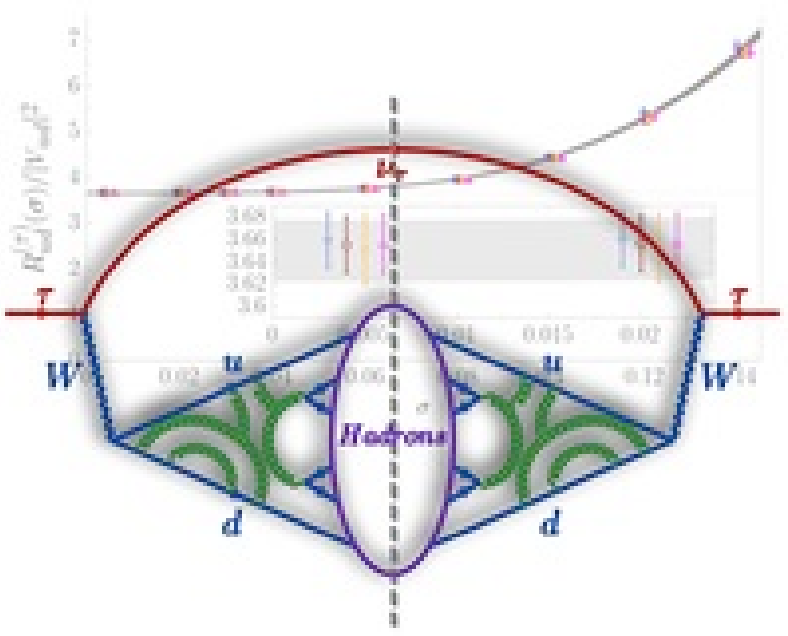
Inclusive decay of τ into hadrons



EDITORS' SUGGESTION

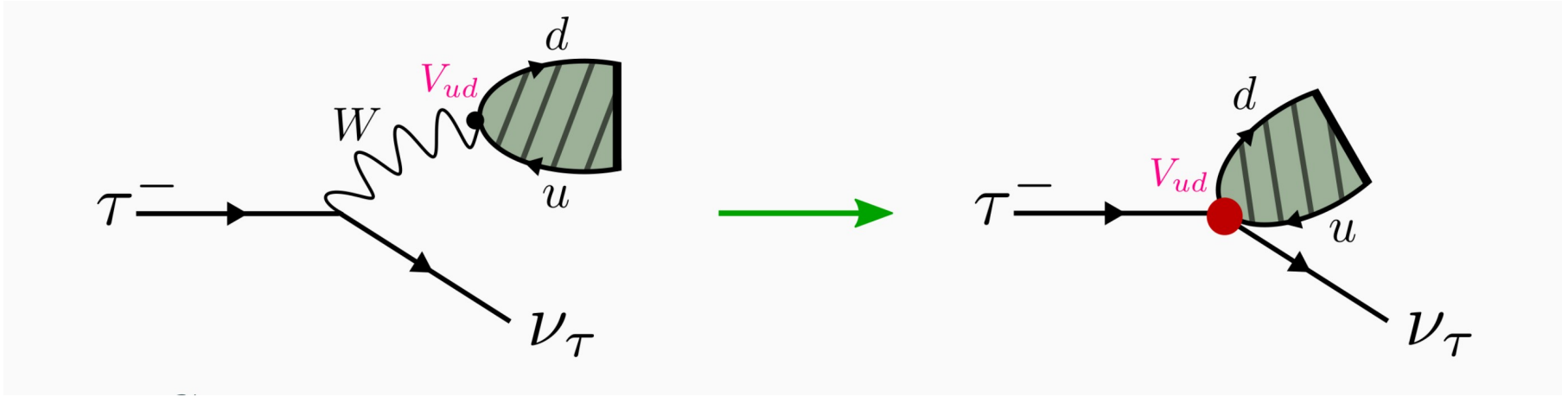
Inclusive hadronic decay rate of the τ lepton from lattice QCD

The authors express the inclusive hadronic decay rate of the tau lepton as an integral over the spectral density of the two-point correlator of the weak $V - A$ hadronic current which they compute fully nonperturbatively in lattice QCD. In a lattice QCD computation with all systematic errors except for isospin breaking effects under control, they then obtain the CKM matrix element V_{ud} with subpercent errors showing that their nonperturbative method can become a viable alternative to superallowed nuclear beta decays for obtaining V_{ud}.

A. Evangelista *et al.*

Phys. Rev. D **108**, 074513 (2023)

The process at LO in electroweak theory



We go directly for the rate

$$\sum_{X_{ud}} \left| \tau^- \to \nu_\tau \; q \; V_{ud} \; d \; u \; X_{ud} \right|^2 = \frac{1}{2m_\tau} \, 2\mathrm{Im} \; \tau^- \to \tau^- \; q \; V_{ud} \; V_{ud} \; d \; u \; q$$

p_τ, p_ν, p_τ, p_ν

The rate involves two form factors

$$R_{ud}^{(\tau)} = 6\pi S_{\rm EW}|V_{ud}|^2 \int_0^1 {\rm d}s\,(1-s)^2\left[(1+2\,s)\,\rho_{\rm T}(s)+\rho_{\rm L}(s)\right]$$

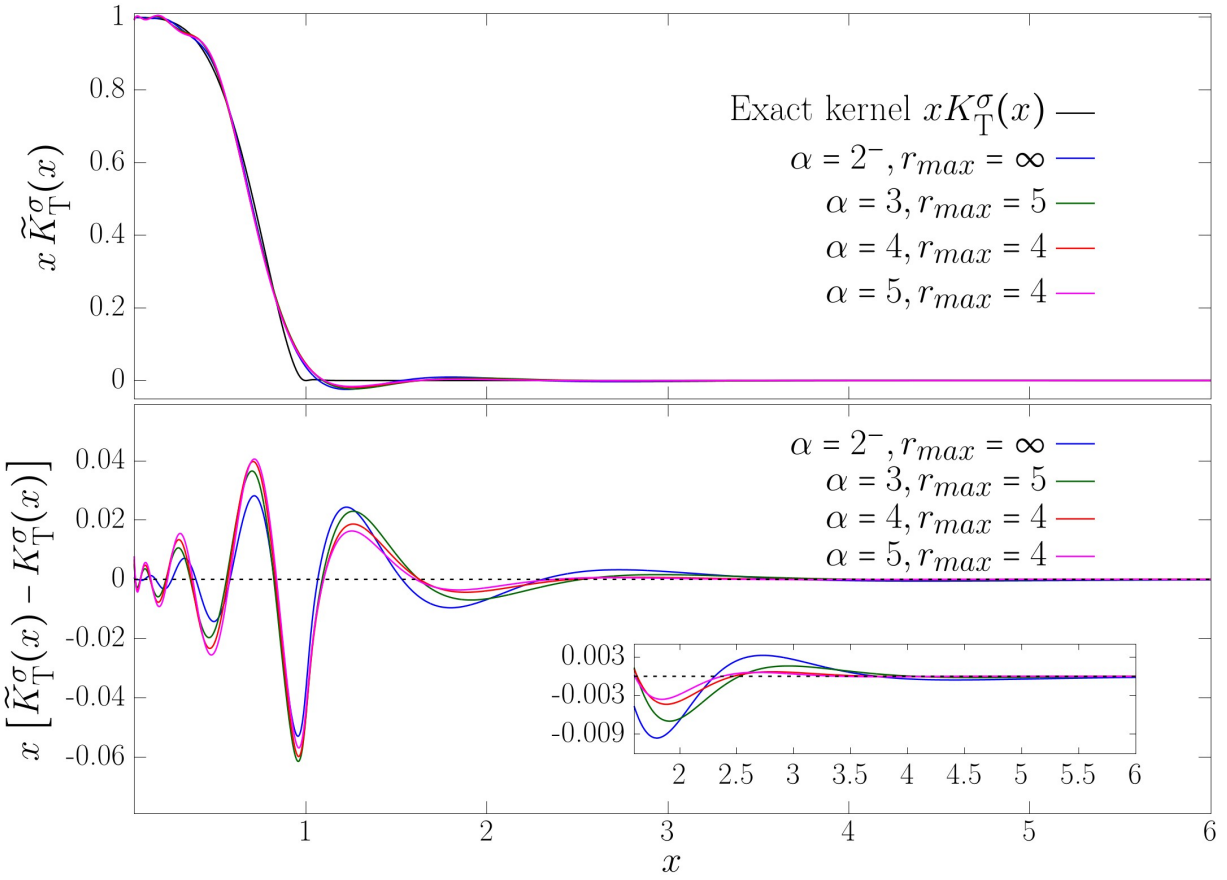
$$= 12\pi S_{\rm EW}\frac{|V_{ud}|^2}{m_\tau^3}\int_0^\infty {\rm d}E\left[K_{\rm T}\left(\frac{E}{m_\tau}\right)E^2\rho_{\rm T}(E^2)+K_{\rm L}\left(\frac{E}{m_\tau}\right)E^2\rho_L(E^2)\right]$$

To be extracted from longitudinal/transverse correlation function of EW currents

$$C_{\rm L}(t)\equiv C^{00}(t,\mathbf{0})=\int_0^\infty\frac{dE}{2\pi}e^{-Et}\rho_{\rm L}(E^2)E^2$$

$$C_{\rm T}(t)\equiv\frac{1}{3}C^{ii}(t,\mathbf{0})=\int_0^\infty\frac{dE}{2\pi}e^{-Et}\rho_{\rm T}(E^2)E^2$$

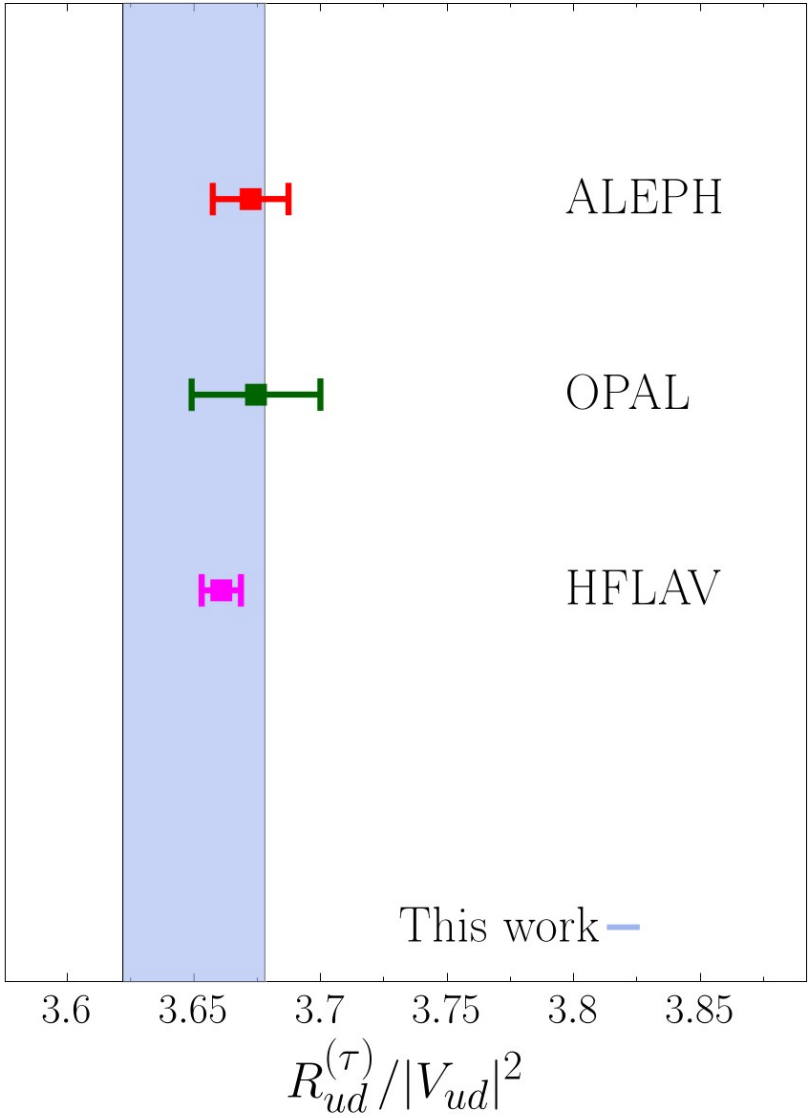
Transverse kernel reconstructed via HLT



Allows to extract Vud

Not competitive with nuclear decay approach

But ok, independent



Novelty: the *us* channel

$$R_{us}(\sigma) = 12\pi S_{EW}|V_{ud}|^2 \int_0^\infty \frac{dEE^2}{m_\tau^3}\left\{K_T^\sigma\left(\frac{E}{m_\tau}\right)\rho_T(E^2) + K_L^\sigma\left(\frac{E}{m_\tau}\right)\rho_L(E^2)\right\}$$

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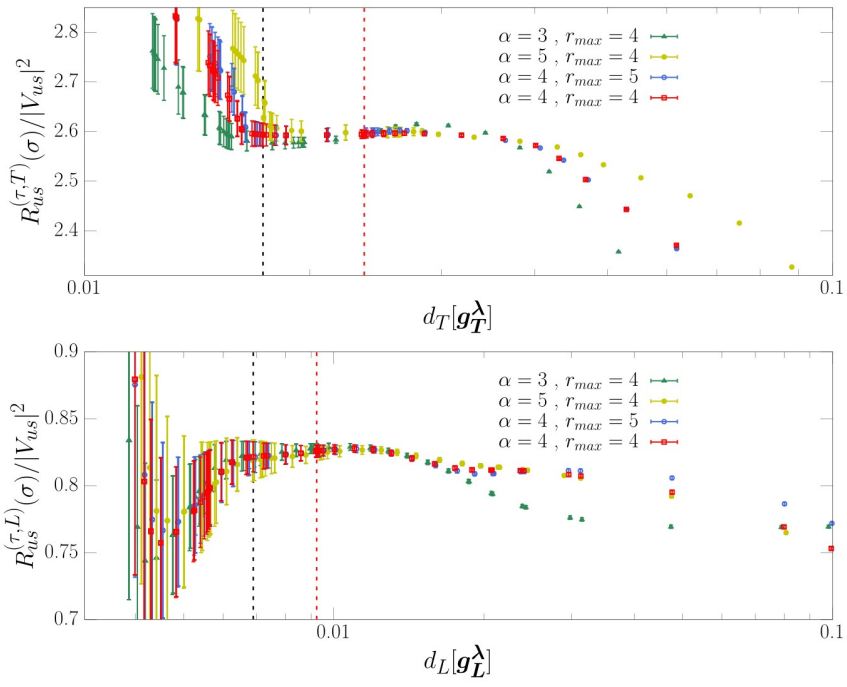
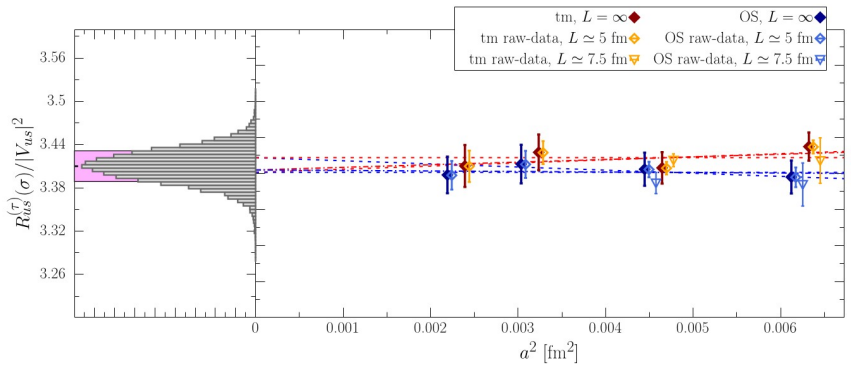
Inclusive Hadronic Decay Rate of the τ Lepton from Lattice QCD: The $\bar{u}s$ Flavor Channel and the Cabibbo Angle

