

Nuclear-physics research @ FI & possible synergies with the Quantum Technology Initiative

Ann-Cecilie Larsen

Nuclear-physics group, FI

a.c.larsen@fys.uio.no

HULK



ChatGPT

Nuclear physics is a branch of physics that deals with the study of atomic nuclei and their interactions. It encompasses the properties and behavior of atomic nuclei, including their composition, structure, stability, and reactions. Nuclear physics explores the fundamental forces, such as the strong nuclear force and weak nuclear force, that govern interactions within the nucleus.

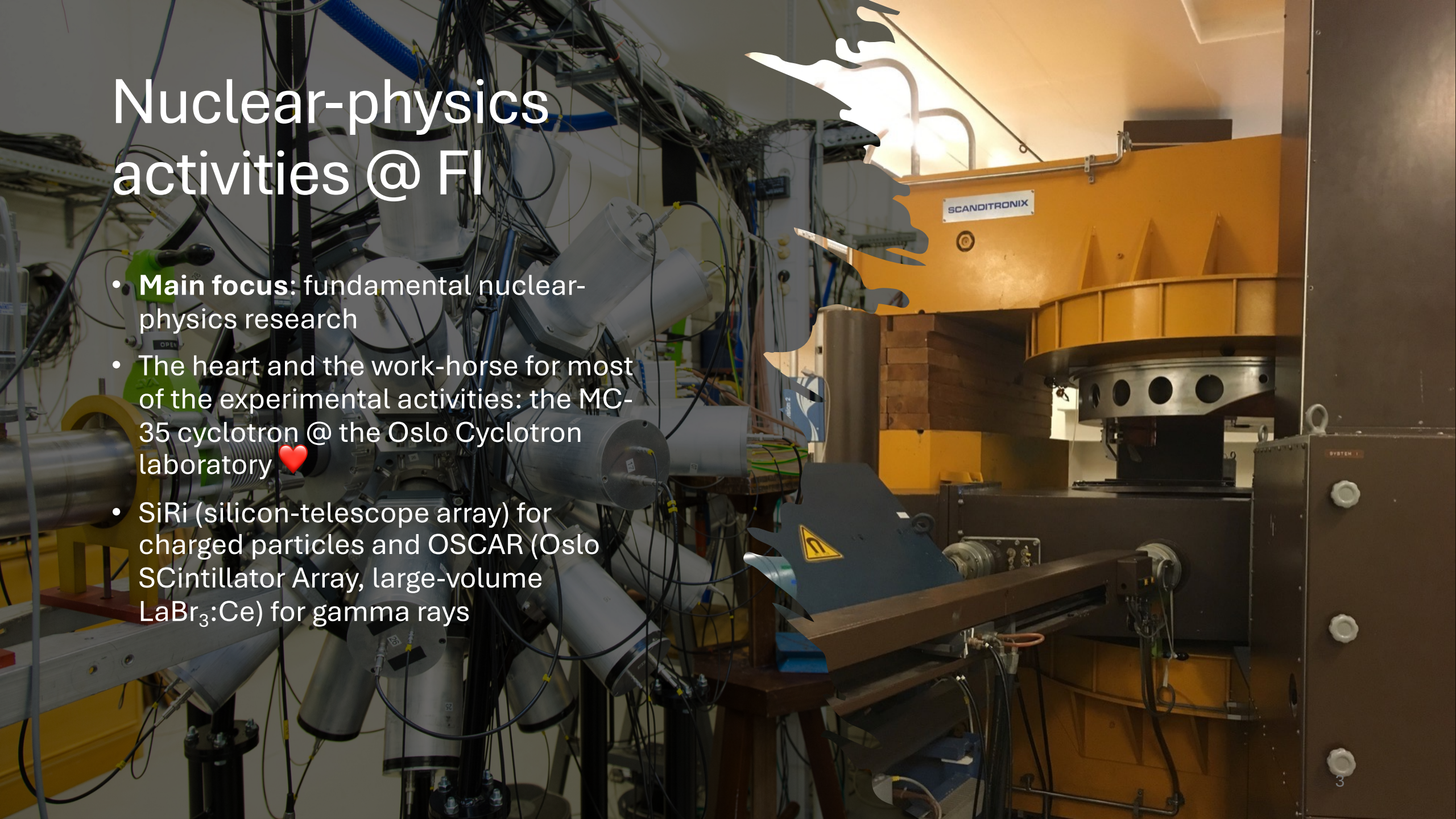
Key areas of study within nuclear physics include:

1. Nuclear structure: Investigating the internal structure of atomic nuclei, including the arrangement of protons and neutrons, energy levels, and nuclear shapes.
2. Nuclear reactions: Understanding the processes by which nuclei interact and transform, such as nuclear fusion, nuclear fission, radioactive decay, and particle interactions.
3. Nuclear astrophysics: Exploring the role of nuclear processes in astrophysical phenomena, such as stellar nucleosynthesis, supernovae explosions, and the synthesis of elements in the universe.
4. Nuclear technology: Applying principles of nuclear physics to various technological applications, including nuclear power generation, medical imaging and treatment (such as PET scans and radiation therapy), and nuclear weapons.

What is
nuclear
physics? 🤔

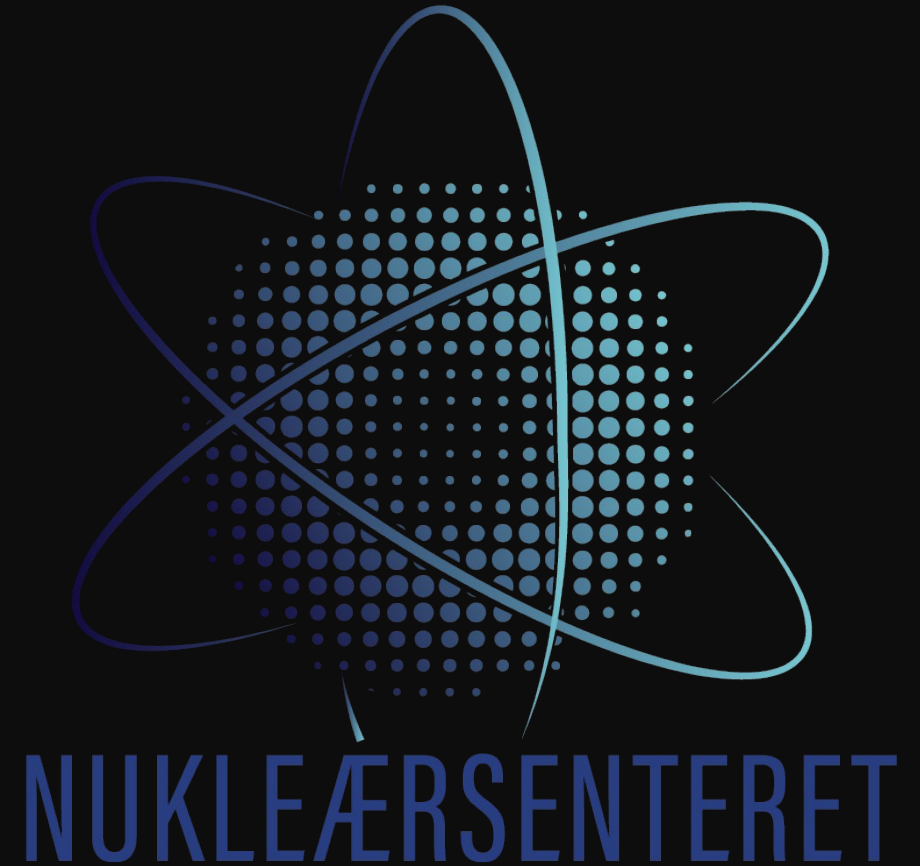
Nuclear-physics activities @ FI

- **Main focus:** fundamental nuclear-physics research
- The heart and the work-horse for most of the experimental activities: the MC-35 cyclotron @ the Oslo Cyclotron laboratory ❤️
- SiRi (silicon-telescope array) for charged particles and OSCAR (Oslo SCintillator Array, large-volume $\text{LaBr}_3\text{:Ce}$) for gamma rays



