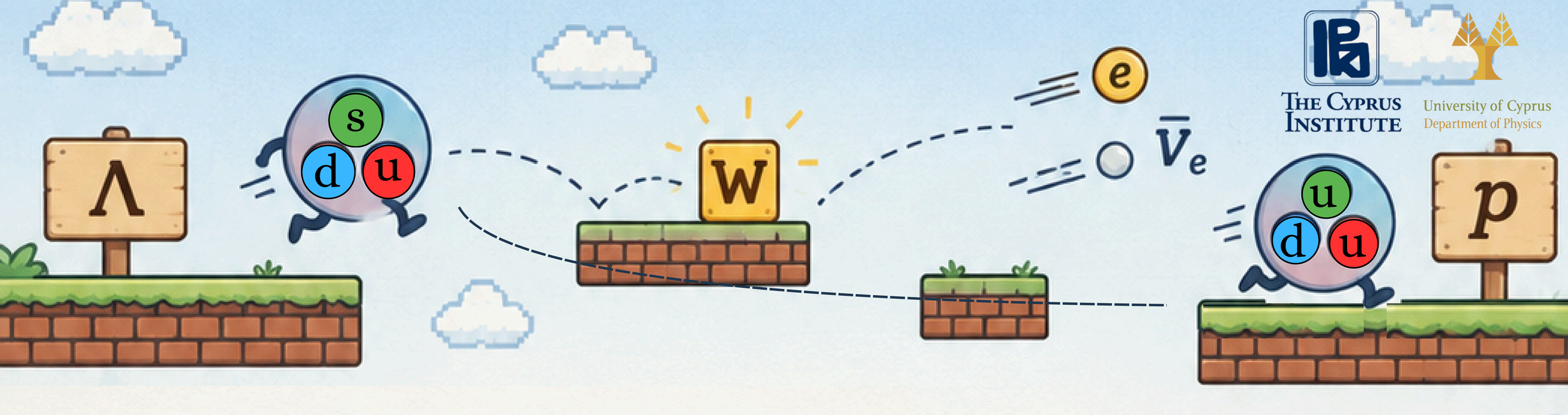


The Cyprus Institute
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Department of Physics

$\Lambda \to p \ell \bar{\nu}_e$: AN ADVENTURE FROM LATTICE TO THE PHYSICAL WORLD

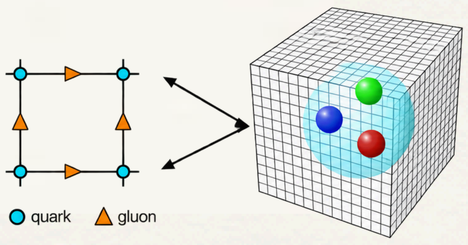
BY SIMONE BACCHIO AND ANDREAS KONSTANTINOU

START

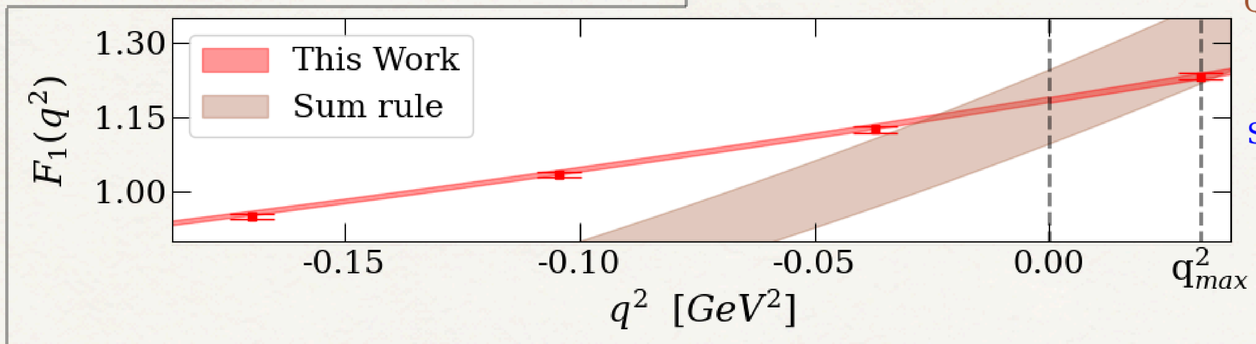
WORLD 1-1 : WE DISCRETIZE SPACE AND TIME TO MAKE STANDARD MODEL PREDICTIONS ON A COMPUTER.

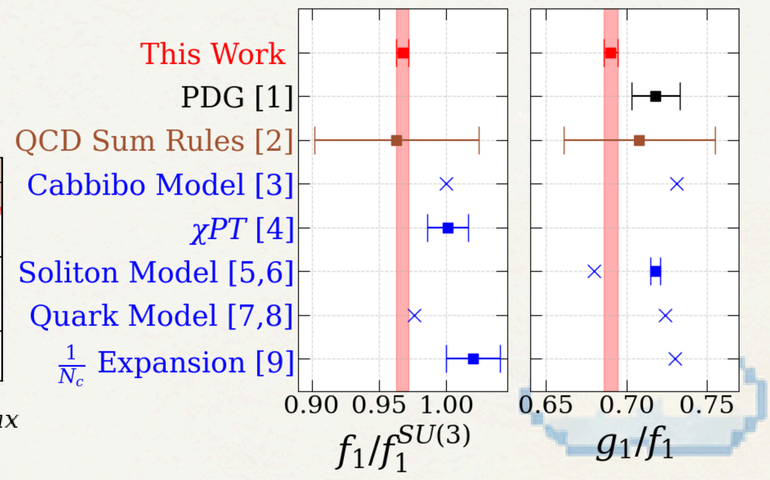
$$\langle \mathcal{O} \rangle = \frac{1}{Z} \int \mathcal{D}[U] \mathcal{O}(D^{-1}[U], U) \left(\prod_{f=u,d,s,c} \mathrm{Det}(D_f[U]) \right) e^{-S_{\mathrm{QCD}}[U]}$$





WORLD 1-2 : WE COMPUTE TWO- AND THREE-POINT CORRELATION FUNCTIONS TO EXTRACT THE FORM FACTORS, WHICH ENCODE THE EFFECTS OF THE STRONG INTERACTION.





