

NUCLEON CHARGES ON 2+1 FLAVOR NME CLOVER ENSEMBLES

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Rich Physics

Precision tests of the Standard Model

- V_{ud} from β decay to test CKM unitarity, spin of the nucleon
- Searches for new scalar and tensor interactions
- Dark matter and EDM phenomenology

Nucleon isovector charges probed in neutron β decay experiments

- g_A : neutron β decay
- g_S : scalar BSM interactions
- g_T : tensor BSM interactions and EDMs

Status

Lattice calculation of nucleon matrix elements

- Eleven 2+1-flavor NME Clover Ensembles

- Spectrum and scale setting:

[arXiv:2601.10857](https://arxiv.org/abs/2601.10857)

- Isovector Nucleon Charges g_A, g_S, g_T

(under analysis)

- Axial Form factors

(under analysis)

- Electric and Magnetic form factors

(under analysis)

- Second Mellin moments: $\langle x \rangle_q, \langle x \rangle_{\Delta q}, \langle x \rangle_{\delta q}$

(To appear on arXiv next week)

Controlling systematics:

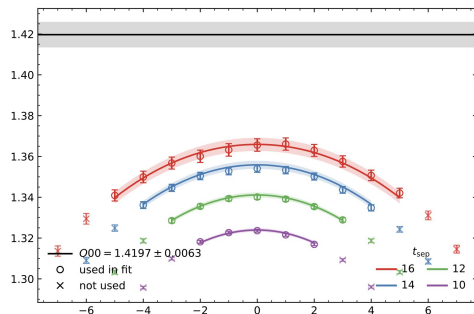
- Removing contributions of excited states
- Chiral – continuum - finite volume extrapolation
- Renormalization

[arXiv:2601.10857](https://arxiv.org/abs/2601.10857)

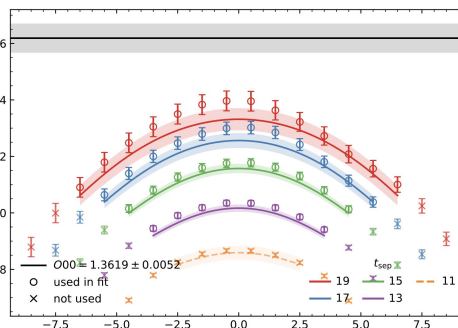
Lattice Details

Ens. ID				a (fm)			L (fm)	Total Lattices
a117m310	$32^3 \times 96$	6.1	1.249310	0.117	310	5.85	3.7	4865
a087m290L	$48^3 \times 128$	6.3	1.205366	0.087	289	6.16	4.2	6223
a087m230	$48^3 \times 128$	6.3	1.205366	0.087	233	5.0	4.2	5200
a087m230X	$48^3 \times 128$	6.3	1.205366	0.087	228	5.0	4.2	3167
a086m180L	$64^3 \times 128$	6.3	1.205366	0.086	179	5.1	5.5	6622
a068m290	$48^3 \times 128$	6.5	1.170082	0.068	290	4.18	3.3	7620
a067m230	$64^3 \times 192$	6.5	1.170082	0.068	234	5.2	4.4	3604
a067m175	$72^3 \times 192$	6.5	1.170082	0.068	175	4.4	4.9	5556
a067m135	$96^3 \times 192$	6.5	1.170082	0.067	135	4.4	6.4	2904
a053m295	$64^3 \times 192$	6.7	1.142727	0.053	295	4.8	3.4	5301
a053m230	$72^3 \times 192$	6.7	1.142727	0.053	226	4.5	3.8	3331

Isovector Axial Charge

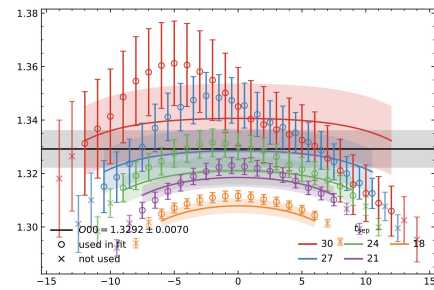


$a12m310$

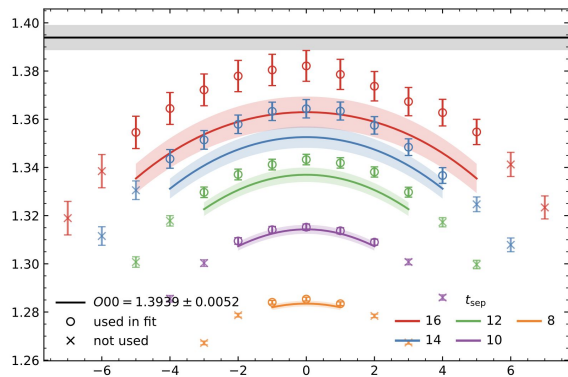


$a087m290L$

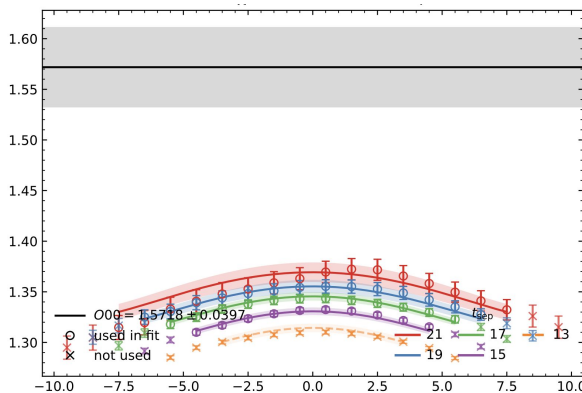
$a068m290$



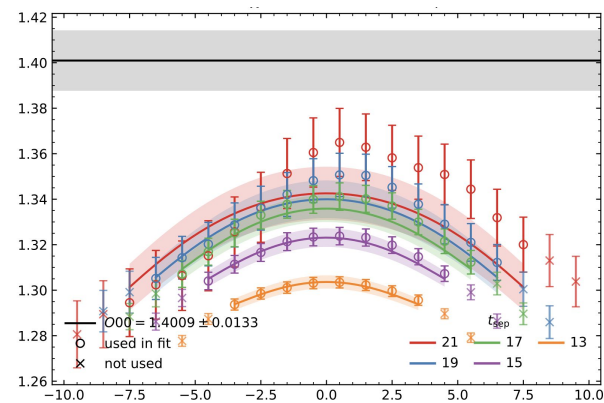
$a053m295$



$a086m180L$

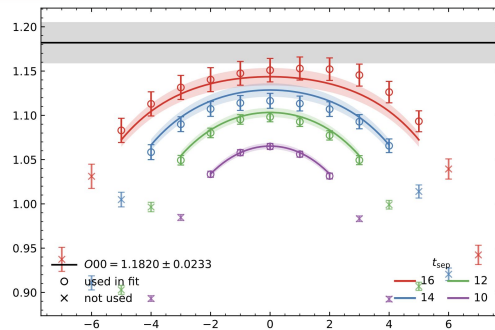


$a067m175$



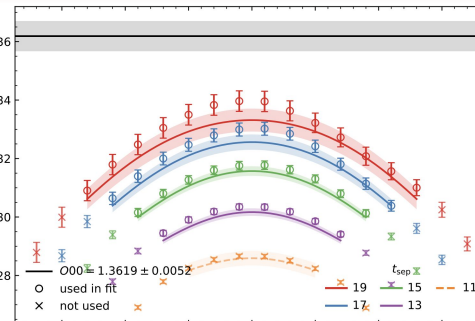
$a067m135$

Isovector Scalar Charge

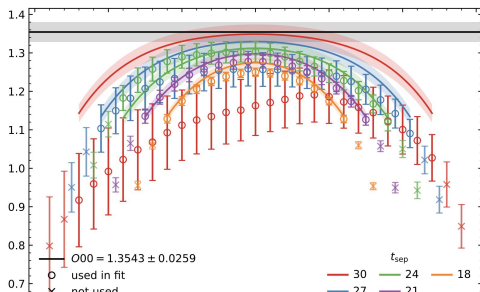


$a_{12}m_{310}$

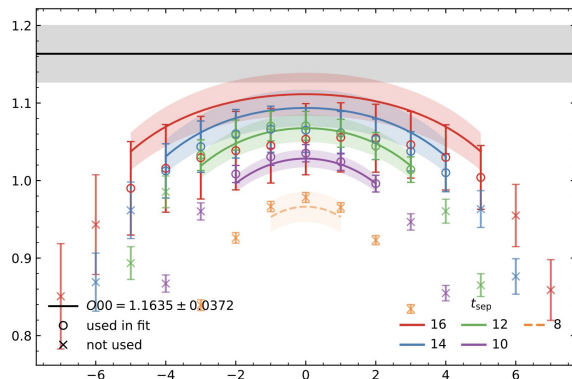
$a_{087}m_{290L}$



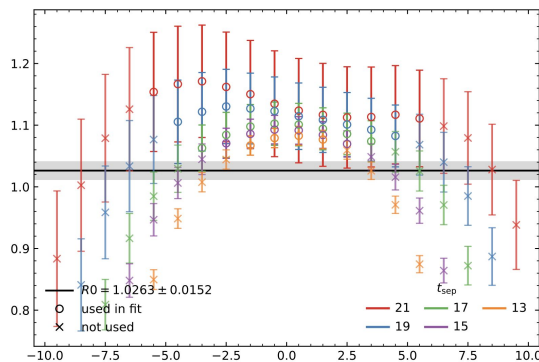
$a_{068}m_{290}$



