Les Houches 05, session 2

BSM-SUSY, experimental

EGRET point

Philippe Gris, Lauren Tompkins, Dirk Zerwas

EGRET SUSY Point

Philippe Gris, Lauren Tompkins, Dirk Zerwas

m_0 =1400 GeV $m_{1/2}$ = 180 GeV
A_0=700 GeV tanβ = 51 μ > 0

- Motivated by gamma ray data [Astro-ph/0408272 (Wim de Boer)]
- mSUGRA $\tilde{g} + \tilde{g}$
- Dominated by $\tilde{\chi}_1^{\pm} + \tilde{\chi}_2^{0}$, $\tilde{\chi}_1^{\pm} + \tilde{\chi}_1^{\mp}$

$\tilde{q} \approx 1440$
$\tilde{l} \approx 1400$
$\tilde{g} = 534.27$
$\tilde{\chi}_1^0 = 73.09$
$\tilde{\chi}_1^{\pm} = 141.66$
$\tilde{\chi}_2^0 = 141.77$

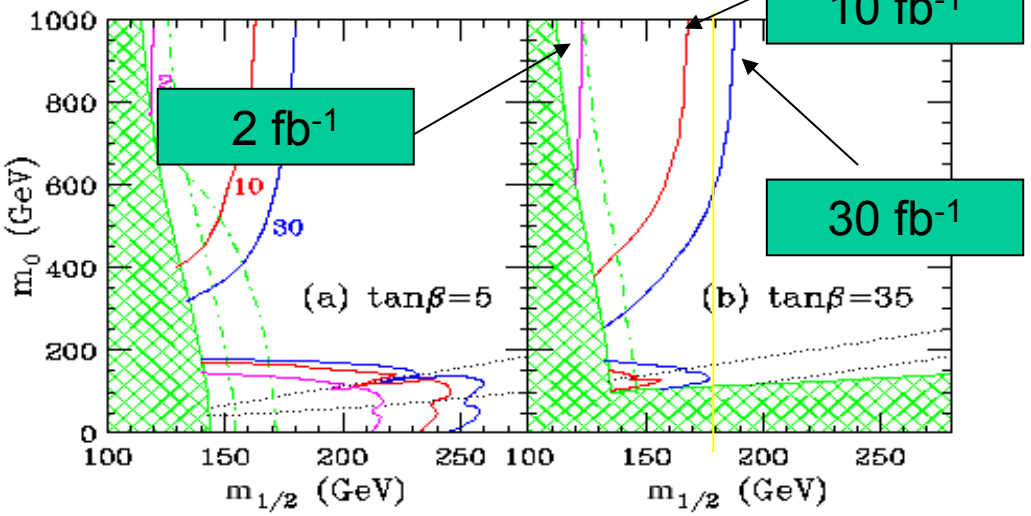
Tevatron Perspective:

- Inclusive xsec: .5 pb
- Only accessible channel: $\tilde{\chi}_1^{\pm} + \tilde{\chi}_2^0$

$$\sigma \times BR(\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \rightarrow 3l) = 0.009 \text{ pb}$$

  - 9 evts for 1fb-1
  - between 36 and 72 events in 2009
  - background: WZ,W+jets, tt,Z+jets

Plots generated with A0=0, masses remain the same



Report of the SUGRA Working Group for Run II of the Tevatron, hep-ph/0003154

EGRET SUSY Point

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ATLAS Perspective:

Inclusive xsec: 19.7pb

$\tilde{\chi}_1^{\pm} + \tilde{\chi}_2^0$ 4.59 pb

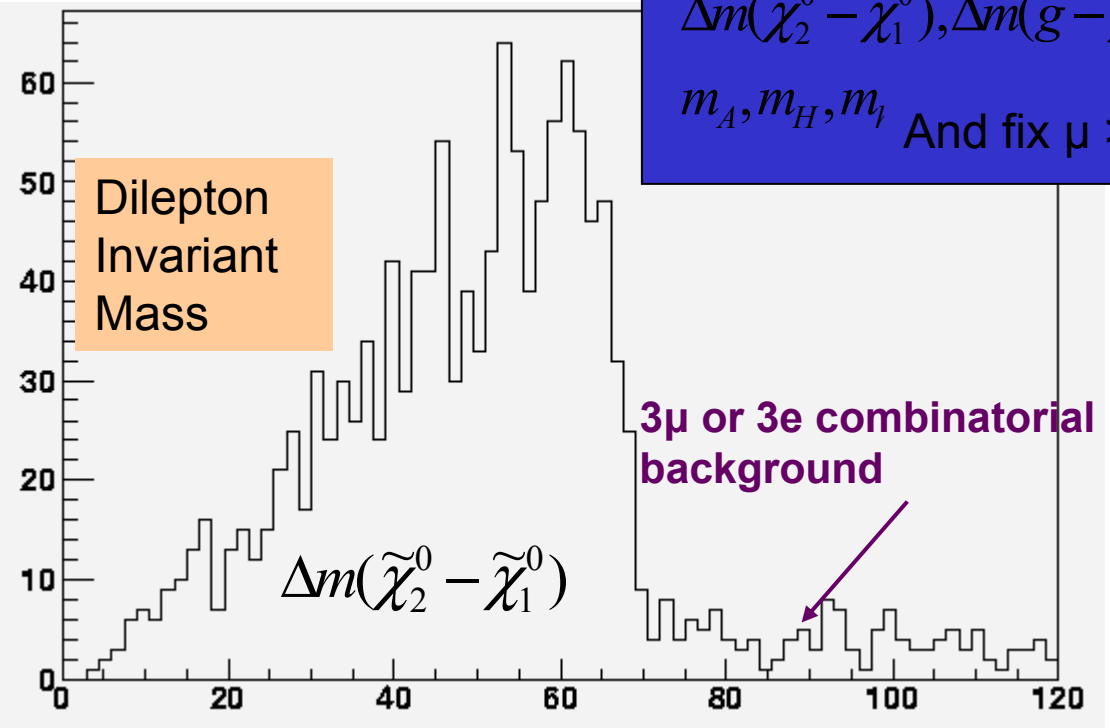
$\tilde{g} + \tilde{g}$ 11.0 pb

Don't have traditional cascades but have 3 body decays→measure mass differences.

Can make '5' measurements:

$\Delta m(\tilde{\chi}_2^0 - \tilde{\chi}_1^0), \Delta m(\tilde{g} - \tilde{\chi}_2^0)$

m_A, m_H, m_l And fix μ > 0



In infinite statistics, perfect detector limit ATLAS can do mSUGRA fit:

m_0 =1400 ± (50 – 530)GeV

$m_{1/2}$ = 180 ± (2-12) GeV

A_0=700 ± (181-350) GeV

tanβ = 51 ± (0.33-2)

*errors vary with uncertainty on b and top quark masses (large effect on m_A, m_H)

Taus in SUSY cascades

Boudjema, Desch, Godbole, Guchait, Houchu, Kraml,
Moortgat, Moortgat-Pick, Porod … ???

Tau polarization in SUSY cascades

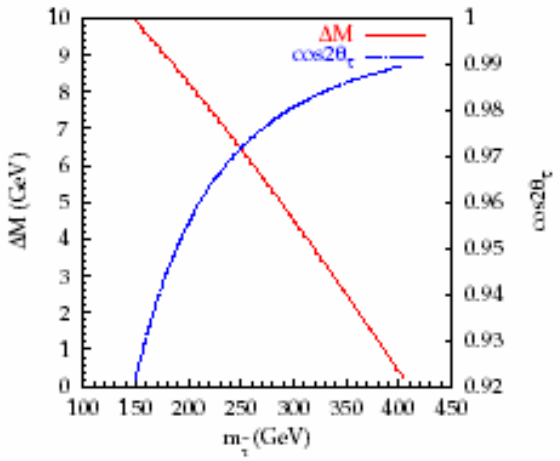
Consider the decay chain $\tilde{\chi}_2^0 \to \tilde{\tau}_1^{\pm}\tau^{\mp} \to \tau^{\pm}\tau^{\mp}\tilde{\chi}_1^0$:

* The polarizations of the two τ's reflect the $\tilde{\chi}^0$ and $\tilde{\tau}$ mixings,
  e.g. $\tilde{\chi}_2^0 \sim \tilde{W}^0$, $\tilde{\chi}_1^0 \sim \tilde{B}$, $\tilde{\tau}_1 \sim \tilde{\tau}_R \rightsquigarrow P(\tau_{near}^-) \simeq -1$, $P(\tau_{far}^-) \simeq +1$

* $\tilde{\chi}_1^0$–$\tilde{\tau}_1$ coannihilation region: $m_{\tilde{\tau}_1} - m_{\tilde{\chi}_1^0} \lesssim 10$ GeV !!
  $\to$ τ_{far} very soft, may be used to discriminate between the two τ's (?)

Questions for LHC analyses:

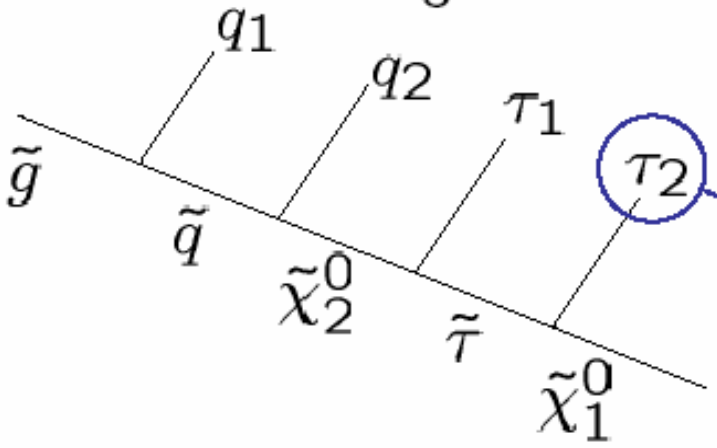
- How well can $P(\tau)$ be measured?
- How soft may τ_{far} be?
- May knowledge of e.g. $m_{\tilde{\chi}_2^0} - m_{\tilde{\chi}_1^0}$ from $\tilde{\chi}_2^0 \to \tilde{l}^{\pm}l^{\mp} \to l^{\pm}l^{\mp}\tilde{\chi}_1^0$ help?



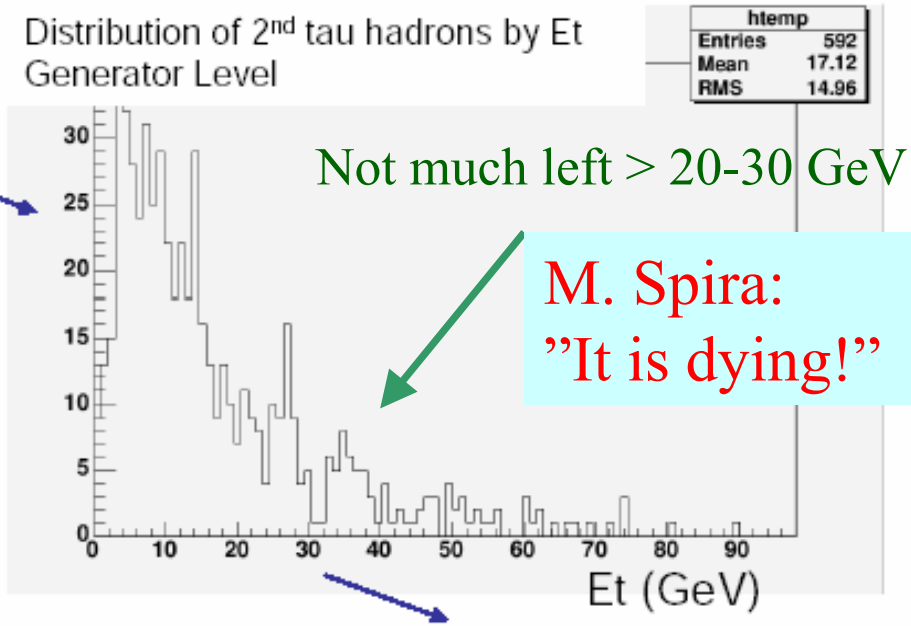
Soft taus

L. Houchu

mSUGRA cascade at point LM2 =
(m0,m1/2,tanβ,A0,sign(μ)) = (185,350,35,0,+)
using PYTHIA 6.225-ISAJET 7.69



$$M_{\tilde{\tau}} - M_{\tilde{\chi}_1^0} = 15.5 GeV/c^2$$



Not much left > 20-30 GeV

M. Spira:
"It is dying!"

Difficult reconstruction

Stable Charged Particles

(GMSB, GDM, Split SUSY, …)

Kazana, Moortgat, Richardson, Rizzi, …

Split SUSY & GMSB

- Geant4 framework for "Custom" particle implemented
- Tested with staus and R-hadrons
- Particle definition (PDG code, mass, name) specified in SLHA-like file
- Geant4 ionzation & multiple scattering used
- Toy-process for charge flip (cross section from A.Kraan article)

A. Rizzi

```
#PDGcode Mass      Name
 1000993   501.   # ~g glueball
 1009213   501.   # ~g rho+
 1009313   501.   # ~g K*0
 1009323   501.   # ~g K*+
 1009113   501.   # ~g rho0
 1009223   501.   # ~g omega
 1009333   501.   # ~g phi
 1091114   501.   # ~g Delta-
 1092114   501.   # ~g Delta0
 1092214   501.   # ~g Delta+
 [...]
```

Stable charged particles

Non standard generators for interfaced with CMS full-simulation

- Herwig (CMS full simulation done)
- Pythia (CMS full simulation in progress)

Full simulation allow to (with higher #ev):

