# SUSY related models

Mihoko Nojiri

# in Collider Physics

- Models with Lightest stable particle --connection with dark matter
- Two models  SUSY vs “Same spin partners”
  - Spin dependence
  - Change in dominant channel
- Purpose of this talk: How to look into decay patterns, interactions and masses

# Topics

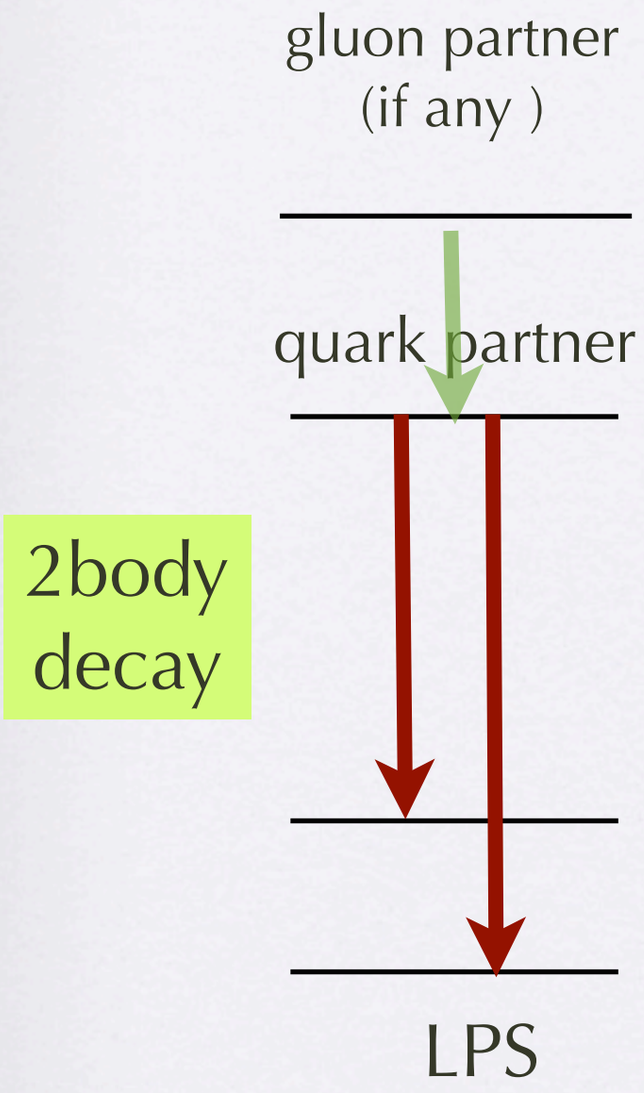
1) mass ordering, mass determination of strongly interacting partners

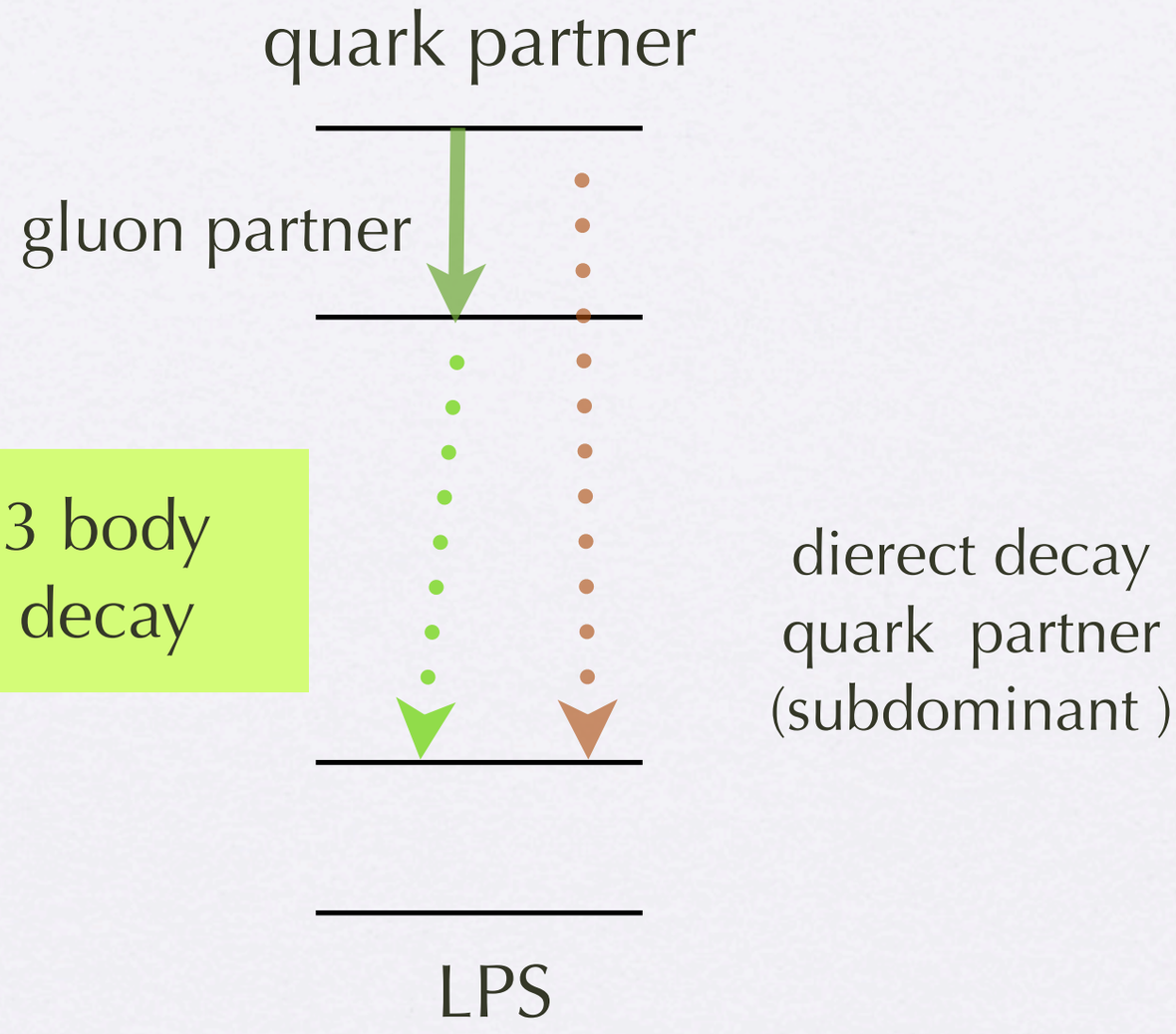
2)spin dependence in 2 jet mode for “same spin partner model”

