Technology Offer:

Improved Safety: Real-Time Monitoring of Thermal Power of a Nuclear Reactor
Ref.-No.: 0102-5836-WT

The invention relates to a new and easy to use device for real-time monitoring of the thermal power of a nuclear reactor. It is based on the easy to access ^{16}N decay rate in the cooling water. The robust and easy to implement method significantly improves the safety of nuclear facilities.

Nuclear reactors require high standards of safety and detailed information about changes are needed in order to control them in a safe manner. Besides detailed real-time simulations, direct determination of the reactor power forms the basis to judge the reactor's dynamics.

Inside the reactor core ^{16}N is produced in the cooling water which is pumped with high flow velocities out of the biological shield of the reactor. Hence its decay rate is proportional to the reactor's thermal power and monitoring the decay rate using a Germanium-diode allows easy access to this information.

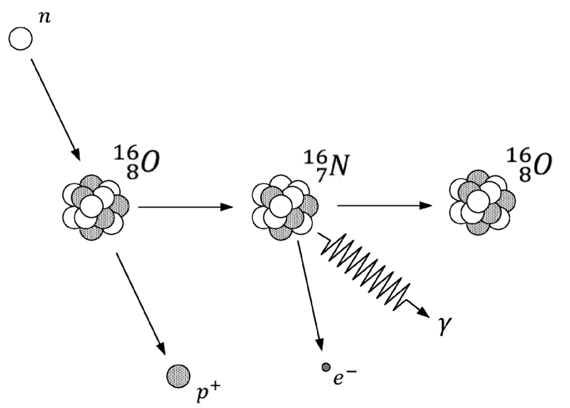

Fig. 1: ^{16}N nuclei in the cooling water can absorb the fission neutrons inside the reactor core releasing a proton. The formed ^{16}N nucleus decays and emits a gamma particle that can reach the detector

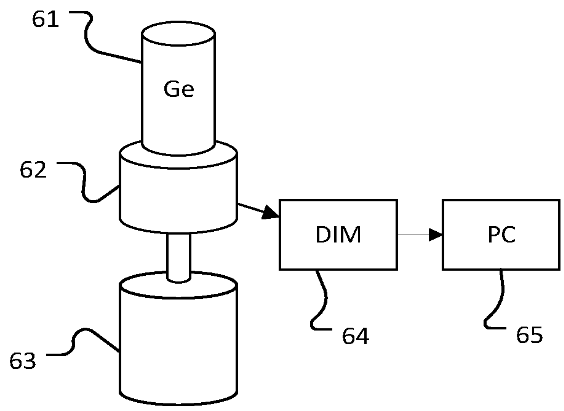

Fig. 2: The gamma detector comprises a large Germanium diode, an amplifier and a cooling

Advantages

- Real-time measurements
- Low noise, high accuracy
- Easy to calibrate
- Low maintenance requirements
- Compact and easy to move
- Cheap
- Robust and reliable

Applications

- Pressurized water reactors
- Light water reactors
- Research reactors

Max-Planck-Innovation GmbH
Amalienstr. 33
80799 München
www.max-planck-innovation.de

Background

Controlling and monitoring the thermal power of a nuclear reactor is crucial to maintain safe operation. Increasing power can occur due to the nature of the nuclear chain reaction, making real-time measurements of these variations key. Different concepts are being used for that purpose. Examples are the measurement of the enthalpy in the secondary cooling cycle and the conversion of neutron flux into measurable alpha radiation within inserts in the core. However, the requirements of a reliable and simple setup measuring the thermal power that can be operated outside of the biological shield and therefore be maintained even during reactor ON phases are unreached by state-of-the-art methods.

Technology

A new monitoring device (cf. Fig. 2) has been designed to overcome the aforementioned shortcomings. It is based on the detection of gamma rays from the cooling cycles that are emitted from decaying ^{16}N nuclei.

Providing the desired gamma-ray sensitivity of the detector, the invention comprises a large germanium diode (61) sized in the range of approximately two kilograms of weight. Following as a second component a preamplifier (62) is provided to amplify the detection signal of the photon counting diode. The entire detector assembly is kept at low operating temperature by an electrical cryo-cooling (63) in order to ensure high performance. From the preamplifier the output signal is fed into the detector interface module (64) and further into the data processor (65).

As shown in figure 3, the system can be used within the security perimeter of a nuclear power plant but outside the biological shield of the nuclear power plant making it easy to access even during reactor operation. Besides that, the simple, compact and lightweight setup makes it highly flexible and robust.

For the validation of the concept and method, a detector according to the invention was tested at nuclear power plant Brokdorf during operation. Accuracy above 99% was demonstrated during this test.

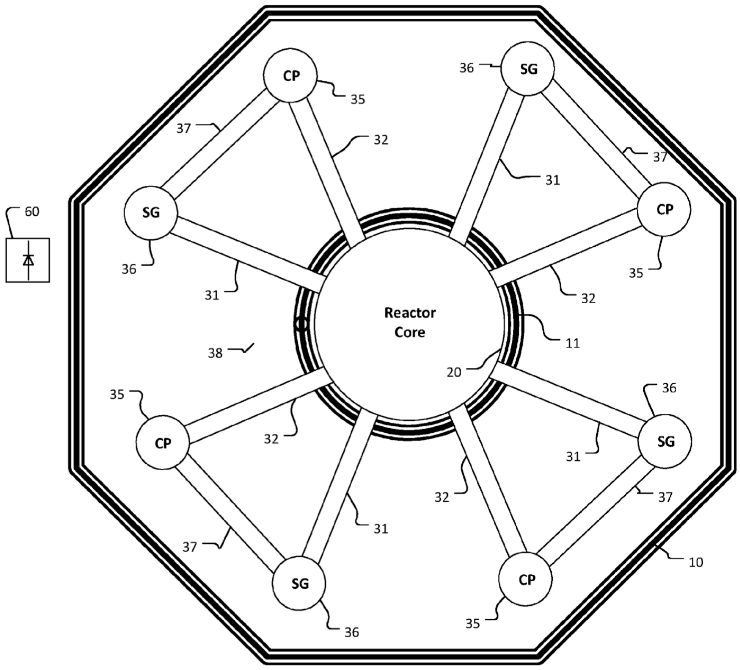

Fig. 3: The detector assembly can (60) can be operated outside of the biological shield (10). Gamma rays from the main cooling cycles including pumps and steam generators (31-37) are being detected even at larger distances.

Patent Information

PCT *(WO2021140220A1)*, EPO *(EP3848943A1)*

Publications

Tobias Schierhuber *“Ultra-Low Background Germanium Spectroscopy”*, Master thesis (2017).
J. Hakenmüller *et al.* “*Neutron-induced background in the CONUS experiment*”, Eur. Phys. J. (2019)

Contact

Dr. habil. Wolfgang Tröger
Senior Patent- & License Manager
Physicist
Phone: +49 (0)89 / 29 09 19 - 27
eMail: troeger@max-planck-innovation.de

Max-Planck-Innovation GmbH
Amalienstr. 33
80799 München
www.max-planck-innovation.de