Split Supersymmetry

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The LHC is soon

Don’t know what to expect

No theories appear “sure things”

Outline

- Motivations

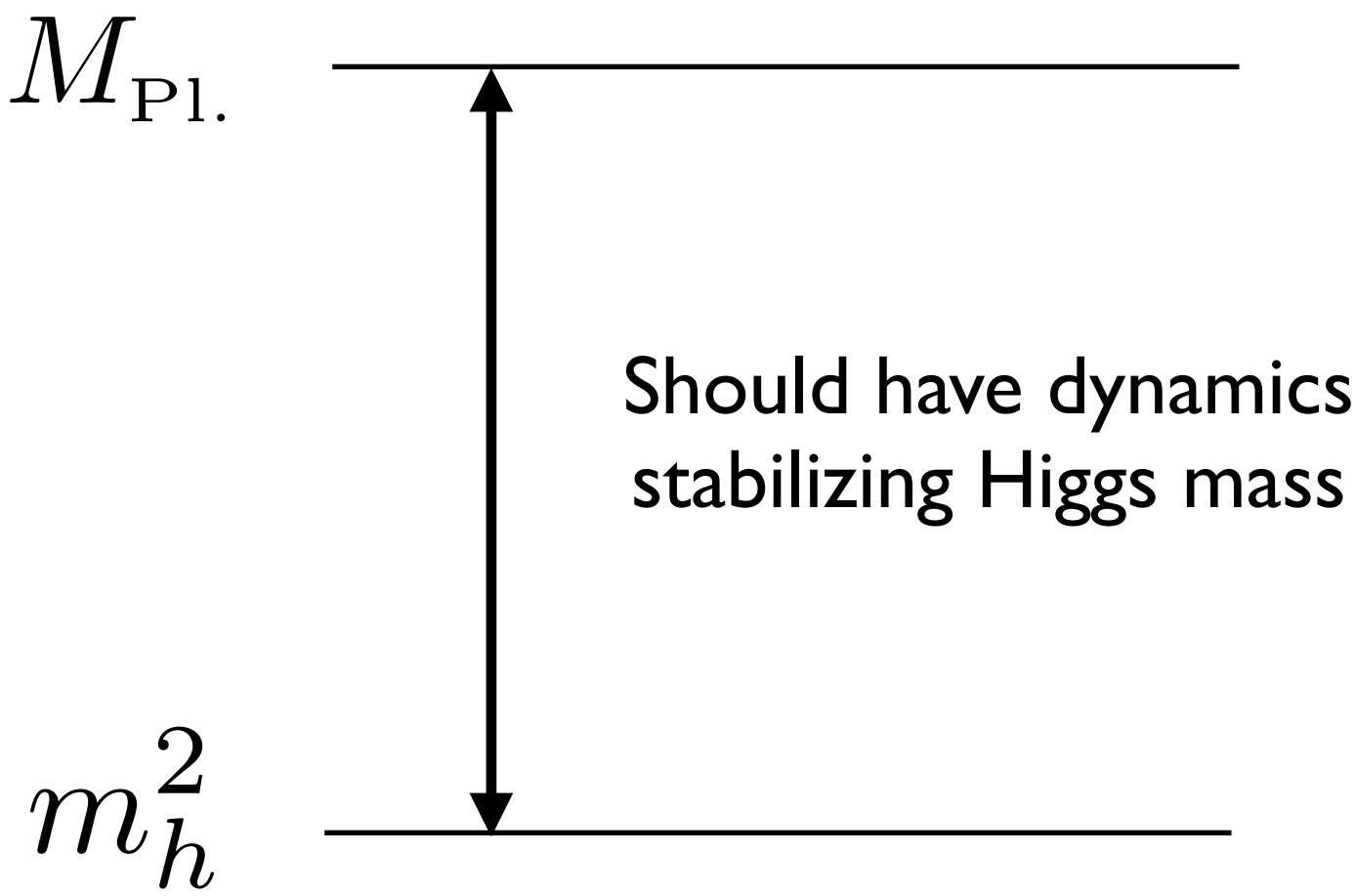
Split susy

Predictions

Outlook

Naturalness

Primary motivation for new theories



Supersymmetry

Doubles the number of particles

quark $\longrightarrow$ squark
lepton $\longrightarrow$ slepton

gauge boson $\longrightarrow$ gaugino
2 Higgs $\longrightarrow$ Higgsinos

Predicts the Higgs mass (up to radiative corrections)

Susy particles @ TeV scale $\longrightarrow$ gauge coupling unification

Lightest susy particle $\longrightarrow$ Dark Matter

Adds 100+ new parameters

MSSM
Pros & Cons

Circa 1986

Natural	FCNCs
Gauge Coupling Unification	CP Violation
Dark Matter	Proton Decay

In 1991 LEP I

Found gauge couplings unify

S & T Parameters were small

Absolutely sure that the Higgs would be found soon

Where are the new particles?

MSSM
Pros & Cons
After LEP 2

Natural	FCNCs
Gauge Coupling Unification	CP Violation
Dark Matter	Proton Decay
	Higgs Mass

Is a prediction of susy,
only depends weakly on parameters

Since 1991...

