Inverting the LHC at the ILC

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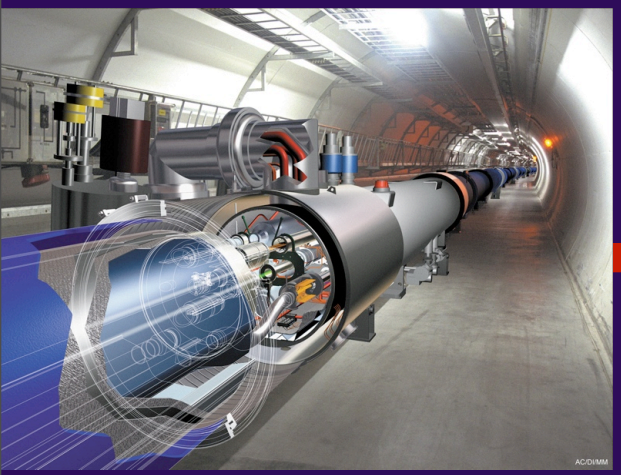
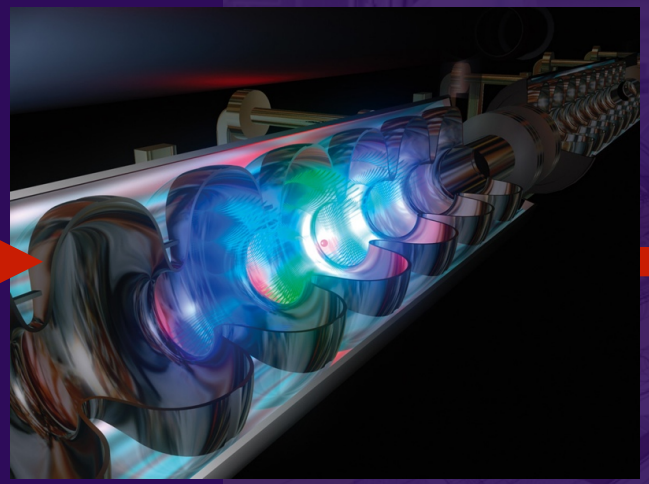
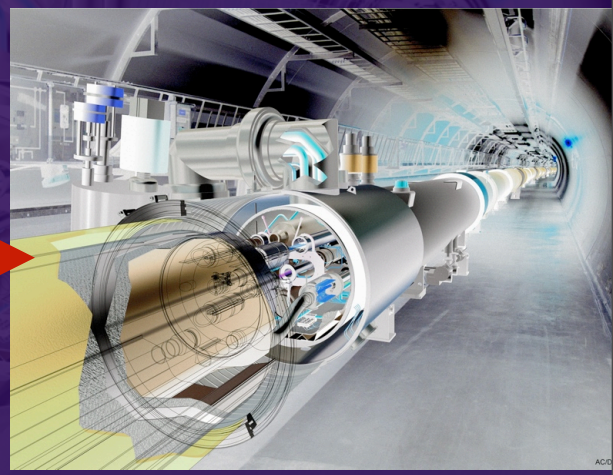
Argonne / University of Chicago







Outline

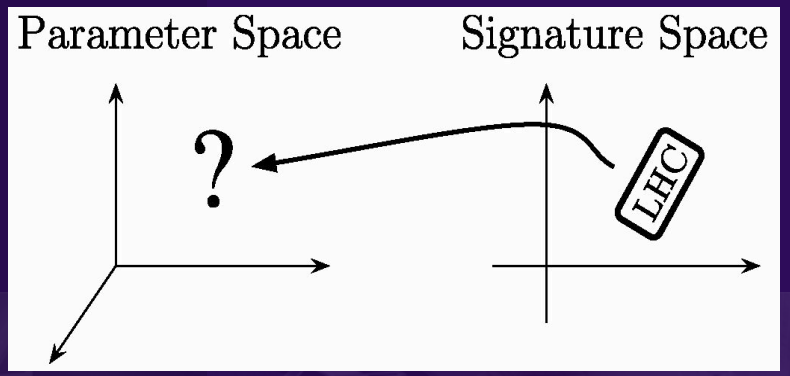
C. F. Berger, J. S. Gainer, J. L. Hewett, B. Lillie, and T. G. Rizzo
To appear

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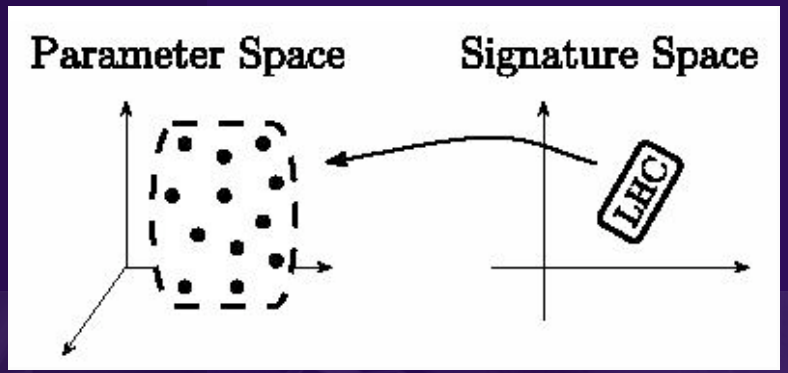
- What is the nature of the inverse mapping?
- Each parameter can be well measured, but many islands can be degenerate!



