$B_s \to \mu\mu$

as an electroweak precision test

Diego Guadagnoli
LAPTh Annecy

See: Buchalla, Buras '93; Misiak, Urban '99

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$$BR[B_s \to \mu^+\mu^-] \simeq \frac{1}{\Gamma_s} \times \left(\frac{G_F^2 \alpha_{\text{e.m.}}^2}{16\pi^3 s_W^4} \right) \cdot \left| V_{tb}^* V_{ts} \right|^2 \cdot f_{B_s}^2 \; m_{B_s} \cdot m_\mu^2 \cdot Y^2 (m_t^2 / M_W^2)$$

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- f_{Bs} is among the simplest quantities for lattice QCD
- high-precision calculations possible, and in part already reality

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- Masses' & couplings' dependence of the BR = "usual" FCNC-related suppression $\times \boxed{\dfrac{m_\mu^2}{M_W^2}}$

Additional "chiral" suppression: relative 10^{-6} factor

$B_s \rightarrow \mu\mu$

and new physics

Model-independent approach: effective operators

Beyond the SM,
a total of 6 operators can contribute:

(One may write also two tensor operators,
but their matrix elements vanish for this process.)

$$O_A \equiv \left(\bar{b}\gamma_L^\alpha s\right)\left(\bar{\mu}\gamma_\alpha\gamma_5\mu\right) \qquad O'_A \equiv \left(\bar{b}\gamma_R^\alpha s\right)\left(\bar{\mu}\gamma_\alpha\gamma_5\mu\right)$$

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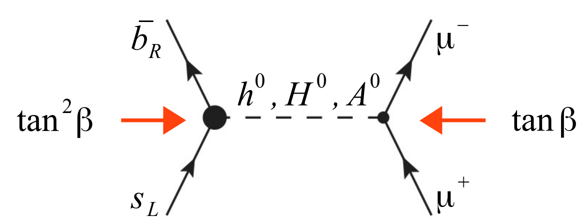
One famous example:
the MSSM with large tanß



Effectively tree-level diagrams:
Enhancement going as:

$$BR[B_s \to \mu^+\mu^-] \propto A_t^2 \frac{\tan^6\beta}{M_A^4}$$

BR[$B_s \to \mu\mu$] as an EW precision test

DG, Isidori, PLB 13

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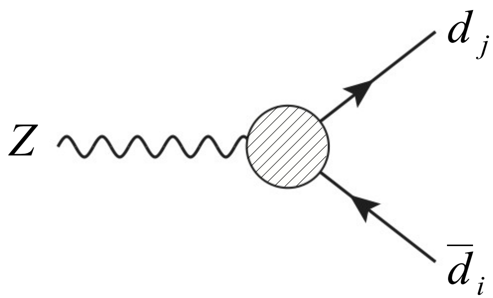

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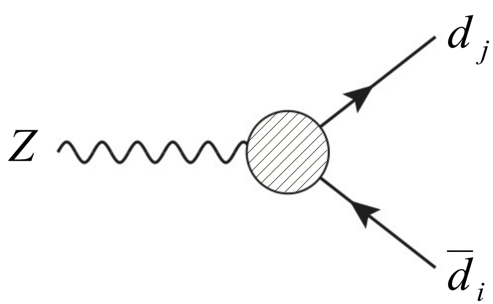
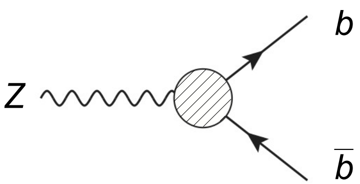


Flavor-diag: *$i = j$ (= 3)*

Affects LEP-measured
$Z \to b\,\bar{b}$ observables: R_b, A_b, A^b_{FB}



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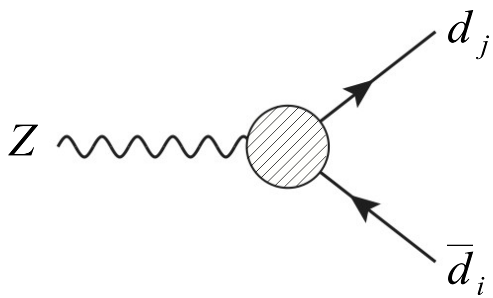

