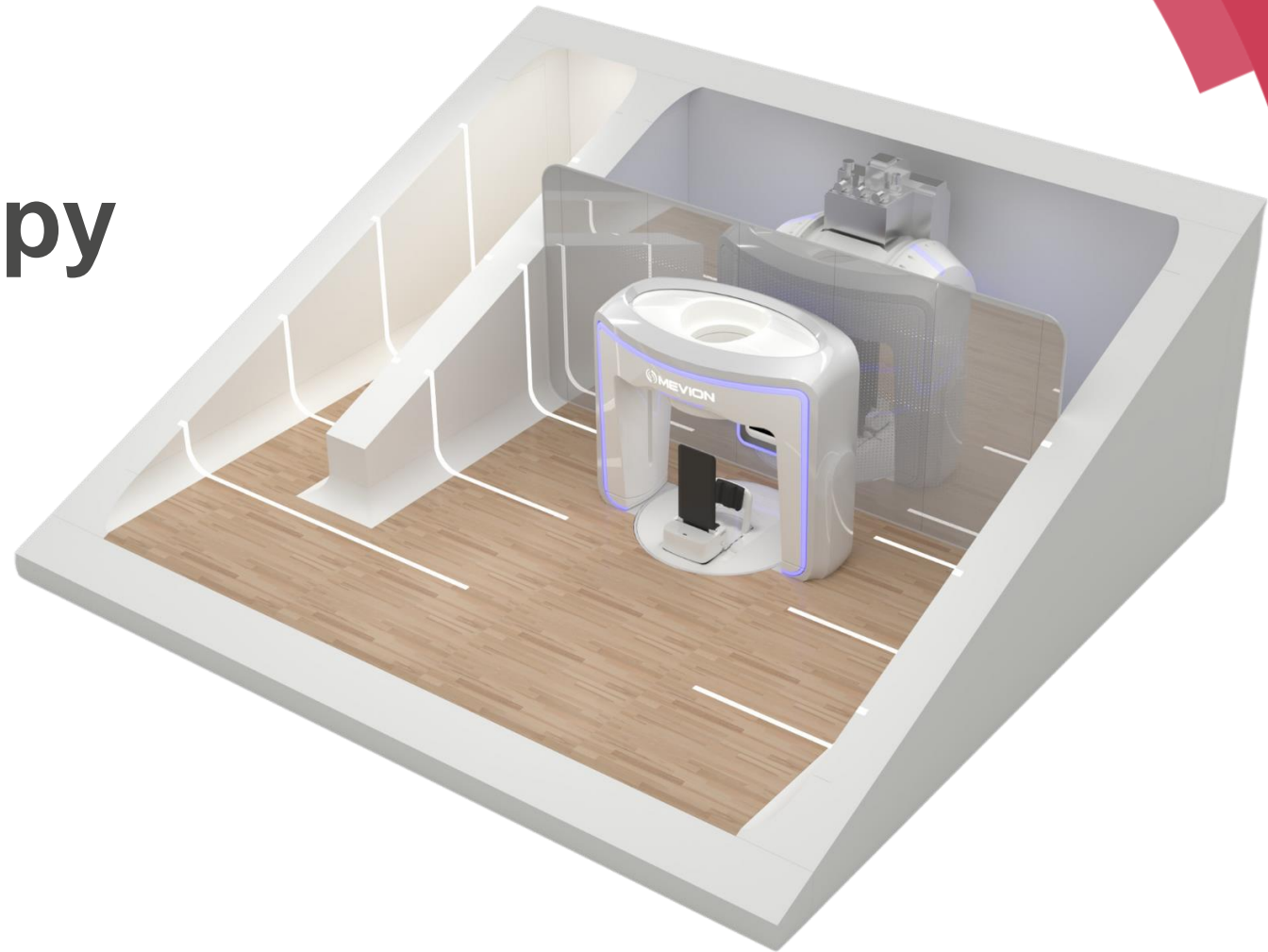


Upright Proton Therapy

An Opportunity for Proton Imaging

Mark Jones
Chief Technology Officer
mjones@mevion.com
October 21, 2024





About Mevion



S250i Gantry Proton Therapy System



S250-FIT Upright Proton Therapy System



Upright Proton Therapy with Proton Imaging



RE-IMAGINE



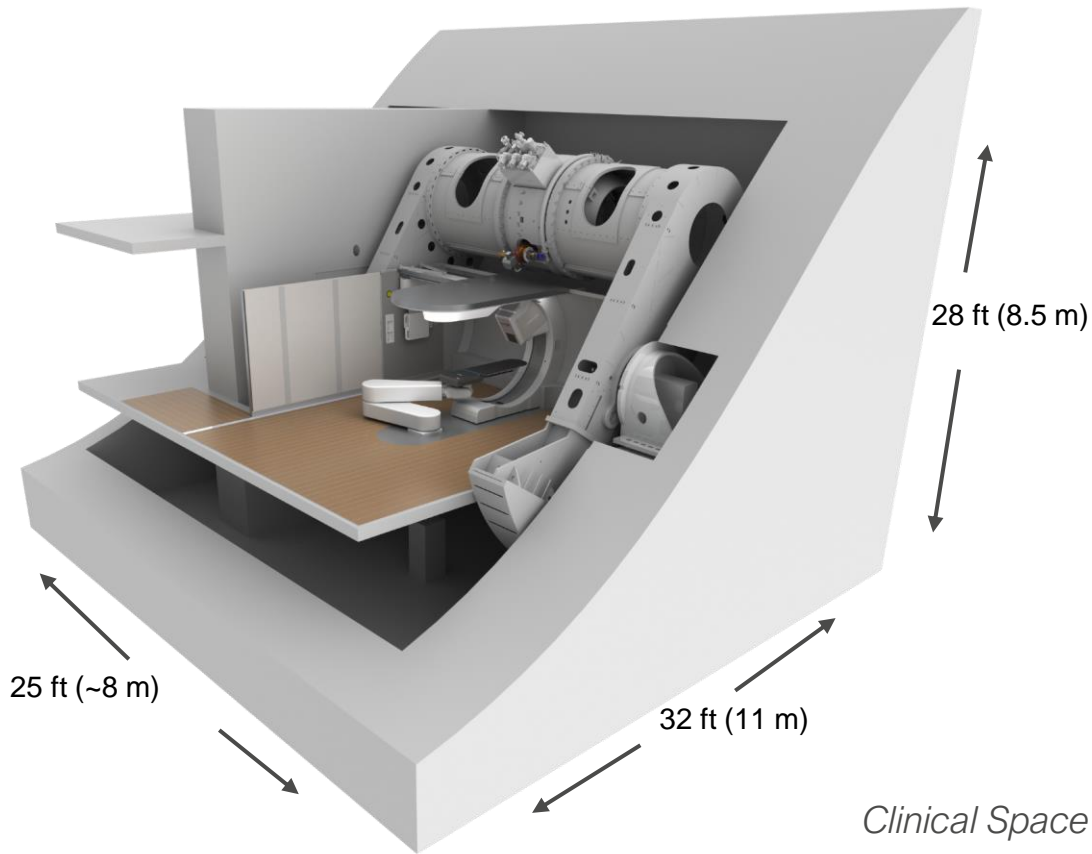
About Mevion



In 2004, Mevion was founded with a clear purpose
To provide superior proton therapy to as many cancer patients as possible

