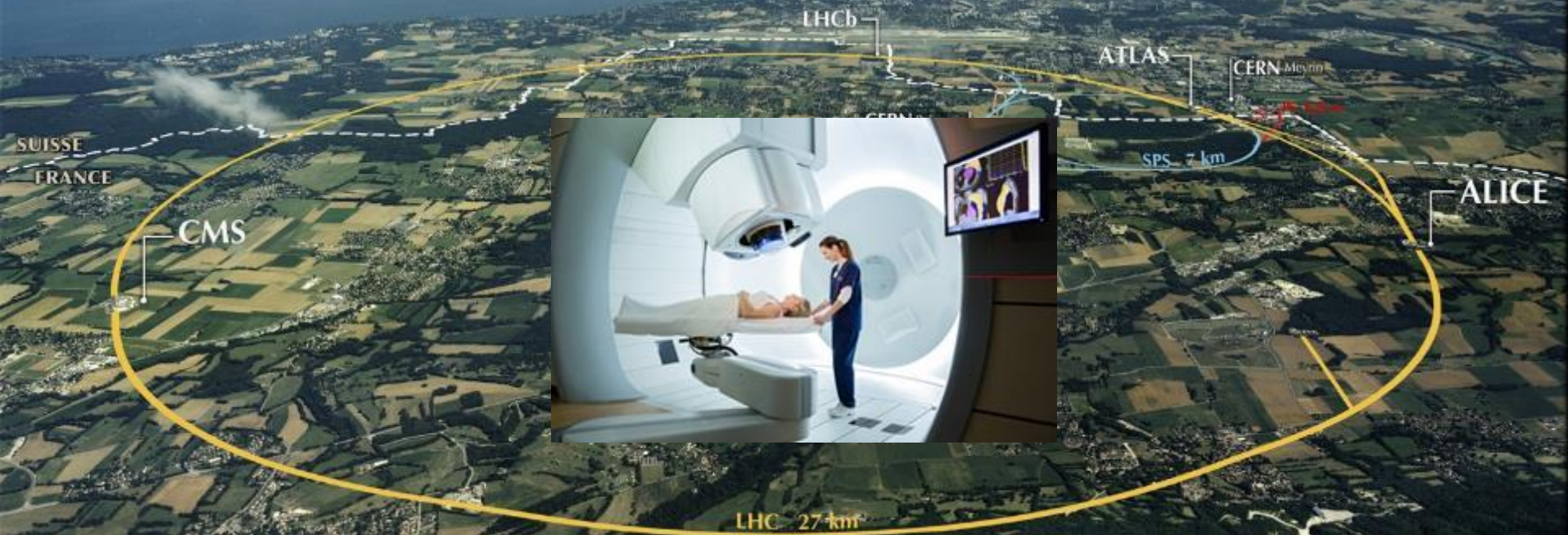


From fundamental research

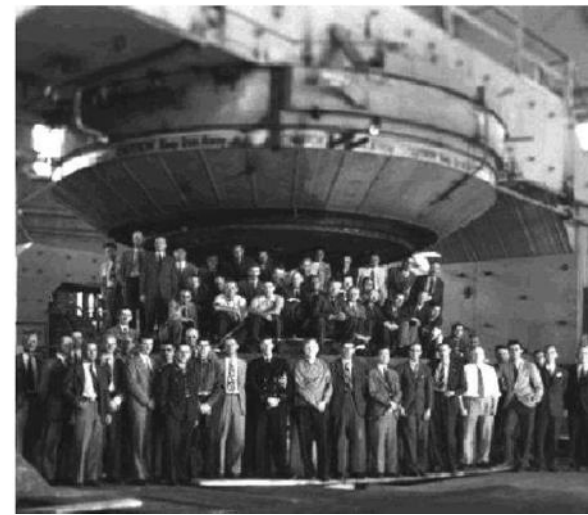
to medical applications



Accelerators for health

Particle Accelerators: From Big Bang Physics to Hadron Therapy

Ugo Amaldi




Berkeley cyclotron Nobel Prize 1939

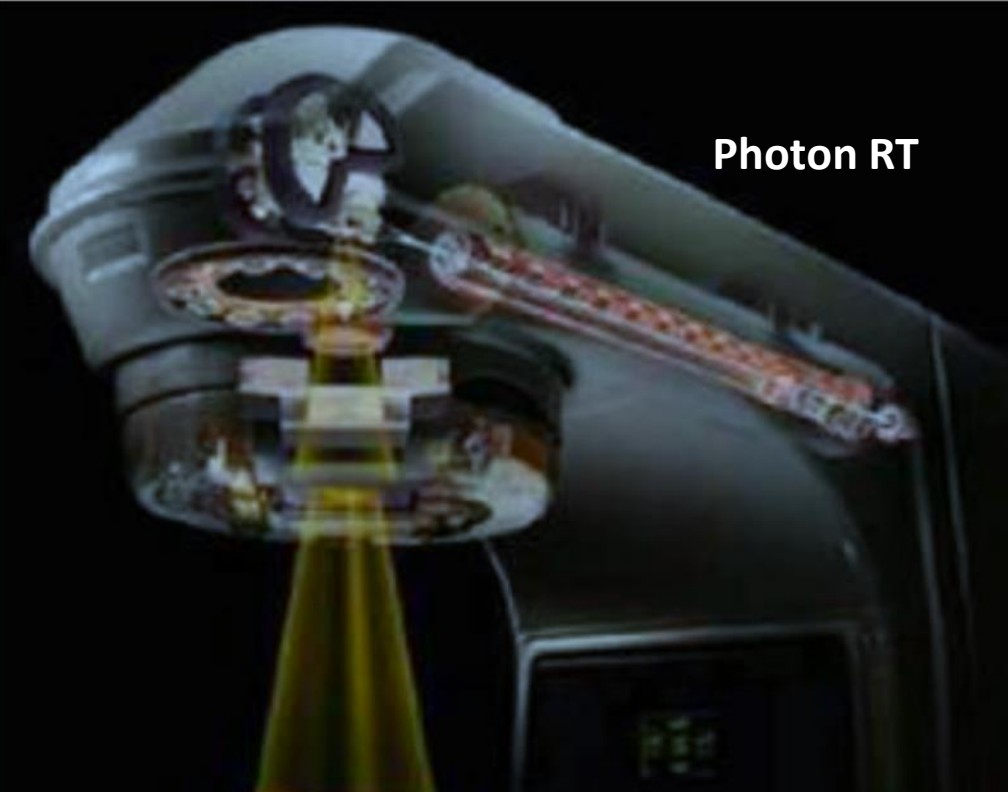
In 1936, the new Berkeley 37-inch cyclotron was producing isotopes for physics. In 1938 starts direct irradiation of patients with neutrons from the new 60-inch cyclotron (**Lawrence brothers**).

