

# CheckMATE

## LLP implementation

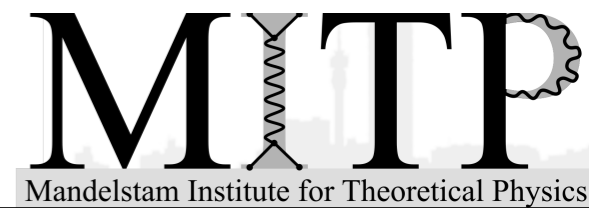
Joint Session with Long-Lived Particles Workshop

CERN

16/05/2018

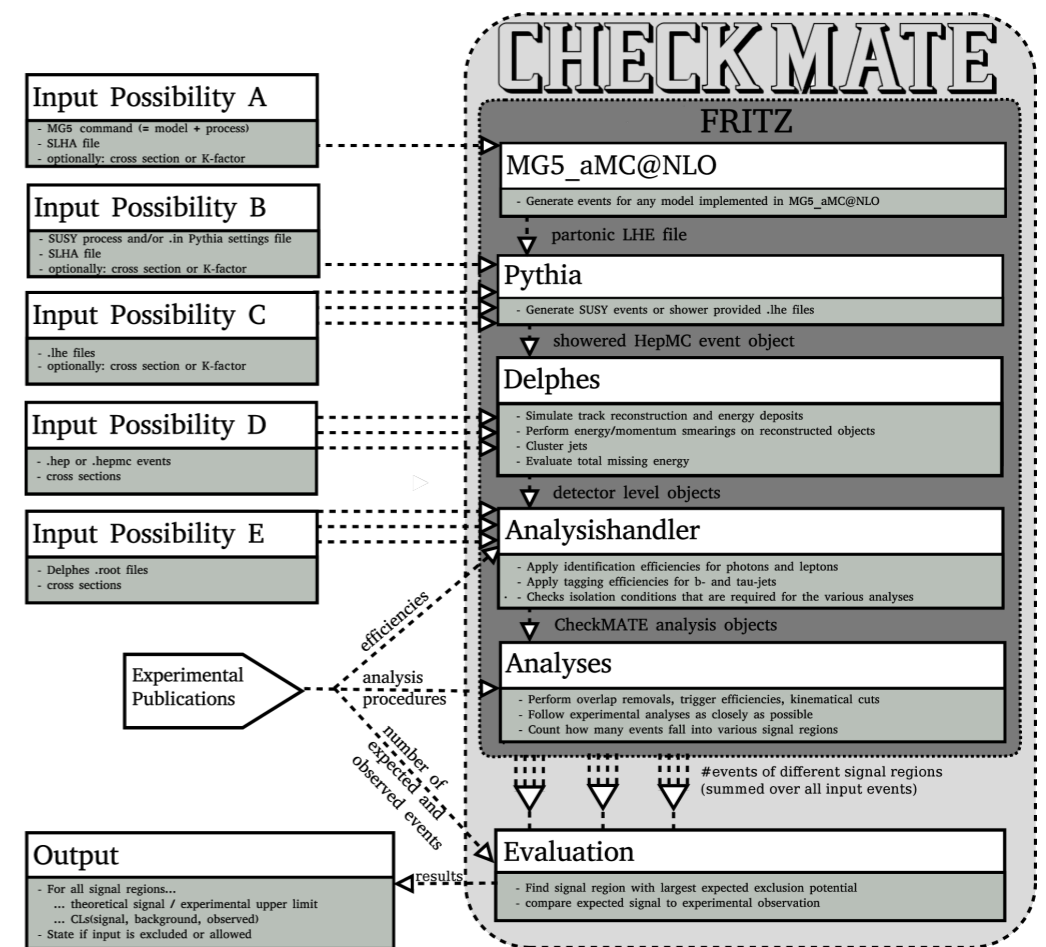
Jong Soo Kim

University of the Witwatersrand, South Africa



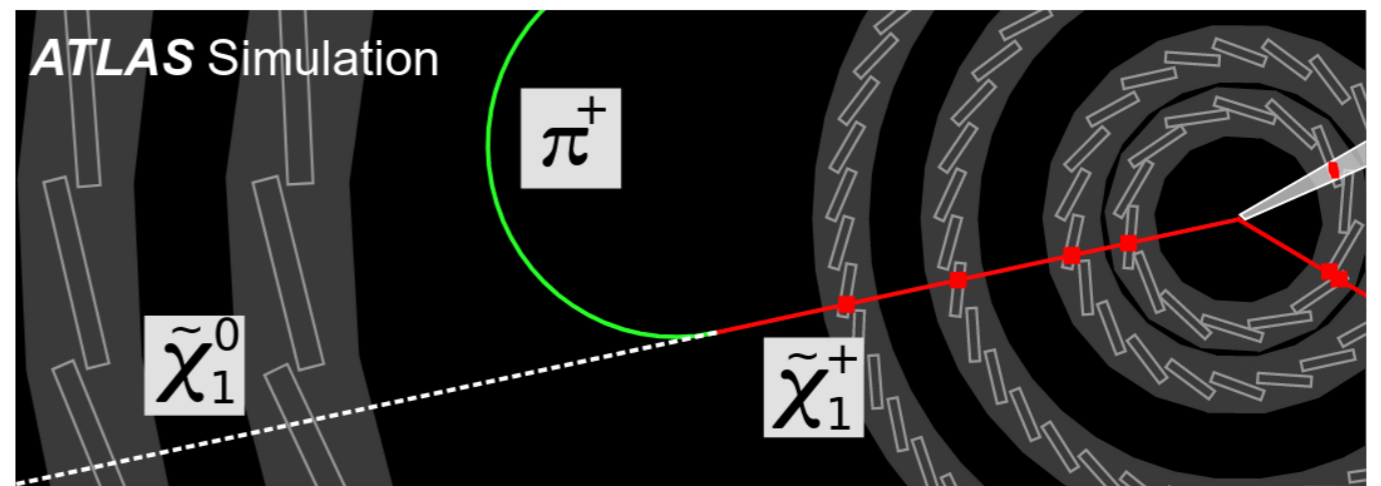
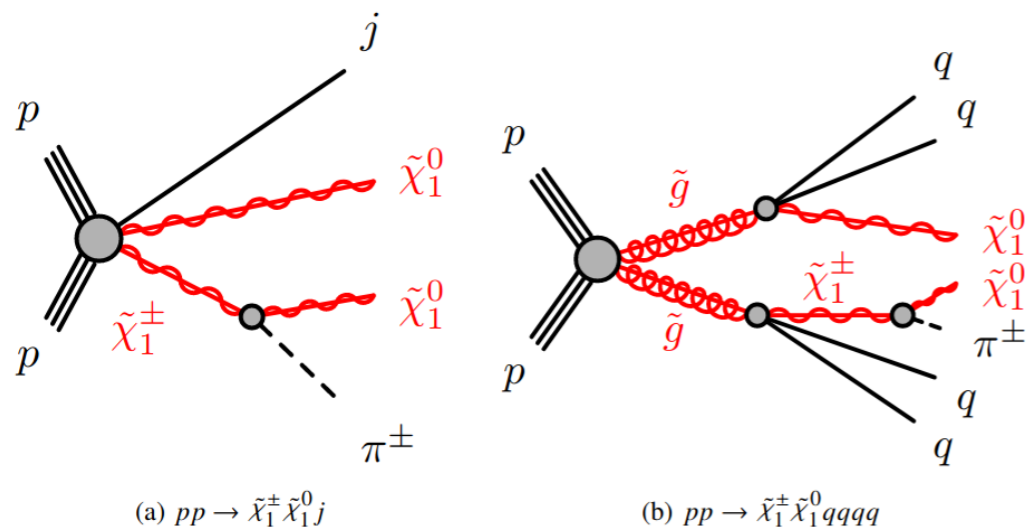
# CheckMATE in a Nutshell

- **Check Models At Terascale Energie** tests any BSM against LHC data
- takes many event file formats as input
- CM can be interfaced with Madgraph and Pythia for event generation
- large library of 13 TeV searches
- however, no LLP implementation so far



# LLP Search Implementation

- 1712.02118 searches for long-lived charginos based on a disappearing track signature
- ATLAS study considers EW and strong production of winos which decays into almost mass degenerate wino LSP and soft pions in very short tracks (tracklets)



# Analysis Details

**EW SR**

**strong SR**

lepton veto

lepton veto

at least one jet with  $p_T > 140$  GeV

$p_T(\text{jet1}) > 100$  GeV,  $p_T(\text{jet2}) > 50$  GeV  
and  $p_T(\text{jet3}) > 50$  GeV

