Reactor Physics Experiments in PURNIMA Sub Critical Facility Coupled with 14 MeV Neutron Source

Rajeev Kumar[1], S.B.Degweker[2]*
[1]Reactor Physics Design Division, [2]Theoretical Physics Division.
Bhabha Atomic Research Centre, Mumbai - 400085, INDIA
* *email: degweker@barc.gov.in*

Abstract. As part of the ADSS Reactor Physics research programme a sub-critical facility is coming up in BARC which will be coupled with an existing 14 MeV neutron generator. The sub-critical assembly consists of natural uranium metal rods moderated by light water. Another core also which consisting of natural uranium metal moderated by high density polyethylene (HDP) and reflected by BeO has been proposed. Experiments are proposed to be carried out in this facility for validating computational tools and for establishing methods for measurement of sub-critical reactivity of sub critical reactor systems including noise based methods. Noise characteristics of ADSS are expected to be different from that of traditional reactors due to the non-Poisson statistical features of the source. Hence it is important to experimentally study the statistical properties of the neutron source for noise experiments. The statistical properties of 14 MeV neutrons was studied experimentally and are reported in this work.

Keywords: Sub-criticality measurement, Noise methods, Non Poisson source

PACS 89.30.Gg;28.41.-I; 28.50 –K

INTRODUCTION

Accelerator Driven sub critical Systems (ADSS) are attracting increasing worldwide attention due to their superior safety characteristics and their potential for burning actinide and fission product waste and energy production. A number of countries around the world have drawn up roadmaps / programs for development of ADSS. Indian interest in ADSS has an additional dimension, which is related to the planned utilization of our large thorium reserves for future nuclear energy generation.

A programme for development of ADSS is taken up at the Bhabha Atomic Research Center (BARC) in India. This includes R&D activities for high current proton accelerator development, target development and reactor physics studies. As part of the ADSS reactor physics research programme, a sub-critical facility is coming up in BARC which will be coupled with an existing D-D/ D-T neutron generator. The neutron generator has been upgraded to give the yield of 10^{10} neutron per sec with tritium target. The sub-critical reactor assembly consists of natural uranium metal rods moderated by light water. Another core consisting of natural uranium metal moderated by high density polyethylene (HDP) and reflected by BeO is proposed. Various reactor physics experiments will be carried out in this facility.

Measured data will help in validating the computational tool of sub critical reactor physics and for establishing techniques for sub-criticality measurement and monitoring. The various methods proposed for the purpose of sub-criticality measurement include pulsed neutron, source jerk and noise methods.

Noise characteristics of ADSS are expected to be different from that of traditional reactors due to the non-Poisson statistical features of the source. A new theory incorporating these features has been developed at BARC[1]. Hence it is important to experimentally study the statistical properties of the neutron source for noise experiments. Experiments have been initiated in Kyoto, Japan to investigate this behavior[2].The statistical properties of 14 MeV neutrons were studied experimentally and it was found that the source is different from a purely Poisson source.

SUB CRITICAL FACILITY

The neutron producing target of the accelerator (Fig 1a) will be surrounded by a sub-critical assembly consisting of a hexagonal lattice of Natural Uranium rods moderated by light water as shown in Fig. 1b. Another assembly consisting of a square lattice of natural uranium rods with high density polyethylene (HDP) as moderator has also been proposed. The neutron yield of the accelerator is 10^{10} Neutrons/sec with DT Reaction. Provision of DD reaction is also there. Expected K_{eff} of the subcritical core is in the range 0.87-0.90.

FIGURE 1a. Neutron Generator

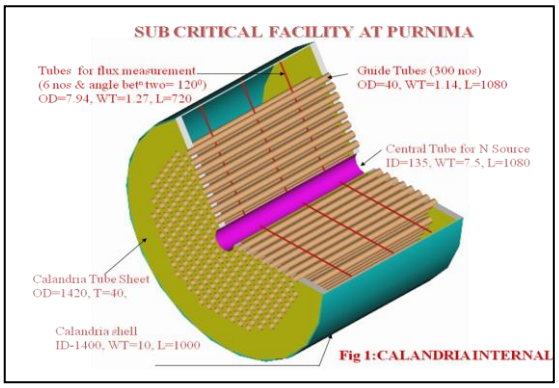

FIGURE 1b. Sub Critical Core

PROPOSED EXPERIMENTS

Various reactor physics experiments like measurement of the source strength, neutron flux distribution, buckling estimation and sub-critical source multiplication are planned. Apart from this, measurement of the total fission power and neutron spectrum will also be carried out. Mainly activation detectors will be used in all in-

core neutron flux measurement. Kinetic experiments for measurement of degree of sub criticality using pulsed neutron as well as neutron noise experiments are also planned. Helium detectors with time stamping data acquisition card will be used for the neutron noise experiments.

