Neutron Detector Calibration for the KATANA Facility: Experimental and Computational Validation of Water Activation Neutron Emission

J. Peric[a,b], D. Kotnik[a], D. Govekar[a,b], L. Snoj[a,b], Z. Vykydal[c], M. De Pietri[d], V. Radulović[a,b]

[a]*Reactor Physics Department, Jožef Stefan Institute, Ljubljana, Slovenia*
[b]*Faculty of mathematics and physics, University of Ljubljana, Ljubljana, Slovenia*
[c]*Czech Metrology Institute, Prague, Czech Republic*
[d]*MIT, Plasma Science and Fusion Center, Cambridge, United States*

julijan.peric@ijs.si

CHALLENGE

- **$^{17}O(n,p)^{17}N$** reaction research
- Absolute measurement of neutron emission from water activation

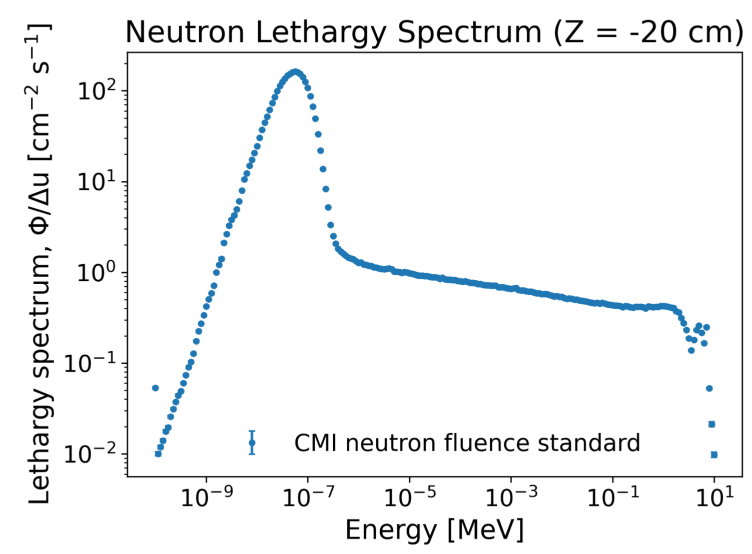
METHOD

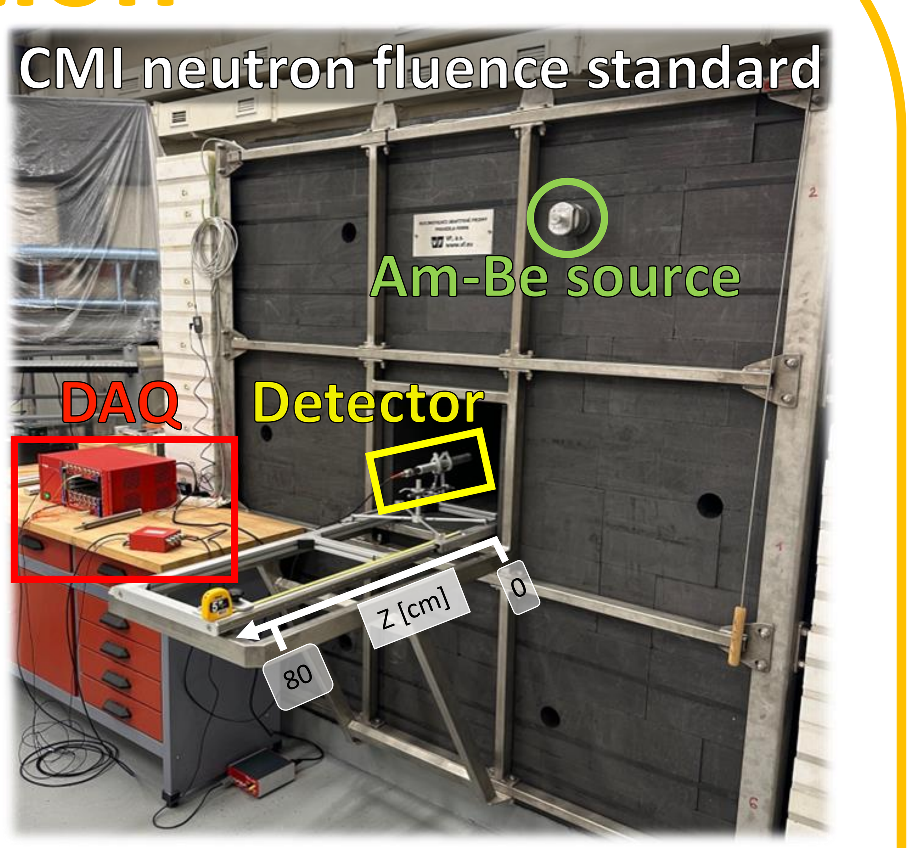
- Calibration at neutron reference field
- ^{17}N neutron emission rate modelling and measurement

CONCLUSION

- Precise calibration obtained
- ^{17}N activity measured with uncertainty below 3.1%

Detector calibration





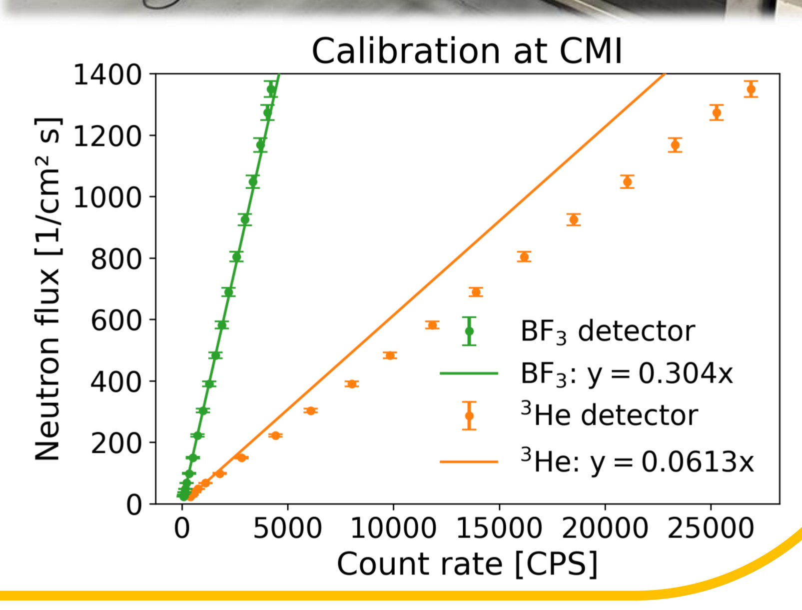
The Czech Metrology Institute (CMI) maintains the national reference for thermal neutron fluence rate using a **graphite pile facility**.

Assembly:

- *1.95 m × 1.95 m × 2.0 m;* graphite pile
- *0.40 m × 0.40 m x 1.3 m; measurement volume*
- Six lateral source channels (R = 80 cm)
  - *Pu–Be* and/or *Am–Be* sources

Detector calibration coefficients:

- **k_{BF3}= 0.3045 CPS/(1/cm²s) ± 2.5%**
- **$k_{He\text{-}3}$= 0.0613 CPS/(1/cm²s) ± 5.8%**



Experiments

^3He and BF_3 calibration

At the CMI thermal neutron fluence-rate field, neutron signals were recorded at multiple positions using ^3He and BF_3 detectors to determine the detector response at absolute fluence rate. These measurements were used to normalise the Snail No. 1 MCNP model.

KATANA neutron emission measurement

The experiment was conducted during the stable irradiation scenario of KATANA, with a flow rate of 0.66 l/s, using the JSI TRIGA reactor at 250 kW steady state. The neutron signal was measured inside Snail No. 1 with ^3He and BF_3 detectors.

