Петербургский институт ядерной физики им. Б.П. Константинова
НИЦ «Курчатовский институт»

Precise research of neutron decay and the need to Standard Model extension

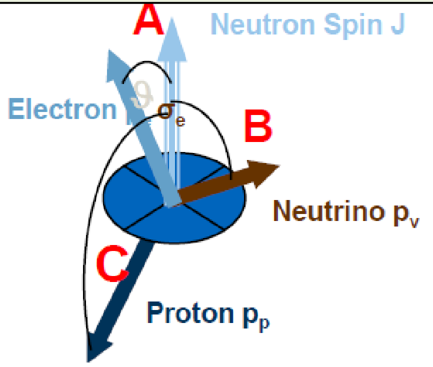
Anatolii Serebrov

May 19, 2026

Precision studies of neutron decay and the search for deviations from the Standard Model

$$\frac{d^3\Gamma}{dE_e d\Omega_e d\Omega_\nu} = \frac{1}{2(2\pi)^5} G_F^2 |V_{ud}|^2 \left(1+3|\lambda|^2\right) p_e E_e \left(E_0 - E_e\right)^2$$
$$\times \left[1 + a\frac{\vec{p}_e \cdot \vec{p}_\nu}{E_e E_\nu} + b\frac{m_e}{E_e} + \frac{\langle \vec{\sigma}_n \rangle}{\vec{\sigma}_n} \cdot \left(A\frac{\vec{p}_e}{E_e} + B\frac{\vec{p}_\nu}{E_\nu} + D\frac{\vec{p}_e \times \vec{p}_\nu}{E_e E_\nu} \right)\right]$$

Jackson, Treiman, Wyld, Nucl. Phys. 4, 1957



$$A = -2\frac{\lambda^2+\lambda}{1+3\lambda^2}$$ $\boxed{-0.11958(21) \quad 0.17\%}$

$$B = 2\frac{\lambda^2-\lambda}{1+3\lambda^2}$$ $\boxed{0.9807(30) \quad 0.3\%}$

$\lambda = g_A/g_V$ $\boxed{-1.2757(5) \quad 0.04\%}$

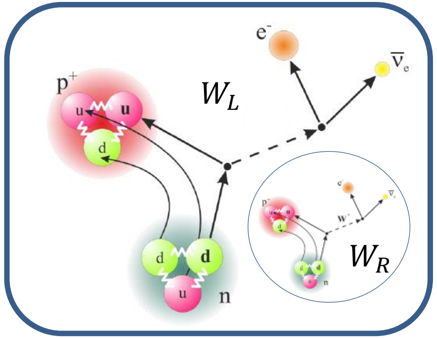
$$a = \frac{(1-\lambda^2)}{(1+3\lambda^2)}$$ $\boxed{-0.10402(82) \quad 1.3\%}$

$$D = 2 \cdot \frac{\mathrm{Im}(\lambda)}{1+3|\lambda|^2}$$ $\boxed{-1.2\ (2.0)\times 10^{-4}}$

Neutron lifetime

$$\tau^{-1} = G_F^2 |V_{ud}|^2 (1+3\lambda^2) \frac{f^R m_e^5 c^4}{2\pi^3 \hbar^7}$$

$\boxed{877.75 \pm 0.35\,\mathrm{s} \quad 0.04\%}$



Unitarity CKM

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

$$V_{ud}^{unit} = \sqrt{1 - V_{us}^2 - V_{ub}^2} = 0.97452(18).$$

The description of experimental results within the framework of the V-A version of the theory turns out to be unsatisfactory, since it cannot be represented by a single value of the parameter $\lambda = G_A / G_V$

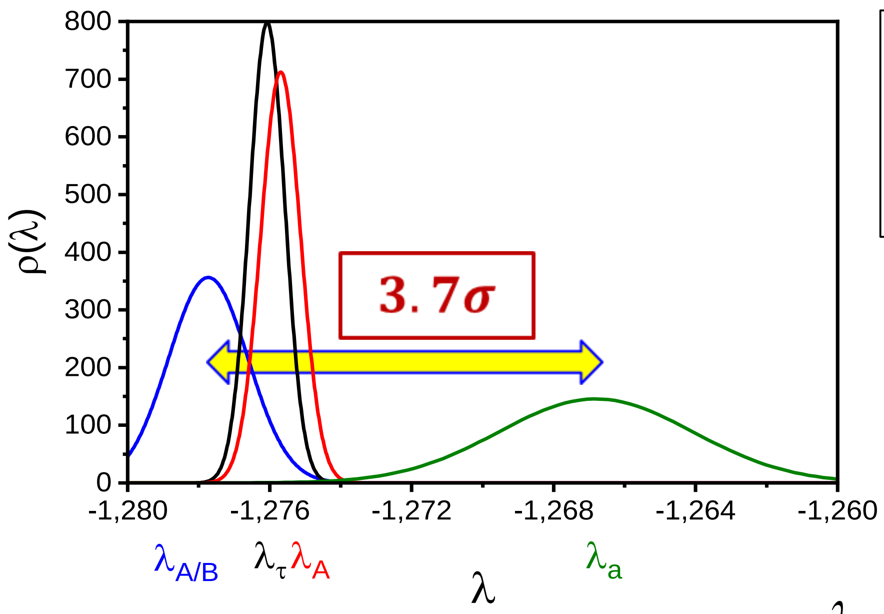
$$\tau_{\exp} = \frac{4905,7}{V_{ud}^2 (1+3\lambda^2)}$$

$$a_{\exp} = \frac{(1-\lambda^2)}{(1+3\lambda^2)}$$

$$A_{\exp} = -\frac{2\lambda(\lambda+1)}{1+3\lambda^2}$$

$$B_{\exp} = \frac{2\lambda(\lambda-1)}{1+3\lambda^2}$$

$$\boxed{\begin{aligned} \tau_{\exp} &= 877.75(35) \\ a_{\exp} &= -0.10402(82) \\ A_{\exp} &= -0.11958(21) \\ B_{\exp} &= 0.9807(30) \\ V_{ud}^n &= 0.97477(37) \end{aligned}}$$



Results of calculating the parameter value $\lambda = G_A / G_V$ within the V-A version of the weak interaction theory, the experiments for a, A, B and τ cannot be represented by a single value.

Deviation from Standard Model is 3.7 sigma

Physical Review D 3 112, 115012 (2025) A.P. Serebrov, et. al.

At the same time, the results of measurements of the neutron lifetime and decay asymmetries **can be successfully reconciled** within the framework of the **simplest left-right manifesto model of weak interaction**

M. A. B. Beg, R. V. Budny, R.N. Mohapatra, and A. Sirlin, Phys. Rev. Lett. 38, 1252 (1977),

B. R. Holstein and S. B. Treiman, Phys. Rev. D **16**, 2369 (1977),

P. Herczeg, Phys. Rev. D **34**, 3449 (1986),

P. Herczeg, Prog. Part. Nucl. Phys. **46**, 413 (2001)

N. Severijns, M. Beck and O. Naviliat-Cuncic, Rev. Mod. Phys. **78**, 991 (2006)]

$$\begin{pmatrix} W_L^{\pm} \\ W_R^{\pm} \end{pmatrix} = \begin{pmatrix} \cos\zeta & +\sin\zeta \\ -\sin\zeta & \cos\zeta \end{pmatrix} \begin{pmatrix} W_1^{\pm} \\ W_2^{\pm} \end{pmatrix}$$

where ζ is the mixing angle of the flavor states W_L and W_R, and δ is the ratio of the squares of the masses of the states W_1 and W_2.

