HITRI plus
Heavy Ion Therapy Research Integration

Project Overview

Sandro Rossi

Coordinator

Project Meeting and Hadrontherapy Workshop

From Innovation to Implementation

Podgorica, March 24th-25th, 2025

SCIENCE AND TECHNOLOGY PARK OF MONTENEGRO, PODGORICA

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

FORUM on New International Research Facilities in South East Europe

develop a research excellence nucleus in SEE
benefit for science and technology, training, investment in young people, job creation, reverse of brain drain, knowledge based economy

Two options for the Institute:

- **4th Generation Synchrotron Light Source**
- **Facility for Tumour Therapy and Biomedical Research with protons and heavier ions**

SCIENCE FOR SOCIETY

ICTP and Ministry of Science Montenegro

The Abdus Salam International Centre for Theoretical Physics

25 & 26 January 2018, ICTP, Trieste, Italy

Organizing Committee:
Herwig Schopper (Chairman, former DG of CERN)
Fernando Ferroni (President of INFN)
Christoph Quitmann (Director of MAXIV, Sweden)
Nicholas Sammut (Deputy Dean, University of Malta)
Hans J. Specht (Heidelberg Univ., former DG of GSI)
Ruediger Voss (President of EPS)

Local Organizers:
Nadia Binggeli (ICTP)
Saša Ivanović (MNA)

UNESCO IAEA EPS

Registration to the Forum is free. For a restricted number of participants from the region travel subsistence would be possible. Please register at **http://indico.ictp.it/event/8408/**

HITRI – Hadron Ion Therapy Research Infrastructure
Design Study Proposal – EU H2020 INFRADEV-01-2019-2020 call

TIARA prepared to give advice

HITRI Consortium

Several beneficiaries from SEE Region through SEEIIST

HITRI*plus* Consortium (started April 2021)

H2020-INFRAIA-2018-2020

23 Institutes

(4 CIRT centres, 11 research institutions, 5 universities, 3 SMEs)

14 European Countries

4.5 years Project

(1st April 2021 – 30th September 2025)

Total budget: 5 MEuro

iba

NHa NORMANDY HADRONTHERAPY

TeraCare

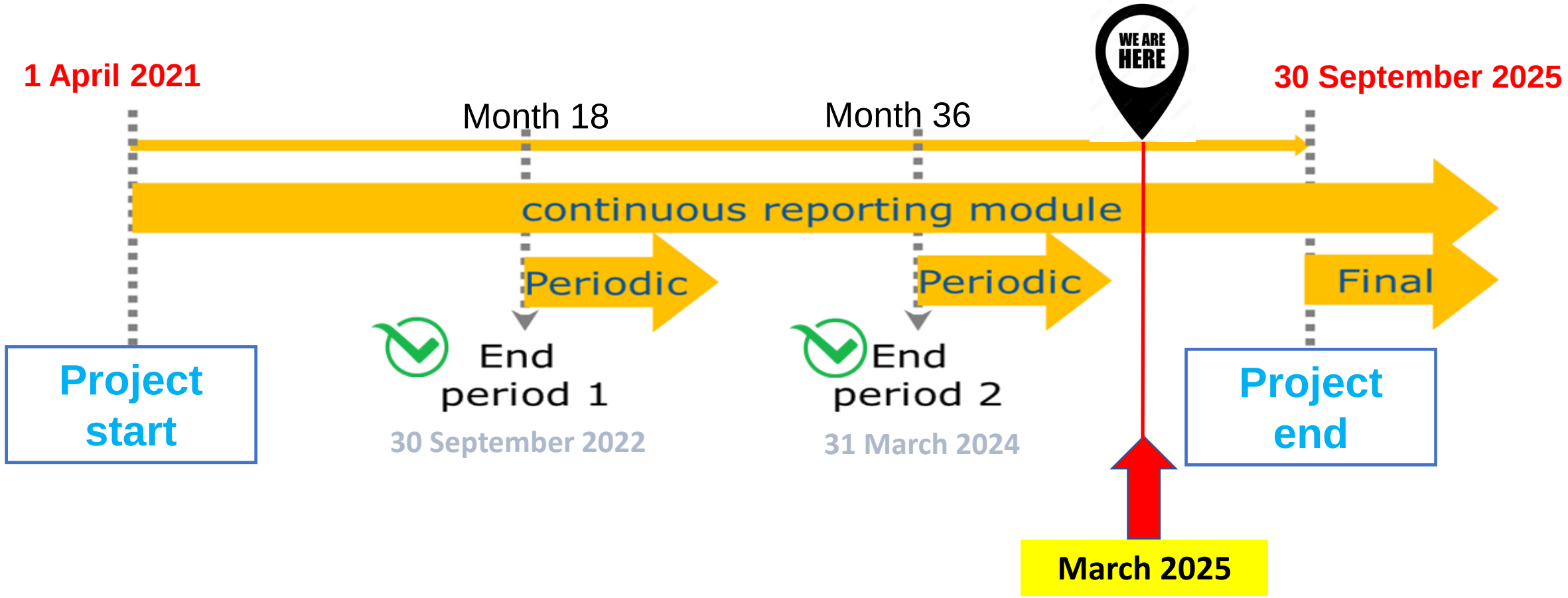
CYCLHAD

CYCLOTRONS POUR L'HADRONTHÉRAPIE

HITRI*plus*

Heavy Ion Therapy Research Integration

Where are we?



Extension to March 2026 requested

HITRI*plus* Objectives

1. To **integrate, open up and broaden the leading European Research Infrastructure** for the treatment of cancer with **beams of ions,** ranging from helium to carbon and to heavier ions.

2. To **coordinate and strengthen the research programmes on heavy ion therapy** of different European institutions, by promoting synergies, collaborations, innovation, knowledge transfer, new initiatives and sharing of tools and data.

3. To **develop** in a joint and coordinated way **novel technologies** to improve the accelerators and their ancillary systems that provide particle beams to this scientific community. These technologies will **improve the present generation** of facilities and will be the **foundation for a next generation** European design for ion therapy facilities.

4. To **establish a European multidisciplinary community** for heavy ion therapy research, aiming at improving treatment strategies and modalities by connecting physics and engineering with medicine, biology and biophysics, and to **extend this community** towards emerging European regions, addressing in particular **new initiatives in South East Europe**.

5. To **define** the main technical features and the scientific programme of **a future pan-European Research Infrastructure** for medical and radiobiological research with heavy ion beams, to be built in South East Europe or in another European region.

