

# Neutron Radiography: Research, Application and Recent Developments in Bangladesh



Sudipta Saha<sup>1</sup>, M. N. Islam<sup>2</sup>, B. Schillinger<sup>3</sup>

1) Institute of Nuclear Science and Technology, Bangladesh Atomic Energy Commission

2) Training Institute, Bangladesh Atomic Energy Commission

3) Heinz Maier-Leibnitz Zentrum (FRM II), Technische Universitaet Muenchen, Germany



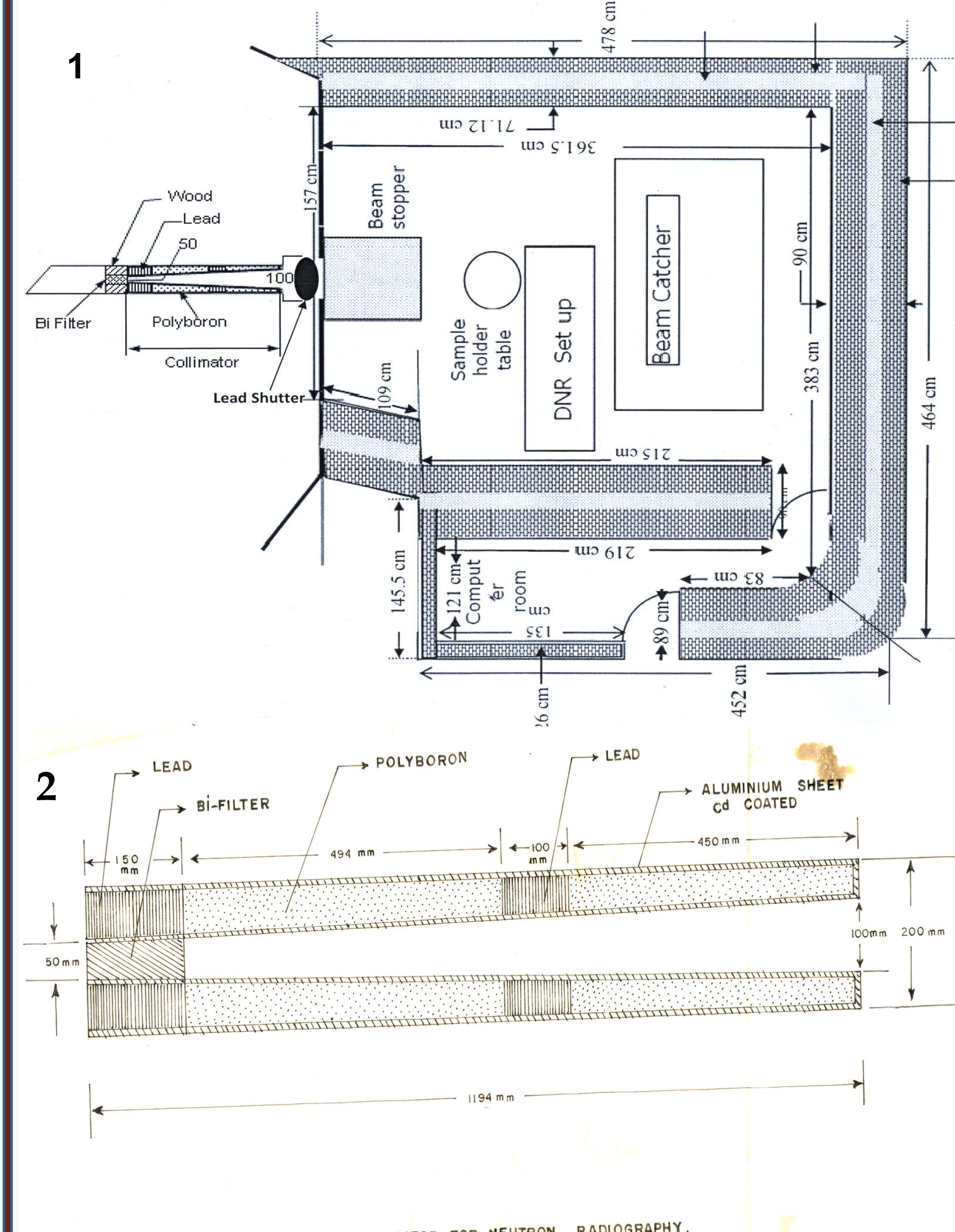
## INTRODUCTION

Neutron Radiography is a very promising facility installed at the tangential beam port of the 3MW BAEC TRIGA Research Reactor in Savar, Dhaka, that was commissioned in 1987. In recent days, plans have been made to install a CCD based system to replace the direct film radiography technique. Sensitive CCD detectors for neutron imaging allow to sacrifice intensity for better collimation, so a new collimator was designed that improves the suppression of unwanted fast neutron and gamma radiation, and increases the L/D ratio.

