Study of $\tilde{t}$ and $\tilde{b}$ at LHC

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in collaboration with

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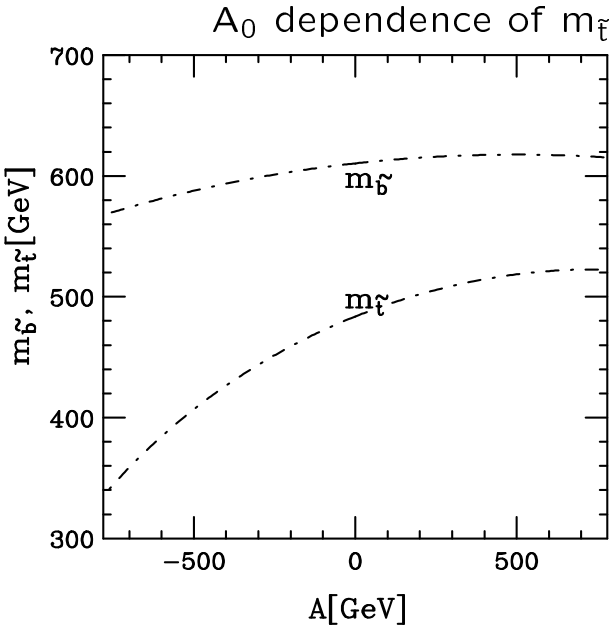
$\tilde{t}$ and $\tilde{b}$ are key particle to understand SUSY Phenomenology

- Yukawa effect
  mass, $\tilde{t}_L - \tilde{t}_R$ mixing effect and Yukawa effect in the decay Br

- non-universal supersymmetric model

- Radiative correction to
  the higgs mass $\tilde{t}$, $\mathbf{A_t}$

- **Flavor Physics**
  $\mathbf{Br(b \to s\gamma)}$....



Role of LHC? LC?

Major Decay Chains

Reconstruction of $\tilde{g} \to tbX$ including

"Edge Modes" (subsequent two body decay)

$\tilde{g} \to \tilde{t}t$
$\quad \hookrightarrow b\tilde{\chi}^{\pm}$
$\tilde{g} \to \tilde{b}b$
$\quad \hookrightarrow t\tilde{\chi}^{\pm}$
$\tilde{g} \to \tilde{b}b$
$\quad \hookrightarrow \tilde{t}W$
$\quad\quad \hookrightarrow b\tilde{\chi}^{\pm}$

$\mathbf{M_{tb}}$ **the end point of the** m_{tb} **distribution** (combination of $\mathbf{m_{\tilde{g}}, m_{\tilde{b}}, m_{\tilde{t}}}$....)

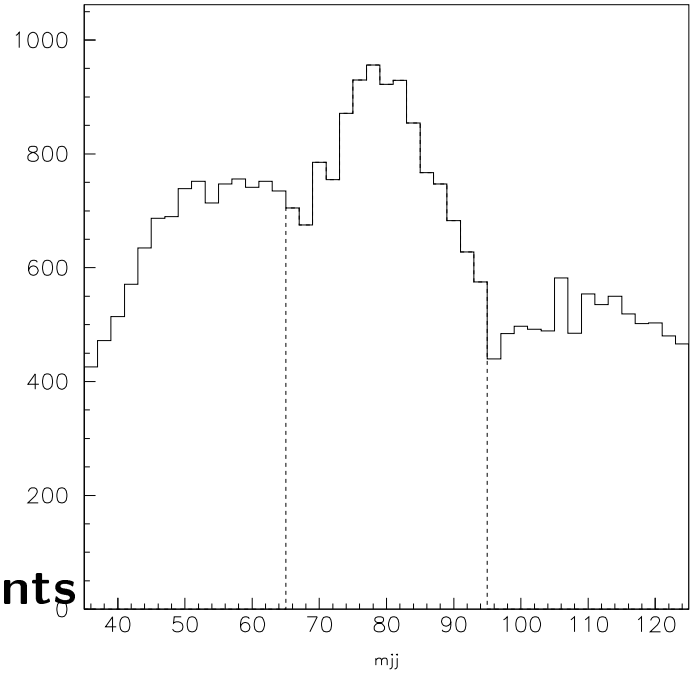
Edge heights: $\to \frac{Br(\tilde{g} \to \text{edge modes})}{Br(\tilde{g} \to bbX)}$