HITRI*plus*
Heavy Ion Therapy Research Integration

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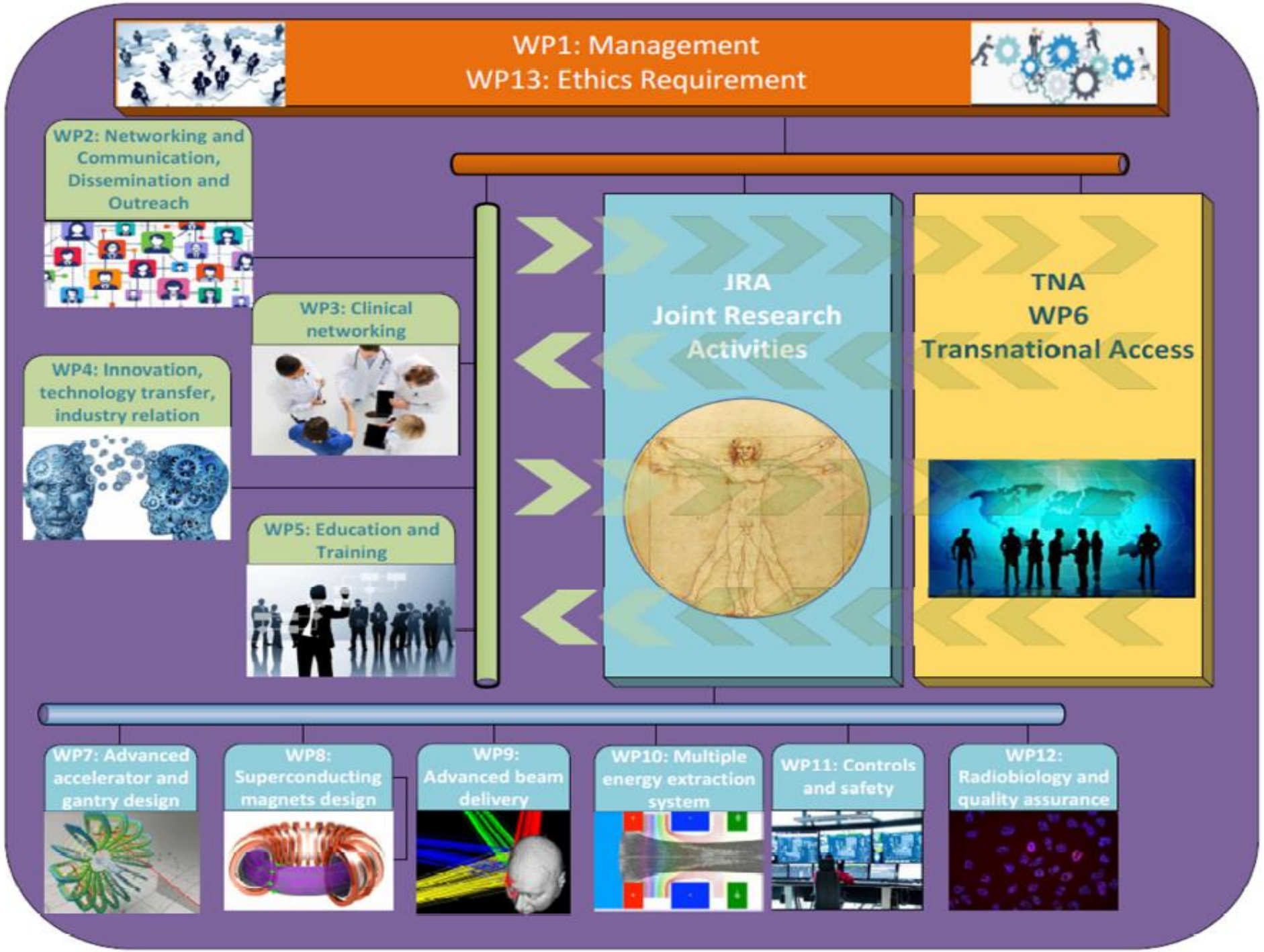


1 General Assembly

2 Advisory Boards

3 Pillars

13 Work Packages

HITRI*plus* Governance

General Assembly
1 representative per Party

Sanja Damjanovic, SEEIIST
Sanja.Damjanovic@cern.ch

Frederick Bordry

Katia Parodi

Jens Habermann

Felipe Calvo

External Scientific Advisory Board

Giovanni Anelli

Chiara Delaini

Paolo De Carlo

Advisory Board for ethical/legal/ industrial issues

The Pillars

Networking Activities NA

Manjit Dosanjh
Senior Advisor for Medical Applications at CERN and visiting professor at University of Oxford.
Manjit.Dosanjh@cern.ch

Trans National Access TNA

Marco Durante
Director of the Biophysics Department of GSI and full Professor of Physics at the Technical University of Darmstadt, Germany.
M.Durante@gsi.de

Joint Research Activities JRA

Maurizio Vretenar
Senior physicist and project manager at CERN.
(HITRI*plus* Deputy Project Coordinator)
Maurizio.Vretenar@cern.ch

WP1 Managment: ‘the Angels’

‘Actual’ Deputy

Angelica Facoetti, CNAO
Angelica.Facoetti@cnao.it

Communication

Silvia Meneghello , CNAO
Silvia.Meneghello@cnao.it

Administration & Finance

Maria Vittoria Livraga , CNAO
mariavittoria.livraga@cnao.it

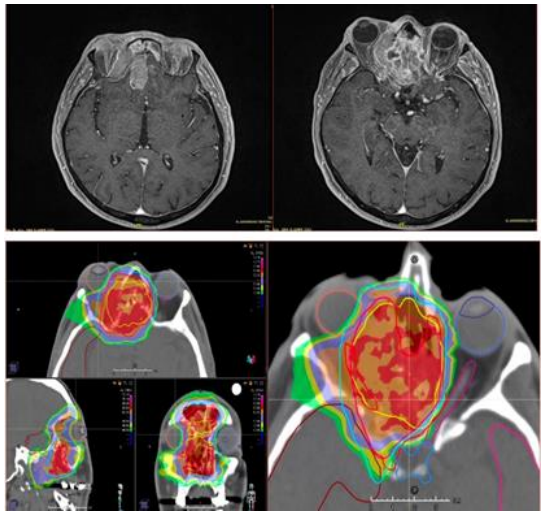
Organization

Chiara Marazzi , CNAO
Chiara.Marazzi@cnao.it

NA: Networking Activities

WP2
Networking and Communication, Dissemination and Outreach

Peter Grübling, SEEIIST



WP3
Clinical Networking

Piero Fossati, MEDA

- ✓ Design **one trial** as a template for bringing innovative heavy ion therapy approaches in the clinics
- ✓ Set up a **European registry** to collect data on rare cancers treated with heavy ion therapy
- ✓ Review existing data on **OARs dose costraints** in use in the clinical facilities

