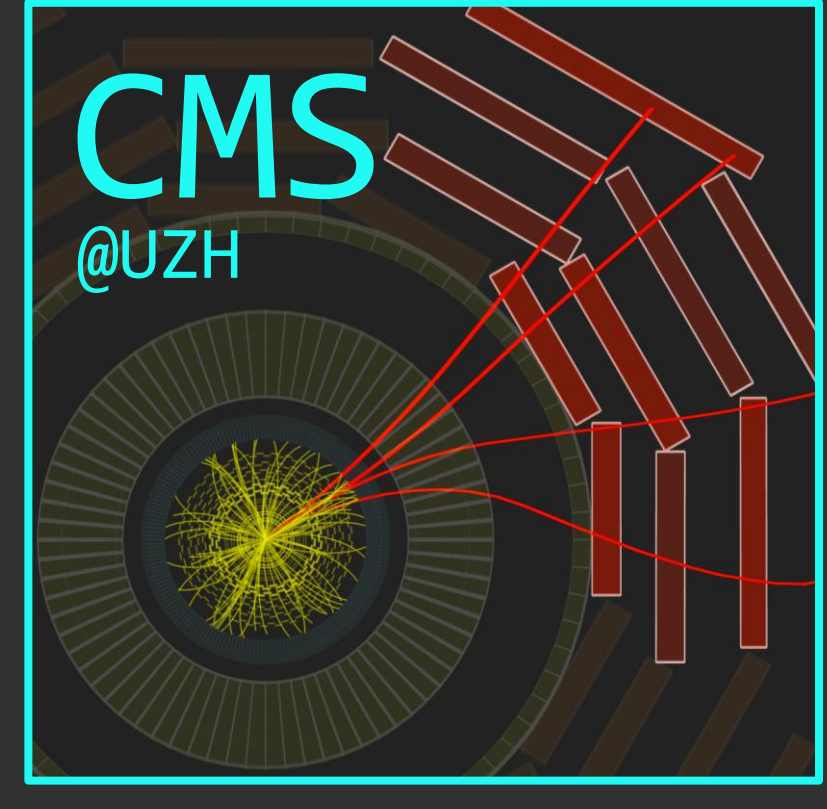
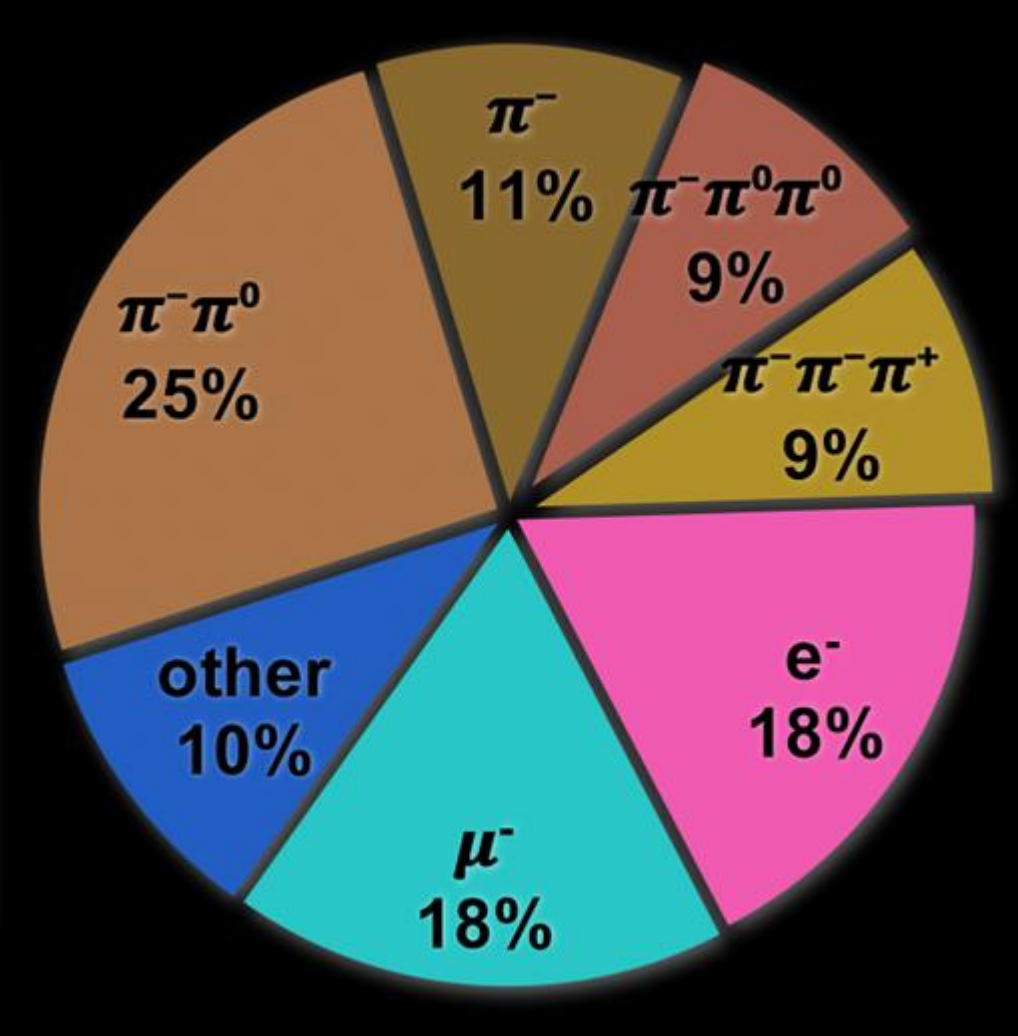
