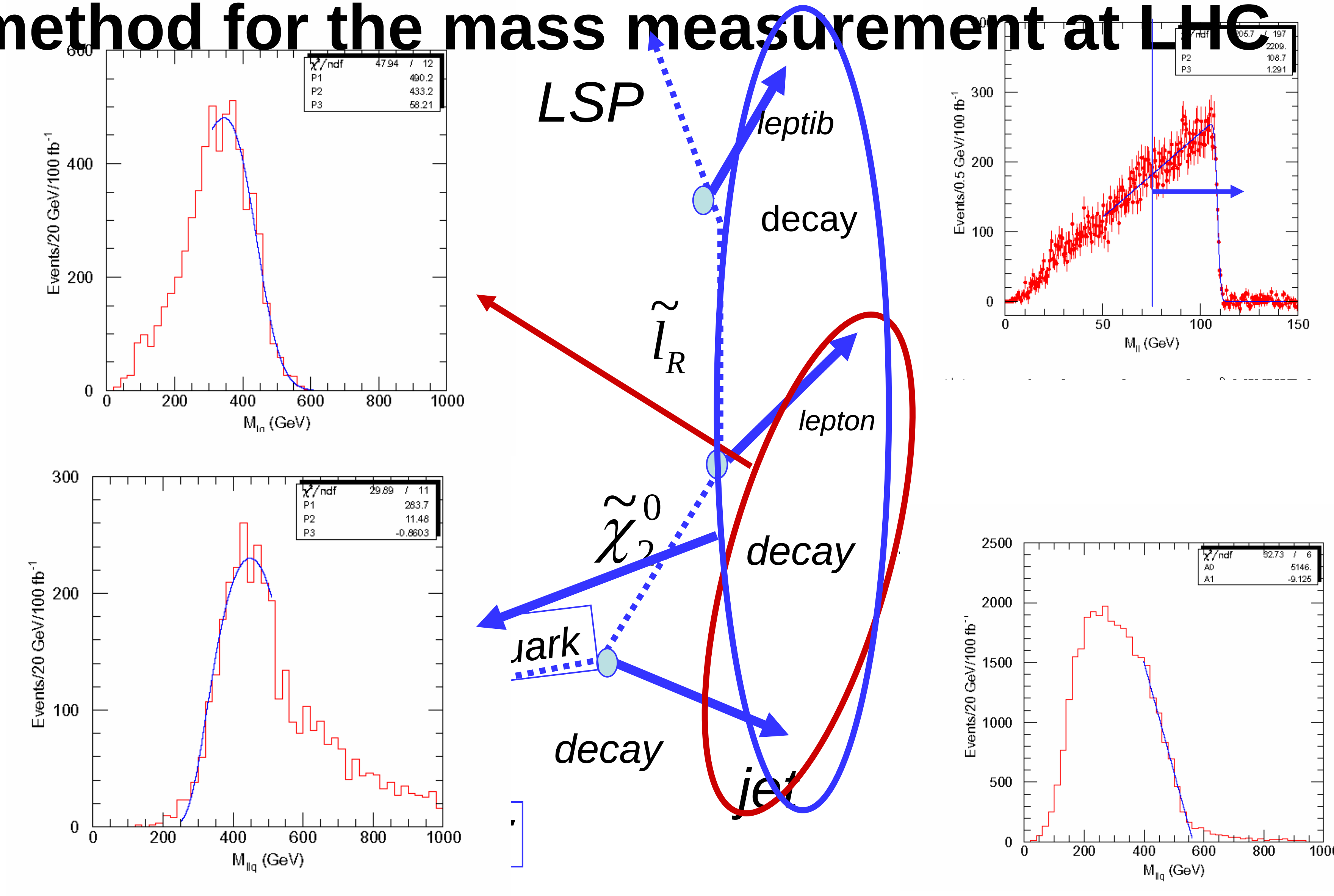
Full reconstruction at LHC

Mihoko M. Nojiri

Based on the work with Polleselo, Tovey, Kawagoe

End point measurement is one of the basic method for the mass measurement at LHC



Summary of endpoint study at SPS1a

particle	mass	error(low)	stat+chi01	stat	error(high)	comment
$\tilde{g}$	595	16.3	15.1	7.0	8.0	bbll mode
$\tilde{q}_L$	540	21.2	20.8	2.6	8.7	jll mode
$\tilde{q}_R$	520	17.7	13.9	3.6	11.8	M_{T2}10 GeV sy
$\tilde{\chi}_4^0$	378	14.6		6.6	5.1	high ll edge
$\tilde{\chi}_1^0$	96	13.4			4.7	jll
$\tilde{\chi}_2^0$	177	13.2			4.7	jll
$\tilde{b}_1$	492	average			7.5	jll mode
$\tilde{b}_2$	525	only			7.9	jll mode

From LHCLC document

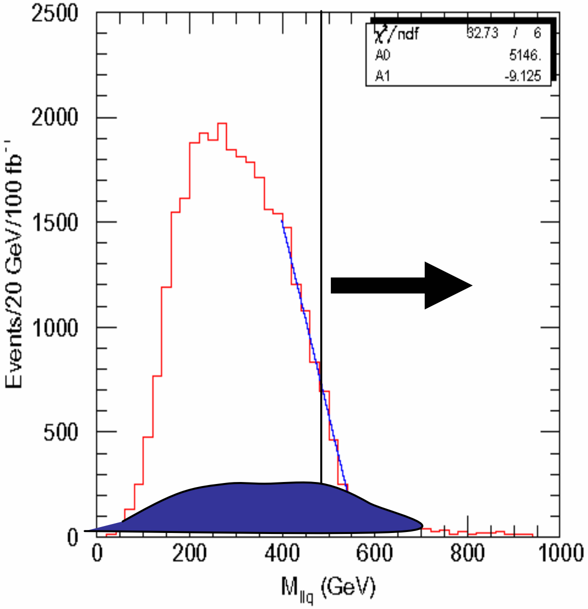
Based on the endpoint analysis, sparticle masses may be understood very well. The lepton channels are important.

LSP mass ⇨dark matter mass

Slepton mass, neutralino mass ⇨Dark matter density