NA: Networking Activities

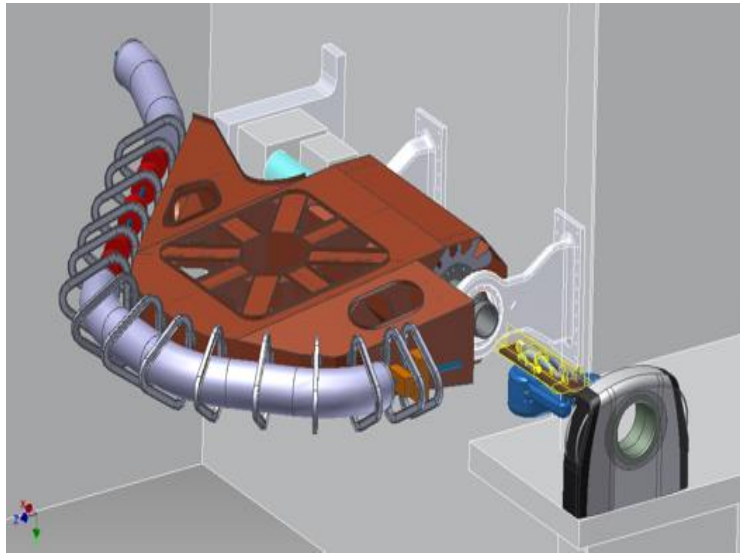
WP4
Innovation, technology transfer, industry relation

Manuela Cirilli, CERN

WP5
Education and training

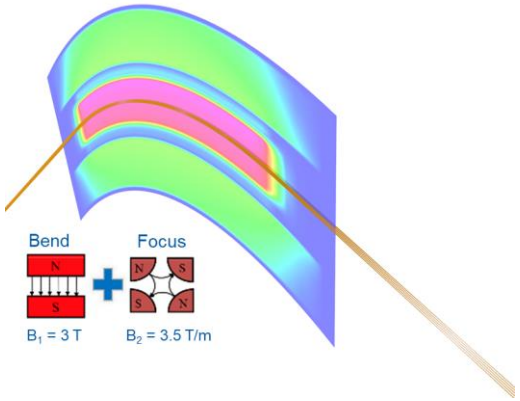
Nicholas Sammut, UM

JRA: Joint Research Activities



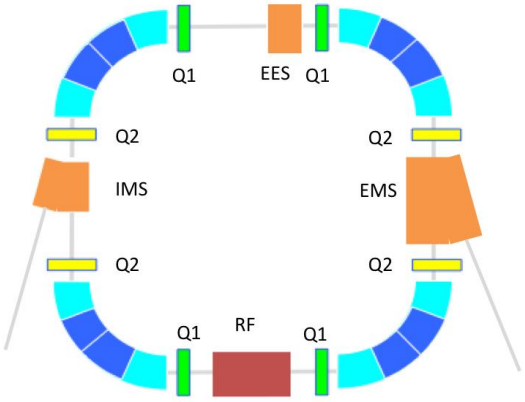
WP7
Advanced accelerator and gantry design

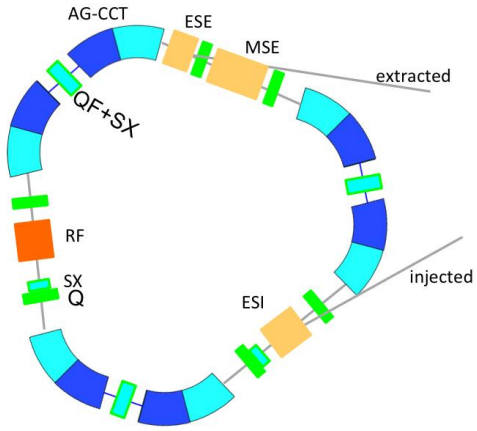
Maurizio Vretenar, CERN

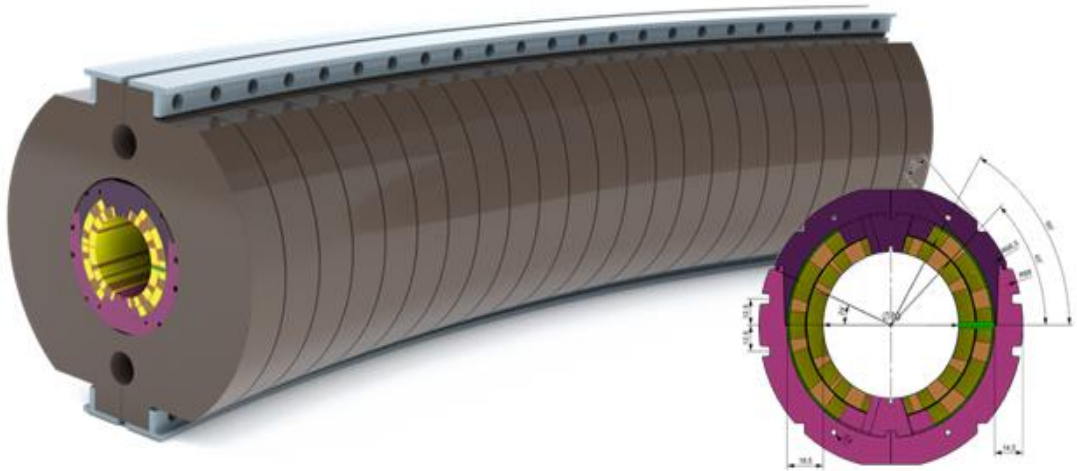


WP8
Superconducting magnet design

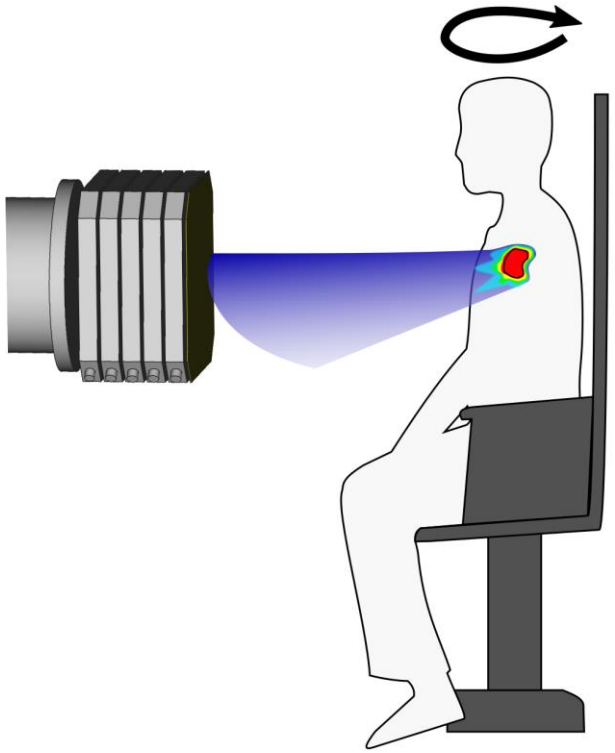
Ernesto De Matteis, INFN







JRA: Joint Research Activities

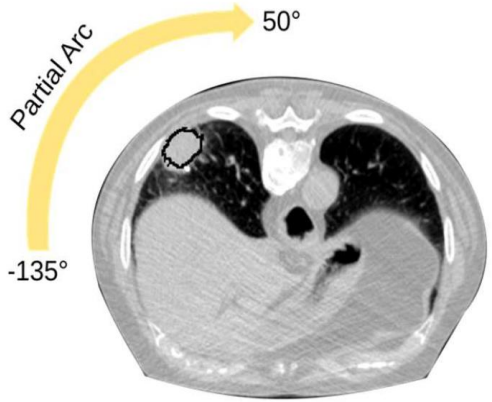


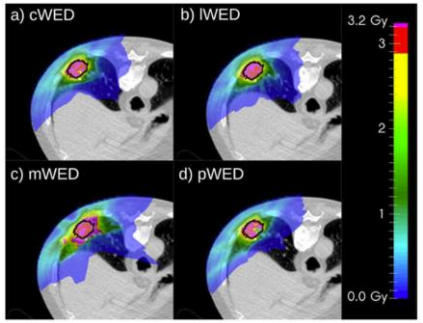
WP9
Advanced beam delivery

Christian Graeff, GSI

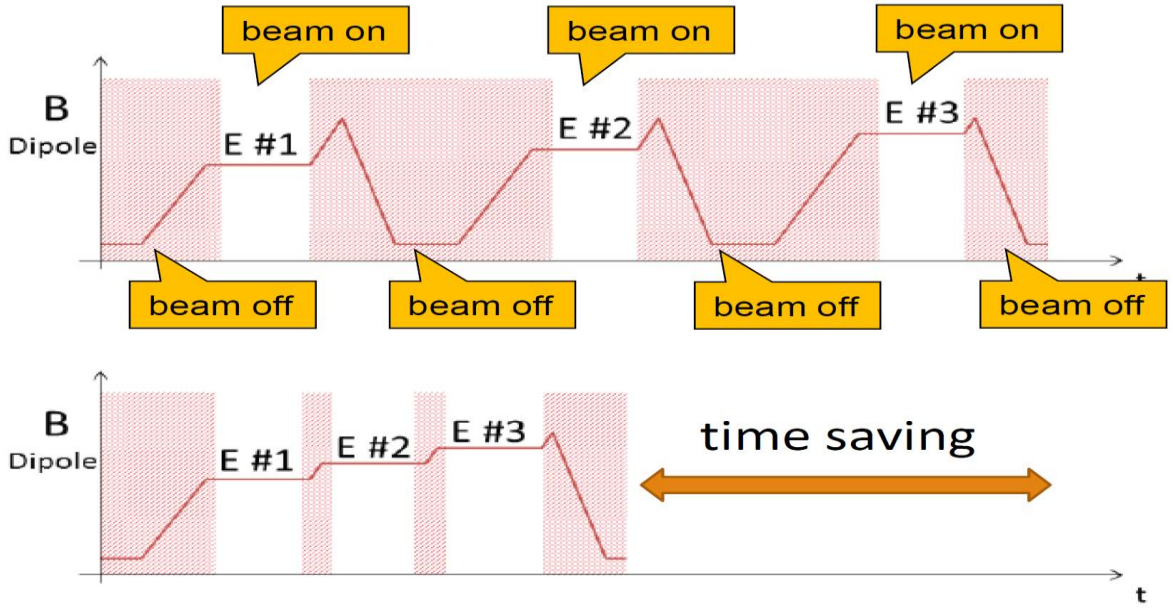
WP10
Multiple energy extraction system

Thomas Haberer, UKHD/HIT





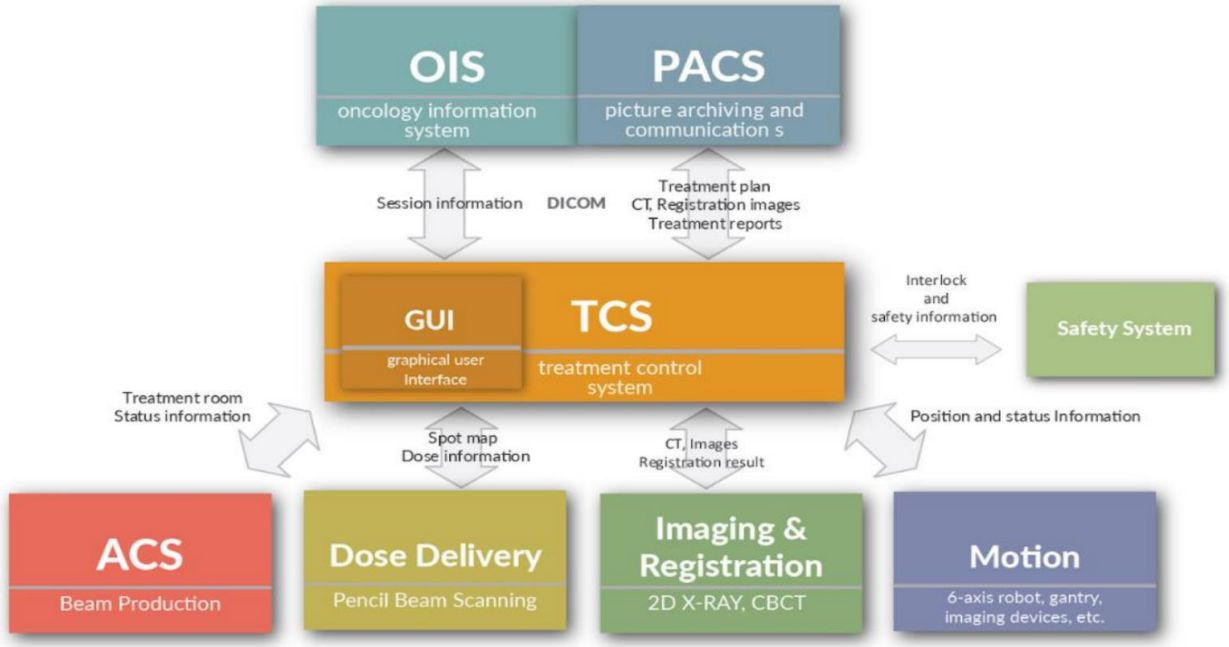
Arc - Therapy



JRA: Joint Research Activities

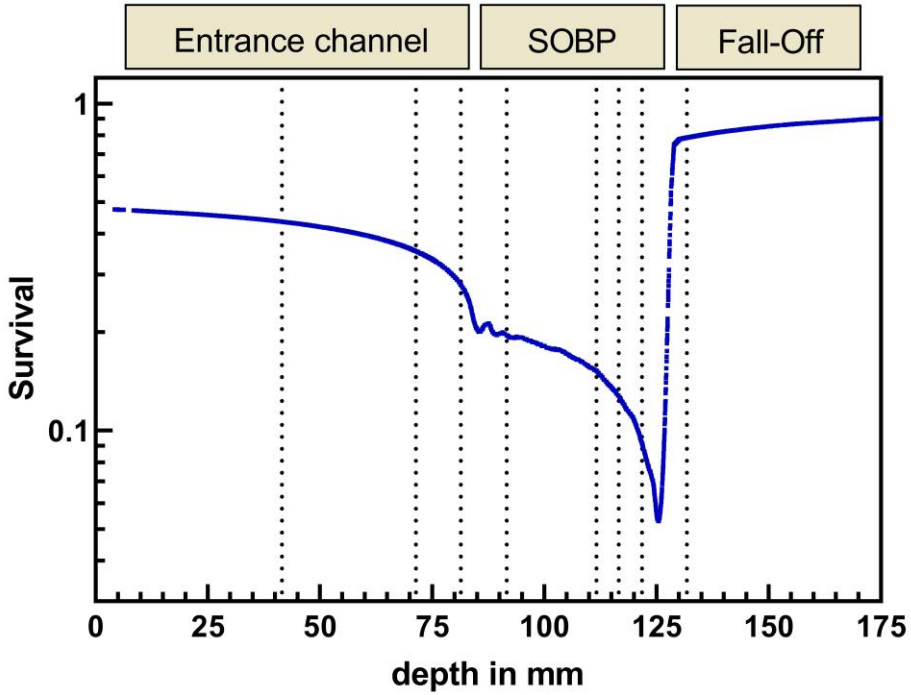
WP11
Controls and Safety

Dominik Perusko, CSL



WP12
Radiobiological Dosimetry and QA

Ulrike Schötz, UMR

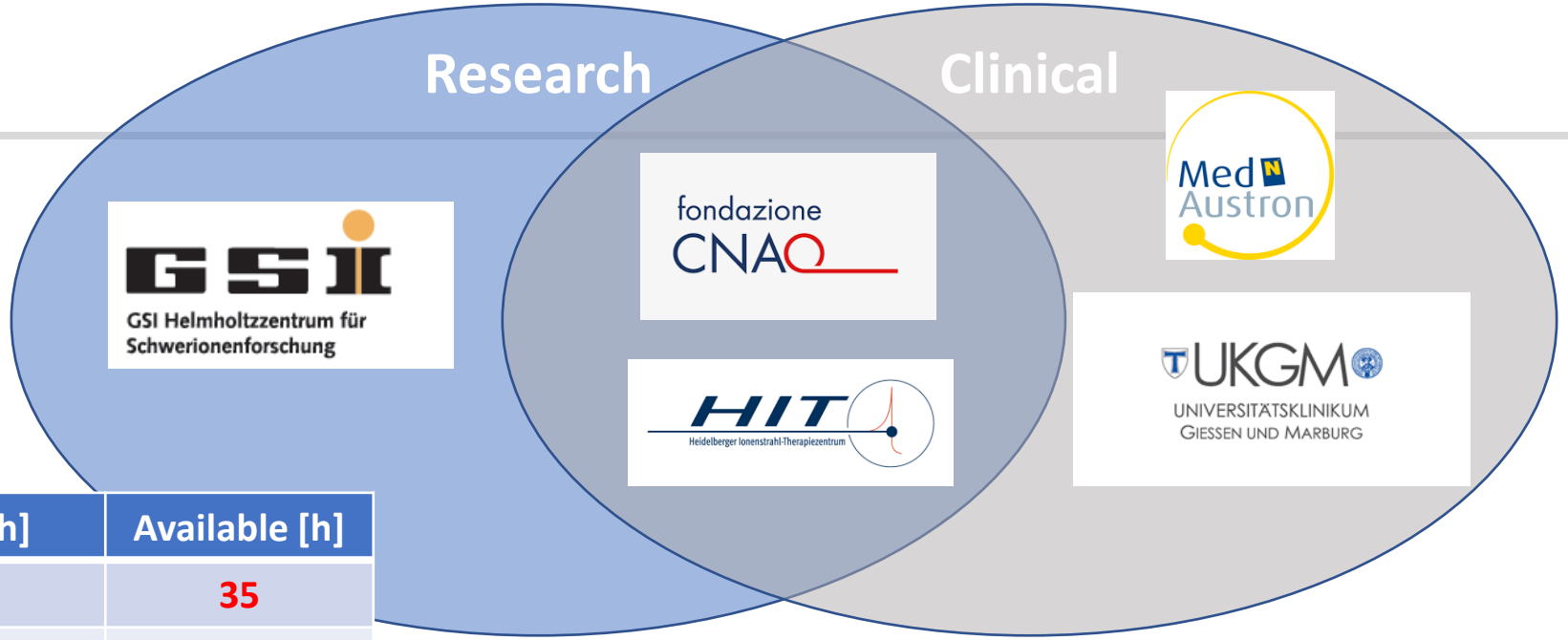


TNA: Trans National Access

The **Clinical Research Access** gives the opportunity **to clinicians/medical physicists/technicians** to join clinical research in hadron therapy through the submission of a clinical case for C-ion treatment, the comparison of treatment plans (photons, C-ions, protons), the discussion for C-ion eligibility of clinical cases or for clinical research trials in Hadrontherapy, and actively participate in the workflow of hadron treatment. .

The **Research Access** will attract universities, research centres, and hospitals, which will connect all the groups **to perform research activities with carbon ion beams**. Industrial partners are also encouraged to take part in the research programme, to be involved in the development of new clinical procedures and new medical devices.

