INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

Inclusive transverse mass analysis for squark/gluino mass determination

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M.M.Nojiri, Y.S, S.Okada, K.Kawagoe, arxiv:0802.2412
M.M.Nojiri, K.Sakurai, Y.S, M.Takeuchi, in preparation

Pheno08, 2008/04/28

Introduction

- gluino/squark can be produced copiously at the LHC. The squark/gluino masses are important parameters.
- The cascade decay chains depend on the SUSY parameters.
- The leptonic channel is clean but the BR is small typically O(5%) or even smaller.
- Inclusive jet analysis is important at the early stage of the LHC experiments.

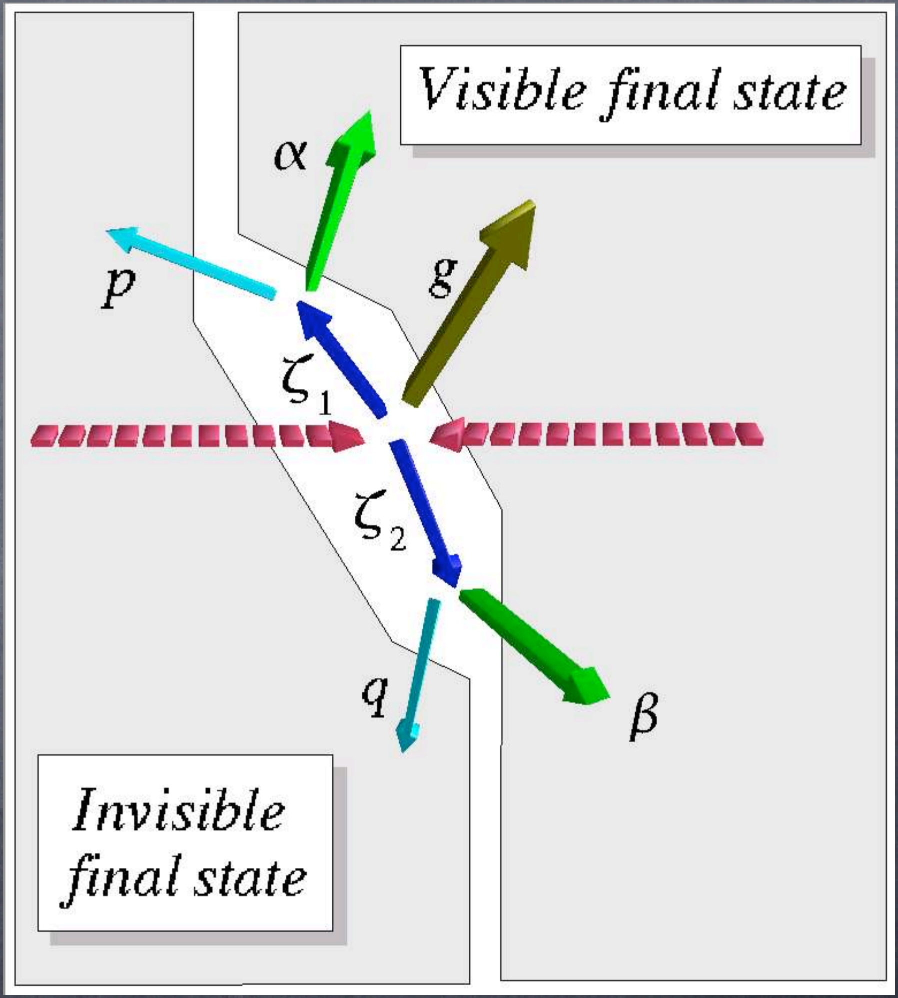
SUSY events at the LHC

$$pp \longrightarrow \zeta_1\zeta_2 \longrightarrow (\alpha p)(\beta q)$$

squark/gluino are pair-produced.

Two invisible LSPs. Each momentum cannot cannot be measured.

ECM is not known at the LHC



Is it possible to measure squark/gluino masses?