The Cosmological Constant
has been measured

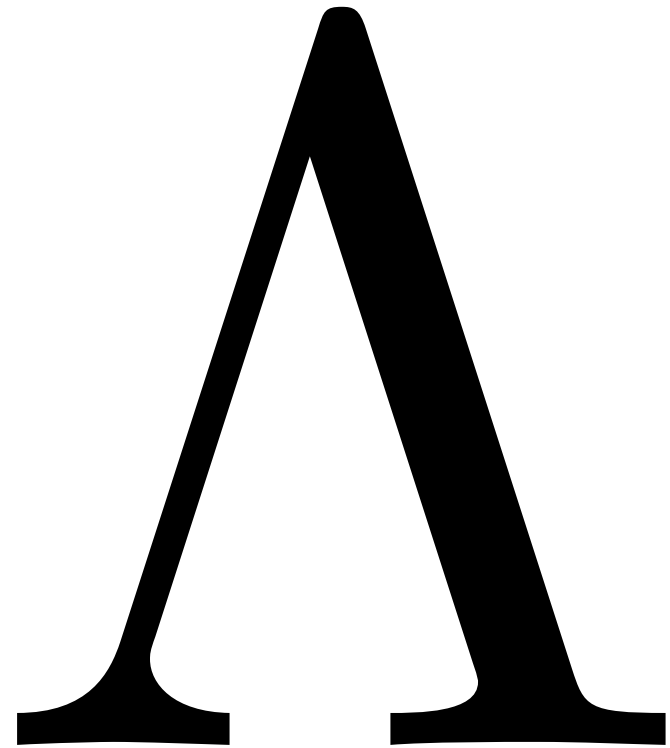
1998: $\Lambda = (1\ \mathrm{meV})^4$

Introduced a new scale in the Standard Model

Left us:

m_h^2

Look here



Ignore this

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Living in a fine tuned universe

If the Higgs is fine tuned to be light,

is there anything to discover besides the Higgs?

Dark Matter

Gauge Coupling Unification?

Splitting Susy

Arkani-Hamed & Dimopoulos hep-th/0405159
Giudice & Romanino hep-ph/0406088

Imagine if susy is broken so that
the gauginos and Higgsinos are light

(Fermion masses are protected by chiral symmetry)

One Higgs is fine tuned to be light

The gauginos/Higgsinos are the dark matter
and lead to gauge coupling unification

Scales in Split Susy

$M_{\rm Pl.}$ 10^{16} TeV

Scalars
(Squarks, sleptons, ...)

$M_{\rm susy}$? { 10^{9} TeV, 10 TeV

Fermions
(Higgsinos, gauginos)
+SM Higgs

$M_{\rm weak}$ 1 TeV

$M_{\rm CC}$ 10^{-15} TeV

Particles and Couplings

H $\quad\quad$ $\widetilde{B}$ $\widetilde{W}$ $\tilde{g}$ $\quad\quad$ $\widetilde{H_u}$ $\widetilde{H_d}$

Higgs $\quad\quad$ Gauginos $\quad\quad$ Higgsinos

$$m_1\widetilde{B}^2 + m_2\widetilde{W}^2 + m_3\tilde{g}^2 + \mu\widetilde{H_u}\widetilde{H_d}$$

$$\lambda|H|^4 - m^2|H|^2$$

Higgs Quartic

$$\lambda = \frac{1}{8}(g^2 + g'^2)\cos^2 2\beta$$

$$\kappa_u H\widetilde{H_u}\widetilde{W} + \kappa_d H^\dagger\widetilde{H_d}\widetilde{W}$$

$$\kappa'_u H\widetilde{H_u}\widetilde{B} + \kappa'_d H^\dagger\widetilde{H_d}\widetilde{B}$$

Gaugino Yukawas

$$\kappa_u = g\sin\beta$$
$$\kappa_d = g\cos\beta$$

No gluino interactions!

