Medical Applications of Particle Physics

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CERN – Knowledge Transfer
Medical Applications Section

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Knowledge transfer – X-rays

Wilhelm Röntgen

8/11/1895

22/12/1895

1901
Magnetic Resonance Imaging

First human body scan

- 1940: NMR
- 1950: Nobel prize in physics and first image
- 1960: First clinically useful image
- 1970: First human body scan
- 1980: Nobel prize in medicine
- 1990: Nobel prize in medicine
Tools of the trade

Accelerators

Detectors

Computing
4th pillar of technology - collaboration

- Hospitals
- Imaging centres
- Research institutes
- Academic institutes
- Industry
- Funding agencies
- ICT
- Doctors
- Policy makers
- Epidemiologists
- Biologists
- Physicists & Medical physicists
- Physicians & Medical physicists
Cancer – a growing challenge

More than 3 million new cancer cases in Europe each year and 1.75 million associated deaths

Increase by 2030: 75% in developed countries and 90% in developing countries
Surgery

Radiotherapy

Chemotherapy (+ others)

X-ray, IMRT, Brachytherapy, Hadrontherapy

Hormones; Immunotherapy; Cell therapy; Genetic treatments; Novel specific targets (genetics..)

AIM:
Survival, Quality of life
Antimatter – science fiction?

PET
PET: how it works

- Drug is labeled with positron (β+) emitting radionuclide.
- Drug localizes in patient according to metabolic properties of that drug.
- Trace (pico-molar) quantities of drug are sufficient.
- Radiation dose fairly small (<1 rem = 0.01 Sv).
PET – How it works
PET Scan

Brain Metabolism in Alzheimer’s Disease: PET Scan

- Annihilation
- Image Reconstruction
- Coincidence Processing Unit
- Sinogram/Listmode Data

Normal Brain
Alzheimer’s Disease
The detector challenge
Similar challenges

- New materials
- Compact
- low noise electronics
- Algorithms
Multimodal imaging

FIGURE 1. CT, PET, and PET/CT of lung cancer with adrenal metastases.

Proposed by David Townsend
Crystal Clear
ClearPEM

Extremely sensitive to small tumour masses
MEDIPIX
Towards digital imaging
Accelerators for cancer treatment
Use of accelerators today

~ 9000 of the 17000 accelerators operating in the World today are used for medicine.
Conventional radiotherapy

- least expensive cancer treatment method
- most effective
- no substitute for RT in the near future
- rate of patients treated with RT is increasing

30% of patients cancer comes back in the same location after RT
Single beam of photons
2 opposite photon beams
Alternative – Hadron Therapy

• 1946: Robert Wilson

Protons can be used clinically

Robert Wilson
Why hadron therapy

- Photons
- Carbon
- Protons

Depth in the body (mm)

Tumours near critical organs
Tumours in children
Radio-resistant tumours
Carbon ions: pilot project in Europe

GSI & Heidelberg

– 450 patients treated
Particle therapy centres in Europe - 2015

In operation:
- Proton
- Dual Ion

Under construction:
- Proton
- Dual Ion

Being planned:
- Proton
- Dual Ion

Source: PTCOG, October 2015 and ENLIGHT
HIT - Heidelberg

Ion source

Synchrotron

Beam transport line

Quality control

Gantry

Treatment rooms

Siemens Medical
CNAO - Italy (Pavia)
Challenges

- In-beam PET @ GSI (Germany)
- MonteCarlo simulations
- Organ motion

MC simulated | measured
European NoVel Imaging Systems for ION therapy
ISOLDE
isotopes for detection & treatment

In collaboration with
University Hospital Geneva
Computing for medical applications

If I'd known they wanted me to use all this info— I would never have asked for it!

Concorde
(15 Km)

Mt. Blanc
(4.8 Km)
The Grid

Data and Resources
Mammogrid - a grid mammography database

- Second Opinion
- Cancer Screening
- Education and Training
- Reference Database / Repository

From: David MANSET, CEO MAAT France, www.maat-g.com
Simulation
cern.ch/virtual-hadron-therapy-centre
References

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