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From SuperNEMO to Proton Therapy: Adapting the SuperNEMO Optical Module for Proton Energy QA

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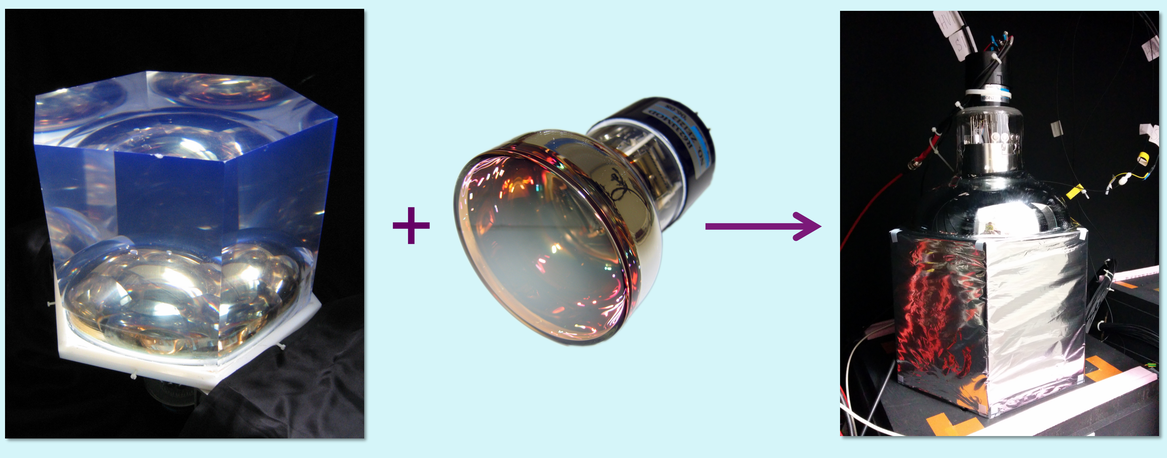
Quality Assurance (QA)

At clinical proton therapy facilities, a range of essential daily QA checks are carried out to verify a number of aspects of the clinical beam. Existing techniques for energy QA are largely based around verifying the position of the Bragg Peak at a handful of energies using ionisation chambers. These measurements can be time consuming to set up and carry out.

A detector is under development to improve the accuracy and reduce the measurement time (to around 2-3 minutes) for proton energy QA using an adapted calorimeter module that was designed for the SuperNEMO high energy physics experiment.

The SuperNEMO Optical Module

PVT Scintillator + High Quantum Efficiency PMT, wrapped in reflective material:



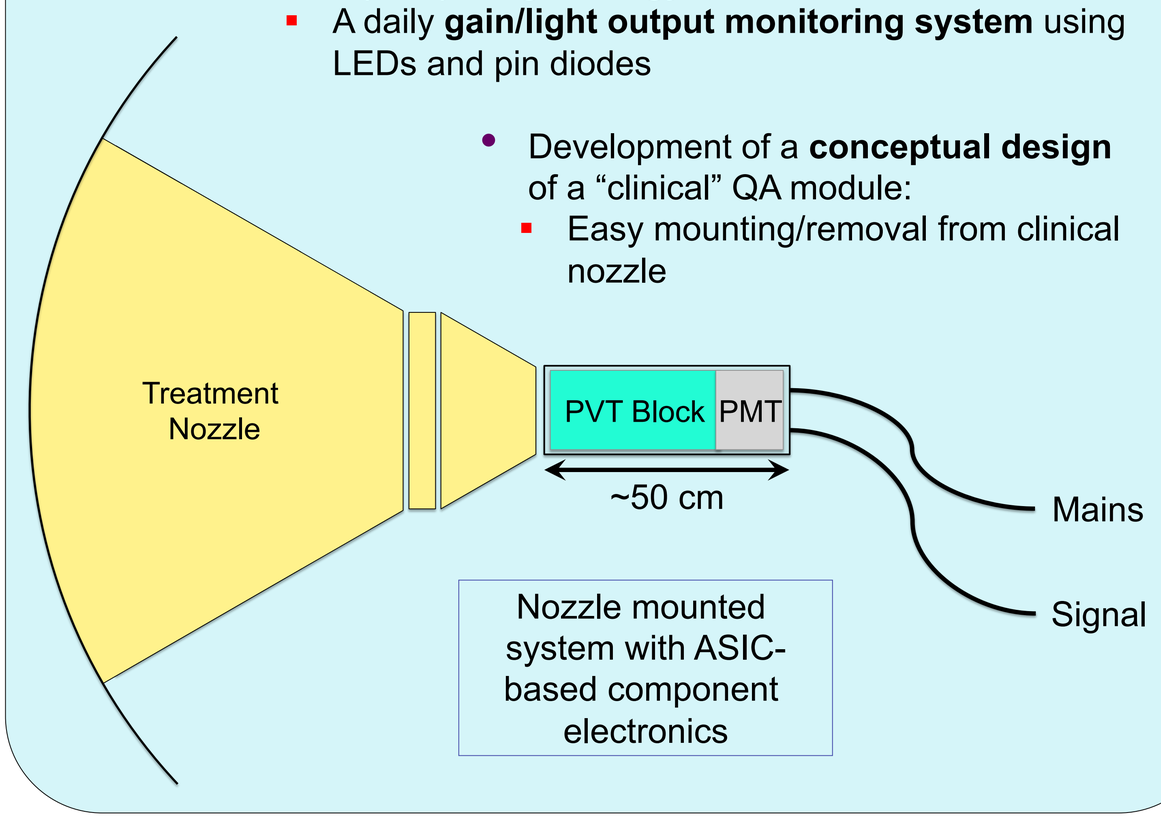
- High light output
- Fast response time (on the order of ns)
- Compact – mountable on beam nozzle
- Cheap
- PVT scintillator is water equivalent:

Beam Energy, MeV	SCINT stopping distance, mm	WATER stopping distance, mm	SCINT σ of stopping distance, mm	WATER σ of stopping distance, mm
60	30.21	30.54	0.33	0.33
200	255.4	257.1	2.48	2.44
300	505.9	509.9	4.64	4.78

GEANT4 pencil beam simulations of the SuperNEMO PVT scintillator vs. water equivalent.

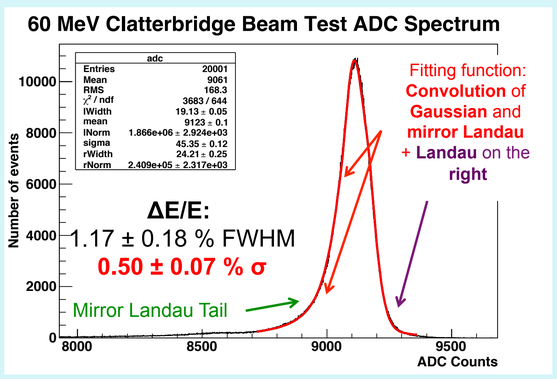
Ongoing Work

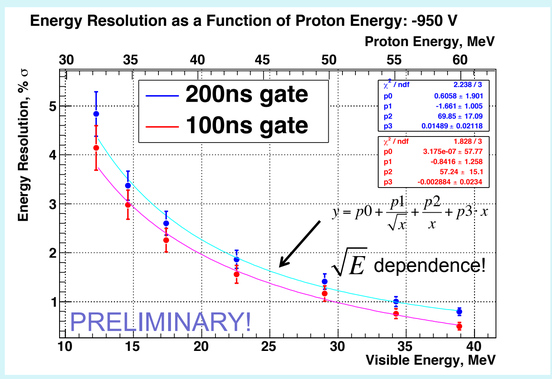
- Development of a **<1% σ** performance with realistic proton therapy facility rates (**1 – 10 MHz**)
  - Removal of pile up due to fast rates through pulse shape discrimination analysis
- Development of a calibration system:
  - A yearly **range-energy calibration**
  - A daily **gain/light output monitoring system** using LEDs and pin diodes
- Development of a **conceptual design** of a "clinical" QA module:
  - Easy mounting/removal from clinical nozzle



