On weighting superpartners at "early stage" of LHC

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based on recent collab's with

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Wong-Sang Cho (IPMU) //
Mandal, Sudano, Yanagida(IPMU)

LHC starts from 7TeV and 1fb-1

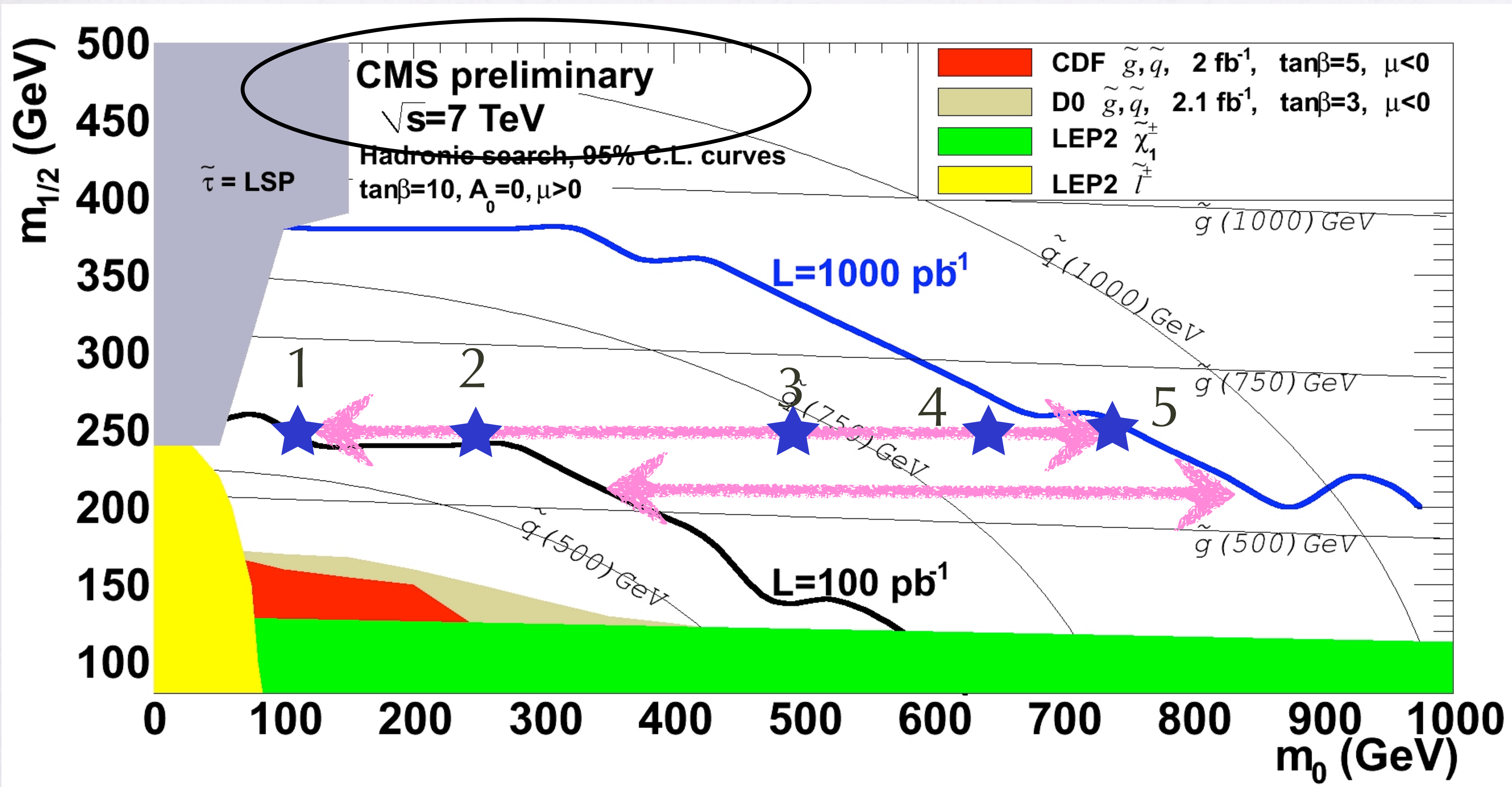
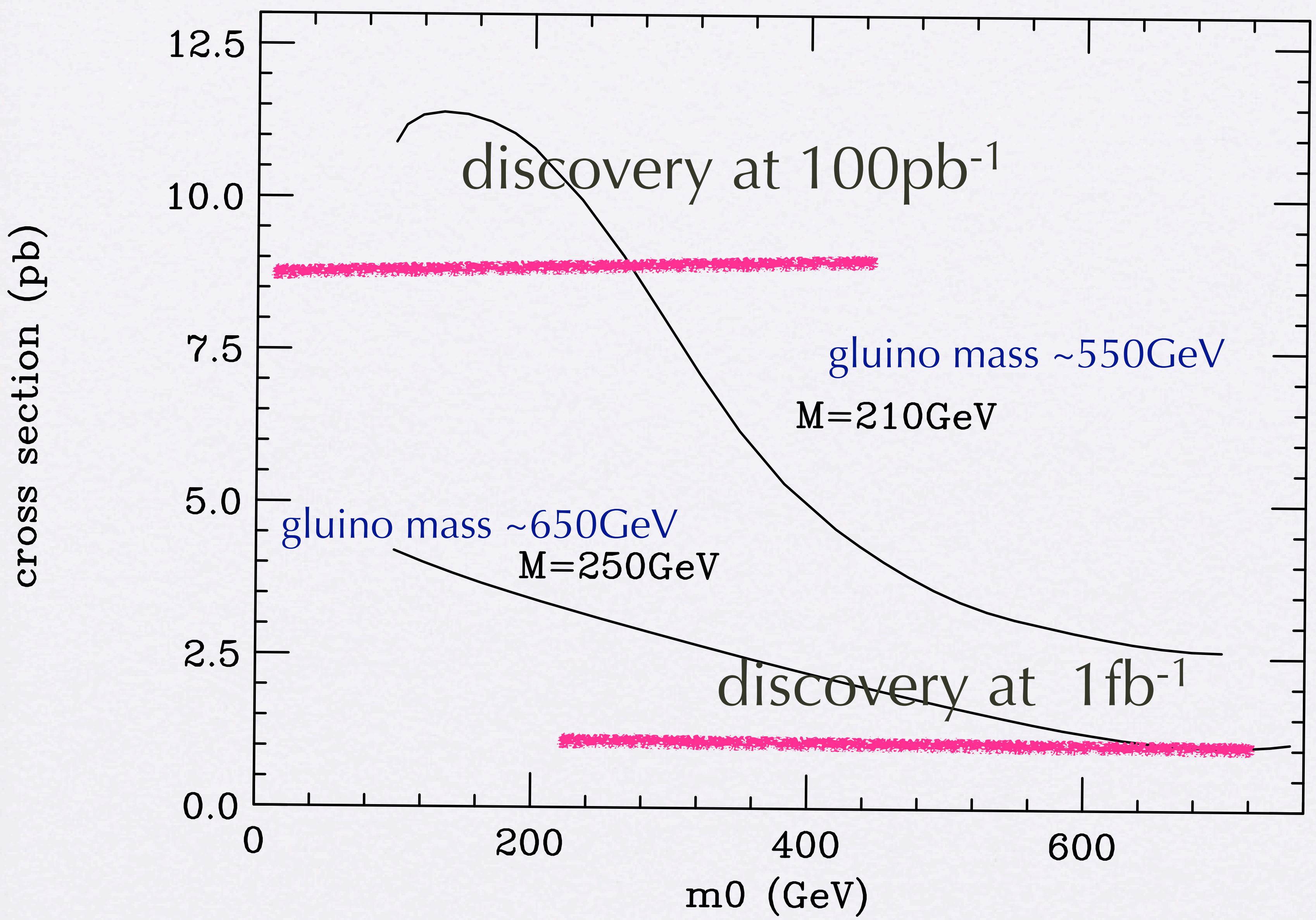


