

The Cf-252 method - a new detector

Imre Pázsit

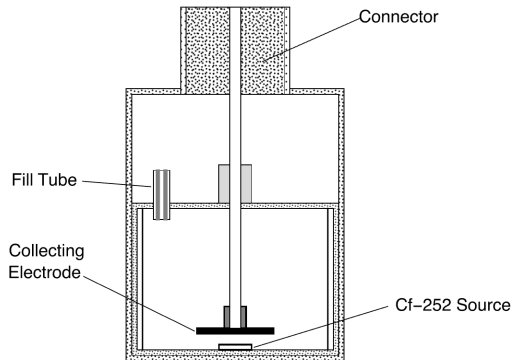
Chalmers University of Technology
Division of Subatomic, High Energy and Plasma Physics
Nuclear Engineering Group



IMORN-33, Grenoble, France
7 July 2026

The original Cf-252 source/detector

It is a plate type ionisation chamber, with the Cf-252 electrochemically coated on one of the electrodes.



The ionisation chamber based Cf-252 source/detector



Fig. 1. Front view (a) and side view (b) of the Cf source-detector.

Ionisation chamber Cf-252 detector

- In 2003, in Chalmers we received two such Cf-252 detectors from the JNC Oarai Centre (Japan Nuclear Cycle Development Institute) free of charge.
Kind mediation by Prof. Yoshihiro Yamane
- The photo on the previous page was taken from one of these detectors
- We tested the use of the detector for measuring subcritical reactivity in collaboration with SCK CEN in 2010 at the VENUS facility.

A measurement at SKC CEN

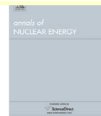


ELSEVIER

Contents lists available at ScienceDirect

Annals of Nuclear Energy

journal homepage: www.elsevier.com/locate/anucene



Determination of the subcriticality level using the ^{252}Cf source-detector method

P. Baeten^a, A. Lafuente^{b,*}, J. Janssens^a, A. Kochetkov^a, I. Pázsit^c, G. Van Grieken^a, G. Van den Eynde^a

^a SKC-CEN, Boeretang 200, B-2400 Mol, Belgium

^b Universidad Politécnica de Madrid, 28006 Madrid, Spain

^c Chalmers University of Technology, SE-412 96 Goteborg, Sweden

ARTICLE INFO

Article history:

Received 7 September 2009

Received in revised form 18 January 2010

Accepted 20 January 2010

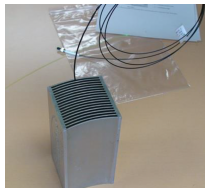
Available online 3 March 2010

ABSTRACT

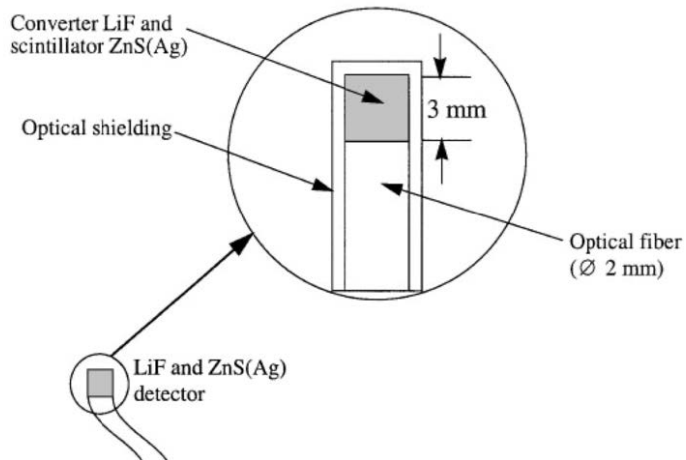
Measurement and monitoring of reactivity in a subcritical state, e.g. during the loading of a power reactor, has a clear safety relevance. The methods currently available for the measurement of k_{eff} in stationary subcritical conditions should be improved as they refer to the critical state. This is also very important in the framework of ADS (accelerator driven systems) where the measurement of a subcritical level without knowledge of the critical state is looked for. An alternative way to achieve this is by mean of the ^{252}Cf source-detector method. The method makes use of three detectors inserted in the reactor: two “ordinary” neutron detectors and one ^{252}Cf source-detector which contains a small amount of ^{252}Cf that introduces neutrons in the system through spontaneous fission. By observing fissions through the detection system and correlating the signals of the three detectors, the reactivity ρ (and hence the multiplication factor k) can be determined.

The idea for the new detector

- Through our Japanese contacts, we got access to the know-how of manufacturing LiF-ZnS(Ag) scintillation neutron detectors (fiber based).
- These were originally developed for measuring radiation dose with high spatial resolution (Chizuo Mori, Nagoya University)
- They were developed further and used at KURRI (Kyoto University Research Reactor Institute, now KURNS) in Kumatori.
- We even received a few copies for own use from KURRI/KURNS



The LiF-ZnS(Ag) neutron detector



Aerial view of KURNS, Kumatori







Chalmers students on lab exercise in KURRI

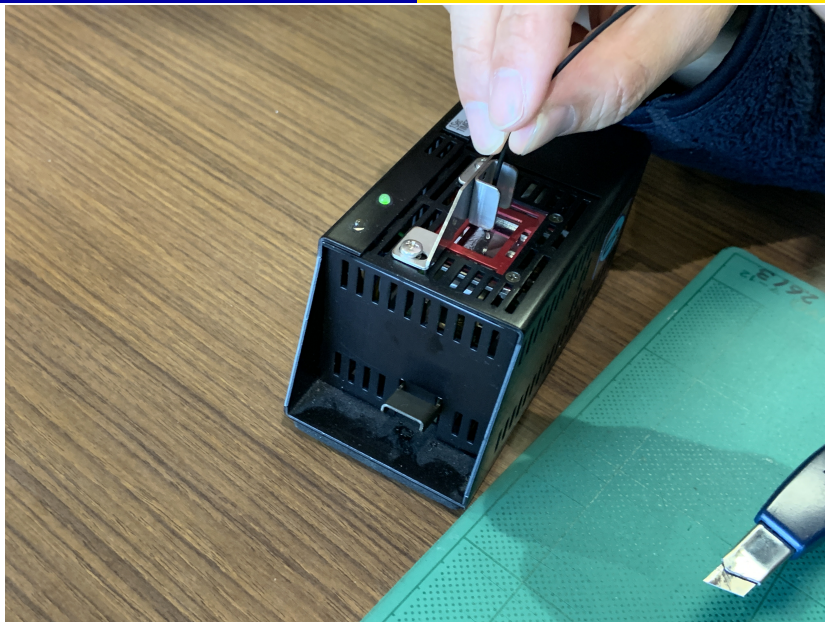


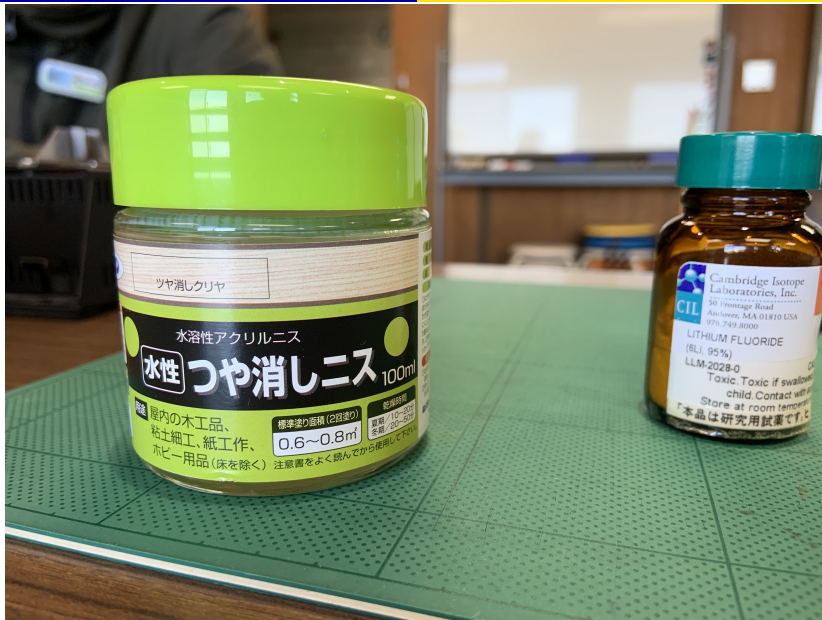
Chalmers students on lab exercise in KURRI

