

CERN: history and applications

Rita Ferreira

CERN Knowledge Transfer, Medical Applications

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Credits: Manuela Cirilli, Giovanni Porcellana, CERN Knowledge Transfer

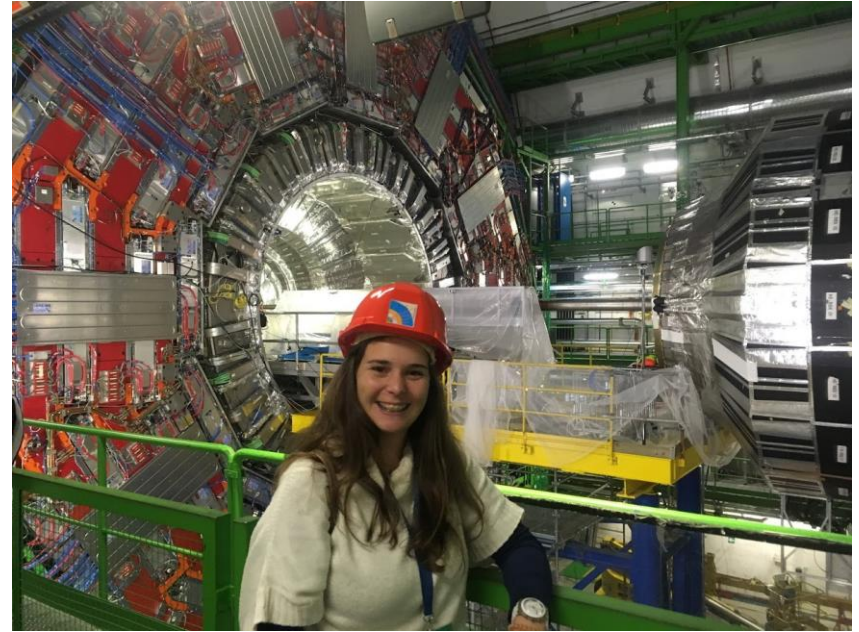


Who?



Rita Ferreira

- Chemical and Biochemical Engineer
- From Lisbon, Portugal



What (and where)?

PhD/Researcher (before) and CERN (now)



- Medical Applications
- Accelerators for Hadron Therapy
- Magnets
- Outreach
- ...

Welcome to CERN!



Conseil Européen pour la Recherche Nucléaire
European Organization for Nuclear Research



LHC – Large Hadron Collider



- World's largest and most powerful particle accelerator
- 27 kilometer ring
- 10 September 2008



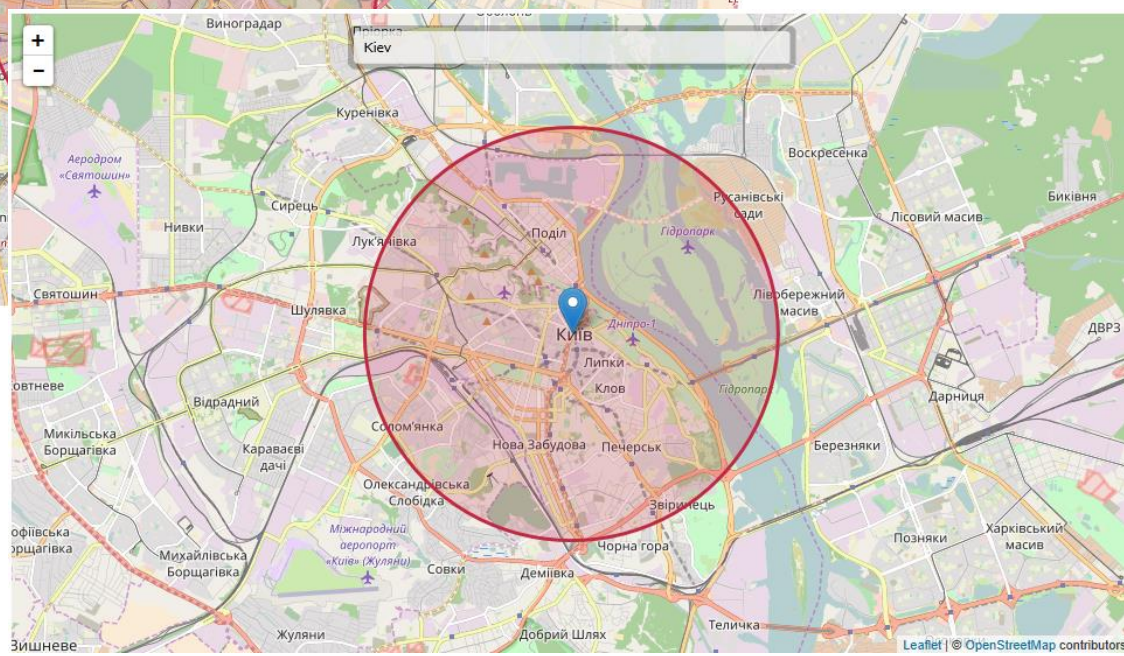
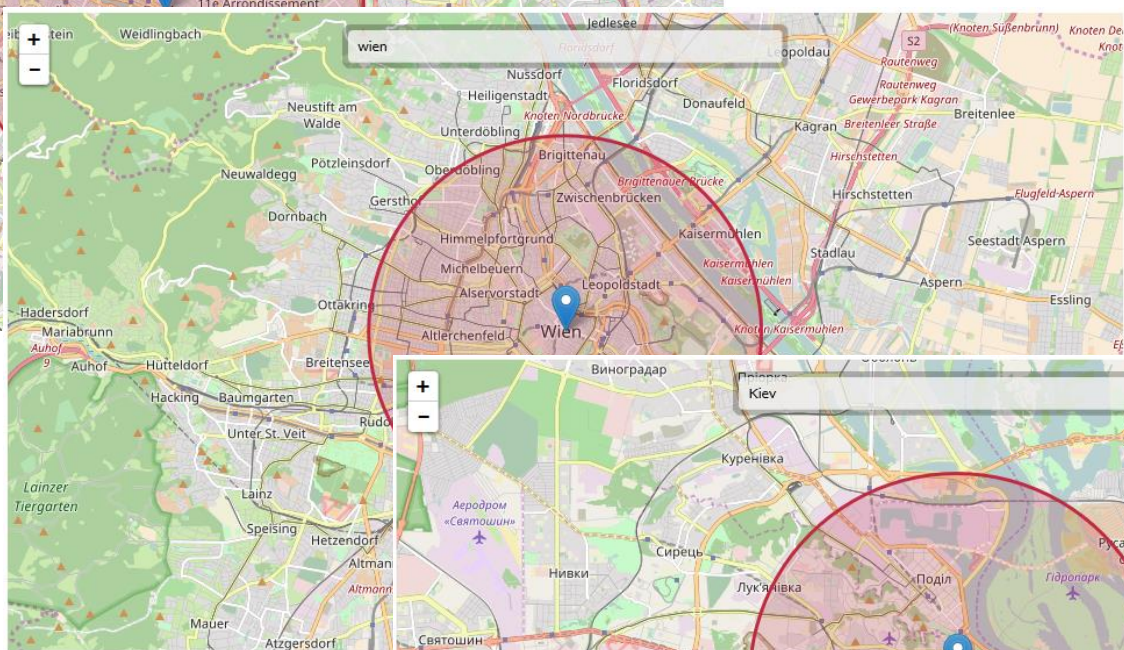
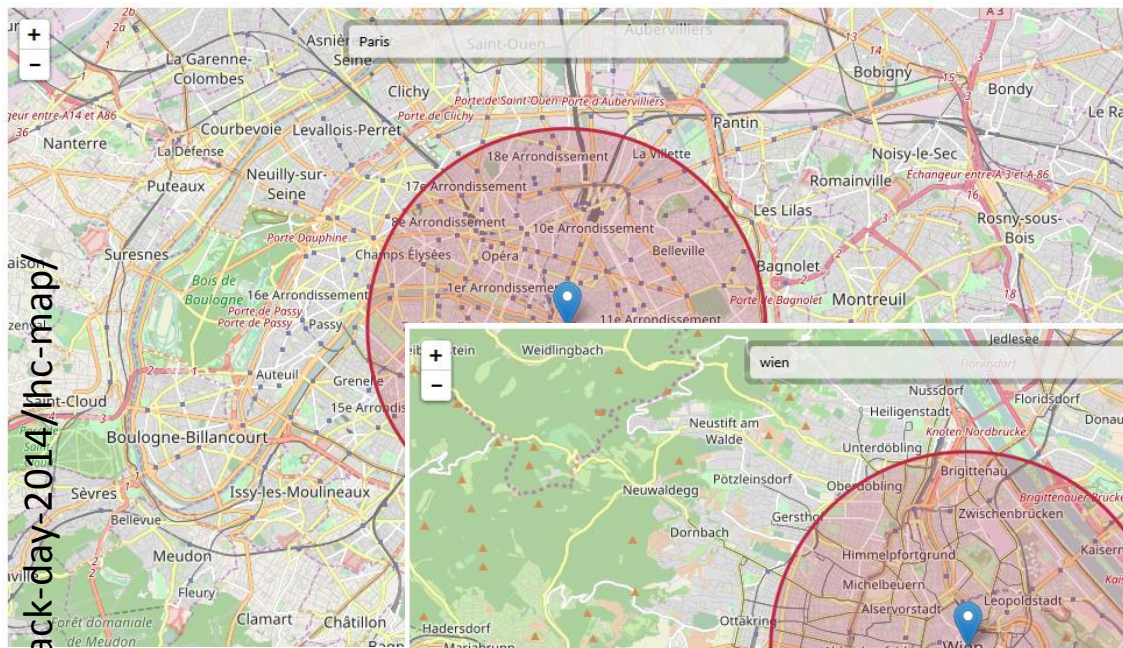
4 Particle Detectors

