V_{us}: an inclusive measurement in τ decays

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Belle II DESY τ meeting - 11.04.25

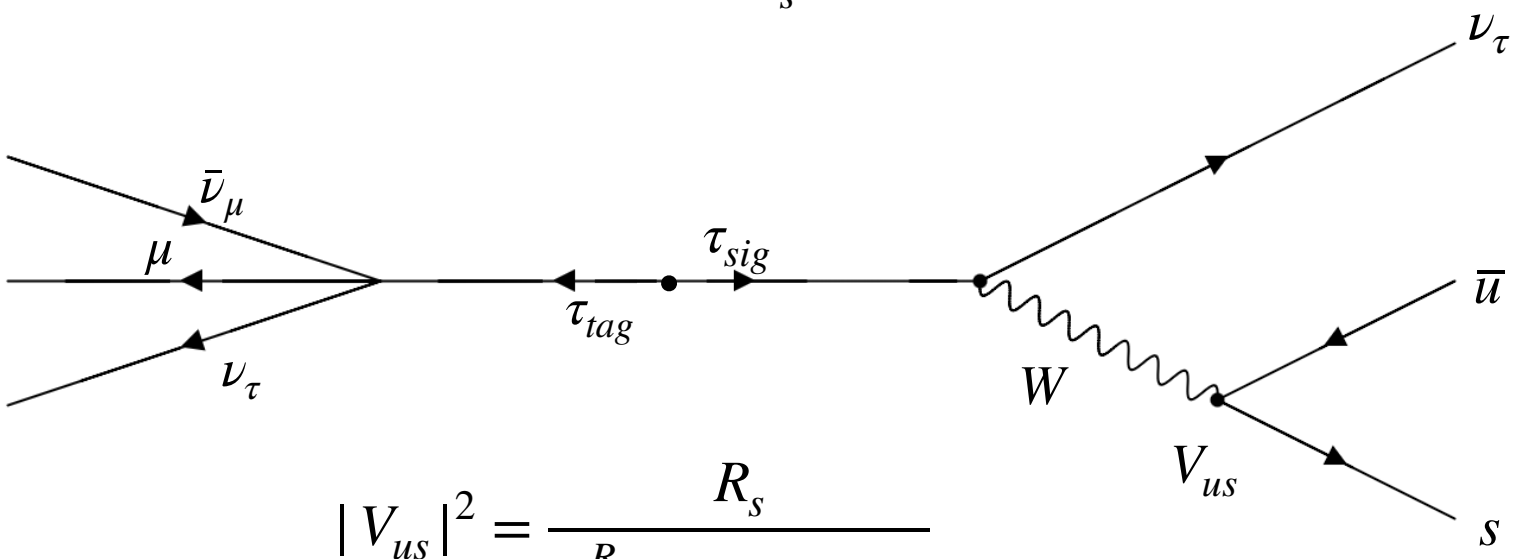
HELMHOLTZ

DESY.

$|V_{us}|$ from $\mathcal{B}(\tau \to X_s \nu)$

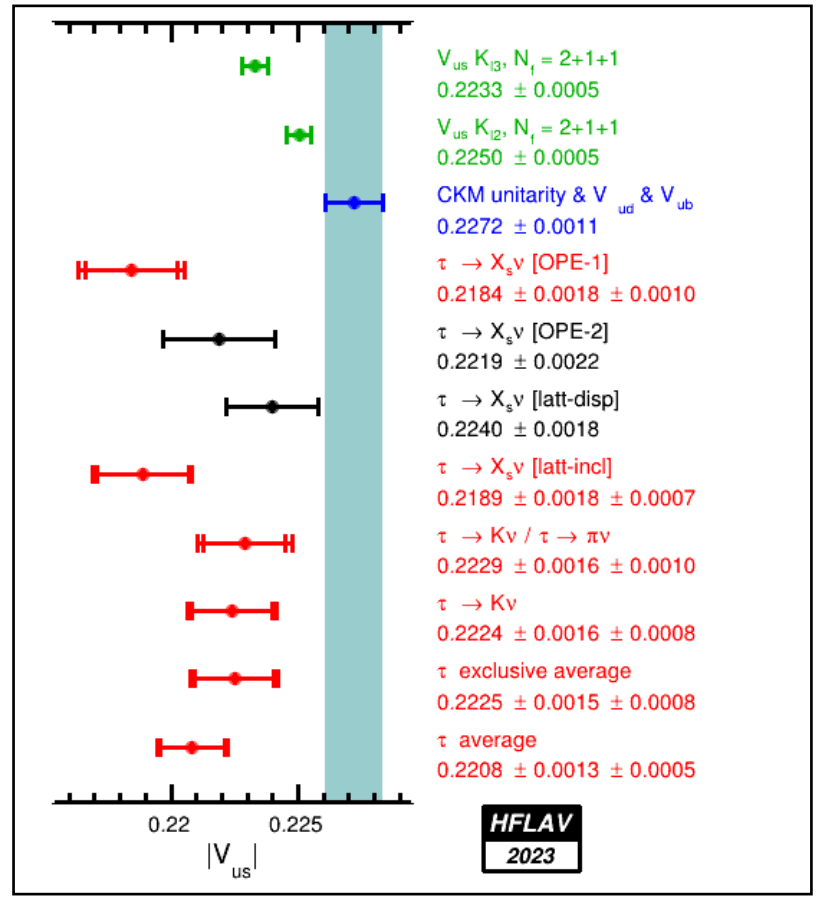
Precision measurement of $|V_{us}|$ is a test of CKM unitarity, where an anomaly is present