OUTCOME
MSUGRA parameter
m_0, M, $\tan\beta$, $\mathbf{A_0}$,

Model independent study

$$\begin{pmatrix} m^2_{\tilde{t}_L} & m_t(A_t + \mu \text{ct}\beta) \\ m_t(A_t + \mu \text{ct}\beta) & m^2_{\tilde{t}_R} \end{pmatrix}$$

$t \to bjj$ Reconstruction



- m_{jj} in **W mass region** (I)

  $n_{bjet} = 2$

  $|m_{jj} - m_W| < 15$ GeV

  $|m_{bjj} - m_t|$GeV < 30 GeV

  (+ additional cuts like M_{eff},

  p_T miss, number of jets...)

- m_{jj} in **non-W region**(II) and (III)

for estimation of mis-reconstructed events

$|m_{jj} - (m_W \pm 30\text{GeV})| < 15$ GeV

$\to$ momentum rescale to W mass region

$|m_{bjj}(\text{rescaled}) - 175\text{GeV}| < 30$ GeV

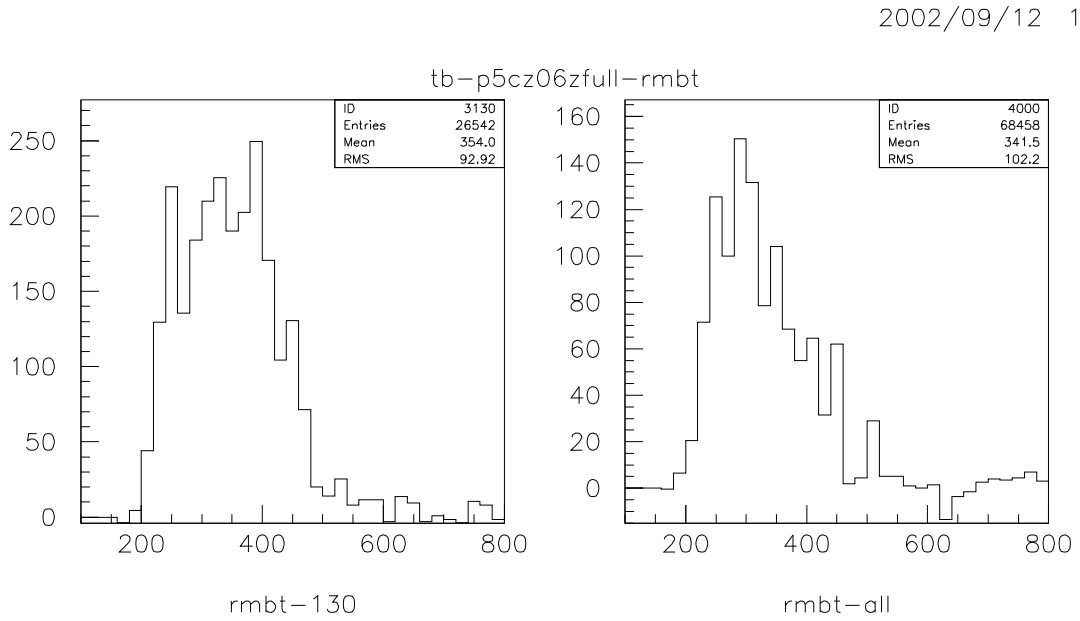
$\to$ SIDE BAND SUBTRACTION

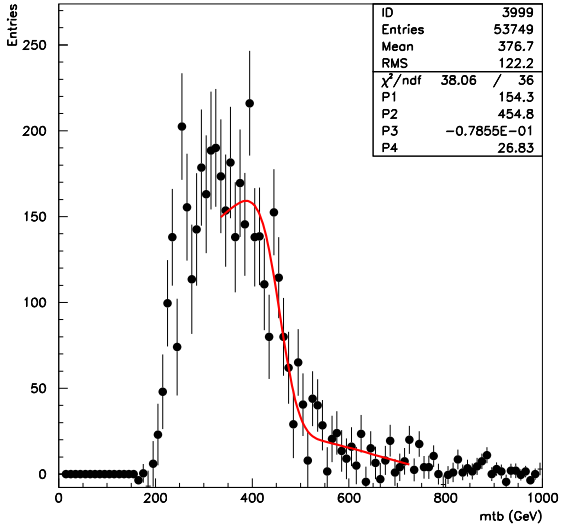
to reconstruct parton level distribution

$$\text{SIGNAL} = (\text{I}) - \frac{[(\text{II}) + (\text{III})]}{2} \qquad (1)$$

The $\mathbf{m_{tb}}$ Distributions after Side Band Subtraction

