



reflexion

ACCELERATOR DRIVEN RADIOTHERAPY

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Reflexion Medical

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LINAC BASED RADIOTHERAPY

- *Electron, MeV photon*
- *Realtime Imaging. Reflexion (PET) (CT), Viewray (MR), Elekta Unity (MR), Varian Halcion (CT)*
- *Proton*
- *Boron Neutron Capture Therapy, (Li Target)*

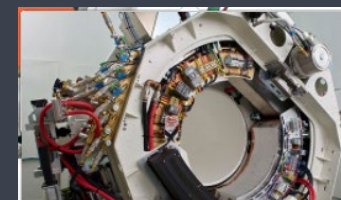
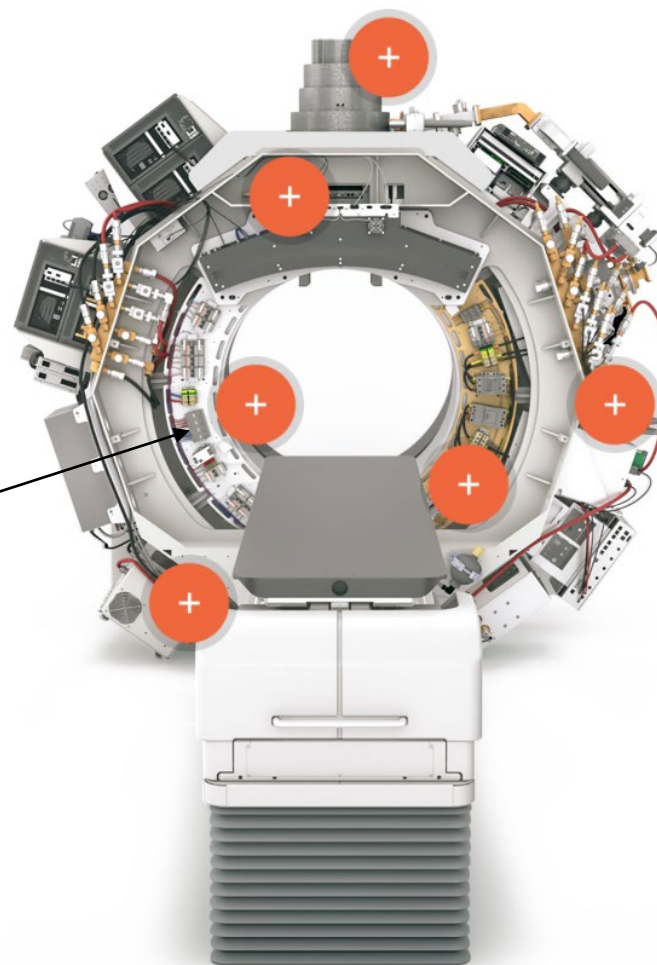
DISCOVER THE REFLEXION X1 MACHINE.

A closer look at the proprietary technologies that combine to create our game-changing approach to cancer treatment.



PET Detector Arcs

Dual 90-degree arcs of PET detectors composed of state-of-the-art, solid state SiPM arrays collect a live stream of tens of thousands of emissions from the radiotracer as it accumulates in the tumor.

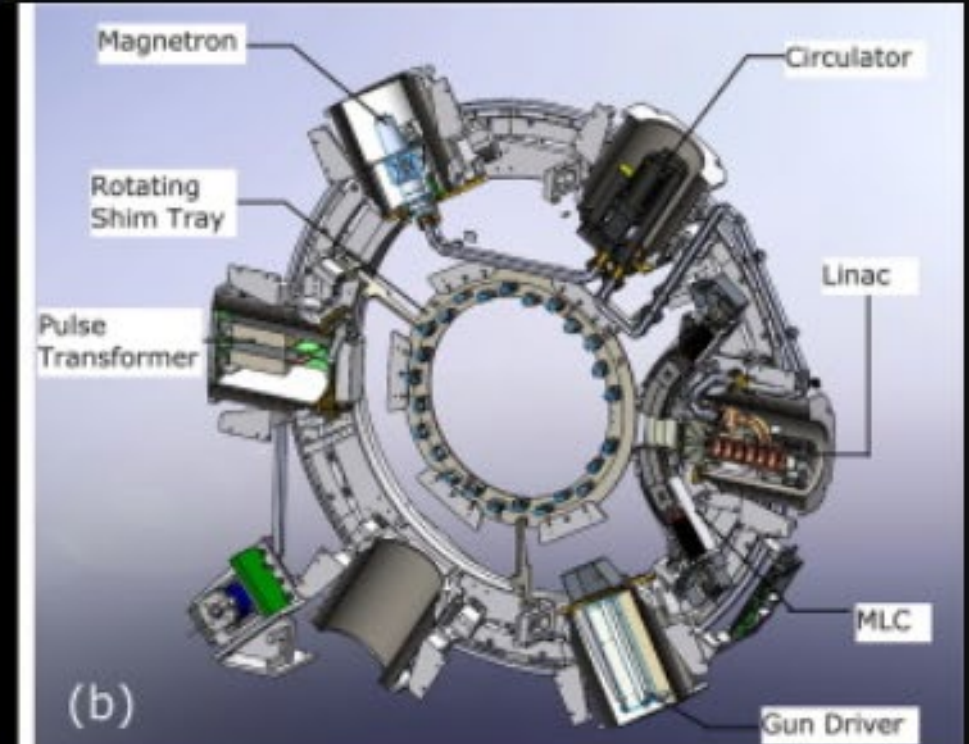
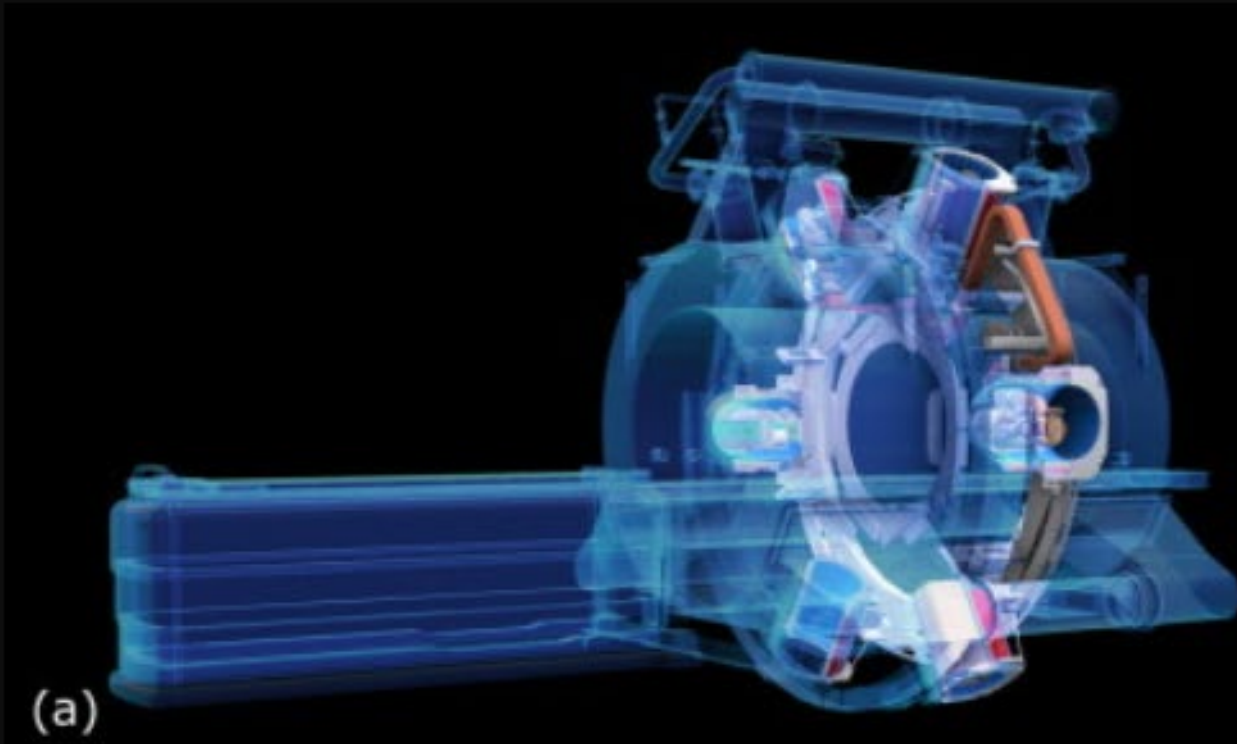


Rotating Ring Gantry

Key components of the Reflexion X1 mount on a ring gantry rotating continuously at 60 RPM to enable radiation delivery concurrently with PET emission detection.

<https://reflexion.com/our-technology>

MRI GUIDED TREATMENT: VIEWRAY MRIDIAN LINAC



STATE OF THE ART SW ELECTRON LINAC!

- Majority of electron/photon based systems
- Reliable
- Mature manufacturing process
- Compact
- Magnetron Source 6Mev
- Klystron >6 MeV

RESONANT SIDE-COUPLED CAVITY ELECTRON ACCELERATORS

By

E. A. Knapp, W. J. Shlaer, G. R. Swain, and J. M. Potter

The development of the side-coupled cavity chain as a high shunt impedance accelerator structure represents a significant change in accelerator design.^{1,2} To further investigate the properties of this type resonant cavity chain accelerator system we have built and operated two short electron accelerators, and are building a 20 MeV multi-section

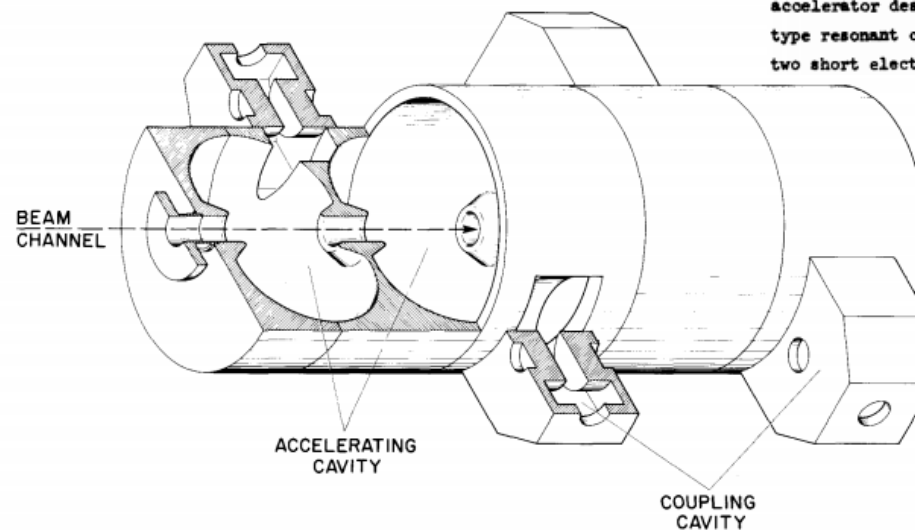
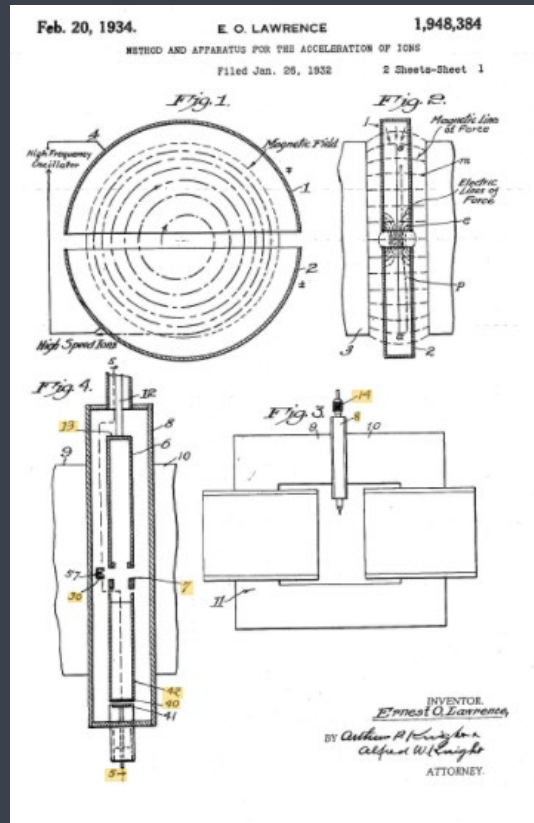


Fig. 1. Cutaway drawing of a side-coupled optimized shunt impedance cavity chain.

PROTON/CARBON ION BEAM SYSTEMS MOSTLY CYCLOTRON... (UP TO 250MEV)



ProBeam 360°

1. Superconducting Cyclotron

The most powerful particle accelerator available today to treat cancer.

2. Beam Transport System

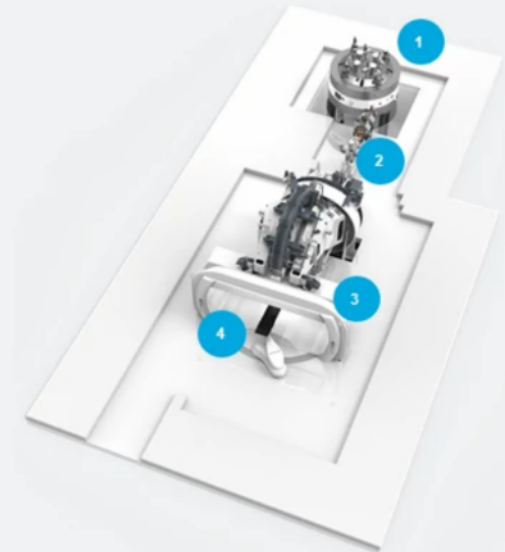
Focuses, shapes, and guides the beam to the treatment room, creating the small beam size necessary for IMPT and enabling clinicians to target very small spots across the full energy range.

3. 360-degree Rotating Gantry

360-degrees of freedom to image and treat the patient from any angle without additional repositioning.

4. Patient Treatment Room

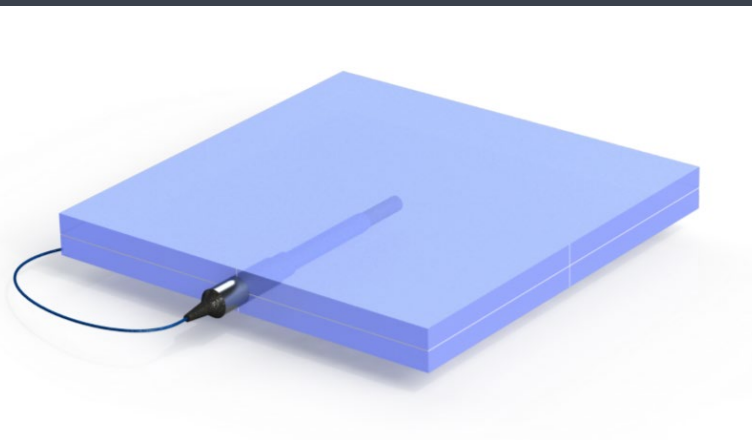
Ample space for personnel and equipment around the patient.



LINAC SETUP WITH PHOTON BEAM PARAMETERS FOR DOSE DELIVERY

Beam Characterization Tools

- Ion Chambers for external reference dosimetry
- Ion Chamber/Diode profile array characterization
- Water Tank Scans, standard for system acceptance testing

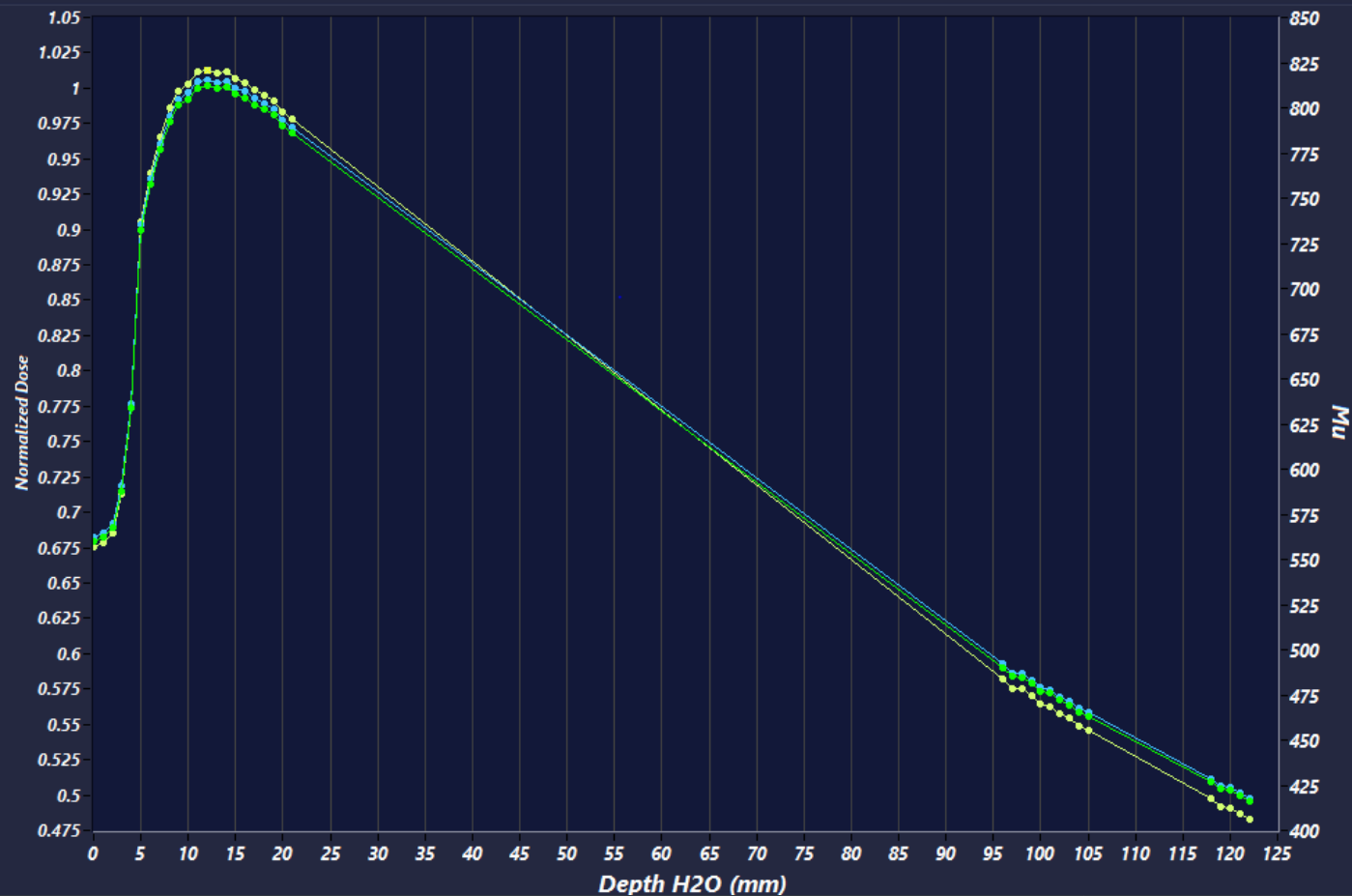


1D WATER TANK SCAN

file path (dialog if empty)

C:\Users\jlewandowski\Documents\Water Tank 1D\A3 SN6RR\
SN6RR_1038HV_Mag_103A_Grid15V_Gun_625mA_100Hz_Cath_15KV_Jan31_2021.csv

XY Graph



Plot 0
Plot 1
Plot 2
Plot 3
mu

- Gun Grid 15V @ 15KV: 620mA
- Water Tank Data

Normalize to Calculated peak?



Dmax mm

12.8735

D15mm mu D15/100 %

816.126

0.57589

Dmax mu

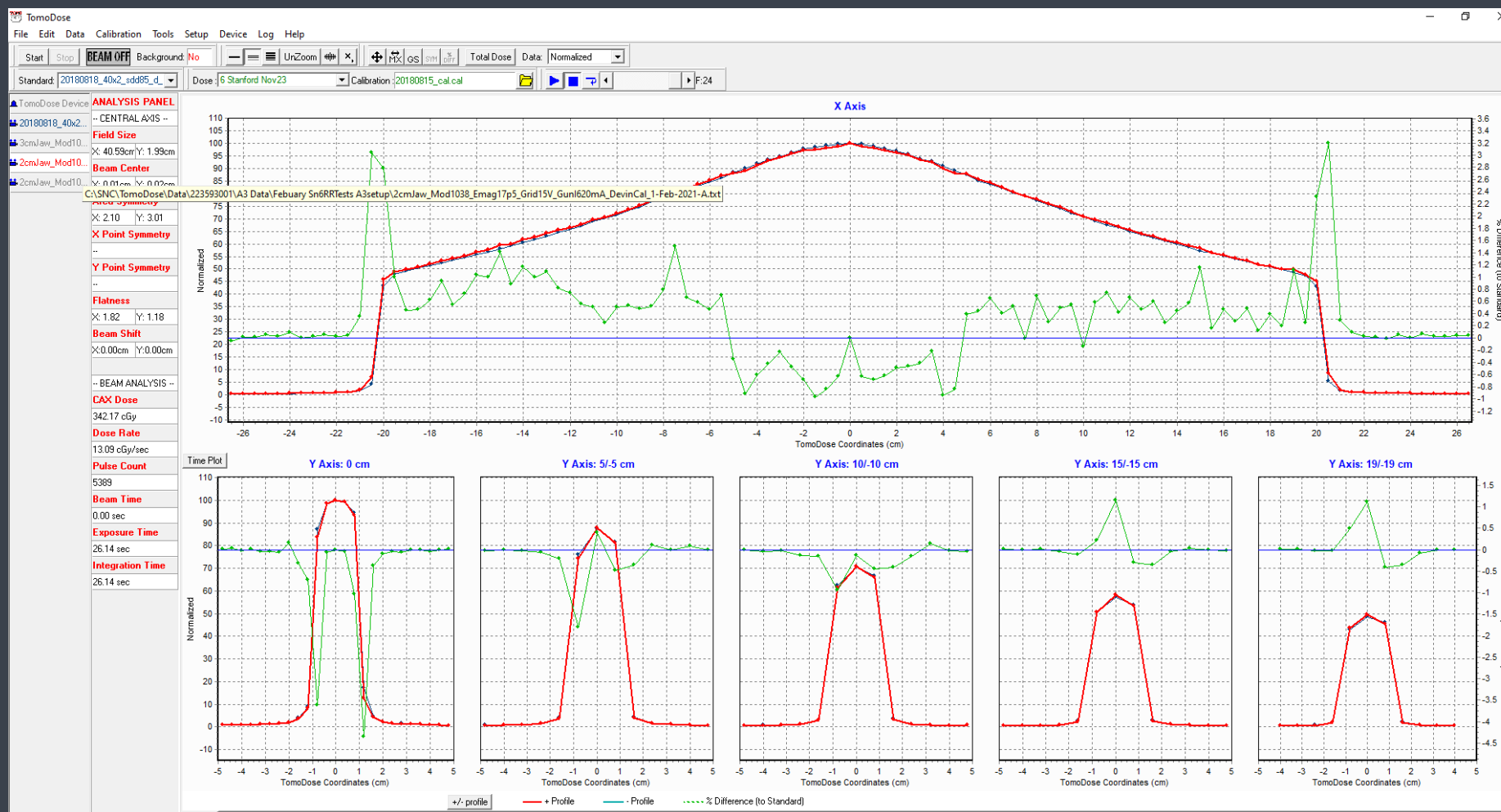
819.6

D10 mU

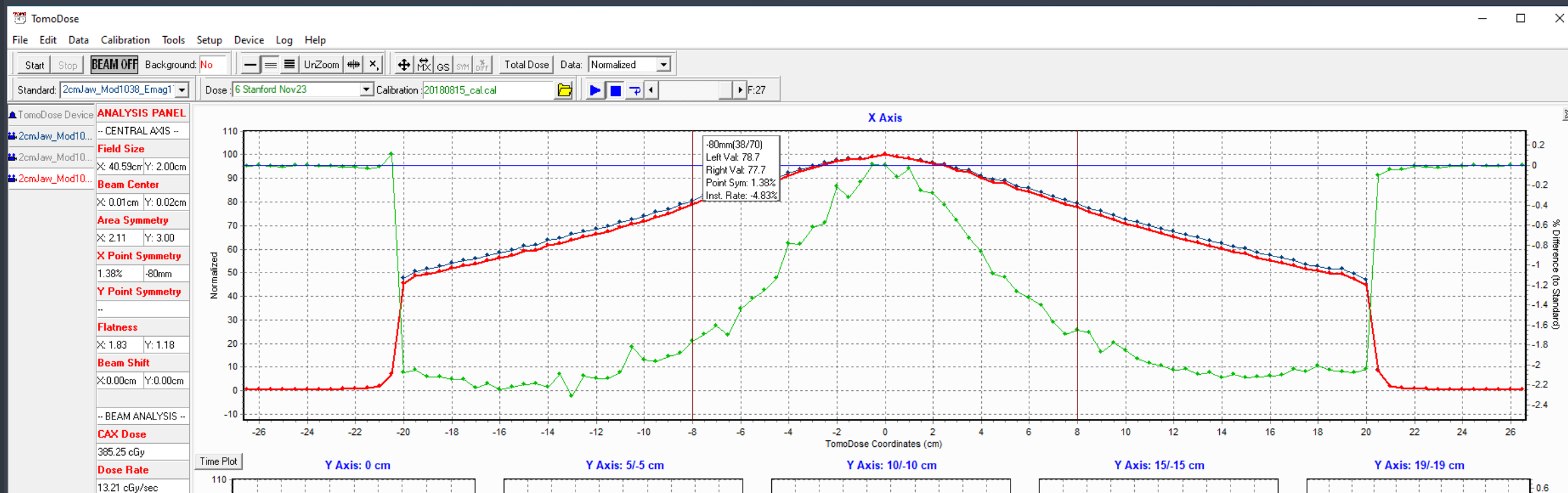
0.573449

TOMODOSE DIODE ARRAY PROFILE

CATHODE 15KV, GRID 15V, GUNI 662MA ADC



BEAM LOADING FINE TUNE PROFILE DIFFERENCE 820MA VS 640MA GUN CURRENT



FFF (FLATTENING FILTER FREE) PHOTON BEAM PROFILE

INCREASE OUTPUT, PLANNING SYSTEM COMPENSATES FOR NON FLAT DOSE DISTRIBUTION

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Georg, Knöös, and McClean: Flattening filter free photon beams

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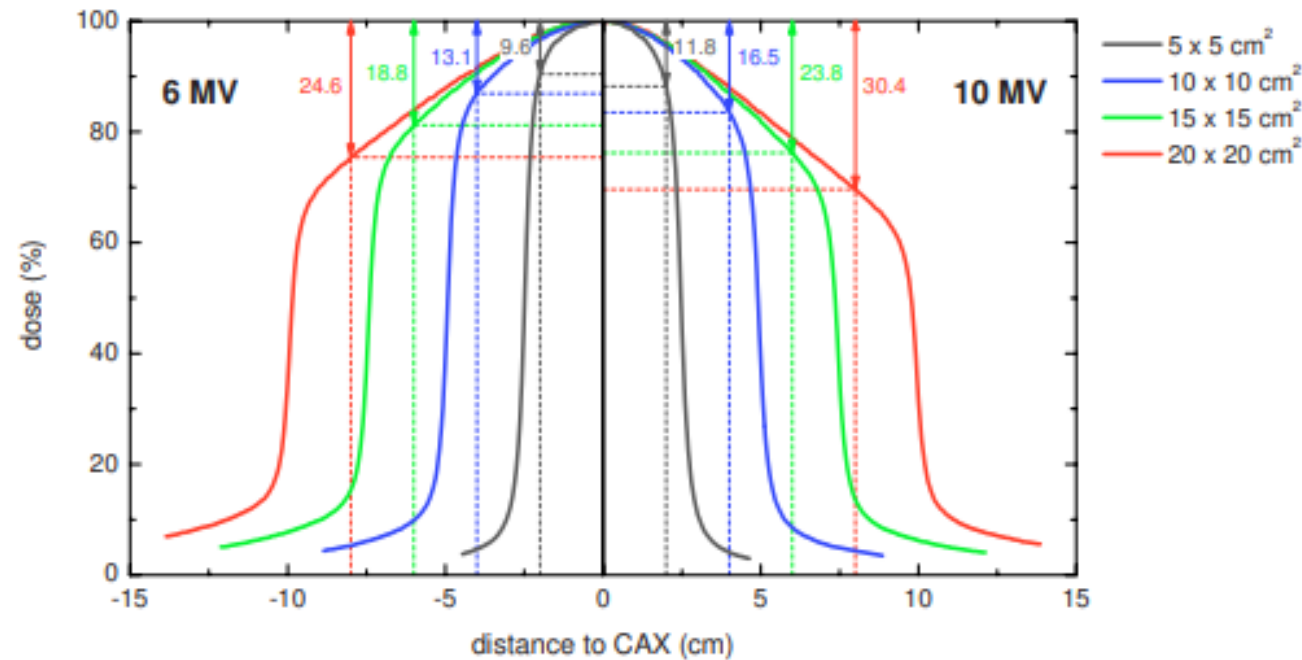


FIG. 3. Beam profiles of 6 and 10 MV unflattened photon beams provided by an Elekta accelerator, determined at 10 cm depth at source surface distance of 90 cm in a large water phantom with a diode (IBA, type SFD, $0.3 \text{ mm}^2 \times 60 \text{ }\mu\text{m}$).

Current status and future perspective of flattening filter free photon beams^{a)}

Dietmar Georg,^{b)} Tommy Knöös, and Brendan McClean
Department of Radiotherapy, Division of Medical Radiation Physics, Medical University of Vienna/AKH Vienna, A-1090 Vienna, Austria; Department of Physics, St. Luke's Hospital, Highfield Rd., Rathgar, Dublin 6, Ireland; and Radiation Physics, Lund University and Skåne University Hospital, S-221 85 Lund, Sweden

ACCELERATOR SYSTEM ISSUES

- Integration with imaging systems, pulsed EMF interference (MR),
- Imaging detector noise from linac radiation.
- Pulse to pulse stability without thermal equilibrium.
- Thermal response issues with dose, gun backheating
- Dark Current from cavity cells, Gun leakage.
- Target failure, pulsed heating, long term damage, crystal structure changes. How to set beam output? Balance peak Current issues vs higher rep rates to produce output.
- Radiation field uniformity for dose planning and delivery
- Accelerator tuning systems, "AFC" Automatic Frequency Control, transient response to thermal beam loading change, single pulse dose fill.
- Linac operation in high magnetic field, .35-1T.
- Dose distribution distortion due to Lorentz steering of secondary electrons in magnetic field. MRI Linac

ACCELERATOR DARK CURRENT RELATED ISSUES

- *New IEC Dark current specification, 1% of delivered patient dose.*
- *High E-Field cavity wall surface emission and capture*
- *Gun Design, leakage due to Grid bias, Barium Deposition emission sources*

