Fast Detector Simulation in the New Look pMSSM

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M. Cahill-Rowley, J. Hewett, S. Hoeche, AI, Tom Rizzo, to appear

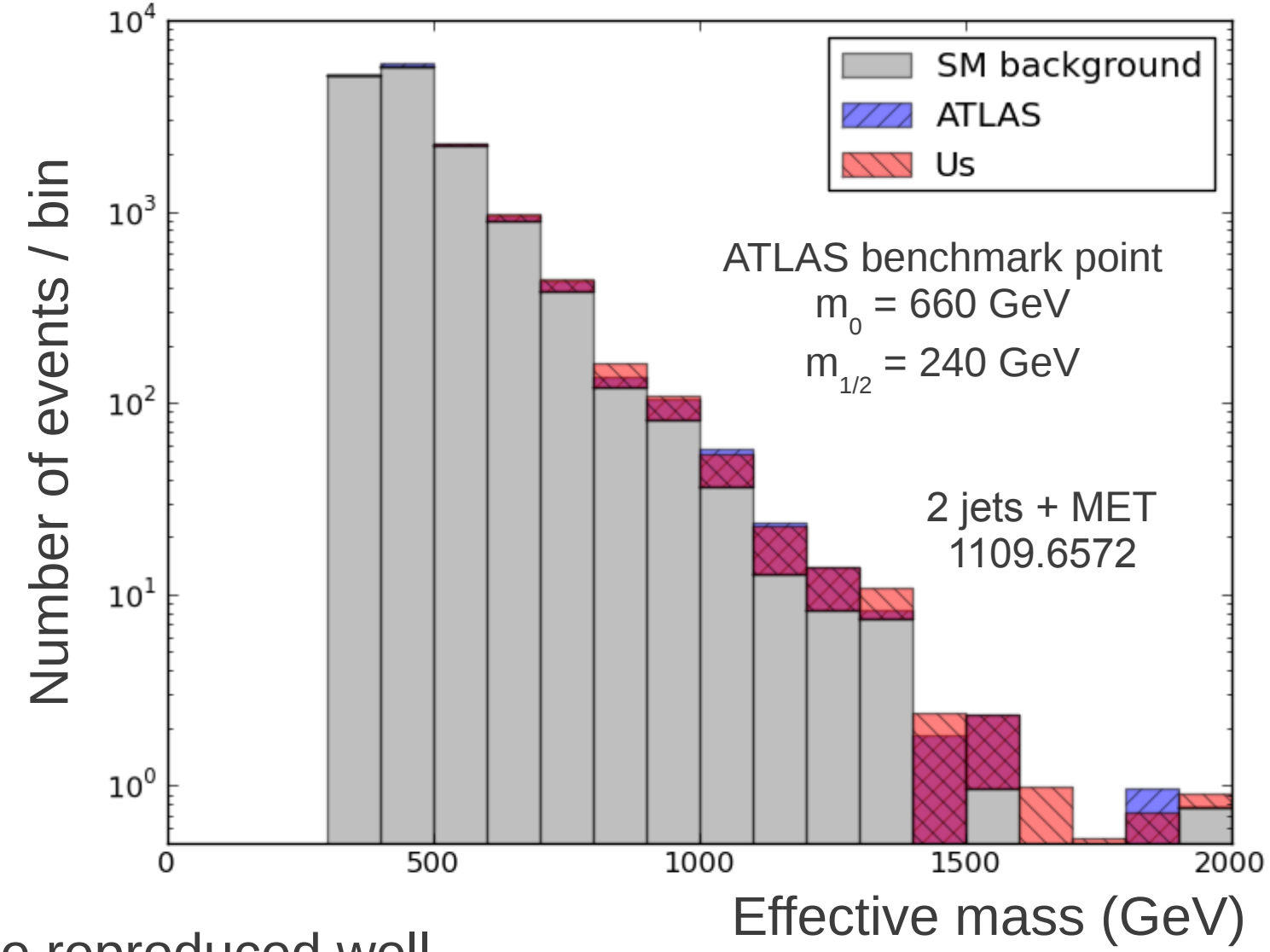
The phenomenological MSSM

- Impose experimentally motivated constraints on full MSSM parameter space to get set of 19 (20) weak-scale SUSY parameters
- Scan over these spaces, keeping models with neutralino (gravitino) LSPs that pass existing searches: collider, dark matter, ….
- Then, implement LHC searches by simulating events for all relevant SUSY processes with Pythia, scaling to NLO with Prospino, and passing the events through PGS
- This talk: how well does PGS do?

