Updates to NIMROD for low density nuclear matter studies, and new potting method for feedthroughs

N. Shaffett and K. Hagel

A reliable understanding of the nuclear Equation of State (EOS) at various densities and temperatures is a vital component to understanding various nuclear and astrophysical phenomena. In particular, studies of temperatures of several MeV and densities below normal nuclear matter density $n_B^0 \sim 0.15$ fm−3 are necessary in the study of core collapse supernovae [1]. Previous research into this field has been done at Texas A&M using "The Neutron Ion Multi-detector for Reaction Oriented Dynamics" (NIMROD) and upgrades to this array will aid in future research [1,2].

NIMROD is a 4π array of detectors built to study reaction mechanisms in heavy ion reactions [3]. It consists of a 166 segment charged particle array set in a neutron ball. The Array is arranged in 12 rings of Si-CsI telescopes or single CsI detectors arranged concentrically around the beam axis as shown in Fig.1. The CsI detectors are 1-10 cm thick TI doped crystals read by photomultiplier tubes, with a pulse shape discrimination method being employed to identify light particles in the CsI [4]. Previous work with NIMROD to study low density nuclear matter has employed coalescence model methods to extract the source size, and by extinction the density [1,2]. However an alternative method of determining source size is to use correlation functions [5-7]. Extracting correlation functions using NIMROD will require improved position data, leading to the current work of replacing some of NIMROD's quadrant detectors with strip detectors.

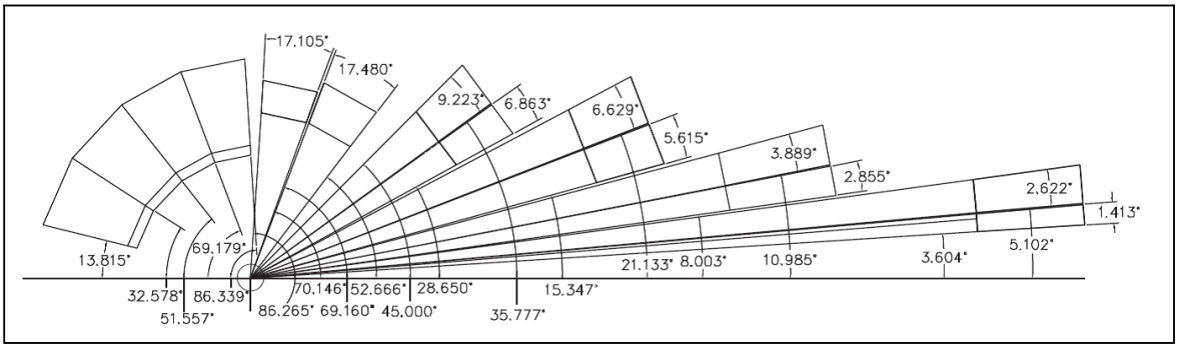

FIG. 1. Angular configuration of the NIMROD detectors.

The current focus is on the modules in ring 8-9 since this angular range highlights the intermediate velocity source while minimizing contributions from secondary decays of projectile like and target like sources [2]. In order to replace the quadrant detectors, which each have 5 signals (4 front and one back), with strip detectors, which each have 17 signals (16 front and one back), the current setup of 13 cables per module will need to be modified to 37 cables per module. Thinner cables and new boards have been ordered for this purpose and assembly is currently beginning. To accommodate these changes the feedthroughs for ring 8-9 need to be replaced. In order to prevent excess leaking in the feedthroughs a new potting method has been tested and will be implemented in the production of the feedthroughs. The method and results of the test will take up the remainder of this report.

Two spare feedthroughs, like the one shown in Fig. 2, were potted by mixing equal amounts of the epoxy resin and hardener and then applying it to the feedthrough using a 5mL syringe. The tip of the syringe was cut off to allow larger beads of epoxy to be applied and tape was used to prevent epoxy getting into the o-ring slots of the feedthrough.

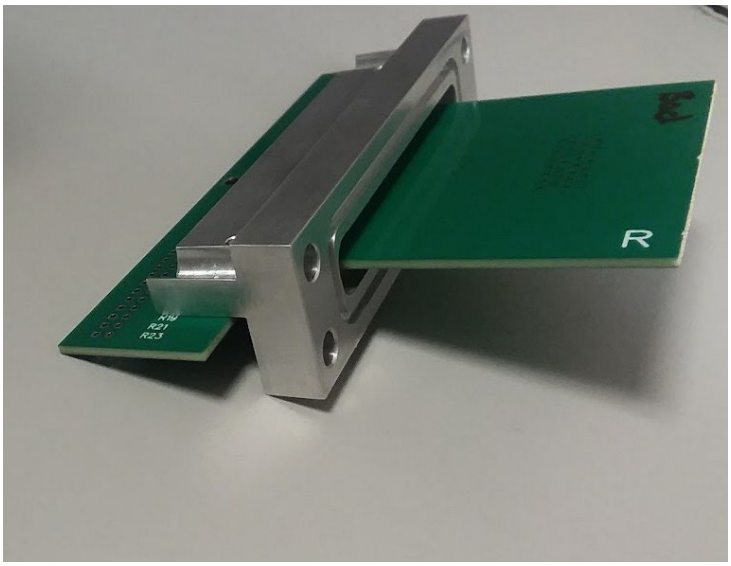

FIG. 2. Feedthrough before potting.

The new aspect of this method was to release any trapped air bubbles in the epoxy by placing it under a vacuum. The feedthroughs were placed in a vacuum chamber and the pressure was dropped so that the epoxy started to expand outwards releasing the trapped air. After letting it sit for a few moments the chamber was brought back up to air and the epoxy settled back into place. Any cavities in the top layer of epoxy caused by the popped bubbles were smoothed out and the feedthrough was left to dry for 36 hours.

FIG. 3. Feedthrough after potting.

After drying, the potted feedthroughs were placed on a small test chamber which was brought down to vacuum. The amount of epoxy needed was slightly overestimated leading to a small overflow preventing a seal from completely forming during leak testing, but this was easily fixed by using a knife to shave off the excess epoxy. An example of a finished feedthrough can be seen in Fig. 3. Overall the new potting method showed decent results and is planned to be applied to the new NIMROD feedthroughs that are being designed.

[1] M. Hempel, K. Hagel, J. Natowitz, G. Röpke, and S. Typel, Phys. Rev. C **91**, 045805 (2015), doi: 10.1103/PhysRevC.91.045805.

[2] L. Qin *et al.*, Phys. Rev. Lett. **108**, 172701 (2012), doi: 10.1103/PhysRevLett.108.172701.

[3] "NIMROD Multipurpose charged particle array at Texas A&M University." Accessed: May 18, 2024. [Online]. Available: https://cyclotron.tamu.edu/nimrod/

[4] S. Wuenschel *et al.*, Nucl. Instrum. Methods Phys. Res. **A604**, 578 (2009), doi: 10.1016/j.nima.2009.03.187.

[5] G. Verde, Braz. J. Phys., **37**, 885 (2007), doi: 10.1590/S0103-97332007000600005.

[6] G. Verde, D. A. Brown, P. Danielewicz, C. K. Gelbke, W. G. Lynch, and M. B. Tsang, Phys. Rev. C, **65**, 054609 (2002), doi: 10.1103/PhysRevC.65.054609.

[7] G. Verde, A. Chbihi, R. Ghetti, and J. Helgesson,Eur. Phys. J. A 30, 81 (2006), doi :10.1140/epja/i2006-10109-6.