Mass Determination of SUSY Particles from Endpoints

Børge Kile Gjelsten
University of Oslo

Based on:

B. K. Gjelsten, P. Osland, D. J. Miller

hep-ph/0410303, ATL-PHYS-2004-029

CONTENTS

INTRODUCTION

R-parity (to avoid proton decay)

- $P_R = (-1)^{3(B-L)+2s}$

  $P_R = +1$: SM particles

  $P_R = -1$: SUSY particles

- Any interaction term must have $\prod P_R = +1$

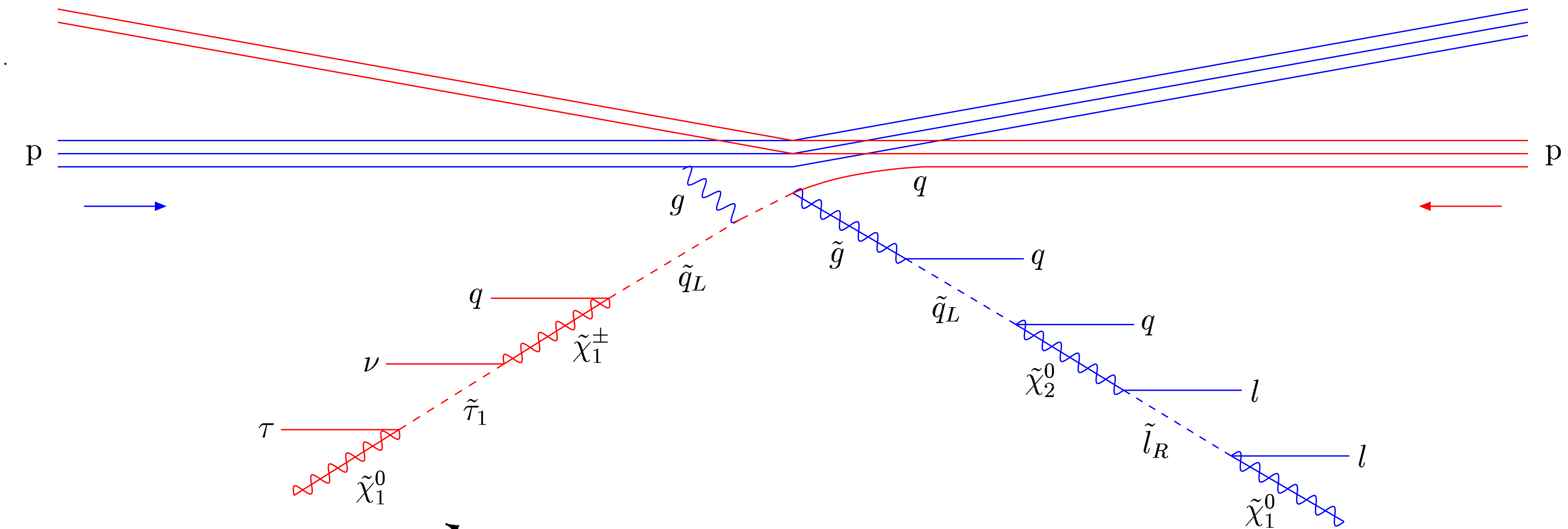
  $\Rightarrow$ Vertex must have even number of sparticles

  $\Rightarrow$ Lightest sparticle (LSP) is stable

  $\Rightarrow$ Any sparticle must eventually decay into the LSP

  $\Rightarrow$ Collider: Sparticles are pair produced

Typical SUSY event at LHC:

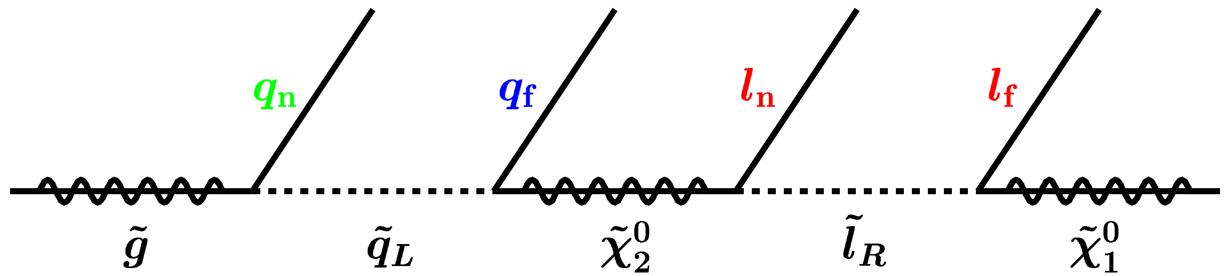


If LSP neutral,
missing momentum

$\Longrightarrow$ Cannot reconstruct mass peaks

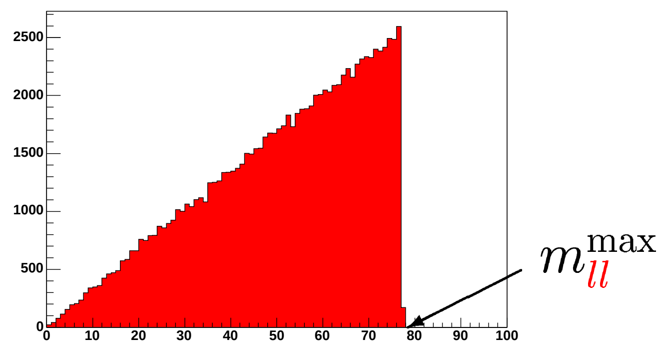
$\Longrightarrow$ Need other method

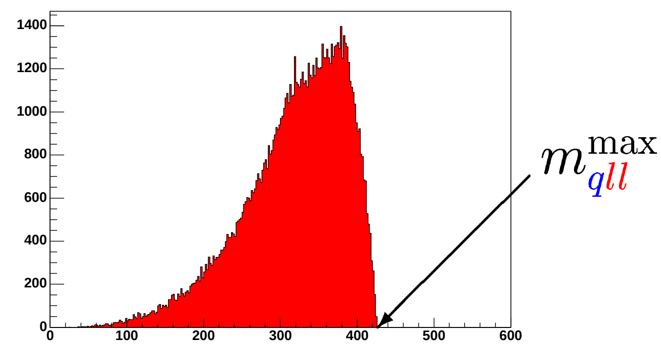
ENDPOINT METHOD



Construct mass distribution of the SM particles.

Kinematical endpoints relate to masses of intermediate sparticles





2 particles (l_n,l_f) $\Longrightarrow$ 1 mass distribution (3 unknown masses)

3 particles (q_f,l_n,l_f) $\Longrightarrow$ 4 mass distributions (4 unknown masses)

[4 particles (q_n,q_f,l_n,l_f) $\Longrightarrow$ 11 mass distributions (5 unknown masses)]

Complication:

Experimentally, cannot distinguish $l_{\rm n}$ from $l_{\rm f}$

Instead of $m_{ql_{\rm n}}$ and $m_{ql_{\rm f}}$, use distrubutions

$m_{ql({\rm high})} = \max(m_{ql_{\rm n}}, m_{ql_{\rm f}})$

$m_{ql({\rm low})} = \min(m_{ql_{\rm n}}, m_{ql_{\rm f}})$

(constructed on an event by event basis)

Additional endpoint:

m_{ll} carry exact information on angle between leptons in $\tilde{l}_R$ rest frame

Can combine m_{qll} with this info to get

$m_{qll(\theta>\frac{\pi}{2})}$ (threshold)

$$(m_{ll}^{\max})^2 = (m_{\tilde\chi_2^0}^2 - m_{\tilde l_R}^2)(m_{\tilde l_R}^2 - m_{\tilde\chi_1^0}^2)/m_{\tilde l_R}^2$$

$$(m_{qll}^{\max})^2 = \begin{cases} \frac{(m_{\tilde q_L}^2 - m_{\tilde\chi_2^0}^2)(m_{\tilde\chi_2^0}^2 - m_{\tilde\chi_1^0}^2)}{m_{\tilde\chi_2^0}^2} & \text{for } \frac{m_{\tilde q_L}}{m_{\tilde\chi_2^0}} > \frac{m_{\tilde\chi_2^0}}{m_{\tilde l_R}}\frac{m_{\tilde l_R}}{m_{\tilde\chi_1^0}} \quad (1) \\ \frac{(m_{\tilde q_L}^2 m_{\tilde l_R}^2 - m_{\tilde\chi_2^0}^2 m_{\tilde\chi_1^0}^2)(m_{\tilde\chi_2^0}^2 - m_{\tilde l_R}^2)}{m_{\tilde\chi_2^0}^2 m_{\tilde l_R}^2} & \text{for } \frac{m_{\tilde\chi_2^0}}{m_{\tilde l_R}} > \frac{m_{\tilde l_R}}{m_{\tilde\chi_1^0}}\frac{m_{\tilde q_L}}{m_{\tilde\chi_2^0}} \quad (2) \\ \frac{(m_{\tilde q_L}^2 - m_{\tilde l_R}^2)(m_{\tilde l_R}^2 - m_{\tilde\chi_1^0}^2)}{m_{\tilde l_R}^2} & \text{for } \frac{m_{\tilde l_R}}{m_{\tilde\chi_1^0}} > \frac{m_{\tilde q_L}}{m_{\tilde\chi_2^0}}\frac{m_{\tilde\chi_2^0}}{m_{\tilde l_R}} \quad (3) \\ (m_{\tilde q_L} - m_{\tilde\chi_1^0})^2 & \text{otherwise} \quad (4) \end{cases}$$

