GGI CONF. THE DARK MATTER CONNECTION:THEORY & EXPERIMENT,

FIRENZE, 17 – 21 MAY 2010

BETTING ON DARK MATTER IN THE RACE FOR NEW PHYSICS

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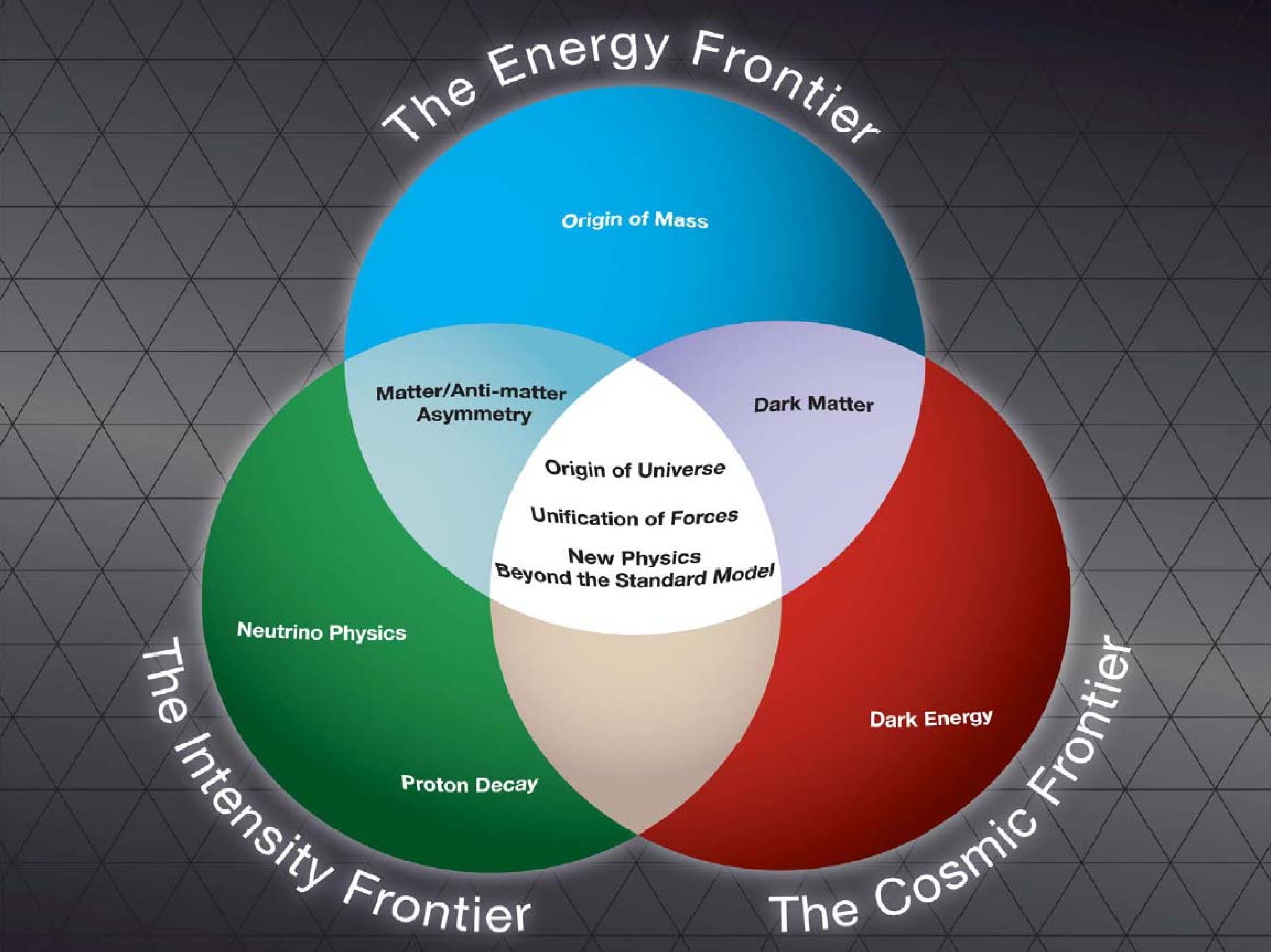

The Energy Frontier
Origin of Mass
Matter/Anti-matter Asymmetry
Dark Matter
Origin of Universe
Unification of Forces
New Physics Beyond the Standard Model
Neutrino Physics
Dark Energy
Proton Decay
The Intensity Frontier
The Cosmic Frontier

Present "Observational" Evidence for New Physics

- NEUTRINO MASSES ☆☆☆
- DARK MATTER ☆☆☆
- MATTER-ANTIMATTER ASYMMETRY ☆☆
- INFLATION ☆

THEORETICAL REASONS TO GO BEYOND THE SM

- ***FLAVOR PUZZLE*** → **RATIONALE FOR FERMION MASSES AND MIXINGS**

- ***UNIFICATION PROBLEM*** → **NO REAL UNIF. OF ELW.+STRONG INTERACTIONS +GRAVITY LEFT OUT OF THE GAME**

- ***HIERARCHY PROBLEM(S)*** →
- **ULTRAVIOLET COMPLETION OF THE SM TO (NATURALLY) STABILIZE THE ELW. BREAKING SCALE**
- **TUNING OF THE COSMOLOGICAL CONSTANT**
- **STRONG CP PROBLEM (TUNING OF THE QCD θ ANGLE)**

The Energy Scale from the "Observational" New Physics

- neutrino masses
- dark matter
- baryogenesis
- inflation

→ NO NEED FOR THE NP SCALE TO BE CLOSE TO THE ELW. SCALE

The Energy Scale from the "Theoretical" New Physics

☆ ☆ ☆ Stabilization of the electroweak symmetry breaking at M_W calls for an ***ULTRAVIOLET COMPLETION of the SM already at the TeV scale*** +

☆ ***CORRECT GRAND UNIFICATION "CALLS" FOR NEW PARTICLES AT THE ELW. SCALE***

SOMETHING is needed at the TeV scale to enforce the unitarity of the electroweak theory

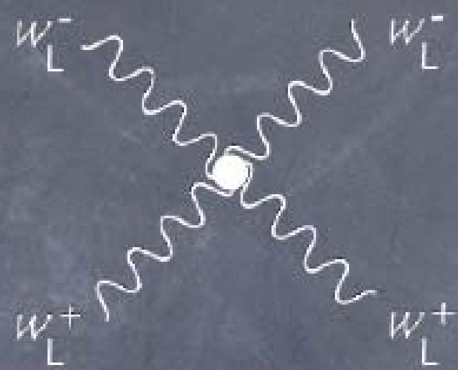
What is the mechanism of EWSB?

susy, LH... models assume that we already know the answer to

What is unitarizing the WW scattering amplitudes?

W_L & Z_L part of EWSB sector ⊃ W scattering is a probe of Higgs sector interactions

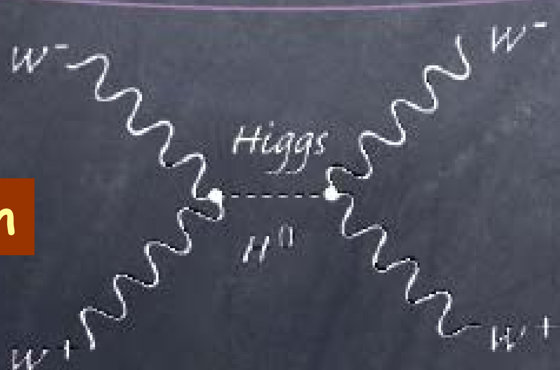
$$\epsilon_l = \left(\frac{|\vec{k}|}{M}, \frac{E}{M} \frac{\vec{k}}{|\vec{k}|} \right)$$



$$A = g^2 \left(\frac{E}{M_W} \right)^2$$

loss of perturbative unitarity
around 1.2 TeV

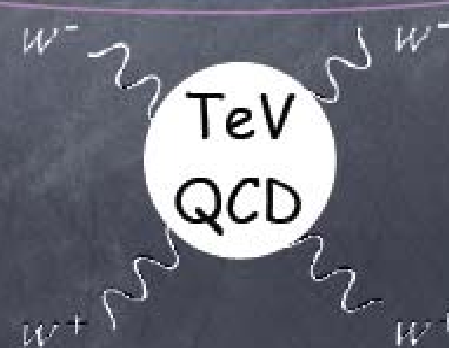
Weakly coupled models



prototype: Susy

susy partners ~ 100 GeV

Strongly coupled models

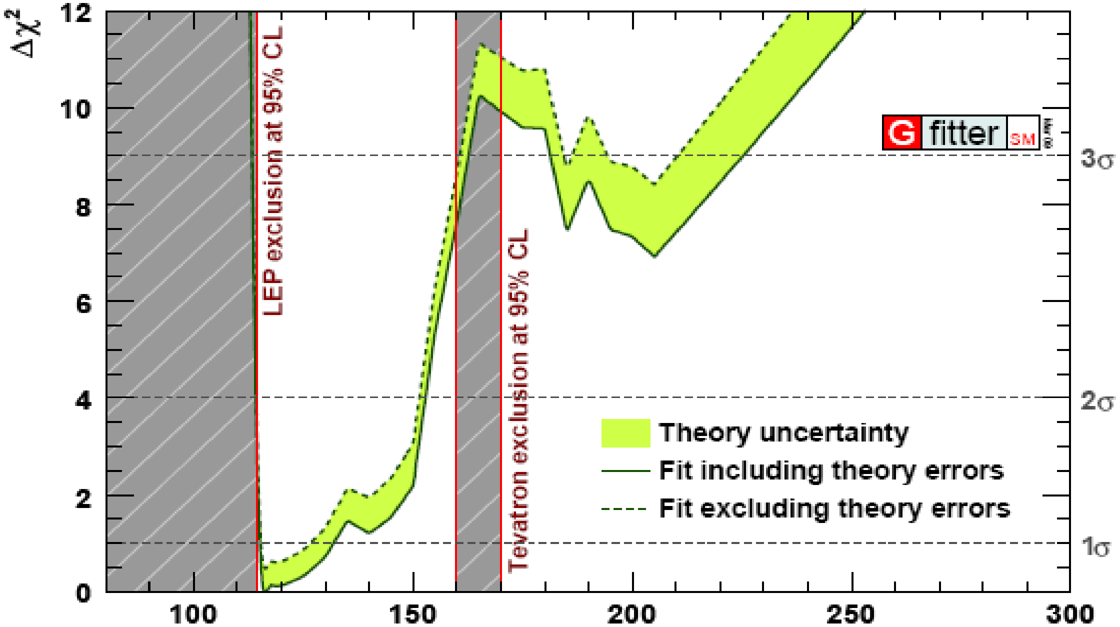


prototype: Technicolor

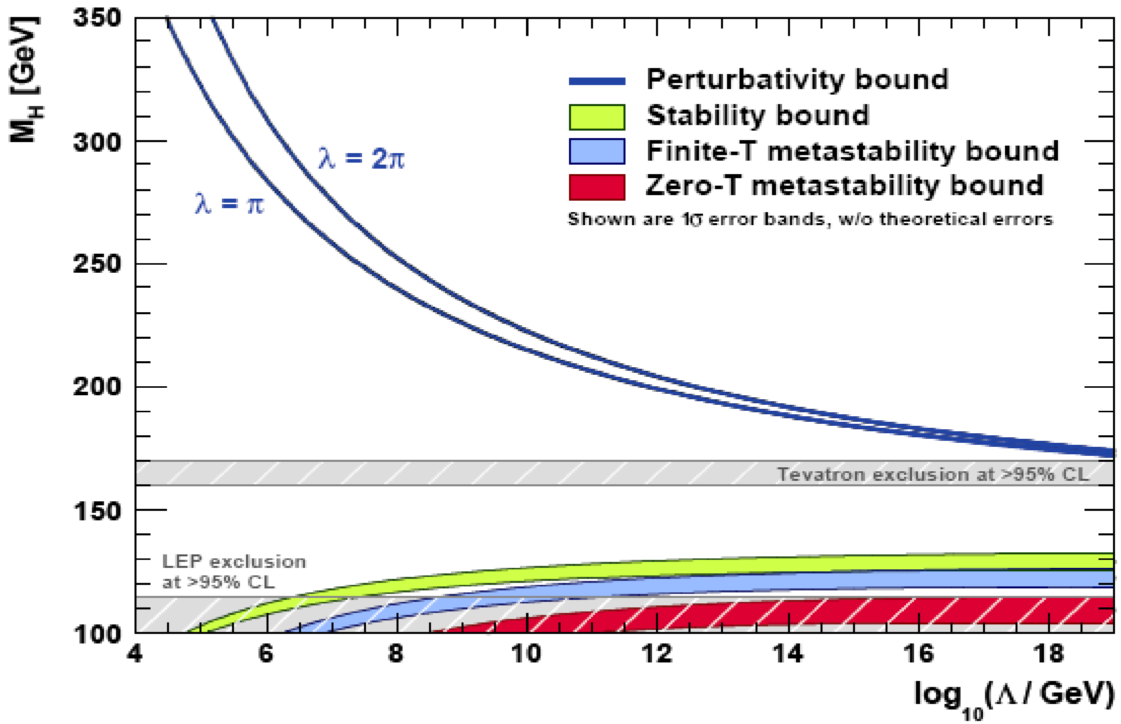
rho meson ~ 1 TeV

Different signatures at the LHC!

Grojean



a light higgs (or something mimicking it) is definitely favored



the big desert between the TeV and the GUT scales only if the higgs is a narrow band between 130 and 180

Ellis, Espinosa, Giudice, Hoecker, Riotto

Is it possible that there is "only" a light higgs boson and no NP?

- This is acceptable if one argues that no ultraviolet completion of the SM is needed at the TeV scale simply because there is no actual fine-tuning related to the higgs mass stabilization (**the correct value of the higgs mass is "environmentally" selected**). This explanation is similar to the one adopted for the cosmological constant

- Barring such wayout, **one is lead to have TeV NP to ensure the unitarity of the elw. theory at the TeV scale**

THE LITTLE HIERARCHY PROBLEM

SUSY CASE

$$m_h^2 \approx M_Z^2 \cos^2 2\beta + \frac{3m_t^4}{4\pi^2 v^2} \ln \frac{m_{stop}^2}{m_t^2}$$

$$m_h > 115 \text{ GeV} \quad \Rightarrow \quad m_{stop} \geq O(1 \text{ TeV})$$

$$\frac{1}{2} M_Z^2 \approx -(m_{H_u}^2 + \mu^2)|_{tree} + 0.1 M_{SUSY}^2 \ln \frac{\Lambda_{MSSM}}{M_{SUSY}}$$

$$10^{-2}\text{TeV} \quad \text{vs} \quad O(1)\text{TeV}|_{tree} + O(1)\text{TeV}$$

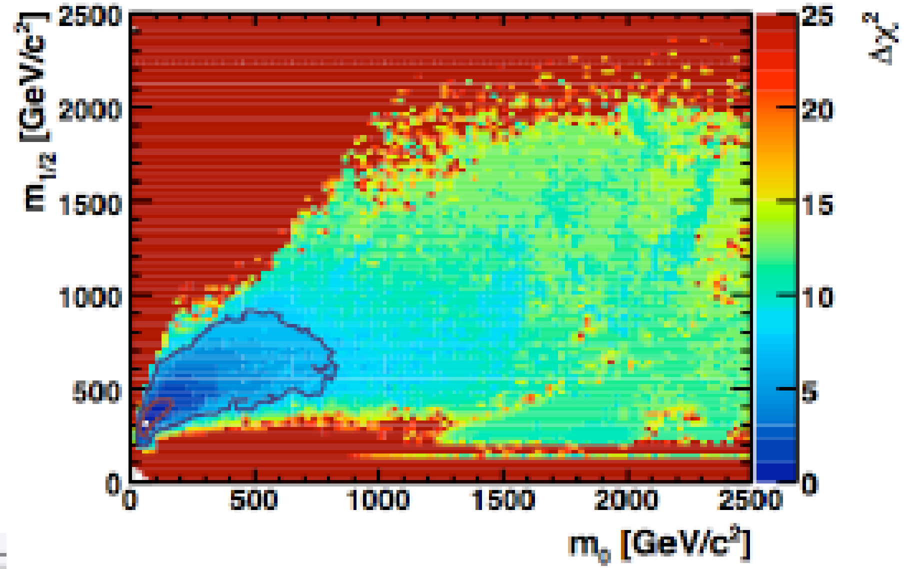
% FINE-TUNING FOR THE NEW PHYSICS AT THE ELW. SCALE

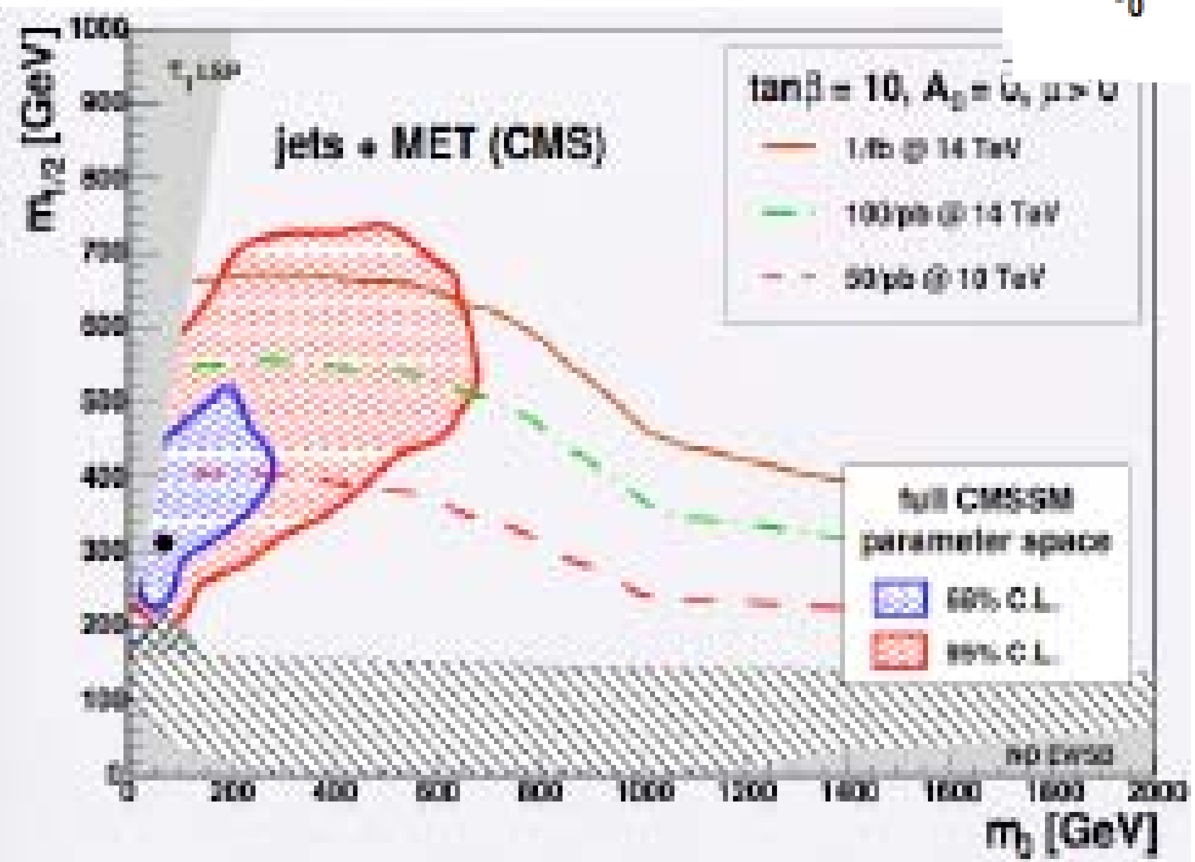
- **Elementary Higgs** → In the **MSSM** % fine-tuning among the SUSY param. to avoid light SUSY particles which would have been already seen at LEP and Tevatron

- **Elementary Higgs** → **PSEUDO-GOLDSTONE boson in the LITTLE HIGGS model** → Λ^2 div. cancelled by new colored fermions, new W,Z, γ, 2Higgs doublets… → % fine-tuning to avoid too large elw. Corrections

- **COMPOSITE HIGGS** in **a 5-dim**. holographic theory (Higgs is a PSEUDO-GOLDSTONE boson and the elw. symmetry breaking is triggered by bulk effects (in 5 dim. the theory is **WEAKLY** coupled, but in 4 dim. the bulk looks like a **STRONGLY** coupled sector) → also here % fine-tuning needed to survive the elw. precision tests

LIGHT SUSY IS PREFERRED BY DATA!





