SPS1A in ATLAS:

a status report

Giacomo Polesello

INFN, Sezione di Pavia

Point SPS1A

$$m_0 = 100 \text{ GeV}, \; m_{1/2} = 250 \text{ GeV},$$

$$\tan\beta = 10, \; A = -100 \text{ GeV}, \; \mu > 0$$

Mass spectrum

Particle	Mass (GeV)	Particle	Mass (GeV)
$\tilde{g}$	595.5	$\tilde{u}_R$	520.5
$\tilde{u}_L$	537.25	$\tilde{d}_L$	543.04
$\tilde{b}_1$	491.92	$\tilde{t}_1$	379.14
$\tilde{e}_L$	202.12	$\tilde{e}_R$	143.00
$\tilde{\tau}_1$	133.39	$\tilde{\tau}_2$	206.02
$\tilde{\chi}_1^0$	96.05	$\tilde{\chi}_1^\pm$	176.37
$\tilde{\chi}_2^0$	176.80	$\tilde{\chi}_4^0$	377.83
h	113.98	A	394.37

BR($\tilde{\chi}_2^0 \to \tilde{\ell}_R \ell$)=12.6% BR($\tilde{\chi}_2^0 \to \tilde{\tau}_1 \tau$)=87%

BR($\tilde{\chi}_1^\pm \to \tilde{\tau}_1 \nu_\tau$)$\sim 100\%$

Many τ's, reduced lepton activity.

Strategy:

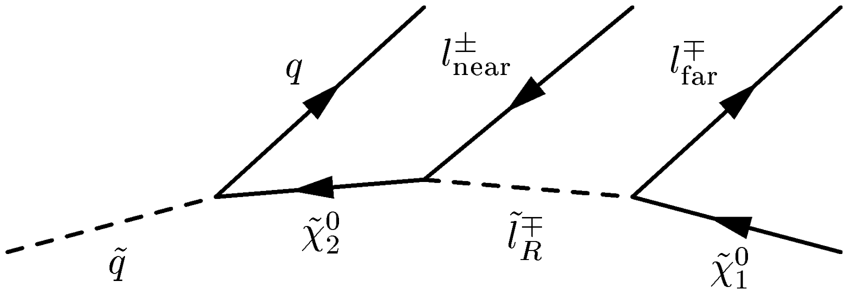
- Start from two-lepton (e, μ) analysis, basis signature is

$$\tilde{\chi}_2^0 \to \tilde{\ell}_R \ell \to \ell^+ \ell^- \tilde{\chi}_1^0$$

- Using thresholds and edges measure $m(\tilde{q}_L)$, $m(\tilde{\ell}_R)$, $m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$
- Apply b-tagging and try to extract $\tilde{b}_1$ with similar procedure
- Use measured values to extract mass measurements from all further analyses
- Require two tagged b's, and try full reconstruction of $\tilde{g} \to \tilde{b}_1 b$ (requires $m(\tilde{\chi}_1^0)$ from previous steps)
- Reconstruct $\tilde{\chi}_4^0 \to \tilde{\ell}_L \ell$ from tail of $m(\ell\ell)$ distribution
- Jetless two-lepton: direct production of ℓ_L, ℓ_R
- Apply τ-tag, search for $\tilde{\chi}_2^0 \to \tau_1 \tau \to \tau^+ \tau^- \tilde{\chi}_1^0$
- Look for $\tilde{q}_R$ in events with two/four jets and high $\not{E}_T$
- Stop $\to$ Mihoko

Analysis 1: $\tilde{q}_L$ Decay chain

(nice systematics in Allanach et al. hep-ph/0007009)



l^+l^- edge $\quad (m^{\rm max}_{ll})^2 = (\tilde{\xi}-\tilde{l})(\tilde{l}-\tilde{\chi})/\tilde{l}$

l^+l^-q edge $\quad (m^{\rm max}_{llq})^2 = (\tilde{q}-\tilde{\xi})(\tilde{\xi}-\tilde{\chi})/\tilde{\xi}$

l^+l^-q thresh

$$(m^{\rm min}_{llq})^2 = \begin{cases} [\ 2\tilde{l}(\tilde{q}-\tilde{\xi})(\tilde{\xi}-\tilde{\chi}) \\ +(\tilde{q}+\tilde{\xi})(\tilde{\xi}-\tilde{l})(\tilde{l}-\tilde{\chi}) \\ \quad -(\tilde{q}-\tilde{\xi})\sqrt{(\tilde{\xi}+\tilde{l})^2(\tilde{l}+\tilde{\chi})^2-16\tilde{\xi}\tilde{l}^2\tilde{\chi}}\ \ ] \\ /(4\tilde{l}\tilde{\xi}) \end{cases}$$

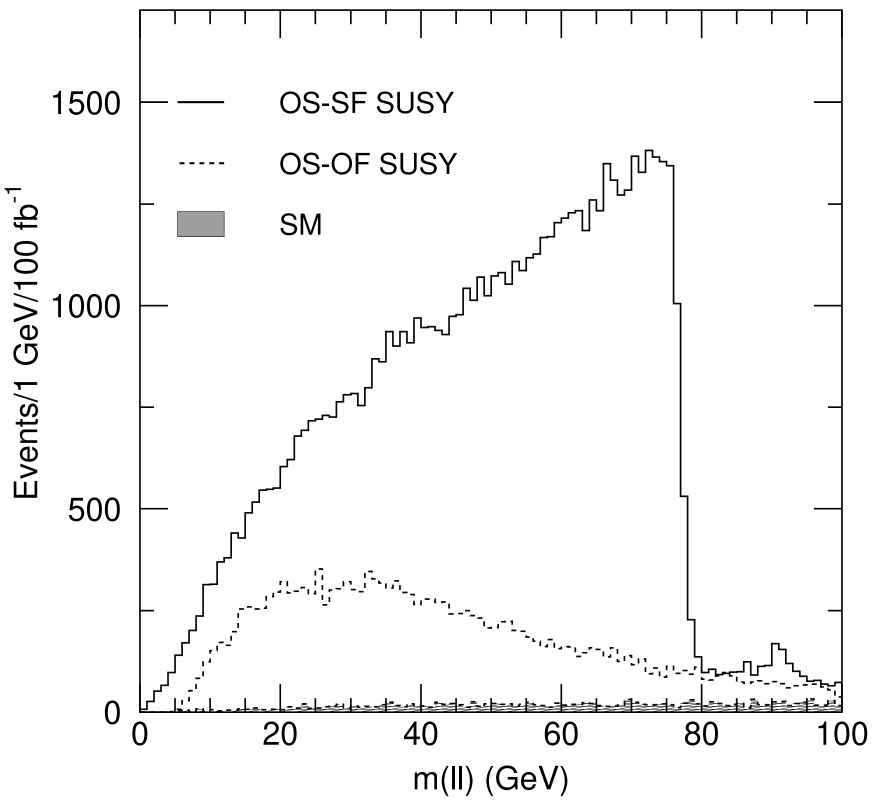
$l^{\pm}_{\rm near}q$ edge $\quad (m^{\rm max}_{l_{\rm near}q})^2 = (\tilde{q}-\tilde{\xi})(\tilde{\xi}-\tilde{l})/\tilde{\xi}$

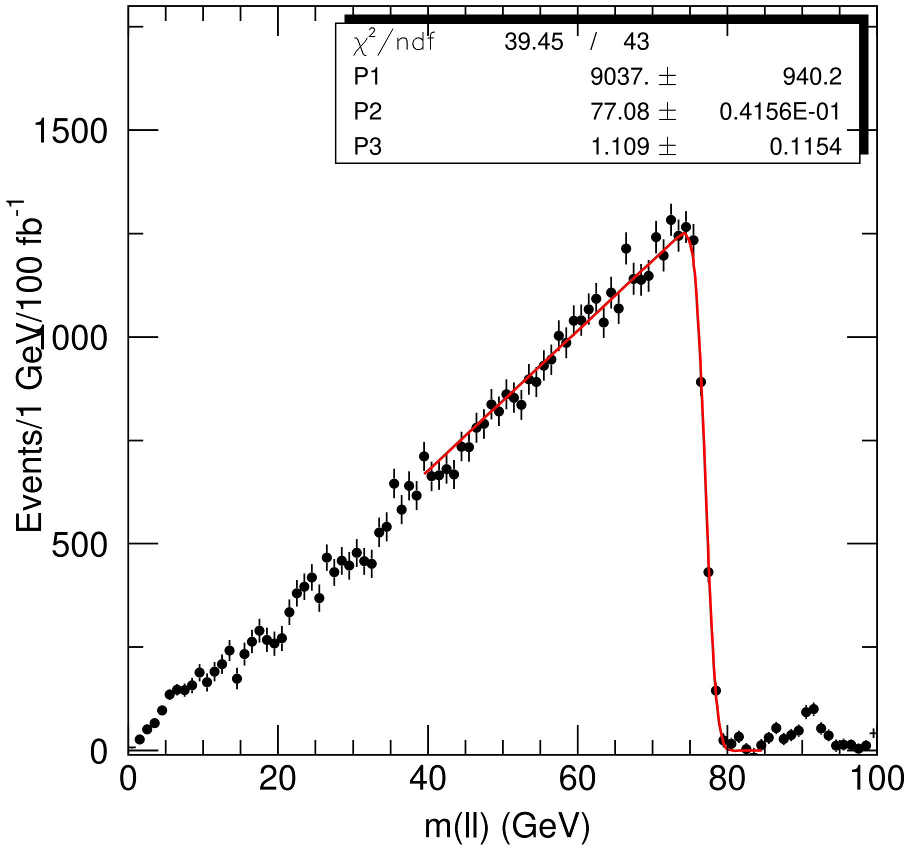
$l^{\pm}_{\rm far}q$ edge $\quad (m^{\rm max}_{l_{\rm far}q})^2 = (\tilde{q}-\tilde{\xi})(\tilde{l}-\tilde{\chi})/\tilde{l}$

With $\quad \tilde{\chi} = m^2_{\tilde{\chi}^0_1}, \qquad \tilde{l} = m^2_{\tilde{l}_R}, \qquad \tilde{\xi} = m^2_{\tilde{\chi}^0_2}, \qquad \tilde{q} = m^2_{\tilde{q}}$

Isolate exclusive chain by requiring:

- At least four jets with $p_{T,1} > 150\,\text{GeV}$ $p_{T,2} > 100\,\text{GeV}$, $p_{T,3} > 50\,\text{GeV}$.
- $M_{\text{eff}} > 600$ GeV ($M_{\text{eff}} = p_{T,1} + p_{T,2} + p_{T,3} + p_{T,4} + \not{E}_T$)
- $\not{E}_T > \max(100\,\text{GeV}, 0.2M_{\text{eff}})$.
- Two isolated same-flavour opposite-sign (SF-OS) leptons (e, μ) $P_T(\ell_1) > 20$ GeV, $P_T(\ell_2) > 10$ GeV.