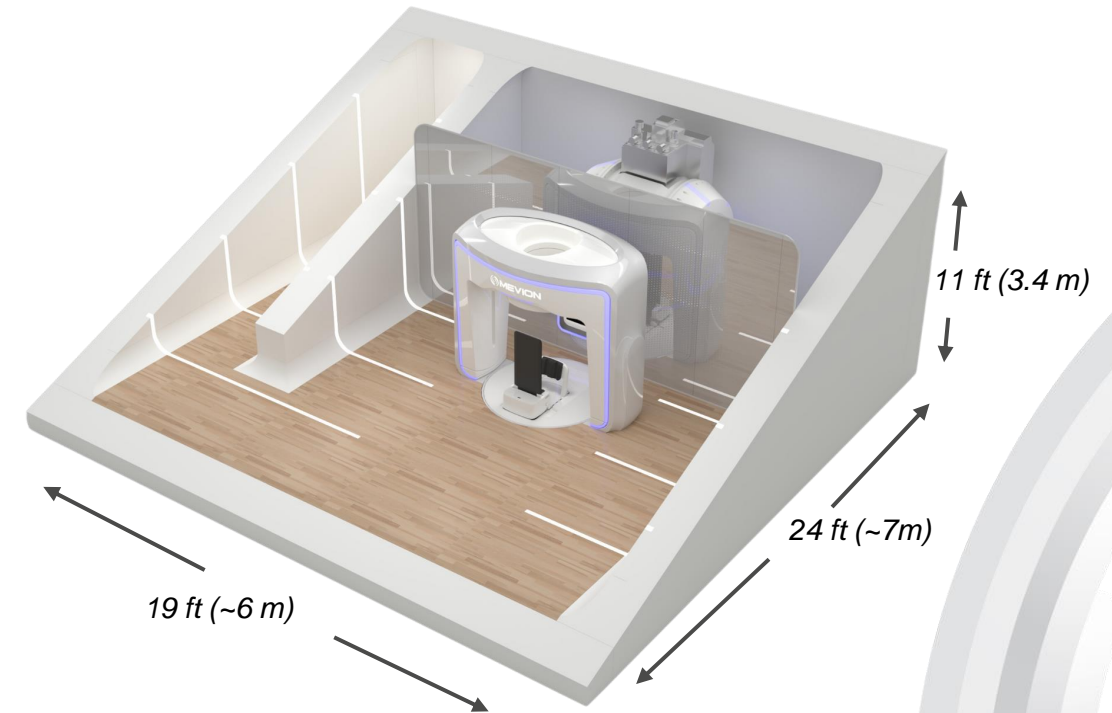
Single Focus. Single Passion. Proton Therapy.

Celebrating 20 Years of Compact Proton Therapy



MEVION S250i

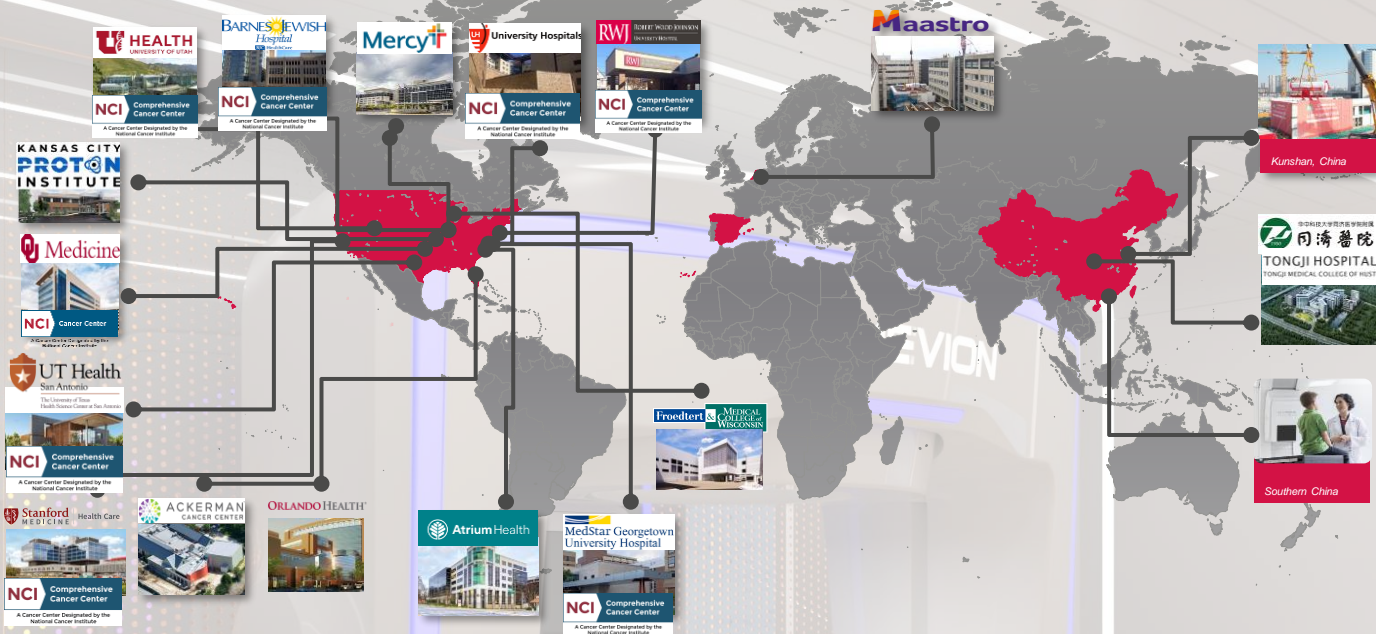
- Compact footprint
- 6-month accelerated installation



MEVION S250-FIT

- Ability to FIT in a LINAC vault
- 12-month turnkey project completion

Clinical Space Internal Dimensions



An Expanding Mevion Network

20+

Clinical partners worldwide

8 NCI

More US NCI-designated cancer centers have selected Mevion for proton therapy than any other proton therapy supplier

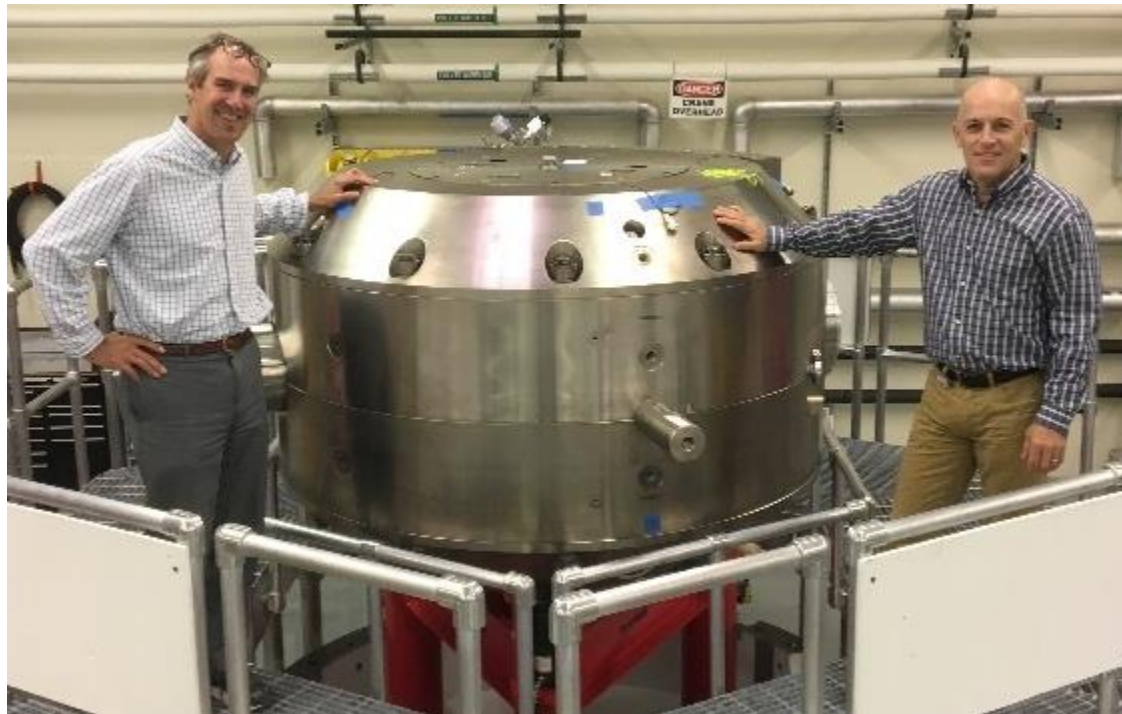
56%

of clinical operating single-room compact proton centers in the USA use Mevion systems

**MEVION S250i
Gantry
Proton Therapy System**

Mevion Proprietary Core Technology

World's Smallest Proton Therapy Accelerator



- Superconducting synchrocyclotron
- 230 MeV, 1 – 20 nA
- Pulsed beam extraction
- 750 Hz pulse frequency
- 1 to 20 μ s ion source pulse width modulation of charge per pulse
- 1 pC/pulse minimum
- Pulse-to-pulse gating
- < 5 mm spot at isocenter
- Self-shielded accelerator

