LNF May 24, 2007

ROUND TABLE KAON ‘07

HINTS FROM THEORY

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A FUTURE FOR FLAVOR PHYSICS IN OUR SEARCH BEYOND THE SM?

- The traditional **competition** between direct and indirect (FCNC, CPV) searches to establish who is going **to see the new physics first** is no longer the priority, rather

- **COMPLEMENTARITY** between direct and indirect searches for New Physics is the key-word

- Twofold meaning of such complementarity:

i) **synergy in "reconstructing" the "fundamental theory"** staying behind the signatures of NP;

ii) **coverage of complementary areas of the NP parameter space** (ex.: multi-TeV SUSY physics)

FLAVOR BLINDNESS OF THE NP AT THE ELW. SCALE?

- THREE DECADES OF FLAVOR TESTS (Redundant determination of the UT triangle $\longrightarrow$ verification of the SM, theoretically and experimentally “high precision” FCNC tests, ex. $b \longrightarrow s + \gamma$, 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 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

FROM DETERMINATION TO VERIFICATION OF THE CKM PATTERN FOR HADRONIC FLAVOR DESCRIPTION

$$|V_{us}| \equiv \lambda, \qquad |V_{cb}|, \qquad R_b, \qquad \gamma,$$

TREE LEVEL

$$|V_{us}| \equiv \lambda, \qquad |V_{cb}|, \qquad R_t, \qquad \beta.$$

ONE - LOOP

$$R_b \equiv \frac{|V_{ud}V_{ub}^*|}{|V_{cd}V_{cb}^*|} = \sqrt{\bar{\varrho}^2 + \bar{\eta}^2} = \left(1 - \frac{\lambda^2}{2}\right) \frac{1}{\lambda} \left| \frac{V_{ub}}{V_{cb}} \right|$$

$$R_t \equiv \frac{|V_{td}V_{tb}^*|}{|V_{cd}V_{cb}^*|} = \sqrt{(1 - \bar{\varrho})^2 + \bar{\eta}^2} = \frac{1}{\lambda} \left| \frac{V_{td}}{V_{cb}} \right|.$$

$$R_b = \sqrt{1 + R_t^2 - 2R_t \cos\beta}, \qquad \cot\gamma = \frac{1 - R_t \cos\beta}{R_t \sin\beta},$$

A. BURAS et al.

Reference Unitarity Triangle and UUT (CMFV)

$(R_b)_{CMFV} = 0.363 \pm 0.016$

$(R_b)_{true} = 0.428 \pm 0.027$

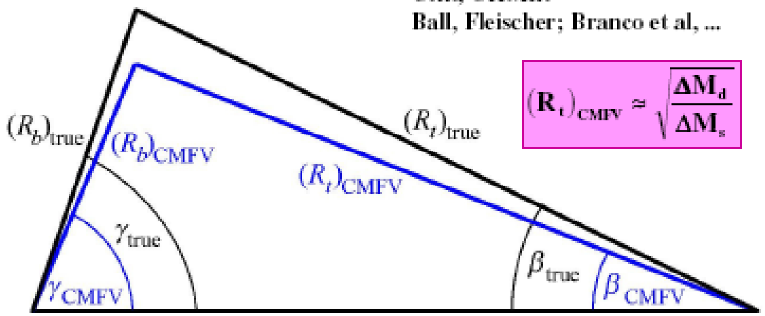
$\gamma_{true} = (82 \pm 20)^\circ$

$\sin 2\beta_{CMFV} = 0.675 \pm 0.026$

$\sin 2\beta_{true} = 0.749 \pm 0.063$ "true"= RUT

Blanke, AJB, Guadagnoli, Tarantino
Utfit, CKMfit
Ball, Fleischer; Branco et al, ...

$(R_t)_{CMFV} \simeq \sqrt{\frac{\Delta M_d}{\Delta M_s}}$



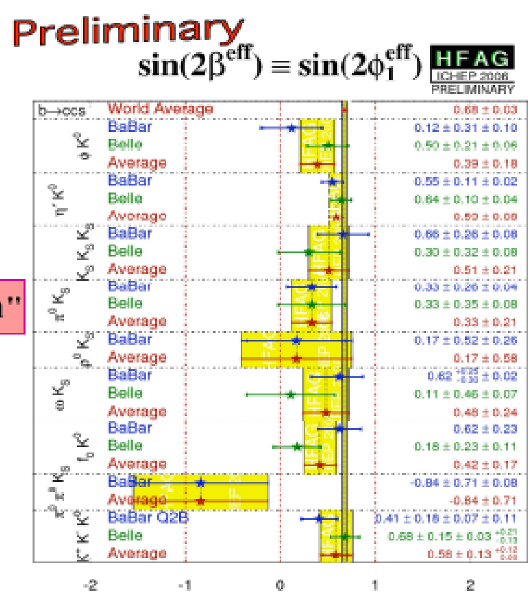
$\beta_{CMFV} = \beta_{\psi K_s}$

"sin 2β Problem"

Is this a $|V_{ub}|$ Problem?

second

"sin2β Problem"



Single channels understood?

