A Compact 10 Tesla Superconducting 250 MeV Synchrocylotron for Cancer Therapy

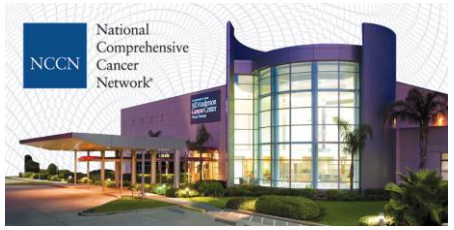
Lawrence Tian

Proton Era 3.0 – Accelerated Growth Stage

The first experiments on radiation therapy with protons were conducted at the Lawrence Berkeley National Laboratory at the University of California, Berkeley. The world's first proton therapy treatment took place in 1954, for a patient with advanced breast cancer.

▼ 1952

Opening of the MD Anderson Proton Therapy Center



▼ 2006

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▼ 2012

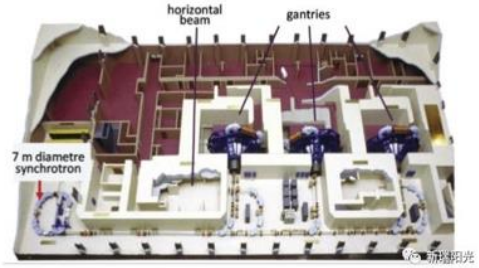
PT 1.0 - Early Years | **PT 2.0 - Multi-Room System** | **PT 3.0 – Single Room System**

▲ 1903

British physicist William Henry Bragg discovers the Bragg peak effect in 1903.

▲ 1990

The first hospital-based proton therapy center is built at Loma Linda University Medical Center in the United States, ushering in the modern era of proton therapy



▲ 2009

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▲ 2017

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The Need For a More Affordable System

