Novel reconstruction technique for new physics with ISR

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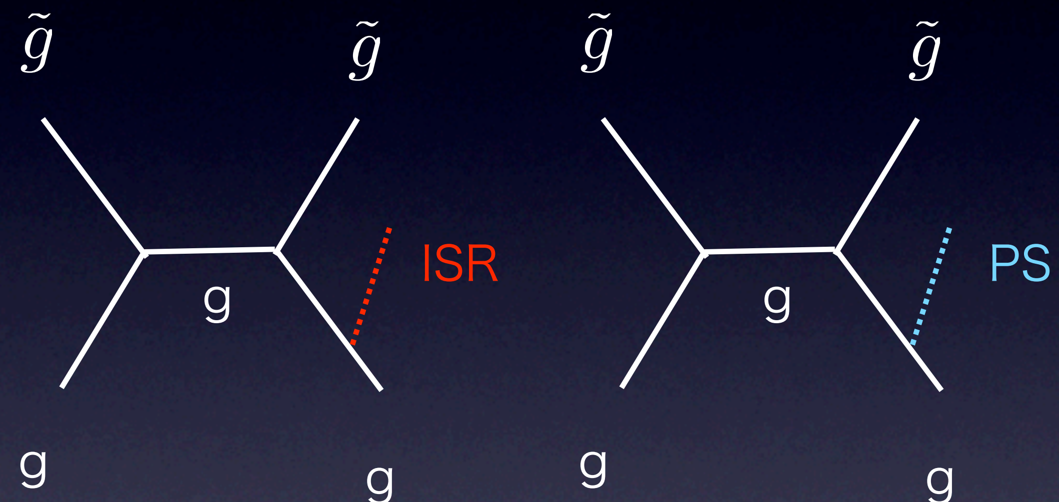
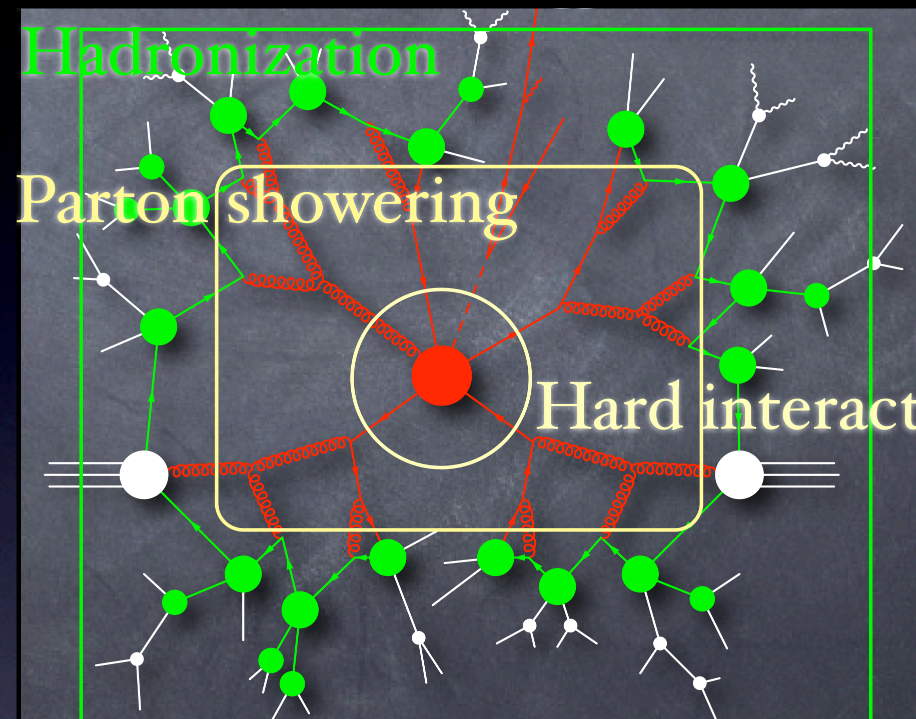
Introduction

- Gluino/squarks will be produced copiously at the LHC.
- 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.