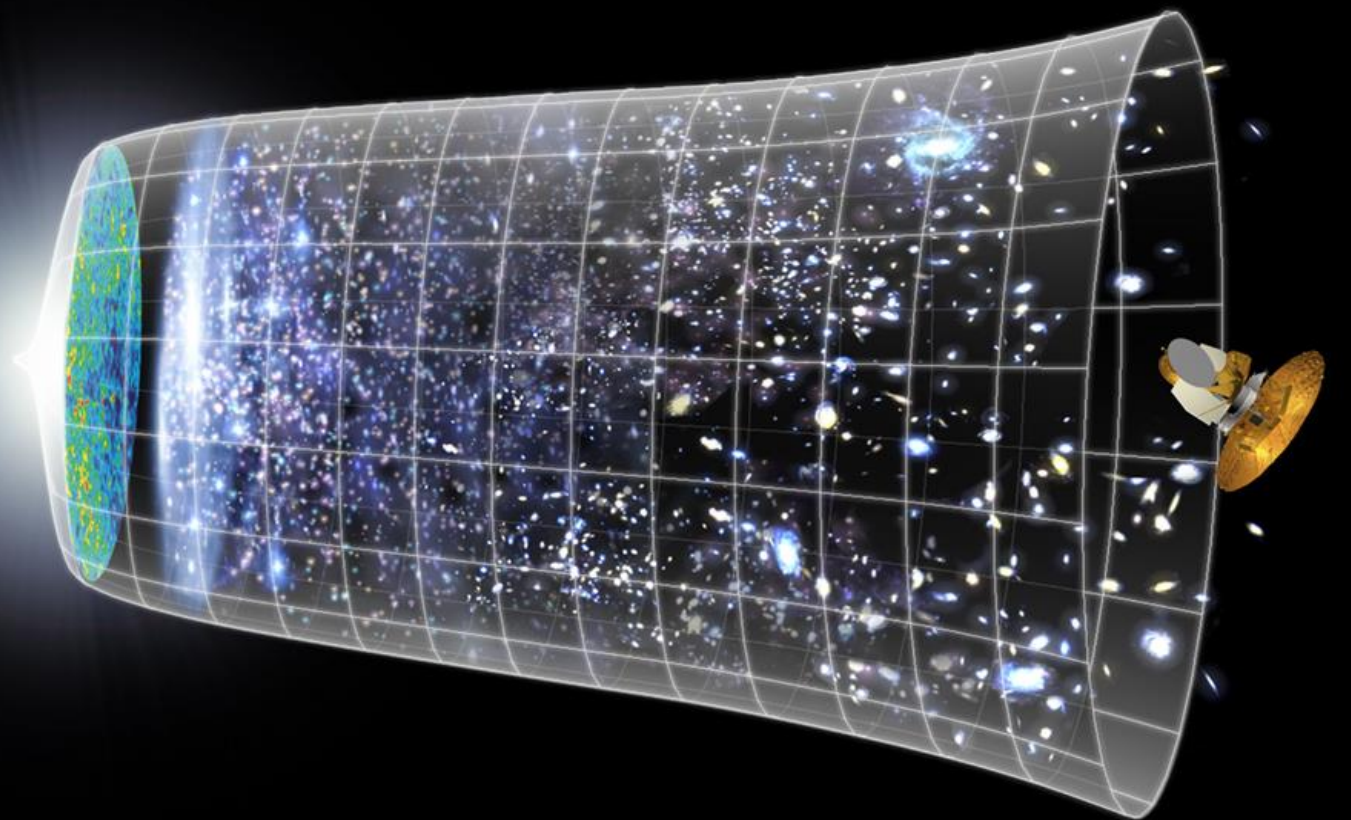


LHC - What if...