5 Couplings from 1 parameter!

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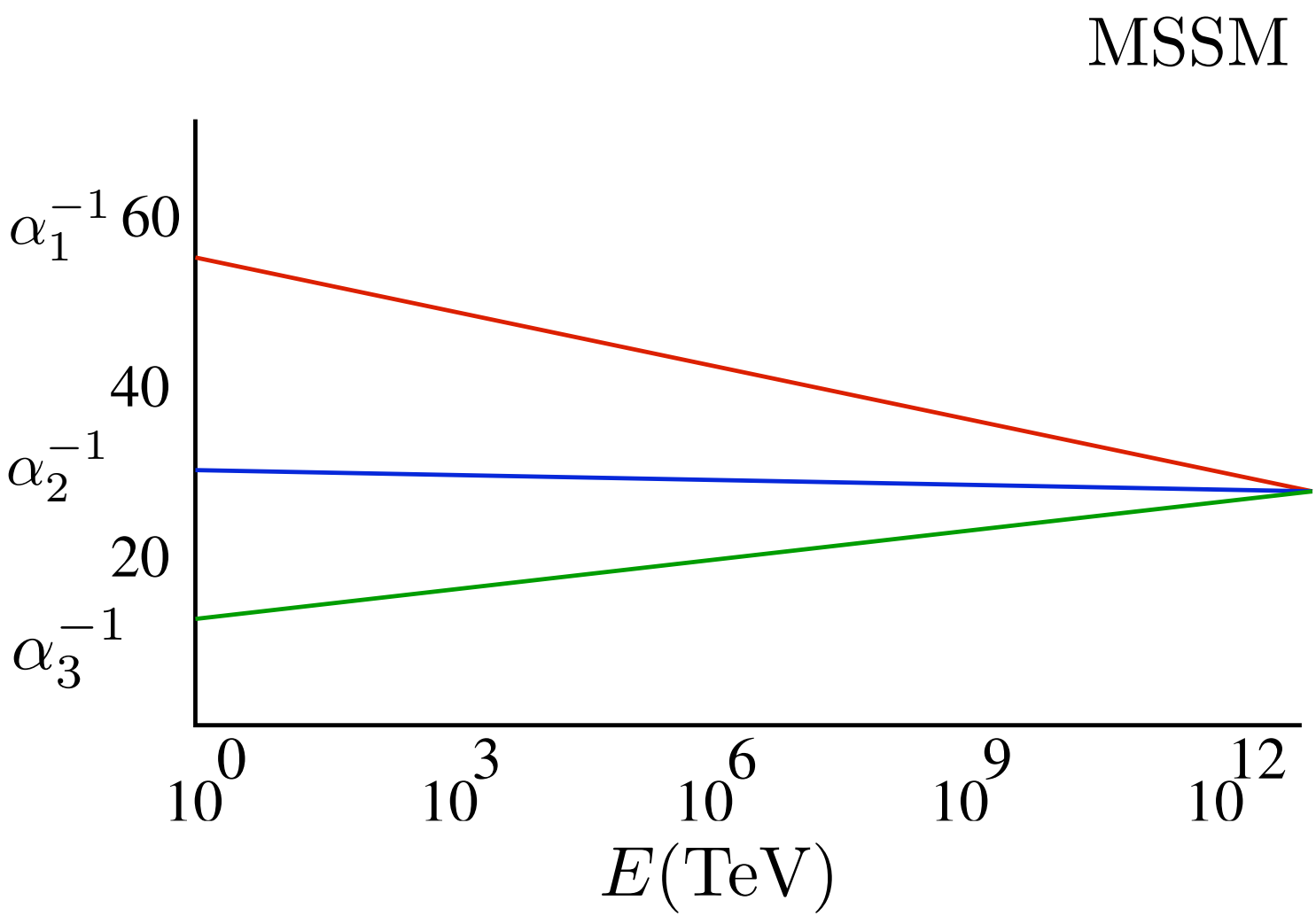
Gauge Coupling Unification

Squarks and Sleptons don't alter unification

(One less Higgs doublet helps unification)



