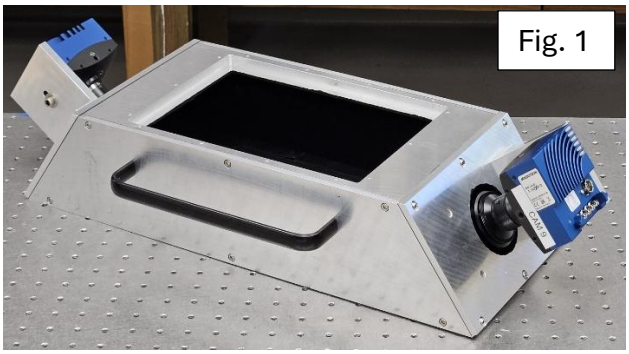
The Proton FLASH-RT Challenge: Ultrafast Beam Monitoring & Dosimetry in Real Time

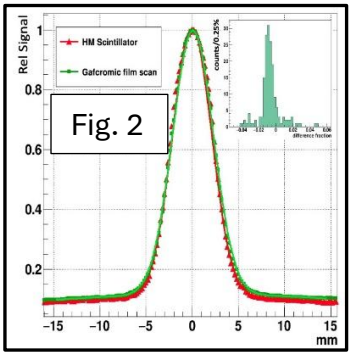
Proton FLASH Radiotherapy demands essentially ***instantaneous*** beam monitoring, analysis, dose verification, and beam termination (if required), all requirements that standard dosimetry tools cannot meet, especially over large areas (e.g., **> 300 cm²**). By way of comparison, Gafchromic film cannot provide real-time beam monitoring as it requires about one day to fully develop and read out the recorded beam results.

The FLASH Beam Scintillator-based Monitor and dosimeter (**FBSM**), developed by Integrated Sensors, LLC in partnership with the University of Michigan, meets the requirements demanded for future clinical proton FLASH-RT dose delivery systems.

LARGE-AREA, DUAL-CAMERA MONITORING SYSTEM

- Each camera in the FBSM (**Fig. 1**) operates independently at **20,000 frames/sec**. Each image is analyzed before the next image is captured, avoiding image pileup.





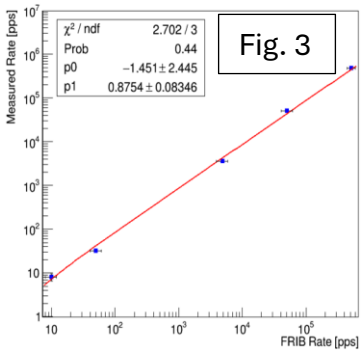


Fig. 1 – Photograph of 2nd Generation, dual-camera FBSM with 15x23-cm² scintillator.
Fig. 2 – FBSM electron beam scan with HM scintillator vs. same scan using Gafchromic film.
Fig. 3 – Response linearity showing measured FBSM prototype signal vs. actual beam current.

- The FBSM employs a proprietary hybrid-material (HM) scintillator with an active area of **15x23-cm²** providing similar performance and resolution (~ 25 µm) as Gafchromic film (see **Fig. 2**), but in real-time with an **update/refresh rate of 50 µs** and **linearity demonstrated over at least six (6) orders-of-magnitude** (see **Fig 3**).

SYSTEM INTEGRATION & PROFILE

- **Minimal Beam Impact:** The FBSM with a total water-equivalent mass thickness of **< 0.5 mm** causes **much less energy loss and beam scattering** than the column of air between the nozzle and the patient.
- **Folded Optics Design:** Employs mirrors for a reduced system depth of 12 cm.

FRPT-2025, Abstract #125, Integrated Sensors, LLC, Florida, USA (P.S. Friedman, peter@isensors.net)

VALIDATED PERFORMANCE METRICS

- **Dosimetry Accuracy:** Dosimetric error is currently 4% but should reach 1-2% using a new algorithm already tested in software, establishing a clear path to high-precision dose verification.
- **Exceptional Radiation Hardness/Damage Resistance:** Longevity is critical for clinical throughput. The FBSM has been subjected to worst-case scenario testing to prove its durability. Measured signal loss of **0.024%/kGy**, equivalent to **~1.2% signal loss/year** for continuous FLASH-RT treatment. This extreme durability ensures minimal maintenance and maximizes clinical uptime.

REAL-TIME DATA ACQUISITION AND CONTROL – The FPGA Advantage

The FBSM utilizes a sophisticated **FPGA-based** architecture to deliver fully corrected data in *microseconds*.

- **Data Processing Speed:** Images are downloaded within ~42 µs, with analysis (beam finding, profile, dose) performed in < 2 µs.
- **Automated Real-Time Correction:** Provides reliable data instantly, correcting for background subtraction, image optical distortion, keystoning, vignetting, etc.
- **Beam Safety:** When detected, an **out-of-tolerance beam interrupt signal** can be generated within a few *microseconds* of analysis, ensuring patient safety.

CALIBRATION ASSURANCE

The system includes an integrated Quality Assurance tool to maintain precision.

- **Robotic Calibrator:** A large area system (>15x23-cm^2) employs a stable source as a uniform "*standard candle*" beam for position-specific intensity corrections.

PROJECT OUTCOME and CALL TO PARTNERSHIP

We are now actively seeking partners to integrate our system into a commercial proton FLASH-RT unit for use in clinical trials.

CONTACT US FOR PARTNERSHIP OPPORTUNITIES

Integrated Sensors
transforming radiation detection

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