<http://natronics.github.io/science-hack-day-2014/lhc-map/>





13.7 billion years

Today

10^{28} cm

History



Isidor Rabi



Louis de Broglie

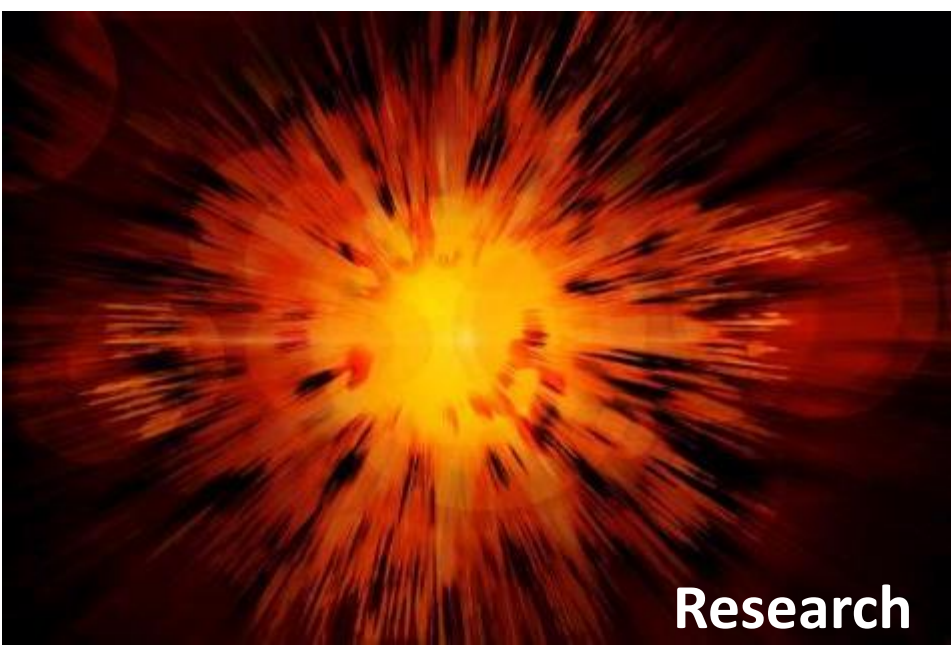


Edoardo Amaldi

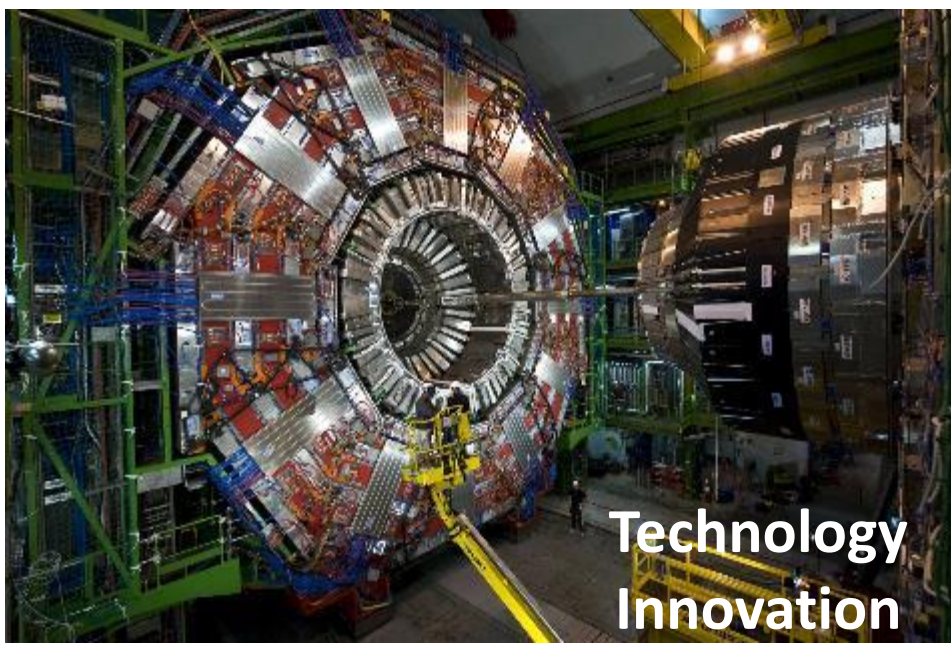
12 founding Member States



CERN's mission



Research



**Technology
Innovation**

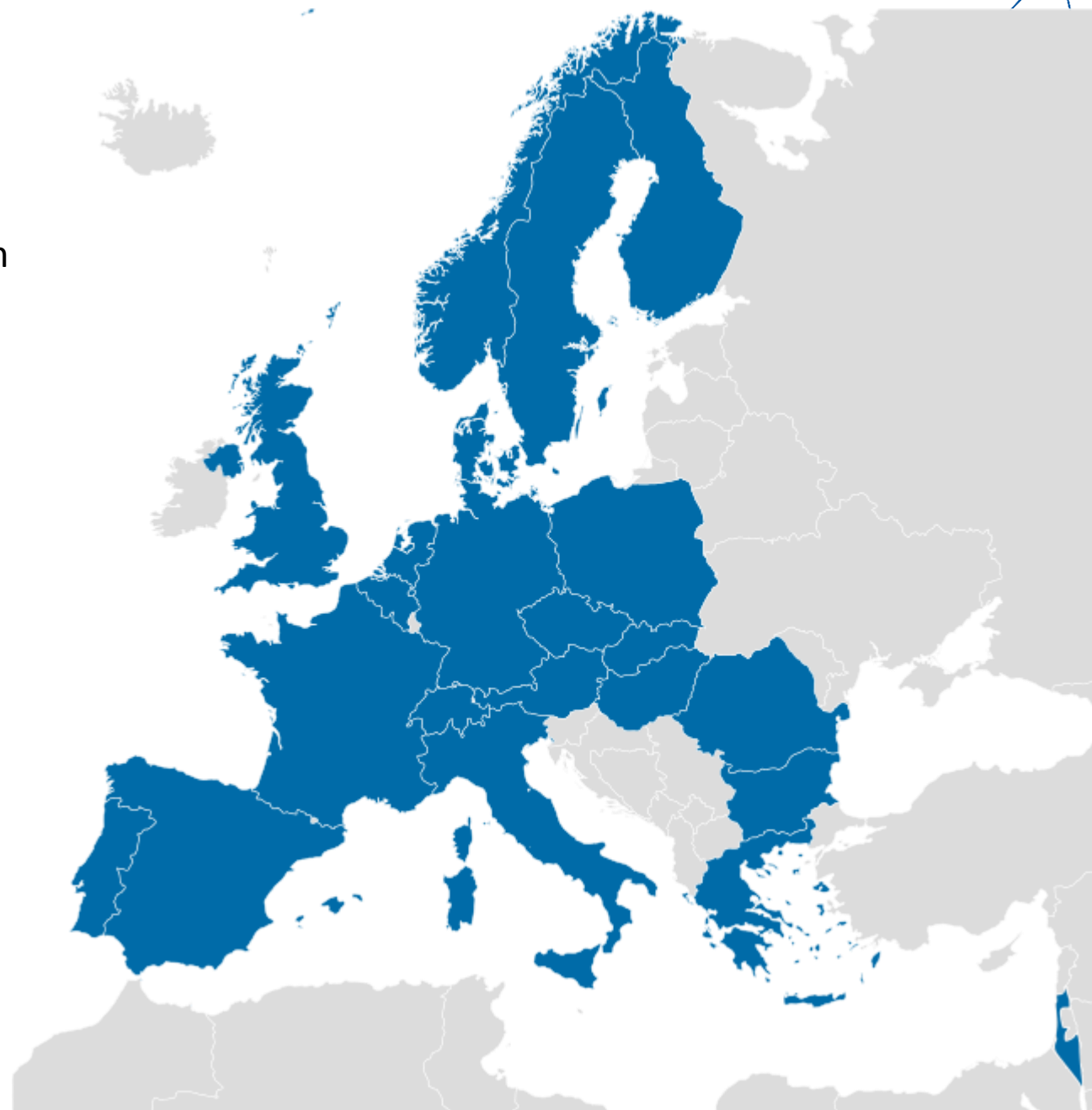


Education



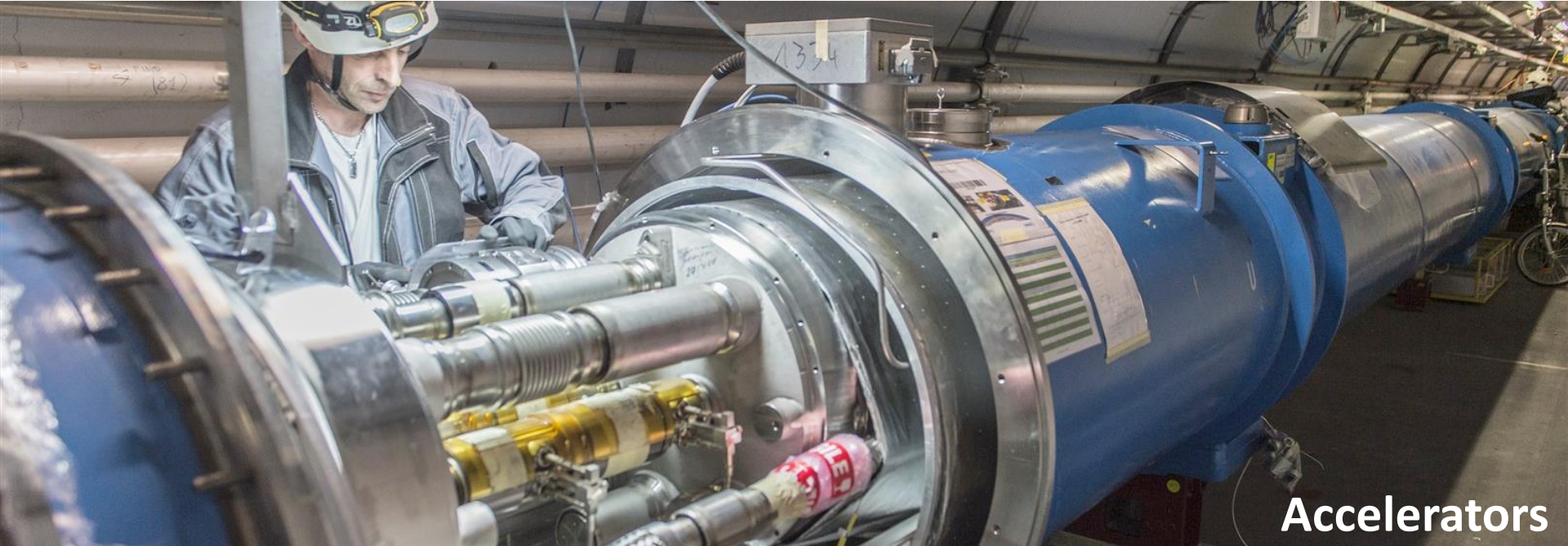
Collaboration

22 Member States



- 36 Non-member states with co-operation agreements
- 19 Countries with scientific contacts

The three pillars



Accelerators



Detectors



Computing

Knowledge Transfer



Everyday, everywhere!

Knowledge Transfer Mission



Maximize the technological and knowledge return to the member states' industry and society

Promote CERN's image as a centre of excellence for technology

Knowledge Transfer

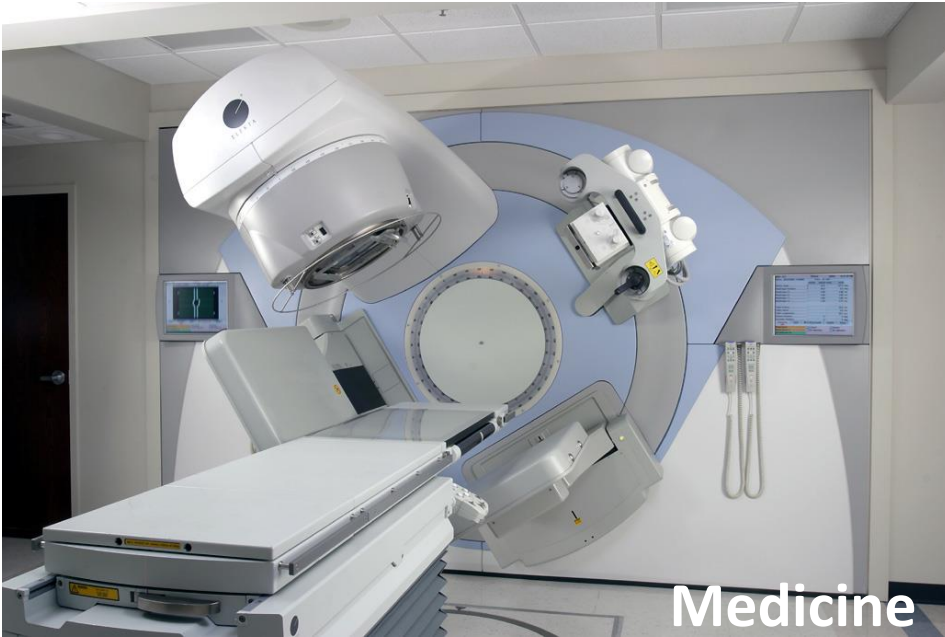


Tim Berners-Lee



Bent Stumpe

From physics to...