Anatomy of a HYPERSCAN Nozzle



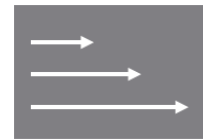
Scanning
Magnet
20 x 20 cm



Dosimetry



Fast Energy
Modulation
0 to 32 g/cm²



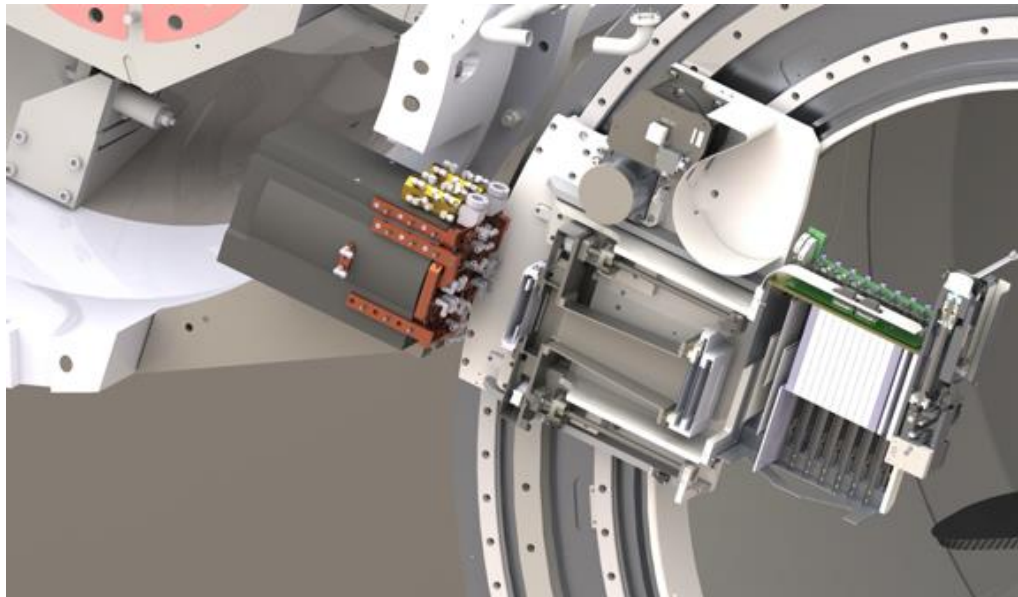
Proton MLC



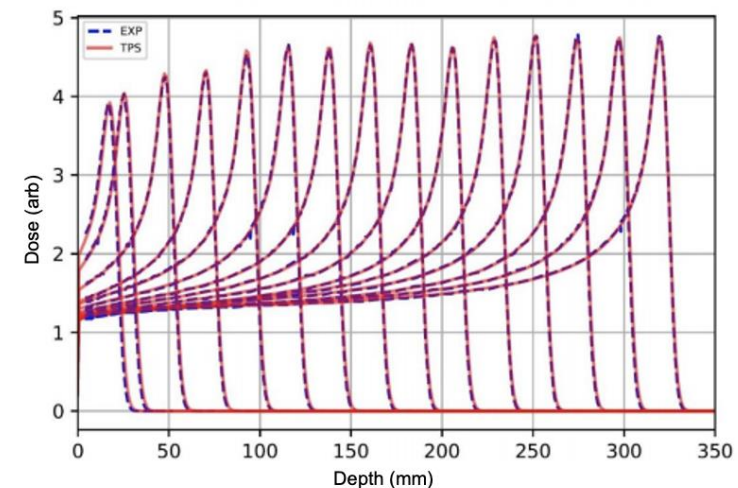
Mevion Proprietary Core Technology

Direct Beam for Next Generation Pencil Beam Scanning

- Most efficient beam line
 - Ultra-high dose rate at all energy
 - Bragg Peak FLASH IMPT



MEVION S250I DIRECT BEAM DELIVERY

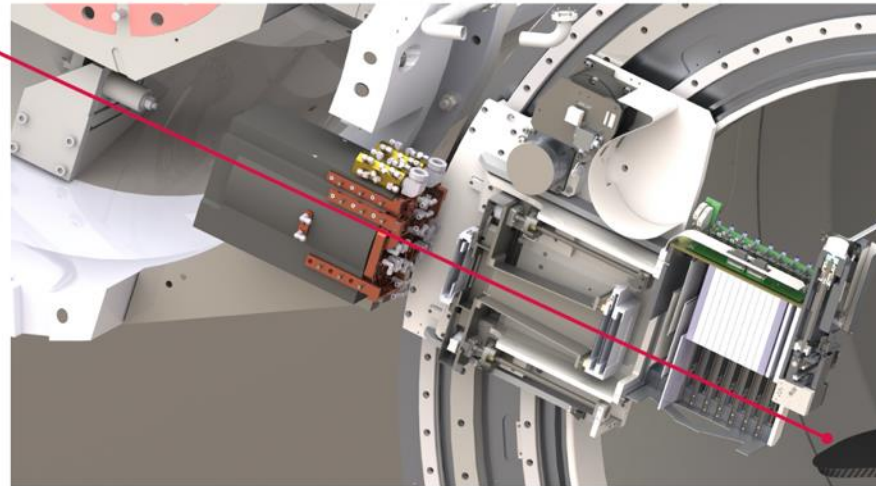


70% TRANSMISSION AT < 50 MEV

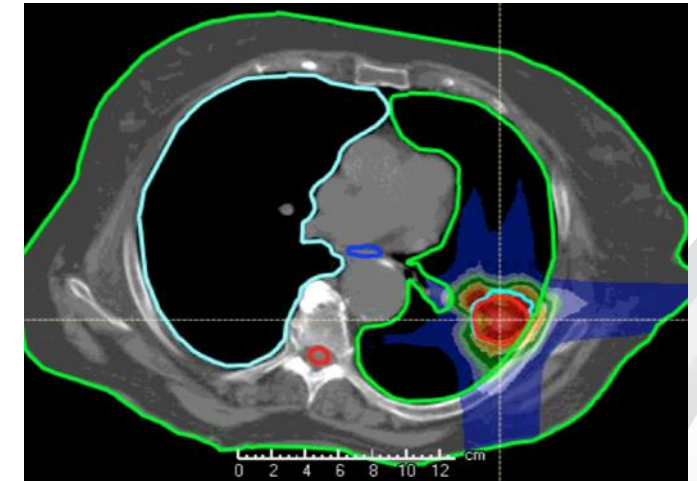
Mevion Proprietary Core Technology

HYPERSCAN Fast Volumetric Scanning

- Target motion is a challenge for PBS
- Longer treatments have greater risk of motion during beam delivery
- Motion occurring during beam delivery can result in hot and cold spots (interplay effects)



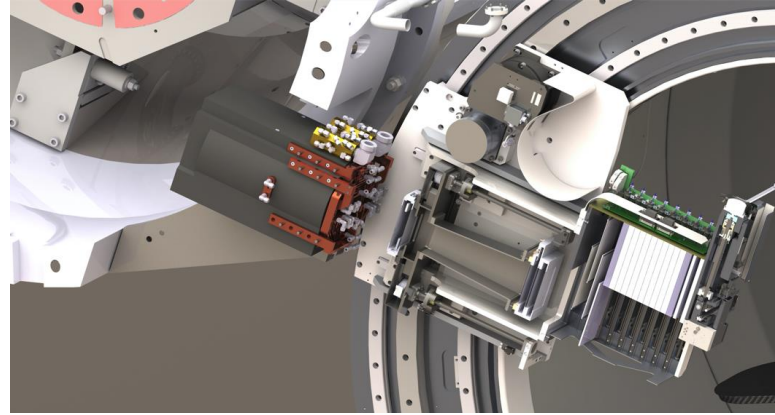
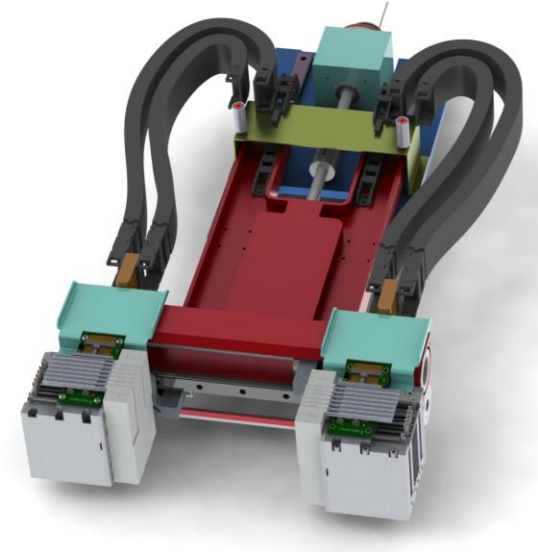
Direct beam eliminates inefficiency of beam transport : **50 ms layer switching**



