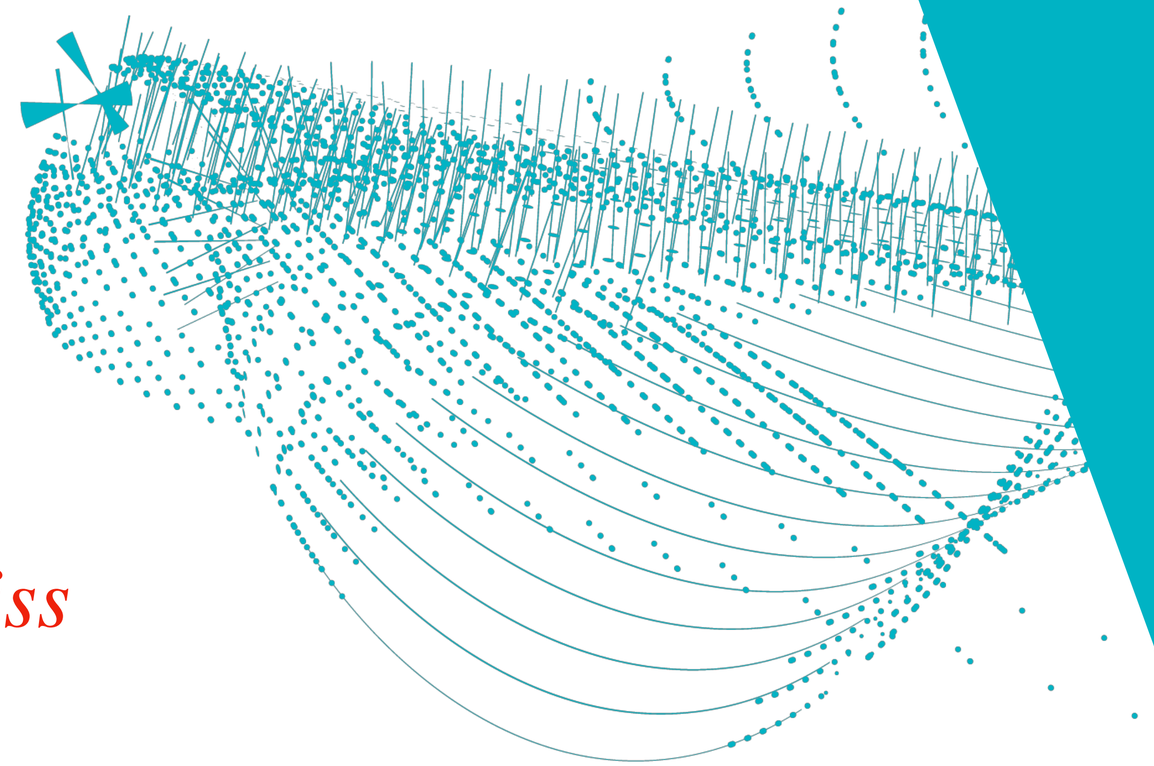
Nikhef

SEARCHES WITH THE ATLAS EXPERIMENT

SUSY WITH LOW E_T^{miss} AND THREE SOFT LEPTONS



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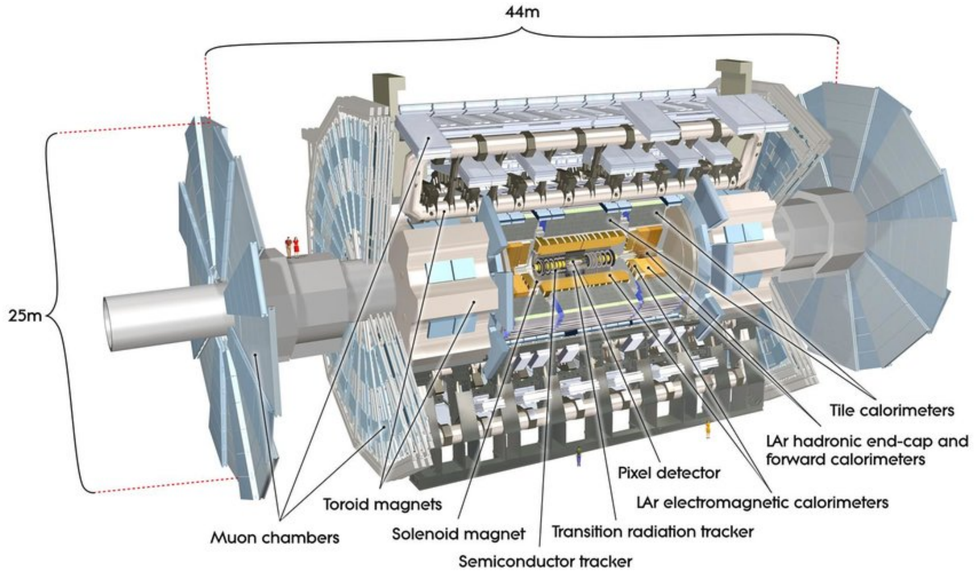
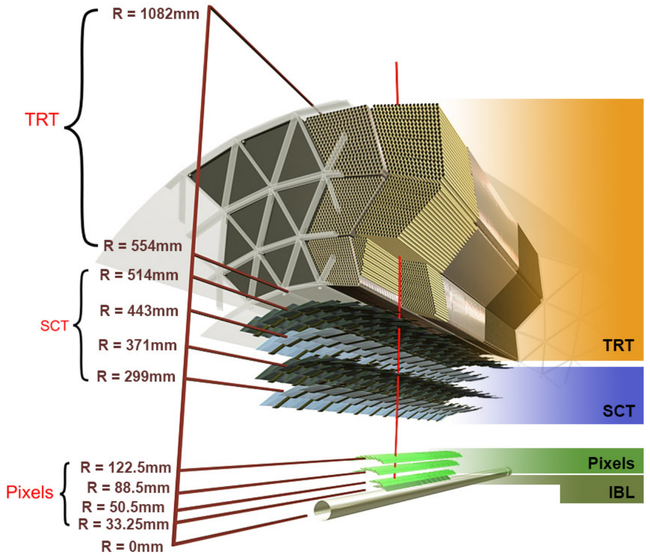
Sascha Caron
Paul de Jong

