Novel reconstruction technique for new physics with ISR

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PRL:103(2009)151802

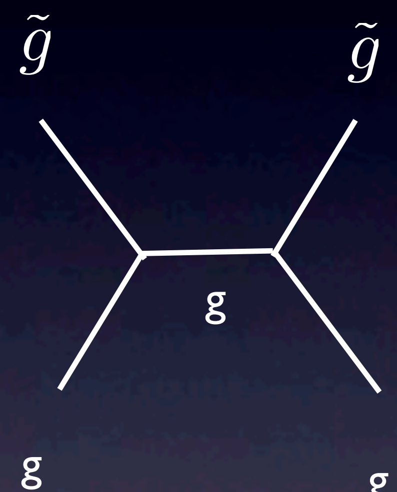
2010/5/10-13@Madison, WI

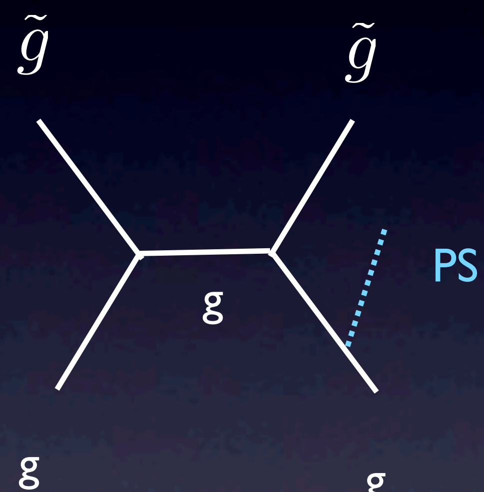
Introduction

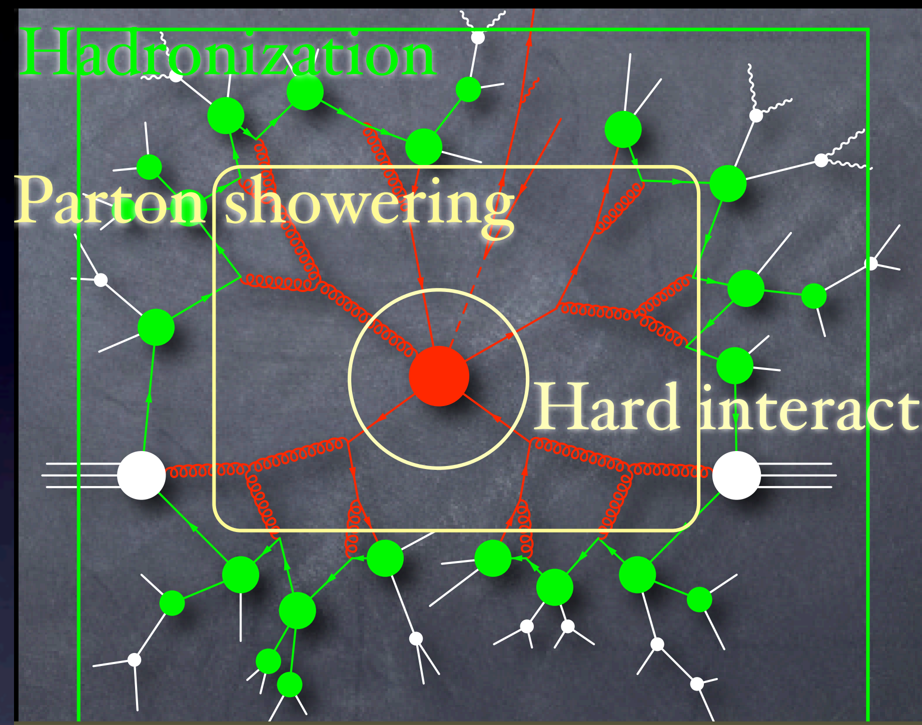
- Gluino/squarks will be produced copiously at the LHC if the masses are less than 1 TeV.
- Gluino/squark mass reconstruction is very important issue.
- For heavy particle productions, initial state radiation (ISR) jets are rather hard.
- The hard ISR jets become serious BG for SUSY mass reconstruction.
- We propose a new method to remove the ISR BG using MT2.

ISR in heavy particle production at the LHC

ISR jets in heavy particle productions get rather high pt.







Jets from PS are soft.

PS may not describe the high pt jet distribution correctly.

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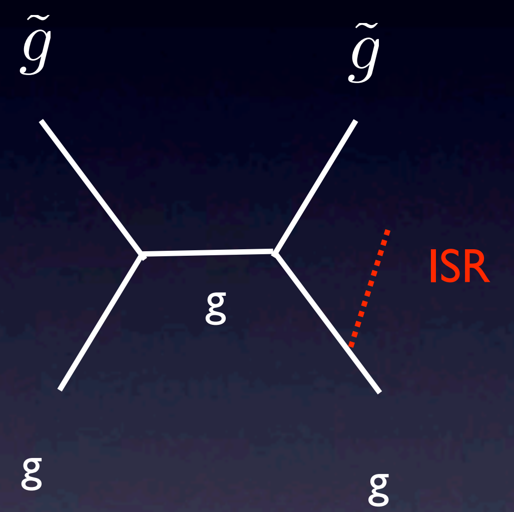

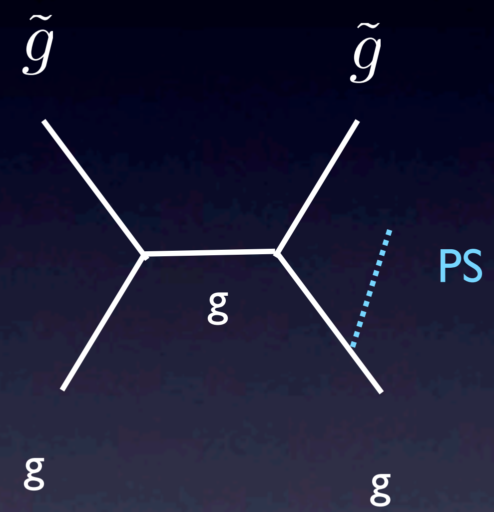

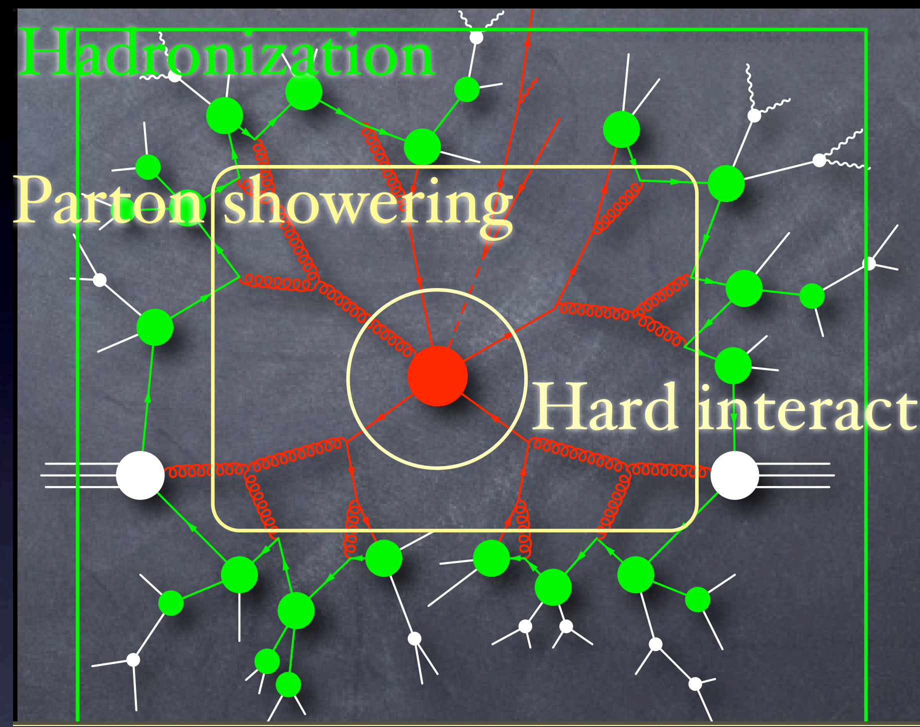

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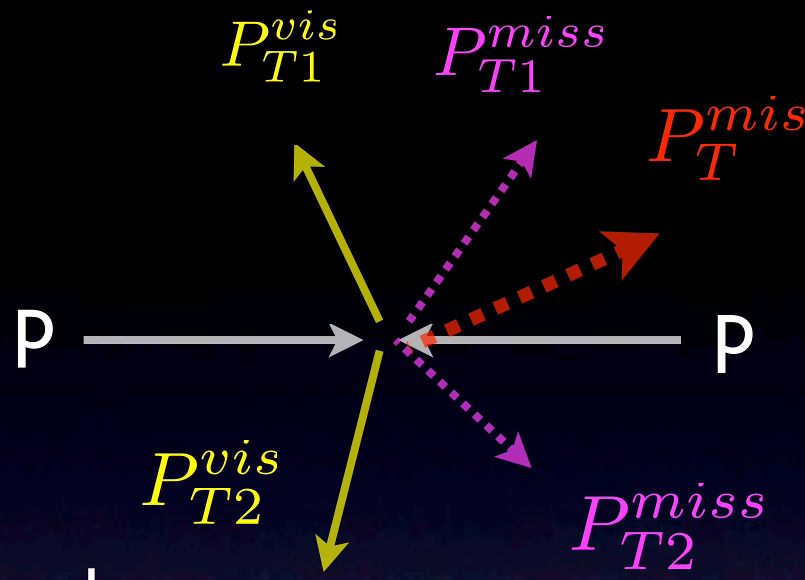
MT2

'99 Lester, Summer
'03 Barr, Lester

pp → gluino gluino
→ (vis+LSP)₁ (vis+LSP)₂



Two invisible LSP in the final states and each momenta cannot measured separately.

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