LHC Inverse problem

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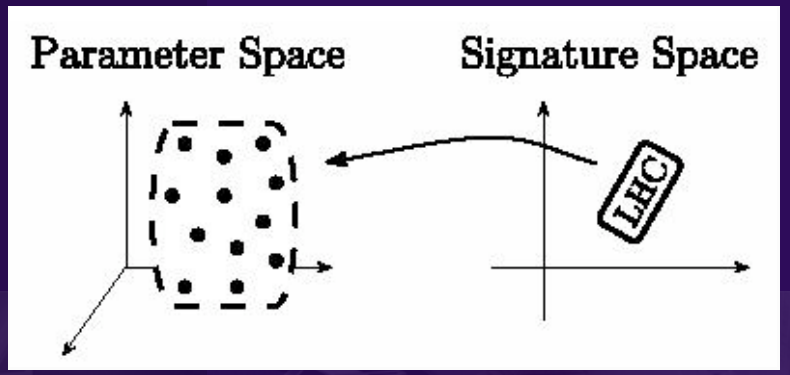


Simulated ~40k points in parameter space

Found ~300 degeneracies

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

Degeneracies

Flipper:

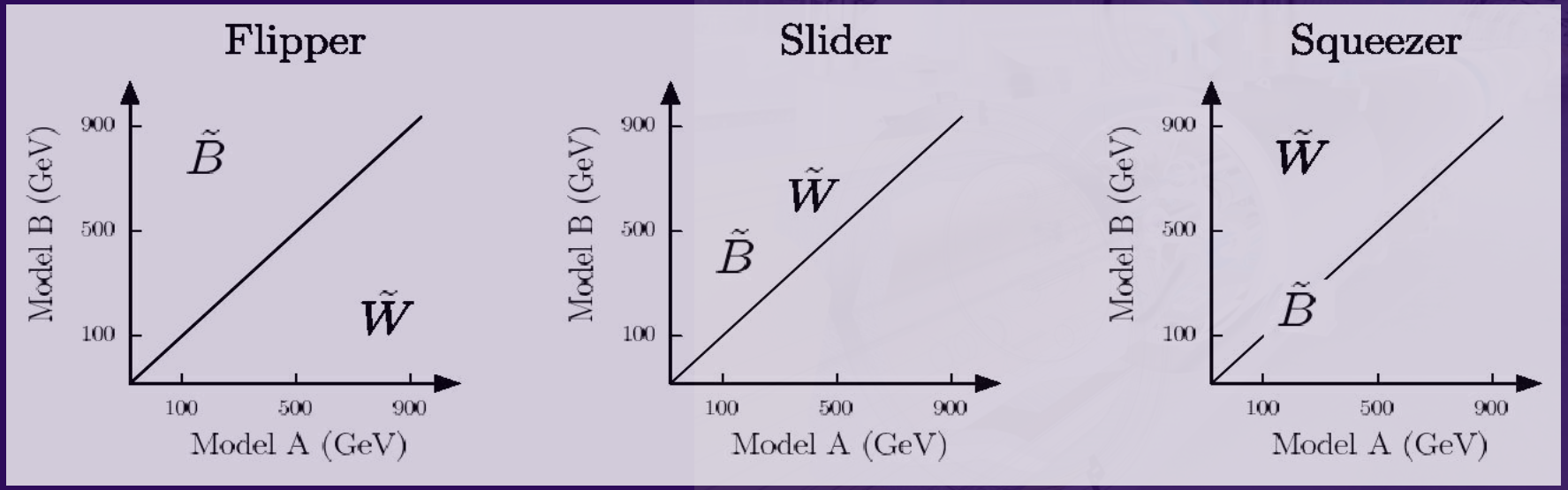
Mixing content switched

Slider:

Absolute mass scale changed, differences preserved

Squeezer:

Chargino highly degenerate with LSP has little effect



Can the ILC invert the LHC?

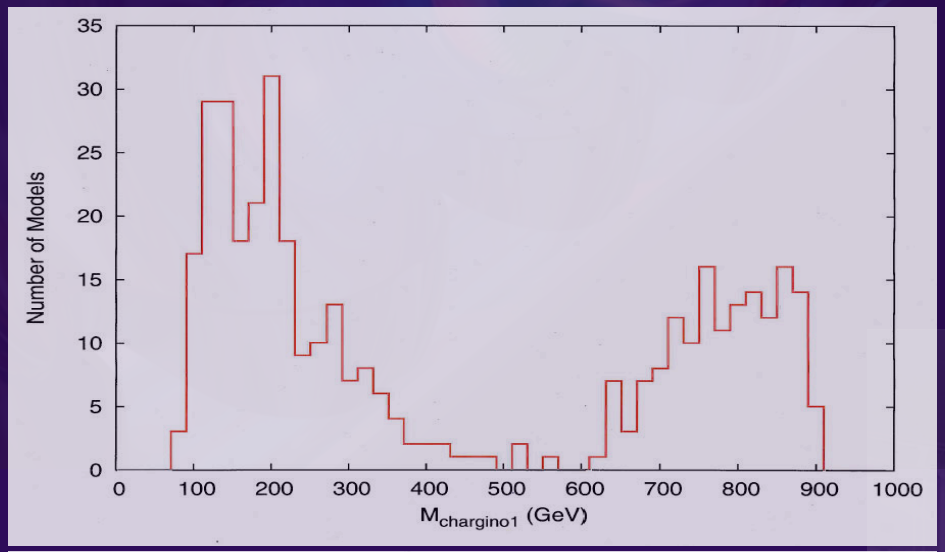
i.e. can we break the remaining degeneracies?

