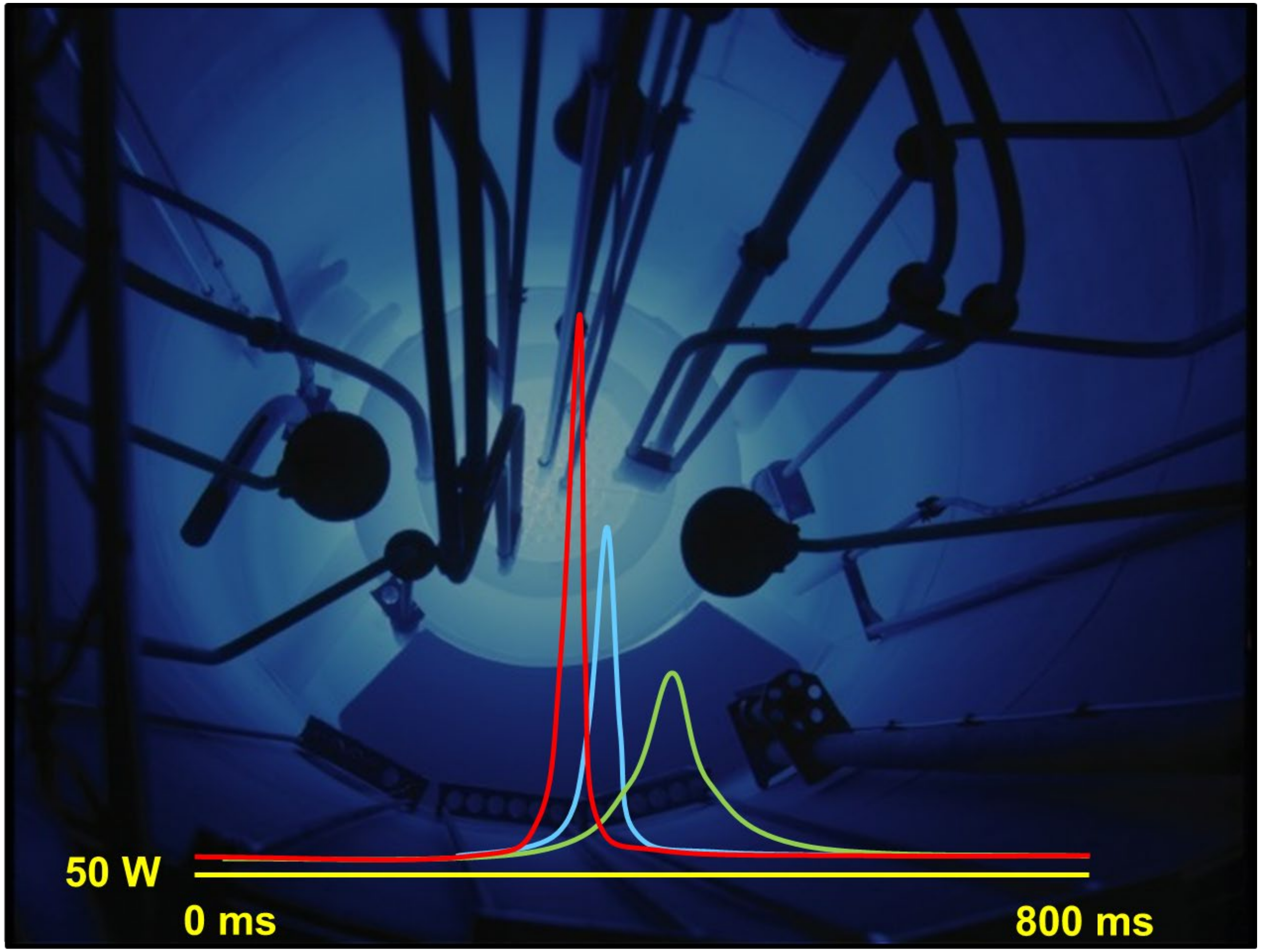
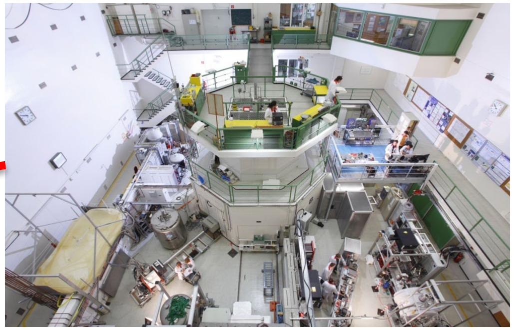
Report TRIGA Mainz 2018



Research Reactors in Germany

BERII, Helmholtz Zentrum Berlin (10 MW)

Shut-down in 2019



TRIGA Mainz (100 kW)

FRM II, Munic (20 MW)

TRIGA Mainz

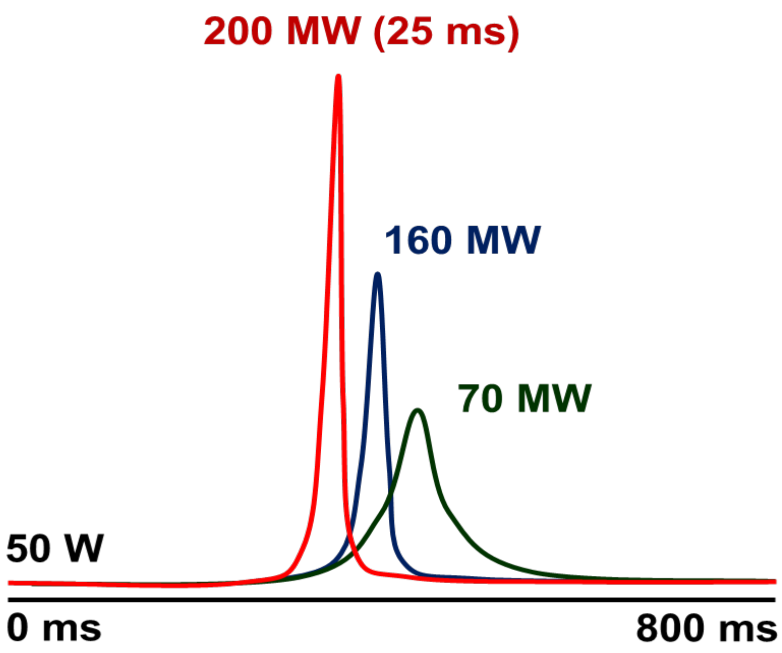
<u>Swimming pool reactor, TRIGA type</u>

- Steady state power: 100 kW_{th}
- Pulse mode : 200 MW_{th} (25 ms)
- 3rd of August 1965: First criticality
- Normally one-shift operation
- 12 weeks per year two-shift operation (UCN-sources @ beam port C+D)

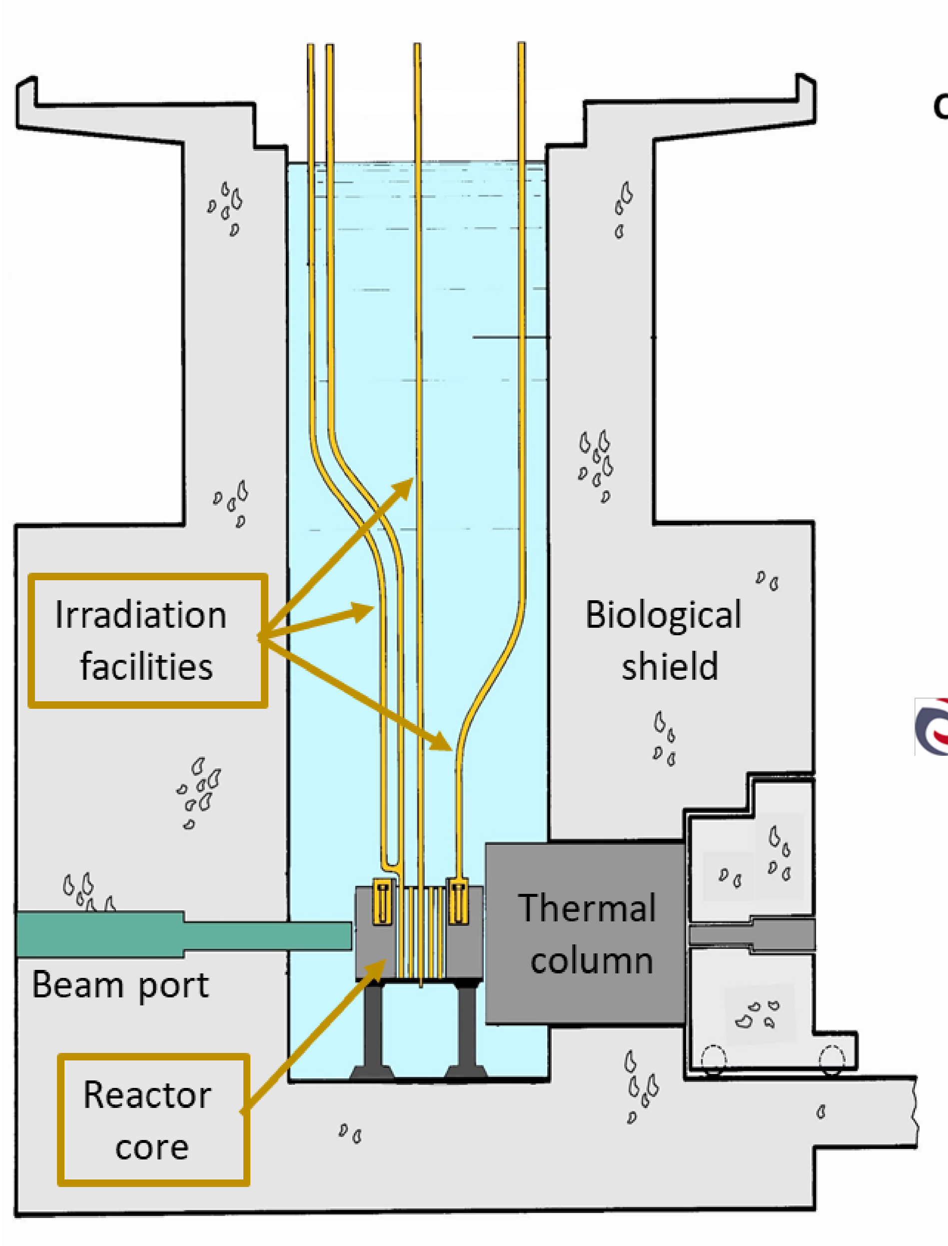
> 23636 Pulses since 1965

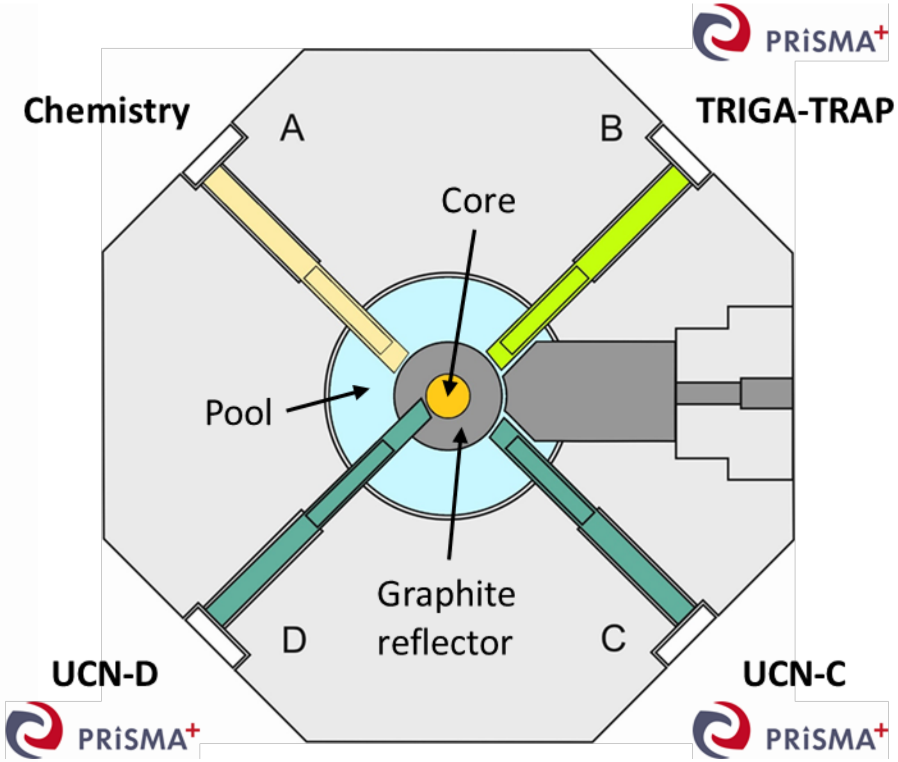
200 MW / 25 ms / 10^{15} cm^{-2}

April 3rd 1967: official inauguration.



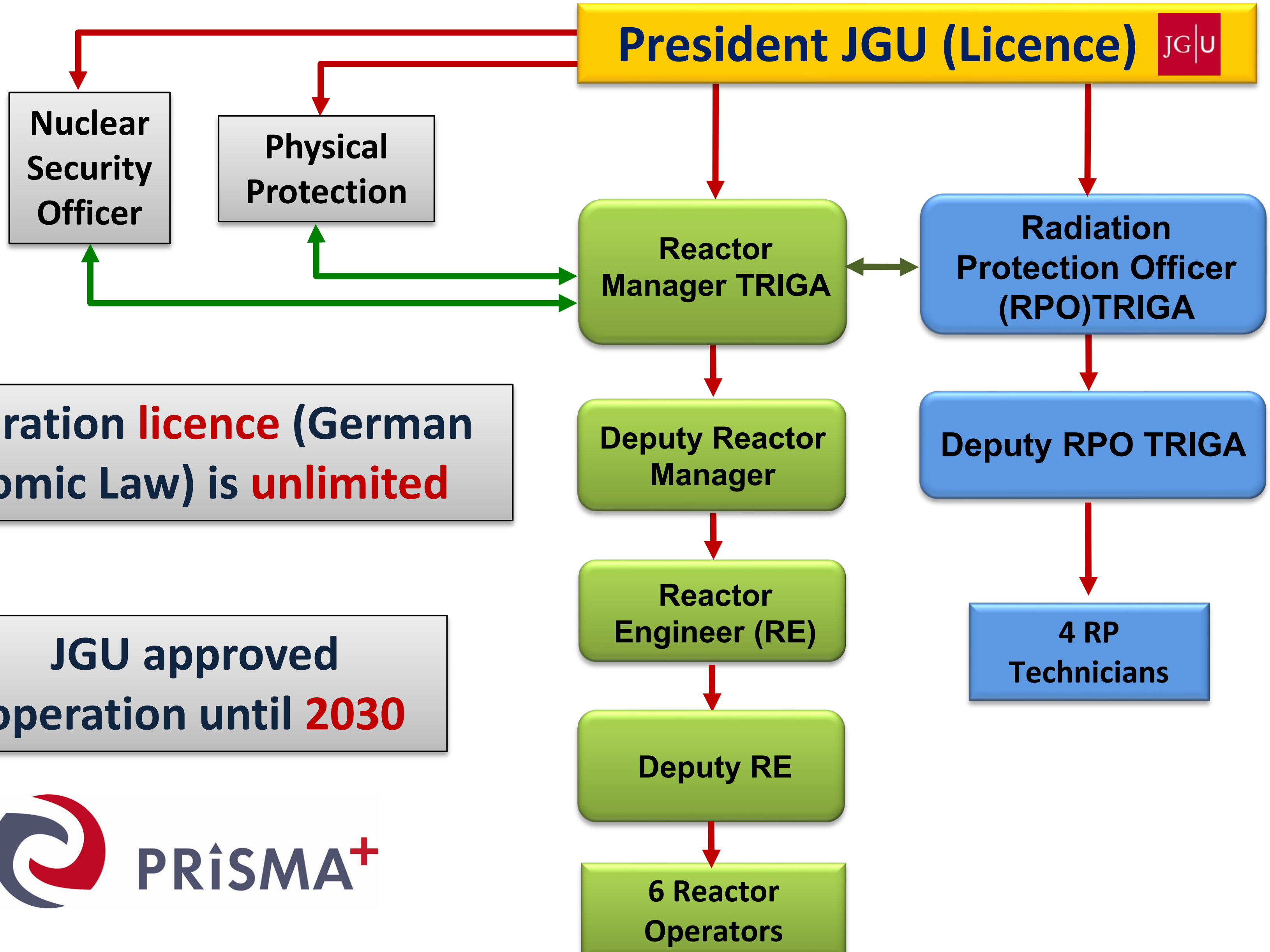
TRIGA Mainz





- α-, β- γ-, delayed neutron counters
- 6 NAA spectrometers
- Radiochemical laboratories
- Radiographic imaging
- SEM for actinide samples
- XPS for actinide samples

TRIGA Mainz: Staff, Organizational Structure



Operation licence (German Atomic Law) is unlimited

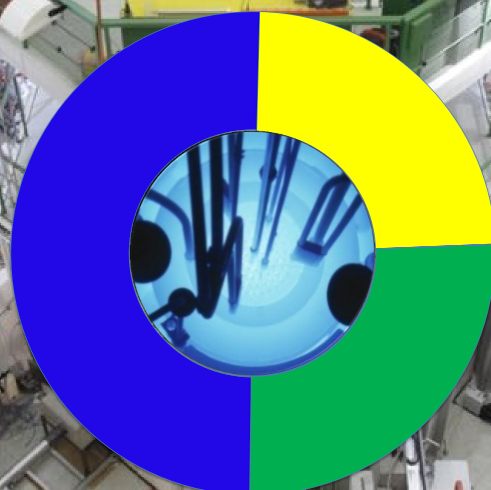
JGU approved operation until 2030

PRISMA+

Applications TRIGA Mainz

Fundamental research

- Chemistry of the heaviest elements (beam port A)
- Penning Trap Mass Spectrometry of exotic nuclei (beam port B)
- Experiment with ultra-cold neutrons - UCN (beam ports C+D)
- Neutron absorption cross section measure-ments (rabbit system, lazy susan)



Applied science

- Neutron Activation Analysis (NAA)
- Test of neutron de-tectors and electro-nic components
- Tracer production

Education and training

- Reactor courses (hands-on)
- Nuclear chemistry lab courses
- Radiation protection courses

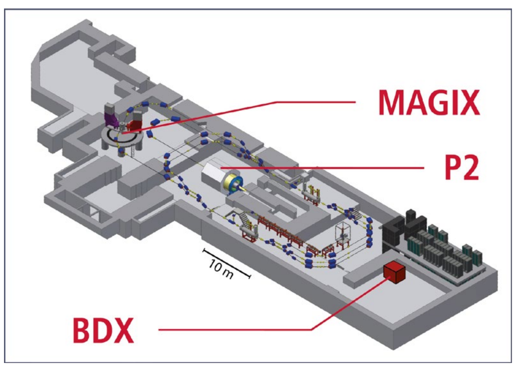
TRIGA Mainz @ PRISMA+

PRISMA+ | Cluster of Excellence
Precision Physics, Fundamental Interactions and Structure of Matter

DFG

Rheinland-Pfalz

MESA
Mainz
Energy-recovering
Superconducting
Accelerator



TRIGA Mainz

PRISMA
DETECTOR LAB

mitp
Mainz Institute for Theoretical Physics

TRIGA Mainz @ PRISMA+

PRISMA+ Cluster of Excellence
Precision Physics, Fundamental Interactions and Structure of Matter

DFG

Rheinland-Pfalz

First funding period: 2012 – 2017

Intermediate funding: 2018 – 2019

- **Investments** (He-liquifier) funded by PRISMA - **1.5 M€**
- **One scientist, two reactor operators** funded by PRISMA - **300 k€/a**

PRISMA+ (second funding period) recently approved by DFG : Start May 2019

- Two sources for **Ultracold Neutrons (UCN)** operational
- **User Facility** for UCN research
- Penning-Trap Mass Spectrometer **TRIGA-TRAP**

MAX-PLANCK-INSTITUT FÜR KERNPHYSIK HEIDELBERG

JG|U

HIM Helmholtz-Institut Mainz

TUM Technische Universität München

Education and Training

Diploma- , PhD-,

bachelor- and master-thesis

Chemistry

Physics

Chemistry- + physics magisterium

Radiation protection at schools

Lab courses for students

- Nuclear chemistry I
- Nuclear chemistry II
- Reactor operator course

Training in RP

- Radiation protection
- Requisite qualification course on radiation protection at schools
- Operator training for future reactor operators

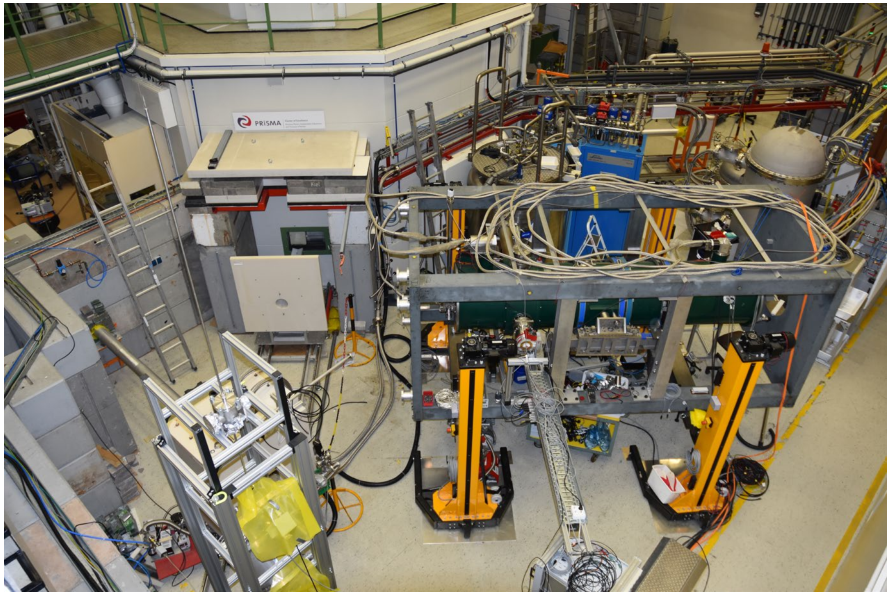
TRIGA Utilization 2018

Availability of the TRIGA Mainz:

- Typically about 150-180 days/a in operation
- Normally one-shift operation
- 12 weeks per year two-shift operation (UCN-sources @ beam port C+D)
- Life-time core: Burn-up approx. 206 g since 1965

Operation in 2018: 145 days

Pulses in 2018: 1105



“Typical” operation mode TRIGA:

- < 70 % continuous mode operation
- > 30 % pulse mode operation

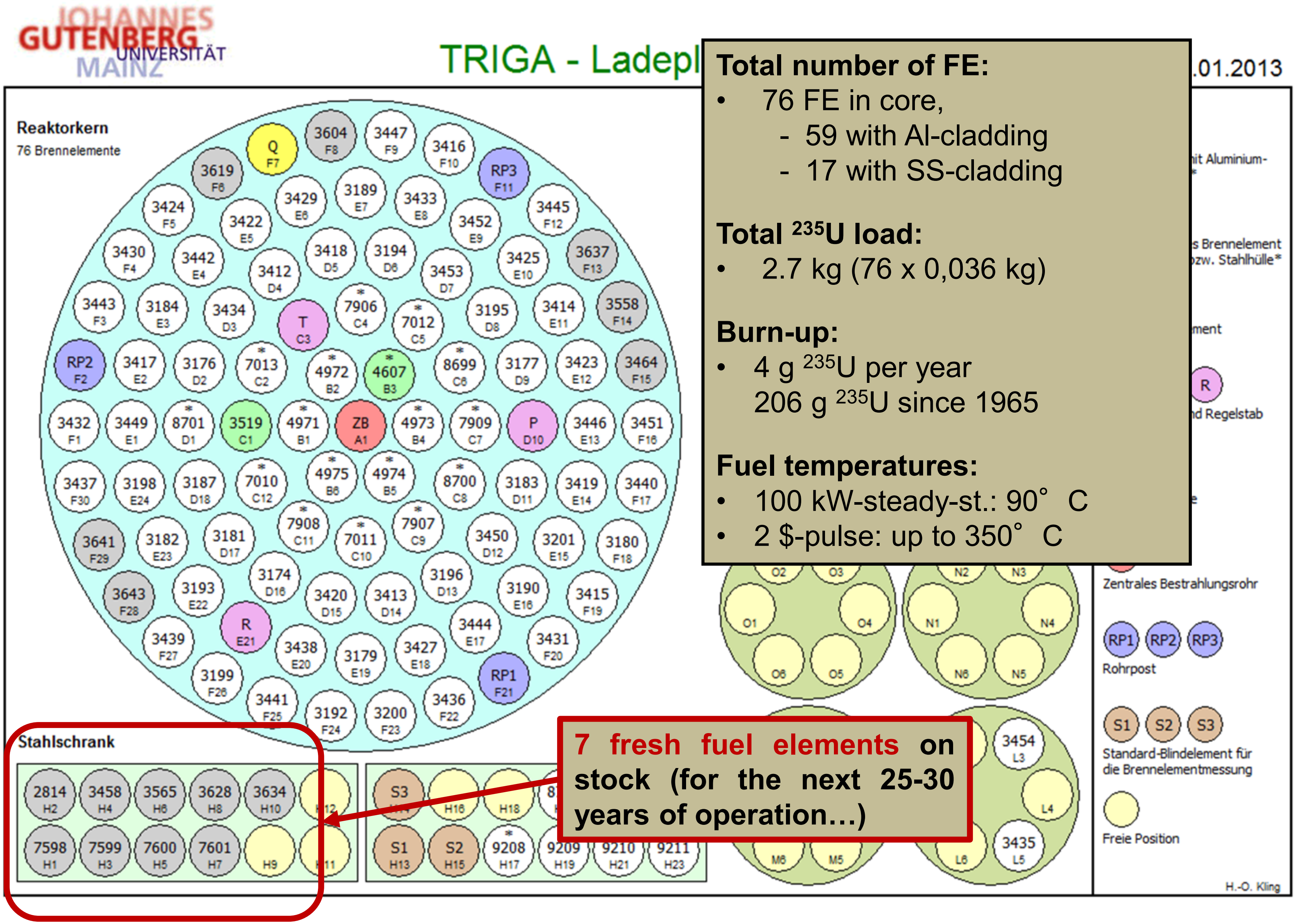
Irradiations:

- total 532 (261 inhouse, 271 ext. user)

Pulses (UCN-sources):

- 1105 in 2018
- 23578 pulses since 1965

TRIGA Mainz Core configuration



Total number of FE:

- 76 FE in core,
  - 59 with Al-cladding
  - 17 with SS-cladding

Total ^{235}U load:

- 2.7 kg (76 x 0,036 kg)

Burn-up:

- 4 g ^{235}U per year
  206 g ^{235}U since 1965

Fuel temperatures:

- 100 kW-steady-st.: 90° C
- 2 $-pulse: up to 350° C

7 fresh fuel elements on stock (for the next 25-30 years of operation…)

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TRIGA Mainz Performance Indicators 2018

Availability		Shutdowns	
A1 [%]	A2 [%]	B1	B2
93	40	1	0

A1: N_P / (N_P + N_S)

A2: N_P / 365

N_P : Number of days at power

N_S : Number of days of ***unscheduled*** shutdown

B1: Number of *unplanned* reactor shutdowns initiated by reactor protection system / manual intervention

B2: Number of ***unplanned*** reactor shutdowns initiated by experiments under irradiation

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TRIGA Mainz Performance Indicators 2018

Radiation dose exposure (LOD: 0.1 mSv per month ⇒ 1.2 mSv per year)

- **D1a ⇒ Collective dose to reactor operation staff [mSv]: < LOD**
- **D1b ⇒ Number of reactor operations staff: 11**
- **D1c ⇒ D1a/D1b [mSv/person]: < LOD**
- **D2a ⇒ Collective dose to all staff from reactor related work [mSv]: < LOD**
- **D2b ⇒ Total number of staff involved: 17**
- **D2c ⇒ D2a/D2b [mSv/person]: < LOD**

Radioactivity released

- **E1 ⇒ Rare gas released into atmosphere [TBq]: 0.14 (Ar-41 only)**
- **E2 ⇒ Tritium released into atmosphere [TBq]: n.a.**
- **E3 ⇒ Tritium discharged into water [GBq]: n.a.**
- **E4 ⇒ Iodine released into atmosphere [MBq]: below LOD**

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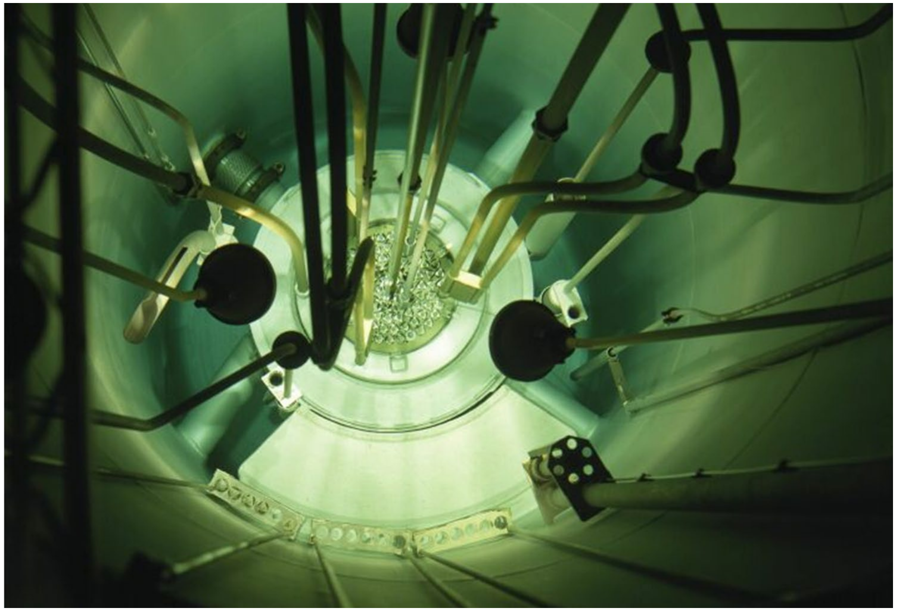
TRIGA Mainz Ageing Management

Ageing management is part of the periodic maintenance and inspection schedule, including nuclear and conventional (non-nuclear) components:

- Inspection of pool and core components
- Inspection of beam ports
- Fuel inspection
- Reactor console
- ……………
- Pressure vessels
- Electrical installations
- Building
- …………..



Most inspections are reviewed by external experts.

