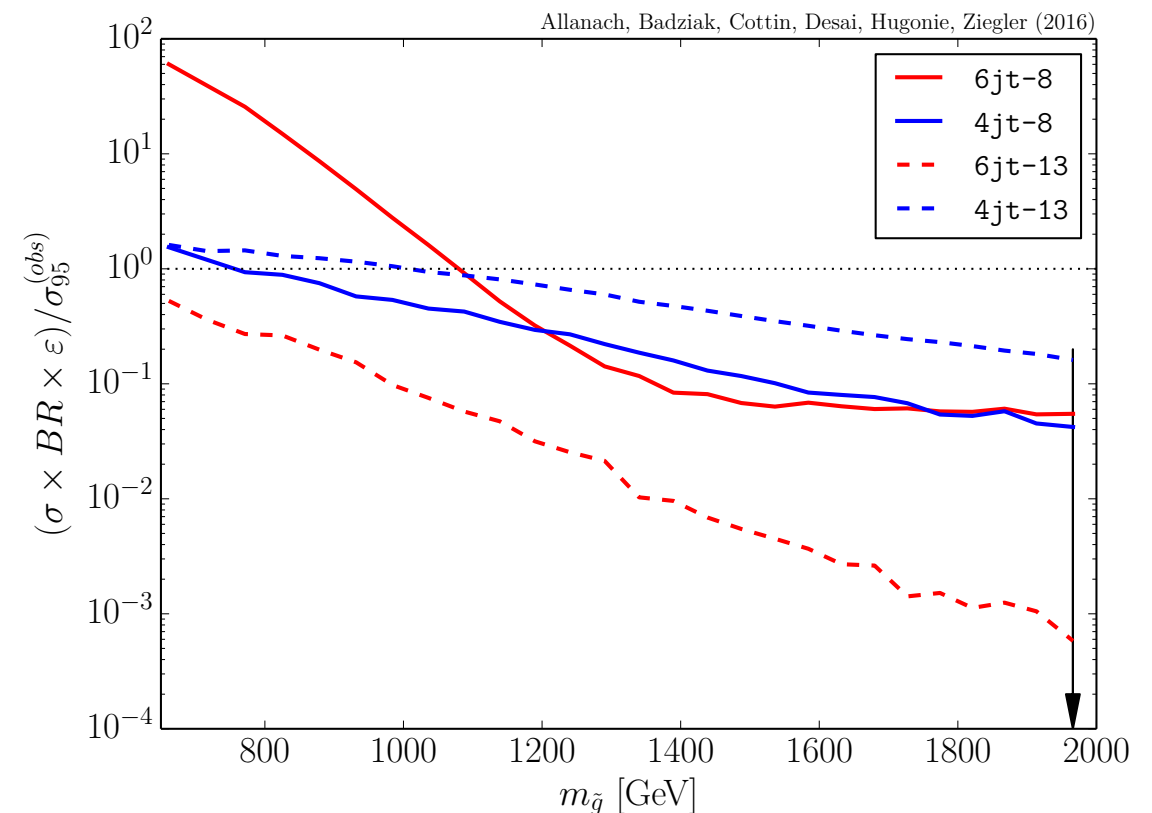
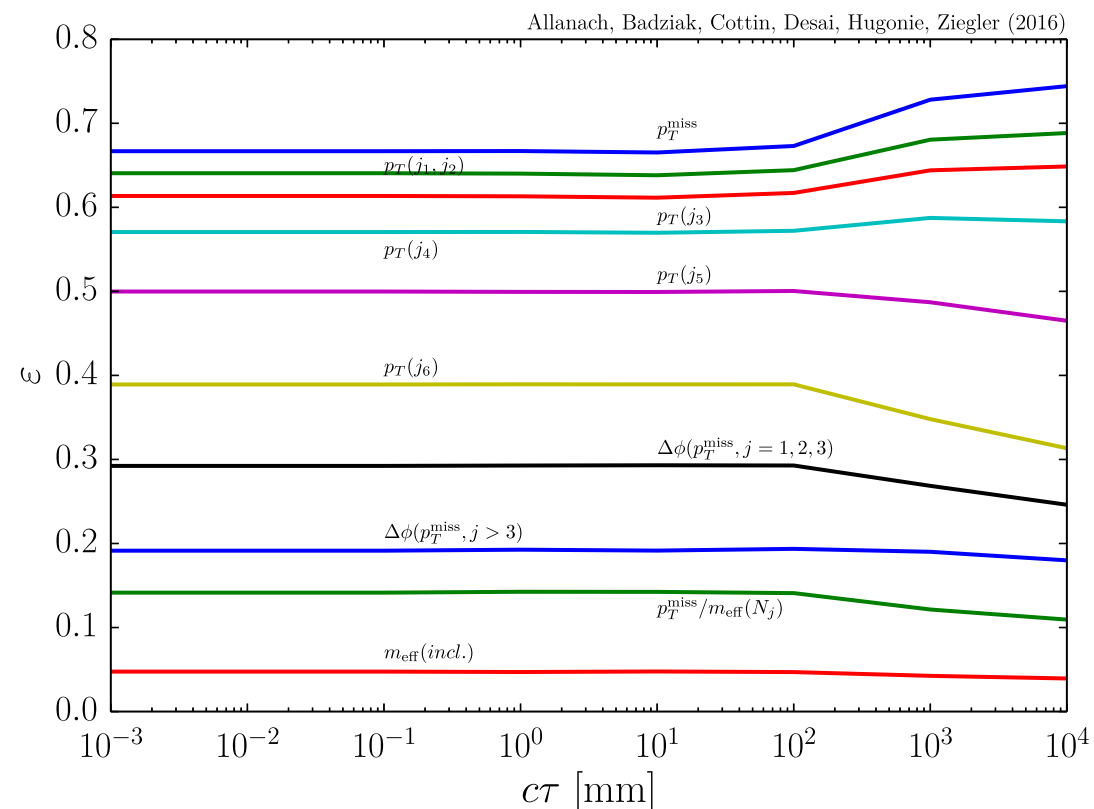
a_1 decays mainly to $b\bar{b}$, decay is long lived!

Recasting SUSY jets+MET search

ATLAS coll. EPJC (2016)

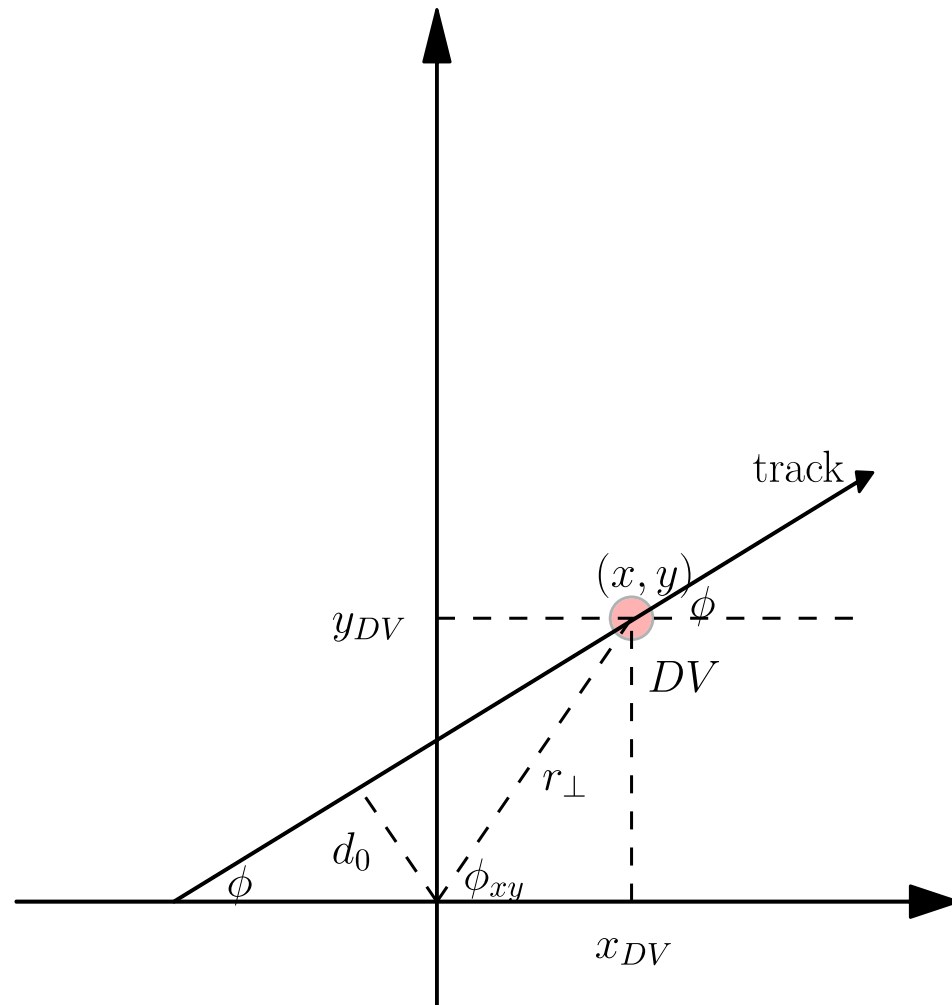


$\sqrt{s}$	8 TeV		13 TeV	
Signal region	4jt-8	6jt-8	4jt-13	6jt-13
$p_T^{\text{miss}}/\text{GeV} >$	160	160	200	200
$p_T(j_1)/\text{GeV} >$	130	130	200	200
$p_T(j_2)/\text{GeV} >$	60	60	100	100
$p_T(j_3)/\text{GeV} >$	60	60	100	100
$p_T(j_4)/\text{GeV} >$	60	60	100	100
$p_T(j_5)/\text{GeV} >$	—	60	—	50
$p_T(j_6)/\text{GeV} >$	—	60	—	50
$\Delta\phi(\text{jet}_{1,2,3}, \mathbf{p}_T^{\text{miss}})_{\min} >$	0.4			
$\Delta\phi(\text{jet}_{j>3}, \mathbf{p}_T^{\text{miss}})_{\min} >$	0.2			
$p_T^{\text{miss}}/m_{\text{eff}}(N_j) >$	0.25		0.2	
$m_{\text{eff}}(\text{incl.})/\text{GeV} >$	2200	1500	2200	2000