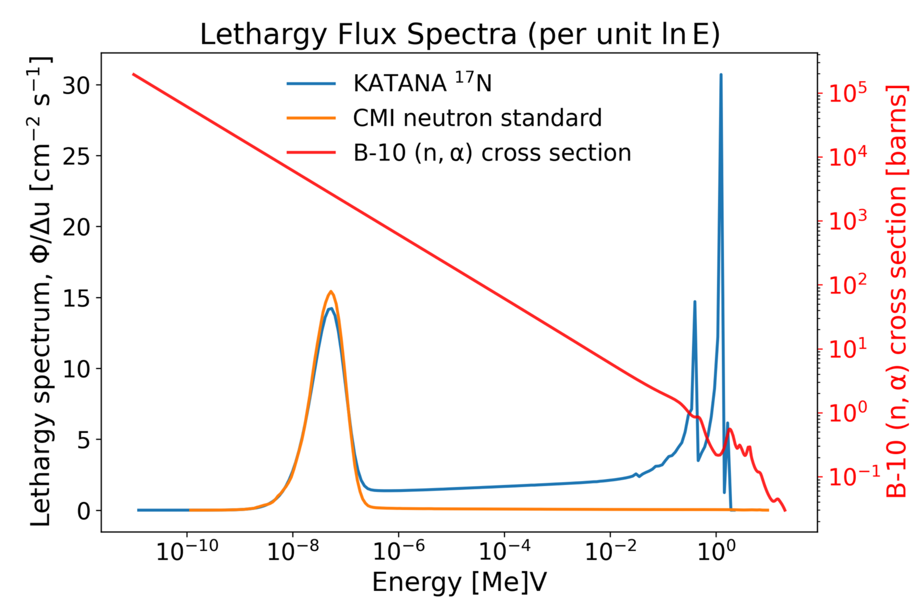
Experimental setup

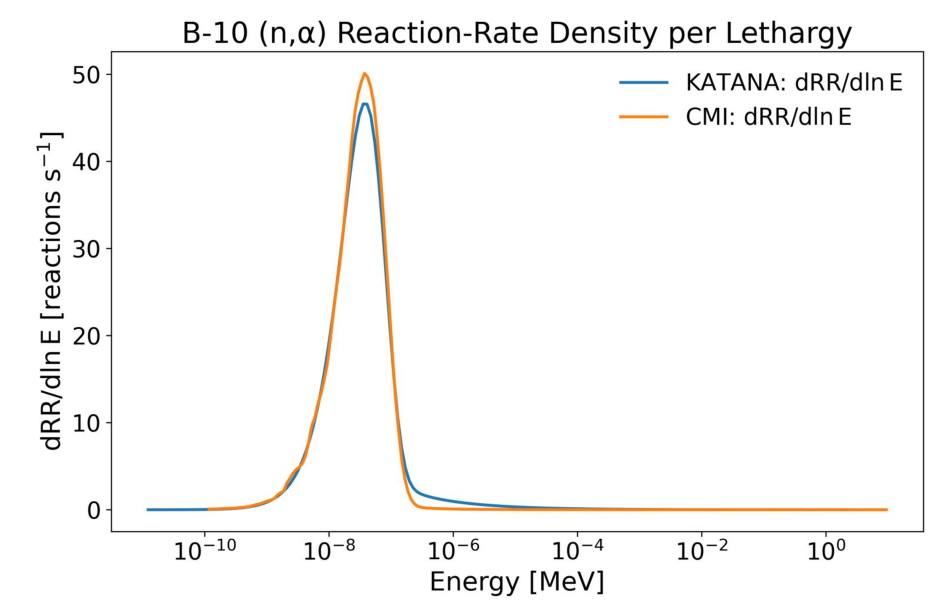
- Neutron detector LND 202 (BF_3) LND 25371 (^3He)
- Preamplifier CAEN A1422
- Digital MCA CAEN V1782
- *Data acquisition CAEN COMPASS*
- HV supply CAEN V6533

Results

The BF_3 and ^3He detectors are primarily sensitive to the thermal component of the neutron spectrum. To account for the difference in neutron energy distributions between the CMI reference and the KATANA field, the reaction rate (RR) was used as the calibration variable.

$$\int \phi_{CMI}(E)\sigma(E)NdE = \boldsymbol{RR_{CMI}} = \boldsymbol{RR_{KATANA}} = \int \phi_{KATANA}(E)\sigma(E)NdE$$

