Signature-based searches How realistic and useful are they?

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For **the ATLAS collaboration**,

and special thanks to

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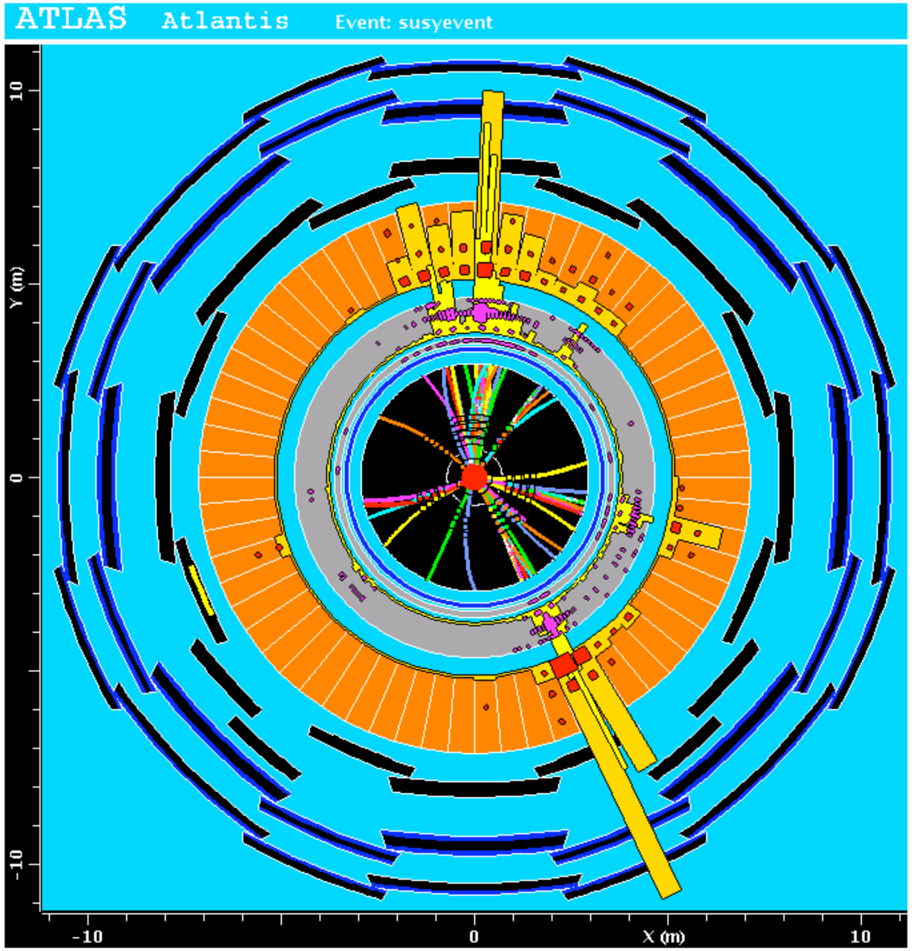
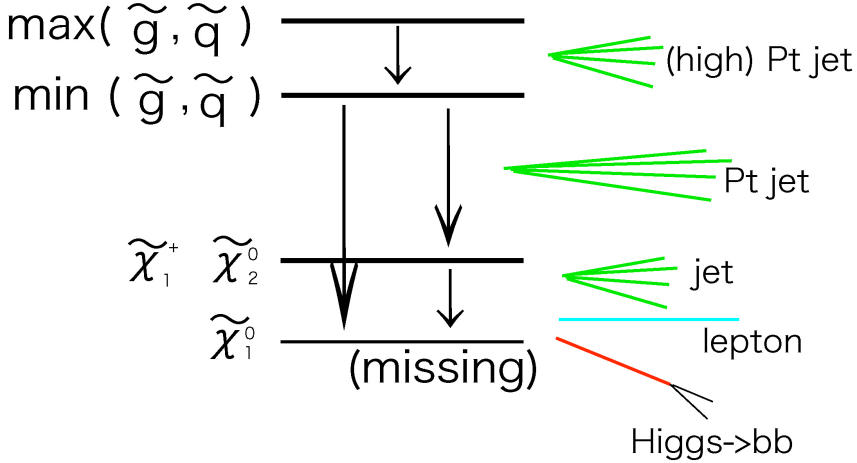
"Typical" Events topology of SUSY signal is like this

Gluino/squark are produced first,
then cascade decay is followed.





event topologies of SUSY

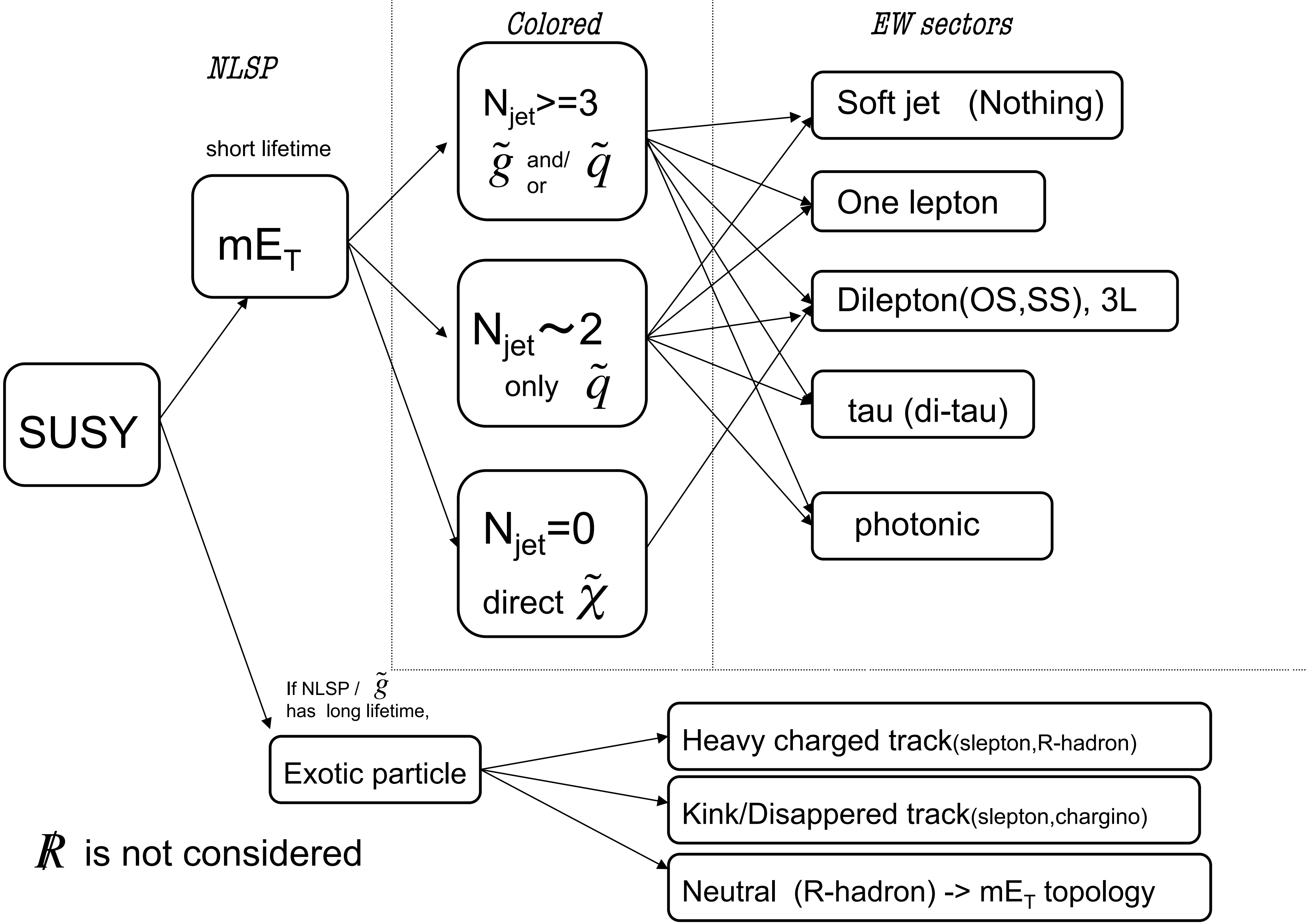
multi leptons

$\not{E}_T$ + High P_T jets + b-jets

τ-jets

Especially
no or one lepton mode is promising for Discovery

more detail classification are necessary for general studies:



$R\!\!\!/$ is not considered

Various topologies are possible and "Topology-based" study is important:

N·Jets + M·Lepton + (M')·τ +(N')·bjet+ K·photon with mE_T
(+) Exotic tracks/clusters

But in the real world, "complete non-biased study" is not "realistic" ;

(1) There are too many combinations ! Not only N,M,M',N',K…
How much threshold on P_T of jet/lepton is applied?
How much on mE_T ? Lepton ID loose? tight? which is used?
Too complicated. We need some guides !!!

