# #122: AN UPDATE ON THE ULTRA-HIGH DOSE RATE SCINTILLATOR-BASED BEAM MONITOR FOR PROTON, VERY HIGH-ENERGY ELECTRON and PHOTON FLASH RADIOTHERAPY

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**P. S. Friedman**[1], C. Ferretti[2], D. S. Levin[2], N. Ristow[2], D. Litzenberg[3], V. Bashkirov[4], R. Schulte[4], Ioannis Stratakos[5]

[1] *Integrated Sensors, LLC, Palm Beach Gardens, Florida, 33418, USA,* [2] *University of Michigan, Department of Physics, Ann Arbor, Michigan, 48109, USA,* [3] *University of Michigan Hospital, Radiation Oncology, Ann Arbor, Michigan, 48109, USA,*
[4] *Loma Linda University, Biomedical Engineering Sciences, Loma Linda, California, 92350, USA,* [5] MicroLab, School of Electrical & Computer Engineering, National Technical University of Athens, Greece

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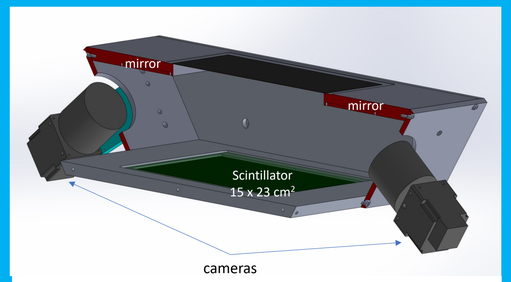
## FLASH Scintillator Beam Monitor Features

- Two high-speed machine-vision cameras
- Folded optics reduced profile ~12 cm
- Positioned between nozzle & patient
- Novel low-mass thickness (<0.5 mm water equivalent) transmissive *hybrid* inorganic crystal + polymer scintillator

## Fast, Real-Time DAQ

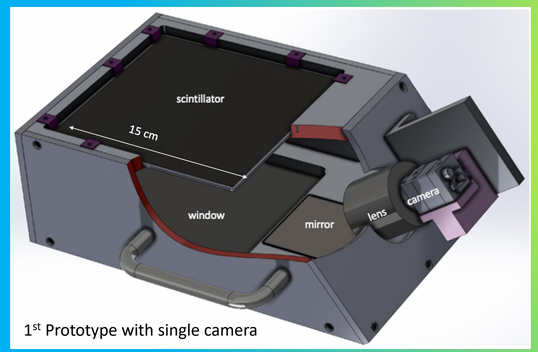
- FPGA-based image processing & analysis
- Continuous real-time analysis during treatment
- Images acquired at 20 kHz frame rate & analyzed in < 50 µs
- Fast analysis of beam position, profile, and dose
- Dose measurement is referenced to clinical radiation program
- Out-of-tolerance beam interrupt signal generated 50 µs after dose is delivered.




Beam monitor design with 2 cameras

## 1st Prototype Design & Test Facilities

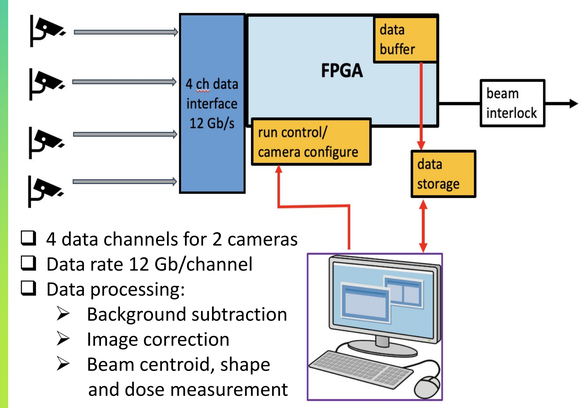
- 8 MeV electrons, FLASH compatible beam (used at Notre Dame Radiation Lab)
- 6-16 MeV electrons using Varian LINAC at UM Hospital Radiation Oncology (**UMH**)
- 10 MV photons at UMH
- FLASH-level 16 MeV electrons on modified Varian Trilogy at UMH




1st Prototype with single camera


1st Prototype tested with Varian ***6-16 MeV electron*** linac at UMH

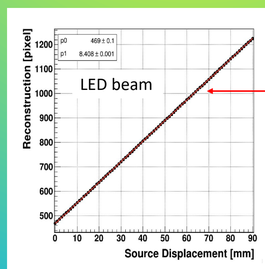
## FPGA Readout




- ❑ 4 data channels for 2 cameras
- ❑ Data rate 12 Gb/channel
- ❑ Data processing:
  - ➢ Background subtraction
  - ➢ Image correction
  - ➢ Beam centroid, shape and dose measurement

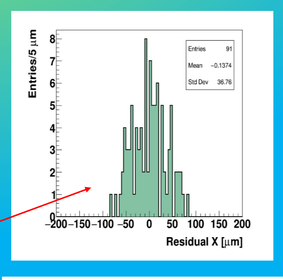
## Prototype Performance Test Results

1. Spatial resolution using test bench LED ”beam”



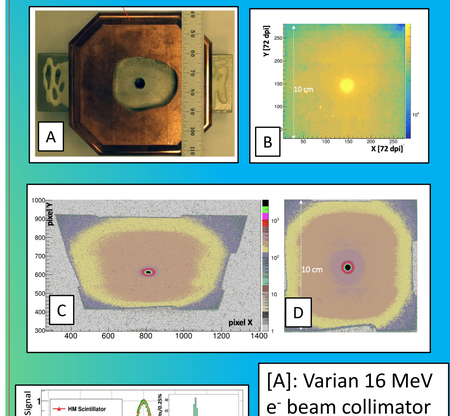

Reconstructed beam centroids vs true LED beam position of stepper motor

Residuals of above linear fit shows spatial resolution of ~ 36 µm




Spatial position resolution

2. Varian LINAC at UMH: 6-16 MeV electrons at conventional therapeutic dose rates.




[A]: Varian 16 MeV e⁻ beam collimator

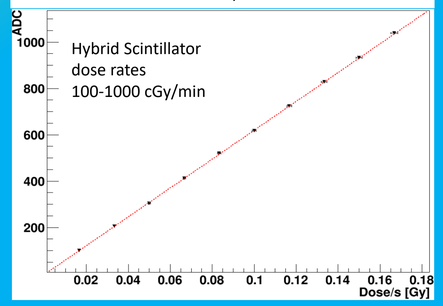
[B]: Beam image on Gafchromic film

[C]: Beam monitor “raw” image

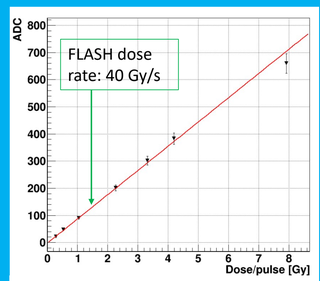
[D]: Beam monitor image in clinic coordinates

[E]: Beam profiles from monitor and Gafchromic film

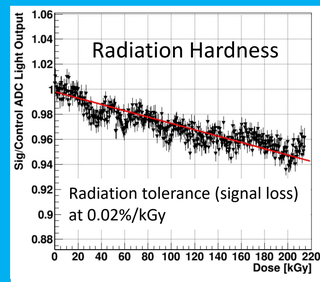
Measured signal vs dose linearity at UMH Conventional, Low Dose Rates




3. Notre Dame Radiation Lab: 8 MeV e⁻ FLASH compatible beam




Signal vs dose linearity exceeding FLASH dose rate




Signal vs dose exposure

## Conclusions

- 1st Prototype FLASH beam monitor built & tested.
- Performs analysis of the beam parameters within 50 µs.
- Beam intensity measurement is linear with dose for conventional and FLASH rates.
- High spatial resolution that matches Gafchromic film, but is provided “instantly” within 50 µs.
- Exceptional radiation hardness.

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