# Triggering disappearing tracks

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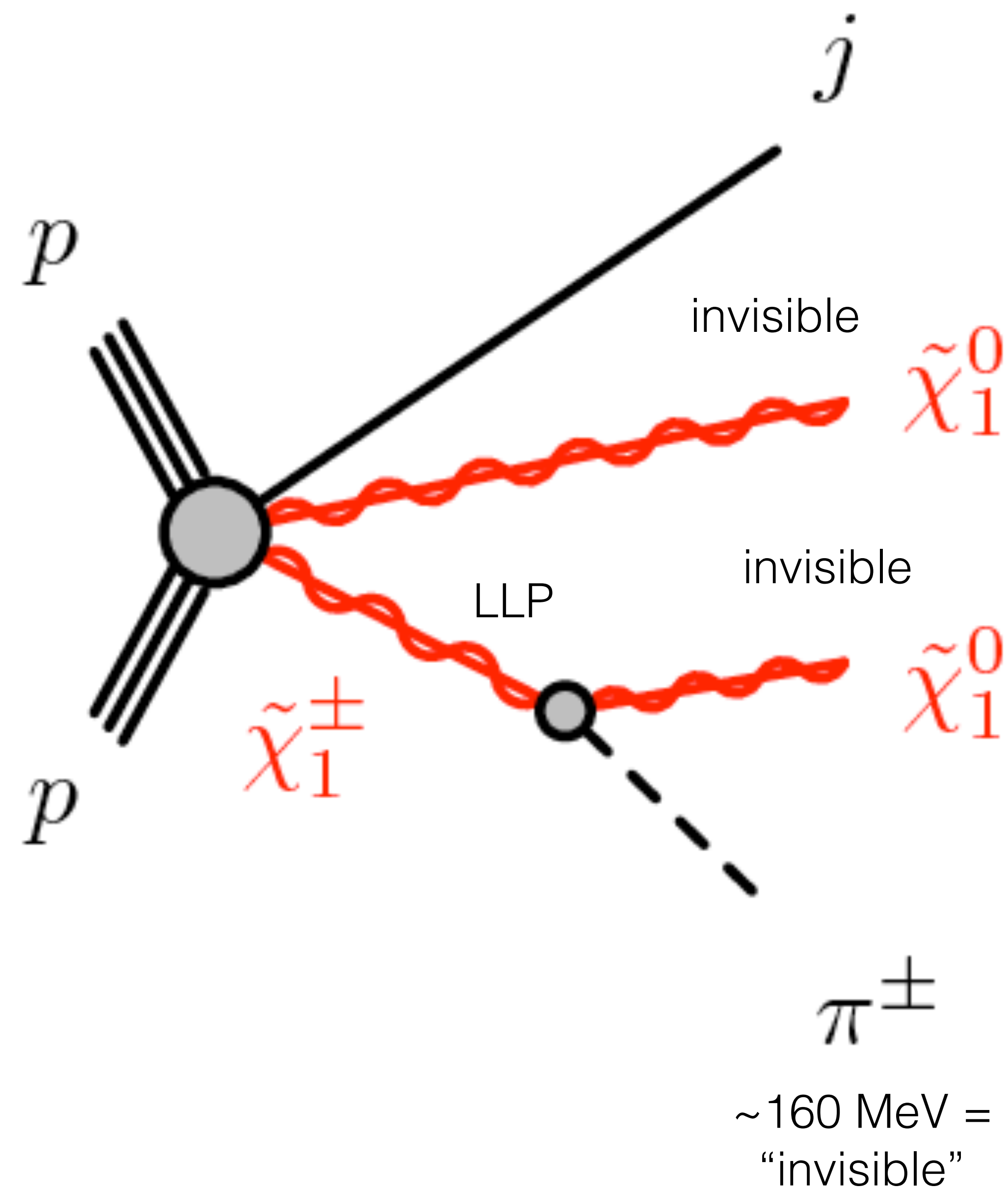
# Raiders of the lost arc