To: AMSB

To: mSUGRA

To: Degenerate model

(2) Background & performance of Detector

No body believes naively the MC prediction
of the background estimation.
There are large uncertainties especially in normalization.
Also much studies are need on the shape of the distributions

Backgrounds should be estimated with the real data.
Furthermore lepton ID efficiencies, Fake probabilities,
Trigger effect …… are also estimated with real data itself.

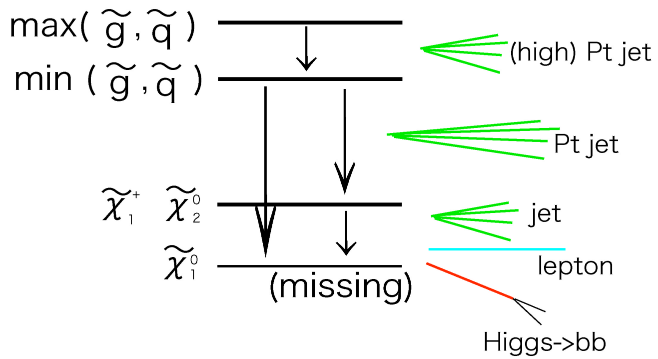
Not so easy work as I will show letter.

We select the "Only" topologies and kinematics in which background can be reliable and estimable.
Otherwise we see many "fake excesses".

SUSY is not "peak business", different from Higgs,
And SUSY events have wide kinematics, Signal excess are seriously affected by the uncertainties of background/performance:
Very limited information are obtained from pp-collision.

[1] mE_T + Jets(N_{jet}>=3,4) with/without lepton

These topologies are gold-plated and useful for the many models and wide parameters.

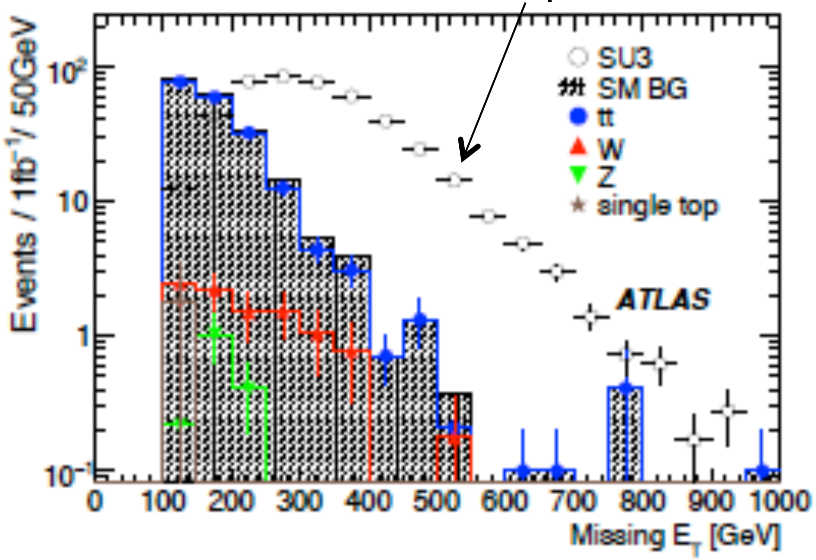


Simple selections are applied

for **one-lepton** mode

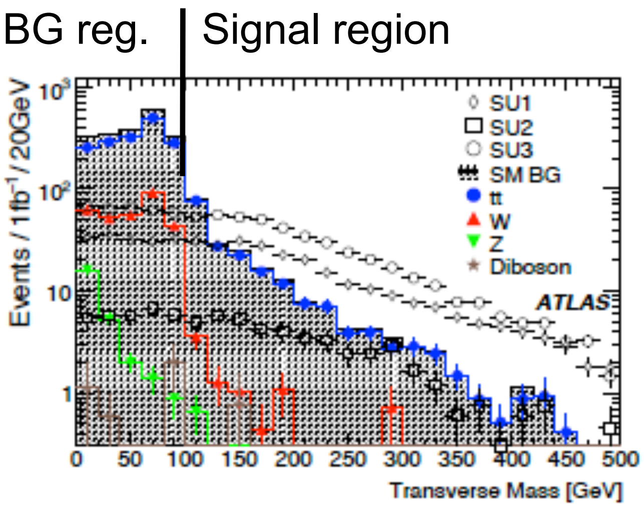
1. Njet(P_T>50GeV, |η|<2.5) >= 4 (or 3)
2. 1^{st} jet P_T > 100GeV
3. mE_T > 100GeV
4. mE_T > 0.2 * Meff(=mE_T+ΣP_{TJ})
5. S_T > 0.2
6. N_{lep}(P_T>20GeV) =1
7. MT(lepton and mE_T)>100GeV

