IFAE 2010, ROMA 7 – 9 MAGGIO 2010

PROSPETTIVE FUTURE

Antonio Masiero
Univ. di Padova and INFN, Padova

3 domande

- **Siamo sicuri che ci sia nuova fisica alla scala del TeV?**
- **Se si', siamo sicuri che LHC vedra' qualcosa di "nuovo", cioe' qualcosa che non sia SM con il suo "canonico" higgs?**
- **Se c'e' NP al TeV, la strada del "flavor" (inclusa la fisica del neutrino) e quella astroparticellare possono dire qualcosa a LHC e cosa possono sentirsi dire da LHC? (piu' brutalmente: se LHC comincia trovare qualche segnale di NP, flavor e DM restano "competitivi" o arriveranno, se arriveranno, a pranzo ormai finito?)**

Present "Observational" Evidence for New Physics

- **NEUTRINO MASSES** ★★★
- **DARK MATTER** ★★★
- **MATTER-ANTIMATTER ASYMMETRY** ★★
- **INFLATION** ★

SM FAILS TO GIVE RISE TO A SUITABLE COSMIC MATTER-ANTIMATTER ASYMMETRY

:

- **NOT ENOUGH CP VIOLATION IN THE SM**

  NEED FOR ***NEW SOURCES OF CPV IN ADDITION TO THE PHASE PRESENT IN THE CKM MIXING MATRIX***

- FOR M_{HIGGS} > 80 GeV THE ELW. PHASE TRANSITION OF THE SM IS A SMOOTH CROSSOVER

NEED ***NEW PHYSICS BEYOND SM***. **IN PARTICULAR, FASCINATING POSSIBILITY:** ***THE ENTIRE MATTER IN THE UNIVERSE ORIGINATES FROM THE SAME MECHANISM RESPONSIBLE FOR THE EXTREME SMALLNESS OF NEUTRINO MASSES***

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***

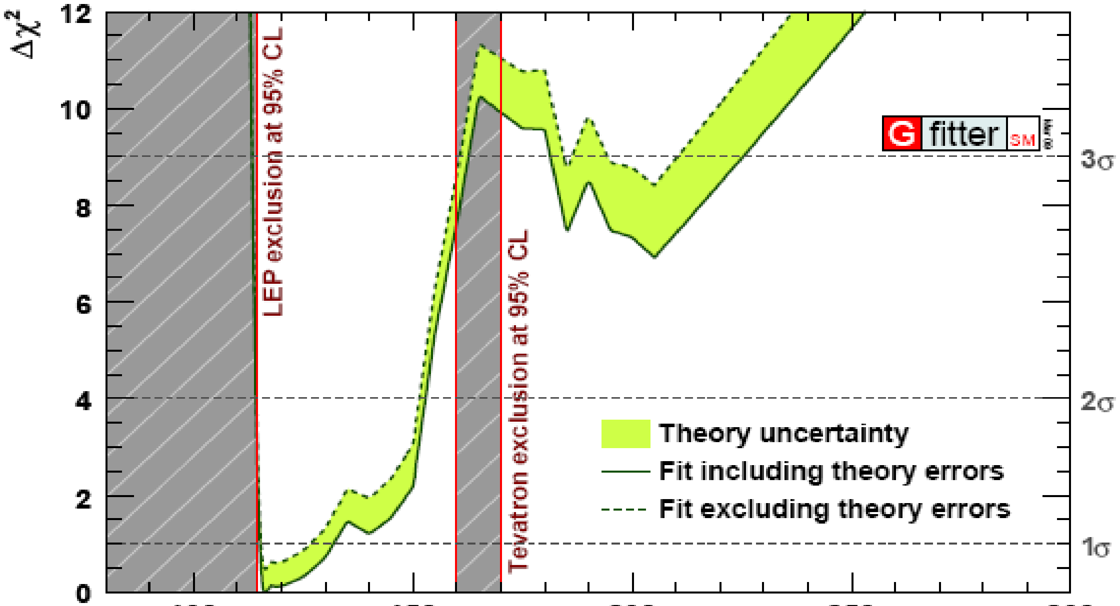
OPINIONE PERSONALE SULLA non CONNESSIONE DEI FINE-TUNINGS

- **Fine-tuning per cancellare I contributi radiativi che spingerebbero "naturalmente" l'higgs alla scala GUT o Planck**

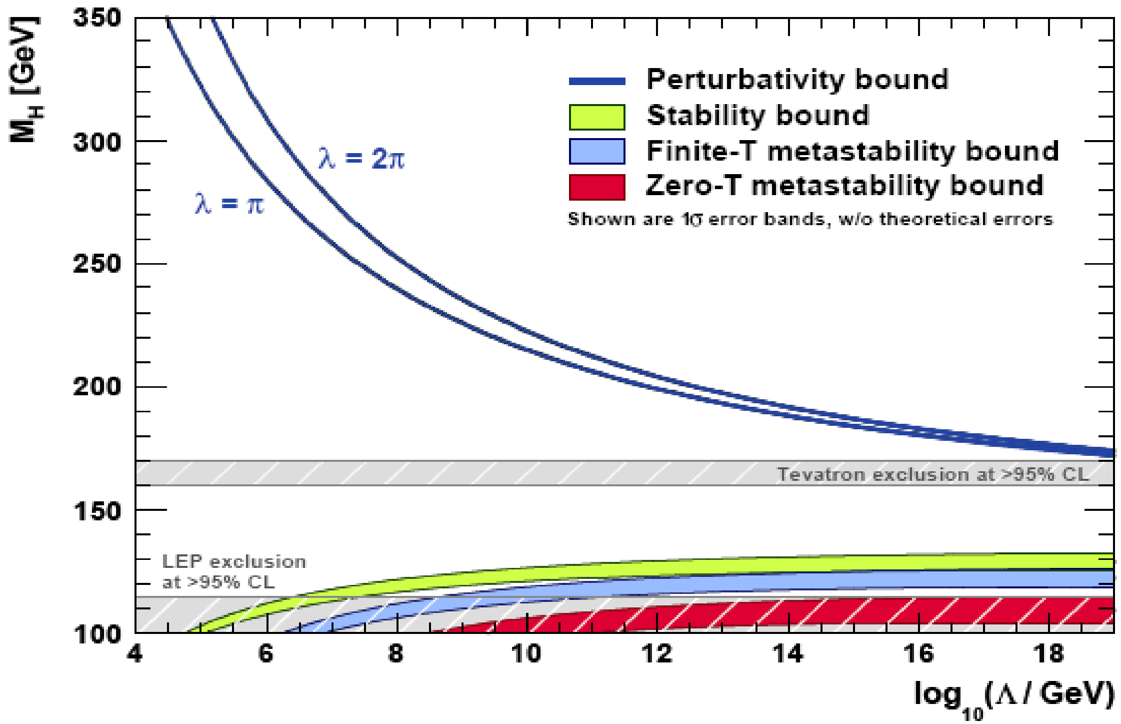
- **Fine-tuning per cancellare il contributo all'energia del vuoto del potenziale scalare dell'SM → probl. Costante cosmologica**

- **In uno scenario di teoria fondamentale con grandissimo numero di vuoti "realizzabili", i due "apparenti" fine-tuning di cui sopra sono in realta' frutto di una comune "selezione ambientale" che seleziona il solo vuoto che conduce ad un universo con le carattestiche del nostro**

- **A parer mio, i due fine-tuning sono disaccoppiati; la questione della cost. cosmologica puo' essere legata a proprieta' della gravita' su grande scala, mentre la stabilizzazione della rottura elettrodebole richiede che … ci sia necessariamente una NUOVA FISICA al TeV che la renda possibile (in altre parole ci dobbiamo dar da fare noi a trovare questa nuova fisica che impedisca un fine-tuning di 14 ordini di grandezza, invece di invocare una selezione ambientale che faccia il lavoro per noi)**



Higgs leggero (o qualcosa che lo “mimi”) e’ nettamente favorito



Il “grande deserto” tra scala elw. e GUT o Mplanck solo se l’higgs sta in una stretta fascia tra 130 e 180 GeV.

Ellis, Espinosa, Giudice, Hoecker, Riotto

Cosa sappiamo oggi sulla "massa"

- La fisica delle interazioni elettrodeboli e' governata da una **simmetria locale** (di gauge)
- Tale simmetria e' **rotta spontaneamente** (cioe' sappiamo che il ***meccanismo di Higgs esiste!)***
- Le **masse dei bosoni di gauge** della simmetria rotta derivano da un **meccanismo di Higgs**
- Le **masse dei fermioni del SM** derivano da un **meccanismo di Higgs**
- L'esistenza (provata da LEP in particolare) di un meccanismo di Higgs ***non implica l'esistenza dell'higgs***
- **Se esiste un bosone di higgs – particella elementare – la sua massa (nell'SM) *non* deriva dalla rottura di alcuna simmetria**

Sulla necessita' di "qualcosa" al TeV che garantisca l'unitarieta' della teoria elw.

- Teoria elw. di Fermi → interazioni di contatto a 4 fermioni → per renderla unitaria introduzione di bosoni vettoriali intermedi

- Teoria di gauge elettrodebole spont. rotta → massa a W, Z (esistenza comp. long. di W e Z) → interazioni di contatto della comp. longitudinale di W e Z → scambio "bosone intermedio" per unitarizzare la teoria

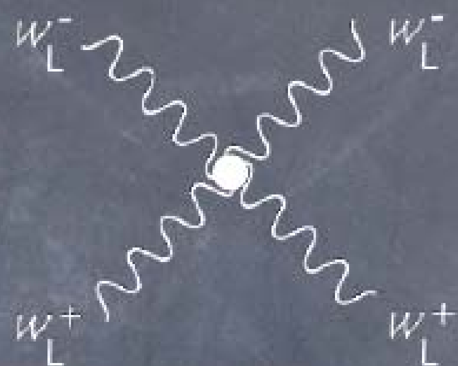
What is the mechanism of EWSB?

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

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

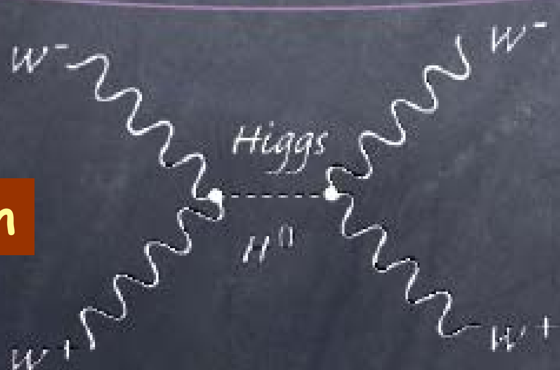


$$A = g^2 \left(\frac{E}{M_W} \right)^2$$

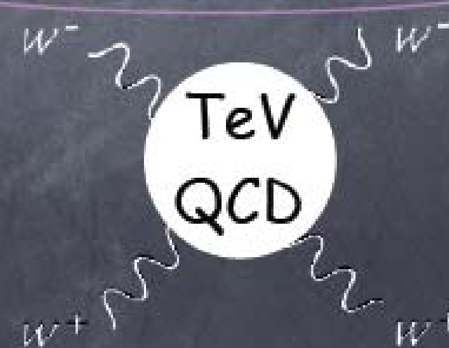
loss of perturbative unitarity
around 1.2 TeV

Weakly coupled models

Strongly coupled models



Different signatures at the LHC!



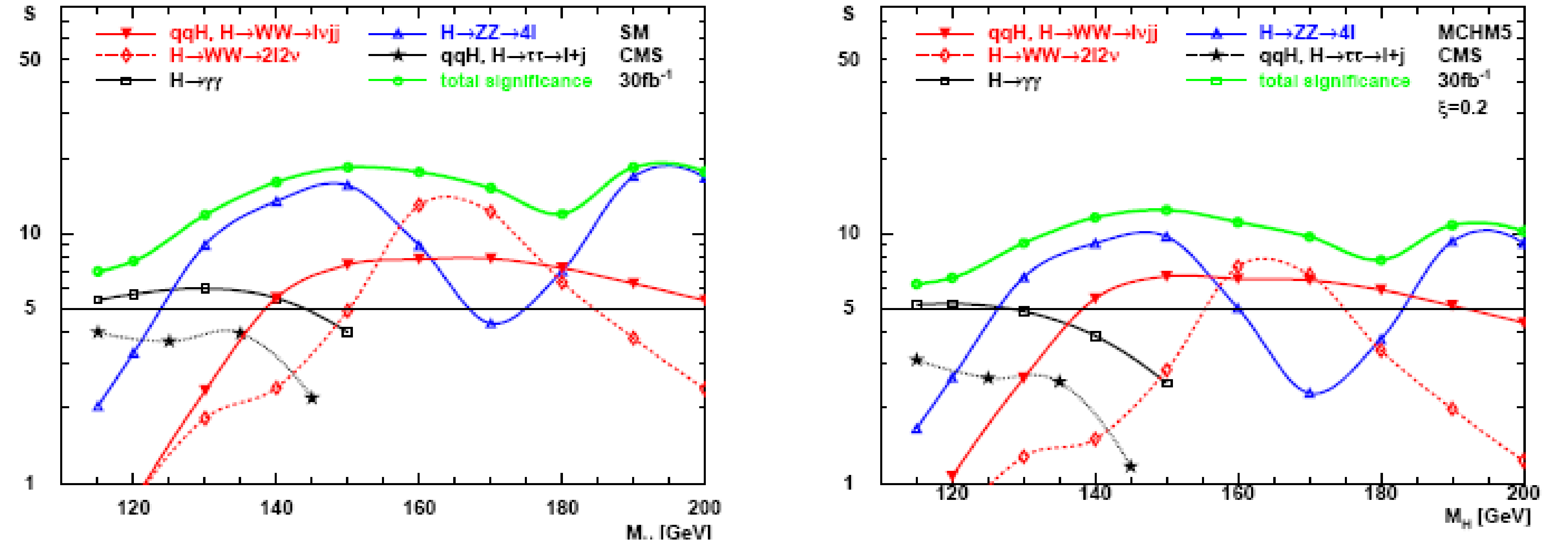
Grojean

prototype: Susy

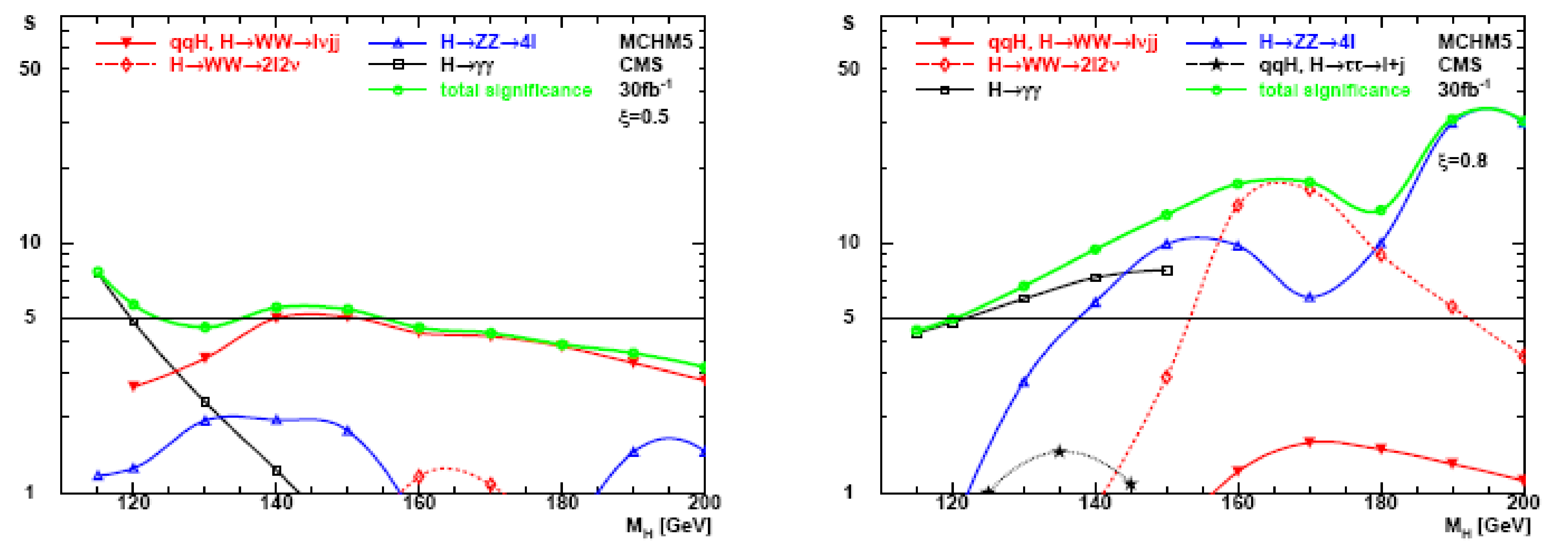
susy partners ~ 100 GeV

prototype: Technicolor

rho meson ~ 1 TeV



ESPINOSA, GROJEAN, MUEHLLEITNER



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

Lessons from model building

G. Altarelli , LP09

In all the new physics models we mentioned

there is a light Higgs (< 200 GeV)

[except in Higgsless models (if any) but new light new vector bosons exist in this case]

there is at least a % fine tuning

Fine tuning appears to be imposed on us by the data

Is it possible that the Higgs is not found at the LHC?

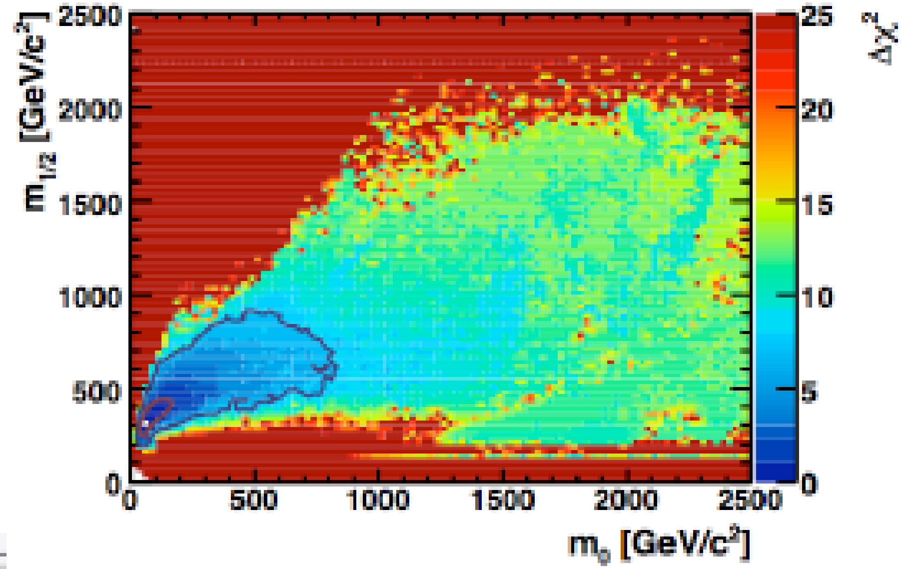
Here "Higgs" means the "the EW symmetry breaking mechanism"

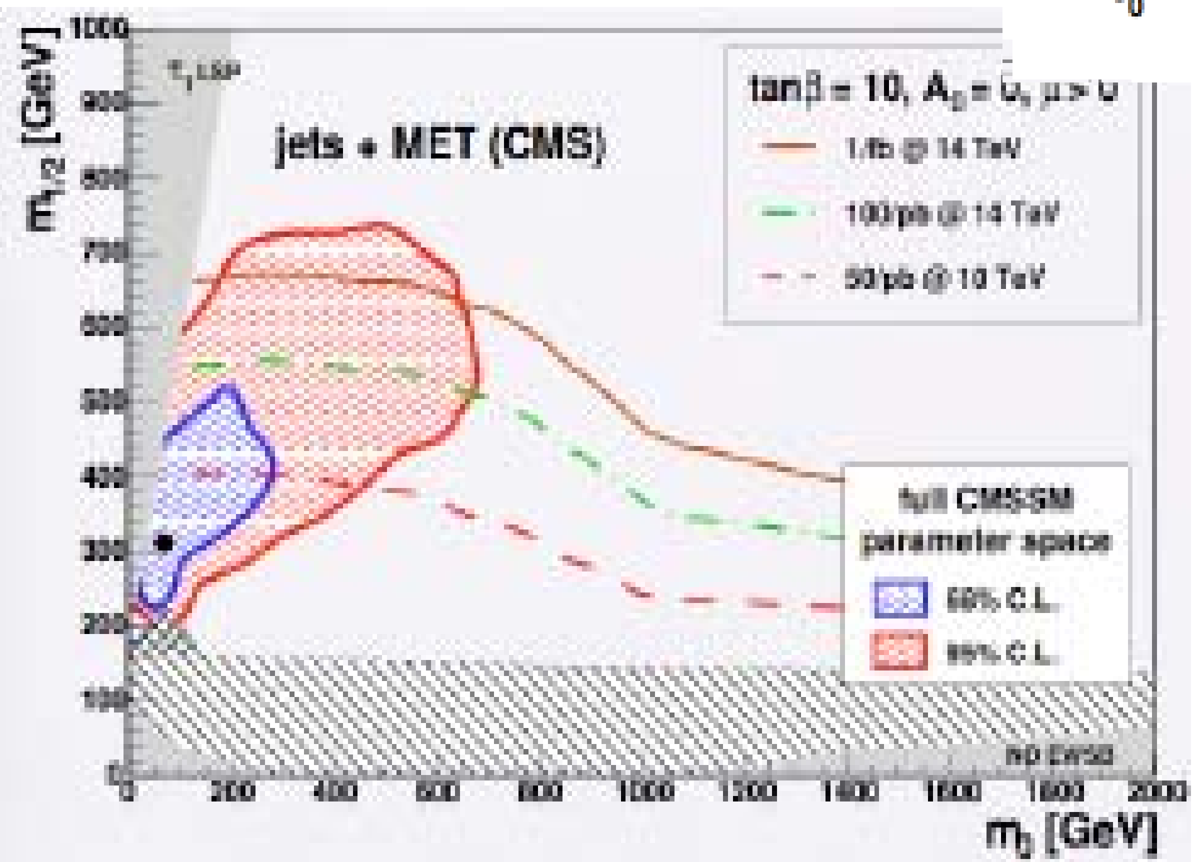
Looks pretty unlikely!!

The LHC discovery range is large enough: $m_H < \sim 1$ TeV
the Higgs should be really heavy!

Rad. corr's indicate a light Higgs (whatever its nature)

LIGHT SUSY IS PREFERRED BY DATA!





LIGHT SUSY IS TESTABLE AT THE LHC

ELLIS ET AL.

Baer, Barger, Lessa, Tata (2009)

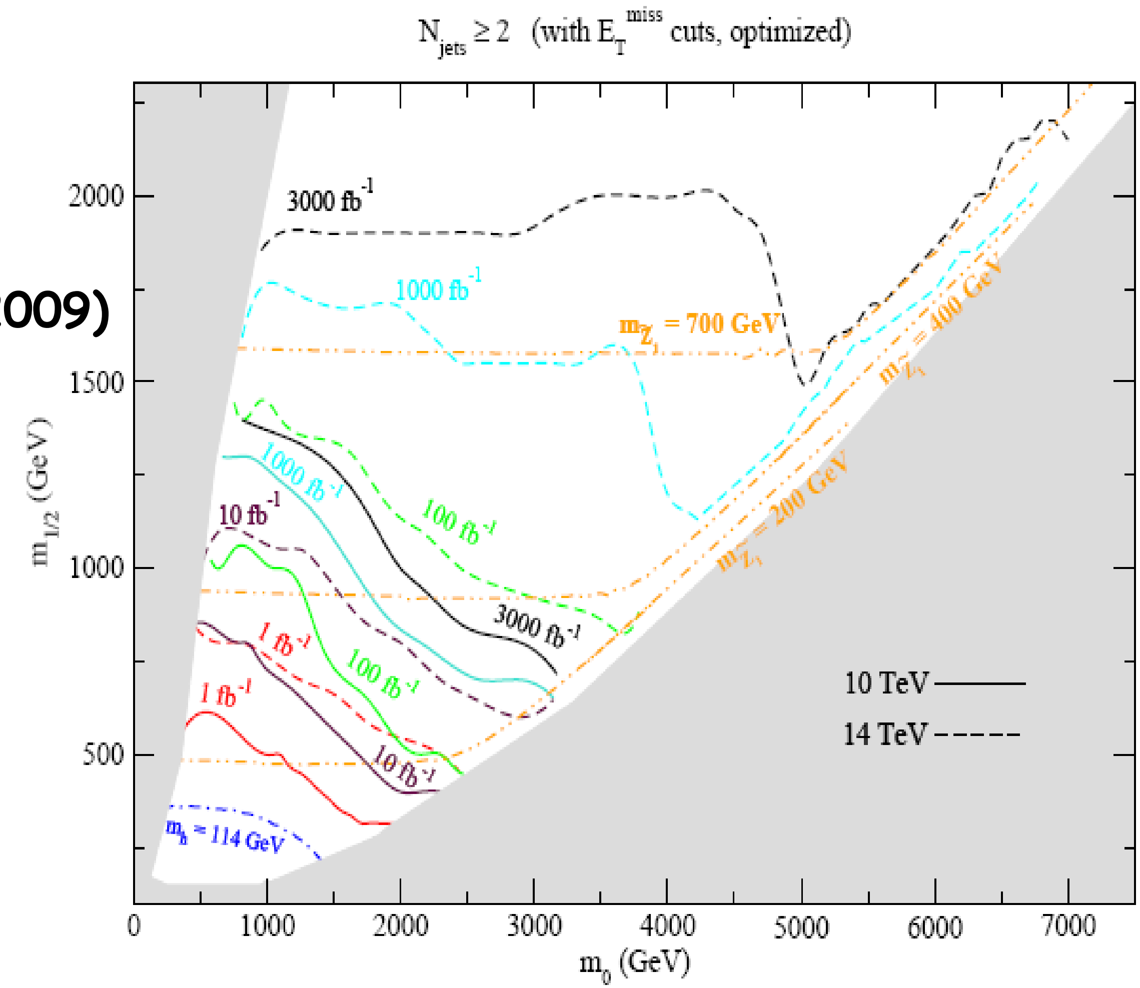


Figure 21: The ultimate SUSY reach of LHC within the mSUGRA framework for $\sqrt{s} = 10$ TeV (solid) and $\sqrt{s} = 14$ TeV (dashed) for various values of integrated luminosities. The fixed mSUGRA parameters are $A_0 = 0$, $\tan\beta = 45$ and $\mu > 0$. Isomass contours for the LSP (double dot-dashed)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

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

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

THE "*WIMP MIRACLE*"

Bergstrom

Table 1. Properties of various Dark Matter Candidates

Type	Particle Spin	Approximate Mass Scale
Axion	0	μeV-meV
Inert Higgs Doublet	0	50 GeV
Sterile Neutrino	1/2	keV
Neutralino	1/2	10 GeV - 10 TeV
Kaluza-Klein UED	1	TeV

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

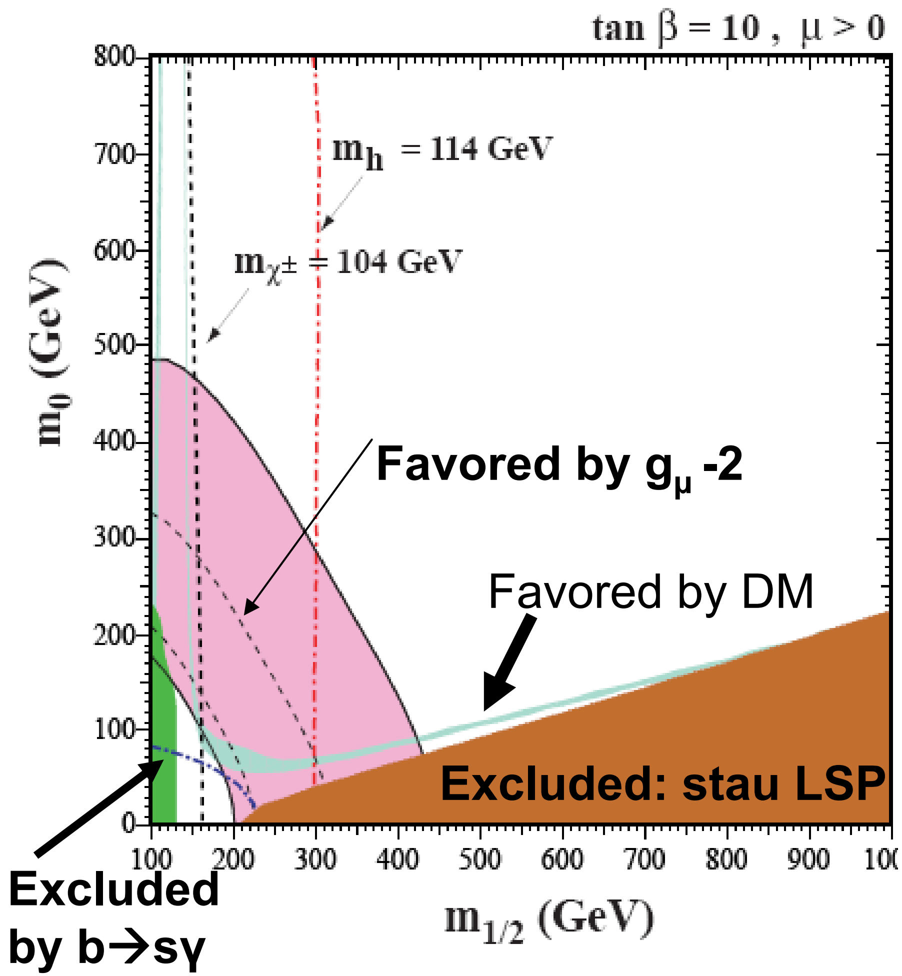
STABLE ELW. SCALE WIMPs from PARTICLE PHYSICS

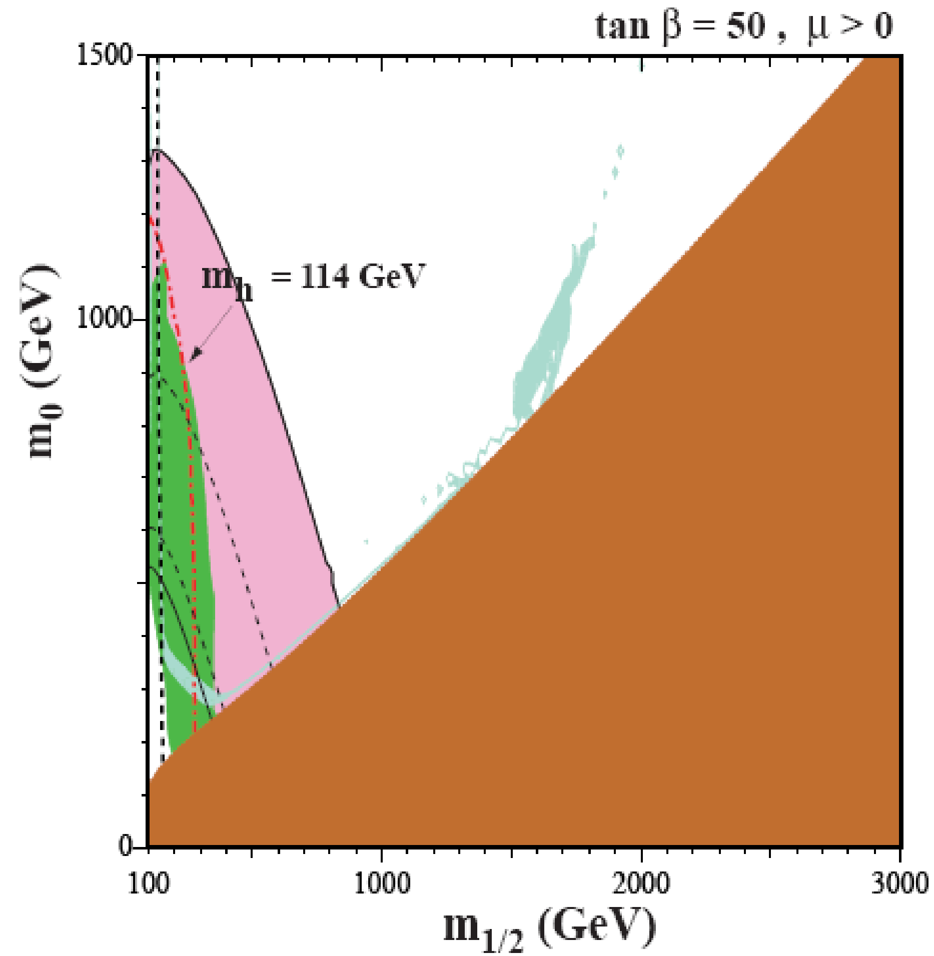
	SUSY	EXTRA DIM.	LITTLE HIGGS.
1) **ENLARGEMENT OF THE SM**	(x^μ, θ) Anticomm. Coord.	(x^μ, j^i) New bosonic Coord.	SM part + new part to cancel Λ^2 at 1-Loop
2) **SELECTION RULE** → **DISCRETE SYMM.** → **STABLE NEW PART.**	**R-PARITY LSP** Neutralino spin 1/2	**KK-PARITY LKP** spin1	**T-PARITY LTP** 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

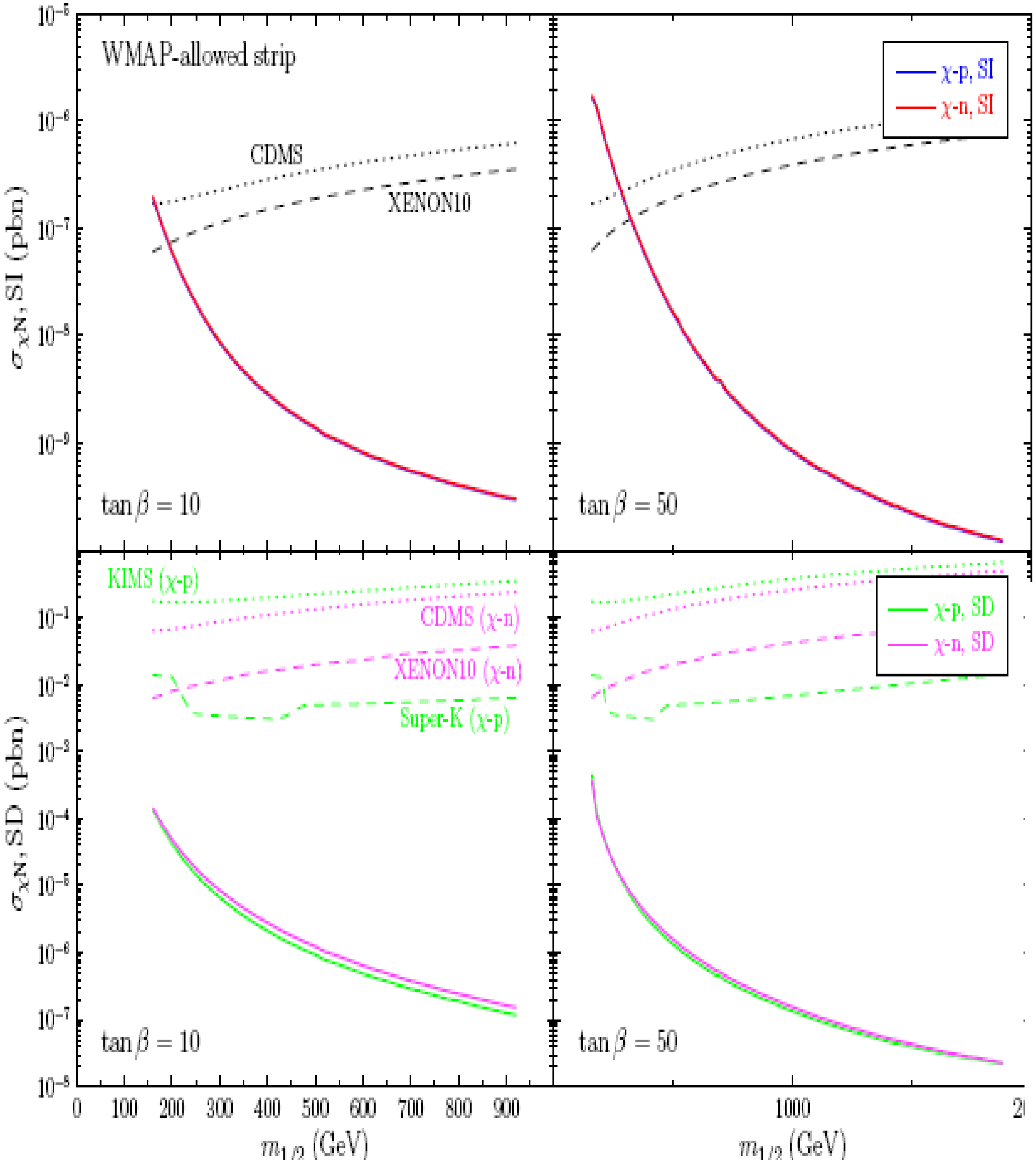
NEUTRALINO LSP IN THE CONSTRAINED MSSSM: A VERY SPECIAL SELECTION IN THE PARAMETER SPACE?





Ellis, Olive, Santoso, Spanos

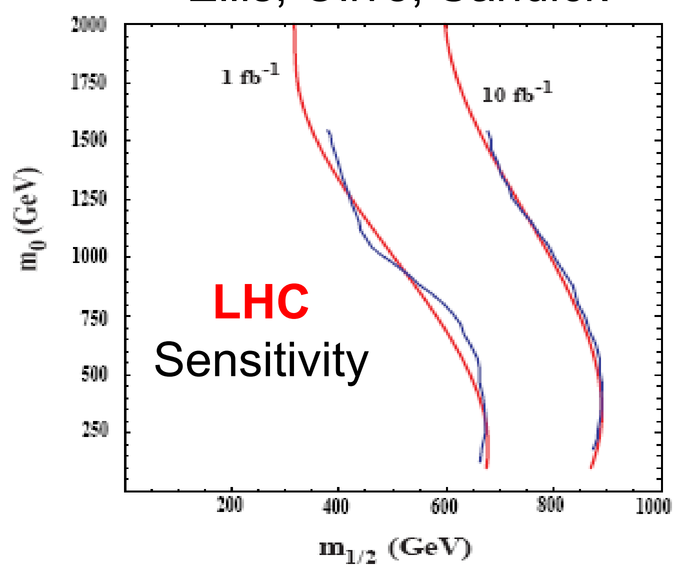
Neutralino-nucleon scattering cross sections along the WMAP-allowed coannihilation strip for tanbeta=10 and coannihilation/funnel strip for tanbeta=50 using the hadronic parameters



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



HUMAN PRODUCTION OF WIMPs

WIMPS HYPOTHESIS

DM made of particles with mass 10Gev - 1Tev

ELW scale

With WEAK INTERACT.

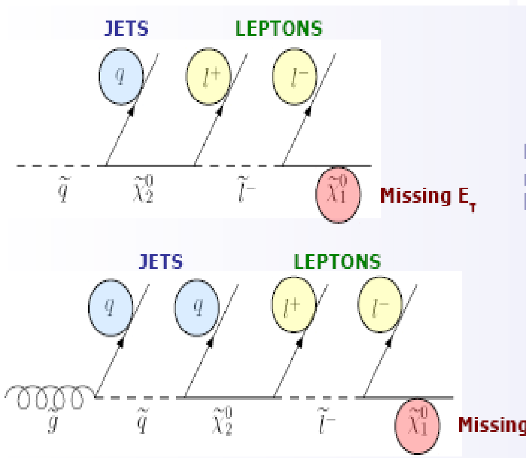
LHC, ILC may PRODUCE WIMPS

WIMPS escape the detector

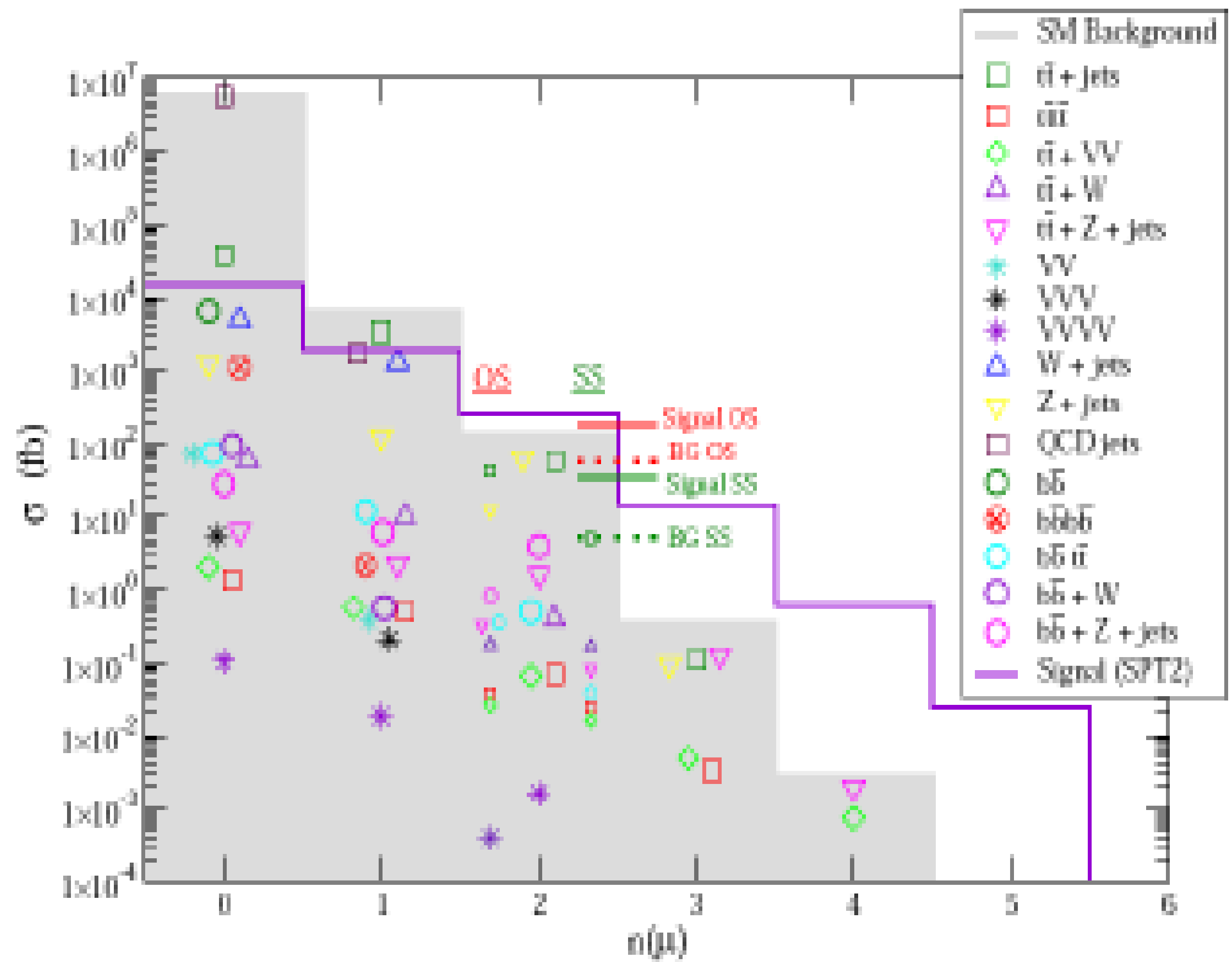
→ MISSING ENERGY SIGNATURE

POSSIBILITY TO CREATE OURSELVES IN OUR ACCELERATORS THOSE DM PARTICLES WHICH ARE PART OF THE RELICS OF THE PRIMORDIAL PLASMA AND CONSTITUTE 1/4 OF THE WHOLE ENERGY IN THE UNIVERSE

DM through the jets + missing energy signature at the LHC

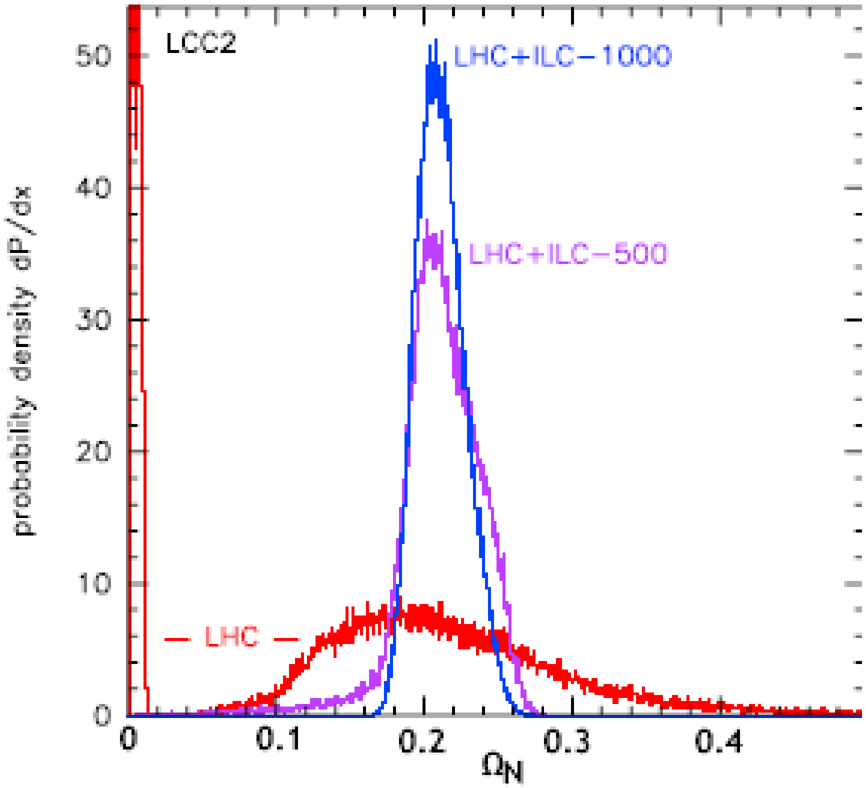


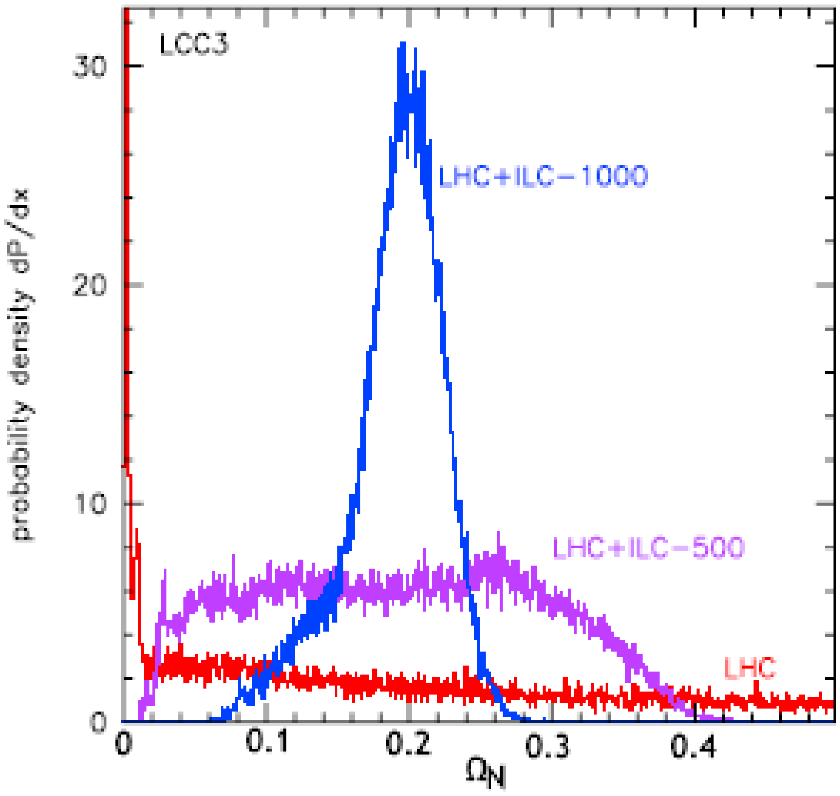
Estimation of the SM background for 4 jets + n leptons



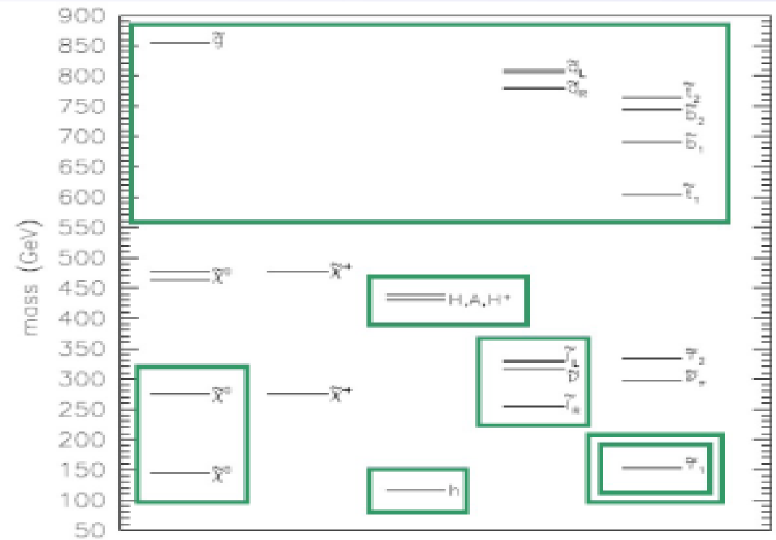
(Baer, Barger, Lessa, Tata '09)

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

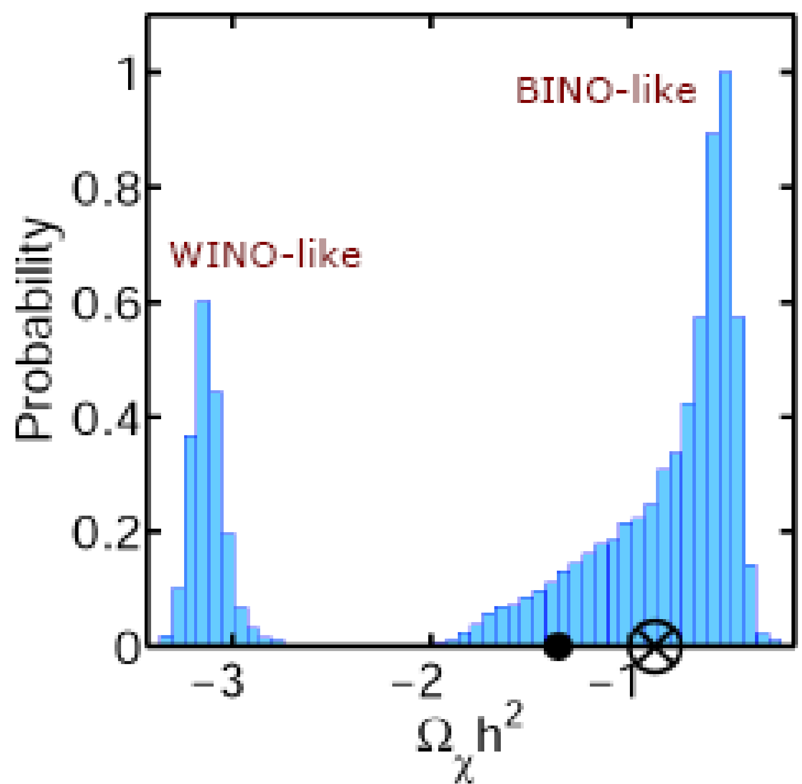


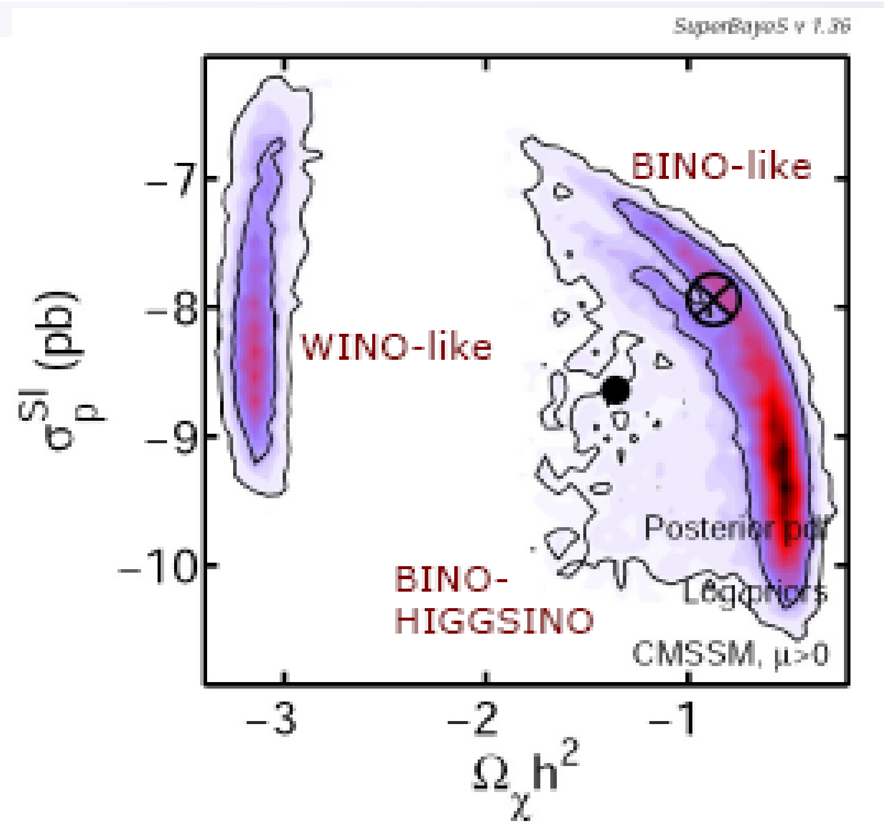


BALTZ, BATTAGLIA, PESKIN, WIZANSKY



Supponiamo di trovare (parte dello spettro di) particelle SUSY a LHC: possiamo "ricostruire" chi sia lo LSP, candidato WIMP di DM?





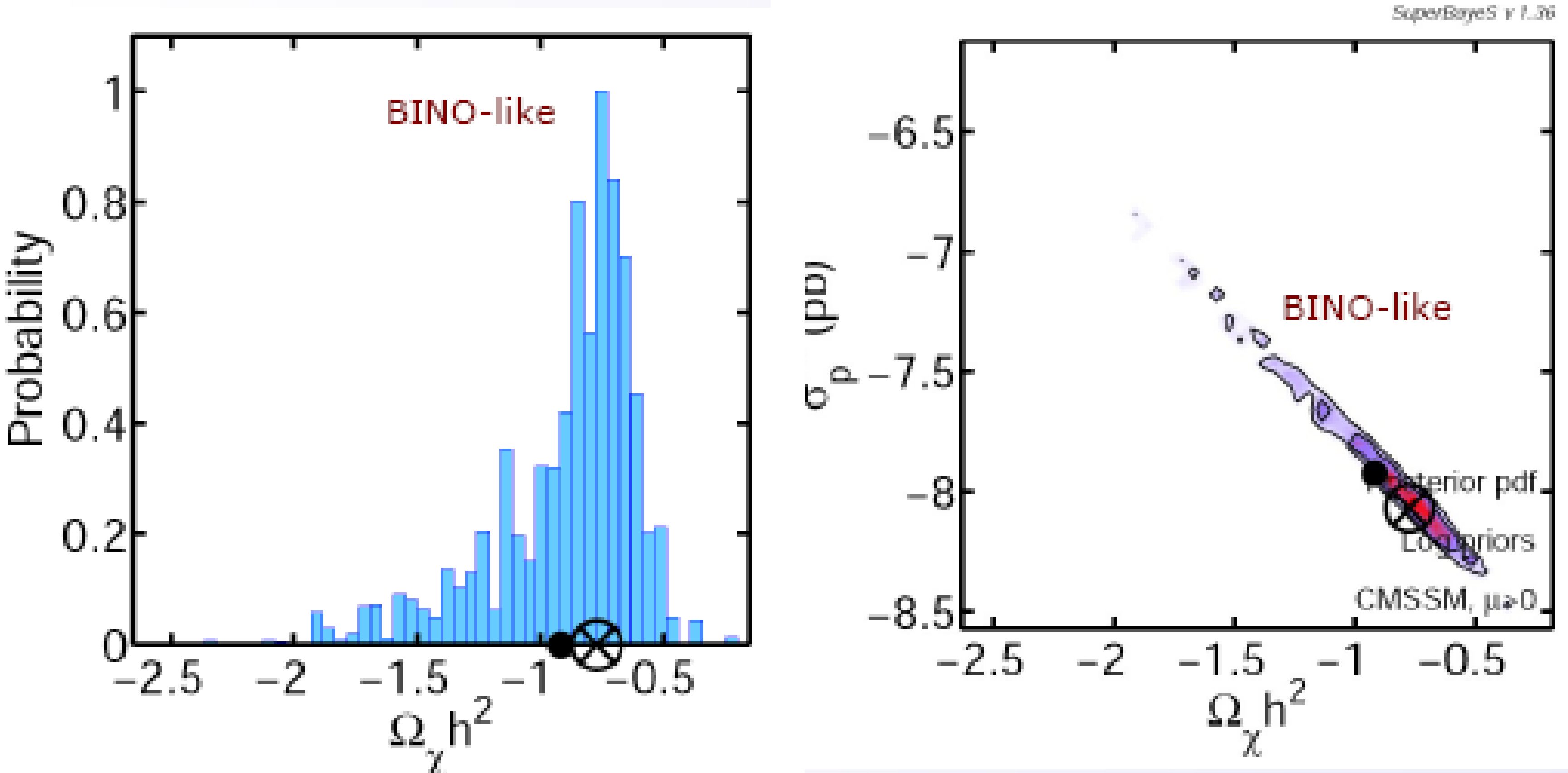
…ma se insieme troviamo la DM

sinergia LHC - DM

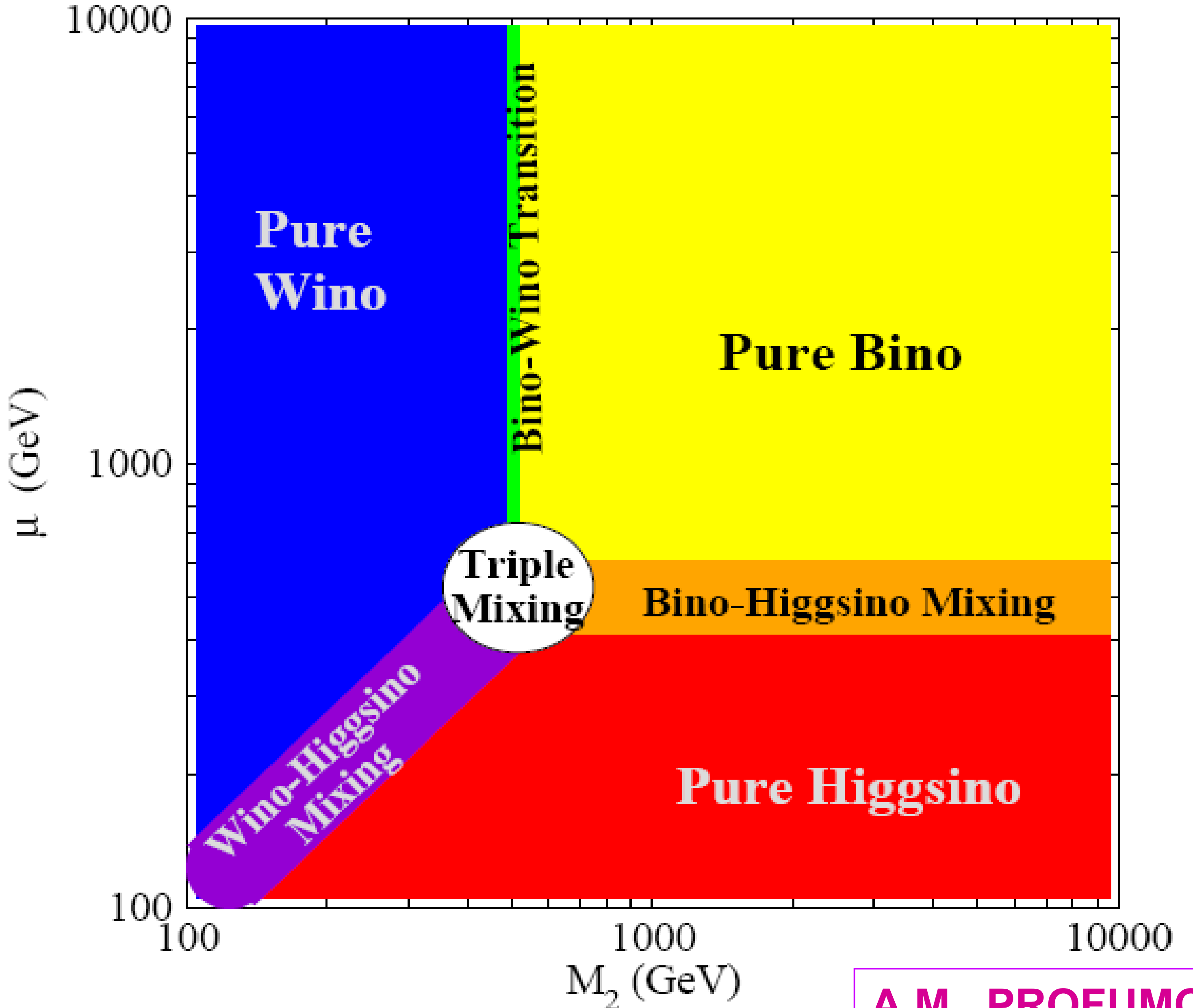
The combination of LHC data with Direct Detection data can resolve the degeneracy

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

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

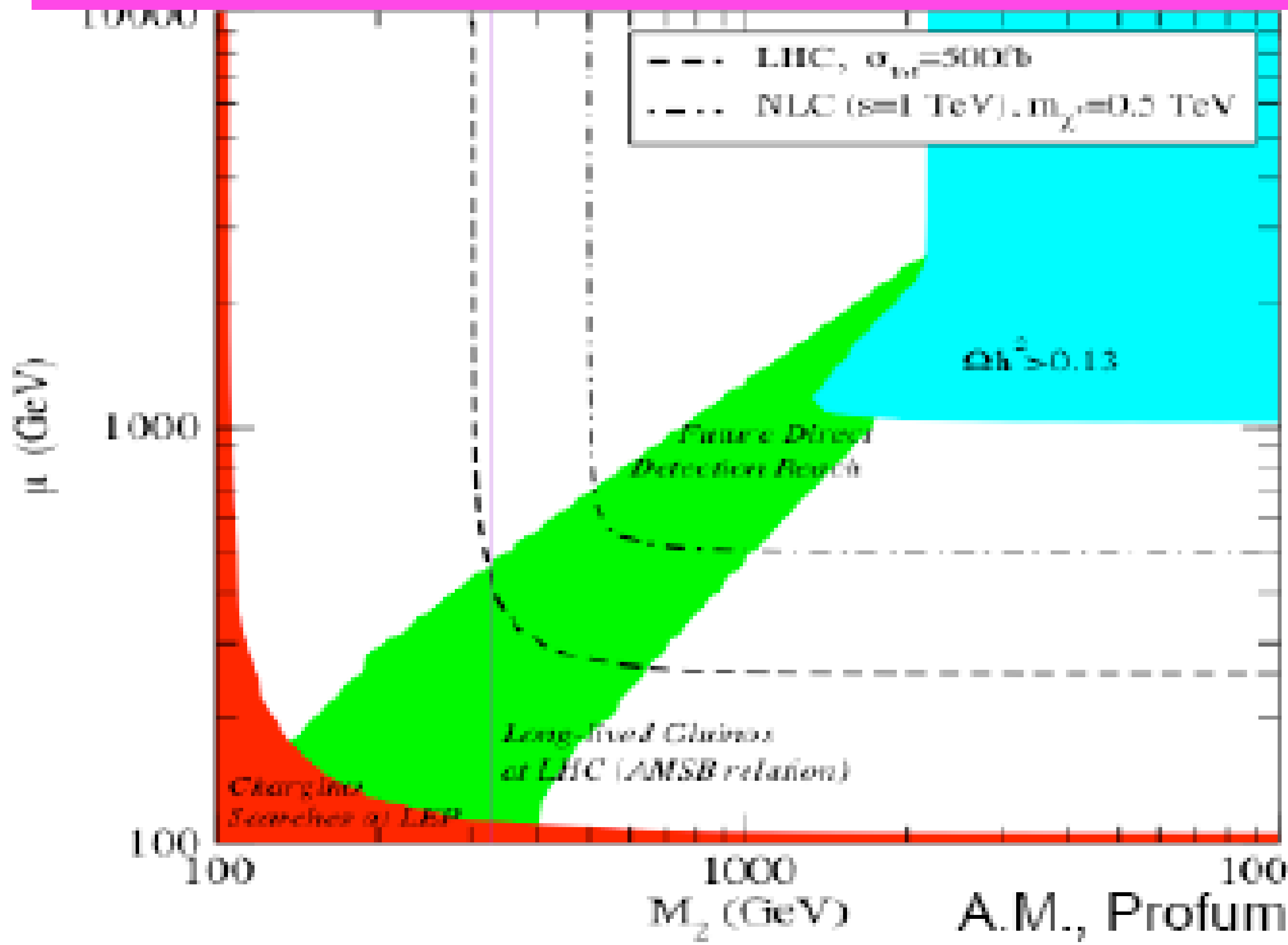


NEUTRALINO LSP IN SUPERGRAVITY



A.M., PROFUMO, ULLIO

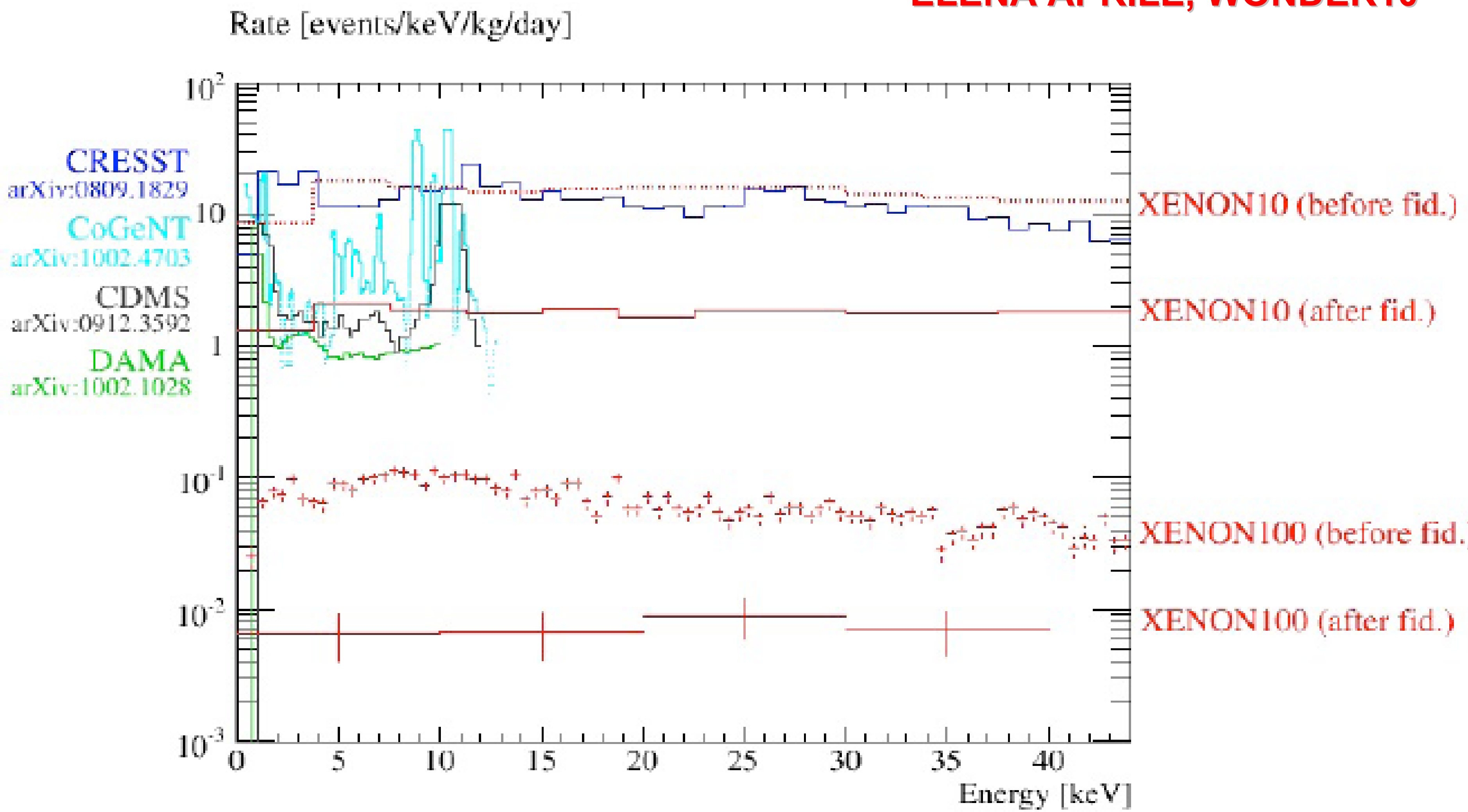
LHC, ILC, DM SEARCHES SENSITIVITIES



A.M., Profumo, Ullio

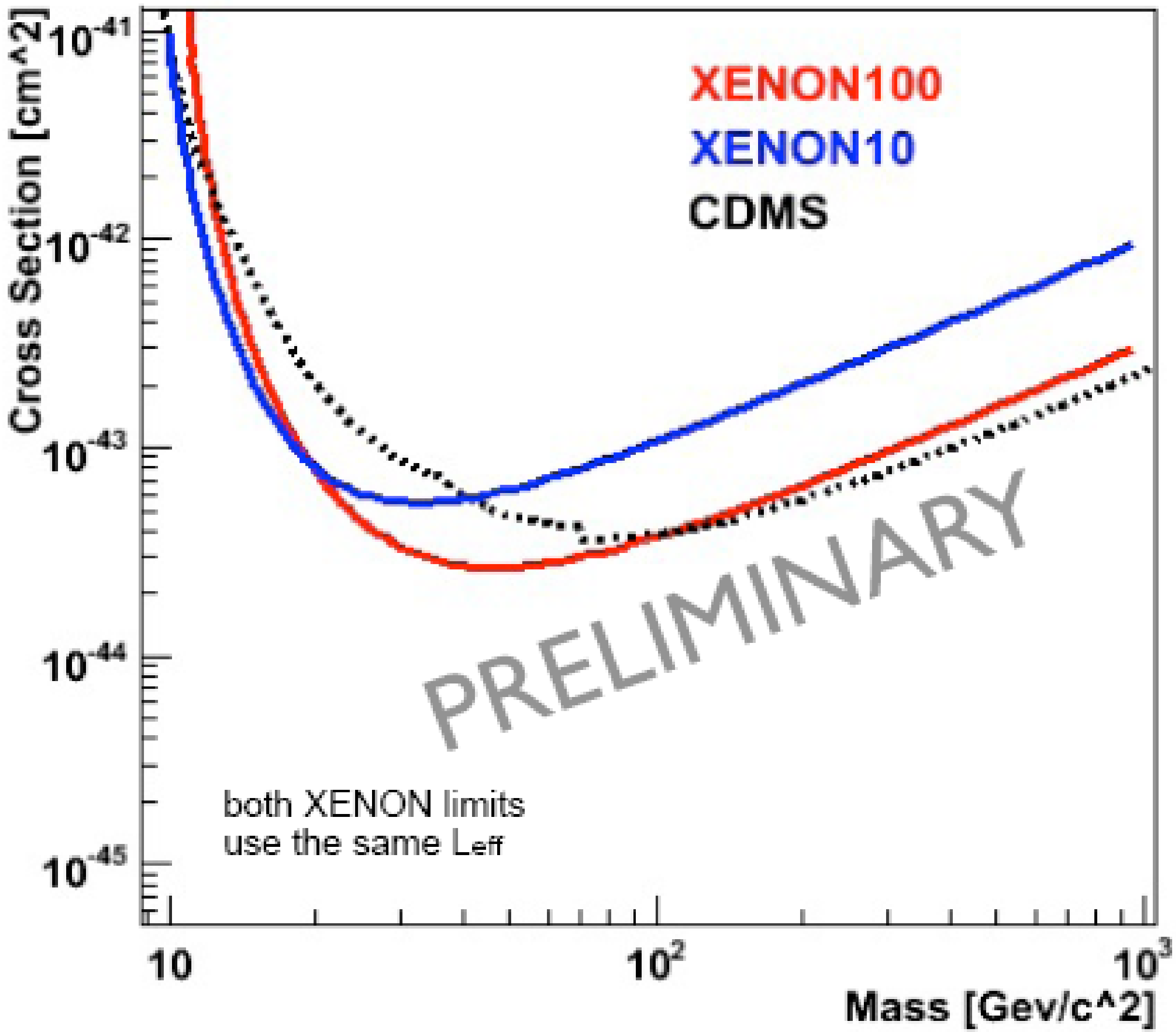
XENON100: the lowest background of all DM detectors

ELENA APRILE, WONDER10



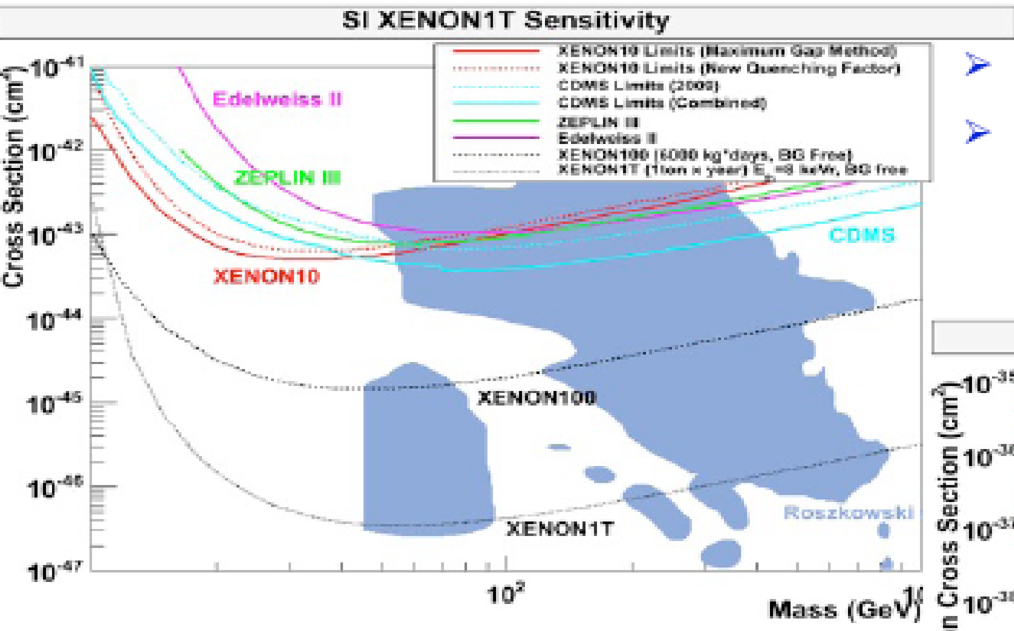
XENON100: First Spin Independent Limit

Elena Aprile for the XENON Coll., WONDER10 at LNGS, March 23, 2010

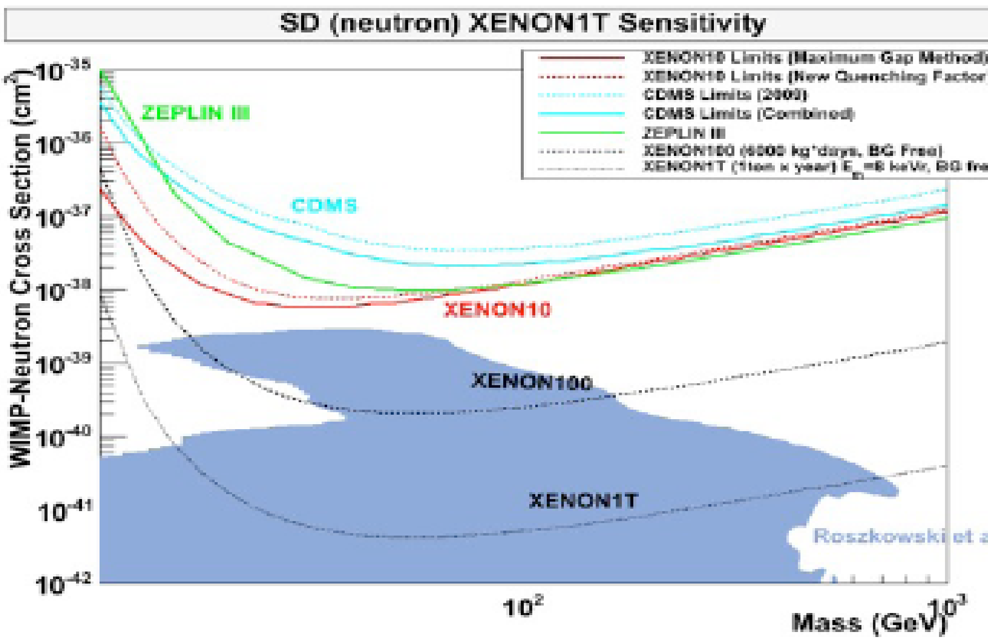


Prospect with a 1-ton detector with noble liquids

XENON1T: A tremendous scientific reach

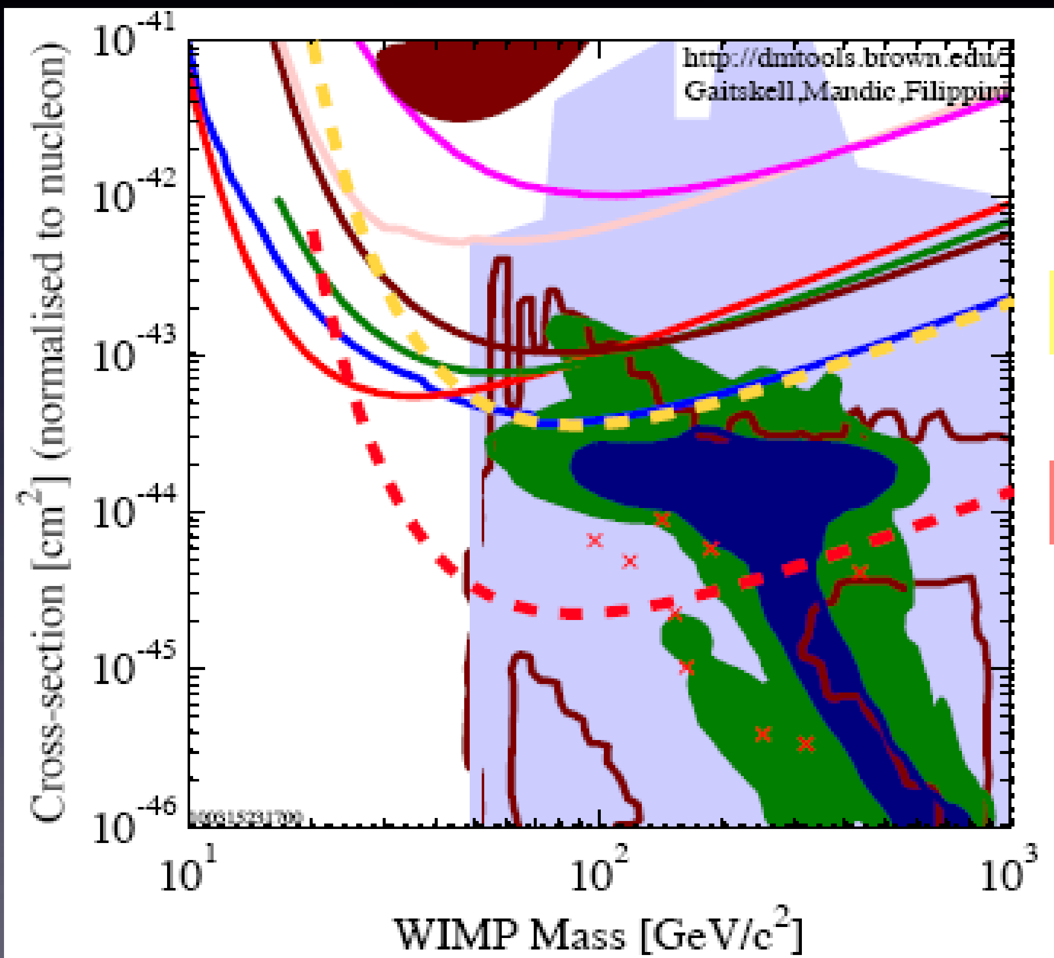


- probe simultaneously SI and SD channels
- explore the entire MSSM parameter space