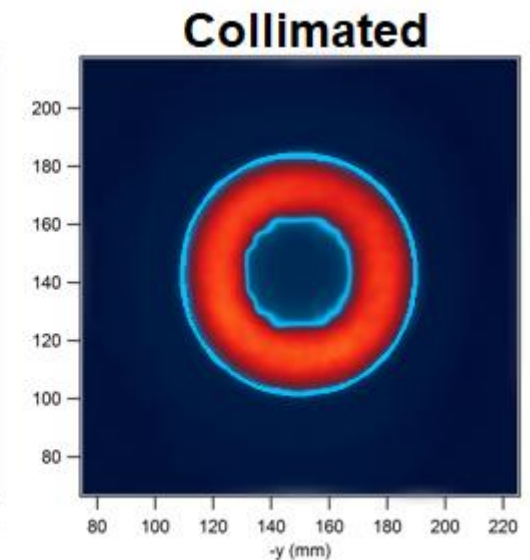
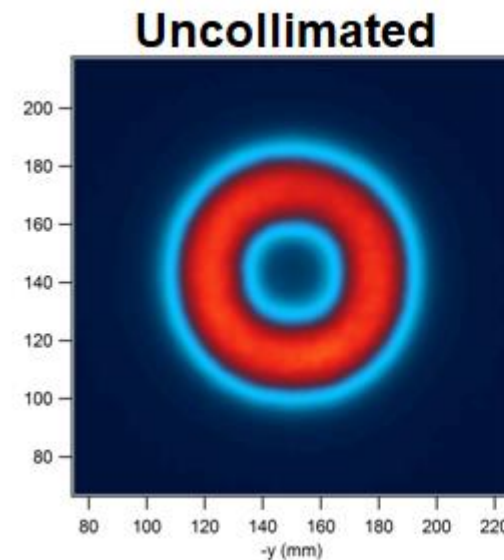
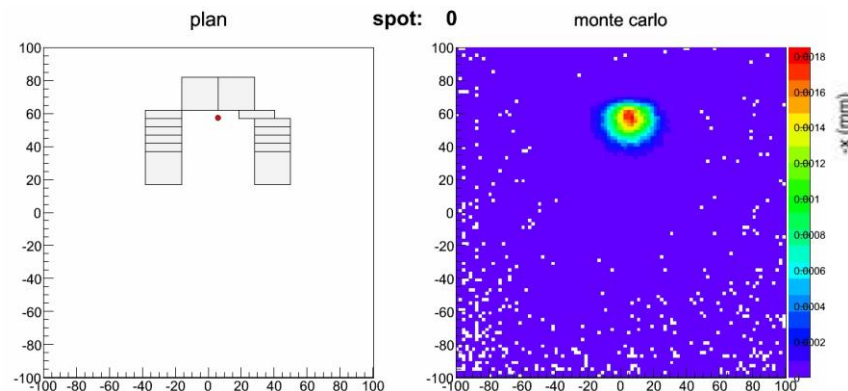
Deliver 2 Gy to a 4 cm sphere in less than 5 sec.

Mevion HYPERSCAN is the fastest volumetric scanning system

HYPERSCAN Proton MLC



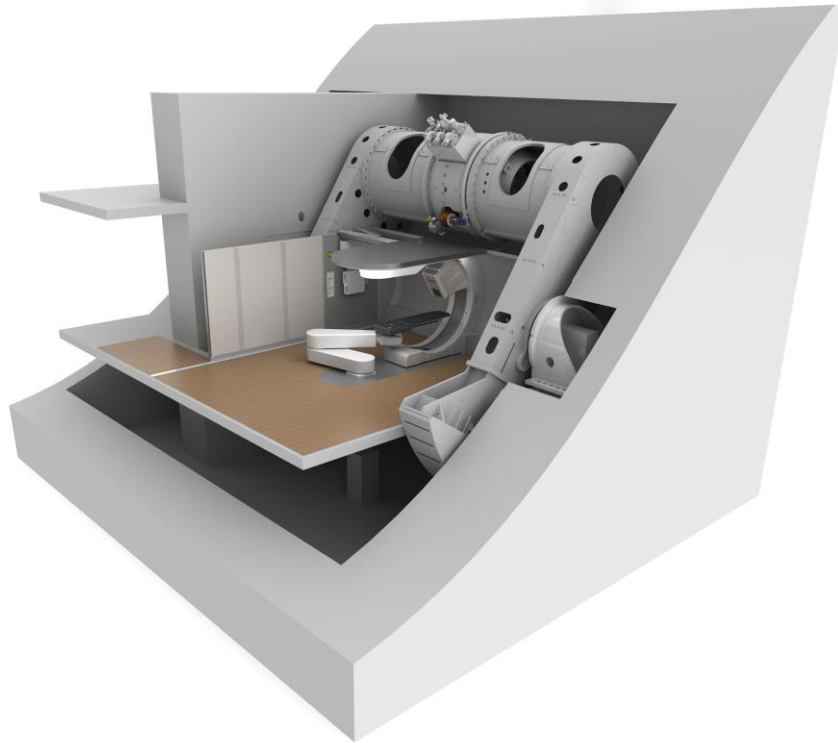
- 2 mm collimated spot size; 4 mm native
- Collimate any spot over the full field
- Sharper penumbra



