ATLAS: Missing Transverse Energy in the Search for Supersymmetry

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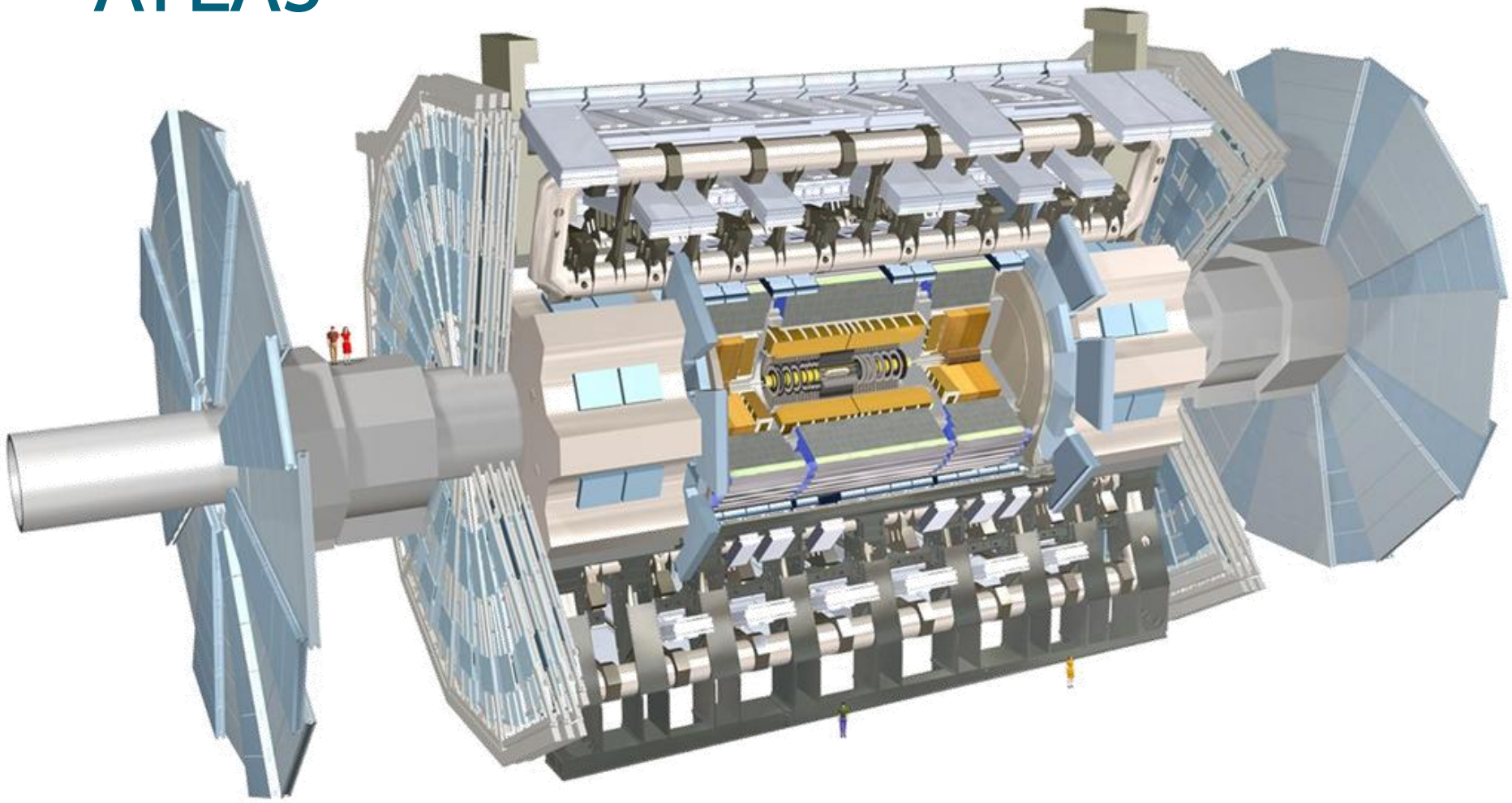
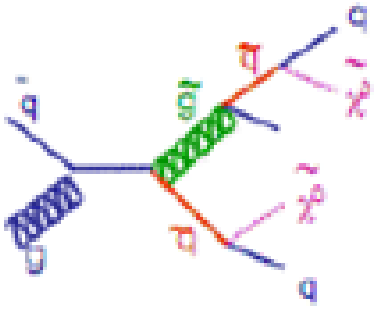
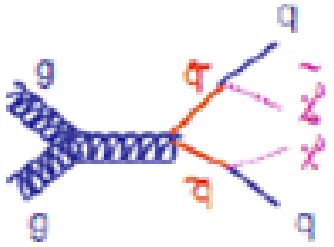
ATLAS

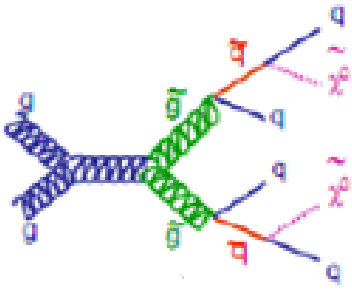


SUSY

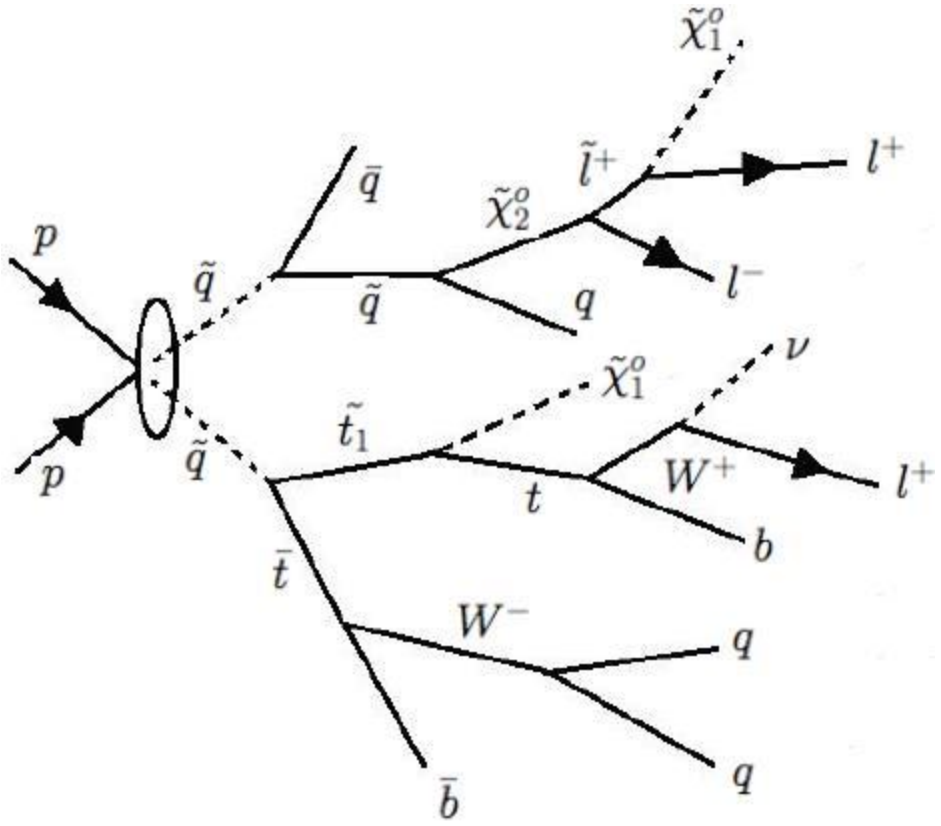


- Solve Standard Model Problems
  - Hierarchy Problem
    - What keeps the Higgs Mass from Blowing Up?
    - 100 GeV [Electroweak] vs. 10^19 GeV [Gravity]
- Sparticles – Supersymmetric Partner Particles
- Favored Model: mSUGRA

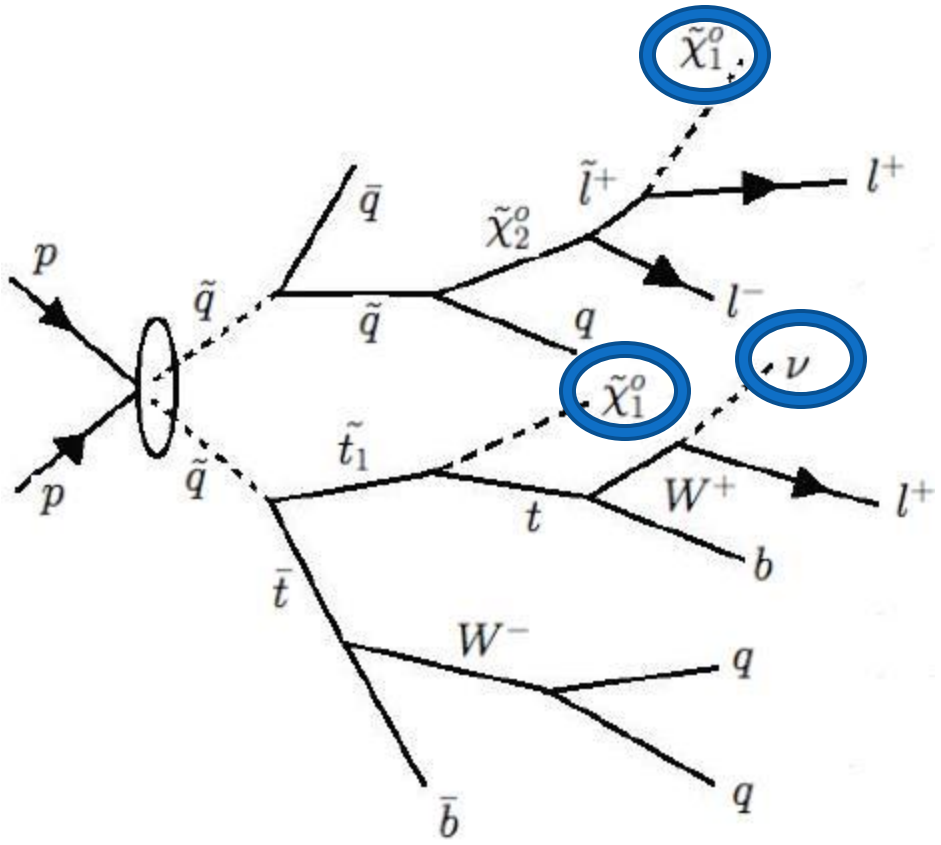




Missing Transverse Energy (ET)

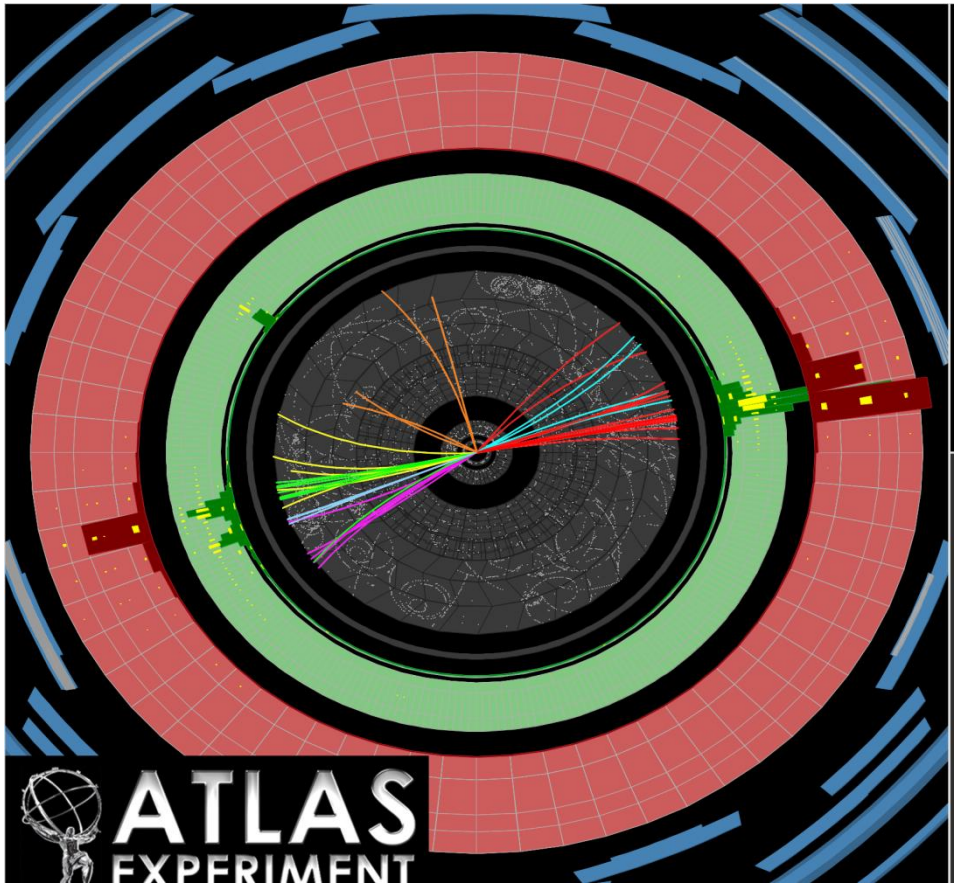


Missing Transverse Energy (ET)

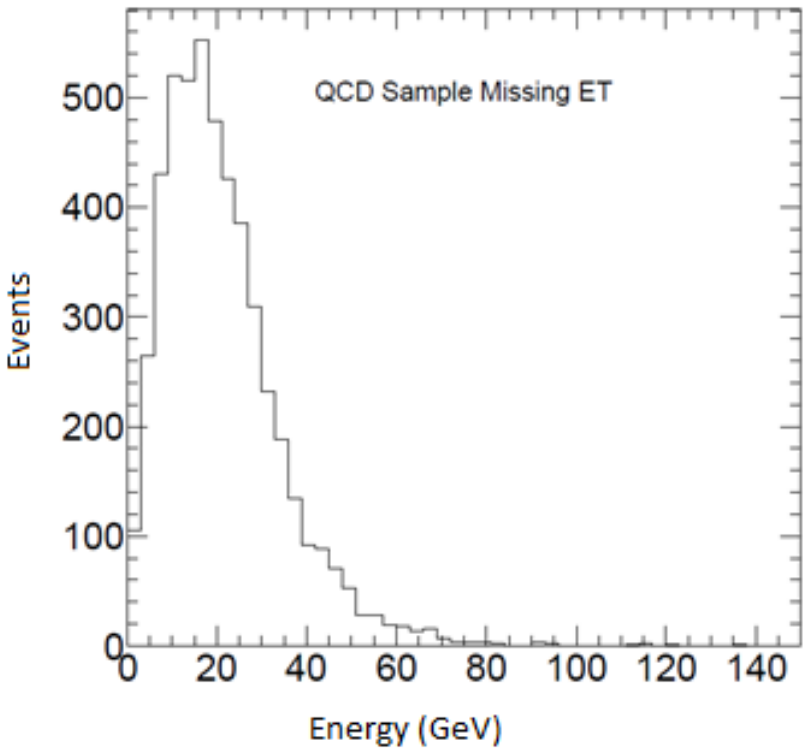


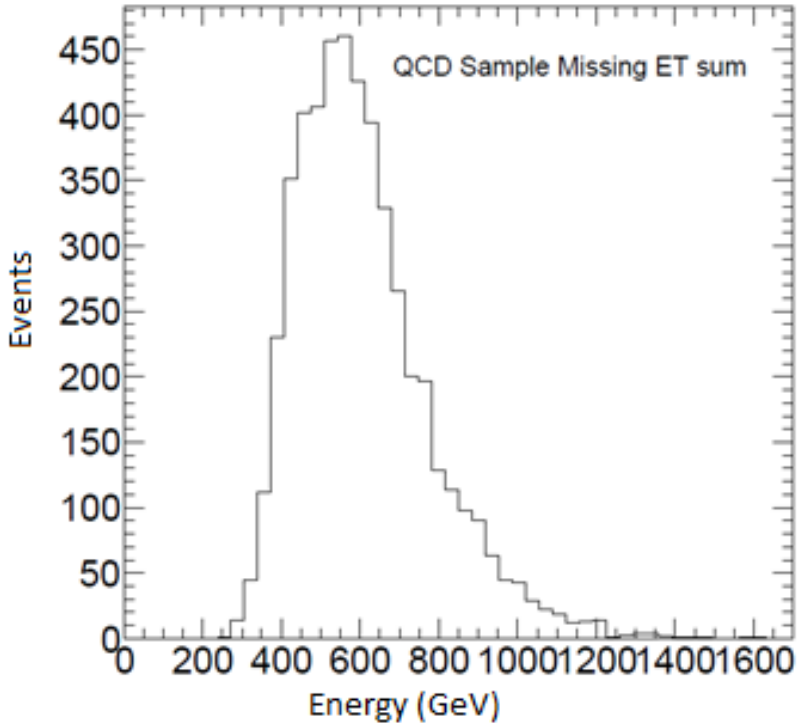
Missing ET – SM Background

- W+Jets
- Z+Jets
- QCD jet (mismeasurement)
- T Tbar

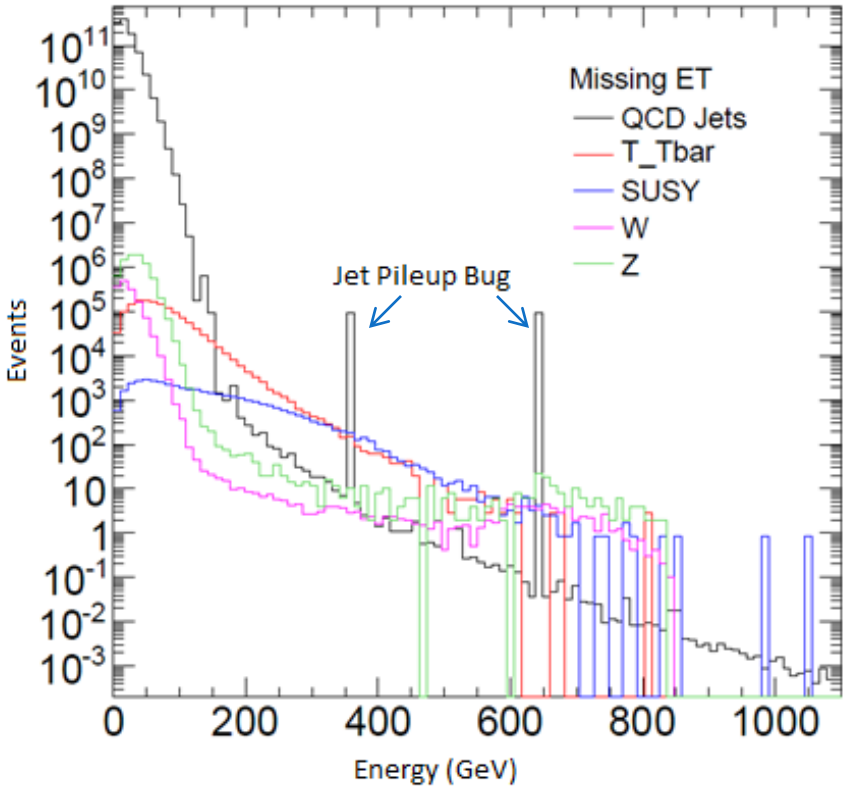