The Norwegian Nuclear Research Centre

- <https://www.nnrc.uio.no/english/>
 - “The goal of the Norwegian Nuclear Research Centre is to increase Norway's competence within the fields of nuclear physics and nuclear chemistry. Our work includes research on properties of the atomic nucleus as well as applications within the fields of medicine, energy, and preparedness.”
 - UiO, NMBU, IFE
-



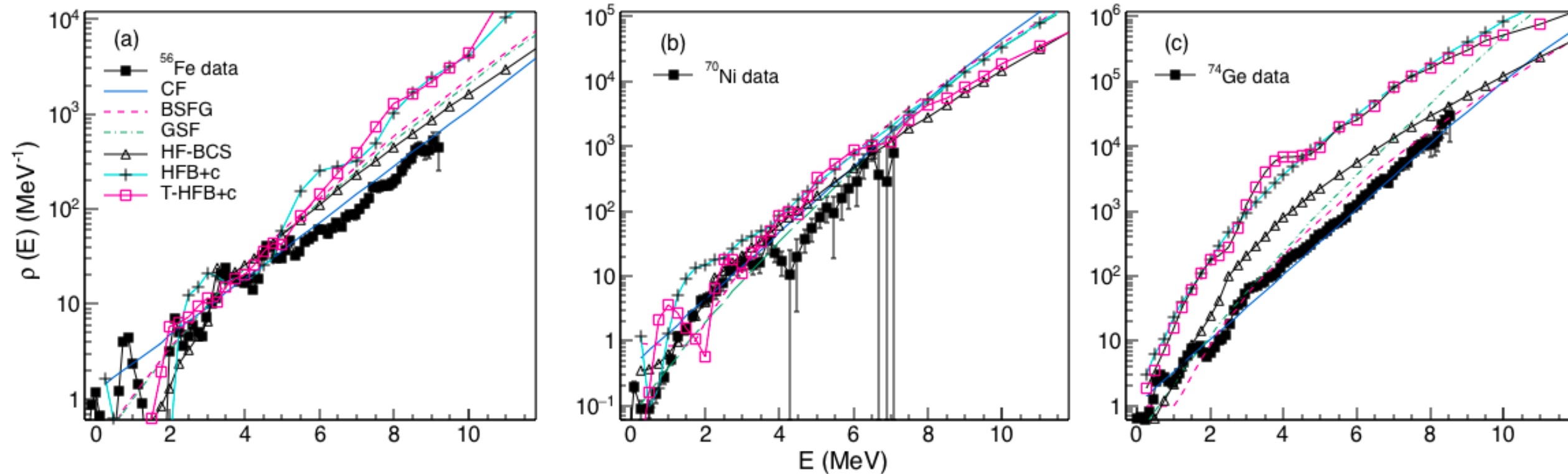
Problems (=challenges) in nuclear physics today

- There is ***no “standard model”*** within nuclear physics – the description of the nuclear force on the length and energy scales relevant for low-energy nuclear structure and nuclear astrophysics is ***not well established!*** 🤔
- New and existing experimental facilities are providing/ will provide a wealth of new data, but it is still ***far too scarce*** to fully answer the many remaining open questions



