Virtual Access

RADIANT

Radii Analysis and Data for InterActive Nuclear Table

Project Leaders:

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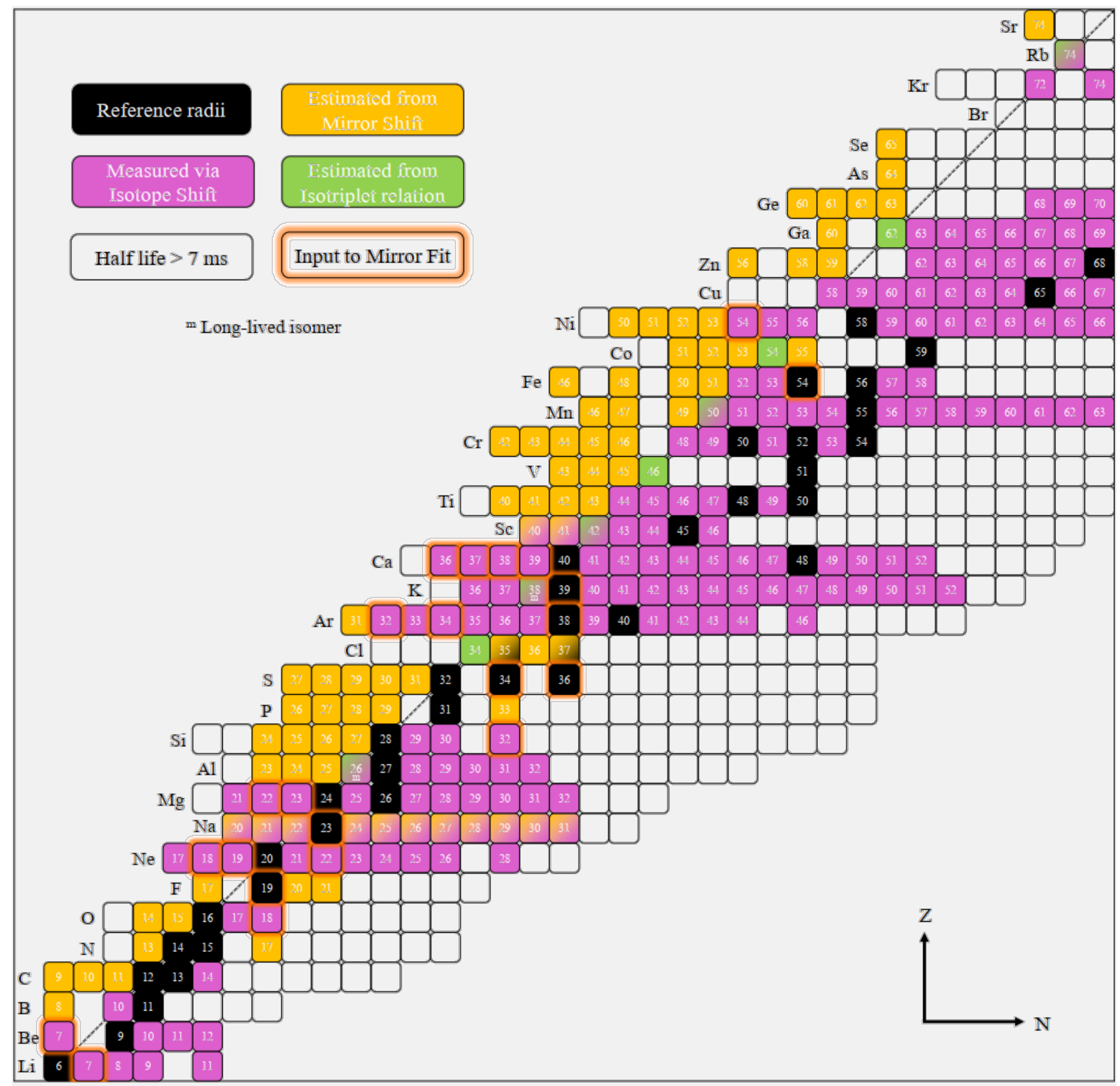
Endre Takacz (Clemson U., USA)
Mikhail Gorshteyn (*JGU Mainz)*

Nantes, July 2025



Precise nuclear radii:

fundamental nuclear property and input in many fields of physics

Example #1: tests of Standard Model with CKM unitarity

$^{26m-27}\mathrm{Al}$ Isotope Shift with collinear laser spectroscopy by ISOLDE

Plattner et al, arXiv: 2310.15291

Measured charge radius of $^{26m}\mathrm{Al}$ isomer

$$R_c(^{26m}\mathrm{Al}) = 3.130(15)\ \mathrm{fm}$$

Previous guess $R_c(^{26m}Al) = 3.040(20)\,\mathrm{fm}$

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Consequences for superallowed $^{26m}\mathrm{Al} \to {}^{26}\mathrm{Mg}$ transition

MG, Ohayon, Sahoo, Seng, arXiv: 2502.17070

Major impact on Ft value uncovered

$$\mathscr{F}t[^{26m}\mathrm{Al} \to {}^{26}\mathrm{Mg}] = 3072.4(1.1)_{\mathrm{stat}}\,\mathrm{s} \to 3070.0(1.2)_{\mathrm{stat}}\,\mathrm{s}$$