$\sigma_{95}^{\text{obs}} (\text{fb})$	0.15	0.32	2.7	1.6



The displaced vertex search

ATLAS Coll. Phys. Rev. D (2015)



DV jets

4 or 5 or 6 jets with $|\eta| < 2.8$ and $p_T > 90, 65, 55$ GeV, each

DV reconstruction

DV made from tracks with $p_T > 1$ GeV, $|\eta| < 2.5$ and $|d_0| > 2$ mm, satisfying a tracking efficiency

Vertices within 1 mm are merged

DV fiducial

DV within $4 \text{ mm} < r_{DV} < 300 \text{ mm}$ and $|z_{DV}| < 300 \text{ mm}$

DV material

No DV in regions near beampipe or within pixel layers:

Discard tracks with $r_{DV}/\text{mm} \in \{[25, 38], [45, 60], [85, 95], [120, 130]\}$

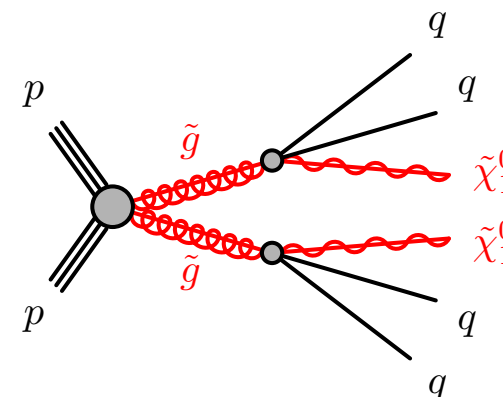
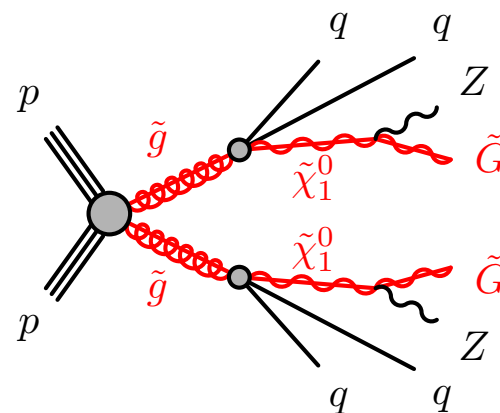
N_{trk}

