Trap System for Measuring Neutron Capture Cross Section of Short-lived Isotopes

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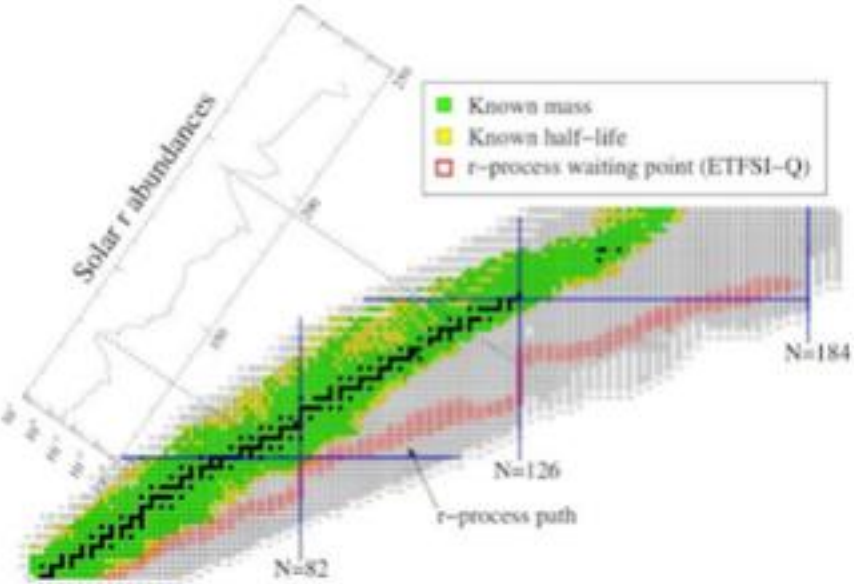
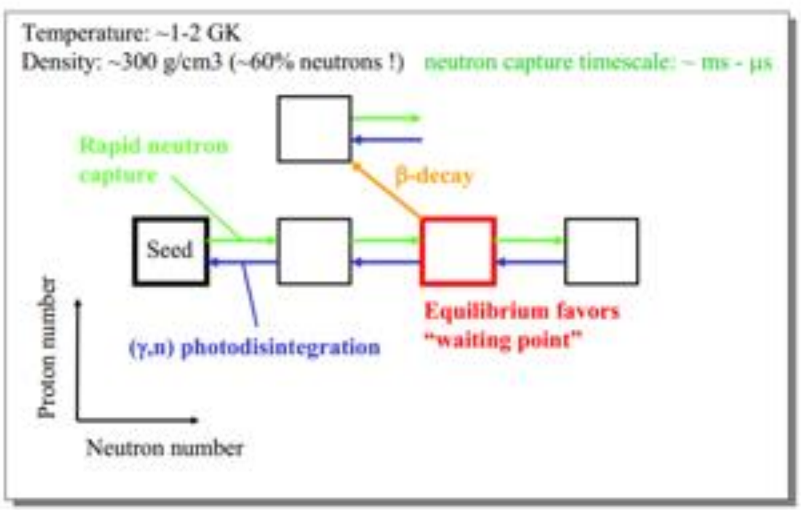
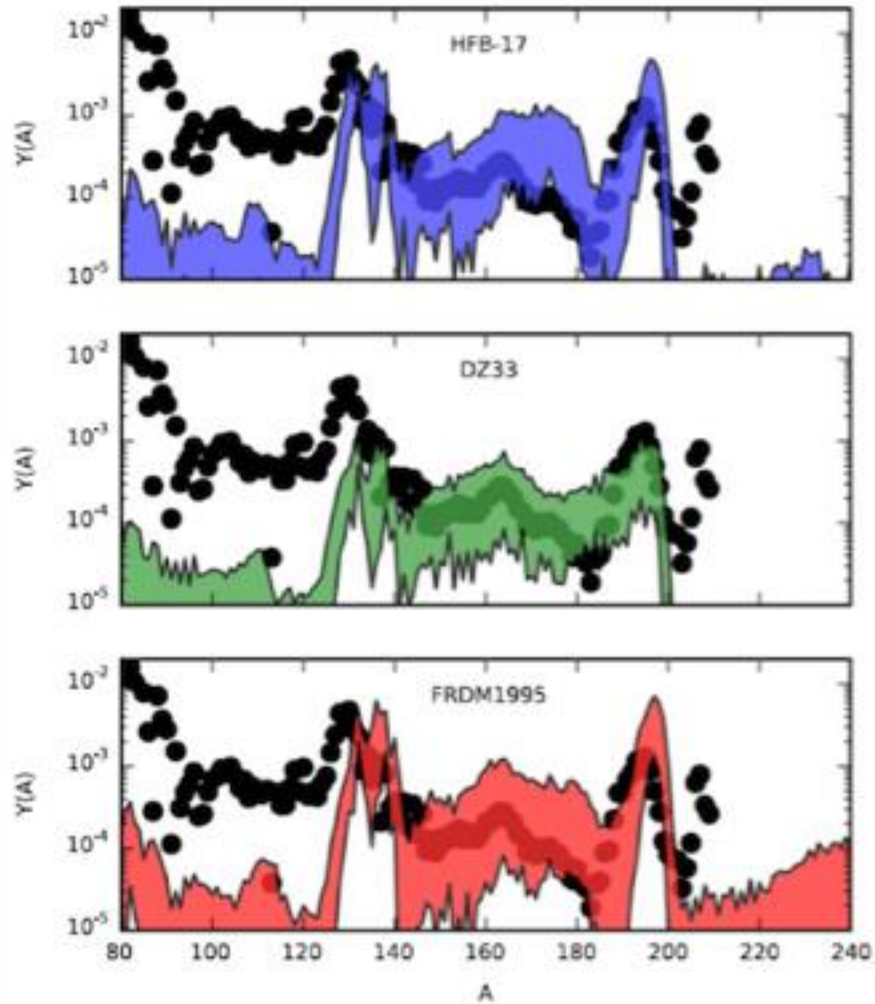
ChETEC-INFRA SNAQs

