Study of Background for SUSY @LHC

1. Event topologies of SUSY
2. SM background processes
3. Problem in the current estimation
4. Production with ME information
5. ME-PS matching
6. Results
7. Extrapolation for SUSY
8. Summary

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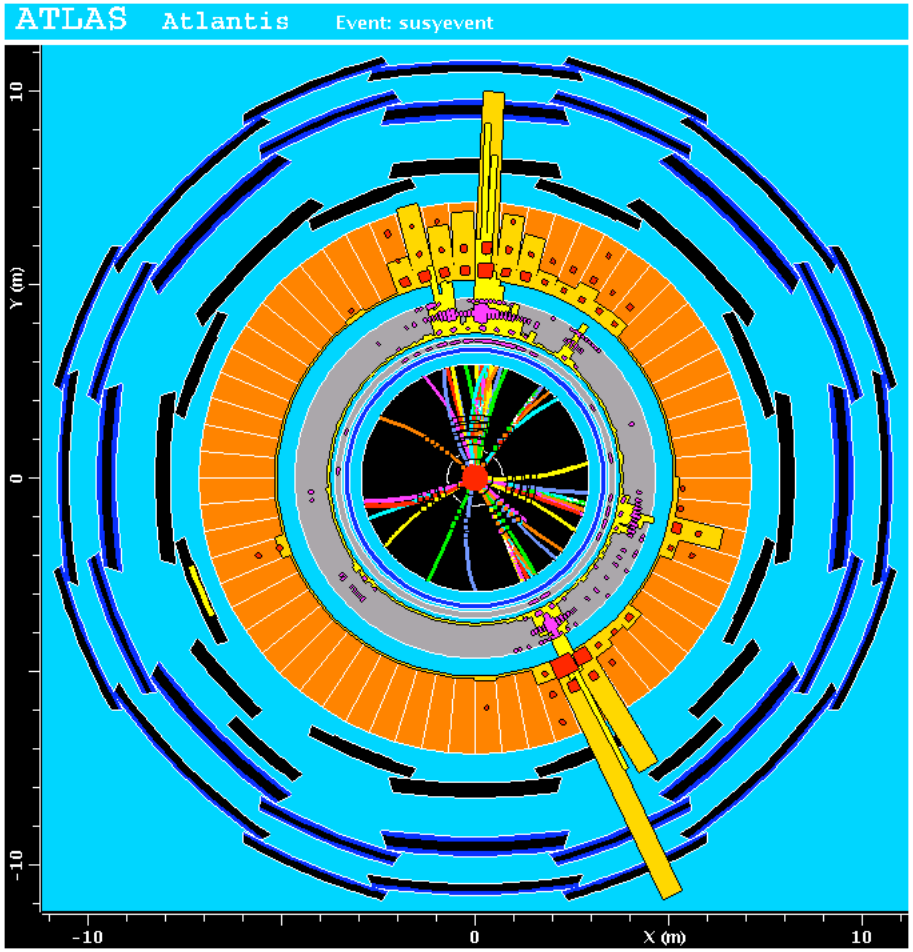
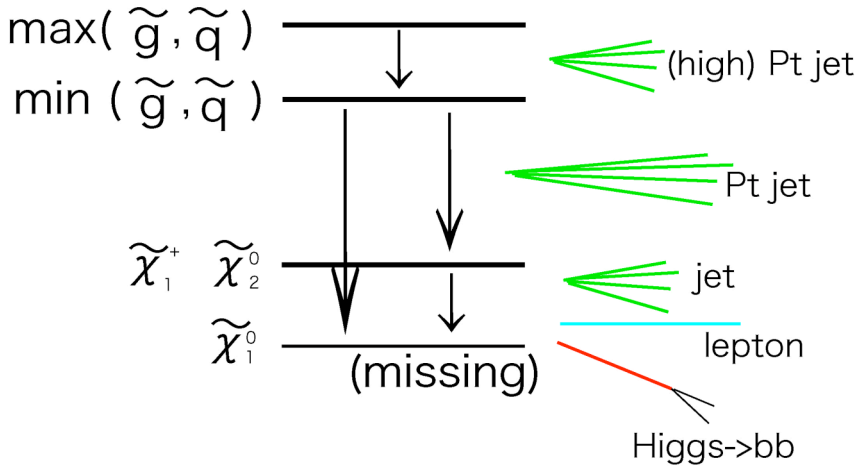
(University of TOKYO)

1.Events topology of SUSY (Gravity- mediation + R-parity)

Gluino/squark are produced copiously,
Cascade decay is followed.





event topologies of SUSY

$$\not{E}_T + \text{High } P_T \text{ jets} + \begin{matrix}\text{multi} \\ \text{b-jets} \\ \tau\text{-jets}\end{matrix} \quad \text{leptons}$$

Especially no or one lepton mode is promising for Discovery

2. SM Background processes

No lepton mode: $Z(\nu\ \nu, \tau\ \tau)$+ N jets

$W(\tau\ \nu)$ + N jets

tt + N jets

QCD multi-jets

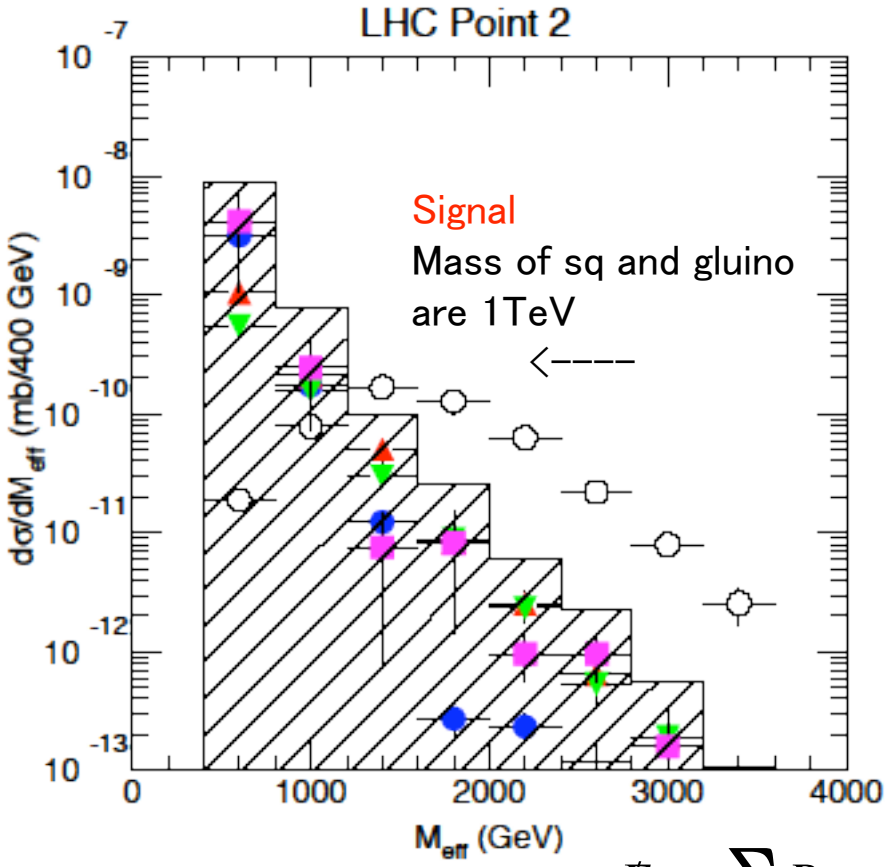
(Fake-missing Et)

One lepton mode: W + N jets

tt + N jets

$Z(\tau\ \tau)$ + Njets

(--> discuss latter)



$= \not{E}_T + \sum P_T$

Up to 4jets

SUSY signal is larger than BG by factor about 10 for large Meff region. S/B > 10 !

And "Discovery" is believed to be easy job.

High Pt multi-jet also contribute to separate signal from BG.

No lepton mode: $Z(\nu\ \nu, \tau\ \tau)$+ N jets

$W(\tau\ \nu)$ + N jets

tt + N jets

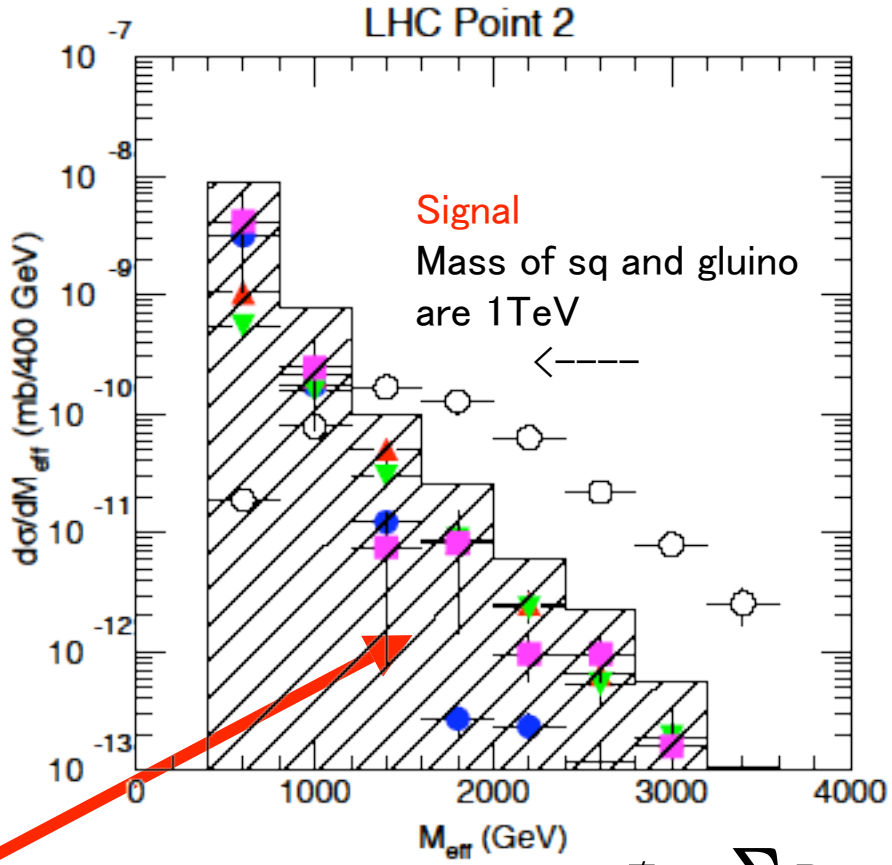
QCD multi-jets

(Fake-missing Et)

One lepton mode: W + N jets

tt + N jets

$Z(\tau\ \tau)$ + Njets



$= \not{E}_T + \sum P_T$

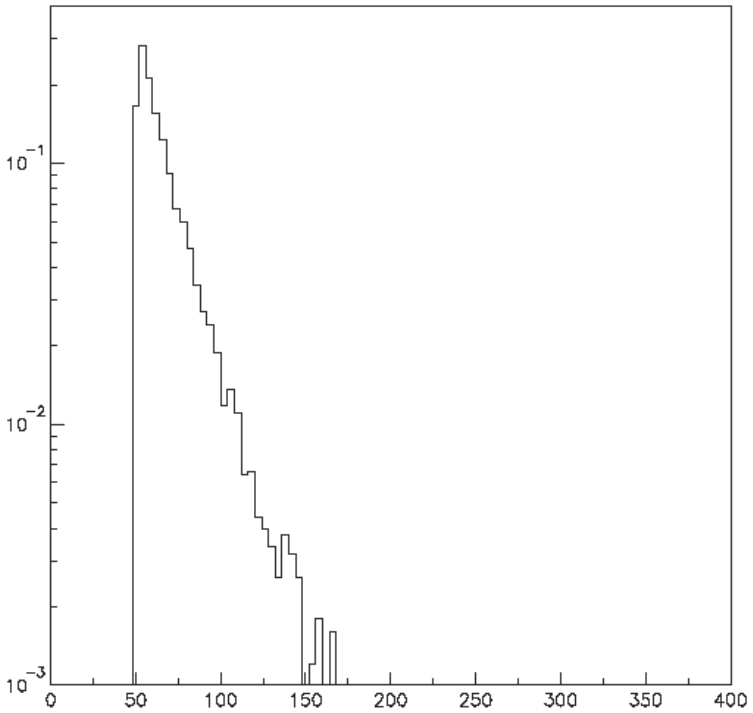
Up to 4jets

But these backgrounds are estimated with **Parton shower model !!!!!!** and are underestimaed.

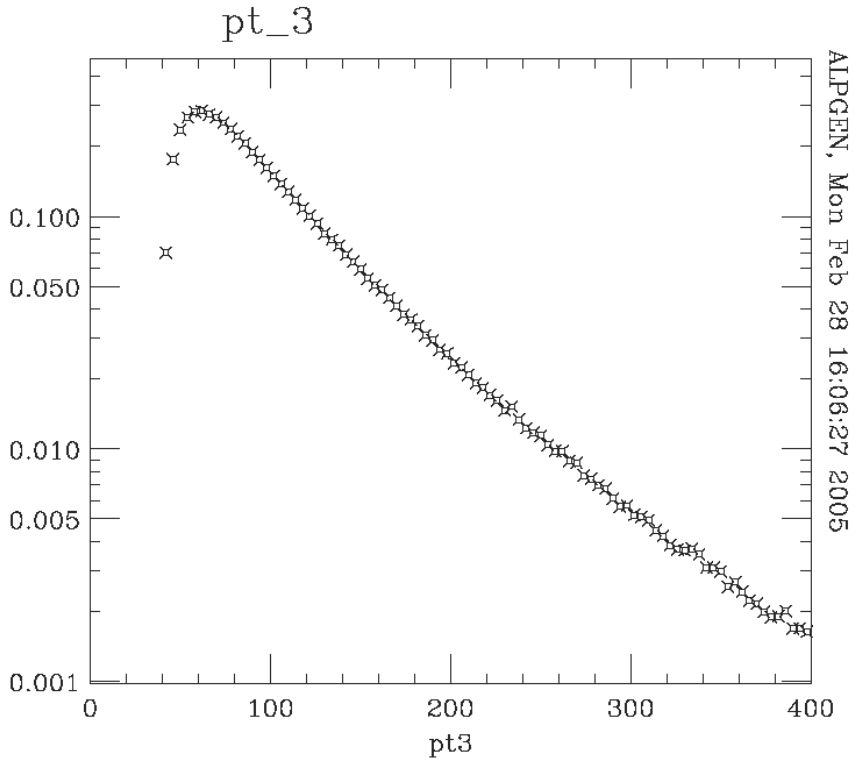
High Pt multi-jet also contribute to suppress BG.

3. Problem in the current estimation of background

Pt distributions of 3rd jet for Z+ Njets processes



Parton Shower (PYTHIA 6.203)

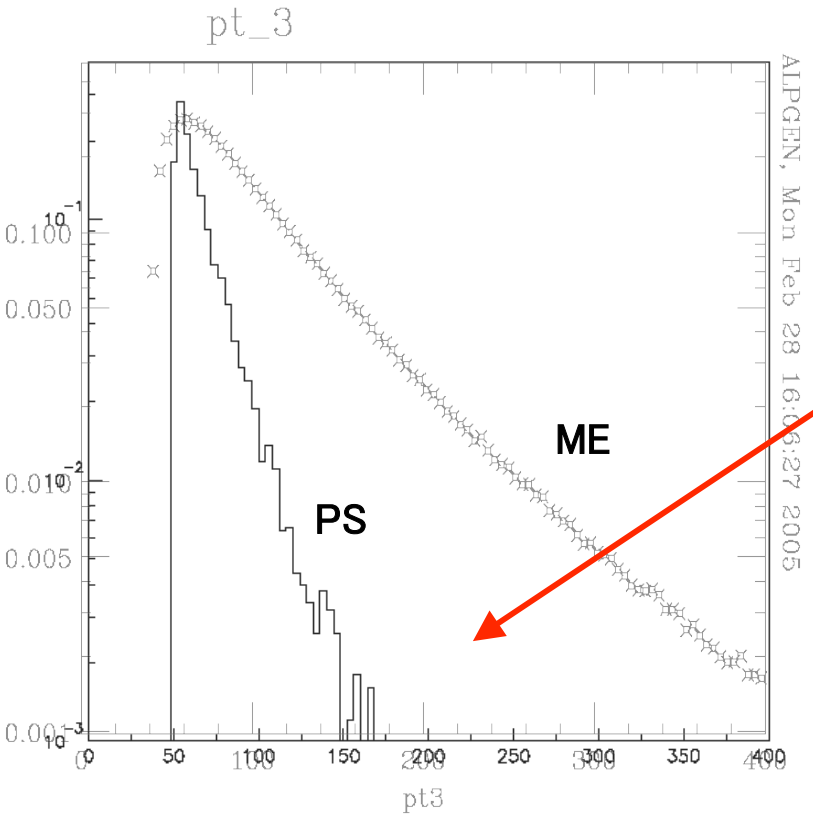


Matrix Element (ALPGEN) Parton level

Missing Et > 100GeV
At least one jet(parton) has pt > 100GeV
At least four jets(partons) have pt>50GeV

Qfac=Qren=SQRT(Mz^2+Pt^2)
for both calculations.

Pt distributions of 3rd jet for Z+ Njets processes



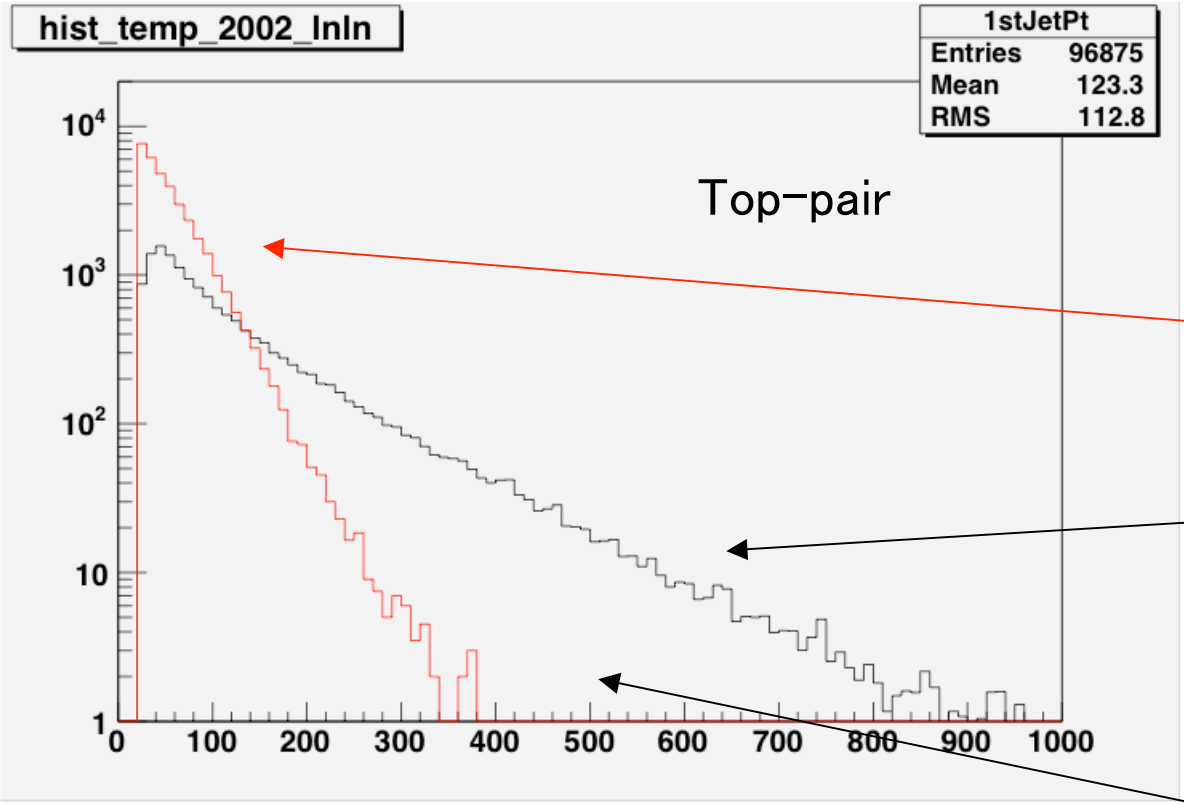
Missing Et > 100GeV
At least one jet(parton) has pt > 100GeV
At least four jets(partons) have pt>50GeV

When the distributions
are superimposed,
You can see significant difference.

Hard jet is not emitted in Parton Show:
(It is famous problem.)

- Factor of more then 100 is different.
- The same problem is in 2nd,3rd,4th,,,, jets
- Jet contribution should be underestimated in current estimations.

The same problem is observed in the top-pair production.



Red: PS prediction estimated with PYTHIA

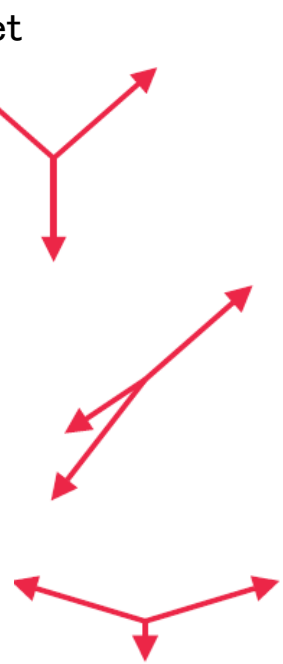
Black shows ME prediction (ALPGEN)

High Pt jets are emitted in tt production.

tt system is boosted

The Pt distribution (GeV) of the highest Pt of the additional jets.

4. Production with ME



◆ME has advantage for high Pt jet
as you can see in the previous section.
To remove collinear and soft divergence
Pt>20GeV and Rjj>0.7 are required
for production.

ALPGEN(V133) is used for ME

◆Soft and collinear kinematic regions are
covered by Parton Shower model (PYTHIA)

◆ATLAS detector effect is taken into account using
ATLFAST （Smear Monte Carlo : ATHENA9)

	Generated Num	Luminosity(fb^{-1})
tt(WW→lvqq)+Njets	~ 3×10^7	~100
tt(WW→lvlv)+Njets	~ 1×10^7	~ 100
W(W→lv)+Njets	~ 5×10^6	~ 50
Z(Z→ll)+Njets	~ 1×10^6	~ 100
Z(Z→vv)+Njets	~ 1×10^6	~ 100
QCD (PS by PYTHIA)	~ 3×10^7	~ 0.5

←

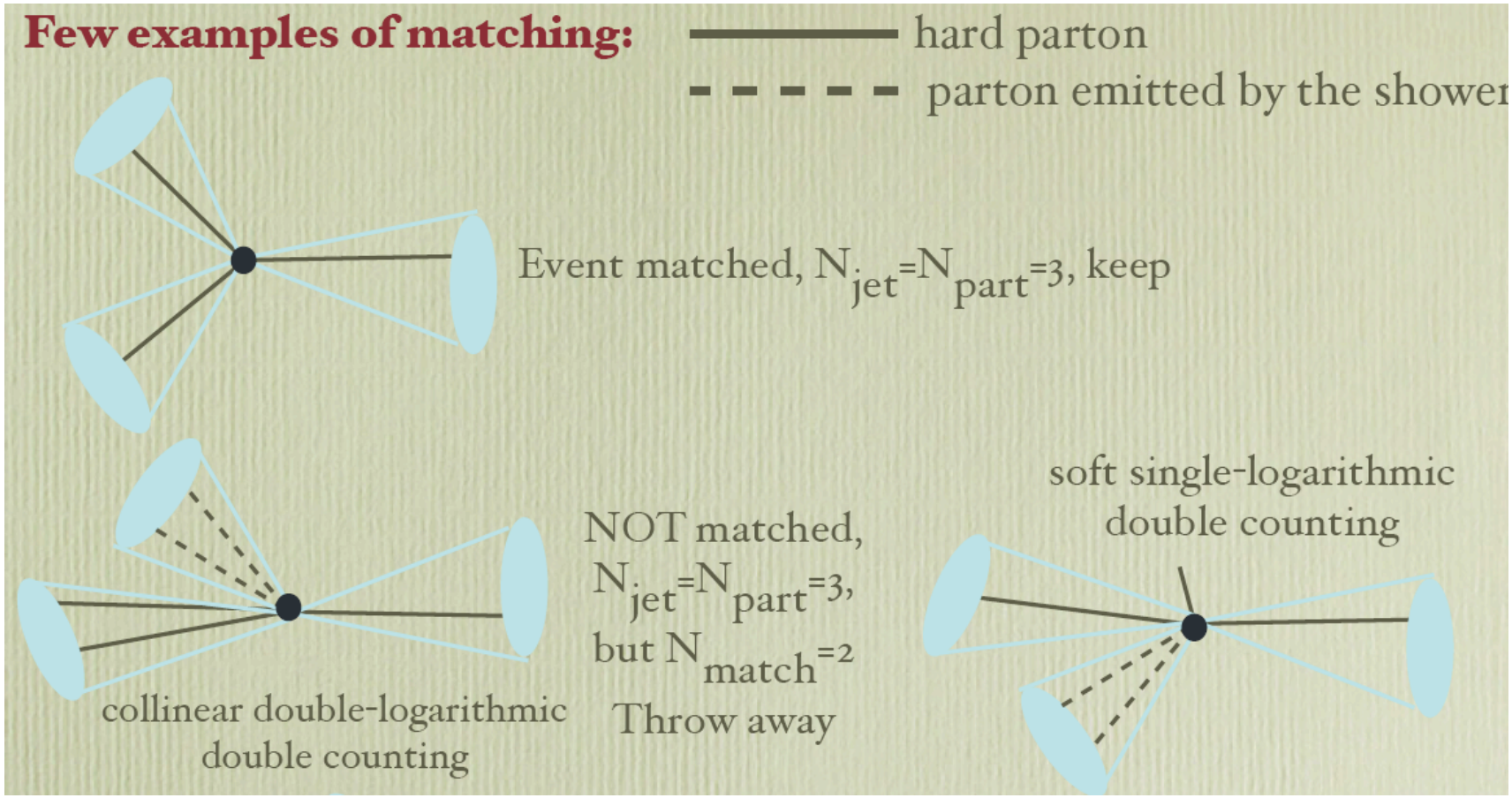
Temporary

- Fot toptop N upto 3
  For W/Z N upto 6
- They are generated with ALPGEN.
- QCD is generated with Pythia (Not ME just PS. tentative)

Fake mEt (multi-jet) is also important business of TeV4LHC,
Sorry, I have not yet establish good method to estimate QCD

5. ME–PS matching

MLM matching http://mlm.home.cern.xh/mlm
M. Mangano [Merging matrix element and Shower] @ Lund, Univ. Oct. 2004



Jet is defined : Et> 15GeV cone R=0.4 These are matching parameters:

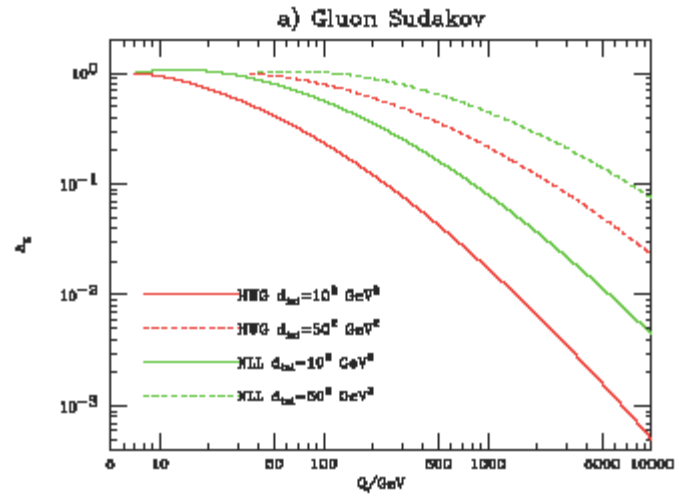
o ME partons are generated with Pt>20GeV and R>0.7
and some preselections for SUSY.

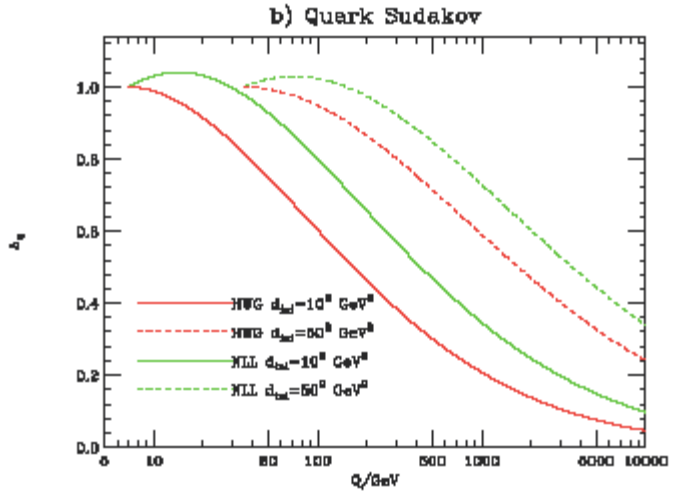
o Event is rejected if PS jet in the kinematics of ME region
(Shower Veto to avoid "double counting")

o ME parton should be matched to "jet"
jet is defined with Et_cut >15GeV and R=0.4 cone

Results are stable against the matching condition:
R=0.4 -> 0.7 results change within 20%

o This rejection is corresponding to "Sudakow factor":
mean rejection factor is about 0.5
Results depend on Qps : (Δ(Qo,Qps))
Qo∽Pt_cut and Qps=Mean of Pt of ME jets



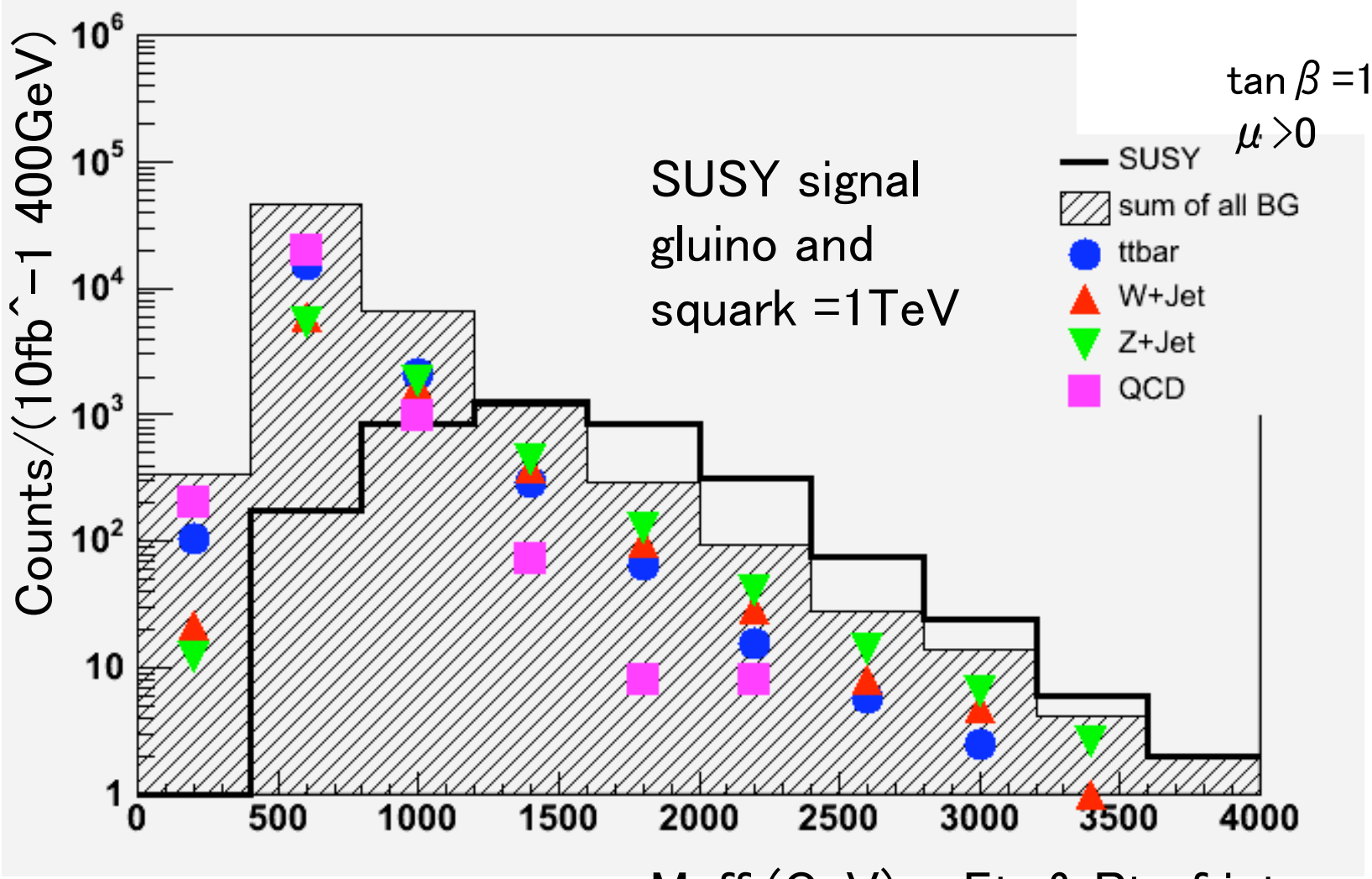


S.Mrenna hep-ph/0312274

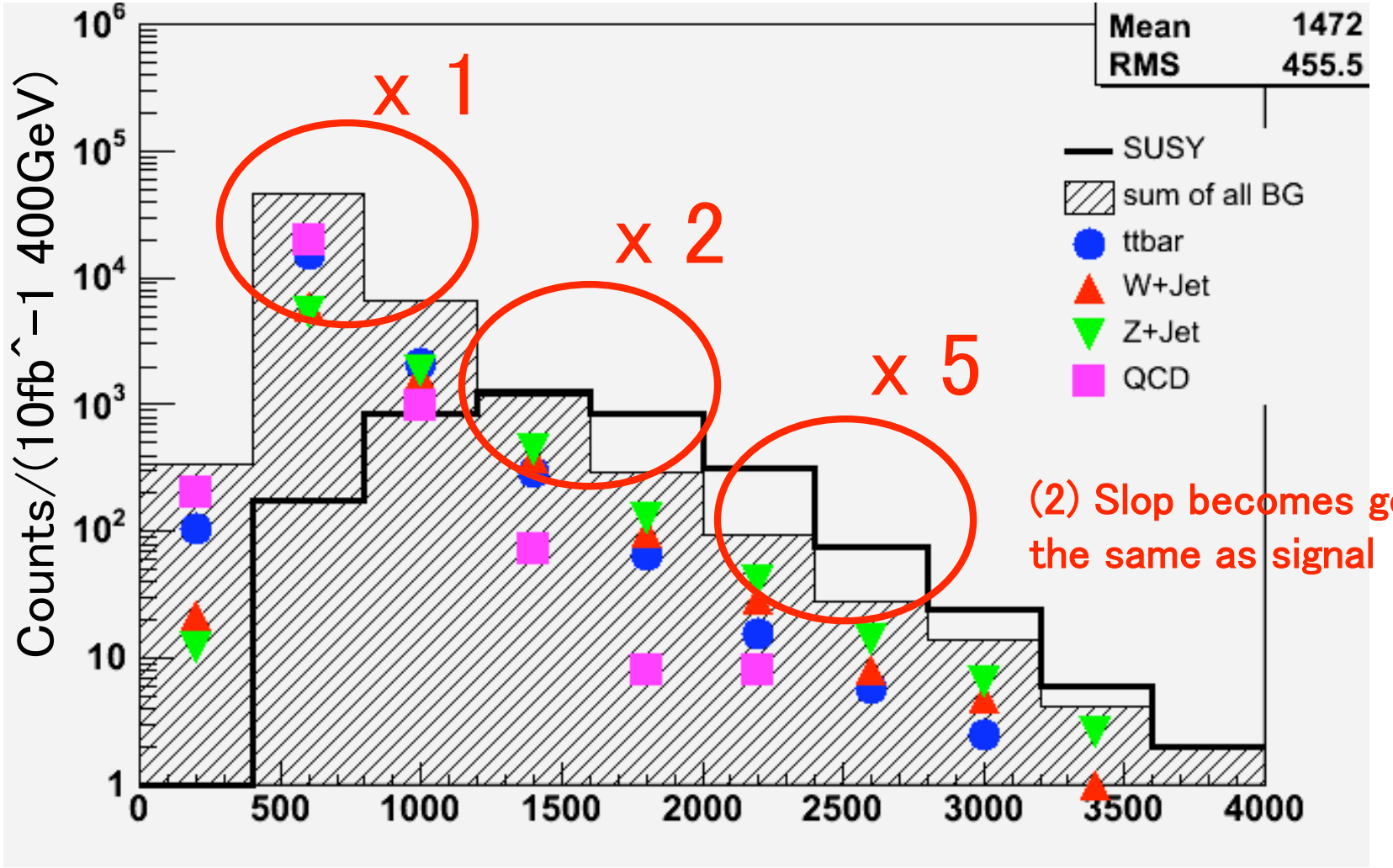
Rejection factor is consistent
with Sudakow (?)
still checking

- This rejection is corresponding to "Sudakow factor":
  mean rejection factor is about 0.5
  Results depend on Qps : (Δ(Qo,Qps))
  Qo∽Pt_cut and Qps=Mean of Pt of ME jets

6. Results (Background estimated with ME info)

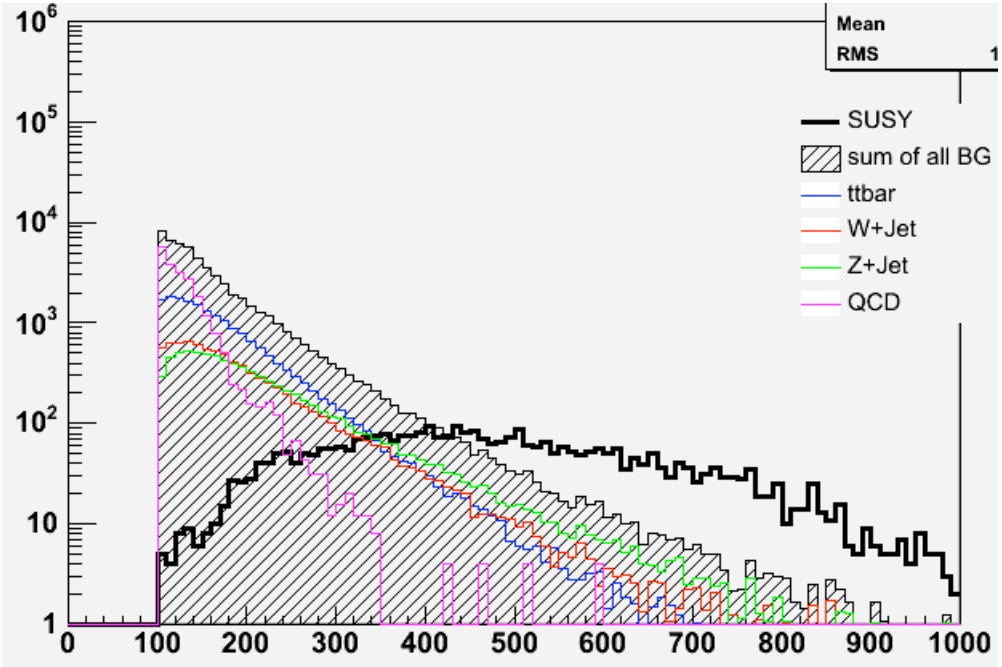


(1) Background increses by facor 2–5 depending on Meff



(2) Slop becomes gentle, the same as signal

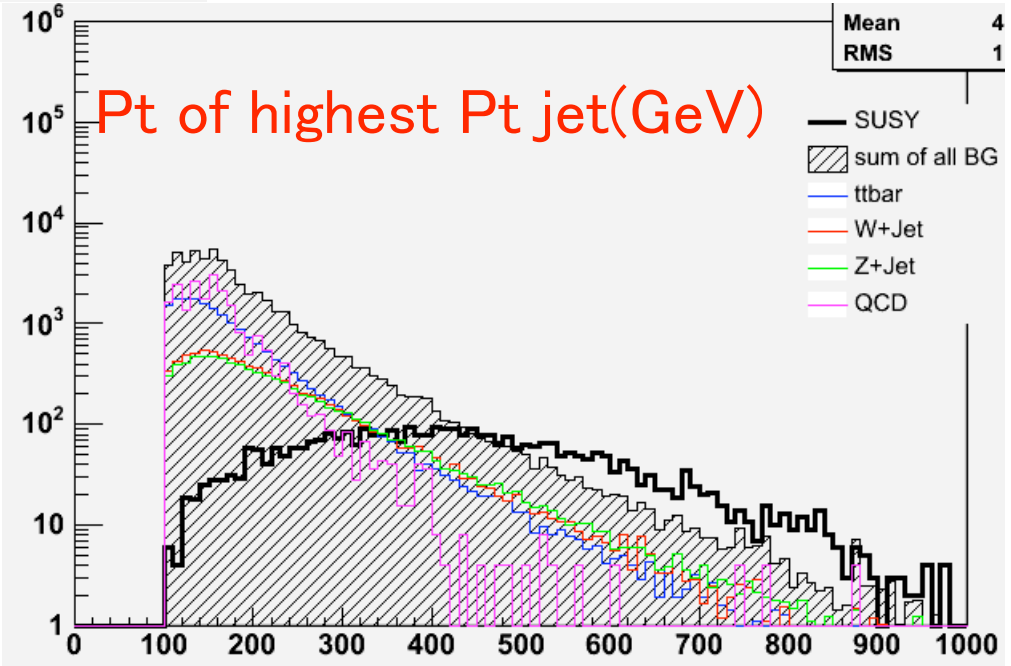
Meff (GeV)=mEt & Σ Pt of jet



Missing Et (GeV)

Meff is sum of mEt and
Pt of high Pt jets:
Let's see separately.

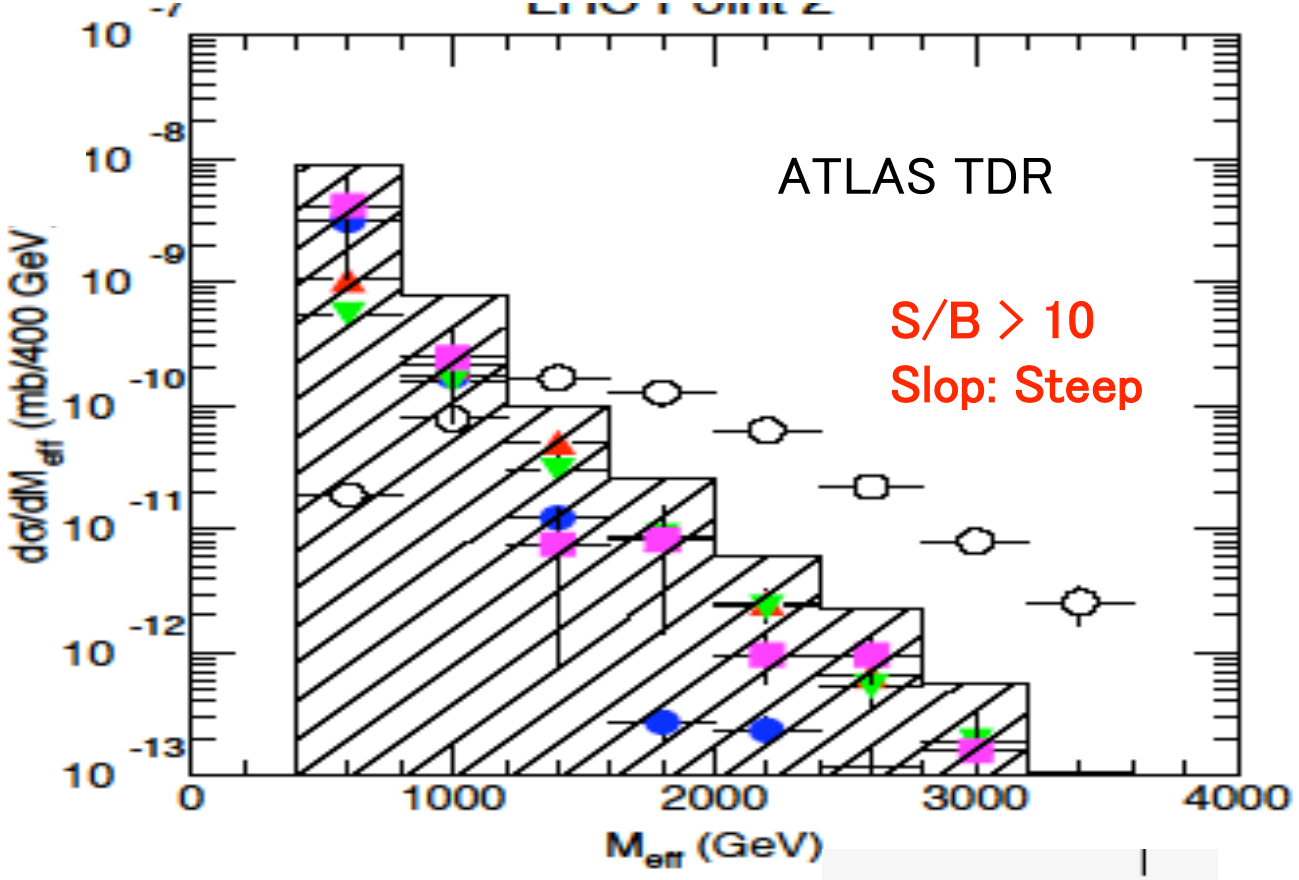
For mEt>700GeV
Clear excess can be observed

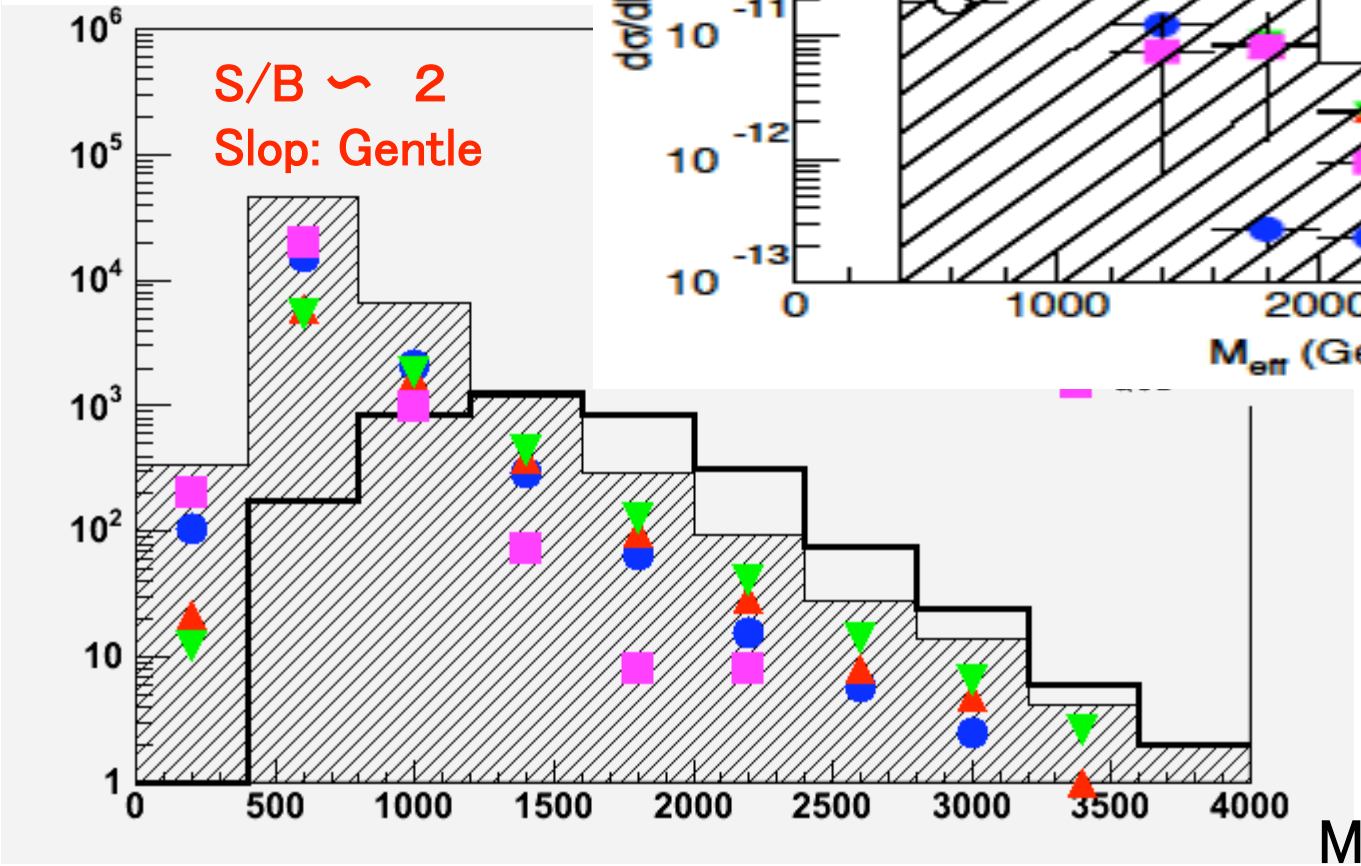


Pt of highest Pt jet(GeV)

High Pt jet is also emitted
in background
Not good separation

ME vs PS

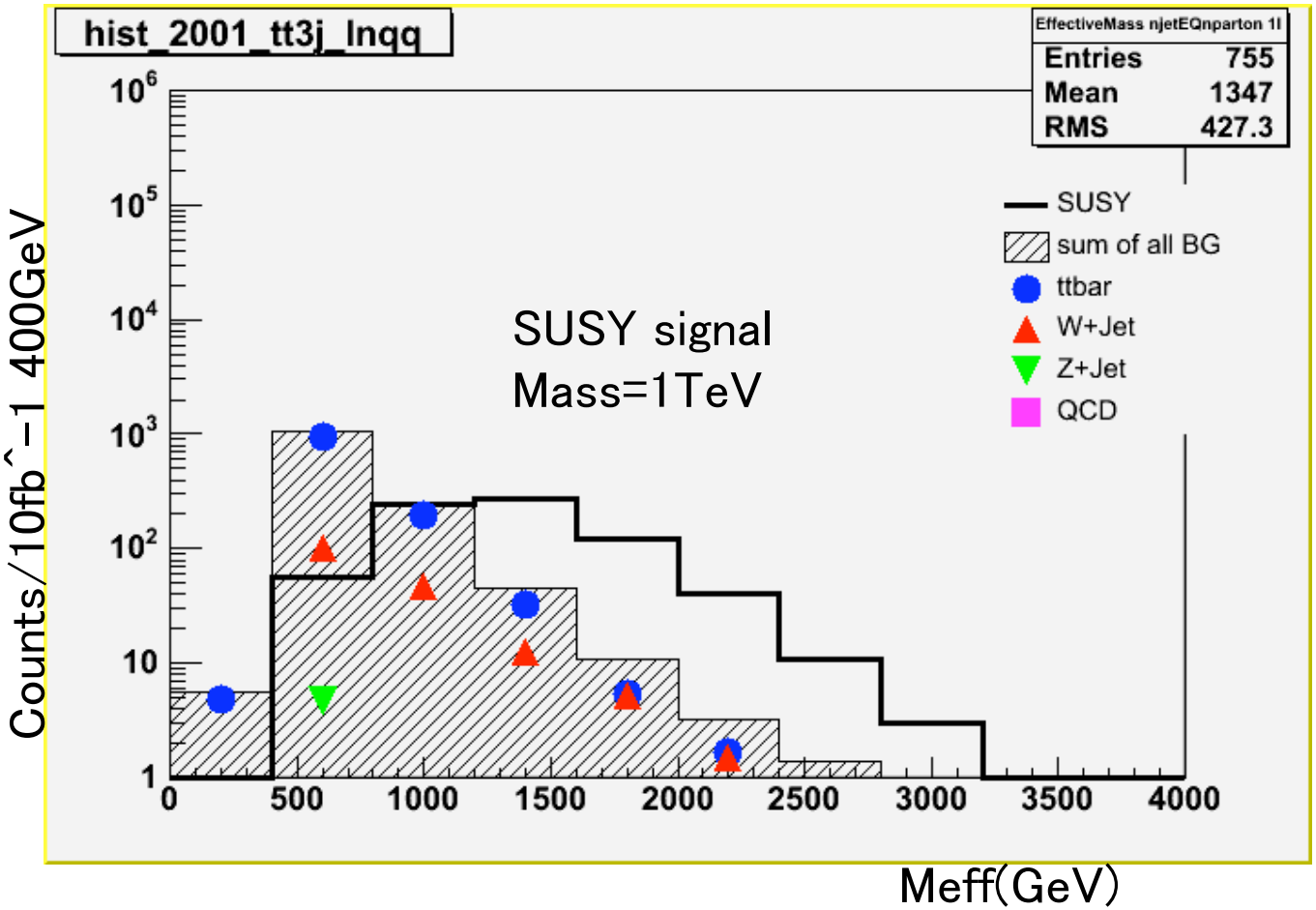

ATLAS TDR
S/B > 10
Slop: Steep
dσ/dM_eff (mb/400 GeV)
M_eff (GeV)


S/B ∽ 2
Slop: Gentle
SUSY
sum of all BG
ttbar
W+Jet
Z+Jet
QCD
Meff (GeV)

One lepton mode : tt + N jets
: W + N jets

Signal is reduced to 20–40% of no lepton mode,
Background suppress by about factor 20–30

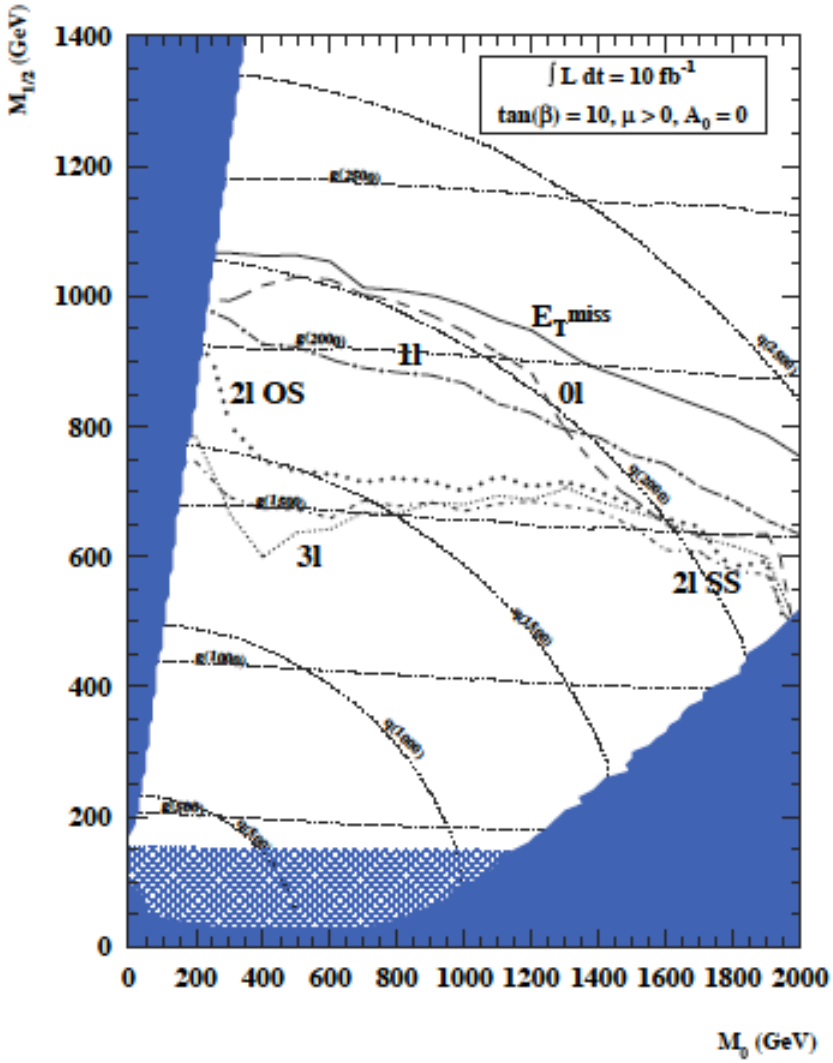
S/B is better than
no lepton mode.



Selection criteria should be re-optimised for new background. Using no lepton and one lepton Modes, discovery potential will be re-examined.

(1) Background increase
(2) High Pt jets
(3) Top pair significantly increases

High mass reach is maybe suffered.

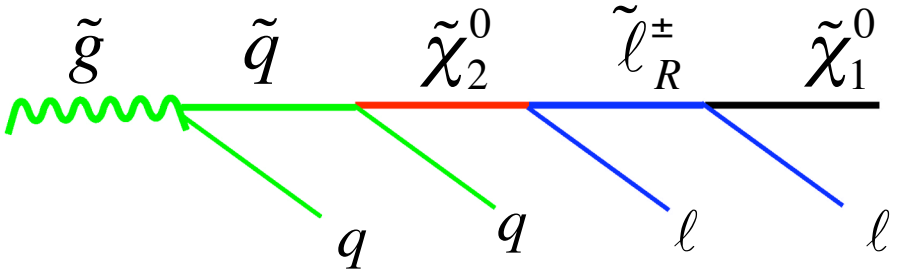


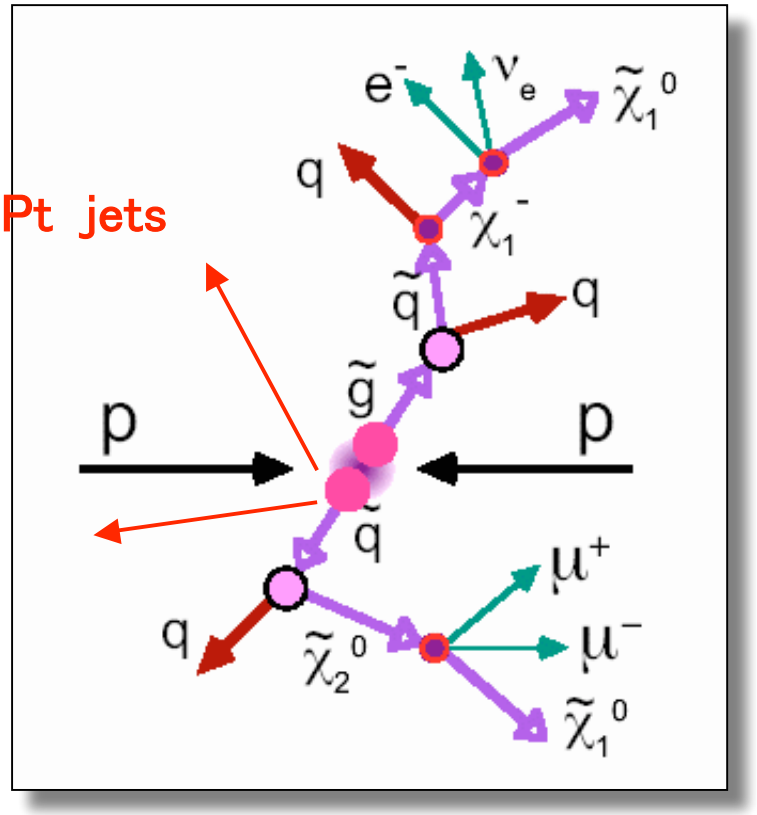
D.Tovey Eur.Phys. J. Direct C4 N4

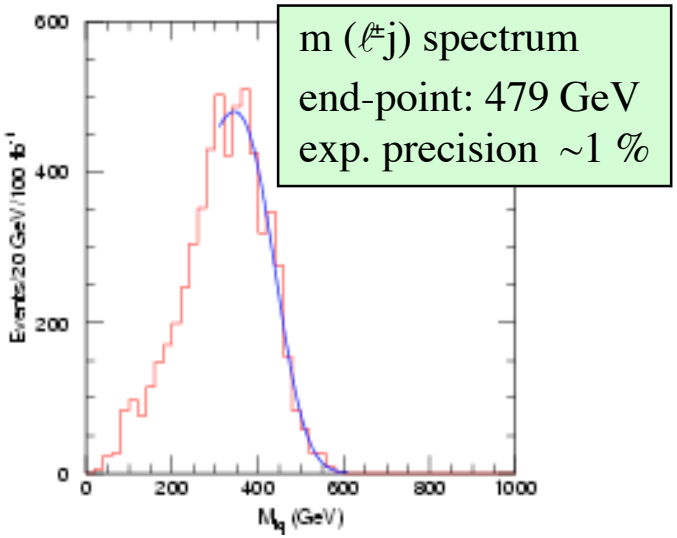
Also affect on the reconstruction of decay chain.

High pt jets due to BG and additional jets in SUSY signal increases.
(SUSY+Njets should be estimated with ME as the same as BG)

Contamination of high Pt jet increases, and purification of these quarks becomes worse.







7. Extrapolation

We have good control sample of Z(->ee,mumu) + N jets.

Only 16 events are expected in the first year (L=10fb^-1) for
Z(->ee,mumu) + N jets with Meff > 2000GeV region.
Stat. is too limited to use this control sample directly.

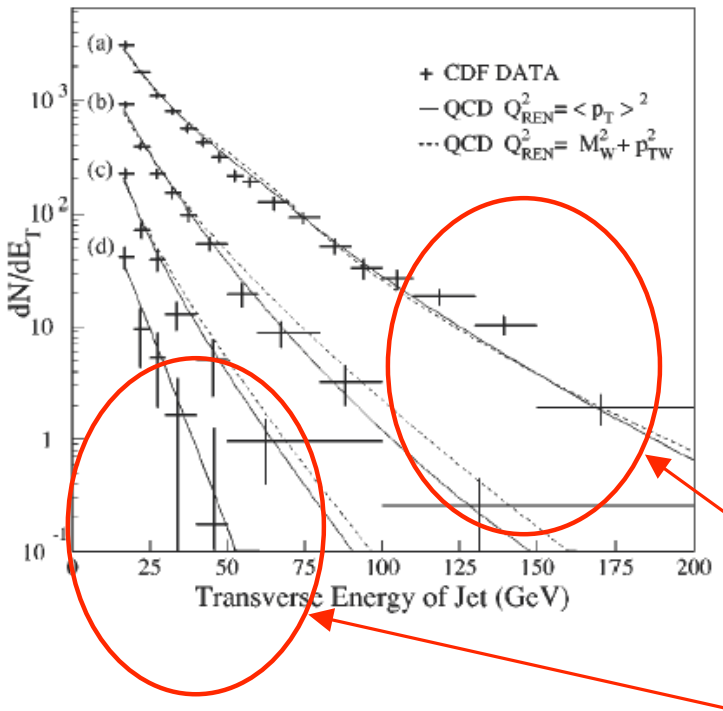
We need extrapolation form low Pt region to
SUSY signal region.

◆Dependence on Pt and multiplicity can be very precisely study at
Tevatron Run-II (There is RunI result but, not stat. not enough
--> Next Page)
◆Not trivial extrapolation from Tevatron to LHC

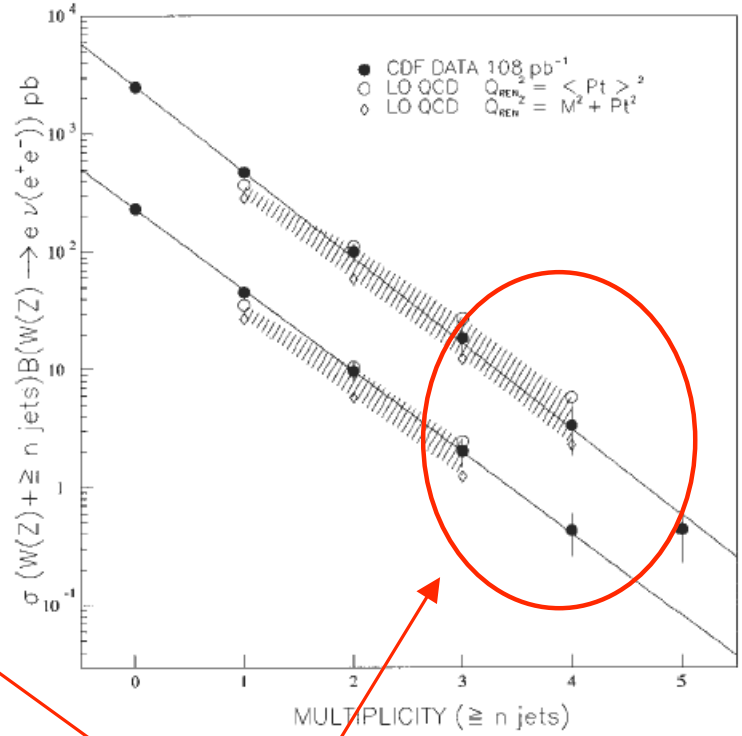
Establish method to estimate BG in early stage of LHC (a few fb^-1)
using LHC data, Tevatron results and theoritcal works.

Run1 Phys. Rev. D 63, 072003 (2001)

Pt dependence



N-dependence



Large error for interesting regions

8. Summary

(1) We estimated Background with ME generator. (W/Z and top pair)

(2) ME-PS matching is performed with MLM method, and result is stable.

(3) The contributions of the background increases by factor 2-5.
Background contribution including high Pt jets increases significantly

(4) Results and knowledge at Tevatron is crucial to estimation BG for SUSY search in early stage of LHC.

W/Z + Njets
tt+Njets @ Tevatron (-> some hint to squark pair + Njets at LHC ?)
mEt
How to extrapolate these results to LHC energy?

(5) Homework (mEt and third generation) in progress (Sorry!!)