

From particle physics to medical applications

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Knowledge Transfer Group



Cancer Incidence

- Every year >3 millions new cases in Europe
- About one third of us will have cancer
- Number of patients needing treatment is increasing as people are living longer
- Main cause of death between the ages of 45 and 65 in Europe
- Second most common cause of death in Europe after heart-disease

Cancer is a large and growing challenge

Need: Earlier diagnosis, better control, fewer side-effects

How?

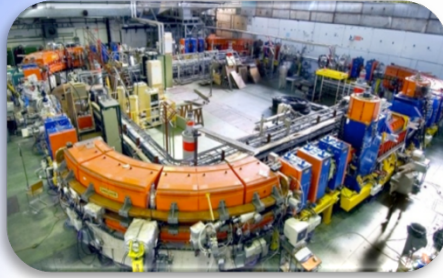
- **new technologies**
 - Imaging, dosimetry, accelerator & detector technology
 - Better understanding – genetics, radiobiology...
 - Advanced healthcare informatics ...
- **international collaboration**
 - If progress is to be maintained

Although cancer is a common condition, each tumour is individual

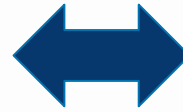
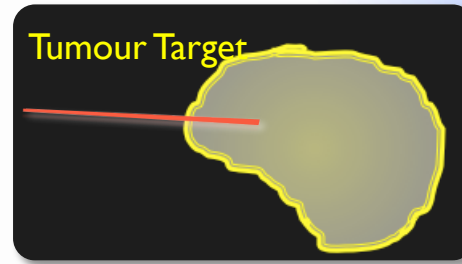
- personalised approach
- Large patients data-sets to understand key drivers of the disease

4th pillar: catalysing and facilitating collaboration

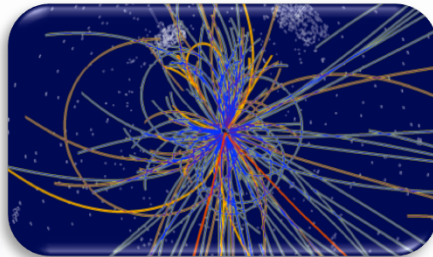
Accelerating particle beams



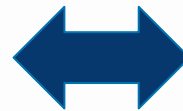
Particle Therapy



Detecting particles



Medical imaging



Large scale **computing** (Grid)



Grid computing for medical data management and analysis



Catalysing collaboration in health field

Challenges:

- Bring together physicists, biologists, medical physicists, doctors
- Cross-cultural at European and global level

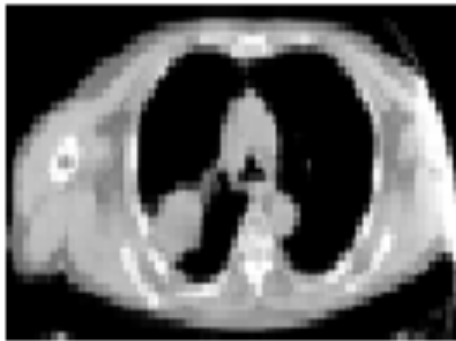
Why is CERN well placed to do this?

- It is widely acknowledged as a **provider of technologies** and as a **catalyst** for collaboration.
- It is international, non-commercial, not a health facility.

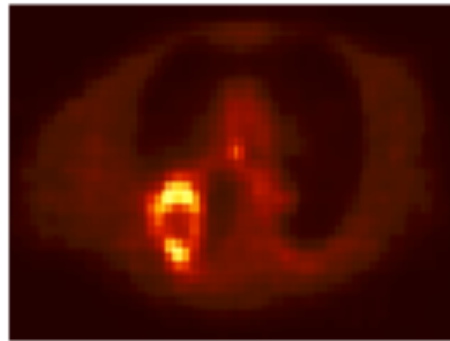


Detector Technologies

- Detector technology – improved photon detection and measurement: Crystal Clear, PET, PEM, Axial PET
- Electronics and DAQ – high performance readout: (Medipix)
- Multimodality imaging: PET-CT (proposed by Townsend, future with PET-MRI)