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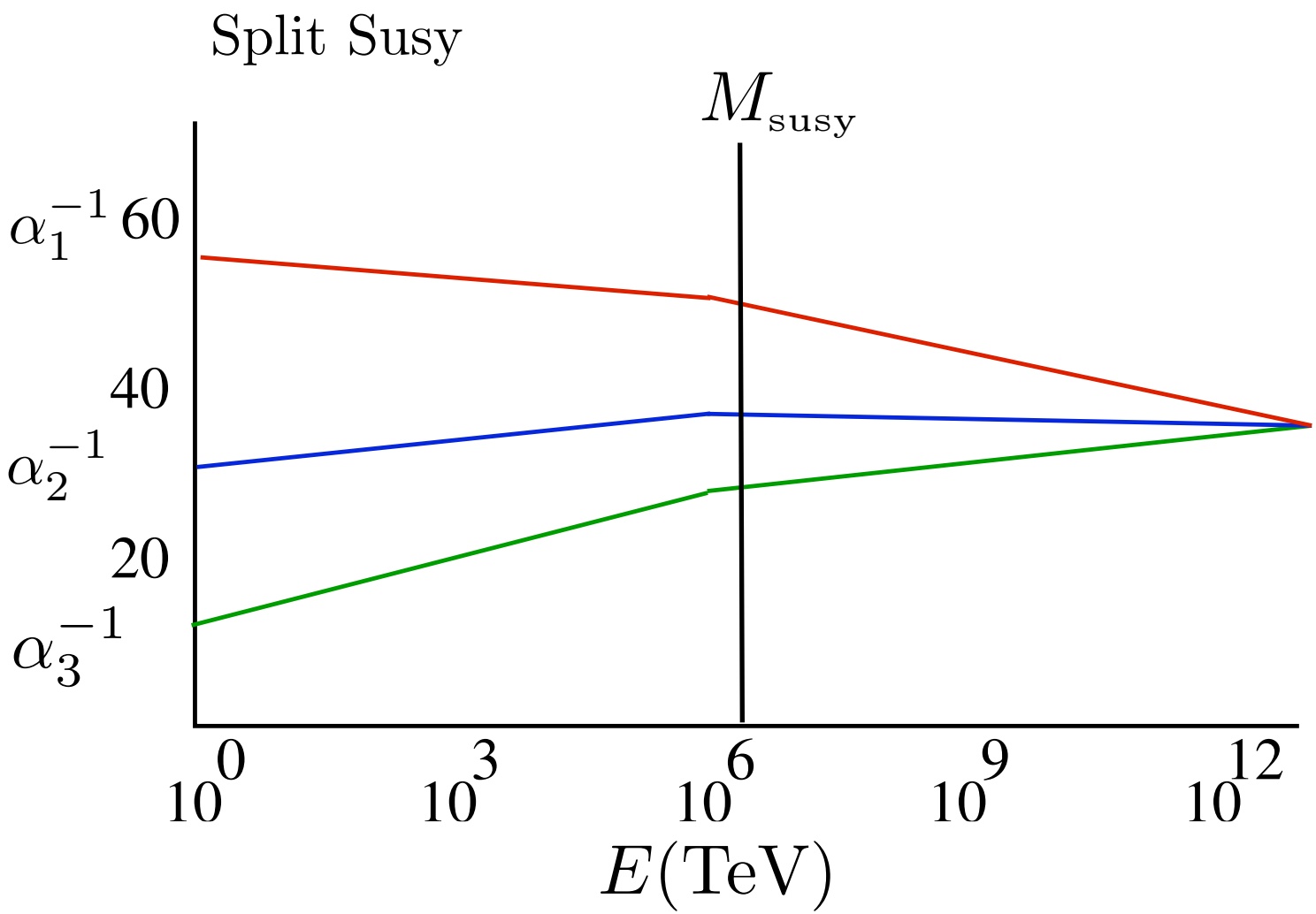
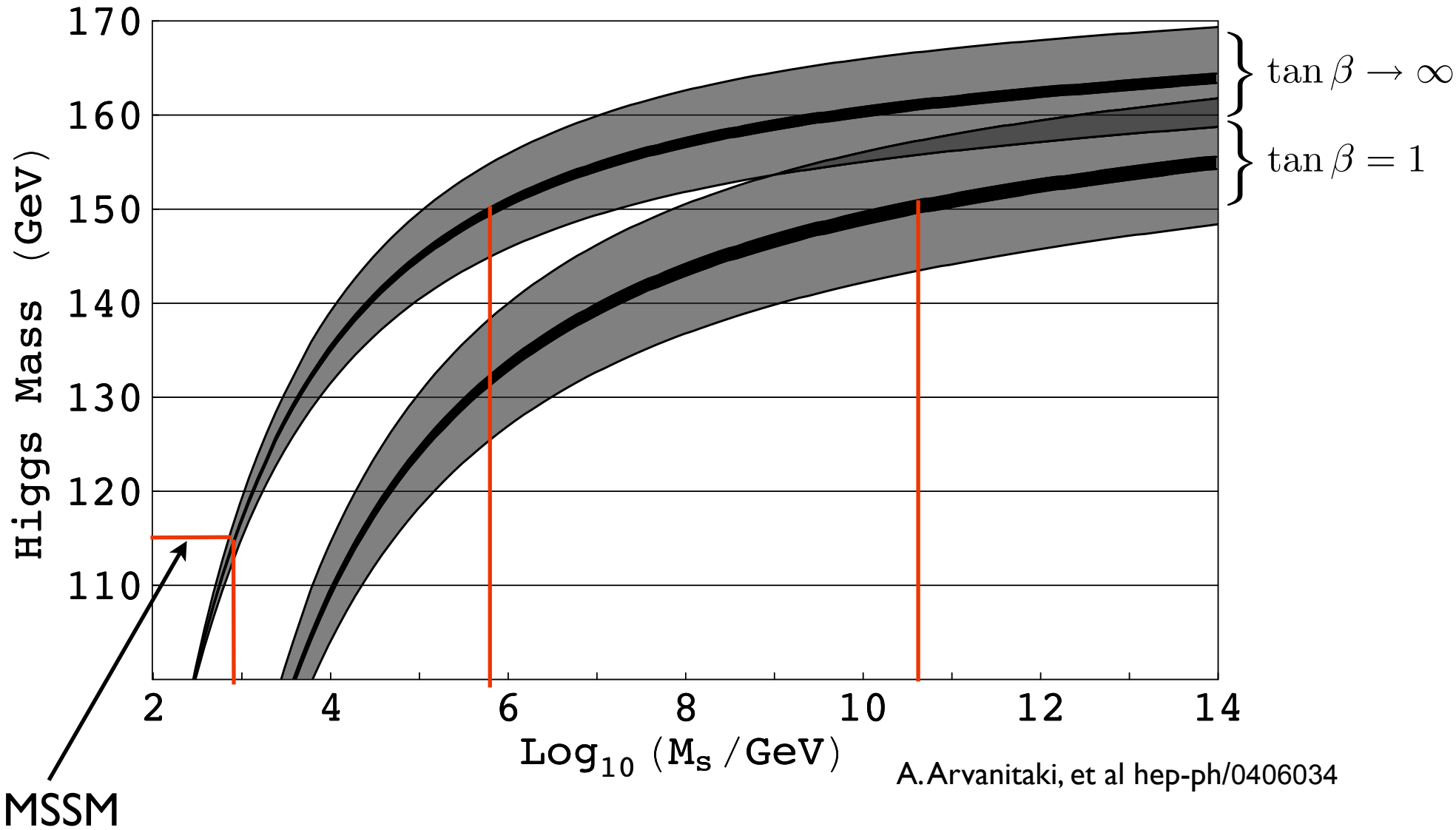


The Higgs Mass

Slow RG Evolution from $M_{\rm susy}$ to weak scale

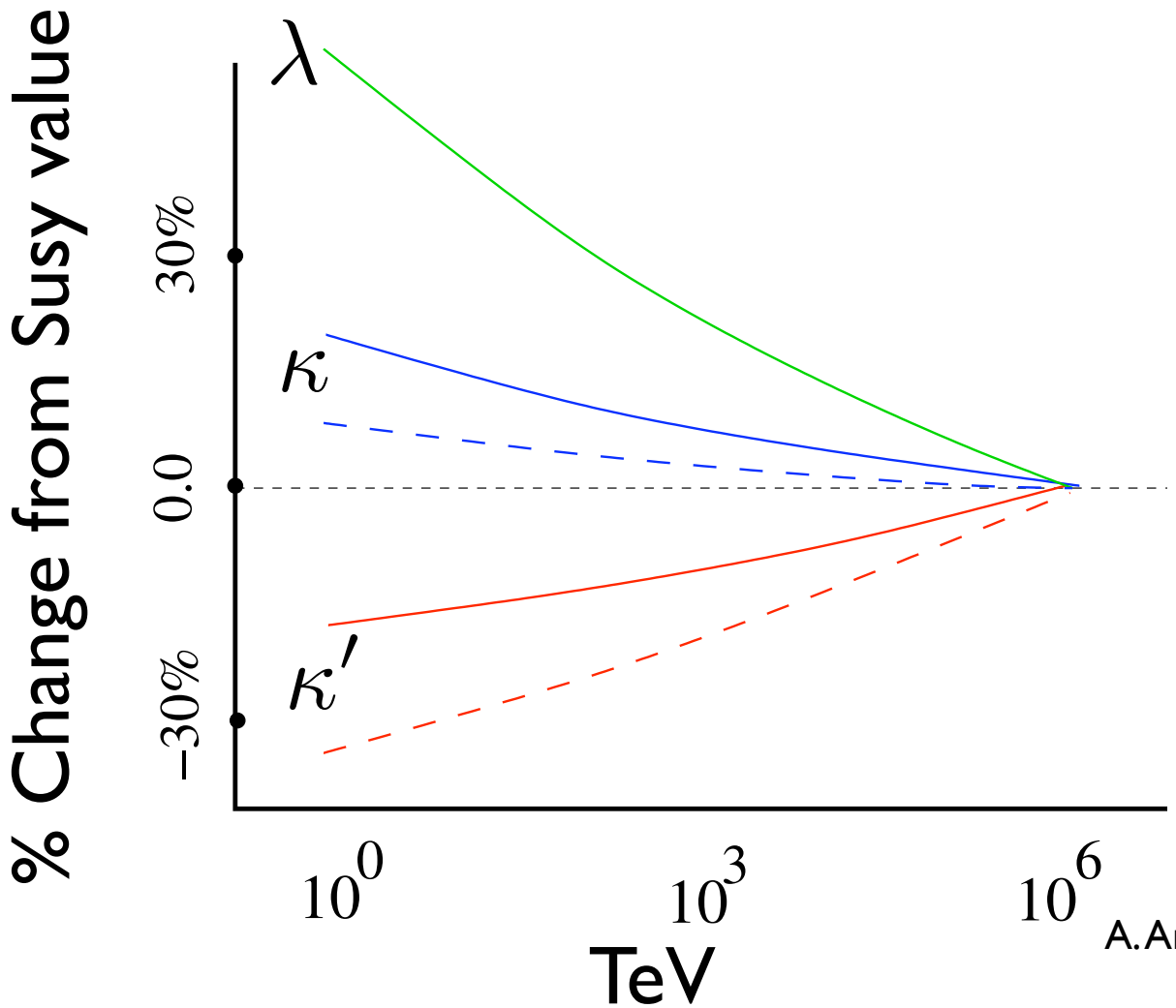


A. Arvanitaki, et al hep-ph/0406034

The New Unification

5 Couplings from 2 Parameters

$$M_{\rm susy} \quad \tan\beta \longrightarrow \lambda \;\; \kappa_u \;\; \kappa_d \;\; \kappa'_u \, \kappa'_d$$



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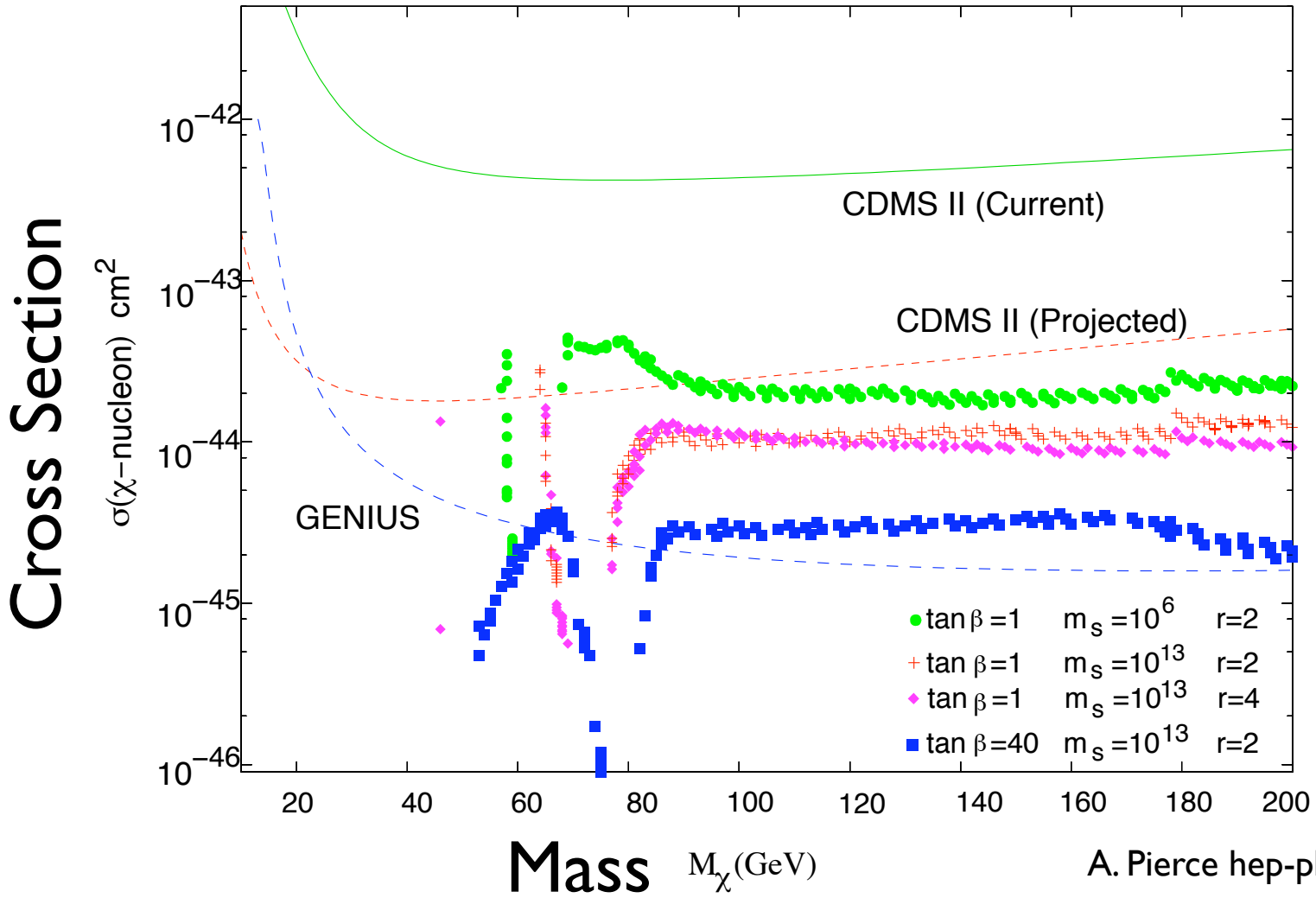
Dark Matter Detection

Almost identical to MSSM

(Fewer parameters/resonances)