3) $M_{CT2}$ vs $M_{T2}$ in 2 lepton channel

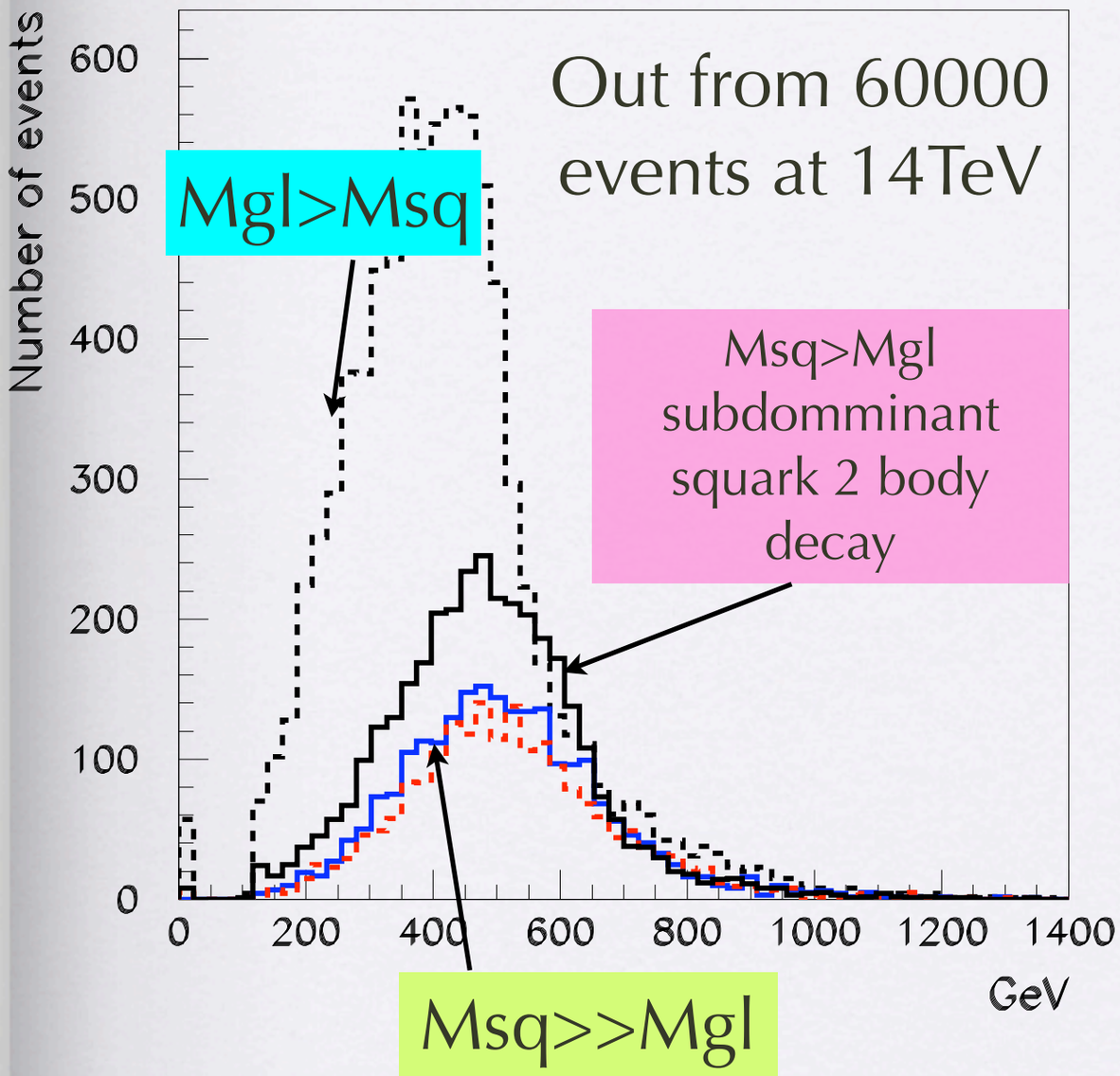
4)Reconstructing masss -- ISR removal

# 1) Decay pattern of the SUSY like model



# Checking mass ordering




- Inclusive MT2 distribution for Mgl~600 GeV
  - divide events into two using Lund distance and calculate MT2 from two visible system
- Selection: Events at least 2 jets with pT>200GeV
- msq<mgl: large branch sharp edge. The mode with 2 high pT jet stands!

Nojiri, Sakurai

# 2) 2 jet mode in the same spin partner models

- Base line model
  - SUSY: |particle spin -partner spin|=0.5
  - Little Higgs model and Universal Extra dimension model (particle spin)=(partner spin)
- Forget about mass constraint of the models (SUSY-MSSM, UED -split type)
