

Robust Wire Scanner for High Intensity Beam Profile Diagnostics

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- RadiaBeam – an accelerator company
- Need for Fast Wire scanner
- Phase I feasibility results
- Engineering
 - Diagnostics
 - Timing
 - Layout
- Phase II experiment studies at JLab
- Summary

RadiaBeam

an accelerator company

A quick overview.

The Beam Team



- Founded in 2004
- Approximately 55 employees and growing
 - PhD Scientists (12), Engineers (22), Machinists (10), Technicians (6), and Administrative (5)
- 32,000 ft² headquarters
 - Located in Santa Monica, CA, near Los Angeles
 - Fabrication shop, radiation bunkers, laboratories
- In-house design, engineering, manufacturing & testing
- \$11 million revenue in 2017
- Current product line:
 - Linac systems and betatrons
 - RF structures
 - Magnetic optics
 - Beam diagnostics
- Strong R&D program in the following areas
 - Advanced acceleration techniques
 - Improved industrial and medical accelerators
 - Novel accelerator components and instrumentation

We love beams.

RadiaBeam's purpose is to contribute meaningfully to the world of accelerator science and technology.

High-energy particle beams are cool.

That is why we do what we do. We are a company founded by accelerator physicists, for accelerator physicists.

We are driven by an **entrepreneurial spirit** to make our operations as efficient and profitable as possible, without sacrificing our purpose.

Our work shows our **love for accelerators**. We understand what our products do and want them to fulfill their purpose to the greatest extent possible.

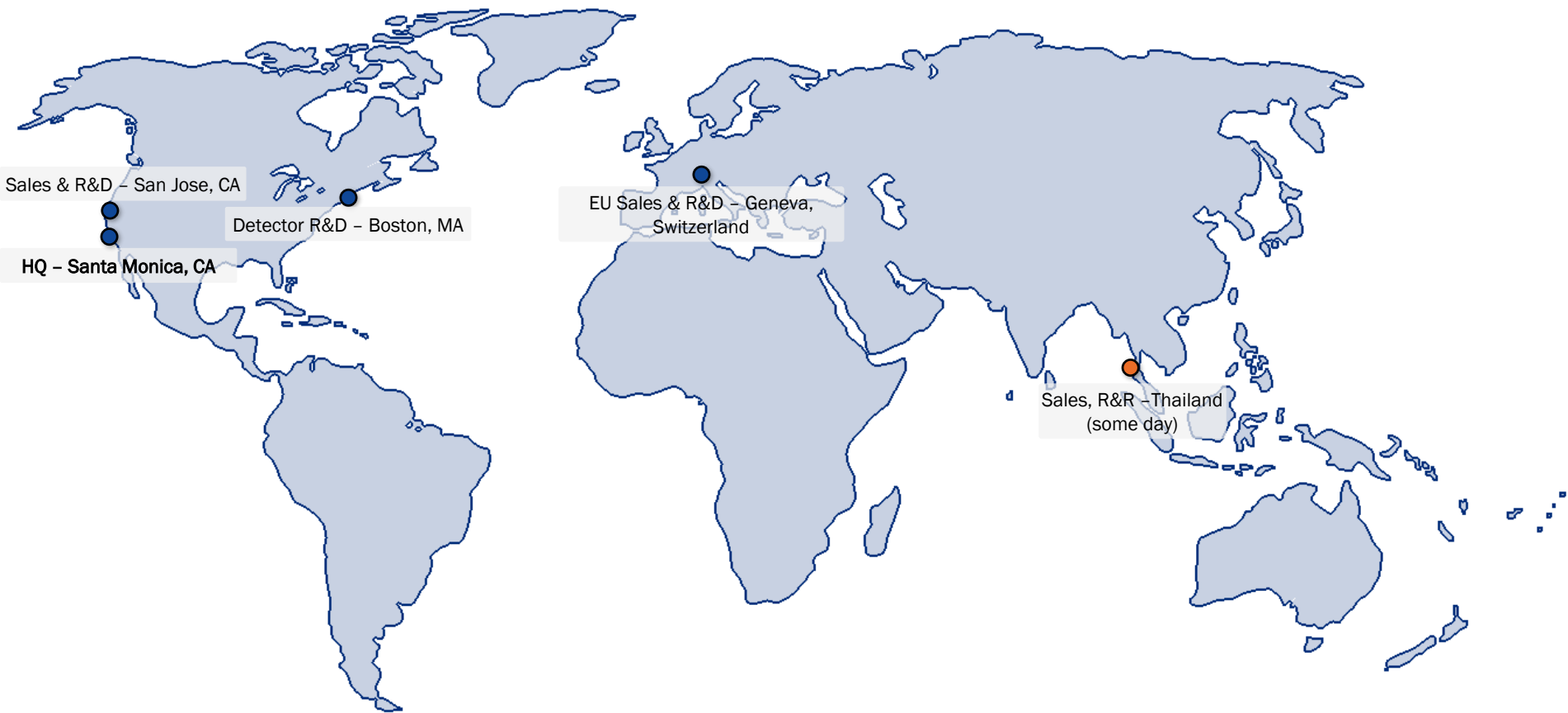
In less than a decade, we became the predominant accelerator R&D company in the US. We believe our innovative approach has the potential to serve large commercial markets, such as **radiotherapy and X-ray inspection**, with superior accelerator products.



Global Locations



Three locations in US and one in the EU.



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www.radiabeamsystems.com

Our Products



More than 1,000 products delivered since 2004. Everything we build has been custom designed, engineered, and built in-house. Several new products are designed and launched every year.



Magnets



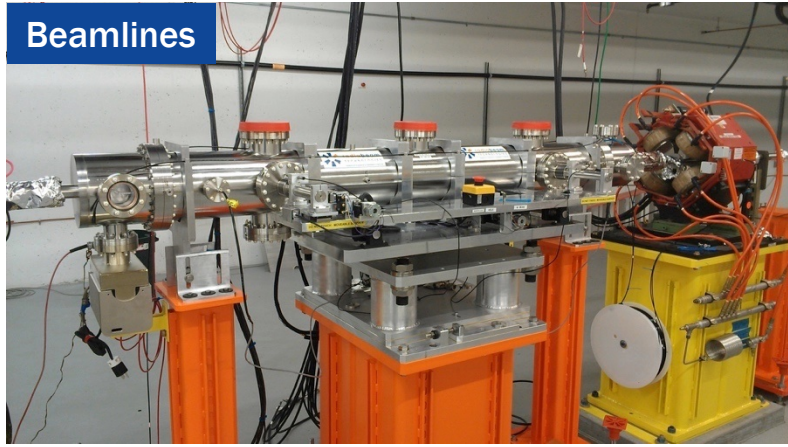
Diagnostics



RF Structures



Linac Systems



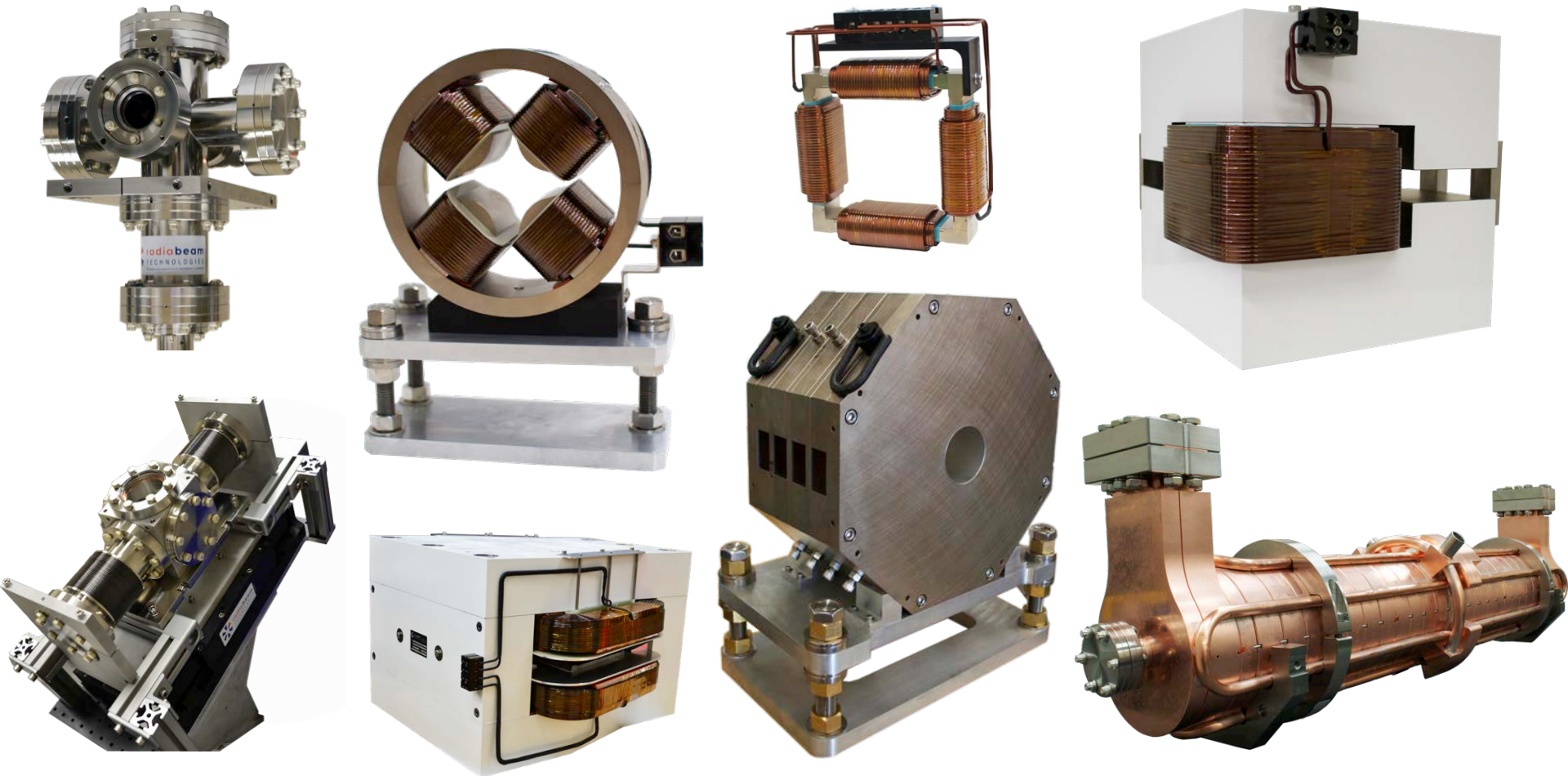
Beamlines



Betatron

Wide range of offerings

A small selection of key components



Our Customers



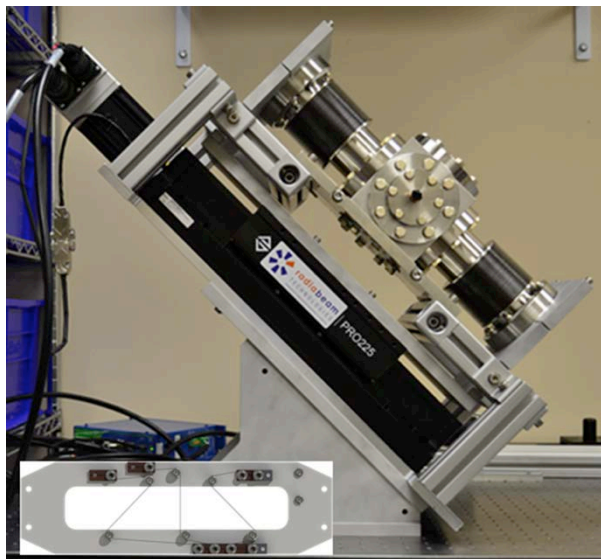
Research institutions, universities, and industrial. More than 50% of our sales are exports.



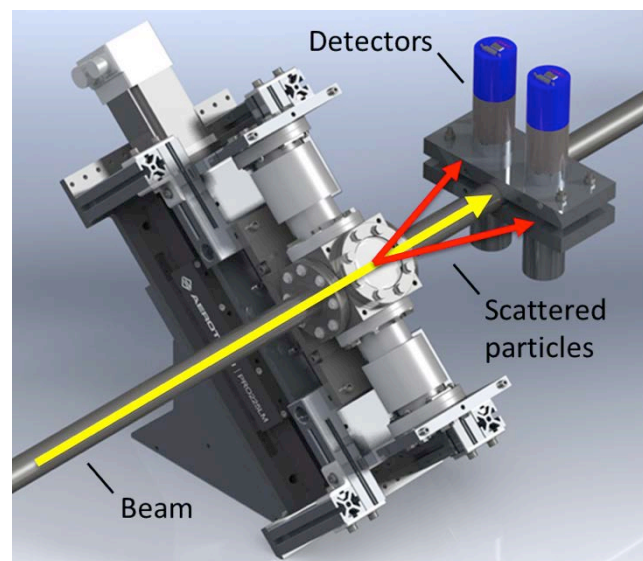
BNNT Wire Scanner Development

The *Ultra Wire Scanner*

- RadiaBeam is experienced company in particle beam and radiation diagnostics
 - Array of various customizable modular diagnostics
 - Relations with National Labs, universities, industrial partners, US and international
 - Currently offer a wire scanner for XFELs, installed at the PAL-XFEL
 - Motion control + diagnostics for Dechirper at SLAC
 - Nearly one-hundred actuated beam diagnostics in service
- Commercialization of wire scanner for multi-use applications
 - Use lessons-learned for streamlining product
 - Modular components for “quick” customization



- Wire scanners
 - Diagnostics for particle accelerators that provide transverse profile information
 - Thin wire moves through beam; interception produces X-rays
 - Simultaneous measurement of position and X-ray signal
- Issues
 - Resolution depends on wire thickness
 - Damage threshold of thin wires (intense beam application)



Typical Designs

- Single-ended actuator
- Typically use traditional rotary motors
- Tend to use rotary encoders, causing error in measured position
- Basic wires: tungsten, silicon carbide, carbon, CNT

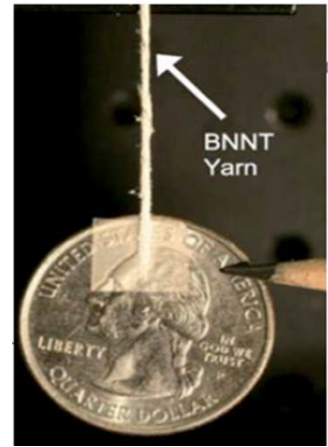
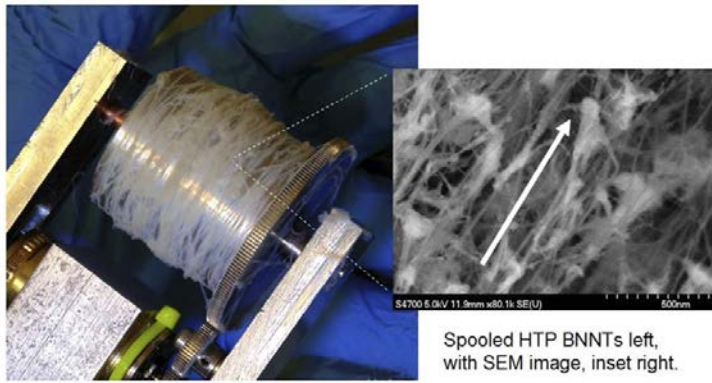
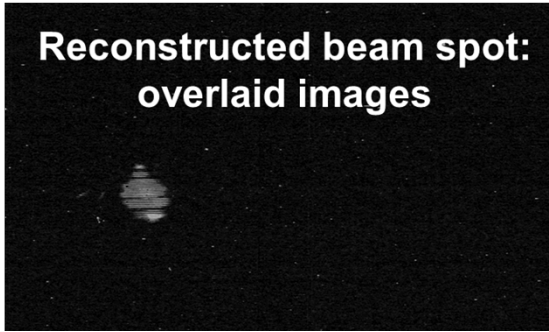
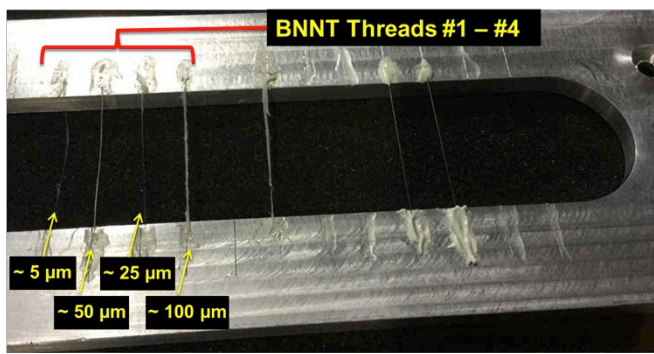
State-of-the-art

- XFEL wire scanners
 - Fast linear motors
 - Dual encoders, one fast-triggering, one absolute
 - Dual-ended reduces vibrations
 - Cherenkov fiber signal detectors
 - Advanced control scheme
- Flying and rotary wires

- **Project Goal:** Develop Fast Wire Scanner with robust BNNTs
 - As a product, not an experiment
- **DOE NP Relevance:** Beam diagnostics for high power beam are necessary technology for DOE NP accelerators (and others)
 - Improve current designs mechanically
 - Integrated system for drop-in operations
 - Realize truly novel designs – more physics driven, less manufacturing driven
 - BNNT for high resolution
 - BNNT for robust operation under extreme conditions

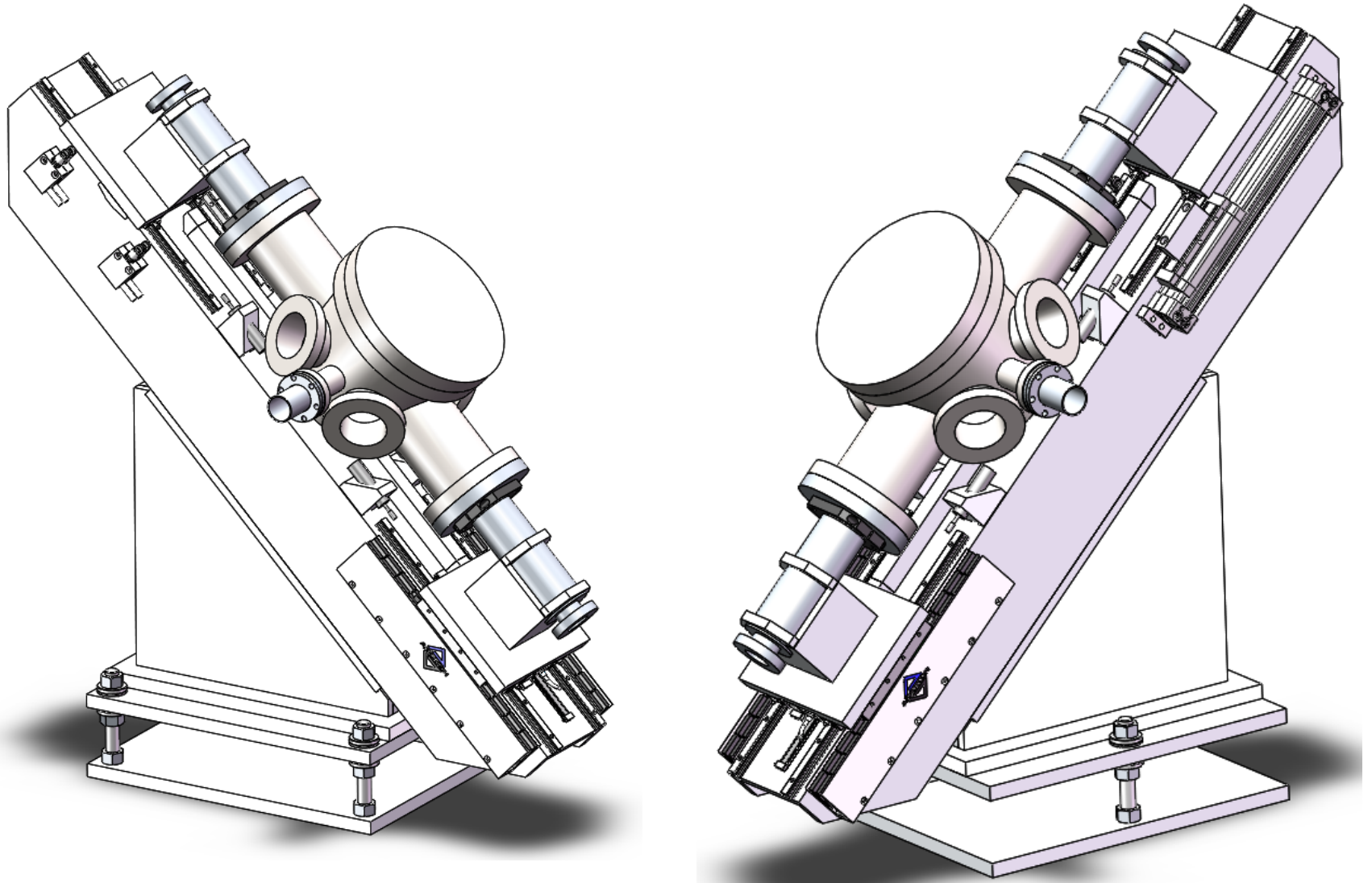
- Boron-Nitride Nanotubes (BNNT)
 - Similar to CNT
 - Mechanically robust and superior at high temperatures
 - Ideal for Wire scanner for intense beam application
- Tested in Phase I feasibility studies
 - Survivability
 - Integrability
 - Photon emission (flourescent, coherent?) also key
- Current project
 - Engineer fast wire scanner with BNNT
 - Also compatible for traditional radiators
 - Complete *mechanical* system “plug and play” with detectors, motion, etc

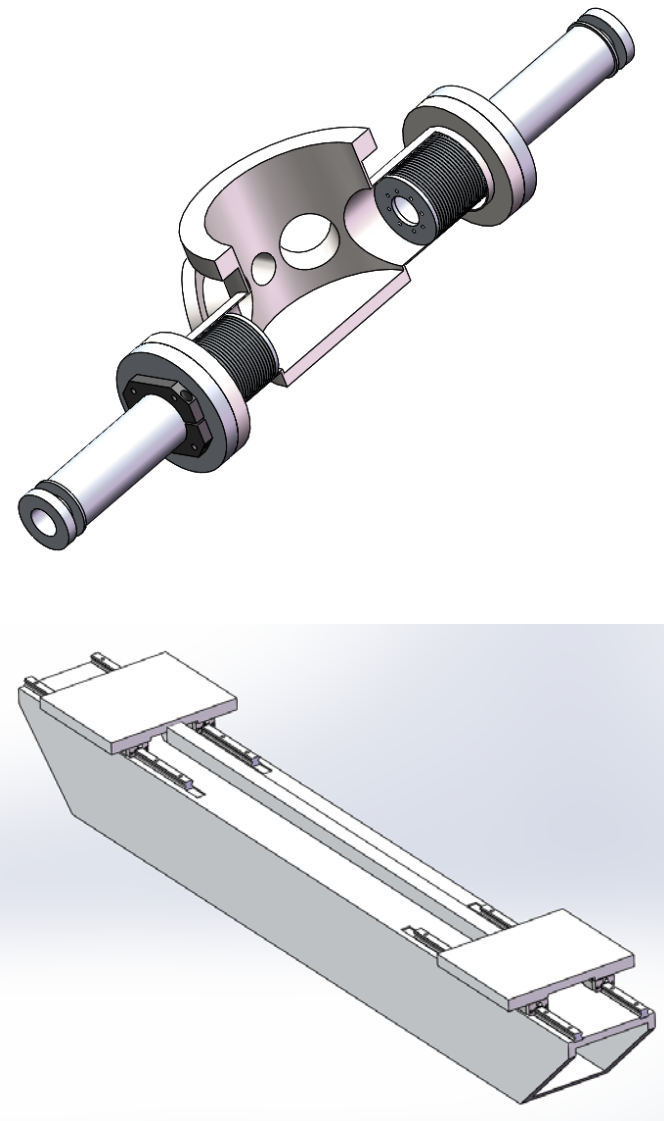
- Beam mounted on fork
- Profile reconstruction
- Anomalous photon emission
 - useful for benchmarking



Engineering

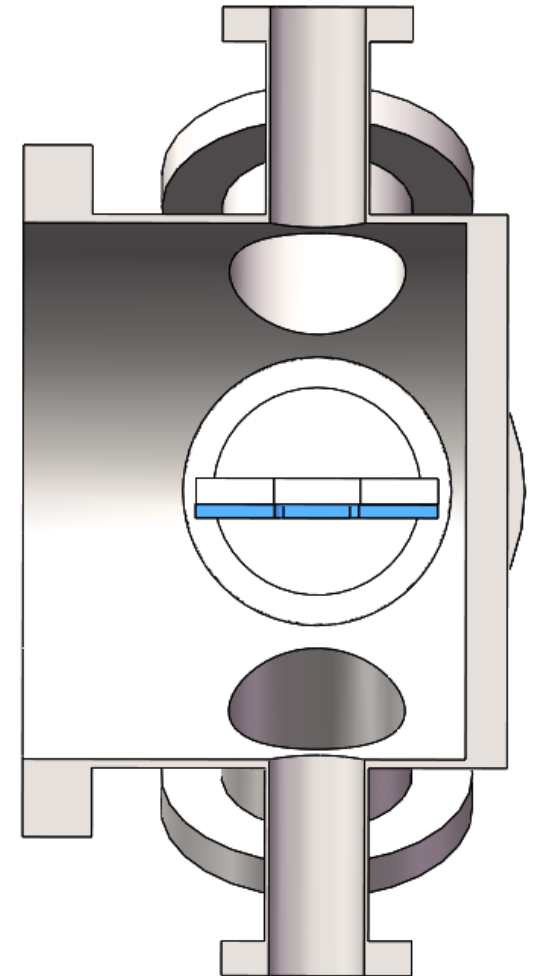
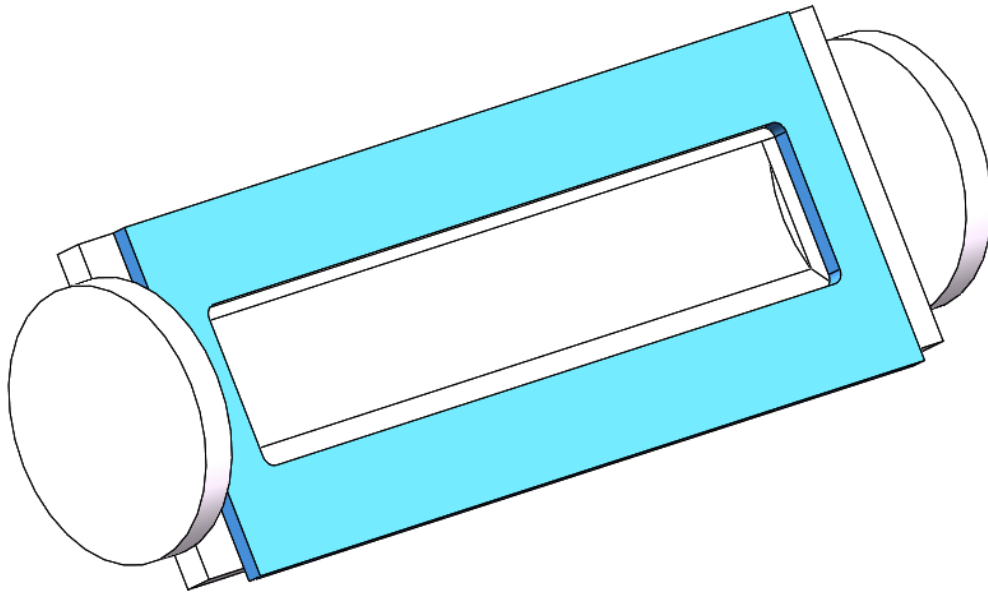
RadiaBeam fast wire scanner





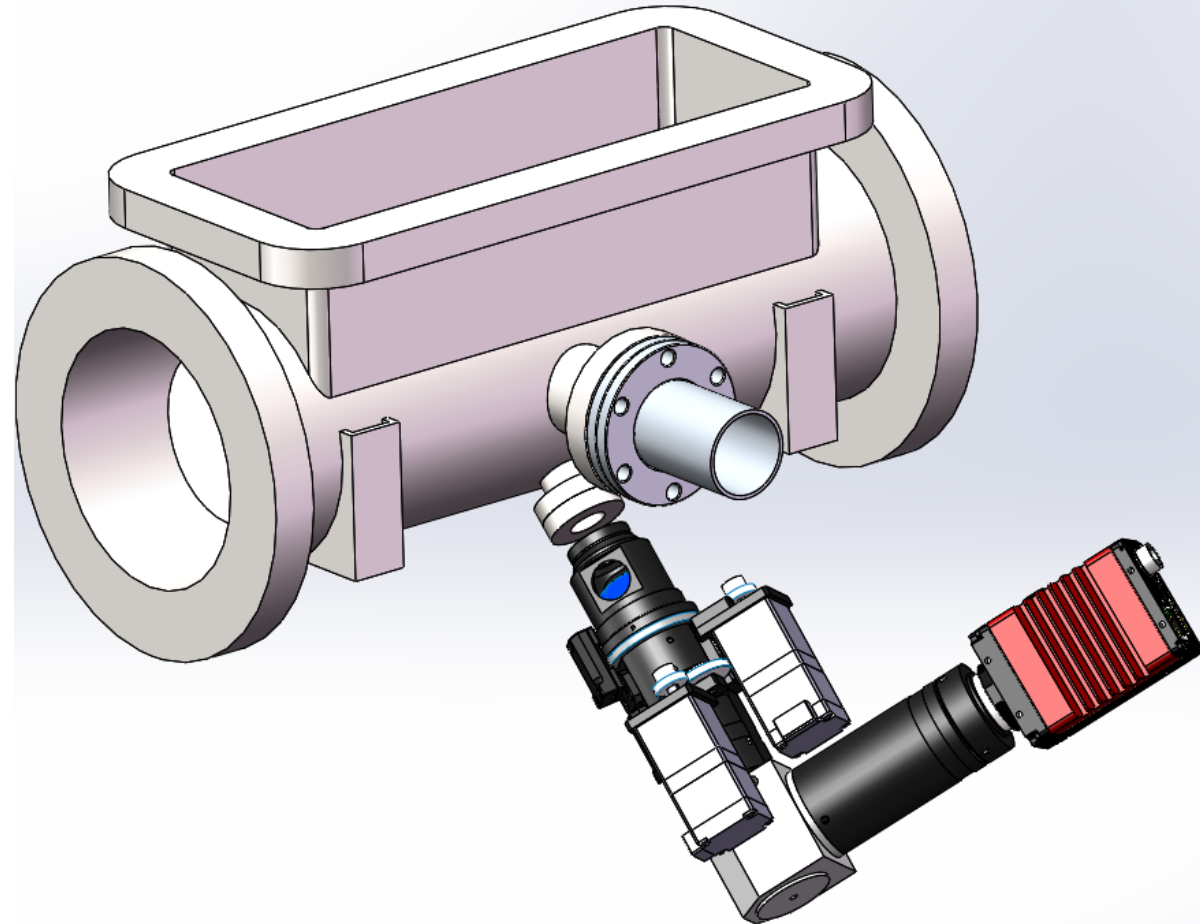
- An improvement over our XFEL wire scanner used at PAL-XFEL
- Uses our standard “re-entrant” bellows for robust and continuous operation – excels in superconducting areas
- Singular strong back for reproducibility
- Rad-hard fast encoders
- Triple redundant fail-safes built in