CHARACTERISATION OF 14 MeV NEUTRON SOURCE

Noise characteristics of ADSS are expected to be different from that of traditional reactors due to the non-Poisson statistical features of the source. A new theory incorporating these features has been developed at BARC[1]. Hence it is important to experimentally study the statistical properties of the neutron source for noise experiments. To characterize the statistical properties of the 14 MeV neutron source, neutron counts were collected from DT reaction using a time stamping data acquisition card. Data were analyzed to obtain the variance to mean (v/m) ratio and auto correlation function. The study indicates that the source is different from a purely Poisson source.

Experimental Setup

Helium detector surrounded by HDP layer for neutron moderation was kept at 1m distance from Tritium target. Neutron counts was collected using standard nuclear instrumentation employing a time stamping card which stores the time history of neutron counts. The stored data was processed and analysed off line.

Data Analysis

Data was collected using two different neutron sources viz. a Pu-Be source (which is known to be a Poisson source) and the accelerator based neutron generator (DT). Collected data was processed by Fortran programmes to obtain the V/M to look for non-Poisson features if any.

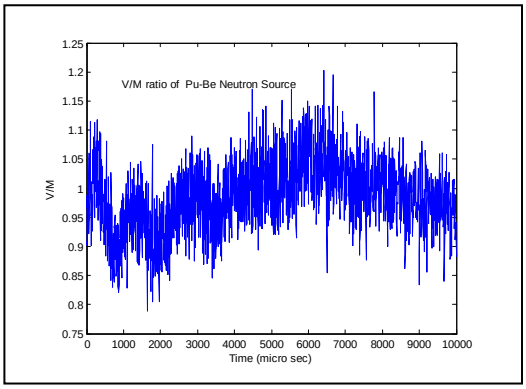

FIGURE 2a. v/m curve for Pu-Be neutron source

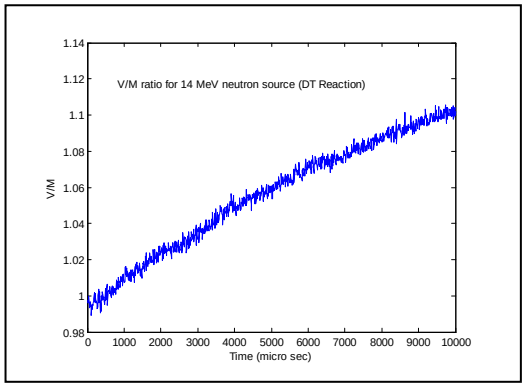

FIGURE 2b. v/m curve for 14 MeV Neutron

The results for the two types of sources are shown in Figs. 2a and 2b. It is seen that the variance to mean ratio for Pu-Be source fluctuates around 1.0. On the other hand for the accelerator based neutron generator, the ratio starts at 1.0 for short intervals and goes on increasing as the interval length is increased. This suggests that the latter source is non-Poisson in nature.

CONCLUSION

It can be seen (Fig. 2a & 2b) that v/m ratio of DT reaction keeps on increasing with time as compare to the same in Pu-Be case in which V/M is fluctuating around 1(poison source). These facts shows that 14 MeV neutrons source (DT reaction) is different than the poison source. To confirm the results, experiment with DD reaction and PSD analysis of the data is in progress.

Acknowledgement

The authors would like to express gratitude to Dr. Amar Sinha Head N&XPF and Shri Tarun Patel, N&XRF for their generous help and advice through the course of this experiment. We are also thankful to Dr. P.D.Krishnani, Head RPDD and Shri B.Krishna Mohan Head ERPS, RPDD for their kind support and encouragement.

REFERENCES

1.Degweker, S.B., 2002. Annals of Nuclear Energy 30, 223–243.
2.Hiroshi taninaka etal., Journal of NUCLEAR SCIENCE and TECHNOLOGY, Vol. 48, No. 9, p. 1272– 1280 (2011).
3. R.P. Anand and Pritty Choudhary, Theme Meeting on Neutron Sources and its applications, NEHU, Shillong, 2004.