DV track multiplicity ≥ 5

m_{DV}

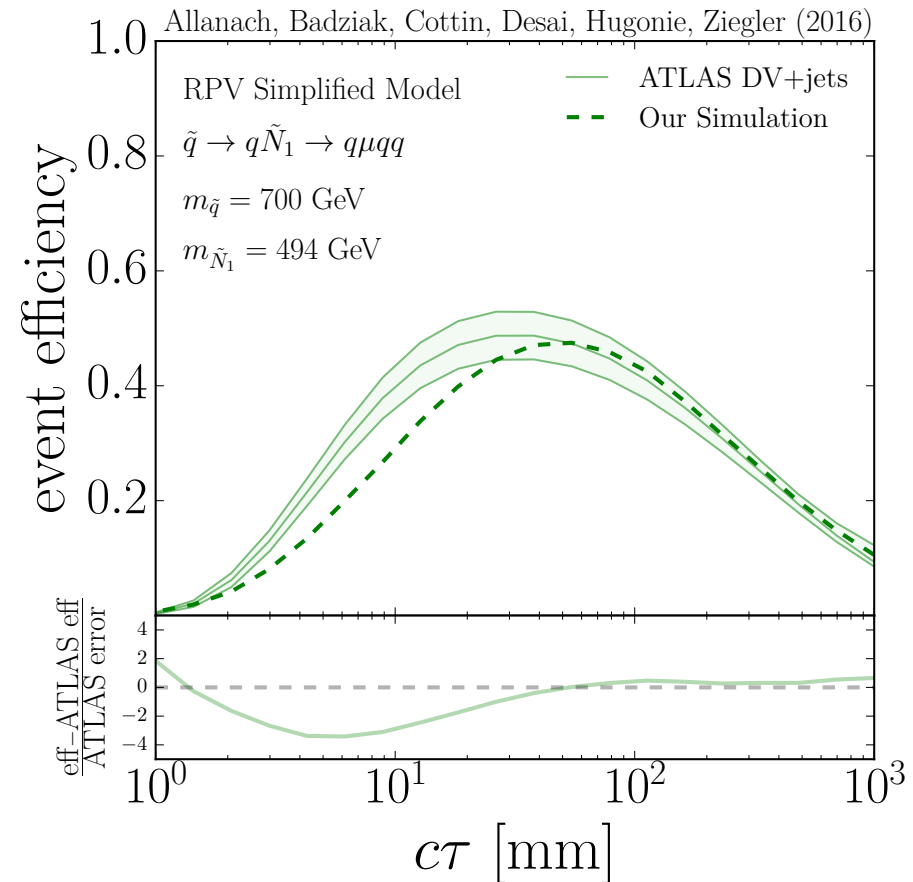
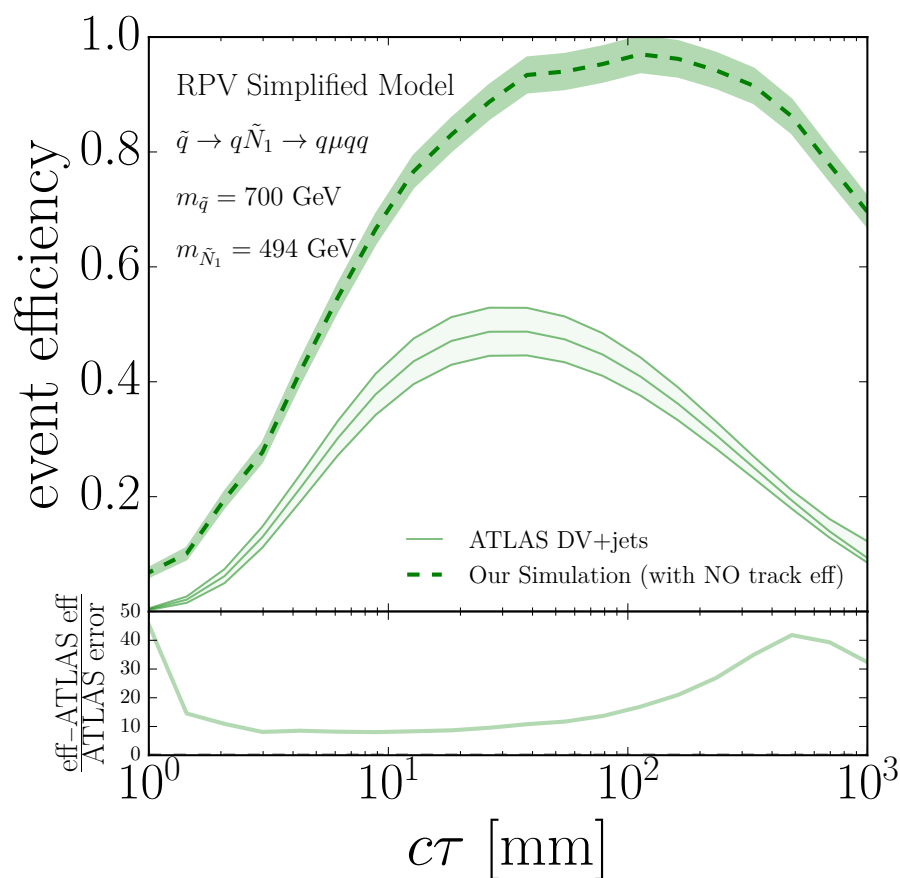
DV mass > 10 GeV

Gauge Mediated benchmarks



RPV benchmark

Finding the track efficiency



Tracking efficiency determined by fitting parameters of an empirical function

$$\varepsilon_{\text{trk}} = 0.5 \times (1 - \exp(-p_T/[4.0 \text{ GeV}]))$$

$$\times \exp(-z/[270 \text{ mm}])$$

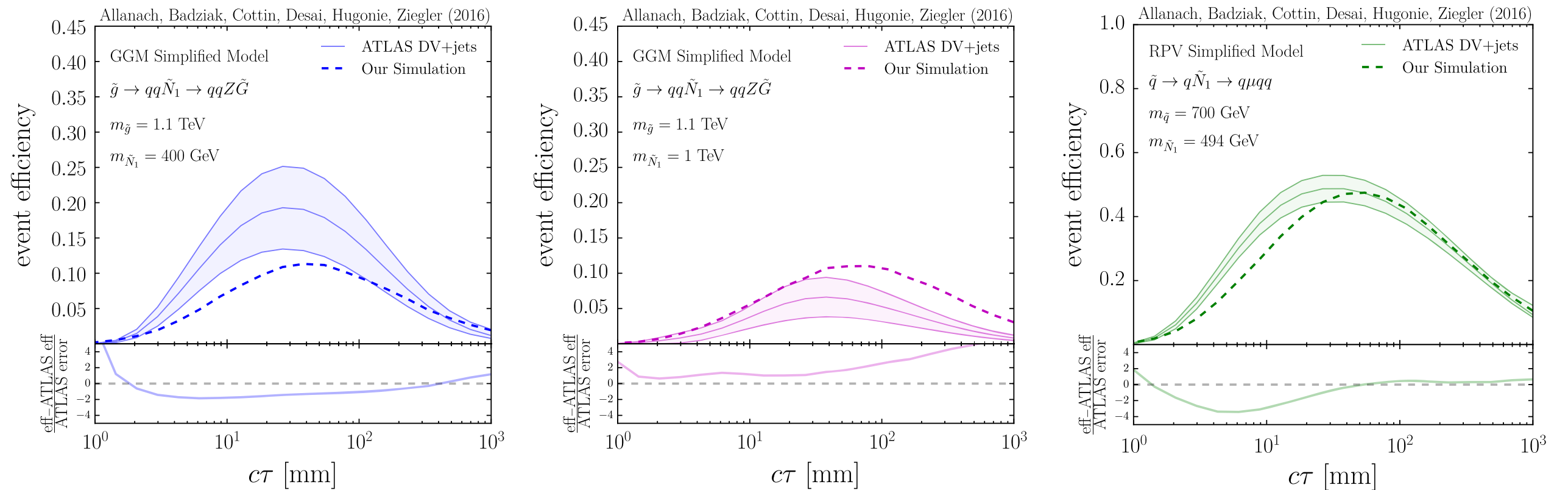
$$\times \max(-0.0022 \times r_{\perp}/[1 \text{ mm}] + 0.8, 0)$$

Remove low p_T

Dependence on z of DV (i.e. truth of decay vertex)

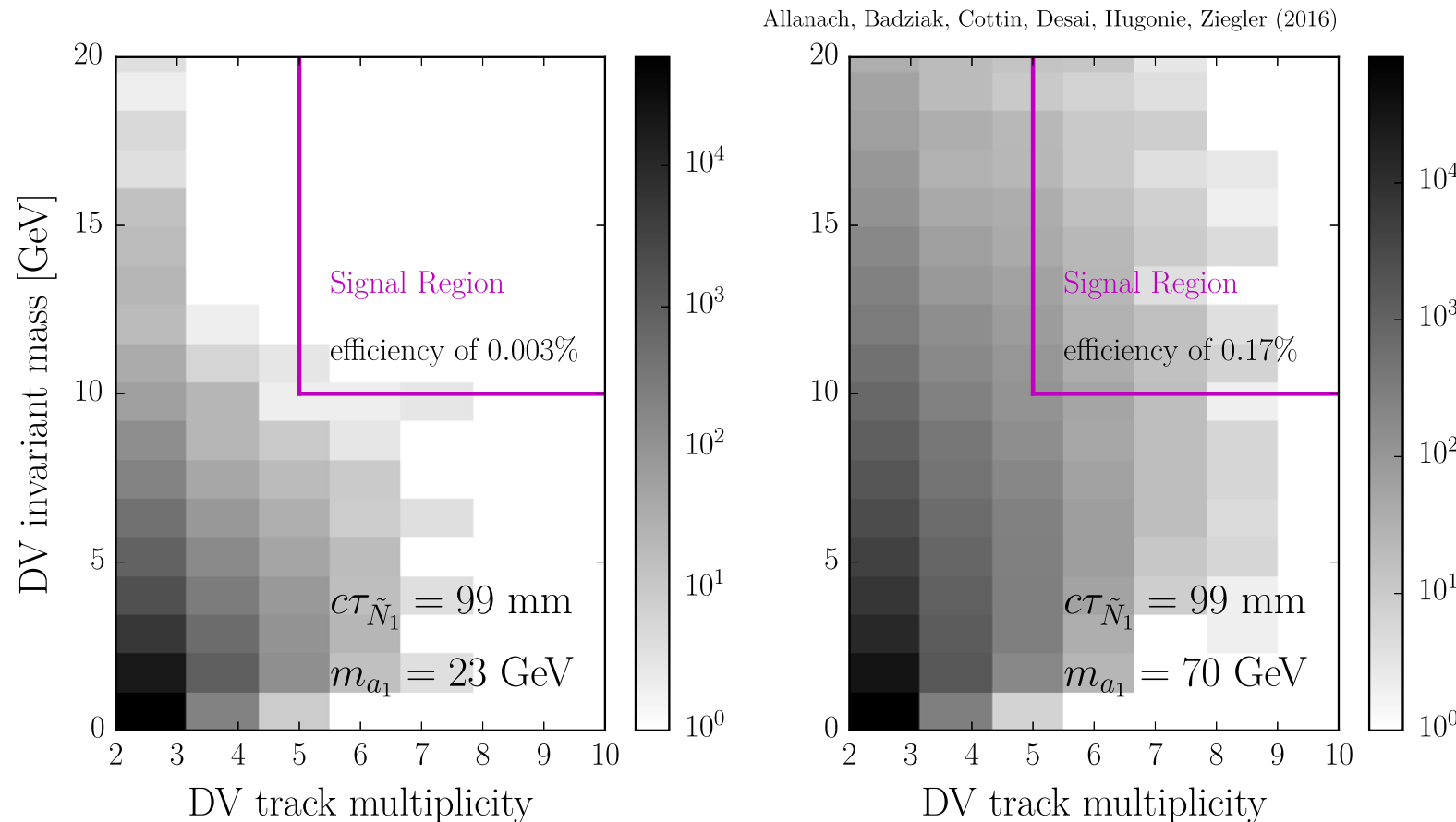
Dependence on radial distance of DV

Finding the track efficiency

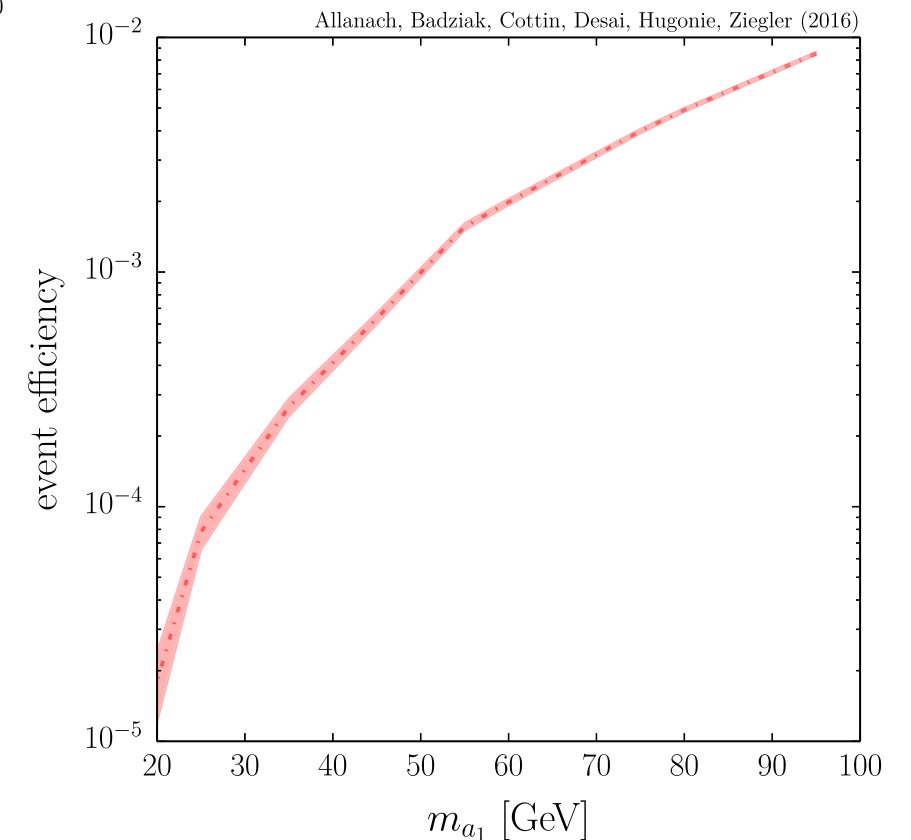


- Fitting any one benchmark gives vary bad fit for others
 - ➔ Not the right parameters? (we tried d_0 , z_0 with no improvement)
 - ➔ Hidden dependence on extra variables?
- Three benchmarks used to fit tracking parameters as a compromise