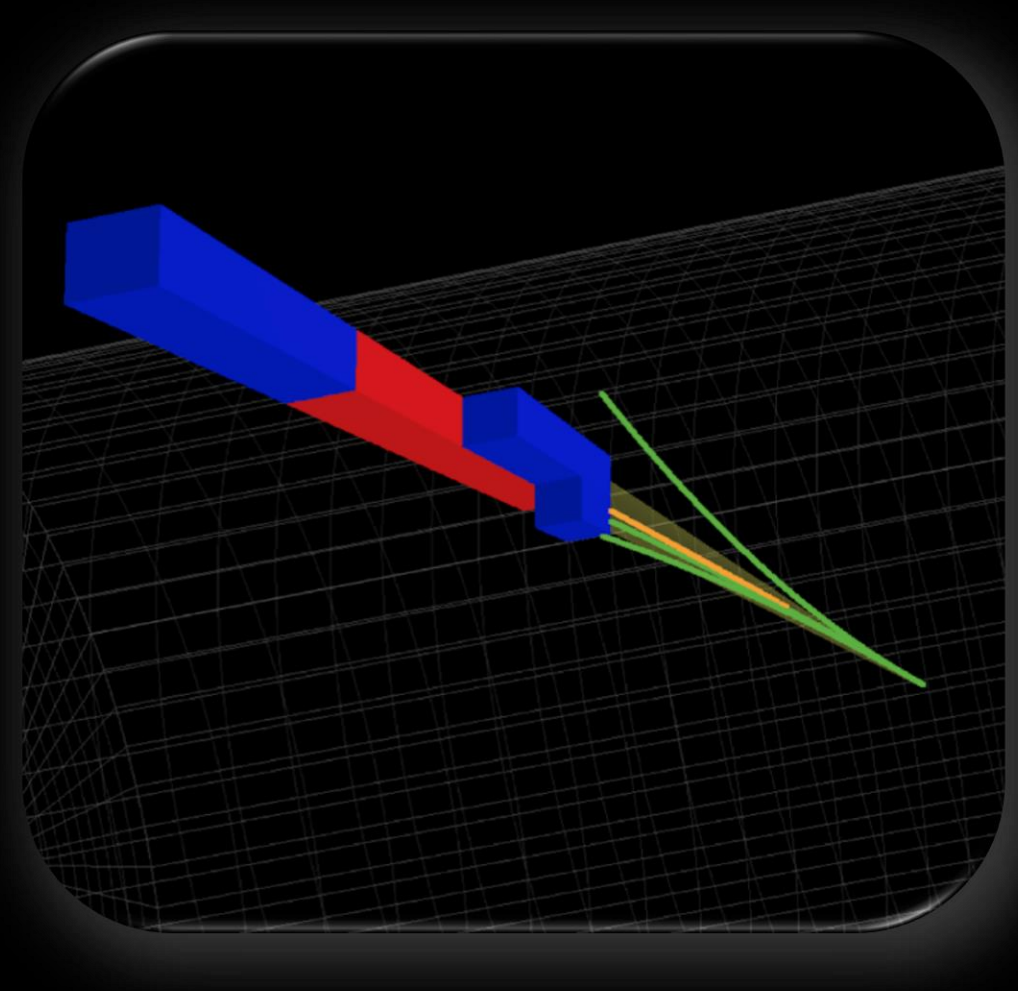




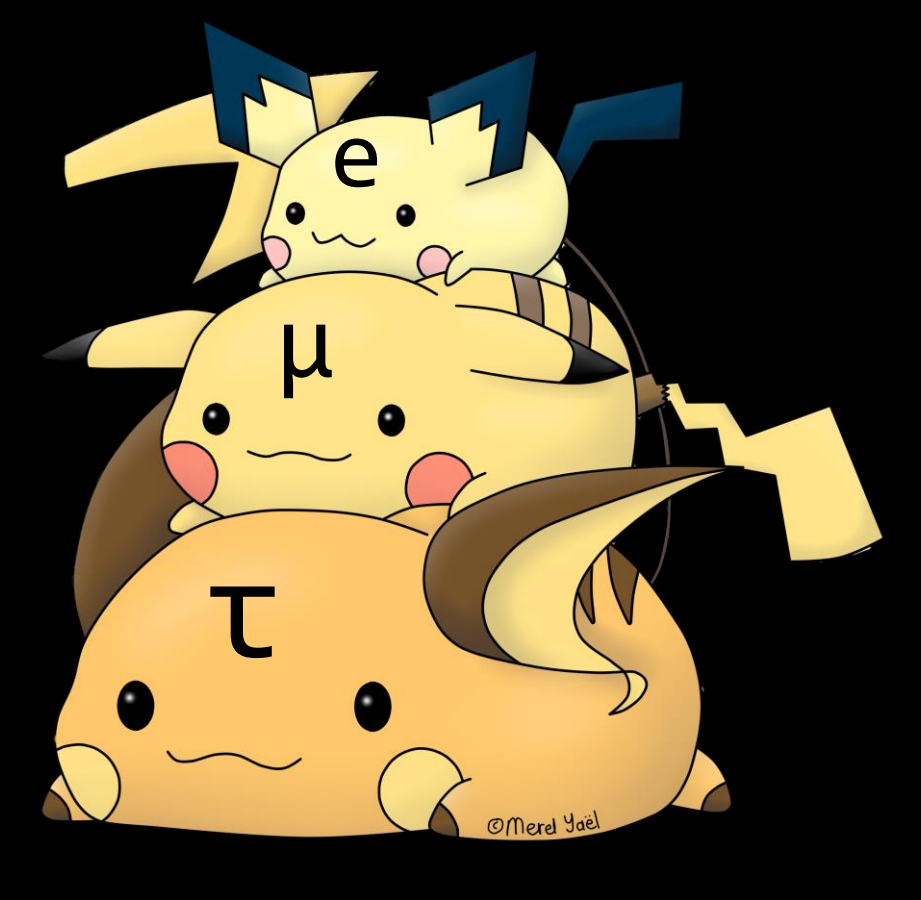
τ to Unlock Universe Mysteries with the CMS Experiment