m_0=100,$m_{1/2}$=300GeV
tanβ=6 A=-300GeV



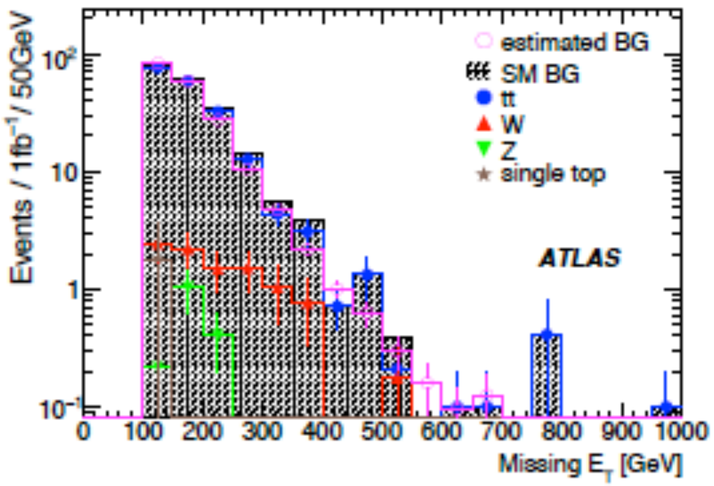
Clear excess is observed in large mE_T/M_{eff} regions.
Top and W+jets are the dominant BG processes for one-lepton/multijet topology. These BG should be estimated using the real-data self.

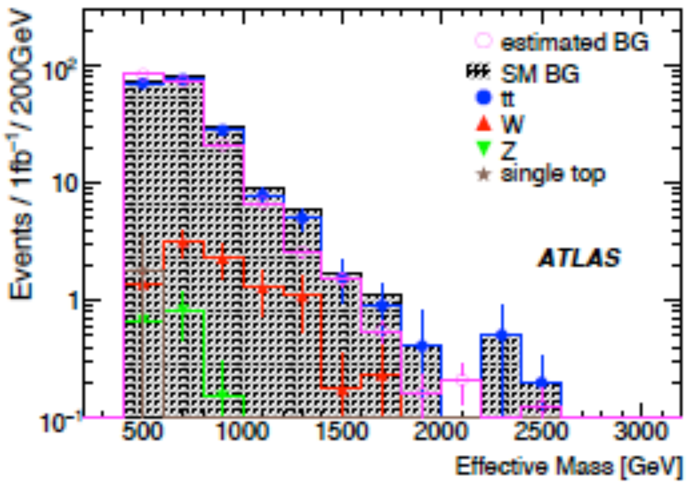
MT method is useful for the top/W BG



- MT>100GeV Signal dominant
- MT<100GeV BG dominant

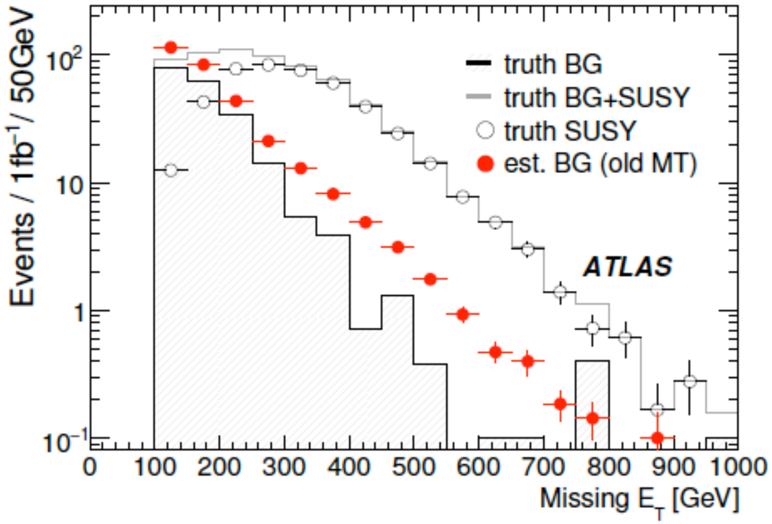
mE_T and jet P_T are indipend on MT,
since MT is related to leptonic decay of W.
$mE_T/P_{T(JET)}$ distributions are obtained from the BG region and normalized in the Signal region.
Normalization factor is obtained with small mE_T (< 150GeV) to reduce the effect of SUSY signal.



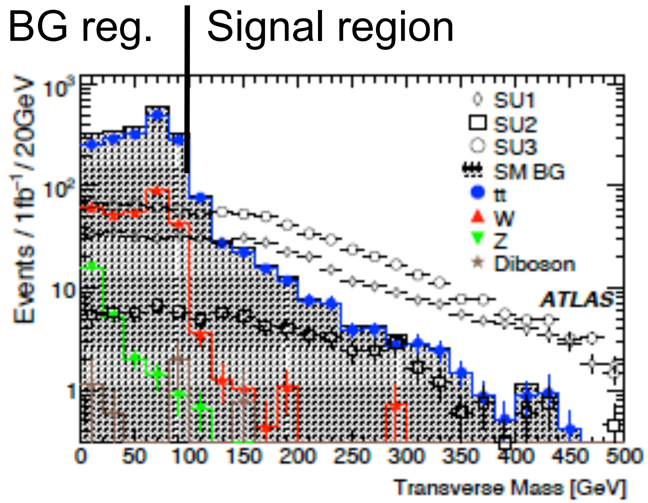


BG distributions are reproduced well for all mE_T, M_{eff} and P_{Tjet} distributions
Systematic uncertainties are about 15% (mainly due to jet P_T distribution,L-ID)
This MT method can be used also for the OS dilepton mode.

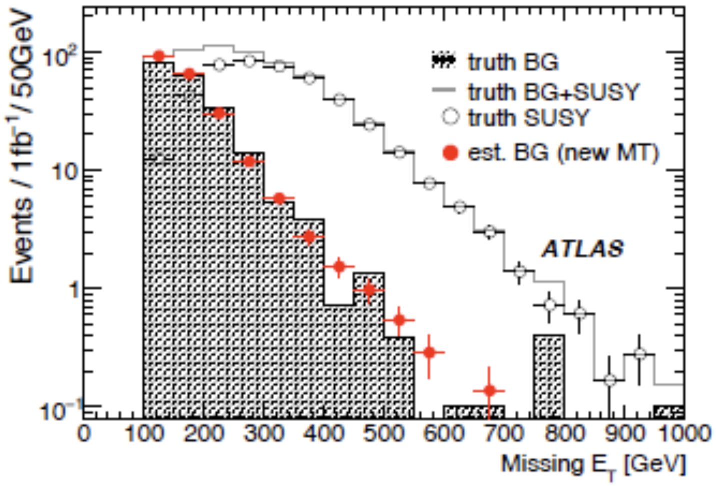
But situation becomes worse when the SUSY exists.



SUSY also contributes to CS region and make estimated distribution harder.