The Problem





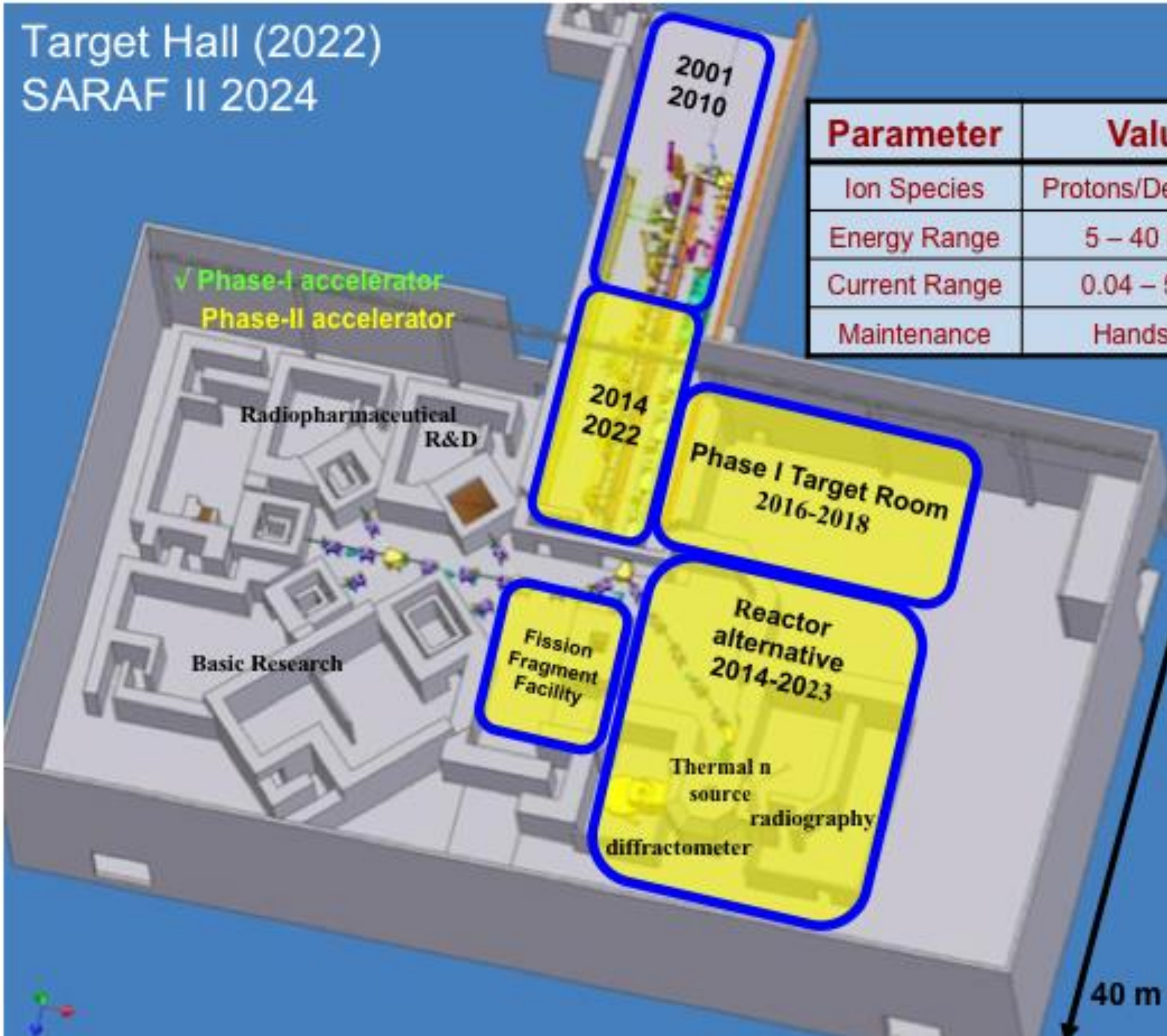
Effect of uncertain neutron capture rates



Progress in Particle and Nuclear Physics 86 (2016) 86–126

<u>Experimental Challenge</u>: Target and projectile are **unstable**.