Medicine



Aerospace

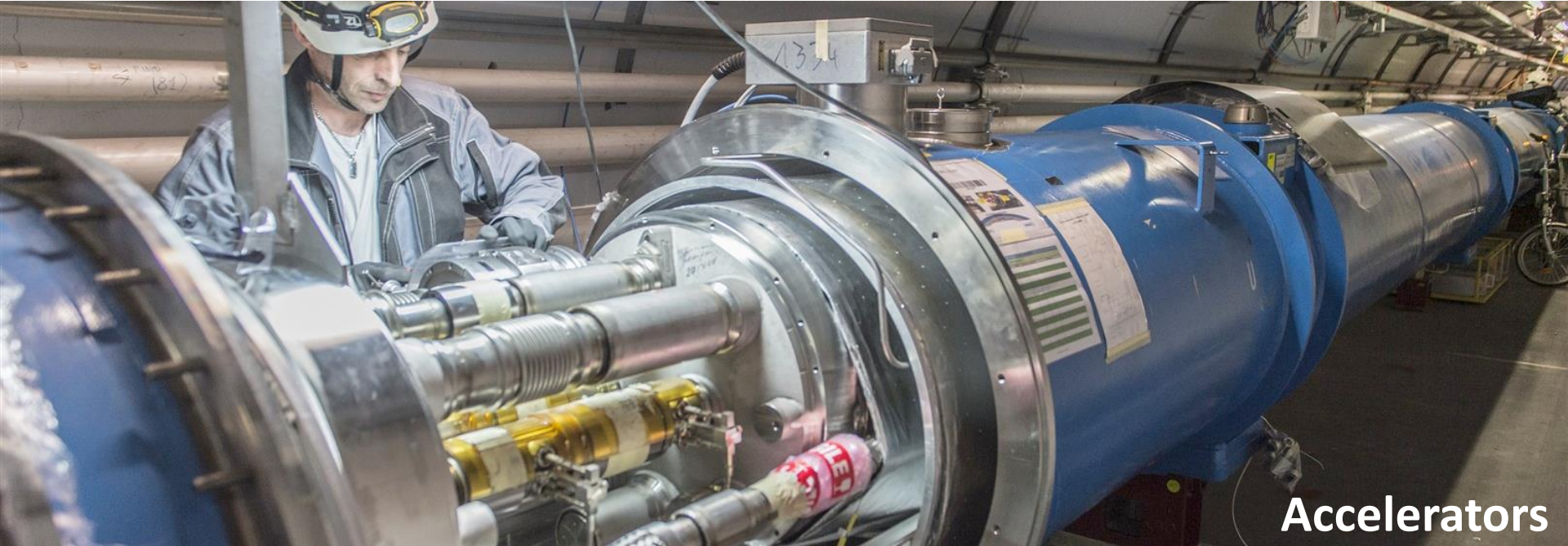


Safety



Global Communities

The three pillars



Accelerators

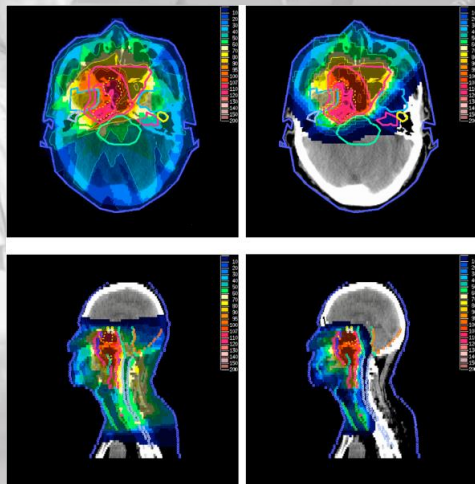


Detectors



Computing

HEP technologies in Medical Application



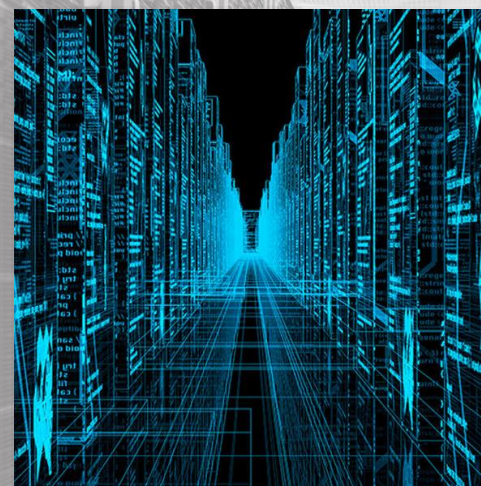
Cancer
treatment

Accelerators



Medical
imaging

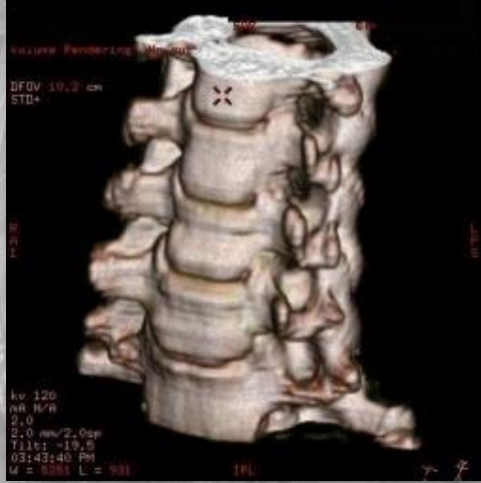
Detectors



Medical data
management
and analysis

Computing

Detectors for Medical Imaging



Medical imaging

Detectors

X-rays

- 8 November 1895:
X-rays discovery
- 22 December 1895:
First radiography



Wilhelm Röntgen

Nobel Prize in PHYSICS 1901

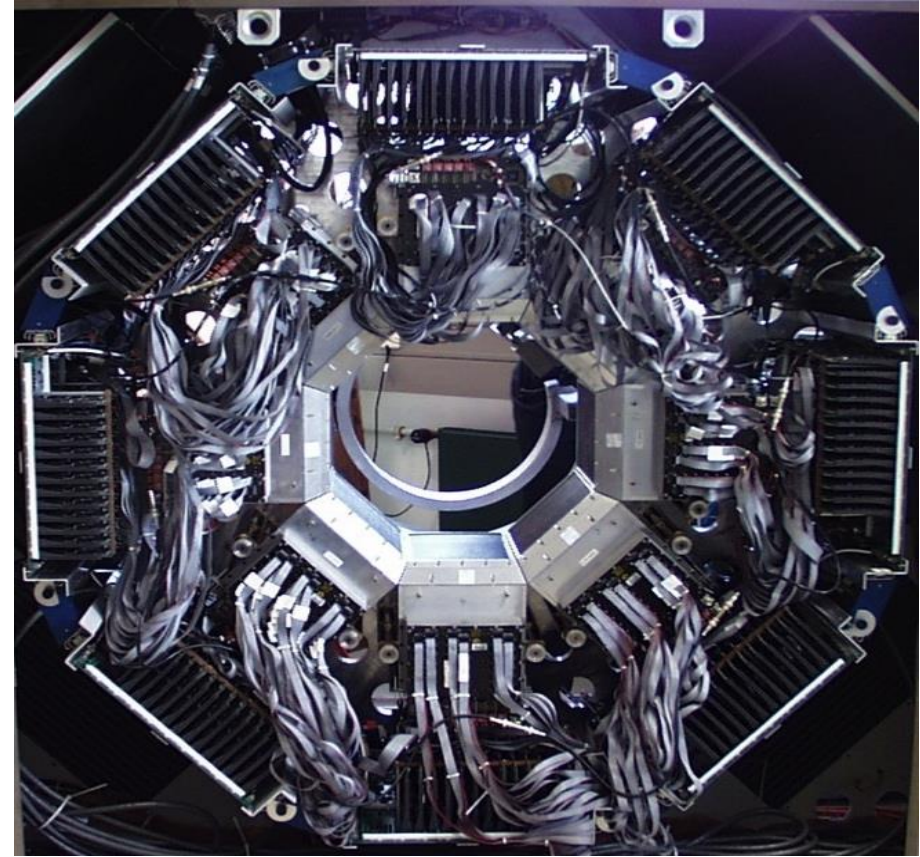
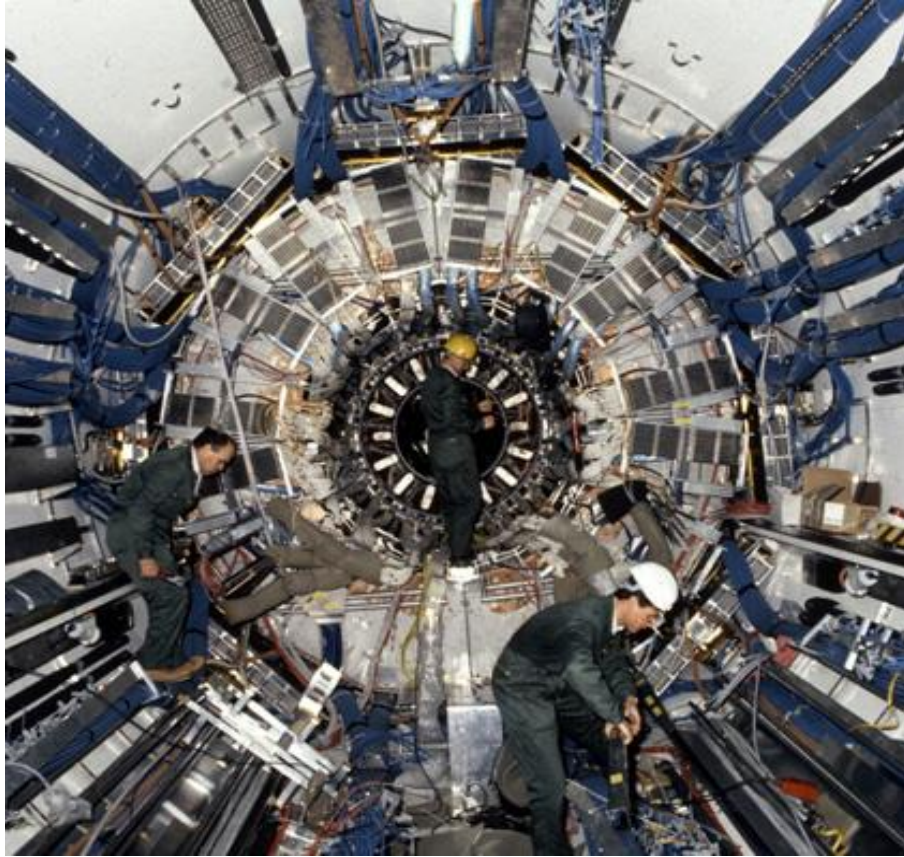


Courtesy of Roentgen museum

More and more details



Medical imaging and particle physics: The same challenge?

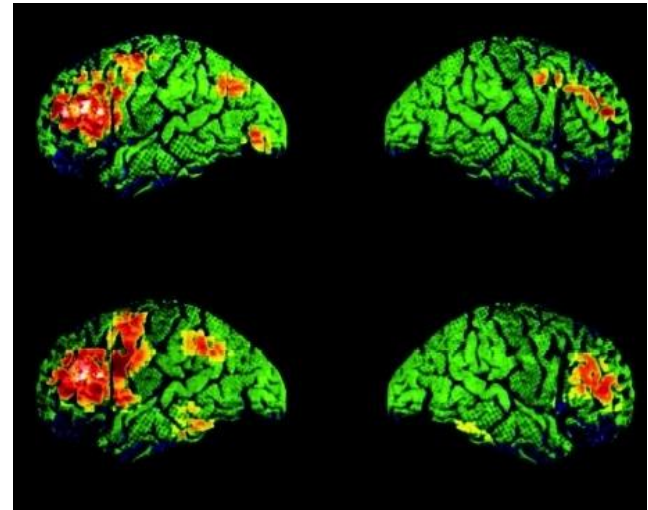
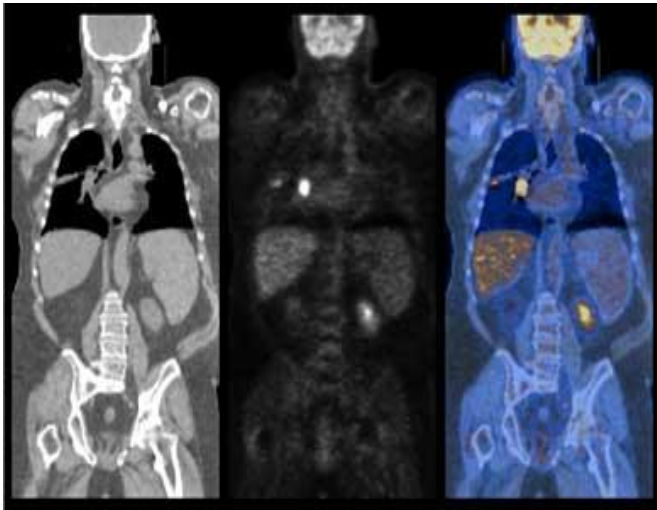