E. Aprile, WONDER10

Sensitivity for SI case

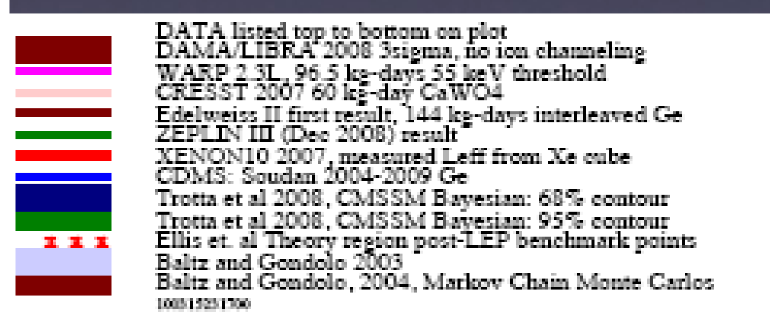


10^{-4} dru, 100 kg fiducial

XMASS 800 kg 10 days

XMASS 800 kg 1 year

(flat bg assumed)



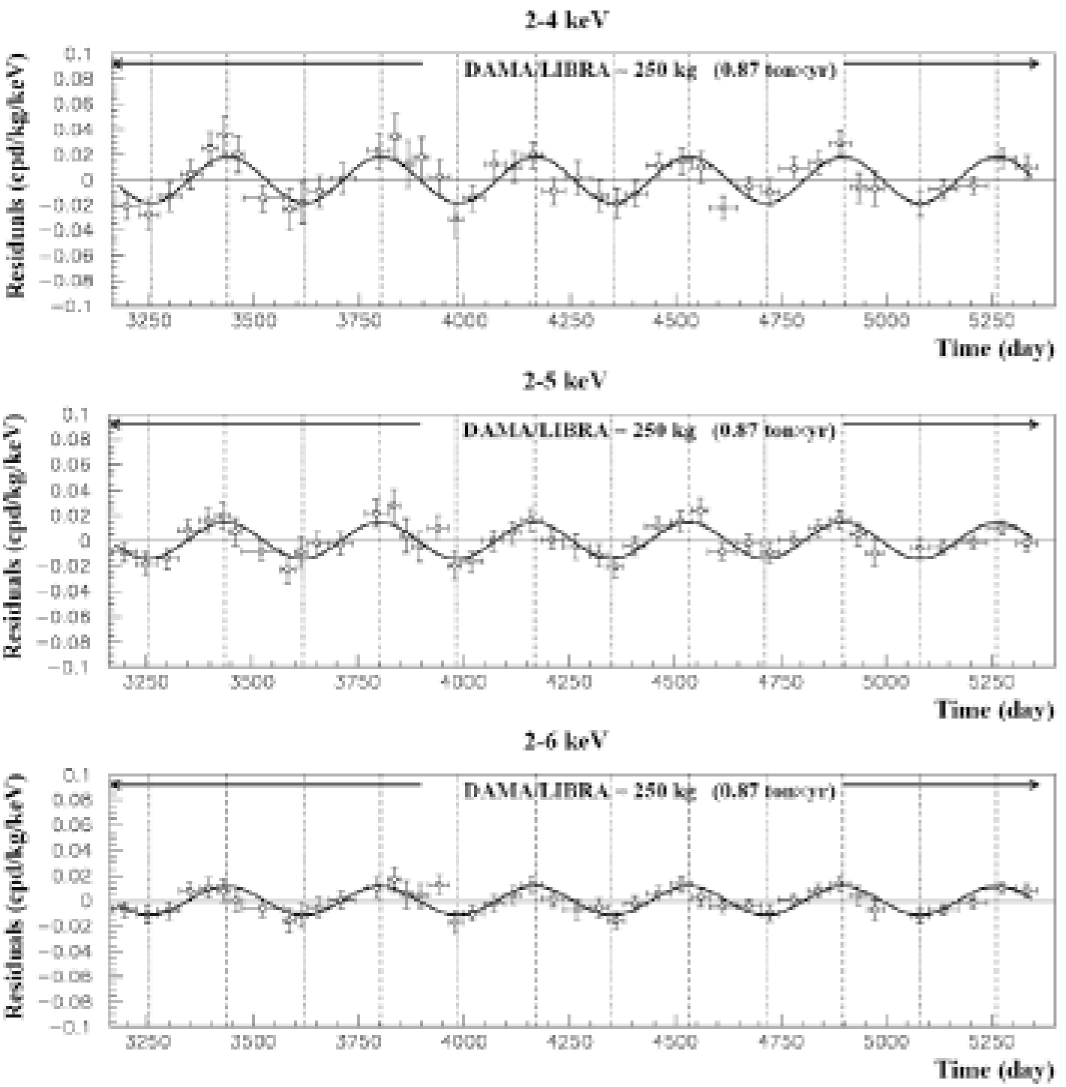
Masaki Yamashita

DAMA/LIBRA-1 to 6 Model Independent Annual Modulation Result

experimental single-hit residuals rate vs time and energy

$A\cos[\omega(t-t_0)]$; continuous lines: t_0 = 152.5 d, T = 1.00 y

DAMA/LIBRA-1,2,3,4,5,6 (0.87 ton × yr)



The fit has been done on the DAMA/NaI & DAMA/LIBRA data (1.17 ton × yr)

2-4 keV

A=(0.0183±0.0022) cpd/kg/keV

χ^2/dof = 75.7/79 **8.3 σ C.L.**

Absence of modulation? No

χ^2/dof=147/80 ⇒ P(A=0) = 7×10^{-6}

2-5 keV

A=(0.0144±0.0016) cpd/kg/keV

χ^2/dof = 56.6/79 **9.0 σ C.L.**

Absence of modulation? No

χ^2/dof=135/80 ⇒ P(A=0) = 1.1×10^{-4}

2-6 keV

A=(0.0114±0.0013) cpd/kg/keV

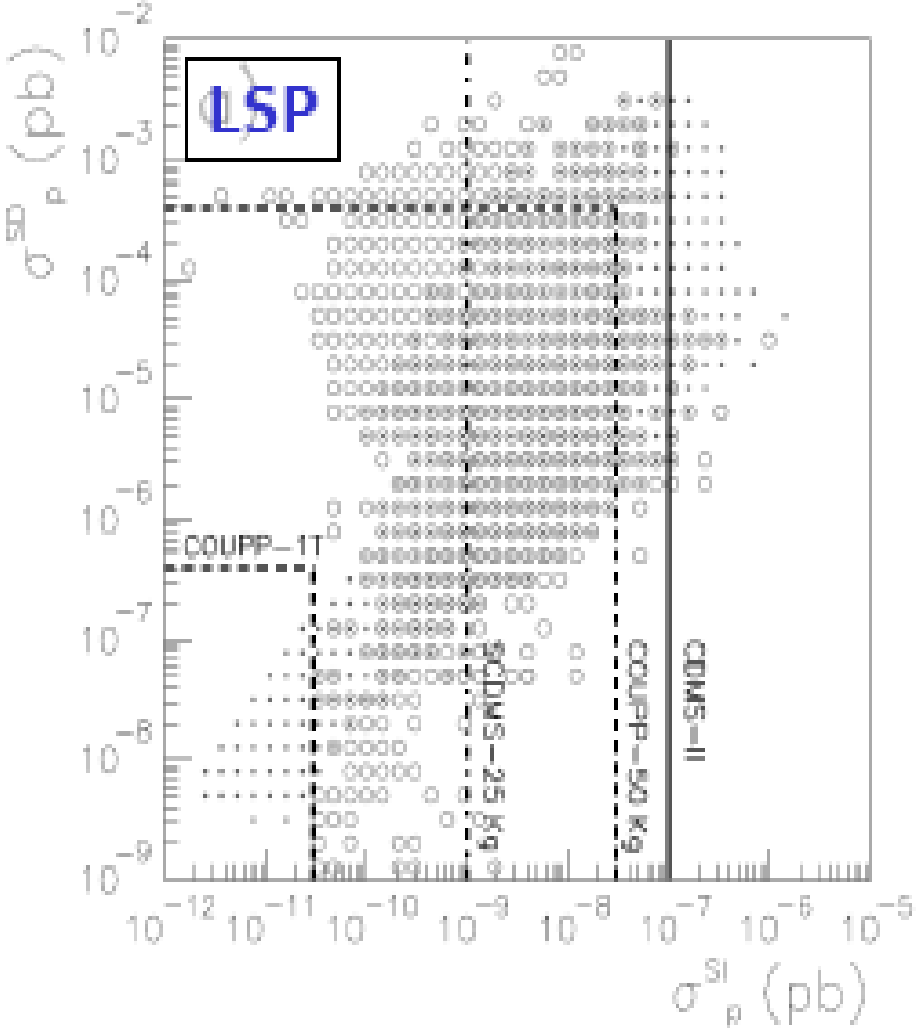
χ^2/dof = 64.7/79 **8.8 σ C.L.**

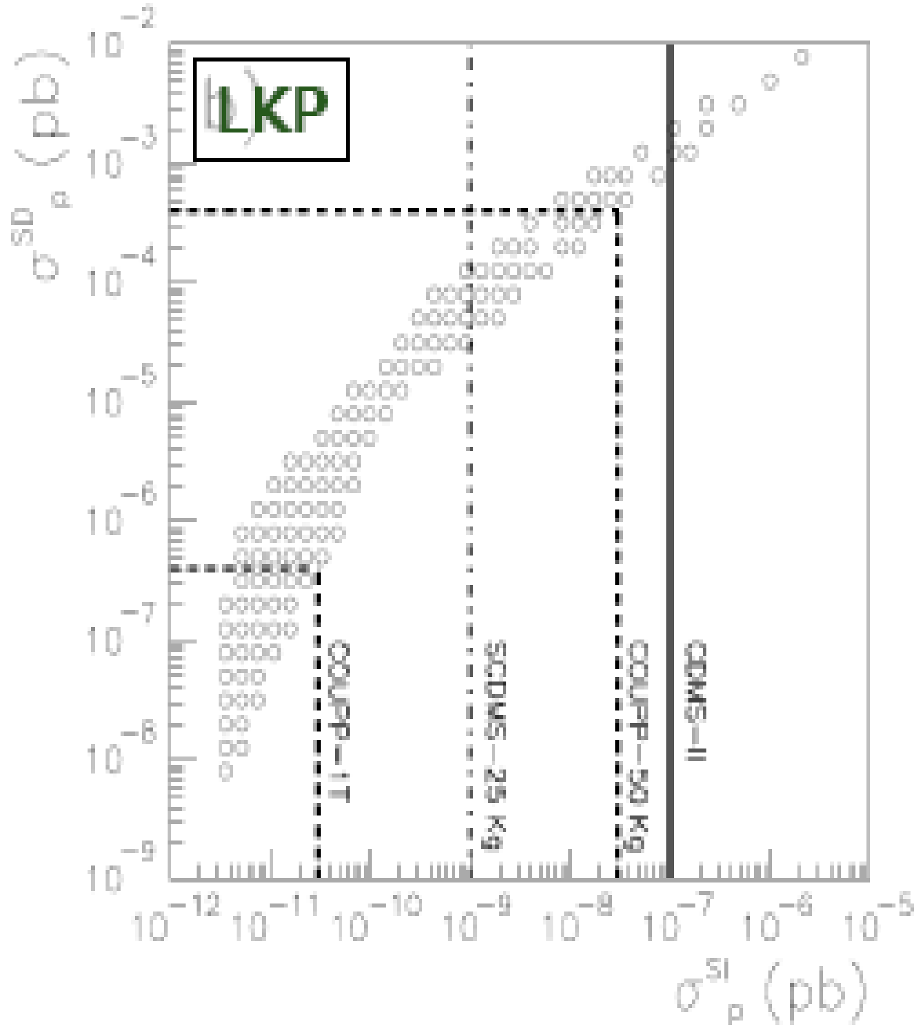
Absence of modulation? No

χ^2/dof=140/80 ⇒ P(A=0) = 4.3×10^{-5}

The data favor the presence of a modulated behavior with proper features at 8.8σ C.L.

Importante misurare sia la sez. D'urto spin-indipendente che quella spin-dipendente per discriminare tra candidati WIMP di DM





LIGHT WIMP in the 5-10 GeV range → challenge for LHC searches?

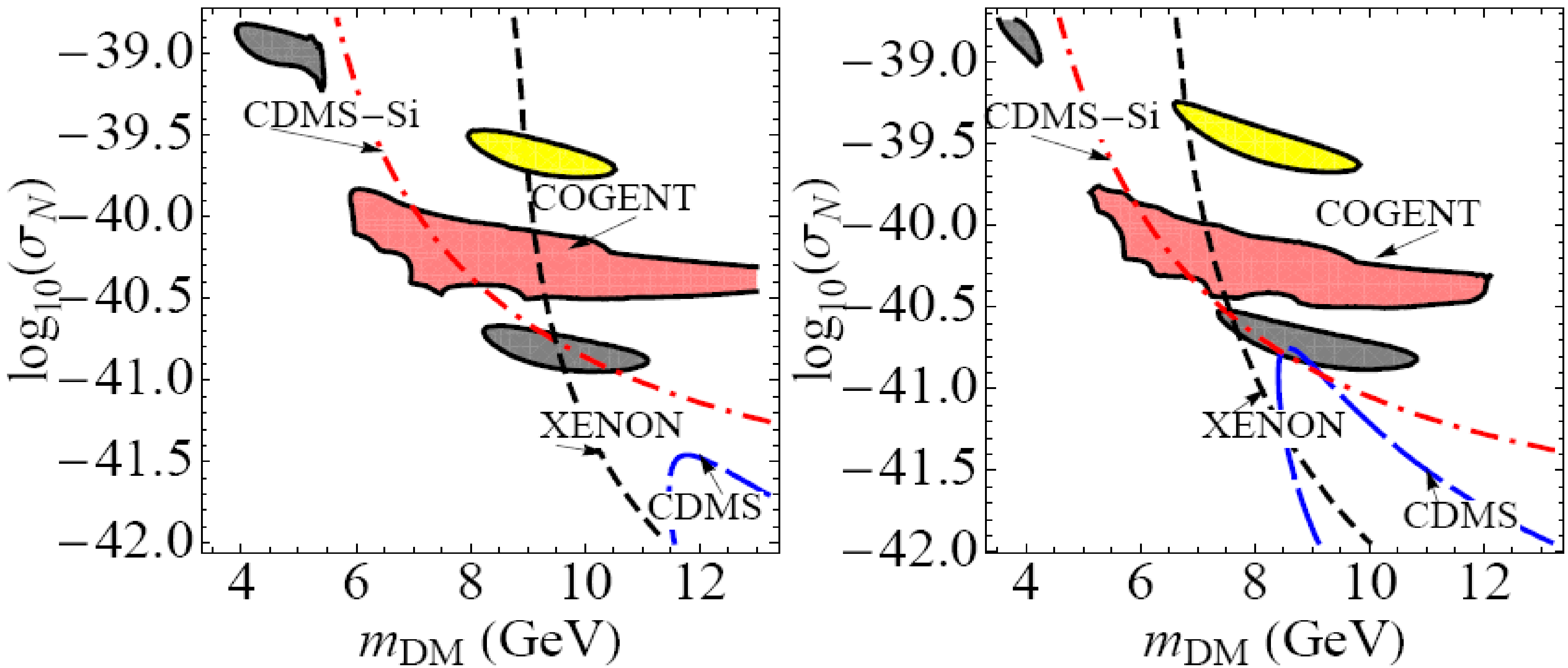


FIG. 1: The regions in the elastic scattering cross section (per nucleon), mass plane in which dark matter provides a good fit to the CoGeNT excess, compared to the region that can generate the annual modulation reported by DAMA (darker grey regions). In this figure, we have adopted $v_0 = 270$ km/s and use two values of the galactic escape velocity: $v_{esc} = 490$ km/s (left) and $v_{esc} = 730$ km/s (right). In calculating the DAMA region, we have treated channeling as described in Ref. [23]. If a smaller fraction of events are channeled in DAMA than is estimated in Ref. [23], the DAMA region will move upward, toward the yellow regions (near $\sigma_N \approx 10^{-39.5}$ cm^2, which include no effects of channeling), improving its agreement with CoGeNT. Also shown is the 90% C.L. region in which the 2 events observed by CDMS can be produced. If the escape velocity of the galaxy is taken to be relatively large, this region can also approach those implied by CoGeNT and DAMA. Constraints from the null results of XENON10 and the CDMS silicon analysis are also shown. For the XENON10 constraint, we have used the lower estimate of the scintillation efficiency (at 1σ) as described in Ref. [24].