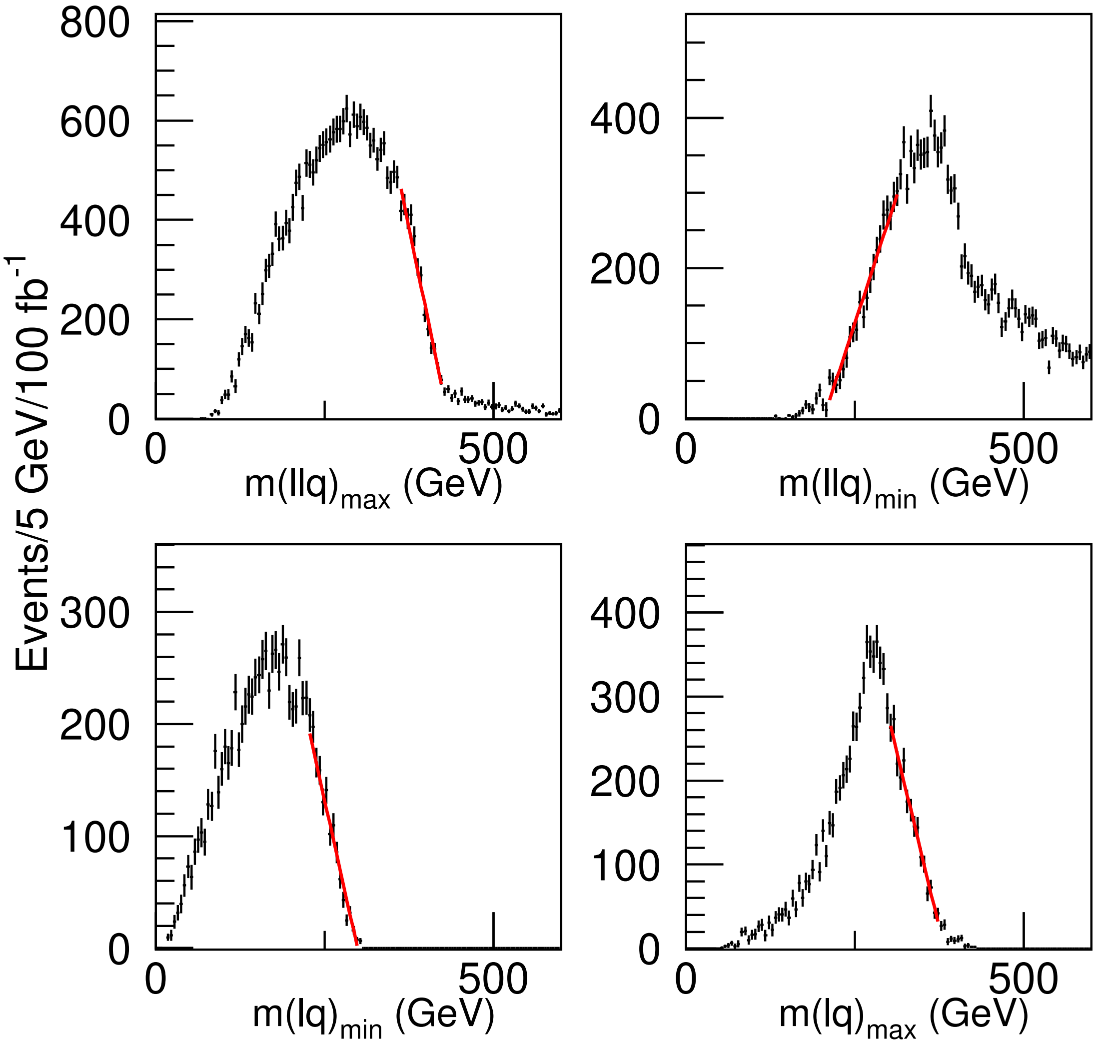
After subtraction, error include both SUSY and SM subtraction

(100 fb^{-1})

Fit edge to triangular shape with gaussian smearing. Result:

$$(m_{ll}^{\mathrm{max}}) = 77.077 \pm 0.042 \quad (\mathrm{stat}) \quad \pm 0.08i \quad (\mathrm{E\ scale})$$

Nominal value is 77.024



In real experiment expect detailed study of shapes

Here estimate end-point with linear fits

Take error on fit parameter as estimate of statistical error

Fit results (100 fb^{-1}):

Variable	Fit value (GeV)	stat	sys (E scale)	nominal
m_{ll}^{max}	77.077	0.042	0.08	77.024
m_{llq}^{max}	433.1	1.4	4.3	431.1
m_{llq}^{min}	203.6	2.1	2.0	202.9
$m_{l_{\text{near}}q}^{\text{max}}$	298.4	0.8	3.0	302.0
$m_{l_{\text{far}}q}^{\text{max}}$	382.2	1.7	3.8	380.4

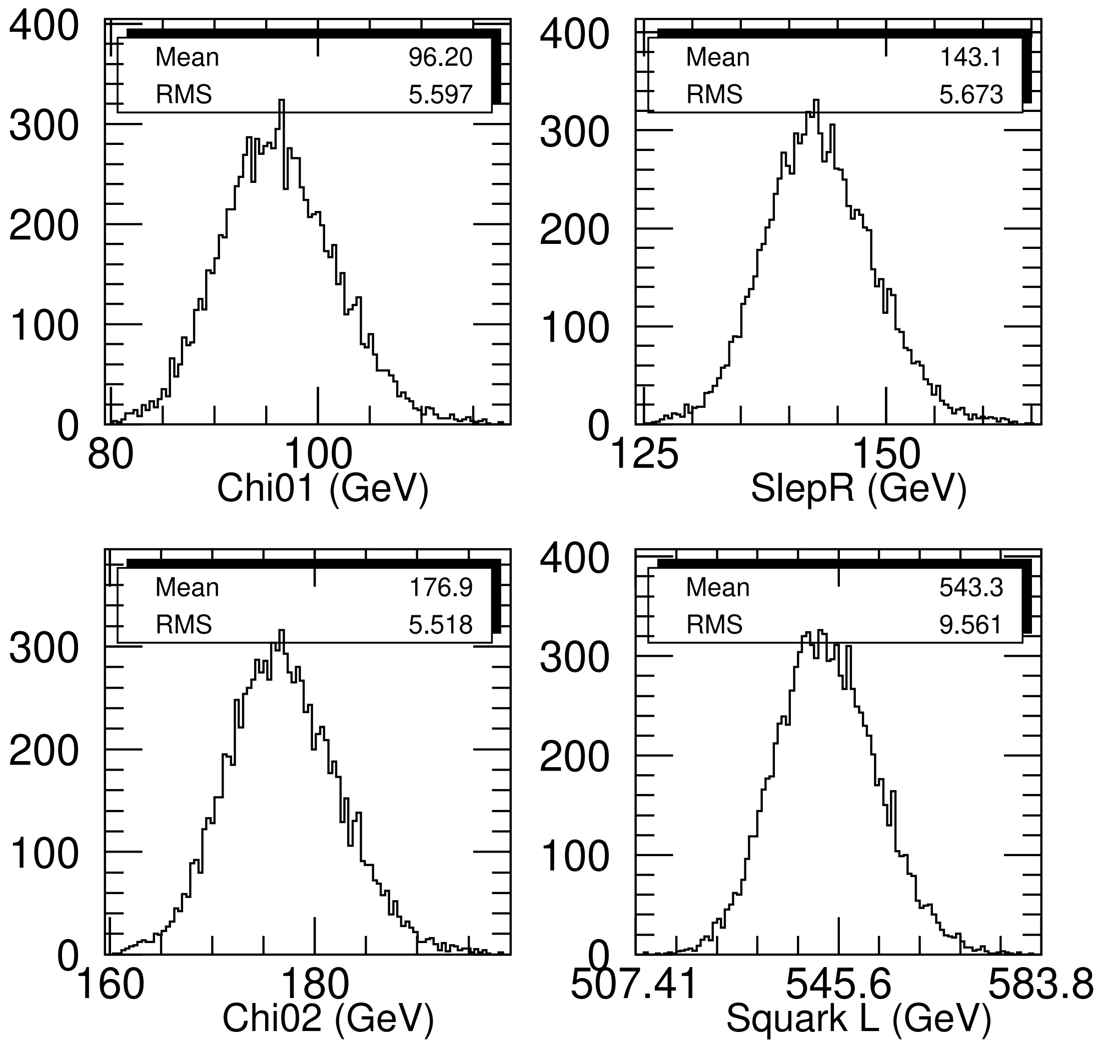
Reasonable agreement with nominal values, given simple-minded fit

