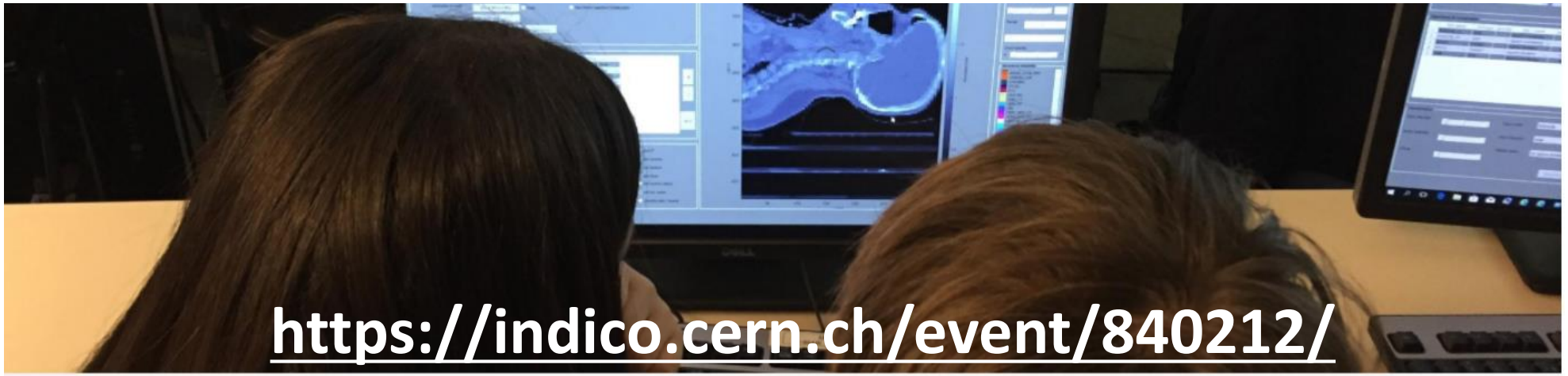
Particle Therapy MasterClass



Yiota Foka (GSI/CERN)

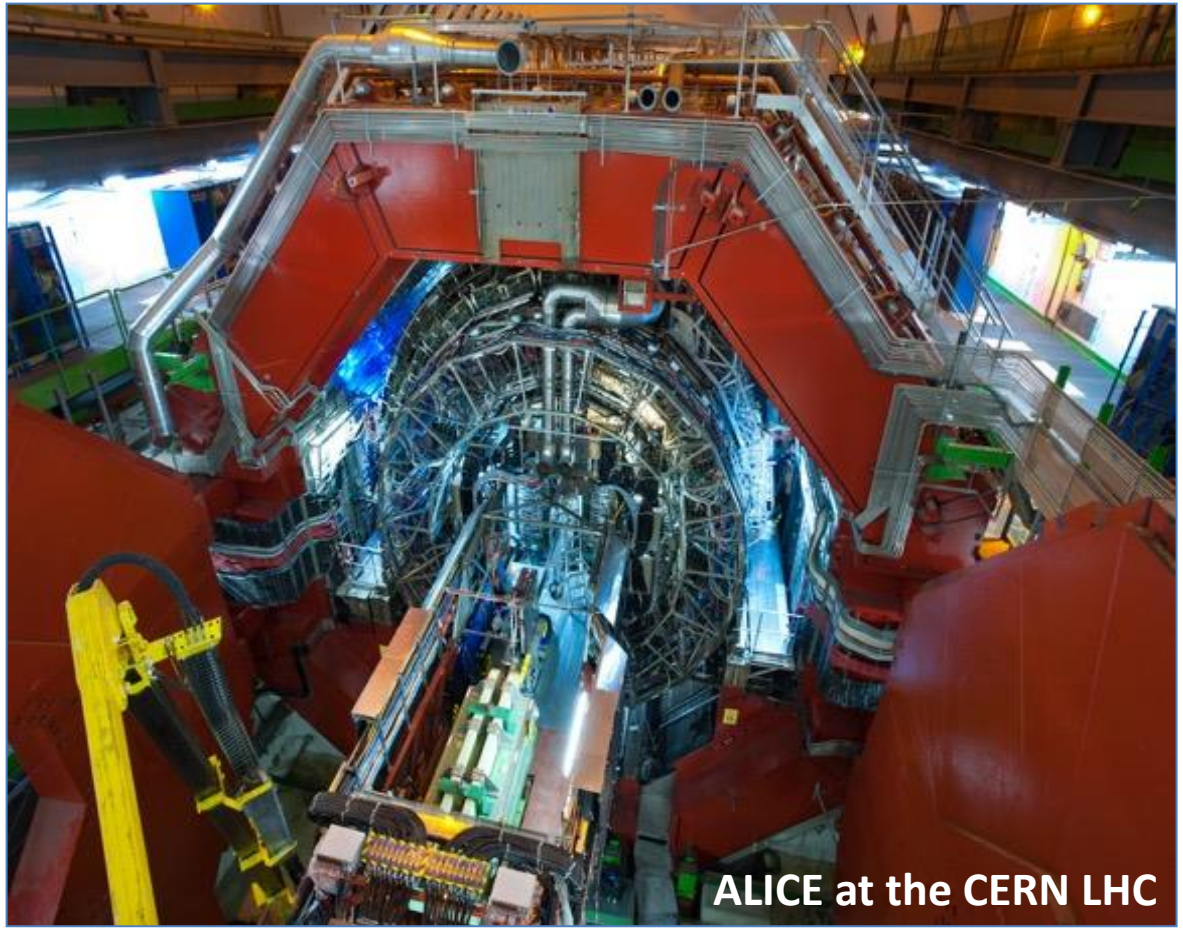
on behalf of

IPPOG and IMC Steering Group

From Particle Physics to Particle Therapy

From heavy-ion research to heavy-ion therapy


Control Room of ALICE at CERN

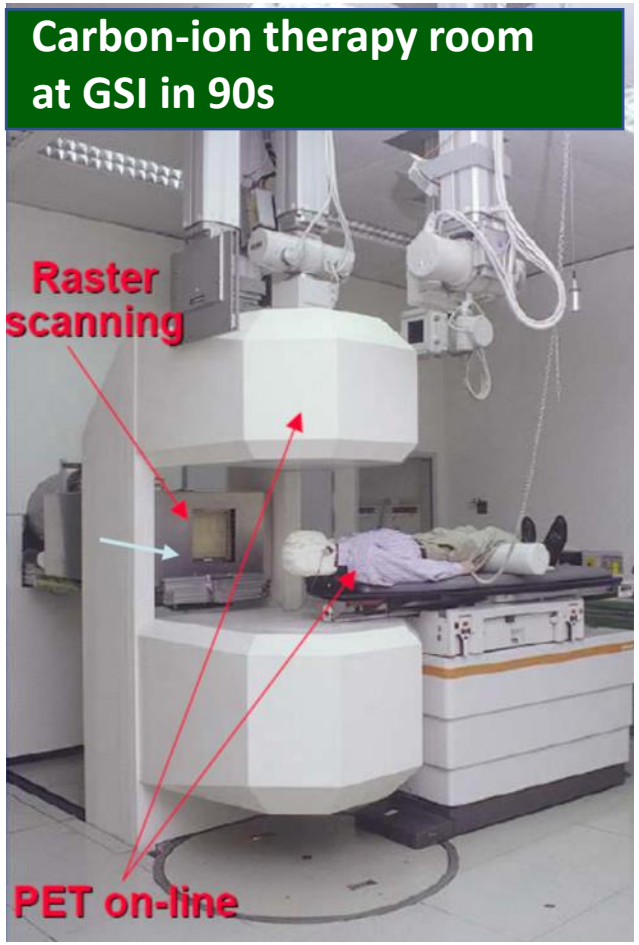

ALICE at the CERN LHC

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

Heavy-ion research and heavy-ion therapy at GSI

GSI and future FAIR facility, Darmstadt, Germany

Carbon-ion therapy room at GSI in 90s



Pioneered heavy-ion (carbon) therapy for cancer tumours in Europe (90s)
Implemented in the HIT Heidelberg Ion Treatment centre and later in Marburg

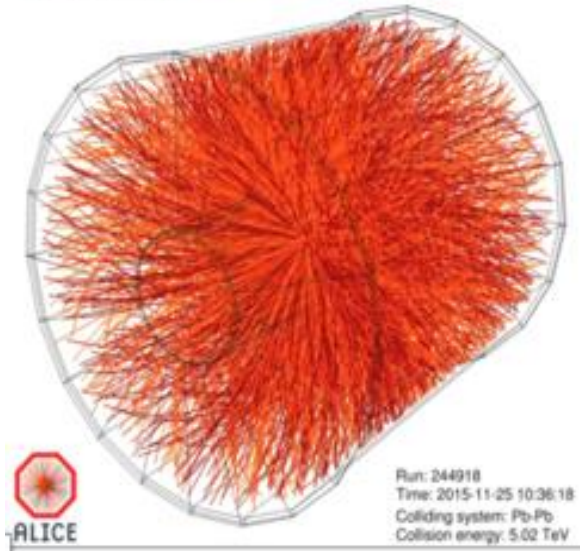
Mission and mandate of research institutes: fundamental research
Developed technologies and acquired knowledge find applications for society

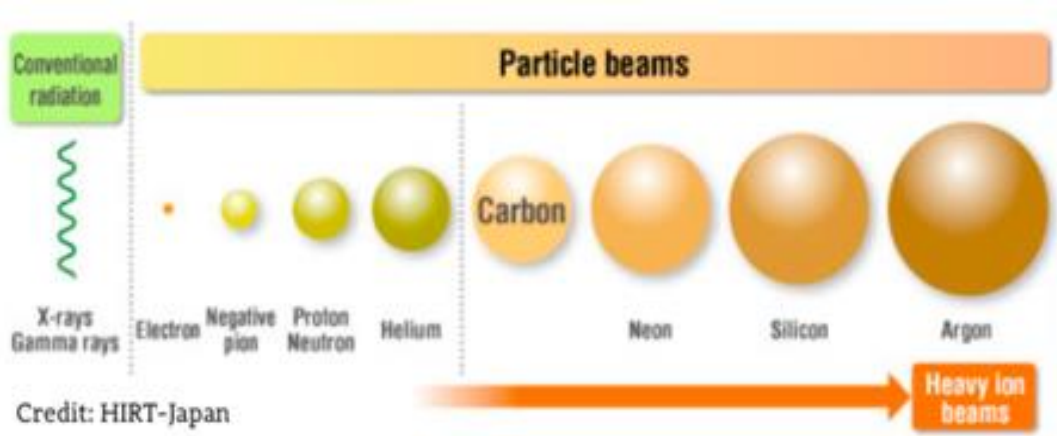
Heavy-ion research and heavy-ion therapy

Pb-Pb at 5.5 TeV
pp at 14 TeV

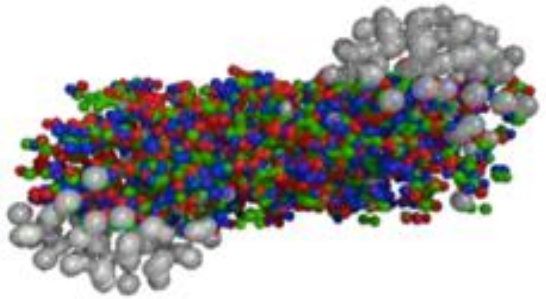
fundamental science
QGP studies

Credit: CERN





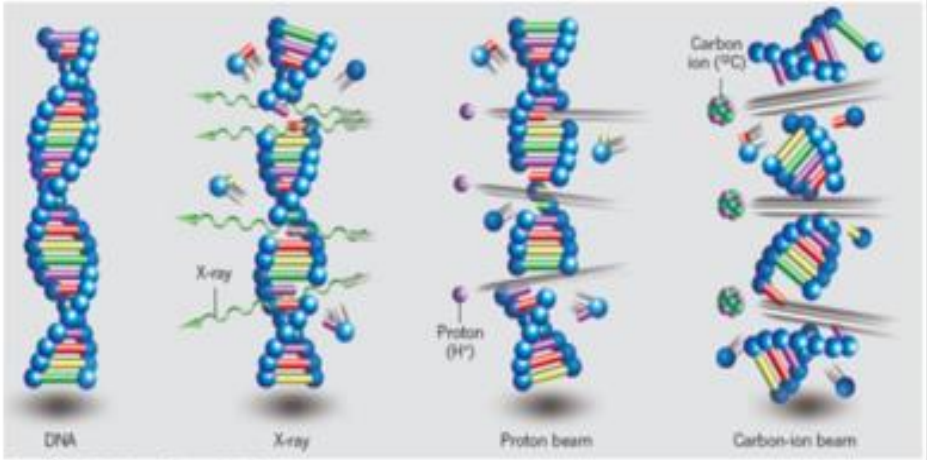
Credit: HIRT-Japan



88-430 MeV/u carbon
50-221 MeV/u protons

applied science
medicine

Credit: HIT Heidelberg



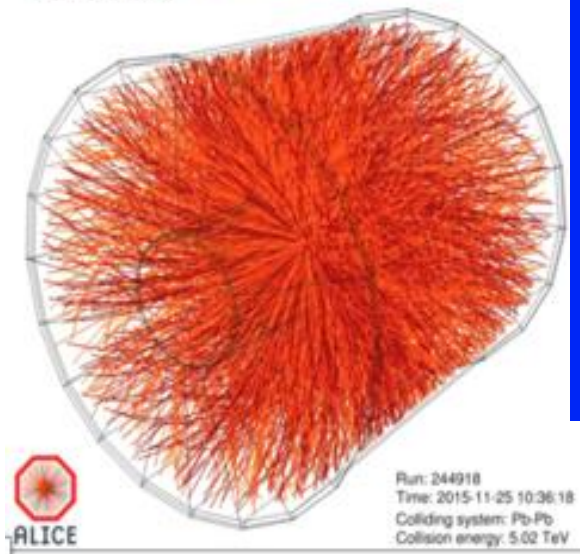
Credit: T. Nomiya, NIRS Japan

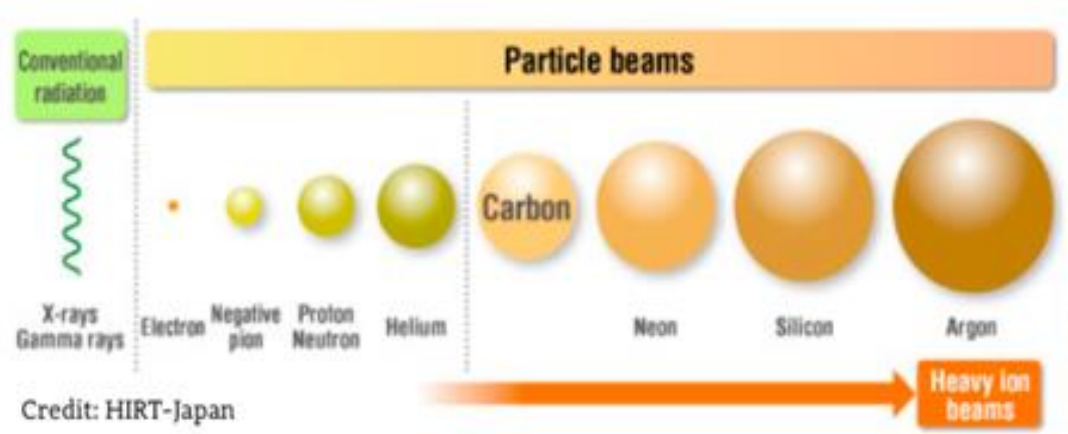
Heavy-ion research and heavy-ion therapy

