A portable test-bench for real-time radiation damage measurements in scintillating and wavelength-shifting fibres

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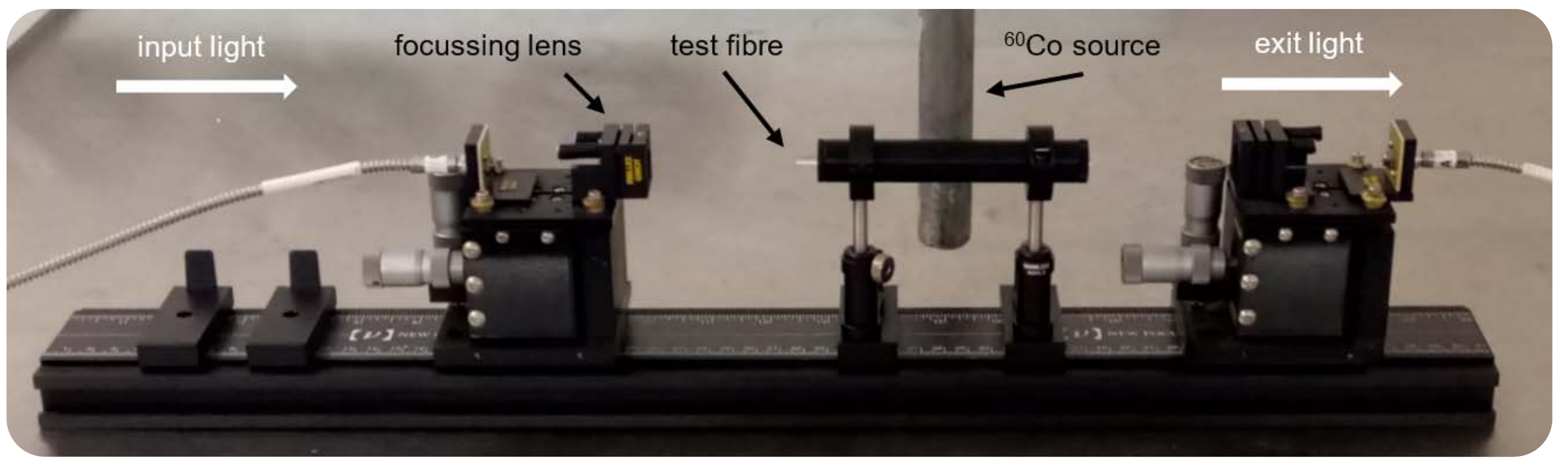
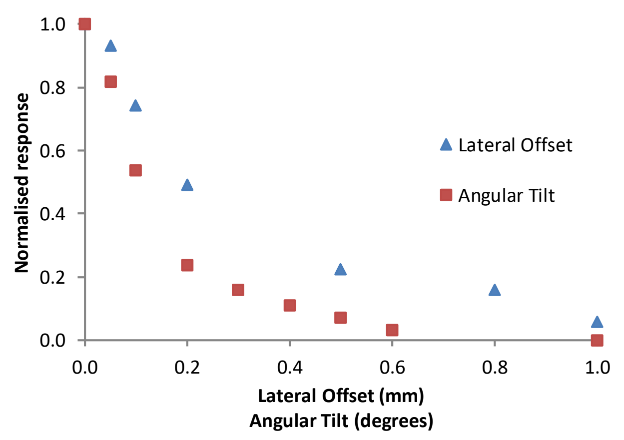
Motivation

A portable test-bench has been designed and constructed as part of the AIDA-2020 project [1] to enable the real-time measurement of radiation-induced absorption in scintillating and wavelength-shifting fibres typically used in the readout of fibre calorimeters or scintillating tiles such as those used in some hadron calorimeters. The test-bench has been designed to be used in a range of facilities, such as ^{60}Co irradiators or high-intensity test beam facilities, and can accommodate fibres with length up to 300 mm and diameter greater than 1.0 mm.

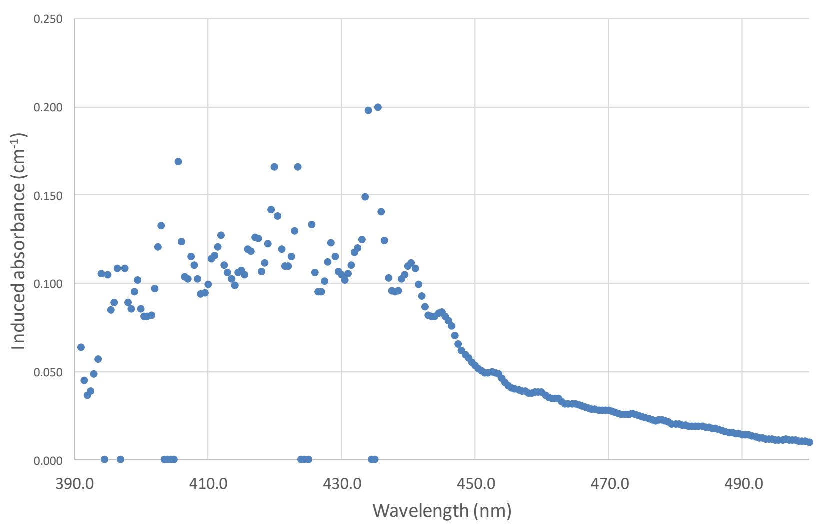
Test-bench Operation



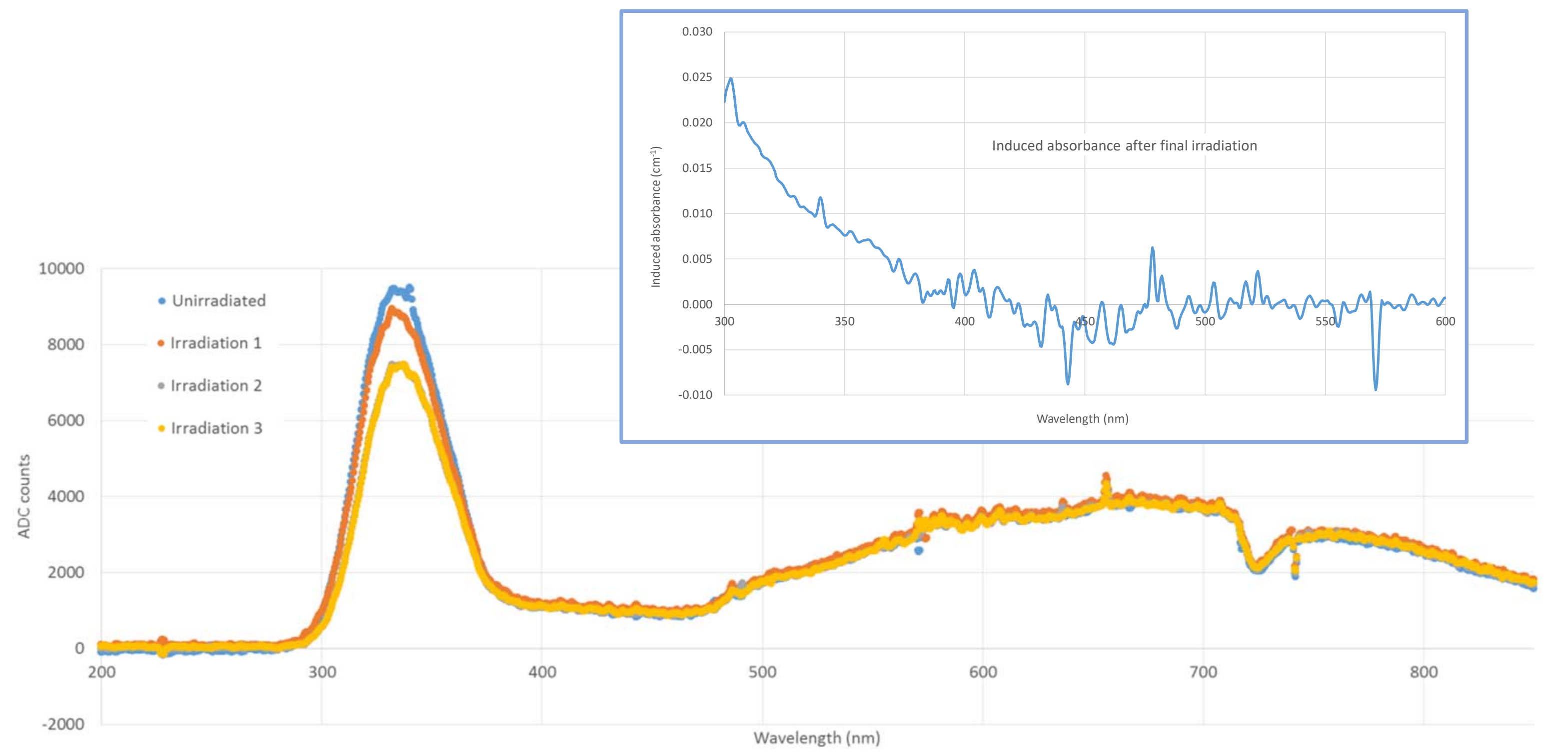


Fibres are illuminated by a combined deuterium and halogen light source focussed onto the end of the fibre with a 0.25 NA radiation-tolerant quartz lens. Light transmitted by the fibre is collected by an identical lens and measured as a function of wavelength with a linear CCD spectrometer covering a wavelength range of 190 to 850 nm. We simulated the sensitivity to misalignment using ZEMAX [2]