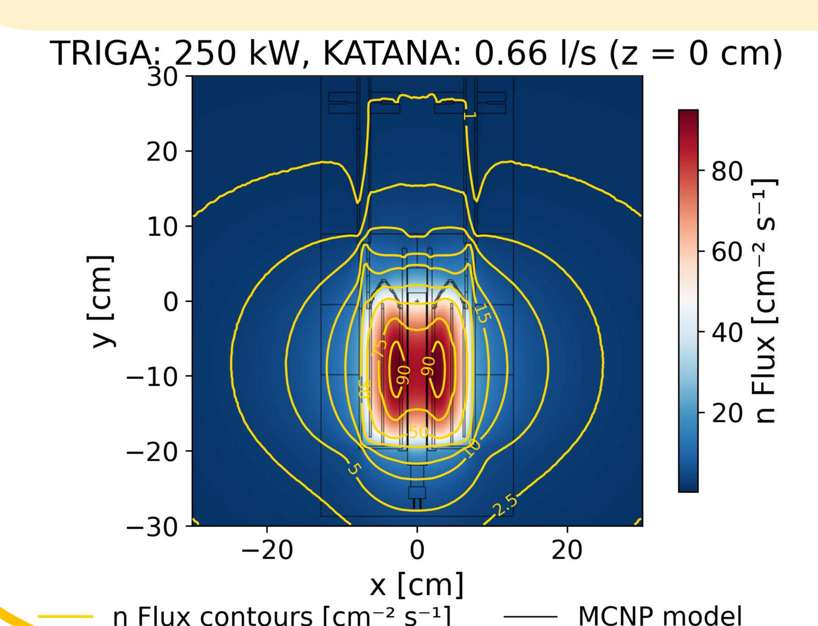


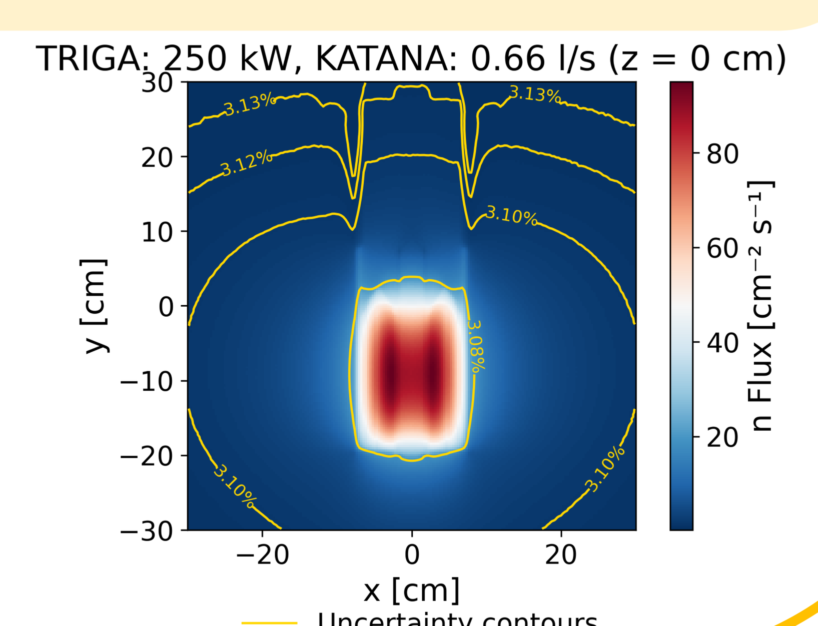


A uniformly distributed volumetric neutron source was implemented inside the irradiation Snail, with its strength derived from experimental measurements.

Snail No. 1 ^{17}N activity (*TRIGA: 250 kW, KATANA: 0.66 l/s*):

- **A_{BF3} = $\mathbf{1.7186 \cdot 10^4\ (1 \pm 3.08\ \%)}$ Bq**
- **$A_{He\text{-}3}$ = $\mathbf{1.6128 \cdot 10^4\ (1 \pm 6.07\ \%)}$ Bq**





Conclusions

- **A precise calibration of the BF_3 and ^3He detector response was achieved with the CMI thermal neutron reference field.**
- **The derived calibration coefficient ensures accurate translation of measured count rates into absolute neutron fluence rates within the KATANA facility.**
- **The ^{17}N activity measurement reached a relative uncertainty below 3.1%, demonstrating the reliability of both the experimental setup and the computational model.**
- **The KATANA water activation facility provides an ITER relevant stable source of neutrons, which are produced during the decay of ^{17}N.**

Acknowledgement

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 - EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Contact info: