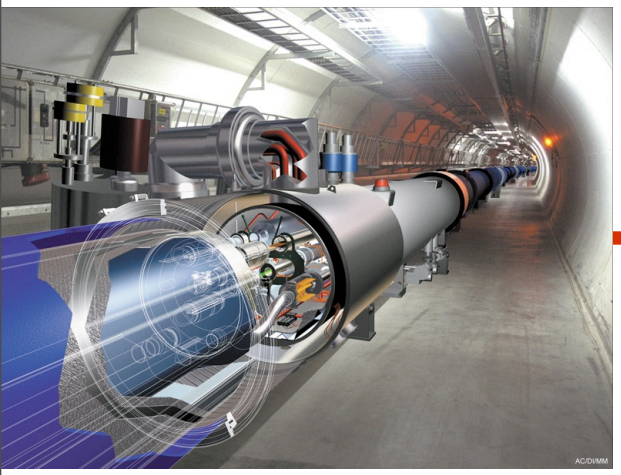
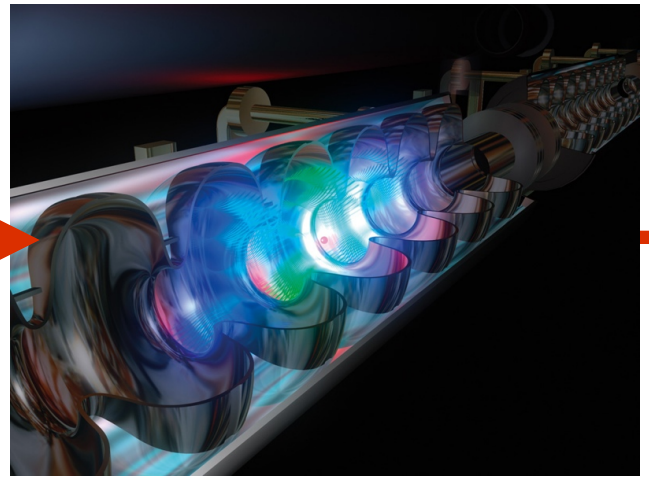
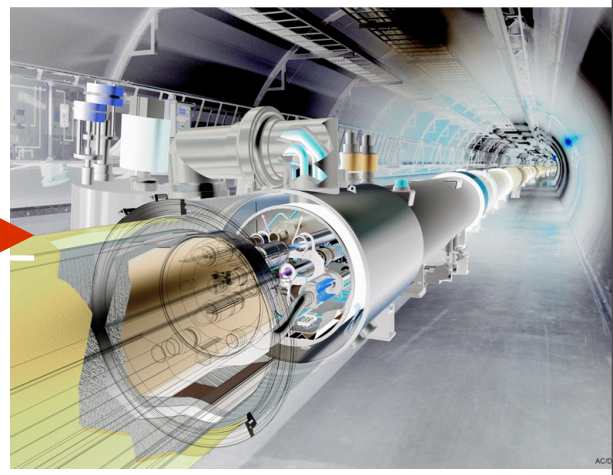
Inverting the LHC at the ILC

Ben Lillie
Argonne / University of Chicago







Outline

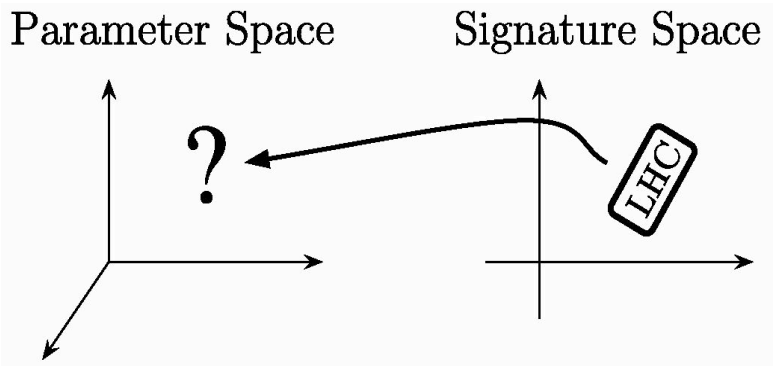
C. F. Berger, J. S. Gainer, J. L. Hewett, B. Lillie, and T. G. Rizzo

- LHC Degeneracies
- Analyses
- Results
- Outlook

LHC Inverse problem

Arkani-Hamed, Kane, Thaler, Wang hep-ph/0512190

- How to map from observables to a Lagrangian?
- What is the nature of the inverse mapping?