HOOPER ET AL. 2010

INDIRECT SEARCHES OF DM

- **WIMPs collected inside celestial bodies** (Earth, Sun): their annihilations produce energetic neutrinos
- **WIMPs in the DM halo**: WIMP annihilations can take place (in particular, their rate can be enhanced with there exists a CLUMPY distribution of DM as computer simulations of the DM distribution in the galaxies seem to suggest. From the WIMP annihilation:

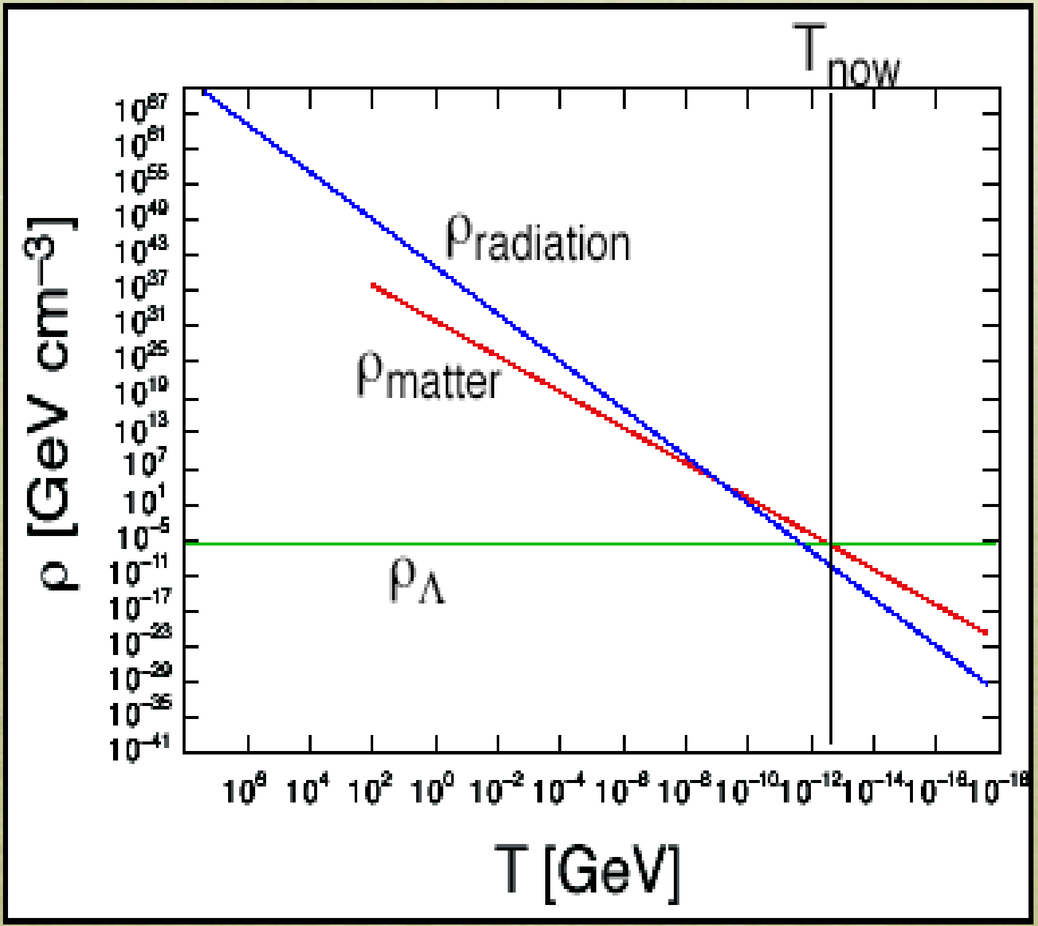
-- **energetic neutrinos** (under-ice, under-water exps Amanda, Antares, Nemo, Nestor, …)

--photons in tens of GeV range (gamma astronomy on ground Magic, Hess, … or in space Agile, Fermi…)

--antimatter: look for an excess of antimatter w.r.t. what is expected in cosmic rays (space exps. Pamela, AMS, …)

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

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, SCHELKE

FLAVOR BLINDNESS OF THE NP AT THE ELW. SCALE?

- **THREE DECADES OF FLAVOR TESTS** (Redundant determination of the UT triangle → 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 $B_s \to J/\Psi\varphi$ 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 →

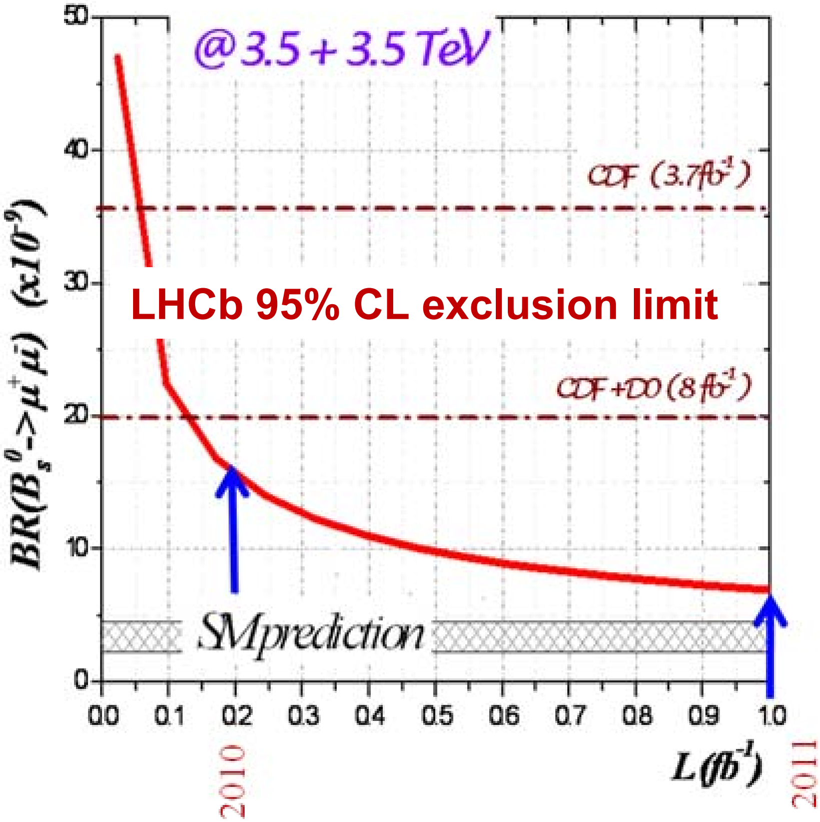
MINIMAL FLAVOR VIOLATION

MFV : Flavor originates only from the SM Yukawa coupl.

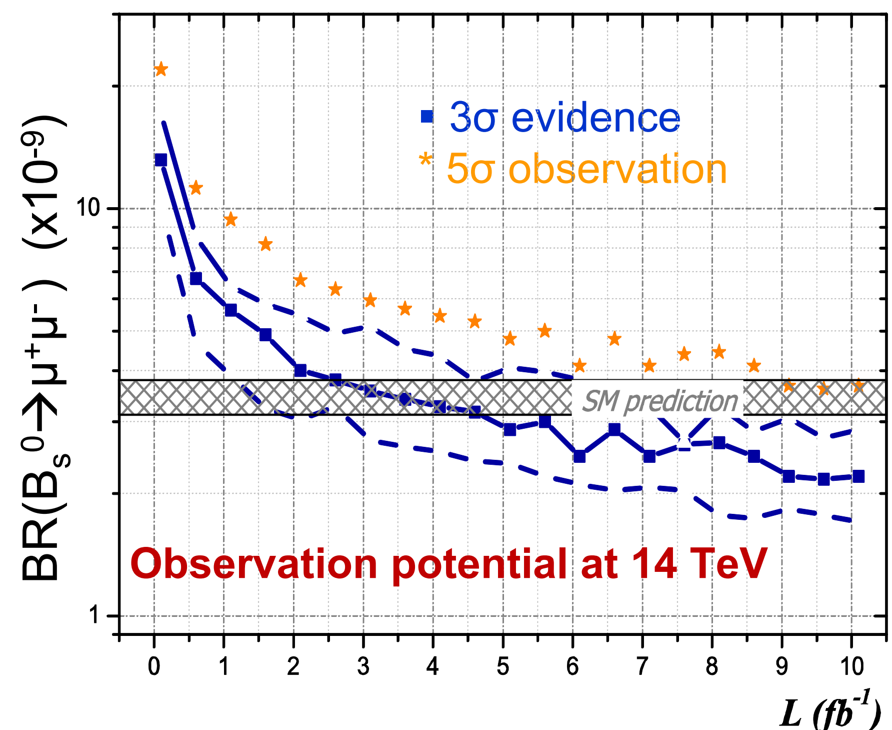
New Physics introduces

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

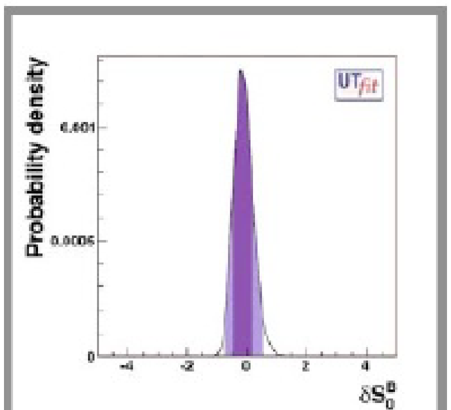
$$S_0(x_t) \to S_0(x_t) + \delta S_0(x_t)$$

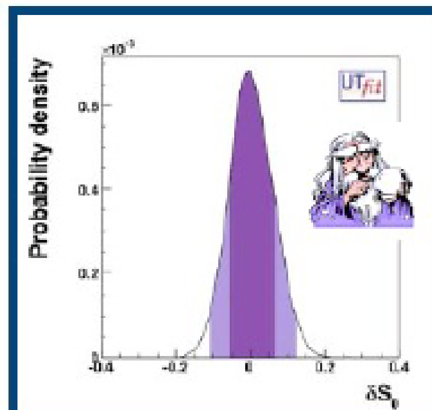
$$\delta S_0(x_t) = 4a\left(\frac{\Lambda_0}{\Lambda}\right)^2$$

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

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

$\delta S_0^B = \delta S_0^K$





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

$\delta S_0 = -0.16 \pm 0.32$

$\Lambda > 5.5$ TeV @95%

$\delta S_0 = 0.004 \pm 0.059$

$\Lambda > 28$ TeV @95%

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

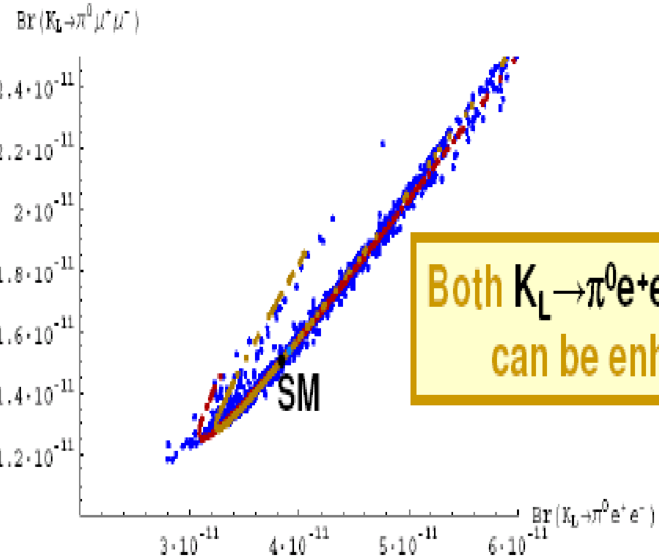
Estimates of error for 2015

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)	±2-3%
$K_L \to \pi^0 \nu\bar{\nu}$	$(2.6\pm0.3)\cdot10^{-11}$	$< 2.1\cdot10^{-7}$ (KTeV,KEK)	±1-2%
$K_L \to \pi^0 e^+ e^-$	$(3.5\pm1.0)\cdot10^{-11}$	$< 28\cdot10^{-11}$ (KTeV)	$\pm15\%$
$K_L \to \pi^0 \mu^+ \mu^-$	$(1.4\pm0.3)\cdot10^{-11}$	$< 38\cdot10^{-11}$ (KTeV)	$\pm15\%$

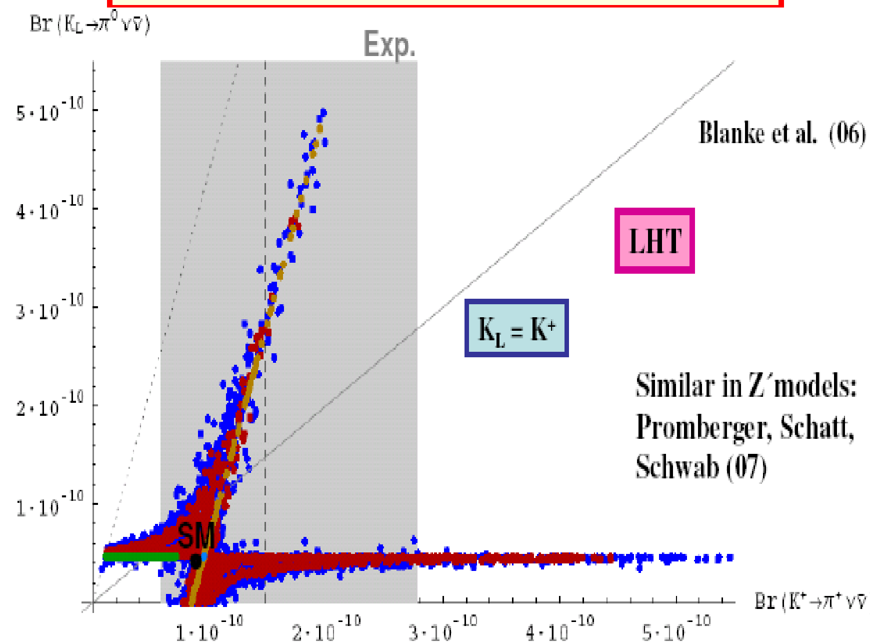
K-system: $K_L\to\pi^0 e^+e^-$ and $K_L\to\pi^0\mu^+\mu^-$



Friot, Greynat, de Rafael (04)
General correlation:
Isidori, Smith, Unterdorfer (04)
Mescia, Smith, Trine (06) ★

Both $K_L\to\pi^0e^+e^-$ and $K_L\to\pi^0\mu^+\mu^-$ can be enhanced by ~2

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



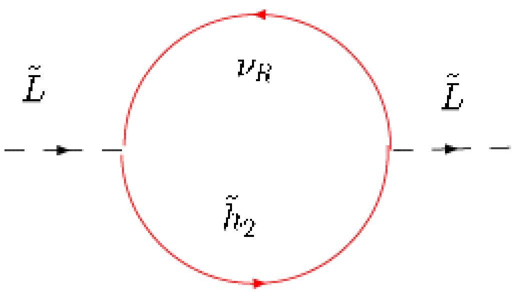
Similar in Z′models:
Promberger, Schatt, Schwab (07)

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)