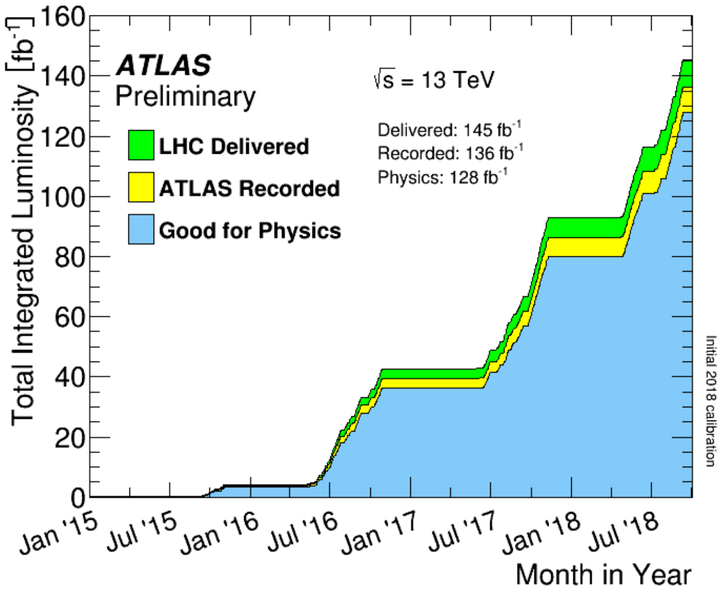
Lunteren 2018

THE ATLAS DETECTOR

- Main change for run 2 is the Insertable B-Layer (IBL)
- Improved vertexing capabilities







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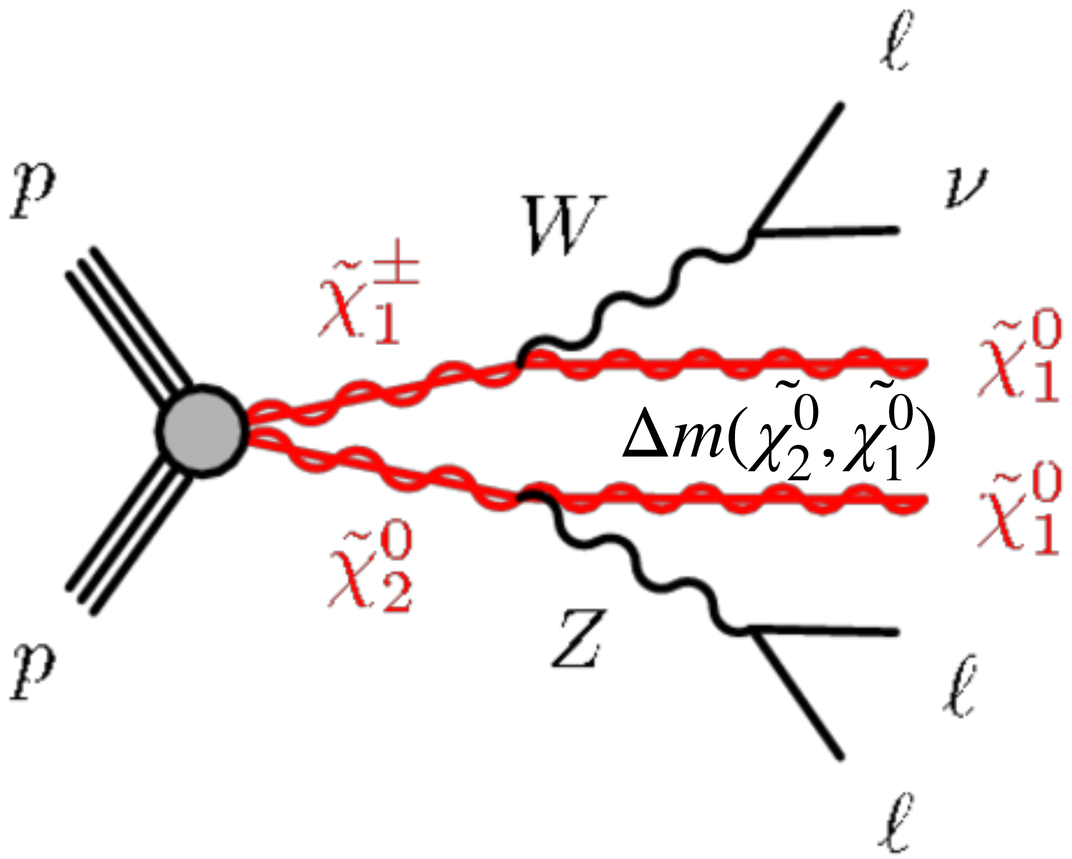
WHAT DO WE TARGET?