- Signals are the “Same” in the first level ‘jets and missing ET
- There are actually big difference which can be seen in early stage..

# A parameter

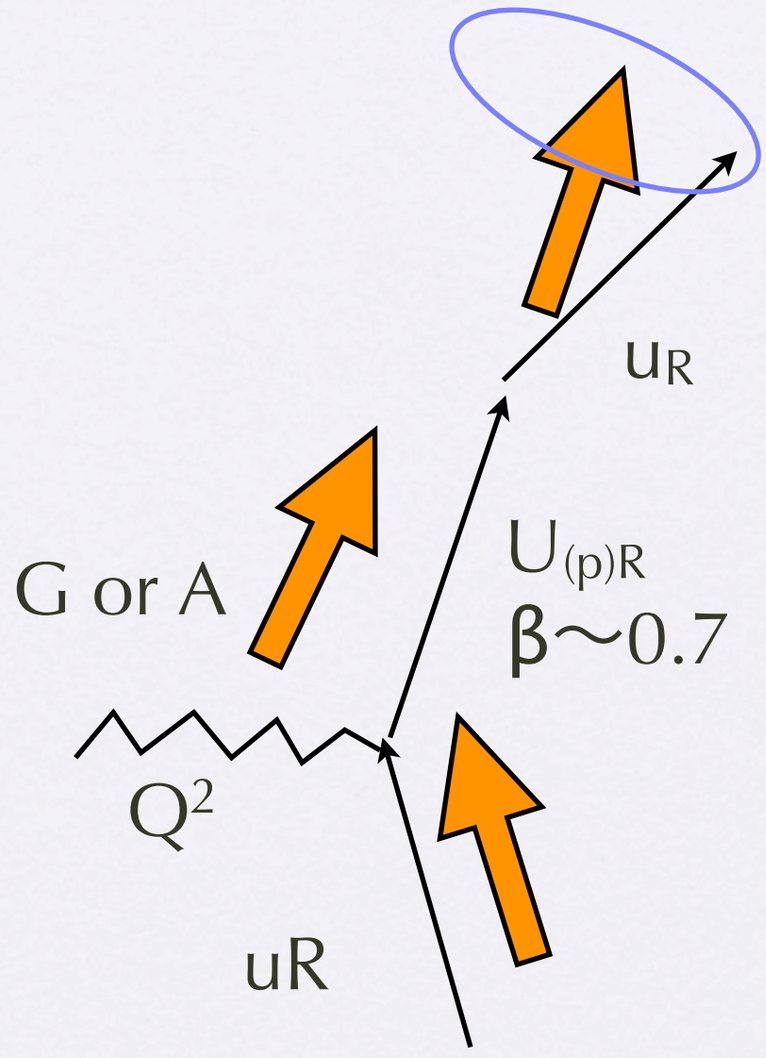
- QCD section $G_{(p)}$: 700 GeV, $Q_{(p)LR}$ :600GeV
- Weak sector $W_{(p)}$:300 GeV $A_{(p)}$:100 GeV
- cross section $\sigma(G_{(p)}G_{(p)}) << \sigma(G_{(p)}\ Q_{(p)}), \sigma(Q_{(p)}Q_{(p)})$ Madgraph --Jing Nojiri in progress

| | $G_{(p)}G_{(p)}$ | $Q_{(p)R}G_{(p)}$ including antiparticle | $Q_{(pR)}Q_{(pR)}$ (including antiparticle) | $Q_{(pR)}Q_{(pR)}$ (particle only ) | URUR(gluon exchnage only ) |
|---|---|---|---|---|---|
| This model | 0.6pb | 1.9pb | 5.8pb | 5pb | 0.7pb |
| A:200GeV | | | 2.7pb | 2.2pb | |

