Gauge-mediated supersymmetry breaking and goldstini phenomenology

arXiv:1112.5058 R. Argurio, KDC, G. Ferretti, A. Mariotti, K. Mawatari, Y. Takaesu

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Outline

- Introduction to GMSB
- The 'Two Goldstini Model'
- Parameter choice
- Collider phenomenology

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Supersymmetry

- SUSY solves part of the remaining problems of the SM
- SUSY has to be broken at the weak scale
- By the introduction of soft breaking terms (= no quadratic divergences)
- Reduce number of free parameters by assuming an organising principle behind SSB

SUSY breaking by mediation

Freedom in choice of

- SSB mediation mechanism
- Nature of the SSB hidden sector

SUSY breaking by mediation

Mediating interactions should be flavor blind to avoid FCNC

2 main proposals:

- Gravity mediated SSB (PMSB)
- Gauge mediated SSB (GMSB)

PMSB vs GMSB

- related to general relativity and physics beyond the Planck scale
- E.g. mSUGRA
- Troubles with FCNC

- SSB terms < loop diagrams involving messenger particles
- SM gauge interactions
- FCNC naturally solved

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SUSY breaking by mediation

- Usually a single SSB sector is considered
- Generalise to multiple SSB sectors

First step

Investigate collider signatures of two SSB sectors

SSB sector

- Two independent SSB sectors
- Spontaneous SB yields two goldstini
- One linear combination is eaten by the gravitino G (< SuperHiggs mechanism)
- Pseudo-goldstino G' left with the mass as free parameter

SSB sector

- Coupling between the G/G', gaugino and gauge boson:

$$\frac{m_\lambda}{2\sqrt{2}F}\lambda\sigma^\mu\bar{\sigma}^\nu G F_{\mu\nu}+K_\lambda\frac{m_\lambda}{2\sqrt{2}F}\lambda\sigma^\mu\bar{\sigma}^\nu G' F_{\mu\nu}$$

  - K_λ is essentially a free parameter
  - Similar terms for the G/G' - fermion - sfermion vertex

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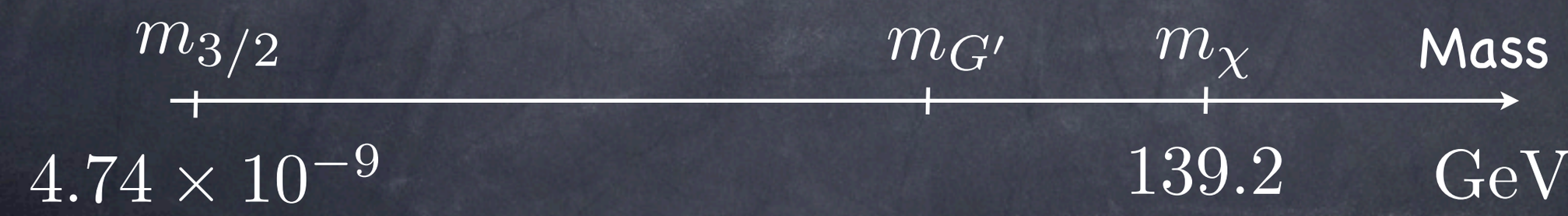
Mass spectrum:

choice of G′ mass

- In GMSB the gravitino is the LSP
  (= lightest SUSY particle)

- Our case: lightest neutralino is LOSP
  (= lightest observable SUSY particle)

- Choose $m_{G'}$ as NLSP
  (= next-to lightest SUSY particle)



Neutralino decay:

choice of K_λ

Decay channels:

$\chi \to \gamma G$

$\chi \to \gamma G'$ Soft photons!