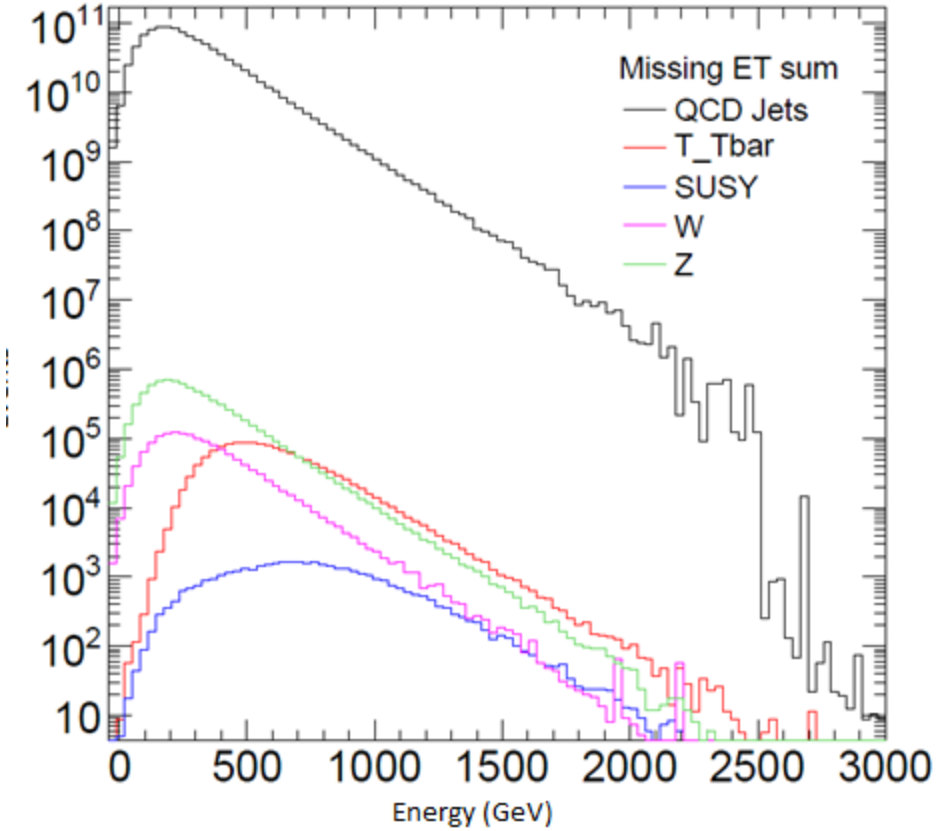
Early Plots – Jet Sample





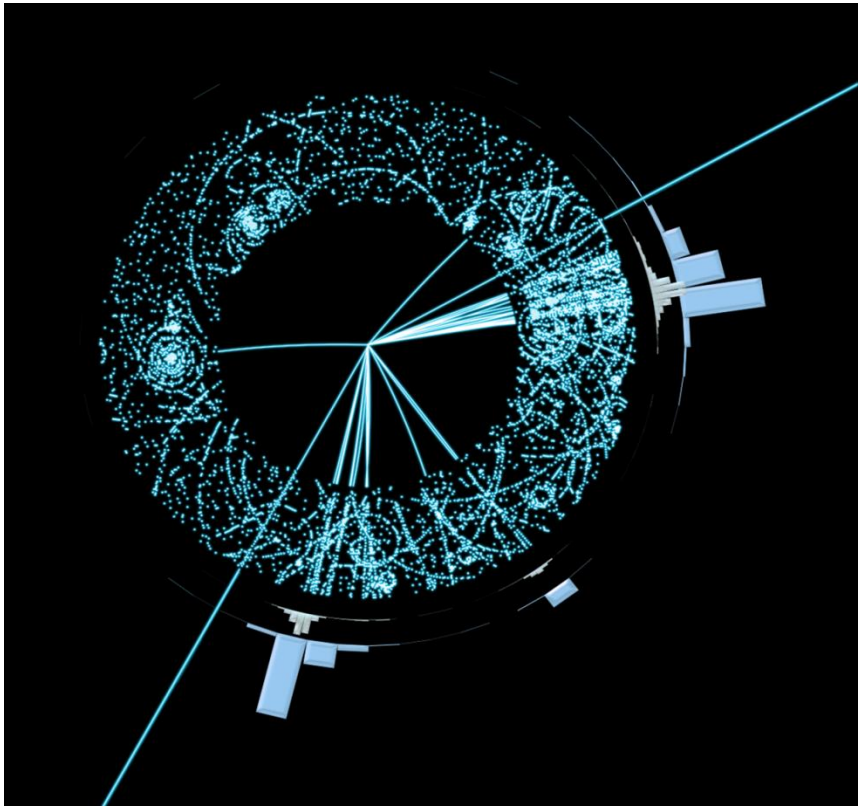
Plots in Progress





Goals

- Compare to Event Data
- Apply Cuts
- Find Evidence of Supersymmetry!