Limitations of the end point method

- Events are not fully reconstructed. LSP is missing.
- Events off the end points are not used.
- Need statistics enough to see the end point. (great loss of the mass reaches)
- Very often, signals come from several cascades, and all mixed up.
- Many jets but no kinematical constraint, even though you know their masses.



Mass relation method

use mass-shell constraint to event(s)

- Full event reconstructions! we see peaks.
- Use all events for mass and distribution study.
- “In principle”, a few events are enough to determine the masses
  (up to jet energy resolutions)
- Kinematical constraints available.

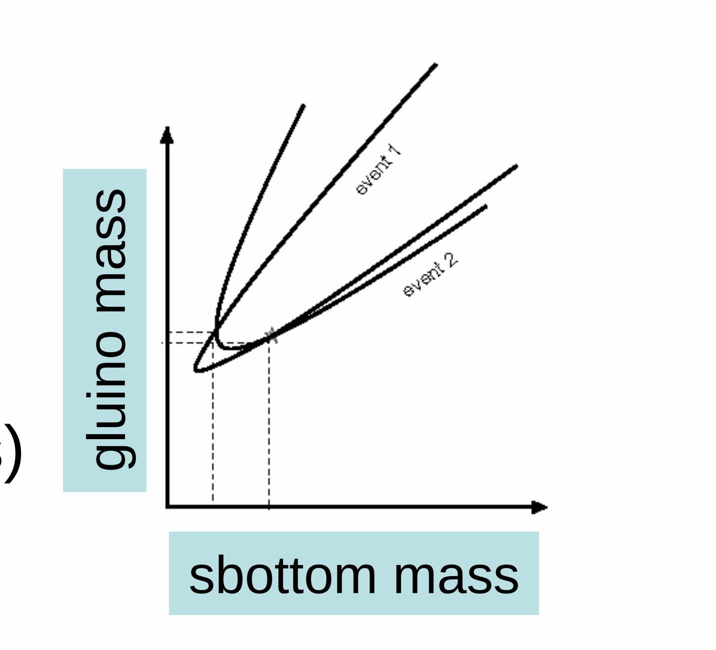
hep-ph/0312317,18

Example of mass relation method

$$\tilde{g} \rightarrow \tilde{b}\, b \rightarrow \tilde{\chi}_2^0 bb \rightarrow \tilde{l}\, lbb \rightarrow \tilde{\chi}_1^0 llbb$$

For simplicity Assume we know mass of $\chi_1^0, \chi_2^0, \tilde{l}$

5 invariant mass constraints
for 6 unknowns
(4 neutralino mometum
and gluino and sbottom masses)



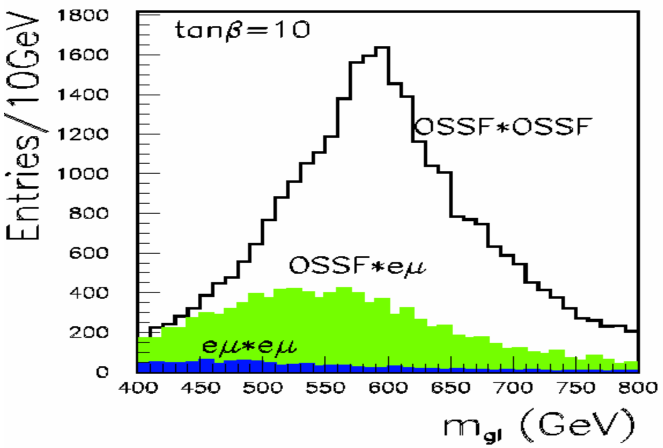
Each event corresponds to a curve in the mass plane
Two events is enough to give the masses.

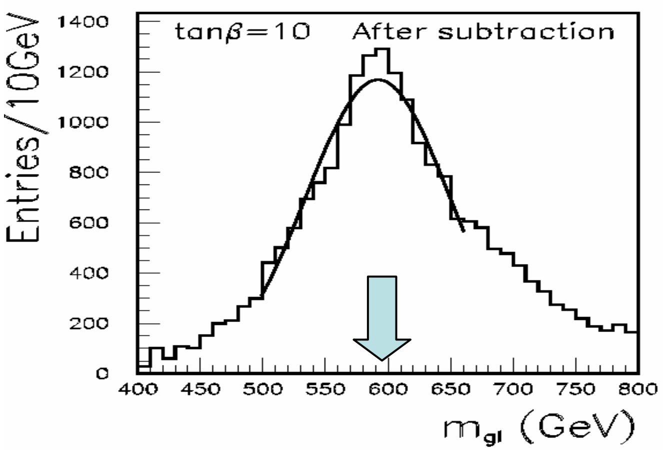
Distributution of the gluino mass solution

- Gluino mass peak appear at the right place.
- Statistical error of the peak is about O(1) GeV. Peak position is consistent to the input

- Each event is used O(10) times each.
- 4 jets involved.

Kawagoe, Preliminary





Distribution of signal + background (Background subtracted).

Sbottom reconstructions

Once gluino mass is reconstructed, we can solve both sbottom masses and LSP momentum event by events. (FULL reconstruction)

In SUSY models we have two sbottoms, which are degenerated in universal assumptions.