Pb-Pb at 5.5 TeV
pp at 14 TeV

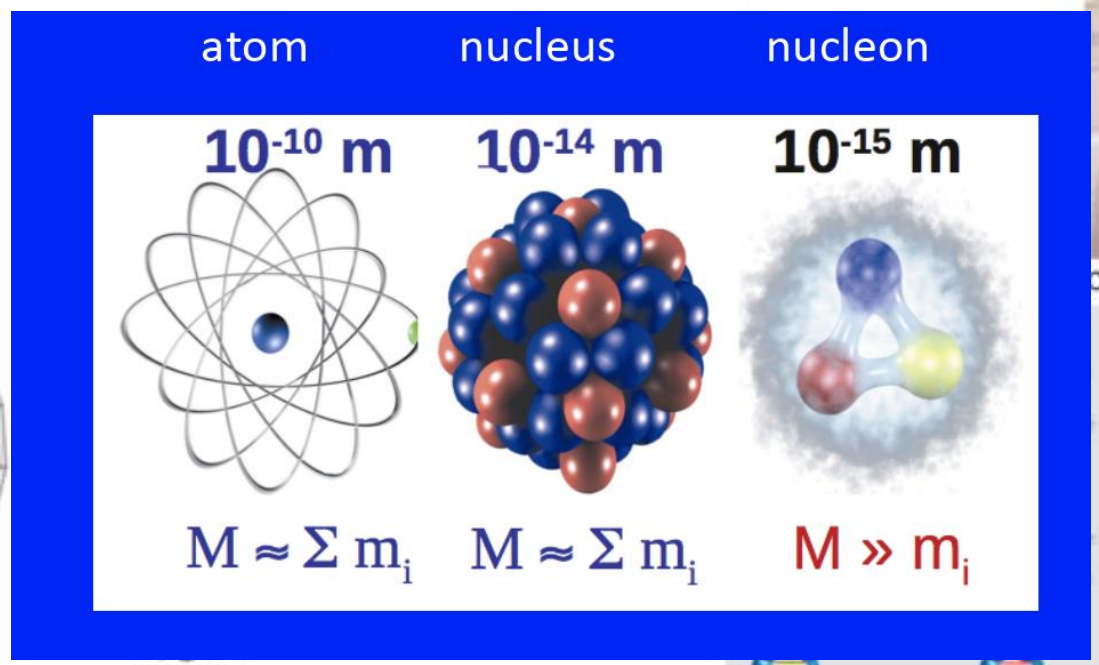
fundamental science
QGP studies

Credit: CERN





Credit: HIRT-Japan



88-430 MeV/u carbon
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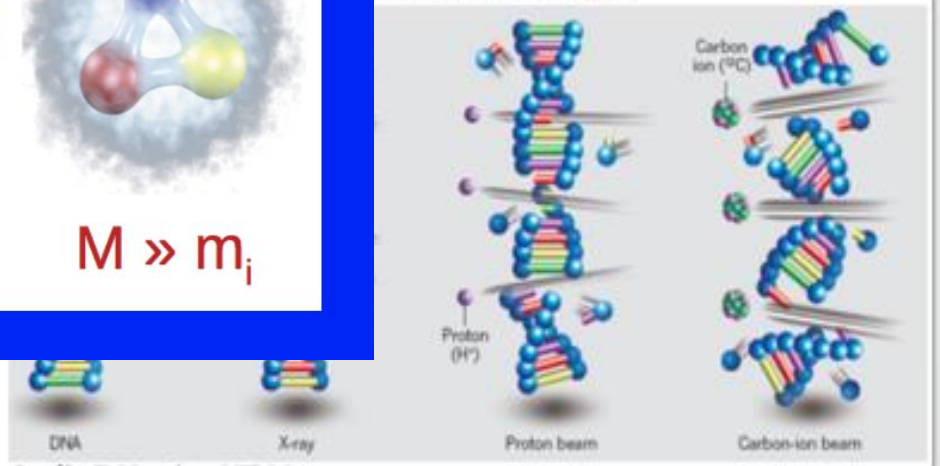


Credit: T. Nomiya, NIRS Japan

What are the International MasterClasses

and

What is the Particle Therapy MasterClass

International MasterClasses

Motivate the next generations of scientists !

The "International Masterclasses" IMC project

is an educational/outreach activity that brings the excitement

of cutting-edge high-energy physics research into the classroom !!

Classes by masters, experts

Today's masters

Joao Seco (DKFZ, Germany)

https://de.linkedin.com/in/joao-seco-5428726?original_referer=https%3A%2F%2Fwww.google.com%2F

Sandro Rossi (CNAO, Italy)

https://it.linkedin.com/in/sandro-rossi-1897b2137

Jennifer Hardt (DKFZ, Germany)

https://de.linkedin.com/in/jennifer-hardt-696839226

Borislav Pavlov et al Sofia Uni

Become scientist for a day !

Students are given the opportunity to analyze real data the same way that scientists do.

New PTMC:

- what physics has to do with medicine
- how we go from Particle Physics to Particle Therapy
- *different new career opportunities,* various possibilities that physics and STEM studies may open up for interesting jobs

IMC typical Reach and Statistics

Motivate the next generations of scientists !

60 countries

255 institutes

15 000 students

IMC dates :
11 Feb – Before Easter

Brings scientific methods and real data to schools!

Coordination QuarkNet / TU Dresden

- 51 institutes (48)
- 54 LHC Masterclasses (50)
  - 22 ATLAS (19)
  - 32 CMS (31)
- 12 MINERvA Masterclasses

- 188 institutes (177)
- 266 LHC Masterclasses (257)
  - 30 ATLAS W (35)
  - 101 ATLAS Z (104)
  - 64 CMS (58)
  - 41 LHCb (39)
  - 27 ALICE SP (18)
  - 3 ALICE R_AA (3)

Flagship project of IPPOG, the International Particle Physics Outreach Group

IMC typical daily and weekly schedule

14.03. - 19.03.2022

	Mon, Mar 14	Tue, Mar 15	Wed, Mar 16	Thu, Mar 17	Fri, Mar 18	Sat, Mar 19
topic		VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS W
moderators		Guglielmo	Denis	Anke	Ana P.	André
moderators		Matt	Ennio	Eleanor	Hassnae	Joshua
moderators		Niamh	Jennifer	Matt	Joshua	Muhammad Alhr.
		Grenoble	Genova	Zaragoza	Ankara, METU	Porto
		Bologna	Wuppertal	Lublin	Louisiana Tech	São Tomé e Príncipe
		Prague CU	Rzeszow	Opava	Granada	Dresden
		Amsterdam	Faro	Dortmund	Olomouc	Funchal
			Maynooth	Grenoble		

International MasterClasses https://physicsmasterclasses.org/

INTERNATIONAL MASTERCLASSES
hands on particle physics

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES

hands on particle physics

https://physicsmasterclasses.org/

- Home
- Information for High School Students
- Information for Teachers and Educators
- Information for Institutes and Physicists
- Schedule
- Intl. Day of Women and Girls in Science
- My Country
- Physics
- In the Media
- Published Papers
- Archive
- Contributors
- Contact Us

Follow @physicsIMC

Hands on Particle Physics Masterclasses

SCHEDULE 2021

At the end of each Masterclass day a videoconference between the institutes and with moderators at CERN, at Fermilab, TRIUMF, KEK, or GSI is established. The schedules for 2021 will be created early in 2021.

© CERN

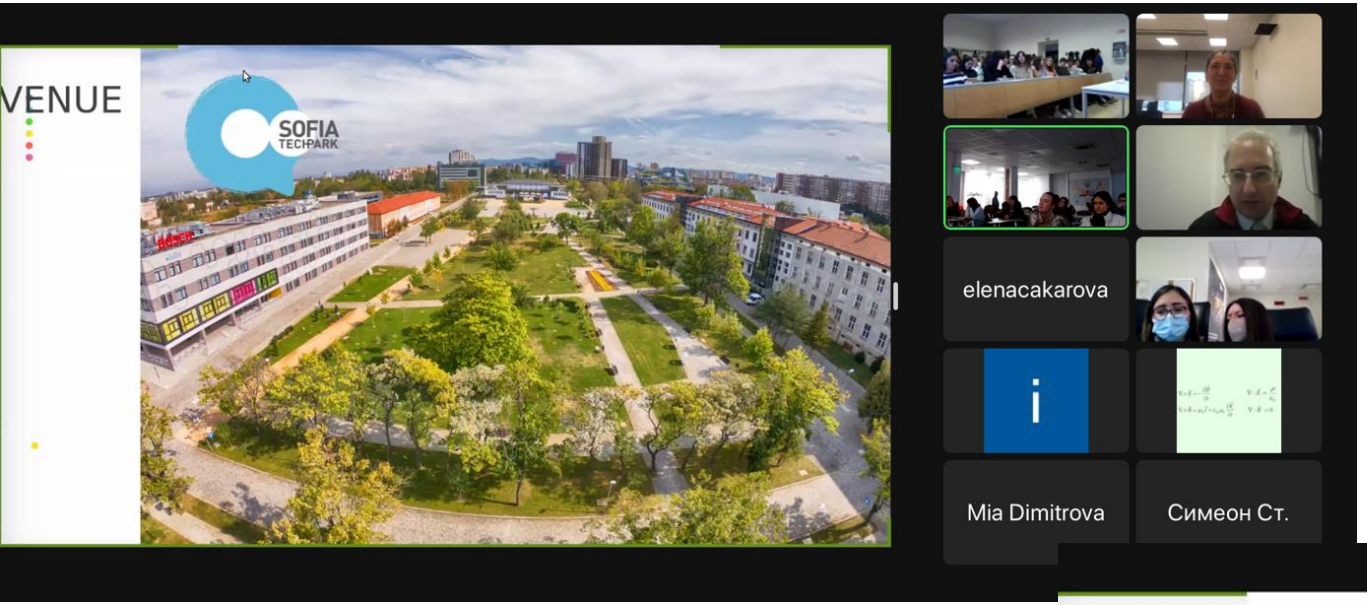
© Fermilab

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

INTERNATIONAL MASTERCLASSES

hands on particle physics

Particle Therapy MasterClass in Sofia



10 Feb 2023

celebrating women day in STEM

Hosted by Tech Park

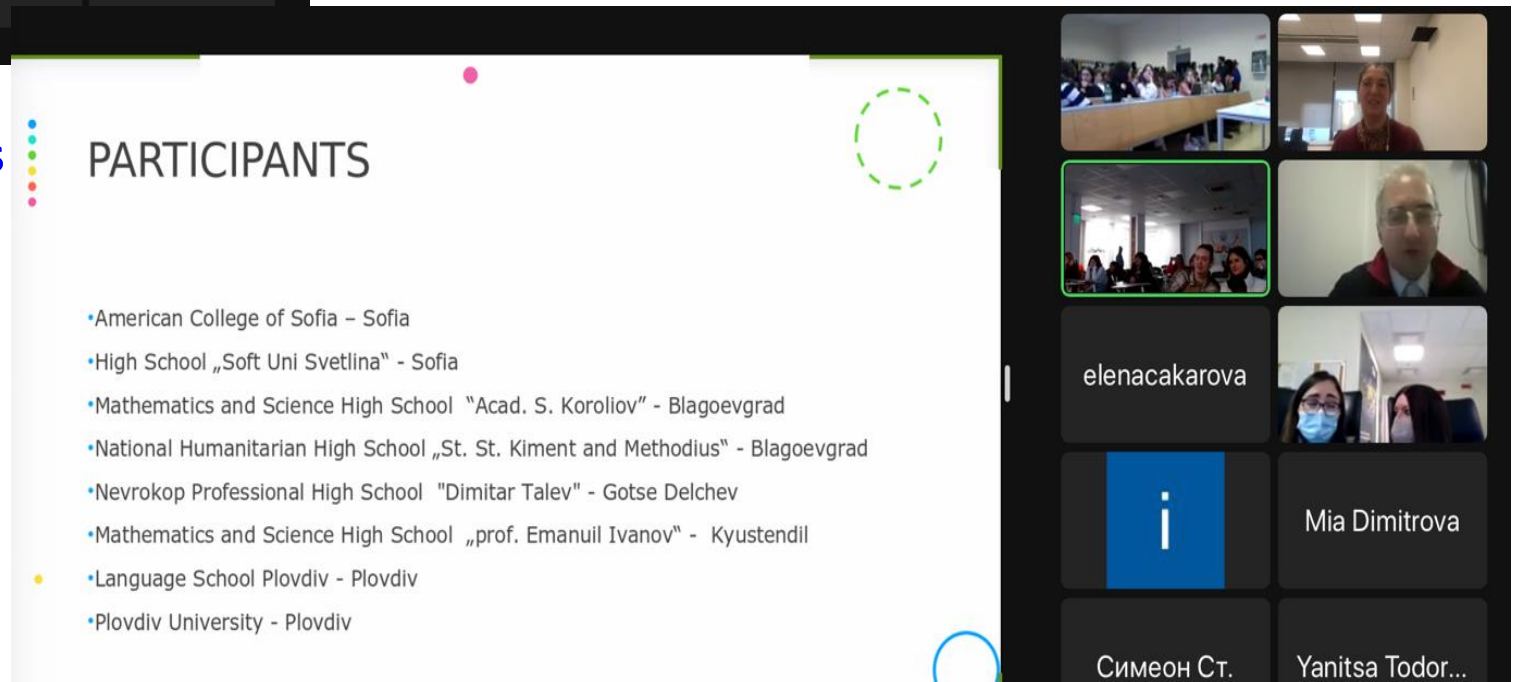
Organised by Borislav Pavlov et al

Participation in all PTMC:
26.03.21, 11.02 22, 10.02.23

Participation of students from several schools

39 students subscribed for the PTMC

29 girls and 10 boys
almost 3:1 ratio in favour of girls



PTMC: Typical MasterClass Day Agenda

Adapted online on zoom

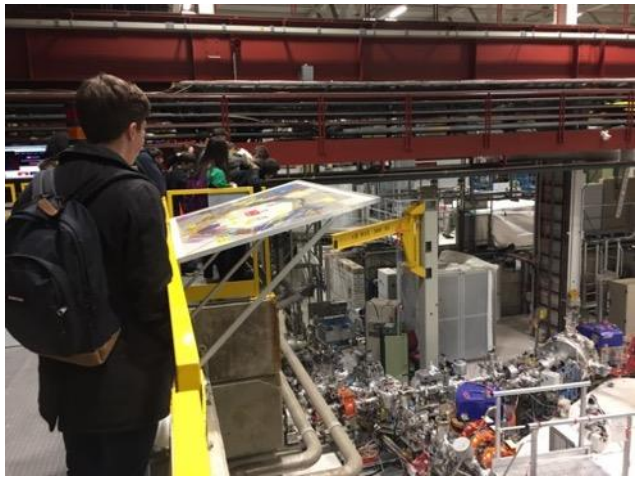
Every year, during the months of
February-April
school-children (15-19 year old)
are invited **at/by** an institute of their area.

LOCAL TIME:	ACTIVITY
8:30 - 9:00	Registration and Welcome
9:00 - 10:00	Introductory lectures
10:30 - 11:30	Visit of a lab or experiment
12:00 - 13:00	Lunch
13:00 - 15:00	Hands-on session
15:00 - 16:00	Discuss results locally
16:00 - 17:00	**Common Video Conference**

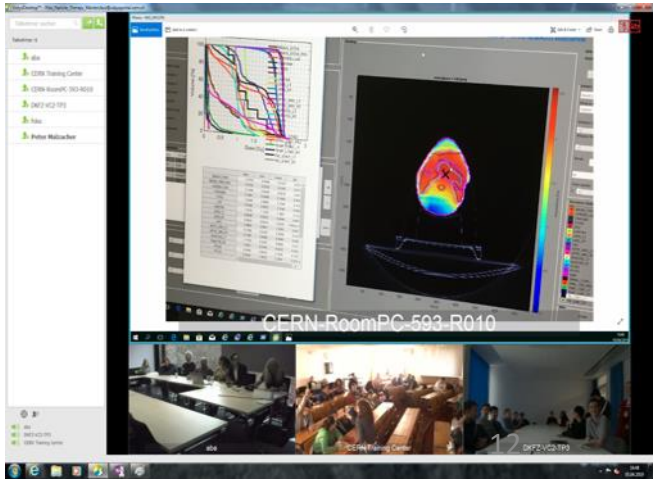
Local: Morning Presentations

Local: Afternoon Hands-on

Local: Morning Visits



Common: Afternoon at 16:00 Video-Conference



PTMC: Typical MasterClass Day Agenda

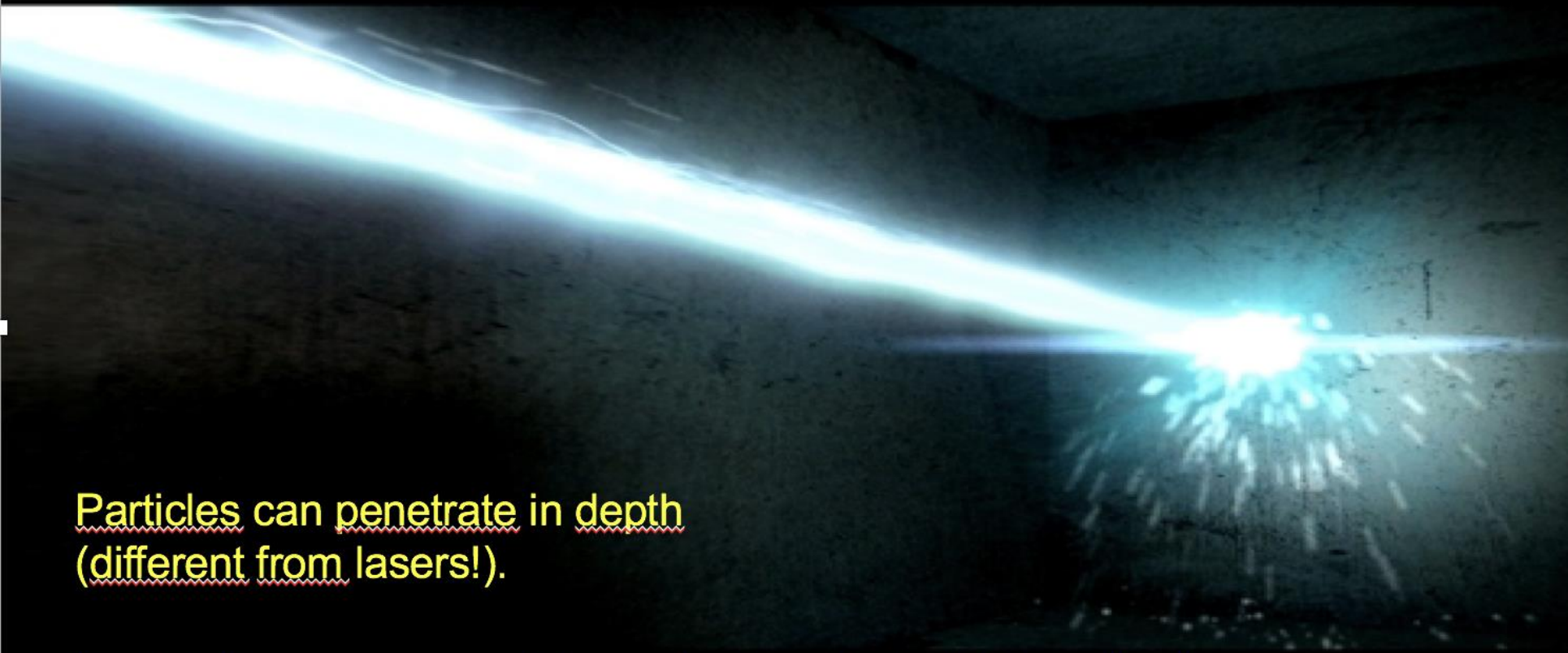
Start with videos on hadron therapy procedures in a virtual hadron therapy center while participants arrive (or join the zoom session)

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

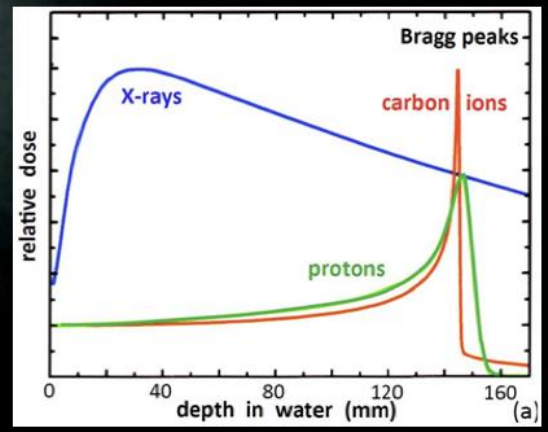
See presentations by :
Joao Seco (DKFZ)
Sandro Rossi (CNAO)

Accelerators: can precisely deliver energy

A «beam» of accelerated particles is like a small “knife” penetrating into the matter



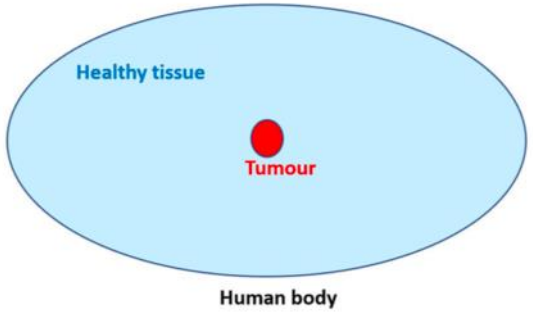
A particle beam can deliver energy to a very precisely defined area, interacting with the electrons and with the nucleus.



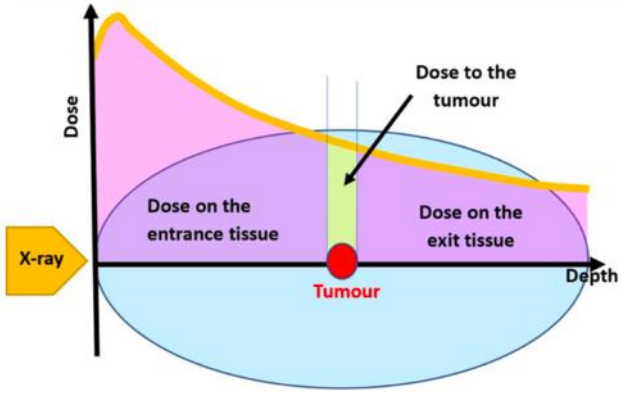
Particles can penetrate in depth (different from lasers!).

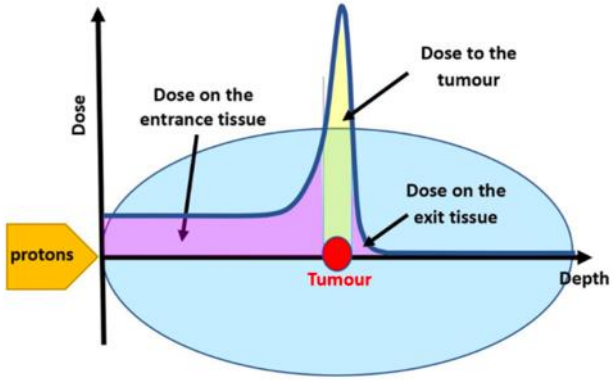
Particle beams are used in medical and industrial applications, e.g. to cure cancer, delivering their energy at a well-defined depth inside the body (Bragg peak)

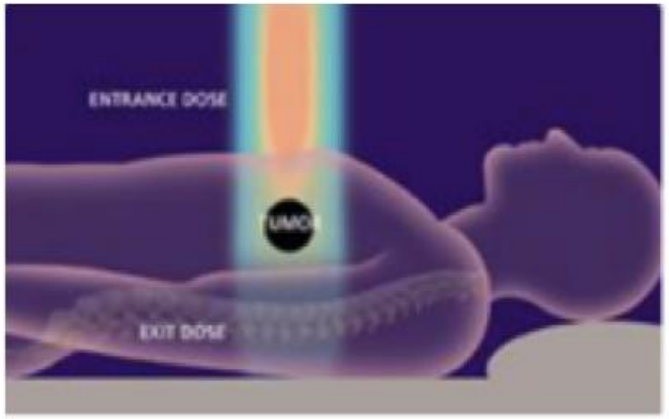
Particle properties and cancer therapy

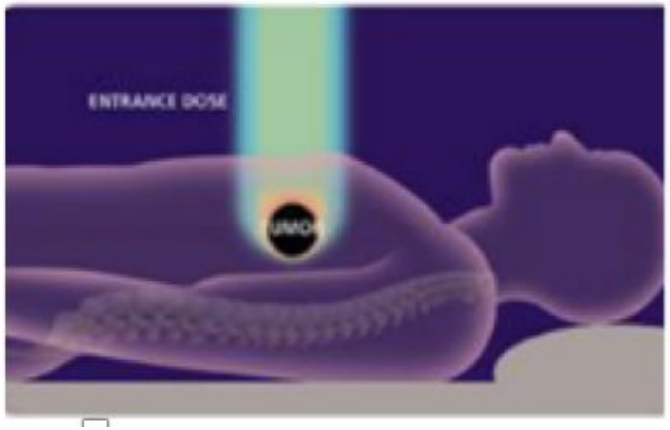


Advantages of hadron therapy with protons or carbon ions



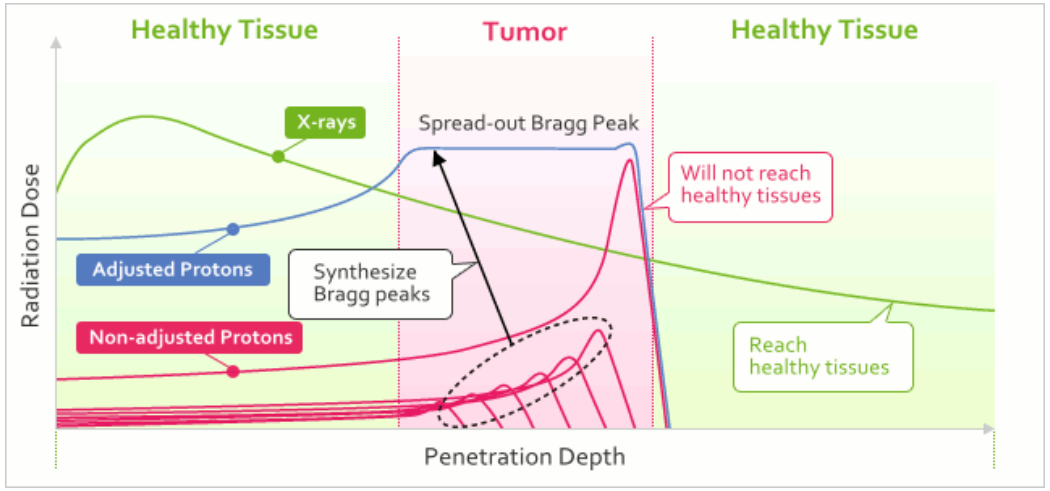




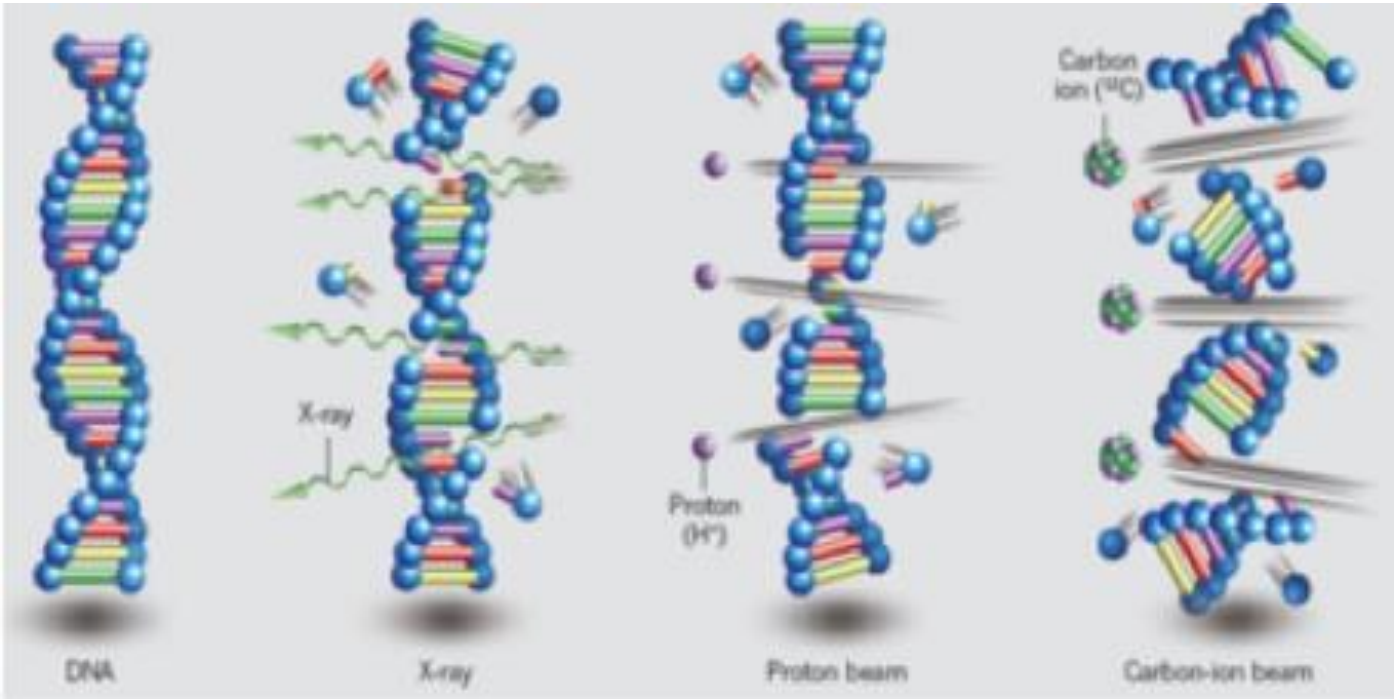


Different from X-rays or electrons, protons (and ions) deposit their energy at a given depth inside the tissues, **minimising dose to the organs close to the tumour**, sparing nearby organs.

Spread-out Bragg peak



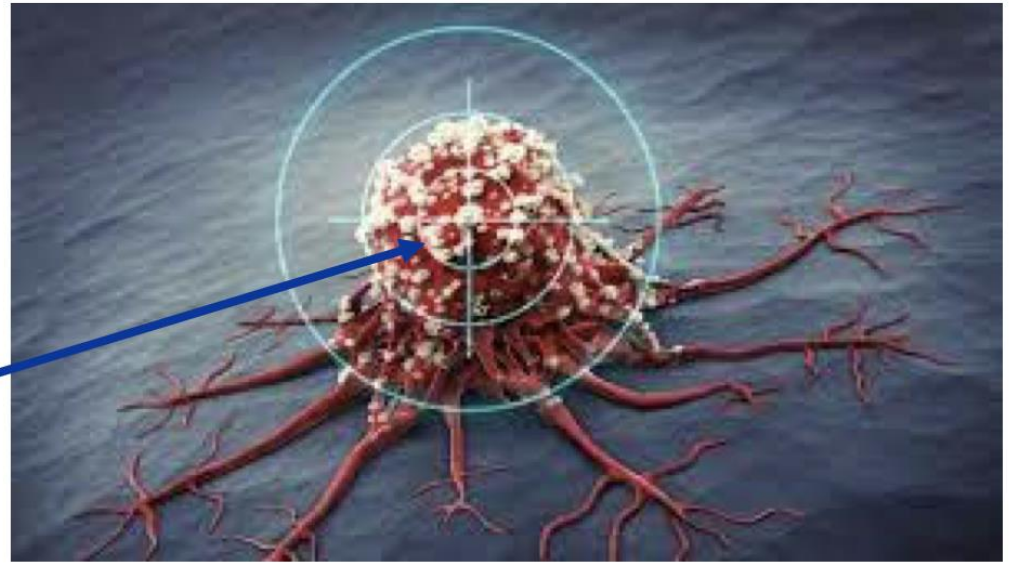
A particle beam can break the DNA and kill a cell



In addition to ballistic effects carbon-ions induce different radio-biological effects/damage. Therefore, they are more effective, and the only solution for some rare types of cancer tumours

Advantages of particle therapy with: protons or carbon ions

And if the cell has the cancer? Killed !



See presentation by : Joao Seco (DKFZ)

Particle Therapy MasterClass

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

- Instruction in Albanian
- Instructions in Bosnian
- Instructions in French
- Instructions in Greek
- Instructions in Lithuanian
- Instructions in N.Macedonian
- Instructions in Spanish

Material in different languages including animations and demos

"PTMC in a kit"
in different languages
with introduction by DKFZ
including recordings

https://drive.google.com/drive/folders/1L94yhos6L7k3FQlMzD9Ql7kpk_c_ABD7

See presentation by Jennifer Hardt (DKFZ)

PTMC: Typical MasterClass Day Agenda in Sofia

https://indico.cern.ch/event/1248143/

Hands-on by

Jennifer Hardt (DKFZ)

Borislav Pavlov et al Sofia Uni

Particle Therapy MasterClass: International Day of Women and Girls in Science, Sofia University, Bulgaria

Friday 11 Feb 2022, 09:00 → 18:30 Europe/Sofia

Zoom (Virtual)

Yiota Foka (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE)) , Aristeidis Mamaras (Aristotle University of Thessaloniki (GR))

Description Commemorating all the valuable work done by women in science all over the globe.

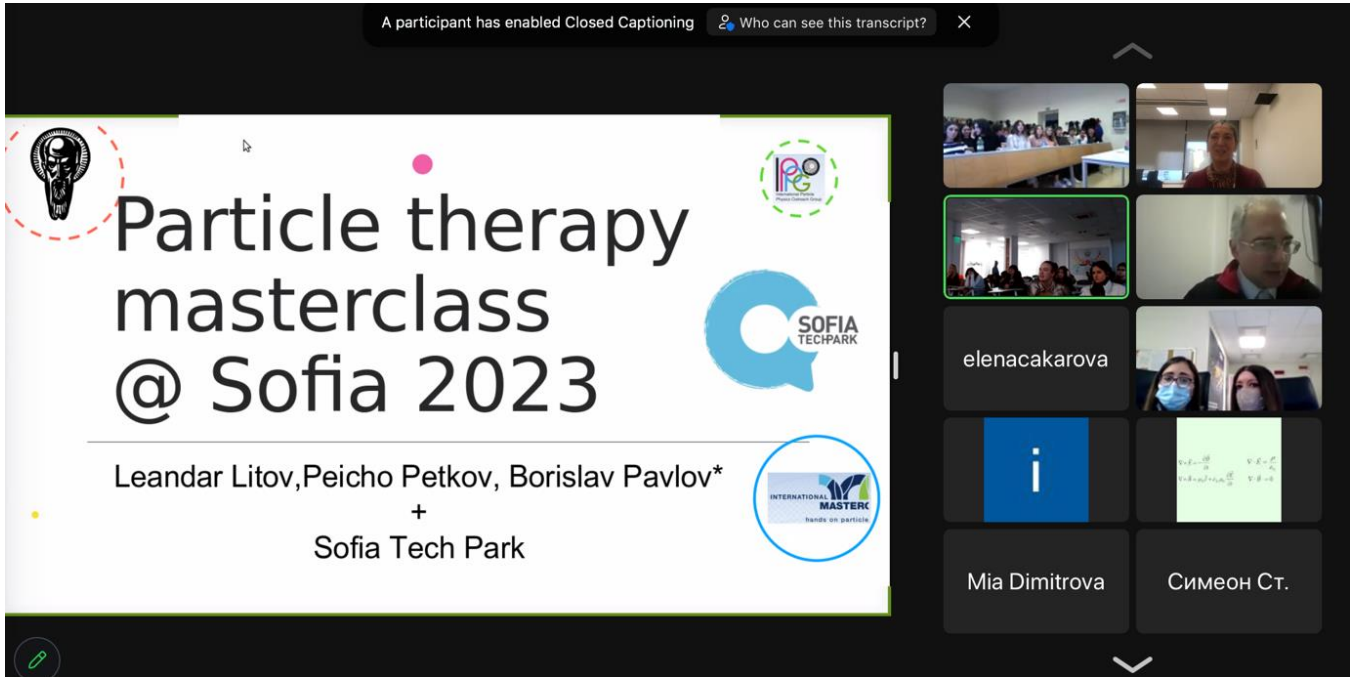
PTMC Main Page: https://indico.cern.ch/event/840212/

10:00 → 10:05	Welcome	
10:05 → 10:15	Welcome and Introduction to PTMC	
10:15 → 11:45	Адронна терапия **Speaker**: Leandar Litov (University of Sofia - St. Kliment Ohridski (BG))	1h 30m
11:45 → 12:00	Coffee break	15m
12:00 → 12:30	Въведение в matRad **Speaker**: Borislav Pavlov (University of Sofia - St. Kliment Ohridski (BG))	30m
12:30 → 12:45	Coffee break	15m
12:45 → 13:15	Virtual visti to ALICE experiment at CERN	30m
13:15 → 14:10	Lunch Break	
14:10 → 15:55	Hands-on session **Speaker**: Borislav Pavlov (University of Sofia - St. Kliment Ohridski (BG)) Moderators-DS.pdf Practical_MatRad.pdf	

17:00 → 18:00 **Video Conference INDICO and LINK**

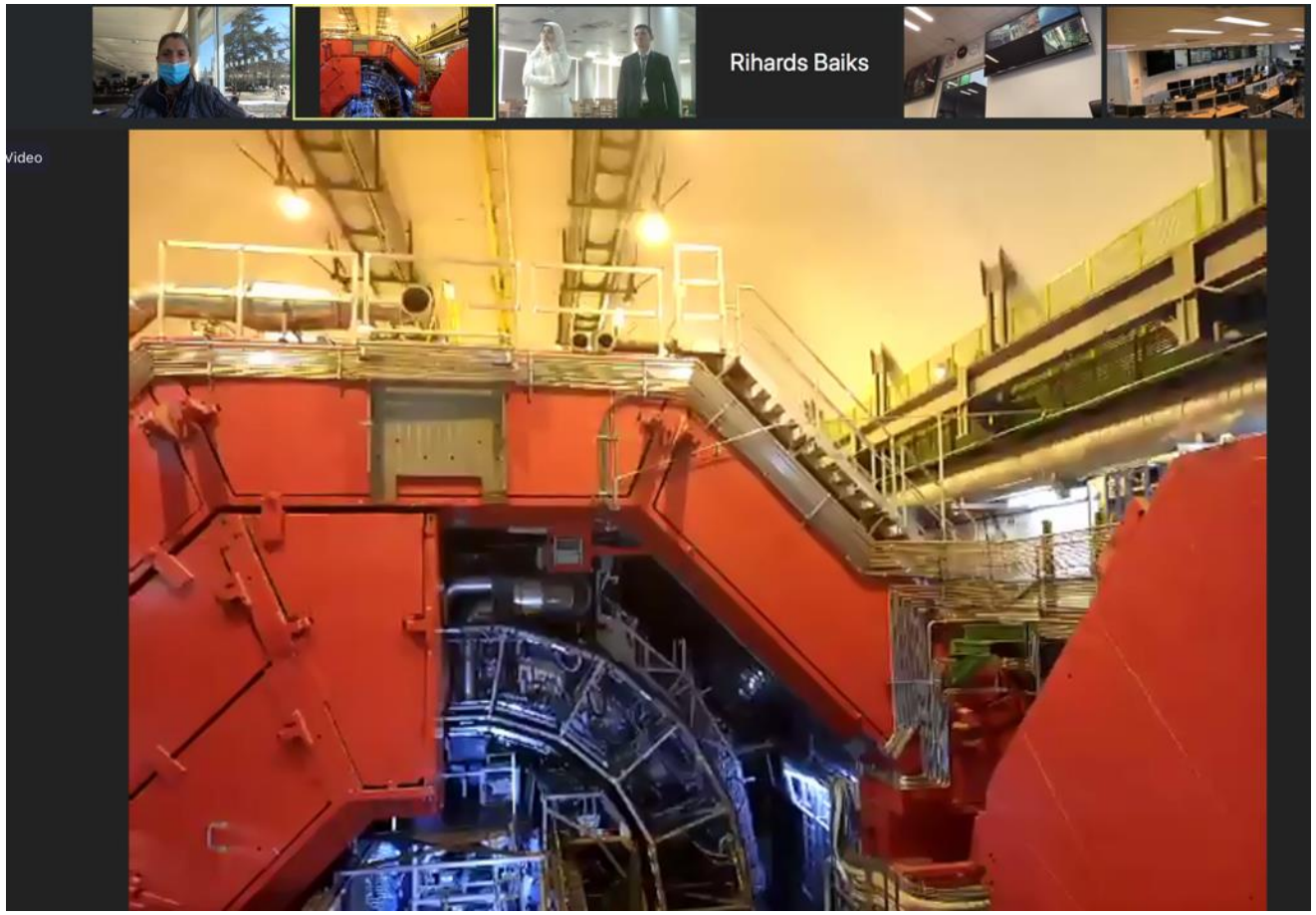
VIDEO-CONFERENCE INDICO https://indico.cern.ch/event/1246300/
LINK: https://cern.zoom.us/j/67488766361?pwd=UDBkM05yeFhqSkdjTXRBU3JoOFhpZz09

VIDEO-CONFERENC... VIDEO-CONFERENC...



PTMC: Typical MasterClass Day Agenda

Real-time virtual visits at the end of the morning lectures to ALICE heavy-ion experiment



Thanks to the ALICE Outreach coordinator: Despina Chatziphotiadou

16:00 **Virtual Visit**

Particle accelerator: https://youtu.be/DtOsEPwtSkQ
Tumor therapy: https://youtu.be/2KUzT7YZzTA
HIT: https://youtu.be/Fw9H_hceNIA
FAIR: https://youtu.be/N48YCJli1lo
3 Years in 3 Min FAIR: https://youtu.be/x0RTwqaRock
Biological modeling: https://youtu.be/azVNWptPA40

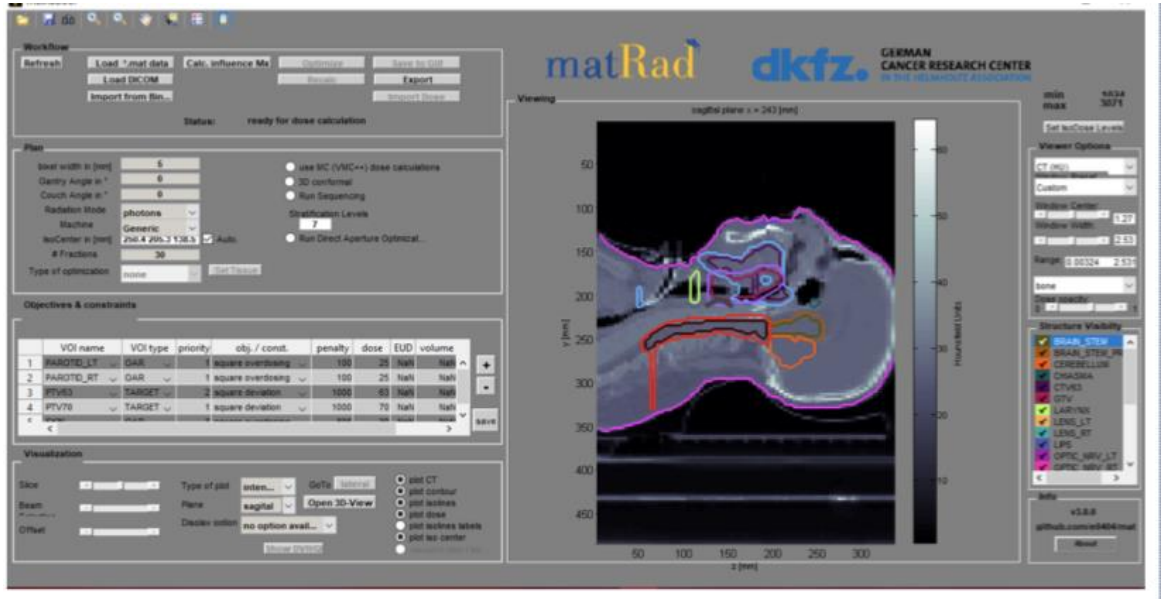
As an alternative to a visit to a local lab or experiment, videos can be used (see the link below)
Animations Link:
https://indico.cern.ch/event/840212/page/18000-animations

Alternatively, use of provided videos in the PTMC web pages

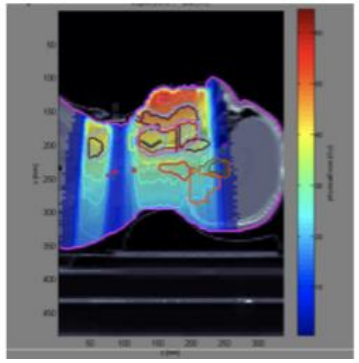
PTMC hands-on Treatment Planning

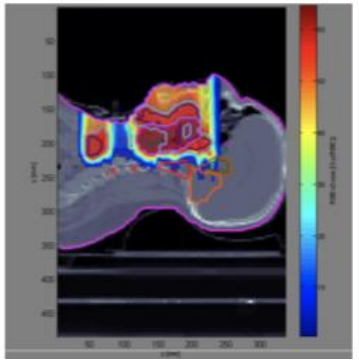
Based on professional open source treatment planning: **matRad** developed by DKFZ, Heidelberg www.matrad.org

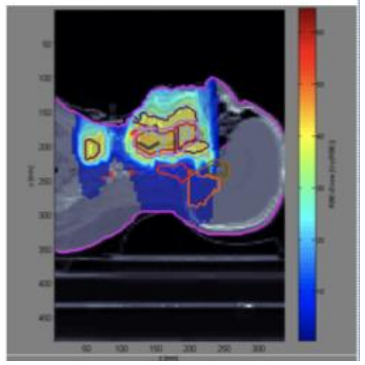
See presentation by Jennifer Hardt (DKFZ) and hands-on



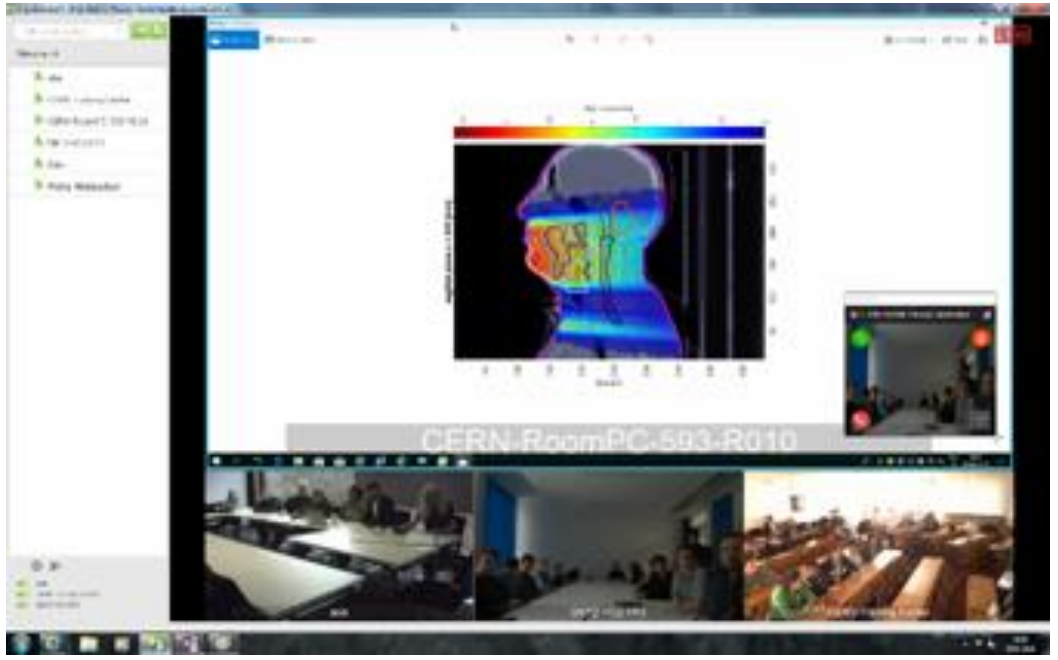
Demo[4] of the matRad software kit for Treatment Planning .







Dose prescription using photons, protons and carbon ions

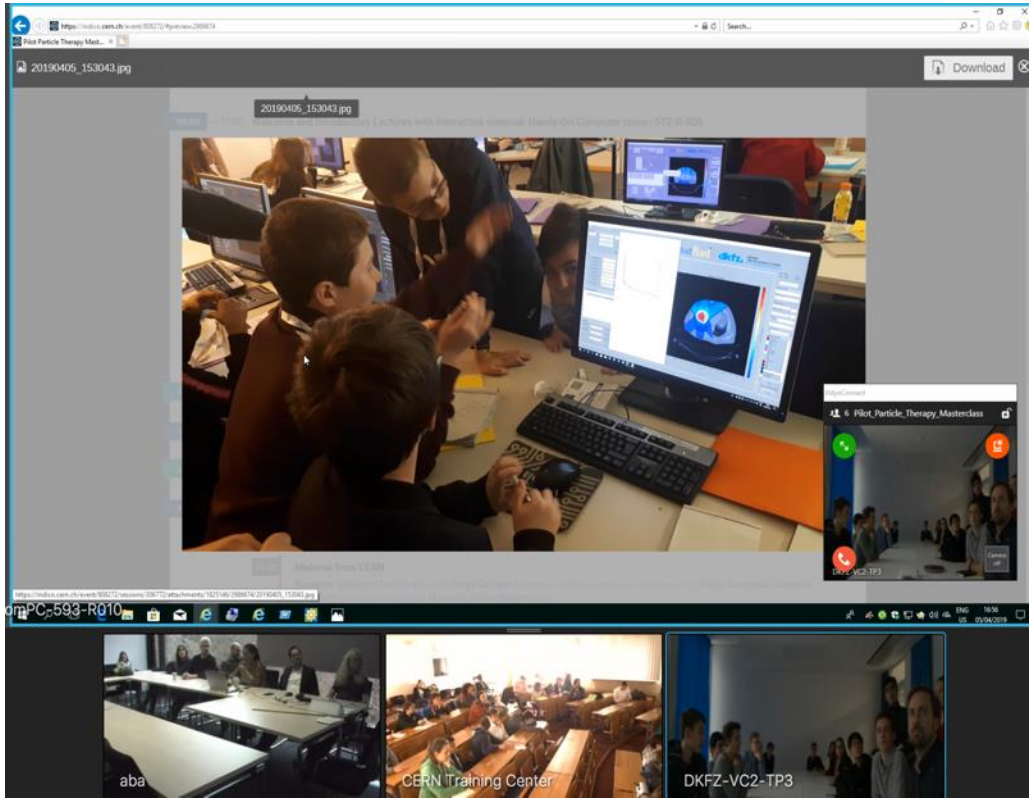


Simplified version for PTMC

PTMC and matRad Treatment Planning

First Local Test: GSI Feb 2019

International Pilot: CERN, GSI, DKFZ April 2019

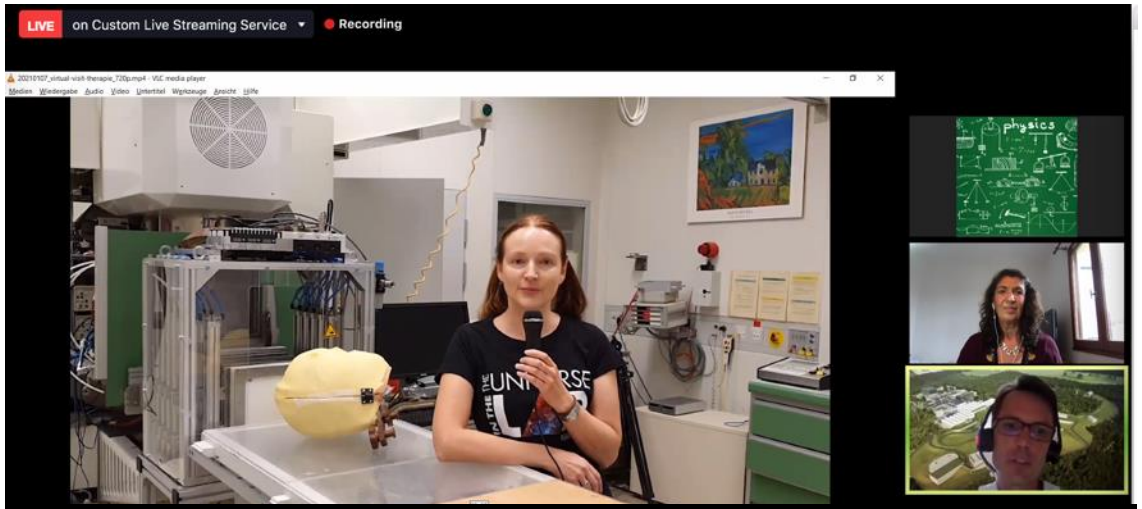


Web page: UNSA students at CERN, Aug 2019

- First local test: GSI Feb 2019
- First International Pilot: CERN, GSI, DKFZ Heidelberg, Apr 2019
- **IMC Steering Group Approval: GSI May 2019**
- Web pages: UNSA Sarajevo Uni students Aug 2019 at CERN
- CERN Open days: UNSA Sarajevo Uni students Sep 2019

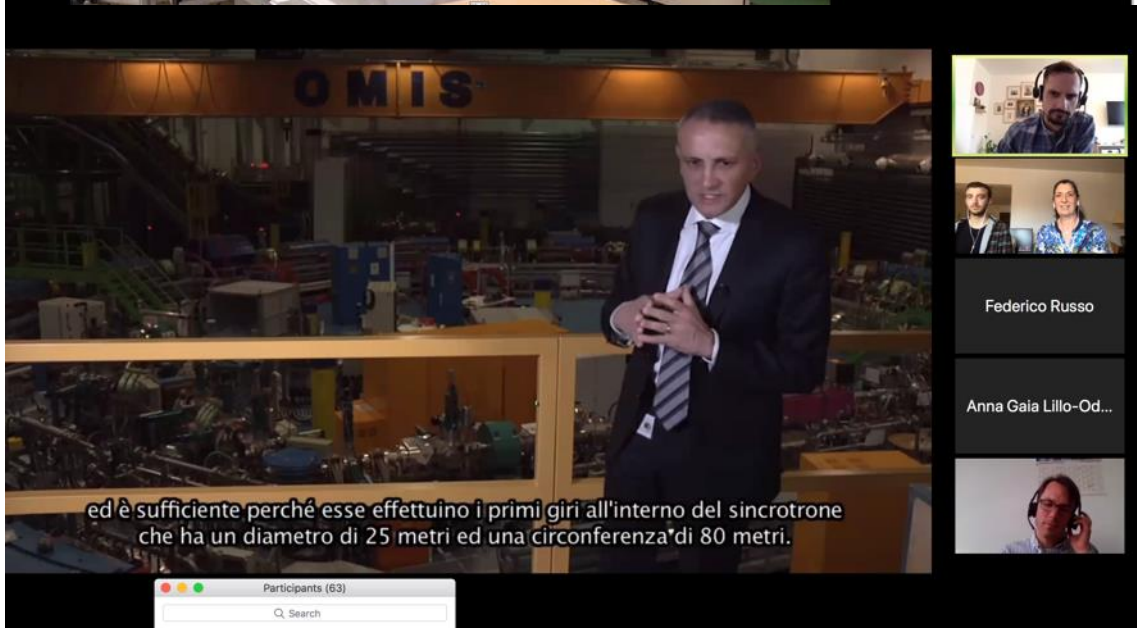
PTMC: Typical MasterClass Day Agenda

Virtual visits during video-conferencing to GSI research institute and CNAO therapy center



GSI moderator

CNAO moderator

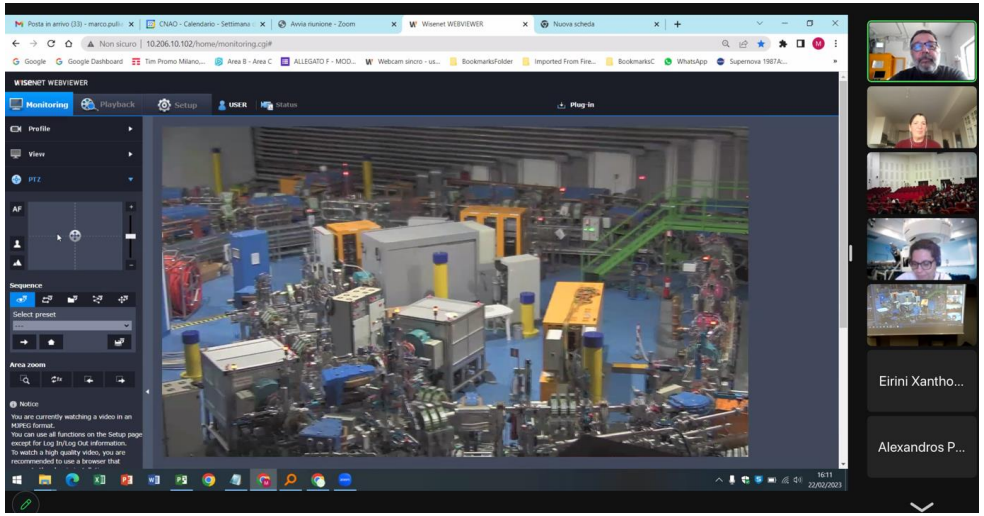


PTMC Coommon Video-Conference

International Particle Physics Outreach Group

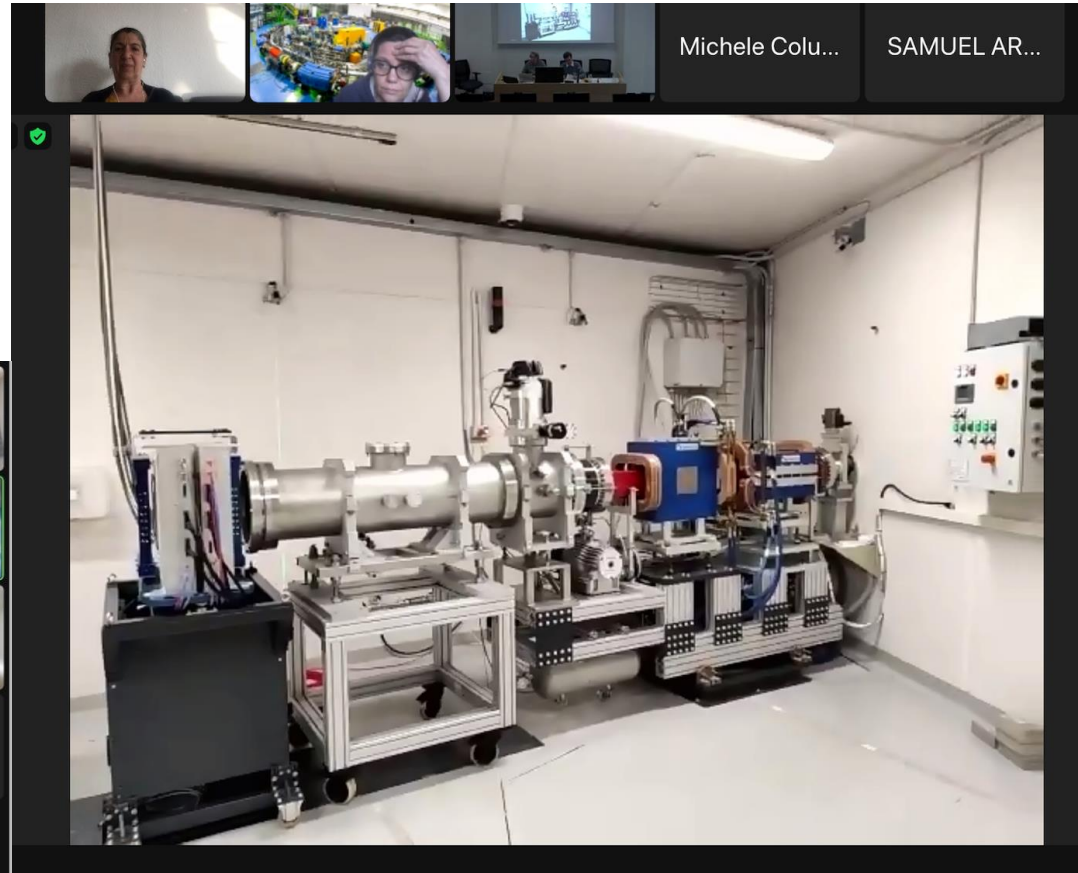
INTERNATIONAL MASTERCLASSES
hands on particle physics

see the CNAO accelerators via webcam

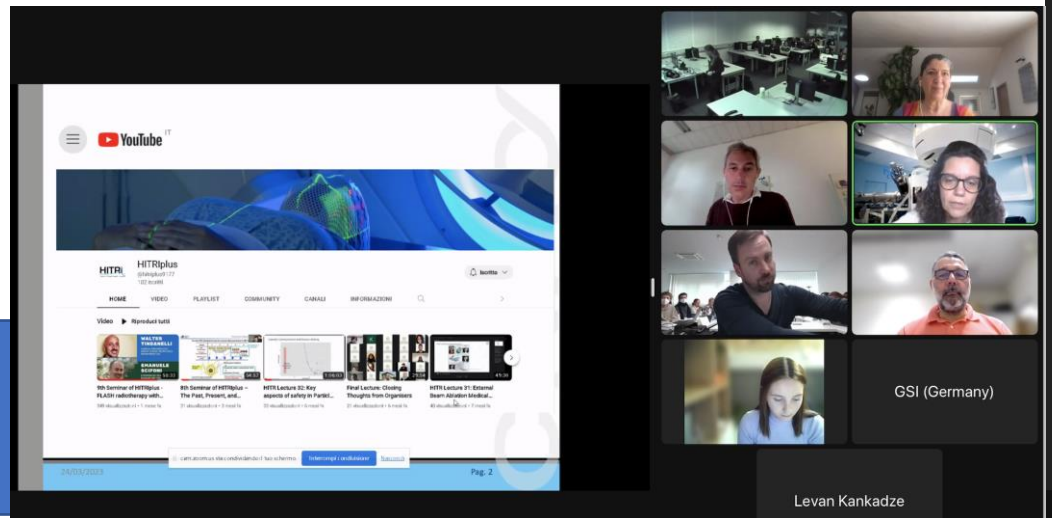


Virtual real-time visits during video-conferencing to CNAO therapy center

visit the CNAO experimental room



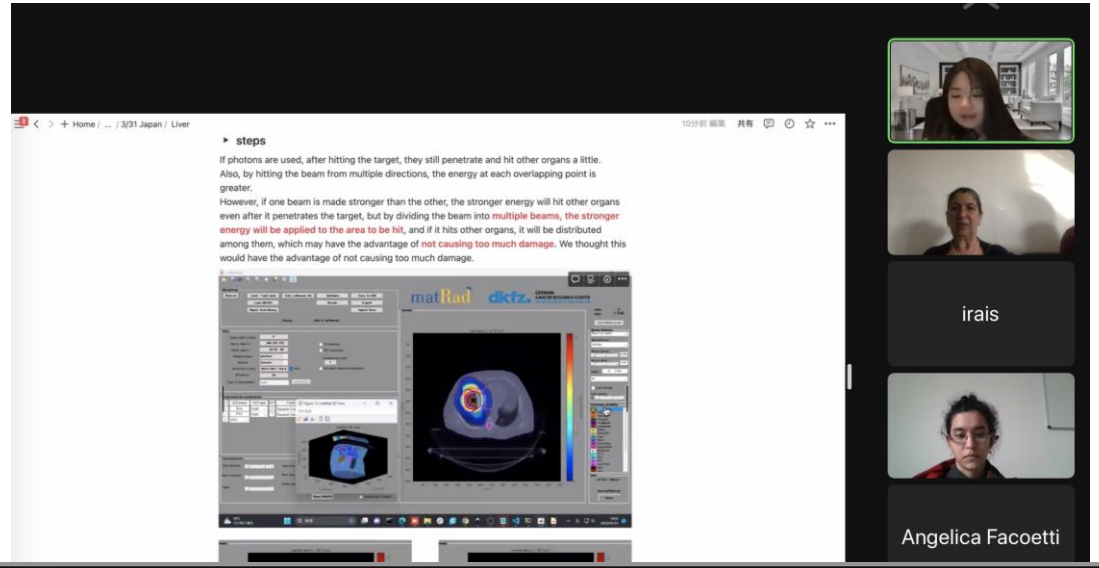
learn how to find PT educational material and opportunities provided by HITRIplus EU-funded project



See presentation by Sandro Rossi

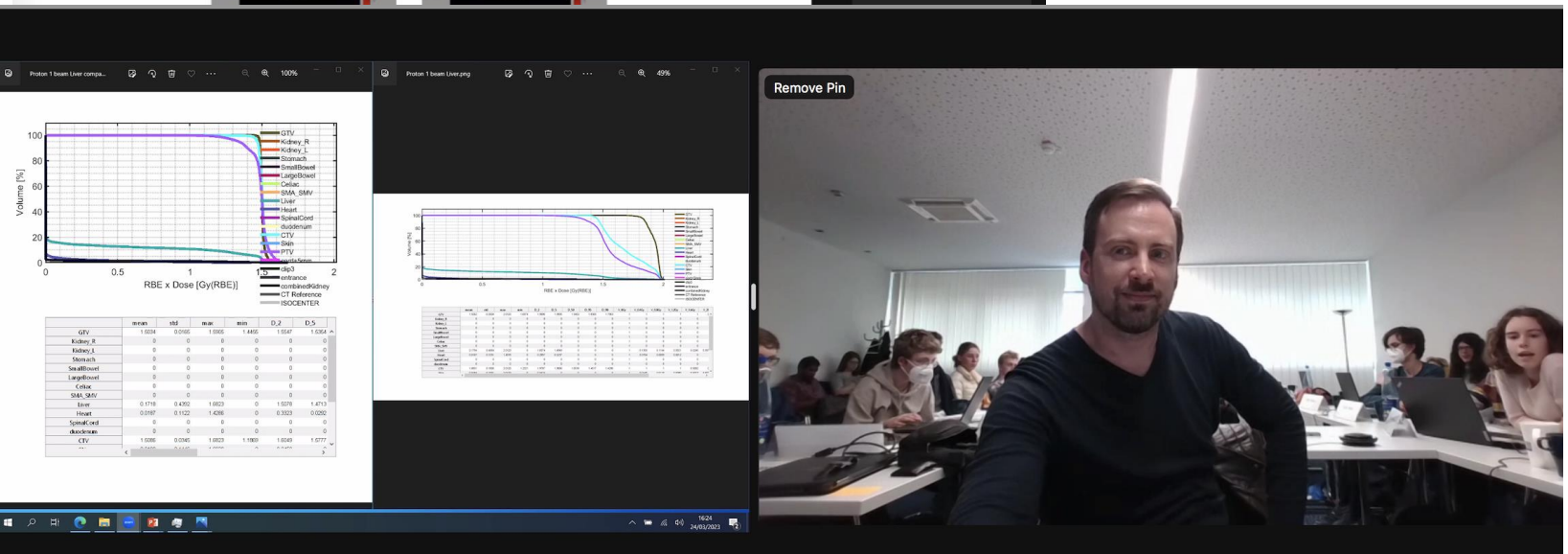
PTMC VC discussion of results

Highlight benefit of collaborations discussing results among partners around the world



Show how big collaborations work:
remote communications routinely
On 31 March: 10 institutes:
from Japan, Mexico, Europe….

