

Flavor Taskforce Report

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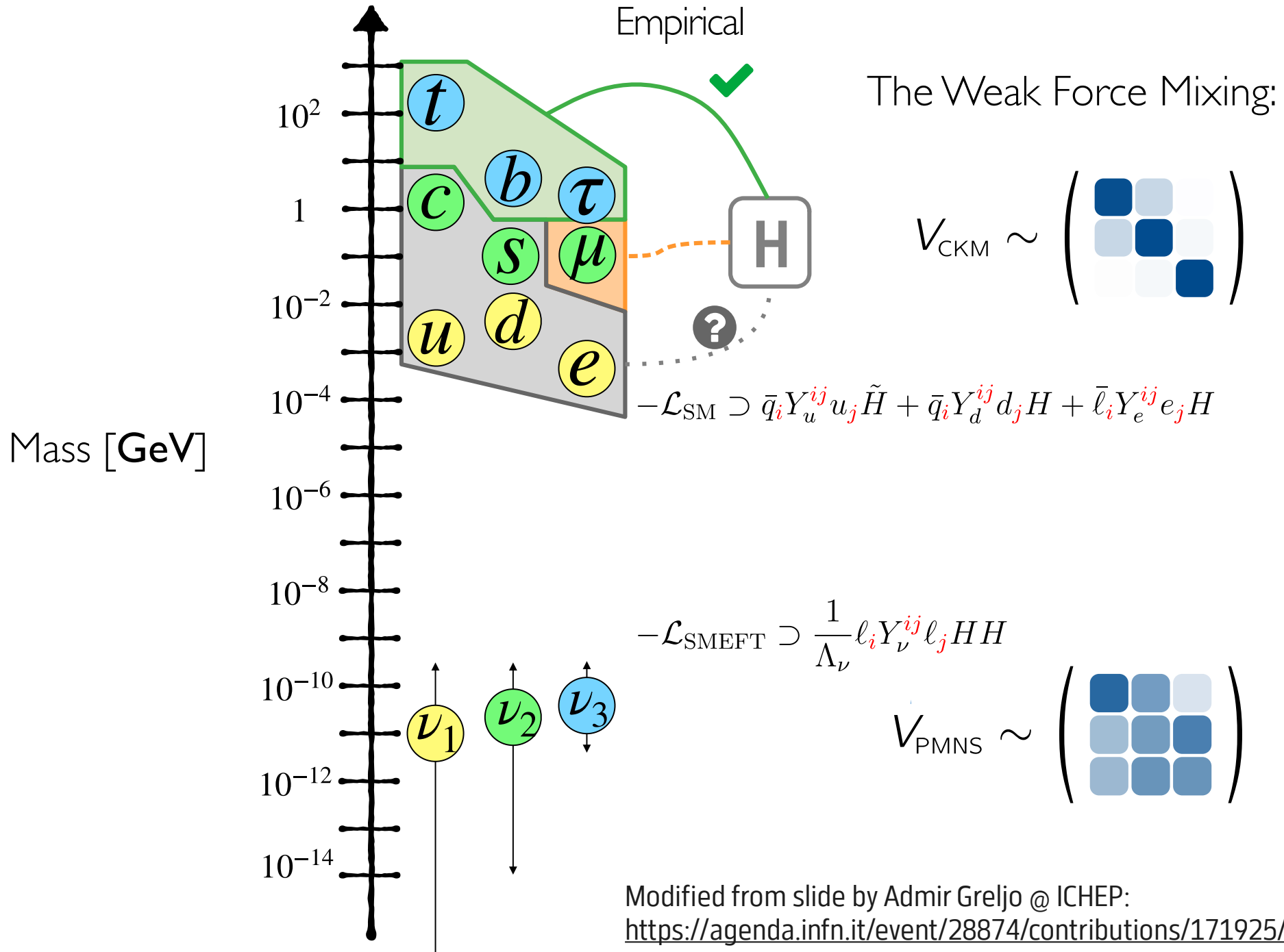
Retreat #2
14 December 2022



