Continuing development of compact MWPC detectors for TRINAT experiments

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As we prepare for further runs of the TRINAT experiment, work continues on developing position sensitive multiwire proportional counter (MWPC) detectors to replace the current 300 μm-thick double-sided Si-strip (DSSSD) ΔE-detectors making up part of the current β telescope assembly. The significant energy loss (∼100 keV) and backscattering incurred by the DSSSDs represent a limiting systematic of the current iteration of TRINAT β-decay experiments. Work is in progress on a revision of the MWPC design from last year [1], incorporating onboard charge-sensitive shaping preamplifiers to achieve greater signal strength and fidelity.

Revised MWPC detector design

The wire chamber topology of the revised design will feature two anode wire planes and three planar cathodes, spaced at a distance of 4 mm. Similarly to the previous design, the revised MWPC will be constructed as a stack of PCB frames, supporting the anode and cathode electrodes and occupying a cylindrical form factor. The PCB frame elements will range in thickness from 0.5 mm to 2 mm, with the full stack occupying a total height of 16 mm, an improvement in form factor over the previous design which stood at 26 mm in height. This will allow for an improvement in the solid angle spanned by the scintillator behind each MWPC. Fig. 1 shows a 3D model of the layers comprising the MWPC.

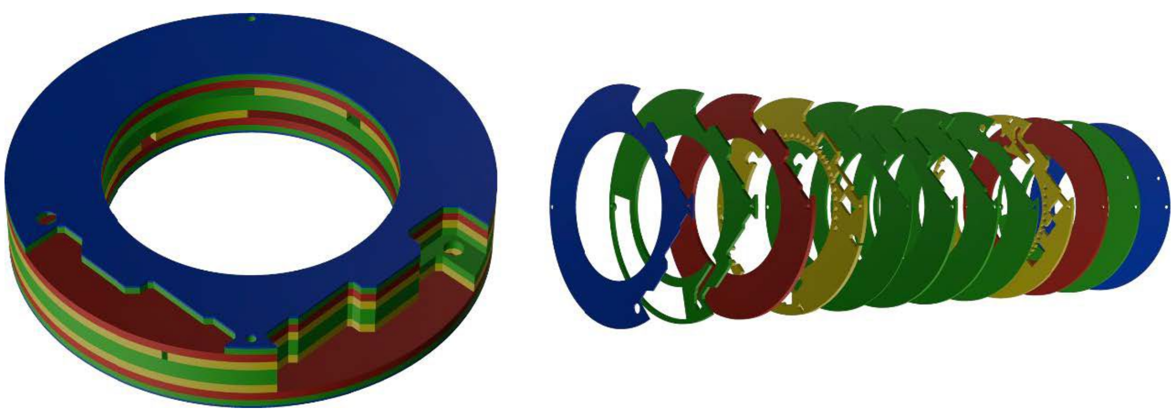

FIG. 1. CAD drawing of the revised MWPC design. On the left is shown the assembled view, while the right shows an exploded view of the various PCB

Per-channel preamplifiers

The PCB frame supporting each anode wire-plane will also hold a set of twenty charge-sensitive shaping pre-amplifier channels, with each pre-amplifier receiving input from one of the twenty wires supported by each anode layer. These pre-amplifiers will be embedded within the PCB frame layers upon the assembly of the MWPC, reducing the effect on signal-to-noise ratio of any noise introduced outside of the detector. The pre-amplifier circuit topology and a fabricated pre-amplifier circuit is shown in Fig.2.

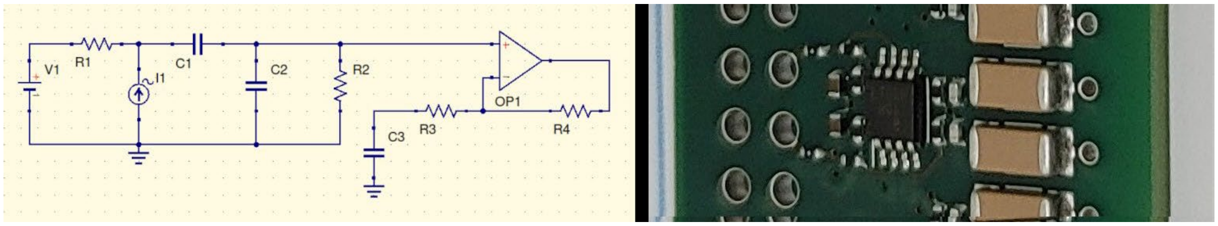

FIG. 2. Per-channel preamplifier circuit design (left) and fabricated testboard (right).

The output of each charge-sensitive shaping pre-amplifier will leave the detector through its own 50Ω cable. Thus, from two anode layers containing twenty wires each, forty output channels will be supplied by each detector. The preamplifier outputs are matched to the 50Ω line impedance, reducing any reflections along the signal pathway.

Anode PCBs

To accommodate the twenty anode wires, charge-sensitive shaping pre-amplifier channels, and 50Ω output channels, each anode PCB frame will be a 6-layer PCB containing high-voltage supply electronics for the anode wires, solders pads on front and back for the 265 SMD components which comprise the charge-sensitive shaping pre-amplifier circuits, and four layers of signal routing along curved 50Ω traces to the output connectors. A CAD rendering of one of these anode frames is shown in Fig. 3.

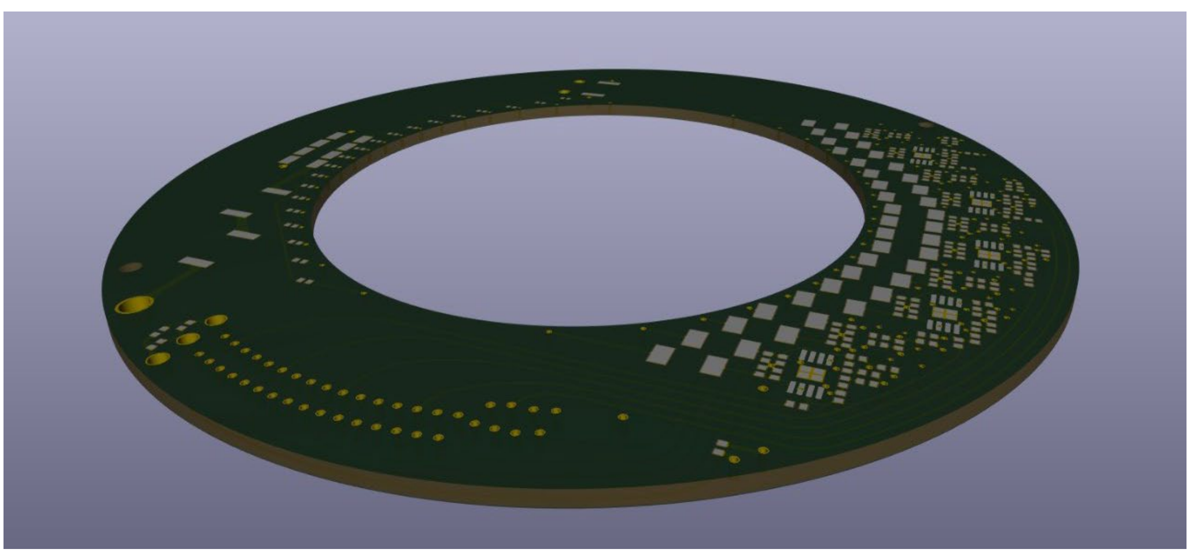
FIG. 3. CAD rendering of the lower anode PCB frame.

The design process for this revised MWPC is nearly complete and we expect to have the new MWPC detectors fabricated and assembled by the end of the year.

[1] J. Klimo *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2022-2023), P. IV-29.