Highlight the benefit of collaboration:
big projects do not come from one person
nor one institute, one country…..



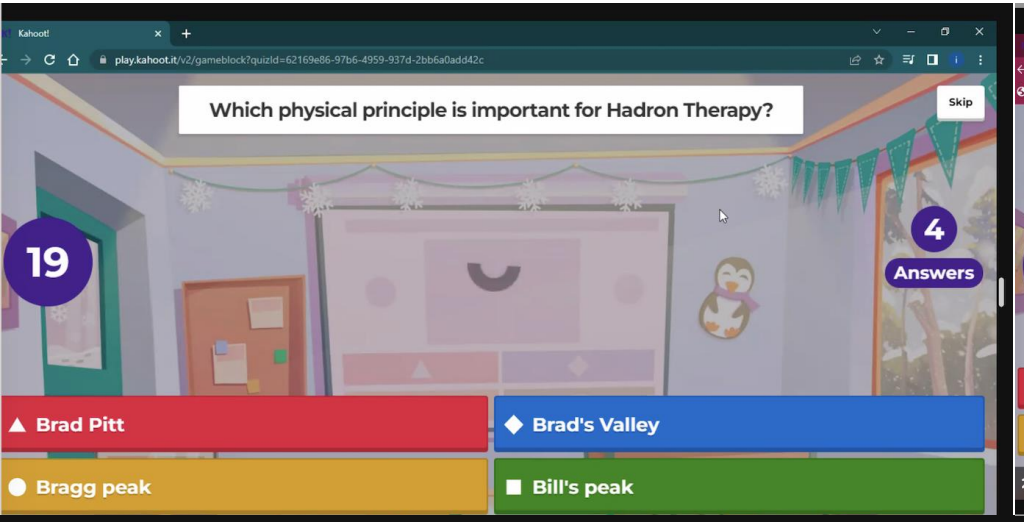
Comments on results by DKFZ experts

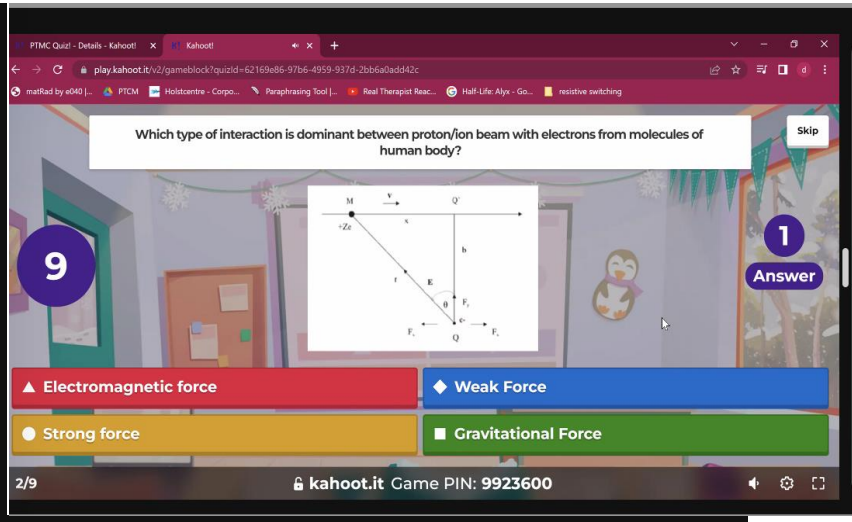
Good, “out-of-the-box” creative results

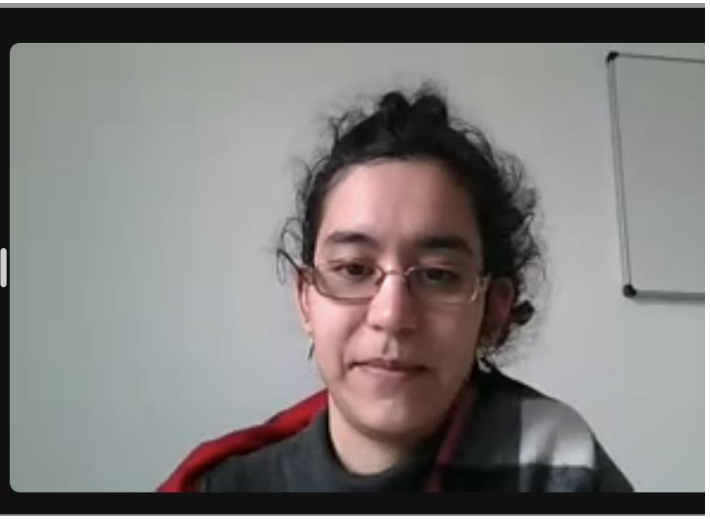
PTMC quiz: a fun way to finish

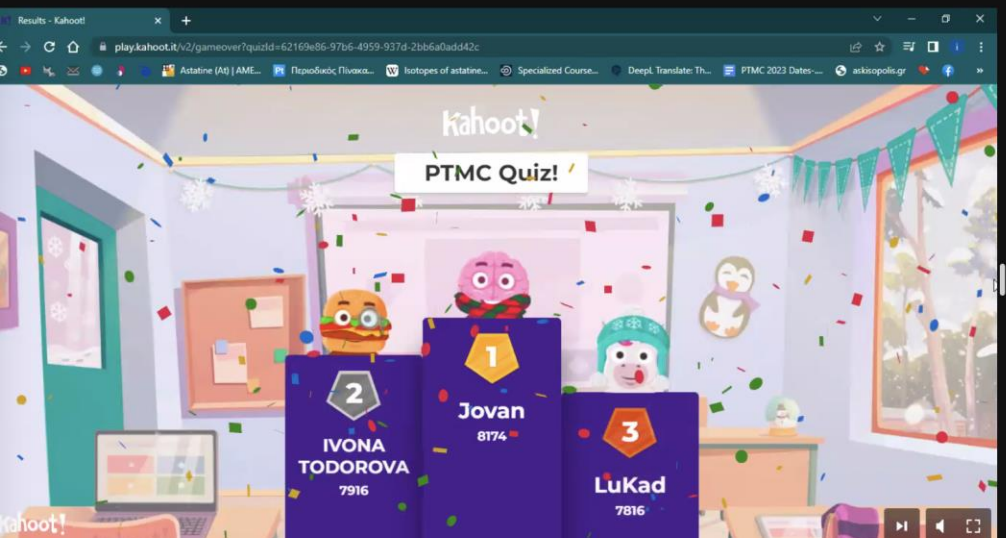
What we have learnt

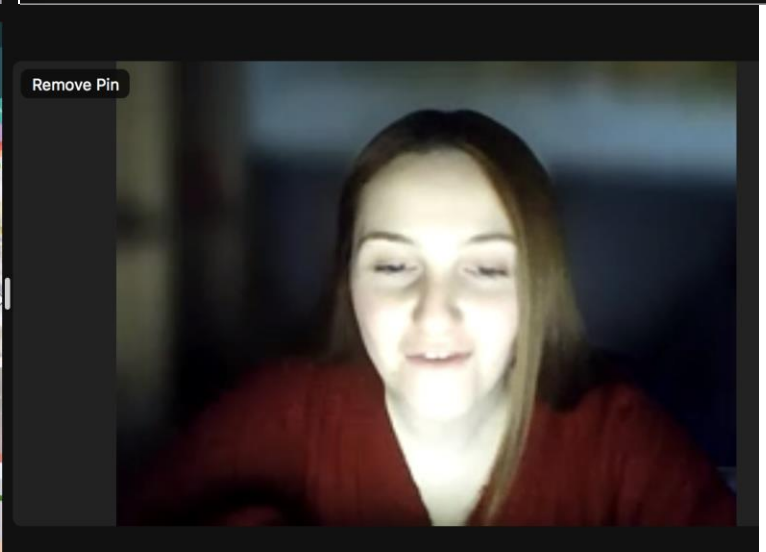
Gentle competition: who is the winner !?











PTMC training and instructions

PTMC session example agenda

Particle Therapy Masterclass Training 26th February

Friday 26 Feb 2021, 13:00 → 15:40 Europe/Zurich

UNSA

Description PTMC Training for collegues.

https://indico.cern.ch/event/1011063/

13:00 → 13:05 **Welcome**

Welcome and aim of the PTMC training day, set the stage.
For a visual impression a virtual Particle Therapy centre is in the link below.

A good summary connecting physics and particle therapy can be found on the animation link.

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

YF-PTMC-TRAINING... YF-PTMC-TRAINING...

13:05 → 13:20 **PTMC Indico Webpage Example**

PTMC Example

13:20 → 13:25 **Animations** 5m

Animations

13:25 → 13:30 **Theoretical Material for Tutors** 5m

Dosanjh-Physics_to... MasterClass_theory... Radiotherapy.pdf

13:30 → 13:50 **Hands-on-Session Material for Tutors** 20m

ALDERSON.mat BOXPHANTOM.mat HEAD_AND_NECK.... LIVER.mat MatRad GitHub PROSTATE.mat

PTMC Hands-on Se... PTMCpres_-_Englis... Recording MatRad-... TG119.mat Workflow_English.pdf

13:50 → 13:55 **PTMC Webpage** 5m

PTMC in a kit PTMC Webpage

13:55 → 14:15 **MatRad Installation Material** 20m

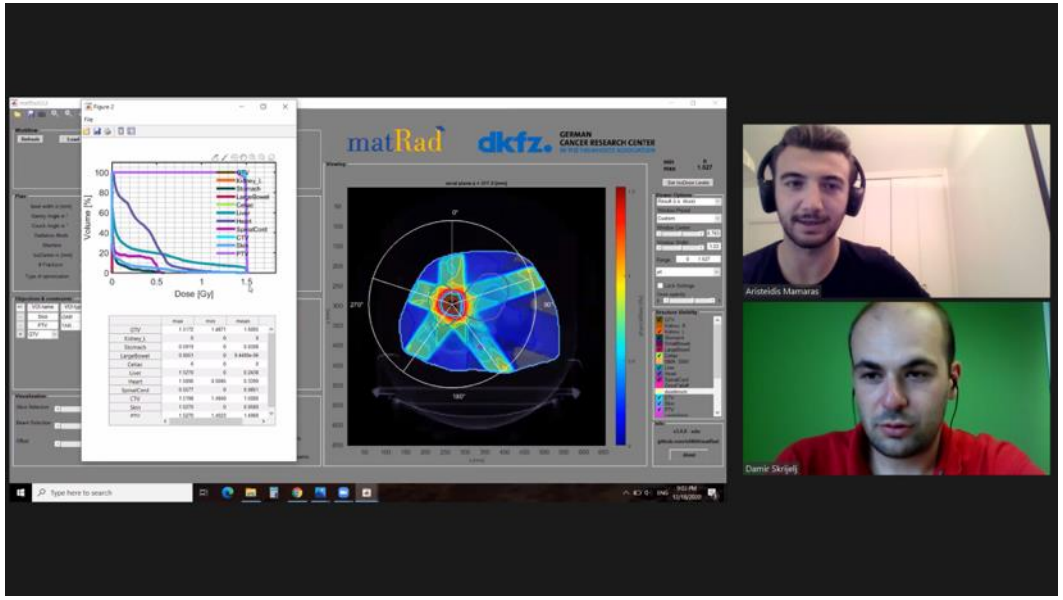
MatRad Installation ... README_Installatio... README_Installatio...

14:15 → 14:25 **Videoconferencing material** 10m

Moderators-DS.doc Particle therapy ma... Particle therapy ma... Particle therapy ma... Particle therapy ma...

quiz-PTMC-2020-DS... quiz-PTMC-2020-DS... Video conferencing ...

matRad tutorials and workflow recordings



Installation instructions are sent in advance

Ongoing work for browser-based version
by DKFZ colleagues

Importance of training teachers
Example of UNSA/Sarajevo:

- in-person at university
- in-person at schools
- common lectures online

PTMC Important Links

- Information about the PTMC, in a different languages, can be found through the PTMC web page and the “PTMC in a kit” Google Drive links:

  PTMC web page: https://indico.cern.ch/event/840212/overview
  Google Drive: https://drive.google.com/drive/folders/1jRnLf49N_yRoOGg8V8vwq3DIpnetWdF0?usp=sharing

- Material for the matRad installation can be found through the word document in the link below, together with a video describing the procedure:

  Installation: https://drive.google.com/file/d/1vT9tQ9ft1C7AwUSbU18pftC9H-ep4BPC/view
  Video: https://drive.google.com/file/d/1BdkjN63StX-1kFEqR_FgTgj_pgZ2-PhL/view?usp=sharing

- Additional instructions for the use of matRad are provided through the workflow, which is available in many languages through the PTMC web page A video describing the workflow of different cases is provided via the google drive:

  Workflow: https://indico.cern.ch/event/840212/page/17991-workflow
  Video: https://drive.google.com/file/d/1jyCzJFfS7I_-0e45ZEcyb4fnXTaRJmpK/view?usp=sharing

- Units and terminology of matRad can be found here:

  Link: https://indico.cern.ch/event/840212/page/18006-definitions

Took it a step further !

A week school insired by the PTMC format

Advanced material for uni students
and up to professionals

The level can be adjusted
by the level of lectures
and details of matRad cases

Full week schools

in the framework of HITRIplus EU-funded project
(more details in presentation of Sandro Rossi)

Heavy Ion Therapy Masterclass School

1050 participants

17-22 May 2021
Sarajevo-Online
Europe/Sarajevo timezone

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

Upcoming: 3-7 July 2023
specialized clinical course

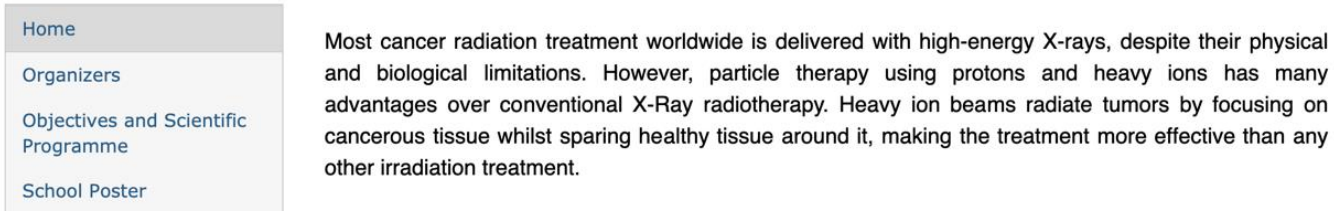
Including: train-the-trainer matRad sessions

Visible impacts:
Tutors motivated to chose/follow these paths
Using matRad for their research

Specialized Course on Clinical Aspects of Heavy Ion Therapy Research

3–7 Jul 2023
Online
Europe/Zurich timezone

https://indico.cern.ch/event/1248018/

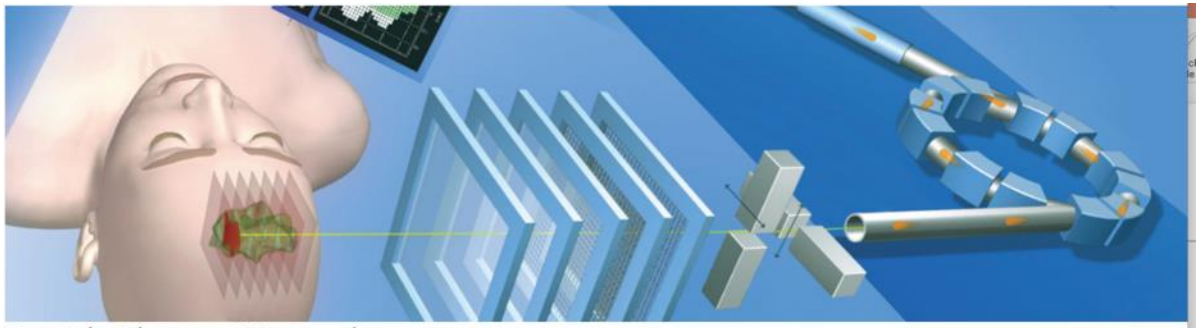


HITRI
Heavy Ion Therapy Research Integration

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

Heavy Ion Therapy Masterclass School

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



Particle Therapy Masterclass

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

Full week course

The HITM school is aimed at university students, and up to early stage researchers.

One day activity

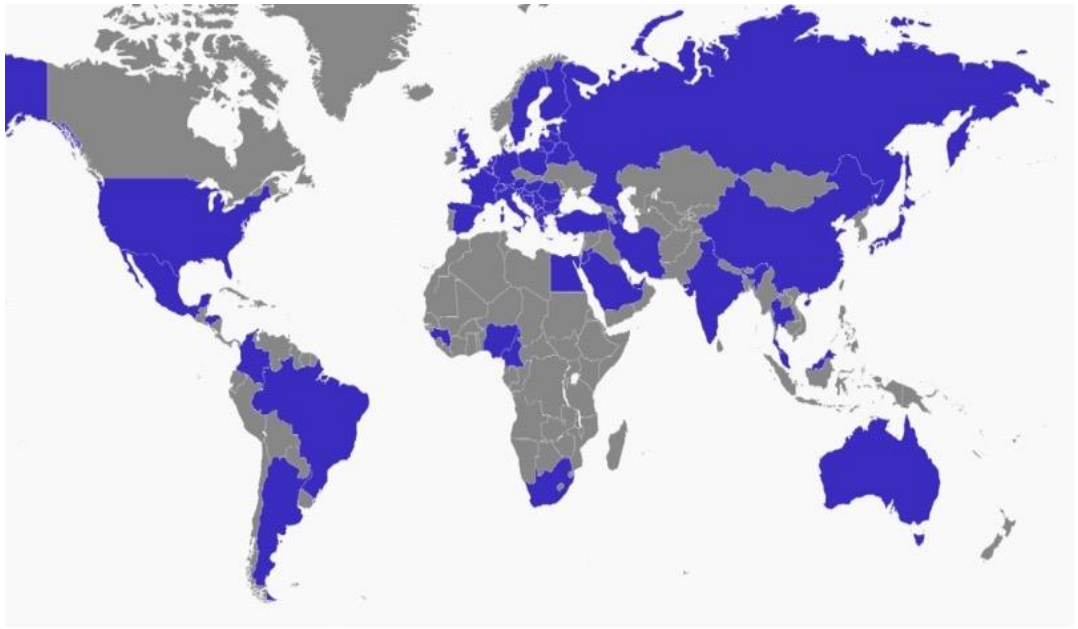
The Particle Therapy MasterClass, is aimed at high-school students (16-18)

Future tutors

Different options studying physics, for example accelerator physics, medical physics, bio-physics… that can provide interesting career paths in upcoming fields where there is lack of specialised personnel

World-wide reach motivating next generation of scientists

HITRIplus full week heavy-ion therapy masterclass school

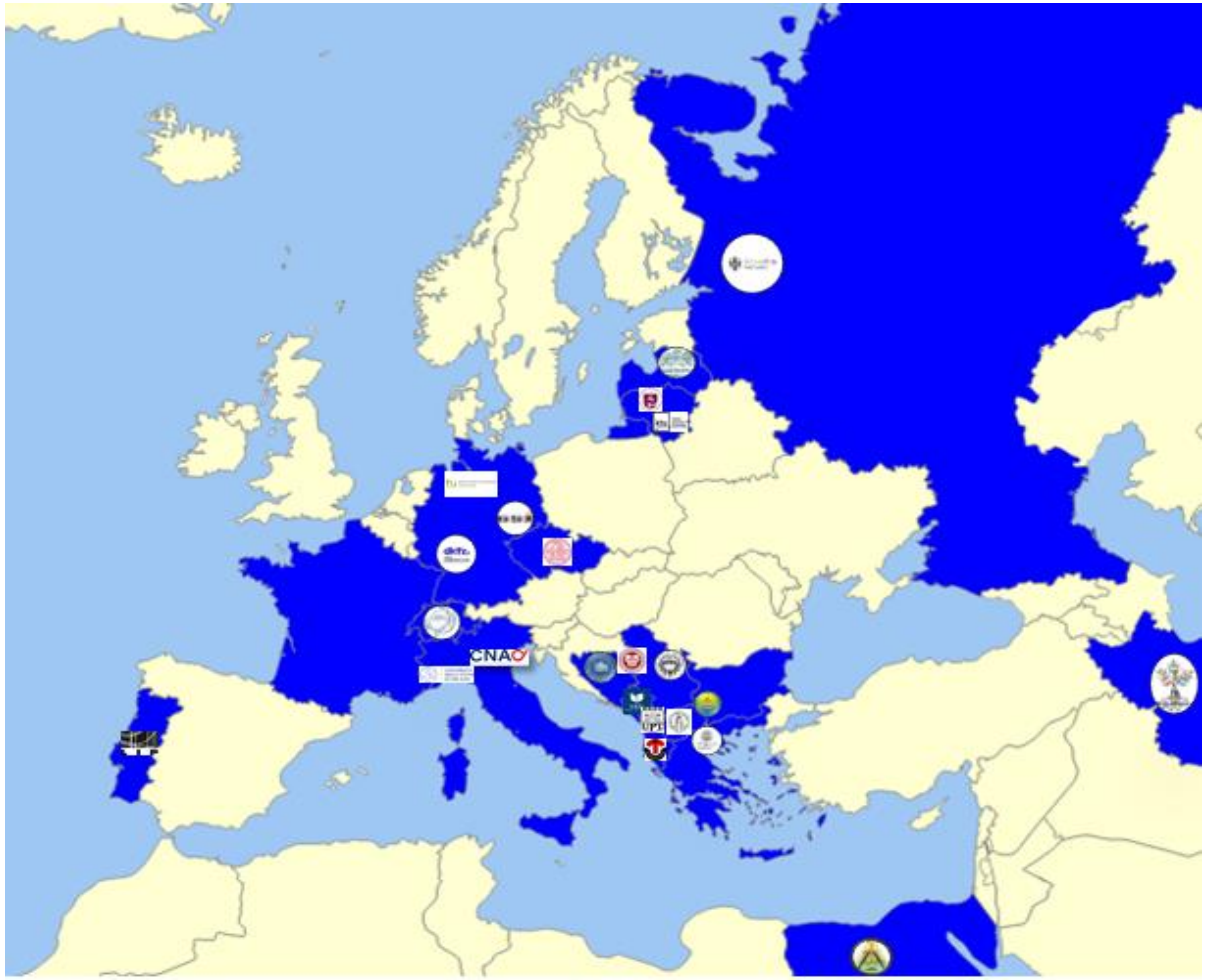


International MasterClasses one day activity

Power of Networks !

Participants of online PTMC in IMC2021

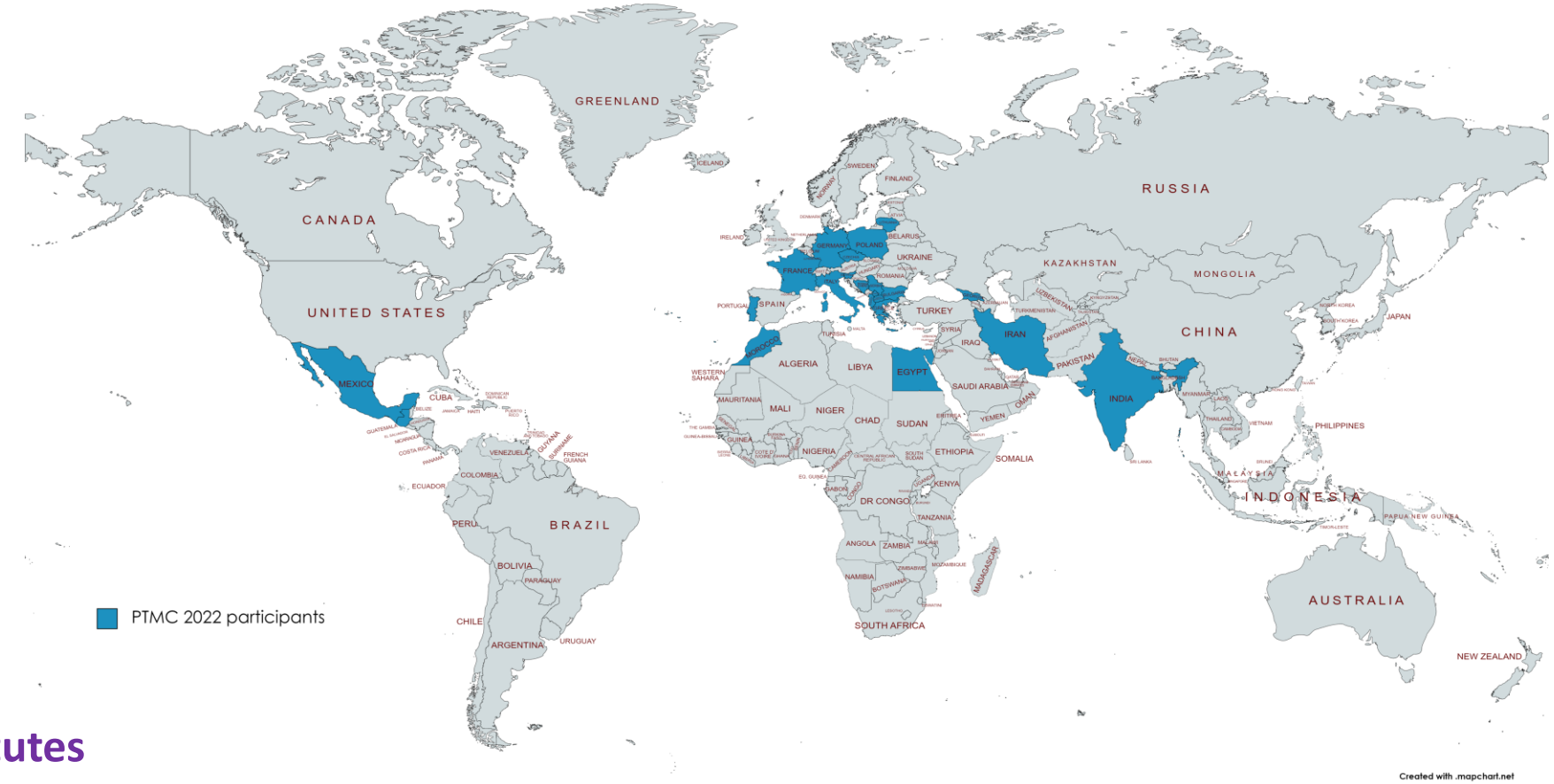
PTMC: https://indico.cern.ch/event/840212/



PTMC2021 online:
6 sessions, 1500 students
from 20 countries and 37 institutes

Participants of online PTMC in IMC2022

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



PTMC2022 online/hybrid:
6 sessions, 1500 students
from 22 countries and 37 institutes

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

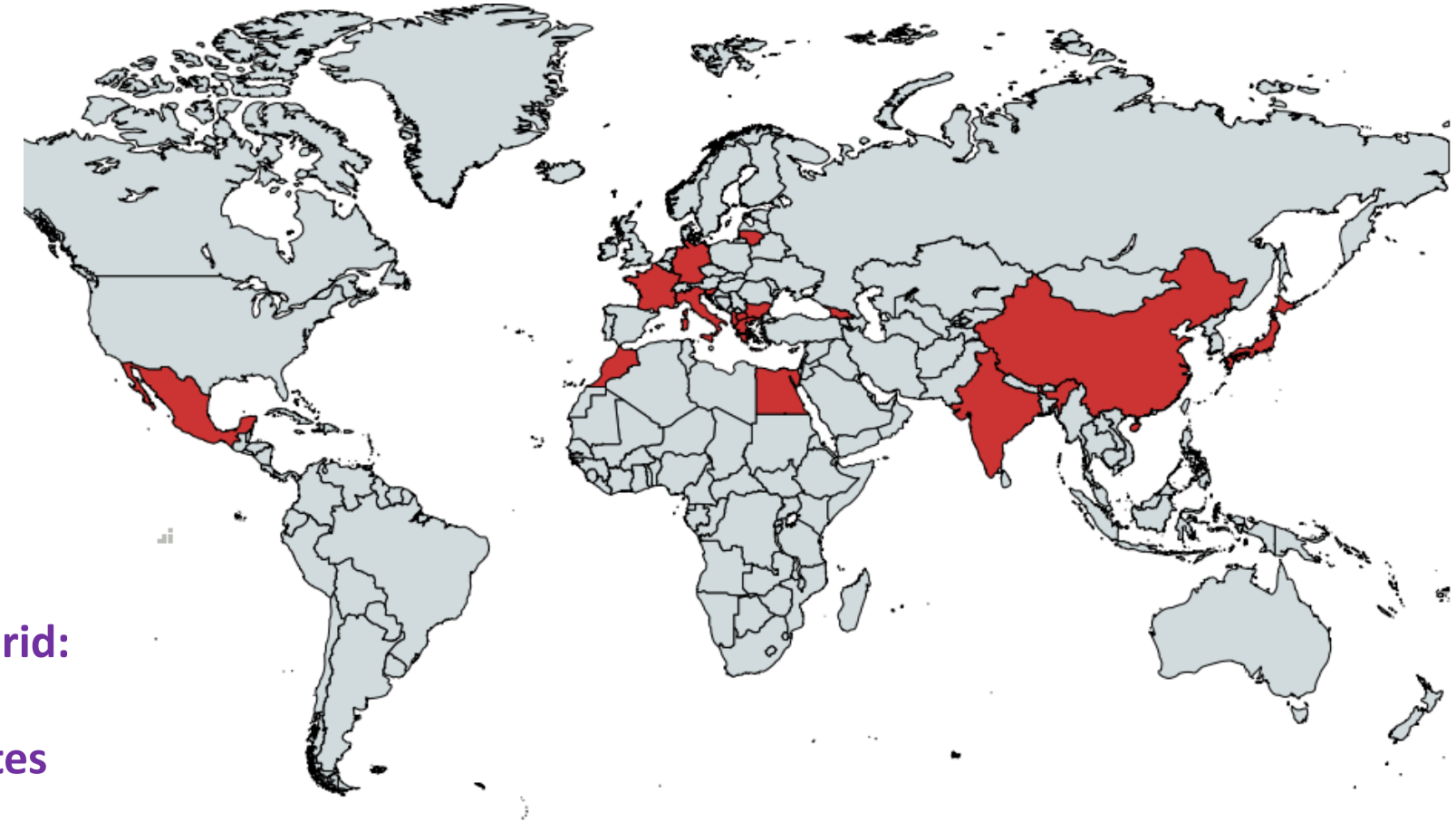
Interest of students, motivation of tutors (voluntary work), potential impact

Participants of online PTMC in IMC2022

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

From Japan to Latinoamerica

Contacted by Mayo Clinic in Florida, US
(getting a carbon-ion facility)



PTMC2023 in person/online/hybrid:
9 sessions
from 22 countries and 38 institutes

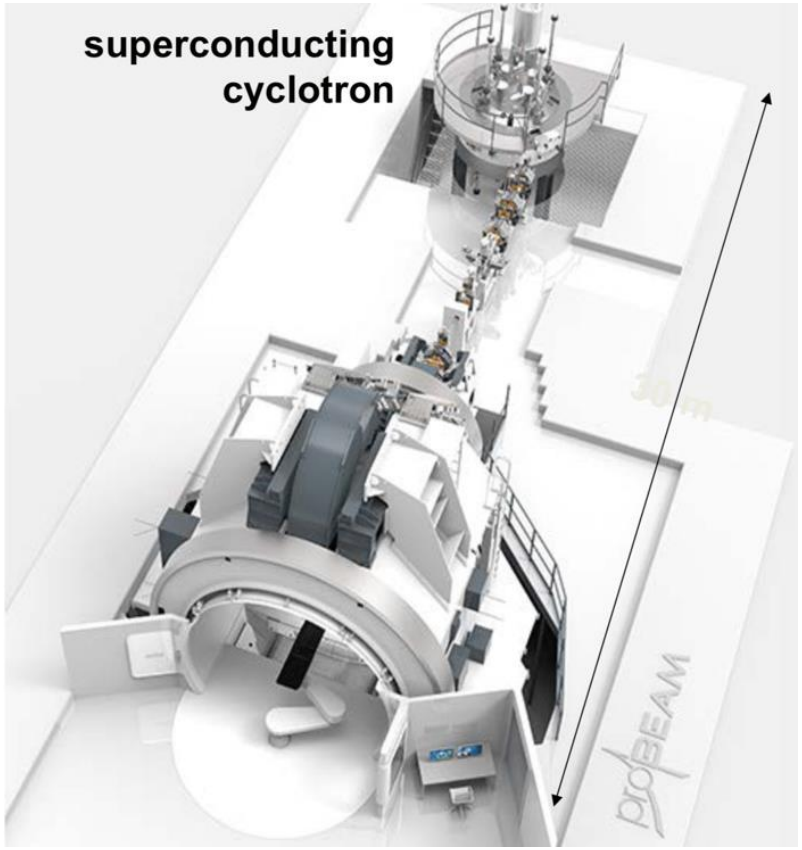
web pages with agendas of every institute with material in different languages, publicly available for future events

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

Particle Therapy Facilities Current Status and Future Perspectives

Conventional x-ray Radiotherapy

Particle/Hadron Therapy with protons



Hadron Therapy centers in Europe (2018)

Accelerators for health

Four carbon-ion cancer therapy centers in Europe

CNAO, Italy

HIT, Germany

MIT, Germany

MedAustron, Austria

Towards the future

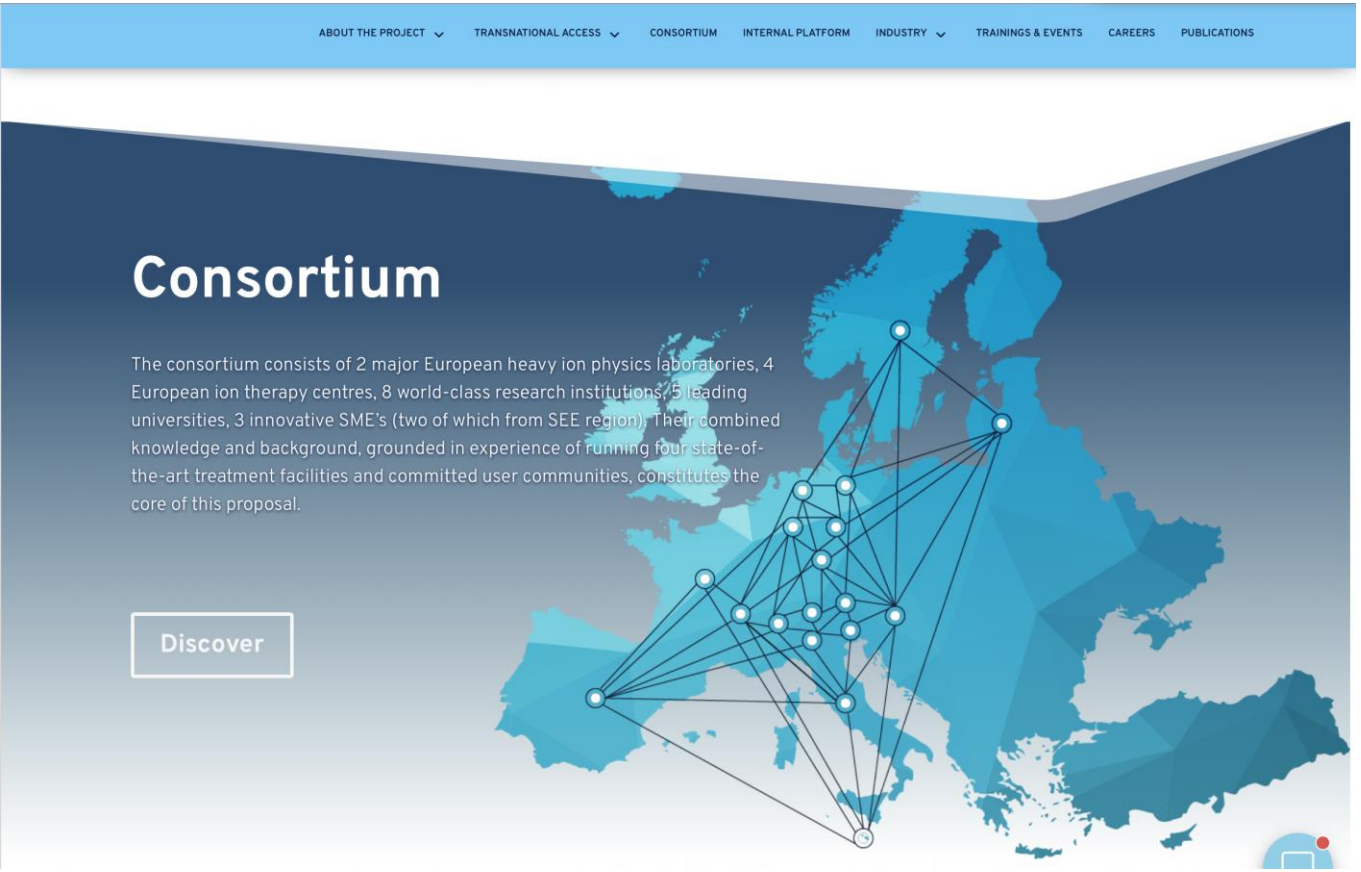
I.FAST EU-funded project:
Innovation in Accelerator Science and Technology

Leaflets available

I.FAST EU-funded project:
Strong Training and Outreach components

Development of novel components:
e.g. magnets….

Capacity building in relevant sciences:
e.g. accelerators physics ….



Towards the future

HITRIplus aims

Main aims:

(a) transnational access,

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

(a) networking, training and education (capacity building)

HITRIplus EU-funded project

Large consortium of research infrastructures including CERN and GSI,
plus universities, industry, all four existing European heavy-ion therapy centres,
and the future research infrastructure SEEIIST (South-East Europe International Institute for Sustainable Technologies)

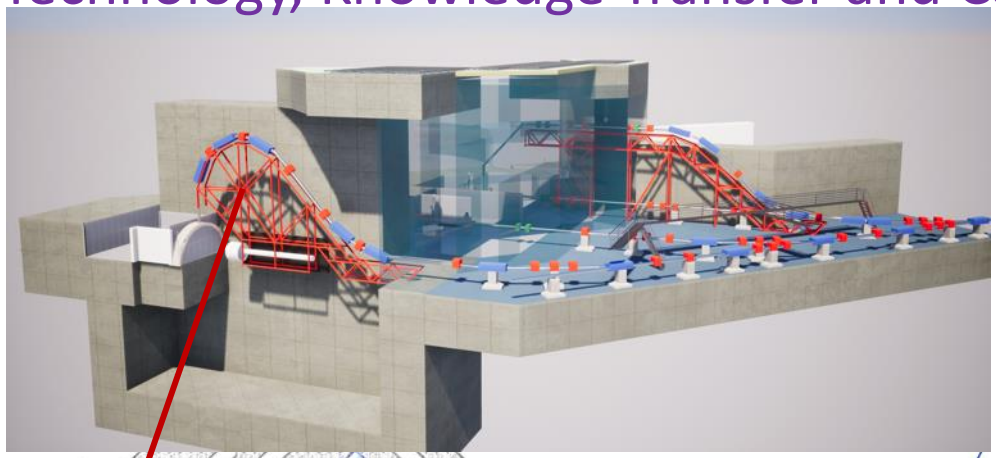
See presentations by :
Sandro Rossi (CNAO)
Leaflets available

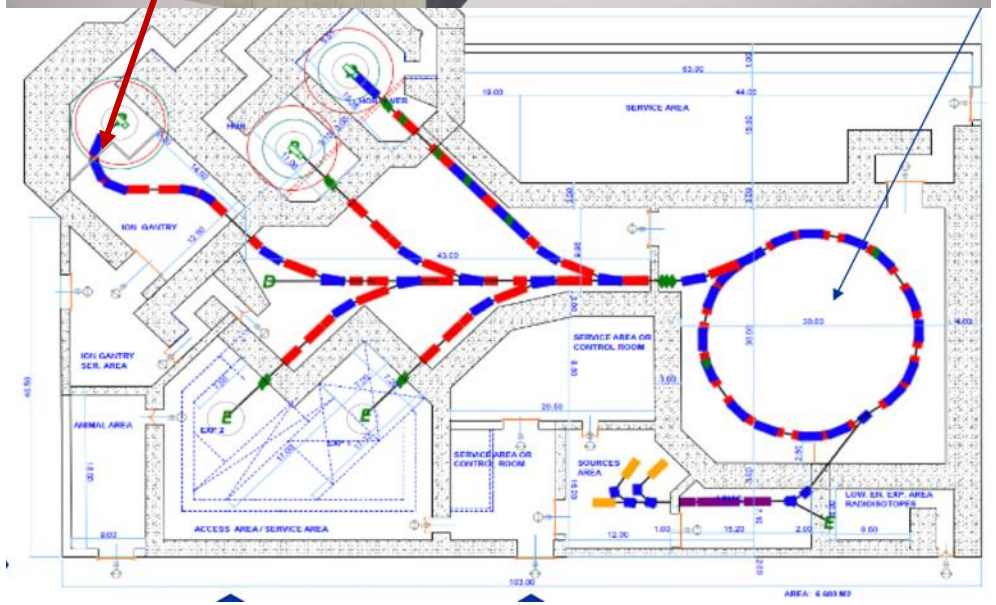
HITRI plus
Heavy Ion Therapy Research Integration

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

Next generation facility for cancer tumour therapy and research with heavy-ion beams

Technology, Knowledge Transfer and Capacity Building





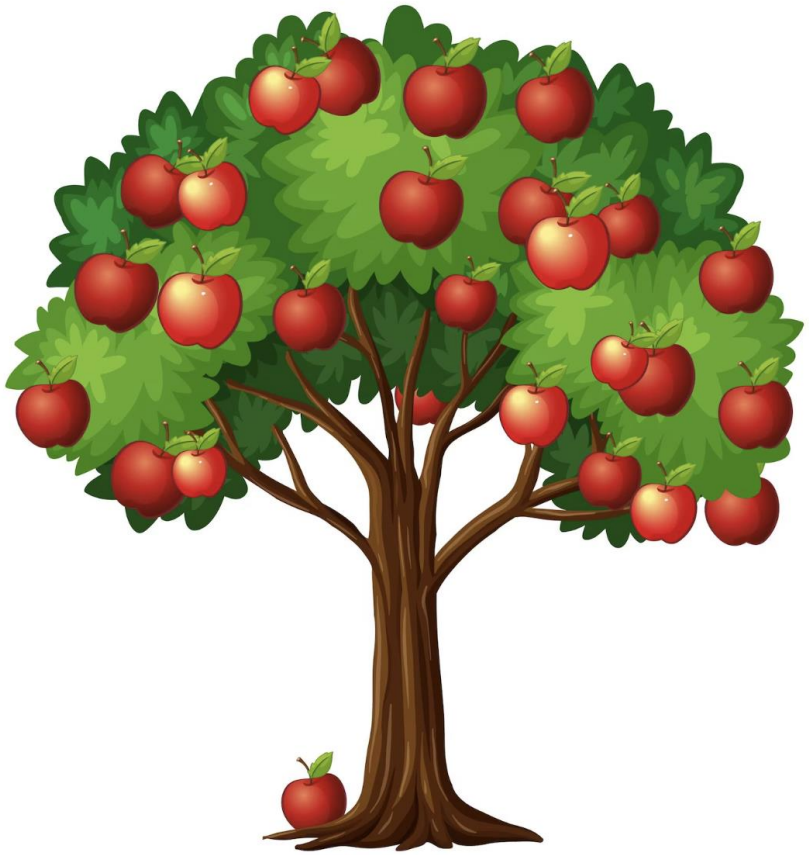
Leaflets in Bulgarian: key person, chair Leandar Litov

Proposal for a facility in South East Europe: SEEIIST

Main Message: need for fundamental research

To get the fruit you need the tree with its roots, trunk, branches….

- **Attract school-children to STEM at early stages: decide future studies/career**
- **Cultivate confidence through the hands-on (I can do it!) and "demystify the difficulty" of physics, math….**
  NOTE: a Master thesis survey/study has shown that students do learn!
- **Support female students** (i.e. 11 Feb, 8 March sessions) **handle prejudices** (i.e. M
- **Create groups of Uni assistants/tutors that learn better in order to teach**
- **Demonstrate a return to society from investment in fundamental research**
- **Enhance awareness of broader public**
  extended reach to family, friends, personal environment
- **Prepare future generations aware of importance of fundamental research and it**
  - favourable politicians,
  - evidence-based decision-making society



- **Demonstrate a return to society from investment in fundamental research**

Direct application of fundamental research for society, medicine, citizens health

From participants to collaborators

Attendees of IMC were attracted by Science, Technology, Engineering and Math careers.
It was definitely our case

It is inspiring to young students.

This could mean more professionals in STEM topics

Noteworthy fact:
now we collaborate in UNAM with our IMC tutor Antonio Ortiz Velasquez

.

First PTMC in Mexico 2 march 2020:
brings hope and motivation

Acknowledgements PTMC

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Wahl, Niklas
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LoC: Wahl, Niklas
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Noa Homolka Amit Ben Antony Bennan

GSI

LoC: Yiota Foka
GSI Biophysics:
Christian Graeff, Radek Pleskac
GSI ALICE, EMMI :
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GSI IT :
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Osdoba, Sascha

Sofia Team
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Leandar Litov
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CERN (staff and users)

CERN: tutors
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Alexander Gerbershagen
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Elena Benedetto

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CERN/ENLIGHT: Manjit Dosanjh Petya Georgieva
CERN/KT: Manuela Cirilli Anais Rassat Rita Ferreira
Giovanni Porcellana
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CERN: Training Centre: Eric Bonnefoy M-L LECOQ

Uni Sarajevo: web pages
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Amra Ibrahimovic
Mirsad Tunja
Damir Skrijelj

Online mode, web pages, training
Aris Mamaras (AUTH), Damir Skrijelj (UNSA), Elpida Theodoridou et al (AUTH)

Sponsors : Edmond Offermann

General Coordination :
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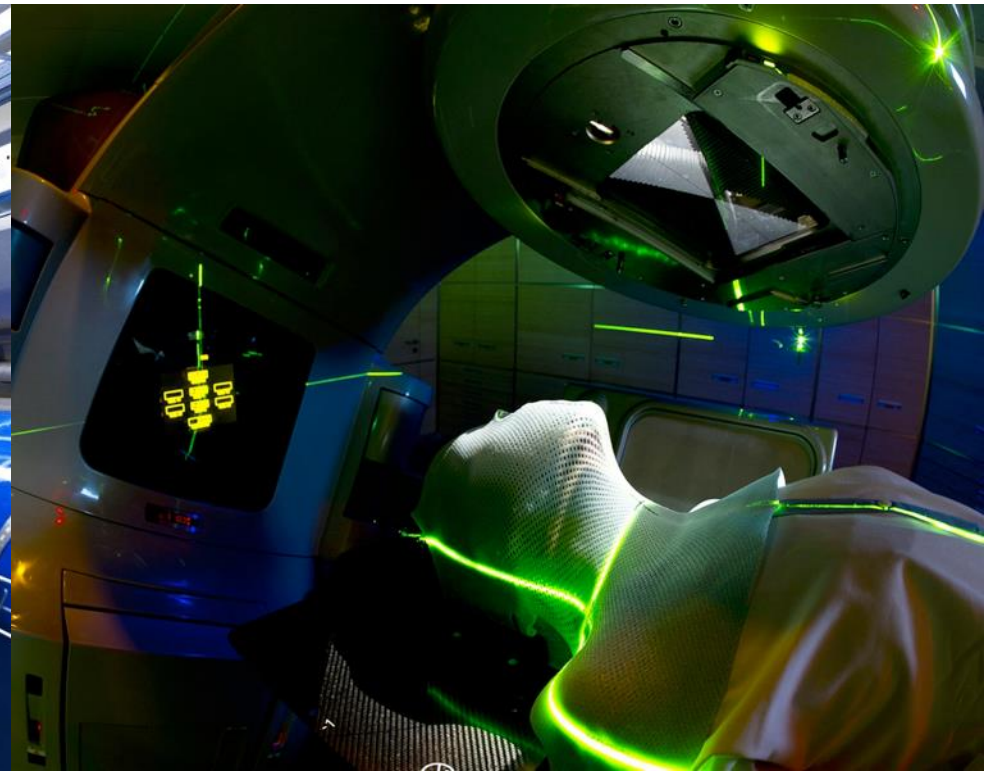
BACKUP

Towards the future Accelerators for health

From fundamental research…



……to medical applications

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%

INTERNATIONAL MASTERCLASSES
hands on particle physics