Cherry-picking some key research questions

- Density of quantum energy levels as function of excitation energy

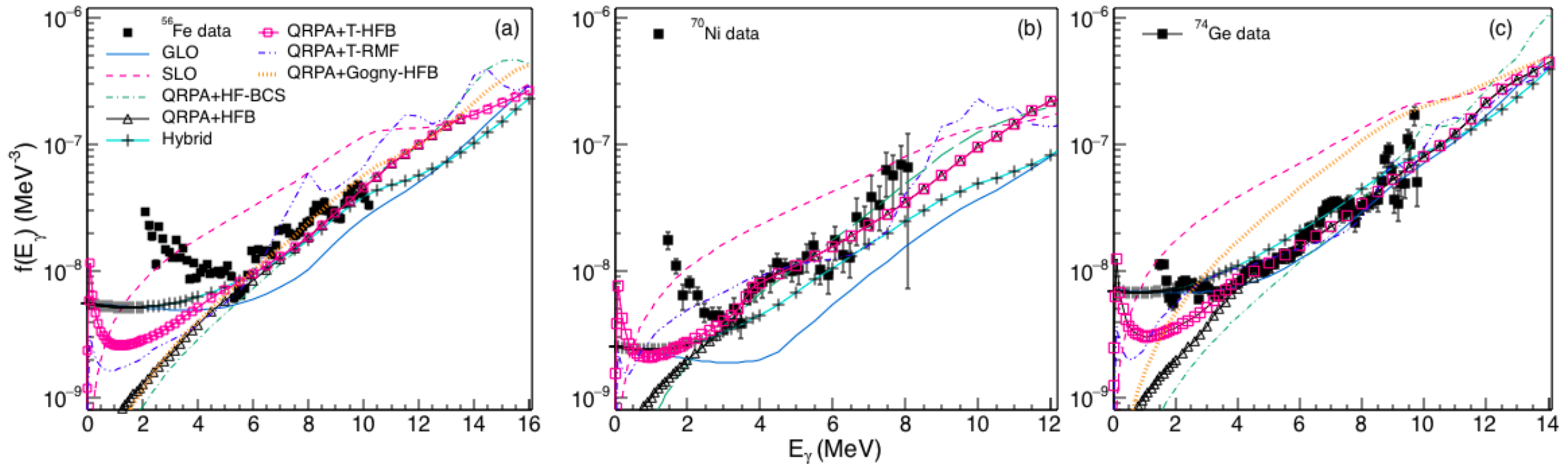


Data from Oslo Cyclotron lab and Michigan State University (ask me for refs. if you are interested 😊).
Models are input models in one of the most used nuclear-reaction codes (“TALYS”)



Cherry-picking some key research questions

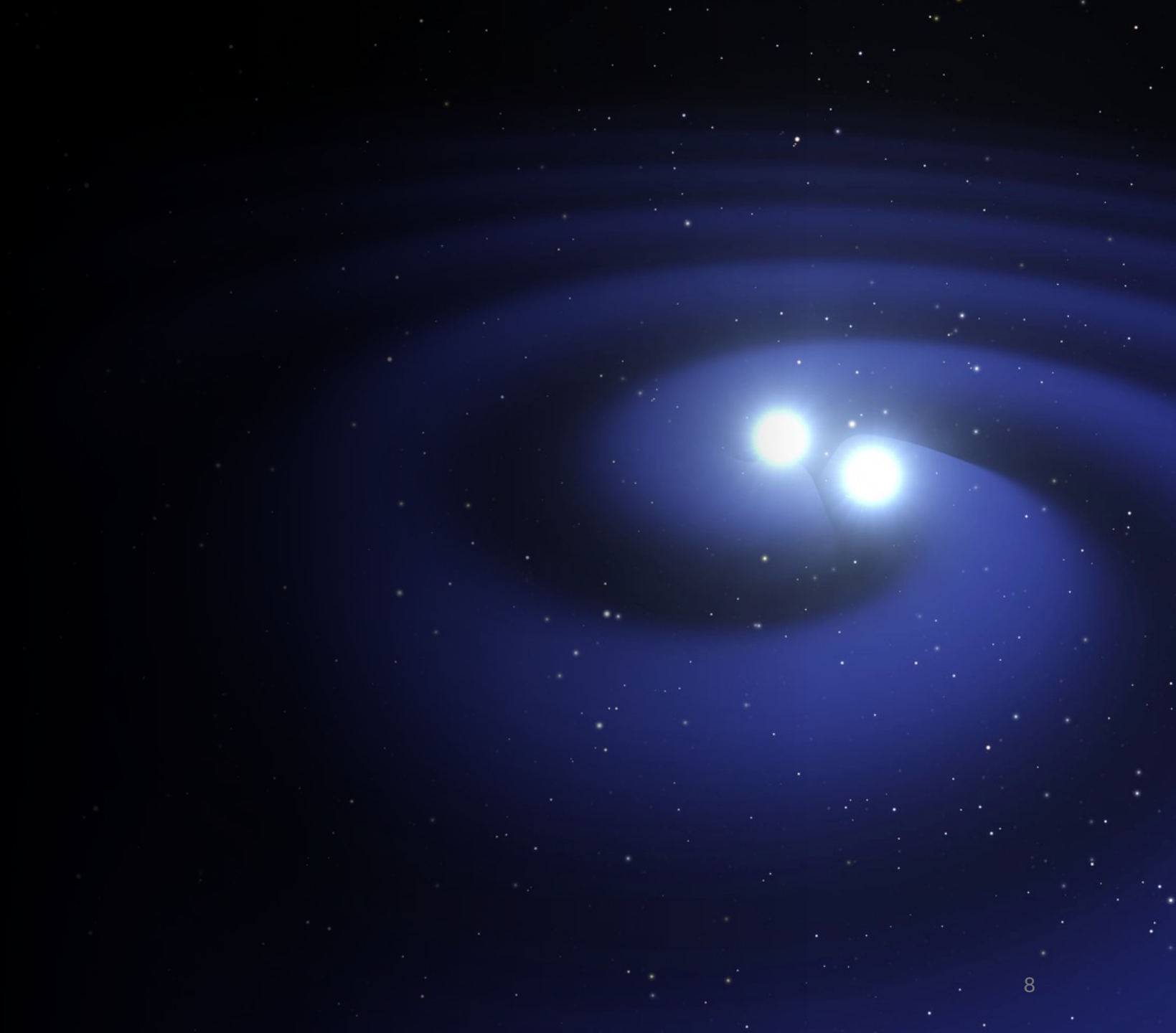
- Average gamma-decay strength from highly excited quantum levels



Data from Oslo Cyclotron lab and Michigan State University (ask me for refs. if you are interested 😊).
Models are input models in one of the most used nuclear-reaction codes (“TALYS”)