CT



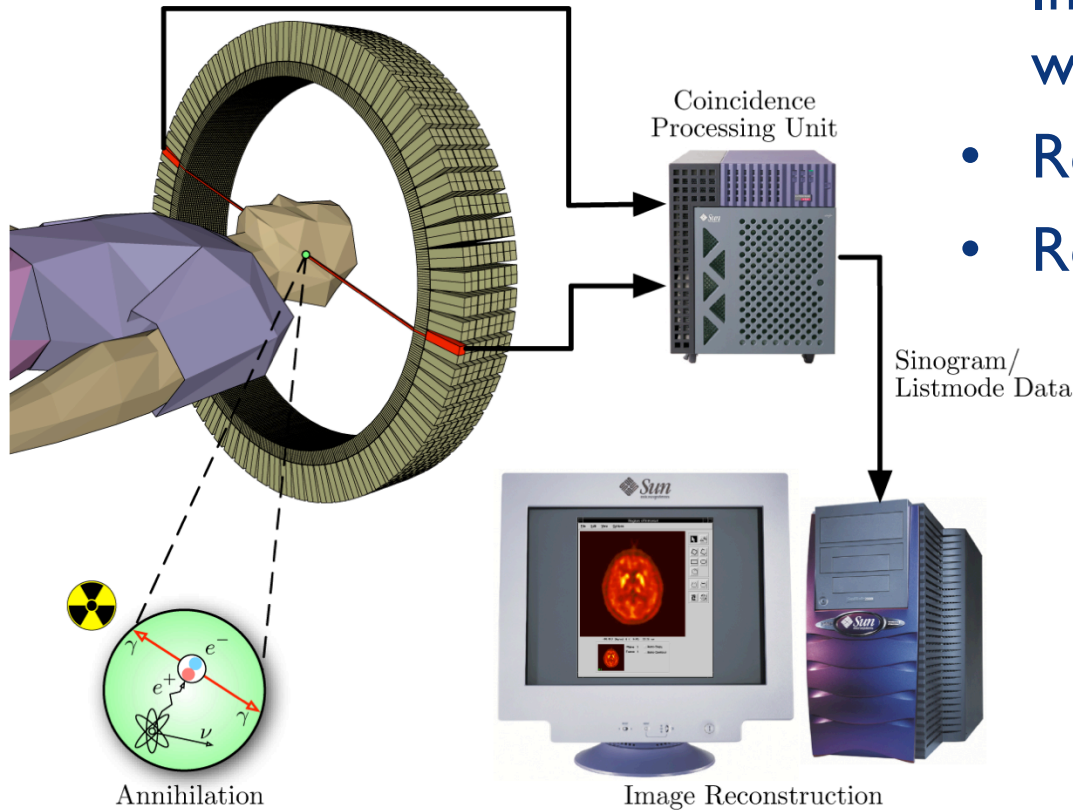
PET



PET-CT

PET (Positron Emission Tomography)

- Detects pairs of photons emitted by an injected positron-emitting radionuclide



- Images tracer concentration within the body
- Reflects physiological activity
- Reconstructed by software

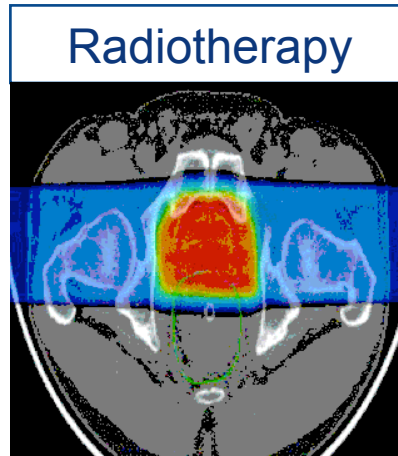
LHC detector systems
used in PET Systems

Computing Technologies

GRID – data storage, distributed, secure computing

- **MammoGrid:** European-wide database of mammograms and support collaboration
- **Health-e-Child:** combining various types (clinical, imaging...) of data and share in distributed, clinical arena.
- **HISP:** Hadrontherapy Information Sharing Platform

Cancer Treatment Options...