$\text{MET} > 140$  GeV

$\text{MET} > 150$  GeV

$\Delta\Phi(\text{MET}, \text{jets50}) > 1$

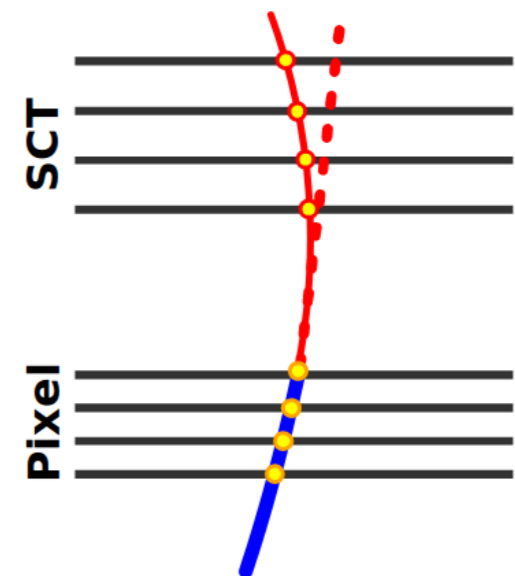
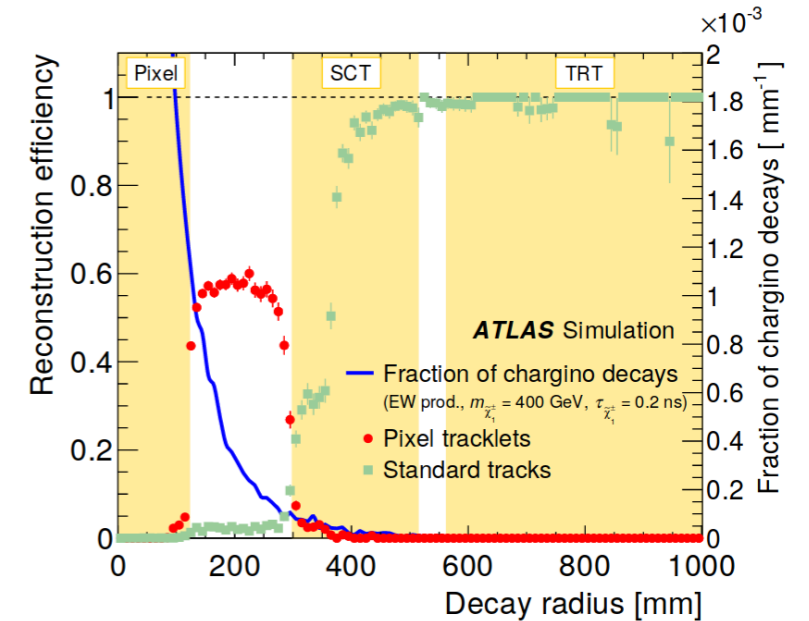
$\Delta\Phi(\text{MET}, \text{jets50}) > 0.4$

cuts on tracklet with  $p_T > 100$  GeV

cuts on tracklet with  $p_T > 100$  GeV

# Tracklet Cuts

- isolation and pT requirement on tracklet
- geometric acceptance:  $0.1 < |\eta| < 1.9$
- quality requirement: the tracklet is required to have hits in all four pixel layer
- disappearance condition: the number of SCT hits associated with the tracklet must be zero
- we cannot simulate the quality requirement and disappearance condition



Browse all

Hide Publication Information

Search for long-lived charginos based on a disappearing-track signature in  $pp$  collisions at  $\sqrt{s} = 13$  TeV with the ATLAS detector

The ATLAS collaboration

Aaboud, Morad , Aad, Georges , Abbott, Brad , Abdinov, Ovsat , Abeloos, Baptiste , Abidi, Syed Haider , AbouZeid, Ossama , Abraham, Nicola , Abramowicz, Halina , Abreu, Henso

No Journal Information, 2017

http://dx.doi.org/10.17182/hepdata.78375

INSPIRE Record HepData Resources

Abstract (data abstract)

CERN-LHC. This paper presents a search for direct electroweak gaugino or gluino pair production with a chargino nearly mass-degenerate with a stable neutralino. It is based on an integrated luminosity of  $36.1 \text{ fb}^{-1}$  of  $pp$  collisions at  $\sqrt{s} = 13$  TeV collected by the ATLAS experiment at the LHC. The final state of interest is a disappearing track accompanied by at least one jet with high transverse momentum from initial-state radiation or by four jets from the gluino decay chain. The use of short track segments reconstructed from the innermost tracking layers significantly improves the sensitivity to short chargino lifetimes. The results are found to be consistent with Standard Model predictions. Exclusion limits are set at 95% confidence level on the mass of charginos and gluinos for different chargino lifetimes. For a pure wino with a lifetime of about 0.2 ns, chargino masses up to 460 GeV are excluded. For the strong production channel, gluino masses up to 1.65 TeV are excluded assuming a chargino mass