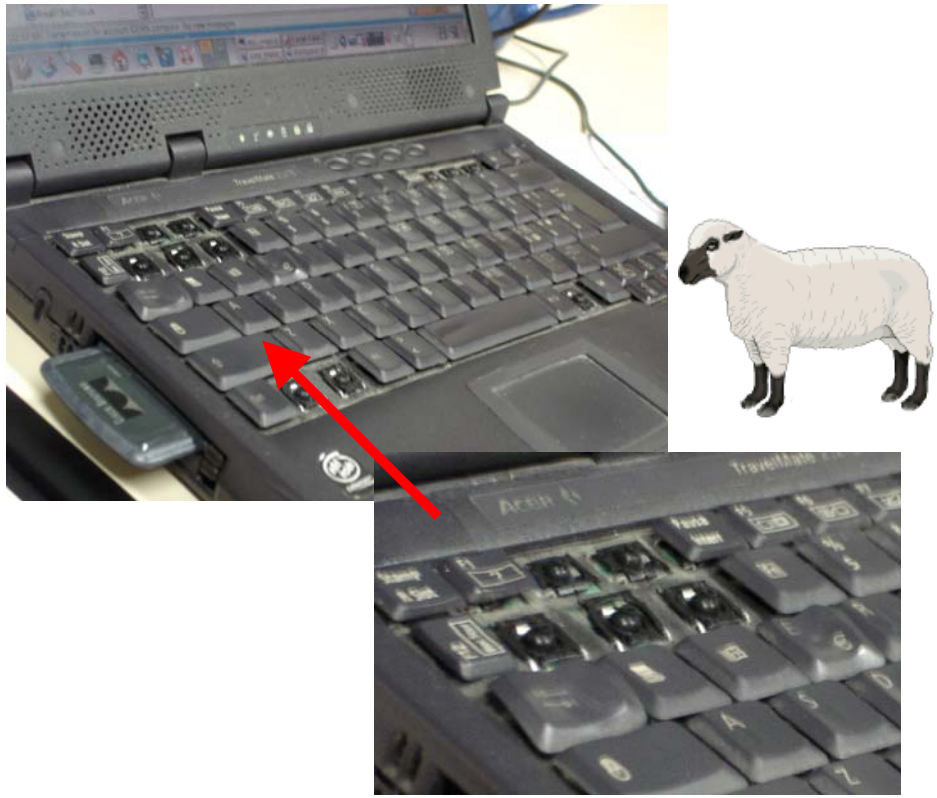
- Trigger studies
  - Will those "heavy muons" arrive "in time" for L1 ? Most of them
  - Is the charge-flip a problem ? It seems it is not
  - Are the gluino hadrons "isolated" ? No☹! (herwig)
- Offline identification (tof, dE/dX in tracker)

Stable charged particles

TODO-list:

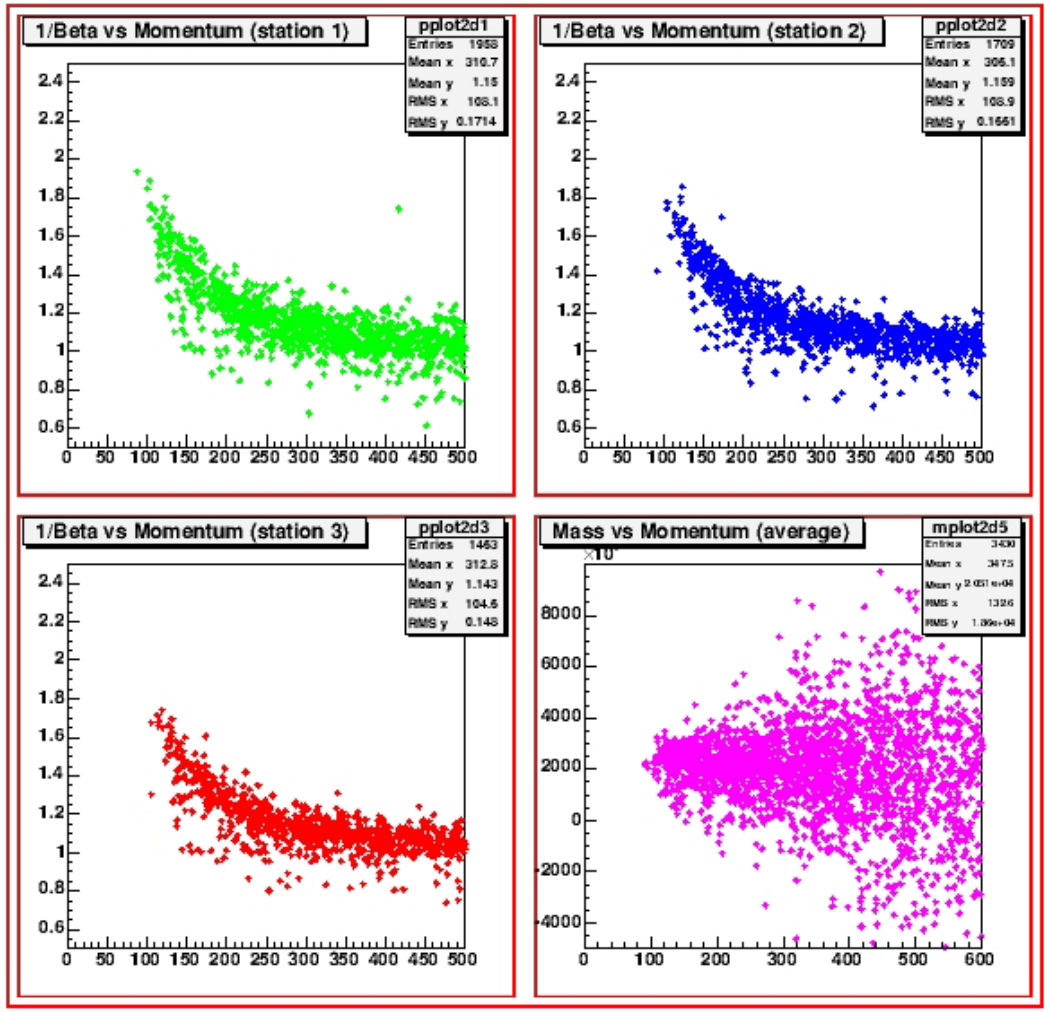
- Test code for stop hadrons from Sjostrand/Mrenna
- Implement Aafke Kraan's model in G4 (the framework is there now)
- Decays inside the detector
- Use these tools!