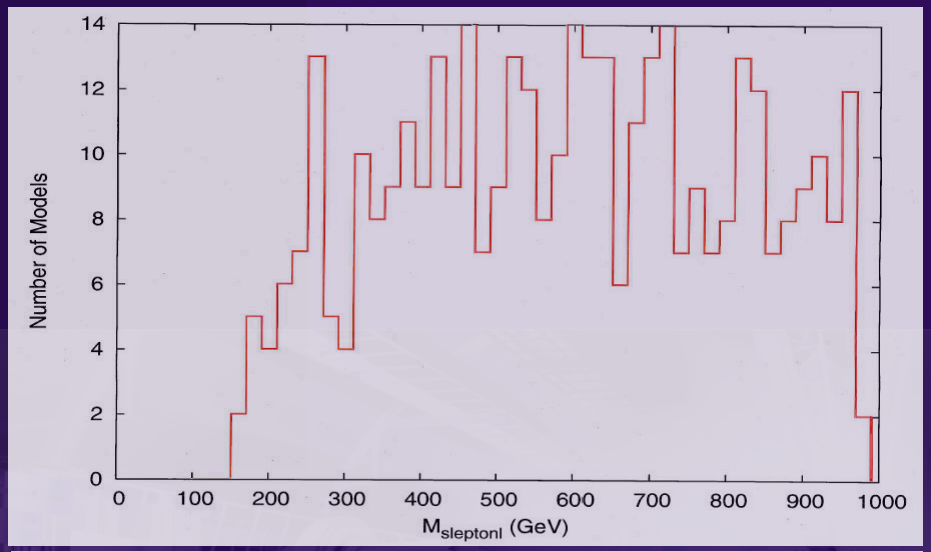
Model Counting at the ILC

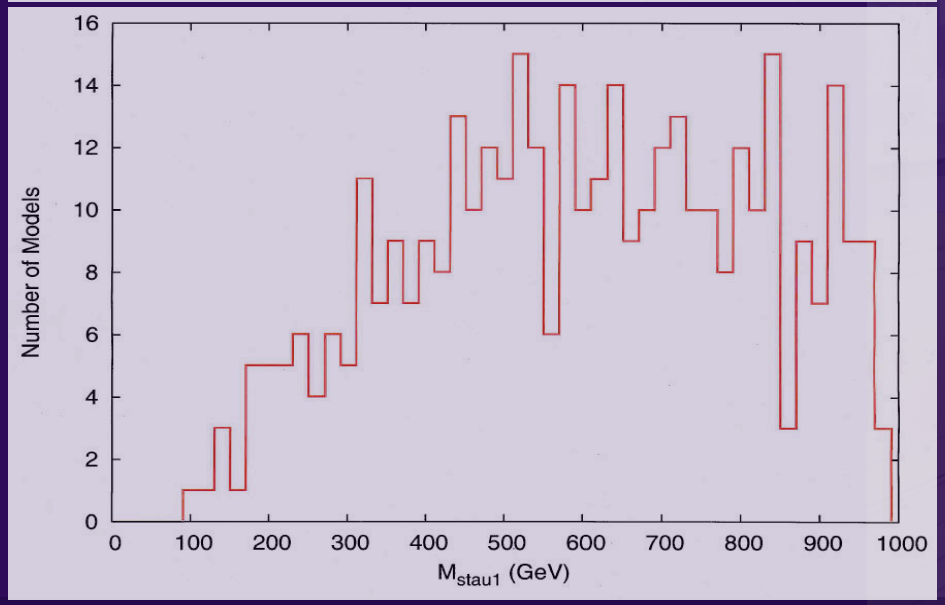
242 Models
165 Pairs

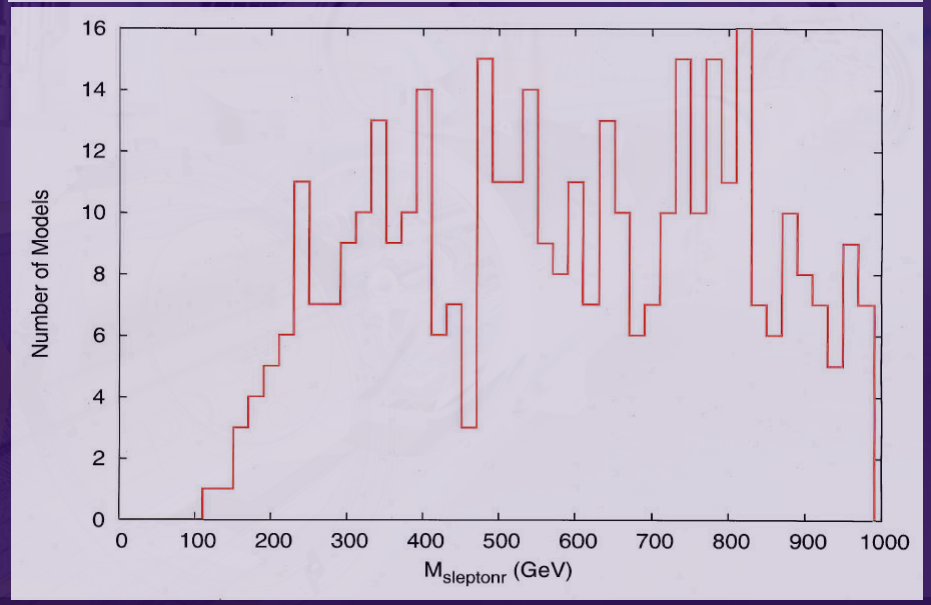
- 500 GeV:
  - 20 models with selectrons & smuons.
  - 28 models with staus, 7 of which also have selectrons/smuons
  - 53 models with charginos, 2 of which also have selectrons/ smuons,
  - 8 of which also have staus
  - 99 models with only LSP (lightest neutralino)
  - 36 models with no kinematically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









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, 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: $m_{\chi_1^+} - m_{\chi_1^0} < 1\ \mathrm{GeV}$
    - "Stable", radiative
  - Separated
    - 4 jets, 2 jets + muon, 2 muons
- Radiative neutralinos