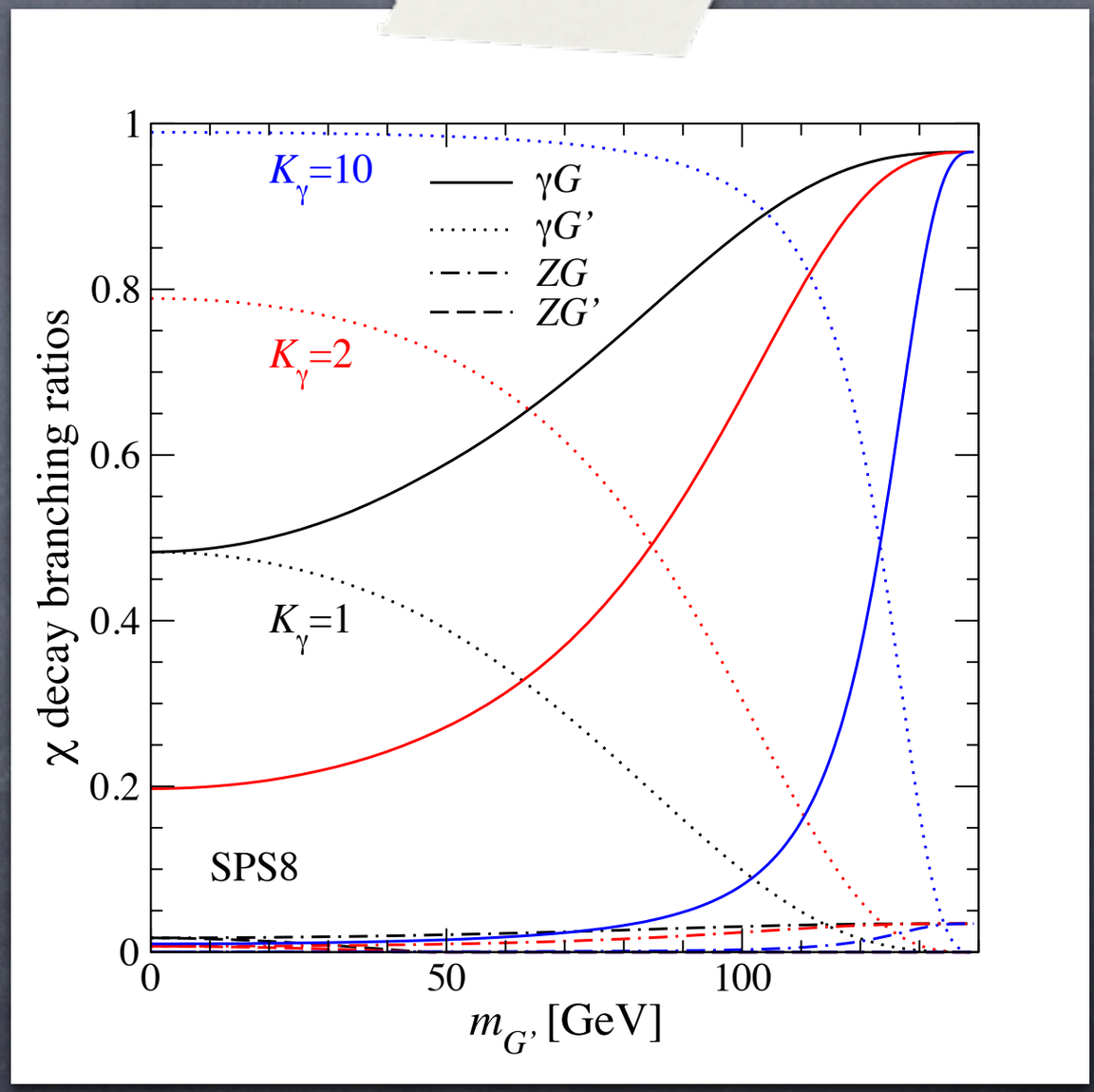
$\chi \to Z G$

$\chi \to Z G'$

Z decay negligible

$K_{Z_L} = K_{Z_R} = 1$

$1 < K_\gamma < 100$



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Implement into FeynRules ...

```
(* ***************************** *)
(* *****      Fields      ***** *)
(* ***************************** *)
M$ClassesDescription = {
  F[10] == { ClassName        -> gld,
             SelfConjugate    -> True,
             Mass             -> Mgld,
             Width            -> Wgld,
             ParticleName     -> "gld",
             PDG              -> 1000039,
             PropagatorLabel  -> "gld",
             PropagatorType   -> Straight,
             PropagatorArrow  -> None},
  F[11] == { ClassName        -> pgld,
             SelfConjugate    -> True,
             Mass             -> {Mpgld, 100.},
             Width            -> Wpgld,
             ParticleName     -> "pgld",
             PDG              -> 2000039,
             PropagatorLabel  -> "pgld",
             PropagatorType   -> Straight,
             PropagatorArrow  -> None}
};
```

... and run MadGraph5 @ SPS8

Single photon production

$$e^+e^- \to \chi G/G'$$

Single hidden sector

- Cross section:

$$\sigma \sim \frac{1}{m_{3/2}^2}$$

- To get a reasonable cross section we need

$$m_{3/2} \sim 10^{-5} - 10^{-4}\mathrm{eV}$$

Lower then standard value for GMSB

Two hidden sectors

- Cross section:

$$\sigma \sim \frac{K_\lambda^2}{m_{3/2}^2}$$

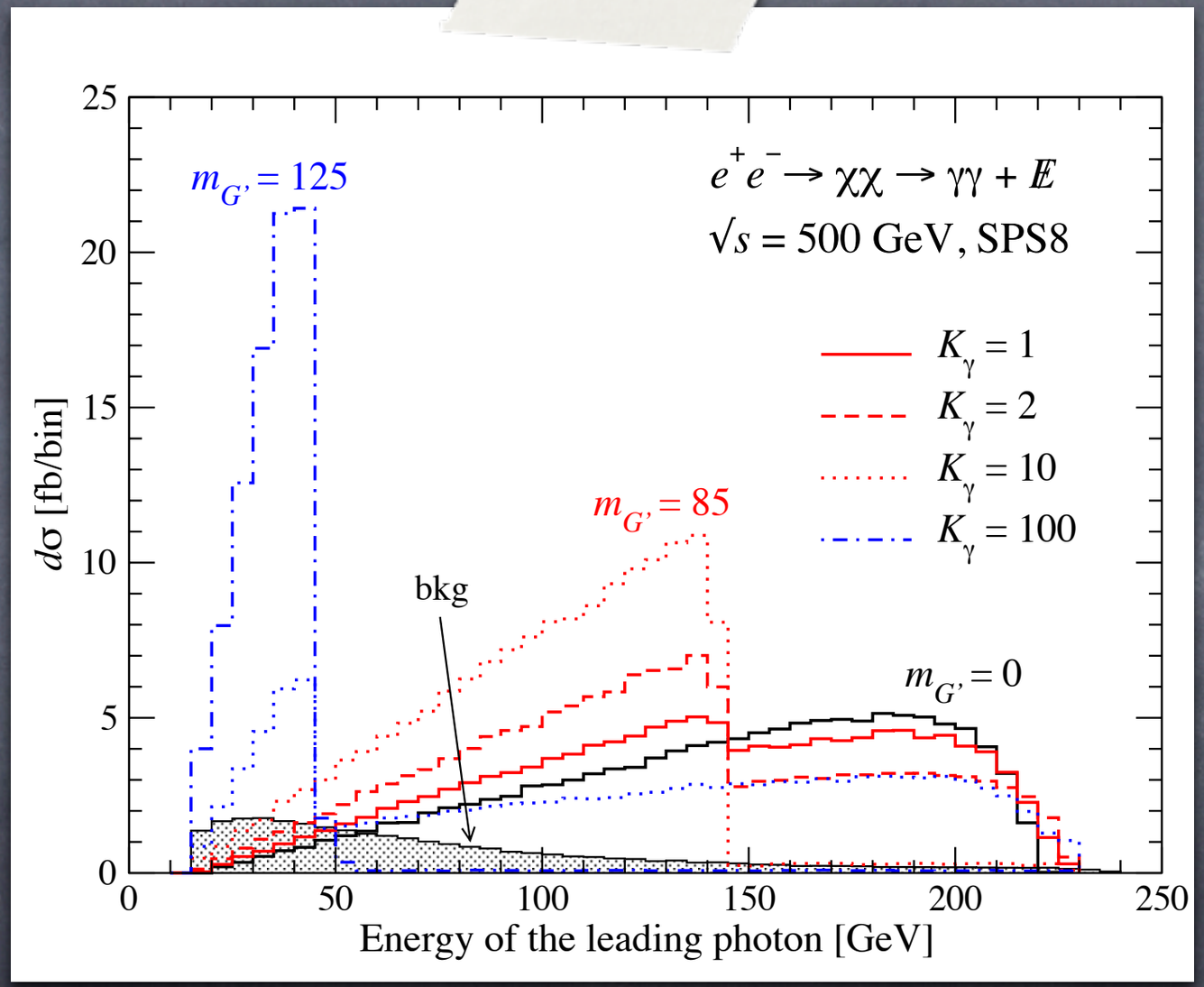
- To get a reasonable cross section we can tune K_λ and obtain

$$m_{3/2} \sim \mathrm{eV}$$

Standard value in GMSB

Diphoton + ME @ ILC

$$e^+e^- \to 2\chi \to 2\gamma + \not{E}$$

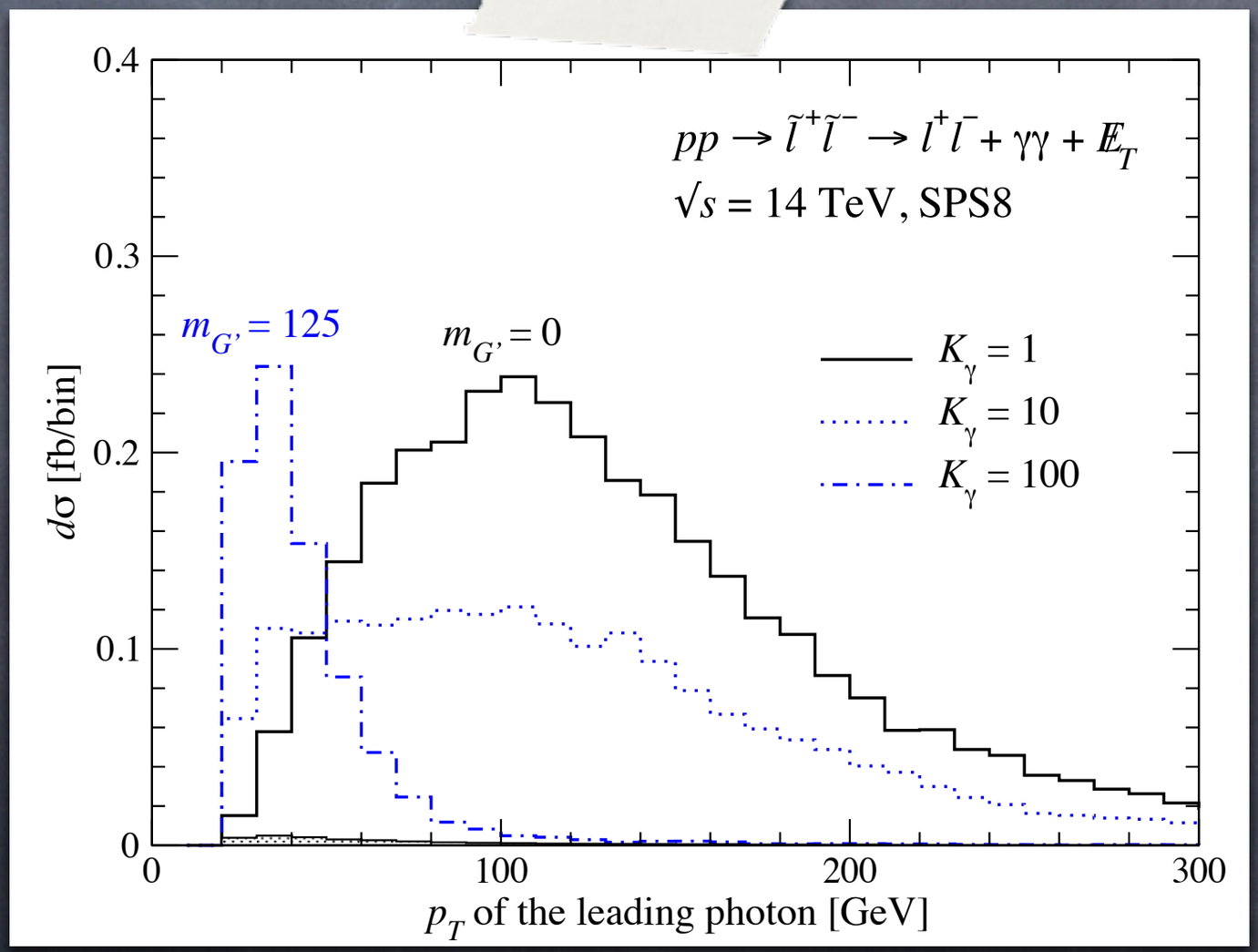


$$E_\gamma^{\max,\min} = \frac{\sqrt{s}}{4}\left(1 - \frac{m_{G'}^2}{m_\chi^2}\right)\left(1 \pm \sqrt{1 - \frac{4m_\chi^2}{s}}\right)$$

Di-photon + ME @ LHC

$$pp \to 2\chi \to 2\gamma + \not{E} \qquad \sigma \sim 1 \text{ fb}$$

$$pp \to \tilde{l}^+_{R/L}\tilde{l}^-_{R/L} \to l^+l^- + 2\gamma + \not{E} \qquad \sigma \sim 2 \text{ fb}$$



Summary

- Generalisation to two SSB sectors
- Gravitino LSP, pseudo-goldstino NLSP and lightest neutralino LOSP
- 2 characteristic collider signatures
  * soft photons
  * specific shapes in E and pT distribution
- Will be extended to stau LOSP

Thank you!