Andrea Rizzi's laptop:



(Did the sheep knibble on it?)

Stable staus



Standard algorithm:

local 4d ϕ RecHits:
7,8 out of 8 hits only

muon stations 1, 2, 3 only, because no η measurement in the 4th station

The 4th panel contains mass squared estimated from the average $1/\beta$

M. Kazana

Focus point MSSM scenario @ LHC and ILC

Desh, Kalinowski, Moortgat-Pick, Rolbiecki, Stirling

Focus Point MSSM Scenario @ LHC+ILC

K.Desch,J.Kalinowski,G.Moortgat-Pick,K.Rolbiecki,J.Stirling,

Motivation: what can be done in a scenario with only few sparticles accessible at LHC + ILC?

Extraction of Gaugino/Higgsino Sector Parameters M_1,M_2,μ,tan β ?
Prove that sfermions are indeed heavy ?

Scenario: mSugra with m_0=2 TeV, $m_{1/2}$ =144 GeV, A_0 =0, tanβ = 20

LHC: dilepton edge from χ_2^0 (three-body) decay ~ $m(\chi_2^0) - m(\chi_1^0)$

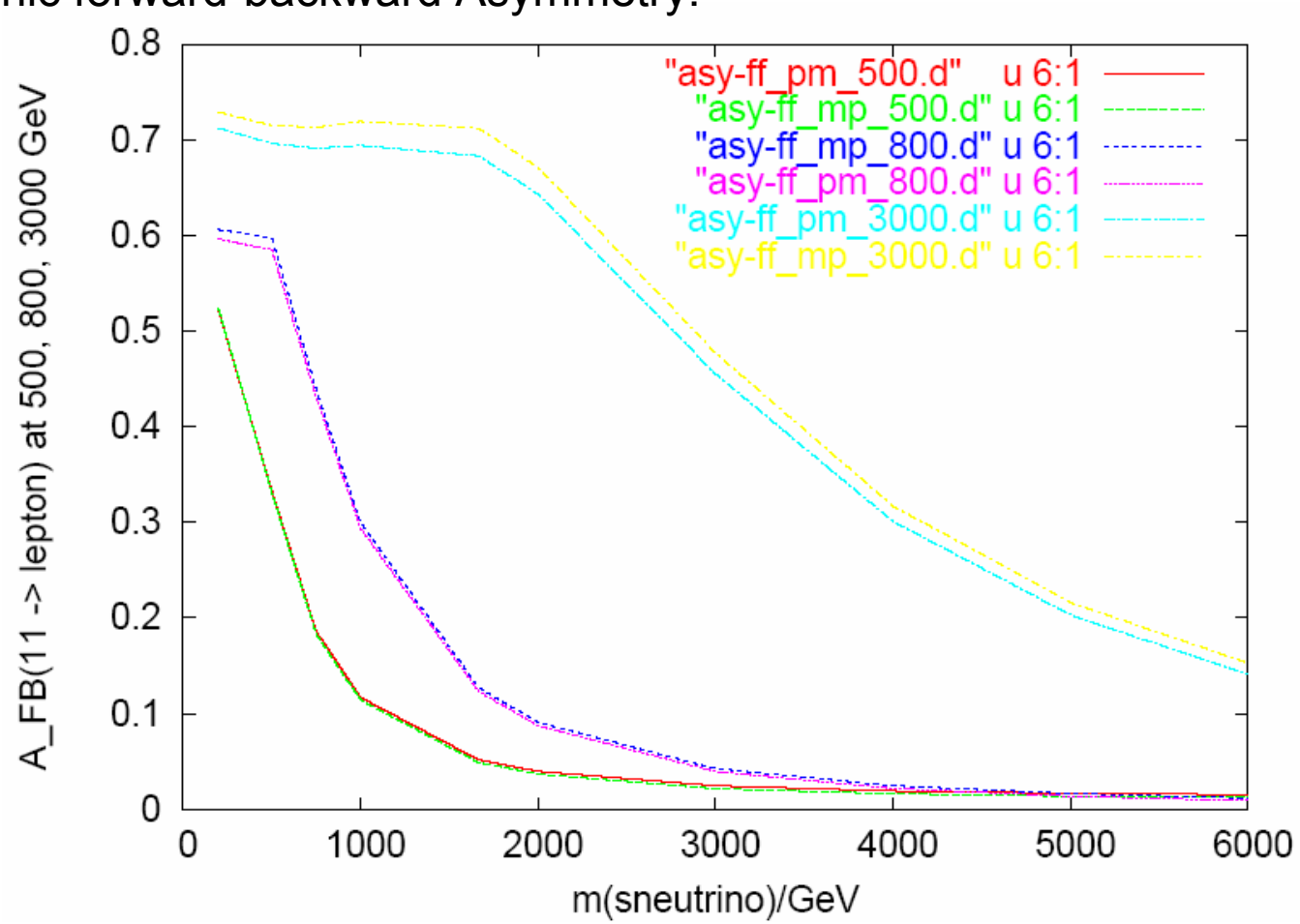
ILC: $m(\chi_1^+)$ from chargino threshold, $m(\chi_1^+) - m(\chi_1^0)$ from m(qq)
+ polarized cross sections at 2 cms energies
+ lepton forward-backward asymmetry (with full spin-correlations)