Figure 13: Estimated 95% C.L. exclusion limits for the all-hadronic SUSY search, expressed in mSUGRA parameter space.

cross section for discovery

$100pb^{-1} \sim \sigma_{SUSY} > 9pb$ $1fb^{-1} \sim \sigma_{SUSY} > 1pb$



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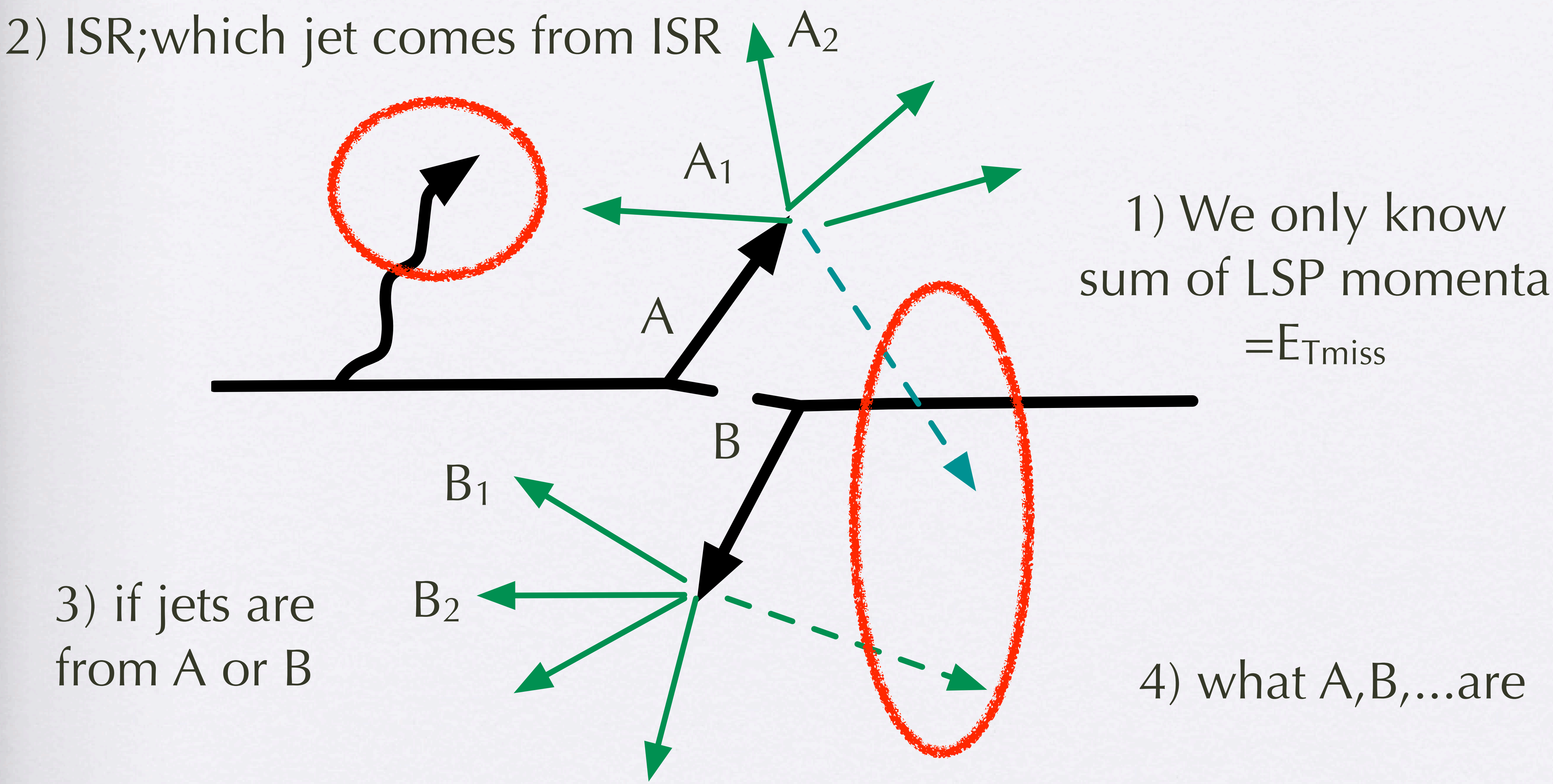
How to study the SUSY scale

- Cross section ⇄squark mass scale for fixed gluino mass
- need absolute measure of squark/gluino- LSP mass..
- traditional measures
  - M_{eff} : sum of transverse activities. Peak position of Meff scale with m(squark) + m(gluino) but MC dependent
  - End points of jet+ ll's : need large number of events, Br ratios is very small for normal MSUGRA model point.
  - M_{T2}, M_{CT2}: in this talk→ lepton's

we don't know...


2) ISR;which jet comes from ISR
A_2
A_1
A
1) We only know
sum of LSP momenta
$=E_{Tmiss}$
B
B_1
B_2
3) if jets are
from A or B
4) what A,B,...are

1)Handling E_{Tmiss}

- assumption 1 $P_{miss}=p_1(LSP)+p_2(LSP)$
- assumption 2 pp→ AB, A→ v_A+ LSP(p_1) B→ v_B+LSP(p_2) topology.
  - split jets and leptons into two visible objects. split missing pt into two visible momentum→M_{T2} is naturally defined for two narrow objects with missing momenta.
  - Naively, $M_{T2}< \max(m_A, m_B)$ when assumed LSP mass is correct. useful to reconstruct both LSP and squark/gluino mass.

$$m_{T2}(\mathbf{p}_T^{vis(1)},\, m_{vis}^{(1)},\, \mathbf{p}_T^{vis(2)},\, m_{vis}^{(2)},\, m_\chi) \equiv \min_{\{\mathbf{p}_T^{\chi(1)}+\mathbf{p}_T^{\chi(2)}=-\mathbf{p}_T^{vis(1)}-\mathbf{p}_T^{vis(2)}\}} \left[\max\{m_T^{(1)}, m_T^{(2)}\}\right],$$

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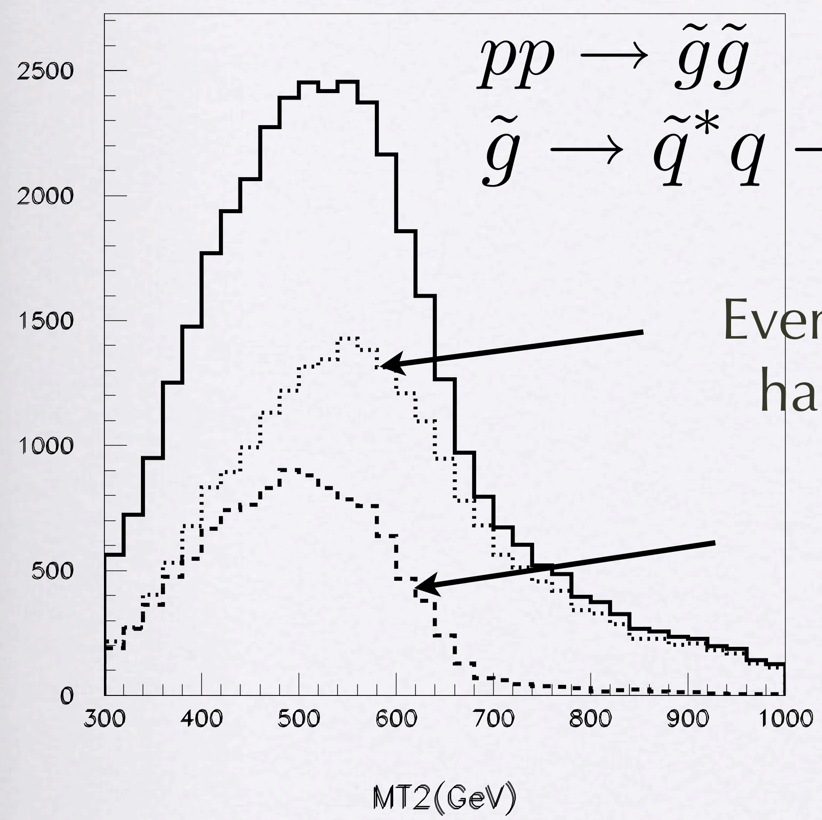
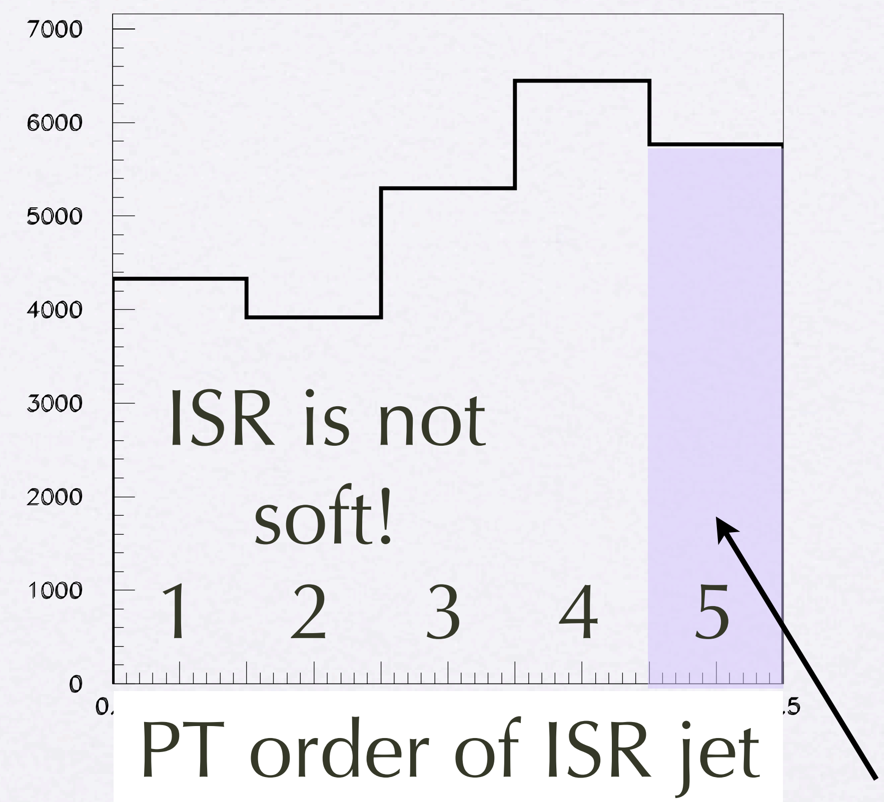
2) Handling ISR

Alwall, Hiramatsu, Nojiri, Shimizu (2009)



$$pp \to \tilde{g}\tilde{g}$$
$$\tilde{g} \to \tilde{q}^* q \to q\bar{q}\tilde{\chi}_1^0$$



M_{T2} calculated from 4 highest p_T jets(η<2.5 p_T> 50Gev) Madgraph/pythia

wISR /no hard ISR =1.4 for gluino pair
0.8 for squark pair

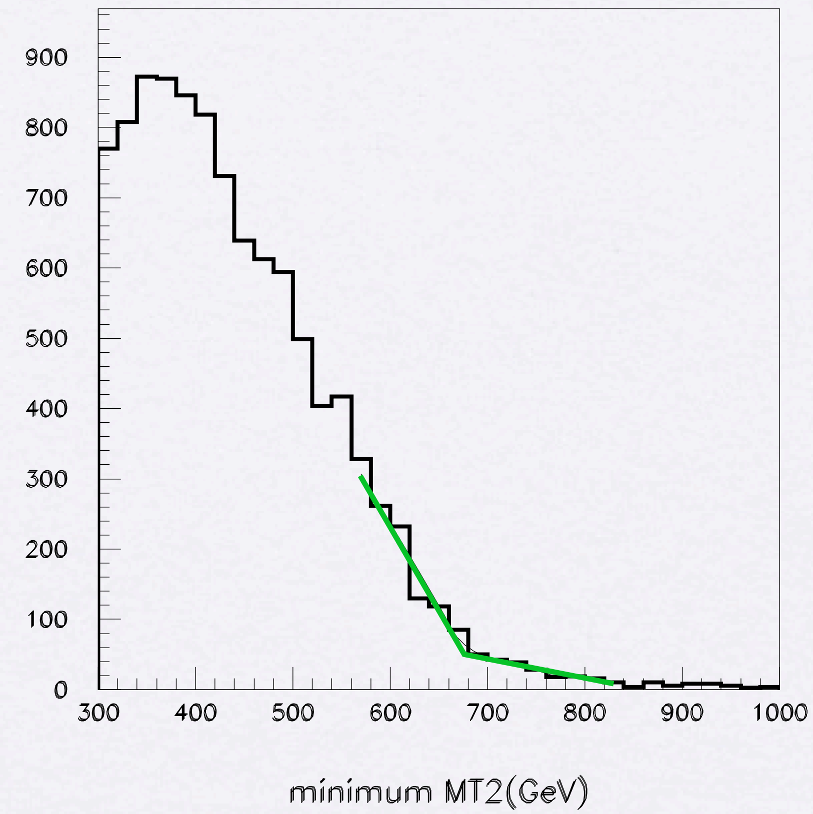
- ISR could be a problem of the event reconstruction (especially for three body decay

A protocol to remove ISR contamination in SUSY reconstruction

Alwall, Hiramatsu, Nojiri, Shimizu (2009)

$$pp \to \tilde{g}\tilde{g}$$
$$\tilde{g} \to \tilde{q}^* q \to q\bar{q}\tilde{\chi}_1^0$$

jet level



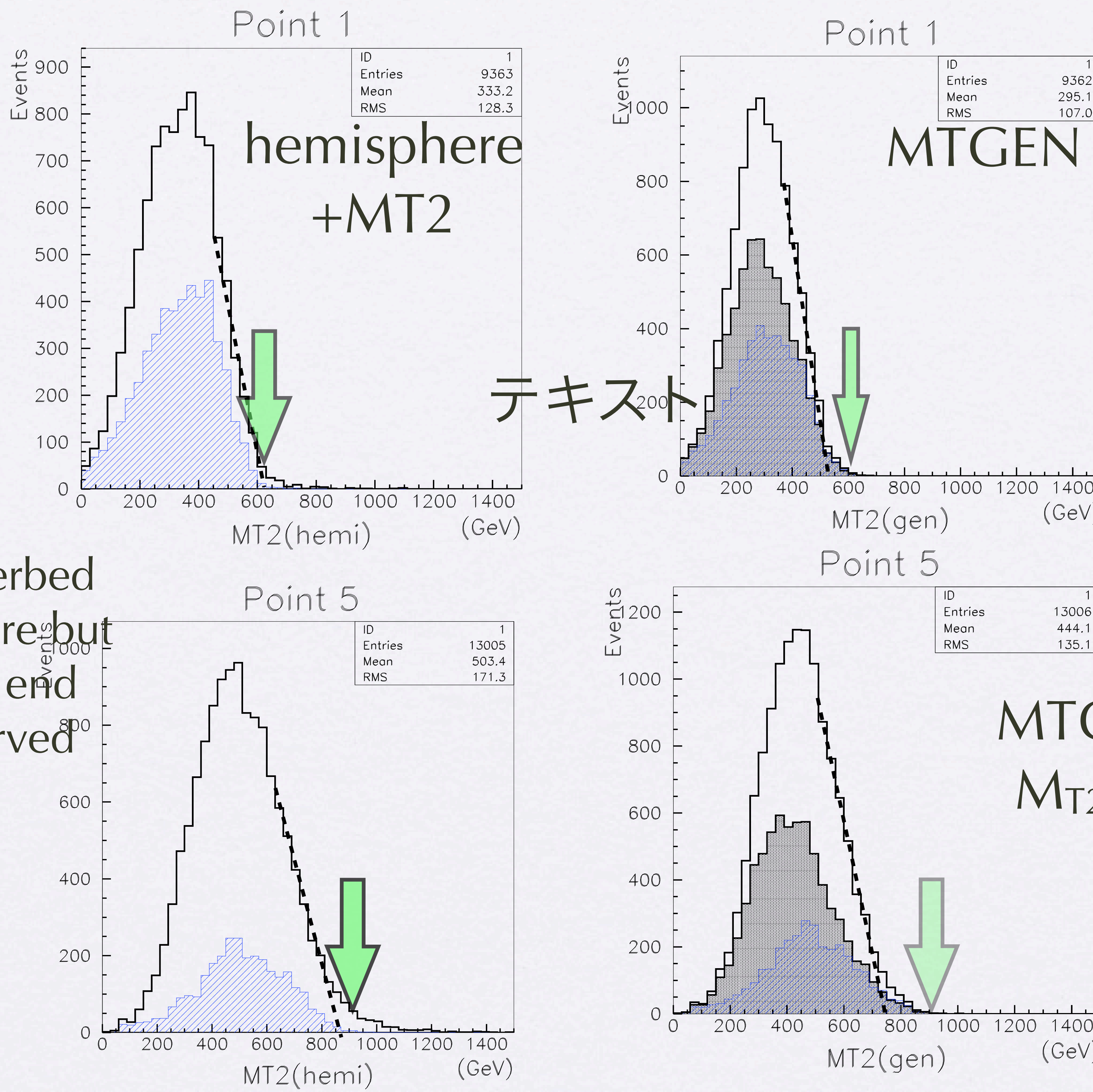
- Try all possible combination to take 2 pair of jets among 5 jets=assume one of the five jet is ISR. (generalization will be discussed later)
- M_{T2}min=min$_{i=1\sim5}$ M_{T2}(i)
- MT2(i) is the MT2 after removing i-th jet
- ISR tail disappear significantly

675.4 +/- 6.4 (imin. ge.3)
672.7+/- 3.5 (for all)

3) Handling (mis-)grouping

- We need to split visible objects into two to define M_{T2}
- Definition
  - Hemisphere method: Take the two highest PT jets and merge softer jets to them using certain measure. (Moortgat →application to M_{T2} Nojiri, Shimizu, Okada,Kawagoe, 2008)
  - MTGEN :Look for the combination of visible objects that minimize $M_{T2.}$ Just try Σ_m nCm combinations and take minimum!
- Task: select the combination that satisfy $M_{T2} < M(\text{parent})$ but end point is still visible.

Comparison(parton level) at 14 TeV(Nojiri, Sakurai to appear)



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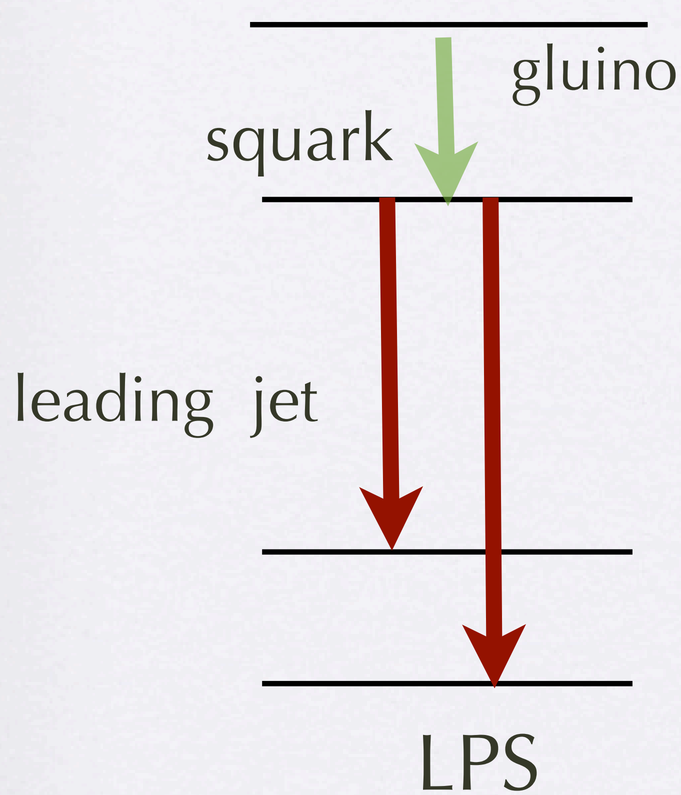
Some tail is obserbed
with heremisphere but
events near the end
point are preserved

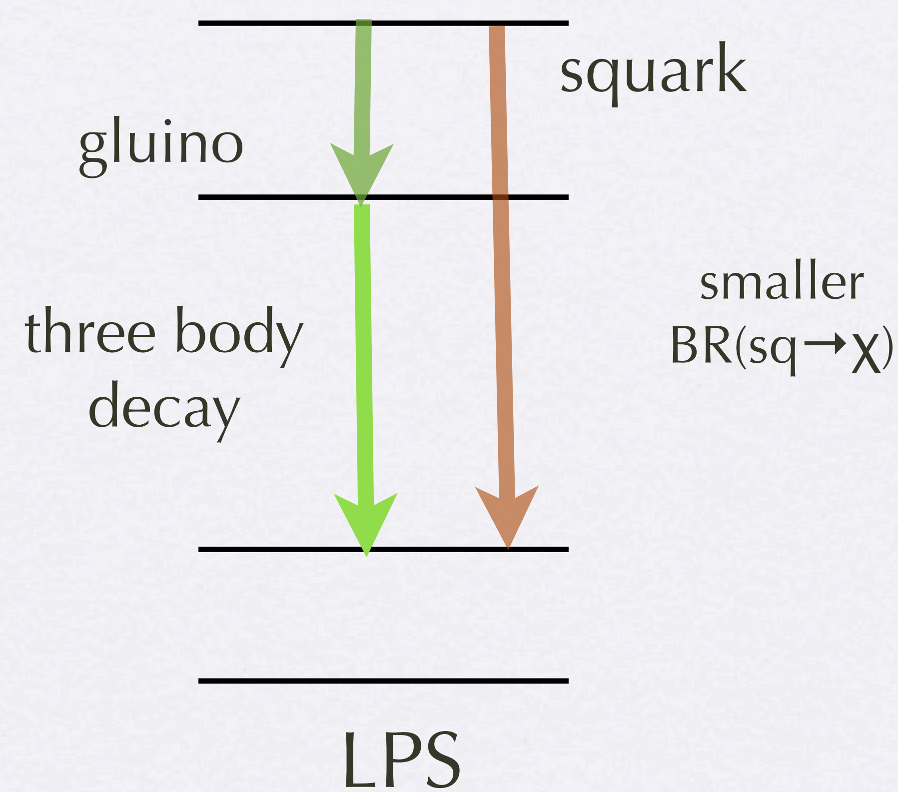
MTGEN kills event
$M_{T2} \sim \max(m_{sq}, m_{gl})$

4) Handling mixed production

(Nojiri Sakurai, appear soon)

- squark-gluino production is more than 40% of total production cross section
- removing a correct jet from sq-glsystem lead gl-gl system. ex. M_{T2}sub = $M_{T2}(1)$ proposed for $m_{gl} << m_{sq}$ case.
- Fror glgl, M_{T2}(min) =min_i (M_{T2}(i)) is good for gluino mass reconstruction.
- endpoint of M_{T2}min = mgl? Need attention to decay pattern.





for $m_{sq}<m_{gl}$, jet from squark decay is very high p_T. The 1st and 2nd jet is not ISR

When we see significant 2 jet+ E_{Tmiss} events modifiy

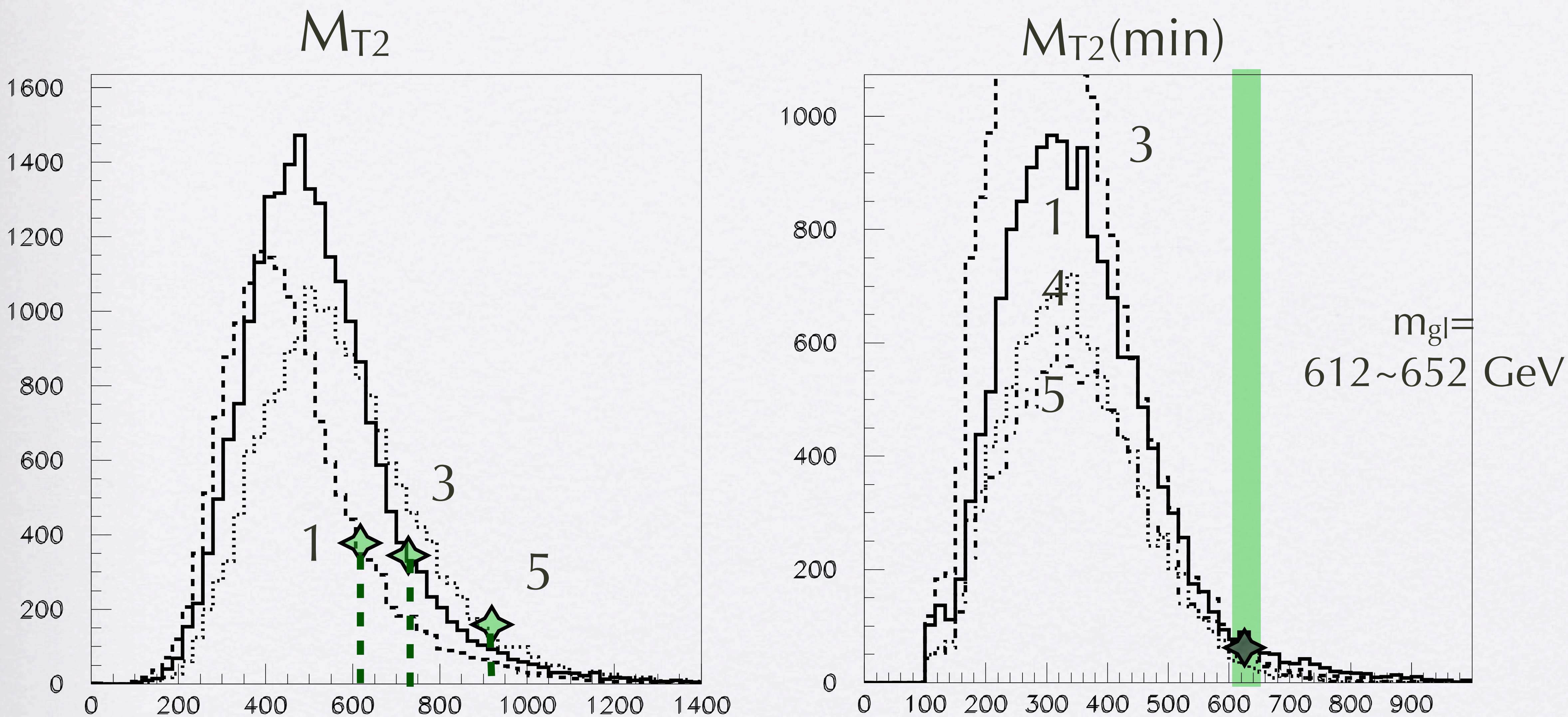
$M_{T2}min=min(M_{T2}(3),M_{T2}(4)....$

	$m_{sq}<m_{gl}$	$m_{gl}<m_{sq}$	$m_{gl}<<m_{sq}$
M_{T2}	ISR	ISR	$\sim m_{sq}$
M_{Tmin}(sq gl)	m_{sq}(for i≧3)	m_{sq}(for i≧3)	m_{gl}
M_{Tmin}(gl gl)	m_{gl}(for i≧3)	m_{gl}	m_{gl}

some squark still directly decay into inos. by selecting event with two high p_T jets. we may recover squark mass scale

ISR is less important

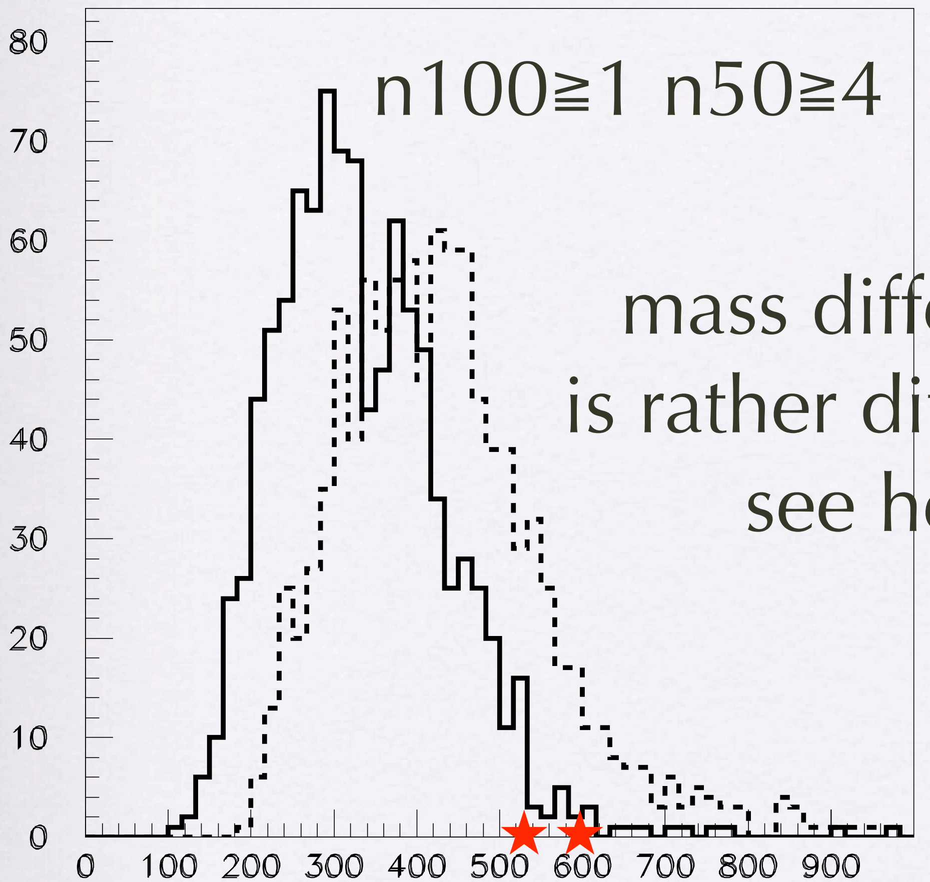
M_{T2}(min) for mixed case (14TeV, 60000 events)

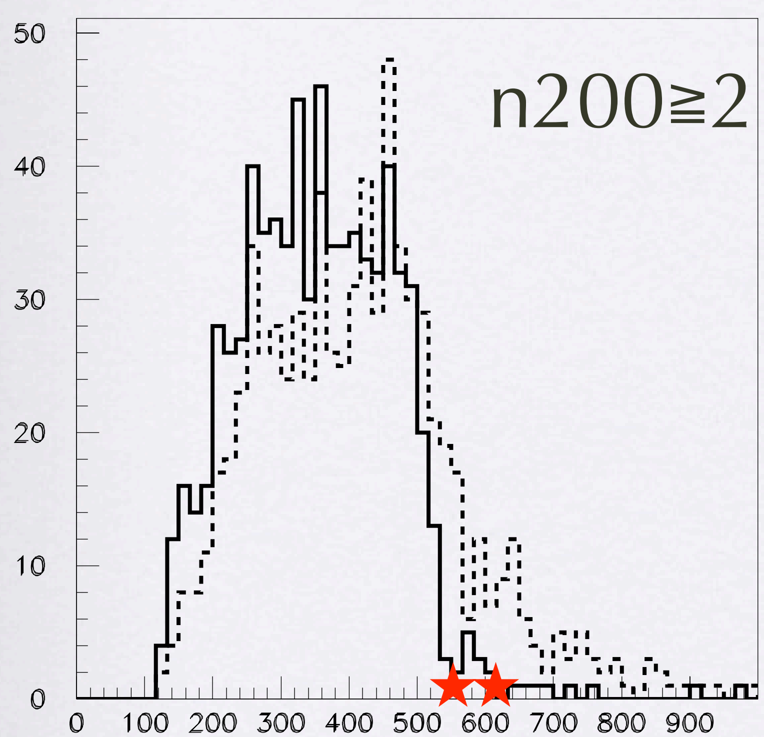


MT2 is more affected by ISR
gluino mass ~ M_{T2}(min) end point.
Total SUSY cross section ⇄squark mass scale.

