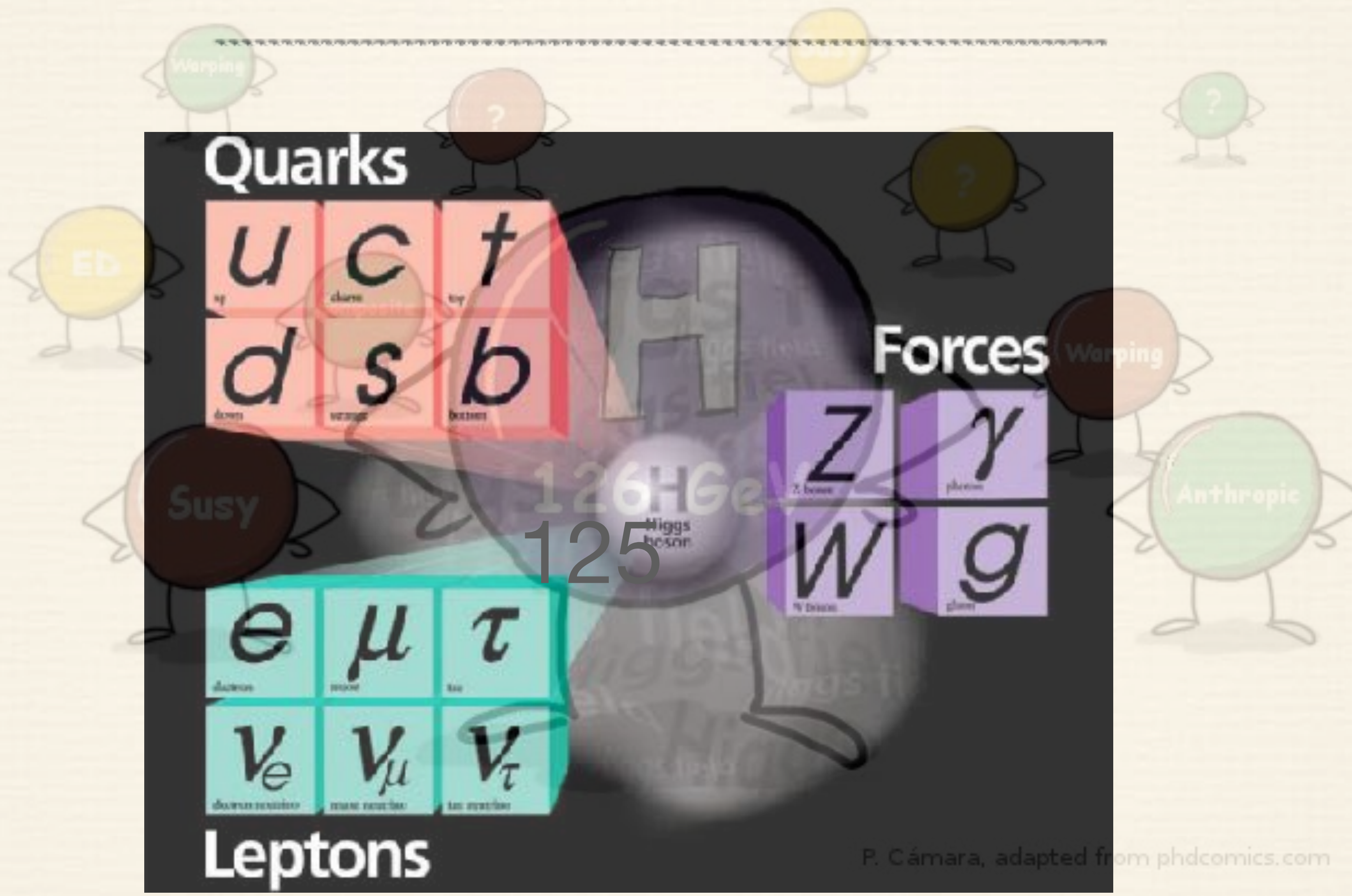