## EXISTING FACILITY

The existing facility constructed for neutron radiography inside reactor hall is shown as schematic diagram in Fig-1. The facility room provides a 361.5 cm long and 293 cm wide space to accommodate beam stopper, sample holder table, beam catcher, Digital Neutron Radiography setup, a few lead blocks as well as required free space for passage. It also consists of a little extension of 121 cm wide space to place a computer for data acquisition from the digital device. The facility wall is constructed in a sandwich pattern of polyboric wax (2:1:3 formation) in the middle and heavy concrete brick walls on both sides, which ensures safety to radiation workers from both neutron and gamma rays even while the beam port is open.

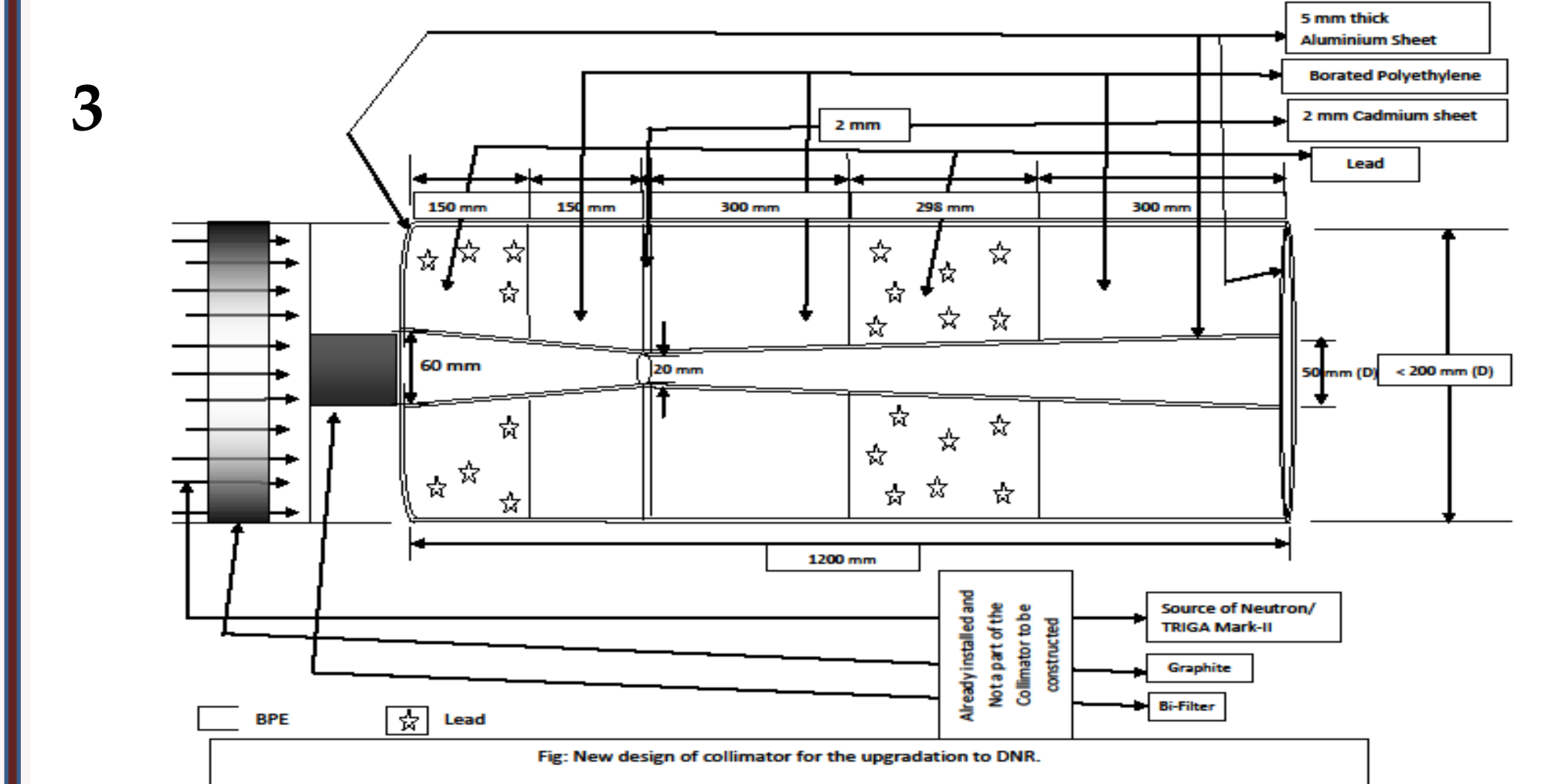
In order to have a collimated neutron beam a conical shaped 120 cm long aluminum cylindrical divergent collimator was installed at the tangential beam port. It has an inner diameter of 5 cm and outer diameter 10 cm, which means the L/D ratio is only 60. The conical cylinder is inserted inside another hollow aluminum cylinder of 20 cm uniform diameter of the same length and is fixed together with flanges on both ends. A mixture of paraffin wax and boric acid in the ratio of 3:1 by weight is used to fill the empty space for neutron shielding between the two cylinders. For gamma shielding three lead rings are used. They have a diameter of 15 cm in front, 10 cm in middle and 1.5 cm shielded end of the reactor. The total weight of 75 kg lead and 25 kg of polyboron shielding materials are used.



