Recent Research Interests

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about me

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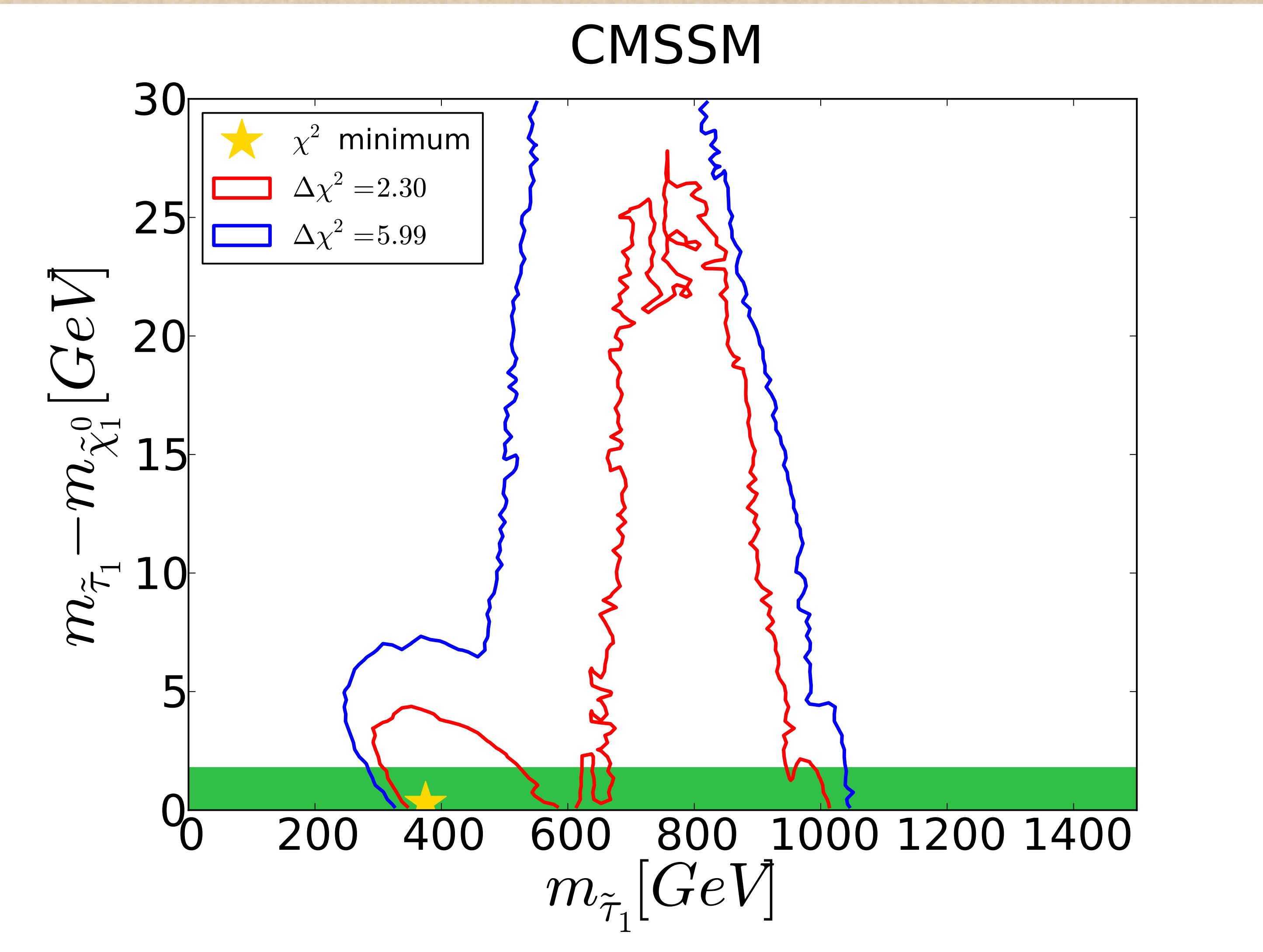
Outline

- test SUSY in LHC
- constrain BSM in BBN and solve lithium-7 problem
- Higgs bremsstrahlung in DM annihilation

explore the *entire* CMSSM stau-neutralino coannihilation region in LHC

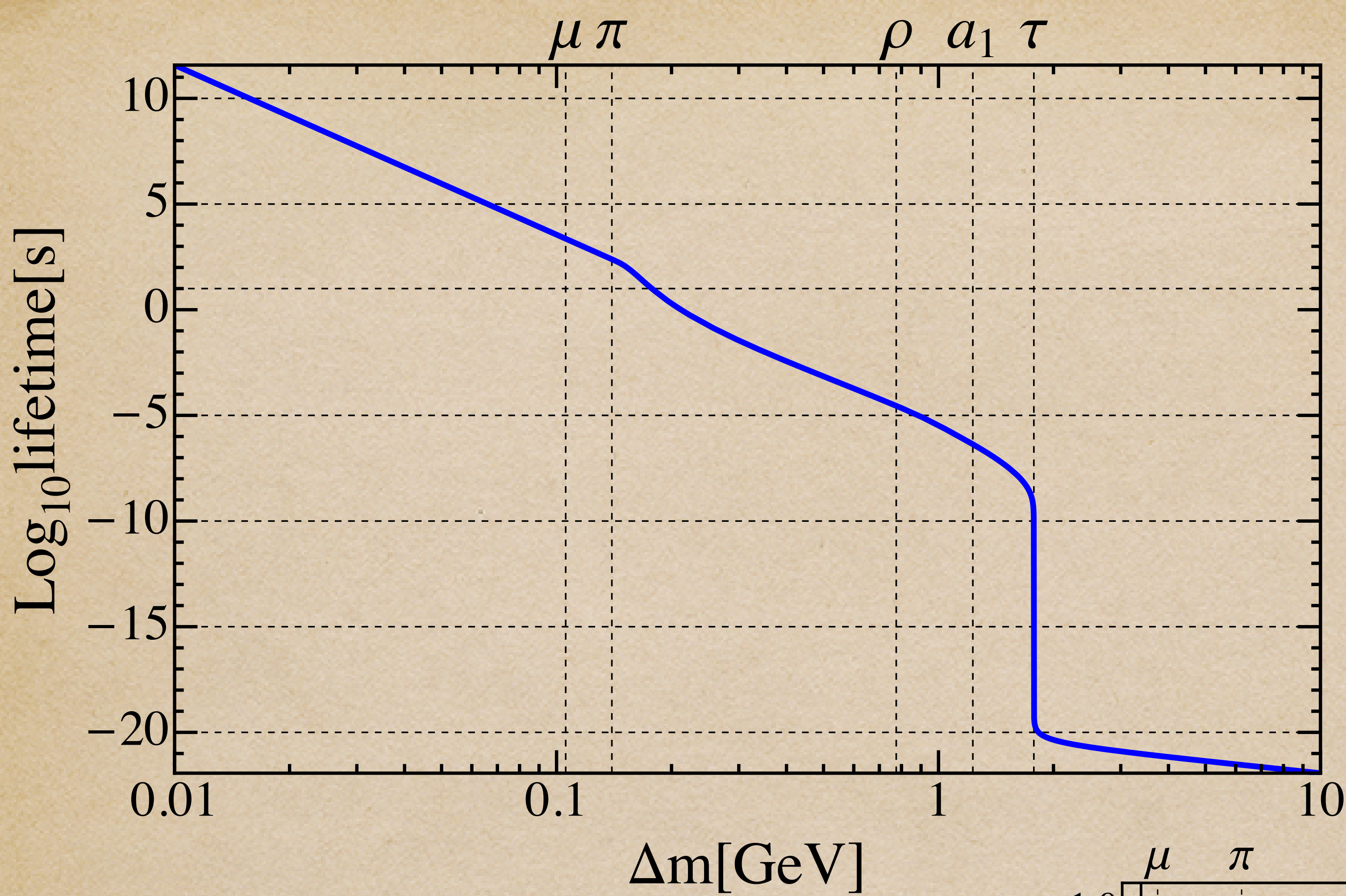
Citron, Ellis, FL, Marrouche, Olive, de Vries (2012)

Desai, Ellis, FL, Marrouche (2014)

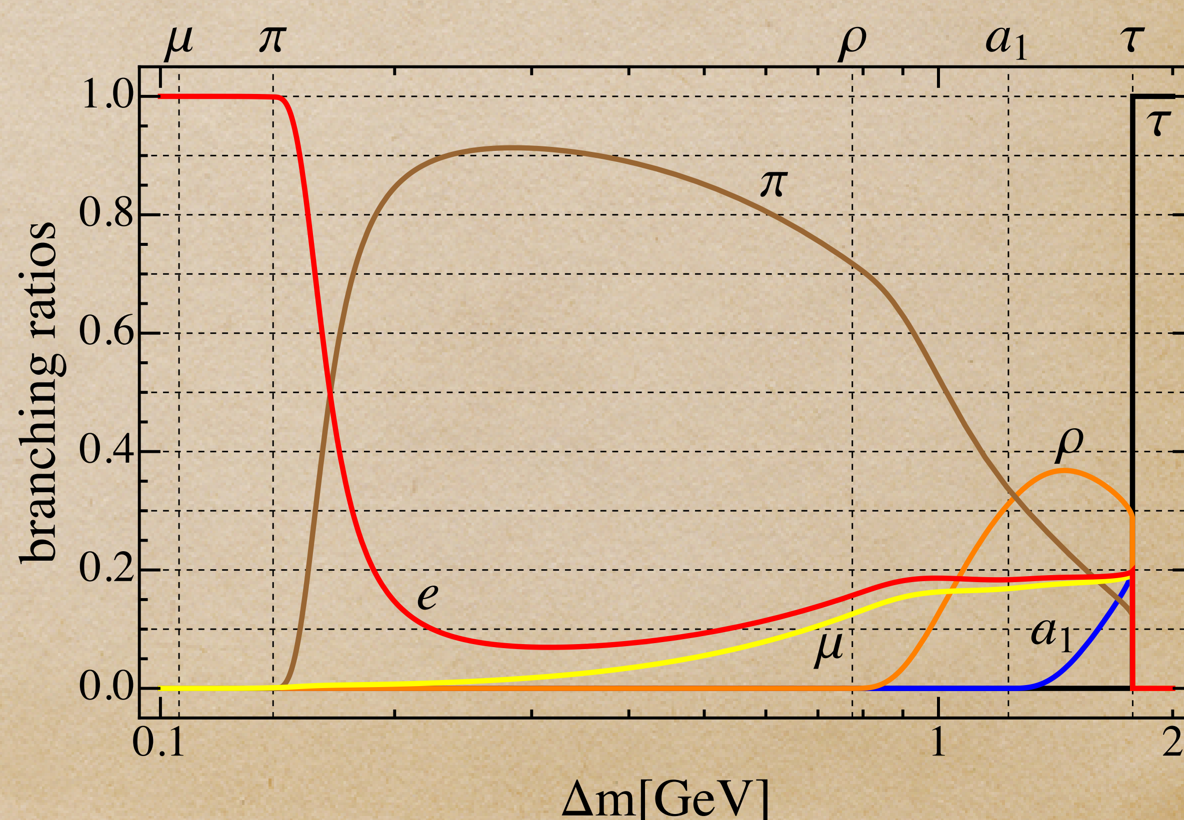


MasterCode Collaboration (2012)

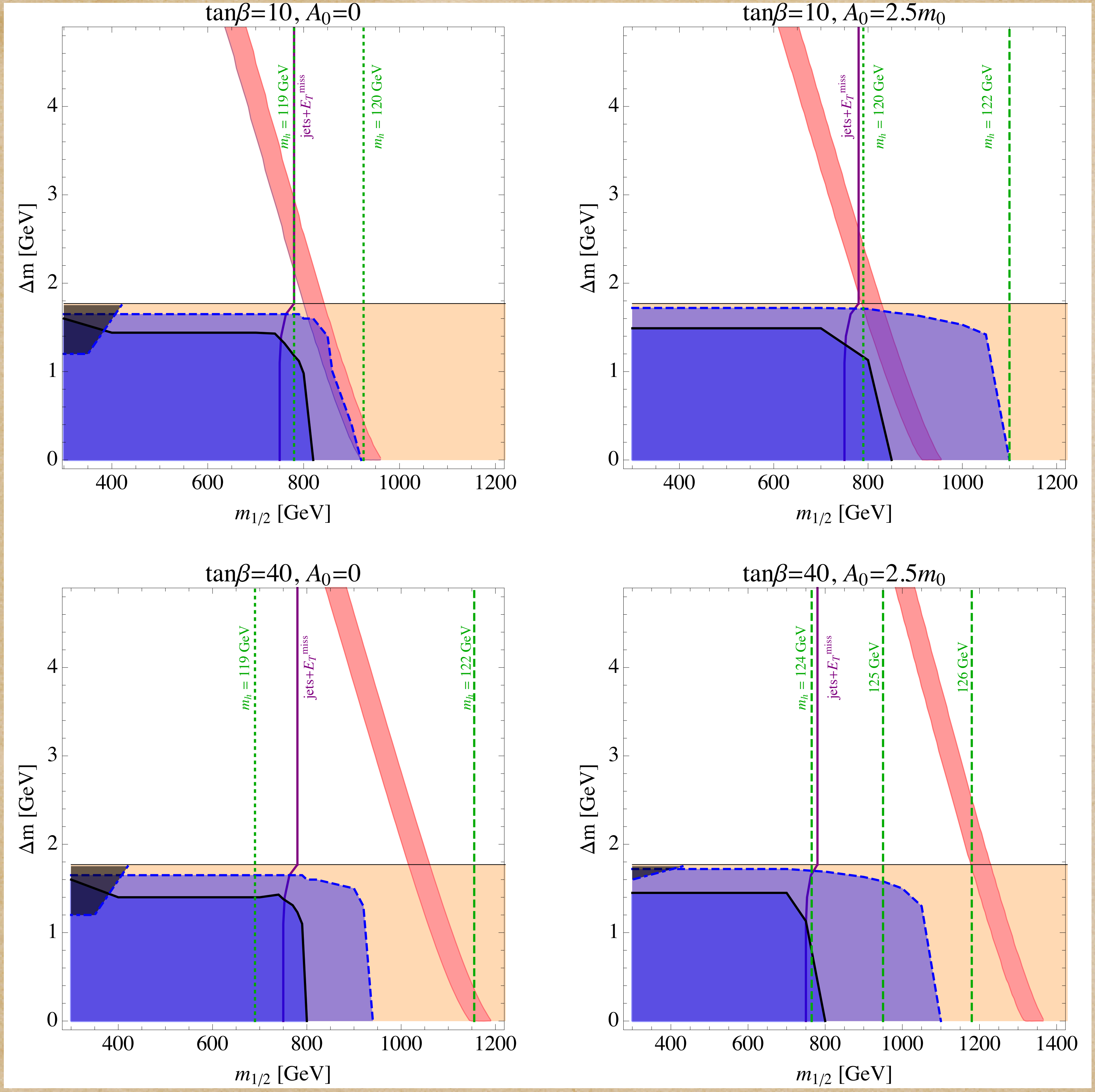
http://mastercode.web.cern.ch/mastercode/



