
TRIGA Vienna
Austria
RROG
30TH ANNUAL MEETING
14th to 17th May 2019
Mainz
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# History of the TRIGA Mark II Reactor Vienna

- 250 kW TRIGA Mark II reactor at the Atominstitut in Vienna critical since March 7th, 1962.
- Initially started up with 66 TRIGA fuel elements type 102 (Al-cladding, LEU).
- Following years elements of type 104 (SST-cladding, LEU) were purchased.
- In 1972 fuel elements of type 110 (SST-cladding, 70% enriched) where acquired and placed in the core.
- The last 8 fresh fuel elements were acquired from the TRIGA reactor in Heidelberg.
- Core conversion in November 2012.
- Major Refurbishment from 2015 to 2017.

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# Fuel Inventory as per 01.01.2019

| Date | Number of FE | Type | Remarks |
|---|---|---|---|
| 05.12.61 | + 66 | Al, 20% | 2 instrumented fuel elements |
| 07.07.62 | - 2 (retour) | Al, 20% | |
| 19.02.65 | + 2 | Al, 20% | |
| 02.08.66 | + 3 | SST, 20% | |
| 21.10.68 | + 3 | SST, 20% | 1 instrumented fuel element 5284 TCE |
| 19.10.72 | + 9 | SST, 70% | |
| 02.12.80 | **+ 1** | SST, 20% | 1 instrumented fuel element 8257 TCE |
| 09.08.82 | + 3 | SST, 20% | |
| 15.02.83 | **+ 2** | SST, 20% | 2 instrumented fuel elements 8730, 8731 TCE |
| 21.08.87 | + 3 | SST, 20% | |
| 19.10.88 | + 3 | SST, 20% | |
| 01.02.90 | + 3 **(+ 2)** | SST, 20% | |
| 14.12.00 | **+ 8** | SST, 20% | |
| 30.10.2012 | **+ 77** | SST, 20% | 75 FE from Musashi and 2 FE from Cornell |
| 07.11.2012 | - 91 (retour) | SST 20% and 70%, Al 20% | 3 instrumented fuel elements |
| total: | 90 | | |

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# Main technical Data of the TRIGA Mark-II Reactor Vienna (1)

**1. Reactor**

| | |
|---|---|
| Fuel-moderator material | 8.5 wt% uranium<br>89.9 wt% zirconium<br>1.6 wt% hydrogen |
| Uranium enrichment | 19.8 % and 70% uranium-235 |
| Active core volume | 49.5 cm diameter<br>38.1 cm high |
| Core loading | 80 fuel elements, |
| Amount of U-235 per fuel element | approx. 38 grams |
| Reflector | graphite |
| Reactor control | 2 motor-driven control rods<br>1 pneumatic control rod material<br>prompt negative temperature coefficient of the fuel |

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# Main technical Data of the TRIGA Mark-II Reactor Vienna (2)

**2. Steady state reactor operation mode**

| | |
|---|---|
| Maximum thermal power | 250 kW |
| Maximum thermal neutron flux density | $1x10^{13}$ $cm^{-2}s^{-1}$ |
| Maximum fuel temperature | 220 °C |
| Maximum primary water temperature | 35 °C |

**3. Transient reactor operation mode**

| | |
|---|---|
| Peak, power thermal | 250 MW |
| Integrated energy production | 12 MWs |
| Total duration of power pulse | 40 ms |
| Minimum reactor period | 10 ms |
| Maximum fuel temperature | 360 °C |

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# Specification of Fuel Elements

| | Type 102 | Type 104 | Type 110 (FLIP) |
|---|---|---|---|
| Fuel moderator material | | | |
| H/Zr-ratio | 1.0 | 1.65 | 1.65 |
| Uranium content [wt%] | 8.5 | 8.5 | 8.5 |
| Enrichment [%] | 20 | 20 | 70 |
| Diameter [mm] | 35.8 | 36.3 | 36.3 |
| Length [cm] | 35.6 | 38.1 | 38.1 |
| Poisoning | $SmO_3$-disks | none | Er with 1.6 w/o |
| Graphite reflector | | | |
| Porosity | 20 | 20 | 20 |
| Diameter [mm] | 35.8 | 36.3 | 36.3 |
| Length [cm] | 10.2 | 8.73 | 8.81 |
| Fuel cladding | | | |
| Material | Al-1100 F | 304 SS | 304 SS |
| Wall thickness [mm] | 0.76 | 0.51 | 0.51 |
| Overall dimensions | | | |
| Outer diameter [mm] | 37.5 | 37.5 | 37.5 |
| Length [cm] | 72.06 | 72.06 | 72.06 |

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# Fuel Element Situation as per 01.01.2019

| Number of FE | Location | Cladding | | Enrichment | Remarks |
|---|---|---|---|---|---|
| | | Al | SST | | |
| 80 | core | - | 80 | 80 FE 20% | 2 instr. FE |
| 5 | storage pits | - | 5 | 5 FE 20% | |
| 5 | fresh fuel storage | - | 5 | 5 FE 20% | 1 instr. FE |
| - | spent fuel storage | - | - | | |
| 1/3 | hot storage facility | 1/3 | - | 1/3 part FE 20% | cut into 3 pieces |
| total: 90 | | 1/3 | 90 | | |

Total uranium weight: 17 287.19 g

U-235 weight: 3 436.33 g

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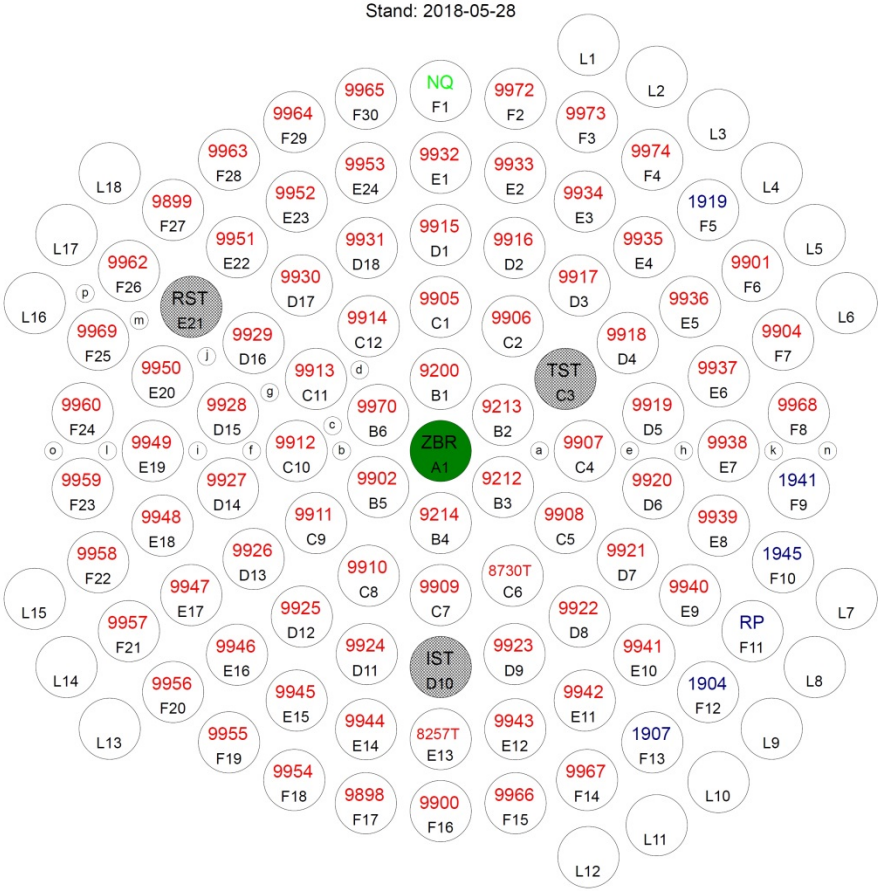
## Brennelementschema

Stand: 2018-05-28




Brennelement
Graphitelement
Neutronenquelle

## Lagertaschen

Stand: 2018-05-28

| | | LA | LB | LC | LF | LE | LD | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | RP | | 10197 | | | | 1 | |
| | 2 | | | 10198 | | | | 2 | F |
| K | 3 | | | 10255 | | | | 3 | |
| | 4 | | | 10256 | | | | 4 | E |
| A | 5 | | | | | | | 5 | |
| | 6 | | | | | | | 6 | N |
| N | 7 | | | | | | | 7 | |
| | 8 | | | 1881 | | | | 8 | S |
| Z | 9 | | | 1999 | | | | 9 | T |
| | 10 | | | 1926 | | | | 10 | |
| E | 11 | | | | | | | 11 | E |
| | 12 | | | | | | | 12 | R |
| L | 13 | | | | | | | 13 | |
| | 14 | | 9961 | | | | | 14 | |
| | 15 | | | | | | | 15 | |