Salève

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturda	Sunday
Schedule	from 9:30 to 19:00	from 9:30 to 19:00	from 9:30 to 19:00	from 9:30 to 23:00	from 9:30 to 23:00	from 9:30 to 23:00	from 9:30 to 19:00

Hierarchy Problem - Backup

Since all quarks, leptons, and EW gauge bosons acquire mass from the Higgs, the entire spectrum on the SM is affected by this fine tuning.

What do we need to avoid this problem?

$\frac{1}{7}\Lambda_{UV} \sim 100$ ⟶ Leads to Λ_{UV} of order hundreds of GeV to a TeV

If we are to trust naturalness we need new physics at an order of a TeV.

SUSY at an order of a TeV offers an intriguing solution to these problems (but keep in mind, it is an extremely ambitious theory).

Hierarchy Problem - Backup

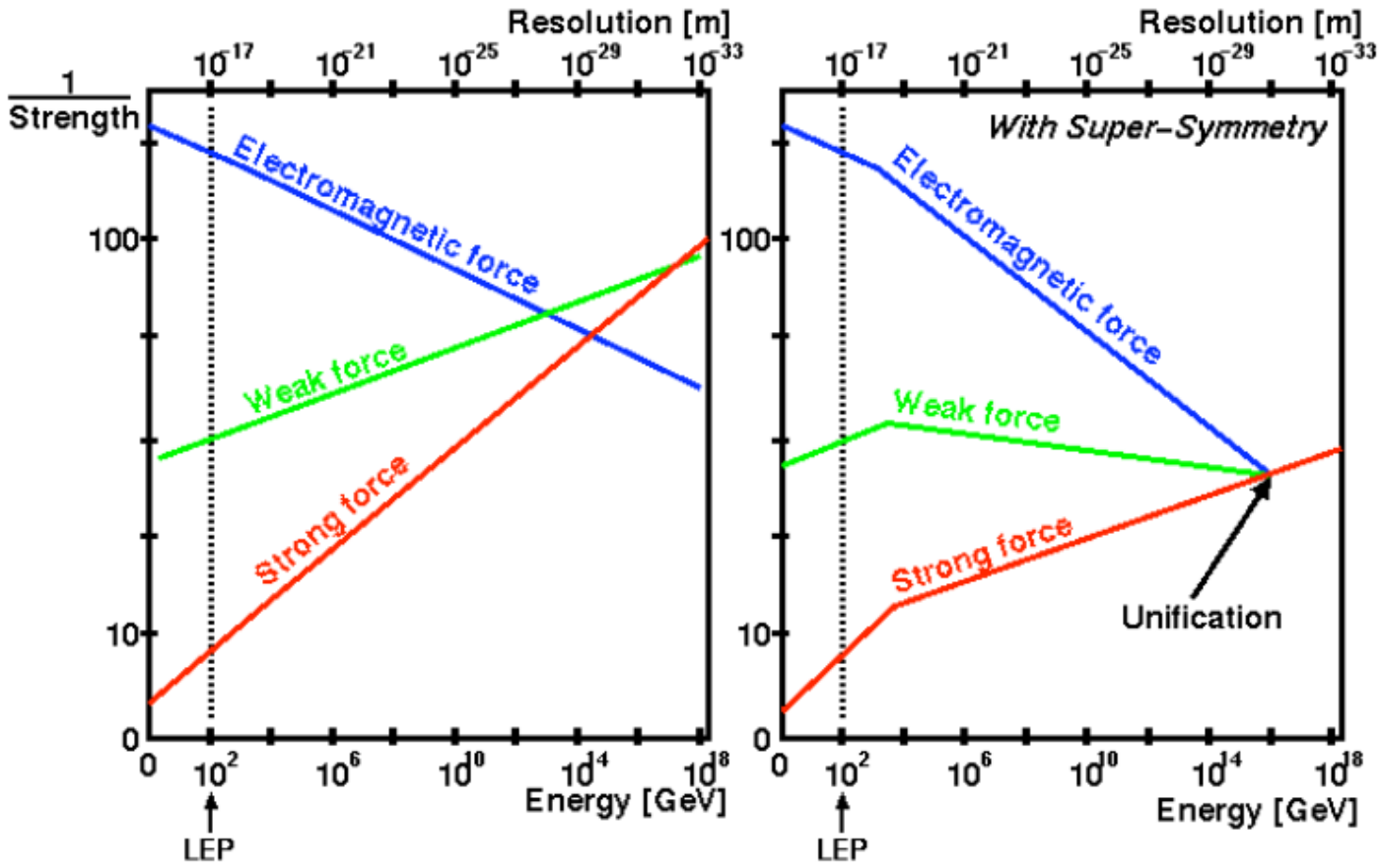
So what do we need from SUSY to cancel this fine tuning?...
A scalar loop to introduce a minus sign in the mass correction...