Cuts

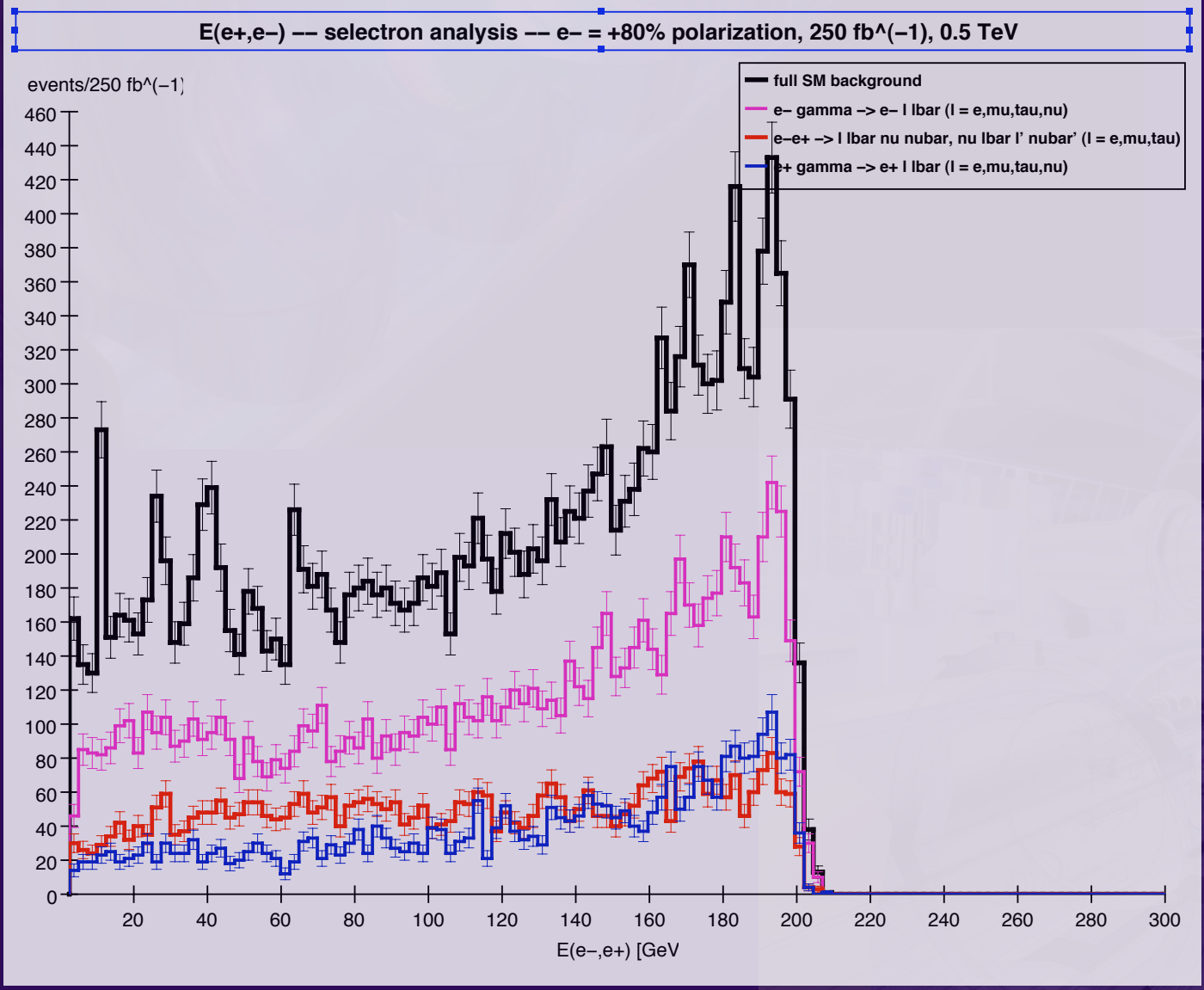
Adapted and expanded analyses from:

- 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)

SM backgrounds

$\gamma\gamma$ & $e^{\pm}\gamma$

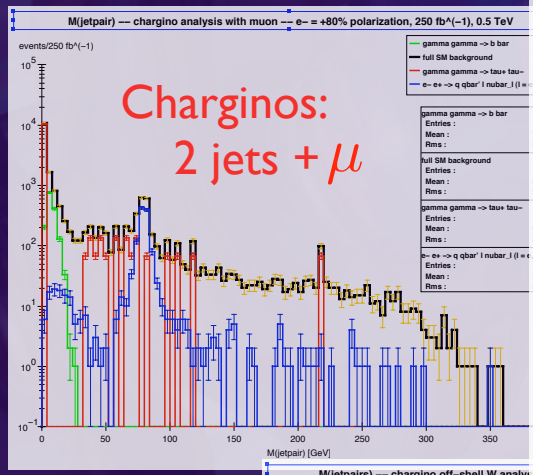


Main problems:

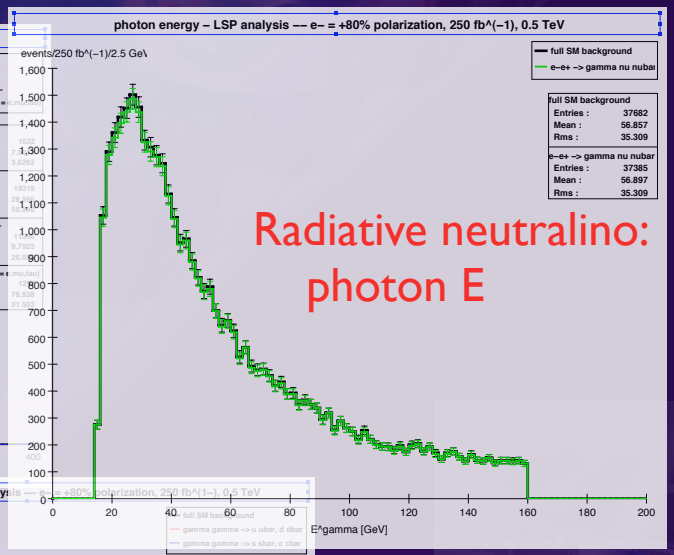
(1) Events where electrons and photons lost down the beampipe

(2) No tracking below 150 mrad. So, no electron/photon separation and low angle muons invisible