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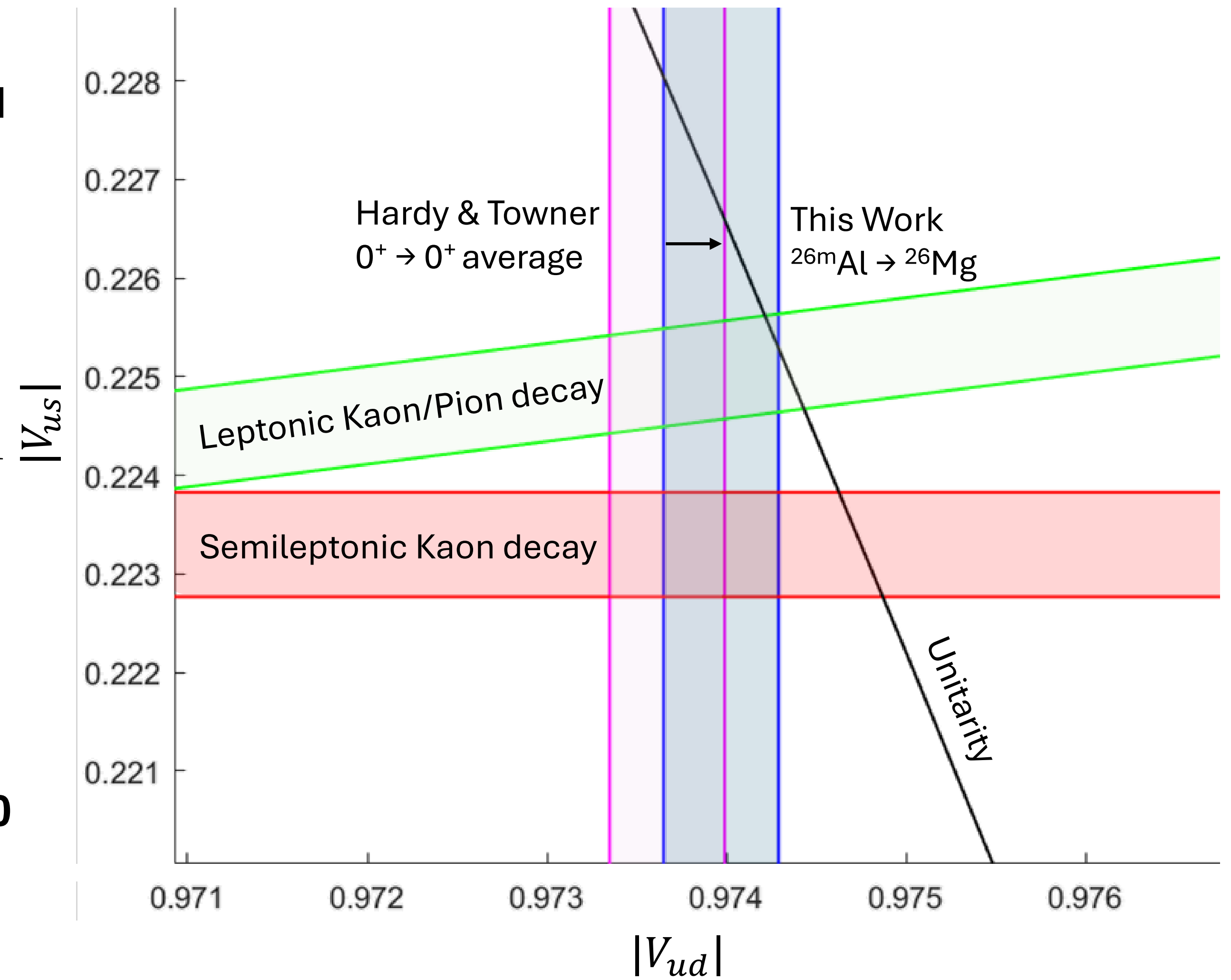

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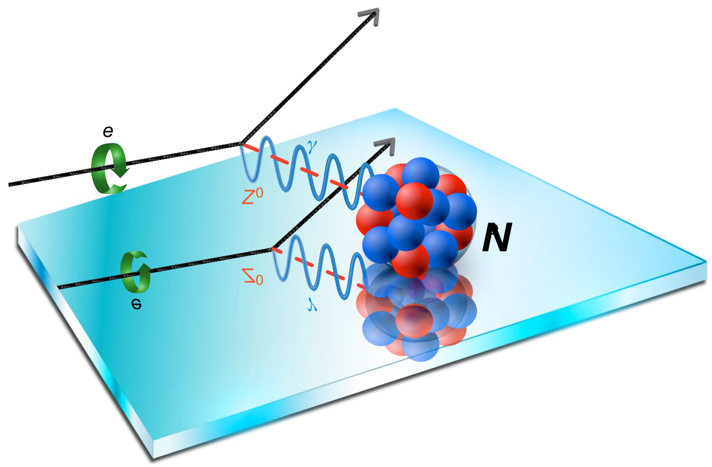
$^{26m}\mathrm{Al} \rightarrow {}^{26}\mathrm{Mg}$ transition most precisely measured —> impacts CKM unitarity test

$$|V_{ud}|^2 + |V_{us}|^2 = 0.9985(7) \text{ —> } |V_{ud}|^2 + |V_{us}|^2 = 0.9991(7)$$