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

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

MT2 end points gives squark/gluino masses.

Kink in MT2 endpoints

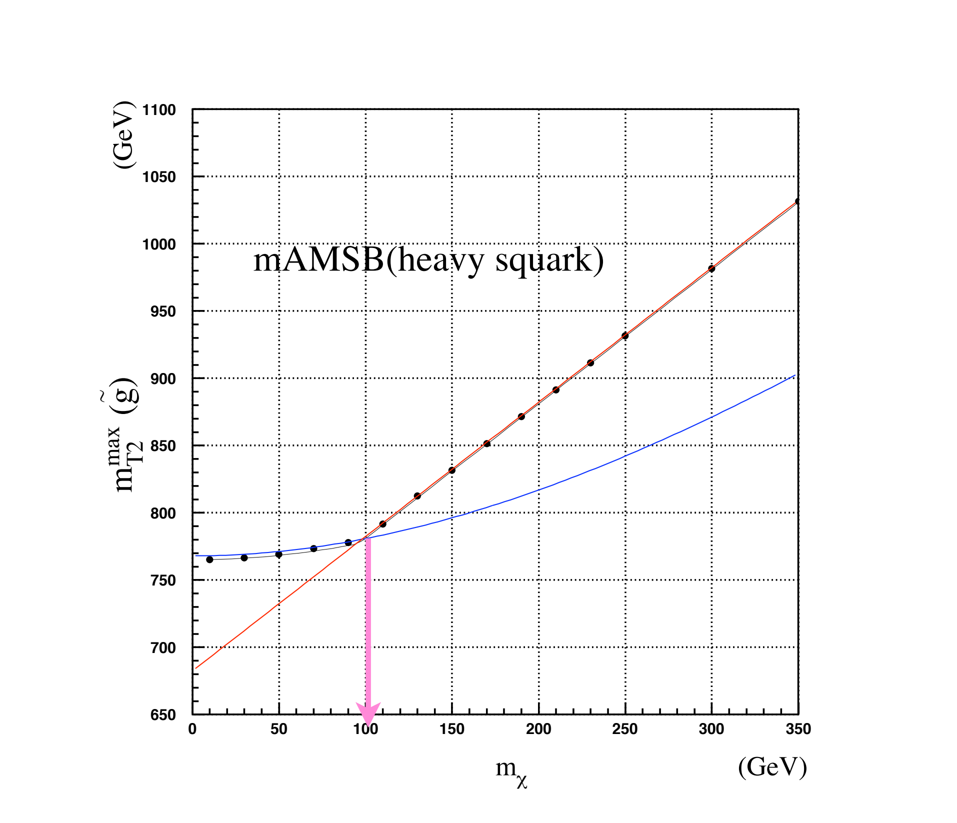
W.Cho et al, arxiv:0709.0288,0711.4526
B.Gripaios, arxiv:0709.2740
A.Barr et al, arxiv:0711.4008

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

$$M_{T2} \leq m_{\tilde{g}} \qquad m_{\chi^{test}} = m_{\chi_1^0}$$

There is a kink at the true LSP mass.

Gluino and the LSP masses are determined simultaneously from the kink.



'07 W.Cho, K.Choi, Y.G.Kim, C.B.Park

We consider effects on MT2 from an additional ISR jet.

MC simulation

$$pp \to \tilde{g}\tilde{g} + j \to (qq\tilde{\chi}_1^0)(qq\tilde{\chi}_1^0) + j$$

$$m_{\tilde{g}} = 685 \text{ GeV}, \; m_{\tilde{q}} = 1426 \text{ GeV}, \; m_{\tilde{\chi}_1^0} = 102 \text{ GeV},$$

$$B(\tilde{g} \to qq\tilde{\chi}_1^0) = 1$$

ME/PS matching

Madgraph/Madevent

Detector simulation AcerDet

Cross section = 2.5 pb

Luminosity = 40/fb

How to define pvis

$$M_{T2} = \min_{p^T_{1\chi}+p^T_{2\chi}=p^T_{\rm miss}} \left[\max\left(M_T(p_1^{\rm vis}, p^T_{1\chi}, m_\chi^{\rm test}), M_T(p_2^{\rm vis}, p^T_{2\chi}, m_\chi^{\rm test})\right)\right].$$

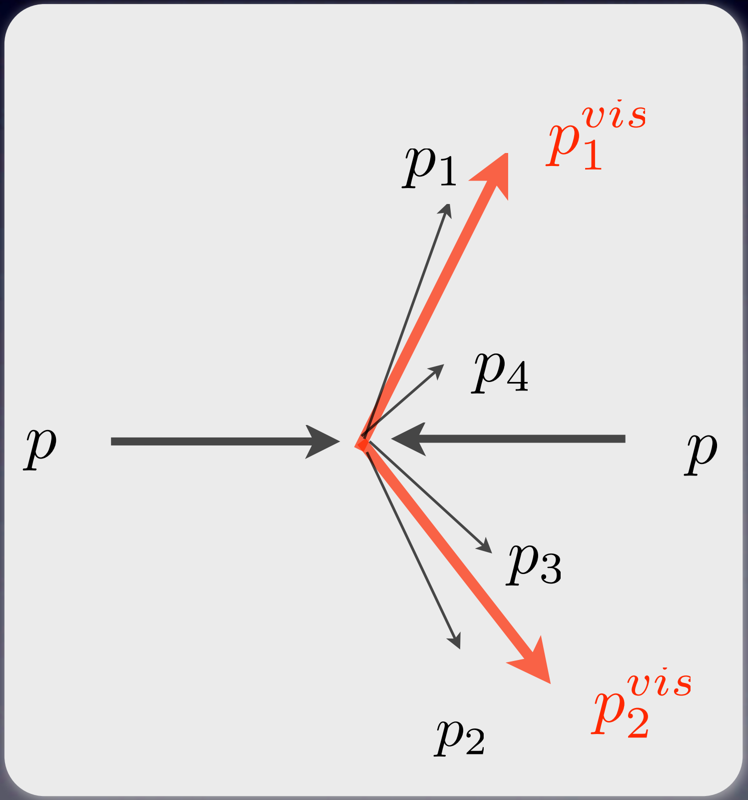
simple example

1. Consider 4 highest pt jets (p1-p4).

2. Assign p1(p2) to p1vis(p2vis)

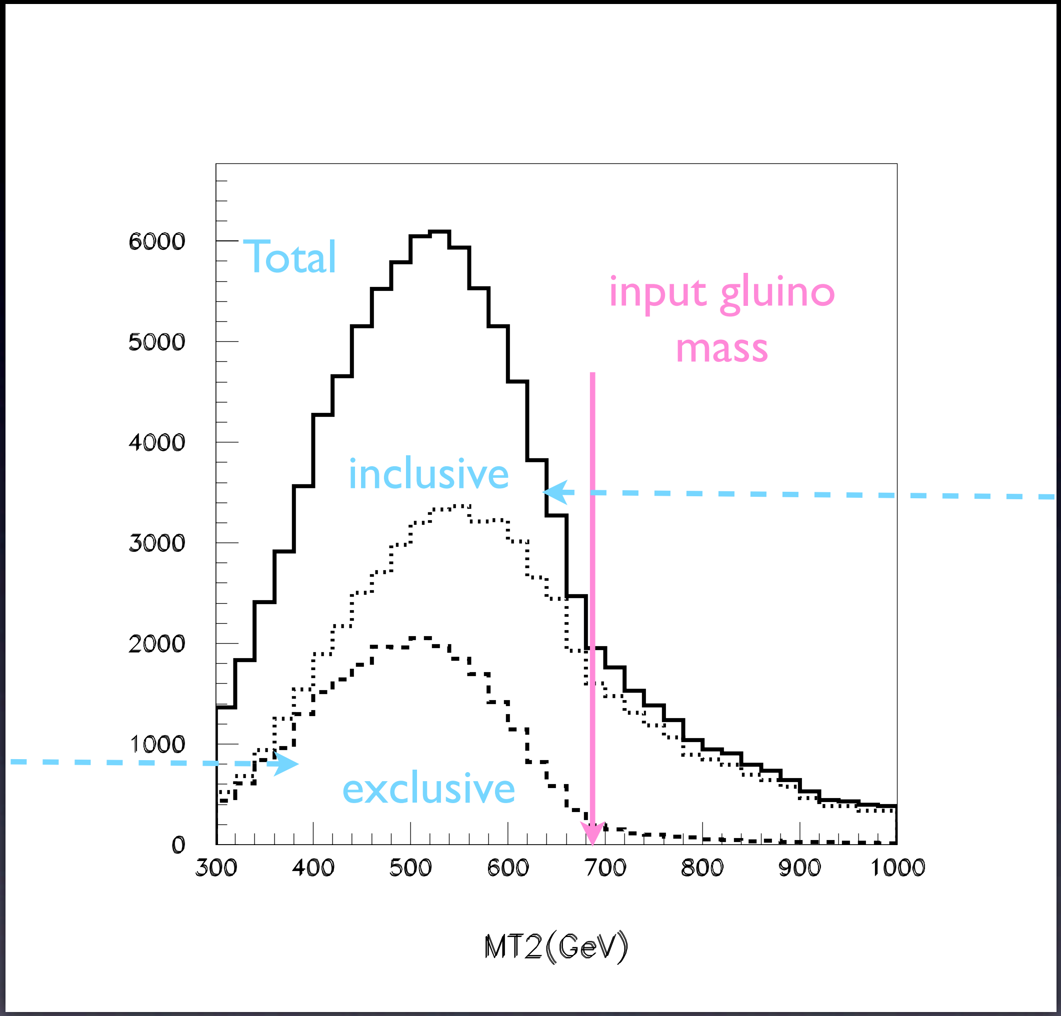
3. Assign p3,p4 to either p1vis or p2vis.

4. take the combination which gives the smallest MT2.



reconstructed MT2

$$m_\chi^{test} = 102 \text{ GeV}$$



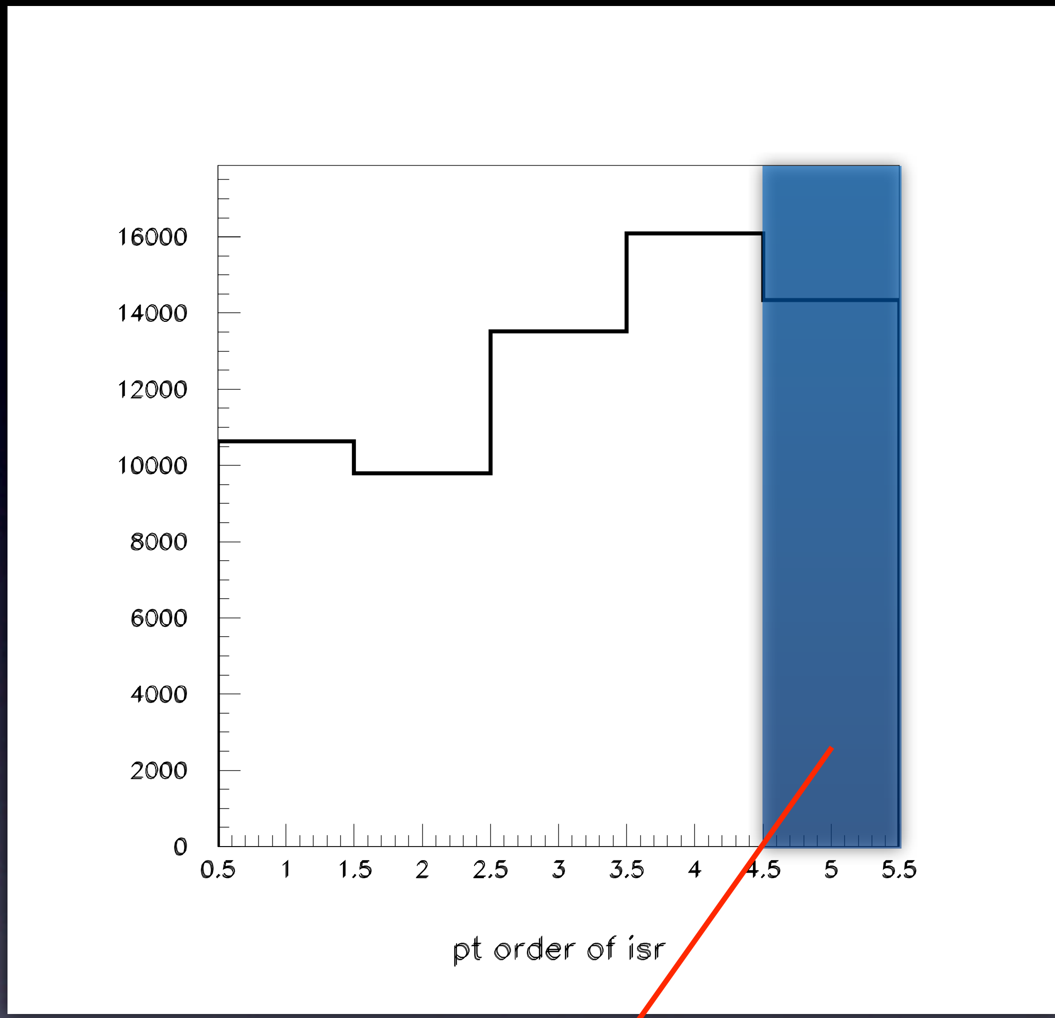
gluino+gluino+hard ISR with PS

gluino+gluino

N(inclusive)/N(exclusive)=1.4

Large contribution from hard ISR.

pt order of ISR parton among five parton



ISR parton is the 5th softest parton: only 22 %

high probability to misidentify the jets from gluino decay

MT2min

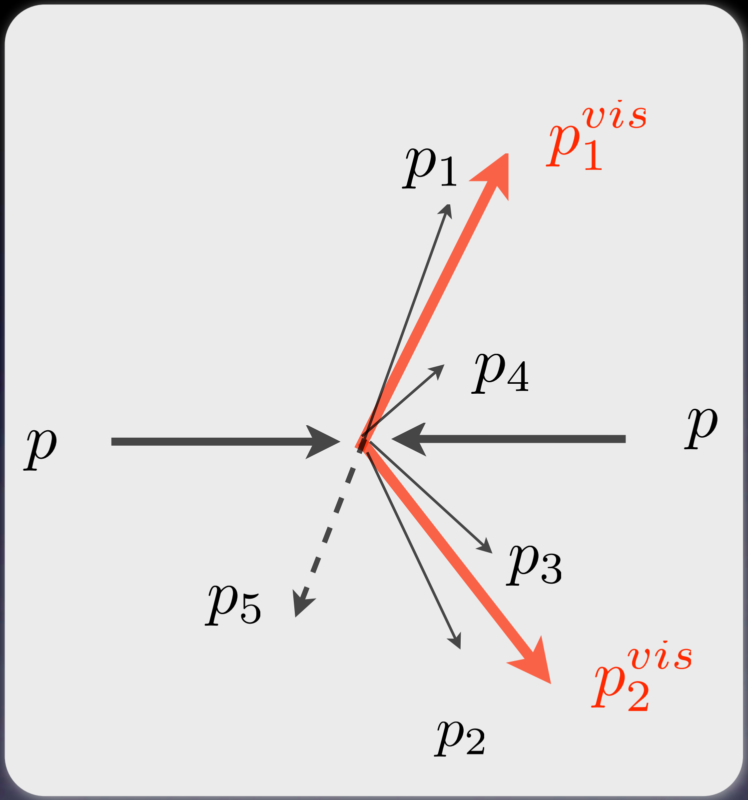
1. Consider 5 (not 4) highest pt jets (p1-p5).

2. Remove one of p1 and calculate MT2(i).

$$M_{T2}(i) = M_{T2}(p_1, ..., p_{i-1}, p_{i+1}, ...p_5)$$

3. Take the minimum of MT2(i).

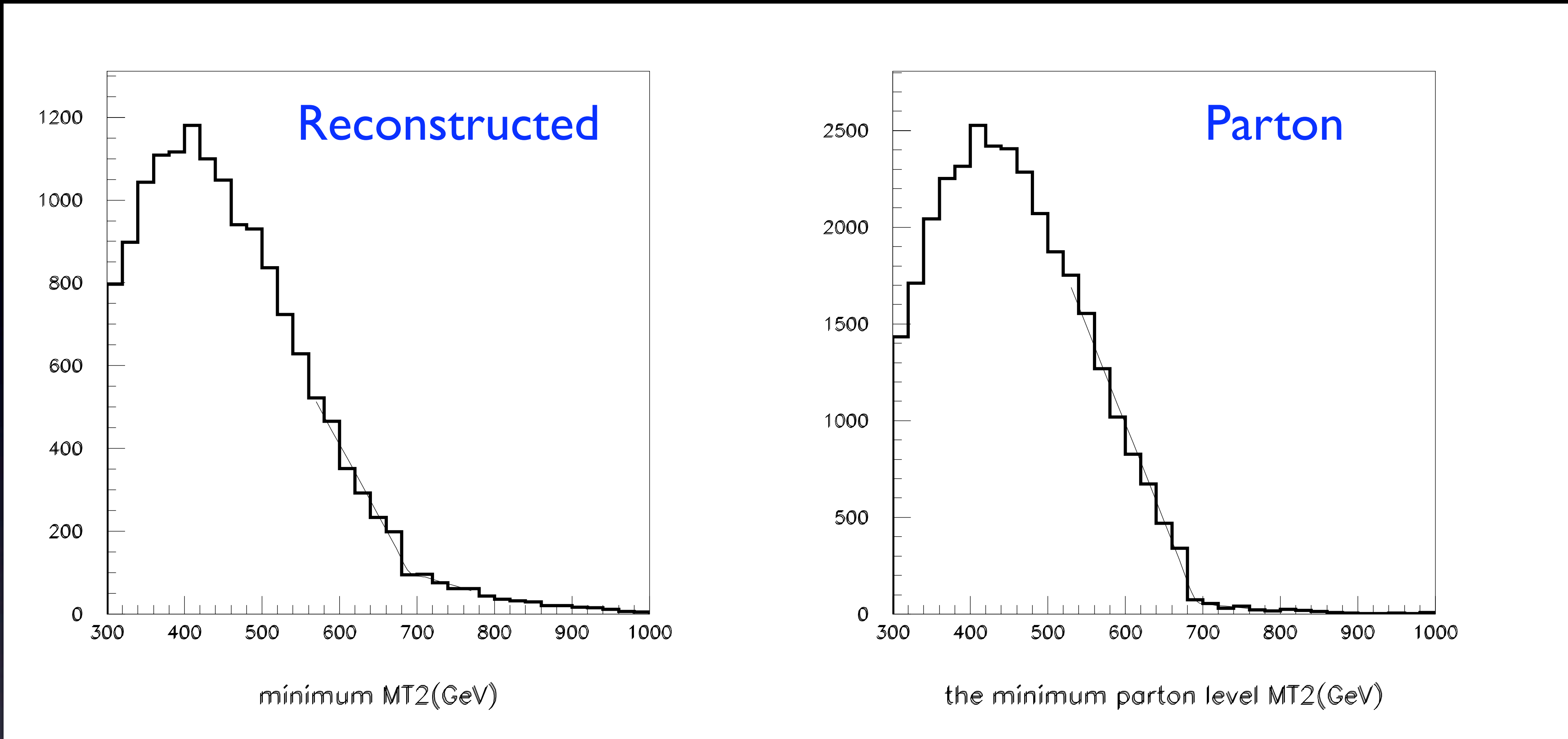
$$M_{T2}^{\min} \equiv \min_{i=1,..5}(M_{T2}(i)).$$



If we misidentify the ISR jet as a jet from gluino decay, MT2 tends to be large.