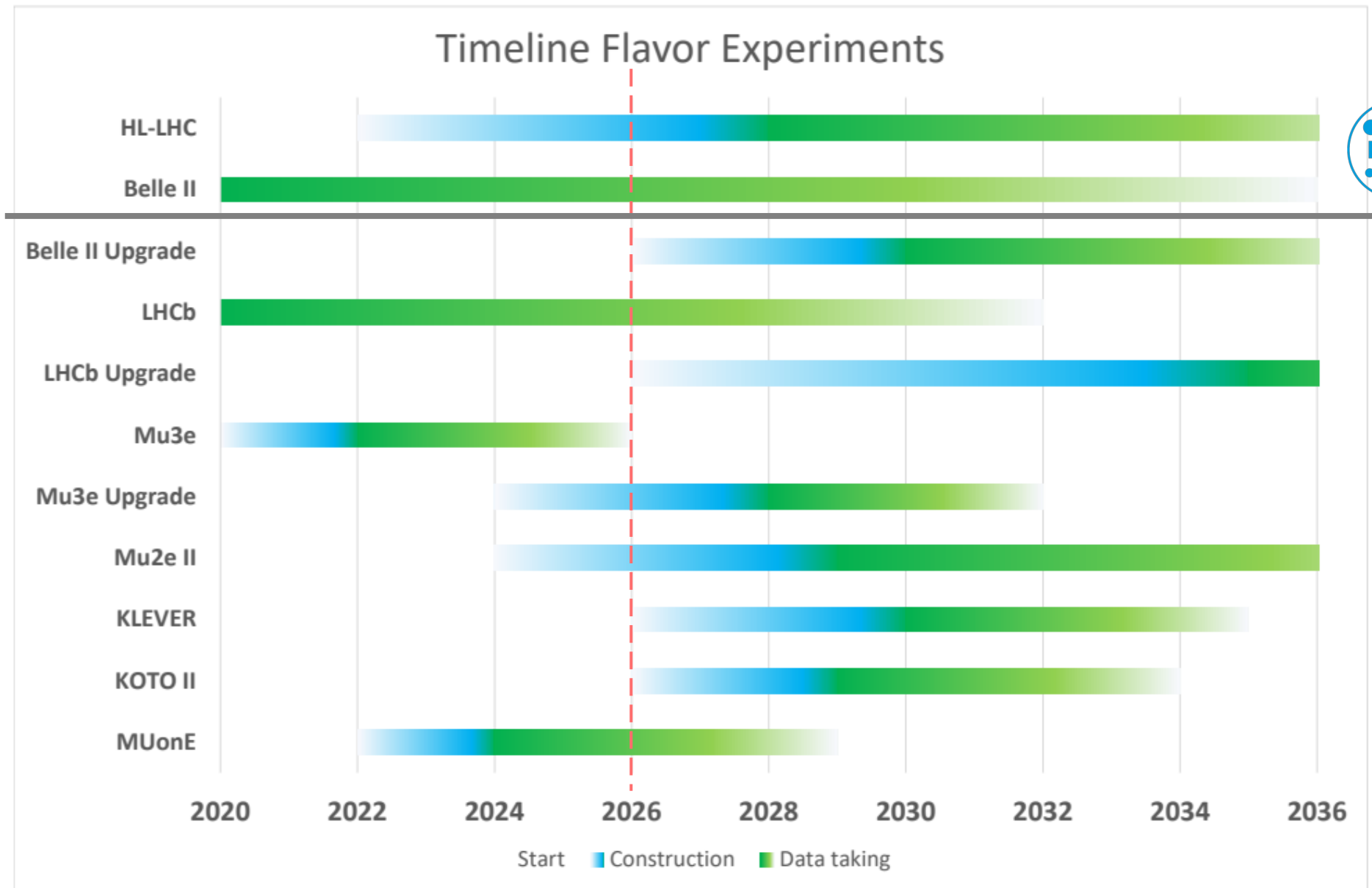
Mandate: opportunities in flavor physics

- DESY contributions in 2026+? Including:
 - Belle II $\oplus$ High-lumi LHC (HL-LHC)
 - LHCb?
 - New dedicated charm, tau, muon expt's
- Follow European strategy 2020 & snowmass 2021/22
- Primary consideration: **physics interest**
- View on DESY as hub for German participation

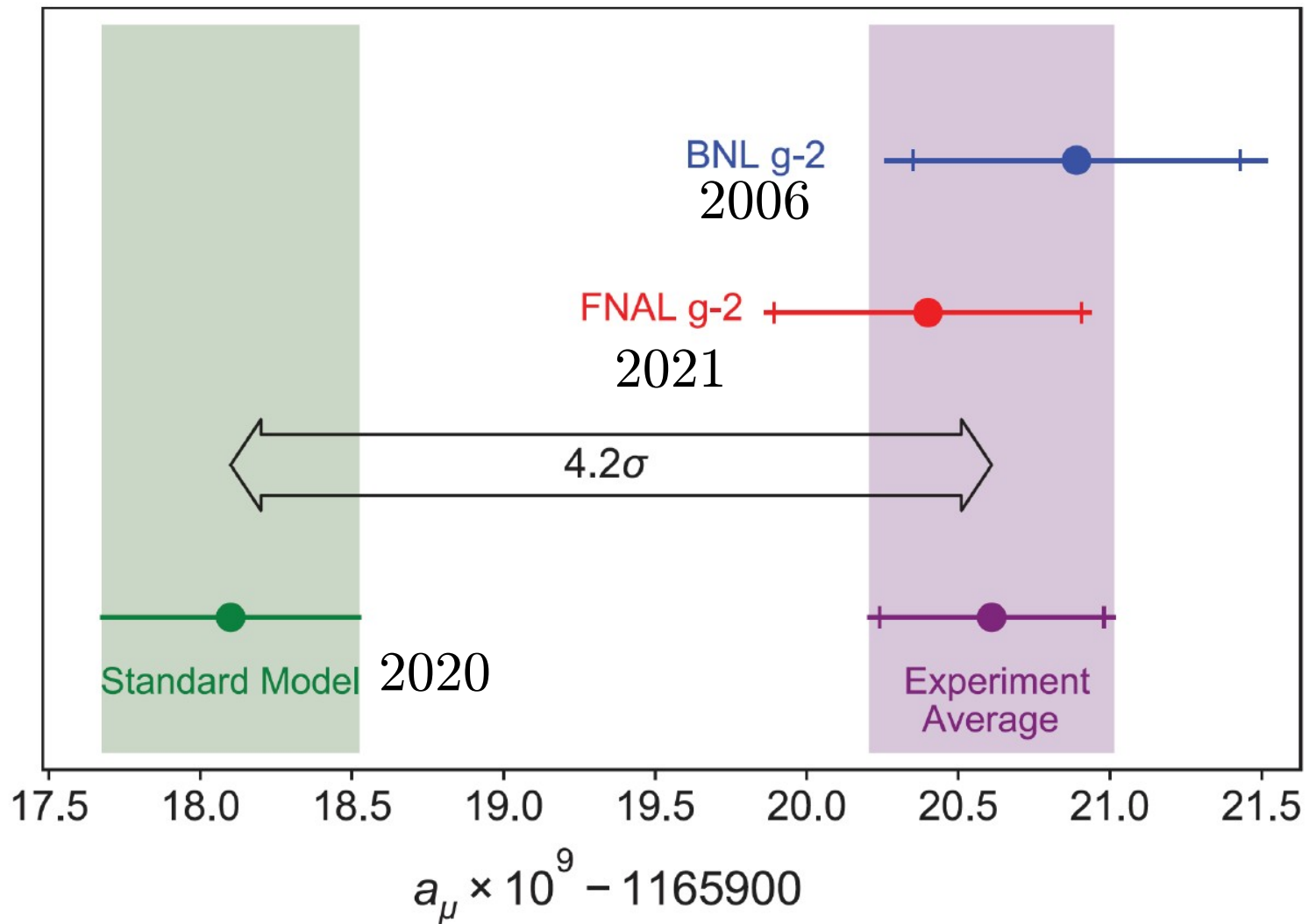
Flavour Puzzle



Timeline Flavor Experiments



Muon (g-2)



Theory

- ❓ Hadronic vacuum polarization (HVP)
- Updated lattice results: BMW, ETMC, & CLS/Mainz agree in “window” → if holds tension with SM reduced
- ❗ Lattice and dispersion relations $\sim 4.2\sigma$ tension

FNAL experiment

- Ultra-relativistic muons in a storage ring; precision: $0.46 \rightarrow \sim 0.1$ ppm

J-PARC experiment

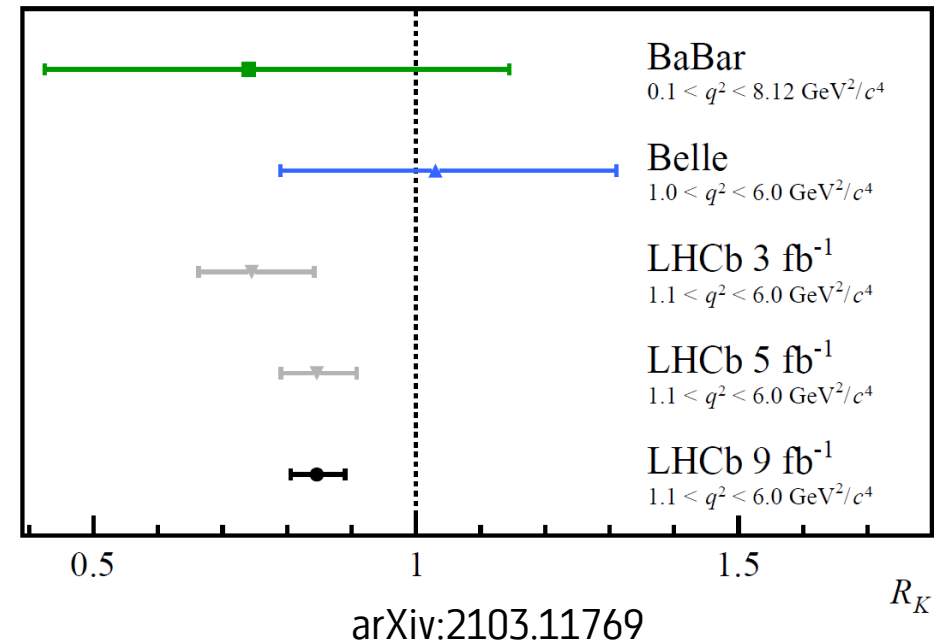
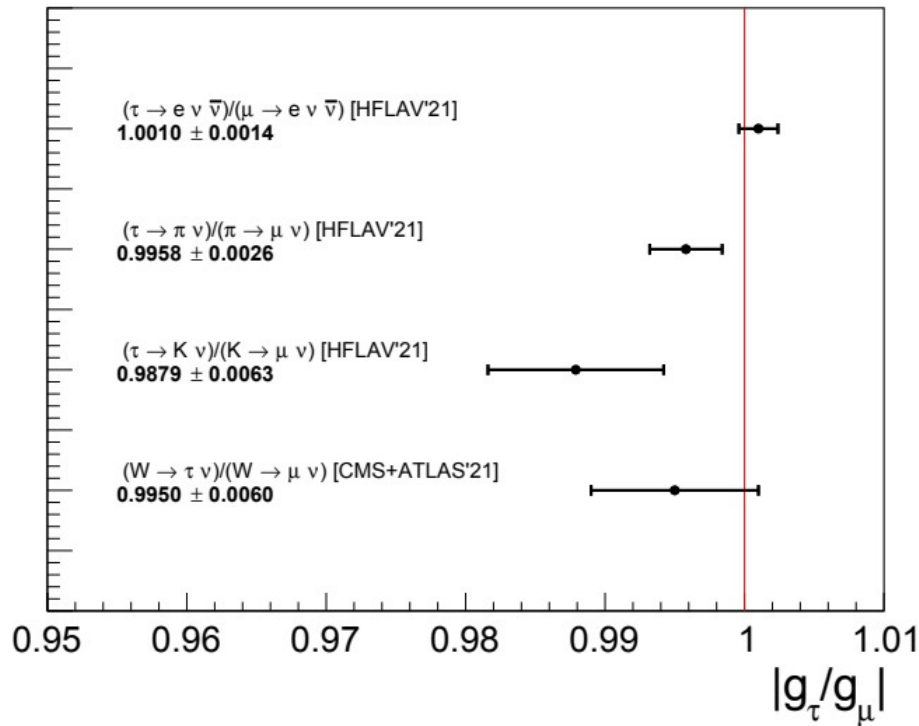
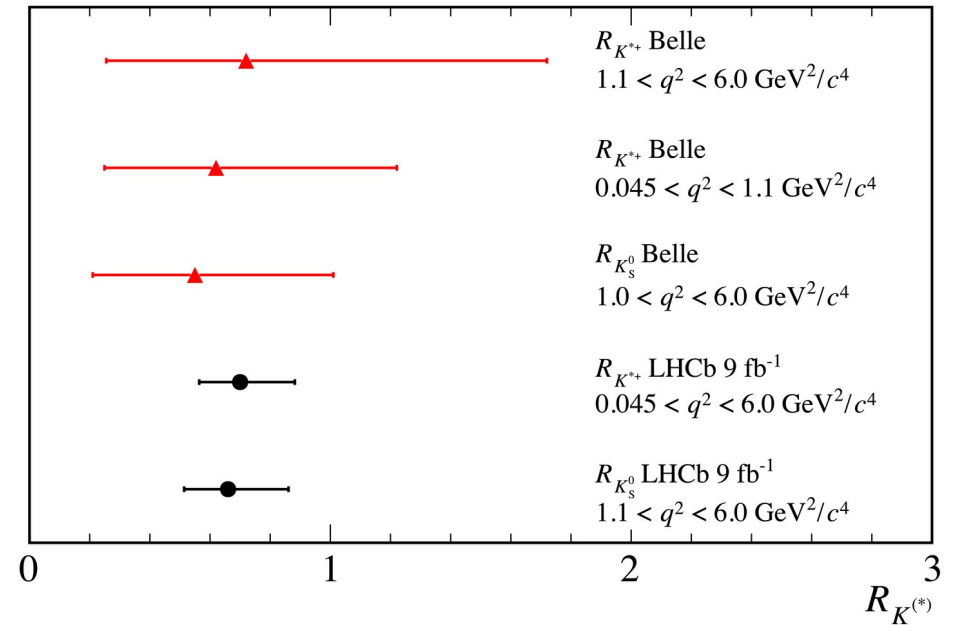
