

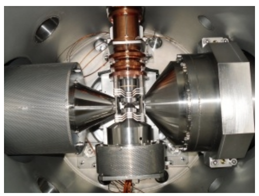
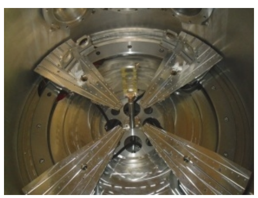

Introduction session physique nucléaire et inter-disciplinaire

Diego Gruyer

Normanie Université, ENSICAEN, UNICAEN, CNRS/IN2P3, LPC Caen, France
diego.gruyer@lpccaen.in2p3.fr

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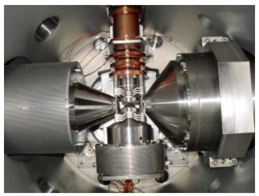
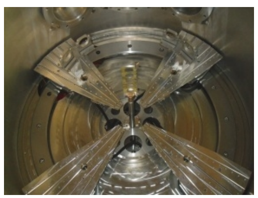
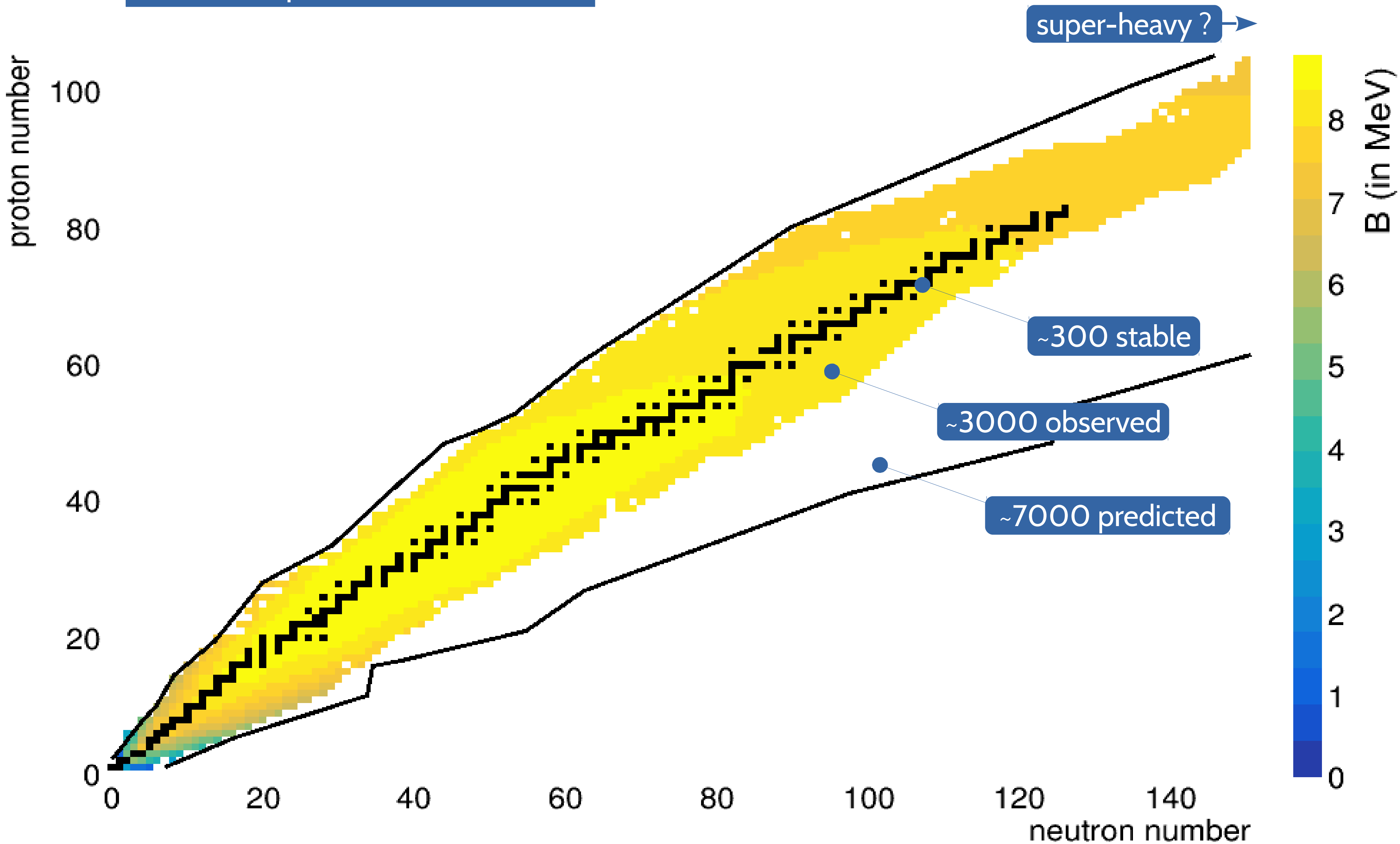



Nuclear physics : what your mother never told you

Nuclei = Z protons + N neutrons



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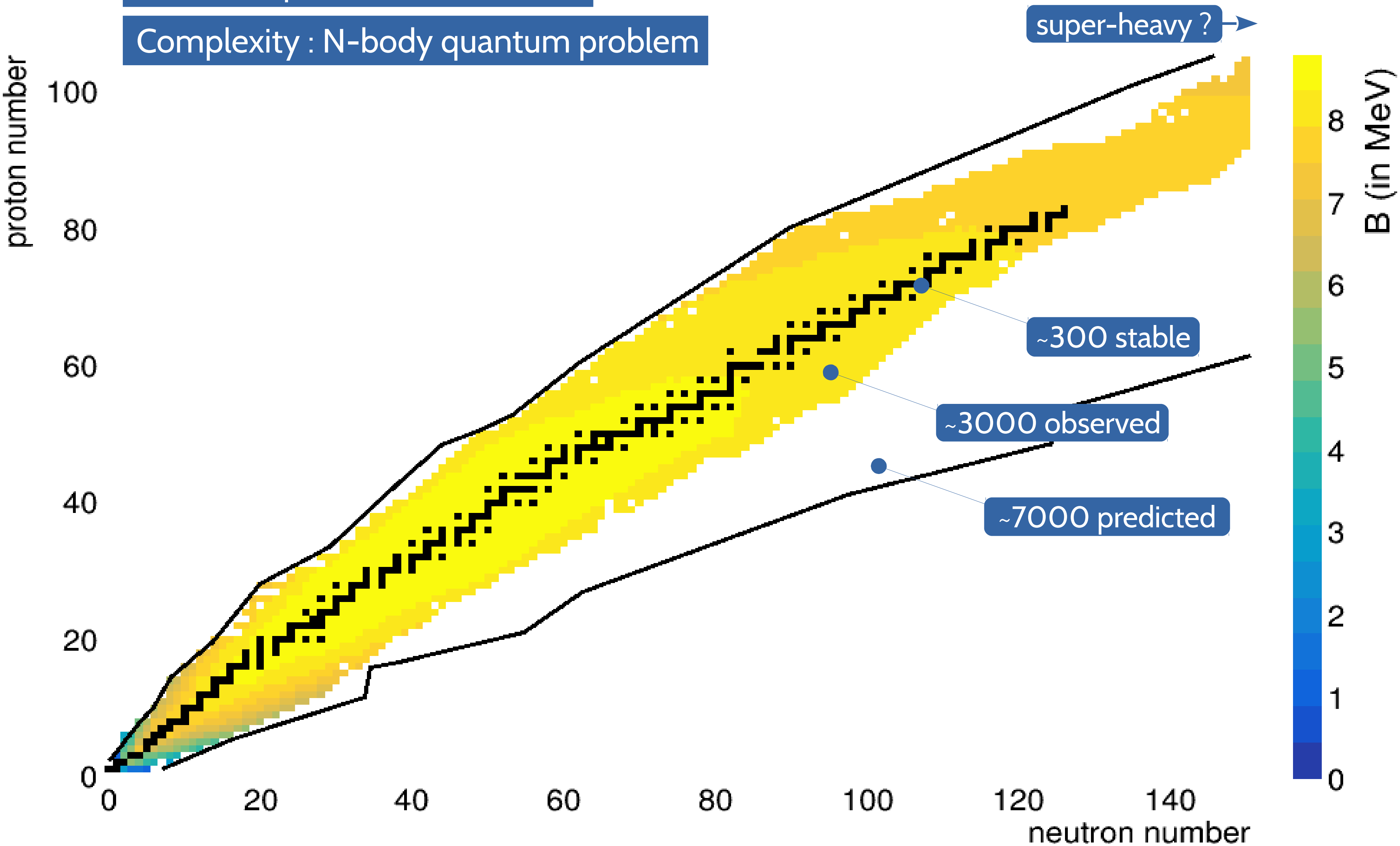
Complexity : N-body quantum problem



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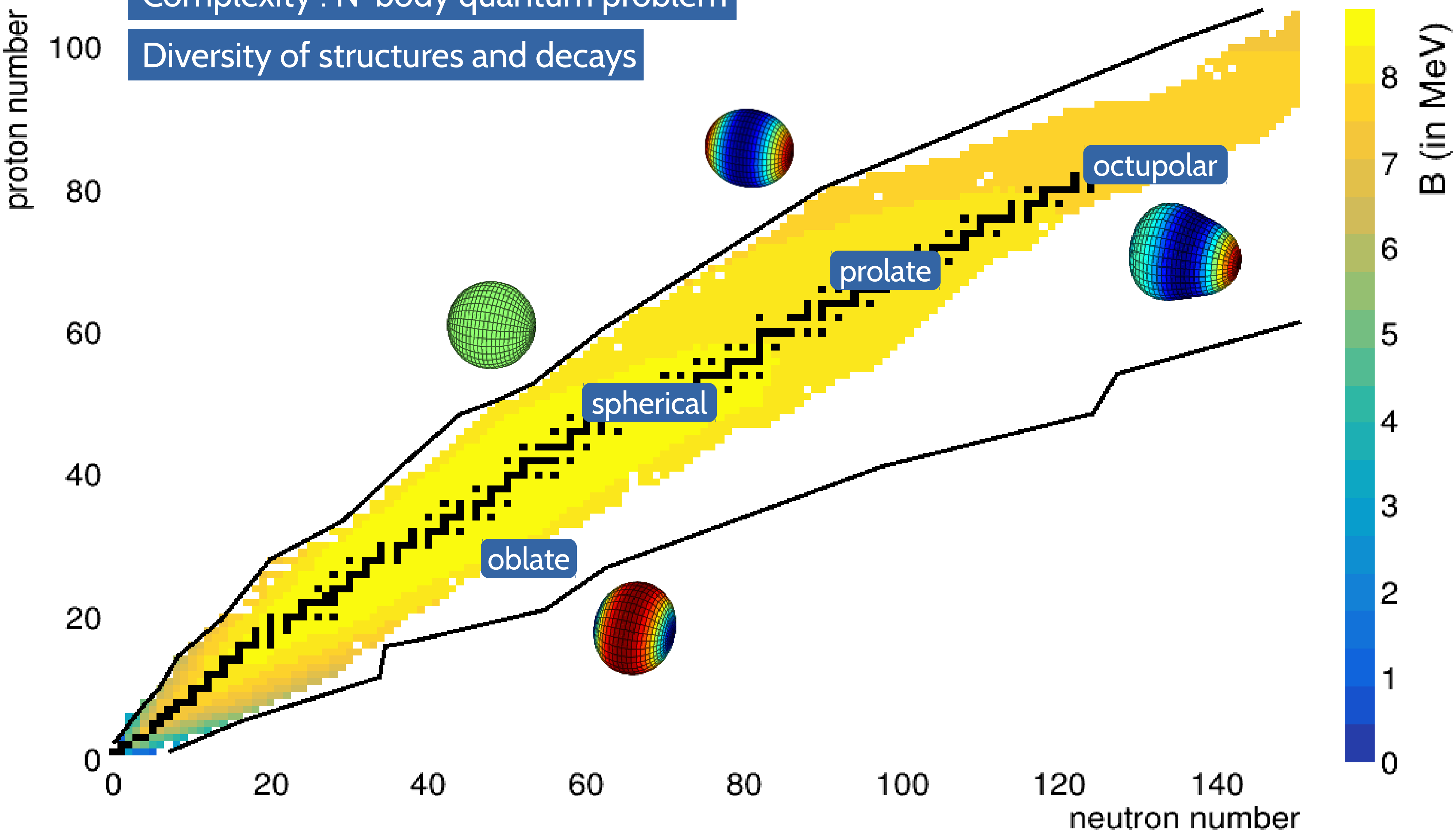
Diversity of structures and decays



