



ACCURAY

Accuray's Experience Implementing the M100i Modulator on Radixact[®]

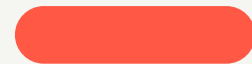
ScandiNova Users Meeting 2023



Gregory Garstka, Ph.D.
Senior Linac Systems Physicist
Linear Accelerator Systems R&D

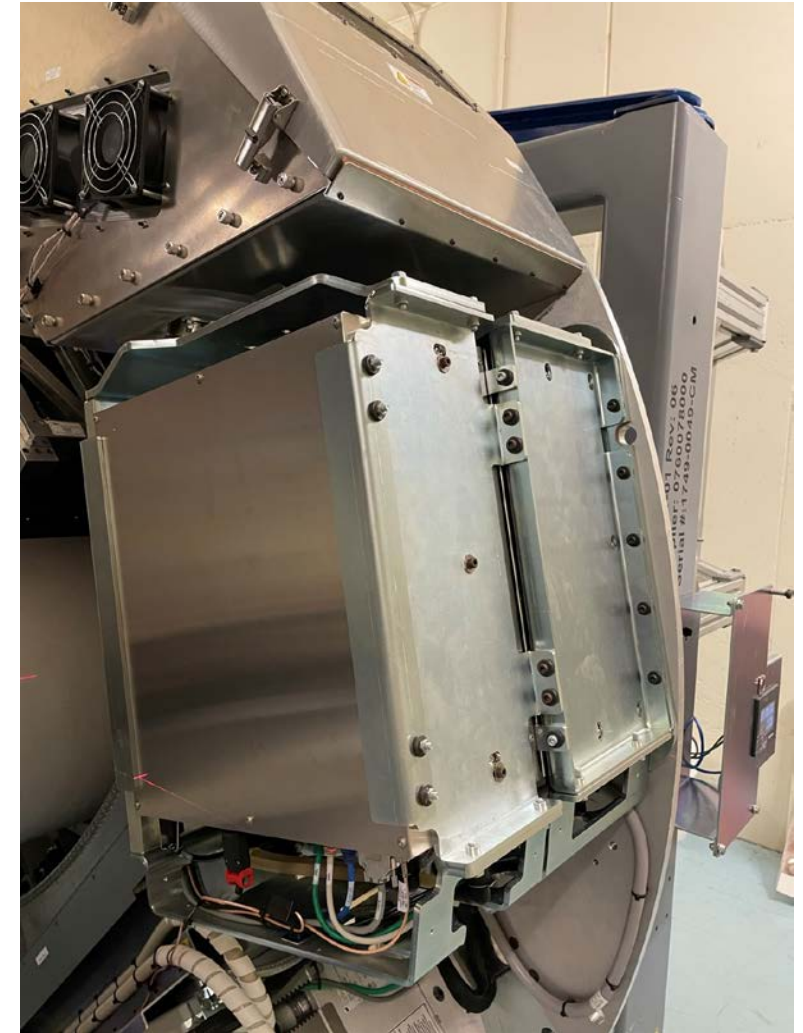
April 13-14, 2023

"Disclaimer: I am an employee of Accuray Incorporated. The views expressed in this presentation are my own and do not necessarily reflect the views of Accuray."



Overview

- About Accuray
- The Radixact Treatment Delivery System
- Implementing the M100i on Radixact
- Successes...
- ...and Challenges



A Brief History of Accuray

Accuray is a recognized leader in precise, innovative tumor treatments

A joining of two great Radiotherapy companies



Accuray Inc: Founded in 1990 by John R. Adler, MD, a neurosurgeon and professor at Stanford University



TomoTherapy Inc: Founded in 1999 by Rock Mackie, PhD, a medical physicist and a professor at the University of Wisconsin, Madison and his partner Paul Reckwerdt



In 2011, Accuray acquired TomoTherapy Inc. merging these two companies and products under the Accuray name



Sunnyvale, CA:
Corporate Headquarters, Robotics & Linac R&D



Madison, WI:
Manufacturing, R&D and Training

Accuray: Global Strength, Local Expertise

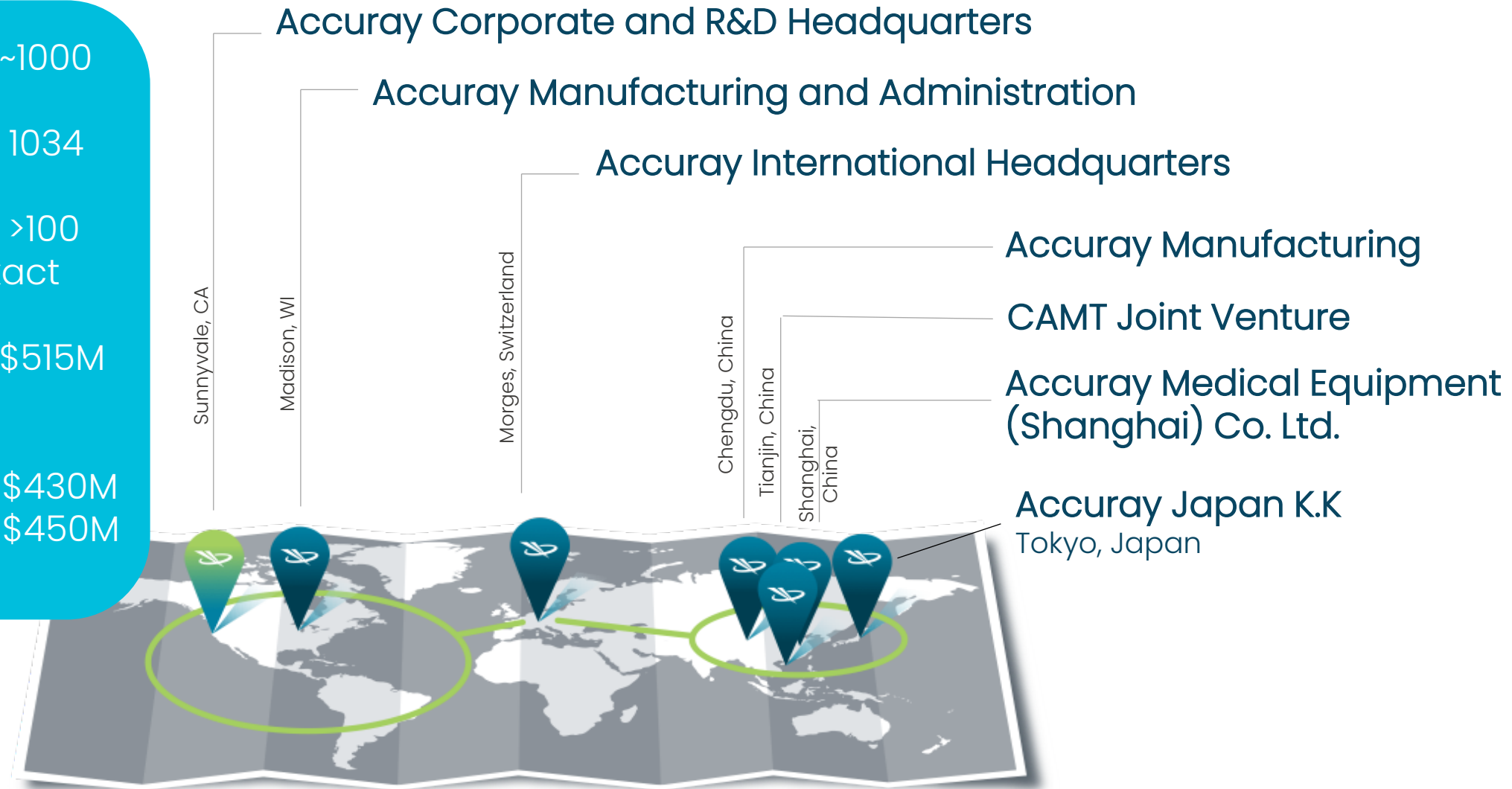
Employees: ~1000

Installed Base: 1034

Systems per Year: >100
Cyberknife & Radixact

Backlog: \$515M

Revenue:
2022 \$430M
2023 (proj) \$450M



Accuray's Products

Cyberknife

Radixact

Robotic
Radiosurgery

TomoTherapy



Cyberknife



- 6 MV Photon Energy
- X-Band (9.3 GHz)
- Magnetron 1.7 MW/1.4 kW
- Dose Rate: 800/1000cGy/m
- Non-Coplanar Capability
- PFN Modulator
(Pulse-Forming-Network)

Robotic Radiosurgery

Radixact

- 6 MV Photon Energy
- Standing Wave S-Band Accelerator (3 GHz)
- Magnetron 3.1 MW/4 kW
- Dose Rate: 850/1000cGy/m
- Tomo-Helical (up to 10 RPM) & Fixed-Angle Delivery
- Solid-State-Modulator

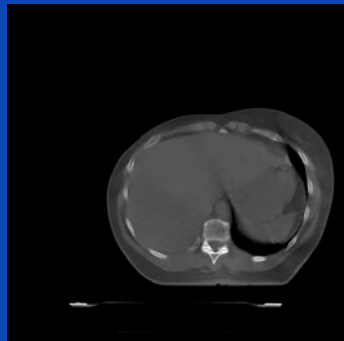
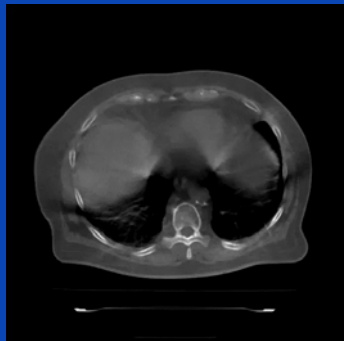
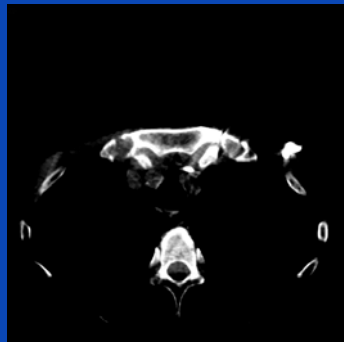


ClearRT™ Helical Fan-beam kVCT

KNOW MORE



ClearRT™



Helical fan-beam imaging provides...

● Image Fidelity

- Image represents true patient anatomy throughout the image

● Efficiency

- Fast rotation; reduced need for time-consuming and potentially inaccurate algorithms to reduce scatter

● Versatility

- Uniformity makes images more suitable for daily adaptive dose calculation
- Flexibility to image the full desired patient volume

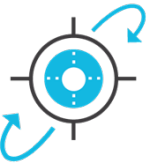
Cone-beam CT is inherently limited in both uniformity and scan volume*

* See, for example, Gardner et al. [https://www.advancesradonc.org/article/S2452-1094\(19\)30001-6/fulltext#fig3](https://www.advancesradonc.org/article/S2452-1094(19)30001-6/fulltext#fig3)

Patient image & image data provided by Willis-Knighton Cancer Center, Shreveport (LA), USA

*ClearRT™ Helical kVCT Imaging for the Radixact® Treatment Delivery System is not available for sale in all markets. ClearRT may be subject to international regulatory approval or licensing processes such that the availability of these products may vary according to geographical location.

No-tradeoff Radiation Therapy with Synchrony®



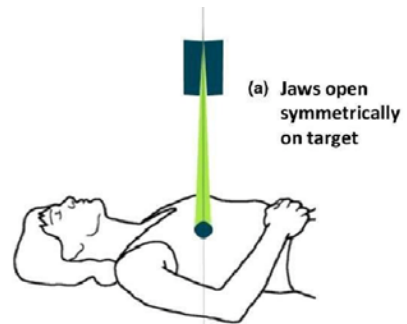
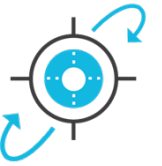
Synchrony® real-time tracking and delivery adaptation



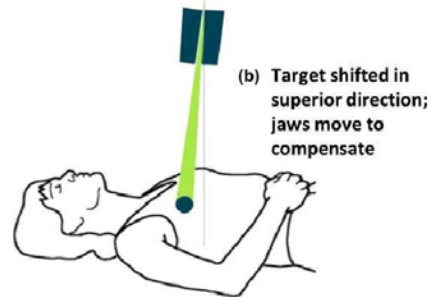
Leverage the same ClearRT™ kV hardware to precisely and efficiently treat targets that move

Synchrony[®] for the Radixact[®] System

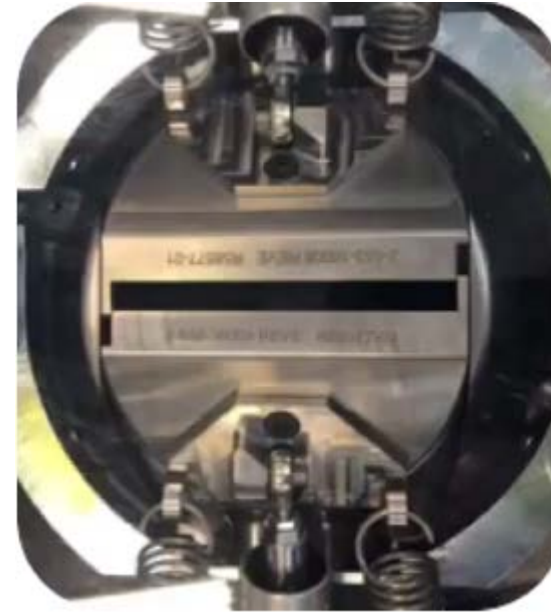
ENABLES CONTINUOUS DELIVERY AND PATIENT COMFORT



(a) Jaws open symmetrically on target

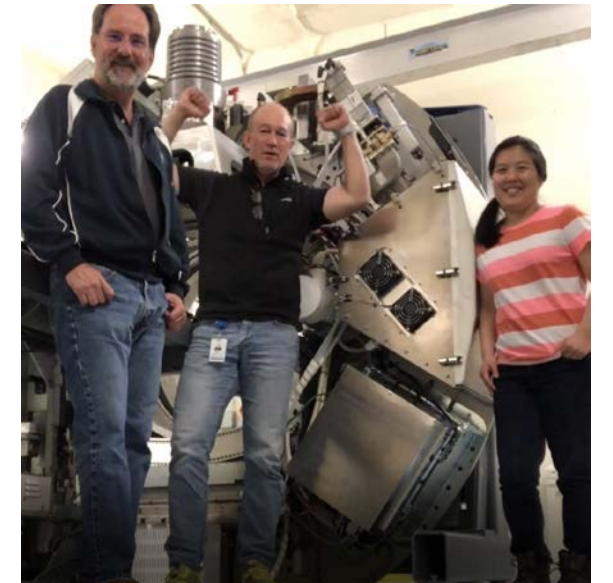
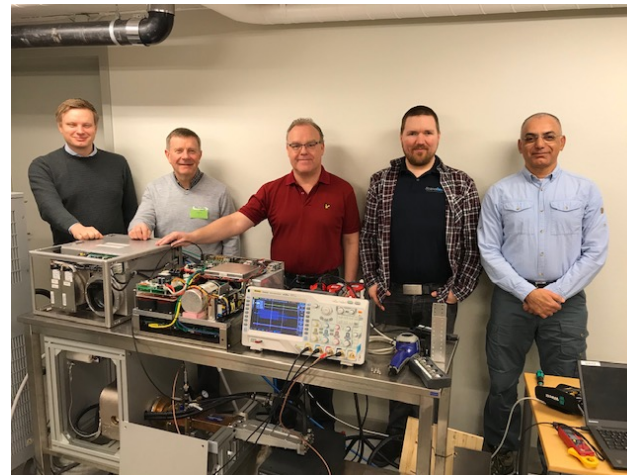


(b) Target shifted in superior direction; jaws move to compensate



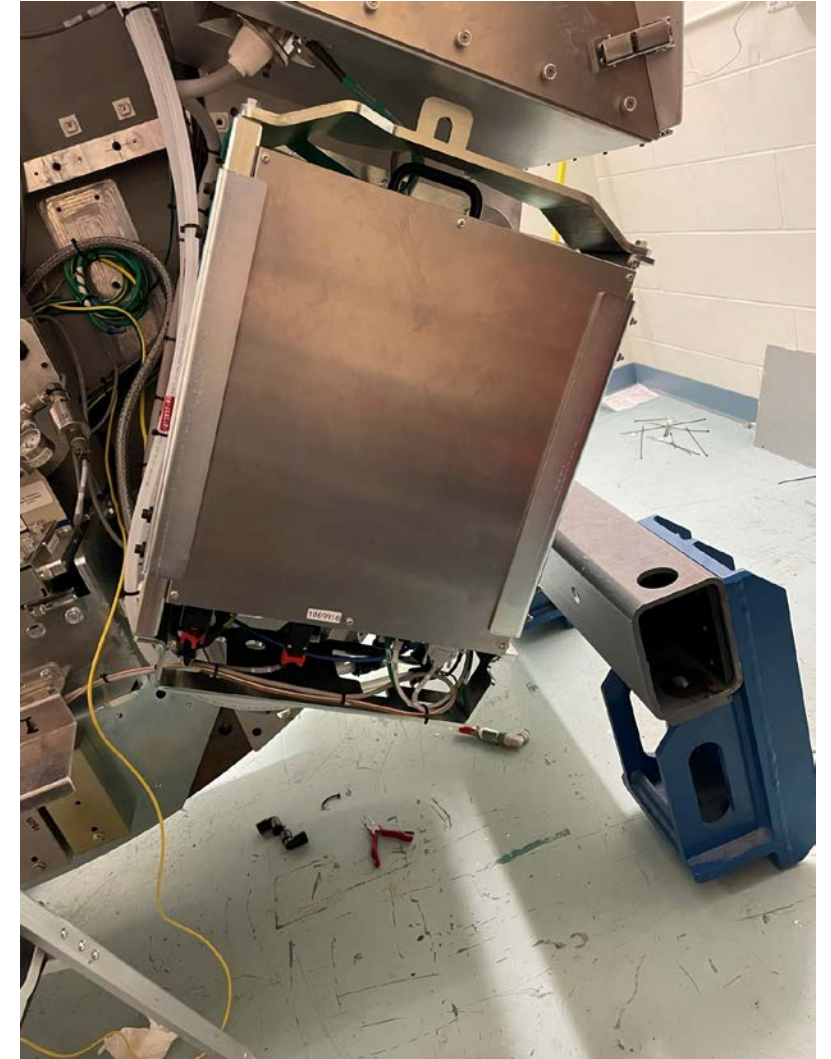
The M100i Modulator on Radixact: Timeline

- 2018: ScandiNova workshop held in Madison
- 2019: Project to implement M100i kicks off
 - Most of the development took place during COVID restrictions
- Sept 2020: First customer system goes clinical
- March 2023 M100i status:
 - Fully cut into forward production
 - Multiple field upgrades
 - Minimal issues – so far!



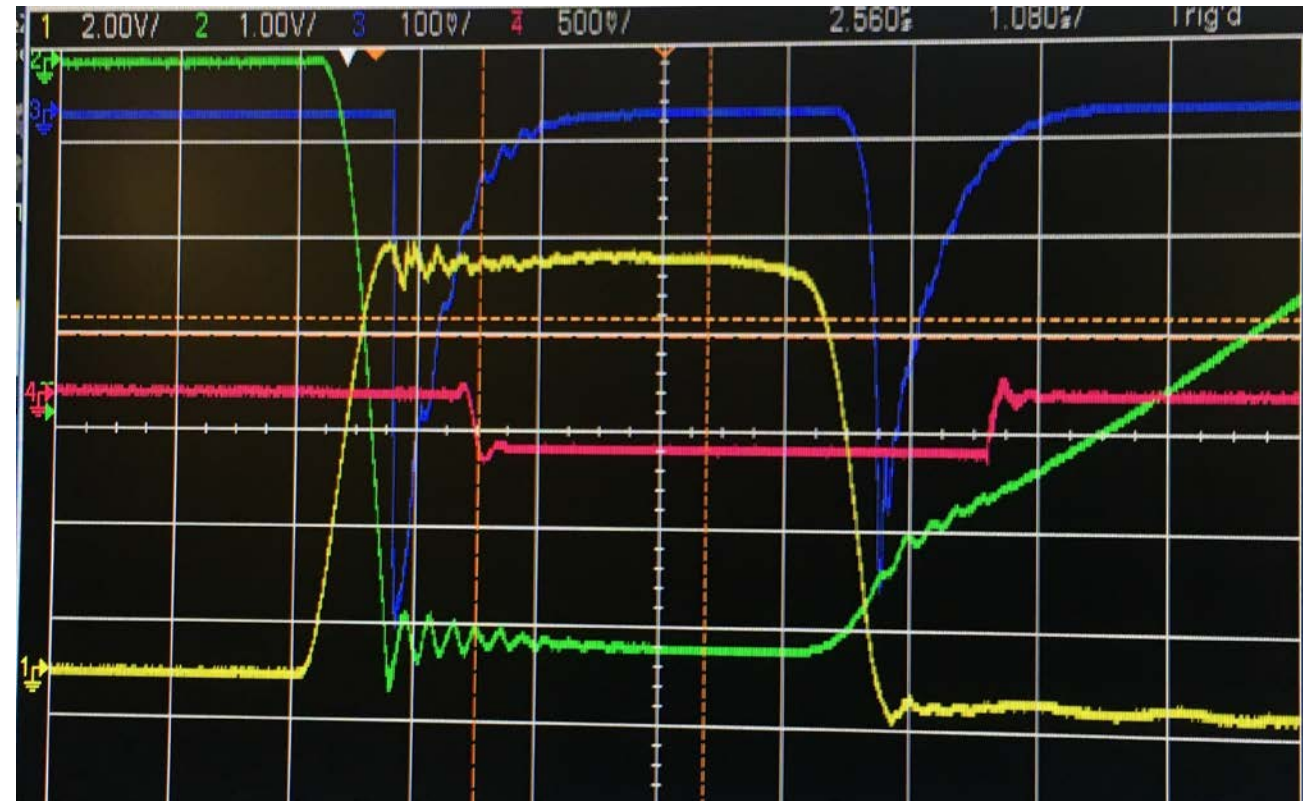
Why did Accuray choose the M100i for Radixact?

- Cost of goods
 - Roughly 25% reduction in cost over legacy modulator
- Footprint
 - Frees up room on gantry for other hardware
 - Enabled the ClearRT feature
- Serviceability and diagnosability
 - Separate components with clear functionality
- Reliability
 - Promising reliability testing in-house at Accuray and at ScandiNova



Successes!

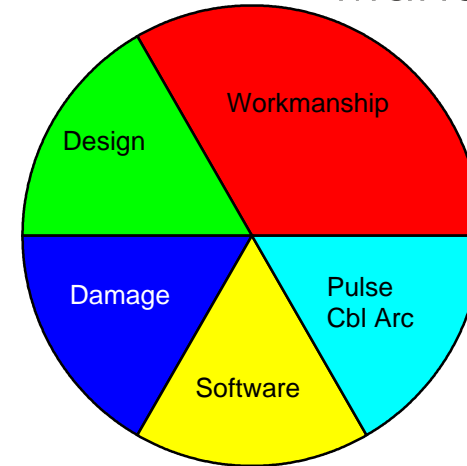
- Design & Implementation:
 - Introduction of CA4 connector (75kV) to eliminate connector failure issues others have experienced with CA11 connector
 - Introduction of adjustable bias voltage, minimizing audible noise
 - Successful operation at both treatment and MV imaging levels
- Manufacturing:
 - Full cut-in to forward production
 - 98 systems shipped
 - Integration into new product releases
- Field:
 - 19 field upgrades for ClearRT; more coming
 - Release of read-only GUI as service tool
 - Qualification of control board FRU



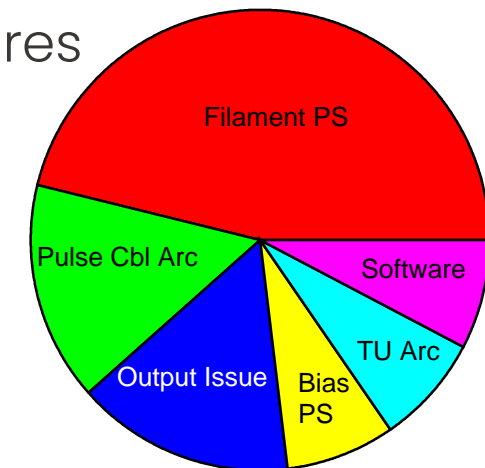
And Challenges...

- Manufacturing Failures: 6 reported as of February 2023
 - Disregarding minor issues
- Field Failures: 13 reported as of February 2023
 - 5 as out-of-box failures
 - Major causes:
 - Filament & bias power supplies
 - Pulse cable arcing
 - Dose output issues
- Accuray FRU Strategy: Uptime is key
 - Replace pulse unit or tank unit
 - No deeper troubleshooting at customer sites

Manufacturing Failures

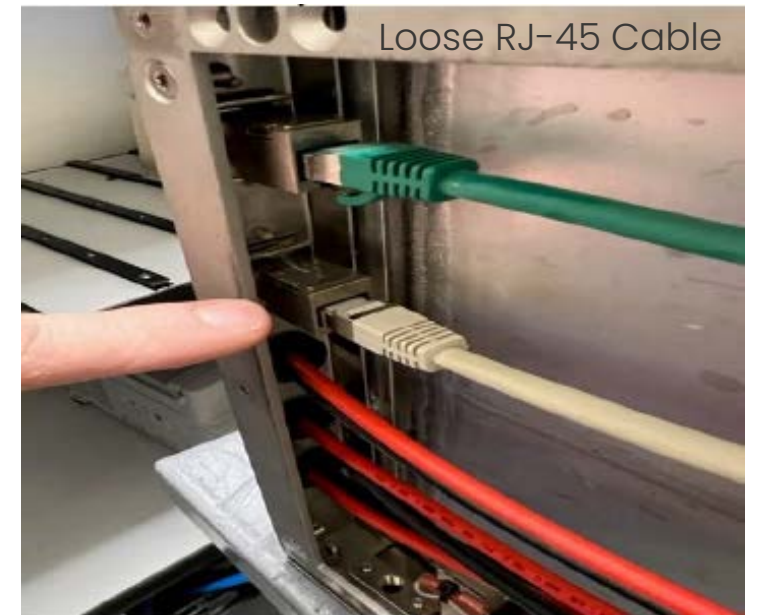


Field Failures



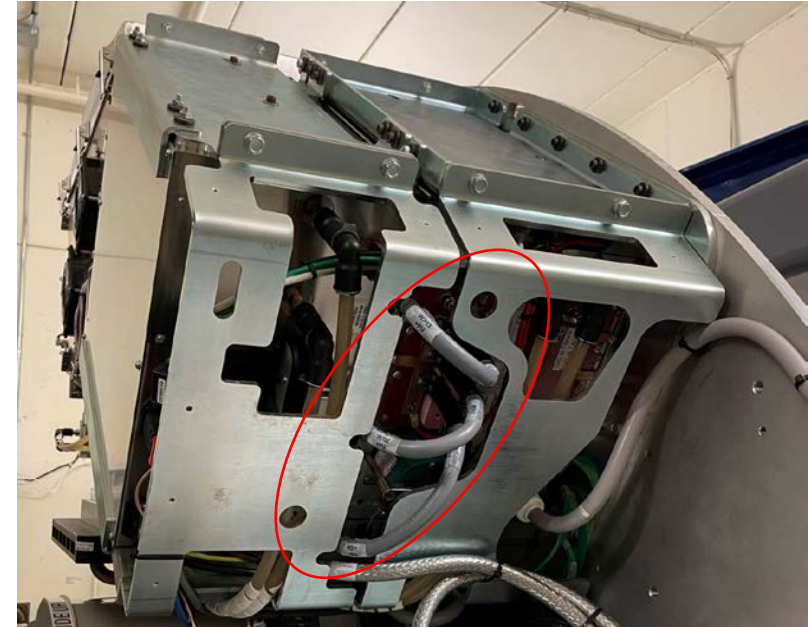
Filament Current Issues

- Multiple returns associated with magnetron filament current errors
- Most failures appear to be caused by poor connections
 - No one single connector or cable at fault
- Observed in the field but not in the factory
 - May be partly due to user error or shipping issues
- Solutions:
 - Identify opportunities for improvement in assembly
 - Improved training of field service personnel
 - HV cable installation, handling
 - Review packaging and shipping procedures



Pulse Cable Arcing

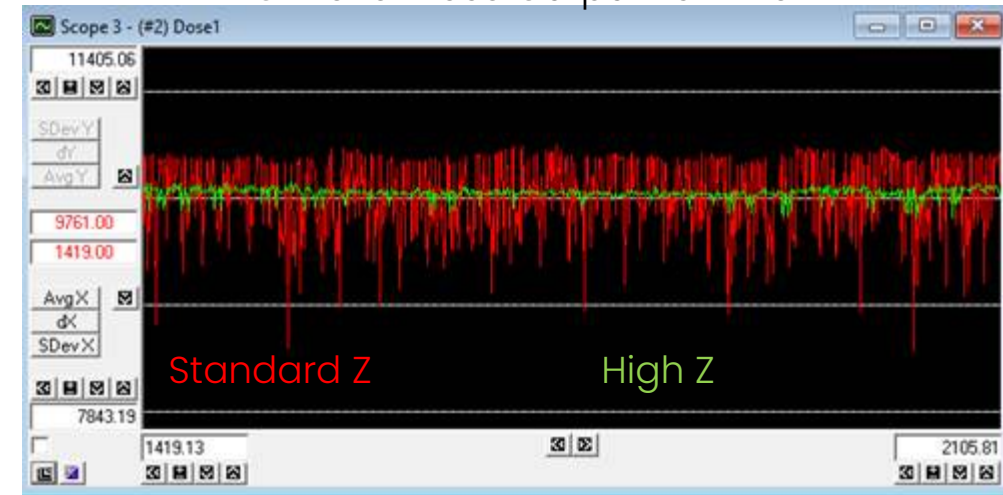
- Radixact design places the TU and PU in close proximity
 - Short pulse cables → tight bend radius
 - Cables often not seated correctly due to improper installation
 - High voltage side installed “blind”
 - Results in series arcing
- Solutions:
 - Improved work instructions (including a detailed drawing from ScandiNova)
 - Better training of personnel



MVCT Level Jitter

- Radixact has two output levels: Treatment (850/1000 cGy/min) and Imaging (75) cGy/min
 - Imaging level ~33 kV pulse output vs ~40 kV for Treat
- Pulse startup RRV $\propto V$
- Magnetrons start best within a narrow range of RRV
- At MVCT, pulse jitter and noisy dose output observed
 - Affects image quality

MVCT Level Dose Output vs Time

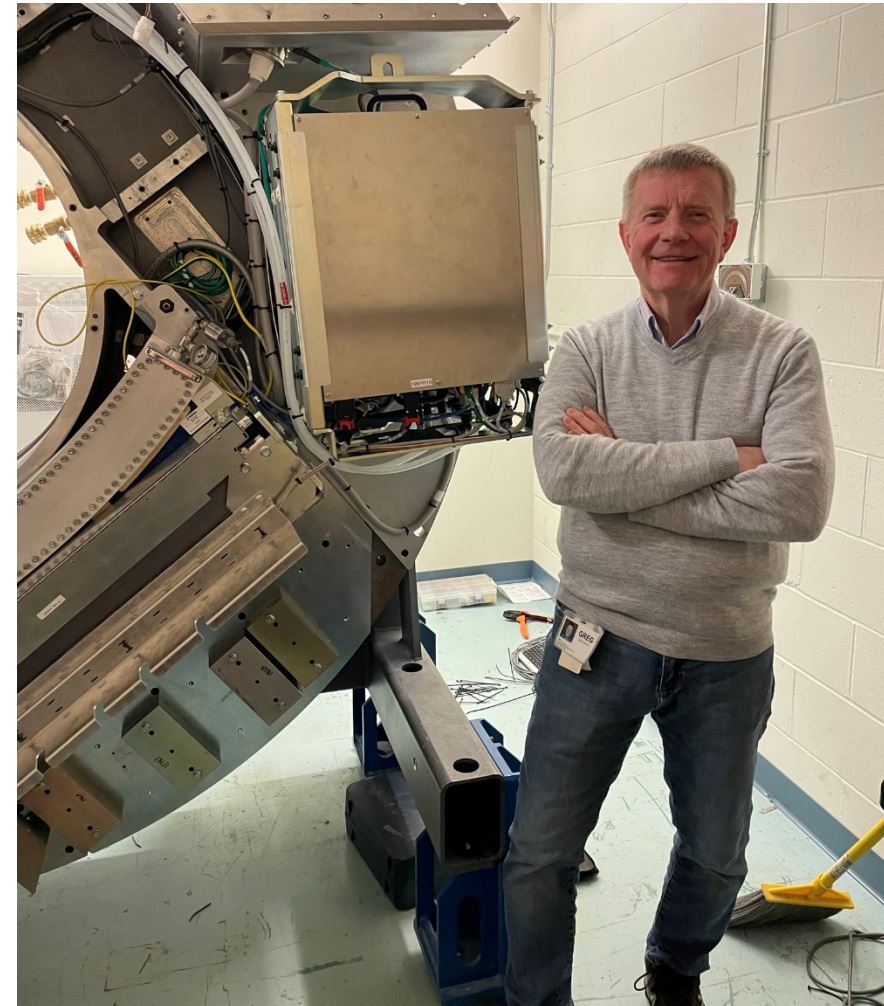


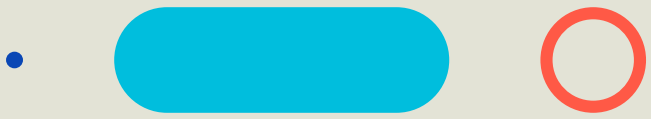
- Solutions:
 - Run at slightly increased impedance!
 - Adjust magnetron electromagnet
 - Increases V & RRV
 - Eliminates jitter



Summary

- The M100i modulator has been successfully implemented on Radixact as the modulator of choice moving forward
- 98 new systems shipped & 19 field upgrades
- Tackling & overcoming learning curve issues
- Looking forward to future development work with ScandiNova as partners





Thank you

ACCURAY