$\tilde{g} \to (\tilde{b}, \tilde{t}) \to tb\tilde{\chi}_1^+$ **Other gluino decay** **Fit to all tb events**

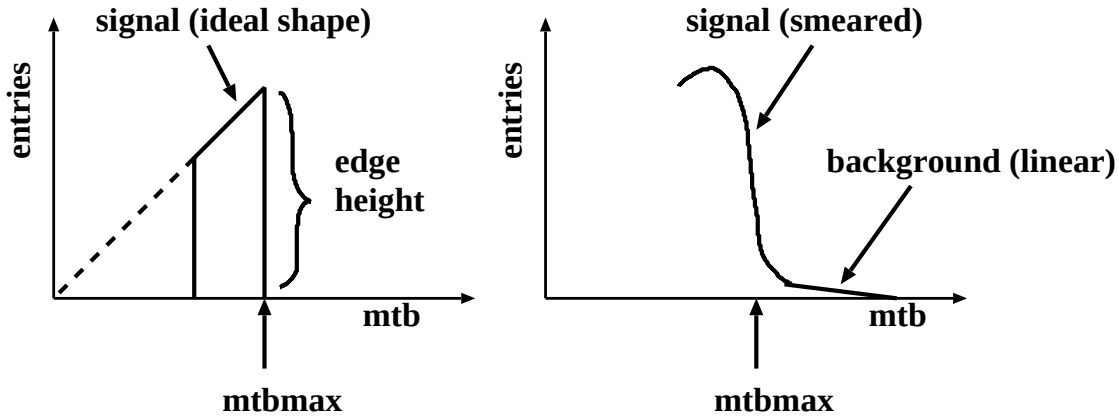




(M_{tb} = 454.8±7.7 GeV, True 459 GeV)

The "edge mode" dominates near the end point

good?



two end points $\longrightarrow$ Weighted end point

$$M_{tb}(\tilde{t}) = M_{tb}(\tilde{g} \to \tilde{t}t \to tb\tilde{\chi}^{+})$$
$$M_{tb}(\tilde{b}) = M_{tb}(\tilde{g} \to \tilde{b}b \to tb\tilde{\chi}^{+})$$

$$M^{w}_{tb} = \frac{M_{tb}(\tilde{t})Br(\tilde{g} \to \tilde{t} \to \tilde{\chi}^{+}) + M_{tb}(\tilde{b})Br(\tilde{g} \to \tilde{b} \to \tilde{\chi}^{+})}{Br(\tilde{g} \to \tilde{t} \to tb\tilde{\chi}^{+}) + Br(\tilde{g} \to \tilde{b} \to tb\tilde{\chi}^{+})} \quad (2)$$

height

$$\text{Estimated Number of events} = \left(\frac{1}{2}\right)(\text{height})\frac{(M^{w}_{tb})^2 - m_t^2}{(\text{bin width})^2} \quad (3)$$

"End Point" fit (14 different point is studied by Pythia and Herwig)

Point studied....