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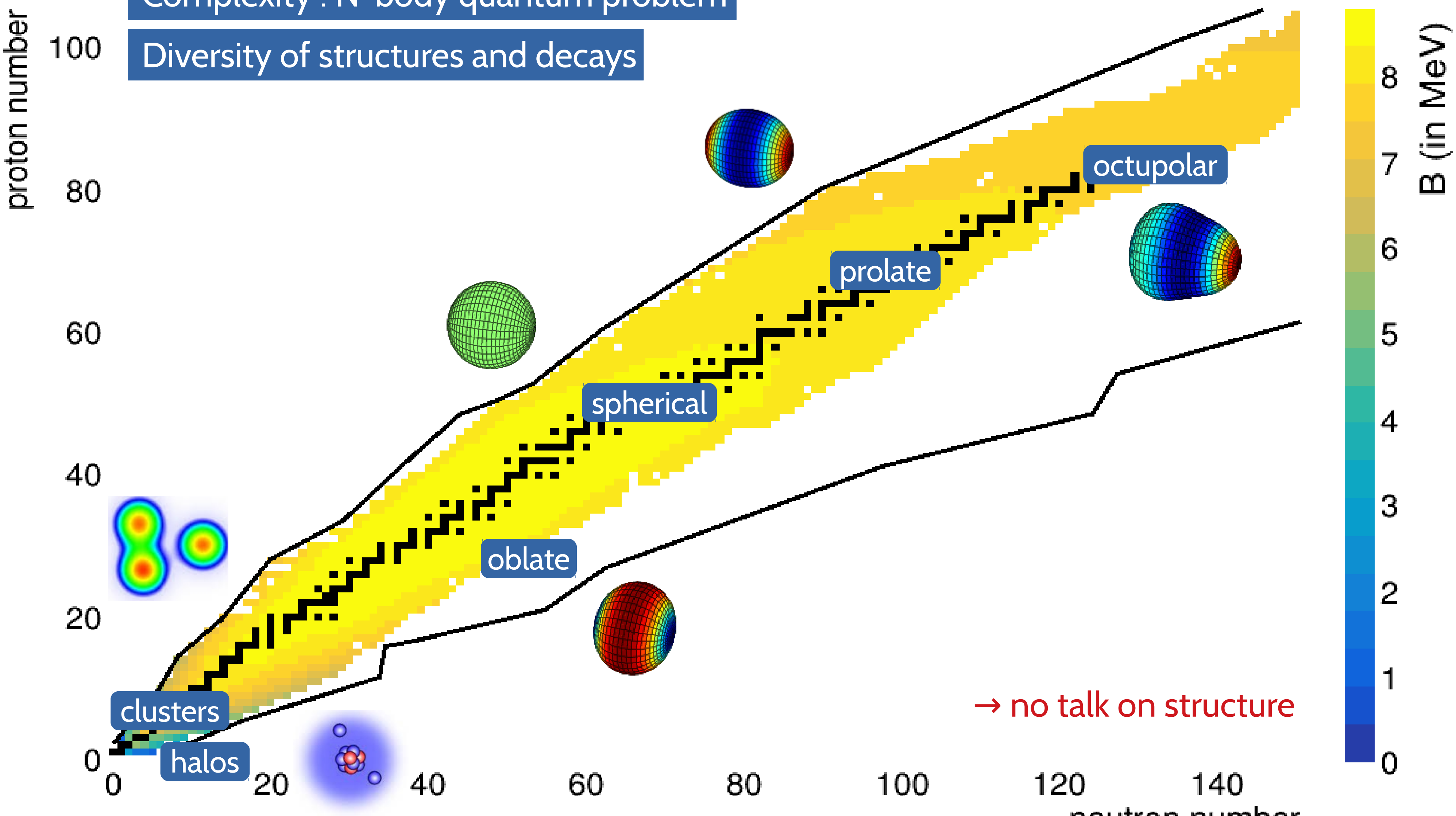

→ no talk on structure

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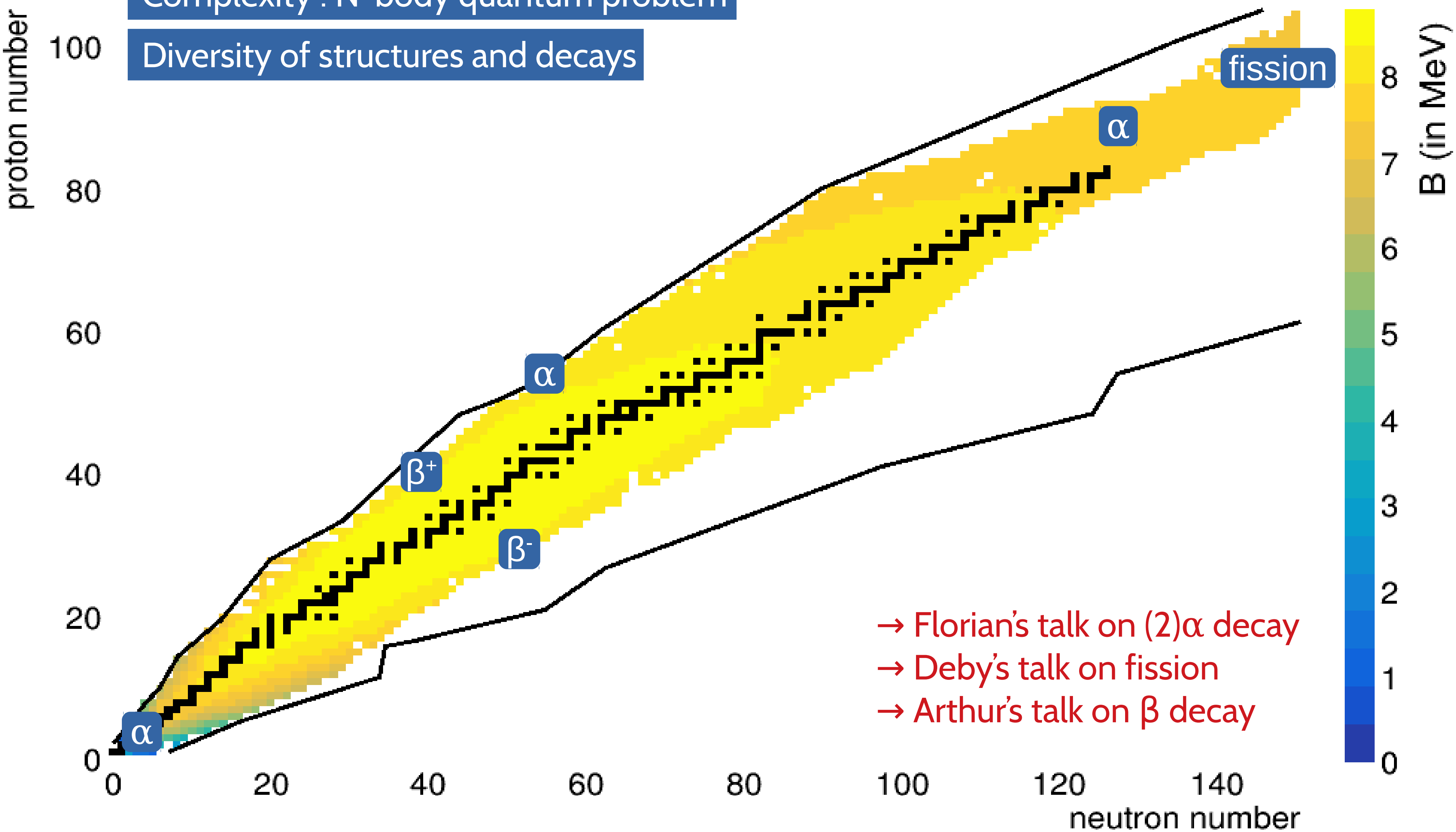

→ Florian's talk on (2)α decay
→ Deby's talk on fission
→ Arthur's talk on β decay

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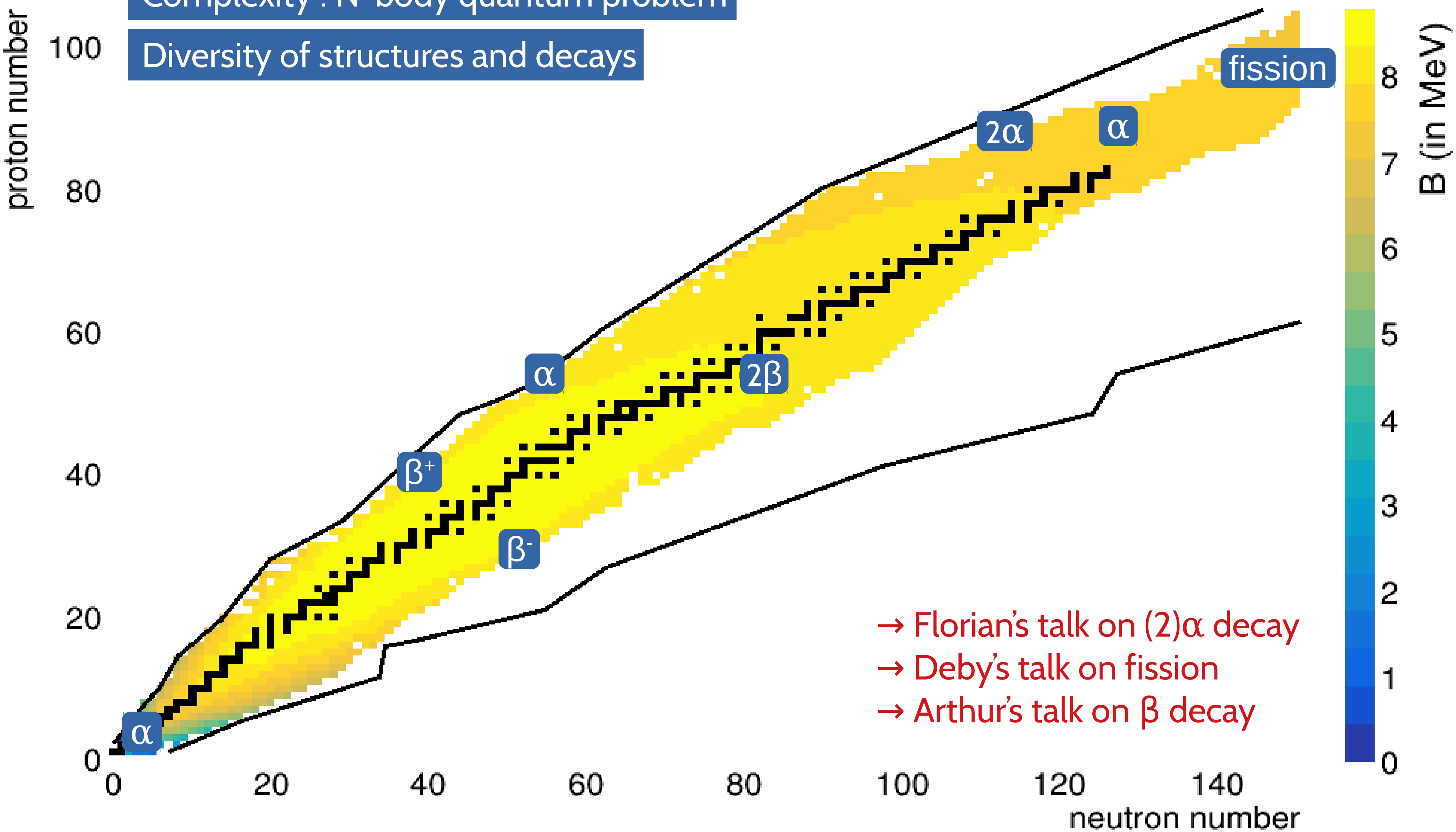