LIGHT SUSY IS TESTABLE AT THE LHC

ELLIS ET AL.

Baer, Barger, Lessa, Tata (2009)

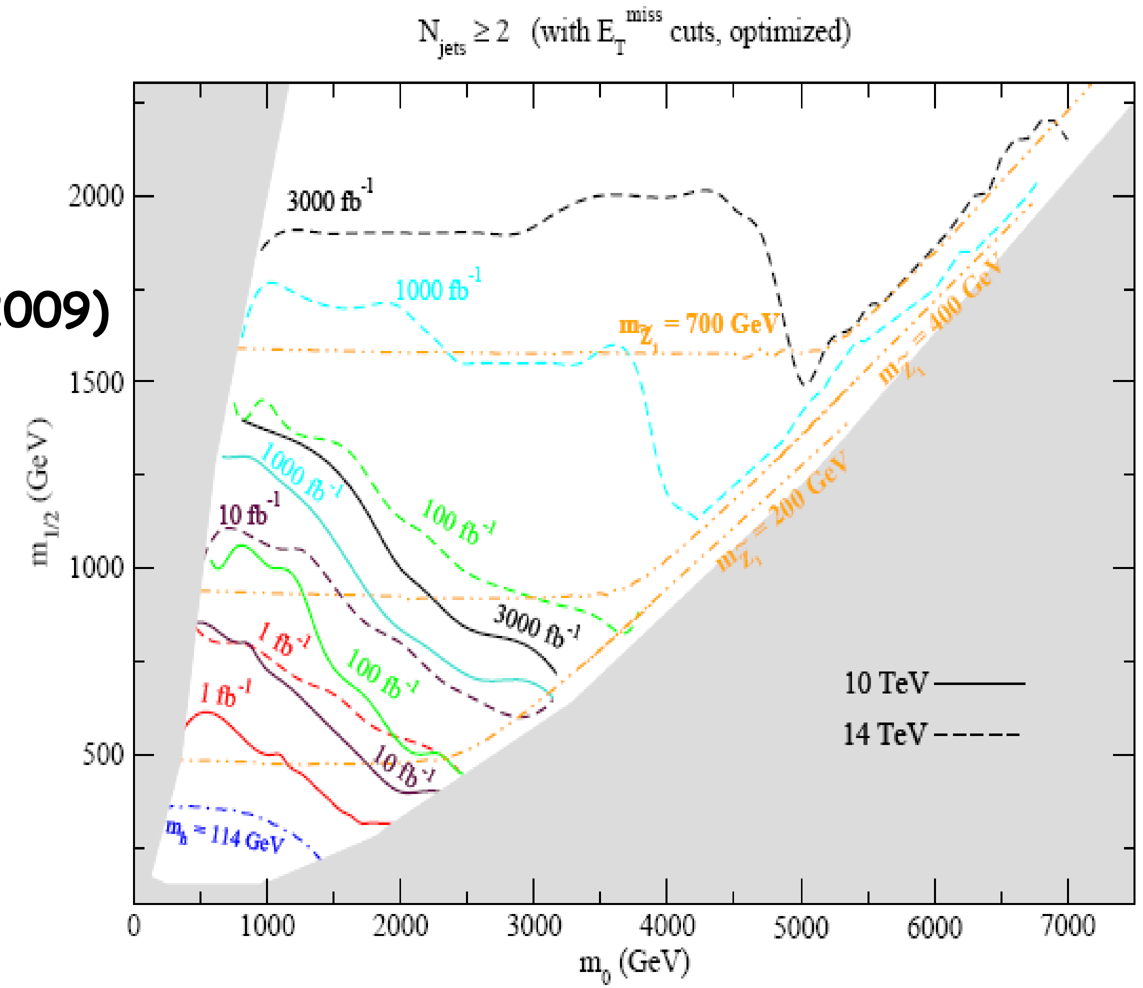


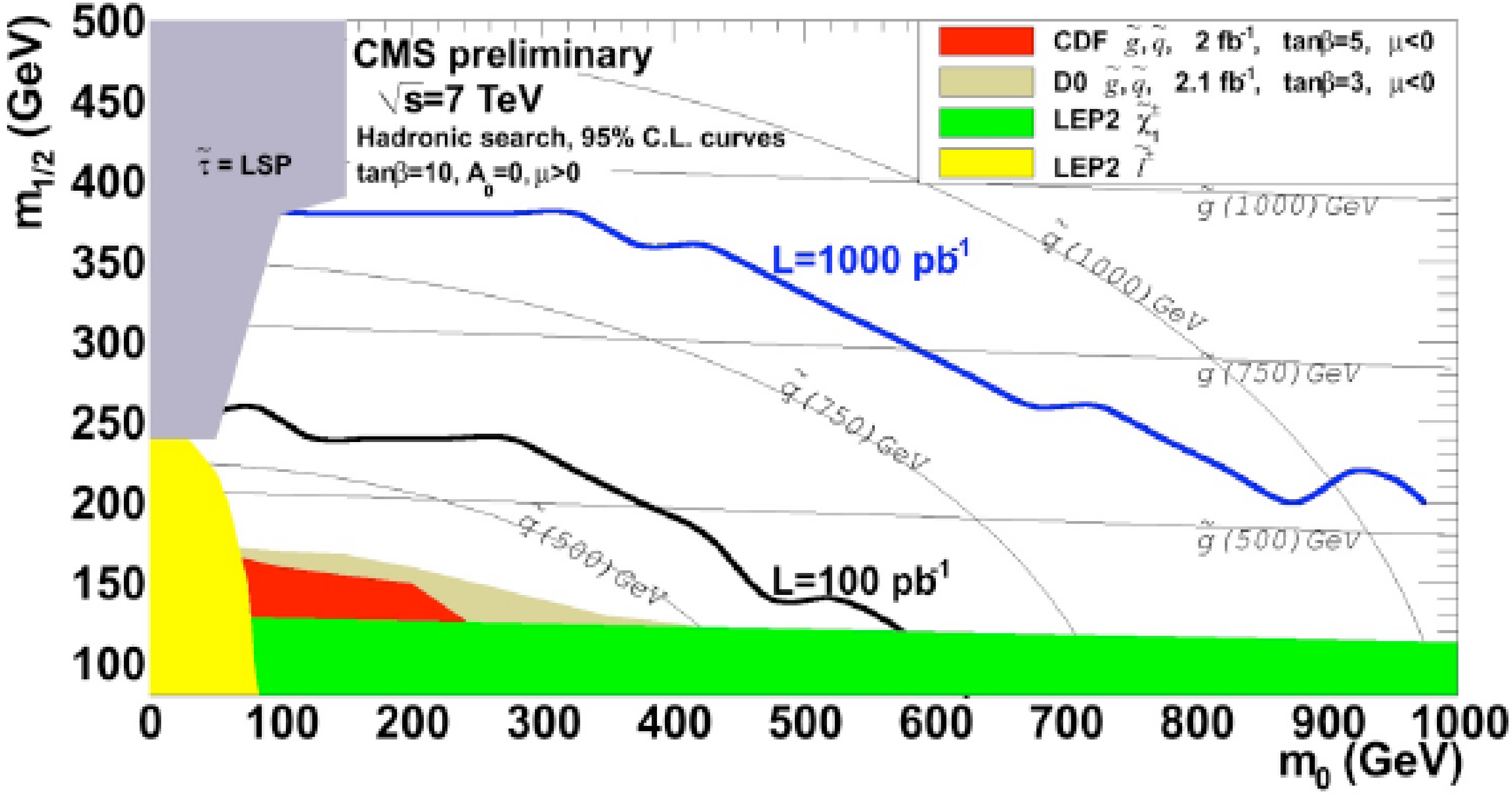
Figure 21: The ultimate SUSY reach of LHC within the mSUGRA framework for $\sqrt{s} = 10$ TeV (solid) and $\sqrt{s} = 14$ TeV (dashed) for various values of integrated luminosities. The fixed mSUGRA parameters are $A_0 = 0$, $\tan\beta = 45$ and $\mu > 0$. Isomass contours for the LSP (double dot-dashed) and for a 114 GeV light Higgs scalar (dot-dashed) are also shown. The shaded areas are excluded

SUSY: jets + missing E_T

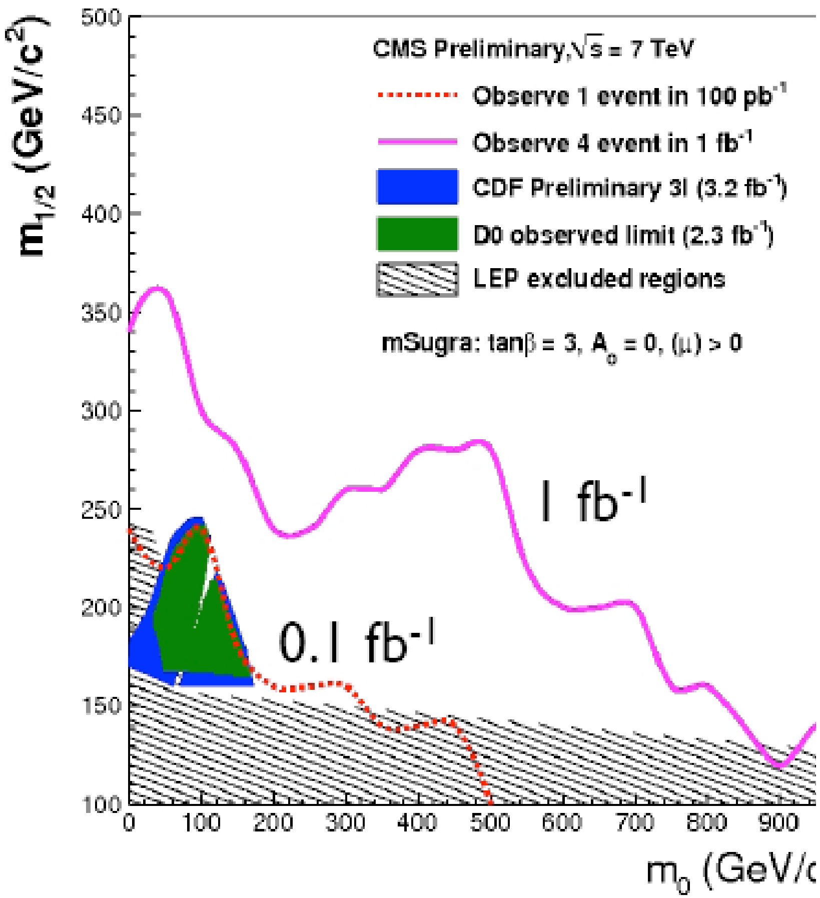
"Classic" all-jets search:

- 3 or more jets, E_T > 50 GeV
- missing E_T > 250 GeV
- no leptons

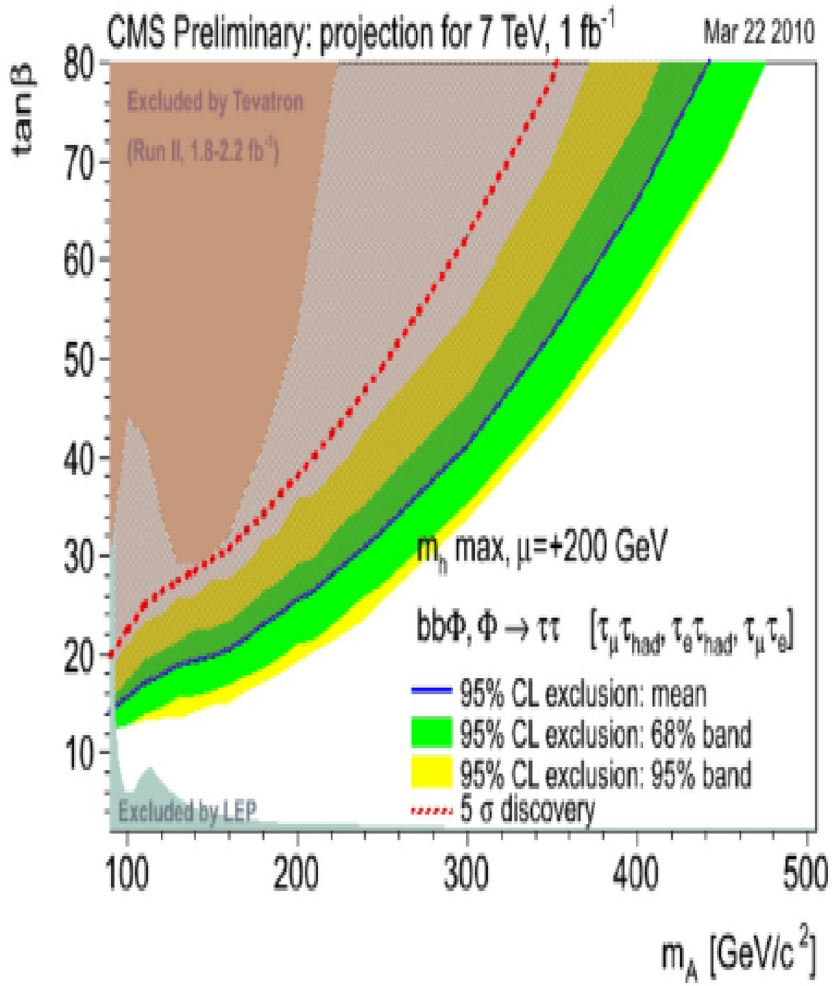
J. CONWAY
PHENO10



SUSY: like-sign dilepto



di-tau sensitivity for H/A will soon exceed Tevatron!



J. CONWAY PHENO10

***THE DM ROAD TO NEW PHYSICS BEYOND THE SM*:**

IS **DM** A PARTICLE OF THE ***NEW PHYSICS AT THE ELECTROWEAK ENERGY SCALE*** **?**

IS THE "*WIMP MIRACLE*" AN ACTUAL MIRACLE?

USUAL STATEMENT

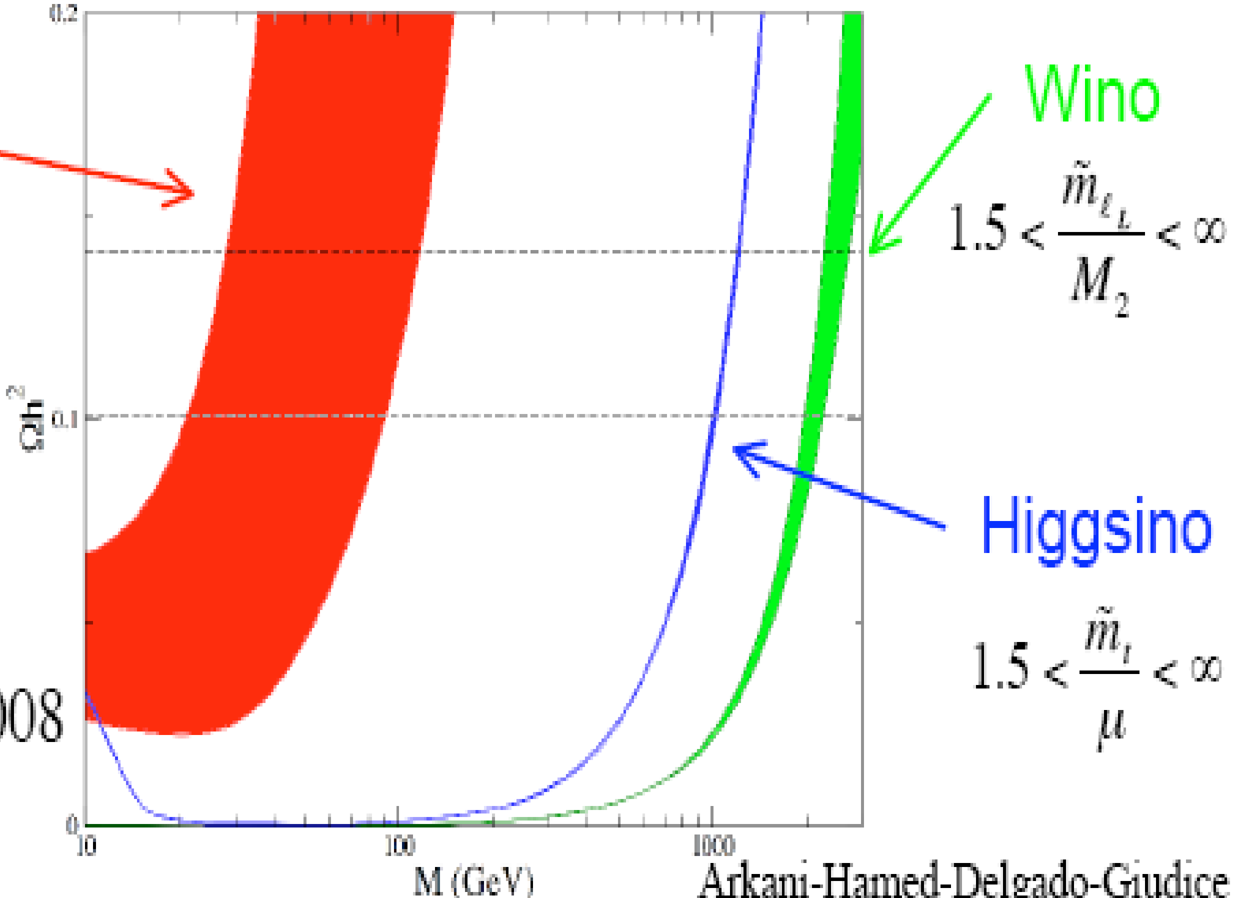
Many possibilities for DM candidates, but WIMPs are really special: peculiar coincidence between particle physics and cosmology parameters to provide a VIABLE DM CANDIDATE AT THE ELW. SCALE

HOWEVER

when it comes to quantitatively reproduce the precisely determined DM density → once again the fine-tuning threat…

After LEP: tuning of the SUSY param. at the % level to correctly reproduce the DM abundance: NEED FOR A "WELL-TEMPERED" NEUTRALINO

$$1.1 < \frac{\tilde{m}_{e_R}}{M_1} < 3$$



$$\Omega_{DM} h^2 = 0.105 \pm 0.008$$

Arkani-Hamed-Delgado-Giudice

DM and NON-STANDARD COSMOLOGIES BEFORE NUCLEOSYNTHESIS

- **NEUTRALINO RELIC DENSITY MAY DIFFER FROM ITS STANDARD VALUE**, i.e. the value it gets when the expansion rate of the Universe is what is expected in Standard Cosmology (EX.: **SCALAR-TENSOR THEORIES OF GRAVITY**, **KINATION**, **EXTRA-DIM. RANDALL-SUNDRUM TYPE II MODEL**, ETC.)