$$\Delta m(\tilde{\chi}_2^0, \tilde{\chi}_1^0) \approx [10,50]$$

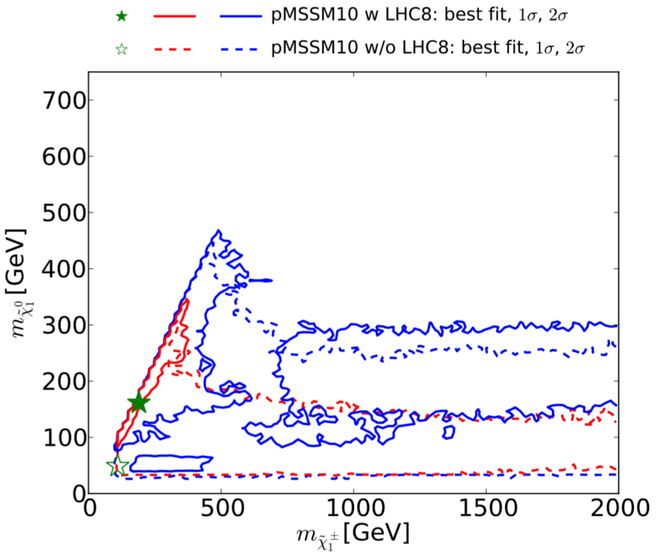
↓

SOFT LEPTONS

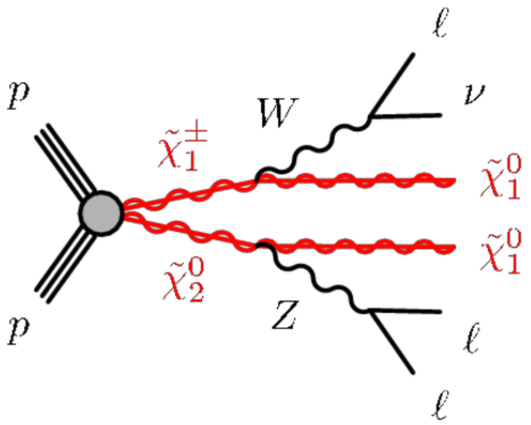
WHY DO WE TARGET THIS REGION?

Best motivated region for SUSY DM in the MSSM

1. Best fit region in MSSM-10 mastercode and MSSM-19 fits (https://arxiv.org/abs/1504.03260)
2. Within best fit region of Gambit (https://arxiv.org/abs/1705.07917)
3. INDEPENDENTLY explanation of Galactic Center excess (http://arxiv.org/abs/1502.05703)
4. Bino Higgsino region has smallest finetuning in the MSSM (and right DM density) (https://arxiv.org/abs/1612.06333)