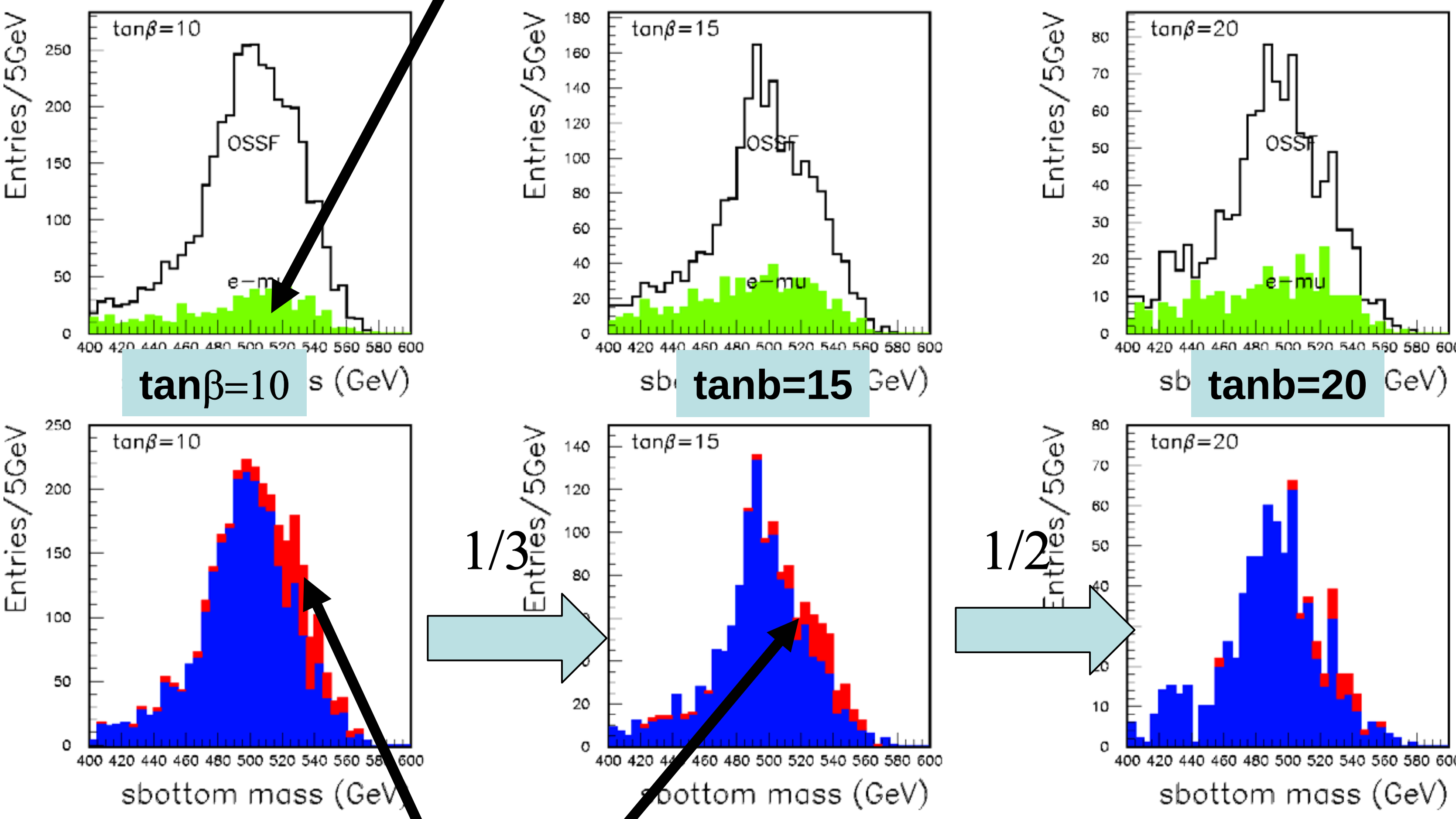
SPS1a	sbottom1	sbottom2	difference	ratio
tan β=10	492GeV	525GeV	33GeV	3.9:1
tan β=15	485GeV	527GeV	42GeV	5.1:1

SUGRA predicitons

Depends on the branching ratio and sbottom mixing angle

Kawagoe, …

Background level



492(525)GeV

485(52)GeV

479(532)GeV

Sbottom2 contribution

Coannihilation point!

