NEUTRON BEAM FACILITIES AT RTP

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Introduction

TRIGA PUSPATI (RTP) is a 1MW research reactor located in Malaysian Nuclear Agency, Bangi, Selangor, Malaysia. RTP was commissioned in June 1982. In 1985, Neutron Radiography (NR) facility was commissioned at beamport#3 of RTP. This facility was refurbished in 2017 with new collimator and shielding bunker. Small Angle Neutron Scattering (SANS) facility was installed in 1995 and experienced upgrading through in-house design systems throughout the years. New facilities such as Neutron Diffraction (ND), Boron Neutron Capture (BNC) research and Prompt Gamma Neutron Activation Analysis (PGNAA) facility are now under development at RTP. This paper discusses the characteristics of these neutron beam facilities which were used in their designs.

Collimator And Shielding Design

To increase the research and development (R&D) works using neutron beam from RTP, the beam ports and thermal column of RTP needs to fitted with suitable collimator and shielding design. These would ensure that the neutron beam could be used for specific research works. Each of the neutron beam facilities in RTP was developed using the neutron spectra available. With four beamports and one thermal column, the quality of these neutron beams was design with followings:

(i) Collimator with gamma and fast neutron filters used

(ii) Neutron energy exiting the beamport

(iii) Shielding design for the neutron beam instrument

The design of item (i) to (iii) as shown in Figure 2 were selected to give each of the beamport the quality needed for its targeted purpose such as:

- NR,
- SANS, ND,
- BNC research and
- PGNAA

The designs were developed and fabricated as a result of IAEA TC MAL 1012 (Capacity Building in Basic Neutron Science and Engineering for Education, Training and Research Using TRIGA Mark II Research Reactor), research collaboration with regional research institutions and local universities using the platform Reactor Interest Group (RIG), a loosely form parties interested in reactor utilization initiated by Nuklear Malaysia in 2001.

How Neutron Scattering Works

In neutron scattering, **Bragg's Law** has been widely used to calculate the neutron scattering angle off a lattice, Figure 1 shows a typical neutron beam (double arrows) that hits a material surface at an incident angle θ and scattered off at from this surface. These scattered neutrons could be collected and analysed by a detector such

as position sensitive detector (PSD).

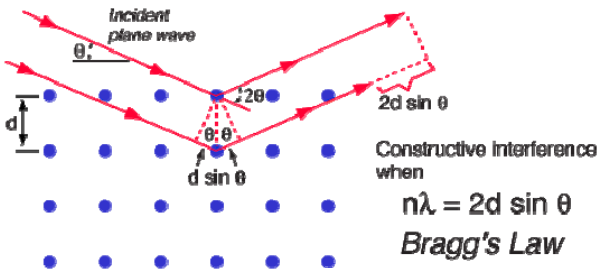

Figure 1. Bragg's Law that calculates the neutron scattering angle off a lattice. (Source: http://hyperphysics.phy-astr.gsu.edu/hbase/quantum/bragg.html)

As neutron has a particle duality, i.e. it can also have a wavelike property, neutron propagating the target the material could be described by a wavelength λ. The neutrons can thus experience interference, whereby neutrons with the same wavelength could form maximum intensity. In Figure 1, wavelength of the neutron could be written in terms lattice spacing d, as:

$$n\,\lambda = d\,\sin\theta \qquad (1)$$

where n is an integer. Thus, the neutron scattering using Bragg equation as above has been widely used to design neutron scattering facilities for specific analysis such as small angle neutron scattering, neutron diffraction, neutron intereferormeter etc.

Figure 2 shows the layout of the neutron beam facilities at RTP. Neutron radiography facility at beamport # 3 is used for neutron tomography imaging, while small angle neutron scattering at beamport #4 is used for nanomaterial characterization. At beamport #1, collimator and shielding has been installed for neutron diffraction. At the thermal column, mobile shieldings and stopper are used for experiments in boron neutron capture research, at beamport #2, prompt gamma neutron activation facility is being planned.

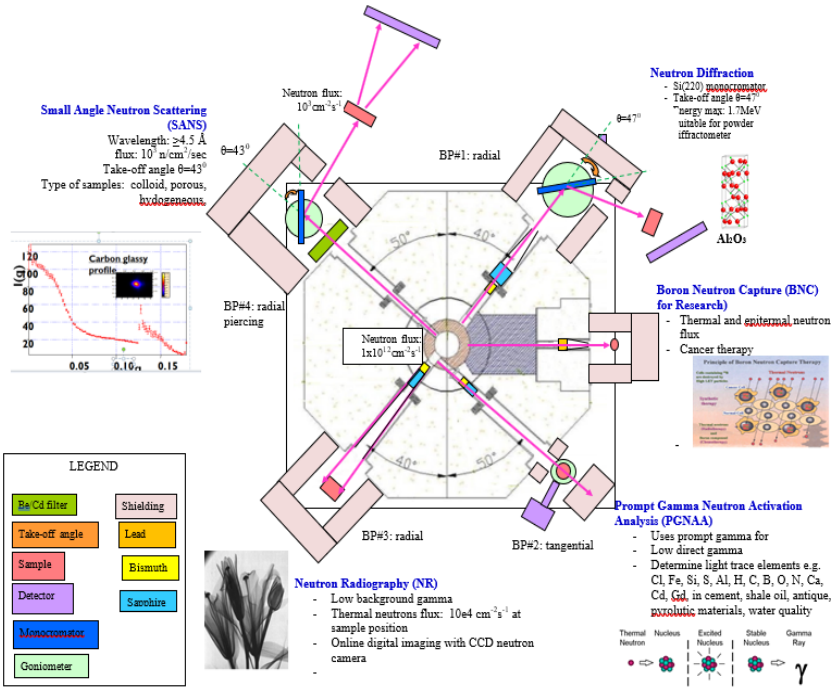

Figure 2. Neutron beam facilities layout at RTP.