Jet algorithms

- Anti-k_T included in latest version of PGS
- Gives more circular jets than k_T algorithm
- Small systematic effects on events in search regions, but well within uncertainty
- e.g. for the benchmark mSUGRA point with m_0 = 2960 GeV, $m_{1/2}$ = 240 GeV, A_0 = 0, $\tan\beta$ = 10, $\mu > 0$, anti-k_T algorithm gives slightly (<20%) fewer events than k_T for signal regions in the 5/fb 6-9 jets + MET search

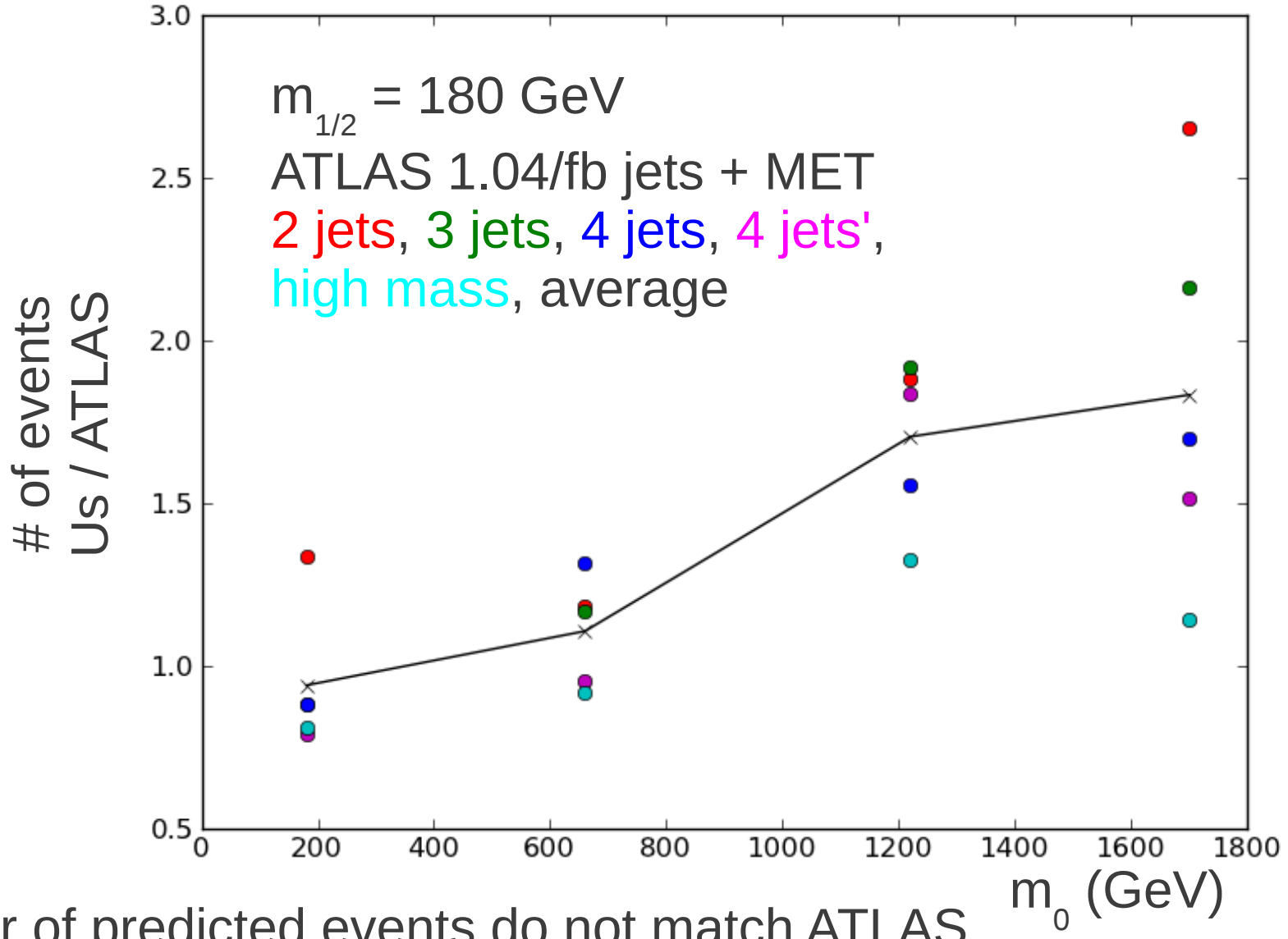
Validation



Shape reproduced well

Normalization good given ~35% uncertainty quoted by ATLAS

Validation

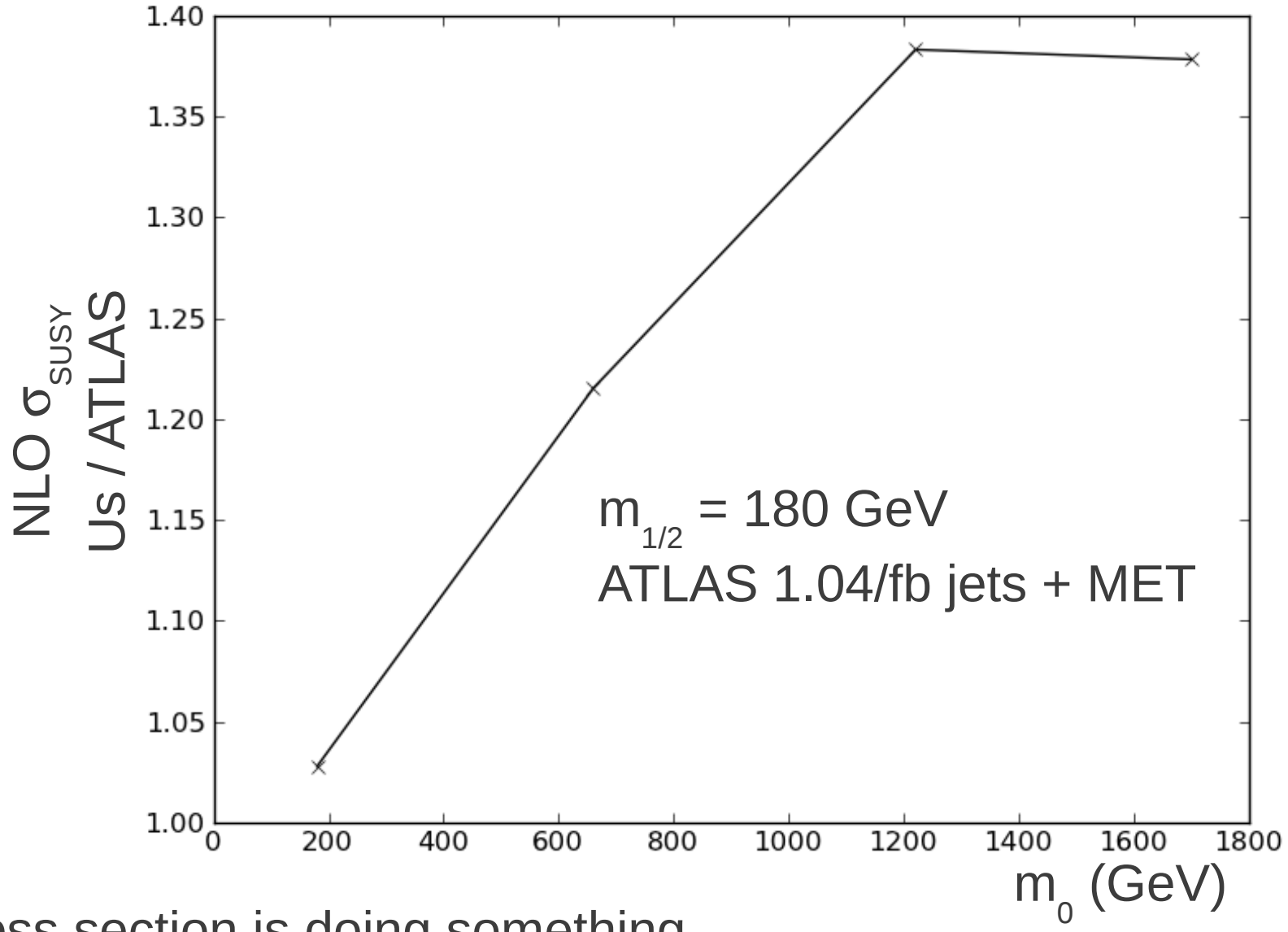


Number of predicted events do not match ATLAS simulations for models with heavy sparticles!

Validation

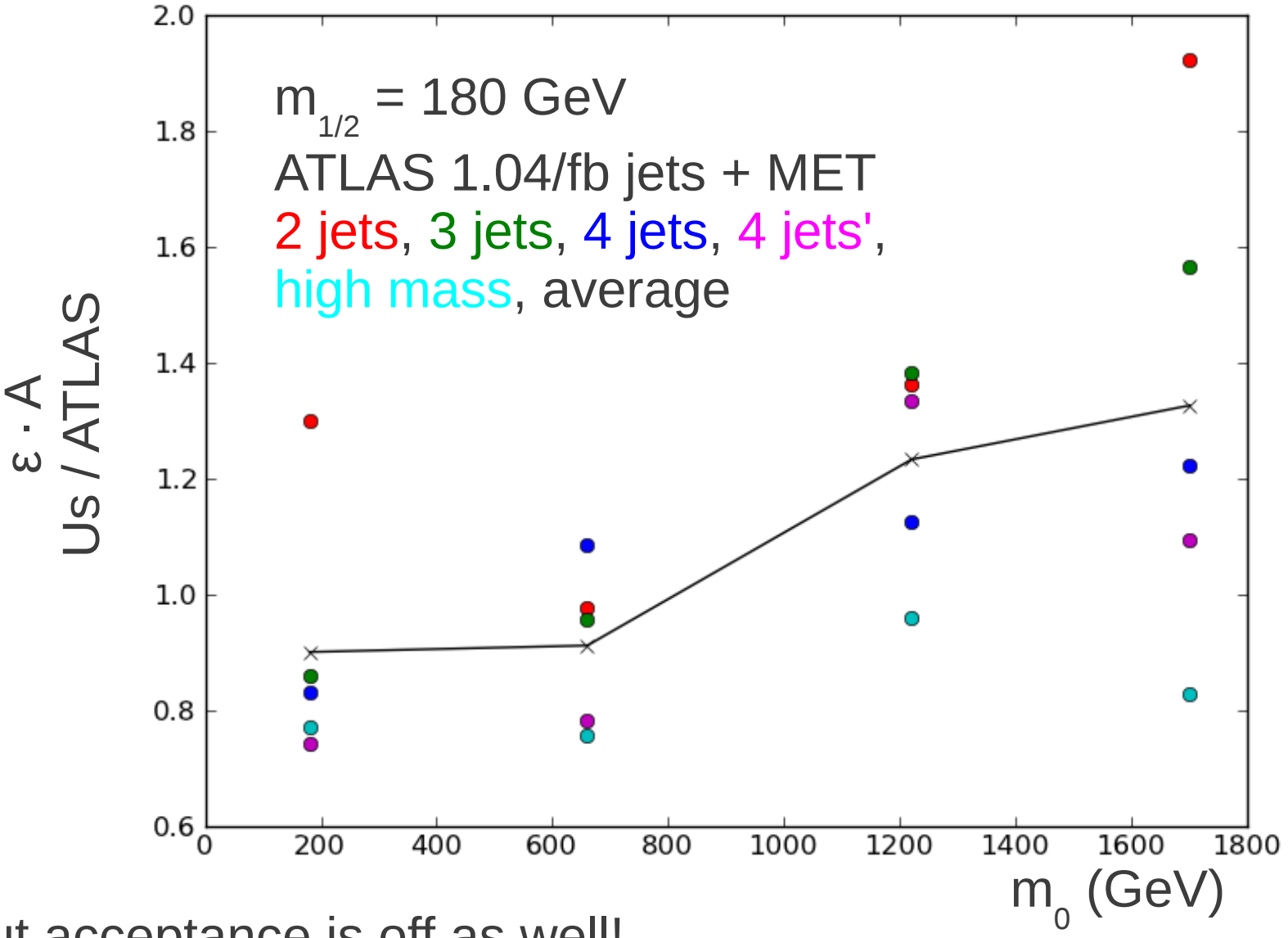
- Total number of events = cross section × acceptance × efficiency × luminosity
- Can separate out effects of cross section calculation versus detector simulation using quoted ATLAS cross section values for benchmark models in HepData
- We use Pythia + Prospino + PGS, while ATLAS uses Herwig++ + Prospino + Geant4

Validation



Cross section is doing something....

Validation



...but acceptance is off as well!

Object implementation

- We change some definitions in PGS to more accurately match the ATLAS analyses
- e.g. the “medium” electron definition, used by many searches with lepton vetoes, does not involve a p_T isolation cut → remove the isolation requirement from the list of criteria defining an electron
- Effect is relatively small, and does not lead to appreciable differences in numbers of events in signal regions

Object implementation

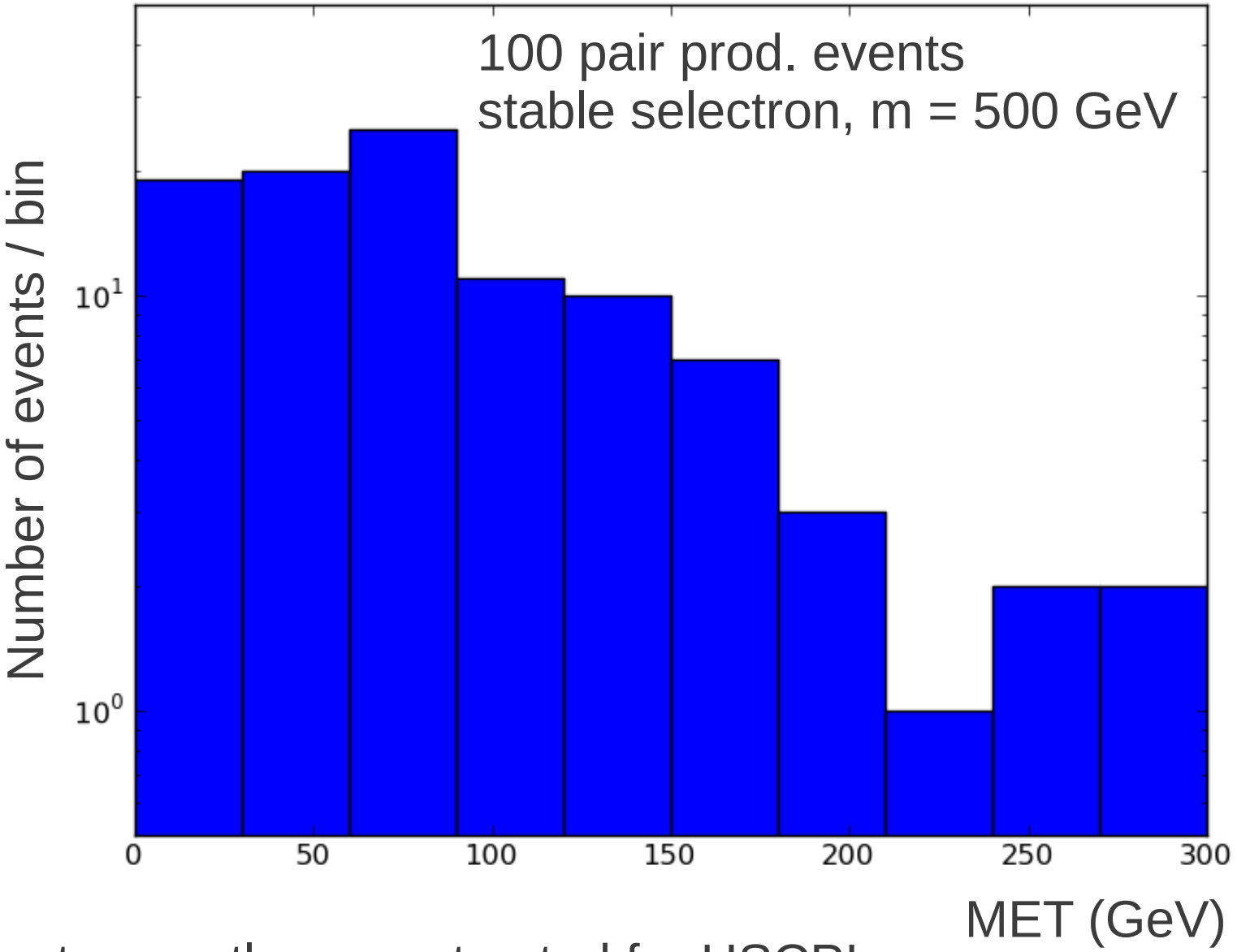
- Tau definition in PGS involves looking for 1 or 3 tracks depositing energy in hadronic calorimeter and having low invariant mass
- In SU(2960, 240, 0, 10, +), gluino weighs 700 GeV and can only decay through neutralino/chargino cascades to LSP
- W, Z, and h BF to taus are all at or below 10%
- Yet out of 2900 gluino pair production events (25/fb) for this model, over 1/3 have a τ in the final state! $\rightarrow$ high τ mistag rate

Object implementation

- Heavy stable charged particles are common in both our neutralino and gravitino LSP sets
- PGS looks for HSCP with $\eta < 0.6$ (we changed to 3.0), $p_T > 30$ GeV, m > 10 GeV, and

  $0.40 < \beta\gamma < 0.85$ (we changed to $0.40 < \beta\gamma$), applying a total efficiency of ~80%
- Code notes that efficiency is too high “by a factor of 2 to 3” for colored particles, which would lose more energy before reaching muon spectrometer

Object implementation



MET not correctly reconstructed for HSCP!

Summary

- In the absence of a publicly available and experimentally approved fast detector simulation, PGS indeed does a “pretty good” job of reproducing ATLAS signals for SUSY benchmark models
- Agreement is worse at higher sparticle masses
- Outstanding issues in taus, heavy stable charged particle reconstruction