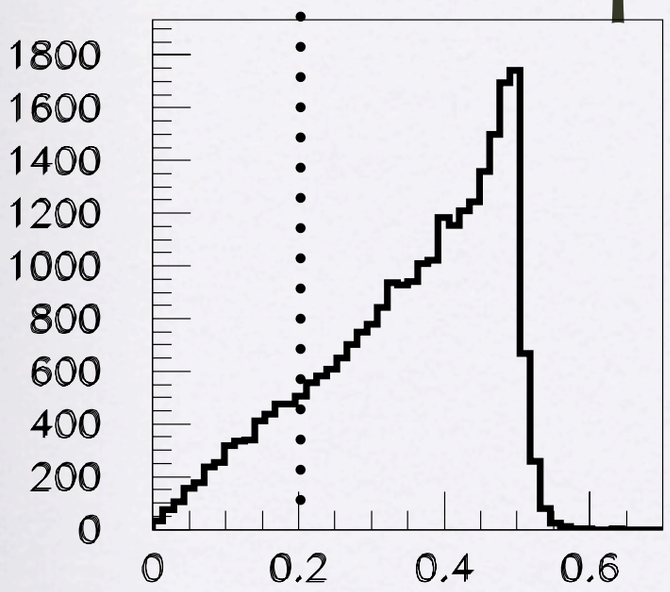
dominant in SUSY

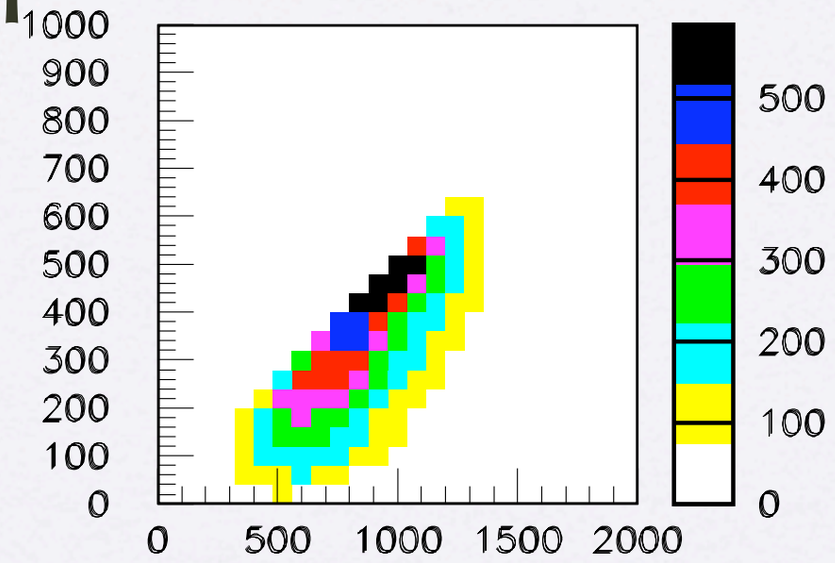
# The difference in spin

- SUSY: scalar partner decays spherically
- production and decay processes are chiral
  - 2jet + missing for $Q_RQ_R$ production
- The lightest vector partners from decay is h~0 if $m_Q >> m_A$. The final state q goes in the direction of parent spin of Q .
- $Q_R$ polarization depends on $m_A$ strongly though T channel exchange of gauge boson.

