CERN: history and applications

Rita Ferreira
CERN Knowledge Transfer, Medical Applications
rita.ferreira@cern.ch

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/
Today
13.7 billion years
$10^{28}$ cm
History

12 founding Member States

29 September 1954
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

- Accelerators
- Detectors
- Medical imaging
- Cancer treatment
- Medical data management and analysis
- Computing
Detectors for Medical Imaging

Medical imaging
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

Images courtesy of Dr. F. Fellner
Medical imaging and particle physics: The same challenge?
Antimatter – science fiction?

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

Photo: HealthHub
Crystal PEM

• 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

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

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

Conventional Treatment

Surgery
Chemotherapy
Radiotherapy
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

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

CERN - TERA - MedAustron
CNAO – Italy

First Patient 2011

Collaboration agreement with CERN

MedAustron – Austria

First Patient 2016

Collaboration agreement with CERN
Exploitation of jointly developed knowhow
European Centers
The Miniature Linear Accelerator

A new high-frequency RFQ
- Compact, lightweight, low beam loss
- 2.5 MeV/m (vs <1 MeV/m)

First Application
- Proton Therapy

Potential Applications
- On-site radioisotope production
- Alpha-particle radiotherapy
- Analysis of archeological materials
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
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
The fourth pillar
The collaborative spirit of particle physics and medical applications

Think like a proton & Stay positive

Thanks for your attention!!!
Cern: Virtual particle therapy centre

https://www.youtube.com/watch?v=wgwDJiTYDI0
How to KT?