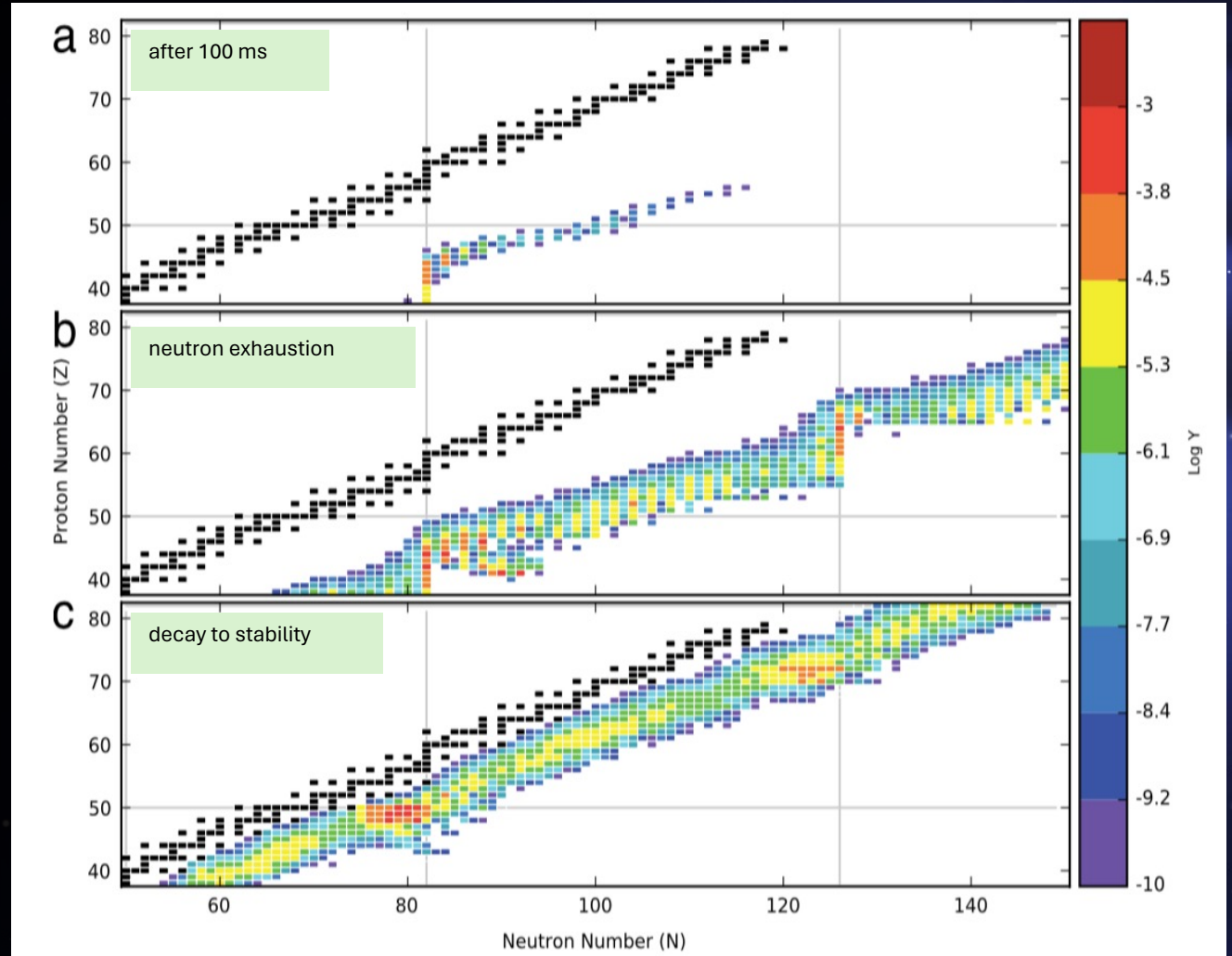
... And consequences for e.g. nuclear astrophysics...

- The neutron star merger event in 2017 showed that the rapid neutron-capture process takes place in such collisions
- That means: we need to include 5000 nuclei and 50 000 nuclear reaction rates in the nucleosynthesis network calculations – of which only a few are experimentally measured (and only indirectly)!



... And consequences for
e.g. nuclear
astrophysics...

- The neutron star merger event in 2017 showed that the rapid neutron-capture process takes place in such collisions
- That means: we need to include 5000 nuclei and 50 000 nuclear reaction rates in the nucleosynthesis network calculations – of which only a few are experimentally measured (and only indirectly)!



“Snapshots”, r process in neutron star collision [one trajectory!]
Mumpower, Surman, McLaughlin, Aprahamian, Prog.Part. Nucl. Phys. 86, 86 (2016)

Opportunities within the Quantum Technology Initiative

White paper on

Quantum Information Science and Technology for Nuclear Physics

Input into U.S. Long-Range Planning,
2023

“Solving grand challenges in Nuclear Physics (NP) requires the ***development of fundamentally new tools for simulation and sensing***. U.S. Nuclear Science is in an early stage of benefiting from and contributing to the advancement of Quantum Information Science and Technology (QIST).”

Opportunities within the Quantum Technology Initiative

From Dr. Michael Doser's seminar 5 March:

- A possible starting point: collaborative effort on detector development (scintillators)?