- MSUGRA point with

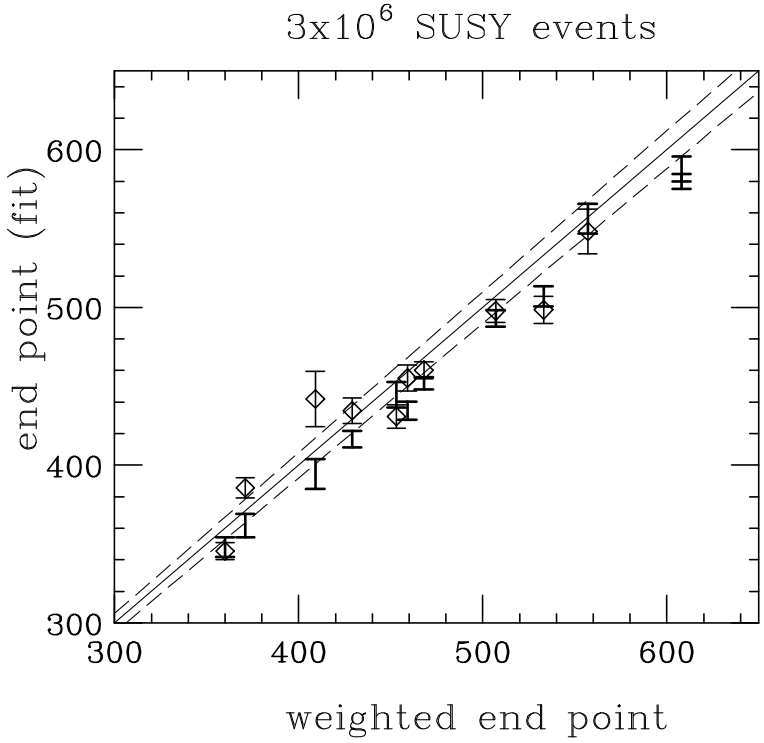
$m = 100$ GeV $M = 300$ GeV

with $A_0 = 300, -300$GeV

modification: non MSUGRA stop sector

modification: increased gluino mass

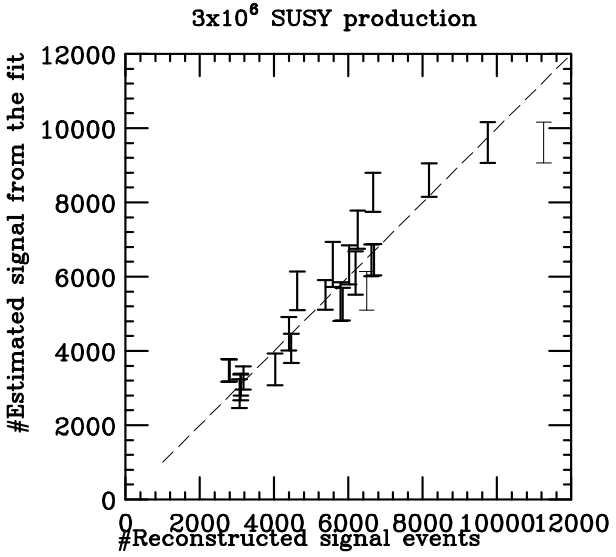
- MSUGRA point from hep-ph
- $\tilde{g} \to \tilde{t}_1$ 100 % (2 cases)
- "higgsino like LSP" " wino like LSP"



No systematics found. $\pm 5 \sim 8$ GeV
for 3×10^6 SUSY events and Br($\tilde{g} \to \tilde{t}, \tilde{b}$) $> 10\%$

N(events) estimation

No systematics for
N(Reconstructed) vs N(Estimated)



However, N(Reconstructed) depends on **generators** (Herwig vs. Pythia) & **jet definition** ("jet cone" or K_T)