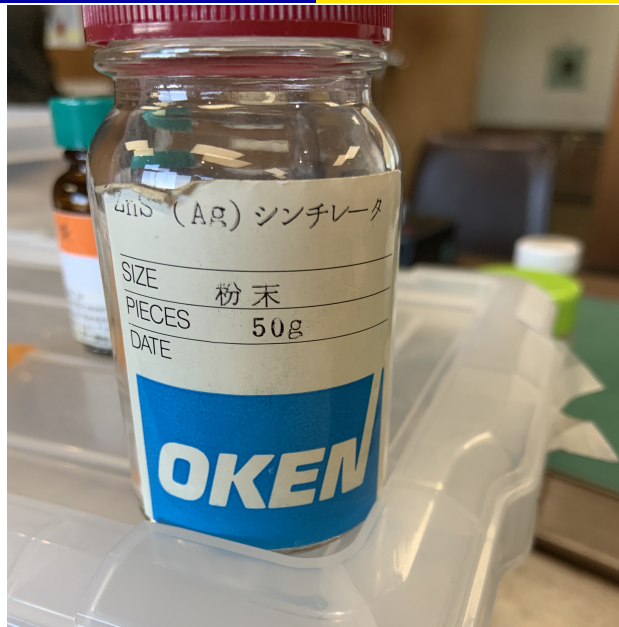


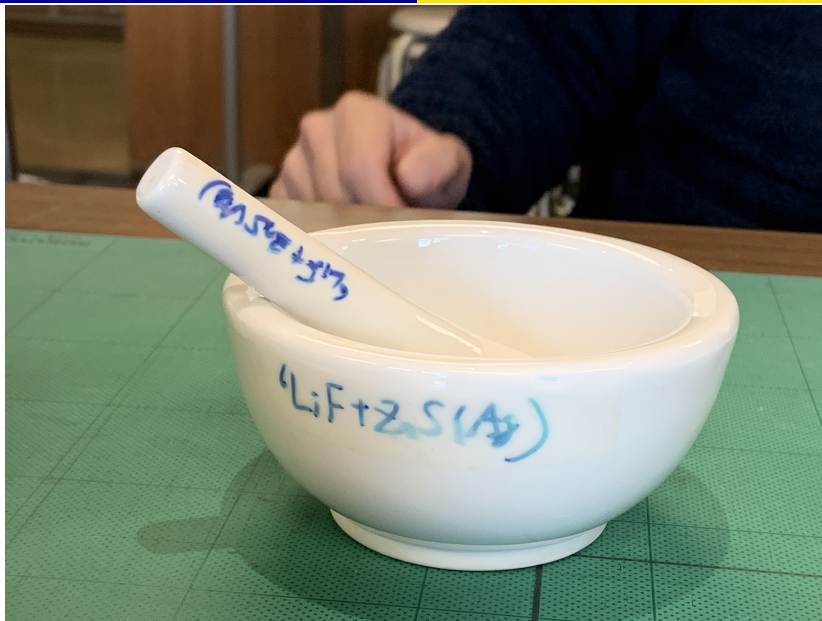
Making of the detector









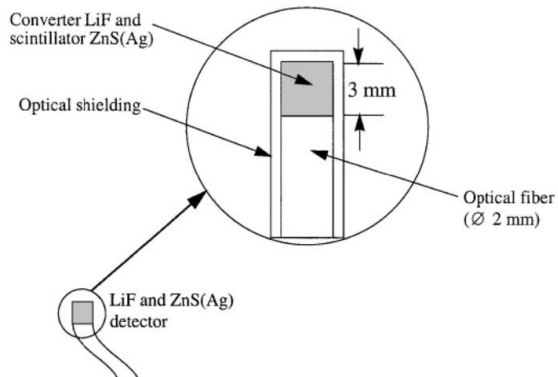






The new concept

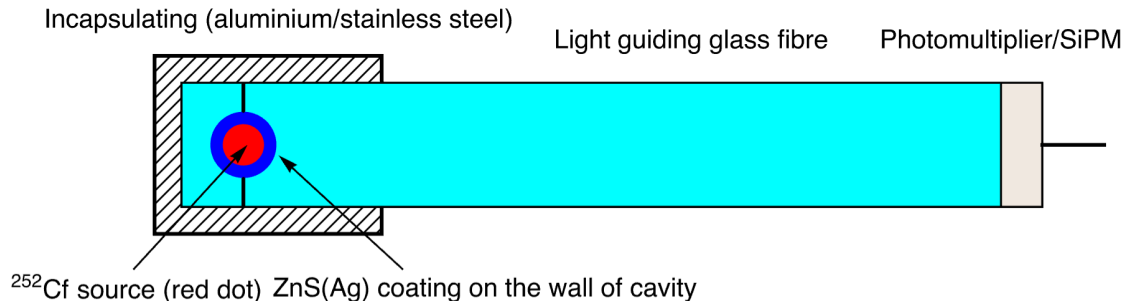
First idea: replace the LiF with Cf-252



The new concept

- Cf-252 can be purchased from Frontier Technologies in form of a miniature grain
- Pulverising and mixing 1 μg of Cf-252 is not practical
- The final concept is to put the Cf-252 into a (spherical cavity) whose walls are coated with a thin layer of ZnS(Ag) scintillation material
- The range of fission products in ZnS(Ag) is few micrometers, hence a thin layer of coating is sufficient, which is good for the escape of light from the coating
- No vacuum is needed between the Cf-252 and the coating, because a thin layer of air will not stop the fission fragments
- No Pulse Shape Discrimination is needed, because the alpha particles induce one to two order of magnitude smaller signals. Hence the detector can be used in high flux in continuous mode (reactor startup)

The final concept (patent pending)



Potential manufacturers

- Georgia Tech
- KURNS (Kyoto University Integrated Institute for Radiation and Nuclear Science)
- If the concept holds, commercial manufacturers may also be interested.

Possible research lines

- Simulation of the detector with Geant4 for the whole chain (including generation of scintillation light, quenching etc.
- Optimising the detector for various applications and flux levels
- Investigating the feasibility of measuring subcritical reactivity and performing Cf-252 driven differential die away analysis
- ...and many more