$$(m_{ql(\text{low})}^{\max}, m_{ql(\text{high})}^{\max}) = \begin{cases} (m_{ql_\text{n}}^{\max}, m_{ql_\text{f}}^{\max}) & \text{for } 2m_{\tilde l_R}^2 > m_{\tilde\chi_1^0}^2 + m_{\tilde\chi_2^0}^2 > 2m_{\tilde\chi_1^0}m_{\tilde\chi_2^0} \quad (1) \\ (m_{ql(\text{eq})}^{\max}, m_{ql_\text{f}}^{\max}) & \text{for } m_{\tilde\chi_1^0}^2 + m_{\tilde\chi_2^0}^2 > 2m_{\tilde l_R}^2 > 2m_{\tilde\chi_1^0}m_{\tilde\chi_2^0} \quad (2) \\ (m_{ql(\text{eq})}^{\max}, m_{ql_\text{n}}^{\max}) & \text{for } m_{\tilde\chi_1^0}^2 + m_{\tilde\chi_2^0}^2 > 2m_{\tilde\chi_1^0}m_{\tilde\chi_2^0} > 2m_{\tilde l_R}^2 \quad (3) \end{cases}$$

$$(m_{ql_\text{n}}^{\max})^2 = (m_{\tilde q_L}^2 - m_{\tilde\chi_2^0}^2)(m_{\tilde\chi_2^0}^2 - m_{\tilde l_R}^2)/m_{\tilde\chi_2^0}^2$$

$$(m_{ql_\text{f}}^{\max})^2 = (m_{\tilde q_L}^2 - m_{\tilde\chi_2^0}^2)(m_{\tilde l_R}^2 - m_{\tilde\chi_1^0}^2)/m_{\tilde l_R}^2$$

$$(m_{ql(\text{eq})}^{\max})^2 = (m_{\tilde q_L}^2 - m_{\tilde\chi_2^0}^2)(m_{\tilde l_R}^2 - m_{\tilde\chi_1^0}^2)/(2m_{\tilde l_R}^2 - m_{\tilde\chi_1^0}^2)$$

Note 1: mass *differences*
Note 2: multiple expressions define 9 mass regions (i,j)

Masses from endpoints: 2 methods

1. Analytical inversion of 4 endpoint formulae $m_{ll}^{\max}, m_{qll}^{\max}, m_{ql(\mathrm{high})}^{\max}, m_{ql(\mathrm{low})}^{\max}$

   – only possible if #endpoints = #masses

   + transparent w.r.t. endpoint dependence

   + transparent w.r.t. multiple mass regions

   – unique set of inversion formulae for each 6/9 mass region

   – In 3/9 regions the 4 endpoints are not independent: need 5$^{\mathrm{th}}$ endpoint

2. Numerical fit

   - only way if #endpoints > #masses
   - not transparent
   - need to look for several minima
   - difficult near borders between mass regions;

     e.g. $m_{qll}^{\max}$ is continuous across borders, but not its derivatives

     $\Longrightarrow$ challenge for some minimisers

1. Inversion formulae for mass region *(1,1)*:

$$m^2_{\tilde{\chi}^0_1} = \frac{\left[(m^{\max}_{qll})^2 - (m^{\max}_{ql(\text{high})})^2\right]\left[(m^{\max}_{qll})^2 - (m^{\max}_{ql(\text{low})})^2\right]}{\left[(m^{\max}_{ql(\text{low})})^2 + (m^{\max}_{ql(\text{high})})^2 - (m^{\max}_{qll})^2\right]^2}(m^{\max}_{ll})^2$$

$$m^2_{\tilde{l}_R} = \frac{(m^{\max}_{ql(\text{low})})^2\left[(m^{\max}_{qll})^2 - (m^{\max}_{ql(\text{low})})^2\right]}{\left[(m^{\max}_{ql(\text{low})})^2 + (m^{\max}_{ql(\text{high})})^2 - (m^{\max}_{qll})^2\right]^2}(m^{\max}_{ll})^2$$

$$m^2_{\tilde{\chi}^0_2} = \frac{(m^{\max}_{ql(\text{low})})^2(m^{\max}_{ql(\text{high})})^2}{\left[(m^{\max}_{ql(\text{low})})^2 + (m^{\max}_{ql(\text{high})})^2 - (m^{\max}_{qll})^2\right]^2}(m^{\max}_{ll})^2$$

$$m^2_{\tilde{q}_L} = \frac{(m^{\max}_{ql(\text{low})})^2(m^{\max}_{ql(\text{high})})^2\left[(m^{\max}_{ql(\text{low})})^2 + (m^{\max}_{ql(\text{high})})^2 - (m^{\max}_{qll})^2 + (m^{\max}_{ll})^2\right]}{\left[(m^{\max}_{ql(\text{low})})^2 + (m^{\max}_{ql(\text{high})})^2 - (m^{\max}_{qll})^2\right]^2}$$

Similiar expressions (sometimes more difficult) are found for the other of 6 mass regions where the four endpoints are independent.

2. Numerical fit:

Minimise the least-square function,

$$\Sigma = [\mathbf{E}^{\rm exp} - \mathbf{E}^{\rm th}(\mathbf{m})]^T \mathbf{W} [\mathbf{E}^{\rm exp} - \mathbf{E}^{\rm th}(\mathbf{m})] \tag{1}$$

$\mathbf{W}$: 'Weight matrix', is the inverse of the ...

$\mathbf{W}^{-1}$: 'Covariance matrix'/'Error matrix'

$$(\mathbf{W}^{-1})_{ii} = \sigma_{ii}^{\rm stat} + \sigma_{ii}^{\rm scale} = (\sigma_i^{\rm stat})^2 + (\sigma_i^{\rm scale})^2$$

$$(\mathbf{W}^{-1})_{ij} = \sigma_{ij}^{\rm scale} = \langle E_i^{\rm exp} E_j^{\rm exp} \rangle - \langle E_i^{\rm exp} \rangle \langle E_j^{\rm exp} \rangle = \sigma_i^{\rm scale} \sigma_j^{\rm scale}, \quad i \neq j$$

$$(\mathbf{W}^{-1})_{i1} = 0, \quad i \neq 1 \quad (i = 1 \text{ corresponds to } m_{ll}^{\rm max})$$

$\sigma_i^{\rm stat}$: statistical error of endpoint i

$\sigma_i^{\rm scale}$: systematic error of endpoint i due to jet (and lepton) energy scale uncertainty in ATLAS

APPLICABILITY OF METHOD

Require ($m_{\tilde{g}} >$) $m_{\tilde{q}_L} > m_{\tilde{\chi}_2^0} > m_{\tilde{l}_R} > m_{\tilde{\chi}_1^0}$

Require sufficient cross-section

Require sufficient branching ratio

mSUGRA: 4/5 parameters: $m_0, m_{1/2}, A_0, \tan\beta, \mathrm{sign}(\mu)$

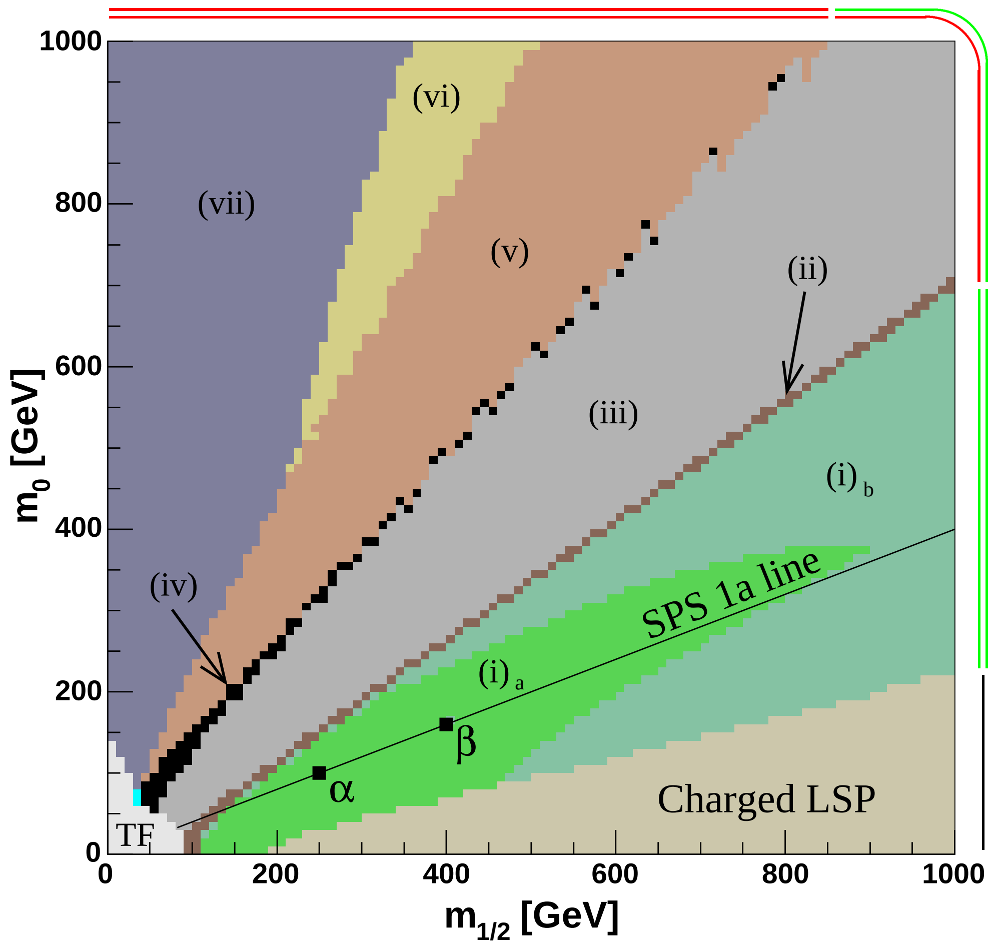
Nearly always: $m_{\tilde{g}}, m_{\tilde{q}_L} > m_{\tilde{\chi}_2^0}, m_{\tilde{l}_R}$

$m_{\tilde{g}} < m_{\tilde{q}_L}$

$m_{\tilde{\chi}_2^0} < m_{\tilde{l}_R}$

$m_{\tilde{g}} > m_{\tilde{q}_L}$

$m_{\tilde{\chi}_2^0} < m_{\tilde{l}_R}$

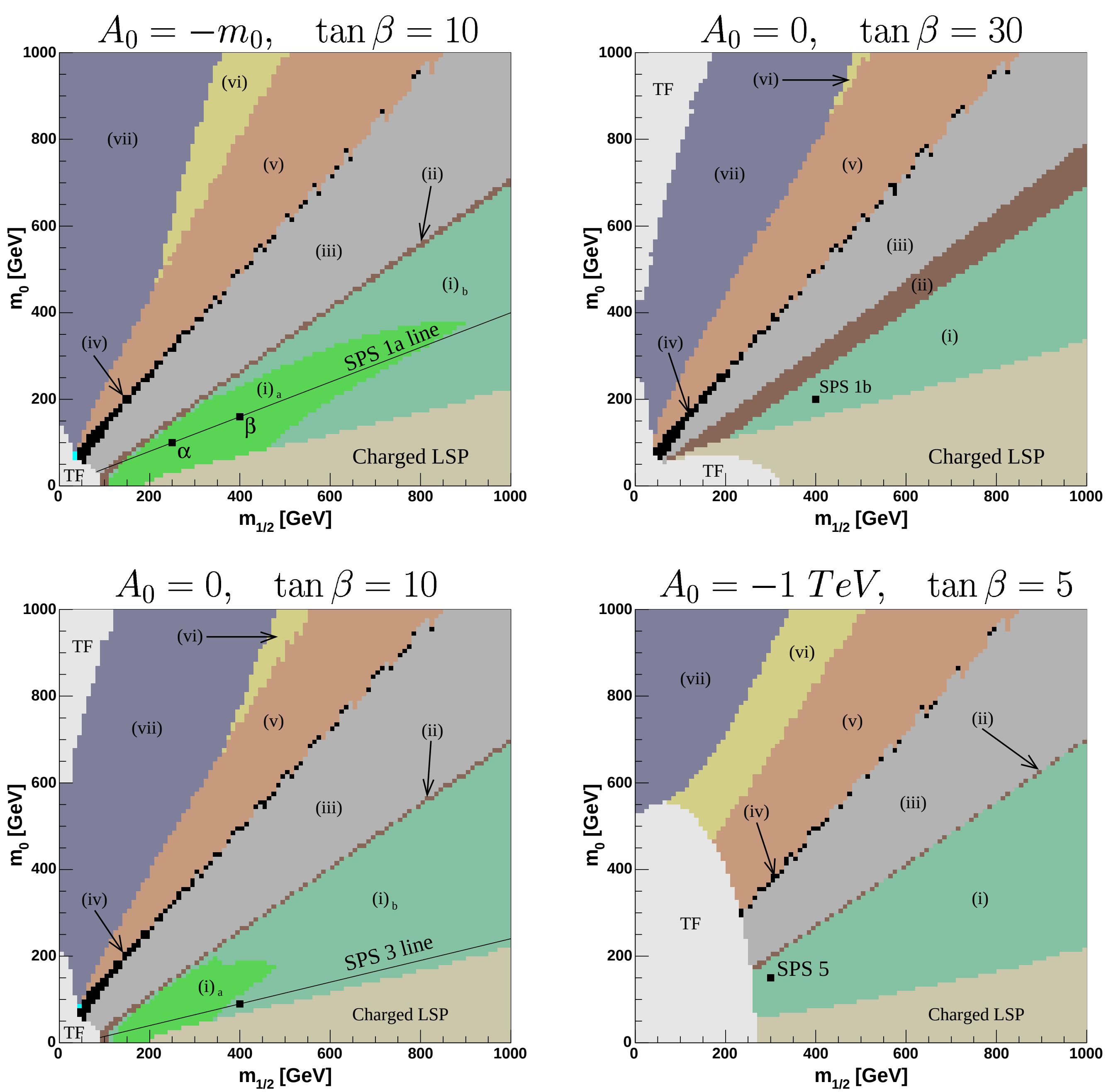


$m_{\tilde{g}} > m_{\tilde{q}_L}$

$m_{\tilde{\chi}_2^0} > m_{\tilde{l}_R}$ (ok)

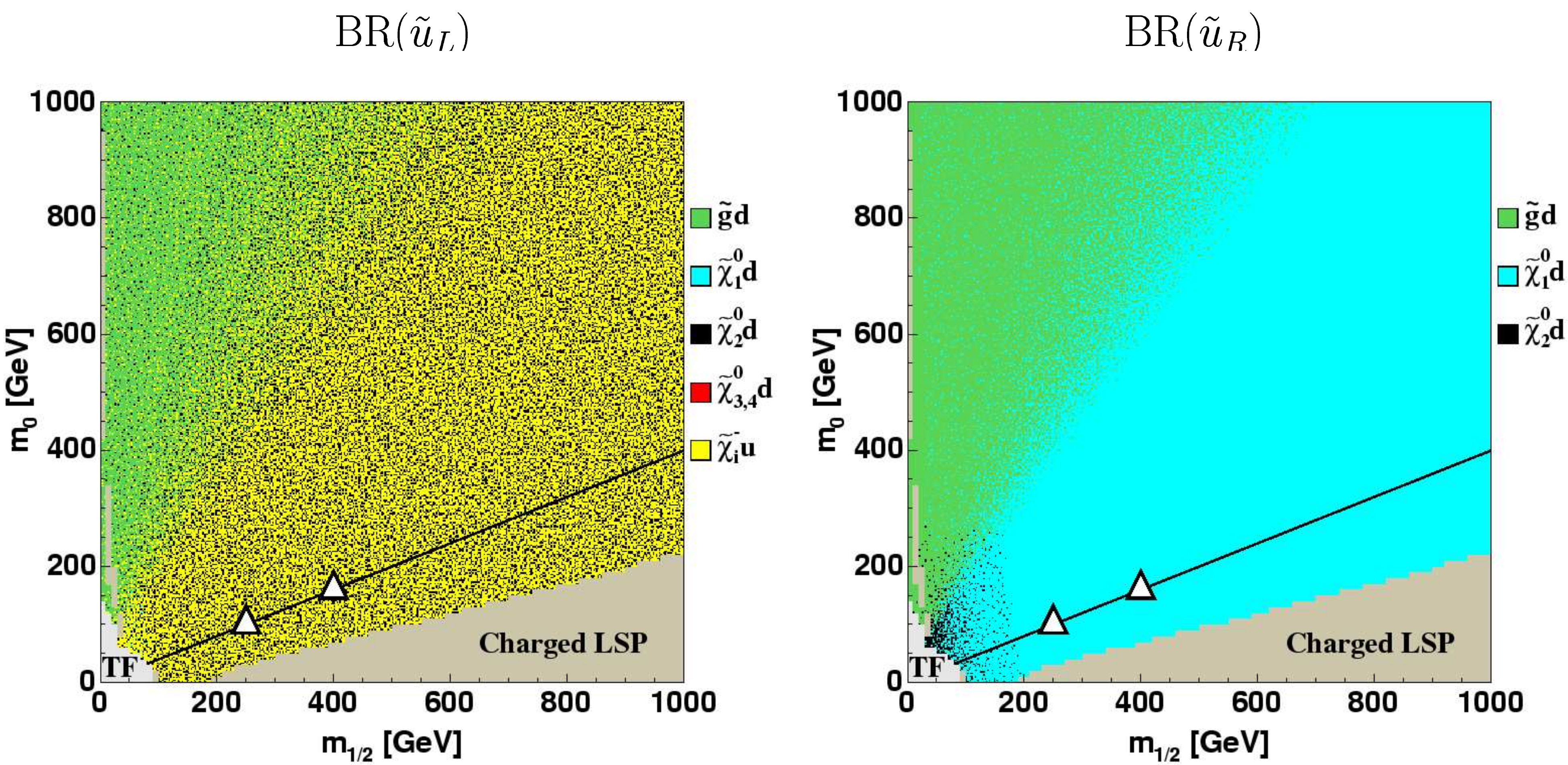
$m_{\tilde{\tau}_1} < m_{\tilde{\chi}_1^0}$

$$A_0 = -m_0, \quad \tan\beta = 10, \quad \mu > 0$$


$A_0 = -m_0, \quad \tan\beta = 10$
(vii)
(vi)
(v)
(iv)
(iii)
(ii)
(i)$_b$
(i)$_a$
SPS 1a line
α
β
Charged LSP
TF
$A_0 = 0, \quad \tan\beta = 30$
TF
(vi)
(vii)
(v)
(iv)
(iii)
(ii)
(i)
SPS 1b
Charged LSP
TF
$A_0 = 0, \quad \tan\beta = 10$
TF
(vi)
(vii)
(v)
(iv)
(iii)
(ii)
(i)$_b$
(i)$_a$
SPS 3 line
Charged LSP
TF
$A_0 = -1\,TeV, \quad \tan\beta = 5$
(vii)
(vi)
(v)
(iv)
(iii)
(ii)
(i)
TF
SPS 5
Charged LSP
m_0 [GeV]
$m_{1/2}$ [GeV]

Branching ratios ($A_0 = -m_0, \ \tan\beta = 10, \ \mu > 0$)

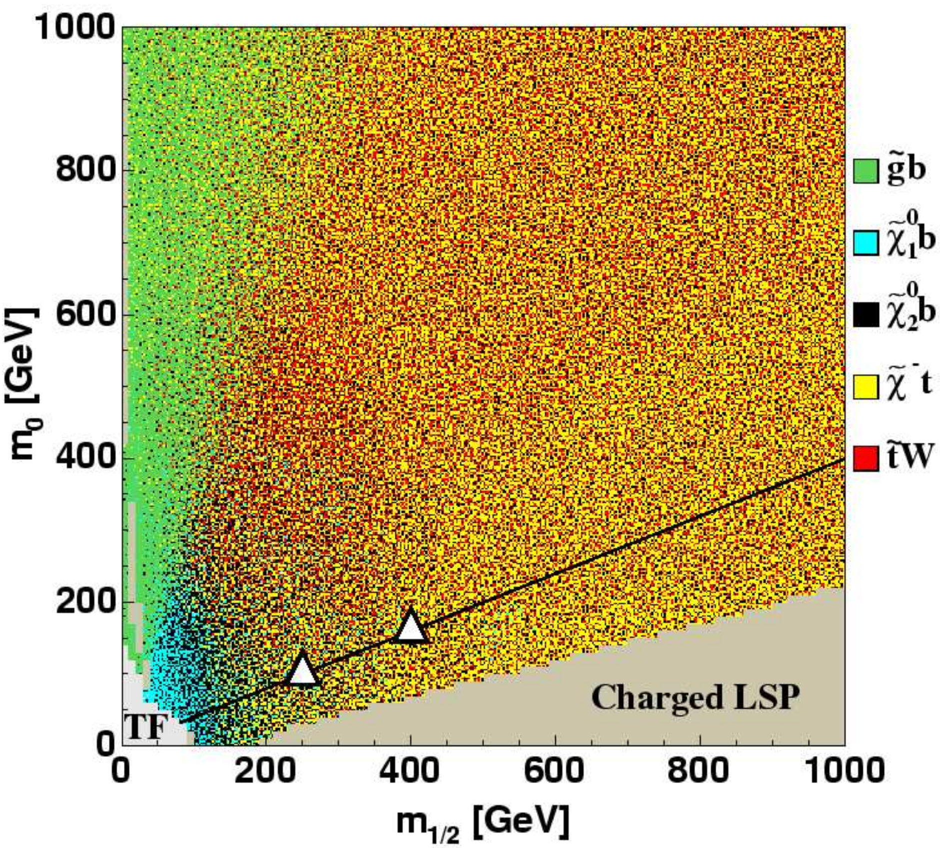
How to read the plots: The branching ratio of a given decay channel in a specific region of the $m_{1/2}$-m_0 plane is equal to the fraction which the corresponding colour occupies in that region.



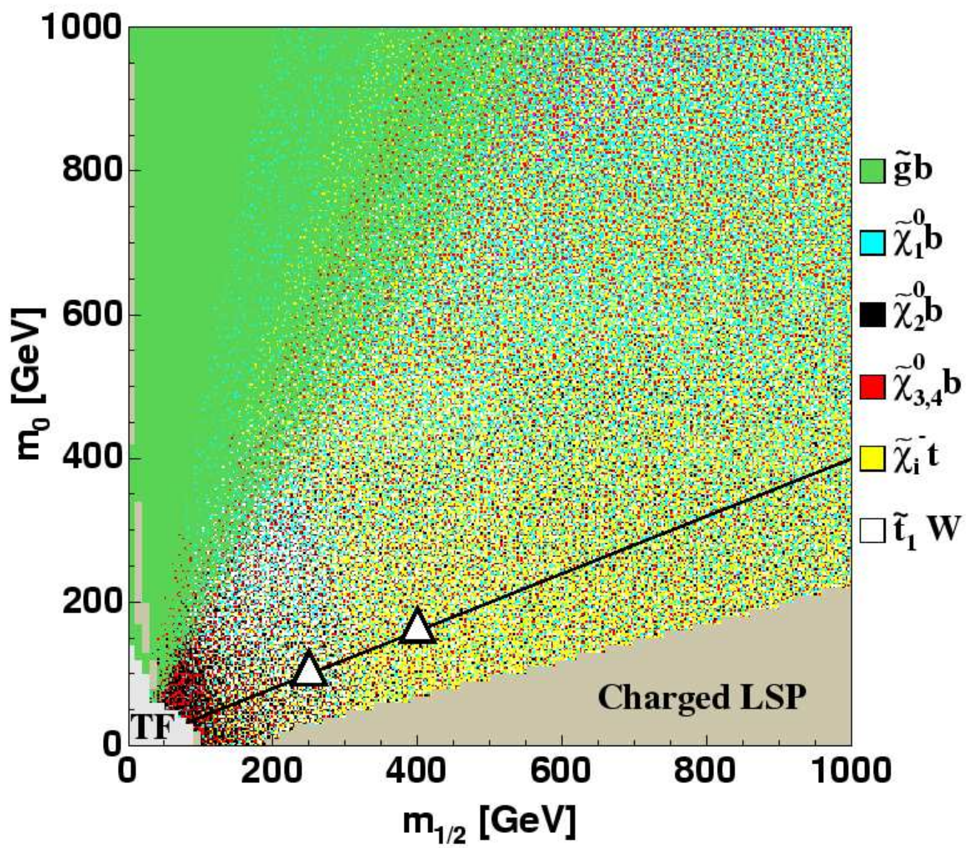
Two triangles are SPS1a (α) and (β).