μ π ρ a1 τ
10
5
0
−5
−10
−15
−20
Log10lifetime[s]
0.01
0.1
1
10
Δm[GeV]

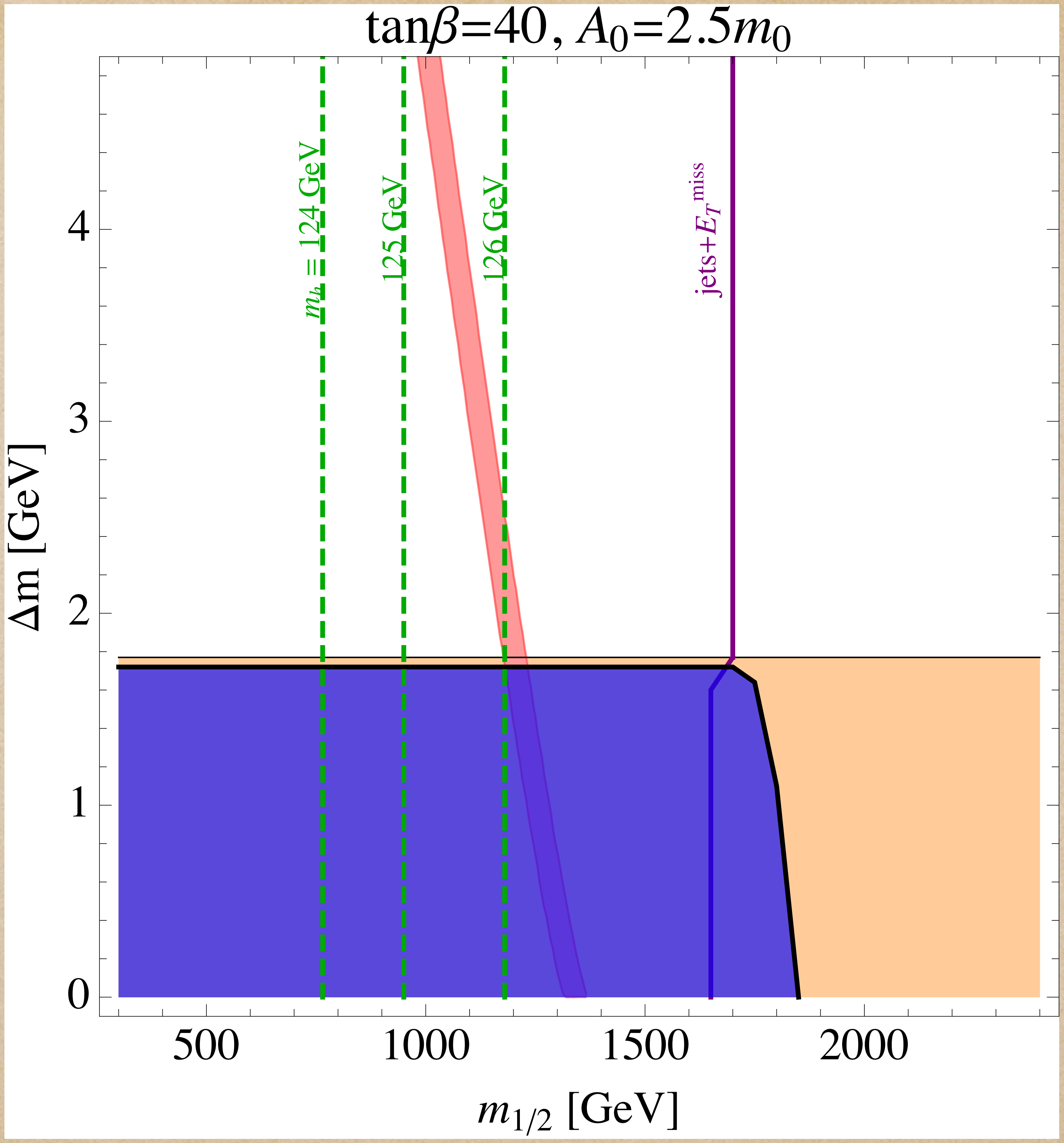


μ π ρ a1 τ
1.0
0.8
0.6
0.4
0.2
0.0
branching ratios
π
ρ
e
μ
a1
τ
0.1
1
2
Δm[GeV]



darker and lighter blue: excluded by searches for the direct and total production of metastable charged particles, respectively.

grey: excluded by searches for particles leaving disappearing tracks.



Projected limits from the 14 TeV Run 2 of LHC with 300/fb integrated luminosity.

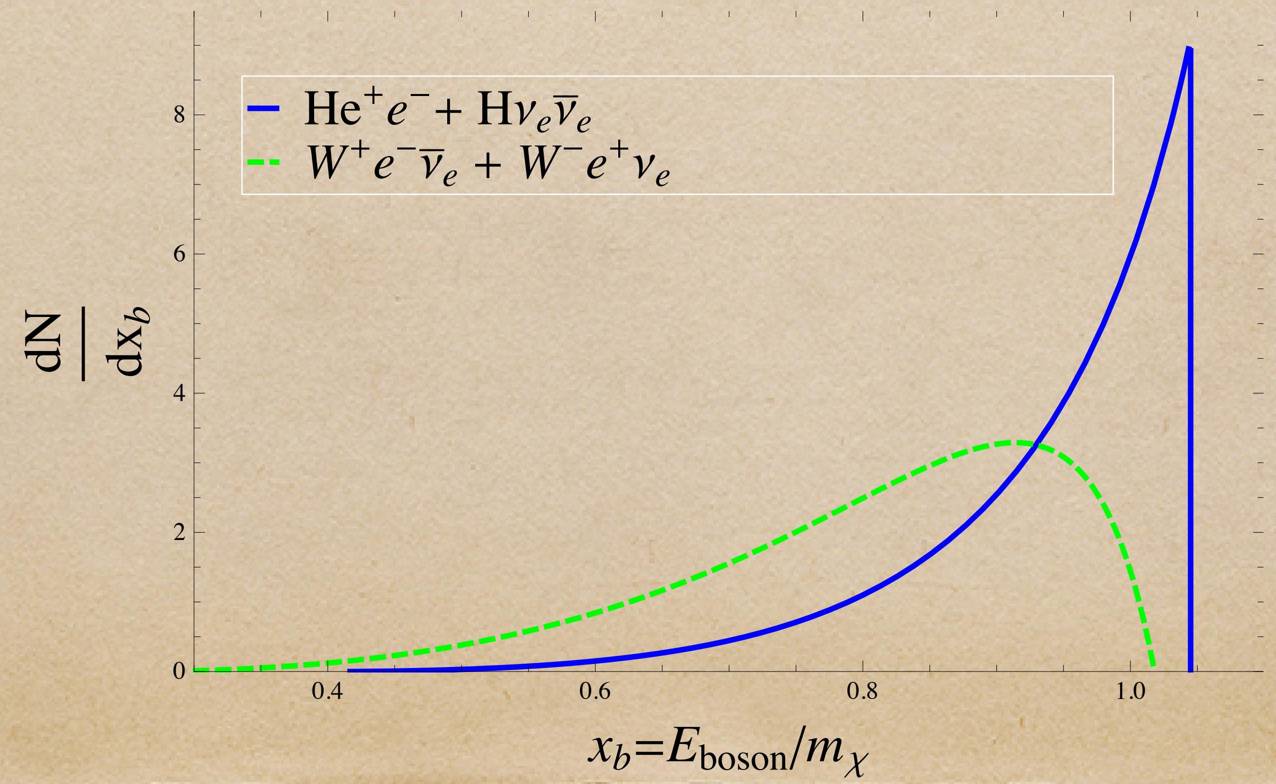
Higgs bremsstrahlung in Majorana DM annihilation