- **WIMPS MAY BE "COLDER"**, i.e. they may have smaller typical velocities and, hence, they may lead to smaller masses for the first structures which form **GELMINI, GONDOLO**

LARGER WIMP ANNIHILATION CROSS-SECTION IN NON-STANDARD COSMOLOGIES

- **Having a Universe expansion rate at the WIMP freeze-out larger than in Standard Cosmology→ possible to provide a DM adequate WIMP population even in the presence of a larger annihilation cross-section** (**Catena, Fornengo, A.M., Pietroni**)

- **Possible application to increase the present DM annihilation rate to account for the PAMELA results in the DM interpretation** (instead of other mechanisms like the Sommerfeld effect or a nearby resonance)

El Zant, Khalil, Okada

DM ⟷ DE

DO THEY "KNOW" EACH OTHER?

- DIRECT INTERACTION ϕ (quintessence) WITH DARK MATTER

DANGER:
ϕ Very LIGHT
$m_\phi \sim H_0^{-1} \sim 10^{-33}$ eV

→ Threat of violation of the equivalence principle
constancy of the fundamental "constants",…

- **INFLUENCE OF ϕ ON THE NATURE AND THE ABUNDANCE OF CDM**

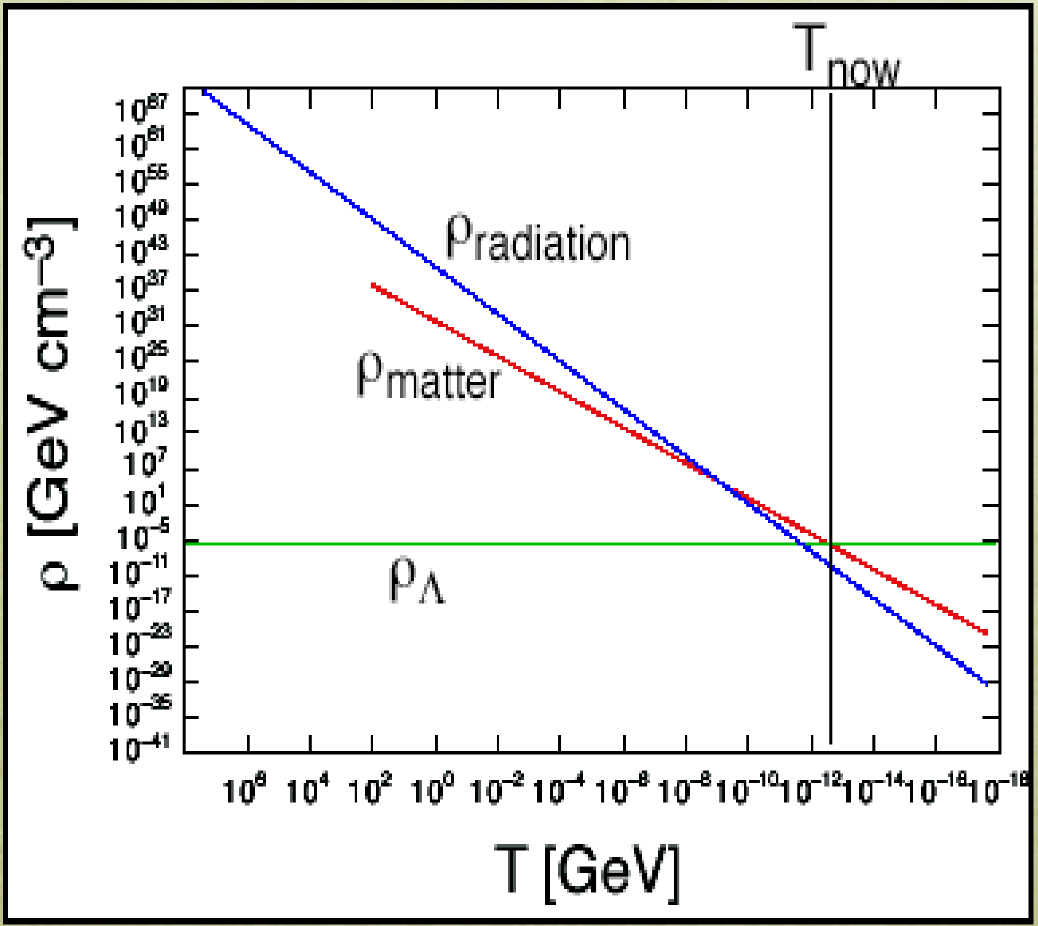
Modifications of the standard picture of
WIMPs FREEZE - OUT

CDM CANDIDATES

CATENA, FORNENGO, A.M., PIETRONI, SHELCKE

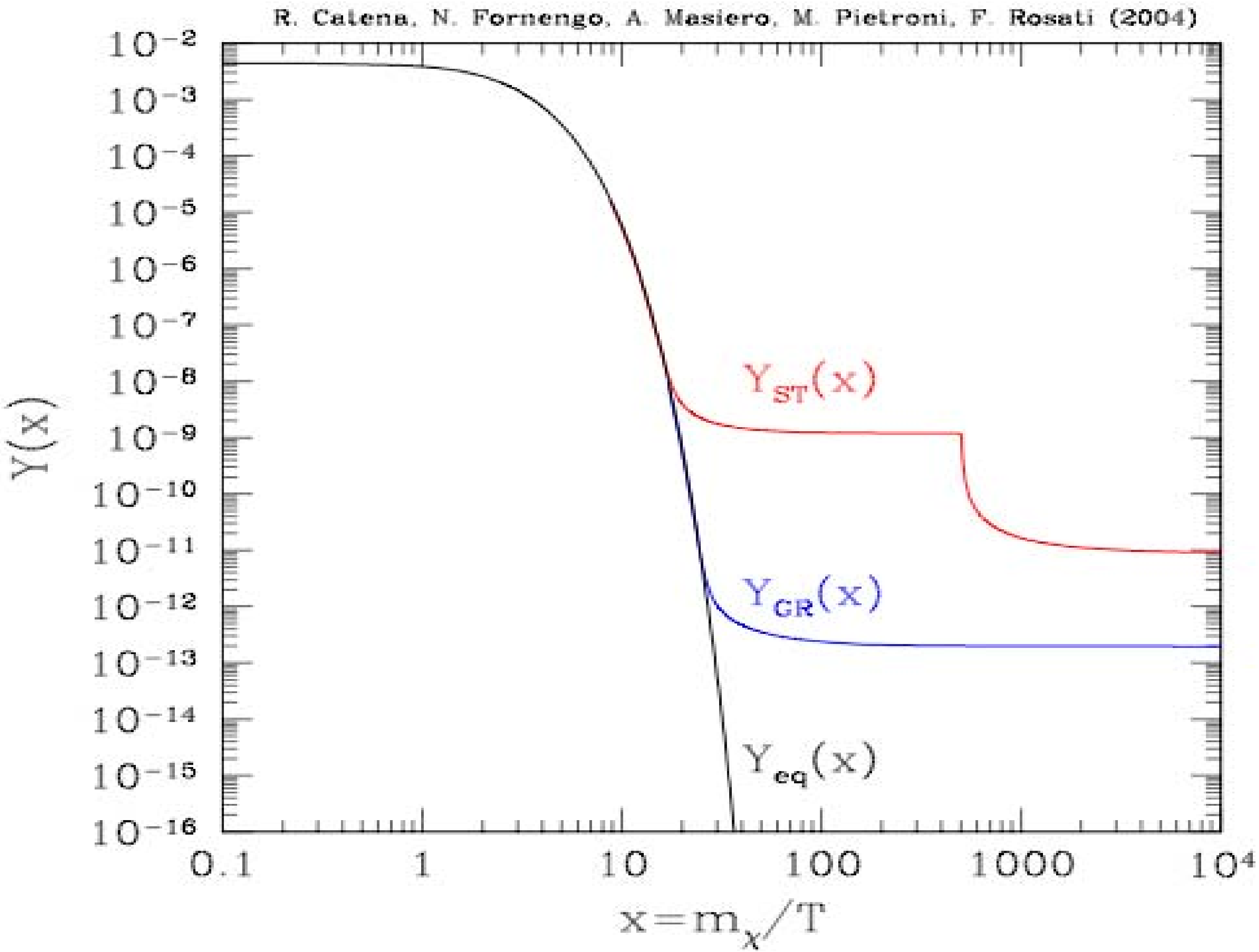
THE “WHY NOW” PROBLEM

- *Why do we see matter and cosmological constant almost equal in amount?*
- *“Why Now” problem*
- *Actually a triple coincidence problem including the radiation*
- *If there is a deep reason for $\rho_\Lambda \sim ((\mathrm{TeV})^2/M_{Pl})^4$, coincidence natural*



Arkani-Hamed, Hall, Kolda, HM

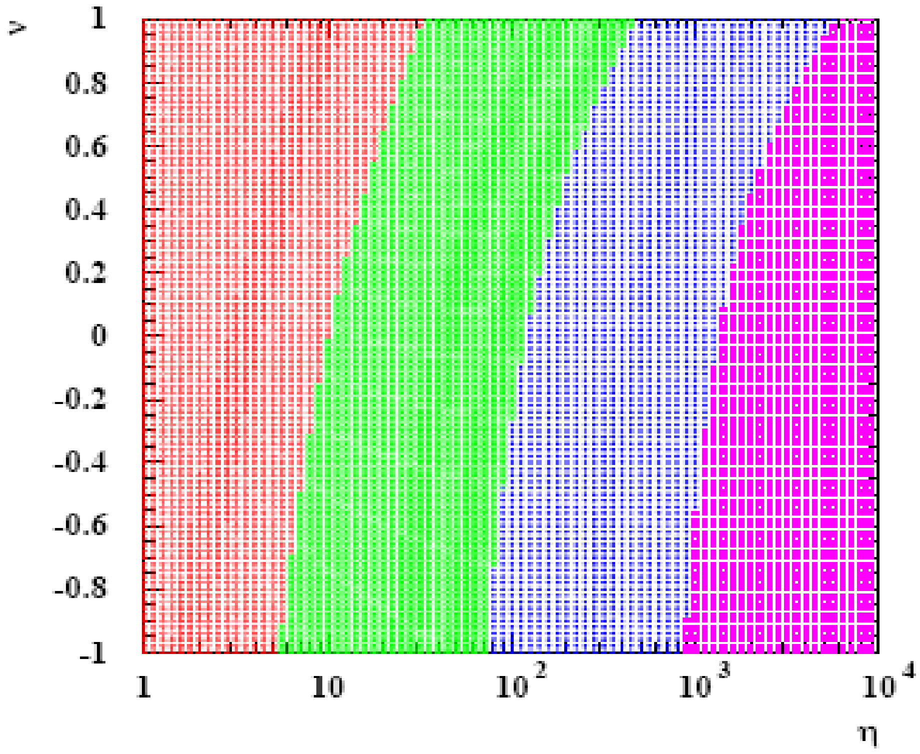
NEUTRALINO RELIC ABUNDANCE IN GR AND S-T THEORIES OF GRAVITY

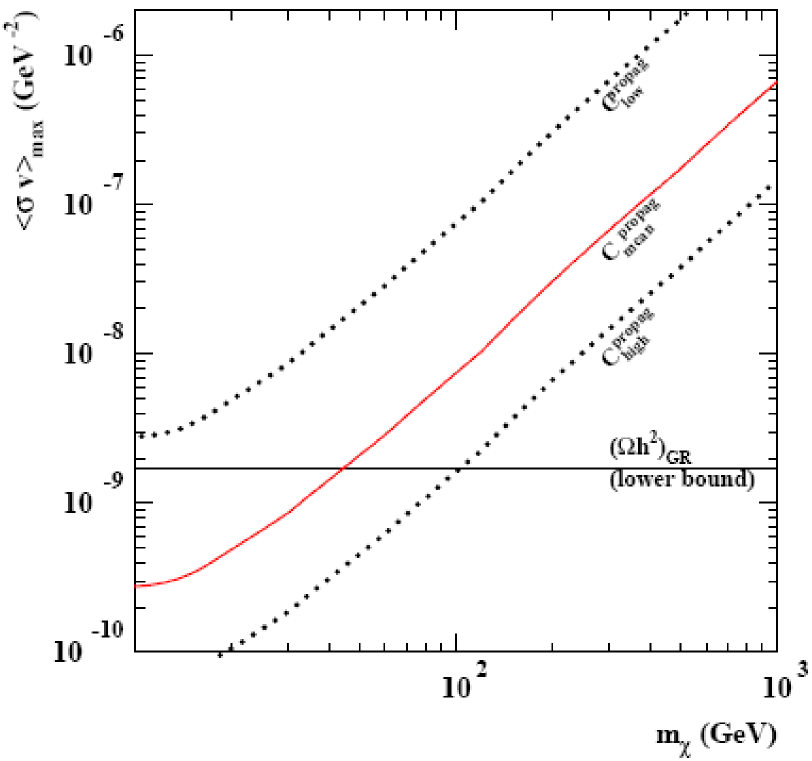


$$H = A(T) H_{std} \quad \text{at early times}$$

$$H = H_{std} \quad \text{at later times}$$

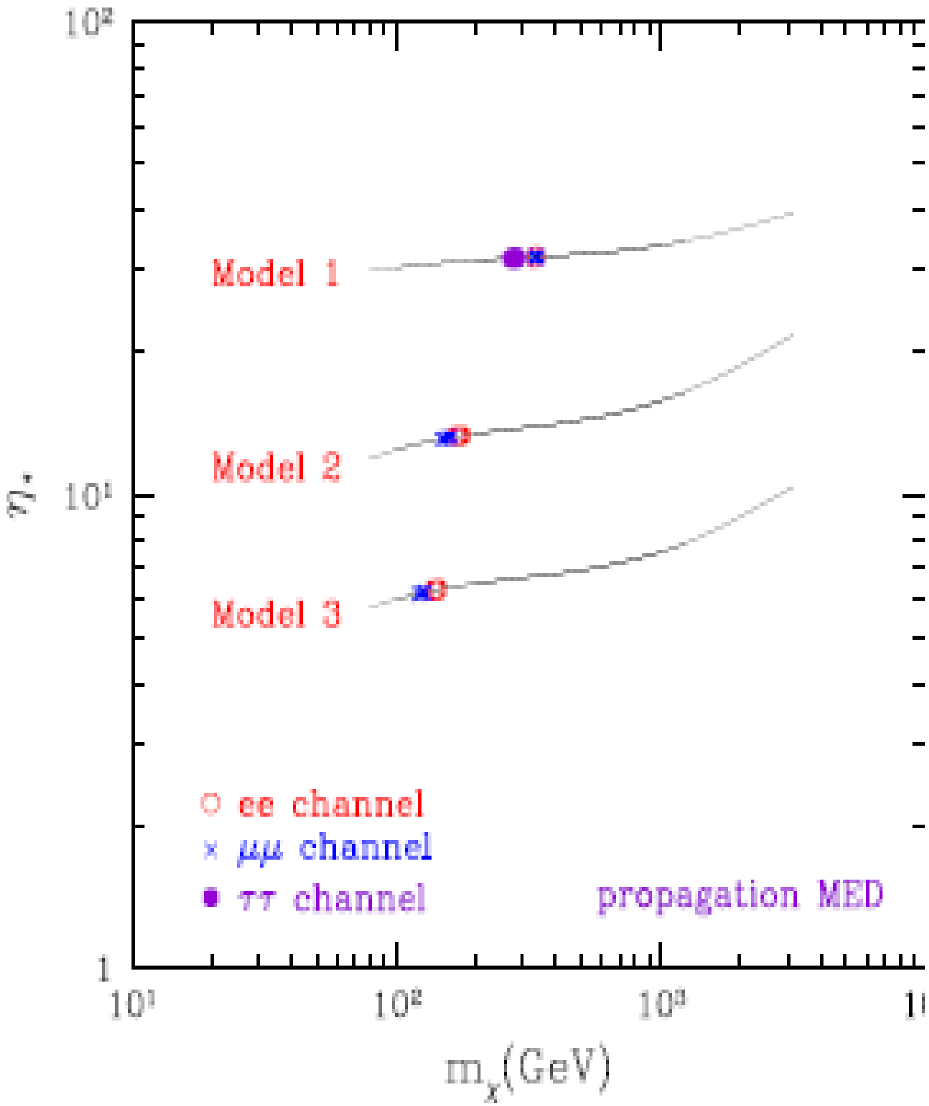
$$A(T) = 1 + \eta \left(\frac{T}{T_f} \right)^{\nu} \tanh \left(\frac{T - T_{re}}{T_{re}} \right)$$

