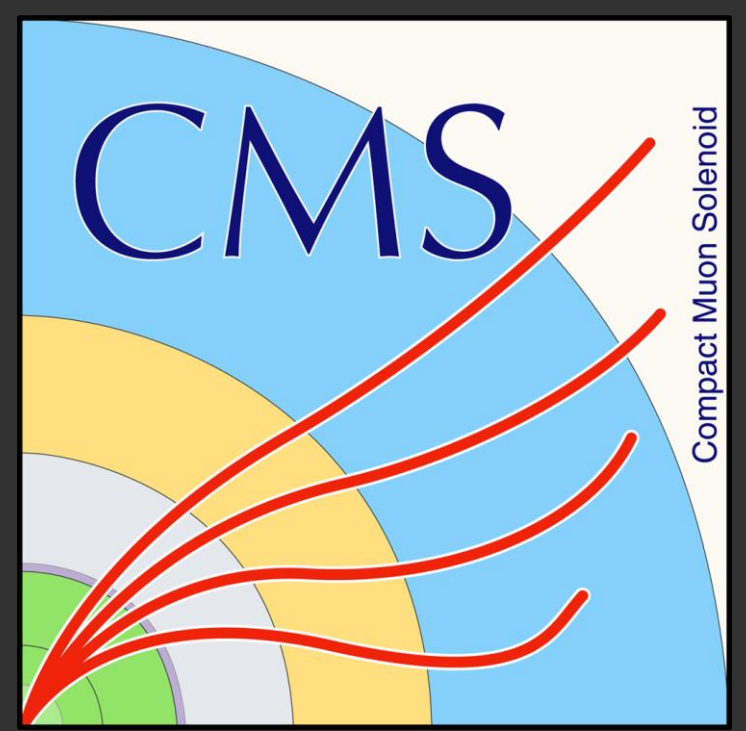
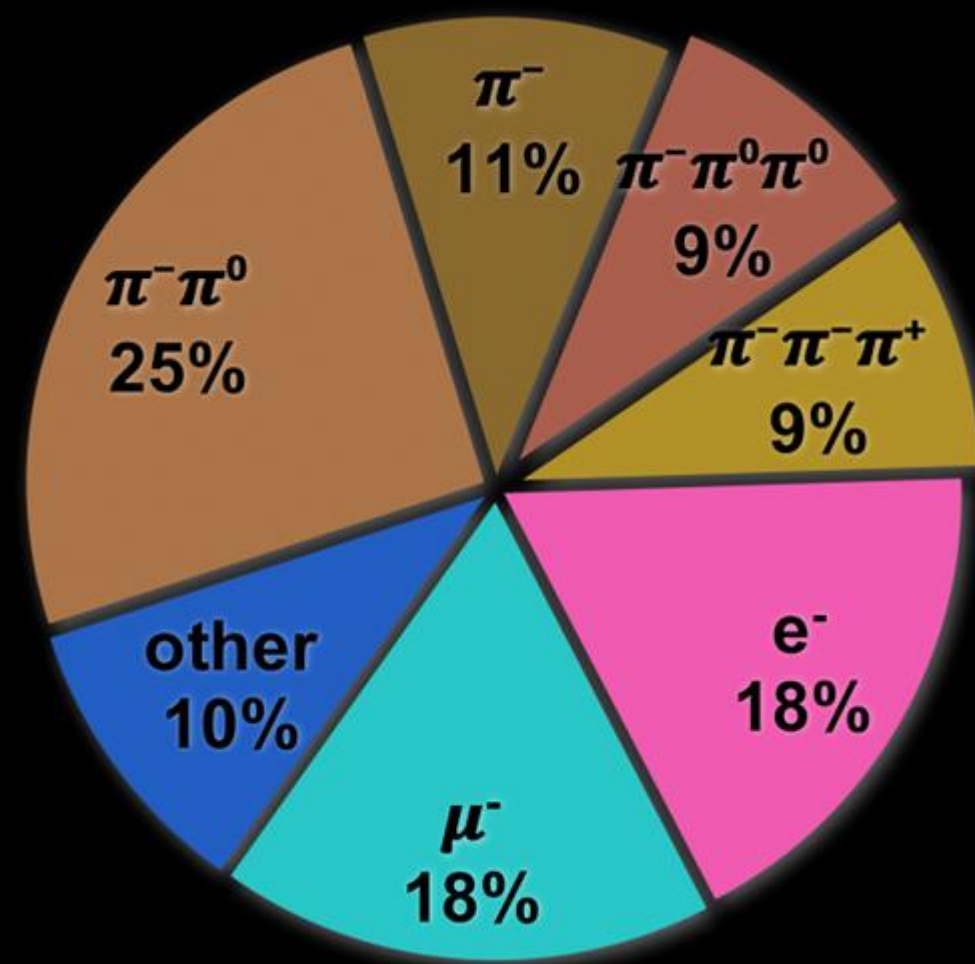
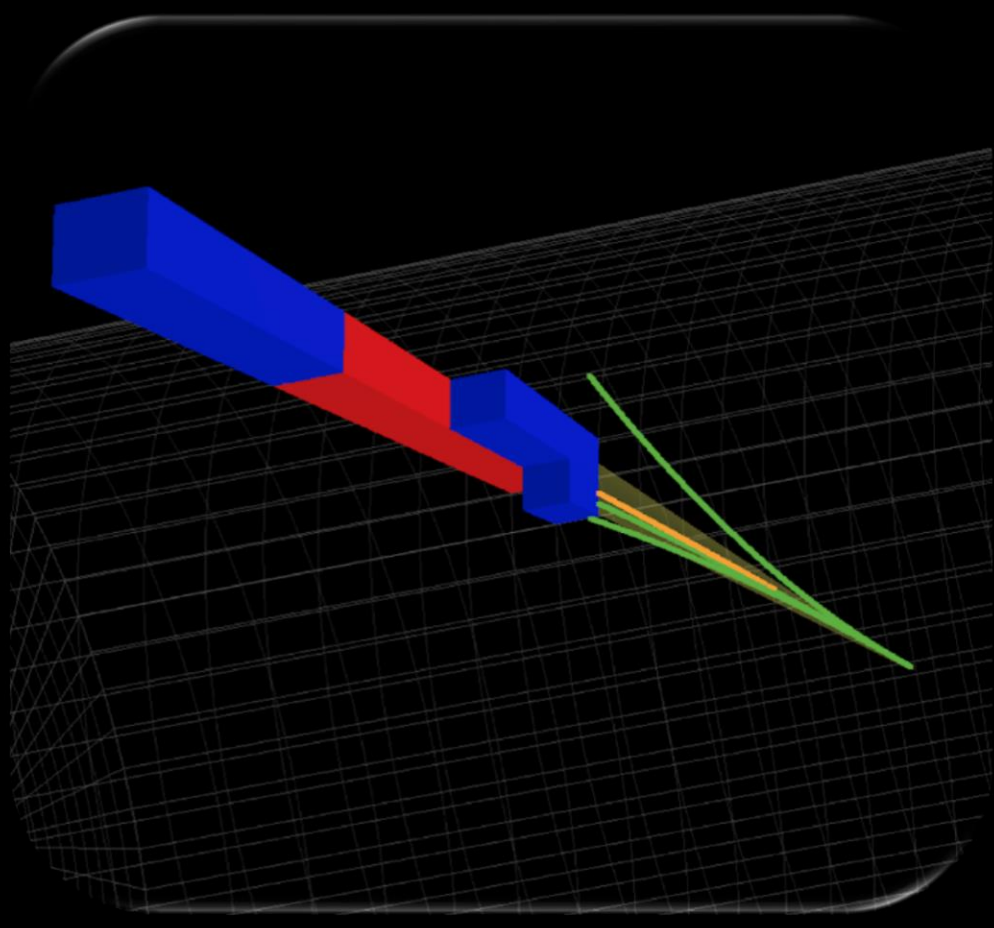




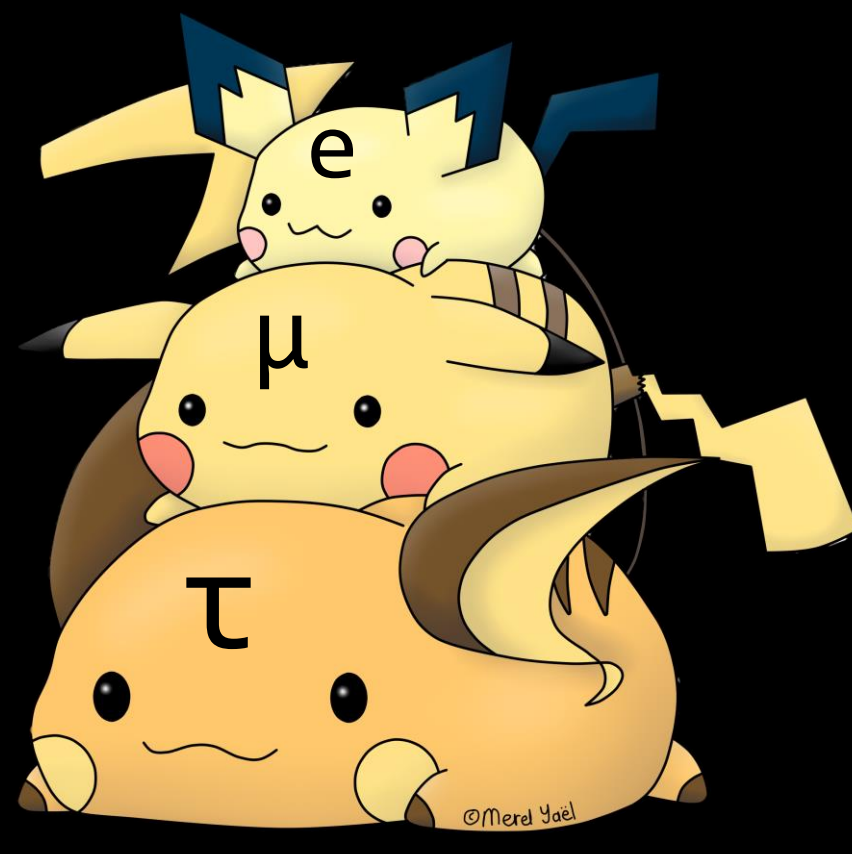
τ to Unlock Universe Mysteries with the CMS Experiment



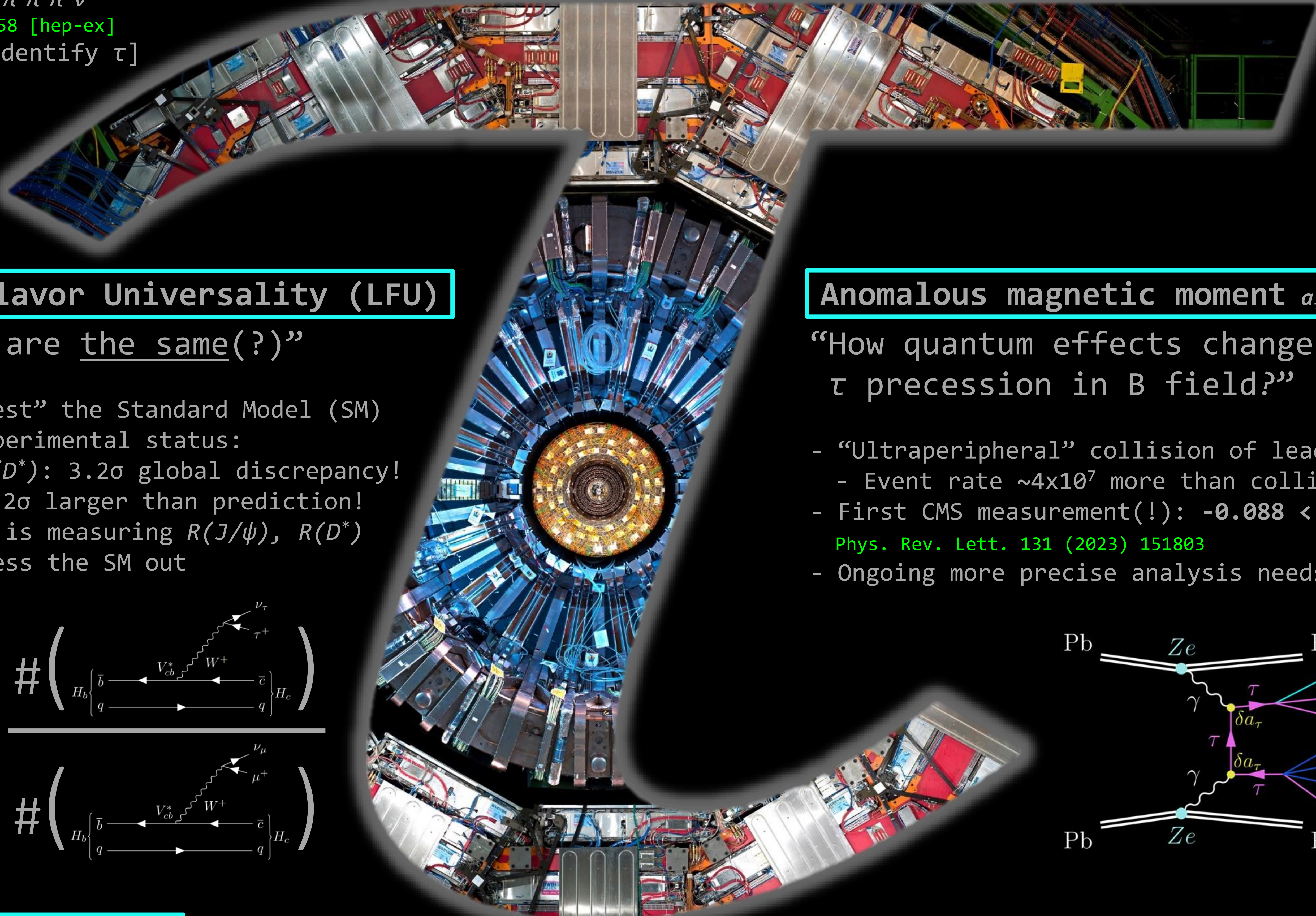
Prof_Ben_Kilminster_group@CMS_experiment:~/phys/open_day/2023



Tau Lepton (τ) Fact Sheet:
Heavier (~3500x) version of the electron
The **only** lepton that can decay hadronically
Heavy particles are affected more by New Physics (NP)



e.g. $\tau^- \rightarrow \pi^- \pi^+ \pi^0 \nu$
[arXiv:2201.08458 \[hep-ex\]](https://arxiv.org/abs/2201.08458)
[Use of ML: identify τ]



Lepton Flavor Universality (LFU)

“e, μ, τ are the same(?)”

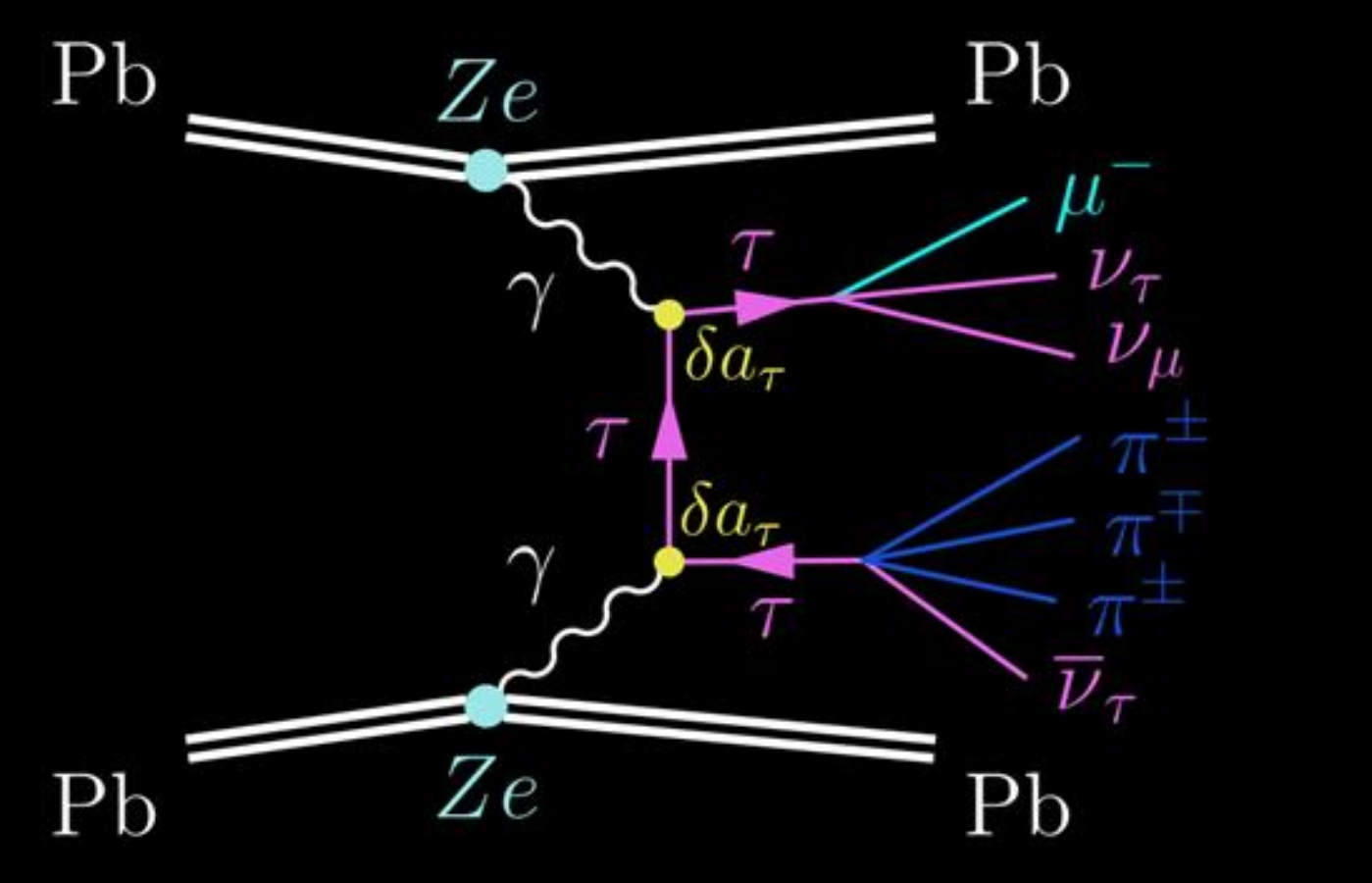
- “Stress test” the Standard Model (SM)
- Global experimental status:
 - $R(D), R(D^*)$: 3.2σ global discrepancy!
 - $R(J/\psi)$: 2σ larger than prediction!
- CMS group is measuring $R(J/\psi), R(D^*)$
- LET’S stress the SM out

$$R(H_c) \equiv \frac{\# \left(\begin{array}{c} \nu_\tau \\ \tau^+ \\ \tau^- \\ \nu_\tau \end{array} \right)}{\# \left(\begin{array}{c} \nu_\mu \\ \mu^+ \\ \mu^- \\ \nu_\mu \end{array} \right)}$$

Anomalous magnetic moment $a_\tau = (g-2)/2$

“How quantum effects change τ precession in B field?”

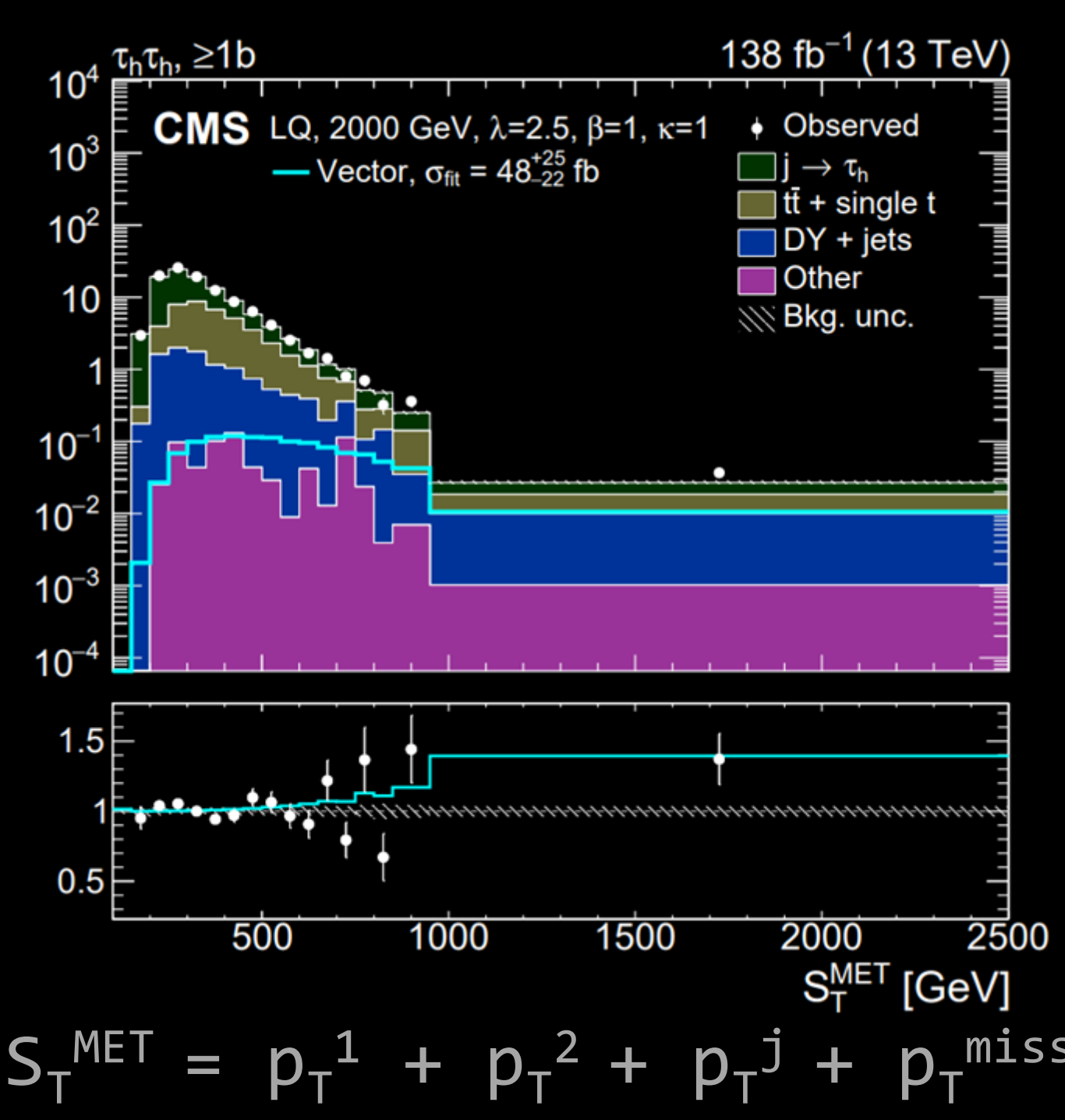
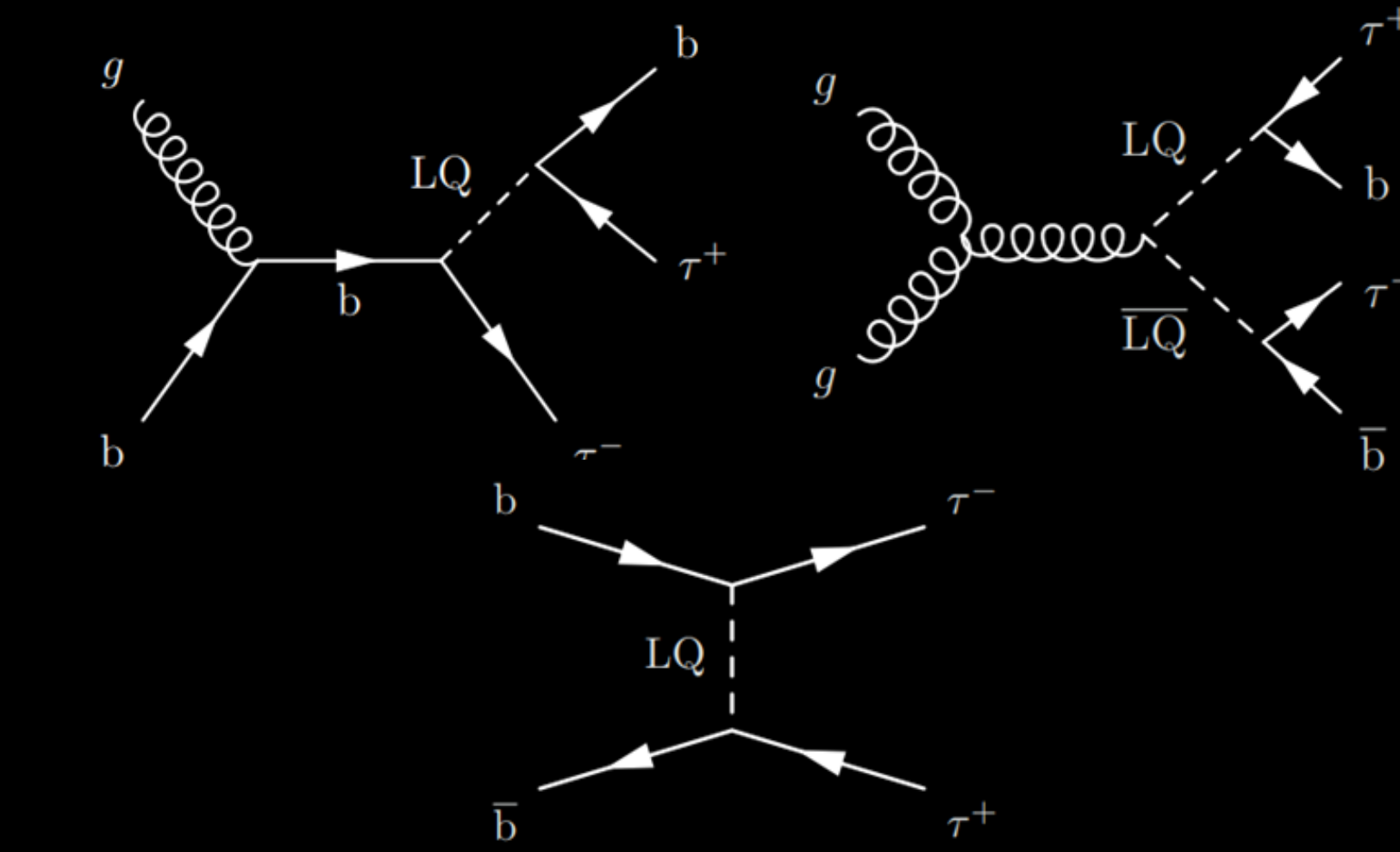
- “Ultraperipheral” collision of lead nuclei
- Event rate $\sim 4 \times 10^7$ more than colliding pp
- First CMS measurement(!): $-0.088 < a_\tau < 0.056$
[Phys. Rev. Lett. 131 \(2023\) 151803](https://arxiv.org/abs/2203.15180)
- Ongoing more precise analysis needs YOU!