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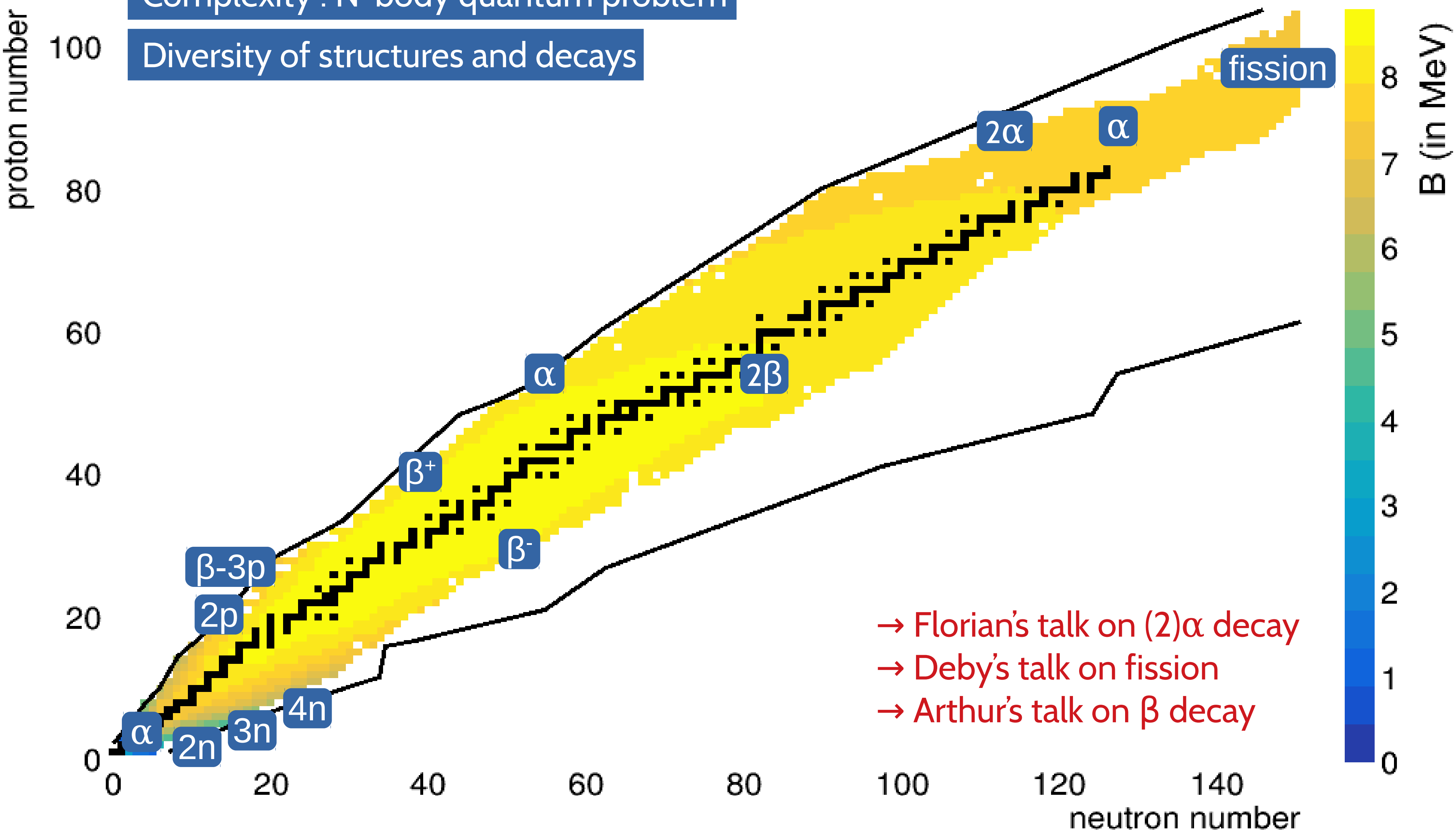

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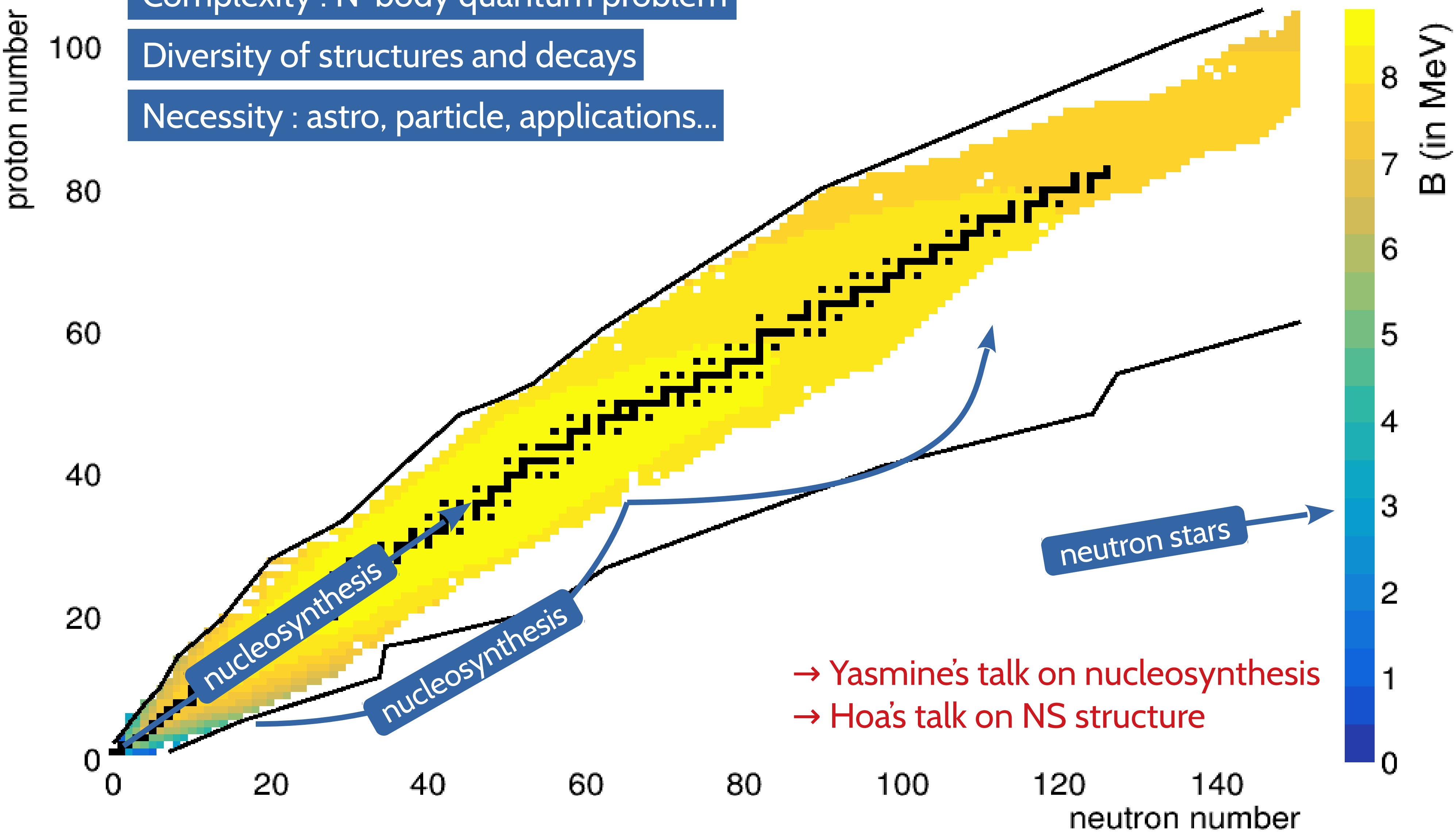
Necessity : astro, particle, applications...



→ Yasmine's talk on nucleosynthesis

→ Hoa's talk on NS structure

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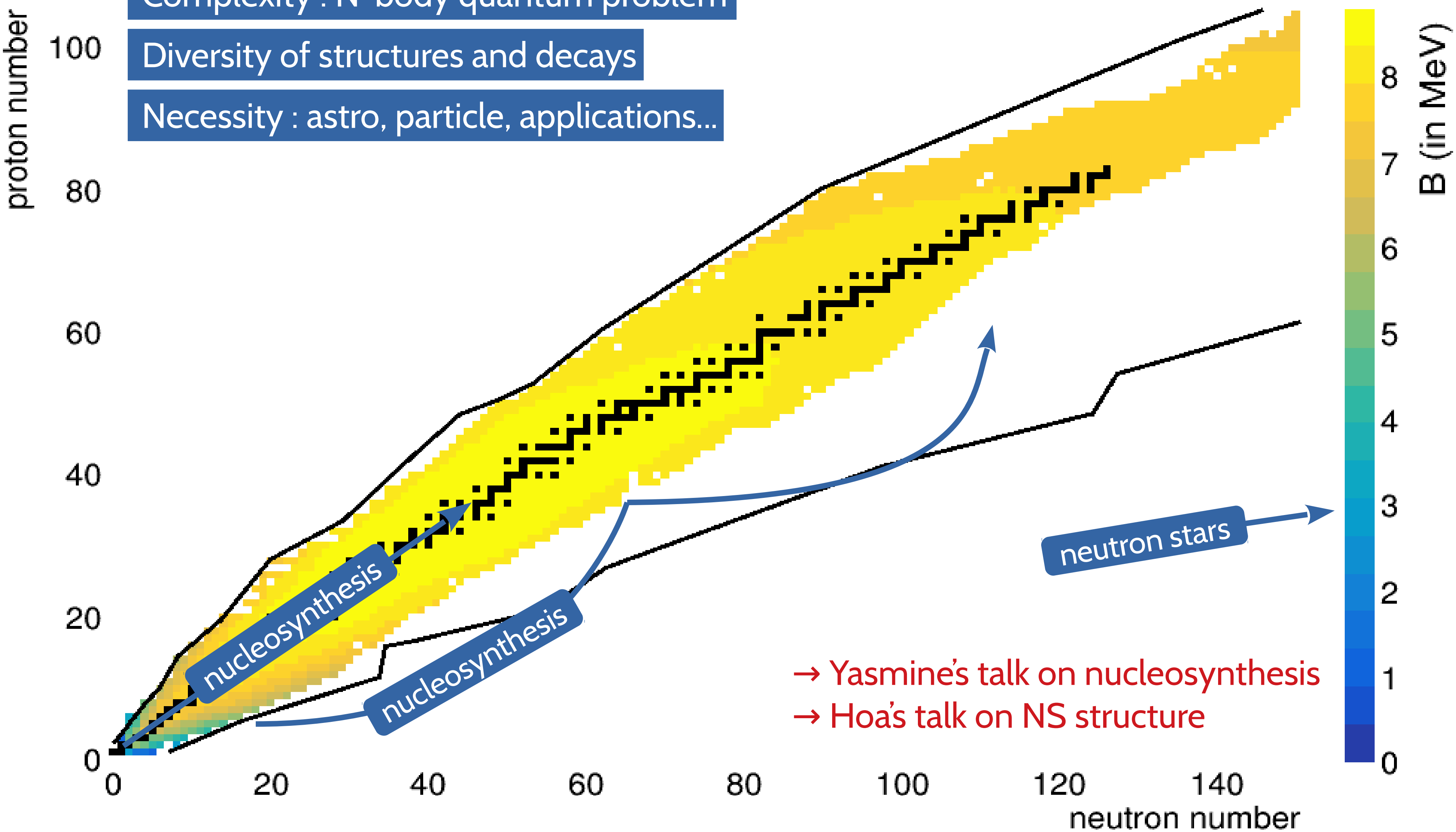

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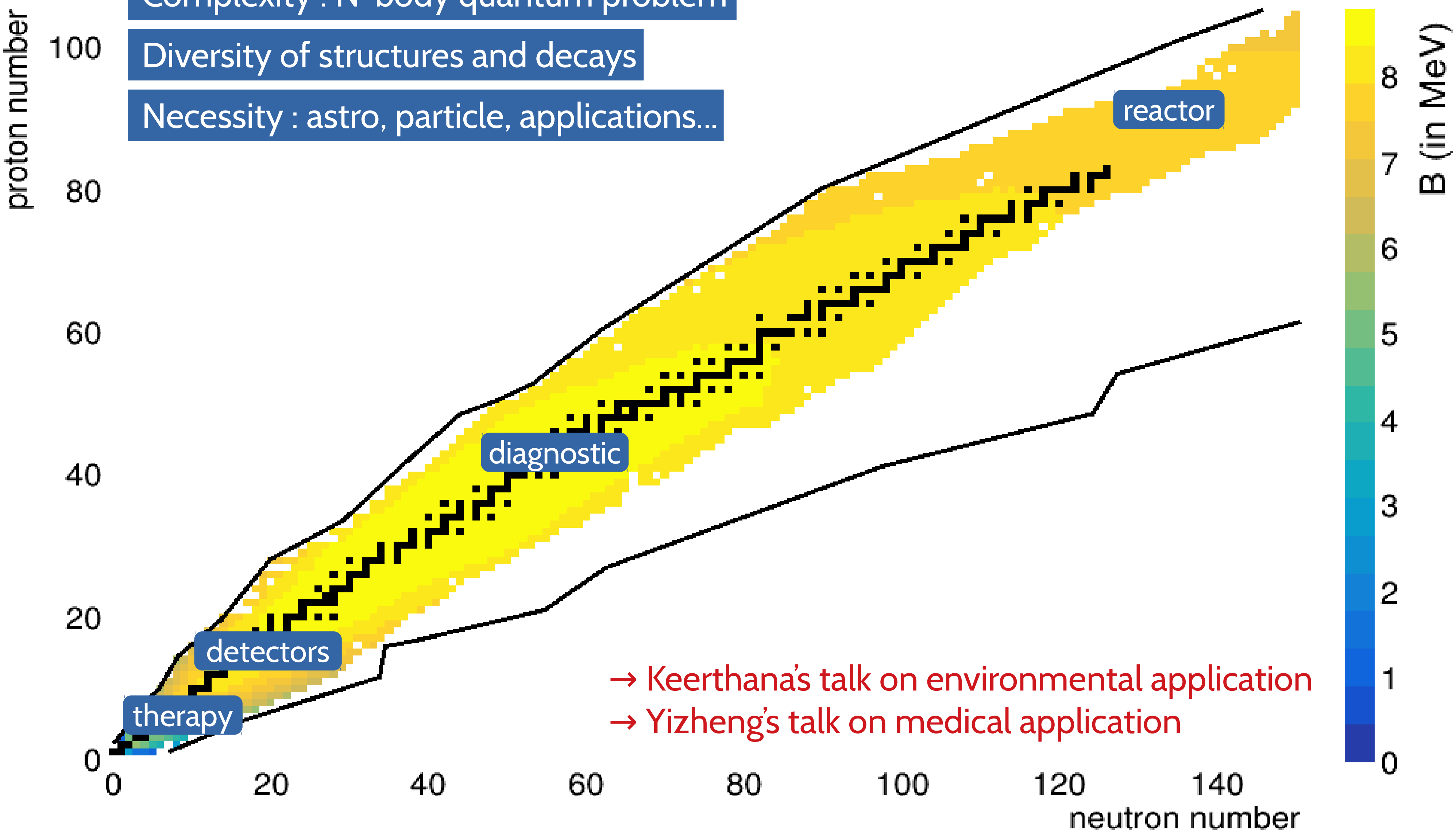
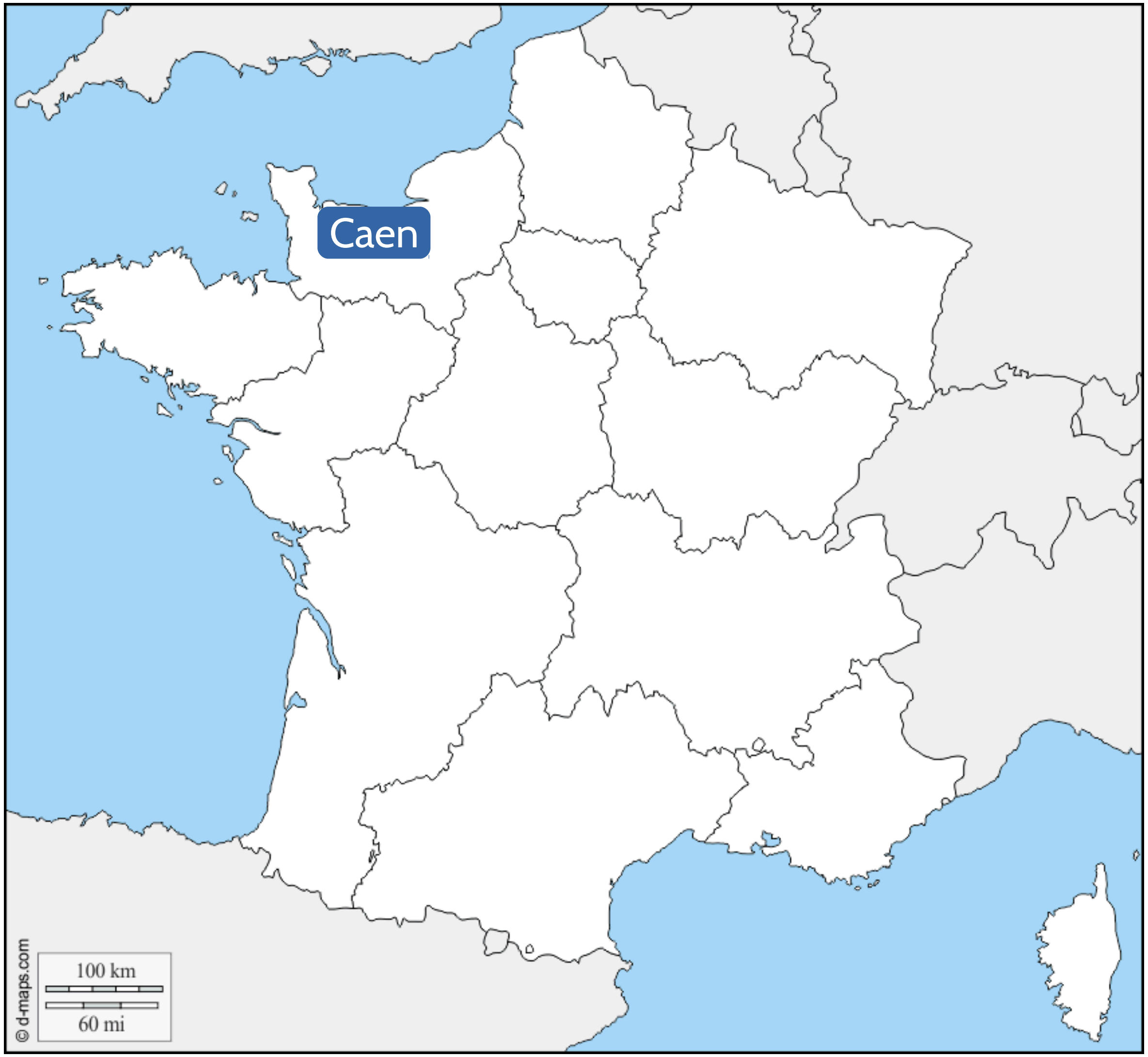


→ Keerthana's talk on environmental application

→ Yizheng's talk on medical application

A very bad analogy



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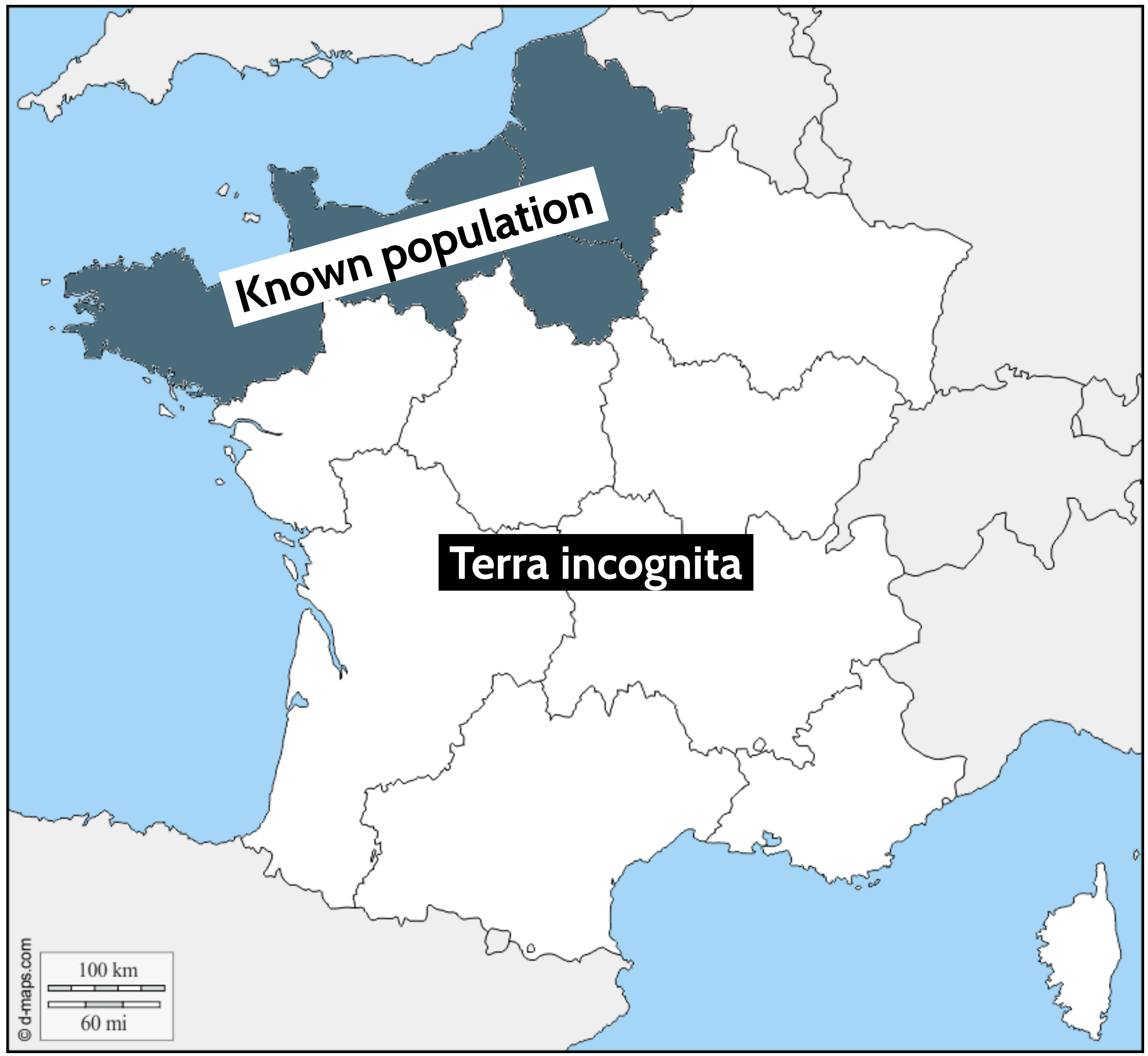

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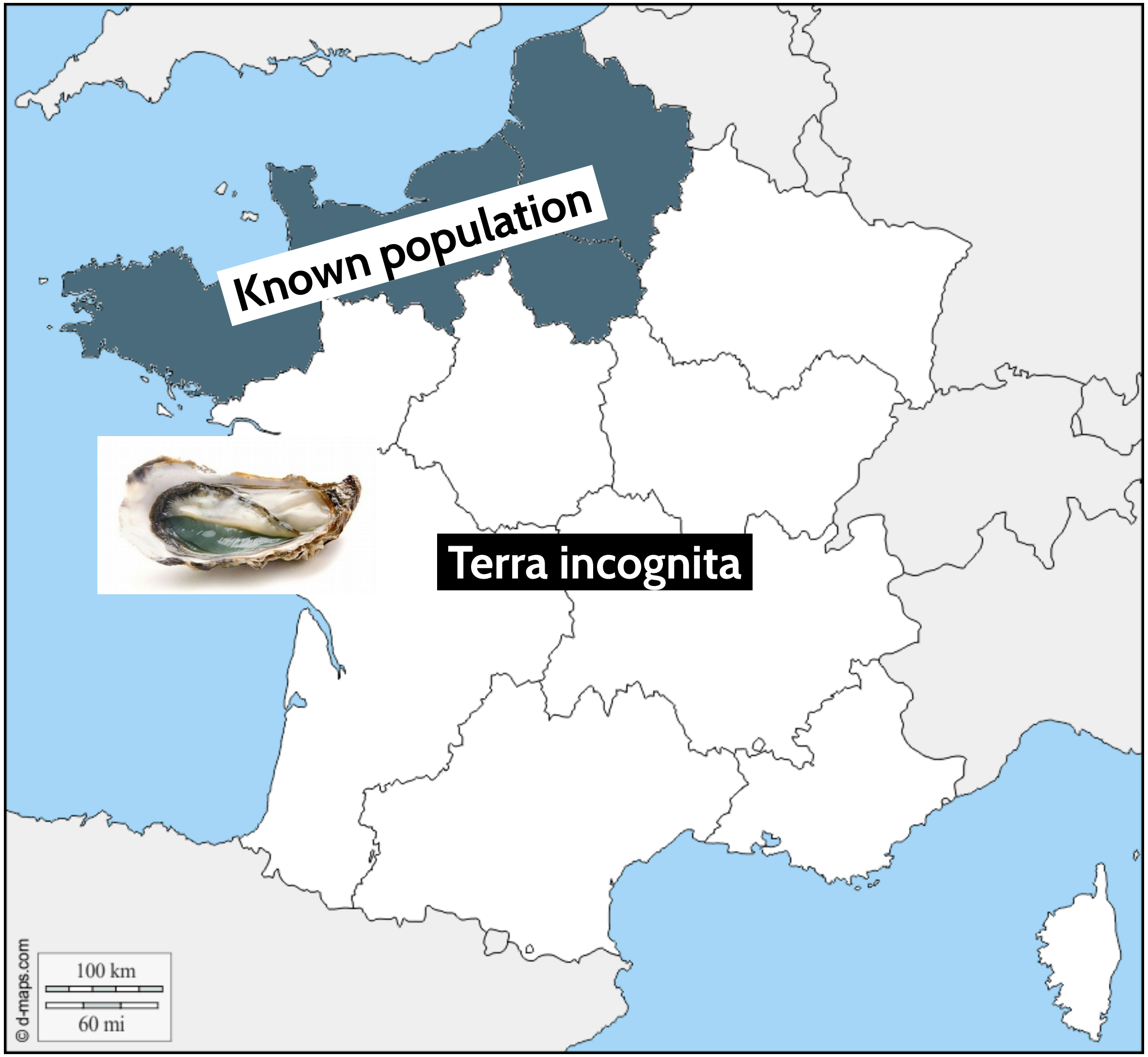
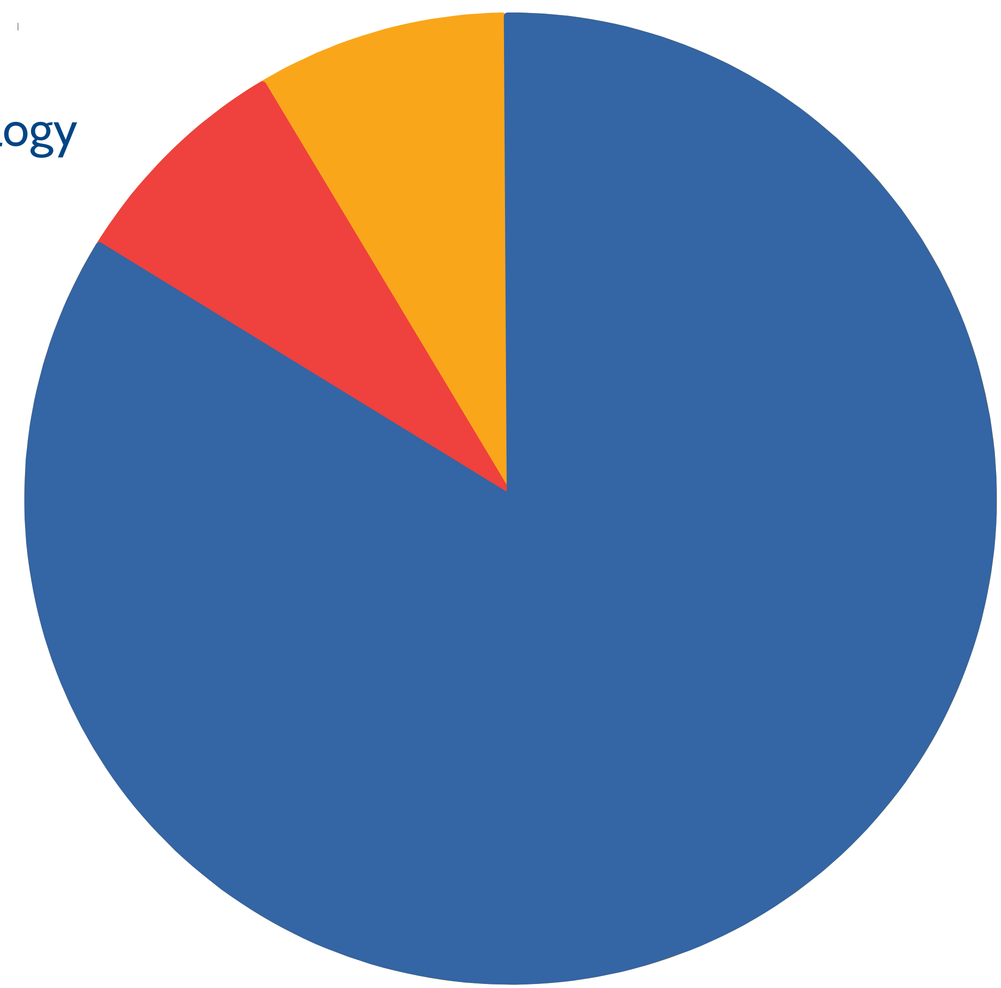


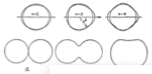
Outline of this presentation

3. Comment few important nuclear physics papers

2. Waste 5 minutes with a stupid analogy

1. Convince everybody that nuclear physics is a complex, diverse, and necessary field





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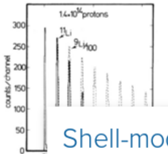

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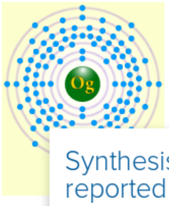

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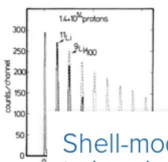

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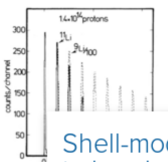

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The nuclear liquid-drop model

Gamow's idea

Protons and neutrons behave like molecules in a drop of liquid

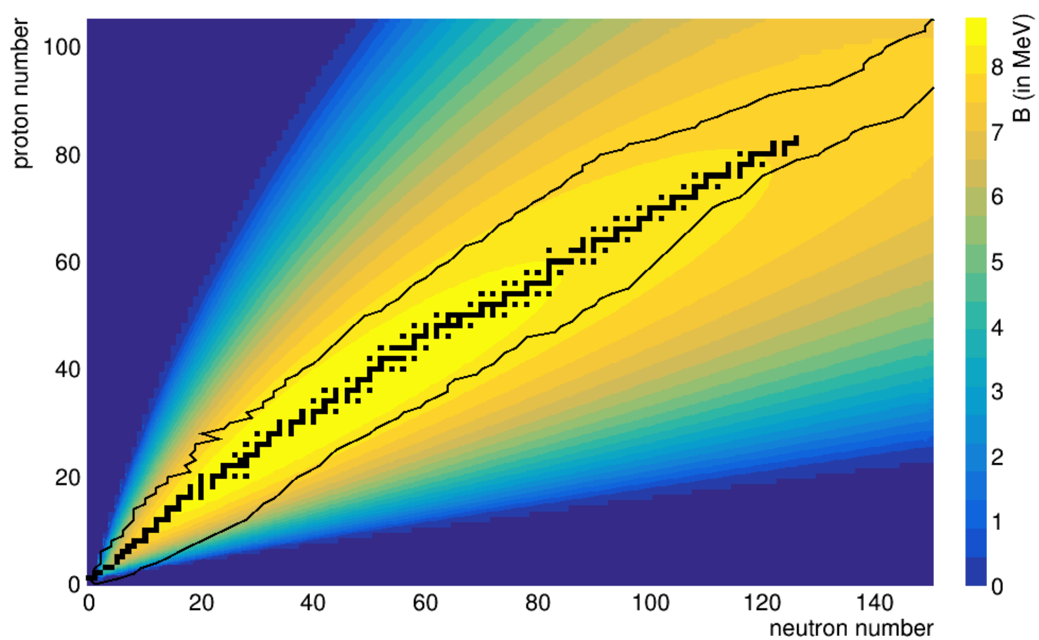
Weizsäcker's semi-empirical mass formula

Binding energy of spherical drops at constant density :

$$E_B = a_V A - a_S A^{2/3} - a_C \frac{Z(Z-1)}{A^{1/3}} - a_A \frac{(A-2Z)^2}{A} \pm \delta(A,Z)$$