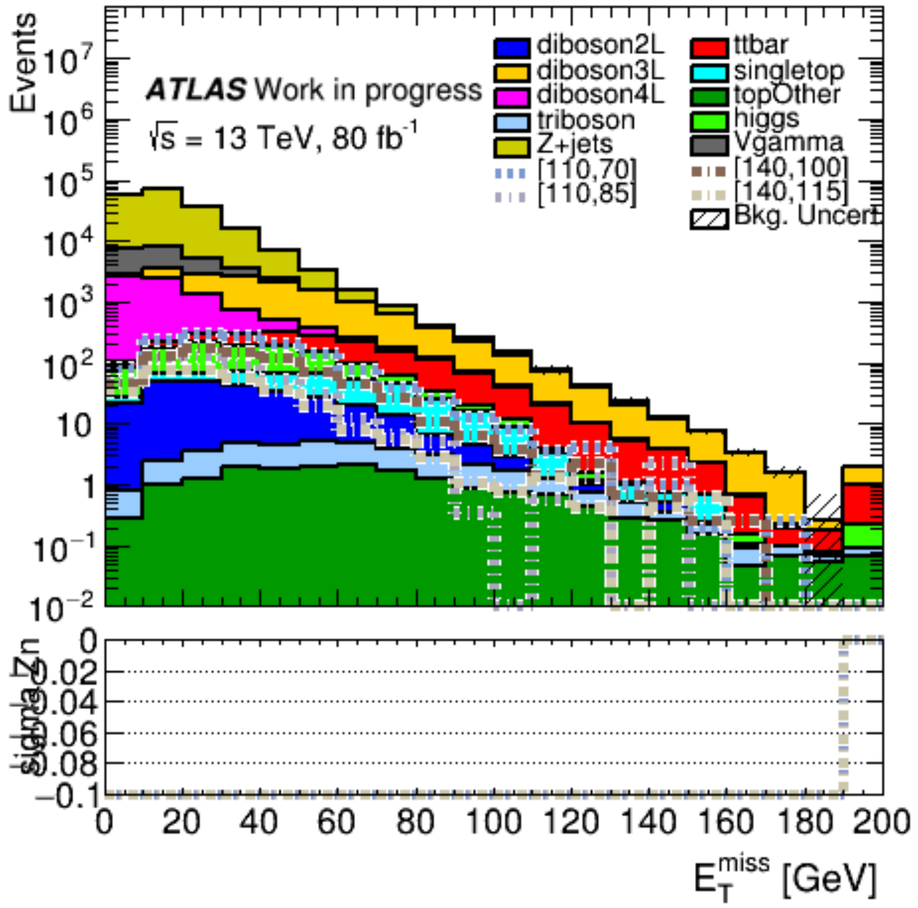


ALSO.. WE WANT TO LOOK IN A LOW E_T^{miss} REGION



$\tilde{\chi}_1^0$

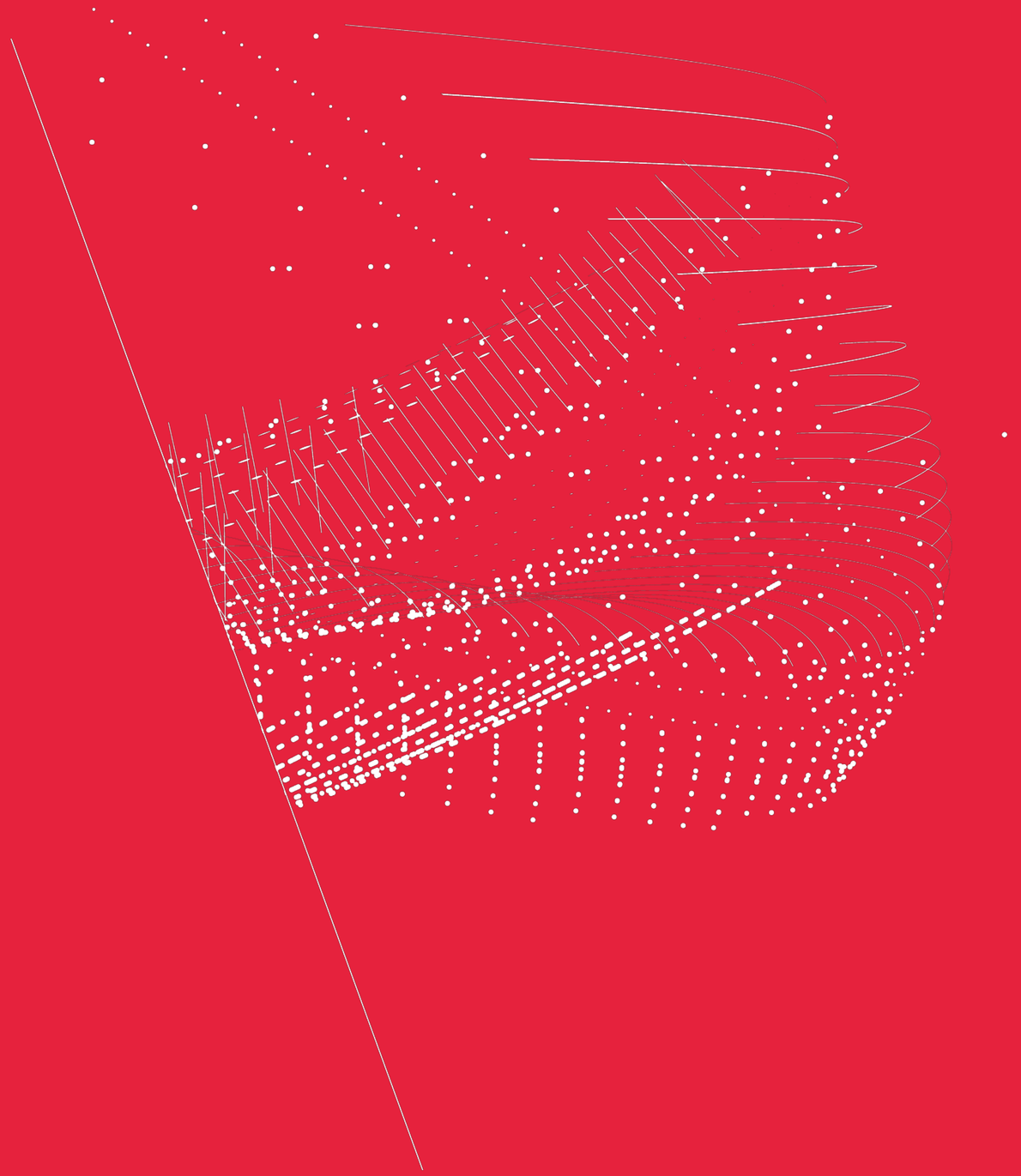
are back to back



Problems:
low lepton p_T + low E_T^{miss}

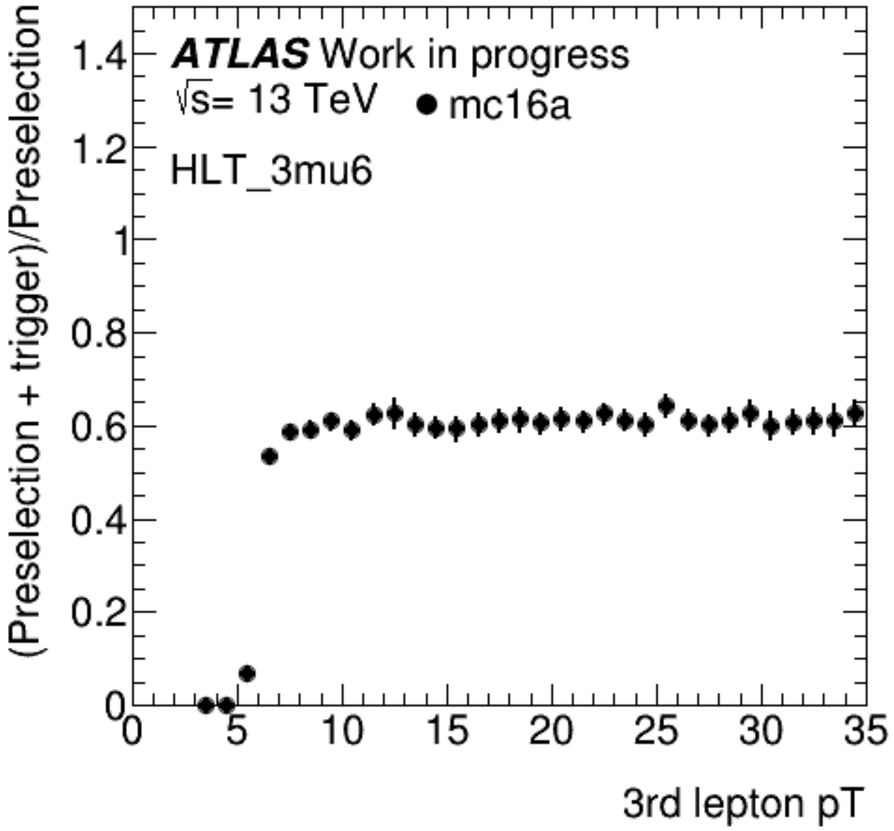
Trigger+isolation
Lots of fakes

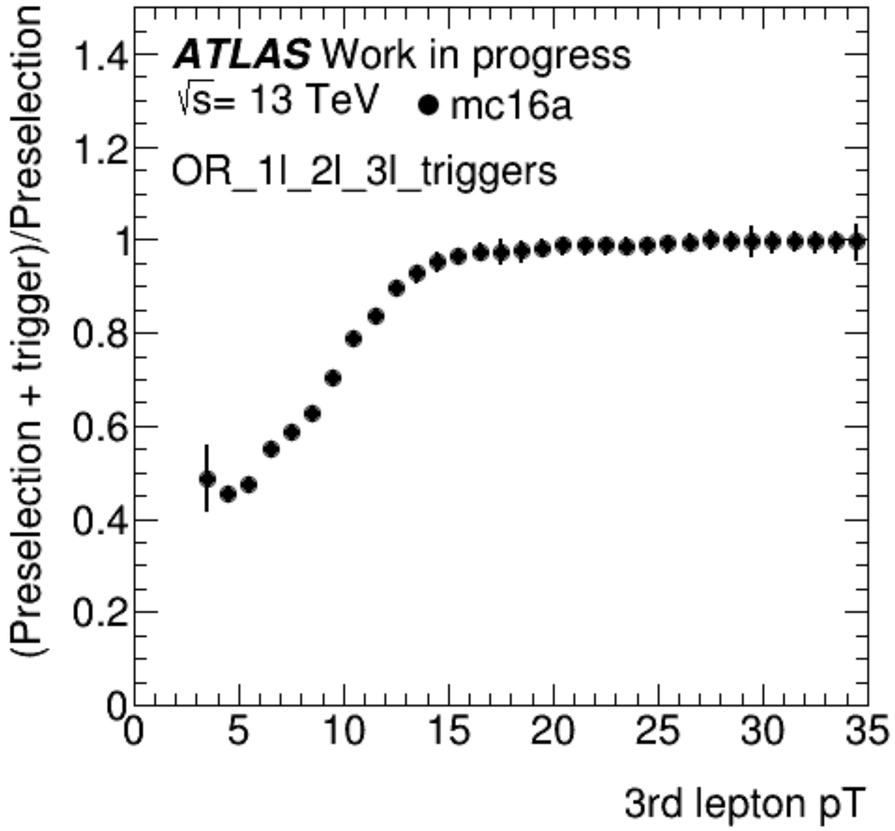
LOW LEPTON P_T



TRIGGER

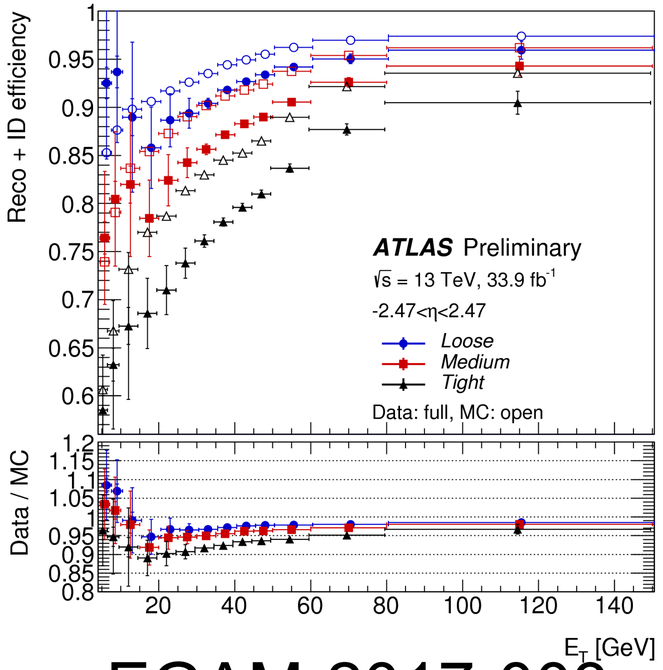
Combination of lepton triggers: OR of 1l/2l/3mu6 trigger



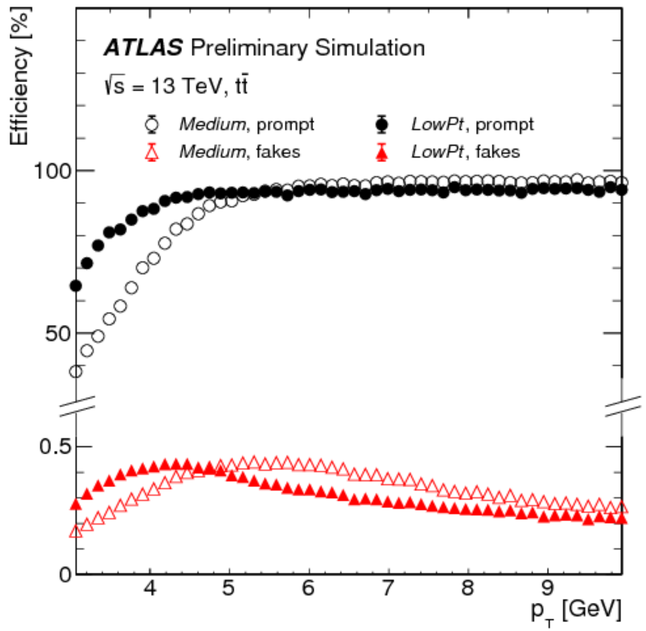


GOING LOWER IN LEPTON PT