$$\delta m_h^2 \sim -\frac{3\lambda_t^2}{16\pi^2}\Lambda_{UV}^2 + \cdots$$

The systematic cancellation brought about by introducing a scalar loop into the mass correction suggests a symmetry... And the symmetry must relate fermions and bosons. So if each of the quarks and leptons of the SM are accompanied by a complex scalar, then Λ_{UV} corrections will cancel.

Therefore the basic prediction of SUSY is the existence, for every particle in the SM spectrum, a corresponding "sparticle" which differs in spin by half a unit.

Supersymmetry Unification - Backup



Monte Carlo - Backup

- Event Generator– generates random numbers and decides whether event happens based on probability
  - ATLAS – after generating events, showers them through the detector to get a readout simulation

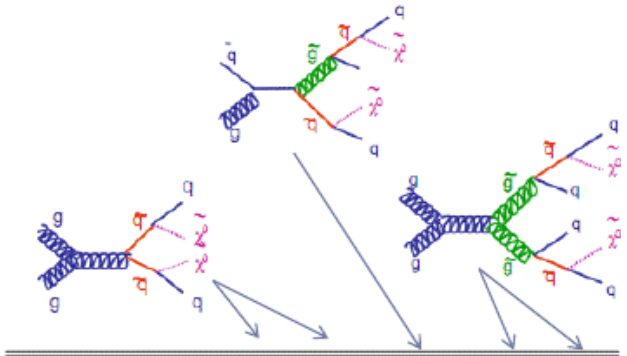
SM Missing ET Background and Cuts-Backup

- **SM Background**
  - W+Jets
    - W→lν in which electron or muon is not reconstructed
    - W →τν, in which τ decays hadronically
  - Z+jets
    - Z→ $\nu\bar{\nu}$
  - QCD mutlijets
    - When one of the jets is mis-measured
    - When a neutrino is emitted from heavy flavour decay
  - Single/pair top production
    - $t\bar{t}$ →$b\bar{b}\tau\nu qq$ when τ decays hadronically

- **Cuts**
  - For QCD background cut on Δφ
  - "Activity" within event, lower for SM processes

$$m_{\text{eff}} \equiv \sum_{i=1}^{n} |\mathbf{p}_{\text{T}}^{(i)}| + E_{\text{T}}^{\text{miss}},$$

  - Cut on $E_{\text{T}}^{\text{miss}}/m_{\text{eff}}$ reduces events in which missing momentum is due to jet mis-measurement in high centre-of-mass events



Signal Region	A	B	C	D	E
$E_{\text{T}}^{\text{miss}}$ [GeV]			> 130		
Leading jet p_{T} [GeV]			> 130		
Second jet p_{T} [GeV]	> 40	> 40	> 40	> 40	> 80
Third jet p_{T} [GeV]	-	> 40	> 40	> 40	> 80
Fourth jet p_{T} [GeV]	-	-	> 40	> 40	> 80
$\Delta\phi(j_i, E_{\text{T}}^{\text{miss}})(i = 1, 2, 3)$			> 0.4		
$E_{\text{T}}^{\text{miss}}/m_{\text{eff}}$	> 0.3	> 0.25	> 0.25	> 0.25	> 0.2
m_{eff} [GeV]	> 1000	> 1000	> 500	> 1000	> 1100