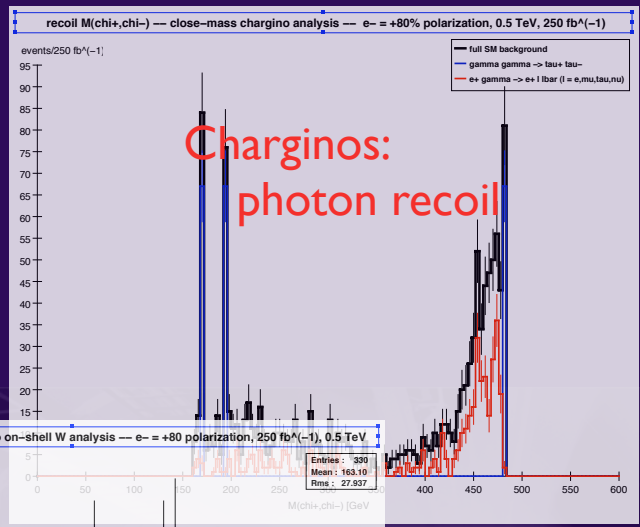
Other analyses - similar story



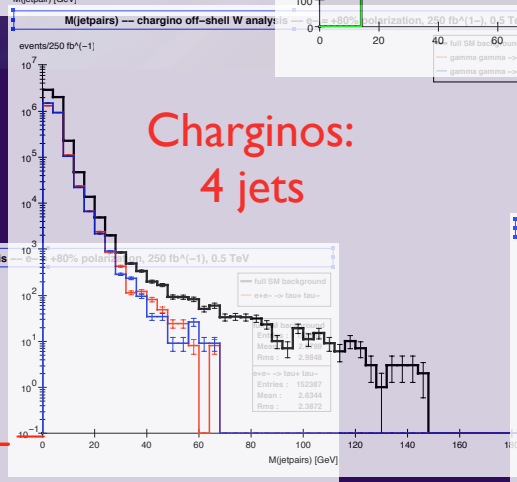
Charginos:
2 jets + μ



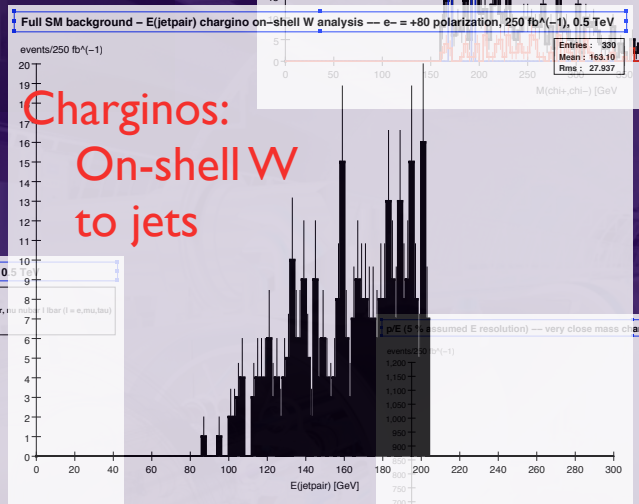
Radiative neutralino:
photon E



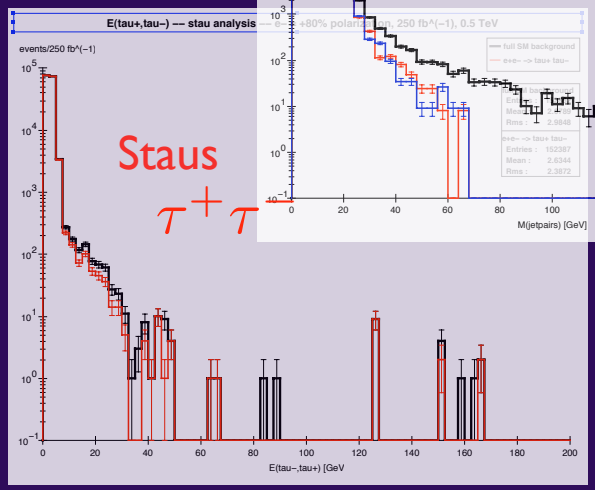
Charginos:
photon recoil



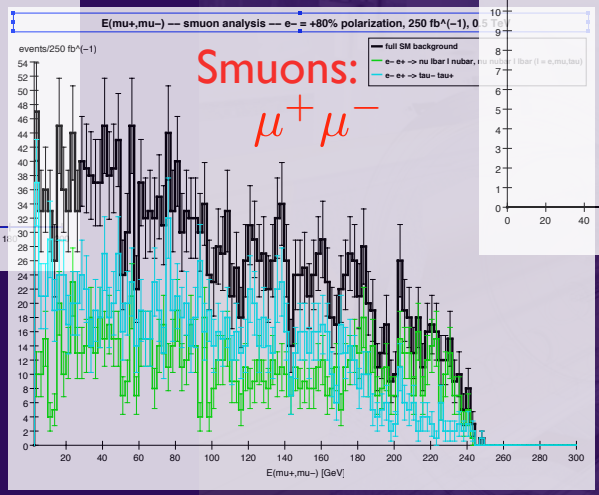
Charginos:
4 jets



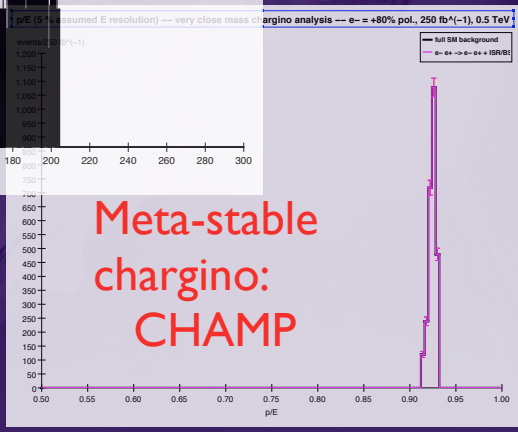
Charginos:
On-shell W
to jets



Staus
$\tau^+\tau^-$

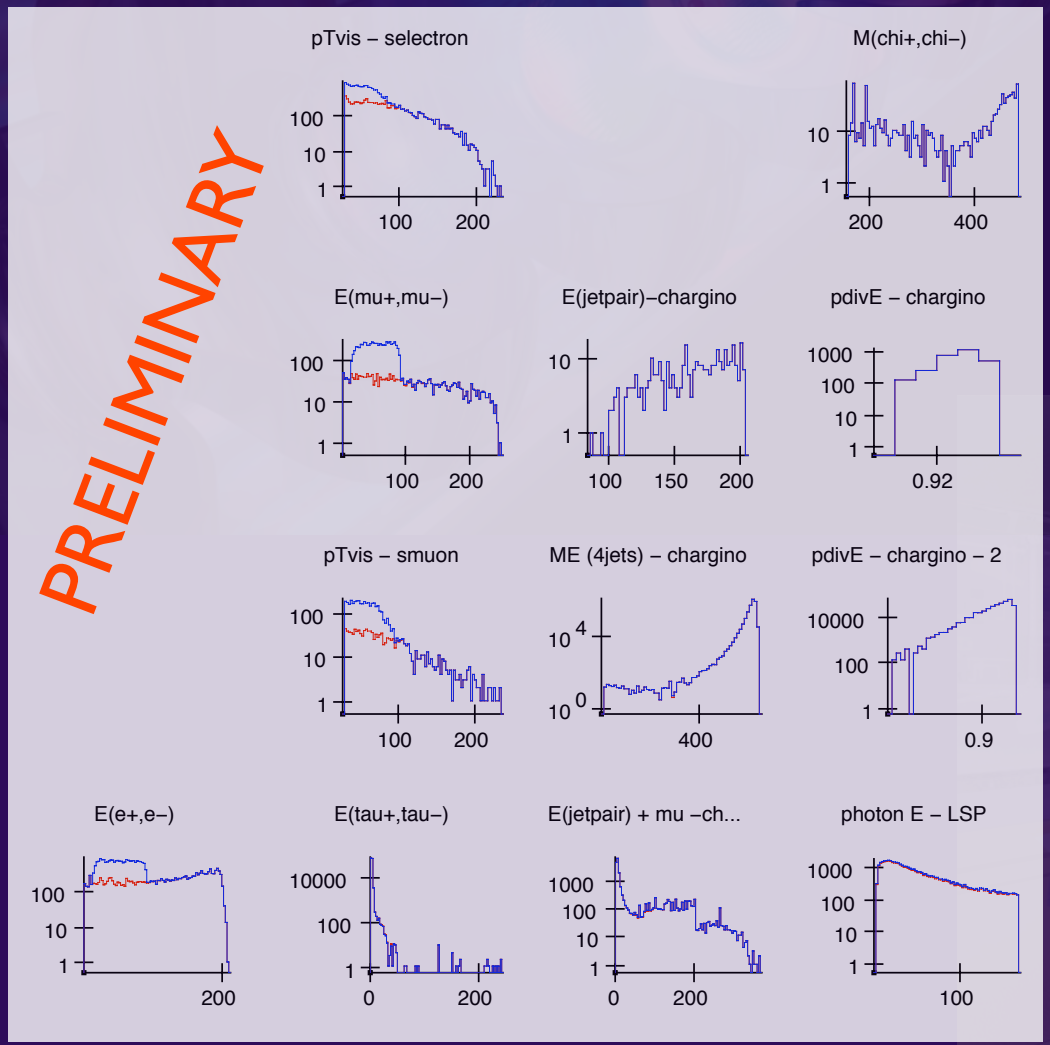


Smuons:
$\mu^+\mu^-$

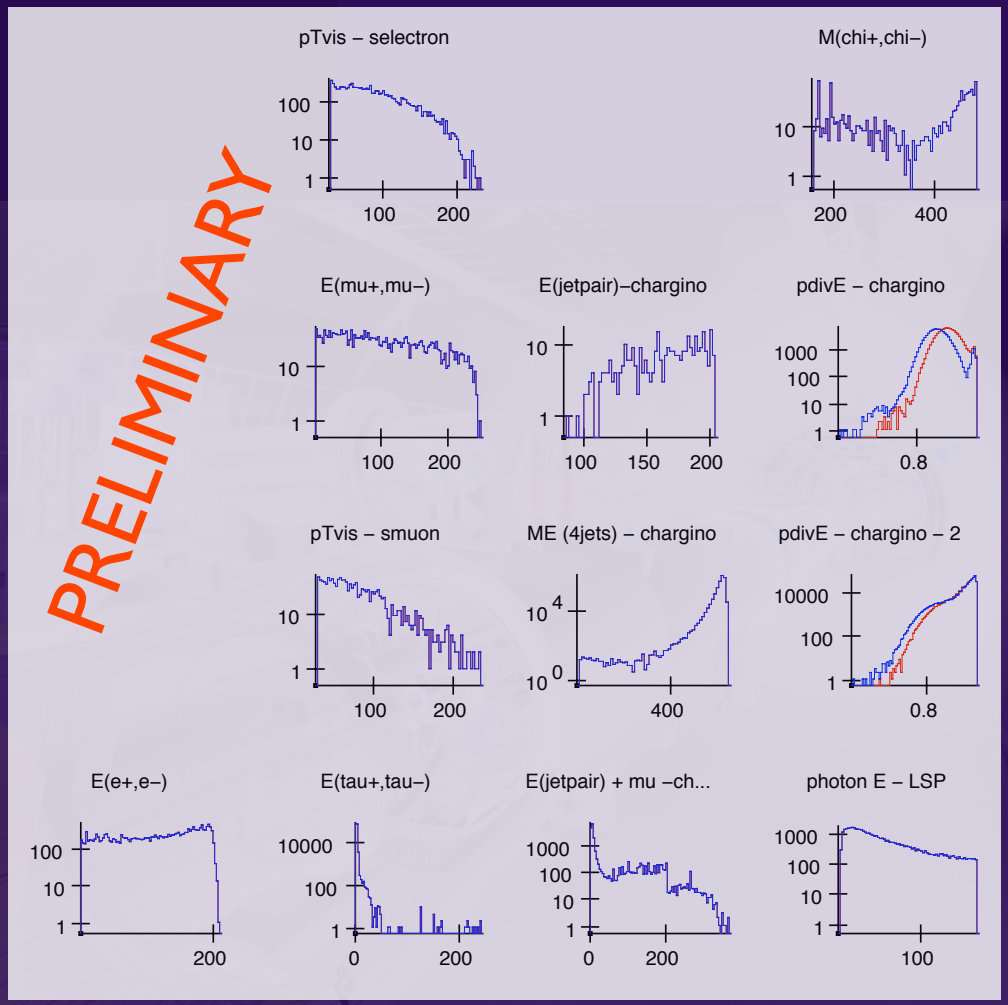


Meta-stable
chargino:
CHAMP

Model comparisons

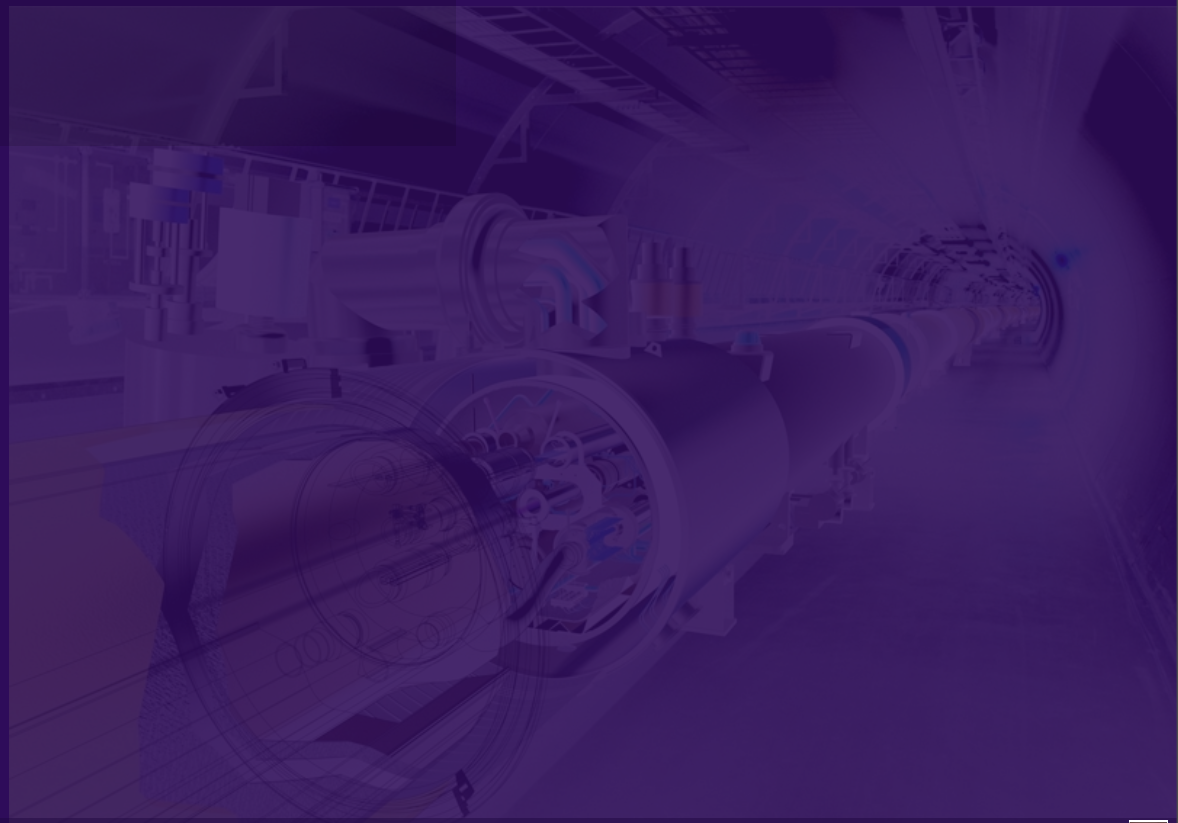


Look at χ^2 in each channel



Examples