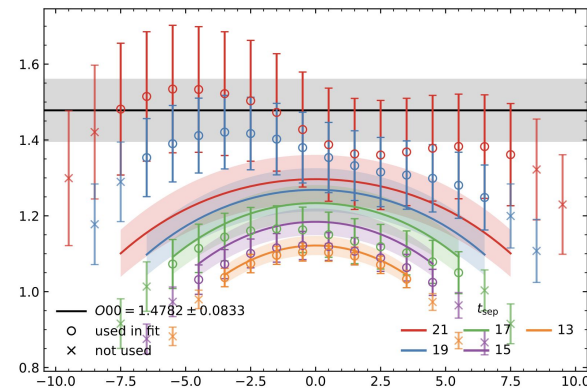
$a_{053}m_{295}$



$a_{086}m_{180L}$



$a_{067}m_{175}$

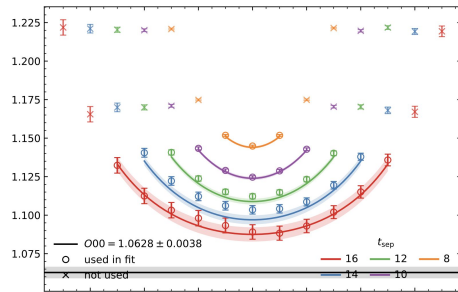


$a_{067}m_{135}$

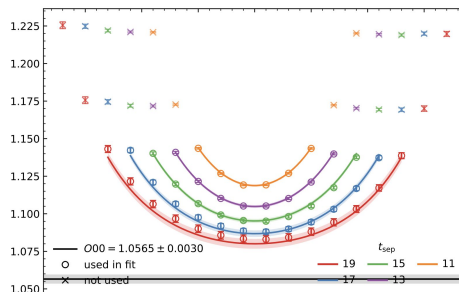
Isovector Tensor Charge



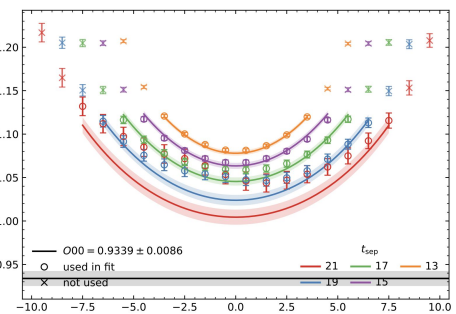
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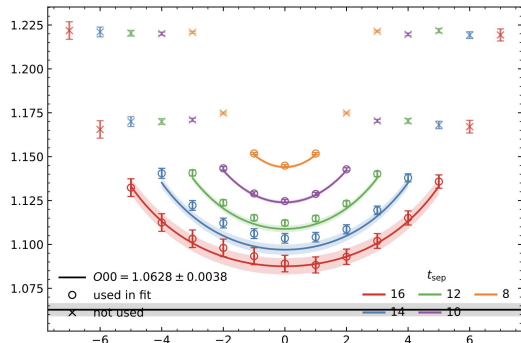
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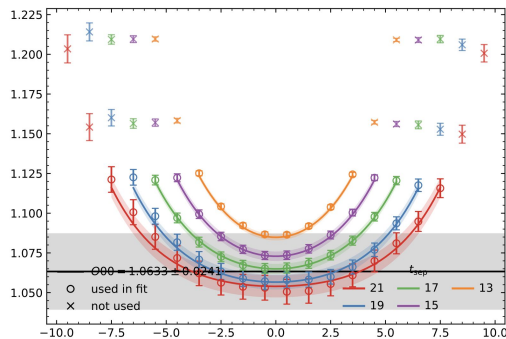
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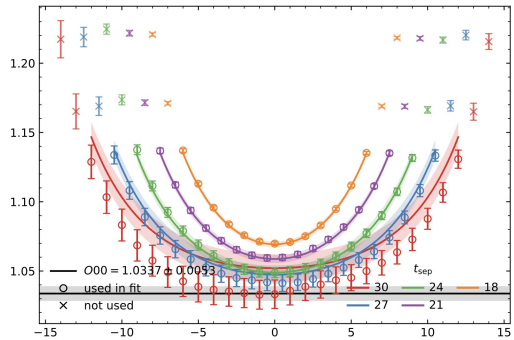
a053m295



a086m180L



a067m175



a067m135

Moments of distributions

JHEP 21, 004 (2020):

arXiv:



$$\langle x \rangle_q = \int_0^1 x [q(x) + \bar{q}(x)] dx$$

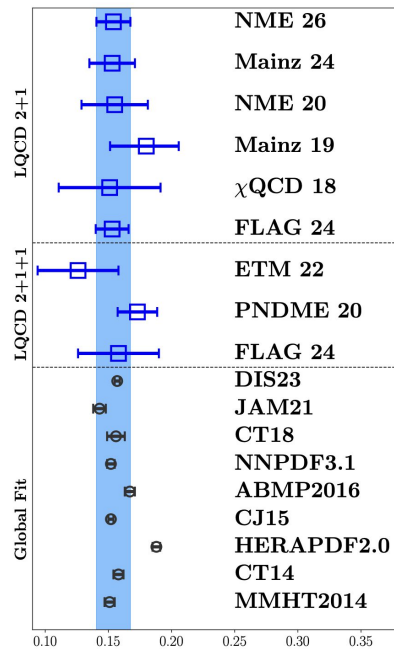
$$\langle x \rangle_{\Delta q} = \int_0^1 x [\Delta q(x) + \Delta \bar{q}(x)] dx$$

$$\langle x \rangle_{\delta q} = \int_0^1 x [\delta q(x) + \delta \bar{q}(x)] dx$$

Status of results:

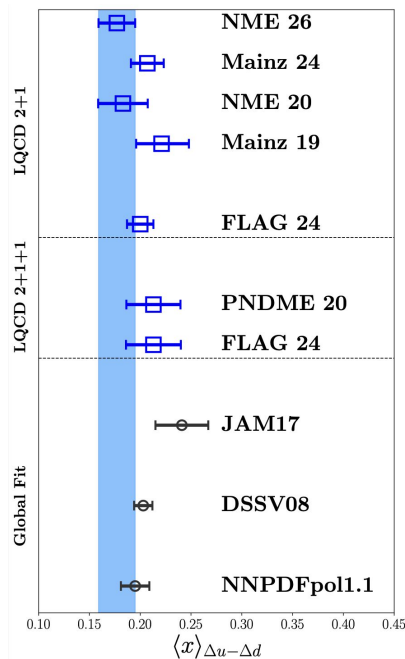


$$\langle x \rangle_q = 0.154(10)(9)$$



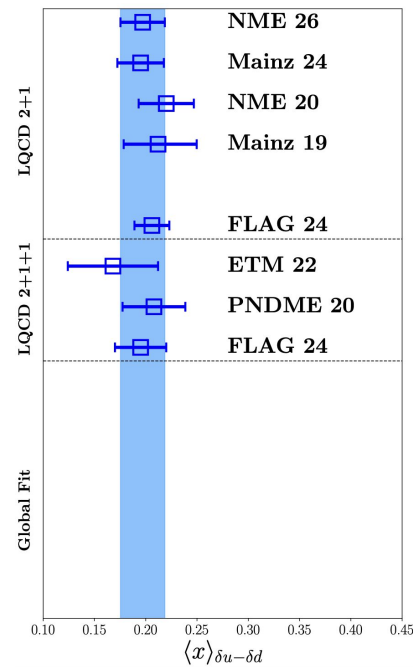
Momentum Fraction

$$\langle x \rangle_{\Delta q} = 0.177(10)(15)$$



Helicity Moment

$$\langle x \rangle_{\delta q} = 0.197(12)(18)$$



Transversity Moment



Conclusions

- Need higher statistics
- Need more ensembles

All these results to be published
by the end of this year

CKM Unitarity

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

First Row Unitarity measure $\Delta_{\text{CKM}} = |V_{ud}|^2 + |V_{us}|^2 + |V_{ub}|^2 - 1$

$|V_{ub}| \sim 10^{-3}$, negligible

Current Δ_{CKM} :

- 2.8 σ deviation when using (K ℓ 3 , K μ 2 / $\pi\mu$ 2)
- 3.0 σ deviation when using (K ℓ 3 , β -decay)
- 1.7 σ deviation when using (K μ 2 / $\pi\mu$ 2 , β -decay)