WP6 - TNA RESEARCH



March 2024

RESEARCH	Total [h]	Done [h]	Available [h]
CNAO	80	45	35
GSI	296	39	257
UKHD/HIT	72	107	-35
	448	191	257

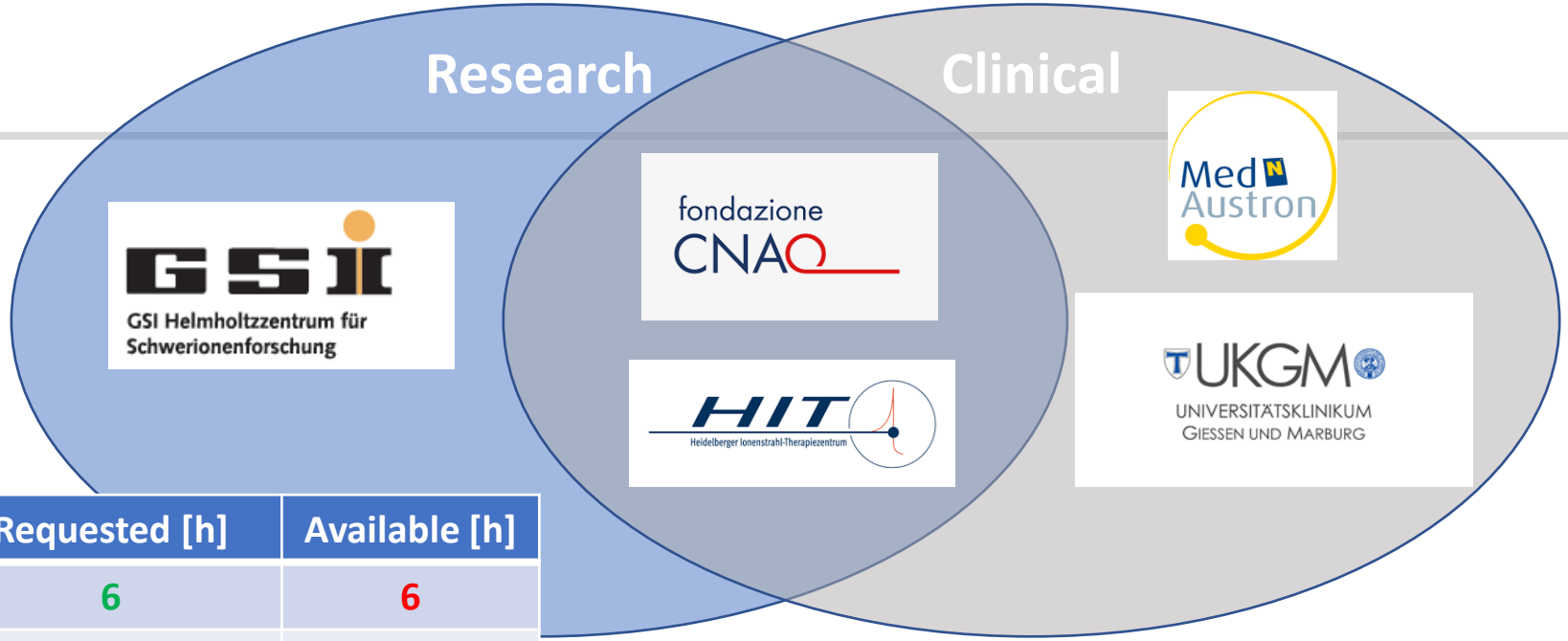
March 2025

RESEARCH	Total [h]	Done and booked [h]	Available [h]
CNAO	**200** (80 + 120)	183	17
GSI	**55** (296-241)	47	8
UKHD/HIT	**193** (72 + 121)	215	- 22
	448	445	3

Research TNA – 20+ research topics

- FragmentatiOn Of Target @ HIT
- Feasibility of real-time PET range verification in proton, He and C therapy using short-lived nuclides
- SIRMIO (Small Animal Proton Irradiator for Research in Molecular Image-guided Radiation-Oncology)
- Heavy ion spatially fractionated radiotherapy
- Assessing radiosensitivity of higher plants and mechanisms for radioresistance at different phenological stages
- Measurements of damages to biomolecules in solution induced by carbon ions and their secondary fragments
- Assessing space like radiation dose exposure and long-term risks in humans by using real-time differential gene expression sequencing analysis
- Stopping power ratio measurements of electron density phantom
- Silver atomic Quantum Clusters of five atoms (Ag5-AQCs), radiosensitizer for heavy-ion particle therapy
- SiFi-CC – commissioning of a setup for prompt-gamma imaging
- Spectral Fibre Dosimetry for Heavy Ion Radiotherapy
- Mixed beam image guidance for particle therapy applications
- Spot scanning proton arc therapy for head and neck cancer patients
- Test of TIARA detector with protons from synchrotron and carbon ions
- Angular distribution measurements of neutron fields generated with a typical clinical ion beams (proton and carbon) applied to anthropomorphic phantom
- An online, high-resolution, microfabricated beam transverse profiler
- Biophysical investigation of clinical helium ion beams for treatment of breast cancer
- Characterization of a novel diamond-based detection system for dosimetry and microdosimetry in ion beam therapy using He and O ions
- Multiscale and comprehensive assessment of the effects of hadrontherapy in head and neck tumors – Stealth-Bomber Paradigm
- PEPITES: toward an ultra-thin distant beam monitor used during patient treatment
- Direct comparison of water calorimetry and ionization chambers in carbon ion and helium ion beams in terms of absorbed dose-to-water

WP6 - TNA CLINICAL



March 2024

CLINICAL	Total [h]	Requested [h]	Available [h]
CNAO	12	6	6
UKHD/HIT	10	0	10
MEDA	12	3	9
MIT	16	2	14
	50	11	39

March 2025

CLINICAL	Total [h]	Requested [h]	Available [h]
CNAO	12	12	-
UKHD/HIT	10	3	-
MEDA	12	12	-
MIT	16	2	-
	50	29	21

Clinical TNA

Affiliation	Country
Thessaloniki	Greece
AEPROT	Spain
Hospital of Lithuanian University of Health Sciences	Lithuania
Amethyst Radiotherapy	Romania
Papageorgiou General Hospital	Greece
University of Babes Bolyai Cluj Napoca	Romania
Centre Baclesse	France
Veszprém County Hospital	Hungary
National Institute of Children's Diseases	Slovakia
Institute of Oncology Ljubljana	Slovenia
University Szeged, Department Oncotherapy	Hungary
Mayo Clinic Florida	USA
Rambam Health Care Campus	Israel
Erasmus MC, University Medical Center Rotterdam	Netherlands
Wollongong University	Australia
Tel Aviv University	Israel
Východoslovenský onkologický ústav a.s.	Slovakia
Proton Therapy Centre Czech	Czech Republic
DR MGR Medical University	India