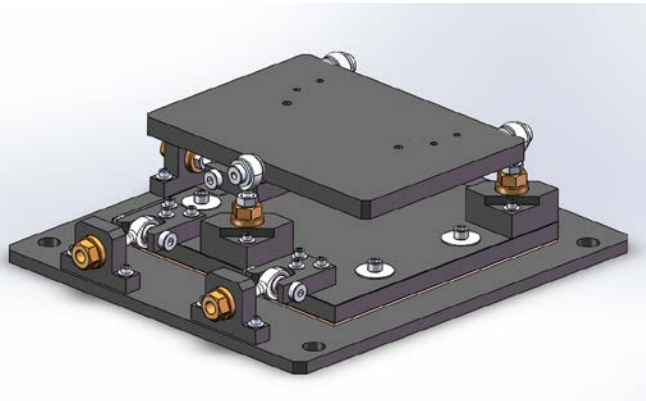
- Custom interaction chamber
- Swappable wire card
 - BNNT or other (Tungsten, Carbon, etc)
 - Minimize downtime when wires fail



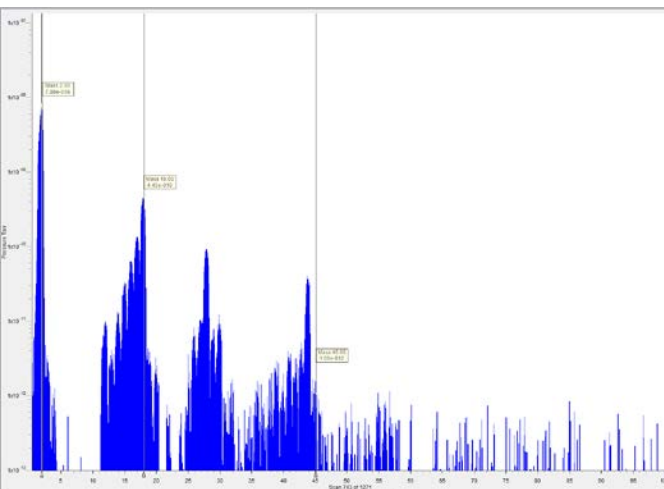
Optical setup

- Optical layout for imaging light emission off BNNT
- Secondary: Monitor for “health” of fibers in-situ
- Built upon our wide-range of beam imaging products
- Allows a new measurement format





- 6-axis alignment
- Vacuum pumps
- “Grout-up” delivery
- Particulate-free processing
- Certified hydrocarbon-free to LCLS-II standards
- Spare wire-cards
- Beam loss monitors
- Future: Control system



- Continued characterization of BNNT threads
 - Specifically for wire scanner application
 - Tensile strength, temperature and radiation resistance
 - Failure modes
- Test at two facilities
 - GTS facility: 40 MeV, 5-50kW
 - Low energy test with focus on fluorescence or prompt emission
 - CEBAF: first with pulsed mode, second MHz
- Measurements
 - Beam loss: Cerenkov fiber + PMT
 - Current loss: directly from custom card
 - Emission: fast photodiode and camera
- Integrate into JLAB eco-system
- Testing commences October 2018, CEBAF test 2019

- Develop fully integrable, drop-in wire-scanner
 - Further develop control system in-house
- Further investigate physics mechanisms of emission to determine if viable for other diagnostics
 - Planar radiator with BNNT “fabric”