Branching ratios

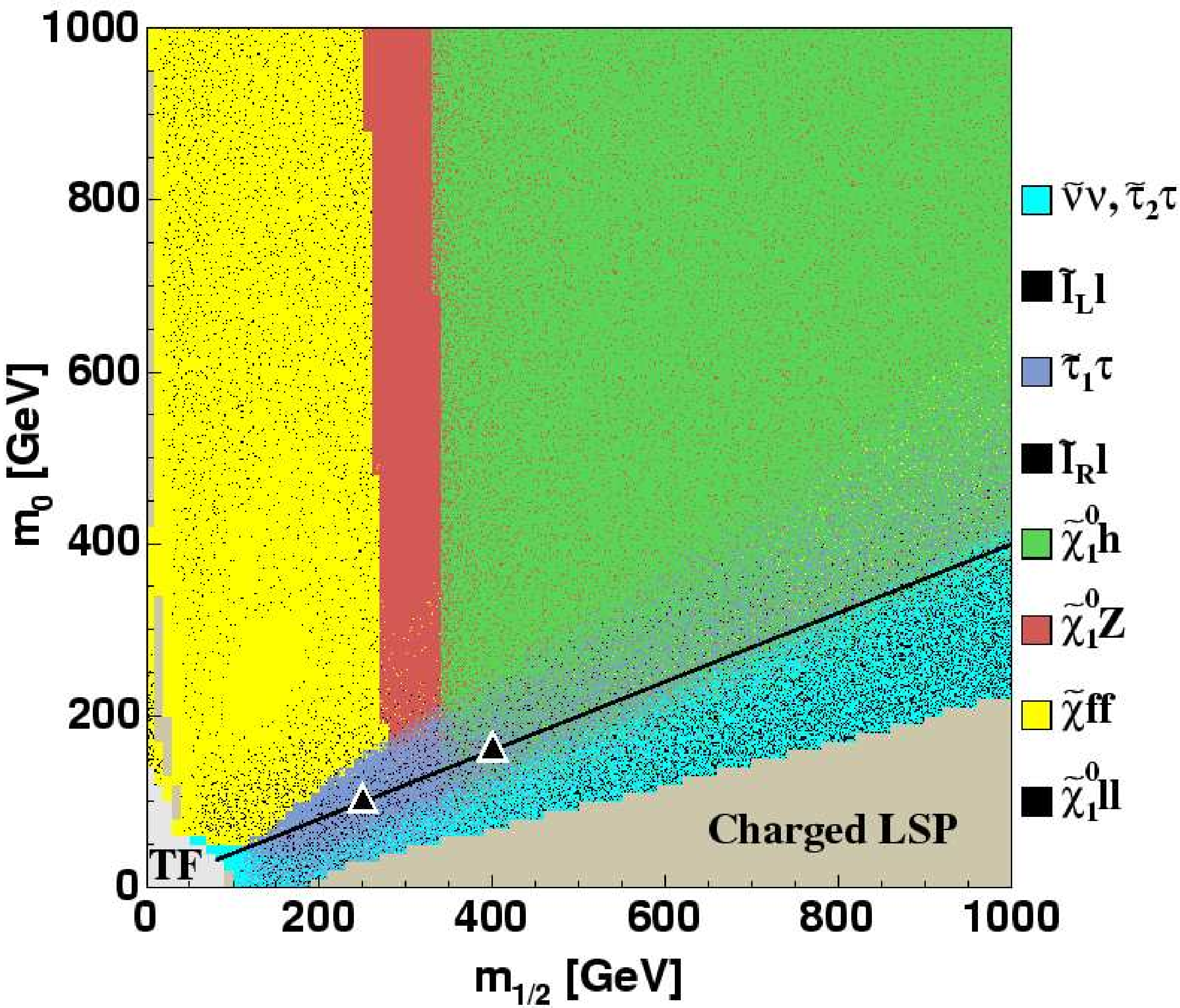
$\mathrm{BR}(\tilde{b}_1)$



$\mathrm{BR}(\tilde{b}_2)$



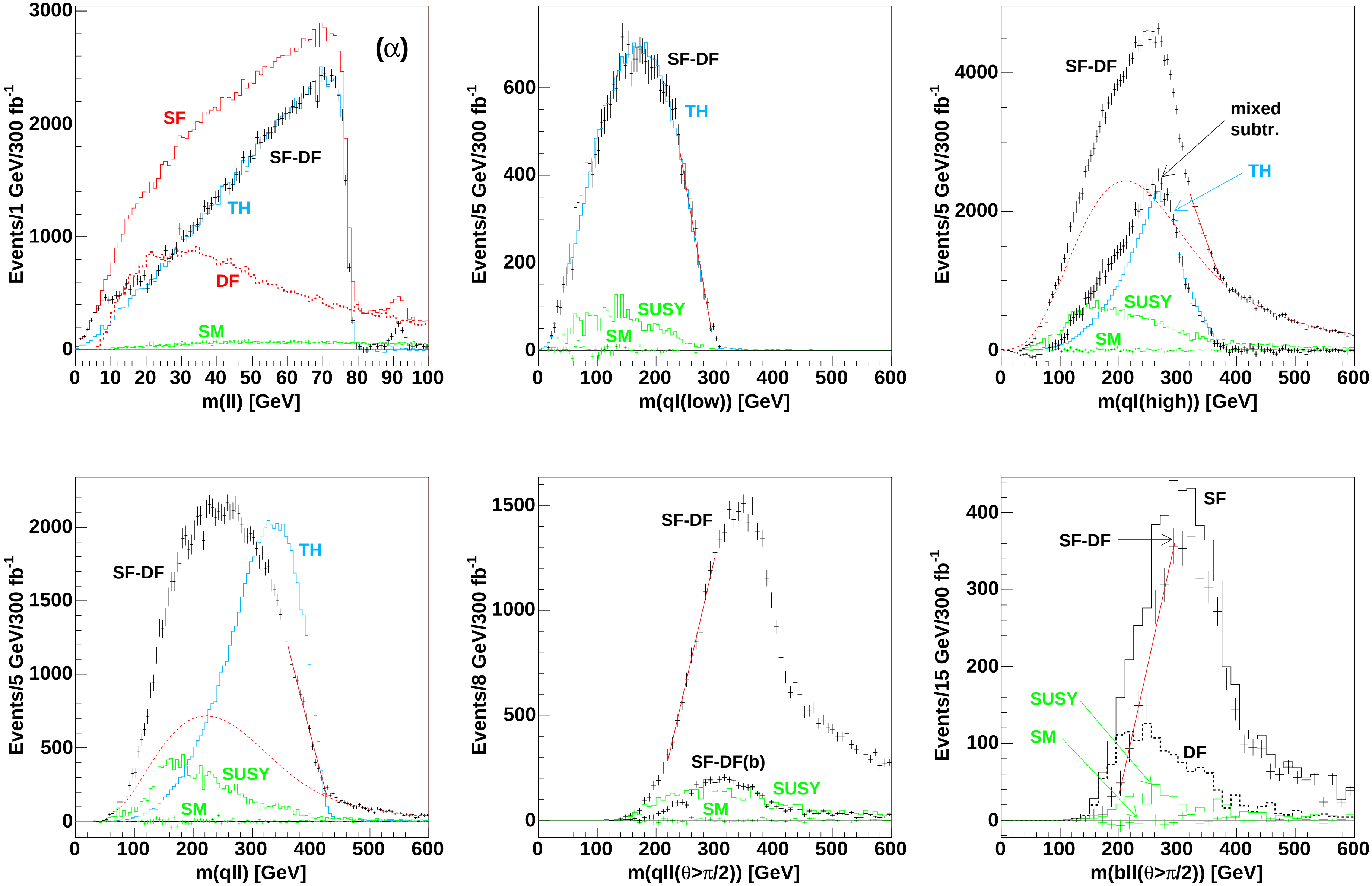
$\mathrm{BR}(\tilde{\chi}_2^0)$



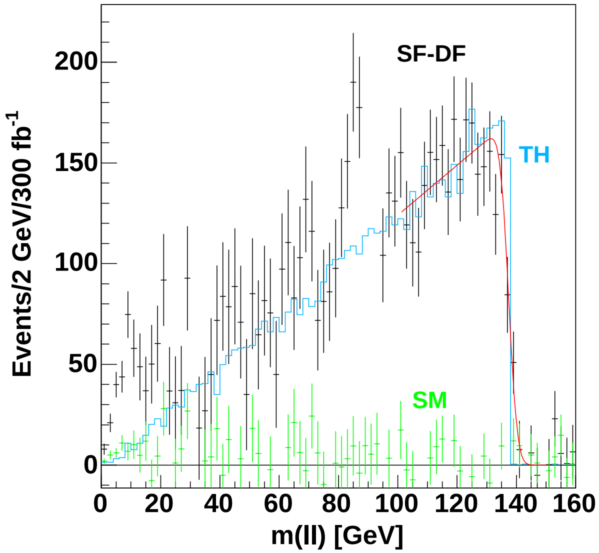
SIMULATION: SPS 1a (α) and (β)

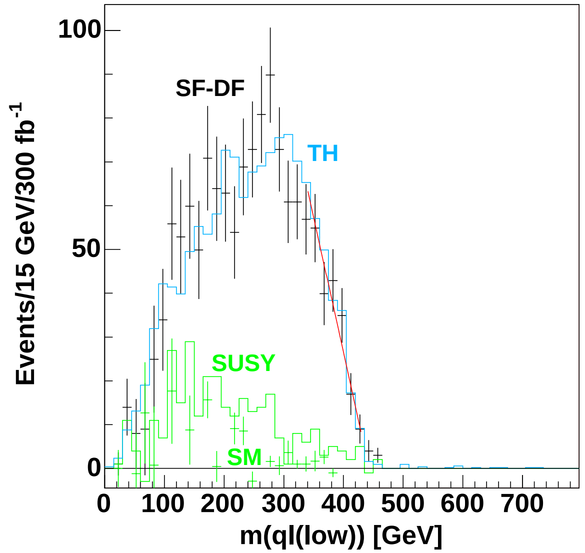
- 'Standard precuts':
  - At least three jets, satisfying: $p_T^{\rm jet} > 150, 100, 50$ GeV
  - $E_{T,\rm miss} > \max(100 \text{ GeV}, 0.2 M_{\rm eff})$ with $M_{\rm eff} \equiv E_{T,\rm miss} + \sum_{i=1}^{3} p_{T,i}^{\rm jet}$
  - Two isolated opposite-sign same-flavour (SF) leptons, $p_T^{\rm lep} > 20, 10$ GeV
- Lepton selection: ok
- Jet selection: selecting incorrect jet gives 'Combinatorial background'
- Multiple squark masses, b-tagging, ... [mSUGRA: degenerate squarks]
- Different-Flavour (DF) subtraction:
  - 'Lepton-uncorrelated background' produces same amount of SF $= e^+e^- + \mu^+\mu^-$ and DF $= e^+\mu^- + \mu^+e^-$.
  - SF and DF have same characteristics (event shape etc.)
  - SF−DF = SF(signal)+SF(bck)−DF(bck) = SF(signal) [statistically]
- Standard Model background is tiny for (α), sizeable for (β)
- Main ('lepton-correlated') background comes from other SUSY processes

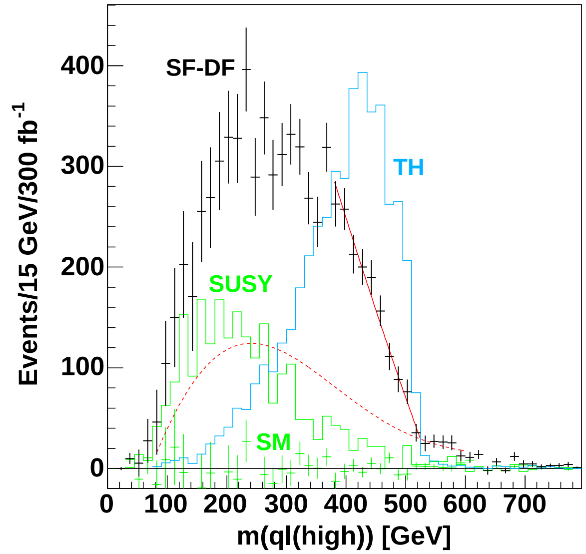
SPS 1a (α)

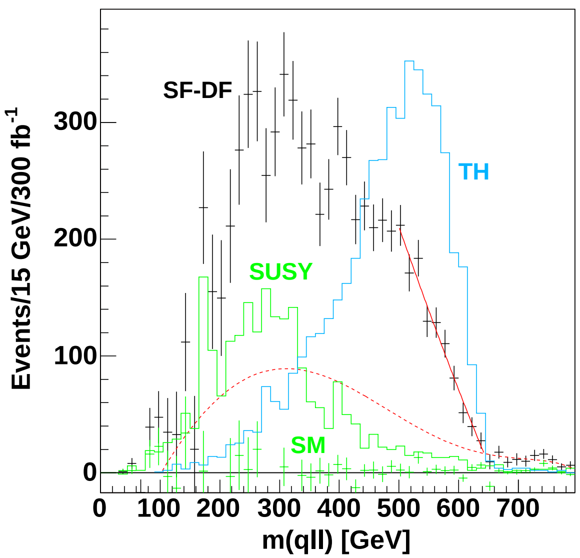

(α)
SF
SF-DF
TH
DF
SM
Events/1 GeV/300 fb-1
m(ll) [GeV]
SF-DF
TH
SUSY
SM
Events/5 GeV/300 fb-1
m(ql(low)) [GeV]
SF-DF
mixed
subtr.
TH
SUSY
SM
Events/5 GeV/300 fb-1
m(ql(high)) [GeV]
SF-DF
TH
SUSY
SM
Events/5 GeV/300 fb-1
m(qll) [GeV]
SF-DF
SF-DF(b)
SUSY
SM
Events/8 GeV/300 fb-1
m(qll(θ>π/2)) [GeV]
SF
SF-DF
SUSY
SM
DF
Events/15 GeV/300 fb-1
m(bll(θ>π/2)) [GeV]

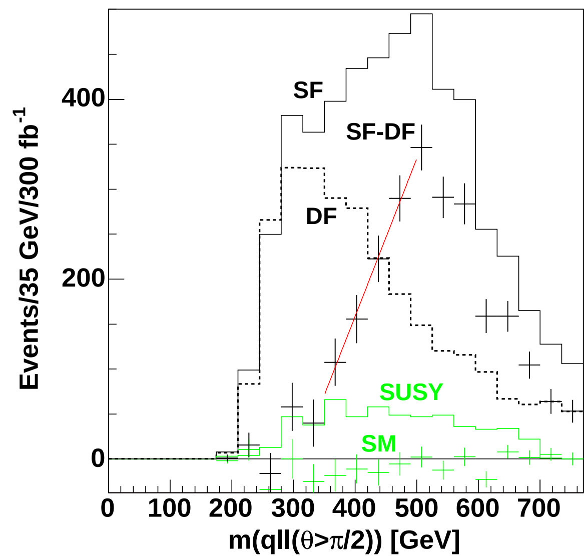
SPS 1a (β)


SF-DF
TH
SM
Events/2 GeV/300 fb-1
m(ll) [GeV]


SF-DF
TH
SUSY
SM
Events/15 GeV/300 fb-1
m(ql(low)) [GeV]


SF-DF
TH
SUSY
SM
Events/15 GeV/300 fb-1
m(ql(high)) [GeV]


SF-DF
TH
SUSY
SM
Events/15 GeV/300 fb-1
m(qll) [GeV]

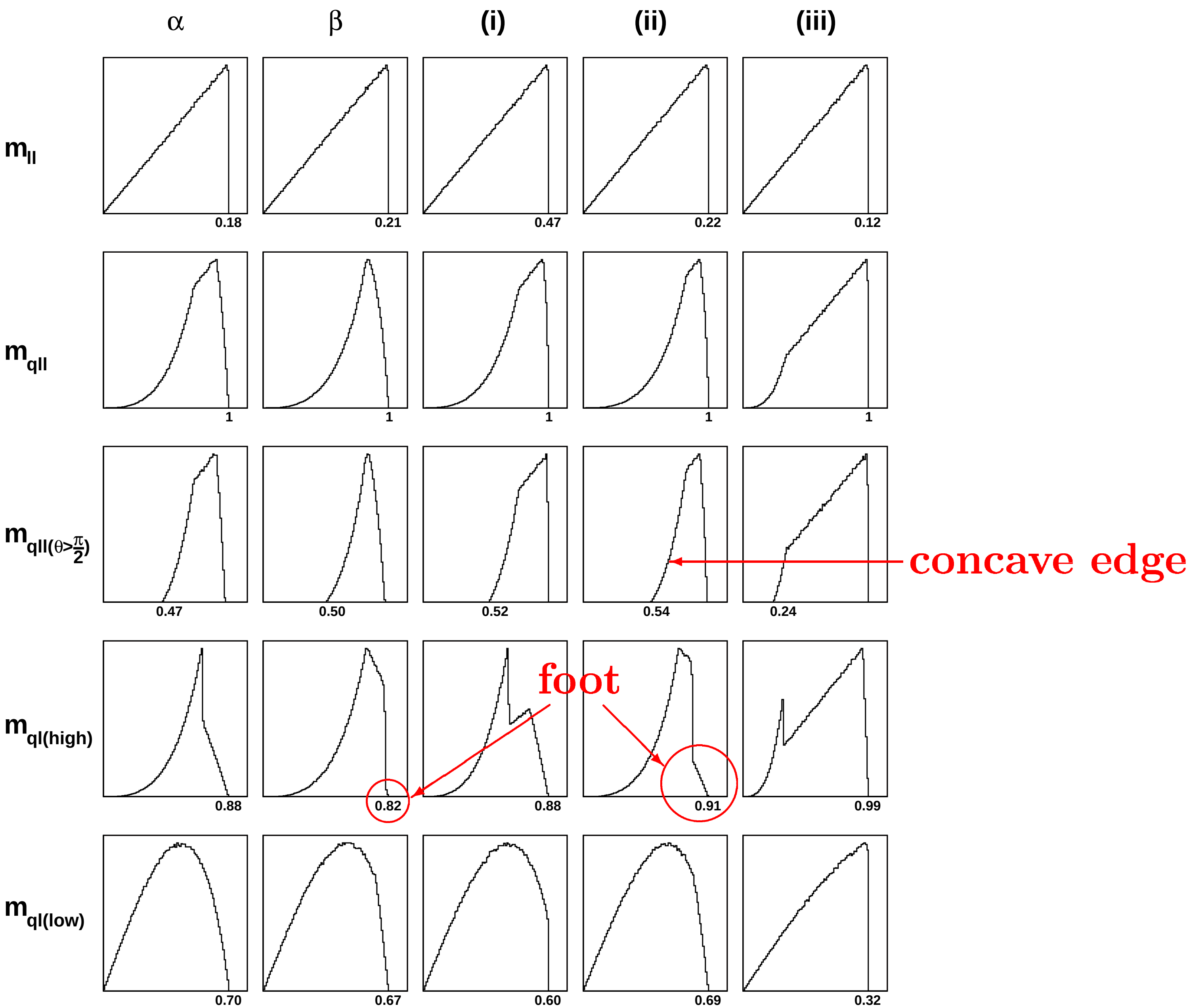

SF
SF-DF
DF
SUSY
SM
Events/35 GeV/300 fb-1
m(qll(θ>π/2)) [GeV]

- Fit to obtain endpoints:
  - signal hypothesis: straight line
  - background hypothesis: (unknown) use polynomial/exponential or mixed events
  - At **present**: **systematics** of fitting procedure are **sizeable**
  - Future: **systematics** below statistical error for most endpoints

  $\Rightarrow$ (Need more study)

- Danger:
  - non-linearity of theory distribution
  - 'foot' in theory distribution

Theory Distributions



Energy Scale Error (differs from LHC/ILC report)

Lepton: 0.1%

Jet: 1%

$\Rightarrow m_{ll}$: 0.1%

$\Rightarrow m_{qq}$: 1%

$\Rightarrow m_{ql}$: 0.5% (!)

$$\left(\frac{\sigma(m_{ql})}{m_{ql}} = \frac{\sigma(m_{ql}^2)}{2m_{ql}^2} = \frac{1}{2}\sqrt{\left(\frac{\sigma(E_j)}{E_j}\right)^2 + \left(\frac{\sigma(E_l)}{E_l}\right)^2} = 0.50\% \right)$$

$\Rightarrow m_{qll} \in (0.1\%, 0.5\%)$ (!)

not even constant

different for different mass scenarios, but always $\in (0.1\%, 0.5\%)$

we have used a constant value 0.5%

correct for SPS 1a is a little lower $\sim$(0.4-0.5)%

Edge	Nominal Value [GeV]	Fit Value [GeV]	Energy Scale Error ($\sigma^{\rm scale}$) [GeV]	Statistical Error ($\sigma^{\rm stat}$) [GeV]	Syst. Fit Error [GeV]
(α)					
$m_{ll}^{\max}$	77.07	76.72	0.08	0.04	0.1
$m_{qll}^{\max}$	425.9	427.7	2.1	0.9	0.5
$m_{ql(\rm low)}^{\max}$	298.5	300.7	1.5	0.9	0.5
$m_{ql(\rm high)}^{\max}$	375.8	374.0	1.9	1.0	0.5
$m_{qll(\theta>\frac{\pi}{2})}^{\min}$	200.7	-	1.0	2.2	2.0
$m_{bll(\theta>\frac{\pi}{2})}^{\min}$	183.1	-	0.9	4.5	4.0
(β)					
$m_{ll}^{\max}$	137.9	137.4	0.14	0.5	0.1
$m_{qll}^{\max}$	649.1	647.0	3.2	5.0	3.0
$m_{ql(\rm low)}^{\max}$	436.6	443.0	2.2	6.3	4.0
$m_{ql(\rm high)}^{\max}$	529.9	520.5	2.6	5.5	3.0
$m_{qll(\theta>\frac{\pi}{2})}^{\min}$	325.7	-	1.6	13.0	10.0

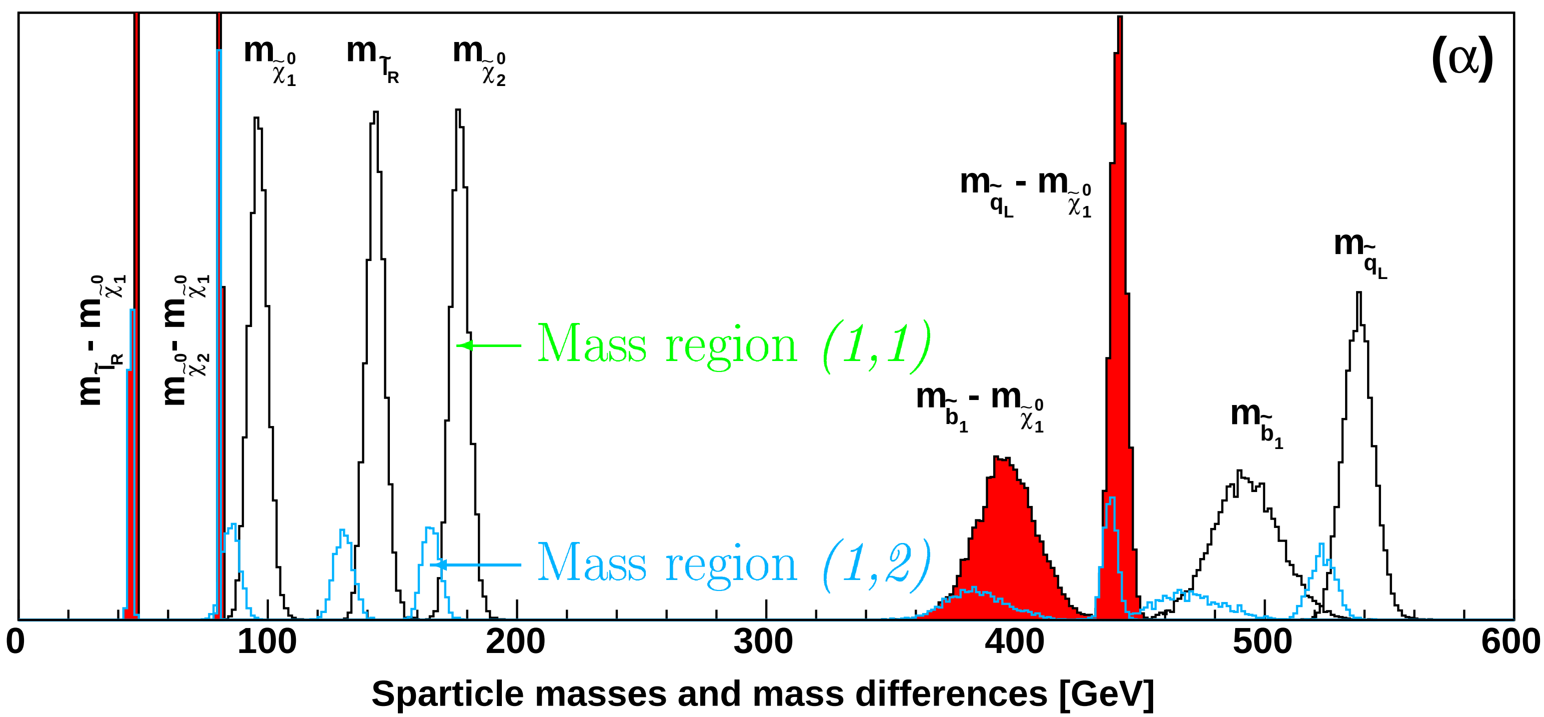
Masses from Endpoints

Method of 10,000 LHC experiments

- To estimate LHC potential, do not use fit values obtained
- Look at an ensemble of LHC experiments:
- Assume errors are normal distributed around nominal values for the ensemble
- For each experiments:
  - use (known) errors to construct measurements:
    $E_i^{\text{exp}} = E_i^{\text{nom}} + A_i \sigma_i^{\text{stat}} + B \sigma_i^{\text{scale}}$
    where A_i and B are picked from Gaussian distribution,
    σ_i^{stat} and σ_i^{scale} are from table
  - find corresponding set(s) of masses
- Investigate ensemble distributions

SPS 1a (α)

	# Minima	(1,1)	(1,2)
$\Delta\Sigma \leq 0$	1.00	90%	10%
$\mathbf{\Delta\Sigma \leq 1}$	**1.12**	**94%**	**17%**
$\Delta\Sigma \leq 3$	1.30	97%	33%
$\Delta\Sigma \leq \infty$	1.88	99%	88%



Note 1: Multiple minima for a given set of endpoint measurements.
Note 2: Mass differences more accurately determined than masses.

SPS 1a (α)

	Nom	(1,1) $\langle m \rangle$	σ	(1,2) $\langle m \rangle$	σ
LHC					
$m_{\tilde{\chi}_1^0}$	96.1	96.3	3.8	85.3	3.4
$m_{\tilde{l}_R}$	143.0	143.2	3.8	130.4	3.7
$m_{\tilde{\chi}_2^0}$	176.8	177.0	3.7	165.5	3.4
$m_{\tilde{q}_L}$	537.2	537.5	6.1	523.2	5.1
$m_{\tilde{b}_1}$	491.9	492.4	13.4	469.6	13.3
$m_{\tilde{l}_R} - m_{\tilde{\chi}_1^0}$	46.9	46.9	0.3	45.1	0.7
$m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$	80.8	80.8	0.2	80.2	0.3
$m_{\tilde{q}_L} - m_{\tilde{\chi}_1^0}$	441.2	441.3	3.1	438.0	2.7
$m_{\tilde{b}_1} - m_{\tilde{\chi}_1^0}$	395.9	396.2	12.0	384.4	12.0
LHC+LC	$\Rightarrow$ (1,2) **solution reduced to ~1%**				
$\tilde{\chi}_1^0$	96.05	96.05	0.05	96.04	0.05
$\tilde{l}_R$	142.97	142.97	0.29	141.90	0.79
$\tilde{\chi}_2^0$	176.82	176.82	0.17	176.34	0.36
$\tilde{q}_L$	537.25	537.22	2.49	537.55	2.67
$\tilde{b}_1$	491.92	492.06	11.68	488.87	11.59

SPS 1a (β)

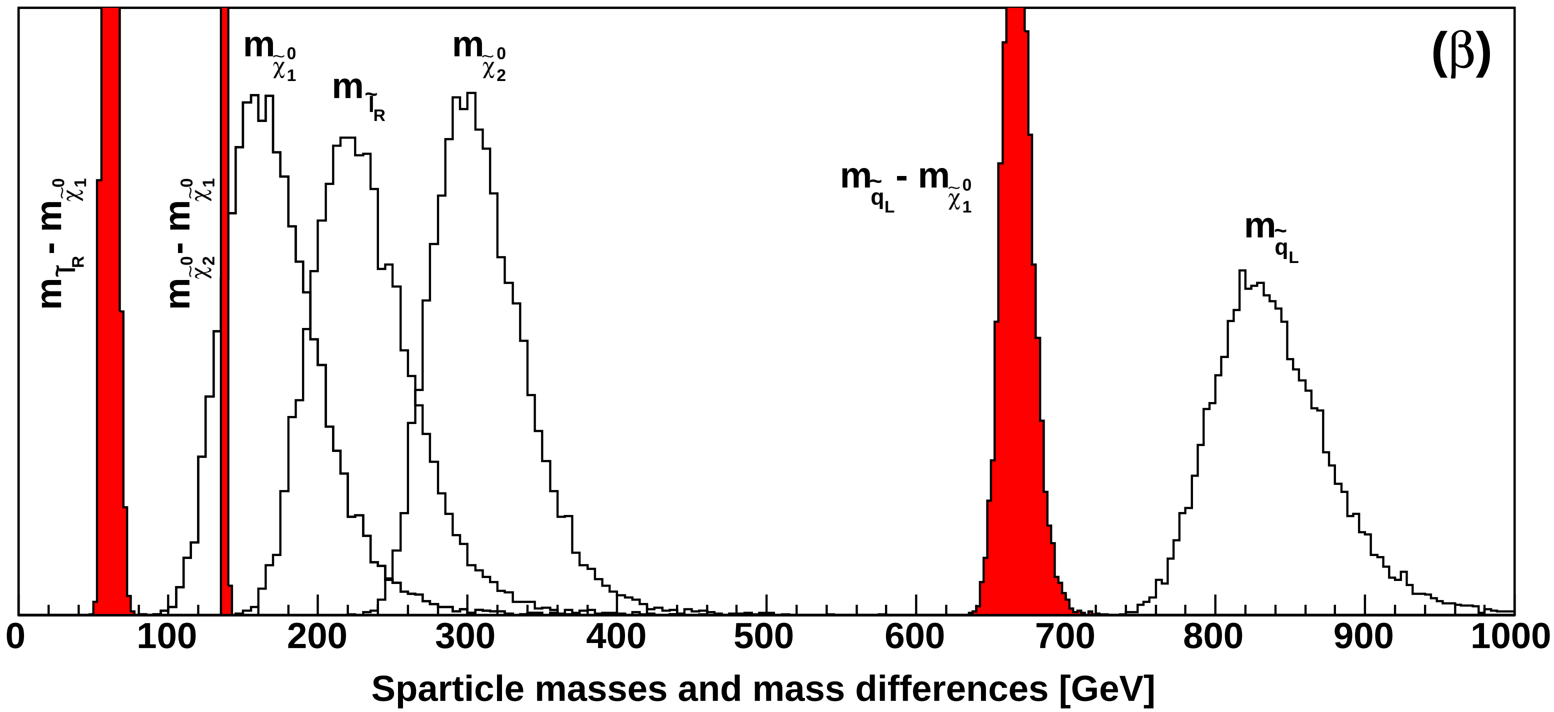
LHC						
			1 sol			2 sol
	# Min	*(1,1)*	*(1,2)*	*(1,3)*	B	*(1,2)&(1,3)*
$\Delta\Sigma \leq 0$	1.0	3%	60%	25%	12%	0%
$\Delta\Sigma \leq 1$	1.2	5%	**52%**	**18%**	**12%**	**16%**
$\Delta\Sigma \leq 3$	1.4	13%	46%	14%	12%	28%
$\Delta\Sigma \leq 99$	2.3	99%	41%	13%	12%	34%
LHC+LC						
$\Delta\Sigma \leq 0$	1.0	-	65%	26%	9%	0%
$\Delta\Sigma \leq 1$	1.2	-	52%	18%	9%	21%
$\Delta\Sigma \leq 3$	1.4	-	36%	10%	9%	45%
$\Delta\Sigma \leq 99$	1.6	-	24%	7%	9%	59%

SPS 1a (β)

					1 solution			2 solutions					
		(1,1)			(1,2)/(1,3)/B			(1,2)			(1,3)		
	Nom	$\langle m \rangle$	σ	γ_1	$\langle m \rangle$	σ	γ_1	$\langle m \rangle$	σ	γ_1	$\langle m \rangle$	σ	γ_1
LHC													
$\tilde{\chi}_1^0$	161	438	88	0.9	175	35	1.0	161	22	0.3	166	27	0.6
$\tilde{l}_R$	222	518	85	0.7	236	37	0.8	221	24	0.3	223	28	0.5
$\tilde{\chi}_2^0$	299	579	85	0.7	313	35	1.0	299	22	0.3	304	27	0.6
$\tilde{q}_L$	826	1146	104	0.8	843	44	0.9	826	30	0.3	835	36	0.5
$\tilde{l}_R - \tilde{\chi}_1^0$	61	81	1.8	-0.3	61	4.4	0.4	61	1.9	-0.2	57	1.3	-0.2
$\tilde{\chi}_2^0 - \tilde{\chi}_1^0$	138	141	0.9	0.1	138	0.6	0.2	138	0.5	0.0	138	0.5	0.0
$\tilde{q}_L - \tilde{\chi}_1^0$	665	708	17	0.1	668	10	0.5	665	9	0.1	669	10	0.2
LHC+LC													
					1 sol			(1,2)			(1,3)		
	Nom				$\langle m \rangle$	σ		$\langle m \rangle$	σ		$\langle m \rangle$	σ	
$\tilde{\chi}_1^0$	161.02		-		161.02	0.05	-	161.02	0.05	-	161.02	0.05	-
$\tilde{l}_R$	221.86		-		221.15	3.26	-	222.22	1.32	-	217.48	1.01	-
$\tilde{\chi}_2^0$	299.05		-		299.15	0.57	-	299.11	0.53	-	299.05	0.52	-
$\tilde{q}_L$	826.29		-		826.12	6.33	-	825.89	5.78	-	828.60	5.52	-

SPS 1a (β)

Both *(1,2) and (1,3)* solutions with $\Delta\Sigma \leq 1$, only LHC:



Skewed distributions, due to

– Large measurement errors

– ‘Border effect’

SUMMARY ('New' things in red)

Introduction (p. 2–3)

Endpoint Method (p. 4–9):

- Standard things (endpoint expressions, ...)
- Analytic inversion formulae
- Least-square function (correlations)
- Emphasis on multiple regions

Applicability of Method (p. 10–15):

- Hierarchy scans in $m_{1/2}$-m_0 plane
- Branching-ratio scans in $m_{1/2}$-m_0 plane
- Alternative way of presenting branching ratios in 2D

Simulation (p. 16–22):

- Attempt: Mixed event sample as background hypothesis
- Standard point: Sps 1a (α)
- New point: SPS 1a (β)
- Study of theory curves (foot, non-linearity)
- Energy Scale Error: new for m_{ql} and m_{qll}

Masses from Endpoints (p. 23–28):

10,000 LHC experiments

Multiple minima

Skewed ensemble distributions for SPS 1a (β)

LC fixes scale

LC reduces number of minima for (α), less so for (β)

OUTLOOK

Add gluino to the chain:

– Calculation of endpoints (done)

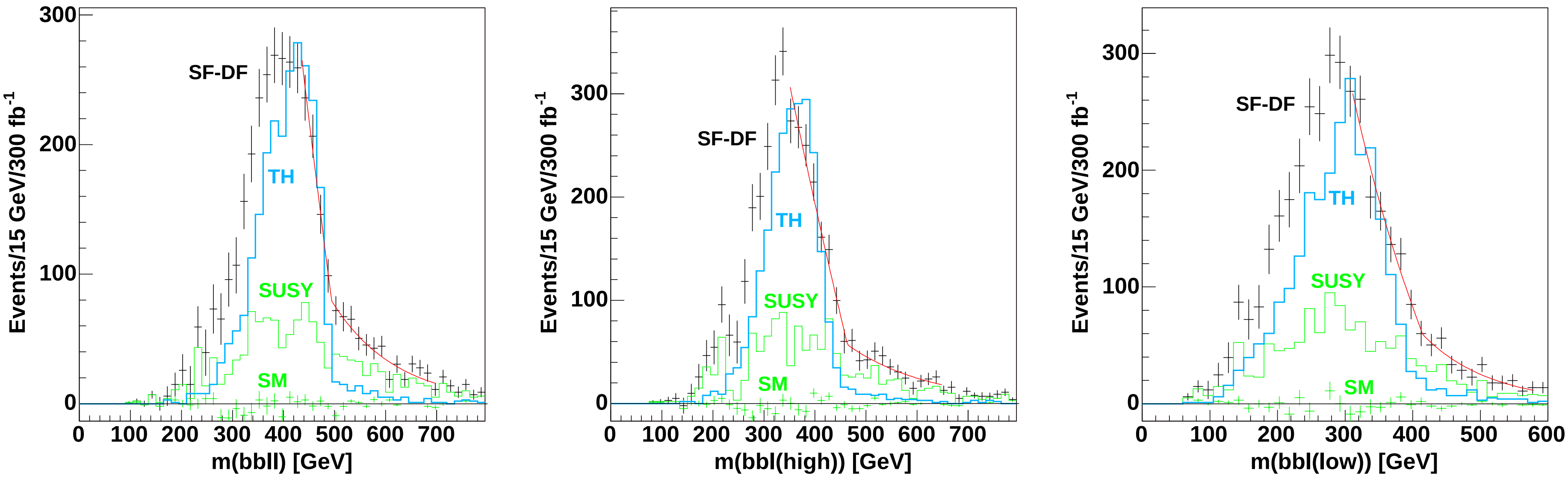
– Analysis at SPS 1a (α) (done)

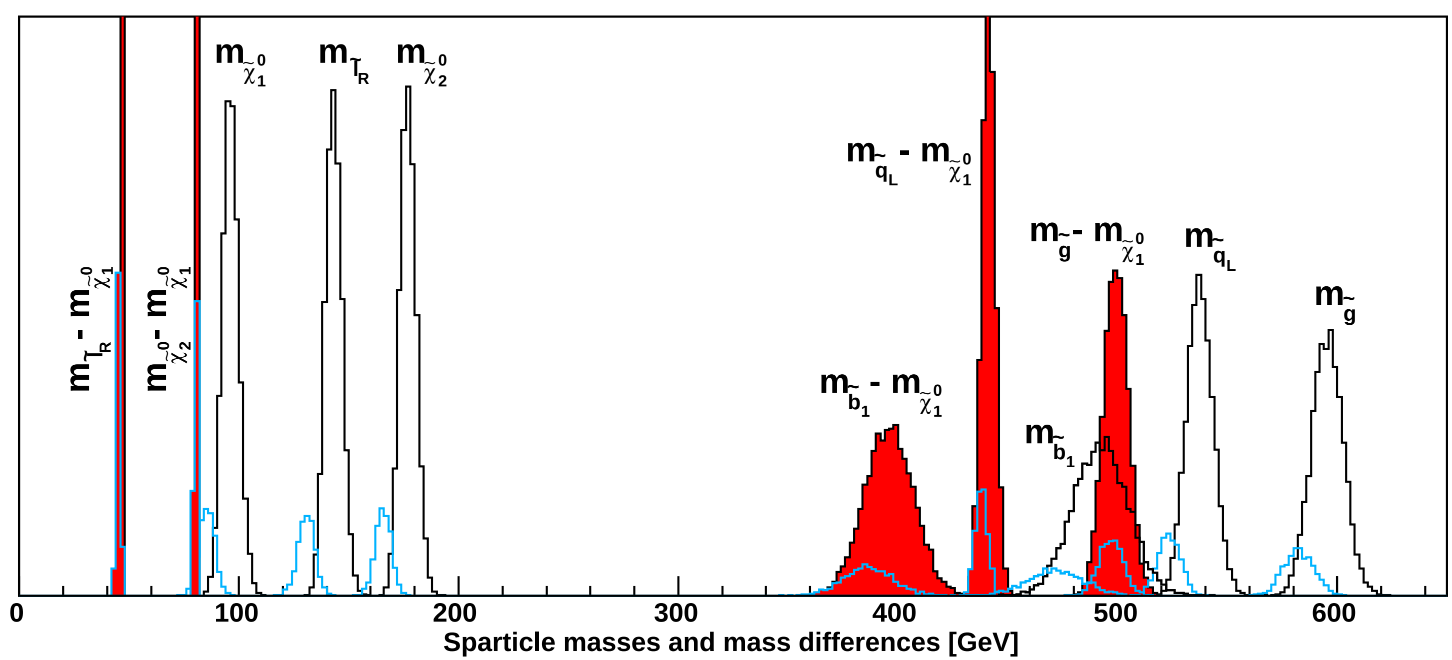
Paper nearly ready

The End

GLUINO

$$\left(m_{qqll}^{\max}\right)^2 = \left\{ \begin{array}{lll} \frac{\left(m_{\tilde{g}}^2 - m_{\tilde{q}_L}^2\right)\left(m_{\tilde{q}_L}^2 - m_{\tilde{\chi}_1^0}^2\right)}{m_{\tilde{q}_L}^2} & \text{for} \quad \frac{m_{\tilde{g}}}{m_{\tilde{q}_L}} > \frac{m_{\tilde{q}_L}}{m_{\tilde{\chi}_2^0}} \frac{m_{\tilde{\chi}_2^0}}{m_{\tilde{l}_R}} \frac{m_{\tilde{l}_R}}{m_{\tilde{\chi}_1^0}} & (1) \\ \frac{\left(m_{\tilde{g}}^2 m_{\tilde{\chi}_2^0}^2 - m_{\tilde{q}_L}^2 m_{\tilde{\chi}_1^0}^2\right)\left(m_{\tilde{q}_L}^2 - m_{\tilde{\chi}_2^0}^2\right)}{m_{\tilde{q}_L}^2 m_{\tilde{\chi}_2^0}^2} & \text{for} \quad \frac{m_{\tilde{q}_L}}{m_{\tilde{\chi}_2^0}} > \frac{m_{\tilde{\chi}_2^0}}{m_{\tilde{l}_R}} \frac{m_{\tilde{l}_R}}{m_{\tilde{\chi}_1^0}} \frac{m_{\tilde{g}}}{m_{\tilde{q}_L}} & (2) \\ \frac{\left(m_{\tilde{g}}^2 m_{\tilde{l}_R}^2 - m_{\tilde{\chi}_2^0}^2 m_{\tilde{\chi}_1^0}^2\right)\left(m_{\tilde{\chi}_2^0}^2 - m_{\tilde{l}_R}^2\right)}{m_{\tilde{\chi}_2^0}^2 m_{\tilde{l}_R}^2} & \text{for} \quad \frac{m_{\tilde{\chi}_2^0}}{m_{\tilde{l}_R}} > \frac{m_{\tilde{l}_R}}{m_{\tilde{\chi}_1^0}} \frac{m_{\tilde{g}}}{m_{\tilde{q}_L}} \frac{m_{\tilde{q}_L}}{m_{\tilde{\chi}_2^0}} & (3) \\ \frac{\left(m_{\tilde{g}}^2 - m_{\tilde{l}_R}^2\right)\left(m_{\tilde{l}_R}^2 - m_{\tilde{\chi}_1^0}^2\right)}{m_{\tilde{l}_R}^2} & \text{for} \quad \frac{m_{\tilde{l}_R}}{m_{\tilde{\chi}_1^0}} > \frac{m_{\tilde{g}}}{m_{\tilde{q}_L}} \frac{m_{\tilde{q}_L}}{m_{\tilde{\chi}_2^0}} \frac{m_{\tilde{\chi}_2^0}}{m_{\tilde{l}_R}} & (4) \\ \left(m_{\tilde{g}} - m_{\tilde{\chi}_1^0}\right)^2 & \text{otherwise} & (5) \end{array} \right.$$


Events/15 GeV/300 fb-1
SF-DF
TH
SUSY
SM
m(bbll) [GeV]
m(bbl(high)) [GeV]
m(bbl(low)) [GeV]


Sparticle masses and mass differences [GeV]