ATLAS Prospects for SUSY and UED Discovery at $\sqrt{s} = 10$TeV
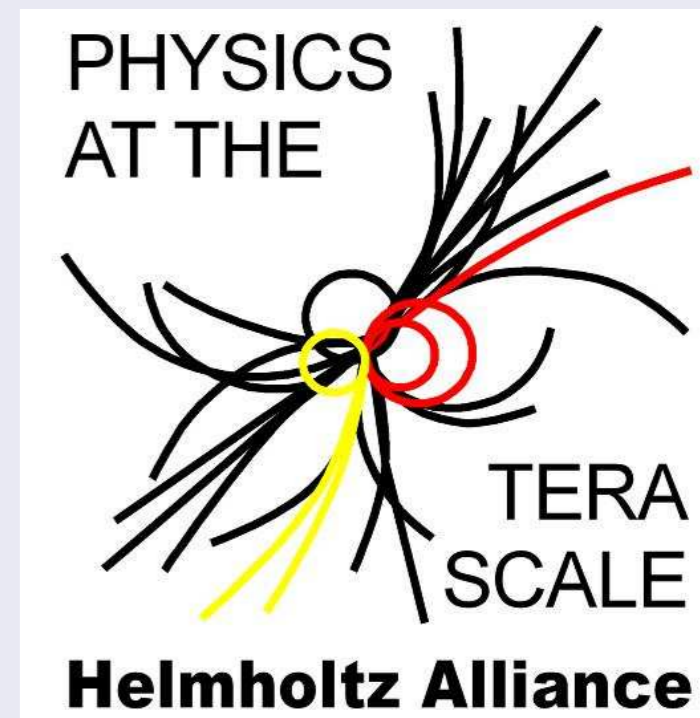
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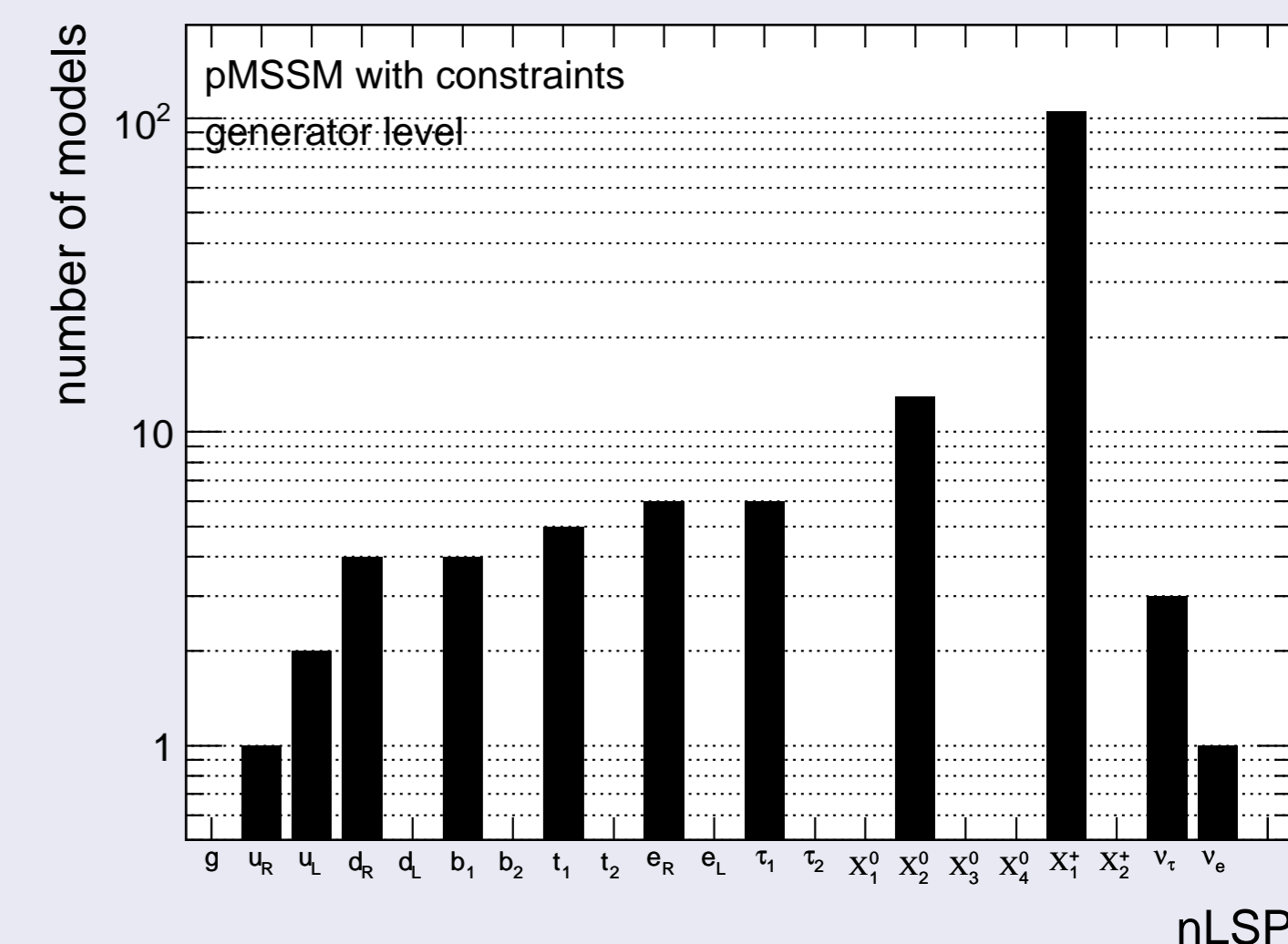PHYSICS AT THE TERA SCALE
Helmholtz Alliance

