SEARCHES WITH THE ATLAS EXPERIMENT

RECONSTRUCTION TECHNIQUES IN SUPERSYMMETRY

Ambrosius Vermeulen (on behalf of the ATLAS collaboration)
• Main change for run 2 is the Insertable B-Layer (IBL)
• Improved vertexing capabilities
WHAT DO WE TARGET?

- Low mass differences, $\Delta m(\tilde{\chi}^0_2, \tilde{\chi}^0_1)$ can result in low $P_T$ jets or leptons
- Large mass differences, $\Delta m(\tilde{g}, \tilde{\chi}^0_1)$ can result in a boosted system with multiple quarks, reconstructed with a large-R jet
- Neutralinos will cause $E_T^{miss}$

Reconstruction techniques in supersymmetry searches with the ATLAS experiment
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
• Further gains are possible with new lower $P_T$ thresholds
• However, 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:1805.11381

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

ARXIV:1712.08891
HIGH MASS RECONSTRUCTION
**RECLUSTERED JETS**

- “Standard” jet finding in ATLAS uses the Anti-Kt algorithm with a radius parameter of 0.4
- In boosted topologies the two jets could be close together
- Two strategies:
  - Use a larger radius parameter
  - Cluster existing calibrated 0.4 radius jets into a larger jet (reclustering)
- Reclustering can use the detailed calibrations and uncertainties from 0.4 jets - allows more flexibility in the parameters of large R jets because no dedicated calibration is needed
FLAVOUR TAGGING

- Production of third generation squarks leads to decay signatures with charm or bottom quarks
- Boosted Decision Tree analyses output of impact parameter, secondary vertex finding and decay chain multi-vertex algorithms
- Significant b-tagging improvements can be seen with respect to run 1 (including IBL)
CHARM TAGGING

- Charm tagging algorithms use additional variables
- Such as invariant mass of secondary tracks, secondary track rapidities, distance from primary to secondary vertex, fraction of jet track energy carried by secondary tracks
- New result from run 2 on stop to charm decays recently released

Reconstruction techniques in supersymmetry searches with the ATLAS experiment
$E^\text{miss}_T$ RECONSTRUCTION
\[ E_T^{\text{miss}} \] WHICH IS FAKE

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

**FOR EXAMPLE**

- 0L suffer from QCD background, a process where real \( E_T^{\text{miss}} = 0 \).
- Bad MC modelling, large cross-sections, and resolution effects result into large fake \( E_T^{\text{miss}} \).
$E_T^{\text{miss}}$ SIGNIFICANCE

- Indicates the degree to which the reconstructed $E_T^{\text{miss}}$ is consistent with momentum resolution and particle identification efficiencies

- Event-based significance: $\mathcal{S} = \frac{E_T^{\text{miss}}}{\sqrt{H_T}}$ or $\mathcal{S} = \frac{E_T^{\text{miss}}}{\sqrt{\sum E_T}}$

- Object-based definition: log-likelihood ratio that the reconstructed $E_T^{\text{miss}}$ is consistent with the hypothesis of 0 real $E_T^{\text{miss}}$, based on full event composition

ATLAS-CONF-2018-038

ATLAS-CONF-2018-040
UNKNOWNNS IN SUSY RECONSTRUCTION
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

$$M_{T2}$$

$$m_{T2}(\chi) = \min_{E_{T1}^{miss}(1)+E_{T2}^{miss}(2)=E_{T}^{miss}} \left[ \max\{m_i^2(p_T^{(1)}, E_T^{miss(1)}, \tilde{\chi}_1^0), m_i^2(p_T^{(2)}, E_T^{miss(2)}, \tilde{\chi}_1^0)\} \right]$$
RECURSIVE JIGSAW

- A collection of approaches expressing masses as a function of unknowns, and then maximizing or minimizing, like $M_{T2}$
- Use measured event properties to approximate rest frames of intermediate particles in a “decay tree”
- RJR gives a new basis of observables based on energies and momenta of objects in these frames

ARXIV:1806.02293
Reconstruction techniques in supersymmetry searches with the ATLAS experiment

- Reconstruction algorithms being used to push into more extreme parts of SUSY phase space
- Many new ideas - lower $P_T$ leptons, BDT for isolation, object based $E_T^{miss}$ significance, recursive jigsaw reconstruction
- Full run 2 results to come from ATLAS SUSY searches on challenging signatures

CONCLUSIONS