

# 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



## Particle Therapy MasterClass

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

**Contacts:**  
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Tangible examples of connecting  
fundamental research and everyday life

Working Group

## Outreach of Application for Society

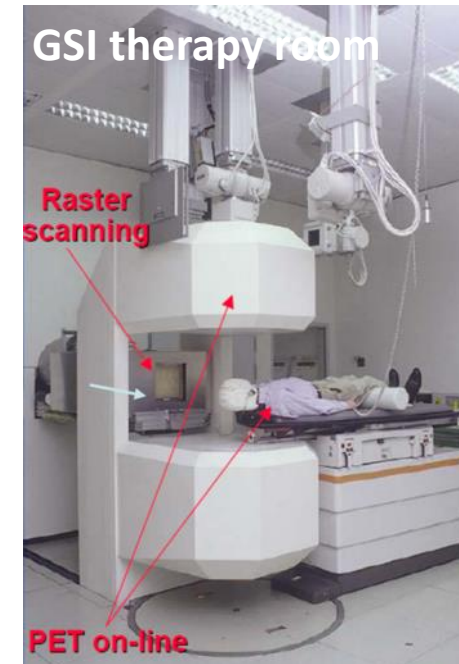
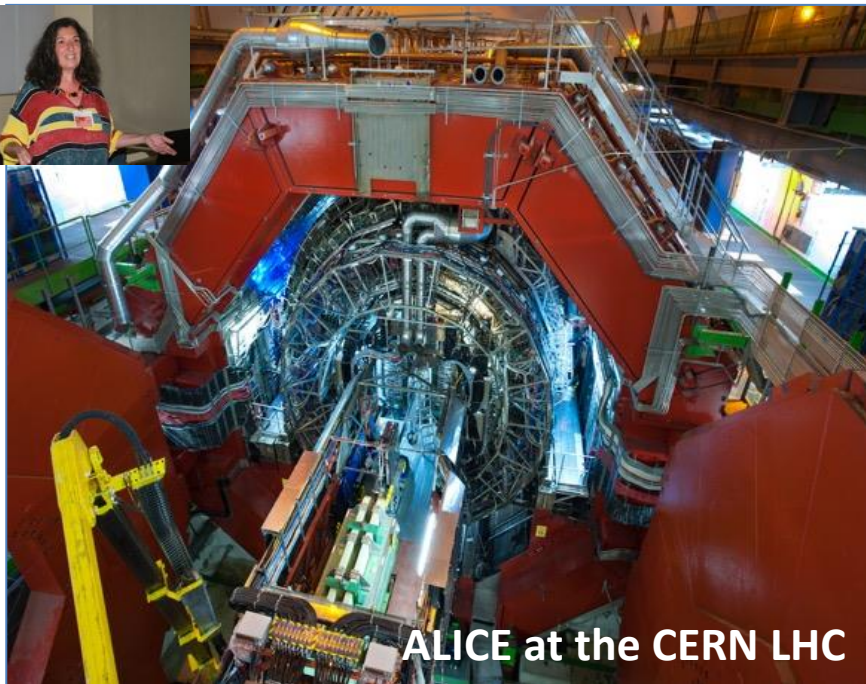
<https://ippog.org/for-ippogers/outreach-application-society>

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[barbora.gulejova@cern.ch](mailto: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



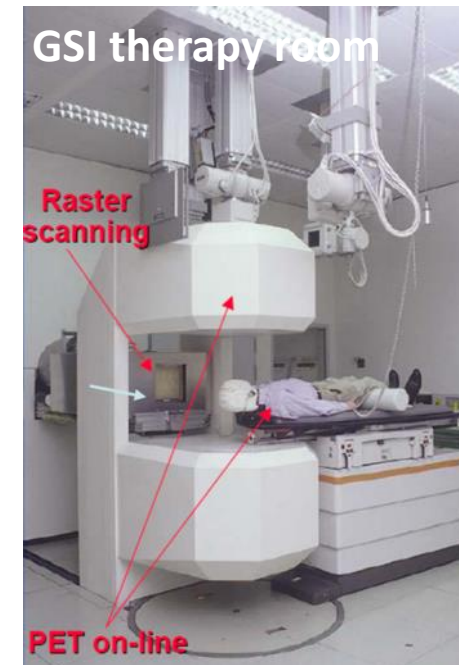
Mission and mandate of research institutes: fundamental research  
Developed technologies and acquired knowledge find applications for society

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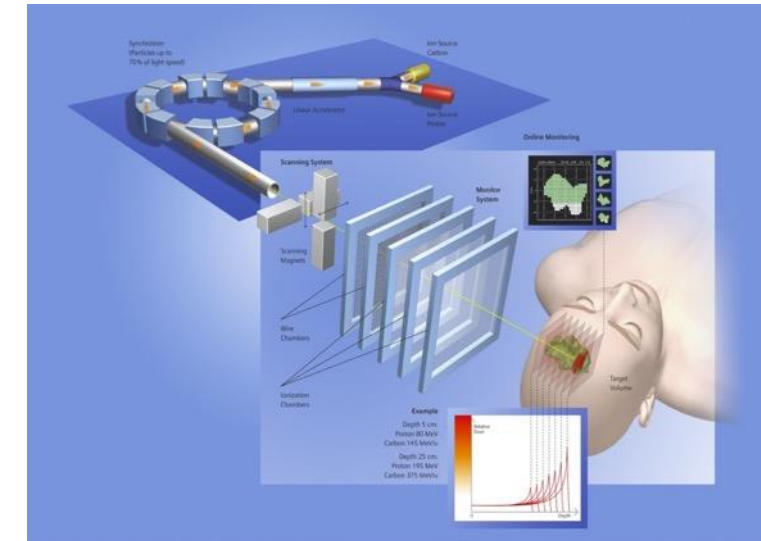
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Heidelberg Ion Therapy HIT centre

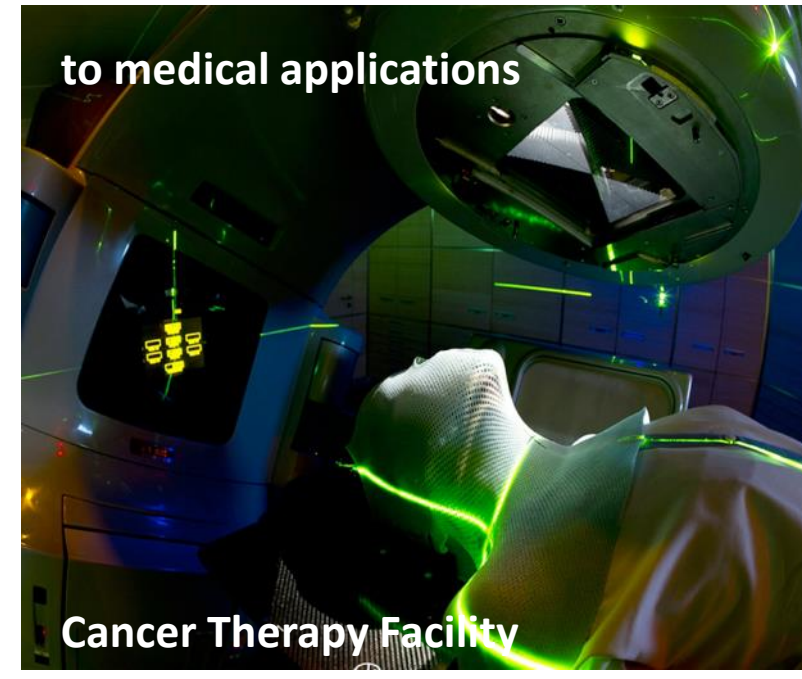


Implemented at HIT, Heidelberg Ion Therapy centre

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

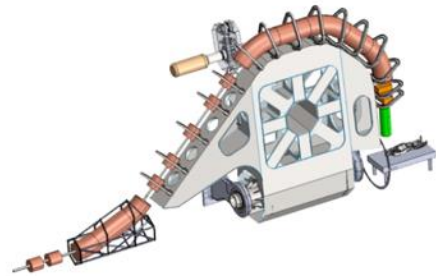
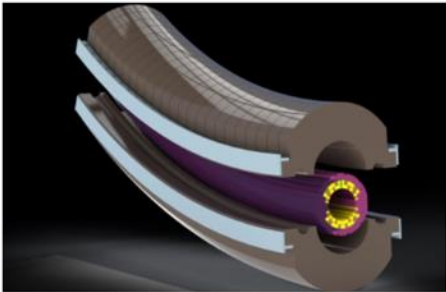
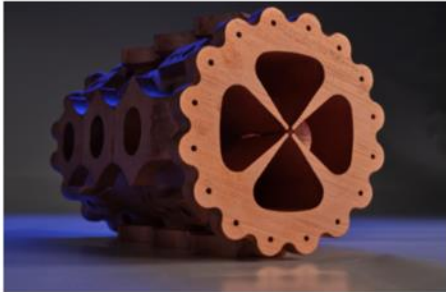
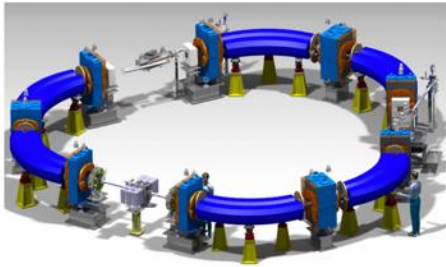


Mission and mandate of research institutes: fundamental research  
Developed technologies and acquired knowledge find applications for society

# Next Ion Medical Machine Study Group Developments

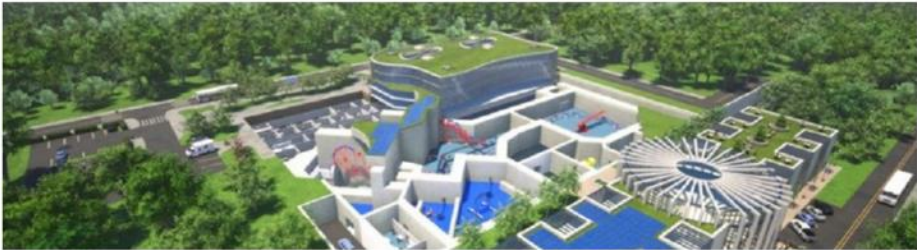


## Our Technological R&D



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



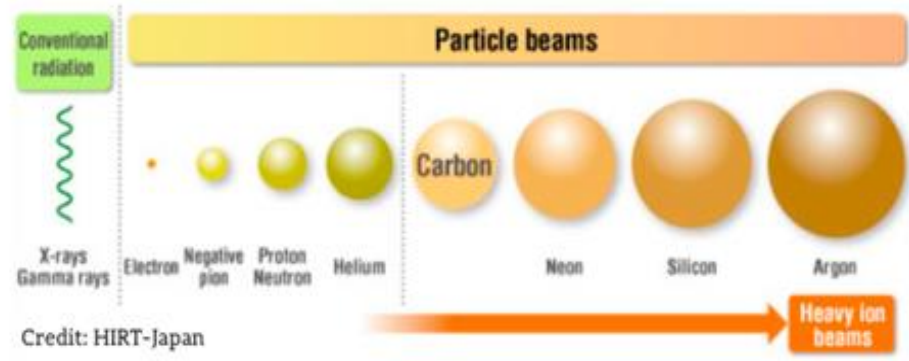
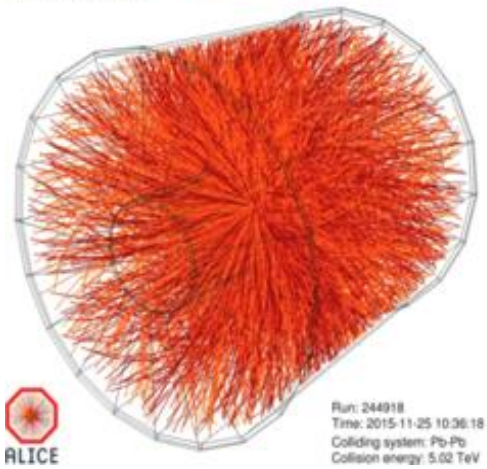
<b>APTCB</b> Advanced Particle Therapy Center for the Baltics	<b>SEEIIST</b> South East European International Institute for Sustainable Technologies
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# Heavy-ion research and heavy-ion therapy

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



Credit: CERN



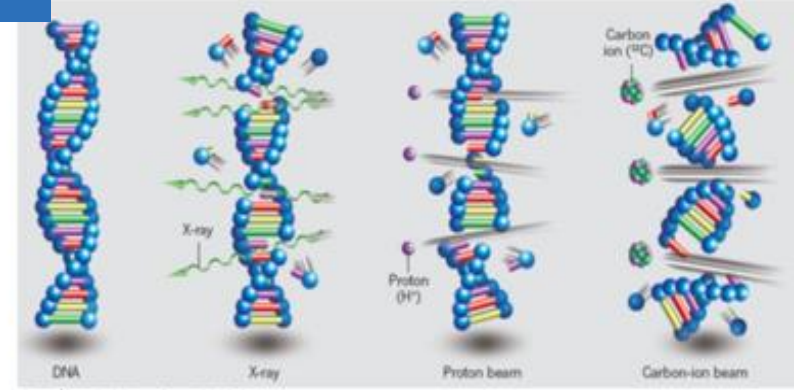
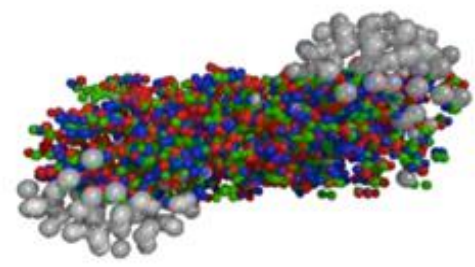
88-430 MeV/u carbon  
50-221 MeV/u protons

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



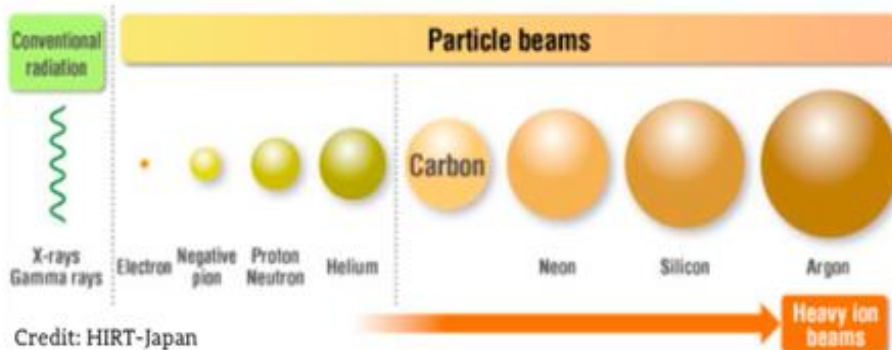
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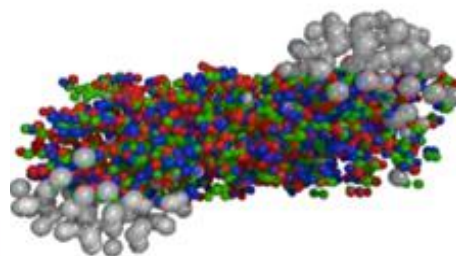
Credit: HIRT-Japan

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

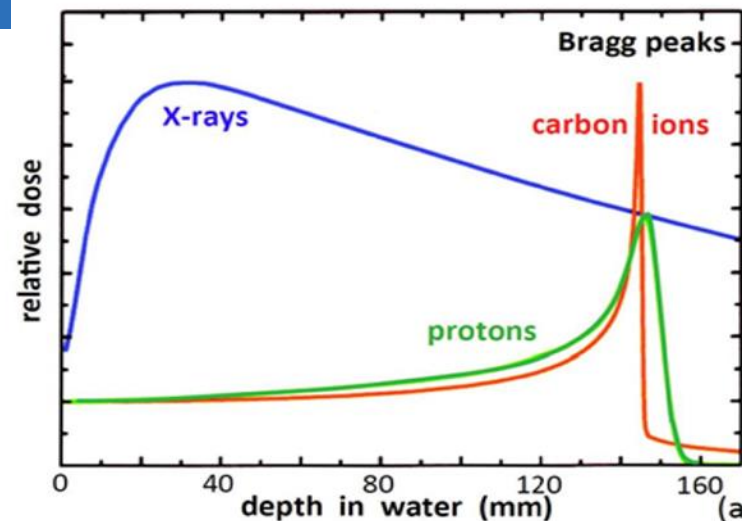
applied science  
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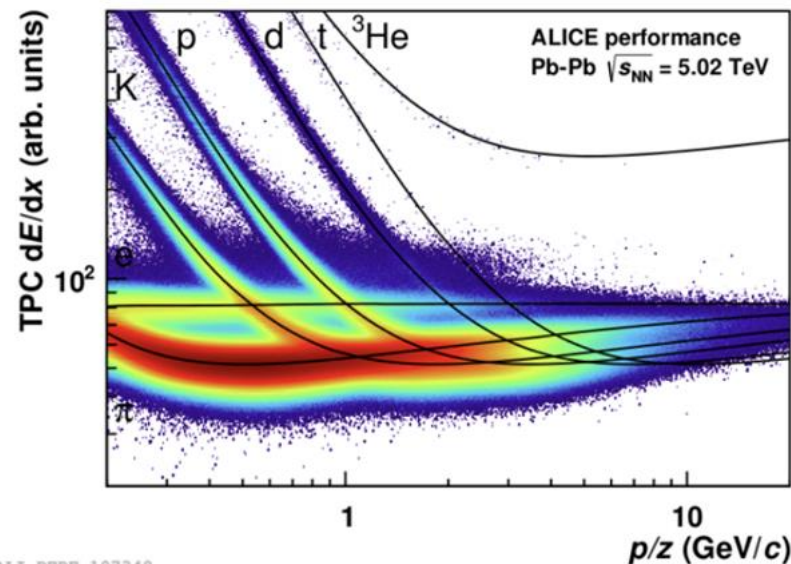
What Physics  
has to do  
with Medicine?



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



to Bragg peak for cancer therapy



# 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



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

# 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

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

Importance of collaboration for common projects

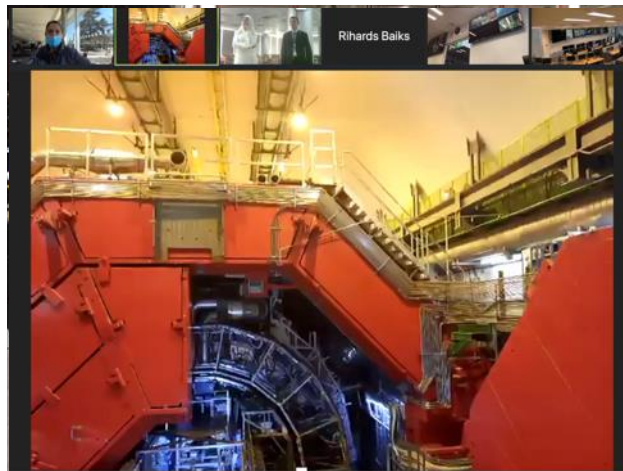
## Local: Morning Presentations



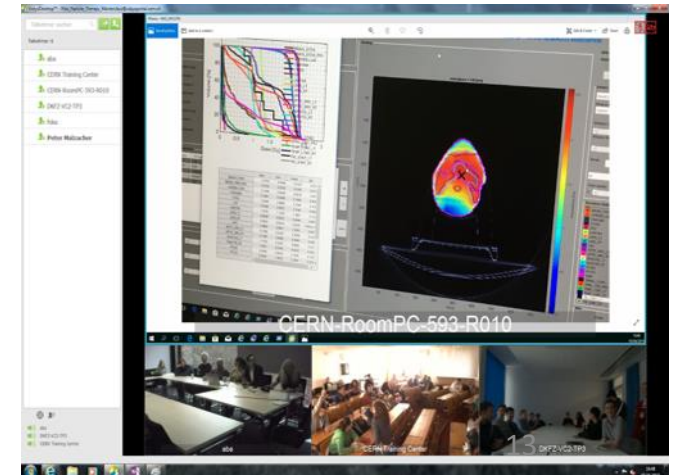
## Local: Afternoon Hands-on



## Local: Morning Visits real-time online ALICE visit



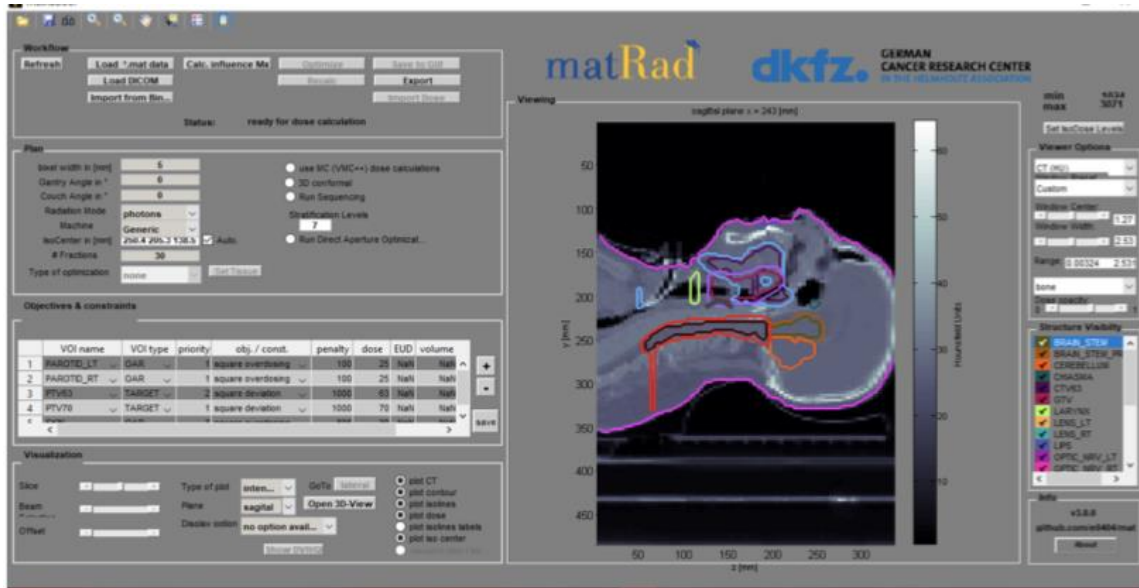
## Common: Afternoon at 16:00 Video-Conference



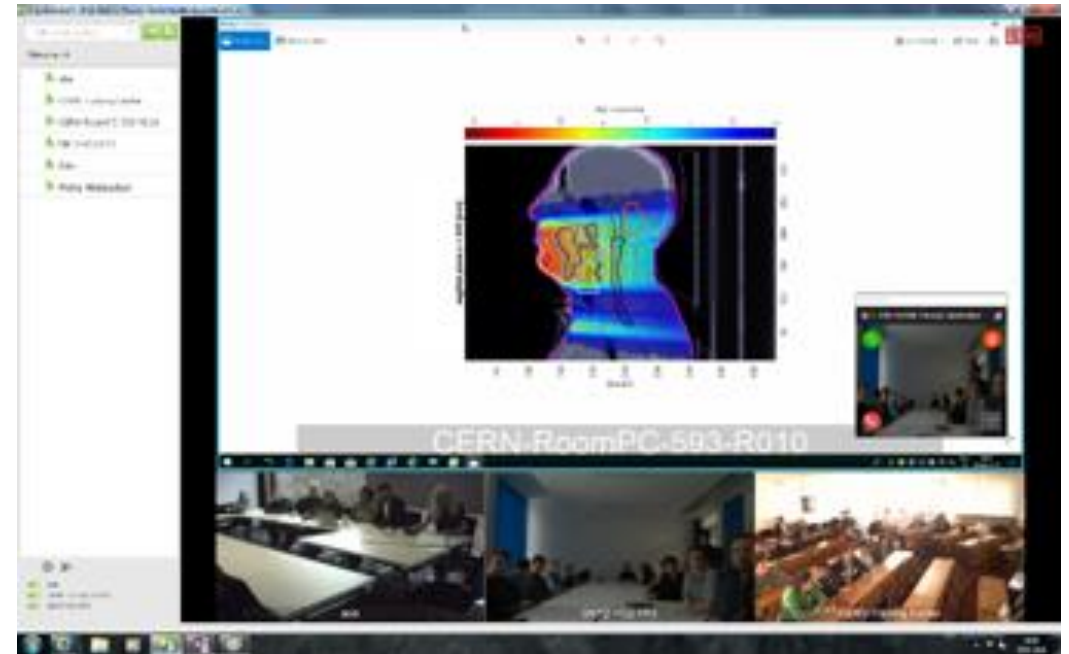
# PTMC hands-on Treatment Planning

Based on professional open source treatment planning: **matRad**  
developed by DKFZ, Heidelberg [www.matrad.org](http://www.matrad.org)

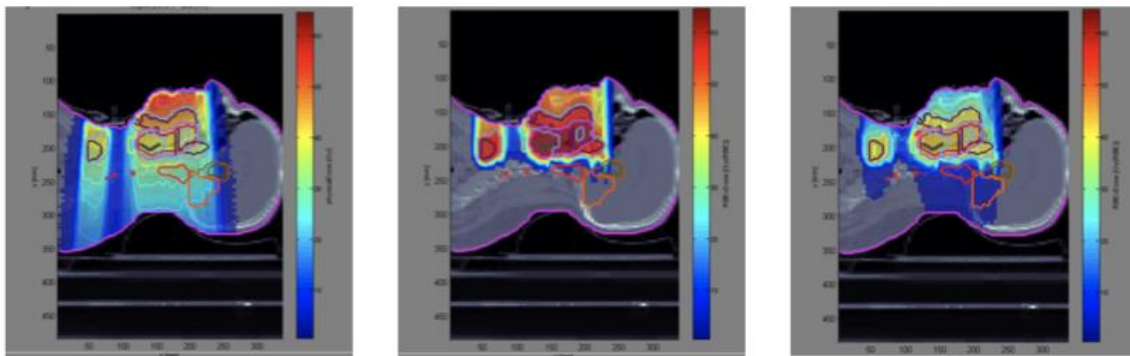
Simplified version for PTMC



Dose prescription  
using photons, protons and carbon ions



Demo<sup>4</sup> 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

LIVE on Custom Live Streaming Service Recording

GSI moderators CNAO moderator medAustron moder.

Christian Graeff Marco Pullia

U. Amaldi: HI therapy pioneer

ed è sufficiente perché esse effettuino i primi giri all'interno del sincrotrone che ha un diametro di 25 metri ed una circonferenza di 80 metri.

HITRIplus EU-funded project

GSI (Germany)

Levan Kankadze

Participants (63)

# PTMC supporting females in STEM

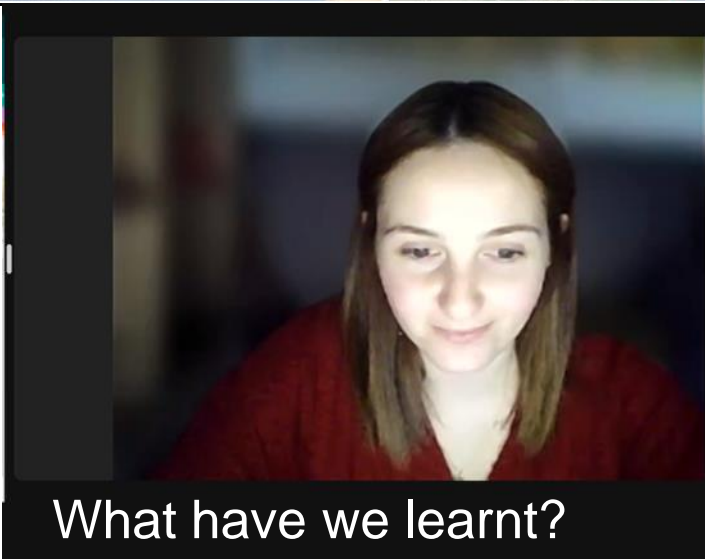
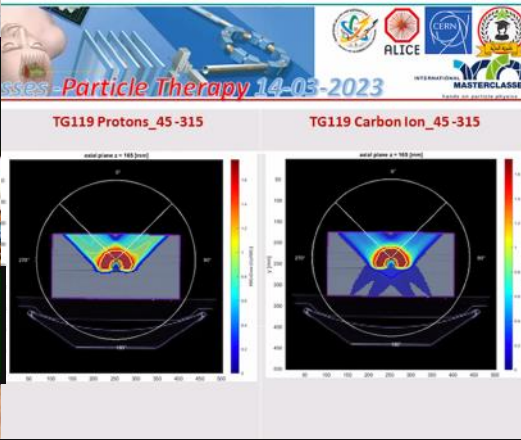


PTMC Video Conference 15 March

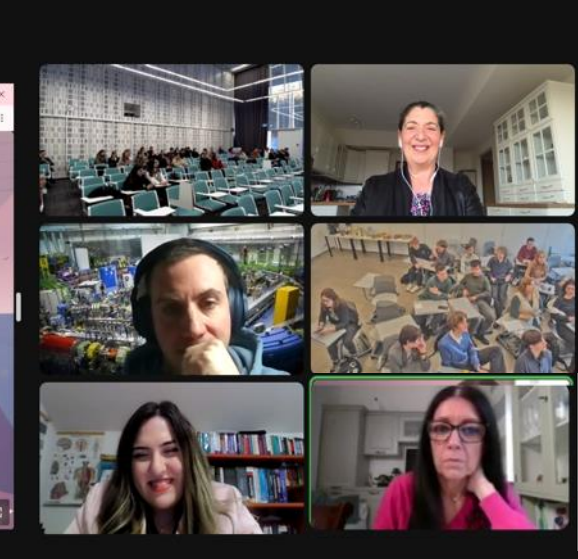
Logos: GSI, FAIR, EMMI, dkfz, CERN, INTERNATIONAL MASTERCLASSES, IPG

Map showing locations: Belgium, Prague, Austria, France, Serbia, Bulgaria, India (Nagpur, ODISHA), Mexico (Guadalajara, Mexico City), Texas (San Antonio, Monterrey).

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](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:

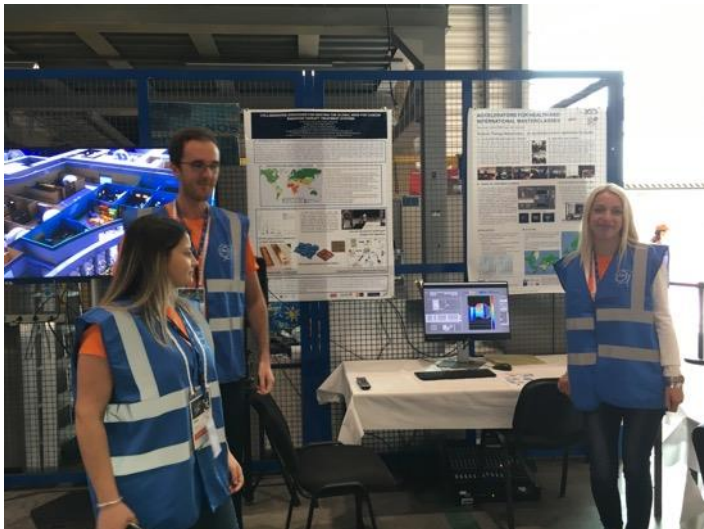
- in-person at university
- in-person at schools
- common lectures online

# PTMC and matRad Treatment Planning

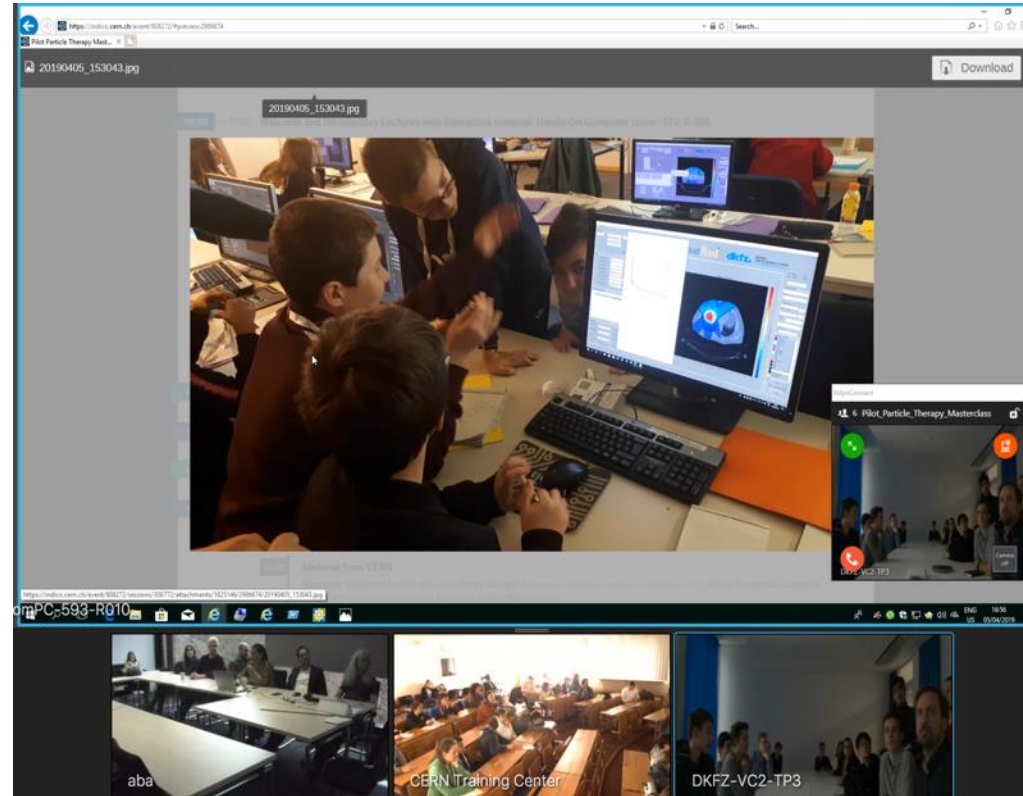
## First Local Test: GSI Feb 2019



## 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>



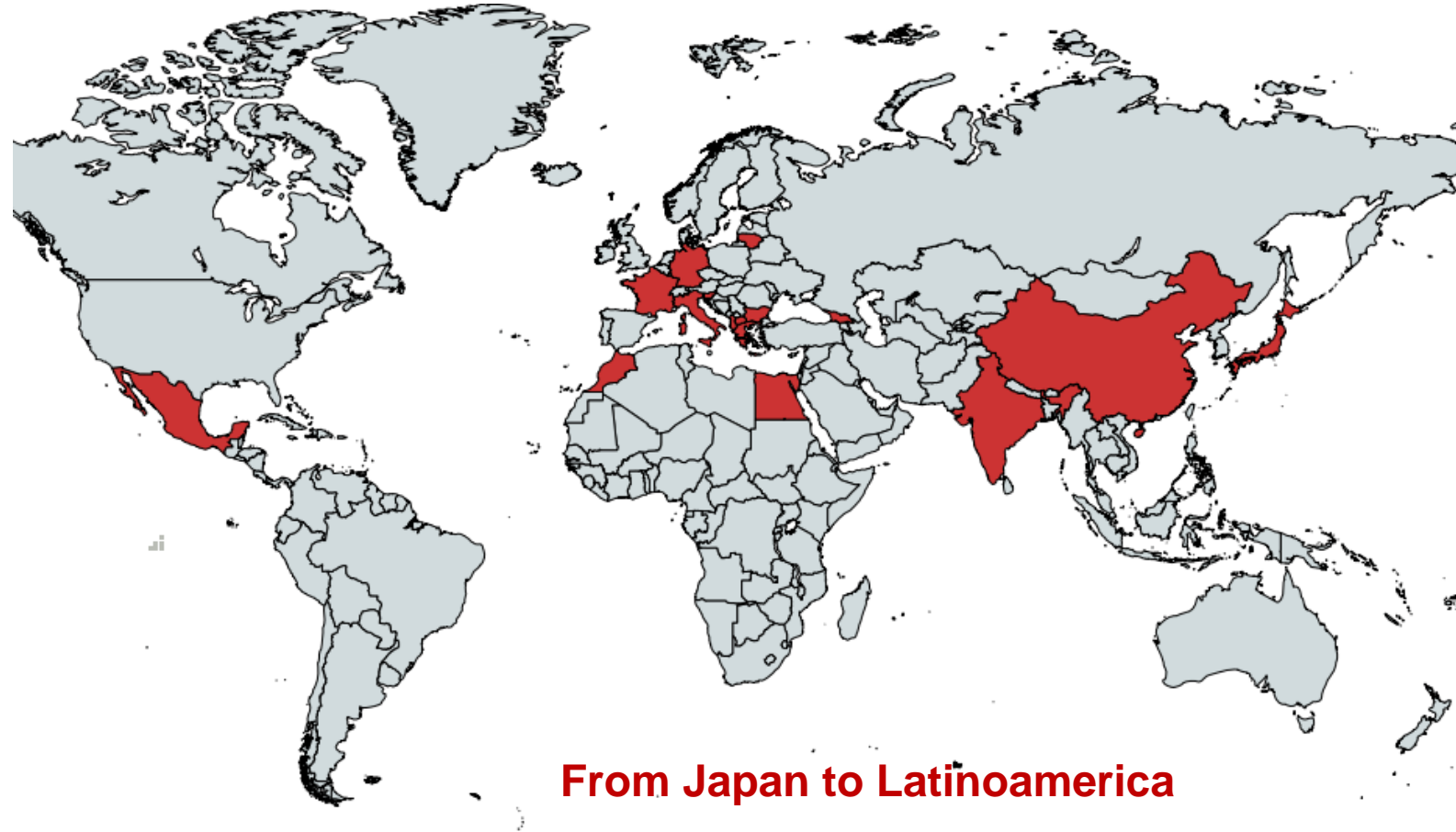
**PTMC2022 online/hybrid:  
6 sessions, 1500 students  
from 22 countries and 37 institutes**

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>



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**

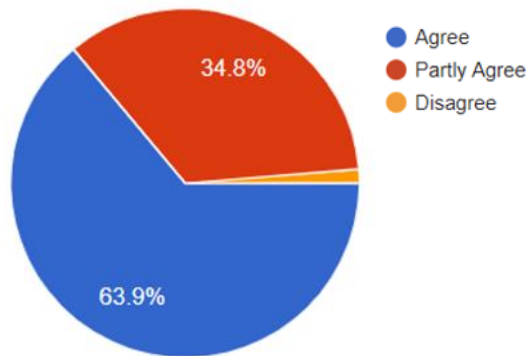
<https://indico.cern.ch/e/PTMC>

Statistics of 22 out of 47 institutes:

Total: 1567

428 female, 430 male

17 in person, 5 hybrid



Some institutes had 2 sessions  
in-person and online

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>





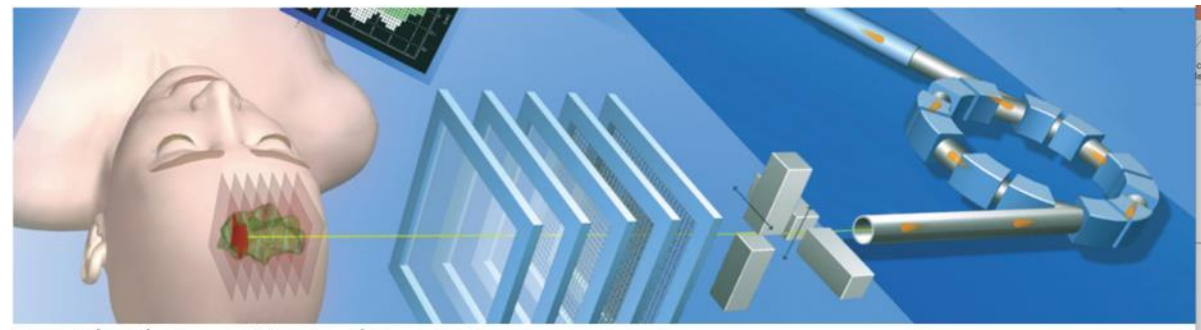


Heavy Ion Therapy Masterclass School

<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)



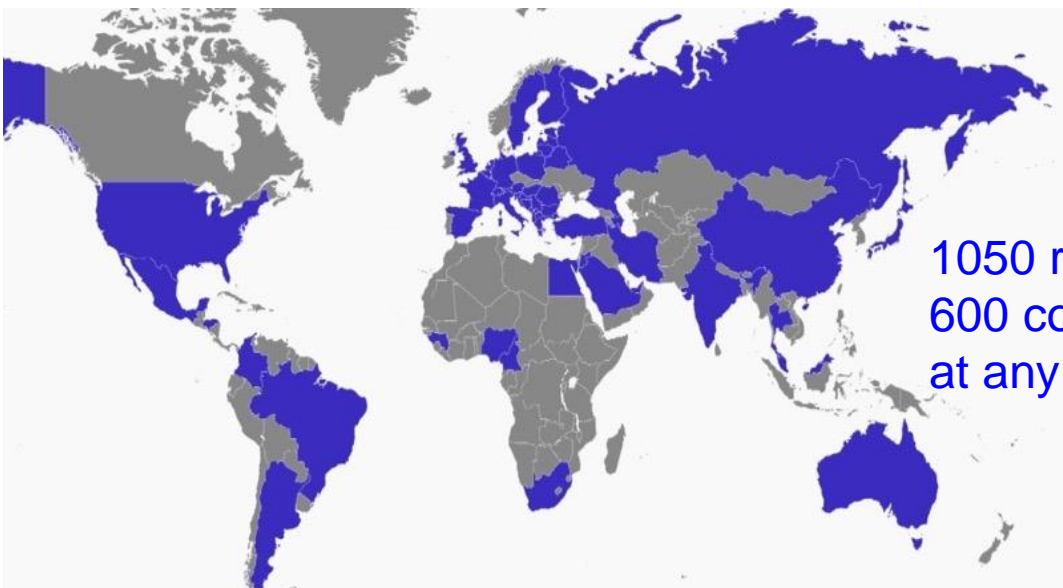
Different options studying physics, for example accelerator physics, medical physics, bio-physics... that can provide interesting career paths in upcoming fields where there is lack of specialised personnel

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

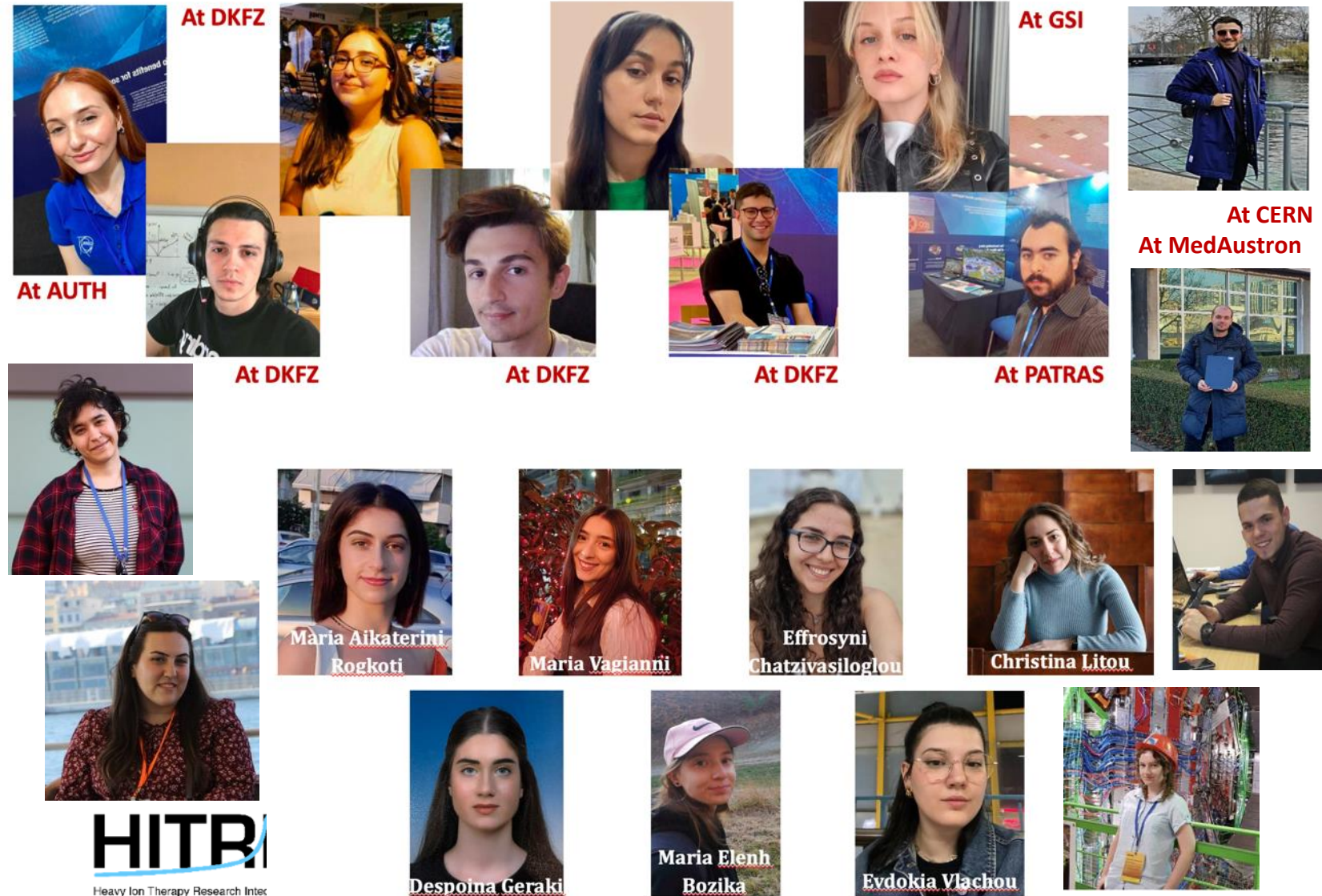


Home  
Information for  
High School Students  
Information for

Hands on Particle Physics Masterclasses  
**SCHEDULE 2021**

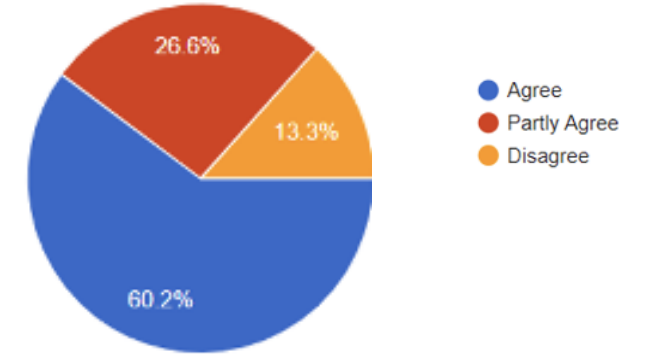


# PTMC and HITRIplus school assistants

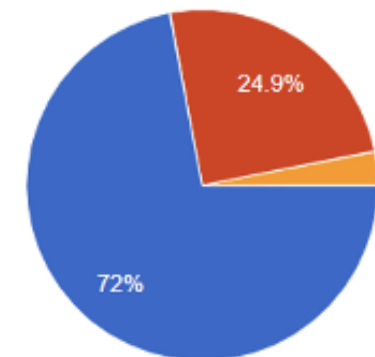


## PTMC surveys cumulative

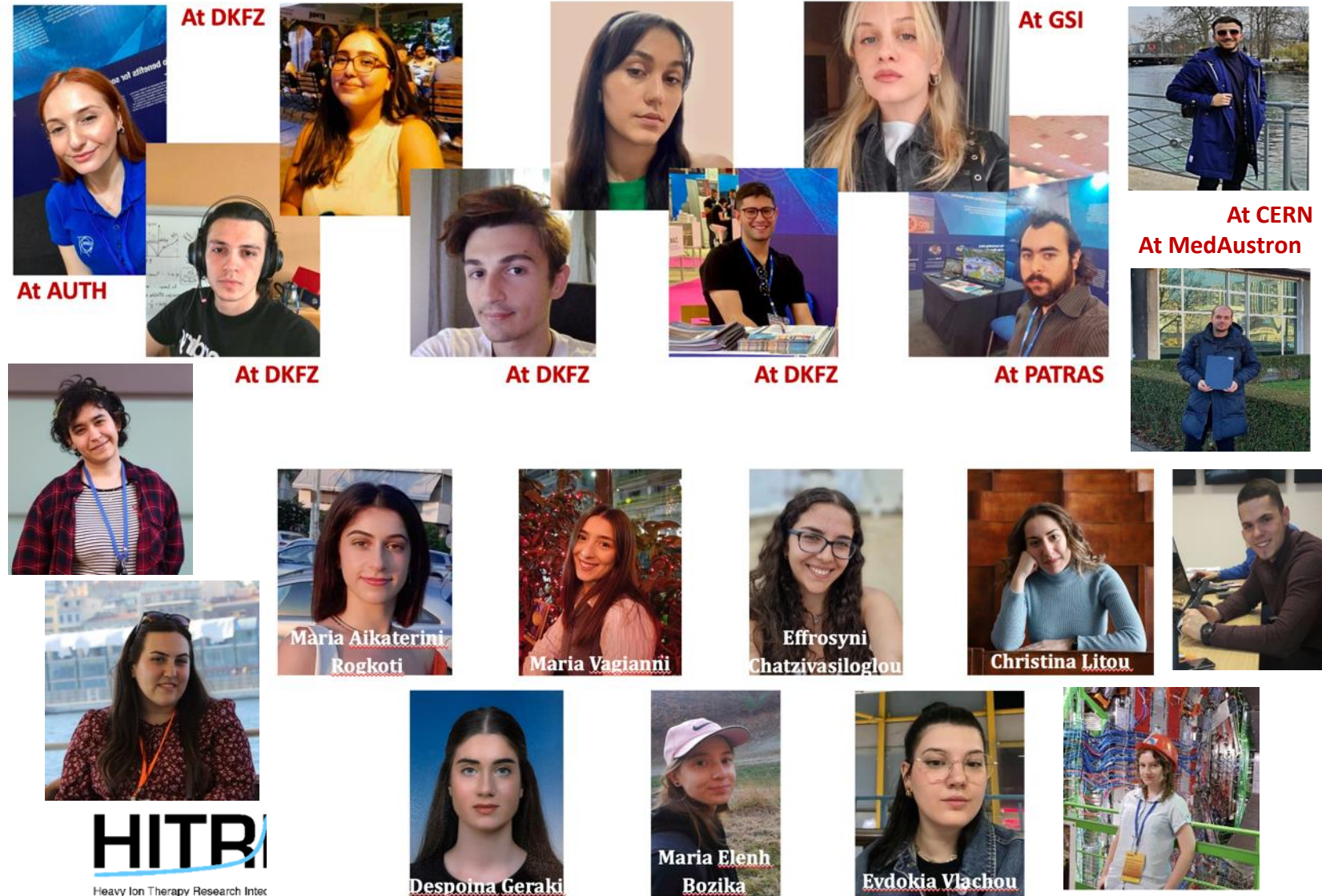
Changed your perspective regarding the job of scientists/physicists



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**

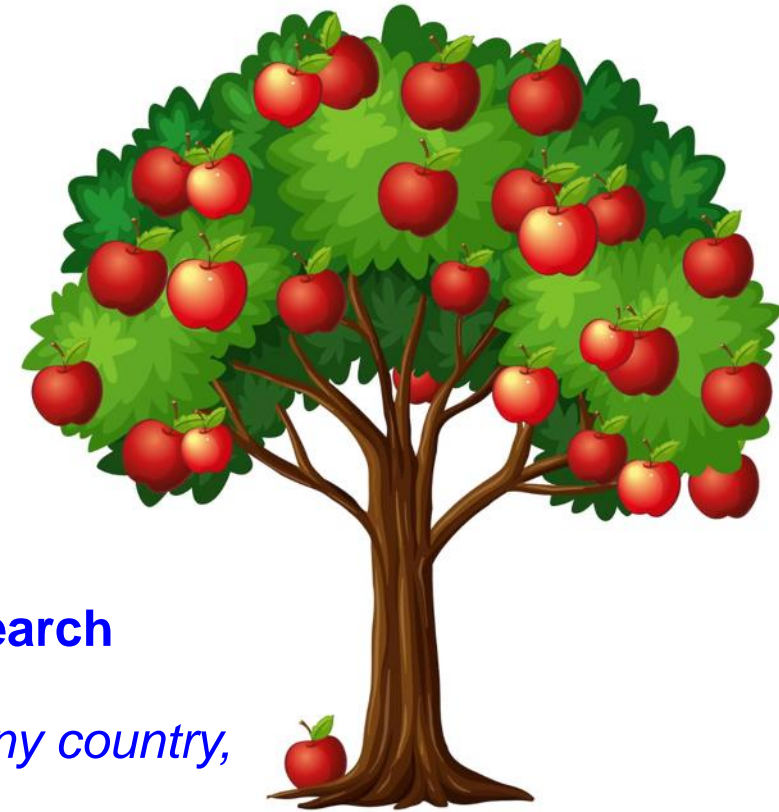
**THESSALONIKI**

# 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**

## 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>

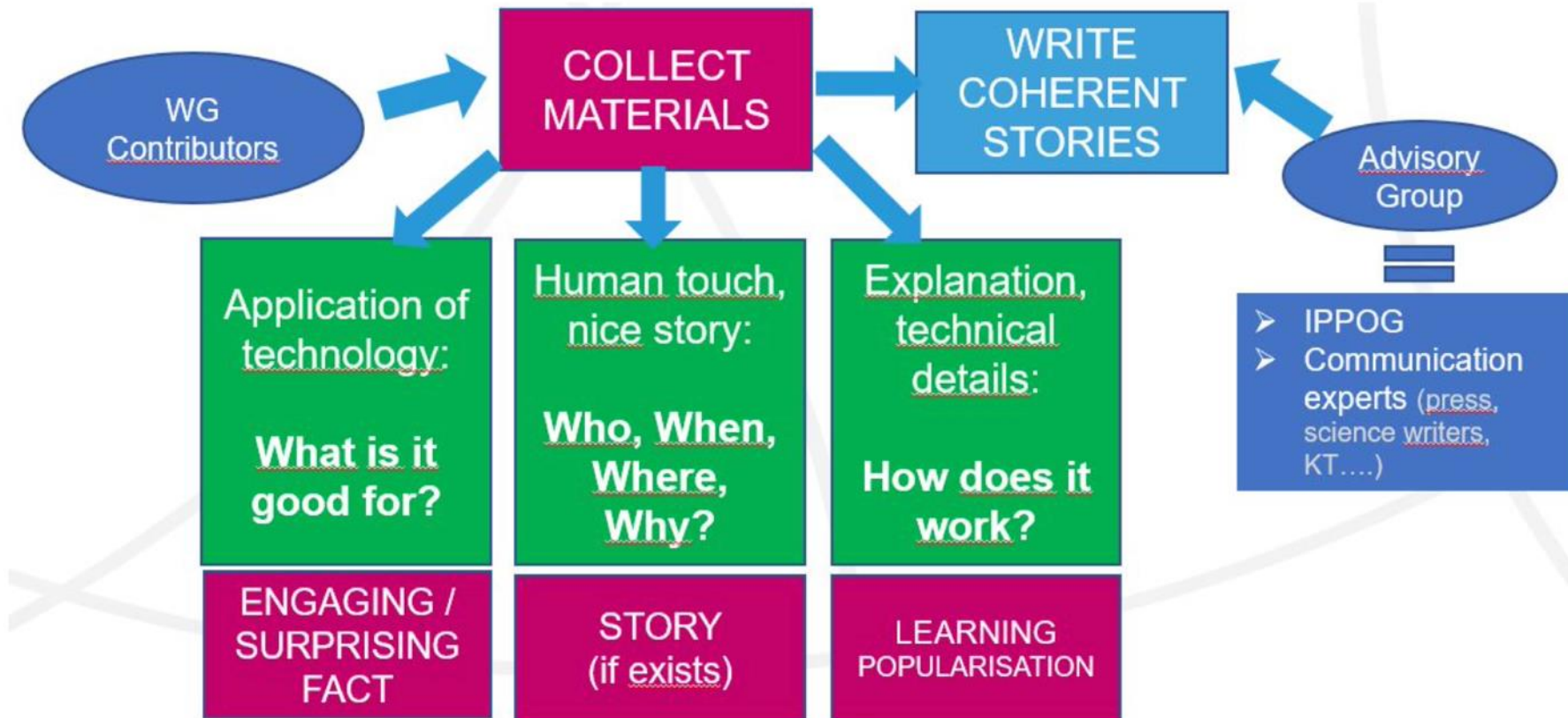
This working group focuses on collecting and making available engaging stories about concrete examples of successful applications for the benefit of society from (particle) physics and related sciences. Out of a wide range of working documents and even more ideas, the stories available so far are:

- 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



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

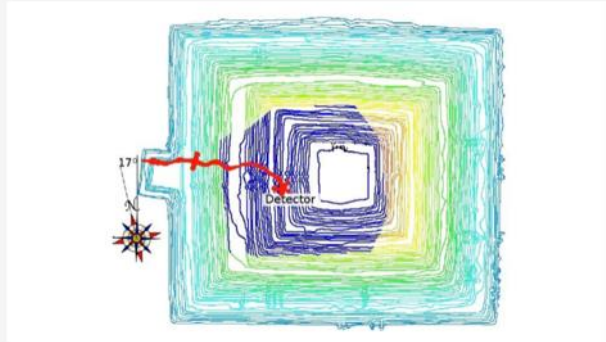
[https://ippog.org/ippog\\_witness\\_stories](https://ippog.org/ippog_witness_stories)



01 July, 2024

### **Accelerators to reduce pollution of maritime traffic**

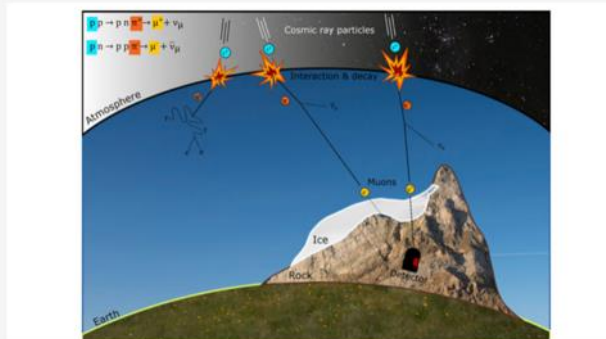
*The accelerator community has a lot of examples of applications of accelerators used for the benefit of the society. One of the most unexpected applications is the pioneering use of compact modular linear accelerators for treating the exhaust gas of diesel engines of ships.*



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

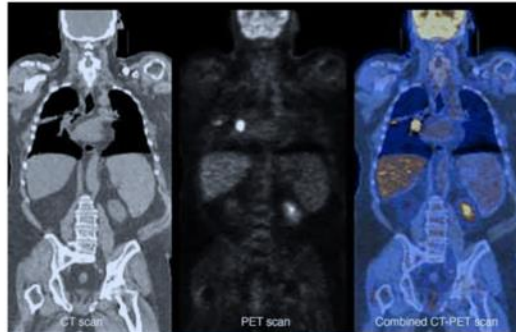
become ambassador, use them to stimulate interest for STEM studies



## 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

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

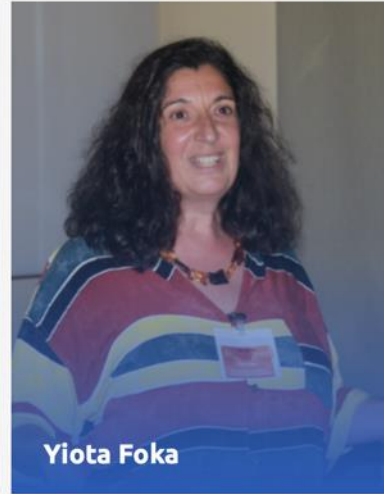
## Unraveling Cosmic Mysteries: the collaboration between ISS and CERN

*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.*

## Conveners



Barbora Bruant Gulejova



Yiota Foka

Thank you  
for your attention!

## Working group members

## Contributions Welcome!

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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](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](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](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

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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

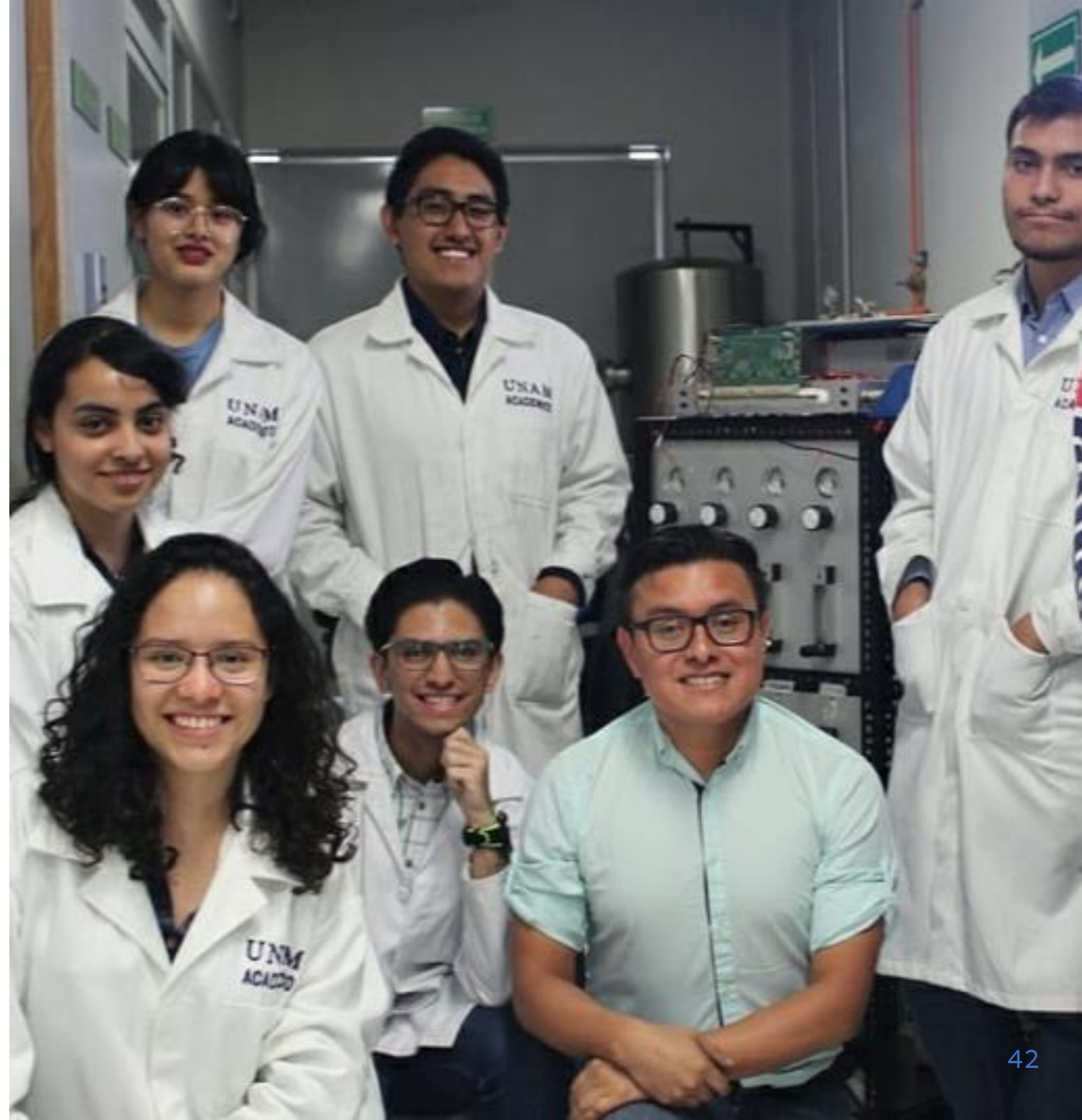


It is inspiring to young students.

This could mean more professionals in STEM topics

Noteworthy fact:

now we collaborate in UNAM with our IMC tutors





# International Masterclasses

**ATLAS**

**ALICE**

**CMS**

**Belle II**

**LHCb**

**MINERVA**

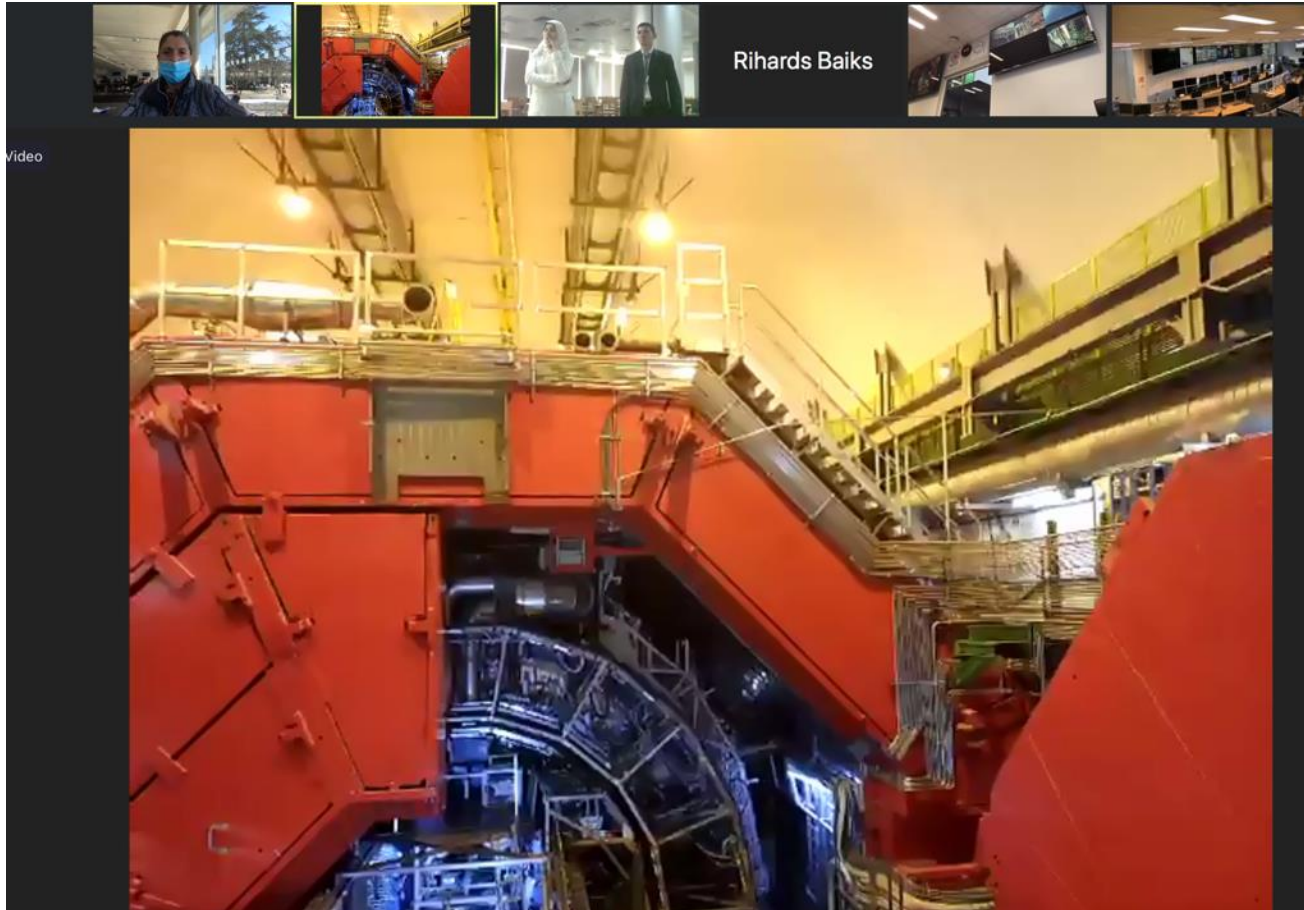
Coordinated and moderated by GSI

Particle Therapy

**Pierre Auger Observatory**



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



16:00

#### Virtual Visit

Particle accelerator: <https://youtu.be/DtOsEPwtSkQ>

Tumor therapy: <https://youtu.be/2KUzT7YZzTA>

HIT: [https://youtu.be/Fw9H\\_hceNIA](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.

<b>Research</b>		<b>6%</b>
	<u>Particle Physics</u>	0,5%
	<u>Nuclear Physics, solid state, materials</u>	0,2 - 0,9%
	<u>Biology</u>	5%
<b>Medical Applications</b>		<b>35%</b>
	<u>Diagnostics/treatment with X-ray or electrons</u>	33%
	Radio-isotope production	2%
	<u>Proton or ion treatment</u>	0,1%
<b>Industrial Applications</b>		<b>&lt;60%</b>
	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%