IPPOG and spin-offs from particle and nuclear physics

Yiota Foka (GSI/CERN)

on behalf of

IPPOG*

IMC Steering Group

WG Outreach of Applications for Society

*IPPOG International Particle Physics Outreach Group
IPPOG Author-List: https://cds.cern.ch/record/2903278

IPPOG activities on benefits for society

Contacts:
yiota.foka@cern.ch

International Particle Physics Outreach Group

Tangible examples of connecting fundamental research and everyday life

Working Group

Outreach of Application for Society

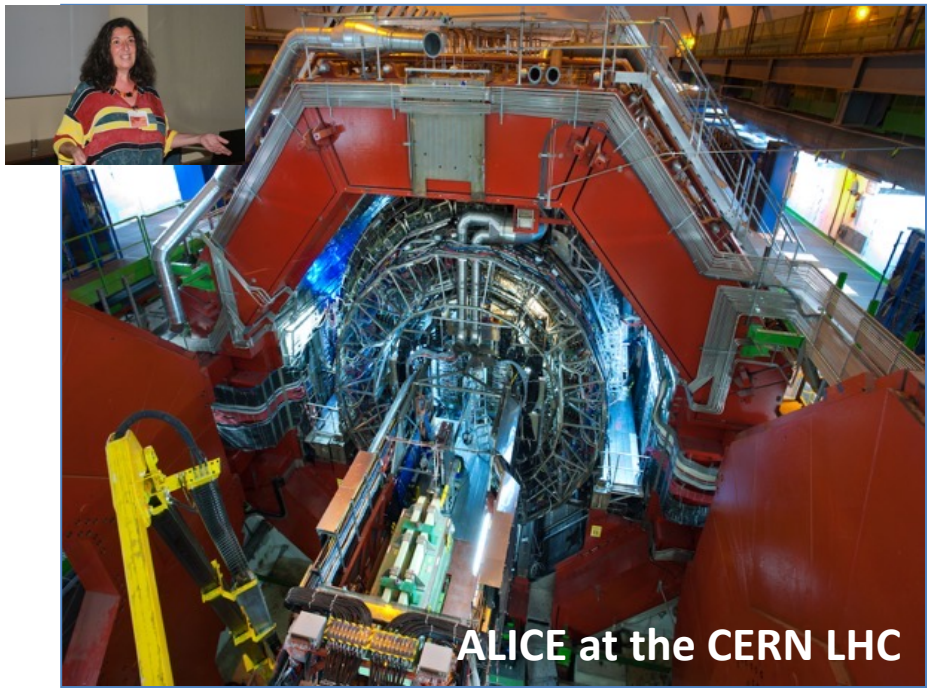
https://ippog.org/for-ippogers/outreach-application-society

Contacts:
yiota.foka@cern.ch
barbora.gulejova@cern.ch

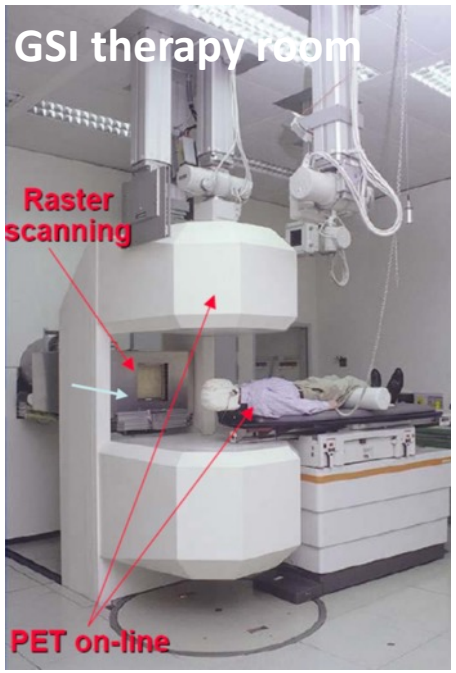
Heavy-ion research and heavy-ion therapy

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



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

Heavy-ion research and heavy-ion therapy

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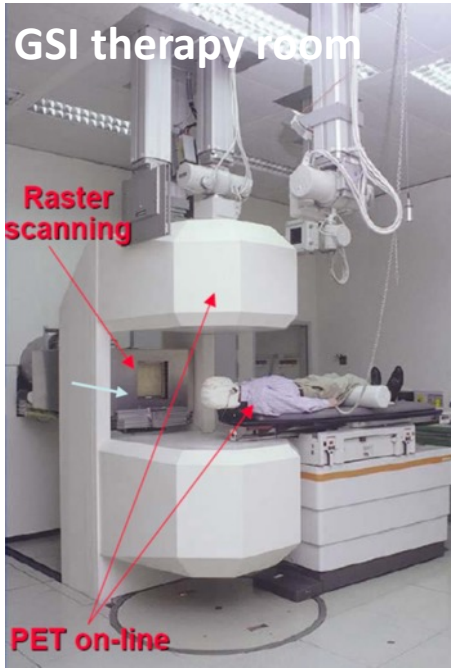

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Heavy-ion research and heavy-ion therapy

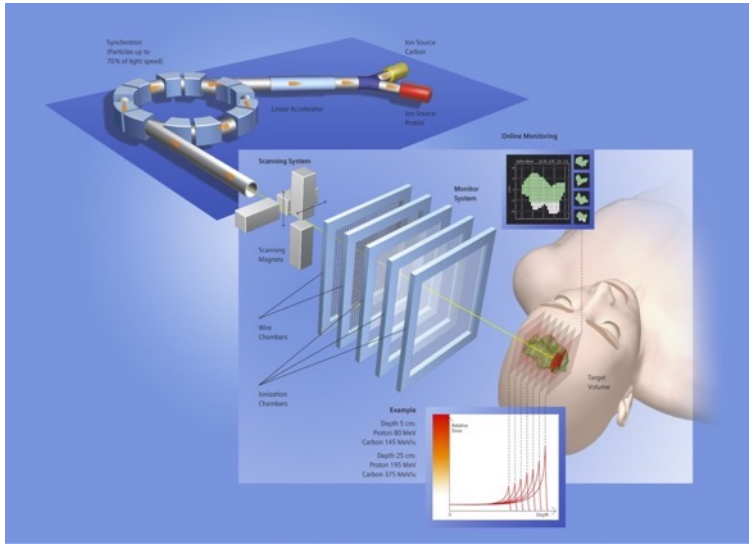
Heavy-ion Physicist, involved with medical applications of heavy-ions for cancer therapy

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

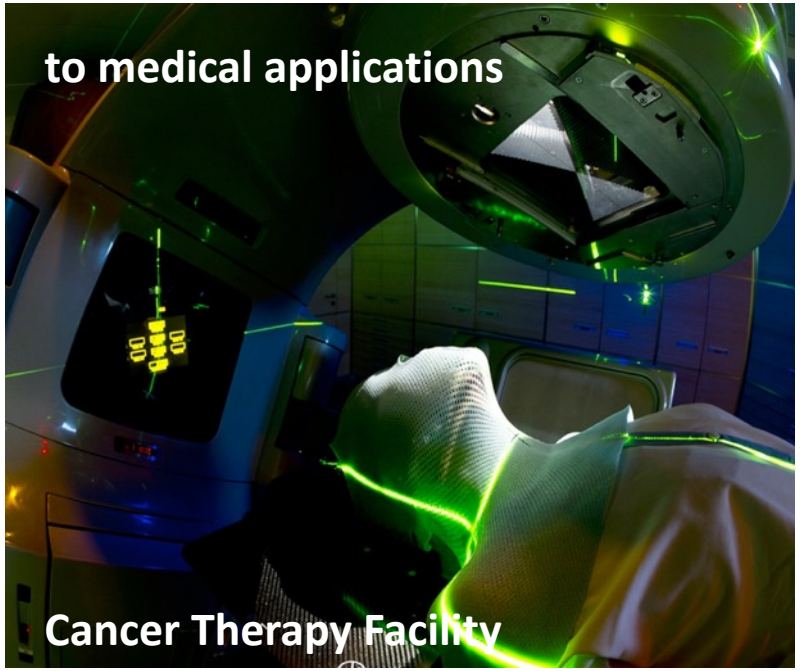
Mission and mandate of research institutes: fundamental research
Developed technologies and acquired knowledge find applications for society

Heavy-ion research and heavy-ion therapy

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

ALICE heavy-ion experiment at CERN

Innovative technologies for next generation ion facilities



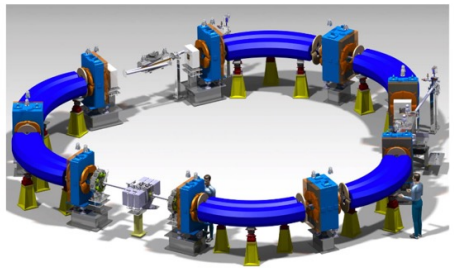
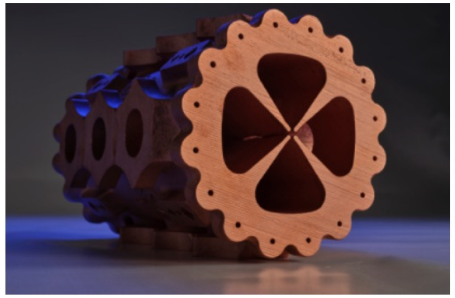
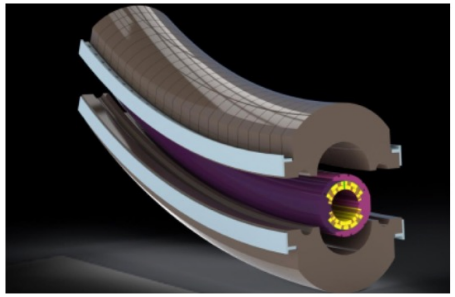
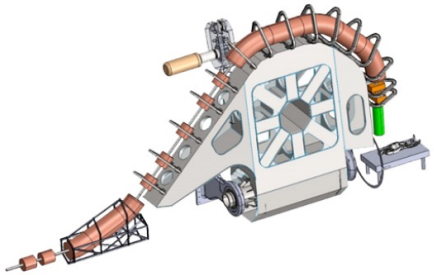
Mission and mandate of research institutes: fundamental research
Developed technologies and acquired knowledge find applications for society

Next Ion Medical Machine Study Group Developments

nimms

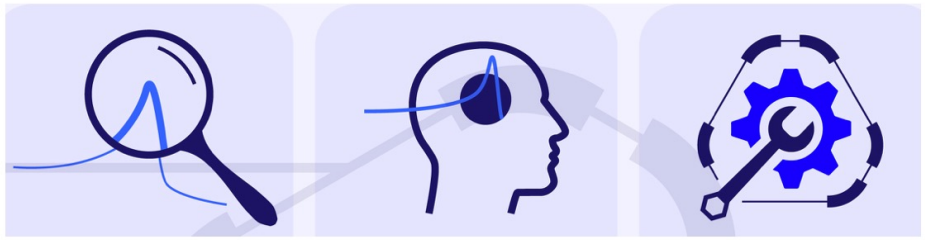
HOME | ABOUT | TECHNOLOGICAL R&D | INITIATIVES | TRAINING | PUBLICATIONS | NEWS

Our Technological R&D

Synchrotron Accelerators	Linear Accelerators	Superconducting Magnets	Superconducting Gantries
HeLICS (Helium Synchrotron), Carbon Synchrotron, and Superconducting Carbon Synchrotron	Innovative LINAC technologies for treatment and radioisotope production	Design and prototyping of novel, compact curved magnets	360° beam delivery with EuroSig & GaToroid

Our Supported Initiatives

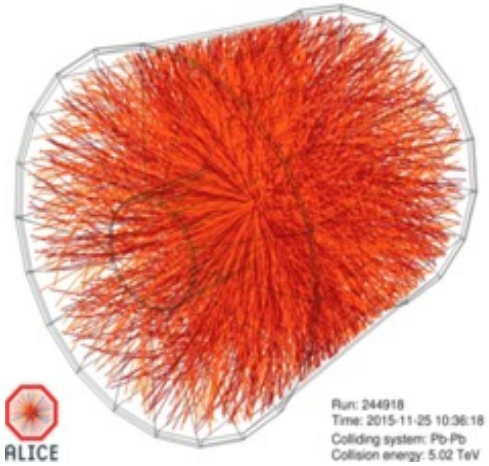


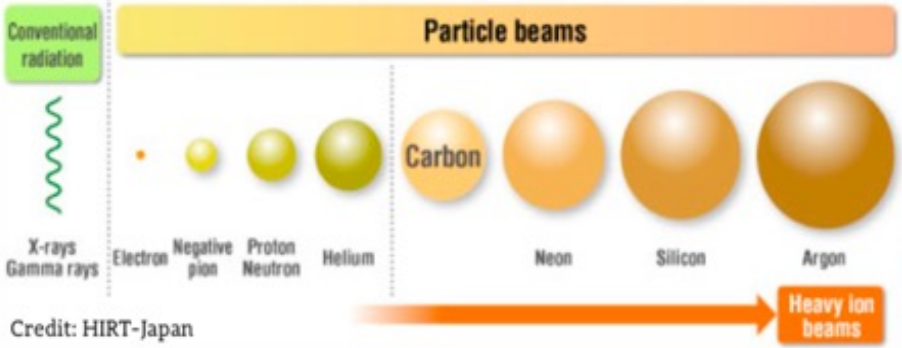

APTCB	SEEIIST
Advanced Particle Therapy Center for the Baltics	South East European International Institute for Sustainable Technologies

Heavy-ion research and heavy-ion therapy

Pb-Pb at 5.5 TeV
pp at 14 TeV
fundamental science
QGP studies

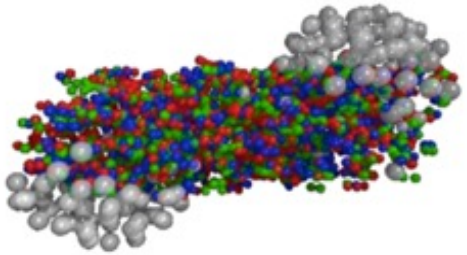
Credit: CERN



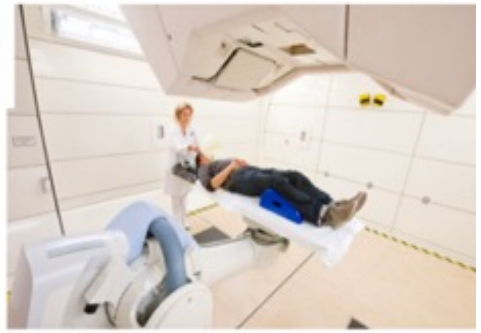


Credit: HIRT-Japan

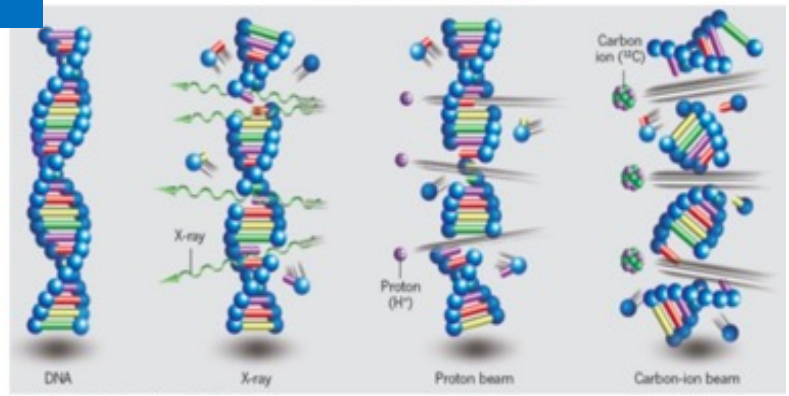
What Physics has to do with Medicine?



88-430 MeV/u carbon
50-221 MeV/u protons
applied science
medicine



Credit: HIT Heidelberg



Credit: T. Nomiya, NIRS Japan

An example of applications of fundamental research for the benefit of society

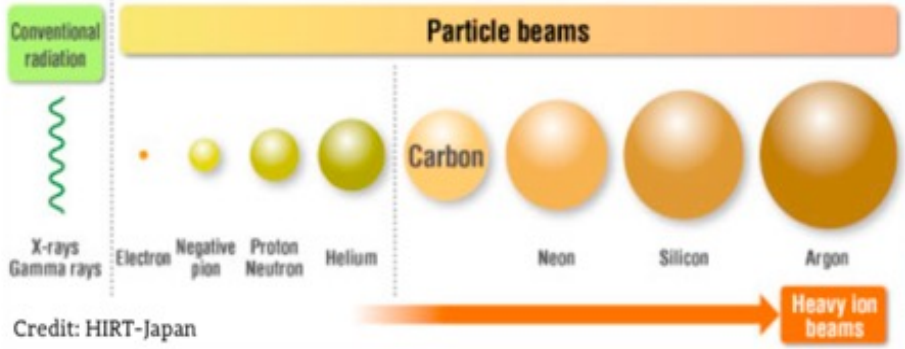
Heavy-ion research and heavy-ion therapy

Pb-Pb at 5.5 TeV
pp at 14 TeV

fundamental science

QGP studies

Credit: CERN



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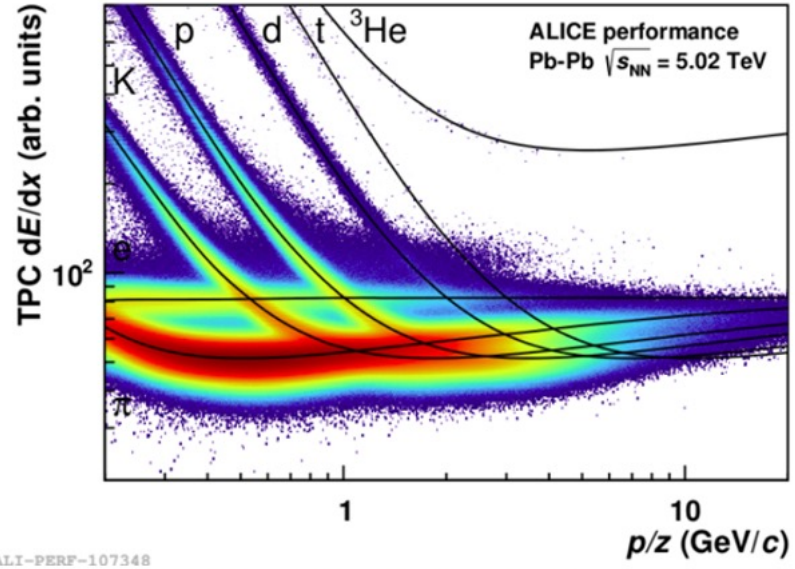
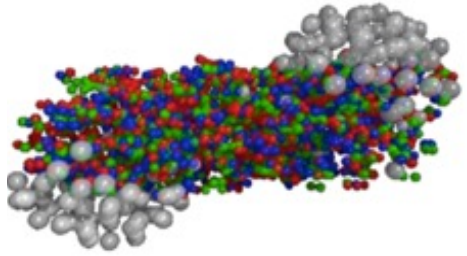
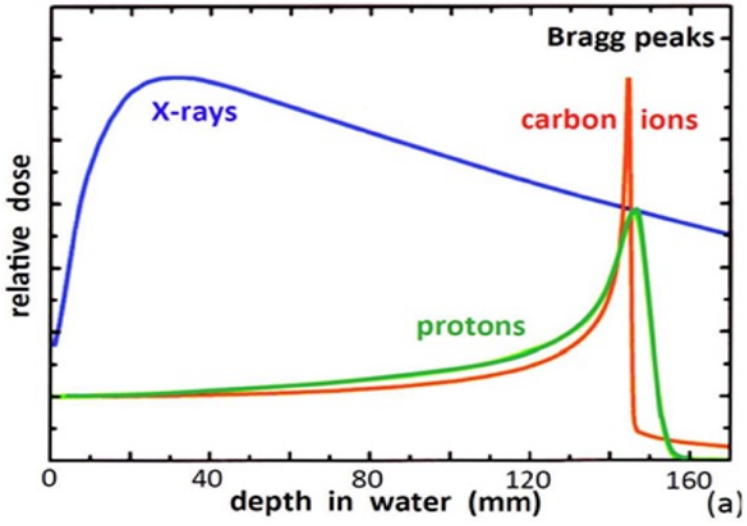


ALI-PERF-107348

From Bethe Bloch ionization for PID



fundamental properties
of particles
and their interaction with matter
in the service of society



to Bragg peak for cancer therapy

International Particle Physics Outreach Group

What are the benefits for society?

The developed accelerator technology is used for cancer research and therapy

Innovative technologies developed for future CERN projects find already applications in medicine

From Fundamental Research….

…..to Medical Applications

Accelerators for Health

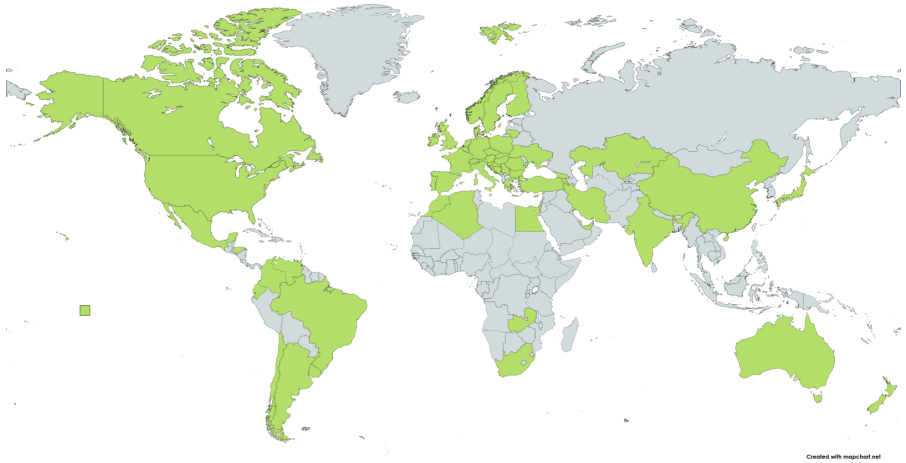
International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES
hands on particle physics

What are the International MasterClasses IMC and Particle Therapy MasterClasses PTMC

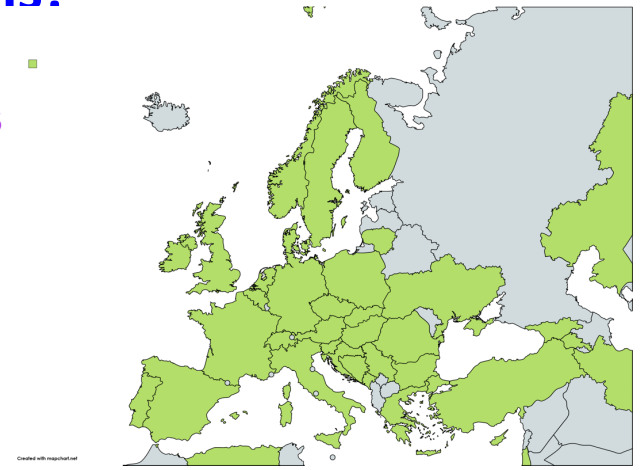
International MasterClasses

Flagship project of IPPOG Brings scientific methods to schools!