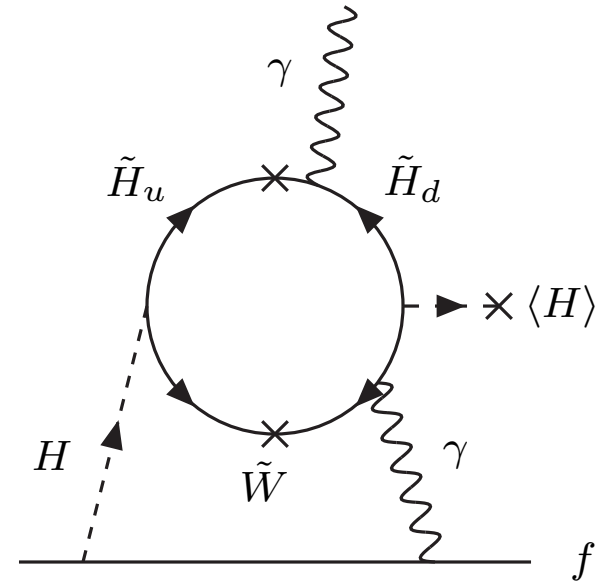


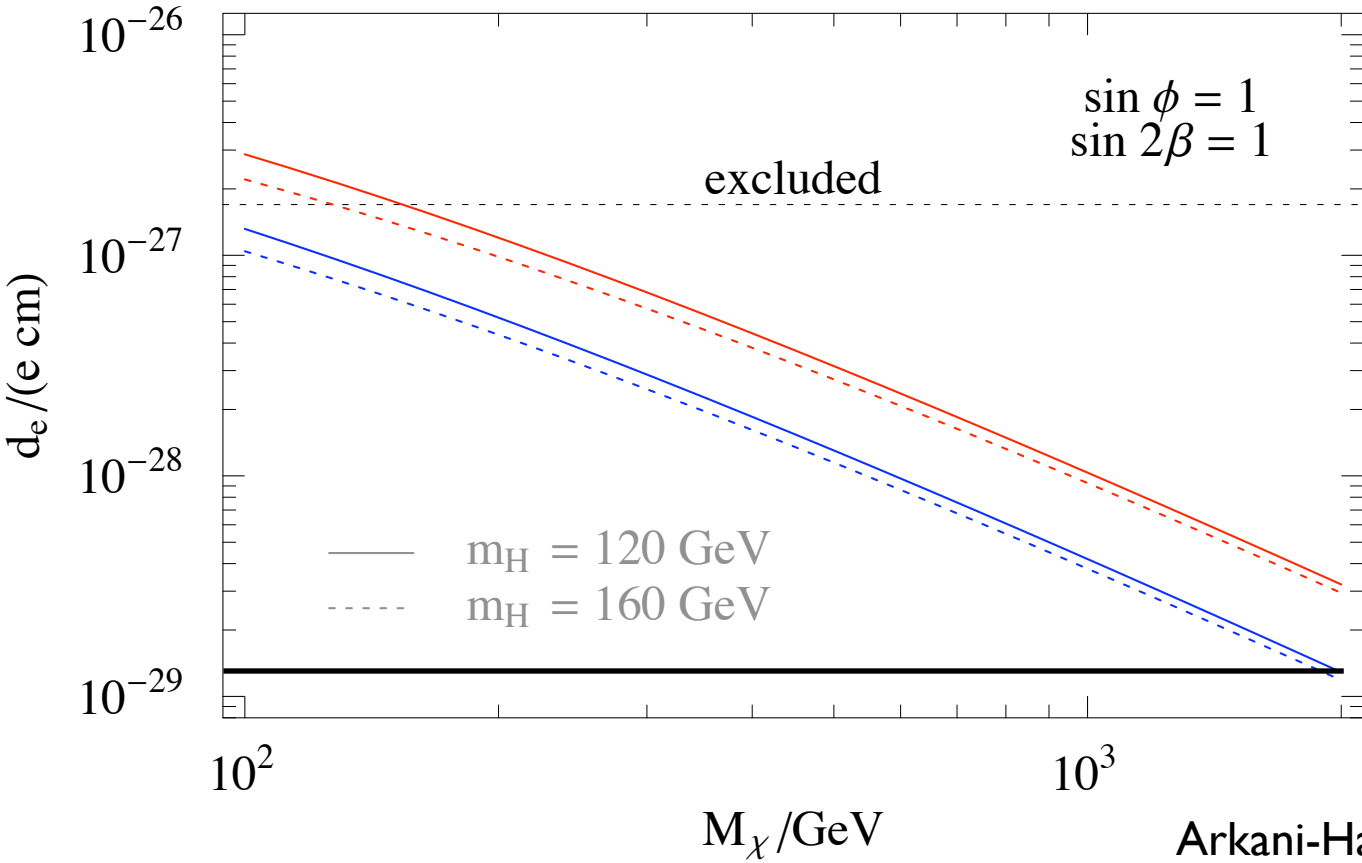
A. Pierce hep-ph/0406144

Electric Dipole Moments

One phase in split susy

Feeds in at 2 loops to neutron EDM





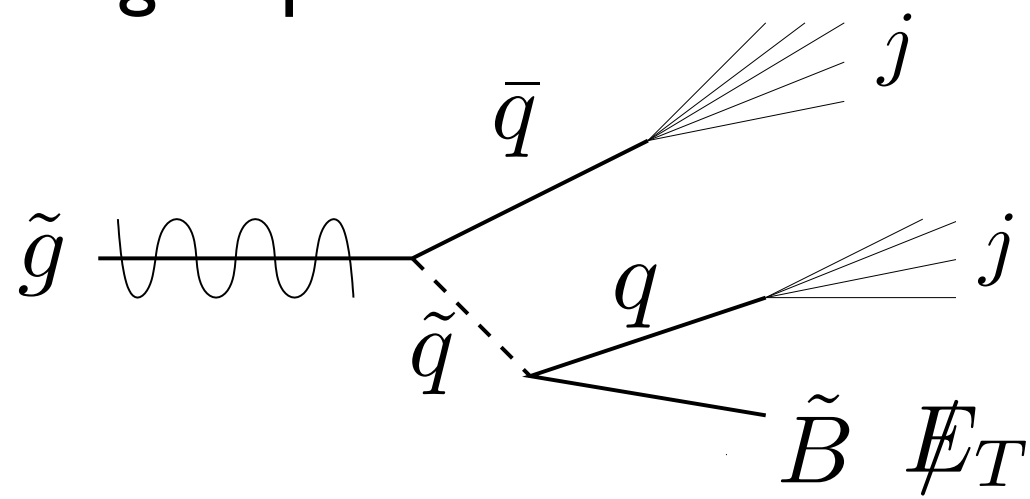
DeMille/Yale Groups by 2007(?)

