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Searches for GMSB at the LHC

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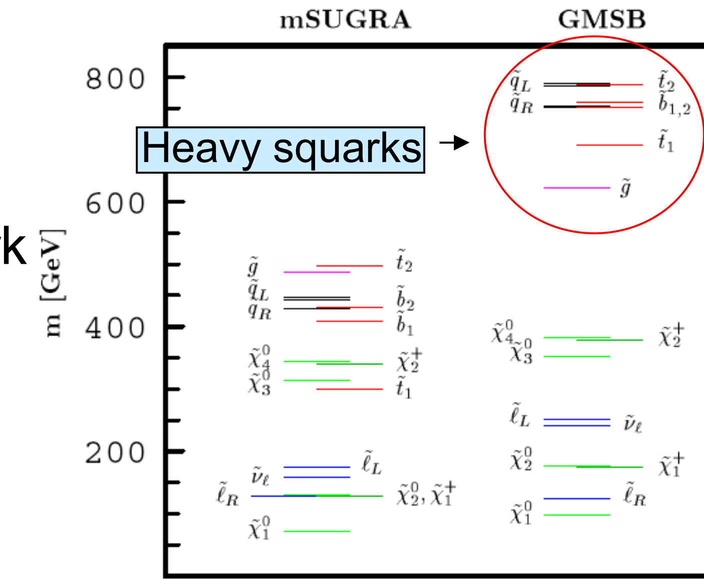
on behalf of the ATLAS and CMS collaborations

Outline

- GMSB Model
- GMSB signatures and discovery potential
  - Photon final states
  - Heavy stable charged particles
- Summary

GMSB – Model I

- SUSY is a good candidate for BSM physics
- SUSY breaking: mediated via gravity, gauge interactions, ...
- GMSB described in renormalizable framework (in contrast to mSUGRA)



Par.	Description
Λ	SUSY breaking scale
M	Messenger mass scale
tanβ	Ratio of Higgs VEVs
N	Number of messenger multiplets
sign(μ)	Sign of Higgs mass parameter
$\mathbf{C_{grav}}$	Scale factor of Gravitino coupling ($\sim 1/C^2_{grav}$)

Features:

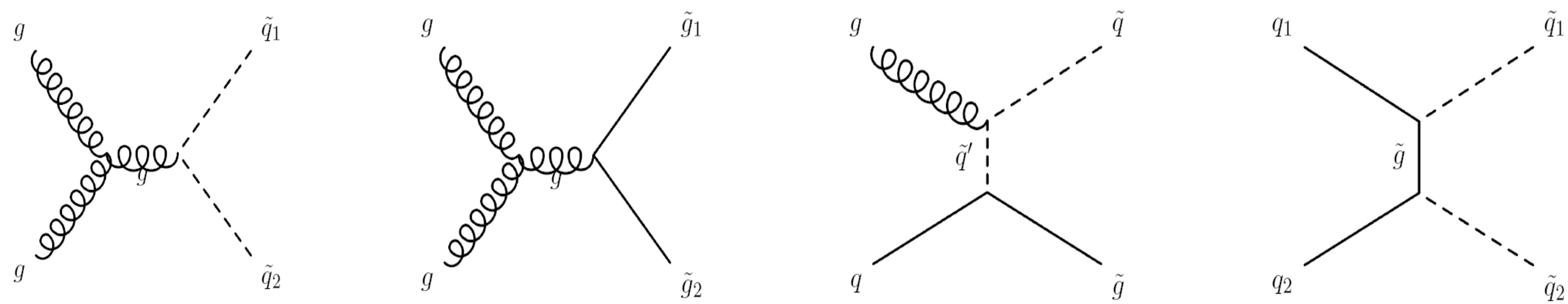
- Lightest SUSY particle (LSP): Goldstino/Gravitino (m ≤ keV)
- 2nd lightest SUSY particle (NLSP): Neutralino or Slepton
- Missing energy from Gravitino
- Final state: hard photons, leptons

Present GMSB limits from TeVatron searches:

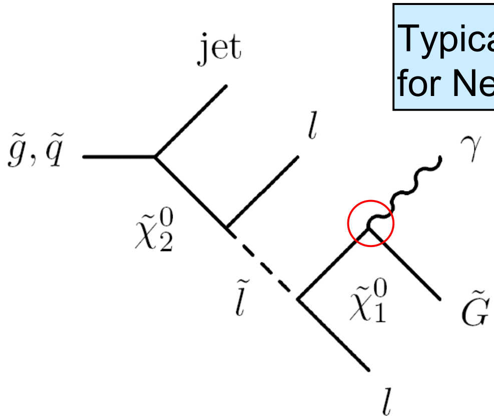
Par.	Λ	$m_{Neutralino}$	$m_{Chargino}$
Limit	> 80 TeV	> 110 GeV	> 200 GeV