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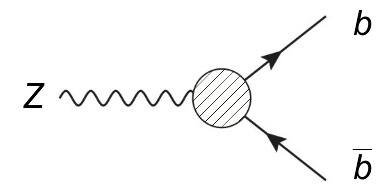

Flavor-off-diag: *$i \neq j$*

Affects Z-penguin-driven FCNCs,
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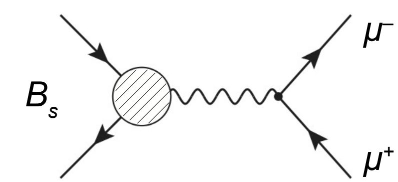

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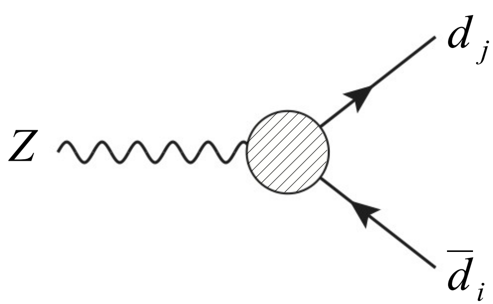

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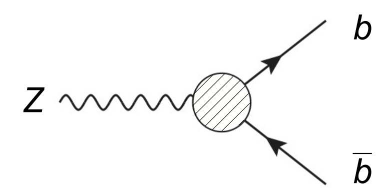

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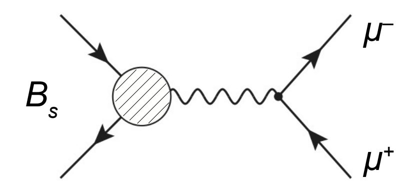

- Shifts in Zdd couplings can be implemented as contributions from effective operators ($\to$ minimal model dep.)

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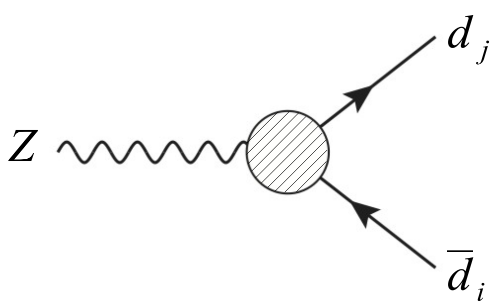

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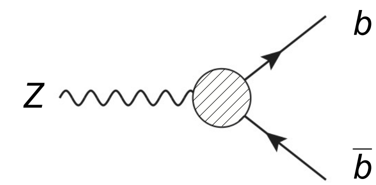

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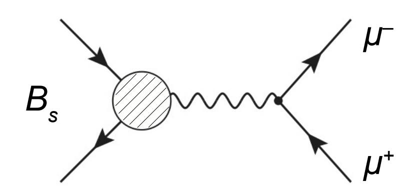

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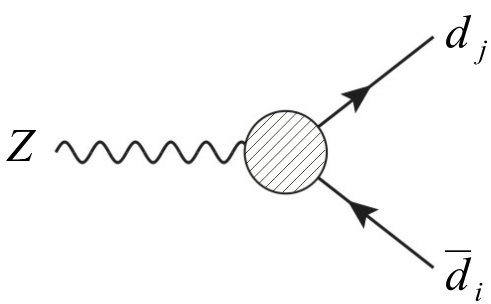

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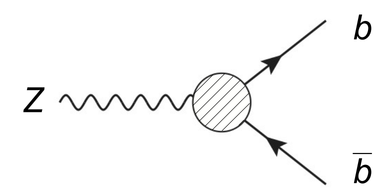

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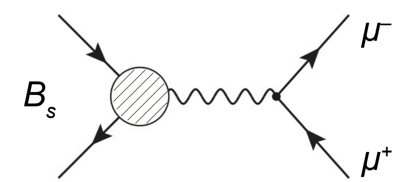

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flavor structure

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DG, Isidori, PLB 13

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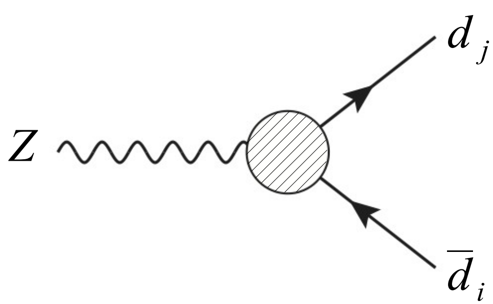

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Affects LEP-measured
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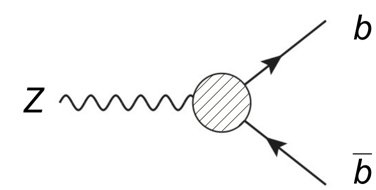

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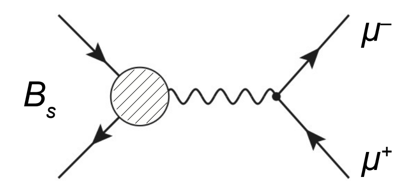

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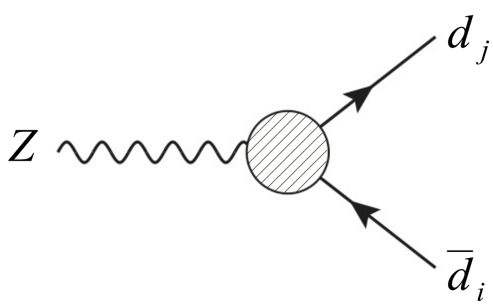

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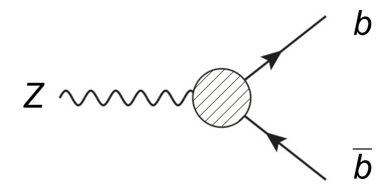

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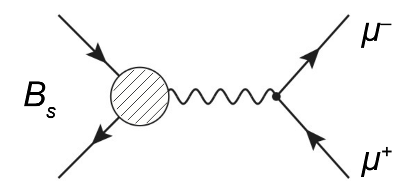

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In either case, FV and FC couplings will be proportional to two universal shifts:
δg_L & δg_R

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See e.g.:
Rattazzi *et al.*, NPB 13

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As in the MFV example, we need to organize EFT operators according to their flavor suppression.

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One way to guess the answer: integrate out O_i in the interactions $\epsilon_i f_i O_i$

The answer would be: $\left(Y_{u,d}\right)_{ij} \propto \epsilon_Q^{(i)} \epsilon_{u,d}^{(j)}$

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Another way to arrive at the same answer is to start with the following picture:

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- Hierarchical kin. terms can arise from **non-trivial profiles of fermion wave-functions** in QFT with extra-dims
- Hierarchies are then **transmitted to the Yukawa interactions** once kin. terms are made canonical

Fixing the couplings. Case 2: Partial Compositeness

Example

Flavor structure of the RH operator $O_{1R}^{32} \equiv i\left(\bar{b}_R \gamma^\mu s_R\right) H^\dagger D_\mu H$

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The flavor structure
is fixed within the PC framework

BR[$B_s \to \mu\mu$] as an EWPT: results

DG, Isidori, 1302.3909

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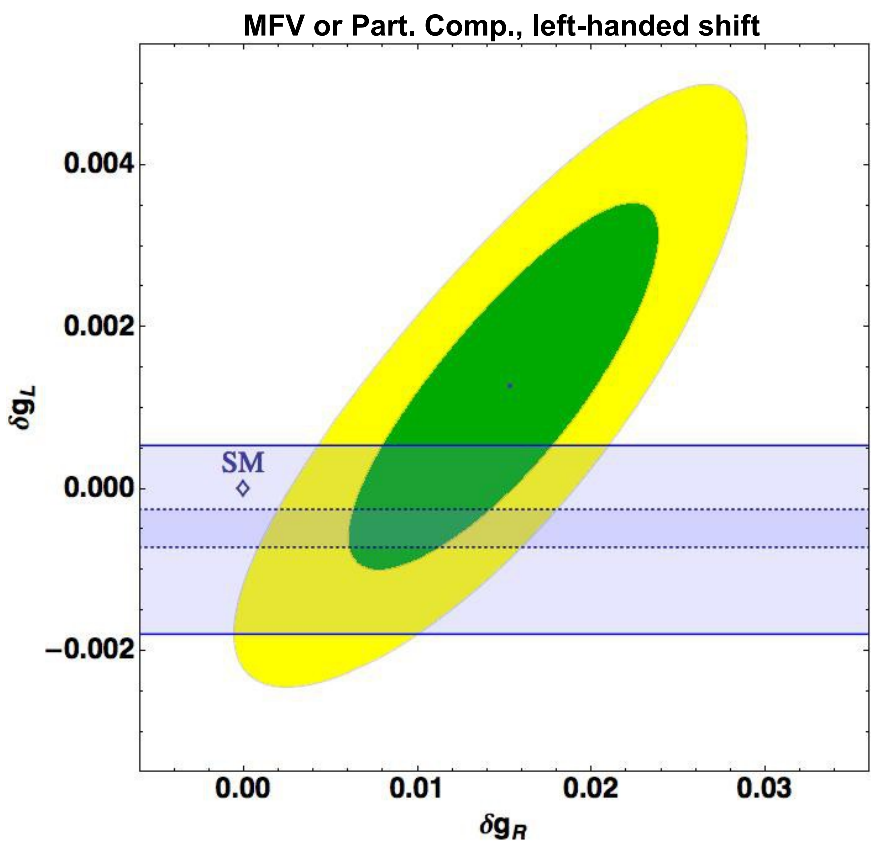

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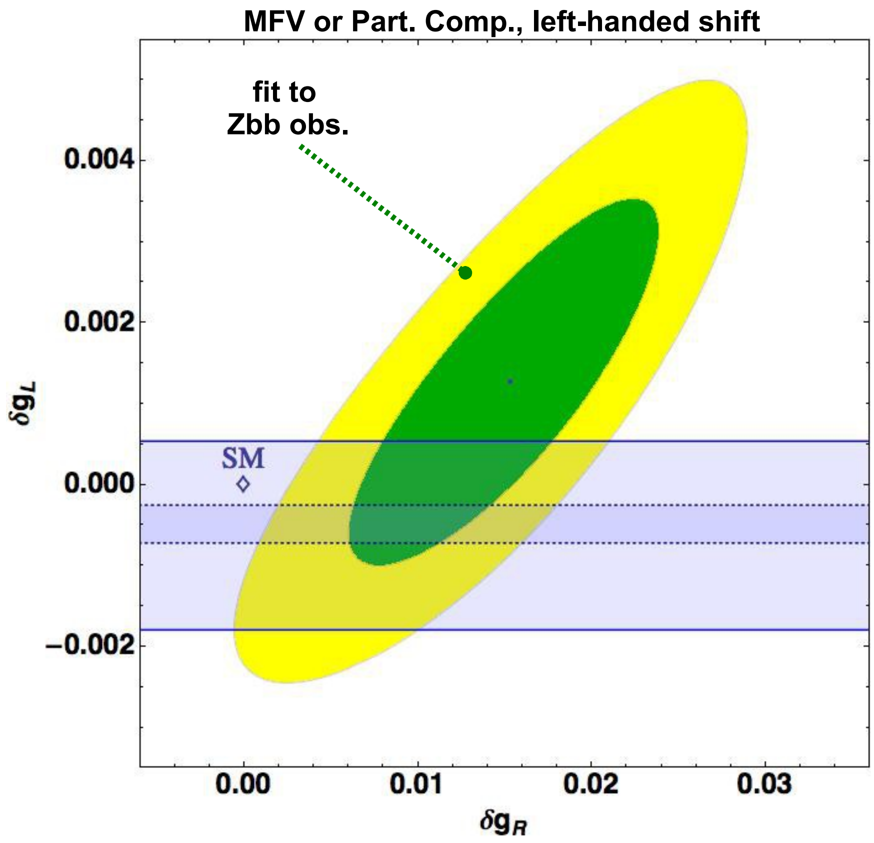

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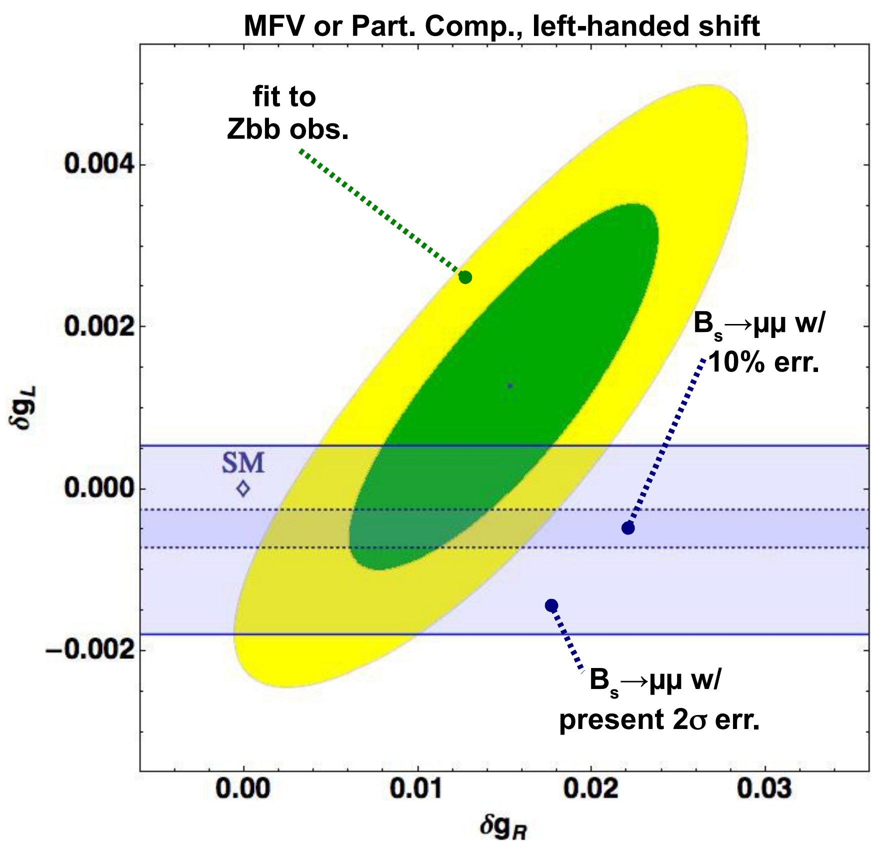

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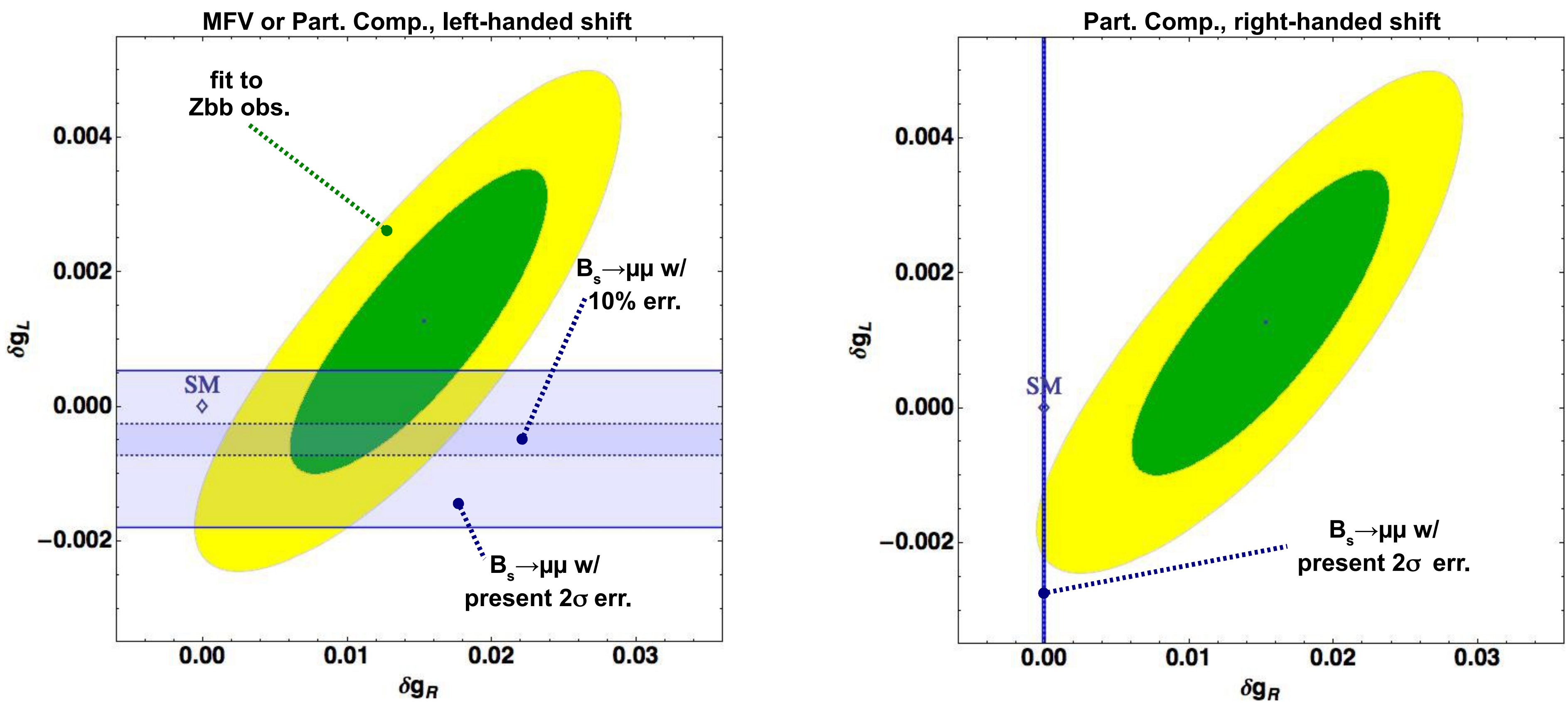

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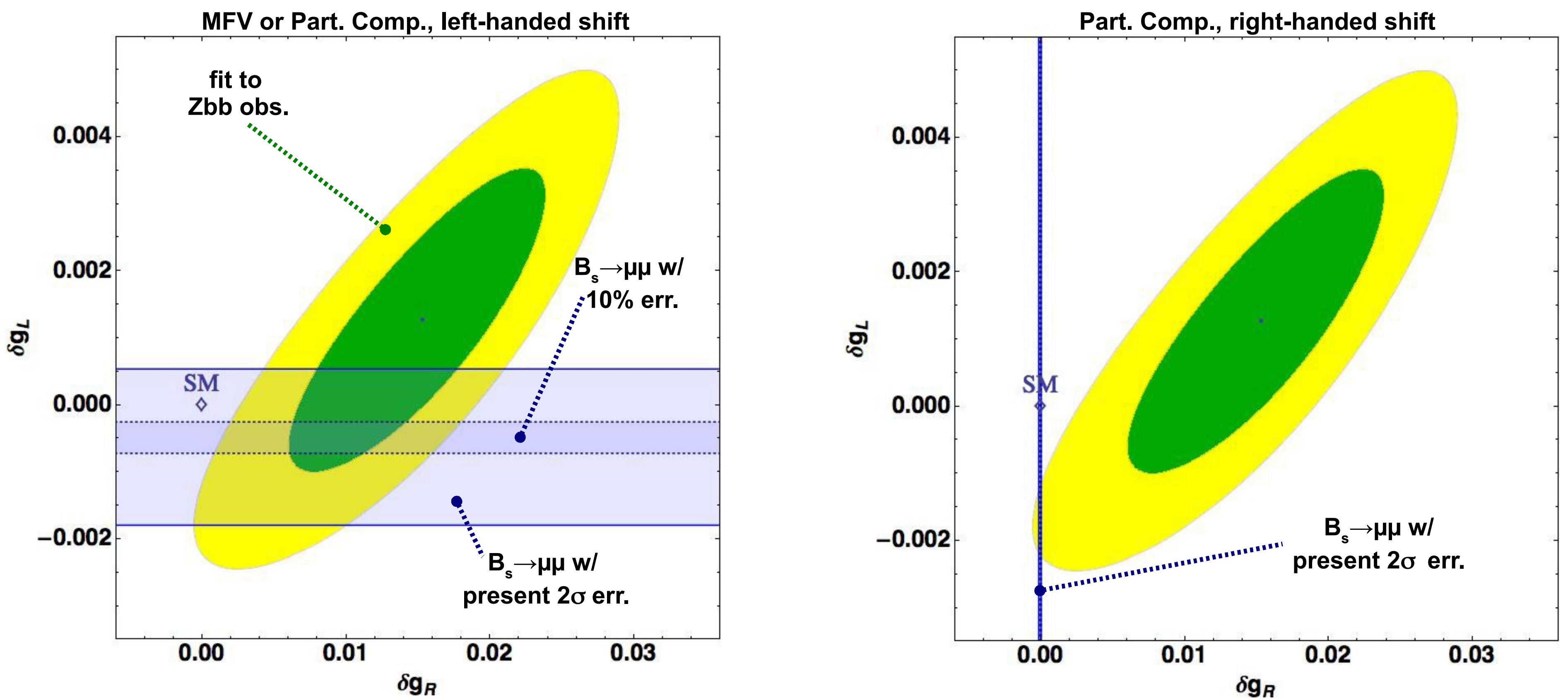

with present $B_s \to \mu\mu$ exp error

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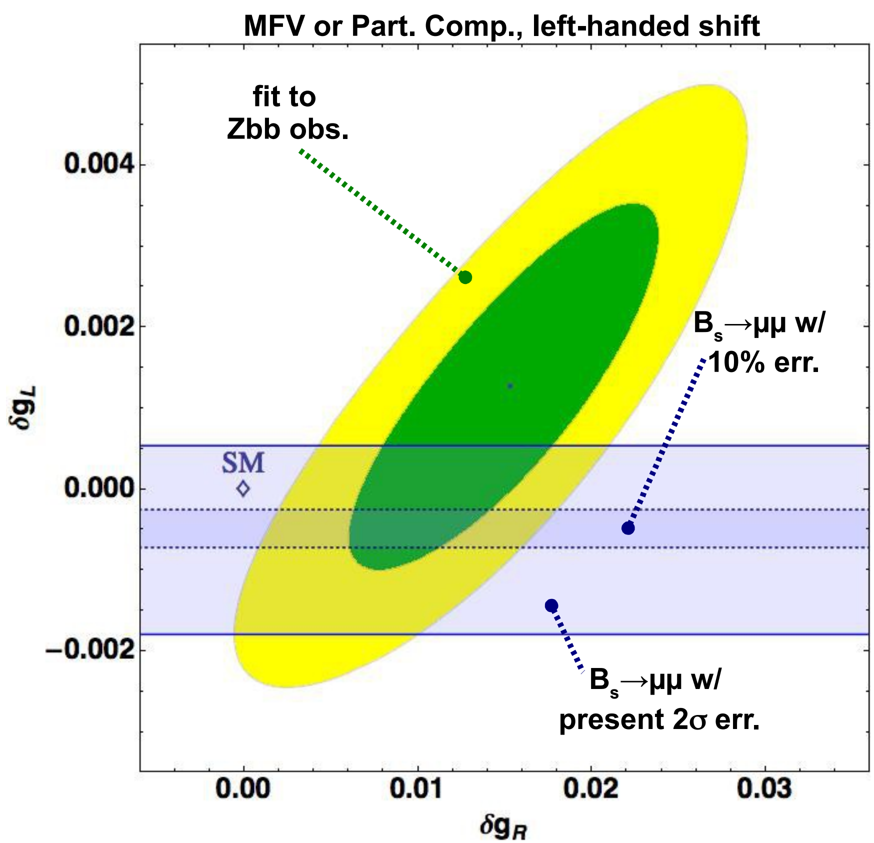

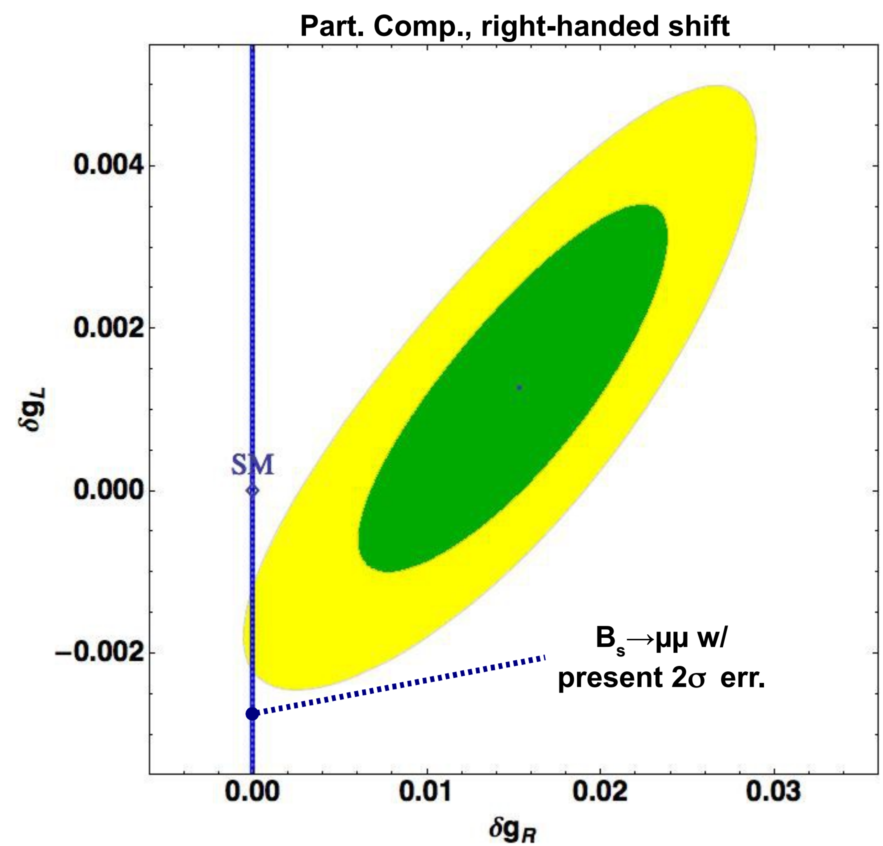

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with ~ 10% $B_s \to \mu\mu$ error	$\vert\delta g_L\vert^{\text{MFV or PC}} < 4.6 \times 10^{-4}$	$\vert\delta g_R\vert^{\text{PC}} < 3.3 \times 10^{-5}$

Conclusions

- *Looking forward to a deviation.*