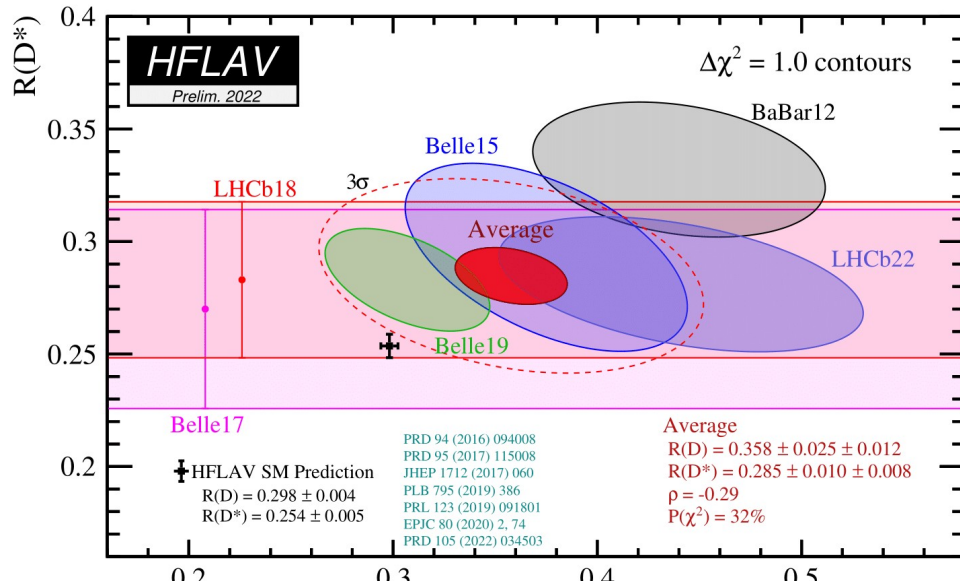
- Ultra-cold/ultra-focused muons helically injected into magnetic storage ring (no E field); precision: $\rightarrow \sim 0.1$ ppm