The decay of a neutron within the model of mixing left and right vector bosons can be successfully described

$\delta = 0.070 \pm 0.010$

ζ = - 0.039 ± 0.014

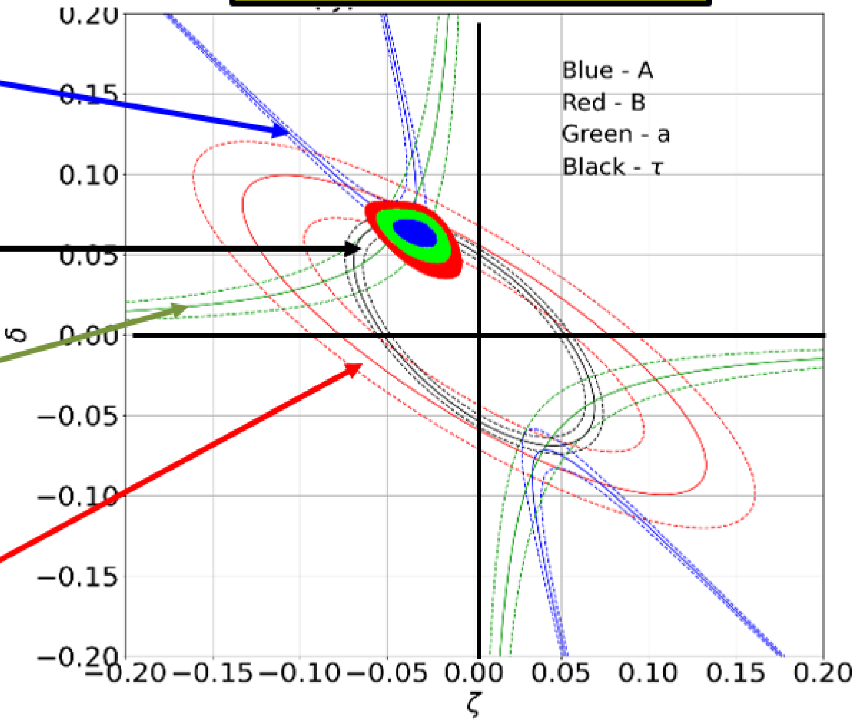
λ_{opt} =1.2738 ±0.0011

$$\frac{A_{\exp} \pm \Delta A_{\exp} - A_{V-A}}{A_{V-A}} \simeq -2\delta^2 - 2\delta\zeta \frac{\left[6\lambda^3 + 3\lambda^2 - 1\right]}{(\lambda+1)(1+3\lambda^2)} - 2\frac{\lambda}{\lambda+1}\zeta^2$$

$$\frac{\tau_{\exp} \pm \Delta\tau_{\exp} - \tau_{V-A}}{\tau_{V-A}} \simeq -\left[\delta^2 + \zeta^2 + 2\frac{(3\lambda^2-1)}{(3\lambda^2+1)}\delta\zeta\right]$$

$$\frac{a_{\exp} \pm \Delta a_{\exp} - a_{V-A}}{a_{V-A}} \simeq -\frac{16}{(1-\lambda^2)(1+3\lambda^2)}\delta\zeta$$

$$\frac{B_{\exp} \pm \Delta B_{\exp} - B_{V-A}}{B_{V-A}} \simeq -2\delta^2 - 2\delta\zeta \frac{\left[6\lambda^3 - 3\lambda^2 + 1\right]}{(\lambda-1)(1+3\lambda^2)} - 2\frac{\lambda}{\lambda-1}\zeta^2$$



Final result of the analysis

As a result of the analysis, it was found that there are indications of the existence of a right vector boson with mass and mixing angle

Письма в ЭЧАЯ. 2024. Т. 22, № 1(258). С. 134–145

ФИЗИКА ЭЛЕМЕНТАРНЫХ ЧАСТИЦ И АТОМНОГО ЯДРА 2025. Т. 56, вып. 3. С. 1405–1426

$$M_{W_R} = 304^{+24}_{-20}\ \mathrm{GeV}$$

$$\zeta = -0.039 \pm 0.014$$

$$\delta = 0.070 \pm 0.010$$

PHYSICAL REVIEW D 112, 115012 (2025)

Analysis of experimental data on neutron decay for the possibility of the existence of the right vector boson WR

A. P. Serebrov , O. M. Zherebtsov, A. K. Fomin, R. M. Samoilov, and N. S. Budanov*

Why resonance W_R

was not detected in collider experiments?

Why resonance W_R was not detected in collider experiments?

Calculation of the cross-section in the left-right model

$$\sigma(s) = \frac{\pi\alpha_W^2}{6} V_{ud}^2 \times \left[\frac{a_{ud}^{L^2} a_{lv}^{L^2} + a_{ud}^{R^2} a_{lv}^{R^2} + a_{ud}^{R^2} a_{lv}^{L^2} + a_{ud}^{L^2} a_{lv}^{R^2}}{\left(s - m_{W_L}^2\right)^2 + \gamma_{W_L}^2 m_{W_L}^2} \right.$$
$$+ 2a_{ud}^{L} a_{lv}^{L} \frac{(s - m_{W_L}^2)(s - M_{W_R}^2) + \gamma_{W_L}^2 \Gamma_{W_R}^2}{\left(\left(s - m_{W_L}^2\right)^2 + \gamma_{W_L}^2 m_{W_L}^2\right)\left(\left(s - M_{W_R}^2\right)^2 + \Gamma_{W_R}^2 M_{W_R}^2\right)}$$
$$\left. + \frac{a_{ud}^{L^2} a_{lv}^{L^2} + a_{ud}^{R^2} a_{lv}^{R^2} + a_{ud}^{R^2} a_{lv}^{L^2} + a_{ud}^{L^2} a_{lv}^{R^2}}{\left(s - M_{W_R}^2\right)^2 + \Gamma_{W_R}^2 M_{W_R}^2}\right]$$

$$\sigma(s) = \frac{\pi\alpha_W^2}{6} V_{ud}^2 * \left[\frac{1}{\left(s - m_{W_L}^2\right)^2 + \gamma_{W_L}^2 m_{W_L}^2} + \sin^2\zeta \frac{2\frac{\cos^4\zeta}{\sin^2\zeta}\delta^2 + (\delta-1)^2\cos^2\zeta\left(e^{2i\omega} + e^{-2i\omega}\right)}{\left(s - M_{W_R}^2\right)^2 + \Gamma_{W_R}^2 M_{W_R}^2}\right]$$

For left resonance
$a_{ud}^{L^2} a_{lv}^{L^2} = (\cos^2\zeta + \delta\sin^2\zeta)^2$
$a_{ud}^{R^2} a_{lv}^{R^2} = (\sin^2\zeta + \delta\cos^2\zeta)^2$
$a_{ud}^{R^2} a_{lv}^{L^2} = (\delta-1)^2 \sin^2\zeta\cos^2\zeta\, e^{2i\omega}$
$a_{ud}^{L^2} a_{lv}^{R^2} = (\delta-1)^2 \sin^2\zeta\cos^2\zeta\, e^{-2i\omega}$

For right resonance
$a_{ud}^{L^2} a_{lv}^{L^2} = (\sin^2\zeta + \delta\cos^2\zeta)^2$
$a_{ud}^{R^2} a_{lv}^{R^2} = (\delta\cos^2\zeta + \sin^2\zeta)^2$
$a_{ud}^{R^2} a_{lv}^{L^2} = (\delta-1)^2 \sin^2\zeta\cos^2\zeta\, e^{2i\omega}$
$a_{ud}^{L^2} a_{lv}^{R^2} = (\delta-1)^2 \sin^2\zeta\cos^2\zeta\, e^{-2i\omega}$

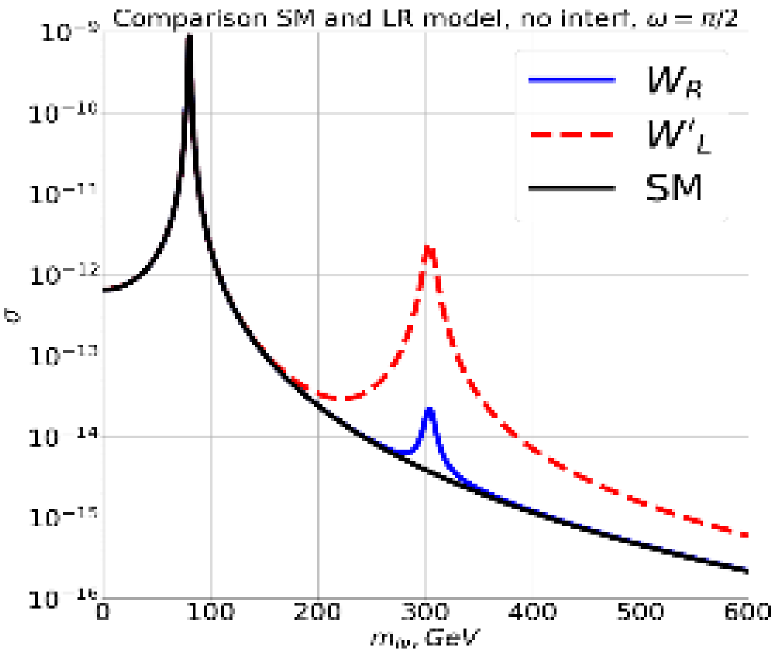
[5] P. Herczeg, Phys. Rev. D **34**, 3449 (1986),