In 1946, Robert Wilson proposed to use protons to treat cancer.

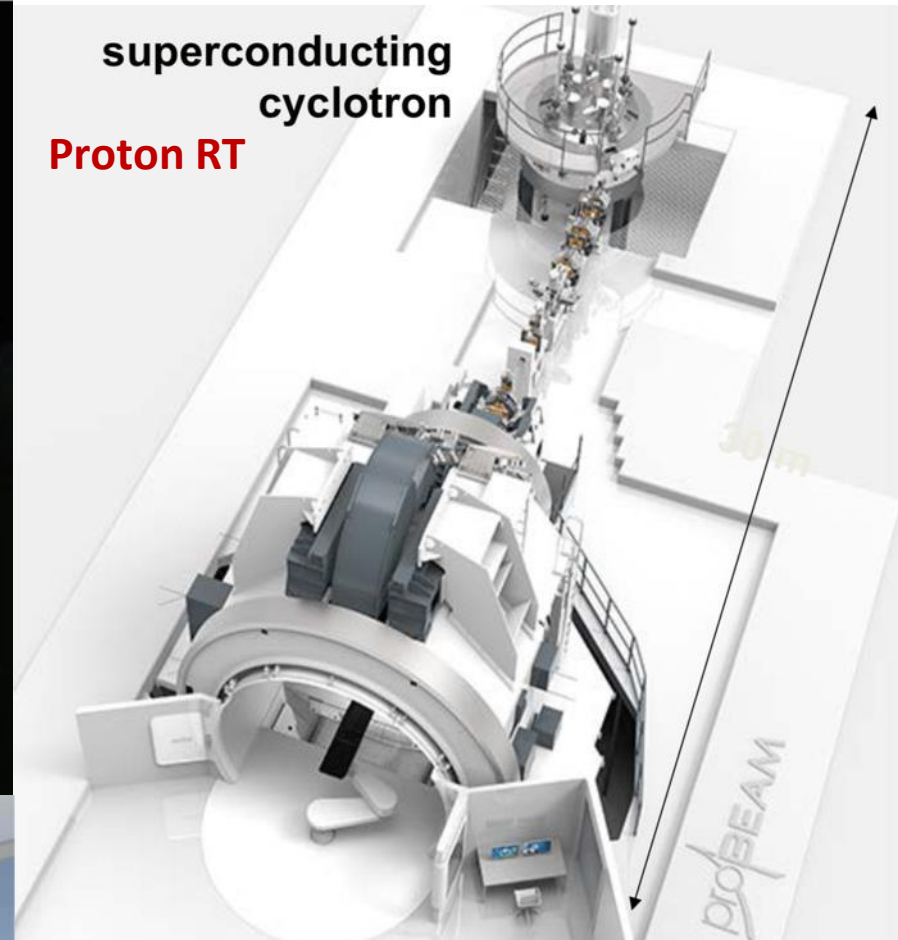
First treatment of pituitary tumours took place at **Berkeley in 1956.**