WORLD 1-3 : BY COMBINING EXPERIMENTAL INPUTS [1], PERTURBATIVE LEPTONIC CONTRIBUTIONS, AND THE HADRONIC INPUTS FROM LQCD, WE CAN DETERMINE THE CKM MATRIX ELEMENTS

$$\mathcal{B}_{\Lambda \to p e \bar{\nu}_e} = \frac{\tau_\Lambda G_F^2 |V_{us}|^2}{192 \pi^3 {m_\Lambda}^3} \int_{{m_\ell}^2}^{q^2_{\max}} dq^2 \sqrt{\lambda({m_\Lambda}^2, {m_p}^2, q^2)}\, L^{\mu\nu} H_{\mu\nu},$$

WORLD 1-4 : OUR DESIRED "PRINCESS" IS CKM MATRIX UNITARITY. ANY DEVIATION FROM UNITARITY COULD SIGNAL PHYSICS BEYOND THE STANDARD MODEL. OUR RESULTS AT ONE LATTICE SPACING ARE SHOWN BELOW.

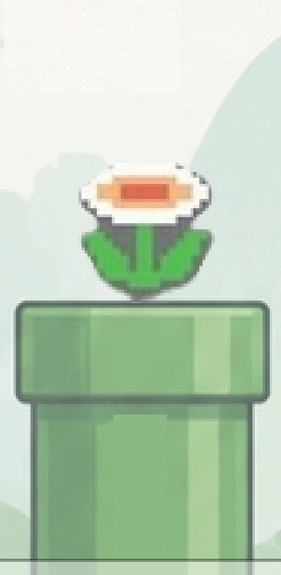


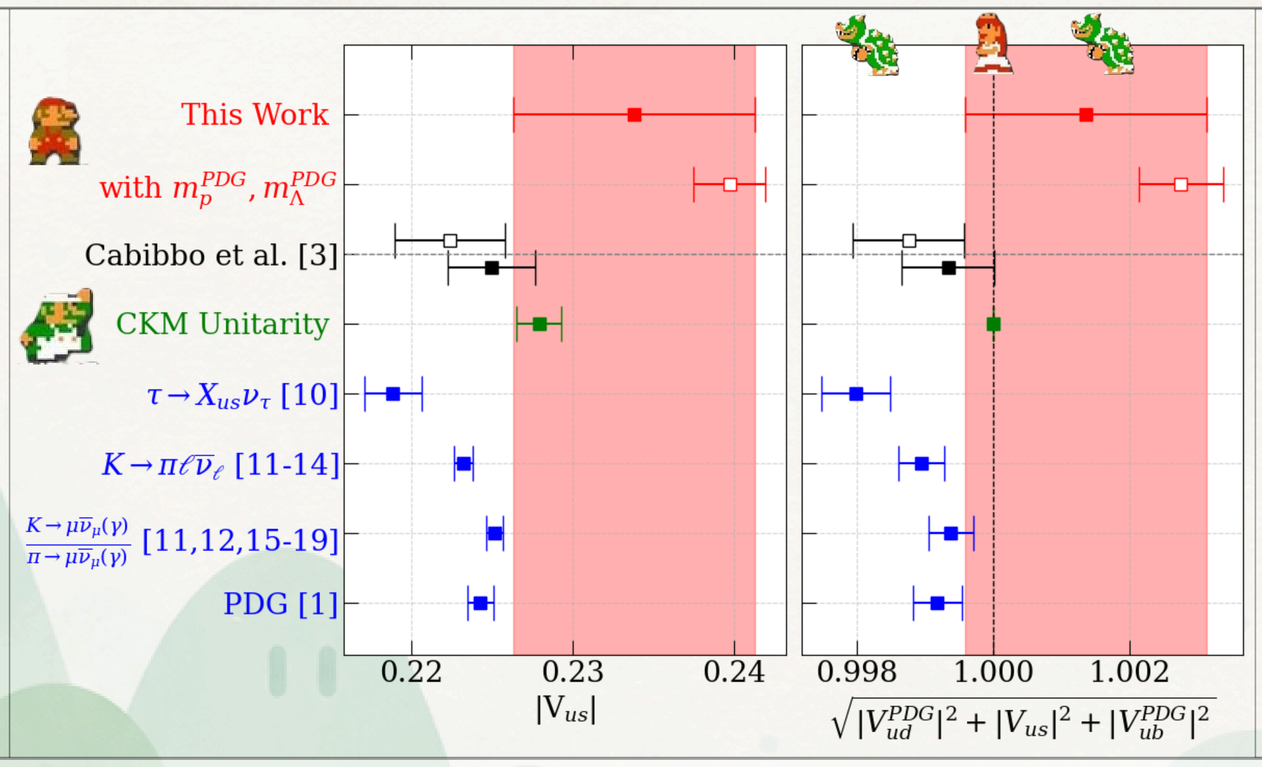
$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

$$|V_{us}| = 0.2338(75)\,,$$

$$\sqrt{|V_{ud}^{\mathrm{PDG}}|^2 + |V_{us}|^2 + |V_{ub}^{\mathrm{PDG}}|^2} = 1.0014(18)\,.$$

SCOREBOEARD





WORK IN PROGRESS:
OUR RESULT STILL NEEDS
THE CONTINUUM LIMIT.



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