GMSB – Model II

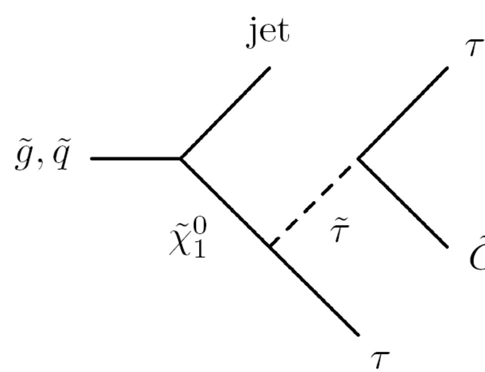
- LHC will probe new energy range in pp@14 TeV
- Squarks and gluinos will be produced (cross section: a few pb) e.g. via



- Different final states compared to mSUGRA



Typical decay chain for Neutralino NLSP



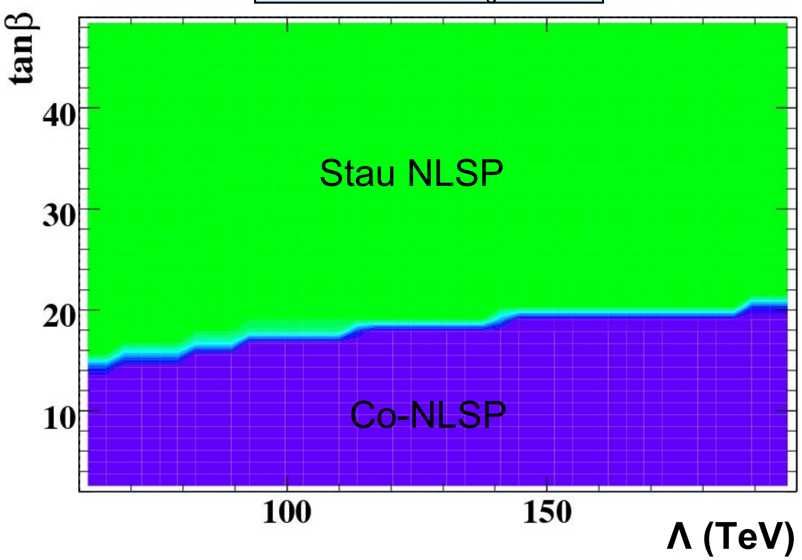
Typical decay chain for Stau NLSP

→ This talk: Results of simulation studies of ATLAS and CMS

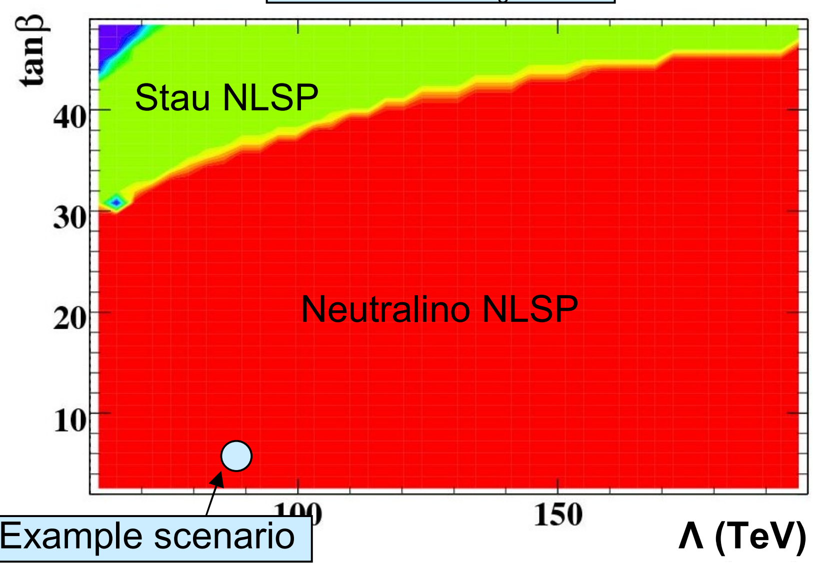
GMSB – Model III

- 4 main topologies in GMSB (red covered in this talk):
  - Neutralino NLSP:
    - -Prompt decay: di-photon events (e.g. N = 1, C_{grav} = 1)
    - -Non-pointing photons (e.g. N = 1, C_{grav} = 55)
  - Slepton NLSP:
    - -Prompt decay: di-lepton final state (e.g. N = 3, C_{grav} = 1)
    - -Long lifetime sleptons: quasi stable sleptons (e.g. N = 3, C_{grav} = 5000)

M = 250 TeV, N = 3, sign(μ) = 1, C_{grav} = 1



M = 500 TeV, N = 1, sign(μ) = 1, C_{grav} = 1



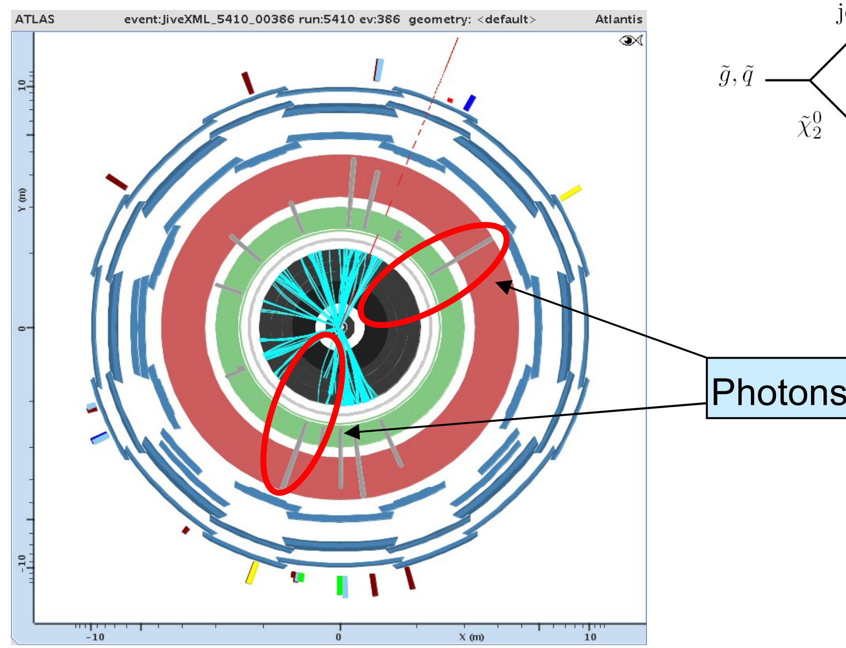
Example scenario

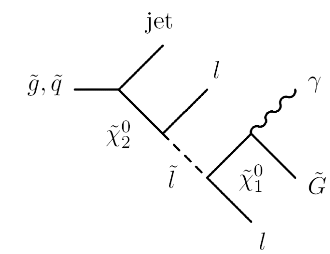
Prompt photon selection ($1 fb^{-1}$)

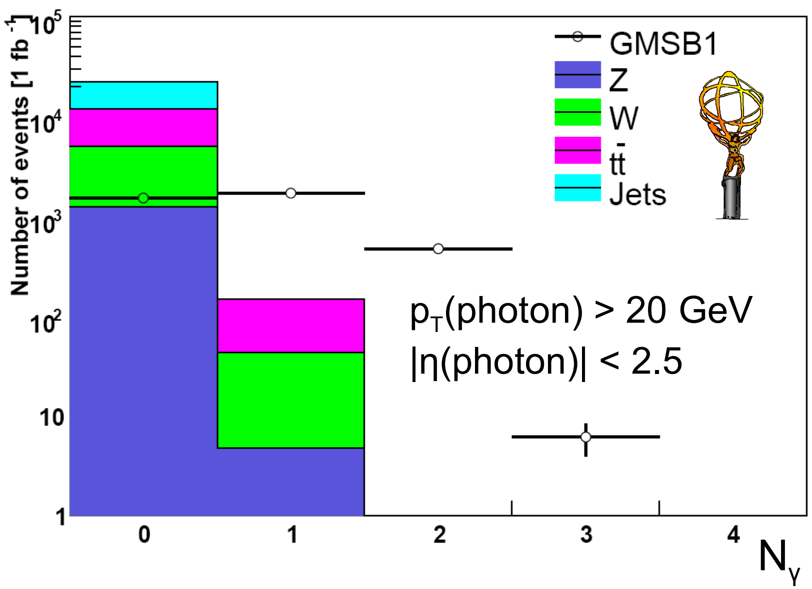
Prompt photon scenario (7.8 pb)

"Standard" SUSY cuts:

- $E_T^{miss} > 100$ GeV
- $E_T^{miss} > 0.2\ M_{eff}$
- $N_{jets} > 4$
- p_T(jets) > 50 GeV
- p_T(leading jet) > 100 GeV





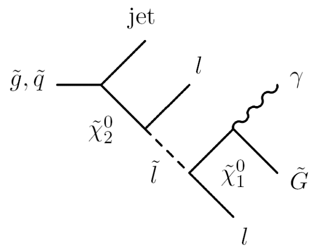


- Cuts on missing energy and effective mass reject BG (full simulation, ALPGEN).
- Striking feature in GMSB1: Prompt photons with high momentum.
- Additional requirement of 2 photons:

→ 252.9 signal events, 0.1 BG events

Di-photon discovery potential ($1fb^{-1}$)

- Discovery potential in di-photon channel?
  → Scan of GMSB parameter space using a fast simulation.



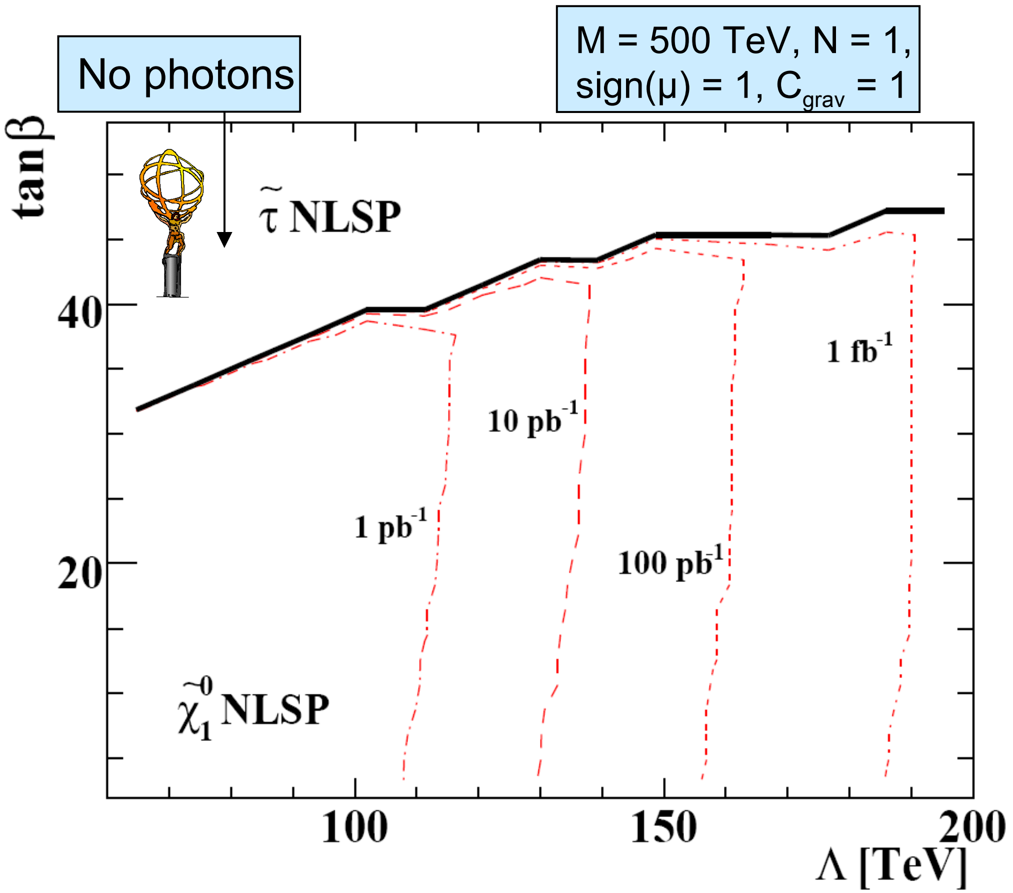
Contour lines with 5 signal events.

Decrease of cross section with Λ

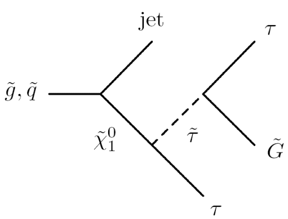
→ Decrease of significance

CMS has performed similar studies with comparable reach.

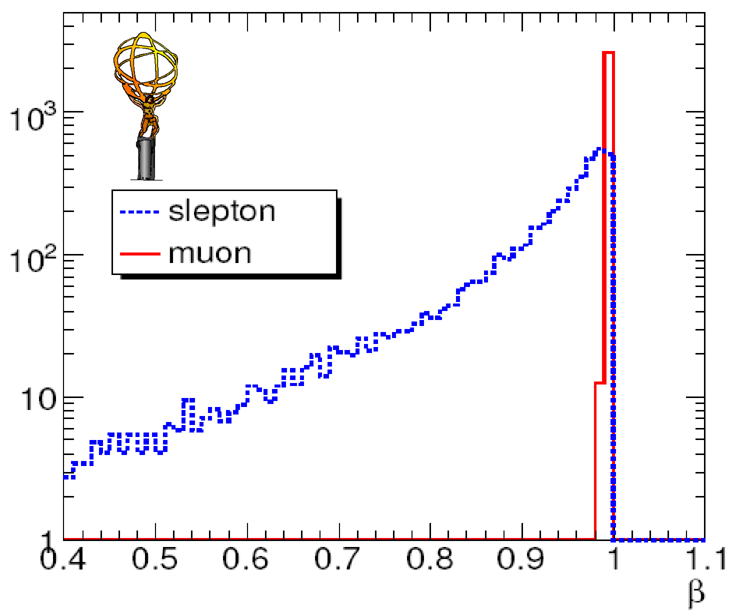
→ Large discovery potential of di-photon signature in part of parameter space.

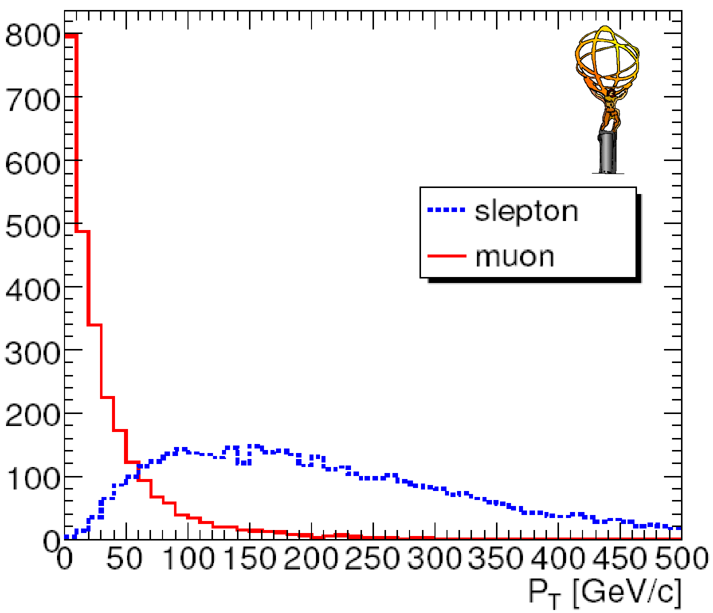


Heavy stable charged particles (HSCPs)



- In some GMSB scenarios: NLSP = Slepton (e.g. N >1, large tanβ).
- Sleptons that couple weakly to Gravitino have long lifetime:
  - Heavy stable charged particle with β < 1.
  - For β ~ 1 not distinguishable from ordinary muons
    → use muon triggers (besides missing energy triggers).
  - For β < 1 bunch crossing identification challenging, but most events contain a high β slepton.

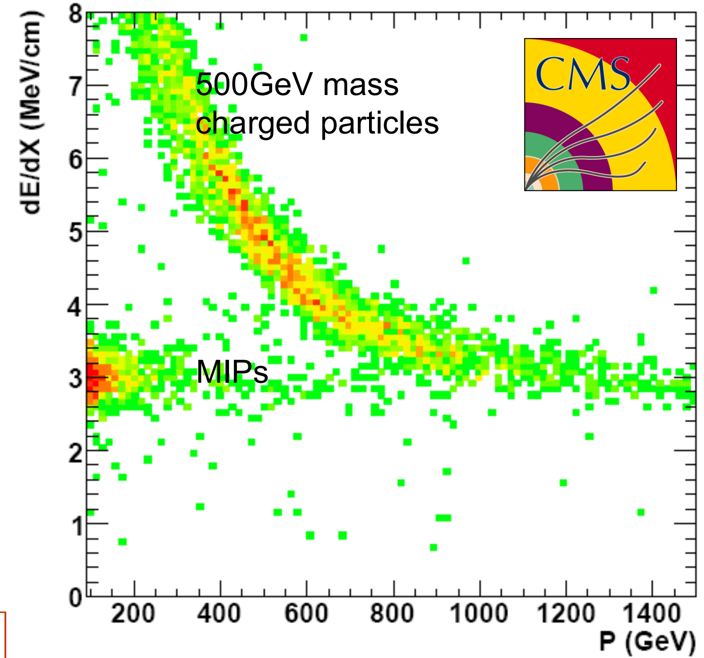


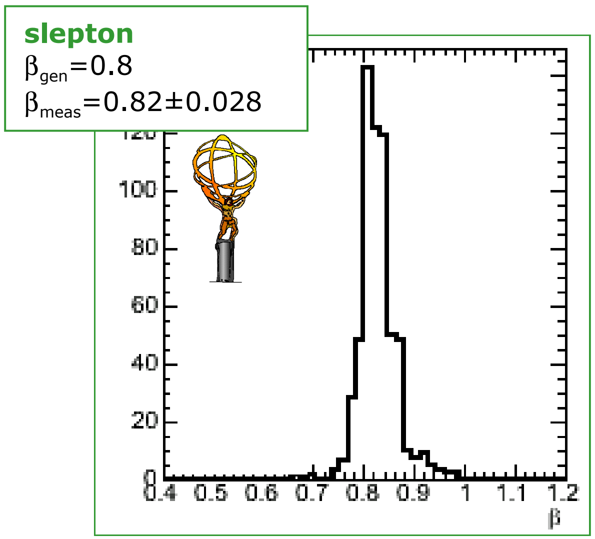


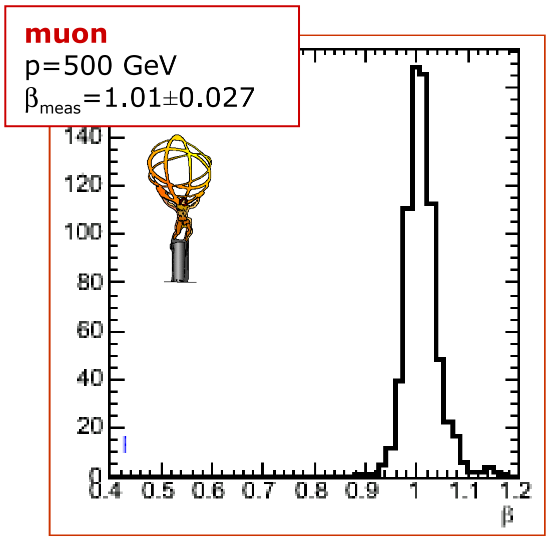
HSCP β measurement

- 2 strategies for measurement of β:
  1. β from time of flight (muon system)
  2. β from ionisation (dE/dx) in tracker (CMS)

     β from time over threshold in transition radiation tracker (ATLAS)
  - Combination of methods allows good BG rejection (see talk from L. Quertenmont).







- Use of hits from next bunch crossing improves efficiency from 65% to 97% for β = 0.6.
- Combination of different muon detectors improves accuracy.

HSCP mass measurement

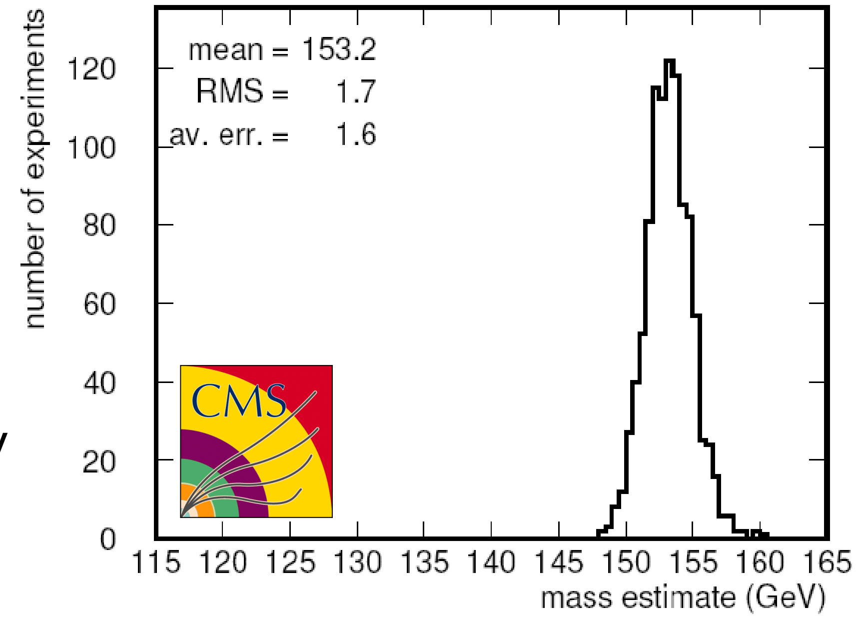
- Stau mass can be estimated from β and p

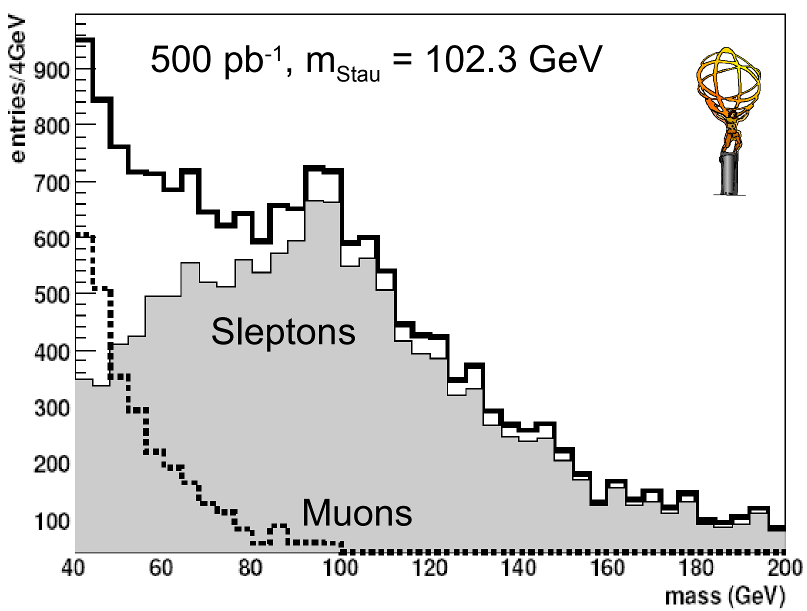
$$m = p\sqrt{\frac{1}{\beta^2} - 1}$$

- Example GMSB scenario (CMS):

  M_{gen} = 152.3 GeV

  M_{est} = [153.2 ± 1.6 (stat.) ± 0.9 (syst.)] GeV





- Slepton mass measureable already at trigger level:
  - β from time of flight in resistive plate chambers (ATLAS)
- Selection:
  - β < 0.97
  - p_T > 40 GeV
  - m > 40 GeV

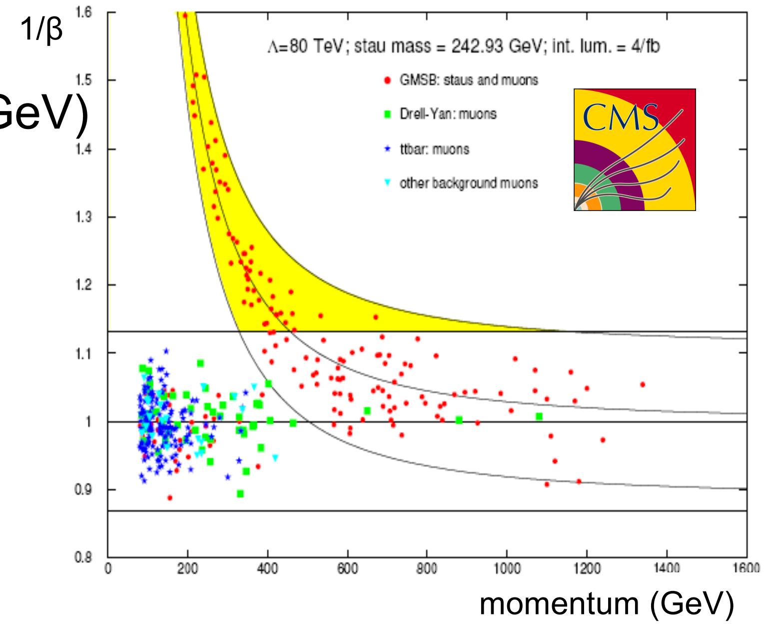
HSCP selection (1fb^{-1})

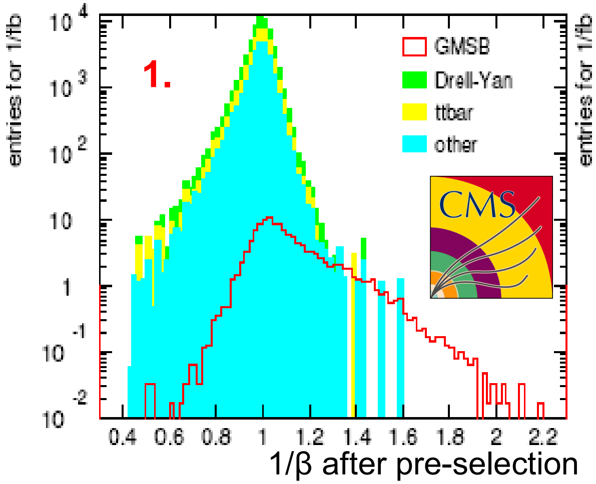
- Selection cuts (Λ = 80 TeV):
  - Pre-selection: single muon trigger (p_T > 80 GeV)
  - Quality requirements (muon system)
  - Selection:

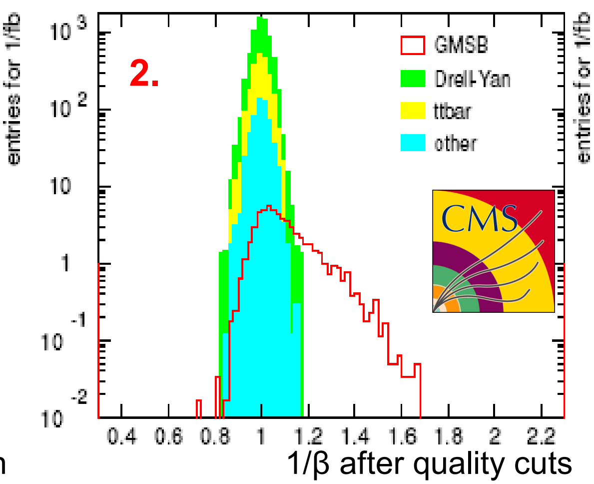
    Muon pair with p_T > 60 GeV, $M_{\mu\mu}$ > 110 GeV

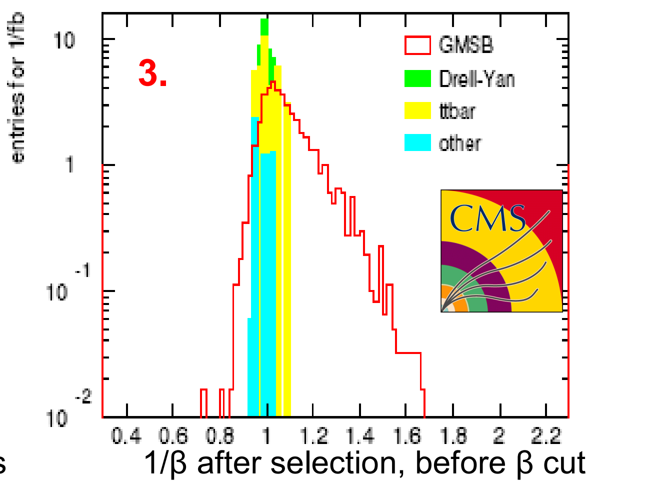
    M_{eff} > 360 GeV
  - β cut

→ 12 signal events, 0.05 background events









Summary

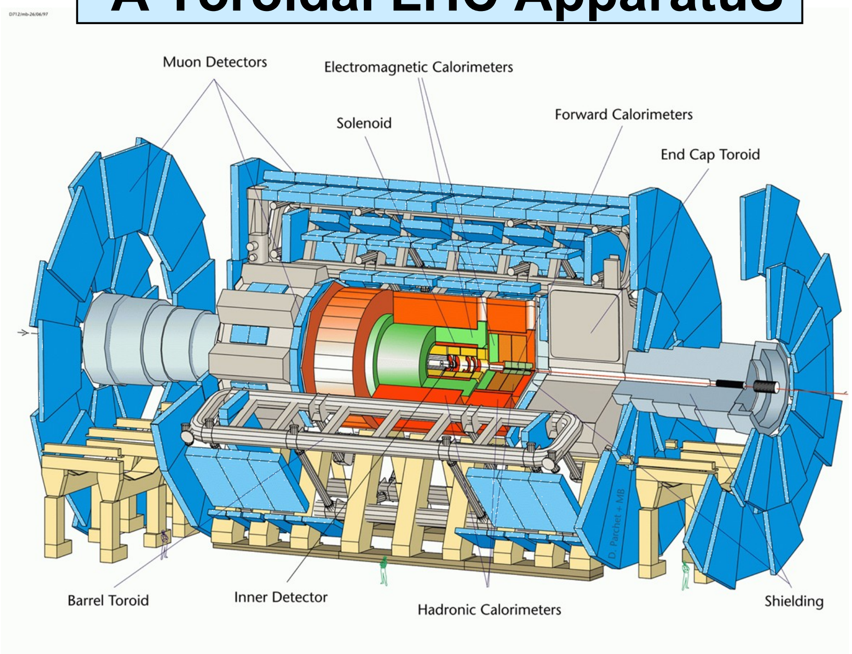
- GMSB possible model for SUSY breaking.
- Striking signatures expected at the LHC:
  - Di-photon (prompt)

    → Clean signal, low background.
  - Quasi stable staus

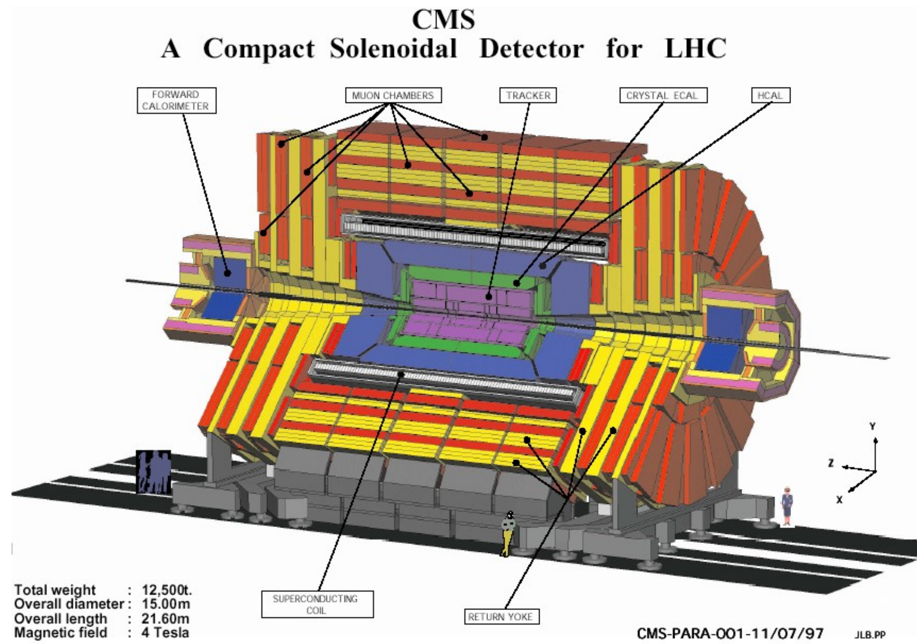
    → Promising results in selection, mass and velocity measurement.
- Discovery possible already with early data!
- Be prepared for first LHC collisions scheduled for this year!

ATLAS and CMS detectors

A Toroidal LHC ApparatuS



Compact Muon Solenoid



Total weight	**7000 t**
Overall diameter	**25 m**
Barrel toroid length	**26 m**
End-cap span	**46 m**
Magnetic field	**2 Tesla**

Total weight	**12 500 t**
Overall diameter	**15 m**
Overall length	**21 m**
Magnetic field	**4 Tesla**

GMSB1 distributions

- Various distributions of cut variables in the prompt photon case.