Real-Time High-Resolution Radiation Fluence Profiling with the ONYX Detector

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Objectives: Quality Assurance (QA) and Quality Control (QC) are critical for ensuring high-precision dose delivery and patient safety in Stereotactic Radiosurgery (SRS) across both photon-based and proton-based modalities.

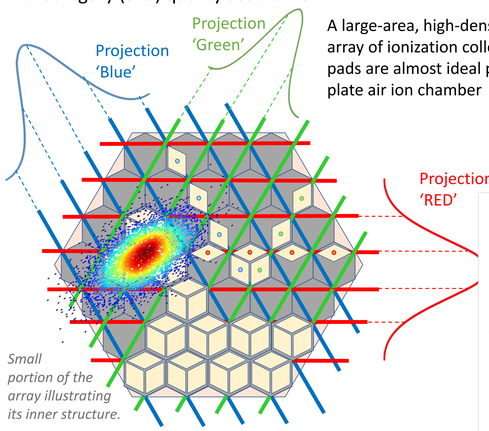
The ONYX detector system was originally developed for proton therapy QA, but its high spatial resolution (<200µm), fast acquisition (40µs timing), and real-time multi-directional ionization array make it **uniquely suited for SRS applications**.

This **preliminary characterization** evaluates the ONYX detector's ability to enhance QA workflows for SRS, focusing on:

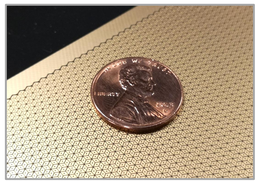
- Sub-millimeter accuracy in beam position verification.
- Real-time monitoring of dose distribution and fluence for small, high-dose radiation fields.
- Pulse-by-pulse beam characterization, critical for both photon SRS (e.g., LINAC, CyberKnife, Gamma Knife) and proton SRS (e.g., PBS, fixed-beam proton therapy).

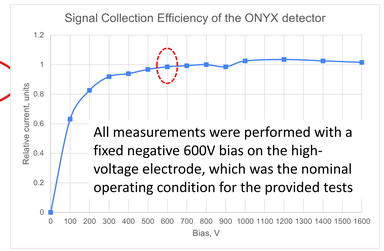
By demonstrated proton pencil scanning QA data from Mayo Clinic Arizona, this study presents ONYX performance in validating high-dose, small-field treatments to spark the initial interest of the SRS community. There is a future plan to develop specific instrument best suited for the SRS modality.

Materials & Methods: A new planar air-parallel ionization chamber, ONYX, developed by RDI Technologies LLC (Tempe, AZ, USA), was evaluated for its potential in stereotactic radiosurgery (SRS) quality assurance.



A large-area, high-density array of ionization collector pads are almost ideal parallel plate air ion chamber



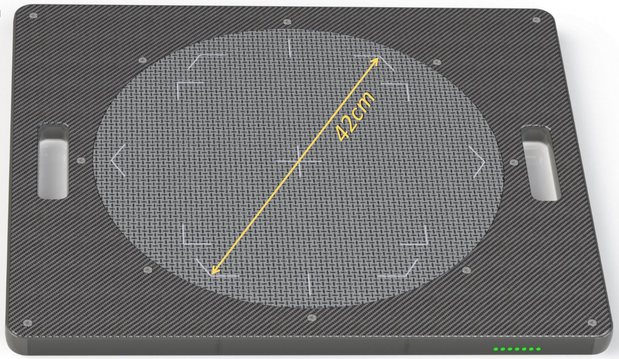


Results: Preliminary proton beam tests confirm that ONYX delivers sub-millimeter spatial resolution (<200µm) and high temporal precision (40µs acquisition) in real-time. The system demonstrated excellent linearity across a wide dynamic range (100 pA – 5 µA), enabling accurate tracking of small-field uniformity, edge sharpness, and dose distribution. These capabilities are critical for SRS QA, ensuring precise beam targeting and minimizing collateral exposure. Future photon-based testing is expected to validate ONYX's applicability to high-dose, small-field stereotactic treatments.

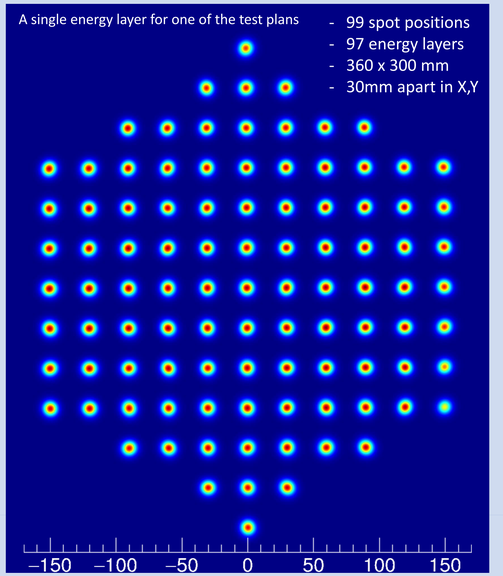
Summary & Plans: For proton SRS, RDI ONYX may enable spot-by-spot verification, dose fluence mapping, and edge sharpness analysis, critical for minimizing collateral exposure. Its high-speed, real-time monitoring capabilities also align with photon SRS QA needs, ensuring accurate beam targeting in single-fraction, high-dose treatments.

Future work will **expand ONYX validation to photon-based SRS** to further solidify its role as a next-generation QA tool for stereotactic radiotherapy.

- Tests with photons / LINAC SRS
- Appreciate a collaboration w/CyberKnife
- Smaller area & size instrument
- Attaches to a nozzle / collimator

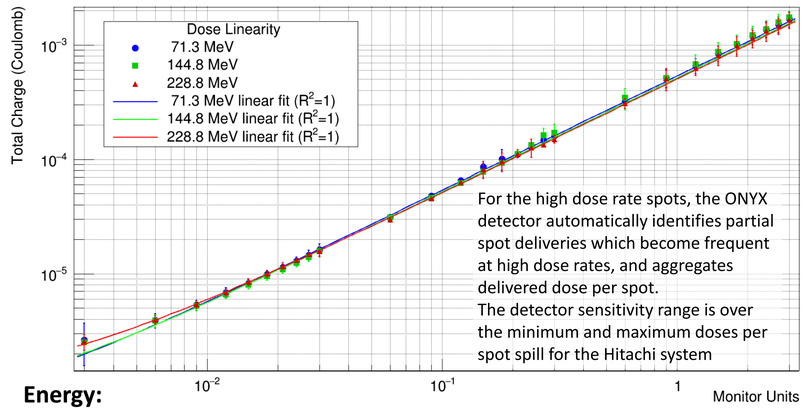


Nominal Technical Specification	Value
Cathode-Anode air gap, mm	5
Planar resolution (peak position), µm	120
Active area (hexagon), cm²	1,280
Longest active area dimension (diagonal), mm	388
Timing resolution, kHz (sampling period, ms)	25 (0.04)
Dynamic range, pA	100 - 5000
Radiation hardness (years of everyday use)	5
Water-equivalent thickness, mm	5.8
Intrinsic water-equivalent buildup, mm	1.25
Detector weight, kg (lbs)	6.4 / 14.1
HV negative bias range, V	0 - 4000
HV nominal operating bias, V	600
Power consumption (idle / peak), W	7 / 22

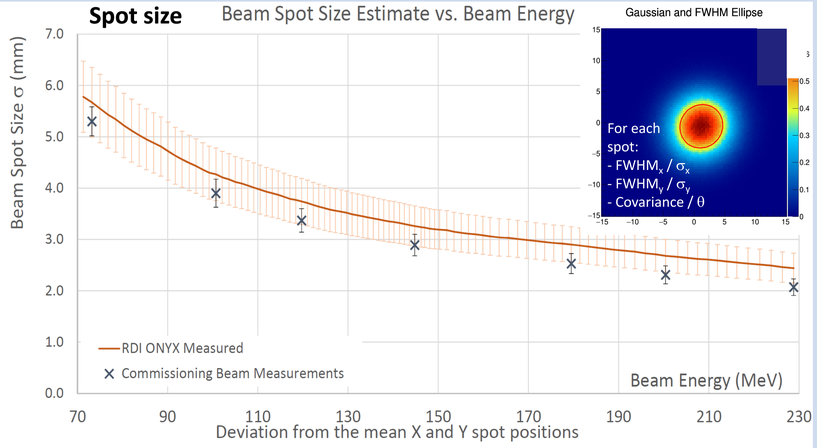


Results Summary:

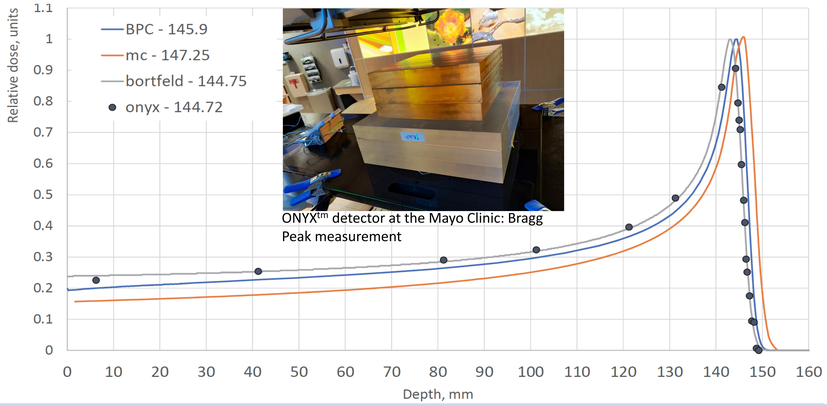
Linearity: Linearity of Response (Beam energies 71.3, 144.8, and 228.8 MeV)



Spot size Beam Spot Size Estimate vs. Beam Energy



Energy:



ONYX[tm] detector at the Mayo Clinic: Bragg Peak measurement

Spot position: