HEPCube-Padova

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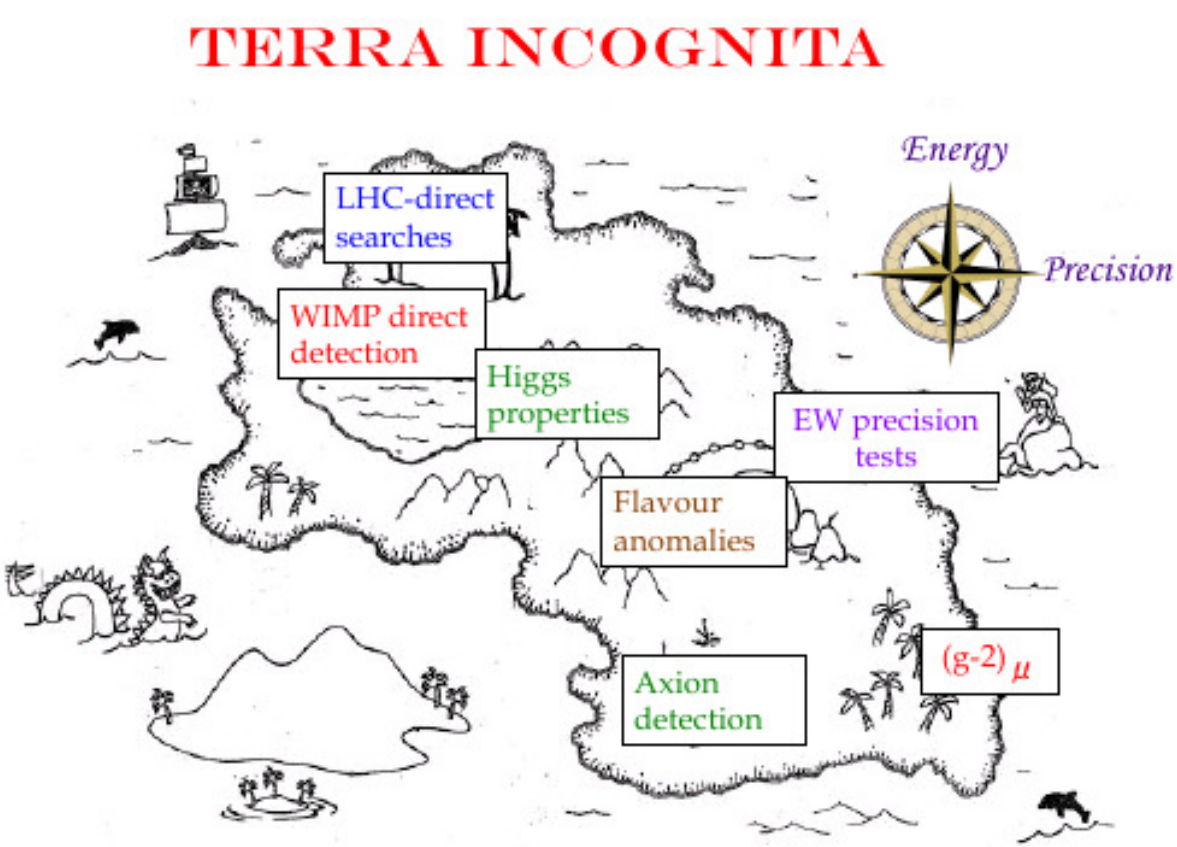
Learning about fundamental interactions

1. **Energy Frontier**
   - Direct searches: what to learn from run-2 and HL-LHC?
2. **Intensity Frontier**
   - Indirect searches: what to learn from LHCb, BelleII, ...?
3. **Cosmic Frontier**
   - Dark Matter, Dark Energy, Inflation, ...

(Desperately) Looking for New Physics



[Casas @ Moriond 2017]

- We do not have a cross in the map to know where the BSM treasure is, as we had for the Higgs boson: we have to explore the whole territory!
- Is the BSM treasure is in the territory to be explored? Does it exist at all?
- The content of the BSM treasure is also a mystery: SUSY, new strong interactions, extra dimensions, something unexpected, ... ?

Where to look for New Physics at low-energy?

- **Processes highly suppressed or even forbidden in the SM**
  - LFV processes ($\mu \to e\gamma$, $\mu \to e$ in N, $\tau \to \mu\gamma$, $\tau \to 3\mu$, $\cdots$)
  - CPV effects in the electron/neutron EDMs
- **Processes predicted with high-precision in the SM**
  - EWPO as $(g-2)_\mu$: $\Delta a_\mu = a_\mu^{exp} - a_\mu^{SM} \approx (3 \pm 1) \times 10^{-9}$ (3σ discrepancy!)
  - LFUV in $B \to D^{(*)}\ell\nu$, $B \to K\ell\ell'$ (3σ discrepancy!)