Deliverables

WP No	Del Rel.	Del No	Title	Description	Lead I	Nature	Dissemin	Est. Del ▲	Rev. Due Da	Receipt Dat	Approval Date	Status
WP1	D1.1	D1	All governance boards inst	The General Assembly (GA), the Technical Proje...	CNAC	Report	Public	30 Apr 20		30 Apr 20	08 Mar 2023	Approved
WP2	D2.1	D4	Dissemination to the comr	Inform medical and research communities about t...	CNAC	Report	Public			29 Jun 20	08 Mar 2023	Approved
WP1	D1.3	D3	Data Management Plan	The data management plan describing the data ma...	CNAC	Repor				30 Sep 20	08 Mar 2023	Approved
WP13	D13.1	D39	H - Requirement No. 1	The procedures and criteria that will be used t...	CN			Sep 20		30 Sep 20	08 Mar 2023	Approved
WP10	D10.1	D30	Beam Characteristics Libra	Generation of a beam Characteristics Library op...			Confide	30 Nov 20		30 Sep 20	08 Mar 2023	Approved
WP9	D9.1	D27	Conceptual Design Report	From market and literature research, recommen		Report	Public	31 Dec 20		31 Dec 20	08 Mar 2023	Approved
WP8	D8.1	D24	Magnet Assessment for SC	Report on assessment of magnet typ	CEA	Report	Public	31 May 20		31 May 20	08 Mar 2023	Approved
WP3	D3.1	D7	Review of promising innov	Review of promising innov	MEDA	Report	Public	30 Sep 20		11 Oct 20	08 Mar 2023	Approved
WP6	D6.1	D18	HITRIplus delivers 100 hrs	HITRIplus deli NA by m...	GSI	Report	Public	30 Sep 20		09 Mar 20	10 Mar 2023	Approved
WP11	D11.1	D33	Design study on novel trea	Desi st system, which wi...	CSL	Demons	Public	30 Sep 20		28 Sep 20	08 Mar 2023	Approved
WP10	D10.2	D31	Data Distribution and Sync	data distribution and synchro...	UKHI	Report	Confide	31 Jan 20		01 Feb 20	20 Aug 2024	Approved
WP5	D5.1	D14	Delivery of specialise	of two one-week training courses on he...	SEEII	Website	Public	30 Sep 20		01 Oct 20	20 Aug 2024	Approved
WP5	D5.4	D17	Organisati	Organisation of secondments and internships in ...	UM	Website	Public	30 Sep 20		01 Oct 20	20 Aug 2024	Approved
WP7	D7.1	D21	Linac inje	Advanced conceptual design of an optimised lina...	BEVA	Report	Confide	30 Sep 20		10 Oct 20	20 Aug 2024	Approved
WP9	D9.2	D28	Particle arc therapy delive	Using the demonstrator from M9.1, a particle ar...	GSI	Demons	Public	30 Sep 20		29 Jan 20	20 Aug 2024	Approved
WP4	D4.1	D11	HITRIplus technologies anc	Internal report collecting and describing the t...	CERN	Report	Confide	31 Jan 20		31 Jan 20	20 Aug 2024	Approved
WP4	D4.2	D12	Value propositions	Promotional text and visual material aimed at d...	GSI	Report	Public	31 Jan 20		29 Jan 20	20 Aug 2024	Approved
WP5	D5.3	D16	Provision of e-learning cou	Conversion of the training courses and mastercl...	UM	Website	Public	31 Mar 20		30 Mar 20	20 Aug 2024	Approved

18/18 Deliverables APPROVED

HITRI
Heavy Ion Therapy Research Integration

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Deliverables submitted during the 3 RP (since 31 March 2024)

WP8	D8.2	D25	TDR (Technical Design Rep	Final report on Magnet design for SC synchrotro...	INFN	Report	Confide	31 May 2C	21 Aug 20	Submitted
WP3	D3.2	D8	Web based heavy ion ther	Web based heavy ion therapy patient registry wi...	CNAC	Websit	Confide	30	03 Oct 20	Submitted
WP3	D3.4	D10	Trial protocol for innovati	Definition of a pilot clinical trial protocol t...	MEDA	Report			30 Sep 20	Submitted
WP4	D4.3	D13	Technology matching even	Organisation of an event targeted at industry, ...	INFN				30 Sep 20	Submitted
WP7	D7.2	D22	Gantry design	Report describing the main optics parameters an...				30 Sep 20	30 Sep 20	Submitted
WP12	D12.1	D36	Conceptual design report	Generation of standard operating procedure (SOP...			Public	30 Sep 20	30 Sep 20	Submitted
WP11	D11.2	D34	Design study on novel acce	Design novel accelerator control system wit		Report	Public	31 Jan 20	27 Jan 20	Submitted

7 Deliverables SUBMITTED

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Deliverables: 14 to go

WP No	Del Rel.	Del No	Title	Description	Lead I	Nature	Dissemir	Est. Del. Date (annex I)
WP7	D7.3	D23	SC synchrotron design	Design of an optimised synchrotron with SC magn...	SEEII	Report	Public	31 Jan 2025
WP12	D12.2	D37	Modelling of the joint results	Transfer of results from D12.1 to UKHD/HIT for ...	UKHI	Report	Public	31 Jan 2025
WP2	D2.2	D5	Dissemination and outreach activities developed and regularl	Outreach programme for events -1 per year. HITR...	SEEII	Report	Public	31 Mar 2025
WP8	D8.3	D26	Magnet Demonstrator	Completion of the magnet demonstrator with coil...	INFN	Demon:	Confide	31 Mar 2025
WP9	D9.3	D29	Identification of beneficial patient arc therapy scenarios by l	Patient plans with dosimetric benefits will be ...	GSI	Report	Public	31 Mar 2025
WP2	D2.3	D6	Provide an annual activity report for the NA Pillar and final s	Activity report annually The delivery date assi...	SEEII	Report	Public	31 Jul 2025
WP11	D11.3	D35	Design study on novel patient safety systems	Design novel patient safety system, which will ...	CSL	Report	Public	31 Jul 2025
WP12	D12.3	D38	Final report and summary	Results will be summed up and distributed betwe...	UMR	Report	Public	31 Jul 2025
WP5	D5.2	D15	Delivery of masterclasses and train-the-trainer masterclasses	Delivery of a one week training course on heavy...	GSI	Websit	Public	31 Aug 2025
WP1	D1.2	D2	Plenary meetings reports	Reports of the plenary meetings. The delivery d...	CNAC	Report	Public	30 Sep 2025
WP3	D3.3	D9	Dose constraints of OARs in use at European heavy ion therap	Dose constraints of OARs in use at European hea...	UKHI	Report	Public	30 Sep 2025
WP6	D6.2	D19	HITRIplus delivers 498 units of research TA by month 54 and !	Description of TA units delivered by month 54 w...	GSI	Report	Public	30 Sep 2025
WP6	D6.3	D20	Publication of an overview article or a focus issue on the resi	Publishing the results of the TA regarding expe...	GSI	Report	Public	30 Sep 2025
WP10	D10.3	D32	Real-Time Data Generation Strategy	Realization of a quasi-real time data supply mo...	UKHI	Report	Confide	31 Mar 2024

31 Mar 2025

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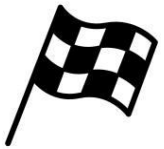
Milestones