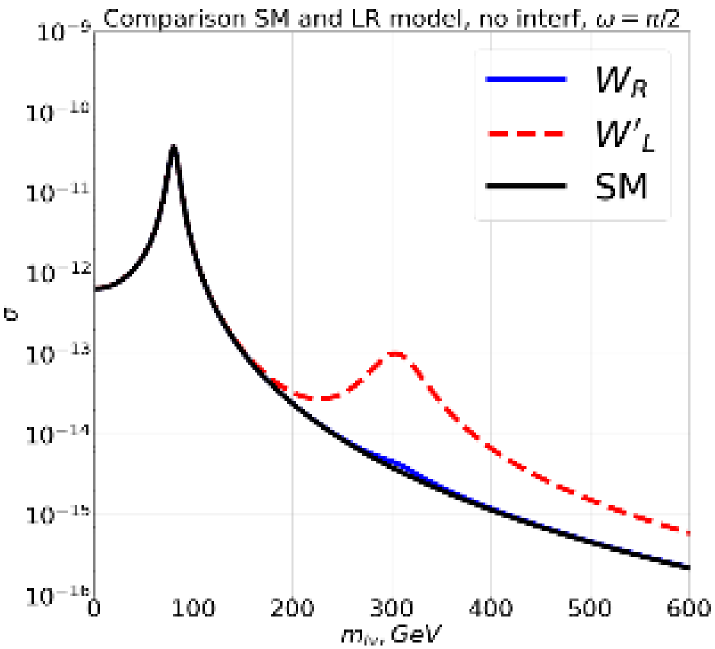
[44] E. Boos, V. Bunichev, L. Dudko, M. Perfilov, Phys. Lett. B **655**, 245 (2007)

Why resonance W_R was not detected in collider experiments?

Calculation of the cross-section in the left-right model

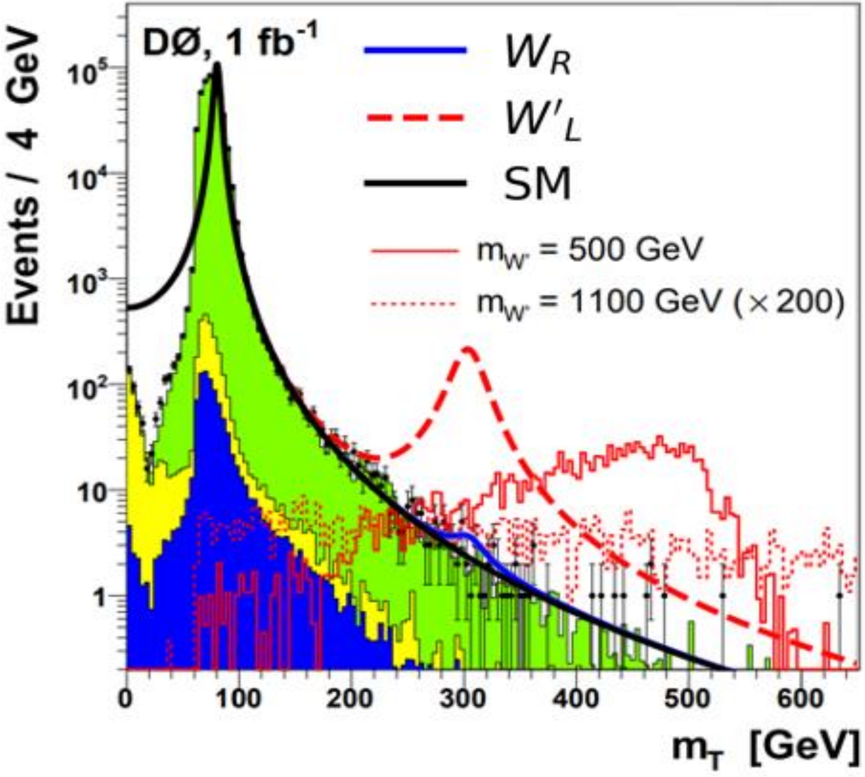
accounting for hardware broadening

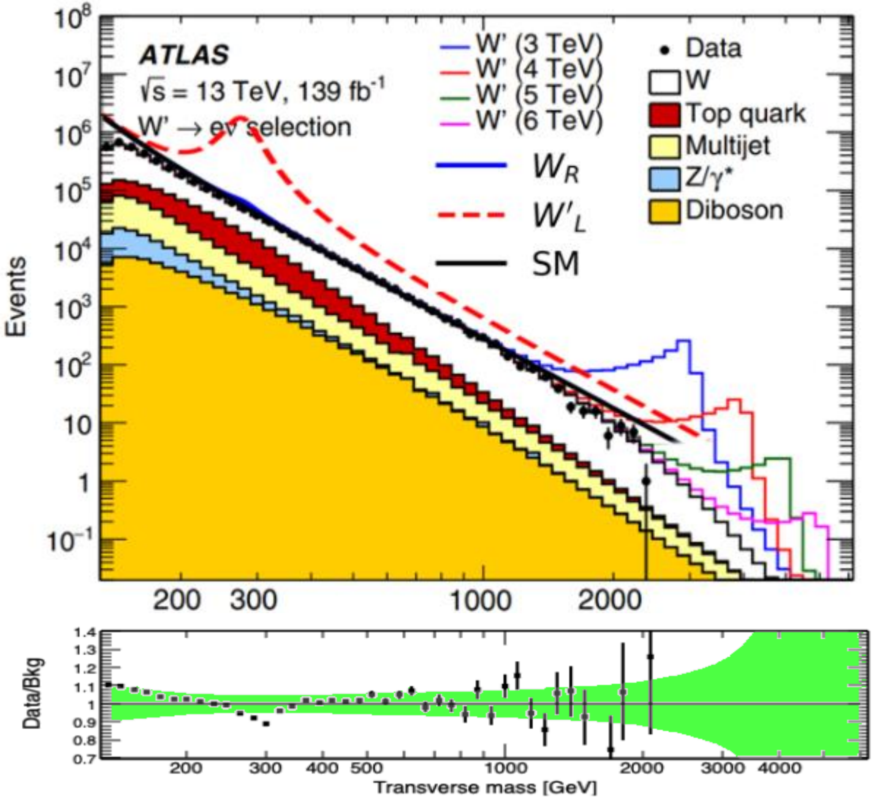




Why resonance W_R was not detected in collider experiments?

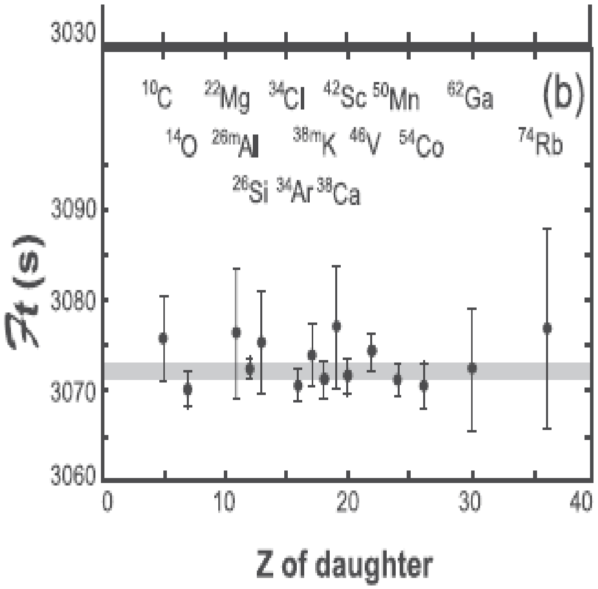
Comparison of the calculation results with experimental data for the Tevatron experiment at Fermilab from publication [45] and for the ATLAS experiment [46] at CERN.