Parameters fitted on experimentally measured masses

Allows to extrapolate to not-observed nuclei/processes



Weizsäcker, Z. Physik **96** (1935) 431

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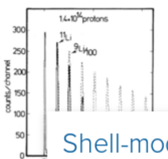

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SEPTEMBER 1, 1939 PHYSICAL REVIEW VOLUME 56

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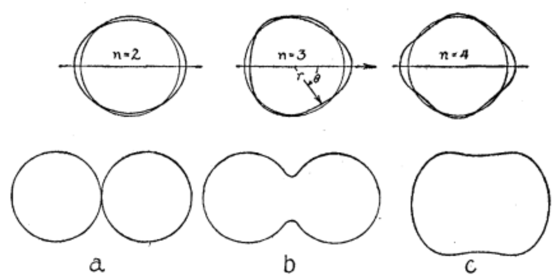
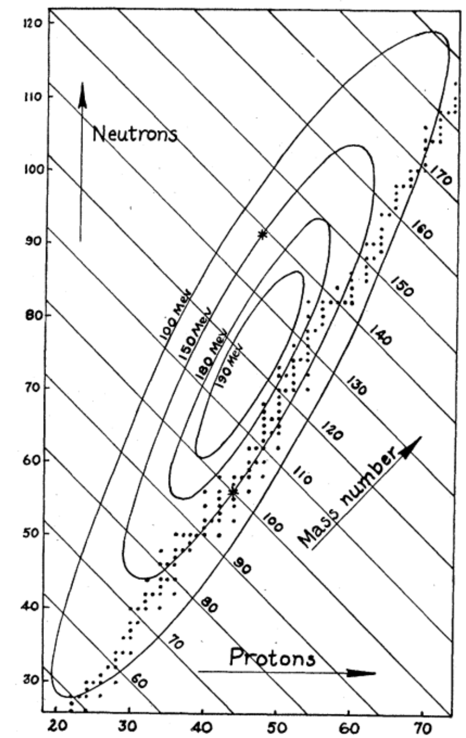
Deformation

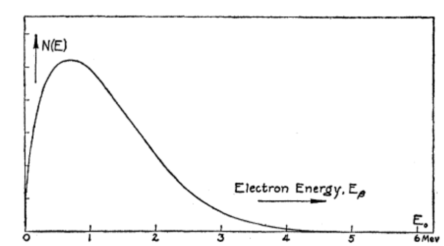
Introduction of deformation modes
Fission as a constant-volume process
Stability of heavy elements agains fission





Fission

Energy release by ^{239}U fission
Production of neutron rich elements
Fission fragment beta decay
Estimation of the composite beta-spectrum
→ Arthur's talk on β decay



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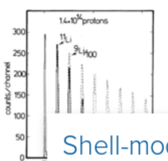

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Modern nuclear fission studies

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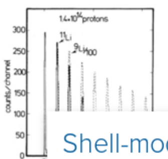

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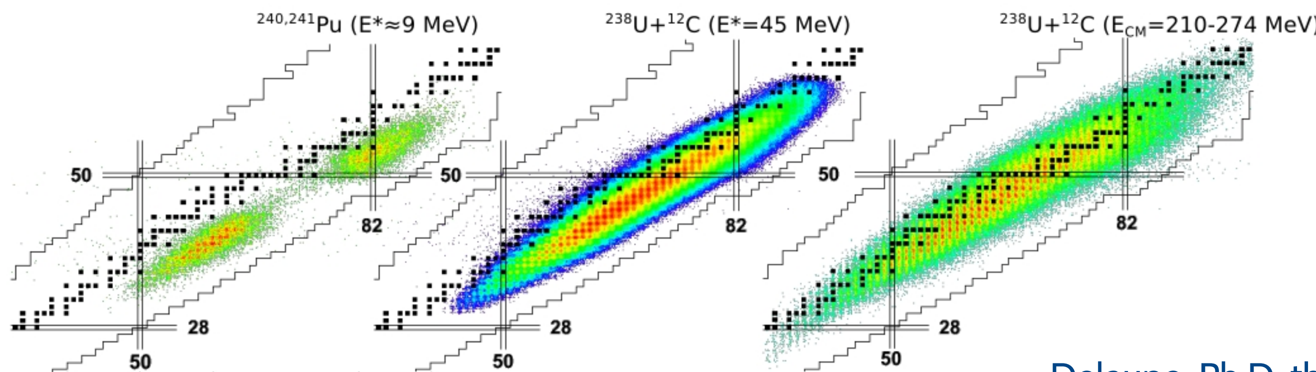
Fission experiments

Fission fragment mass/charge/energy measurement (GANIL, GSI)
Neutron, gamma and charged particle multiplicities
Used to produce exotic nuclei beams (photo-fission sources)

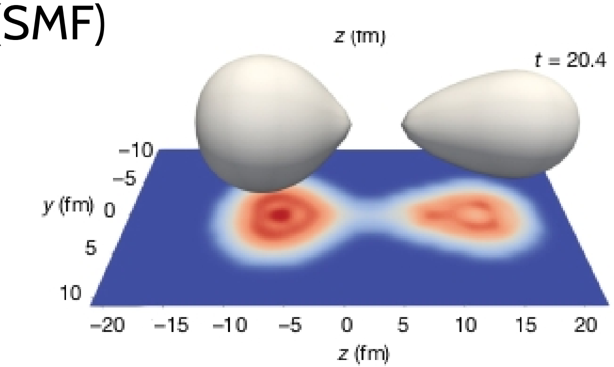


Delaune, Ph.D. thesis
Ramos, PRL **123** (2019) 092503

Fission theory

Liquid-drop models + Langevin/Metropolis
Global coordinate methods (GCM)
Time-dependant stochastic mean field (SMF)

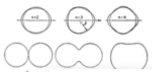
Scamps, Nature **564** (2018) 382



Recent highlights

Fission fragment internal properties
Impact of octupole shell closures
→ Deby's talk

Shell closure ? Magic numbers ?



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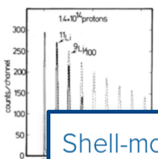

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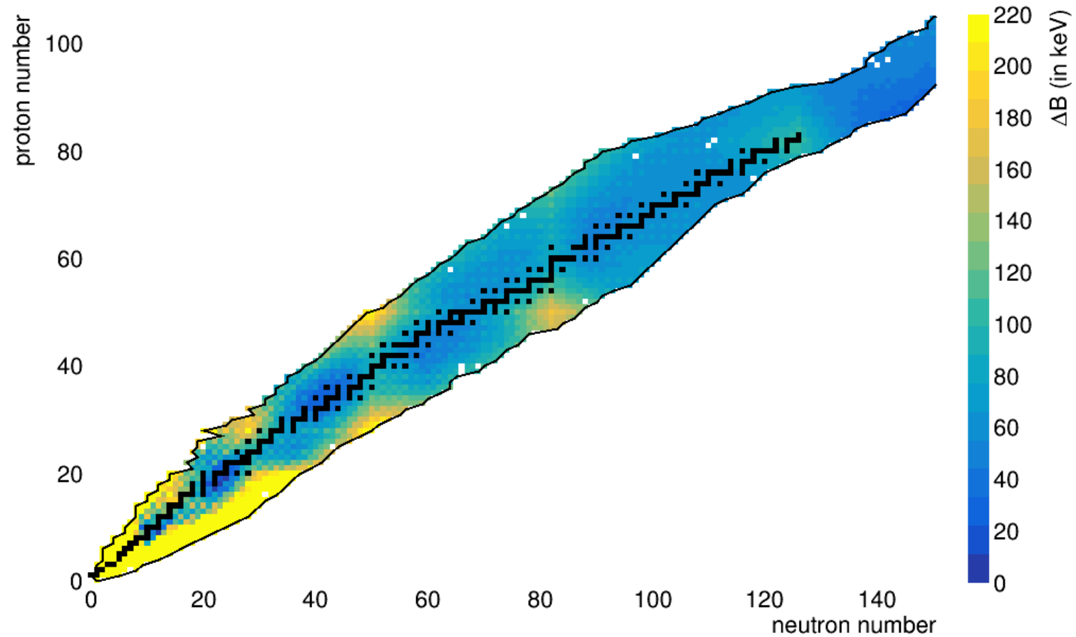

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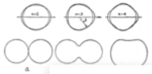

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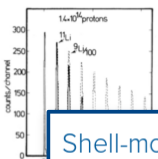

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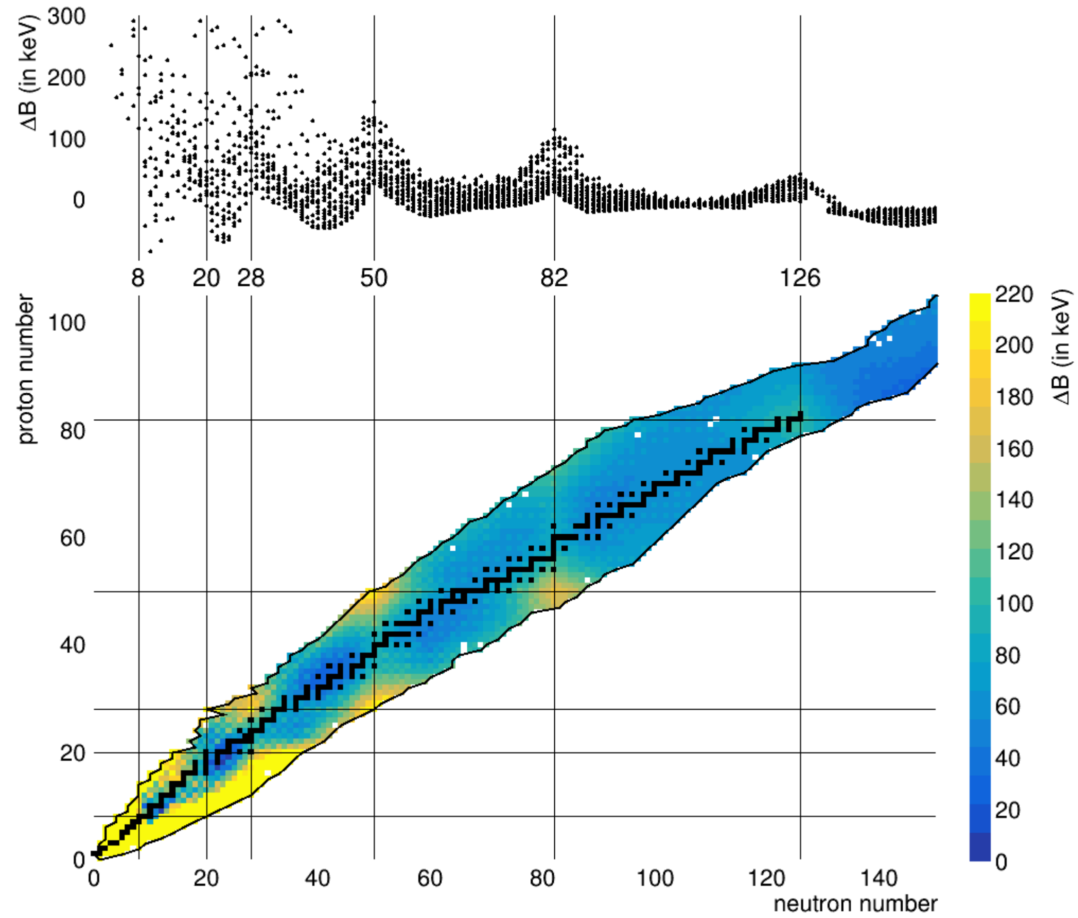