Example #2: Neutron skins from parity-violating electron scattering

Polarized e-scattering

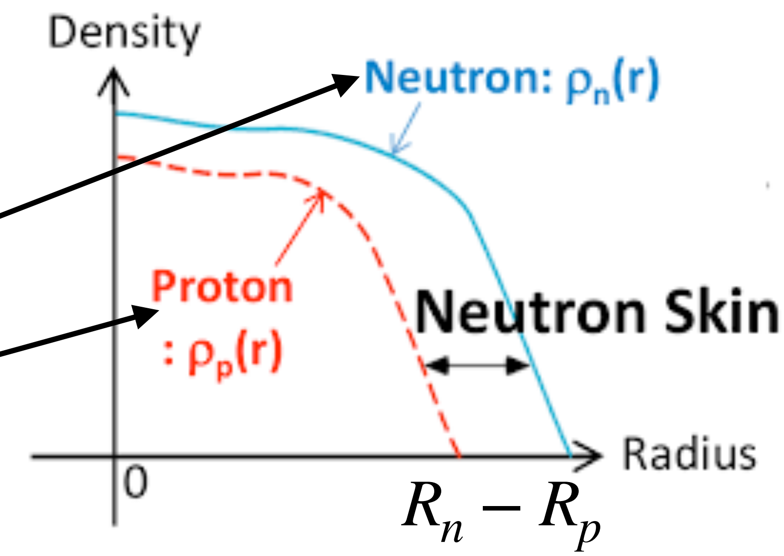


PV asymmetry

$$A^{PV} = \frac{d\sigma/d\Omega_+ - d\sigma/d\Omega_-}{d\sigma/d\Omega_+ + d\sigma/d\Omega_-}$$

$$A_{PV} \approx \frac{G_F Q^2}{2\pi\alpha\sqrt{2}} \frac{F_w(Q^2)}{F_{ch}(Q^2)}$$

Charge and weak FF



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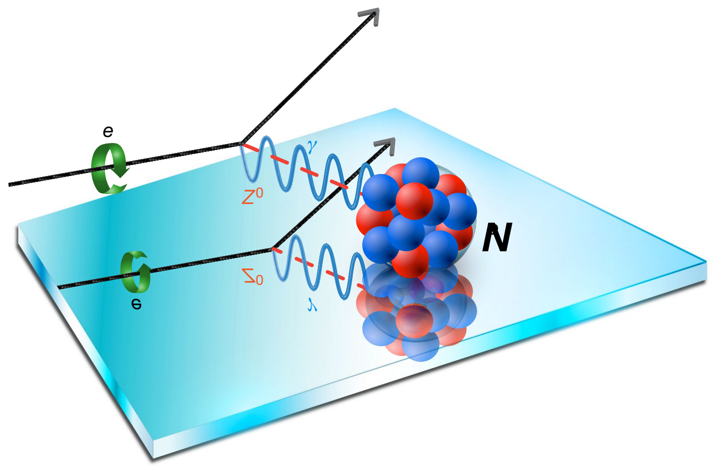

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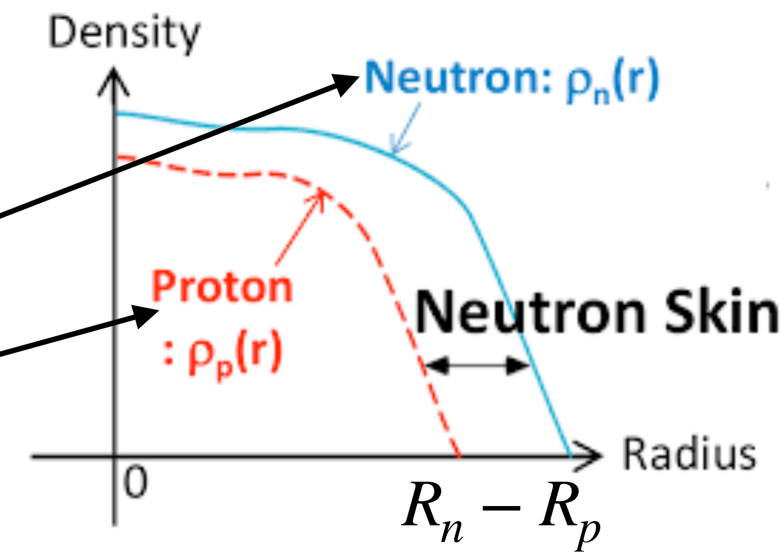


PREX: neutron skin of lead-208

$$R_n - R_p = 0.278 \pm 0.08\,\text{fm}$$

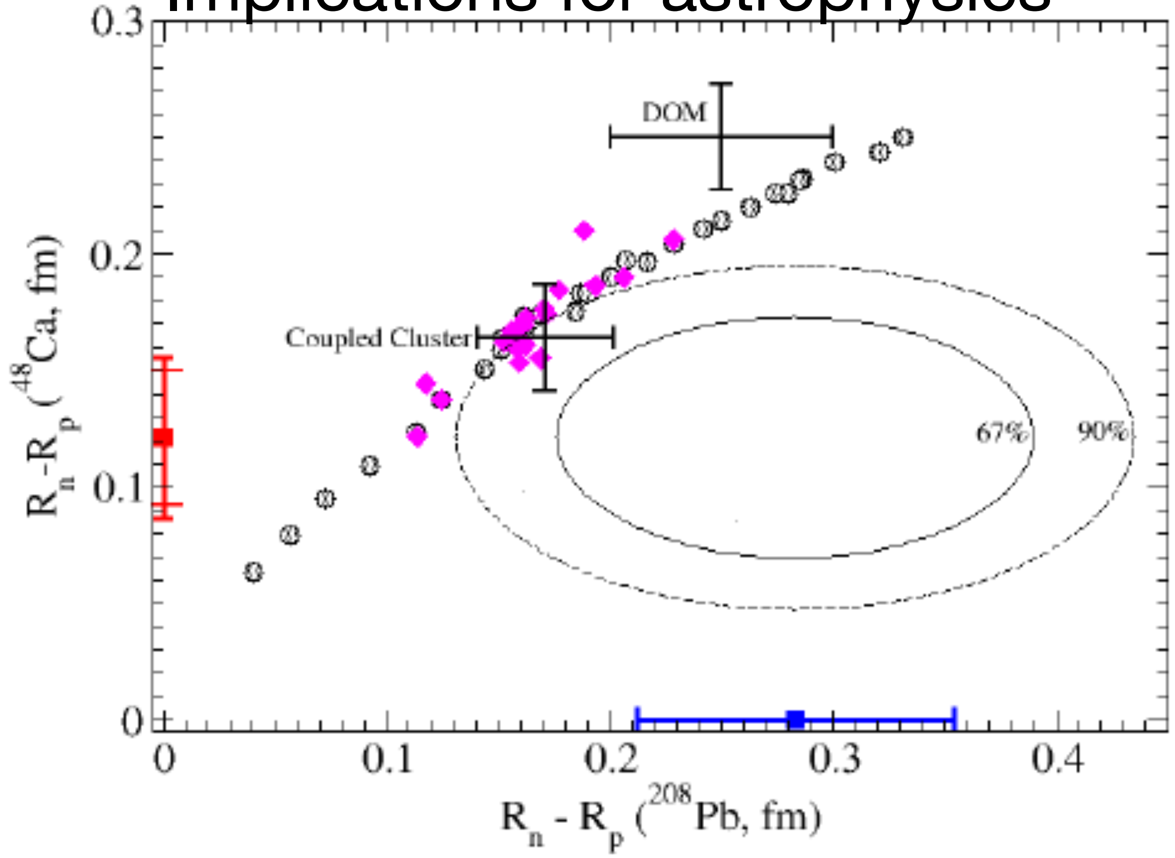
Adhikari et al, arXiv: 2102.10767

CREX: neutron skin of calcium-48

$$R_n - R_p = 0.121 \pm 0.035\,\text{fm}$$

Adhikari et al, arXiv: 2205.11593

Tensions with nuclear models
Implications for astrophysics



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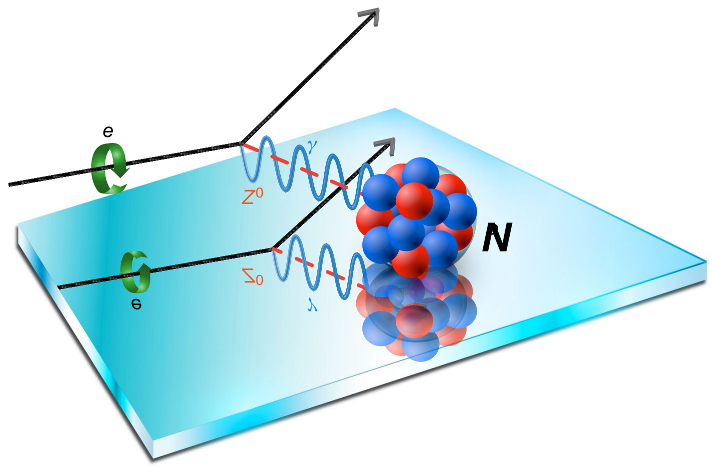

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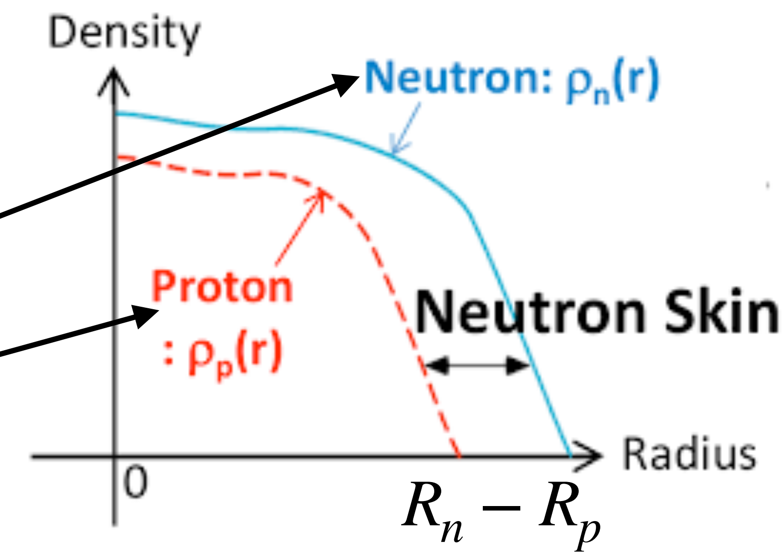

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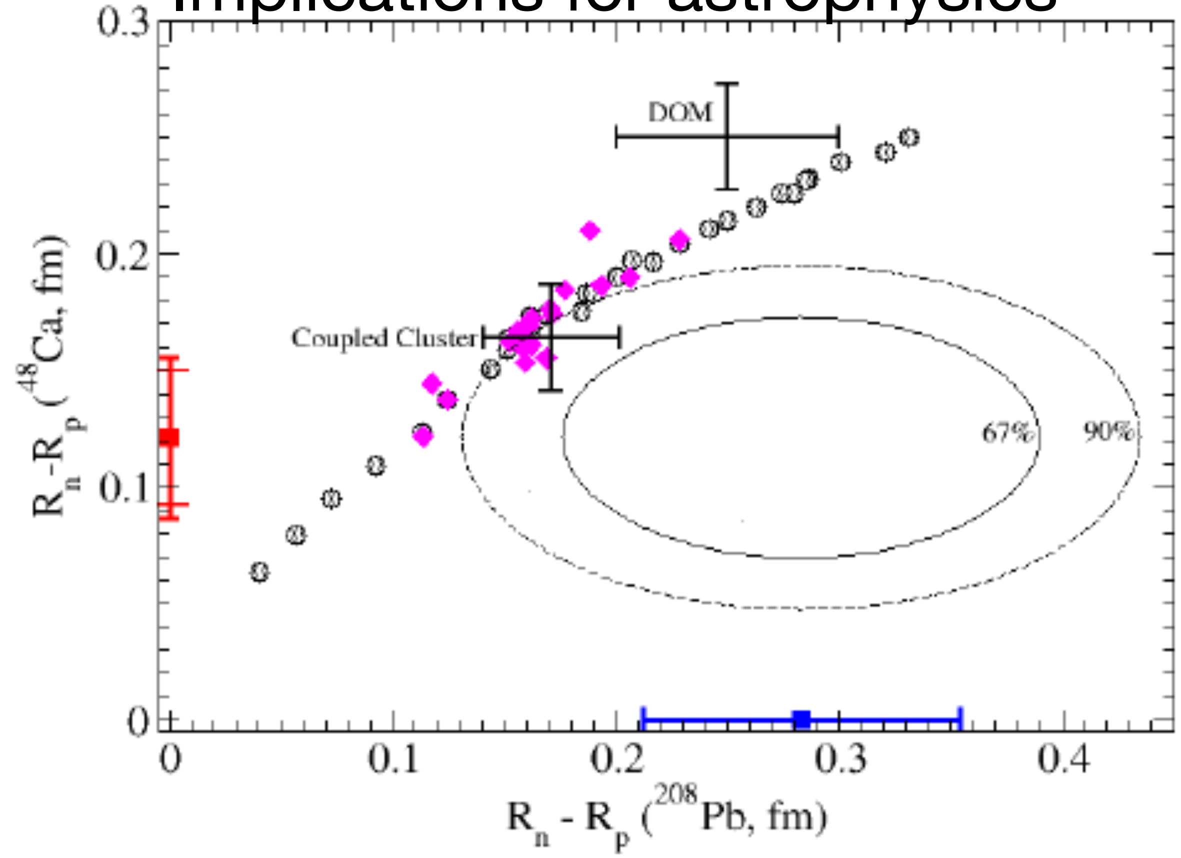
Precise charge radii - prerequisite!

Tensions with nuclear models
Implications for astrophysics



Where do we take nuclear radii from?

Tables of nuclear radii

Contents lists available at SciVerse ScienceDirect

Atomic Data and Nuclear Data Tables

journal homepage: www.elsevier.com/locate/adt

Table of experimental nuclear ground state charge radii: An update

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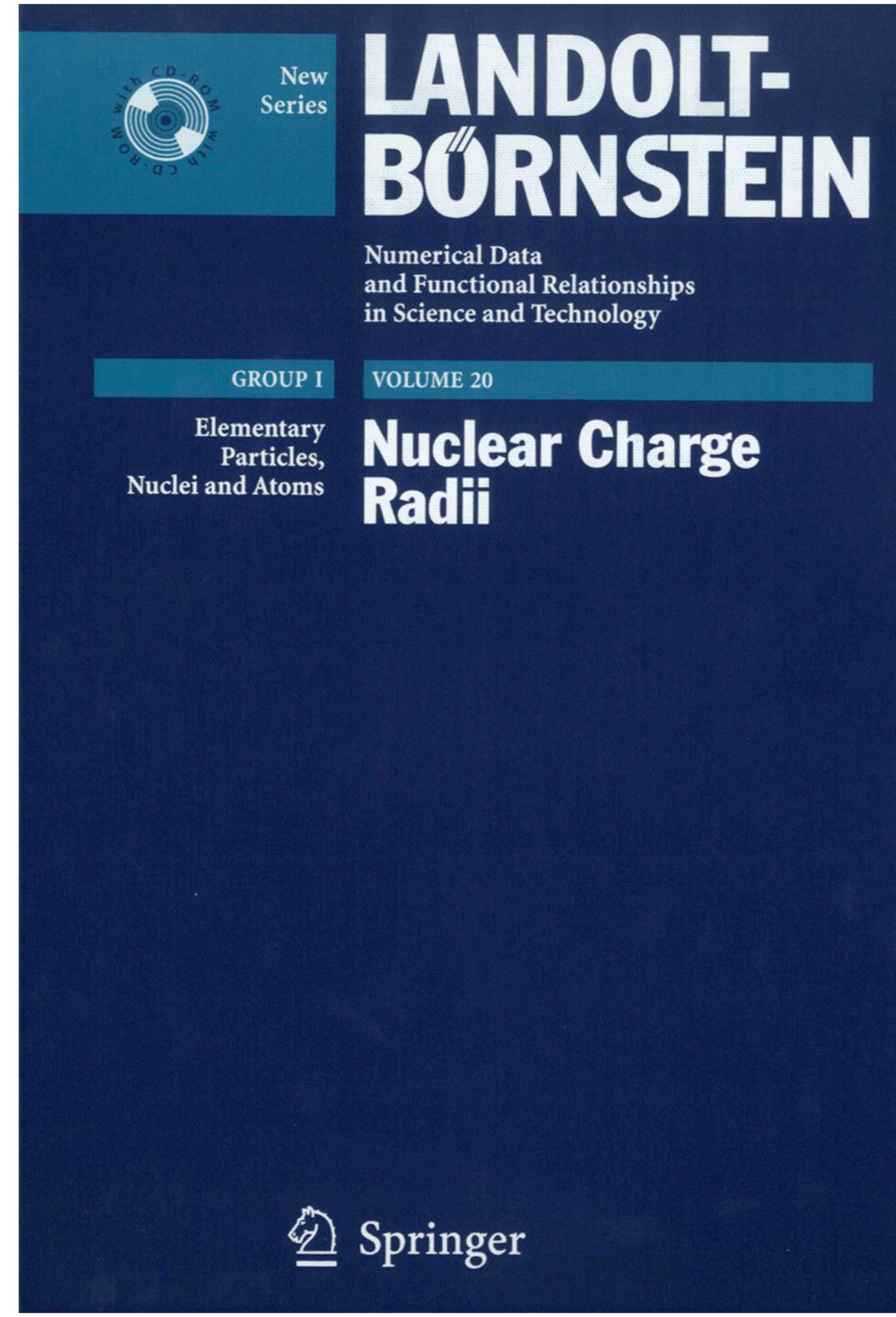
Optical isotope shifts
K_α X-ray isotope shifts
Electron scattering
Muonic atom spectra

ABSTRACT

The present table contains experimental root-mean-square (*rms*) nuclear charge radii *R* obtained by combined analysis of two types of experimental data: (i) radii changes determined from optical and, to a lesser extent, K_α X-ray isotope shifts and (ii) absolute radii measured by muonic spectra and electronic scattering experiments. The table combines the results of two working groups, using respectively two different methods of evaluation, published in ADNDT earlier. It presents an updated set of *rms* charge radii for 909 isotopes of 92 elements from $_1$H to $_{96}$Cm together, when available, with the radii changes from optical isotope shifts. Compared with the last published tables of *R*-values from 2004 (799 ground states), many new data are added due to progress recently achieved by laser spectroscopy up to early 2011. The radii changes in isotopic chains for He, Li, Be, Ne, Sc, Mn, Y, Nb, Bi have been first obtained in the last years and several isotopic sequences have been recently extended to regions far off stability, (e.g., Ar, Mo, Sn, Te, Pb, Po).



Last compilation was made in 2013

Efforts by enthusiasts (not community)

Not always transparent

Methods used (Barrett recipe, theory) need revision

Huge leap in exp. precision —> update badly needed

Recent advancements should be addressed:

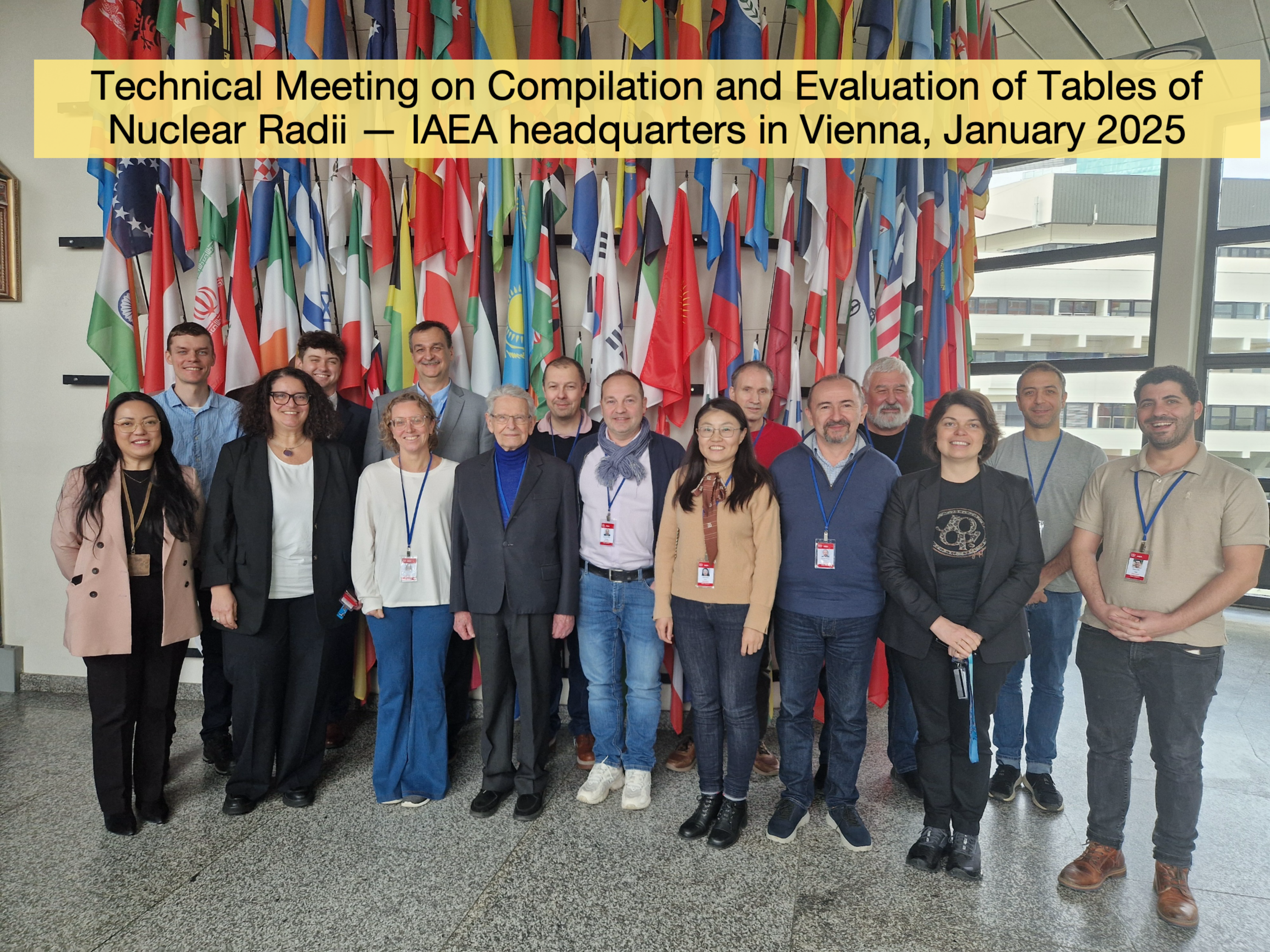
- Revival of muonic atoms spectroscopy (experiment+theory)

- There are “new kids on the block”: experiments in H-like, He-like and Na-like ions which are sensitive to absolute radii (and various differences) at a level which again puts pressure on the value from muonic atoms

- Continued excellence of laser-spectroscopic studies in short-lived nuclei

- Extreme improvement in atomic many-body calculations needed to extract differential radii

The future of tables of nuclear radii



Technical Meeting on Compilation and Evaluation of Tables of Nuclear Radii — IAEA headquarters in Vienna, January 2025

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Gathered experts in various aspects pertinent to radii determination

Muonic atoms, laser spectroscopy, scattering, theory (QED, nuclear)

The goal: prepare an update of Angeli-Marinova tables

Angeli's successors: Endre Takacz of Clemson U. (USA)

Aim for interactive tables with transparent data handling, uncertainty evaluation,

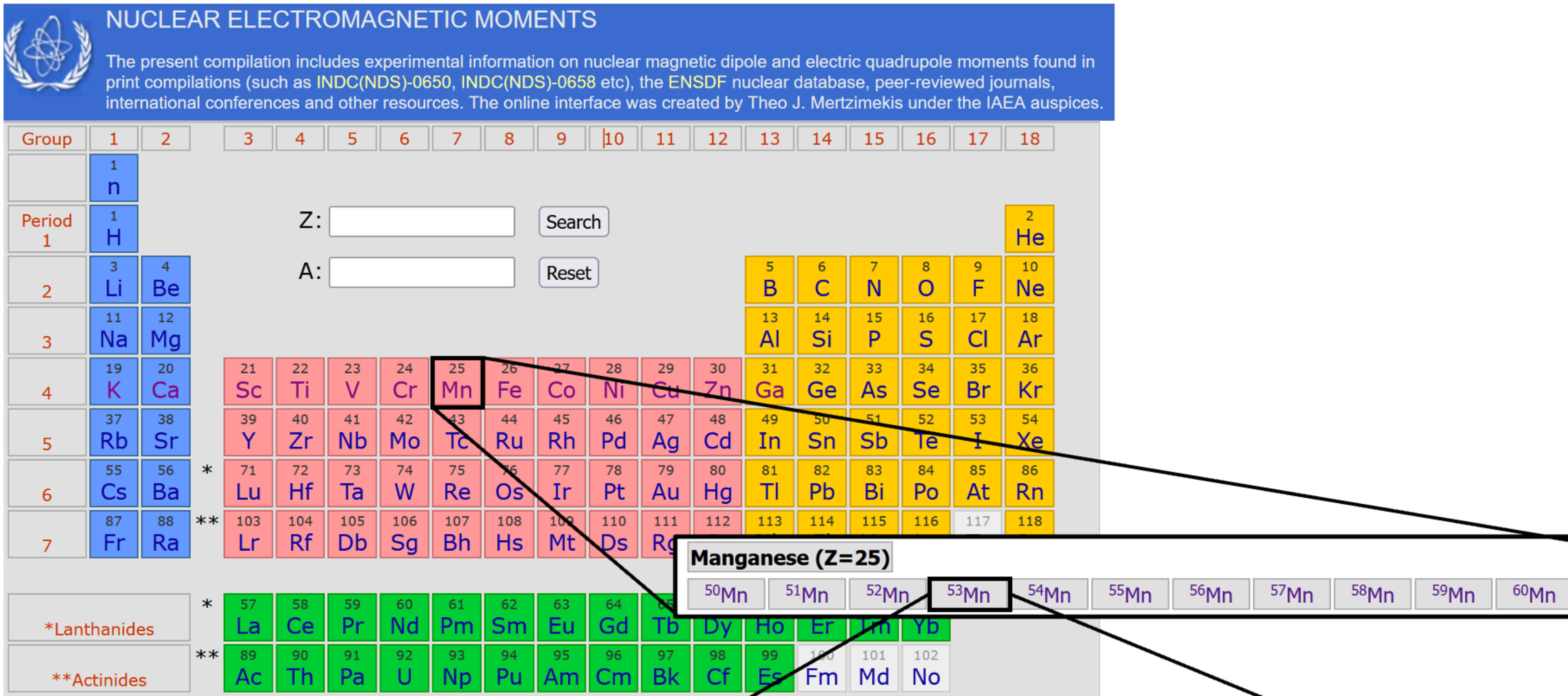
correlations, improved methodology, modern theory, community-driven.

Possibility of technical support of IAEA in maintaining the interactive website

Broad involvement of the community envisioned

The EU Horizon-INFRASERV framework seems perfect for all of this!

Inspiration: IAEA interactive nuclear moment data base



Recommended† magnetic dipole moments

Isotope	Energy [keV]	$t_{1/2}$	Spin/Parity	μ [nm]	Method	Recommended Tables
^{53}Mn	0	3.7x106 y	7/2-	+5.003(5)	CLS	INDC(NDS)-0915
	378	117 ps	5/2-	+3.3(3)	IMPAC	INDC(NDS)-0816

Recommended† electric quadrupole moments

Isotope	Energy [keV]	$t_{1/2}$	Spin/Parity	Q [b]	Method	Recommended Tables
^{53}Mn	0	3.7 106 y	7/2-	+0.17(3)	TLS	INDC(NDS)-0833

Participating researchers and institutions

Technion Haifa, Israel (Ohayon)

JGU Mainz, Germany (Gorshteyn)

Clemson U., USA (Dipti, Staiger, Takacs)

TU Darmstadt, Germany (Nörtershäuser)

MPIK Heidelberg, Germany (Oreshkina, Heiße)

ELI-NP, Bucharest, Romania (Balabanski)

U. Manchester, UK (Flanagan)

CERN (Yordanov)

IJCLAB Orsay France (Georgiev)

FRIB & MSU, East Lancing USA (Gueye, Minamisono, Seng)

Argonne NL Chicago USA (Kondev)

PRL Ahmedabad, India (Sahoo)

Peking U. China (Xiaofei Yang)

Summary report online: https://nds.iaea.org/publications/indc/indc-nds-0918/

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IAEA
International Atomic Energy Agency

INDC(NDS)-0918
Distr. G,MP

INDC International Nuclear Data Committee

Compilation and Evaluation of Nuclear Charge Radii

Summary Report of the Technical Meeting

IAEA Headquarters, Vienna, Austria
27–30 January 2025

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June 2025

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4. RECOMMENDATIONS

Based on the presentations and subsequent discussions, participants formulated the following list of recommendations, which they considered crucial for creating a new table of recommended nuclear charge radii that is both functional and easy to maintain:

- We recommend regular updates and maintenance of the database with all data and enhancing dissemination using modern web interfaces and database technologies.
- We recommend creating a working group that will regularly meet to advise on developments, updates, and dissemination of the database. It should contain data producers, evaluators, and user representatives.
- There is a need for a white paper with detailed recommendations describing the visions and future directions of the field and the future evaluation.
- We encourage the reanalysis of existing data using modern theoretical and statistical techniques, *(for example dispersion correction in electron scattering, nuclear polarization in muonic atoms, and others)*.
- There is a need for additional support from stakeholders for experimental and theoretical groups in acquiring new data as well as developing new and improving existing theoretical frameworks.
- We recommend training the next generation of experts in nuclear charge radii and evaluation.
- Since this database is complementary to the nuclear moments and transition's probability databases, we recommend the results of this effort are communicated to the nuclear structure and decay data network.

White paper in preparation: aimed at sharing vision and inviting the broader community to participate, contribute and critically assess

Budget

2 Workshops (kick-off and closing) 2 x 15 K€ = 30 K€

Travel budget 4 x 25 K€ = 100 K€

1 Postdoc/Technician position for 2 years 150 K€ to work specifically on the project

The technical involvement of IAEA (server, storage, computing, staff) to be defined