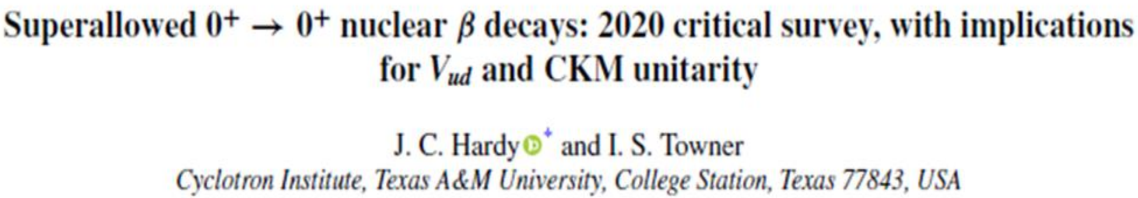




Data from experiments with nuclear superallowed 0+ - 0+ transitions allow us to determine the V_{ud} element of the CKM matrix independently

PROBLEM OF UNITARITY OF THE CKM MATRIX



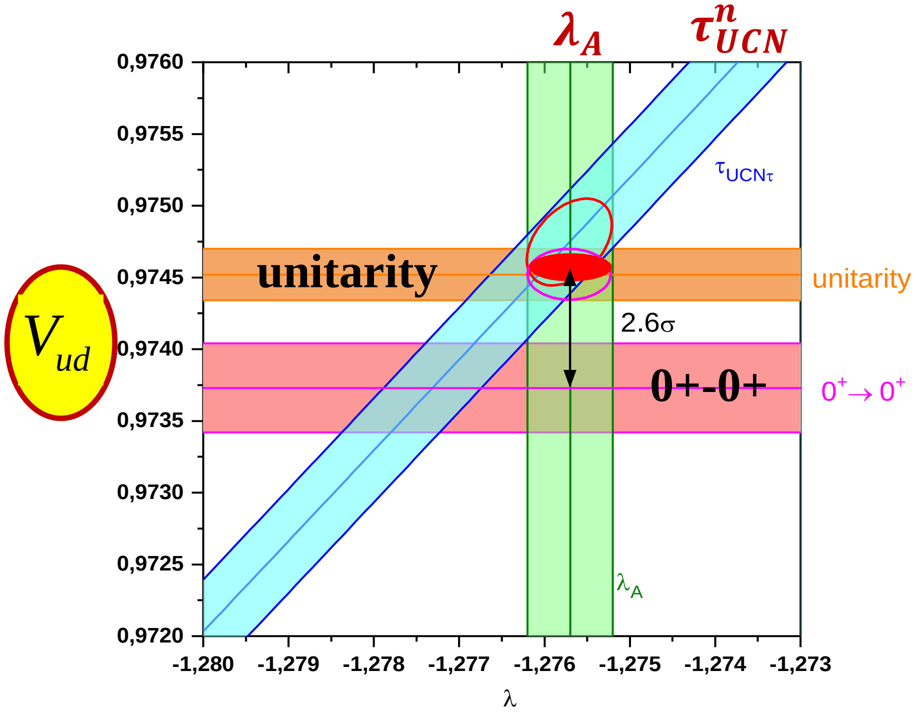


Superallowed $0^+ \rightarrow 0^+$ nuclear β decays: 2020 critical survey, with implications for V_{ud} and CKM unitarity

J. C. Hardy and I. S. Towner
Cyclotron Institute, Texas A&M University, College Station, Texas 77843, USA

J. C. Hardy and I. S. Towner, Phys. Rev. C **102** , 045501 (2020)

The difference in Vud between the matching values from neutron decay and CKM unitarity and the Vud value from 0+-0+ transitions is 2.6 sigma



$$\frac{\Delta V_{ud}}{V_{ud}} = 8.6 * 10^{-4} (2.6\ \sigma)$$

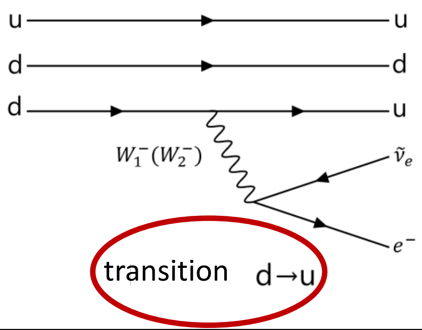
$$\begin{pmatrix} W_L^{\pm} \\ W_R^{\pm} \end{pmatrix} = \begin{pmatrix} \cos\zeta & +\sin\zeta \\ -\sin\zeta & \cos\zeta \end{pmatrix} \begin{pmatrix} W_1^{\pm} \\ W_2^{\pm} \end{pmatrix}$$

Extended version of the left-right model

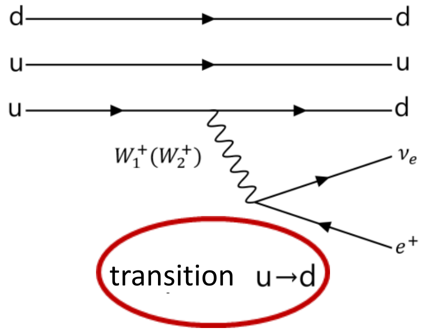
$$\begin{pmatrix} W_L^{\pm} \\ W_R^{\pm} \end{pmatrix} = \begin{pmatrix} \cos\zeta & \mp\sin\zeta \\ \pm\sin\zeta & \cos\zeta \end{pmatrix} \begin{pmatrix} W_1^{\pm} \\ W_2^{\pm} \end{pmatrix}$$

Violations of CP-invariance in baryons

Neutron decay



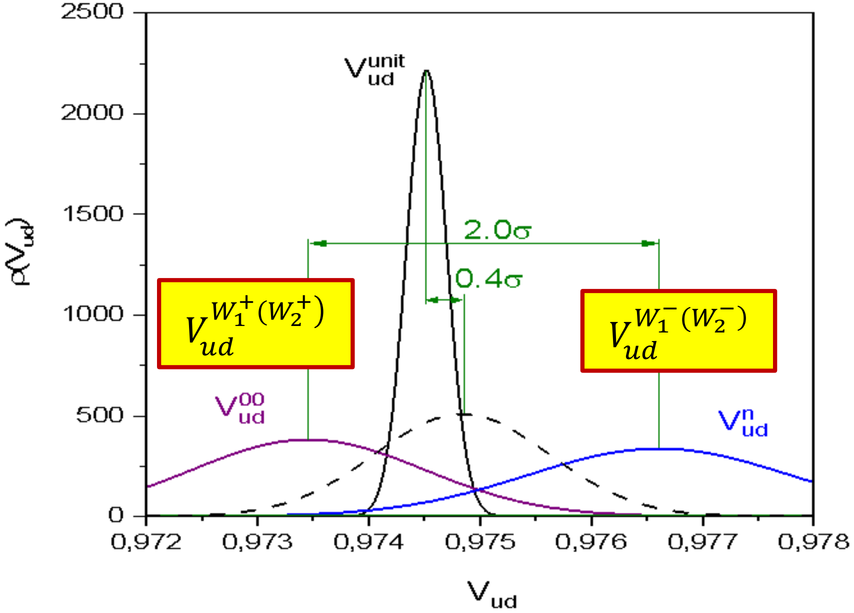
Proton decay in the nucleus



$$A_{p-n} = \frac{(V_{ud}^{00LR})^2 - (V_{ud}^{nLR})^2}{(V_{ud}^{00LR})^2 + (V_{ud}^{nLR})^2} = (-3.2 \pm 1.6)\cdot 10^{-3}(2.0\sigma)$$

$$V_{ud}^{nLR} \equiv V_{ud}^{W_1^-(W_2^-)}$$

$$V_{ud}^{00LR} \equiv V_{ud}^{W_1^+(W_2^+)}$$



The Hamiltonian of the weak interaction can be represented in the same general form as for 0+-0+ transitions. However, K-mesons are pseudoscalar particles with spin zero and negative parity $0^- - 0^-$. Therefore, a sign change occurs before ζ .

$$H_V^N = \bar{e}\gamma_\mu(C_V + C'_V\gamma_5)\nu \cdot \bar{\pi}\gamma_\mu K^0$$

where with decay $W_1^+(W_2^+)$ is related

$$|C_V|^2 + |C'_V|^2 = G_F^2|V_{us}|^2(1 + (\delta - \zeta)^2)$$

where with decay $W_1^-(W_2^-)$ is related

$$|C_V|^2 + |C'_V|^2 = G_F^2|V_{us}|^2(1 + (\delta + \zeta)^2)$$

$$\boxed{A_T^{LR} = \frac{1+(\delta-\zeta)^2 - \left(1+(\delta+\zeta)^2\right)}{2\left(1+\delta^2+\zeta^2\right)} \approx -2\delta\zeta}$$

$$\boxed{A = -2\zeta\delta}$$

Using the previously obtained values from neutron decay

$$\delta = 0.070(10) \qquad \zeta = -0.039(14)$$

Prediction of the left-right model with CP-violation

$$\boxed{A_T^{LR} = (5.5 \pm 2.1)\times 10^{-3}(2.6\sigma)}$$

Experiment (pdg)

$$\boxed{A_T^{\exp} = \left(6.6 \pm 1.3 \pm 1.0\right)\times 10^{-3}(4\sigma)}$$

This value agrees with the experimentally measured asymmetry.