Stransverse mass (mT2)

$$pp \longrightarrow \tilde{q}\tilde{g} \longrightarrow (\text{visible}, LSP)_1 \; (\text{visible}, LSP)_2$$

Lester,Summer(99)
Barr,Lester(03)

$$m_{T2}^2(m_\chi) \equiv \min_{\mathbf{p}_{T1}^{\text{miss}} + \mathbf{p}_{T2}^{\text{miss}} = \mathbf{p}_T^{\text{miss}}} \left[\max\left\{ m_T^2(\mathbf{p}_{T1}^{\text{vis}}, \mathbf{p}_{T1}^{\text{miss}}), m_T^2(\mathbf{p}_{T2}^{\text{vis}}, \mathbf{p}_{T2}^{\text{miss}}) \right\} \right],$$

$$m_T^2\left(\mathbf{p}_{Ti}^{\text{vis}}, \mathbf{p}_{Ti}^{\text{miss}}\right) = (m_i^{\text{vis}})^2 + m_\chi^2 + 2\left(E_{Ti}^{\text{vis}} E_{Ti}^{\text{miss}} - \mathbf{p}_{Ti}^{\text{vis}} \cdot \mathbf{p}_{Ti}^{\text{miss}}\right)$$

Each missing PT cannot be measured and the minimization is done by varying each missing PT.

LSP mass is not know in advance and mT2 is a function of test LSP mass (mχ)

$$m_{T2}^2(m_\chi = m_{\chi_1^0}) \leq max(m_{\tilde{g}}, m_{\tilde{q}})$$

mT2 end points gives squark/gluino masses.

mT2 end points

$$m_{T2}^{\max}(m_\chi) = \begin{cases} \mathcal{F}_<^{\max}(m_\chi) & \text{for} \quad m_\chi < m_{\chi_1^0} \\ \mathcal{F}_>^{\max}(m_\chi) & \text{for} \quad m_\chi > m_{\chi_1^0}, \end{cases}$$

$$\mathcal{F}_<^{\max}(m_\chi) = \mathcal{F}(m_1^{\rm vis} = m_{\min}^{\rm vis}, m_2^{\rm vis} = m_{\min}^{\rm vis}, \theta = 0, m_\chi),$$

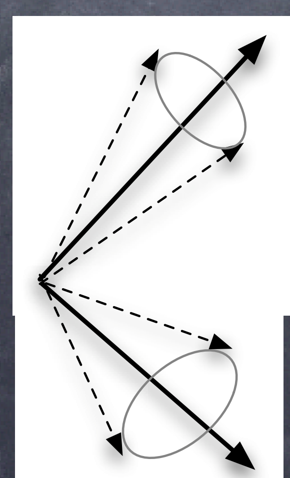
$$\mathcal{F}_>^{\max}(m_\chi) = \mathcal{F}(m_1^{\rm vis} = m_{\max}^{\rm vis}, m_2^{\rm vis} = m_{\max}^{\rm vis}, \theta = 0, m_\chi)$$

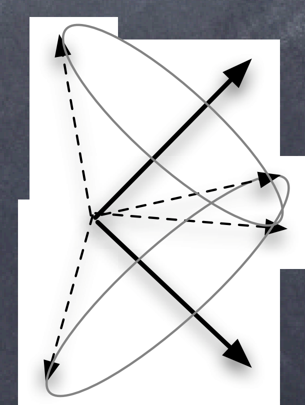
End point events are interchanged at the true LSP mass.

$m_\chi < m_{\chi_1^0}$

$m_i^{\rm vis} \sim m_{\min}^{\rm vis}$

separated





$m_\chi > m_{\chi_1^0}$

$m_i^{\rm vis} \sim m_{\max}^{\rm vis}$

overlapped

Kink in mT2 end point

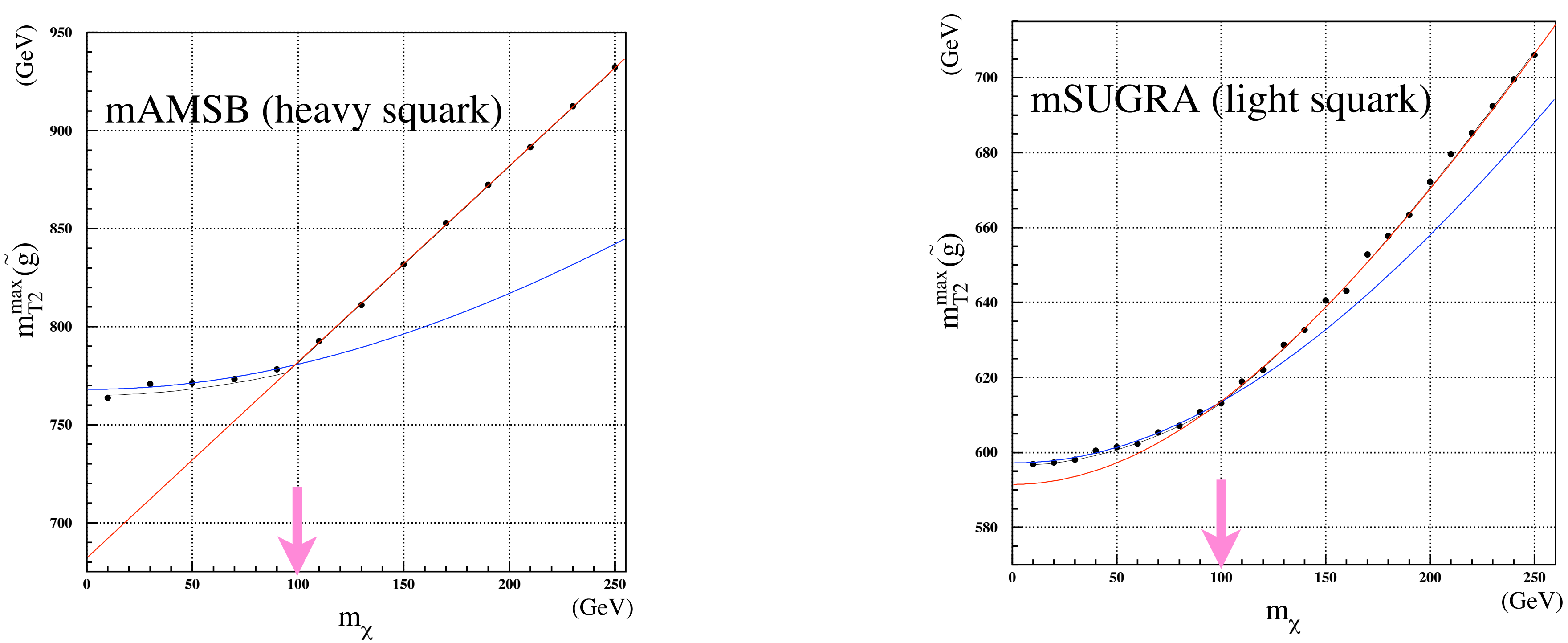
W.Cho et al, arxiv:0709.0288,0711.4526

B.Gripaios, arxiv:0709.2740

A.Barr et al, arxiv:0711.4008

$$p\,p \rightarrow \tilde{g}\,\tilde{g} \rightarrow qq\chi_1^0\,qq\chi_1^0$$

cho et al.



From the kink, gluino/squark and LSP masses can be determined.

Inclusive mT2 analysis

- SUSY spectrum ISAJETv7.75
- 50000 Events are generated with Herwig
- Detector simulation with AcerDet
- Standard cuts: MET>max(0.2*Meff,100 GeV) Meff>1200 GeV.

sample points

$$\sigma = 0.13 \text{ pb}$$

squark/gluino coprodcution is main production.

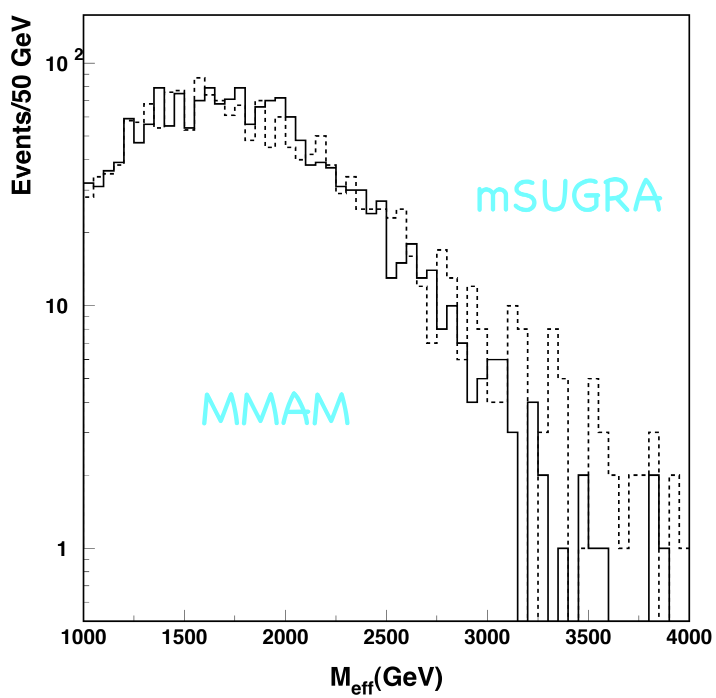
	A: MMAM	B: mSUGRA
	$n_i = 0,\ R = 20,$ $M_3(\text{GUT}) = 650$	$m_0 = 1475,\ m_{1/2} = 561.2,$ $A = 0,\ \tan\beta = 10$
$\tilde{g}$	1491	1359
$\tilde{u}_L$	1473	1852
$\tilde{u}_R$	1431	1831
$\tilde{d}_R$	1415	1830
$\tilde{\chi}_1^0$	487	237