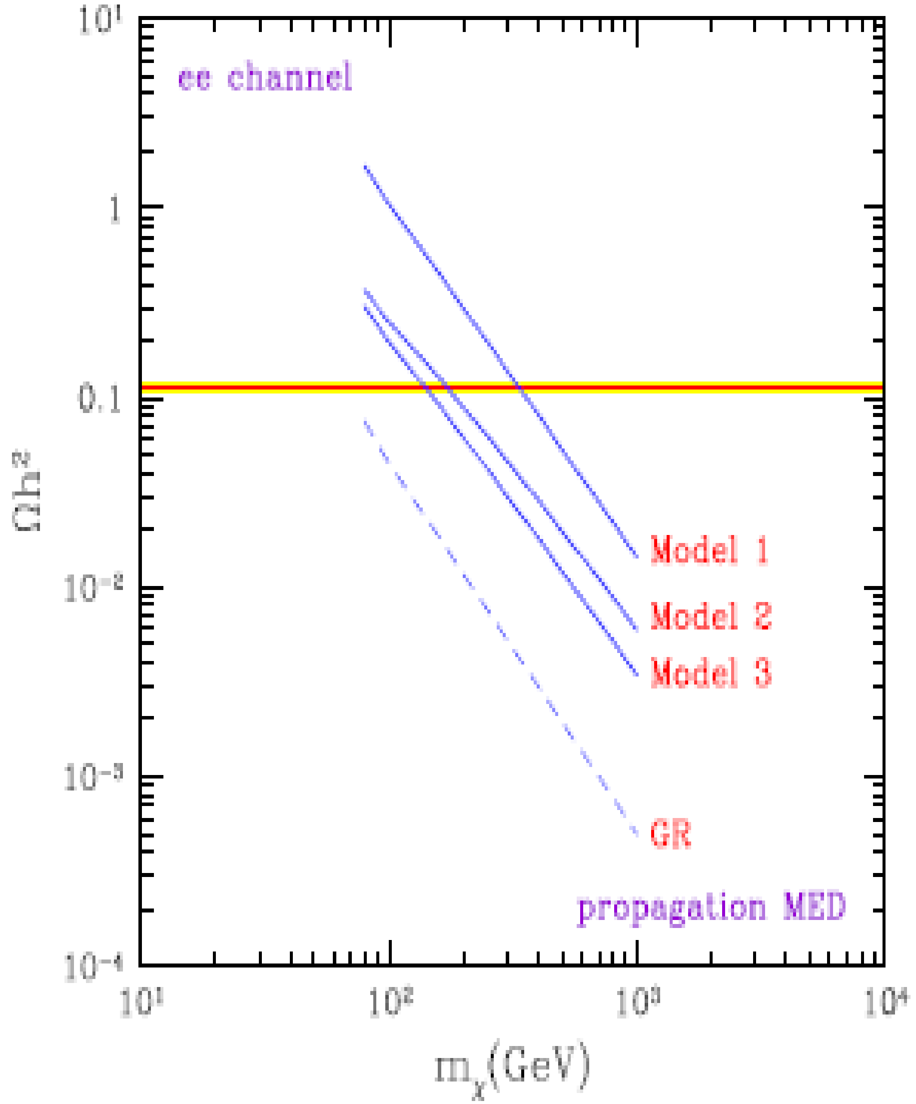




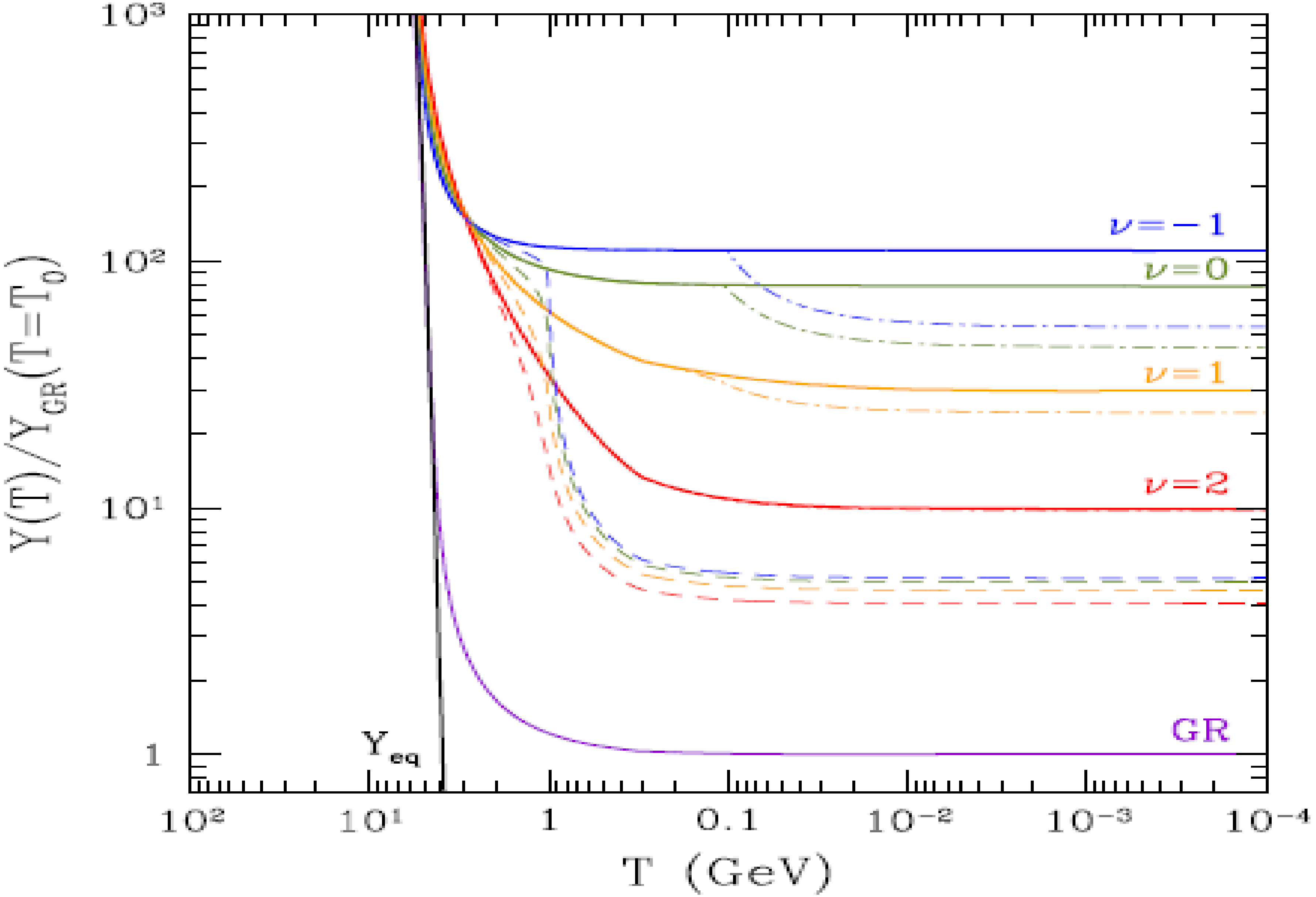
SCHELKE, CATENA, FORNENGO, A.M., PIETRONI

CATENA, FORNENGO, PATO, PIERI, A.M.

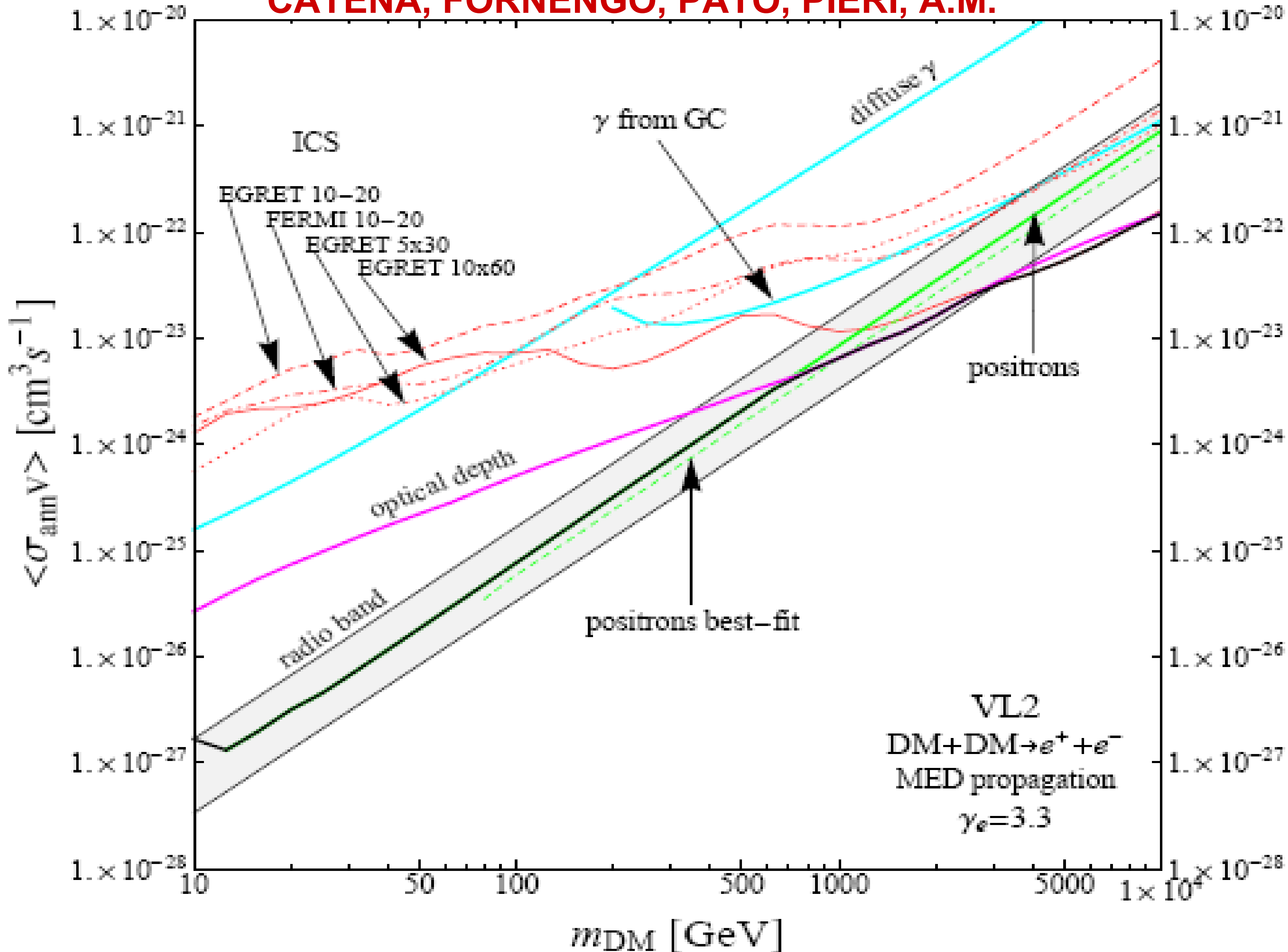




CATENA, FORNENGO, PATO, PIERI, A.M.



CATENA, FORNENGO, PATO, PIERI, A.M.



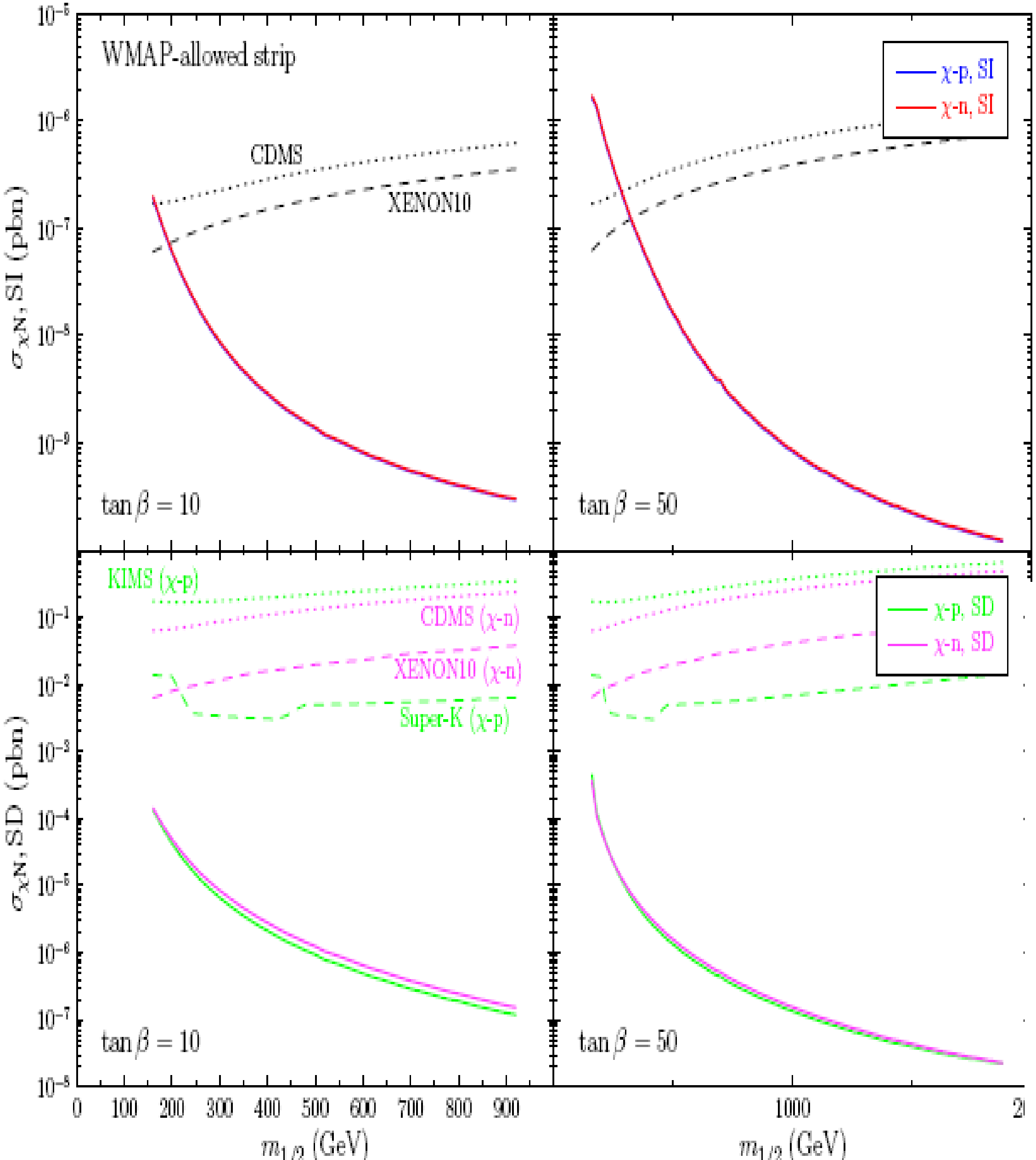
STABLE ELW. SCALE WIMPs from PARTICLE PHYSICS

	SUSY	EXTRA DIM.	LITTLE HIGGS.
1) **ENLARGEMENT OF THE SM**	(x^{μ}, θ)	(x^{μ}, j^{i})	SM part + new part
	Anticomm. Coord.	New bosonic Coord.	to cancel Λ^2 at 1-Loop
2) **SELECTION RULE**	**R-PARITY LSP**	**KK-PARITY LKP**	**T-PARITY LTP**
→ **DISCRETE SYMM.** → **STABLE NEW PART.**	Neutralino spin 1/2 ↓	spin1 ↓	spin0 ↓
3) FIND REGION (S) PARAM. SPACE WHERE THE "L" NEW PART. IS NEUTRAL + $\Omega_L h^2$ OK	m_{LSP} ~100 - 200 GeV *	m_{LKP} ~600 - 800 GeV	m_{LTP} ~400 - 800 GeV

* But abandoning gaugino-masss unif. ⟶ Possible to have m_{LSP} down to 7 GeV

Bottino, Donato, Fornengo, Scopel

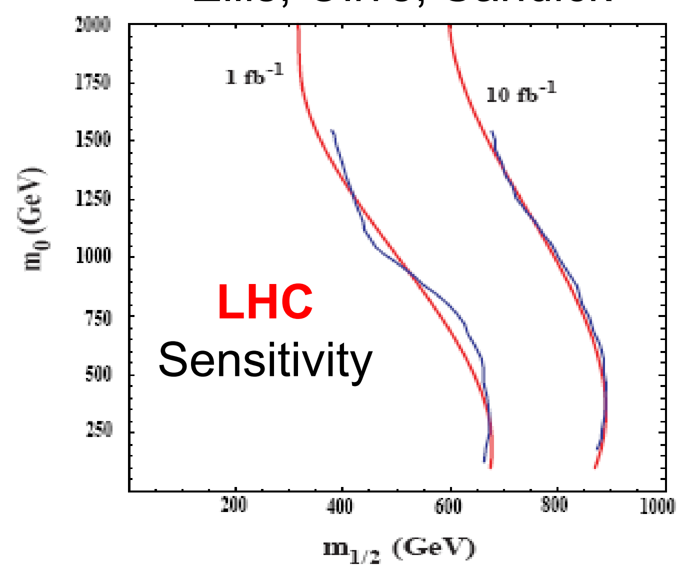
Neutralino-nucleon scattering cross sections along the WMAP-allowed coannihilation strip for tanbeta=10 and coannihilation/funnel strip for tanbeta=50 using the hadronic parameters



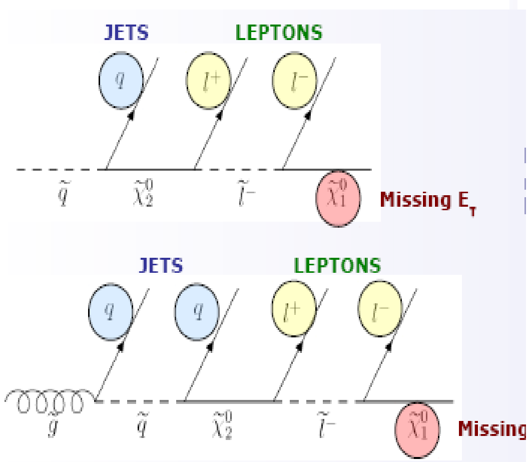
ELLIS. OLIVE. SAVAGE

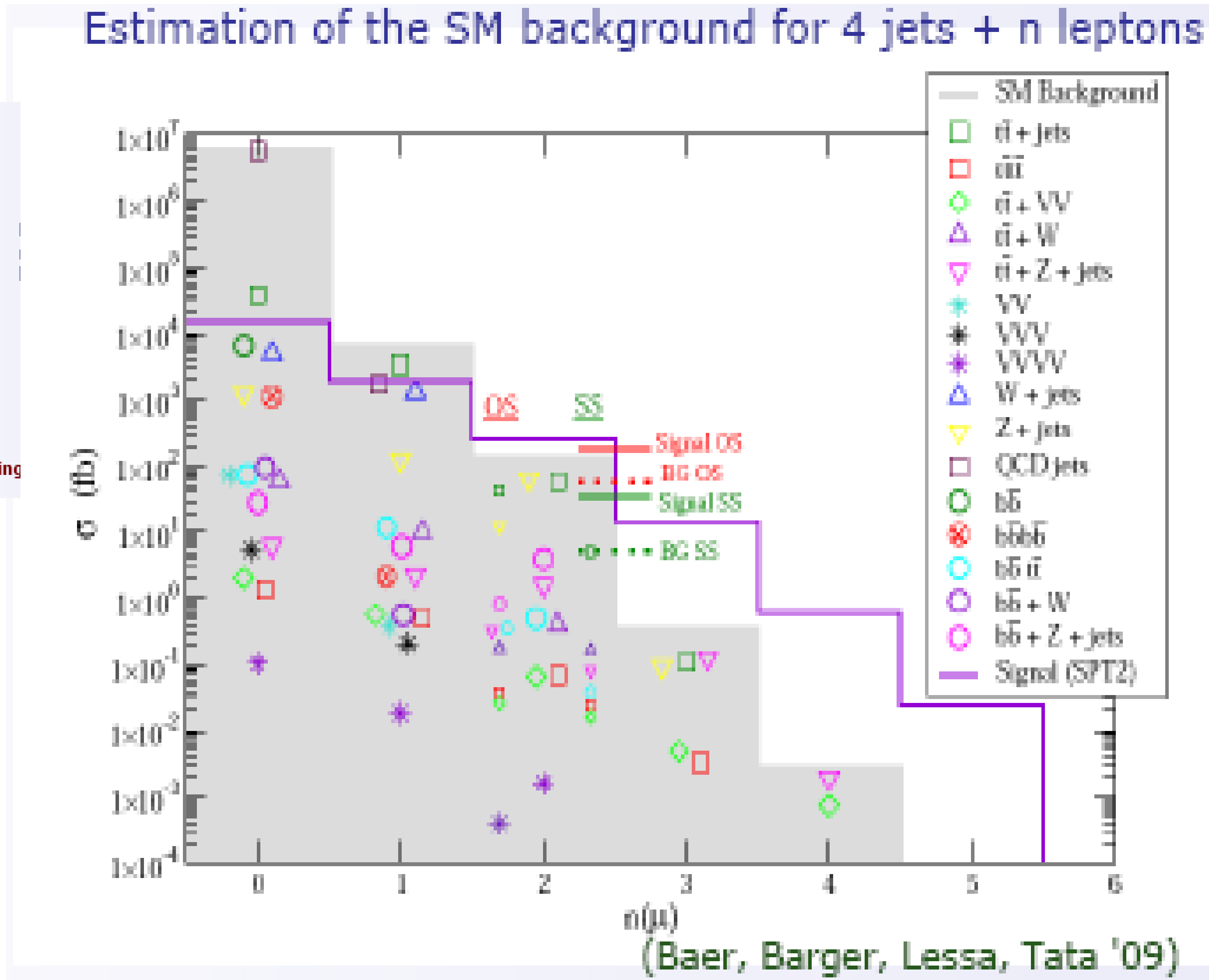
m_u/m_d	0.553	$\pm$	0.043
m_d	5	$\pm$	2 MeV
m_s/m_d	18.9	$\pm$	0.8
m_c	1.25	$\pm$	0.09 GeV
m_b	4.20	$\pm$	0.07 GeV
m_t	171.4	$\pm$	2.1 GeV
σ_0	36	$\pm$	7 MeV
$\Sigma_{\pi N}$	64	$\pm$	8 MeV
$a_3^{(p)}$	1.2695	$\pm$	0.0029
$a_8^{(p)}$	0.585	$\pm$	0.025
$\Delta_s^{(p)}$	-0.09	$\pm$	0.03