Ignore for this exercise systematic error from fit technique

Expect however to be smaller than energy scale systematics

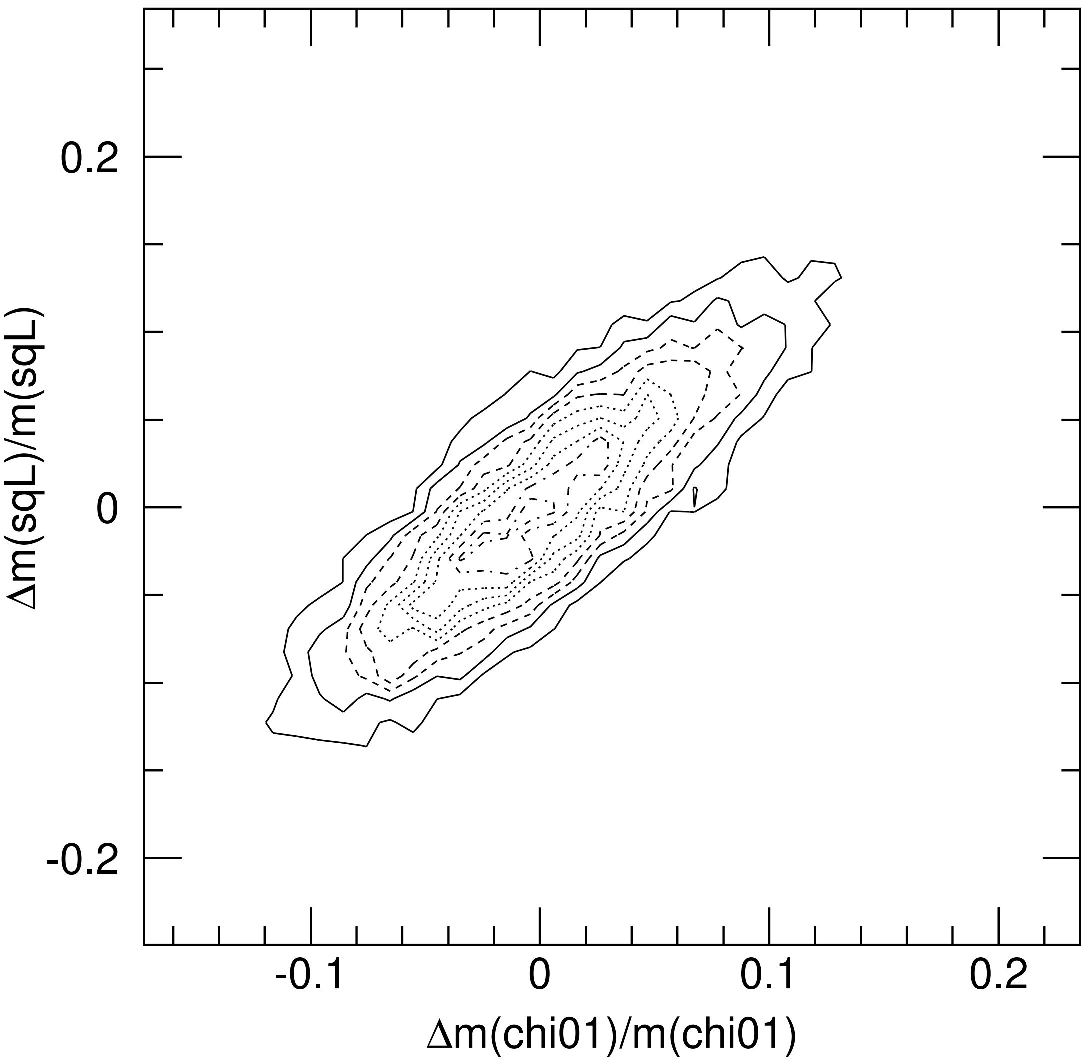
From measured edges calculate masses minimizing a χ^2

Energy scale uncertainty (0.1% leptons, 1% Jets) included in the fit



Edges measure difference of masses: errors of similar magnitude for all four sparticles