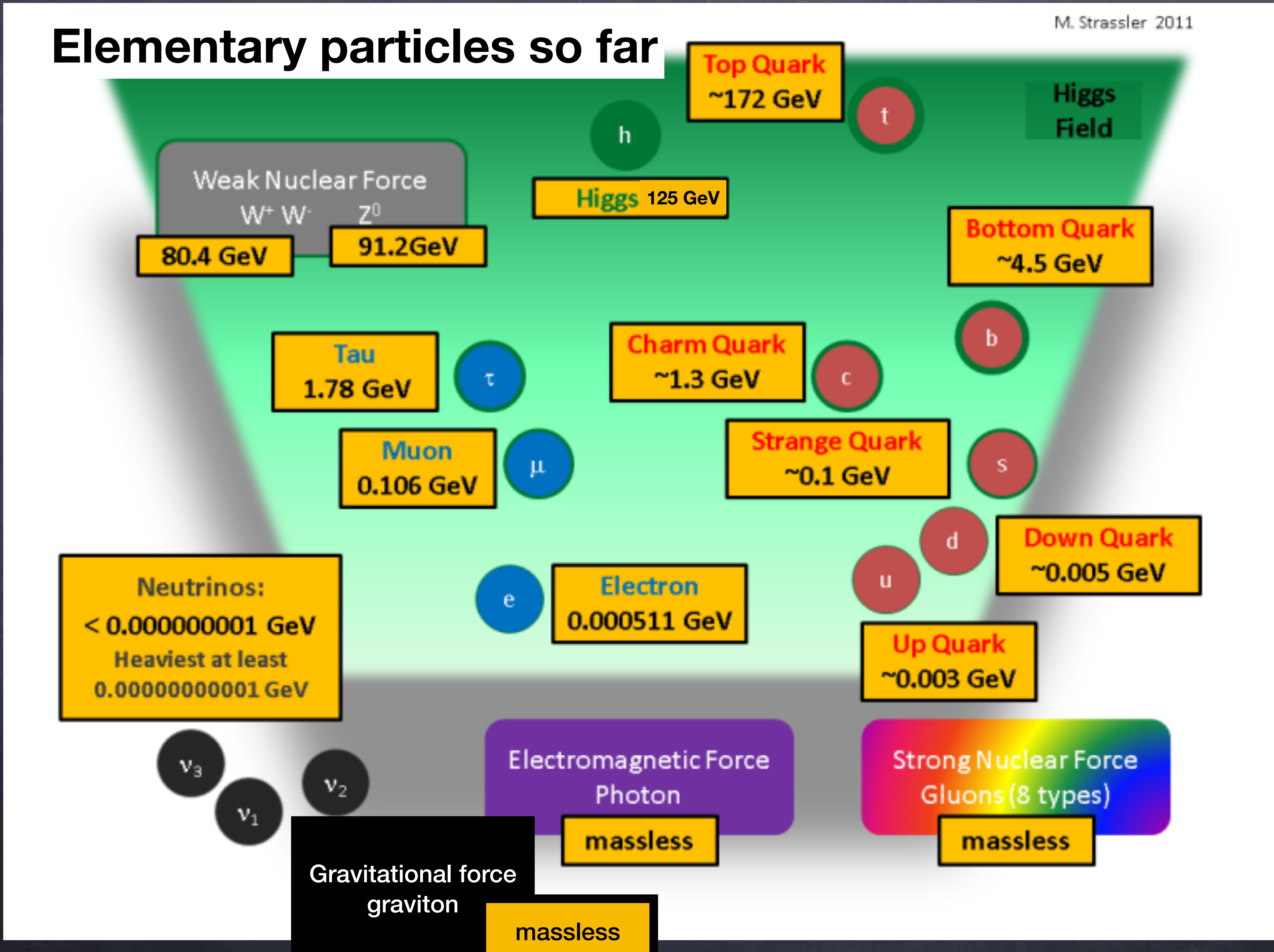
Particle Physics

