

IPPOG and spin-offs from particle and nuclear physics

Yiota Foka (GSI/CERN)

on behalf of

IPPOG*

*IPPOG International Particle Physics Outreach Group



**XVIth Quark Confinement and
Hadron Spectrum Conference**

19 - 24 August 2024 (inclusive)

Cairns Convention Centre, Cairns, Queensland, Australia

IPPOG activities on benefits for society



Contacts:
yiota.foka@cern.ch



Tangible examples of connecting
fundamental research and everyday life

Working Group

Outreach of Application for Society

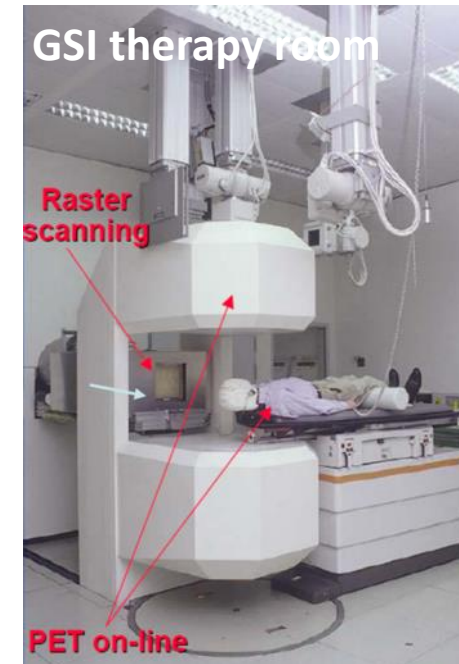
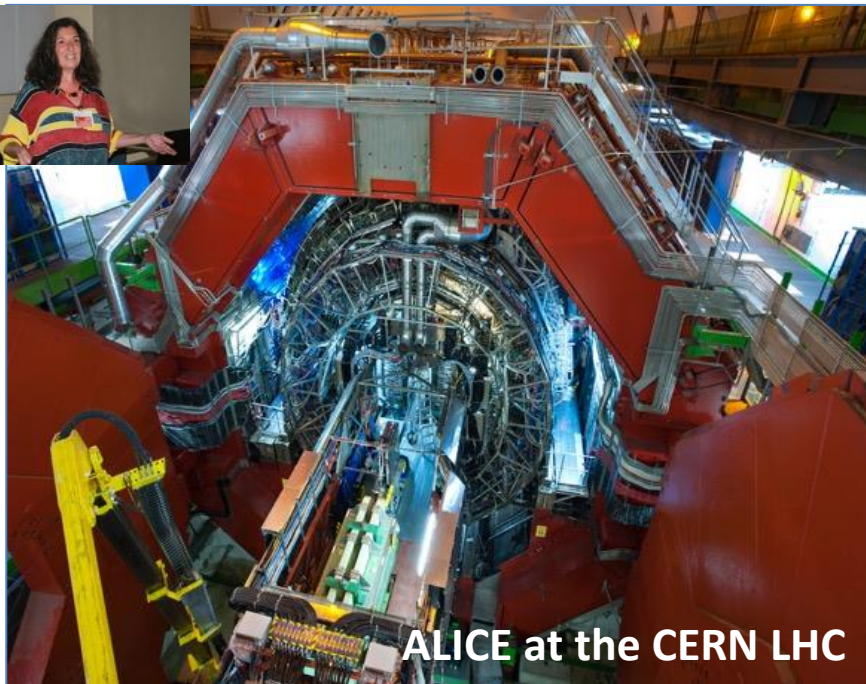
<https://ippog.org/for-ippogers/outreach-application-society>

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

Heavy-ion 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



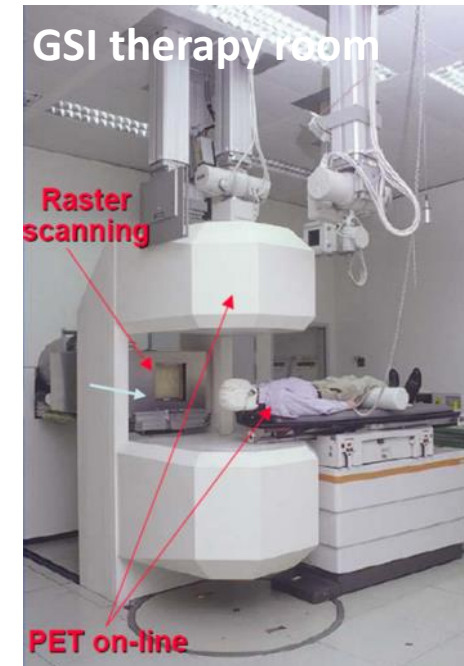
Mission and mandate of research institutes: fundamental research
Developed technologies and acquired knowledge find applications for society

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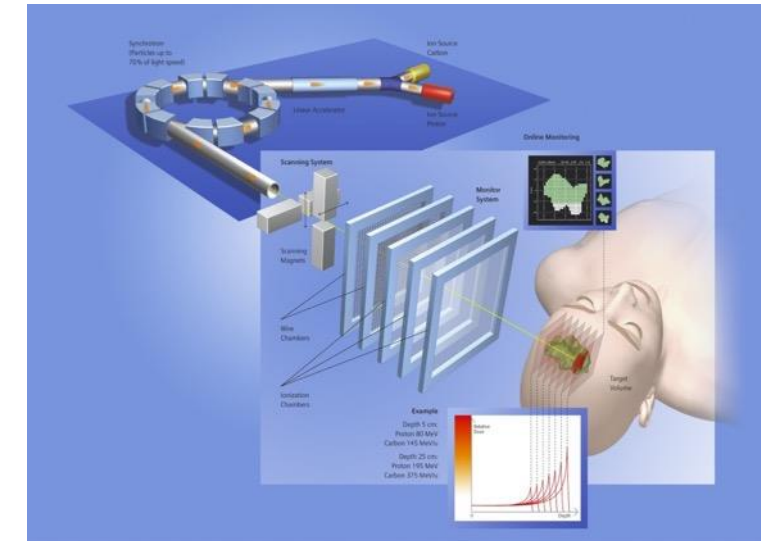


ALICE Control Room

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



Heidelberg Ion Therapy HIT centre

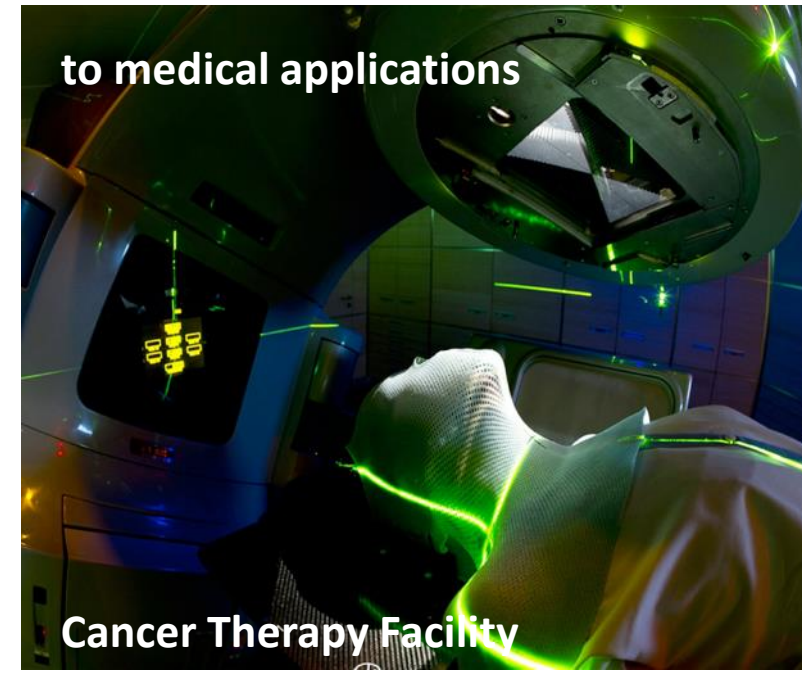


Implemented at HIT, Heidelberg Ion Therapy centre

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

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

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

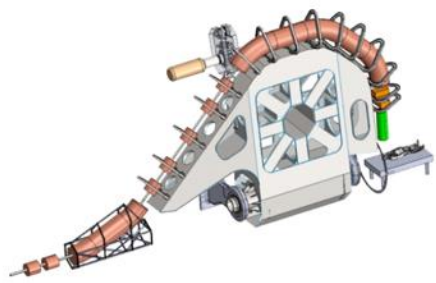
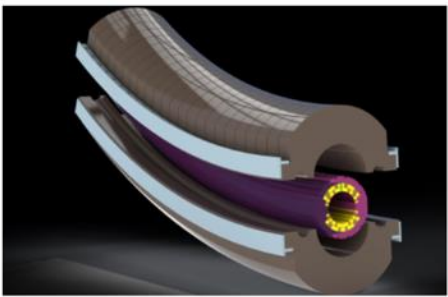
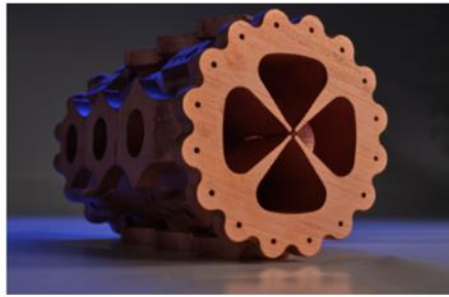
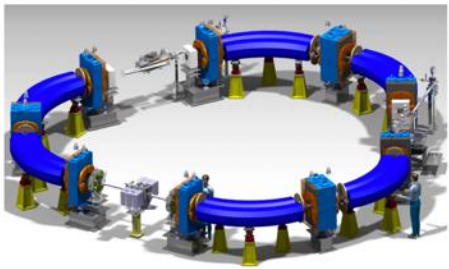


Mission and mandate of research institutes: fundamental research
Developed technologies and acquired knowledge find applications for society

Next Ion Medical Machine Study Group Developments



Our Technological R&D



Synchrotron Accelerators	Linear Accelerators	Superconducting Magnets	Superconducting Gantry
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



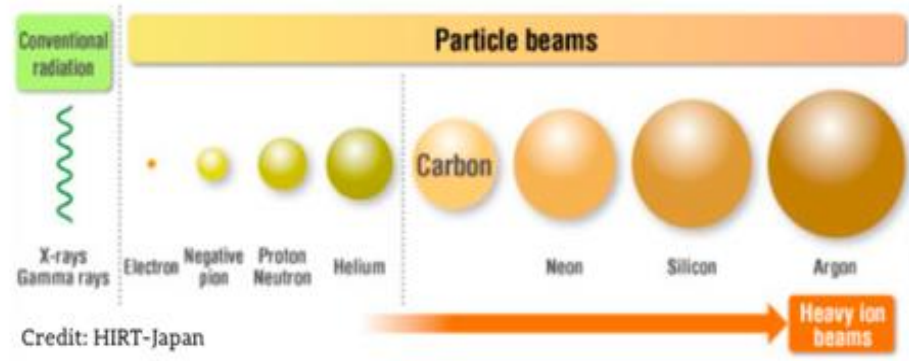
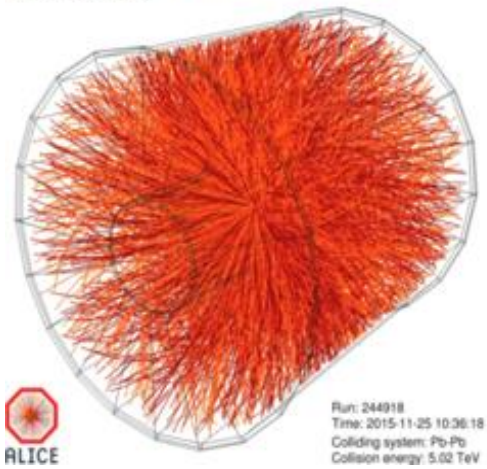
APTCB Advanced Particle Therapy Center for the Baltics	SEEIIST South East European International Institute for Sustainable Technologies
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Heavy-ion research and heavy-ion therapy

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



Credit: CERN



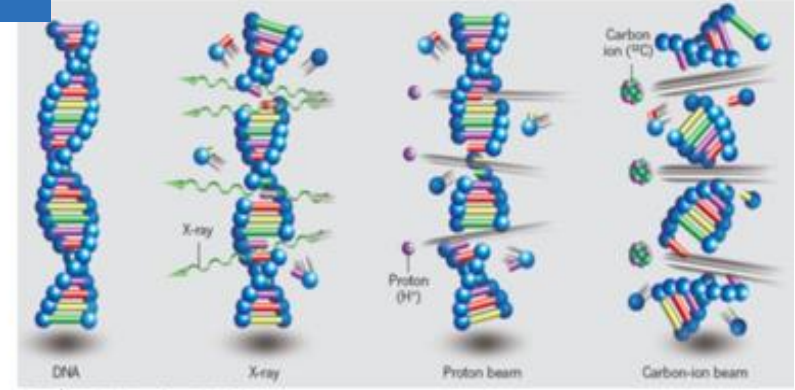
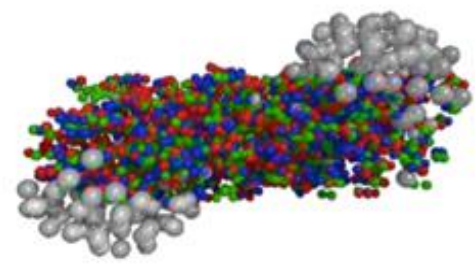
88-430 MeV/u carbon
50-221 MeV/u protons

applied science
medicine



Credit: HIT Heidelberg

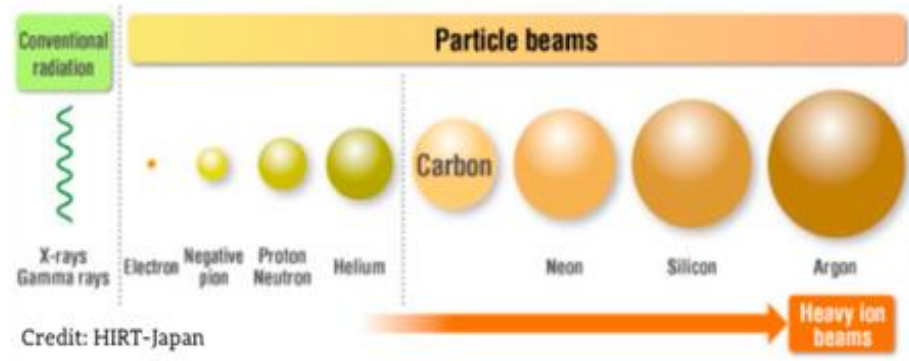
What Physics has to do with Medicine?



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

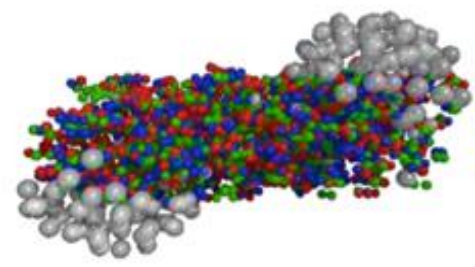
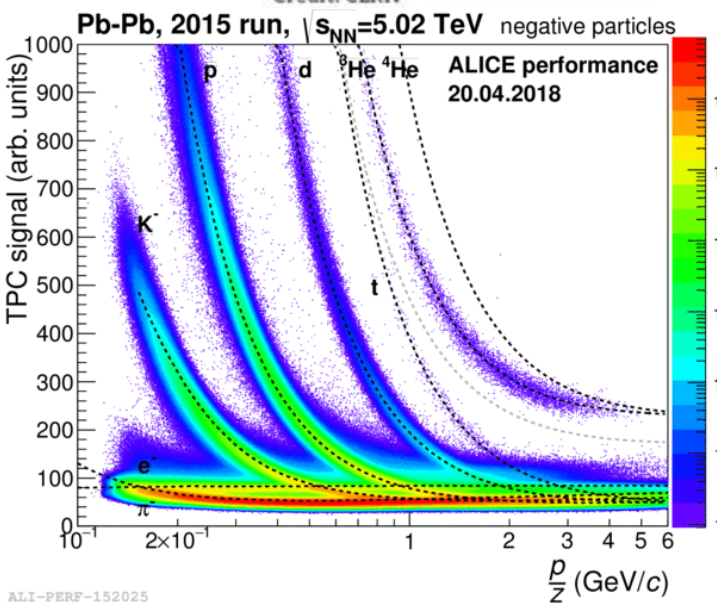


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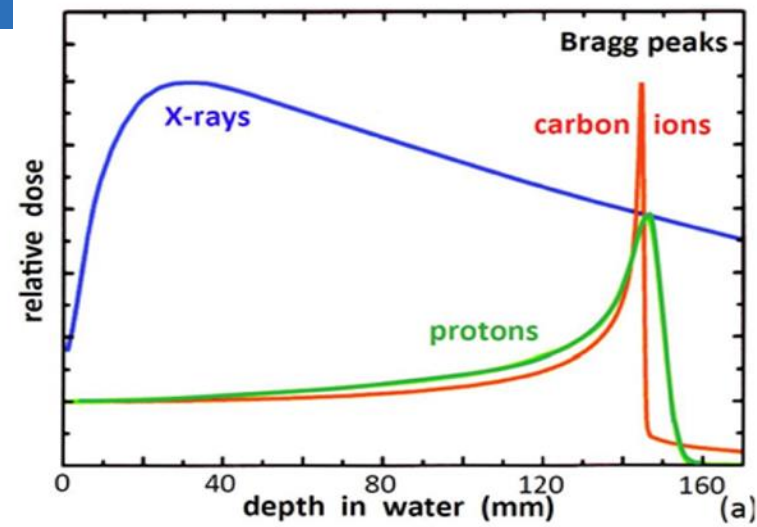
applied science
medicine



What Physics has to do with Medicine?



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



From Bethe Bloch ionization for PID

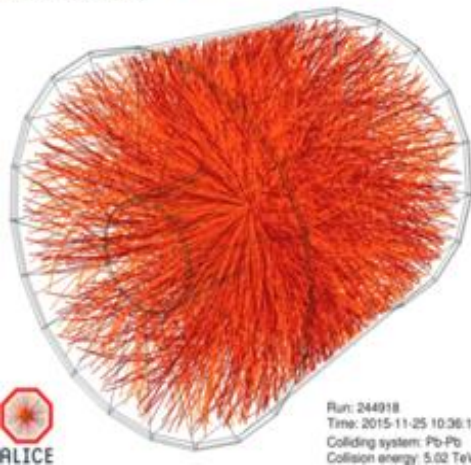
to Bragg peak for cancer therapy

ALICE MasterClass on Strangeness

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



Credit: CERN



TUESDAY, 20 AUGUST 2024

11:00-12:30 ALICE MASTER CLASS

LOCATION M9

PRESENTER Theory Lecture
Jon-Ivar Skullerud

12:30-13:30 LUNCH

13:30-14:30 ALICE MASTER CLASS

LOCATION M9

13:30-14:30 HANDS-ON CLASS 1

14:30-15:00 AFTERNOON TEA

15:00-17:30 ALICE MASTER CLASS

LOCATION M9

15:00-16:30 HANDS-ON CLASS 2

16:30-16:45 QUIZ

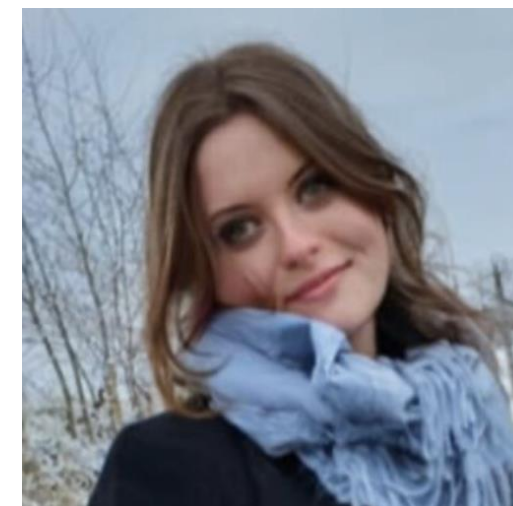
16:45-17:15 Live connection to CERN

17:15-17:30 Questions/Answers

Jon-Ivar Skullerud



Wioleta Rzeska



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

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



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



International Masterclasses

ATLAS

ALICE

CMS

Belle II

LHCb

MINERVA

Coordinated and moderated by GSI

Particle Therapy

Pierre Auger Observatory



**INTERNATIONAL
MASTERCLASSES**

hands on particle physics

Feedback

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

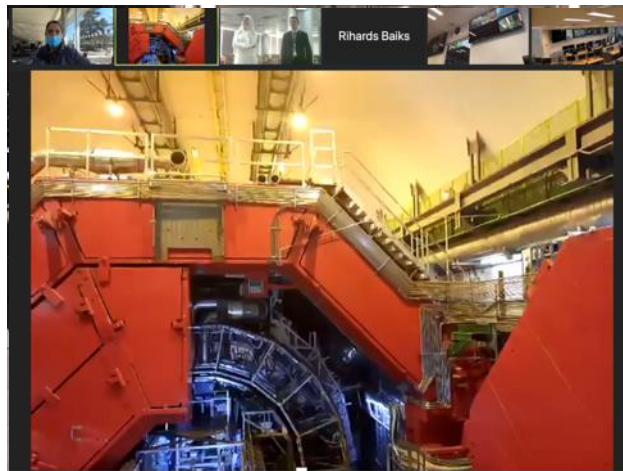
Local: Morning Presentations



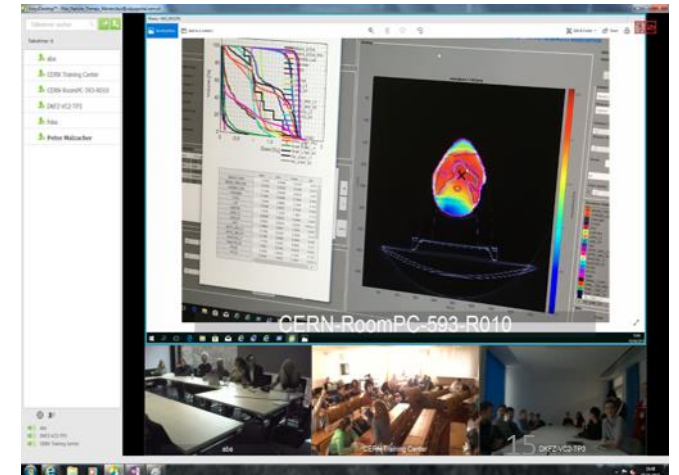
Local: Afternoon Hands-on



Local: Morning Visits real-time online ALICE visit



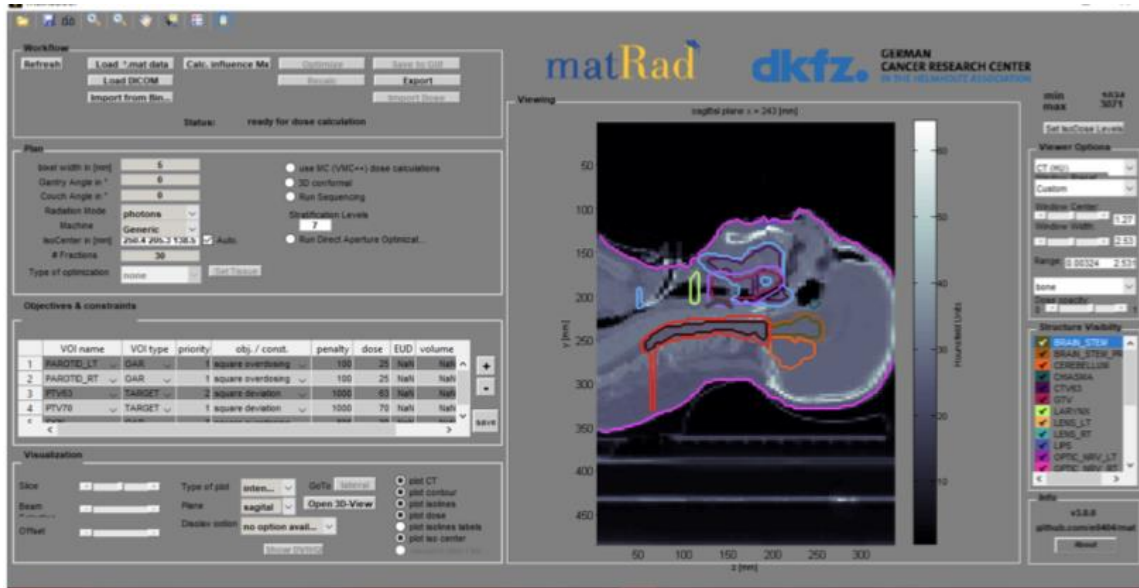
Common: Afternoon at 16:00 Video-Conference



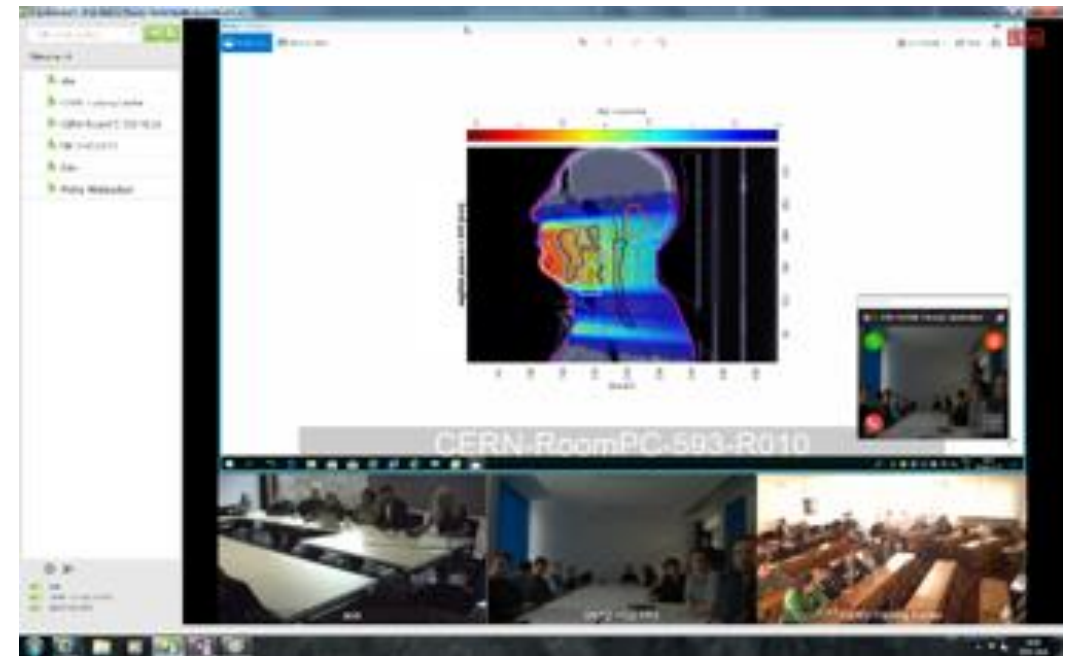
PTMC hands-on Treatment Planning

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

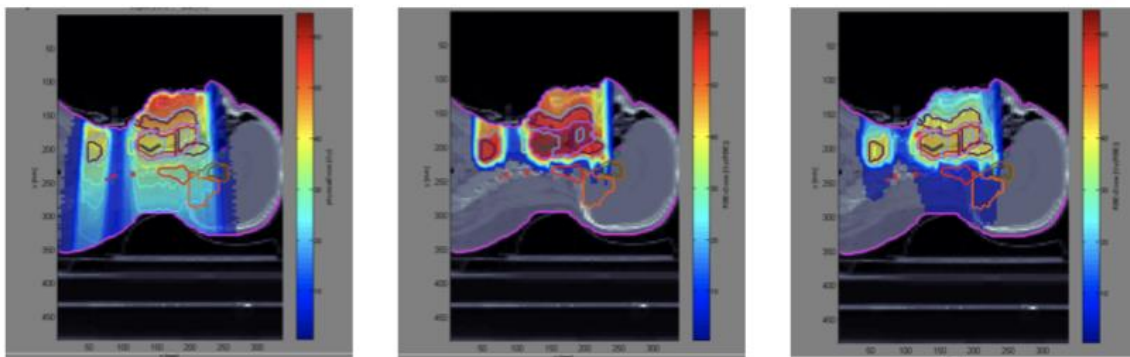
Simplified version for PTMC



Dose prescription using photons, protons and carbon ions



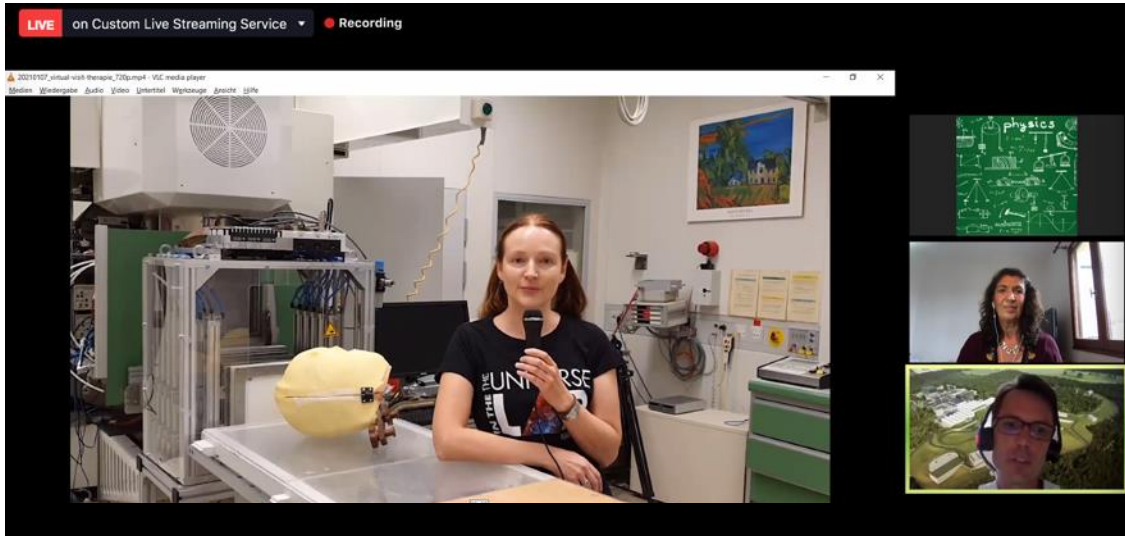
Demo⁴ of the matRad software kit for Treatment Planning .



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



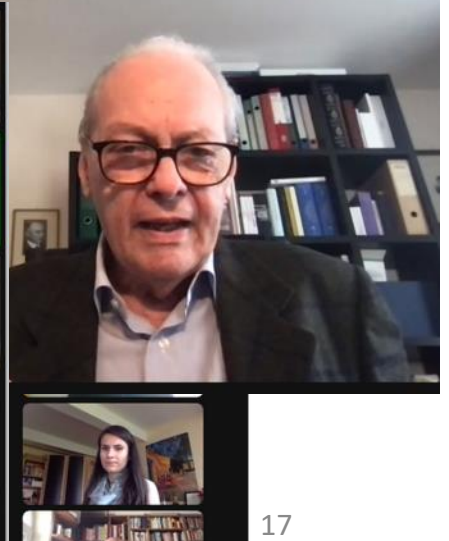
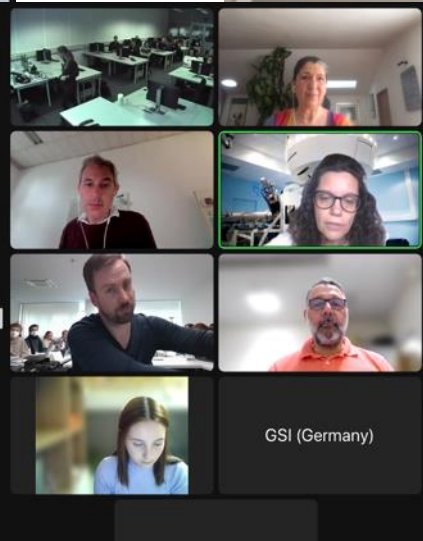
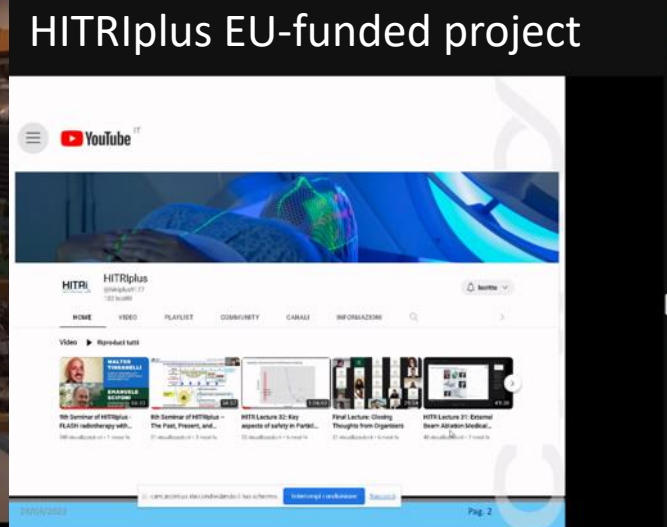
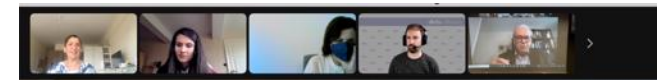
GSI moderators

CNAO moderator

medAustron moder.



U. Amaldi: HI therapy pioneer



PTMC supporting females in STEM



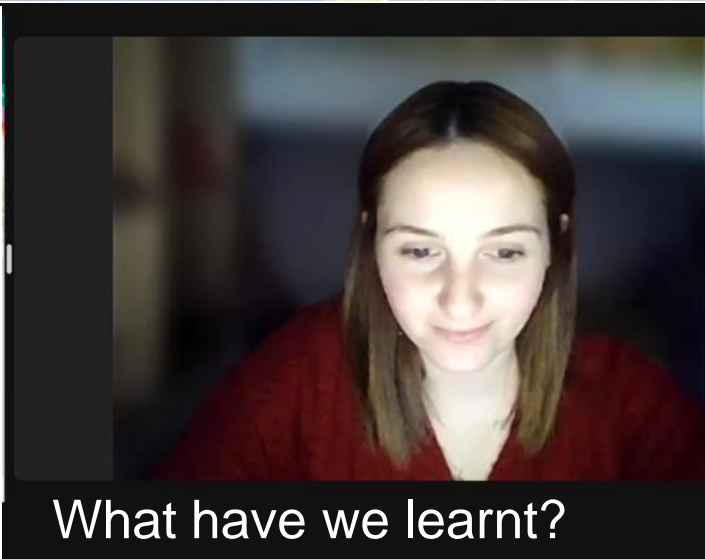
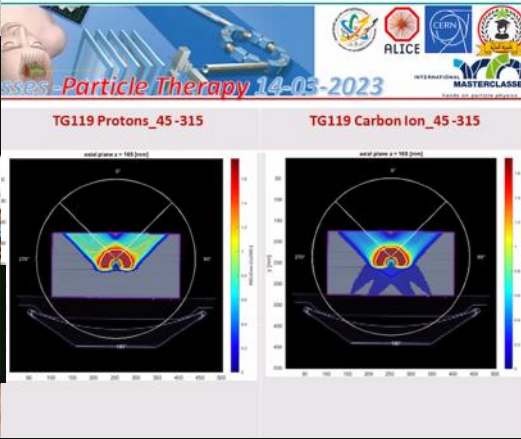
PTMC Video Conference 15 March

Logos: GSI, FAIR, EMMI, dkfz, CERN, INTERNATIONAL MASTERCLASSES, IPG

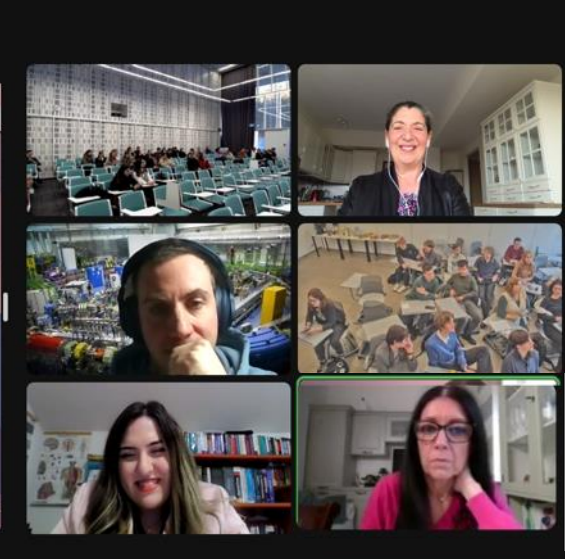
Maps showing locations in Europe, Mexico, and India.



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



What have we learnt?






<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

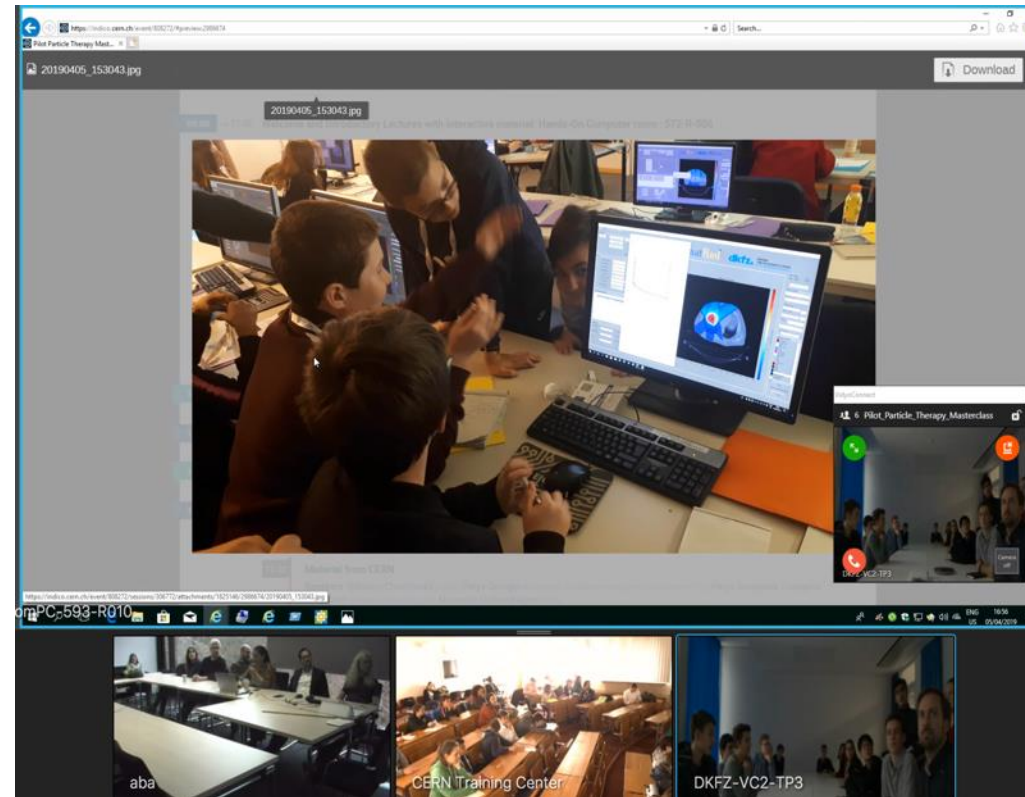
First Local Test: GSI Feb 2019



Web page: UNSA students CERN Open Days, Aug 2019



International Pilot: CERN, GSI, DKFZ April 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>

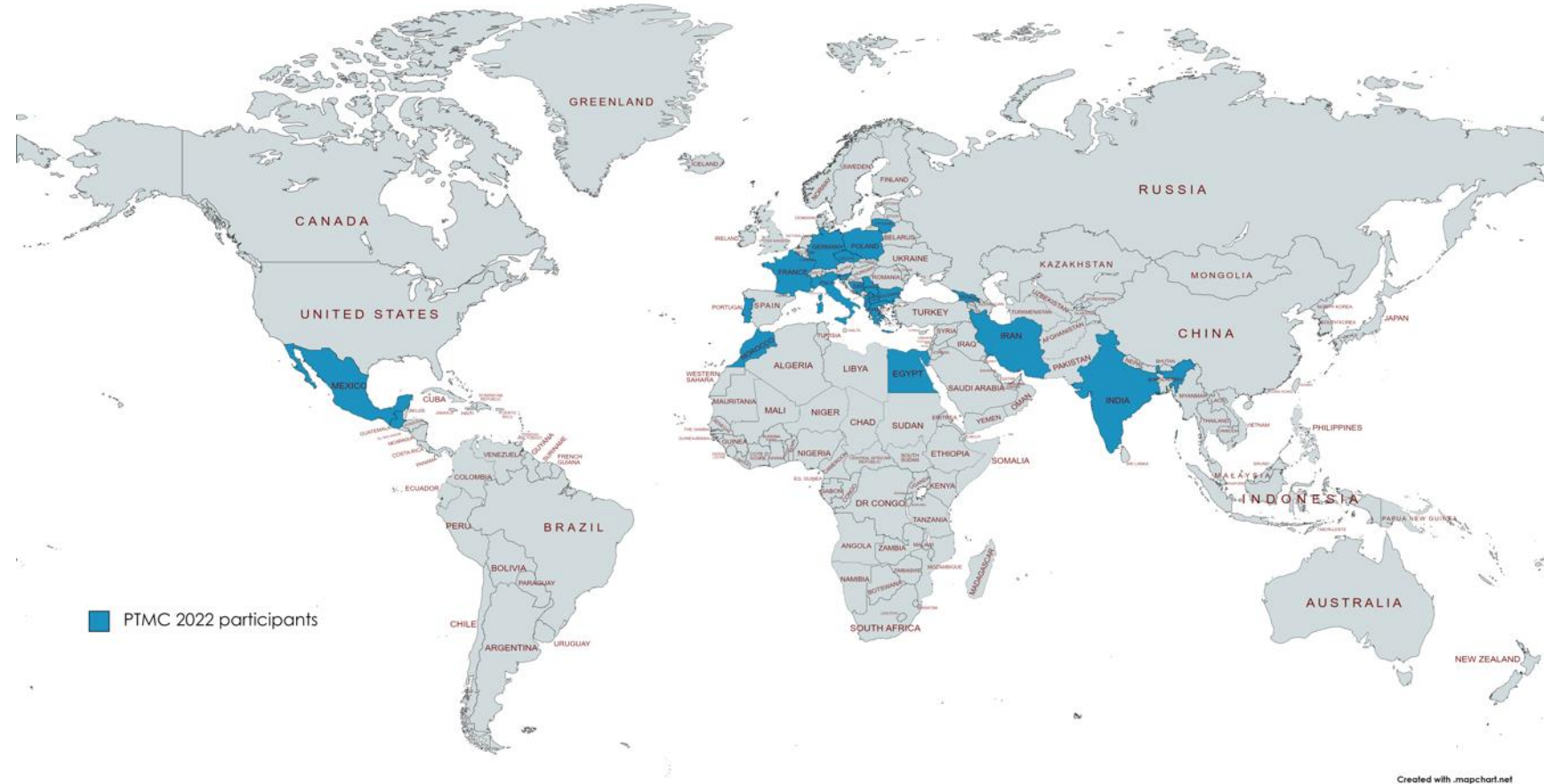


PTMC2021 online:
6 sessions, 1500 students
from 20 countries and 37 institutes



Participants of online PTMC in IMC2022

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



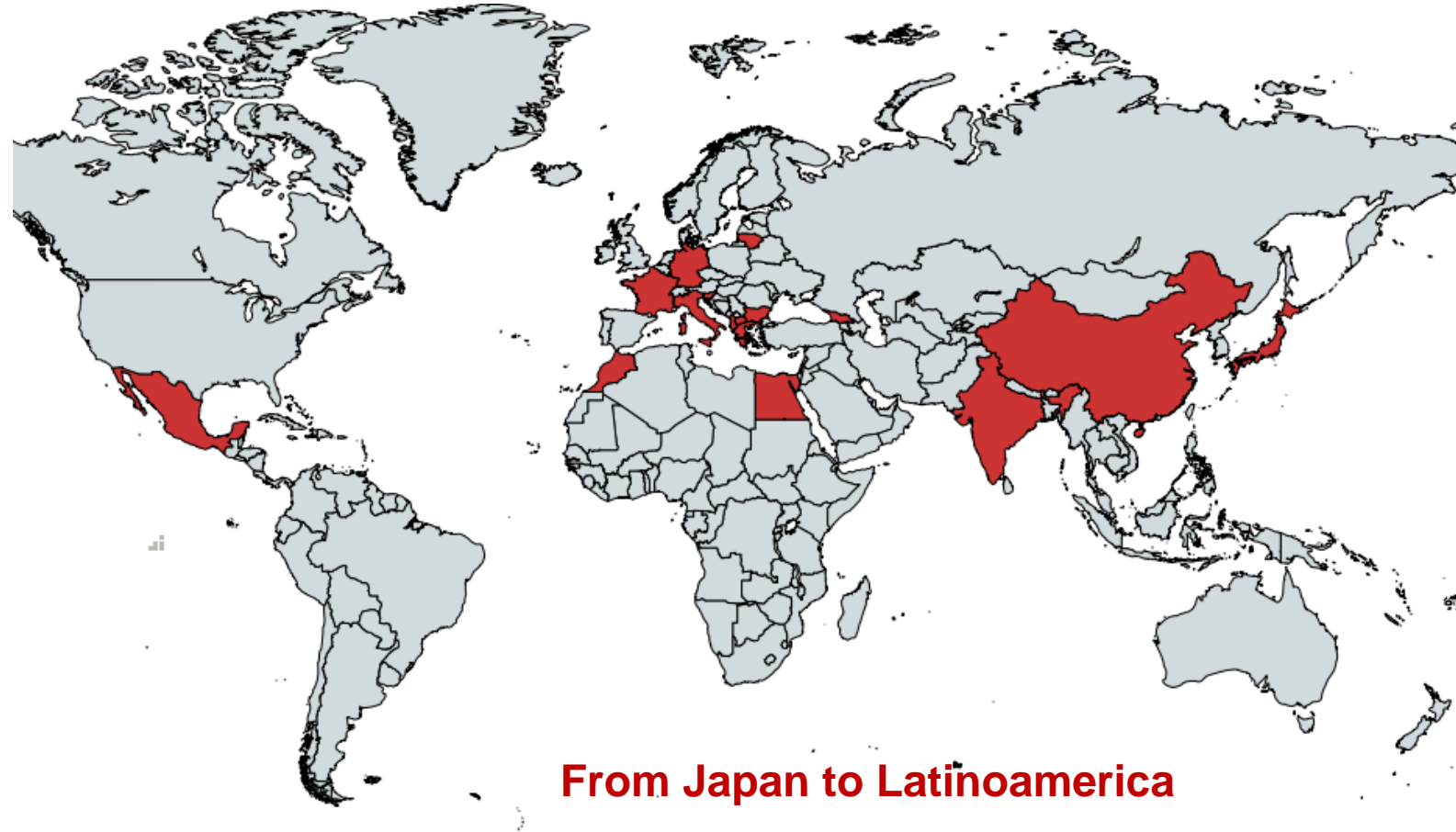
**PTMC2022 online/hybrid:
6 sessions, 1500 students
from 22 countries and 37 institutes**

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

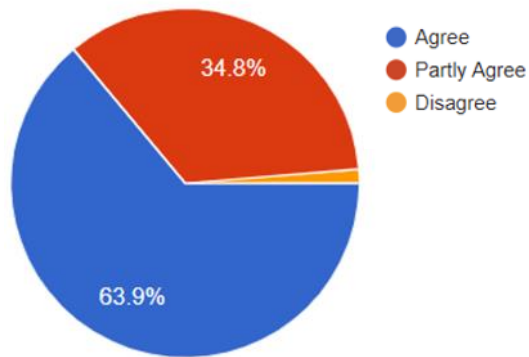
<https://indico.cern.ch/e/PTMC>

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

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

Took it a step further !
A full week MasterClass school
inspired by the PTMC format
within the HITRIplus EU funded project
Advanced material
for uni students and up to professionals
<https://indico.cern.ch/e/HeavyIonTherapyMasterClass>



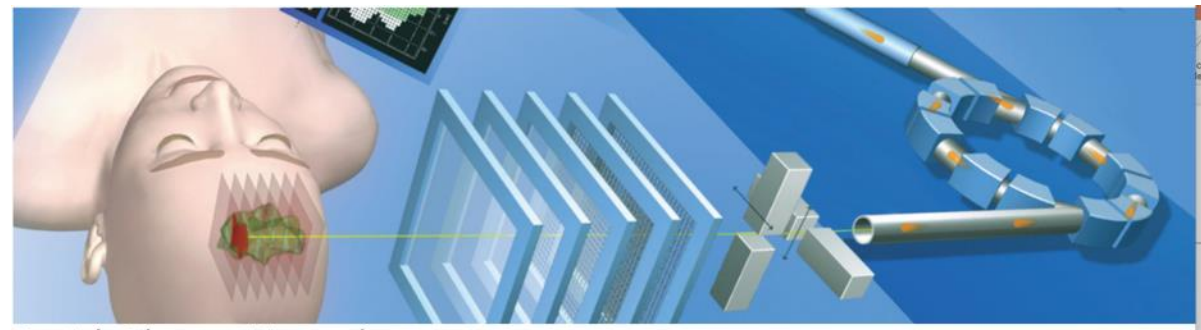


Heavy Ion Therapy Masterclass School

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

Full week course

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



Particle Therapy Masterclass

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

One day activity

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



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

HITRIplus full week heavy-ion therapy masterclass school



Heavy Ion Therapy Masterclass School



1050 registrants,
600 connections
at any given time

International MasterClasses one day activity

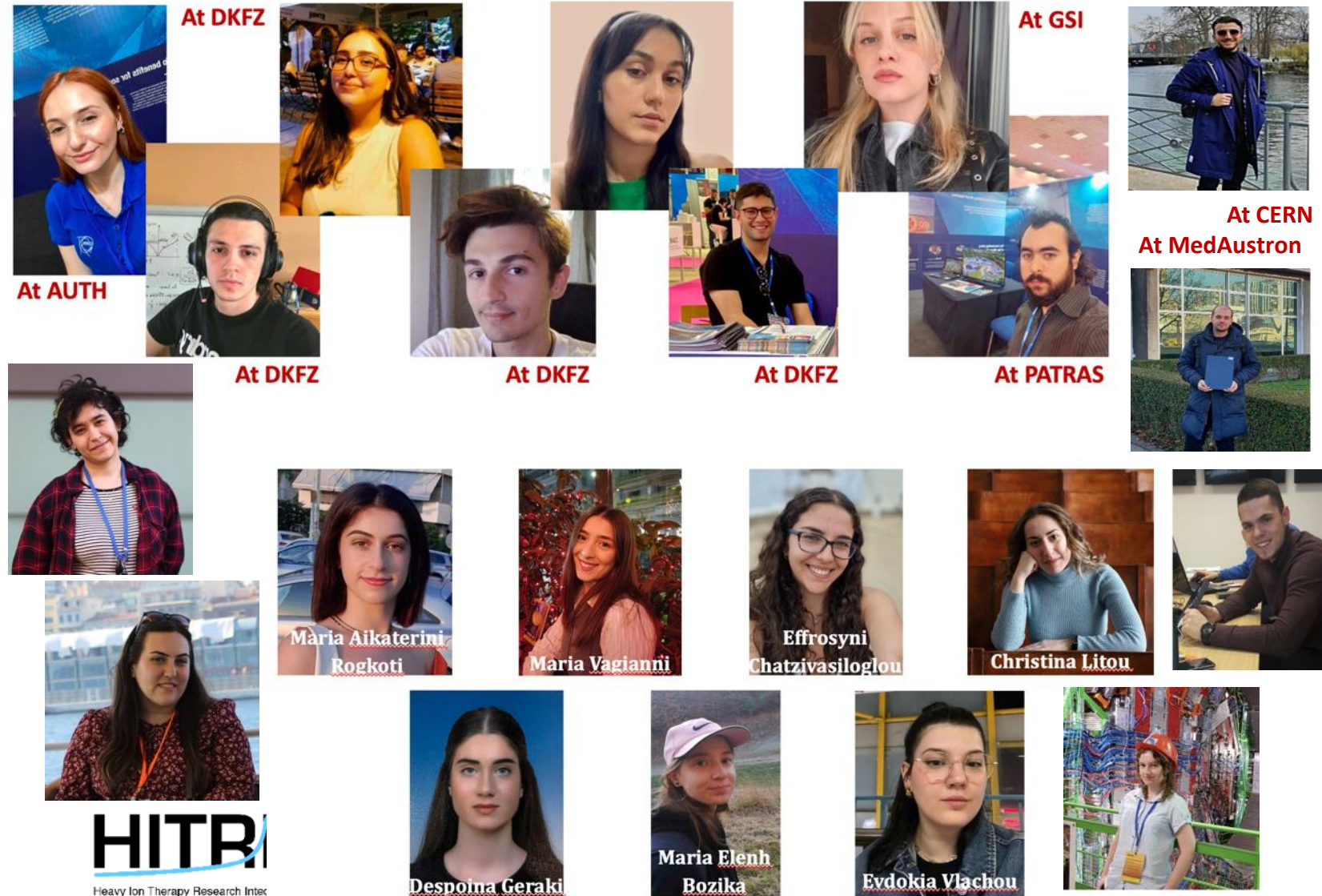


Home
Information for
High School Students
Information for

Hands on Particle Physics Masterclasses
SCHEDULE 2021

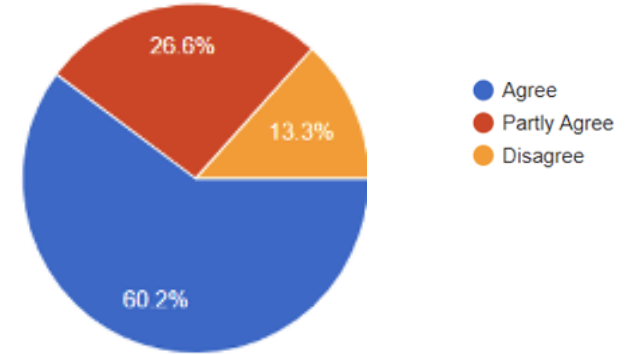


PTMC and HITRIplus school assistants

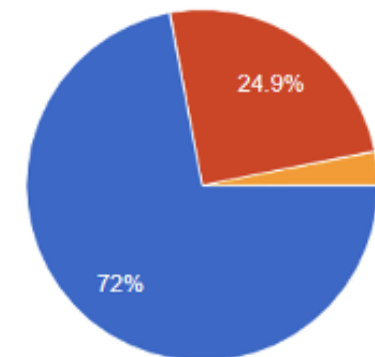


PTMC surveys cumulative

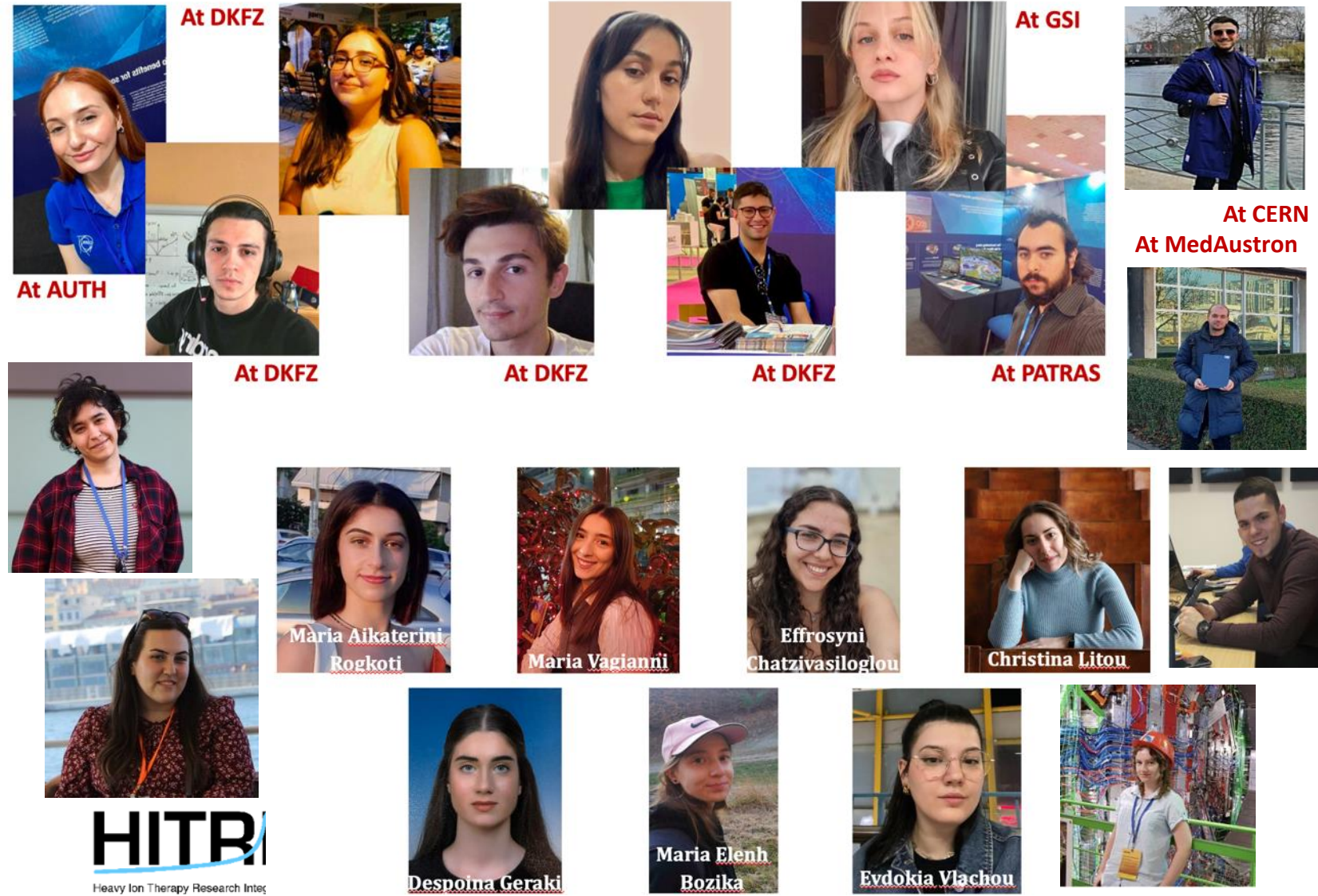
Changed your perspective regarding the job of scientists/physicists



Encouraged you to look for more information on related subjects



PTMC and HITRIplus school assistants



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



HADRON THERAPY SYMPOSIUM

STATUS AND PERSPECTIVES, PLANS FOR NEXT GENERATION FACILITIES

SAVE

18-21 OCTOBER
2024

THE

DATE

THESSALONIKI

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

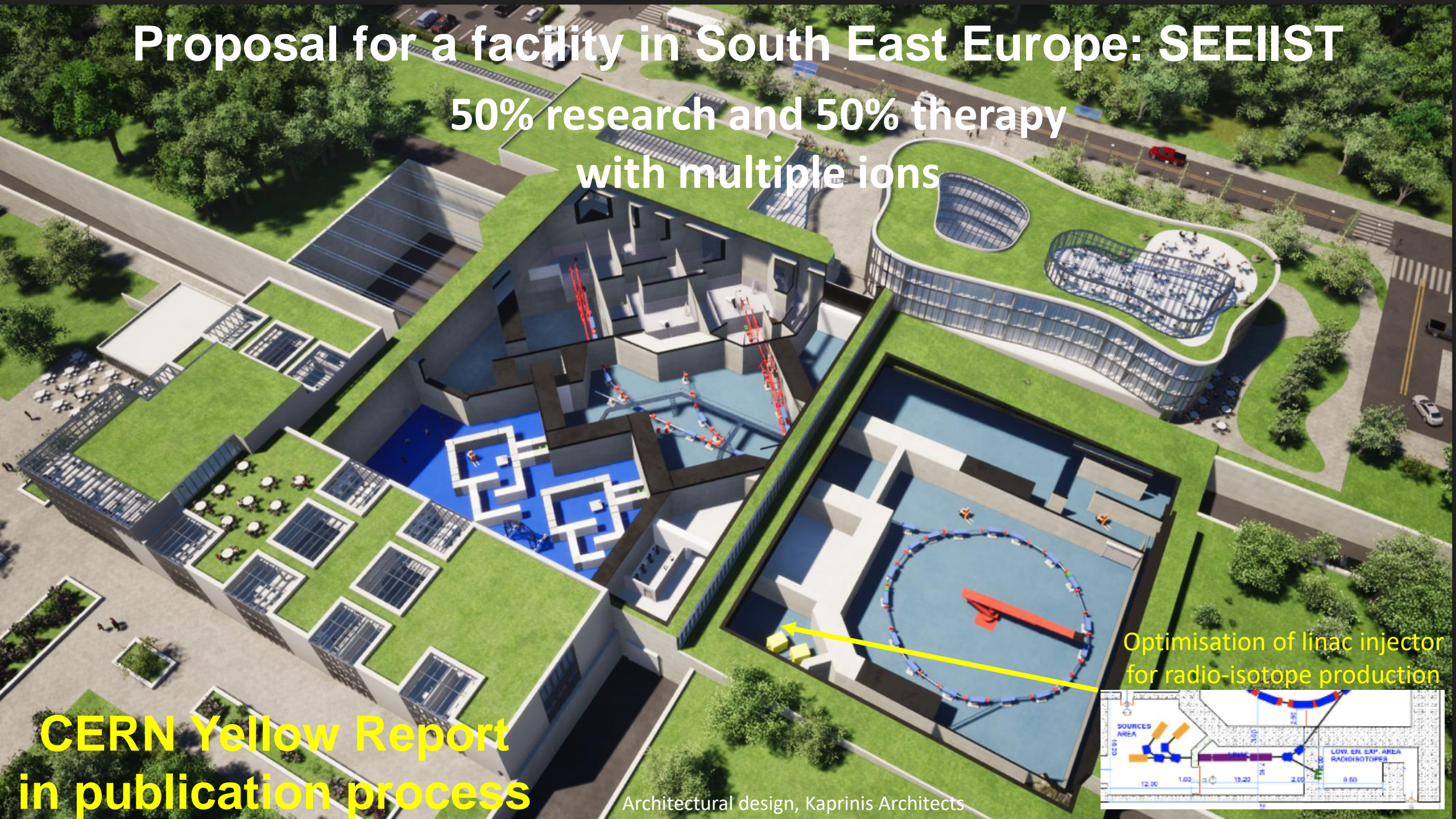


Demonstrate a return to society from investment in fundamental research

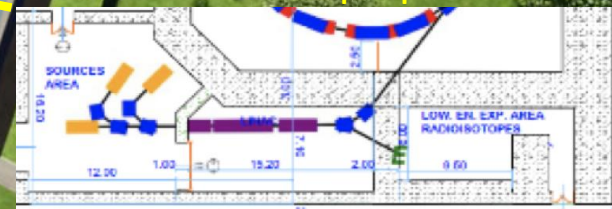
Our reward: the enthusiasm and appreciation of the students

Proposal for a facility in South East Europe: SEEIST

50% research and 50% therapy
with multiple ions



Optimisation of linac injector
for radio-isotope production



CERN Yellow Report
in publication process

IPPOG Working Group

Outreach of Applications for Society

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





Working Group

Outreach of Application for Society

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

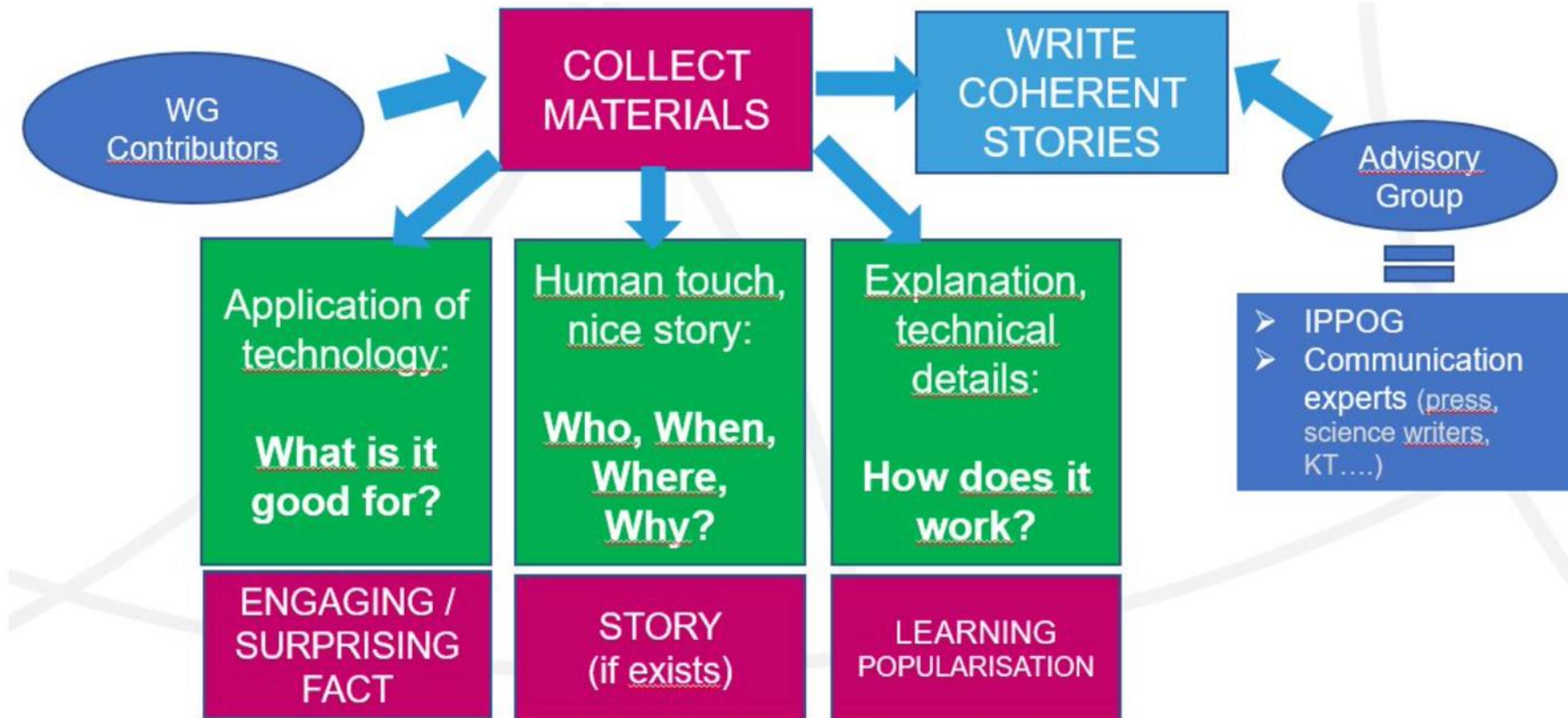
This working group focuses on collecting and making available engaging stories about concrete examples of successful applications for the benefit of society from (particle) physics and related sciences. Out of a wide range of working documents and even more ideas, the stories available so far are:

- 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

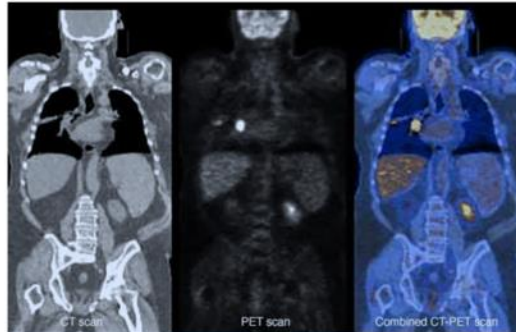
become ambassador, use them to stimulate interest for STEM studies



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](#)

We are paid to produce Knowledge !
and
Knowledge is Power

We share it empowering Students
and
the Broader Society



Thank you for your attention !

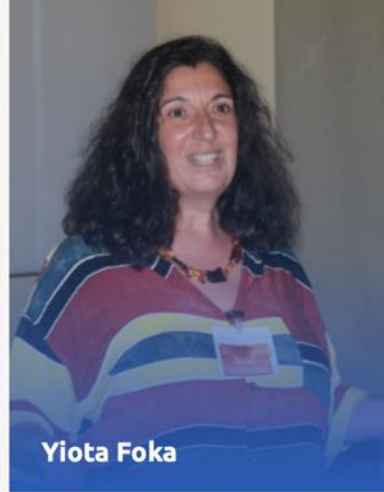
BACKUP



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.

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barbora.gulejova@cern.ch

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

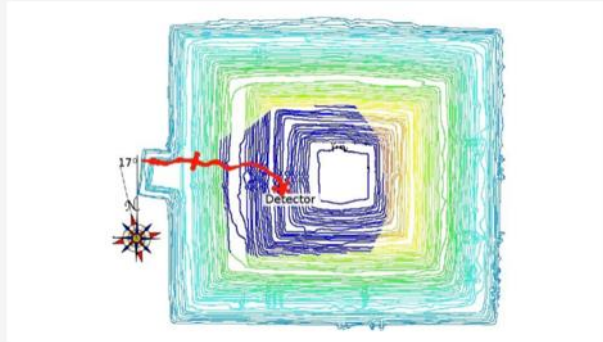
https://ippog.org/ippog_witness_stories



01 July, 2024

Accelerators to reduce pollution of maritime traffic

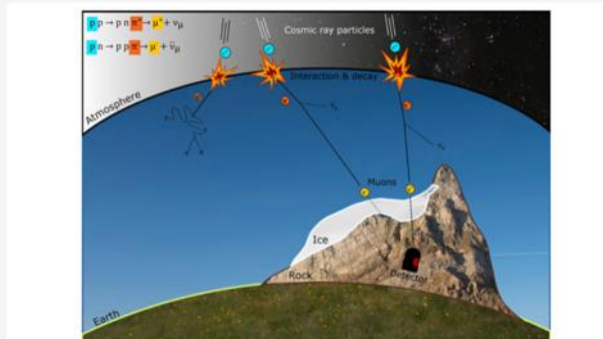
The accelerator community has a lot of examples of applications of accelerators used for the benefit of the society. One of the most unexpected applications is the pioneering use of compact modular linear accelerators for treating the exhaust gas of diesel engines of ships.



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 devices find many direct applications for society spanning from scanning lorries 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



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.

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>

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Online mode, web pages, training

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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 Vilnius, 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

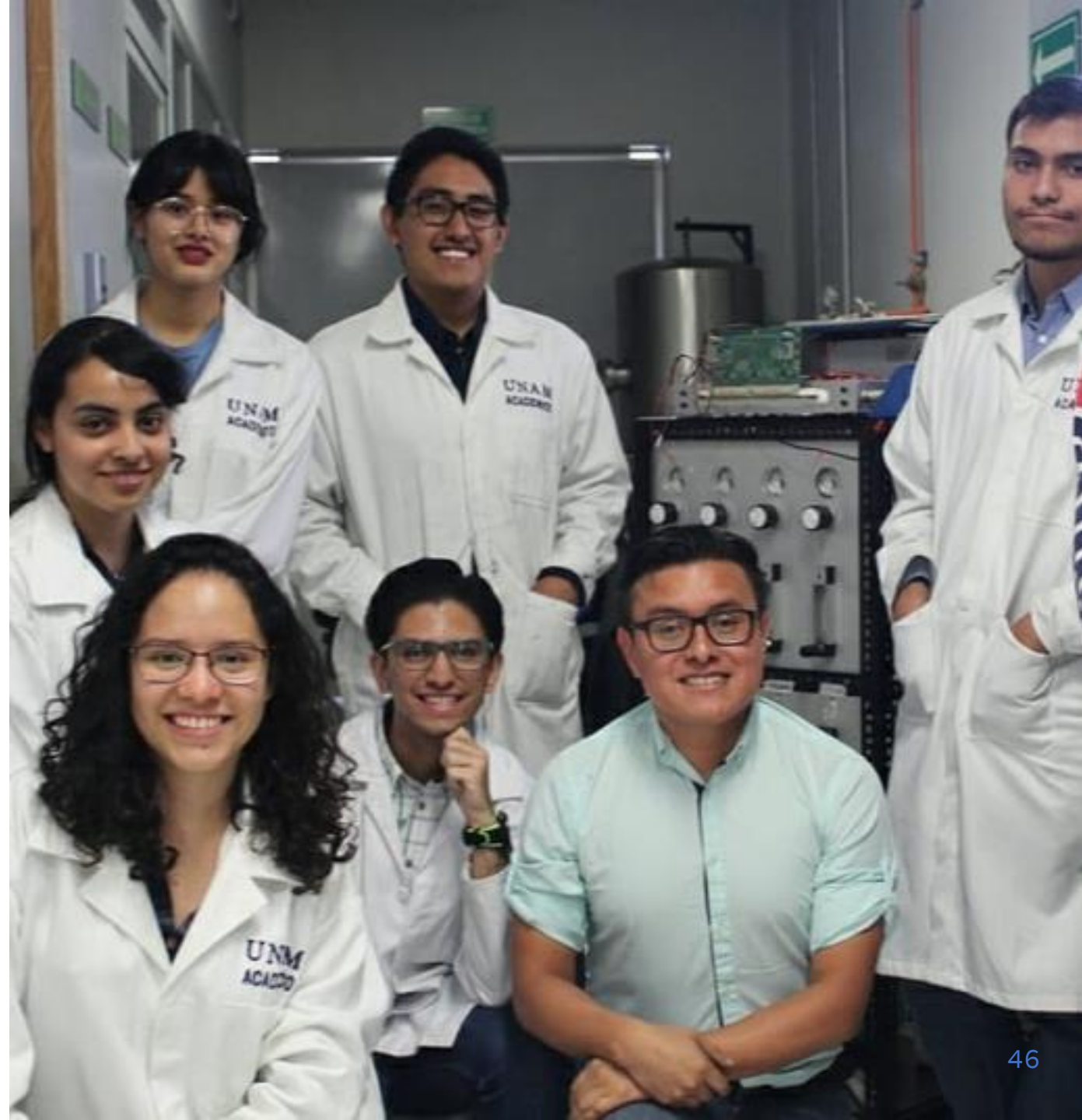


It is inspiring to young students.

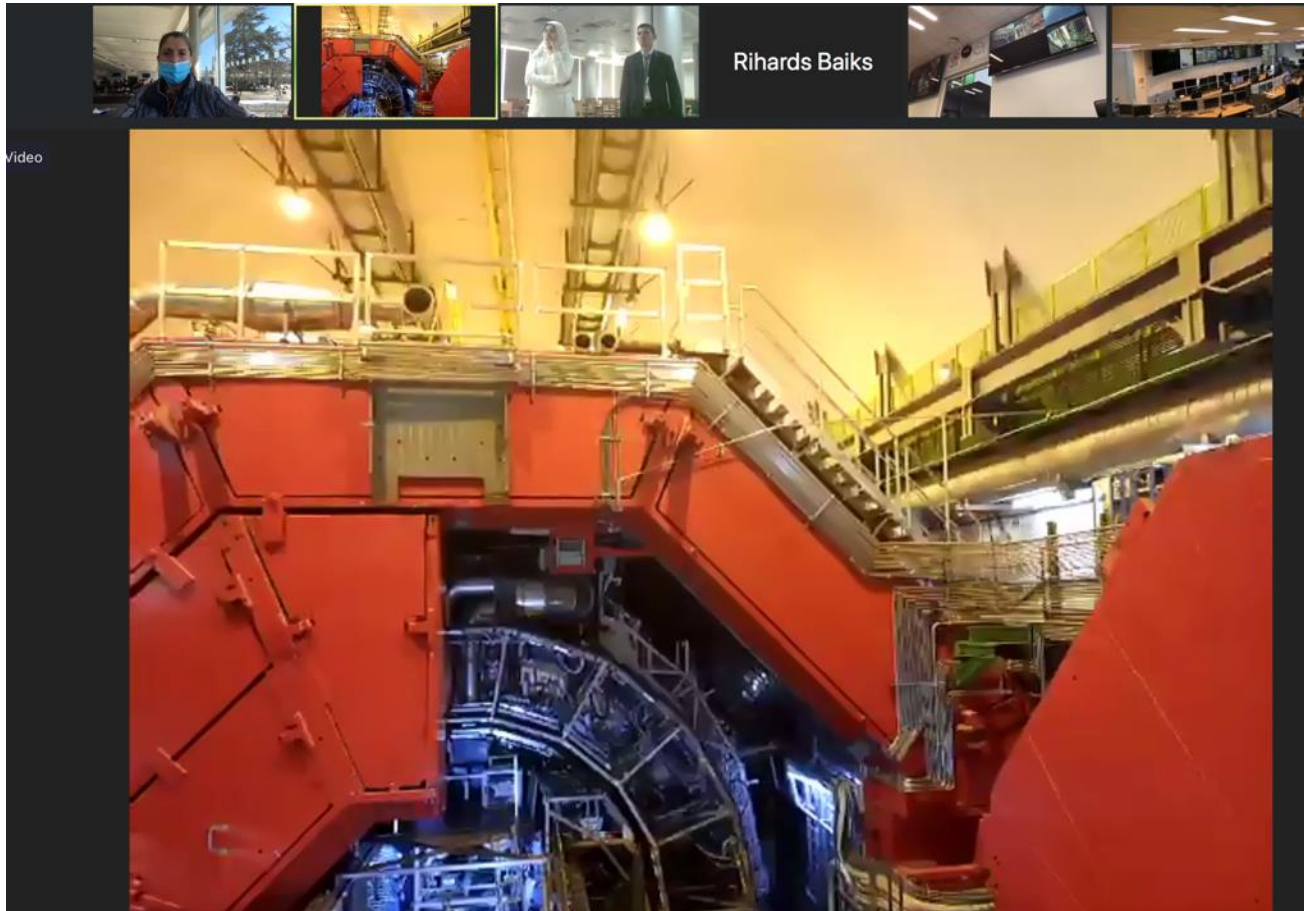
This could mean more professionals in STEM topics

Noteworthy fact:

now we collaborate in UNAM with our IMC tutors



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/N48YCJii1lo>

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