PRELIMINARY



Examples

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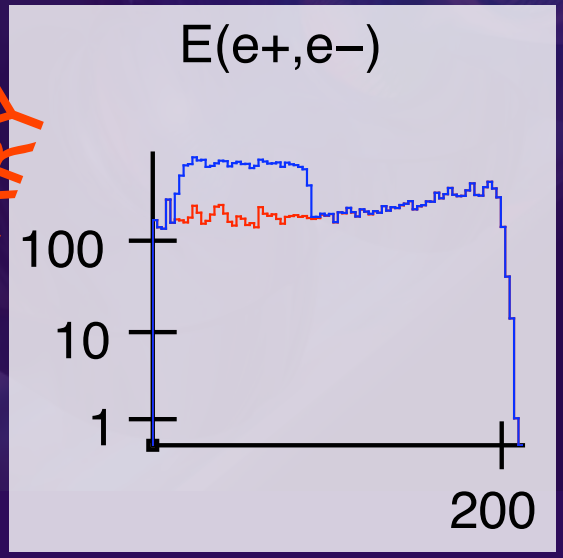


$m_{\tilde{e}}$

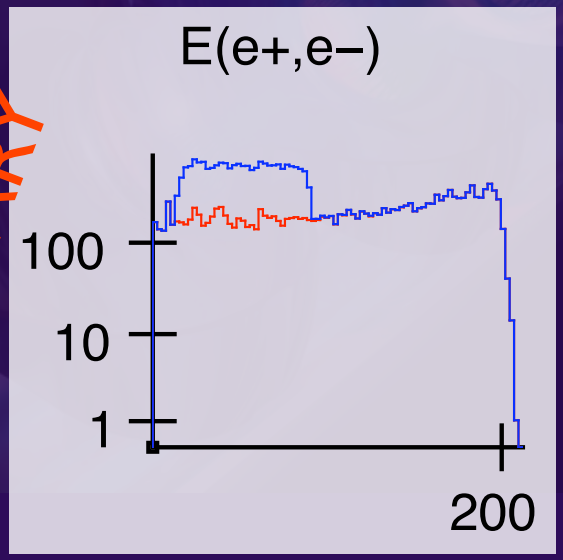
913 GeV (red)

176 GeV (blue)

Squeezer

Examples

PRELIMINARY



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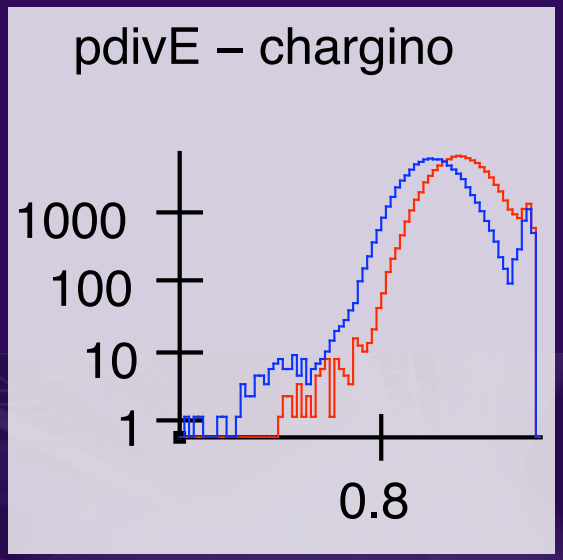


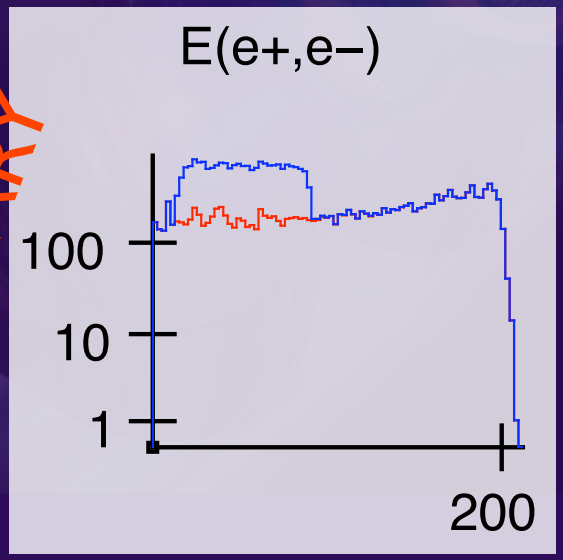
$m_{\chi_1^\pm}$

124 GeV (red)
134 GeV (blue)

Slider

Examples

PRELIMINARY



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Flipper

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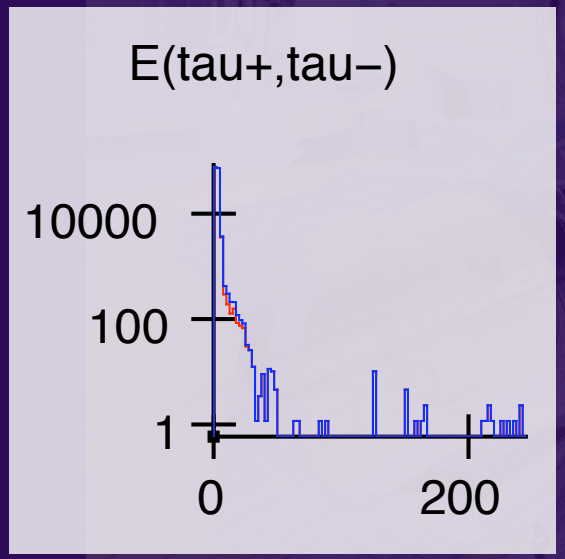

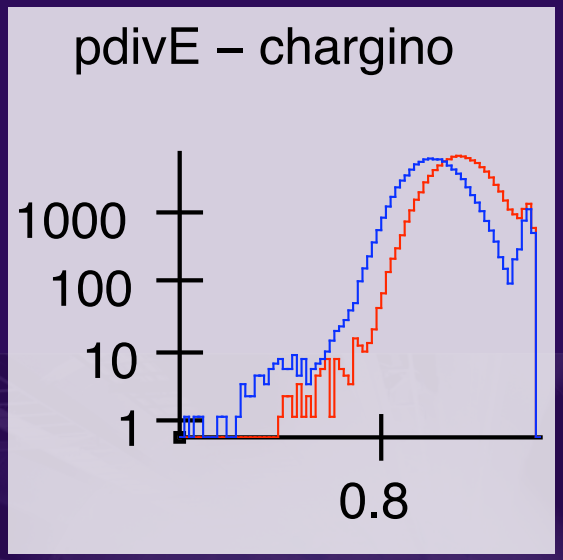

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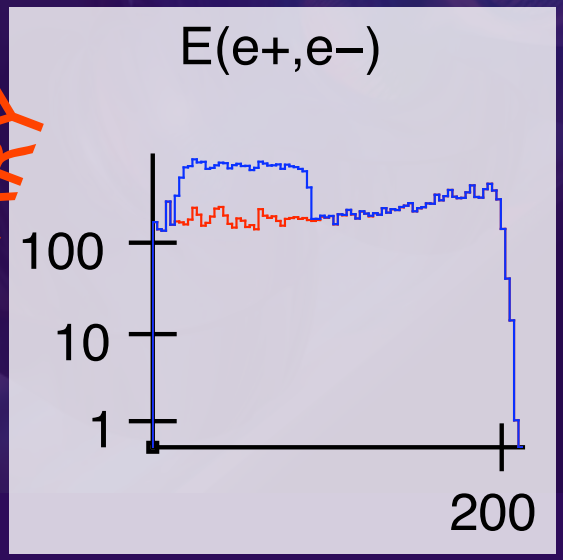
Slider

Examples

χ^2/dof large in all cases

PRELIMINARY



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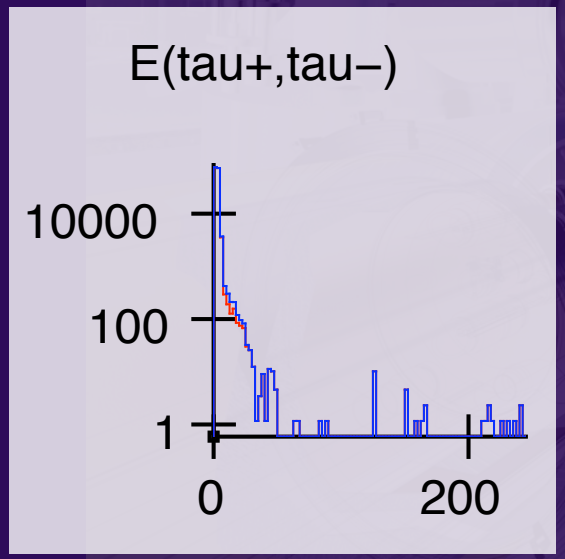

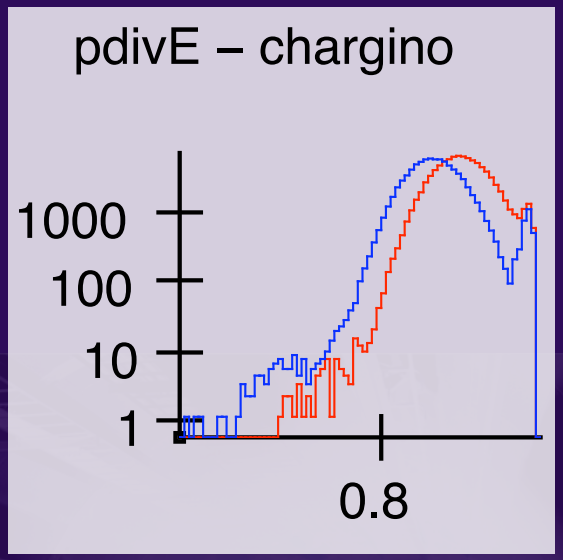

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124 GeV (red)
134 GeV (blue)

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
  - Low angle tracking possibly very important
- First scan of SUSY parameter space independent of model assumptions
  - Not SPS1a
  - Other questions, surveys?