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Neutronenquelle

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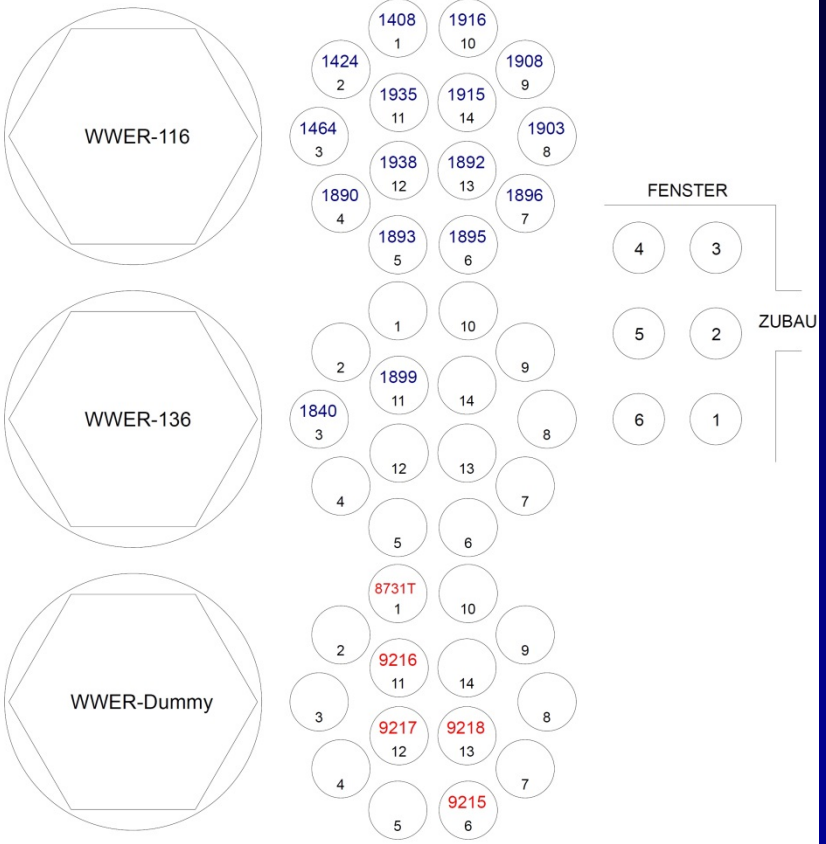
# Hallenlager

Stand: 2017-12-19

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# Staff

- Central facility "Reactor"
  - 1 reactor manager
  - 1 deputy reactor manager
  - 2 reactor operators (new operator since August 2018, the next on will come August 2019)
- Central facility "Nuclear Safety"
  - 1 nuclear security officer
  - 1 deputy security officer
- Central facility "Radiation Protection"
  - 1 radiation protection officer
  - 1 deputy radiation protection officer
  - 1 technician

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# Ongoing Activities

- Reactor was 2018 under "normal operation".
- The **new radiation protection** system works perfect.
- The new beam tube experiment "**White beam**" finished in march 2017 is utilized very well for neutron optics experiments and irradiation tests by the IAEA.
- Inspection of the government in June 2018, **IRRS** mission, by IAEA experts.
- 5 weeks practical courses for the TU Wien, 4 weeks for the IAEA safeguard trainings course, 3 weeks for the IAEA EERRI course and 1 week for the Belarus State University.
- 1 week scientific visitors from Bangladesh (Triga DHAKA).

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# TRIGA MARK II
## Atominstitut Vienna

1962

2019

# TRIGA Mark II Research Fields

Thermal white beam: general purpose neutron facility

Neutron interferometry, material science

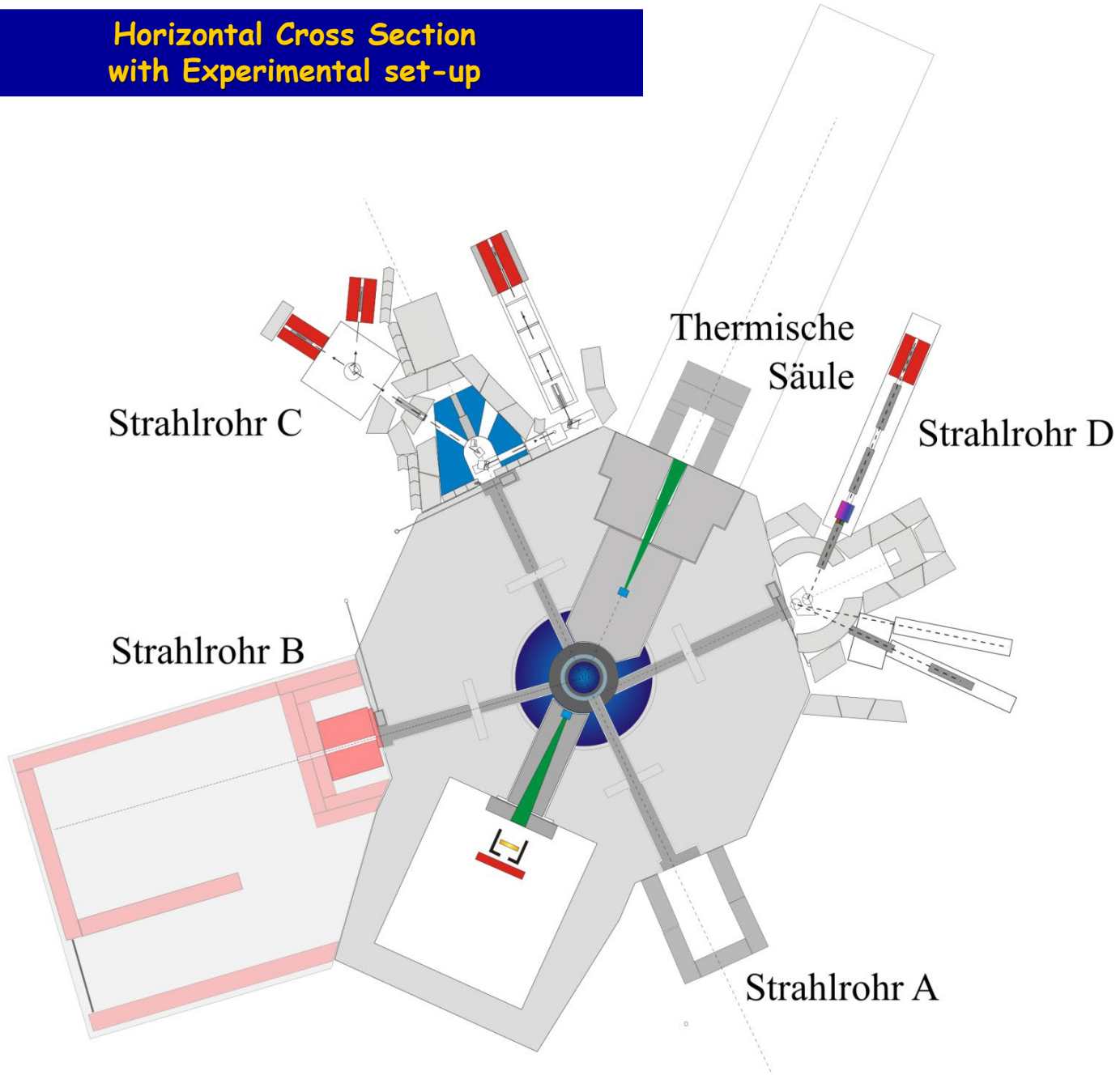
Reactor physics, neutron activation in tubes, CIT

Fully automized ultra fast NAA (planned)

Neutron spin manipulations, uncertainty relations

Neutron radiography

# Horizontal Cross Section with Experimental set-up



# Operational History for 2018

| | | | |
|---|---|---|---|
| January | 2018 | 12.5 | MWh |
| February | 2018 | 24.7 | MWh |
| March | 2018 | 26.7 | MWh |
| April | 2018 | 21.4 | MWh |
| May | 2018 | 20.8 | MWh |
| June | 2018 | 18.4 | MWh |
| July | 2018 | 27.4 | MWh |
| August | 2018 | 3.7 | MWh |
| September | 2018 | 25.3 | MWh |
| October | 2018 | 25.1 | MWh |
| November | 2018 | 17.5 | MWh |
| December | 2018 | 18.6 | MWh |
| | | | |
| Total | | 242.1 | MWh |
| Reactor in operation | | 187 | days |

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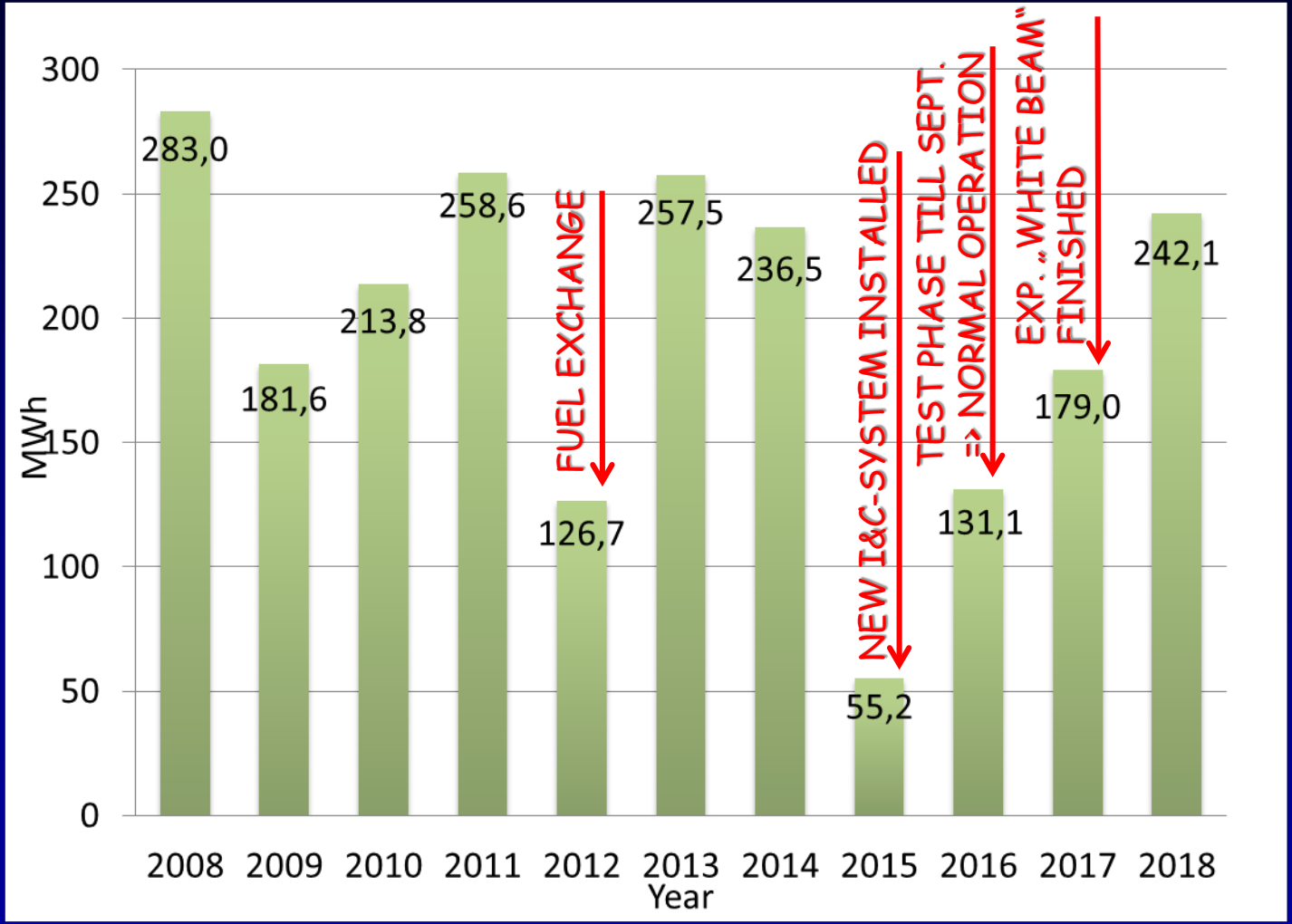
# Operation Performance 2008 to 2018

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# Performance Indicators for 2018 (1)

| Availability | | Unscheduled Shutdowns | |
|---|---|---|---|
| A1 | A2 | B1 | B2 |
| [%] | [%] | [1] | [1] |
| *98.94* | *51.23* | *2* | *0* |

$$A1 = \frac{\text{Number of days at power}}{\text{Number of days at power} + \text{Number of days unscheduled shutdown}} \times 100$$

$$A2 = \frac{\text{Number of days at power}}{365} \times 100$$

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

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

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# Performance Indicators for 2018 (2)

| Radiation Dose Exposure | | | | | |
|---|---|---|---|---|---|
| D1a | D1b | D1c | D2a | D2b | D2c |
| [mSv] | [Persons] | [mSv/Person] | [mSv] | [Persons] | [mSv/Person] |
| *4.28* | *5* | *0.86* | *18.19* | *20* | *0.91* |