Additional Publication Resources

filter

Common Resources 13

- Tracklet pT EW VR (fake) 2
- Tracklet pT EW VR (muon) 2
- Tracklet pT EW VR (hadron/electron) 2
- Tracklet pT EW VR (signal) 2
- Tracklet pT EW VR (total background) 2
- Tracklet pT EW VR (obs) 2
- Tracklet pT Strong VR (fake) 2
- Tracklet pT Strong VR (muon) 2
- Tracklet pT Strong VR (hadron/electron) 2
- Tracklet pT Strong VR (signal) 2
- Tracklet pT Strong VR (total background) 2
- Tracklet pT Strong VR (obs) 2
- Tracklet pT EW SR (fake) 2
- Tracklet pT EW SR (muon) 2

**External Link**  
web page with auxiliary material  
[View Resource](#)

**C++ File**  
pseudocode illustrating the event and object selections for all the signal regions  
[Download](#)

**ROOT File**  
Signal tracklet acceptance times efficiency map for truth snippet  
[Download](#)

**SUSY Les Houches Accord File**  
SLHA file listing the superpartner masses and decay channels for the 91 GeV signal chargino in electroweak production  
[Download](#)

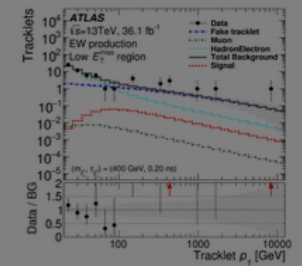
**SUSY Les Houches Accord File**  
SLHA file listing the superpartner masses and decay channels for the 200 GeV signal chargino in electroweak production  
[Download](#)

**SUSY Les Houches Accord File**  
SLHA file listing the superpartner masses and decay channels for the 300 GeV signal chargino in electroweak production  
[Download](#)

Tracklet pT EW VR (total background)	39.46 (bin: 34.2 - 44.72)	1.686 ±0.8843
Data from the publication's Figure 7a 10.17182/hepdata.78375.v1/t5	51.6 (bin: 44.72 - 58.48)	1.546 ±0.6319
Pixel-tracklet $p_T$ spectrum of total background in electroweak channel in the low-Emiss region.	67.48 (bin: 58.48 - 76.47)	1.405 ±0.5282
Tracklet pT EW VR (obs)	88.24 (bin: 76.47 - 100)	1.267 ±0.4598

Last updated on 2017-12-11 09:52 Accessed 418 times Cite JSON

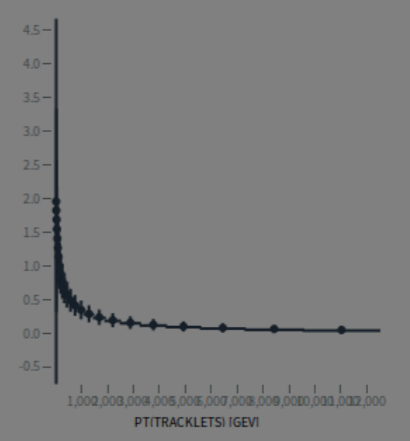
Resources http://www.hepdata.net/reci JSON



reactions

- Proton-Proton Scattering
- Supersymmetry SUSY
- Disappearing Track
- P P → GAUGINO

Visualize

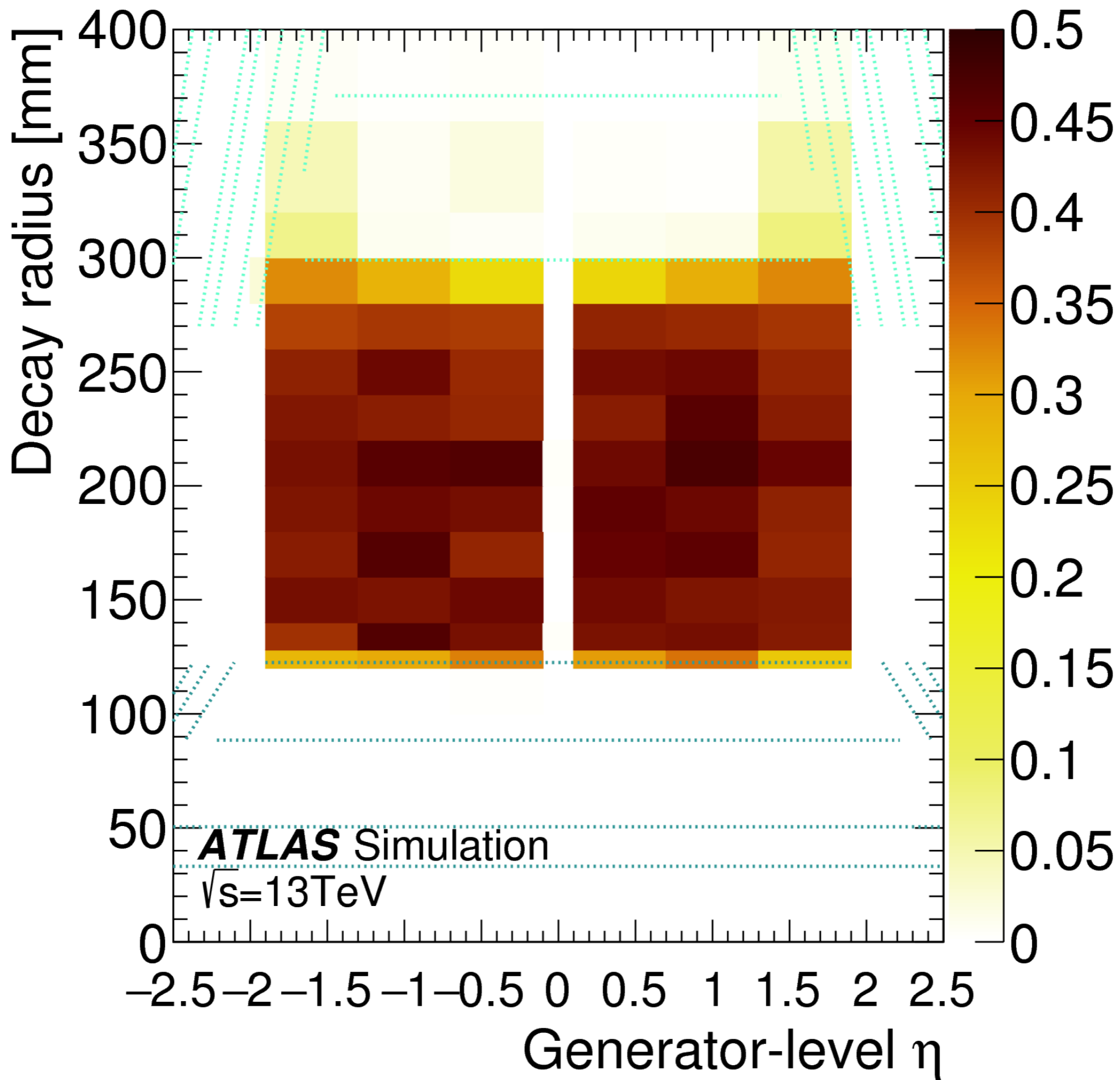


# HEPData

- several benchmark SLHA files for both scenarios are available in HEPData
- ATLAS provides truth level analysis code in c++
- the efficiencies are provided for truth level tracklets in both SR
- ATLAS provides a pT smearing function for truth level chargino

- minor CM modifications required
- extensive HEPData informations enormously simplified the implementation of the LLP analysis into CM
- however, problems with event generation with MG5\_aMC/Pythia8 & CKKW-L matching
- cutflows for the EW and strong SR are provided
- ATLAS provides the efficiency maps for EW SR and strong SR in many digitized formats





# Results

	<b>x1+x1-</b>	<b>x1+n1</b>	<b>x1-n1</b>	<b>all</b>	<b>ATLAS</b>
<b>Trigger</b>	445,1	624,0	274,4	1343,5	1276
<b>Lepton Veto</b>	432,4	608,5	267,3	1308,2	1181
<b>MET &amp; Jet Requirements</b>	164,2	229,6	101,0	494,8	579
<b>EW SR</b>	5,2	4,4	1,6	11,2	13,5

- events are generated with MG5\_aMC 2.6.1 and Pythia 8.230
- we matched events with up to two partons
- cross section normalised with Prospino 2.1

# Summary & Outlook

- CheckMATE tests any BSM against current LHC data
- it is very popular among phenomenologists
- we have started with a disappearing track implementation
- extensive informations provided on HEPData is crucial
- we will work on other LLP searches, e.g. 1504.05162 (events with multitrack displaced vertices or displaced lepton pairs)

<https://checkmate.hepforge.org>