Contribution ID: **279** Contribution code: **P-THU-24** Type: **Poster**

Development of a highly pixelated detector array and a novel digitising DAE for the next generation ISIS instrument, Super-MuSR

Thursday, 1 September 2022 18:40 (20 minutes)

The development of the next generation 'Super-MuSR'instrument at ISIS will provide a transformational improvement in counting rate (to 1000M ev/hr) and timing resolution (to better than 2ns) for pulsed beam measurements. Key to delivering this capability is the highly pixelated cylindrical detector array, built as 64 long 'barrel staves'. This totals 704 pixels providing 75% solid angle coverage. The detector array is combined with novel readout, where the analogue waveforms are fully digitised and processed using digital signal processing (DSP) methods at either software or firmware level.

Each detector pixel will use a Hamamatsu S10362 series SiPM, optically coupled to a BC408 scintillator using wavelength shifting fibre. The fibre is embedded into a scintillator tile, with the ends protruding to ensure good optical coupling. The tile and fibre are surrounded by a reflective inner (PTFE) and light tight outer (Aluminium) wrapping. This design was chosen to maximise the light collection and homogeneity for each of the 8 different pixel sizes used to preserve solid angle across the stave length.

The data pipeline will combine a series of 'firsts'for ISIS. Digitisation will be achieved using the Xilinx Zynq UltraScale series of 'system on a chip'operating with ADCs running at 1G Sample/s, data handling using Kafka event streaming technology, and full digital signal processing to provide advanced data correction techniques.

We will present our design considerations, first results from our 12-pixel prototype stave and discuss the benefits of implementing a DSP 'data pipeline'.

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Session Classification: Posters

Track Classification: New techniques