**D1a: Collective radiation dose to reactor operation staff**

**D1b: Number of reactor operation staff**

**D1c: D1a / D1b**

**D2a: Collective radiation dose to all staff from reactor related work**

**D2b: Total number of staff involved**

**D2c: D2a / D2b**

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# Performance Indicators for 2018 (3)

| Radioactivity released | | | |
|---|---|---|---|
| E1 | E2 | E3 | E4 |
| [TBq] | [TBq] | [MBq] | [MBq] |
| *0.81* | *n.a.* | *5.88* | *< 0.037** |

*** below the limit of detection**

**E1: Rare gas released to atmosphere (Ar-41)**

**E2: Tritium released to atmosphere**

**E3: Tritiated water discharged**

**E4: Iodine released to atmosphere**

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# Performance Indicators Summary (1)

| Year | Availability | | Unscheduled Shutdowns | |
|---|---|---|---|---|
| | A1 | A2 | B1 | B2 |
| | [%] | [%] | [1] | [1] |
| 2013 | 92.21 | 58.36 | 18 | 0 |
| 2014 | 90.00 | 56.71 | 23 | 0 |
| 2015 | 89.83 | 14.52 | 6 | 0 |
| 2016 | 89.26 | 36.43 | 16 | 0 |
| 2017 | 93.06 | 44.11 | 12 | 0 |
| 2018 | 98.94 | 51.23 | 2 | 0 |

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# Performance Indicators Summary (2)

| Year | Radiation Dose Exposure | | | | | | Radioactivity released | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | D1a | D1b | D1c | D2a | D2b | D2c | E1 | E2 | E3 | E4 |
| | [mSv] | [Persons] | [mSv/Person] | [mSv] | [Persons] | [mSv/Person] | [TBq] | [TBq] | [MBq] | [MBq] |
| 2013 | 4.28 | 4 | 1.07 | 18.53 | 18 | 1.03 | 0.66 | n.a. | 24.00 | < 0.037 |
| 2014 | 4.22 | 4 | 1.06 | 21.51 | 22 | 0.98 | 0.46 | n.a. | 11.90 | < 0.037 |
| 2015 | 3.77 | 4 | 0.94 | 19.74 | 22 | 0.90 | 0.13 | n.a. | 4.16 | < 0.037 |
| 2016 | 3.89 | 4 | 0.97 | 19.39 | 21 | 0.92 | 0.42 | n.a. | 25.12 | < 0.037 |
| 2017 | 3.88 | 4 | 0.97 | 19.75 | 20 | 0.99 | 0.62 | n.a. | 4.26 | < 0.037 |
| 2018 | 4.28 | 5 | 0.86 | 18.19 | 20 | 0.91 | 0.81 | n.a. | 5.88 | < 0.037 |

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# Ageing management and decommissioning of research reactor (1)

- **Periodic safety assessment** performed in 2014.
- Description of the actual condition was based on the
  - Annually § 17 meeting with the regulatory body
  - Evaluation of the periodic maintenance schedule and in-service inspection.
  - Every relevant system and part of the research reactor was presented, any work performed on the system within the last 10 years was described and a conclusion to the current status of the system was drawn.
- Analysis of the operational experience is based on the evaluation of the last 53 years of records in the reactor log book:
  - All notes in the reactor log book were entered into a database and assigned to the categories defined in the IAEA safety standards.

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# Ageing management and decommissioning of research reactor (2)

- => **major refurbishment** starting in 2015, replacement of all reactor relevant parts.
- **Service contracts** with all companies involved in the refurbishment. Every year all major components are inspected and if necessary repaired or replaced. In addition the neutron channels of the I&C system are every 3 years calibrated by the company dataPartner.
- Maintenance in in-service inspection plan based on the operation experience of the last 57 years.
- Reactor operators collect every relevant values during operation two times per day. => **trend analysis**

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# Ageing management and decommissioning of research reactor (3)

- **ATIB 1017 Entsorgungskonzept des Atominstituts**, describes all relevant topics related to the decommissioning of the facility, the radiochemistry labs and all reactor relevant components. The expected waste in mass, volume and activity is described. This data is based on simulations and on the experience gathered during the decommissioning of the reactor in Seibersdorf.
- => the **related costs** based on the waste and the man power requirements add up to a total sum of 8 million €.

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