Number	Name	Lead Beneficiary	Due Date	Ne	Achieved	Delivery Date (actual)	Comments
1	Mid-term General Assem	CNAO	30 Sep 2022		☑	29 set 2022	The HITRplus mid-term General Assembly meeting ...
2	Project website launche	CNAO	31 May 2021		☑	2021	https://www.hitriplus.eu/
4	First meeting of the Tecl	CERN	30 Nov 2021		☑	21	The first meeting of the Technology Overview C...
5	Specialised Courses and	SEEIIST	30 Sep 2022			2022	The goal of WP5 is to increase the European Poo...
6	Implementation of a USF	GSI	30 Nov 2021			29 ott 2021	USP structure: Two user selection panels (USP) ...
7	Linac and Gantry concep	CERN	31			31 mar 2022	An internal report describing the basic paramet...
8	Magnet Layout decision a	INFN			☑	30 nov 2022	After the design comparison study (deliverable ...
9	Finished simulation envi	GSI	022		☑	29 set 2022	The completion of the simulation setup for part...
10	Real-Time Data Generati	UKHD	30 Nov 2024		☑	29 nov 2024	Within work package 10 of the HITRplus project
11	Intermediate report on t	CSL	31 Mar 2022		☑	16 mar 2022	An internal report providing an overview of th...
13	Ethical documents distril	CNAO	31 Jul 2021		☑	31 lug 2021	The following documents are available upon requ...
14	Evaluation of web based	MEDA	30 Sep 2022		☑	29 set 2022	A proposal for a web based registry to provide ...

☑ 12 Milestones completed

2 Milestones to go



Number	Name	Lead Beneficiary	Due Date	New Due Date (if delay)	Achieved
3	Evaluation of impact on European centres OARs constraints	MEDA	31 Mar 2025		☐
12	Generation of a standardized dosimetry for collaborative radiobiological experiments between the facilities	UMR	31 Jan 2025		☐

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Scientific contributions

Invited scientific talks

- S. Rossi, CNAO experience and international pe
  Developing Human Resources for Setting Up ar
  Headquarters – Vienna
- S. Rossi, Ion Therapy Ce
  Sofia, 12-13th May 202
- S. Rossi, HITRIplus – He
  Conference, Madrid, 1
- S. Rossi, Practical exper
  Research: consideratio
- S. Rossi, HITRIplus, Onli
- S. Rossi, Introduction t
  CERN, Geneva, Octobe
- S. Rossi, IS CNAO THE R
  Development of a hadr
  BNCT. Workshop CNAC
- A.Facoetti, HITRIplus –
  status and perspective
  existing. Scientific day
- S. Rossi, Health ecosyst
  knowledge exchange &
- S. Rossi, Hadrontherap
  Annual Meeting of Arg
  Aires, Georgetown. No

- Fossati P. Co
  Symposium-
- Fossati P. Car
  Therapy Sym
- Fossati P. Car
  Particle Ther
- Ankita Nacha
  Joanna Gora,
  strategy in ca
  2023, Vienna
- Ankita Nacha
  Gora, Gernot
  ion radiother
  2023, Madric
- Marco Duran
- M. Vretenar,
  HITRIplus ser
- M. Vretenar,
  11-13.10.23
- E. Benedetto
  HEP Projects,
- R.Taylor, Slov
- H.Huttunen,

Scientific Talks
(78 speeches)

Public talks
(40 events)

Webinars
(19 events)

Lectures
(21 events)

le

e-to-mass Ratio of 1/2 with a
erence (CBC 2022),
an Ion Therapy Accelerator

gy layer optimization for carbon ion arc therapy"
TCOG) annual meeting, PTCOG60, 1st of July 2022,
le yet
t therapy" ESTRO Physics workshop 2022: Particle
ality , 7th of October 2022, Lisbon, Portugal;

ins-Fekete „Focus stacking particle radiography"
ER, 2022.
, M. Durante, U. Weber, C. Graeff "Characterizing
ms with CMOS sensors " PTCOG 2023 annual

Durante, A. Mairani, X. Ding, C . Graeff, T. Li
ic Radiosurgery of Multiple Brain Metastases"
uncil symposium recognition, full oral presentation
M. Durante, C. Graeff, C.-A. Collins-Fekete
ime image guidance" 4th Ion Imaging workshop

erence 2023, Darmstadt, GER

Publications

More than 50 publications *in extenso*

Last ones

- Mamaras A *et al* 2024 *J. Phys.: Conf. Ser.* 2687 052010DOI 10.1088/1742 6596/2687/5/052010
- Toral F *et al*., "Status of Nb-Ti CCT Magnet EU Programs for Hadron Therapy," in *IEEE Transactions on Applied Superconductivity*, vol. 34, no. 5, pp. 1-5, Aug. 2024, Art no. 4401705, doi: 10.1109/TASC.2023.3349252.
- Pullia MG *et al* 2023 *J. Phys.: Conf. Ser.* 2420 012099
- Rossi L *et al* 2024 *J. Phys.: Conf. Ser.* 2687 092009DOI 10.1088/1742-6596/2687/9/092009
- Benedetto E and Vretenar M 2024 *J. Phys.: Conf. Ser.* 2687 092003DOI 10.1088/1742-6596/2687/9/092003
- Benedetto E *et al* 2024 *J. Phys.: Conf. Ser.* 2687 062007DOI 10.1088/1742-6596/2687/6/062007
- Sorti S *et al*., "Electromagnetic Losses in Fast-Ramped Canted-Cosine-Theta Magnets," in *IEEE Transactions on Applied Superconductivity*, 2024, Art no. 4003506, doi: 10.1109/TASC.2024.3360933.
- Nikitovic L *et al* 2024 *J. Phys.: Conf. Ser.* 2687 052011DOI 10.1088/1742-6596/2687/5/052011
- Prioli M *et al 2024.* First Winding Trial for the Superconducting Ion Gantry (SIG) Dipole Demonstrator Magnet., doi: 10.1109/TASC.2024.3361440.
- Georgieva P. and Dosanjh, M. ENLIGHT (European Network for Light Ion Hadron Therapy) and its role in Hadron therapy. *Health Technol.* 2024. https://doi.org/10.1007/s12553-024-00837-8
- Volz L et al. Focus stacking single-event particle radiography for high spatial resolution images and 3D feature localization. Phys Med Biol. 2024. doi: 10.1088/1361-6560/ad131a.
- Volz L. Focus stacking single-event particle radiography for high spatial resolution images and 3D feature localization. Phys Med Biol. 2024. doi: 10.1088/1361-6560/ad131a.
- Bertho A et al. Carbon minibeam radiation therapy results in tumor growth delay in an osteosarcoma murine model. Sci Rep. 2025 Mar 1;15(1):7305. doi: 10.1038/s41598-025-91872-6.

HITRI
Heavy Ion Therapy Research Integration

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THANK YOU!

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