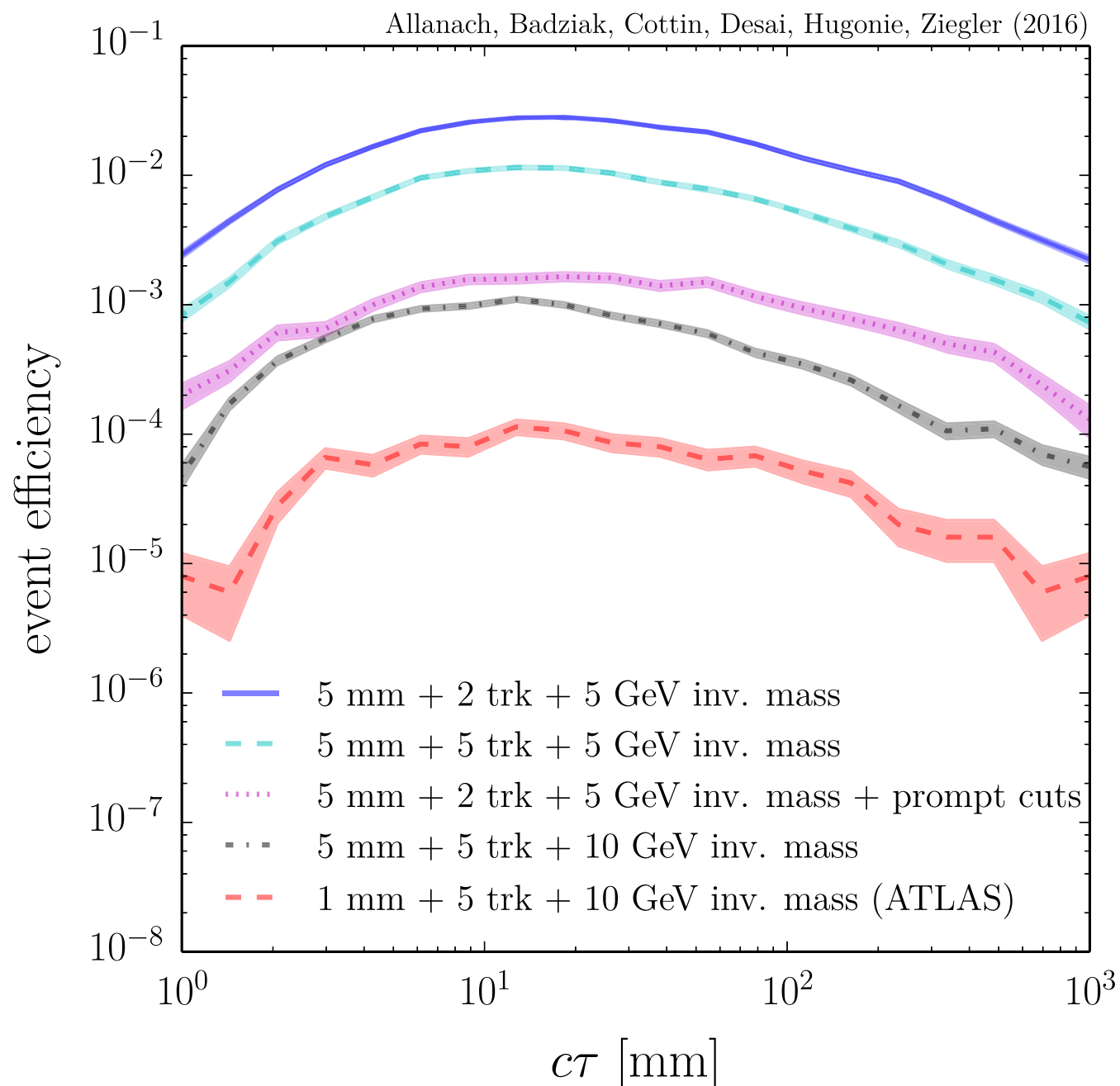
Dependence on DV mass and N_{trk}



Our model fails to satisfy the DV cuts because of long lived B-mesons in the final state. This improves with heavier a_1 .



Modifying the displaced vertex criteria



- It is possible to significantly improve efficiency by relaxing cuts
- Not easy to estimate background for these changes
- Our solution: combine prompt cuts + DV cuts & use prompt background estimate as a conservative upper limit
- Reach can be 1.9 TeV with 100/fb
- Much better sensitivity possible with better estimate of background

Summary

- Prompt searches lost sensitivity for this model due to presence of long-lived particles
- Using displaced vertex signature with hard prompt cuts improves sensitivity of analysis + points to underlying model
- Much more optimisation of this search possible with a dedicated background estimate.
- It is currently not easy to recast displaced vertex searches; more input needed from experimentalists
- Also for proposing new searches: how to estimate background for this kind of searches?