LHC Inverse problem

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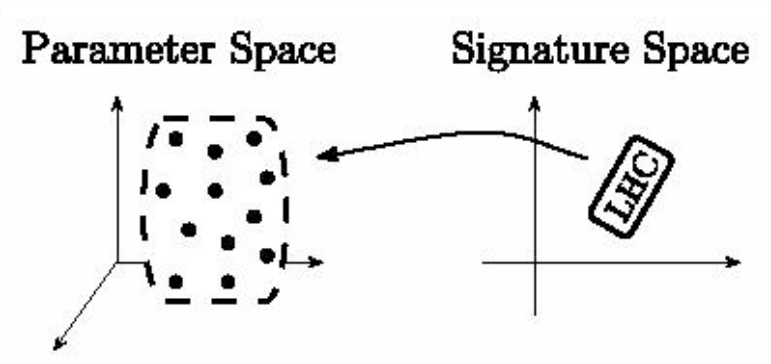
- What is the nature of the inverse mapping?
- Each parameter can be well measured, but many islands can be degenerate!



LHC Inverse problem

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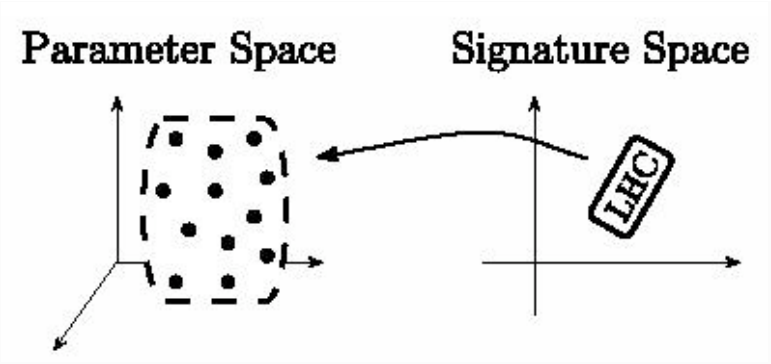


Simulated ~40k points in parameter space

Found ~300 degeneracies

Expect ~30 model points consistent with any "generic" set of data

Degeneracies

Flipper:

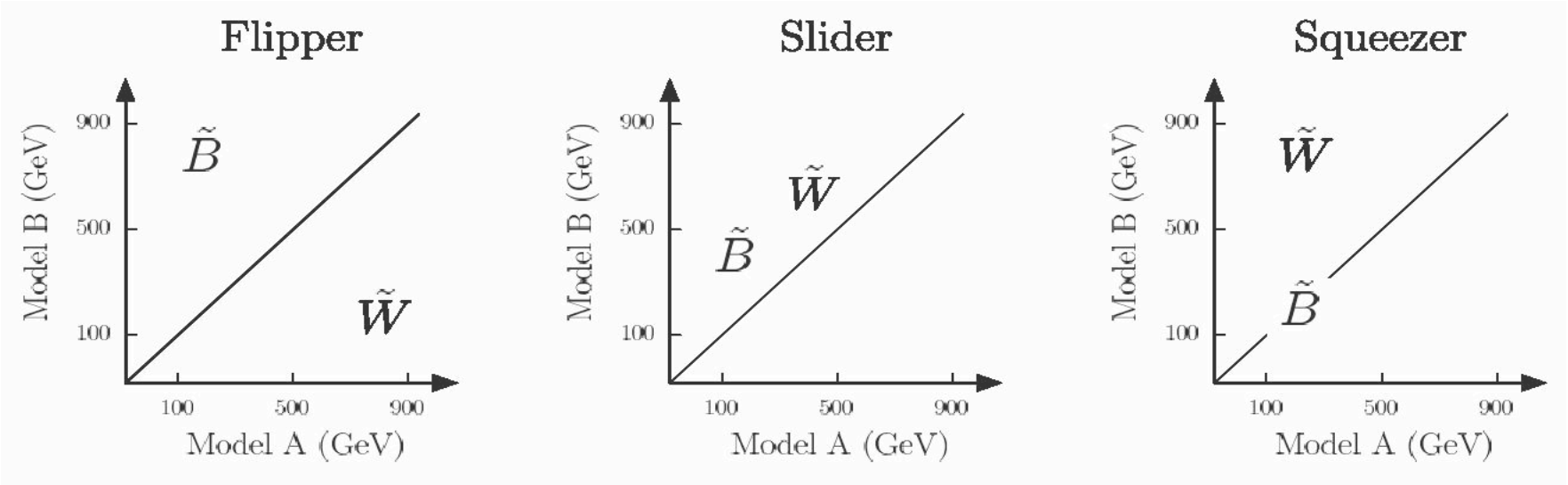
Mixing content switched

Slider:

Absolute mass scale changed, differences preserved

Squeezer:

Chargino highly degenerate with LSP has little effect



Can the ILC invert the LHC?

i.e. can we break the remaining degeneracies?

Model Counting at the ILC

242 Models
165 Pairs

- 500 GeV:
  - 20 models with selectrons & smuons.
  - 28 models with staus, 7 of which also have selectrons/smuons
  - 53 models with charginos, 2 of which also have selectrons/ smuons,
  - 8 of which also have staus
  - 99 models with only LSP (lightest neutralino)
  - 36 models with no kinematically accessible sparticles

1 TeV:

116 models with selectrons & smuons

125 models with staus, 55 of which also have selectrons/smuons

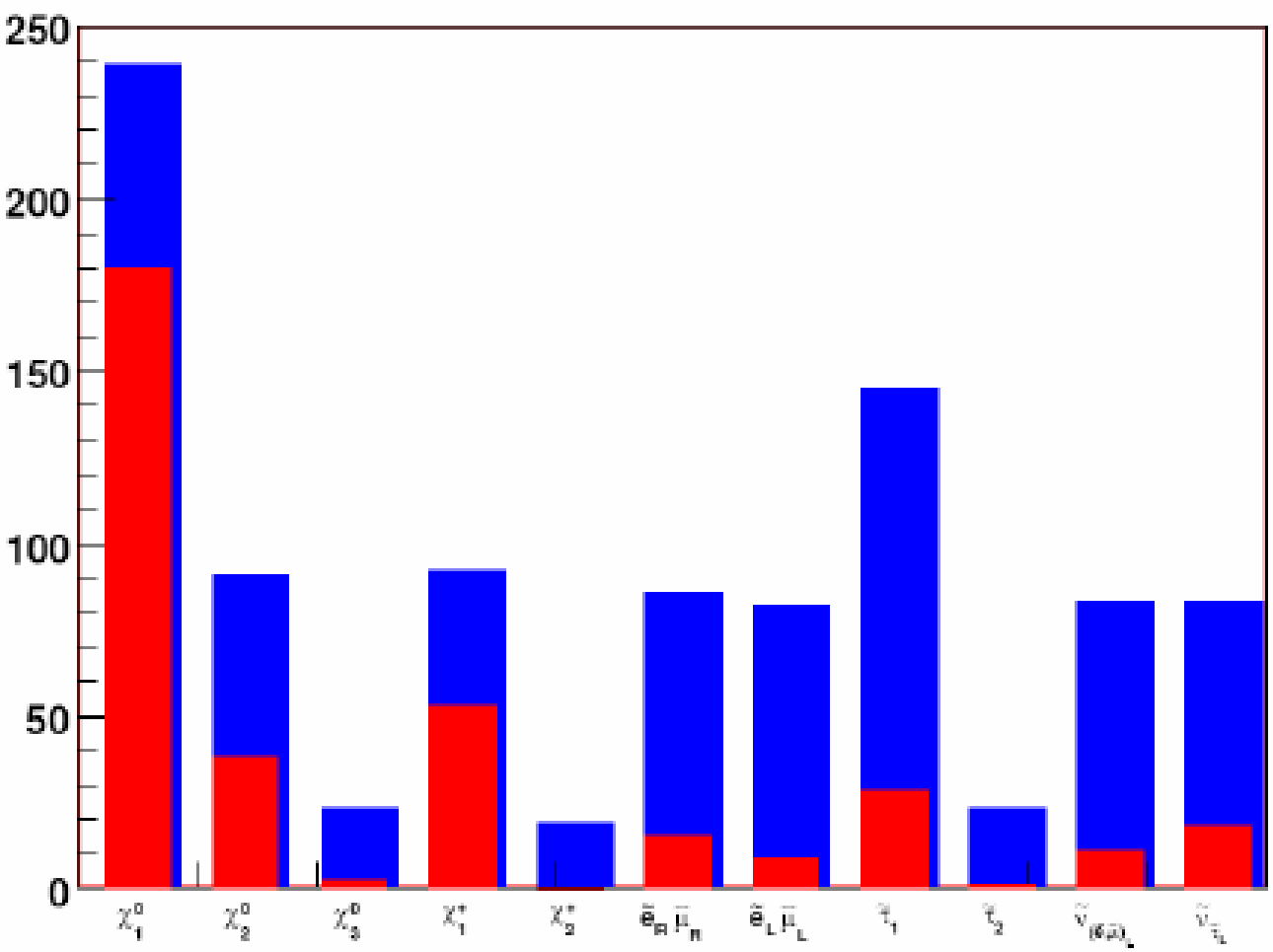
25 models with first chargino, 16 models with second chargino; 12 of which

also have selectrons/smuons, 15 of which also have staus

1 model with only LSP (lightest neutralino)

1 model with no kinematically accessible sparticles

Sparticle spectra



Many models do not produce visible signals at 500GeV

Accessible at 500 GeV, 1 TeV c.m. energy

Sparticle counts

	500 GeV	visible?	1 TeV
selectrons or smuons	22	15?	116
staus	27	6?	125
All slepton types	7	6?	55
χ^+_1	53	15?	78
χ^+_1+smuons	2	?	12
χ^+_1 + staus	8	?	12
$\chi^+_1 \chi^-_2$	0	0	16
$\chi^0_1 \chi^0_1$ only	99	0	1
$\chi^0_1 \chi^0_2$	46	3?	178
nothing	59	0	1

- ★ Out of 242 models, at 500 GeV:

  59+99=158/242 = 65 %

  have NO signal observable…

- ★ The percentage is actually higher (~75 % !) after some further investigation

Simulation

- Generate events with PYTHIA
  - 500 fb^{-1}; Includes ISR, beamstrahlung, beamspread from GuineaPig, and 80% e- polarization.
  - Use CompHEP for processes requiring hard radiation
- Run fast detector simulation with lcsim
  - used SiD concept for geometry
- Add background generated by Tim Barklow
  - Contains all SM processes up to 6 fermion final states with full ME(!), including e-gamma and gamma-gamma events
- Run 10 analyses looking for various sparticles
  - Used previous studies + additional optimization

Analyses

- Selectrons
- Smuons
- Staus
- Charginos
  - Close mass:
    - "Stable", radiative
  - Separated $m_{\chi_1^+} - m_{\chi_1^0} < 1 \text{ GeV}$
    - 4 jets, 2 jets + muon, 2 muons
- Neutralinos
  - $\chi_2^0 \chi_1^0$
  - Radiative