- Electrons currently reconstructed down to 4.5 GeV, using topologically formed clusters and dedicated Bremstrahlung correction
- Muons are reconstructed down to 3 GeV (average energy loss in the calorimeter is 3 GeV)
- Current published SUSY analyses use muons as far down as 4 GeV



EGAM-2017-003

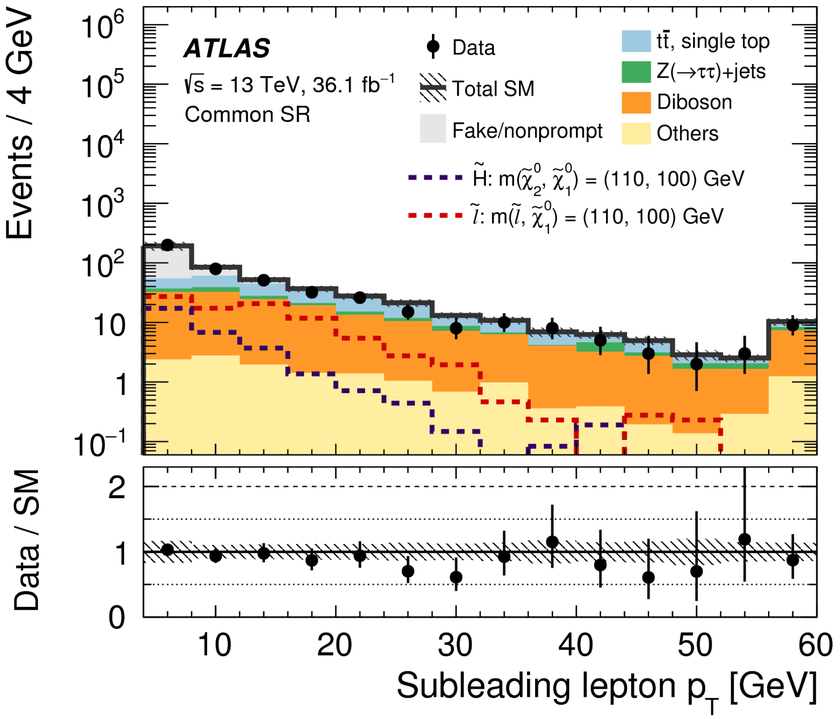


MUON-2018-005

HOWEVER.. CONSEQUENCES OF SOFT LEPTONS

- Lots of extra background is fake lepton from heavy flavour decays
- Key to improving the performance lies with lepton isolation and impact parameters

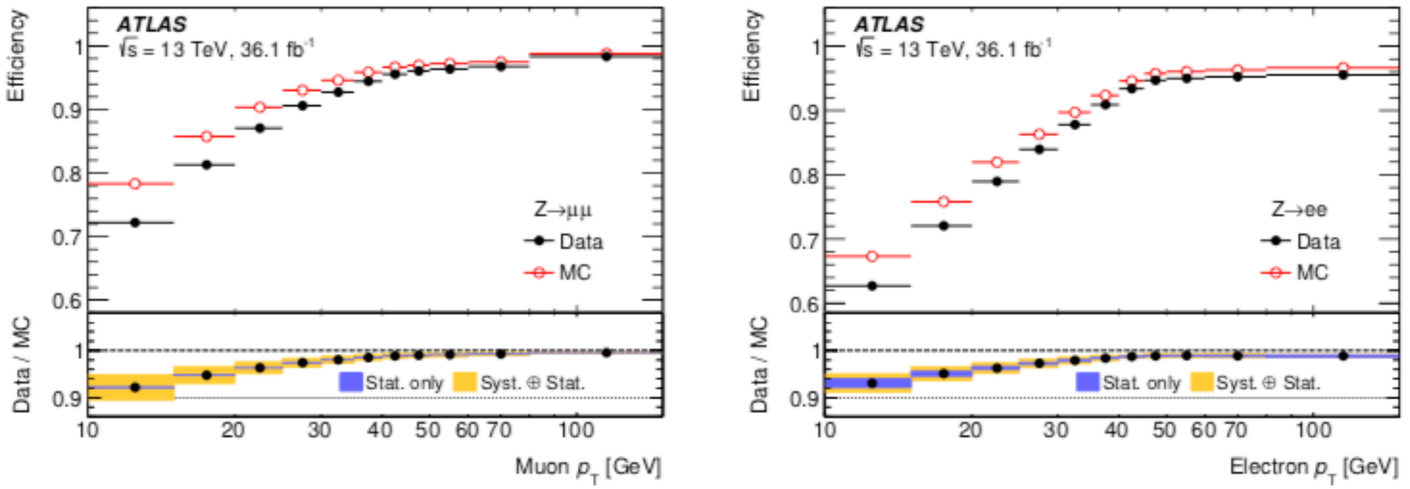
- New ideas could replace isolation algorithms, such as a **BDTs**



ARXIV:1712.08119

A PROMPT LEPTON TAGGER

- To replace isolation algorithms. A BDT could be trained which could potentially have better performance for rejection of heavy flavour decays
- Taking as input the energy deposits and charged-particle tracks in a cone around the lepton direction
- Example by the ttH group. Large SF's at low P_T, this could be improved with choosing a different working point