→ 5 parameter (M_1,M_2,μ,tan β, $m(\tilde{\nu})$) fit with Fittino

Focus Point MSSM Scenario at LHC + ILC

K.Desch,J.Kalinowski,G.Moortgat-Pick,K.Rolbiecki,J.Stirling,

Leptonic forward-backward Asymmetry:



Combinatorics in SUSY cascades

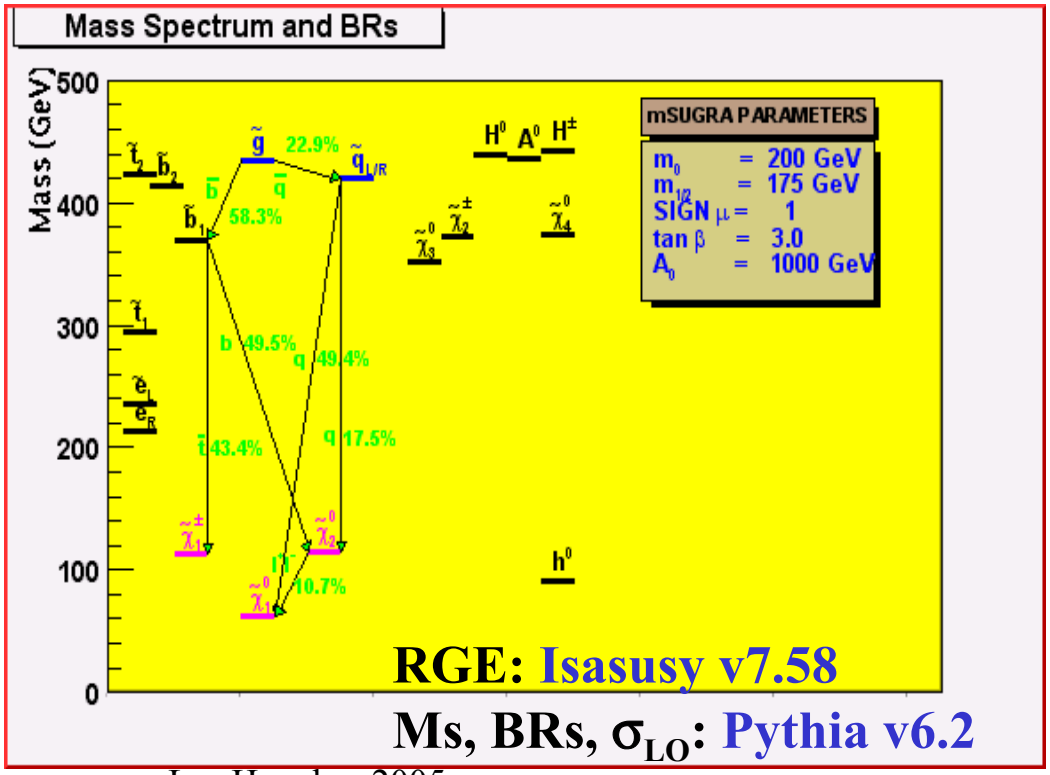
Steve Muenza

S-cascade study @ LHC

Main interests:

Effects on SUSY observables from:

- **on/off-line selection cuts**
- **SM & SUSY bkgd contaminations**
- **How SUSY bkgd and objects combinatorics**



Process:

$$p+p/\bar{p}\rightarrow\tilde{q}+\tilde{g}$$

$$\tilde{q}\rightarrow q+\tilde{\chi}_1^0$$

$$\tilde{g}\rightarrow\tilde{b}_1 b\rightarrow b\bar{b}+\tilde{\chi}_2^0\rightarrow b\bar{b}+\ell^+\ell^-+\tilde{\chi}_1^0$$

Cross Section:

$$\sigma_{LO}(p+p/\bar{p}\rightarrow\tilde{q}+\tilde{g})\approx 100\,pb$$

$$K-factor=\frac{\sigma_{NLO}(CTEQ5M)}{\sigma_{LO}(CTEQ5L)}\approx 1.8$$

(Prospino v1)

S-cascade study @ LHC

- Event generation: Pythia 6.2+CTEQ5L, 50k/process, (norm: LO σ below)
- Online selection: single+di-leptons, jet+ E_T^{miss}, E_T^{miss}

Preselection:

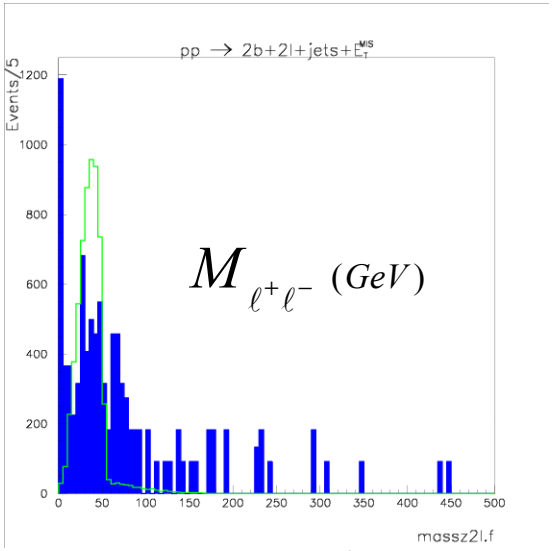
➢2 OS-SF l, 3jets

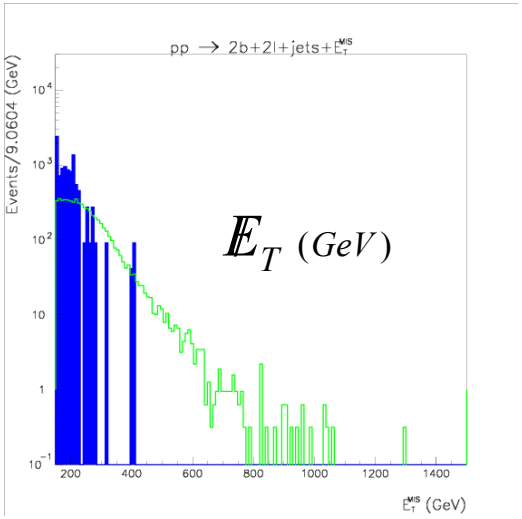
➢Large E_T^{miss}, 1 hard jet

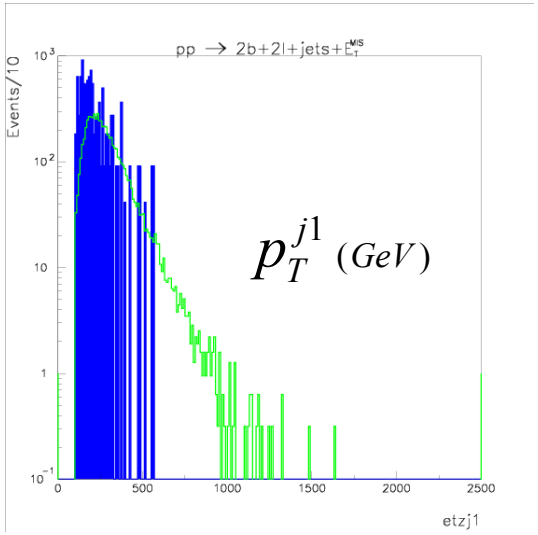
Private fast simulation:

- Simple resolutions smearings
- PYCELL jets
- No B-field, no MI, no energy sharing,…
- Will move to ATLFAST v2

$\tilde{q}+\tilde{g}$ — $t\bar{t}+tq$ — $10fb^{-1}$







SUSY & Higgs interplay benchmarks

Moretti, Shepherd, Moortgat, Salerno, …

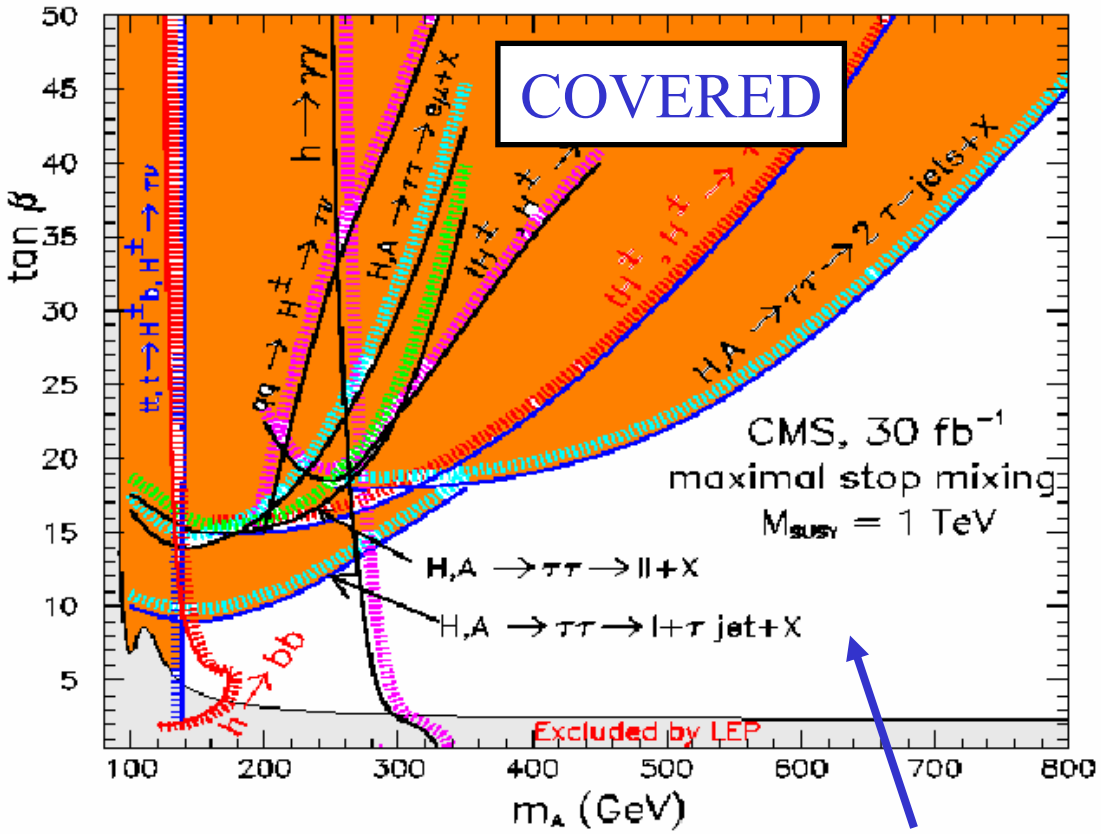
SUSY - Higgs

Define benchmark points where the interplay between SUSY and Higgs sector are manifest:

- squark-squark-Higgs
- Heavy Higgs → SUSY
- SUSY cascades → Higgs

S. Moretti

SUSY Higgs Discovery reach



- discovery of the heavy MSSM Higgses limited to upper triangle in m_A – tan β plot
- note: the h^0 can always be found
- problem is that production mechanism (e.g. bbA^0,H^0) needs tan β enhancement

Need new ideas to cover low tanβ - high m_A region …

Cascade production mechanisms

$$pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} \quad \to \quad \tilde{\chi}_2^{\pm}, \tilde{\chi}_3^0, \tilde{\chi}_4^0 + X$$
$$\to \quad \tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0, \tilde{\chi}_1^0 + h, H, A, H^{\pm} + X$$

$$pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} \quad \to \quad \tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0 + X$$
$$\to \quad \tilde{\chi}_1^0 + H^{\pm}, h, H, A + X$$

$$pp \quad \to \quad \tilde{t}_2\tilde{t}_2^*, \tilde{b}_2\tilde{b}_2^* \text{ with } \tilde{t}_2(\tilde{b}_2) \to \tilde{t}_1(\tilde{b}_1) + h/H/A \text{ or } \tilde{b}_1(\tilde{t}_1) + H^{\pm}$$

$$pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{q}^*, \tilde{q}\tilde{g} \quad \to \quad t/\bar{t} + X \to H^{\pm} + X$$