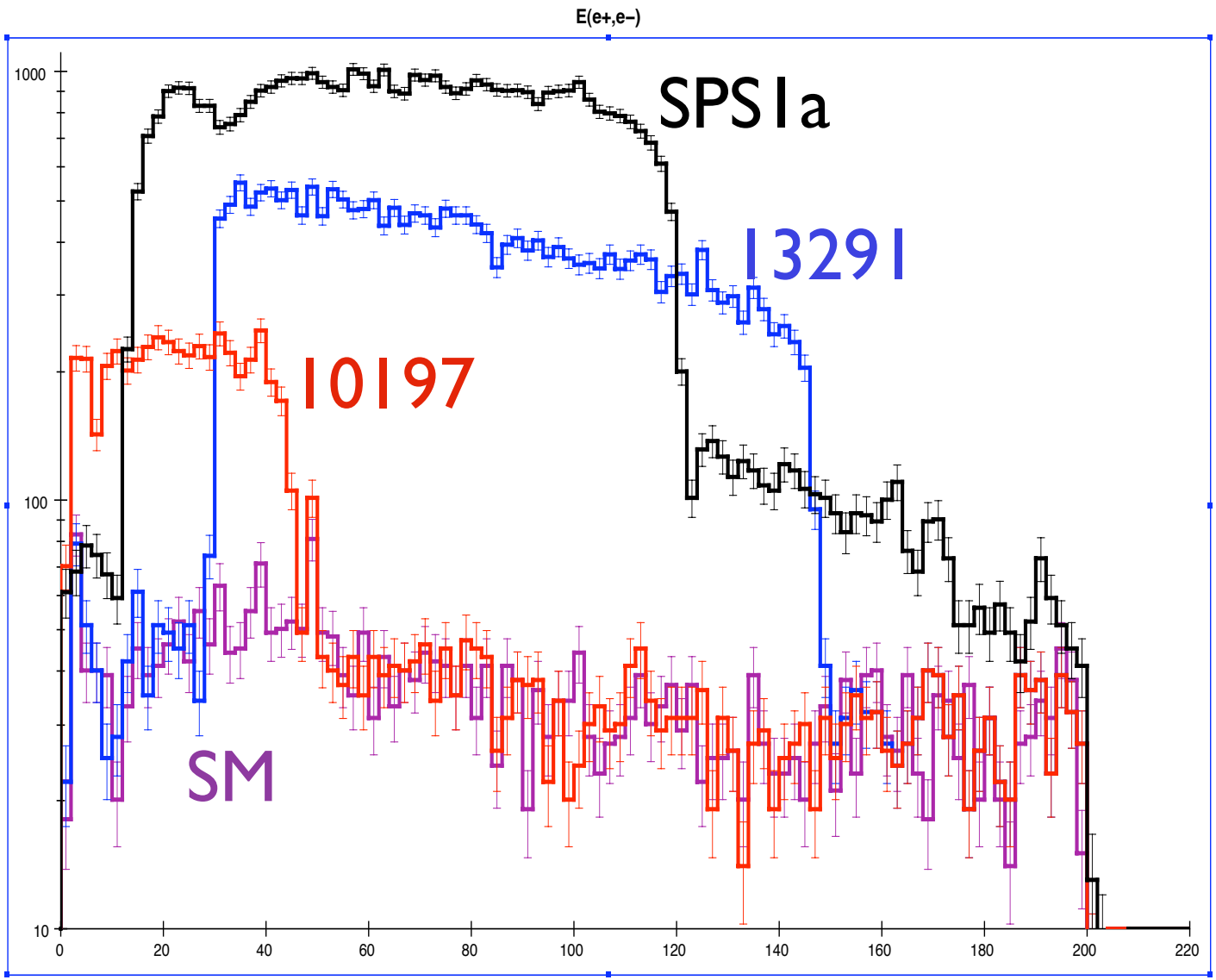
Cuts

Adapted and expanded analyses from:

- Supersymmetry Study Group, UC Boulder
  - Selectrons, charginos
- Gunion and Mrenna, hep-ph/0103167
  - Long-lived charginos
- H. U. Martyn hep-ph/0408226
  - Smuons, staus
- Dreiner, Kittel, Langenfeld, hep-ph/0703009
  - Radiative neutralinos

Details to appear "soon" (we promise)

Sleptons

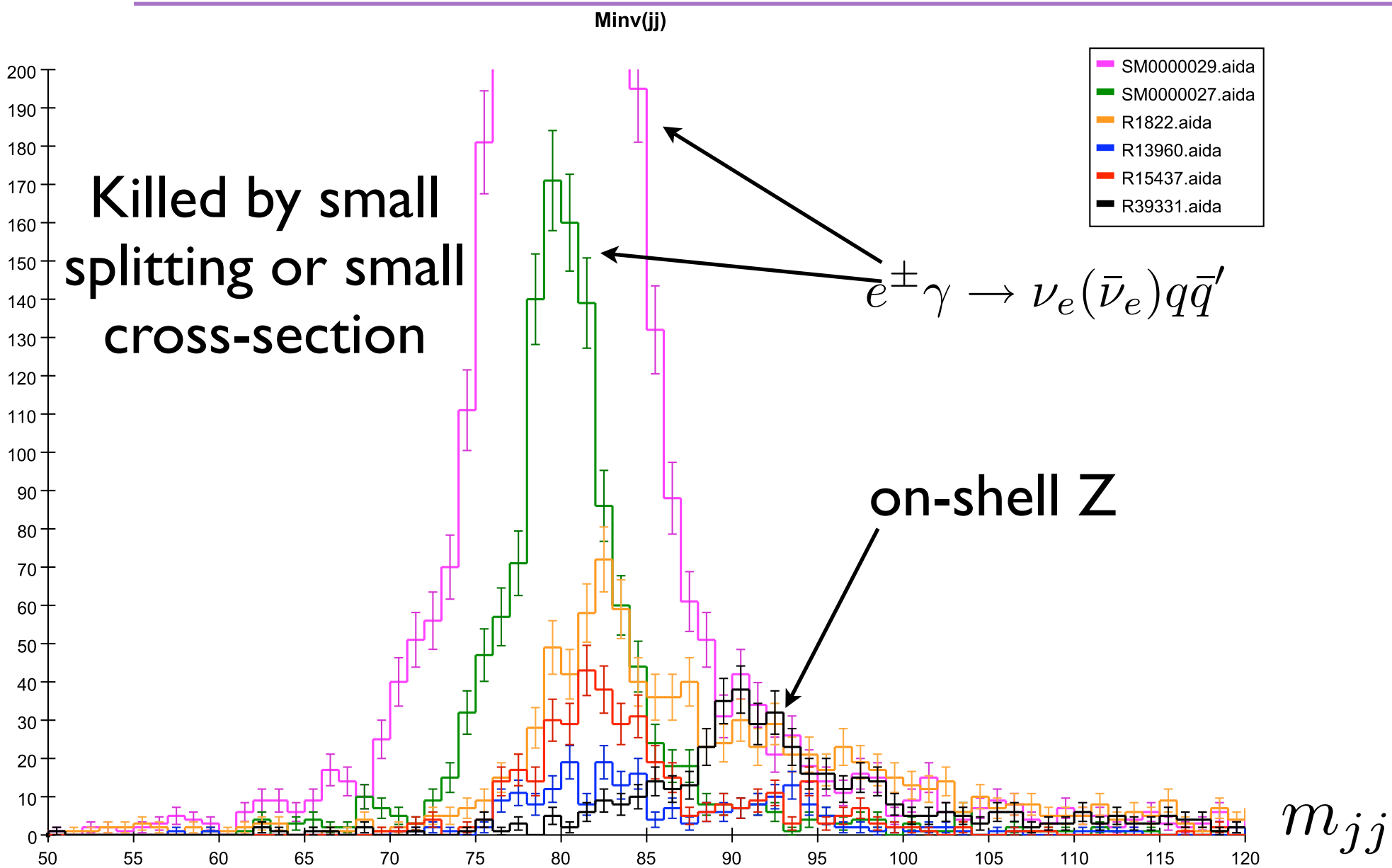


Selectron masses

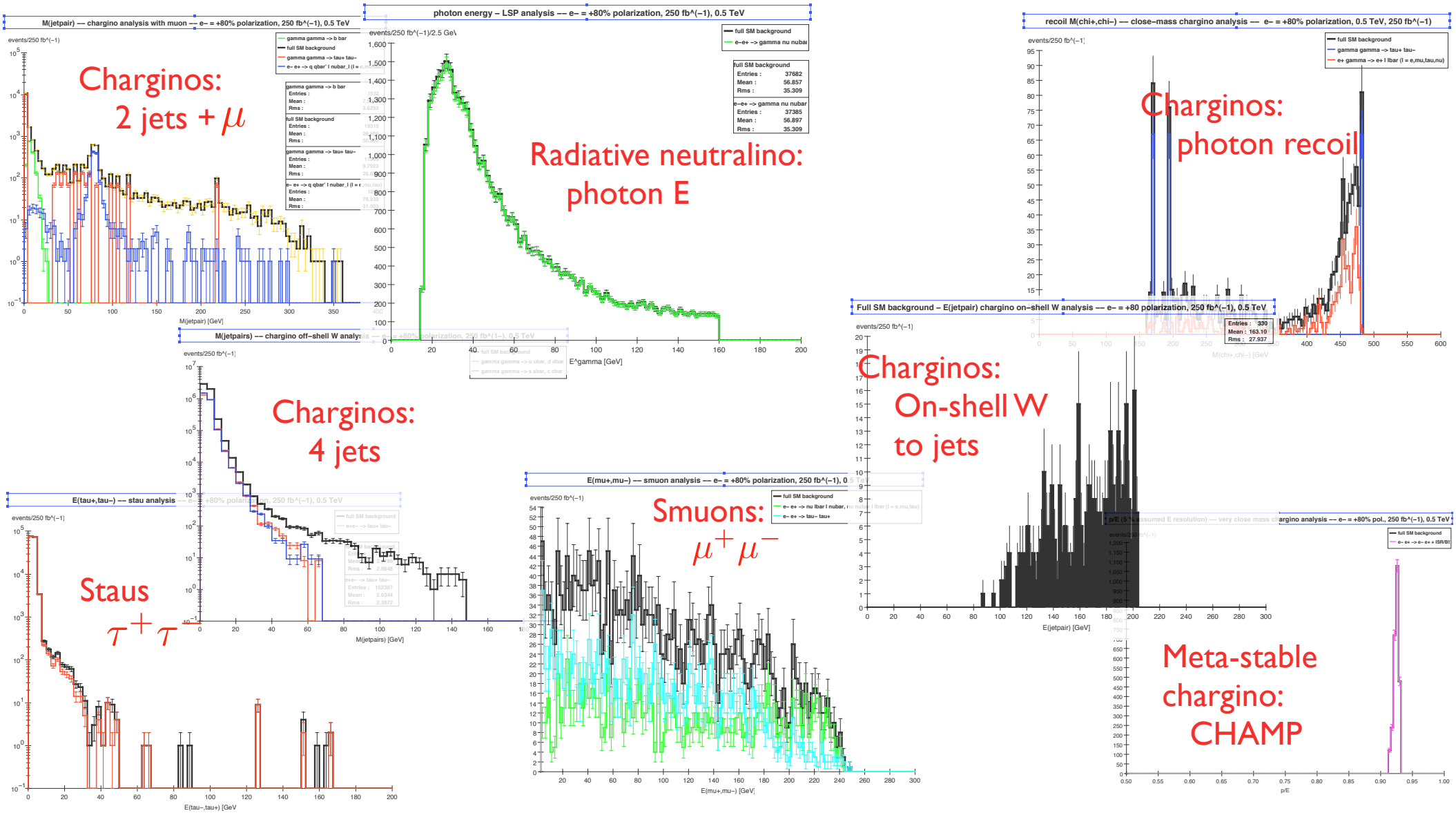
- Model 13291
  - L: 969 GeV
  - R: 187 GeV
- Model 10197
  - L: 795 GeV
  - R: 171 GeV
- SPS1a
  - L 202 GeV
  - R 143 GeV

$\chi_1^0\chi_2^0\ (jj+\not{E})$

Not that easy!



Other analyses



Model comparisons

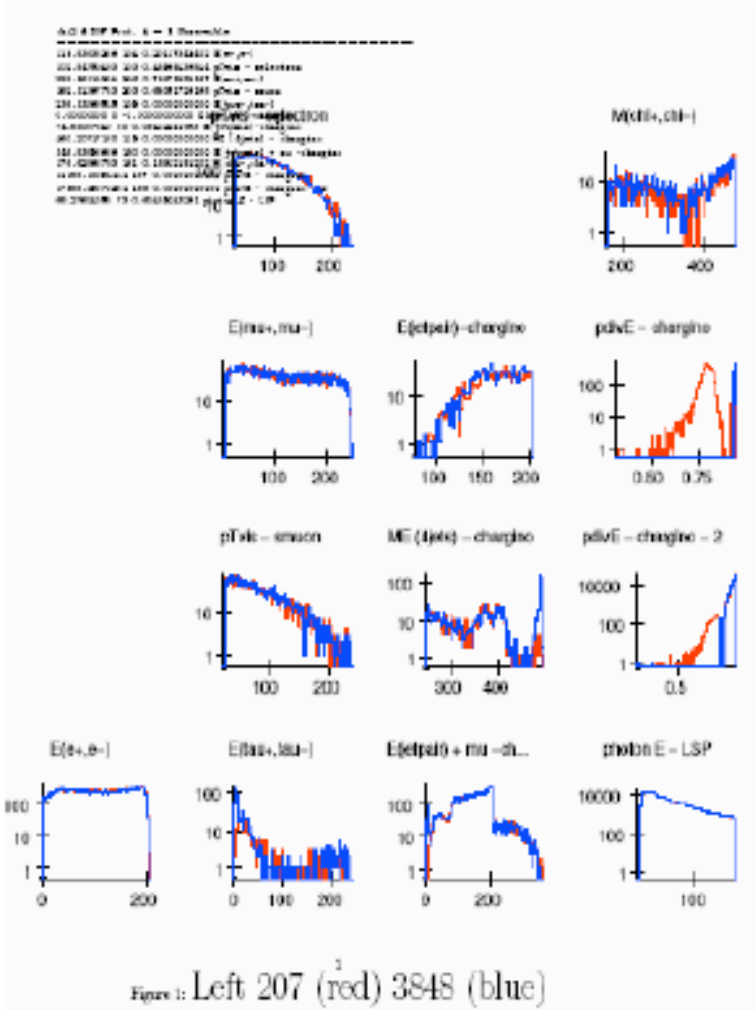


Figure 1: Left 207 (red) 3848 (blue)

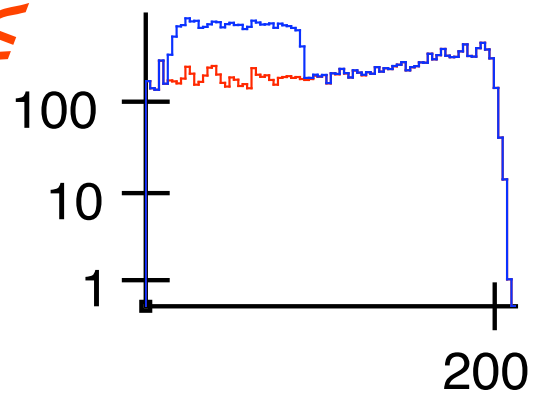
- We combine the results for each analysis of Model A and Model B with those obtained from two different full background samples, B1 & B2
- For each e- polarization we perform a statistical comparison of the various distributions for (A+B1) vs (B+B2)
- We then ask if the 2 models are distinguishable at a given level of significance, e.g, 5σ
- We're just starting to do these comparisons

Examples

χ^2 large in all cases

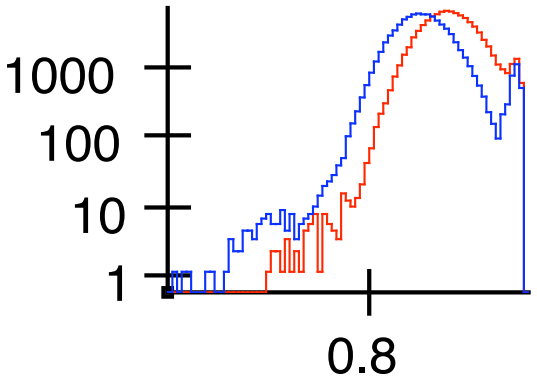
PRELIMINARY

E(e+,e–)



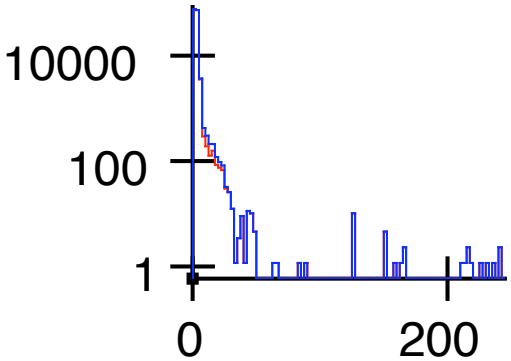
Flipper

pdivE – chargino



E(tau+,tau–)

Squeezer



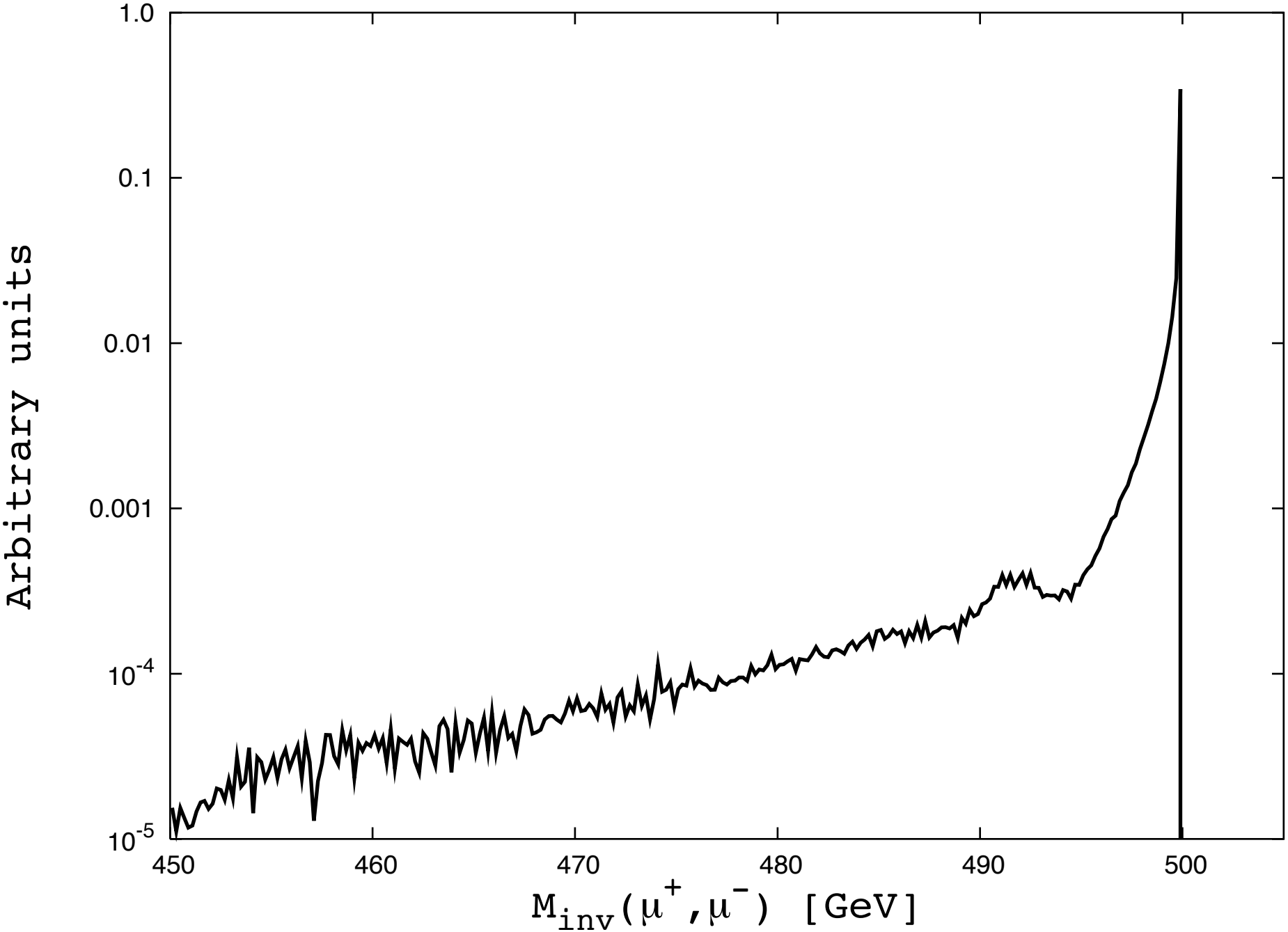
Slider

Outlook and observations

- Next step: finish model comparison
  - CPU time limiting factor. Complete BG set ~2TB
- TeV machine will likely break all degeneracies in our sample
- First time "users" have performed analysis with full background sample
- First scan of SUSY parameter space independent of model assumptions
  - Not SPS1a
  - Other questions, surveys?

Backup slides

Beamstrahlung spectrum



Selectron cuts