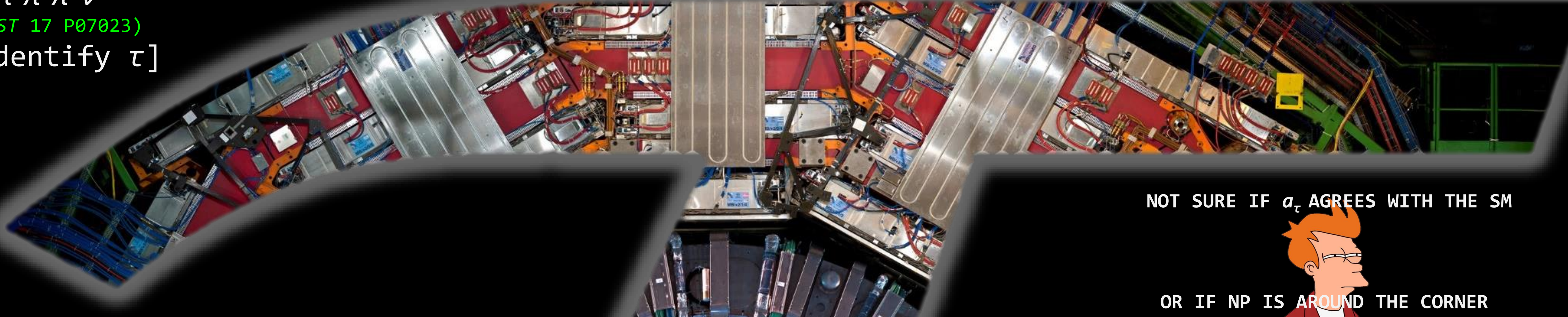
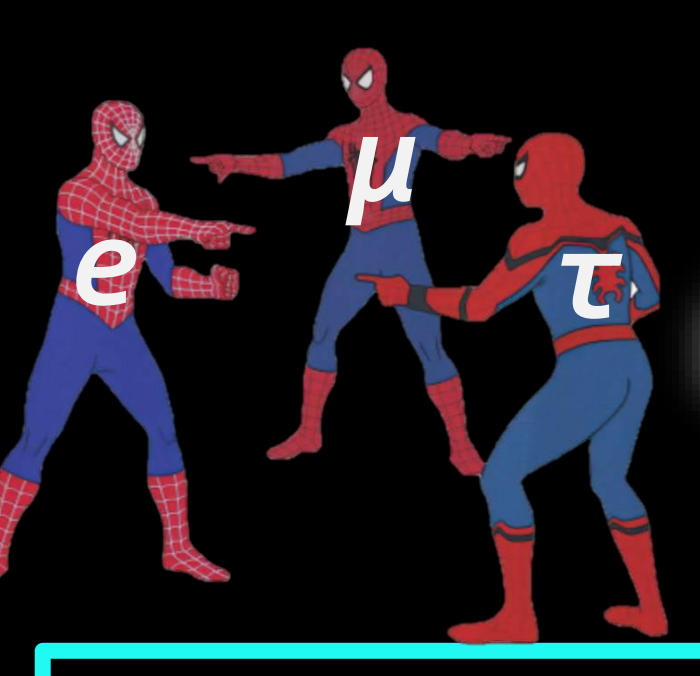
Prof_Ben_Kilminster_group@CMS_experiment:~/phys/open_day/2024