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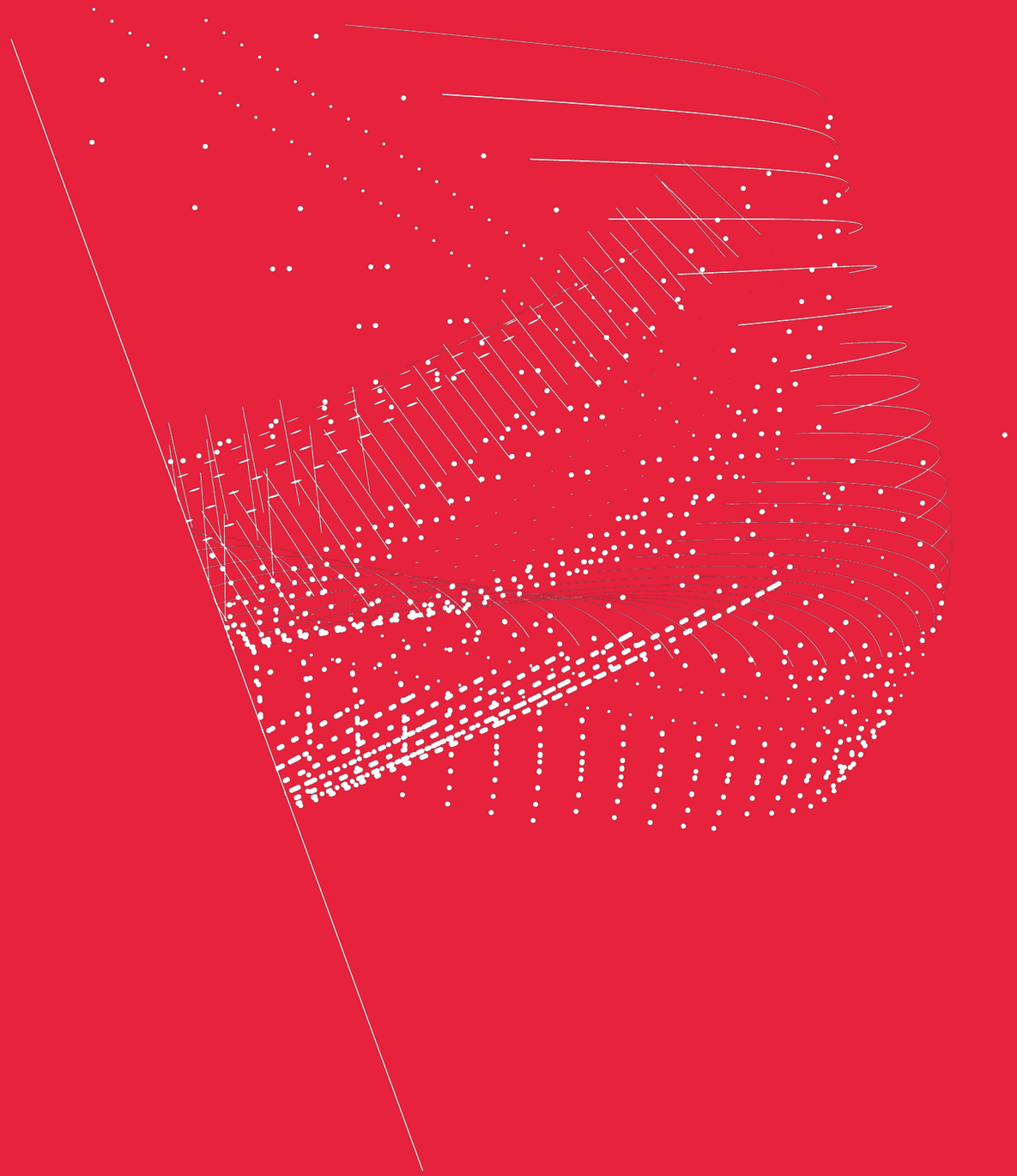
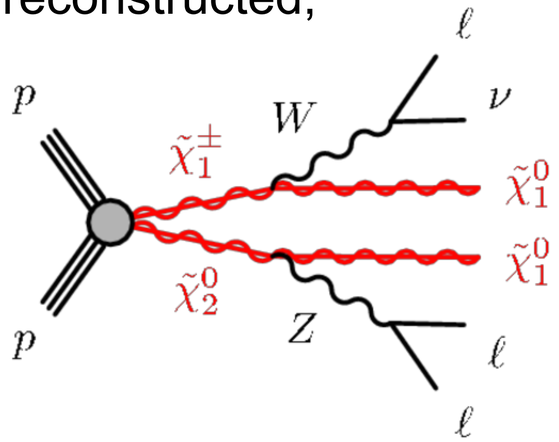
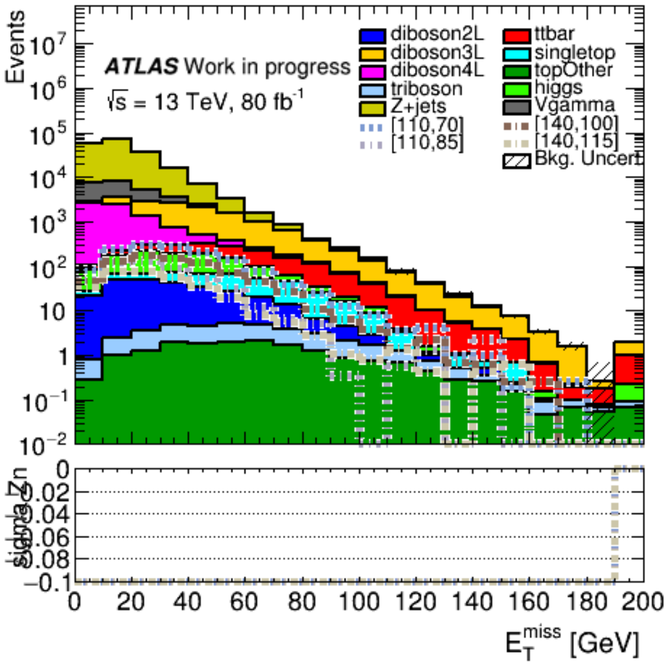
LOW E_T^{miss}



E_T^{miss} WHICH IS FAKE

- E_T^{miss} is an important variable in searches as it is indicative of the neutralinos
- Fake E_T^{miss} can arise from interacting particles which escape the acceptance of the detector, are inaccurately (resolution) reconstructed, or fail to be reconstructed all together

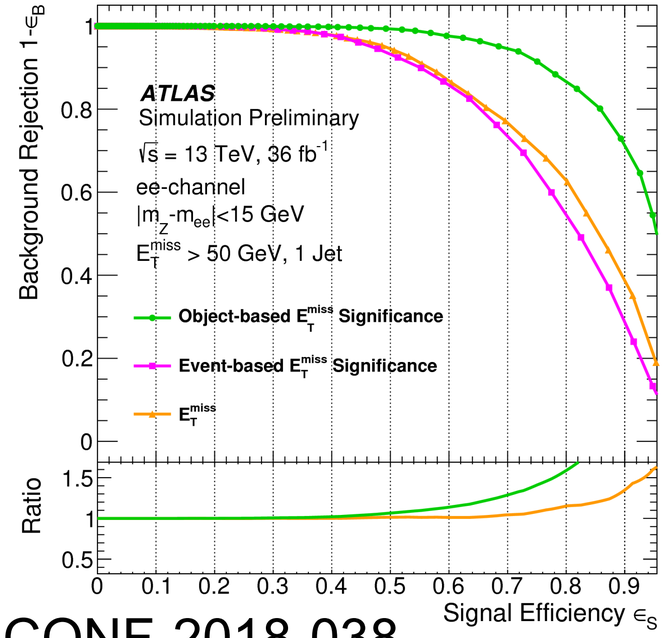




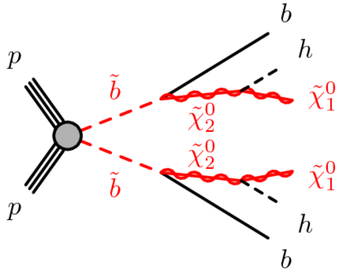
- Our analysis suffers from Z+jets, a process where real $E_T^{miss} = 0$
- This is because of MC modelling and resolution effects which result into fake E_T^{miss}
- Also when a jet gets reconstructed as a lepton only the track (only charged particles) of the jet gets added to the E_T^{miss} (particle flow would be interesting here)