Pôle théorie IJClab
Journée des Nouveaux Entrants
26/03/2025



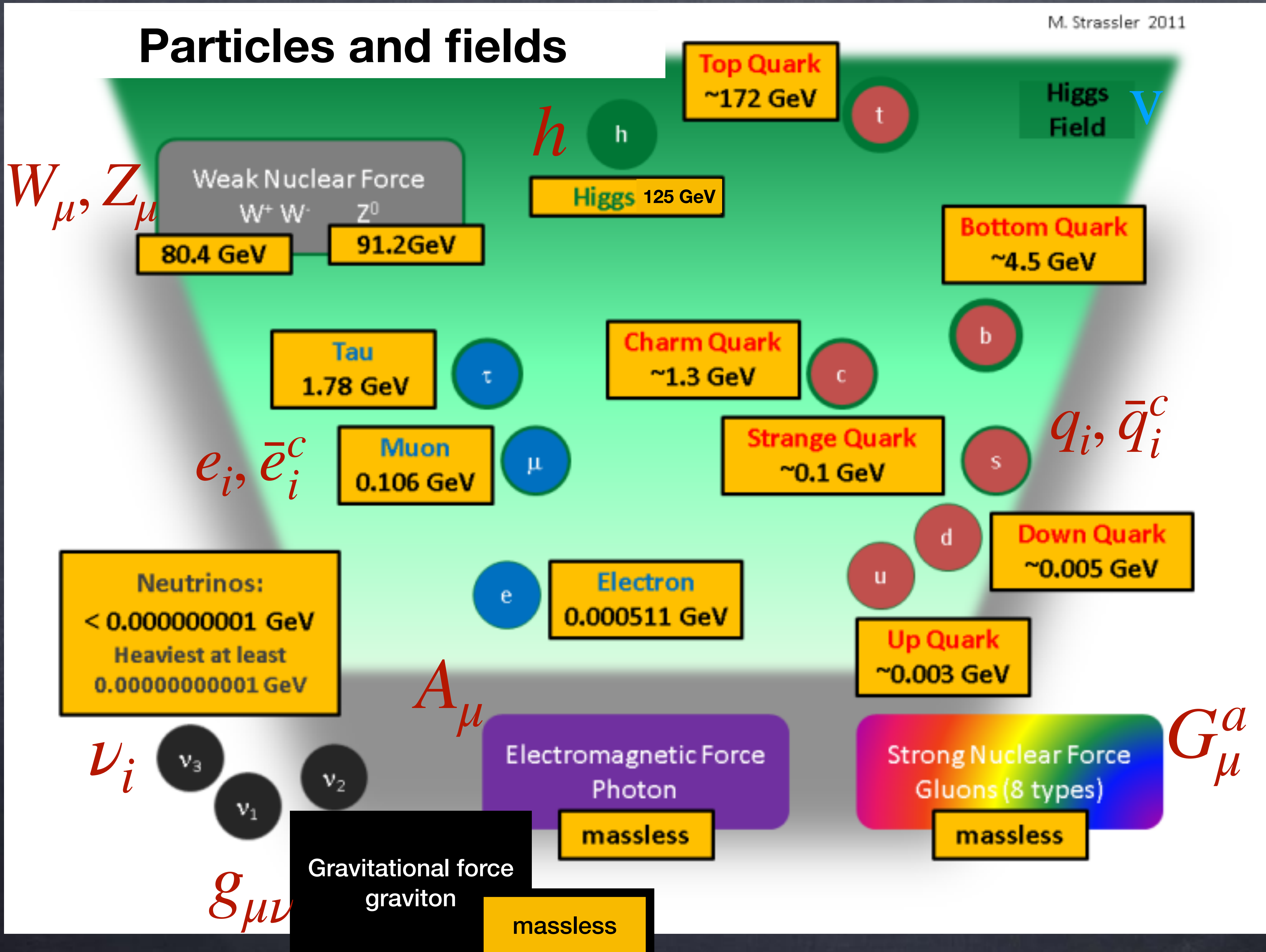
IJCLab
Irène Joliot-Curie

Elementary particles so far



Borrowed from Matt Strassler's blog: http://profmattstrassler.com/

Particles and fields



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Theory of everything (we know)

Lagrangian can be organized according to canonical dimensions of each term:

$$\mathcal{L} = \sqrt{-g}\left\{ \mathcal{L}_0 + \mathcal{L}_1 + \mathcal{L}_2 + \mathcal{L}_4 + \mathcal{L}_5 + \mathcal{L}_6 + \dots \right\}$$

This organises the infinity of possible interactions according to their importance at low energies

Each $\mathcal{L}_n$ contains all possible interactions terms allowed by Poincaré invariance, locality, hermiticity, and the gauge symmetry (totalitarian principle)

$$\mathcal{L}_0 = - M_{\rm Planck}^2 \Lambda_{\rm cosmo}^2$$

Experiment: $\Lambda_{\rm cosmo} \sim 10^{-33}$ eV

$$\mathcal{L}_1 = 0$$

$$\mathcal{L}_2 = \frac{M_{\rm Planck}^2}{2} R + \mu_H^2 H^\dagger H$$

Experiment: $M_{\rm Planck} \sim 10^{18}$ GeV $\qquad \mu_H \sim 100$ GeV

$$\mathcal{L}_3 = 0$$

$$\mathcal{L}_4 = -\frac{1}{4} \sum_{V \in B, W^i, G^a} V_{\mu\nu} V^{\mu\nu} + \sum_{f \in q,u,d,l,e} i \bar{f} \gamma^\mu D_\mu f$$

$$- \left(\bar{u} Y_u q H + \bar{d} Y_d H^\dagger q + \bar{e} Y_e H^\dagger l + {\rm h.c.} \right)$$

$$+ D_\mu H^\dagger D^\mu H - \lambda (H^\dagger H)^2 + \tilde{\theta} G_{\mu\nu}^a \tilde{G}_{\mu\nu}^a$$

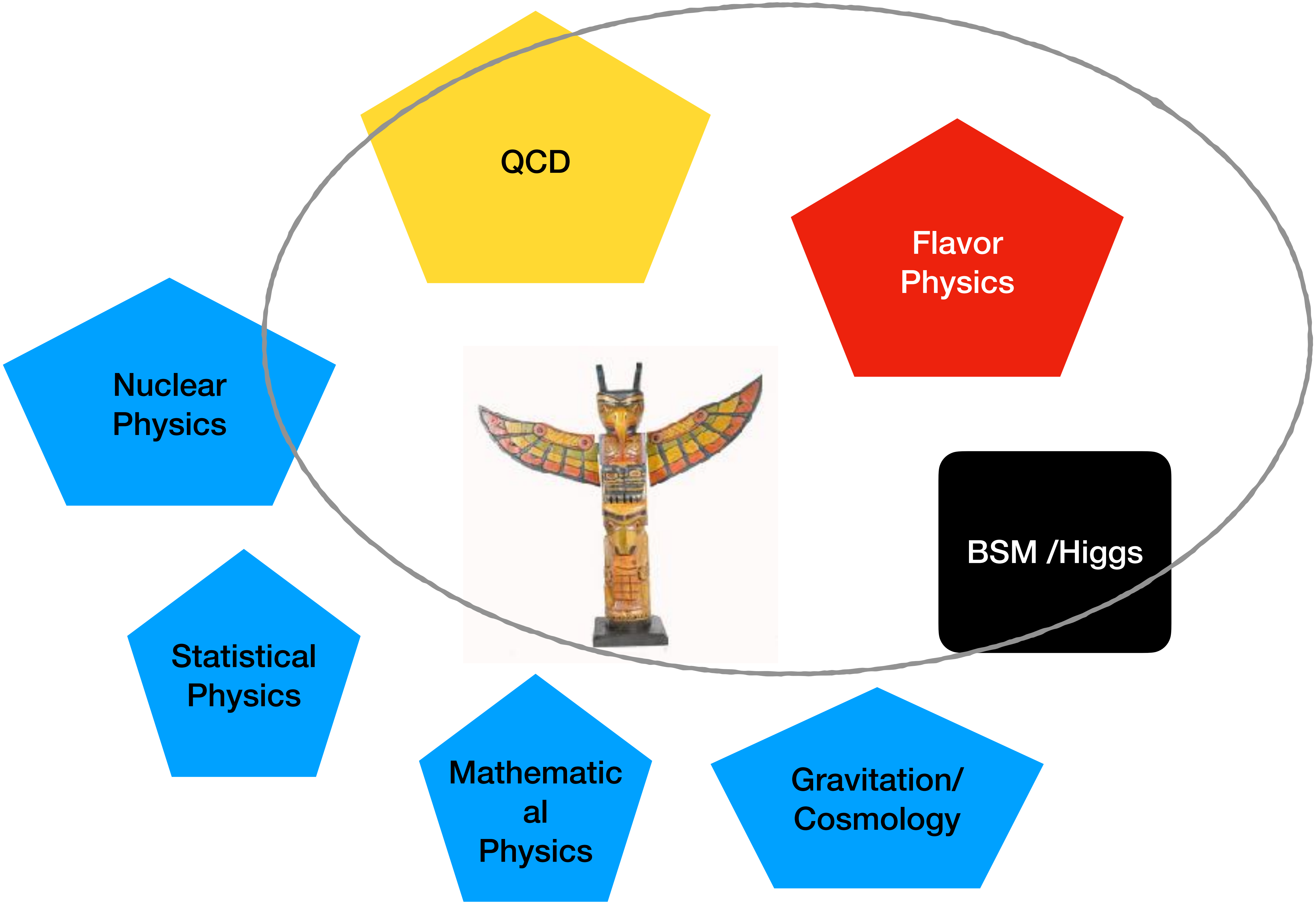
$$\mathcal{L}_5 = \frac{1}{\Lambda_5} (HL) C_\nu (HL)$$

Experiment: $\Lambda_5 \sim 10^{15}$ GeV

$$\mathcal{L}_6 \sim \frac{1}{\Lambda_6^2}$$

Experiment: $\Lambda_6 \sim ?$ GeV

Position within Theory Pole



BSM/Higgs

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Claire Chevalier

Yann MAMBRINI (DR)

Mathieu GROSS

Gregory MOREAU (MdC)

Adam FALKOWSKI (DR)

Panagiotis MARINELLIS
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BSM/Higgs

BSM/Higgs group asks a lot of question

- Are there new particles beyond those of the Standard Model
- Is nature natural
- How is electroweak symmetry broken
- How do neutrinos get their mass
- What was happening in the first seconds of the universe
- What is the nature of dark matter
- What caused matter-antimatter asymmetry
- Are there extra dimensions of spacetime
- ...