MUonE experiment

- Independent and precise determination of HVP contribution

LFU Violation

arXiv:2110.09501



arXiv:2103.11769

Charged decays: $b \rightarrow c\ell\nu$

- BABAR, Belle, and LHCb show $\sim 3.1\sigma$ tension with SM
- LHCb: new result with $R(D)$!
- final will have to include Belle II $\oplus$ LHCb
- CMS will also contribute: huge B -parking dataset

Neutral decays: $b \rightarrow s\ell\ell$ & $b \rightarrow d\ell\ell$

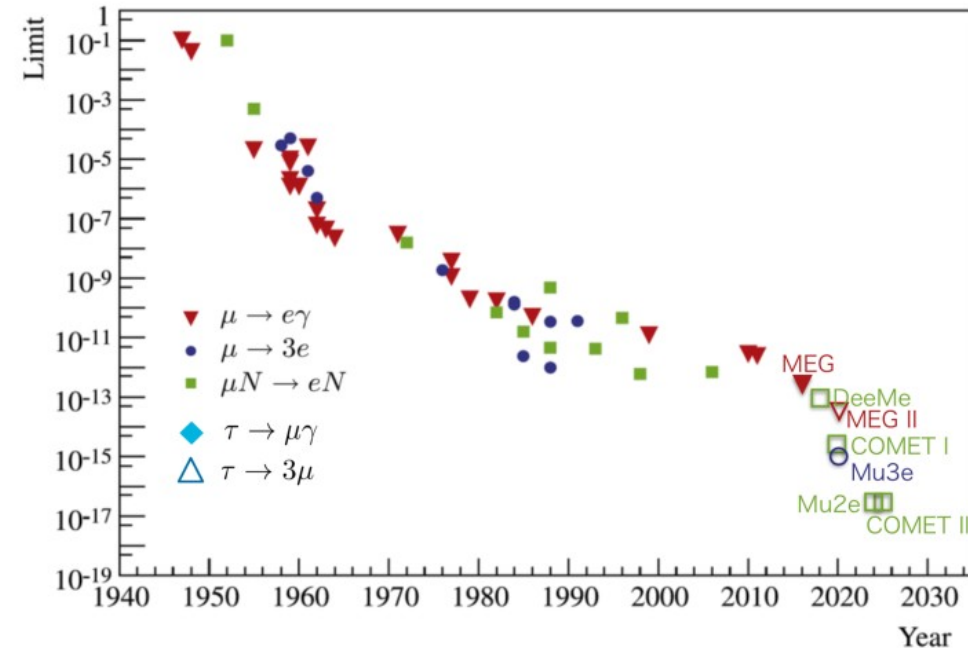
- LCHb: $\sim 3.1\sigma$ tension with SM in $b \rightarrow s$
- $b \rightarrow d$ less precise but agree with SM
- CMS B -parking data: $B \rightarrow K^*(\rightarrow K^-\pi^+)\ell\ell$, $B^+ \rightarrow K^+\ell\ell$

