Heavy Ion Therapy Research Integration

WP7: Advanced accelerator and gantry design

with focus on Task 7.2 (the Synchrotron)

ELENA BENEDETTO, SEEIIST

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

WP 7 – Management structure

(*) cfr. MV presentations
@ WP7 Kickoff meeting, 19/4/2021 and
@ HITRIplus Kickoff meeting, 13/4/2021

WP Coordinator: M. Vretenar, CERN
Deputy WP Coordinator: E. Benedetto (SEEIIST)

Task Leaders:

	Task	Task Leader
7.1	Coordination and communication	M. Vretenar, CERN
7.2	SC Synchrotron and advanced components design	E. Benedetto, SEEIIST
7.3	Operational modes, beam transport and instrumentation	M. Sapinski, SEEIIST
7.4	Injector linac design	U. Ratzinger, Bevatech
7.5	Integration of an innovative superconducting gantry	M. Pullia, CNAO

HITRI plus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

WP7 – The Consortium

WP number	WP7		Lead beneficiary			CERN	
WP title	JRA1- Advanced accelerator and gantry design						
Participant nr.	4	13	7	1	18	10	2
Participant	CERN	SEEIIST	GSI	CNAO	RTU	MEDA	BEVA
Person months	14	48	4	8	40	2	28
Start Month	1		End month			42	

2 large scientific laboratories
2 particle therapy centres
1 (new) research institution
1 university
1 SME
from 6 European countries

Excellent blend of competences and expertise

7 partners:

CERN: WP Coordination, contribution to synchrotron, gantry and linac design

SEEIIST: Task leader for synchrotron design and beam transport, contribution to linac and gantry design

CNAO: Task leader for gantry design, contribution to synchrotron and beam transport design

Bevatech GmbH: Task leader for linac design

MedAustron: contribution to synchrotron, beam transport, and gantry design

Riga Technical University: contribution to gantry mechanical design

GSI: internal communication and support to coordination

duration: 3.5 years

GSI, CNAO and MEDA contribute with internal resources only (no EC contribution)

HITRI plus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

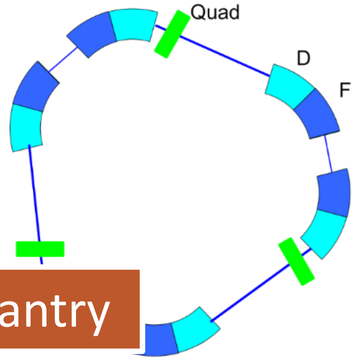
WP7 Objectives

higher beam intensity

advanced SC-magnet synchrotron: compact, innovative & reference for EU industry

To design solutions that could **improve performance** of the existing accelerators for heavy ion research and therapy: multiturn injection for higher beam intensity, improved extraction and beam transport – in particular for new FLASH therapy modality, and new linac injector for higher intensity and parallel production of isotopes for research and therapy.

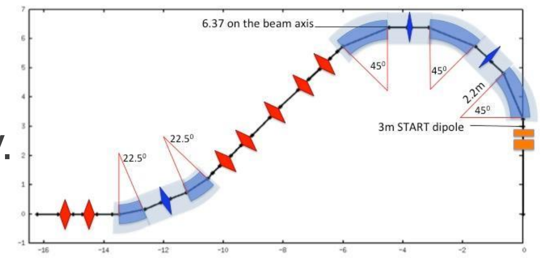
To combine these accelerator solutions with the superconducting (SC) magnets developed in WP8 to develop the **advanced conceptual design of a compact and innovative SC heavy ion synchrotron** for cancer research capable of operating with multiple ion species, from protons to argon as required for research projects, particularly helium, carbon and oxygen.



SC-magnet gantry

To propose a simplified version of this compact SC accelerator (with single- or double-ion operation at fixed parameters) as the reference for a **new generation of compact ion therapy accelerators** to be built by European industry to address the global ion therapy market.

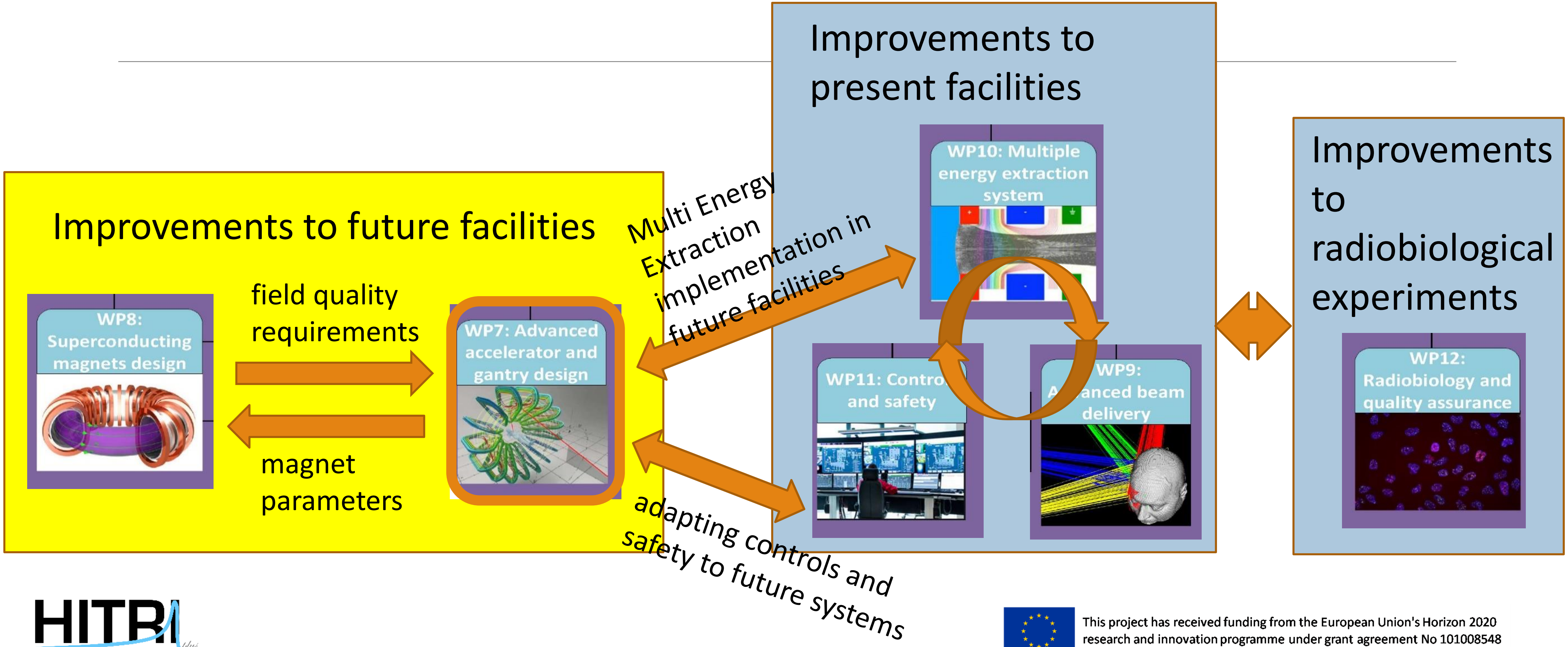
To convert the most promising of the existing conceptual designs for superconducting gantries into a **detailed technical design integrating all components** including diagnostics and beam delivery, and prepare for a **final industrialisation and production phase** by European industry.



HITRI plus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Interactions between the HITRIplus JRA’s



HITRIplus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Task 7.2 - SC Synchrotron and Advanced Components Design (SEEIIST, CERN, CNAO, MEDA) – Task Leader: E. Benedetto

Focus on SC-magnet synchrotron, but lot of R&D on improvement of “conventional” synchrotrons on optics, higher intensity and extraction: multi-energy & FLASH

- Sub-Task 7.2.1, **Lattice for a SC synchrotron**: definition of an appropria design defined in WP8, including modelling of magnets and particle trackir CERN).
- Sub-Task 7.2.2, **Multi-turn injection** in resistive and SC synchrotrons: c injection of 10^{10} ions per pulse into a reference synchrotron with resistive magnets, and in the SC synchrotron (SEEIIST, CERN, CNAO).
- Sub-Task 7.2.3, **Extraction and beam transport**: conceptual design of slow and fast extraction for different treatment options and for experimental research, in coordination with beam transport and delivery teams, for a synchrotron with resistive magnets and with SC magnets (SEEIIST, CERN, CNAO).
- Sub-Task 7.2.4, **Longitudinal and transverse beam dynamics** studies and assessment: preliminary analysis of acceleration, collective effects, space charge, intra-beam scattering and collimation (SEEIIST).

D7.4: Design of an optimised synchrotron with SC magnets and advanced features: high beam intensity, fast and slow extraction, multiple ion operation, optimised linac injector, optimised instrumentation and QA procedures	40

HITRI plus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Task 7.3 - Operational modes, beam transport and instrumentation (SEEIIST, CERN, CNAO, MEDA) – Task Leader: M. Sapinski

- (fast & safe) switch between therapy and research
- what you cannot see you cannot control

- Sub-Task 7.3.1, **Operational modes**: identification of sp… due to switching between therapy and research operation modes (for the sources, injector linac, ring and transfer lines) (SEEIIST, CNAO, MEDA).
- Sub-Task 7.3.2, **Beam transport lines**: definition of improved layouts of the transport lines to the experimental and clinical treatment areas, with special attention to safety due to switching between the 2 modes, e.g. beam-dump, shielding (SEEIIST, MEDA, CNAO).
- Sub-Task 7.3.3, **Beam instrumentation and QA**: identification of advanced beam instrumentation options and of their possible application to present and future medical synchrotrons (SEEIIST, MEDA).

D7.2: Report on operational modes, beam transport and instrumentation	36

HITRI plus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Mariusz contributing

Task 7.4 - Injector Linac Design (BEVA, CERN, SEEIIST). Task Leader: U. Ratzinger

Compact, cheaper and reaching higher current

- analysis of **heavy ion source options** for high ion intensity and selection of new designs to improve performance of present and future ion therapy and research infrastructures;
- conceptual **design of a 325 MHz 10 MeV/u multiple ion injector**: stripping energy optimisation, RFQ energy, RF system design, accelerating structure design and preliminary beam optics design. Comparison with layout, cost and performance of a **217 MHz injector** with improvements against the existing standard injector;
- **detailed design of the preferred option** (325 MHz or 217 MHz), with final beam optics design and overall design of RF accelerating structures, of amplifier system, and of instrumentation layout. Analysis of the impact on the design of a **double operation mode**, for injection into the synchrotron and using additional beam pulses for production of experimental radioisotopes for imaging and therapy.

D7.1: Advanced conceptual design of an optimised linac injector for multiple ions at 10 MeV/u	24

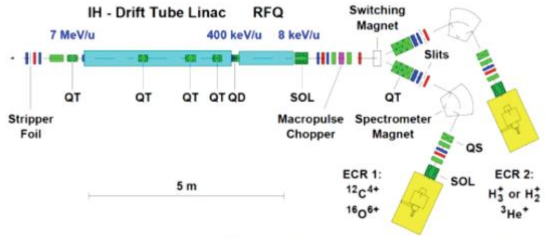
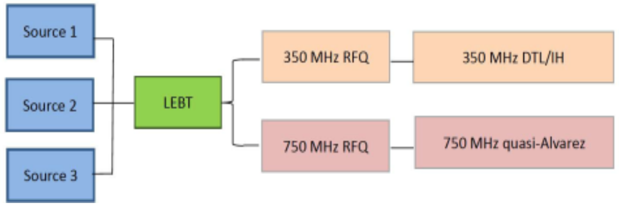


Figure 2.5: European "standard" injector linac design. (Image courtesy of HIT)



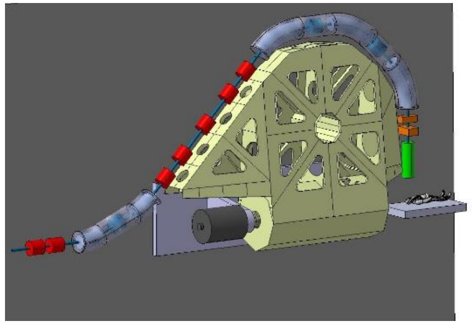
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Task 7.5 - Integration of an innovative superconducting gantry: optics, mechanics, beam delivery (CNAO, CERN, SEEIIST, MEDA, RTU). Task Leader: M. Pullia

Elena contributing

The «SIGRUM» SC gantry
by TERA&CERN



Examination and comparison of the different existing conceptual gantry designs and selection of the most promising option.

- Sub-Task 7.5.1, **Basic structure and mechanical design**: After having identified the baseline conceptual design, the mechanical structure and the technical solutions of the beam transport and the magnets will be investigated in detail. This sub-Task will start from a general mechanical and optics design of the gantry to integrate actual magnet designs, beam instrumentation, dose delivery, cryogenics aspects, etc. into a detailed mechanical design. (CNAO, RTU, CERN).

- Sub-Task 7.5.2 **Simulation of optics, scanning techniques**: Global simulation optimisation of the gantry considering optics, magnets, power converters, beam d mechanics, dose delivery. The design shall be flexible enough to adapt the gantry the existing and future facilities, and to be easily industrialised and reproduced in several units.

SC technology + innovative support to reduce weight and dimensions (and price)
~40tons Vs. 600tons(!) HIT gantry

D7.3: Report describing the main optics parameters and integration features of the gantry	36

HITRIplus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

WHAT I'm up to…

- Set-up a Working Group of Field Quality for Curved Magnets (joint WP7+WP8)
  - beam dynamics, magnet design and measurements
  - our second meeting on Tue 8th June
- Documentation on SIGRUM and TERA Gantries for hand-over to Task 7.4
  - done, now regular exchanges
- Identified best energy for injection into the synchrotron → specs for the new linac (Task 7.2)
  - done, yesterday! ;D (need to document)
- Review of layout options for SC ring
- Supervision (and co-supervision) of Students: extraction, optics and magnets
- Closing the "DLR Contract" Report on injection&extraction
  - 2nd year of activities in preparation of SEEIIST

HITRIplus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

HOW DO WE WORK

- Collaboration with experts from EU medical facilities and CERN colleagues
- Tight synergies with CERN NIMMS activities
  - CERN Doctoral student on Extraction (“slow” conventional and FLASH) from Imperial College
  - collaborations with UK, U.Melbourne (several PhD studs available)
  - interest from Belgium and Spain (with students and engineers)
  - trainees from the SEE region (U.Sarajevo, IAEA fellows,…)

Need to grow participation from SEE countries
CAPACITY BUILDING is key!!!

HITRI plus
Heavy Ion Therapy Research Integration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548