Description of neutral meson oscillations in a left-right CP-violation model

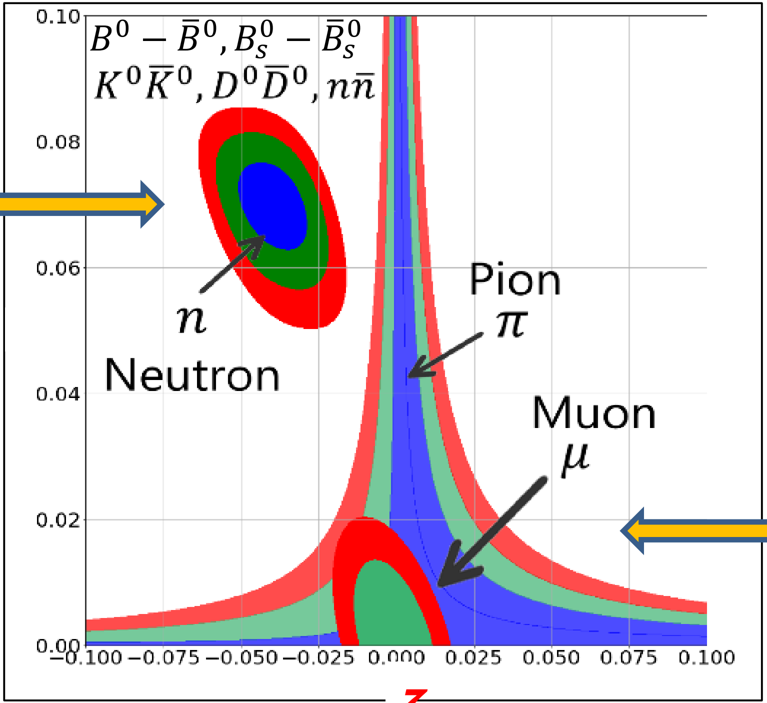
arXiv:2604.04716

CP-violation effects in neutral meson oscillations in the left-right weak interaction model

A.P. Serebrov, O.M. Zherebtsov, A.K. Fomin, R. Samoilov, N.S. Budanov

neutral

δ



ζ

charged

CPT

arXiv:2406.03440

15

The cause of CP- violation is the mixing of quarks.

(CPT)

Standard Modelwith CP-violation

$$\begin{pmatrix} M - i\dfrac{\Gamma_0}{2} & \Delta m - i\dfrac{\Delta\Gamma}{2} \\ \Delta m - i\dfrac{\Delta\Gamma}{2} & M - i\dfrac{\Gamma_0}{2} \end{pmatrix}$$

Here, we took into account flavor mixing and CP-violation. We obtained interference. Difficulties in separating processes.

The cause of CP-violation is the mixing of left-handed and right-handed bosons.

(CPT)

Left-right model with CP violation

$$\begin{pmatrix} M - i\dfrac{\Gamma_0 - \delta\Gamma}{2} & \Delta m - i\dfrac{\Delta\Gamma}{2} \\ \Delta m - i\dfrac{\Delta\Gamma}{2} & M - i\dfrac{\Gamma_0 + \delta\Gamma}{2} \end{pmatrix}$$

Here, only flavor mixtures were taken into account.

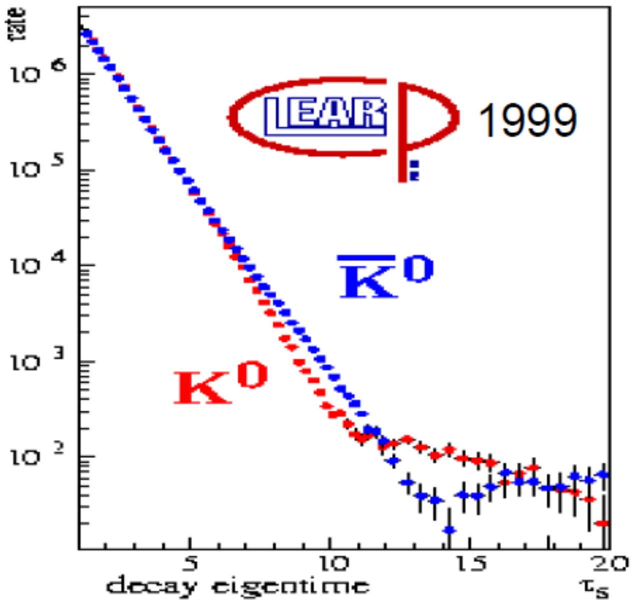
Here, only the CP-violation was taken into account.

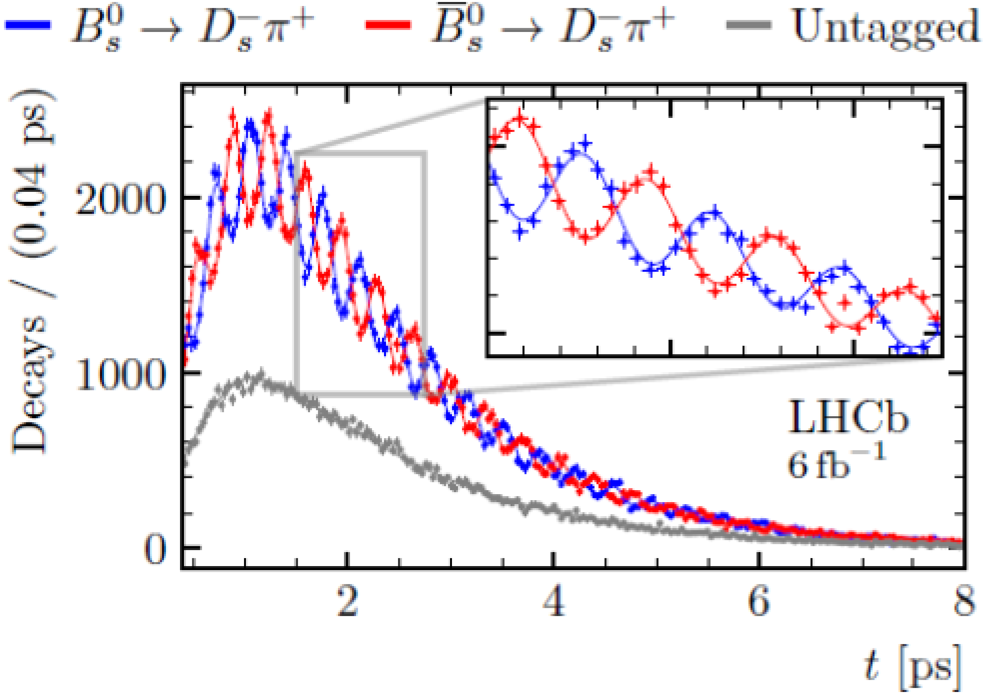
$$\delta\Gamma / \Gamma = -2\delta\zeta = 5.5\times 10^{-3}$$

CPT-conservation from decays *K0, K0*

$$\frac{\left(\Gamma_{K^0} - \Gamma_{\bar{K}^0}\right)}{\Gamma_{\text{average}}} = \left(5.4 \pm 5.4\right)\times 10^{-4}$$

The process of oscillations of neutral mesons is the transition of particles into antiparticles and back from antiparticles into particles. Transitions between neutral particles do not violate CPT invariance, but during these transitions, CP invariance may be violated.





Criteria for the validity of the CP-violation scheme in the left-right model

№1. The integral (average value over several decay periods) **effect of CP violation is practically zero** when the **oscillation period is significantly shorter than the decay time.**

№2. The integral **effect of CP violation appears** when the **oscillation period is significantly longer than the decay time.**

№3. The differential effect of CP violation (dependence on the decay time) **changes the sign of the effect to the opposite** when passing from a particle to an antiparticle, when the **oscillation period is significantly shorter than the decay time.**

Our task is **to calculate** the behavior of the integral and differential effects of CP violation depending on the above conditions and **compare with experimental results**.

