CNAO

Centro Nazionale di Adroterapia Oncologica

https://fad.accmed.org/course/info.php?id=1325

AIM:
Strengthen user community,
Capacity building
Learn from existing facilities

Deliverable of the HITRIplus EU-funded project (with SEEIIST as beneficiary)
In conjunction with IAEA Regional workshop under the Technical Cooperation project RER6039 supporting SEEIIST

Participants:
Antonio Capizelo (AHEPA), Kosmas Badiavas (Papageorgiou)
and Maria Mpigaki (Papageorgiou and IAEA Greek contact for the above project)
Plus 8 AUTH students

Next one: Thessaloniki, 18-21 October 2024
Invited by Aristotle Medical Forum
In cooperation with Mr Bamidis, Triaridis, Anastasiadis

PROGRAMME: https://mcusercontent.com/3b675bca18e962fbbc9709f23/files/cd9f3d03-e70b-d116-3815-55f6783355c5/Handrontherapy_status_and_perspectives_and_Scientific_day_on_BNCT_definitive_program.pdf

Information on SEEIIST

SEEIIST Summary Document with Links attached here: https://indico.cern.ch/event/1421561/ and
Direct link: https://indico.cern.ch/event/1421561/sessions/551007/attachments/2865058/5014405/SEEIIST%20SUMMARY%20INFO%20and%20DOCUMENTS-For28may2024atMacedoniaPalace.pdf

Publication as CERN Yellow Report in progress: for any next generation hadron therapy facility (see MV)

SEEIIST - Μία σύγχρονη προηγμένη ερευνητική υποδομή για καινοτόμο θεραπεία καρκινικών όγκων

Τι είναι το SEEIIST

Το Διεθνές Ινστιτούτο Βιώσιμων Τεχνολογιών Νοτιοανατολικής Ευρώπης (South East European International Institute for Sustainable Technologies - SEEIIST) στοχεύει στην ανάπτυξη, στη διευρυμένη περιοχή των Βαλκανίων, μιας **προηγμένης ερευνητικής υποδομής για καινοτόμο έρευνα και θεραπεία όγκων καρκίνου χρησιμοποιώντας δέσμες σωματιδίων** όπως πρωτονίων, ηλίου, άνθρακα και άλλων ιόντων. Η υλοποίηση της τεράστιας αυτής πρόκλησης βασίζεται σε τεχνολογίες αιχμής στον τομέα των επιταχυντών και ανιχνευτών, που αναπτύσσονται στο CERN[1], GSI[2] και σε άλλους ευρωπαϊκούς ερευνητικούς οργανισμούς.

Το SEEIIST έλαβε την αρχική χρηματοδότηση από την Ευρωπαϊκή Επιτροπή για τις μελέτες σχεδιασμού της εγκατάστασης και από την Διεθνή Υπηρεσία Ατομικής Ενέργειας, IAEA[3], για την ανάπτυξη ικανοτήτων προωθώντας παράλληλα τη διεθνή συνεργασία στην περιοχή της Νοτιοανατολικής Ευρώπης (NAE). Μετά τον αρχικό σχεδιασμό, μια ομάδα ειδικών συνεχίζει να αναπτύσσει τις τεχνικές λεπτομέρειες της εγκατάστασης.

SEEIIST Summary and key figures
https://cernbox.cern.ch/index.php/s/iR7lGERHOdavyuB

SEEIIST

SEE Hadron Therapy and research Facility by Ugo Amaldi et al (CERN Yellow Report)
https://cernbox.cern.ch/index.php/s/deb9lyWe8kVjYUS

ESFRI application Sep 2020 : http://bit.ly/esfriseeiist
Contributing Authors: https://cernbox.cern.ch/index.php/s/g5eAgMdBRrSgju4

SEEIIST Association

SEEIIST Association: Information
https://cernbox.cern.ch/index.php/s/td2cailt46qrXNQ

SEIIST Member States contributions for Association
https://cernbox.cern.ch/index.php/s/fY6UcbcJLNUCcCE

TOWARDS ERIC:

SEEIIST Legal Framework_ERIC_proposal_final.pd
https://cernbox.cern.ch/index.php/s/pEXCwqLwz5jKnbo

Financial Annex
https://cernbox.cern.ch/index.php/s/W1ypuQkxeshbZEw

EU Support

HITRIplus: https://www.hitriplus.eu
I.FAST: https://ifast-project.eu
SF(16) DLR Deliverables: https://indico.cern.ch/event/1119243/page/24249-sf16-dlr-deliverables

BROCHURES and Leaflets

Leaflet in English: https://cernbox.cern.ch/index.php/s/iDHkMxjtrDL6wkm
Leaflet in Greek: https://cernbox.cern.ch/index.php/s/t8WH6diyesEdp6U

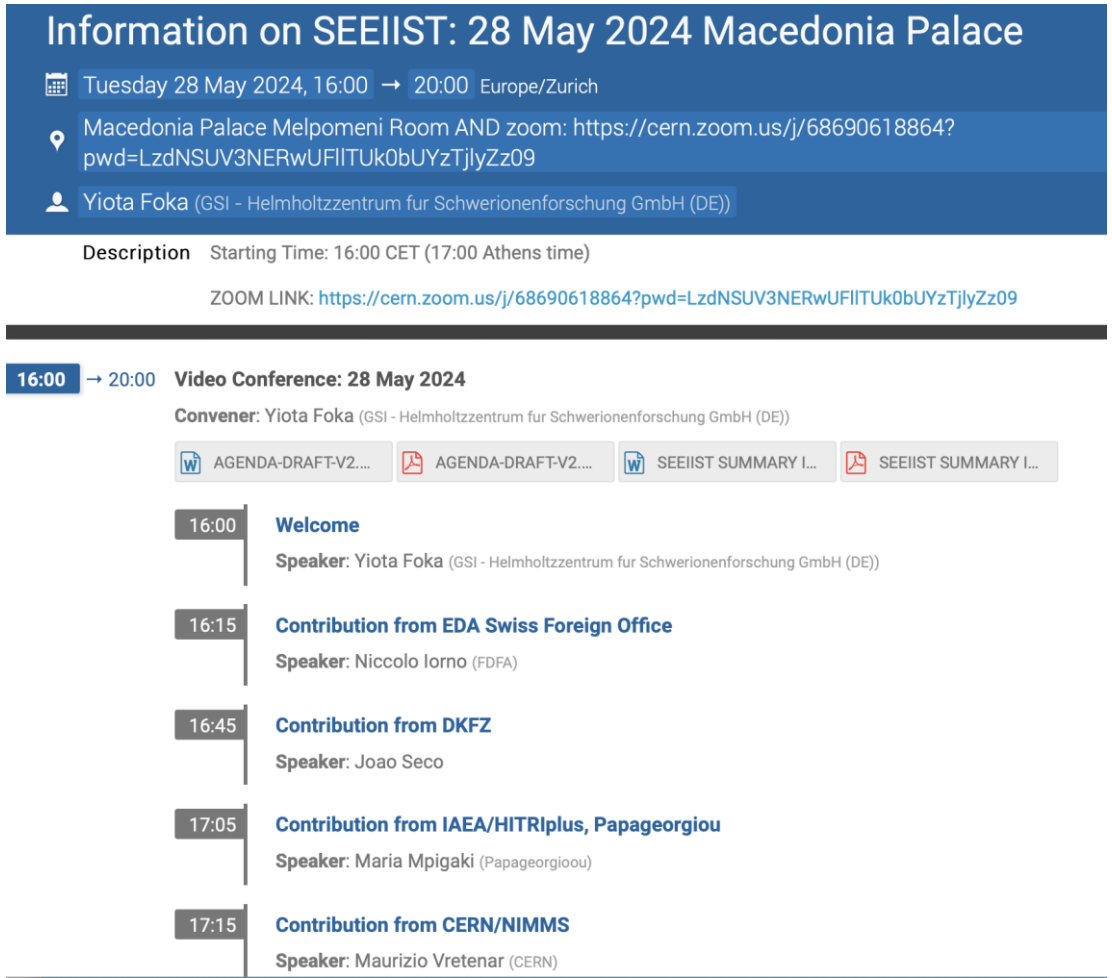
Brochure in english
https://cernbox.cern.ch/index.php/s/Lifg63bLNZkq9r5

SEEIIST and Greece

MoU SEEIIST Association and AUTH Medical School
(signed by K. Annastasiadis and P. Bamidis Dec 2023)
https://cernbox.cern.ch/index.php/s/TcqQUTPnb8SOys1

Information on SEEIIST

Presentations available here:
https://indico.cern.ch/event/1421561/
YF presentation with comments: no time to go through
(with references to experts presentations for completeness)



Information on SEEIIST: 28 May 2024 Macedonia Palace

Tuesday 28 May 2024, 16:00 → 20:00 Europe/Zurich

Macedonia Palace Melpomeni Room AND zoom: https://cern.zoom.us/j/68690618864?pwd=LzdNSUV3NERwUFlITUk0bUYzTjlyZz09

Yiota Foka (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

Description Starting Time: 16:00 CET (17:00 Athens time)

ZOOM LINK: https://cern.zoom.us/j/68690618864?pwd=LzdNSUV3NERwUFlITUk0bUYzTjlyZz09

16:00 → 20:00 **Video Conference: 28 May 2024**

Convener: Yiota Foka (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

AGENDA-DRAFT-V2.... AGENDA-DRAFT-V2.... SEEIIST SUMMARY I... SEEIIST SUMMARY I...

16:00 **Welcome**
Speaker: Yiota Foka (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

16:15 **Contribution from EDA Swiss Foreign Office**
Speaker: Niccolo Iorno (FDFA)

16:45 **Contribution from DKFZ**
Speaker: Joao Seco

17:05 **Contribution from IAEA/HITRIplus, Papageorgiou**
Speaker: Maria Mpigaki (Papageorgioou)

17:15 **Contribution from CERN/NIMMS**
Speaker: Maurizio Vretenar (CERN)

Aim: provide information by experts
Time for Q&A to experts directly

Executive Summary, in Greece, in numbers

Related to specialised hands-on training: doctors/professionals (details by Maria Mpigaki)

5 patient cases submitted to HIT/CNAO/MedAustron via HITRIplus TNA
3 members of AHEPA/Papageorgiou and 8 AUTH students at CNAO/IAEA workshop (Oct 2023)
2 pax at IAEA/Vienna workshop (Jan 2024)
2 doctors of Papageorgiou at CNAO via HITRIplus TNA (Feb 2024)
3 medical physicists from AHEPA/Papageorgiou at ICTP Trieste school (April 2024)

Related to education/training

2 HITRIplus online schools: May 2021, July 2023 with 1050 and 600 online participants
10 AUTH students in organization team
4 online PTMC in Greece, every year since 2021
250 high-school students participating on Saturdays
15 AUTH students in organization team and as tutors
7 AUTH students following masters, PhDs (4 in DKFZ, 1 at CERN, 2 in Greece)

Related to EU proposals and collaborations

1 MoU with AUTH Medical School
2 EU proposals submitted on related topics, widening era,
(with coordinator AUTH, important consortia/collaborations)

Related to information events (scientific and public)

2 online scientific information events
5 exhibitions at HELEXPO (TIF, BEYOND, FORWARD GREEN)

Growing interest and community

Upcoming workshop plus hands-on training: 18-21 October 2024 (during AMF)

Growing community and interest in Greece, including new generation

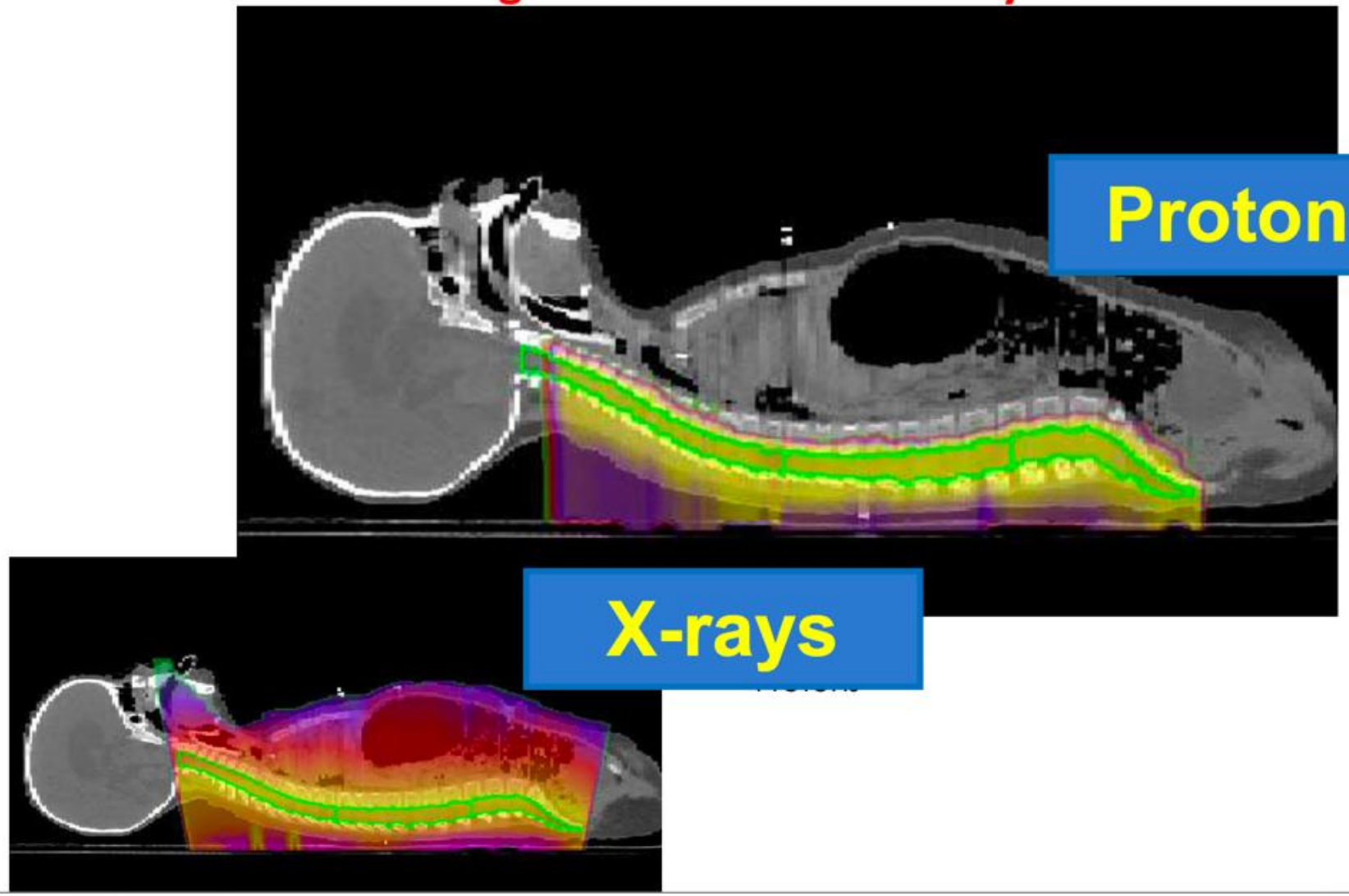
AUTH Assistants team for 3rd HITRIplus school

J.S.

To be trained and come back !

Pediatric patients elective for protons

Less dose to healthy tissues
to reduce long term risks of secondary tumours



Introductions

Experts Presentations : https://indico.cern.ch/event/1421561/

SEEIIST SC meeting in Thessaloniki https://indico.cern.ch/event/1103276/
https://m.youtube.com/watch?v=JaNQAWDLWz0&feature=youtu.be

14th SEEIIST Steering Committee meeting in Thessaloniki

SEE IST South East European International Institute for Sustainable Technologies

SEEIIST meetings in Thessaloniki

4–6 Apr 2022
Venue: Helexpo
Europe/Athens timezone

https://indico.cern.ch/event/1103276/

https://m.youtube.com/watch?v=JaNQAWDLWz0&feature=youtu.be

Overview
Venue
Agenda

The main scientific goal of SEEIIST is the realisation of a **"Facility for Tumour Hadron Therapy and Biomedical Research"**. Such a Regional Center of Scientific Excellence will strengthen local scientific expertise for future projects and the development of a sustainable economy and social cohesion. The facility is expected to stimulate the development of complementary technologies, such as the use of alternative energy sources or the development of advanced digital systems, and to trigger spin-offs. To maximise benefits it is planned as a regionally distributed facility with hubs in different countries offering numerous opportunities for technology transfer and benefits to South-East European industry as well as international cooperation opportunities.

The **SEEIIST** project has entered the **Design Phase** thanks to the first financial support of the **European Commission (DG RTD)** and the EU funded **HITRIplus** project, where state-of-the-art particle accelerator design is developed in collaboration with the main European research centres **CERN** and **GSI-FAIR**.

The SEEIIST meetings in Thessaloniki will be in hybrid mode, preferably in person and will include the:

- Open Steering Committee Meeting
- Closed Steering Committee Meeting
- Legal Framework Working Group Meeting
- Site Selection Working Group Meeting

April 16, 2022 | News, SC Meetings

A BIG STEP FORWARD FOR SEEIIST PROJECT

THE 14th MEETING OF THE SEEIIST STEERING COMMITTEE HELD ON 4 APRIL 2022 IN THESSALONIKI, GREECE The 14th meeting of the SEEIIST Intergovernmental Steering Committee (SC) was held on April 4, 2022 in Thessaloniki, Greece. The welcome address was given by

Articles and Photos

Contact
Yiota.Foka@cern.ch

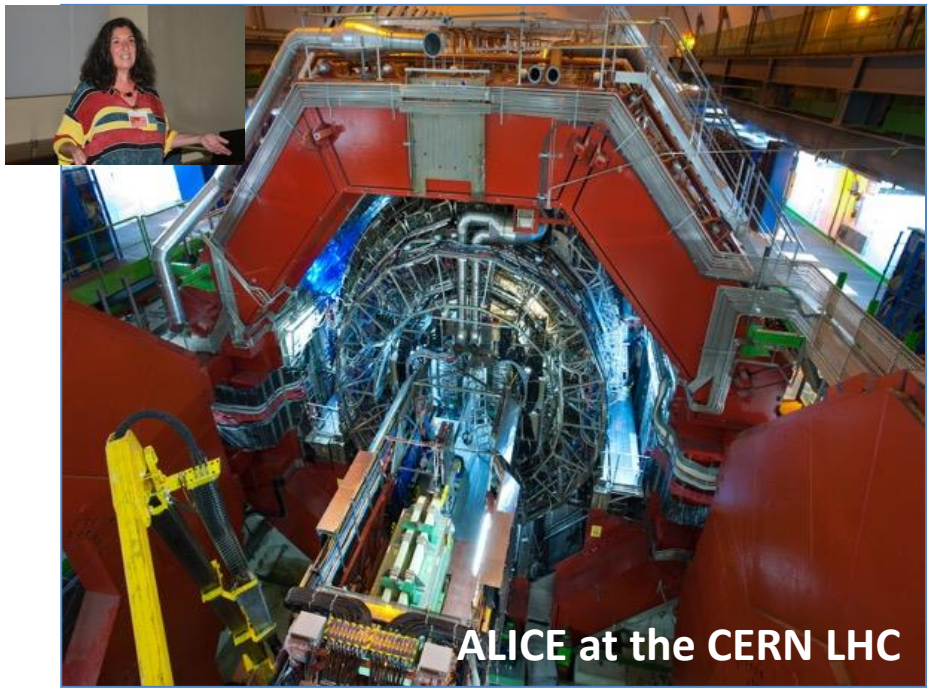
https://indico.cern.ch/event/1103276/page/25237-articles-and-photos

Comments by A.Tzikas/M.Chavouzis

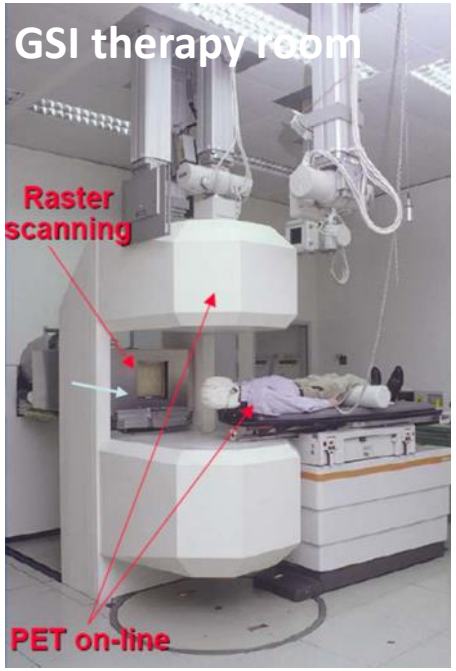
Heavy-ion research and heavy-ion therapy

Heavy-ion Physicist, involved with medical applications of heavy-ions for cancer therapy

ALICE heavy-ion experiment at CERN



GSI, pioneering heavy-ion cancer therapy in the 90s



Heavy-ion research and heavy-ion therapy

Heavy-ion Physicist, involved with medical applications of heavy-ions for cancer therapy

ALICE heavy-ion experiment at CERN

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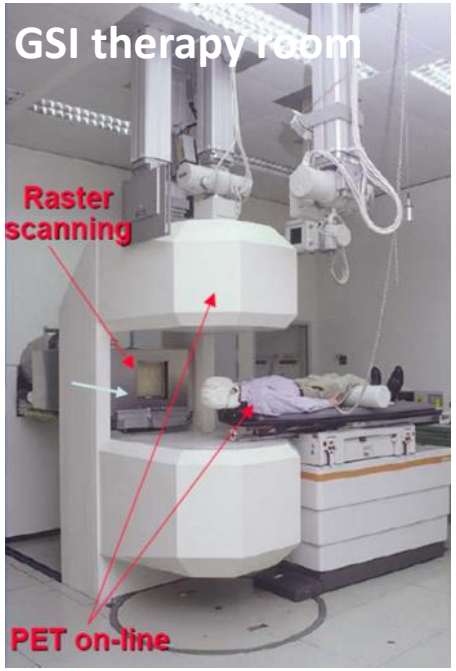


Heavy-ion research and heavy-ion therapy

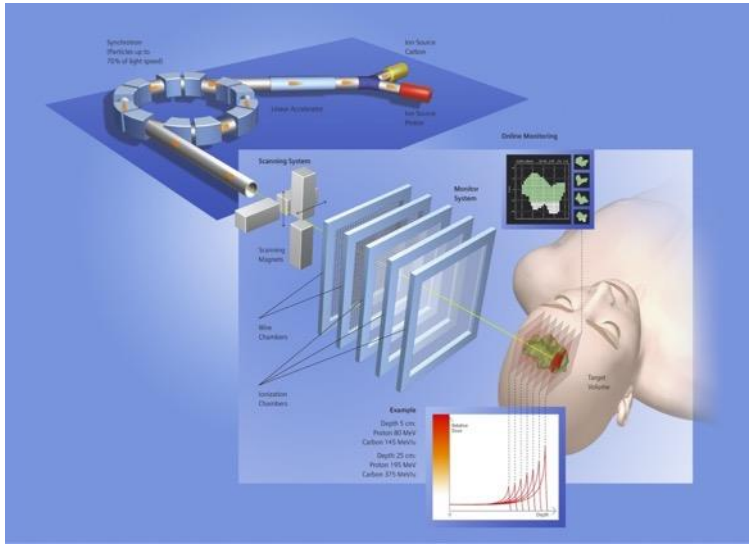
Heavy-ion Physicist, involved with medical applications of heavy-ions for cancer therapy

ALICE heavy-ion experiment at CERN

ALICE Control Room

GSI, pioneering heavy-ion cancer therapy in the 90s

Heidelberg Ion Therapy HIT centre

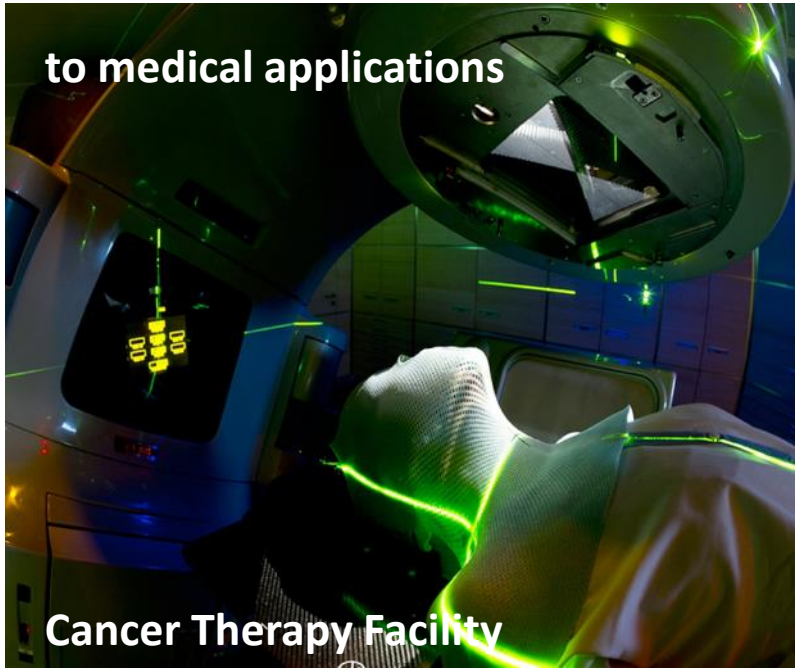


Implemented at HIT, Heidelberg Ion Therapy centre

Heavy-ion research and heavy-ion therapy

Heavy-ion Physicist, involved with medical applications of heavy-ions for cancer therapy

ALICE heavy-ion experiment at CERN **Innovative technologies for next generation ion facilities**

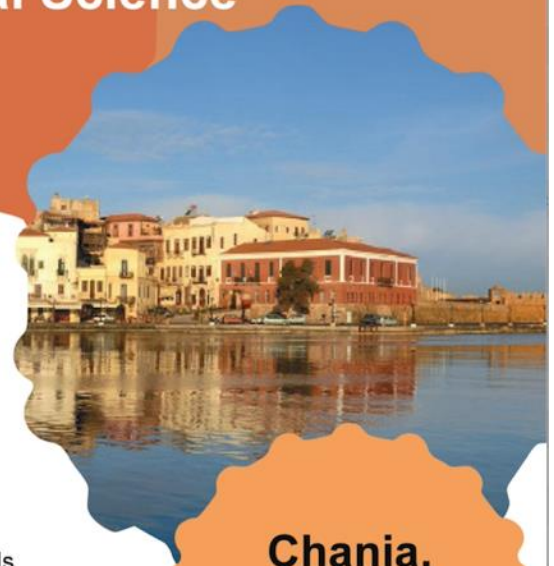


Next Steps: Next Ion Medical Machine Study, NIMMS, CERN group

Workshop on Ions

for Cancer Therapy, Space Research and Material Science

SPACE RESEARCH WORKSHOP ON IONS FOR CANCER THERAPY MATERIAL SCIENCE



Chania, Crete, Greece

26 - 30 August 2017

Workshop Main Topics

28-30 of August at Great Arsenali

Particle therapy status
- Centres worldwide
- Treatment planning and imaging novel methods
- Challenges, new R&D directions

Space research and dosimetry
Nanotechnology, electronics and material research
Modelling and benchmarking of experiments
Novel accelerators and training

Public Events

26 of August - science fair at Neorio Moro
27 of August - public talks at Great Arsenali
30 of August - coffee with scientists at Neorio Moro

https://indico.cern.ch/e/ions2017/

International Advisory Committee

Etiennette Auffray Hillemanns (CERN, Switzerland)
Philip Burrows (University of Oxford, UK)
Marco Durante (TIFPA, INFN, Italy)
Paolo Giubellino (GSI & FAIR, Germany)
Apostolos Karantanas (Medical School, University of Crete, Greece)
Vladimir Kekelidze (JINR, Russia)
Panos Razis (University of Cyprus, Cyprus)
Boris Sharkov (ITEP, Russia)
George Stavrakakis (Technical University of Crete, Greece)
Thomas Stoehlker (GSI & FAIR, Germany)

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Y. Foka (GSI, Germany) - chair
C. Balas (TUC, Greece)
E. Dimovasili (CERN, Switzerland and UCY, Cyprus)
C. Graeff (GSI, Germany)
N. Kallithrakas (TUC, Greece)
R. Pleskac (GSI, Germany)
E. Tsesmelis (CERN, Switzerland and Oxford, UK)
M. Vretenar (CERN, Switzerland)
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Web Assistants

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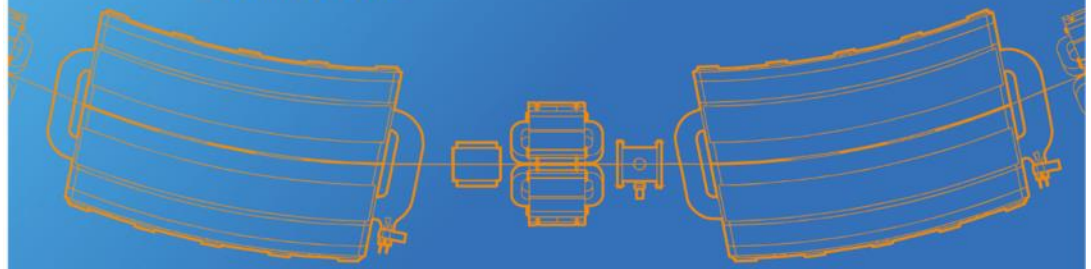
K. Foka Sandoval (EPFL, Switzerland)
L. Graczykowski (WUT, Poland)
M. Janik (WUT, Poland)
A. Katanaeva (UB, Spain and SPbSU, Russia)
D. Shukhobodskaia (SPbSU, Russia)

PIMMS2 @CERN

Workshop
Location Archamps, France
Venue: European Scientific institute (ESI)
Dates: 19-21 June 2018

Ideas and technologies for a next-generation facility for medical research and therapy with ions



MAIN TOPICS:

- EXISTING FACILITIES
- CURRENT INITIATIVES
- NEW TECHNOLOGIES
- DESIGN PARAMETERS
- TECHNICAL OPTIONS

https://indico.cern.ch/e/ions2018

photo credit : PIMMS Proton Ion Medical Machine Study

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A. Zens (MedAustron, Austria)

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Workshop on Ions

for Cancer Therapy, Space Research and Material Science

SPACE RESEARCH WORKSHOP ON IONS FOR CANCER THERAPY MATERIAL SCIENCE

Basic requirements of the next generation cancer therapy accelerator:

- ❑ Operation with multiple ions: protons, helium, carbon, oxygen, etc. for therapy and research.
- ❑ Lower cost and dimensions, compared to present;
- ❑ Faster dose delivery with higher beam intensity and new delivery schemes (FLASH)
- ❑ A gantry device to precisely deliver the dose to the tumour.

https://indico.cern.ch/e/ions2017/

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D. Shukhobodskaia (SPbSU, Russia)

WORKSHOPS ON IONS FOR CANCER THERAPY SPACE RESEARCH

PIMMS2 @CERN

Workshop
Location Archamps, France
Venue: European Scientific institute (ESI)
Dates: 19-21 June 2018

Ideas and technologies for a next-generation facility for medical research and therapy with ions

MAIN TOPICS:

- EXISTING FACILITIES
- CURRENT INITIATIVES
- NEW TECHNOLOGIES
- DESIGN PARAMETERS
- TECHNICAL OPTIONS

https://indico.cern.ch/e/ions2018

photo credit : PIMMS Proton Ion Medical Machine Study

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M. Vretenar (CERN, Switzerland)

Next Ion Medical Machine Study, NIMMS

M.V

The Next Ion Medical Machine Study is an international collaboration based at CERN, established in 2018 with the support of the CERN KT for Medical Applications, with the goal of developing new technologies for the future generation of accelerators for cancer therapy with ions heavier than protons.

- Building on the experience of the PIMMS (proton-ion medical machine study) of 1996/2000;
- Federating partners to develop designs and technologies for next-generation ion therapy;
- Concentrating on technologies for ions – protons are covered by commercial companies;
- **Partners** can use the NIMMS technologies to assemble their own optimized facility.

nimms

NIMMS collaboration in 2023 (19 partners)

- SEEIIST (South East European International Institute for Sustainable Technologies)
- TERA/TERA-CARE Foundation (Italy/CH)
- Riga Technical University (Latvia)
- GSI (Germany)
- INFN (Italy)
- CIEMAT (Spain)
- Cockcroft Institute (UK)
- University of Manchester (UK)
- CNAO (Italy)
- Imperial College (UK)
- MedAustron (Austria)
- U. Melbourne (Australia)
- ESS-Bilbao (Spain)
- Sarajevo University (Bosnia &H.)
- University of Thessaloniki (Greece)
- PARTREC (Netherlands)
- TENMAK (Turkey)
- ITRE (Slovenia)
- University of Malta

NIMMS Funding:

- CERN Knowledge Transfer
- SEEIST, RTU and TERA (personnel at CERN)
- European projects HITRIplus and I.FAST
- Donation

In 2022/23 NIMMS has supported:

- 8 PhD Students
- 3 Post-Docs
- 1 Master student

NIMMS supported designs for areas with no ion facilities

M.V

NIMMS toolbox

Particle therapy centres in Europe. Courtesy of ENLIGHT, 2020

80% increase of cancer cases
below the age of 50 in the last 30 years

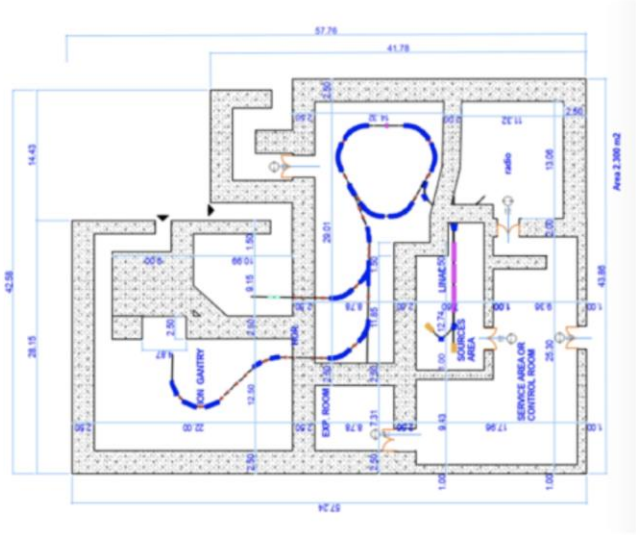
NIMMS supported designs for areas with no ion facilities

M.V

nimms

HOME ABOUT TECHNOLOGICAL R&D INITIATIVES TRAINING NEWS

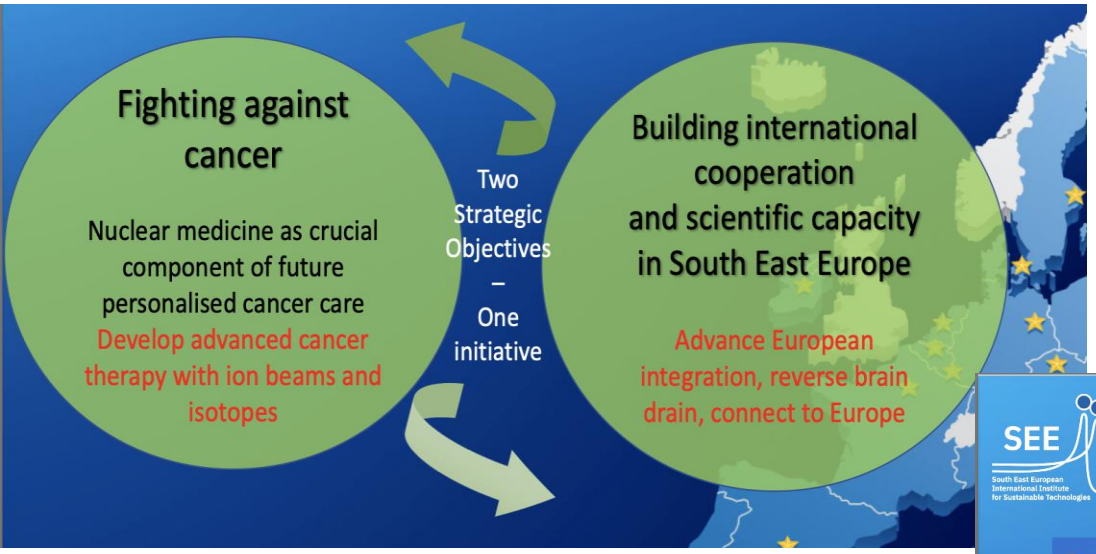
Our Initiatives



Baltic Collaboration	SEEIIST
Heavy Ion Therapy Facility for the Baltic States	Heavy Ion Therapy Facility for the Balkans States

80% increase of cancer cases
below the age of 50 in the last 30 years

Presentations at CERN



Towards Greece becoming full member

SEE ST
South East European International Institute for Sustainable Technologies

Political steps taken so far

Declaration of Intent signed at CERN on October 25, 2017

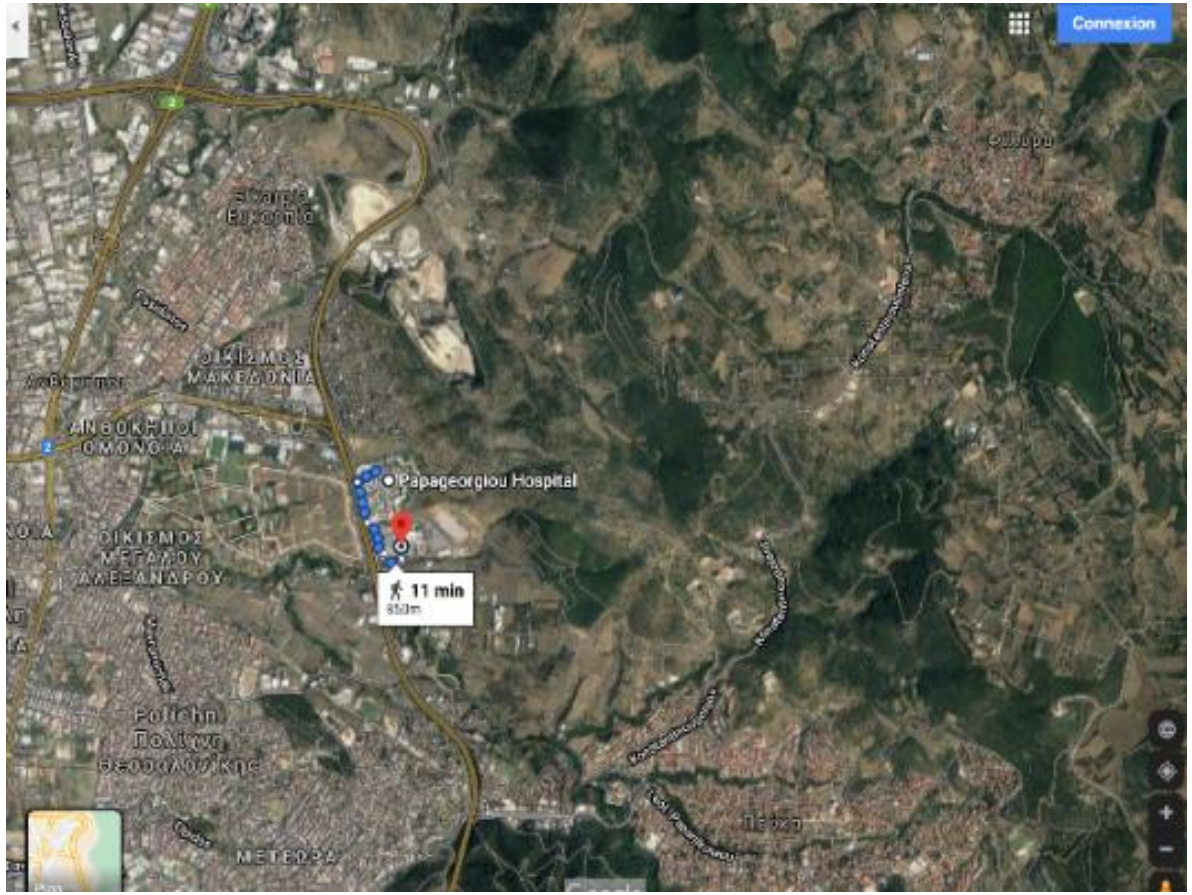
Ministers of Science/corresponding Ministers or their representatives from the SEE Region

Memorandum of Cooperation signed by six Prime Ministers of the SEE Region

Signature of Memorandum on 5 July 2019 in Poznan, Poland at the occasion of the 6th Summit of the Berlin Process

Prime Ministers of the SEE Region

Searching suitable location in Thessaloniki



Via satellite/google search identify a possible location/candidate

Contact to Papageorgiou via AUTH colleagues

Online Scientific Information Events in Greece

Information event for scientific/medical communities in Greece: https://indico.cern.ch/event/1138945/

6 April 2022

Under the auspices of AUTH

Speakers:

DKFZ German Cancer Research Center

CNAO therapy centre

GSI, CERN, IAEA

and AUTH

Introductory info event

6 November 2020

https://indico.cern.ch/event/968289/

Speakers:

SEEIIST Sanja Damianovic

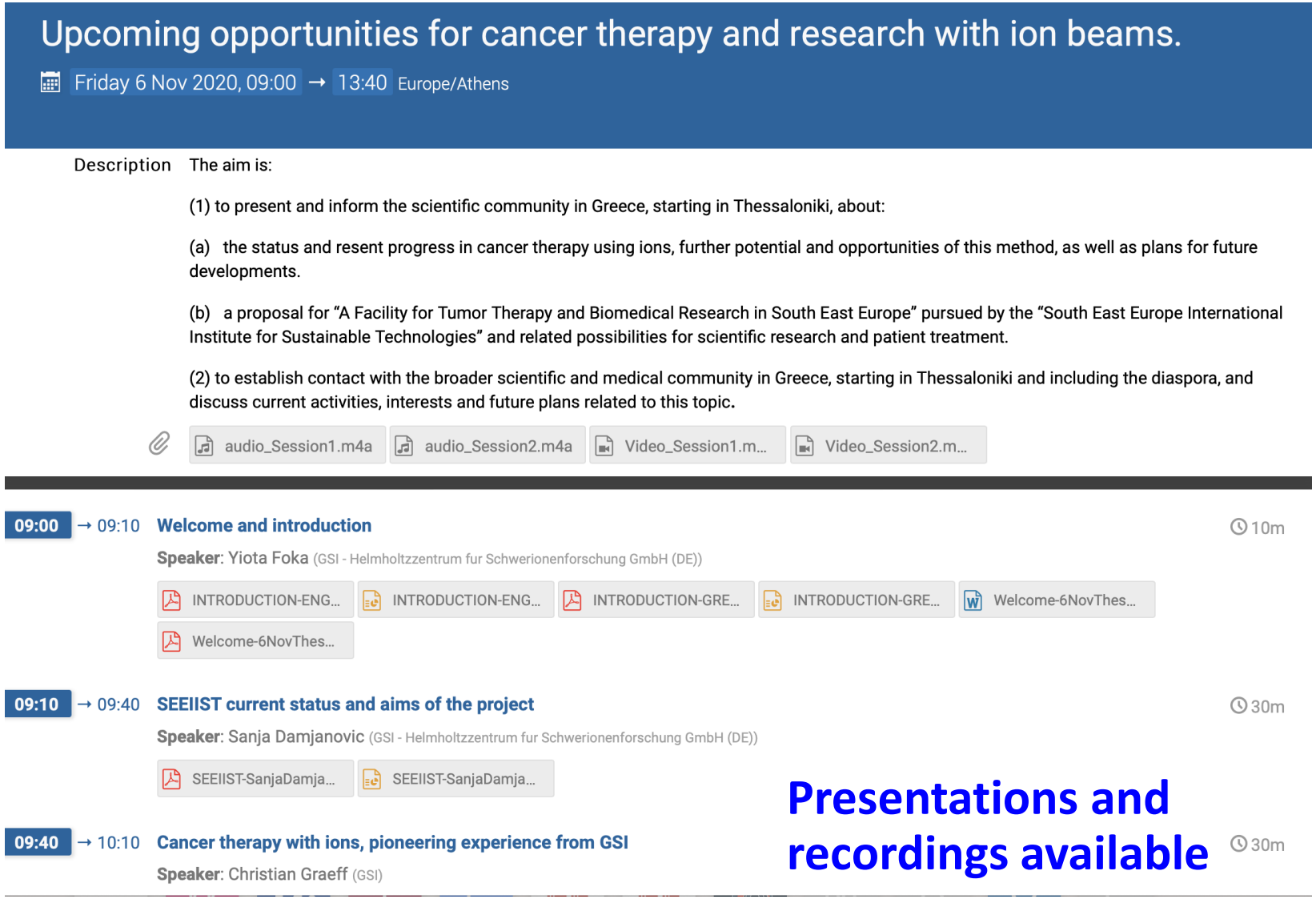
GSI, CERN, IAEA

HIT Heidelberg Ion Therapy centre

and AUTH (Alexandra Ioannidou)

Technopolis,

Papageorgiou



Presentations and recordings available


SEEIIST
South East European International Institute
for
Sustainable Technologies
50% research and 50% therapy
with multiple ions
Architectural design, Kaprinis Architects

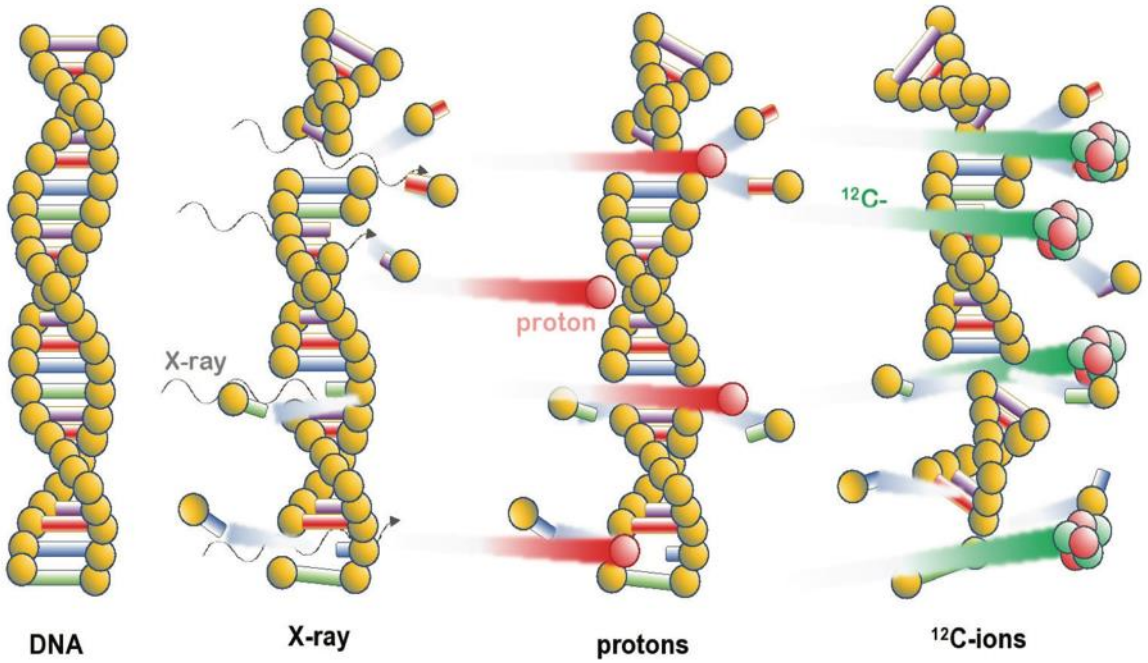
Why ?
What are the benefits

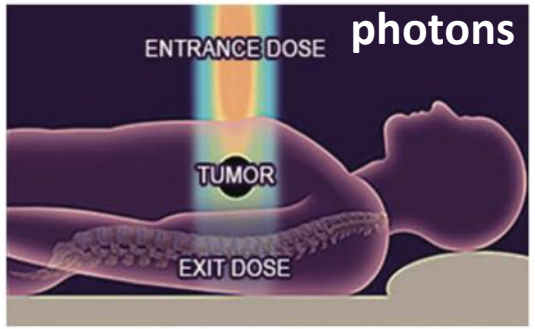
Health care, research,
technology developments, industry boost, education and training

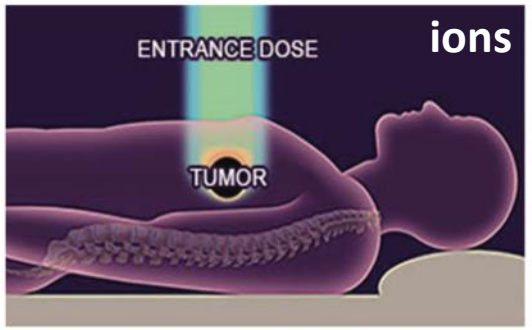
Details in
- SEEIIST Brochure and leaflet
- CERN Yellow Report
available via links the summary document

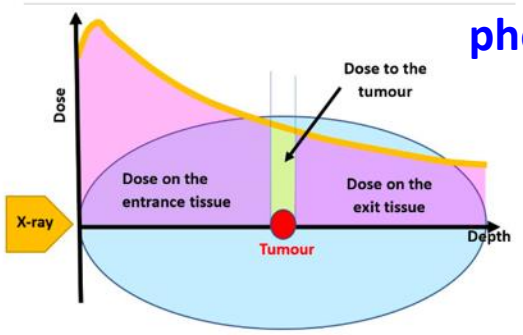
Heavy-ion research and heavy-ion therapy

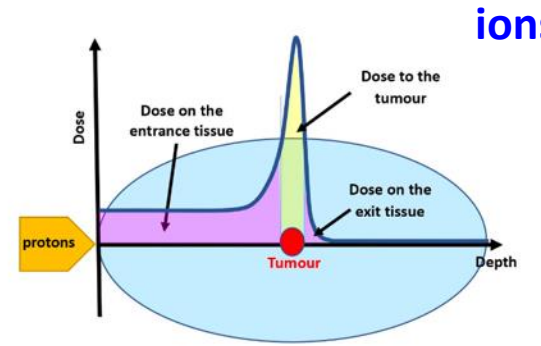
Why heavy ions for cancer tumour therapy?
Fundamental properties of particles and their interaction with matter









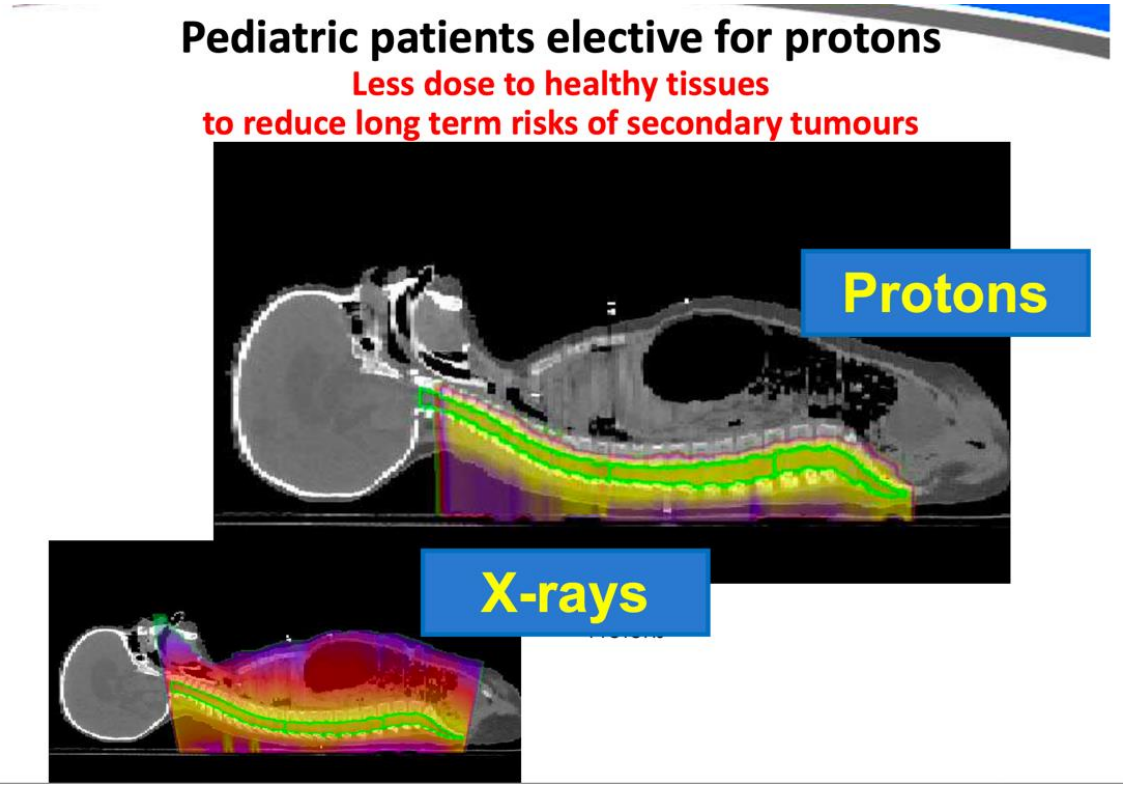


Bragg peak

Contrary to x-rays or electrons, protons and heavier ions deposit their energy at a given depth inside the tissues, minimizing dose to the traversed tissues, sparing nearby organs.

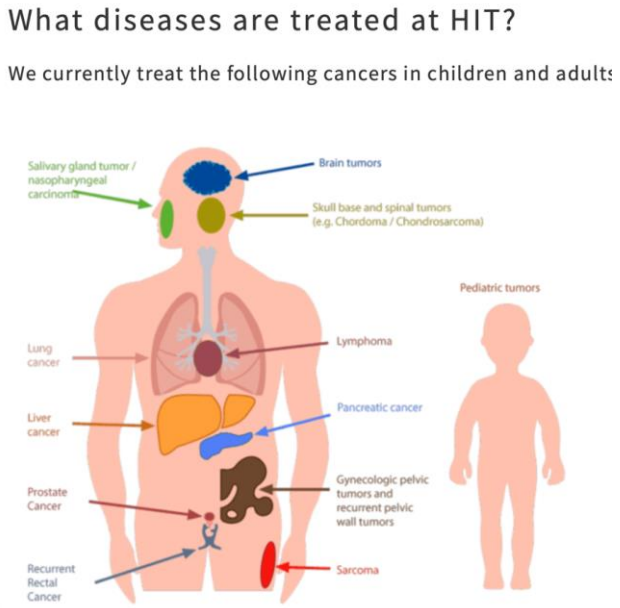
Heavy-ion research and heavy-ion therapy

Why heavy ions for cancer tumour therapy?

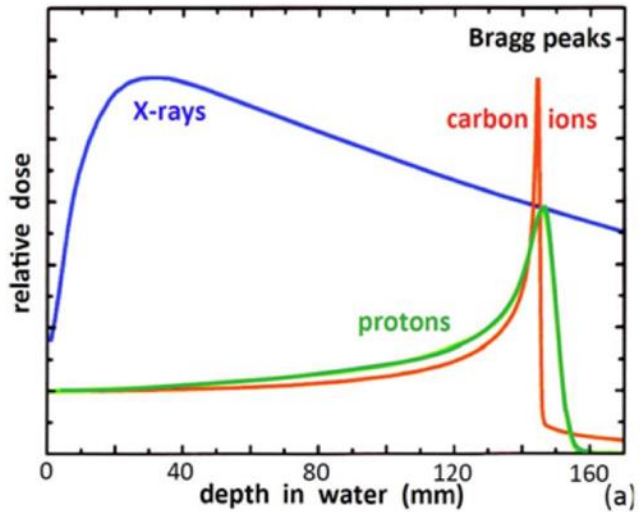


Particularly important for pediatric patients to reduce damage to their growing bodies and long-term effects:

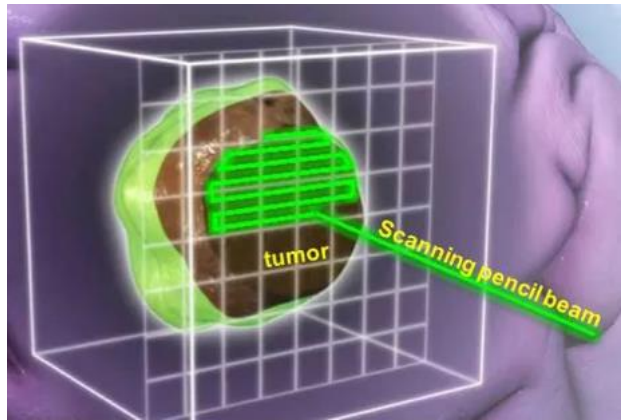
proton therapy becomes the standard

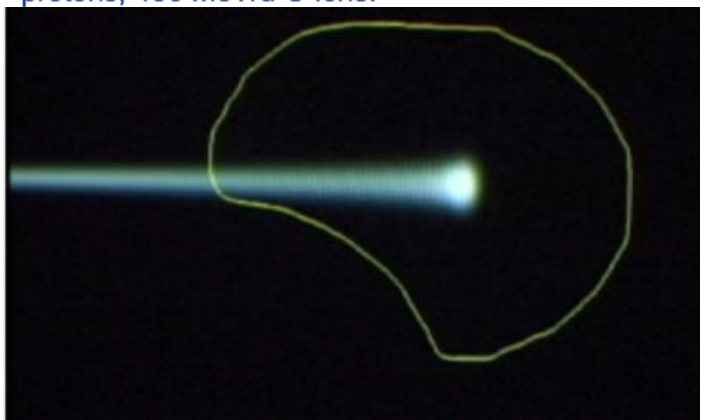


Bragg peak



Required energy for full-body penetration: 230 MeV protons, 450 MeV/u C-ions.





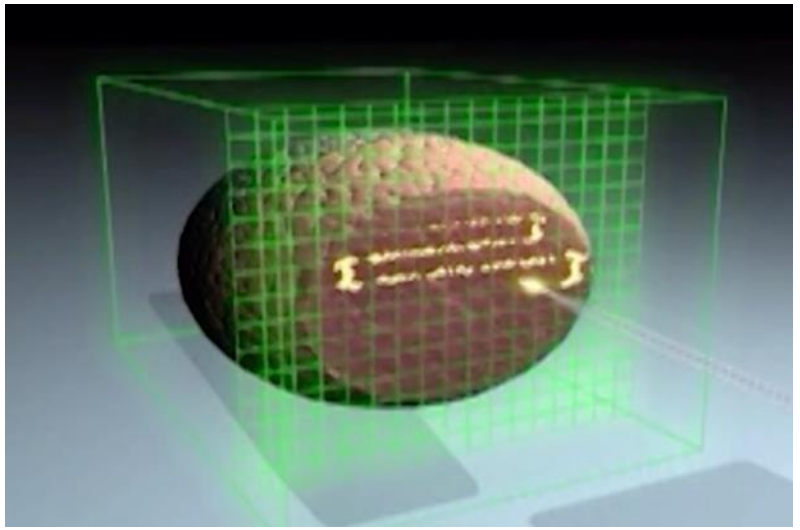
Medical accelerators requirements and parameters

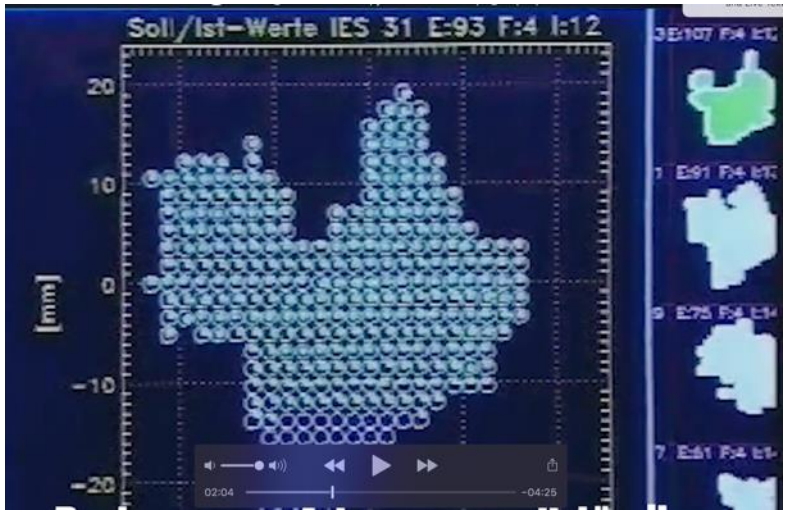
Accelerator Requirements for Scanning

Example: beam parameters Heidelberg Ion Therapy (HIT)

Parameter	
ions	protons and carbon (**3 ion sources**); pre-clinical: helium, research: oxygen (from carbon source)
intensity	2 x 10^6/s to 8 x 10^7/s for carbon 8 x 10^7/s to 4 x 10^8/s for protons **10 steps**; maximum extraction time 5 s **Increase needed ~ 5x (FLASH not understood today)**
energy	88-430 MeV/u for carbon 50-221 MeV/u for protons **255 steps**, 1-1.5 mm spacing, 2-30 cm range in water
focus	3.5-13 mm FWHM 11-33 mm FWHM **4 steps**

→ a total of 3 x 10 x 255 x 40 = 30600 settings per treatment room!





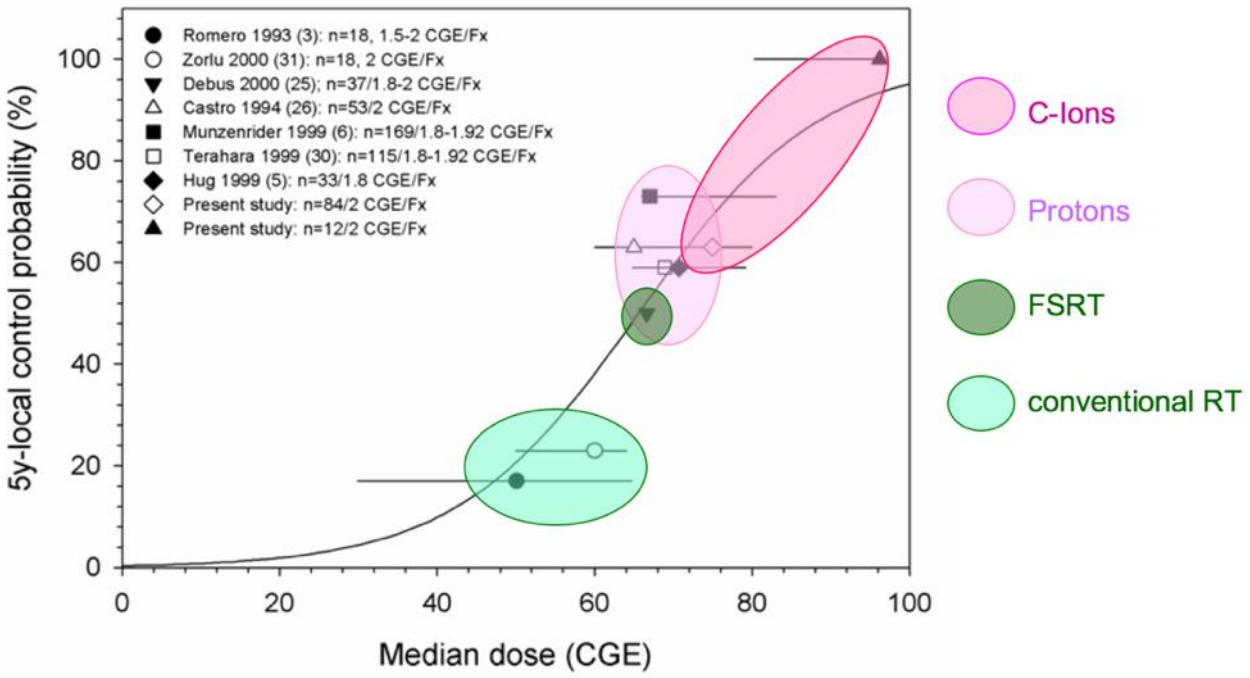
Carbon ion cancer therapy

Is it effective?

Carbon ions: a “different drug”

5-year control probability

Radiotherapy of Skull Base Chordomas
Motivation: Dose Response Relationship



D. Schulz-Ertner, IJROBP 2007

Is it effective?

Assessed by clinical trials results

- Chondrosarcoma discovered and surgically removed in 2003
- Recurring tumor in 2007 at age 8
- Treated in GSI Cave M with carbon ions

- Local control of tumor for 10 years and counting
- Under regular supervision in Heidelberg
- 2017 - enrollment in informatics

- **No long-term side effects**

Higher RadioBiological Efficiency RBE (x3), overcoming radioresistant, hypoxic tumours

Carbon ion cancer therapy

Is it effective?

Carbon ions: a “different drug”

5-year control probability

Radiotherapy of Skull Base Chordomas

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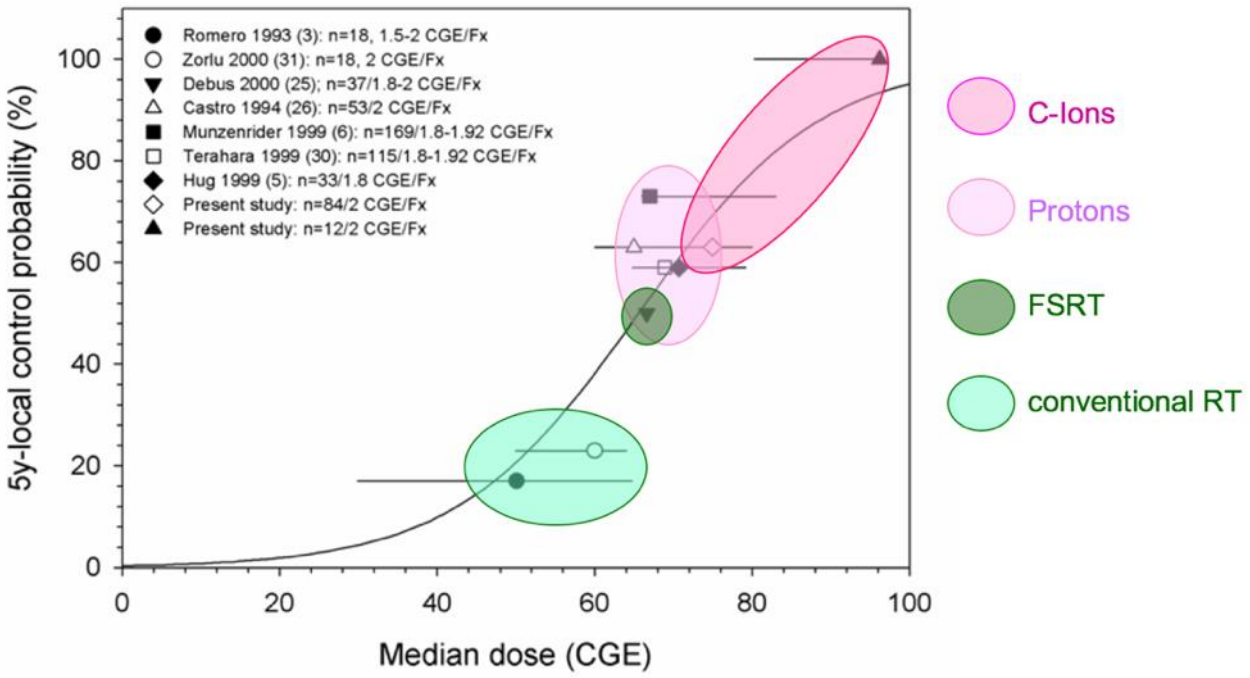

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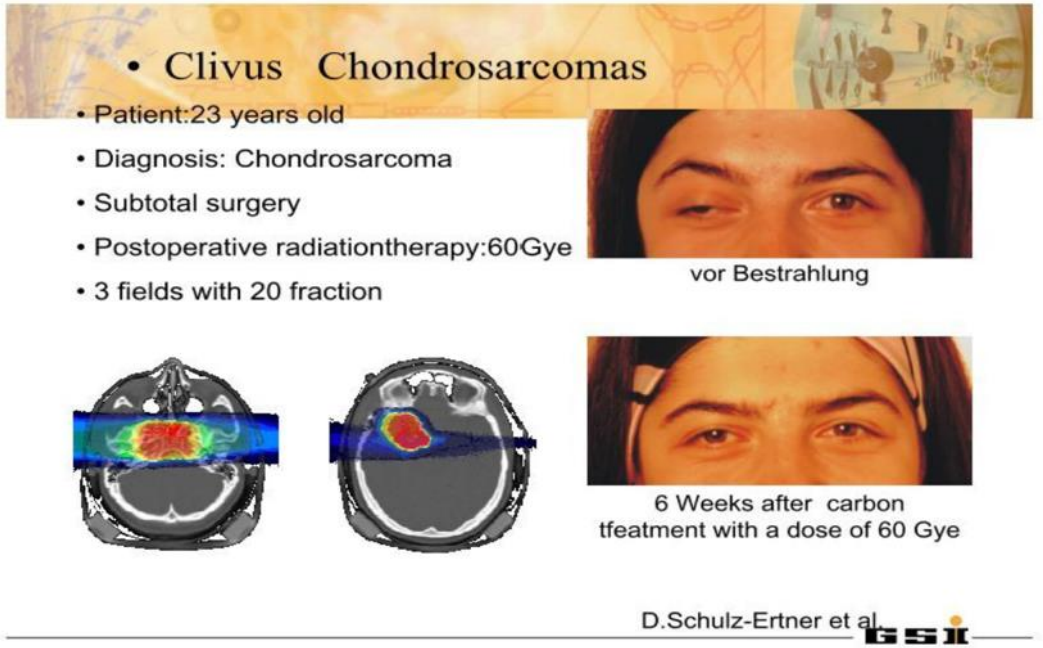


Treating pregnant women and pediatrics, deep seated tumours, close to organs at risk

Figure 1.24: Foetus dosimetry during radiotherapy of a pregnant woman with C-ions at HIT.

Higher RadioBiological Efficiency RBE (x3), overcoming radioresistant, hypoxic tumours

Hadron therapy centres

Different accelerators for different particles

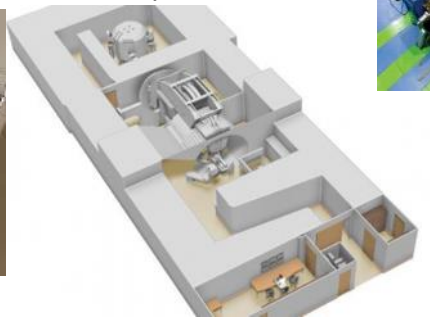
Ions deliver more energy to the tissues but need more energy to enter the body → higher energy accelerator, factor 2.8 in diameter with respect to protons

Required energy for full-body penetration: 230 MeV protons, 450 MeV/u C-ions.

Conventional x-ray Radiotherapy

protons

courtesy IBA



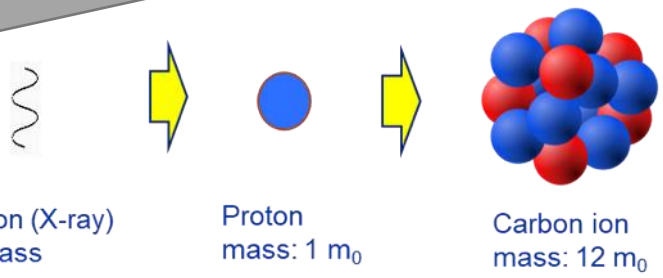
CNAO, Italy

HIT, Germany

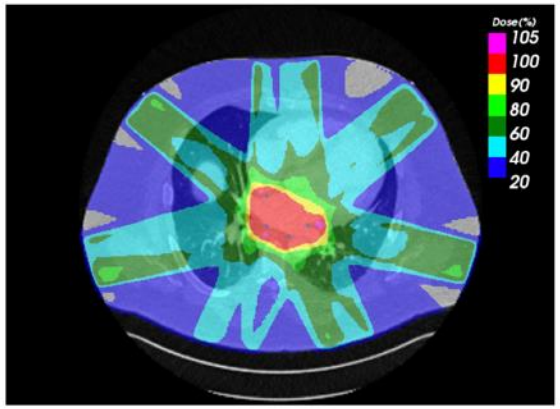
Linac, X-rays
~50 m^2
~5 M€

Cyclotron, protons
~500 m^2
~40 M€

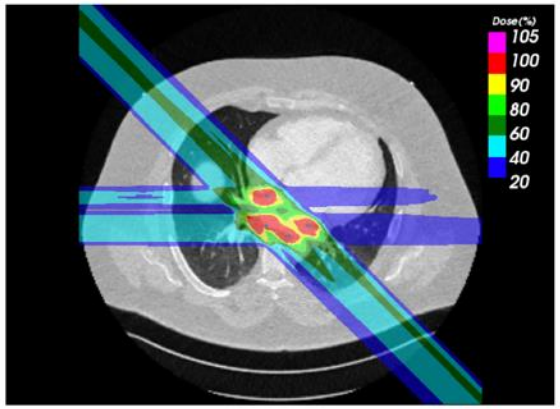
Synchrotron, heavy ions
~5,000 m^2
~200 M€



Better results come at a price



Photons

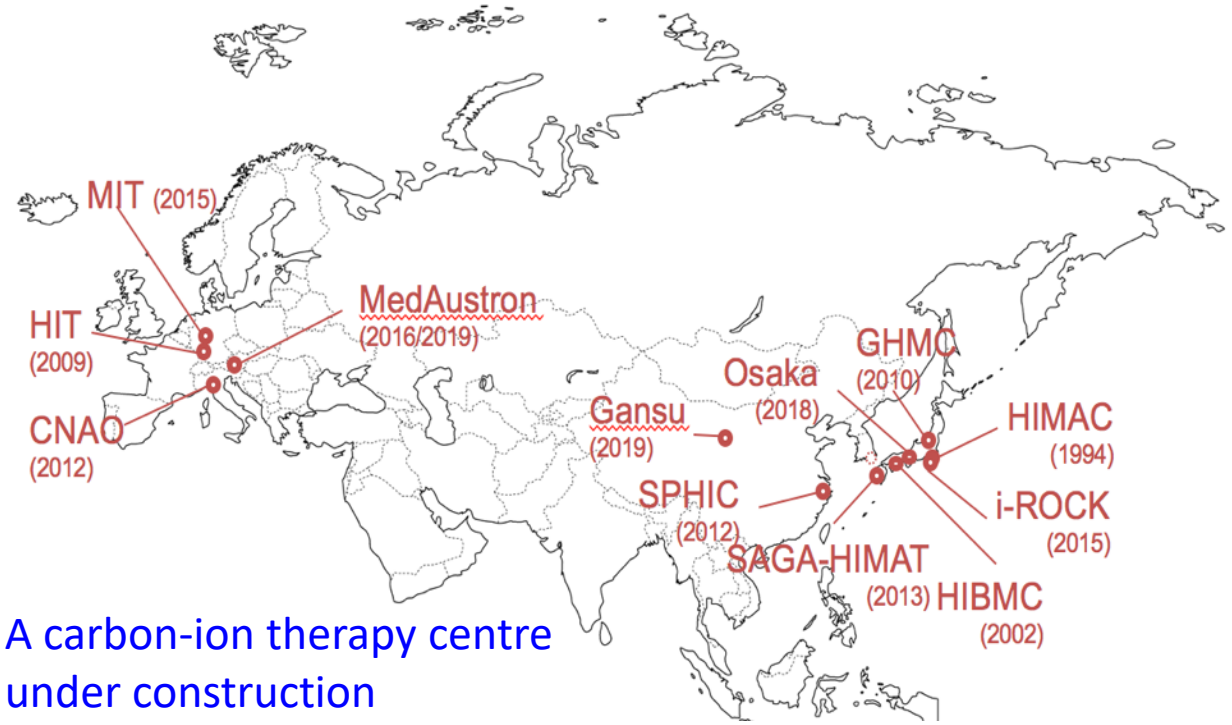


Carbon

Hadron therapy centres

Based on similar accelerator technologies

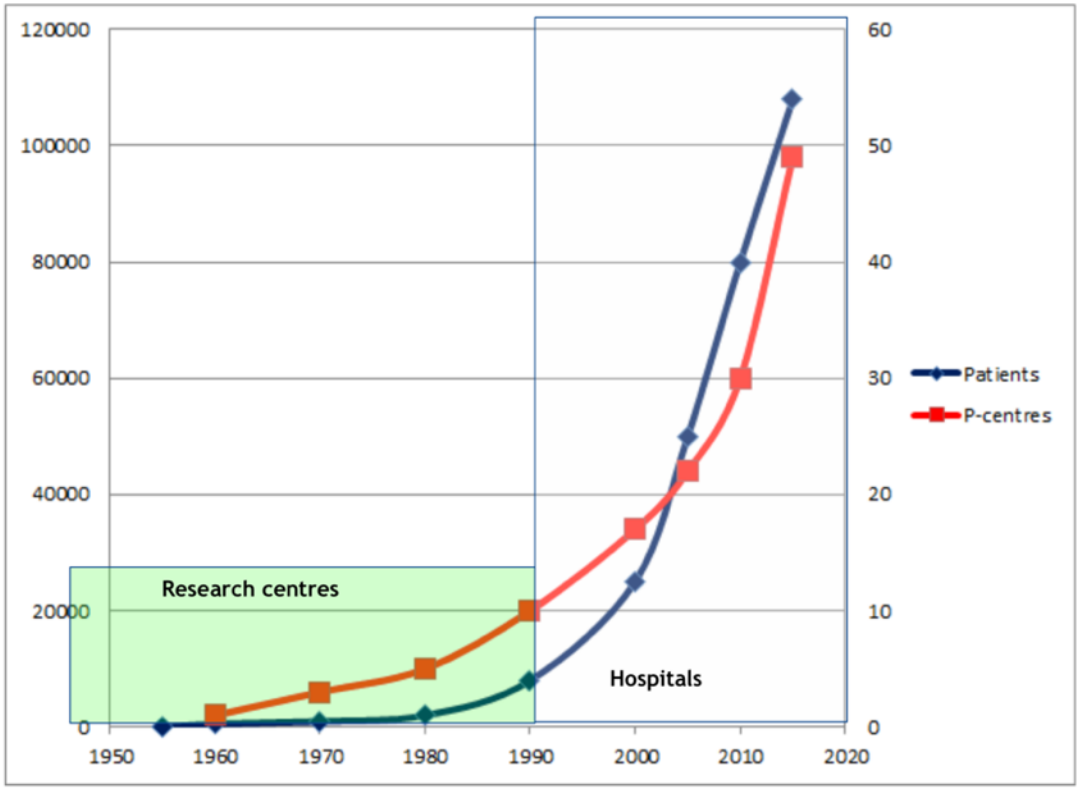
Carbon therapy centres



A carbon-ion therapy centre
under construction
by Mayo Clinic in Florida US

Proton therapy centres

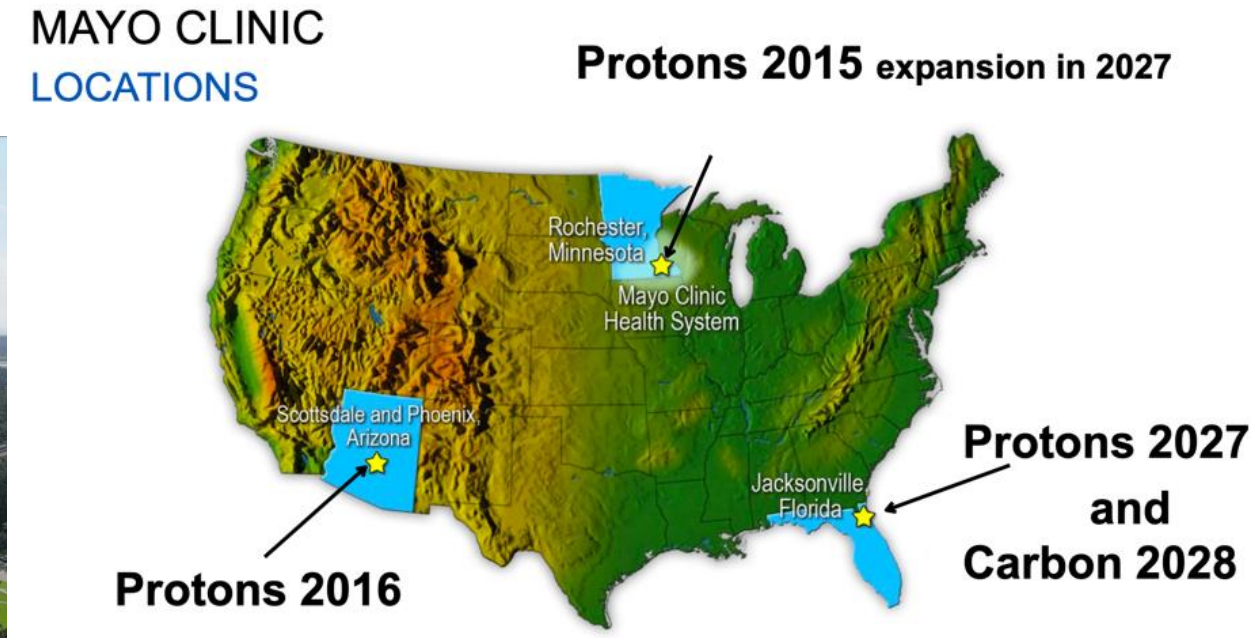
[Data from www.ptcog.ch]



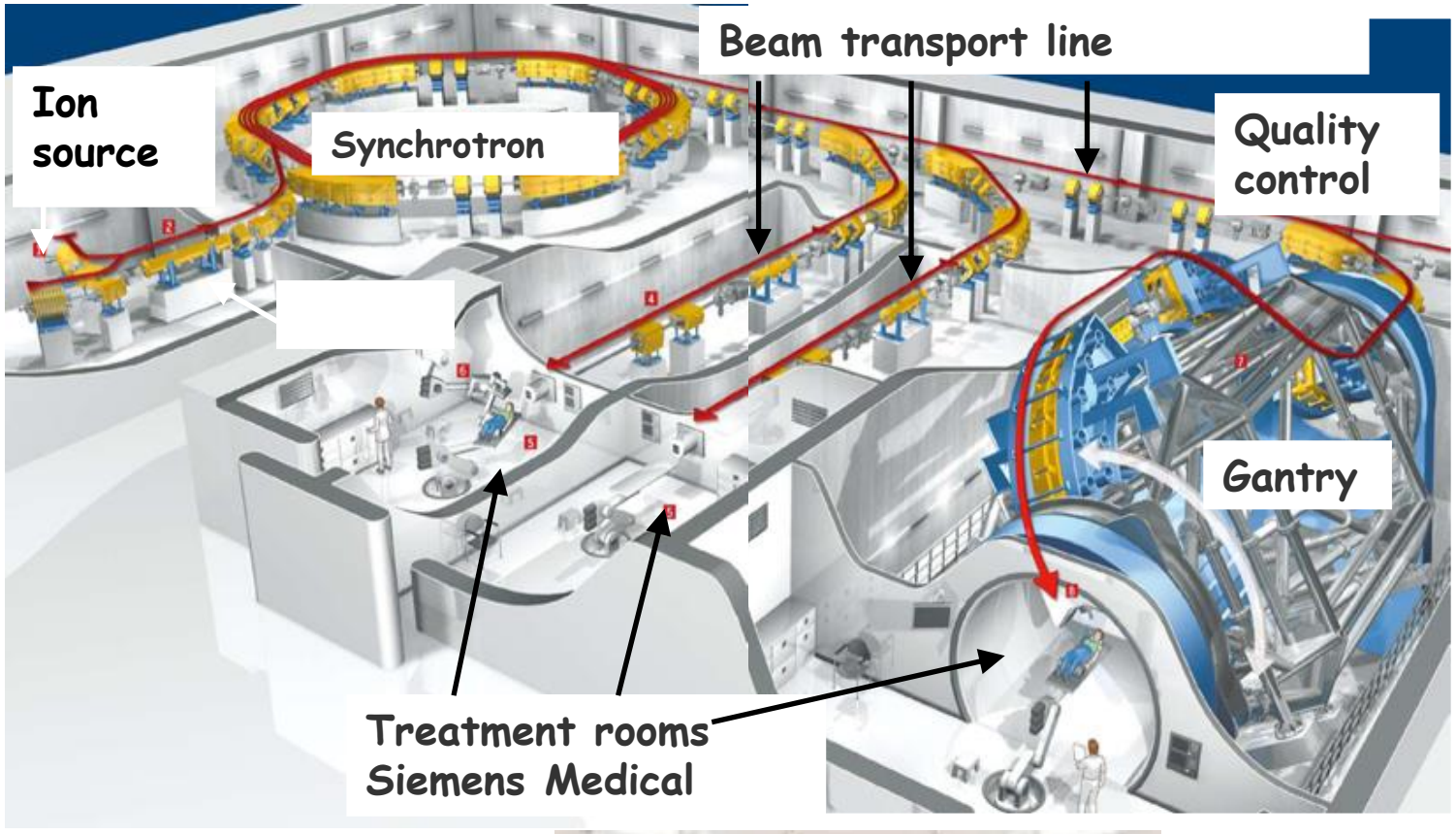
Hadron therapy is an advanced niche in cancer therapy:
22,000 patients/year (2018) treated with particle beams against 25,000,000 patients/year with conventional RT.

For some of them, C-ion therapy is the only option.

Towards the Future in US



Heidelberg Ion Therapy Centre, HIT



Gantry: 600 tons
rotating beam delivery system

Can we do better?

about 70% of the cost of a facility is due to the accelerator and gantry

Use novel accelerator technologies developed the last years

M.V

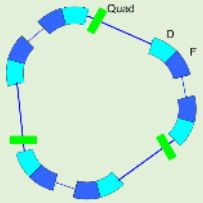
NIMMS
Next Ion
Medical Machine Study

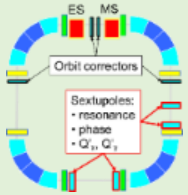
Courtesy Maurizio Vretenar (CERN, NIMMS group leader)
Slides shown at CNAO special event, 11-13 oct 2023
Hadron therapy: status and perpectives
https://fad.accmed.org/course/info.php?id=1325

The four NIMMS Work Packages

M.V

1. Small synchrotrons for particle therapy



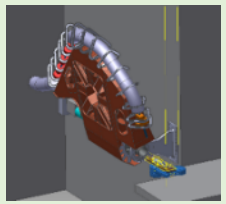


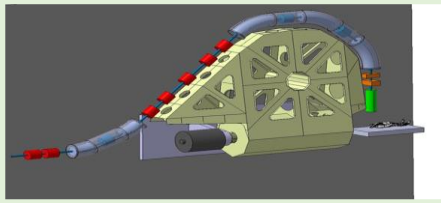
Reduced dimensions with improved performance (injection, extraction)

2. Curved superconducting magnets for synchrotrons and gantries

Canted Cosine Theta, NbTi or HTS

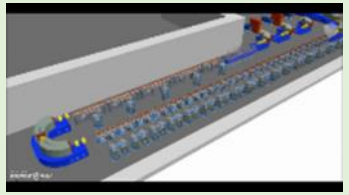
3. Superconducting gantries

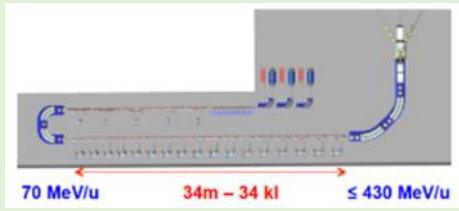




Precise beam delivery on multiple angles

4. High-frequency ion linacs





Compact bent layout

HITRIplus EU project

IFAST EU project

EU supporting initiatives

Main accelerator research lines for future ion therapy

NIMMS supported designs:
1. SEEIIST C-ion therapy and research facility

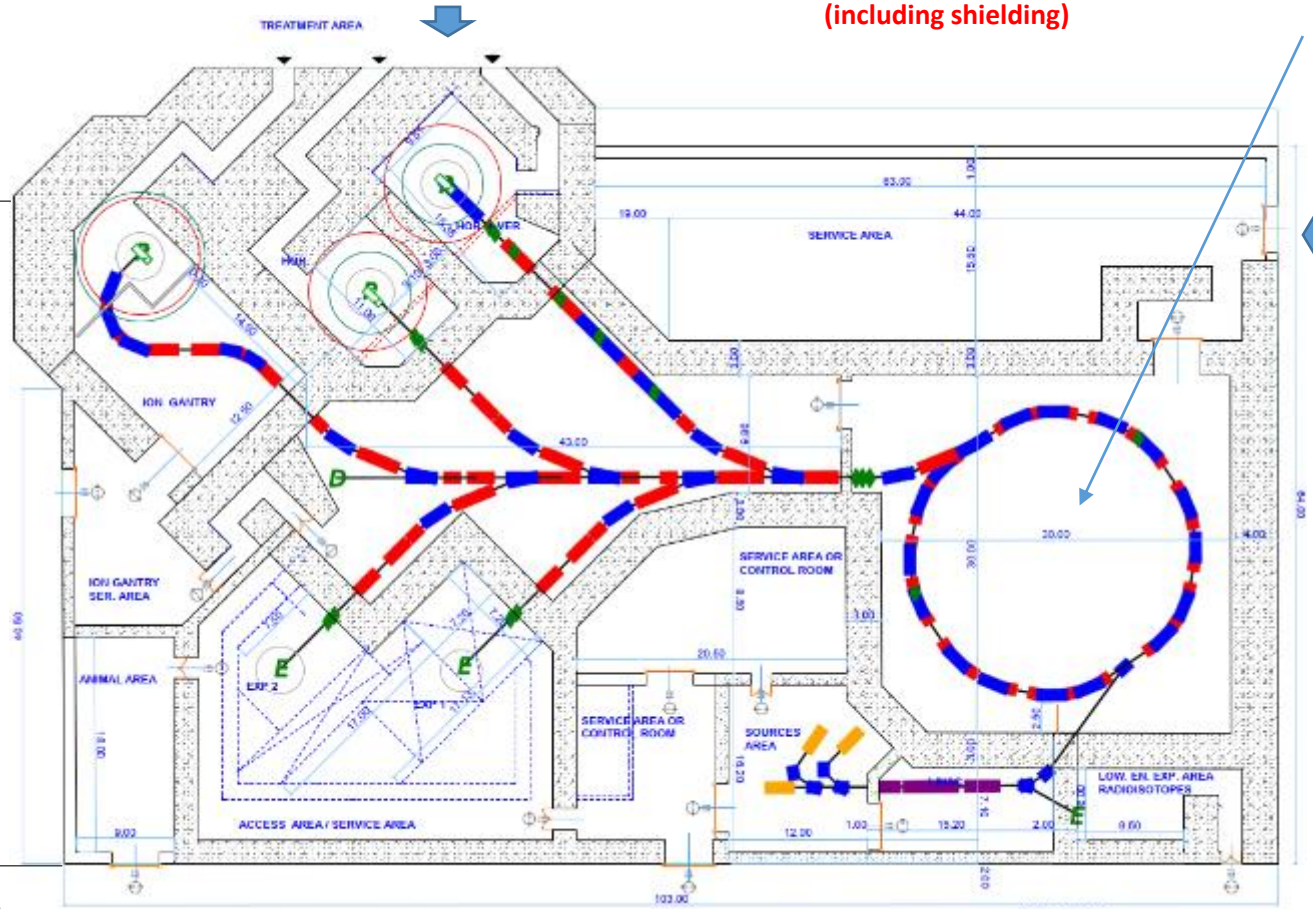
M.V

Design to be presented in a CERN Yellow Report in preparation

Access for therapy

Total 5,400 m²
(including shielding)

The synchrotron can be replaced by an SC version if R&D successful



Equipment room and access to synchrotron

Area for future expansion

Target for isotope production

Access for animal testing

Architectural design, Kaprinis Architects

Reconfigurable experimental room

Access to experimental room and linac

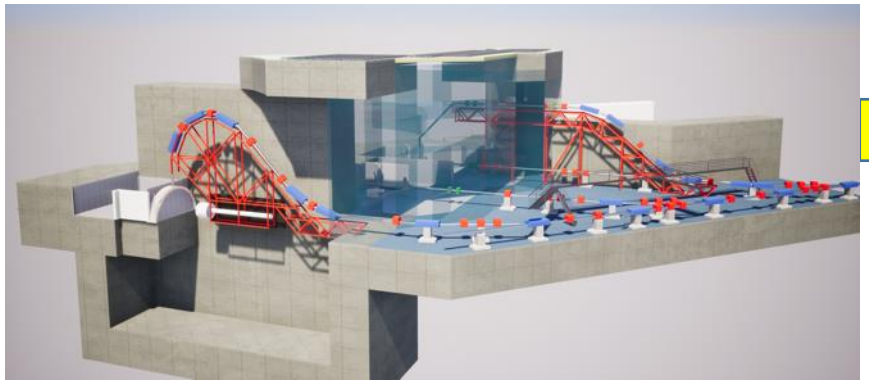
complete modern facility for research and therapy with ions up to Oxygen

NIMMS supported designs:
1. SEEIIST C-ion therapy and research facility

M.V

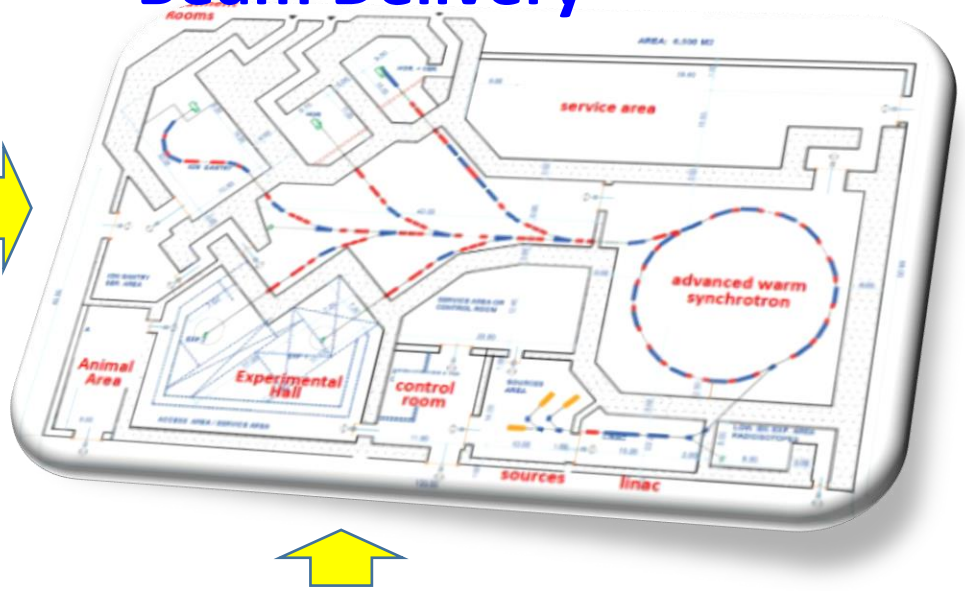
Intensive design work in 2019/20 in **collaboration between CERN and SEEIIST**, with the contribution of the CERN/NIMMS partners and of the main European ion therapy centres **has led to successful EU funded projects**

Gantry at SEEIIST



Less than 100 tons

Beam Delivery



Gantry at HIT

600 tons

B. Advanced SEEIIST features (common to other advanced facilities):

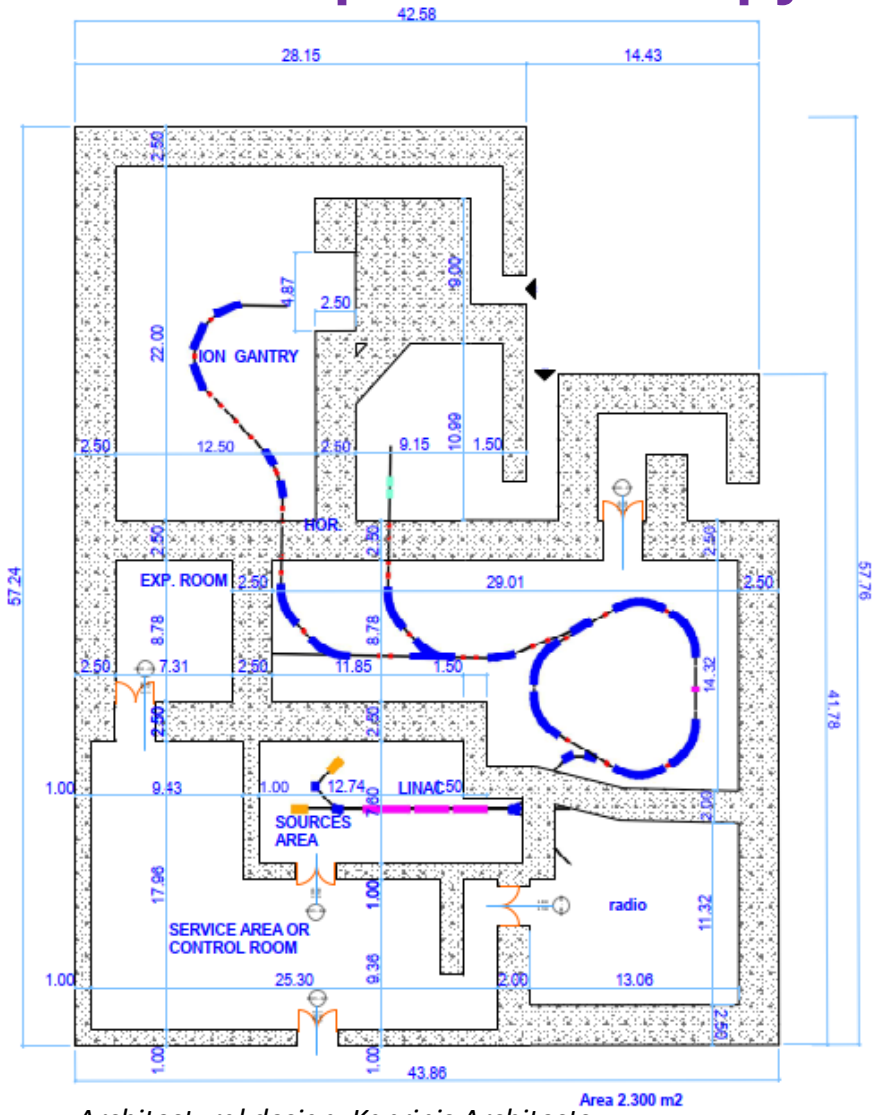
1. Operation with multiple ions: protons, Helium, Carbon, Oxygen, Argon;
2. Multiple energy extraction for faster treatment;
3. Equipped with a compact superconducting gantry of novel design.

HITRIplus and I.FAST: novel components of next generation facilities

NIMMS supported designs:
2. Compact research and therapy facility with p and He beams

M.V

Advanced particle therapy facility for the Baltic states



Architectural design, Kaprinis Architects

CERN Baltic Group

Draft concept-paper

Advanced Particle Therapy Center for the Baltic States

Concept developed in collaboration between CERN (NIMMS study) and the CERN Baltic Group, facility to be based in the **Baltic States** (Estonia, Latvia, Lithuania) as a regional project with EC support – 5 possible sites considered. Strongly supported by the Health Committee of the Baltic Assembly (inter-parliamentary union).

Strategy: the NIMMS Collaboration (main contributors: CERN, RTU, TERA-CARE Foundation) will complete in June 2025 a **Technical Design Report**, without details on the implementation ("green field").

In parallel, the CERN Baltic Group will prepare a **Feasibility Study** covering medical, infrastructural, and economical aspects (business plan).

Implementation in the Baltic States

- The Baltic States are without a particle therapy centre. Support is growing in the region to construct such a facility.
- Incidence rate of 630 cases per 100 000 inhabitants: 34% receiving radiotherapy.
- 28 radiotherapy LINACs in region: **Sufficiently developed to move towards particle therapy.**
- Plans for head and neck tumours, sarcomas, complex localisations & paediatric cancers.
- Above treatment, provides **opportunities in accelerator technology, medical physics and (pre-)clinical research.**

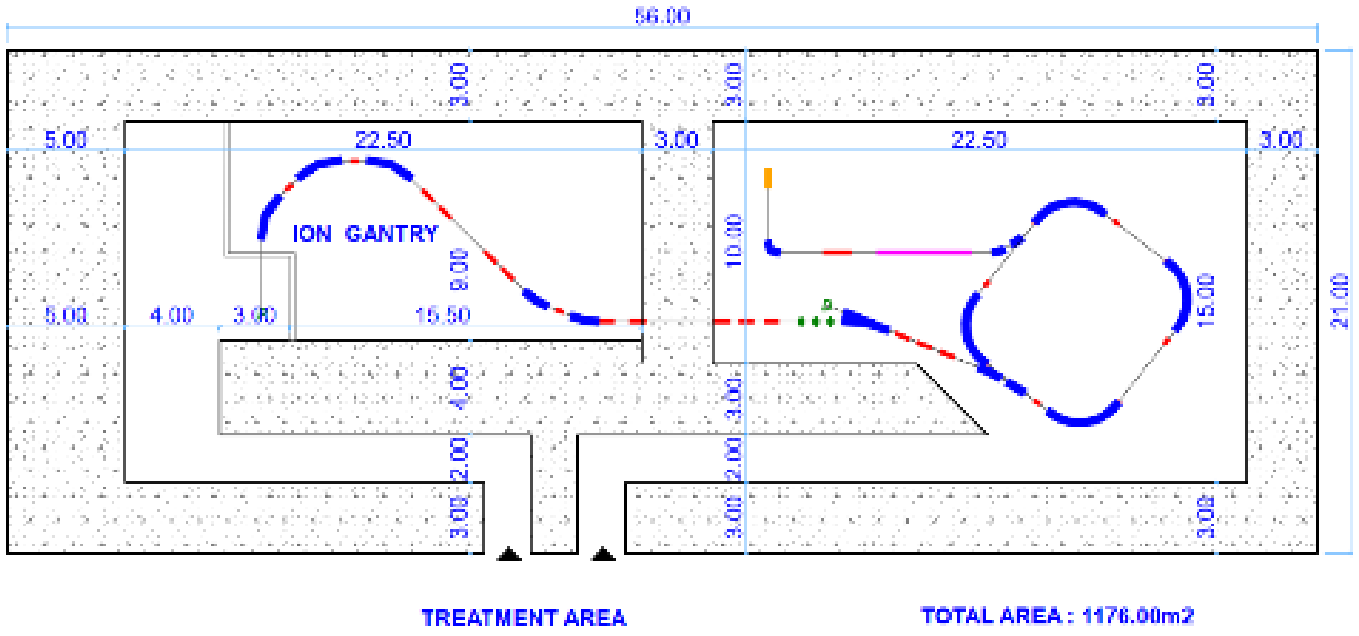
Compact layouts: superconducting synchrotron

M.V

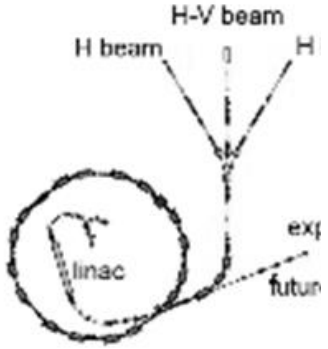
Considerable gain in dimensions relative to PIMMS design thanks to superconductivity

Goal: a compact single-room ion therapy facility in about 1,000 m²

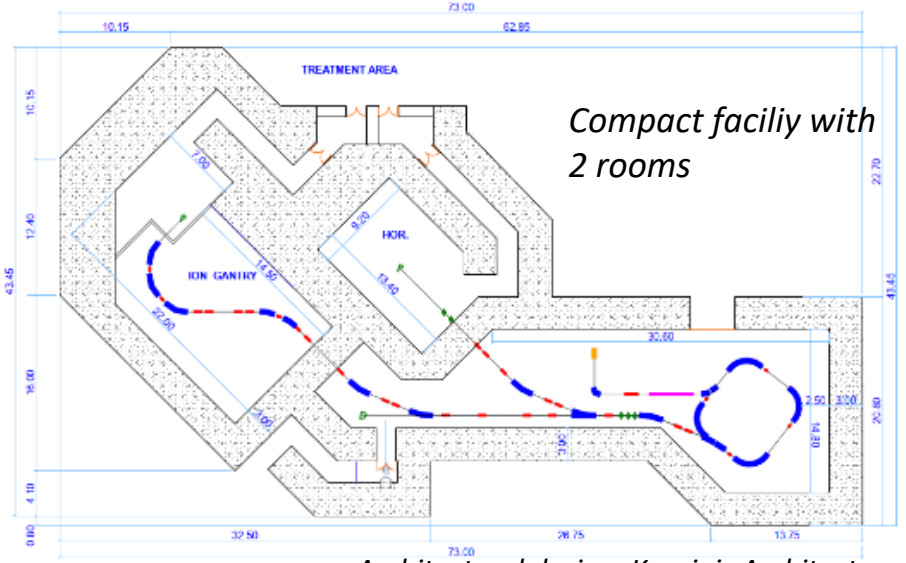
Alternative synchrotron layouts



CNAO, PIMMS based design



Superconducting proposal



Compact faciliy with 2 rooms

Architectural design, Kaprinis Architects

E. Benedetto et al., Comparison of accelerator designs for an ion therapy and research facility, CERN-ACC-NOTE-2020-0068, http://cds.cern.ch/record/2748083?ln=en

Based on Technical Advancements the community wishes to address many emerging Research Topics

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

Research with particle therapy and immunotherapy

Does Heavy Ion Therapy Work Through the Immune System?

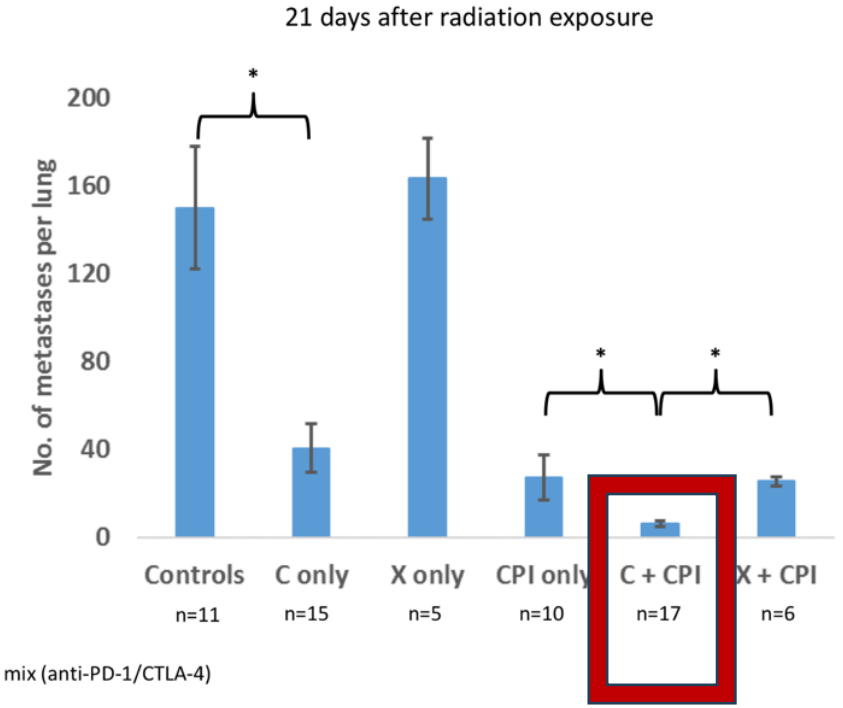
Marco Durante, PhD,* David J. Brenner, PhD,† and Silvia C. Formenti, MD‡

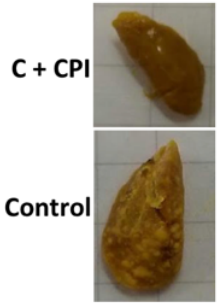
Abscopal effects, reductions of metastases

Osteosarcoma - Reduction of lung metastases

FAIR GSI

NIRS





Synergies with pharmaceutical companies

Towards treating different parts of the tumour with different types of ions
Towards treating with ultra-fast high dose delivery: FLASH therapy

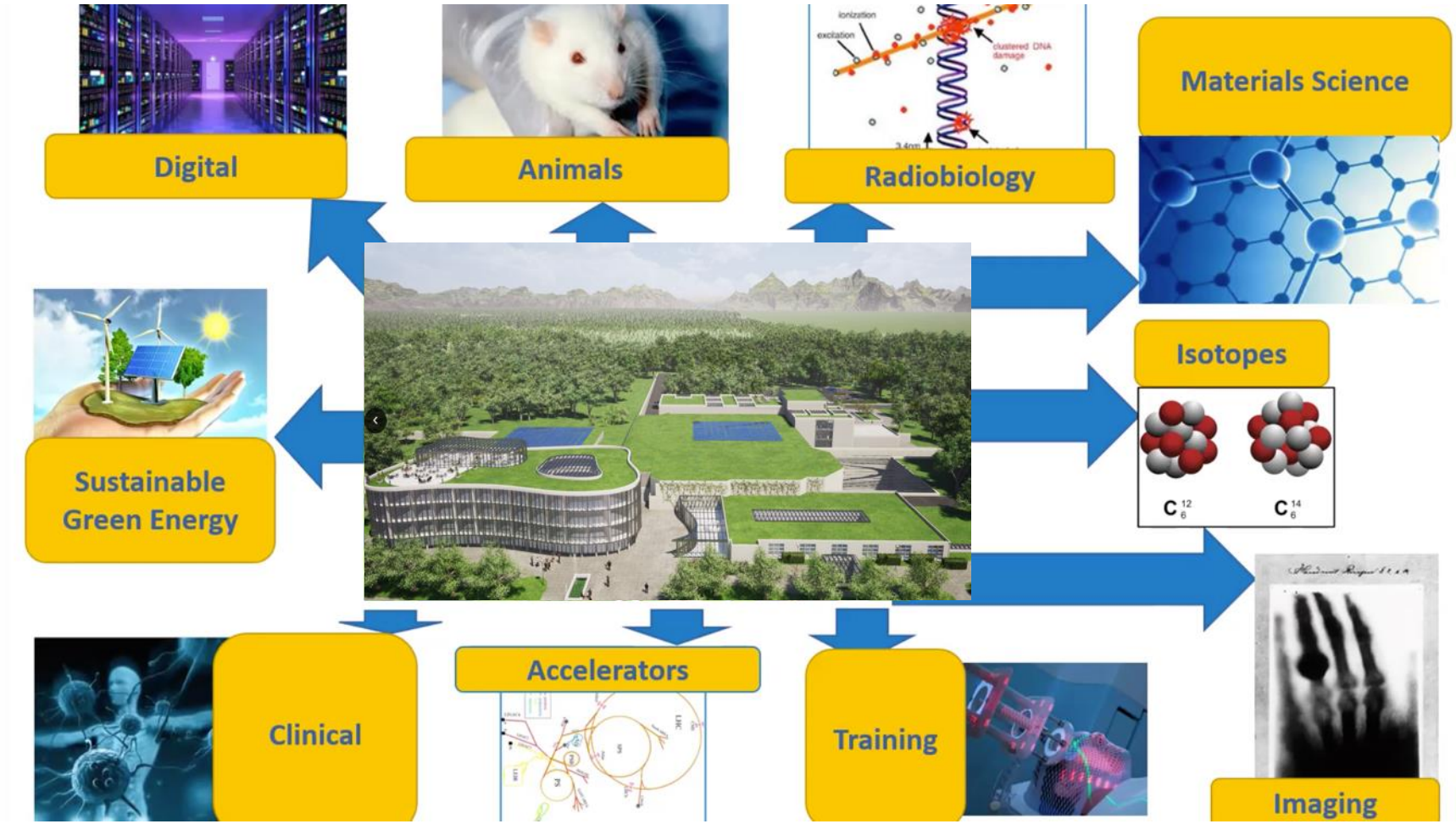
J.S.

Research Activities

1. Radiobiology – Pre-clinical radiobiology is an essential tool to support new therapy solutions
2. Medical physics – Ultra-fast dose delivery methods will extend ion therapy to the special group of tumours in moving organs
3. Nuclear medicine and Radioisotope production – Many isotopes for medical applications (diagnostics and cancer treatment) can be produced by the novel Injector-Linac (Linear Accelerator)
4. Material science – Innovative material research using high-energy ions (radiation hardness, space microelectronics, nano- tubes)

Material science, space microelectronics

Opportunities for Research and Development



Radioisotope Production First part of SEEIIST or Standalone

Linear accelerators radio-isotope production

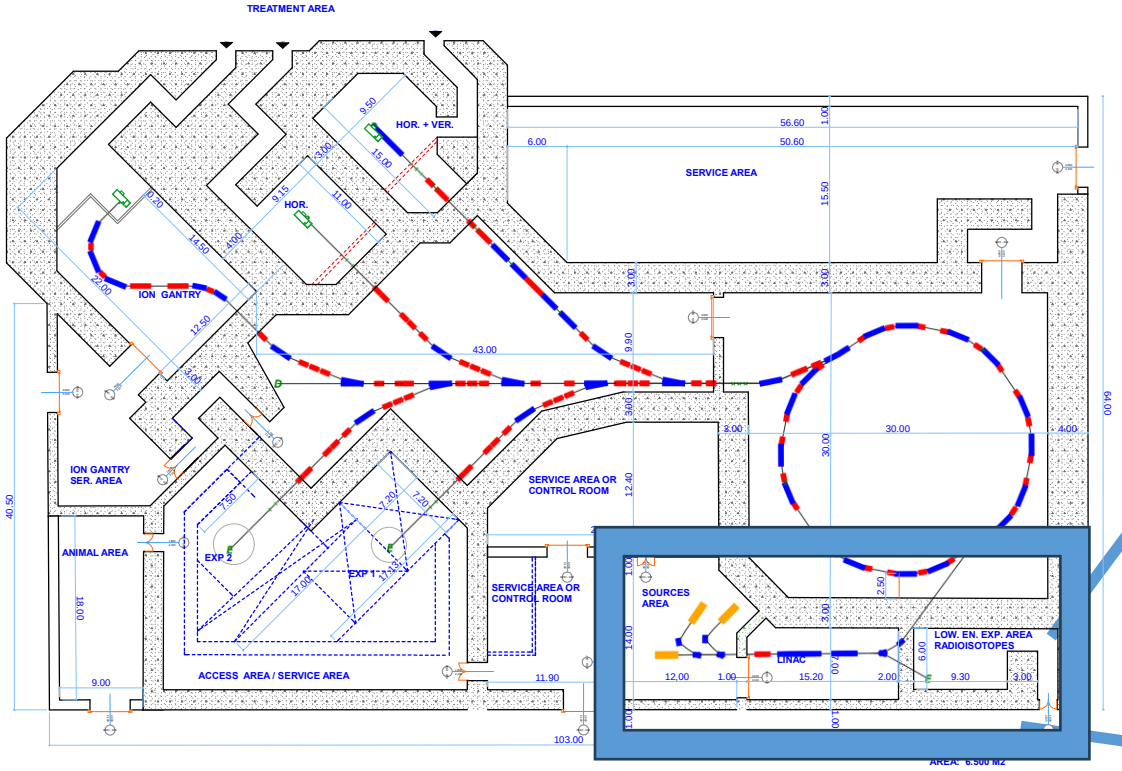
M.V
Y.P

Radio-isotope production exploiting linear accelerators: double use of the linac injector for radioisotope production
Advantage: possibility to operate at or close to hospitals or places to use

For diagnosis (i.e. PET):
production of short-lived radioisotope (F18, C11)
with proton beams

For **Targeted Alpha Therapy (TAT) and thera-gnostics**
production of short-lived alpha emitters radioisotopes (At211)
with alpha beams

Based on technology developed at CERN



Linear accelerators radio-isotope production in US

M.V
Y.P

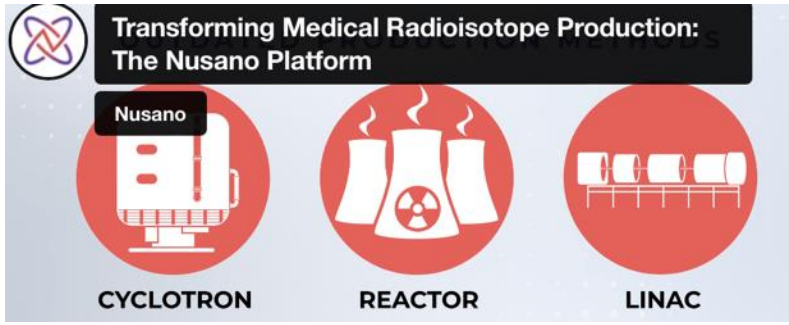
PRODUCTION

WEST VALLEY CITY, UTAH

Nusano is building a state-of-the-art production facility in Utah's Salt Lake Valley. It will not only create radioisotopes needed by health care, drugmakers and researchers, but also bring new, high-tech jobs to the area.

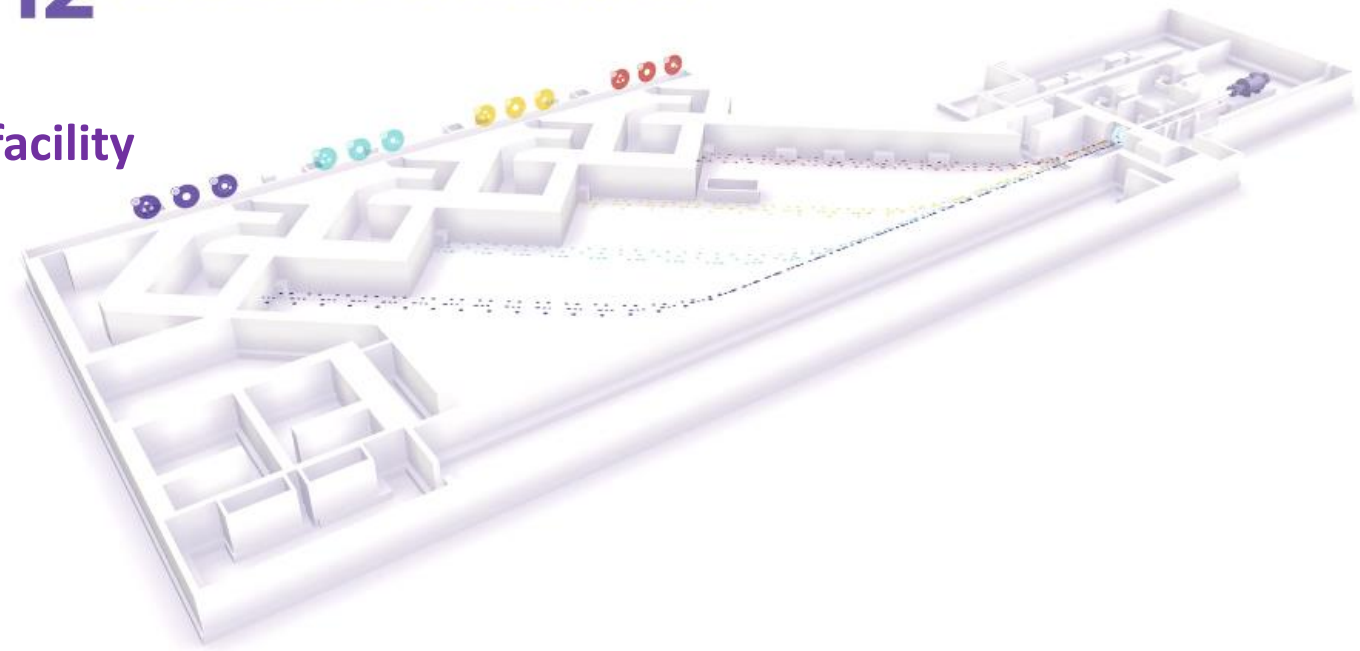
UTAH

Simultaneous production of up to
12 DIFFERENT RADIOISOTOPES



Based on technology developed at CERN

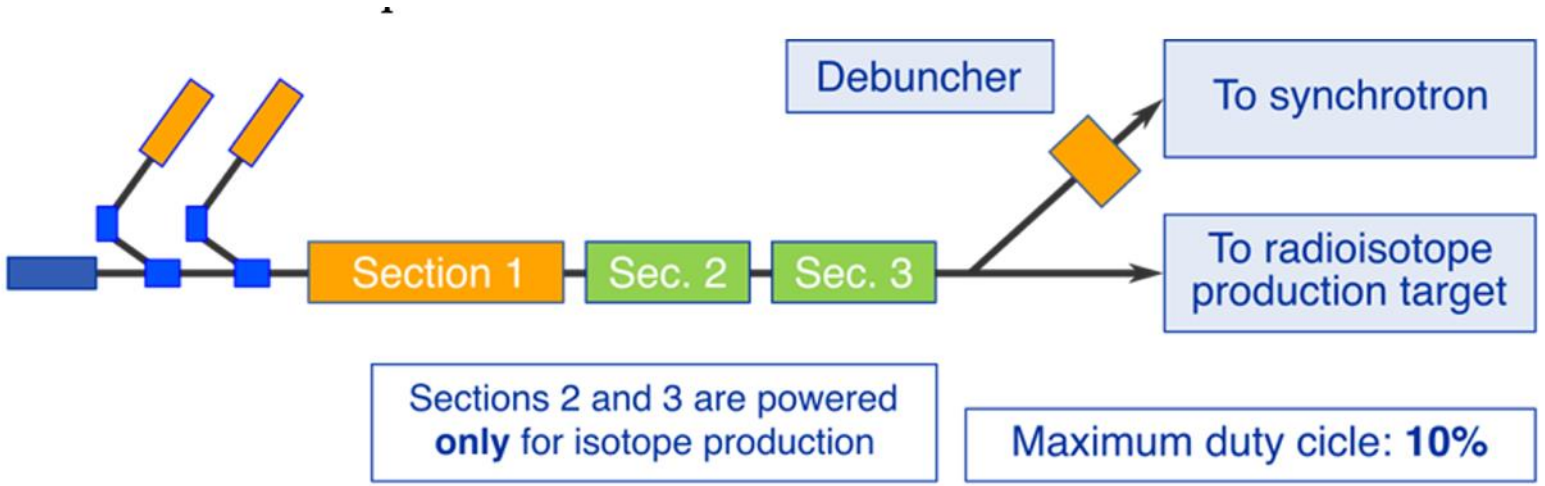
NUSANO
planned radioisotope production facility in US, UTAH



Linear accelerators radio-isotope production

M.V
Y.P

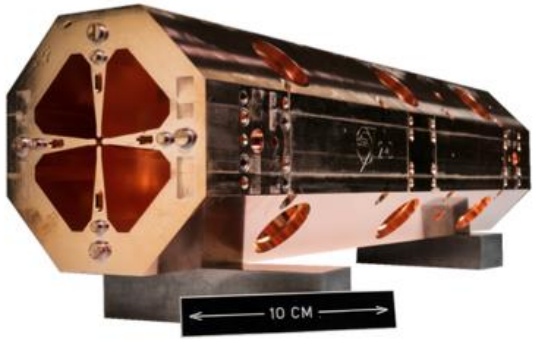
Radio-isotope production exploiting linear accelerators: double use of the linac injector for radioisotope production
Advantage: possibility to operate at or close to hospitals or places to use



Master thesis of AUTH student, (continuing with PhD)
plus PhD of Montenegro/Riga student.

Submission of EU proposal (widening era)
Greece, Slovenia, BiH, Cyprus

Basic unit



Test bench at CERN

Ion source arriving at CERN
funded by "Three Physicists Foundation"
supporting BiH/UNSA group

Cooperation with AUTH PhD student

Gain know how on accelerator technologies

M.V
Y.P

Accelerator and Society

Over 30'000 particle accelerators are in operation world-wide.

Only ~1% are used for fundamental research.

Medicine is the largest application with more than 1/3 of all accelerators.

Research		**6%**
	Particle Physics	0,5%
	Nuclear Physics, solid state, materials	0,2 - 0,9%
	Biology	5%
Medical Applications		**35%**
	Diagnostics/treatment with X-ray or electrons	33%
	Radio-isotope production	2%
	Proton or ion treatment	0,1%
Industrial Applications		**<60%**
	Ion implantation	34%
	Cutting and welding with electron beams	16%
	Polymerization	7%
	Neutron testing	3.5%
	Non destructive testing	2,3%

HITRIplus
Heavy-Ion Therapy
Research Infrastructure
EU-funded project

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

HITRIplus Project

strengthen scientific capacity in a variety of disciplines related to particle therapy

23 Institutes

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

14 European Countries

Duration 4.5 years

1st April 2021 –31st September 2025

Main aims:

(a) transnational access,

(b) new developments for the future SEEIIST facility and upgrades of the existing ones

(a) capacity building: training and education, networking

SEEIIST is one of the main beneficiaries

HITRIplus
Heavy Ion Therapy Research Integration

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HITRIplus Open Access: Transnational Access TNA

M.B

The ***Clinical Access*** gives the opportunity to clinicians/medical physicists/technicians referring patients to the hadrontherapy facilities to personally follow patient's treatment and follow up.

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.

TNA: Clinical

Available and effective
Capacity Building
in SEE Countries
for Clinicians and Researchers

www.hitriplus.eu

Big opportunity for SEEIIST Members!!!

FORMS for TNA Access

CLINICAL: https://www.hitriplus.eu/transnational-access-ca/

RESEARCH: https://www.hitriplus.eu/transnational-access-ra/

CERN visits Thessaloniki International Fair 2022 - Από την θεμελιώδη φυσική στην τεχνολογία για ιατρικές εφαρμογές και την θεραπεία καρκίνου

Publicity and Exhibitions

https://www.papageorgiou-hospital.gr/hitriplus/

HITRIplus TNA Clinical Transnational Access web page via Papageorgiou Hospital

Διακρατική – Κλινική πρόσβαση σε ιατρούς και ασθενείς

M.B

Προκειμένου να προγραμματιστεί η επίσκεψη ενός ασθενή σε ένα από τα κέντρα αδρονοθεραπείας, θα πρέπει αρχικά να συμπληρωθεί **ηλεκτρονικά η φόρμα που βρίσκεται στο** https://www.hitriplus.eu/transnational-access-ca/

Μέσω του ηλεκτρονικού εντύπου θα μπορεί **ο ιατρός (παθολόγος ογκολόγος ή ακτινοθεραπευτής)** να υποβάλει την αίτηση του ασθενούς για πρόσβαση στην κλινική TNA που διατίθεται από τους εταίρους του HITRIplus.

Σας υπενθυμίζουμε ότι, για να αξιολογηθεί το αίτημά σας, θα πρέπει να πληροίτε τις ακόλουθες προϋποθέσεις:

- Να έχετε τη **συγκατάθεση του ασθενούς** για να παράσχετε τα στοιχεία του για την επιτροπή αξιολόγησης της επιλεξιμότητας του περιστατικού.
- Να αποστείλετε τα **απαραίτητα έγγραφα τεκμηρίωσης στην αγγλική γλώσσα**, πρωτότυπα ή κατάλληλα μεταφρασμένα από κλινικούς εμπειρογνώμονες.
- Να γνωρίζετε και να ενημερώσετε τον ασθενή ότι **τα δεδομένα του/της θα χρησιμοποιηθούν για τον αποκλειστικό σκοπό της αξιολόγησης της περίπτωσής του και του αιτήματός σας** για την θεραπεία του, και εάν η περίπτωση δεν αξιολογηθεί θετικά, θα διαγραφούν εντός 3 μηνών από την αίτησή σας.

Το πρόγραμμα **επιχορηγεί το ποσό των 3.000,00 €**, που αφορά στα έξοδα (μετακίνησης, διαμονής κλπ) του ιατρού που επιθυμεί να συνοδεύσει τον ασθενή στο κέντρο θεραπείας.

Οι ασφαλισμένοι στο σύστημα κοινωνικής ασφάλισης της Ελλάδας έχουν δικαίωμα να ταξιδέψουν στο εξωτερικό με σκοπό την πρόσβαση σε υγειονομική περίθαλψη, γνωστή και ως προγραμματισμένη περίθαλψη, ειδικά σε περιπτώσεις που η περίθαλψη δεν παρέχεται στην Ελλάδα ή η παροχή της δεν είναι δυνατή στον ιατρικώς αποδ
χρόνο για την κατάσταση της υγείας τους.

Spread the word, prepare next generation scientists

With enthusiastic participation of many students

Assistants/tutors for HITRIplus schools and PTMC

Many of them now for Masters in DKFZ, Heidelberg etc

TIF 2022

PM: I know the project, it interests me

In Technopolis: discussions with ministers
A. Georgiadis and Dimas

TIF 2023

Y.P

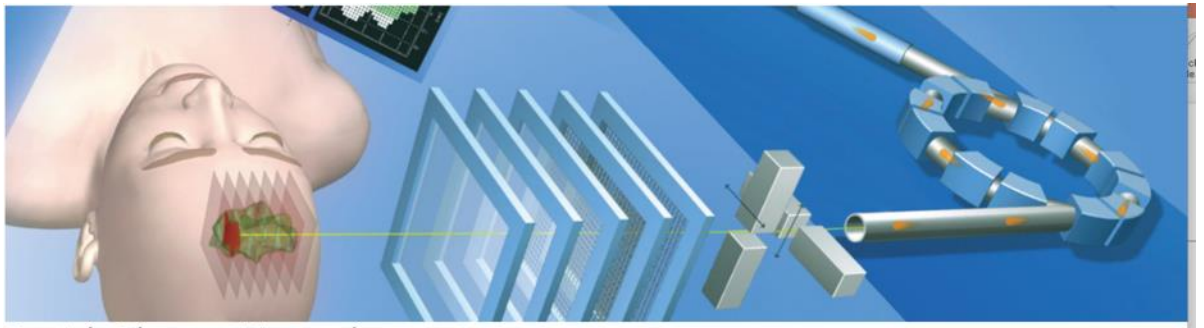
At HELEXPO exhibition centre

With lectures for students

TIF 2023

Heavy Ion Therapy Masterclass School

https://indico.cern.ch/e/HeavyIonTherapyMasterClass



Particle Therapy Masterclass

https://indico.cern.ch/event/840212/

Full week courses

HITRIplus schools aimed at university students, and up to early stage researchers and professionals

One day activity

The Particle Therapy MasterClass PTMC, is aimed at high-school students (16-18)

Future tutors

Introduce students, but also professionals, to HI therapy

Interesting career paths in emerging fields where often there is lack of specialised personnel

Information about upcoming modern techniques for cancer tumour therapy and new research avenues, where clearly the development of technology and the expertise of research laboratories is crucial.

HITRI plus
Heavy Ion Therapy Research Integration

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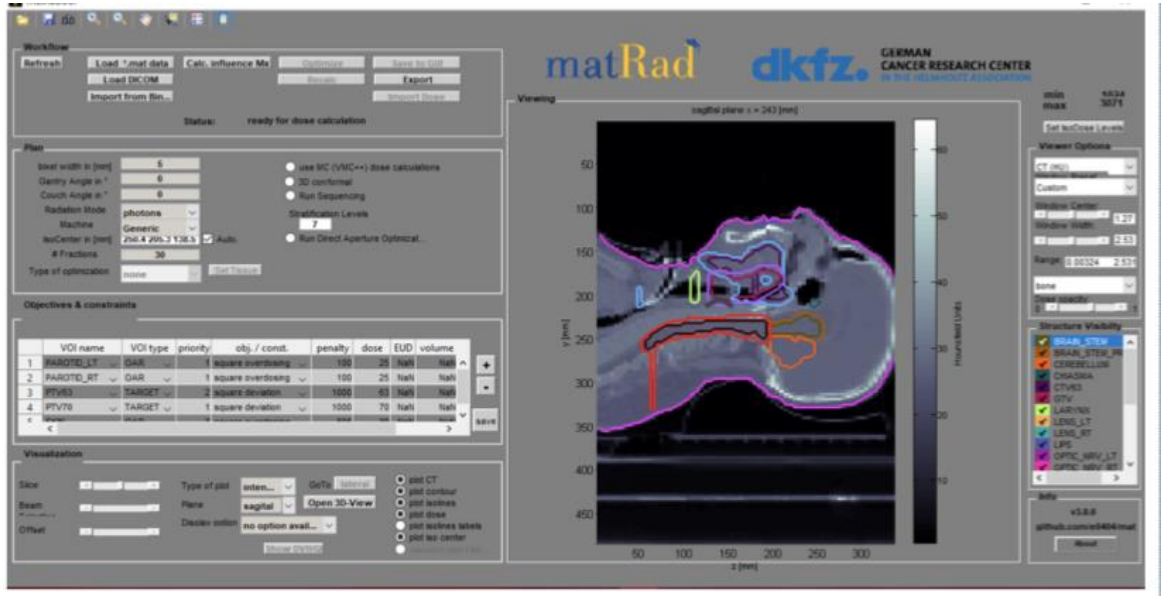
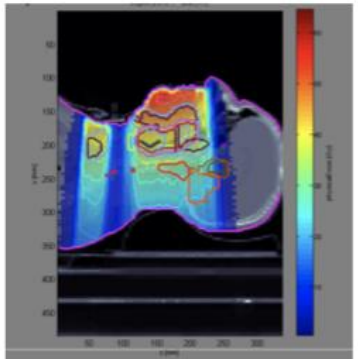
New PTMC and Treatment Planning

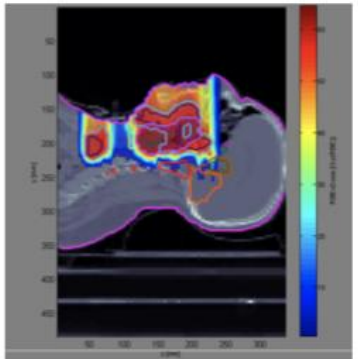
J.S.

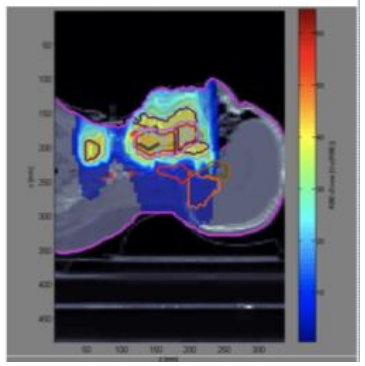
Based on professional open source treatment planning: matRad www.matrad.org
developed by Heidelberg DKFZ for education and research



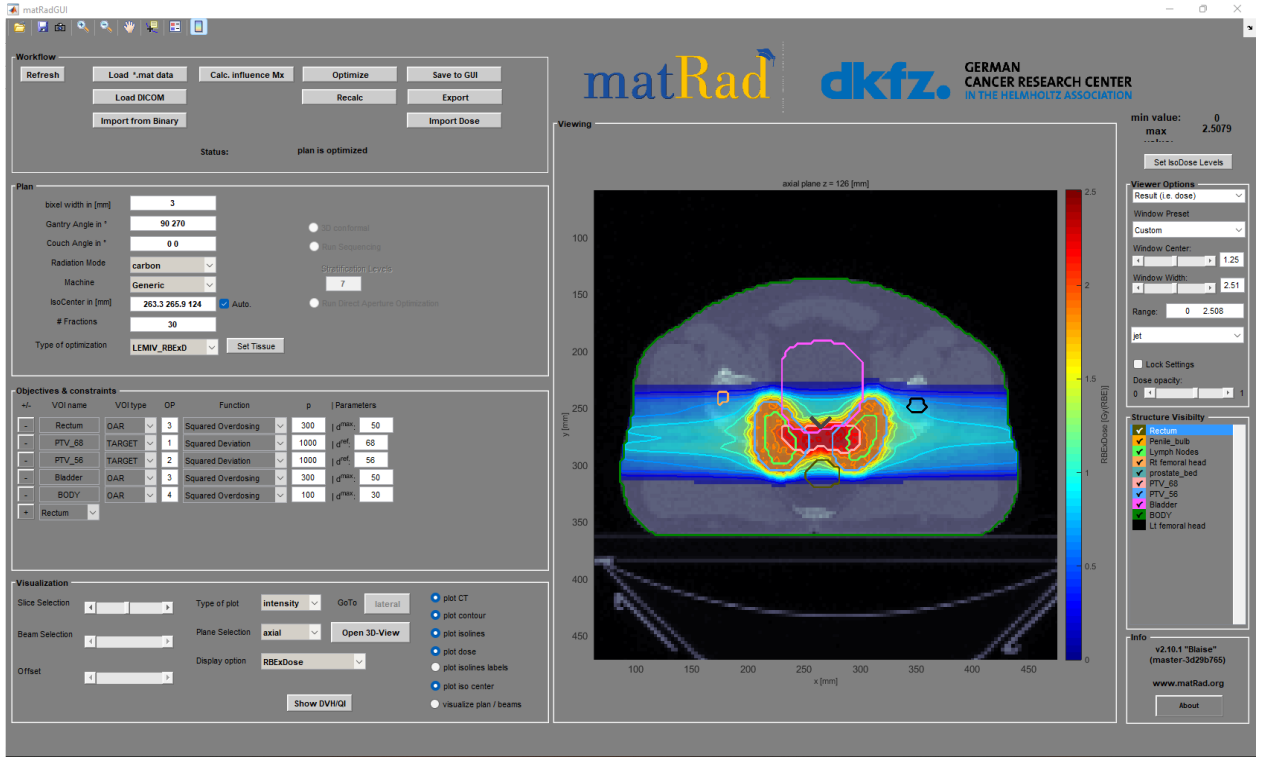
Demo[4] of the matRad software kit for Treatment Planning .







Simplified version for PTMC
Using photons, protons and carbon ions



Participants of online PTMC in IMC2022

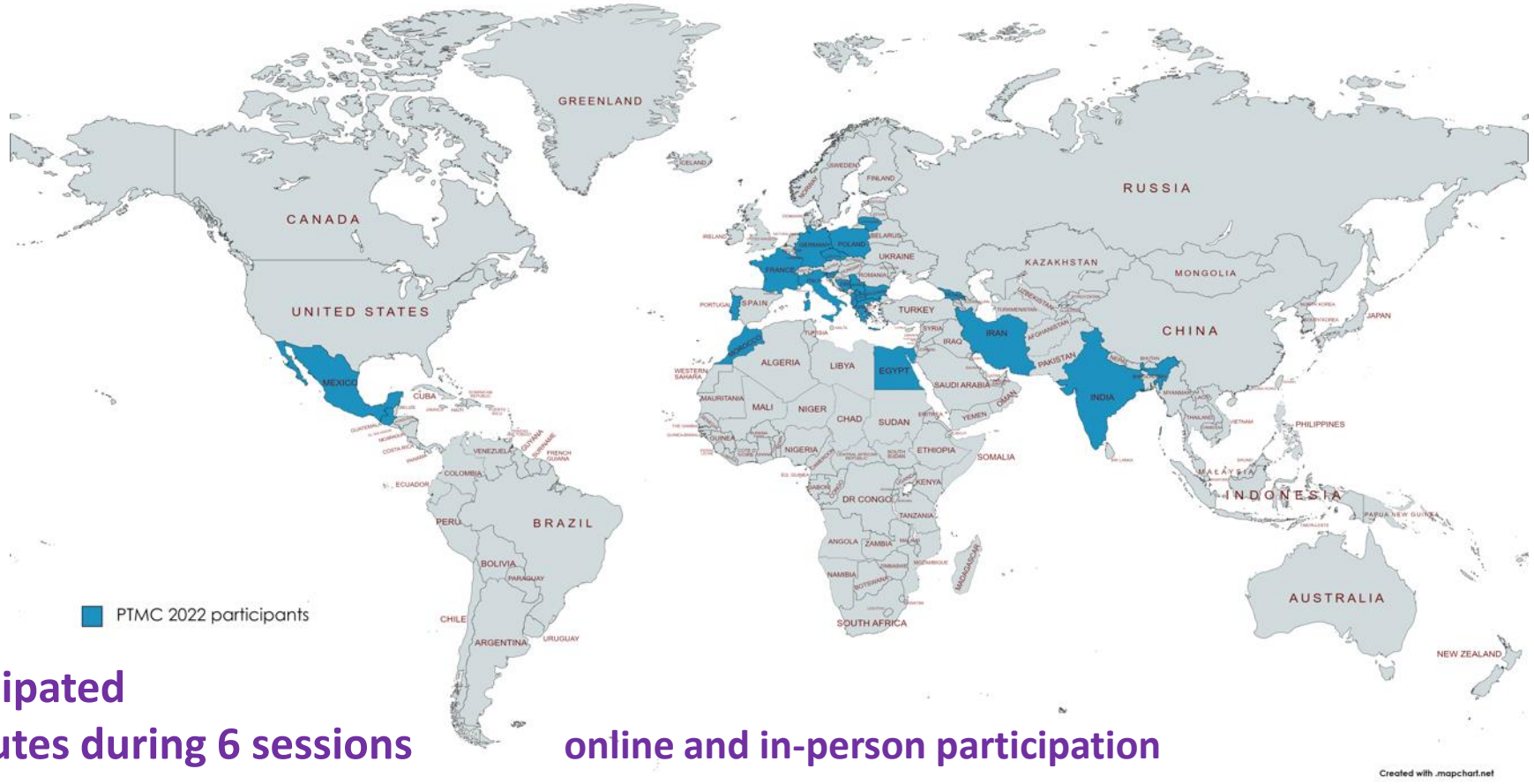
PTMC: https://indico.cern.ch/event/840212/

PTMC2024: 8 sessions

22 countries, 43 institutes,

more than 48 local sessions

(several institutes did 2 sessions)



PTMC2022 online:
more than 1500 students participated
from 22 countries and 37 institutes during 6 sessions

online and in-person participation

web pages with agendas of every institute with material
in different languages, publicly available for future events

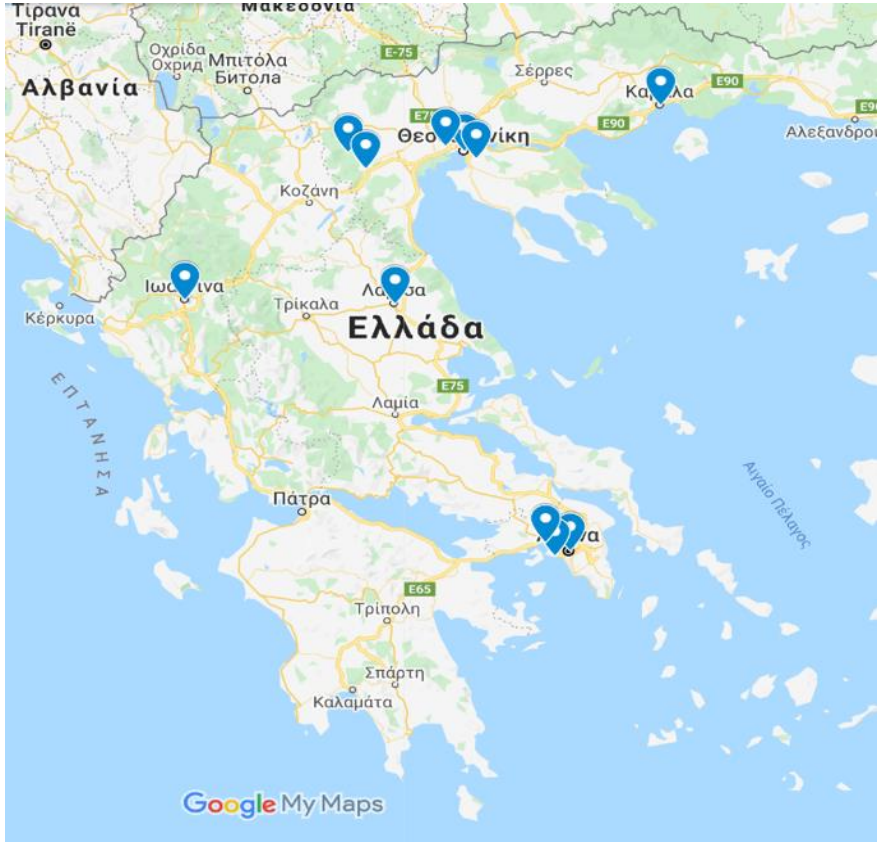
Interest of students, motivation of tutors (voluntary work), potential impact

PTMC online in Greece

PTMC2024: 23/3, 275p

PTMC2021 online: through Library of Veroia

Total of 366 live views
from at least 20 major regions of Greece

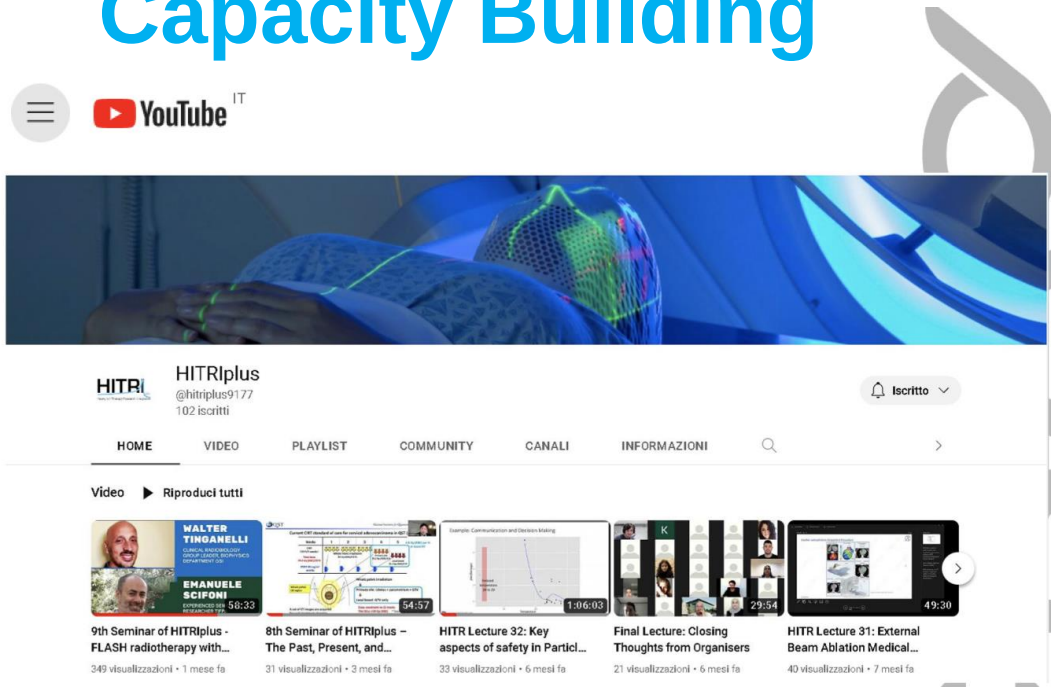


- Press Release published in **nation-wide media**
- Post on Facebook resonated with **3,600** people
- Announcement viewed **941 times** on website

PTMC online: 150-250 participants

AUTH uni, Dimokritos research centre, Papageorgiou Hospital, Technopolis.
Publicity: Library of Veroia extended networks and national press

Capacity Building



HITRIplus schools: online

https://www.hitriplus.eu/event-calendar/

- 17-21 May 2021 (1050 pax)
  https://indico.cern.ch/event/1019104/
- 4-8 July 2022 (60 pax)
  https://indico.cern.ch/event/1160802/
- 3-7 July 2023 (600 pax)
  https://indico.cern.ch/event/1248018/

HITRI 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

Actively preparing next generation of scientists for next generation ion facilities

GSI FAIR EMMI

PTMC Coordination : p.foka@gsi.de yiota.foka@cern.ch

SEEIIST and EDA

Nicollo Iorno