Leptoquarks (LQs)

“Hypothetical particles that unify all matters.”

- ~1TeV LQs can explain $R(D), a_\mu$ anomalies
[=> possible to probe in the LHC!]
- Could interact with **Dark Matter**!?
- CMS group found 2.8σ excess!
[arXiv:2308.07826 \[hep-ex\]](https://arxiv.org/abs/2308.07826)
- WE can find what is there!

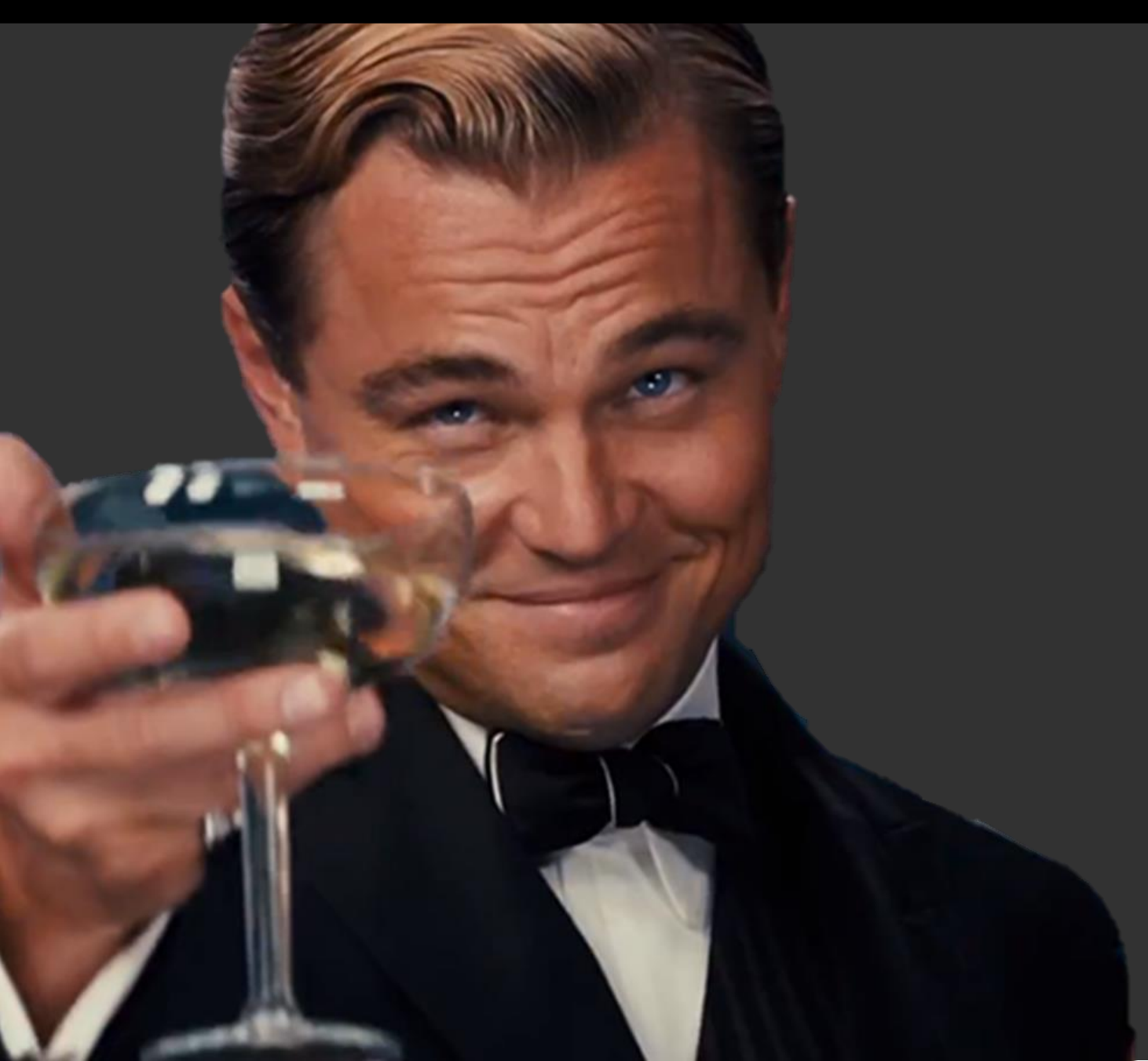
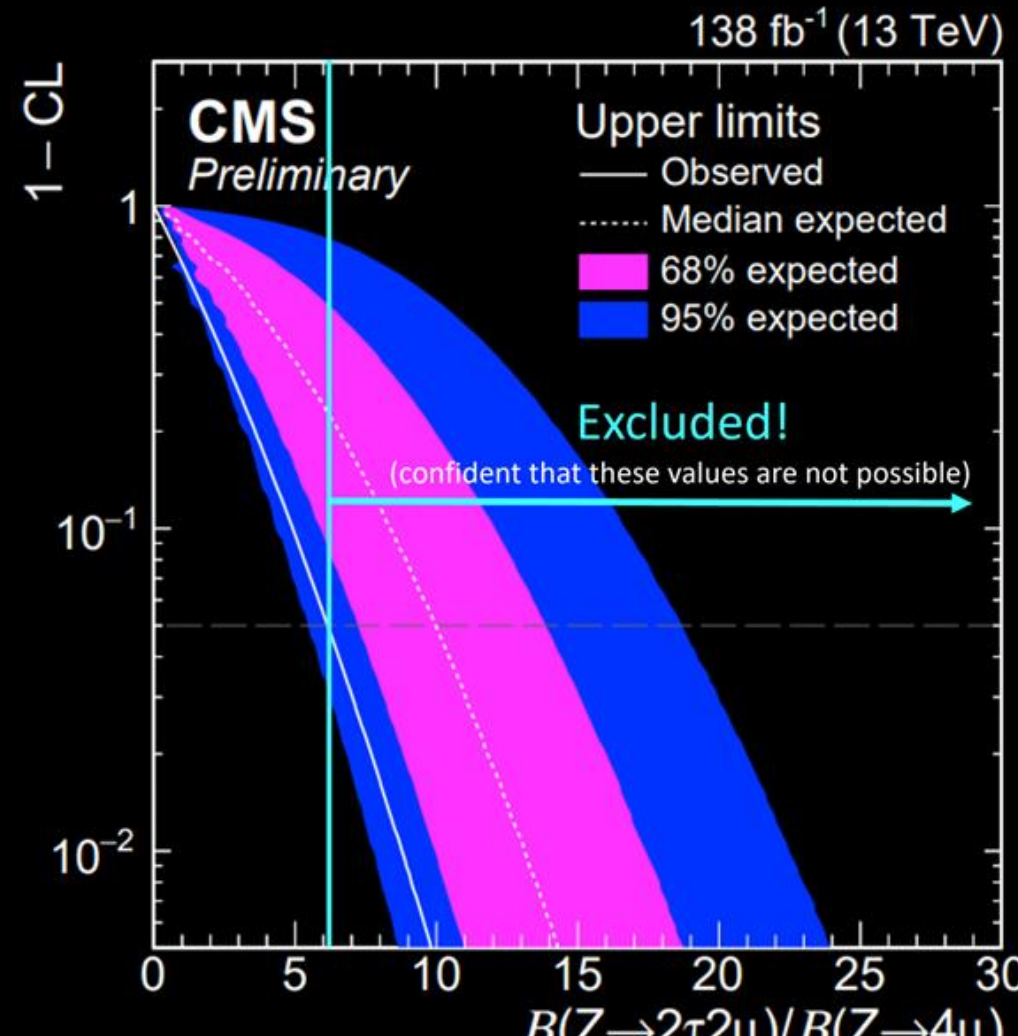
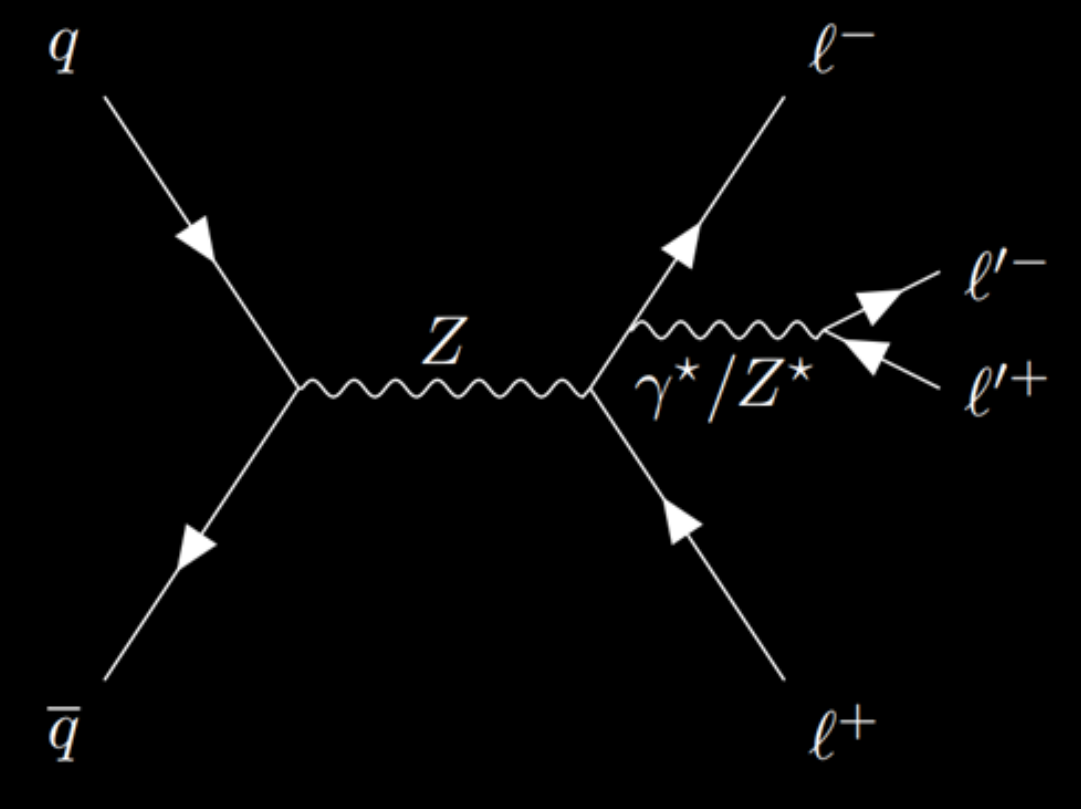


$$S_T^{MET} = p_T^1 + p_T^2 + p_T^j + p_T^{miss}$$

Searching NP in rare process

“NP can change the event rate!”

- 1 $Z \rightarrow \tau\tau\mu\mu$ in $\sim 10^5$ Z decays
- Info. of new force(s)
- Completely untested region in the SM
[CMS-PAS-SMP-22-016](https://arxiv.org/abs/2203.016)
- Taste Test it TOGETHER!



Want to have champagne together? 🍷

Join us in unraveling the mysteries of the universe!
Collaborate with CERN and worldwide physicists!

- You will have opportunity to:
- Study the SM, and Beyond the SM (BSM) physics
 - Program in python, C++, ROOT, ...
 - Apply/Develop advanced analysis tools (e.g. deep learning)
 - Discuss, present, document & publish results

Contact Prof. Ben Kilminster at ben.kilminster@physik.uzh.ch