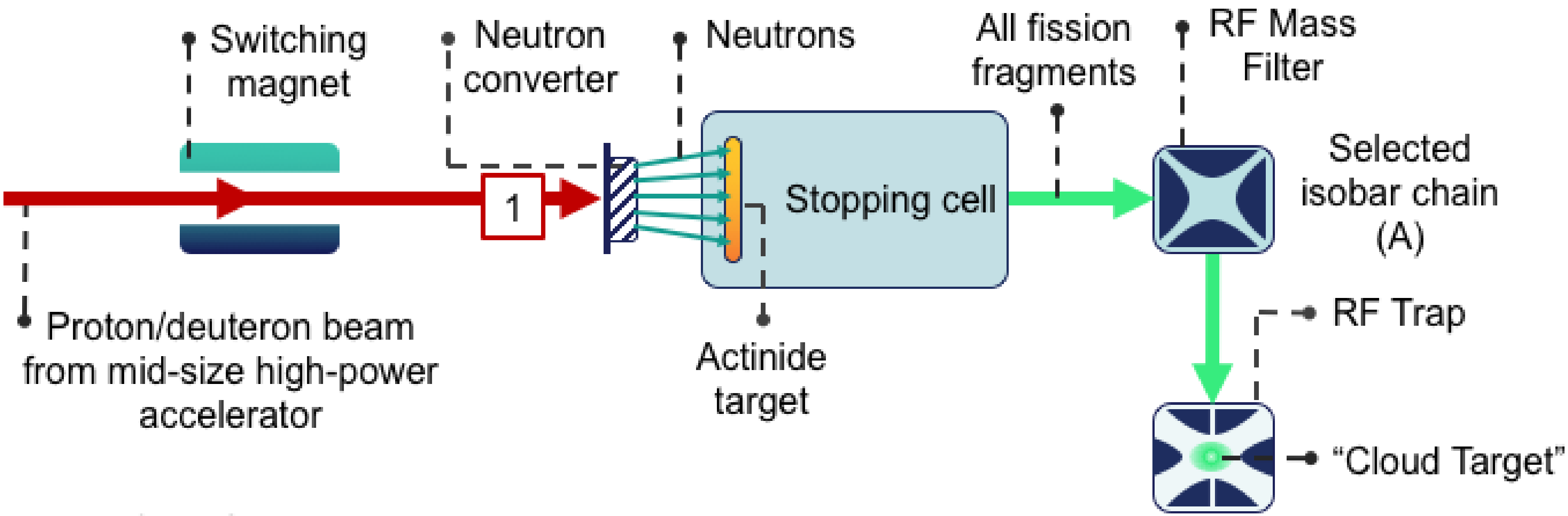
Soreq Applied Research Accelerator Facility (SARAF)



Parameter	Value	Comment
Ion Species	Protons/Deuterons	M/q ≤ 2
Energy Range	5 – 40 MeV	Variable energy
Current Range	0.04 – 5 mA	CW (and pulsed)
Maintenance	Hands-On	Very low beam loss