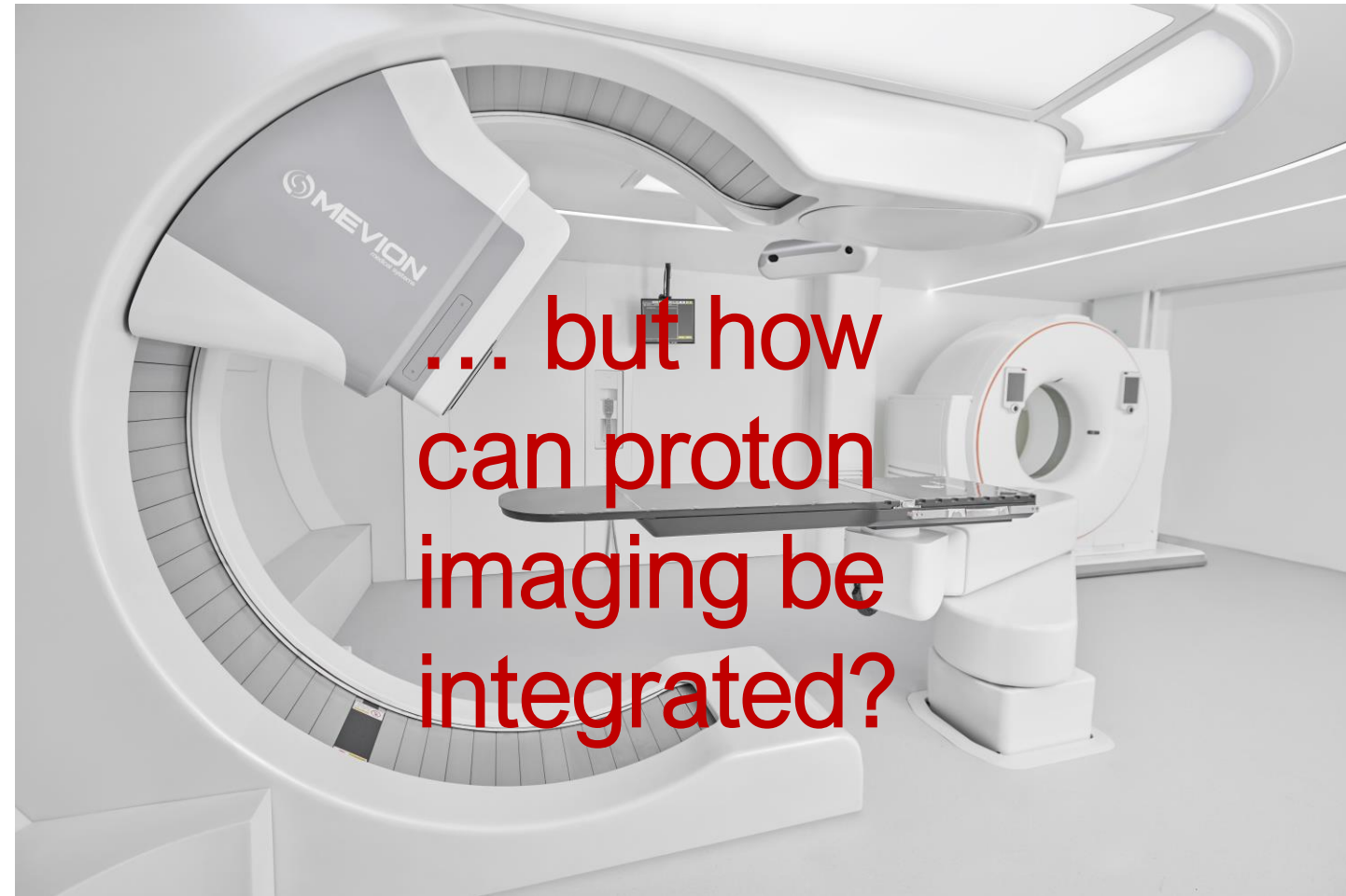
Enabling Compact Proton Therapy



Enabling Compact Proton Therapy



Industry-changing gantry-mounted cyclotron, enabling compact proton therapy



MEVION S250i Proton Therapy System

MEVION S250-FIT
Upright
Proton Therapy System

MEVION S250-FIT – Fast. Integrated. Transforming

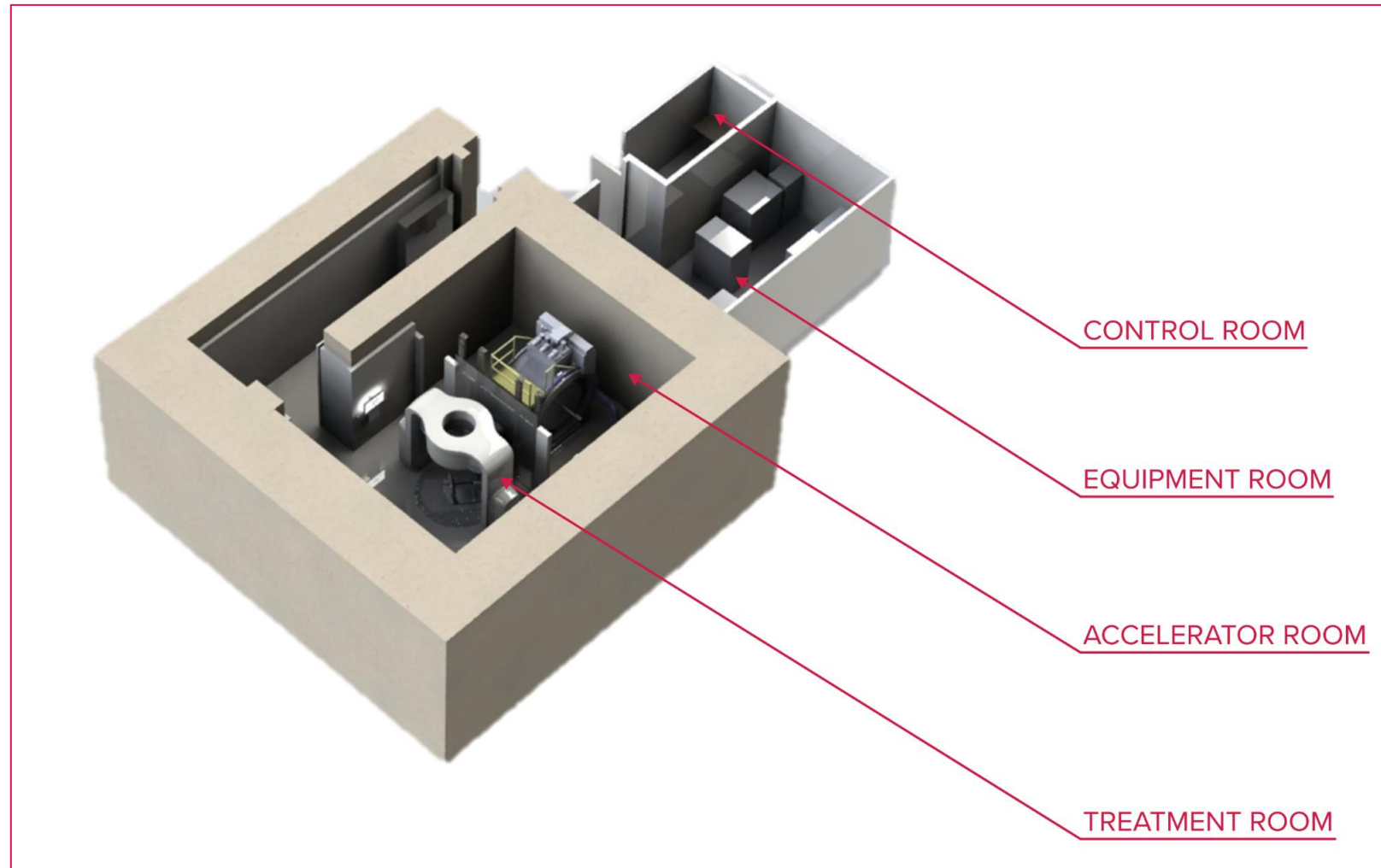
Compact

Upright Treatment
Position

Direct Beamline

Fast Integration

Flash Capability



MEVION S250-FIT



- Fixed horizontal beam
- 360° patient rotation
- Patient seated/standing
- 6-axis patient positioning
- Accelerator & nozzle identical to gantry system

First FIT Installation at Mevion R&D Vault

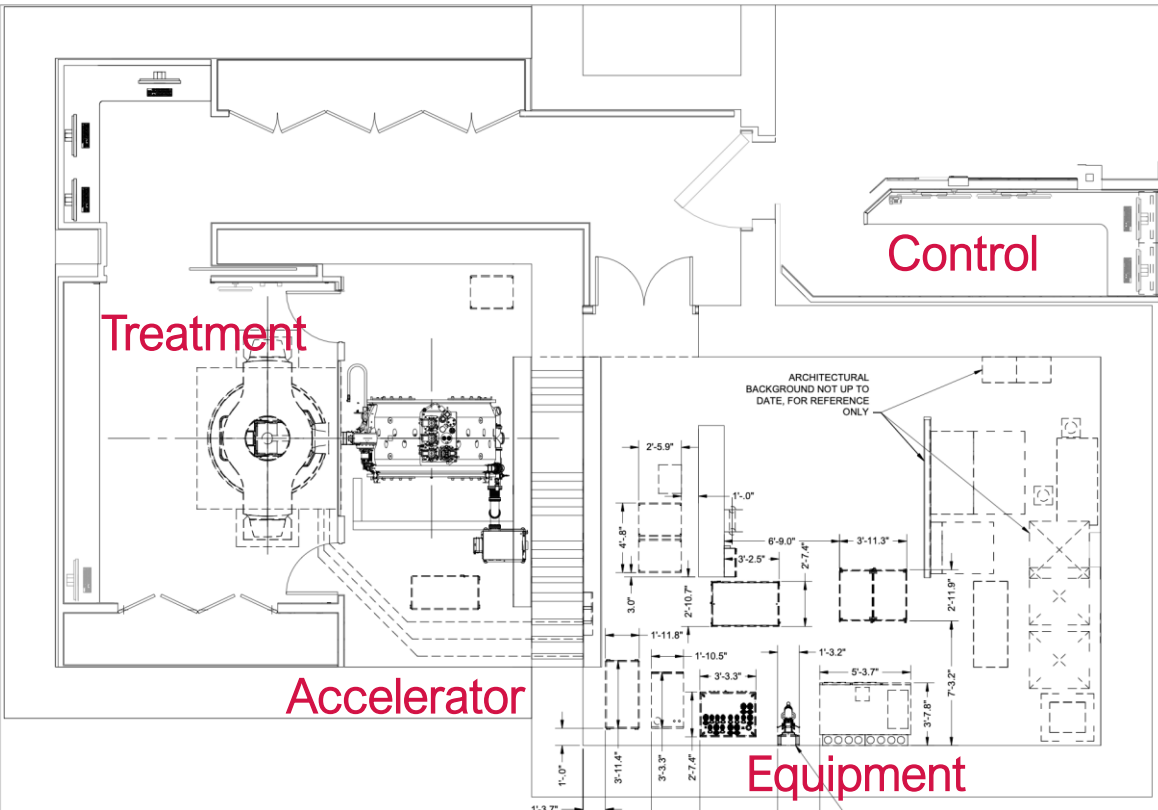
The MEVION S250-FIT Proton Therapy System
is not yet available for clinical use.



The MEVION S250-FIT Proton Therapy System is not yet available for clinical use.

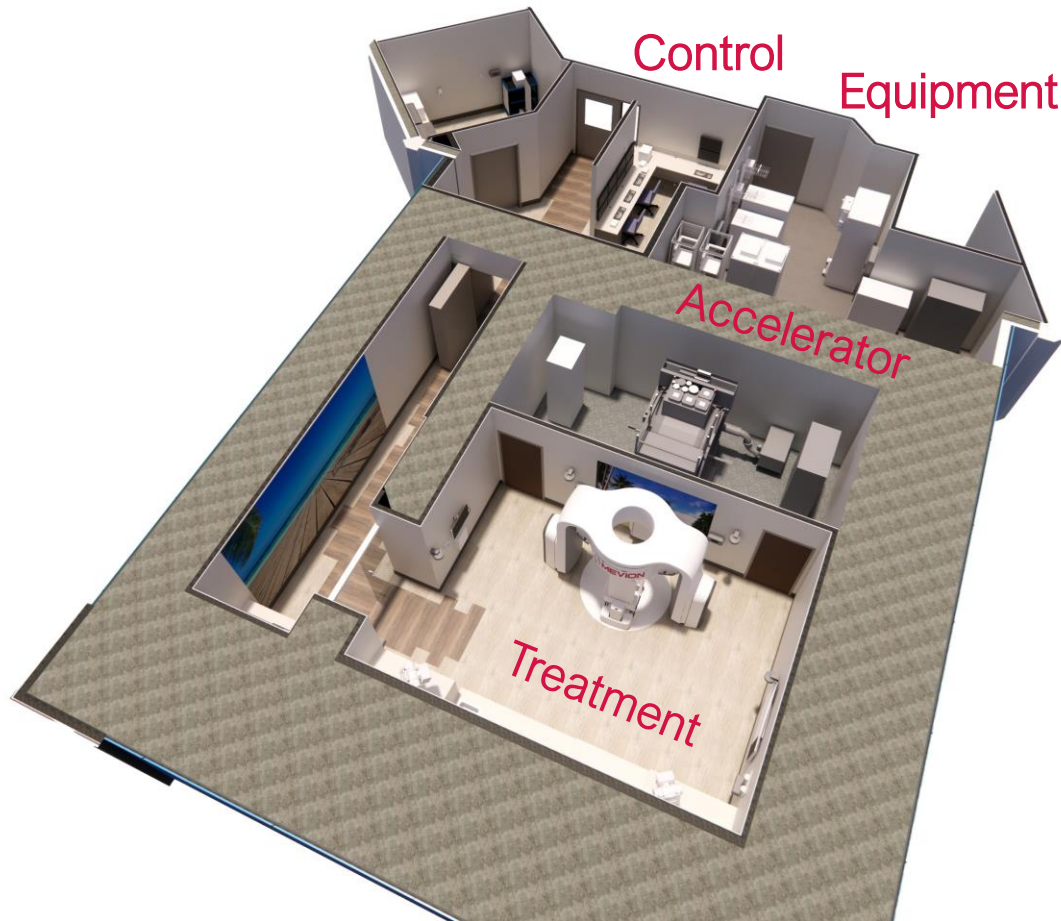
Stanford FIT Proton Therapy

Expansion of an existing Vault, Stanford Cancer Center



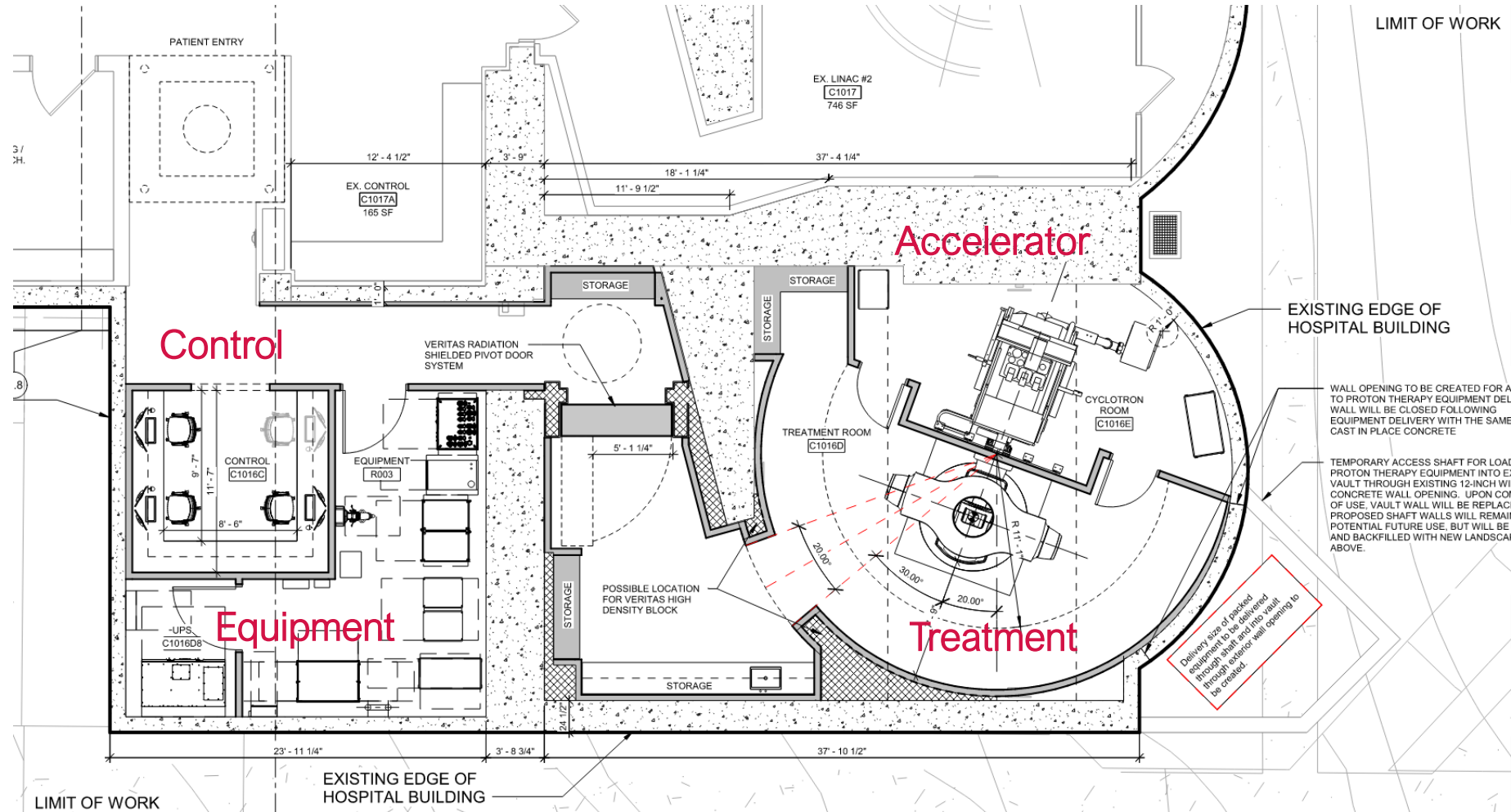
BayCare FIT Proton Therapy

Addition of a FIT Vault, Tampa, FL



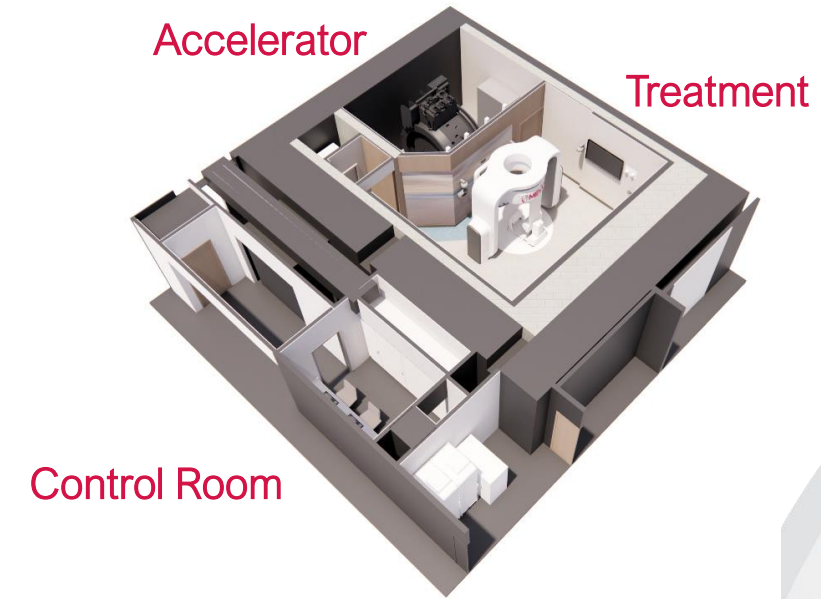
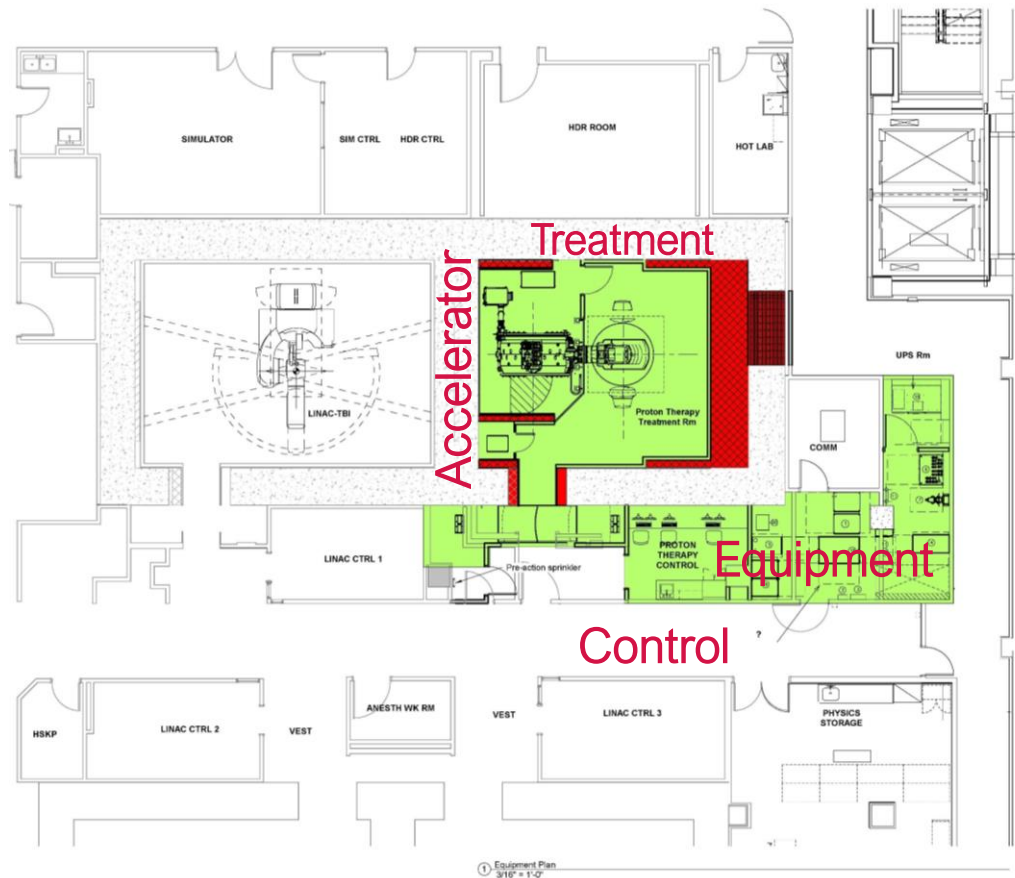
Atlantic Health FIT Proton Therapy

Renovation of an Existing Linac Vault, Morristown, NJ



Nebraska Medicine

Renovation of an Existing Linac Vault



The MEVION S250-FIT Proton Therapy System is not yet available for clinical use.