During installation of the CCD based Digital Neutron Radiography system, two major problems have been identified, which must be solved urgently to get a standard digital image. The first one is the high gamma dose inside facility room, and the second is the low collimation or L/D ratio.

## PROPOSED COLLIMATOR

Designing a new collimator with small inlet aperture and application of appropriate shielding materials inside can solve these two issues. So, a new collimator is designed to suppress unwanted fast neutrons and gamma rays, which also increases the L/D ratio to 115. Two conical shaped aluminum cylinders are placed adjacently, which makes the collimator first converging and then diverging. The first inner diameter just after the Bi-filter is 6 cm, and the diameter of main inlet aperture is only 2cm, while the outer diameter is 5 cm. This structure will create an L/D ratio of at least 115. The main inlet aperture is shaped using 2mm thick cadmium sheet, which is a good thermal neutron absorbing material and can provide a sharp edge on the imaging plane. Since cadmium produces high energy 1.2 MeV gammas and absorbs only thermal neutrons with energies below the cadmium cutoff at 4eV, the main collimator body with the converging and diverging cones consists of several pieces of borated polyethelene (750 cm total) and lead (450cm total) to downscatter and absorb fast neutrons in the B-PE and to absorb gammas from the reactor core as well as gammas generated in the borated PE during absorption of neutrons in the lead parts.