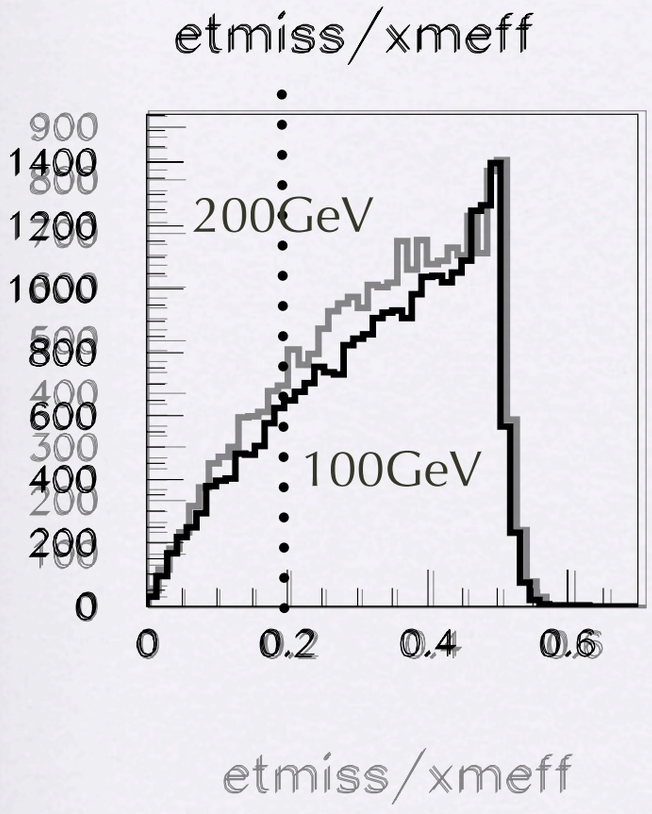


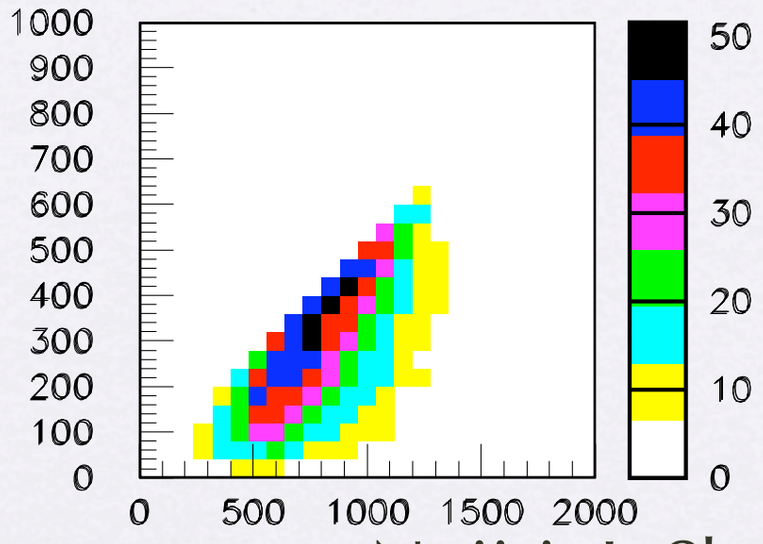
# The jet level distribution for $pp \rightarrow U_R U_R$ channel




No spin
(Madgraph 2 by 2
→pythia/bridge )




Madgraph
2 by 4
(and Herwig)

Nojiri, J. Shu.. work in progress

# Lessons and some info

- No “phase space decay” for leading objects :Non-polarized decay fails to reproduce physics processes even in such simple case.

- “Consistent treatment” Production in T channel and decay are correlated.

- Madgraph (till final decay) works. Herwig (though I have not tried for the case) must be fine.

- Madgraph (up to pp→ Q(p) Q(p) ) →Pythia or Bridge fails to reproduce the correct distribution. ( I am not sure if I treated Bridge correctly. )

# 3)a new kinematical object

## $M_{CT2}$ vs $M_{T2}$ with upstream momentum

Mass determination

Using cascade in one side: invariant mass distribution

Using both of the decay chain :

inv under z boost $M_{T2}$

inv under contra boost $M_{CT2}$

New variable help to determine chargino mass

# Upstream momentum dependence of $M_{CT2}$ and $M_{T2}$(ISR)

- Definition

$$M_{CT2}(\chi) = \min_{k_{1T}+k_{2T}=\not{E}_T} \left[\max\{M_{CT}^{(1)}, M_{CT}^{(2)}\}\right]$$

$$M_{CT}^{(1)}(\chi)^2 = \chi^2 + 2(|\alpha_T| e_1 + \alpha_T \cdot k_{1T}),$$

test mass

test energy and momentum

- upstream momentum dependence of the end point

$$M_{CT2}^{max2} = 2\chi^2 + |\bar{\delta}_T|^2 \quad \text{for } \chi \le \chi_* \qquad (4)$$

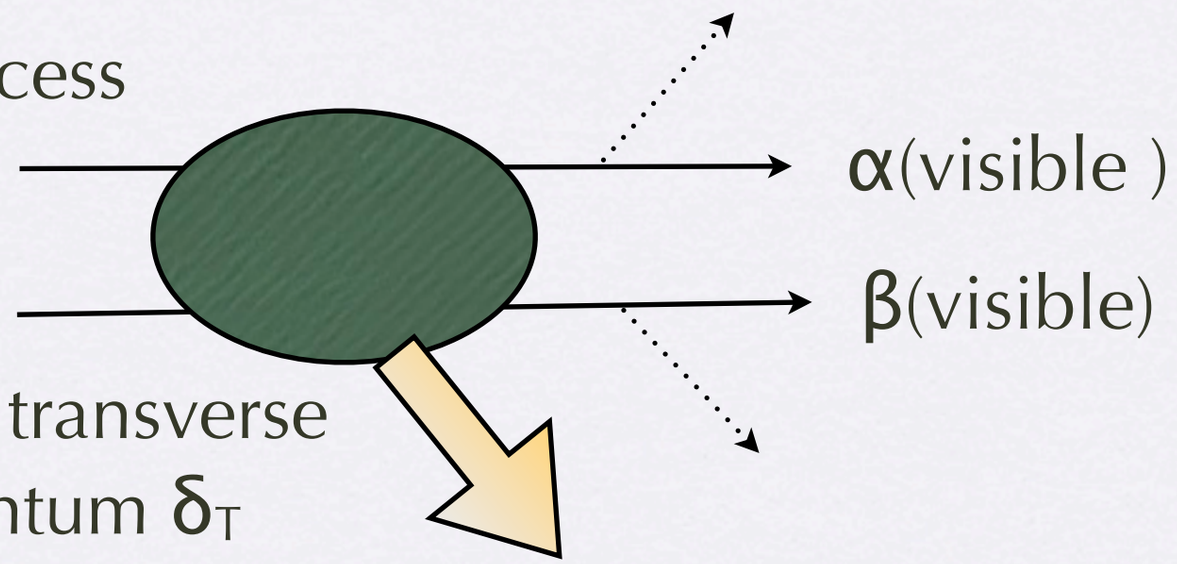
$$= \chi^2 + 2\alpha(|\bar{\delta}_T| - \alpha) + 2\alpha\sqrt{\chi^2 + (|\bar{\delta}_T| - \alpha)^2} \quad \text{for } \chi \ge \chi_* \qquad (5)$$

$$\alpha_0 = \frac{m_Y^2 - m_X^2}{2m_Y} \text{ (MT2)}$$

$$\alpha = |\alpha_0|(\frac{|\bar{\delta}_T|}{m_Y} + \frac{E_Y}{m_Y})$$

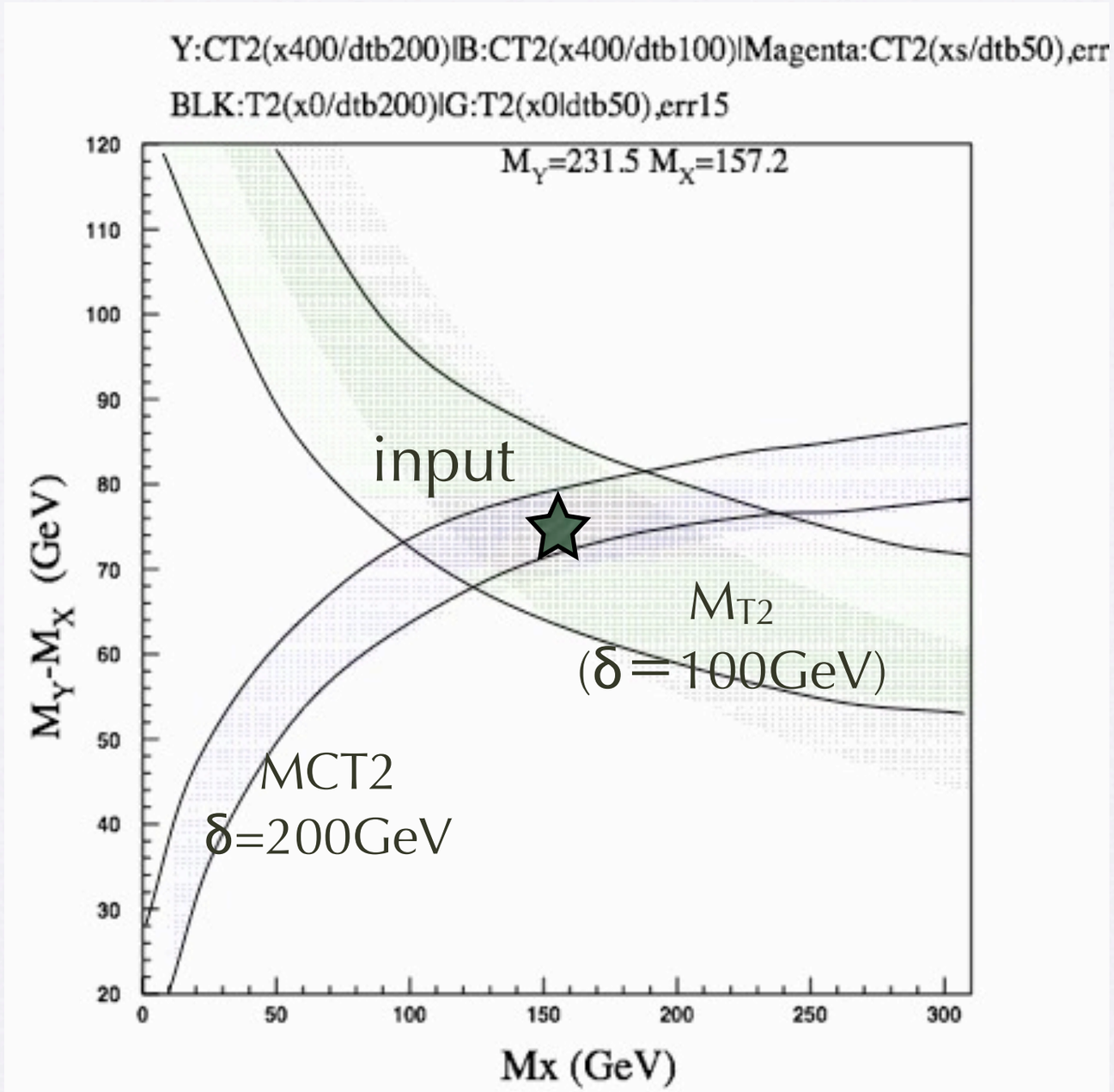
- sharp end point for the process

$$\tilde{\chi}_1^{\pm} \to \tilde{\nu} + \ell^{\pm}$$



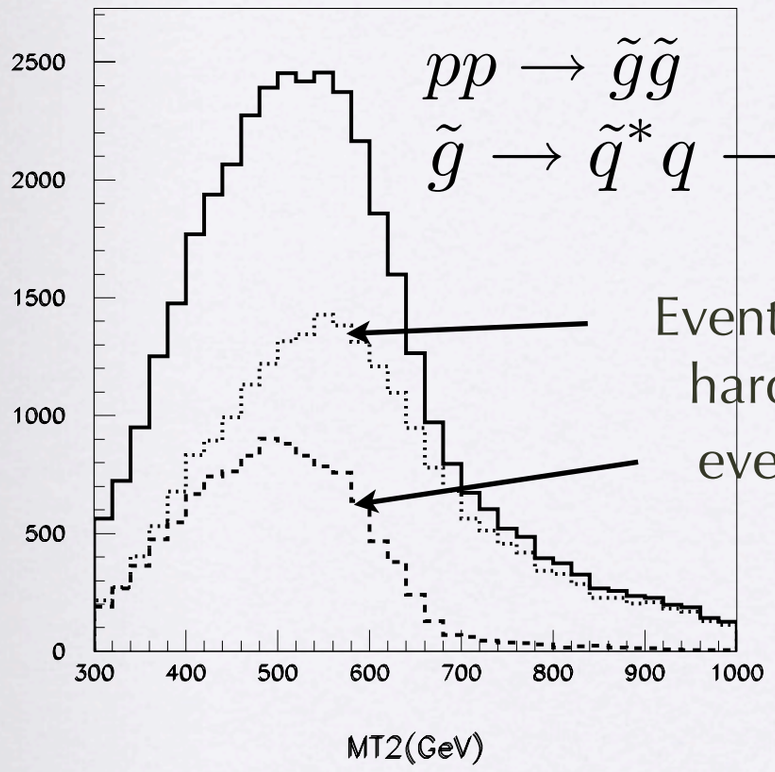