Upright Proton Therapy with Proton Imaging

System Integration of Imaging Detectors

Advantages:

- Simple patient rotation for pCT projections
- BEV imaging using treatment source
- Excellent patient access during setup
- Isocentric imaging at treatment position
- Imaging may be interleaved with beams
- Stationary detectors improve image quality vs. gantry-mounted detectors

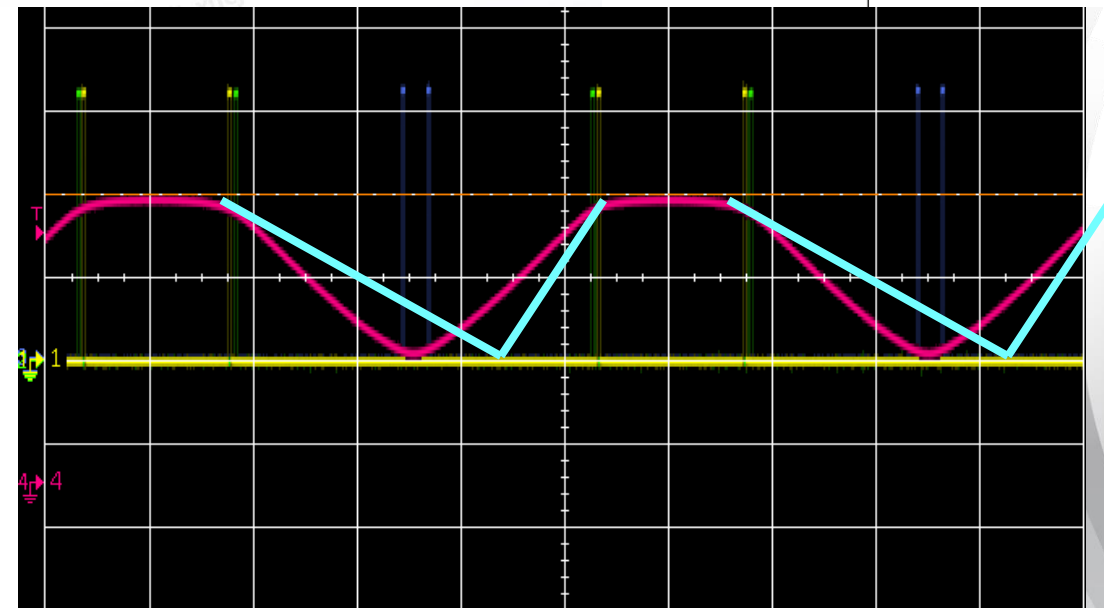
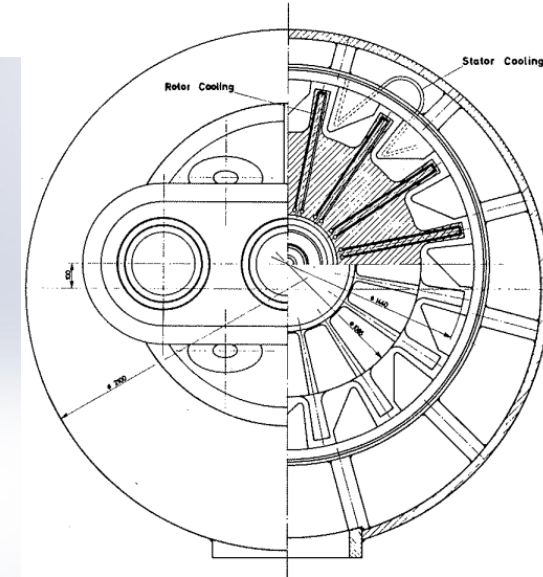
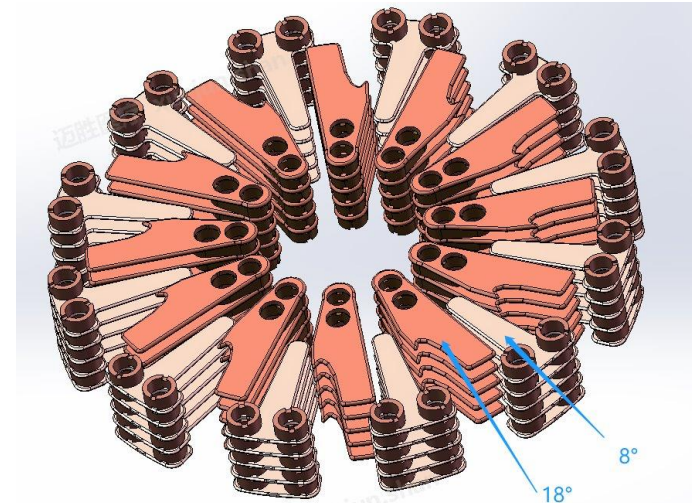
Proximal imaging detectors integrated into nozzle exit window