at 7TeV and $1 fb^{-1}$

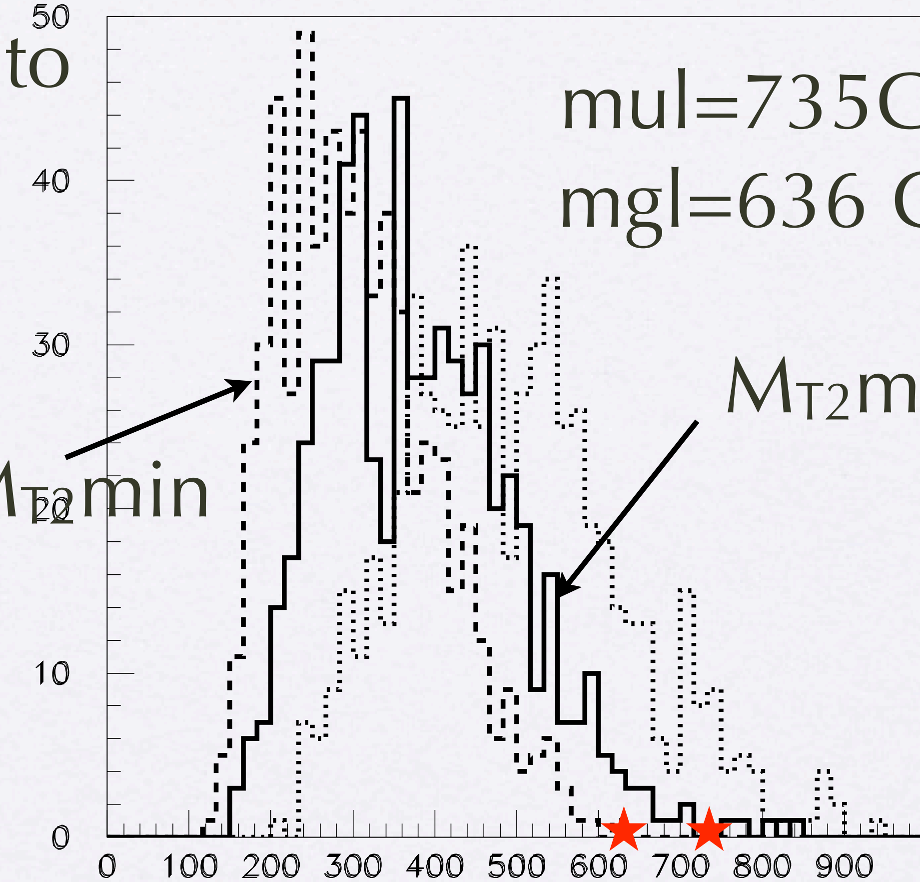
mul=520GeV mgl=610GeV





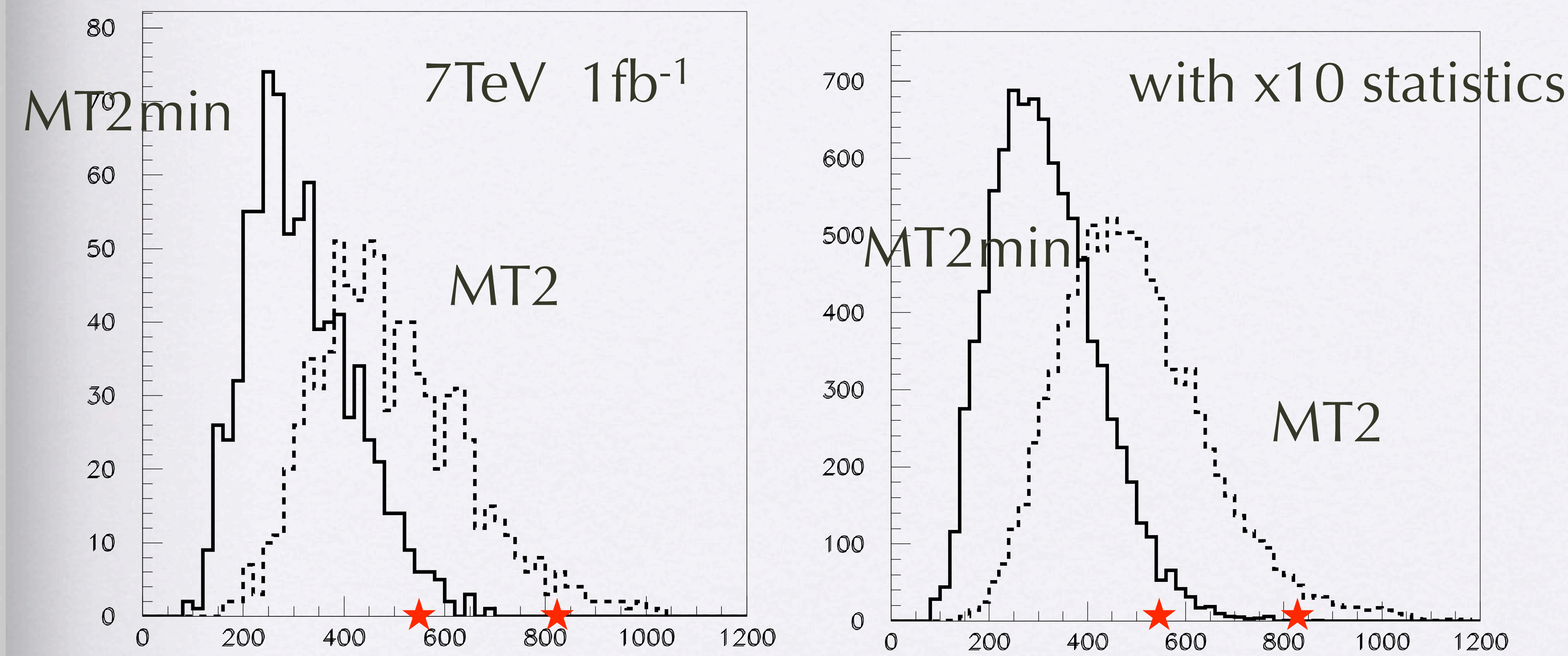
mass difference
is rather difficult to
see here

point 3



★ True squark/gluino mass

mgl=558GeV mul=825 GeV

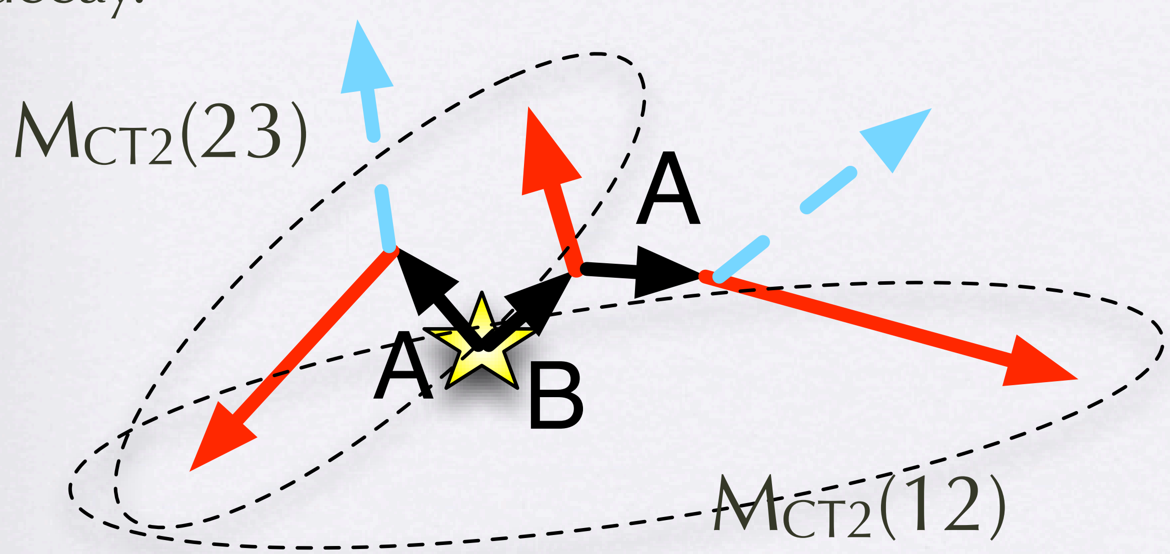


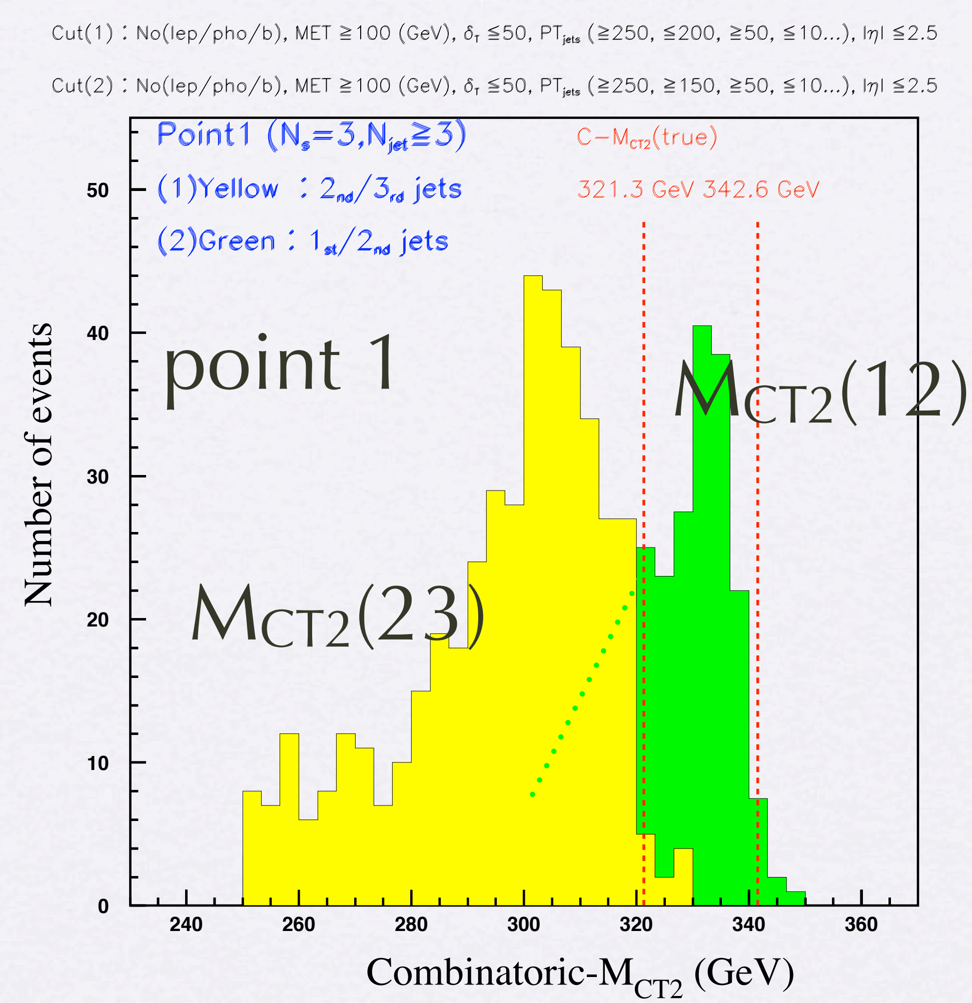
using global shape probably more useful.

M_{CT2} and sq→ gl+j reconstruction

(Wong-Sang Cho, Nojiri, appear soon)

- M_{CT2} not Lorentz invariant but end point invariant under contra-boost
- Large enhancement near the MCT2 end point
- It is useful to see the hidden decay patterns. example : extraction of jet from gluino squark decay.





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Lepton mode

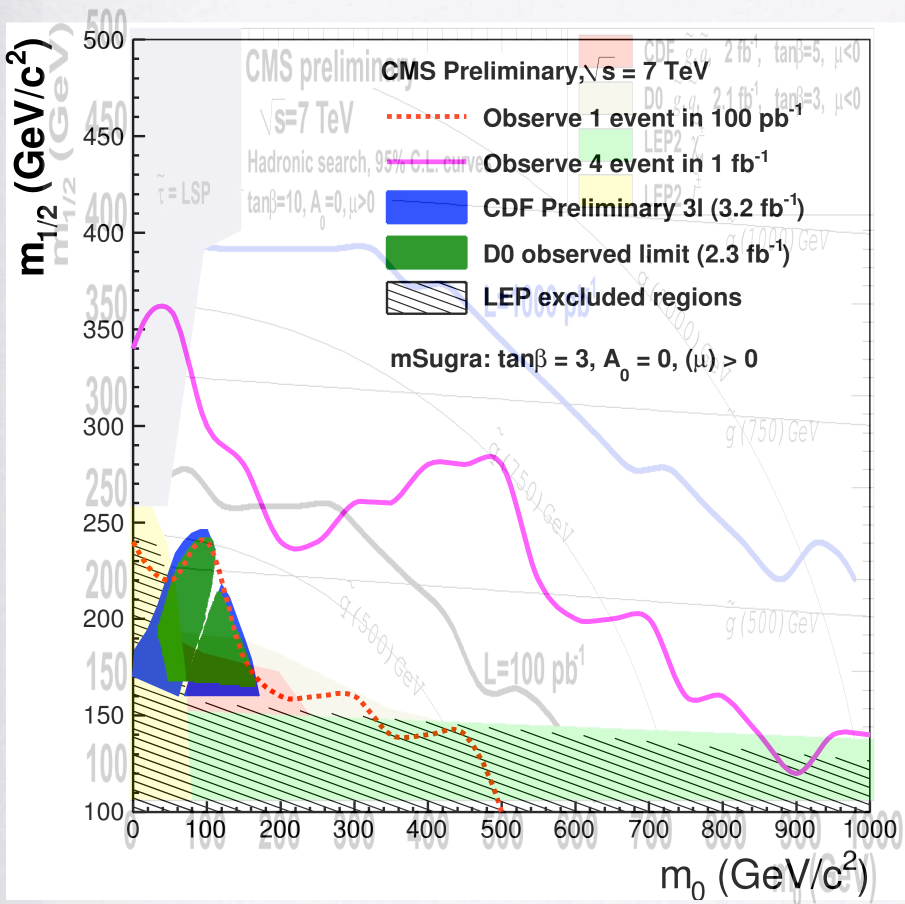
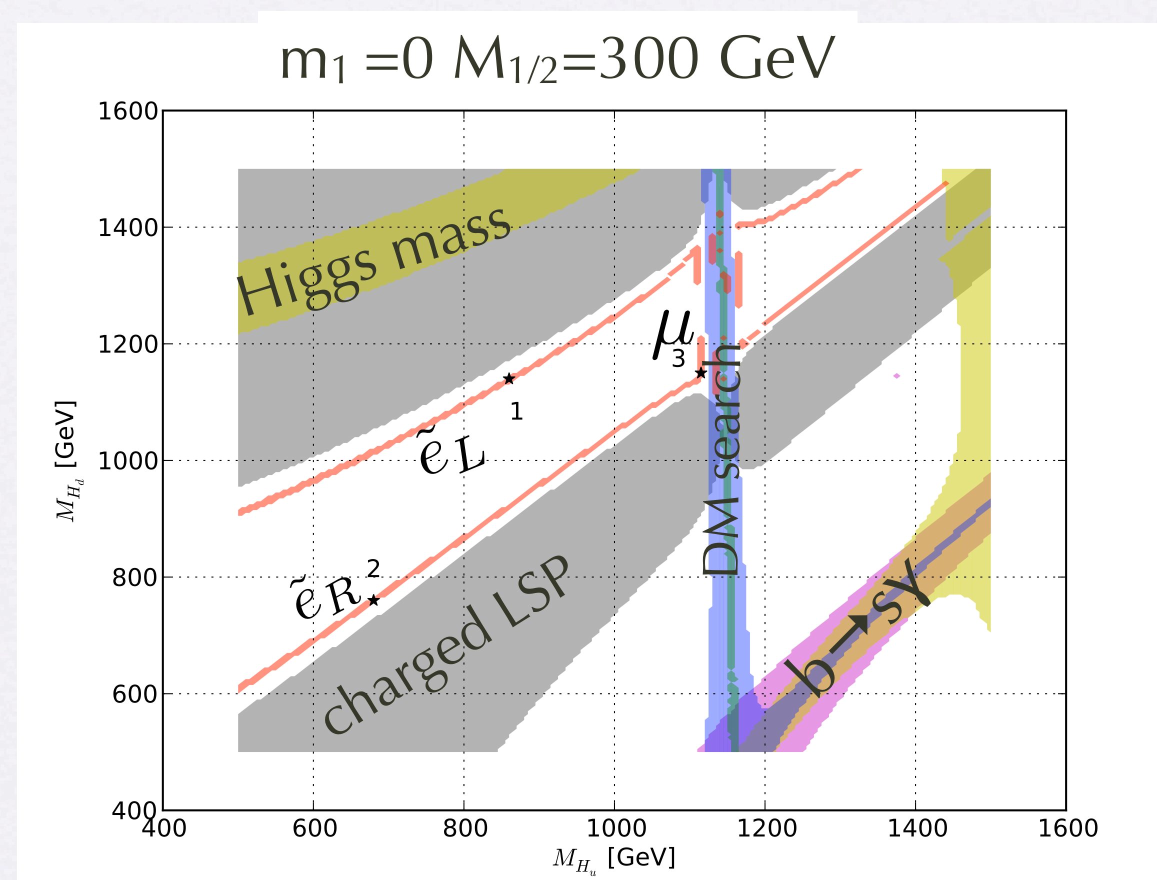


Figure 13: Estimated 95% C.L. exclusion limits for the all-hadronic SUSY search, expressed in mSUGRA param-
eter...

- Experimental reach based on leptons are not impressive compared with jets.
- We may focus on the models with large lepton branching ratio (looking for a key under the...)

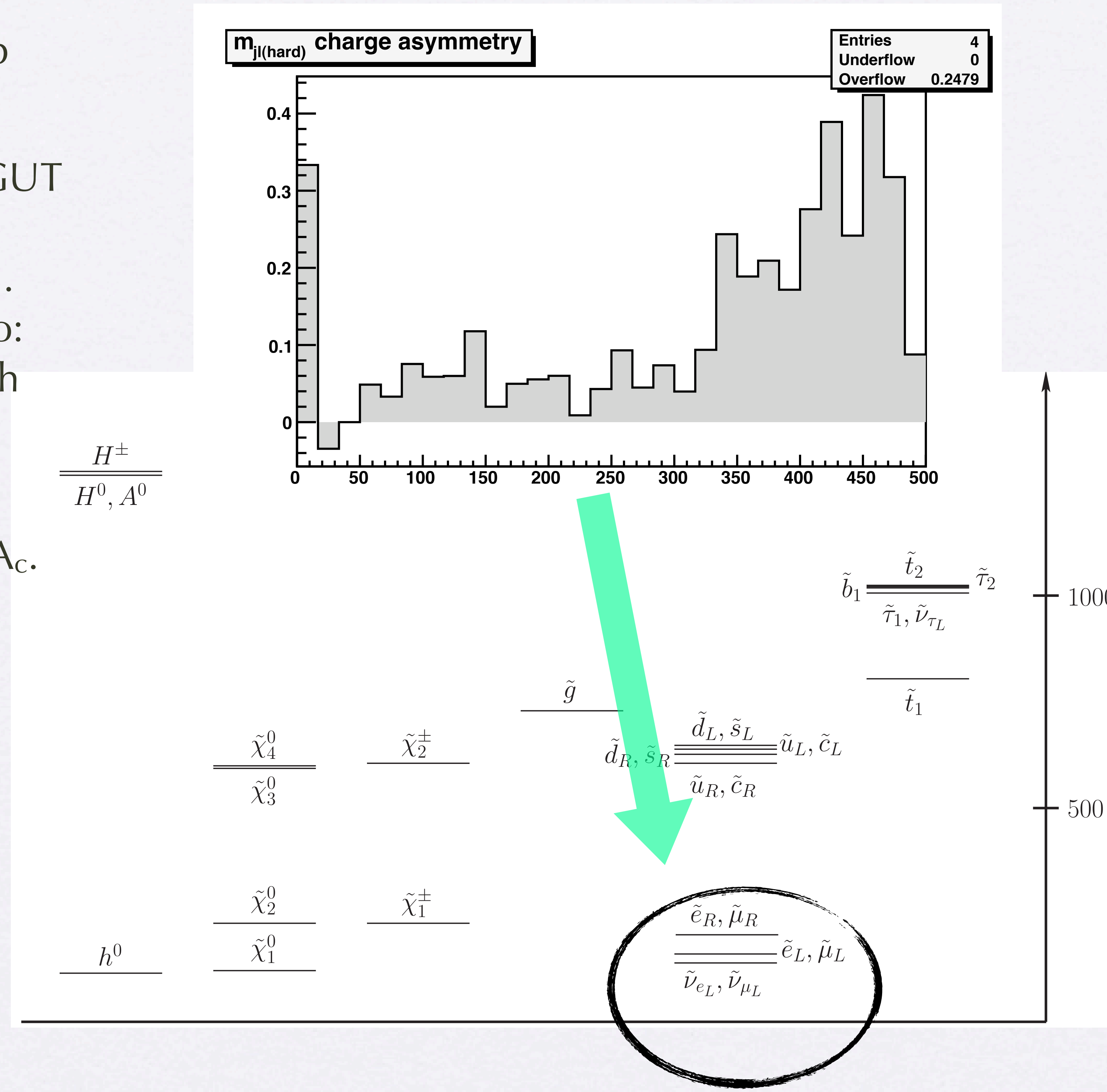
- model with m1,m2<<m3 ex. first two generation as NG boson. (arXiv1004.4164[hep-ph], Mandal,Nojiri, Sudano, Yanagida)
- the large third generation scalar mass⇄less constraint from B decay, higgs mass,...
- DM constraint ⇄Higgs mass at GUT scale.
- Three DM consistent solution



signature m1=m2~0 << m3

- non-universal heavy third generation → no tau, no (^^)b
- non-universal Higgs mass at GUT scale →radiative correction to SUGRA slepton mass relation . Three DM acceptable scenario: small μ or co-annihilaiton with $\tilde{e}_L/\tilde{e}_R$
- slepton interaction: measured from m(jl) charge asymmetry Ac. (Barr, Goto Nojiri)

$$A_c \equiv \frac{N(l^+) - N(l^-)}{N(l^+) + N(l^-)}$$



Summary

- Event has structures, and kinematical variables will help you to access it to reveal particles natures behind.
  - invariant mass
  - missing momentum
  - M_{T2} and M_{CT2} and that of subsystems