JOURNÉE DES NOUVEAUX ENTRANTS

Pierre Arthuis

A short biography

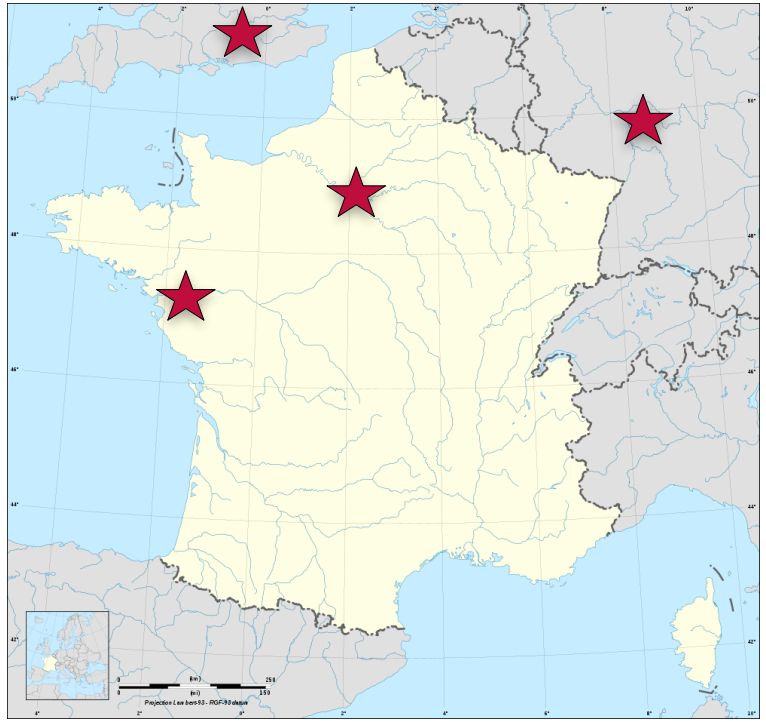
1991
Birth

2008
Baccalauréat

2008-2010
Prépa

2010-2012
Ecole d'ingénieur

2012-2014
M.Sc. Physik



2015-2018
Doctorat

2018-2020
Postdoc

2020-2024
Postdoc

2024 - 2026
Marie Curie Fellow

What I do when I am not working

Music listener

You wanna *guess* my 2024 Top 1 artist?

It's Charli, baby!

Reader

Mostly essays

Need to catch up on Sally Rooney's *Intermission* though

Geography-based team e-sport player

Did you know Krakow's phone numbers start with 12?

GEOGUESSR

La Ligue de Loisir Géographique

Former (amateur) rugby player

Mais la thèse, tu connais…

USRO Union Sportive de Ris Orangis

Sportpark Ziegelbusch TG 1875

Languages / writing systems learner

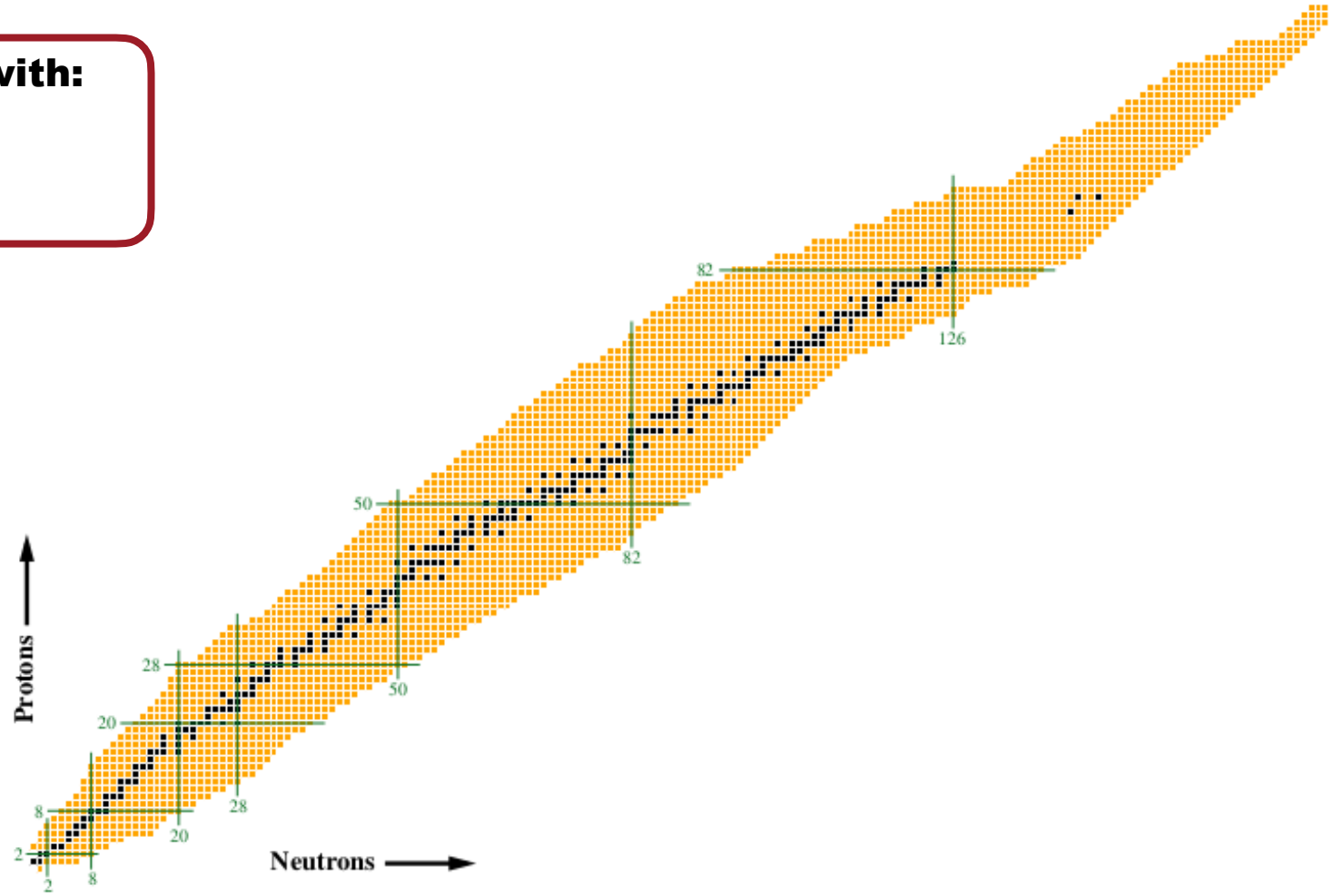
Currently trying my luck with hangeul

한글

A-body system with:

Z protons

N neutrons



Low-energy ab initio nuclear theory

A-body system with:

Z protons

N neutrons

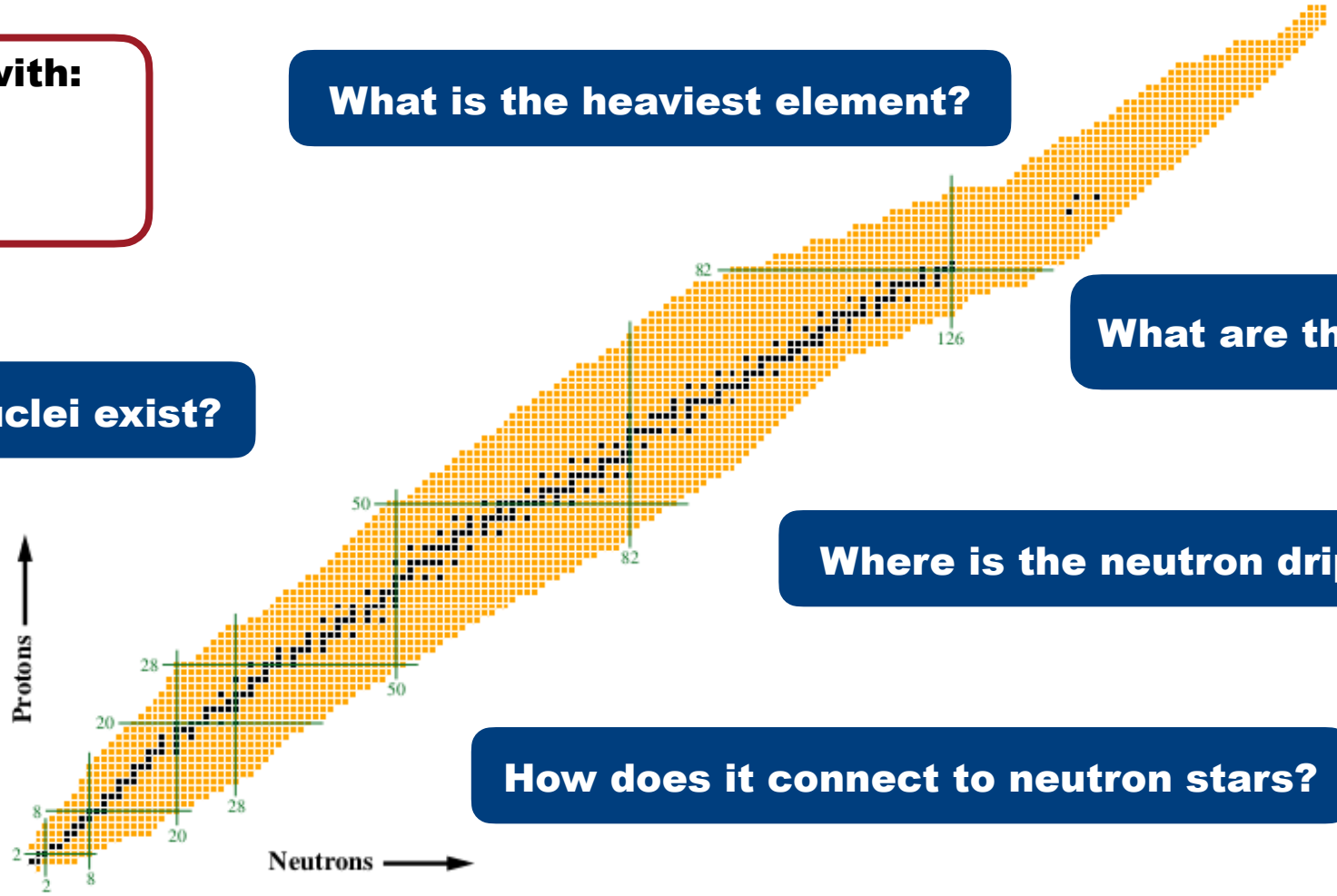
What is the heaviest element?

What are the magic numbers?

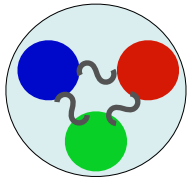
How many nuclei exist?

Where is the neutron dripline?

How does it connect to neutron stars?

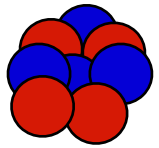


Ab initio many-body scheme



Particle physics

No direct application of
quantum chromodynamics
(Lattice QCD only for few nucleons)



Nuclear theory

Interactions anchored in Effective Field Theory

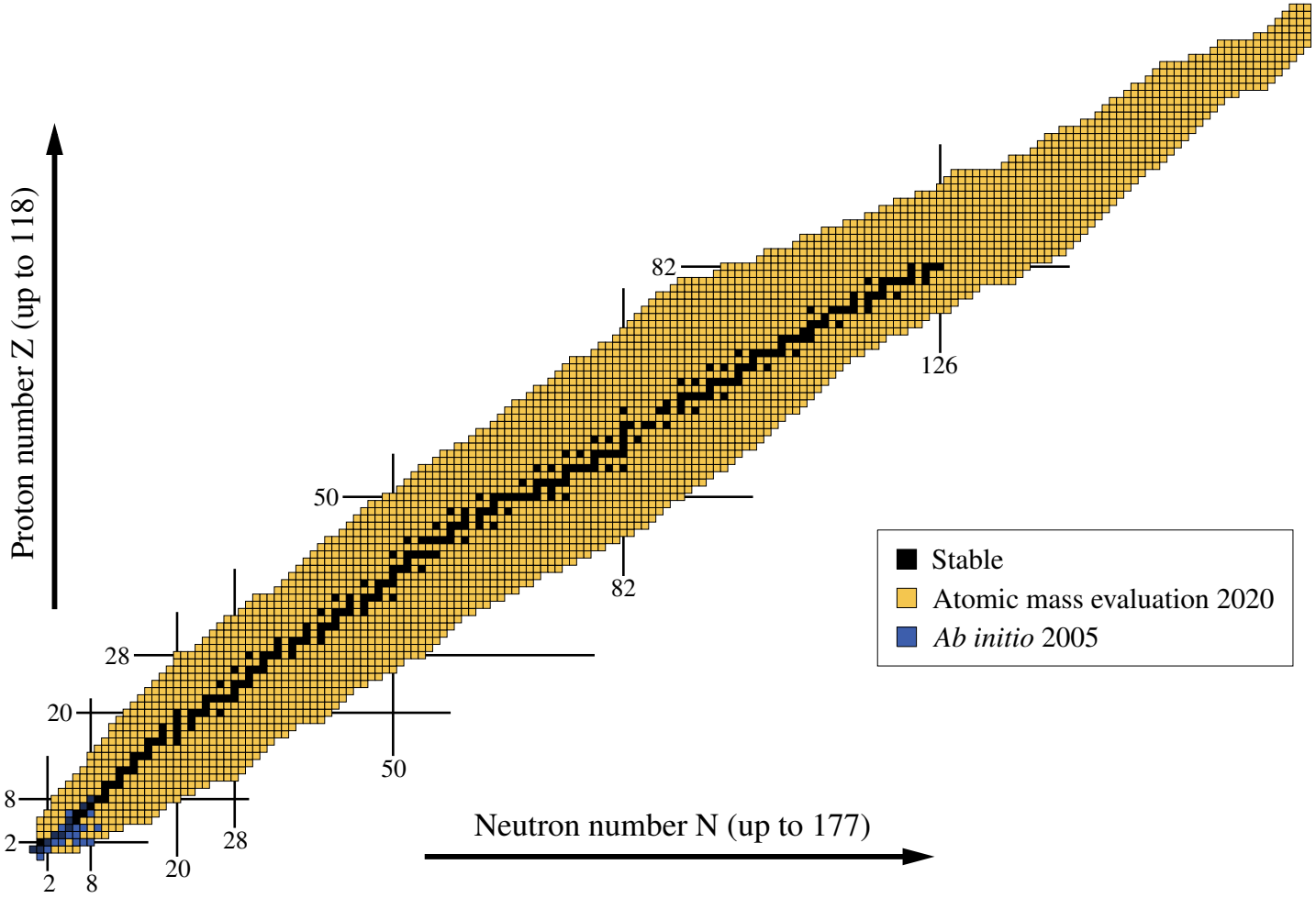
A-body Schrödinger equation

$$H\,|\Psi^{A}\rangle = E^{A}\,|\Psi^{A}\rangle$$

Obtain a description that is:

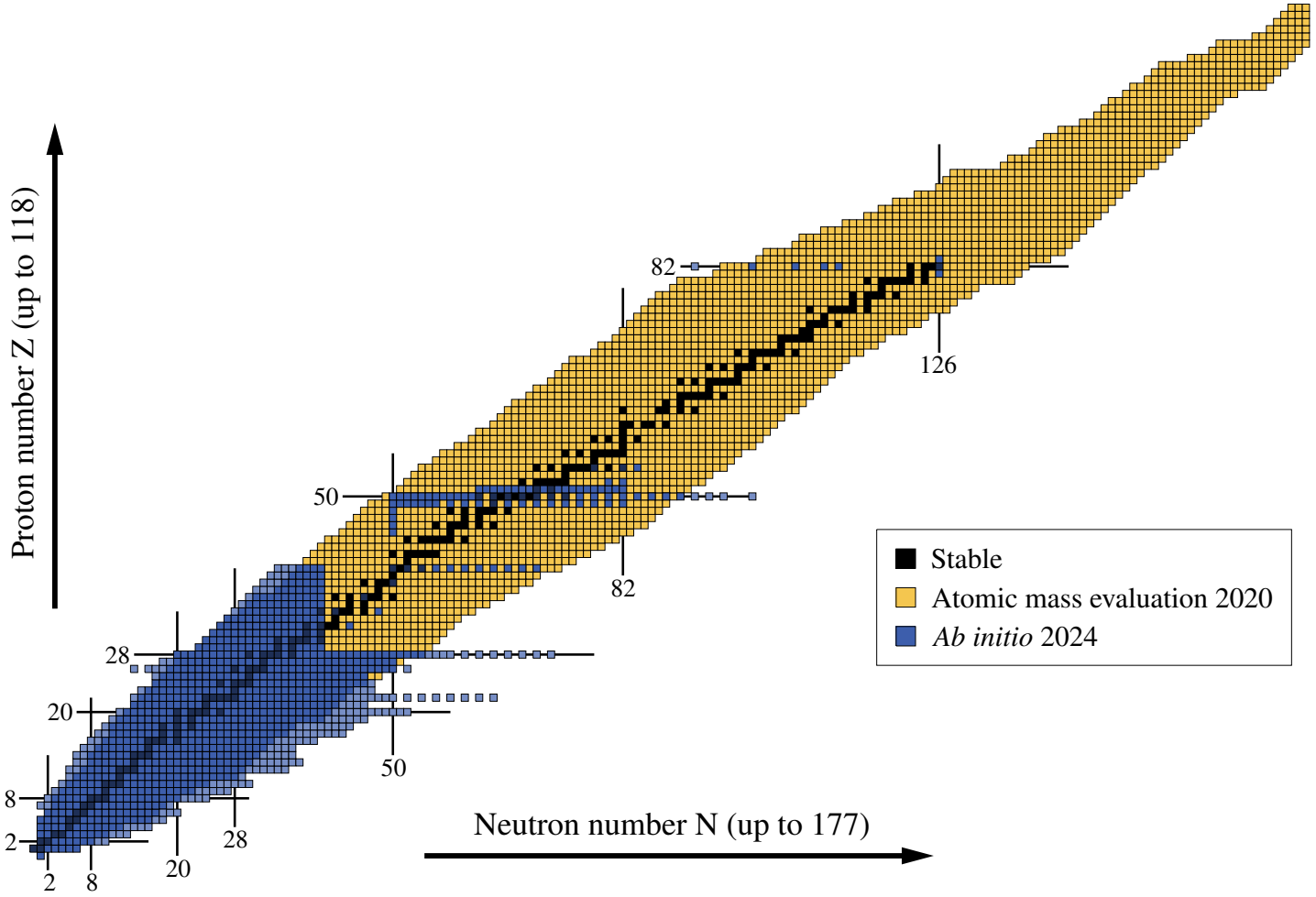
- Consistent
- Systematic
- Accurate enough
- From inter-nucleon interactions
- Rooted in quantum chromodynamics

Ab initio many-body methods range



Adapted from B. Bally

Ab initio many-body methods range



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Expansion methods

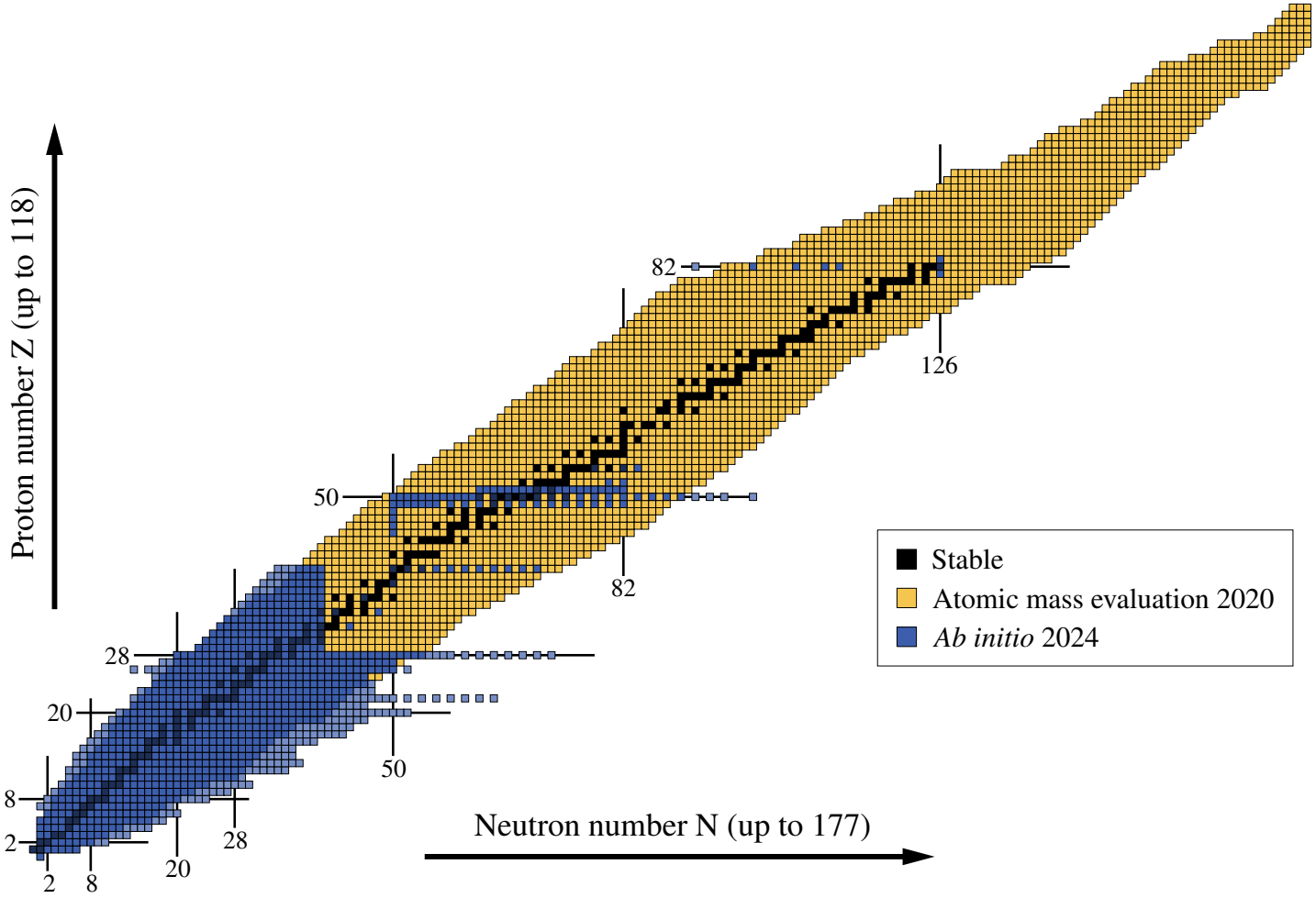
$$H|\Psi\rangle = U(\infty)|\Phi\rangle$$
$$= (U_1 + U_2 + U_3 + \ldots)|\Phi\rangle$$

- Expand the correlations order by order
- Truncate at desired order
- Estimate uncertainties

Controlled expansion & uncertainty

Moderate cost

A look at experimental facilities



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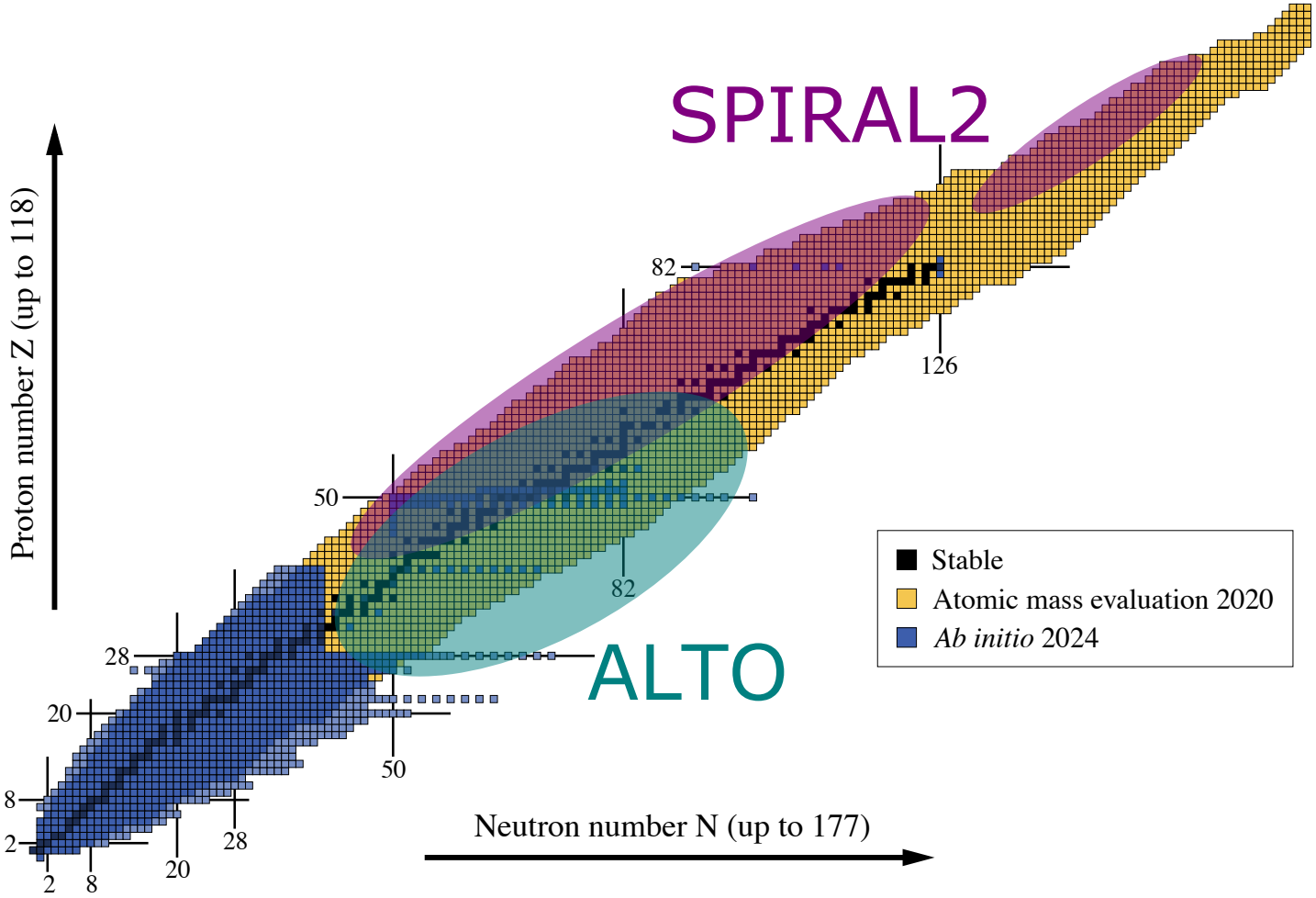
A look at experimental facilities



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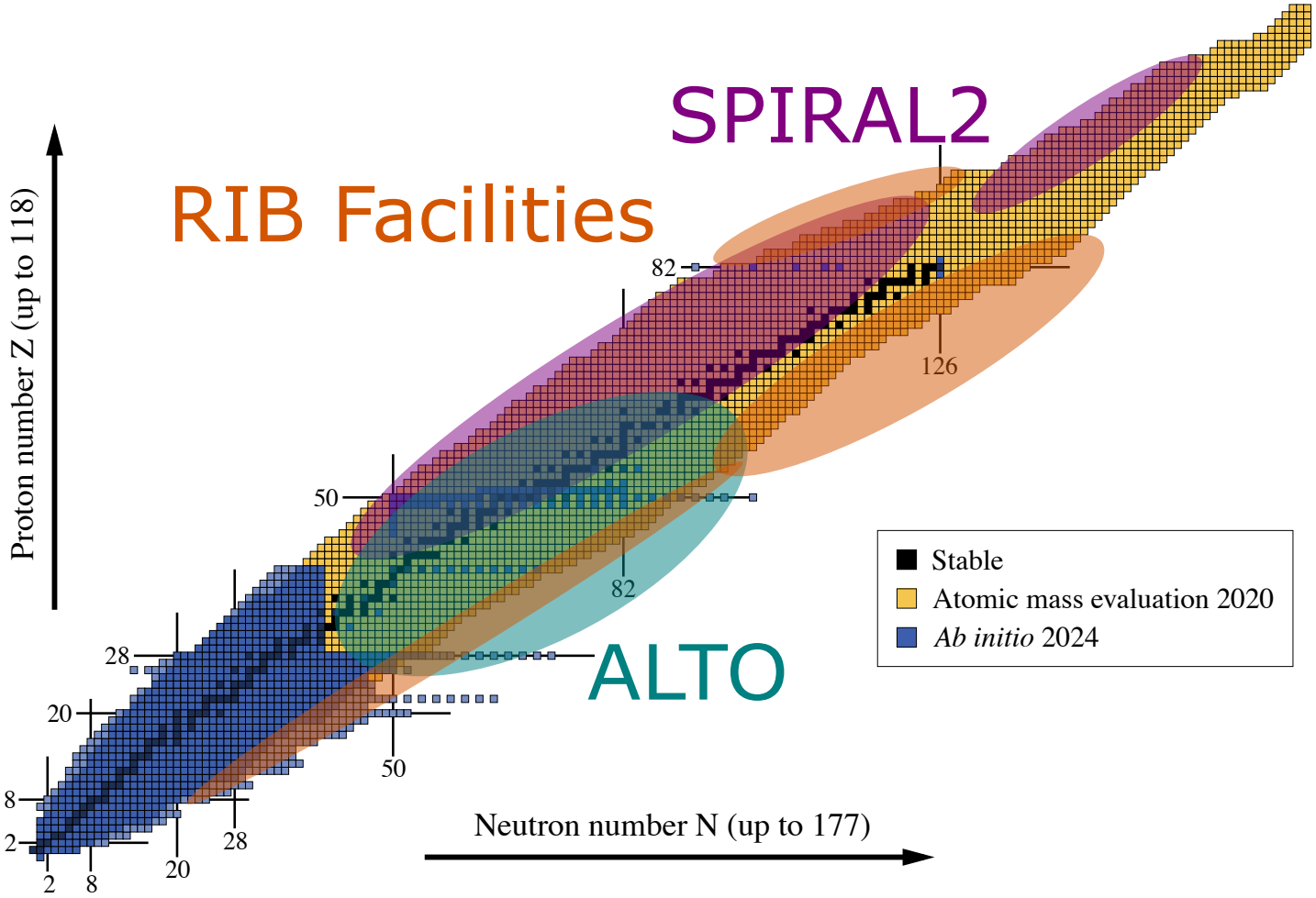


Adapted from B. Bally

New era of shared effort

Heaver nuclei

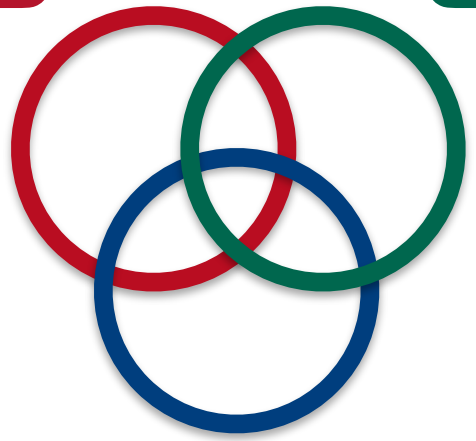
More exotic nuclei

Nuclear physics challenge(s)

Determine an observable O for a system S with precision η

Nuclear interaction

Many-body method



Numerical method

Accurate low-resolution interactions

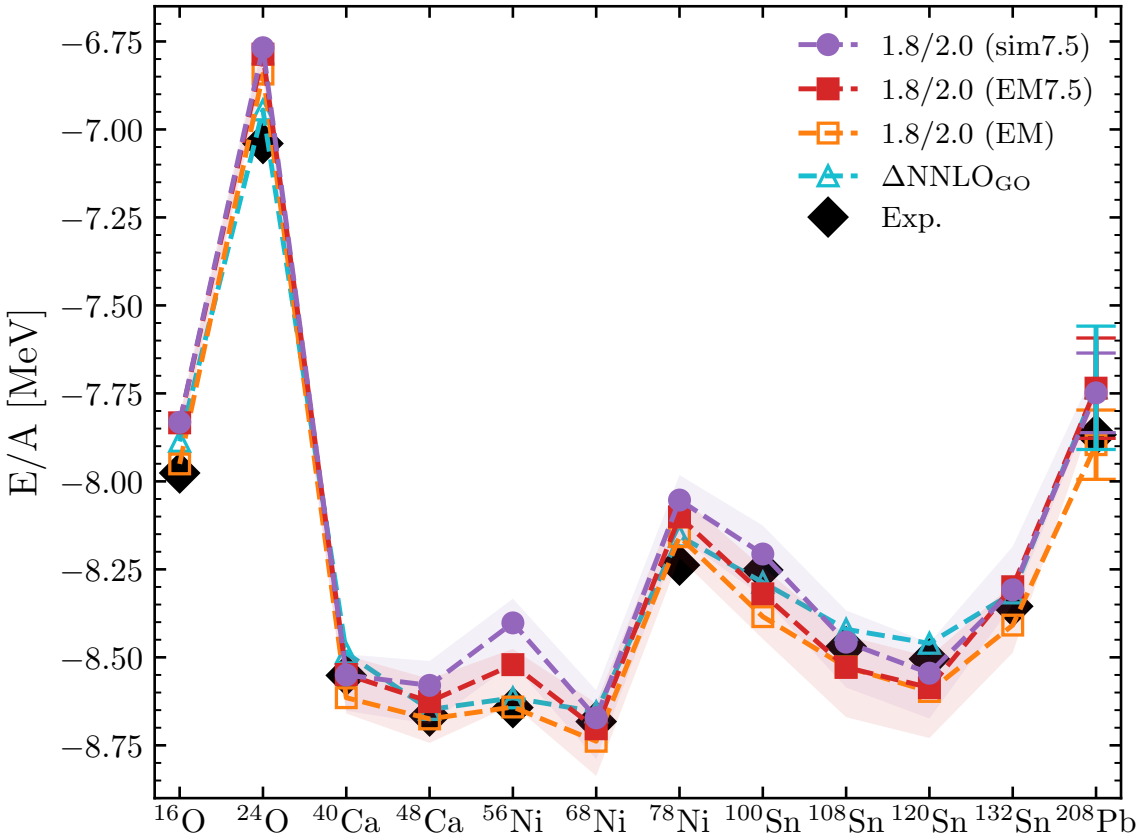
[Arthuis, Hebeler, Schwenk, arxiv:2401.06675]

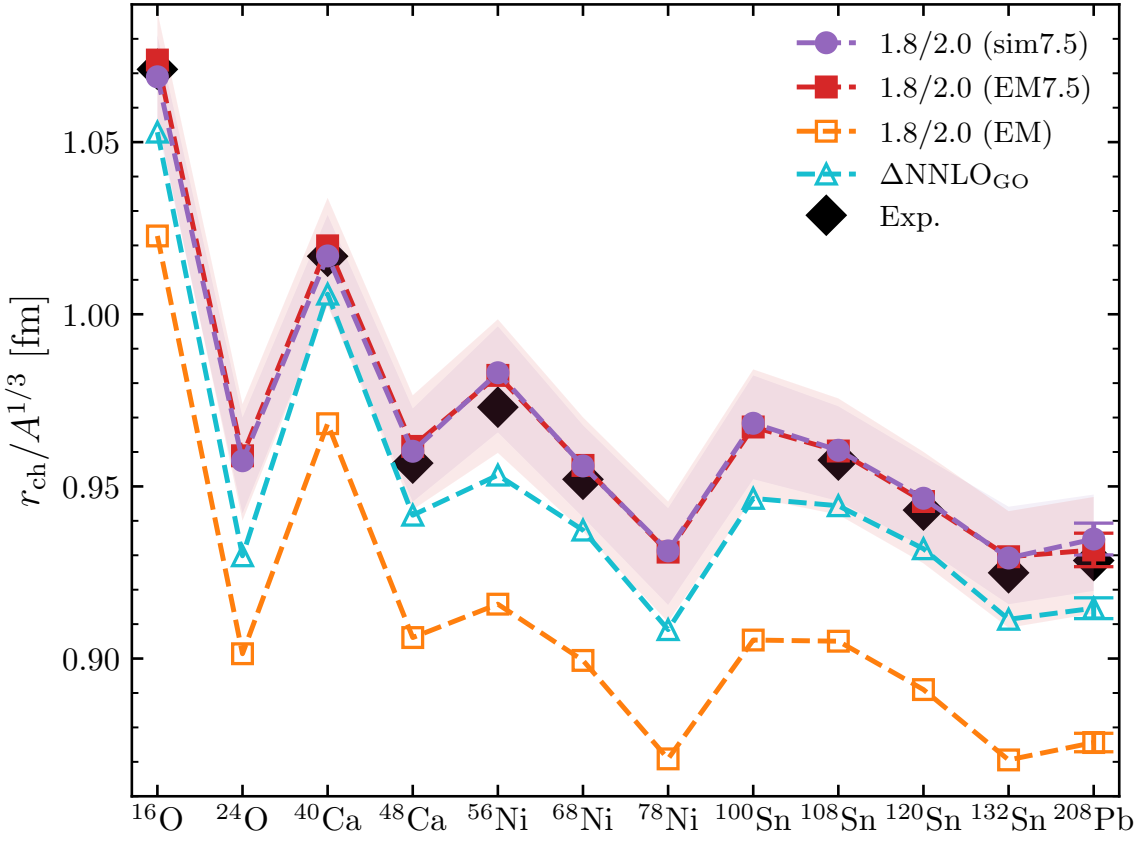
Motivation

- Need for *soft* interaction for fast convergence
- Correct previous deficiencies in the reproduction of radii

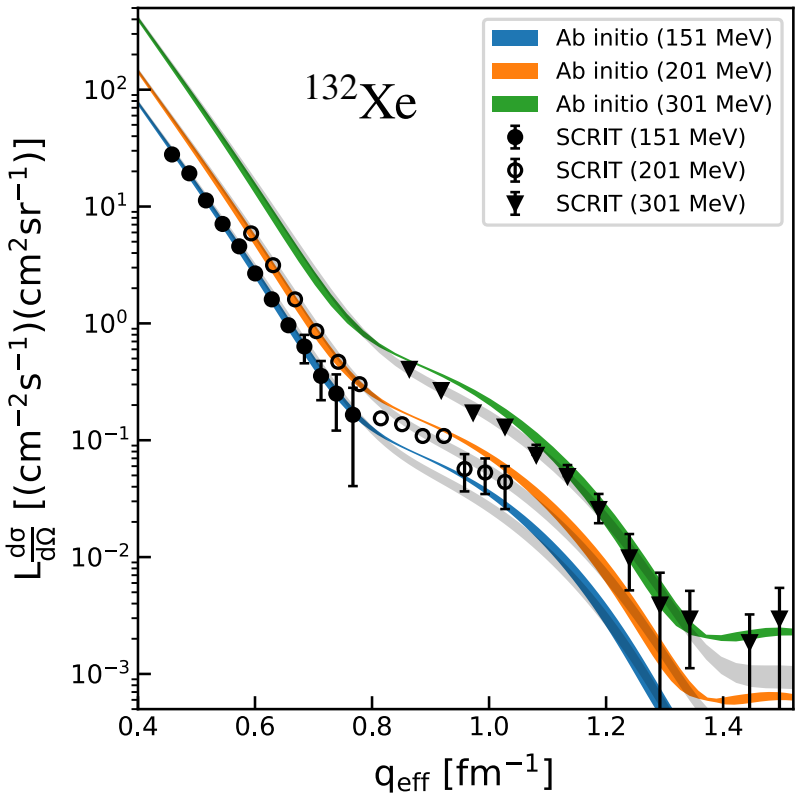
Progress towards better interactions

- *Accurate* reproduction of energies and radii
- Better understanding of chiral EFT parameters





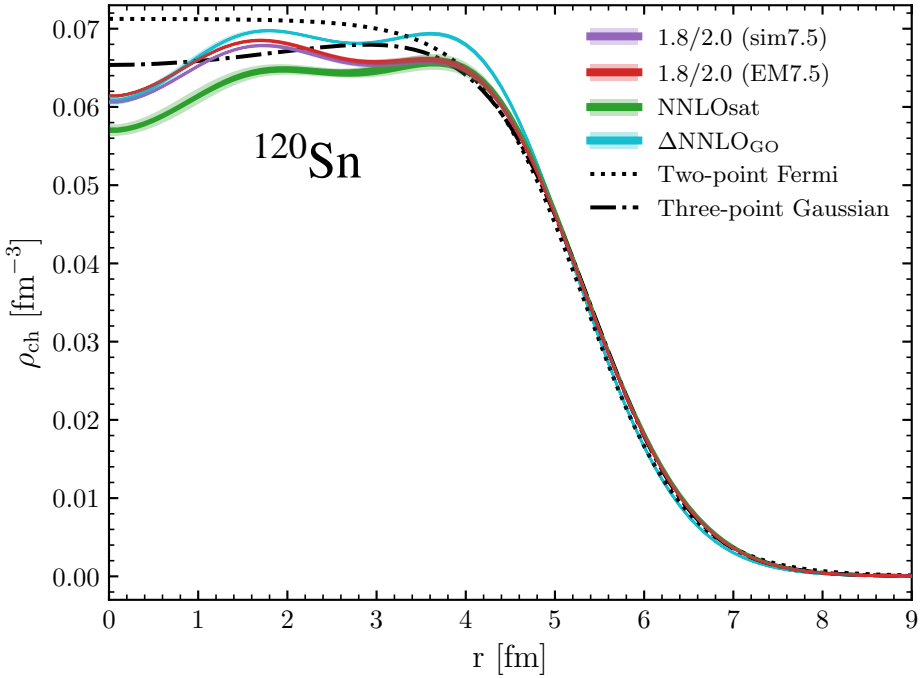
Tins and Xenons computations



[Arthuis, Barbieri, *et al.*, *PRL* **125** (2020)]

Motivation

- *Ab initio* ready for heavy, open-shell nuclei ?
- Ability to support experimental endeavours past the Sn line ?



[Arthuis, Hebeler, Schwenk, arXiv:2401.06675]

Ab initio mature for heavy nuclei

- Reproduction of experimental cross-sections
- Tests of interactions at the *ab initio* frontier

Automated diagram generator for many-body methods

[Arthuis et al., CPC **240** (2019) & CPC 261 (2021), Tichai, Arthuis et al., EPJA 58(2022)]

Formal stage → **Prototype code** → **Production code** → **Numerical results**

Months to years | ~ 6 months | ~ 6 months

github.com/adgproject/adg

Safe and fast through automatisation

- Graph-theory methods
- New formal and numerical knowledge gained

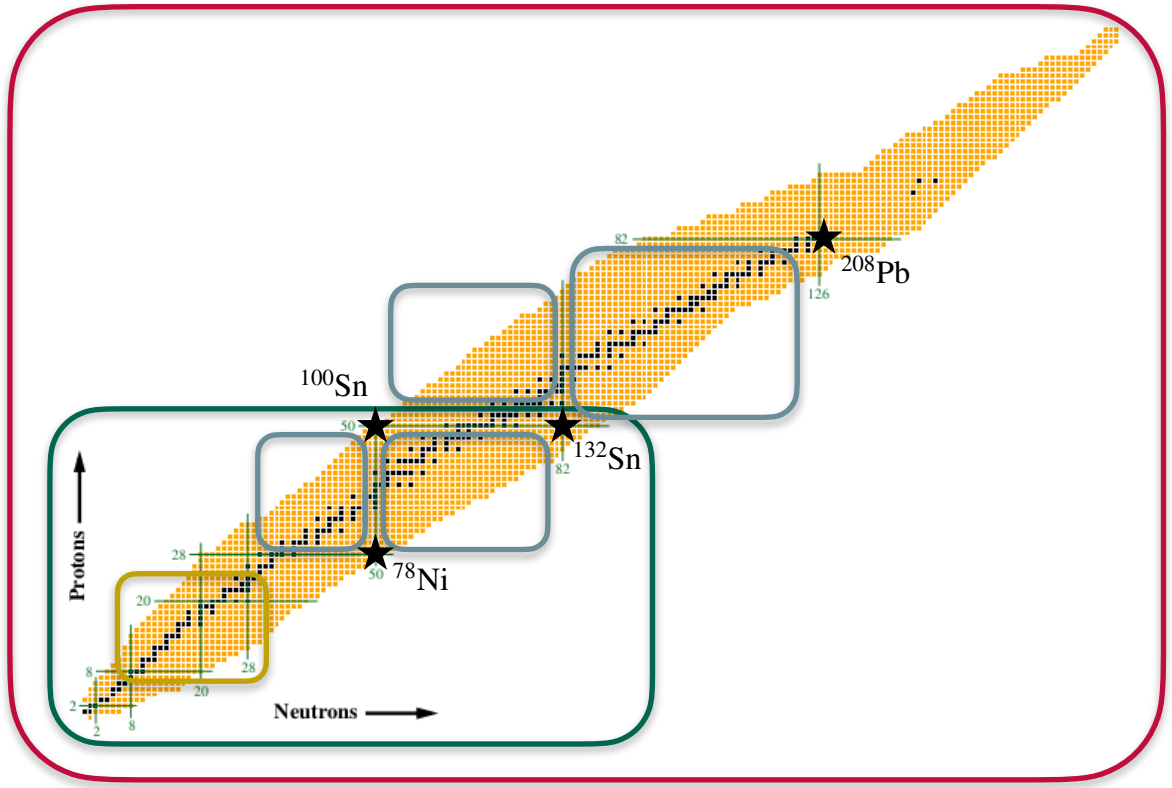
Handle high-order complexity

PBMBPT(N)	1	2	3	4
# Équations	1	6	189	13 046

Used for high-order infinite matter calculations

[Drischler *et al.*, *ARNPS* **71** (2021), Keller *et al.*, *PRL* **130** (2023)]

A roadmap for nuclear *ab initio* methods



Accurate interactions

- Calibration on medium-mass nuclei
- Incorporate tests in many-body codes

More routine access to the heavy sector

- Reduce open-shell systems computing costs
- Generate pseudo-data for density functionals colleagues

High-precision methods

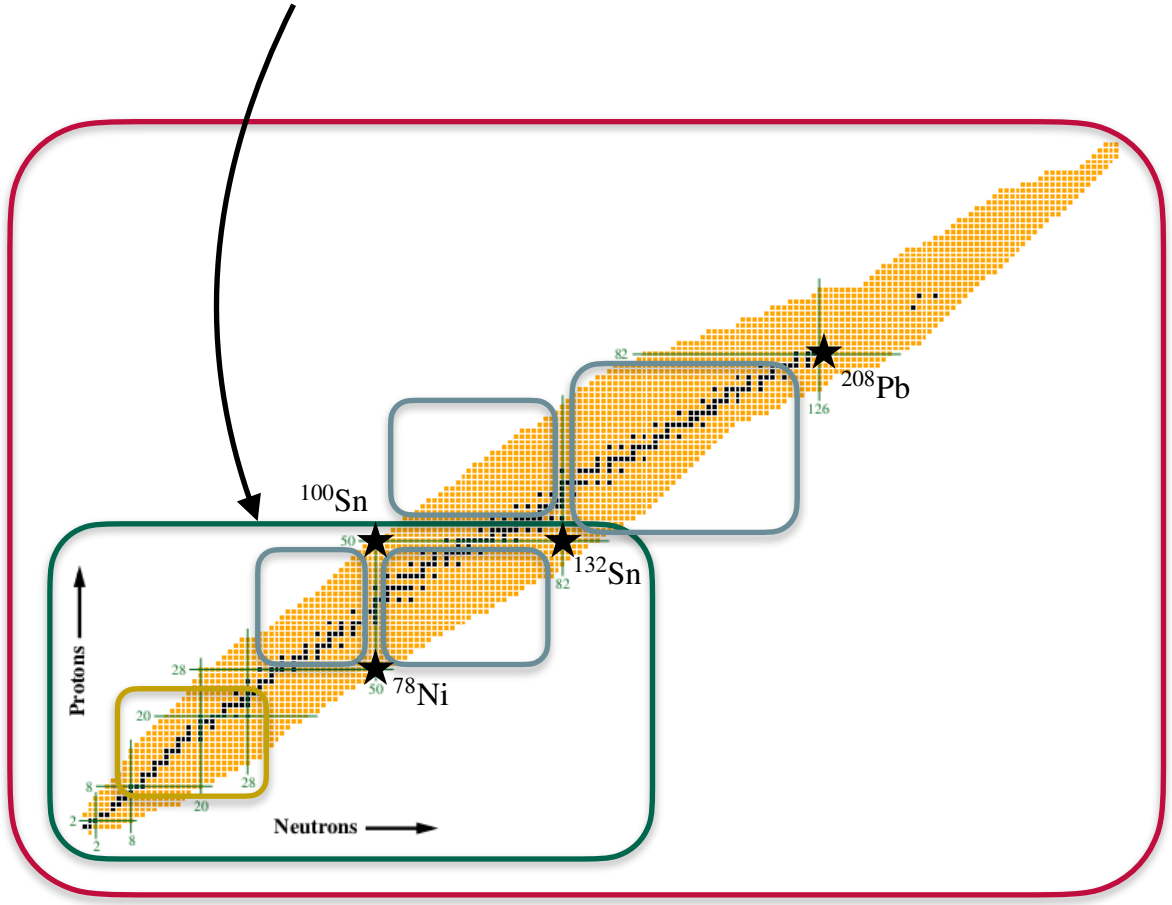
- Enable targeted key studies

Ab initio reactions

- Perturbative methods for medium-mass nuclei

A roadmap for nuclear *ab initio* methods

Target high precision where already possible…



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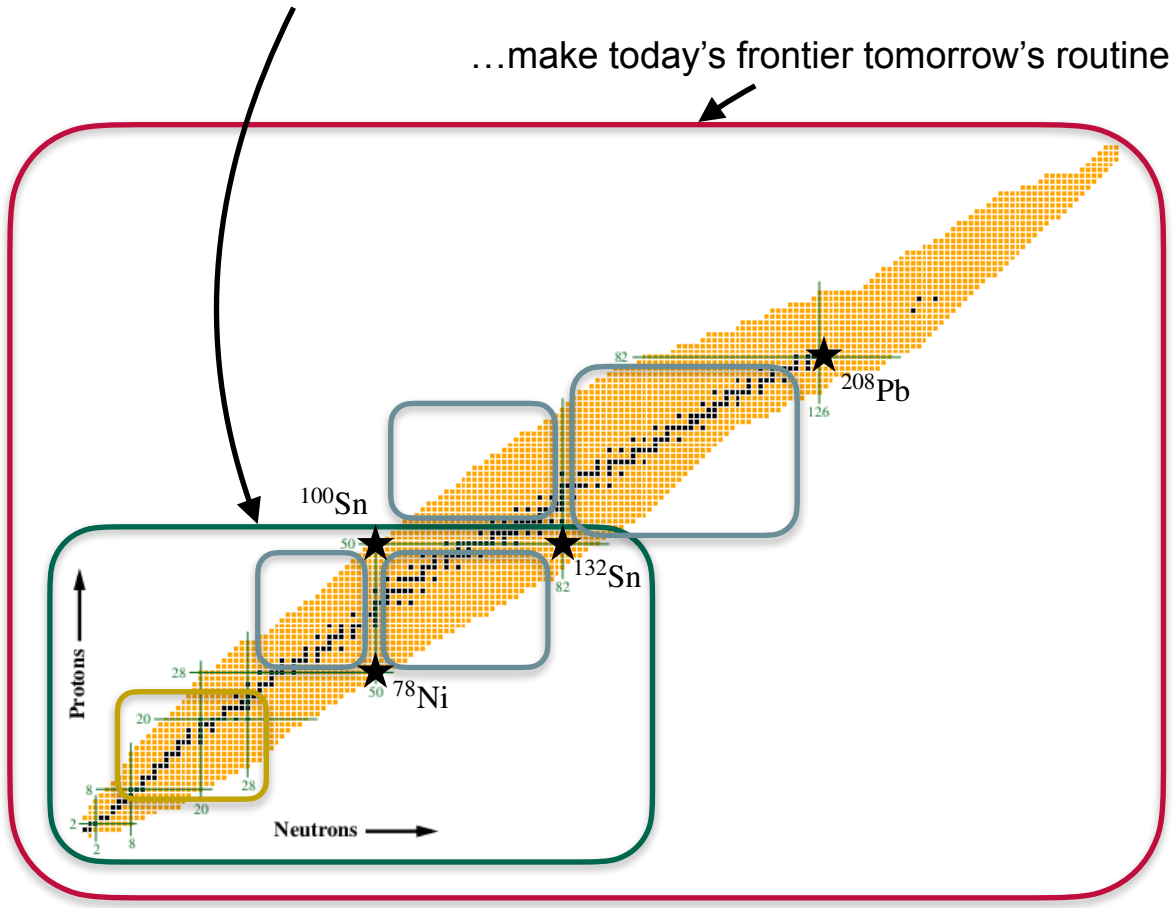
A roadmap for nuclear *ab initio* methods

Target high precision where already possible…

…make today's frontier tomorrow's routine



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Thank you for your attention!

Come and see me in 100A-A206!