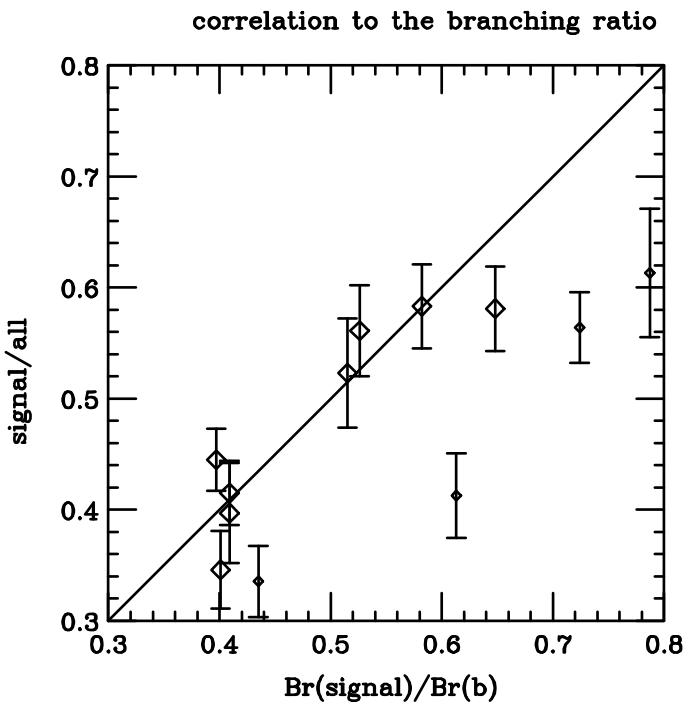
MC	kt/jc	R	signal before subtraction	signal after subtraction
py	jc	0.4	9695	2462
	kt	0.5	8607	2808
hw	jc	0.4	10180	2949
	kt	0.5	9118	3239

N(before) 5% difference
N(after) 20% difference
(for mode $\tilde{g} \to \tilde{t} \to \tilde{\chi}^+$)

Br estimation

- **very good correlation between**

N(edge)/N(all tb) vs
Br(edge mode)/Br($\tilde{g} \to bbX$)
if $\tilde{q}\tilde{g}$ production dominates
$\leftrightarrow$ mostly 2 b



- **No generator dependence found**

Does not work if

- $\tilde{q} \to \tilde{g}$

$\to$ 4b signal

- If $m_{\tilde{t}} \ll m_{\tilde{g}}$:

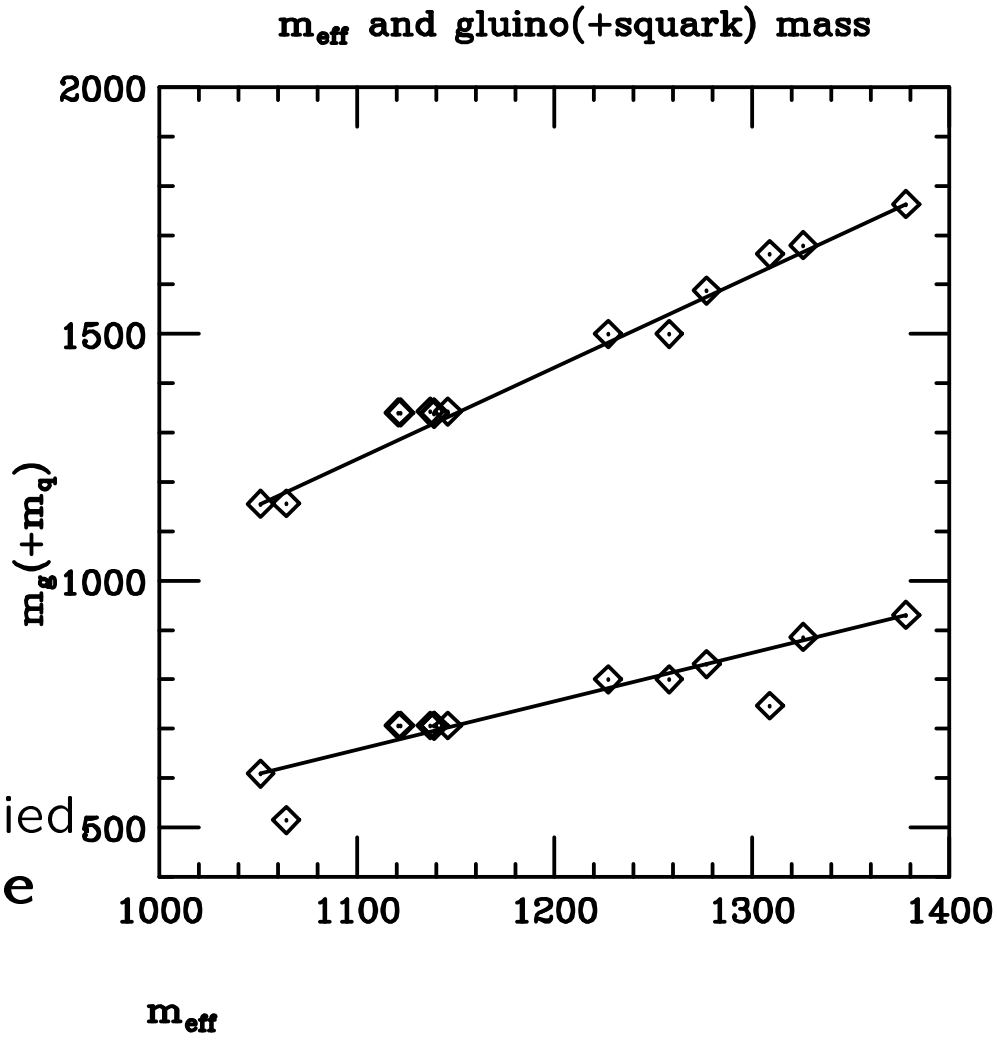
stop pair production significant.

$M_{eff}(\equiv \sum P_{Tj})$ analysis

upper line:
peak of $\mathbf{M_{eff}} \propto \mathbf{m_{\tilde{q}}} + \mathbf{m_{\tilde{g}}}$
for events with selected tb

bottom line:
peak of $\mathbf{M_{eff}}$ does not
correlated to $m_{\tilde{g}}$
if $m_{\tilde{q}} \gg m_{\tilde{g}}$

systematical error is within
4%for the parameter we tried
No generator dependence



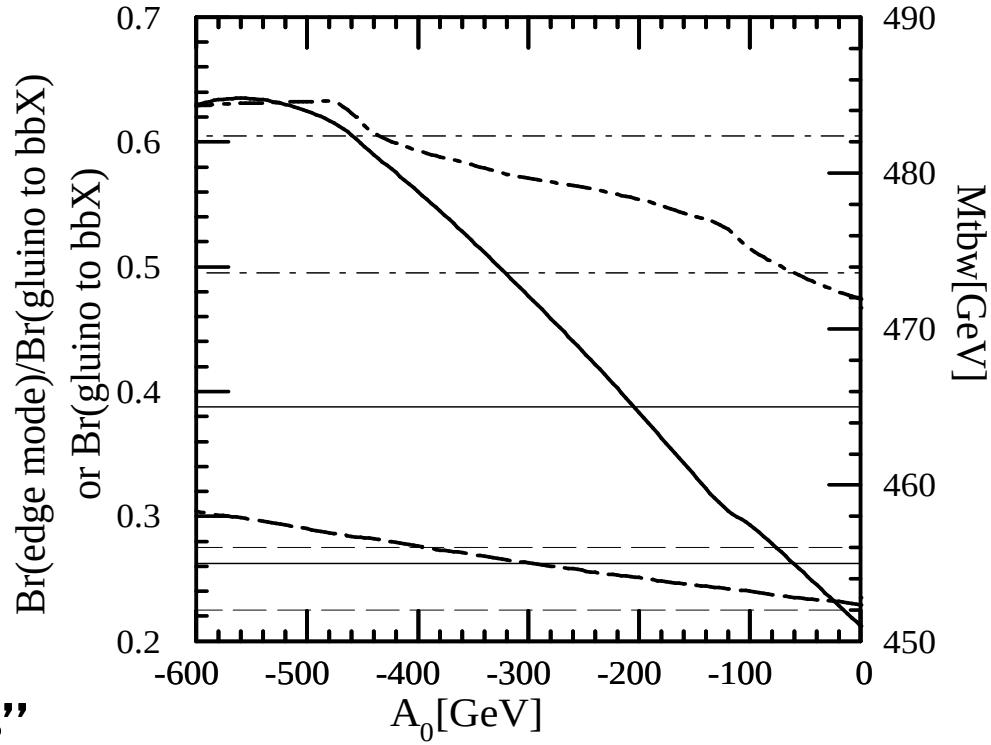
A_0 dependence in MSUGRA

m = 230 GeV
M = 300 GeV
$\tan\beta = 0$(fixed)
L $\sim 100 fb^{-1}$

M^{w}_{tb} end point
$\rightarrow \delta A_0 \sim 50$ GeV

Br(edge mode)/Br($\tilde{g} \rightarrow$ bbX)
N(all tb)

10 % systematics is shown

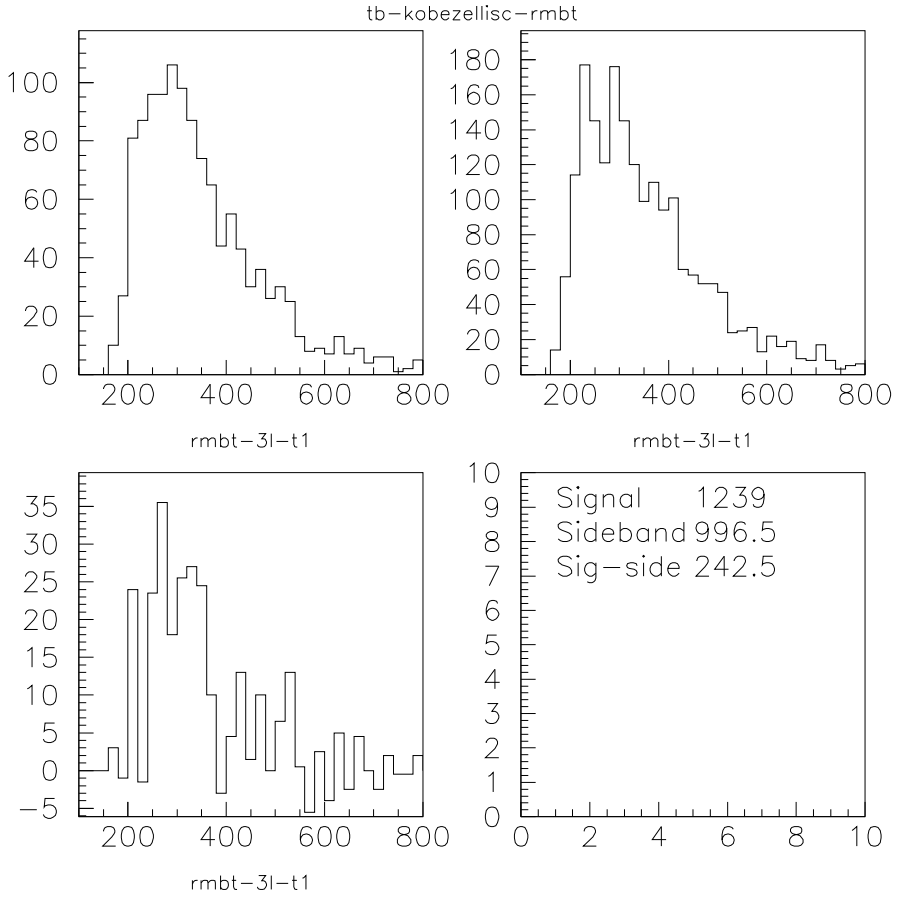


"consistency of observables"

$\rightarrow$ model independent tag

Other applications

1)$\tilde{g} \to t\tilde{t} \to tt\tilde{\chi}_i^0$
Similar selection.
tb final state contaminates
Require additional leptons
from $\tilde{\chi}_2^0 \to ll\tilde{\chi}_1^0$
$\to$ Pick up $\tilde{g} \to \tilde{t} \to \tilde{\chi}_2^0$



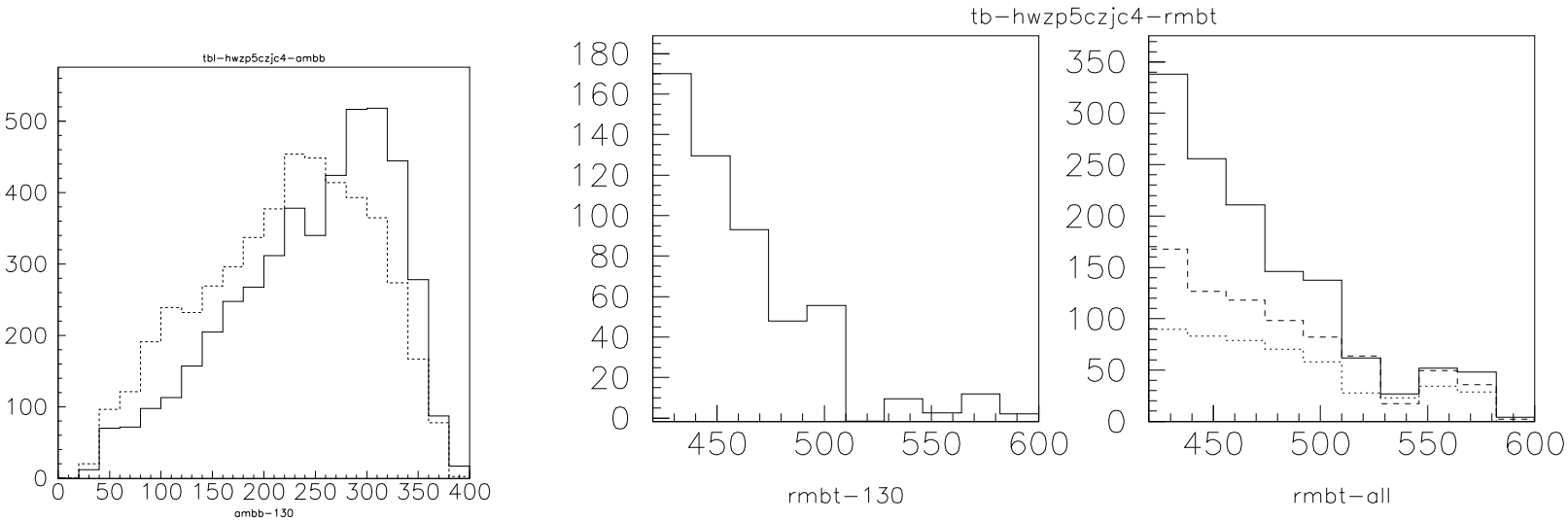
2)**Decay into** $\tilde{\chi}_2^+$

$\tilde{t}$:large coupling both to $\tilde{H}$, $\tilde{W}$

Require 3l or Z to pick up
$\tilde{g} \to \tilde{t} \to \tilde{\chi}_2^+$
cost of statistics
but SM background is also small.

3)**Top polarization**

$\tilde{g} \to \tilde{t}t$
stop L-R mixing, $\to$ **top polarization** P_t
$\to m_{bb}$ distribution (for the events near the m_{tb} end point)
Herwig takes care the polarization. PY does not.



statistically 3σ difference between t_L and t_R for this case...

Problems and hopes....

- Generator dependence
  M_{tb} end point, M_{eff} OK
  normalization ???

- no perfect generator

	Herwig	Pythia	Isajet
fragmentation	QCD based	String	Independent
Pol.	Yes	No	No
Gluino width	No	Yes	No

- jet definition

- High Luminosity? b tagging? minimum bias?

- LC+LHC $\rightarrow$ better estimate of mass itself.