Allowed to take the avg.?

Is CP violation entirely due to the KM mechanism? Y.Nir

For CPV in FLAVOR CHANGING* PROCESSES it is VERY LIKELY** that the KM mechanism represents the MAIN SOURCE***

- *FC CPV : as for flavor conserving CPV there could be new phases different from the CKM phase (importance of testing EDMs!)

- **VERY LIKELY: the alternative is to invoke some rather puzzling coincidence (e.g., it could be that sin2β is not that predicted by the SM , but H_{SM} + H_{NP} in the B_d-B_d mixing has the same phase as that predicted by the SM alone or it could be that the phase of the NP contribution is just the same as the SM phase)

- *** MAIN SOURCE : Since $S_{\psi K}$ is measured with an accuracy ~ 0.04, while the SM accuracy in predicting sin2β is ~0.2 → still possible to have

$H_{NP} \leq 20\%\ H_{SM}$ in B_d-$\overline{B}_d$ mixing

☐What to make of this triumph of the CKM pattern in 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 <10 -20% in the "flavor observables" which have already been observed!

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

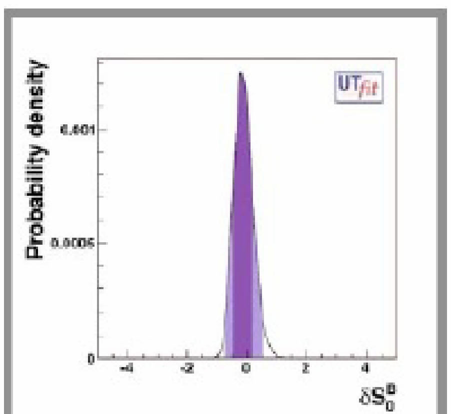
$$S_0(x_t) \to S_0(x_t) + \delta S_0(x_t)$$

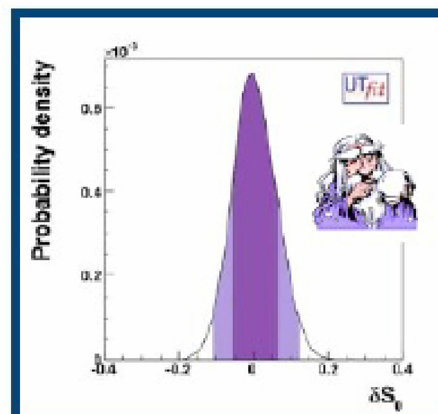
$$\delta S_0(x_t) = 4a\left(\frac{\Lambda_0}{\Lambda}\right)^2$$

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

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

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





$\delta S_0 = -0.16 \pm 0.32$

$\Lambda > 5.5$ 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

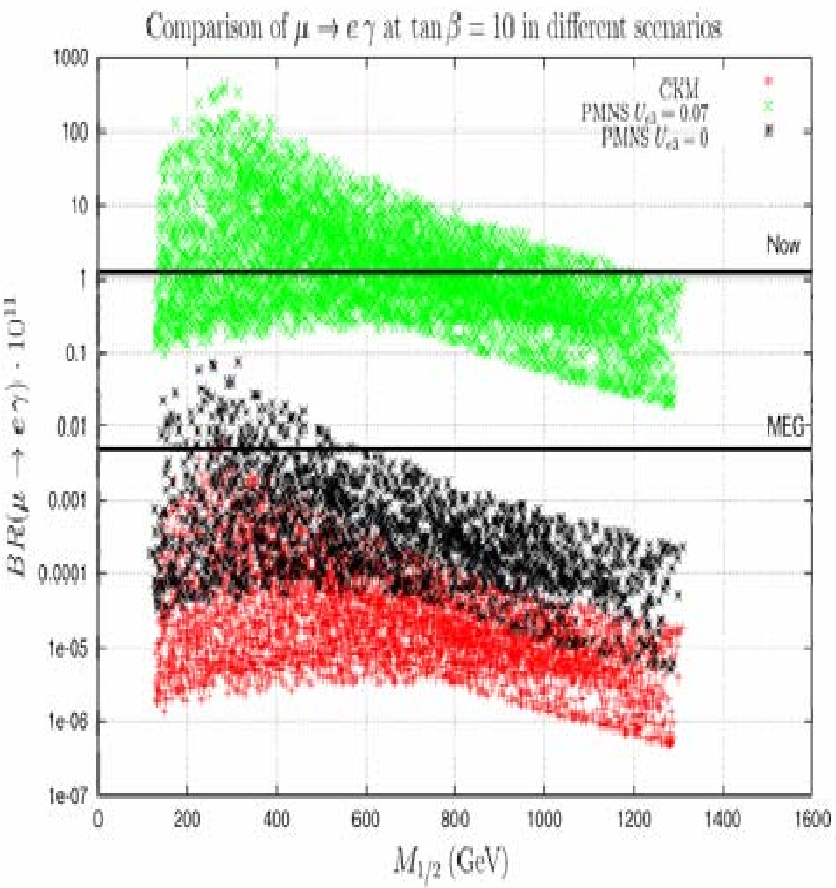
SuperB vs. LHC Sensitivity Reach in testing Λ_{SUSY}