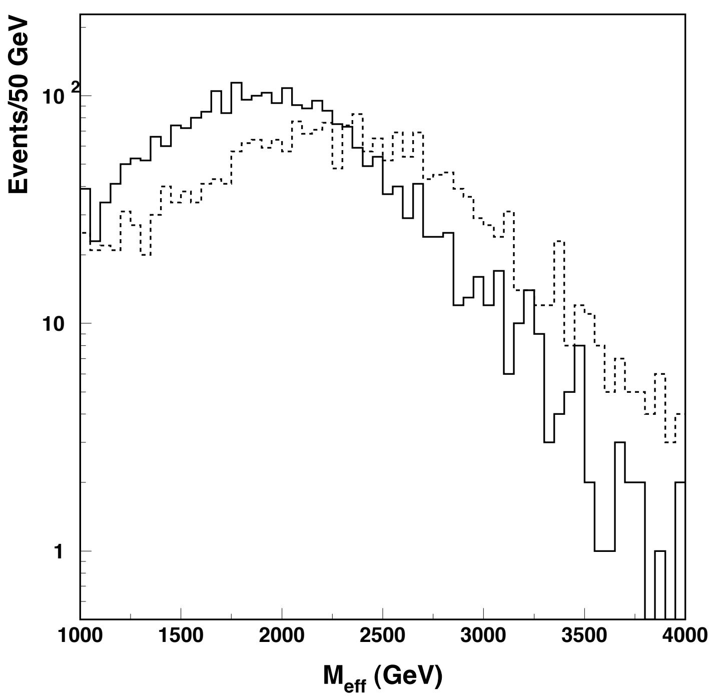
Meff distributions

Two sample points give similar Meff distribtions.

$$M_{\rm eff} \equiv \sum_{i=1,..,4}^{leading-4jets} P_T + \sum^{leptons} P_T + \not{E}_T$$

$$M'_{\rm eff} \equiv \sum_{i=1,..,}^{P_T>50} P_T + \sum^{leptons} P_T + \not{E}_T$$





Can we distinguish two sample points by mT2?

Hemisphere method

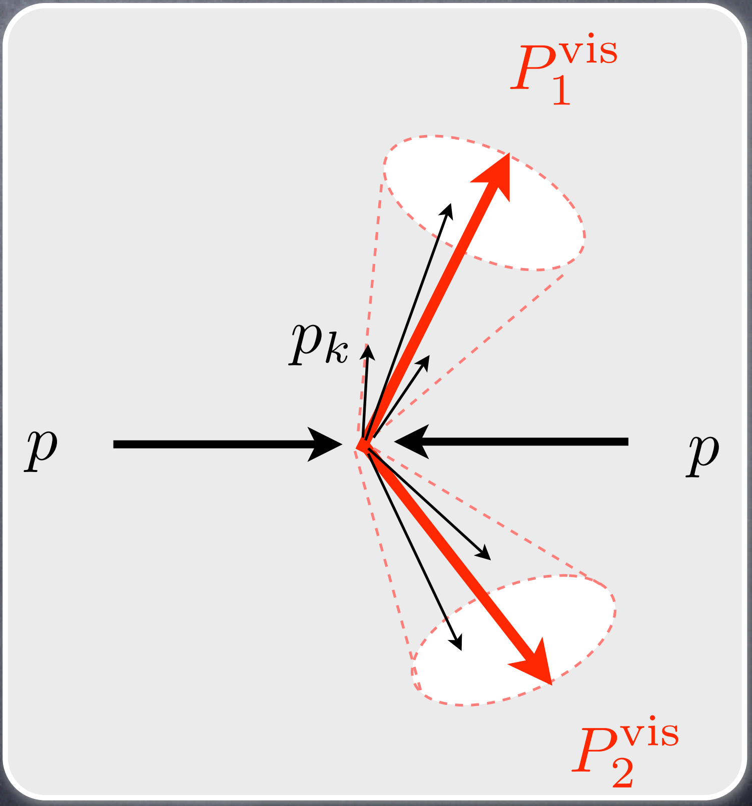
We need to separate two cascade decay chains to calculate mT2

(1). Each hemisphere is defined with Pivis, summing high pT objects. (pT>50 for jets, pT>10 for leptons/photons)

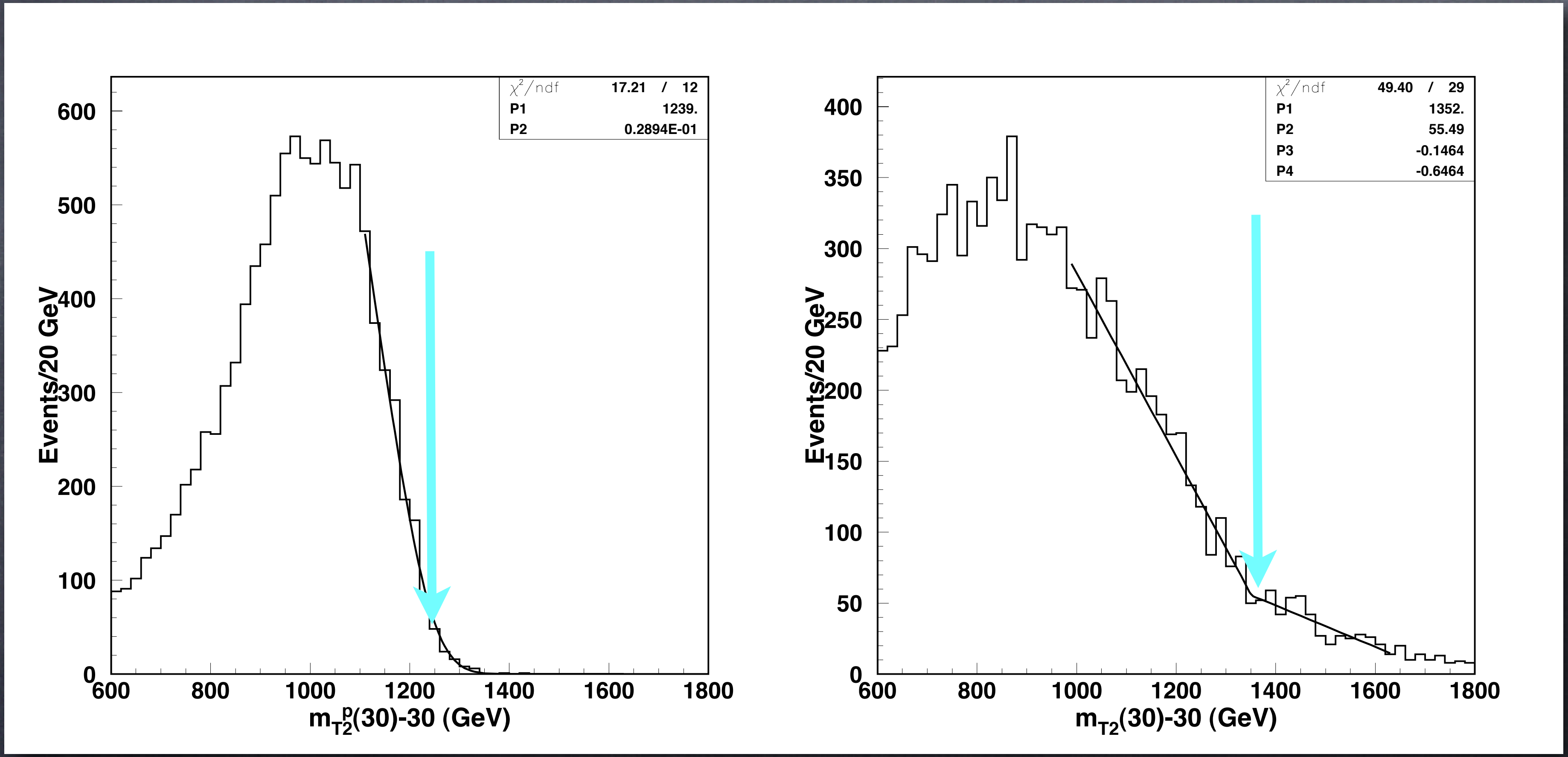
(2). High pT objects satisfy the following conditions