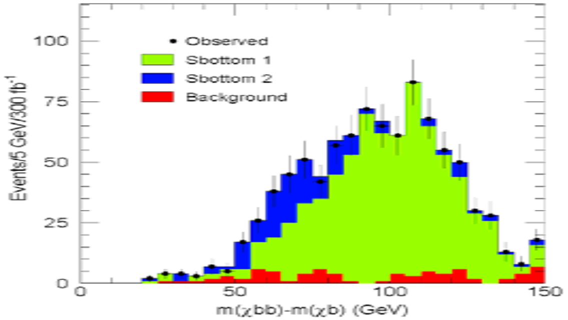
Kawagoe Preliminary

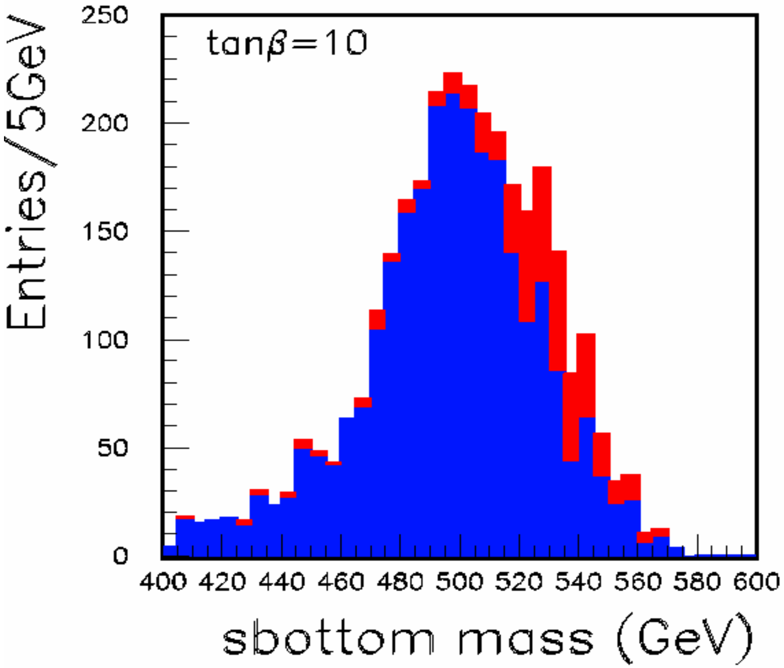
Improvement from previous end point study

- Improved statistics (2～3 times) because we use all events
- Can be applied to large mass and large tan β SUSY cases.
- No approximation involved.
- Previous fit result

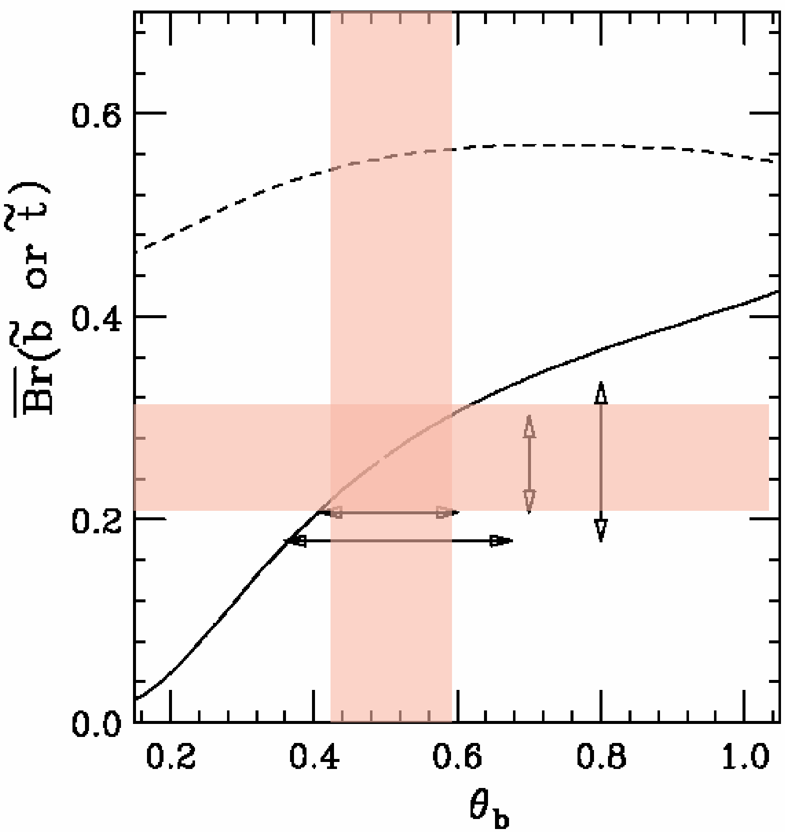
$$\Delta m_{\tilde{g}} - m_{\tilde{b}_1} \sim 1.5 \text{ GeV}$$
$$\Delta m_{\tilde{g}} - m_{\tilde{b}_2} \sim 2.5 \text{ GeV}$$