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. $\tau^- \rightarrow \pi^- \pi^+ \pi^0 \nu$
(Published in: JINST 17 P07023)
[Use of ML: identify τ]



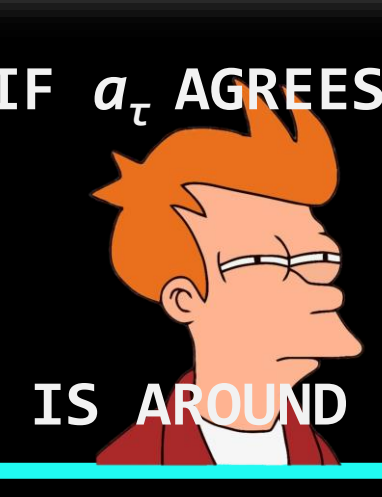
Lepton Flavor Universality (LFU)

- (Published in: CMS-PAS-BPH-23-001)
- “e, μ , τ are the same(?)”
- “Stress test” the Standard Model (SM)
 - Global experimental status:
 - $R(D)$, $R(D^*)$: 3.2 σ global discrepancy!
 - $R(J/\psi)$: CMS measured $0.49 \pm 0.25 \pm 0.09$
 - CMS group is measuring $R(J/\psi)$, $R(D^*)$
 - Let's stress the SM out!!!

$$R(H_c) \equiv \frac{\# \left(H_b \left\{ \begin{array}{c} \bar{b} \xrightarrow{V_{cb}^*} W^+ \xrightarrow{V_{cq}} c \\ q \end{array} \right\} H_c \right)}{\# \left(H_b \left\{ \begin{array}{c} \bar{b} \xrightarrow{V_{cb}^*} W^+ \xrightarrow{V_{cq}} \mu^+ \\ q \end{array} \right\} H_c \right)}$$

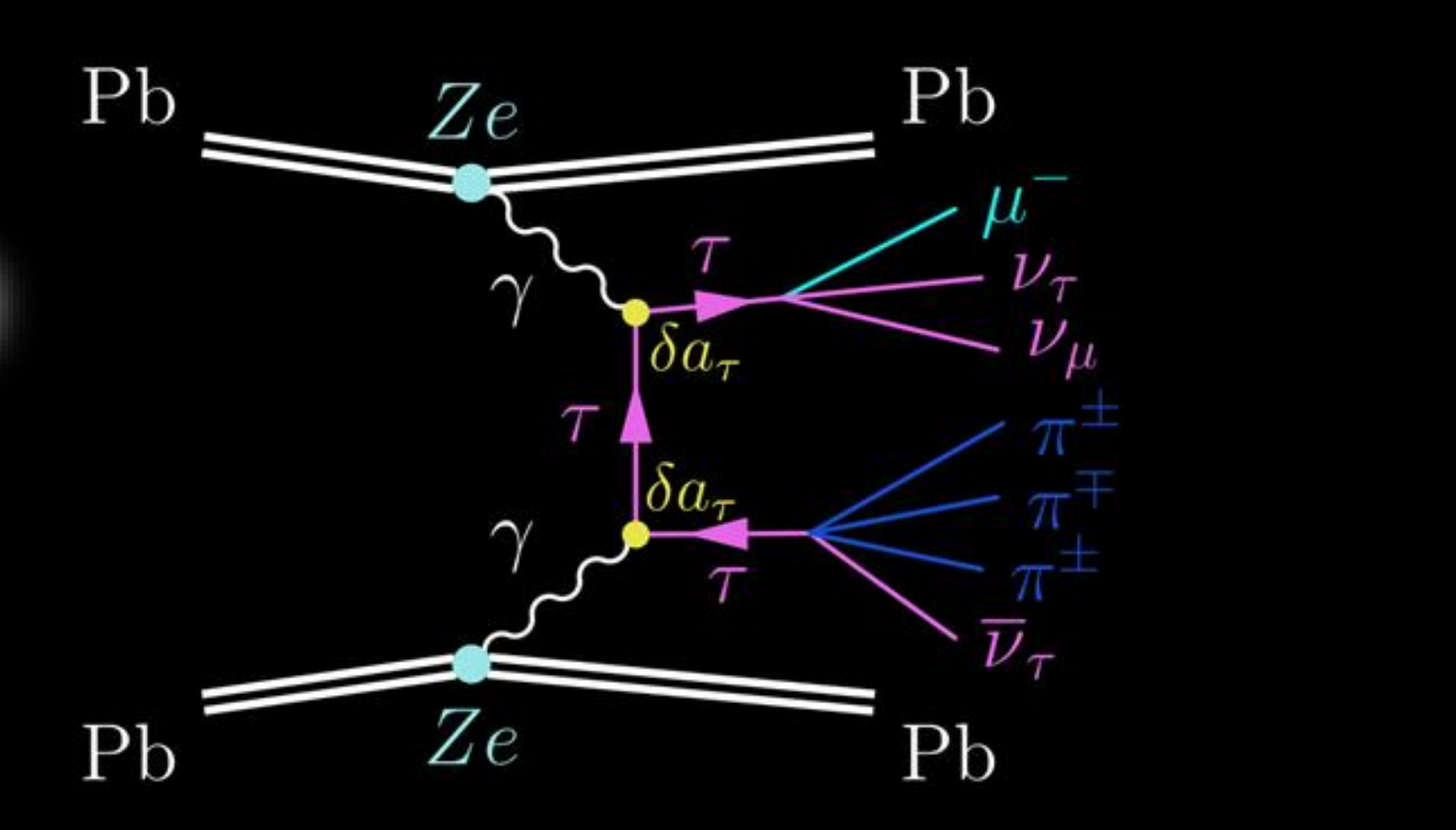
Anomalous magnetic moment $a_\tau = (g-2)/2$

- (Published in: Phys. Rev. Lett. 131, 151803, CMS-PAS-HIN-24-011)
- “How quantum effects change τ precession in EM field?”
- $a_\tau = a_\tau^{SM} + a_\tau^{NP}$: If $a_\tau \neq a_\tau^{SM} \Rightarrow$ potential NP!!!
 - “Ultraperipheral” collision of lead nuclei
 - Event rate $\sim 4 \times 10^7$ more than colliding pp
 - One of the 1st CMS measurements!
 - Combined 4 channels: $-0.045 < a_\tau < -0.017$
 - Ongoing more precise analysis needs you!!!



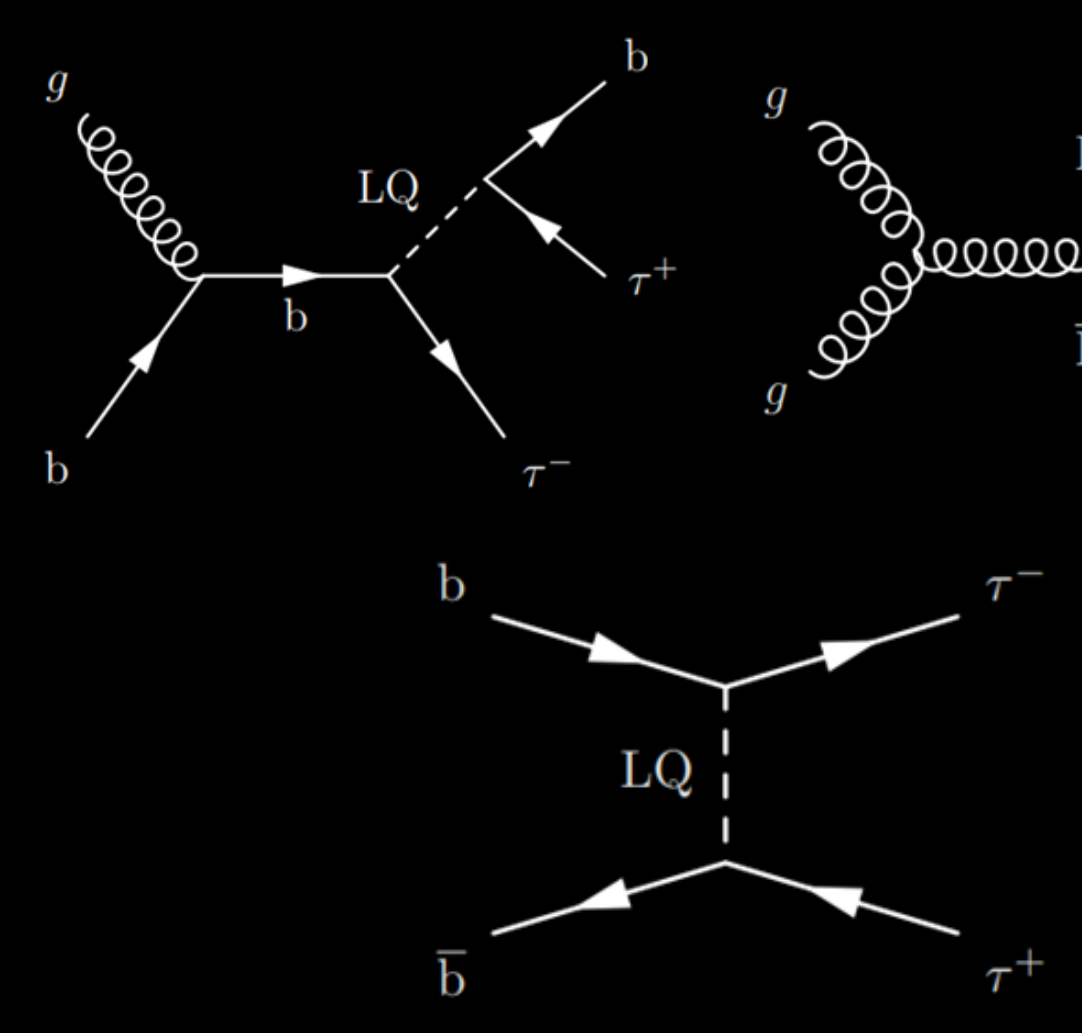
NOT SURE IF a_τ AGREES WITH THE SM

OR IF NP IS AROUND THE CORNER

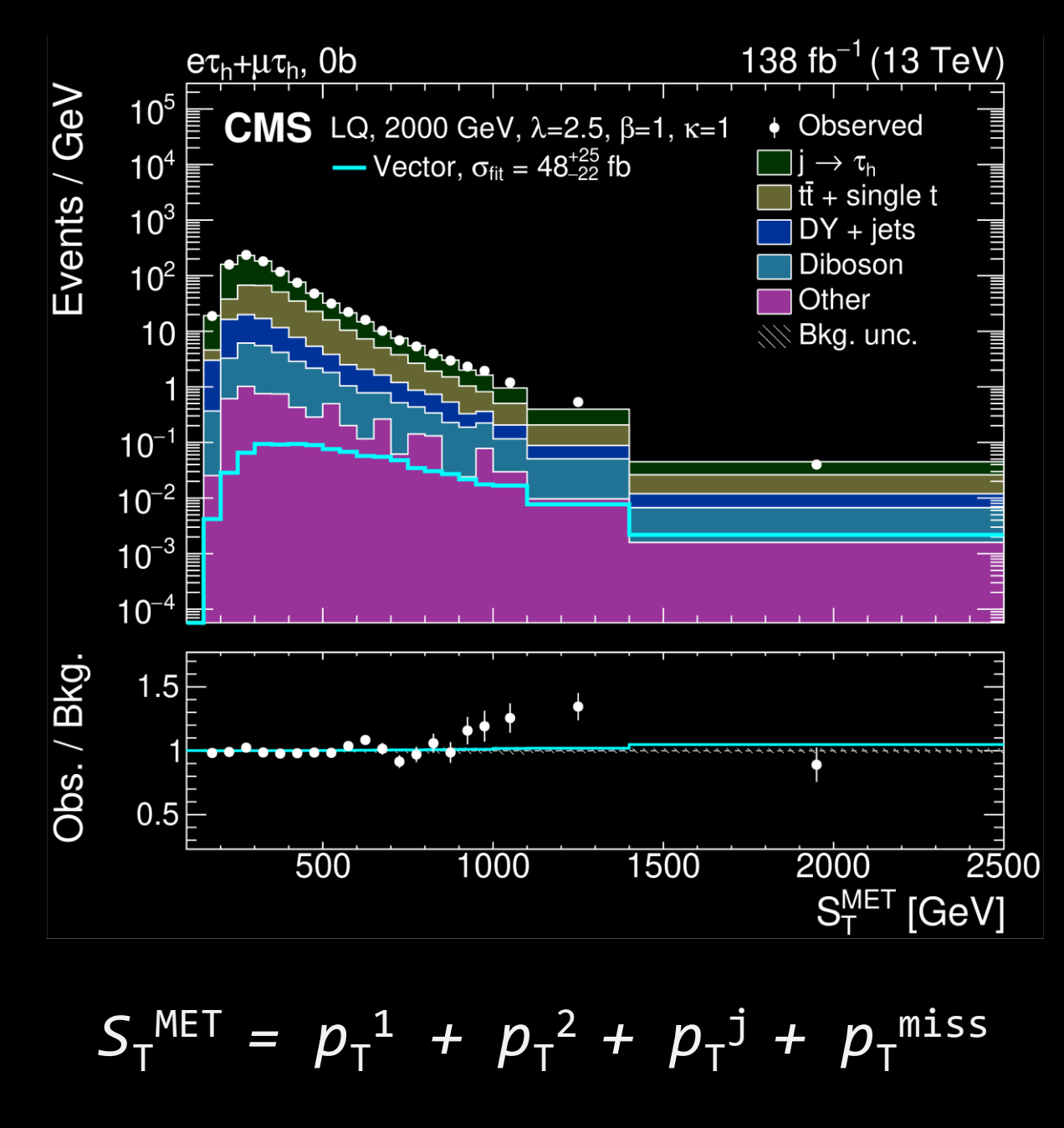


Leptoquarks (LQs)

- (Published in: JHEP 05 311)
- “Hypothetical particles that unify all matters.”
- ~1TeV LQs can explain $R(D)$, a_μ anomalies [=] possible to probe in the LHC!]
 - Could interact with Dark Matter!?
 - CMS group found 2.8 σ excess!
 - We can find what is there together!!!



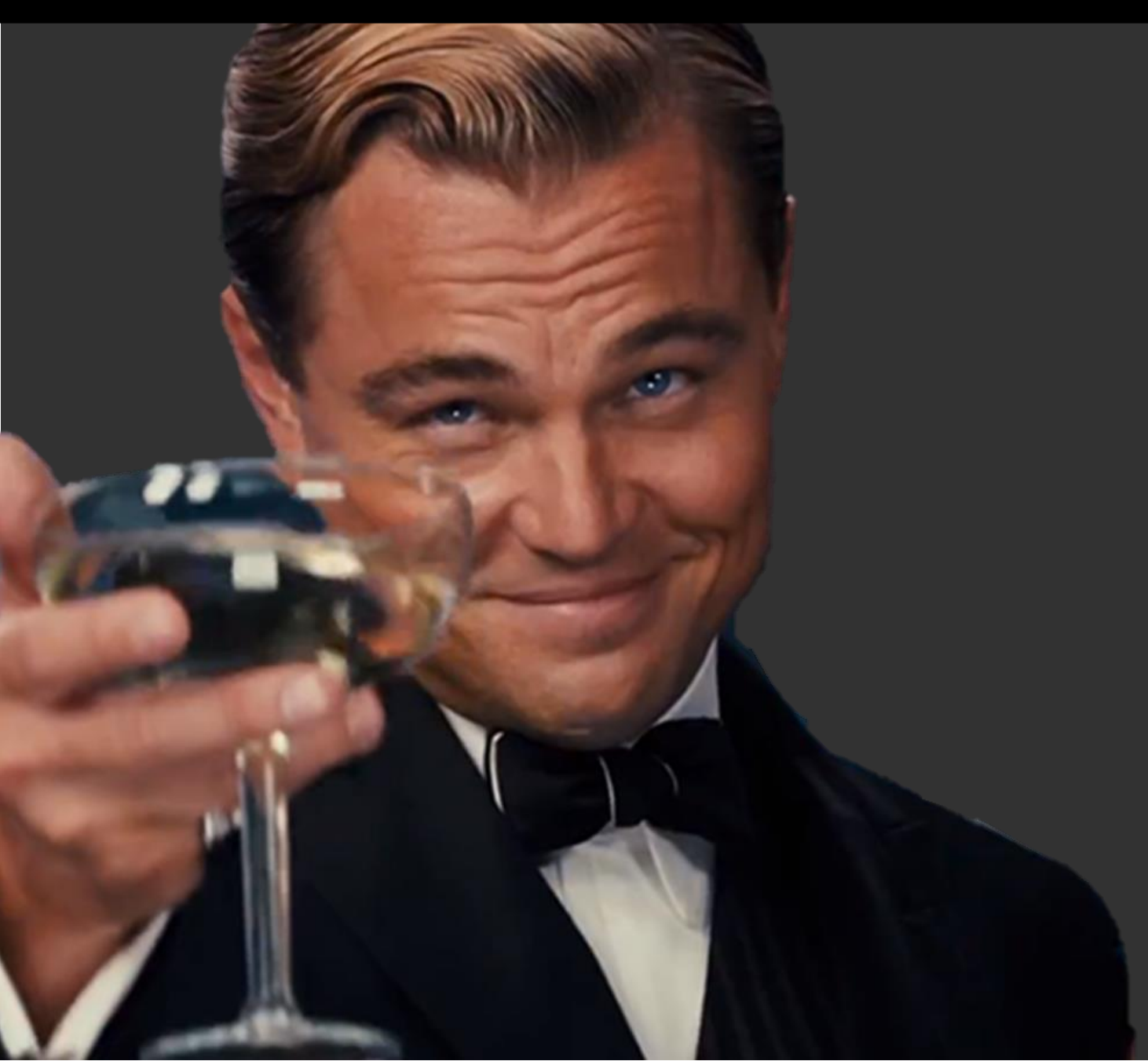
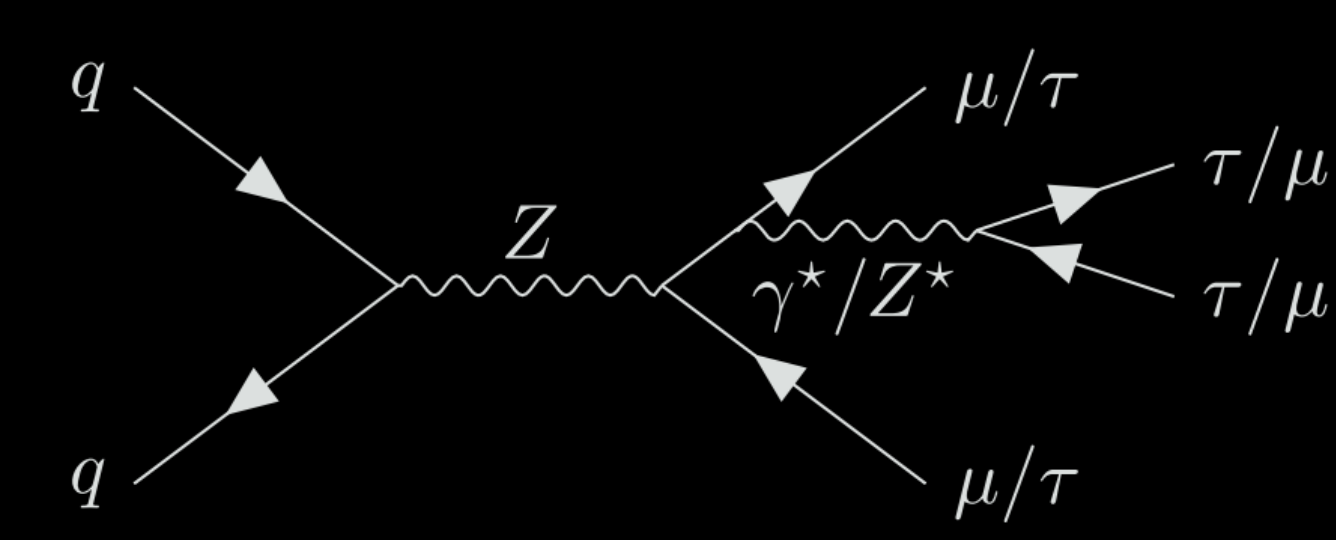
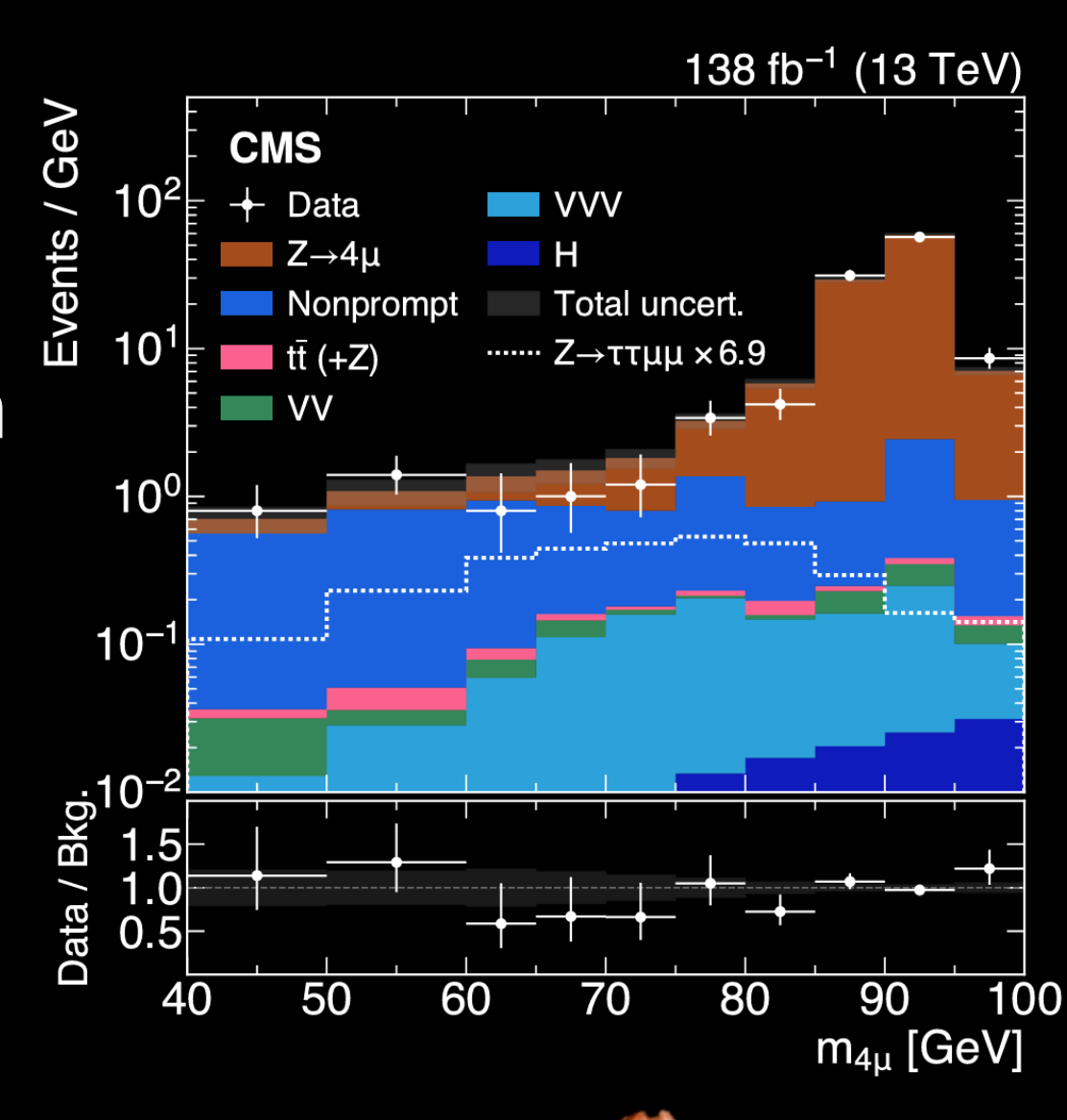
YOU GET A SOLUTION
EVERYONE GETS A SOLUTION



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

Searching NP in rare process

- (Published in: Phys. Rev. Lett. 133, 161805)
- “NP can change the event rate!”
- The 1st LHC search!
 - 1 $Z \rightarrow \tau\tau\mu\mu$ in $\sim 10^5$ Z decays
 - Measured $< 6.9 \times$ prediction [Agrees with the SM]
 - Info. of new force(s)
 - First EFT constraints on untested SM region
 - 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