SARAF II
Under construction at
Soreq Nuclear Research
Center
Yavne, Israel

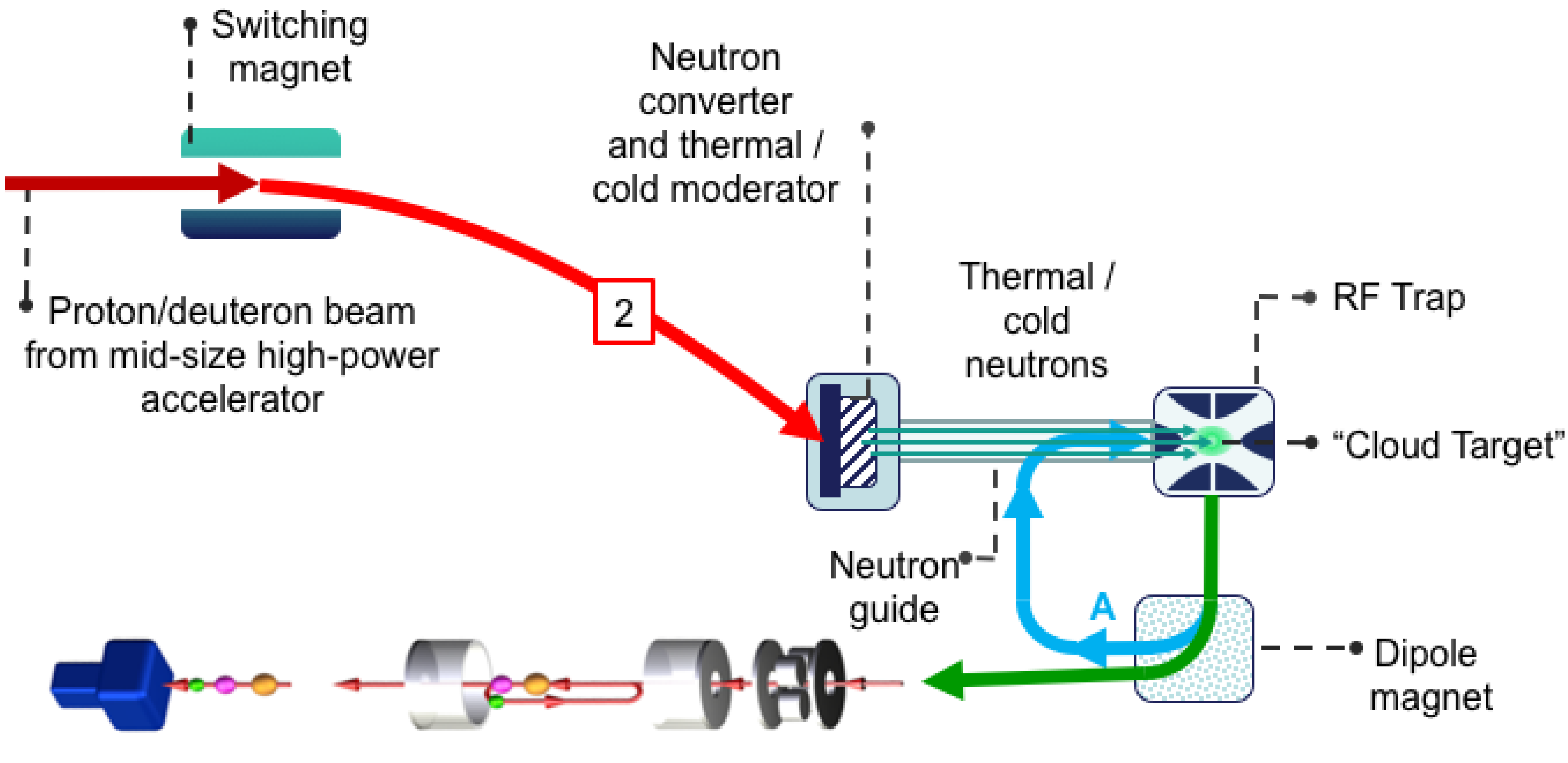
Project Sketch

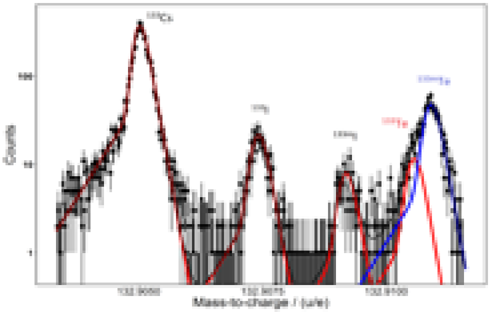


Final Trap Specifications

- "Cloud Target": **~10^{10} ions** with same A, in the region **A ~ 85-155** (fission products)
- Trapping duration: **~300 s**
- Trap volume can/should be cylindrical. **Transverse** dimensions of **a few mm**. **Longitudinal** can be longer, up to **~ 10's cm**
- Trap should enable irradiation by **cold/thermal neutrons** (~1-25 meV)
- Trap should contain ion kinetic energy of up to **~100's eV**
  - ***β*-decay** (A daughters of short-lived FPs) **and (n,*γ*)** (A+1 daughter)
- A+1 ions should be ejected in a **particular direction (axial or radial)**, towards a mass spectrometer

Project Sketch

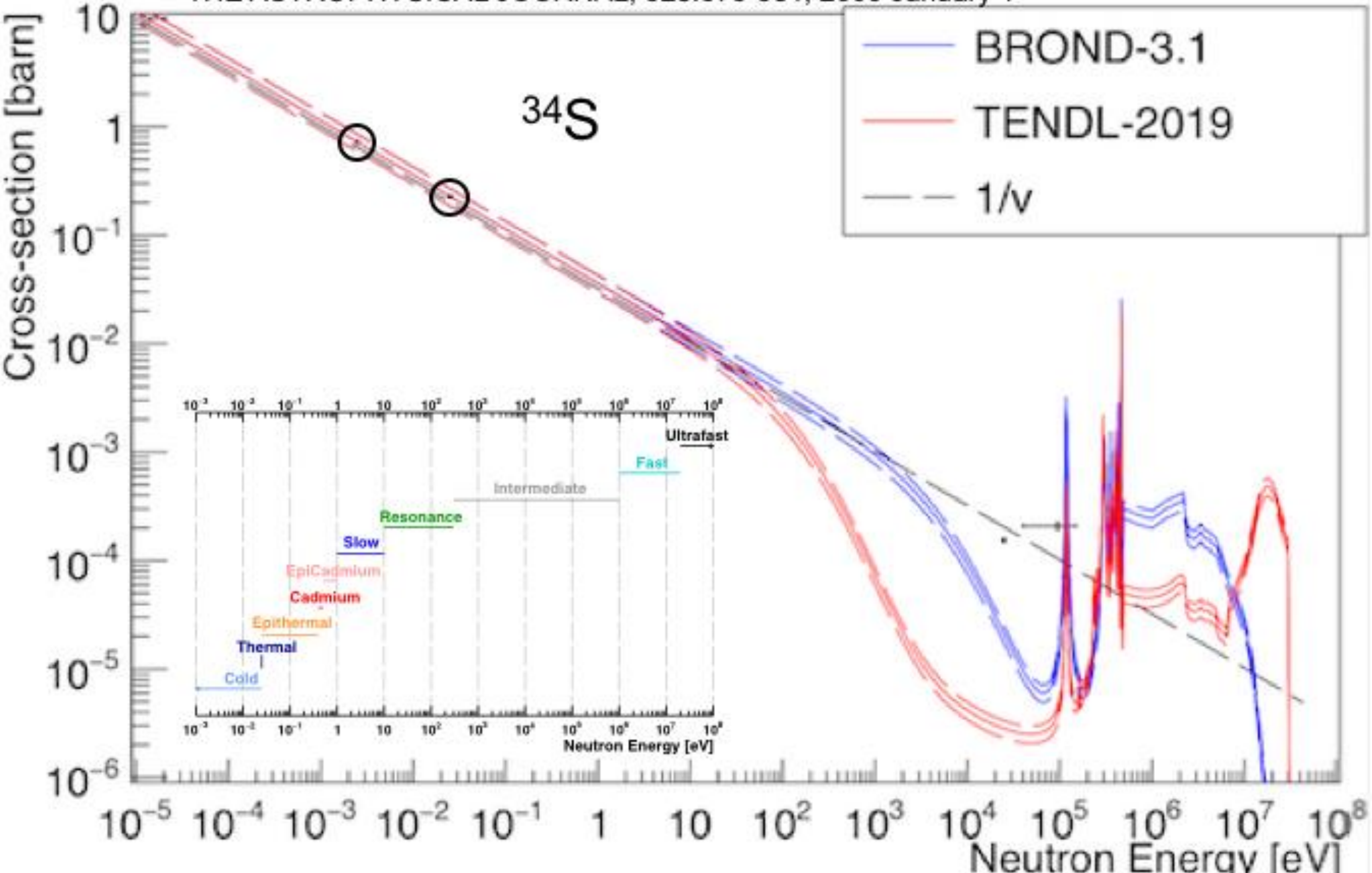




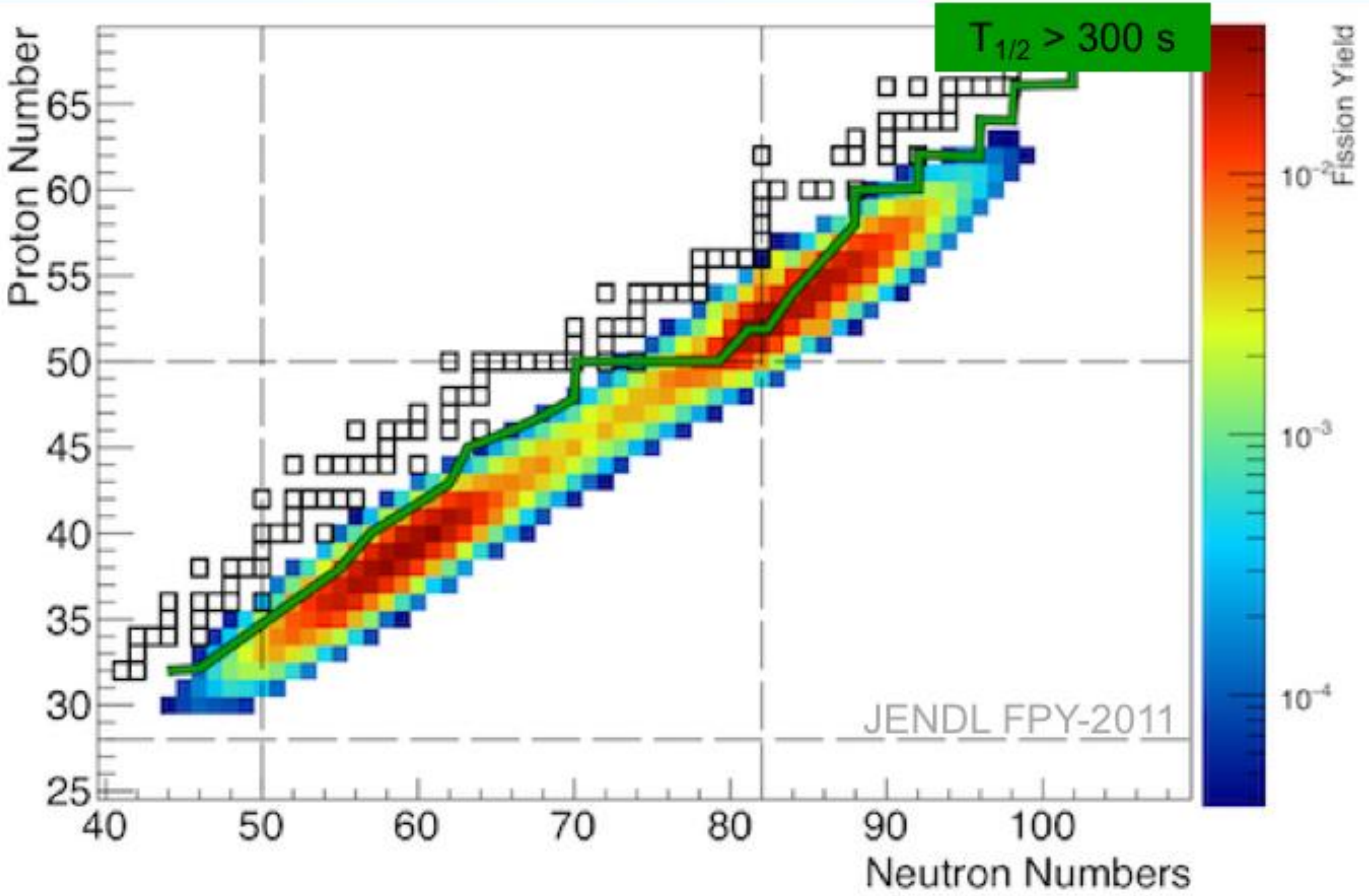
"NG-TRAP: Measuring neutron capture cross-sections of short-lived fission fragments" (on ResearchGate.net)

Neutron Cross Section

R. Reifarth, K. Schwarz and F. Käppeler
THE ASTROPHYSICAL JOURNAL, 528:573-581, 2000 January 1

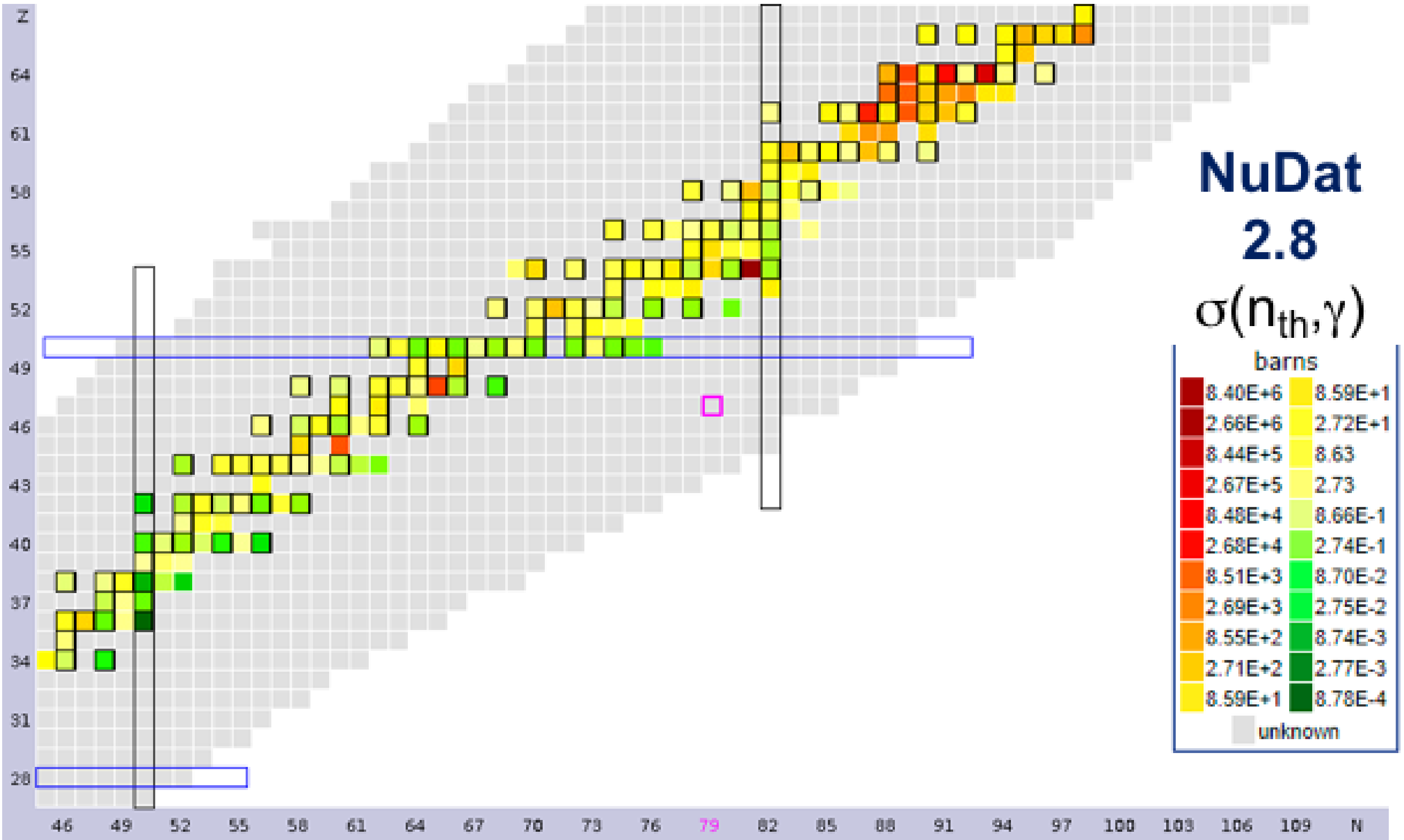


Fission Yields of 238U at 14 MeV



https://wwwndc.jaea.go.jp/cgi-bin/FPYfig

Comparison to measured $\sigma(n_{th},\gamma)$ so far



- Cross section values are from TALYS
- TALYS gives σ for thermal neutrons
- We assume $\sigma(\text{cold}) \sim 2 \cdot \sigma(\text{thermal})$ ($1/E^{1/2}$ trend)

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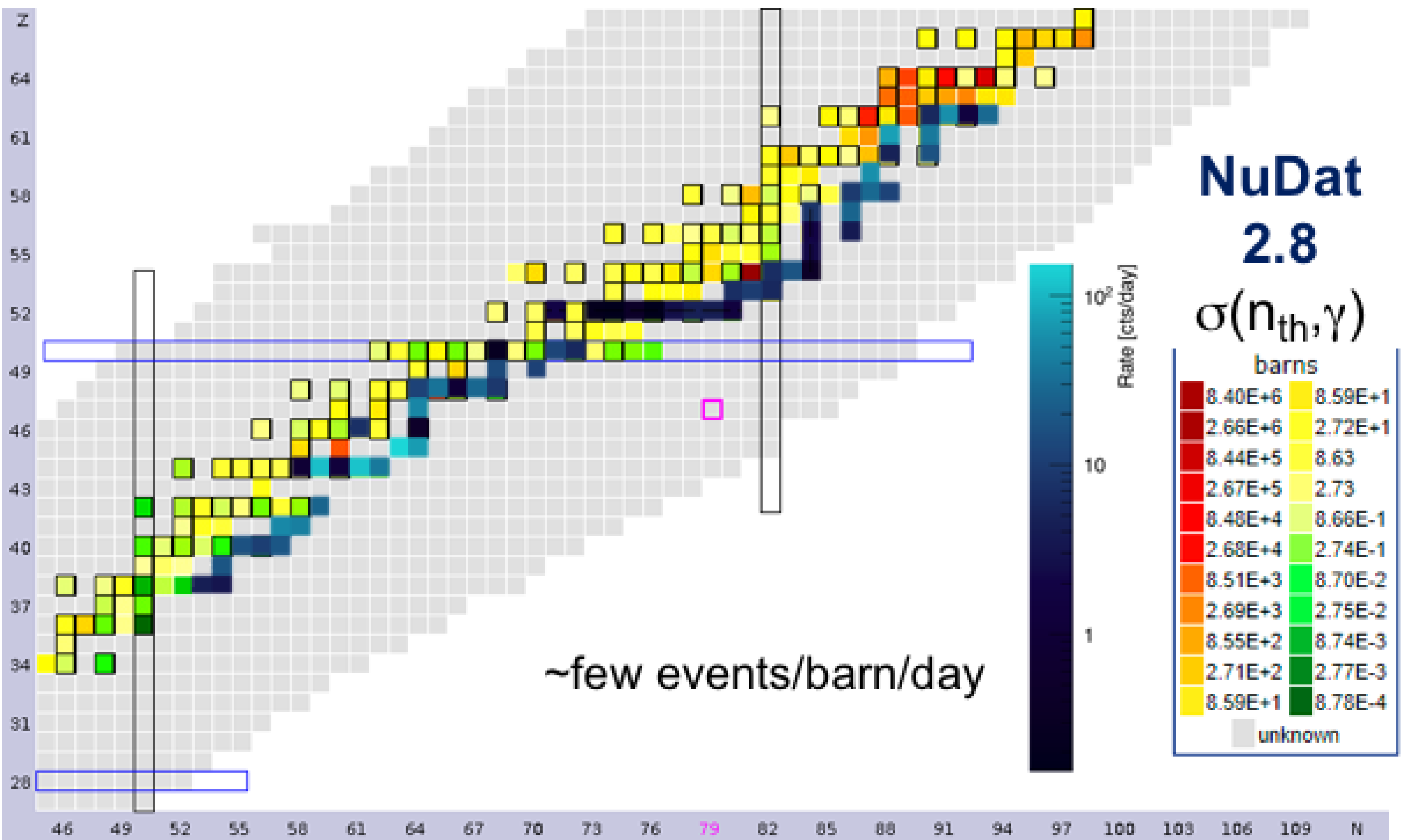

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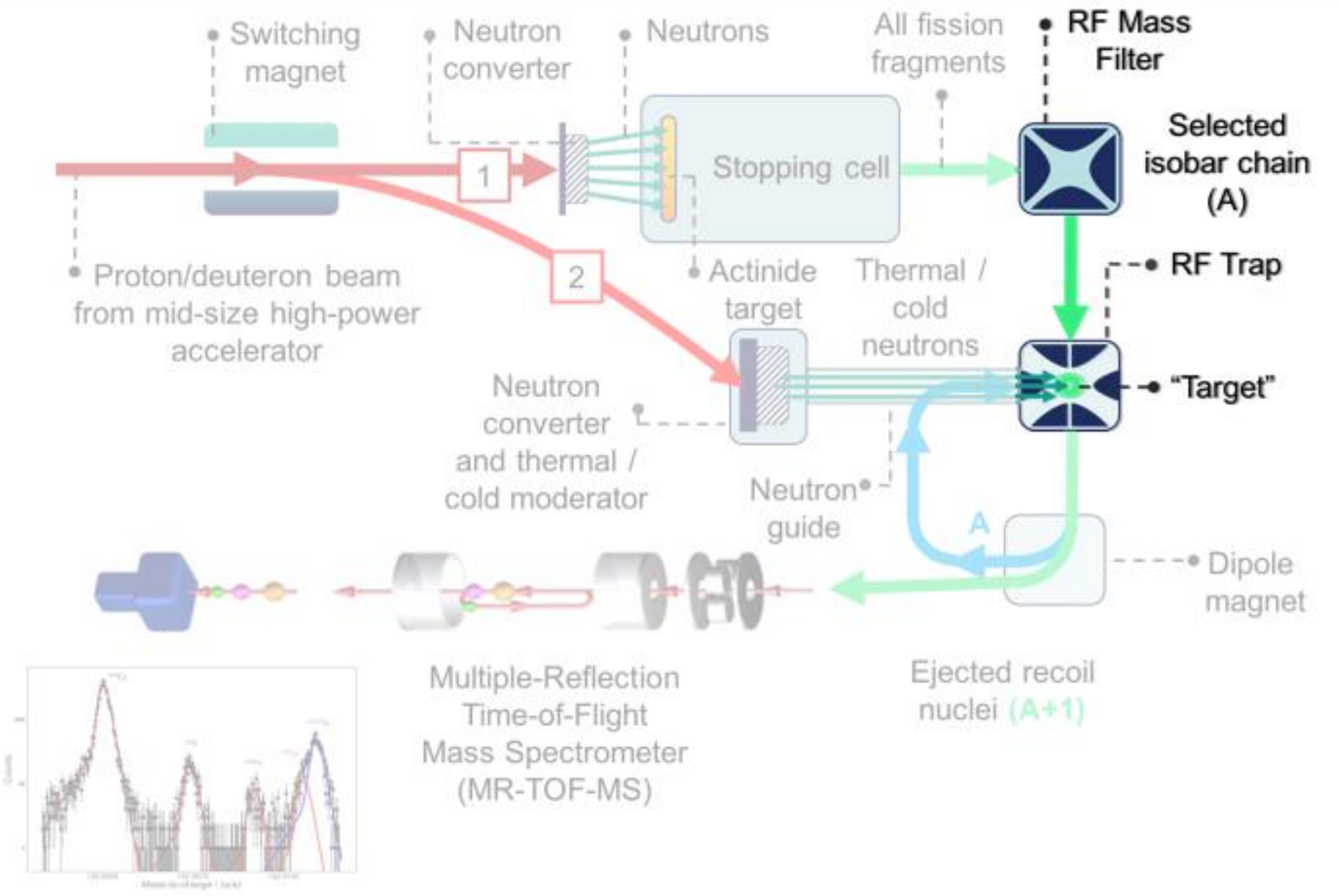
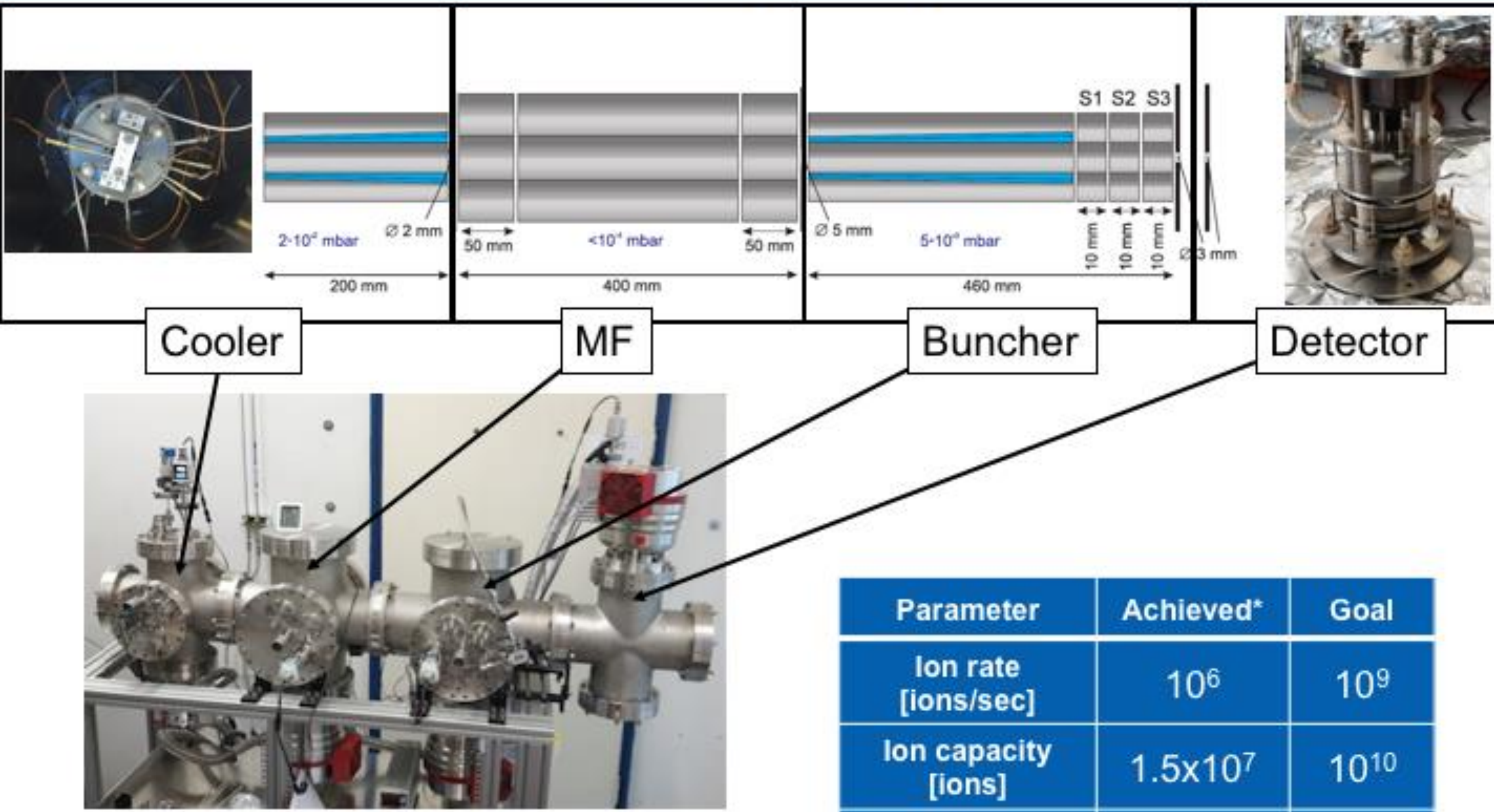
Project Focus



NG-Trap Setup



Parameter	Achieved*	Goal
Ion rate [ions/sec]	10^6	10^9
Ion capacity [ions]	1.5×10^7	10^{10}
Storage time [sec]	25	600

*E. Haettner *et al.*, A versatile triple radiofrequency quadrupole system for cooling, mass separation and bunching of exotic nuclei, Nucl. Inst. Meth. A 880 (2018) 138

Conclusion and outlook

- Start/continue simulations of all components
  - n-induced fission product (FP) generation
  - FP extraction and transport
  - NG-Trap RF simulations with space charge,
  - neutron-ion kinematics
  - neutron flux enhancement via reflectors around trap
- Test concept by hydrogen capture on molecules
- Construction of a dedicated RF trap and demonstration
- Tests with a neutron beam and a target of stable ions (with high $\sigma(n,\gamma)$ values, e.g. $^{155,157}Gd$, ^{149}Sm)
- Installation and testing at SARAF-II

Thank you for listening.