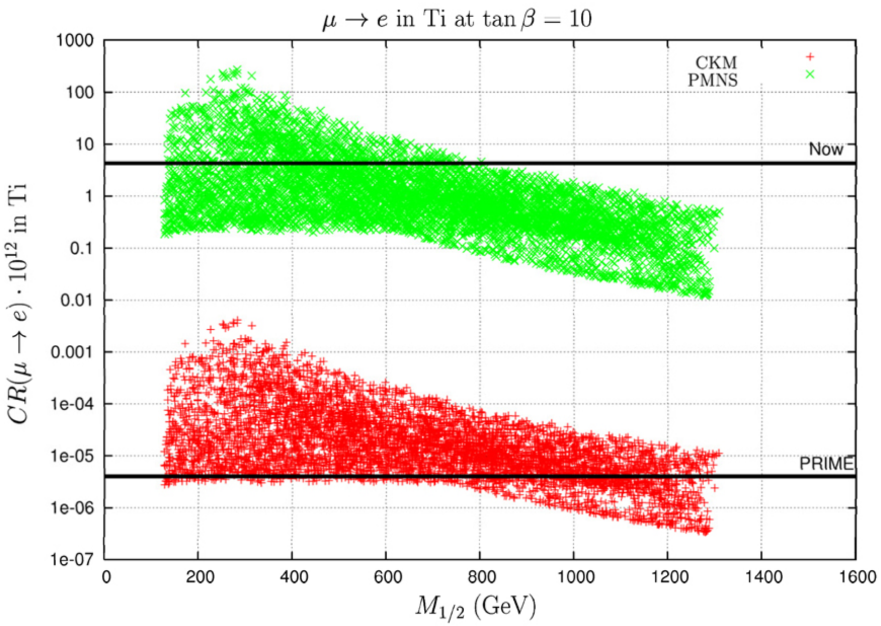
$$L = f_l \, \bar{e}_R L h_1 + f_\nu \, \bar{\nu}_R L h_2 + M \, \nu_R \nu_R$$

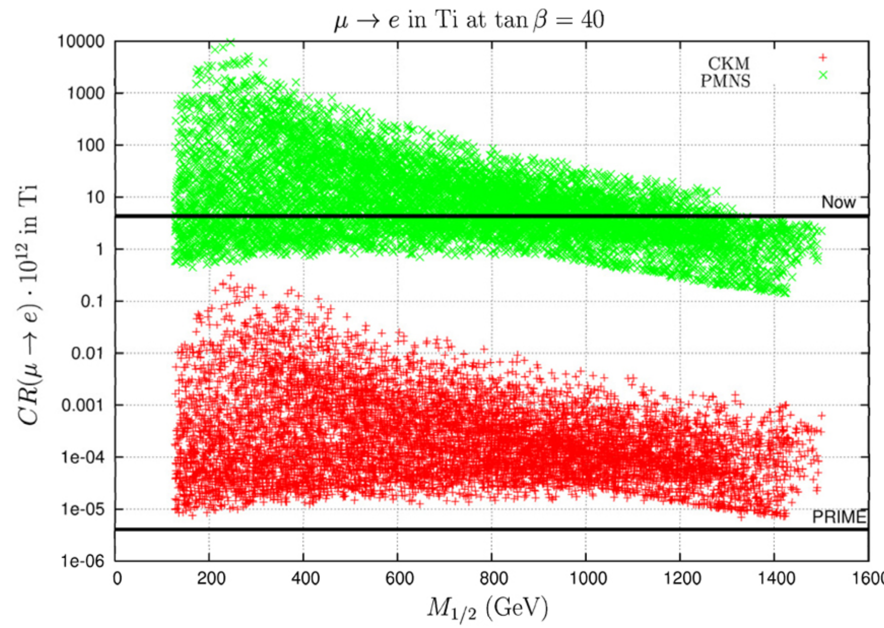


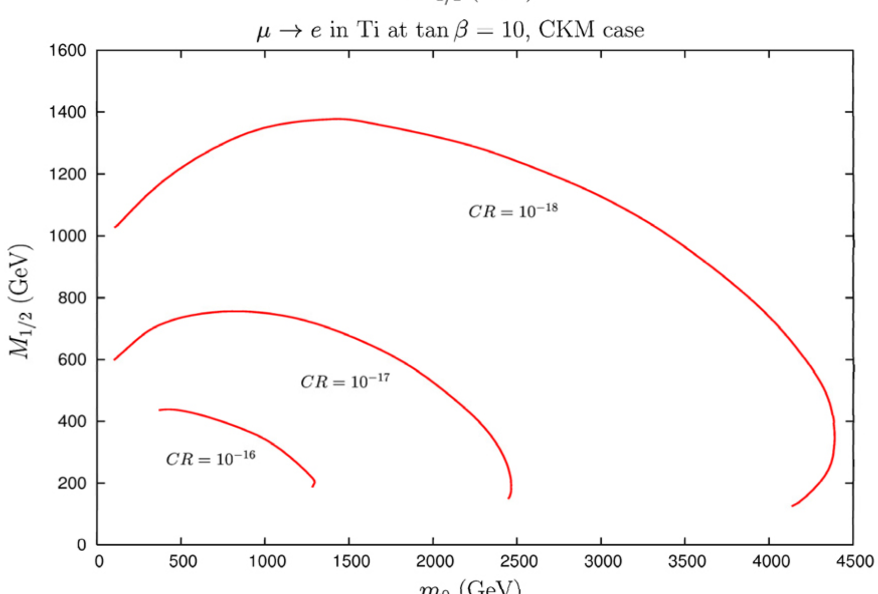
$$\left(m^2_{\tilde{L}}\right)_{ij} \sim \frac{1}{8\pi^2}\left(3m_0^2 + A_0^2\right)\left(f_\nu^\dagger f_\nu\right)_{ij} \log\frac{M}{M_G}$$

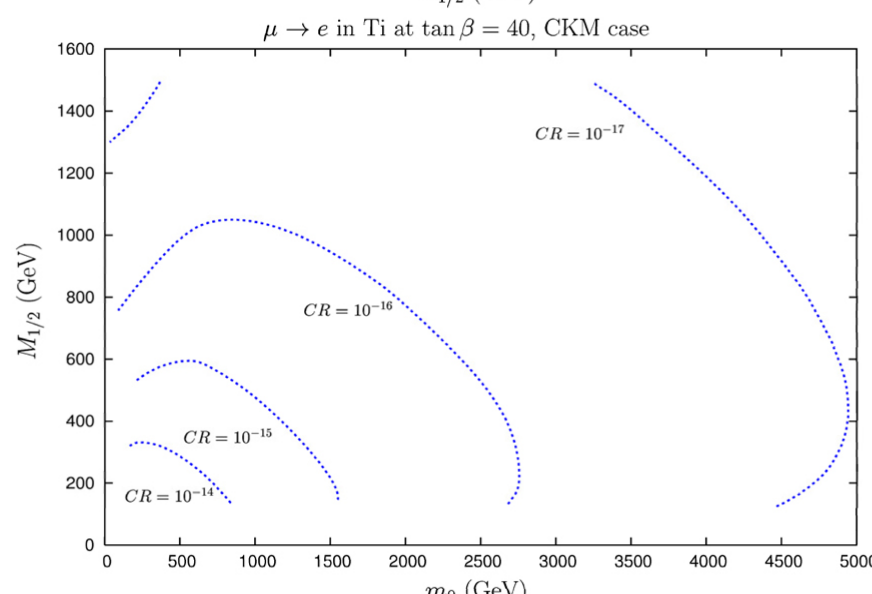
Non-diagonality of the slepton mass matrix in the basis of diagonal lepton mass matrix depends on the unitary matrix U which diagonalizes ($f_\nu^+ f_\nu$)

$\mu \to e$ in Ti and **PRISM/PRIME** conversion experiment



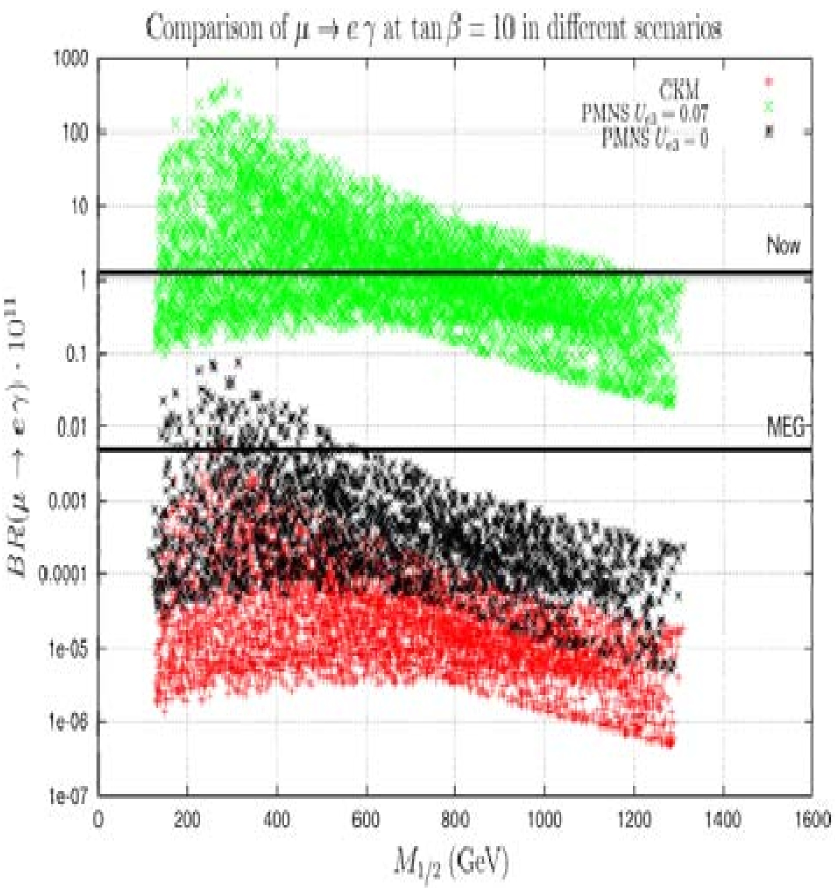


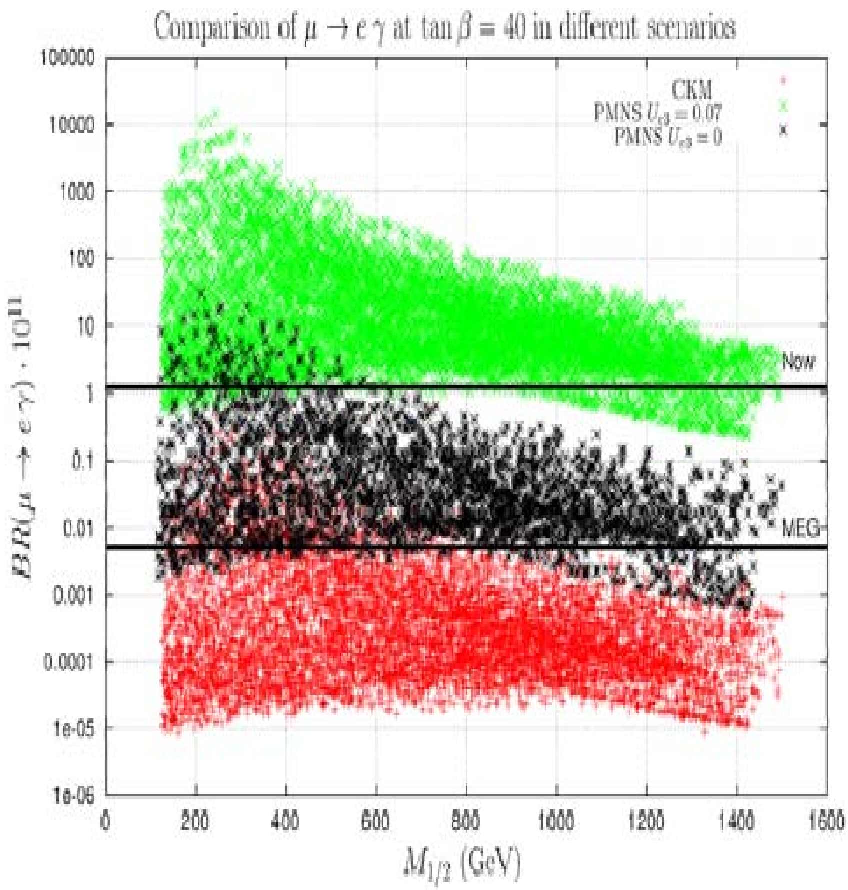




μ → e+γ in SUSYGUT: past and future

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





Catena, Faccia, A.M., Vempati

Importante correlare LFV, g-2, EDMs

LFV vs. MUON (g – 2) in MSSM

Isidori, Mescia, Paradisi, Temes

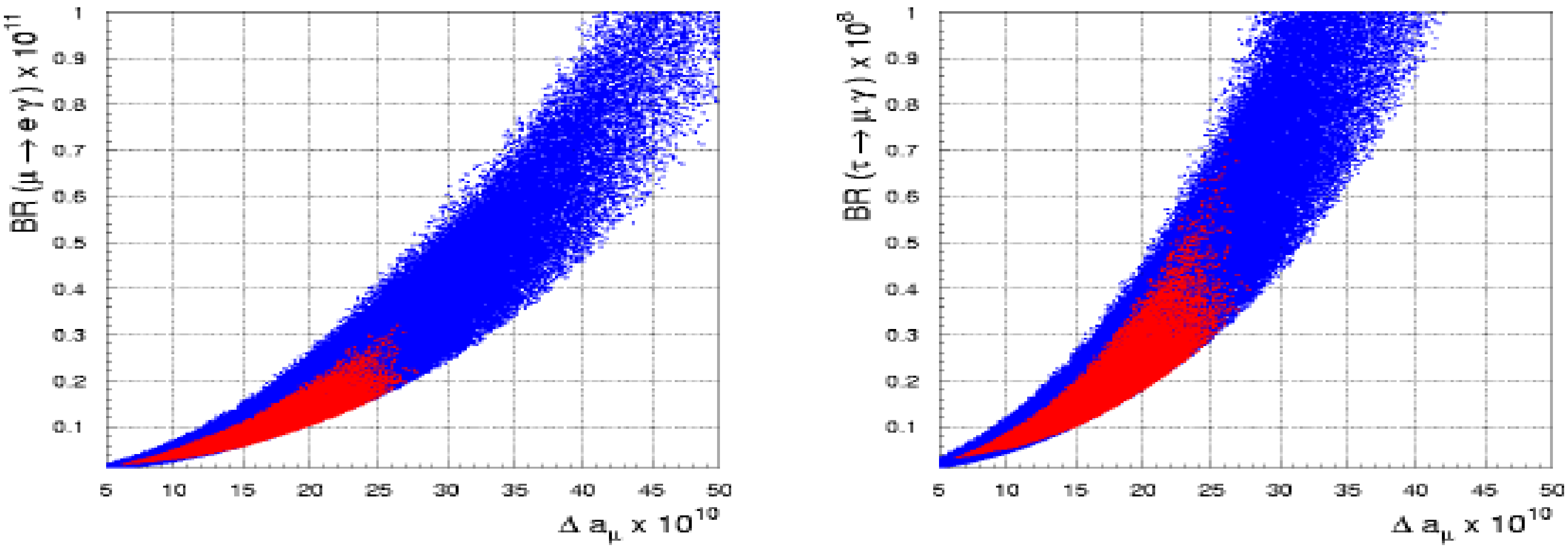


Figure 6: Expectations for $\mathcal{B}(\mu \longrightarrow e\gamma)$ and $\mathcal{B}(\tau \longrightarrow \mu\gamma)$ vs. $\Delta a_\mu = (g_\mu - g_\mu^{SM})/2$, assuming $|\delta_{LL}^{12}| = 10^{-4}$ and $|\delta_{LL}^{23}| = 10^{-2}$. The plots have been obtained employing the following ranges: 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 [$\mathcal{B}(B_s \longrightarrow \mu^+\mu^-) < 8 \times 10^{-8}$, $1.01 < R_{Bs\gamma} < 1.24$, $0.8 < R_{B\tau\nu} < 0.9$, $\Delta M_{B_s} = 17.35 \pm 0.25$ ps^{-1}].

il 2012…

- Per molti, anche dopo il film, brrr…
- Per noi “anno delle decisioni” (?):

- sapremo parecchio di piu’ sull’**higgs** debolmente interagente e forse avremo qualche indicazione su possibili alternative di higgs fortemente interagente (da Tevatron e LHC)
- sapremo se c’e’ **SUSY colorata** (squark, gluini) fino a ~800 GeV , Z’, W’ fino a 1.5 TeV, etc. → probabilmente capiremo se vale la pena pensare a un **LC** di 500GeV
- sapremo se $\boldsymbol{\theta_{13}}$ e’ molto piccolo o se e’ abbastanza grande da procedere a caccia di CPV nella fisica dei neutrini
- avremo risultati di **ricerche dirette e indirette** (AMS volera’) **di DM** che ci faranno capire dove puntare per exps. di nuova generazione
- **avremo l risultati di MEG, di LHCb, Tevatron sul flavor**… e sapremo cosa ci attende sulla strada della di fisica rara del B e del tau in termini di **nuove macchine**…

G. Martinelli