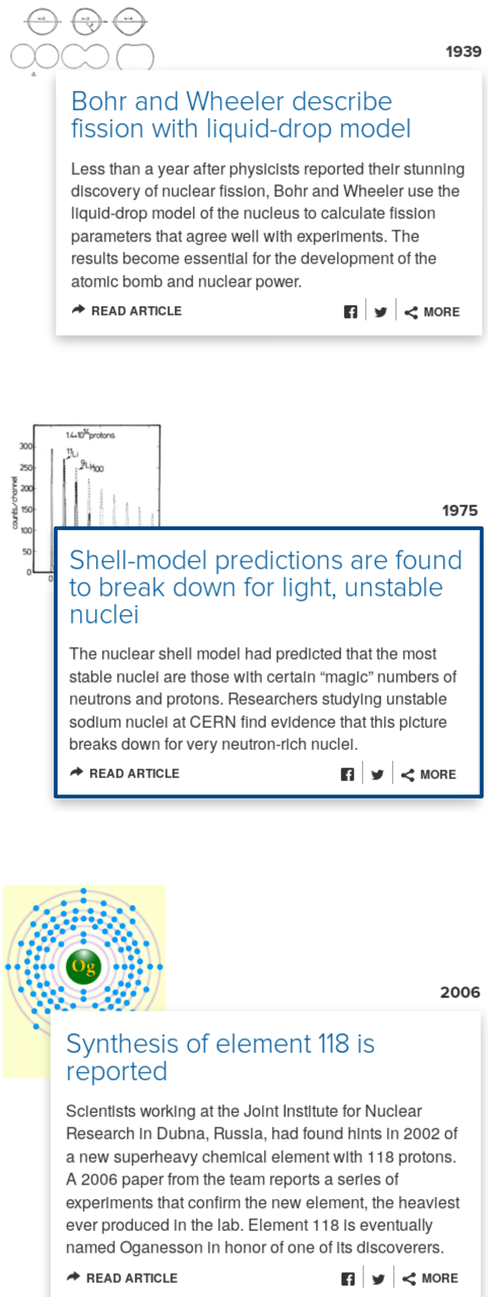

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Bohr and Wheeler describe fission with liquid-drop model

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The nuclear shell model

$H = T + V = (T + U) + (V - U) = H_0 + H_1$

T	:	kinetic part
V	:	nucleon-nucleon interaction part
U	:	external central potential
H_0	:	single particle energy
H_1	:	residual interaction

Spherical magic numbers

Harmonic potential → 2, 8, 20, ~~40~~, ~~70~~

Woods-Saxon or l^2 → l splitting

Spin-orbit coupling → Nobel price 

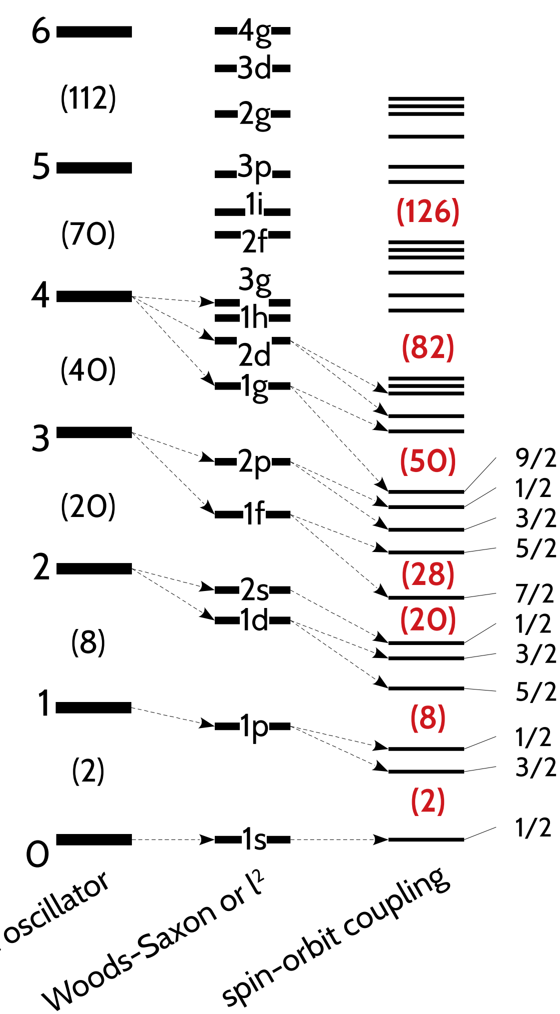
Single particle model

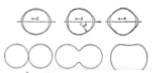
Magic numbers = shell gaps

Spin/parity of ground state

Excited states close to shell closure

→ Zhen Li's talk in theory session





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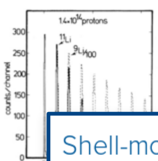

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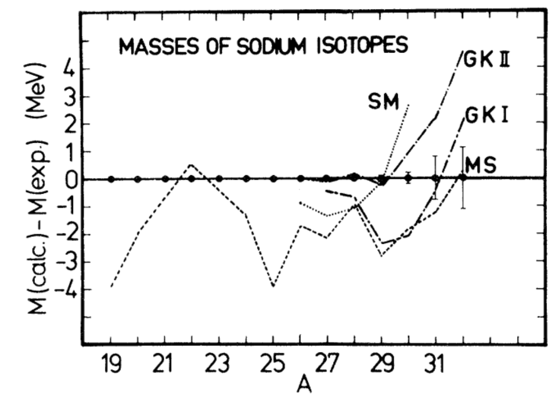
PHYSICAL REVIEW C VOLUME 12, NUMBER 2 AUGUST 1975

Direct measurement of the masses of ^{11}Li and $^{26-32}$Na with an on-line mass spectrometer

C. Thibault, R. Klapisch, C. Rigaud, A. M. Poskanzer,* R. Prieels,† L. Lessard,‡ and W. Reisdorf§
Laboratoire René Bernas du Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse, 91406 Orsay, France
(Received 17 March 1975)

Deviation to Shell Model (SM)

Mass measurement of n-rich Na isotopes
Close to N=20 spherical magic number
Strong deviation to SM prediction



New magic numbers

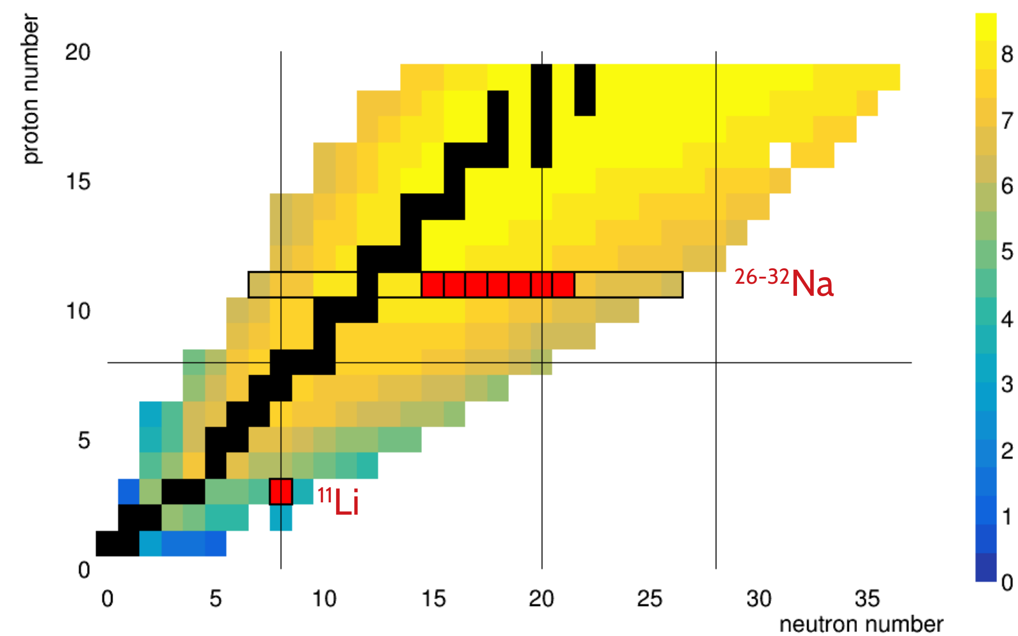
Disapearence of magic number far from stability
Emergencence of new shell closure

Modern studies

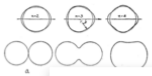
Residual interaction
Shape coexistence

Other approaches

→ Florian's talk
→ Arthur's talk
→ Phillipe's talk
→ Thomas's talk



The quest of super-heavy nuclei



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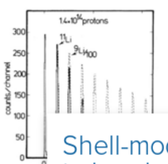

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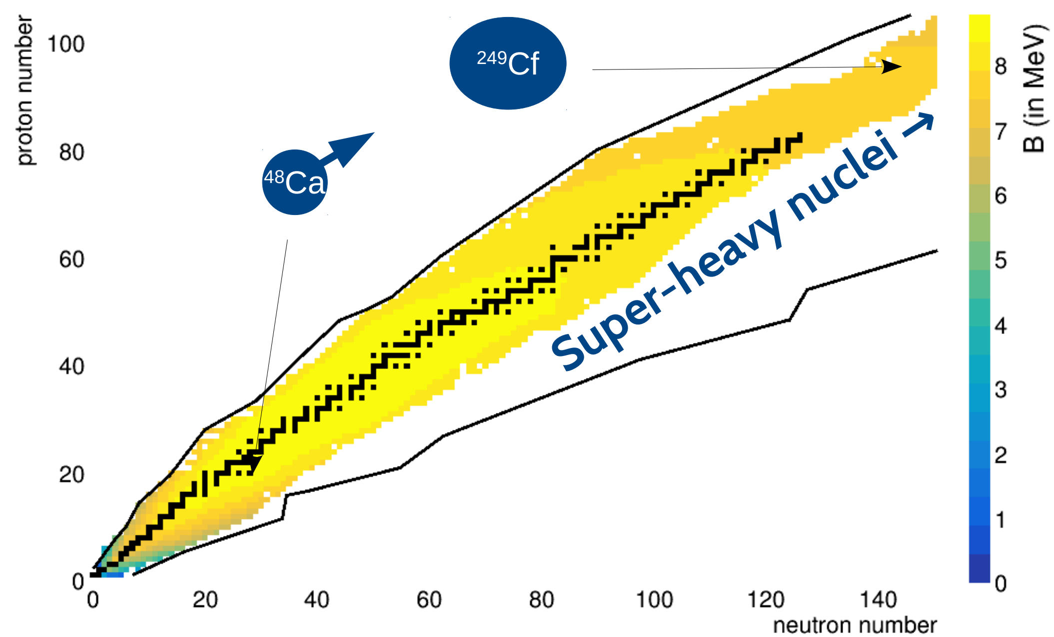
Heaviest element

Liquid drop model : Z~104 (wrong)
Super-heavy only possible with shell closure
Many microscopic models predict an island of stability (Corsica ?)

Experimental strategy

^{48}Ca beam (4.1 10^{19}) on heavy ^{249}Cf and ^{245}Cf target for Z=116,118
Energy close to the Coulomb barrier to maximize survival probability
No heavier target available → find the new golden projectile
Characterization of these nuclei → S^3@SPIRAL2 in GANIL



Oganessian, PRC **74** (2006) 044602

Nuclear physics in astro/particle physics

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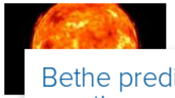
Prediction of nuclear abundances on cosmologic arguments by Gamow

Still a strong interplay between nuclear structure and astrophysics

→ Yasmine's talk on p-process



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Bethe predicts stellar nuclear reactions

Bethe shows that two types of helium-yielding nuclear reactions could power stars: the fusion of hydrogen and the so-called carbon-oxygen-nitrogen cycle. Nine years later, Bethe, Alpher, and Gamow propose an explanation for the abundance of the chemical elements using one of the first models of the post-big-bang Universe.

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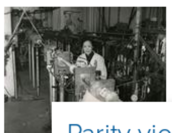

1956

Parity violation is found in weak interaction

Mirror symmetry or, as physicists call it, parity symmetry, holds the status of a sacred principle until theorists Lee and Yang show that they can explain puzzling cosmic-ray data by assuming that the symmetry is violated in weak interactions. A year later, beta-decay experiments by Wu and her collaborators prove that parity is, in fact, violated.

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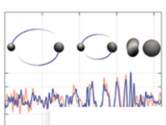

2016

LIGO reports observation of gravitational waves

The collaborations behind the Laser Interferometer Gravitational-Wave Observatory (LIGO) and the Virgo experiment report that LIGO's sensitive interferometers have picked up a gravitational-wave signal from the merger of two black holes—the first detection of the waves that Einstein had predicted in 1916. LIGO's success sets the stage for a new era of gravitational-wave astronomy, and it is soon followed by a joint detection with Virgo of a binary neutron star merger.

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Evidence of parity violation in ^{60}Co beta decay by Madame Wu's team
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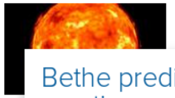
→ Talks by Sacha and Mohamad in BSM session



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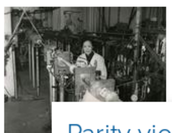

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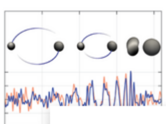

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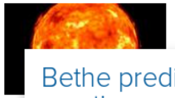

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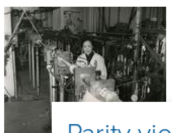

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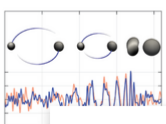

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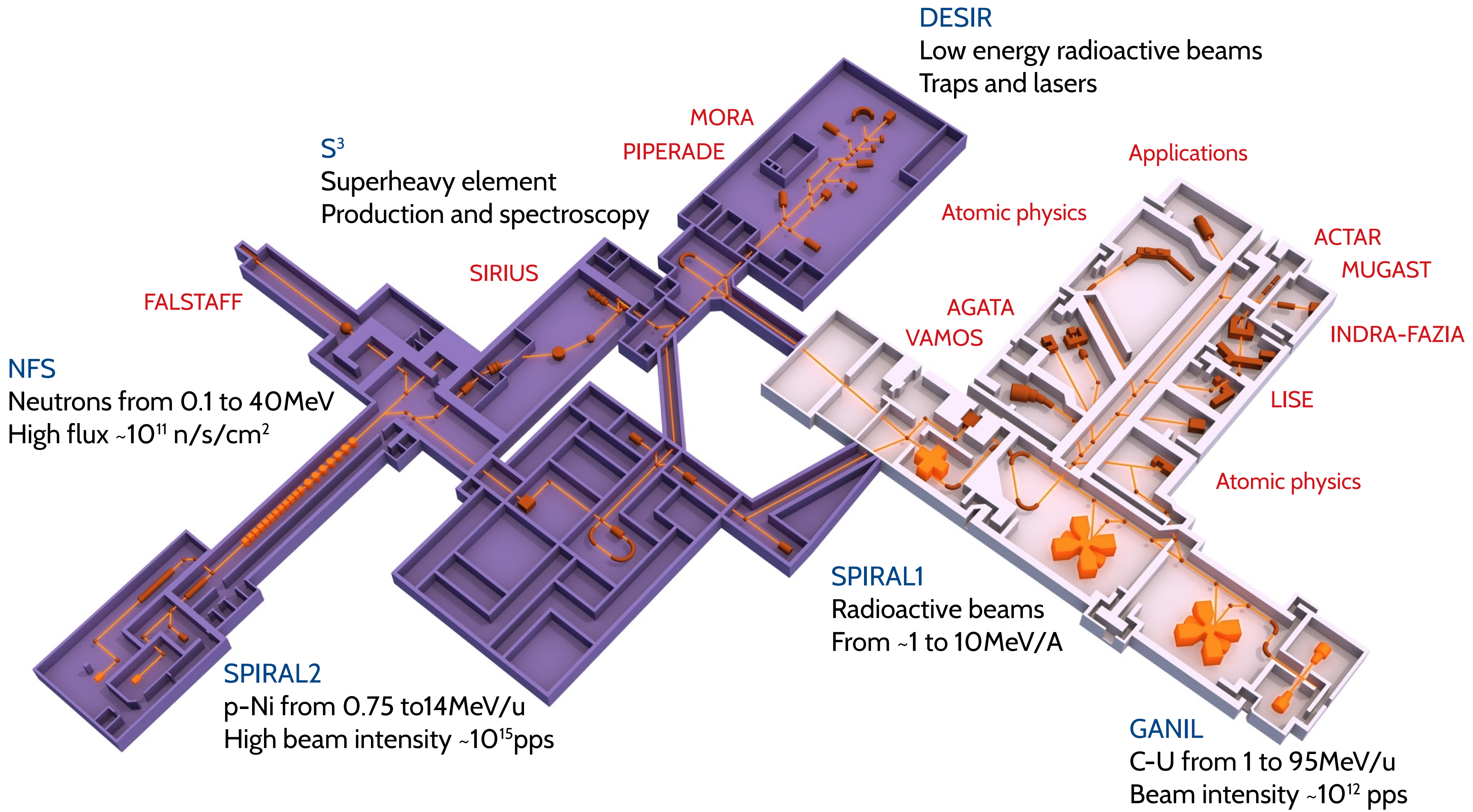
Nuclear equation of state

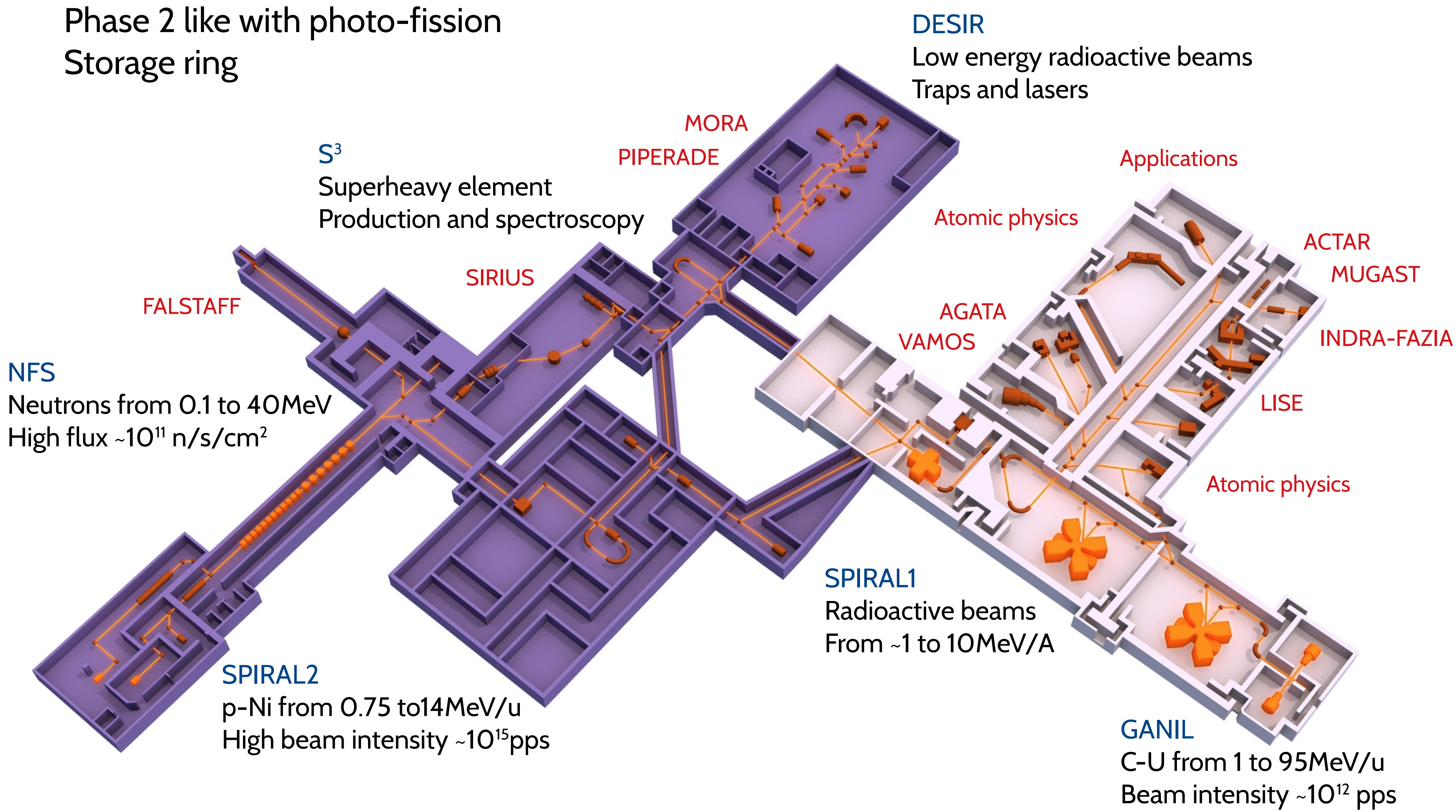
First BH-BH and NS-NS gravitational wave signal by LIGO/VIRGO
NS-NS merger electro-magnetic counterpart detected
New window on dense matter equation of state
Low density part only accessible in violent heavy-ion collisions
→ Neutron star calculation by Hoa

Quick overview of GANIL in Caen



Quick overview of GANIL in Caen

Future of GANIL
No phase 2 for Spiral2
Electron-ion collider
Phase 2 like with photo-fission
Storage ring



La suite des hostilités

Nuclear physics

Florian MERCIER
Description microscopique relativiste des systèmes nucléaires et application à la radioactivité

Deby Treasa KATTIKAT MELCOM
Fission studies of neutron deficient N = 100 isotones ($^{176}Os^{*}$ and $^{179}Au^{*}$)

lunch

Arthur BELOEUVRE
First-forbidden β-decay study in the pnQRPA approach

Astrophysics

Yasmine DEMANE
Measurement of $^{72}Ge(p,\gamma)^{73}As$ cross section for the astrophysical p-process

Hoa DINH THI
The nuclear matter density functional under the nucleonic hypothesis

Leo LAVY
Impact of an impurity in the thermalization of water nanodroplets

Denis COMTE
Interstellar methanol: the challenge of reactivity in astrophysical conditions

coffee

Applications

Keerthana KAMALAKANNAN
Development of laser ionization technique coupled with mass separation for environmental and medical applications: A case study of Copper

Yizheng WANG
Développement et optimisation d'une cible de gadolinium enrichi pour la mesure de sections efficaces de production de terbium radioactif à visée médicale

PHYSICAL REVIEW JOURNALS 125 YEARS

1893

1893
The Physical Review begins publication at Cornell University's Franklin Hall in Ithaca, New York

1899
The American Physical Society is founded

1910s

1913
The American Physical Society takes over *The Physical Review*

1913

Millikan determines the electron's charge

Millikan's oil-drop experiment proves that electric charge comes only in discrete, integer multiples of a fundamental constant, rather than in a continuum of values. Millikan determines this constant—the charge of the electron—to within half of a percent of today's accepted value.

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