First hospital-based proton treatment center at **Loma Linda (US) in 1990.**

 Springer

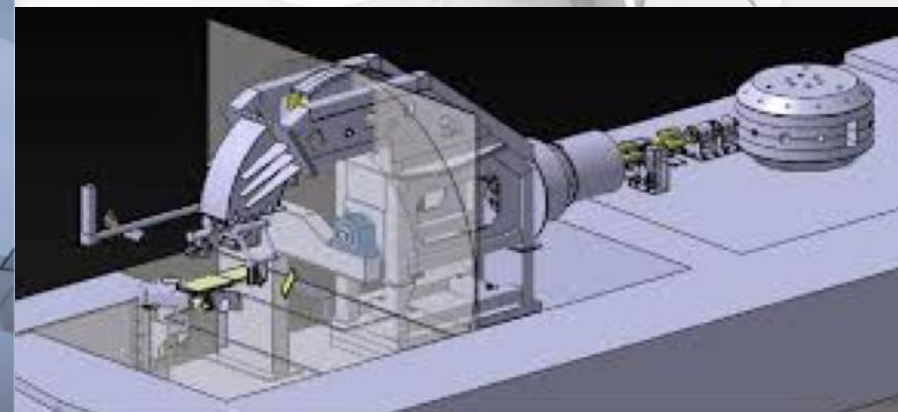


Photon RT



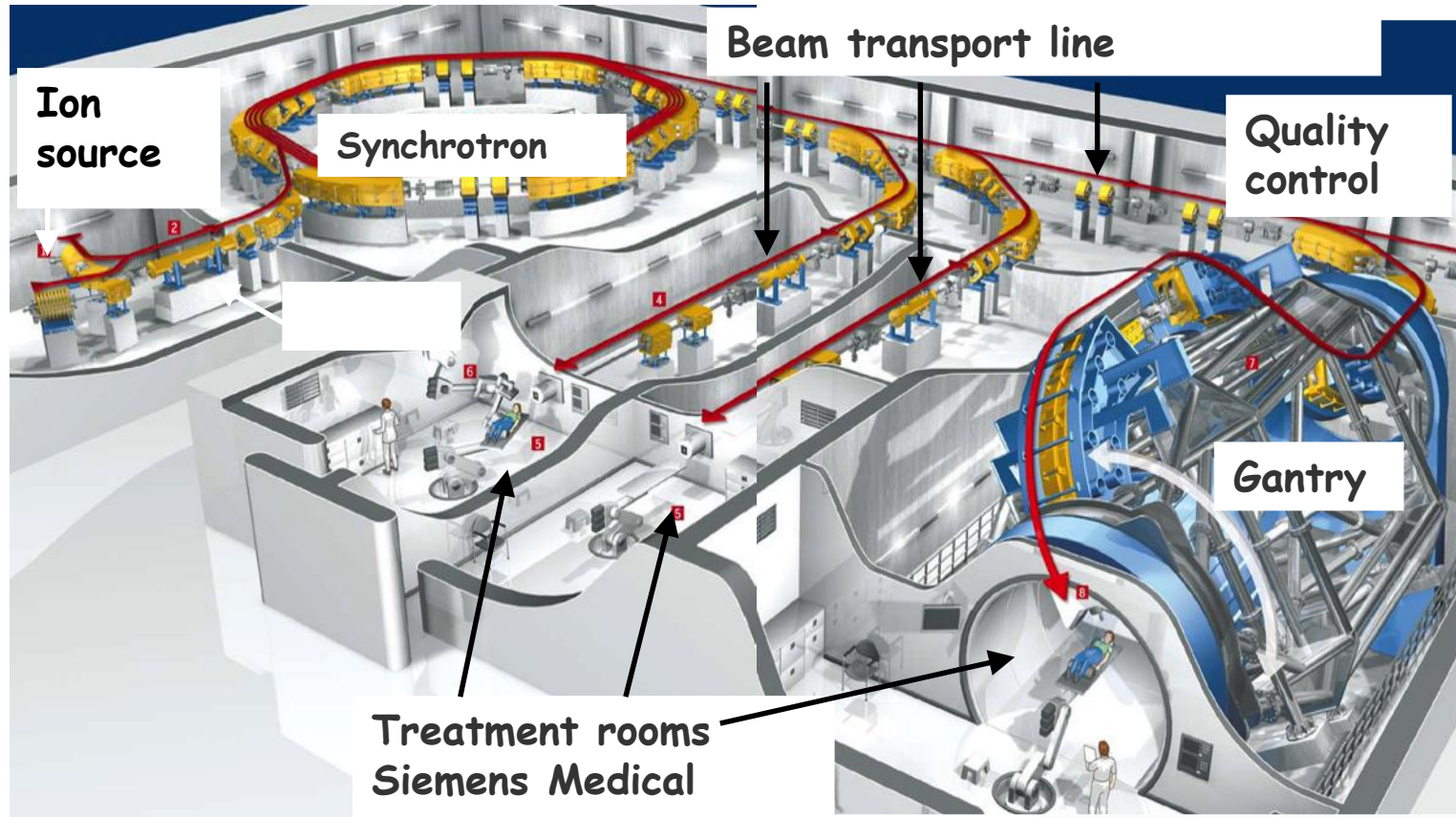
superconducting
cyclotron

Proton RT



ProteusONE™

HIT carbon-ion facility for cancer therapy



**First carbon facility in Europe:
HIT in Heidelberg
started treating patients in 2009.
Followed by MIT in Marburg**

**The HIT gantry:
600 tons**

Workshop on Ions

for Cancer Therapy, Space Research and Material Science

SPACE
RESEARCH
WORKSHOP
ON IONS FOR
CANCER THERAPY
MATERIAL
SCIENCE



**Chania,
Crete, Greece**

**26 - 30
August
2017**

Workshop Main Topics

28-30 of August at Great Arsenali

Particle therapy status

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

Space research and dosimetry

Nanotechnology, electronics and material research

Modelling and benchmarking of experiments

Novel accelerators and training

Public Events

26 of August - science fair at Neorio Moro

27 of August - public talks at Great Arsenali

30 of August - coffee with scientists at Neorio Moro

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

International Advisory Committee

Etienne Auffray (Helmholtz, Switzerland)
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Paolo Giubellino (GSI & FAIR, Germany)
Apostolos Karantanas (Medical School, University of Crete, Greece)
Vladimir Kekele (JINR, Russia)
Panos Razis (University of Cyprus, Cyprus)
Boris Sharikov (ITEP, Russia)
George Stavrakakis (Technical University of Crete, Greece)
Thomas Stoelker (GSI & FAIR, Germany)

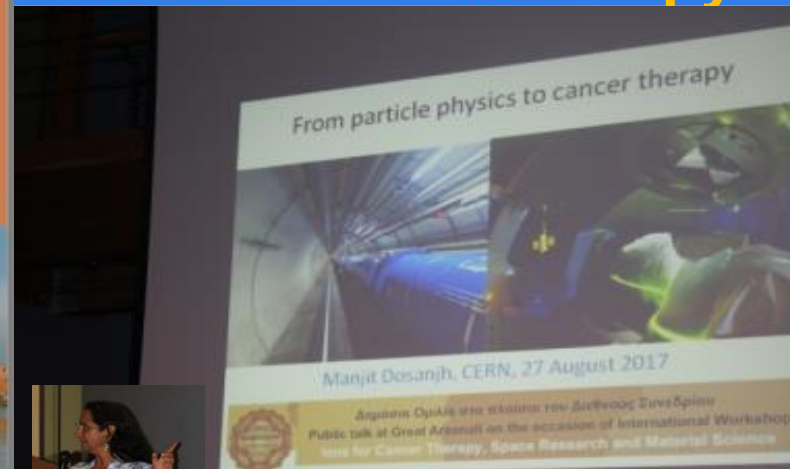
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N. Kalitragakis (TUC, Greece)
R. Plešiac (GSI, Germany)
E. Tsismelis (CERN, Switzerland and Oxford, UK)
M. Vretenar (CERN, Switzerland)
M. Zervakis (TUC, Greece)

Web Assistants

E. Andronov (SPbSU, Russia)
K. Foka Sandoval (EPFL, Switzerland)
L. Graczykowski (WUT, Poland)
M. Janik (WUT, Poland)
A. Kataneva (UB, Spain and SPbSU, Russia)
D. Shukhobodskaya (SPbSU, Russia)

**Ions for
cancer therapy**



**ENLIGHT, CERN
BIOMAT and BIOPHYSICS, GSI**



IONS2017

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

Archamps, 19 June 2018

Public Event, scenario and material

IONS2017 <https://indico.cern.ch/e/ions2017>

Sunday 27 august at 20:15

While people come play animations

- of event displays (as we had them in the big laptop)
- videos from CERN and GSI/FAIR
- <http://cds.cern.ch/record/2020780>
- <http://cds.cern.ch/record/1495143>
- [tp://cds.cern.ch/record/1228924](http://cds.cern.ch/record/1228924)

Last film before starting:

- a. video on CERN: <http://cds.cern.ch/record/986165>

Start

2. YF welcome and explaining the basic idea
3. YF thanks to all locals that helped: list of names and titles
4. YF call Kanelos to greet the public
5. **YF call Kalliopi for singing**
6. YF call Tasos Liolios (15'')
 - a. Tasos: Fundamental research, CERN, basics of accelerators, LHC program, discoveries: Higgs, Matter-AntiMatter, Quark-gluon-plasma....
Stress greek contributions
7. YF fill in: CERN is best known for Higgs boson discovery and Nobel price but as Tasos Liolios said ALICE is using collisions of lead ions to create and study quark gluon plasma, a primordial type of matter that existed at the early universe after the big bang
8. **YF call Kalliopi for singing** (to have time to call Despina)
9. YF call Despina Chatzifotiadou, virtual visit at CERN, ALICE control room
 - Despina: see video on ALICE
 - <http://cds.cern.ch/record/1018975?ln=en>
 - Despina: about QGP and ALICE via vidyo (< 15'')

11. YF call Christina Kourkouveli (15'')
 - a. Christina: research at CERN and education
 - b. CERN beam for schools; you will have the opportunity of a presentation by Curiosity science team (application for beam, listed 10th)
 - c. IPPOG and MasterClasses
 - d. Creations
 - e. Activities in Greece
12. YF call Astrinos Tsoutsoudakis
 - Astrinos: presentation of the activities of the team
13. YF fill in: while the primary aim is to develop the tools (accelerators and detectors) for fundamental research purposes, we always try to identify cases of use in everyday life. Some notable examples are: the web....
Most importantly: the use os such tools in medicine and in particular diagnosis and therapy of cancer that is the todays theme
12. YF call Manjit (15''):
 - a. see video as an intro: <http://cds.cern.ch/record/1611721?ln=en>
 - b. Manjit: developments for research and their applications for cancer therapy
 - c. Manjit: see video as summary: <http://cds.cern.ch/record/2002120>

An interactive virtual visit to a hadrotherapy centre:
<http://www.cern.nymus3d.nl/maps#> (not used)
14. **YF call Kalliopi: singing**
15. YF call Giorgos Dedes (30'')
 - a. Giorgos presentation on details on cancer therapy
16. **YF call Kalliopi: singing**
17. YF call speakers for questions
18. **YF call Kalliopi: last song, flowers !!**

Workshop on Ions for Cancer Therapy, Space Research and Material Science

SPACE
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WORKSHOP
ON IONS FOR
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A. Katanaeva (UB, Spain and SPBSU, Russia)
D. Shukrobodskaya (SPBSU, Russia)



Workshop

Location Archamps, France

Venue: European Scientific Institute (ESI)

Dates: 19-21 June 2018

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



Proposal
submitted
12 nov 2019

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

MAIN TOPICS:

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

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L. Rossi (GSI, France)
M. Vetter (CERN, Switzerland)



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

Yiota Foka

Archamps, 19 June 2018

From particle tracking to Medipix

- High Energy Physics original development:
 - Particle tracking detectors
 - Allows counting of single photons in contrast to traditional charge integrating devices like film or CCD
- Main properties:
 - Fully digital device
 - Very high space resolution
 - Very fast photon counting
 - Good conversion efficiency of low energy X-rays

Seminar:

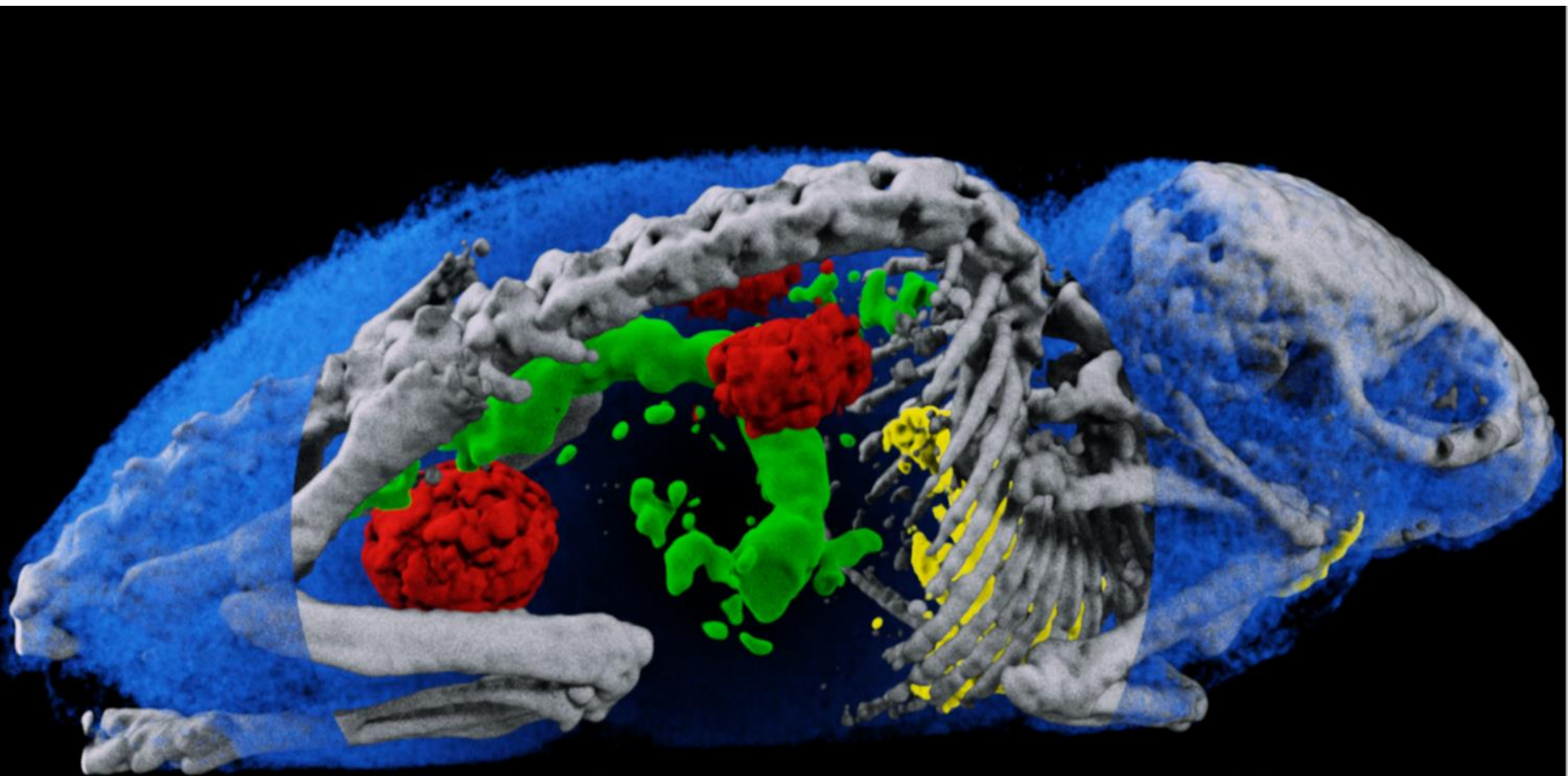
<https://indico.cern.ch/event/820083/attachments/1861456/3061478/KTSeminarMC.pdf>



Credits: Simon Procz, University of Freiburg

From particle tracking to Medipix

Spectroscopic information permits material separation



The water has been partly cut away to reveal the
bone, gold, gadolinium and iodine



Taking it to humans

CT image of Phil Butler's wrist, *Uni. Of Canterbury*



The world is watching !!

Image viewed over 40 M times on Twitter

Highest number of hits on CERN website since the Higgs announcement





Spectral CT : true colour x-ray imaging

Computed Tomography is 3D X-rays

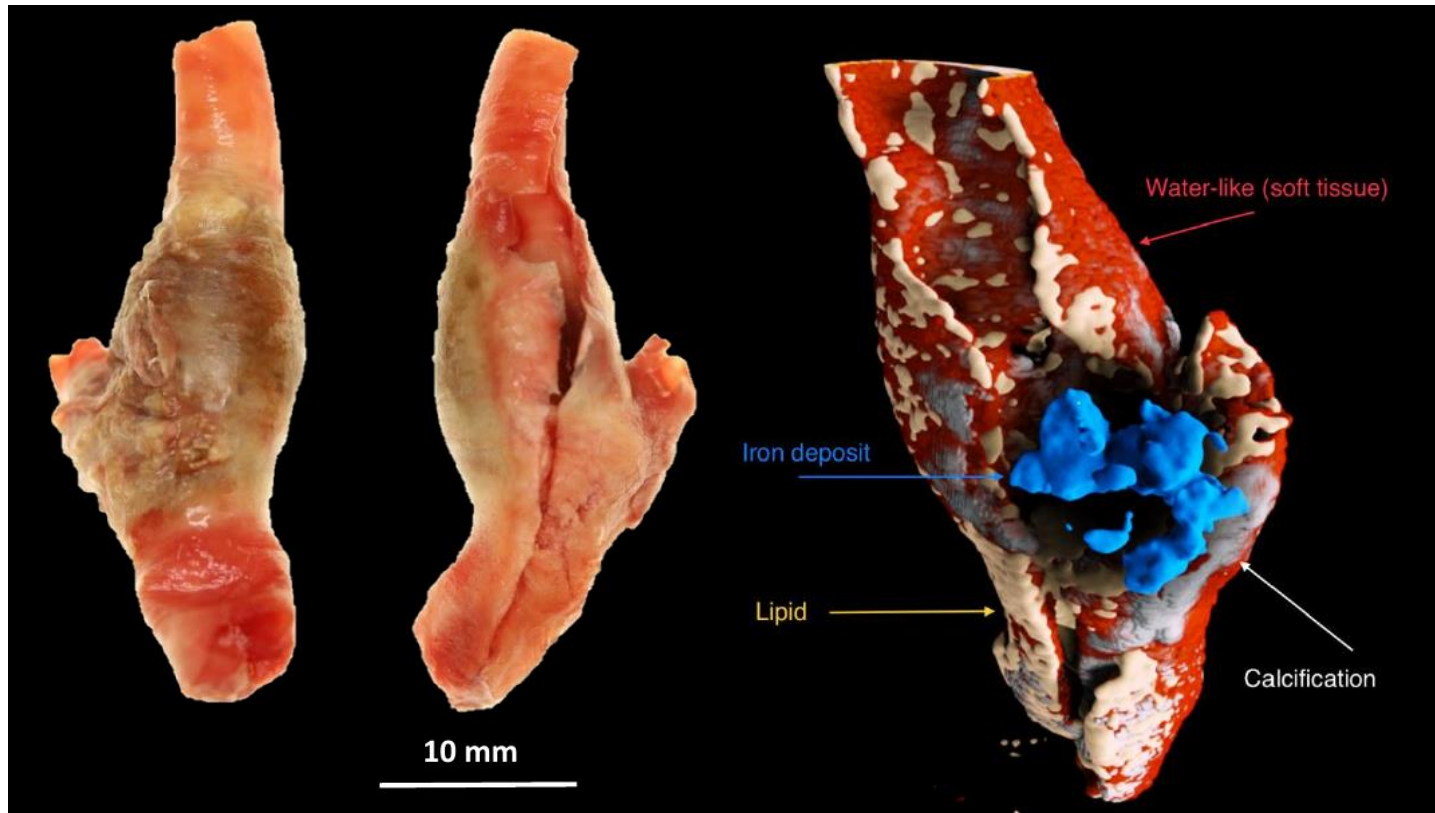


Rontgen 1895,

to CERN technology 2018



Molecular imaging



Cardiovascular disease causes 37% of EU deaths

Steven Giesege, Uni. Canterbury

Bringing it to the schools !!

INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

Need for specialized personnel !!

Particle Therapy MasterClass



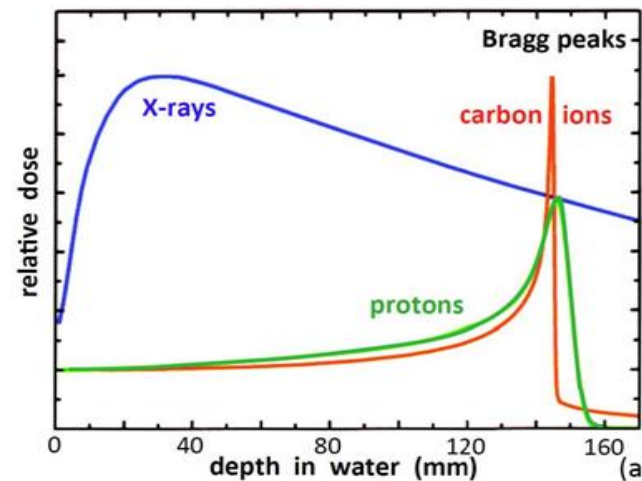
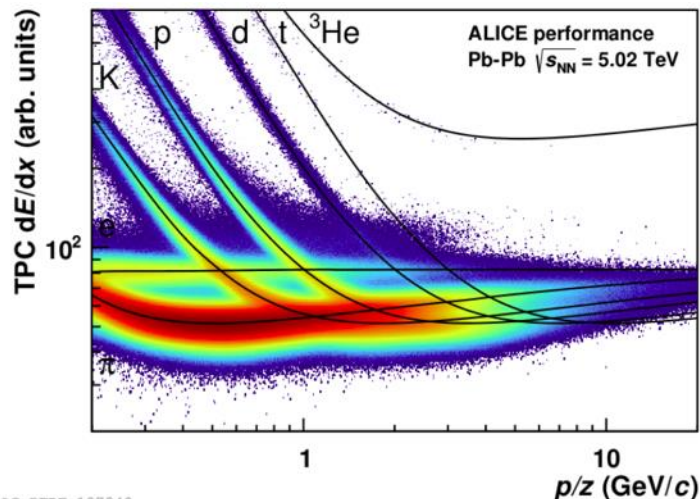
<https://indico.cern.ch/event/840212/>

Aim: benefits for society from fundamental research

Direct applications for health of instrumentation and methods developed for fundamental research: accelerators, detectors, software....

Aim: enhance awareness on HT cancer therapy possibilities

From Bethe Bloch ionization for PID to Bragg peak for cancer therapy



Particle Therapy MasterClass



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

Home

Posters

Aim

Materials

Agenda

Instructions

Invitation

Survey

Articles

Photos

Contacts and Teams

Events

Sponsors

Contact

✉ pt.mc@cern.ch

ENLIGHT Animations

Short video presentation of the ENTERVISION project



Initial Training Network for hadron therapy



Particle Therapy MasterClass



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

Events

15.09.2019 CERN Open Days

01.10.2019 Open Science Days at Montenegro

3.04.2020 Public event at Sarajevo

CERN Open Days stand



The CERN Open Days took place on 14th and 15th of September 2019. The ENLIGHT stand presented animations and the Particle Therapy Masterclass. There were in total four screens. Two of them were showing ENLIGHT animations, one about the Carbon ions facility and procedure of treatment, and the other about a future project that is going to use real time imaging while treating patients. There was also a touch screen with an interactive virtual visit to a Carbon ions facility. The demo of the Particle Therapy Masterclass was shown on a fourth screen at the end of the stand. Two posters were complementing the stand, one about the Particle Therapy Masterclass and one about collaborative strategies for meeting the global need for cancer radiation therapy treatment.

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Aim

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Agenda

Instructions

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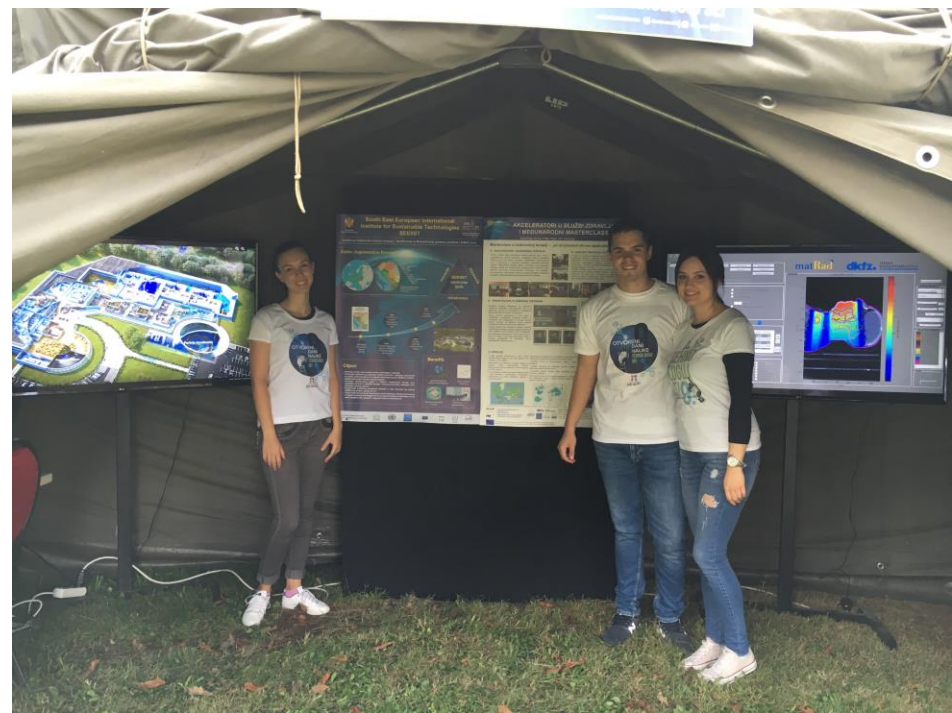
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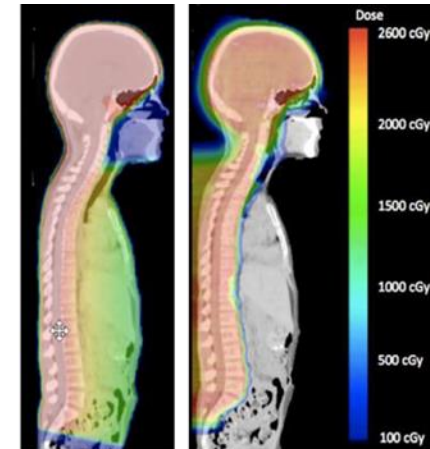
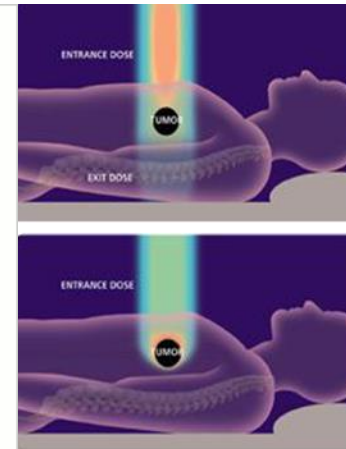
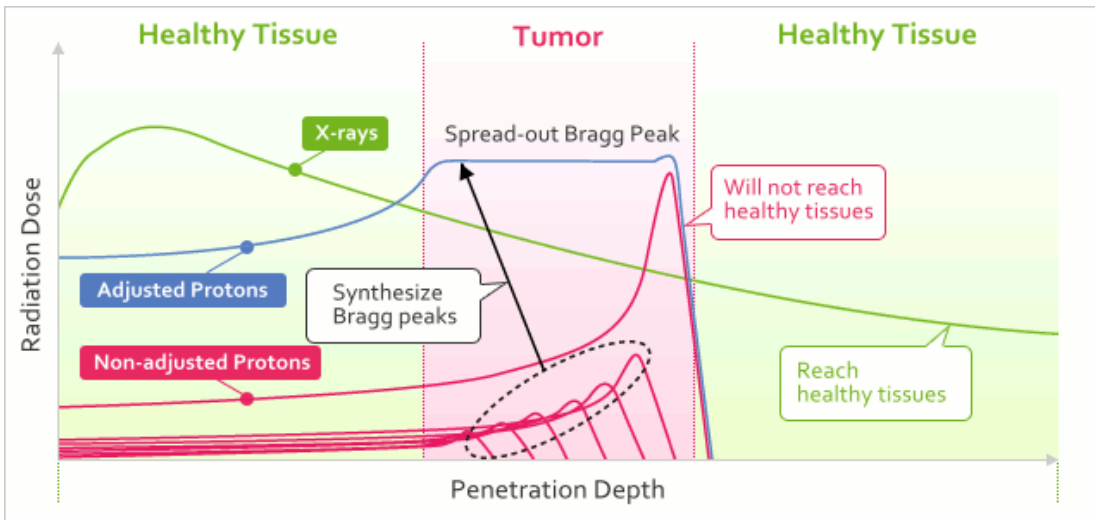


Physics for Health

Hadron (proton, ion) Radiation Therapy, HT, is a precise and effective way to destroy cancer cells sparing healthy tissues.

preferred for children, pregnant women, deep-seated, radio-resistant tumours

Direct application of different particle properties and ionization loss in matter



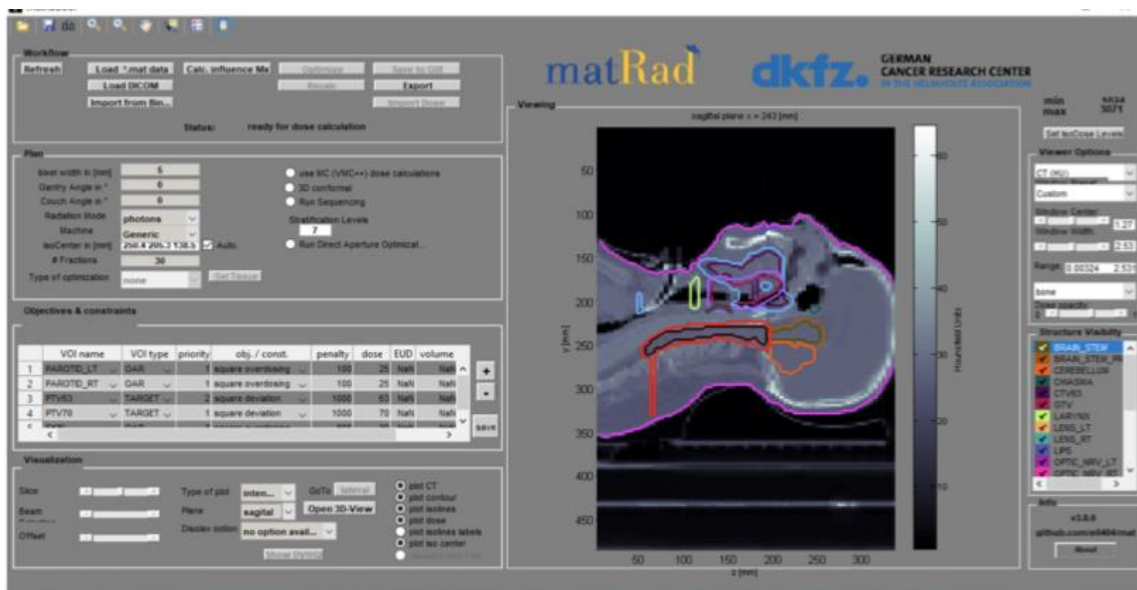
New Particle Therapy MasterClass

Based on professional open source research and training toolkit for calculation of dose delivery (treatment planning) : **matRad** developed by Heidelberg DKFZ

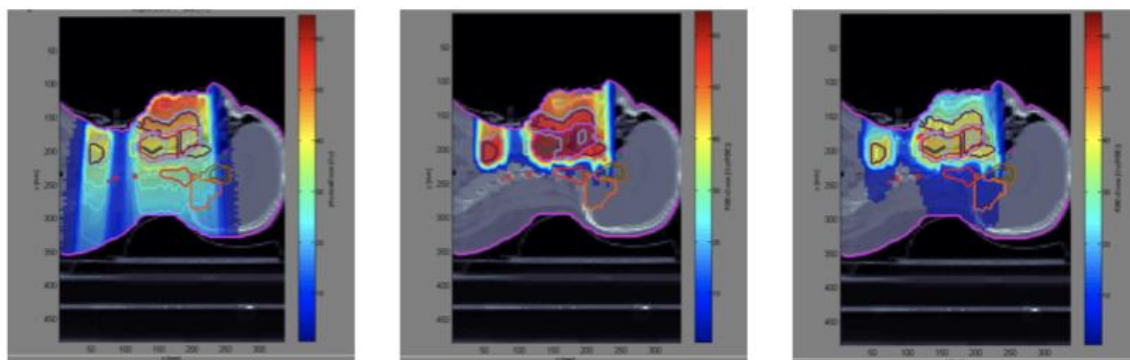
[matRad: www.matrad.org](http://www.matrad.org)

with photons,
protons, ions

Head and Liver Data




Demo⁴ of the matRad software kit for Treatment Planning .



PTMC publicity, articles

Articles in web page: ARIES, ENLIGHT, GSI...



GSI Helmholtzzentrum für Schwerionenforschung GmbH

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50 years GSI




FAIR

The new accelerator facility FAIR is under construction at GSI. [Learn more.](#)



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GSI Helmholtzzentrum für Schwerionenforschung

GSI Helmholtzzentrum für Schwerionenforschung operates a unique large-scale accelerator for heavy ions. Researchers from around the world use this facility for experiments that help them make fascinating discoveries in basic research. In addition, they continually develop new and impressive applications.

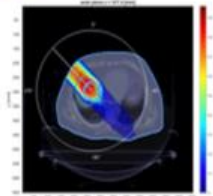
International group of experts presents final report on the FAIR project



The shareholders of FAIR GmbH had decided in 2015 to have the project re-evaluated in the spring of 2019. The international committee of experts charged of the evaluation has now presented its final report to the shareholders of FAIR GmbH. In addition to scientific and technical aspects, the experts also analyzed the currently foreseeable increase in the cost of the project as well as time delays and in-kind services provided by international partners and other risks.

[More](#)

New Masterclass for pupils on particle therapy



In April, a pilot Masterclass on particle therapy took place at GSI and FAIR, as well as at the Deutsches Krebsforschungszentrum (DKFZ) in Heidelberg and the European research center CERN in Geneva, Switzerland. School children with an age distribution spanning from 12 to 17 years were invited to immerse in the world of scientists for a day. At the end of the event they joined a common video conference to share their experiences.

[Read more](#)



PTMC Conferences, Open Days

International Particle Physics Outreach Group

Invitation to CONF14, Norway, 27 July 2019

ENLIGHT, Caen, 2019

Open Days: CERN and Montenegro 2019

ACCELERATORS FOR HEALTH AND INTERNATIONAL MASTERCLASSES

Yiota Foka, for the PTMC Team, GSI, Germany

Particle Therapy MasterClass – an accelerator-driven application for health

ACCELERATORS AND PARTICLE THERAPY

During the past century, particle accelerators played an essential role on advancing scientific knowledge and on improving standards of living. Today, they are being increasingly used not only in research laboratories but also in hospitals and industry. As accelerator technology develops, the potential for new applications expands. Such developments are systematically supported by EU funded projects such as ESCARDO, ARIES, among others. In particular, the potential of accelerator-driven therapy and diagnostic techniques increased considerably over past decades, playing an increasingly important role in identifying and curing otherwise difficult to treat cancers.



MASTERCLASS CONCEPT

With the aim to highlight benefits from fundamental research for medical applications and cancer treatment, a new MasterClass on Particle Therapy was developed. It was proposed to enrich the program of the International Physics MasterClasses (IMC) an educational outreach activity and flagship project of the International Particle Physics Outreach Group (IPPOG). The program engages young people with fundamental research and its applications offering them the chance to become scientists for a day and get a hands-on experience on real data. At the end of the day they join a common video conference to discuss their results as international scientific collaborations do.



HANDS ON: TREATMENT PLANNING

The newly developed Particle Therapy IMC is addressing high-school students who are invited at a university or research laboratory for a day to immerse in the world of science.

After introductory lectures on the role of physics in medical applications, a hands-on session allows them to experience actual radiation techniques employed for treatment of cancer tumors using x-rays, protons or carbon ions, in a realistic way. Participants get in touch with this heavily computer aided process via the open source treatment planning research toolkit radpack, developed by the DKFZ Heidelberg. All material is free to be used for any academic purpose. Its potential can be exploited in many ways (i.e. locally at schools, teachers programs, training sessions, laboratories, open days, ...)



PILOT PARTICLE THERAPY IMC

A pilot full day IMC took place in April 2019 with the participation of GSI-FAIR, DKFZ Heidelberg, and CERN, all having the same agenda:

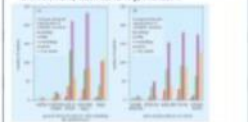
- Lectures, accelerators, medical applications...
- Hands-on: treatment planning
- Hands-on: medical treatment planning
- International Videoconference: results, Q&A



EVALUATION

The goal of the IMC program is to allow school-children to experience methods and tools used in research. Evaluations have shown that they:

- enjoy the event,
- develop an appreciation and interest for fundamental science and its applications,
- get motivated to pursue scientific studies and to contribute to further developments,
- contribute to enhancing awareness of their immediate environment, such as family, friends, ...



OUTLOOK

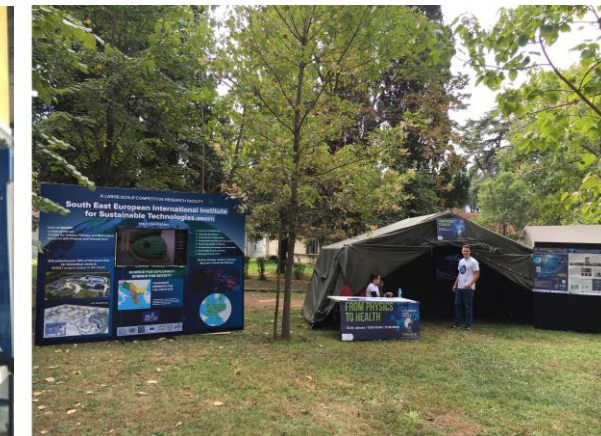
The IMC project reaches out to about 15,000 school children around the world with about 225 institutes from 55 participating countries in 2019.

The Particle Therapy MasterClass was approved by the International Physics MasterClasses Steering group and will be integrated into the IMC 2020 schedule.



Participating institutes (in green) and their contact information:

- 1. GSI Helmholtz Accelerator Laboratory, D-35234 Kassel, Germany
- 2. DKFZ Heidelberg, D-69122 Heidelberg, Germany
- 3. CERN, CH-1211 Geneva, Switzerland
- 4. IPPOG, International Particle Physics Outreach Group





Under development: SEEIIST meets Industry (draft)

1-3 April 2020
Sarajevo City Hall
Europe/Sarajevo timezone

Home

Organization

Workshop Poster

The workshop **SEEIIST meets Industry** will take place 1-3 April 2020 in the **Sarajevo City Hall**, Bosnia and Herzegovina. It will be followed by an event for general public **SEEIIST meets Sarajevo** in the evening of 3rd of April 2020, also in the **Sarajevo City Hall**.

Workshop Outline

Aim of the workshop

- Industry
- Inform the public
- Students, motivate, next generation of scientists for the facility

Outline of Workshop Agenda Proposal

<https://indico.cern.ch/event/839930/page/17879-agenda>

Wed 1 April 14:00 Industry Worskhop

Thu. 2 April 9:00 Industry Worskhop

Fri 3 April 9:00 Academia

Fri 3 April 18:00 Public Event

Educational Outreach

Mon 30 March Particle Therapy MasterClass in Sarajevo UNSA

Tue 31 March Particle Therapy MasterClass in Tuzla, oncology

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

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

General Coordination : Yiota Foka

Sponsors : Edmond Offermann

dkfz.

GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION



GSI



hands on particle physics