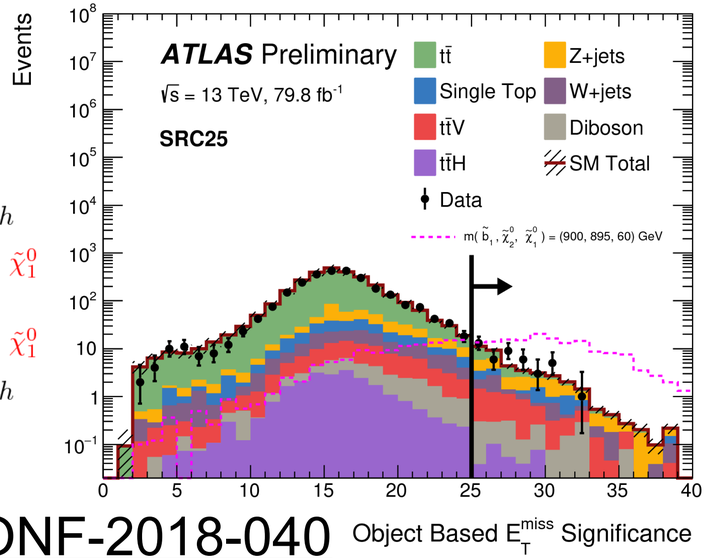
E_T^{miss} SIGNIFICANCE

- Indicates the degree to which the reconstructed E_T^{miss} is consistent with momentum resolution and particle identification efficiencies
- Event-based significance: $\mathcal{S} = \frac{E_T^{miss}}{\sqrt{H_T}}$ or $\mathcal{S} = \frac{E_T^{miss}}{\sqrt{\sum E_T}}$
- Object-based definition: log-likelihood ratio that the reconstructed E_T^{miss} is consistent with the hypothesis of 0 real E_T^{miss}, based on full event composition



ATLAS-CONF-2018-038



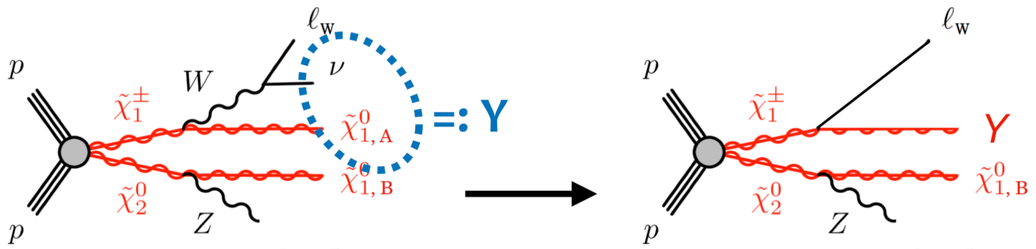


ATLAS-CONF-2018-040

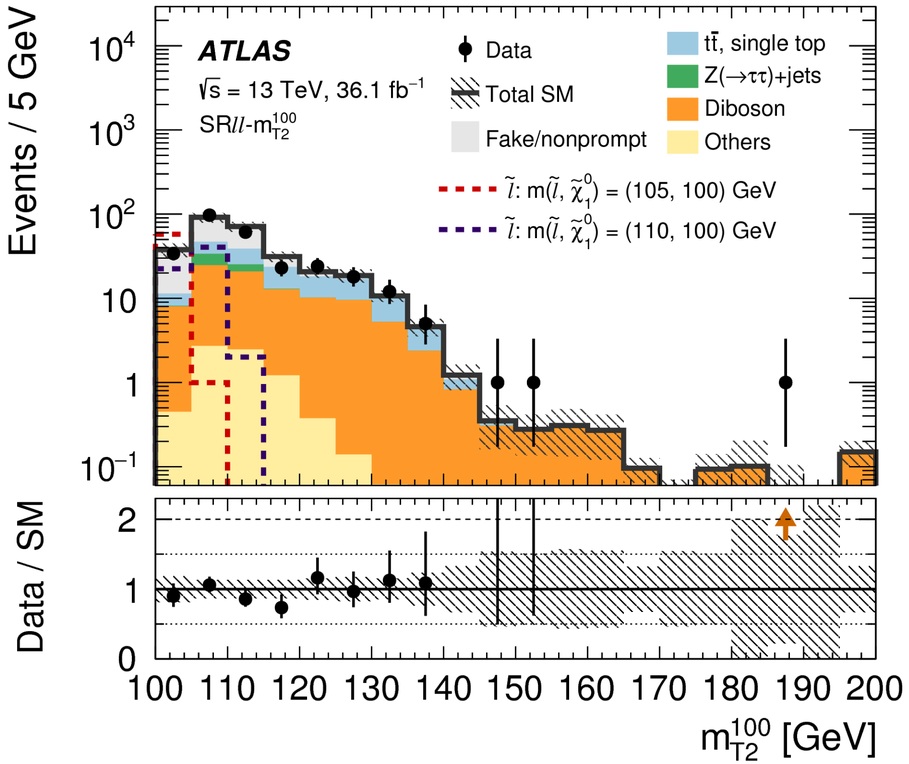
M_{T2}

We measure **one** variable E_T^{miss}, but this is actually **two** particles:

- Two massive particles have escaped undetected
- The masses of these particles are unknown
- The masses of their parent particles are unknown
- The center-of-mass energy of the collision is not known
- The boost along the beam axis is not known



m_{T2} (l_W, Z, E_T^{miss}; m_{N1}, m_{N1})



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$$m_{T2}^2(\chi) = \min_{E_{T1}^{miss(1)}+E_T^{miss(2)}=E_T^{miss}} [max\{m_t^2(p_T^{(1)}, E_T^{miss(1)}; \tilde{\chi}_1^0), m_t^2(p_T^{(2)}, E_T^{miss(2)}; \tilde{\chi}_1^0)\}]$$

CONCLUSIONS

- Best motivated region for SUSY DM in the MSSM
- Complicated region because of:
  - Low lepton p_T
  - Low E_T^{miss}
- However using a (multi-)lepton triggers and special reconstruction techniques like:
  - Improved isolation (PromptLeptonTagger)
  - E_T^{miss} significance
  - M_{T2}
- We get sensitivity