An inclusive measurement of $\tau \to X_s \nu$ was never done before



$$|V_{us}|^2 = \frac{R_s}{\frac{R_{VA}}{|V_{ud}|^2} - \delta R_{theory}}$$

$$R_s = \frac{\Gamma(\tau \to X_s \nu)}{\Gamma(\tau \to e\nu\nu)} \qquad R_{VA} = \frac{\Gamma(\tau \to Y_d \nu)}{\Gamma(\tau \to e\nu\nu)}$$



Decay channels of interest

	Decay	Contribution	BR [10^-3]
1	$\tau^+ \to K^+ X^0 \nu$	Vus	10
4	$\tau^+ \to K^+ K_S X^0 \nu$	Vud	3-4
3	$\tau^+ \to K^+ K^- \pi^+ X^0 \nu$	Vud	1-2
7	$\tau^+ \to K^+ K_L X^0 \nu$	Vud control for 4	-

	Decay	Contribution	BR [10^-3]
2	$\tau^+ \to \pi^+ K_S X^0 \nu$	Vus	10
5	$\tau^+ \to \pi^+ K_S K_S X^0 \nu$	Vud	0.2-0.5
6	$\tau^+ \to \pi^+ K_L K_S X^0 \nu$	Vud	1-2
4b	$\tau^+ \to \pi^+ K_S K^+ \pi^- X^0 \nu$	Vud	<3-4

$$B_{K^+} = B(\tau^+ \to K^+ Y^0 \nu) = \\ = \frac{N_1}{\varepsilon_1} - \frac{N_3}{\varepsilon_3} - 2\frac{3}{2}\frac{N_4}{\varepsilon_4}$$

$$X^0 = \pi^0, \pi^+\pi^-, \\ K_S, K_L, K^+\pi^-$$

$$Y^0 = \pi^0, \pi^+\pi^-$$

$$B_{K^0} = B(\tau^+ \to K^0 \pi^+ Y^0 \nu) = \\ = \frac{3}{2}\left(2\frac{N_2}{\varepsilon_2} - 2\frac{3}{2}\frac{N_4}{\varepsilon_4} - 2\frac{3}{2}\frac{N_5}{\varepsilon_5} - \frac{N_6}{\varepsilon_6}\right)$$

b

Decay channels with three strange mesons are neglected ($X^0 \neq K^+K^-$)

mDST file

/pnfs/desy.de/belle/belle2/DATA/belle/MC/release-08-00-08/DB00003307/MC16rd_proc16/prod00045482/s00/e0012/4S/r03363/taupair/mdst/sub00/mdst_000002_prod00045482_task113362000002.root

Total events: 371605 ($\mathscr{L} = 0.4\,\mathrm{fb}^{-1}$)

Events with τ_{tag} **reconstructed** in $l\nu\nu$: 296753

Example $\tau^+ \to \pi^+ K_S K^+ \pi^- X^0 \nu$:

At least one charged K, at least one Ks (reconstructed in 2 pions, both charged or neutral), at lest two charged pions (from MCParticleList)

2KL	$\tau^+ \to \pi^+ K_L X^0 \nu$	3688	1.24
5KL	$\tau^+ \to \pi^+ K_L K_L X^0 \nu$	114	0.04
4bKL	$\tau^+ \to \pi^+ K_L K^+ \pi^- X^0 \nu$	285	0.09

Too few K_L (or too many K_S ?)

	Decay	N	%
1	$\tau^+ \to K^+ X^0 \nu$	8133	2.74
4	$\tau^+ \to K^+ K_S X^0 \nu$	613	0.21
3	$\tau^+ \to K^+ K^- \pi^+ X^0 \nu$	761	0.26
7	$\tau^+ \to K^+ K_L X^0 \nu$	521	0.18
2	$\tau^+ \to \pi^+ K_S X^0 \nu$	4181	1.41
5	$\tau^+ \to \pi^+ K_S K_S X^0 \nu$	395	0.13
6	$\tau^+ \to \pi^+ K_L K_S X^0 \nu$	664	0.22
4b	$\tau^+ \to \pi^+ K_S K^+ \pi^- X^0 \nu$	502	0.17