FL, You (2013)

Key idea:

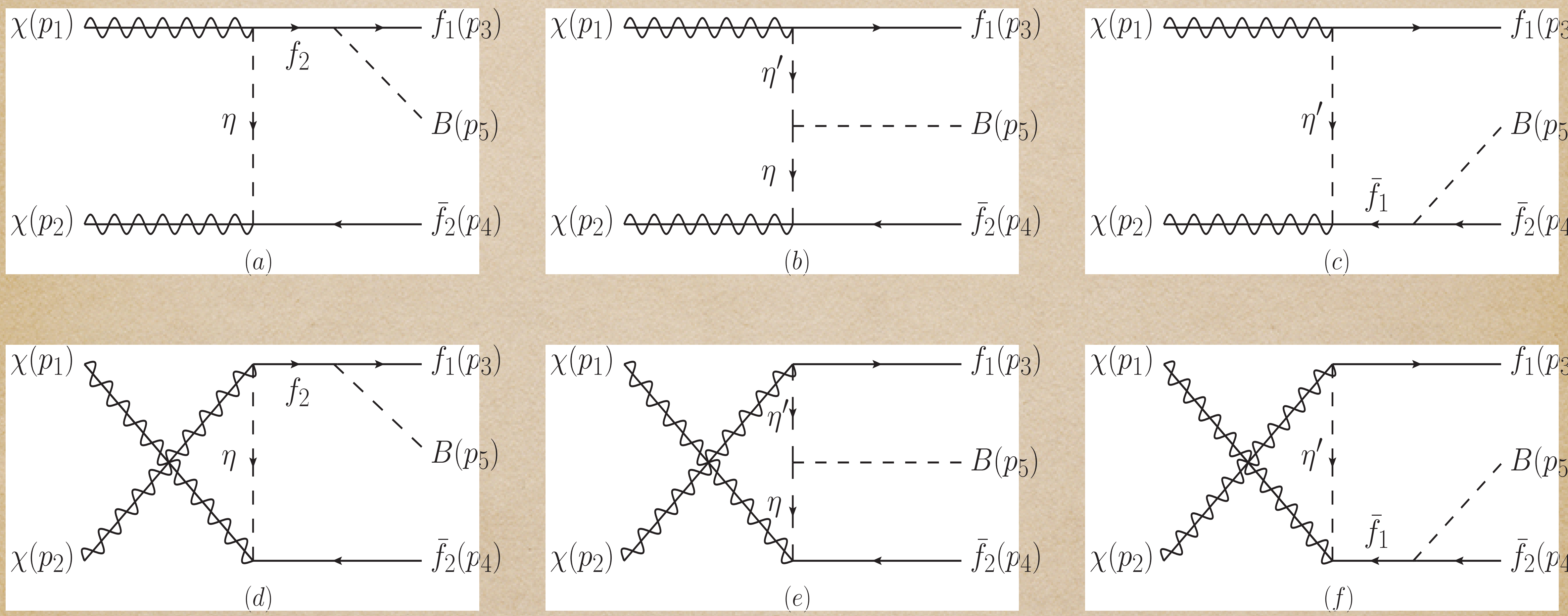
Lift Majorana DM s-wave annihilation by Higgs bremsstrahlung.

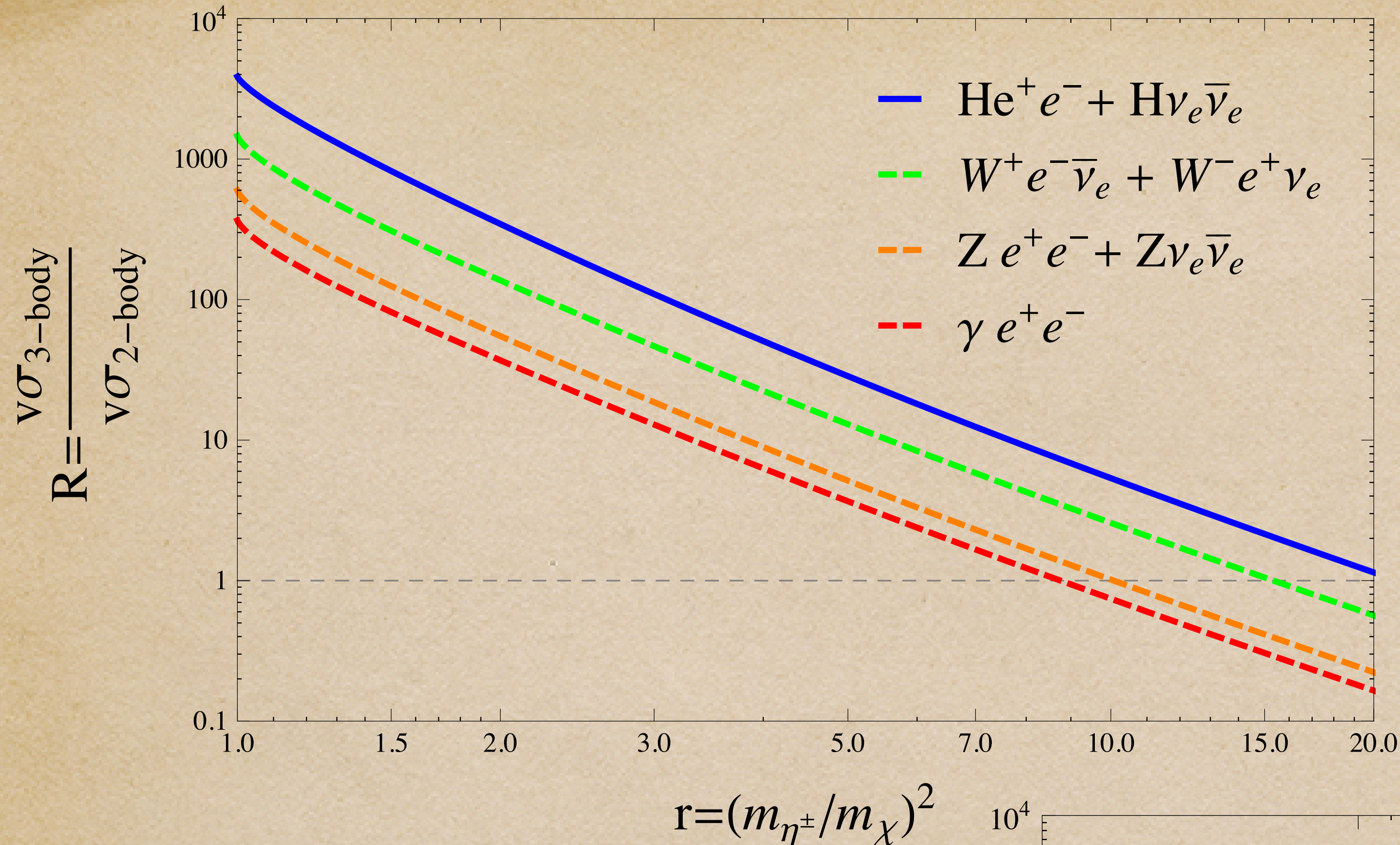
Note: gauge boson bremsstrahlung also does the job, and it has been detailed studied in the literature, e.g., Garny et. al, Bringmann & Calore (2013)



$$\mathcal{L} = \mathcal{L}_{\rm SM} + \frac{1}{2}\bar{\chi} i\partial\!\!\!/\chi - \frac{1}{2}m_\chi \bar{\chi}\chi + (D_\mu \eta)^\dagger (D^\mu \eta) + [y_{\rm DM}\bar{\chi}(Li\sigma_2\eta) + {\rm h.c.}] - V_{\rm scalar}$$

$$V_{\rm scalar} = \mu_1^2 \Phi^\dagger\Phi + \frac{1}{2}\lambda_1(\Phi^\dagger\Phi)^2 + \mu_2^2\eta^\dagger\eta + \frac{1}{2}\lambda_2(\eta^\dagger\eta)^2 + \lambda_D(\Phi^\dagger\Phi)(\eta^\dagger\eta) + \lambda_F(\Phi^\dagger\eta)(\eta^\dagger\Phi)$$