Experimental Results

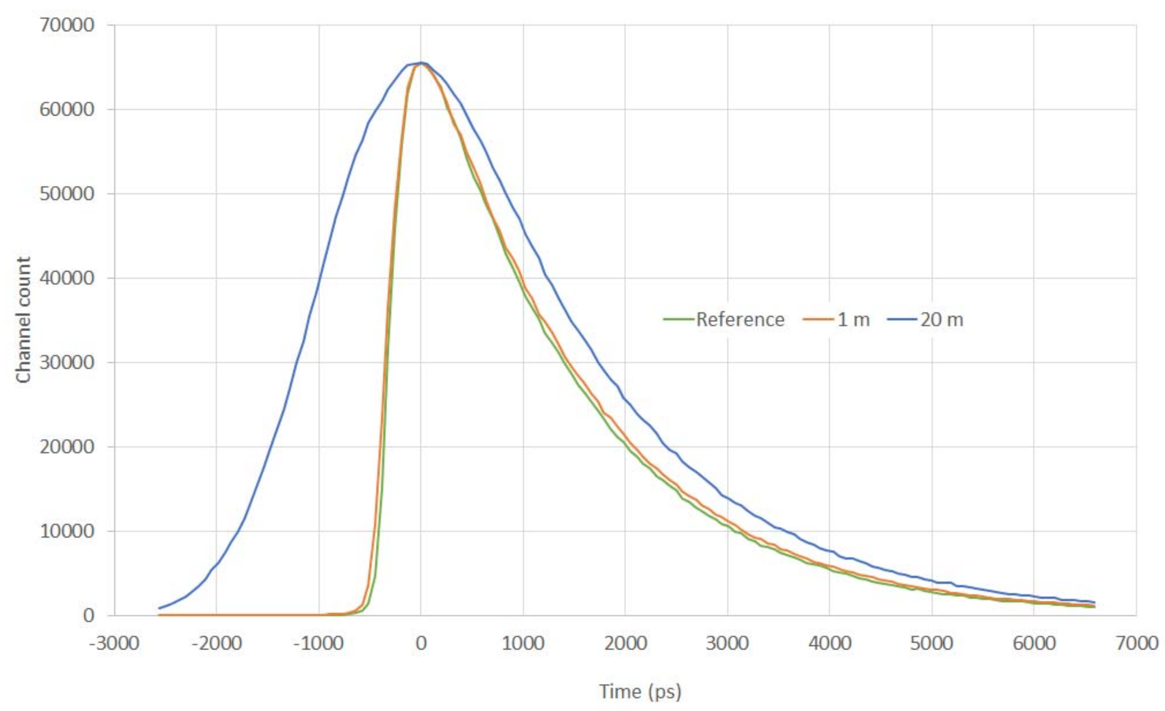


The result of a four-day continuous gamma irradiation, to a total dose of approximately 10 kGy, of a 3 mm diameter commercial polymethyl methacrylate (PMMA) rod that was highly absorbing prior to irradiation at wavelengths shorter than 390 nm due to a UV absorbing additive.



The result of a three-day continuous gamma irradiation, to a total dose of approximately 0.44 kGy, of a 3 mm diameter silica rod. Data are dark count corrected [3]. The transmission dip near 725 nm is due to the 40 m of high-OH silica fibre in the total light path.

The major systematic error is the stability of the light sources which show peak variations of up to 1% between successive measurements taken at 120 s intervals or between repeated measurements taken 360 s after switching on the light sources from cold.



We considered the possibility to measure in real-time the effect of radiation on fluorescent properties of scintillating and WLS fibres.

Using an 80 ps 377 nm diode laser, a fast SiPM based photon detector and a PicoHarp 300 time correlator the effect of time dispersion via the large core diameter multi-mode fibre was investigated.

We used 10 cm (reference), 1 m and 20 m long optical fibres and measured the decay time constant of a fast plastic scintillator (polystyrene with PPO and PPOP fluors) at 20 °C.

Fibre Length (m)	Decay Time (ns)	Error (ns)	Chi-square / DOF
0.1	1.53	± 0.01	6.0
1.0	1.57	± 0.01	8.8
20.0	1.64	± 0.01	6.3

Effect of fibre length on fitted decay constant (single exponential tail fit starting 1 ns after peak).

Acknowledgement

We acknowledge financial support for the development of the fibre test-bench via the AIDA-2020 collaboration which is funded by the EU Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168.

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[3] D. R. Smith, P. R. Hobson, "Spectrometer Testing: Dark frame evaluation of StellarNet Black Comet spectrometer", Brunel University London, Uxbridge, UK. Brunel_Spectrometer_Testing_TN_001.01, Feb. 2016. [Online]. Available: http://bura.brunel.ac.uk/handle/2438/14089