# chargino →sneutrino

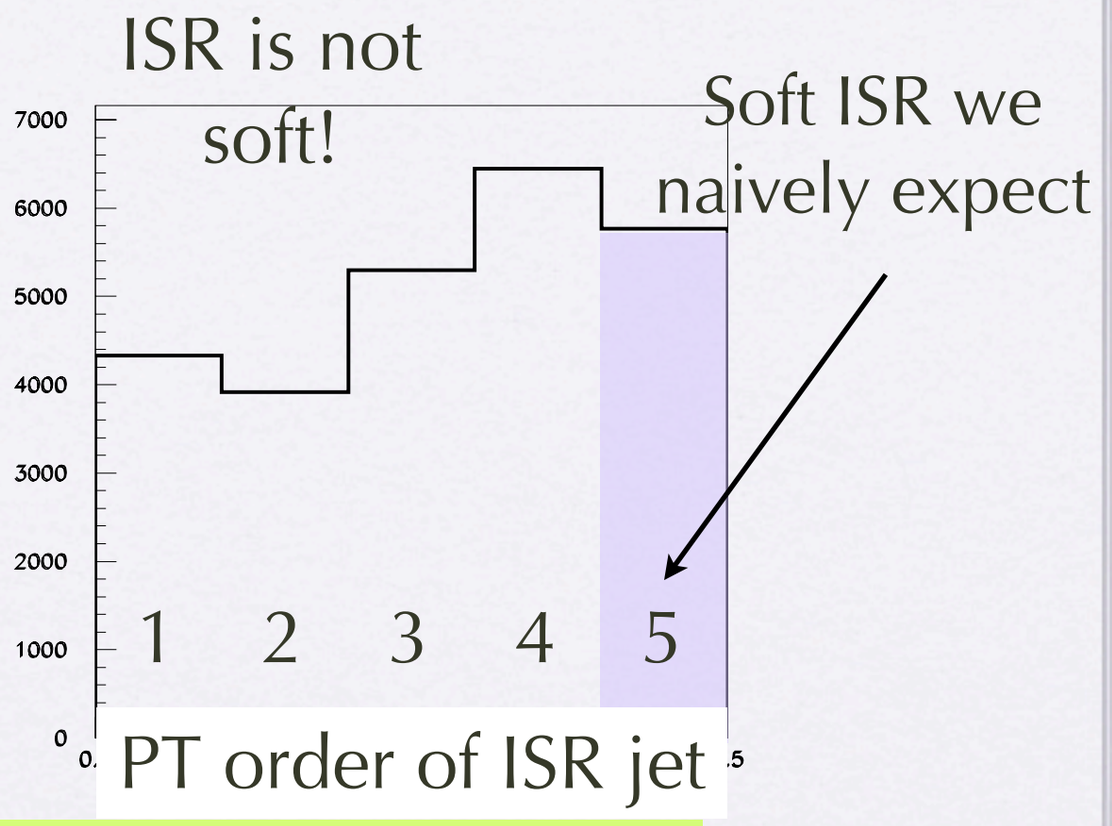
- 2 leptons +missing +upstream activities
- upstream momentum dependence of $M_{T2}$ and $M_{CT2}$ is opposite
  - $M_{CT2}$ has stronger dependence on δ
- chargino and sneutrino masses can be determined by using



# 4) The other source of jets :ISR

Alwall, Hiramatsu, Nojiri, Shimizu (2009)

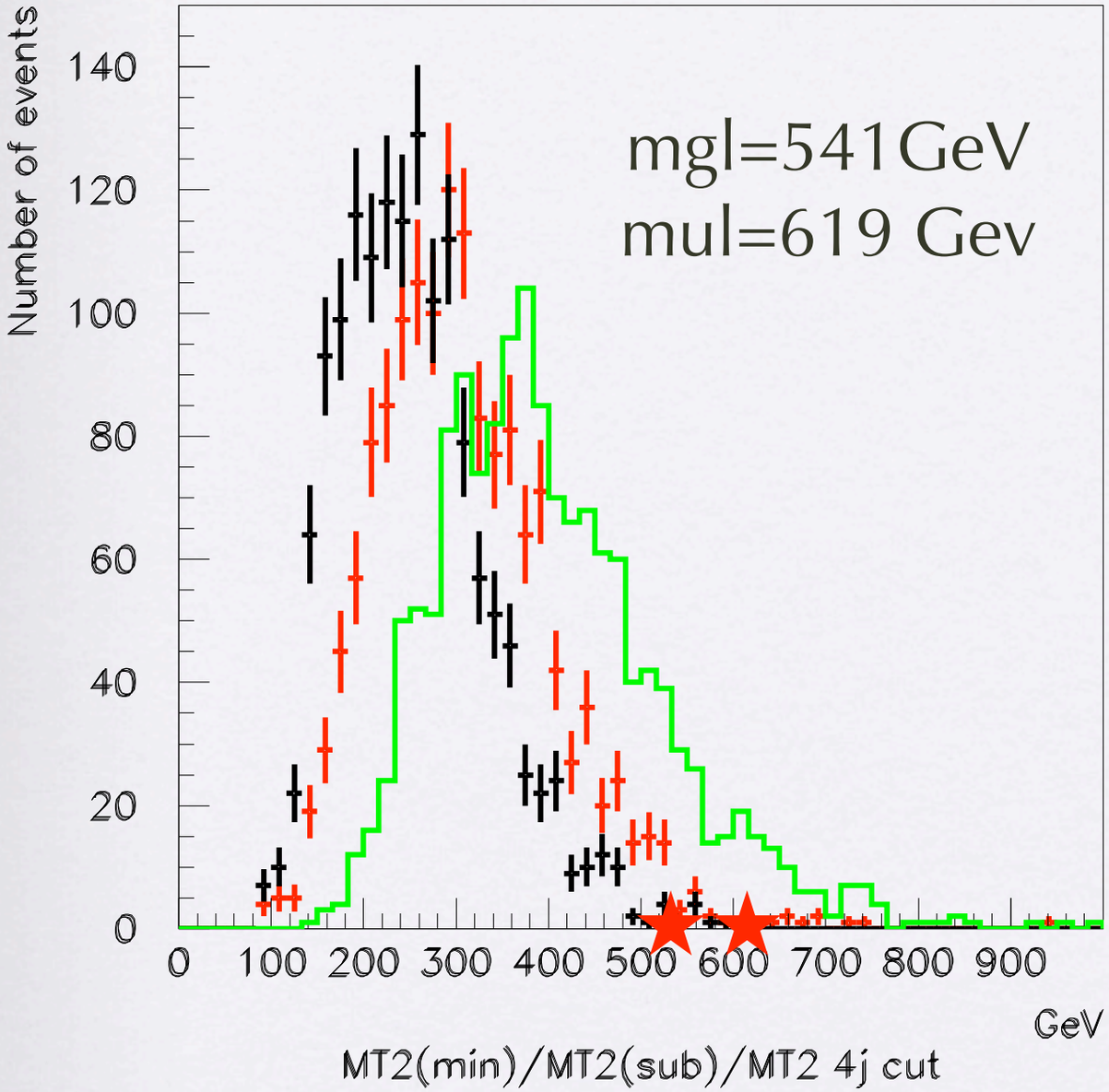



**"general rule to remember"**
**for large hierarchy case**

pT (jets from 2 body quark partner decay)
>> PT (ISR)
>> PT (3 body gluon partner decay)
>> other cascade decay

# Removing ISR in inclusive $M_{T2}$




†: minimizing MT2 after removing i-th jet (i=1~5)

†: minimizing MT2 after removing i-th jet (i=3~5 )
(assume two highest pt jet comes from squark-> chi q decay)

green line : Inclusive MT2

Nojiri, Sakurai arXive 1008.1813

★ True squark/gluino mass

sqrt(s)=7TeV L=1fb$^{-1}$