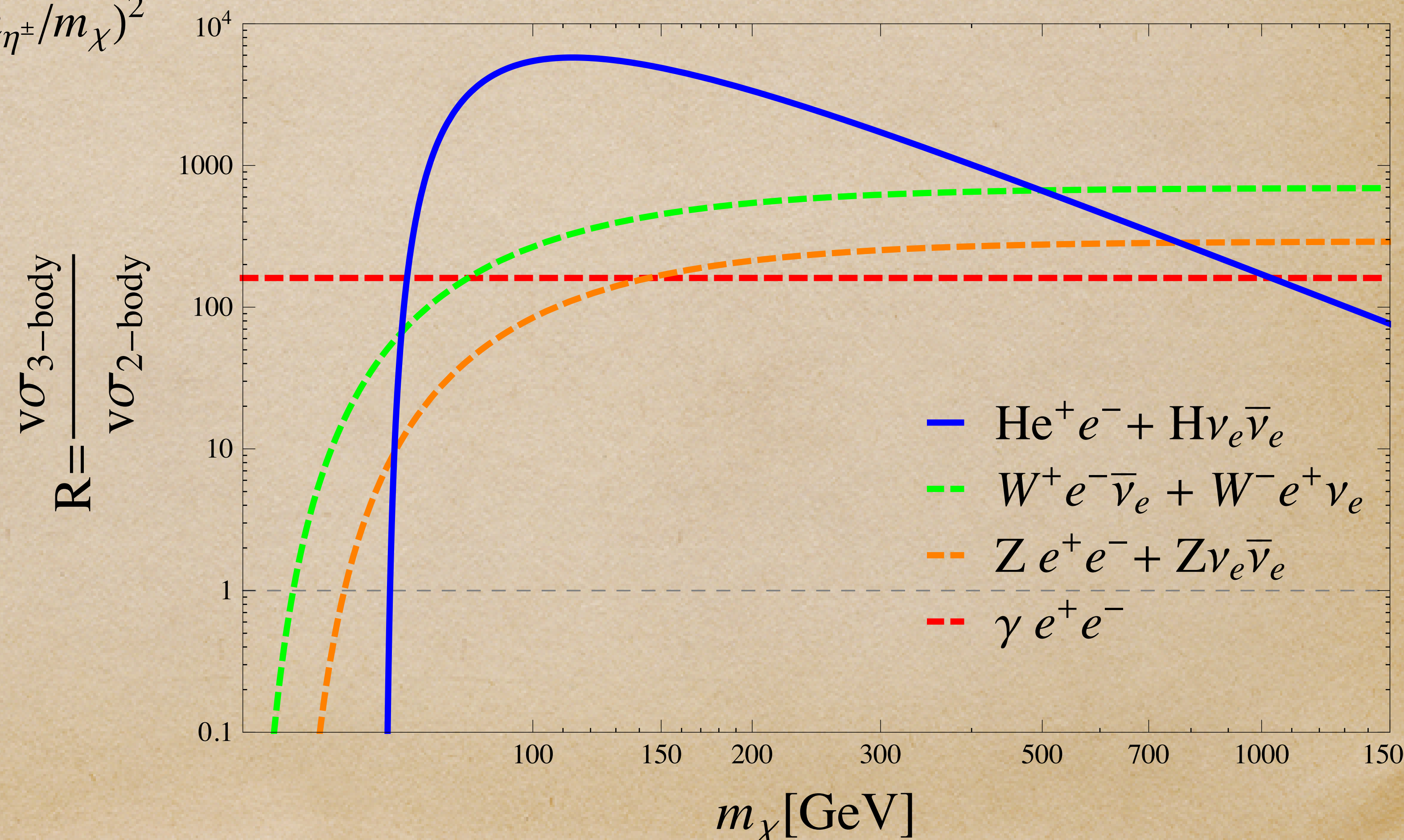
300 GeV DM,

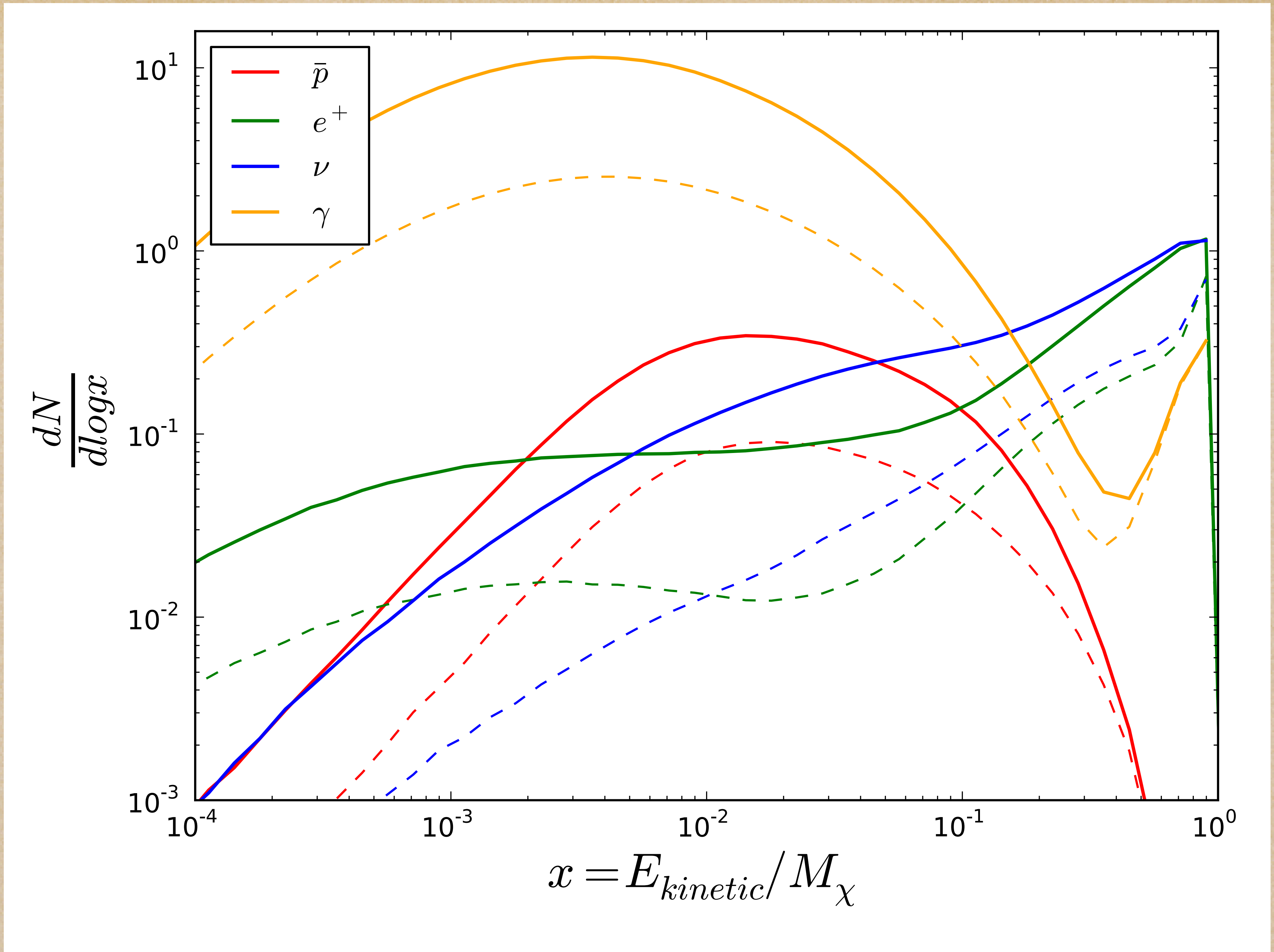
scalar-scalar-Higgs-Higgs coupling ~ 1,

v~10^(-3).

~10% mass splitting between DM and intermediate scalars,

scalar-scalar-Higgs-Higgs coupling ~ 1.





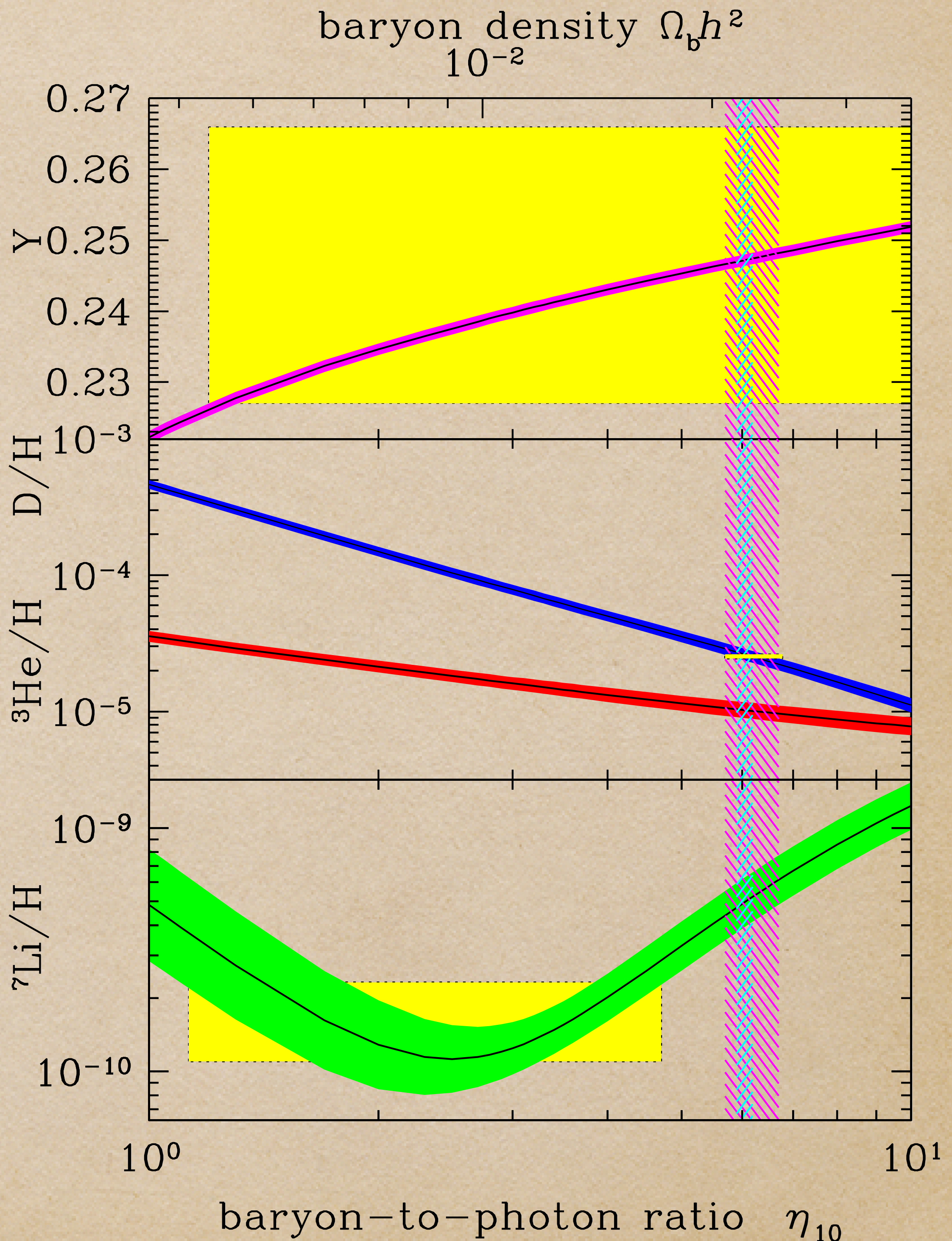
300 GeV DM,

~10% mass splitting between DM and intermediate scalars,

scalar-scalar-Higgs-Higgs coupling ~ 1.

BBN achievement and lithium-7 problem

- sensitive to baryon-to-photon ratio (now can be read from CMB)
- span 9 orders of magnitude, overall good agreement with observations
- lithium-7 problem



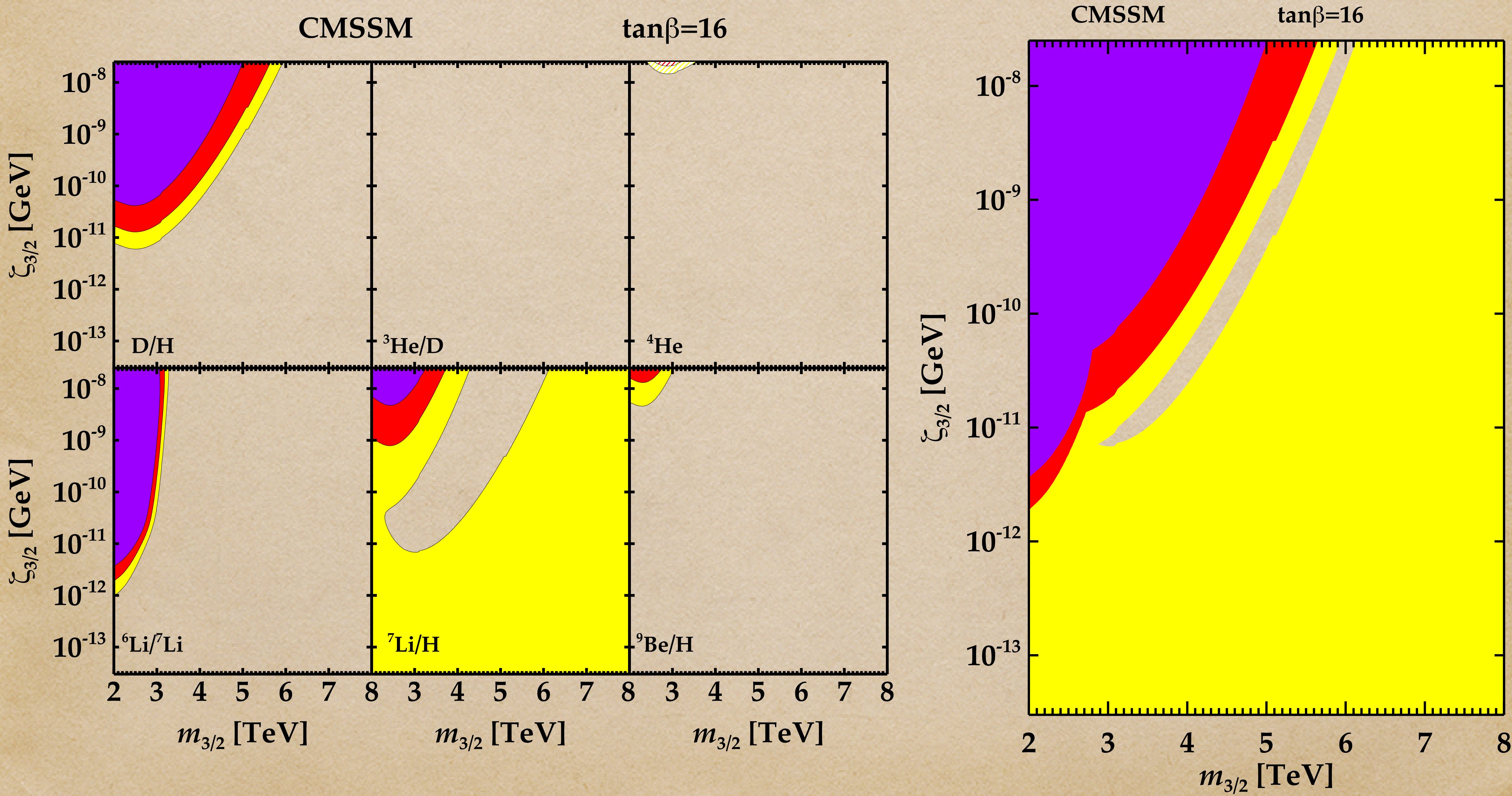
picture from PDG

Key idea:

BSM particle decays or annihilates during or after BBN —> produce electromagnetic and hadronic showers —> interact with background nuclei and change nuclei abundances —> constrain BSM models and maybe solve lithium-7 problem

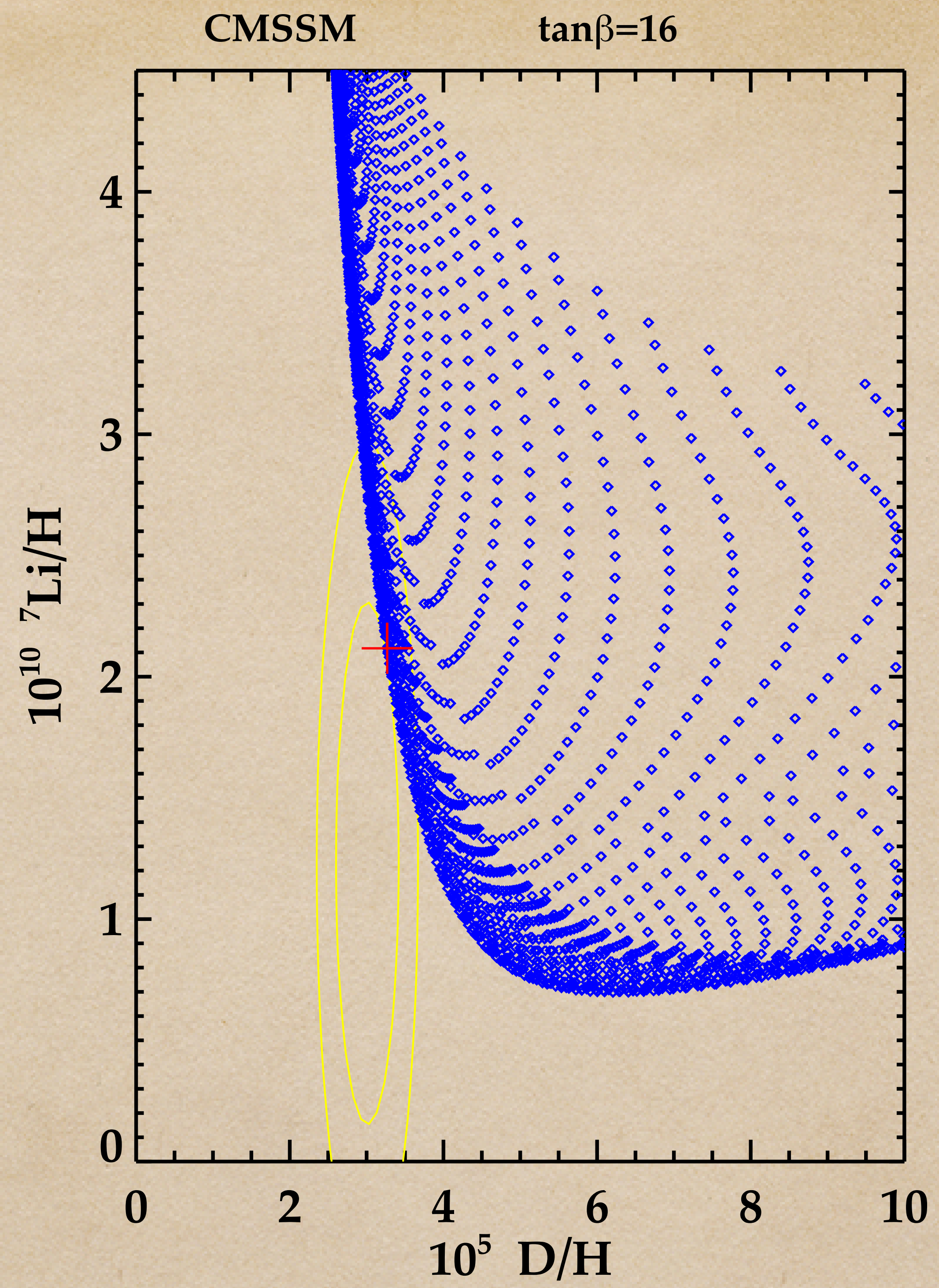
Gravitino Decays and the Cosmological Lithium Problem in Light of the LHC Higgs and Supersymmetry Searches

Cyburt, Ellis, Fields, FL, Olive, Spanos (2013)



ID	Model	Ref	$m_{1/2}$	m_0	A_0	$\tan\beta$	μ	m_χ	m_h	$m_{3/2}$	$\zeta_{3/2}$	$\tau_{3/2}$	$\chi^2_{\min}$
1	CMSSM	[19]	905	361	1800	16	> 0	395	123.8	4560	1.5×10^{-10}	208	2.81
2	CMSSM	[19]	1895	1200	1200	50	> 0	857	123.3	5520	1.8×10^{-10}	231	2.86
3	NUHM1	[19]	970	345	2600	15	2600	427	123.8	4600	1.2×10^{-10}	220	2.82
4	NUHM1	[19]	2800	1040	2100	39	3800	1288	124.0	6200	2.6×10^{-10}	276	3.14
5	CMSSM	Fig. 2d of [21]	1115	1000	2500	40	> 0	496	124.8	4800	1.6×10^{-10}	213	2.87
6	NUHM1	Fig. 5b of [21]	1175	1500	3000	40	500	499	125.9	5000	2.6×10^{-10}	188	2.86
7	NUHM1	Fig. 6b of [21]	1300	1000	2500	30	-550	550	125.5	4700	1.0×10^{-10}	258	2.87
8	subGUT CMSSM	Fig. 9c of [21]	2040	2200	5500	10	> 0	1554	126.7	5400	1.6×10^{-10}	214	2.96
9	subGUT mSUGRA	Fig. 10d of [21]	2400	4000	Polonyi	36	> 0	1099	125.4	6000	1.6×10^{-10}	239	2.91
10	subGUT mSUGRA	Fig. 10d of [21]	1700	2000	Polonyi	33	> 0	1110	124.0	5100	1.6×10^{-10}	219	2.89
11	CMSSM$^{(a)}$	[19]	905	361	1800	16	> 0	395	123.8	4440	1.5×10^{-10}	230	1.25
12	CMSSM$^{(b)}$	[19]	905	361	1800	16	> 0	395	123.8	4520	1.0×10^{-10}	215	0.52
13	CMSSM$^{(c)}$	[19]	905	361	1800	16	> 0	395	123.8	4360	7.1×10^{-11}	245	0.37

Table 2: *The models studied, with references, their input parameters and the corresponding values of m_h calculated using* `FeynHiggs` *[41] (which have an estimated theoretical uncertainty $\gtrsim 1.5$ GeV), the best-fit gravitino mass $m_{3/2}$ and abundance $\zeta_{3/2}$, and the minimum χ^2 in a global fit to the observed values of the light-element abundances. All mass parameters are expressed in GeV units, and the best-fit lifetime $\tau_{3/2}$ is in seconds. The subGUT model in Fig. 9c of [21] assumes $M_{in} = 10^9$ GeV, and those in Fig. 10d of [21] assume $M_{in} = 10^{10}$ GeV. In models 11 through 13, the χ^2 and best-fit values are computed using (a) the D/H sample variance uncertainty, (b) the ^{7}Li/H abundance as determined from globular clusters, and (c) both the D/H sample variance uncertainty and the globular cluster ^{7}Li/H.*

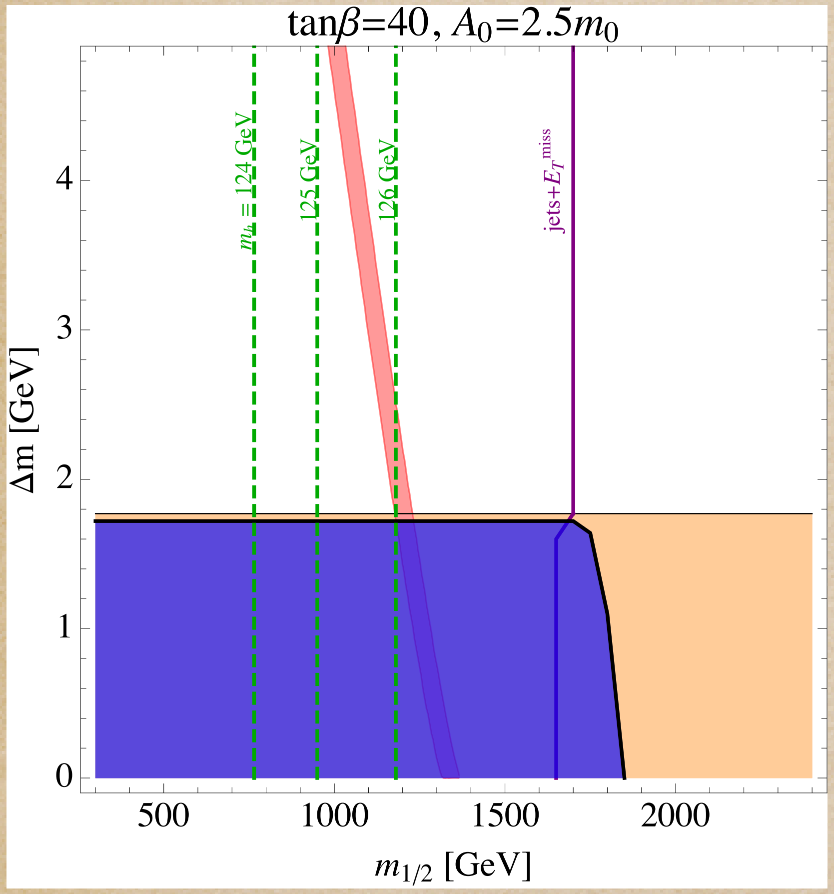


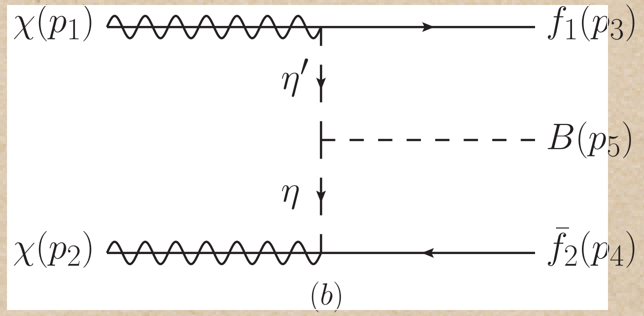
Lower li7 with the cost of increasing D.

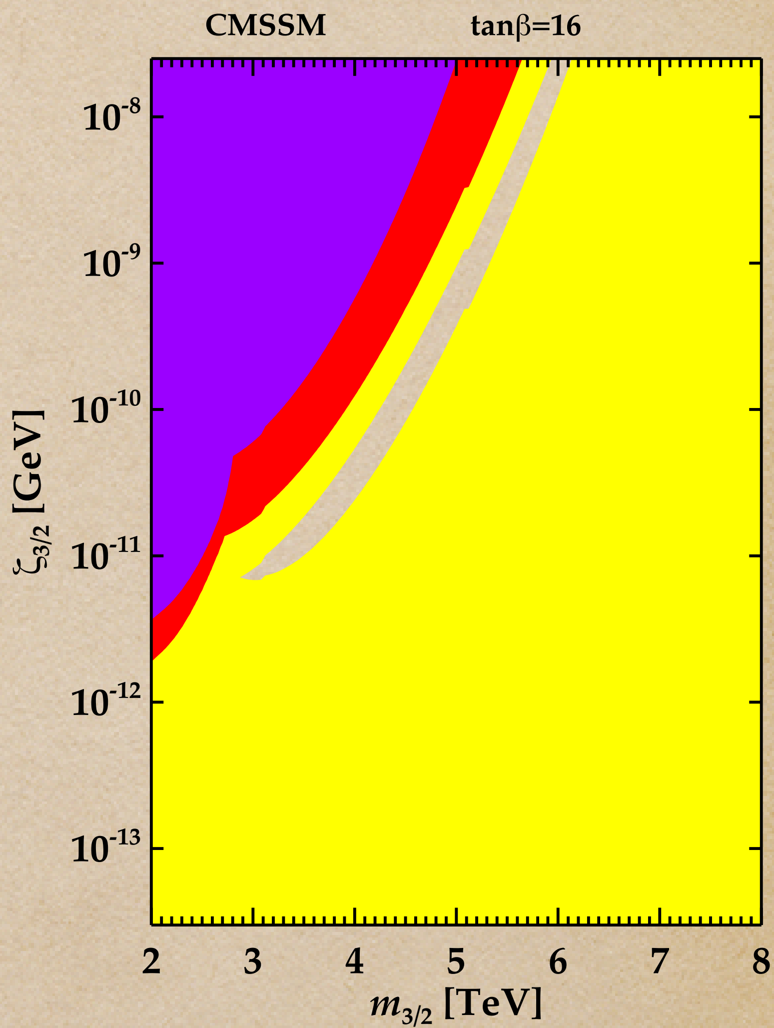
But what if D is measured very accurately, so that there is no room to play? (1308.3240)

Need to think another way.

Summary







Thank you for your attention!