Particle Therapy MasterClass

Yiota Foka (GSI/CERN)

on behalf of

IPPOG and IMC Steering Group

International Particle Physics Outreach Group

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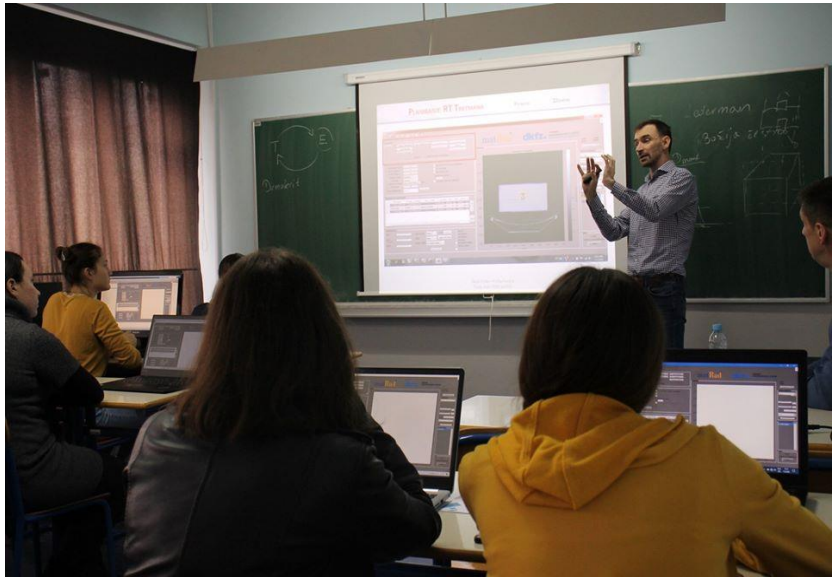
hands on particle physics

Local PTMC in Tuzla



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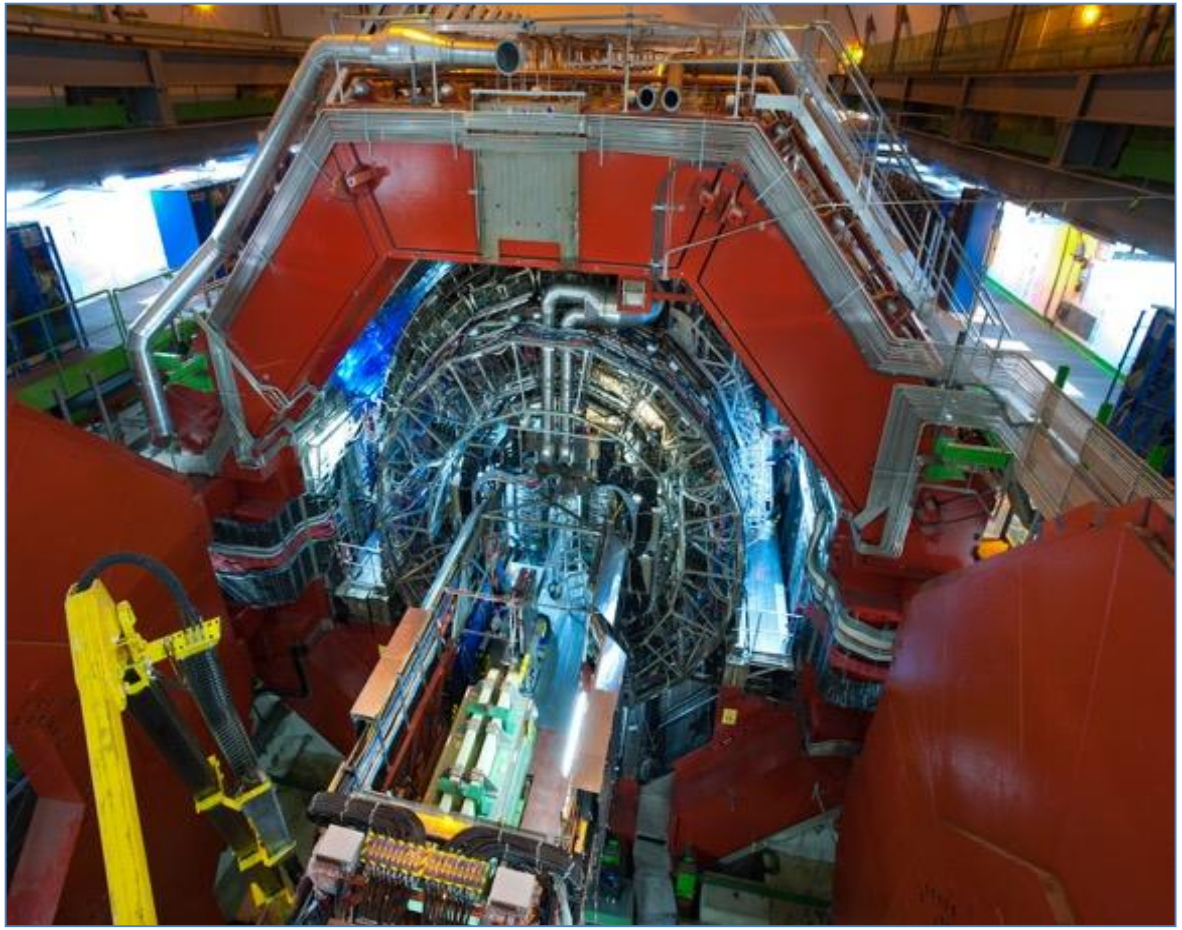
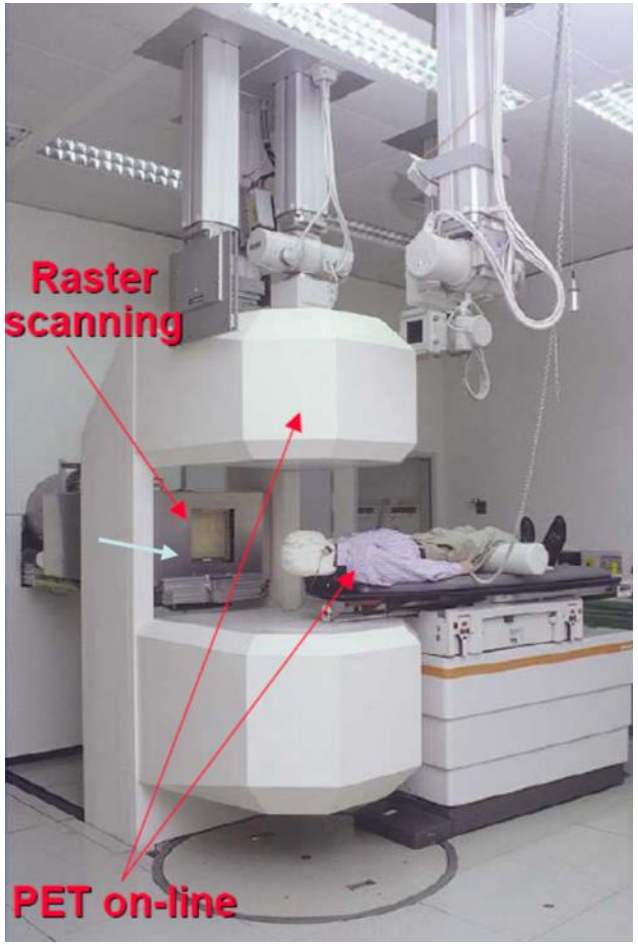
Heavy-ion research and heavy-ion therapy

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



Virtual visit: ALICE heavy-ion experiment at CERN.

Heavy-ion research and heavy-ion therapy at GSI



Pioneered heavy-ion (carbon) therapy for cancer tumours in Europe (90s).

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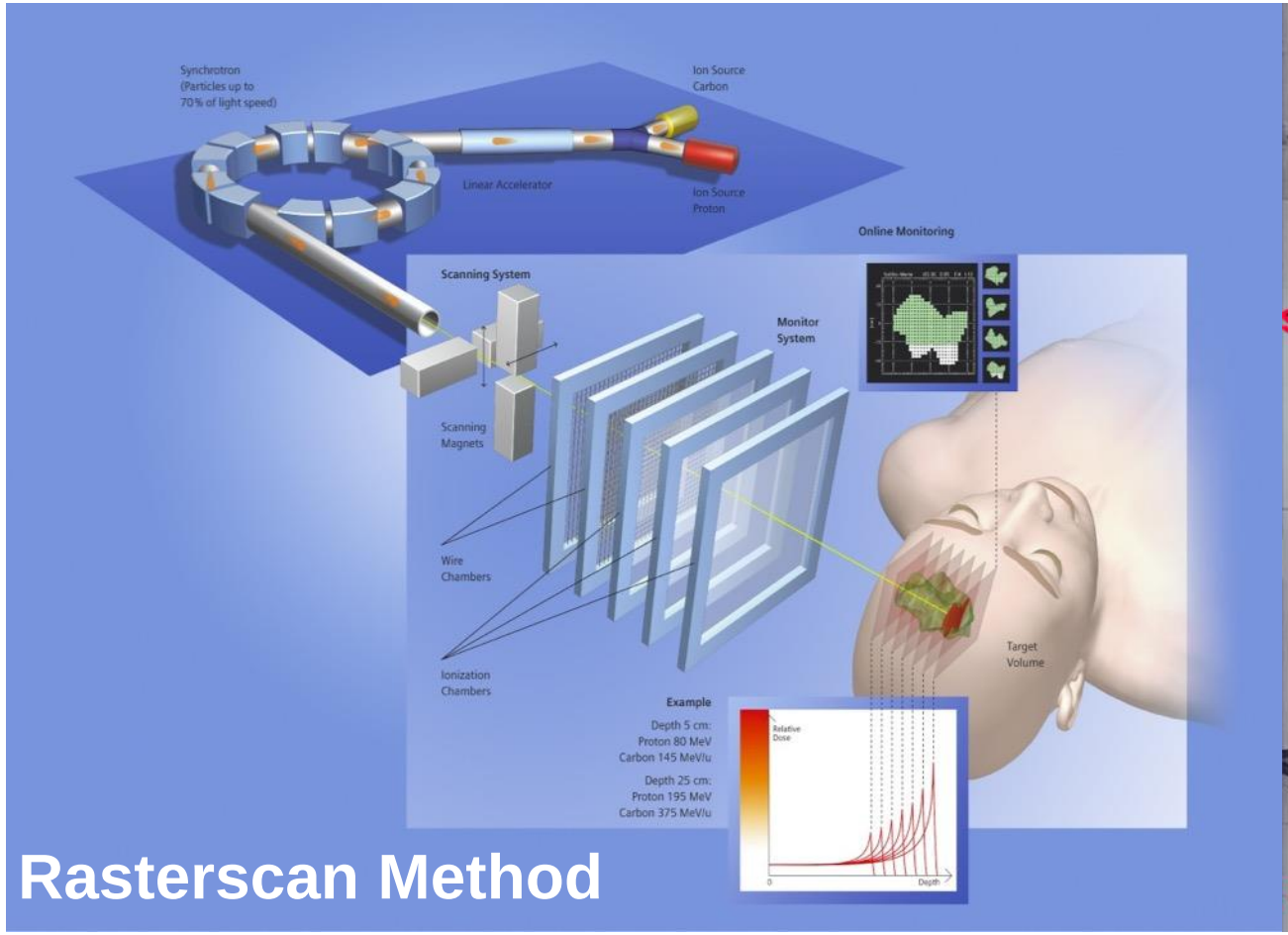
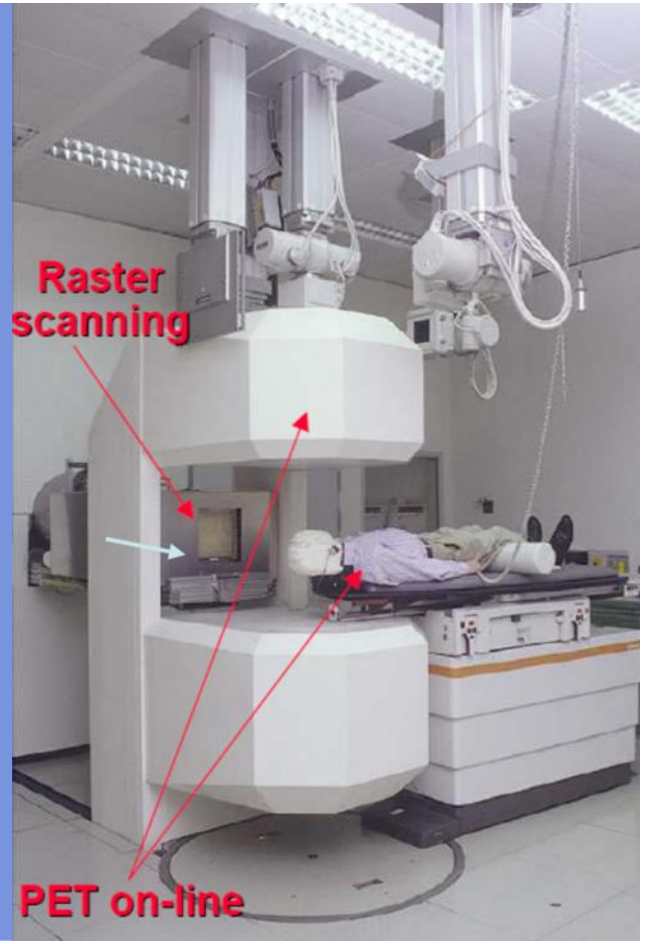
Heavy-ion research and heavy-ion therapy at GSI





Haberer et al., NIM A , 1993

Implemented in the Heidelberg and Marburg Ion Treatment centers (HIT and MIT) in Germany

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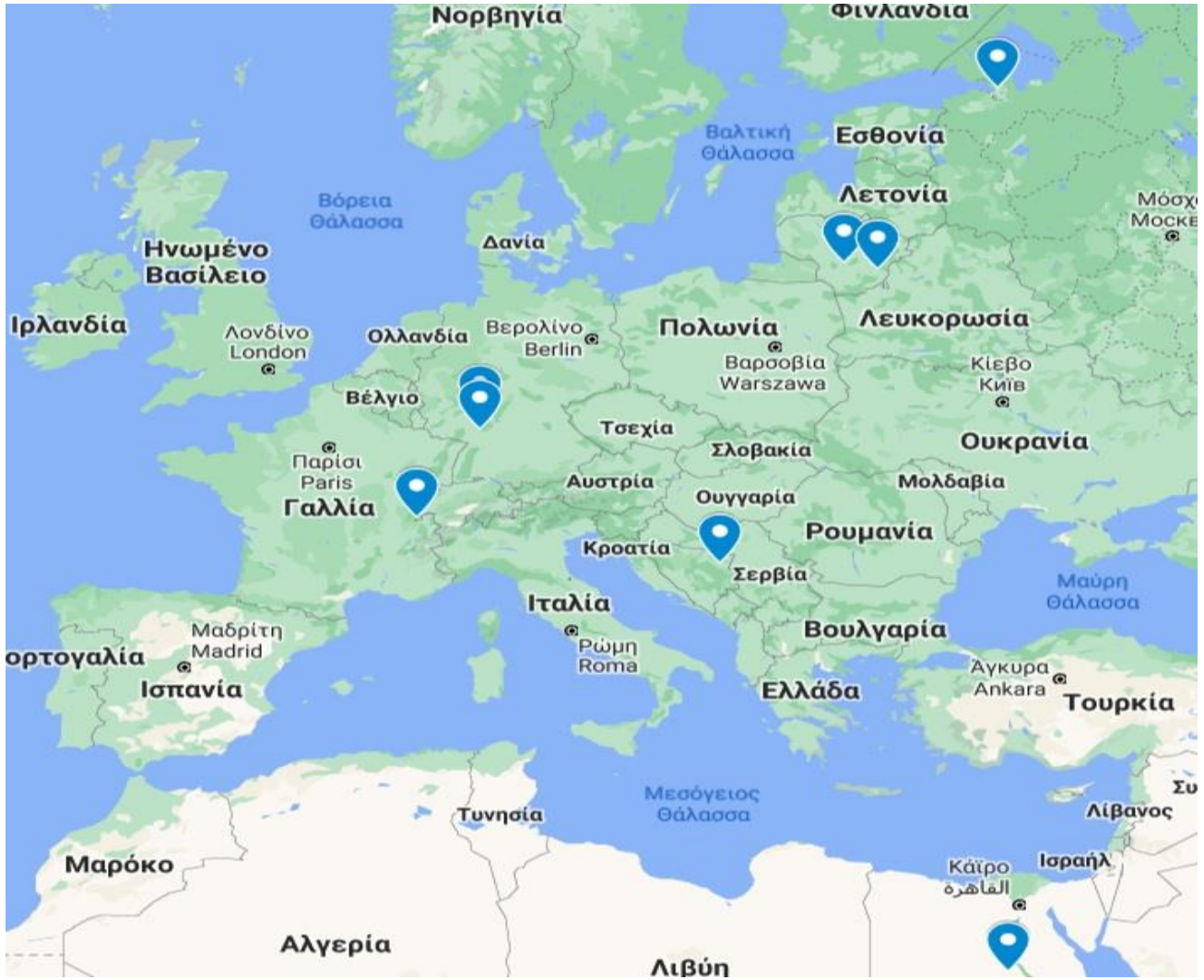
PTMC Participants, 24 March 2021

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



International MasterClasses https://physicsmasterclasses.org/

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International Particle Physics Outreach Group

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hands on particle physics

https://physicsmasterclasses.org/

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Hands on Particle Physics Masterclasses

SCHEDULE 2021

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

© CERN

© Fermilab

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

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IMC Statistics 2019

Motivate the next generations of scientists !

54 countries

255 institutes

15 000 students

5 weeks in 2019

IMC 2021 :
11.2.2021 – 27.3.2021

Brings scientific methods and real data to schools!

Coordination QuarkNet / TU Dresden

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

  (Incl. TRIUMF program)
- 12 MINERvA Masterclasses

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

Flagship project of IPPOG, the International Particle Physics Outreach Group

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Concept and programme of an IMC day

Every year, during the months of
February-March
school-children (15-19 year old)
are invited to an institute of their area.

2-5 institutes per day performing the same programme

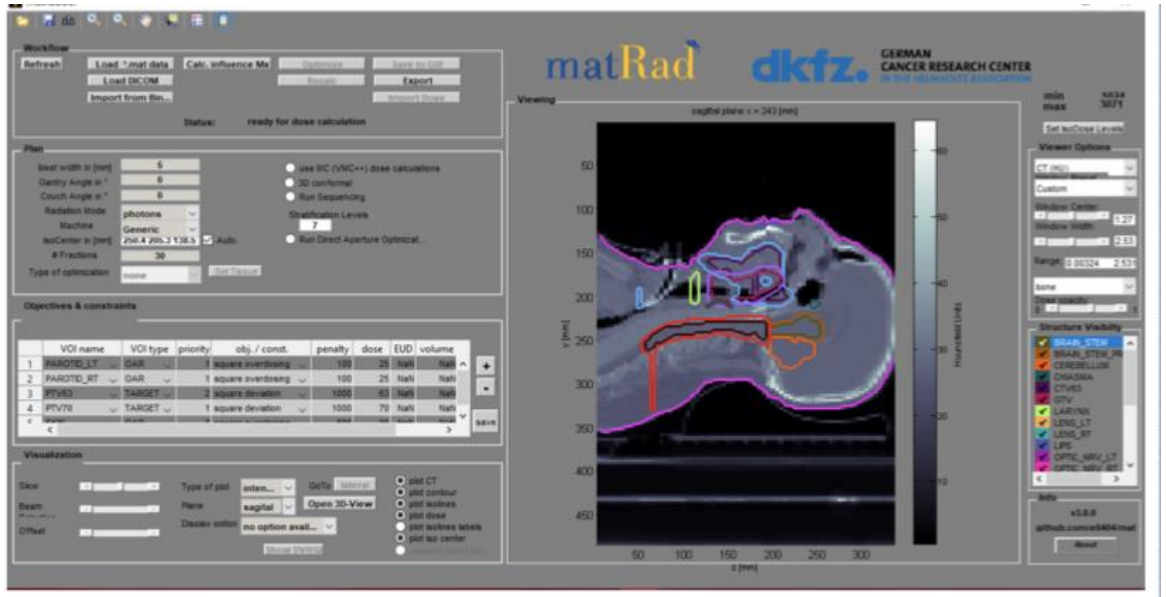
Scientists for a day !!

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	**Video conference**

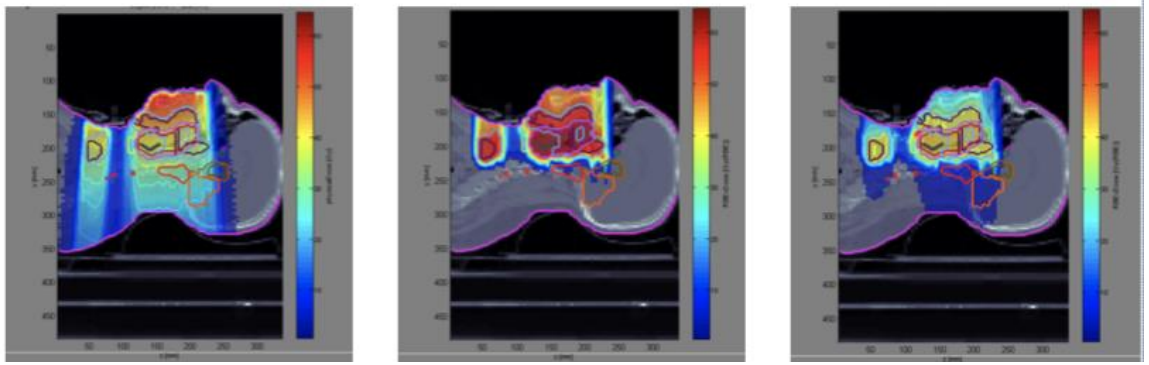
The aim is to get insight into topics and methods of research

New PTMC and Treatment Planning

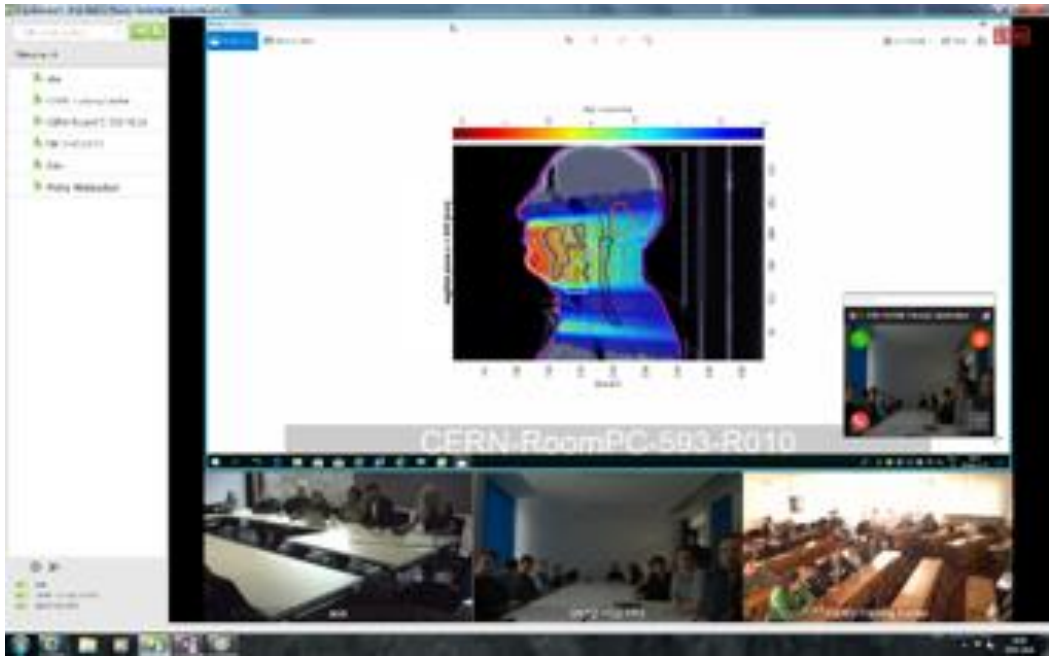
Based on professional open source treatment planning: matRad
developed by Heidelberg DKFZ www.matrad.org



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



Simplified version for PTMC
Using photons, protons and carbon ions



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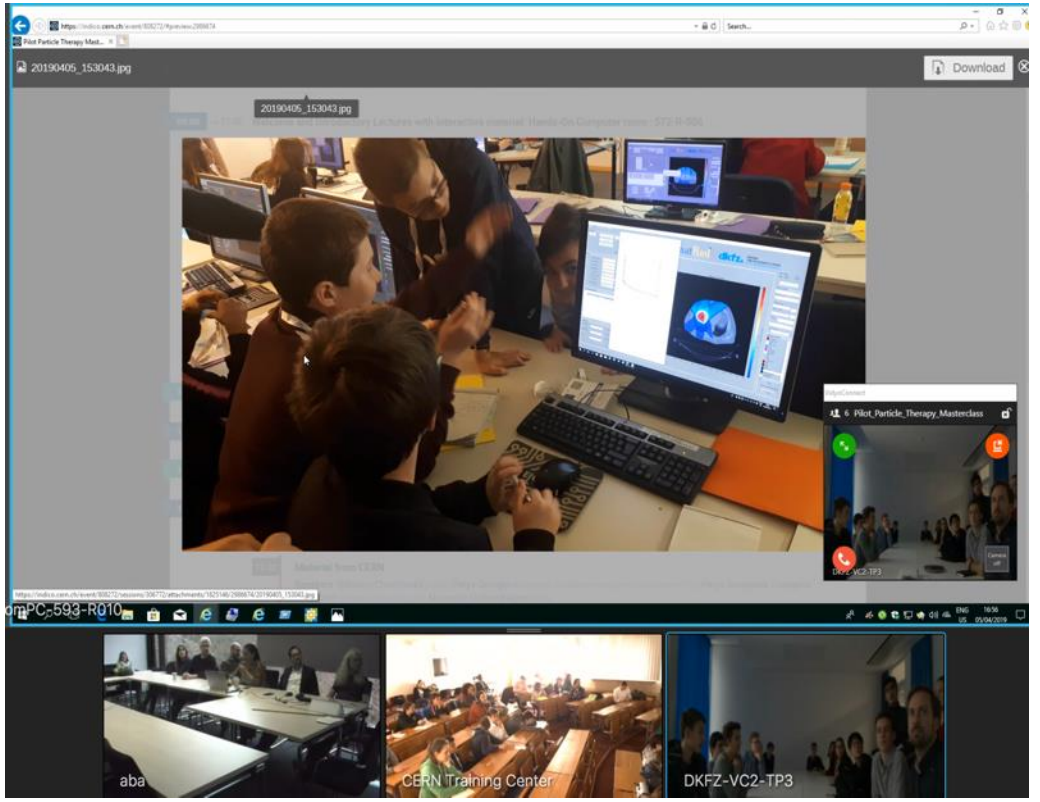
New PTMC and Treatment Planning

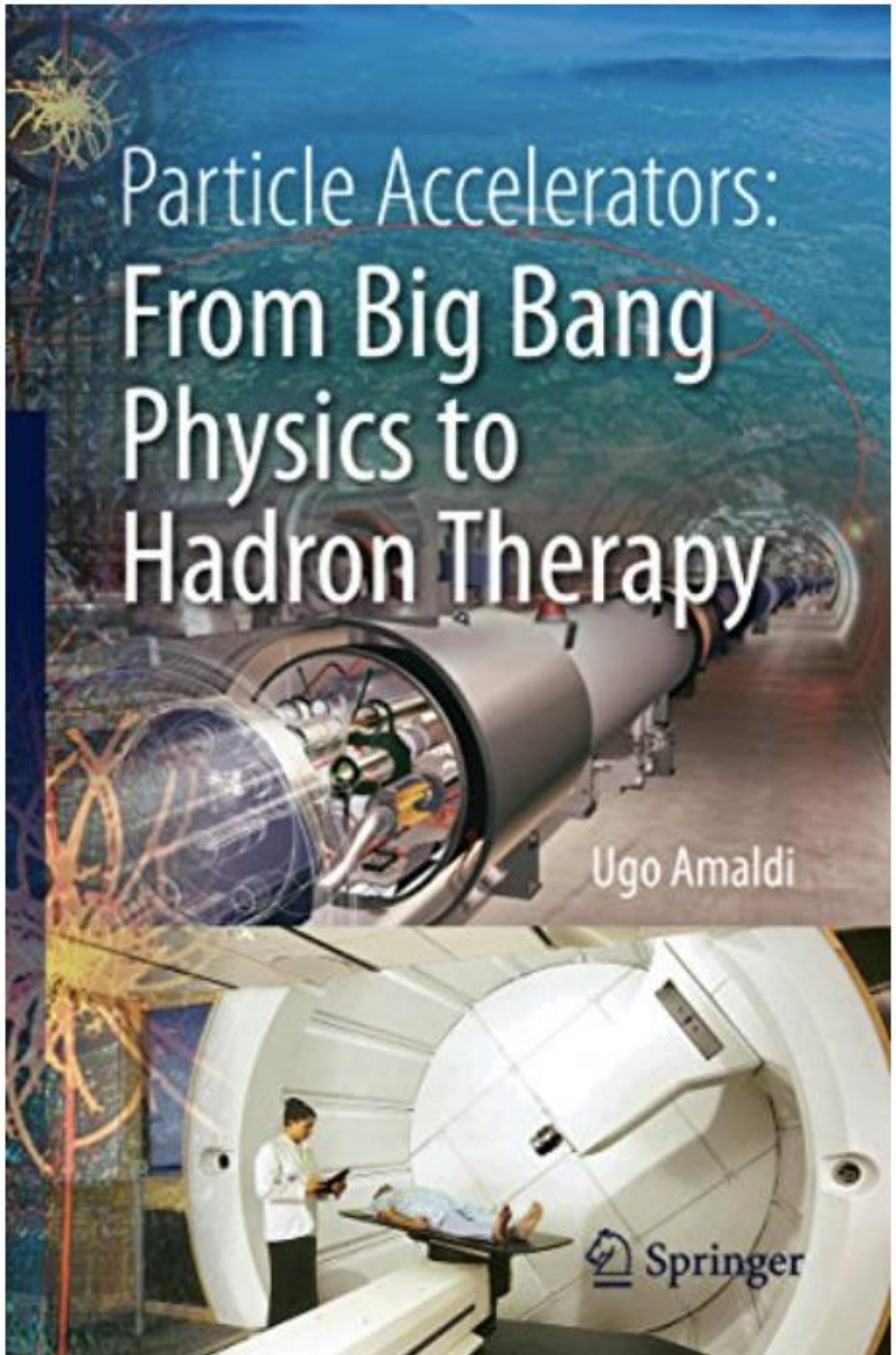
First Local Test: GSI Feb 2019

International Pilot: CERN, GSI, DKFZ April 2019



Web page: UNSA students at CERN, Aug 2019

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



How is physics related to medicine?

What is particle therapy?

How one can use particles for cancer treatment?

Accelerators for research and accelerators for cancer treatment

One of the aims of PTMC: address such questions

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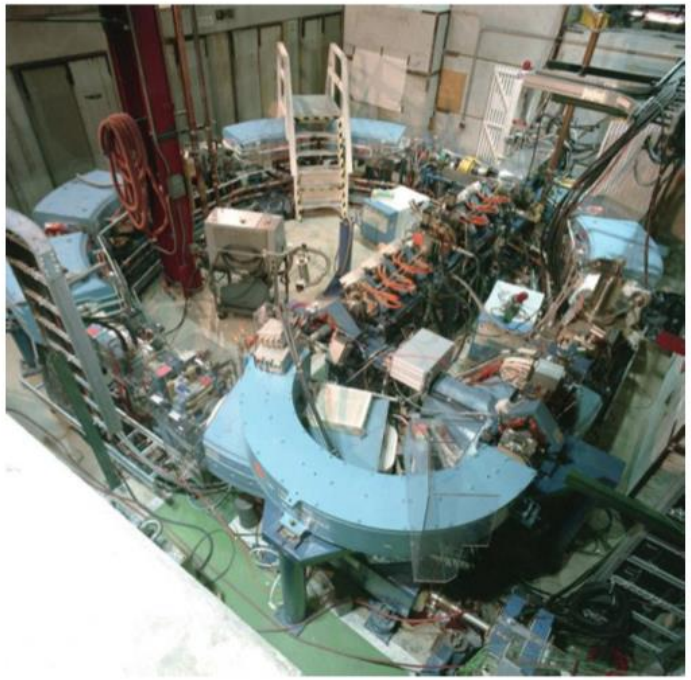
From Physics to Clinics

1993- Loma Linda USA (proton)



First dedicated clinical facility

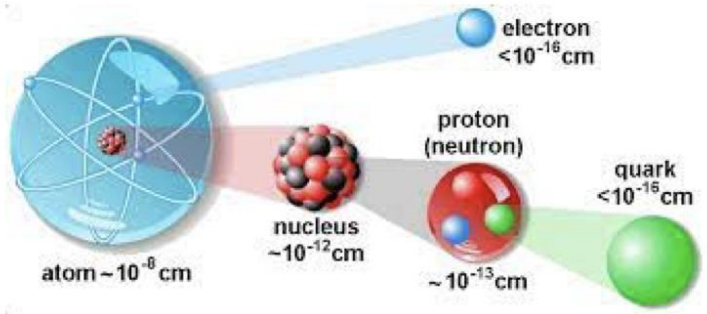
1994 – HIMAC Japan (carbon)

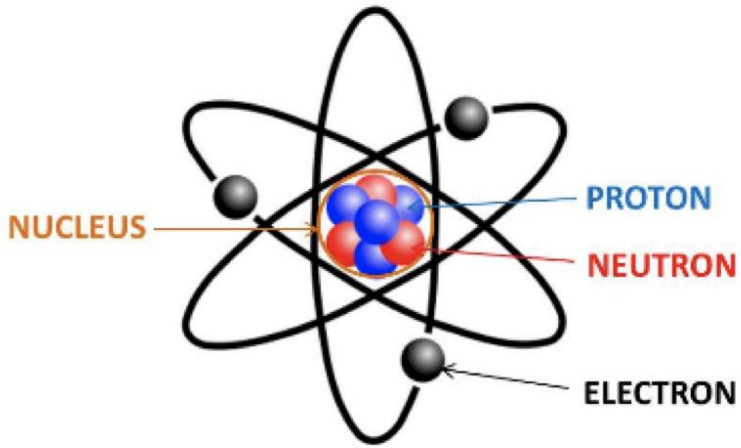
1997 – GSI Germany (carbon)

Accelerators: our key to the subatomic world

Where do we find the particles?

Inside the atoms!





We can use electrons (very light) or protons (1836 times heavier).

Particle accelerators are our door to access the subatomic dimension… and exploit the atom and its components

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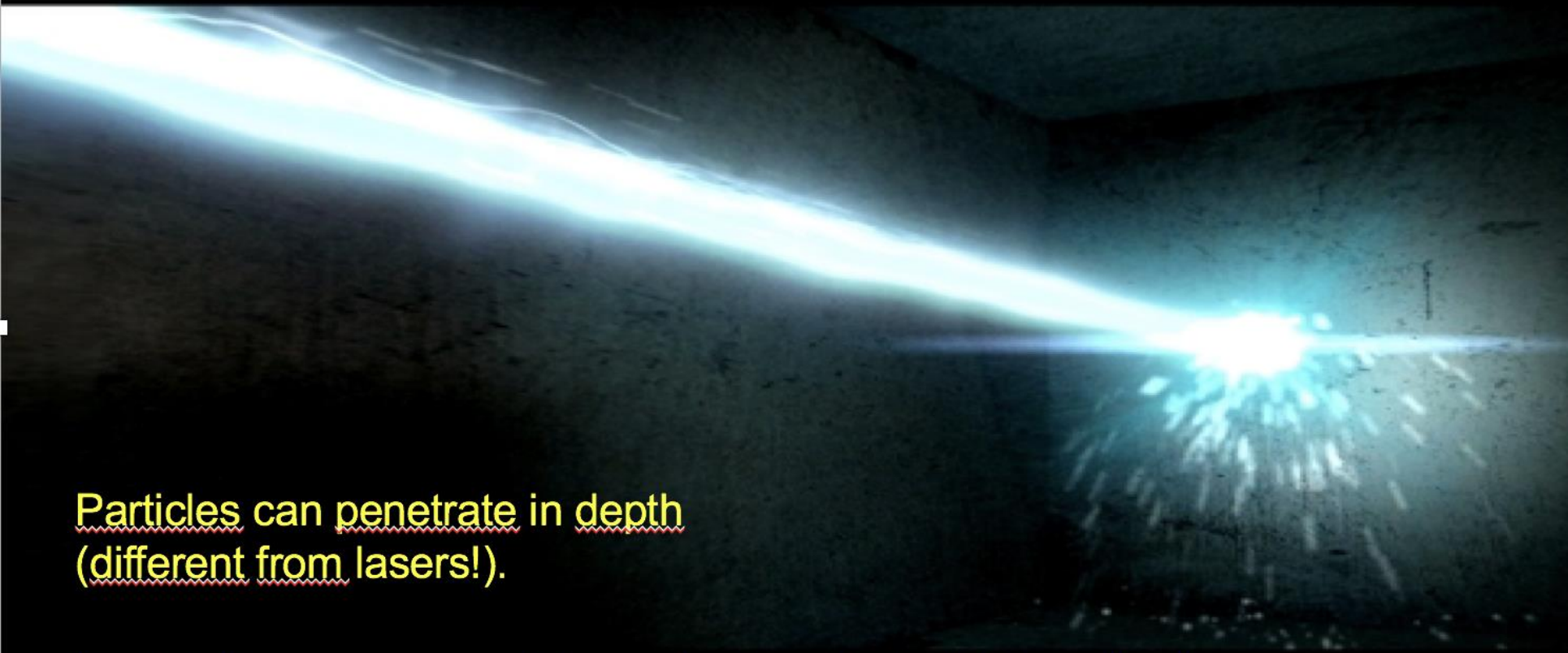
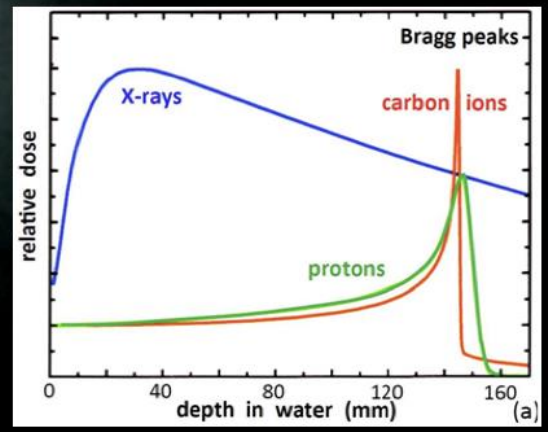
Accelerators: can precisely deliver energy

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



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



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

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

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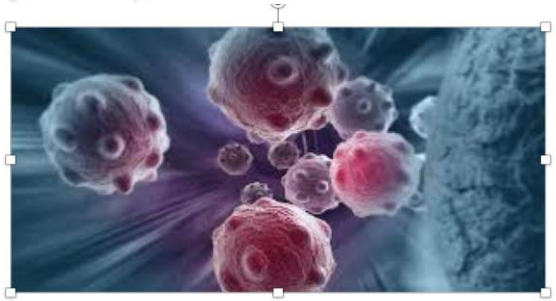
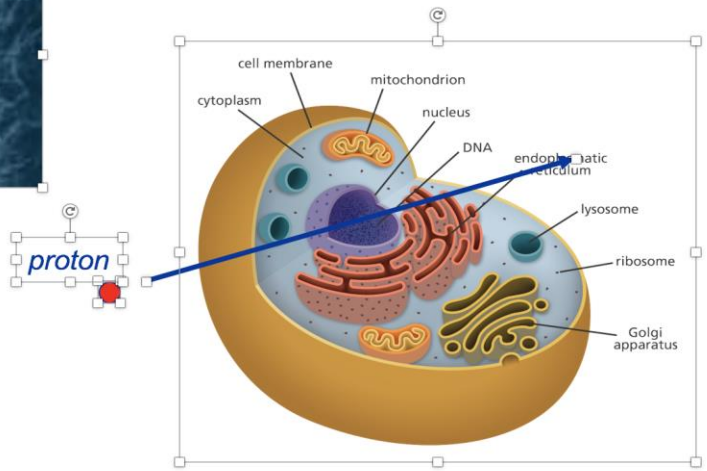
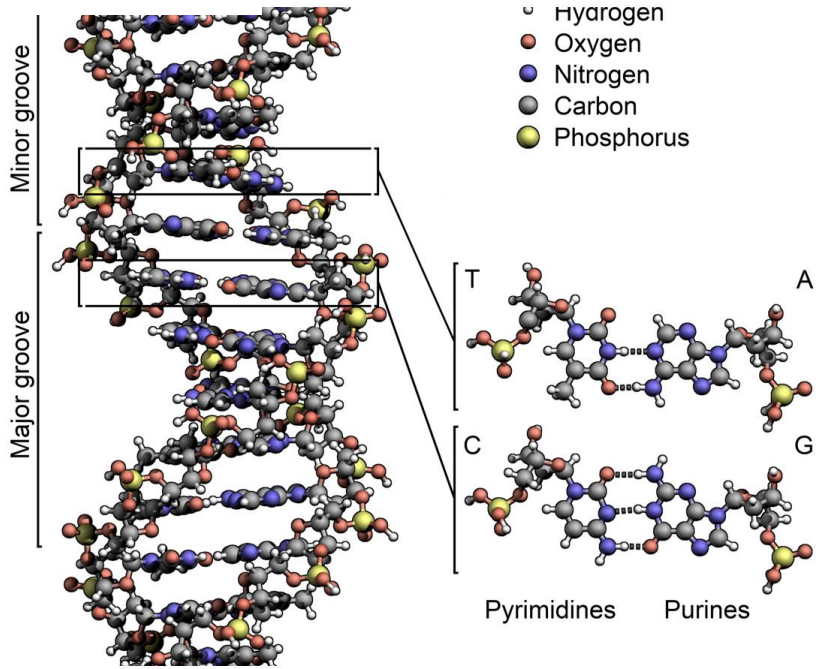
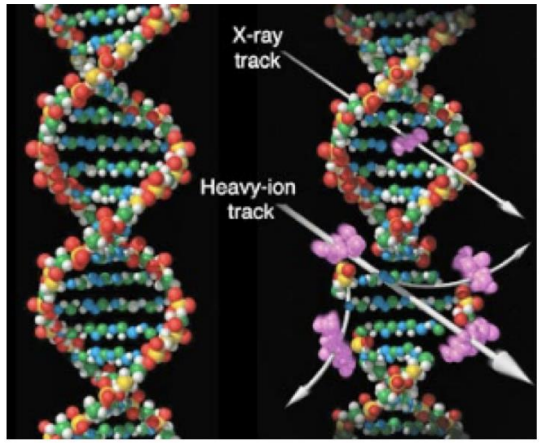
A particle beam can break the DNA and kill a cell









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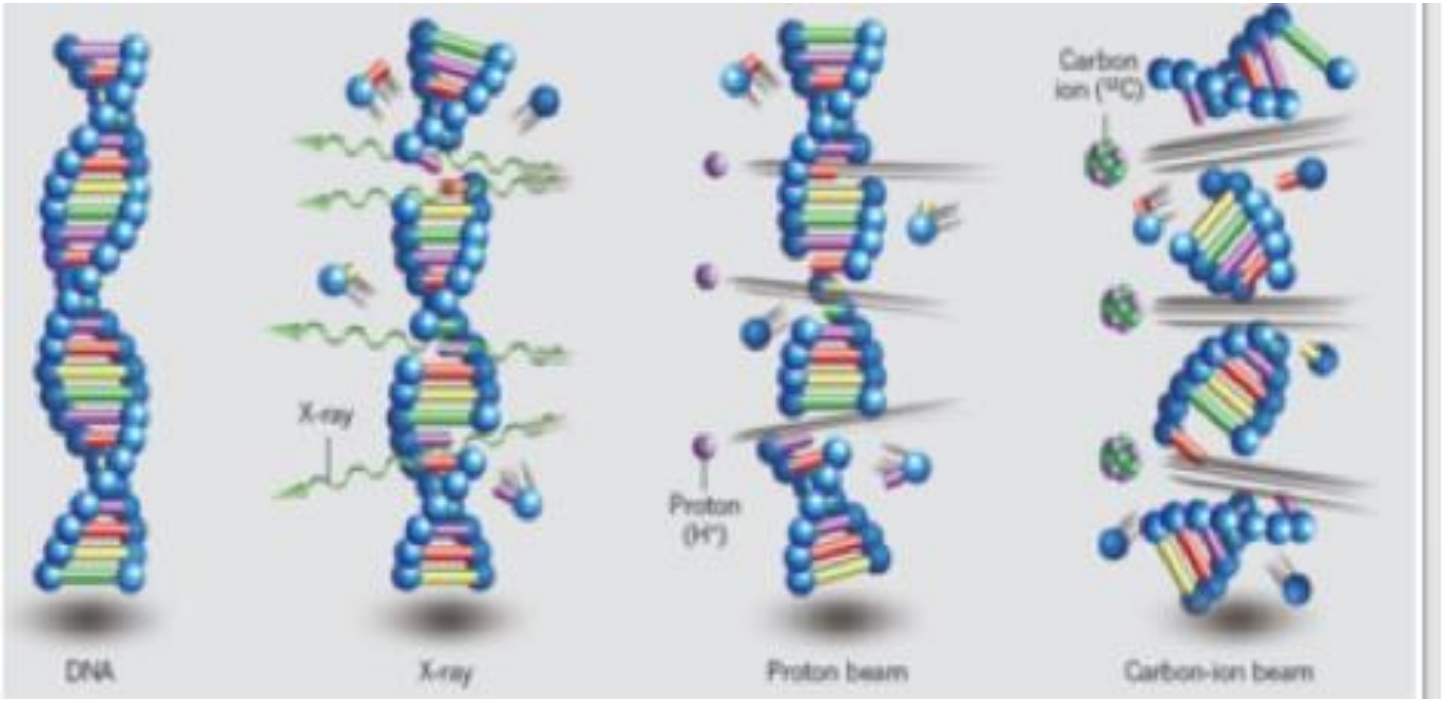
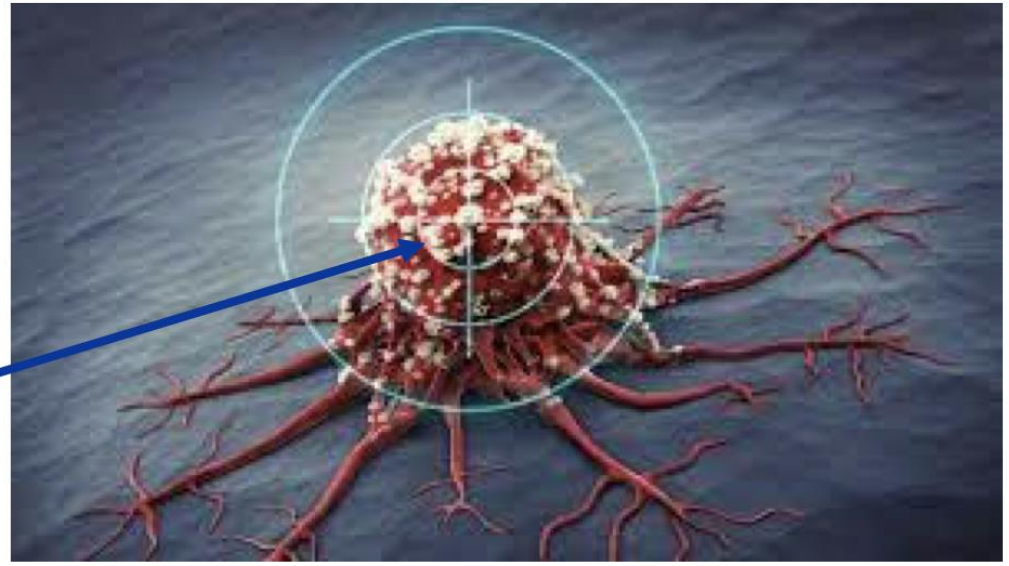
A particle beam can break the DNA and kill a cell

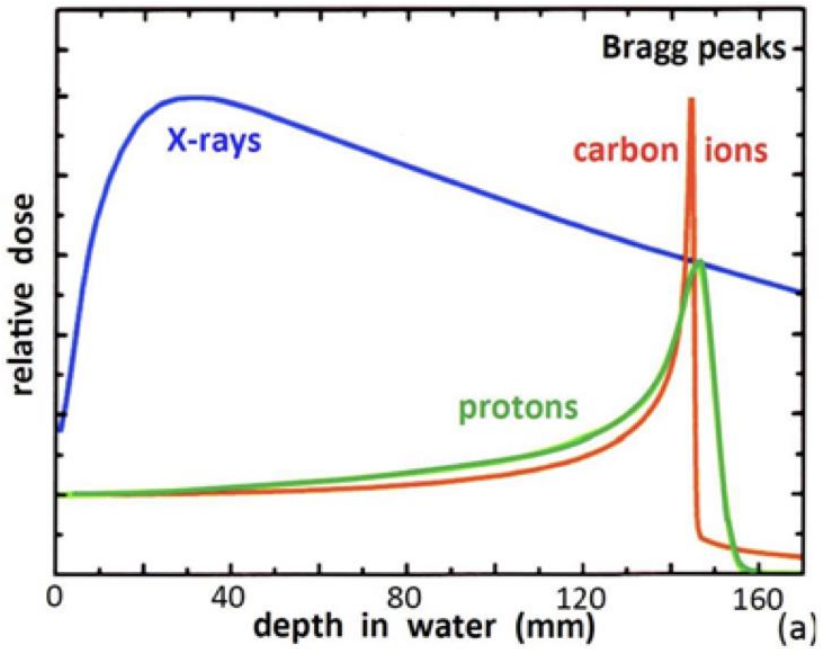


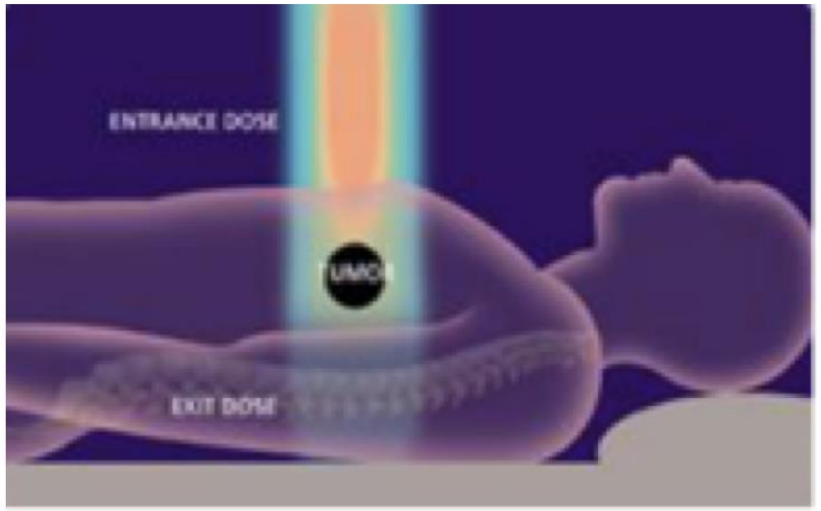
And if the cells has the cancer?
Killed !

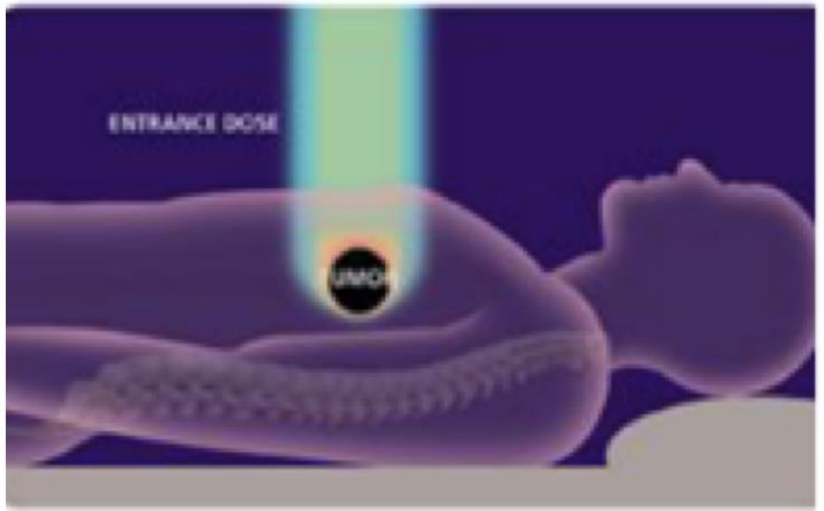


Hadron therapy with protons or ions

The Bragg peak







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

Required energy for full-body penetration: 230 MeV protons, 450 MeV/u C-ions.

22,000 patients/year (2018) treated with particle beams, 25,000,000 patients/year with X-rays.

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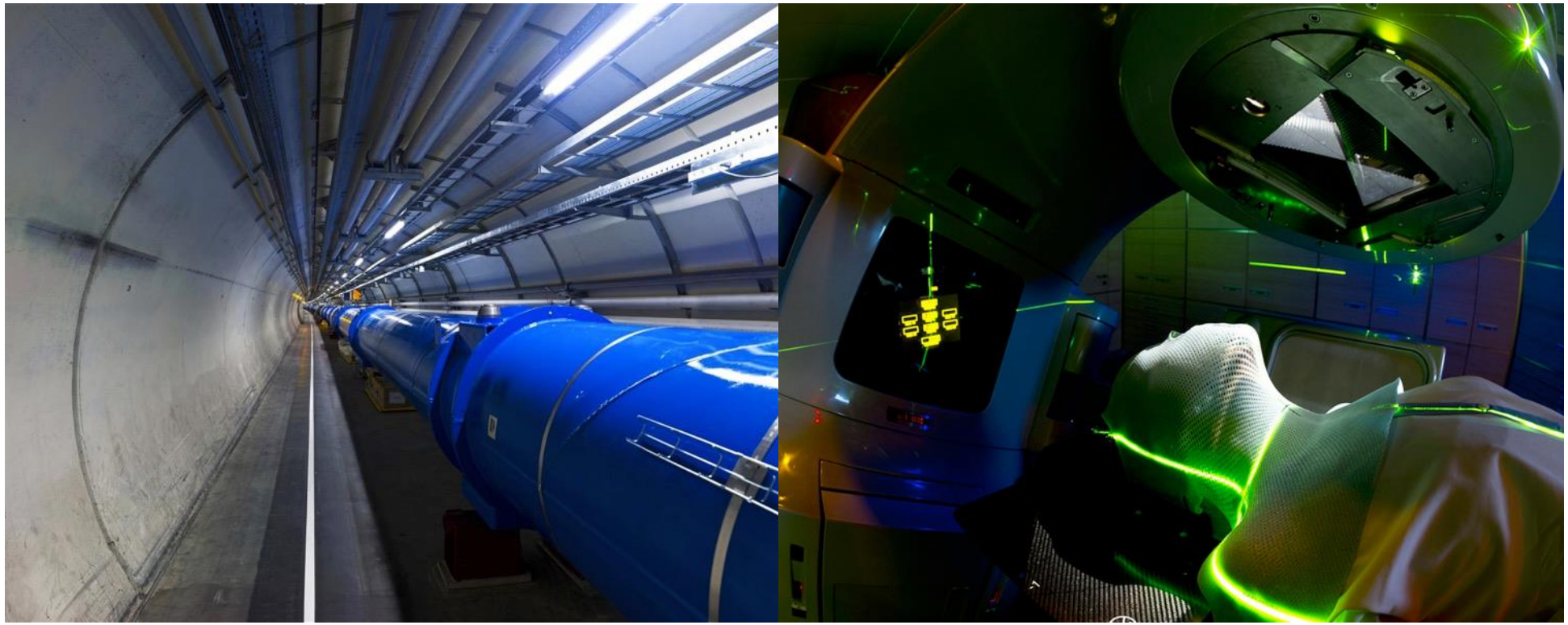
Accelerators for health

From fundamental research…



……to medical applications

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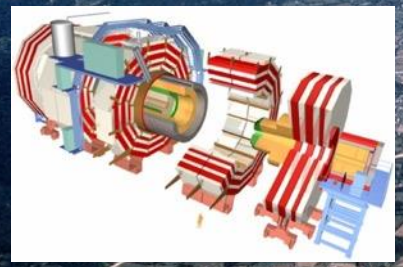
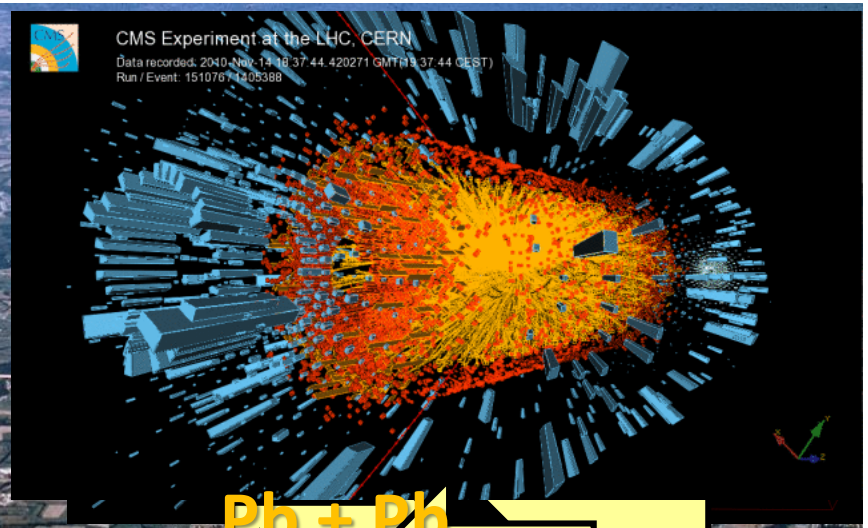
Large Hadron Collider

Collider of 'Large Hadrons'

Design Energy:
14 TeV (pp)
1150 TeV (PbPb)



CMS



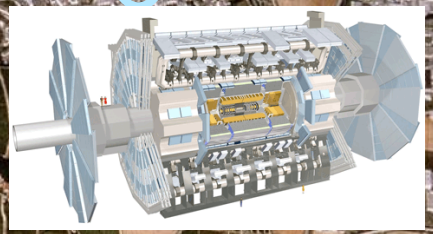
Pb + Pb

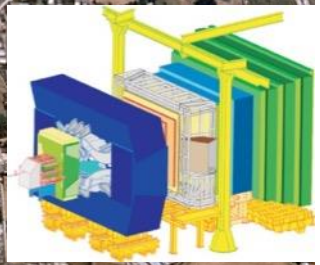
LHCb

Nobel for physics 2013

ALICE

ATLAS

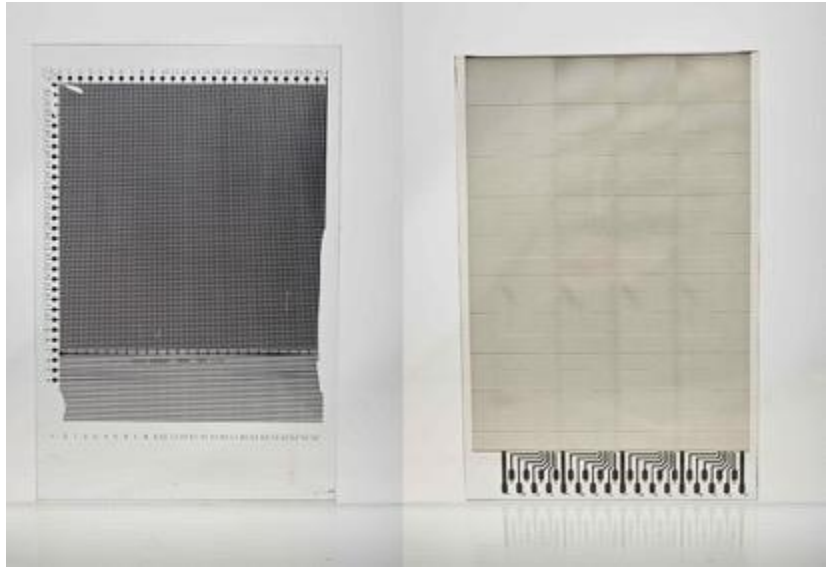




Applications for society

Even if fundamental research does not aim at developing "useful products" the fact is that many applications for the benefit of the broader society are based on developments for physics fundamental research.

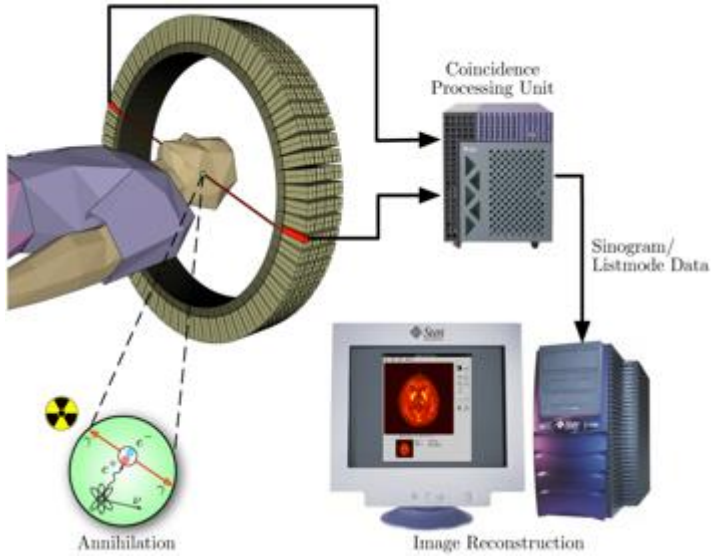
Touchscreen



World Wide Web (WWW)

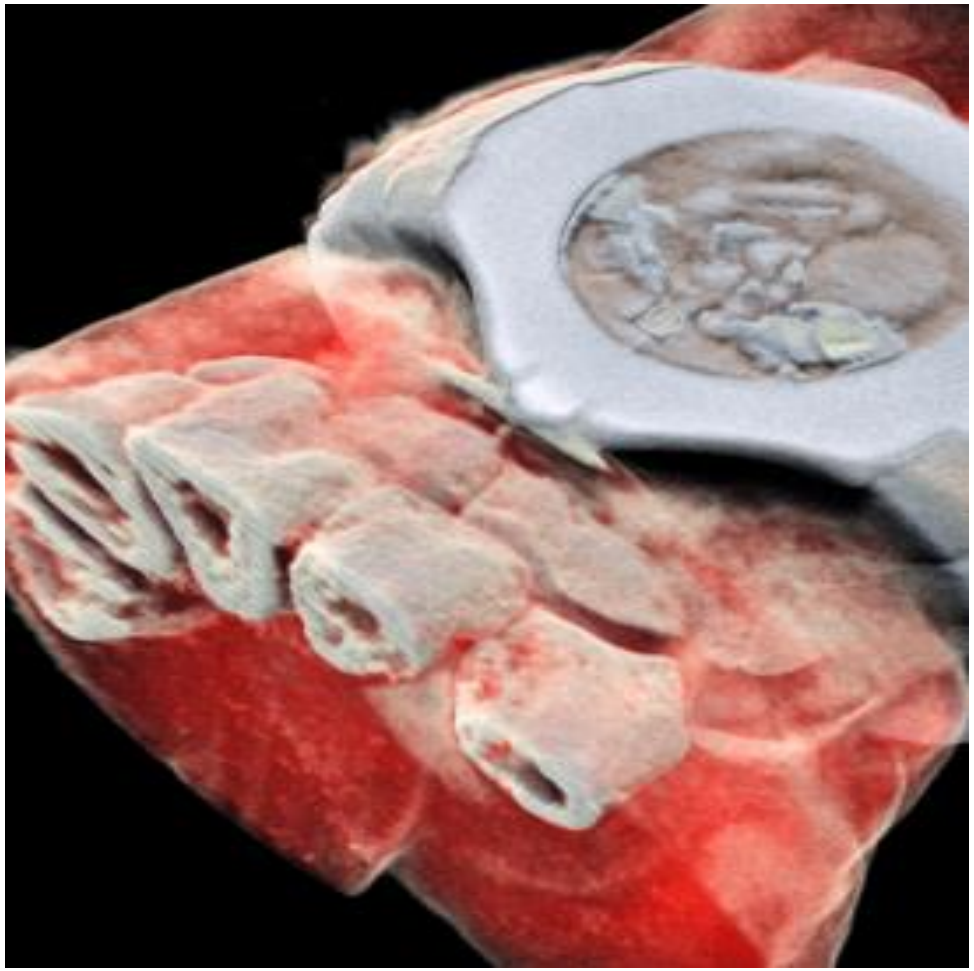
Tim Berners-Lee

PET scan



The aim and mandate of research institutes is fundamental research and knowledge

Colour radiographies

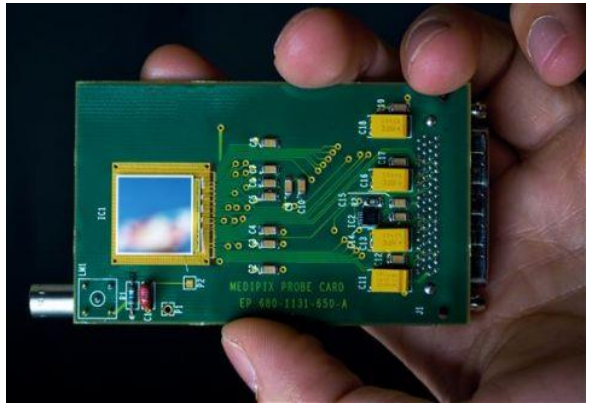


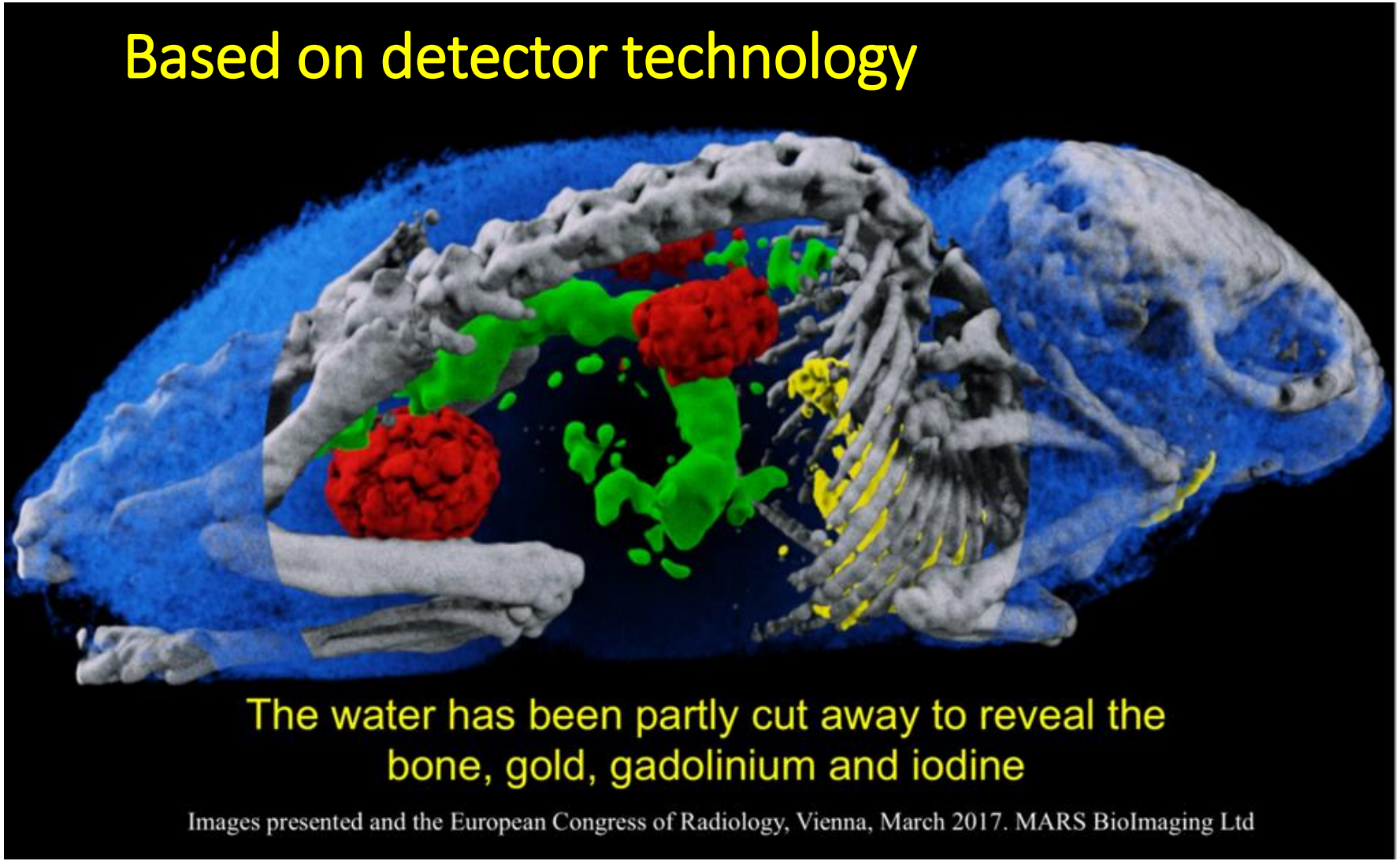
From the first x-ray radiography to the first colour radiography

Rontgen 1895, *to CERN technology 201*

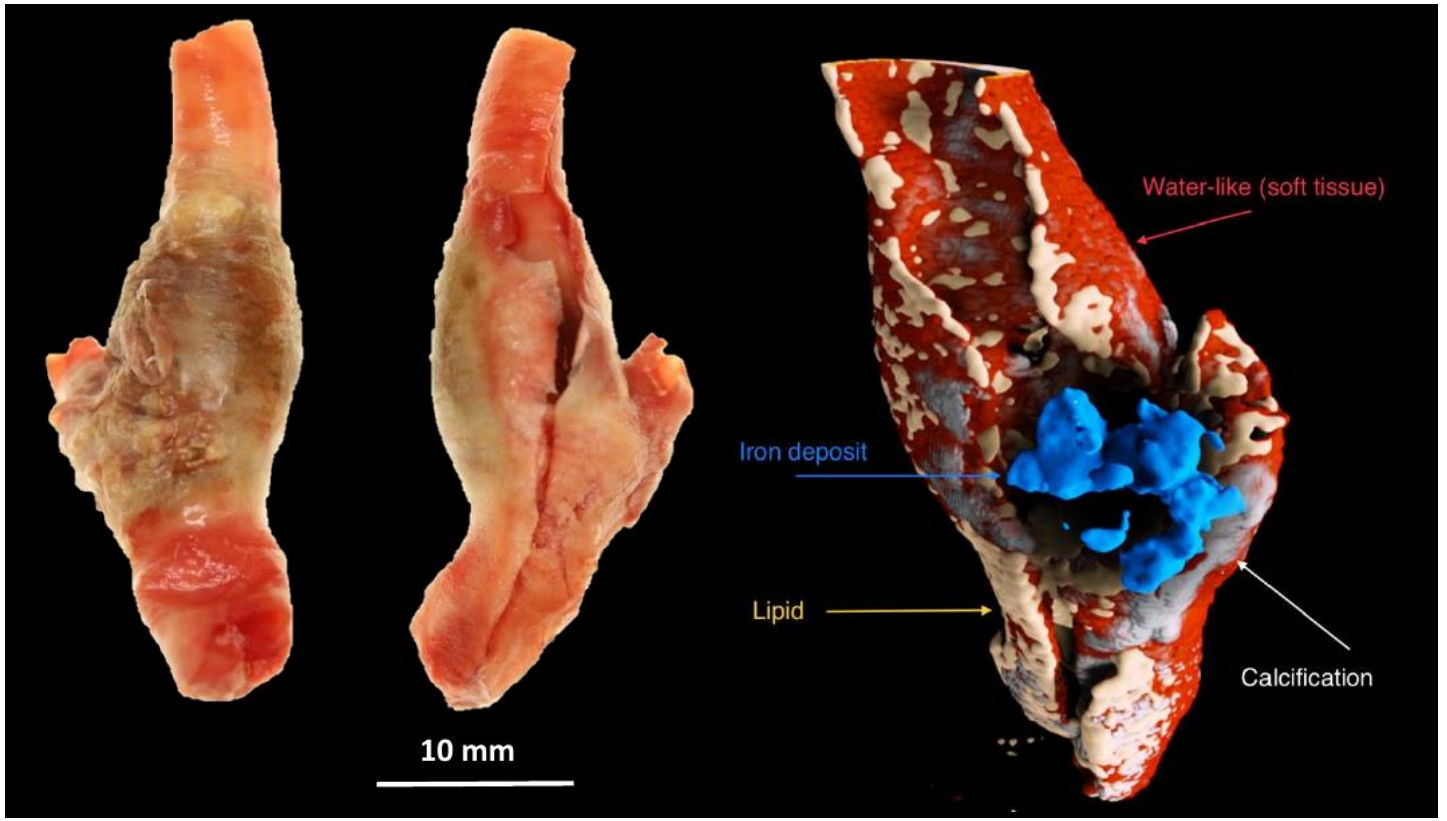
Colour radiographies

From tracing particles with silicon pixel detectors to colour radiographies (Medipix)





Modecular imaging



Cardiovascular diseases: cause of 37% of deaths in EU.

Steven Gieseg, Uni. Canterbury

Proton CT scanner based on ALPIDE ALICE

ALPIDE: A New Methodology for Proton CT

Success Story

Application Domains: Medtech

A new Monolithic Active Pixel Sensor, originally developed to upgrade the ALICE inner tracking system during the second long shutdown of LHC, is on its way to Bergen University for a very different application – Proton Computed Tomography (Proton CT). The University will use the technology for research and development of a Proton CT proof-of-concept project using the high time and space resolution of the ALPIDE chip. Proton CT is a technique based on the measurement of a proton's position/trajectory and energy before and after traversing an object to reconstruct an image of the object. Unlike conventional X-ray CT systems, where the technology is widely understood, proton CT still faces some technological challenges

ALPIDE:
A new **M**onolithic **A**ctive **P**ixel **S**ensor

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%

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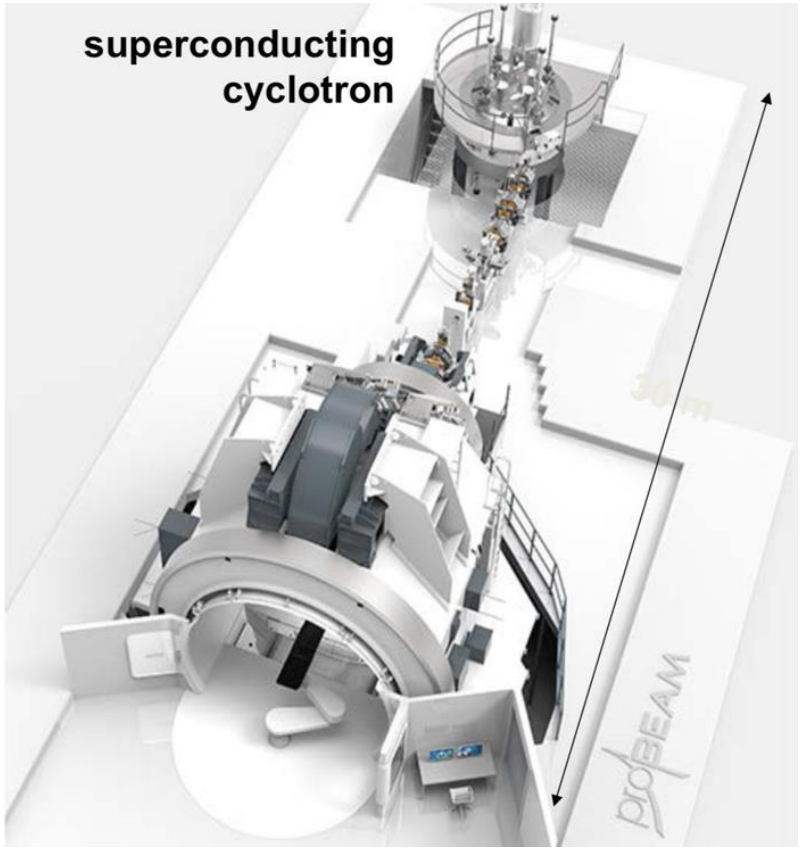
Accelerators for health

Conventional x-ray Radiotherapy

Particle/Hadron Therapy with protons



Hadron Therapy centers in Europe (2018)

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Four carbon-ion cancer therapy centers in Europe

CNAO, Italy

Video-visit@CNAO

HIT, Germany

MIT, Germany

MedAustron, Austria

Virtual Hadron Therapy Center

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

Basic concepts for a

SOUTH-EAST EUROPE INTERNATIONAL INSTITUTE FOR SUSTAINABLE TECHNOLOGIES (SEEIIST)

January 15, 2018

Proposal for a facility in South East Europe: SEEIIST

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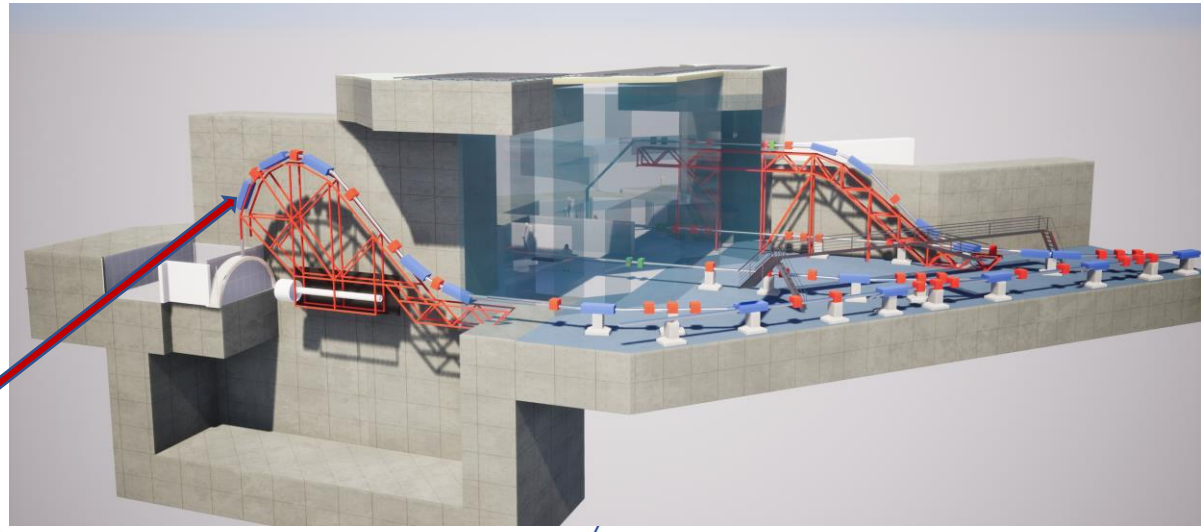
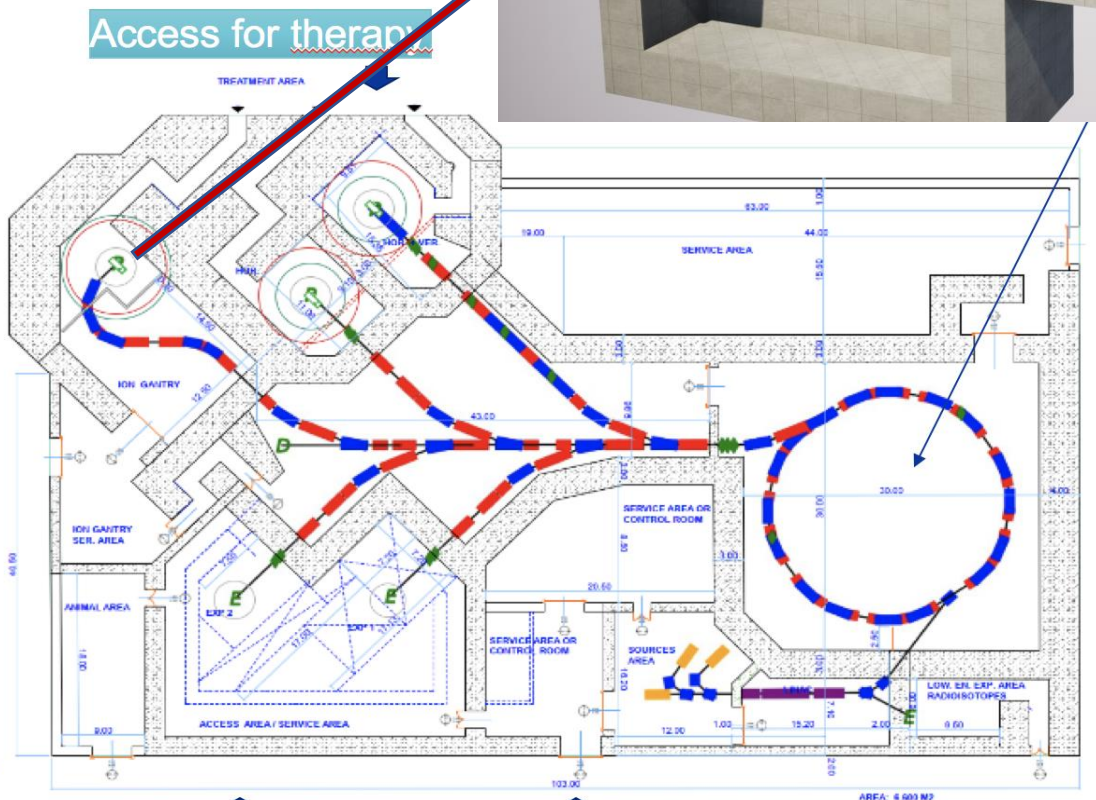
Accelerator and Beam Delivery

Gantry at HIT 600 tons

40 tons Gantry at SEEIIST





SEEIIST facility

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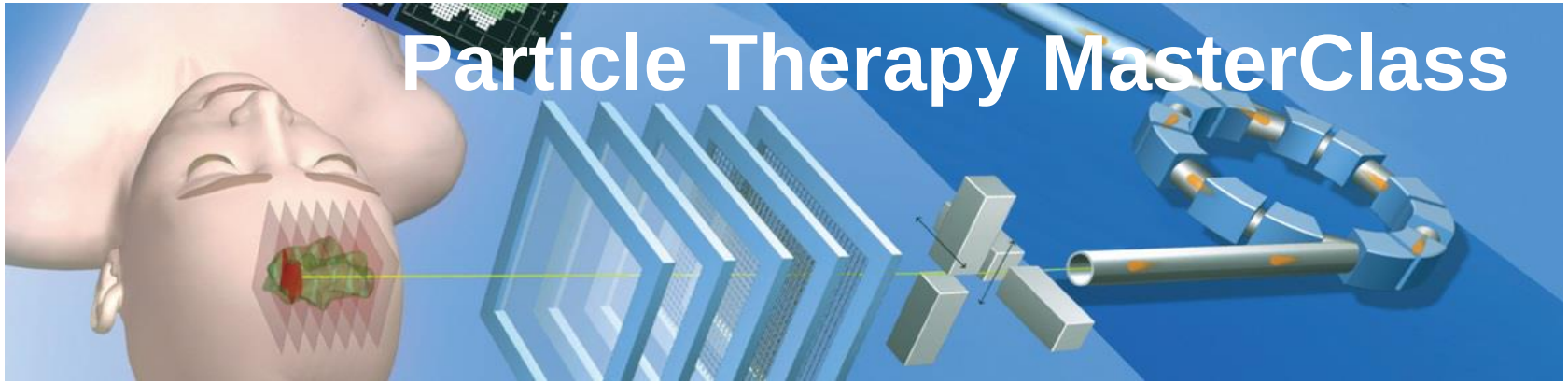
Particle Therapy MasterClass



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Contact

pt.mc@cern.ch

Presentations

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

Presentation of MatRad

matRad

Department of Medical Physics in Radiation Oncology
DKFZ Heidelberg

dkfz.

Particle Therapy Masterclass

Overview and Pilot Report

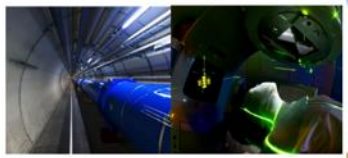
Particle Therapy MasterClass
Overview & Pilot Report

dkfz.

For ppt click **here**.

Presentation of Particle physics to medical applications

Particle physics to medical applications



Manjit Dosanjh, CERN

Introductory presentation in Greek

LMU MEDICAL PHYSICS

Εφαρμογές της Φυσικής στη Θεραπεία του Καρκίνου
Ακτινοθεραπεία

Δρ. Γ. Δέδες
Ludwig-Maximilians-University of Munich
Department of Medical Physics

27 Αυγούστου 2017, Χανιά

Δημόσια Ομιλία στα πλαίσια του Διεθνούς Συνεδρίου
Public talk at Great Arkansli on the occasion of International Workshop
Ions for Cancer Therapy, Space Research and Material Science

Workflow Instructions

Workflow Instrukcije

Material in different languages

Animations

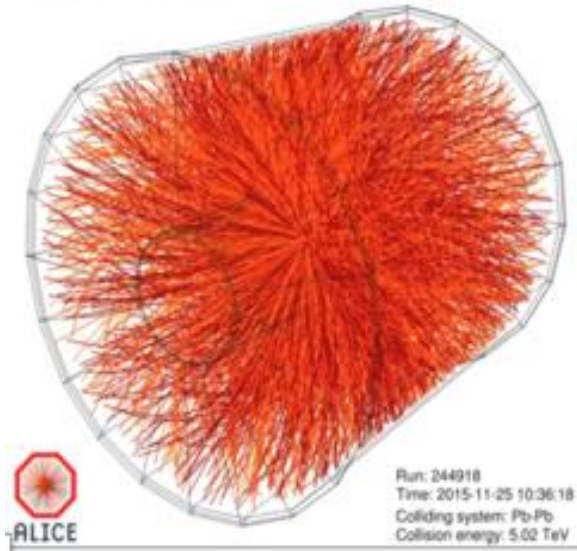
INTERNATIONAL MASTERCLASSES
hands on particle physics

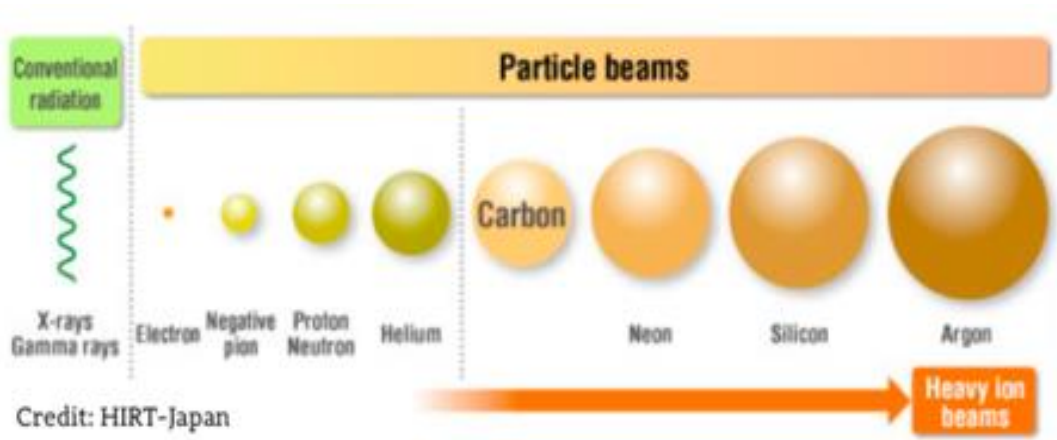
Heavy-ion research and heavy-ion therapy

Pb-Pb at 5.5 TeV
pp at 14 TeV

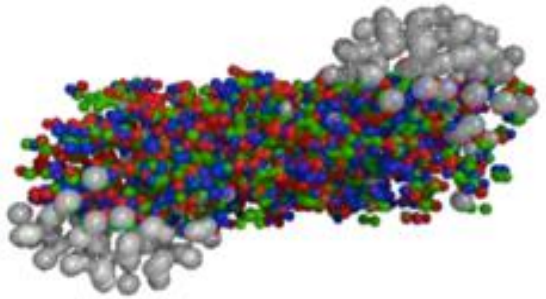
fundamental science
QGP studies

Credit: CERN





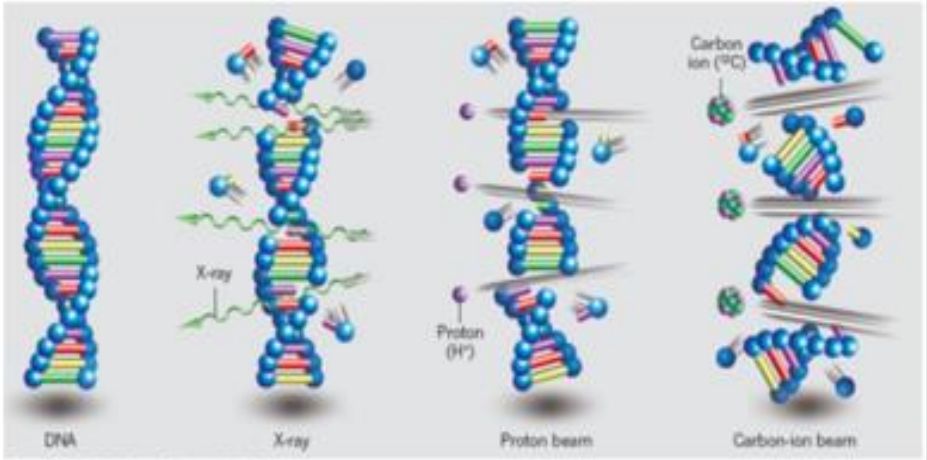
Credit: HIRT-Japan



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

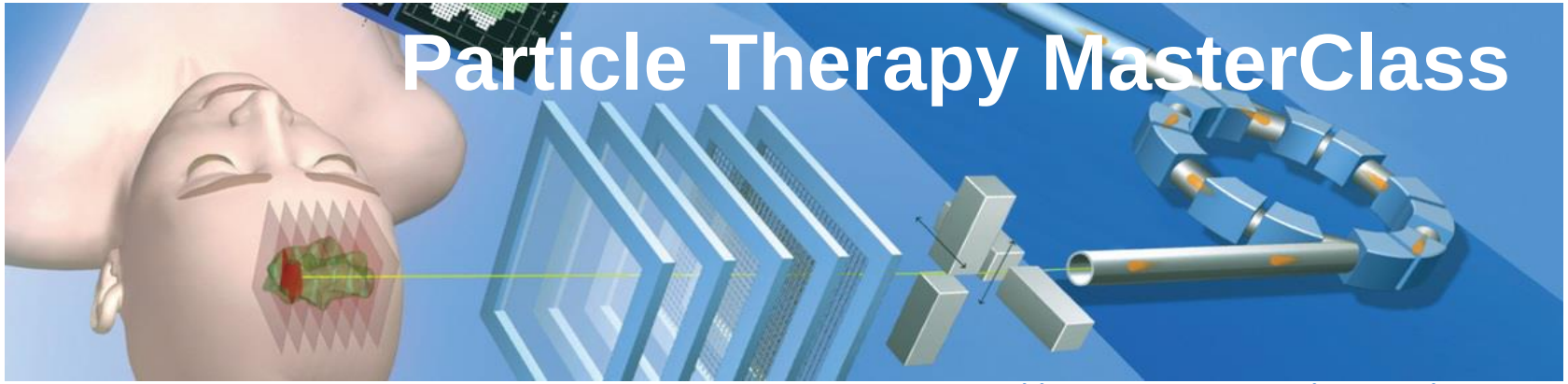
applied science
medicine

Credit: HIT Heidelberg



Credit: T. Nomiya, NIRS Japan

Particle Therapy MasterClass



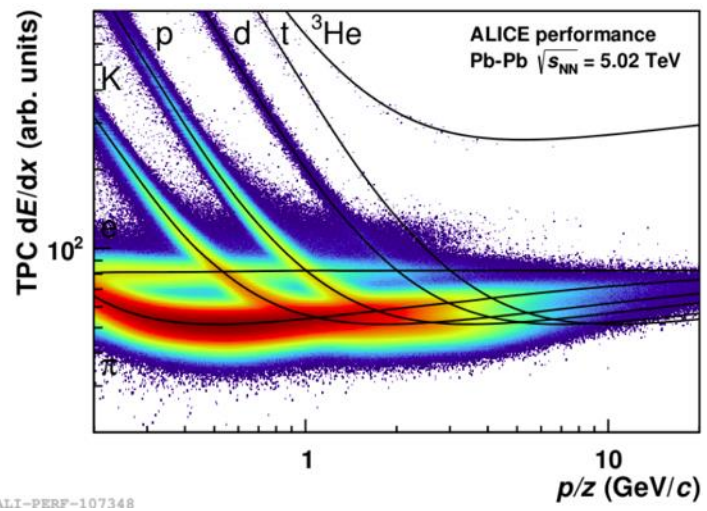
https://indico.cern.ch/event/840212/

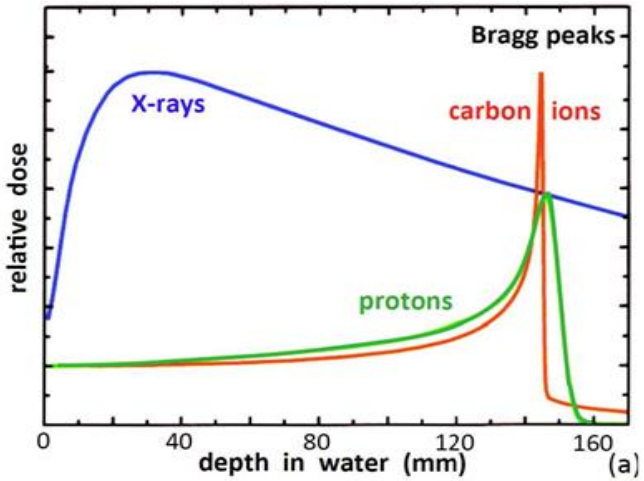
Aim: benefits for society from fundamental research

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





INTERNATIONAL MASTERCLASSES
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