GGM: Status and Prospects

David Shih
Rutgers University

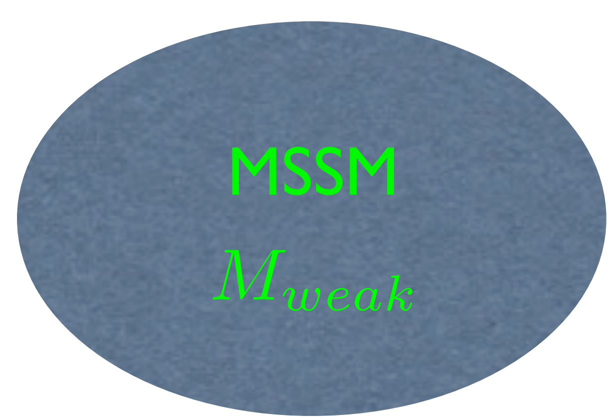
Draper, Meade, Reece & DS (1112.3068)
Kats, Meade, Reece & DS (1110.6444)
Kats & DS (1106.0030)
Ruderman & DS (1009.1665, 1103.6083)
Meade, Reece & DS (0911.4130, 1006.4575)

Outline of the Talk

- A Brief Intro to SUSY and GGM
- The Current Status of SUSY Searches (from a theorist’s perspective)
- Connections to GGM
- GGM and the Higgs
- Summary and Conclusions

A Brief Intro to SUSY and GGM

The SUSY Paradigm



SUSY cannot be broken directly in the MSSM.

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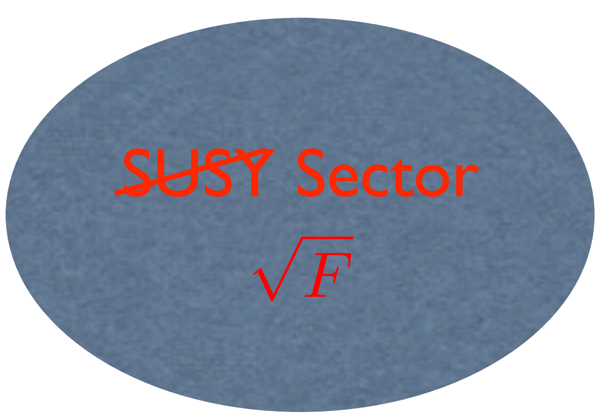

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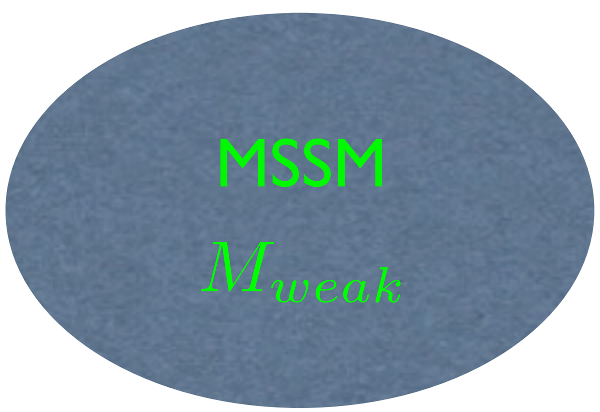

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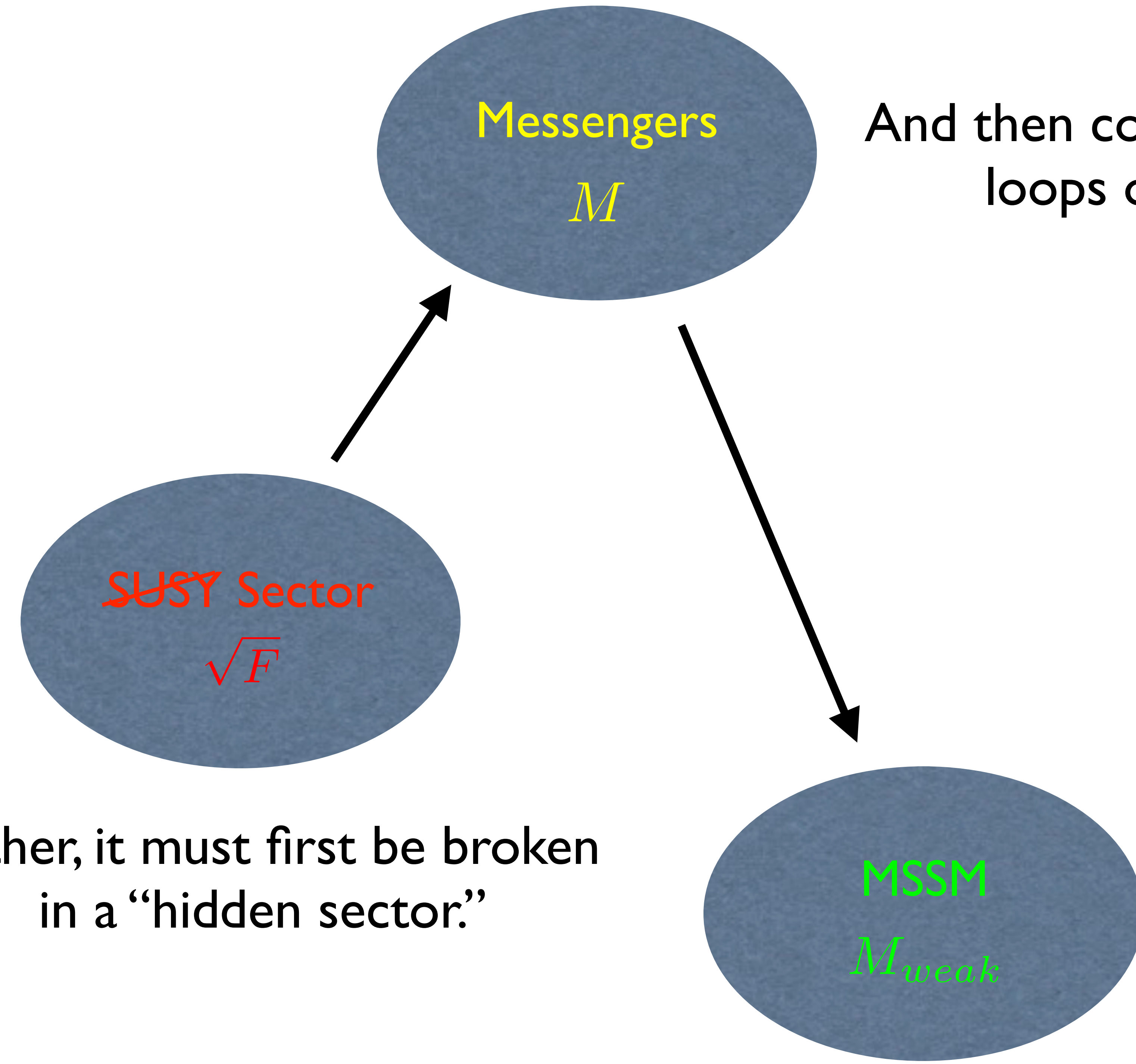

And then communicated through loops of “messengers.”

Rather, it must first be broken in a “hidden sector.”

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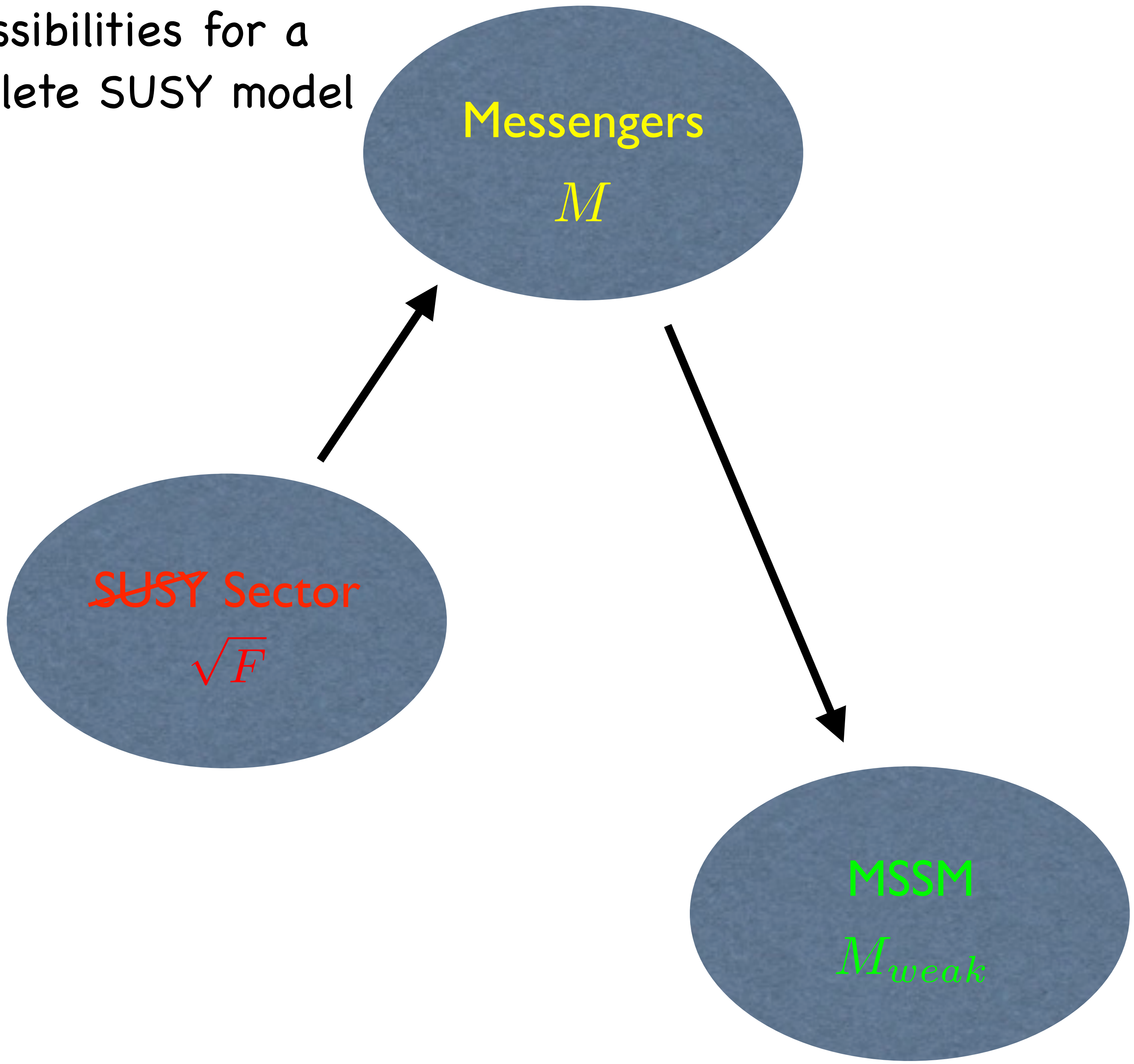
The SUSY Paradigm

There are many possibilities for a complete SUSY model



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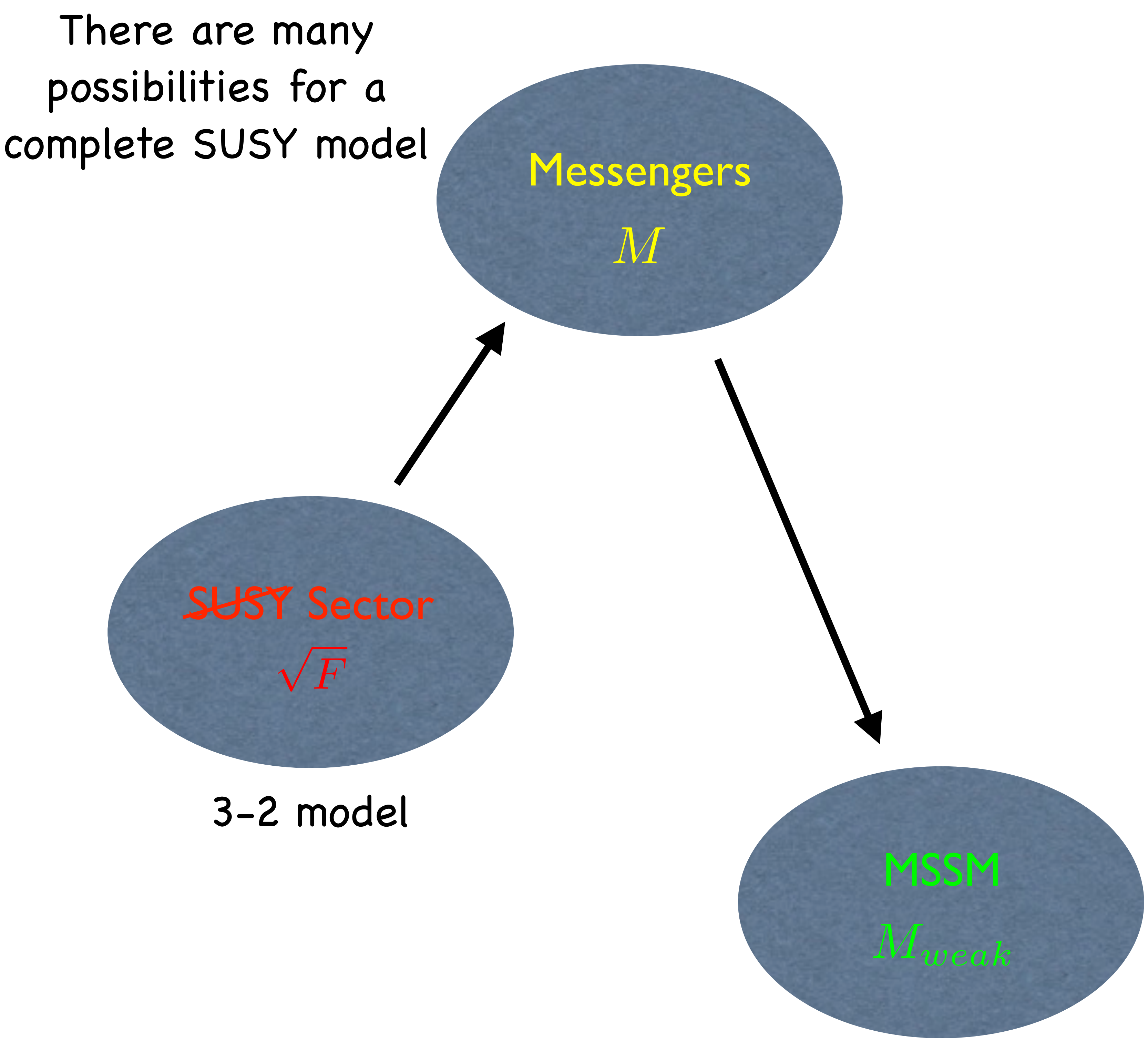

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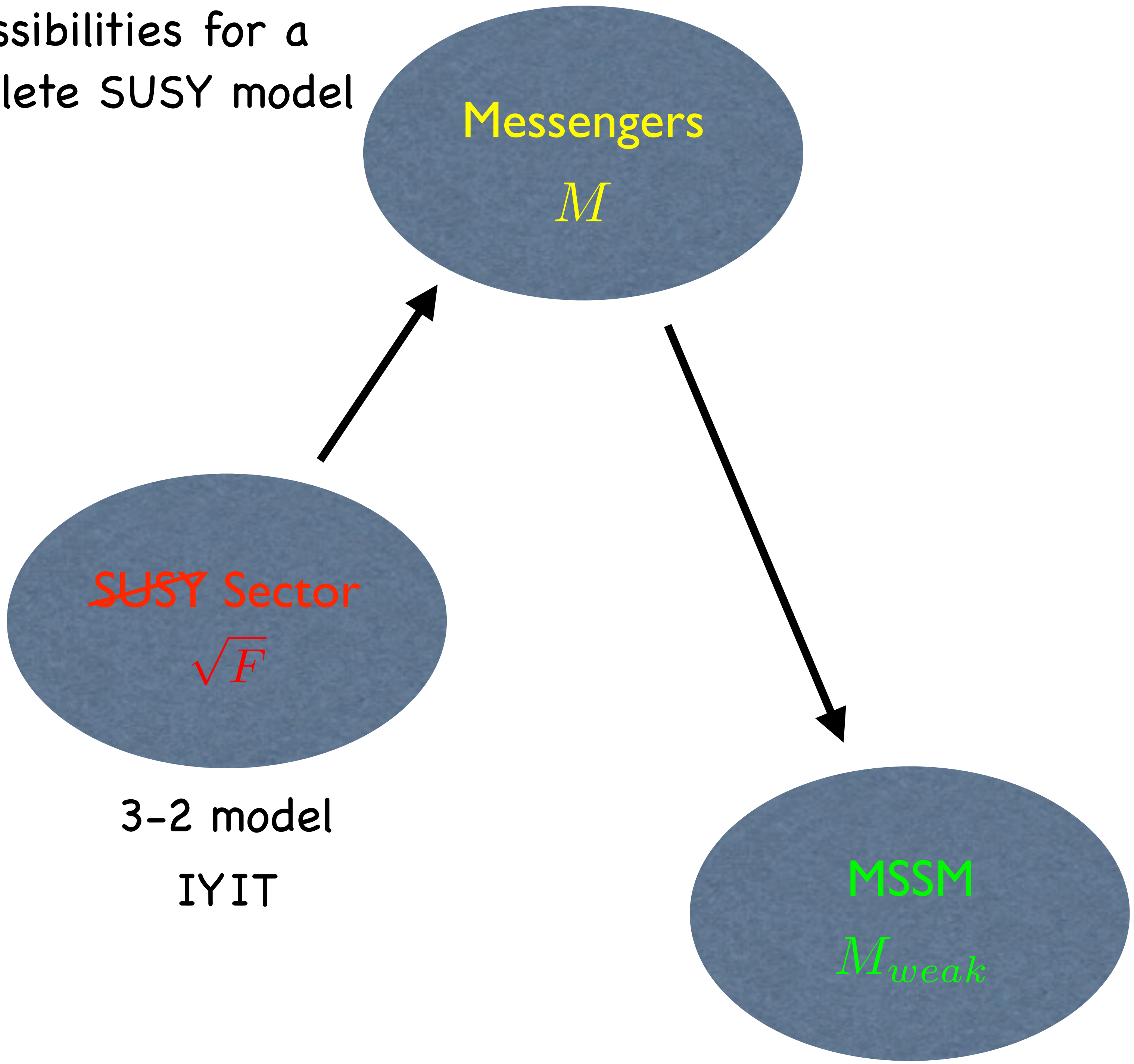

3-2 model

IYIT

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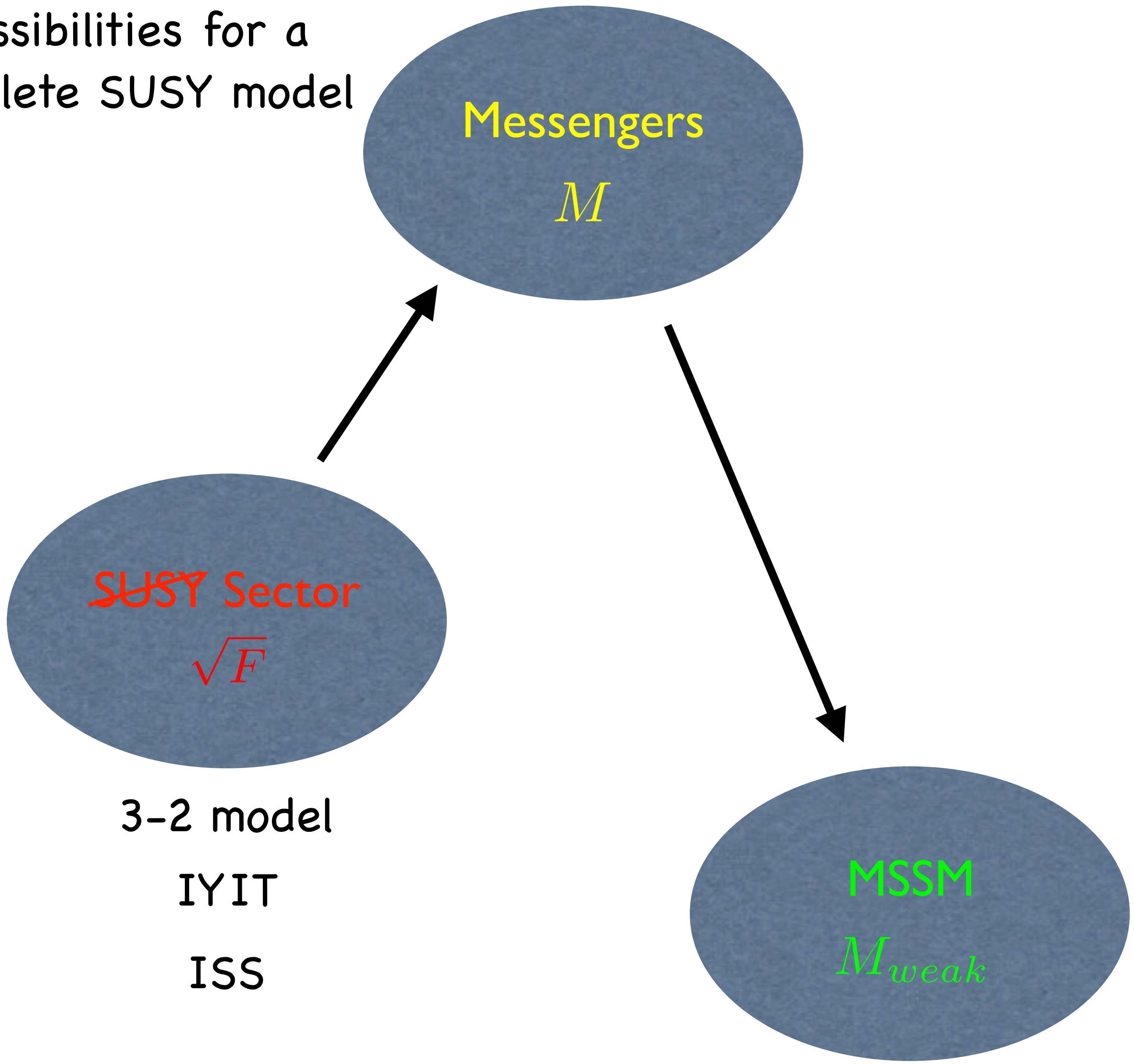

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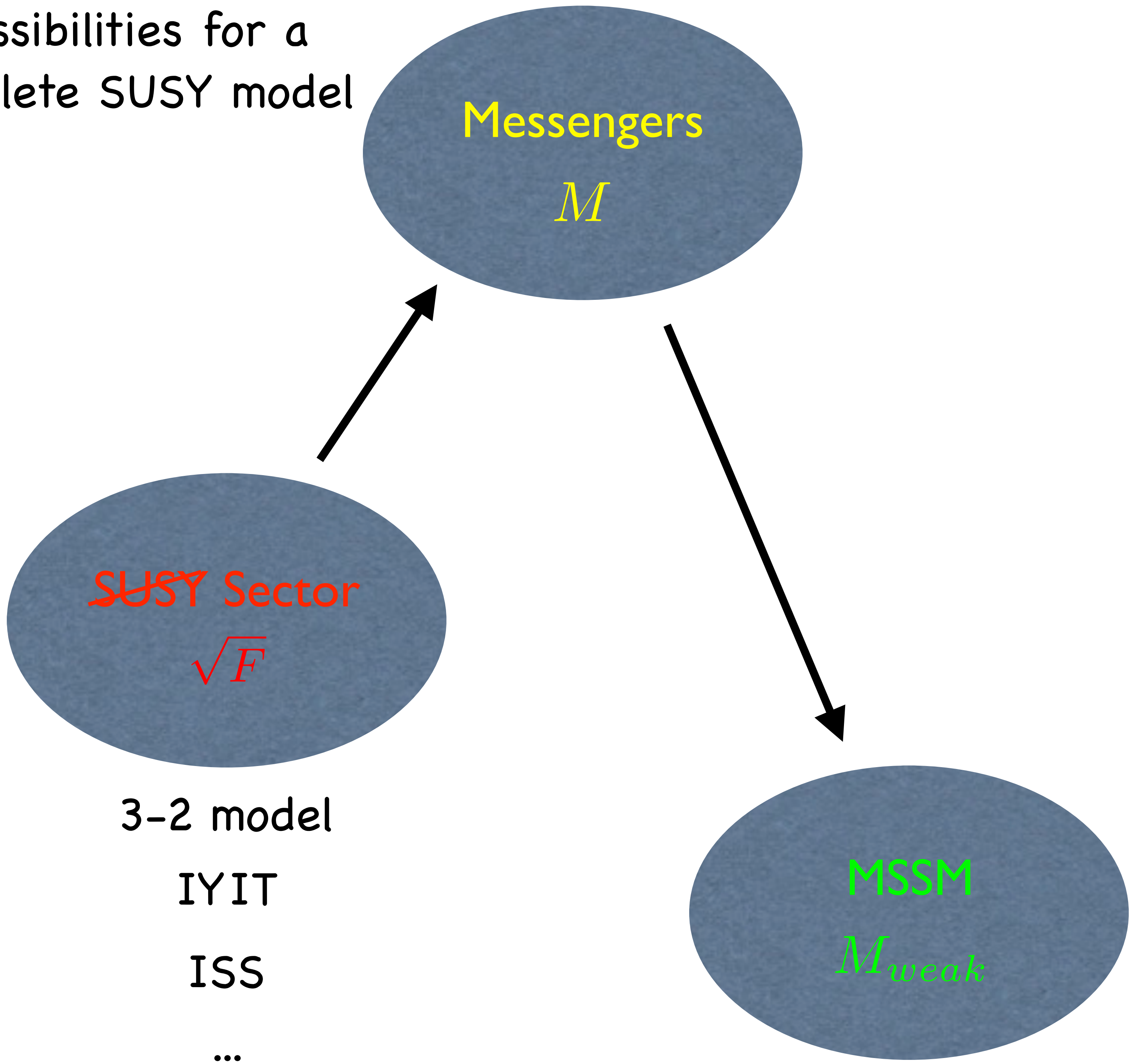

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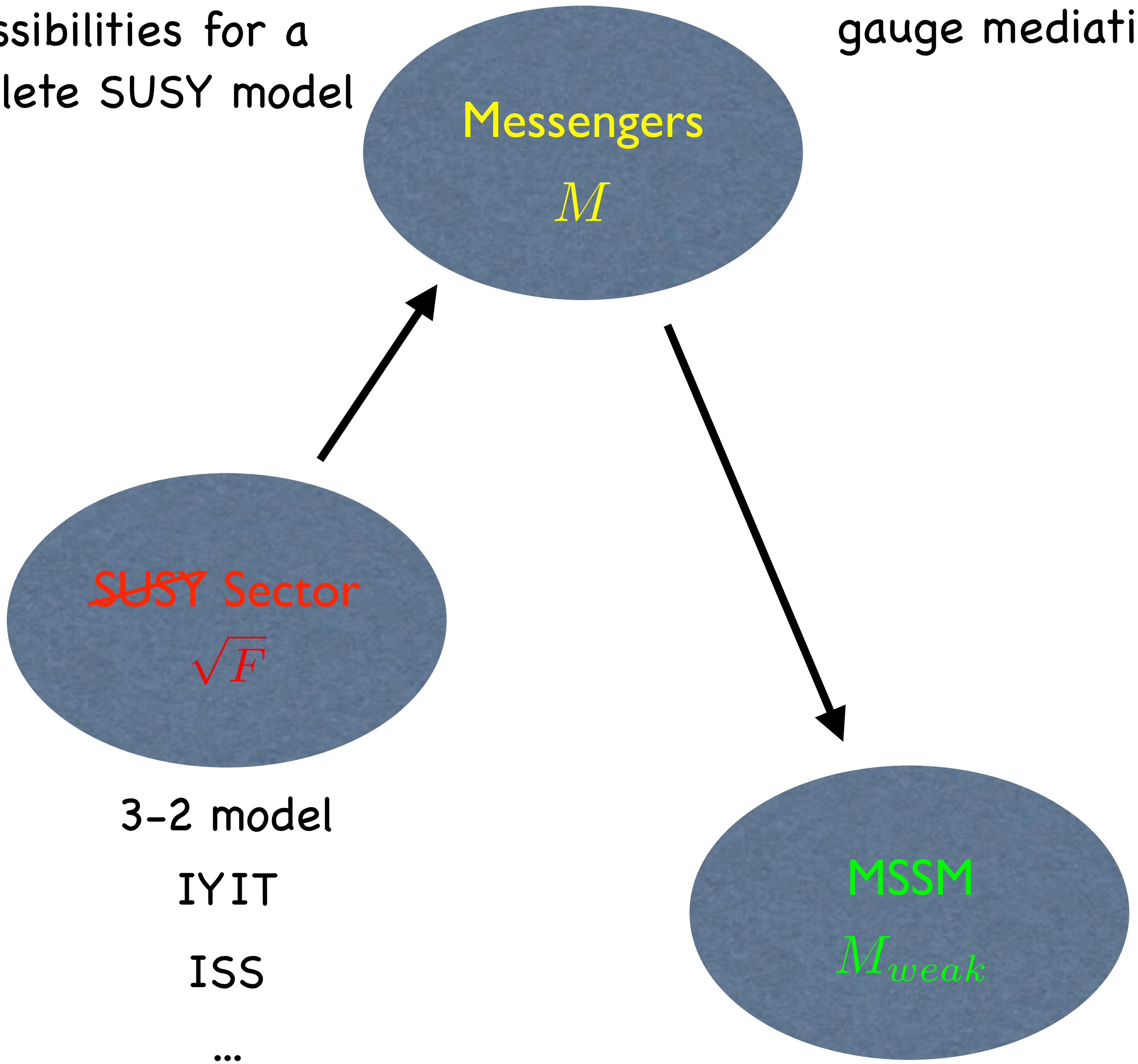

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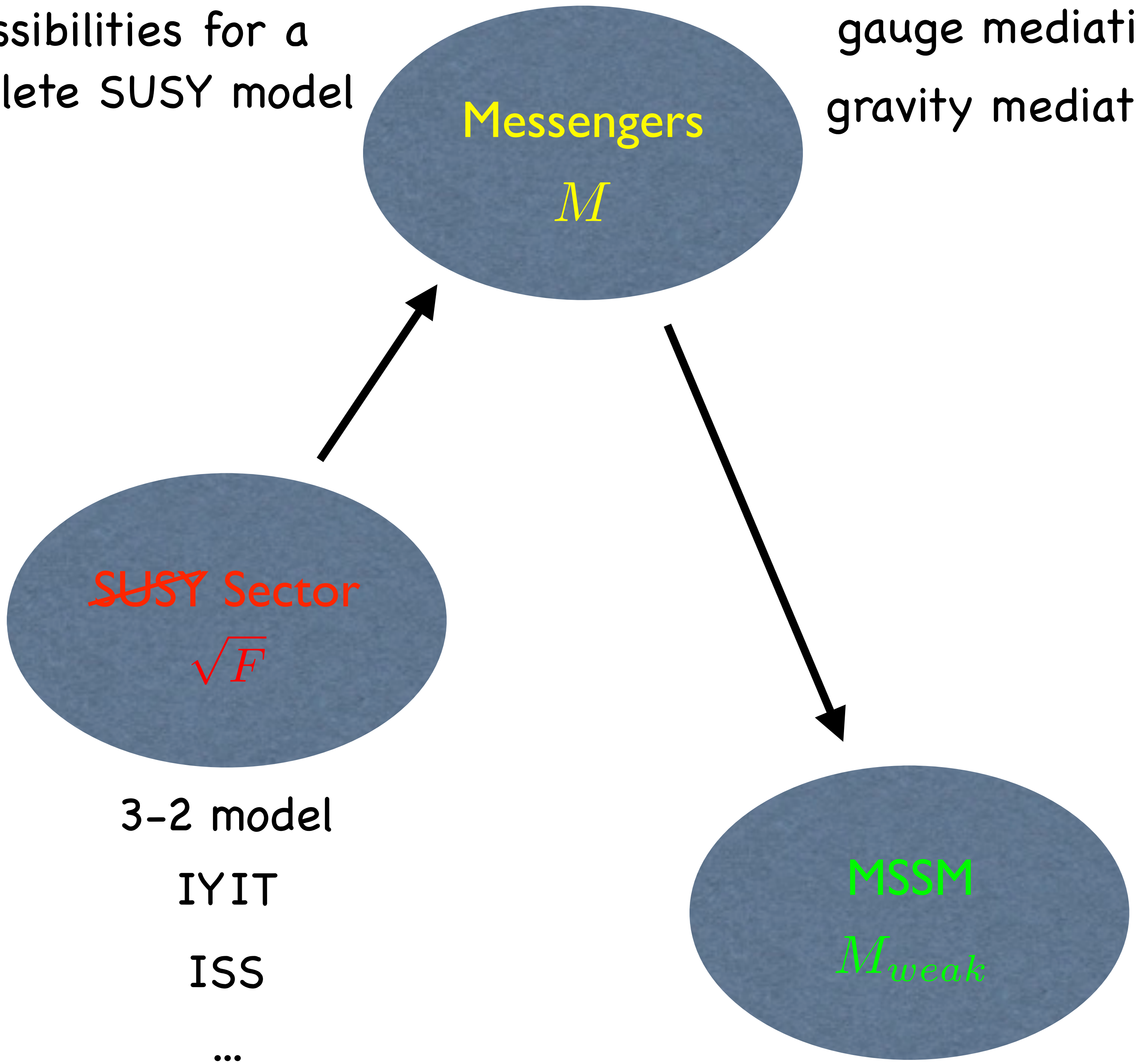

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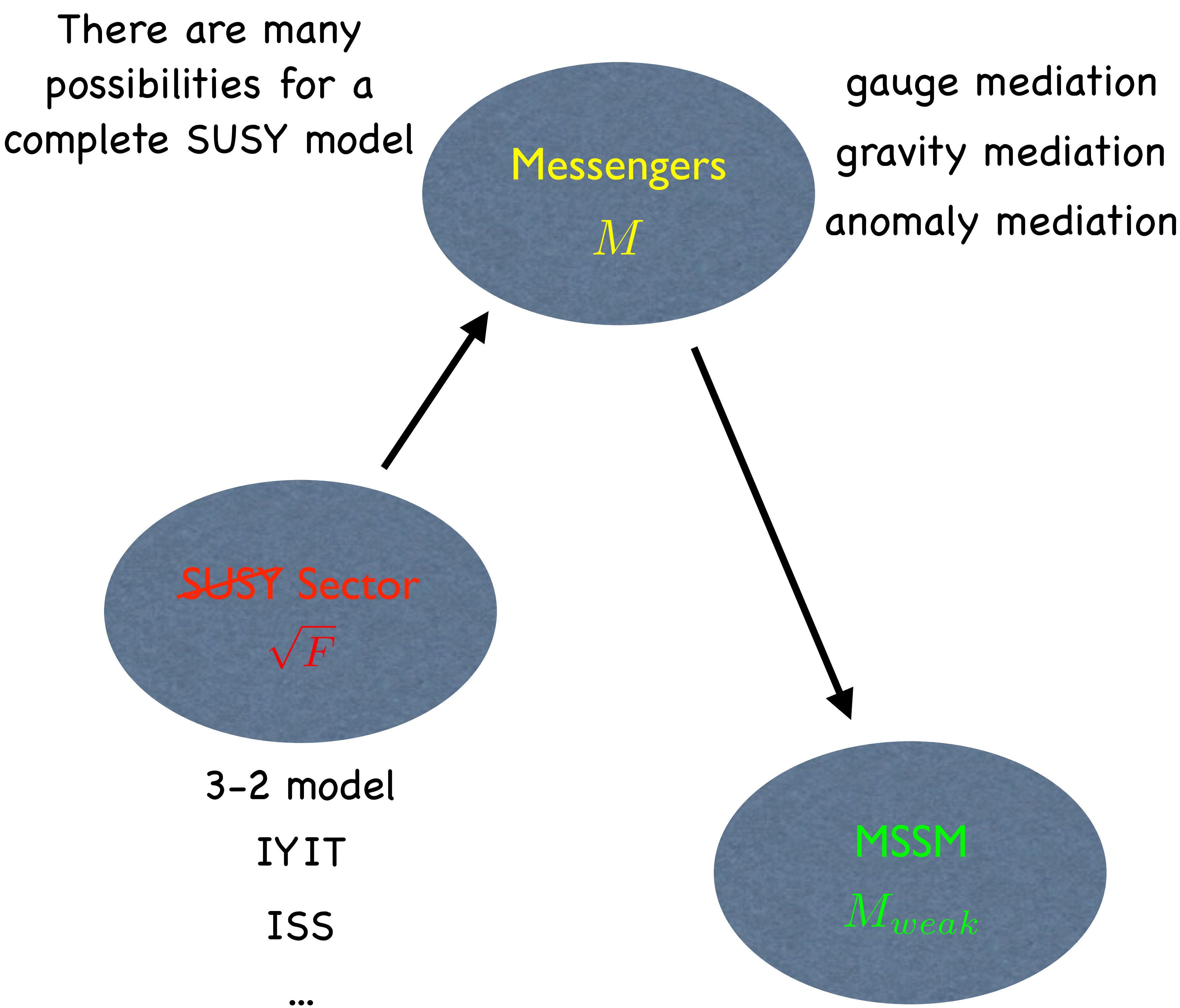

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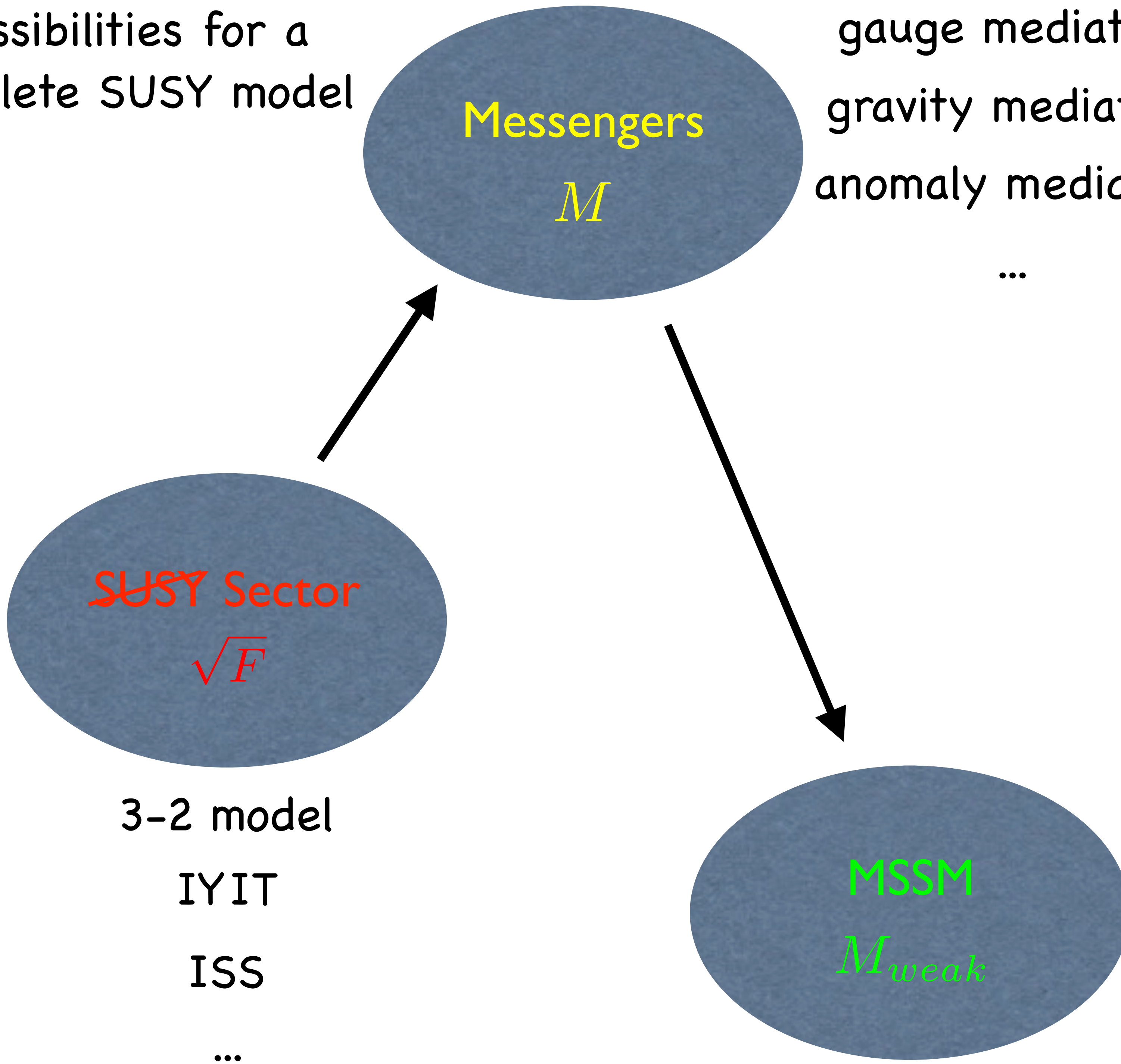

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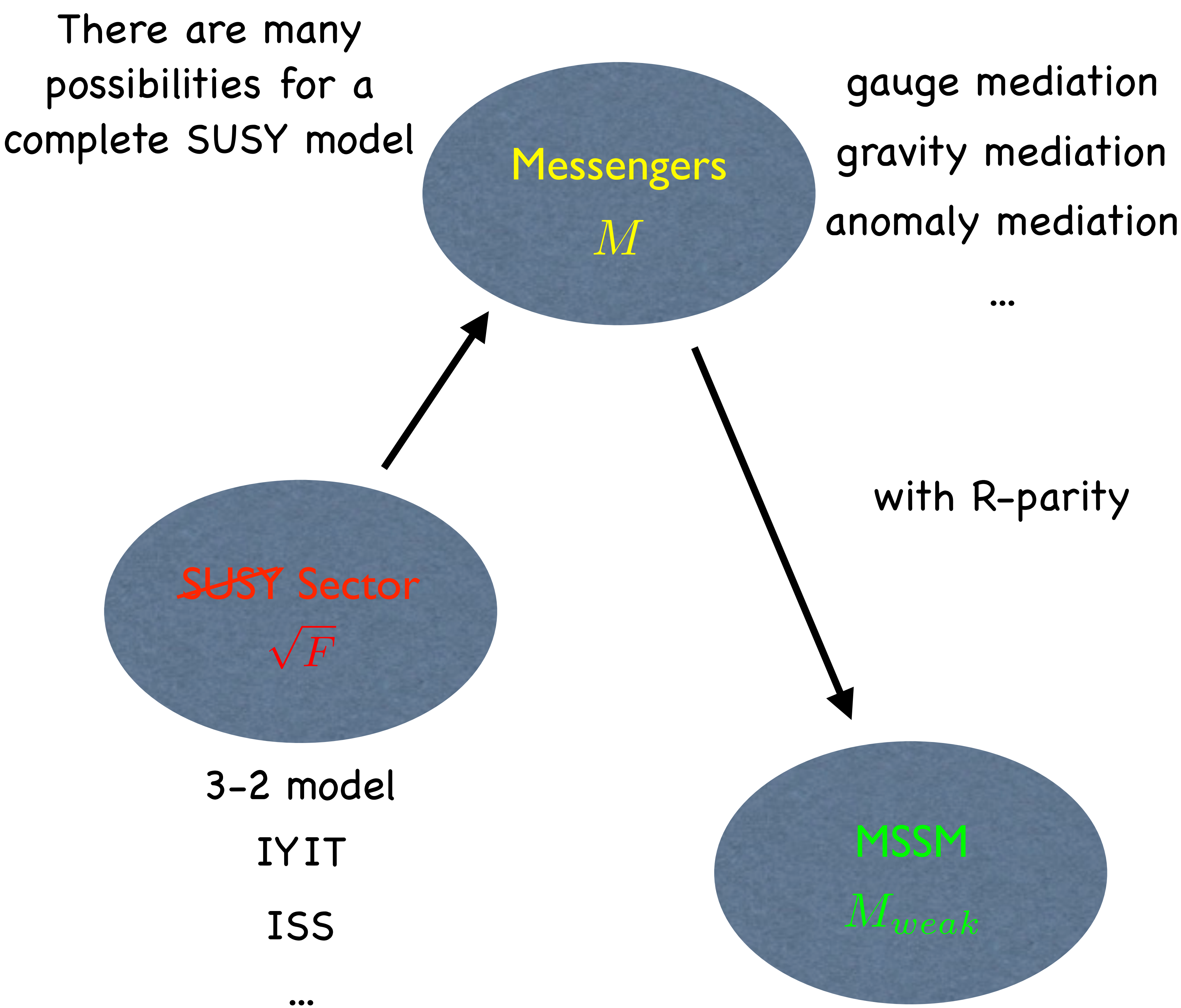

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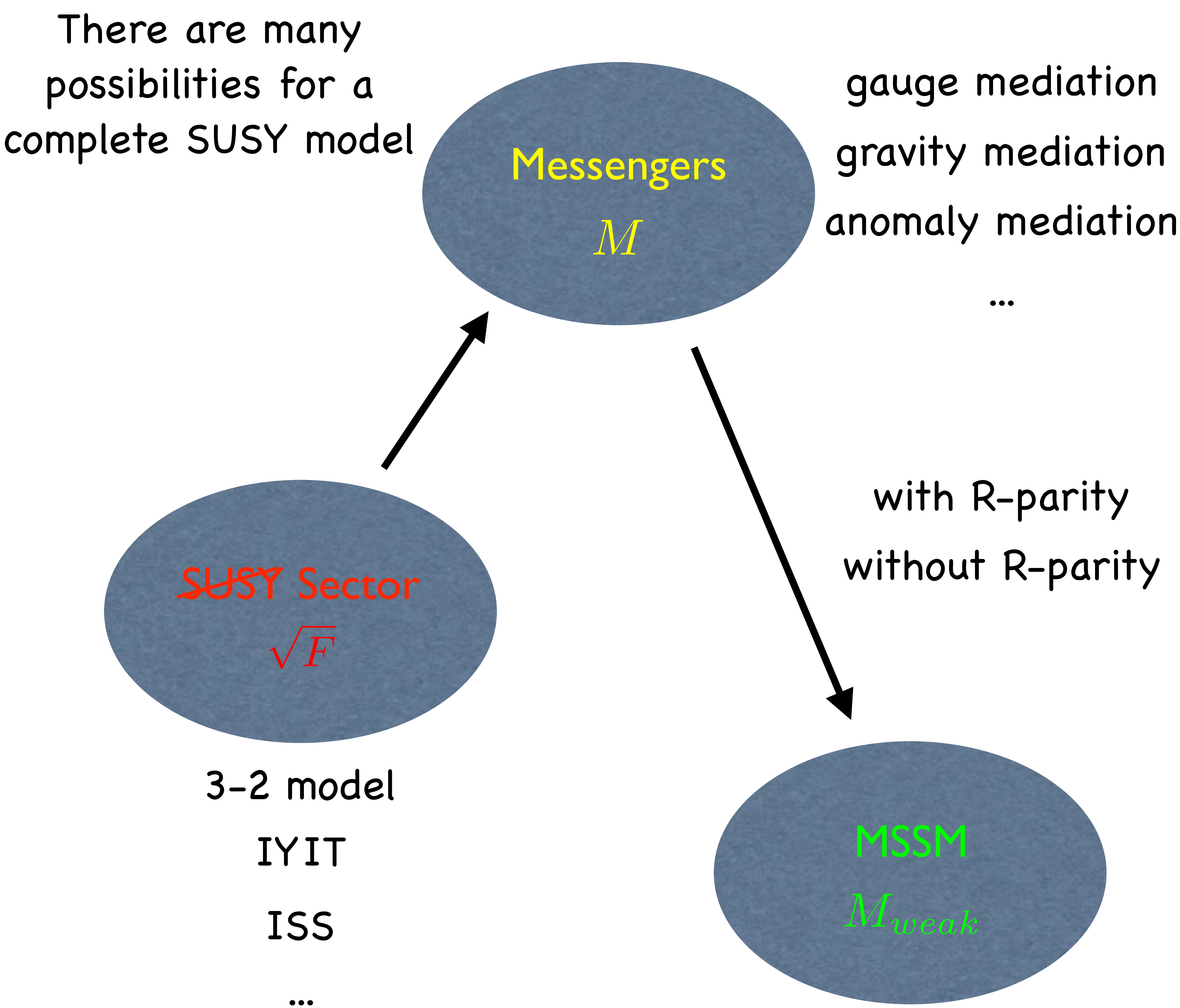

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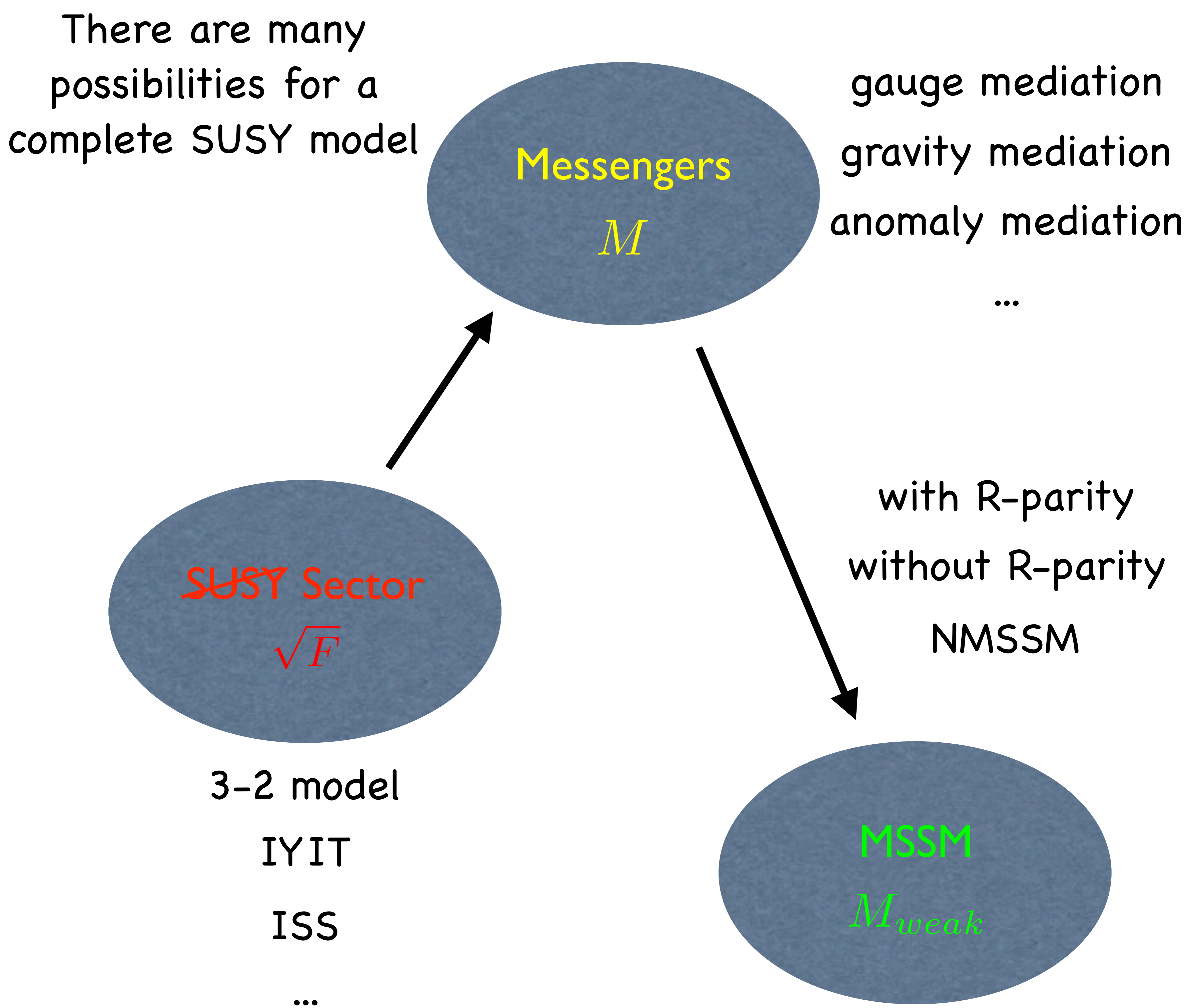

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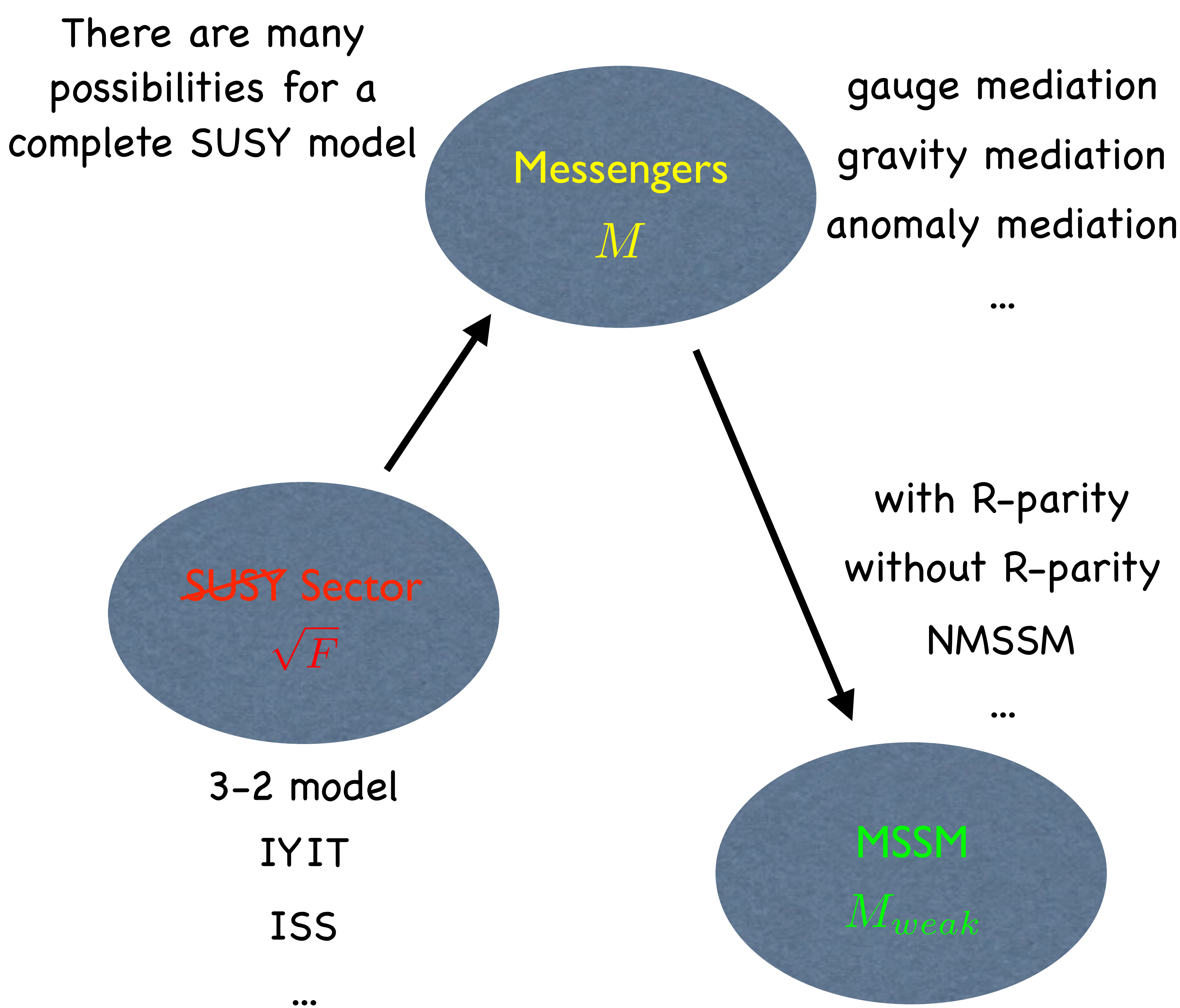

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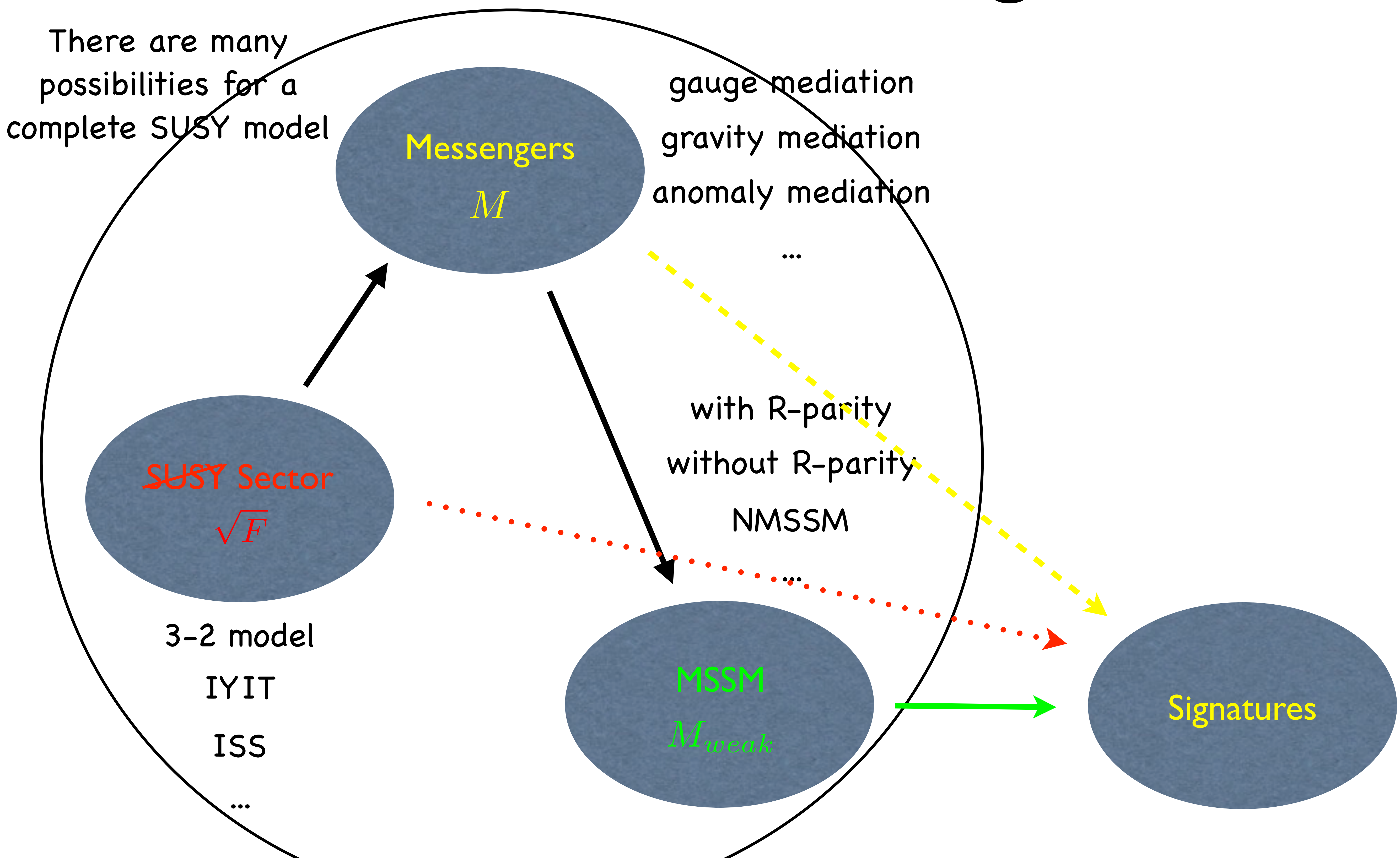

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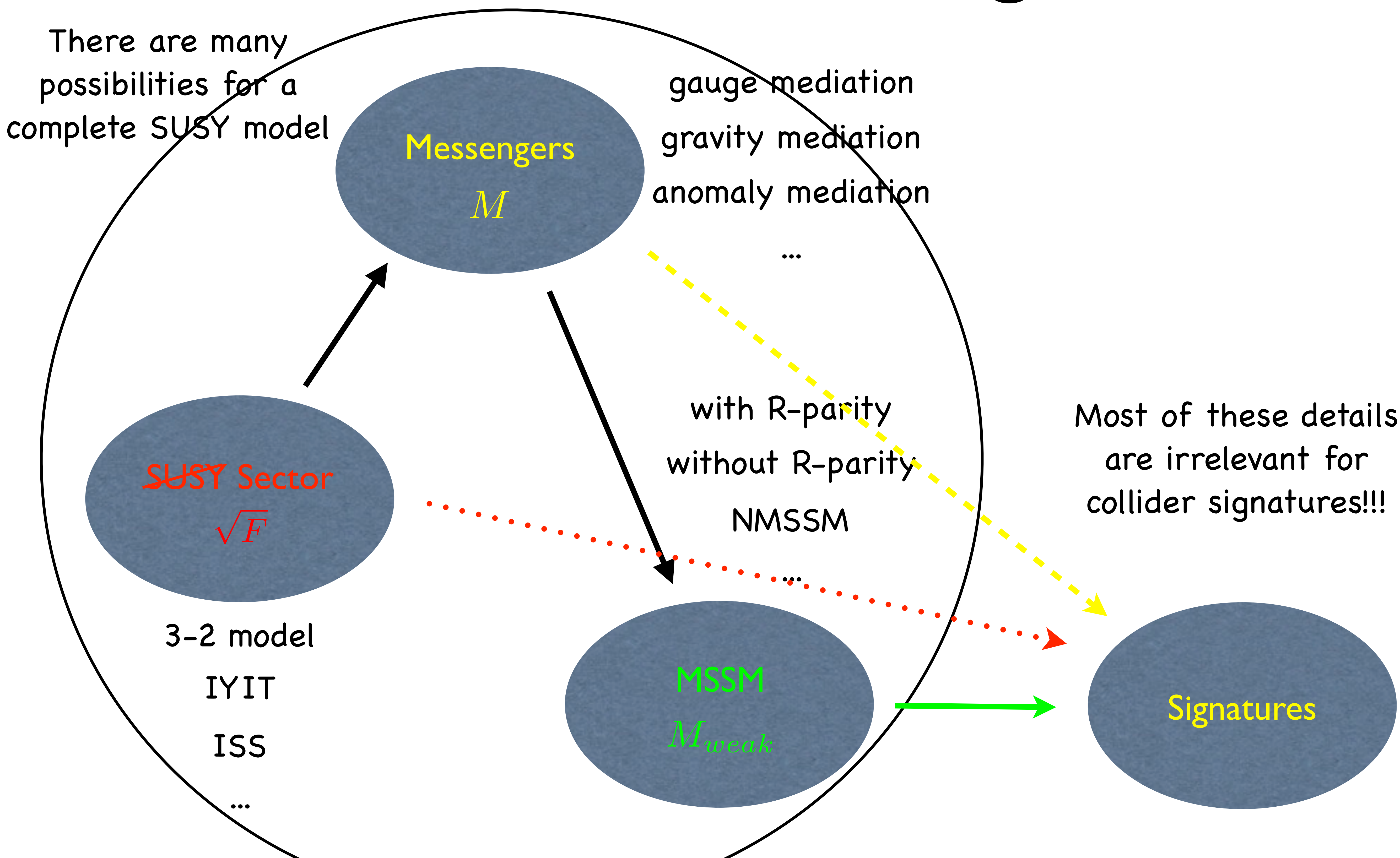

SUSY Scenarios

Type	Mediation Scale	LSP	Pros	Cons
Gravity mediation	M_{pl}	Neutralino or sneutrino	WIMP DM candidate; automatic mu/Bmu	severe SUSY flavor problem; uncalculable framework
Anomaly mediation	$\gg M_{pl}$	Neutralino (wino)	no SUSY flavor problem	tachyonic sleptons; requires "sequestering"
Gauge mediation	$\ll M_{pl}$	gravitino	no SUSY flavor problem; calculable framework; viable spectrum	no WIMP DM mu/Bmu problem

Two views of the SUSY-breaking Scale

10^4 GeV $\quad$ 10^{10} GeV $\quad$ 10^{12} GeV $\quad$ $\sqrt{F}$

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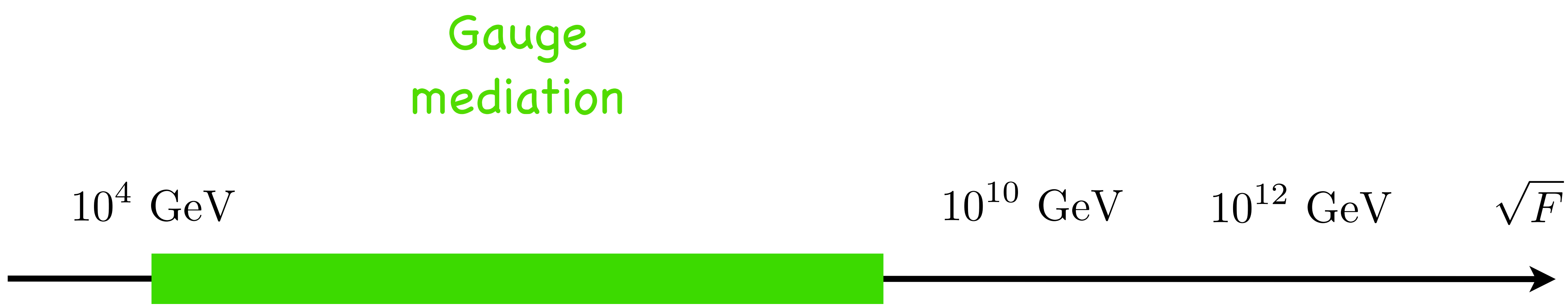

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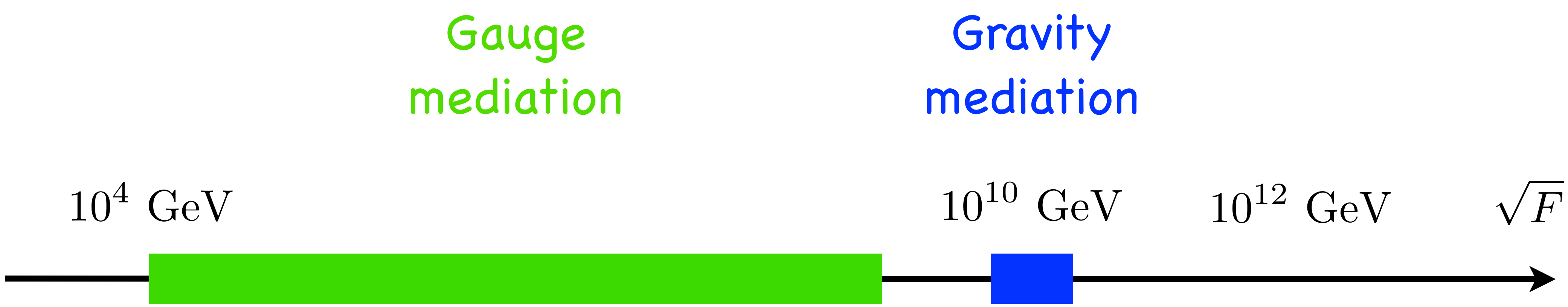

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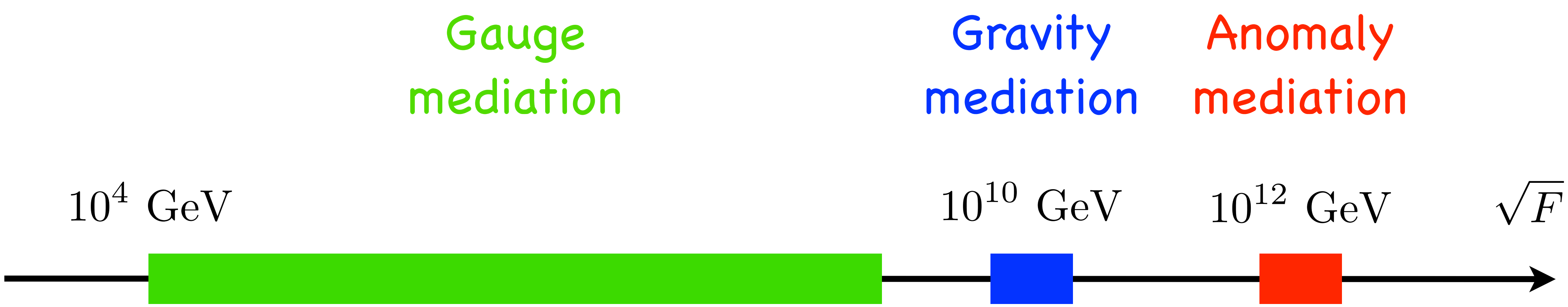

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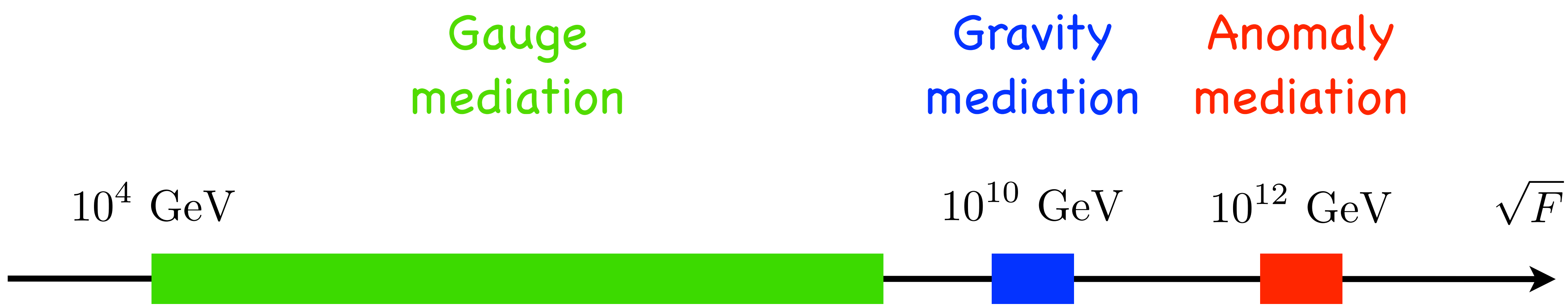

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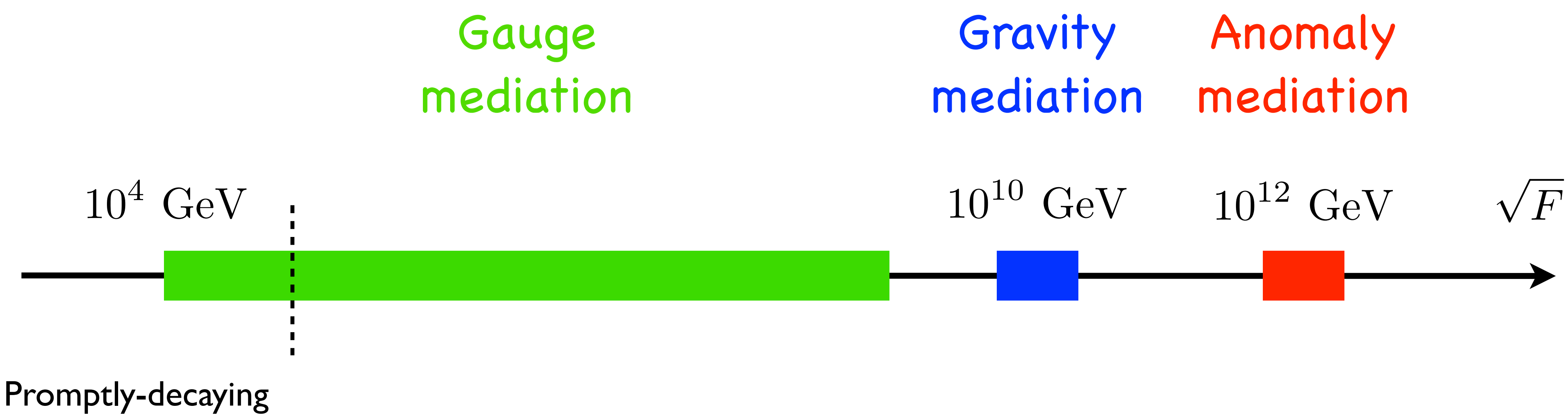

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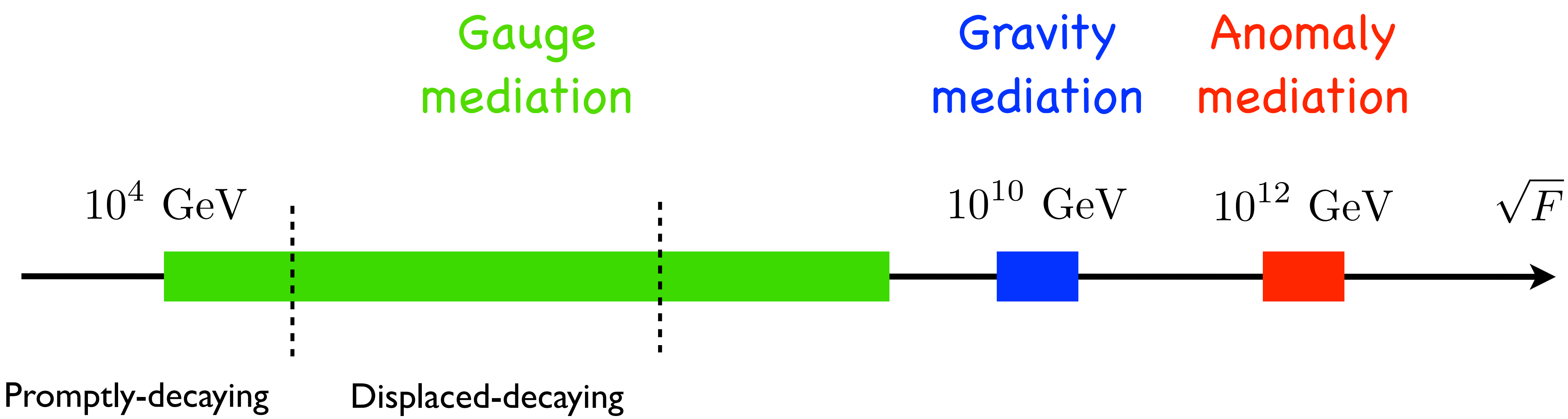

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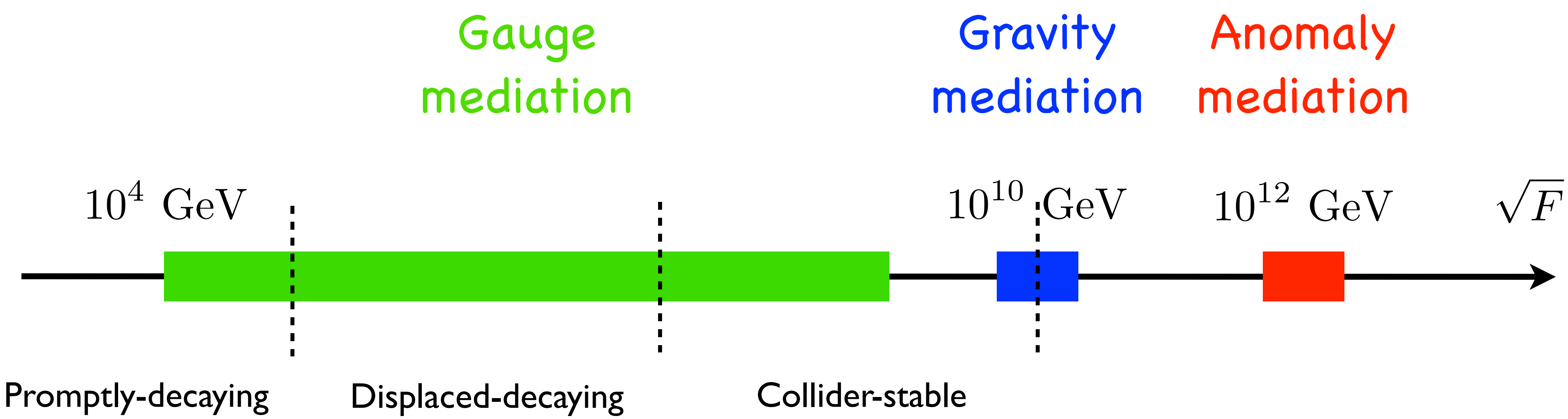

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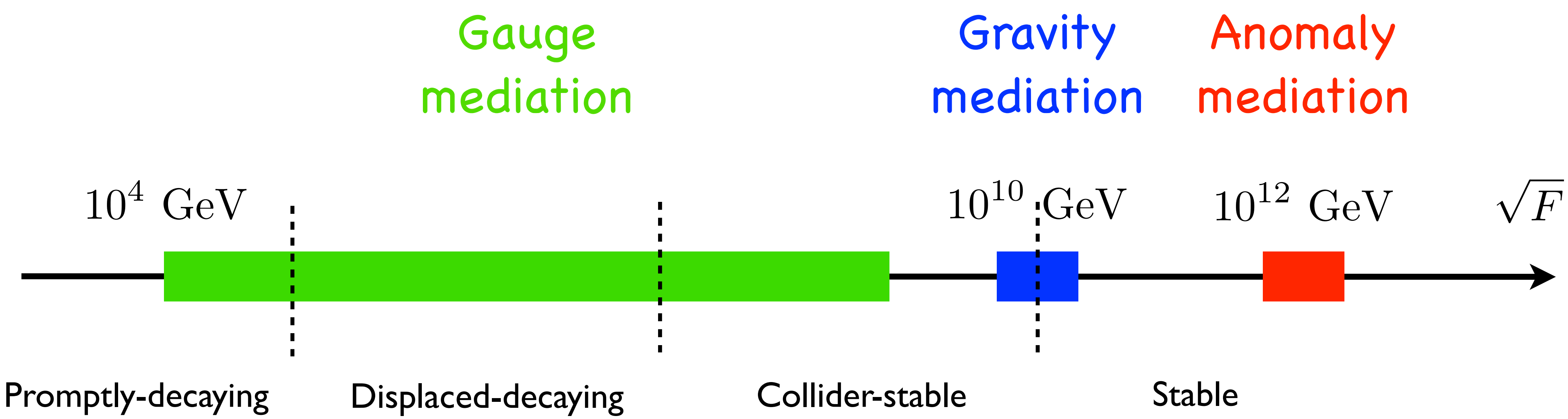

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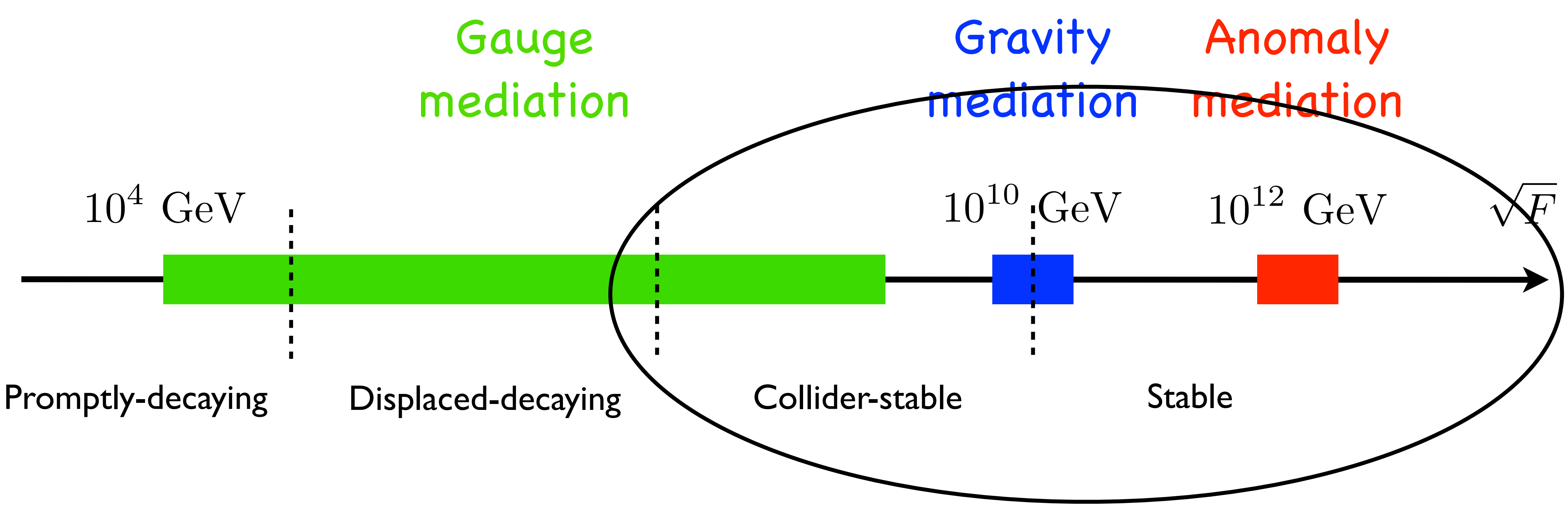

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Viewed like this, there is no phenomenological difference between high-scale GMSB, gravity mediation, and anomaly mediation!!!

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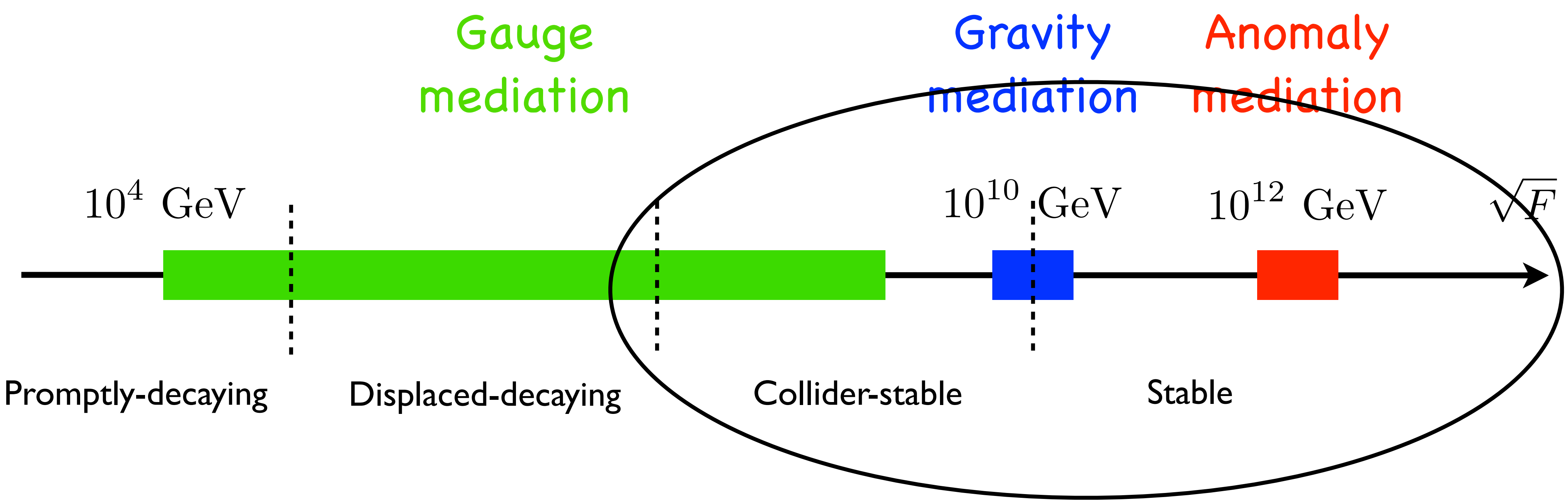

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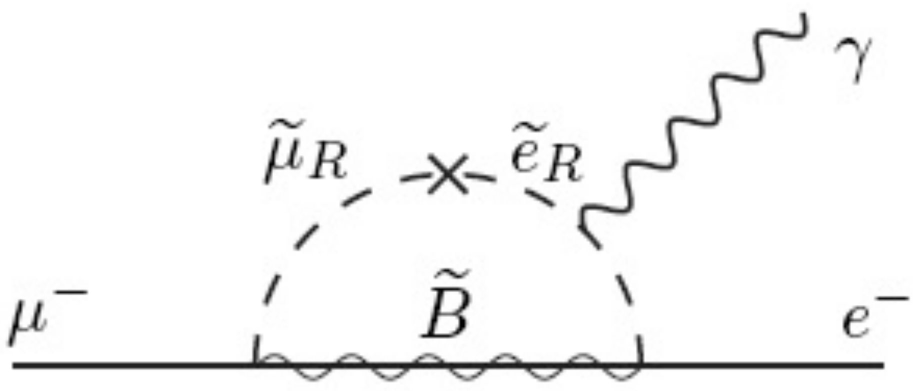
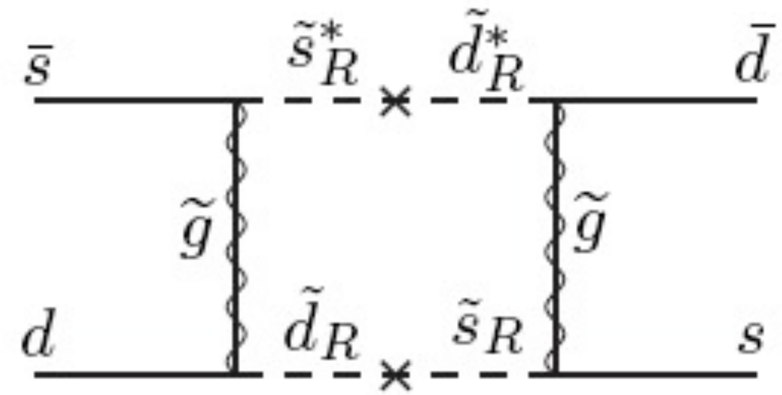
In fact, the latter two are just special cases of the first!

The SUSY Flavor Problem



$\mathrm{Br}(\mu \to e\gamma)_{exp} < 1.2 \times 10^{-11}$



$(\Delta m_K)_{exp} = (3.483 \pm 0.006) \times 10^{-12}$ MeV

- Why do we need gauge mediation?
- There are strong experimental constraints on SUSY-breaking in the MSSM.
- The MSSM soft Lagrangian has 100+ parameters. A generic point in this parameter space is already excluded by precision experimental tests of flavor (and CP).

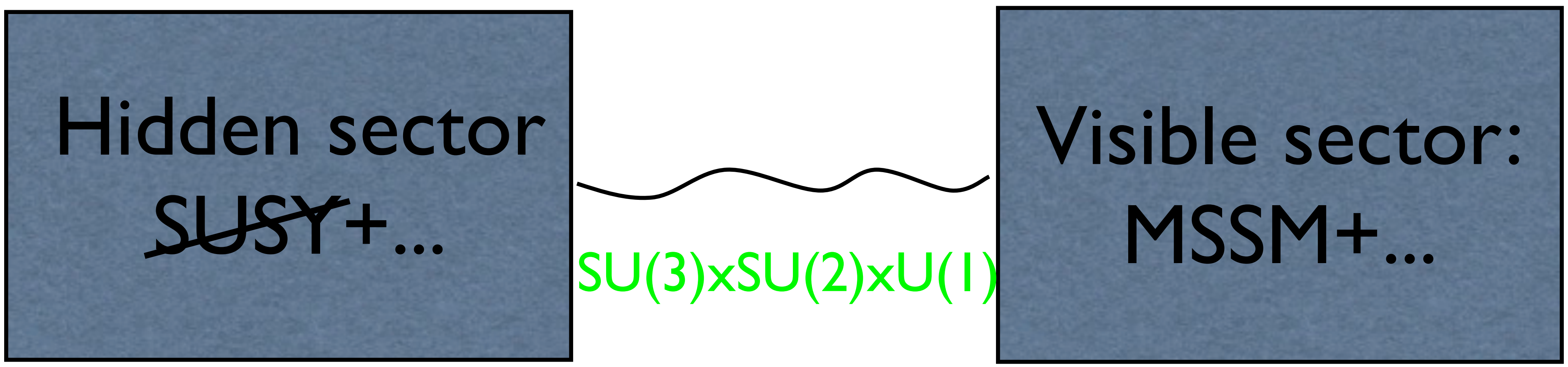
The SUSY Flavor Problem

- In general, the scalar soft masses can be written using a "spurion" for SUSY-breaking:

$$\mathcal{L}_{soft} \supset \sum_{i,j} \int d^4\theta \, \frac{c_{ij}}{M^2} X^\dagger X Q_i^\dagger Q_j, \qquad \langle X \rangle = \theta^2 F$$

- With Planck-scale mediation, no a priori reason for flavor-diagonal scalar masses.
- In scenarios such as "mSUGRA" and the "cMSSM", this property is simply assumed without any justification.
- In gauge mediated SUSY breaking, it is derived from first principles.

General Gauge Mediation



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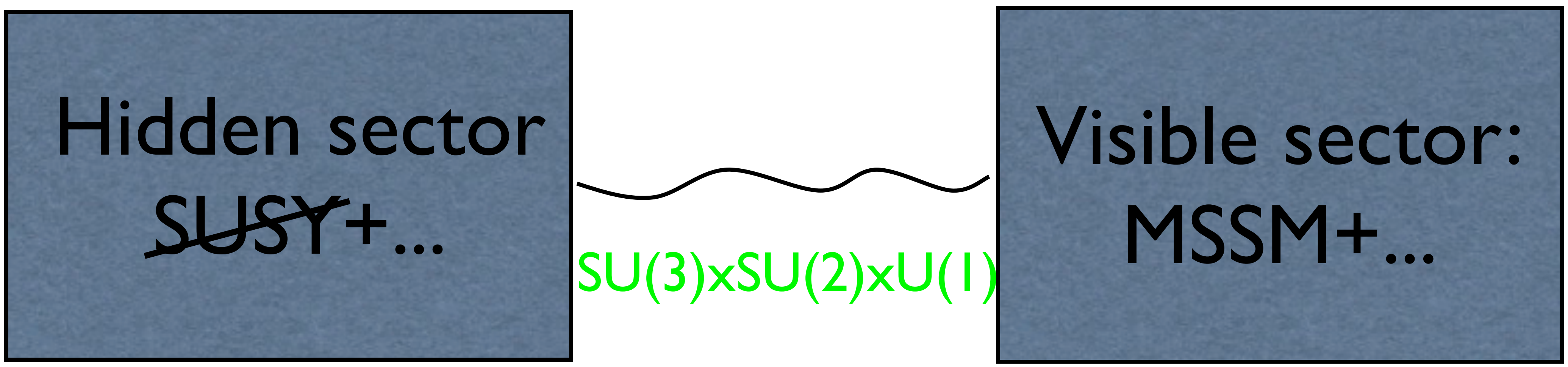

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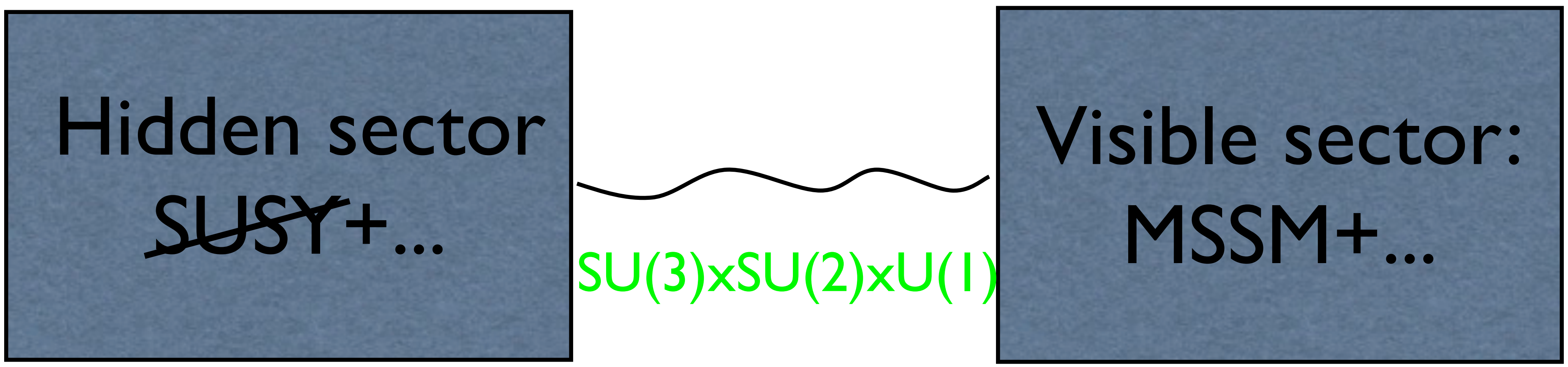

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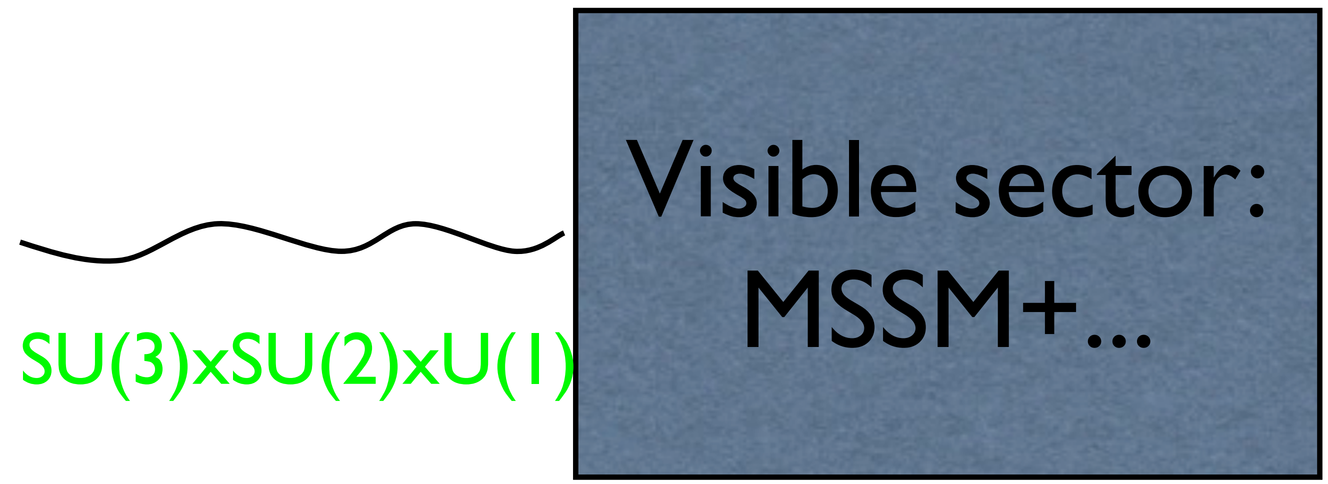

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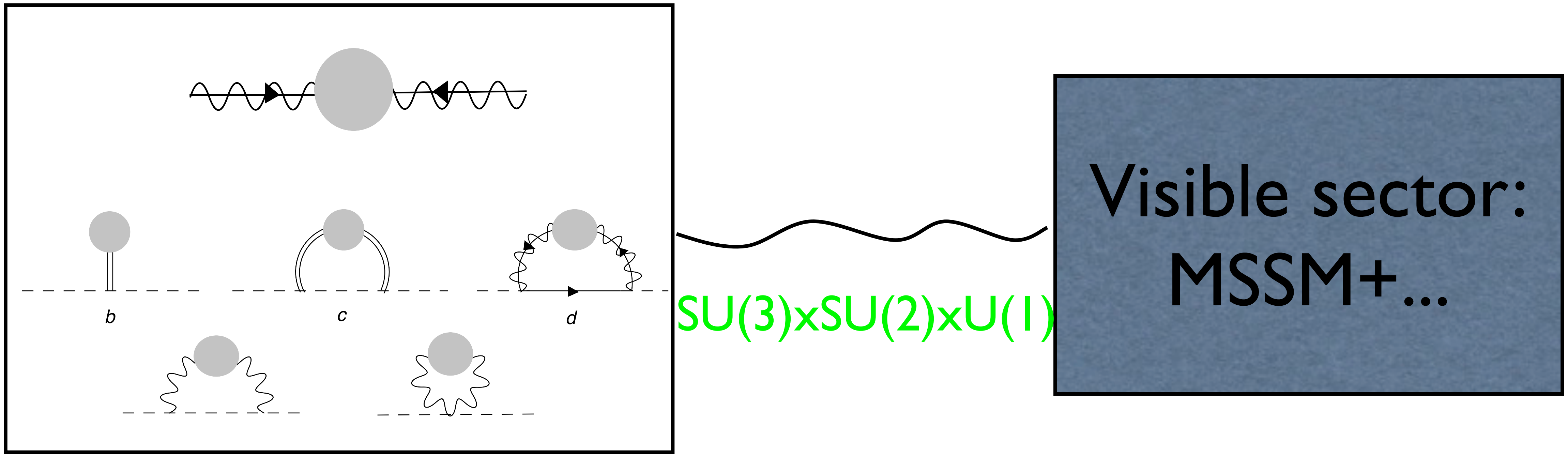

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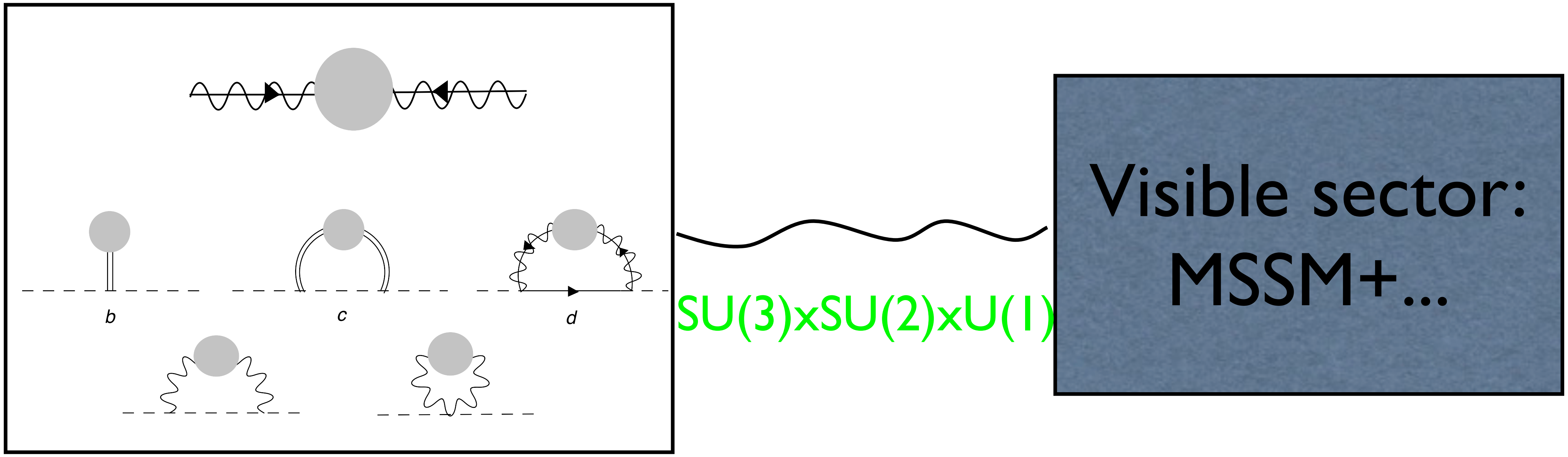

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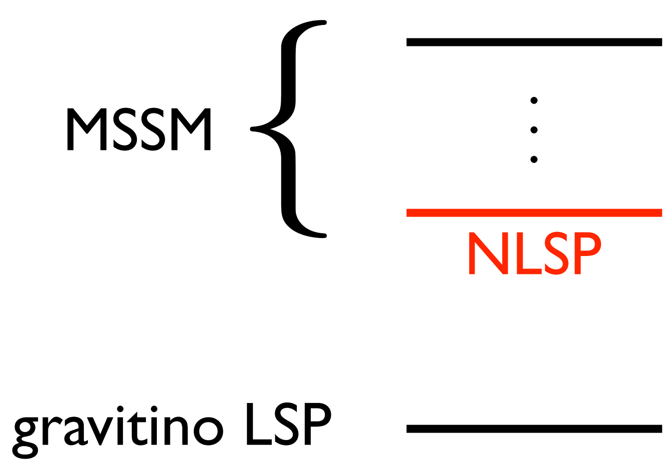
- Using GGM, we understood the most general predictions of gauge mediation.

GMSB Phenomenology

- Gravitino LSP is a universal prediction of gauge mediation models:

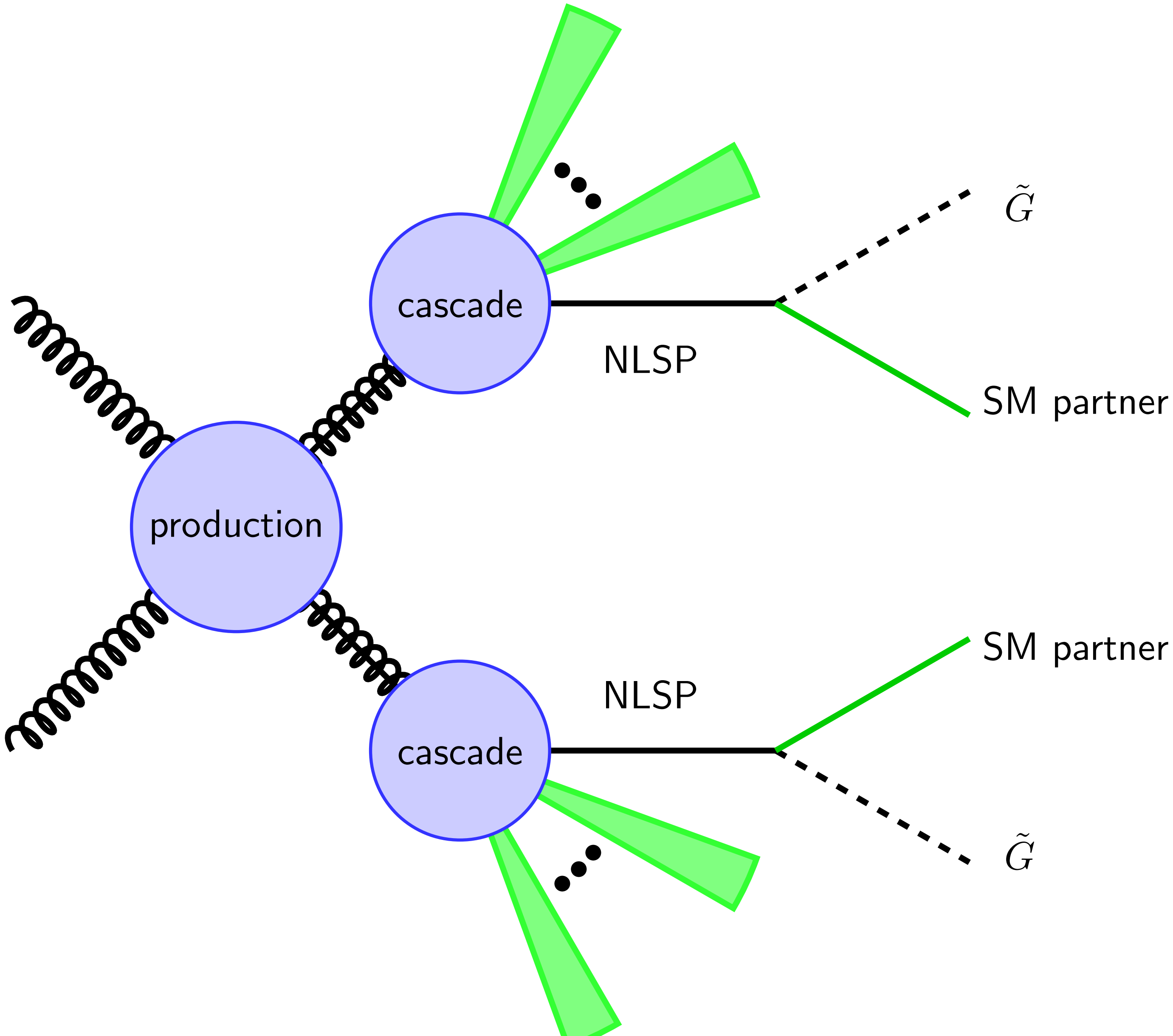
$$m_{3/2} = \frac{F}{\sqrt{3} M_{pl}} \quad (\sim \text{eV} - \text{GeV})$$

- Lightest MSSM sparticle becomes the next-to-lightest superpartner (NLSP).



GMSB Phenomenology

- In gauge mediation, the NLSP type largely determines the inclusive collider signatures.



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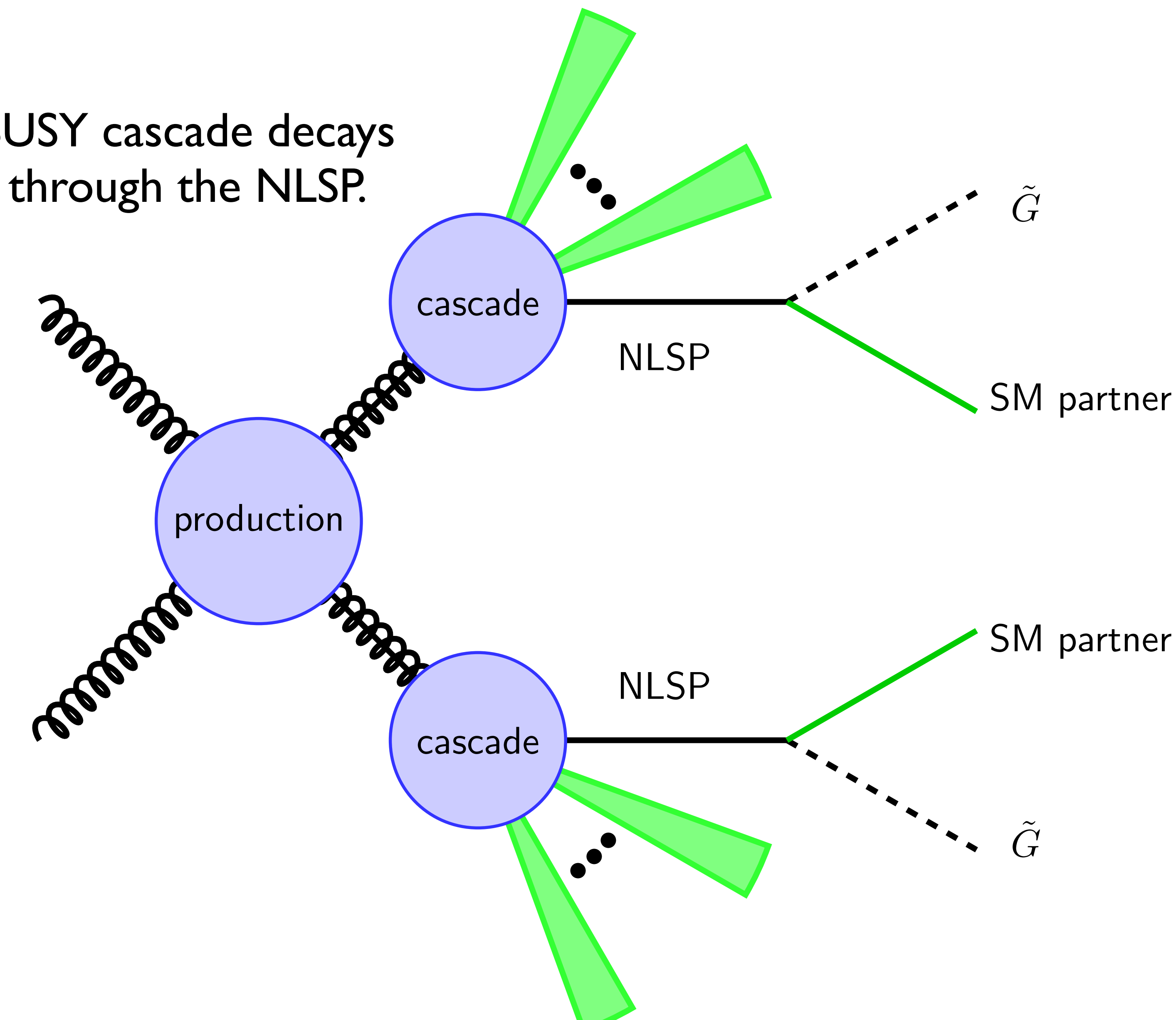

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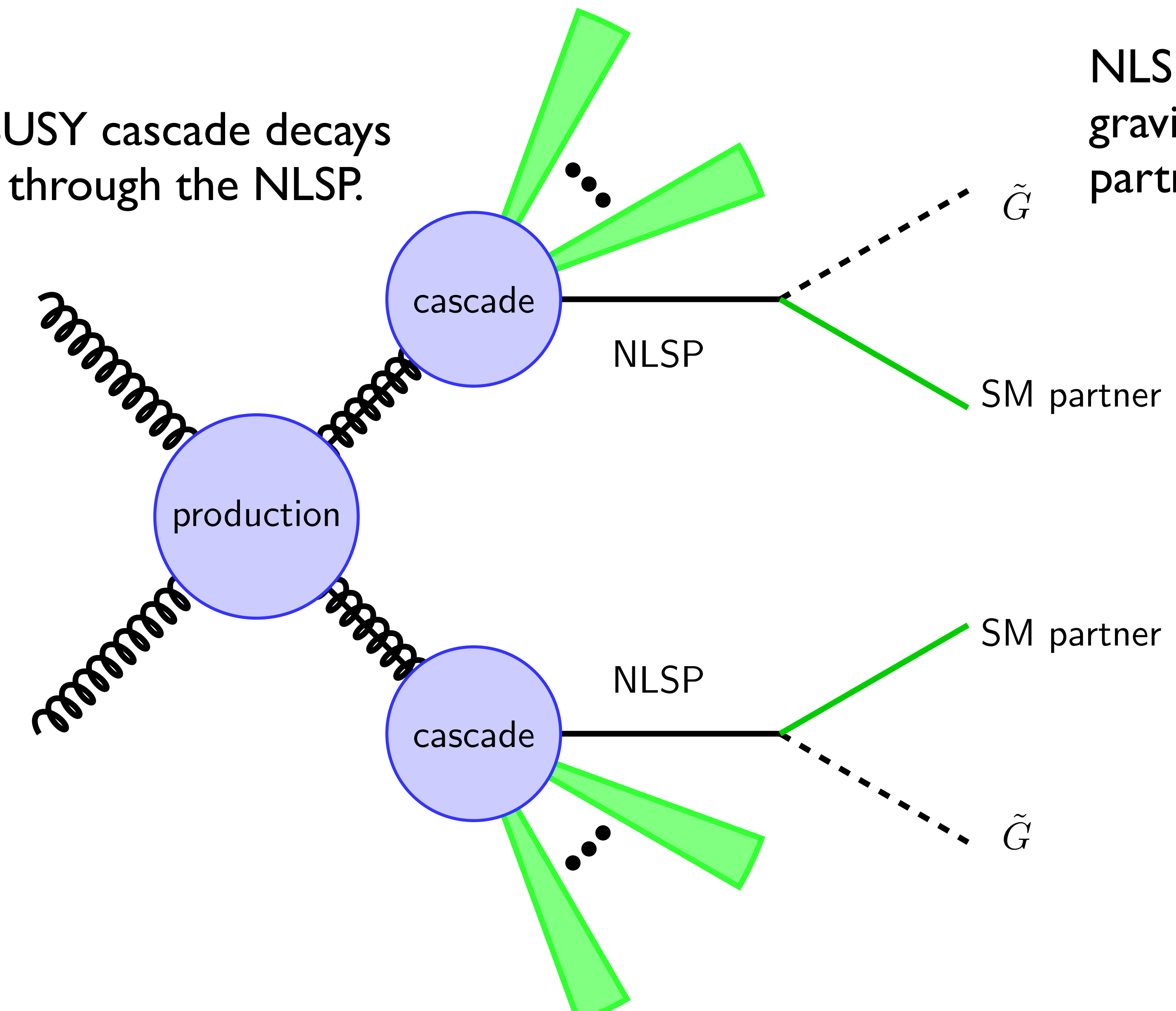

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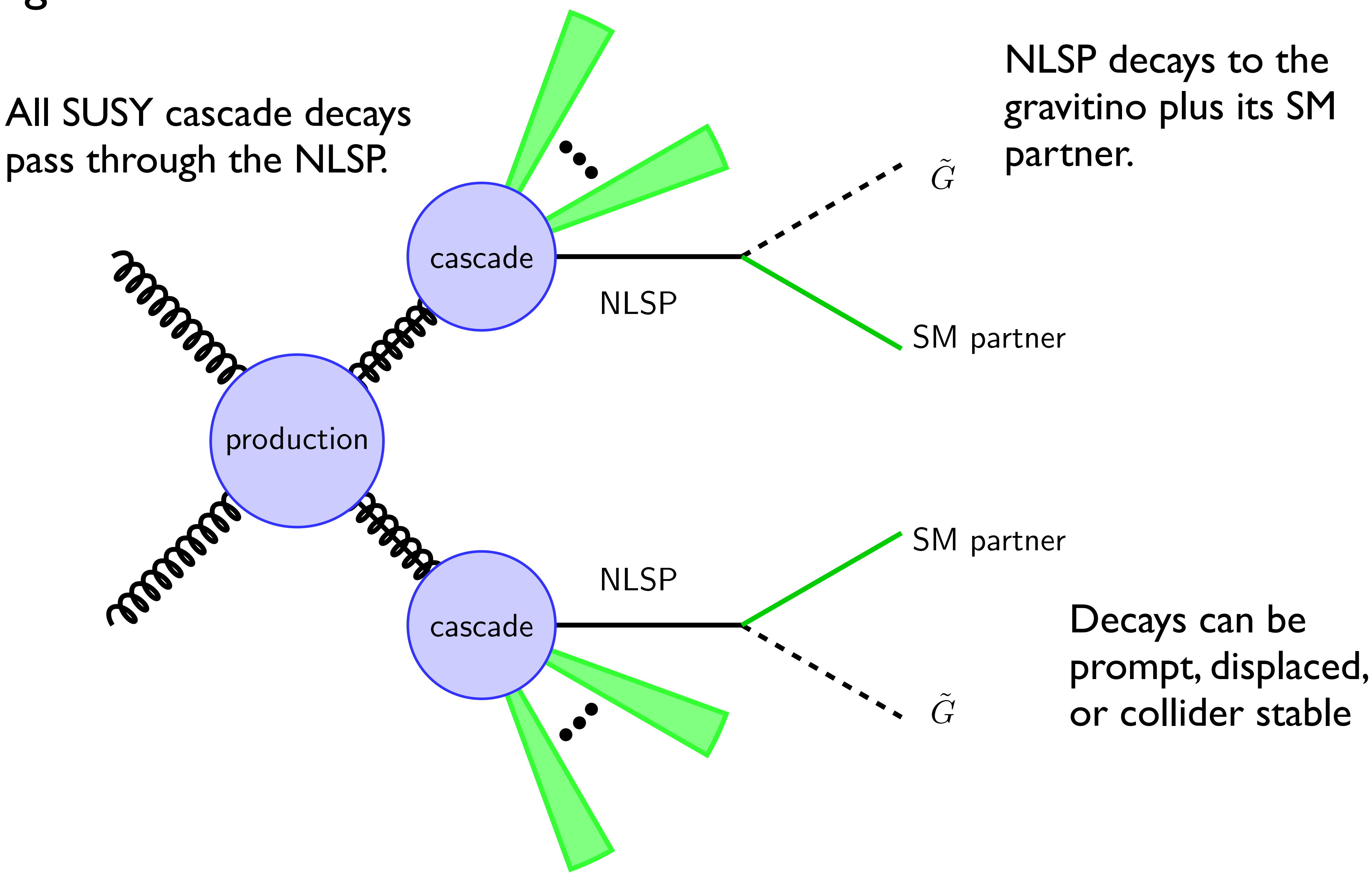

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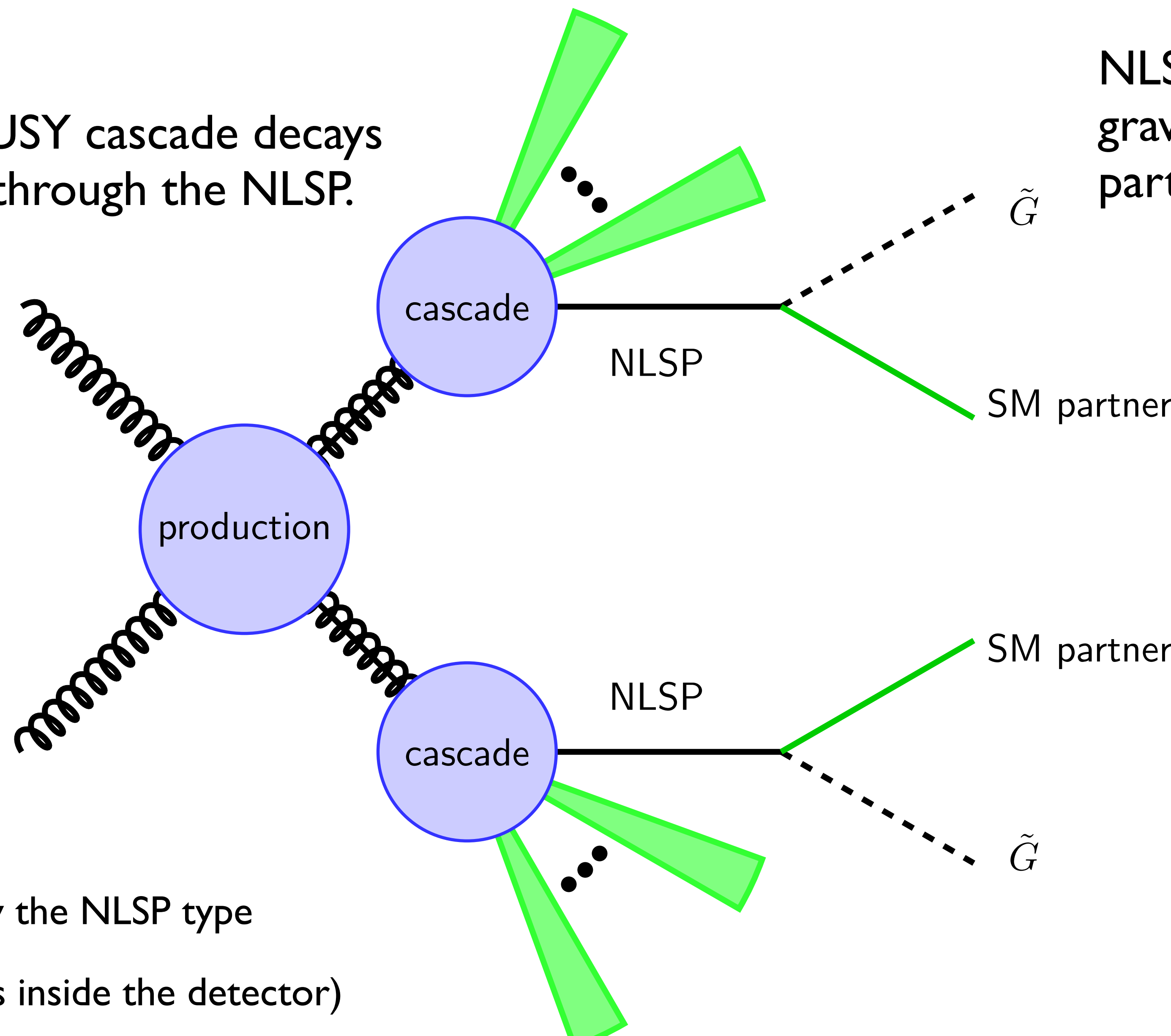
NLSP decays to the gravitino plus its SM partner.



Decays can be prompt, displaced, or collider stable

So all events contain:

- high pT objects determined by the NLSP type
- missing energy (if NLSP decays inside the detector)

General Gauge Mediation

- Parameter space: $(A_1, A_2, A_3) \to m^2_{Q,u,d,L,e}$

  $(B_1, B_2, B_3) \to M_{1,2,3}$

- Sum rules: $\mathrm{Tr}\,(B-L)m^2_{\tilde{f}} = \mathrm{Tr}\,Y m^2_{\tilde{f}} = 0$

- A-terms ≈ 0

- $\mu,\ B_\mu$ require additional dynamics beyond GGM. (Komargodski & Seiberg)

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According to the GGM parameter space, any superpartner in the MSSM can be the NLSP.

Also, the gluino can be arbitrarily light.

NLSP Collider Signatures

NLSP	Prompt(+MET)	Displaced
bino-like neutralino	diphotons	Displaced photons
wino-like neutralino/ chargino (co-NLSP)	photons, leptons (Z's & W's), jets	Displaced photons and leptons, displaced vertices
Z-rich higgsino-like neutralino	leptons (Z's), jets	Displaced leptons, displaced vertices
h-rich higgsino-like neutralino	b-jets (higgses)	Displaced jets
sleptons	multileptons, SS dileptons	CHAMPS, delayed leptons, kinked tracks
gluino/squark	(b-)jets	R-hadrons, displaced vertices, stopped gluinos
stops	ttbar; SS dileptons	R-hadrons, displaced vertices

Meade, Reece, DS (0911.4130, 1006.4575); Ruderman & DS (1103.6083)

Ruderman & DS (1009.1665); Katz & Tweedie (0911.4132, 1003.5664)

Kats & DS (1106.0030)

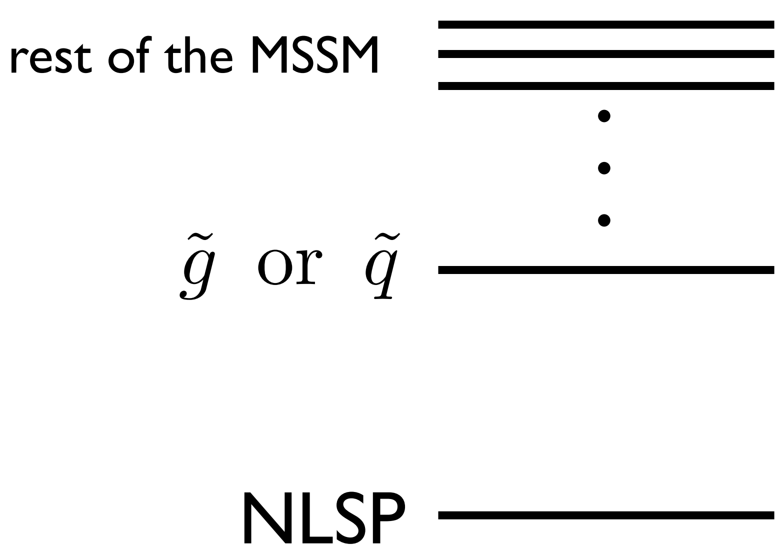
Red: NLSPs still lacking dedicated searches

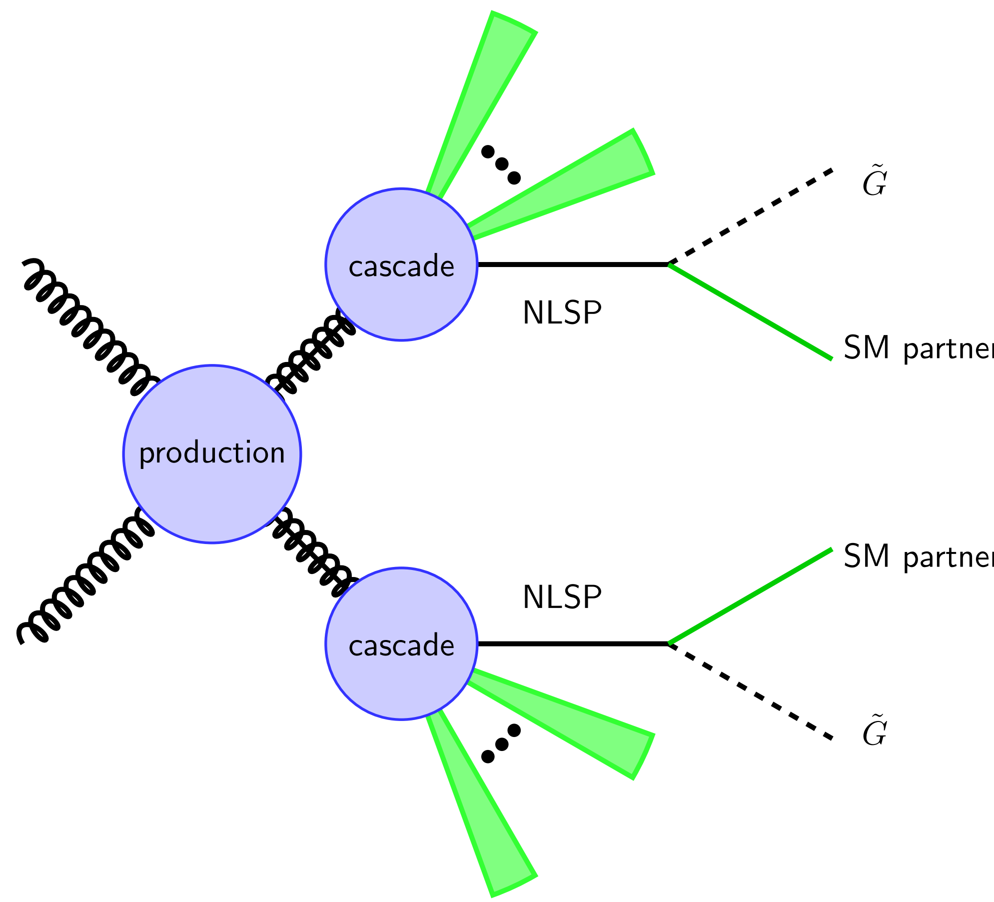
Comments

- Diphotons+MET and multileptons are currently sensitive to EW production. ("Best case scenarios")
- No other searches currently have sensitivity, but neither have they been optimized for EW production.
- Some searches for collider-stable particles exist. These apply straightforwardly to long-lived NLSPs.
- But hardly anything has been done yet on intermediate-lifetime NLSPs which decay inside the detector.

GGM simplified models

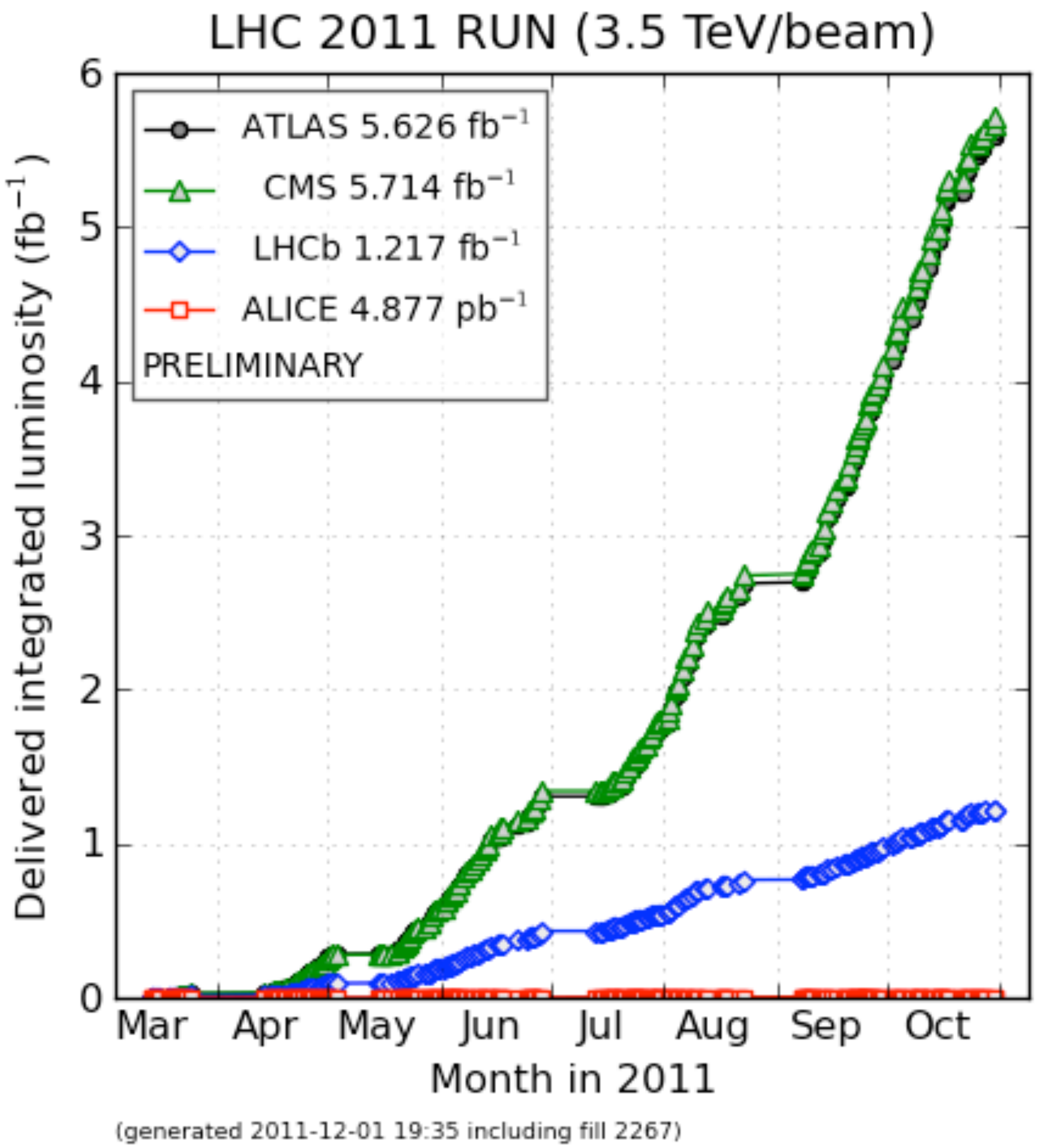
- Focus on the minimal spectra for production and decay.

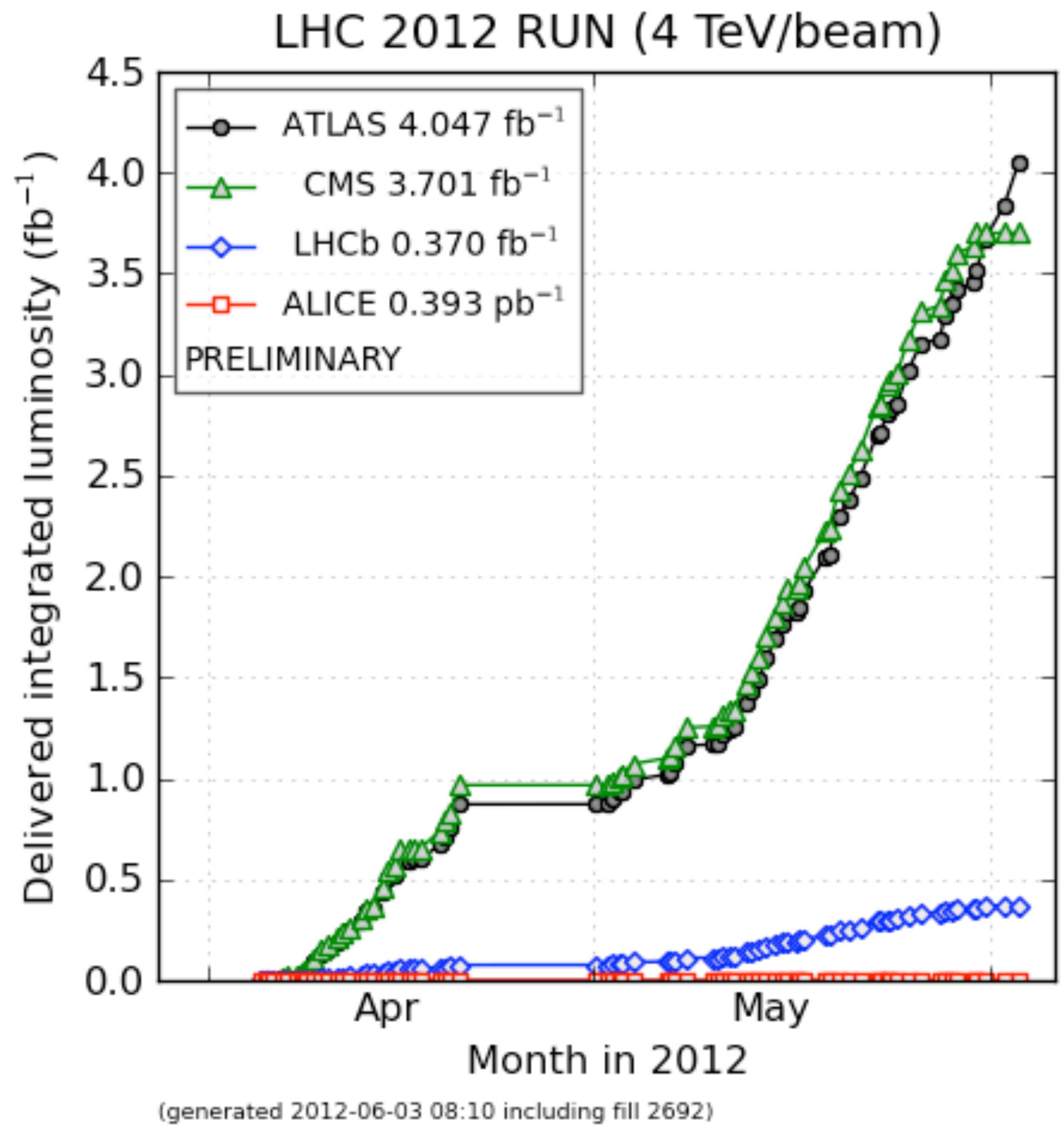




- Show limits in 2D (e.g. M_{gluino} vs M_{NLSP} or M_{gluino} vs M_{squark} with fixed M_{NLSP}).
- Parametrize phenomenology with physical masses, not unphysical model parameters!!

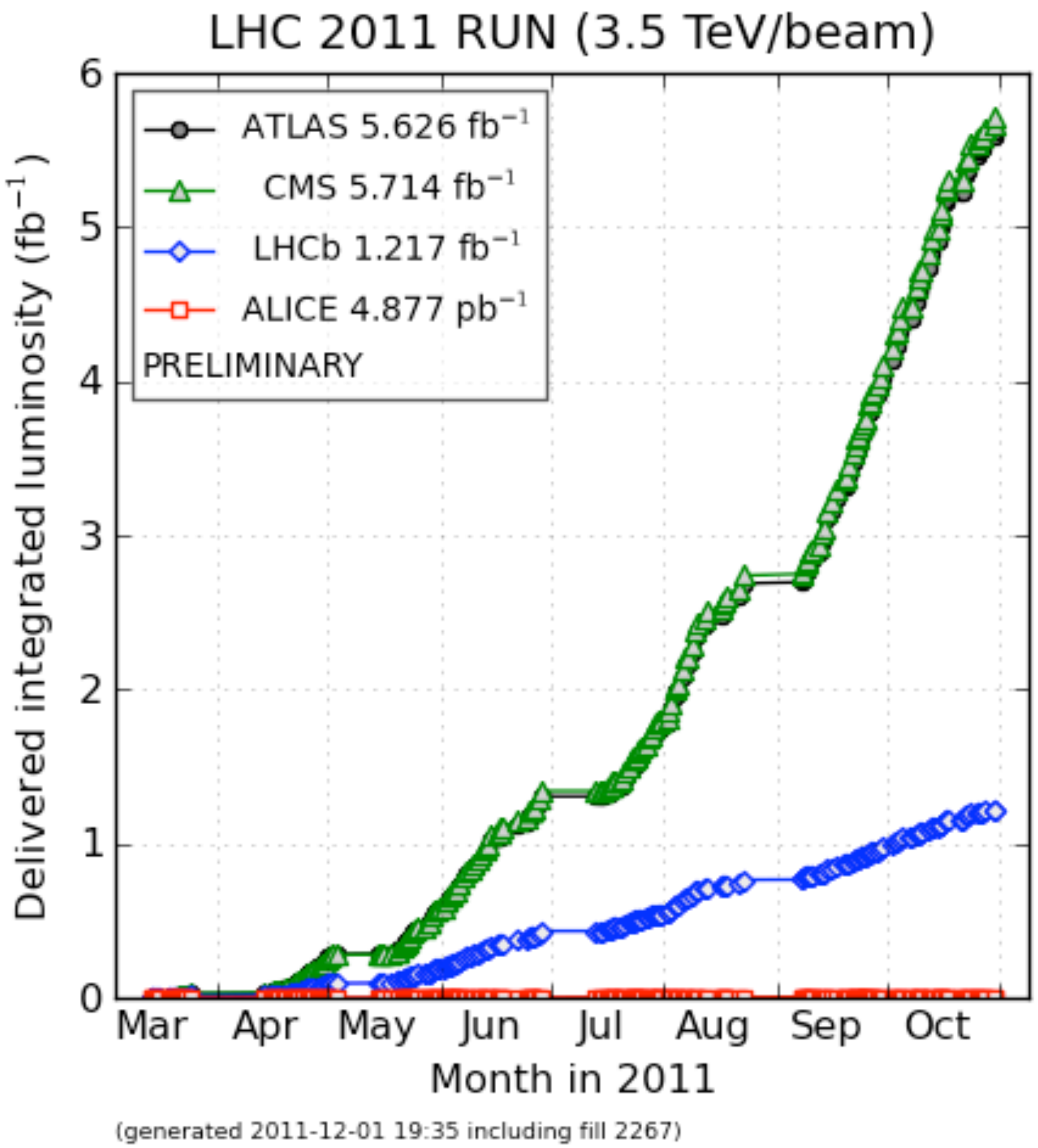
Overview of LHC searches

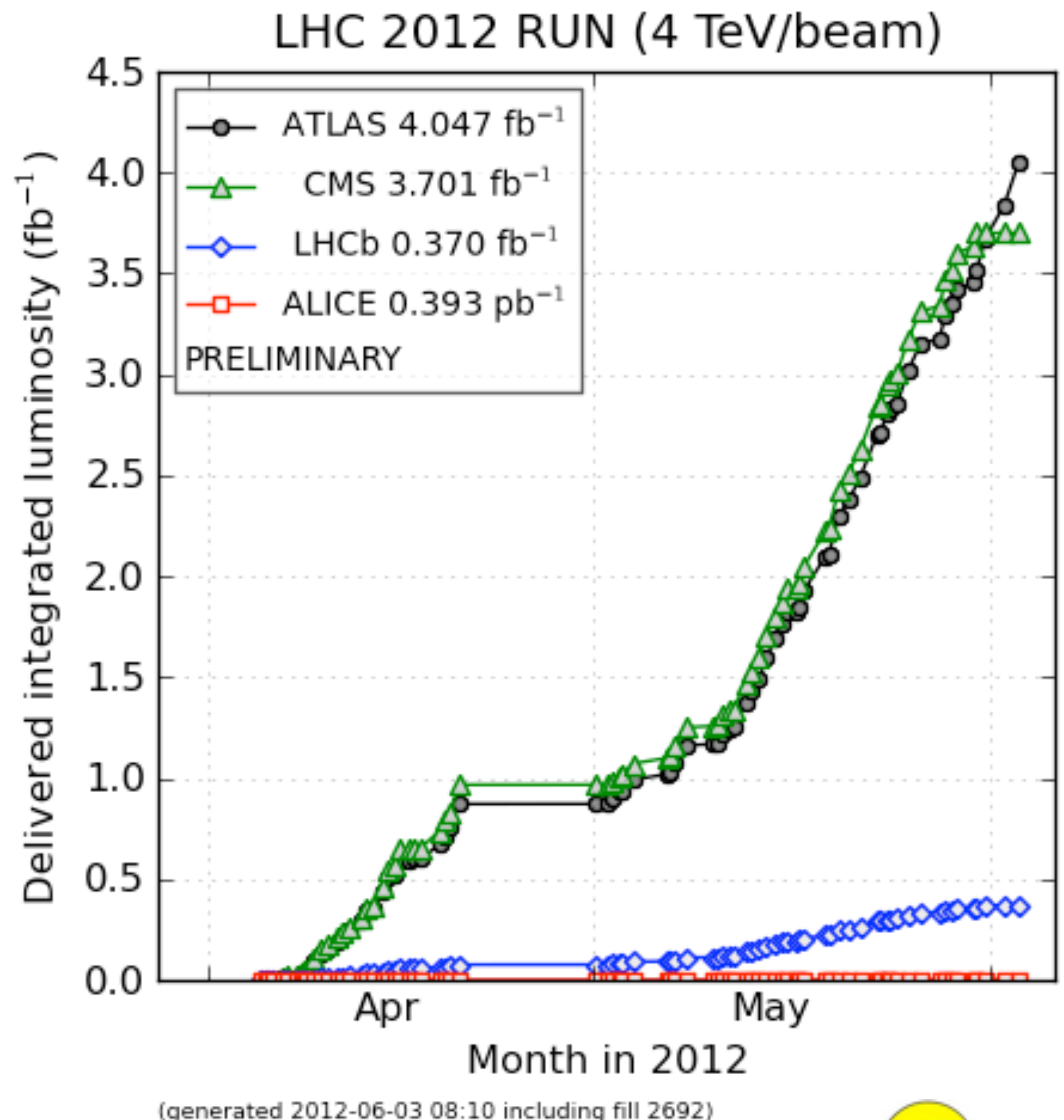




The march of progress at the LHC has been inexorable...

So far, nothing but limits in the search for SUSY.





The march of progress at the LHC has been inexorable...

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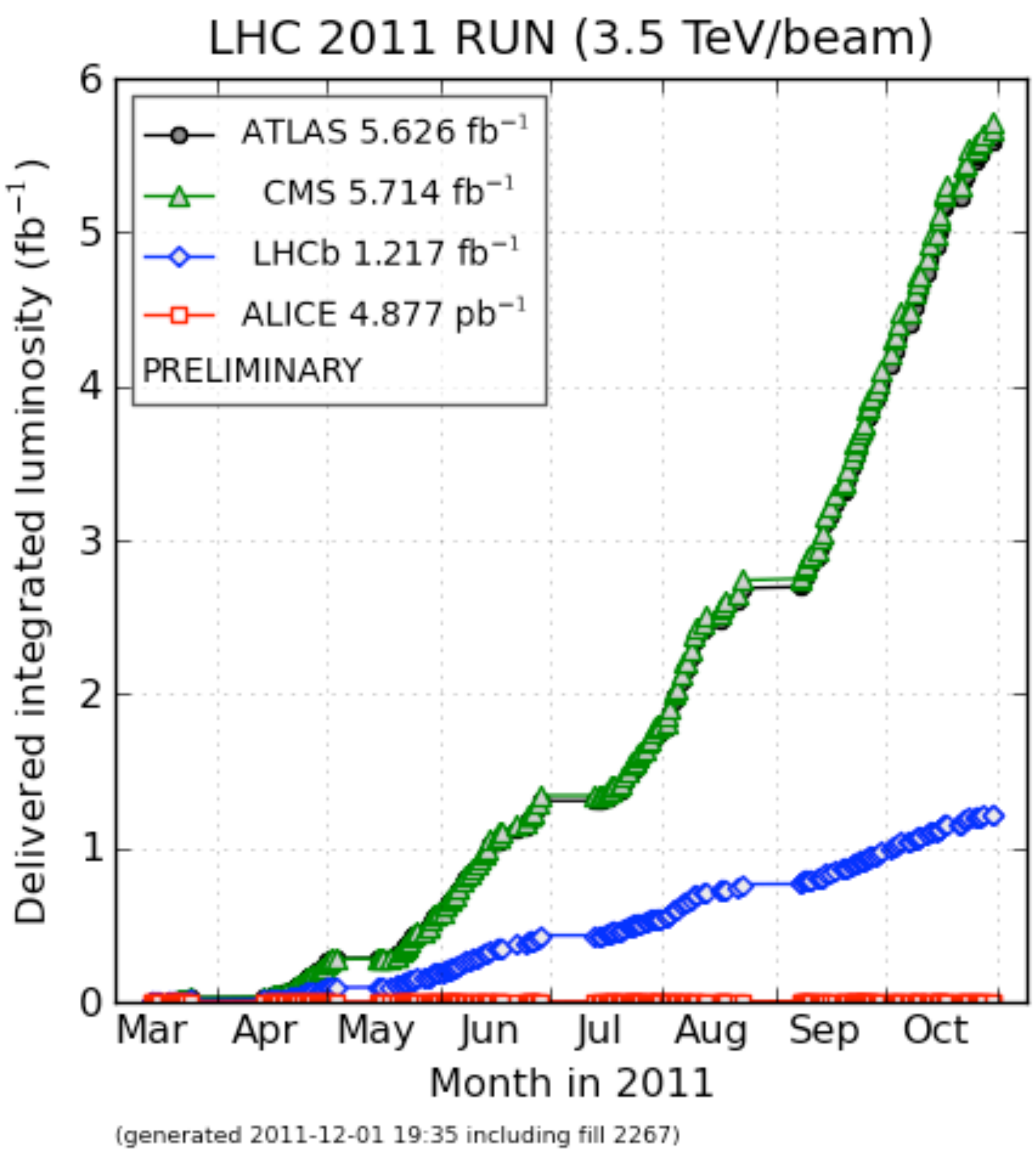
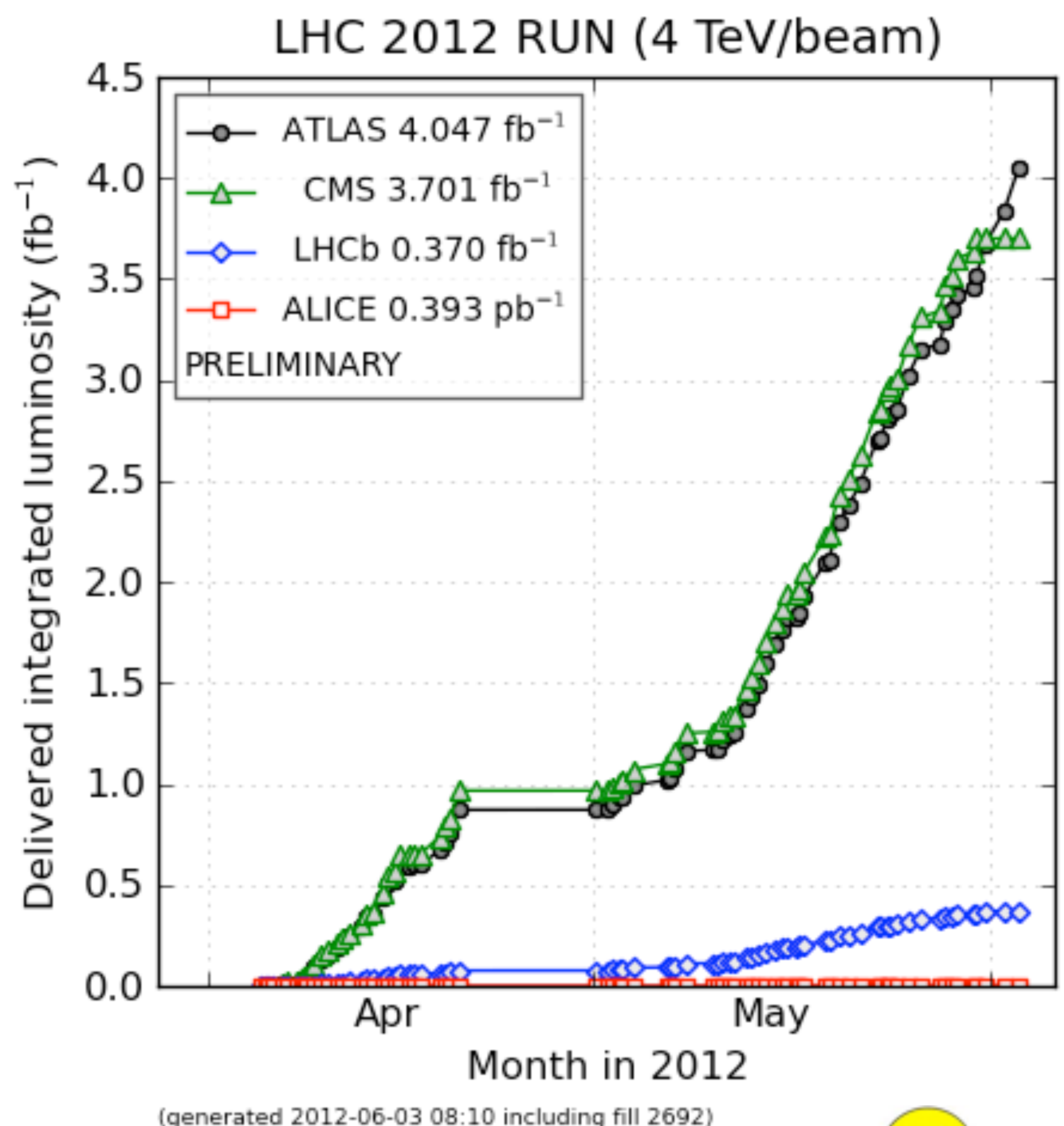
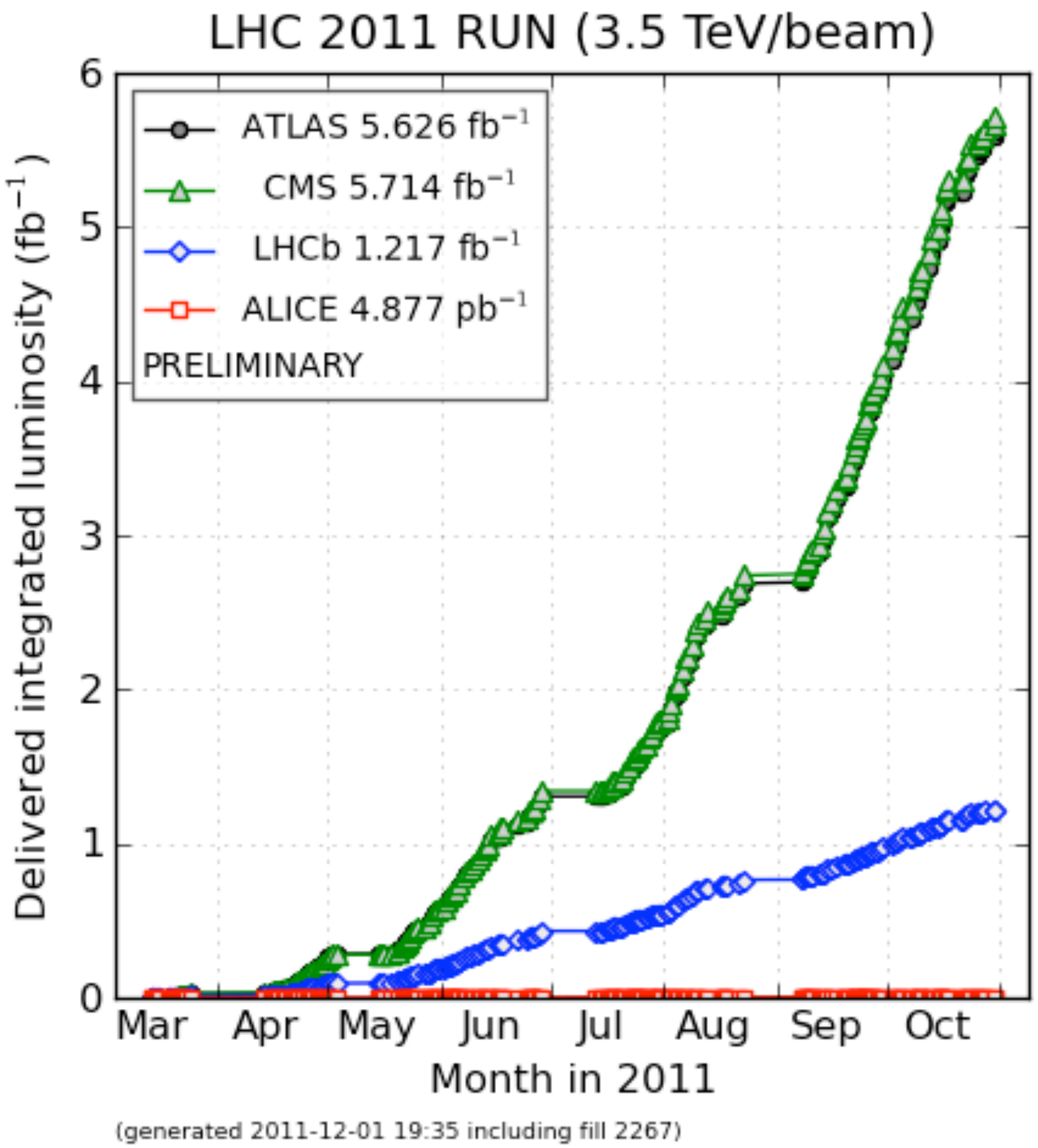


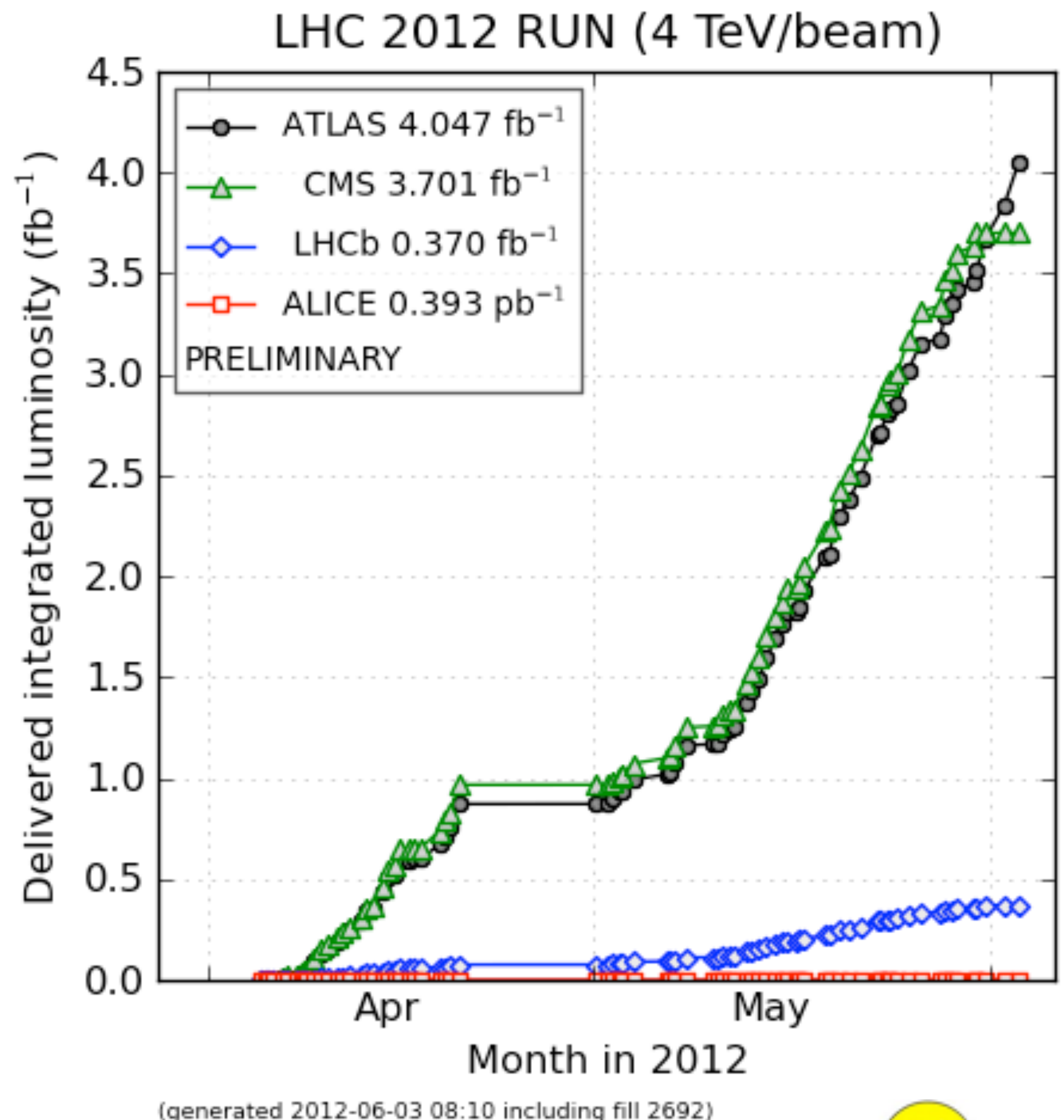


The march of progress at the LHC has been inexorable...

o far t ; b in in th ear for SY.

Should we be concerned?





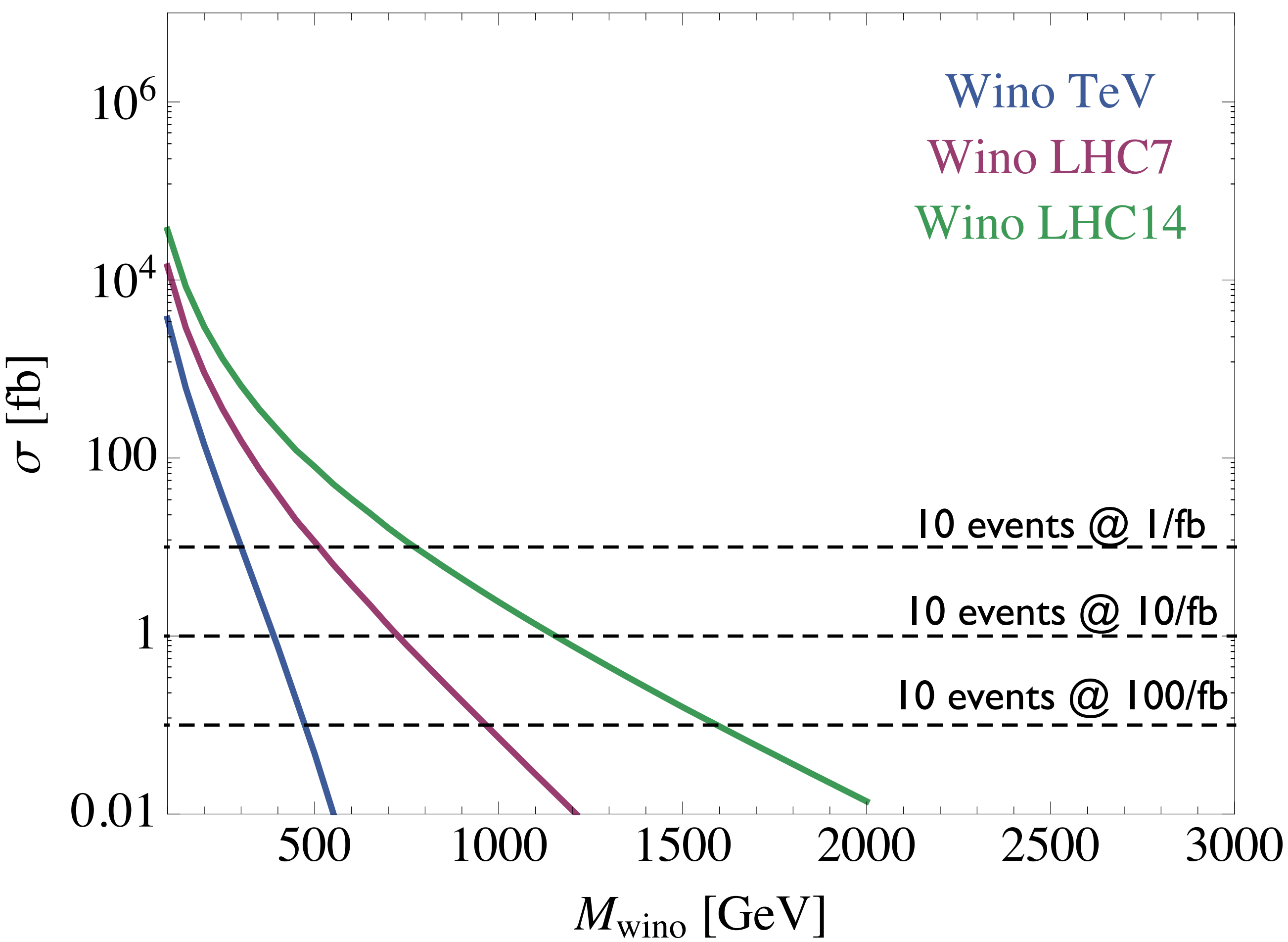
The march of progress at the LHC has been inexorable...

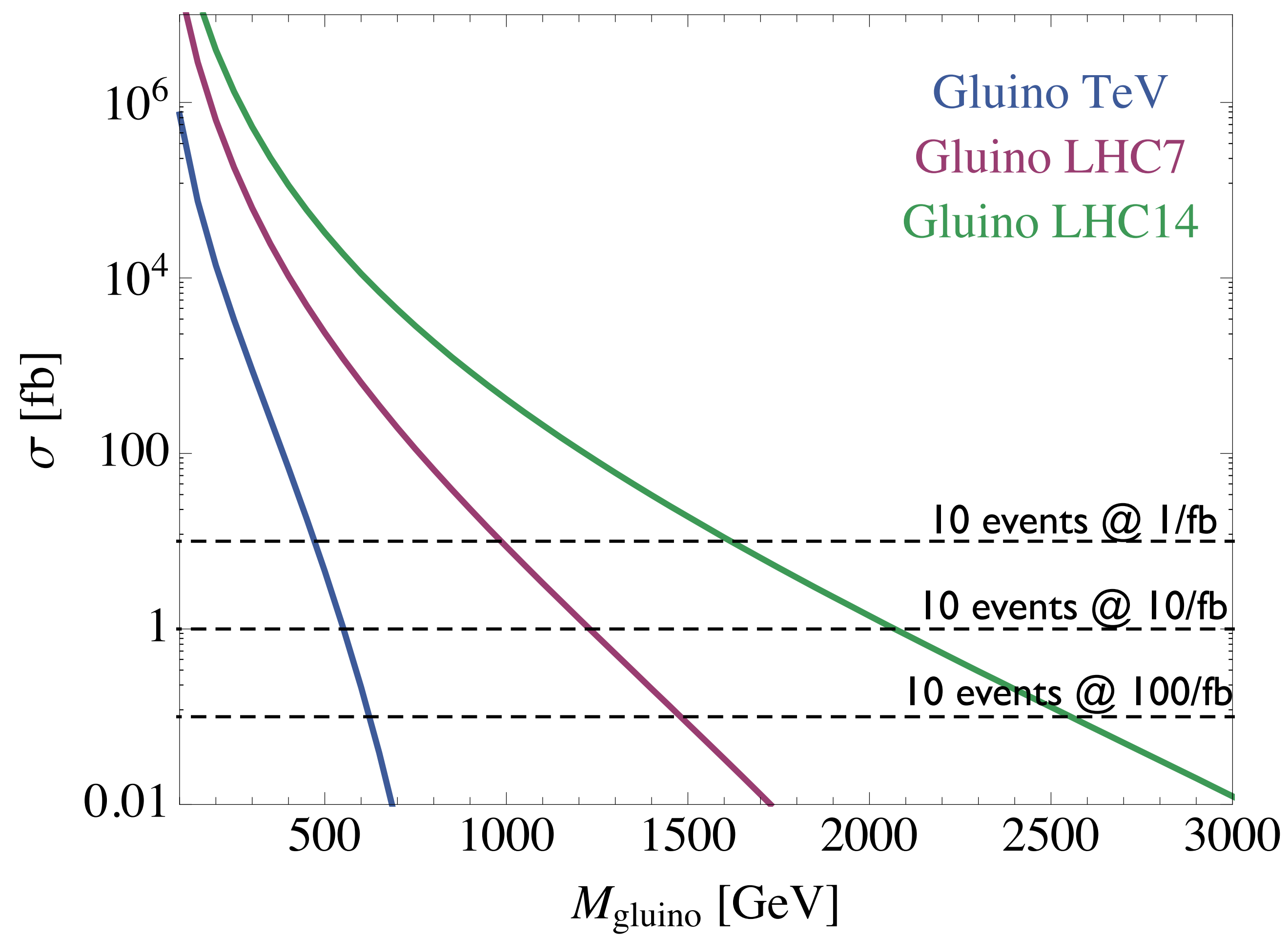
o far t ; b in in th ear for SY.

Should we be concerned?

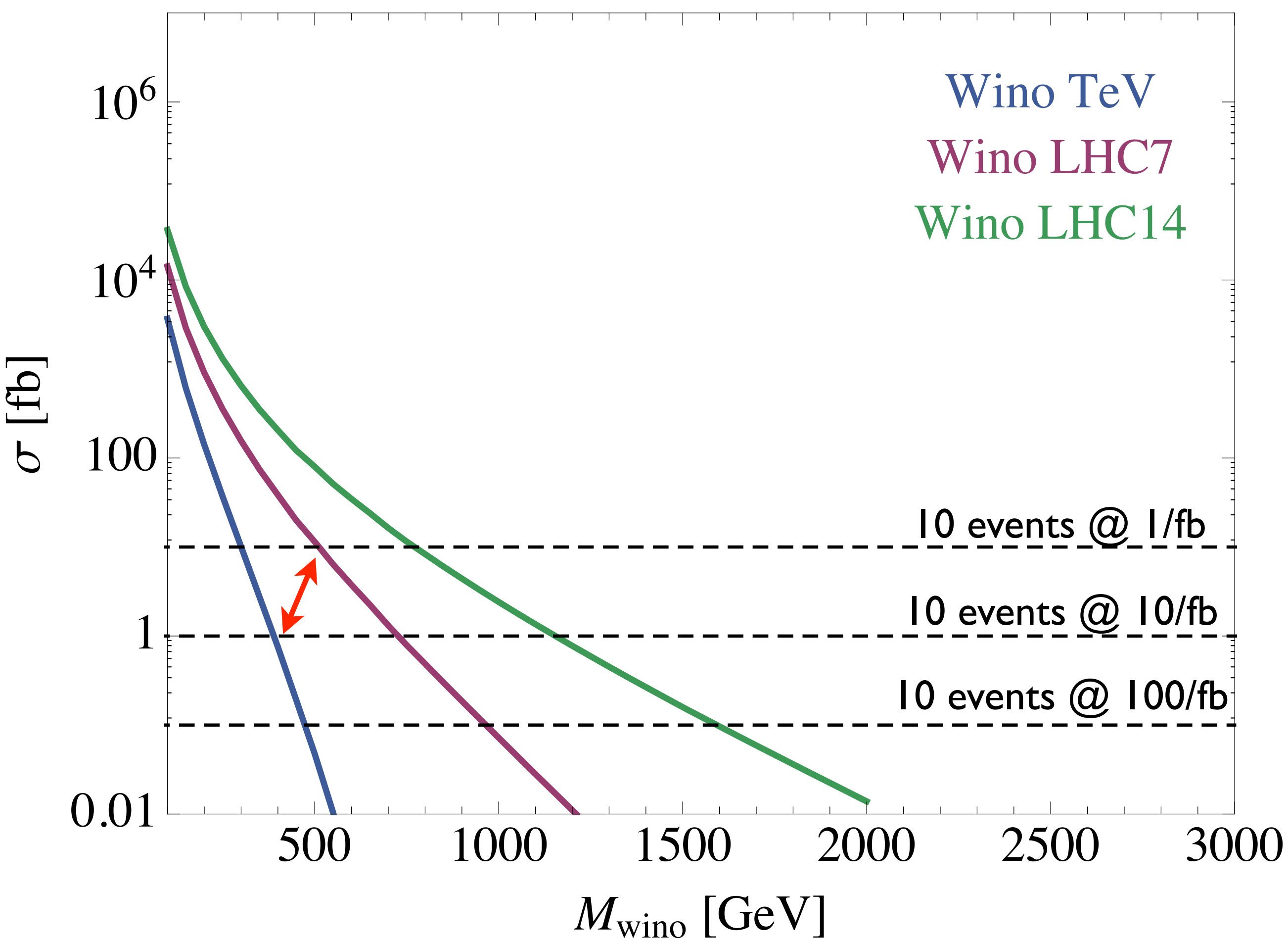
Where should we be looking?

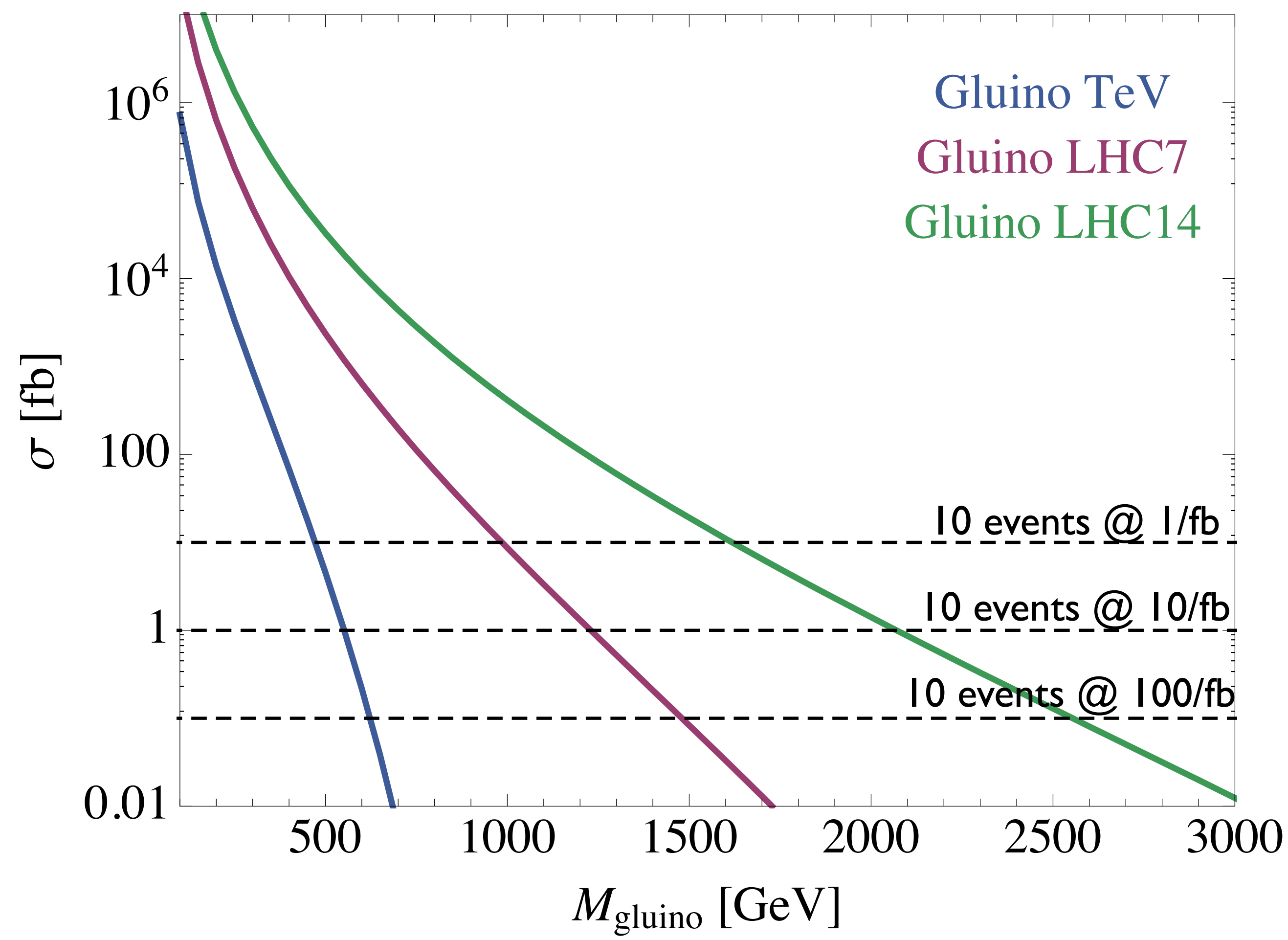
SUSY production at the LHC





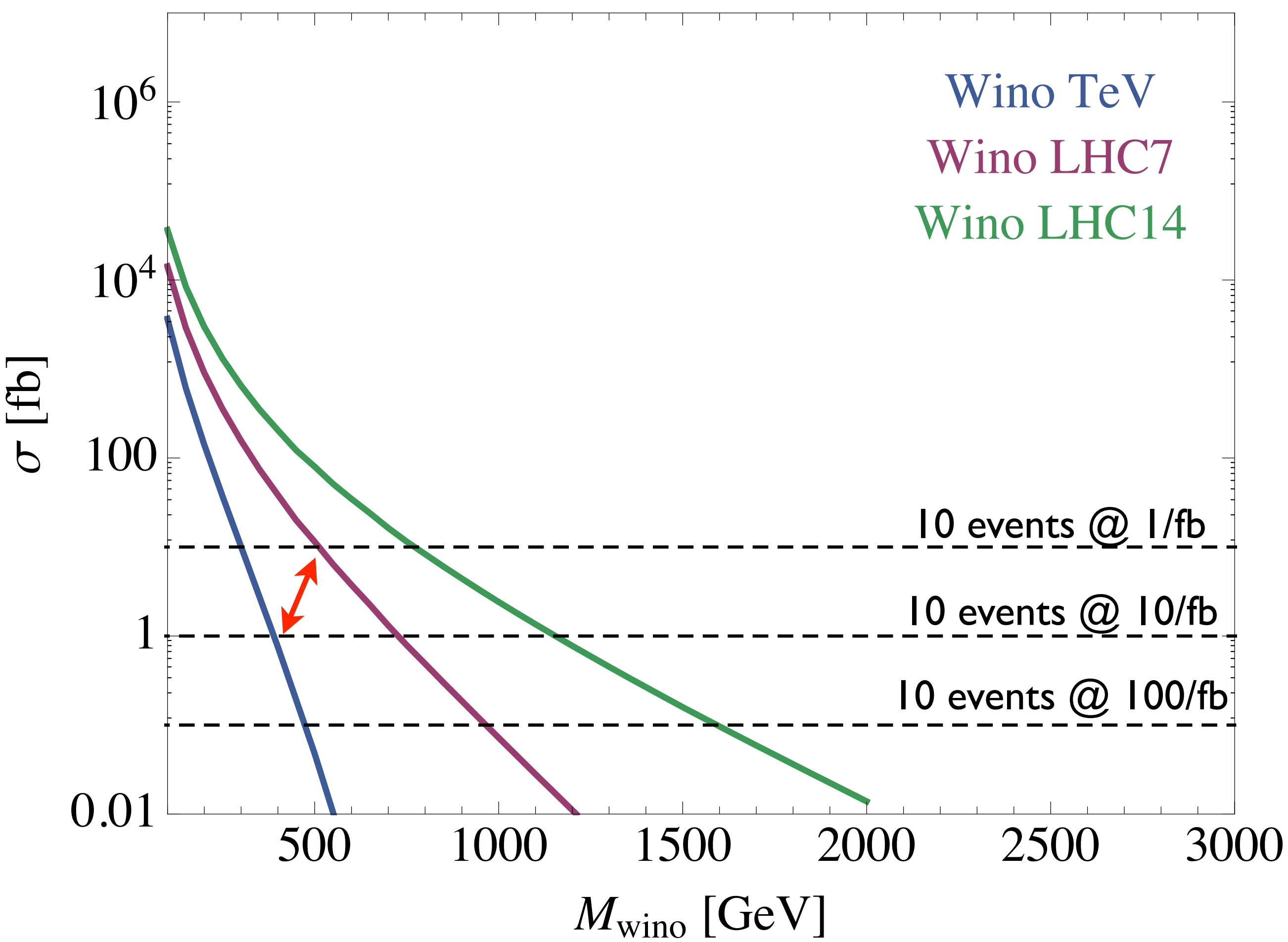
SUSY production at the LHC

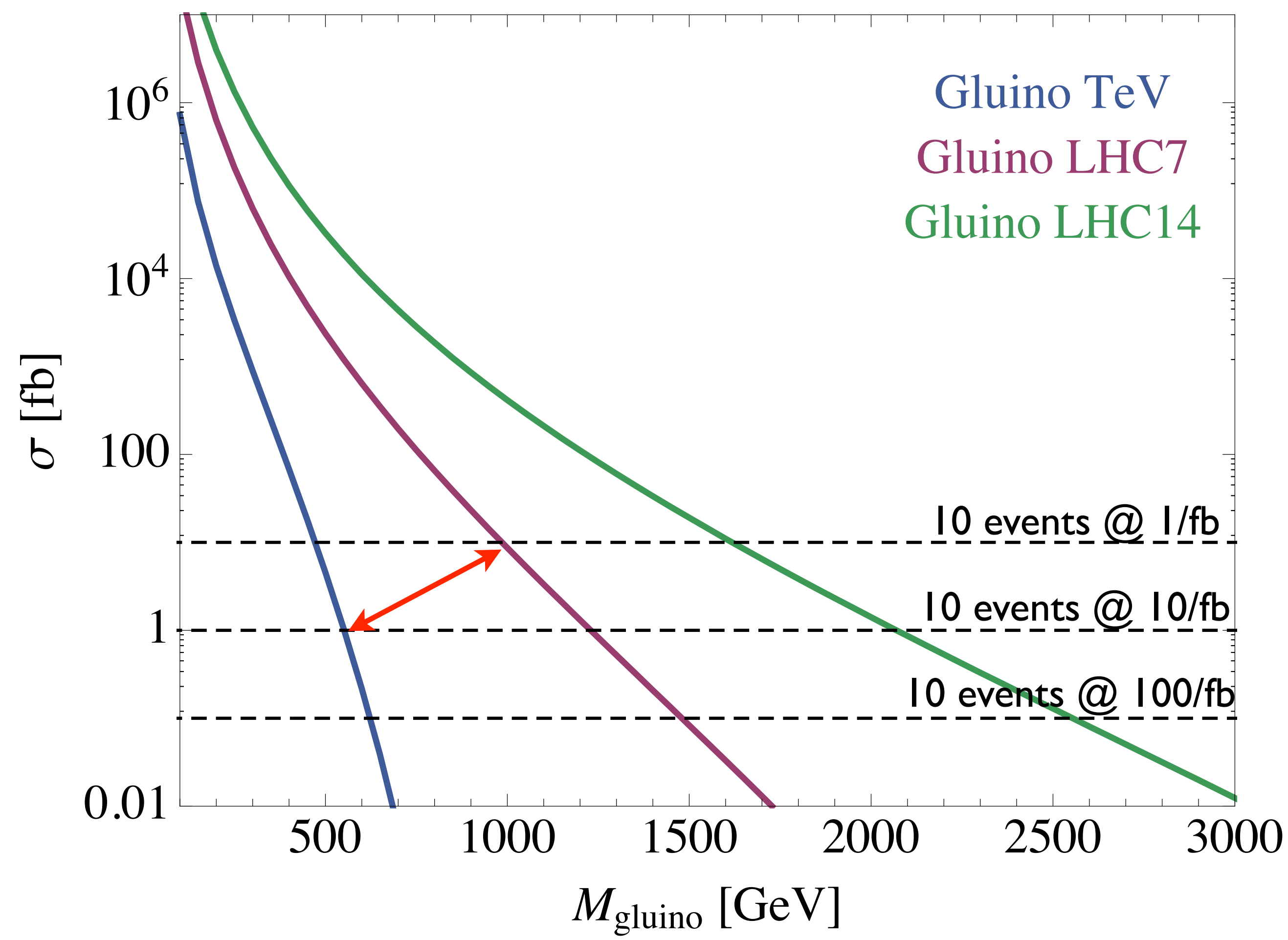




- For EW production, LHC @ 1/fb ~ Tevatron @ 10/fb

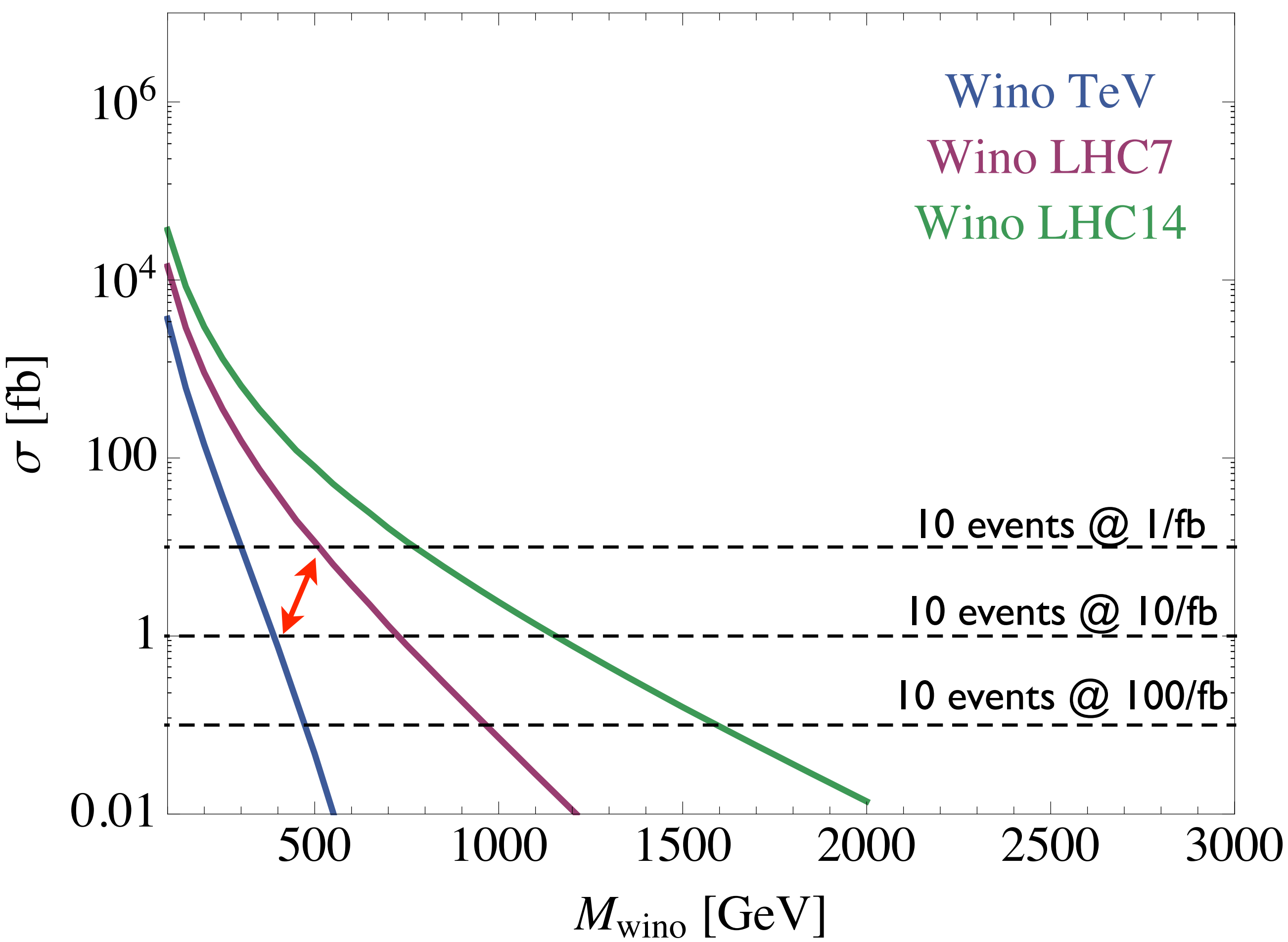
SUSY production at the LHC

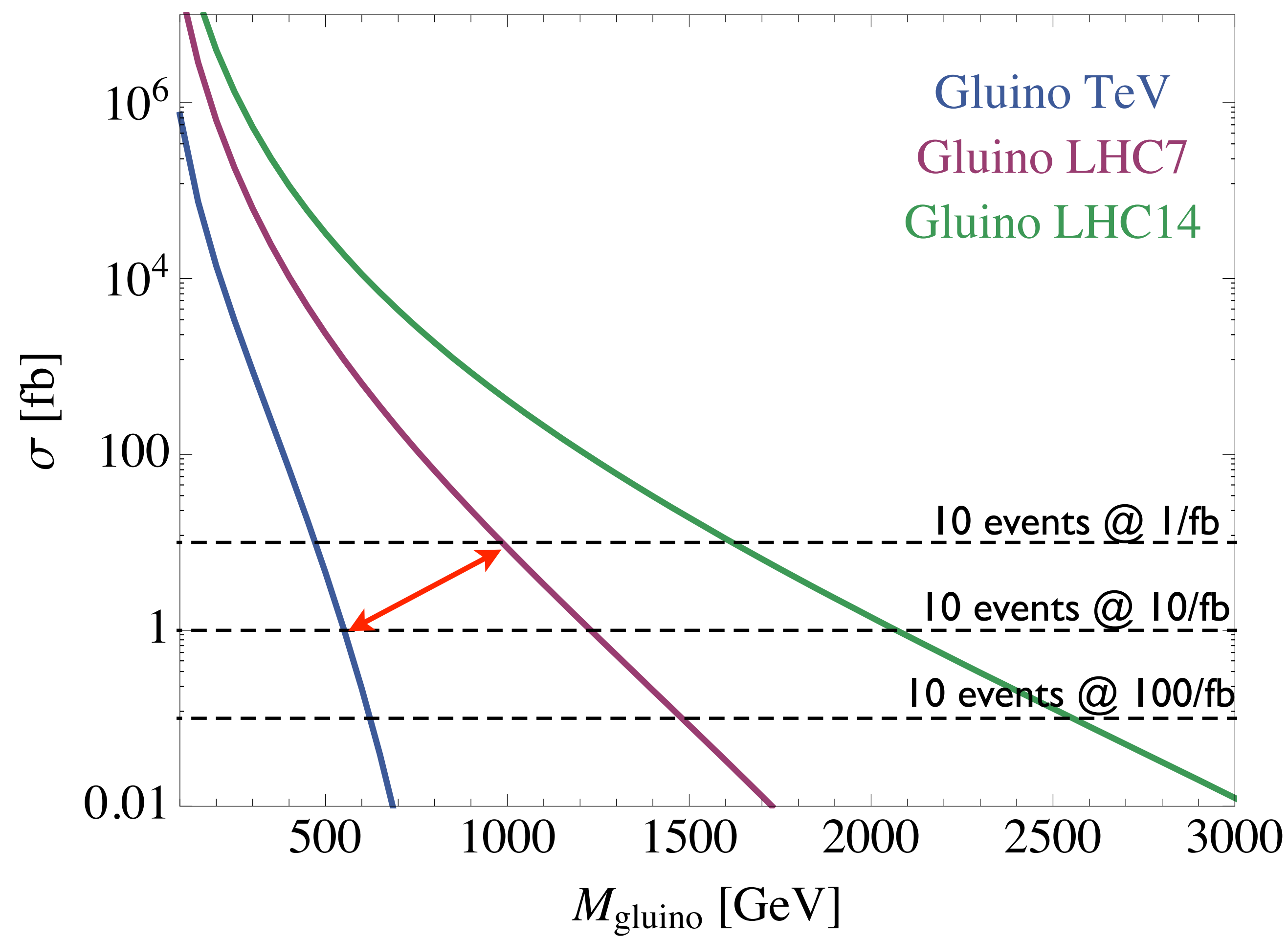




- For EW production, LHC @ 1/fb ~ Tevatron @ 10/fb
- For strong production, LHC @ 1/fb >> Tevatron @ 10/fb

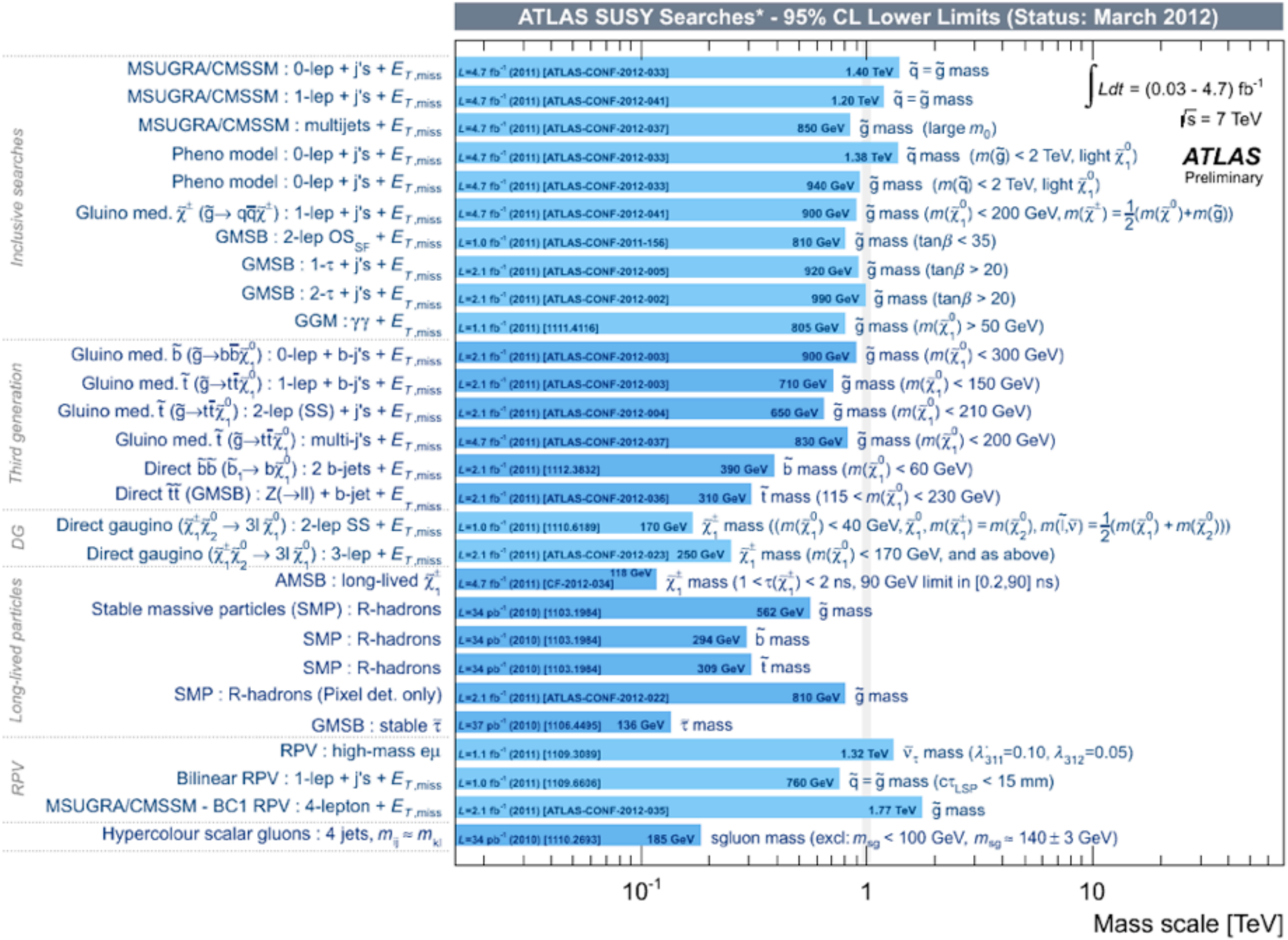
SUSY production at the LHC

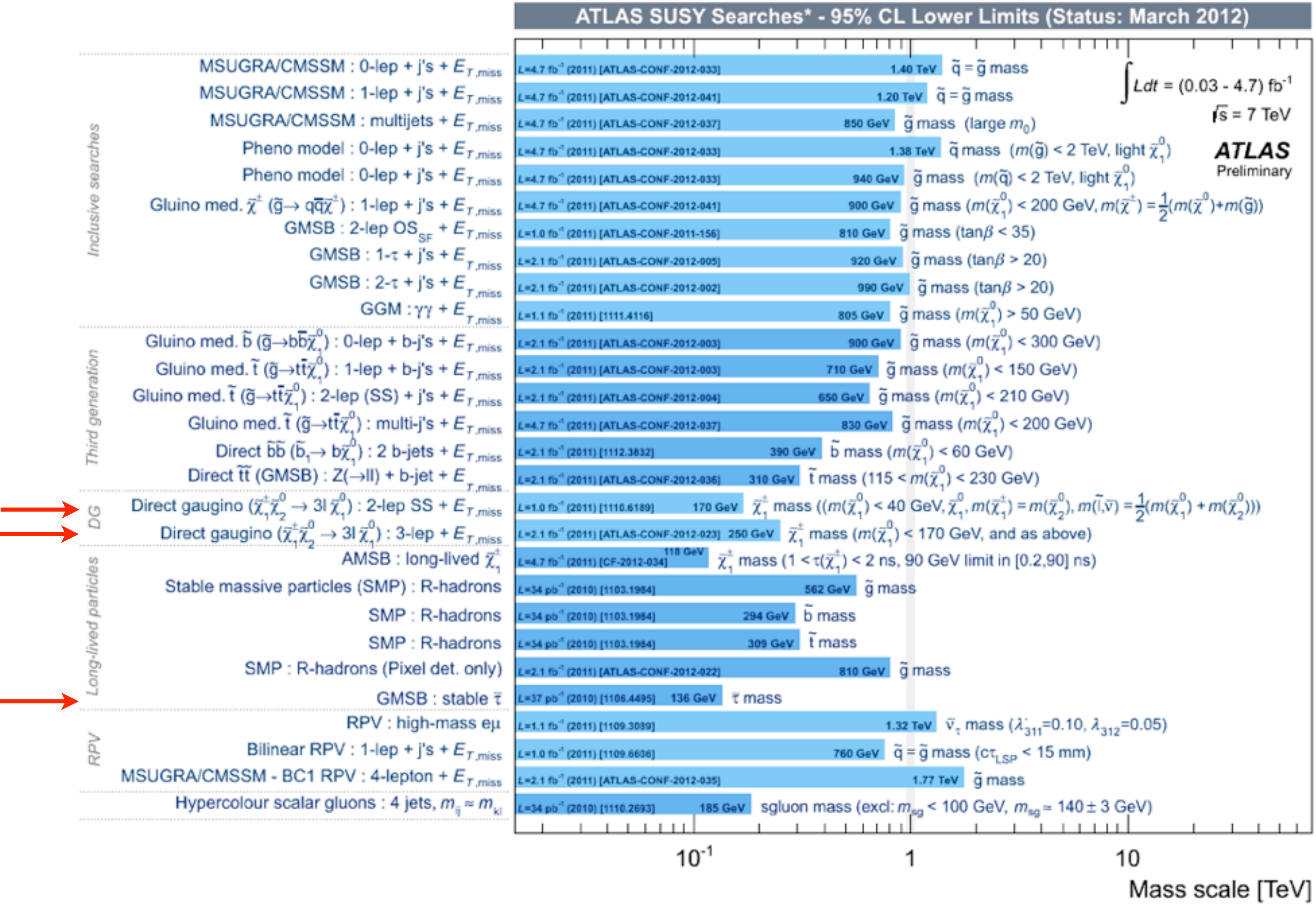




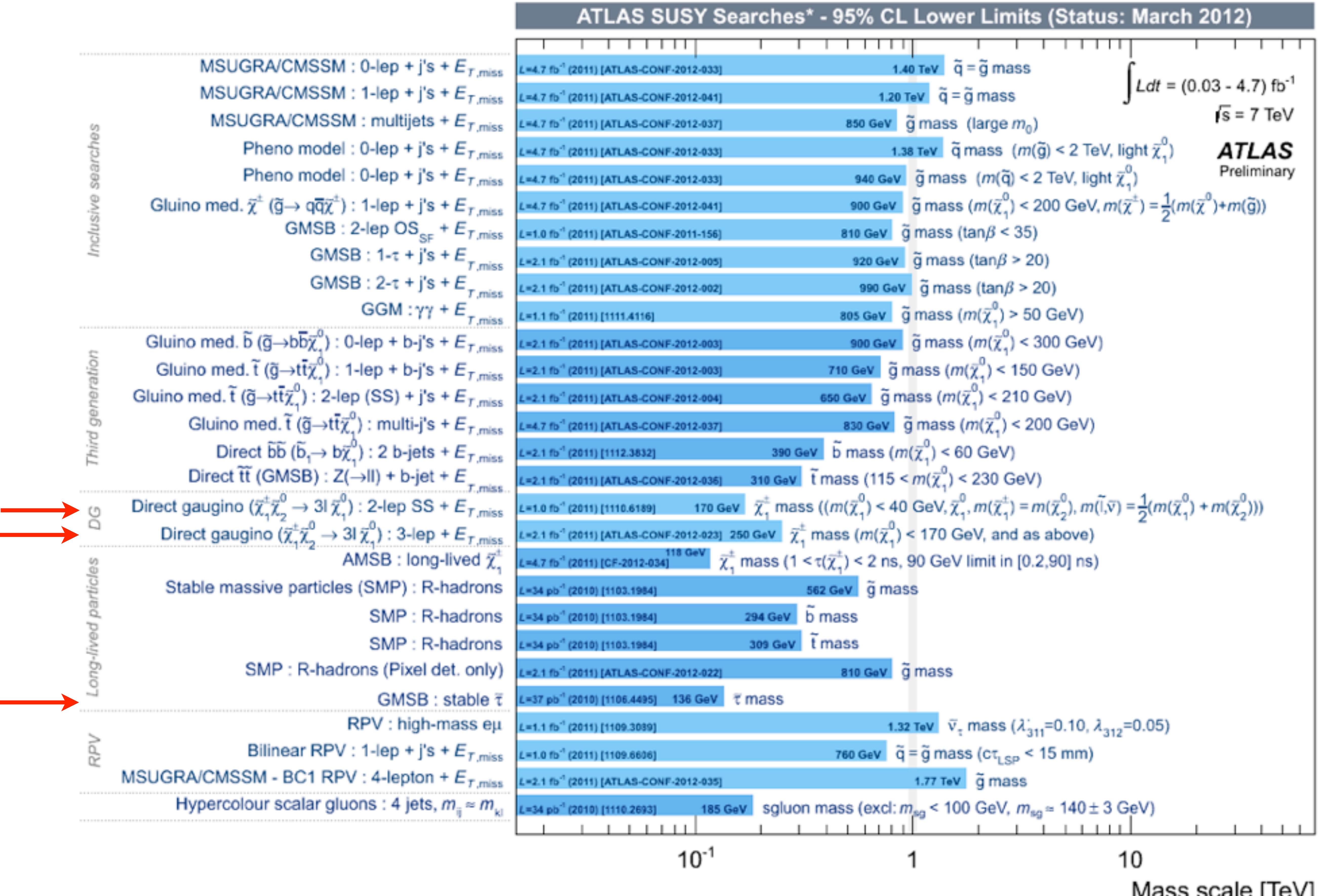
- For EW production, LHC @ 1/fb ~ Tevatron @ 10/fb
- For strong production, LHC @ 1/fb >> Tevatron @ 10/fb

For colored superpartners, SUSY could have been “around the corner” at the LHC.
For EW superpartners, a much harder slog is ahead of us.


ATLAS SUSY Searches* - 95% CL Lower Limits (Status: March 2012)
∫Ldt = (0.03 - 4.7) fb⁻¹
√s = 7 TeV
ATLAS
Preliminary
Inclusive searches
MSUGRA/CMSSM : 0-lep + j's + E_T,miss
L=4.7 fb⁻¹ (2011) [ATLAS-CONF-2012-033] 1.40 TeV q̃ = g̃ mass
MSUGRA/CMSSM : 1-lep + j's + E_T,miss
L=4.7 fb⁻¹ (2011) [ATLAS-CONF-2012-041] 1.20 TeV q̃ = g̃ mass
MSUGRA/CMSSM : multijets + E_T,miss
L=4.7 fb⁻¹ (2011) [ATLAS-CONF-2012-037] 850 GeV g̃ mass (large m0)
Pheno model : 0-lep + j's + E_T,miss
L=4.7 fb⁻¹ (2011) [ATLAS-CONF-2012-033] 1.38 TeV q̃ mass (m(g̃) < 2 TeV, light χ̃⁰1)
Pheno model : 0-lep + j's + E_T,miss
L=4.7 fb⁻¹ (2011) [ATLAS-CONF-2012-033] 940 GeV g̃ mass (m(q̃) < 2 TeV, light χ̃⁰1)
Gluino med. χ̃± (g̃→ qq̄χ̃±) : 1-lep + j's + E_T,miss
L=4.7 fb⁻¹ (2011) [ATLAS-CONF-2012-041] 900 GeV g̃ mass (m(χ̃⁰1) < 200 GeV, m(χ̃±) = ½(m(χ̃⁰)+m(g̃))
GMSB : 2-lep OS_SF + E_T,miss
L=1.0 fb⁻¹ (2011) [ATLAS-CONF-2011-156] 810 GeV g̃ mass (tanβ < 35)
GMSB : 1-τ + j's + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-005] 920 GeV g̃ mass (tanβ > 20)
GMSB : 2-τ + j's + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-002] 990 GeV g̃ mass (tanβ > 20)
GGM : γγ + E_T,miss
L=1.1 fb⁻¹ (2011) [1111.4116] 805 GeV g̃ mass (m(χ̃⁰1) > 50 GeV)
Third generation
Gluino med. b̃ (g̃→bb̄χ̃⁰1) : 0-lep + b-j's + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-003] 900 GeV g̃ mass (m(χ̃⁰1) < 300 GeV)
Gluino med. t̃ (g̃→tt̄χ̃⁰1) : 1-lep + b-j's + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-003] 710 GeV g̃ mass (m(χ̃⁰1) < 150 GeV)
Gluino med. t̃ (g̃→tt̄χ̃⁰1) : 2-lep (SS) + j's + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-004] 650 GeV g̃ mass (m(χ̃⁰1) < 210 GeV)
Gluino med. t̃ (g̃→tt̄χ̃⁰1) : multi-j's + E_T,miss
L=4.7 fb⁻¹ (2011) [ATLAS-CONF-2012-037] 830 GeV g̃ mass (m(χ̃⁰1) < 200 GeV)
Direct b̃b̃ (b̃1→ bχ̃⁰1) : 2 b-jets + E_T,miss
L=2.1 fb⁻¹ (2011) [1112.3832] 390 GeV b̃ mass (m(χ̃⁰1) < 60 GeV)
Direct t̃t̃ (GMSB) : Z(→ll) + b-jet + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-036] 310 GeV t̃ mass (115 < m(χ̃⁰1) < 230 GeV)
DG
Direct gaugino (χ̃±1χ̃⁰2 → 3l χ̃⁰1) : 2-lep SS + E_T,miss
L=1.0 fb⁻¹ (2011) [1110.6189] 170 GeV χ̃±1 mass ((m(χ̃⁰1) < 40 GeV, χ̃⁰1, m(χ̃±1) = m(χ̃⁰2), m(l̃,ν̃) = ½(m(χ̃⁰1) + m(χ̃⁰2)))
Direct gaugino (χ̃±1χ̃⁰2 → 3l χ̃⁰1) : 3-lep + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-023] 250 GeV χ̃±1 mass (m(χ̃⁰1) < 170 GeV, and as above)
Long-lived particles
AMSB : long-lived χ̃±1
L=4.7 fb⁻¹ (2011) [CF-2012-034] 118 GeV χ̃±1 mass (1 < τ(χ̃±1) < 2 ns, 90 GeV limit in [0.2,90] ns)
Stable massive particles (SMP) : R-hadrons
L=34 pb⁻¹ (2010) [1103.1984] 562 GeV g̃ mass
SMP : R-hadrons
L=34 pb⁻¹ (2010) [1103.1984] 294 GeV b̃ mass
SMP : R-hadrons
L=34 pb⁻¹ (2010) [1103.1984] 309 GeV t̃ mass
SMP : R-hadrons (Pixel det. only)
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-022] 810 GeV g̃ mass
GMSB : stable τ̃
L=37 pb⁻¹ (2010) [1106.4495] 136 GeV τ̃ mass
RPV
RPV : high-mass eμ
L=1.1 fb⁻¹ (2011) [1109.3089] 1.32 TeV ν̃τ mass (λ'311=0.10, λ312=0.05)
Bilinear RPV : 1-lep + j's + E_T,miss
L=1.0 fb⁻¹ (2011) [1109.6606] 760 GeV q̃ = g̃ mass (cτLSP < 15 mm)
MSUGRA/CMSSM - BC1 RPV : 4-lepton + E_T,miss
L=2.1 fb⁻¹ (2011) [ATLAS-CONF-2012-035] 1.77 TeV g̃ mass
Hypercolour scalar gluons : 4 jets, m_ij ≈ m_kl
L=34 pb⁻¹ (2010) [1110.2693] 185 GeV sgluon mass (excl: m_sg < 100 GeV, m_sg ≈ 140 ± 3 GeV)
10⁻¹
1
10
Mass scale [TeV]



Limits on EW production currently weak, nearly non-existent, not much better than the Tevatron.

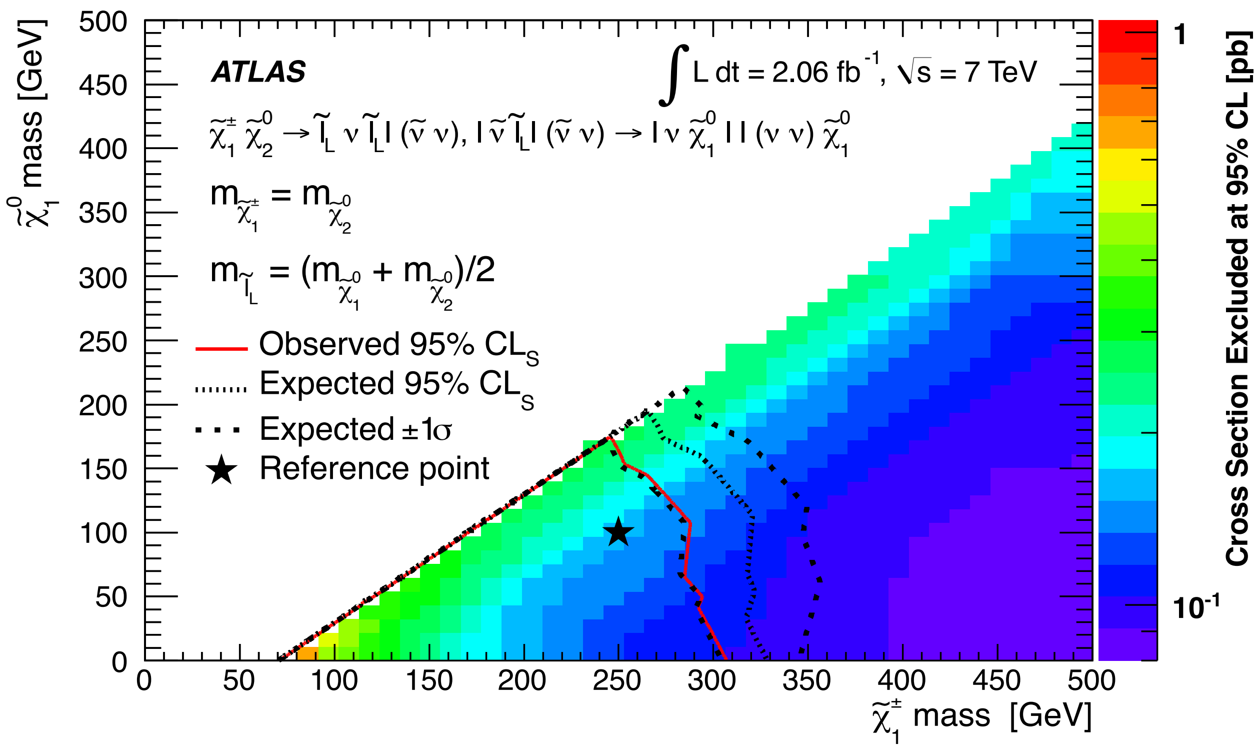


Limits on EW production currently weak, nearly non-existent, not much better than the Tevatron.

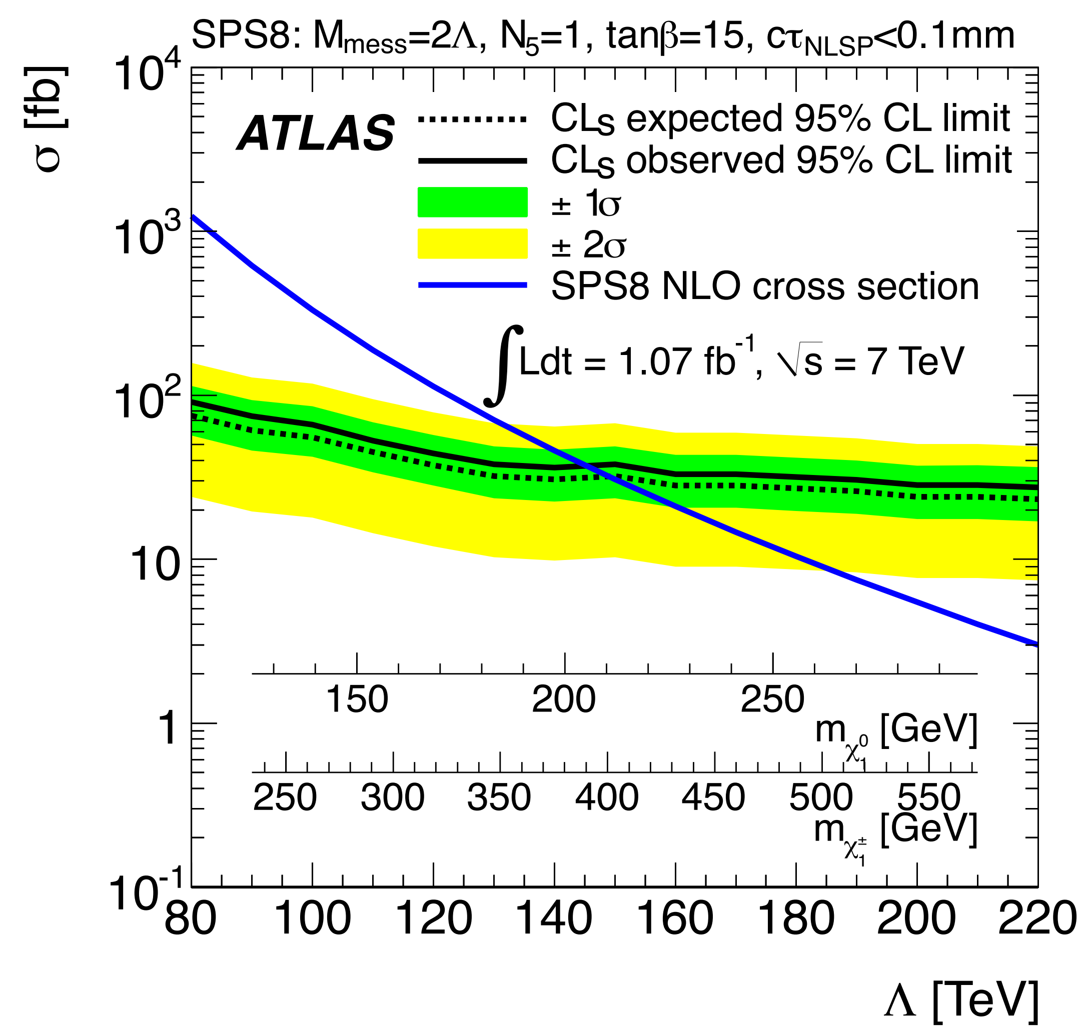
EW much more difficult, because of lower xsec, sensitive to lower masses, kinematics degraded.

LHC Limits on EW production

Currently need to assume best-case scenarios to get a limit:

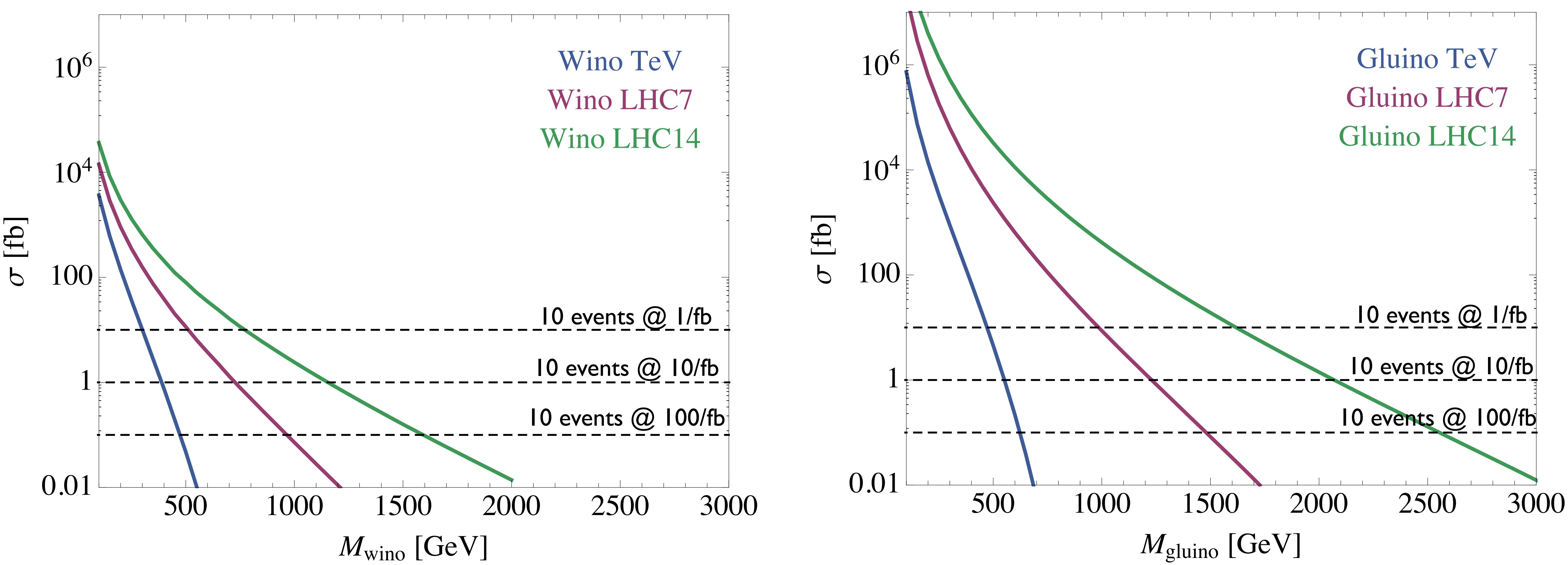


neutralino LSP with 100% BR to leptons

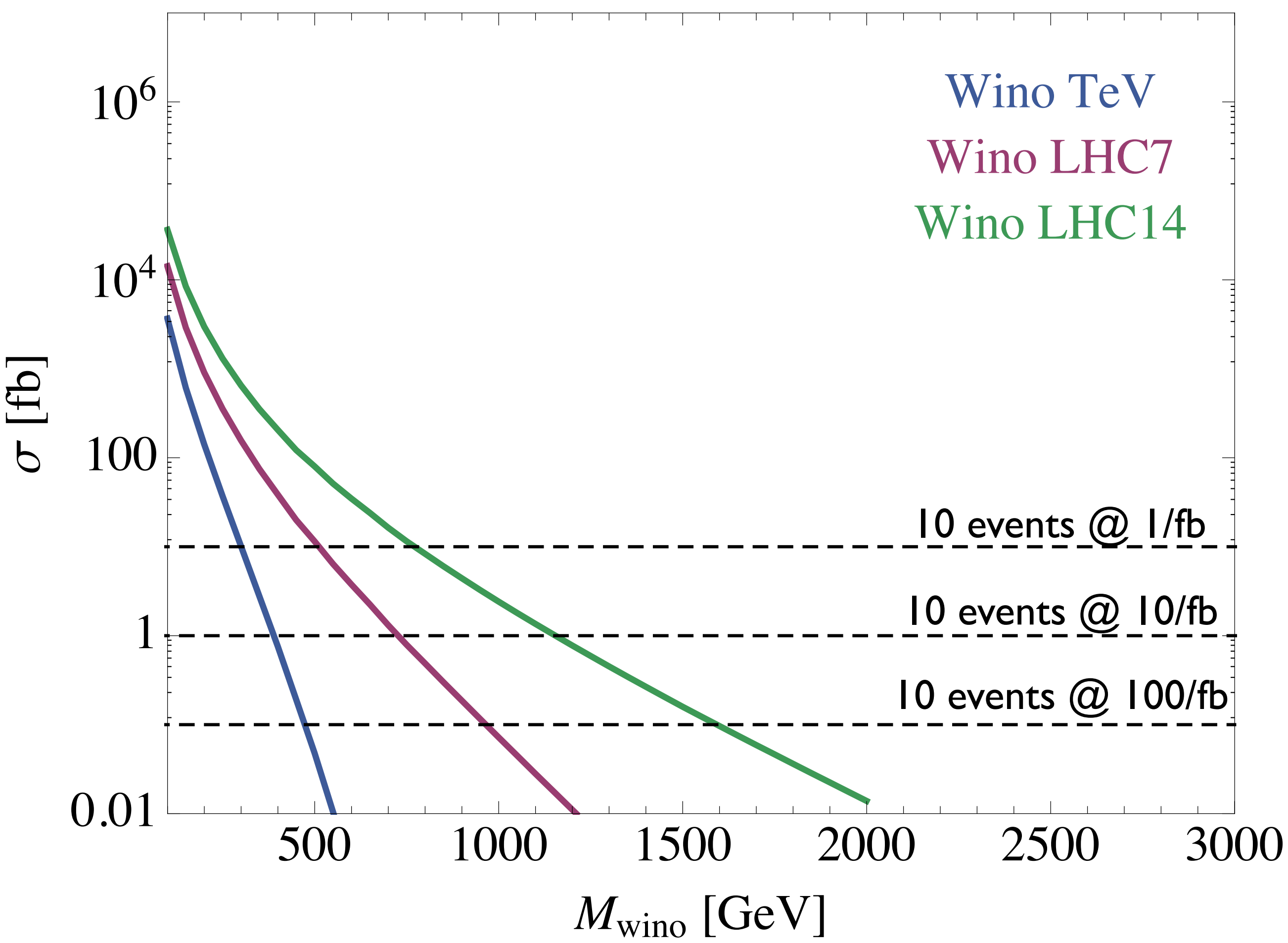


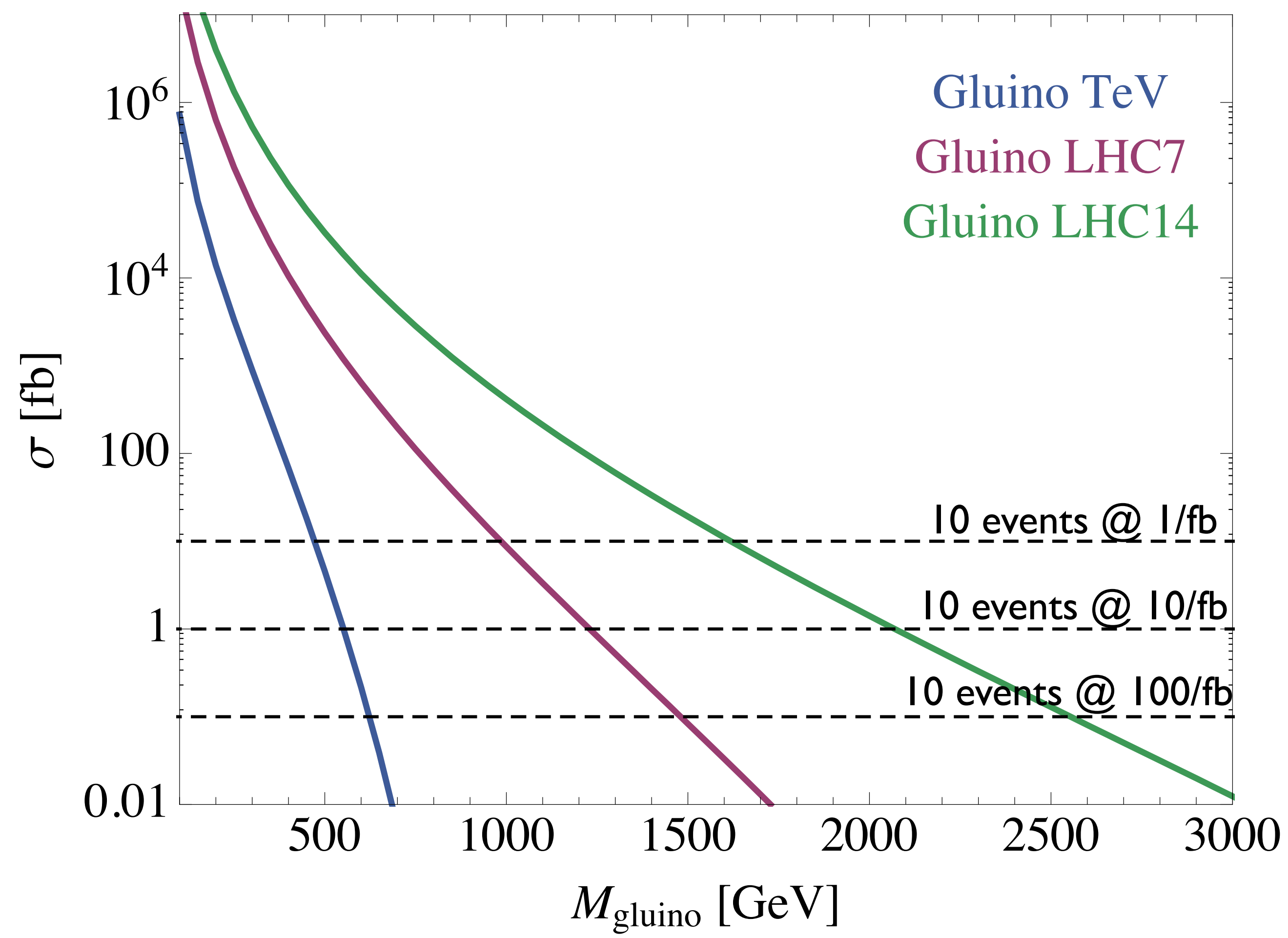
gravitino LSP with 100% BR to photons

SUSY production at the LHC



SUSY production at the LHC

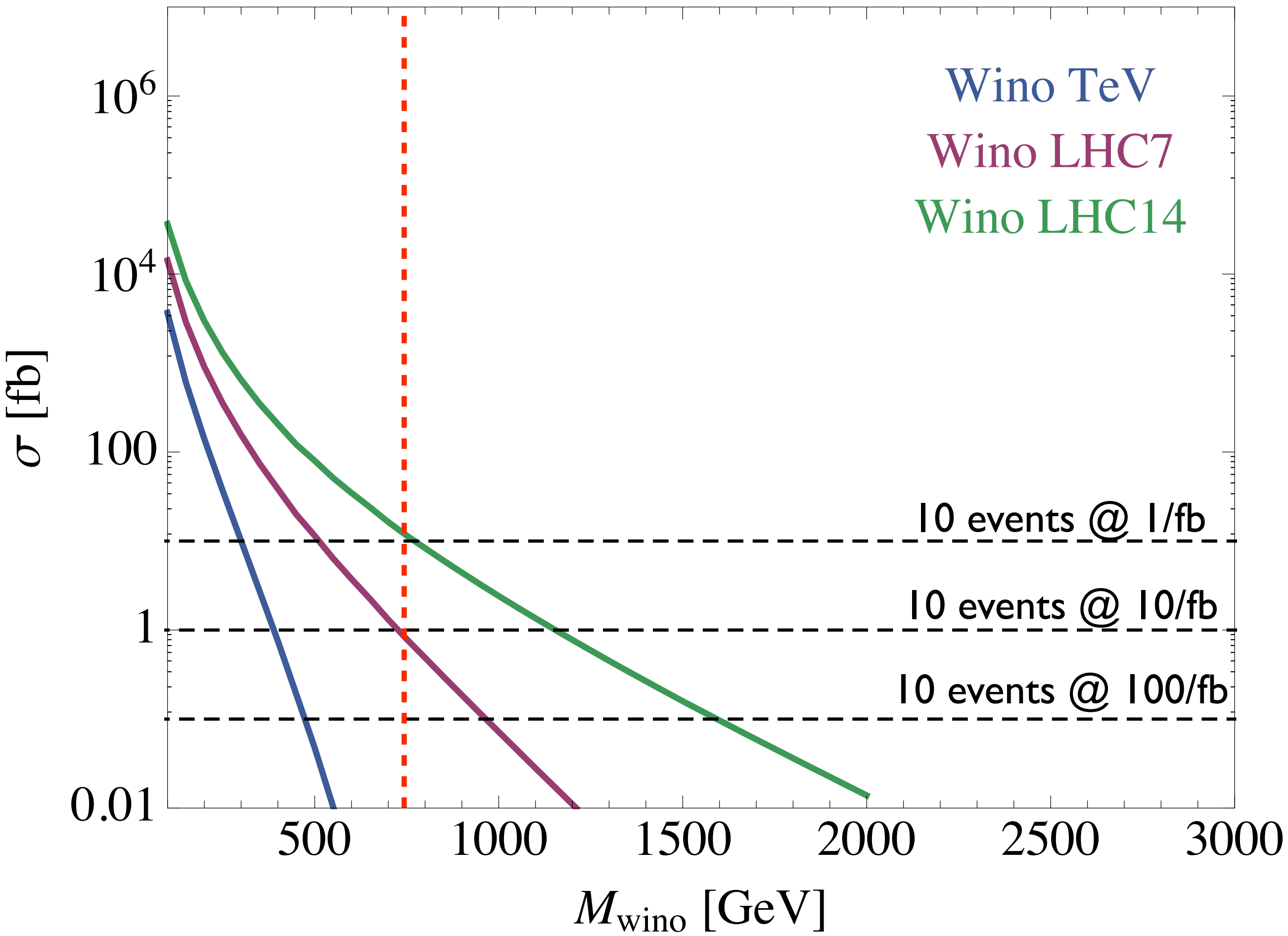


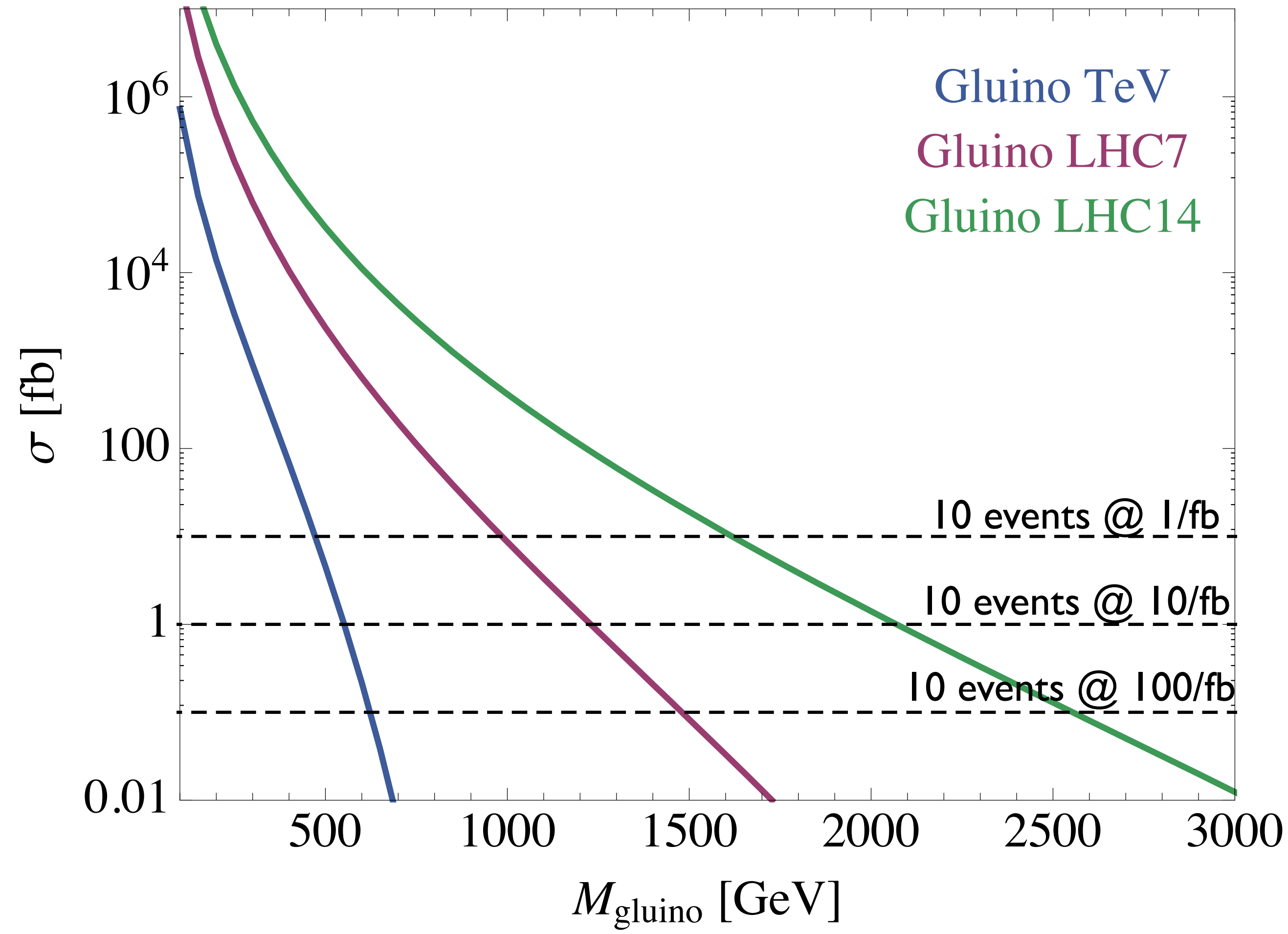


"Kinematic reach" of LHC7:

10 events @ 10/fb

SUSY production at the LHC

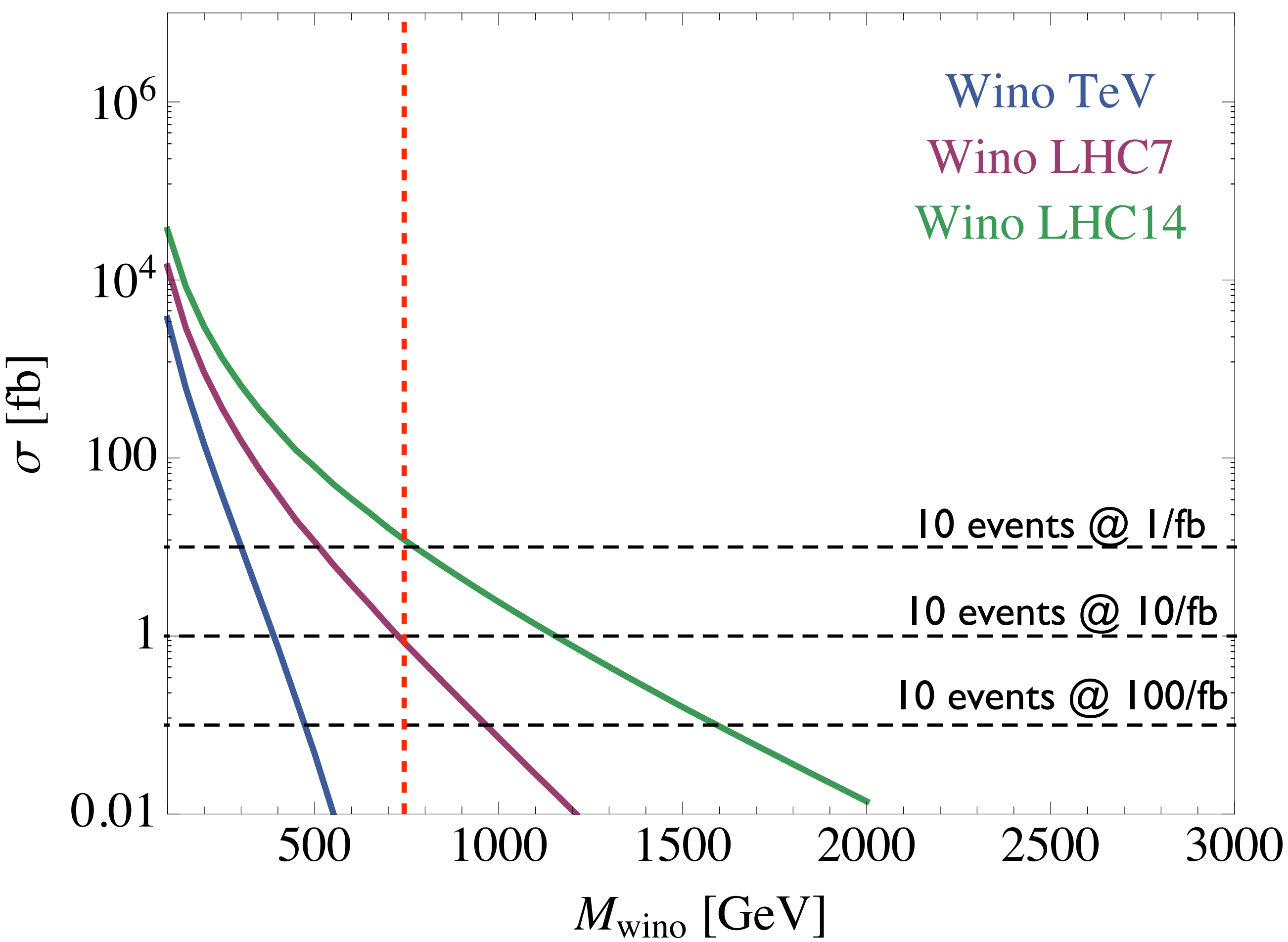


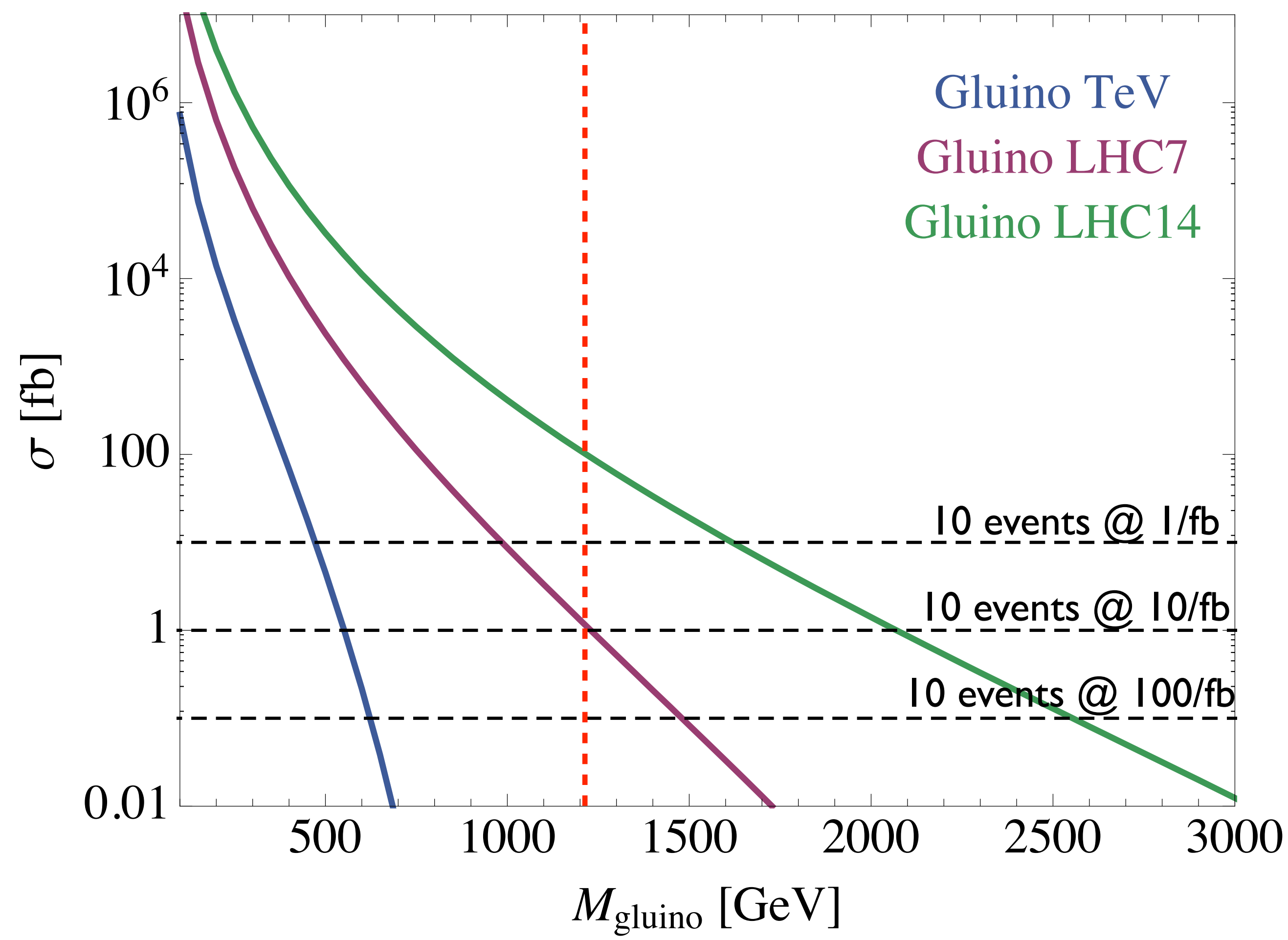


"Kinematic reach" of LHC7: $M_{wino} \sim 700$ GeV

10 events @ 10/fb

SUSY production at the LHC

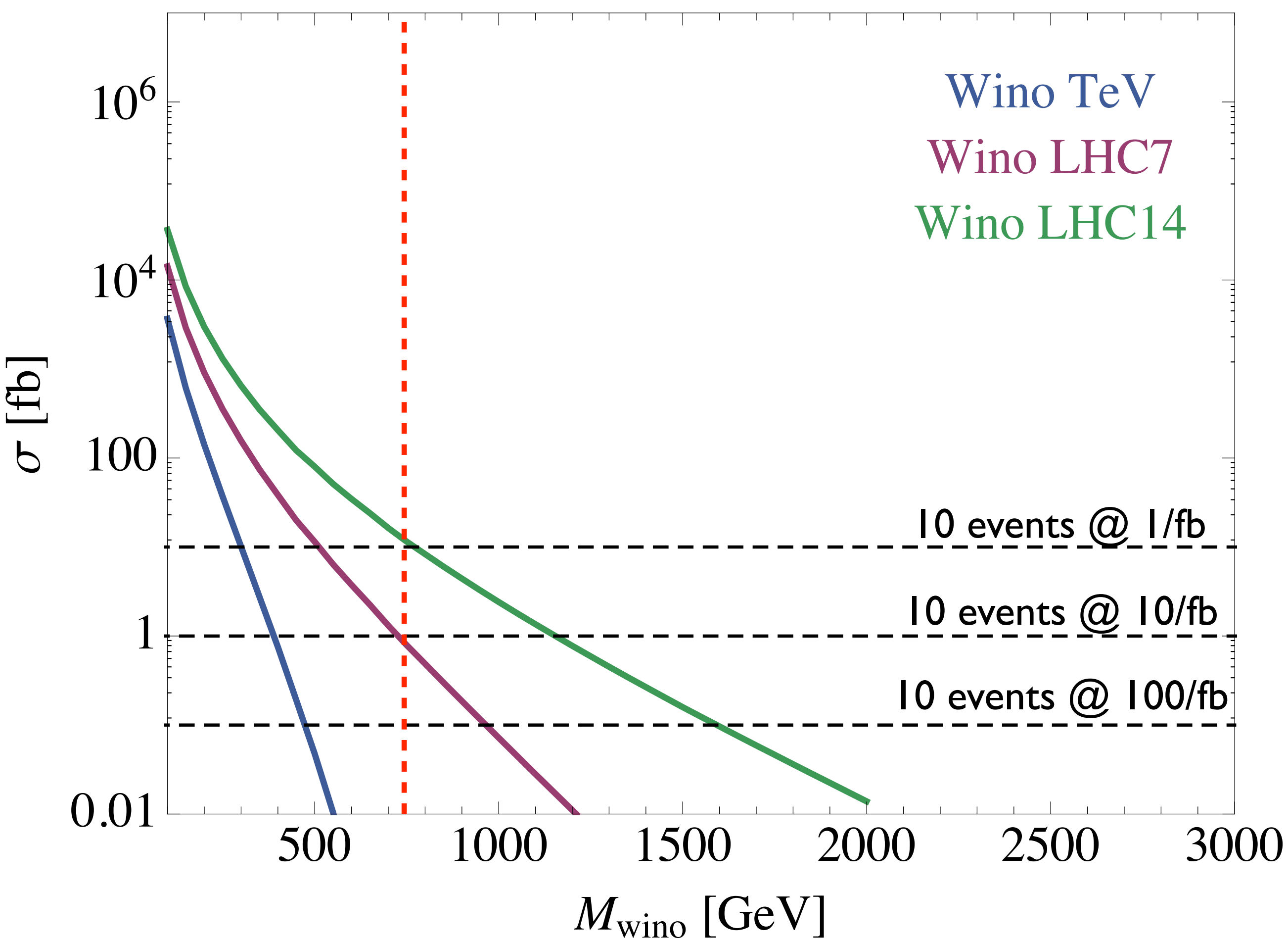


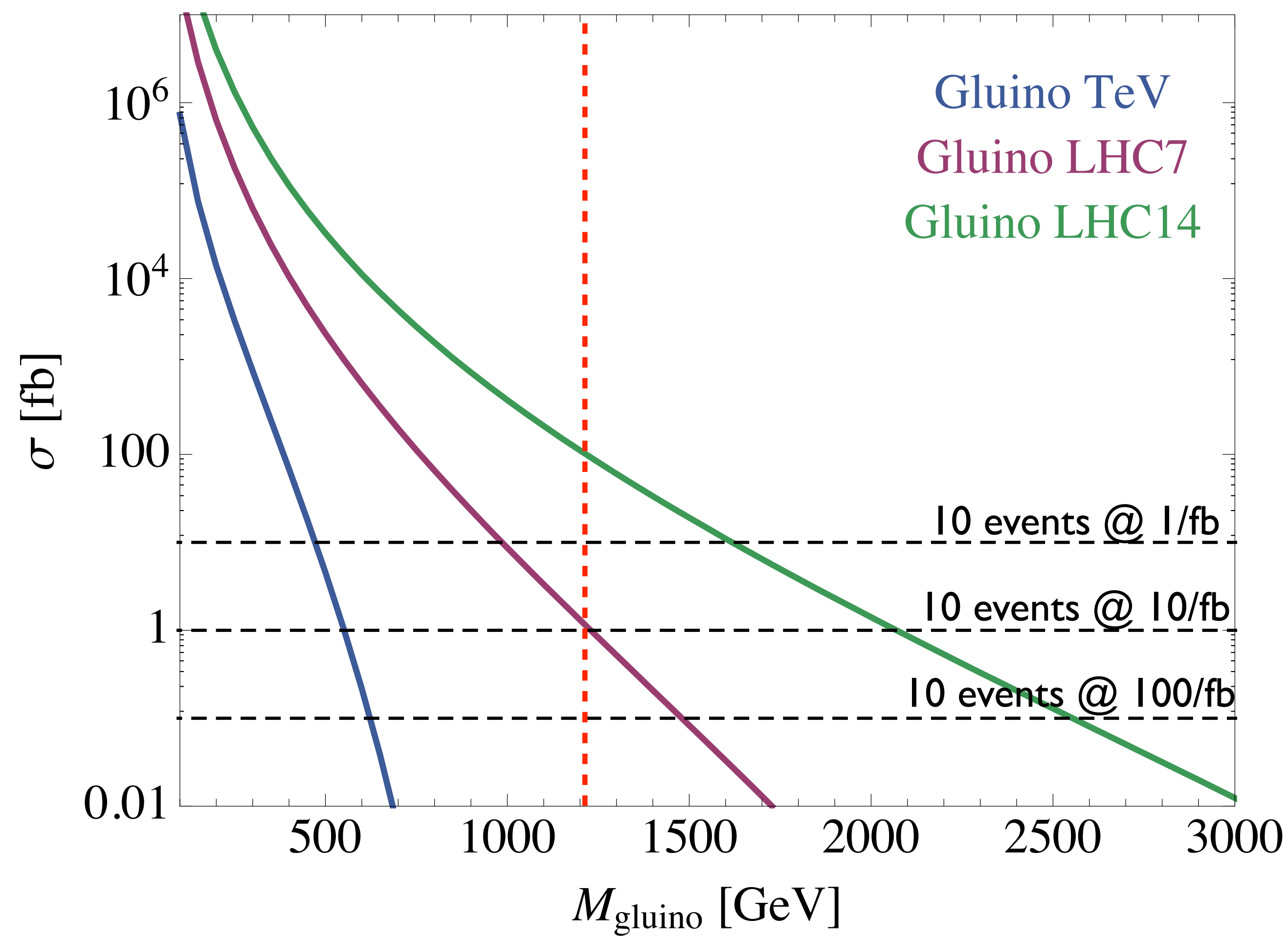


"Kinematic reach" of LHC7: $M_{\text{wino}} \sim 700$ GeV $M_{\text{gluino}} \sim 1200$ GeV

10 events @ 10/fb

SUSY production at the LHC





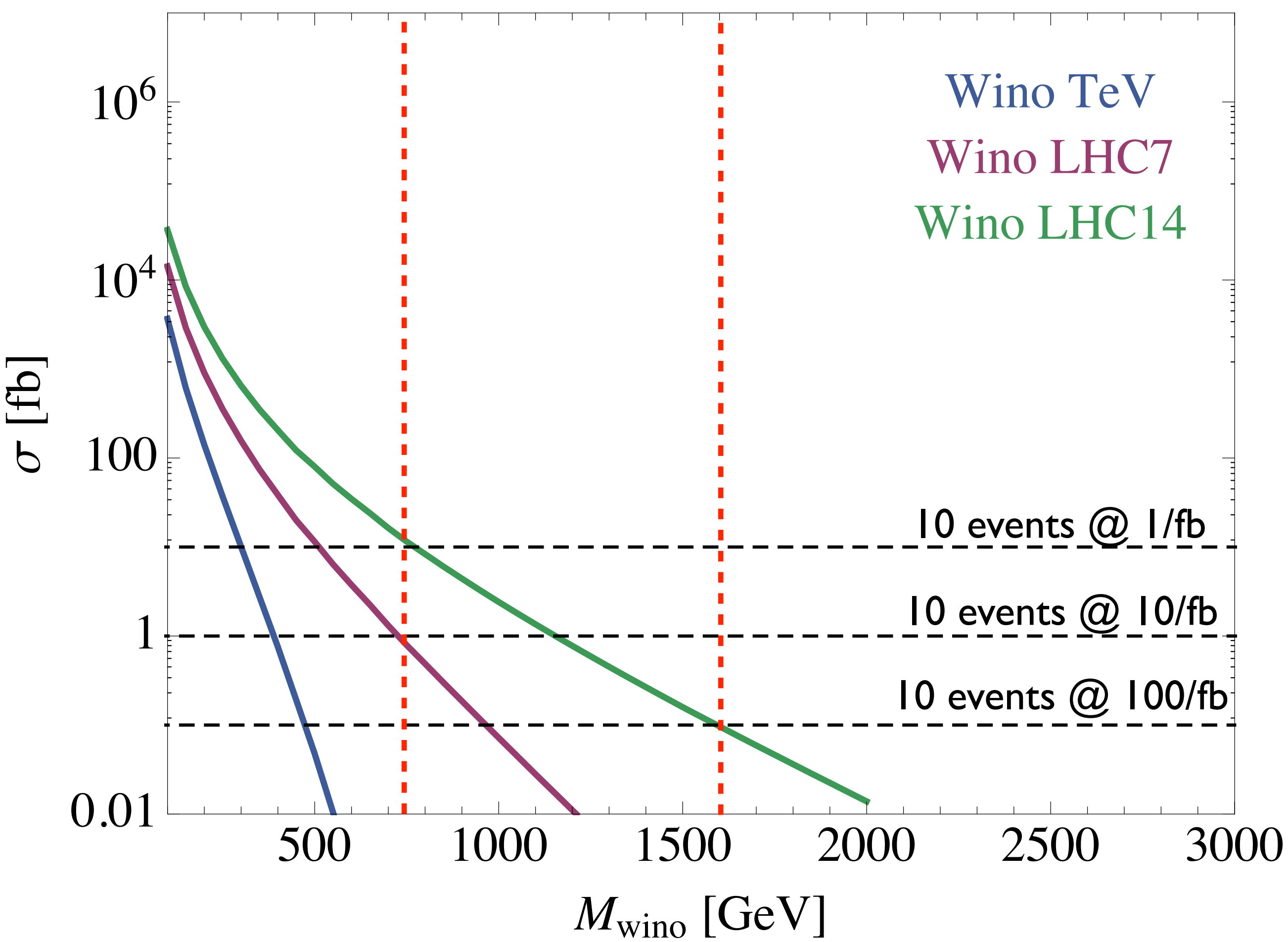
"Kinematic reach" of LHC7: $M_{\text{wino}} \sim 700$ GeV $M_{\text{gluino}} \sim 1200$ GeV

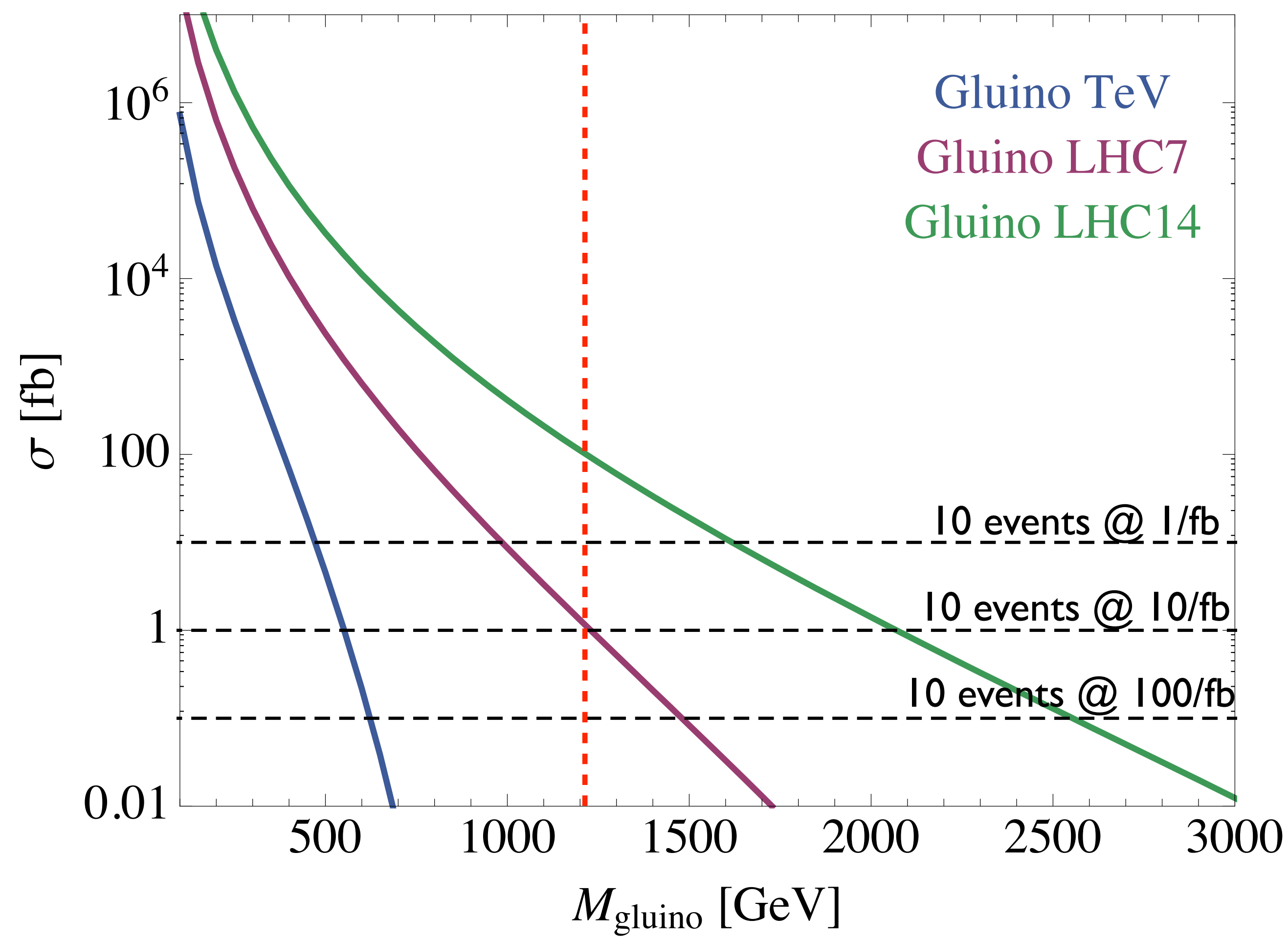
10 events @ 10/fb

"Kinematic reach" of LHC14:

10 events @ 100/fb

SUSY production at the LHC





"Kinematic reach" of LHC7: $M_{\text{wino}} \sim 700$ GeV

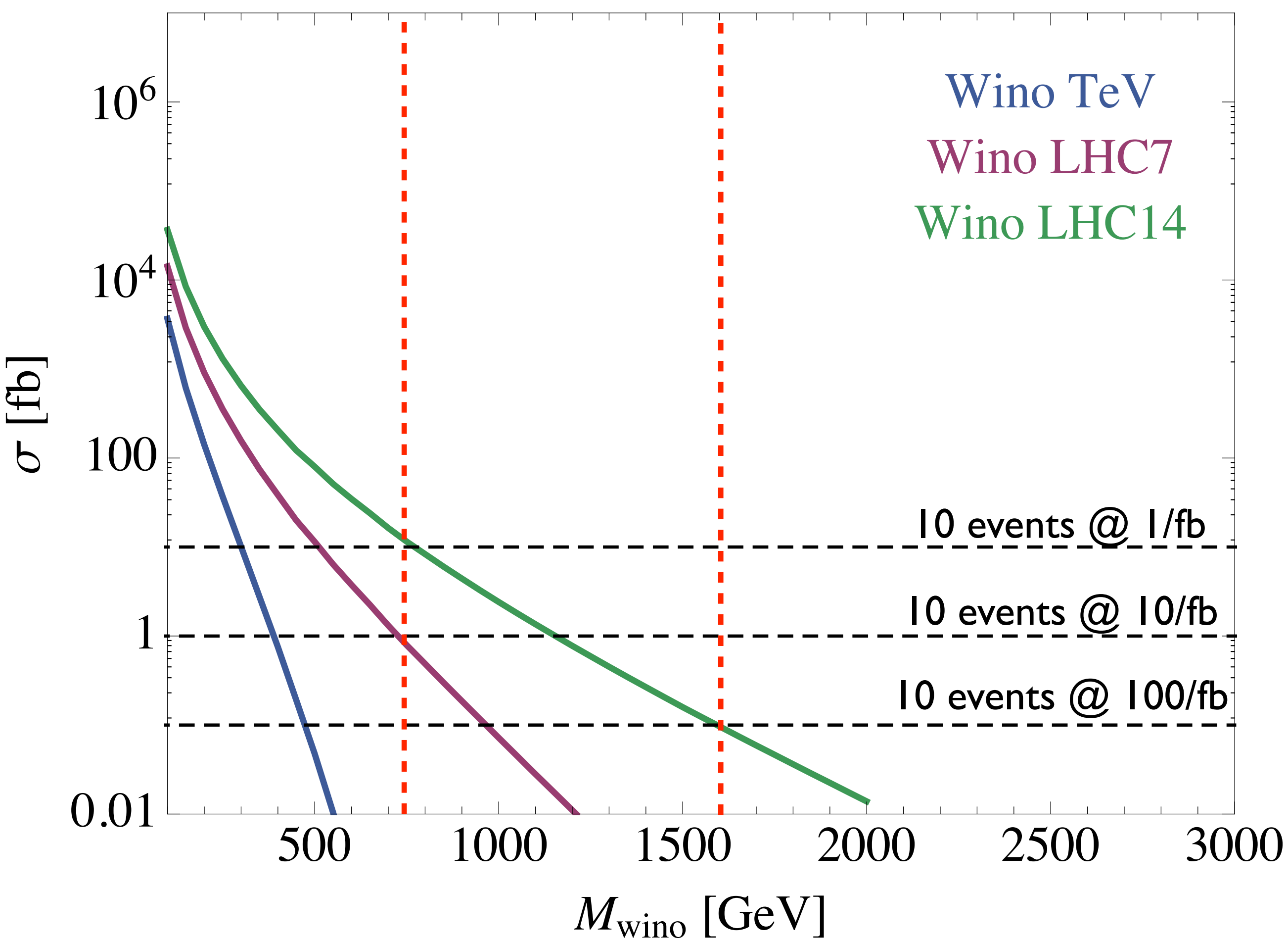
10 events @ 10/fb

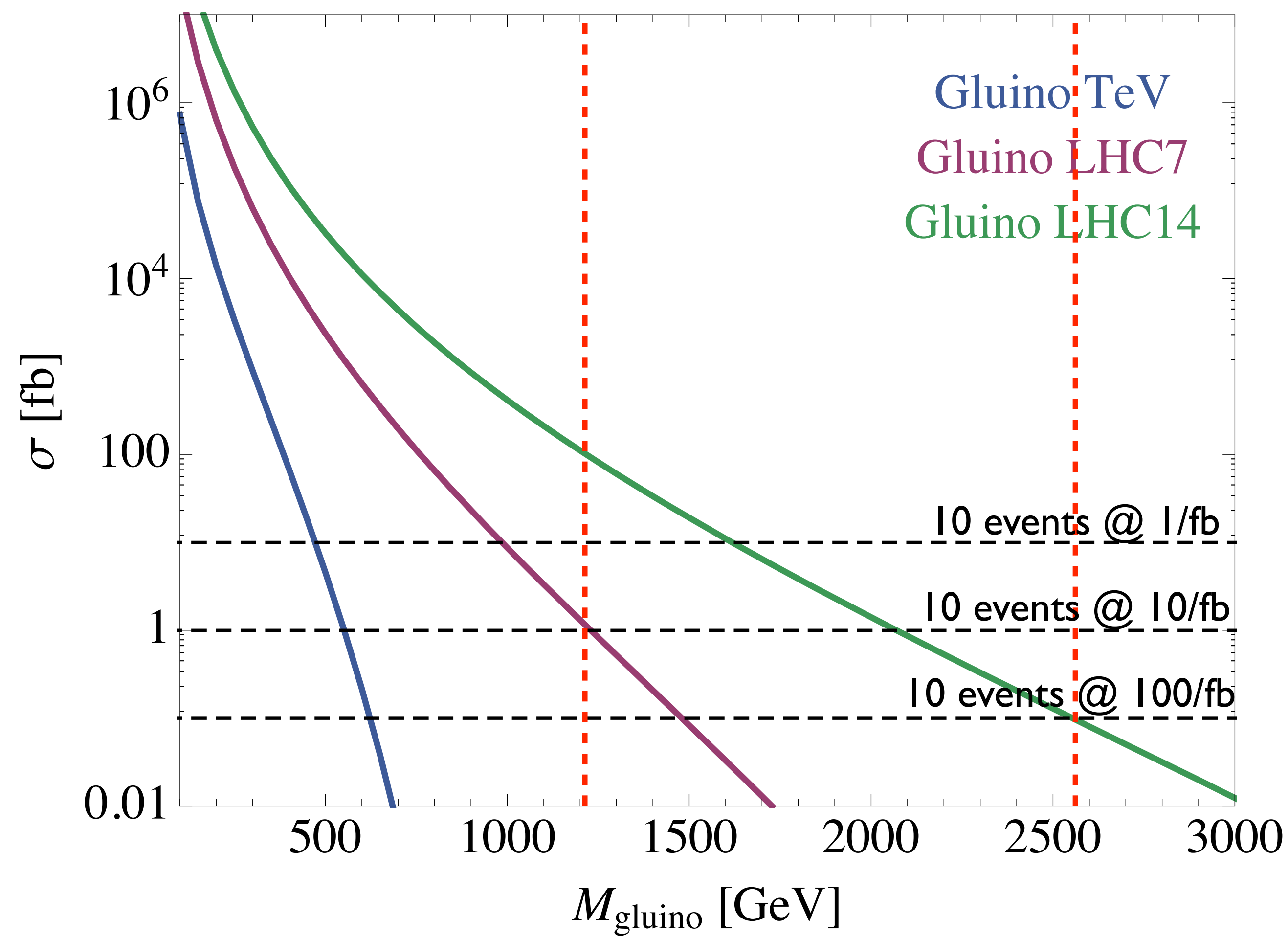
$M_{\text{gluino}} \sim 1200$ GeV

"Kinematic reach" of LHC14: $M_{\text{wino}} \sim 1600$ GeV

10 events @ 100/fb

SUSY production at the LHC





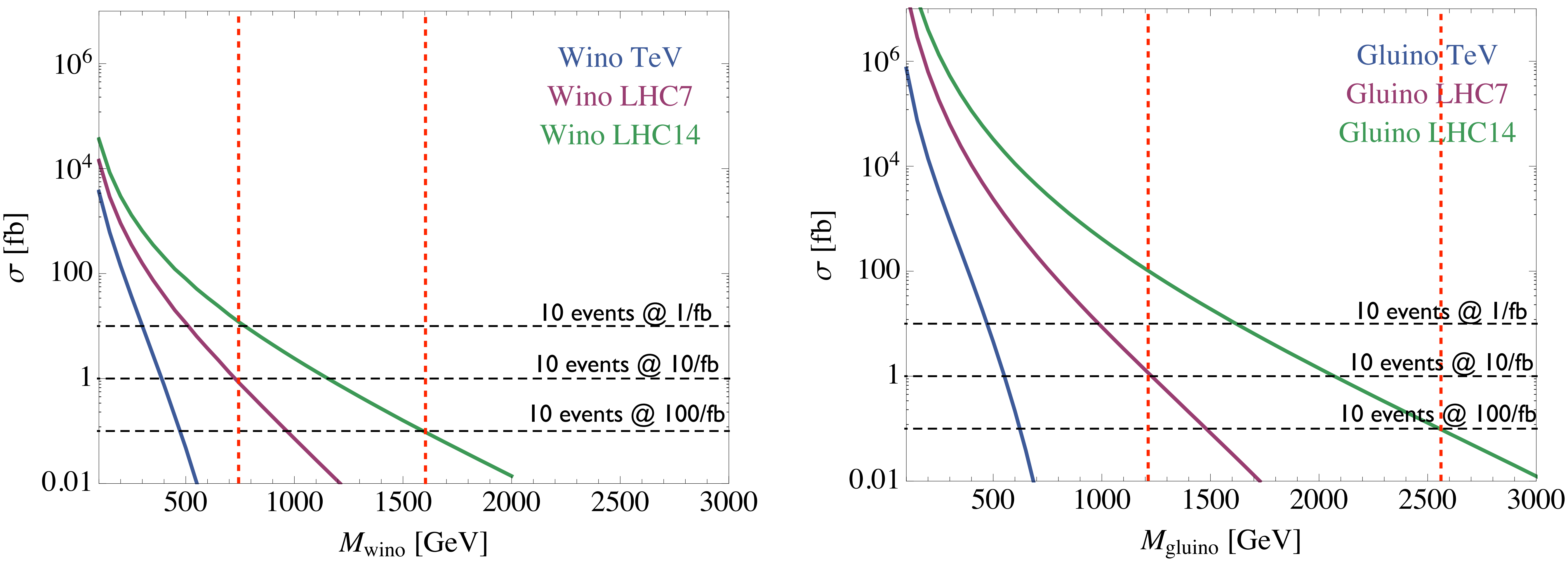
"Kinematic reach" of LHC7: $M_{\rm wino}$ ~ 700 GeV $M_{\rm gluino}$ ~ 1200 GeV

10 events @ 10/fb

"Kinematic reach" of LHC14: $M_{\rm wino}$ ~ 1600 GeV $M_{\rm gluino}$ ~ 2500 GeV

10 events @ 100/fb

SUSY production at the LHC



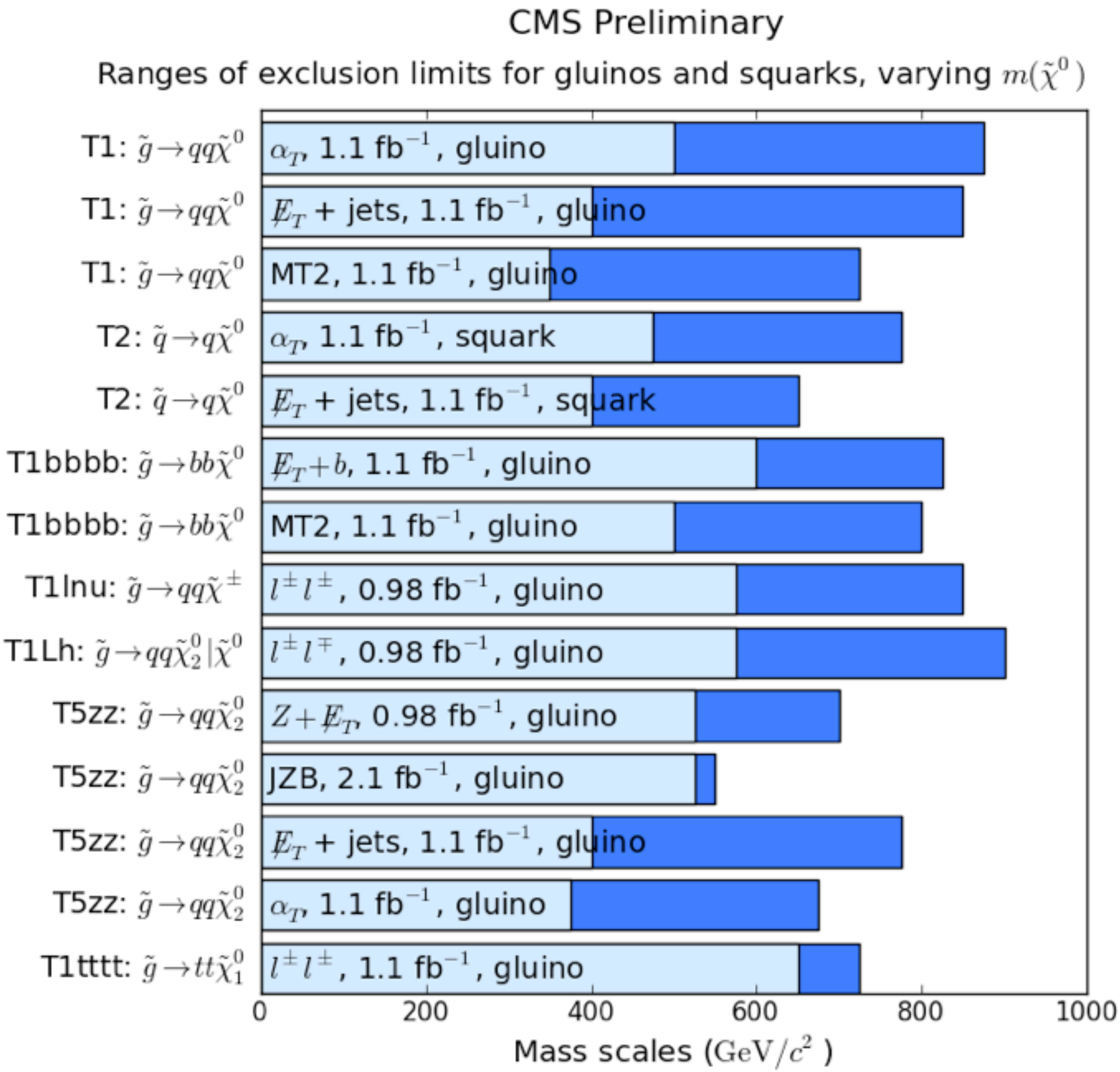
"Kinematic reach" of LHC7: $M_{\text{wino}} \sim 700$ GeV $M_{\text{gluino}} \sim 1200$ GeV

10 events @ 10/fb

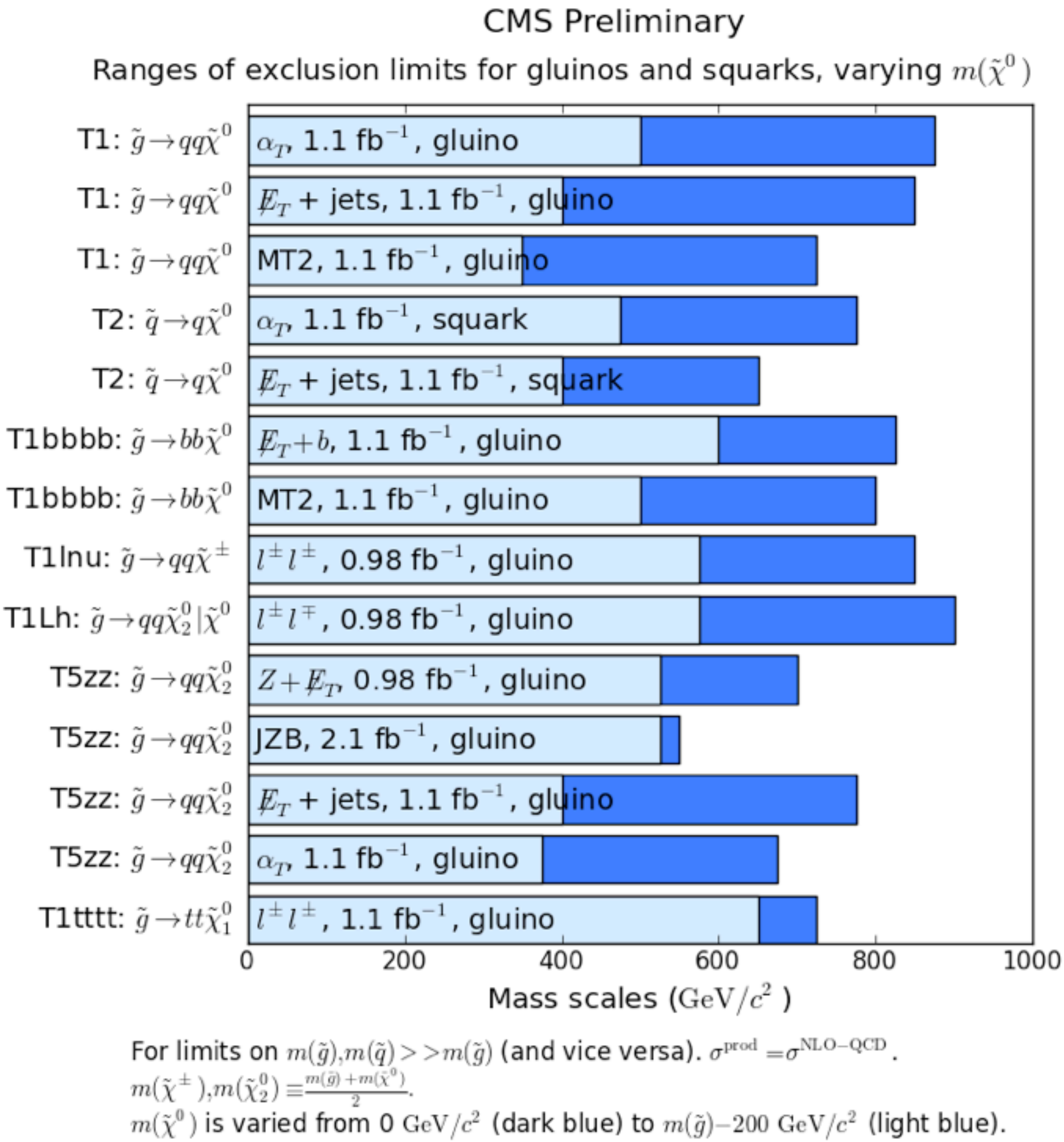
"Kinematic reach" of LHC14: $M_{\text{wino}} \sim 1600$ GeV $M_{\text{gluino}} \sim 2500$ GeV

10 events @ 100/fb

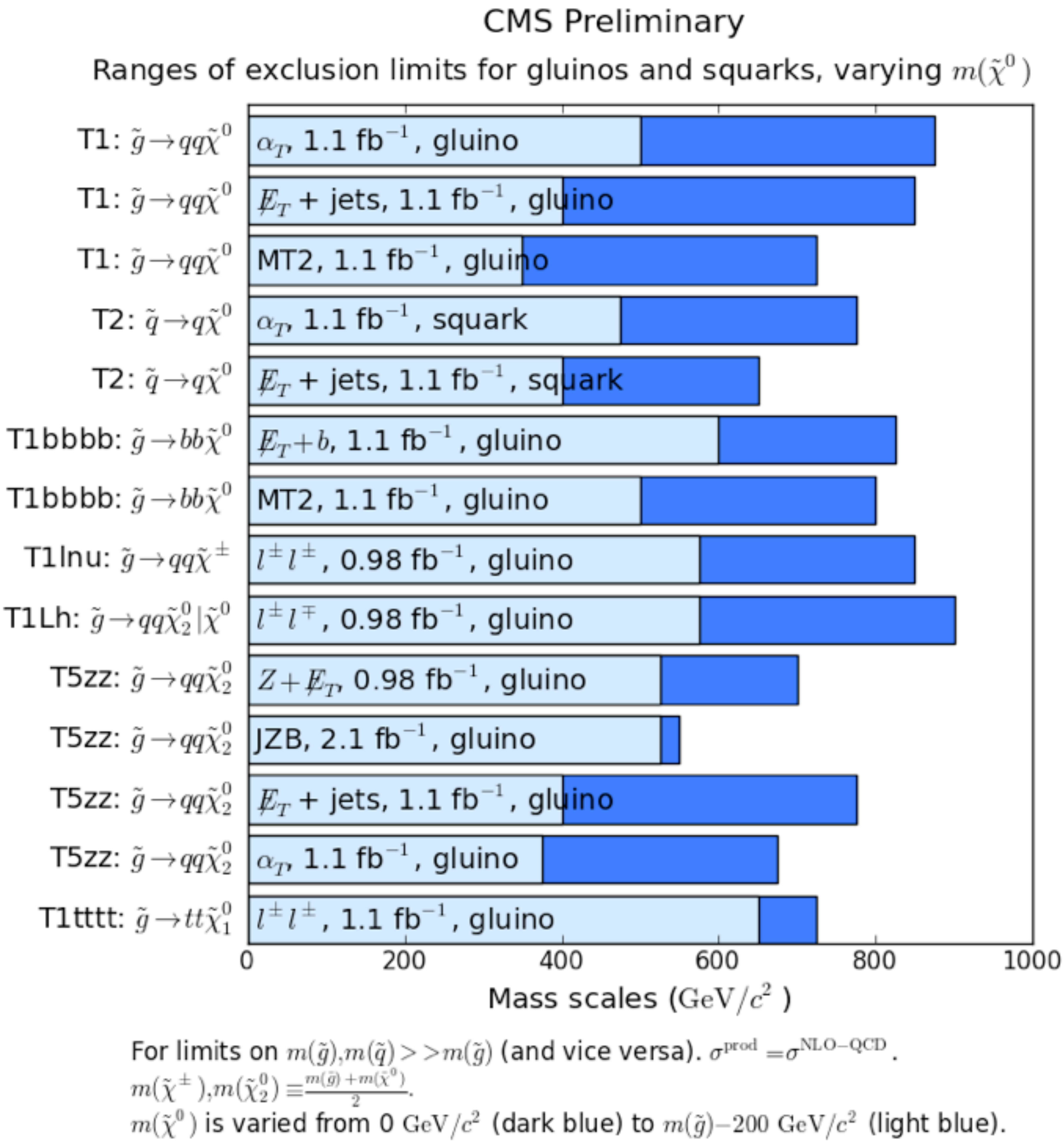
Yardsticks with which to measure the current progress



For limits on $m(\tilde{g}),m(\tilde{q})>>m(\tilde{g})$ (and vice versa). $\sigma^{\mathrm{prod}}=\sigma^{\mathrm{NLO-QCD}}$.
$m(\tilde{\chi}^\pm),m(\tilde{\chi}^0_2)\equiv\frac{m(\tilde{g})+m(\tilde{\chi}^0)}{2}$.
$m(\tilde{\chi}^0)$ is varied from 0 GeV/c^2 (dark blue) to $m(\tilde{g})-200$ GeV/c^2 (light blue).



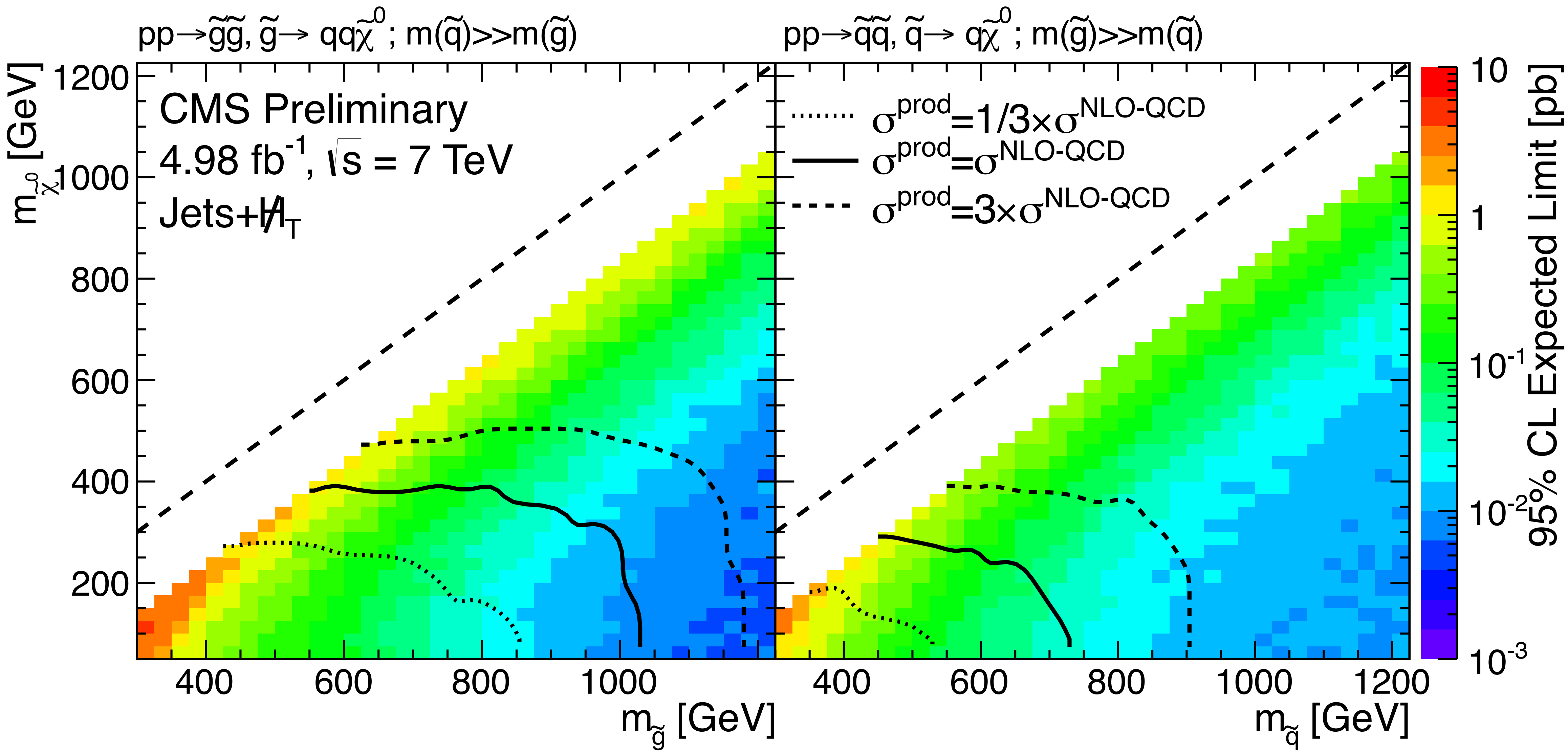
Limits on colored SUSY production are pretty much on track.



Limits on colored SUSY production are pretty much on track.

Squeezed spectra are currently one exception.

Squeezed Spectra



Limit of > 1 TeV for gluino decaying to massless LSP!!

But no limit on gluino mass for m_{LSP} > 400 GeV ??

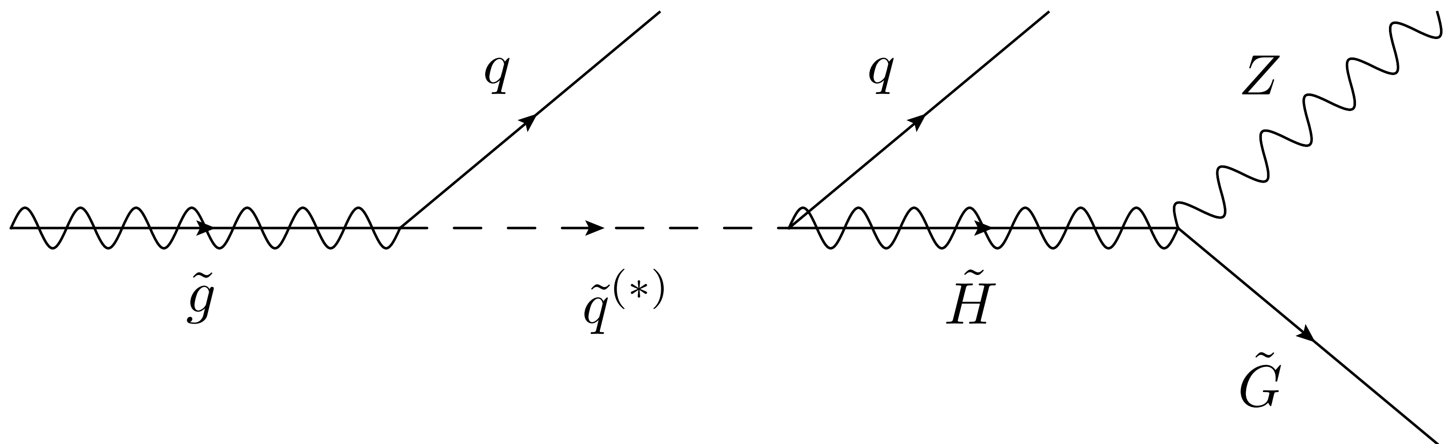
Summary of General Remarks

- Limits are quite high on colored SUSY production with simple decays and large mass splittings. For such scenarios, probably not much discovery potential left at 7-8 TeV.
- One major exception is (even mildly) squeezed spectra.
- Limits on EW SUSY production are nearly non-existent. Can expect more progress here! Much more difficult, but should hopefully improve with more data!
- Obviously, searches without MET are in the minority here. Also, searches which involve displaced decays.

Connections to GGM

Z-rich Higgsino NLSPs

(Matchev & Thomas ’99; Meade, Reece & DS ’09; Ruderman & DS ’11)



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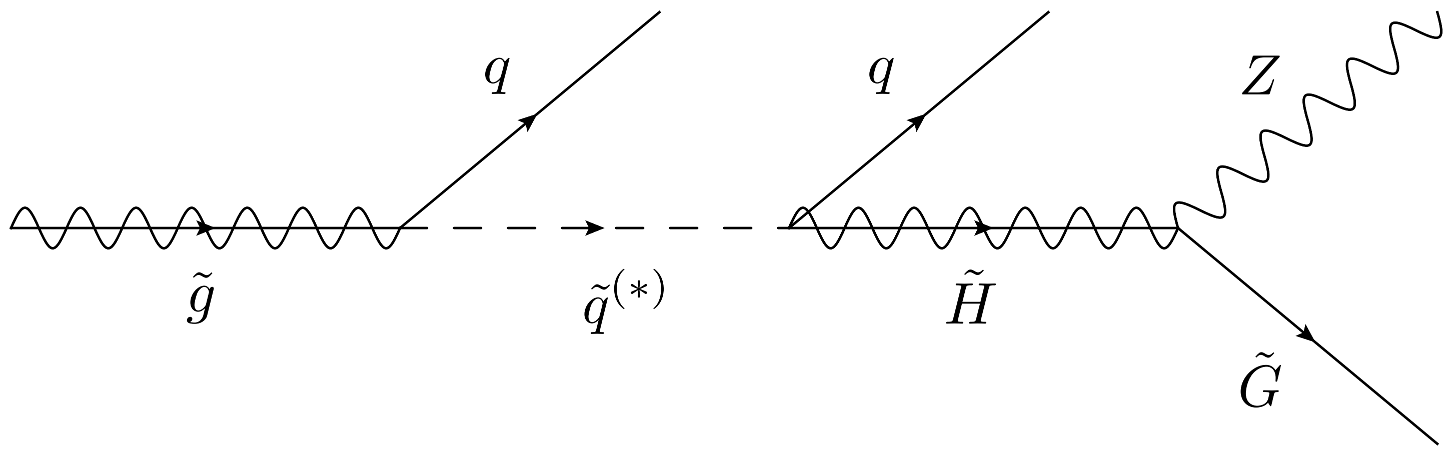

- If the NLSP is a Higgsino which decays primarily to Z's, jets+MET and Z(ll)+jets+MET should be good search channels.

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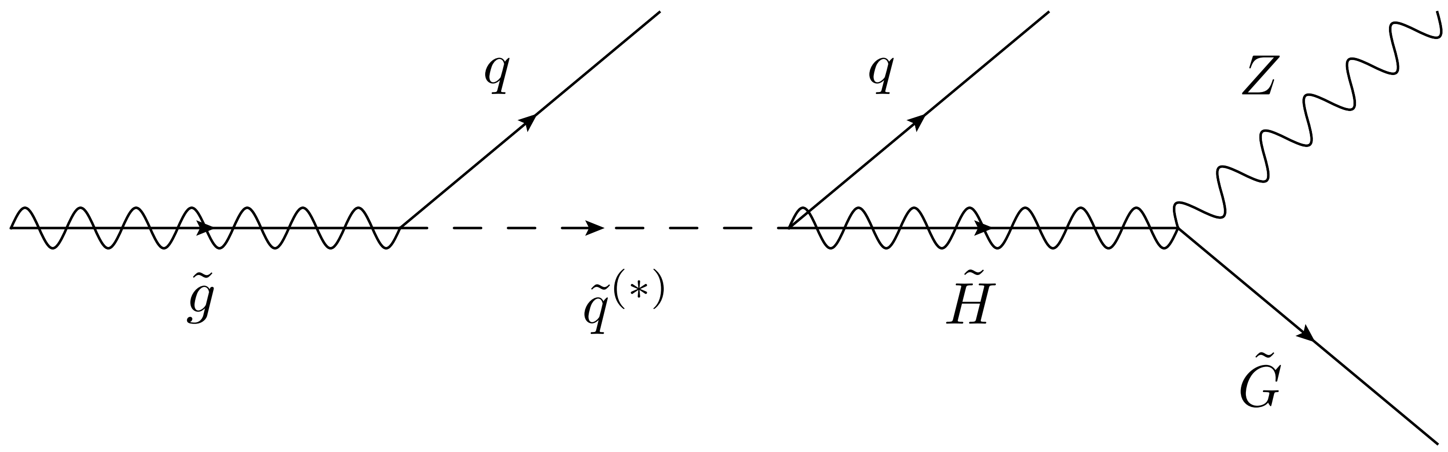
(Matchev & Thomas '99; Meade, Reece & DS '09; Ruderman & DS '11)



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- Hot off the presses is a ATLAS search in the latter final state (ATLAS-CONF-2012-047)

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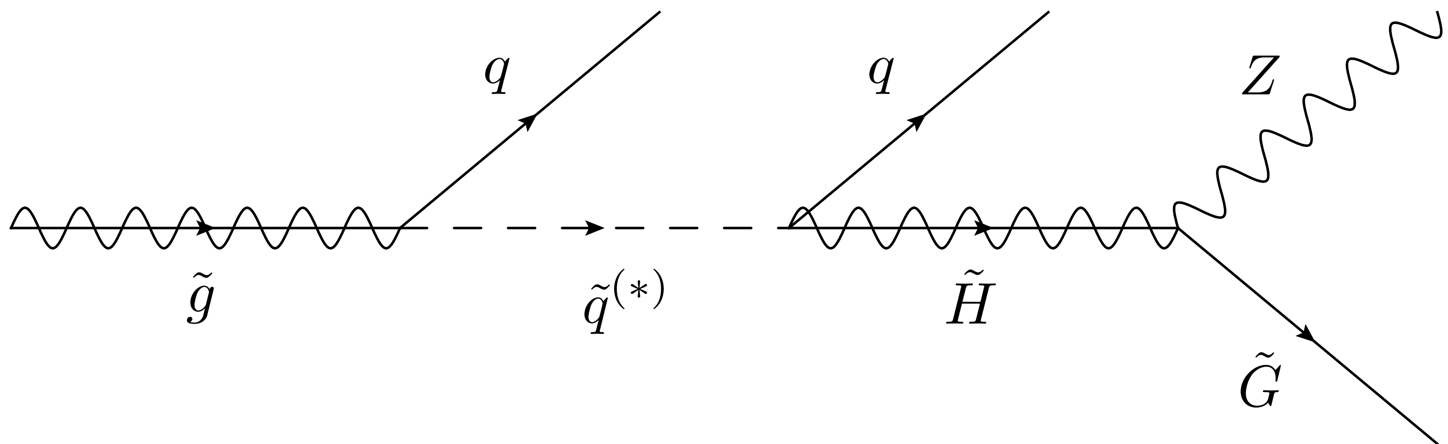

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- First ever dedicated search for higgsino NLSPs!

Z-rich Higgsino NLSPs

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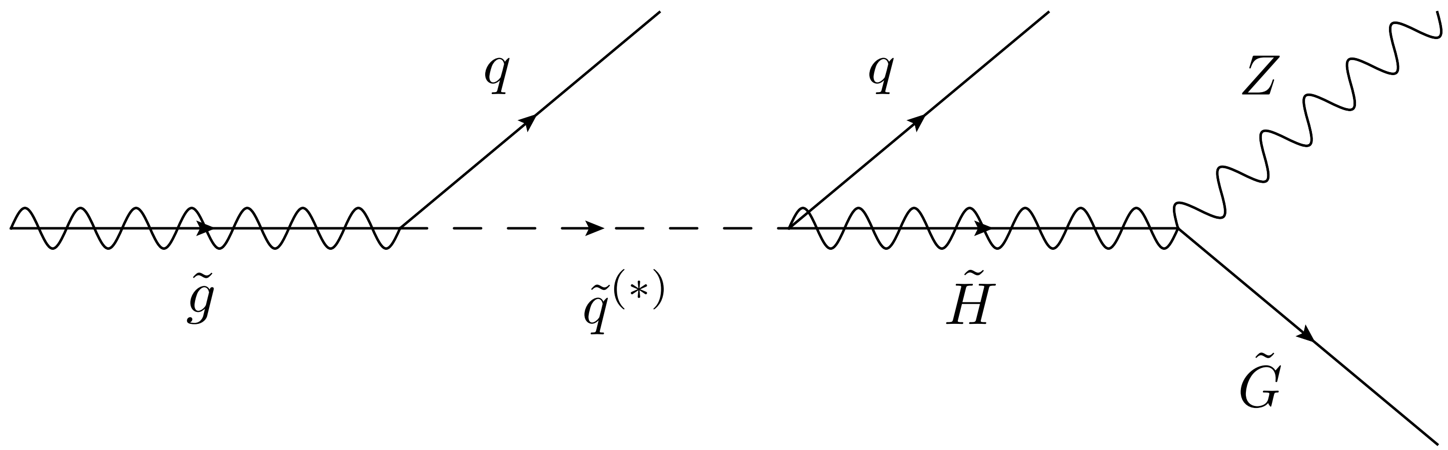

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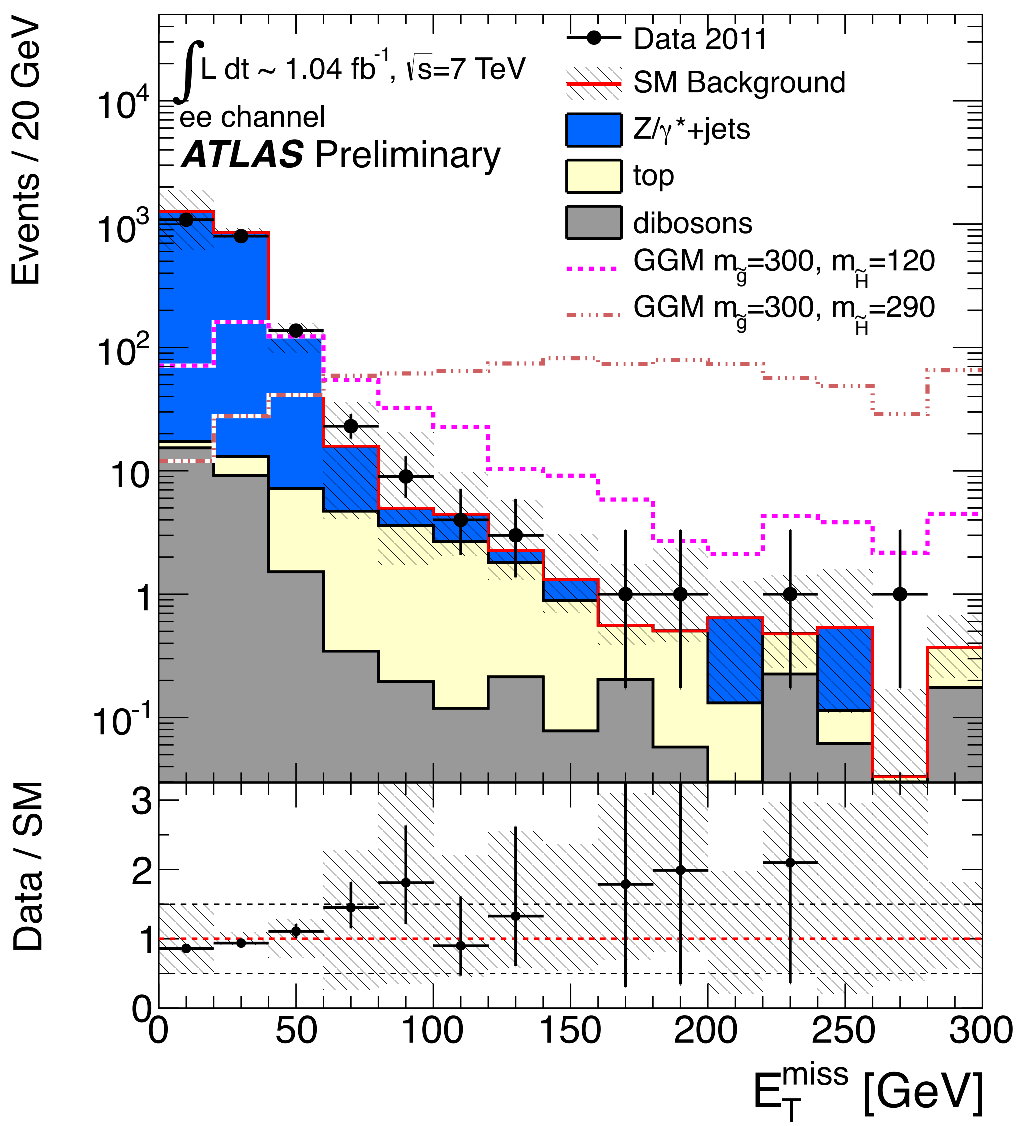
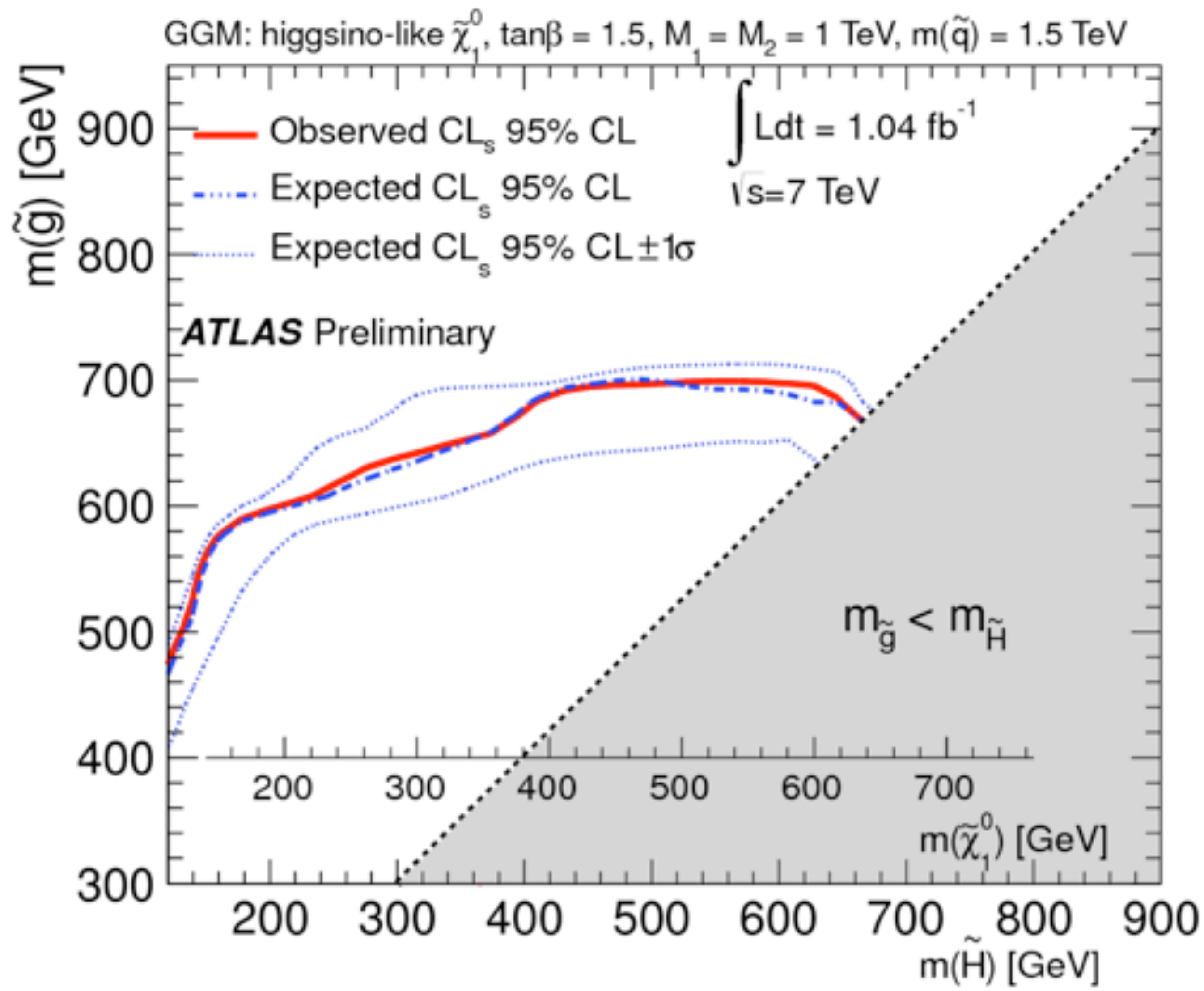
- Hot off the presses is a ATLAS search in the latter final state (ATLAS-CONF-2012-047)
- First ever dedicated search for higgsino NLSPs!
- Final state: Z(ll) + MET + (>=3 jets or HT)

Z-rich Higgsino NLSPs





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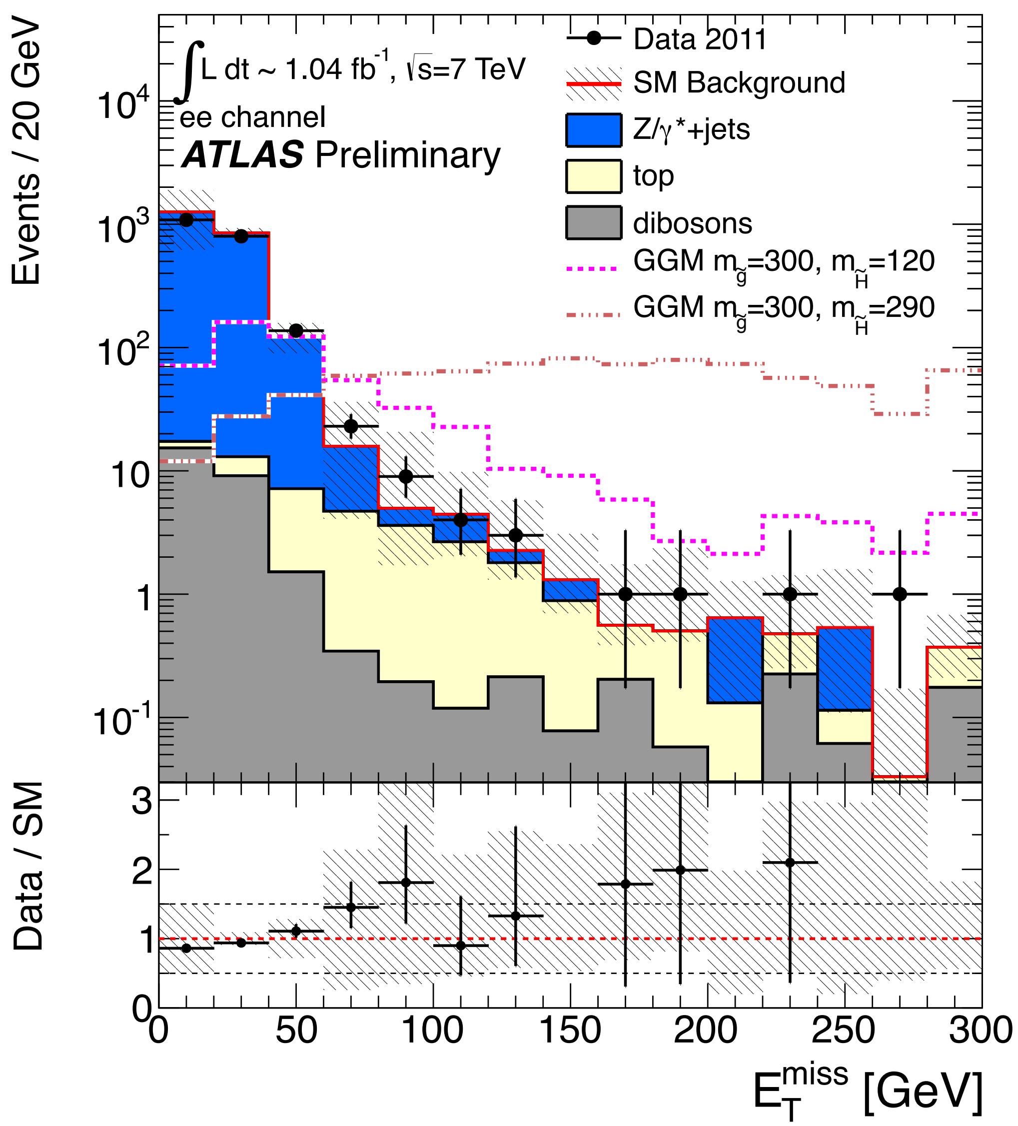

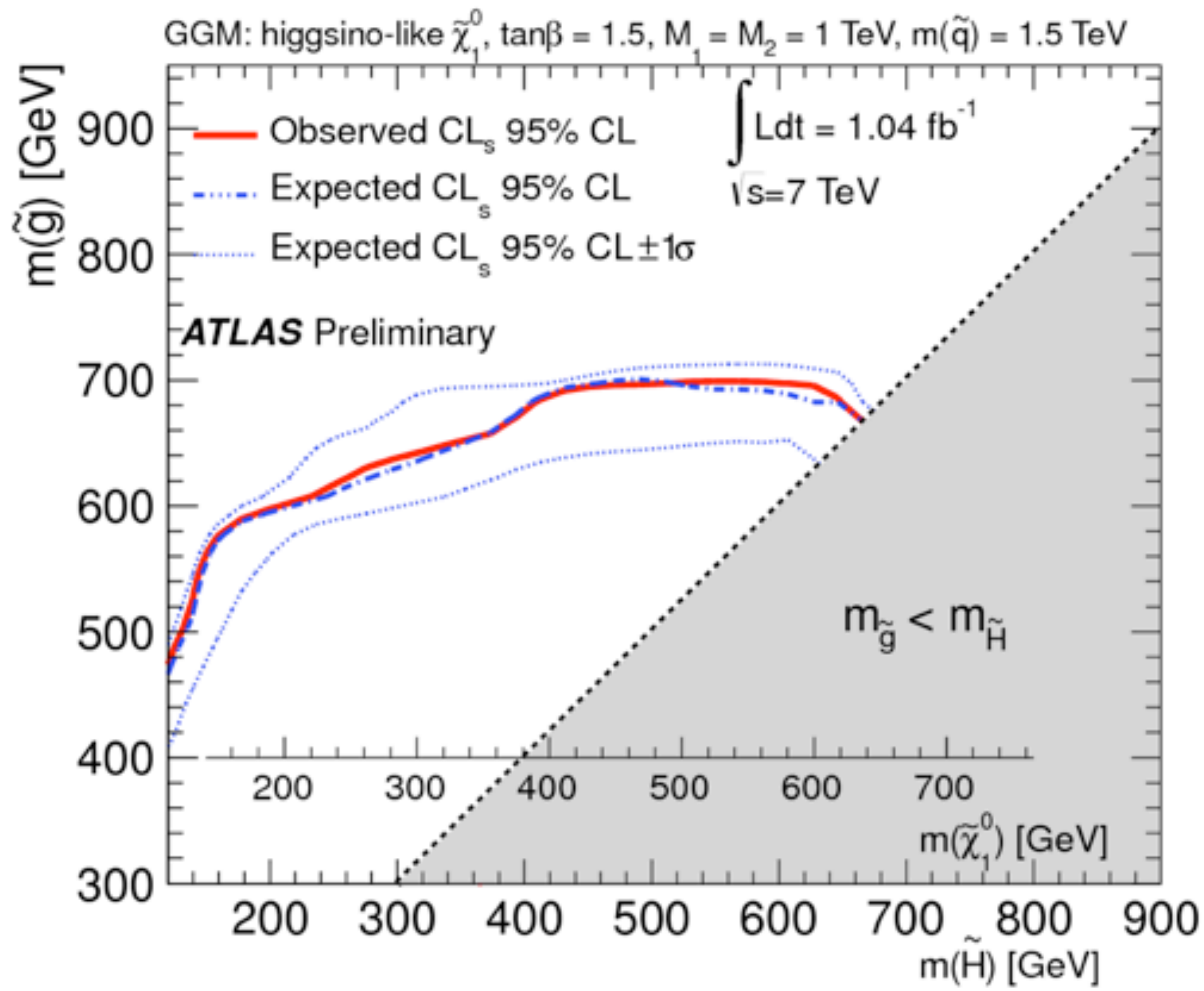

No limit yet on direct Higgsino production...

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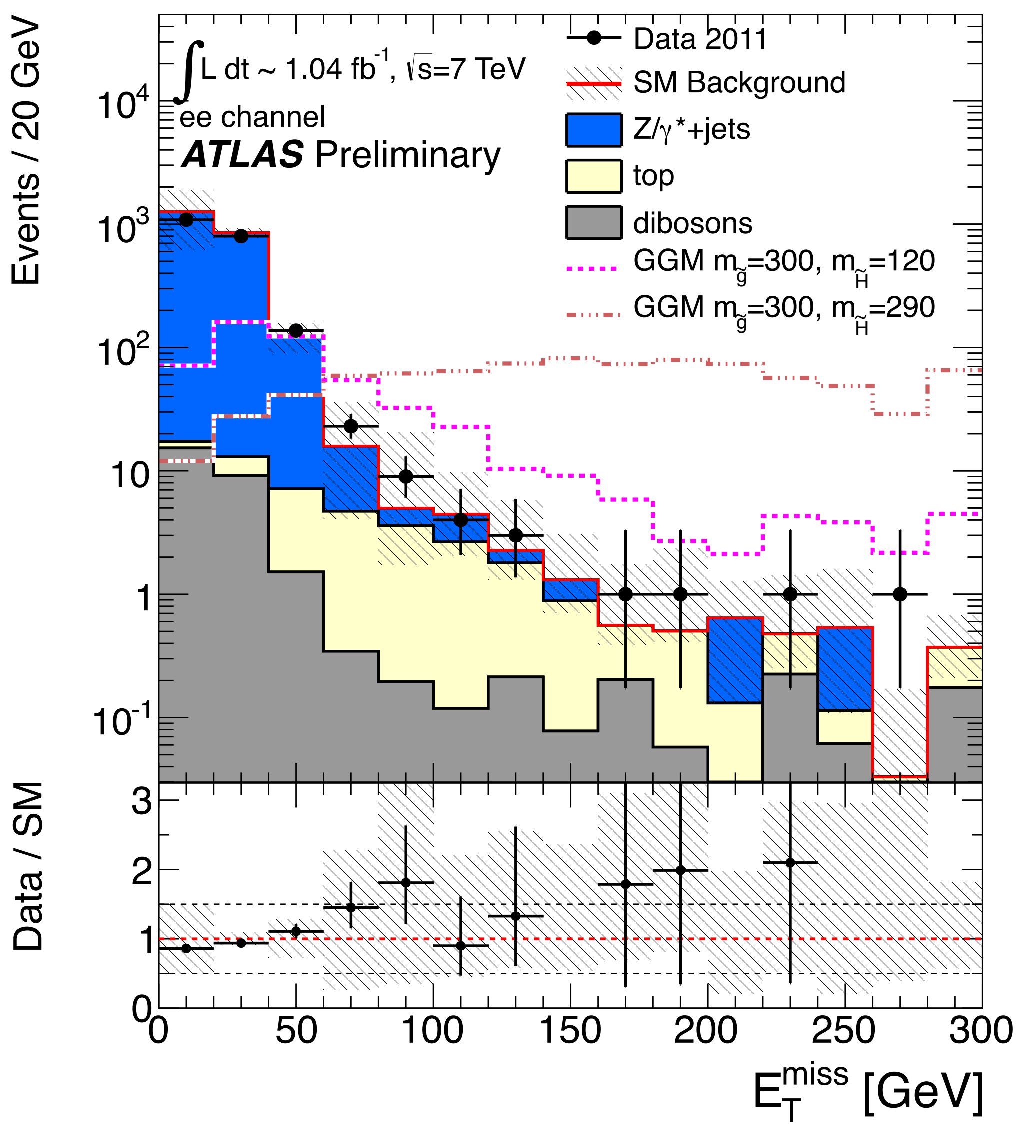

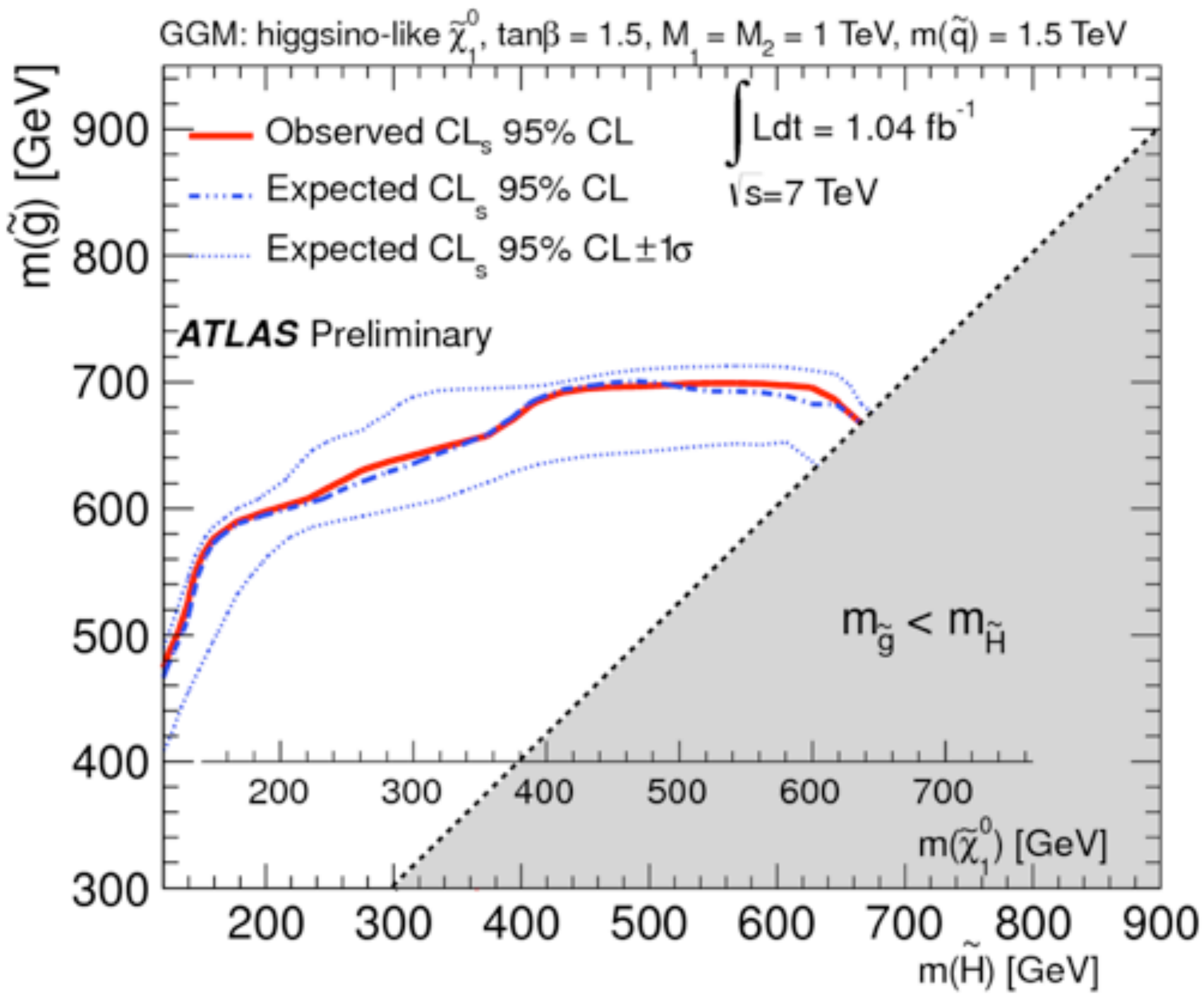

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Limit on gluino mass much worse than 1 TeV...presumably because of Br(Z->ll)

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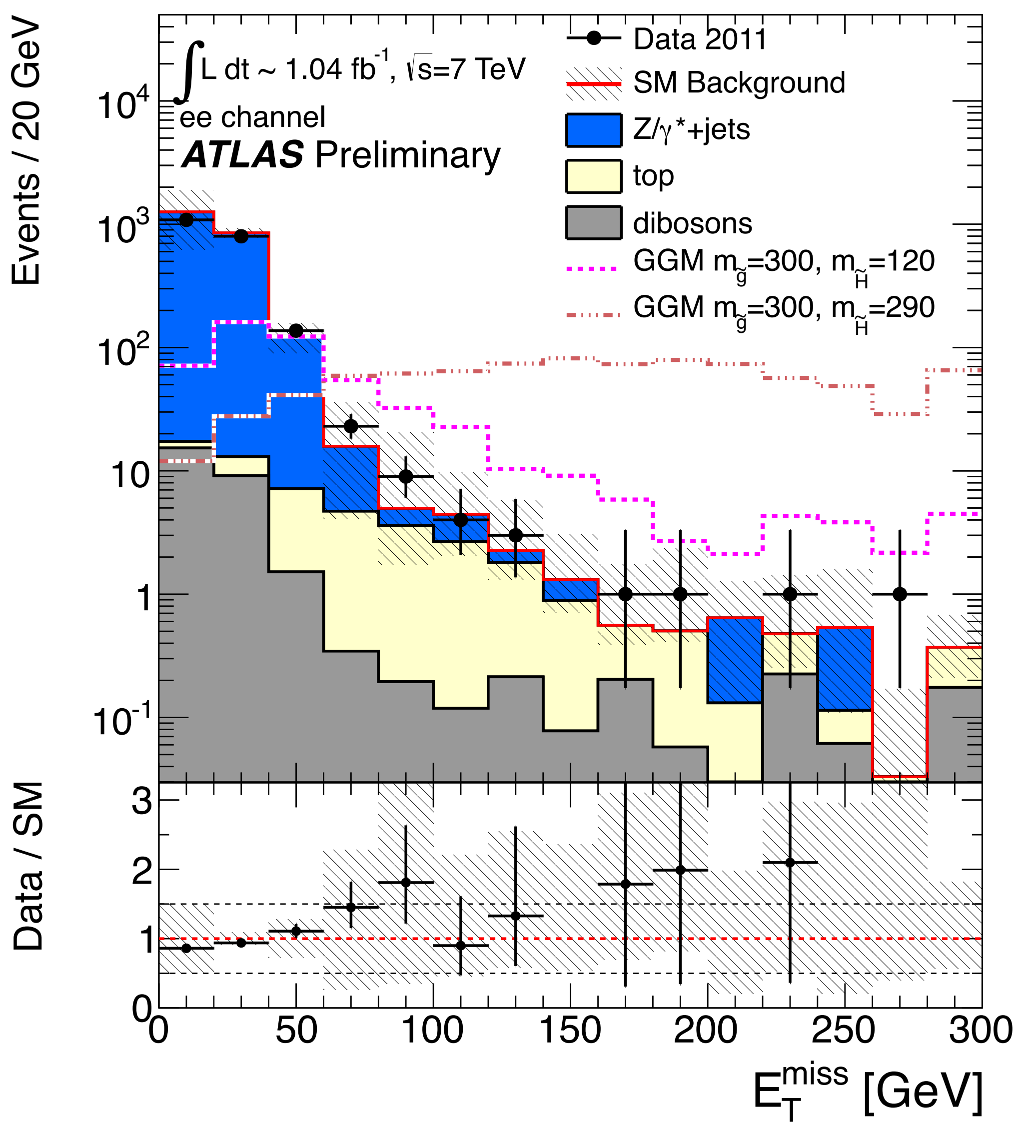

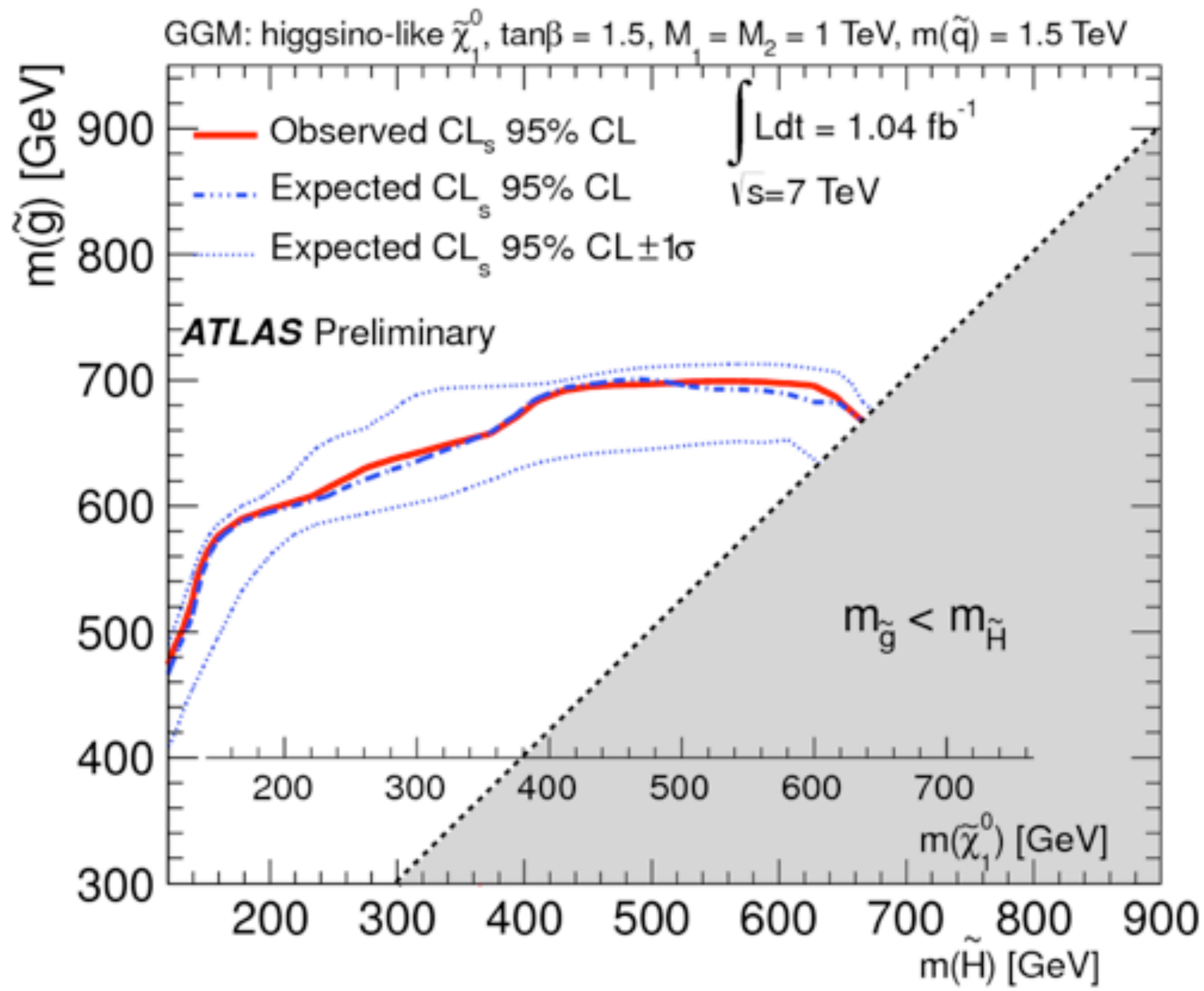

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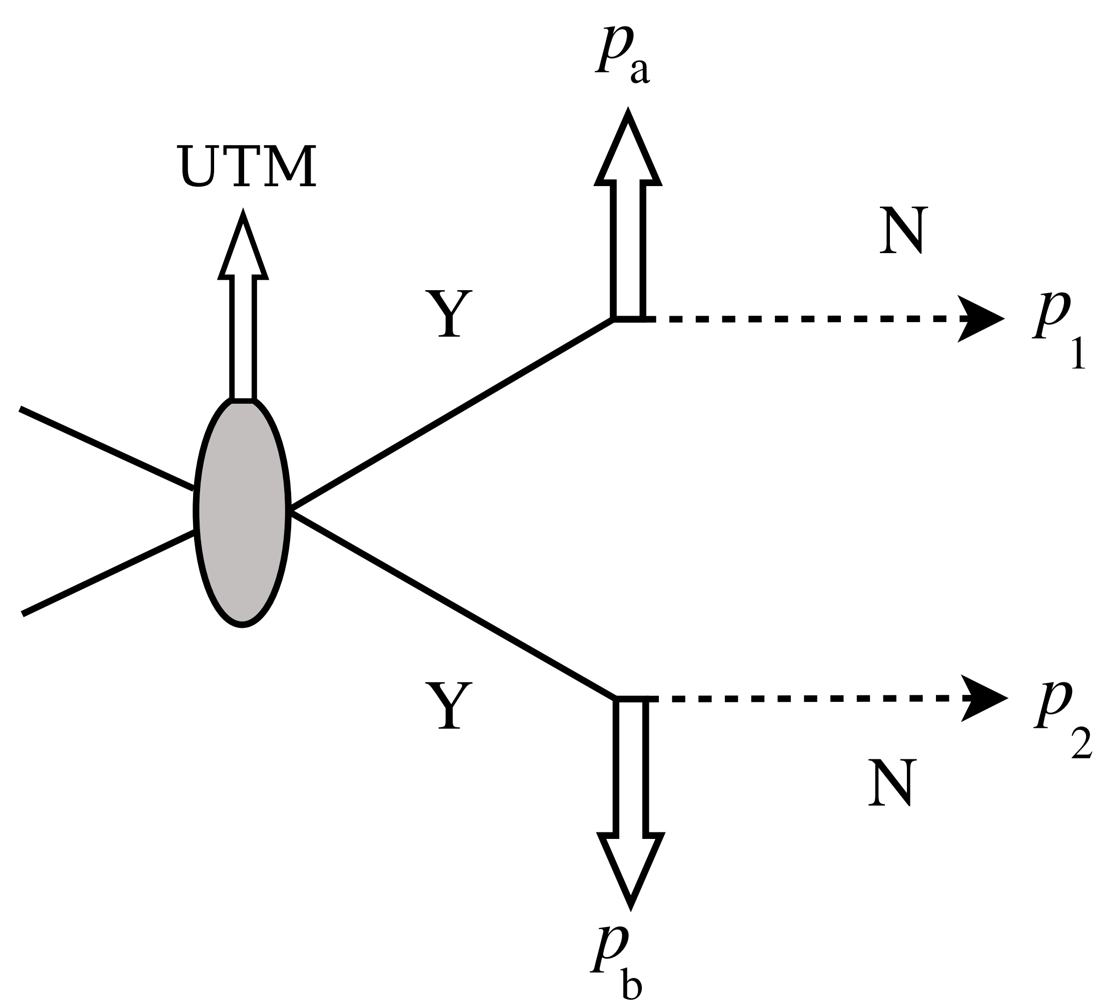
Limit for m(Higgsino)->0 much worse, because Z and MET are being squeezed out!

Leptonic MT2

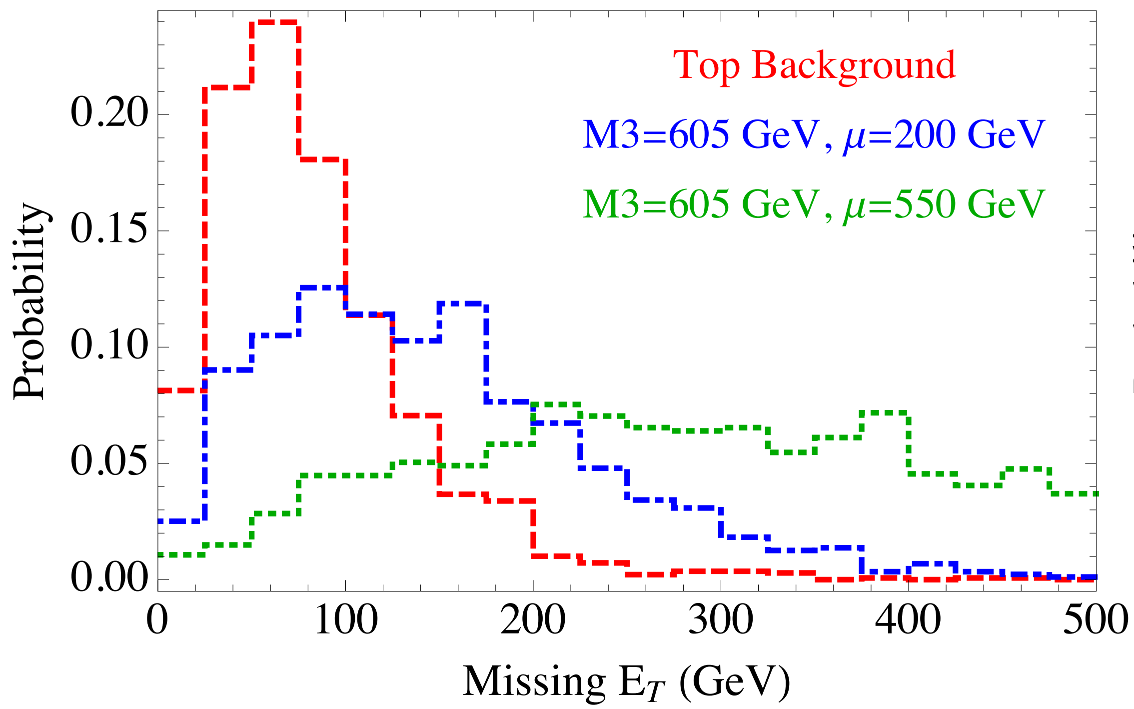
- mT2: generalization of W transverse mass to events with double decay chains ending in invisible particles.
(Barr, Lester, Stephens, Summers, ...)

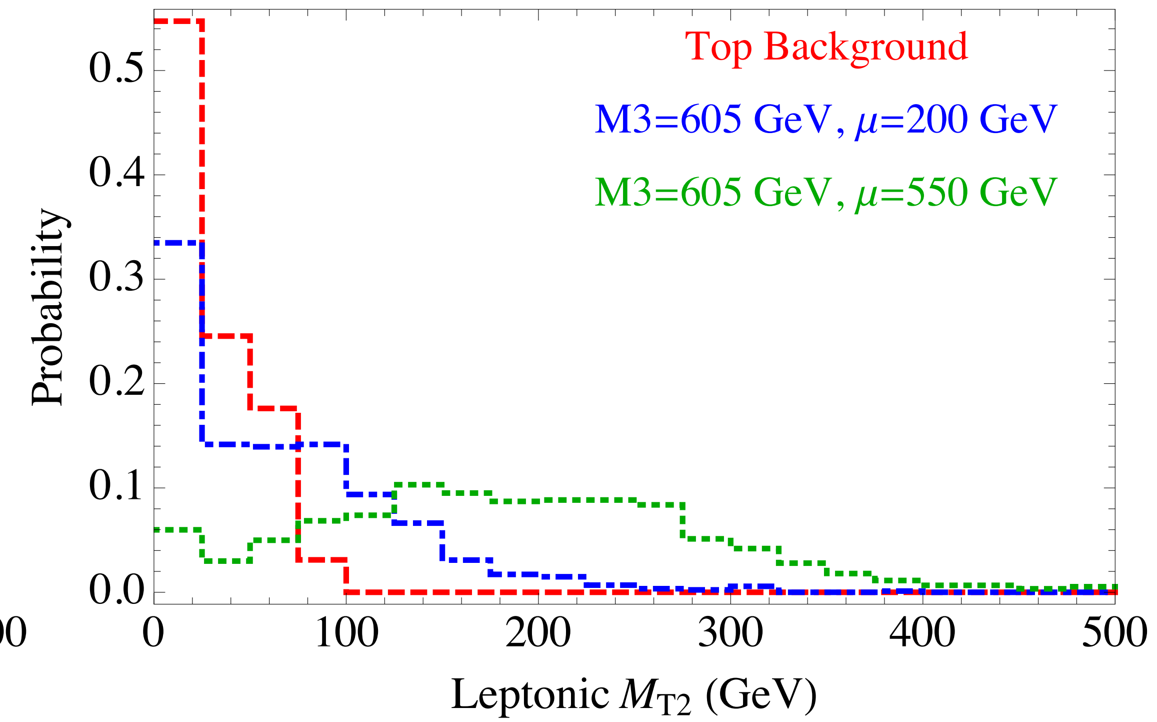
- mT2 has been used for measurements of top properties, but in all cases, the full event was used (leptons+bjets+MET). Expect an endpoint at the top mass, but combinatorics is an issue.

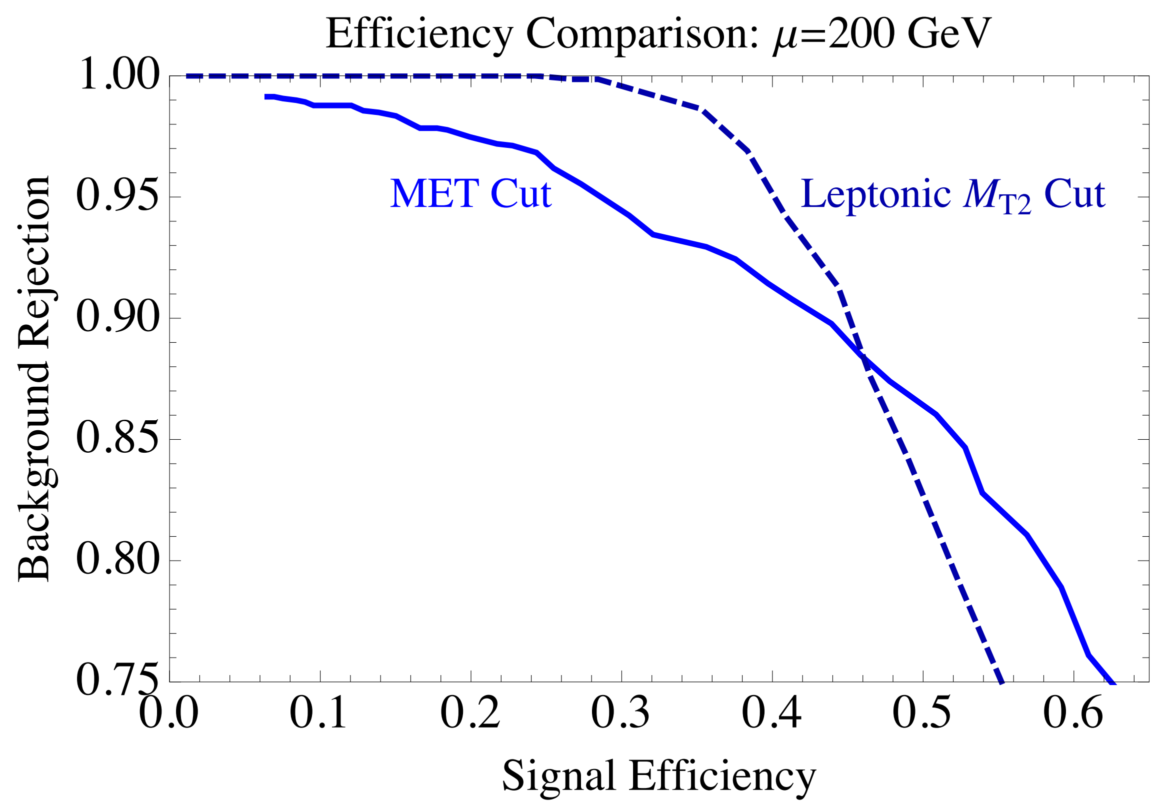
- Dileptonic ttbar is one of the main backgrounds to Z-rich Higgsino NLSPs. We propose computing mT2 using only the leptons and MET to reject ttbar background. For ttbar, expect an endpoint at W mass and no combinatorial confusion. (Kats, Reece, Meade & DS)



(figure from Cheng & Han 0810.5178)



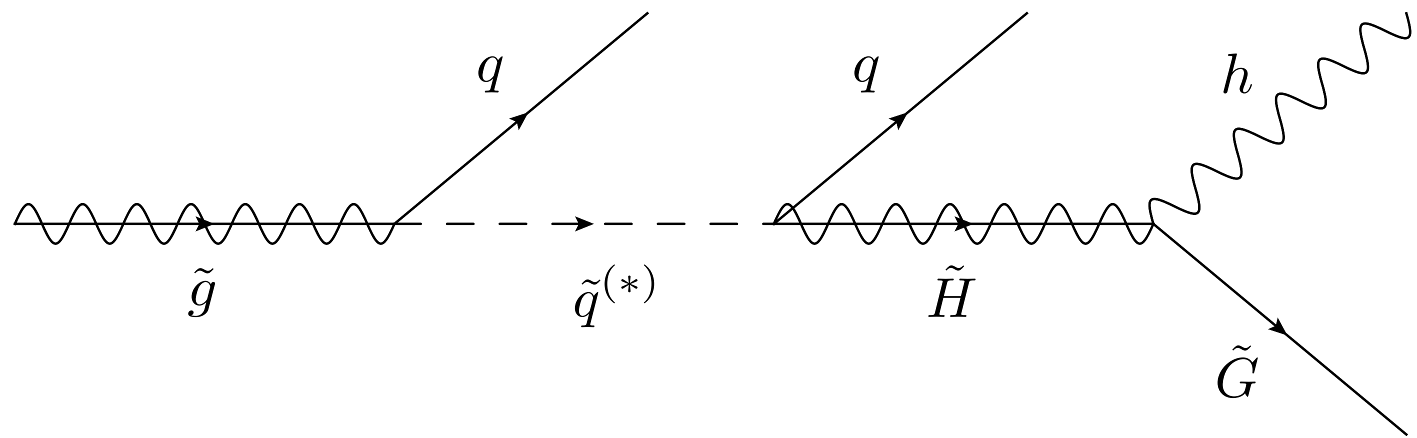




leptonic MT2 could potentially reject much more background for the same amount of signal efficiency

h-rich Higgsino NLSP

(Matchev & Thomas '99; Meade, Reece & DS '09; Ruderman & DS '11)



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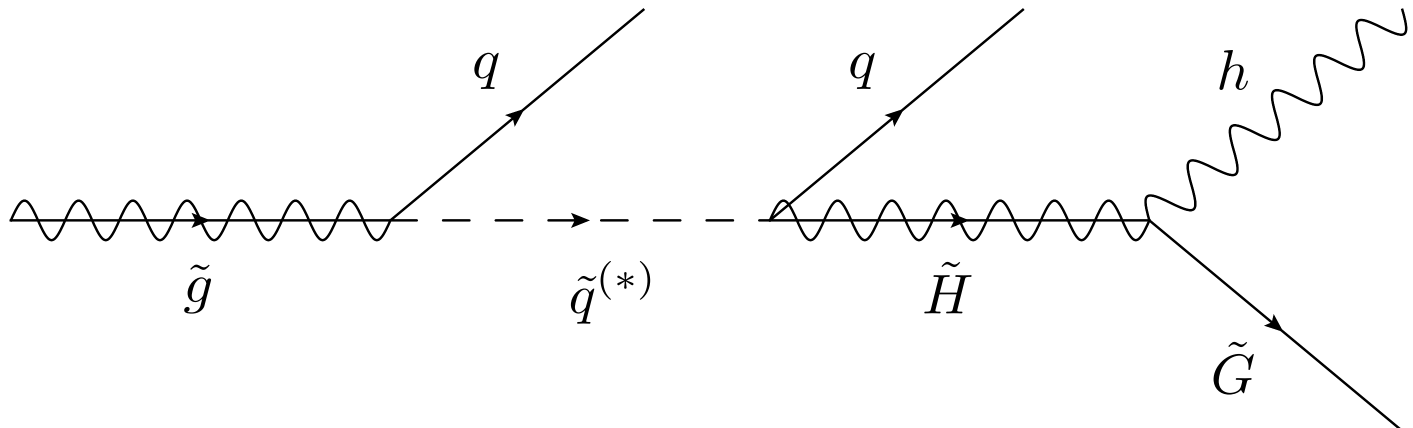

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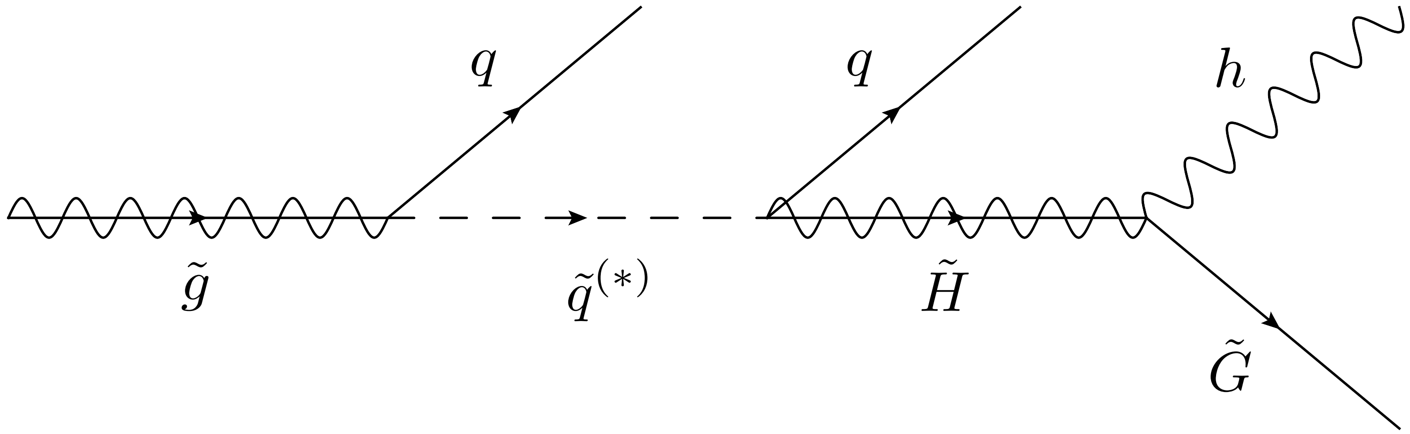

- Higgsino NLSP can also decay primarily to h's. Then jets+MET and bjets+MET are relevant final state.

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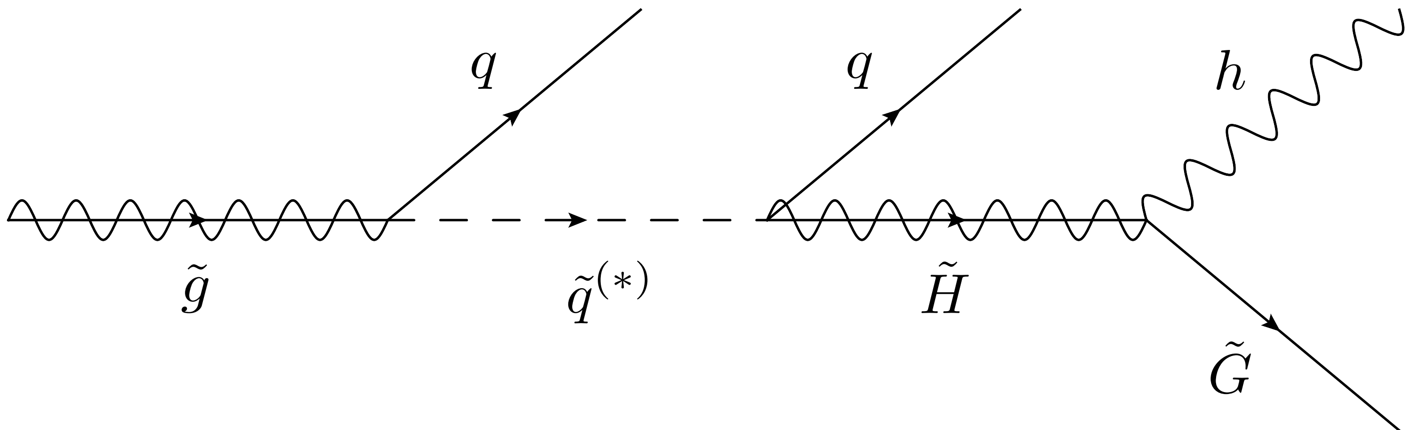

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- Currently, no dedicated search for this scenario. But several are relevant, e.g. ATLAS search for bjets+MET with 0.83/fb

≥1 jet with pT>130, ≥2 additional jets with pT>50
MET > 130, MET/m_{eff} > 0.25, $\Delta\phi_{min}$>0.4

Sig. Reg.	Data (0.83 fb^{-1})	Top	W/Z	QCD	Total
3JA (1 btag m_{eff} >500 GeV)	361	221^{+82}_{-68}	121 ± 61	15 ± 7	356^{+103}_{-92}
3JB (1 btag m_{eff} >700 GeV)	63	37^{+15}_{-12}	31 ± 19	1.9 ± 0.9	70^{+24}_{-22}
3JC (2 btag m_{eff} >500 GeV)	76	55^{+25}_{-22}	20 ± 12	3.6 ± 1.8	79^{+28}_{-25}
3JD (2 btag m_{eff} >700 GeV)	12	$7.8^{+3.5}_{-2.9}$	5 ± 4	0.5 ± 0.3	$13.0^{+5.6}_{-5.2}$

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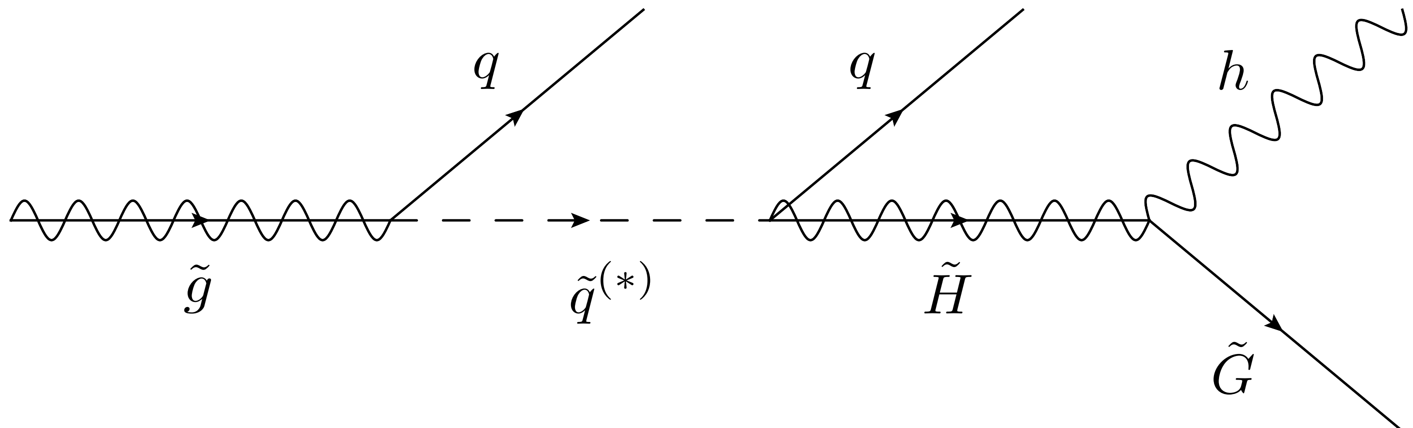

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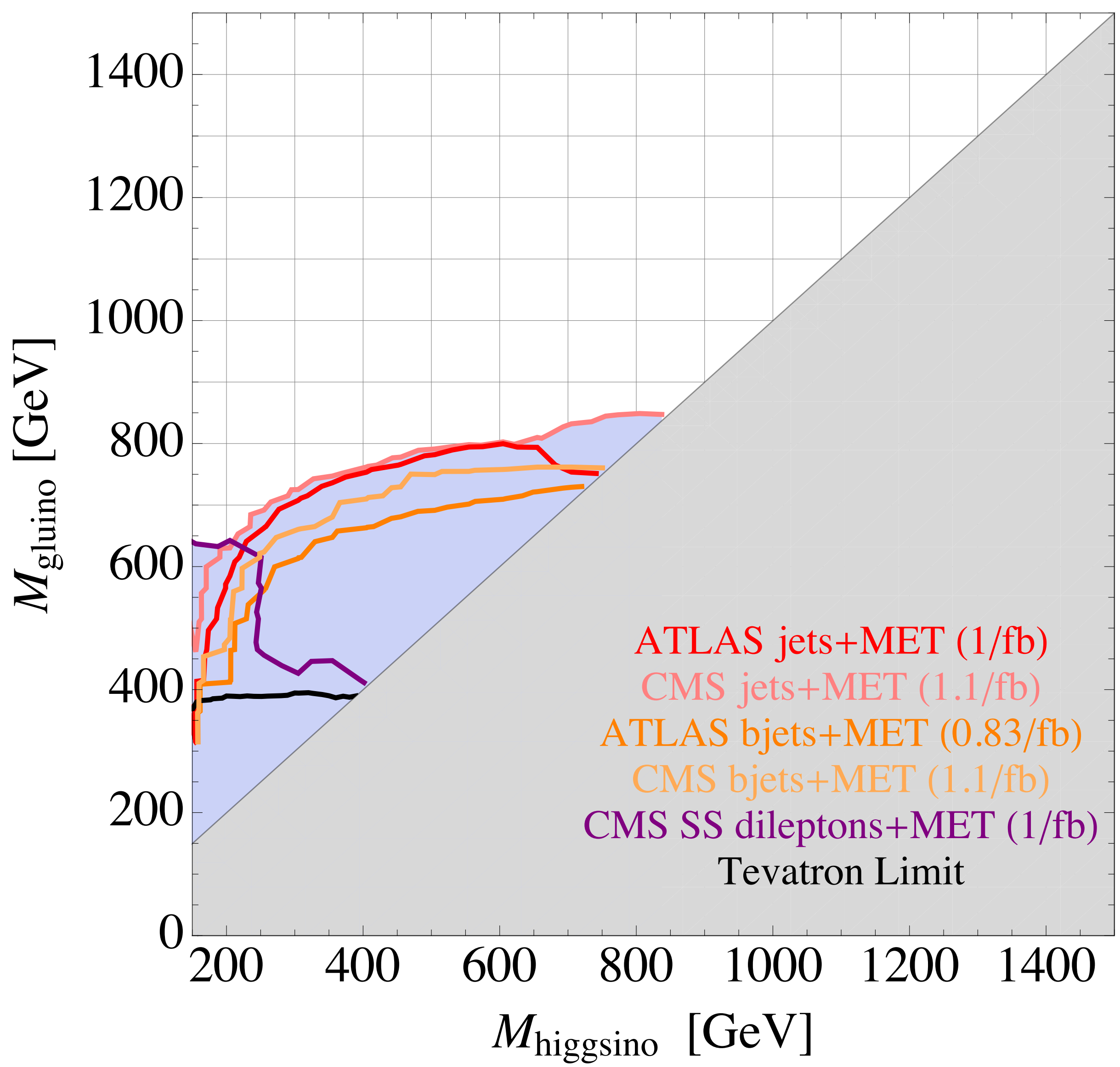
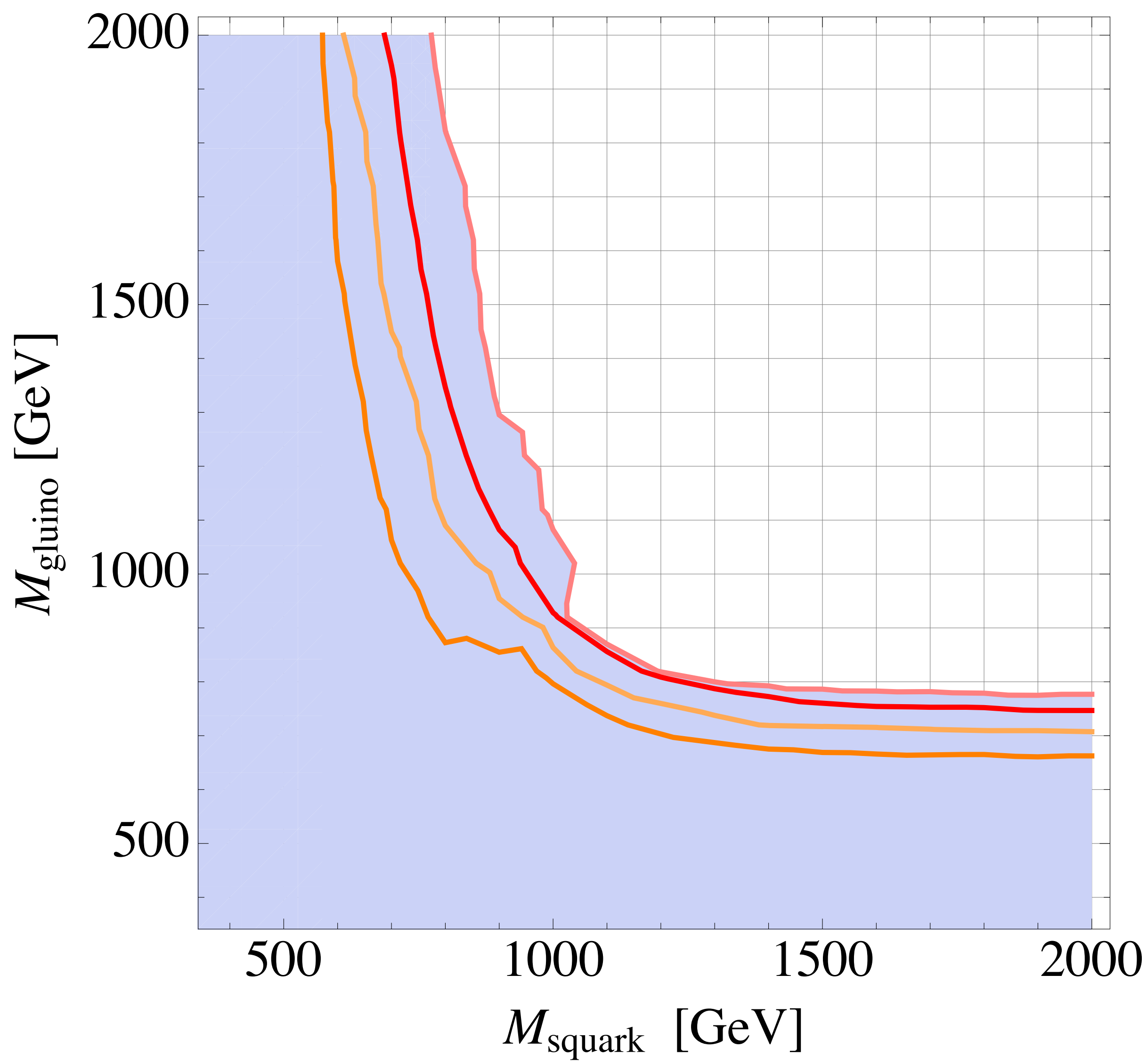
(This has since been updated to 2/fb...)

Expected sensitivity for h-rich Higgsino NLSP

(from Kats, Meade, Reece & DS)





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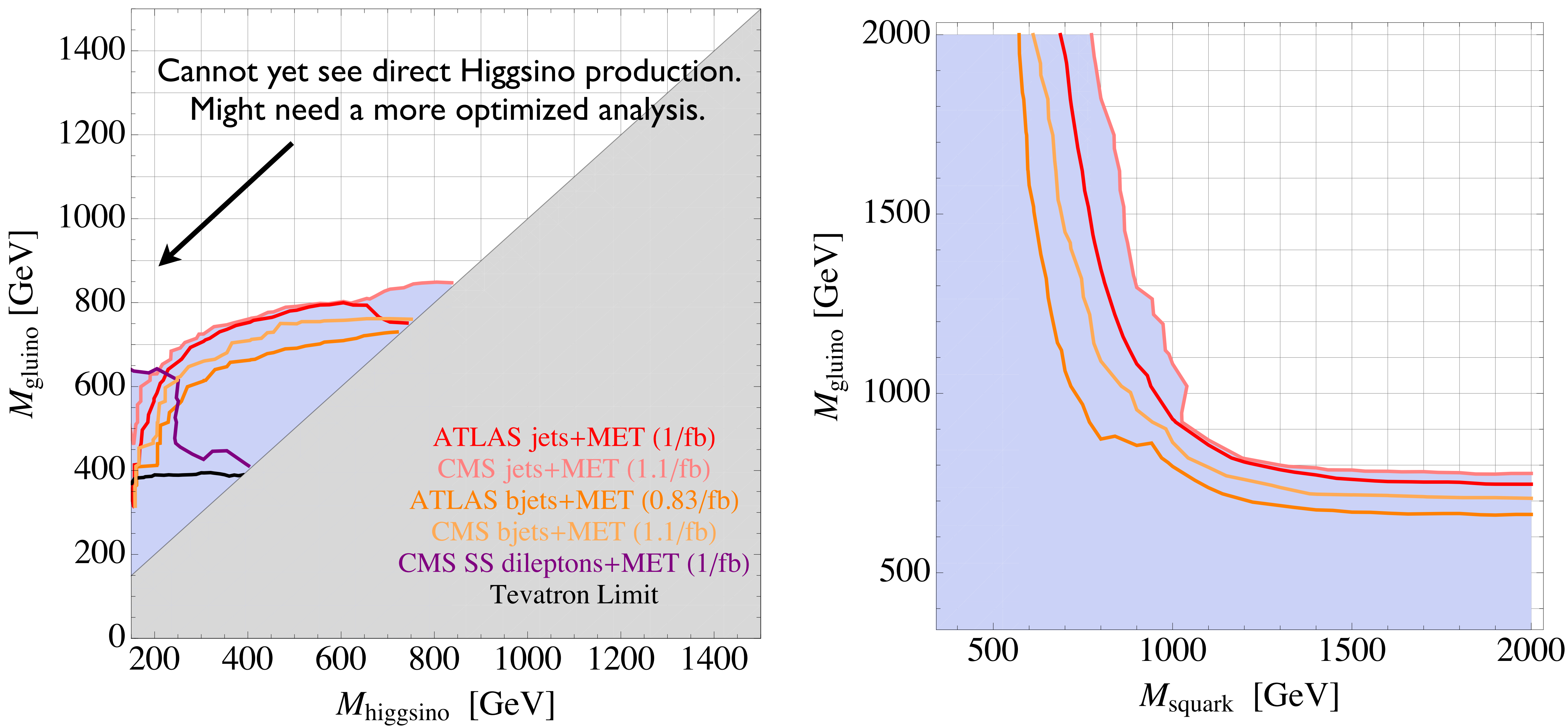

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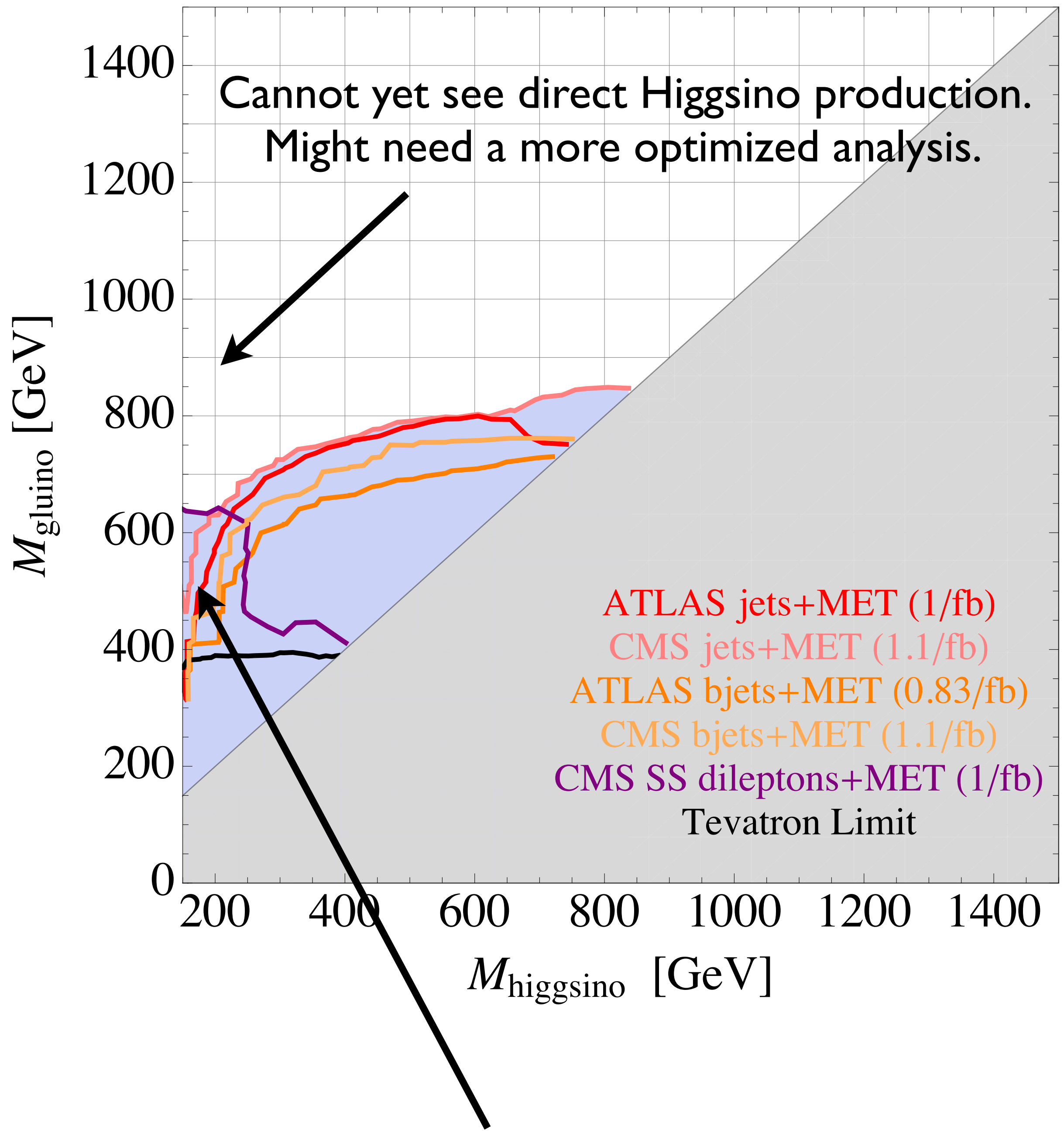
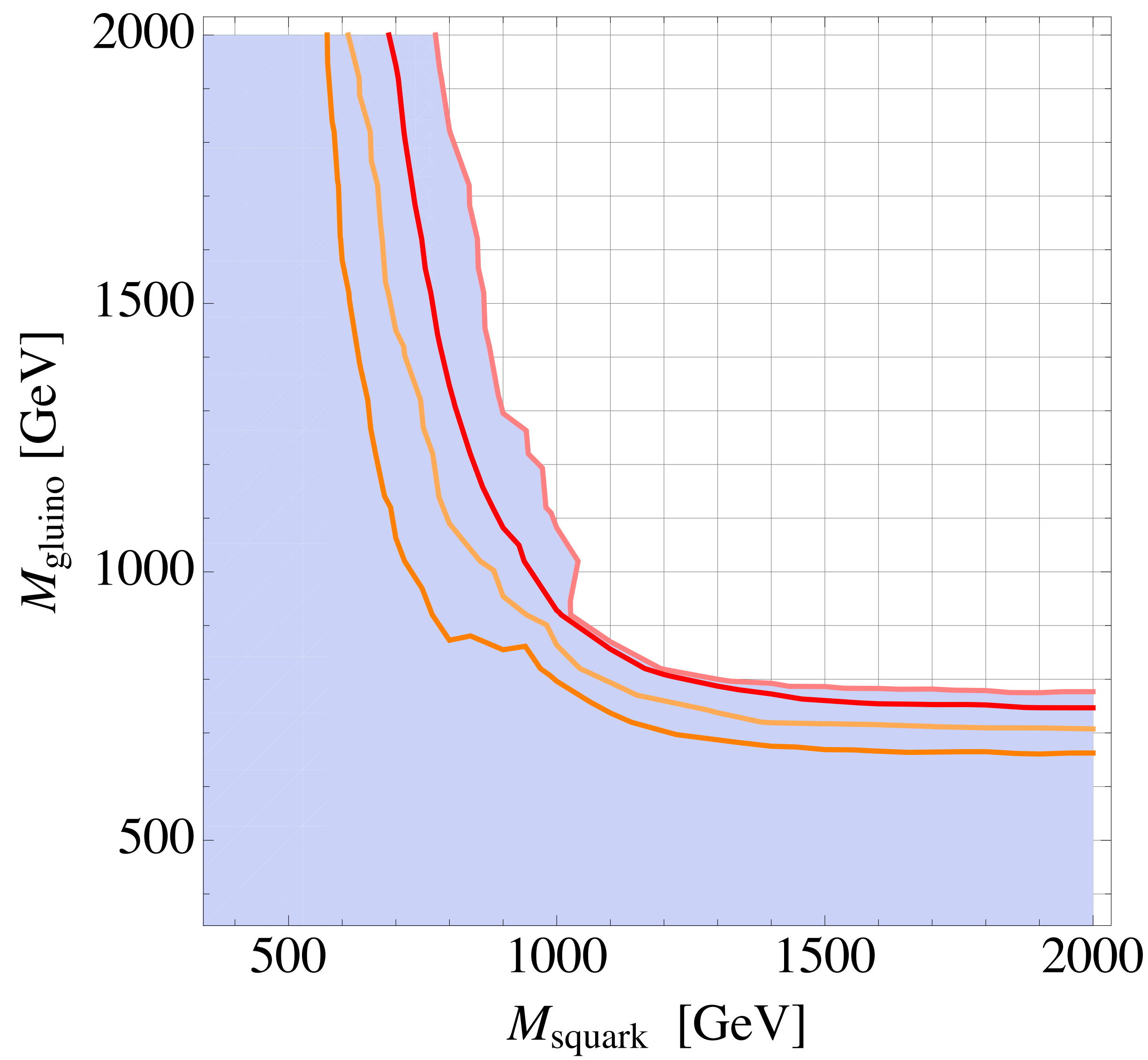
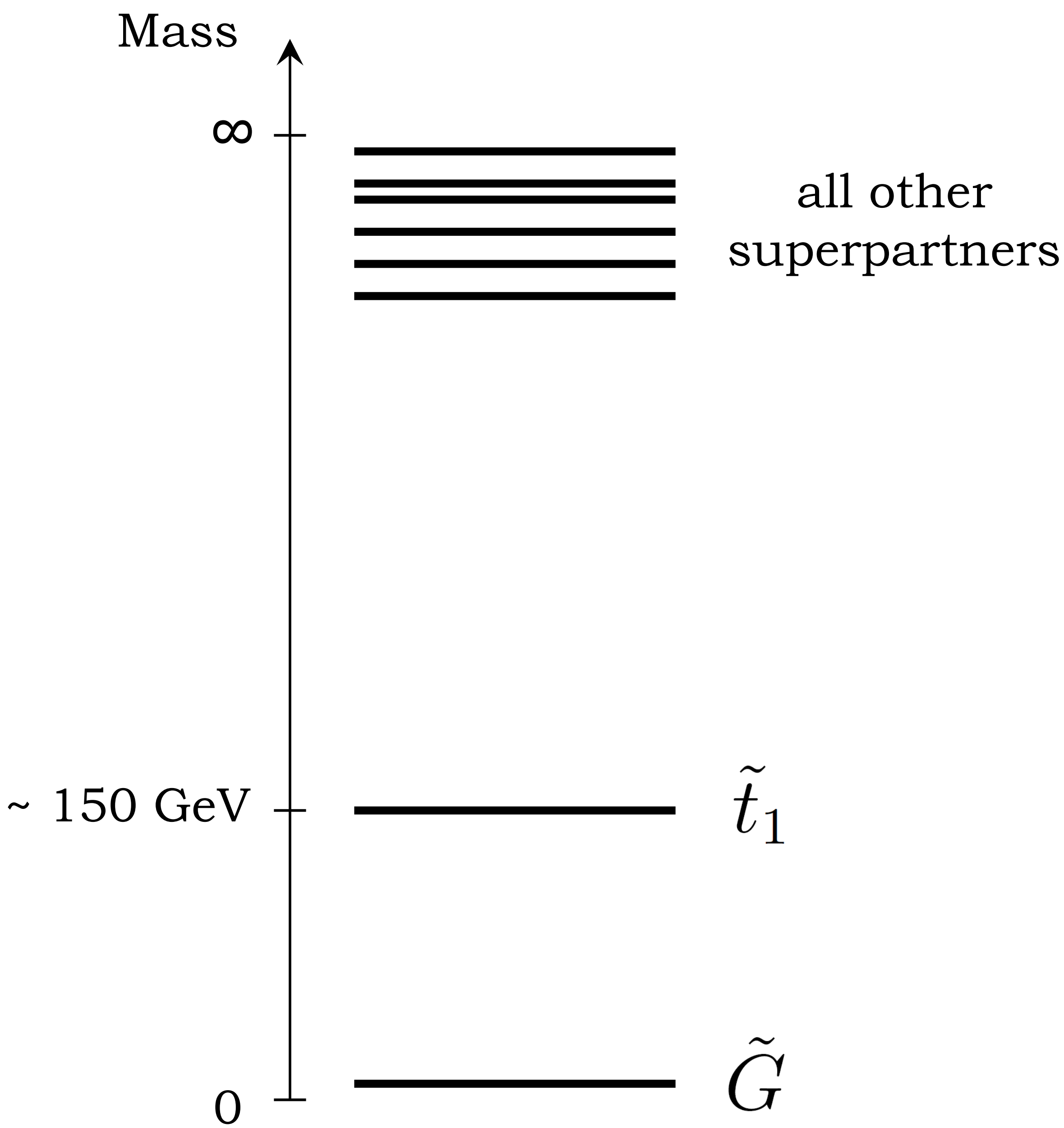
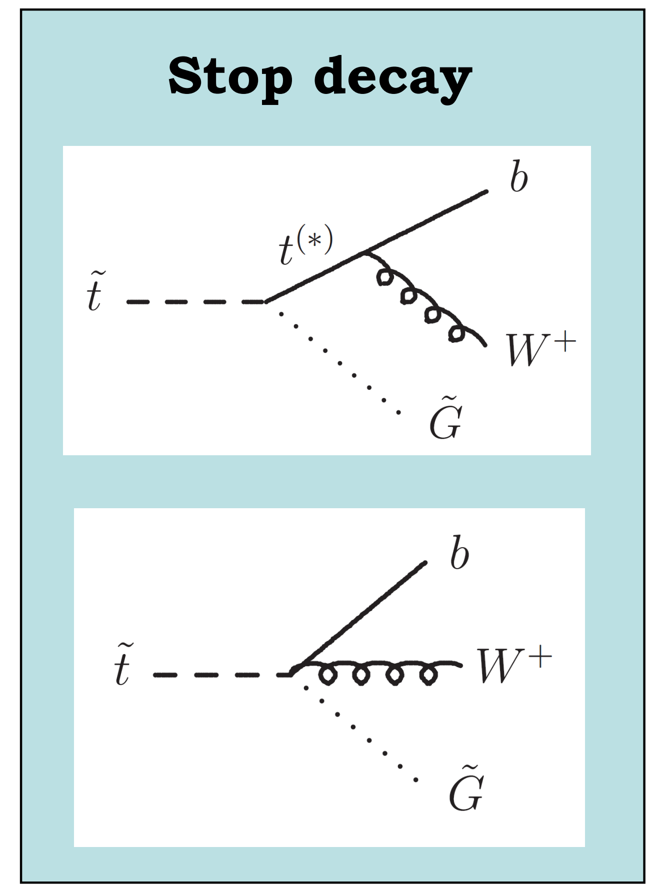




Degraded sensitivity at low NLSP mass -- MET is again being squeezed out!

Stop NLSPs





$$\tilde{t} \to W^+ b\, \tilde{G}$$

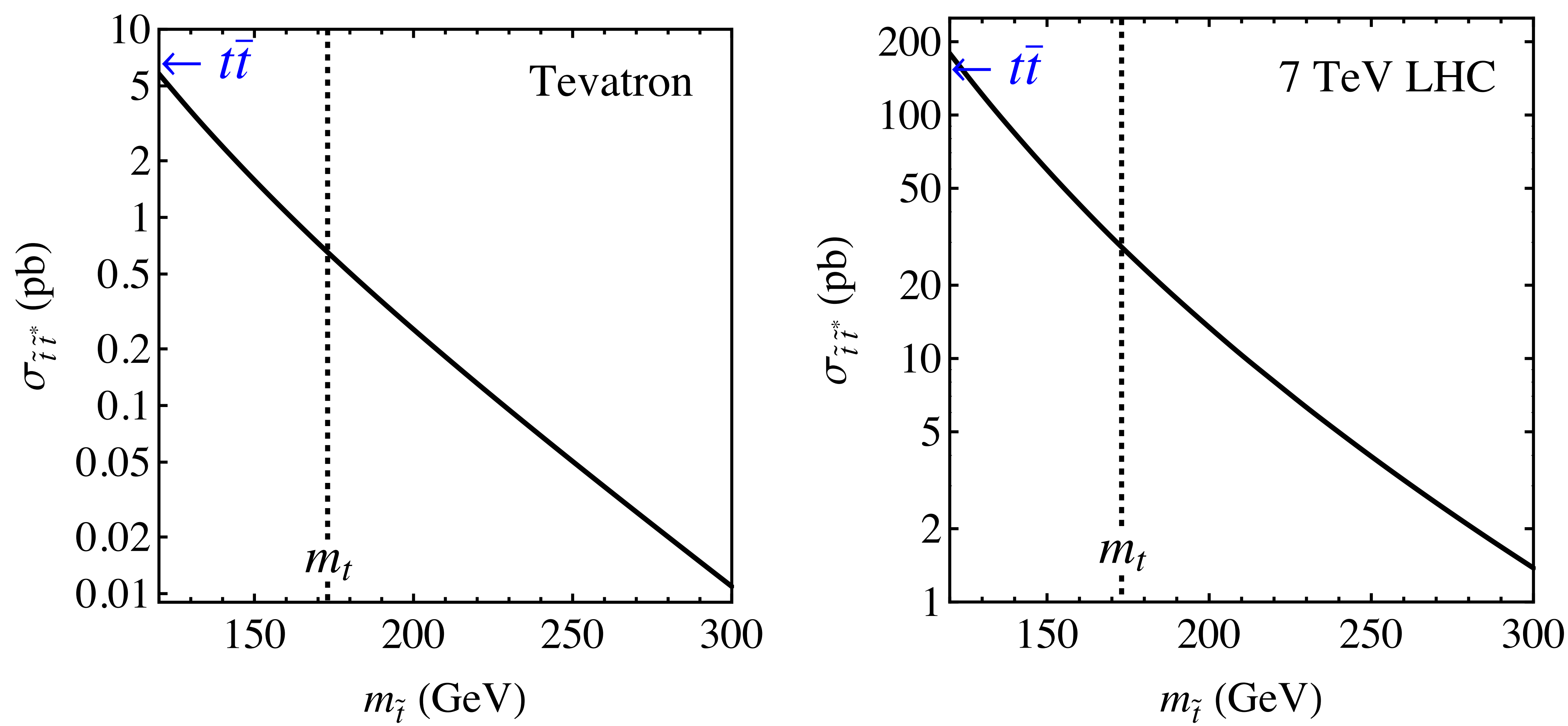
A minimal realization of "natural SUSY"

(Kats & DS "Light Stop NLSPs at the Tevatron and LHC")

cf Chou & Peskin '99

Stop NLSPs

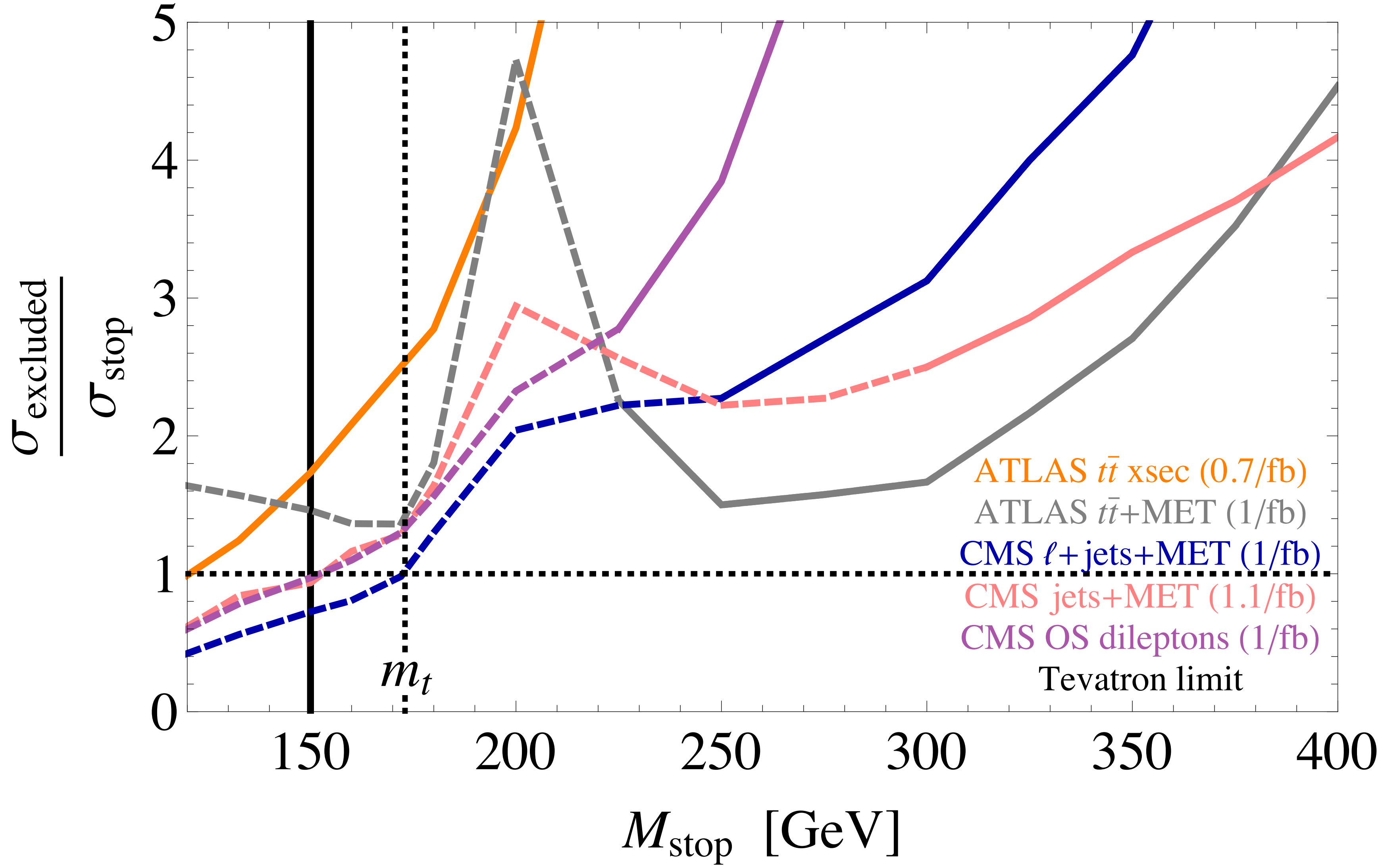
- Direct production of stop; stop → top+MET



Very challenging to see under ttbar background!

Stop NLSPs

- Currently no dedicated searches for stop NLSPs, at either Tevatron or LHC. Stop could still be lighter than the top!!



Again, sensitivity is degraded because

- lower xsec (like EW production)
- mass of the top squeezes out the kinematics

(Kats & DS; Kats, Meade, Reece, DS)

Comments on GGM and the Higgs

- A Higgs at 125 prefers large A-terms (stop mixing) in the MSSM.
- In GGM, the A-terms are zero at the messenger scale. So they must arise from RG evolution.

Draper, Meade, Reece & DS

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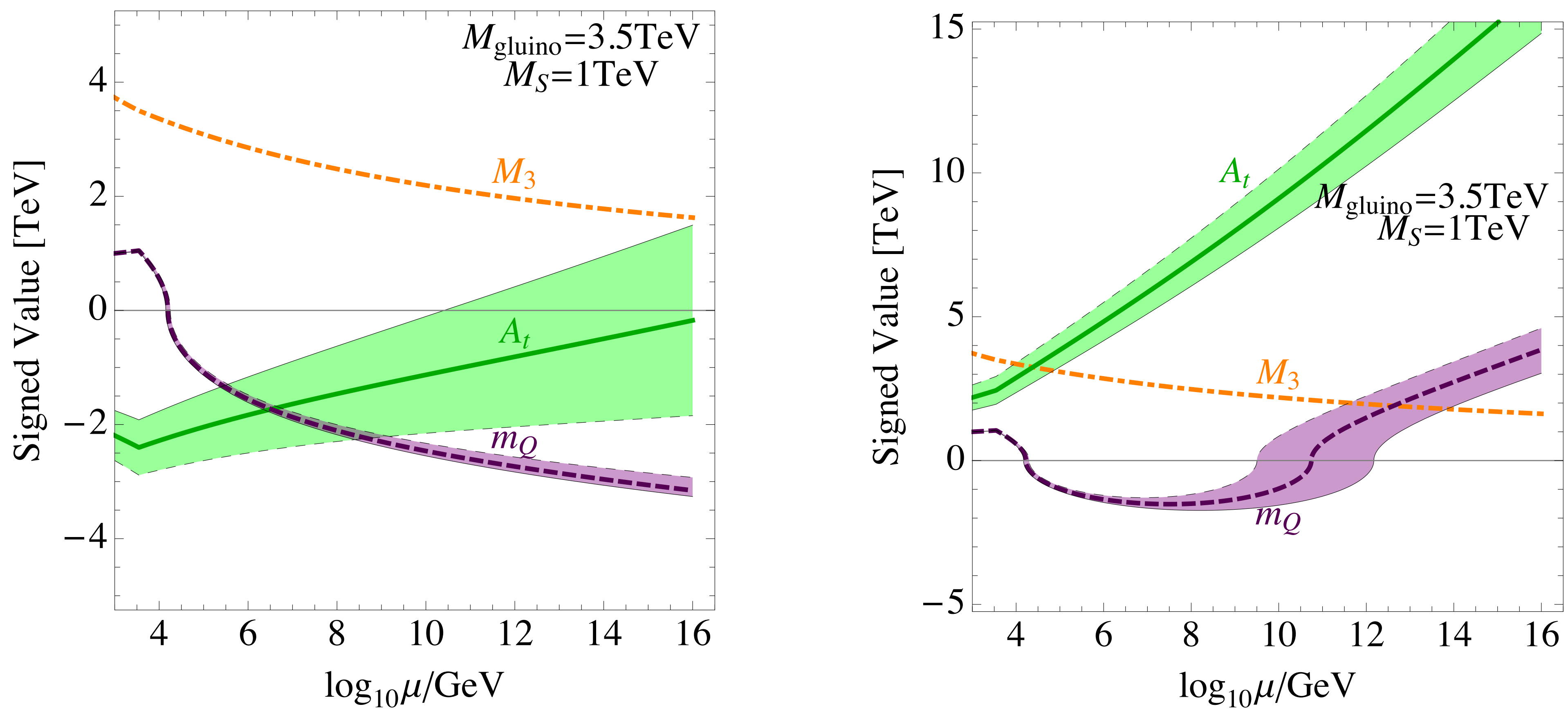
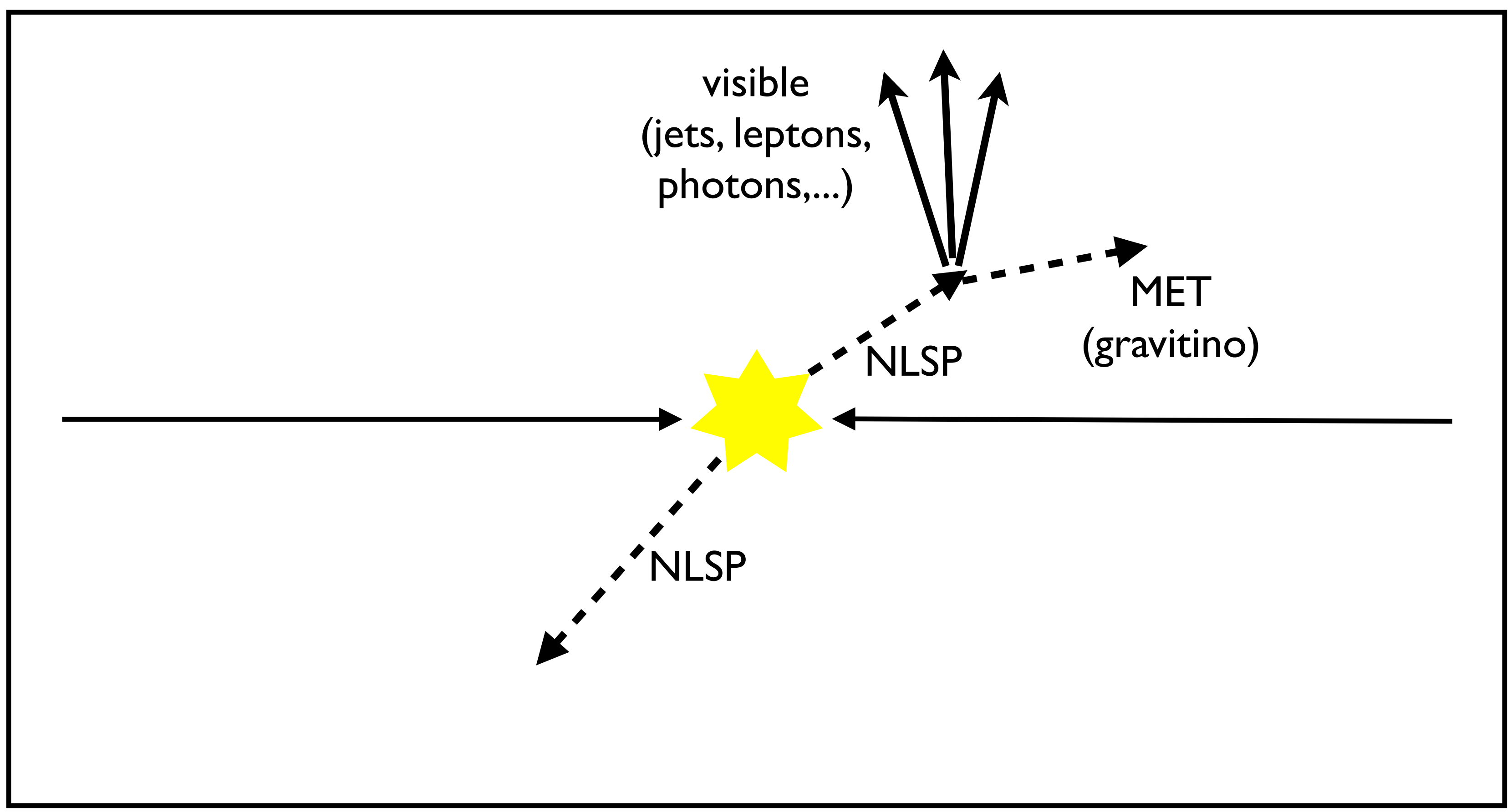


Draper, Meade, Reece & DS

Comments on GGM and the Higgs

- Messenger scale must be extremely high -- $M_{mess} \gtrsim 10^8$ GeV. NLSP decays must be displaced or outside the detector!



- Also, gluinos must be extremely heavy -- $M_3 \gtrsim 3$ TeV. Completely out of reach of the LHC!

Implications for searches

- This strongly motivates searches for long-lived NLSPs (as well as superpartners other than the gluino).
- But it doesn't mean we should drop all the existing prompt searches.
- We can easily imagine that some modification of the Higgs sector of the MSSM+GMSB boosts the Higgs mass to 125 GeV while preserving all the usual collider signatures.
- Much too early to say! Sensible experimentalists should ignore these theoretical struggles and continue looking for new physics!!

Summary

- I have motivated GMSB both as a broad signature generator, and as a natural solution to the SUSY flavor problem.
- I surveyed the LHC searches, and highlighted the strengths and weaknesses from a theorist's POV:
  - Colored superpartners with simple, unsqueezed decays are probably > 1 TeV
  - In the presence of squeezed spectra, these limits are much worse
  - Currently very few limits on EW superpartner production
- I illustrated these points using examples from GGM (Z-rich Higgsino NLSPs, h-rich Higgsino NLSPs, stop NLSPs)

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gluinos, squarks...

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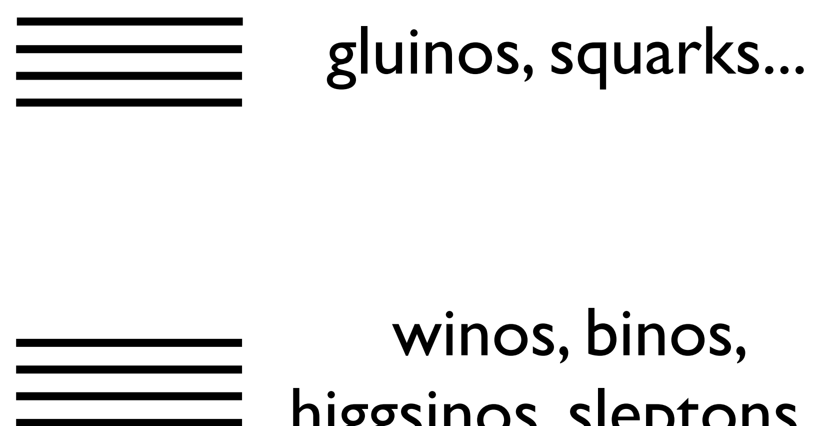

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- Actually, this type of picture is predicted by most minimal SUSY models (e.g. minimal GMSB). Although simplified models have been fashionable lately, maybe Nature will end up being nicer than it needed to be?

The End