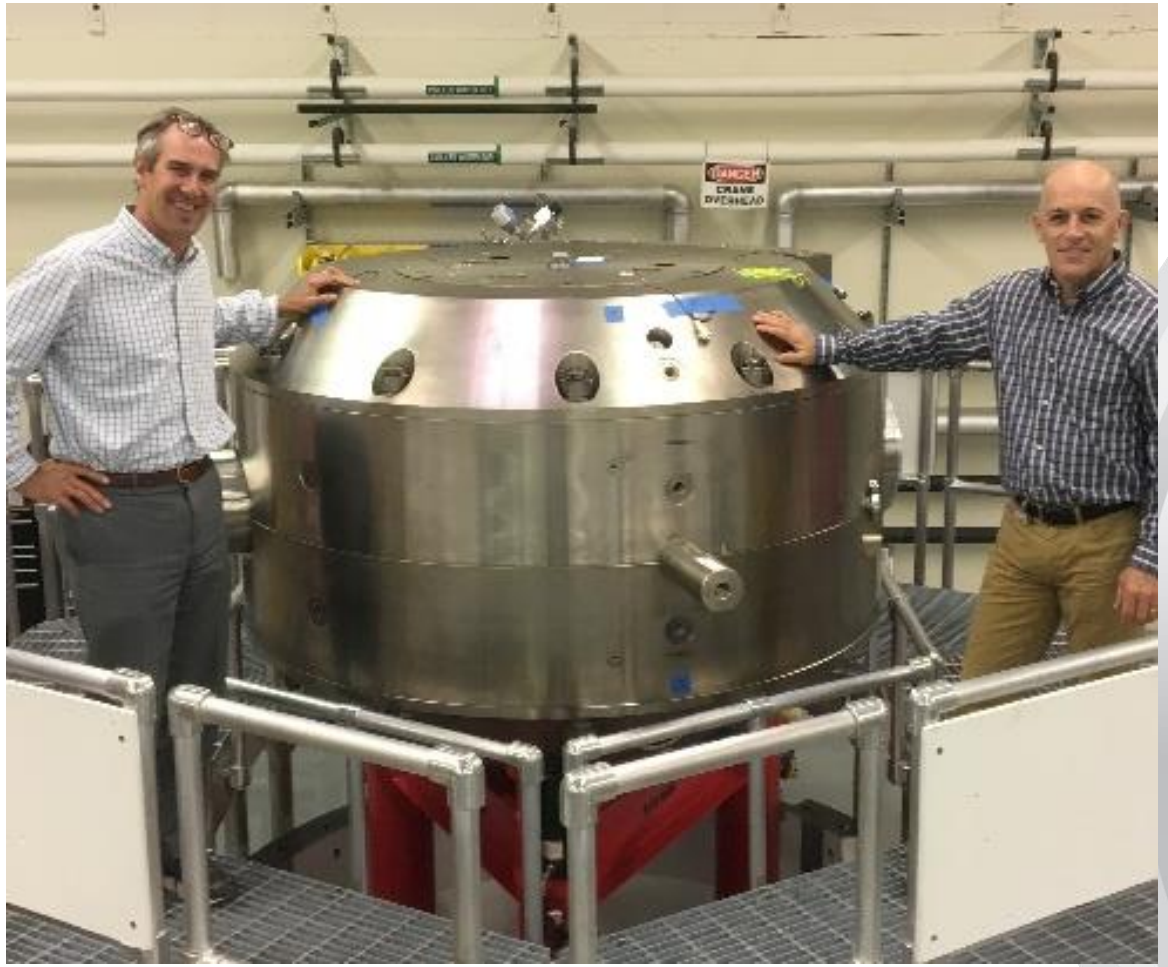
Conventional Multi-Room Center

- $100-$300M project cost
- Stand-alone separate facilities
- Financial performance challenges

- **Too Big**
  - Typically 3 or More Rooms
  - Up to 100,000 Ft.2 for 5 Rooms
- **Too Costly**
  - > $200M for Recent Facility
  - > $1M Annual Energy Costs
  - > 100 Staff for 5 Rooms
- **Too Complex**
  - Multiple Rooms Depend on One Accelerator
  - Complex Beam Transport Requiring Many Steering Magnets & Power Supplies and Large Gantries
  - Daily Maintenance Required
  - Beam Switching & Queuing Complicate Patient Setup
  - Historic Lack of Integrated Imaging & Oncology Info-System Connectivity

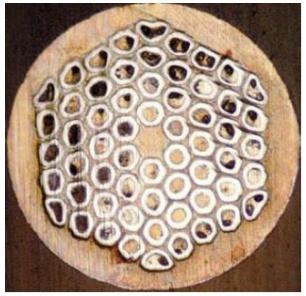
World's Smallest S250 MeV Proton Accelerator

- Development began in 2004 in collaboration with MIT with the direct goal of mounting the accelerator on a rotating gantry.
- Design analysis showed that in order to achieve the desired size, a 10 Tesla magnet field strength was needed.

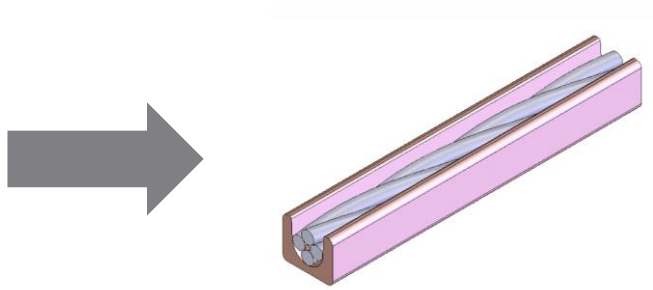


Solving the 10 Tesla Problem

- High field design requires a high current density conductor
- Nb_3Sn conductor can achieve the required 2000 A current, but is difficult to work with and vulnerable to radial forces.
- Mevion utilizes a specialized conductor design that is manufactured in-house via a proprietary process.



Nb_3Sn Strand



Integrated Conductor

Accelerator Key Parameters

Parameter	Value
Maximum Energy	230 MeV or 250 MeV
Beam Current Range	0 to 20+ nA
Radius	1.8 m
Weight	15 tons
Coil	Nb_3Sn
Magnetic Field	10 T
Average Power	15 kW
Cooling	4
Time Structure	Pulsed at 750 Hz
RF	Single dee, ¾ wave resonator
Extraction	Passive regenerative
Ion Source	PIG cold cathode
Vacuum	Dry system

Subsystems: Smaller and More Efficient

Efficient Variable Frequency Drive
SC Magnet Power Supply

Miniature
Penning Ion Source

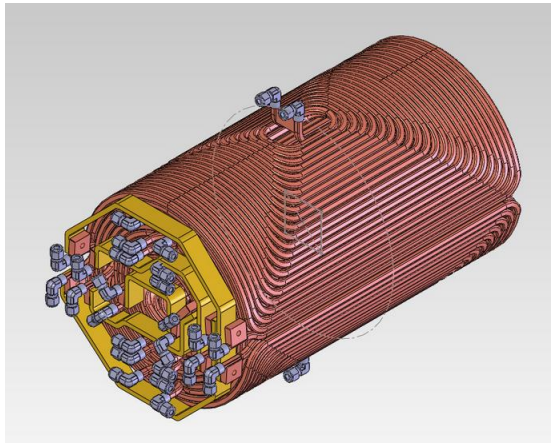
Combined
X-Y
Scanning
Magnet

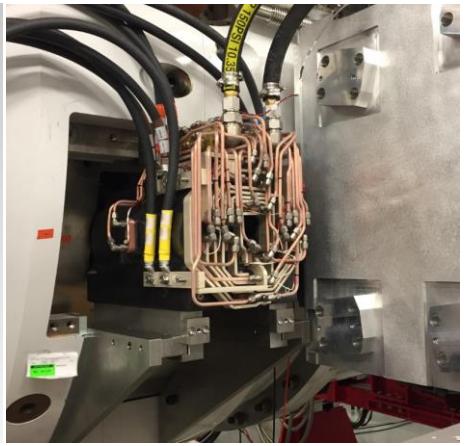
Wide Band FM
Resonator

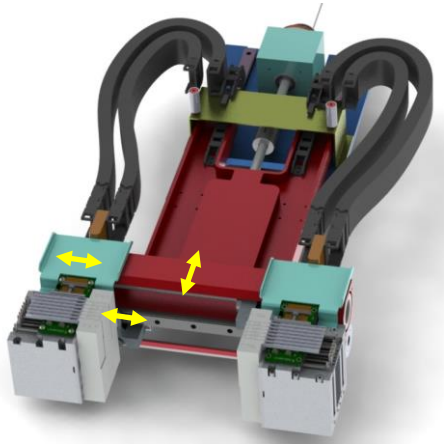
Compact
16 kW RF Amplifier

Solid State
Scanning Magnet
Four Quadrant Drives

HYPERSCAN – IMPT Beam Delivery







Scanning Magnet (XY)

Dosimetry

Energy Modulation (Z)

Adaptive Aperture (XYZ)

Transforming the Market

Mevion Compact Proton Therapy

- $30M project cost
- Integrated to radiation departments
- Successful financial breakeven

Continuing to Innovate

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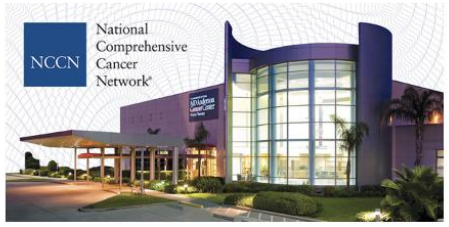

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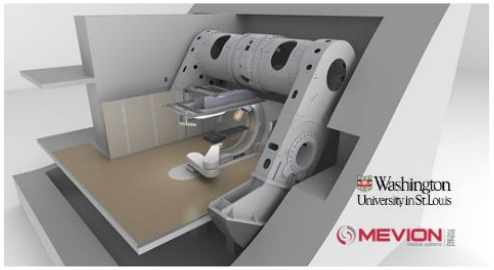

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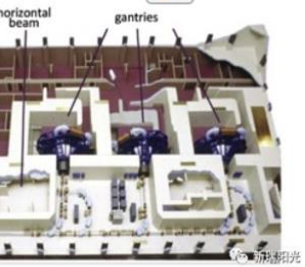

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Arc
Precision
Adaptive
FLASH
4D
SBRT

The Leader in Compact Proton Therapy

MEVION
medical systems

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