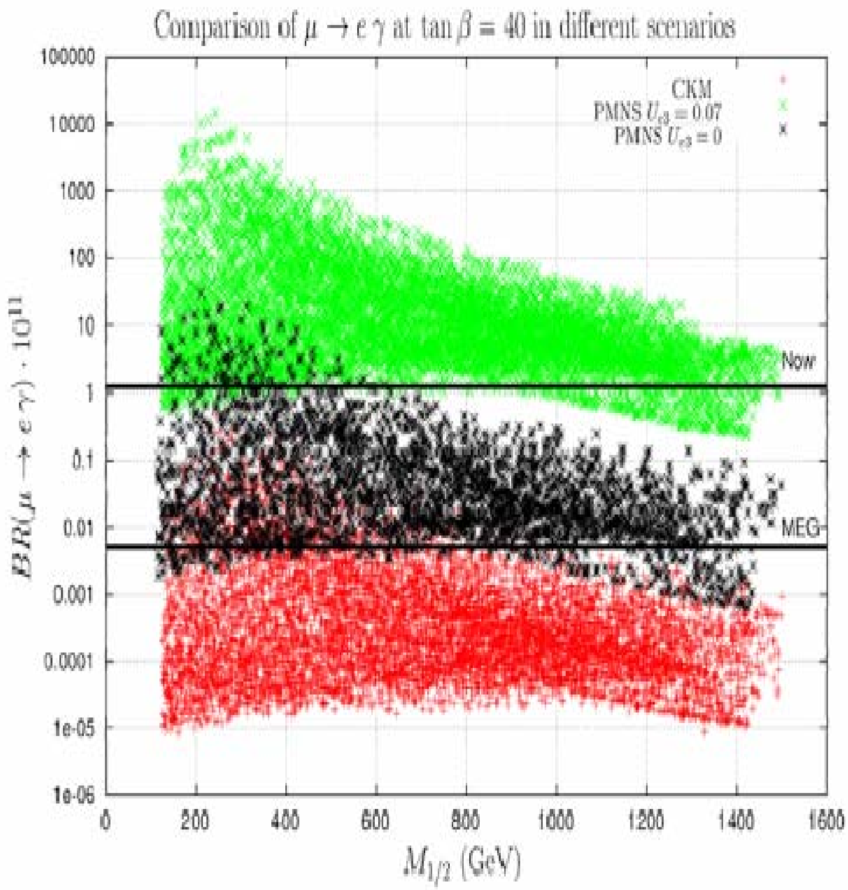
	superB	general MSSM	high-scale MFV
$\left\vert\left(\delta^d_{13}\right)_{LL}\right\vert\ (LL \gg RR)$	$1.8 \cdot 10^{-2} \frac{m_{\tilde{q}}}{(350\mathrm{GeV})}$	1	$\sim 10^{-3} \frac{(350\mathrm{GeV})^2}{m_{\tilde{q}}^2}$
$\left\vert\left(\delta^d_{13}\right)_{LL}\right\vert\ (LL \sim RR)$	$1.3 \cdot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

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

μ → e+γ in SUSYGUT: past and future

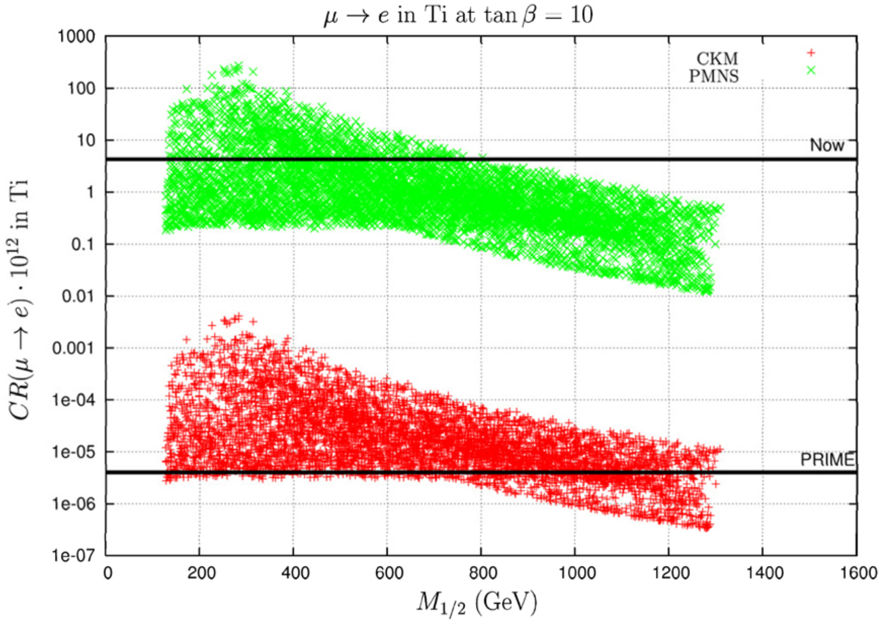
$\mu \to e\gamma$ in the $U_{e3} = 0$ PMNS case