Review report for licencing authority

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TRIGA Mainz Ageing Management

European Nuclear Safety Regulators Group:

- **Topical Peer Review on Ageing Management 2017**
- **NPP and Research Reactors**
- **FRM II and BER II have to participate**
- **TRIGA Mainz volunteered in 2017 and participate in 2019**
- **Only topic for TRIGA Mainz: Electrical cables**

ENSREG
European Nuclear Safety Regulators Group

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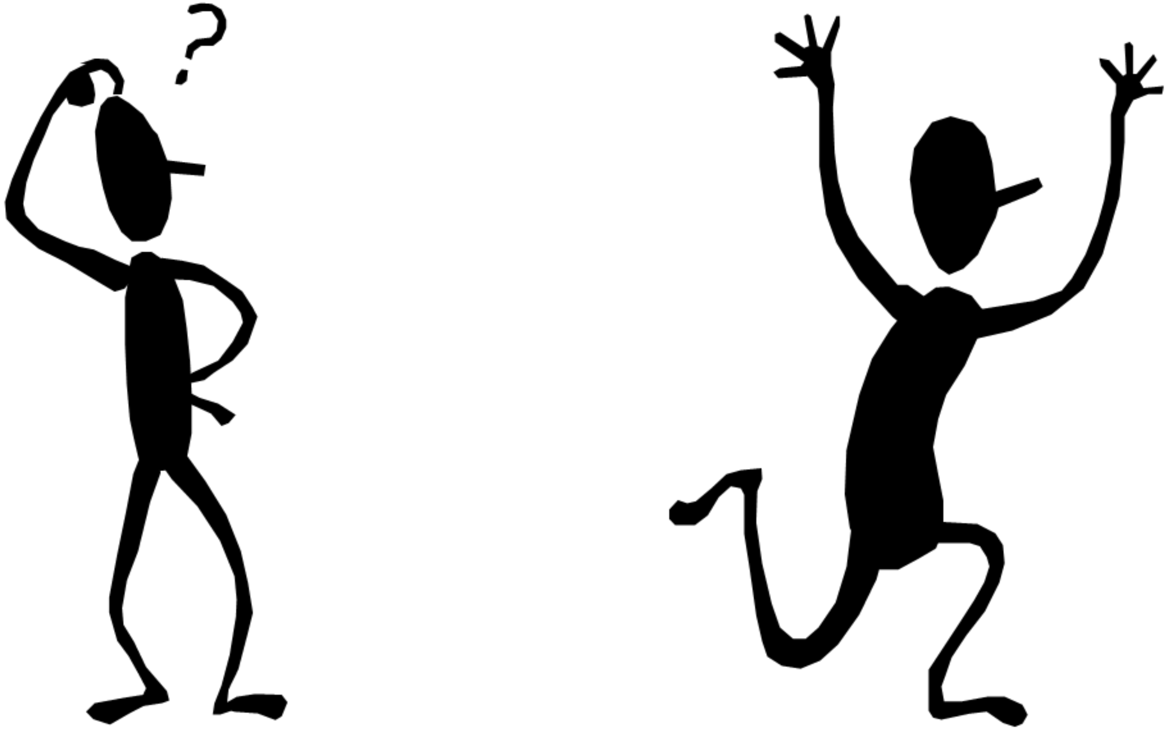
Thank you for your attention

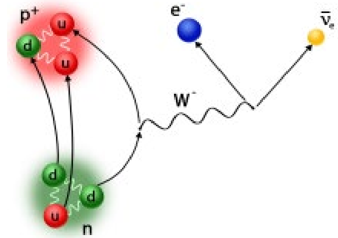


Ulta-cold Neutrons

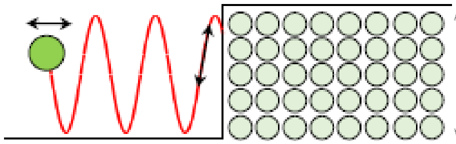
Ultra-cold Neutrons (UCN)

Velocity: $v \leq 10$ m/s

Energy: 250 neV

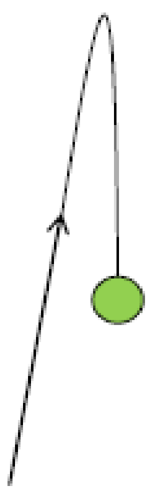


Weak- and strong interaction



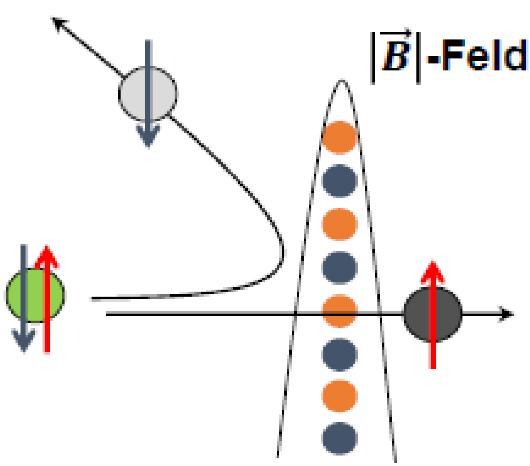
Gravity

$$\Delta E \approx \pm 100\,\mathrm{neV/m} \cdot h$$



Magnetic field

$$\Delta E \approx \pm 60\,\mathrm{neV/T} \cdot B$$



Stainless Steel: 190 neV

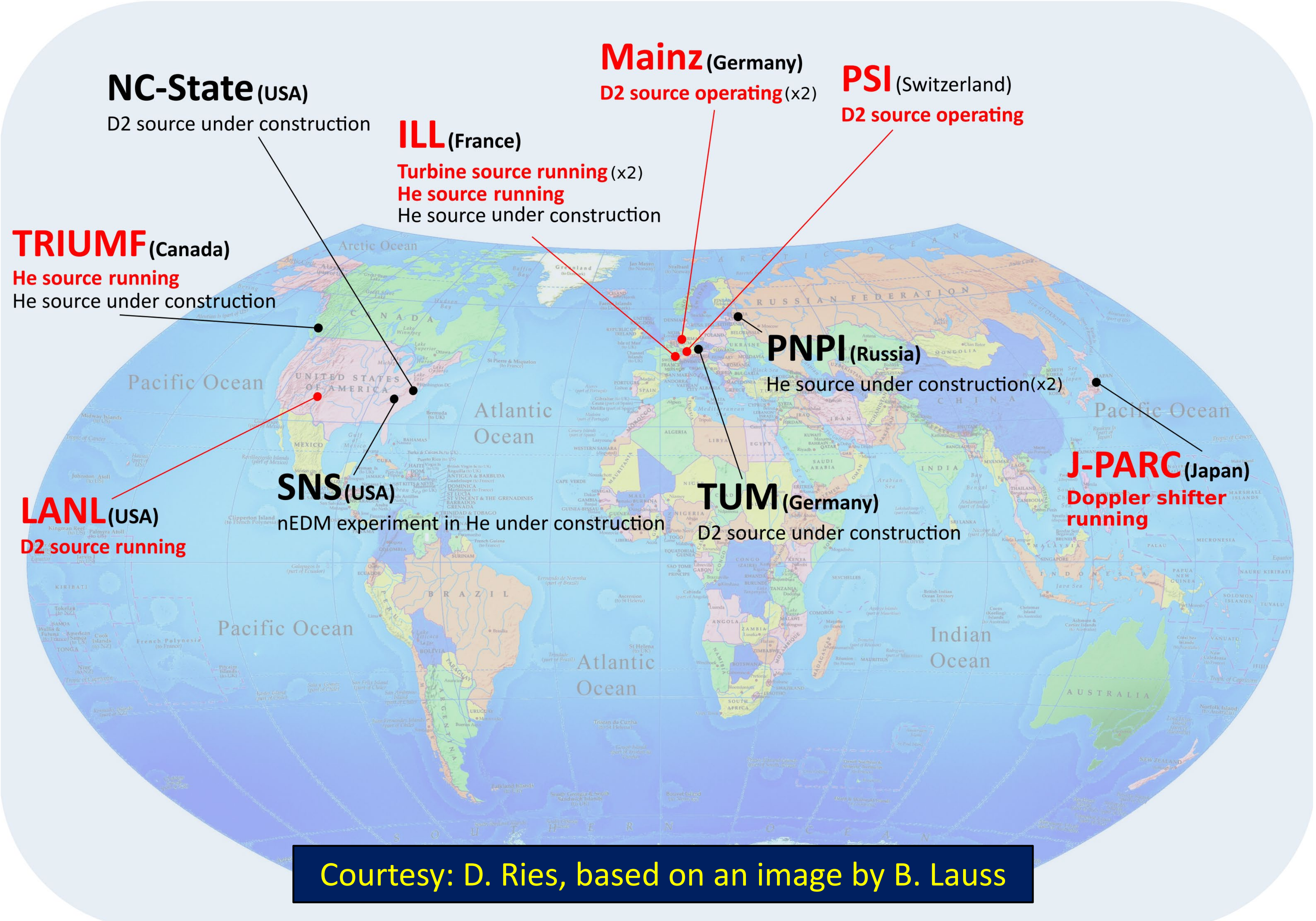
Ni-58: 335 neV

Al: 54 neV

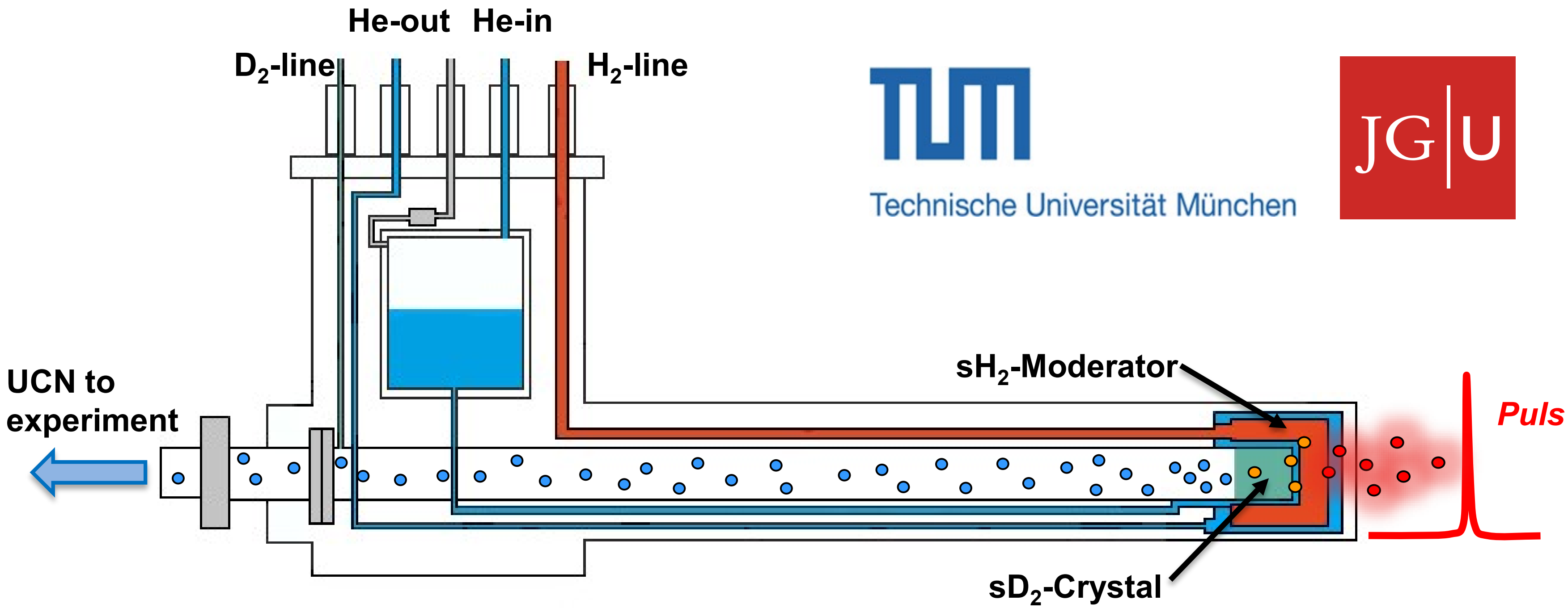
UCN undergo total reflection

UCN can be stored in material bottles

Overview of UCN-sources world-wide



TRIGA Mainz superthermal pulsed UCN-source



Technische Universität München

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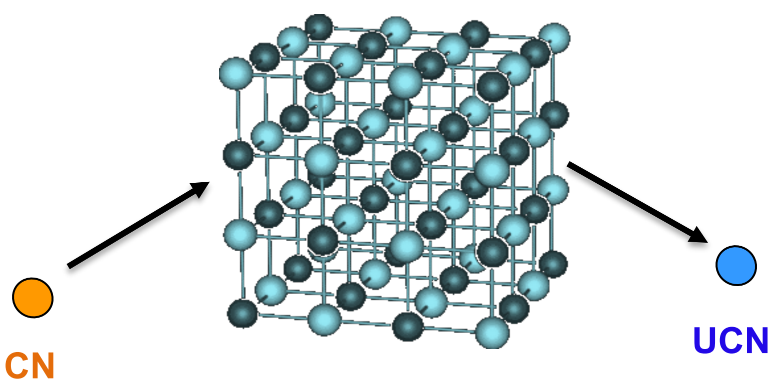
sD_2 (7 K)

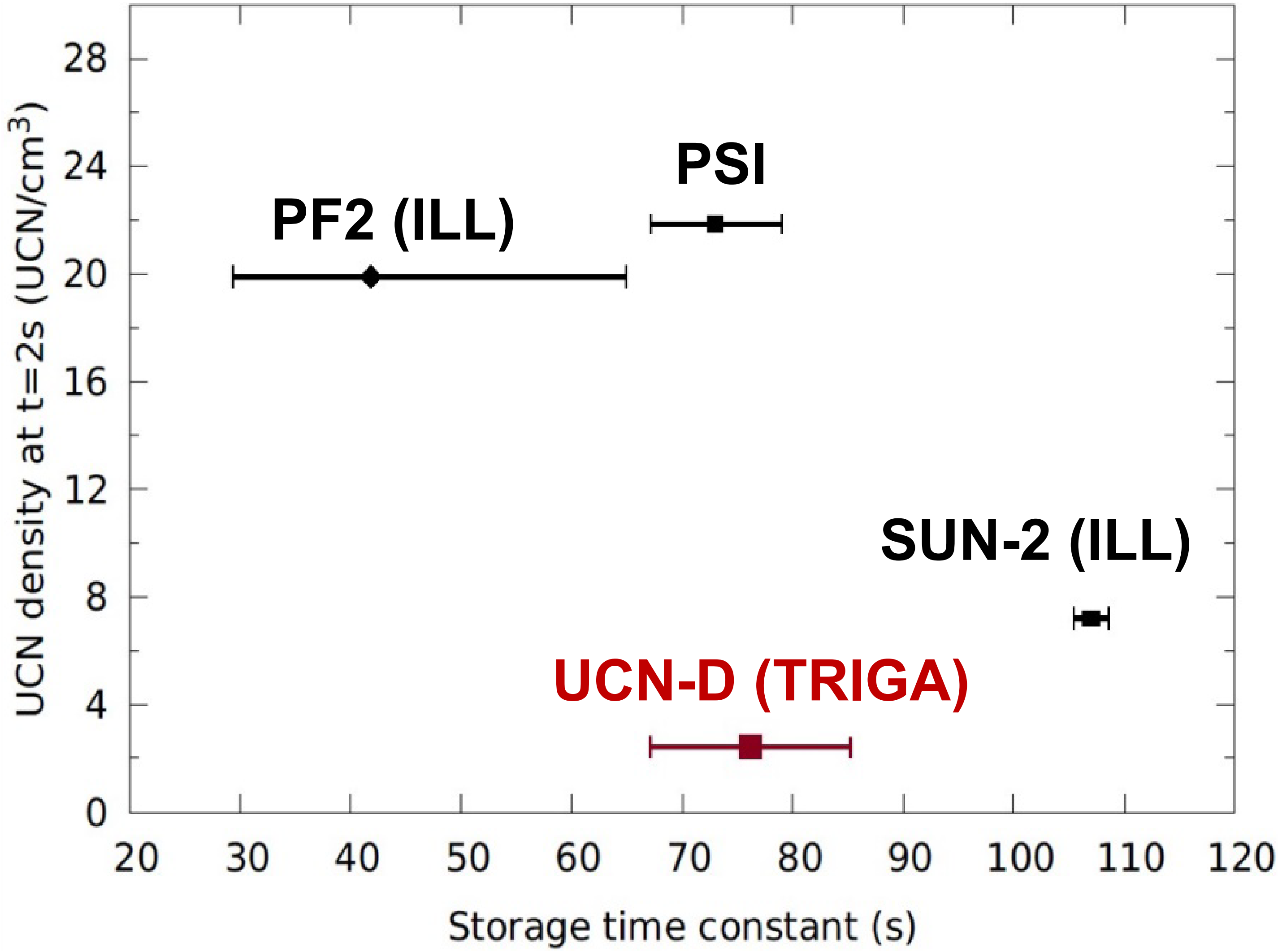


A. Frei et al.: *First production of ultracold neutrons with a solid deuterium source at the pulsed reactor TRIGA Mainz.*
Eur. Phys. J. A 34, 119 (2007)

Phonon-excitation in sD_2-crystal: CN becomes UCN

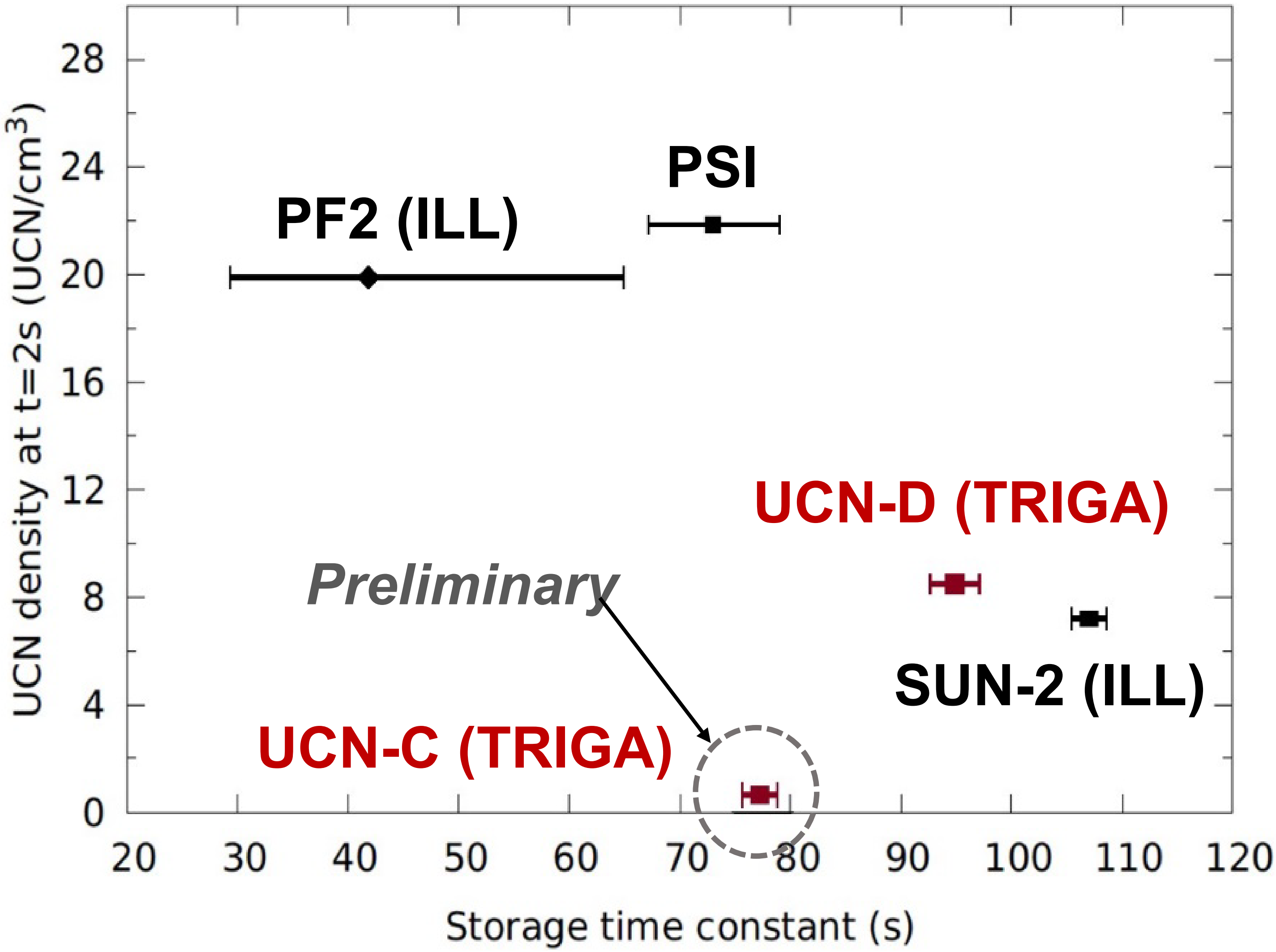
Available UCN-densities: A comparison

G. Bison et al.: ***Comparison of ultracold neutron sources for fundamental physics measurements. Physical Review C 95; (2017) 045503***

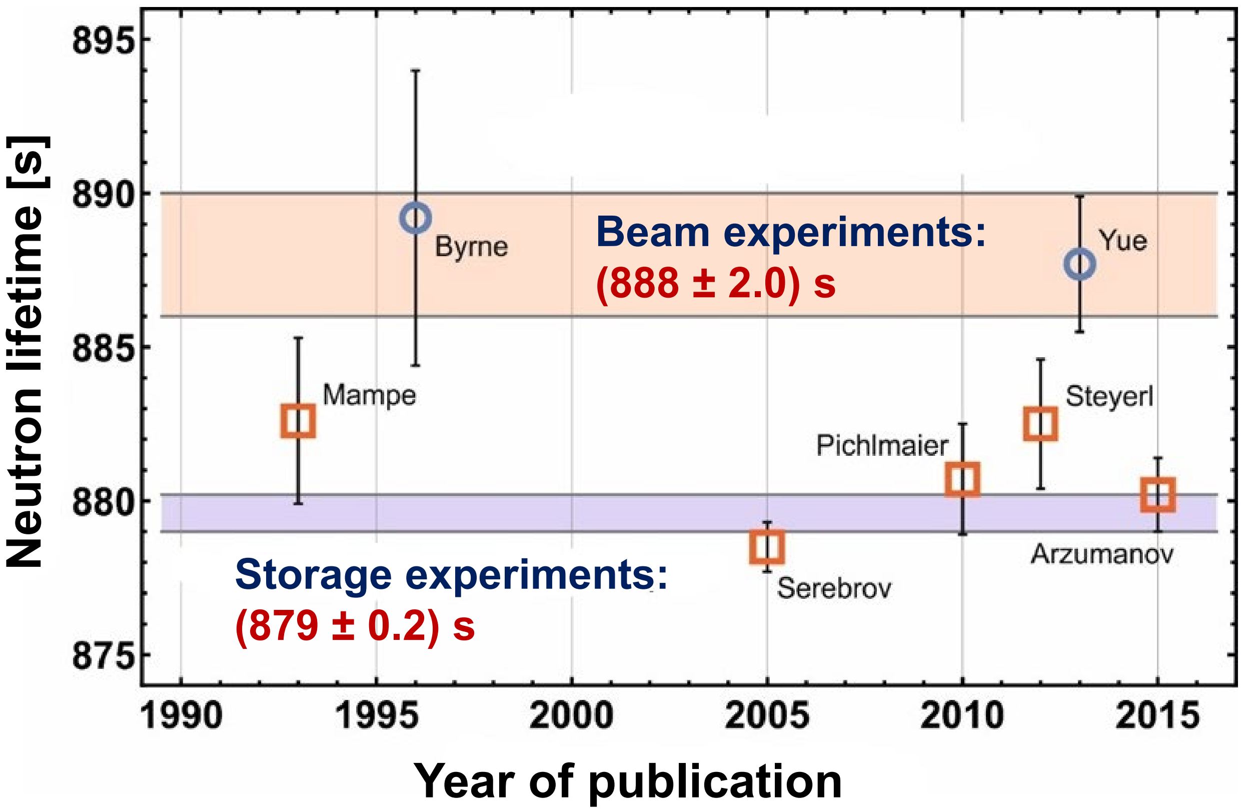


Available UCN-densities: A comparison

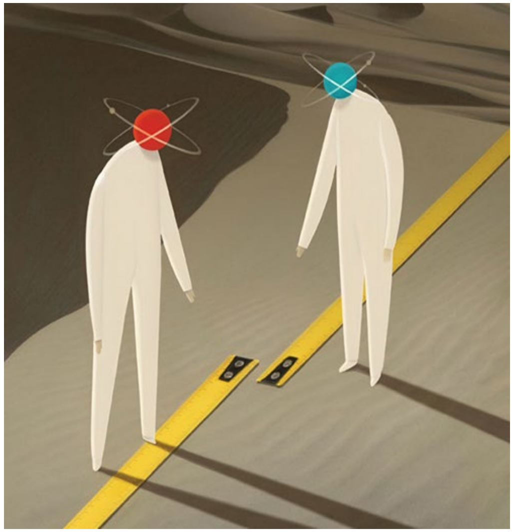
J. Kahlenberg et al.: *Upgrade of the ultracoldneutron source at the pulsed reactor TRIGA Mainz.* Eur. Phys. J. A 53 (2017) 226



Neutron lifetime measurements

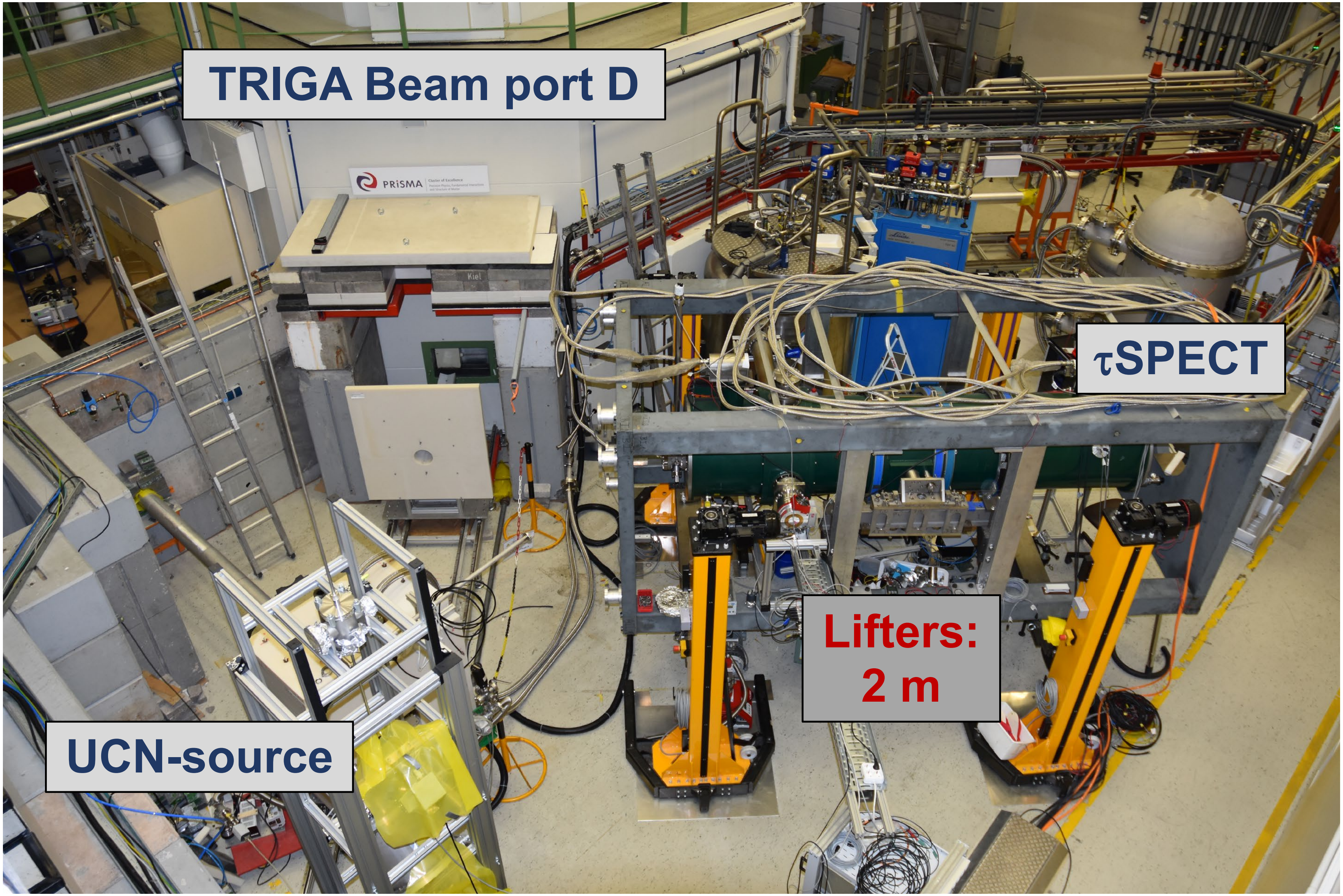


$$\Delta\tau_n \approx 8\ \mathrm{s}$$
$$\simeq 4\sigma$$

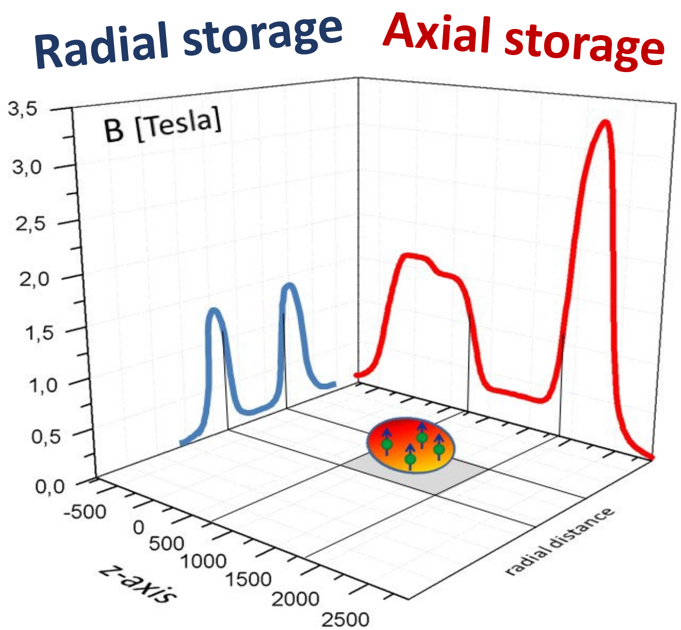


G.L. Greene and P. Geltenbort:
A Puzzle Lies at the Heart of the Atom.
Scientific American, Vol. 314, Issue 4, April 2016

Neutron lifetime measurement with τSPECT



Neutron lifetime measurement with τSPECT



- τSPECT currently set up for full magnetic neutron storage
- Phase 1: τ_N with 1 s precision
- Phase 2: τ_N with 0.3 s precision. Simultanious detection of N and P