Antimatter – ~~science fiction?~~



Angels & Demons

Positrons are used daily in oncology



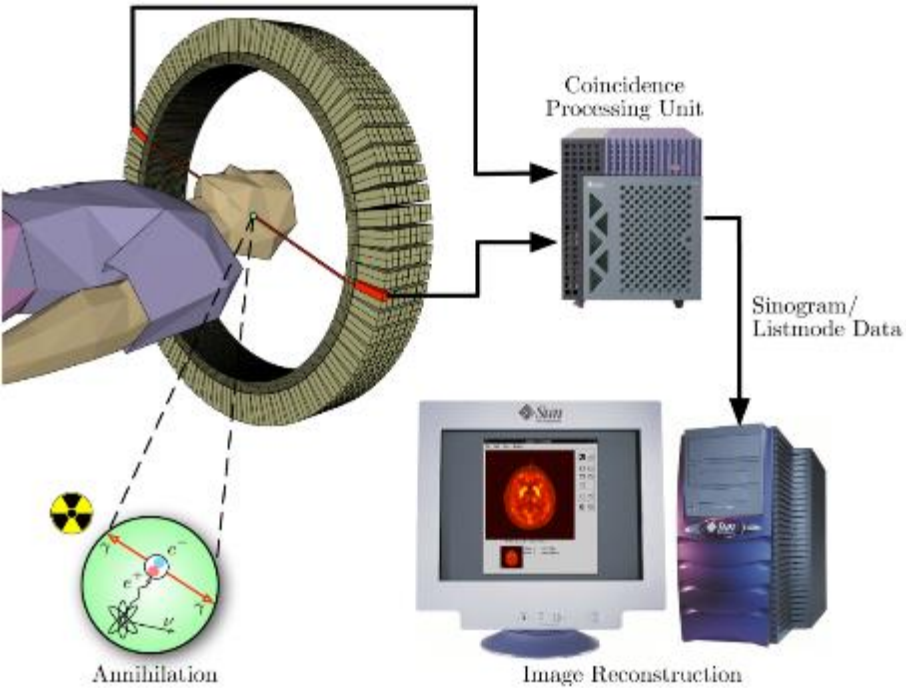
PET - Positron Emission Tomography

Scintillating Crystals

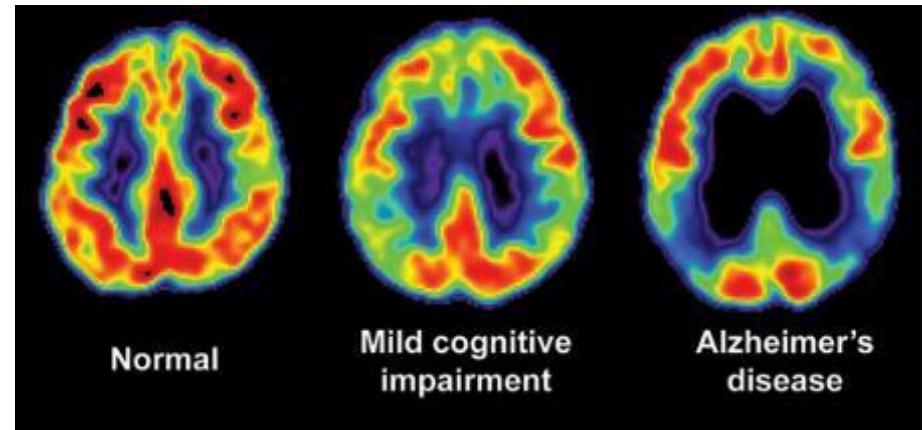


From LHC experiments to PET

PET Scan



Positrons are used daily in oncology

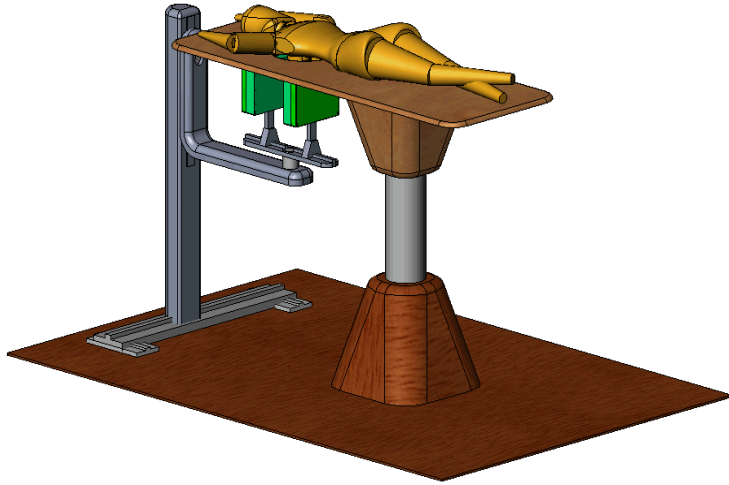


ClearPEM



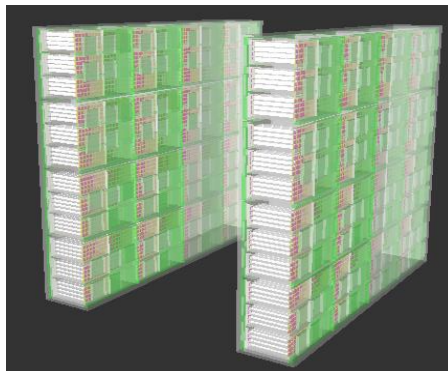
Dedicated PET for breast imaging

Crystal PEM



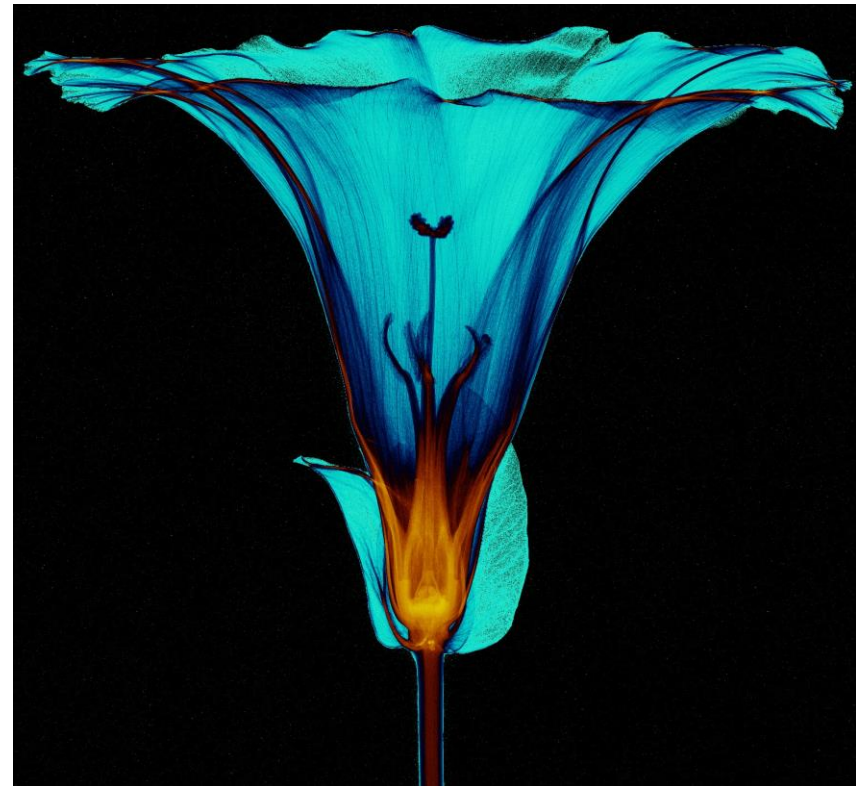
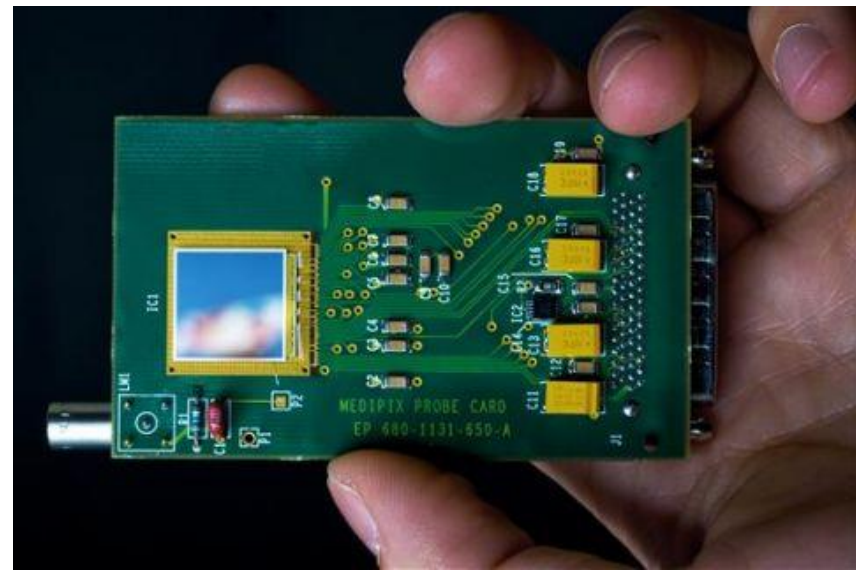
Detection of 3 mm breast lesions in less than 7 minutes exams

- PET detector dedicated to breast cancer screening
 - extremely sensitive to small tumour masses
- Spatial resolution 1-2 mm LYSO:Ce scintillating crystals
- High counting sensitivity
- Short PET exam
- Coupled to ultrasound

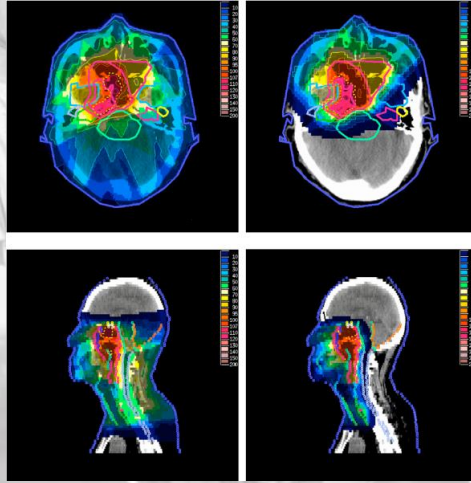


MediPix

- High Energy Physics original development:
 - Particle track detectors
- Main properties:
 - Fast fully digital device similar to the electronic chip in a digital camera but sensitive to X-rays instead of visible light
 - Good conversion efficiency of low energy X-rays
 - Can create the first true colour images with X-rays



Accelerators for Cancer Treatment



Cancer
treatment

Accelerators

Cancer and its treatments



- Every year millions of new cases globally
- Second most common cause of death in Europe, Canada and US.