Formulas describing CP-asymmetry in the left-right model

$$A_{CP}(t) = (-2\delta\zeta)\frac{2\Gamma}{\sqrt{(\Delta\Gamma)^2+(2\Delta m)^2}} \times \frac{(\Delta\Gamma)\,\mathrm{sh}(\Delta\Gamma t)+(2\Delta m)\sin(2\Delta m t)}{\sqrt{(\Delta\Gamma)^2+(2\Delta m)^2}\,[\mathrm{ch}(\Delta\Gamma t)+1]}$$

$$A_{pp\ \overline{p}\overline{p}} = \frac{\left|\psi_{up,p}\right|^2 - \left|\tilde{\psi}_{up,\overline{p}}\right|^2}{\left|\psi_{up,p}\right|^2 + \left|\tilde{\psi}_{up,\overline{p}}\right|^2}$$

$$\boxed{A_{CP}(t) = A^{LR} \times F \times A_{asym}(t)}$$

где $\boxed{A^{LR} = -2\delta\zeta}$ there is a CP-violating asymmetry of the left-right model

$$\boxed{F = \frac{2\Gamma}{\sqrt{(\Delta\Gamma)^2+(2\Delta m)^2}}}$$

- time-independent factor characterizing a specific meson

$$\boxed{A_{asym}(t) = \frac{(\Delta\Gamma)\,\mathrm{sh}(\Delta\Gamma t)+(2\Delta m)\sin(2\Delta m t)}{\sqrt{(\Delta\Gamma)^2+(2\Delta m)^2}\,[\mathrm{ch}(\Delta\Gamma t)+1]}}$$

- time-dependent asymmetry characterizing a particular meson

The integral value of CP-violating asymmetry is: $\boxed{A_{CP} = \int A_{CP}(t)e^{-t/\tau}dt}$

Integral asymmetries $\widetilde{A}_{p\bar{p}}$ for K^0, D^0, B^0 and B_S^0-mesons, which were calculated using wave functions – Exact and approximate formulas – Approx.

$\boxed{A^{LR} = -2\delta\zeta}$ CP-violating left-right model asymmetry

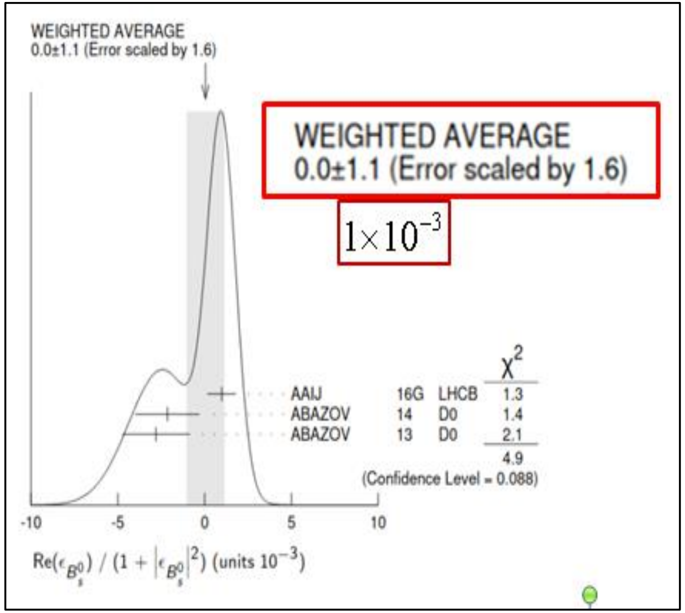
$$\boxed{\delta\Gamma = -2\delta\zeta \times \Gamma = 5.5 \times 10^{-3} \times \Gamma}$$

Meson	Γ, $\delta\Gamma[eV]$	calculated A_{LR}	experimental A_{LR}	$\Gamma / 2\Delta m = T_{osc} / \tau_{dec}$
K^0	3.68×10^{-6} (1.9×10^{-8})	5.5×10^{-3}	$(6.6 \pm 1.3 \pm 1.0) \times 10^{-3}$ [24]	2.13
D^0	1.61×10^{-3} (8.5×10^{-6})	5.3×10^{-3}	$(6.8 \pm 0.65) \times 10^{-3}$ [25]	250
B^0	4.33×10^{-4} (2.3×10^{-6})	3.3×10^{-3}	$(5 \pm 12 \pm 14) \times 10^{-3}$ [26]	1.32
B_S^0	4.33×10^{-4} (2.3×10^{-6})	6.9×10^{-6}	$(0 \pm 1.0) \times 10^{-3}$ [27]	0.036

Fulfillment of the criterion №1 for B_s^0-meson.

The effect is zero with frequent oscillations.

the ratio of the decay rate to the oscillation frequency $\boxed{3.6 \times 10^{-2}}$



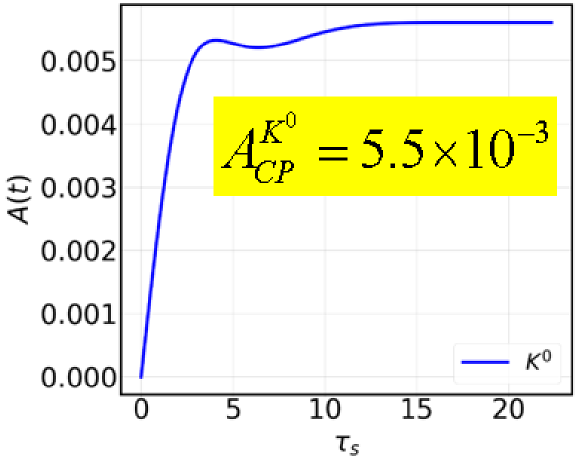
For the B_s^0 meson, the calculated integral effect of CP violation is equal to $\boxed{6.9 \times 10^{-6}}$ since during the oscillations of the B_s^0 meson, the CP asymmetry is averaged out.

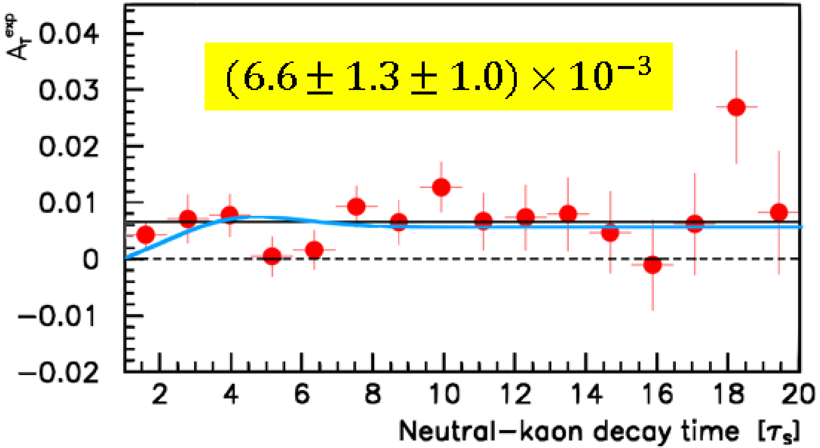
The point is that the sign of the CP-violating effect changes to the opposite during each period of oscillations, in accordance with the formula:

$$\varepsilon_{p\bar{p}} \approx e^{-\Gamma_0 t} \sin(2\Delta m t) \left(\frac{\delta\Gamma}{2\Delta m}\right),$$

Experimental observations with larger statistics in 2021 confirmed the absence of asymmetry with accuracy $\boxed{1.1 \times 10^{-3}}$

For the K^0 meson, the integral asymmetry calculation yielded a result of $A_{CP}^{K^0}$ =5.6 × 10^{-3}

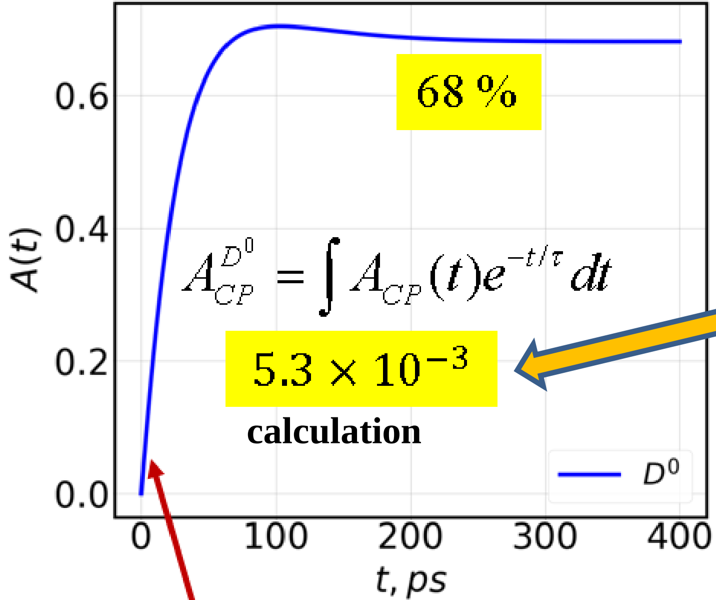




Calculated and experimental dependence of the CP-violating asymmetry effect on the decay time for the K^0meson.

It can be concluded that the experimental results for the K^0meson, within the available accuracy, **can be described in the left-right weak interaction model.**

For the D^0 meson, the ratio of the decay rate to the oscillation frequency is 2.5×10^2



68 %

$$A_{CP}^{D^0} = \int A_{CP}(t) e^{-t/\tau} dt$$

5.3×10^{-3}

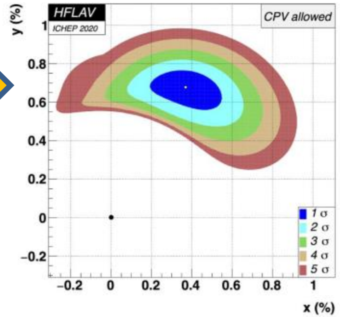
calculation

$$\boxed{\tau(D^0) = 4.1 \times 10^{-13} s}$$

$$\boxed{A = (6.8 \pm 0.65) \cdot 10^{-3}}$$

experiment

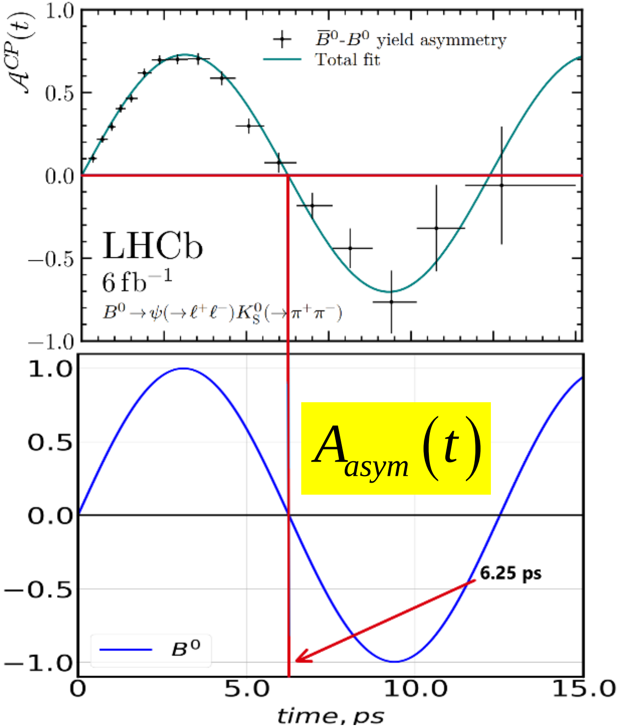
$$y = \frac{\Delta\Gamma}{2\Gamma} = 0.68^{+0.06}_{-0.07}. \quad \textbf{(\%)}$$



LHCb collaboration, JHEP 12 (2021) 141

It can be concluded that the **experimental results for the D^0 meson** within the available accuracy, **can be described by the left-right weak interaction model.**

23

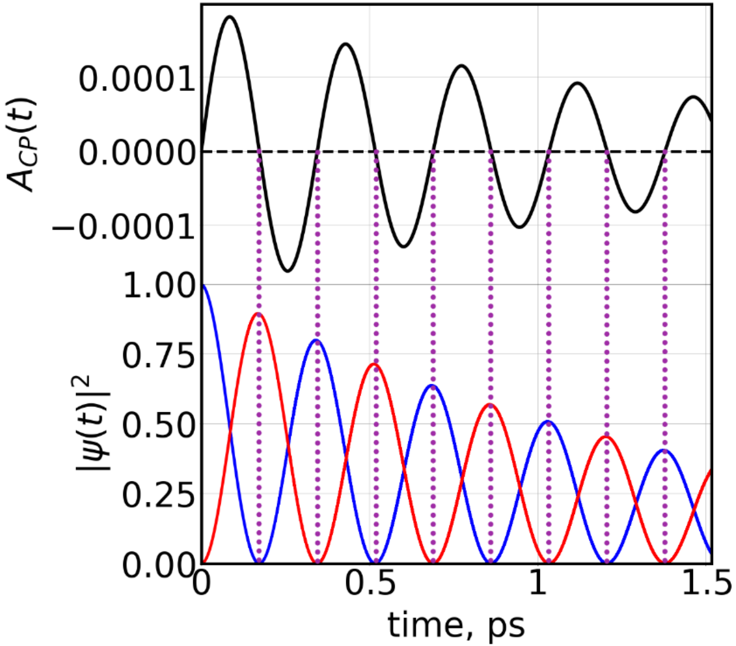


For the B^0 meson, we have fairly clear experimental confirmation that criterion №3 is met, i.e. a change in the sign of CP-violation occurs when moving from B^0 to $\overline{B}^0$.

The experimental result of the time dependence of the CP asymmetry is represented by an amplitude of 75% for the decay mode, which is only 5 10-5 of the total decay probability, and the average integral value of the CP-violating asymmetry for the *B*^0 meson in the PDG data is 0.005±0.012±0.014.

Comparison of the results of measuring the time dependence for the decay asymmetry $B^0 \to \psi K_S^0$ from work [16] and the calculation of the time-dependent component of the asymmetry. $A_{asym}(t)$

24



CP-violating asymmetry for the B_s^0 meson and the probabilities of states during oscillations for the particle (blue curve) and antiparticle (red curve).

Finally, for the B_s^0 meson, the ratio of the decay rate and the oscillation frequency, 3.6×10^{-2}

Clear synchronization in the change of sign of CP violation for the B_s^0 meson:

This is the **essence of the CP-violation process**, since the sign of CP-violation depends on the direction of time of the process, i.e. **in the forward or reverse direction in relation to the current time.**

25

CONCLUSION
about nature of CP violation

The nature of CP violation is in the presence of an admixture of a right vector boson:

$$\zeta = -0.039 \pm 0.014\ ,\ \delta = 0.070 \pm 0.010\ ,$$

but with different signs of the angle ζ for W+ and W-

Baryon asymmetry of the Universe in the left-right weak interaction model

$$\boxed{\frac{dn(t)}{dt}+3H(t)n(t)=-\frac{n(t)}{\tau}}$$

$$H(t)=\frac{0.53}{t[s]}$$

$$\boxed{\frac{dn(t)}{dt}+1.6\frac{n(t)}{t}=-\frac{n(t)}{\tau}}$$

$$n(t)=n_0\left(\frac{t}{t_0}\right)^{-1.6}e^{-\left(\frac{t-t_0}{\tau}\right)}$$

$$A(t)=\frac{n(t)-\bar{n}(t)}{n(t)+\bar{n}(t)}=\frac{1-e^{-(t-t_0)\left(\frac{1}{\tau_2}-\frac{1}{\tau_1}\right)}}{1+e^{-(t-t_0)\left(\frac{1}{\tau_2}-\frac{1}{\tau_1}\right)}}$$

$$\boxed{A(t)=\frac{(t-t_0)}{\tau}\frac{\Delta\tau}{\tau}}$$

$$\boxed{A_{n-\tilde{n}}=(3.2\pm1.6)\cdot10^{-3}=\Delta\tau/\tau}$$

Violation of CP-invariance in baryon-antibaryon

$$A\left(t=10^{-3}\ \mathrm{s}\right)=\frac{t-t_0}{\tau}\frac{\Delta\tau}{\tau}=(3.2\pm1.6)\times10^{-9}$$

$$\frac{t-t_0}{\tau}=\frac{\textbf{Time of hadronization}}{\textbf{Neutron lifetime}}=10^{-6}$$

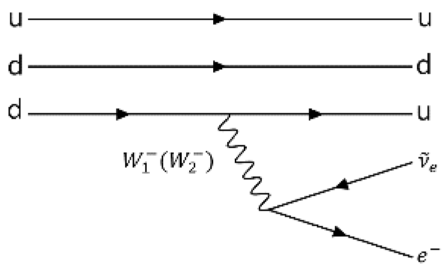
$$t-t_0\approx10^{-3}\ \mathrm{s}\qquad \tau\approx10^{3}\ \mathrm{s}$$

$$\boxed{\eta=\frac{1}{6}A\left(t=10^{-3}\ \mathrm{s}\right)=(5.3\pm2.6)\times10^{-10}}$$

$$\boxed{\eta=\frac{n_B-n_{\tilde{B}}}{n_\gamma}=6.1\times10^{-10}}$$

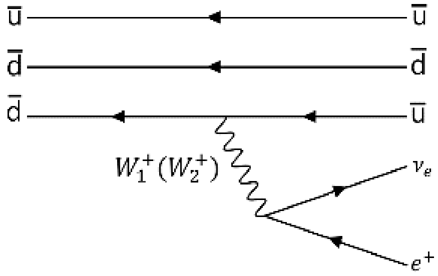
arXiv:2605.15771

Neutron decay



d→u transition

Antineutron decay

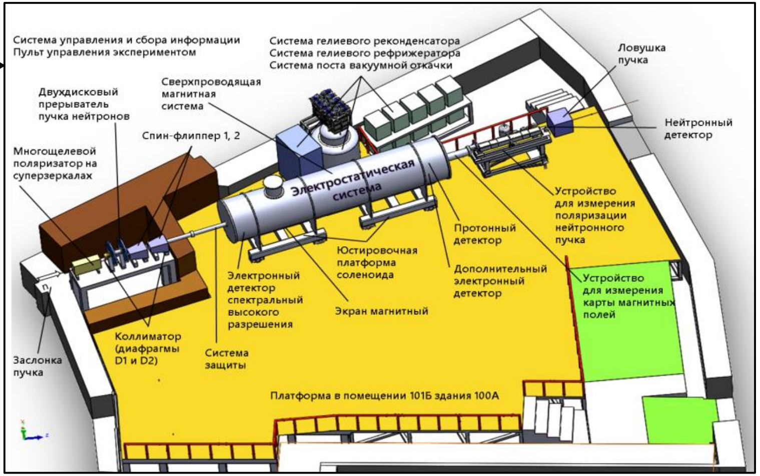


$\bar{d}\to\bar{u}$ transition

The extension of the Standard Model must be confirmed with increased experimental precision.

This can be done at the "Neutron Beta Decay" facility at the PIK reactor.

Project of the installation for measuring neutron decay asymmetries at the PIK reactor



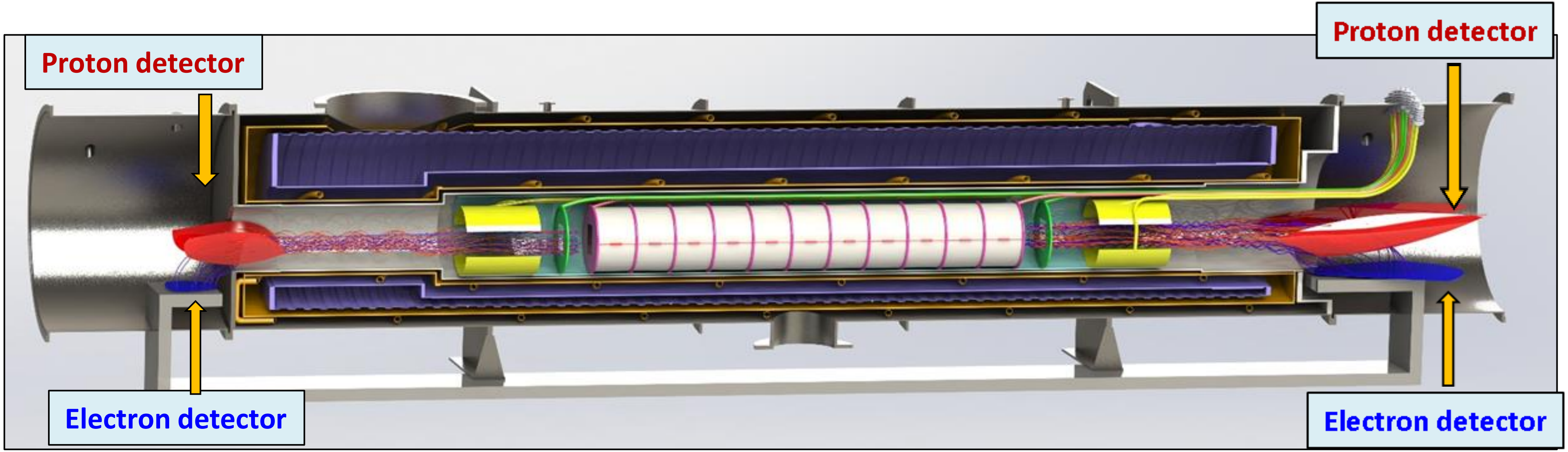
Manufacturing of the installation «NEUTRON DECAY»

Superconducting solenoid

Cryostat

Testing of the installation at NIIEFA 31.05.24.
A current of 1050 A was introduced into the superconducting solenoid.

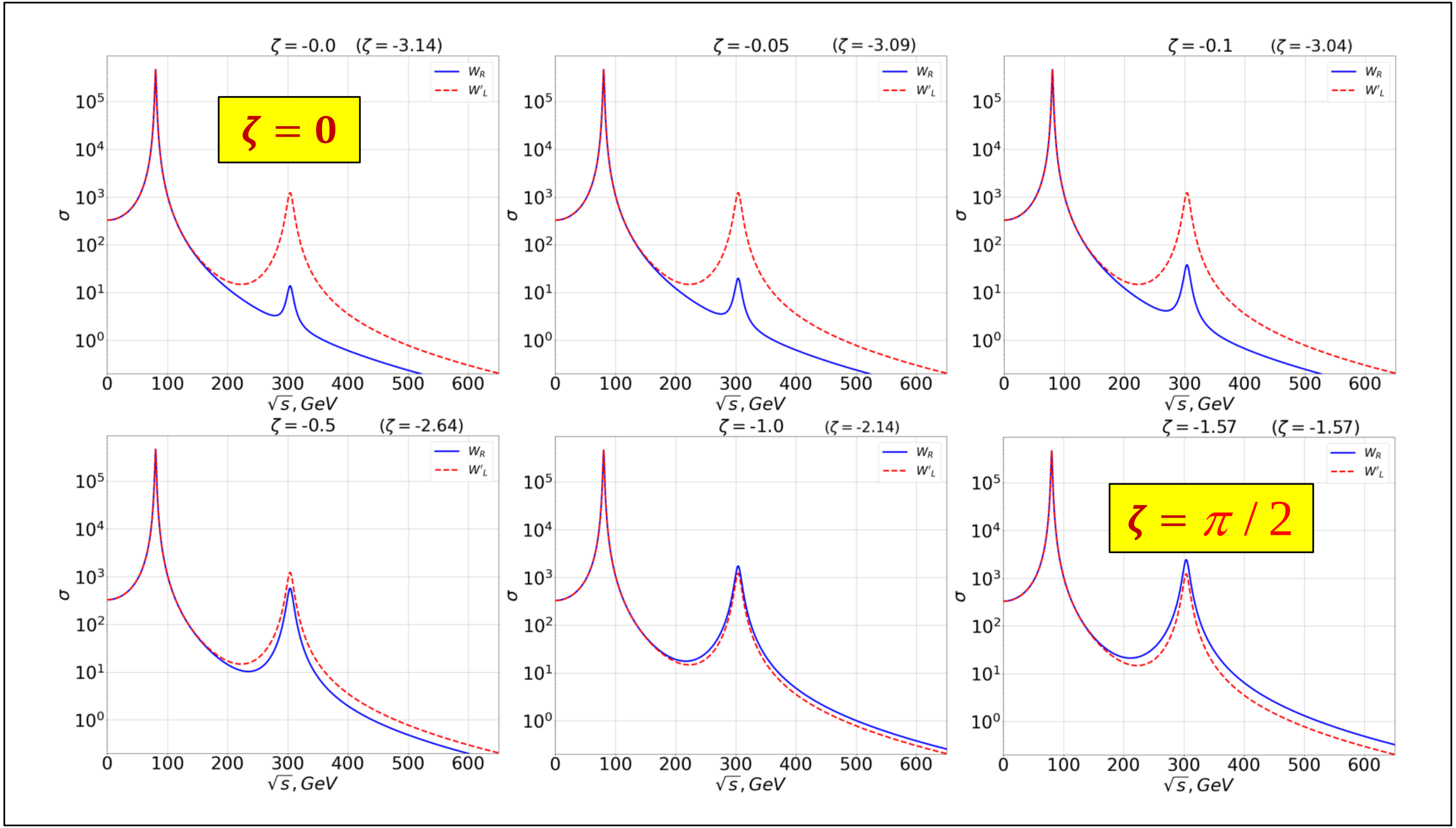
Project of the installation for measuring all three neutron decay asymmetries (a, A and B) at the PIK reactor



The planned increase in measurement accuracy by a factor of 3 will provide an answer to the fundamentally important question about the discrepancy between precision measurements of neutron decay and the Standard Model.

Experiments will show what happens next

Thank you for your attention



ζ = -0.0 (ζ = -3.14)
ζ = 0
ζ = -0.05 (ζ = -3.09)
ζ = -0.1 (ζ = -3.04)
ζ = -0.5 (ζ = -2.64)
ζ = -1.0 (ζ = -2.14)
ζ = -1.57 (ζ = -1.57)
ζ = π / 2
W_R
W'_L
σ
√s, GeV

33