Motivation

► LHC offers a unique opportunity to search for new physics beyond the Standard Model

► Theoretically favoured extensions of Standard Model(SM): **Supersymmetry (SUSY)** and **Universal Extra Dimensions (UED)**

► We studied the R-parity conserving SUSY and Kaluza-Klein-parity conserving UED scenarios where new particles are produced in pairs and decay in cascade into the lightest SUSY/UED particle which should be stable, weakly interacting and thus escapping the detection in ATLAS.

► Typical event signature: large missing transverse energy ETmiss and particles with large transverse momentum (jets, leptons, possibly photons)

► This study assumes an LHC centre-of-mass energy $\sqrt{s} = 10$TeV and an integrated luminosity $\mathcal{L} = 200$ pb^{-1}

Physics models

In order to develop search strategies covering a large variety of signatures, the SUSY/UED parameter space is scanned - three signal grids generated (cross sections $0.1 < \sigma < 2900$ pb).

Model	Characteristics
mSUGRA	SUSY breaking is mediated by gravitational interactions. This model is defined by 5 free parameters: m_0, $m_{1/2}$, A_0, tanβ, μ. Points generated along the radial lines in (m_0, $m_{1/2}$) plane for tanβ=10 and 50, A_0=0, μ>0 .
pMSSM	Phenomenological MSSM with 19 free soft SUSY breaking parameters. All points satisfy experimental bounds from LEP, Tevatron and dark matter density experiments. Points randomly chosen from [Ref Berger,Gainer,Hewett,Rizzo JHEP 02 (2009)023]
UED	Minimal UED scenario with 4+1 dimensions (extra dimension being compactified). Points generated for different compactification scales 1/R= 300,400,...1000 GeV. Mass splitting in the KK excitation mass spectrum fixed at λR=20

The next lightest SUSY particle (nLSP) types in the pMSSM grid:

Analysis based on inclusive searches

Analysed were channels with jets, leptons (e, μ) and missing transverse energy E_T^{miss} (jets multiplicities defined inclusively whereas the lepton multiplicities exclusively)

Jet and E_T^{miss} cuts

Njets	≥2 jets	≥3 jets	≥4 jets
leading jet Pt [GeV]	>180	>100	>100
jets Pt [GeV]	>50	>40	>40
$\Delta\Phi$(jet,E_T^{miss})	[>0.2,>0.2]	[>0.2,>0.2,>0.2]	[>0.2,>0.2,>0.2]
E_T^{miss} [GeV]	>80	>80	>80
E_T^{miss}>f.M_{eff}	f=0.3	f=0.25	f=0.2
transverse sphericity S_T	>0.2	>0.2	>0.2

Lepton cuts

0-lepton	no isolated leptons with Pt>20 GeV
1-lepton	one isolated lepton with Pt>20 GeV and no additional isolated leptons with Pt>10 GeV, $M_T(l,E_T^{miss})$>100GeV
2-lepton OS	two isolated leptons with Pt>10 GeV and opposite charge

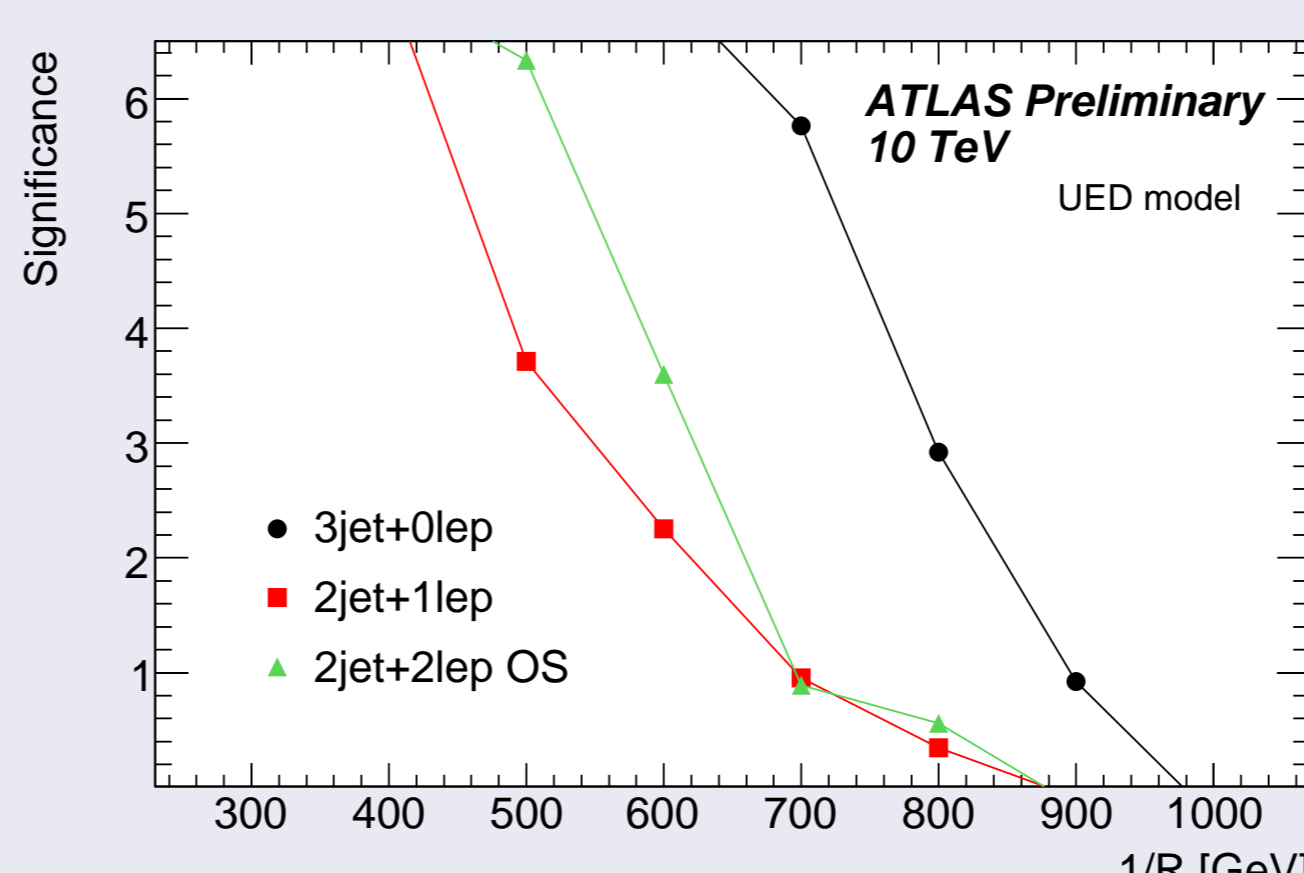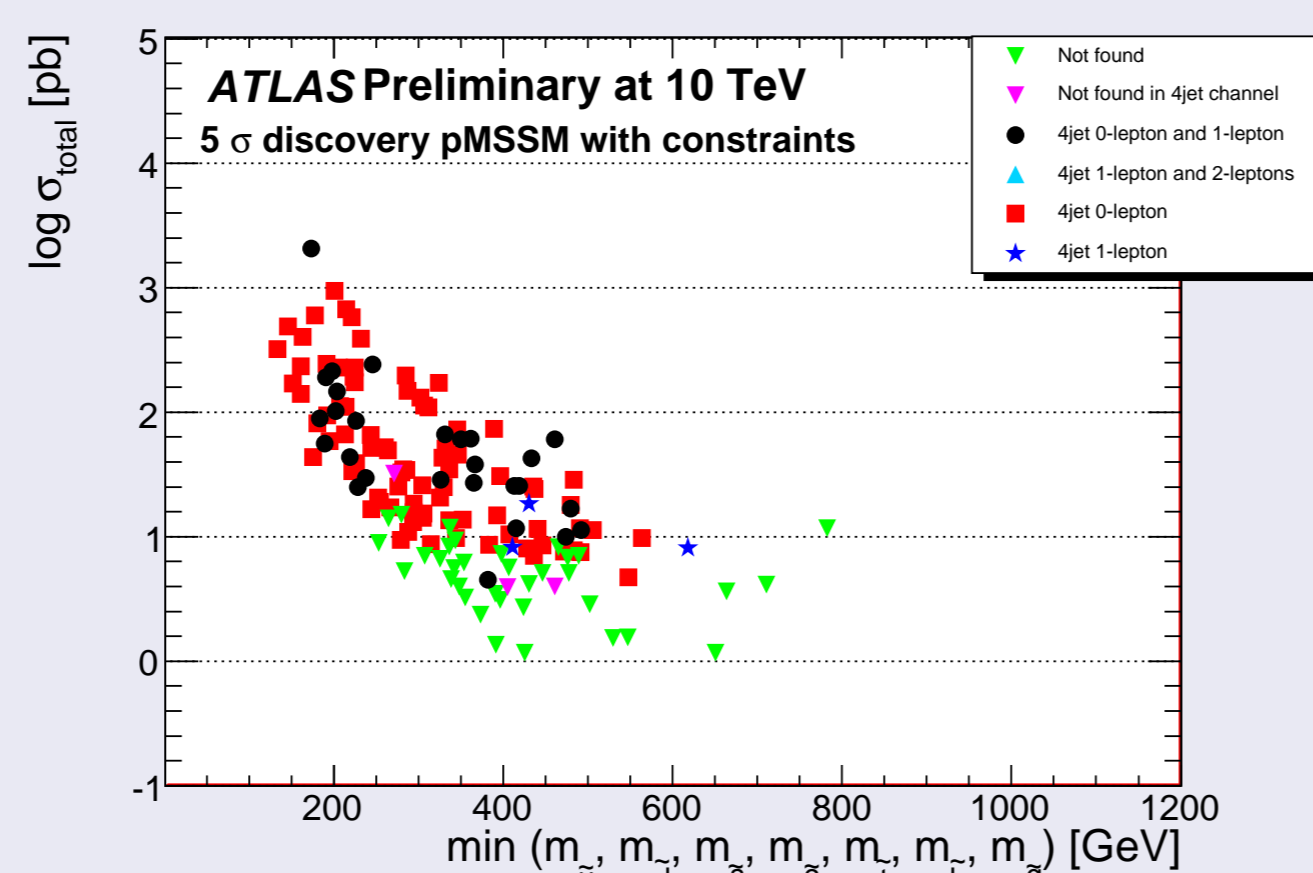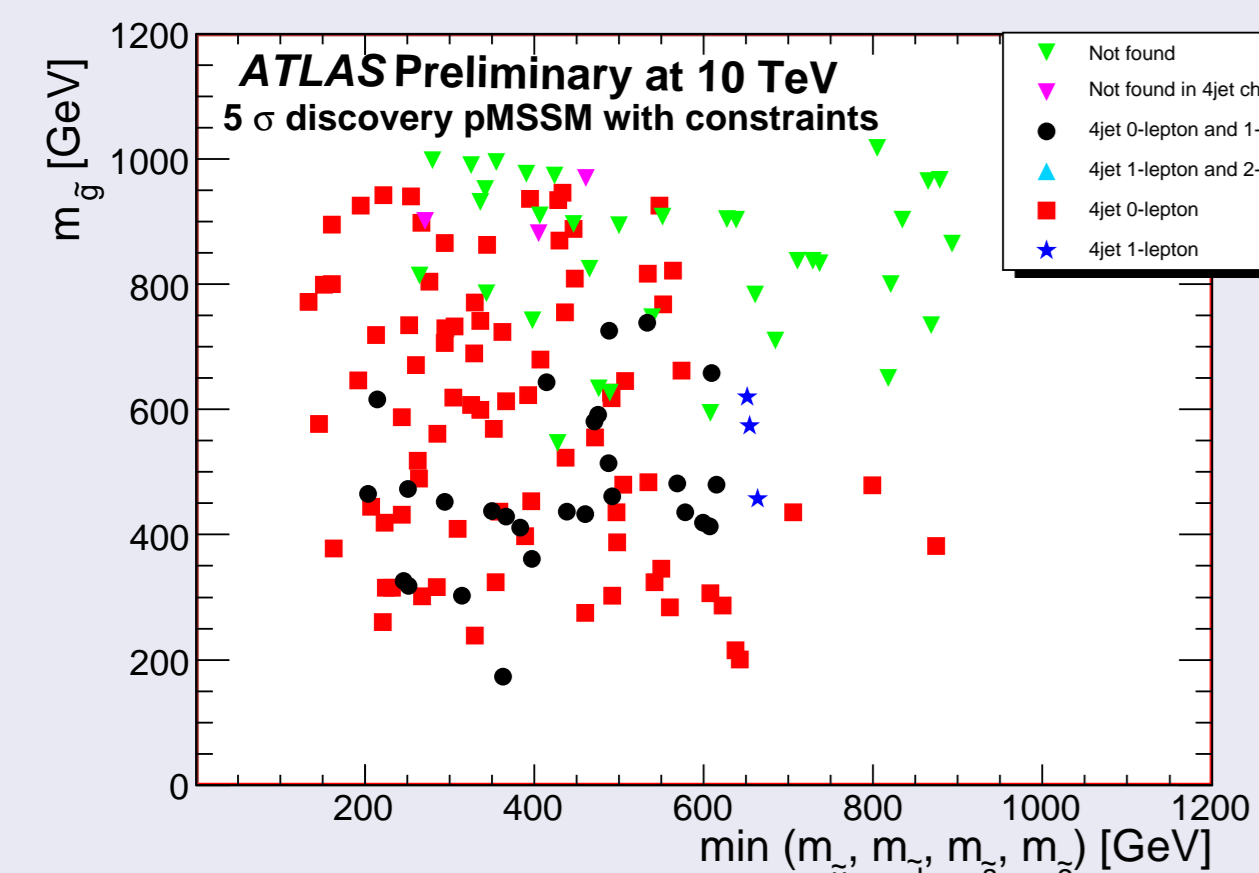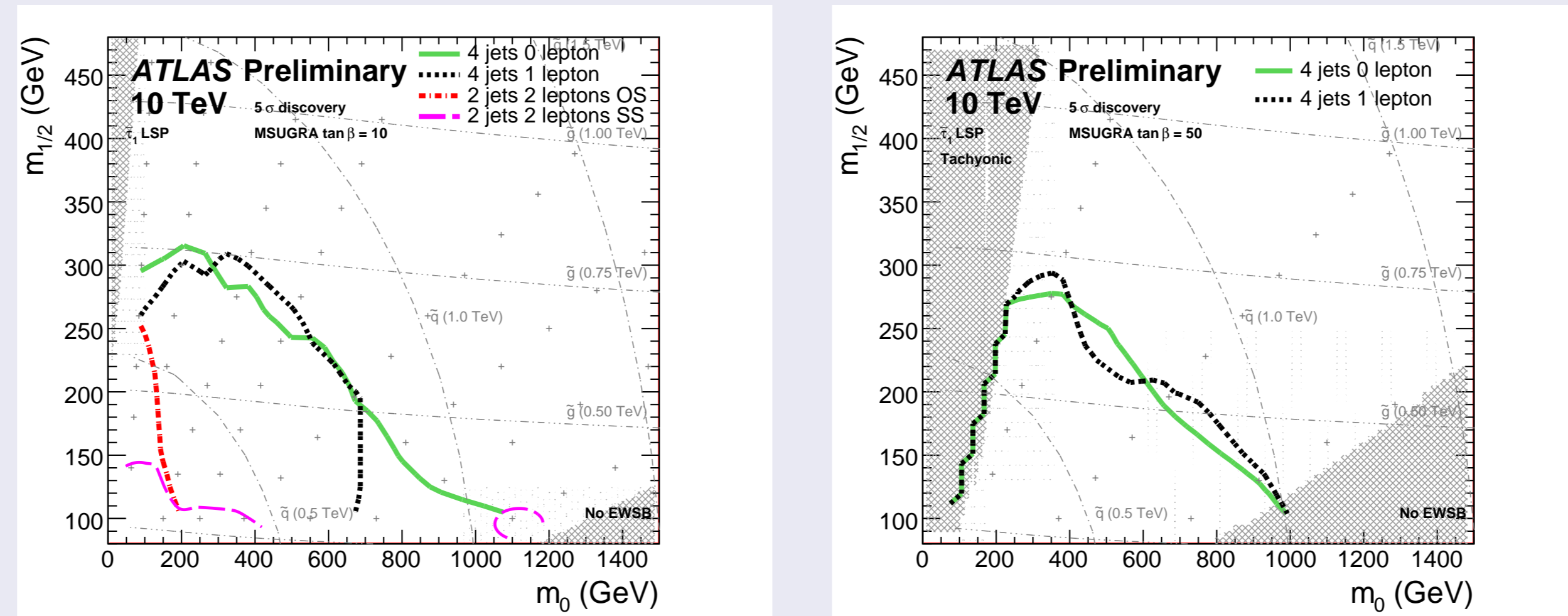**Effective mass** M_{eff} - used to search for deviations between SM+Signal and SM expectation

$$M_{eff} = E_T^{miss} + \sum_{i=1}^{N_{jets}} P_T^{jet,i} + \sum_{j=1}^{N_{leptons}} P_T^{lepton,j}$$

Most relevant SM backgrounds: top pair and W,Z production
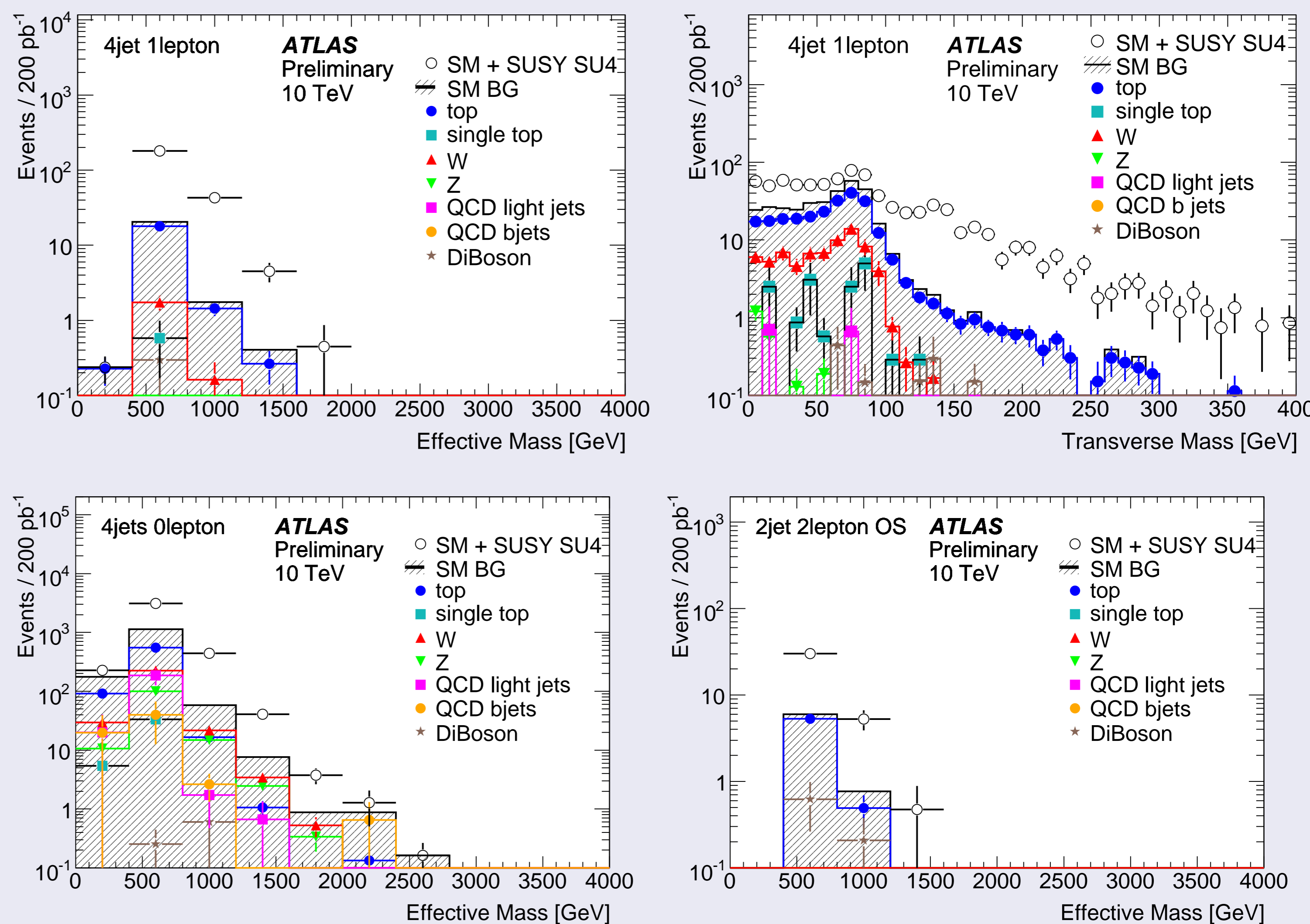
► QCD background suppressed by $\Delta\Phi$ cut
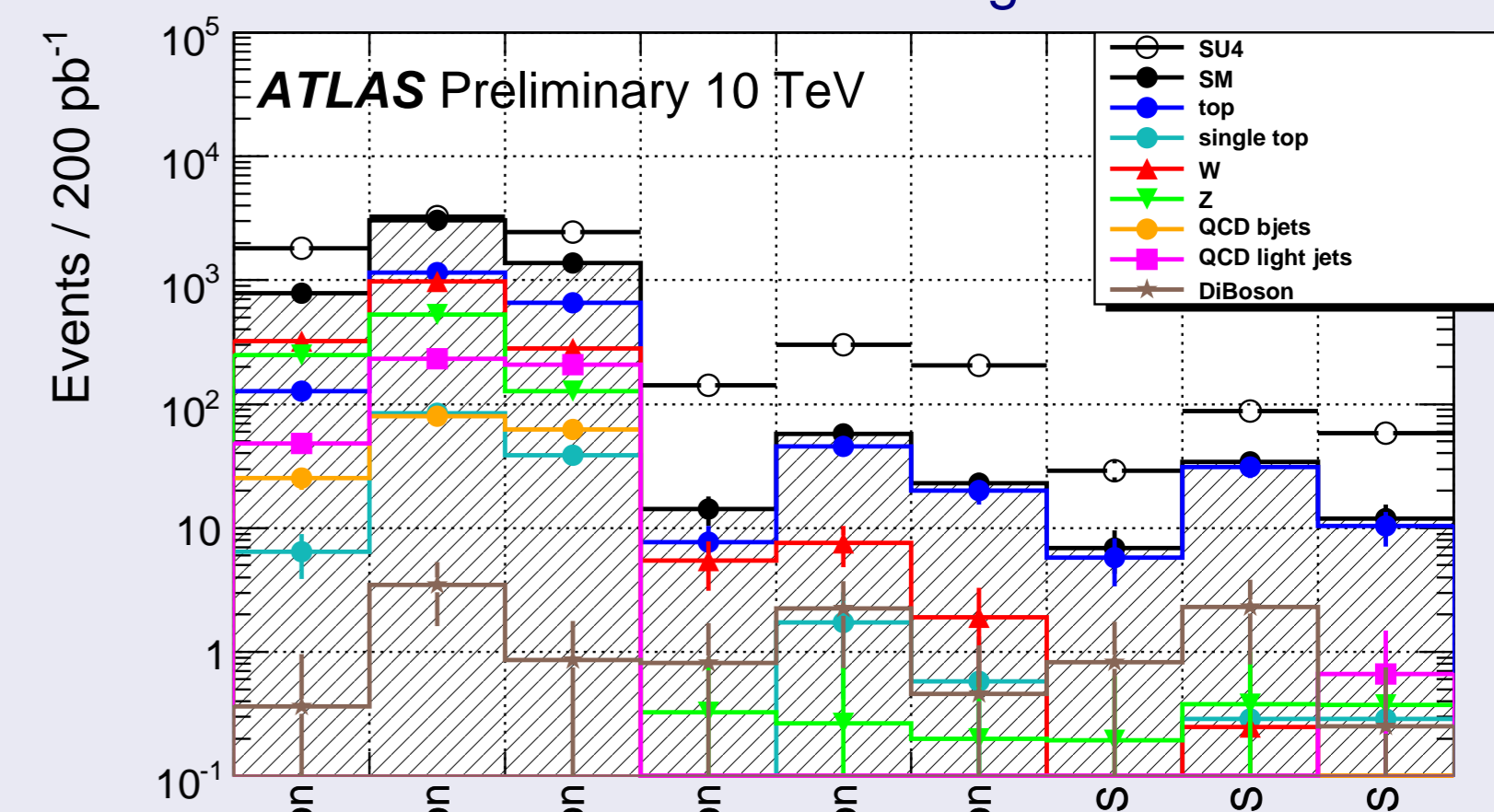► in 1-lepton channel M_T cut introduced to effectively suppress the top and W

Effective mass distributions for channels which yield best performance:

SUSY SU4, σ= 108pb
(m_0=200GeV, $m_{1/2}$=160GeV, A_0=-400, tanβ=10, μ>0)

Number of expected events in all analysed channels for SM and SU4 signal:

Discovery reach

► For the reach plots the M_{eff} region with highest significance (cuts in 400GeV steps) is chosen.

► The significance is calculated as convolution of Poisson and Gauss term to account for systematic errors.

► The overall systematic uncertainty on SM background was estimated to be 50%.

Discovery reach lines (significance> 5σ) for various channels in MSUGRA, pMSSM and UED parameter space:

Conclusions

► The results of scans indicate that ATLAS can discover signals of R-parity conserving SUSY with squark and gluino masses less than 600-700 GeV in many scenarios.

► Signals of Universal Extra Dimensions can be discovered up to compactification scale 1/R= 700 GeV.

► Reference: ATLAS note ATL-PUB-2009-342