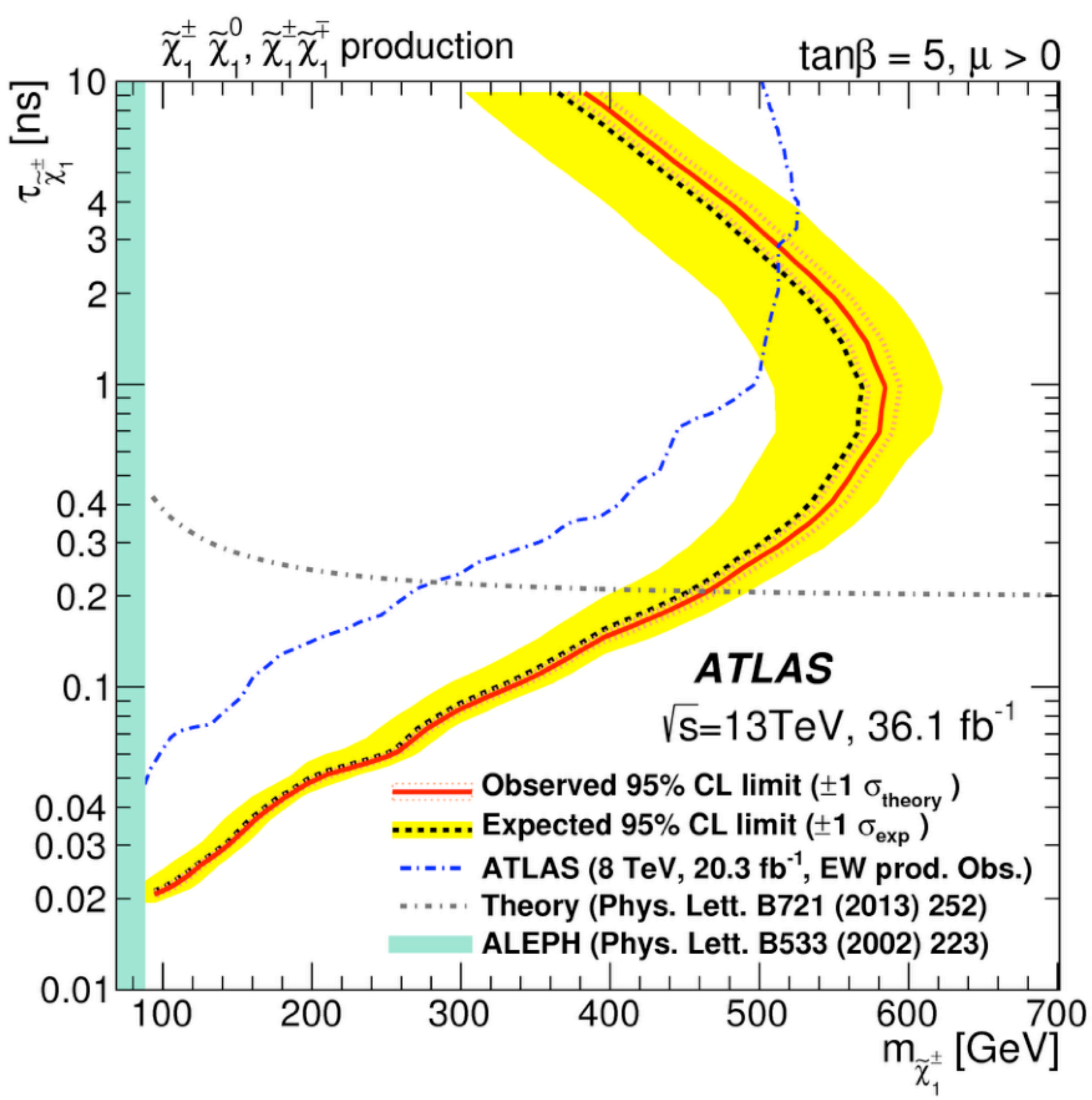
- **Sensitivity**
  - new, massive, charged particles with lifetimes ~10 ps - 10 ns which decays to "invisible"
- **Models**
  - particularly sensitive to pure wino or pure higgsino LSP, in which case the lightest chargino naturally picks up lifetime
    - pure wino: ~0.2 ns
    - pure higgsino: ~0.05 ns
- **Signature**
  - A high pT track in the inner detector which "disappears" at some point inside the ID ("tracklet)
    - requires custom tracking