Ellis, Olive, Sandick

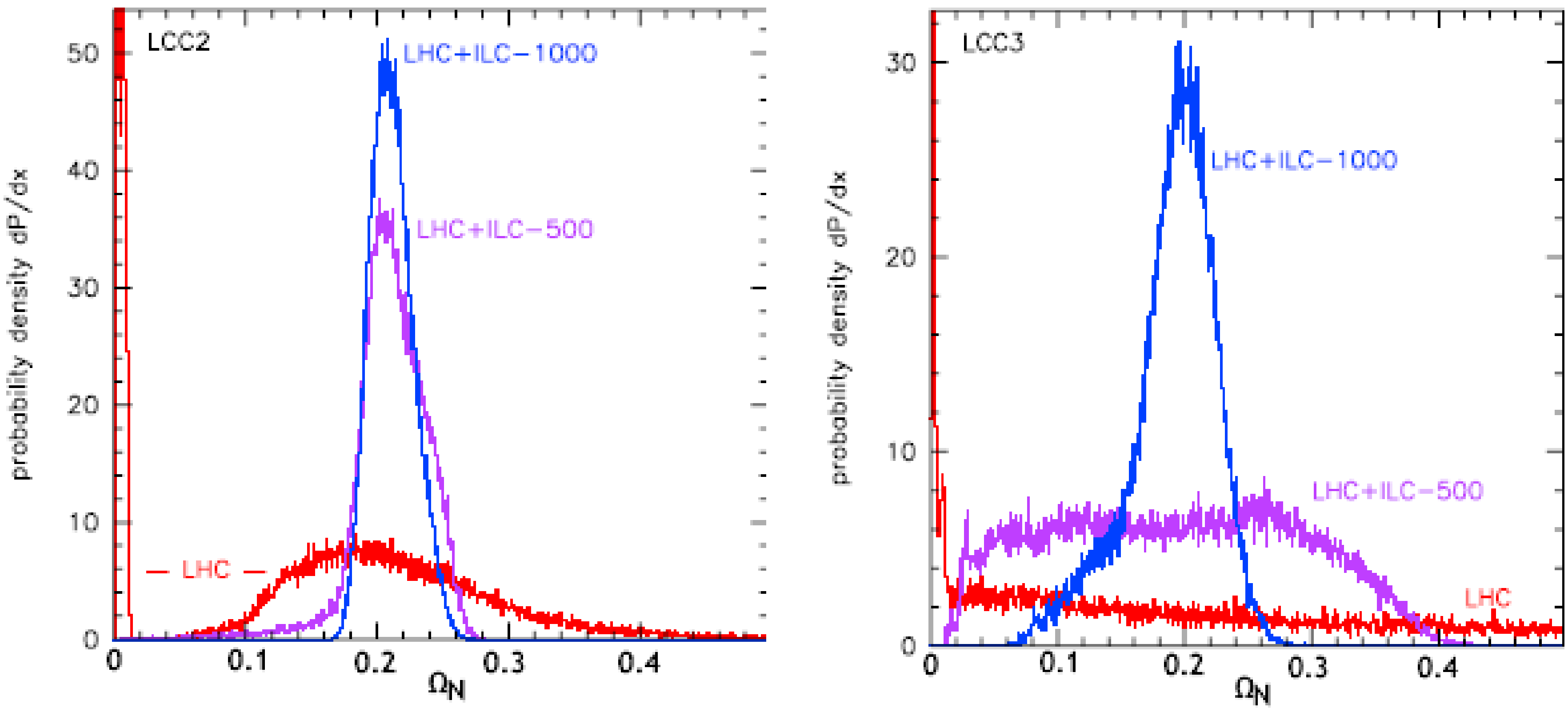


DM through the jets + missing energy signature at the LHC

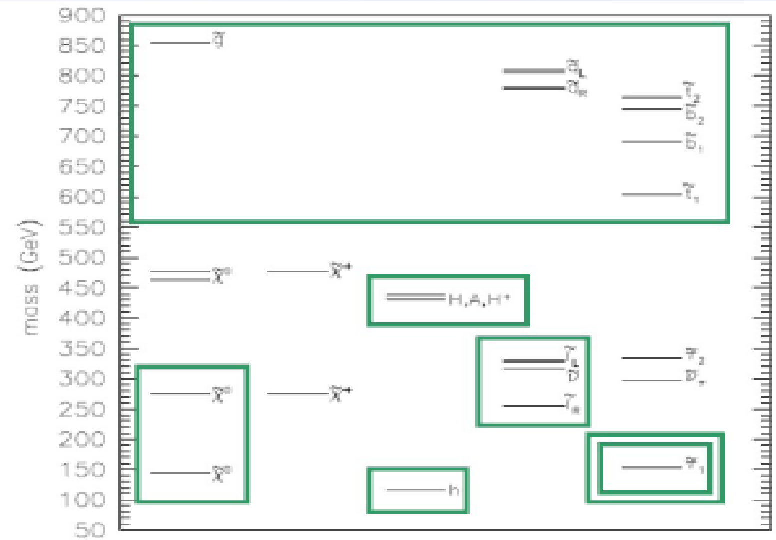




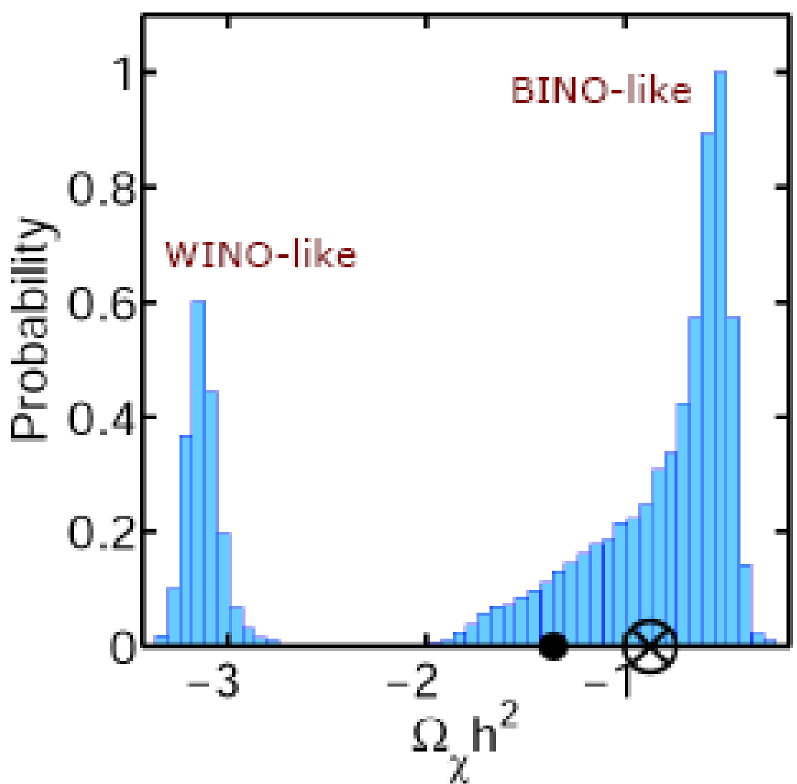
PREDICTION OF Ω DM FROM LHC AND ILC FOR TWO DIFFERENT SUSY PARAMETER SETS

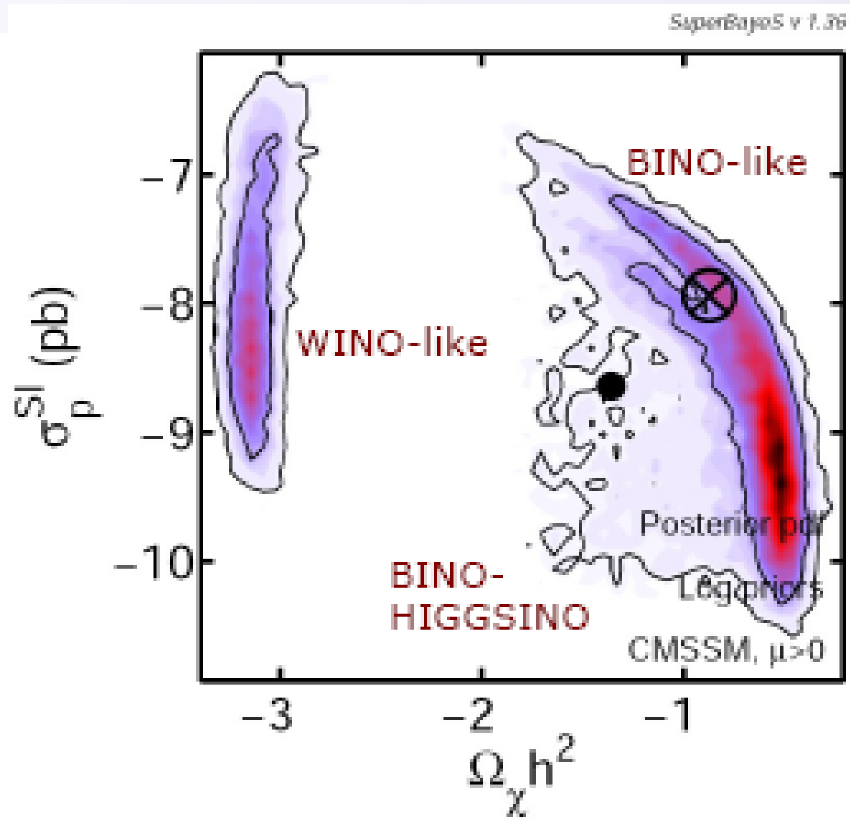


BALTZ, BATTAGLIA, PESKIN, WIZANSKY



Let's suppose to find part of the SUSY particle spectrum at LHC: will we be able to reconstruct then which s-particle is going to be the LSP?





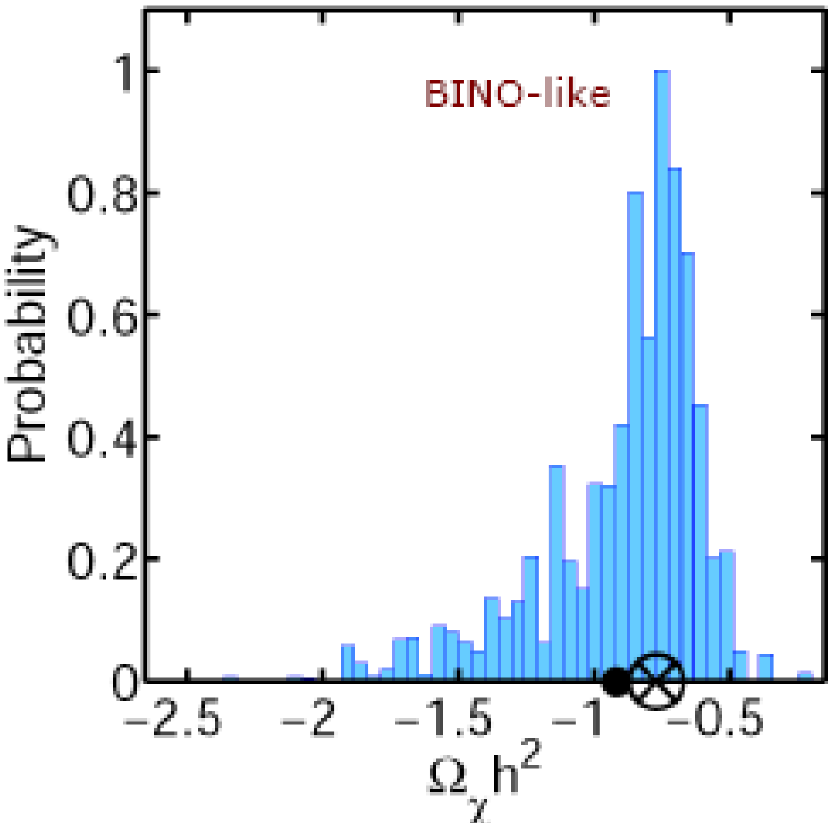
…but if we succeed to find the DM

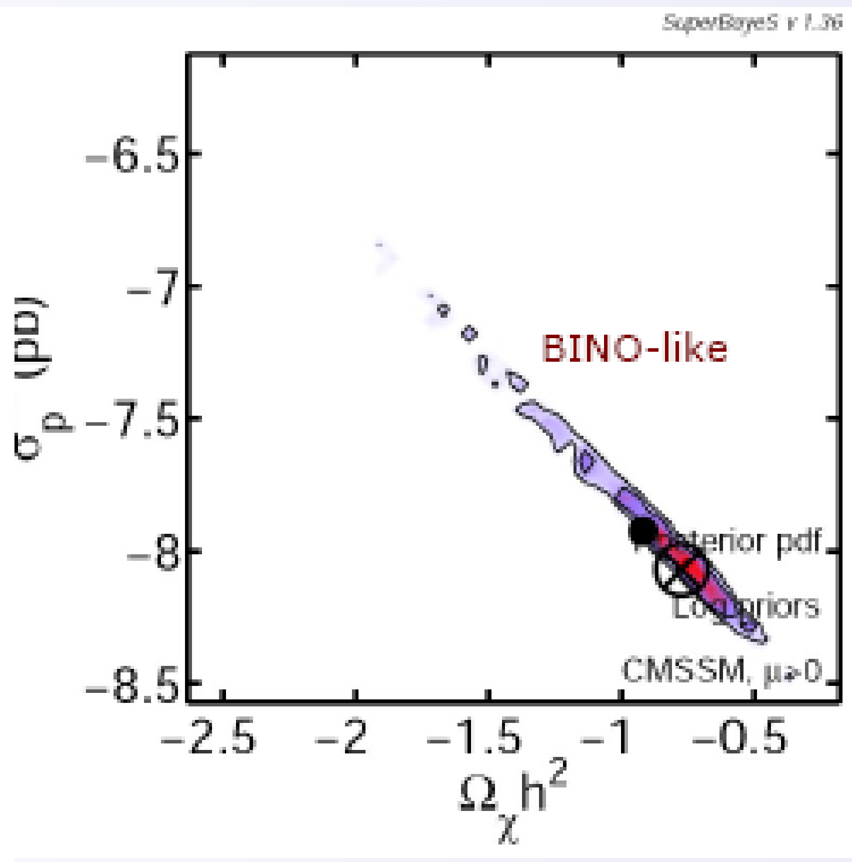
synergy LHC - DM

The combination of LHC data with Direct Detection data can resolve the degeneracy

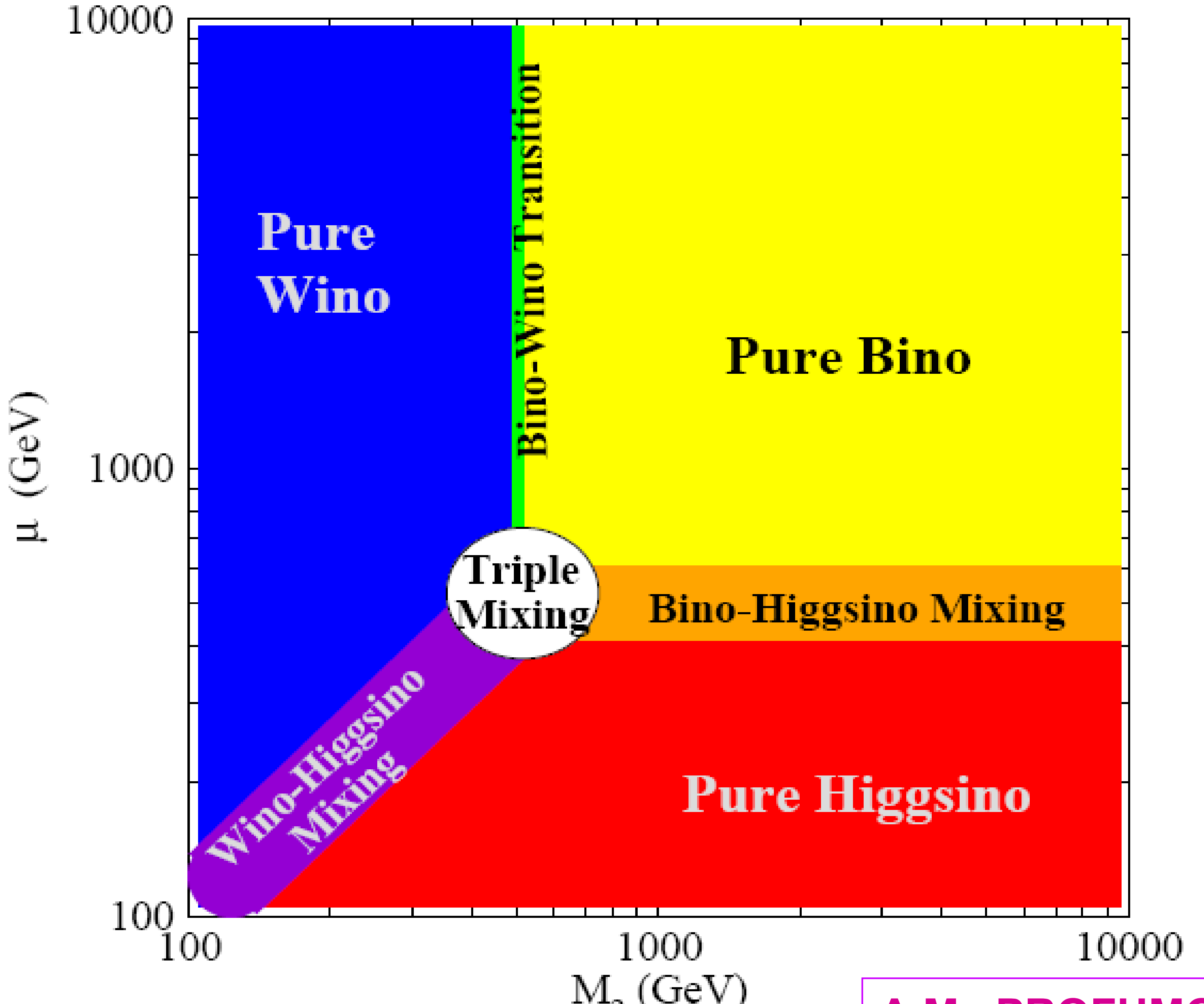
The reconstruction of the relic abundance has a similar accuracy but spurious maxima disappear

(Bertone, Cerdeño, Fornasa, Trotta, de Austri – in preparation)



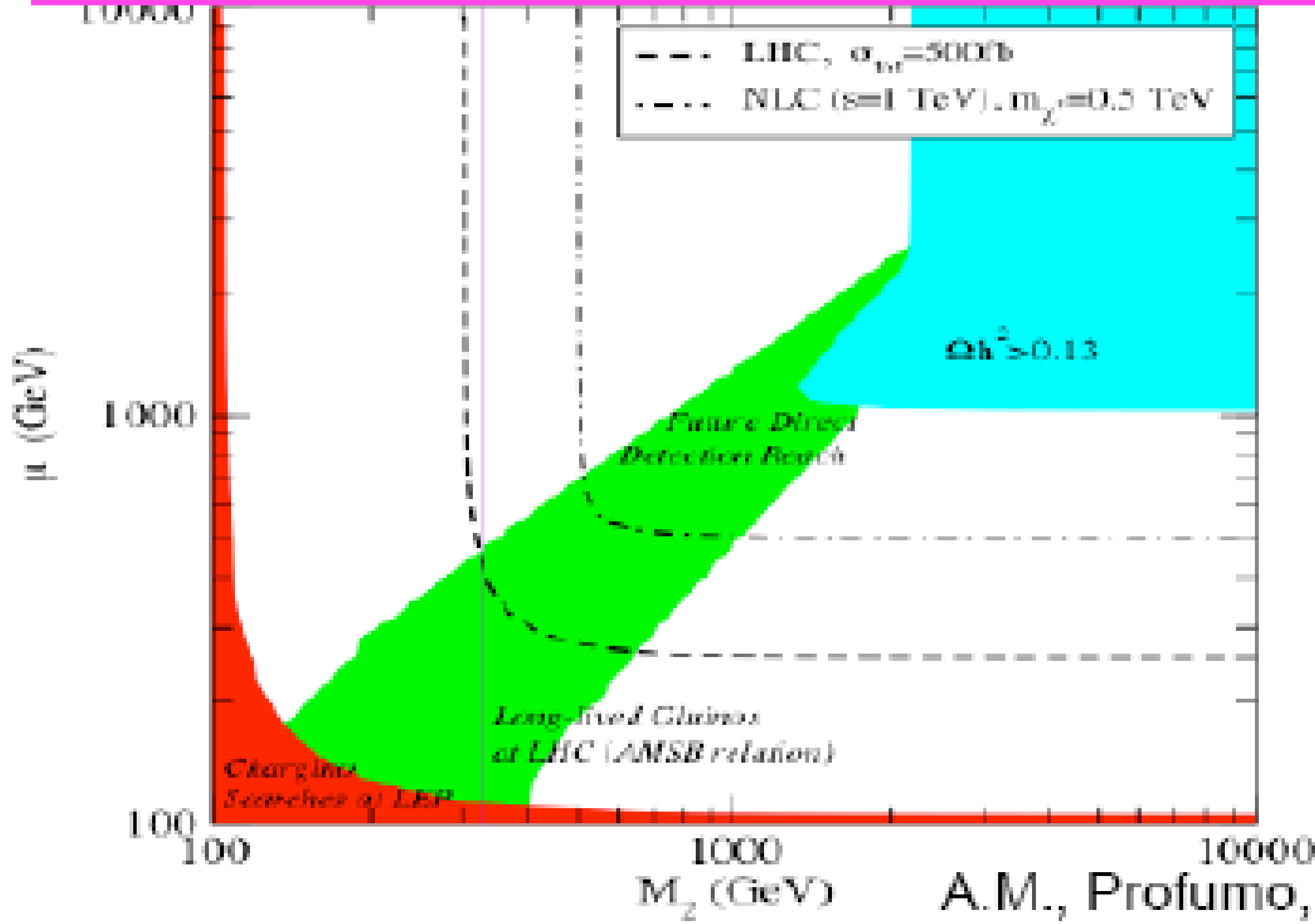


NEUTRALINO LSP IN SUPERGRAVITY



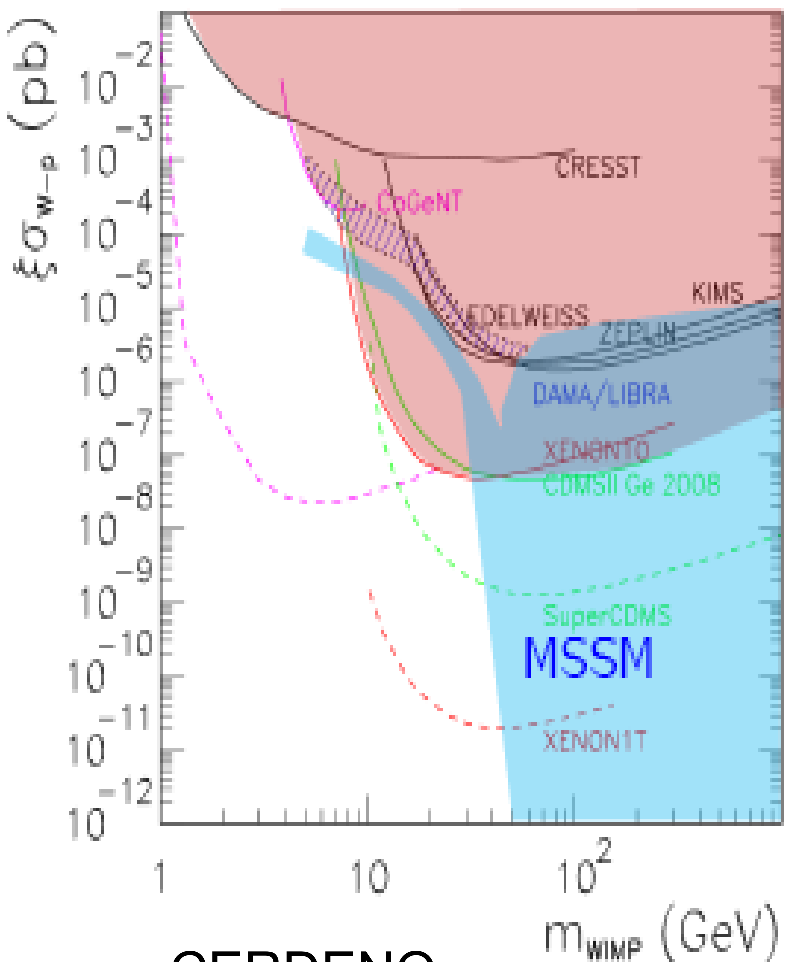
A.M., PROFUMO, ULLIO

LHC, ILC, DM SEARCHES SENSITIVITIES

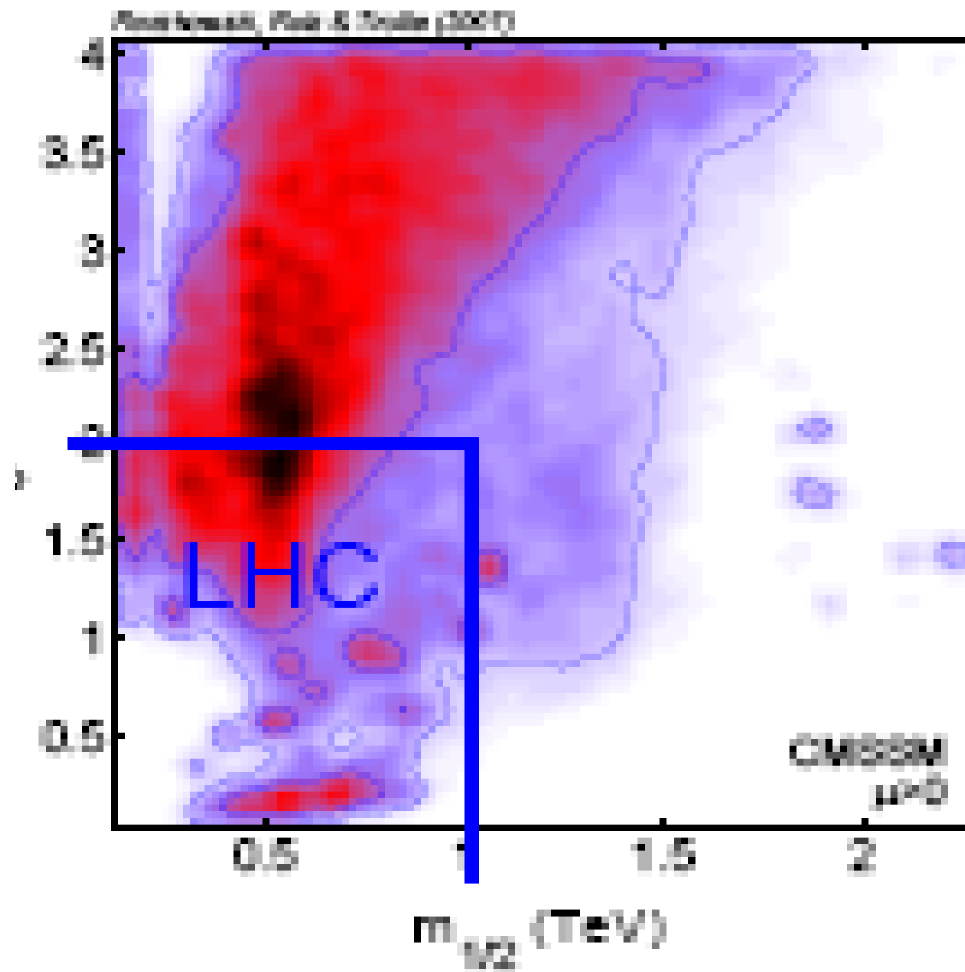


A.M., Profumo, Ullio

On the LHC – Direct DM searches coverage of the MSSM parameter space

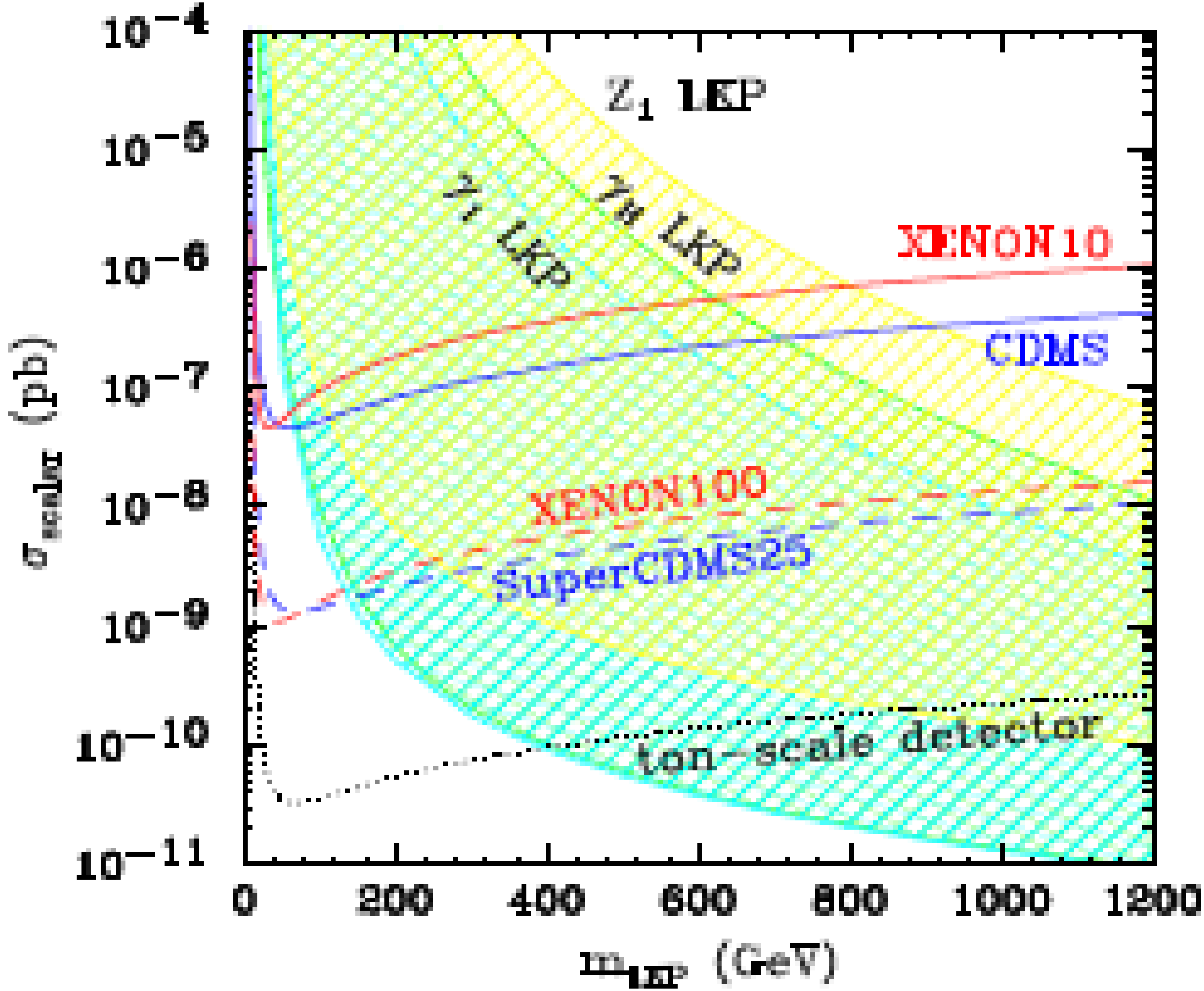


CERDENO
WONDER10



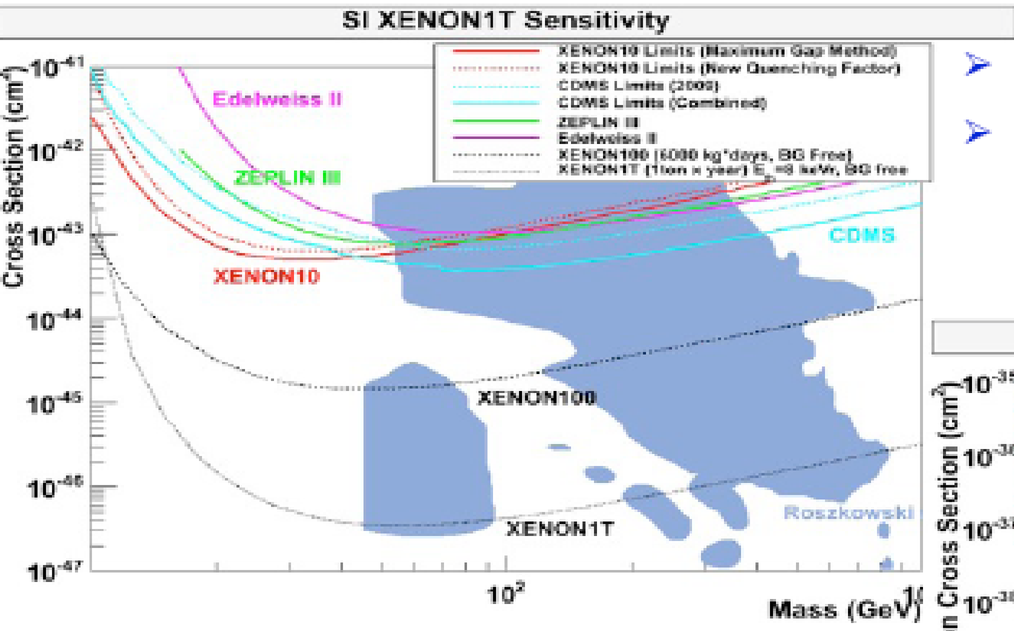
Leszek at this meeting

Arrenberg, Baudis, Kong, Matchev, J. Yoo

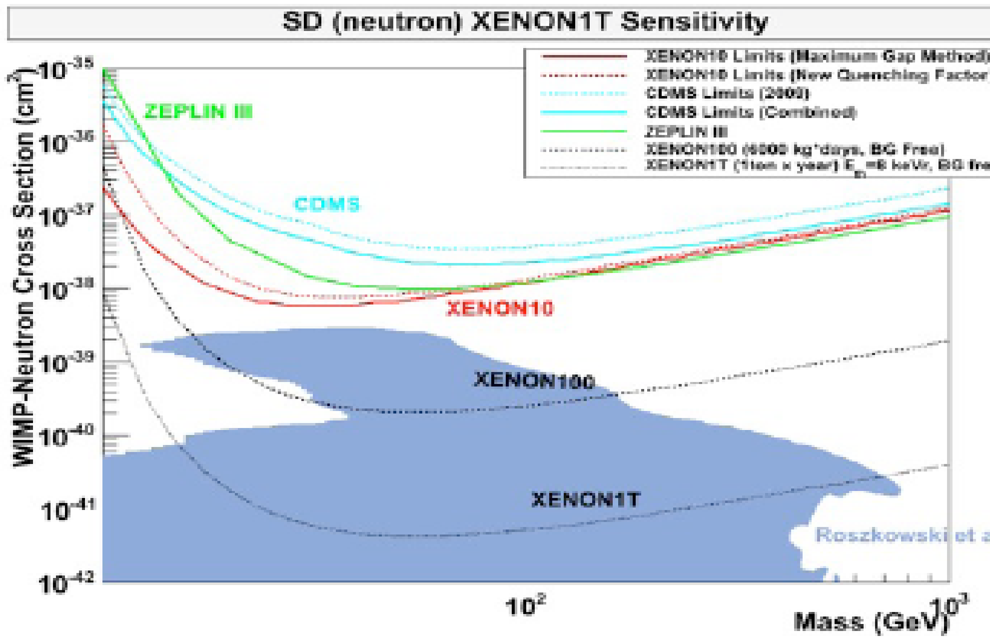


Prospect with a 1-ton detector with noble liquids

XENON1T: A tremendous scientific reach



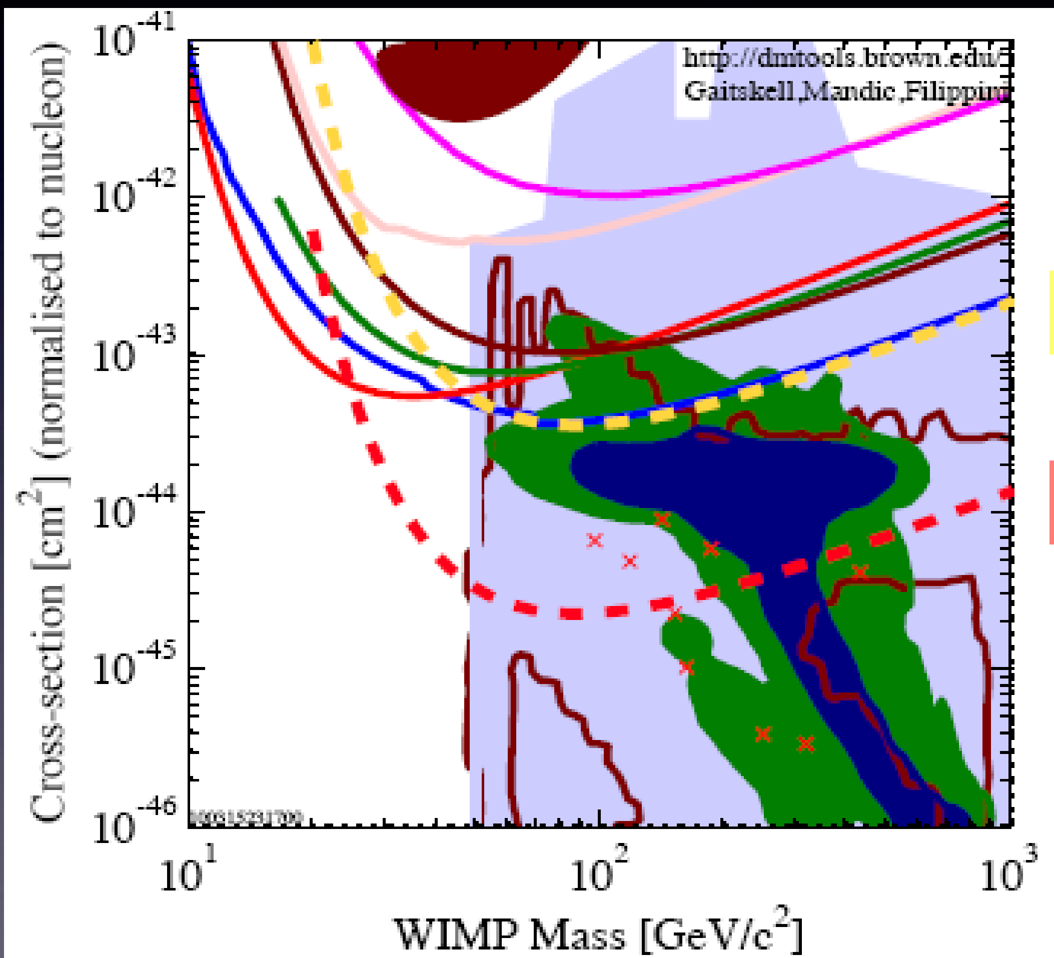
- ➢ probe simultaneously SI and SD channels
- ➢ explore the entire MSSM parameter space



E. Aprile, WONDER10

Sensitivity for SI case

YAMASHITA XMASS COLL. AT WONDER10

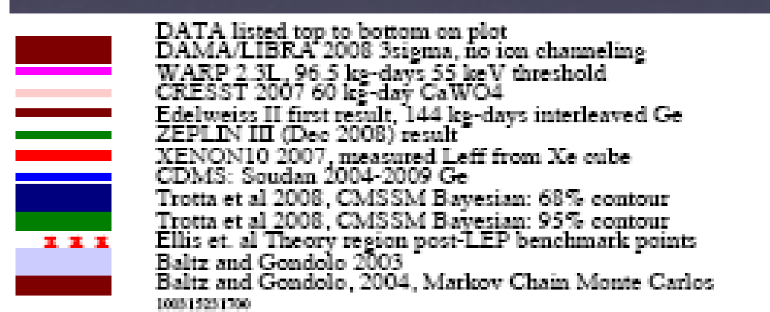


10^{-4} dru, 100 kg fiducial

XMASS 800 kg 10 days

XMASS 800 kg 1 year

(flat bg assumed)

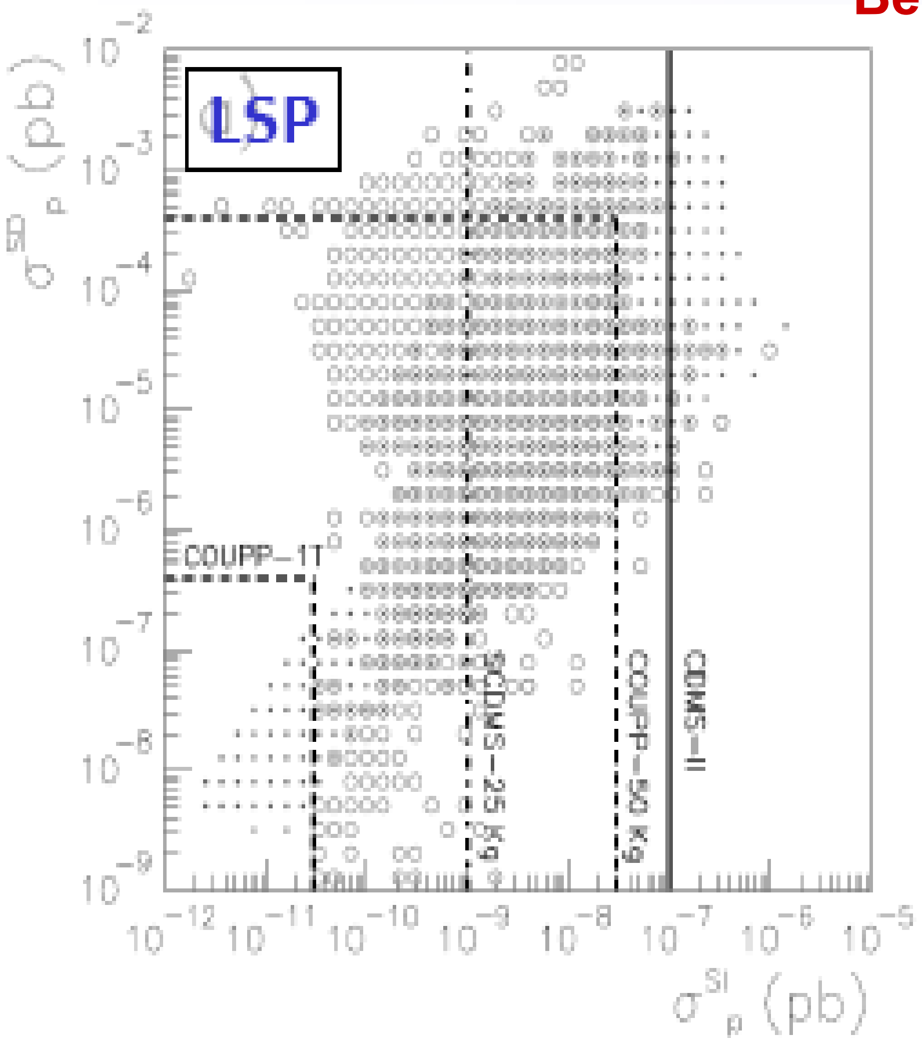


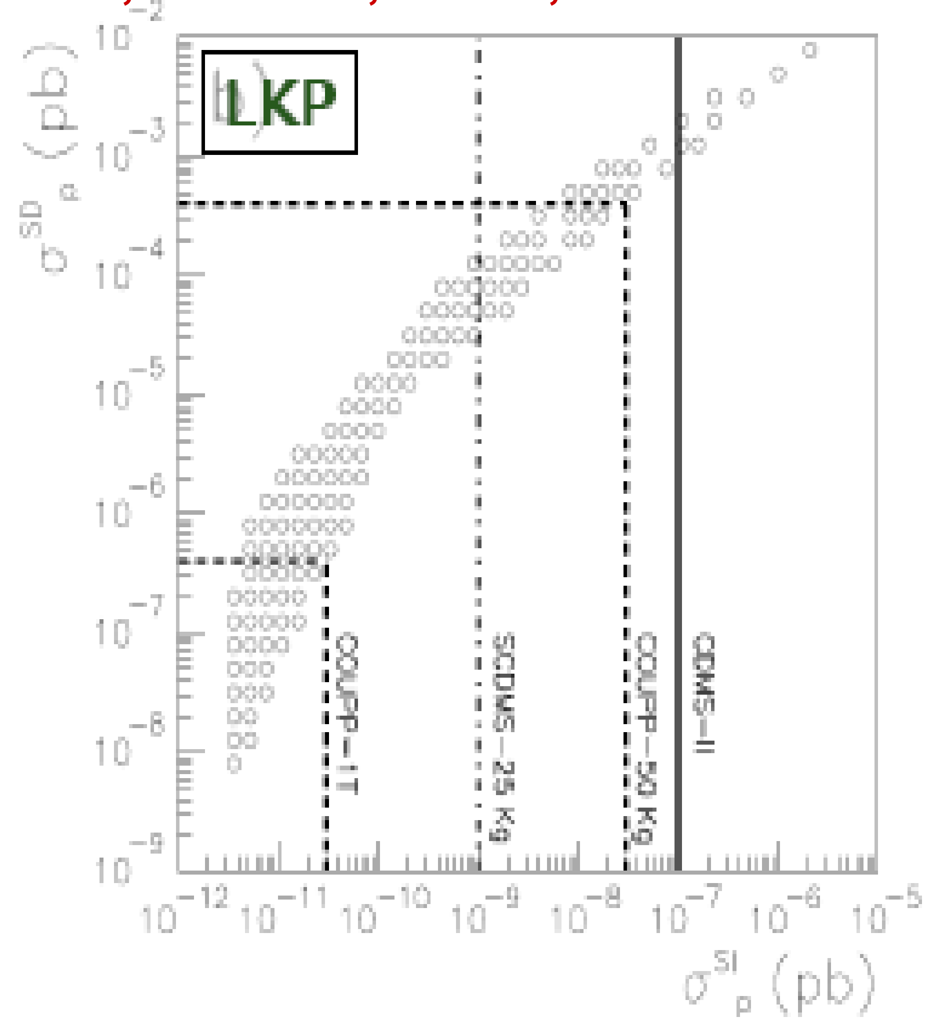
Masaki Yamashita

ON THE DISCRIMINATION AMONG WIMP CANDIDATES:

useful to measure both the SI and SD cross-sections

Bertone, Cerdeno, Collar, Odom





FLAVOR BLINDNESS OF THE NP AT THE ELW. SCALE?

- **THREE DECADES OF FLAVOR TESTS** (Redundant determination of the UT triangle $\rightarrow$ verification of the SM, theoretically and experimentally "high precision" FCNC tests, ex. $b \rightarrow s + \gamma$, CP violating flavor conserving and flavor changing tests, lepton flavor violating (LFV) processes, …) clearly state that:
- A) in the **HADRONIC SECTOR** the **CKM flavor pattern of the SM represents the main bulk of the flavor structure and of (flavor violating) CP violation;**
- B) in the **LEPTONIC SECTOR**: although neutrino flavors exhibit large admixtures, LFV, i.e. non – conservation of individual lepton flavor numbers in FCNC transitions among charged leptons, is extremely small: once again the SM is right (to first approximation) predicting negligibly small LFV

Possible hints for NP in B and K

- sin2β can be measured directly or inferred from the UT ~ 2σ discrepancy

- sin2β can be measured directly also through penguin-mediated B decays ~ 1.5 σ discrepancy

- Comparison of partial rate asymmetries in charged and neutral B decays into Kπ

- Deviation of the time dependent CP asymmetry in $B_s \rightarrow J/\Psi\varphi$ as measured bv CDF and D0 from the SM ~ 2—3 σ (FIRST EVIDENCE OF NEW PHYSICS IN $b \leftrightarrow s$ TRANSITIONS (UT*fit* Collaboration))

- The prediction of the SM for ε_K is ~ 18% below its exp. Value (BURAS et al.)

What to make of this triumph of the CKM pattern in hadronic **flavor tests**?

New Physics at the Elw. Scale is Flavor Blind
CKM exhausts the flavor changing pattern at the elw. Scale →

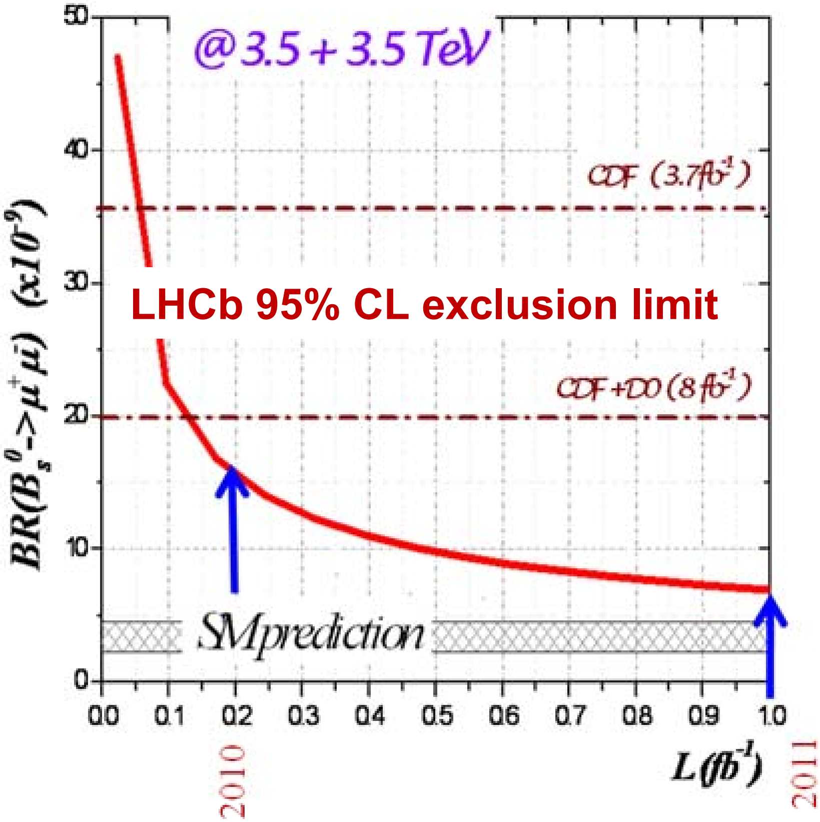
MINIMAL FLAVOR VIOLATION

MFV : Flavor originates only from the SM Yukawa coupl.

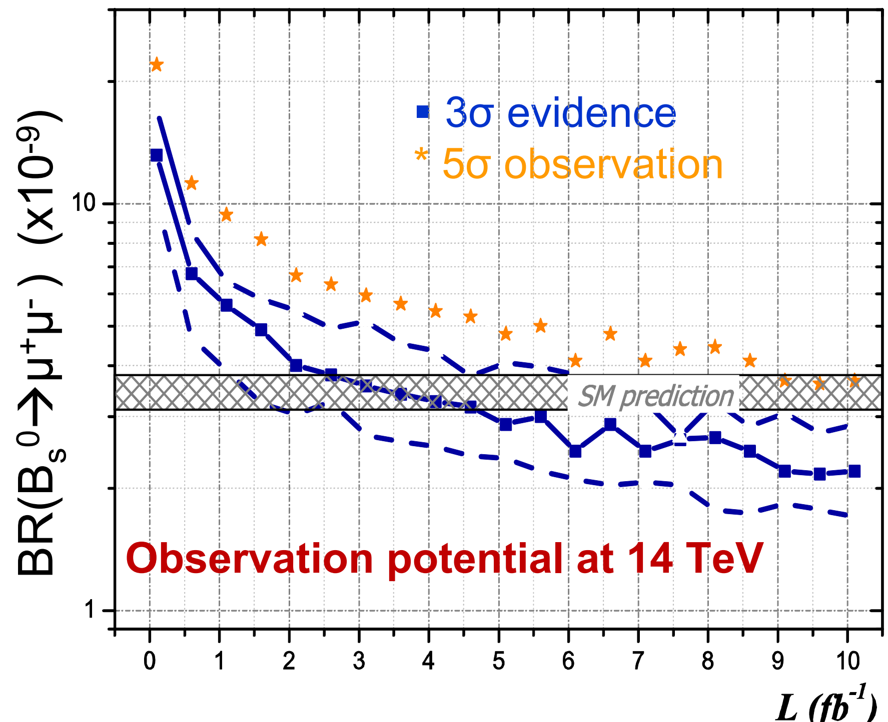
New Physics introduces

NEW FLAVOR SOURCES in addition to the CKM pattern. They give rise to contributions which are <20% in the “flavor observables” which have already been observed!

Physics reach for BR($B_s^0 \rightarrow \mu^+\mu^-$) as function of integrated luminosity (and comparison with Tevatron)



With ~0.2 fb^{-1} LHCb should improve on expected Tevatron limit



→ **Collect ~3 fb^{-1} for 3σ evidence of SM value and ~10 fb^{-1} for 5σ observation of SM**

(Note: ATLAS/CMS will be competitive)

What a SuperB can do in testing CMFV

L. Silvestrini at SuperB IV

Minimal Flavour Violation

In **MFV models** with **one Higgs doublet** or **low/moderate tanβ** the NP contribution is a shift of the Inami-Lim function associated to top box diagrams

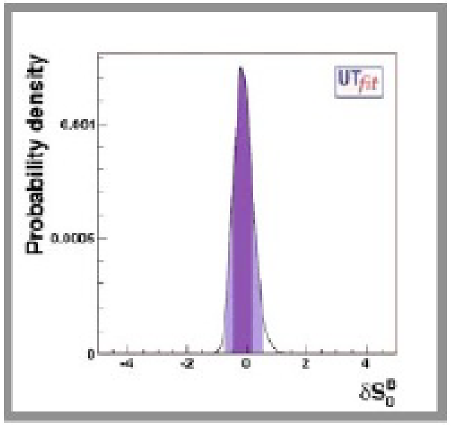
$$S_0(x_t) \rightarrow S_0(x_t) + \delta S_0(x_t)$$

$$\delta S_0(x_t) = 4a\left(\frac{\Lambda_0}{\Lambda}\right)^2$$

$$\Lambda_0 = \frac{\lambda_t \sin^2 \vartheta_W M_W}{\alpha} \simeq 2.4\ \text{TeV}$$

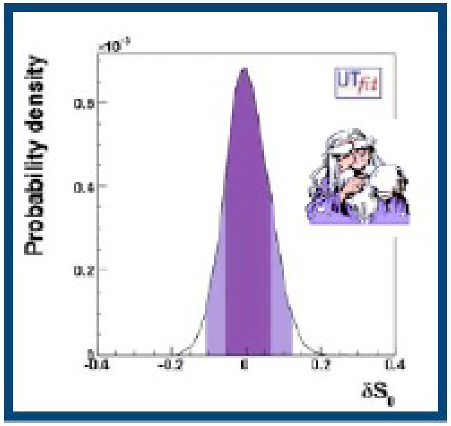
(D'Ambrosio et al., hep-ph/0207036)

$$\delta S_0^{\,B} = \delta S_0^{\,K}$$



$\delta S_0 = -0.16 \pm 0.32$

$\Lambda > 5.5$ TeV @95%



$\delta S_0 = 0.004 \pm 0.059$

$\Lambda > 28$ TeV @95%

The "worst" case: we still probe virtual particles with masses up to ~12 M_W ~1 TeV

SuperB vs. LHC Sensitivity Reach in testing Λ_{SUSY}

	superB	general MSSM	high-scale MFV
$\lvert(\delta^d_{13})_{LL}\rvert$ $(LL \gg RR)$	$1.8 \cdot 10^{-2} \frac{m_{\tilde{q}}}{(350\mathrm{GeV})}$	1	$\sim 10^{-3} \frac{(350\mathrm{GeV})^2}{m^2_{\tilde{q}}}$
$\lvert(\delta^d_{13})_{LL}\rvert$ $(LL \sim RR)$	$1.3 \cdot 10^{-3} \frac{m_{\tilde{q}}}{(350\mathrm{GeV})}$	1	–
$\lvert(\delta^d_{13})_{LR}\rvert$	$3.3 \cdot 10^{-3} \frac{m_{\tilde{q}}}{(350\mathrm{GeV})}$	$\sim 10^{-1} \tan\beta \frac{(350\mathrm{GeV})}{m_{\tilde{q}}}$	$\sim 10^{-4} \tan\beta \frac{(350\mathrm{GeV})^3}{m^3_{\tilde{q}}}$
$\lvert(\delta^d_{23})_{LR}\rvert$	$1.0 \cdot 10^{-3} \frac{m_{\tilde{q}}}{(350\mathrm{GeV})}$	$\sim 10^{-1} \tan\beta \frac{(350\mathrm{GeV})}{m_{\tilde{q}}}$	$\sim 10^{-3} \tan\beta \frac{(350\mathrm{GeV})^3}{m^3_{\tilde{q}}}$

SuperB can probe MFV (with small-moderate tanβ) for TeV squarks; for a generic non-MFV MSSM → sensitivity to squark masses > 100 TeV !

Ciuchini, Isidori, Silvestrini

SLOW-DECOUPLING OF NP IN FCNC

V. Lubicz, SuperB_Padova 2008

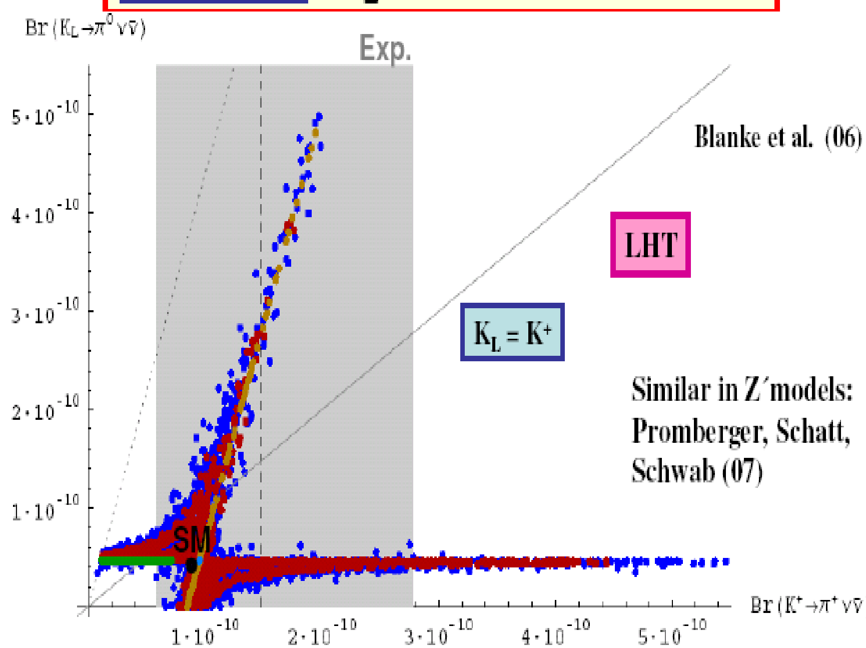
Estimates of error for 2015

Hadronic matrix element	Current lattice error	6 TFlop Year	60 TFlop Year [2011 LHCb]	1-10 PFlop Year [2015 SuperB
$f_+^{K\pi}(0)$	0.9% (22% on 1-f_+)	0.7% (17% on 1-f_+)	0.4% (10% on 1-f_+)	**< 0.1% (2.4% on 1-f_+)**
$\hat{B}_K$	11%	5%	3%	**1%**
f_B	14%	3.5 - 4.5%	2.5 - 4.0%	**1 – 1.5%**
$f_{Bs}B_{Bs}^{1/2}$	13%	4 - 5%	3 - 4%	**1 – 1.5%**
ξ	5% (26% on ξ-1)	3% (18% on ξ-1)	1.5 - 2 % (9-12% on ξ-1)	**0.5 – 0.8 % (3-4% on ξ-1)**
$\mathcal{F}_{B\to D/D^*l\nu}$	4% (40% on 1-$\mathcal{F}$)	2% (21% on 1-$\mathcal{F}$)	1.2% (13% on 1-$\mathcal{F}$)	**0.5% (5% on 1-$\mathcal{F}$)**
$f_+^{B\pi}, \ldots$	11%	5.5 - 6.5%	4 - 5%	**2 – 3%**
$T_1^{B\to K^*/\rho}$	13%	----	----	**3 – 4%**

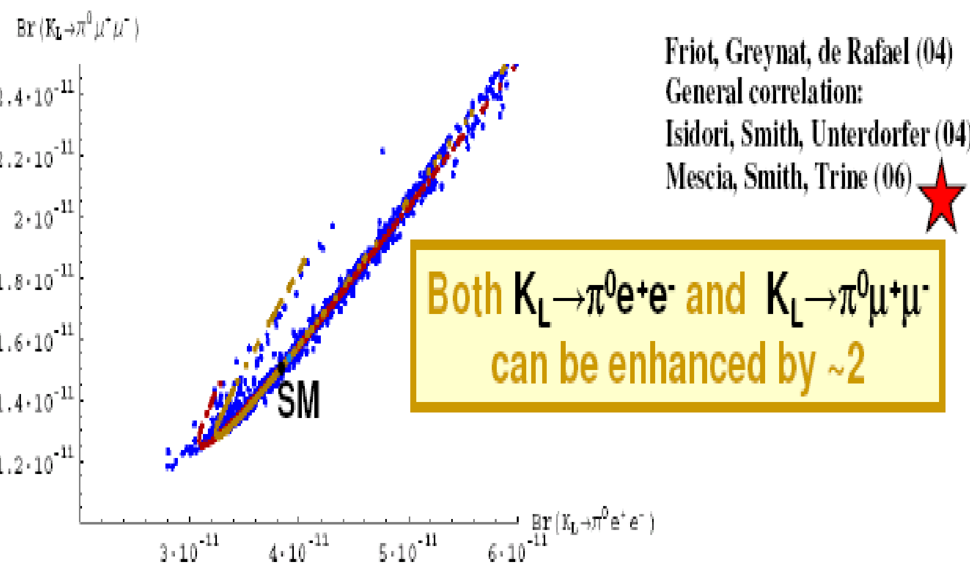
FCNC SL K DECAYS

Decay	SM	Exp	TH
$K^+ \to \pi^+\nu\bar{\nu}$	$(8.1\pm1.1)\cdot10^{-11}$	$(14.7^{+13.0}_{-8.9})\cdot10^{-11}$ (BNL)	$\pm$2-3%
$K_L \to \pi^0\nu\bar{\nu}$	$(2.6\pm0.3)\cdot10^{-11}$	$< 2.1\cdot10^{-7}$ (KTeV,KEK)	$\pm$1-2%
$K_L \to \pi^0e^+e^-$	$(3.5\pm1.0)\cdot10^{-11}$	$< 28\cdot10^{-11}$ (KTeV)	$\pm$15%
$K_L \to \pi^0\mu^+\mu^-$	$(1.4\pm0.3)\cdot10^{-11}$	$< 38\cdot10^{-11}$ (KTeV)	$\pm$15%

K-system: $K_L\to\pi^0\nu\bar{\nu}$ vs $K^+\to\pi^+\nu\bar{\nu}$



K-system: $K_L\to\pi^0e^+e^-$ and $K_L\to\pi^0\mu^+\mu^-$

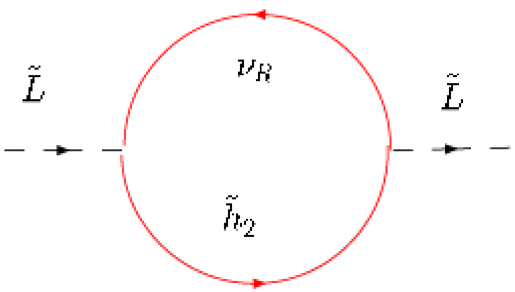


Two distinguished branches appear!
~10 times enhancement in $K_L\to\pi^0\nu\bar{\nu}$
~5 times enhancement in $K^+\to\pi^+\nu\bar{\nu}$

SUSY SEESAW: *Flavor universal SUSY breaking and yet large lepton flavor violation*

Borzumati, A. M. 1986 (after discussions with W. Marciano and A. Sanda)

$$L = f_l\, \bar{e}_R L h_1 + f_\nu\, \bar{\nu}_R L h_2 + M\, \nu_R \nu_R$$

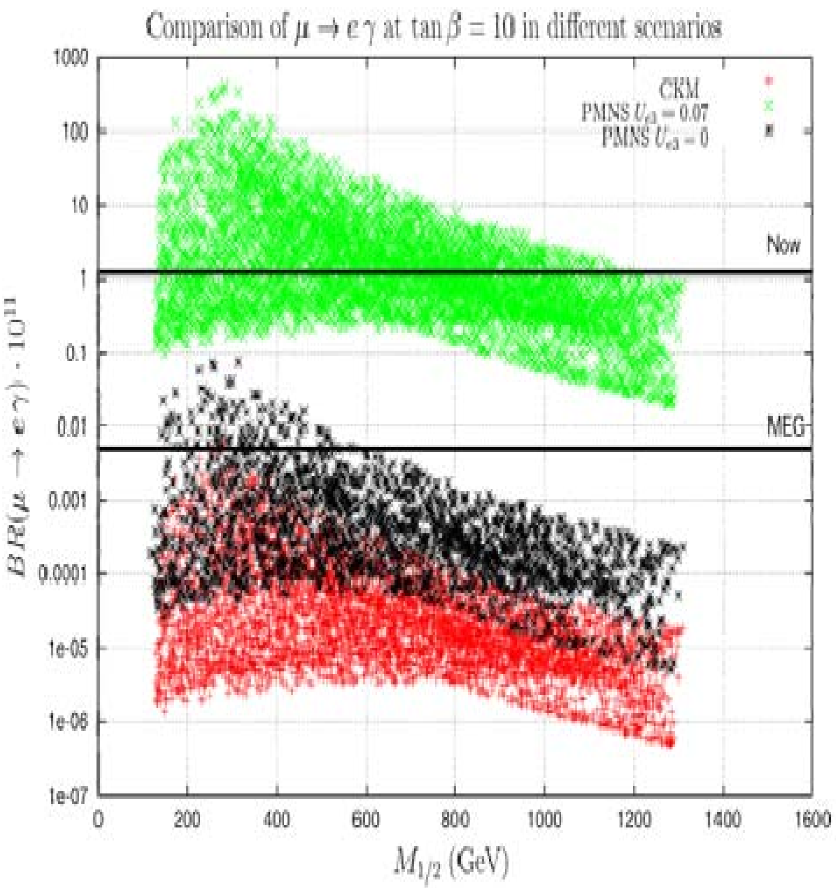


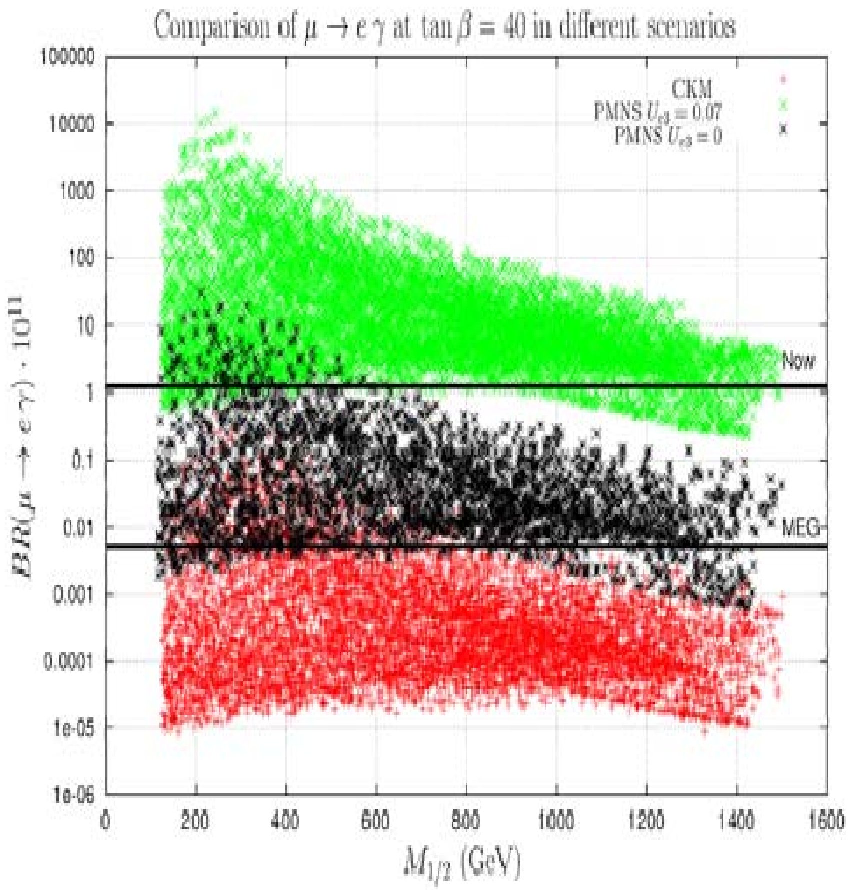
$$\left(m^2_{\tilde{L}}\right)_{ij} \sim \frac{1}{8\pi^2}\left(3m_0^2 + A_0^2\right)\left(f_\nu^\dagger f_\nu\right)_{ij} \log\frac{M}{M_G}$$

Non-diagonality of the slepton mass matrix in the basis of diagonal lepton mass matrix depends on the unitary matrix U which diagonalizes $(f_\nu^+ f_\nu)$

μ → e+γ in SUSYGUT: past and future

$\mu \rightarrow e\,\gamma$ in the $U_{e3} = 0$ PMNS case





Calibbi, Faccia, A.M., Vempati

LFV vs. MUON (g – 2) in MSSM

Isidori, Mescia, Paradisi, Temes

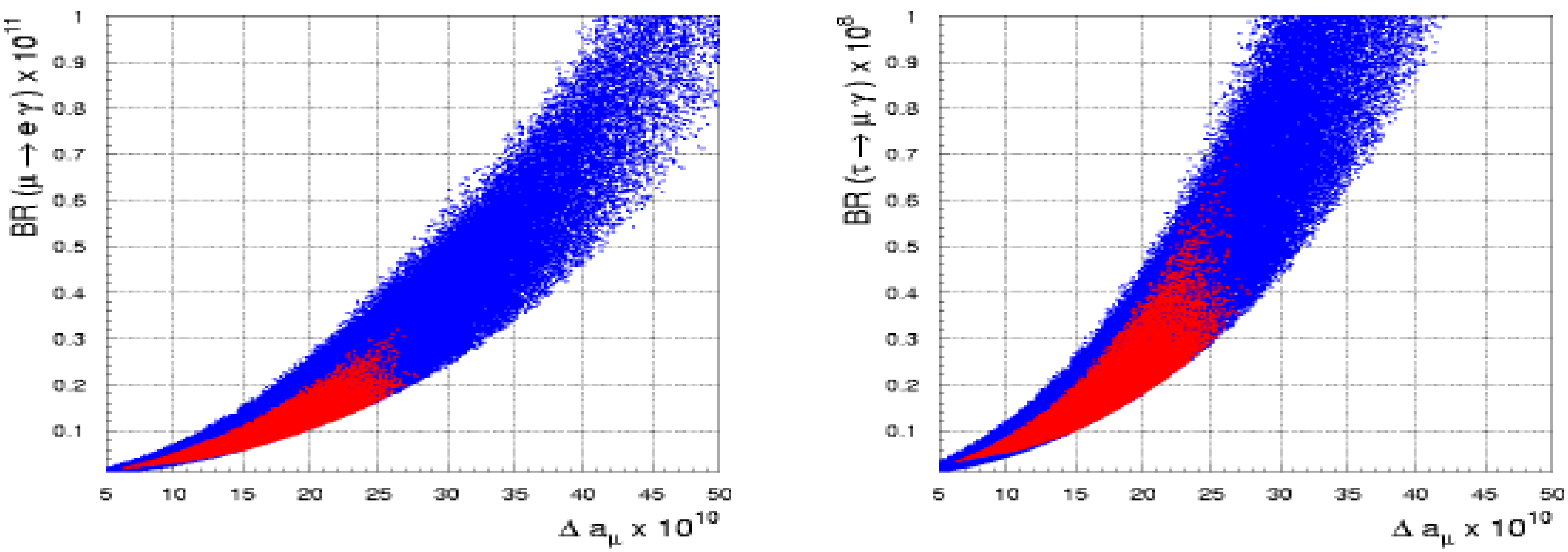


Figure 6: Expectations for $\mathcal{B}(\mu \to e\gamma)$ and $\mathcal{B}(\tau \to \mu\gamma)$ vs. $\Delta a_\mu = (g_\mu - g_\mu^{\rm SM})/2$, assuming $|\delta_{LL}^{12}| = 10^{-4}$ and $|\delta_{LL}^{23}| = 10^{-2}$. The plots have been obtained employing the following ranges: 300 GeV $\leq M_{\tilde{\ell}} \leq$ 600 GeV, 200 GeV $\leq M_2 \leq$ 1000 GeV, 500 GeV $\leq \mu \leq$ 1000 GeV, $10 \leq \tan\beta \leq 50$, and setting $A_U = -1$ TeV, $M_{\tilde{q}} = 1.5$ TeV. Moreover, the GUT relations $M_2 \approx 2M_1$ and $M_3 \approx 6M_1$ are assumed. The red areas correspond to points within the funnel region which satisfy the B-physics constraints listed in Section 3.2 [$\mathcal{B}(B_s \to \mu^+\mu^-) < 8 \times 10^{-8}$, $1.01 < R_{Bs\gamma} < 1.24$, $0.8 < R_{B\tau\nu} < 0.9$, $\Delta M_{B_s} = 17.35 \pm 0.25$ ps^{-1}].

3 QUESTIONS

- Are we sure that there is new physics (NP) at the TeV scale? YES (barring an antropic approach)
- If yes, are we sure that LHC will see something “new”, i.e. beyond the SM with its “standard higgs boson”? YES
- If there is new physics at the TeV scale, what can flavor and DM physics tell to LHC and viceversa? (or, putting it in a less politically correct fashion: if LHC starts seeing some new physics signals, are flavor and DM physics still a valuable road to NP, or are they definitely missing that train? NO, actually to catch the “right train” it is highly desirable, though maybe strictly not necessary, to make use of all the three roads at the same time

G. Martinelli