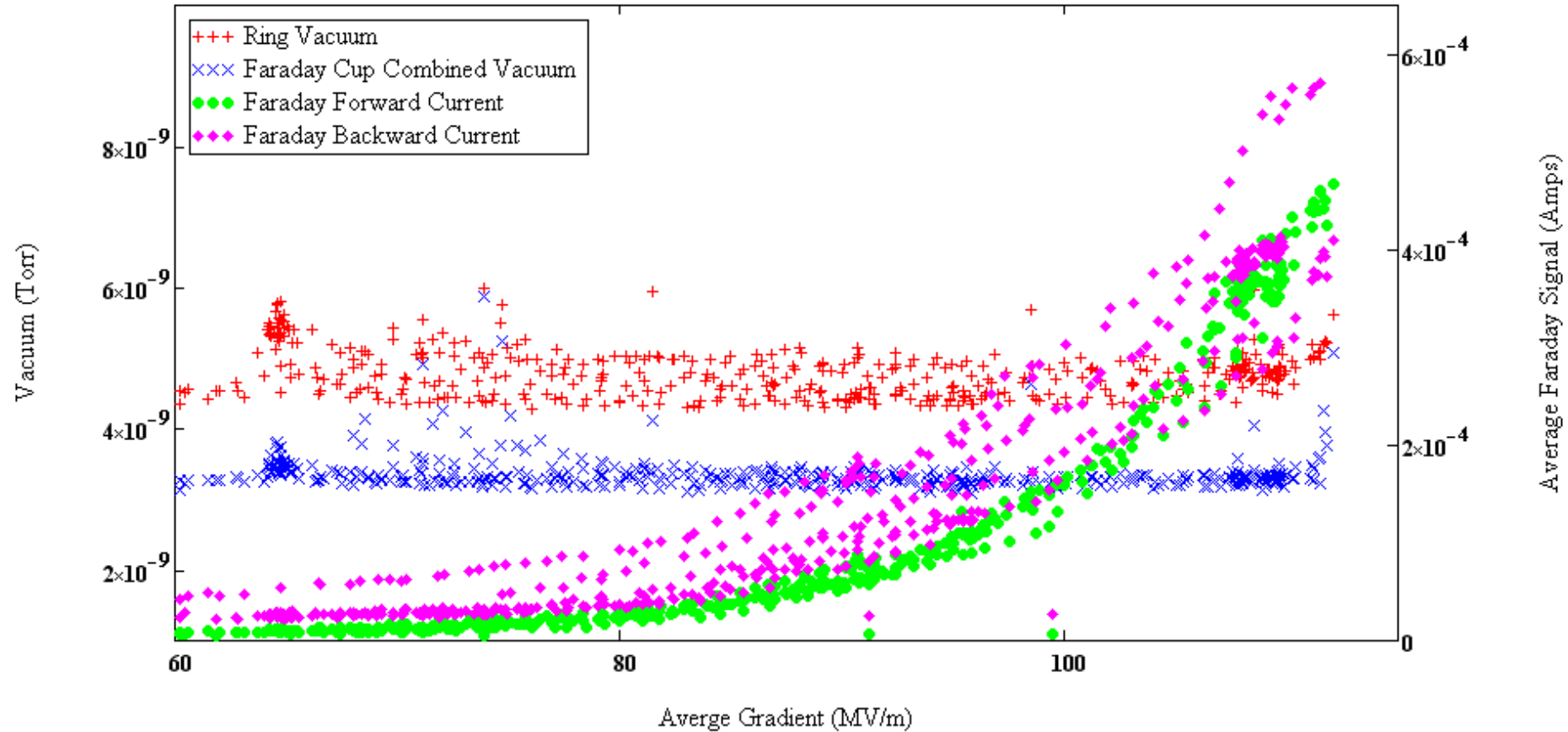
Dark Current Observations in the T18 Resonant Ring

***5th Collaboration Meeting on
X-band Accelerator Structure Design and Test Program
16-18 May, 2011
SLAC National Accelerator Laboratory***

Jim Lewandowski SLAC
5/18/2011

Multiple Power Ramps

T18 Resonant Ring Peak Faraday Current Vacuum Dependence on RF Power 600ns Pulse @ 60Hz



TREATMENT SYSTEM UPTIME

- Treatment system uptime and stability due to these issues..
- RF source failure (6 months magnetron)
- Target Failure? Weeks to months to years depending on design. Electron Gun Failure? Years?
- Failure of Modulator, Gun Driver, waveguide arcing...
- All issues necessitate removal/replacement of components from system affecting patient treatment accessibility

THREATS TO RADIOTHERAPY DUE TO MARKET ISSUES COMPONENT PRODUCTION NOT PROFITABLE (ENOUGH)

- Thyratrons. Previous manufacturers ITT, EEV, Perkin-Elmer....?
- Pulse transformers, a key component still in Solid State Modulator.
- Magnetrons & klystrons...

CONCLUSIONS

Accelerator Radiotherapy relies upon very old designs, 1934, 1962...

Great advances recently marrying real time imaging into treatment.

New paradigm shifts are great, but acceptance of new technology takes years to filter into the hospital.

Its an exciting and personally fulfilling area of accelerator applications to work.