# Current results

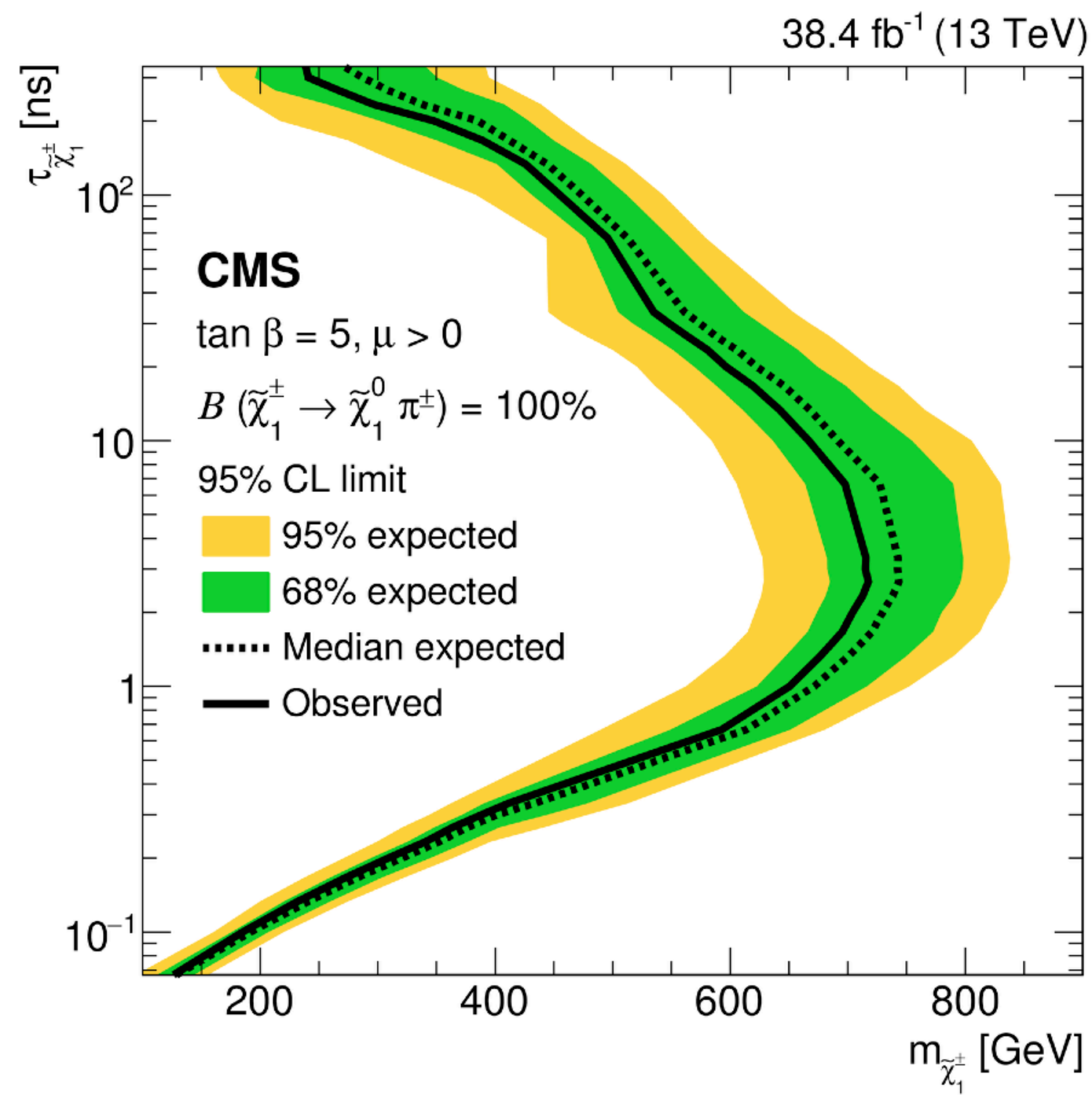
- Limits on chargino mass (pure wino) ~500 — 700 GeV, depending on lifetime

## ATLAS




https://arxiv.org/abs/1712.02118

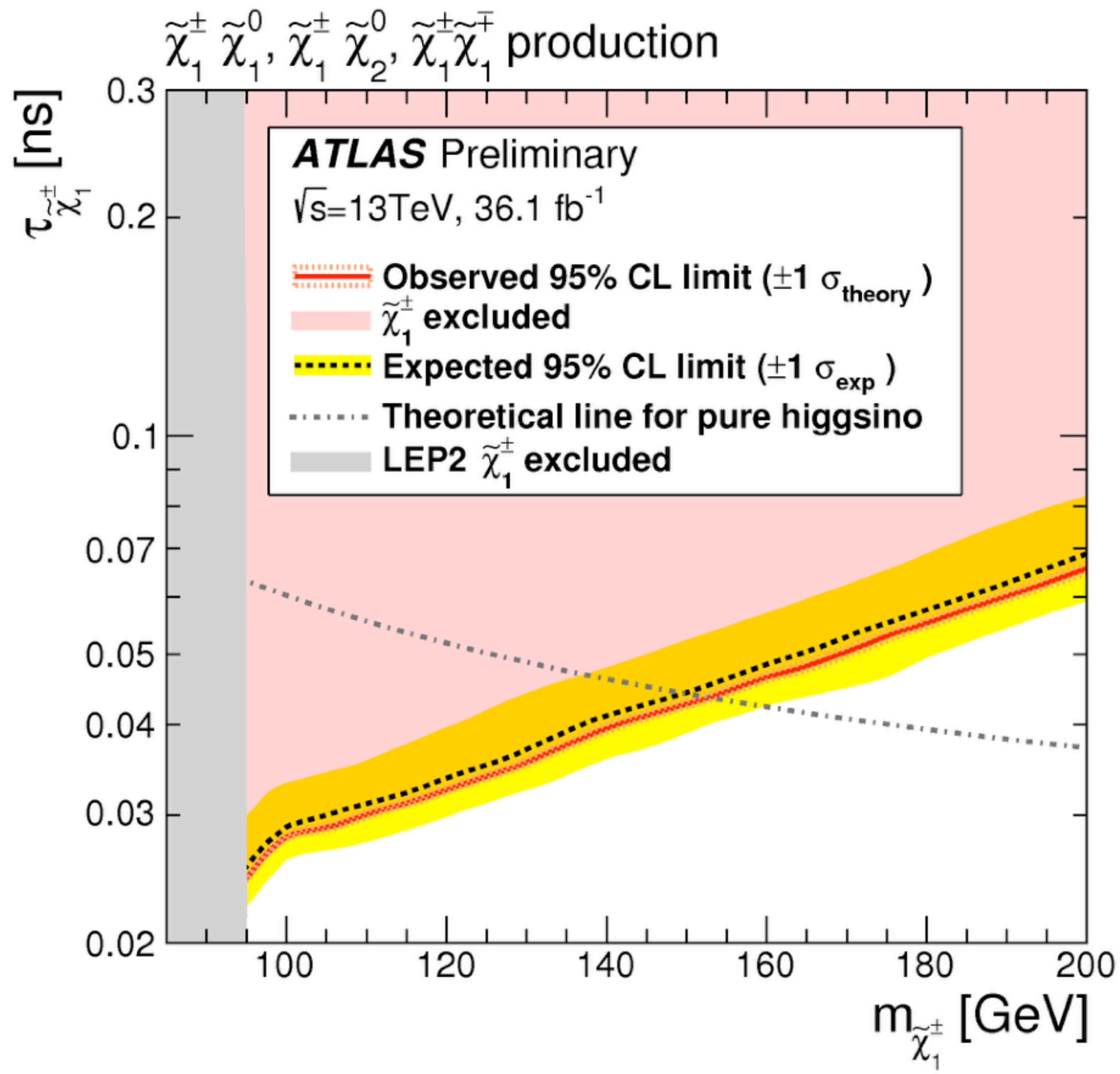
## CMS




http://arxiv.org/abs/1804.07321

# and higgsinos!

- First higgsino limit in this regime since LEP…




http://cdsweb.cern.ch/record/2297480

# Challenge: trigger

- Signature has no intrinsic trigger in calo nor muon system
- Can only trigger if there is ISR in the system
  - then can choose jet or MET
- Both ATLAS and CMS use MET as L1 trigger

## ATLAS cutflow

| Selection requirement | Electroweak channel | | Strong channel | |
|---|---|---|---|---|
| | Observed | Expected signal | Observed | Expected signal |
| Trigger | 434 559 704 | 1276 (0.20) | 434 559 704 | 285 (0.98) |
| Jet cleaning | 288 498 579 | 1181 (0.19) | 288 498 579 | 282 (0.97) |
| Lepton veto | 275 243 946 | 1178 (0.19) | 275 243 946 | 278 (0.95) |
| $E_{\mathrm{T}}^{\mathrm{miss}}$ and jet requirements | 2 697 917 | 579.1 (0.092) | 537 861 | 202 (0.69) |
| Isolation and $p_{\mathrm{T}}$ requirement | 464 524 | 104.2 (0.017) | 107 381 | 43.6 (0.15) |
| Geometrical $\|\eta\|$ acceptance | 339 602 | 83.6 (0.013) | 77 675 | 36.4 (0.13) |
| Quality requirement | 6134 | 29.6 (0.0047) | 1337 | 13.9 (0.048) |
| Disappearance condition | 154 | 24.1 (0.0038) | 35 | 11.0 (0.038) |

# High level trigger

- **ATLAS uses MET as L1 and HLT trigger**
- **L1 threshold: 50 - 60 GeV**
  - HLT threshold: ~120 GeV
- **CMS uses L1 MET**
  - HLT: MET > 75 GeV, plus isolated track(let) with pT > 50 GeV

## Intriguing paragraph in CMS paper

This search is performed on events that pass one or more of several triggers with requirements on missing transverse momentum, a characteristic of signal events where the missing transverse momentum is generated by an ISR jet recoiling off the sparticle pair. For this specific analysis we define the vector $\vec{p}_{\mathrm{T}}^{\mathrm{miss}}$, with magnitude $p_{\mathrm{T}}^{\mathrm{miss}}$, as the projection onto the plane perpendicular to the beam axis of the negative vector sum of the momenta of all reconstructed PF candidates in an event, with the exception of muons, or, in the case of the L1 trigger, of all calorimeter energy deposits. The triggers require $p_{\mathrm{T}}^{\mathrm{miss}}$ at L1, with the specific requirement varying throughout data taking with changes in the instantaneous luminosity. At the HLT, events with either $p_{\mathrm{T}}^{\mathrm{miss}}$ or $p_{\mathrm{T}}^{\mathrm{miss},\mu}$, which is defined similarly to $p_{\mathrm{T}}^{\mathrm{miss}}$ but with muons included in its calculation, are selected. The lowest-threshold trigger, which was developed specifically for this search, requires $p_{\mathrm{T}}^{\mathrm{miss}} > 75\,\mathrm{GeV}$ as well as an isolated track with $p_{\mathrm{T}} > 50\,\mathrm{GeV}$ at the HLT. The higher-threshold triggers require either $p_{\mathrm{T}}^{\mathrm{miss}}$ or $p_{\mathrm{T}}^{\mathrm{miss},\mu}$ to be greater than 90 (120) GeV for the 2015 (2016) data, and are used to mitigate any inefficiency in the HLT isolated track requirement for events with higher $p_{\mathrm{T}}^{\mathrm{miss}}$ or $p_{\mathrm{T}}^{\mathrm{miss},\mu}$. In the offline selection, only $p_{\mathrm{T}}^{\mathrm{miss}}$ is used, in order to mir-

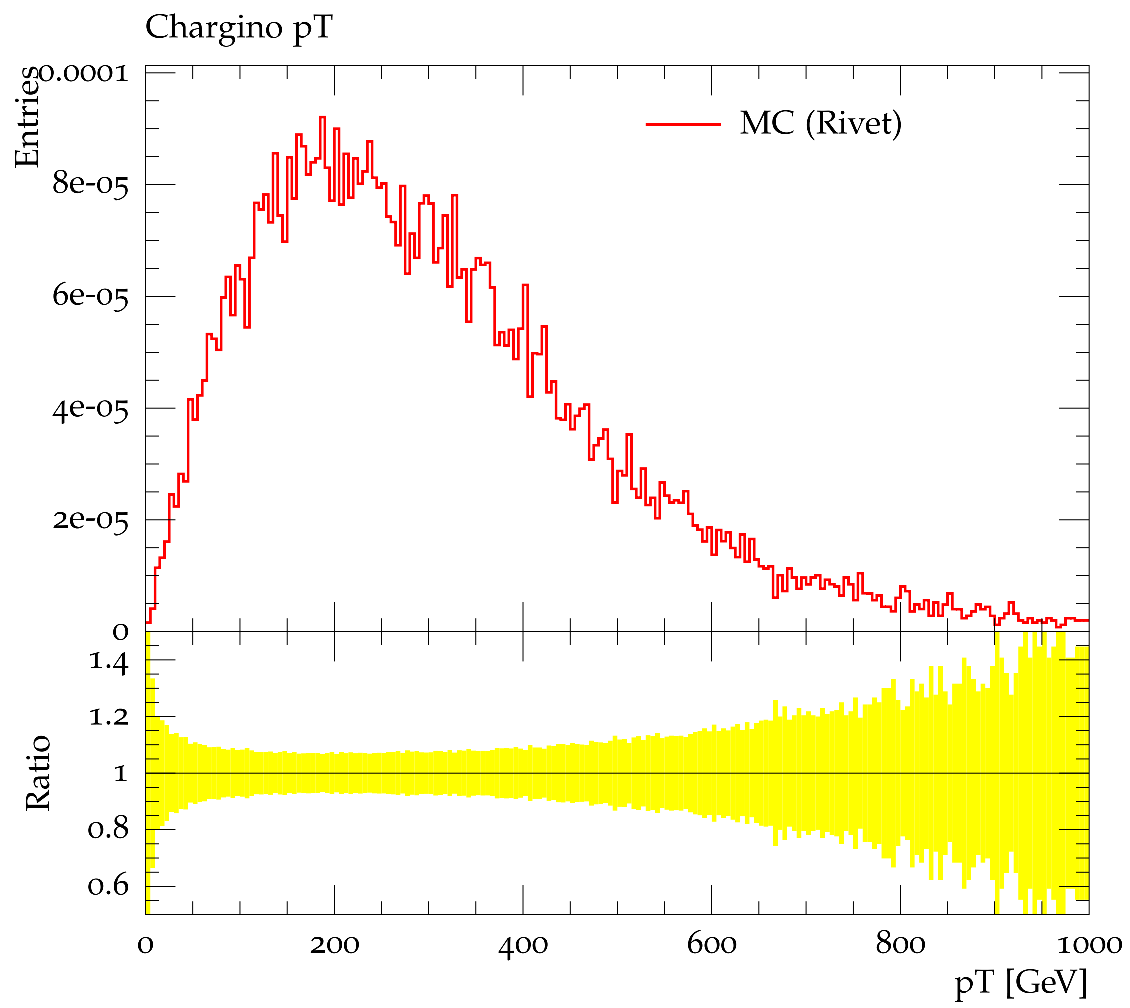
# Challenge (in ATLAS)

- We (ATLAS) would also like to use tracklet signature at HLT, but don't have enough CPU to run tracking everywhere in the event for every event with MET > 75 GeV

- **Idea for this project:**
  - using the MET and jets in the system, can we identify small(er) geometric regions-of-interest (ROIs) in which we can run tracklet reconstruction at HLT?

# Samples

- Produced chargino-chargino mASMB samples with a few masses with madgraph+pythia8 (LO with 2 additional partons)
    - can easily produce more masses
- Chargino does not decay (does not matter for this project, and pythia8 kept crashing when I tried to decay chargino in pythia…)



# Discussion

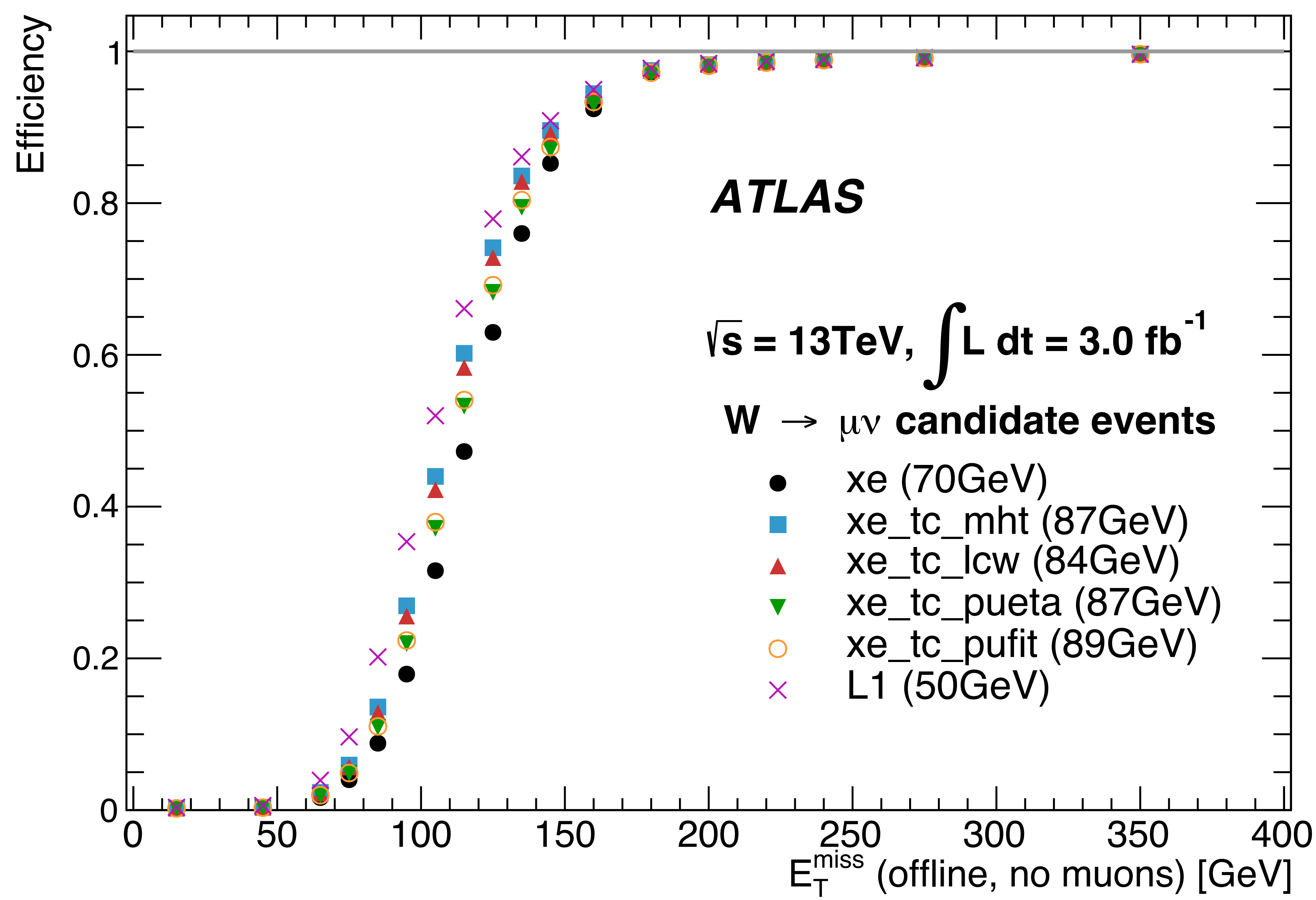
- **What info can we extract from our CMS colleagues here today?**
  - would an ROI method help CMS too? (reduce HLT MET > 75 GeV?)
  - other helpful tips from their trigger they are willing to share?

- **Questions to answer**
  - How much gain is possible with the ideal HLT trigger? (given that we have to trigger at L1)
  - how small could we make ROI and still be sensitive to a reasonable range of chargino masses?
  - what efficiency would we gain, assuming ~100% tracklet reconstruction if its inside the ROI?
  - what other model dependence would we be introducing?
  - Can we improve on L1 or HLT pure MET trigger with some fancy MET+jet variables? (need to consider rate…)

- **Other ideas for improving tracklet triggering welcome!**

# Backup

# MET efficiency in ATLAS, may be relevant




https://arxiv.org/abs/1611.09661

# MET linearity / resolution in ATLAS