Distal imaging detectors rise from pit



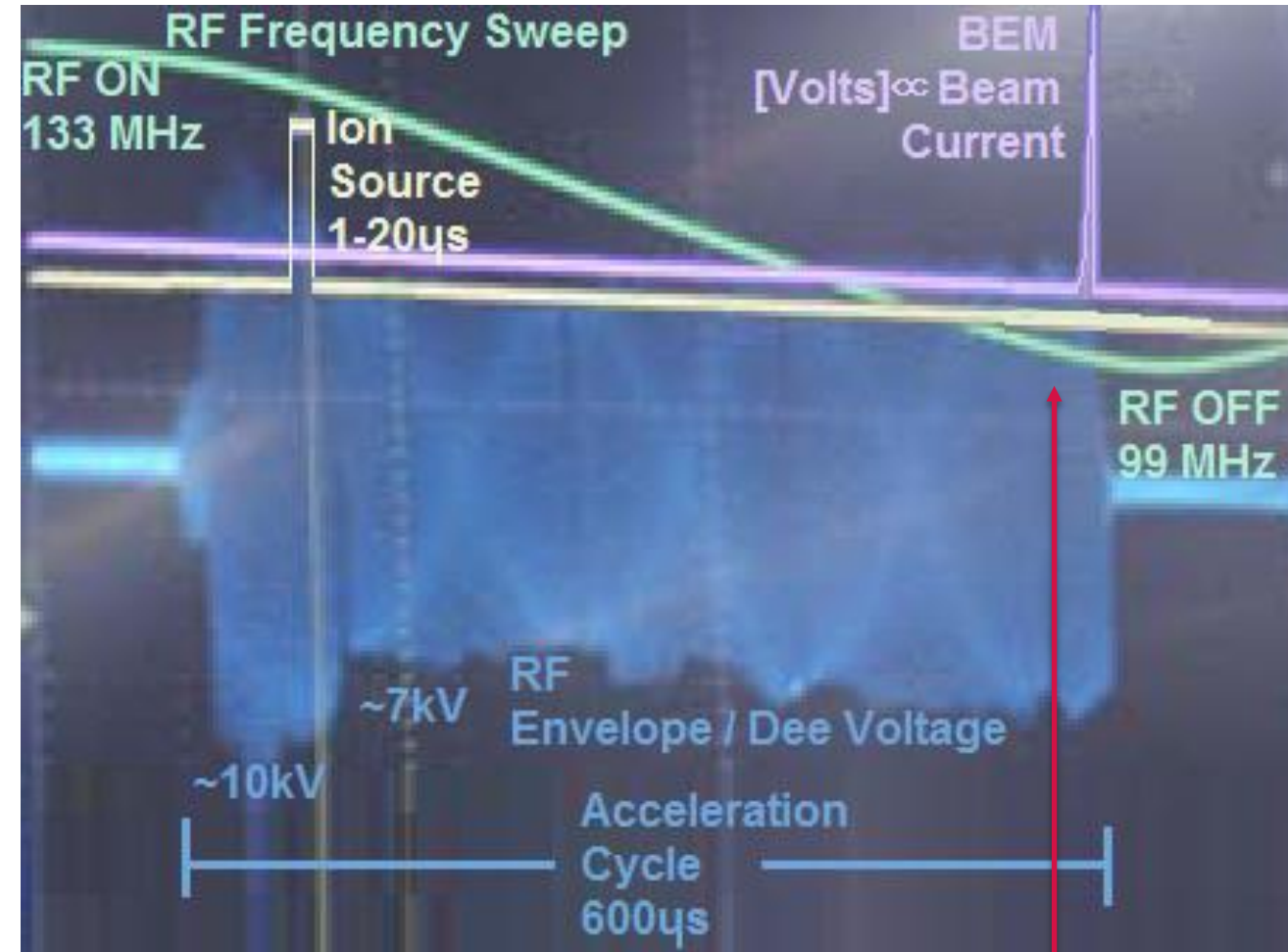
Reduce Beam Output for Single-particle Imaging

- Need to reduce beam output 1,000 to 10,000X for single-particle tracking imagers
- Reduce charge per pulse to $\ll 1\text{pC}$
 - Change ion source from cold to hot cathode
- Slow extraction by modulating resonator FM sweep rate to $\ll 750\text{ Hz}$ using rotational capacitor velocity control
- Increase duty factor of acceleration portion of FM sweep by modifying rotational capacitor design via leaf shaping



Synchrocyclotron Timing & Imaging Trigger

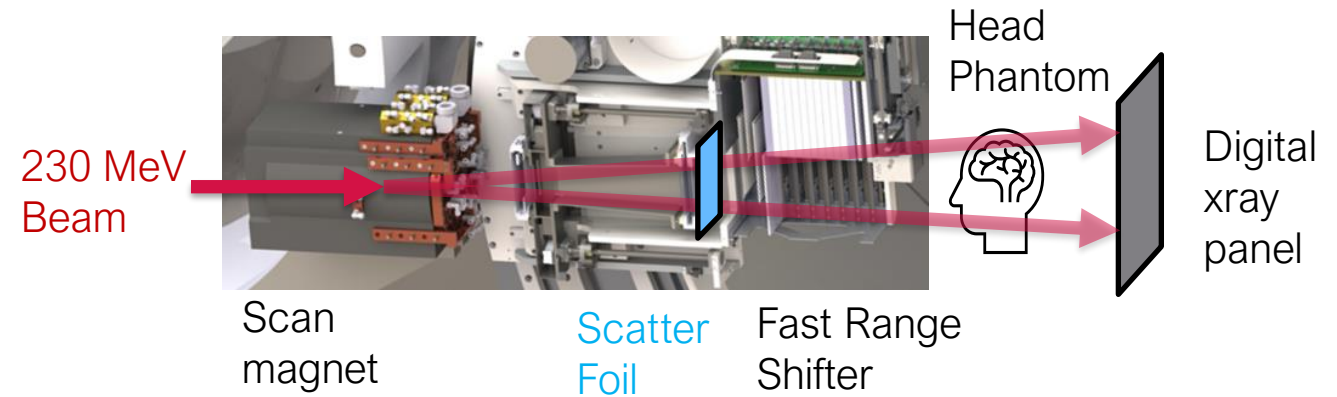
- Pulsed beam extraction
- 750 Hz pulse frequency
- 1 to 20 μs ion source pulse width modulation
- 1 pC/pulse minimum
- Pulse-to-pulse gating
- **Image acquisition trigger**
~500 μs after ion source pulse



Trigger here

Proton Integrating Radiography Experiment

- ~1 pC/pulse
- Single-scattered beam to create large, lower fluence spots
- PBS used to scan the full field
- Head phantom scanned at 12 energies
- 28 sec using fast energy layer switching, 50-100 ms/layer
- Images acquired with COTS x-ray panel
- Low cost
- Poor spatial resolution vs. single-particle tracking



Thank You

We welcome collaboration
with researchers!



...to provide superior proton therapy to
as many cancer patients as possible...

**The MEVION S250-FIT Proton Therapy System, FLASH therapy, online adaptive therapy, and ARC therapy are not yet available for clinical use.*