MT2min distribution

$m_\chi^{test} = 102 \text{ GeV}$



$$f(x) = \theta(x - M^{end})[a_1(x - M^{end}) + b] + \theta(x - M^{end})[a_2(x - M^{end}) + b]$$

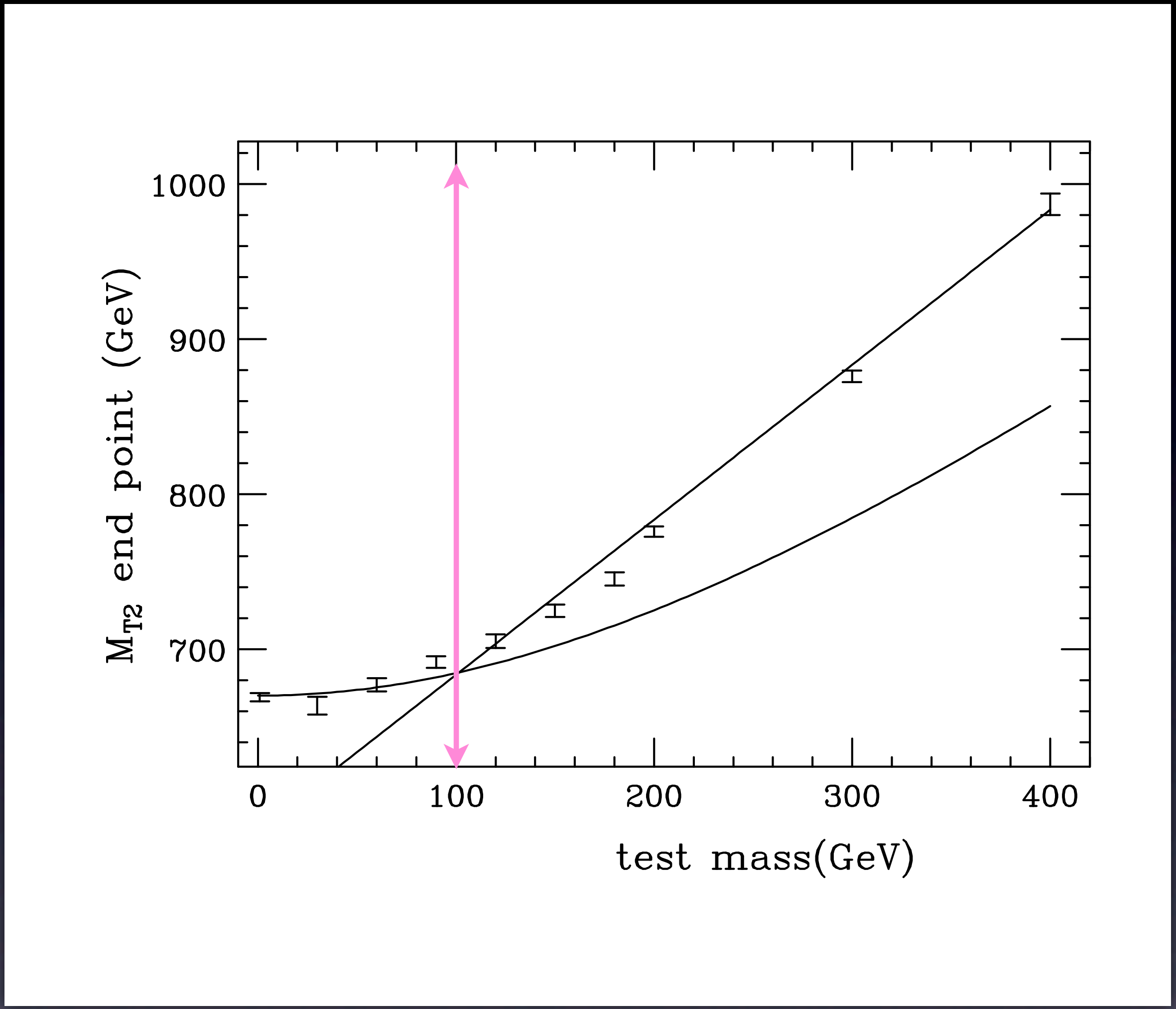
$672.7 \pm 3.5 \text{ GeV}$

$675.4 \pm 6.4 \text{ GeV} \quad i_{min} \geq 3$

$673.9 \pm 2.5 \text{ GeV}$

input gluino mass 685 GeV

MT2 end points



$$n_{jet}(E_T \geq 50GeV) \geq 5$$

$$i_{min} \geq 3$$

MT2 end points are almost consistent with theoretical predictions.

Summary

- ISR is rather hard for heavy gluino productions.
- The hard ISR is included with ME/PS matching by Magraph/ Madevent.
- We defined the MT2min variable by minimizing MT2 variables for all combinations.
- ISR can be removed by cuts to MT2min and MT2min end points become clearer.