IMC2024: 6.5 weeks

64 countries
311 institutes
15 000 students



Classes by masters, experts

Particle Therapy MasterClass

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

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: impact of physics research on medicine advancements
- *different new career opportunities,* various possibilities that physics and STEM studies may open up for interesting jobs

PTMC: Typical MasterClass Day Agenda

Adapted: online/hybrid modes

Every day 3-5 institutes participate,
during the months of February-April.
School-children **(15-19 year old)**
are invited **at/by** an institute of their area.

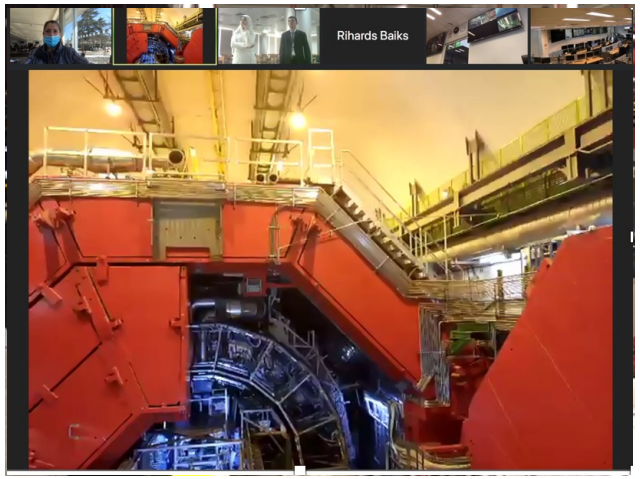
LOCAL TIME:	ACTIVITY
8:30 - 9:00	Registration and Welcome
9:00 - 10:00	Introductory lectures
10:30 - 11:30	Visit of a lab or experiment
12:00 - 13:00	Lunch
13:00 - 15:00	Hands-on session
15:00 - 16:00	Discuss results locally
16:00 - 17:00	**Common Video Conference**

Importance of collaboration for common projects

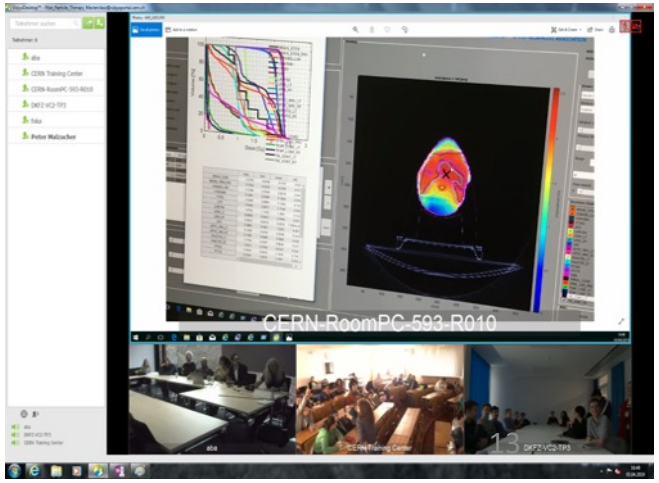
Local: Morning Presentations

Local: Afternoon Hands-on

Local: Morning Visits
real-time online ALICE visit



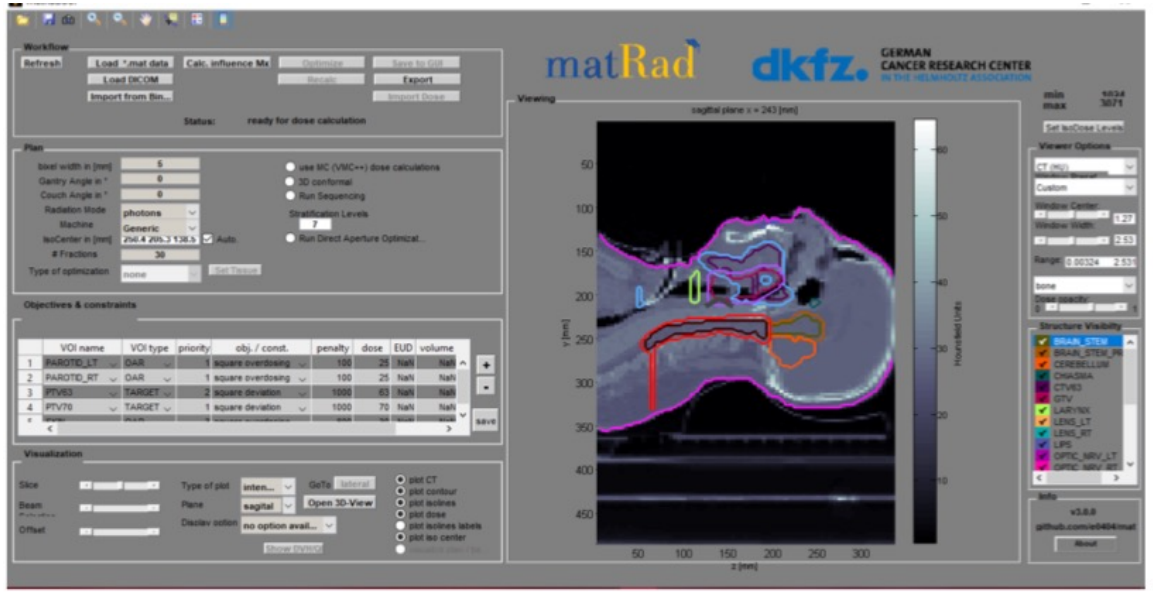
Common: Afternoon at 16:00
Video-Conference



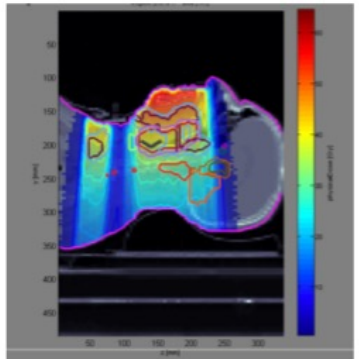
PTMC hands-on Treatment Planning

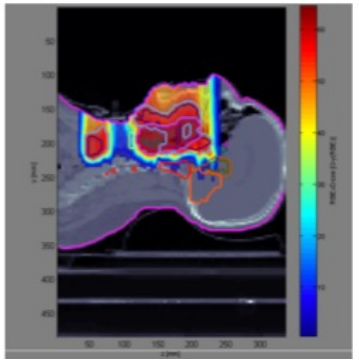
Based on professional open source treatment planning: **matRad**
developed by DKFZ, Heidelberg www.matrad.org

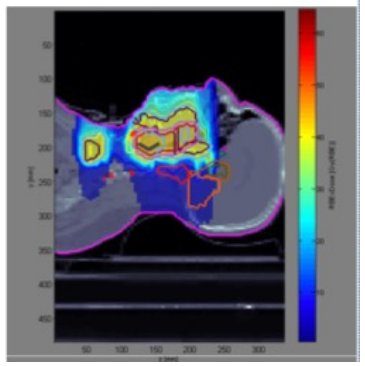
Simplified version for PTMC



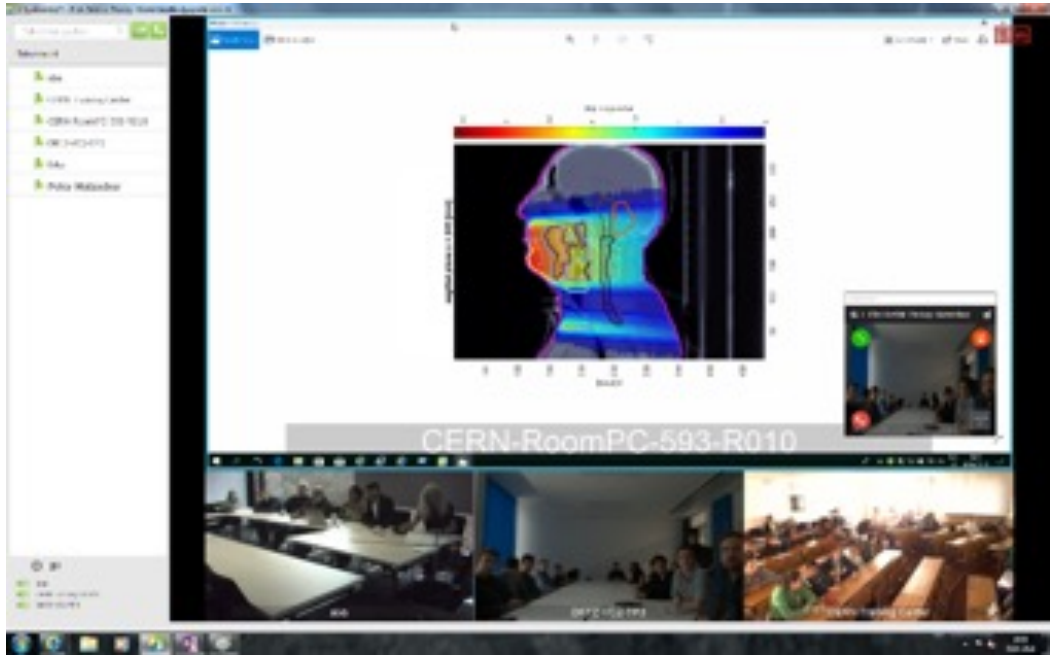
Demo[4] of the matRad software kit for Treatment Planning .







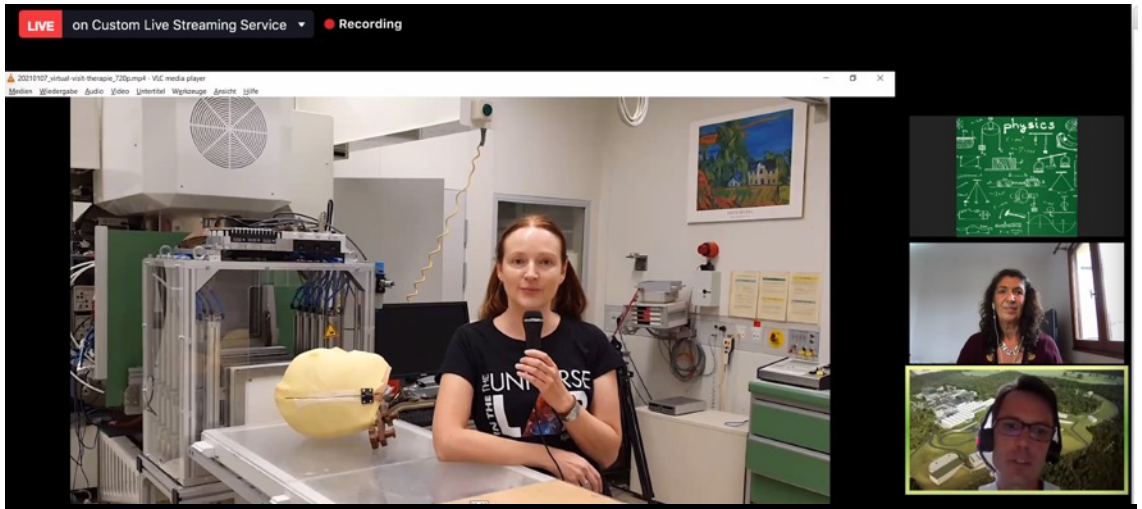
Dose prescription using photons, protons and carbon ions



Easily visible the difference of photons and hadrons

Virtual visits and video-conferences

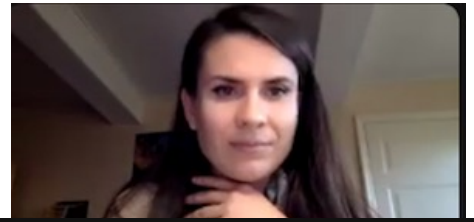
Virtual visits during video-conference: GSI research institute, CNAO, MedAustron therapy centers



GSI moderators

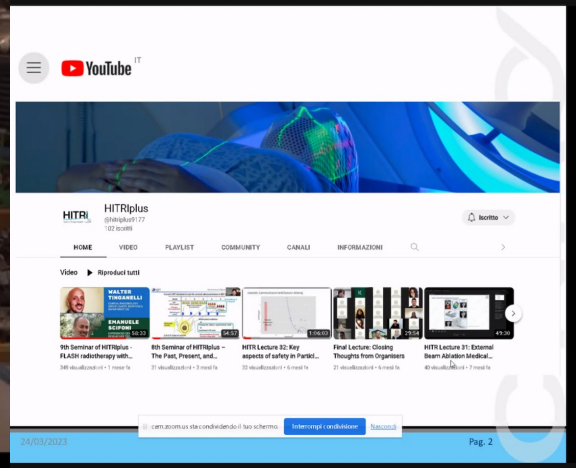
CNAO moderator

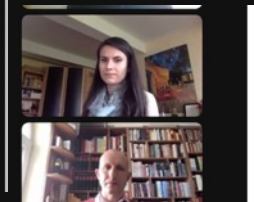
medAustron moder.



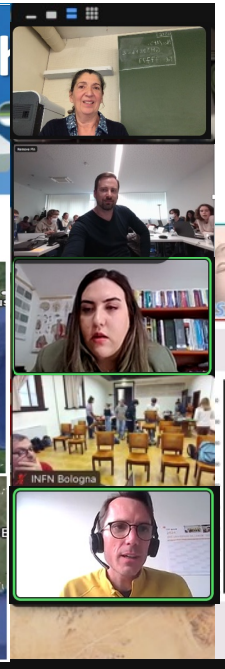
U. Amaldi: HI therapy pioneer

HITRIplus EU-funded project

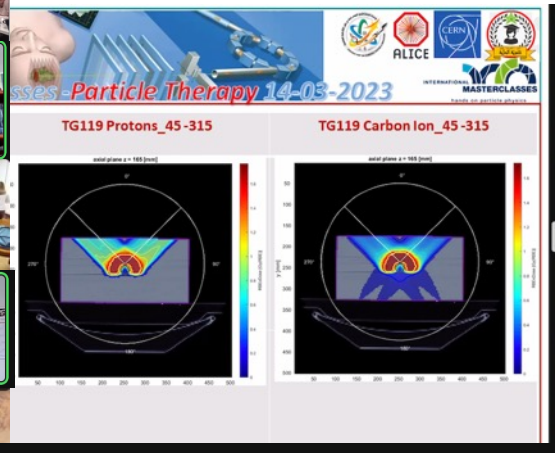


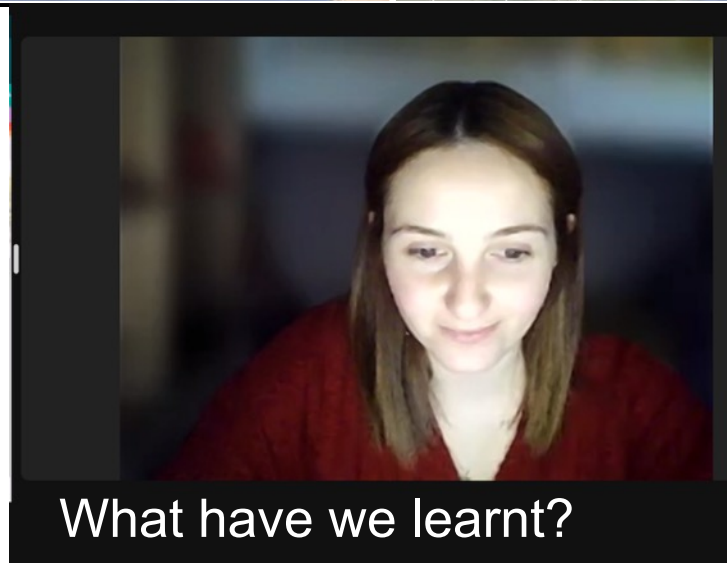


PTMC supporting females in STEM

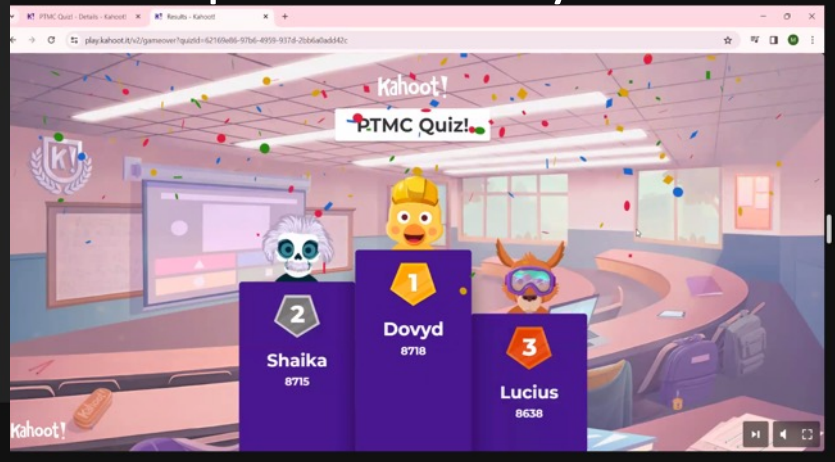


11 Feb and 8 March sessions encouraging female participation and providing role models





PTMC quiz: a fun way to finish



Particle Therapy MasterClass

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

- 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/1L94yhos6L7k3FQIMzD9QI7kpk_c_ABD7

Training sessions: 4-5 per year

Importance of training teachers: Sofia, Madrid, and Sarajevo

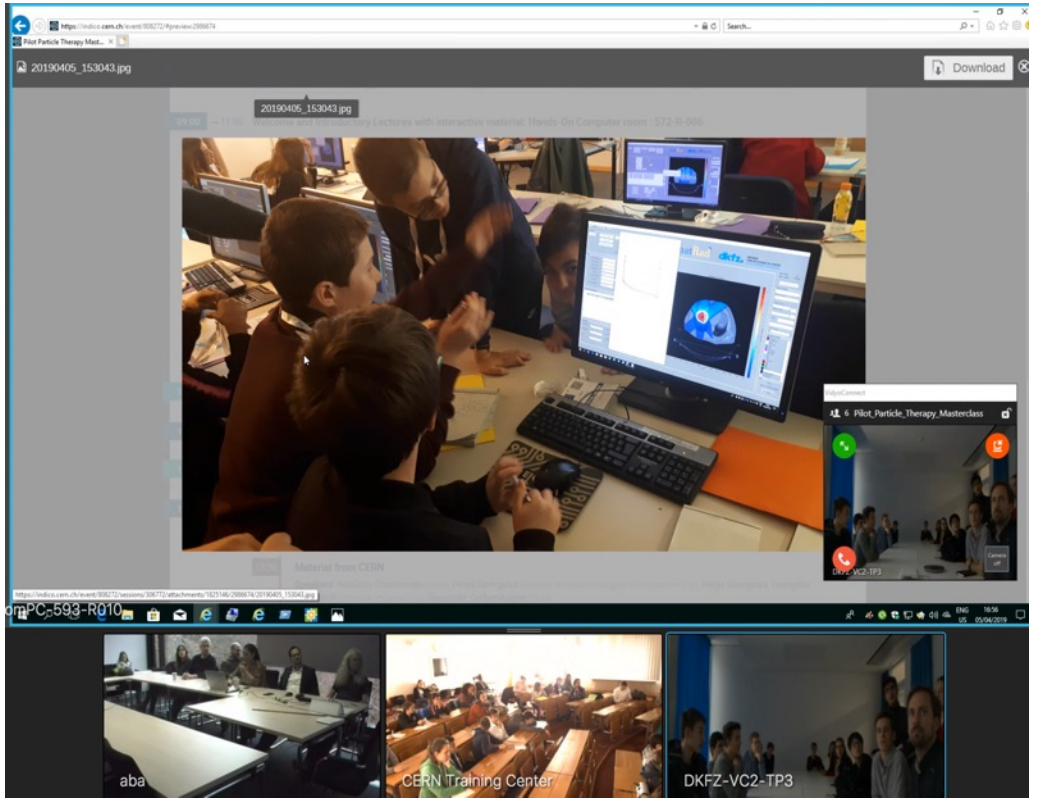
Example of UNSA/Sarajevo:

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

PTMC and matRad Treatment Planning

First Local Test: GSI Feb 2019

International Pilot: CERN, GSI, DKFZ April 2019



Web page: UNSA students CERN Open Days, Aug 2019

IMC Steering Group Approval: GSI May 2019

We could not imagine
what physics has to do with medicine,
that research institutes such as CERN
can contribute to medical applications

First PTMC in IMC2020

Mexico 2nd March 2020, then online due to covid

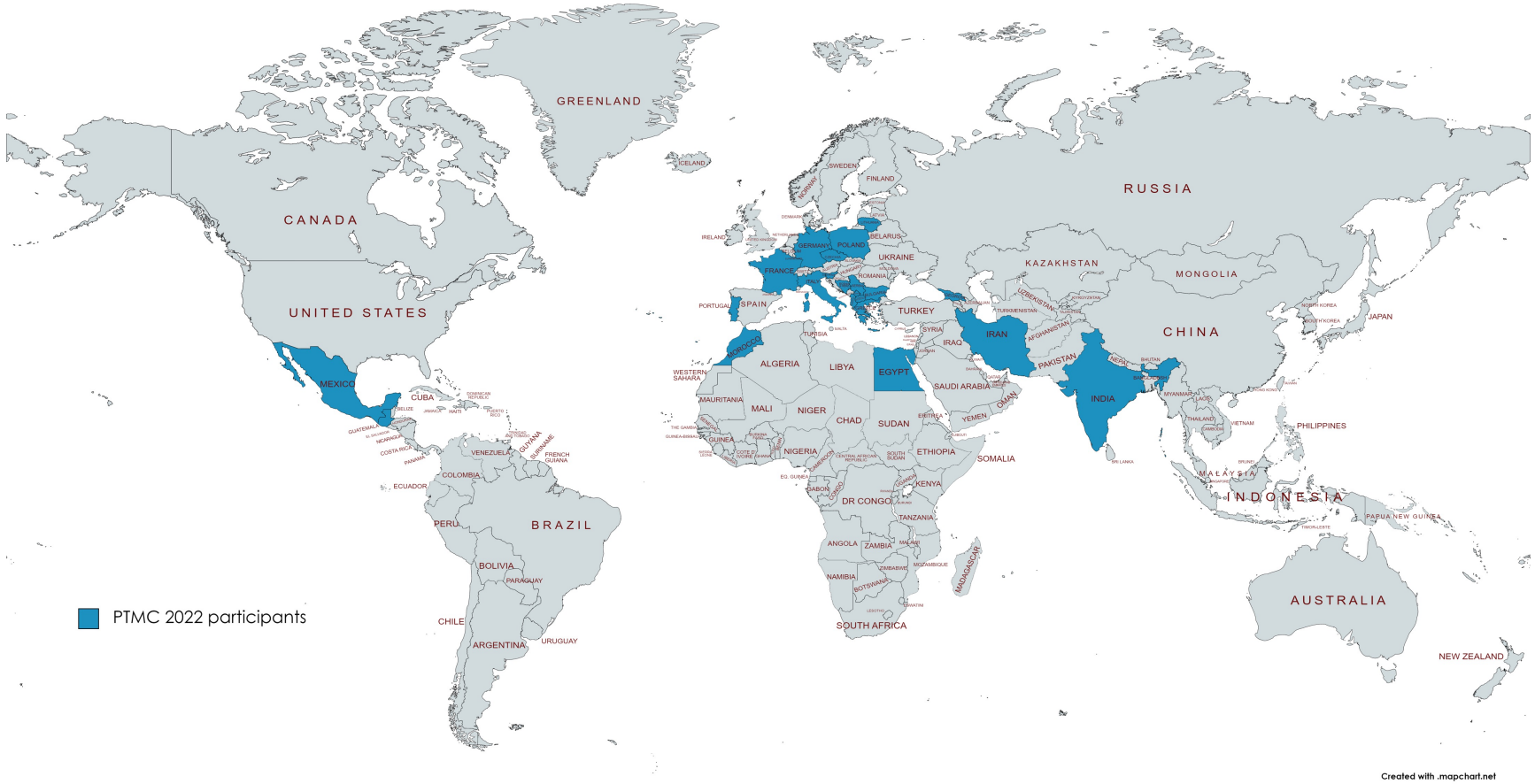
Participants of online PTMC in IMC2021

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

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

Participants of online PTMC in IMC2022

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



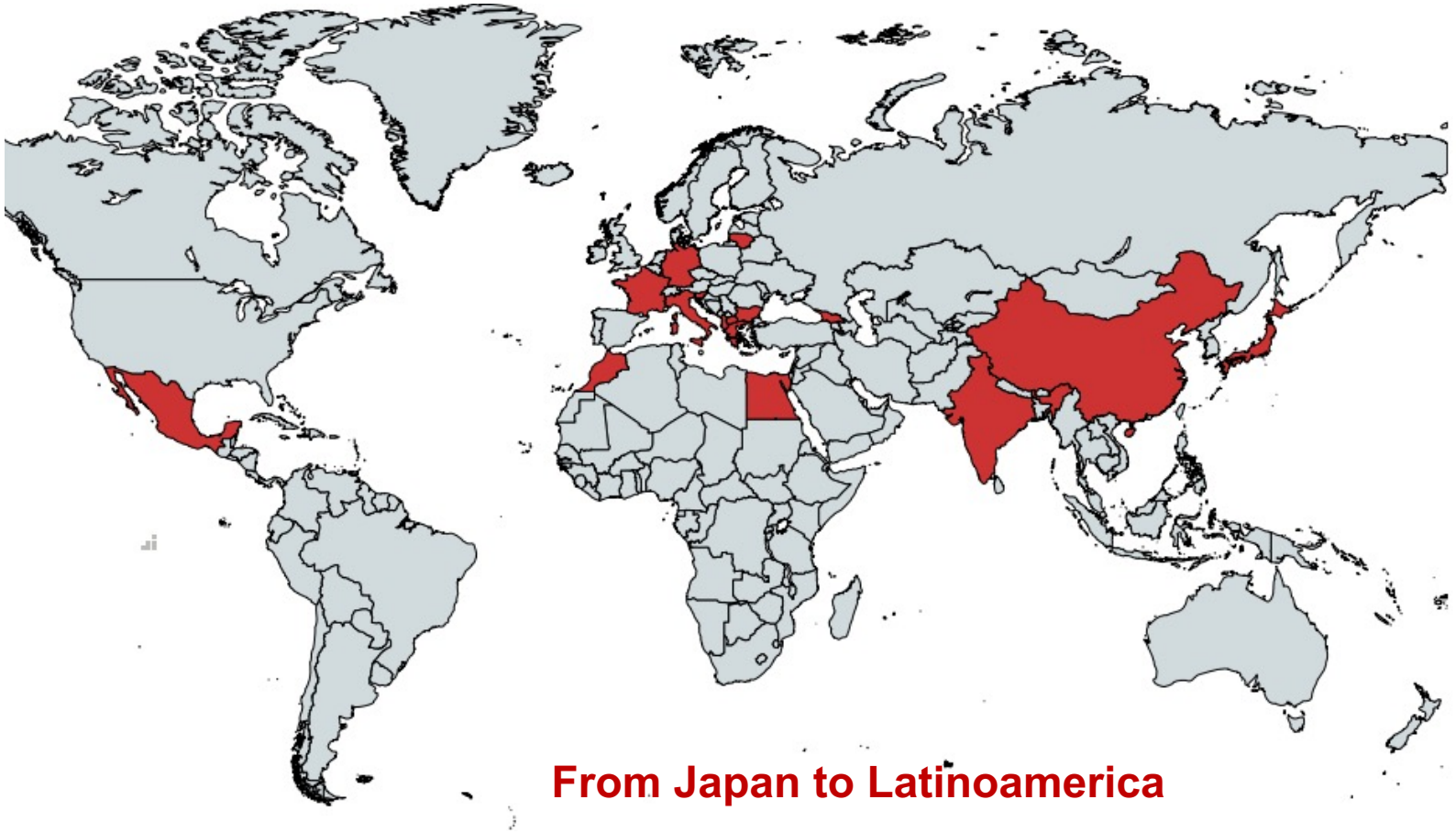
PTMC2022 online/hybrid:
6 sessions, 1500 students
from 22 countries and 37 institutes

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 hybrid PTMC in IMC2023

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



From Japan to Latinoamerica

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

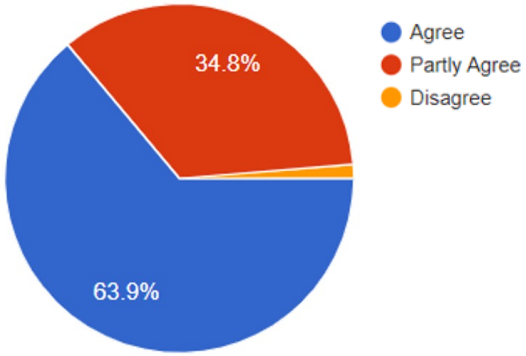
web pages with agendas of every institute with material
in different languages, publicly available for future events

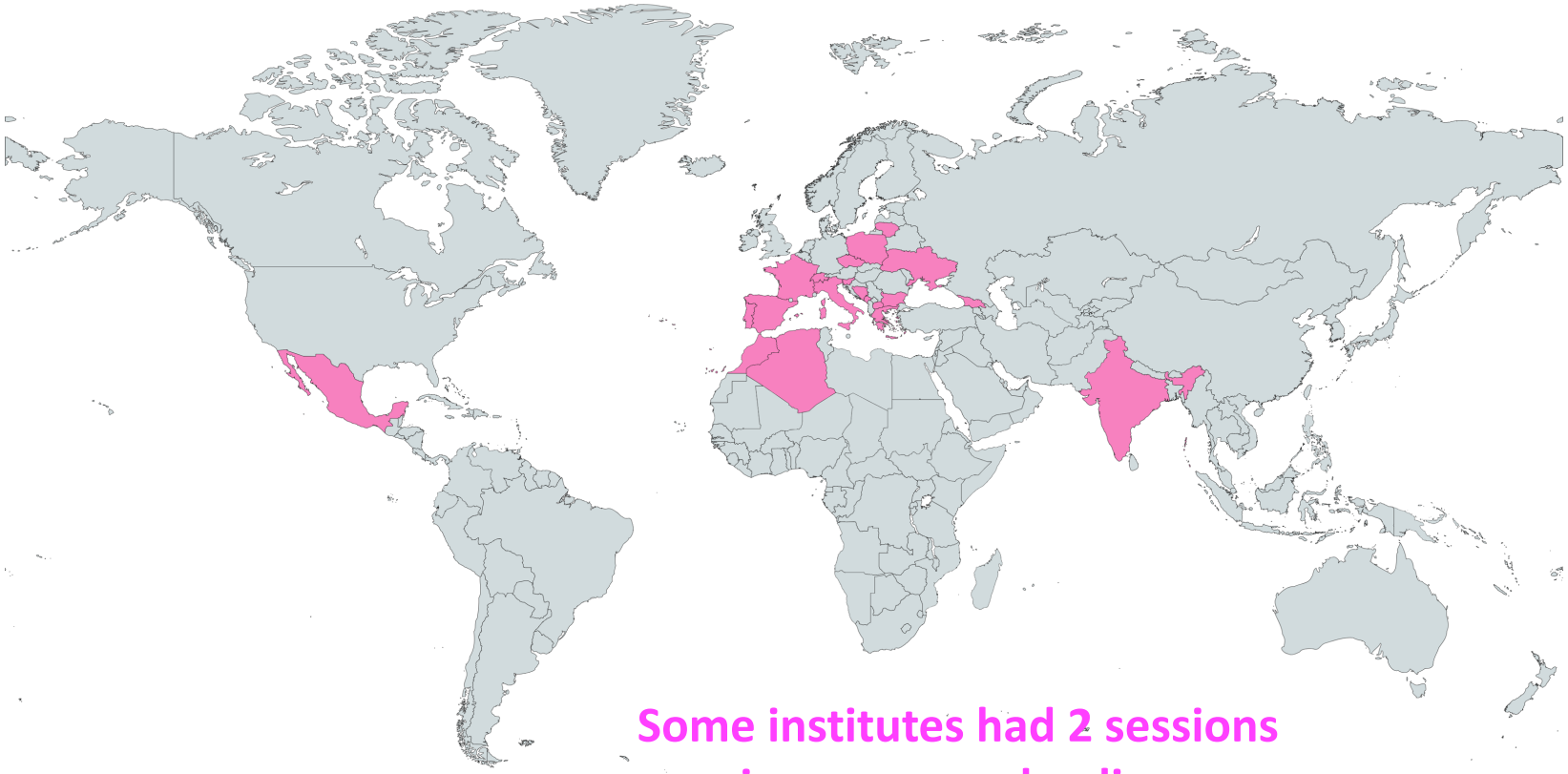
Interest of students, motivation of tutors (voluntary work), potential impact

Participants of hybrid PTMC in IMC2024

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

Statistics of 22 out of 47 institutes:
Total: 1567
428 female, 430 male
17 in person, 5 hybrid





PTMC2023 in person/online/hybrid:
8 sessions, more than 1500 students
from 22 countries and 47 institutes

Some institutes had 2 sessions in-person and online

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

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES
hands on particle physics

Took it a step further !

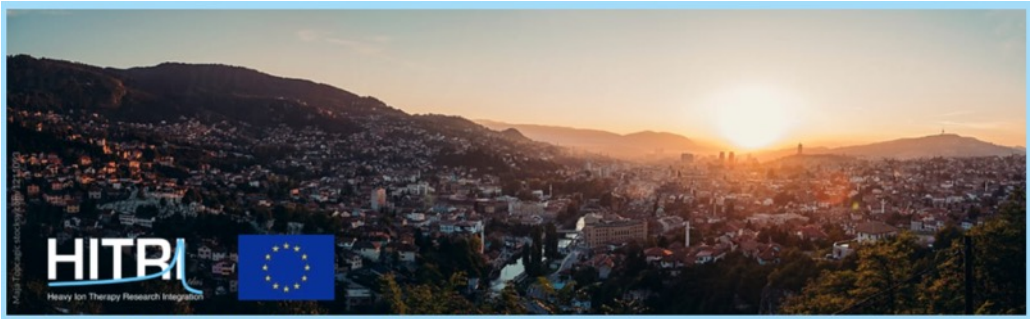
A full week MasterClass school

inspired by the PTMC format

within the HITRIplus EU-fudned project

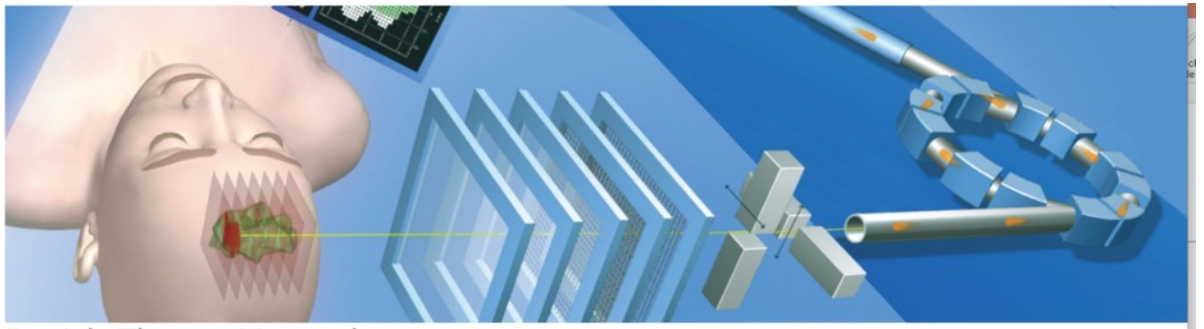
Advanced material
for uni students and up to professionals

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



Heavy Ion Therapy Masterclass School

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



Particle Therapy Masterclass

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

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**

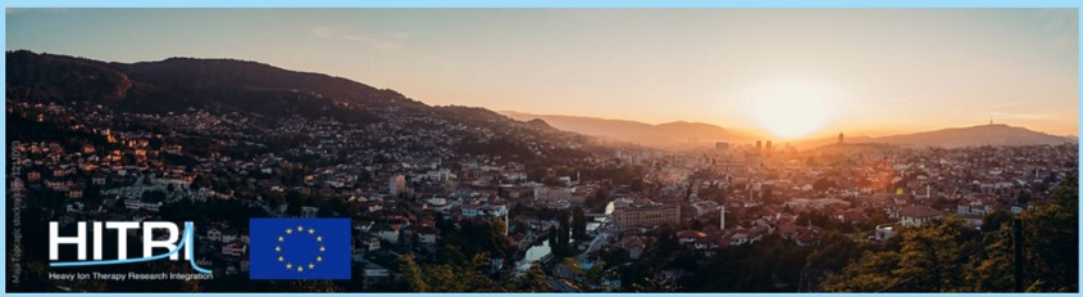
Information about upcoming modern techniques for cancer tumour therapy and new research avenues, where clearly **the development of technology and the expertise of research laboratories is crucial**

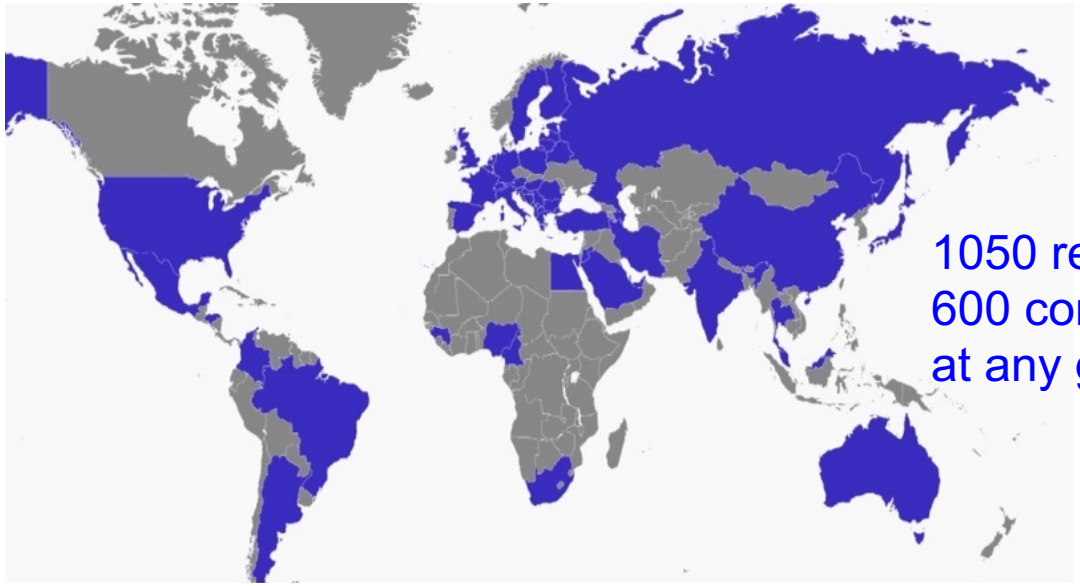
HITRI
Heavy Ion Therapy Research Integration

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

World-wide reach motivating next generation of scientists

HITRIplus full week heavy-ion therapy masterclass school





1050 registrants,
600 connections
at any given time

International MasterClasses one day activity

Power of Networks !

HITRI
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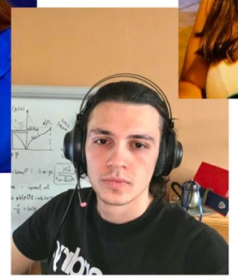
PTMC and HITRIplus school assistants


At AUTH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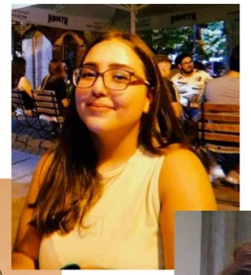
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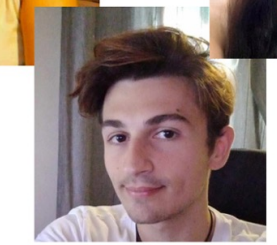
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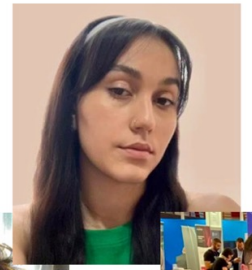
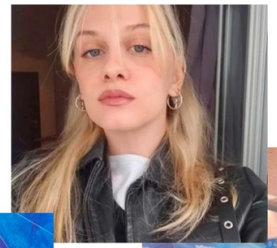
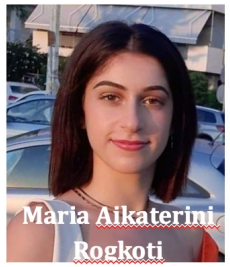

At DKFZ

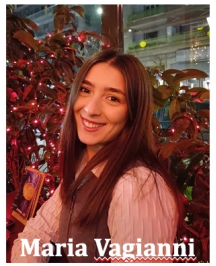

At GSI

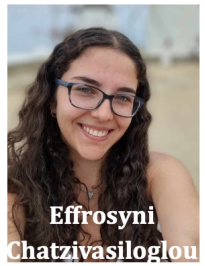

At PATRAS


At CERN

At MedAustron


Maria Aikaterini Rogkoti


Maria Vagianni

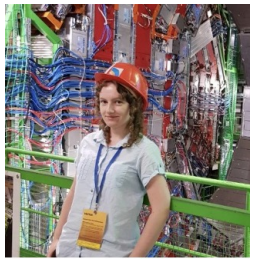

Effrosyni Chatzivasiloglou


Christina Litou


Despoina Geraki


Maria Elenh Bozika

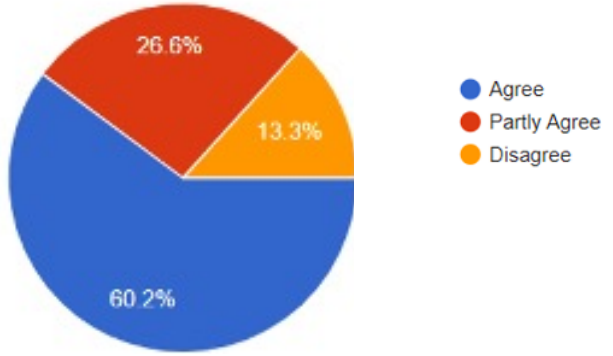

Evdokia Vlachou



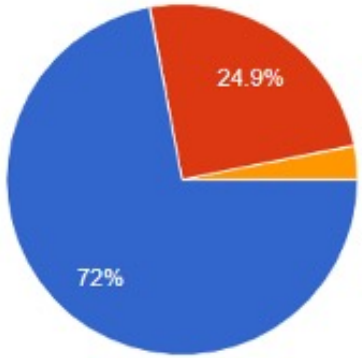
HITRI
Heavy Ion Therapy Research Integ

PTMC surveys cumulative

Changed your perspective regarding the job of scientists/physicists

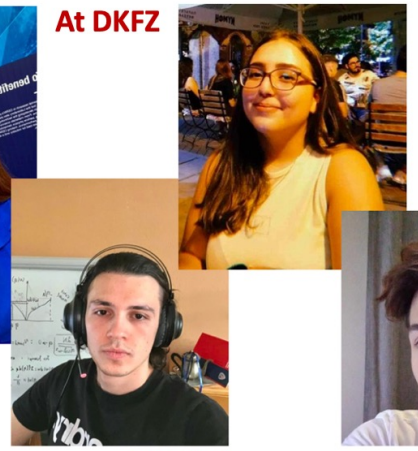


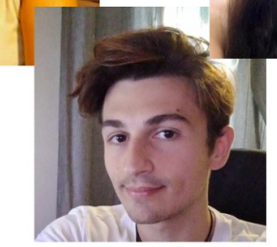
Encouraged you to look for more information on related subjects



PTMC and HITRIplus school assistants


At AUTH


At DKFZ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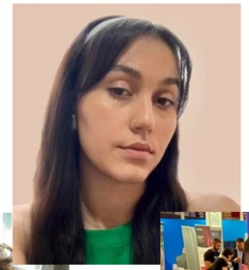


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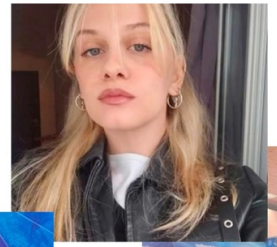
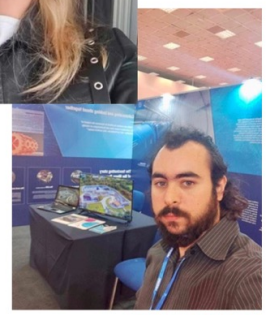
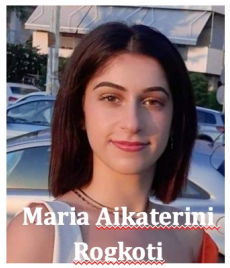

At GSI


At PATRAS


At CERN
At MedAustron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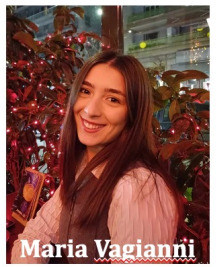
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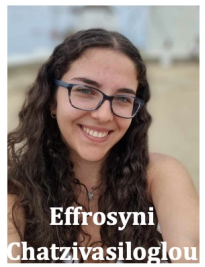
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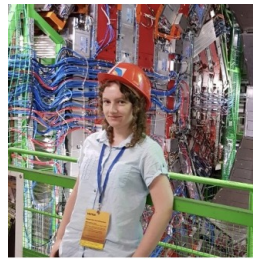
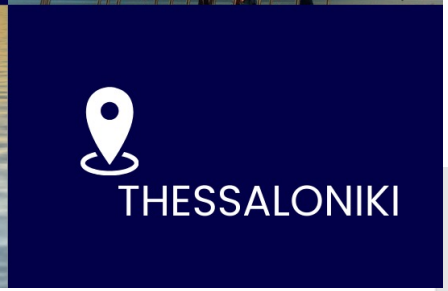


HITRI
Heavy Ion Therapy Research Integration

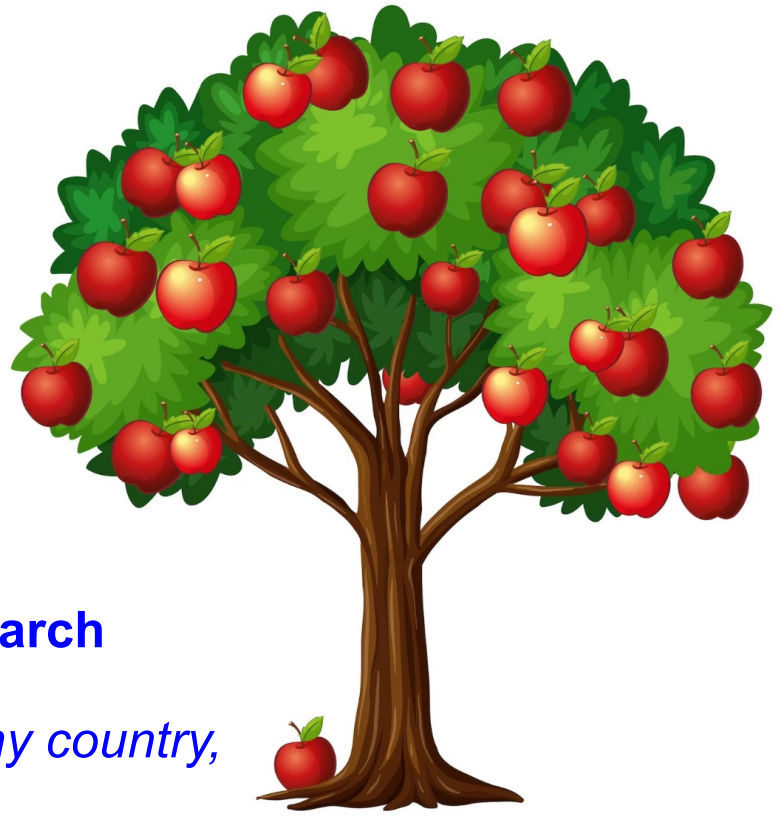
Next one in Thessaloniki
21 October, full day, hybrid
https://indico.cern.ch/event/1431035/



Main Message: need for fundamental research

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

- **Attract high-school students to STEM**
- **Cultivate confidence through the hands-on**
- **Support female participation**
- **Create groups of Uni assistants that learn better in order to teach**
- **Enhance public awareness on benefits from fundamental research**
- **Prepare future generations aware of importance of fundamental research**



a science educated future generation is crucial for shaping the future of any country, based on rational scientific thinking and decision-making processes

Demonstrate a return to society from investment in fundamental research

Our reward: the enthusiasm and appreciation of the students

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES
hands on particle physics

IPPOG Working Group

Outreach of Applications for Society

contribute to making known to general public
the benefits for society from fundamental research

IPPOG witness stories

International Particle Physics Outreach Group

About Resources Activities News Calendar

Working Group

Outreach of Application for Society

https://ippog.org/for-ippogers/outreach-application-society

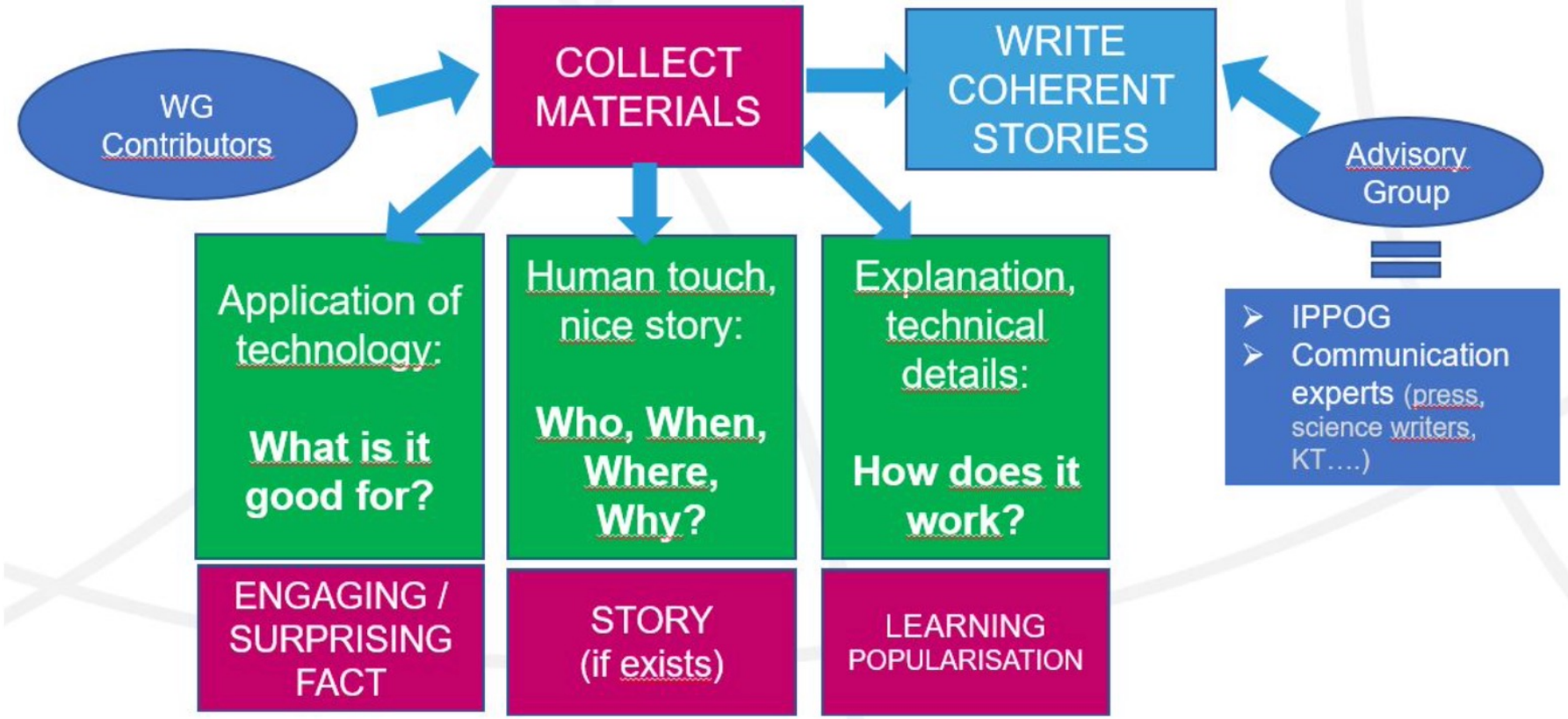
This working group focuses on collecting and making available engaging stories about concrete examples of successful applications for the benefit of society from (particle) physics and related sciences. Out of a wide range of working documents and even more ideas, the stories available so far are:

- Unraveling Cosmic Mysteries: The collaboration between International Space Station and CERN
- Superconductivity – quantum mechanics at work
- Medipix detectors, from colour X-ray imaging to education
- Muography - Invisible particles help to reveal invisible structures
- Searching for hidden cavities inside the Sun pyramid in Mexico
- Einstein's Relativity in Action – the GPS Navigation System knows it
- Positron Emission Tomography: Can crystals used in particle detectors save lives?
- Accelerators to reduce pollution of maritime traffic

Resently compiled, outcome of Hackathons

IPPOG witness stories

Working plan / Guidelines



[IPPOG WG Applications for Society Guidelines for Contributions]

IPPOG witness stories

International Particle Physics Outreach Group

About Resources Activities News Calendar

IPPOG witness stories

Concrete examples of successful applications for the benefit of society from (particle) physics and related sciences

Compiled and presented by the : IPPOG Working Group on Outreach of Application for Society

https://ippog.org/ippog_witness_stories

01 July, 2024

Accelerators to reduce pollution of maritime traffic

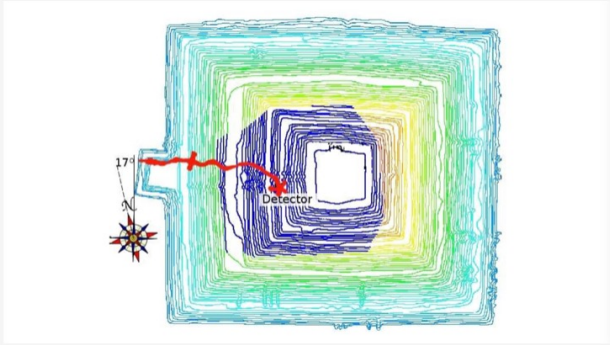
The accelerator community has a lot of examples of applications of accelerators used for the benefit of the society. One of the most unexpected applications is the pioneering use of compact modular linear accelerators for treating the exhaust gas of diesel engines of ships.

IPPOG witness stories

cross-references: general principles and witness cases

International Particle Physics Outreach Group

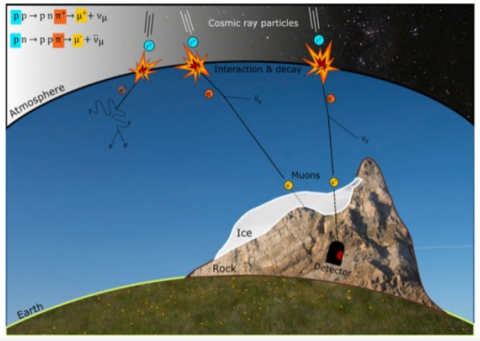
About Resources Activities News Calendar



01 July, 2024

Searching for hidden cavities inside the Sun pyramid in Mexico

A first-hand witness of the experience of the main author searching for hidden cavities inside the Sun pyramid in Mexico, in a collaboration of Mexican physics groups and archeologists. This is explained as an example of the many applications of muon tomography.



01 July, 2024

Muon Tomography - Invisible particles help to reveal invisible structures

Among the IPPOG Forum members, many experimentalists work with (or even developed) specialized muon detectors for the purposes of fundamental research. However, such devises find many direct applications for society spanning from scanning lories and controlling the nuclear fuel that was spent in power plants to exploring underground cavities.

IPPOG witness stories

become ambassador, use them to stimulate interest for STEM studies

Accelerators to reduce pollution of maritime traffic

The accelerator community has a lot of examples of applications of accelerators used for the benefit of the society. One of the most unexpected applications is the pioneering use of compact modular linear accelerators for treating the exhaust gas of diesel engines of ships.

01 July, 2024

Positron Emission Tomography: can crystals used in particle detectors save lives?

The Positron Emission Tomography (PET) is explained as a medical imaging technique widely used in hospitals to detect anomalies in the body of patients (like cancer tumors) on a daily basis. The article explains how PET works and how knowledge of basic physics processes is used to visualize the physiological processes in biological systems.

01 July, 2024

Einstein's Relativity in Action – the GPS Navigation System knows it

One unexpected real-life application of Einstein's theory of relativity, used by almost everybody every day, is the GPS navigation system. Some details of how this works are given in this short story.

Link to the story

IPPOG witness stories

International Particle Physics Outreach Group

become ambassador, use them to stimulate interest for STEM studies

01 July, 2024

Medipix detectors, from colour X-ray imaging to education

Details on how it is possible to visualise the invisible particles of cosmic rays are given with the aim to get students acquainted with radiation. This is just one of the uses of the Medipix/Timepix family of detectors developed for fundamental research experiments at CERN. Details on many other applications spanning from medicine to art authentication are also provided.

01 July, 2024

Superconductivity – quantum mechanics at work

Super-conductivity is brought to the general public by emphasizing one of the most amazing applications: levitating trains like the Maglev in Shanghai. Article written by a witness of the discovery of high-temperature superconductors.

01 July, 2024

Unraveling Cosmic Mysteries: the collaboration between ISS and CERN

CERN and NASA join forces in exploring the secrets of the universe, a challenging endeavour that results in practical benefits for society such as, for example, development of novel materials.

International Particle Physics Outreach Group

ICHEP 2024 | PRAGUE

17–24 Jul 2024
Prague
Europe/Prague timezone

Conveners


Barbora Bruant Gulejova


Yiota Foka

Thank you

for your attention!

Working group members

Contributions Welcome!

IPPOG forum contributors: Ruben Alfaro (HAWC), Beatrice Bressan (core team), Barbora Bruant Gulejova (Switzerland), Yiota Foka (GSI), Despina Hatzifotiadou (ALICE), Katharina Muller (Switzerland), Thomas Naumann (DESY).

External contributors: Pinelopi Christodoulou, Verania Echaide, Azra Gazibegovic-Bussuladzic, Lorenzo Galante.

Contacts:
yiota.foka@cern.ch
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BACKUP

PTMC Important Links

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

- 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

Acknowledgements PTMC

matRad Developers
Wahl, Niklas
Bangert, Mark
Hans-Peter Wieser

DKFZ Heidelberg

LoC: Wahl, Niklas
Katrin Platzer, Malte Ellerbrock
Noa Homolka Amit Ben Antony Bennan

GSI

LoC: Yiota Foka
GSI Biophysics:
Christian Graeff, Radek Pleskac
GSI ALICE, EMMI :
Ralf Averbeck, Malzacher, Peter
GSI IT :
Thorsten Kollegger, Behnert, Katharina
Osdoba, Sascha

Sponsors : Edmond Offermann

CERN (staff and users)

CERN: tutors
Loc Org: Nikolaos Charitonidis
Alexander Gerbershagen
Evangelia Dimovasili
Elena Benedetto

CERN/ARIES: Maurizio Vretenar, Valerie Brunner
CERN/ENLIGHT: Manjit Dosanjh Petya Georgieva
CERN/KT: Manuela Cirilli Anais Rassat Rita Ferreira
Giovanni Porcellana
CERN: Visits Service Erwan Harrouch Francois Butin
CERN: Training Centre: Eric Bonnefoy M-L LECOQ

Uni Sarajevo: web pages
Amila Avdic
Amra Ibrahimovic
Mirsad Tunja
Damir Skrijelj

Online mode, web pages, training
Aris Mamaras (AUTH), Damir Skrijelj (UNSA), Elpida Theodoridou et al (AUTH)
Nermine Muradi (Uni of Tetovo)

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

Participants of hybrid PTMC in IMC2024

More than 1500 students participated from 22 countries and 47 institutes during 8 sessions

Including 11 Feb and 8 March women days

Czech republic, Prague, Proton Therapy centre AND Charles UNI
Mexico Puebla
Mexico Hermosillo Uni of Sonora
Mexico, Mexico city, UNAM
Algeria
Poland
Greece
India
Montenegro
Ukraine
Italy Uni Piemonte Orientale
Italy Bologna
Italy Pavia Uni AND INFN
Italy Torino
Italy Cosenza. Uni AND INFN
Italy Milano UNIMI AND INFN
CERN
Slovenia
Lithuania Vilnious, Uni AND Cancer institute
Lithuania Kaunas Health uni AND Uni of Technology
Germany DKFZ
Georgia
France
Slovenia Uni Ljubljana
N. Macedonia Uni Tetovo
Morocco
Bulgaria Varna Astronomical observatory AND Uni
Bulgaria Sofia Uni
Spain Uni AND Hospital
Portugal Uni Lisbon
BiH Sarajevo AND Tuzla

From participants to collaborators

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

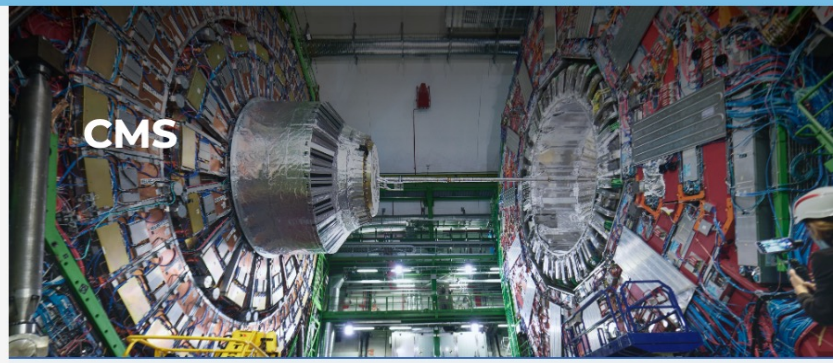
It is inspiring to young students.

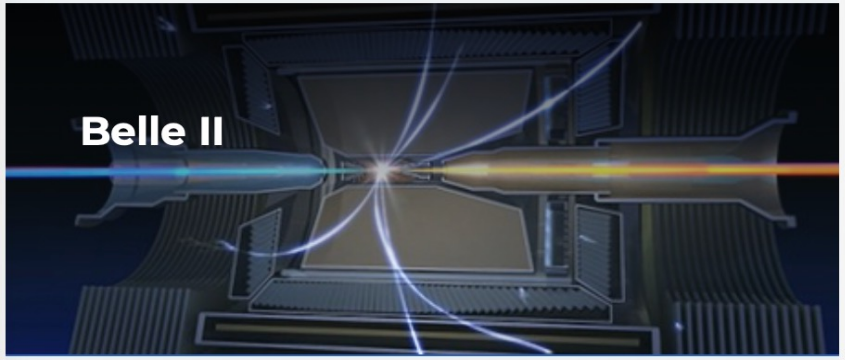
This could mean more professionals in STEM topics

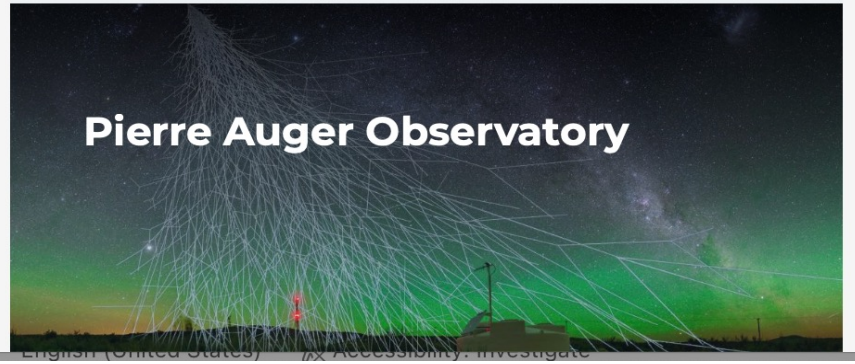
Noteworthy fact:
now we collaborate in UNAM with our IMC tutors

.

International Masterclasses







INTERNATIONAL MASTERCLASSES

hands on particle physics

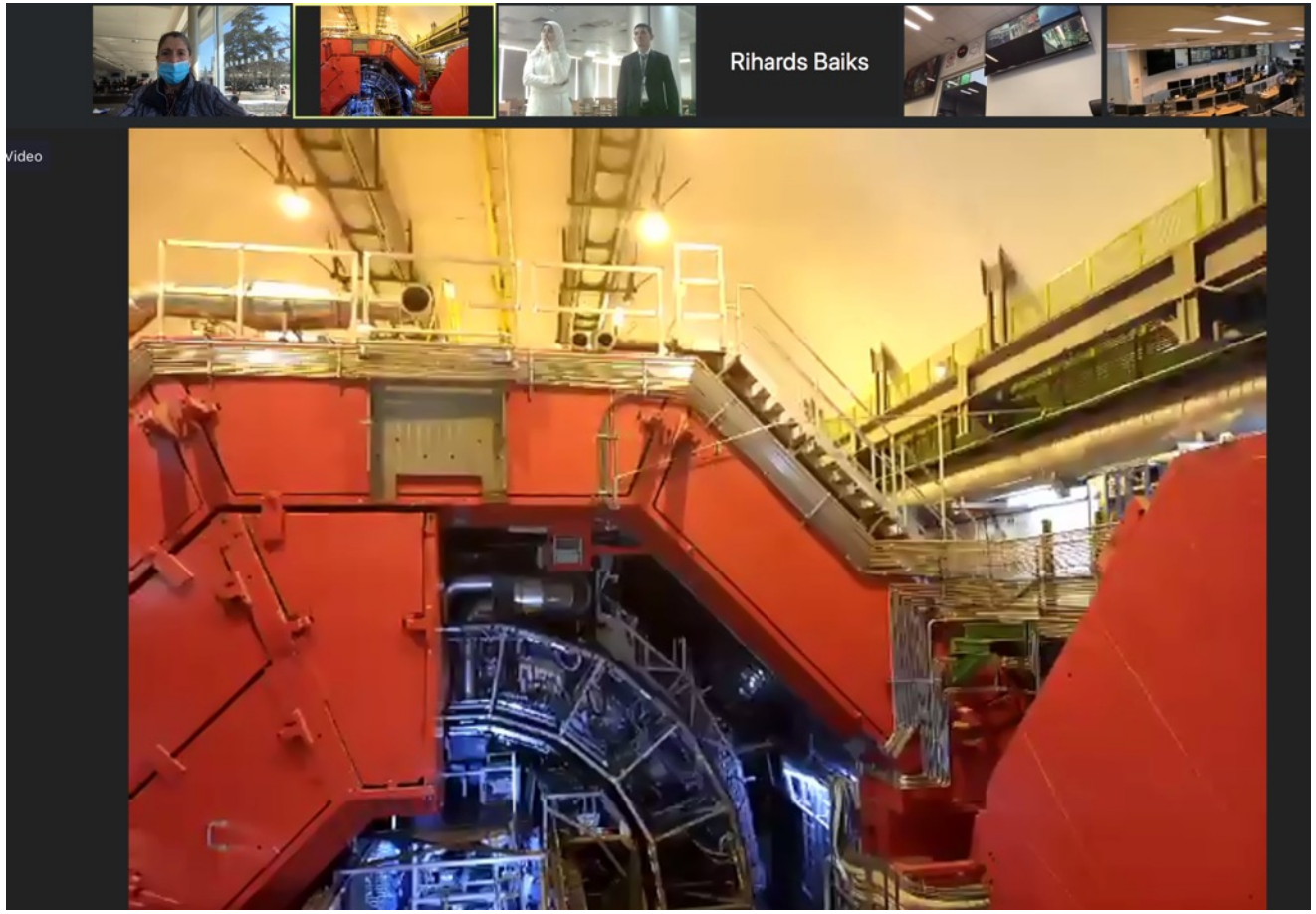
Feedback

PTMC: Typical MasterClass Day Agenda

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES
hands on particle physics

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: 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/

Lectures adapted to the expertise of institutes

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