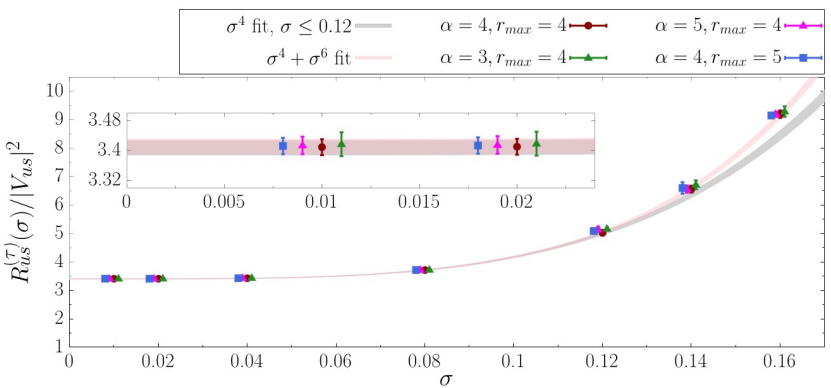
Constantia Alexandrou,[1,2] Simone Bacchio,[2] Alessandro De Santis,[3] Antonio Evangelista,[3] Jacob Finkenrath,[4] Roberto Frezzotti,[3] Giuseppe Gagliardi,[5] Marco Garofalo,[6] Bartosz Kostrzewa,[7] Vittorio Lubicz,[8] Simone Romiti,[6] Francesco Sanfilippo,[5] Silvano Simula,[5] Nazario Tantalo,[3] Carsten Urbach,[6] and Urs Wenger[9]

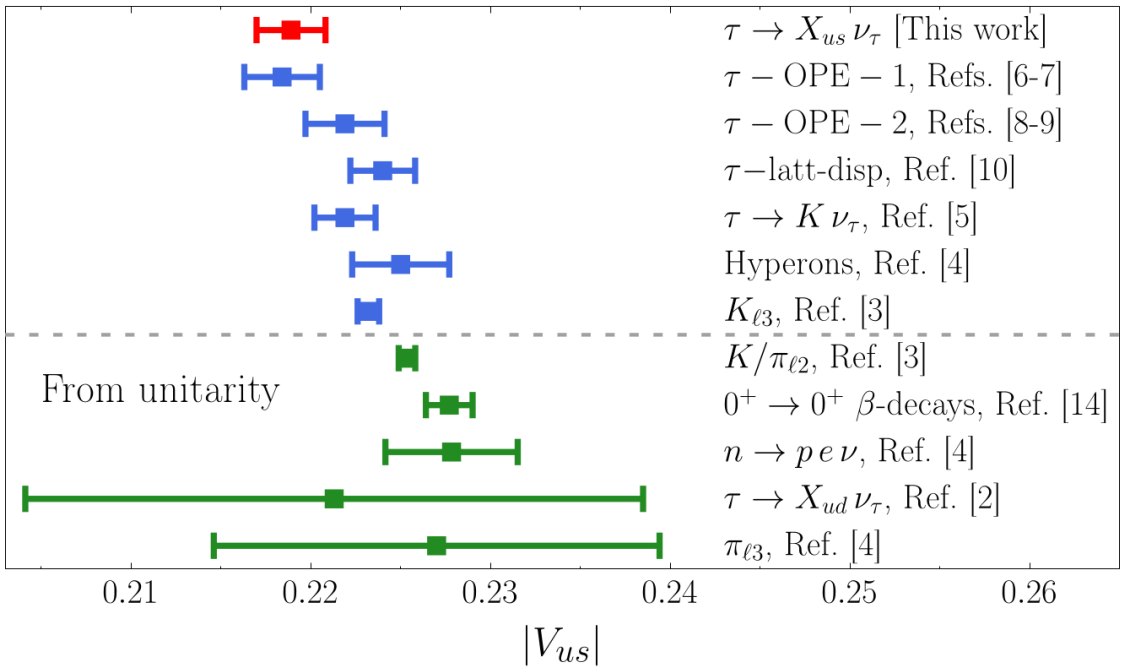
(Extended Twisted Mass Collaboration)



Two regularizations, four lattice spacings, yeah, a complete work!







PHYSICAL REVIEW LETTERS 132, 261901 (2024)

DONE