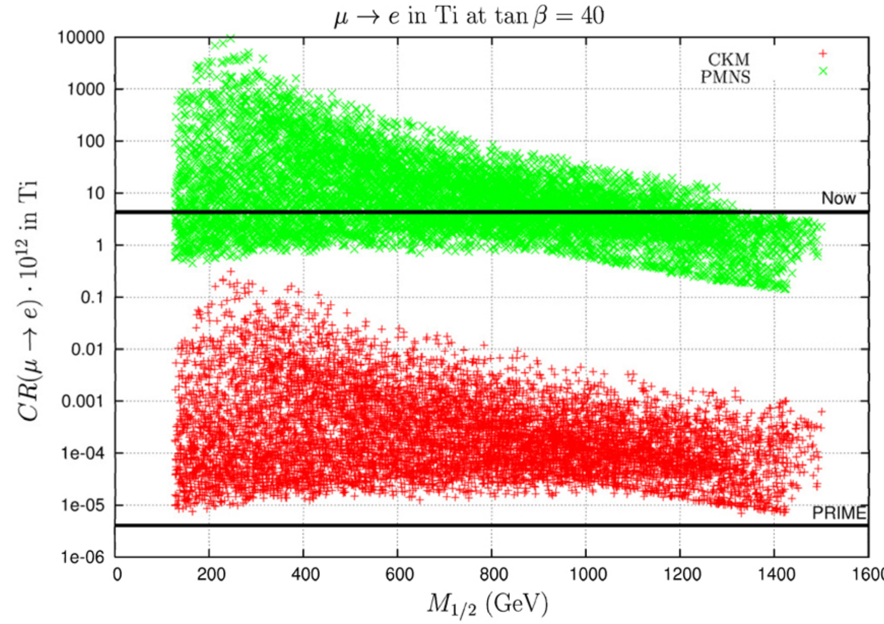


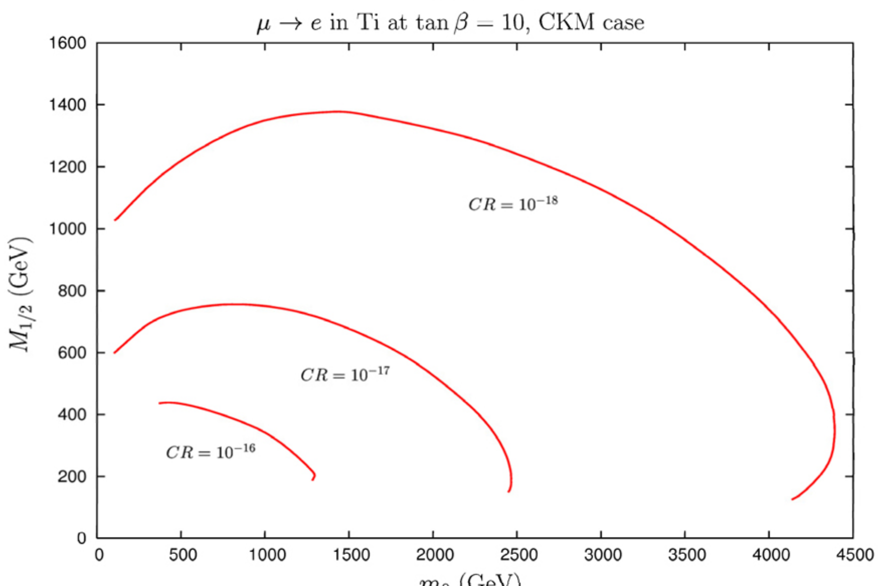


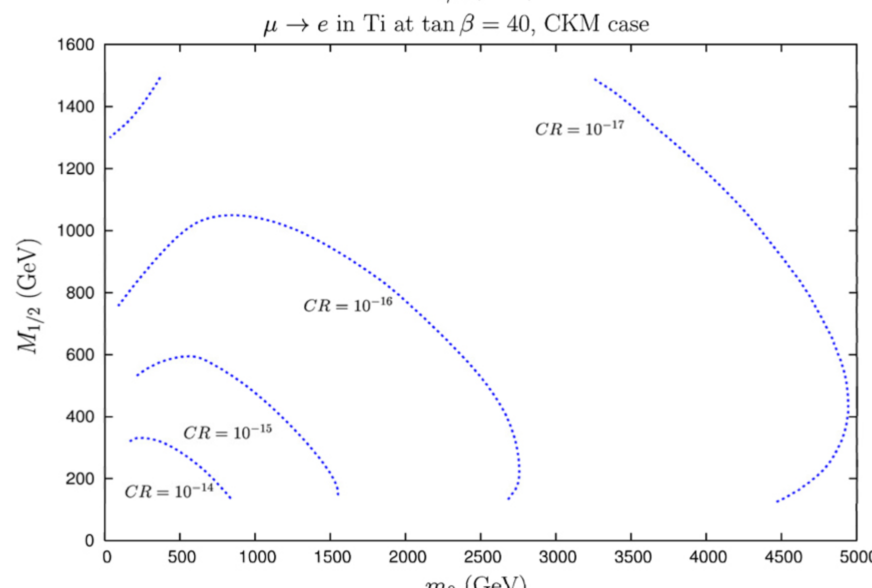
CFMV

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

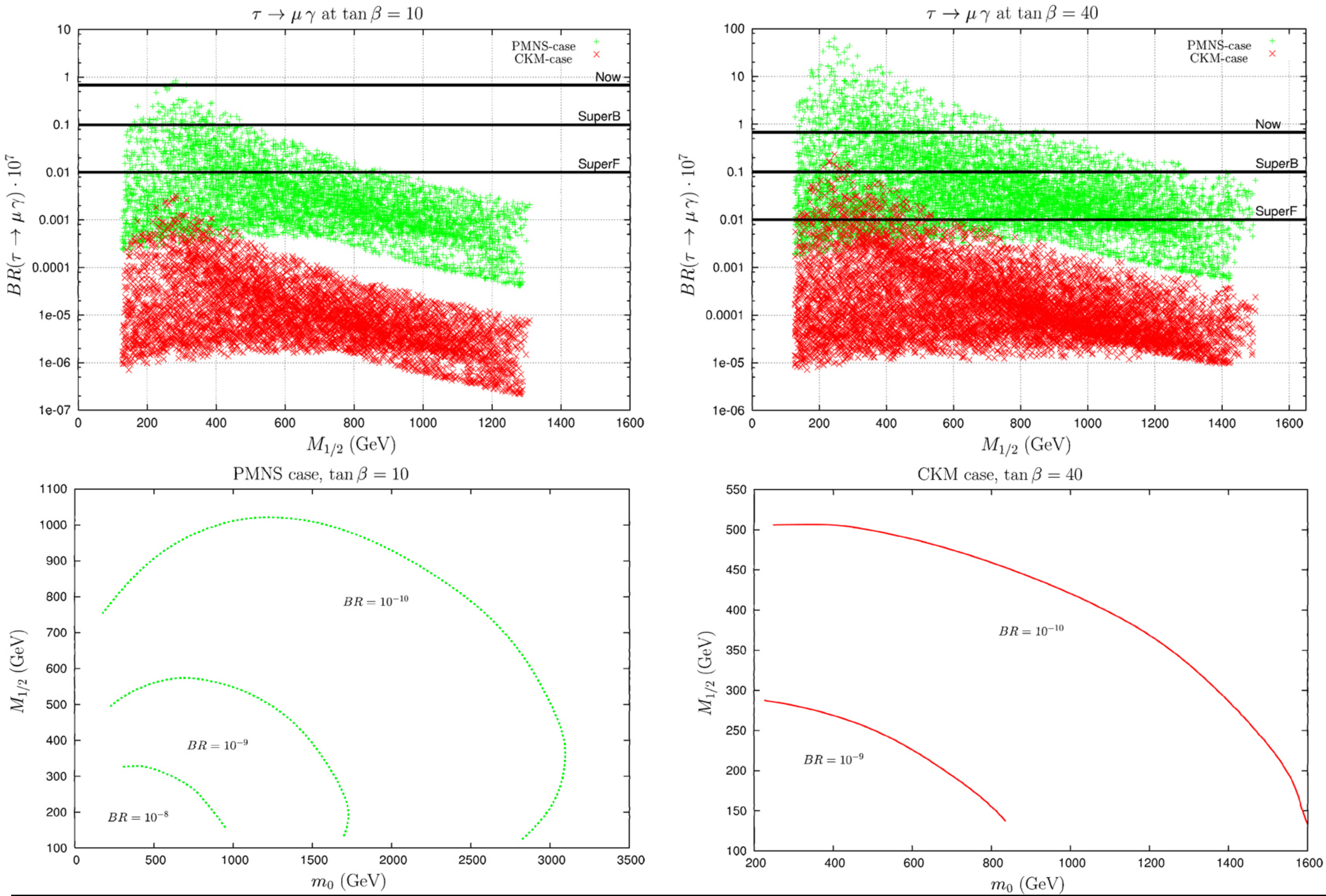








$\tau \to \mu\,\gamma$ and the **Super B** (and **Flavour**) factories

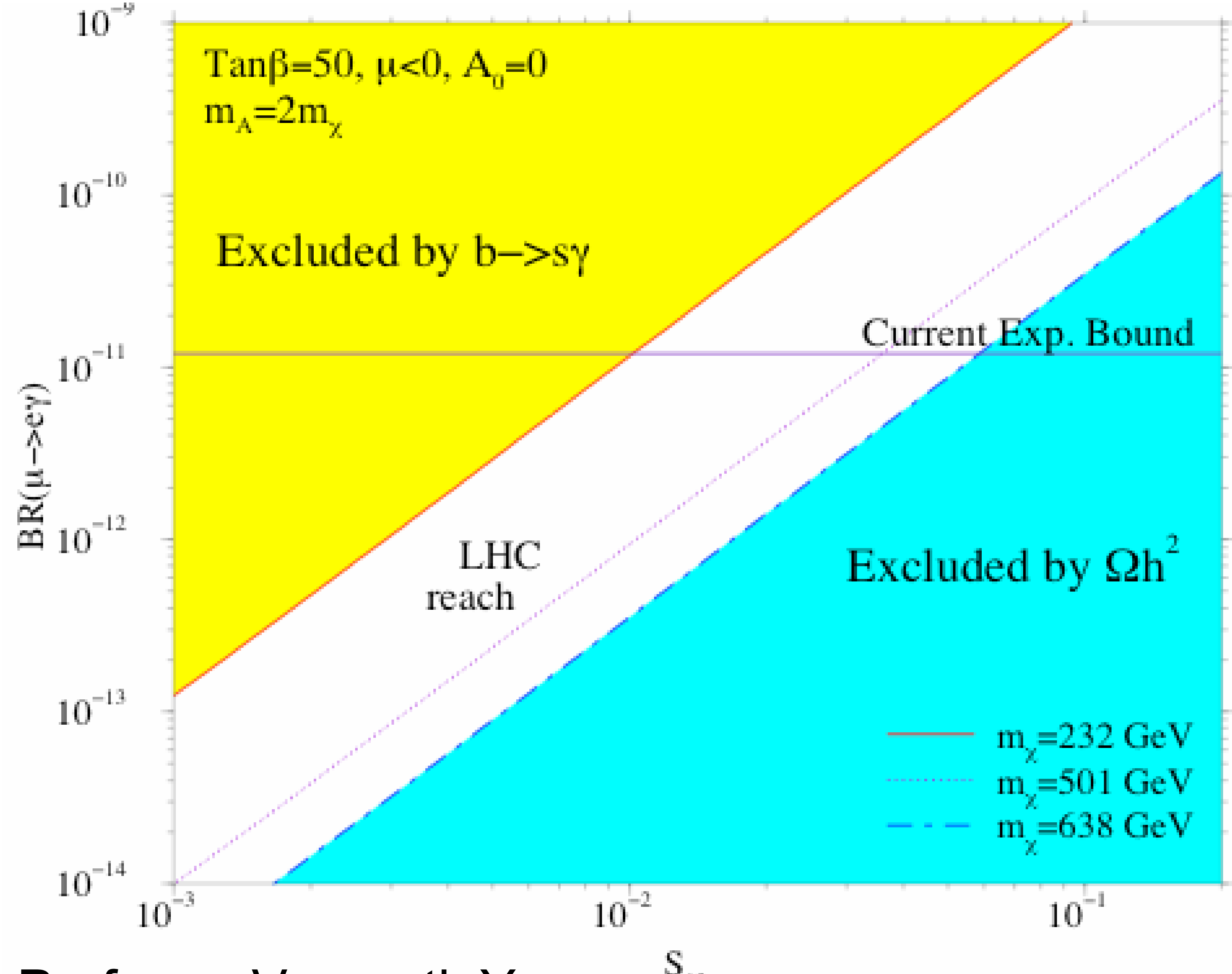


Sensitivity of $\mu \longrightarrow e\gamma$ to U_{e3} for various Snowmass points in mSUGRA with seesaw

A.M., Vempati, Vives

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

LHC vs. LFV REACH for SUSY



A.M., Profumo, Vempati, Yaguna

LFV ⟷ LHC SENSITIVITIES IN PROBING THE SUSY PARAM. SPACE

TABLE IX: Reach in $(m_0, m_{\tilde{g}})$ of the present and planned experiment from their $\tau \to \mu\gamma$ sensitivity.

	PMNS		CKM	
Exp.	$t_\beta = 40$	$t_\beta = 10$	$t_\beta = 40$	$t_\beta = 10$
BaBar, Belle	1.2 TeV	no	no	no
SuperKEKB	2 TeV	0.9 TeV	no	no
Super Flavour [a]	2.8 TeV	1.5 TeV	0.9 TeV	no

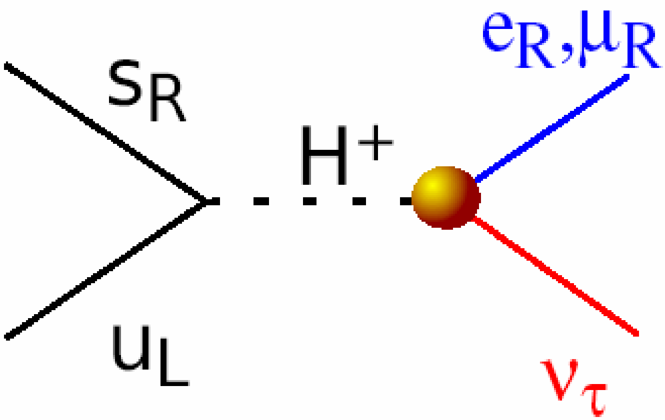
[a] Post–LHC era proposed/discussed experiment

Calibbi, Faccia, A.M., Vempati

H mediated LFV SUSY contributions to R_K

$$R_K^{LFV} = \frac{\sum_i K \to e\nu_i}{\sum_i K \to \mu\nu_i} \simeq \frac{\Gamma_{SM}(K \to e\nu_e) + \Gamma(K \to e\nu_\tau)}{\Gamma_{SM}(K \to \mu\nu_\mu)} \;, \quad i = e, \mu, \tau$$

PARADISI, A.M., PETRONZIO



$$eH^\pm \nu_\tau \to \frac{g_2}{\sqrt{2}} \frac{m_\tau}{M_W} \Delta_R^{31} \tan^2\beta$$

$$\Delta_R^{31} \sim \frac{\alpha_2}{4\pi} \delta_{RR}^{31}$$

$$\Delta_R^{31} \sim 5 \cdot 10^{-4} \quad t_\beta = 40 \quad M_{H^\pm} = 500\mathrm{GeV}$$

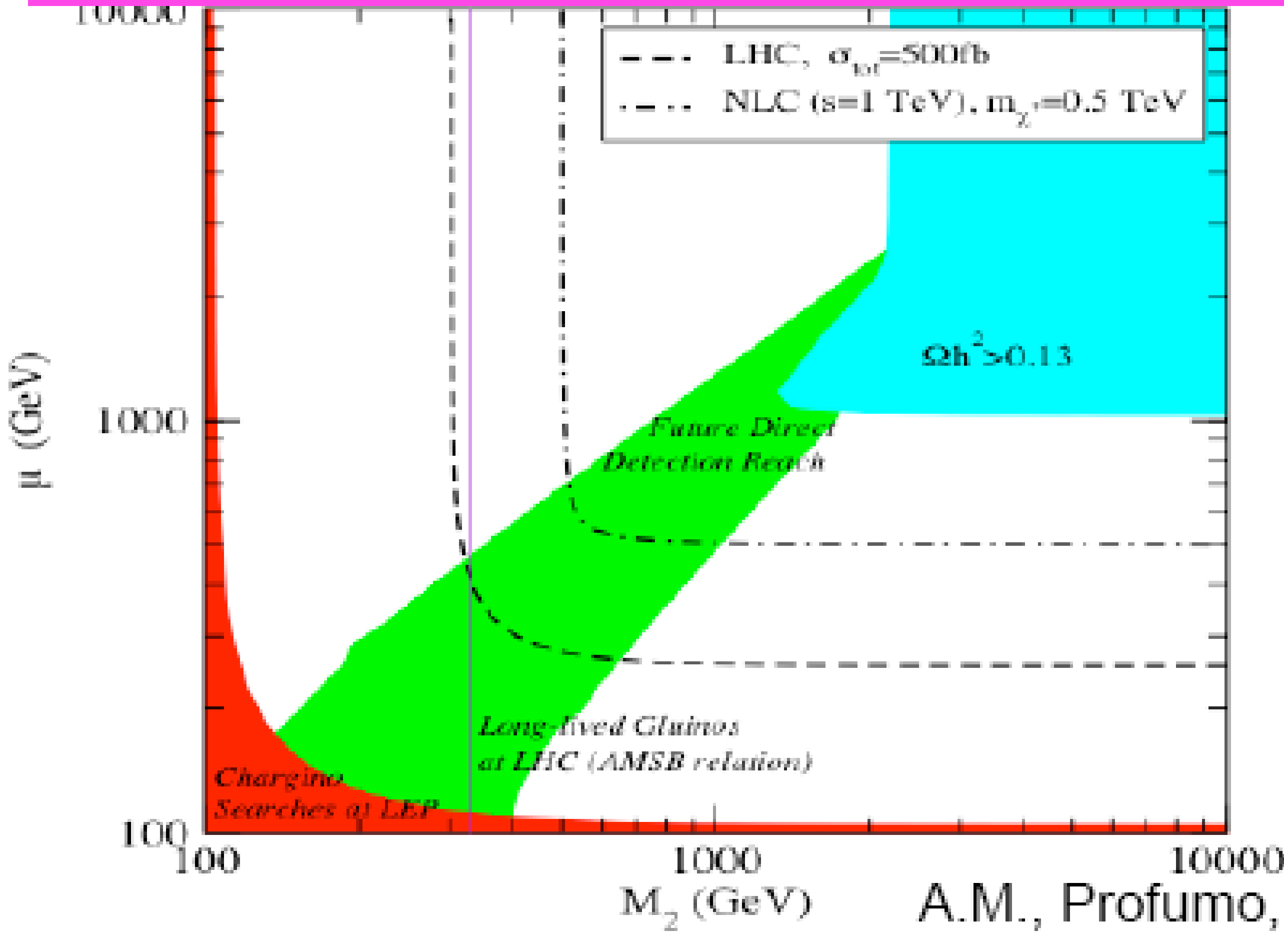
$$\Downarrow$$

$$\Delta r_{K\,SUSY}^{e-\mu} \simeq \left(\frac{m_K^4}{M_{H^\pm}^4}\right) \left(\frac{m_\tau^2}{m_e^2}\right) |\Delta_R^{31}|^2 \tan^6\beta \approx 10^{-2}$$

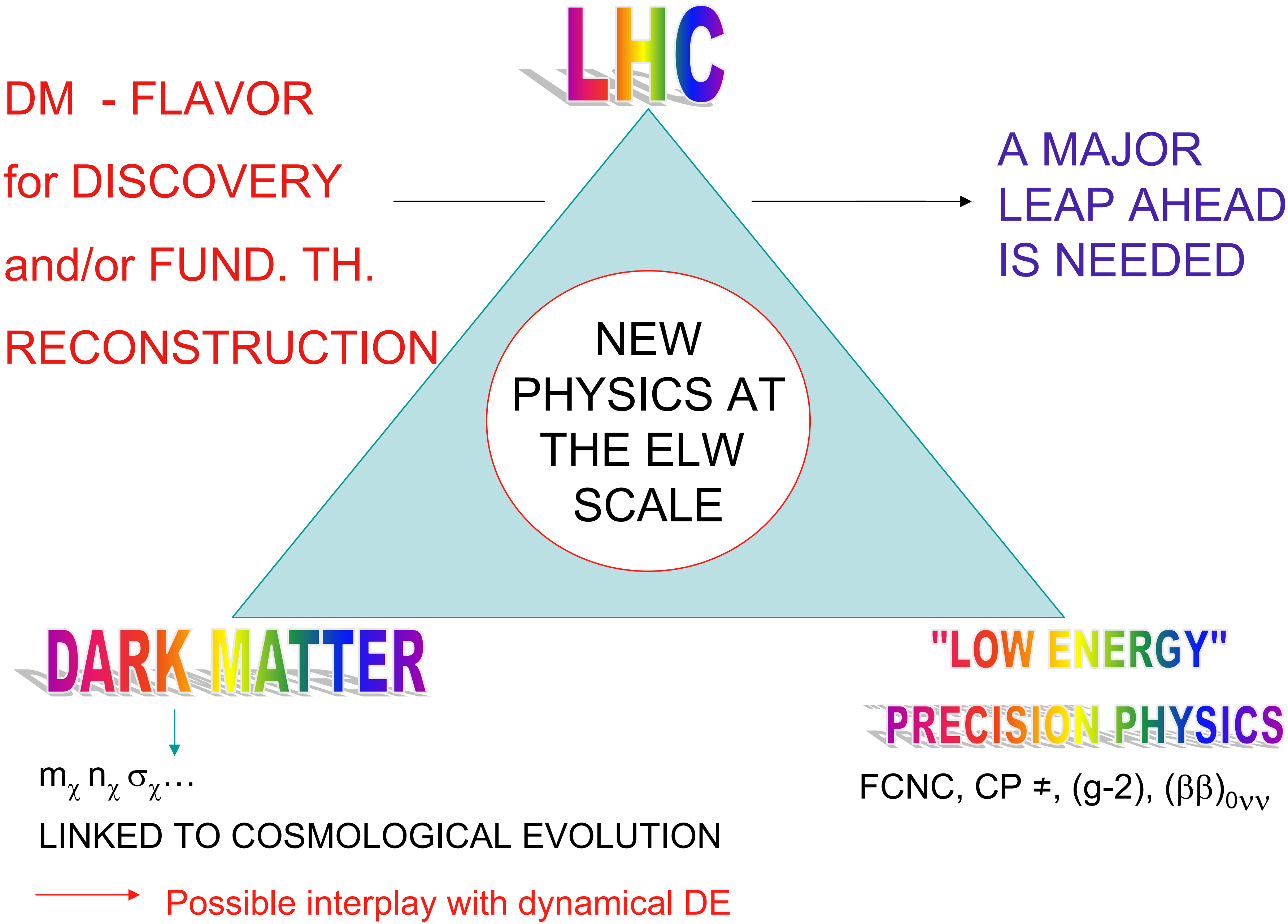
Extension to B → lν deviation from universality

Isidori, Paradisi

LHC, ILC, DM SEARCHES SENSITIVITIES



A.M., Profumo, Ullio


LHC
DM - FLAVOR
for DISCOVERY
and/or FUND. TH.
RECONSTRUCTION
A MAJOR
LEAP AHEAD
IS NEEDED
NEW
PHYSICS AT
THE ELW
SCALE
DARK MATTER
m_χ n_χ σ_χ…
LINKED TO COSMOLOGICAL EVOLUTION
Possible interplay with dynamical DE
"LOW ENERGY"
PRECISION PHYSICS
FCNC, CP ≠, (g-2), $(\beta\beta)_{0\nu\nu}$