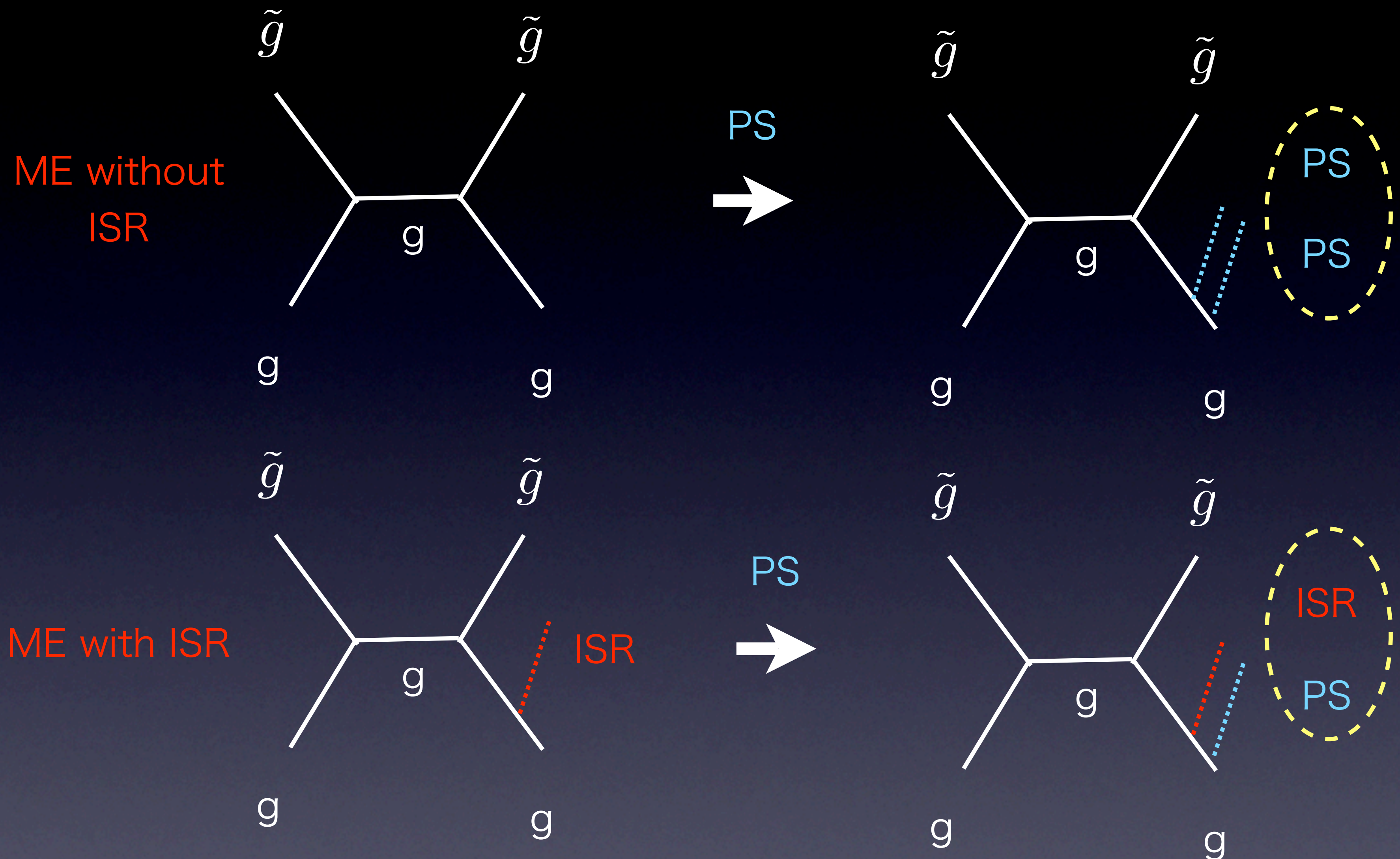




Jets from PS are soft.

PS may not describe the high pt jet distribution correctly.

ME/PS matching

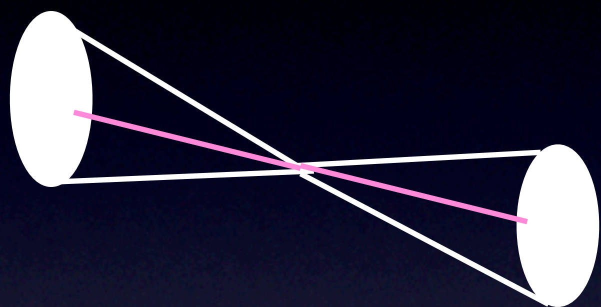


Double counting is avoided by ME/PS matching.

MLM matching

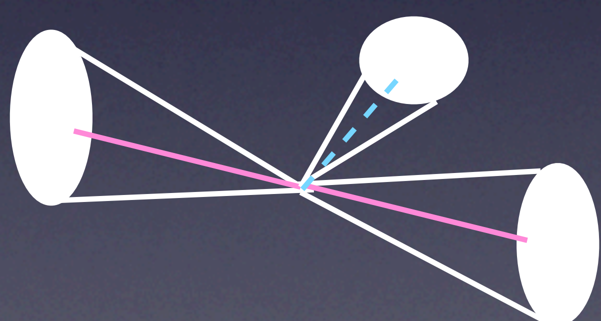
ex. qq+j: qq(exclusive) + qqj (inclusive)

exclusive



2 jet with ME partons

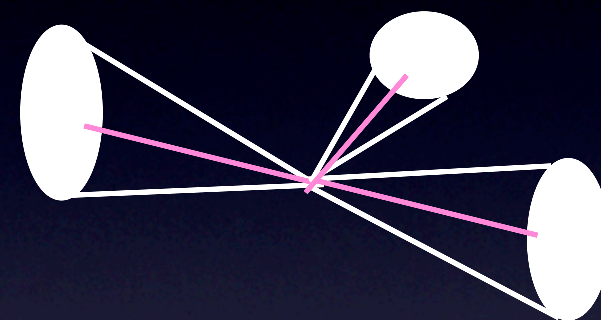
matched



1 jet with PS

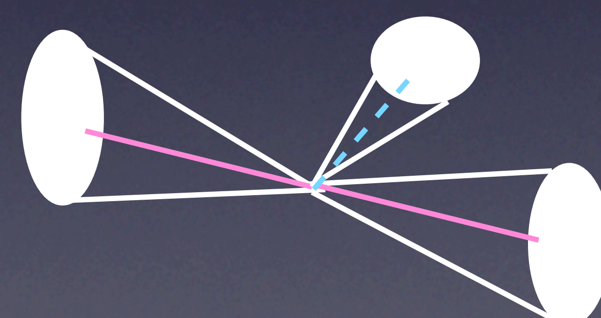
discard

inclusive



3 jet with ME partons

matched



1 jet with PS

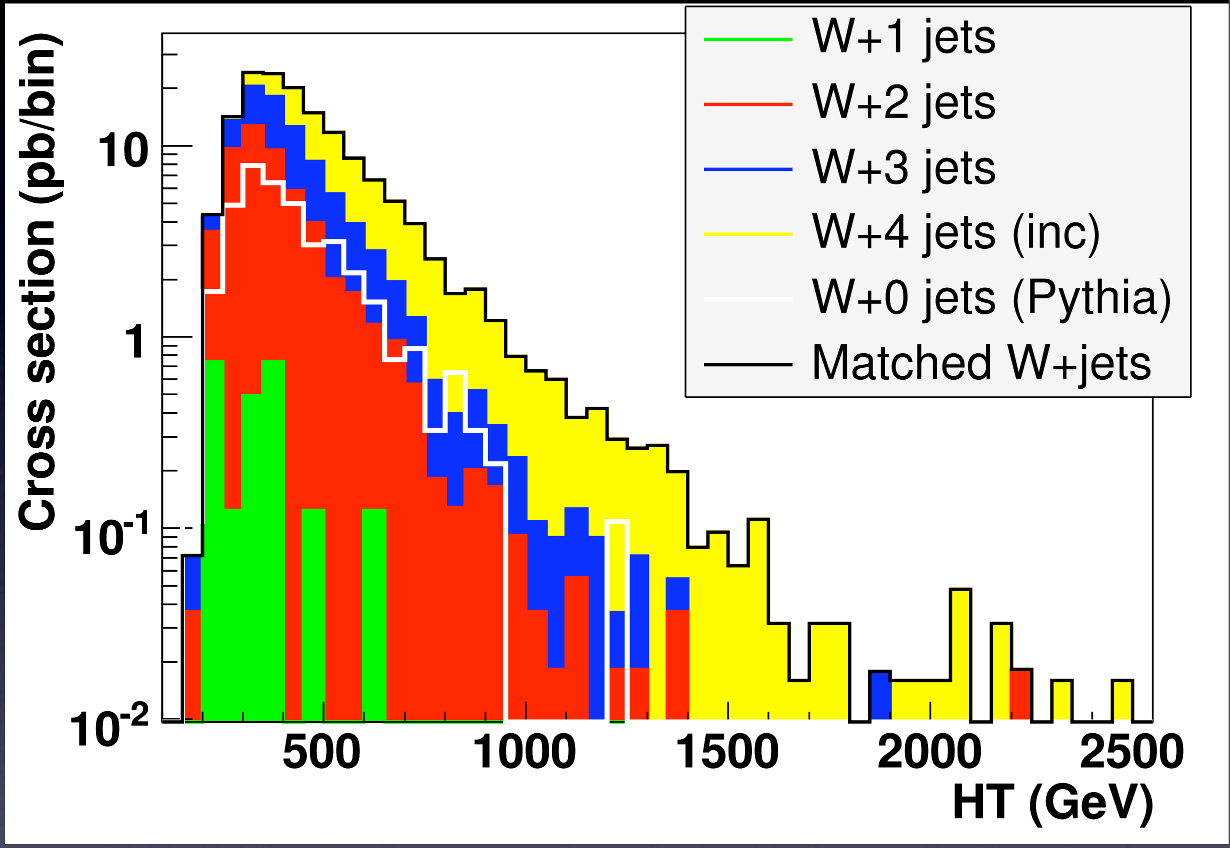
matched

Matching results in W + jets

@Tevatron

$$H_T = \sum_{vis} p_\perp + \not{E}_T$$

$$E_T > 50\,\mathrm{GeV}$$



HT distributions are modified by extra jets mainly from ISR jets

'07 J.Alwall

MT2

'99 Lester, Summer
'03 Barr, Lester

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

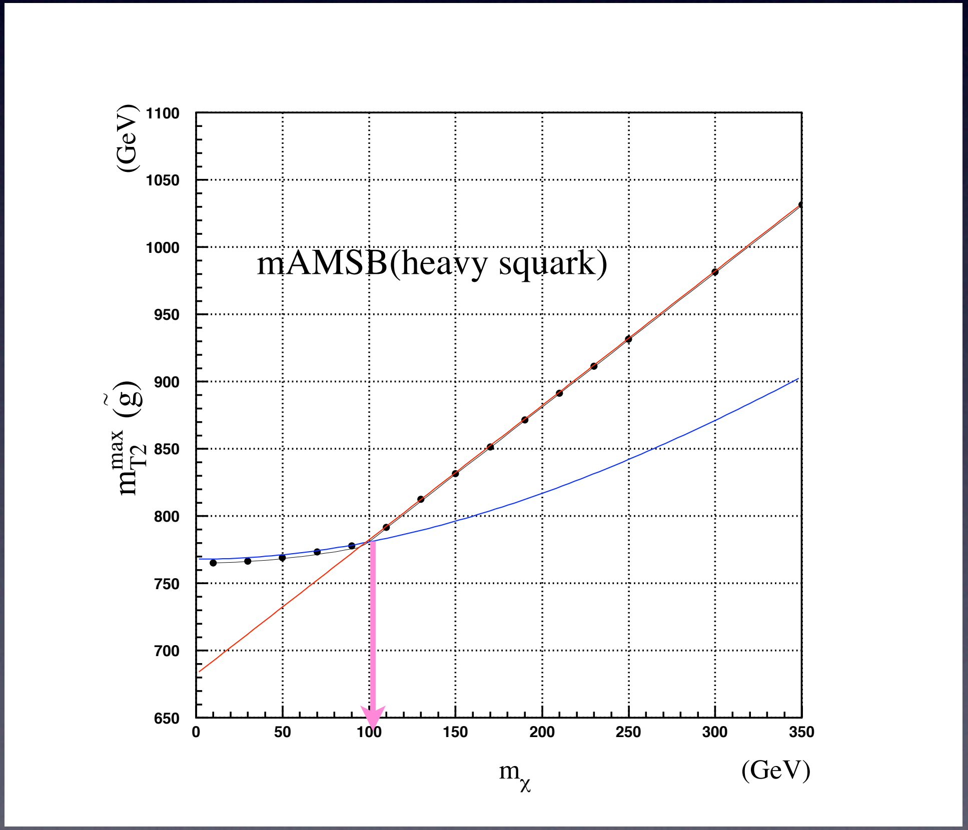
$$m_T^2\left(\mathbf{p}_{Ti}^{\rm vis}, \mathbf{p}_{Ti}^{\rm miss}\right) = (m_i^{\rm vis})^2 + m_\chi^2 + 2\left(E_{Ti}^{\rm vis}E_{Ti}^{\rm miss} - \mathbf{p}_{Ti}^{\rm vis}\cdot\mathbf{p}_{Ti}^{\rm miss}\right)$$

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

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

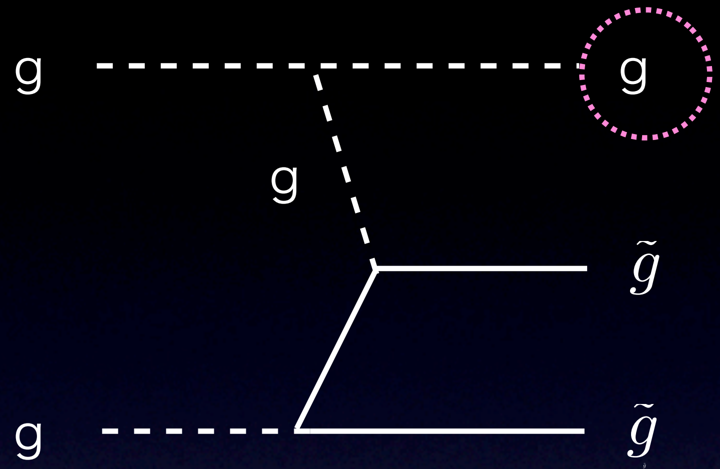
There is a kink at the true LSP mass.

We consider effect on MT2 from an additional ISR jet.

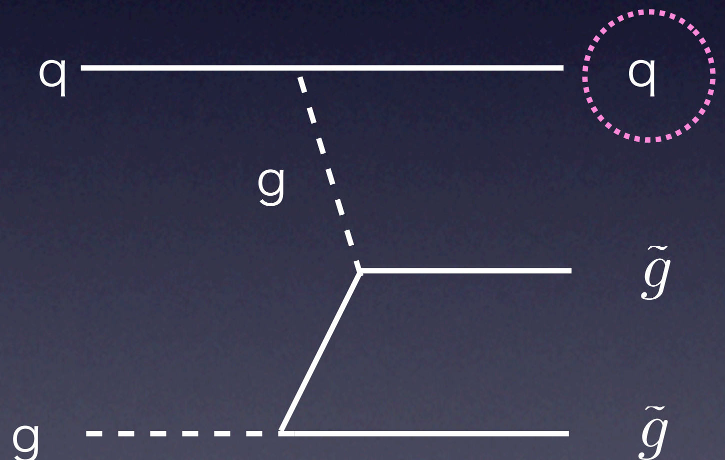


'07 W.Cho, K.Choi, Y.G.Kim, C.B.Park

ISR in gluino production



ISR gluon jet is soft.



Splitting function

$$P_{qq} = C_F \frac{1+z^2}{1-z}, z = \frac{E_q^f}{E_q^i}$$

ISR quark jet is hard and tends to be emitted forward

MC simulation

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

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

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

ME/PS matching

Madgraph/Madevent

Detector simulation AcerDet

Cross section = 2.5 pb

Luminosity = 40/fb

How to define pvis

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

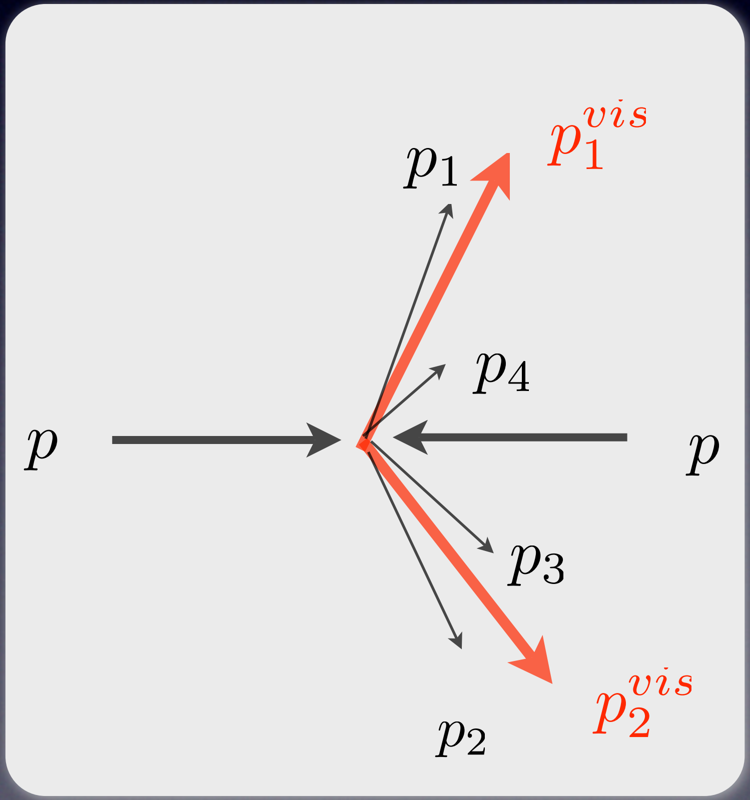
simple example

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

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

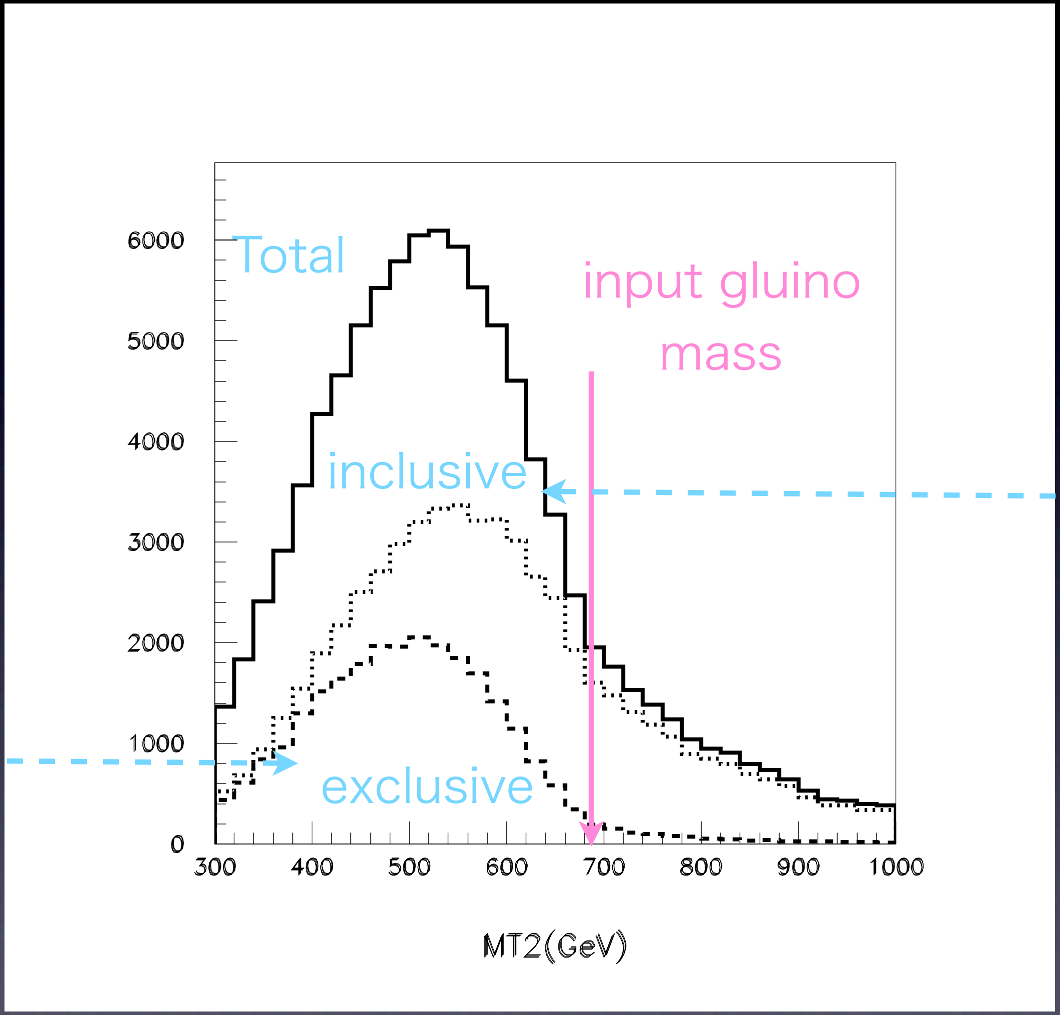
3. Assign p3,p4 to either p1vis or p2vis.

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

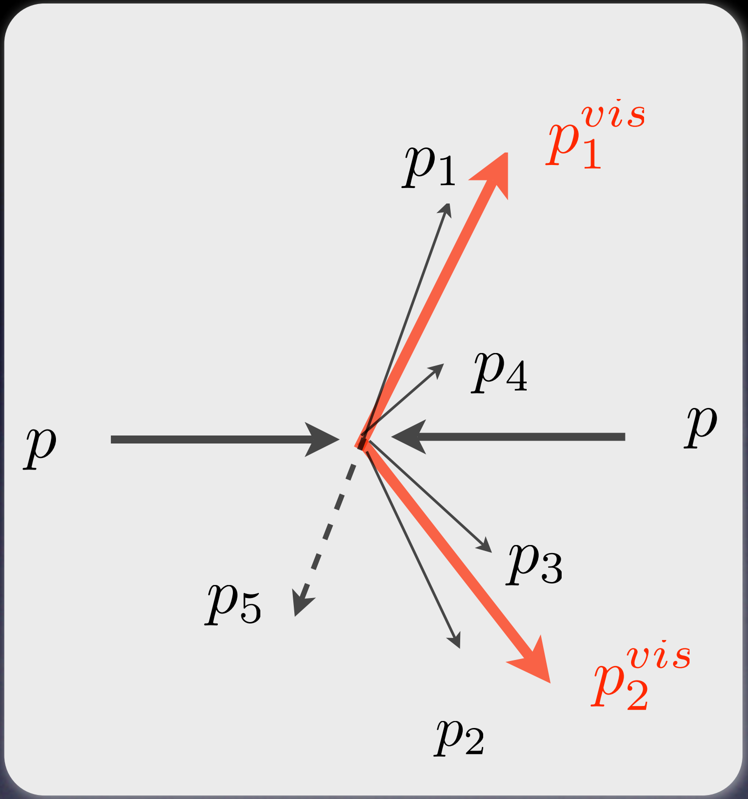
1. Consider 5 (not 4) highest pt jets (p1-p5).

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).

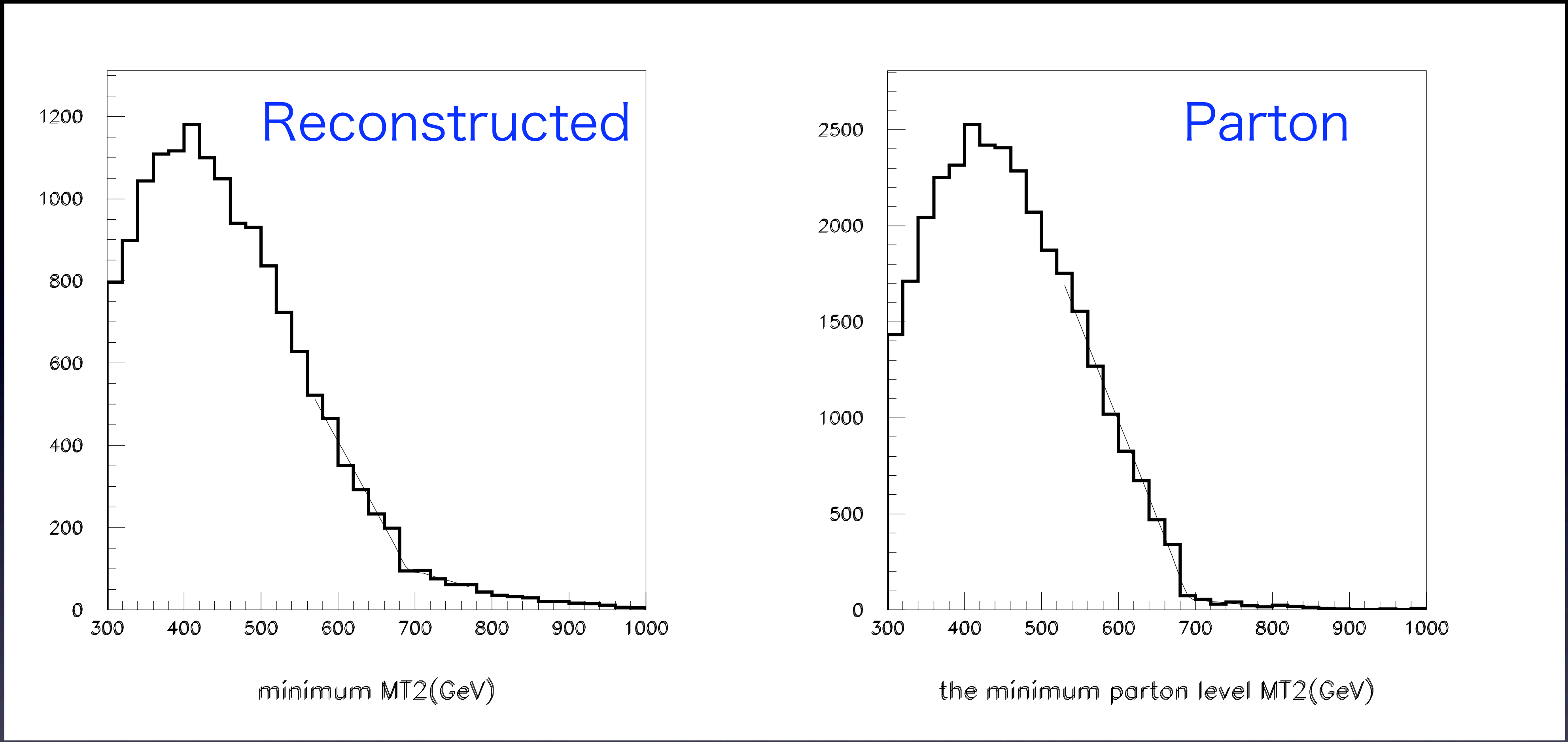
$$M_{T2}^{\min} \equiv \min_{i=1,..5} (M_{T2}(i)).$$



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

MT2min distribution

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



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

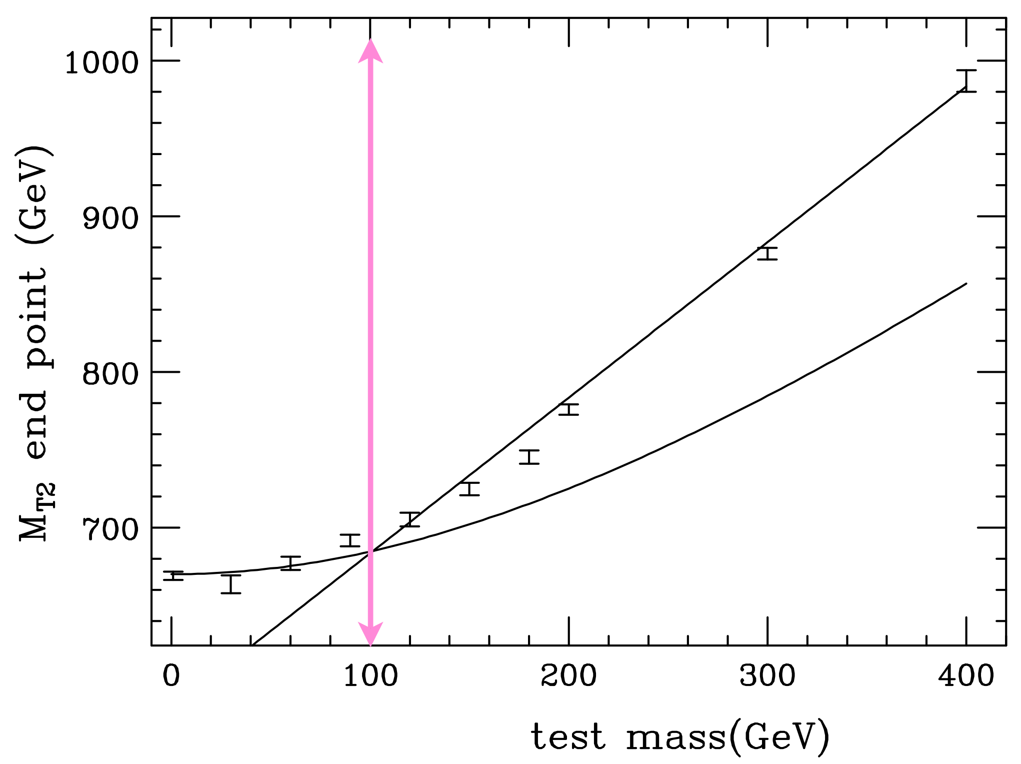
672.7 ± 3.5 GeV

675.4 ± 6.4 GeV $i_{min} \geq 3$

673.9 ± 2.5 GeV

input gluino mass 685 GeV

MT2 end points



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

$$i_{min} \geq 3$$

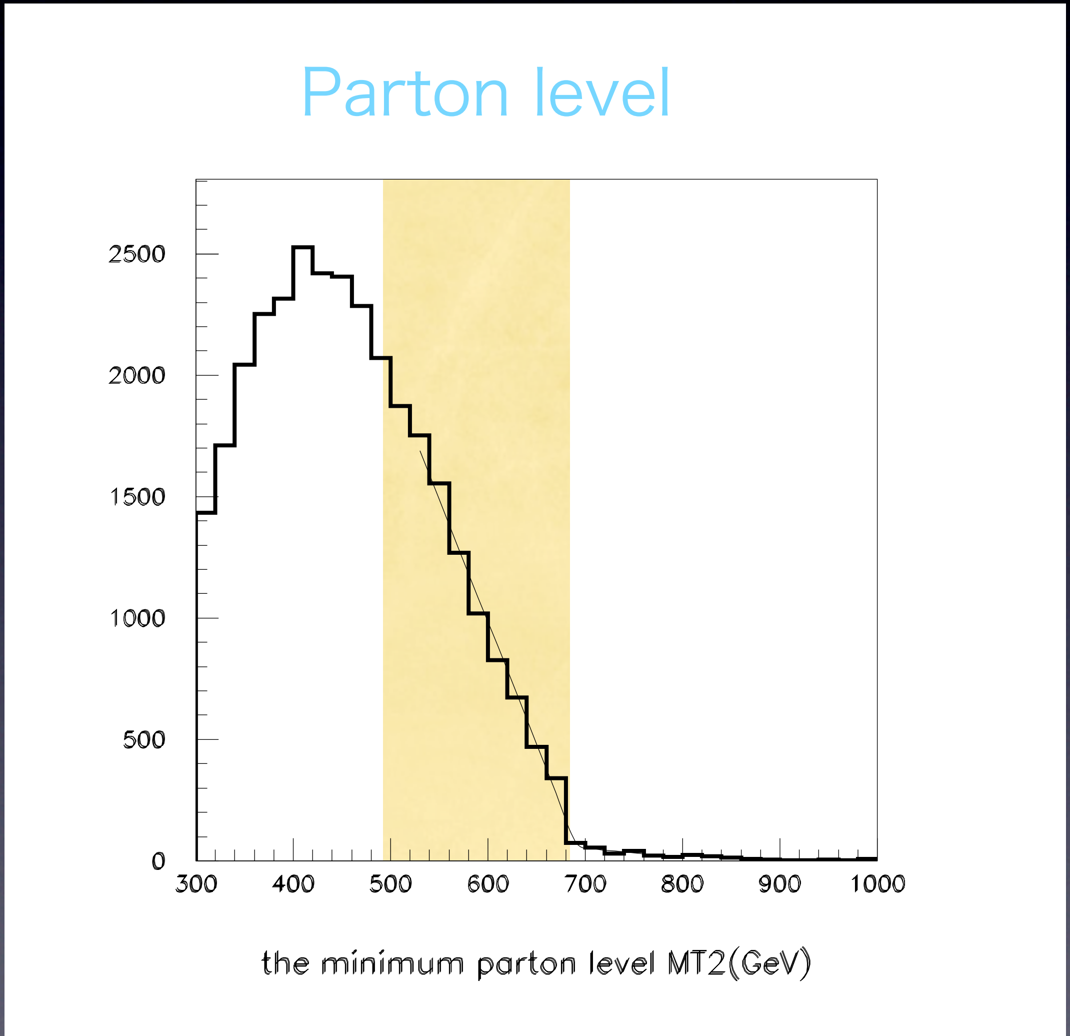
MT2 end points are almost consistent with theoretical predictions.

The removed jet is expected to be from ISR around the MT2min end points.

Probability that removed jet is ISR

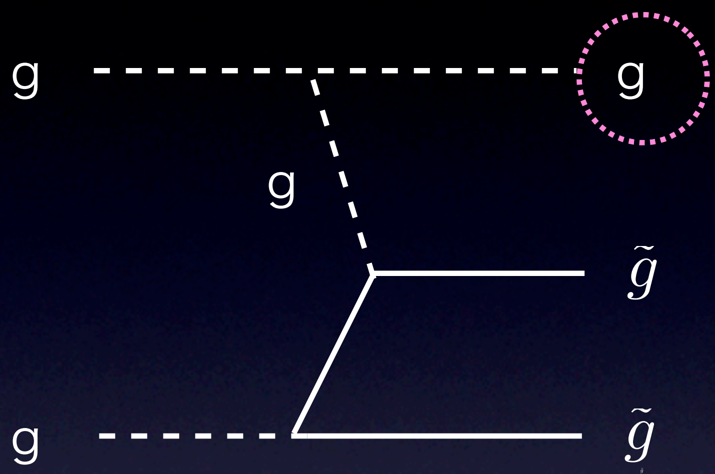
44 % $M_{T2}^{min} \geq 500$ GeV

29 % for all events

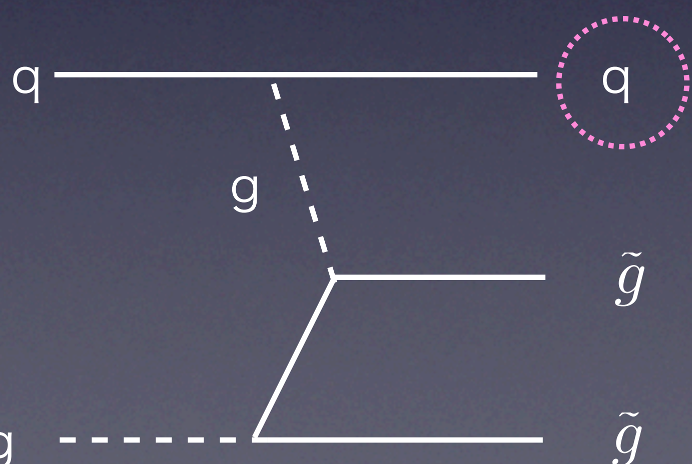


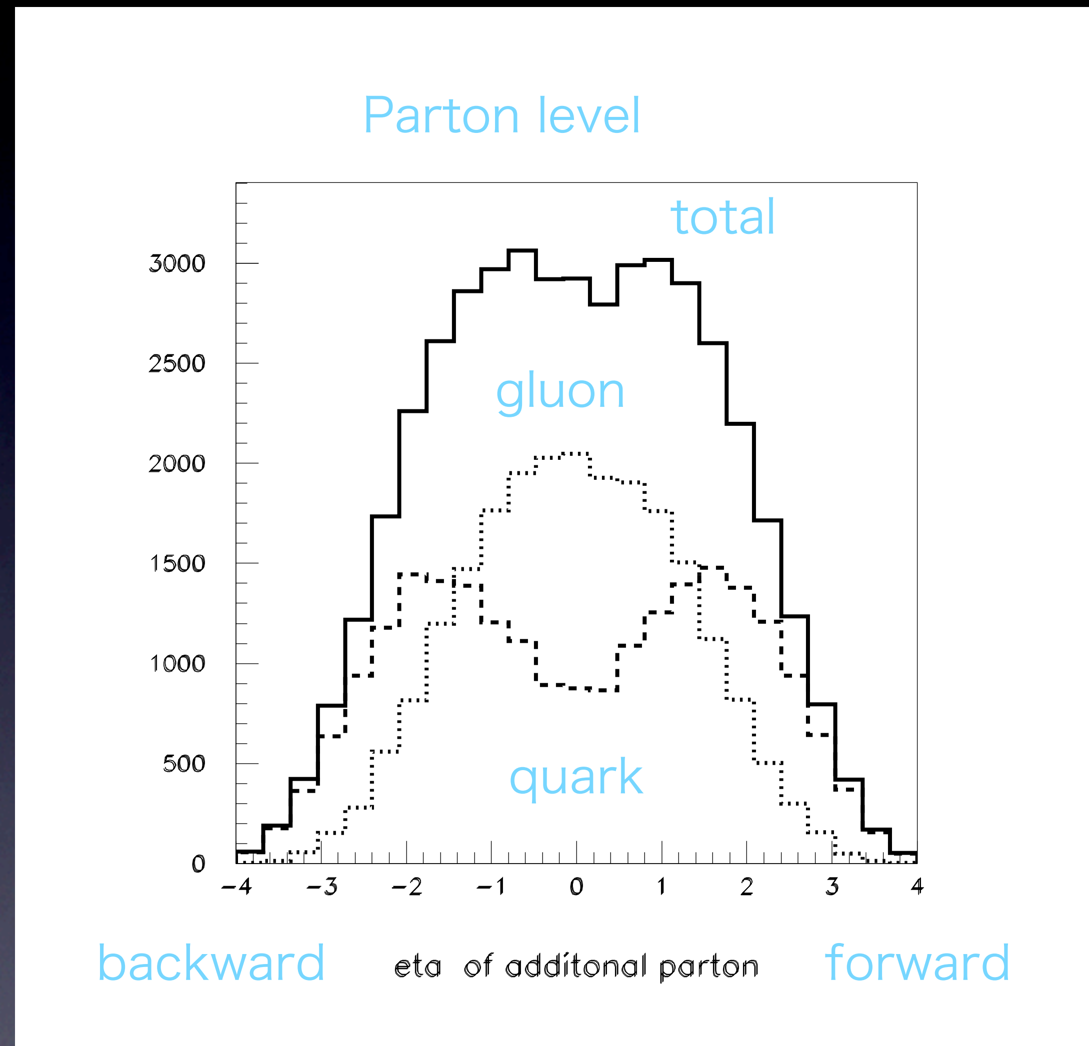
η distribution for ISR jet

central



forward/
backward





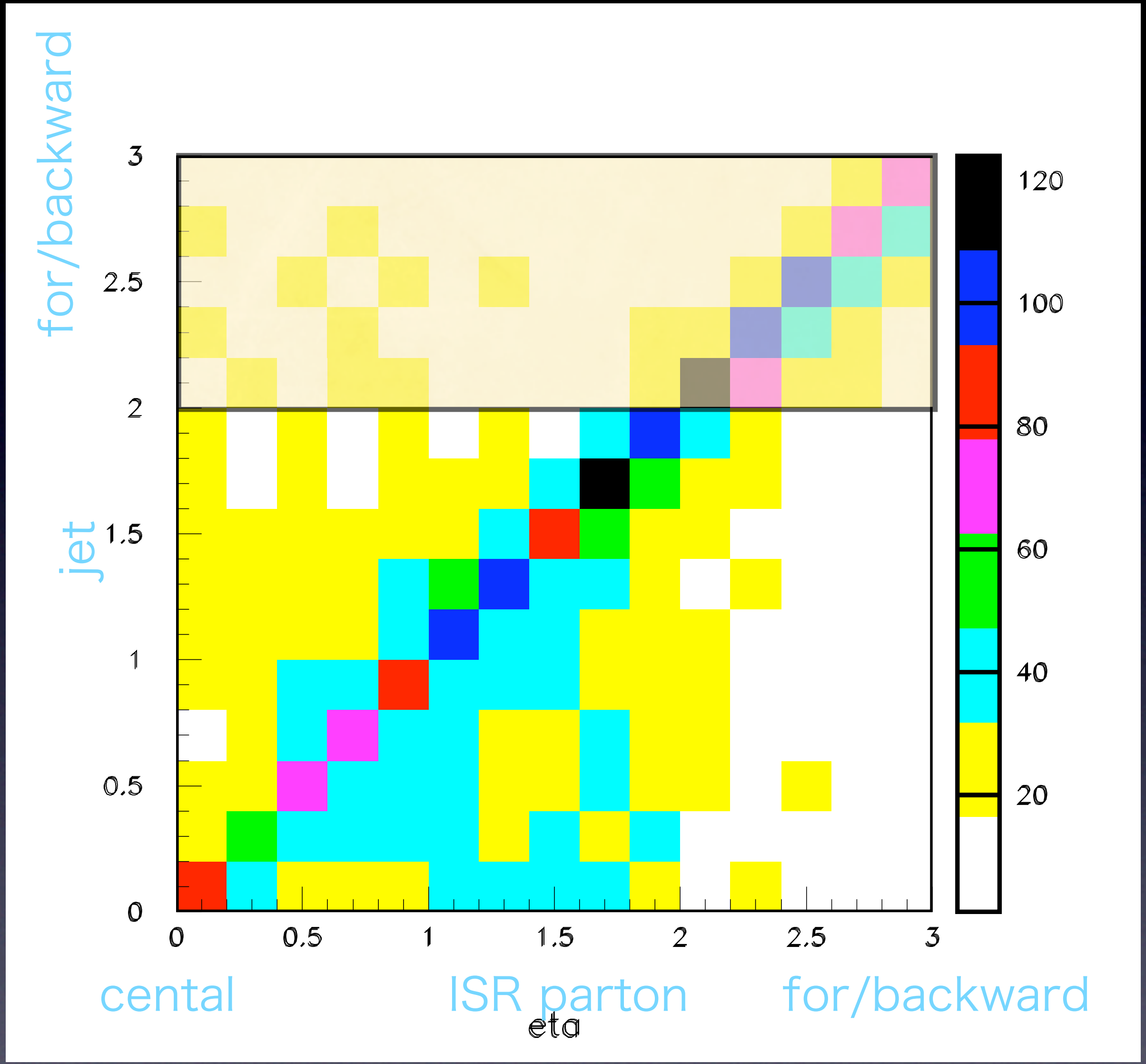
pt>100 GeV

$|\eta|$distribution : ISR parton vs jet that gives MT2min

65 % of the jet that gives MT2min match correctly with ISR parton for |eta|>2.

jets from gluino decay go central

jets from ISR go forward/backward



η cut may be useful to reject ISR jet.

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 clear.