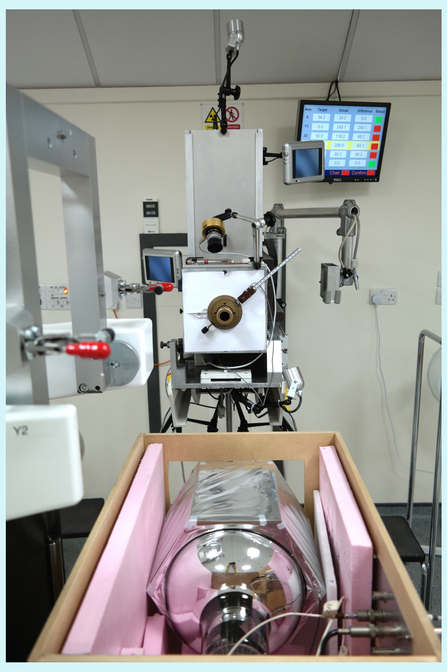
Results from Clatterbridge

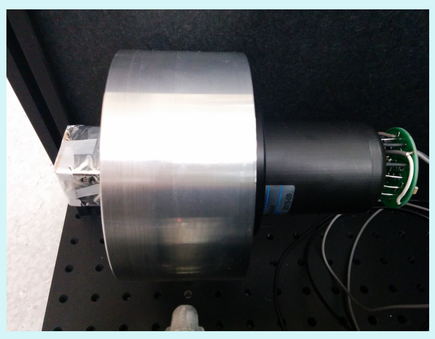
- Best energy resolution (ΔE/E) result achieved so far during four test beam visits (at 70 kHz):
- PMMA absorbers used to decrease beam energy and measure ΔE/E as a function of proton energy:

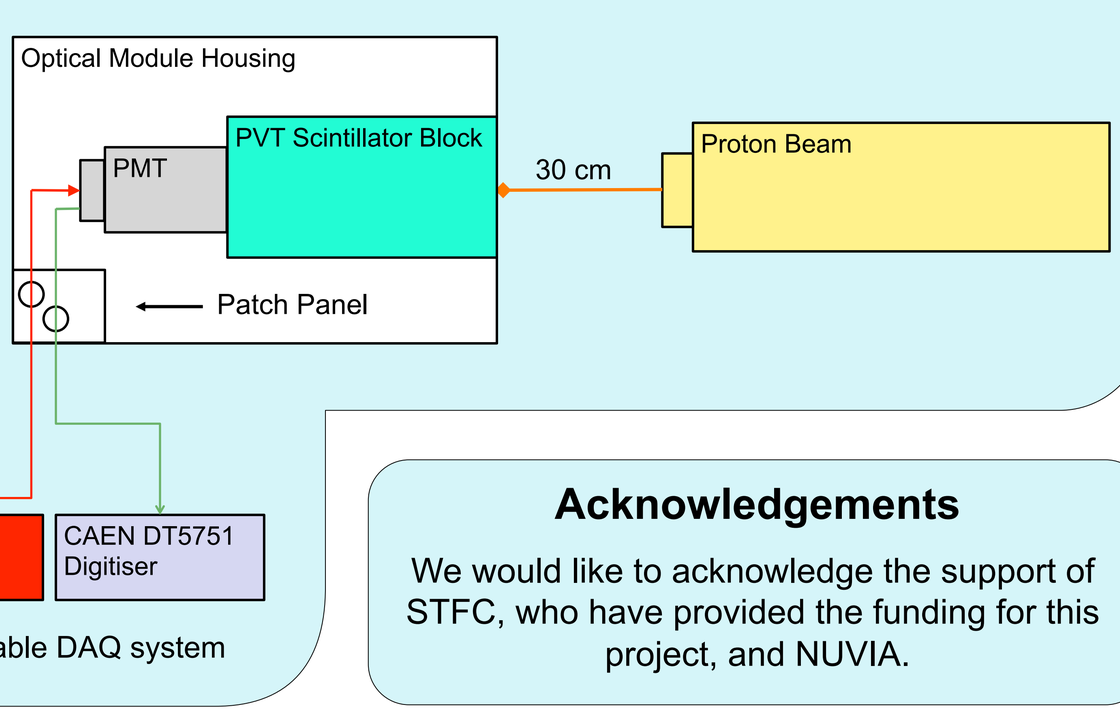




Testing at Clatterbridge Cancer Centre 60 MeV Clinical Beam (Bebington, UK)







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