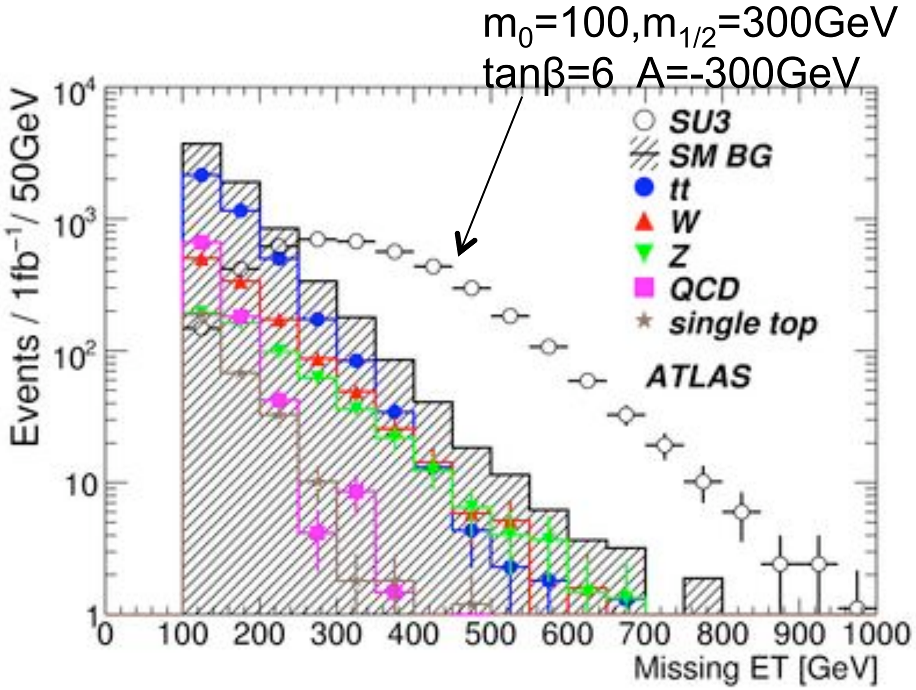
New MT method or



the fitting method can be used:
SUSY contamination in CS is estimated from Signal region with assumption SUSY MT distribution is flat. It works, but depends on model.

for **No-lepton** mode

1. $N_{jet}(P_T>50GeV, |\eta|<2.5)>=4$ (or 3)
2. 1^{st} jet P_T > 100GeV
3. mE_T > 100GeV
4. $mE_T > 0.2 * M_{eff}(=mE_T+\Sigma P_{TJ})$
5. S_T > 0.2
6. $N_{lep}(P_T>20GeV) =0$
7. $\Delta\phi(jet, mE_T) > 0.2$: mE_T is pointed to a jet direction in QCD

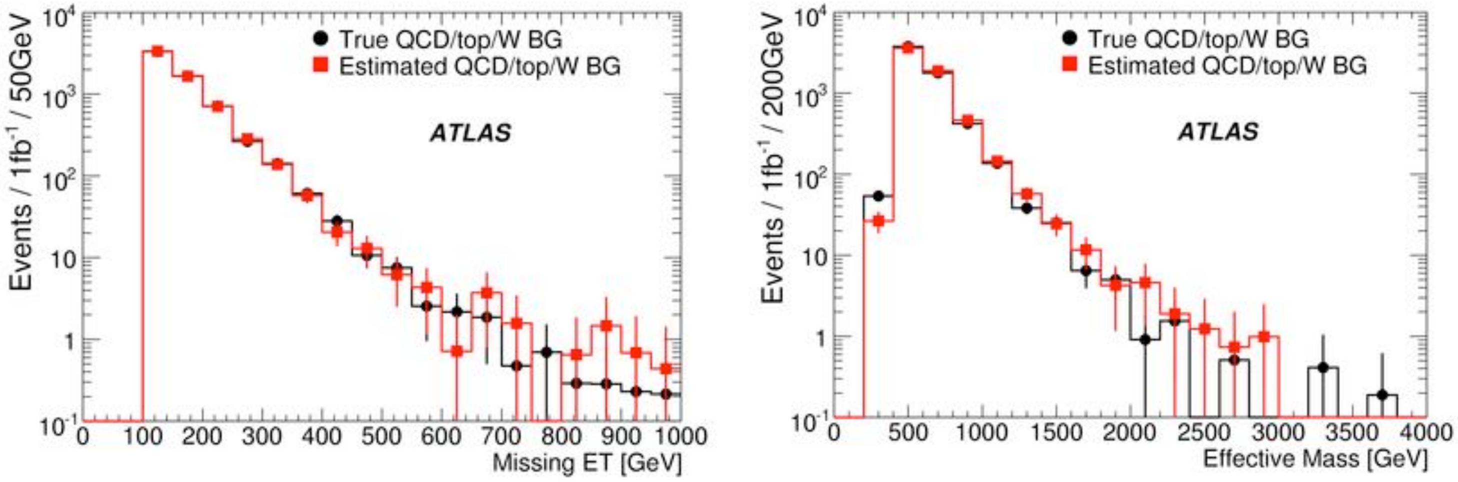


Clear excess is observed in large mE_T/M_{eff} regions.
Top, W+jets, $Z(\rightarrow\nu\nu)$+jets are the same amount and the main BG processes.
Also the QCD processes contribute to the background in relatively small mE_T region.(QCD is not serious BG, but it makes BG normalization difficult)

(1)Top/W $W\rightarrow\tau\nu$ and W→e/mu ν(but P_T<20GeV or out of acceptance) contribute to no-lepton mode (Almost the same ratio)
(2) For the QCD, the detector effect (due to “non-Gaussian tail” of the resolution) is expected to be small.
We can check mE_T performance using the real data in the early stage of collision.
Large mE_T region is also robust for the cosmic ray/hot/some dead counters.
Real mE_T (ν) comes from the semi-leptonic decay of heavy flavour is dominant.