Caveat

- In τ and W decays $\Rightarrow$ no LFU violation observed

Charged LF Violation

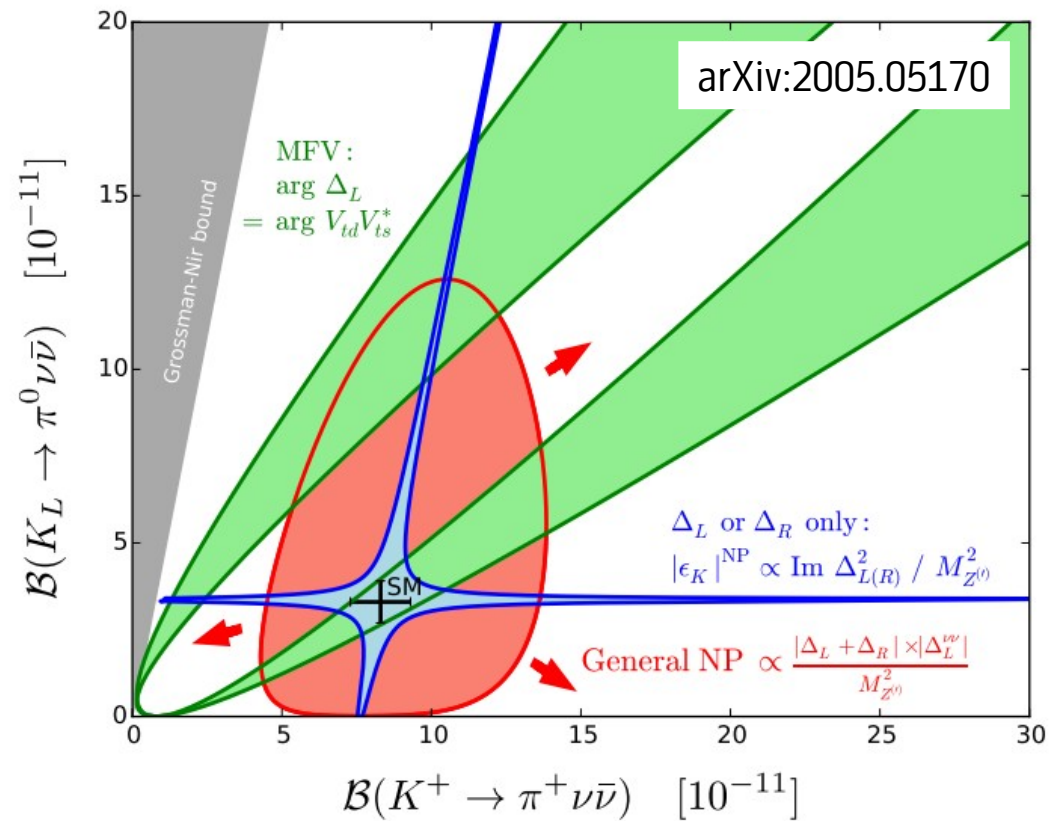
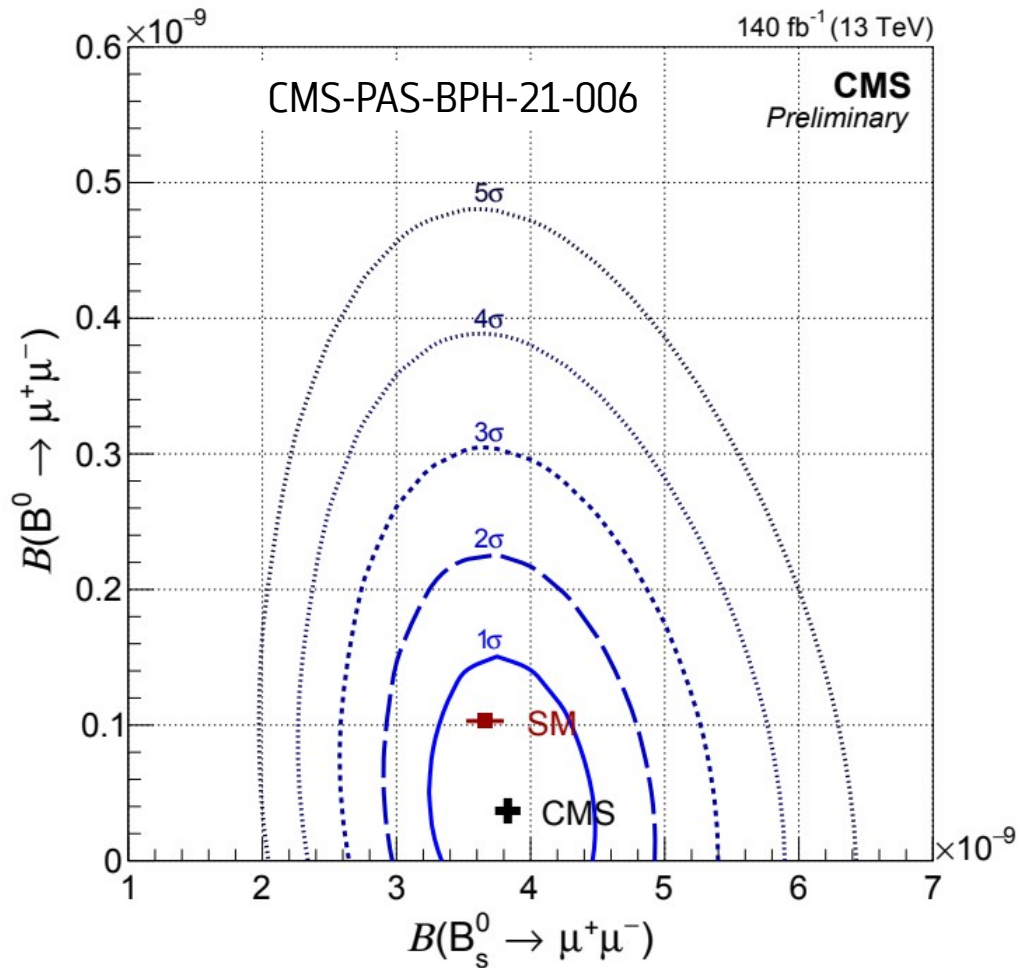
- LFV in τ , H , and Z decays @ Belle (II) and LHC exp'ts already
- LFV in μ decays more sensitive to new physics
- PSI high intensity muon beam (HIMB) and FNAL PIP II will provide orders of magnitude more μ s



Mu3e @ PSI: $\mu^+ \rightarrow e^+ e^- e^+$, $\mu^+ \rightarrow e^+ X$

Mu2e II @ FNAL: $\mu^- N \rightarrow e^- N$, $\mu^- \rightarrow e^- X$

Rare Meson Decays



Rare B meson decays: $B_{(s)}^0 \rightarrow \mu\mu$

- ❶ Latest CMS measurement most precise single exp't!
- Di-muon rare decay probes same operators as in $b \rightarrow s\ell\ell \Rightarrow$ complementary
- Low entry threshold since DESY $\in$ ATLAS & CMS

Rare kaon decays: $K \rightarrow \pi\nu\nu$

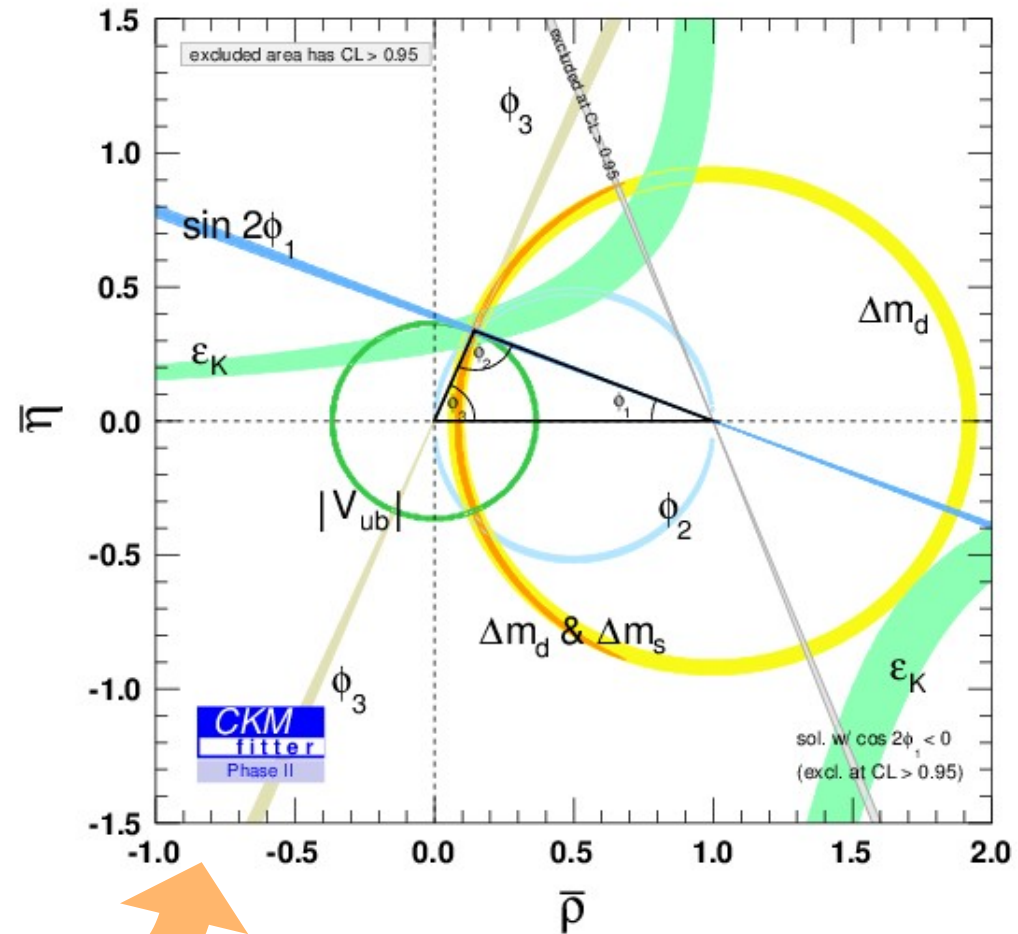
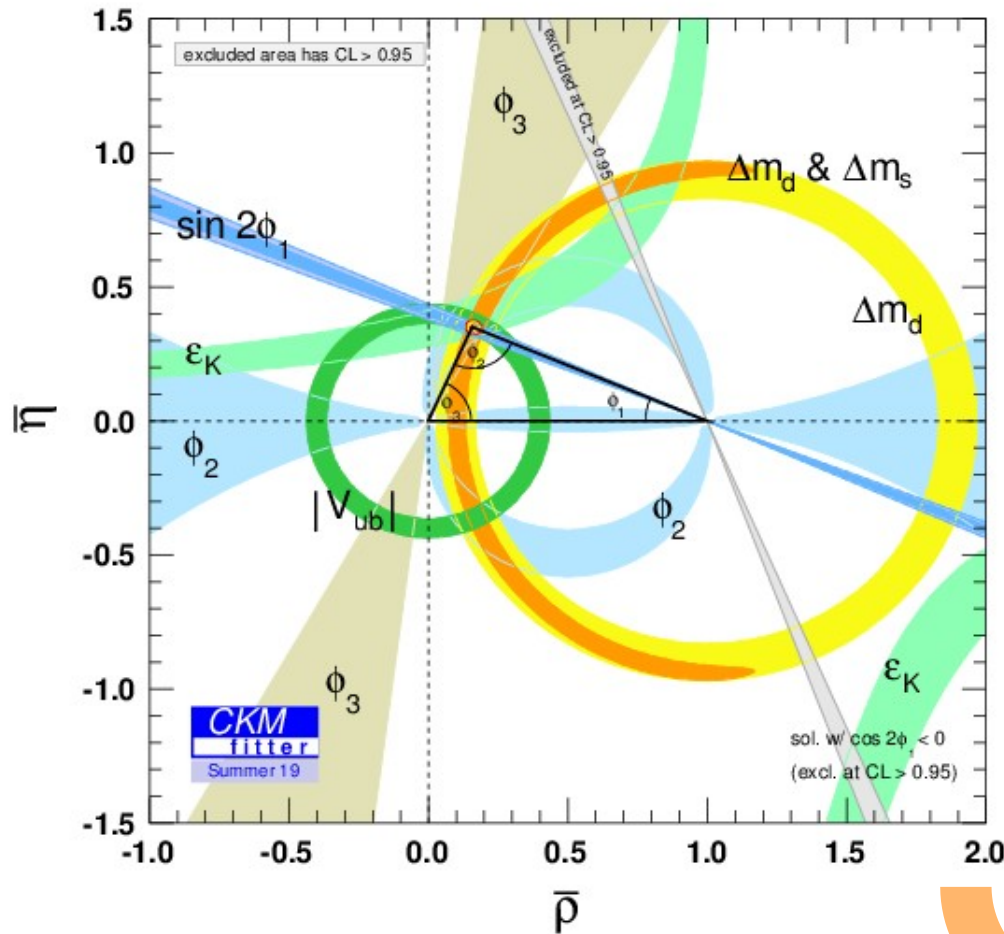
- KOTO II
 - step II vs. I: larger momentum, larger decay volume, new calorimeter, + other detector updates
- KLEVER
 - Kaon peak energy $\gg$ KOTO $\Rightarrow$ complementary
 - Target sensitivity: $\delta\text{BR}/\text{BR}(K_L \rightarrow \pi^0\nu\nu) \sim 20\%$

Summary

- Flavor sector contains most of the SM parameters – interesting regardless of current anomalies
- Many opportunities for DESY to contribute, large- and small-scale exp'ts
- Two paths:
 - Strengthen the role of Belle II, ATLAS, & CMS DESY groups
 - Strategic decision to join a new experiment

Backup

Projected CKM



LHCb(300 fb^{-1}), CMS/ATLAS(3000 fb^{-1}), and Belle II(50 ab^{-1})