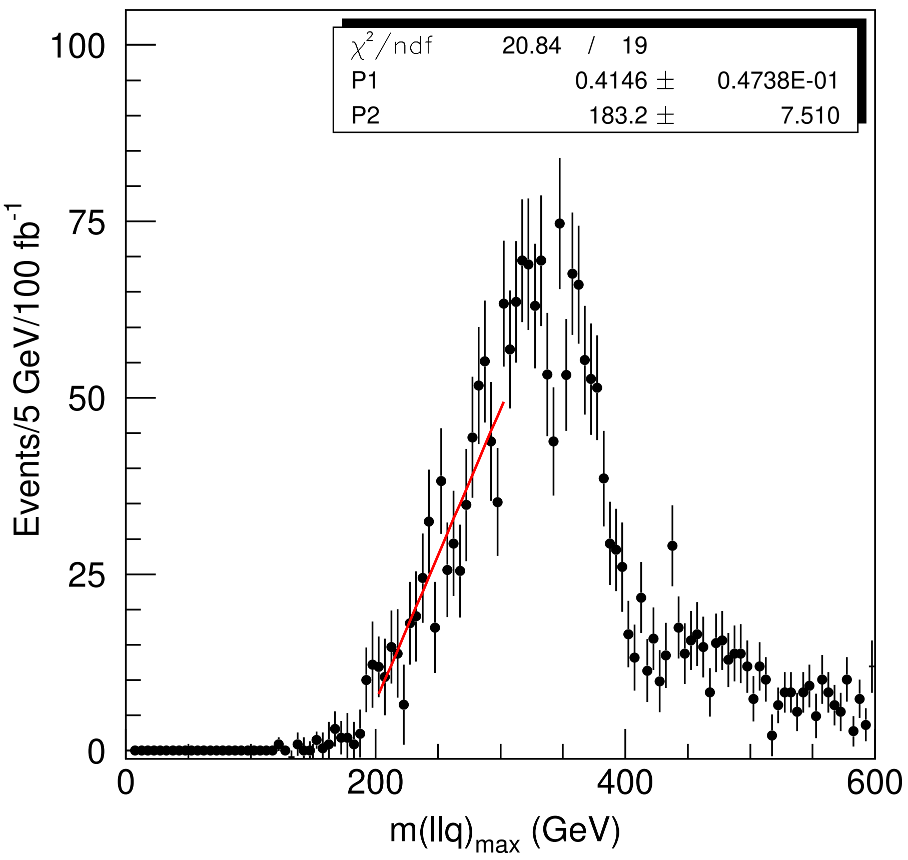
Detailed study of momenta of two leptons in lepton-lepton edge may allow to decouple neutralinos and slepton from squark



Strong correlation among variables because of edges

Need to take into account in model fitting

If jet yielding maximum $m(j\ell\ell)$ is tagged as b-jet, can measure $m_{llq}^{\rm min}$ for $\tilde{b}_1$



Fitted value is:

$$m_{llq}^{\rm min} = 183.2 \pm 7.5\,\text{GeV}$$

Nominal value is 183.0

Analysis 2: Gluino reconstruction

(just a sketch, full analysis being performed by Borge Kile Gjelste)

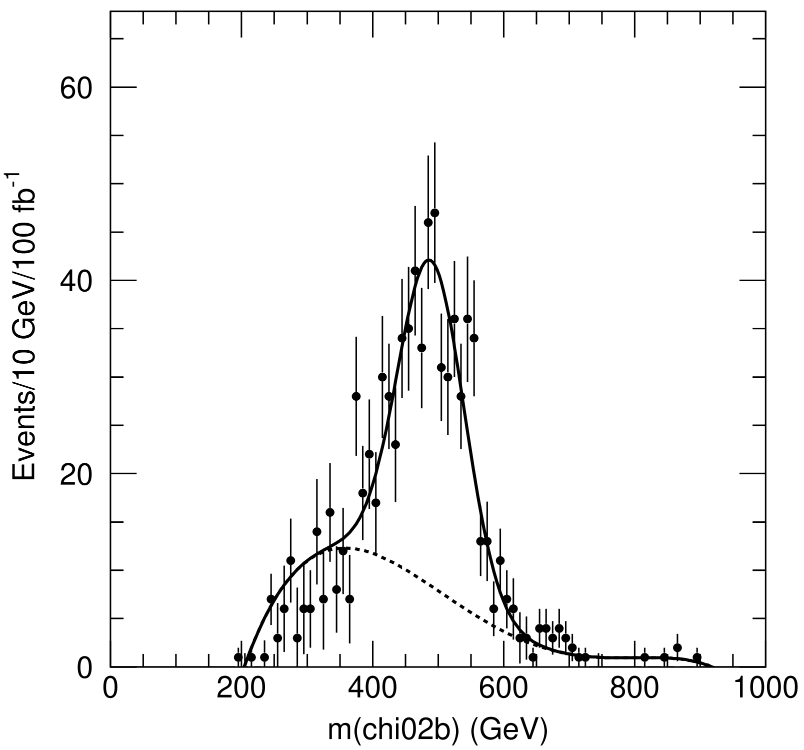
Try to reconstruct chain $\tilde{g} \rightarrow \tilde{b}b \rightarrow bb\tilde{\chi}^2$

Require two b-tagged jets in event

Select events with $m_{\ell\ell}$ near edge: $68 < m_{\ell\ell} < 78$ GeV

If $\tilde{\chi}_1^0$ mass known: $\vec{p}(\tilde{\chi}_2^0) = (1 + m(\tilde{\chi}_1^0)/m_{\ell\ell})\vec{p}(\ell\ell)$

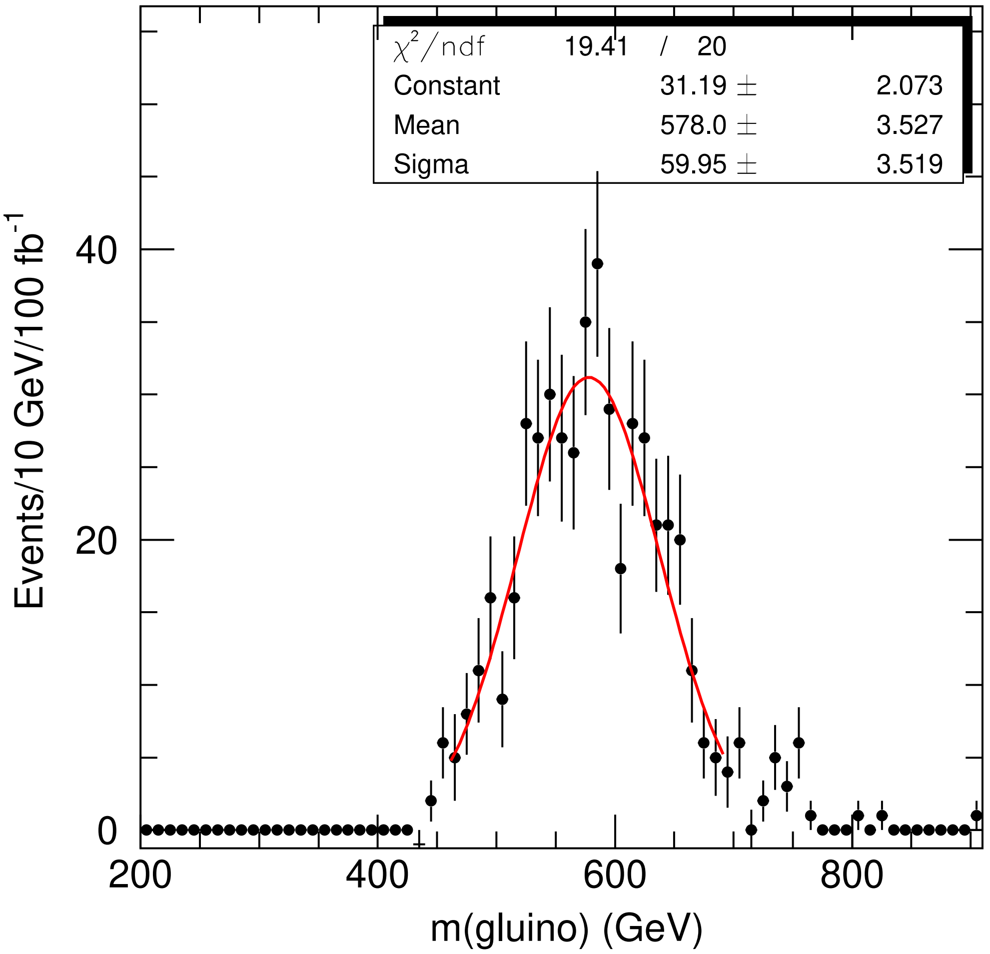
If $\tilde{\chi}_2^0$ mass known, can build invariant mass $m(\tilde{\chi}_2^0 b)$



Gaussian fit gives $m(\tilde{b}_1) = 489.5 \pm 3.9$ GeV (Nominal: 492)

Select events with $400 < m(\tilde{\chi}^0_2 b) < 600$ GeV

Build invariant mass with second b-tagged jet in event



Nominal mass is 595.3 GeV

Analysis 3: $\tilde{\chi}_4^0$

Look in tail of $m_{\ell^+\ell^-}$ distribution for decay chain:

$\tilde{q}_L \to q\tilde{\chi}_4^0 \to \tilde{q}l\tilde{l} \to qll\tilde{\chi}_1^0$

Approximately same requirements as for $\tilde{\chi}_2^0$ analysis.

Require in addition:

- $M_{T2} > 80$ GeV
- $m_{\ell^+\ell^-} > 100$ GeV

with:

$$M_{T2}^2 \equiv \min_{\not{p}_1 + \not{p}_2 = \not{p}_T} \left[\max \left\{ m_T^2(\mathbf{p}_T^{l_1}, \not{p}_1), m_T^2(\mathbf{p}_T^{l_2}, \not{p}_2) \right\} \right] \quad (1)$$

where

$$m_T^2(\mathbf{p}_T^l, \mathbf{q}_T) \equiv 2(E_T^l Q_T - \mathbf{p}_T^l \cdot \mathbf{q}_T), \quad (2)$$

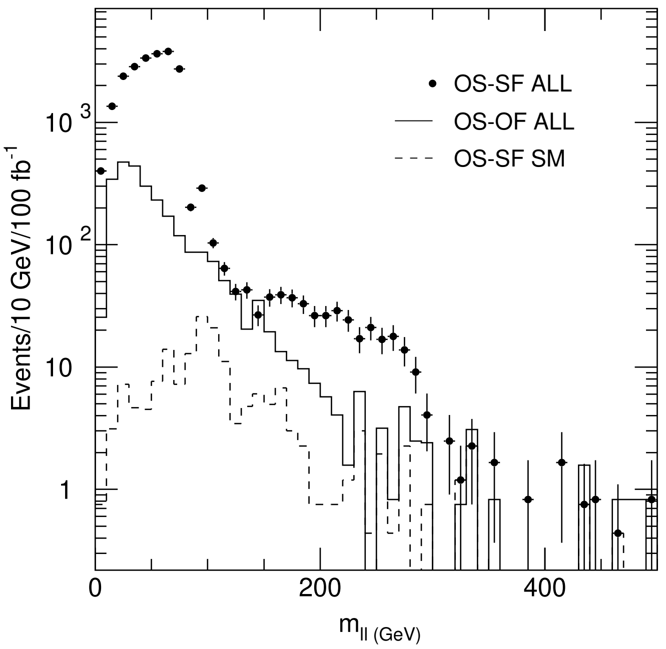
$$E_T^l = |\mathbf{p}_T^l| \quad \text{and} \quad Q_T = |\mathbf{q}_T| a. \quad (3)$$

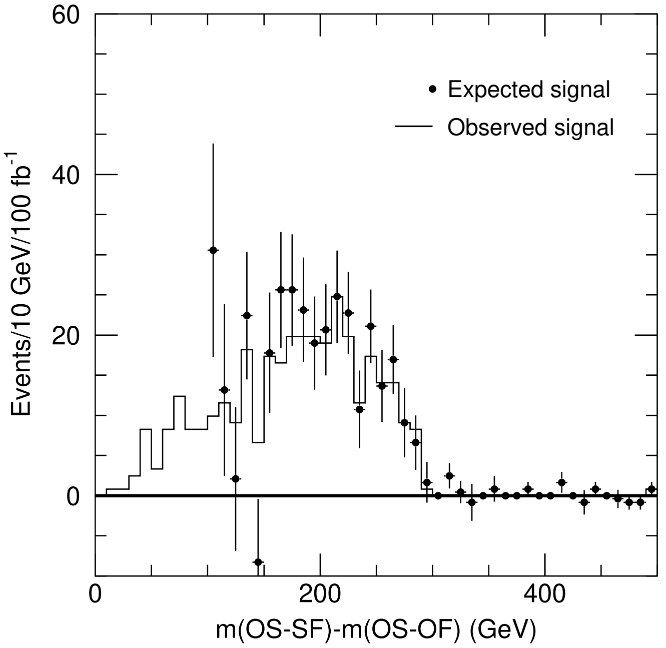
Cambridge M_{T2} variable with $m_\chi = 0$

Strongly reduces $\bar{t}t$ and SUSY background from uncorrelated decays

Edge shape may also include info on ℓ_L and $\tilde{\chi}_2^\pm$ decays

Full details on paper to be submitted (G.P.).





Position of edge measured with a statistical precision of ~ 4 GeV

Analysis 4: Direct slepton production

(Analysis performed by Else Lytken)

Select events with:

- Exclusive two-leptons ($P_T(\ell_1) > 80$ GeV, $P_T(\ell_2) > 30$ GeV)
- Veto Jets $p_T > 30$ GeV
- $\not{E}_T > 70\ GeV$
- Veto $m_{\ell\ell} > 75$ GeV and compatible with Z

Main backgrounds: $\bar{t}t$ WW WZ

Subtract background from $\bar{t}t$ and WW using lepton flavour correlation

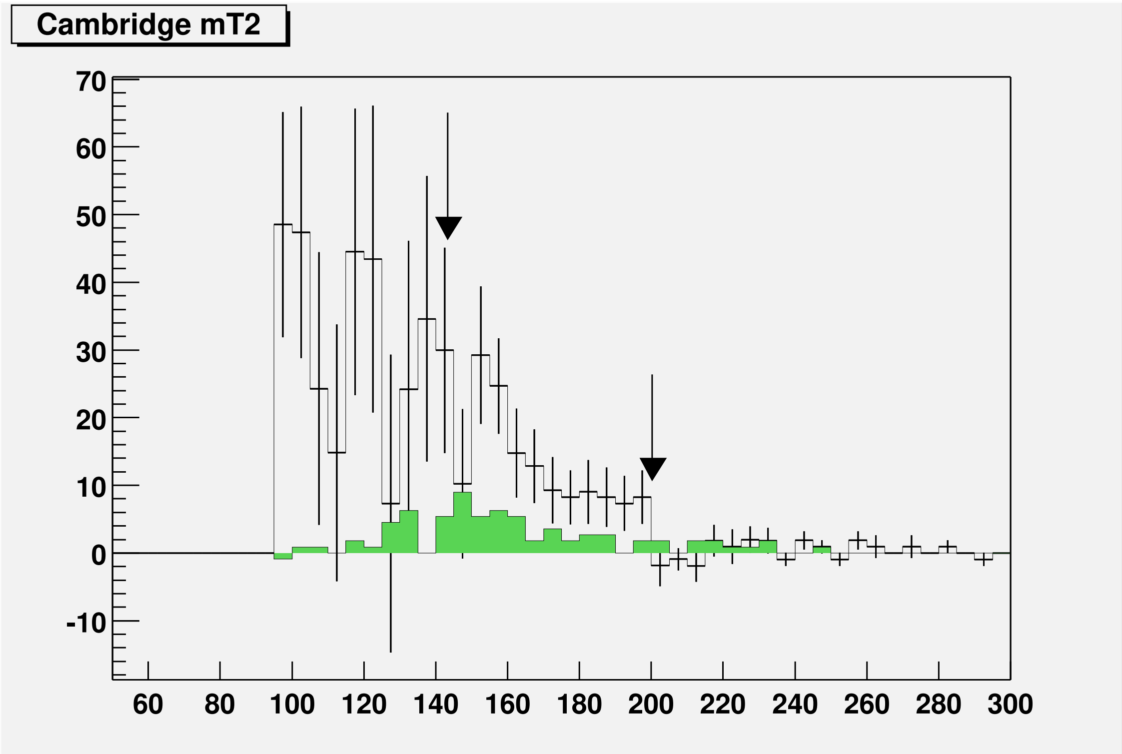
Background from includes flavour-correlated leptons and must be subtracted by MonteCarlo

From knowledge of $\tilde{\chi}_1^0$ mass build Cambridge $MT2$ variable

$MT2$ distribution for sleptons should show edges at $m(\tilde{\ell})$

$MT2$ distribution for backgrounds should stop at

$MT2 \sim 150$ GeV



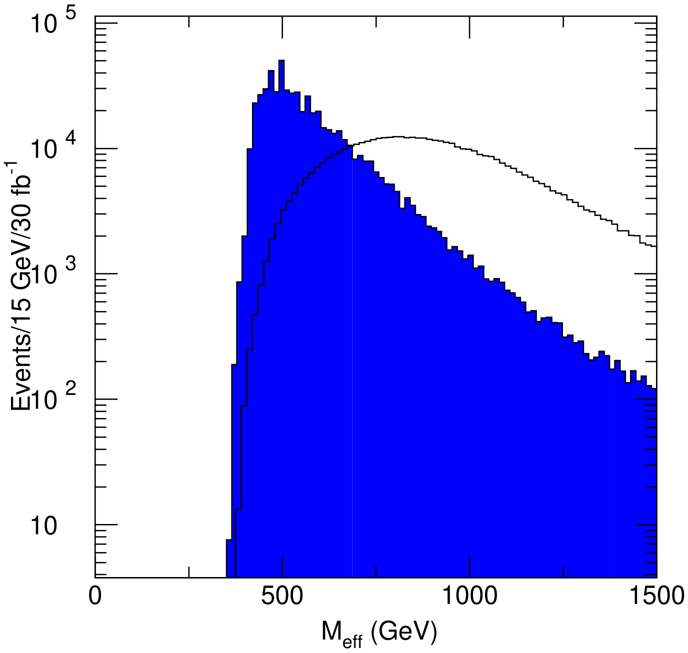
Edge from $\tilde{\ell}_R$ too low, hidden by background fluctuation

Edge from $\tilde{\ell}_L$ clearly visible

WZ background (green in plot) needs careful consideration

Analysis 5: $\tilde{\tau}_1$ in $\tilde{\chi}^2_0$ decays

Requirements on jet multiplicity, $\not{E}_T$ and M_{eff} allow to keep QCD background under control even without requiring electrons and muons



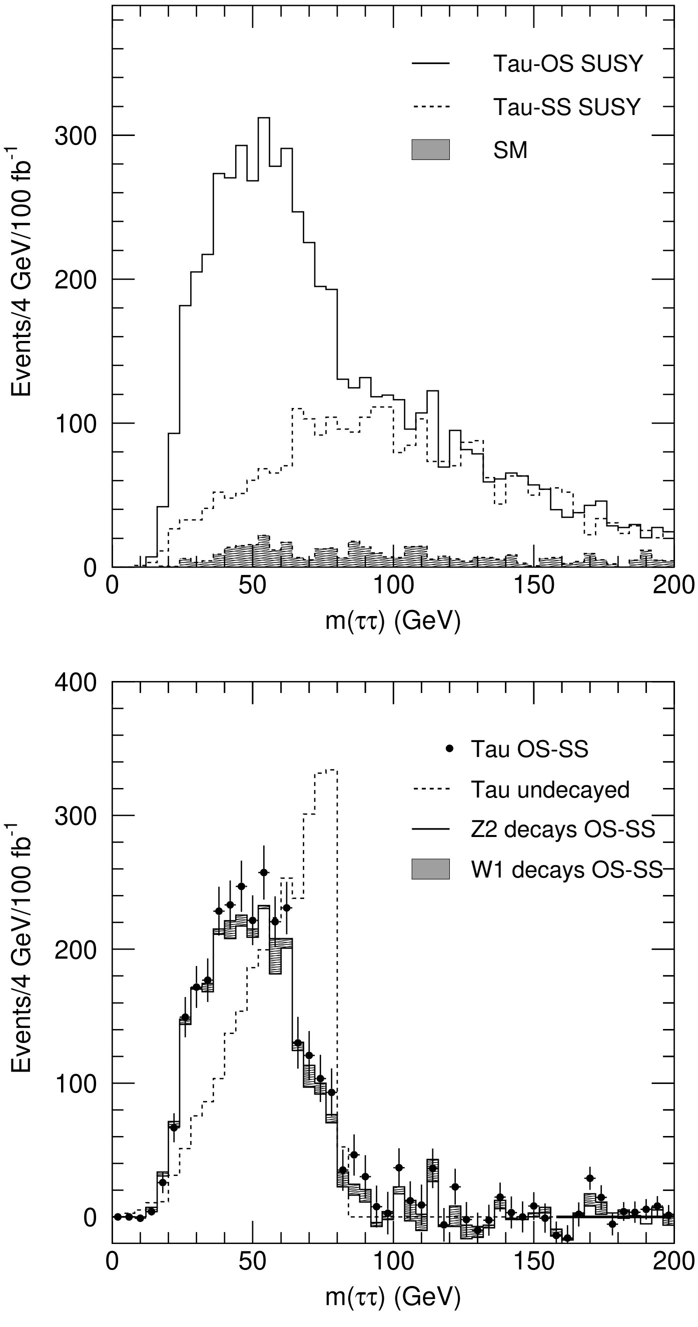
Select decays $\tilde{\chi}^2_0 \rightarrow \tilde{\tau}\tau$ by requiring two jets tagged as hadronic τ decays of opposite sign.

Analysis performed for 30 fb^{-1}

Calculate invariant mass of the two τ-tagged jets

Background from misidentified QCD jets can be subtracted using same-sign pairs

Gluino production dominates over squark production $\rightarrow$ also the bulk of $\tilde{\chi}_1^\pm$ decays can be subtracted with same-sign



To be done: evaluate sensitivity of distribution to $m(\tilde{\tau}_1)$

Analysis 6: Squark right production

In addition to standard cuts:

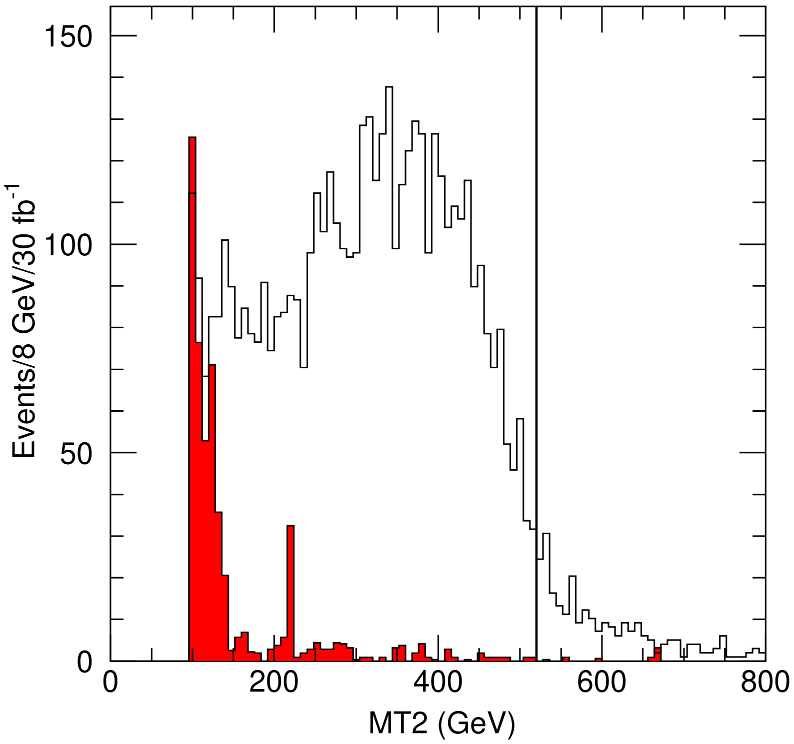
Require harder cut on leading jet > 300 GeV

Require at most 4 jets with $P_T > 50$ GeV

Veto leptons, τ-jets, b-jets

Obtain sample dominated by $\tilde{q}_R$ production

Calculate the Cambridge $MT2$ on two leading jets



Obtain distribution which drops at ~ 520 GeV corresponding to $m(\tilde{q}_R)$. Still to study sensitivity

Conclusions

Full analysis of mass reconstruction in Point SPS1A in ATLAS well underway

Standalone measurement available for most sparticles

Precision driven by jet energy scale

Soon available ntuple containing mass measurement for a set of MonteCarlo experiments, with all correlations taken into account

Necessary step preliminary to:

- Modification of analyses to take into account LC input
- Exercise of extracting mSUGRA parameters from comparison to models
- Exercise of extracting mSUGRA parameters from direct backward evolution