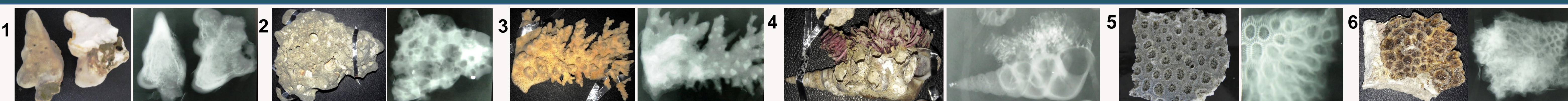
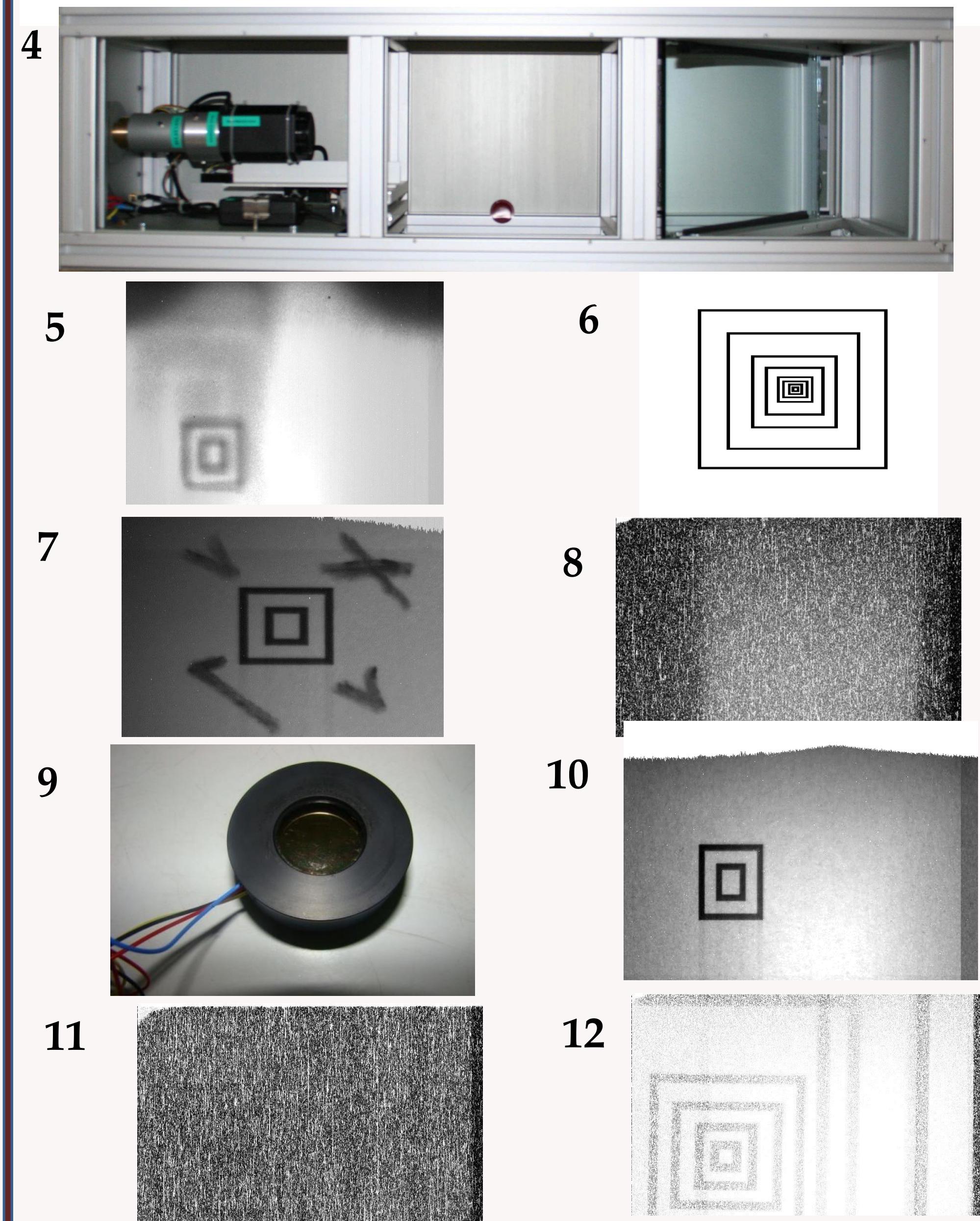


## THE DETECTOR SYSTEM

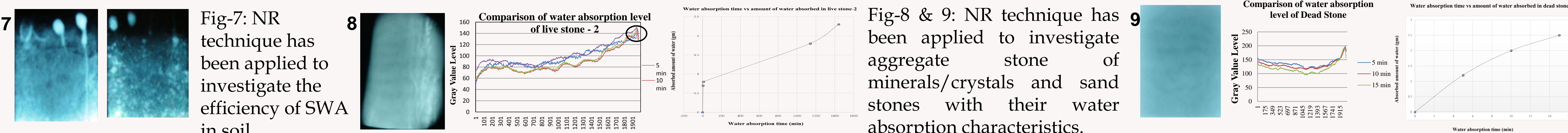
Our new detector system, consisting of a neutron scintillation screen, mirror and a CCD camera coupled with an image intensifier was built by an external company (see pictures on the right).

During first tests, it became obvious that the system had been designed for maximum light sensitivity, but not neutron sensitivity: Since one detected neutron generates some 177,000 photons in the scintillation screen, a lot of light was amplified in the image intensifier which saturated the camera quickly without detecting many neutrons. In tests with visible light, the intensifier and camera were saturated in milliseconds. The medium intensity neutron flux at our facility requires exposure times in the order of minutes, so removing the image intensifier and using the camera directly to view the screen will improve the detection efficiency for neutrons.

Another big problem is the very high gamma background in the experimental chamber. Gamma rays hitting the camera directly will produce charge clouds on the CCD chip that appear as white streaks in the image (see pictures on the lower right). At least, the scintillation screen gave enough light to shine through a thin paper with a test pattern printed on it. Heavy lead shielding must be installed around the camera inside and outside the camera box to shield the gamma background before useful neutron images can be recorded, and we hope to see the first good quality neutron radiographies soon.



The above images of Fig-(1-6) are representing optical and NR images of different types of coral samples, collected from St. Martin, the coral island of Bangladesh.



## CONCLUSION

Installing new detection technologies is always a difficult venture, especially when all boundary conditions have to be determined experimentally. But the new collimator will reduce the background, increase the signal-to-noise ratio and the beam collimation, and with added new lead shielding, we are confident to get good results soon and open whole new fields of research and applications at the BAEC TRIGA reactor in Bangladesh.