MT method can be used for the W/top contributions:

The control sample can be obtained with one lepton & MT<100GeV:

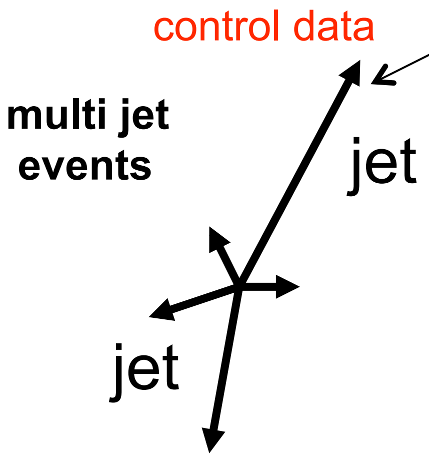


Black histogram shows the true BG distribution and
Red histogram shows the estimated BG with the MT method,
normalized at mE_T =100-150GeV.
Important to notice we have to estimate amount of the QCD background in order to determine the normalization factor, since QCD is the dominant BG in the small mE_T.
If we can estimate the QCD BG with absolute amount, the MT method works well.

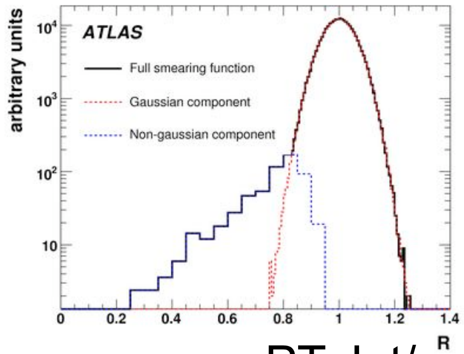
Systematic uncertainties are about 35% (jet energy scale is main)
If SUSY exists, we have the same problem, new MT etc.. not yet checked.

How to estimate the QCD backgrounds: **(Response function method)**

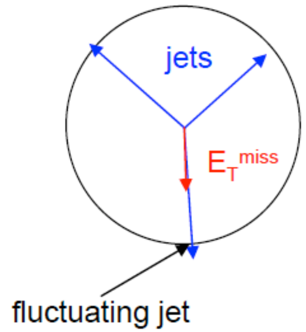
The control sample of the QCD processes are selected (multijet and No mE_T)



Apply "response" function on the jets:

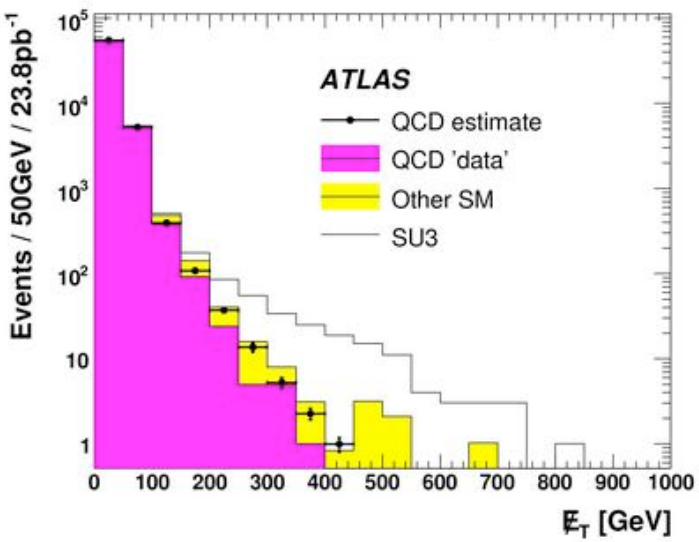


Response function is obtained from data γJ and JJJ



response=PT Jet/ original PT

Original PT is estimated from opposite site (γ, JJ)



The obtained distribution is normalized in mE_T < 50GeV
Agreement is obtained.