Conventional Treatment



The “3 Cs” of radiotherapy



Cheap:

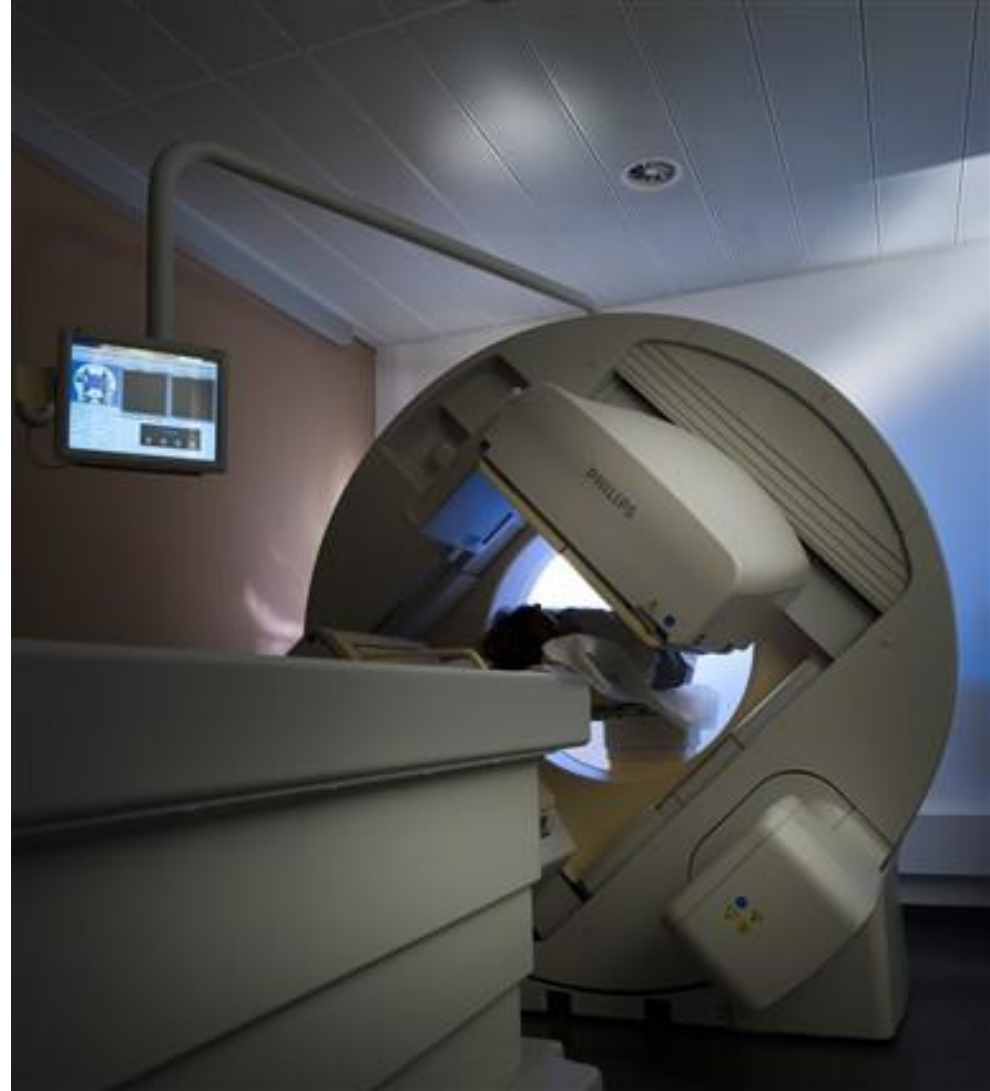
- The least expensive cancer treatment method (around 5% of total cost)

Cure:

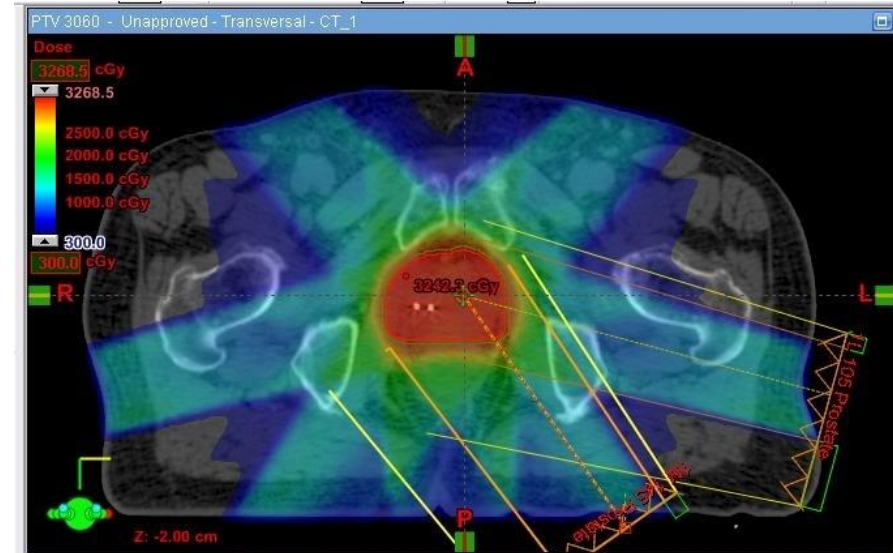
- Good cure rate

Conservative:

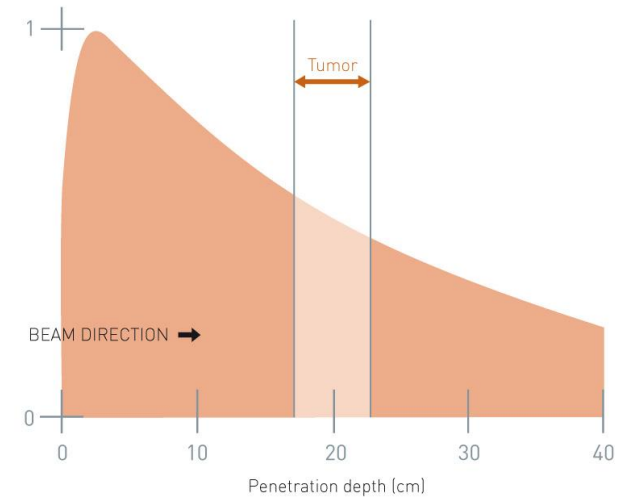
- Generally non-invasive, fewer side effects



Collateral Damage



X-RAYS (linear accelerator 15 MV)



Local dose curve when X-rays penetrate the body
Source: Rinecker Proton Therapy Center

Accelerators for cancer treatment



Innovative practice

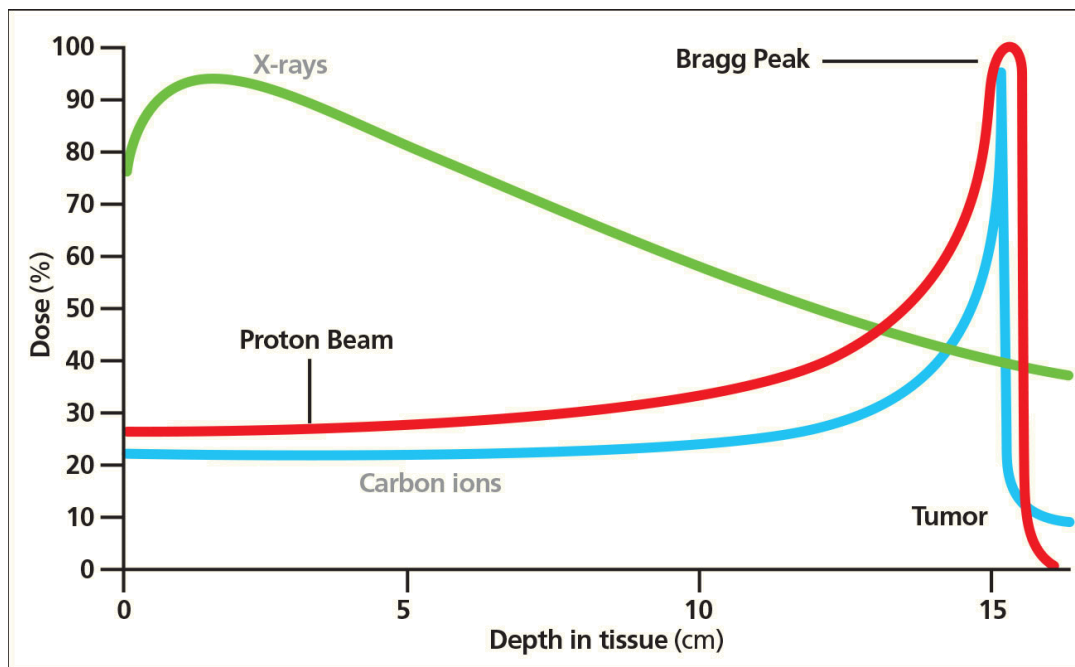
Hadron Therapy



"Hadron therapy is not a replacement for conventional radiotherapy or surgery, but is an additional tool in the toolbox of the oncologists"

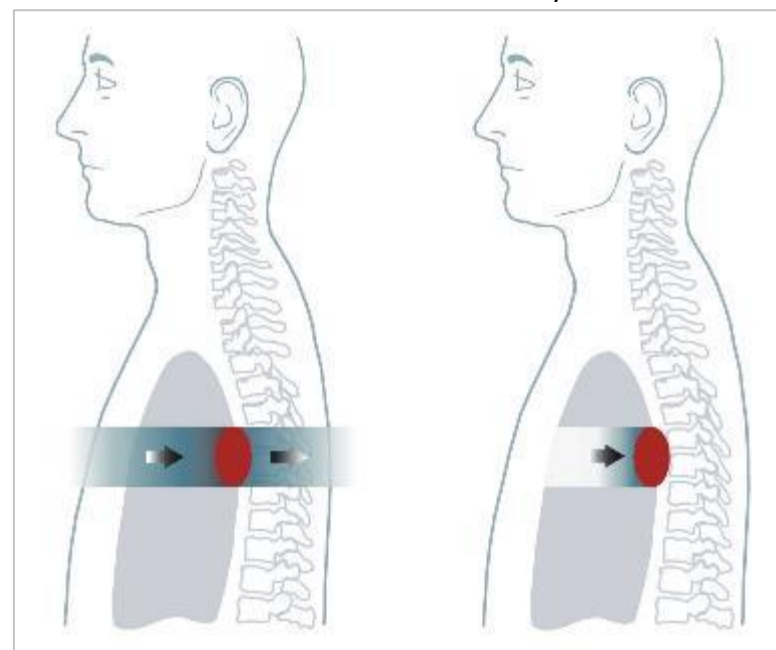
Robert Miller of the Mayo Clinic in the US