Arkani-Hamed, et al hep-ph/0409232

Long Lived Gluinos

$m_{\tilde{g}} = 350 \text{ GeV}$ 1 per second is produced at the LHC

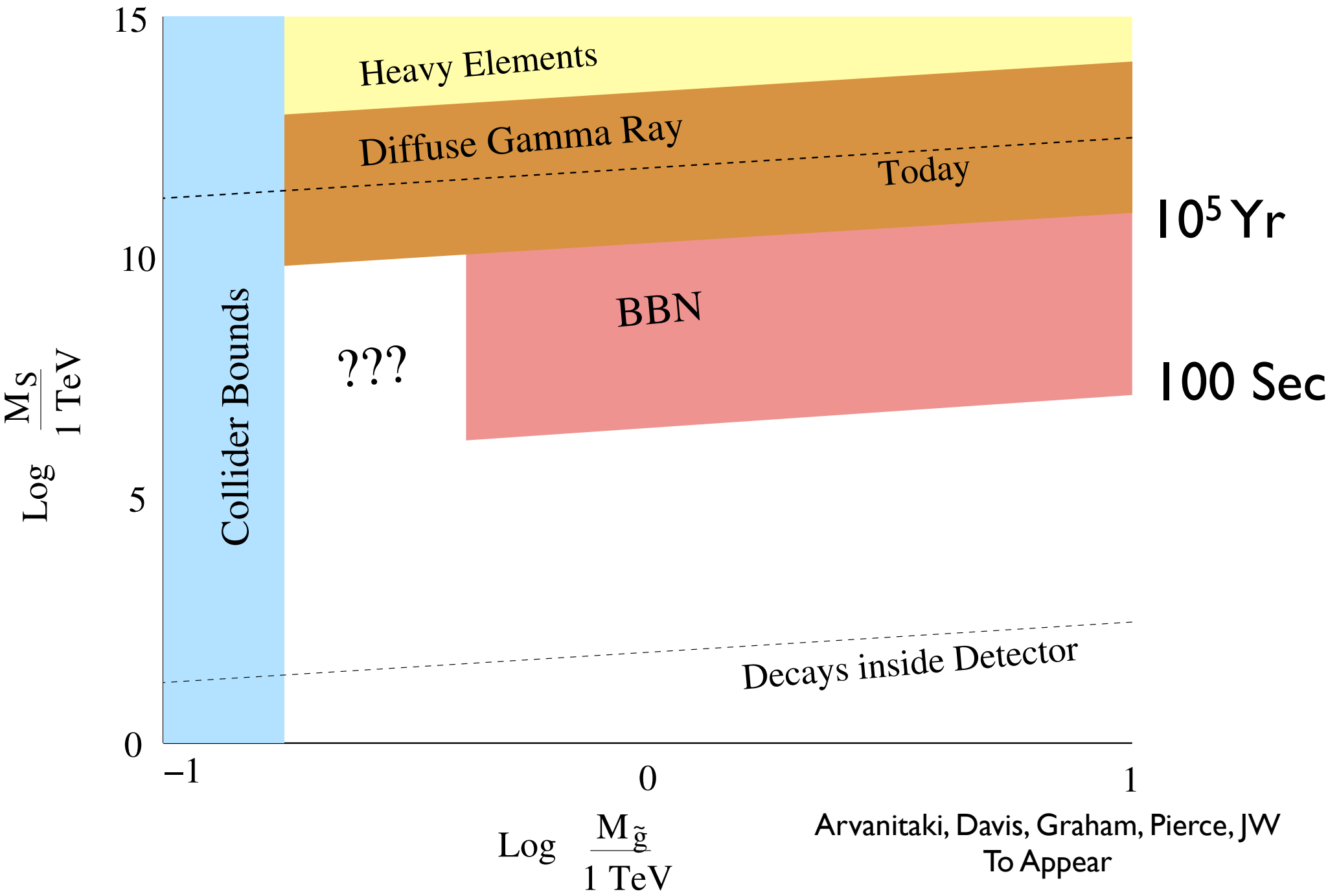
Must decay through squarks



$$\tau_{\tilde{g}} \simeq 2 \text{ sec.} \left(\frac{350 \text{ GeV}}{m_{\tilde{g}}} \right)^5 \left(\frac{M_{\text{Susy}}}{10^6 \text{ TeV}} \right)^4$$

Can be cosmologically long lived

Limits from Gluinos



Arvanitaki, Davis, Graham, Pierce, JW
To Appear

Outline

Motivations

Split susy

Predictions

- Outlook

Split Susy

Different signatures to discover new particles

Fewer Coloured Particles

Tri-Lepton Signature Different

Long lived gluino

Split Susy

New measurements that are interesting

Yukawa unification

How to measure the lifetime of gluino?

Experimental confirmation

of a finely tuned universe

at future colliders