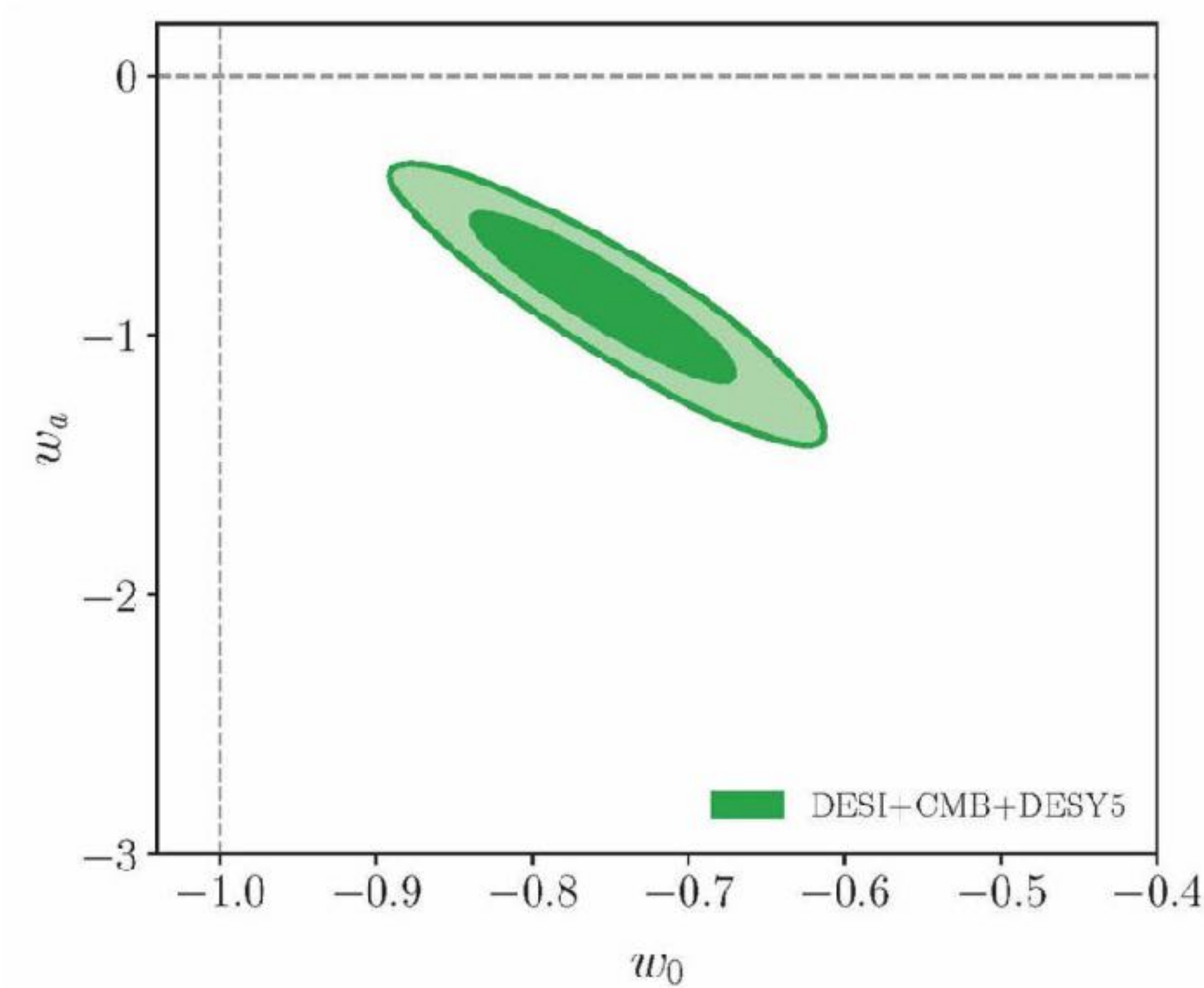
BSM/Higgs

Answers

BSM/Higgs

Clue ?

$$p = w\rho$$
$$w = w_0 + (1 - a)w_a$$



Flavor Physics

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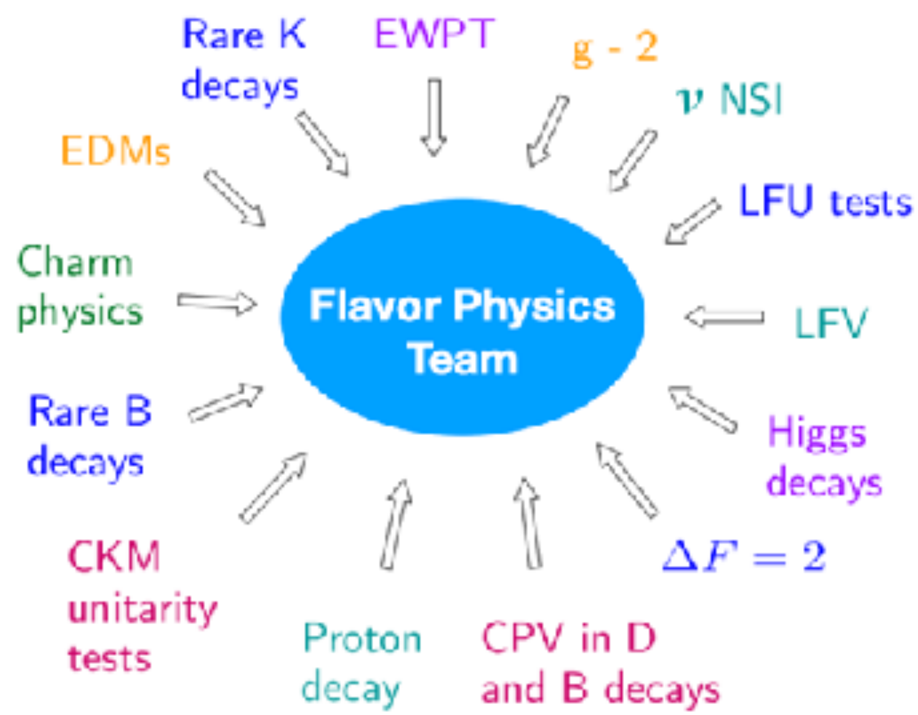
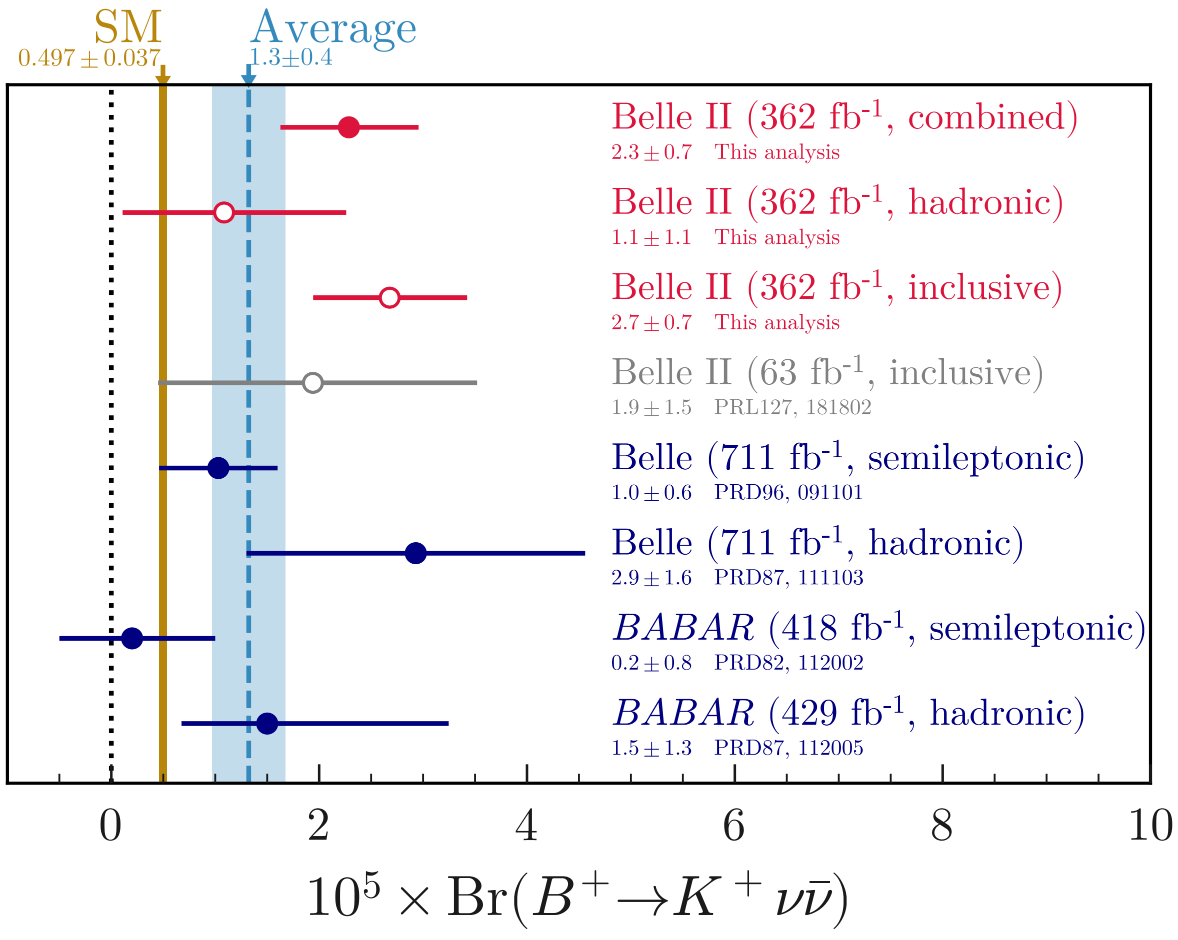
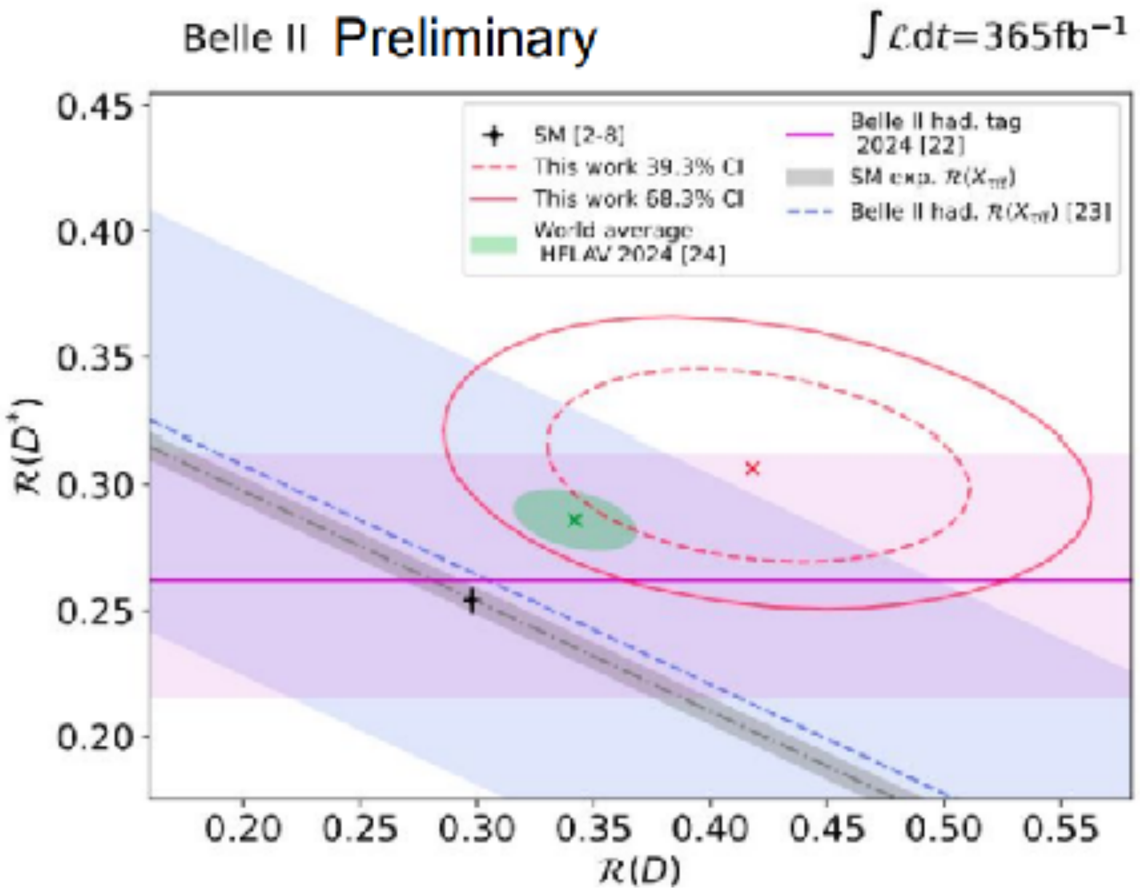


- Flavor physics group is straddling the line between beyond and within the Standard Model
- It is focused on the dynamics and decays of composite particles containing a heavy quark (b or c)
- On one hand, these allow us to better understand the Standard Model, in particular the action of the strong force
- On the other hand, flavor transitions are naturally suppressed in the Standard Model and therefore they are very sensitive to physics beyond the standard model

Flavor Anomalies





QCD

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Kate LYNCH
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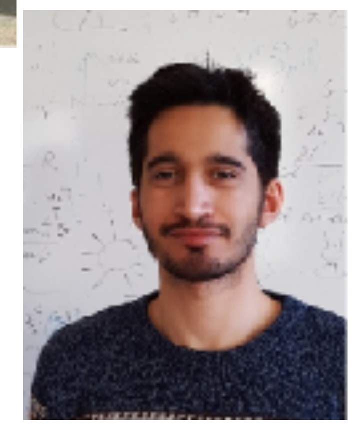

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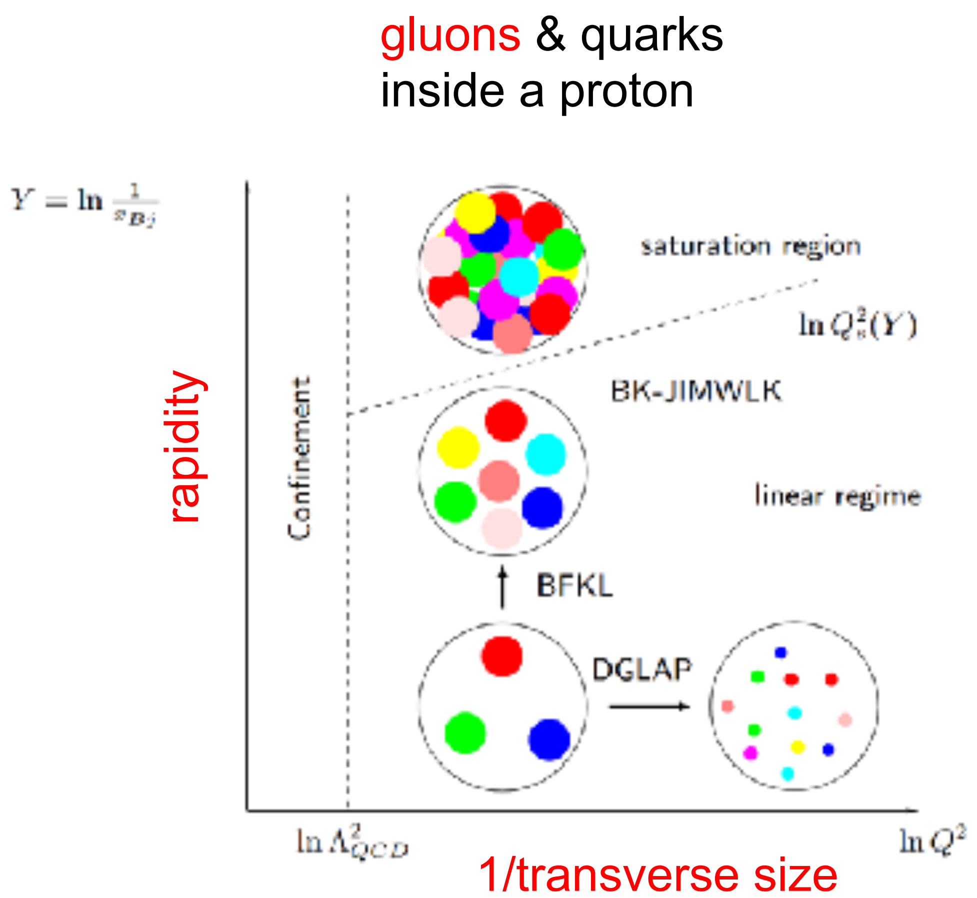
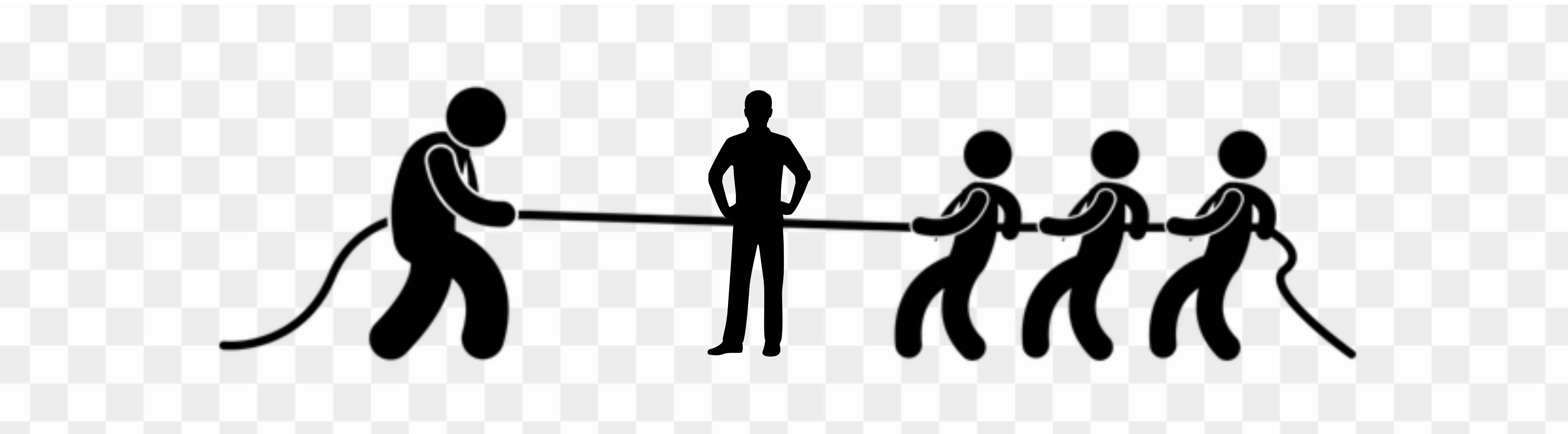


- QCD group attempts to better understand the consequence of the Standard Model strong dynamics in various systems
- Many conceptual and quantitative problems remains to be solved
- Examples of problems tackled in IJClab include quarkonium production, (generalized) parton distribution functions for nucleons and nuclei, Distribution Amplitudesfor light and heavy mesons, small x physics and gluonic saturation , non-perturbative power corrections

Conclusions



SM Flavor BSM