Protons vs X-rays



Hadron Therapy

Courtesy of MedAustron



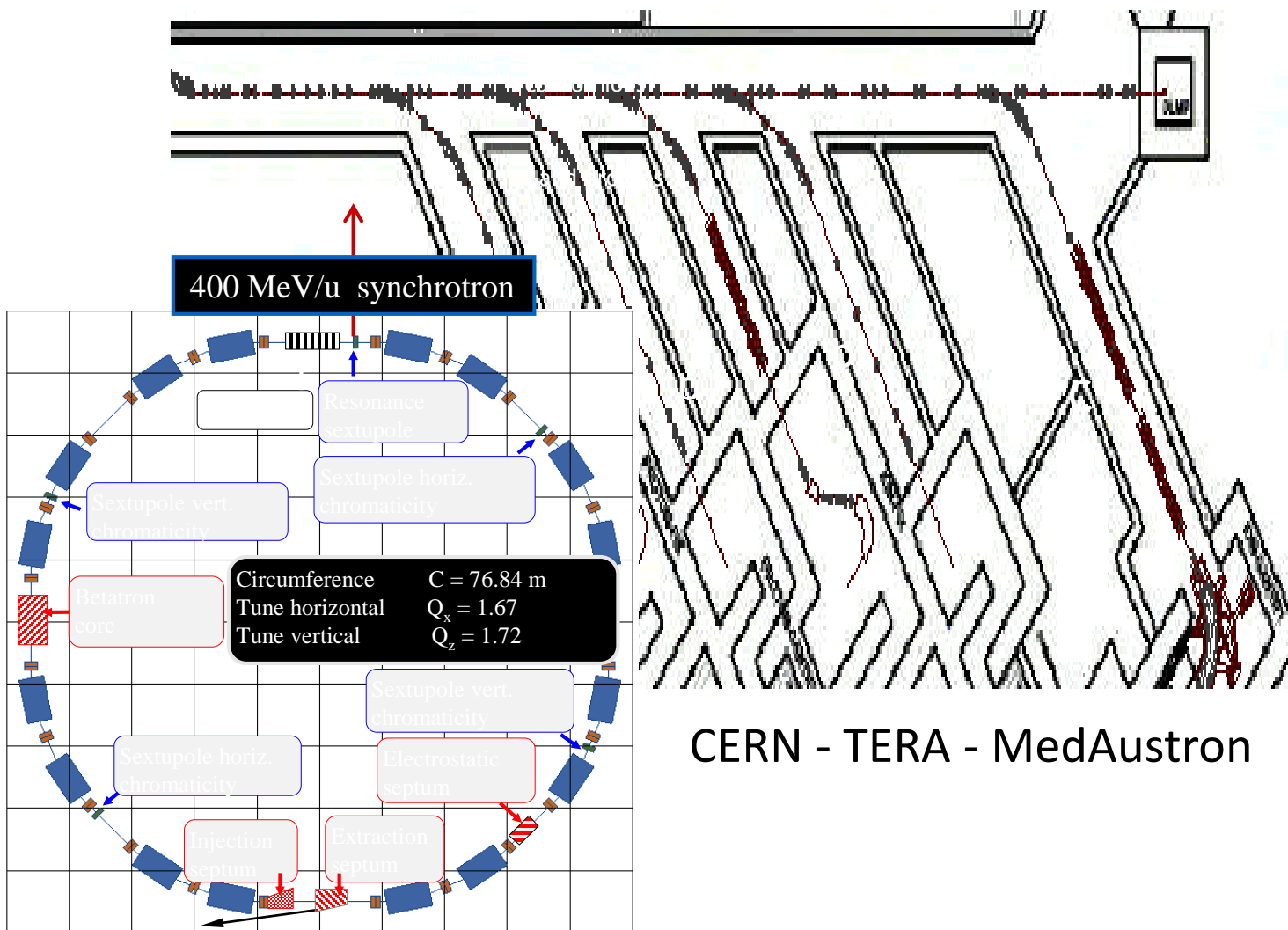
X-rays

Protons

PIMMS at CERN (1996-2000)



Proton Ion Medical Machine Study



CNAO – Italy

First Patient 2011



Collaboration agreement with CERN



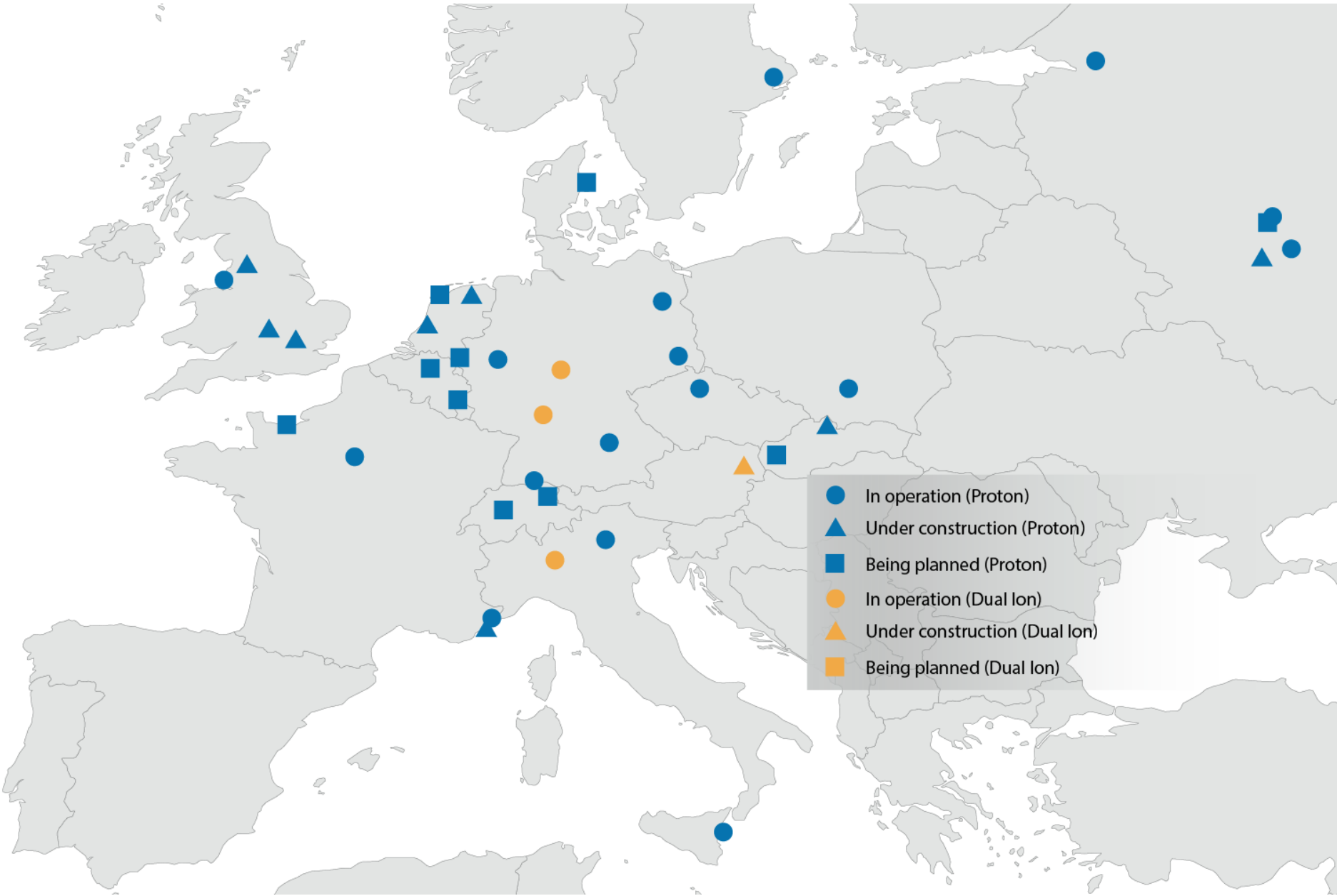
MedAustron – Austria

First Patient 2016

Collaboration agreement with CERN
Exploitation of jointly developed know-how



European Centers



The Miniature Linear Accelerator



A new high-frequency RFQ

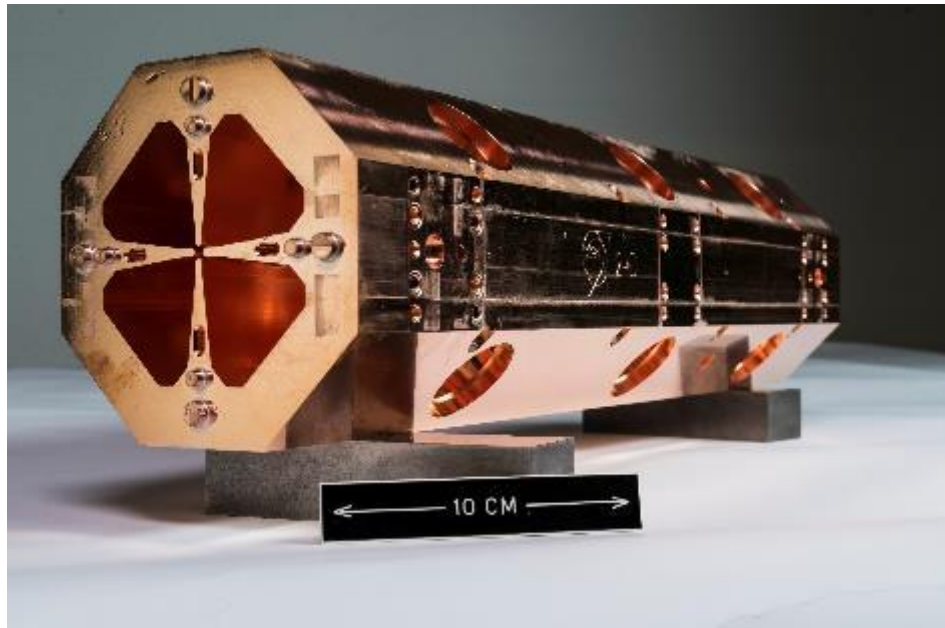
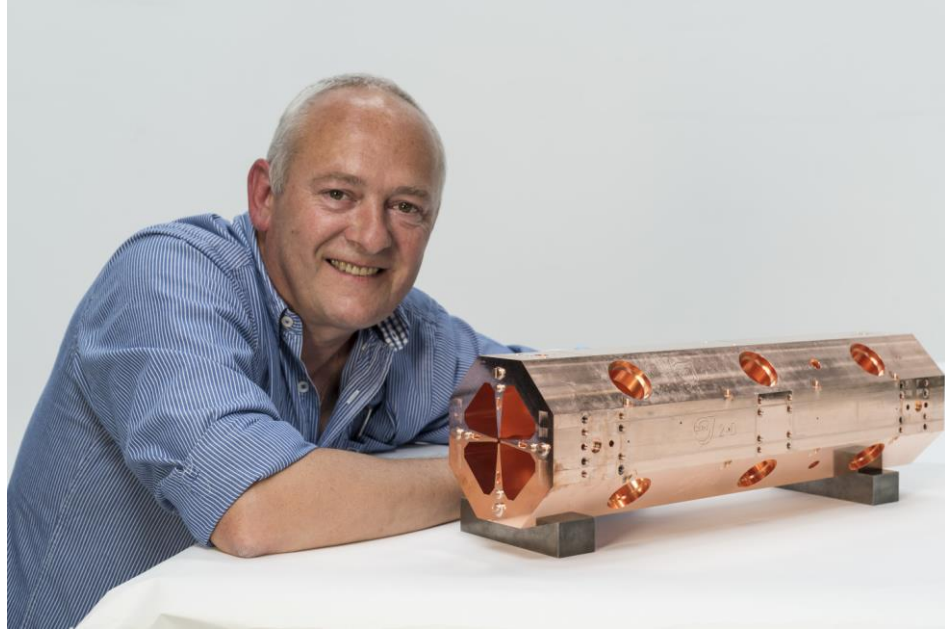
- Compact, lightweight, low beam loss
- 2.5 MeV/m (vs <math><1\text{ MeV/m}</math>)

First Application

- Proton Therapy

Potential Applications

- On-site radioisotope production
- Alpha-particle radiotherapy
- Analysis of archeological materials



AMIT – Advanced Molecular Imaging Technologies

A cyclotron small enough to fit in a hospital lift

- Compact cyclotron for single dose production of radioisotopes for non-standard PET demands
- First prototype in 2016 and possibility of industrialization
- Collaboration agreement with CIEMAT



Photo: CIEMAT

Computing in Medical Field



Medical data
management
and analysis

Computing

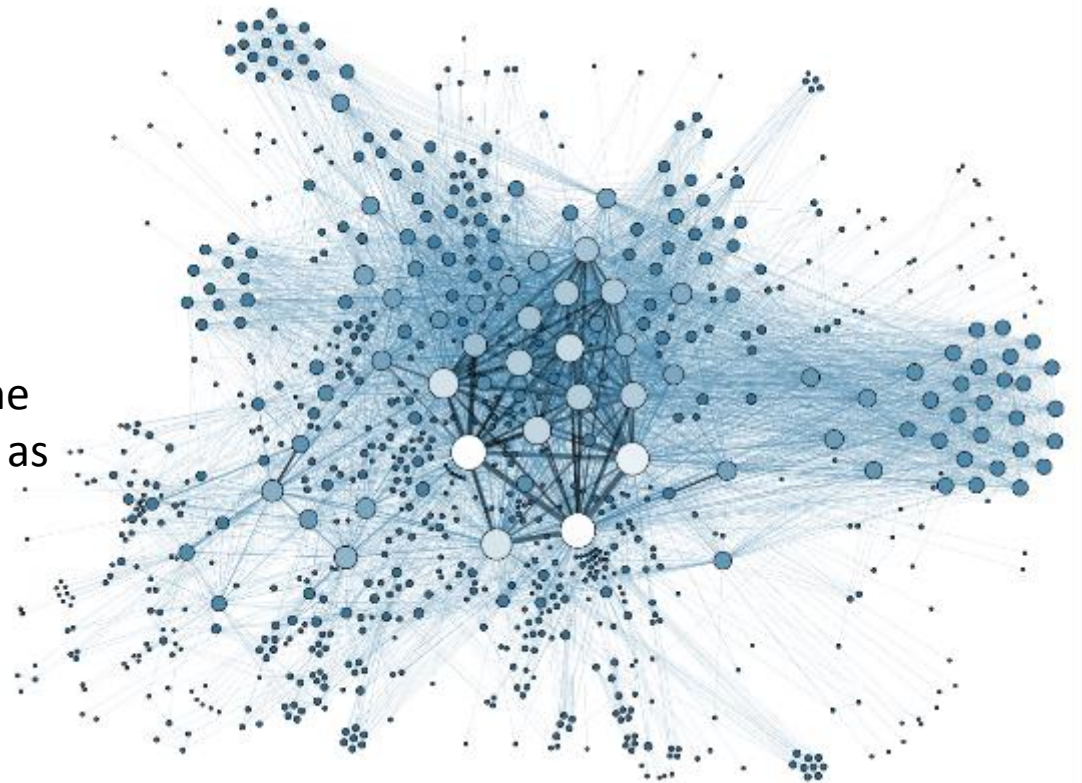
Big Data



- Longstanding tradition of participation and support for IT infrastructures for health research since 2001
- Many requests for “help” with architectures, data storage and sharing, analysis, computing technologies.

Challenge:

- Other communities reuse the same infrastructure, tools and methods as HEP

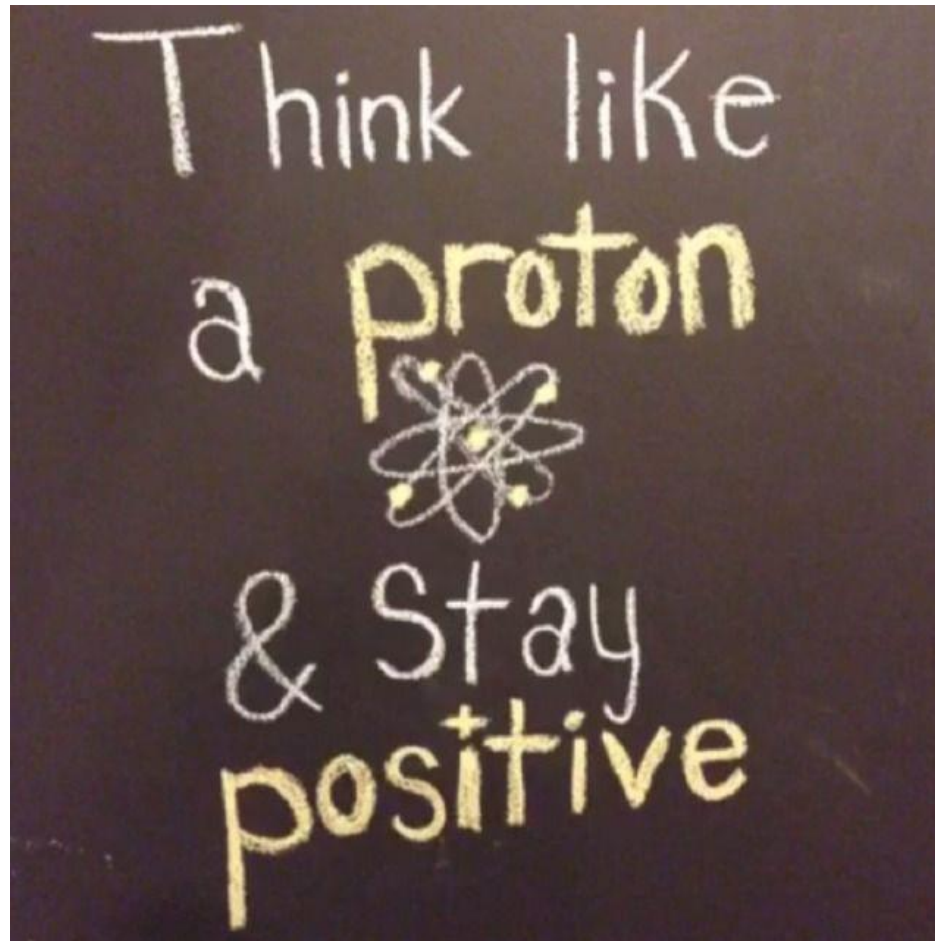


Courtesy Alberto Di Meglio

The fourth pillar



The collaborative spirit of particle physics and medical applications



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Cern: Virtual particle therapy centre



<https://www.youtube.com/watch?v=wgwDJiTYDI0>

A screenshot of a YouTube video player. The video shows a person lying on a treatment table inside a large, futuristic medical facility. The person is wearing a blue patterned gown. The room has a curved, metallic interior with a large, glowing circular opening in the wall. The video player interface includes the YouTube logo, a search bar, and playback controls at the bottom. The video title "Cern: Virtual particle therapy centre" is displayed below the player.

YouTube CH Search

0:00 / 3:18

Cern: Virtual particle therapy centre

<https://cds.cern.ch/record/1611725>

The ENVISION logo, featuring a stylized blue and orange eye shape above the word "ENVISION" in a white serif font with an orange underline.

ENVISION

**European NoVel Imaging Systems
for ION therapy**

How to KT?