$$d(p_k, P_i) < d(p_k, P_j)$$

$$d(p_k, P_i) = (E_i - |P_i| \cos\theta_{ik}) \frac{E_i}{(E_i + E_k)^2}$$



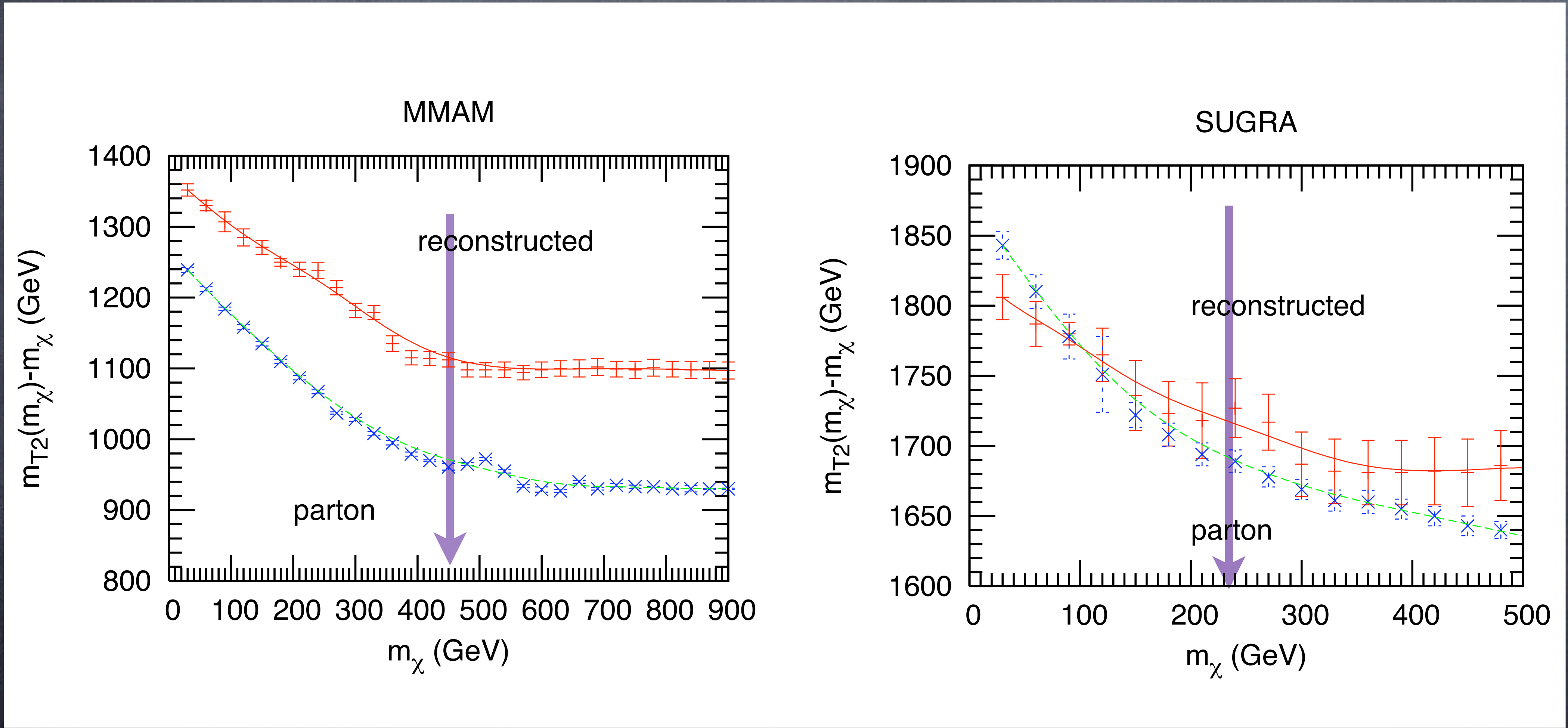
mT2 distributions (MMAM)



parton level reconstructed

mT2 end points

Two sample points gives different mT2 end points



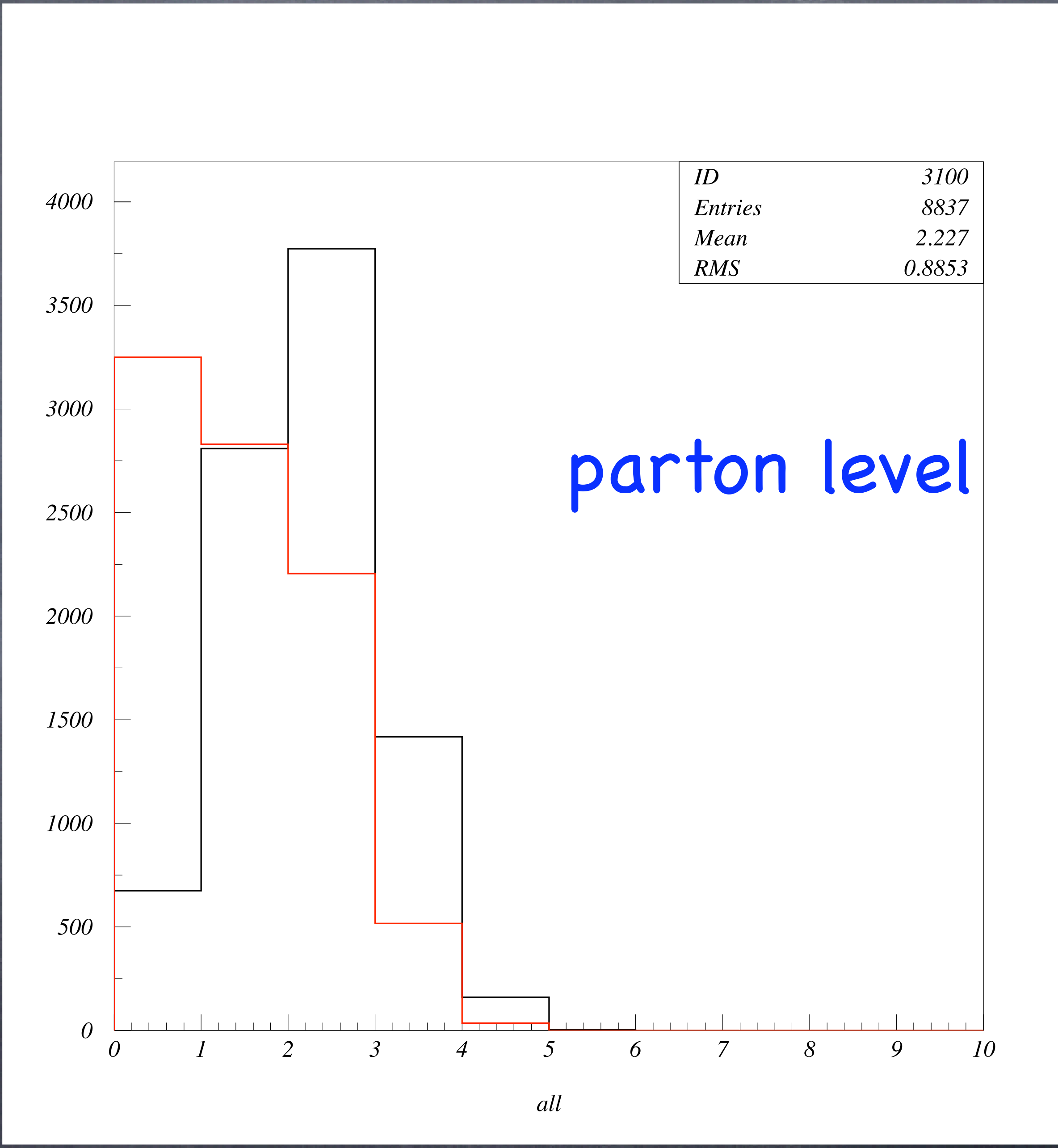
We can see a kink around the true LSP mass for MMAM.

Misreconstruction of Hemispheres

Red:# of misreconstruction by the hemisphere method.

Black:# of misreconstruction by separating randomly.

The hemisphere method can separates two cascade decay products better than random one.



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Summary

- We have considered inclusive mT2 distributions for squark/gluino production.
- We can separate two cascade decay chains by the hemisphere method.
- The end point of mT2 provide information on squark/gluino masses.
- We can determine the squark/gluino and LSP masses from the kink of mT2 end points.

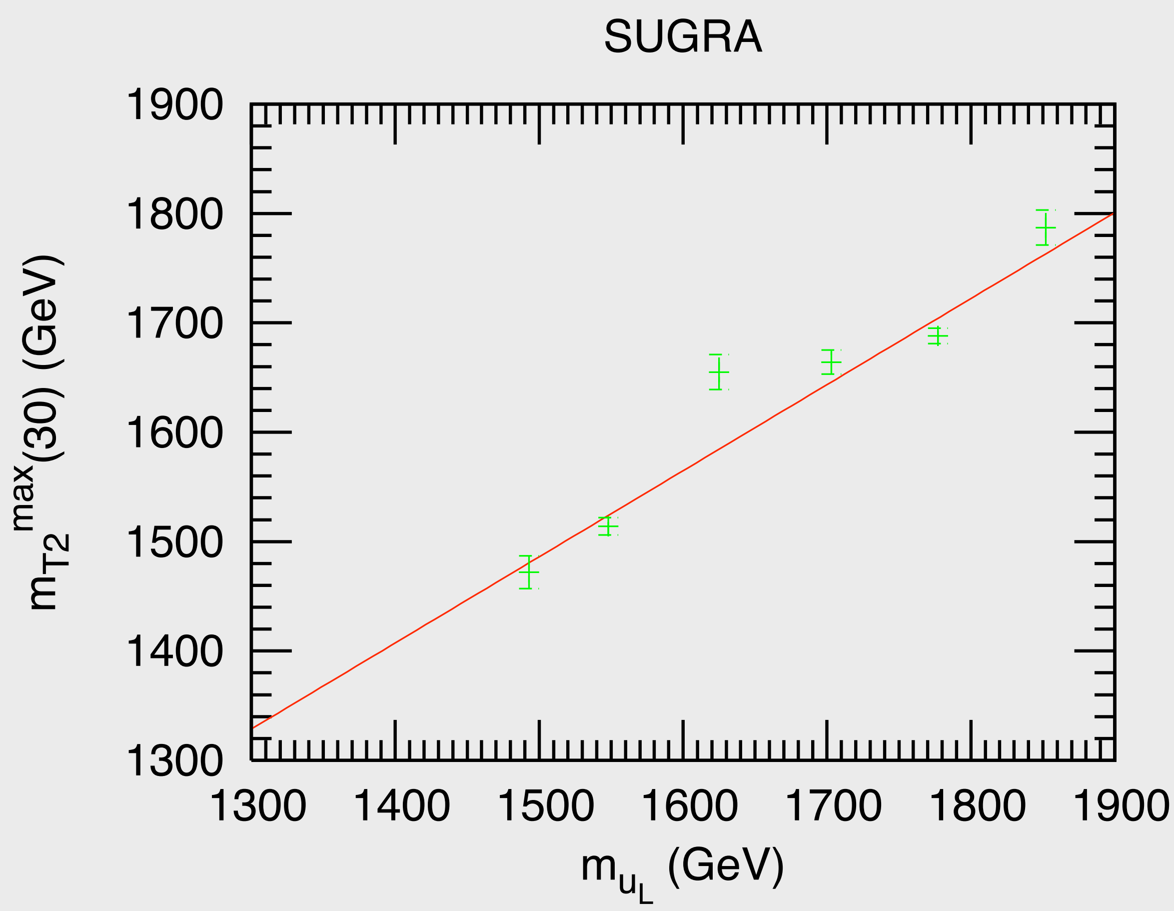
Mirage

$R = 20, m_3(M_{\rm GUT}) = 650, \tan\beta = 10$
$(\alpha = 0.61, M_0 = 802)$

mSUGRA

$m_0 = 1475, m_{1/2} = 561, A_0 = 0, \tan\beta = 10$

	Mirage mass	Mirage Br	mSUGRA mass	mSUGRA Br
$\tilde{g}$	1491	$t\,\tilde{t}_1(67),\ b\,\tilde{b}_1(16)$	1358	$t\,b\,\chi_2^\pm(30),\ t\,t\,\chi_1^0(12)$
$\tilde{q}_L$	1473	$\tilde{q}'_L\,\chi_1^\pm(66),\ \tilde{q}_L\chi_2^0(33)$	1852	$q'\,\tilde{g}(53),\ q_L\chi_1^\pm(30)$
$\tilde{q}_R$	1415	$\tilde{q}_R\,\chi_1^0(100)$	1830	$q\,\tilde{g}(96),\ q\,\chi_1^0(4)$
$\tilde{e}_L$	916	$\nu\,\chi_1^\pm(51),\ e\,\chi_2^0(27)$	1518	$\nu\,\chi_1^\pm(56),\ e\,\chi_2^0(30)$
$\tilde{e}_R$	845	$e\,\chi_0^\pm(100)$	1488	$e\,\chi_0^\pm(100)$
$\tilde{t}_1$	1014	$t\,\chi_0^\pm(63),\ b\,\chi_1^\pm(27)$	1237	$b\,\chi_2^\pm(39),\ t\,\chi_3^0(22)$
χ_2^0	695	$h\,\chi_0^\pm(97),\ Z\chi_1^\pm(2)$	450	$h\,\chi_0^\pm(93),\ Z\chi_1^\pm(7)$
$\chi_1^\pm$	696	$W\,\chi_0^\pm(100)$	450	$W\,\chi_0^\pm(100)$
χ_1^0	487		237	


SUGRA
1300
1400
1500
1600
1700
1800
1900
$m_{T2}^{max}(30)$ (GeV)
m_{u_L} (GeV)