Comparisons of the SM predictions with the measured g-2 value:

$a_\mu^{EXP} = 116592091\ (63) \times 10^{-11}$

E821 – Final Report: PRD73 (2006) 072 with latest value of $\lambda=\mu_\mu/\mu_p$ from CODATA'10

$a_\mu^{\rm SM} \times 10^{11}$	$\Delta a_\mu = a_\mu^{\rm EXP} - a_\mu^{\rm SM}$	σ
$116\,591\,761\ (57)$	$330\ (85) \times 10^{-11}$	3.9 [1]
$116\,591\,818\ (51)$	$273\ (81) \times 10^{-11}$	3.4 [2]
$116\,591\,841\ (58)$	$250\ (86) \times 10^{-11}$	2.9 [3]

with the recent "conservative" hadronic light-by-light a_μ^{HNLO}(lbl) = 102 (39) x 10^{-11} of F. Jegerlehner arXiv:1511.04473, and the hadronic leading-order of:

[1] Jegerlehner, arXiv:1511.04473.
[2] Davier, arXiv:1612:02743.
[3] Hagiwara et al, JPG38 (2011) 085003.

[courtesy of M. Passera]

Hints of LFUV in semileptonic B decays

- **LFUV in CC $b \to c$ transitions** (tree-level in the SM) @ 3σ

$$R_D^{\tau/\ell} = \frac{\mathcal{B}(B \to D\tau\bar{\nu})_{\rm exp}/\mathcal{B}(B \to D\tau\bar{\nu})_{\rm SM}}{\mathcal{B}(\bar{B} \to D\ell\bar{\nu})_{\rm exp}/\mathcal{B}(B \to D\ell\bar{\nu})_{\rm SM}} = 1.34 \pm 0.17$$

$$R_{D^*}^{\tau/\ell} = \frac{\mathcal{B}(B \to D^*\tau\bar{\nu})_{\rm exp}/\mathcal{B}(B \to D^{(*)}\tau\bar{\nu})_{\rm SM}}{\mathcal{B}(B \to D^*\ell\bar{\nu})_{\rm exp}/\mathcal{B}(B \to D^*\ell\bar{\nu})_{\rm SM}} 1.23 \pm 0.07$$

[HFAG averages of BaBar '13, Belle '15, LHCb '15, Fajfer, Kamenik and Nisandzic '12]

- **LFUV in NC $b \to s$ transitions** (1-loop in the SM) @ 3σ

$$R_K^{\mu/e} = \left.\frac{\mathcal{B}(B \to K\mu\bar{\mu})_{\rm exp}}{\mathcal{B}(B \to Ke\bar{e})_{\rm exp}}\right|_{q^2 \in [1,6]\,{\rm GeV}^2} = 0.745^{+0.090}_{-0.074} \pm 0.036 \text{ [LHCb '14]}$$

$$R_{K^*}^{\mu/e} = \left.\frac{\mathcal{B}(B \to K^*\mu\bar{\mu})_{\rm exp}}{\mathcal{B}(B \to K^*e\bar{e})_{\rm exp}}\right|_{q^2 \in [1.1,6]\,{\rm GeV}^2} = 0.685^{+0.113}_{-0.069} \pm 0.047 \text{ [LHCb '17]}$$

while $(R_K^{\mu/e})_{SM} = 1$ up to few % corrections [Hiller et al,'07, Bordone, Isidori and Pattori, '16].

Publications

1. C. M. Carloni Calame, M. Passera, L. Trentadue and G. Venanzoni, "A new approach to evaluate the leading hadronic corrections to the muon *g*-2," Phys. Lett. B **746** (2015) 325
2. G. Abbiendi *et al.*, "Measuring the leading hadronic contribution to the muon g-2 via μe scattering," Eur. Phys. J. C **77** (2017) no.3, 139
3. P. Mastrolia, M. Passera, A. Primo and U. Schubert, "Master integrals for the NNLO virtual corrections to μe scattering in QED: the planar graphs," JHEP **1711** (2017) 198
4. F. Feruglio, P. Paradisi and A. Pattori, "Revisiting Lepton Flavor Universality in B Decays," Phys. Rev. Lett. **118** (2017) no.1, 011801
5. F. Feruglio, P. Paradisi and A. Pattori, "On the Importance of Electroweak Corrections for B Anomalies," JHEP **1709** (2017) 061
6. C. Cornella, F. Feruglio and P. Paradisi, "Low-energy Effects of Lepton Flavour Universality Violation," arXiv:1803.00945 [hep-ph].
7. . . .

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