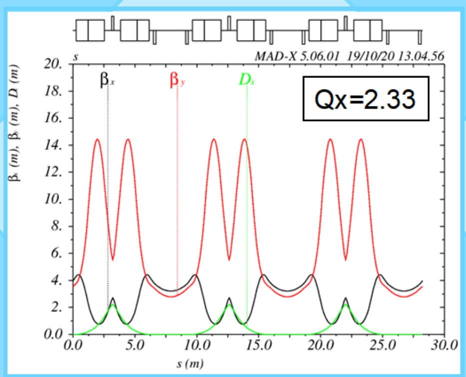
HITRIplus
Heavy Ion Therapy Research Integration

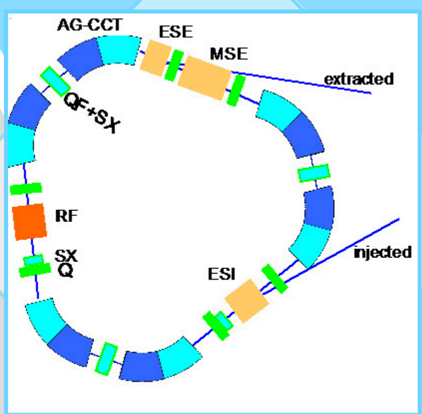
www.hitriplus.eu

SUPERCONDUCTING SYNCHROTRON FOR IONS

DECADES OF EXPERIENCE IN ACCELERATOR DESIGN, CONSTRUCTION AND OPERATION. EXPERTISE AND KNOW-HOW OF SYNCHROTRON DESIGN AND OPERATION



THE TRIANGULAR LATTICE OF THE ION SYNCHROTRON AND THE OPTICS AT EXTRACTION



DESCRIPTION

- **Shape and Magnets**

Triangular synchrotron design
Superconducting magnets with a maximum 3T field

- **Bending at Corners**

120° bending at corners
Two dipole magnets at each corner
Nested alternating gradient layers, each at a 60° angle
Powerful superconducting quadrupole situated in between

- **Quadrupole Magnets**

Carry additional coils for corrections
Corrections for sextupoles and orbit correction

- **Operational Parameters**

Ramp rate of 1 T/s

- **Magnet aperture**

70-90 mm in diameter

- **Optics**

Zero dispersion in the three straight sections

- **Particle Injection**

Ions injected with an energy of 5 MeV/u
Protons injected with an energy of 10 MeV/u

CHALLENGE

Advantages of heavy ion therapy: dose conformity, efficacy against radio-resistant tumours, integration with immunotherapy.

Accessibility limitations: size and cost of accelerator complex.

Focus on Synchrotron: largest and costliest element; R&D needed to reduce size and operating costs.

Challenges and Objectives:
Key challenge is to boost competitiveness of heavy ion treatments.

Goal: Improve accessibility to Hadron therapy by tackling size and cost barriers.

SOLUTION

Intense Treatment
10 times higher intensity than current centres

Efficient Dose Delivery
Quicker treatment for enhanced efficiency and patient well-being

Advanced Features
Multiturn injection, enhanced extraction, beam transport
Introduces FLASH therapy modality

Global Reference
Blueprint for new European synchrotrons
Addresses the global ion therapy market

VALUE

Superconducting magnets shrink synchrotron dimensions by 2-3 times compared to traditional designs.

The synchrotron can provide protons, carbon, helium and oxygen ions for treatment, as well as other ions up to argon for biomedical research.

The intensity is expected to increase tenfold, primarily due to enhancements in the source, linac transmission, and the capability for multi-turn injection of 10^{10} Carbon-ions per pulse into the synchrotron.

This number corresponds to a dose of 2 Gy to a 0.5-liter tumour, provided within one synchrotron cycle.
The synchrotron will have a slow-extraction system based on Radiofrequency Knock-Out (RF-KO) as baseline.

The control system will be suited for multi-energy extraction.
The innovative fast slow extraction scheme swiftly delivers the entire beam in under 500 ms, ideal for advanced treatments like FLASH

Achieving a target ramp rate of 1 T/s, the synchrotron can return to injection energy in just 3 seconds, facilitating rapid acceleration for continuous operation.
Flexible beams for e.g. in-vivo/in vitro radiobiological study.

NORMAL CONDUCTING SYNCHROTRON FOR HELIUM

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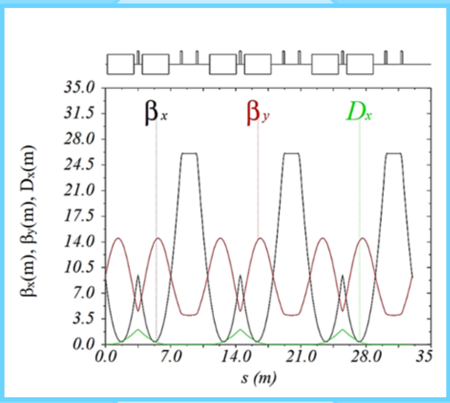
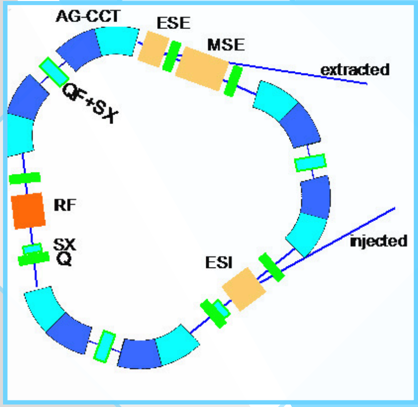
DECADES OF EXPERIENCE IN ACCELERATOR DESIGN, CONSTRUCTION AND OPERATION. EXPRTISE AND KNOW-HOW OF SYNCHROTRON DESIGN AND OPERATION



THE TRIANGULAR LATTICE OF THE HELIUM SYNCHROTRON AND THE OPTICS AT EXTRACTION



DESCRIPTION

- **Helium in Cancer Radiation Therapy**

Helium ions offer precise cancer cell targeting
Comparable precision to carbon ions
Sharp Bragg peak for superior treatment efficacy
Lower uncertainties in biological effect estimations
Reduced neutron biological dose, potential for paediatric patients

- **HITRI*plus* Synchrotron**

Advancing helium ion therapy research

- **Synchrotron Design**

Compact triangular lattice design
Efficient three-bending sections
Zero dispersion for optimal performance

- **Technical Specifications**

Bending radius: 2.7 m
Circumference: 33 m

CHALLENGE

For cancer therapy using carbon ions, traditional conducting synchrotrons are large, complex, and costly, deterring industrial investment.

Superconducting magnet technology shows potential for significant size reduction, but extensive research and development are needed.

Opting for normal conducting options for helium can save time and costs, making it more attractive for industry.

SOLUTION

A helium synchrotron design accelerates carbon, oxygen, and other ions to intermediate energies with reduced penetration range.

With a circumference of 33 m, the ion therapy centre is approximately 1600 m^2, resulting in lower construction and operational costs compared to carbon ion centres.

Helium ions offer enhanced precision in tumour delivery over protons. The synchrotron, combining advanced magnet and injector linac technology, enables both slow and fast extraction for conventional and FLASH radiotherapy.

VALUE

This solution offers lower power consumption compared
to existing direct current solutions, reducing costs and cooling requirements for ion treatment centres.

With a compact circumference of 33 m, the centre occupies approximately 1600 m^2.

Multi-turn injection of 8 x 10^{10} ions per pulse delivers 2 Gy to a 0.5-liter target in one acceleration cycle.

Helium ion beams enhance treatment efficiency, particularly in proximity to vital organs or in pediatric cases.

The slow extraction system ensures uniform beam spill with 10 times higher intensity ion beams, while fast extraction supports both conventional and FLASH therapy.

Featuring a slow-extraction system based on Radiofrequency Knock-Out (RF-KO), the synchrotron is optimised for industry needs.

Flexible beams facilitate in-vivo/in vitro radiobiological studies with various ions, including Carbon and Oxygen, offering versatility for industry research and development.

Additionally, multiple-ion operation allows for advanced imaging and treatment, including proton CT, meeting diverse industry requirements.