Ab initio calculation of the ^{6}He β-decay spectrum for new physics searches

INT Program 23-1b
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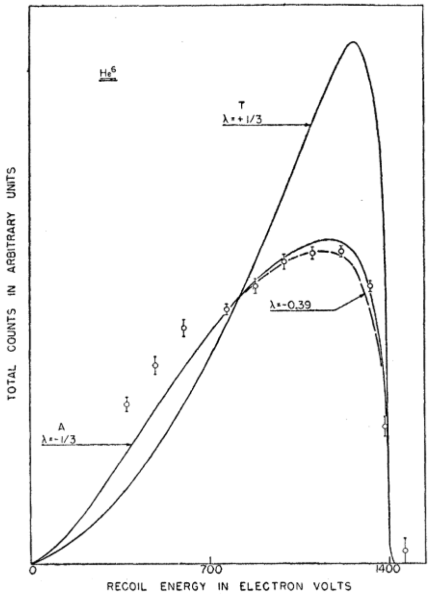
Beta decay for fundamental symmetries

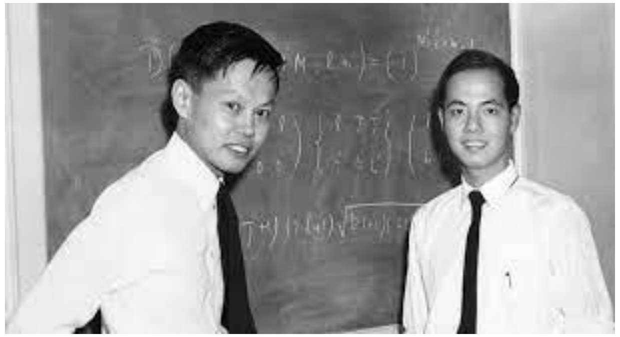
Beta decay has a rich history as a probe of the SM as the fundamental theory of the weak interaction and that continues to this day



Wu et al. Phys. Rev. 105, 1413 (1957)

Feynman and Gell-Mann
Phys. Rev. 109, 193 (1958)

Allen et al.
Phys. Rev. 116, 134 (1959)

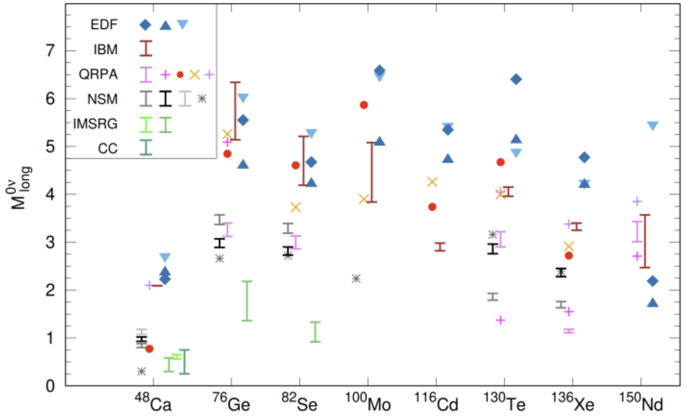


Lee and Yang, Phys. Rev. 104, 254 (1956)

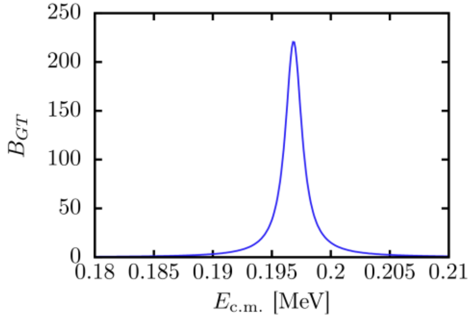
Fermi, Z. Physik 88, 161 (1934)

Beta decay for fundamental symmetries

Improve NMEs for LNV searches

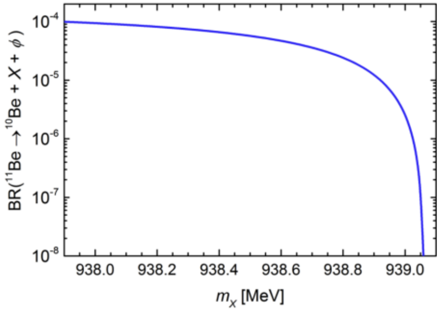


Agostini et al. Rev. Mod. Phys. 95 (2023) 2, 025002

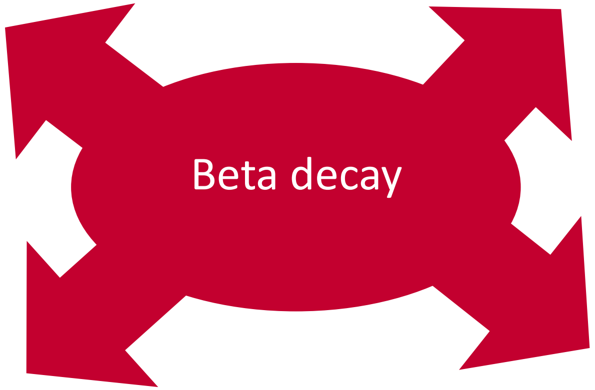


Atkinson et al. PRC 105, 054316 (2022)

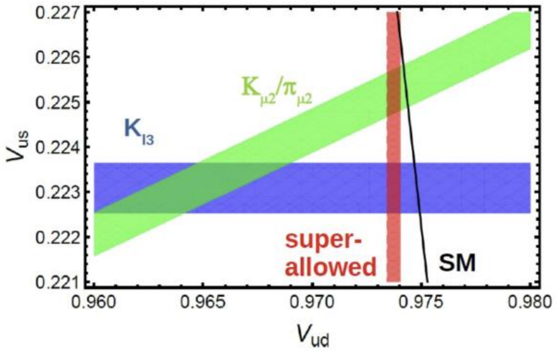
Pfützner and Riisager PRC 97, 042501(R) (2018)

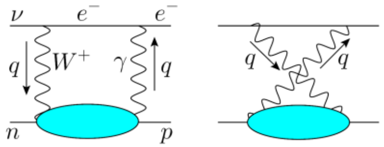


Understanding possible exotic decay signals



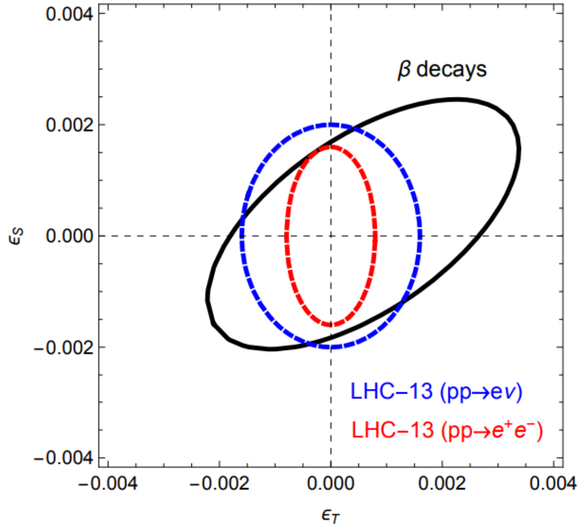
Tests of CKM unitarity





Seng et al. PRD 100, 013001 (2019)

Seng arXiv:2207.10492

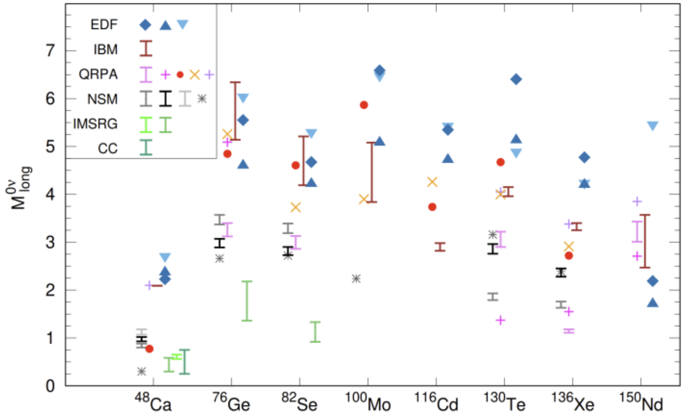


Falkowski et al. J. High Energ. Phys. 2021, 126 (2021)

Probe of non-standard CC weak currents

Beta decay for fundamental symmetries

Improve NMEs for LNV searches



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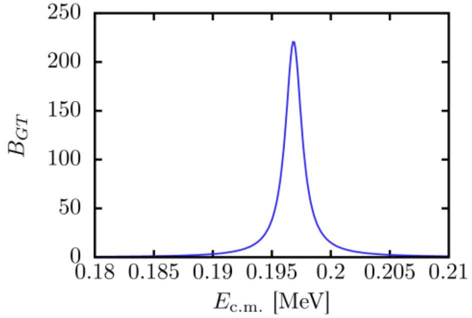

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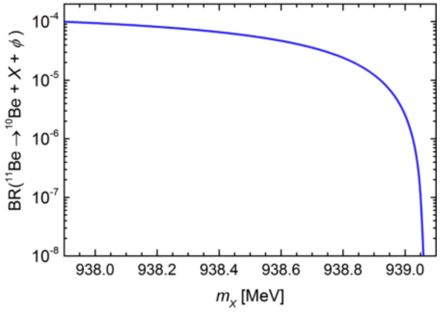
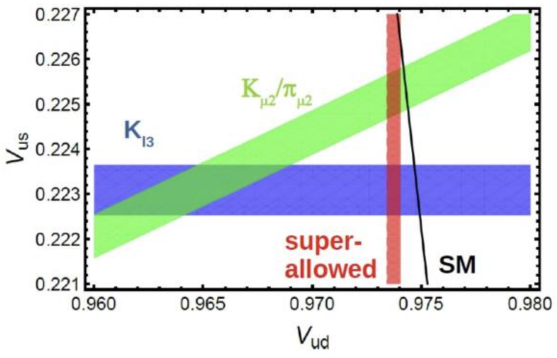
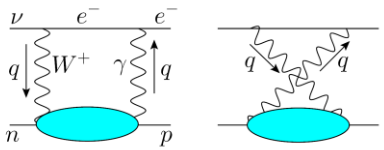


Understanding possible exotic decay signals

An accurate understanding of nuclear structure and dynamics is required to disentangle new physics effects from nuclear effects

Tests of CKM unitarity





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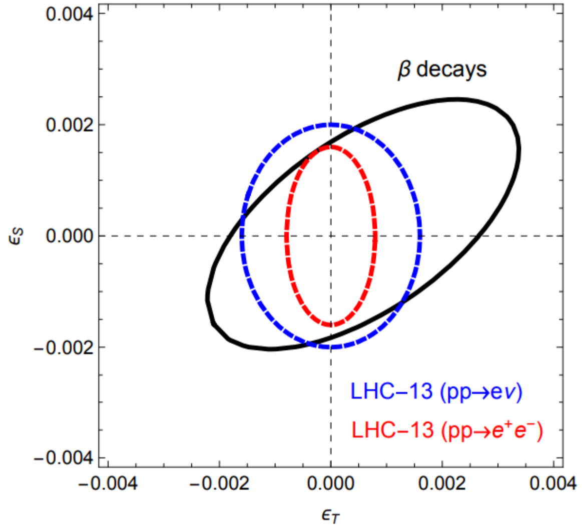


Falkowski et al. J. High Energ. Phys. 2021, 126 (2021)

Probe of non-standard CC weak currents

^{6}He Beta Decay Spectrum

Beta decay in light nuclei is important for experiments searching for beyond standard model physics

Goal: Predict beta decay spectrum for ^{6}He retaining one- and two-body electroweak currents

Vector
Scalar → **Fermi**

Axial
Tensor
Pseudoscalar → **GT**

$$\mathcal{L} = \mathcal{L}_{\mathrm{SM}} + \left[-\frac{G_F}{\sqrt{2}} V_{ud} \sum_i \epsilon_i \bar{l} \gamma_\mu (1-\gamma_5)\nu_l \cdot \bar{u}\Gamma_i^\mu d + \mathrm{h.c.} \right]$$

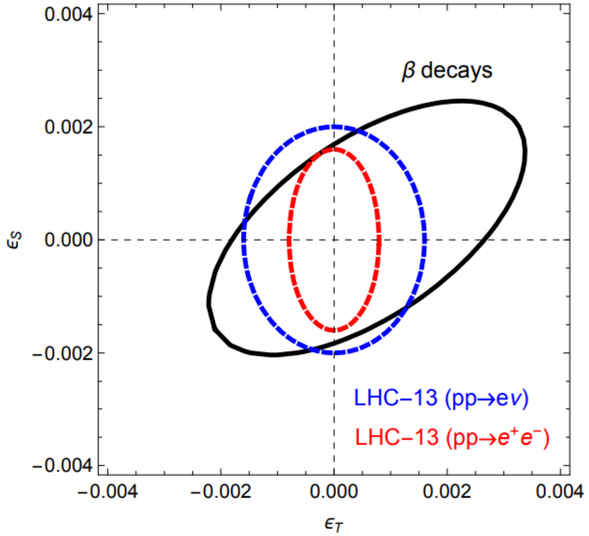
$$i \in \{A, V, P, S, T\} \qquad \epsilon_i \lesssim 10^{-3}$$

$$\Lambda_{\mathrm{BSM}} \sim \frac{v}{\sqrt{\epsilon_i}} \sim 1\text{–}10\ \mathrm{TeV}$$

Precision beta-decay is competitive with accelerator constraints on new electroweak physics parameters

NSCL He6 CRES lpc caen

^{6}He beta-decay spectrum has been/will be measured for BSM searches **aiming for permille (0.1%) uncertainty**



Cirigliano et al. arXiv:1097.02164 (2019)

Falkowski, González-Alonso, and Naviliat-Cuncic J. High Energ. Phys. 2021, 126 (2021)

The Approach

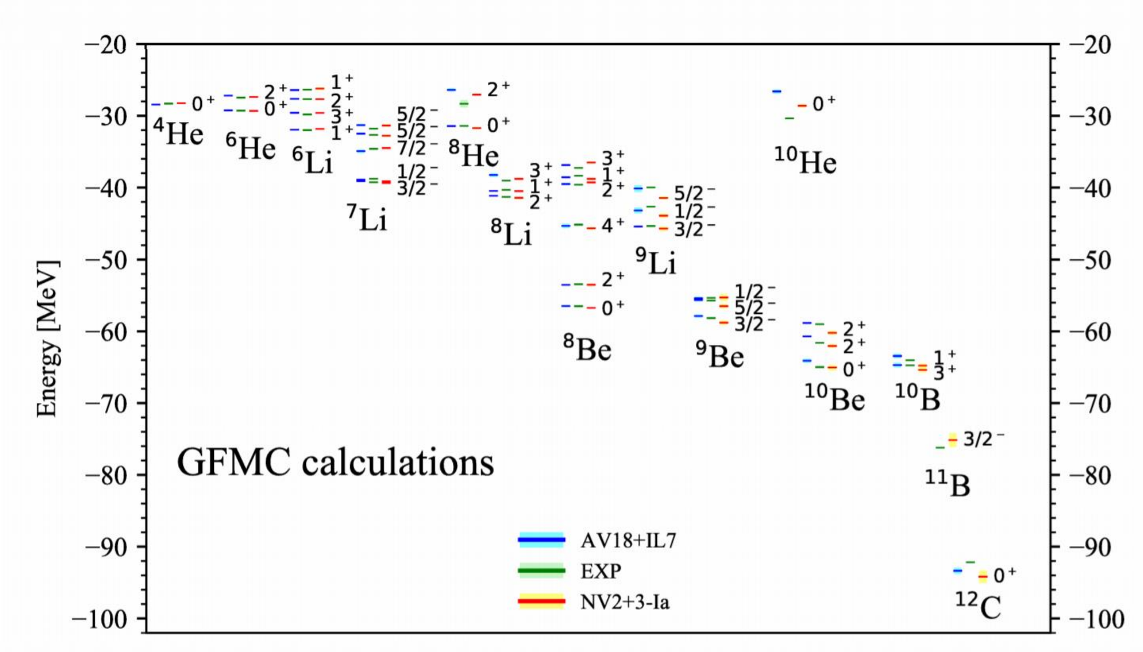
- Use **χEFT Hamiltonians and transition operators** to consistently describe the nuclear forces and many-body currents

- Compute matrix elements with **quantum Monte Carlo** to have controlled and reliable many-body results

- Provide an assessment of **theory and model uncertainty** on the beta decay spectrum

The Norfolk (NV2+3) Interaction

$$H = \sum_i K_i + \sum_{i<j} v_{ij} + \sum_{i<j<k} V_{ijk}$$



Piarulli et al. PRL 120, 052503 (2018)

Derived in χEFT with pion, nucleon, and delta degrees of freedom

NV2 is fully local chiral interaction to N2LO (including some N3LO contributions) containing 26 unknown contact LECs

NV3 includes two long-range interactions and two contact interactions introducing two new unknown LECs, form as derived by **van Kolck PRC 49, 2932 (1994)** and **Epelbaum et al PRC 66, 064001 (2002)**

The Norfolk (NV2+3) Interaction

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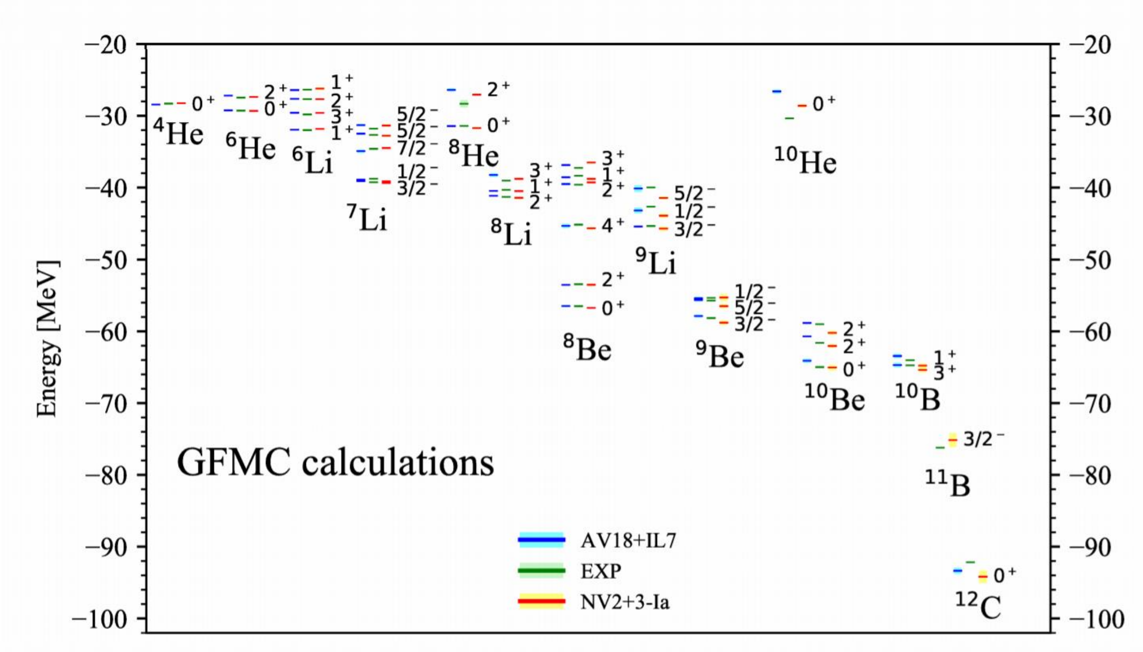
Eight different Model classes:



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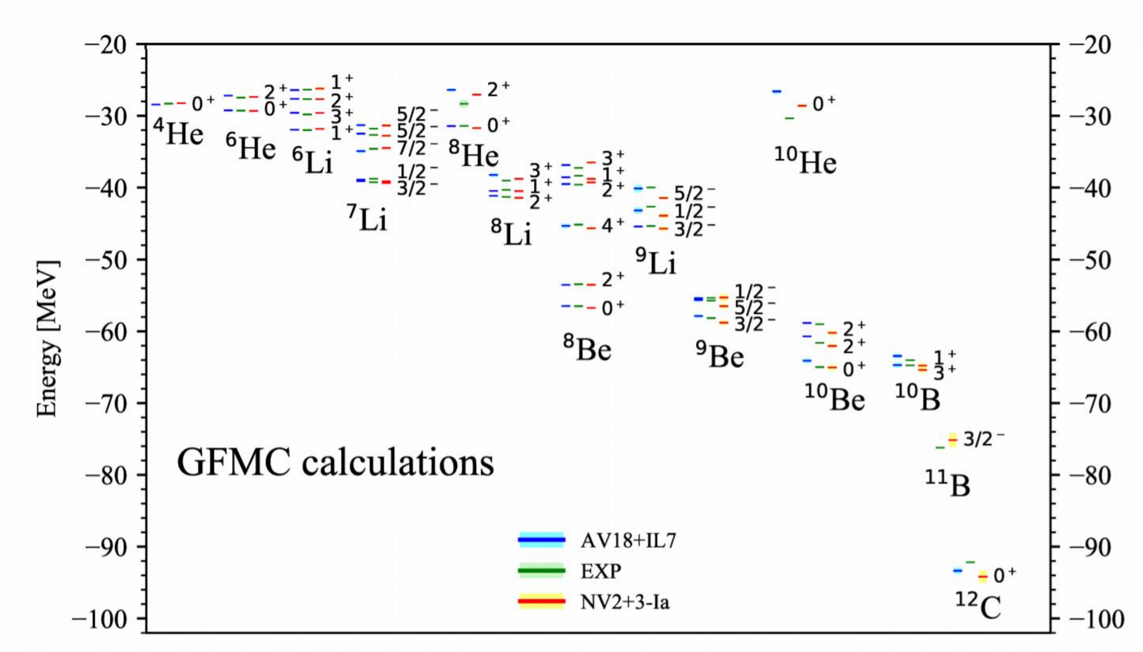

Piarulli et al. PRL 120, 052503 (2018)

Eight different Model classes:

- I [II]: NN scattering to fit two-body interaction from 0 to 125 [200] MeV

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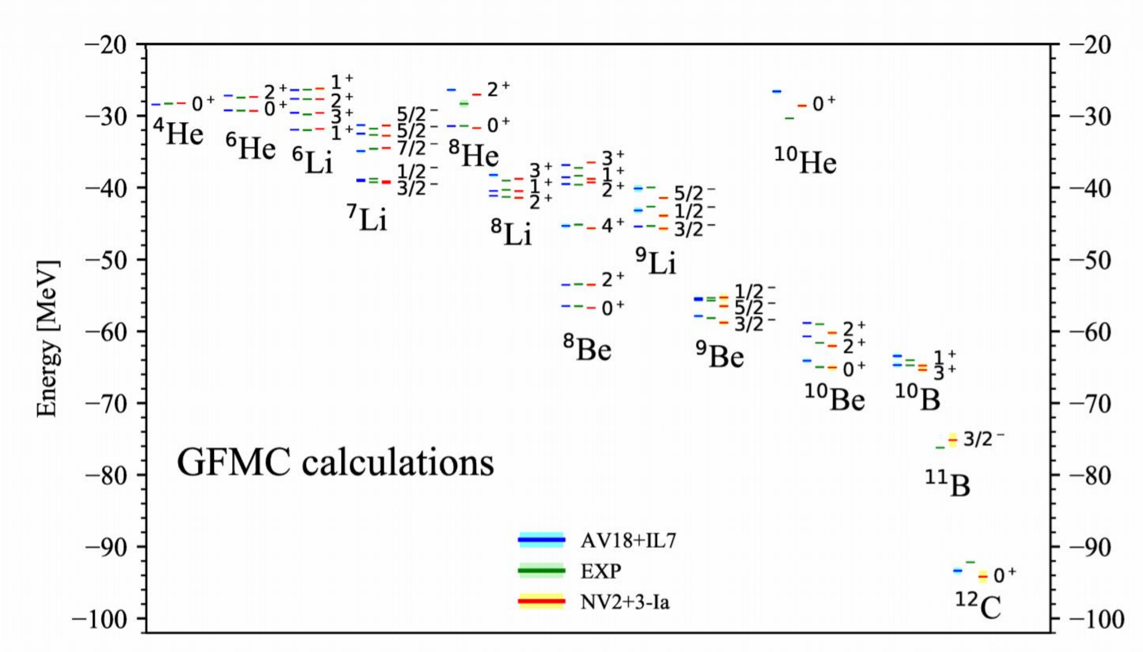

Piarulli et al. PRL 120, 052503 (2018)

Eight different Model classes:

- I [II]: NN scattering to fit two-body interaction from 0 to 125 [200] MeV
- a [b]: Long- and short-range regulators (R_L,R_S) = (1.2 fm, 0.8 fm) [(1.0 fm, 0.7 fm)]

$$C_{R_L}(r) = 1 - \frac{1}{(r/R_L)^6 e^{(r-R_L)/a_L} + 1}$$

$$C_{R_S}(r) = \frac{1}{\pi^{3/2} R_S^3} e^{-(r/R_S)^2}$$

The Norfolk (NV2+3) Interaction

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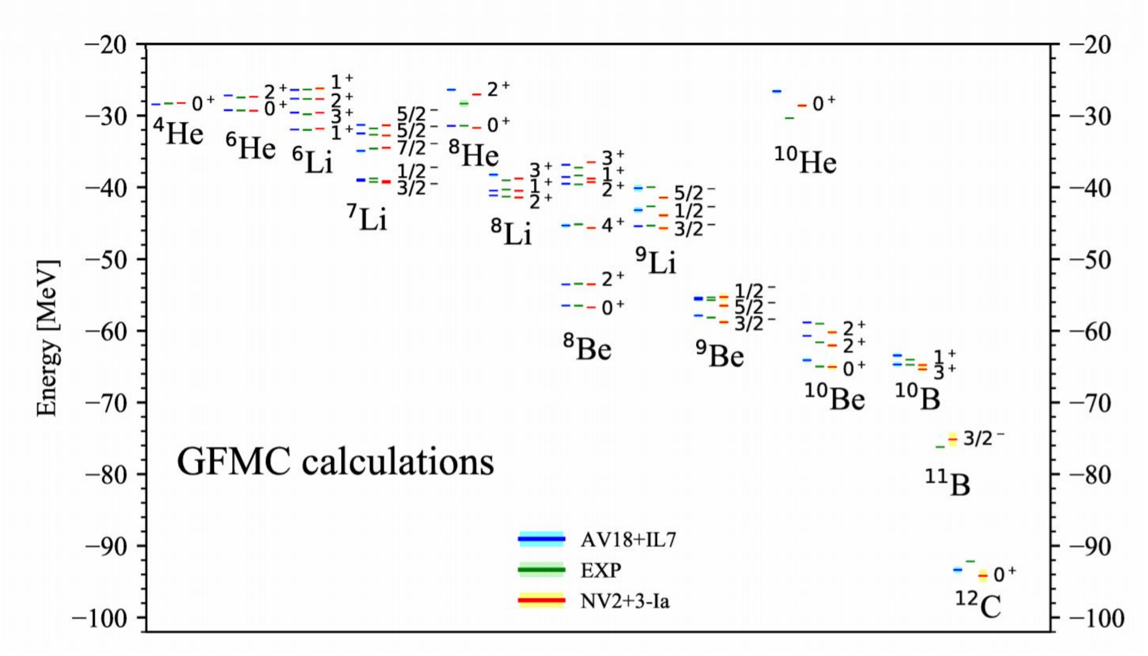

Piarulli et al. PRL 120, 052503 (2018)

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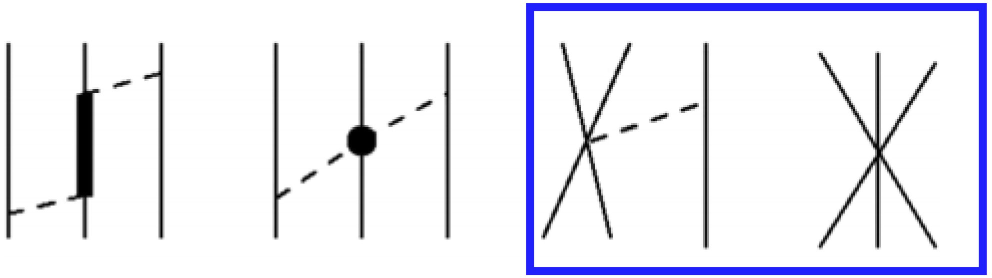
- a [b]: Long- and short-range regulators (R_L,R_S) = (1.2 fm, 0.8 fm) [(1.0 fm, 0.7 fm)]
- Unstarred: Three-body term constrained with strong data only
- Star: Three-body term constrained with strong and weak data



NV2+3 Charge and Currents

Need nuclear vector and axial current operators to study weak processes in light nuclei

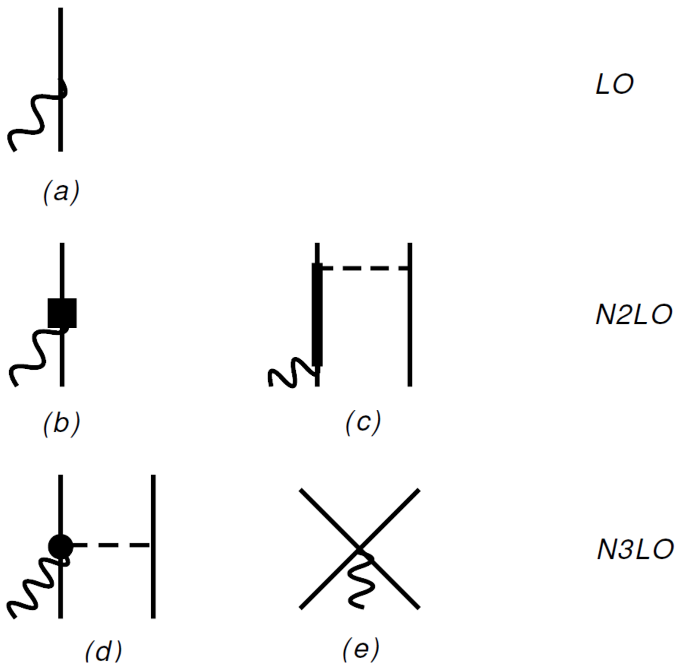
Schematically:

$$\rho = \sum_{i=1}^{A} \rho_i + \sum_{i<j} \rho_{ij} + \ldots$$
$$\mathbf{j} = \sum_{i=1}^{A} \mathbf{j}_i + \sum_{i<j} \mathbf{j}_{ij} + \ldots$$

External field interacts with single nucleons and correlated pairs of nucleons

Use vector and axial currents consistent with NV2+3 derived by JLAB-Pisa group: Pastore et al. PRC 80, 034004 (2009), Pastore et al. PRC 84, 024001 (2011), Piarulli et al. PRC 87, 014006 (2013), Schiavilla et al. PRC 99, 034005 (2019), Baroni et al. PRC 93, 049902 (2016), …

Example: Axial current at zero momentum transfer



Variational Monte Carlo (VMC)

Want to solve: $H\Psi(JMTT_z) = E\Psi(JMTT_z)$ with $H = \sum_i K_i + \sum_{i<j} v_{ij} + \sum_{i<j<k} V_{ijk}$

$$|\Psi_V\rangle = \left[\mathcal{S}\prod_{i<j}(1 + U_{ij} + \sum_{k\neq i,j} U_{ijk})\right]\left[\sum_{i<j} f_c(r_{ij})\right] |\Phi_A(JMTT_z)\rangle$$

Slater determinant of nucleons in s- and p-shell coupled to the appropriate quantum numbers

Pair correlation operator encoding appropriate cluster structure

Two- and three-body correlation operator to reflect impact of nuclear interaction at short distances

Variational Monte Carlo (VMC) is used to find wavefunctions that minimize: $E_V = \frac{\langle \Psi_V | H | \Psi_V \rangle}{\langle \Psi_V | \Psi_V \rangle} \geq E_0$

Carlson et al. Rev. Mod. Phys. 87, 1607 (2015)

Green’s Function Monte Carlo (GFMC)

The variational estimate can be further improved by acting with an imaginary time propagator

$$\Psi(\tau) = e^{-(H-E_0)\tau}\Psi_V = \left[e^{-(H-E_0)\Delta\tau}\right]^n \Psi_V$$

In general, the variational state can be expanded in exact eigenstates of the Hamiltonian

$$|\Psi_V\rangle = \sum_{i=0}^{n} c_n|\psi_n\rangle$$

In the limit of infinite imaginary time

$$\lim_{\tau\to\infty} e^{-(H-E_0)\tau}\Psi_V \to c_0\psi_0$$

Carlson et al. Rev. Mod. Phys. 87, 1607 (2015)

^{6}He Beta Decay Spectrum: Overview

Differential beta decay rate:

$$d\Gamma = \frac{2\pi}{2J_i+1} \sum_{s_e,s_\nu} \sum_{M_i,M_f} |\langle f|H_W|i\rangle|^2 \delta(\Delta E) \frac{d^3k_e}{(2\pi)^3} \frac{d^3k_\nu}{(2\pi)^3}$$

Traces of lepton tensor appearing in the rate depend on the electron and neutrino kinematics

In the $q \to 0$ limit:

$$d\Gamma = d\Gamma_0 \left[1 + a\hat{\boldsymbol{\nu}} \cdot \boldsymbol{\beta} + b\frac{m_e}{E_e} + \langle J \rangle (\ldots)\right]$$

Vanishes for 0^+ ground state of ^{6}He

Within the SM, the predicted values must be corrected for recoil contributions, which must be well-understood to infer new physics **[Glick-Magid et al. Phys. Lett. B 832 (2022)]**

In the integrated SM spectrum, for GT transition, only contributing term is $b = 0 + \delta_b^{\text{recoil}}$

^{6}He Beta Decay Spectrum: Multipoles

The (standard model) matrix element may be decomposed into reduced matrix elements of four multipoles operators:

$$\sum_{M_i}\sum_{M_f}|\langle f|H_W|i\rangle|^2 \propto \sum_{J=0}^{\infty}\left[(1+\hat{\boldsymbol{\nu}}\cdot\boldsymbol{\beta})|C_J(q)|^2+(1-\hat{\boldsymbol{\nu}}\cdot\boldsymbol{\beta}+2(\hat{\boldsymbol{\nu}}\cdot\hat{\mathbf{q}})(\hat{\mathbf{q}}\cdot\boldsymbol{\beta}))|L_J(q)|^2-\hat{\mathbf{q}}\cdot(\hat{\boldsymbol{\nu}}+\boldsymbol{\beta})2\mathrm{Re}(L_J(q)M_J^*(q)\right]$$

$$+\sum_{J=1}^{\infty}\left[(1-(\hat{\boldsymbol{\nu}}\cdot\hat{\mathbf{q}})(\hat{\mathbf{q}}\cdot\boldsymbol{\beta}))(|M_J(q)|^2+|E_J(q)|^2)+\hat{\mathbf{q}}\cdot(\hat{\boldsymbol{\nu}}-\boldsymbol{\beta})2\mathrm{Re}(M_J(q)E_J^*(q))\right]$$

With the standard operator definitions as **[Walecka 1975, Oxford University Press]**:

$$C_{JM}(q)=\int d^3x[j_J(qx)Y_{JM}(\Omega_x)](\rho(\mathbf{x};V)+\rho(\mathbf{x};J))$$

$$L_{JM}(q)=\frac{i}{q}\int d^3x\{\nabla[j_J(qx)Y_{JM}(\Omega_x)]\}\cdot(\mathbf{j}(\mathbf{x};V)+\mathbf{j}(\mathbf{x};A))$$

$$E_{JM}(q)=\frac{1}{q}\int d^3x[\nabla\times j_J(qx)\boldsymbol{\mathcal{Y}}^M_{JJ1}(\Omega_x)]\cdot(\mathbf{j}(\mathbf{x};V)+\mathbf{j}(\mathbf{x};A))$$

$$M_{JM}(q)=\int d^3x[j_j(qx)\boldsymbol{\mathcal{Y}}^M_{JJ1}(\Omega_x)\cdot(\mathbf{j}(\mathbf{x};V)+\mathbf{j}(\mathbf{x};A))$$

Parity and angular momentum selection rules preserve only the four *J*=1, positive parity multipoles for ^{6}He beta-decay

^{6}He Beta Decay Spectrum: Multipoles

$$C_1(q;A) = \frac{i}{\sqrt{4\pi}}\langle {}^6\mathrm{Li}, 10|\rho^\dagger_+(q\hat{\mathbf{z}};A)|{}^6\mathrm{He}, 00\rangle$$

$$L_1(q;A) = \frac{i}{\sqrt{4\pi}}\langle {}^6\mathrm{Li}, 10|\hat{\mathbf{z}}\cdot\mathbf{j}^\dagger_+(q\hat{\mathbf{z}};A)|{}^6\mathrm{He}, 00\rangle$$

$$E_1(q;A) = -\frac{i}{\sqrt{2\pi}}\langle {}^6\mathrm{Li}, 10|\hat{\mathbf{z}}\cdot\mathbf{j}^\dagger_+(q\hat{\mathbf{x}};A)|{}^6\mathrm{He}, 00\rangle$$

$$M_1(q;V) = -\frac{1}{\sqrt{2\pi}}\langle {}^6\mathrm{Li}, 10|\hat{\mathbf{y}}\cdot\mathbf{j}^\dagger_+(q\hat{\mathbf{x}};V)|{}^6\mathrm{He}, 00\rangle$$

The multipoles in the differential rate can be written in terms of matrix elements that can be evaluated with QMC

Schiavilla and Wiringa PRC 65, 054302 (2002)

^{6}He Beta Decay Spectrum: Multipoles

$$C_1(q;A) = -i\frac{qr_\pi}{3}\left(C_1^{(1)}(A) - \frac{(qr_\pi)^2}{10}C_1^{(3)}(A) + \mathcal{O}\left((qr_\pi)^4\right)\right)$$
$$L_1(q;A) = -\frac{i}{3}\left(L_1^{(0)}(A) - \frac{(qr_\pi)^2}{10}L_1^{(2)}(A) + \mathcal{O}\left((qr_\pi)^4\right)\right)$$
$$M_1(q;V) = -i\frac{qr_\pi}{3}\left(M_1^{(1)}(V) - \frac{(qr_\pi)^2}{10}M_1^{(3)}(V) + \mathcal{O}\left((qr_\pi)^4\right)\right)$$
$$E_1(q;A) = -\frac{i}{3}\left(E_1^{(0)}(A) - \frac{(qr_\pi)^2}{10}E_1^{(2)}(A) + \mathcal{O}\left((qr_\pi)^4\right)\right)$$

The multipoles in the differential rate can be written in terms of matrix elements that can be evaluated with QMC

Because q is limited by the reaction Q-value, it is limited to small values (<< m_π) and thus one can consider the multipoles expanded for small q

Naively, retaining terms to order q^2 in the rate gives a 0.001% error, before model uncertainty is accounted for

$$r_\pi = 1/m_{\pi^+} = 1.41382 \text{ fm}$$

$$qr_\pi \lesssim 0.03$$

King et al. PRC 107, 015503 (2023)

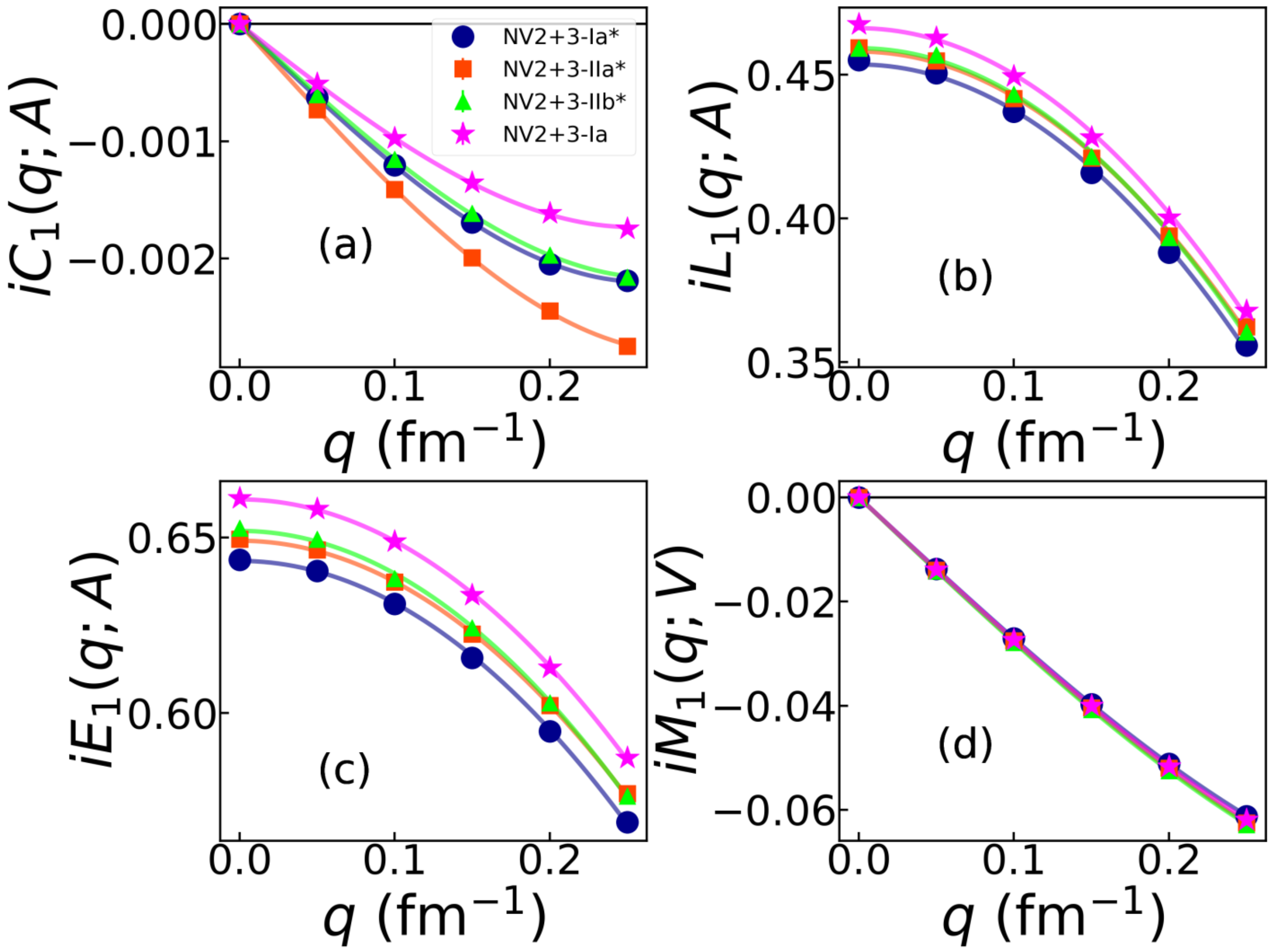
^{6}He Beta Decay Spectrum: SM Results

The strategy: Calculate necessary matrix elements for several small *q* values and fit the small q expansions with several NV2+3 models

Dominant terms $L_1^{(0)}$ and $E_1^{(0)}$ have model dependence of ~1% to ~2% (at the GFMC level)

Linear term model dependencies ~few percent

Quadratic expansion coefficients have significant model dependence, but are suppressed by q^2 in the differential rate



VMC multipoles

King et al. PRC 107, 015503 (2023)

^{6}He Beta Decay Spectrum: SM Results

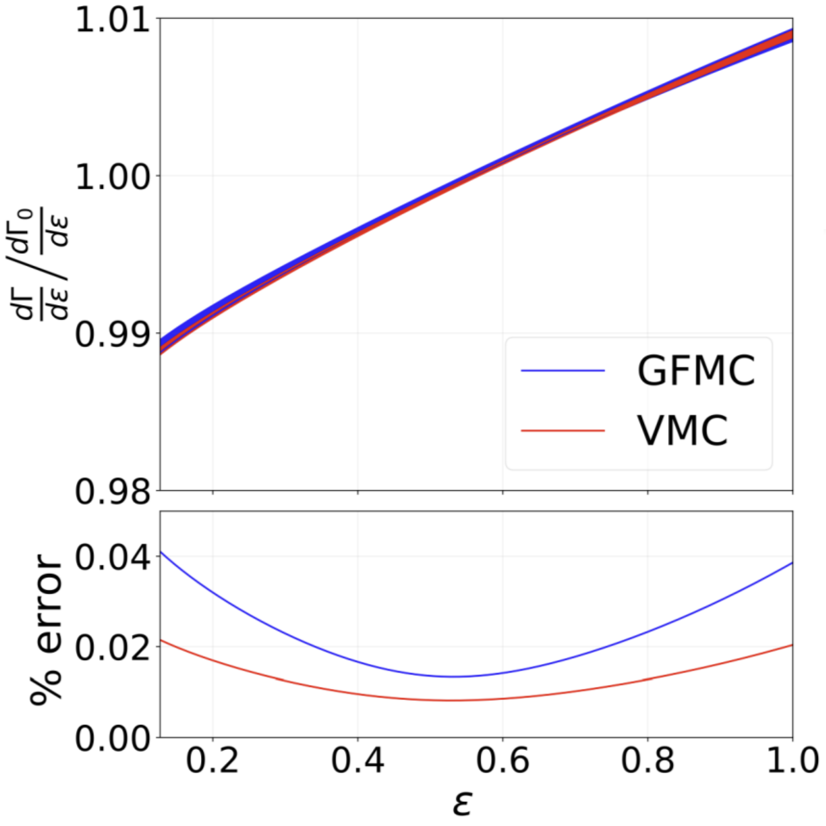
Coefficients fit to VMC and GFMC calculations can be plugged back into decay rate formula

Up to ~1% correction arising from retaining *q* dependence in the Standard Model

Error on $M_1^{(1)}/L_1^{(0)}$ ratio dominates theory error bar

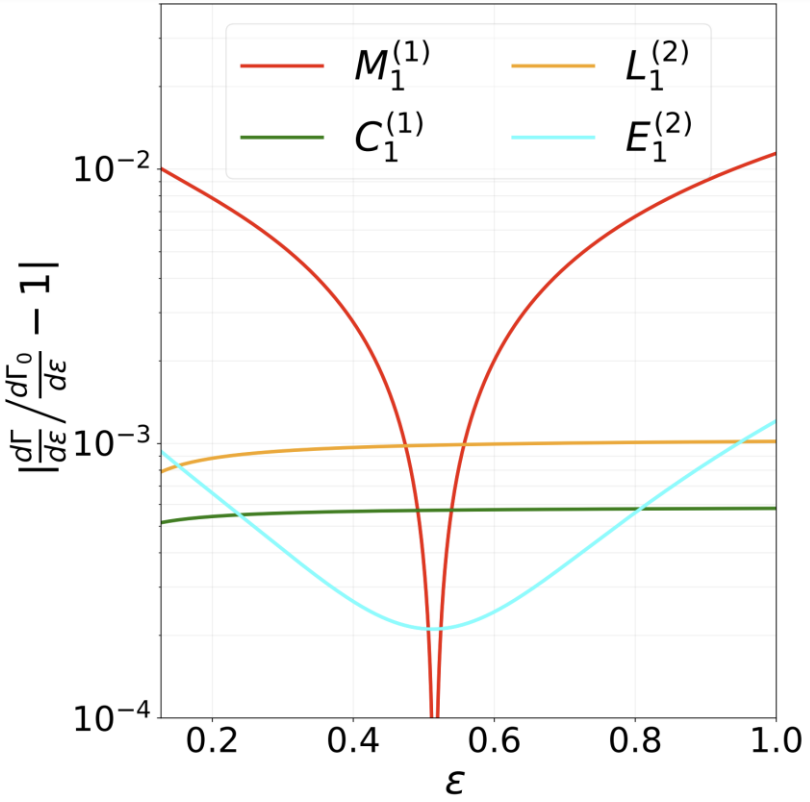
VMC and GFMC average rates:

τ_{VMC} = 762 +/- 11 ms
τ_{GFMC} = 808 +/- 24 ms
$\tau_{Expt.}$ = 807.25 +/- 0.16 +/- 0.11 ms
[Kanafani et al. PRC 106, 045502 (2022)]



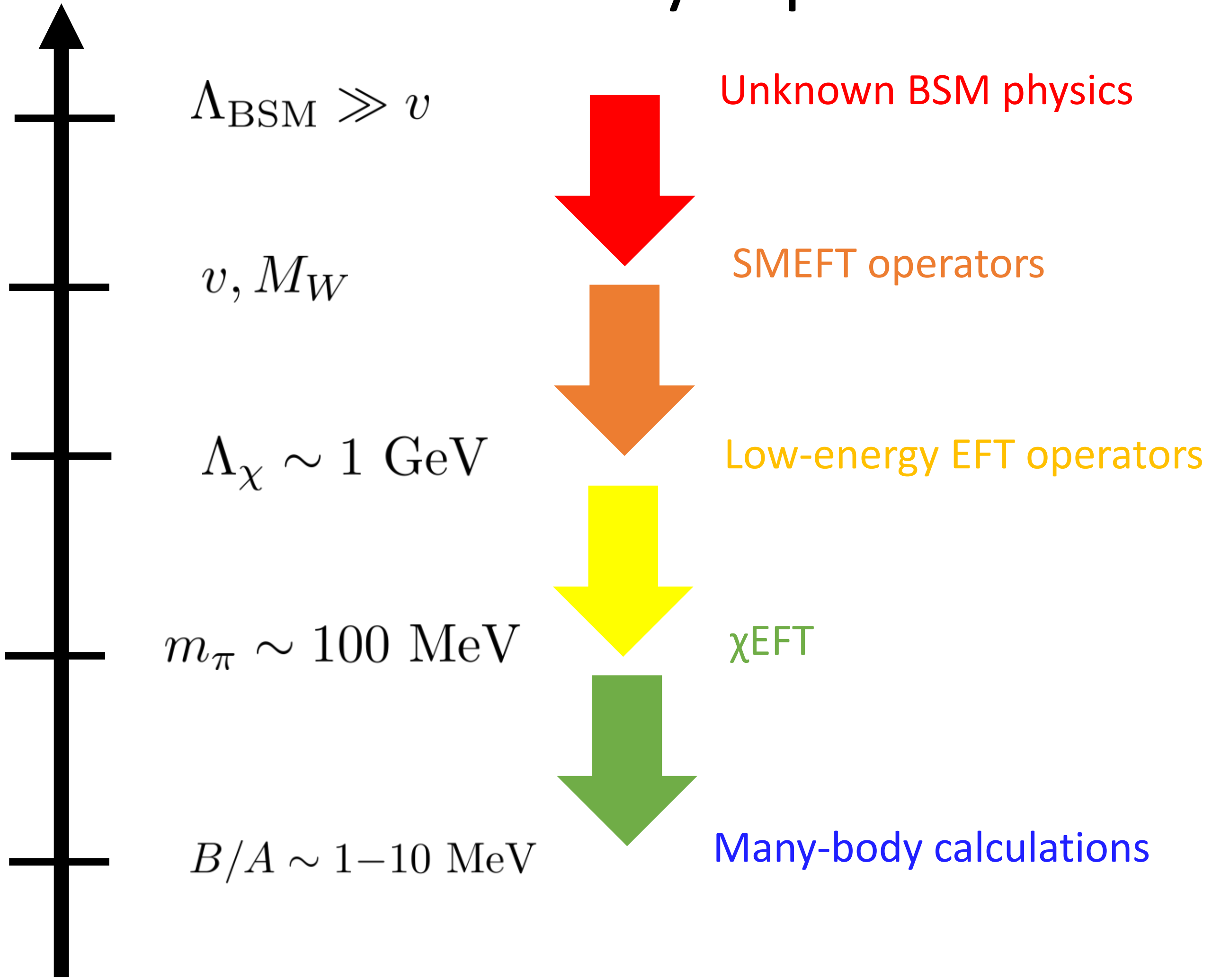
$$\varepsilon = \frac{E_e}{\omega}$$

w/ radiative corrections from **Hayen**



King et al. PRC 107, 015503 (2023)

^{6}He Beta Decay Spectrum: BSM Connections



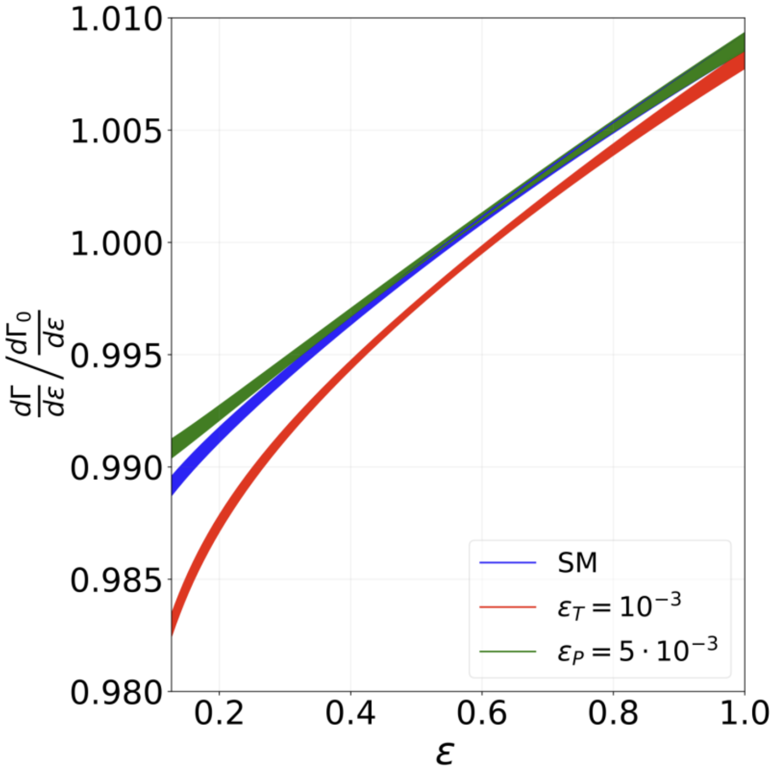
Standard Model Effective Field Theory (SMEFT) gives most general set of gauge-invariant operators complimenting the SM

Tensor and pseudoscalar charged current interactions introduced at dimension-6

Matching the SMEFT to low-energy theory, one can investigate impact of BSM physics on the ^{6}He beta-decay spectrum **(effort led by Mereghetti+)**

King et al. PRC 107, 015503 (2023)

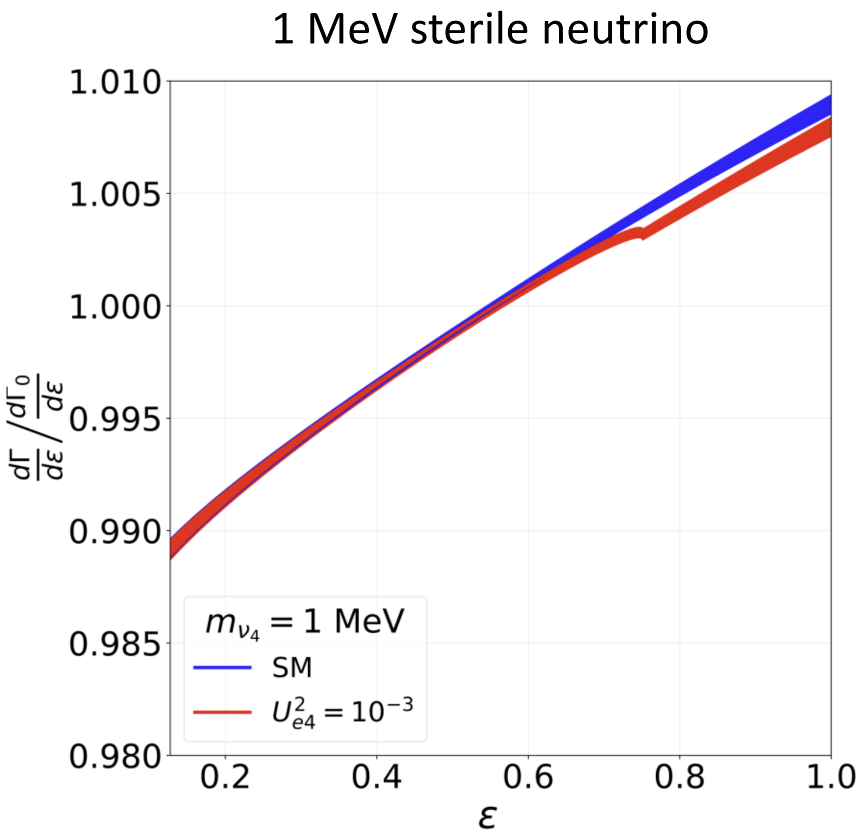
^{6}He Beta Decay Spectrum: BSM Connections



Non-standard CC interactions involving left-handed neutrino

$$\Lambda_{\text{BSM}} \sim \frac{v}{\sqrt{\epsilon_i}} \sim 10 \text{ TeV}$$

King et al. PRC 107, 015503 (2023)

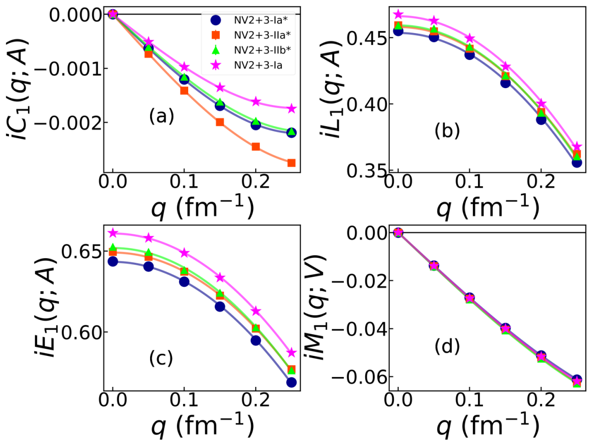


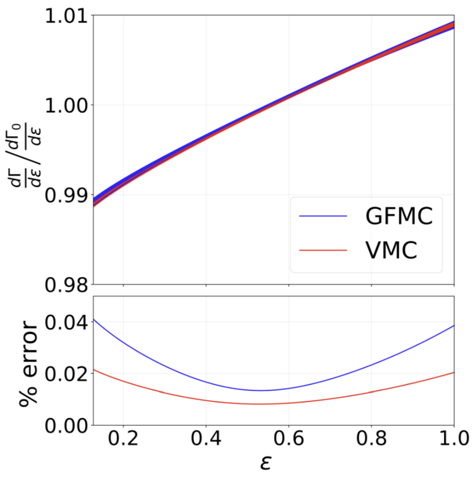
SMEFT to look at leading order tensor and pseudoscalar currents, 1 MeV sterile neutrino **(Mereghetti+)**

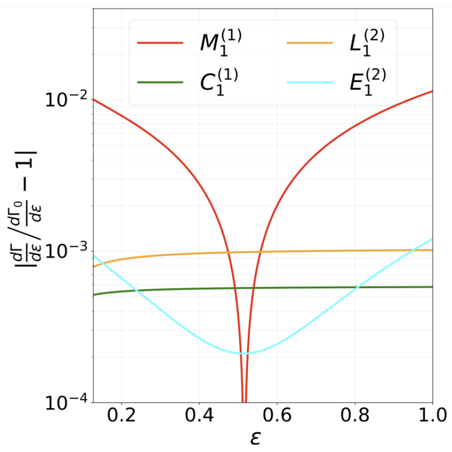
Sensitive to tensor, less so to pseudoscalar, in next-gen experiments

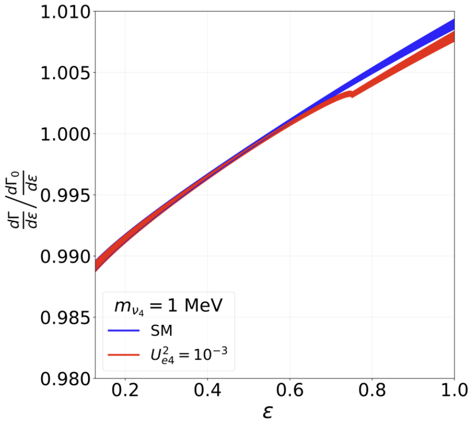
Can put constraints on ~1 MeV sterile neutrino

Conclusions and Outlook









QMC methods combined with the NV2+3 interactions provide a powerful tool to understand electroweak structure and reactions in light nuclei

First prediction of two-body current contributions to the ^{6}He beta decay spectrum

Estimated uncertainty from different approaches to fitting chiral interaction

Able to investigate sensitivity to new physics within the model uncertainty

Future work: radiative corrections to superallowed beta decay, neutrinoless double beta decay, developing robust tools for UQ in QMC calculations with NV2+3 interaction

Collaborators/Acknowledgements

Wash U QMC: Bub (GS), Chambers-Wall (GS)
Andreoli (PD), McCoy (PD), Pastore (PI), Piarulli (PI)
ANL: Wiringa
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MSU+FRIB: Brown, Schmitt, Zegers
NC State: Hayen
UW: Cirigliano

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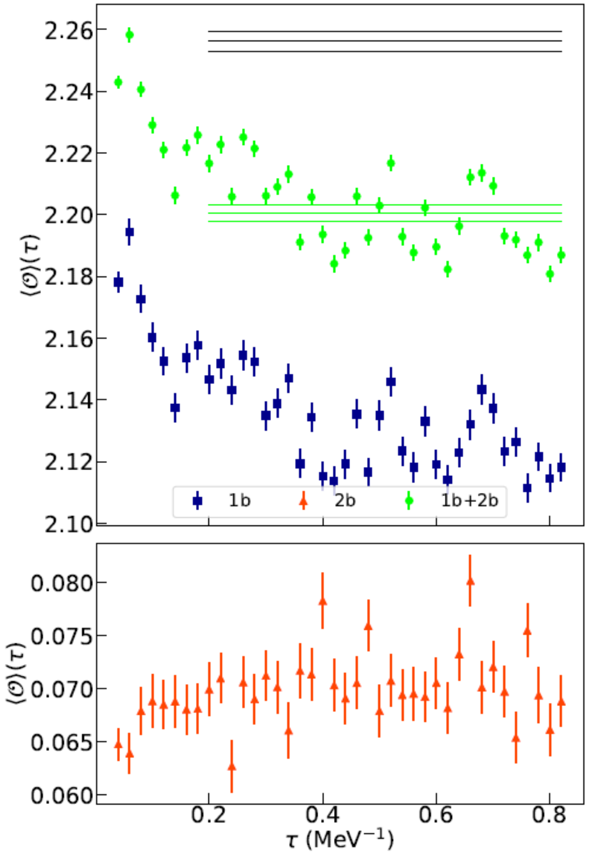
Argonne NATIONAL LABORATORY
Washington University in St. Louis

Additional Slides

Transition Matrix Element from GFMC

^{6}He → ^{6}Li GT RME extrapolation



Assume small correction to VMC: $\Psi(\tau) = \Psi_V + \delta\Psi$

Mixed estimate for off-diagonal transitions:

$$\langle \mathcal{O}(\tau) \rangle = \frac{\langle \Psi^f(\tau) | \mathcal{O} | \Psi^i(\tau) \rangle}{\sqrt{\langle \Psi^f(\tau) | \Psi^f(\tau) \rangle} \sqrt{\langle \Psi^i(\tau) | \Psi^i(\tau) \rangle}}$$

$$\simeq \langle \mathcal{O}(\tau) \rangle_{M_f} + \langle \mathcal{O}(\tau) \rangle_{M_i} - \langle \mathcal{O} \rangle_{\text{VMC}}$$

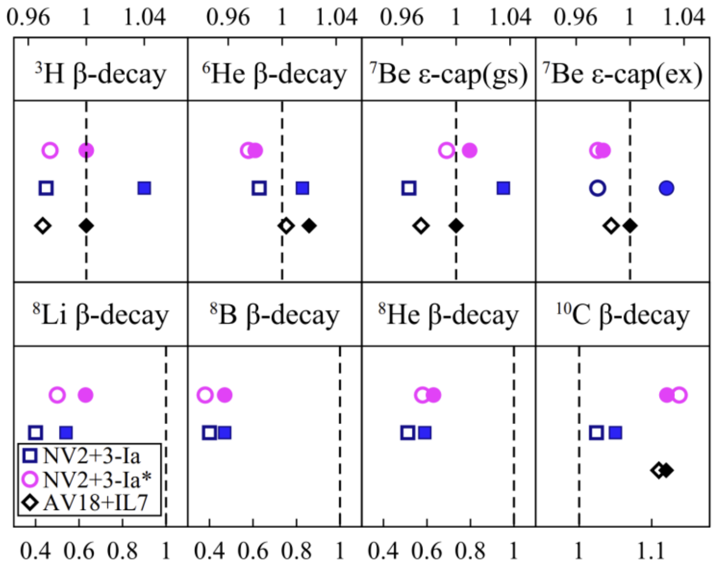
where

$$\langle \mathcal{O}(\tau) \rangle_{M_f} = \frac{\langle \Psi^f(\tau) | \mathcal{O} | \Psi^i_V \rangle}{\langle \Psi^f(\tau) | \Psi^i_V \rangle} \frac{\sqrt{\langle \Psi^f_V | \Psi^f_V \rangle}}{\sqrt{\langle \Psi^i_V | \Psi^i_V \rangle}}$$

Pervin, Pieper, and Wiringa PRC 76, 064319 (2007)

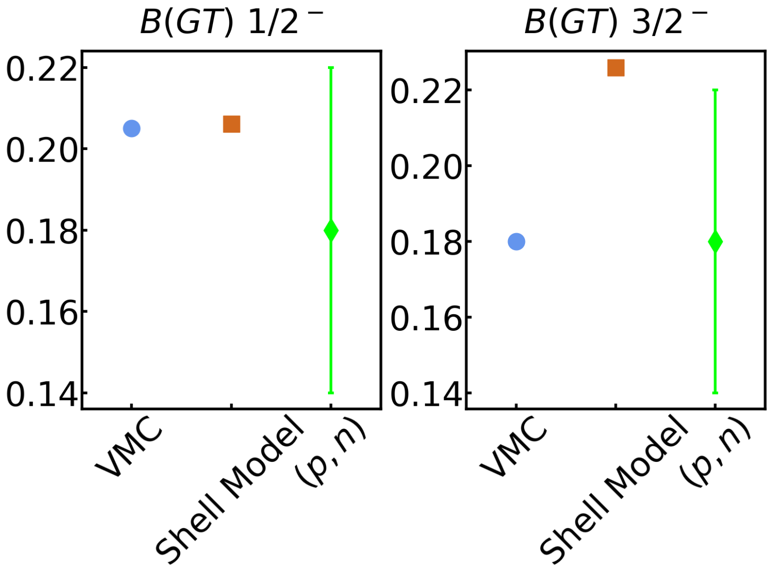
Model Validation

King et al. PRC 121, 025501 (2020)



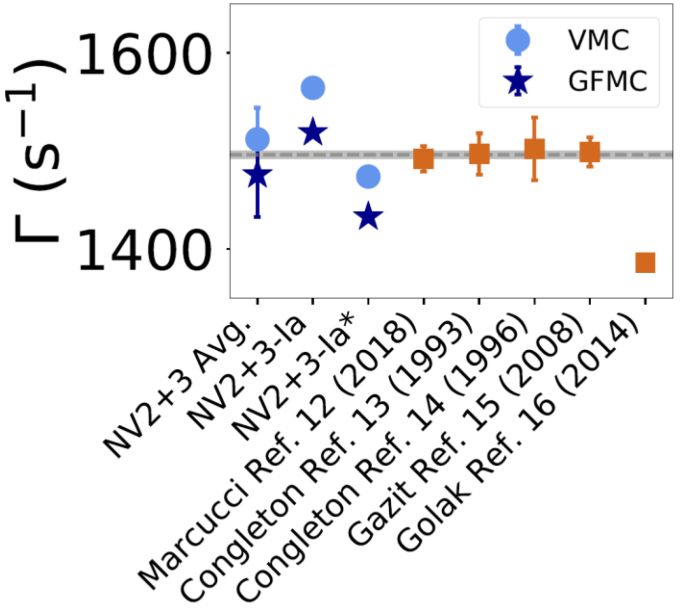
GT RMEs and transition densities for several light nuclei to validate in kinematic region of beta-decay

B(GT) from VMC compared with model-independent extraction with (*p*,*n*) reaction data



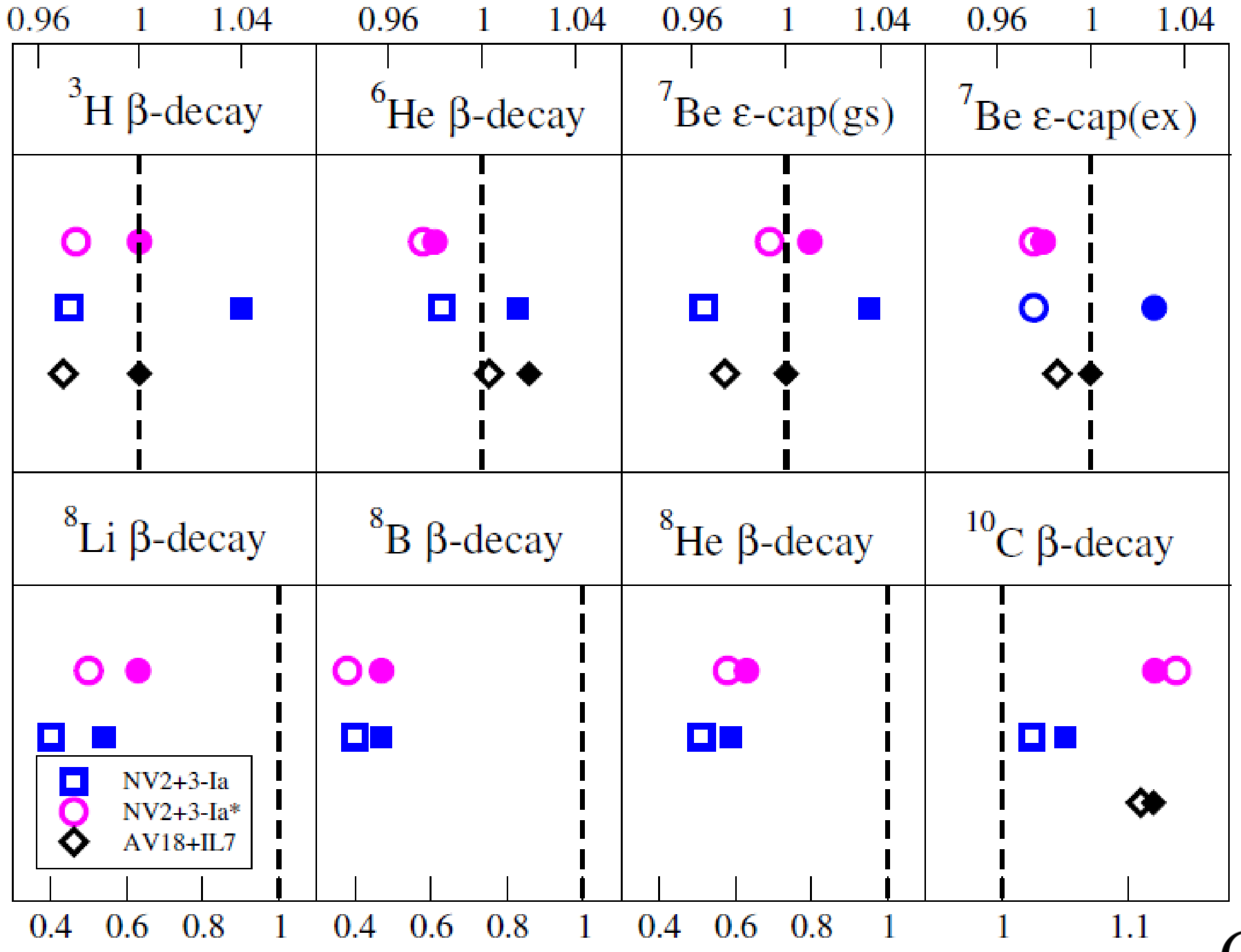
Schmitt, GBK, et al. PRC 106, 054323 (2022)

King et al. PRC 105, L042501 (2022)



Validation at moderate momentum transfer in A=3 and A=6 nuclei using muon capture rates

GFMC GT Reduced Matrix Elements



NV2+3-Ia: Three-body constrained with only strong data
NV2+3-Ia*: Three-body constrained with strong and weak data

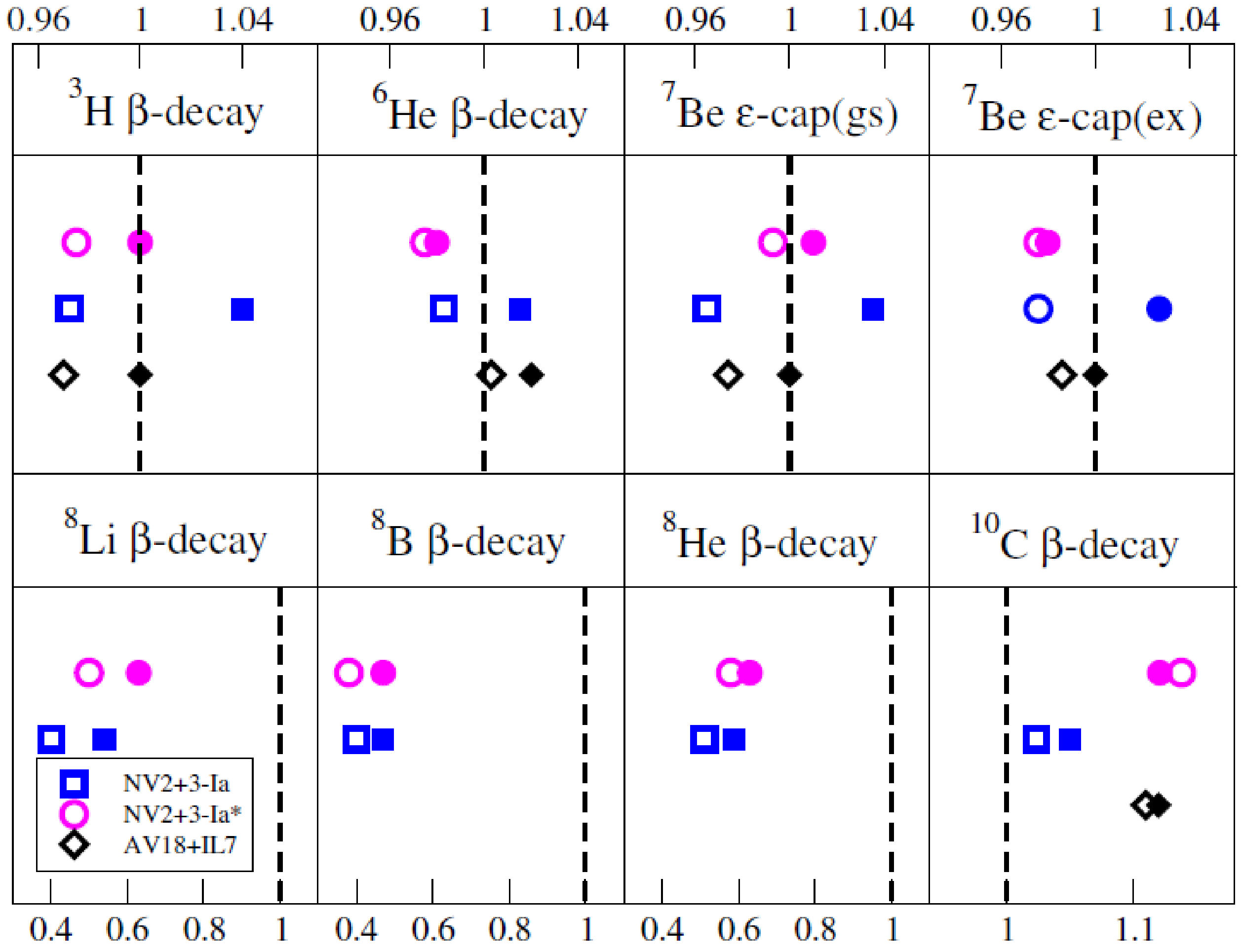
GFMC GT matrix elements compared with results using the AV18+IL7 in **Pastore et al. PRC 97, 022501 (2018)**

Empty symbols are results up to LO, solid symbols up to N3LO

$$\text{GT RME} = \frac{\sqrt{2J_f+1}}{g_A}\frac{\langle J_f M | j^z_{\pm,5}(\mathbf{q}\to 0)| J_i M\rangle}{\langle J_i M, 10 | J_f M\rangle}$$

King et al. PRC 121, 025501 (2020)

GFMC GT Reduced Matrix Elements



In most cases, two-body correction is small (~ few %) and additive

NV2+3-Ia has an enhanced two-body correction relative to the NV2+3-Ia*

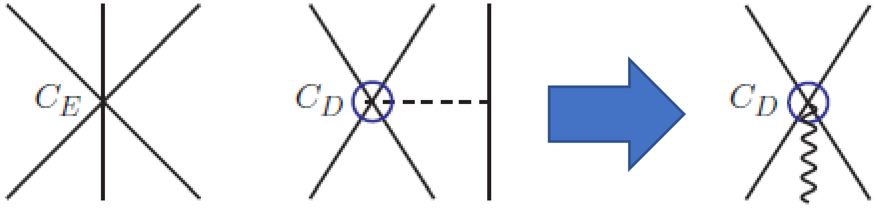
A=8 suppressed at leading order, larger two-body corrections

A=10 for NV2+3-Ia* has a negative two-body correction

$$\text{GT RME} = \frac{\sqrt{2J_f+1}}{g_A} \frac{\langle J_f M | j^z_{\pm,5}(\mathbf{q}\to 0) | J_i M \rangle}{\langle J_i M, 10 | J_f M \rangle}$$

King et al. PRC 121, 025501 (2020)

Three-body LECs and N3LO-CT



$$\mathbf{j}_{5,a}^{\mathrm{N3LO}}(\mathbf{q};\mathrm{CT}) = z_0 \mathrm{e}^{i\,\mathbf{q}\cdot\mathbf{R}_{ij}} \frac{\mathrm{e}^{-z_{ij}^2}}{\pi^{3/2}} \left(\boldsymbol{\tau}_i \times \boldsymbol{\tau}_j\right)_a \left(\boldsymbol{\sigma}_i \times \boldsymbol{\sigma}_j\right)$$

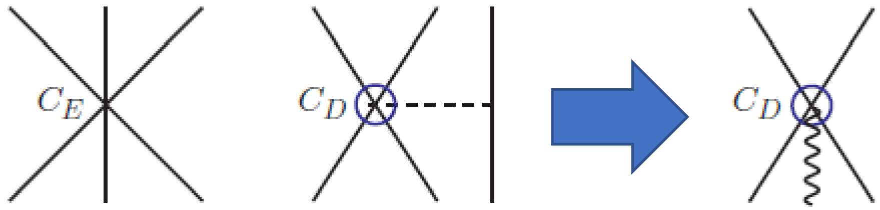
$$z_0 = \frac{g_A}{2} \frac{m_\pi^2}{f_\pi^2} \frac{1}{(m_\pi R_\mathrm{S})^3} \left[-\frac{m_\pi}{4\, g_A \Lambda_\chi} c_D + \frac{m_\pi}{3}(c_3 + 2c_4) + \frac{m_\pi}{6\, m} \right]$$

The NV2+3-Ia model fits the LECS using the *nd* doublet scattering length and trinucleon energies

The NV2+3-Ia* model fits trinucleon energies and the triton Gamow-Teller matrix element

Gardestig and Phillips PRL 96, 232301 (2006)

Three-body LECs and N3LO-CT



$$\mathbf{j}^{\rm N3LO}_{5,a}(\mathbf{q};\rm CT) = z_0 e^{i\,\mathbf{q}\cdot\mathbf{R}_{ij}} \frac{e^{-z_{ij}^2}}{\pi^{3/2}} (\boldsymbol{\tau}_i \times \boldsymbol{\tau}_j)_a (\boldsymbol{\sigma}_i \times \boldsymbol{\sigma}_j)$$

$$z_0 = \frac{g_A}{2}\frac{m_\pi^2}{f_\pi^2}\frac{1}{(m_\pi R_S)^3}\left[\boxed{-\frac{m_\pi}{4\,g_A\,\Lambda_\chi} c_D} + \frac{m_\pi}{3}(c_3 + 2c_4) + \frac{m_\pi}{6\,m}\right]$$

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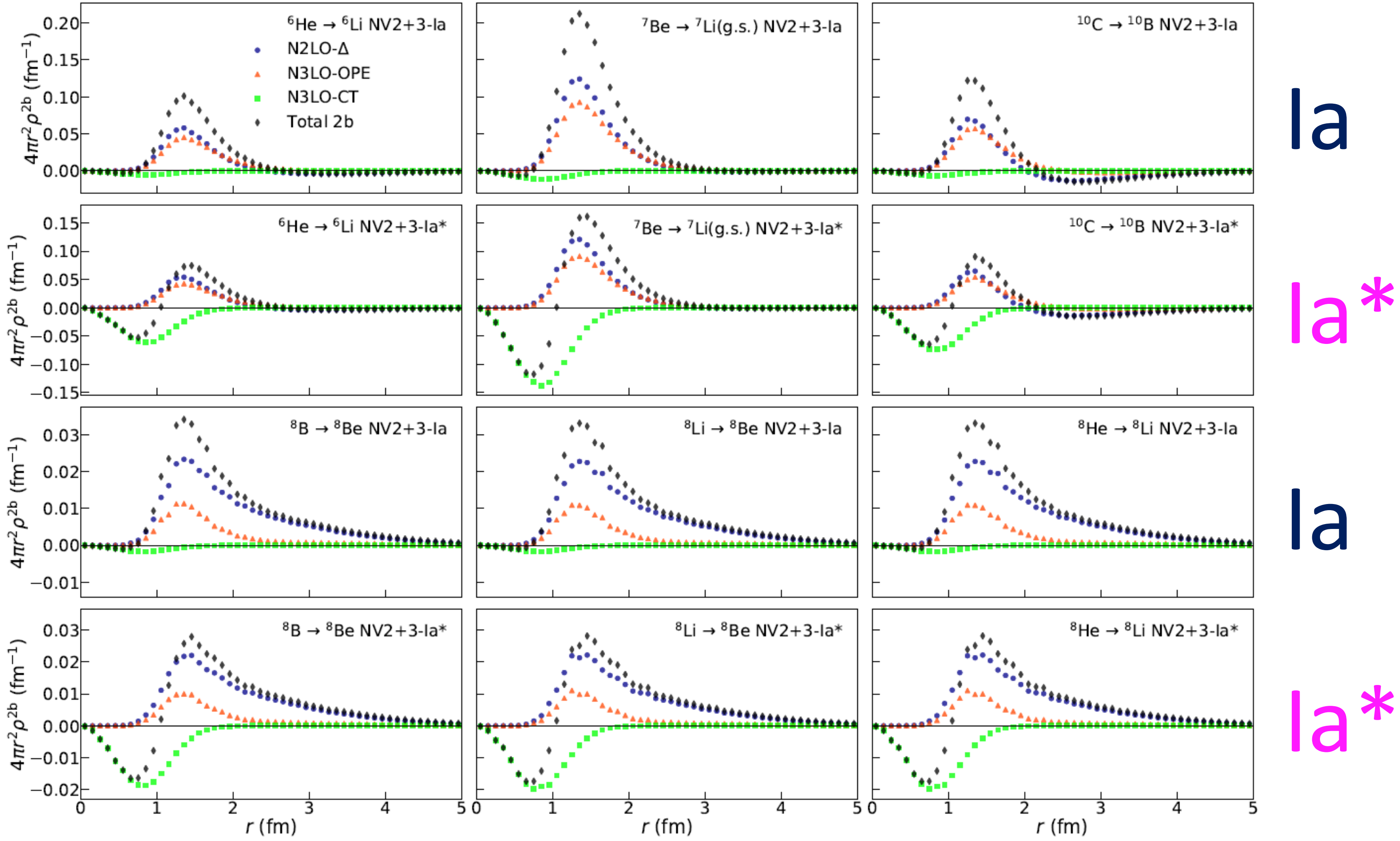
Gardestig and Phillips PRL 96, 232301 (2006)

Two-body VMC transition densities



The N3LO-CT term is a negative contribution is enhanced in the NV2+3-Ia*

N2LO-Δ and N3LO-OPE terms are consistent independent of the data used to constrain the three-body force

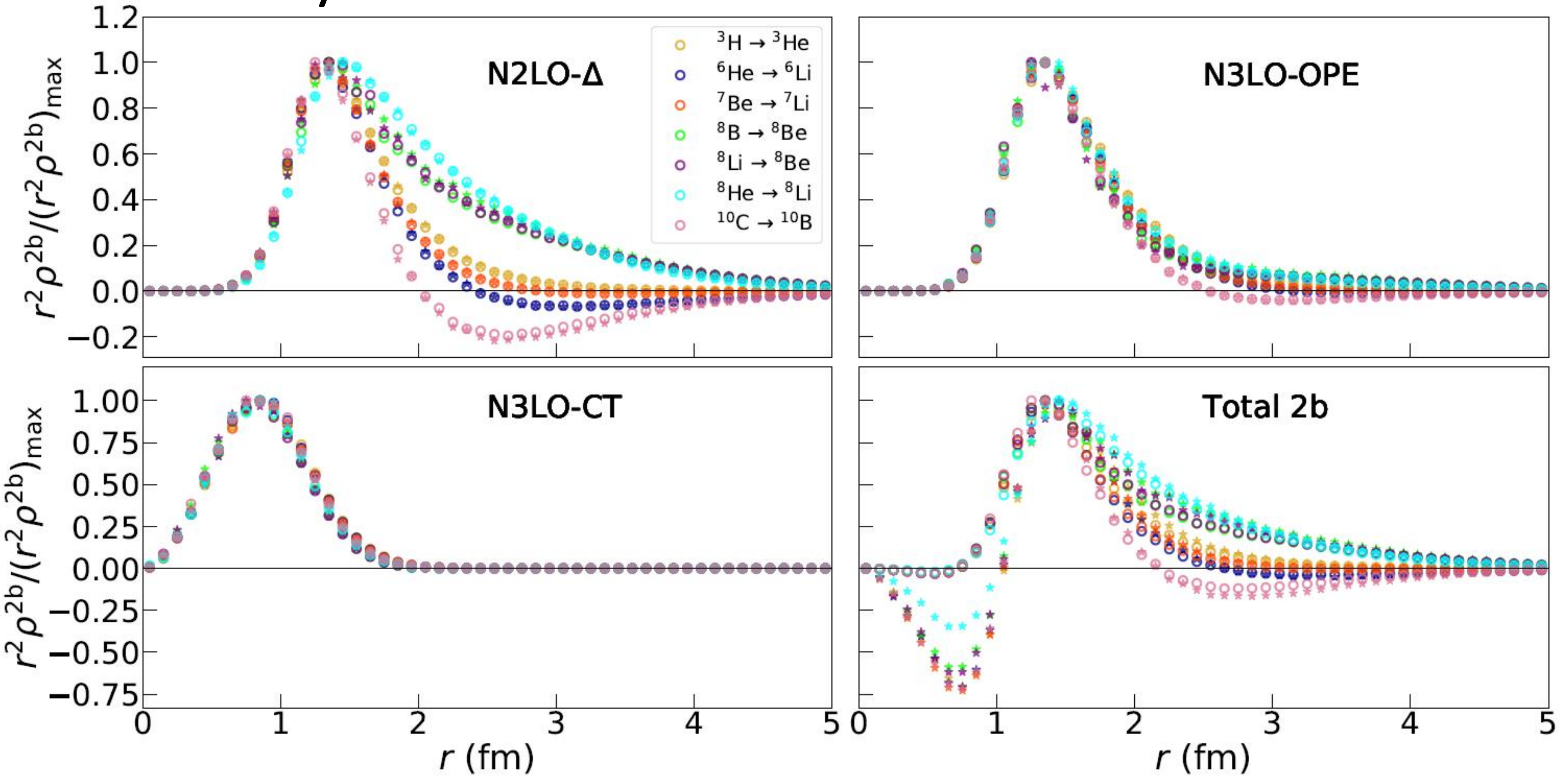
$$\mathrm{RME(2b)} = \int dr_{ij} 4\pi r_{ij}^2 \rho^{2b}(r_{ij})$$

King et al. PRC 121, 025501 (2020)

Scaled Two-body Transition Densities

Long-range N2LO-Δ and N3LO-OPE are transition dependent

Universal shape of the short-range transition density



$$\mathrm{RME(2b)} = \int dr_{ij} 4\pi r_{ij}^2 \rho^{2b}(r_{ij})$$

King et al. PRC 121, 025501 (2020)

B(GT) for A=11 nuclei

$$\mathrm{GT} = \frac{\sqrt{2J_f+1}}{g_A} \frac{\langle J_F M | j^z_{\pm,5}(\mathbf{q}\to 0) | J_i M\rangle}{\langle J_i M, 10 | J_f M\rangle}$$

$$B(GT) = \frac{|\mathrm{GT}|^2}{2J_i+1}$$

Reduced matrix elements from QMC can be used to obtain transition strengths to exclusive final states

B(GT) may be obtained from charge exchange reactions at zero momentum transfer

Do not depend on any model assumptions for the structure of the system

Tests quality of *ab initio* wave functions and many-body methods

B(GT) for A=11 nuclei

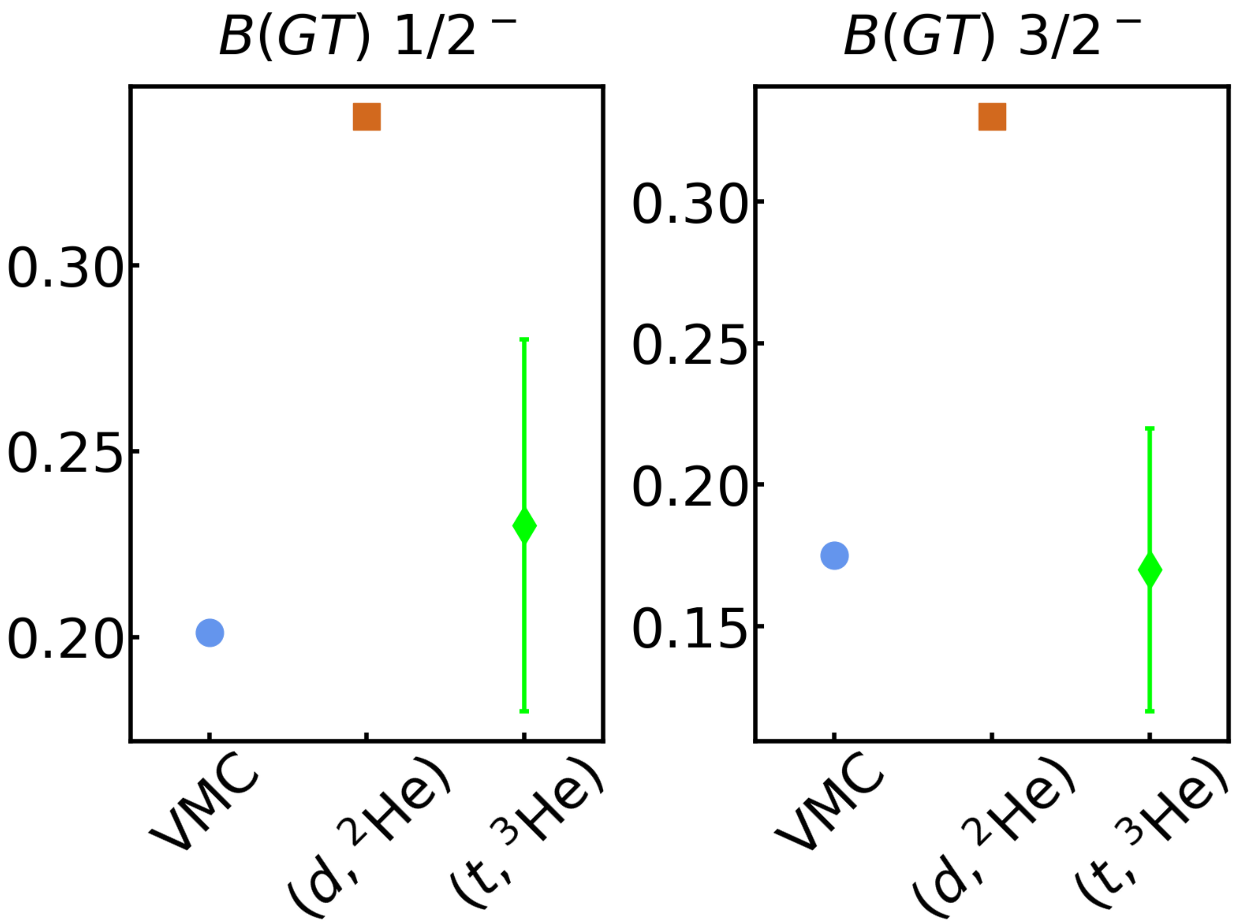
^{11}B(g.s.) → ^{11}Be*

NV2+3-Ia* VMC agrees well with the value extracted from *(t,^{3}He)*

(d,^{2}He) data consistent with unquenched shell model calculation

Two-body effects ~2%-3% and subtractive

$$B(GT) = \frac{|\mathrm{GT}|^2}{2J_i+1}$$



***(d,^{2}He)* – Ohnishi et al., Nucl. Phys. A 687 (2001)**
***(t,^{3}He)* – Daito et al., Phys. Lett. B (1998)**

Schmitt, GBK, et al. PRC 106, 054323 (2022)

$B(GT)$ for A=11 nuclei

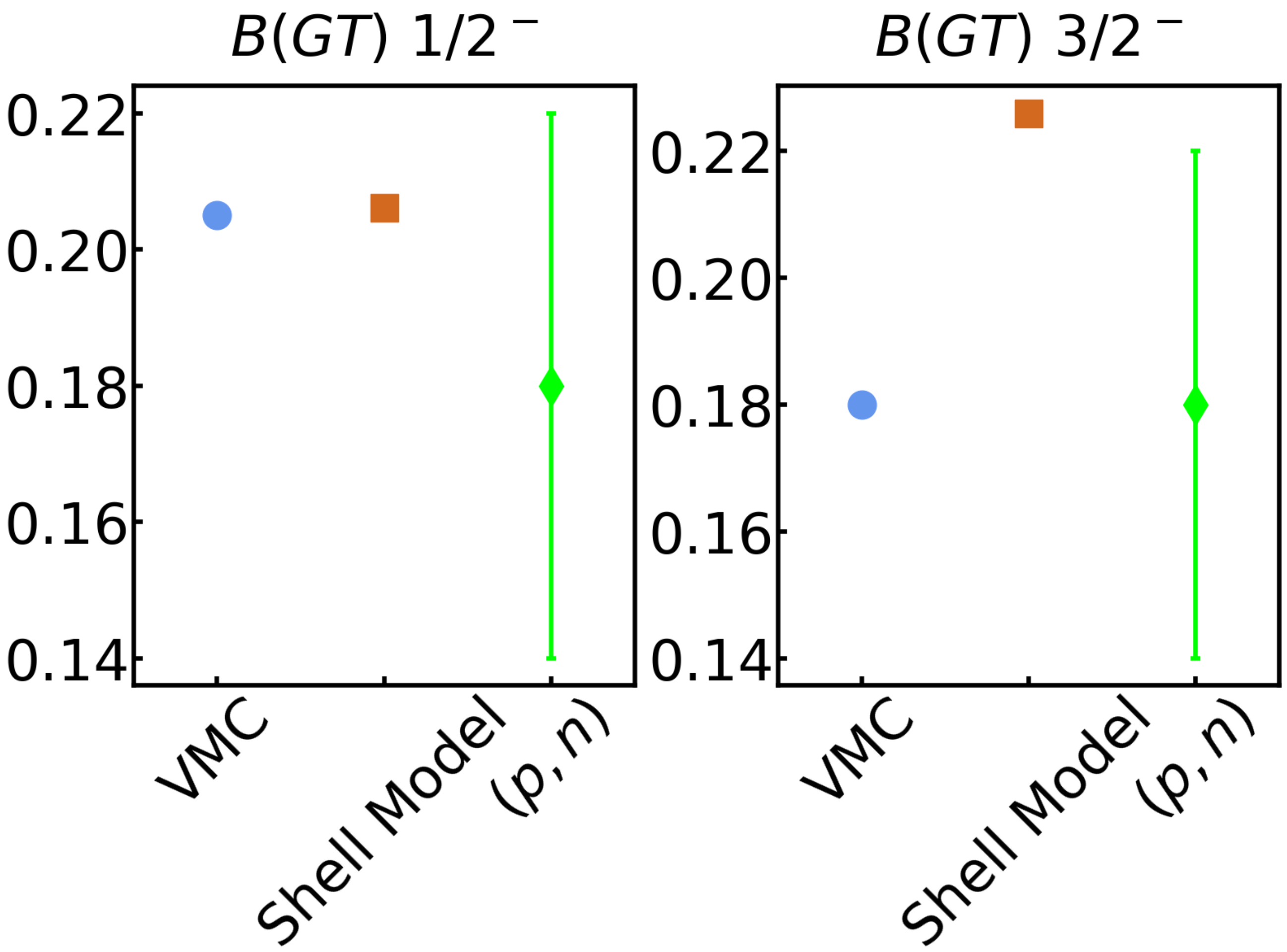
$^{11}C(g.s.) \rightarrow {}^{11}N^*$

NV2+3-Ia* VMC result consistent under isospin symmetry when studying mirror transition

Good agreement between central value of VMC and experimental error bars

Two-body effects ~2%-4% and subtractive

$$B(GT) = \frac{|\mathrm{GT}|^2}{2J_i+1}$$



Shell Model – B. A. Brown (MSU)
***(p,n)* – J. Schmitt (MSU)**

Schmitt, GBK, et al. PRC 106, 054323 (2022)

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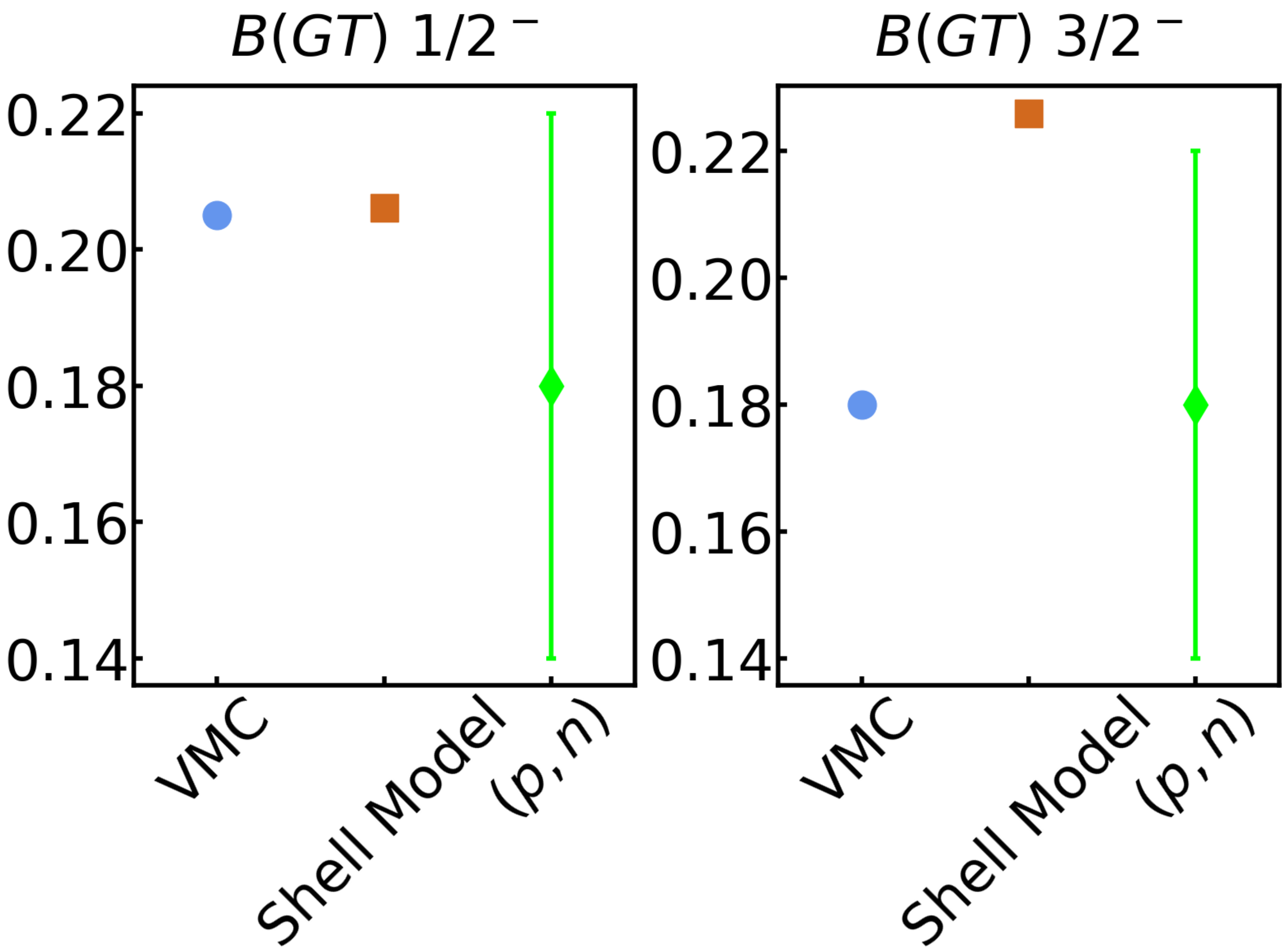
Outlook: Systematic study of GT transitions for nuclei with A ≥ 11 at GFMC level



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