THE THEORY PERSPECTIVE AFTER RUN I

Diphoton excess at 750 GeV?

~ 150 theoretical papers on its interpretation

IS THE EFFECT REAL?

MANY PLAUSIBLE INTERPRETATIONS BUT:

- NONE OF THE „READY" BSM MODELS CAN EXPLAIN IT, ALTHOUGH IN PRINCIPLE THEY CONTAIN „SUFFICIENT INGREDIENTS"

- EVEN THEN, SOME DEGREE OF ARTIFICIALITY ALWAYS PRESENT

NEW PARTICLES NEEDED: SPIN 0 OR SPIN 2

AND NEW FERMIONS AROUND 1 TeV

PERTURBATIVE AND STRONGLY INTERACTING SCENARIOS
(MORE QUALITATIVE)

IN THE FOLLOWING: SPIN 0 (SCALAR OR PSEUDO-SCALAR)
EFFECTIVELY COUPLED AT LEAST TO GLUONS
(FOR PRODUCTION) AND PHOTONS (FOR THE OBSERVED
DECAY CHANNEL)

COUPLINGS TO OTHER SM PARTICLES ARE OF COURSE ALSO
POSSIBLE (MORE MODEL DEPENDENT ISSUE)

UNDER THE ASSUMPTION THAT THE NEW PARTICLE IS PRODUCED

VIA GLUON FUSION, ONE CAN FIT ITS MASS, WIDTH AND

$$\sigma(pp \to X) \times BR(X \to \gamma\gamma)$$

FALKOWSKI, SLONE, VOLANSKY (PRODUCTION VIA GLUON FUSION)
ALTMANNSHOFER ET AL

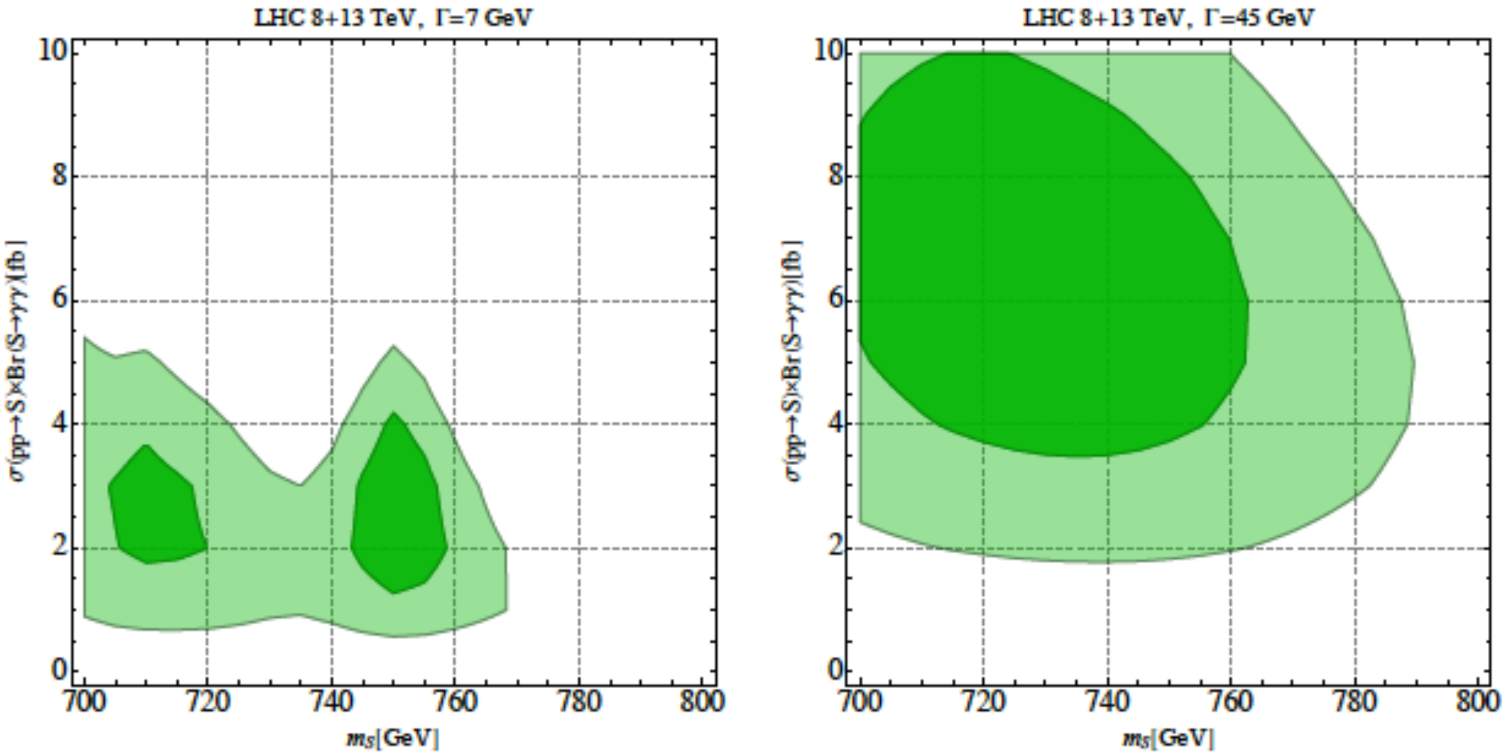


Figure 3. The 68% CL (darker green) and 95% CL (lighter green) regions in the plane of mass vs. cross-section of a scalar resonance decaying to 2 photons favored by the ATLAS and CMS run-1 and run-2 data . The results are presented assuming a Breit-Wigner shape with $\Gamma = 7$ GeV (left) and $\Gamma = 45$ GeV (right).

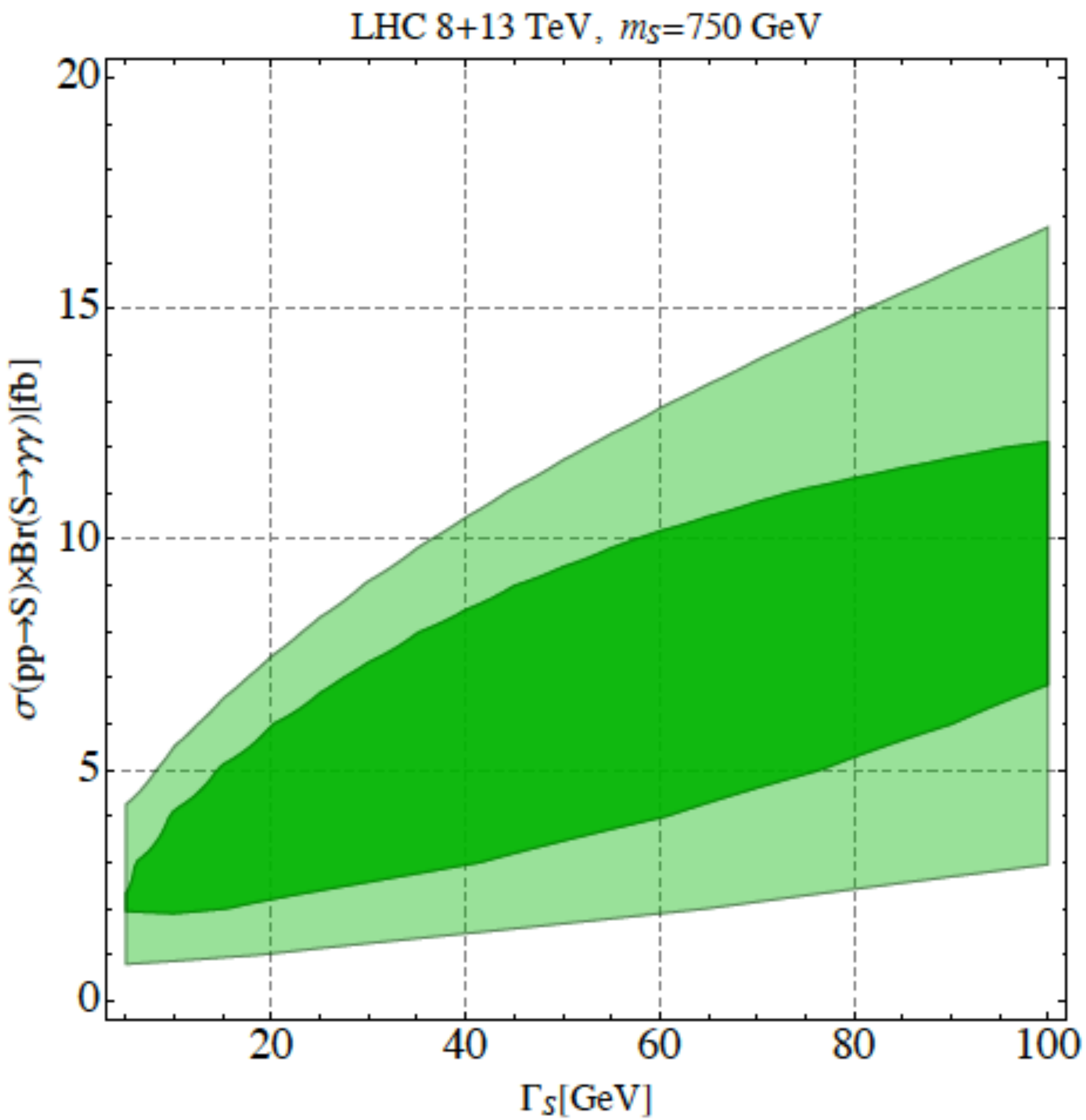
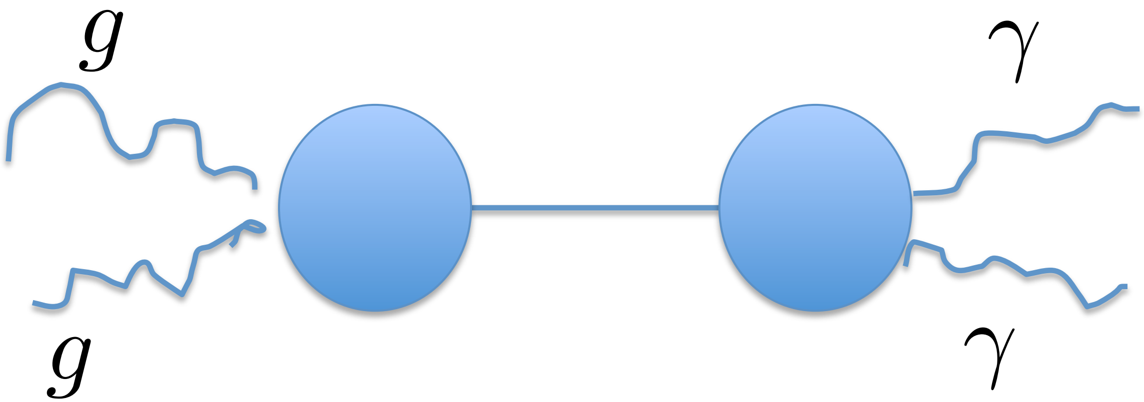


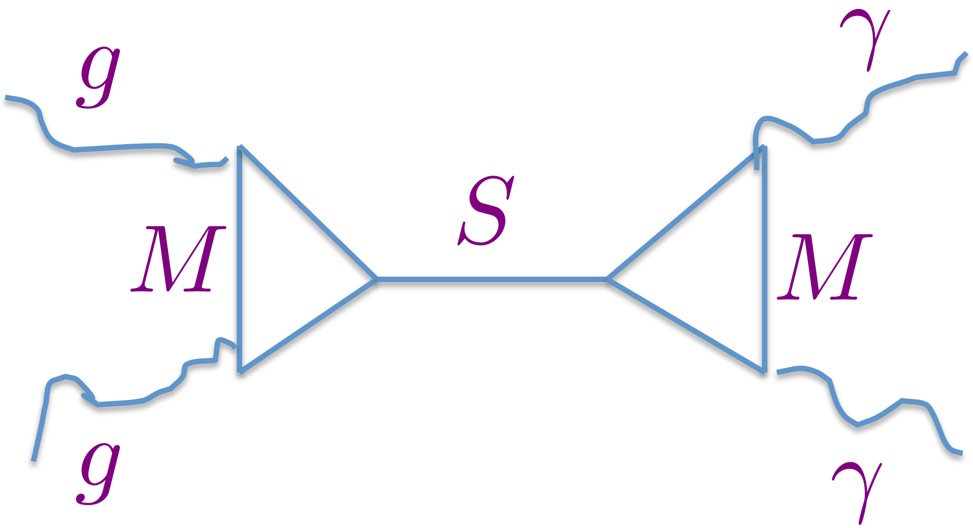
Figure 4. The 68% CL (darker green) and 95% CL (lighter green) regions in the plane of width vs. cross-section of a 750 GeV scalar resonance decaying to 2 photons favored by the ATLAS and CMS run-1 and run-2 data .

EFFECTIVE THEORY (AFTER ELECTROWEAK SYMMETRY BREAKING):

$$\mathcal{L} = \lambda_g \frac{\alpha_s}{12\pi v} S G^a_{\mu\nu} G^a_{\mu\nu} + \lambda_\gamma \frac{\alpha}{\pi v} S F_{\mu\nu} F^{\mu\nu} + \ldots$$



EXPLICIT MODELS, WITH RENORMALIZED COUPLINGS



VECTOR-LIKE FERMIONS IN ALL INTERPRETATIONS
OF 750 GeV EXCESS

S- SINGLET OF SU(2)xU(1)

$$\mathcal{L} = c_f S f \bar{f}$$

FERMIONS ARE COLORED AND CHARGED UNDER SU(2)xU(1) OR PART OF IT;

THE LOOPS CONTRIBUTE TO THE EFFECTIVE LAGRANGIAN AND GIVE

$$\lambda_{g,\gamma} \approx c_f \frac{v}{M} \times \text{GROUP FACTORS}$$

GENERIC PREDICTIONS:

- SEVERAL VECTOR-LIKE FERMIONS AND/OR LARGE YUKAWA COUPLINGS c_f NEEDED
- OTHER DECAY CHANNELS PRESENT (WW, ZZ, Zγ)
- ONLY SMALL WIDTH SOLUTIONS
- ONLY SMALL MIXING OF S WITH h ACCEPTABLE (S→hh DANGEROUS FOR THE FIT)

final state f	σ at $\sqrt{s} = 8\,\text{TeV}$ observed	expected	ref.	implied bound on $\Gamma(S \to f)/\Gamma(S \to \gamma\gamma)_{\text{obs}}$
$\gamma\gamma$	< 1.5 fb	< 1.1 fb	[6, 7]	$< 0.8\ (r/5)$
$e^+e^- + \mu^+\mu^-$	< 1.2 fb	< 1.2 fb	[8]	$< 0.6\ (r/5)$
$\tau^+\tau^-$	< 12 fb	15 fb	[9]	$< 6\ (r/5)$
$Z\gamma$	< 4.0 fb	< 3.4 fb	[10]	$< 2\ (r/5)$
ZZ	< 12 fb	< 20 fb	[11]	$< 6\ (r/5)$
Zh	< 19 fb	< 28 fb	[12]	$< 10\ (r/5)$
hh	< 39 fb	< 42 fb	[13]	$< 20\ (r/5)$
W^+W^-	< 40 fb	< 70 fb	[14, 15]	$< 20\ (r/5)$
$t\bar{t}$	< 550 fb	-	[16]	$< 300\ (r/5)$
invisible	< 0.8 pb	-	[17]	$< 400\ (r/5)$
$b\bar{b}$	$\lesssim 1$ pb	$\lesssim 1$ pb	[18]	$< 500\ (r/5)$
jj	$\lesssim 2.5$ pb	-	[5]	$< 1300\ (r/5)$

S- SECOND HIGGS IN THE 2HDM OR IN MSSM:

SIMILAR RESULTS, IN PARTICULAR TOO SMALL RATES WITH JUST THE SM PARTICLES IN THE LOOPS (THE COUPLINGS TO GLUONS AND PHOTONS ONLY AT THE LOOP LEVEL BUT TREE LEVEL DECAYS TO THE SM FERMIONS MAKE THE TOTAL WIDTH LARGE AND THE BR(H→2γ) TOO SMALL

DIFFERENCES

$$\mathcal{L} = yH\bar{Q}_L U_R + y' H\bar{Q}_R U_L + M\bar{Q}_L Q_R + M\bar{U}_L U_R + \ldots$$

$$\lambda_{g,\gamma} \approx c_f \frac{v^2}{M^2} \times \text{ GROUP FACTORS}$$

DIFFERENCES:

MORE VECTOR-LIKE FERMIONS NEEDED, OF ORDER OF 10

STRONGER MASS SUPPRESSION MEANS LARGER YUKAWA COUPLINGS

ANOTHER INTERESTING POSSIBILITY: NONE OF THE VECTOR-LIKE FERMIONS IS CHARGED UNDER COLOR. S CAN BE PRODUCED THROUGH THE VECTOR BOSON FUSION. IT CAN WORK IF S IS NARROW. MAIN SIGNATURE: NO DI-JETS IN THE FINAL STATE.

OVERALL CONCLUSION:

THE PICTURE IS A BIT FUZZY. VARIOUS OPTIONS ARE OPEN

BUT NONE IS REALLY STRIKING. AN OBVIOUS EXPERIMENTAL

DIRECTION (APART FROM CONFIRMING THE 2 PHOTON

EXCESS) IS TO SEARCH FOR SIGNALS IN OTHER CHANNELS, TO

UNDERSTAND THE ORIGIN OF THE EFFECTIVE LAGRANGIANS.

ON THE THEORY SIDE: DEVELOP MORE COMPLETE MODELS , WITH SOME ADDITIONAL MOTIVATION

Diphoton excess, diboson excess, a couple of flavour anomalies (SOME HINTS OF LEPTON FLAVOUR VIOLATION)…. let's forget them for a moment.

What is then the theory perspective after RUN I?

AT LEAST AT THE ELECTROWEAK SCALE, THE SM IS A CORRECT EFFECTIVE THEORY OF ELECTROWEAK INTERACTIONS

IS THE SM A CONSISTENT THEORY UP TO THE PLANCK SCALE ?

YES!

RENORMALIZABLE

NO LANDAU POLE UP TO Mp

(ALMOST) STABLE VACUUM UP TO Mp

THOSE CONCLUSIONS STRONGLY DEPEND ON

$$m_t = 173GeV, \quad m_h = 125GeV$$

THE SM LOOKS PERFECT BUT IT CANNOT BE
THE THEORY OF EVERYTHING.

INDEED,

DONT RUSH TO A TOO QUICK CONCLUSION   ON THE VALIDITY OF THE SM TO   PLANCK SCALE BECAUSE, E.G:

HIGGS COUPLINGS VERSUS NEW SCALES:

$$M = 1 TeV$$ ⇨ less than (3- 5) % deviations from the SM couplings

VERY CHALLANGING: DEVIATIONS MAY BE OF THE ORDER OF THE PRESENT UNCERTAINITIES IN THE SM PREDICTIONS

IT IS RENORMALIZABLE, SO TO GO BEYOND IT ONE

HAS TWO OPTIONS: PRODUCE NEW PARTICLES (DIPHOTONS, DIBOSONS)

OR SEE ANOMALIES IN PRECISION DATA (FLAVOR ANOMALIES).

ARE WE SO LUCKY??

CONTRARY TO THE PAST, WE ARE NOT DATA DRIVEN TO GET A HINT OF THE VALUE OF A NEW MASS SCALE…

THE FERMI FOUR-FERMION THEORY FOR

THE NEUTRON $\beta -$ DECAY HAS

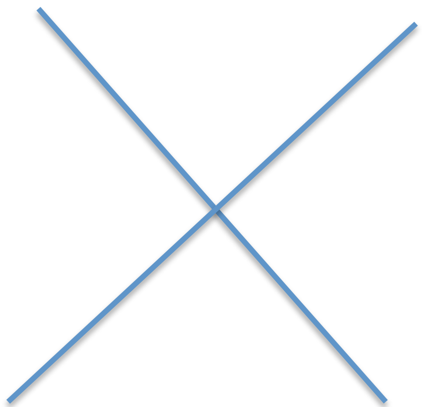
INTRODUCED A NEW MASS SCALE INTO

PARTICLE PHYSICS AND A GUARANTEE

OF NEW DISCOVERIEs

$$\mathcal{L}_F \approx G_F \bar{\Psi}^p_L \gamma_\mu \Psi^n_L \bar{\Psi}^e_L \gamma^\mu \Psi^\nu_L$$

$$G_F \approx 1/10^5 GeV^2$$



$$G_F E^2 \approx \frac{E^2}{(100\ GeV)^2}$$

2+2→2+2 SCATTERING AMPLITUDE

(e.g. N+positron→P+antyneutrino)

EVENTUALLY VIOLATES UNITARITY AND „SOMETHING NEW" MUST HAPPEN TO RESTORE IT!

NOW, THE ONLY „HINT” FOR THE VALUE OF A NEW MASS SCALE IS THE HIERARCHY (NATURALNESS) PROBLEM

TWO MAIN DIRECTIONS:

SUPERSYMMETRY **COMPOSITE HIGGS MODELS**

BOTH PREDICT NEW COLORED TOP PARTNERS (SCALARS IN SUSY, FERMIONS IN COMPOSITE HIGGS)

AT WHAT MASS SCALE?

NON-OBSERVATION OF NEW COLORED PARTICLES UP TO 1 TeV IS PUTTING THE IDEA OF NATURALNESS UNDER CERTAIN PRESSURE (1:100 CANCELLATIONS IN THE HIGGS POTENTIAL ARE NEEDED)

REVIVAL OF THE IDEAS OF HIDDEN (UNCOLORED) NATURALNESS WITH NEW COLORED PARTICLES ABSENT OR SIGNIFICANTLY HEAVIER

TWIN HIGGS

SM-LIKE HIGGS IS A PSEUDO-GOLDSTONE BOSON OF AN APPROXIMATE GLOBAL SU(4) SYMMETRY

$$\mathcal{H} = \begin{pmatrix} H_A \\ H_B \end{pmatrix} \quad \begin{matrix} SU(2) \\ \text{hidden } SU(2) \end{matrix}$$

$$V = \lambda \left(|\mathcal{H}|^2 - f^2/2 \right)^2$$

$$\langle \mathcal{H} \rangle = f/\sqrt{2}$$

SU(4) broken to SU(3)

7 GOLDSTONE BOSONS: 3 + 3 + 1

eaten Higgs

SU(4) IS EXPLICITLY BROKEN BY GAUGE & YUKAWA COUPLINGS OF THE SM.

ADDITIONAL ASSUMPTIONS: SM GAUGE BOSONS AND FERMIONS ARE MIRRORED, SO THAT THE SPECTRUM IS Z_2 SYMMETRIC (NOT A FULL REPRESENTATION OF SU(4))

THE PARTNER PARTICLES ARE NOT RELATED TO SM STATES BY A CONTINOUS SYMMETRY AND SO NEED NOT CARRY SM GAUGE QUANTUM NUMBERS.

TWIN FERMIONS: Q_B → A DOUBLET OF TWIN SU(2) AND A TRIPLET OF TWIN SU(3) („HIDDEN QCD")

T_B --> A SINGLET OF TWIN SU(2) AND A TRIPLET OF TWIN SU(3)

NEW YUKAWA COUPLING $y_t^B \bar{Q}_B H_B T_B$

QUADRATIC DIVERGENCES OF THE TOP QUARK LOOP ARE CANCELLED BY A TOP QUARK PARTNER WITH THE „HIDDEN” COLOR

TWIN SUSY: EXTENDED HIGGS SECTOR -→

none of the scalars couple to *WW* and to fermions exactly like the SM Higgs boson (because of the mixing between them)

HIGGS DECAYS - A POWERFUL TOOL (IN PRINCIPLE),

IS SENSITIVE TO NEW PHYSICS THAT CANNOT BE

SEEN VIA NEW PARTICLE PRODUCTION

UNCOLORED WAY BEYOND THE SM?

UNCOLORED WAY BEYOND THE SM: MOTIVATED ALSO INDEPENDENTLY OF UNCOLORED NATURALNESS.

EXAMPLES:

- ELECTROWEAK SECTOR IN SPLIT OR MINI-SPLIT SUPERSYMMETRY
- DARK MATTER SEARCHES OR, MORE GENERALLY, SEARCHES FOR STABLE PARTICLES WITH $\Omega \leq \Omega_{obs}$
- Z', MULTI-SCALAR MODELS FOR FLAVOR PHYSICS

COLLIDER SIGNATURES: MONOJETS, DISPLACED VERTICES, DISAPPEARING TRACKS, ...

- ELECTROWEAK SECTOR MAY PLAY LEADING ROLE IN DISCOVERING SUPERSYMMETRY

- ACCEPTING THERMAL HISTORY OF UNIVERSE, IN MODELS WITH STABLE NEUTRALINO (R-PARITY), ITS MASS IS BOUNDED FROM ABOVE BY

$$\Omega h^2 \leq 0.12$$

- **DECOUPLED SFERMIONS (actually, it it's enough to have them 20-30% heavier than gauginos/higgsinos)**

PARAMETERS $M_1, \quad M_2, \quad \mu, \quad \tan\beta$

APPLIES TO MSSM AND ALL MODELS WHERE THE ADMIXTURE OF ADDITIONAL STATES TO LSP AND NLSP IS SMALL

DIRECT DETECTION + LHC -> RELEVANT ELECTROWEAKINO PARAMETR SPACE BEGINS TO BE TESTED

- WHAT IS THE RANGE OF VALUES OF INTEREST FOR Ωh^2
- DIRECT DETECTION
- COLLIDER
- THEIR INTERPLAY

ANALYTICAL QUALITATIVE QUIDE AND NUMERICAL SCANS

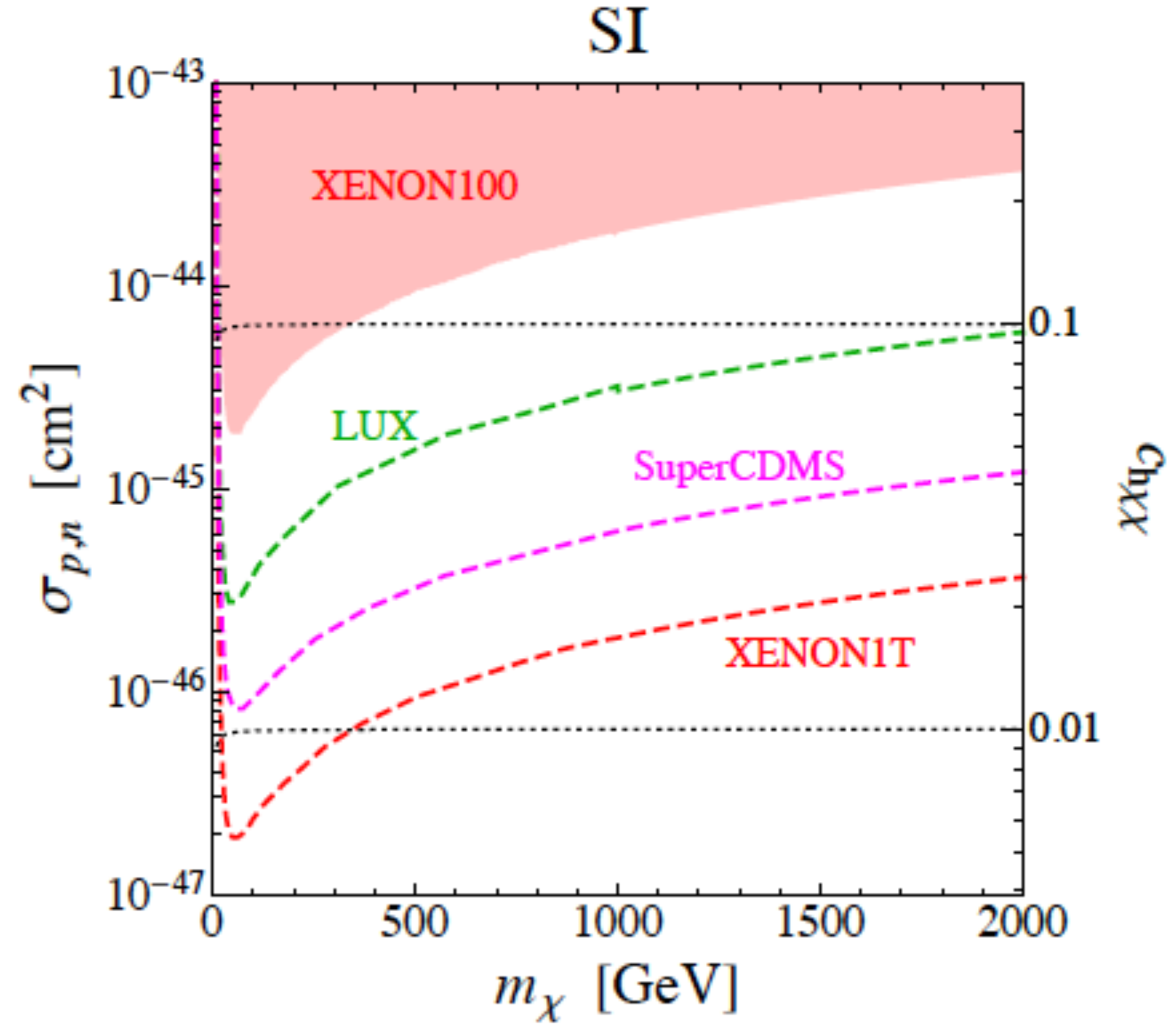
SPIN INDEPENDENT SCATTERING CROSS SECTION

EXCLUSION LIMITS (LUX) AND FUTURE PROSPECTS

REMEMBER: FOR NEUTRALINOS WITH Ω_χ

AND CROSS SECTION σ_{SI}

THE EXCLUSION LIMIT IS $$\frac{\sigma_{SI}^{\chi}}{\sigma_{SI}^{LUX}}\frac{\Omega_\chi}{\Omega_{DM}} > 1$$


SI
XENON100
LUX
SuperCDMS
XENON1T
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
$\sigma_{p,n}$ [cm^2]
0
500
1000
1500
2000
m_χ [GeV]
0.1
0.01
$c_{h\chi\chi}$

CONCLUSIONS (WITH HEAVY SFERMIONS)

DD EXPERIMENTS ARE SENSITIVE TO NEUTRALINOS WITH

$$\Omega h^2 \approx (10^{-4} - 0.12)$$

THE BOUNDS FROM DD EXPERIMENTS PUSH TOWARDS SQUEZEED ELECTROWEAKINO SPECRTRUM, WITH STRONG IMPACT ON THE COLLIDER SIGNATURES

DD EXPERIMENTS + LHC WILL SIGNIFICANTLY EXPLORE THE ELECTROWEAKINO PARAMETER SPACE

(SOME DEGREE OF COMPLEMENTARITY AND SOME OVERLAP IN THE PARAMETER SPACE)

SUMMARY

DIPHOTON EXCESS (ALSO FLAVOR ANOMALIES) REQUIRE MANY NEW STATES AROUND 1 TeV.

THEY MAY NOT BE VERY EXOTIC BUT DO NOT READILY FIT INTO THE EXISTING MODELS, NEITHER (NOT VERY SURPRISING?)

SUCH „FLUCTUATIONS" SHOULD BE TESTED IN A NUMBER OF OTHER CHANNELS

FROM A BROADER PERSPECTIVE,
TESTING A COLORLESS WAY BEYOND THE STANDARD MODEL IS AN IMPORTANT CHALLENGE

NEW COLORED PARTICLES MAY BE HEAVY OR MAY NOT EXIST AT ALL;

IN PARALLEL TO SEARCHING FOR THEIR DIRECT PRODUCTION, TECHNIQUES SHOULD BECOME MORE ADVANCED FOR DISCOVERING NEW UNCOLORED PARTICLES (OR THEIR INDIRECT EFFECTS), WITH MUCH SMALLER
PRODUCTION RATES

BACKUP

FIRST IMPORTANT CONCLUSION:

IN SPITE OF THE (SMALL) FLUX FACTOR,
LUX AND FUTURE DD EXPERIMENTS ARE/WILL
BE SENSITIVE TO NEUTRALINOS EVEN WITH
VERY SMALL Ω_χ

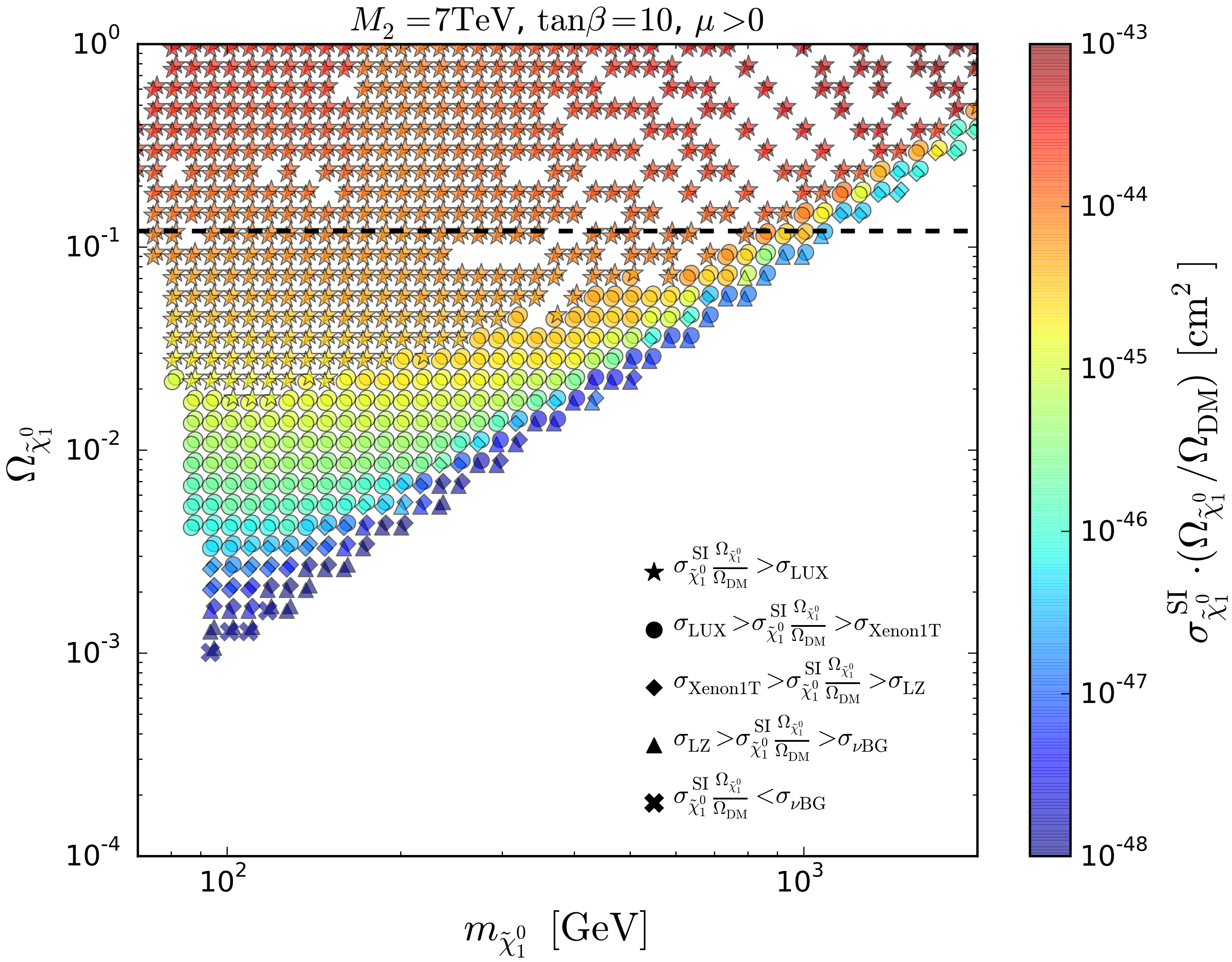
(A SIGNAL WOULD NOT NECESSARILY MEAN THE
DISCOVERY OF THE MAIN DM COMPONENT)

ANOTHER IMPORTANT GENERAL CONCLUSION,
WITH STRONG IMPACT ON THE COLLIDER SEARCHES:

DD LIMITS IMPLY SMALL NLSP-LSP MASS SPLITTINGS

LUX-→ <50 GeV, XENON1T-→ <10GeV

FOLLOWS FROM THE STRONGLY CONSTRAINED FROM ABOVE BINO COMPONENT IN THE LSP BY THE DD LIMITS



$M_2 = 7\mathrm{TeV}$, $\tan\beta = 10$, $\mu > 0$
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
$\Omega_{\tilde{\chi}_1^0}$
10^{2}
10^{3}
$m_{\tilde{\chi}_1^0}$ [GeV]
$\sigma^{\mathrm{SI}}_{\tilde{\chi}_1^0} \frac{\Omega_{\tilde{\chi}_1^0}}{\Omega_{\mathrm{DM}}} > \sigma_{\mathrm{LUX}}$
$\sigma_{\mathrm{LUX}} > \sigma^{\mathrm{SI}}_{\tilde{\chi}_1^0} \frac{\Omega_{\tilde{\chi}_1^0}}{\Omega_{\mathrm{DM}}} > \sigma_{\mathrm{Xenon1T}}$
$\sigma_{\mathrm{Xenon1T}} > \sigma^{\mathrm{SI}}_{\tilde{\chi}_1^0} \frac{\Omega_{\tilde{\chi}_1^0}}{\Omega_{\mathrm{DM}}} > \sigma_{\mathrm{LZ}}$
$\sigma_{\mathrm{LZ}} > \sigma^{\mathrm{SI}}_{\tilde{\chi}_1^0} \frac{\Omega_{\tilde{\chi}_1^0}}{\Omega_{\mathrm{DM}}} > \sigma_{\nu\mathrm{BG}}$
$\sigma^{\mathrm{SI}}_{\tilde{\chi}_1^0} \frac{\Omega_{\tilde{\chi}_1^0}}{\Omega_{\mathrm{DM}}} < \sigma_{\nu\mathrm{BG}}$
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
10^{-48}
$\sigma^{\mathrm{SI}}_{\tilde{\chi}_1^0} \cdot (\Omega_{\tilde{\chi}_1^0}/\Omega_{\mathrm{DM}})$ [cm^2]

$$\sigma_{SI} = 8 \times 10^{-45} cm^2 (\frac{c_{h\chi\chi}}{0.1})^2$$

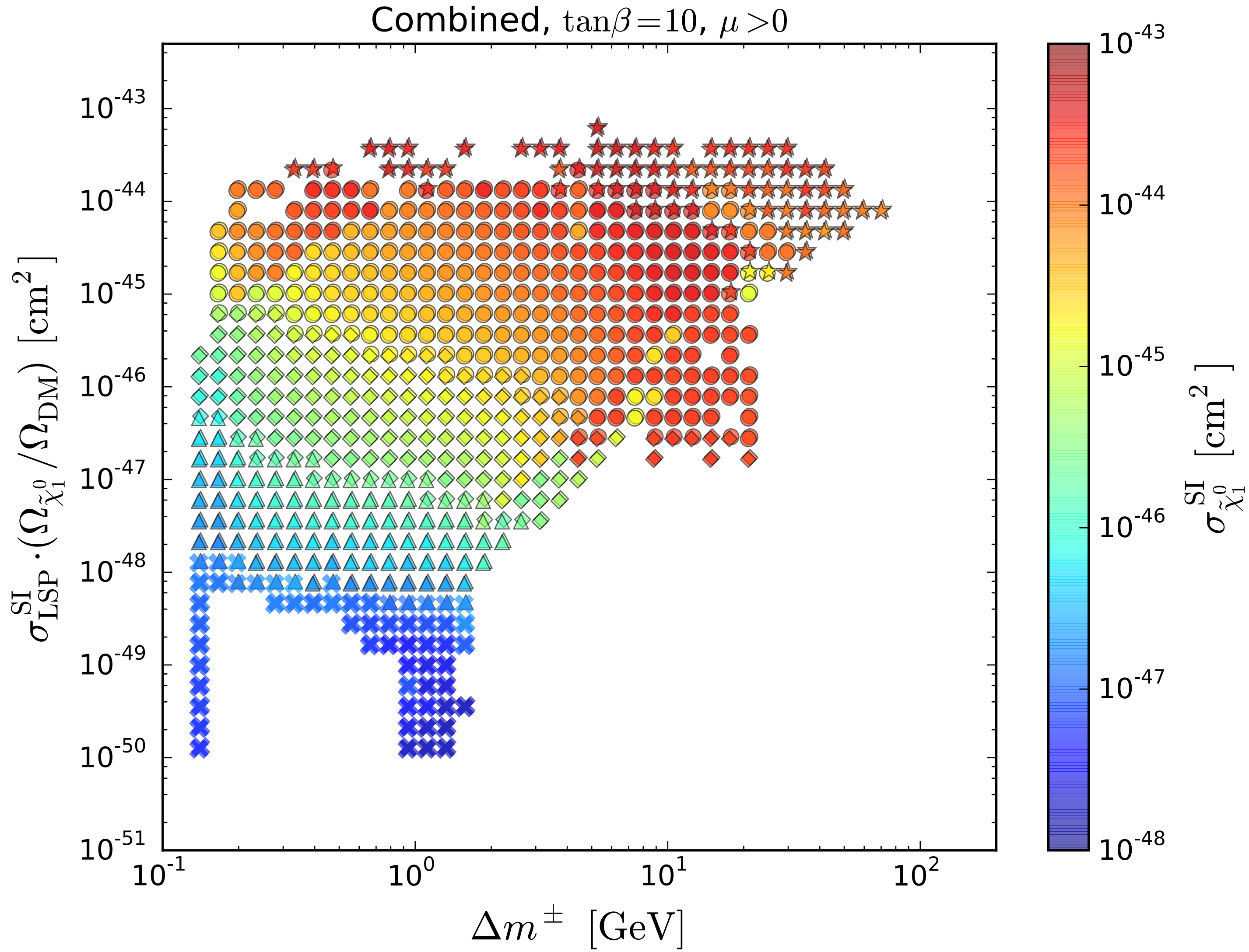
where

$$L = \frac{c_{h\chi\chi}}{2} h(\chi\chi + \chi^\dagger\chi^\dagger)$$

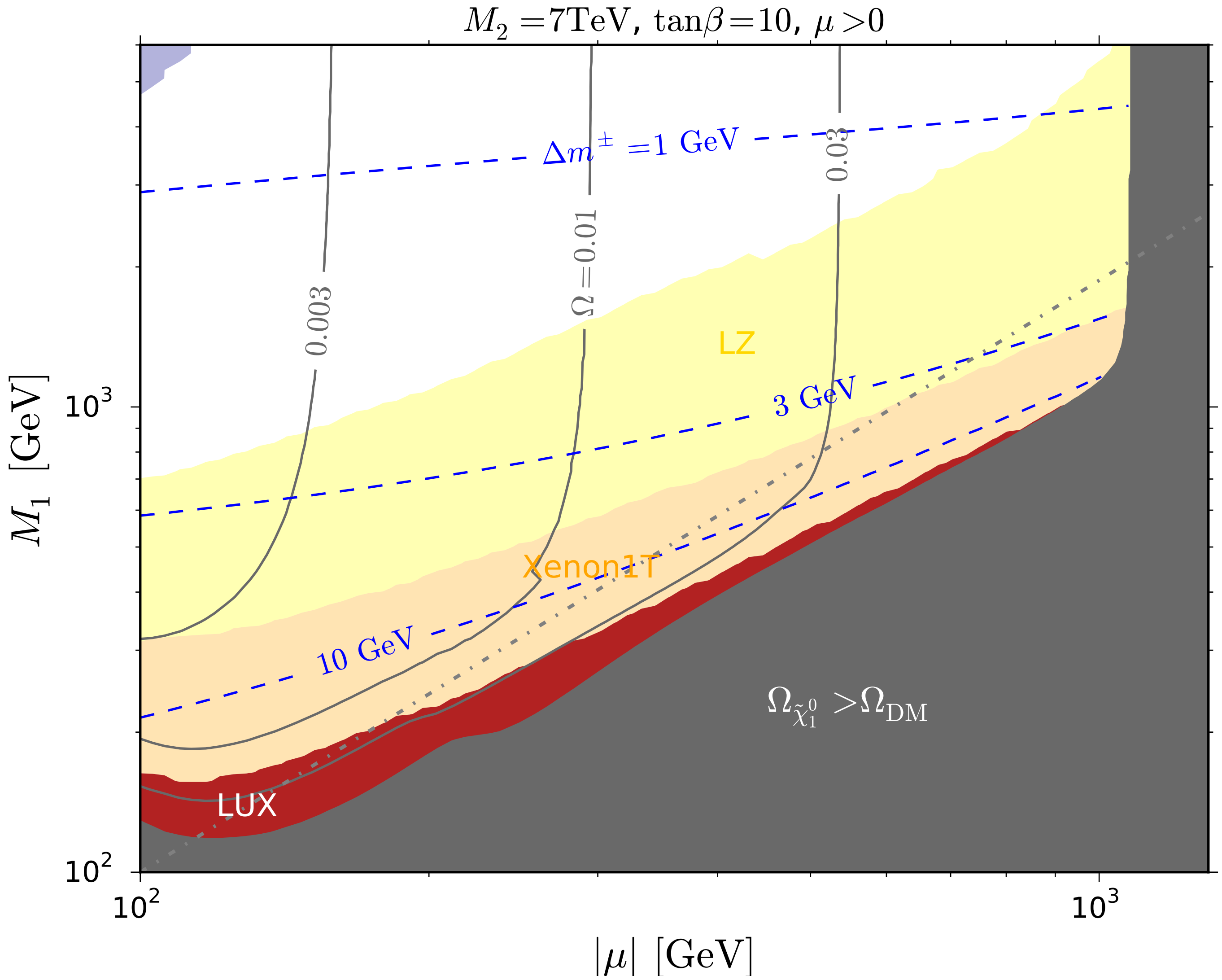
and (approximately) $c_{h\chi\chi} \sim \theta$ (MIXING)

Gaugino/higgsino $\theta = \frac{(\sin\beta \pm \cos\beta)}{\sqrt{2}} (\frac{M_Z}{(\mu \mp M_i)})$

Bino/wino $\theta = \frac{(\sin 2\beta \sin 2\theta_W)}{2} (\frac{M_Z^2}{(M_2 - M_1)\mu})$



Combined, $\tan\beta = 10$, $\mu > 0$
$\sigma^{\rm SI}_{\rm LSP} \cdot (\Omega_{\tilde{\chi}^0_1} / \Omega_{\rm DM})$ [cm^2]
$\Delta m^{\pm}$ [GeV]
$\sigma^{\rm SI}_{\tilde{\chi}^0_1}$ [cm^2]
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
10^{-48}
10^{-49}
10^{-50}
10^{-51}
10^{-1}
10^{0}
10^{1}
10^{2}



M_2 =7TeV, tanβ=10, μ>0
$\Delta m^{\pm}$ =1 GeV
3 GeV
10 GeV
0.003
Ω=0.01
0.03
LZ
Xenon1T
LUX
$\Omega_{\tilde{\chi}_1^0} > \Omega_{\rm DM}$
M_1 [GeV]
$|\mu|$ [GeV]
10^2
10^3

Collider

Drell-Yan production of a pair of gauginos + a hard jet

$\chi_1^+\chi_1^-$, $\chi_2^0\chi_1^0$,

$\chi_1^+\chi_1^0$, $\chi_2^0\chi_1^+$ etc

$$pp \to \text{jet}\ \not{E}_T + X$$

↑ depends on mass differences

Mass differences for $\Omega h^2 \leq 0.12$

$\Delta m = 20-40$ GeV (rare) soft leptons

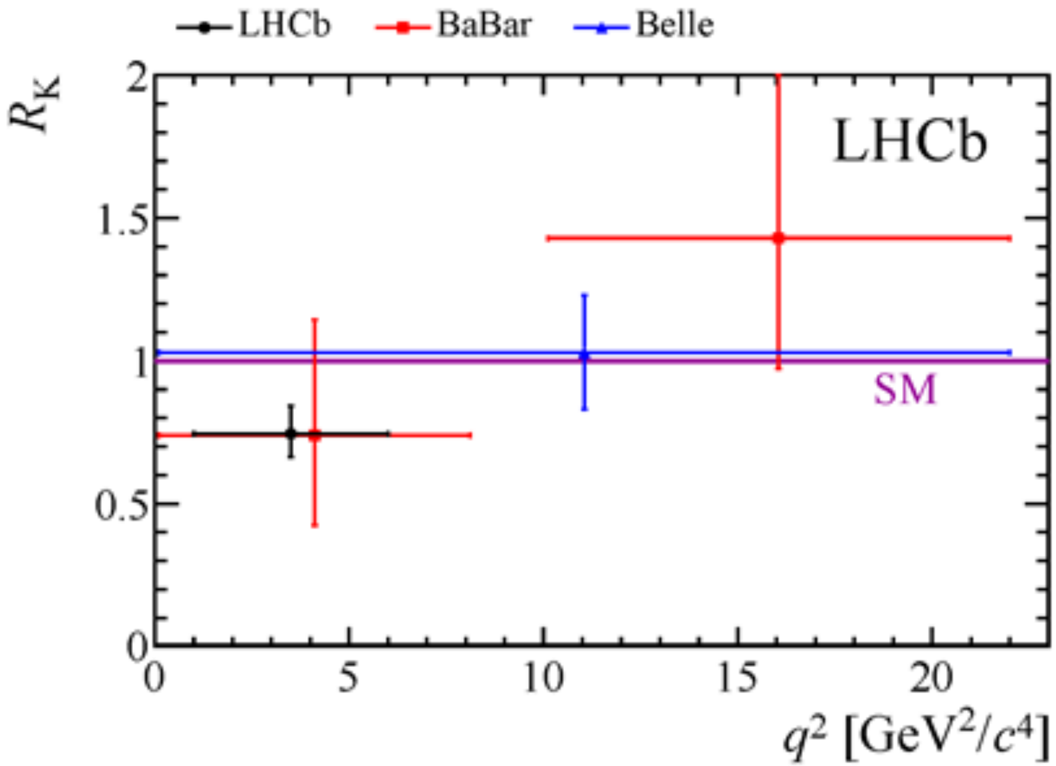
$\Delta m \sim O(1$ GeV$)$ (most frequent, monojets, mono-Z, mono-gamma)

$\Delta m \sim O(200-300$ MeV$)$ (disappearing tracks)

Hints for New Physics in the Flavor Sector

R(K) = B→Kμμ/B→Kee

- Lepton flavour universality violation
- 2.6 σ deviation from the theoretically clean SM expectation



$B \to K^* \mu\mu$

2-3 σ deviation from the SM in some angular distributions

LEPTON UNIVERSALITY VIOLATION IN

$$R(D^{(*)}) \equiv \frac{Br(B \to D^{(*)}\tau\nu)}{Br(B \to D^{(*)}l\nu)}$$

$3-4\ \sigma$ EFFECT

Explanations of the Flavour Anomalies

$b \to s \mu^+ \mu^-$

$b \to c \tau \nu$

Additional neutral gauge bosons (Z')

Leptoquarks

Extended Higgs sector

SUMMARY

FLAVOR IS AN ADDITION TO THE SM BUT CKM MECHANISM OF FLAVOR VIOLATION HAS BEEN CONFIRMED WITH HIGH PRECISION (FLAVOR SENSITIVE FIFTH FORCE)

STRONG SUPPRESSION OF FCNC PROCESSES FOLLOWS FROM EXPERIMENTALLY MEASURED FREE PARAMETRES (YUKAWAS) OF SM

STRONG SUPPRESSION OF FCNCs AND EXP PRECISION → SENSITIVITY TO HIGH MASS SCALES AND TO FLAVOR PATTERN OF NEW FORCES

HINTS FOR LEPTON FLAVOR UNIVERSALITY VIOLATION?

IS FLAVOR A MORE INHERENT PART OF BSM PHYSICS?

Partial unitarization of WW scattering by h :

$$A_{WW} \sim \frac{t}{v^2} - \left(\frac{1}{v^2} - \frac{1}{f^2}\right)\frac{t^2}{t - m_h^2}$$

$$\simeq \frac{t}{f^2} \quad \text{for} \quad t > m_h^2$$

Unitarization must be completed by
- strong sector (resonances)
- or (perturbative case) the scalar $\tilde{S}$

Giudice, Grojean, Pomarol, Rattazzi; Falkowski, SP, Robert

$$g_{hVV} = \sin(\beta - \alpha)$$

$$g_{htt} = \frac{\cos\alpha}{\sin\beta} \qquad g_{hbb} = -\frac{\sin\alpha}{\cos\beta}$$

DECOUPLING LIMIT: $\alpha = \beta - \pi/2$

------→ SM COUPLINGS

H,A heavier than 500 GeV

ADD INFO ON H AND A AS A FUNCTION OF THE HIGGS COUPLINGS

It is covenient to organize the discussion according to the LSP composition

BINO-HIGGSINO MIXING $\left(M_2 = m_{sf} = m_A = 7\,TeV\right)$

HIGGSINO-WINO MIXING $\left(M_1 = m_{sf} = m_A = 7\,TeV\right)$

BINO-WINO MiXING WITH $\mu = 1.1\,min(M_1, M_2)$

AND MORE GENERAL BINO-HIGGSINO-WINO MIXING

PURE HIGGSINO

$$\Omega_h h^2 = 0.10(\frac{\mu}{1\ TeV})^2$$

$$\Omega h^2 < 0.12$$ for

$$\mu < 1 TeV$$

PURE WINO

$$\Omega_w h^2 = 0.13(\frac{M_2}{2.5\ TeV})^2$$

$$\Omega h^2 < 0.12$$ for

$$M_2 < 2.2(2.8) TeV$$

LOWER BOUND ON CHARGINO MASS GIVES LOWER BOUND FOR Ω ; ADDING BINO COMPONENT GIVES LARGER Ω (WHEN SFERMIONS ARE HEAVY)

MOTIVATION

- MULTI-COMPONENT DARK MATTER? WHY ONLY ONE STABLE PARTICLE IN THE „DARK SECTOR”….

- A VARIETY OF GAUGE MEDIATION MECHANISMS, WITH DIFFERENT PATTERNS OF ELECTROWEAKINO MASSES (anomaly med, mirage med……

CONCLUSION: INVESTIGATE ELECTROWEAKINO SECTOR WITH $\Omega_\chi \leq \Omega_{obs}$

THE 1-LOOP RADIATIVE POTENTIAL FOR $H_A \& H_B$

$$16\pi^2 V^{1-loop} = -6\Lambda^2 (y_t^{(A)2} |H_A|^2 + y_t^{(B)2} |H_B|^2)$$
$$+3y_t^{(A)4} |H_A|^4 ln(\Lambda^2 / y^{(A)2} |A|^2) + (A \to B, y_t^A \to y_t^B)$$

$Z_2 : y_t^A = y_t^B \longrightarrow$ **THIS CONTRIBUTION RESPECTS THE GLOBAL SYMMETRY, SO CANNOT CONTRIBUTE TO THE MASS OF THE NGBs**

Λ IS A CUT OFF OF 5-10 TeV
(SOLVING SMALL HIREARCHY PROBLEM)