$$\overline{Br}(\tilde{b}) \equiv \frac{Br(\tilde{g} \to \tilde{b}_2 b \to \tilde{\chi}_2^0 bb)}{Br(\tilde{g} \to \tilde{b}_1 b \to \tilde{\chi}_2^0 bb)} = 0.25 \pm 0.078$$





The ratio of the two sbottom contributions depends on the left-right mixing angle strongly.
Inputs from LC on ino nature is essential to extract the 3rd generation mass matrix fro LHC data.



○ $\tilde{\chi}_2^0 \sim \tilde{W}$ **(←LC)**

couple to left squarks

$Br(\tilde{b}_1 \to \chi_2^0)/Br(\tilde{b}_2 \to \chi_2^0)$

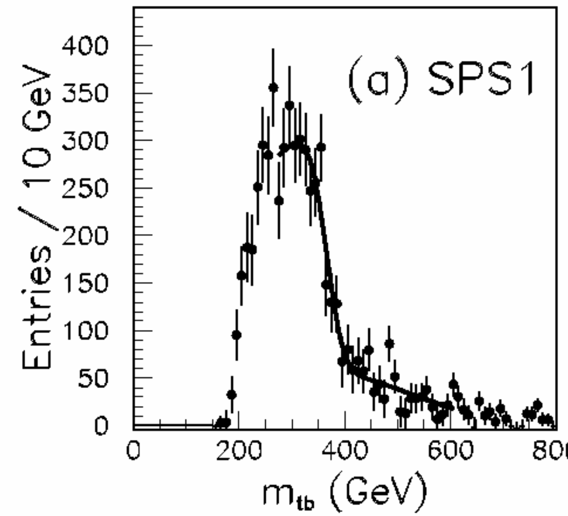
is the function of θ_b

$$\Delta\theta_b = 0.157(\mathrm{stat}+\mathrm{sys})$$

Hisano Kawagoe Nojiri
Contribution to LHCLC

How about stop?(Hisano,Kawagoe, Nojiri PRD68 035007) (Important for both to understand higgs mass, FCNC)

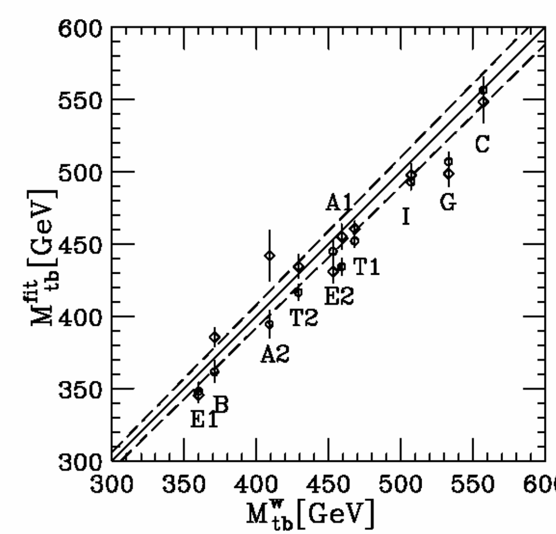
$$\tilde{g} \rightarrow (t\tilde{t} \text{ or } b\tilde{b}) \rightarrow tb\tilde{\chi}_1^{\pm}$$



- Branching ratio is biggest…..
- Two contribution co-exists.
- The stop contribution can be extracted If sbottom mixing angle (~the decay branching ratio)is understood.
  (see previous studies).

$$M_{tb} = \frac{Br(\tilde{g} \rightarrow \tilde{t} \rightarrow \tilde{\chi}+)M_{tb}(\tilde{t}) + Br(\tilde{g} \rightarrow \tilde{b} \rightarrow \tilde{\chi}_1^{+})M_{tb}(\tilde{b})}{Br(\tilde{g} \rightarrow \tilde{t} \rightarrow \tilde{\chi}_1^{+}) + Br(\tilde{g} \rightarrow \tilde{b} \rightarrow \tilde{\chi}_1^{+})}$$

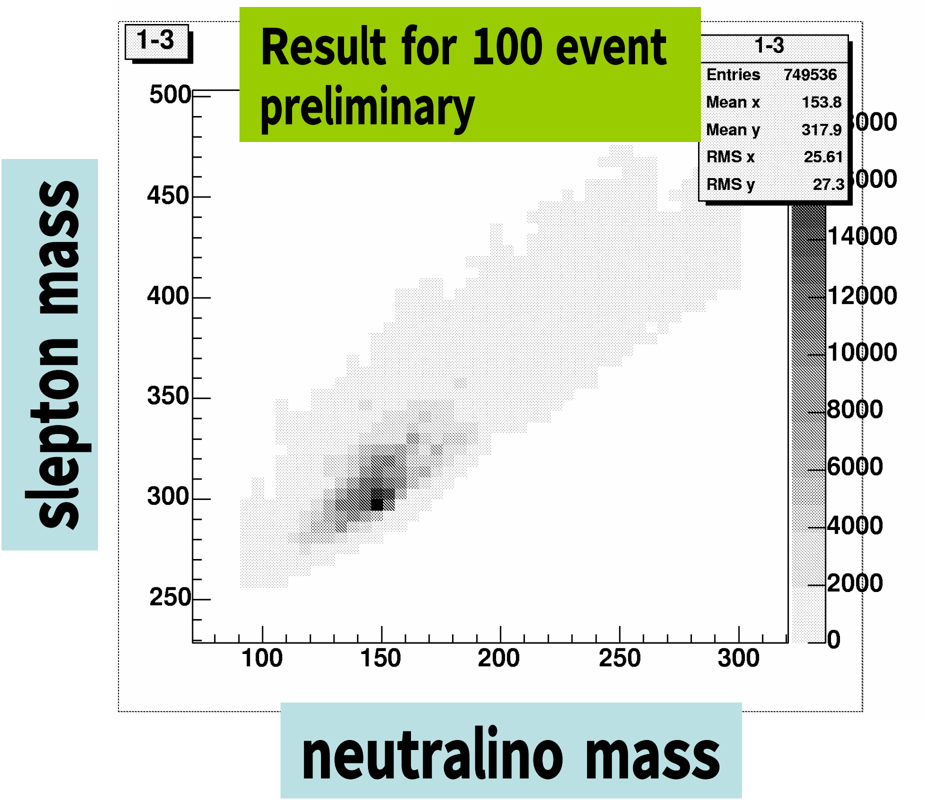
For SPS1a, the error of Mtb end point is Is about 4GeV for 100fb^{-1}



mass relation method
"pushed forward"

When no mass inputs are available a event give a probability distribution of true mass (~4 dim) in
5 dim mass space,

calculate required mis-measuremnet ε of energy for mass assumption m, calculate δ, determine p(data|m)



$$\delta = (\varepsilon_{l1} / \sigma_l)^2 + (\varepsilon_{l2} / \sigma_l)^2 + (\varepsilon_{b1} / \sigma_b)^2 + (\varepsilon_{b2} / \sigma_b)^2$$

(Lester 2004
Les Houch
contribution)

Conclusions

- “full reconstruction” is possible.
- “mass relation method” works for clean and long channel, such as jll. LC inputs makes situation easier.
- It works even for small statistics.
- Note: If event contains many neutrinos,

  the method cannot be applied.

  We need more thoughts and works.
- It starts soon! (2007)