X-ray, IMRT, Brachytherapy, Hadrontherapy

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

Local control

Local control

Limited Local control

Survival
Quality of life



Conventional Radiotherapy in 21st Century

3 "Cs" of Radiation

Cure (~ 45% cancer cases are cured)

Conservative (non-invasive, few side effects)

Cheap (~ 5% of total cost of cancer on radiation)

(J.P.Gérard)

There is no substitute for RT in the near future

The rate of patients treated with RT is increasing

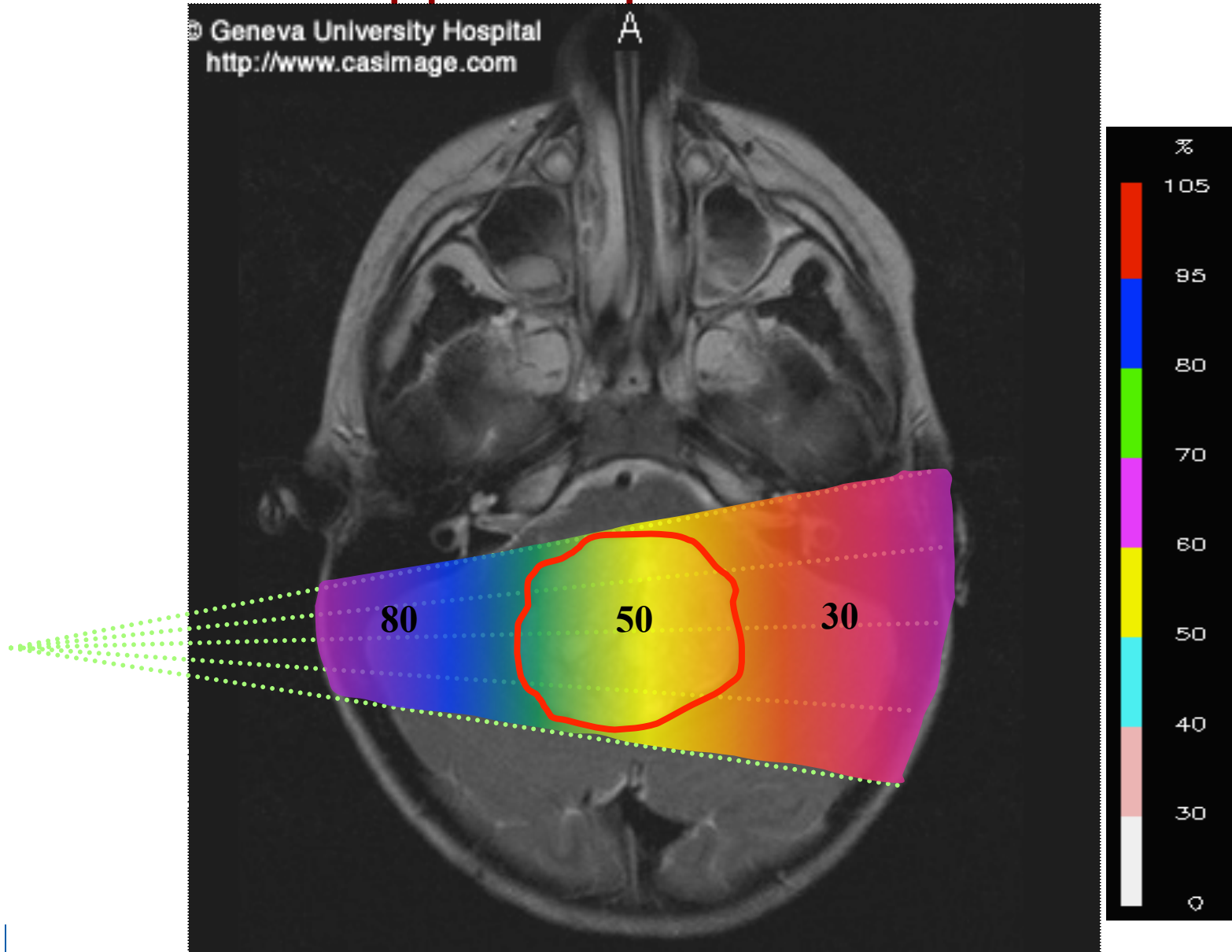
Present Limitation of RT:

~30% of patients treatment fails locally

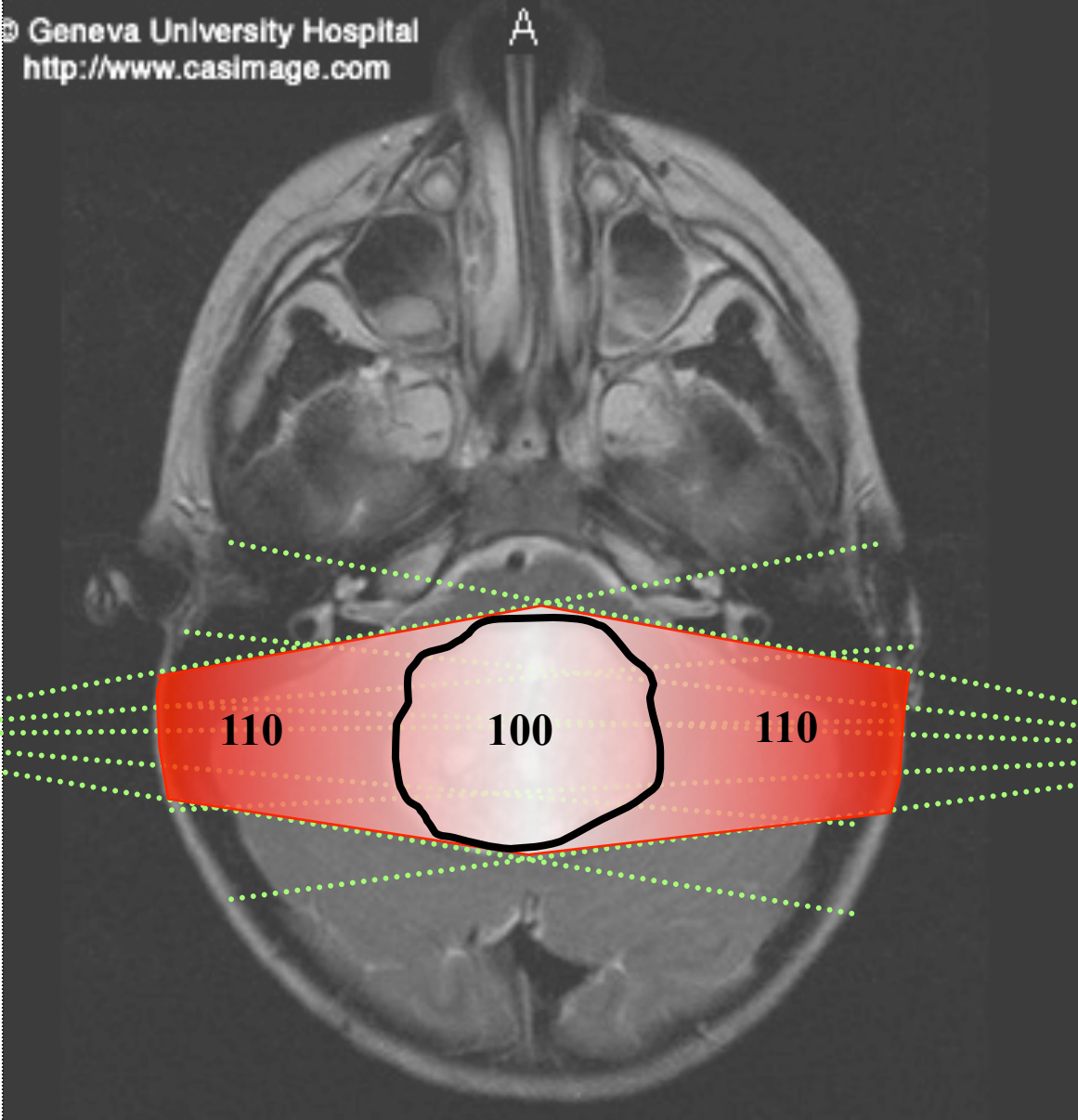
(*Acta Oncol, Suppl:6-7, 1996*)



Two opposite photon beams



Two opposite photon beams



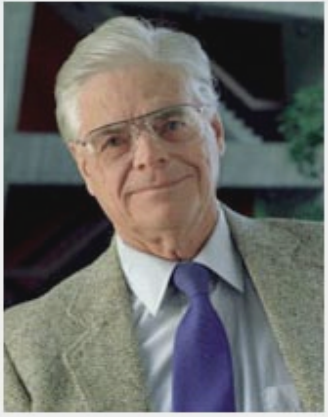
How to decrease failure rate?

- Physics technologies to improve treatment: higher dose
- Imaging: accuracy, multimodality, real-time, organ motion
- Data: storage, analysis and sharing (confidentiality, access)
- Biology: fractionation, radio-resistance, radio-sensitization
- Working together: multidisciplinary

Raymond Miralbell, HUG



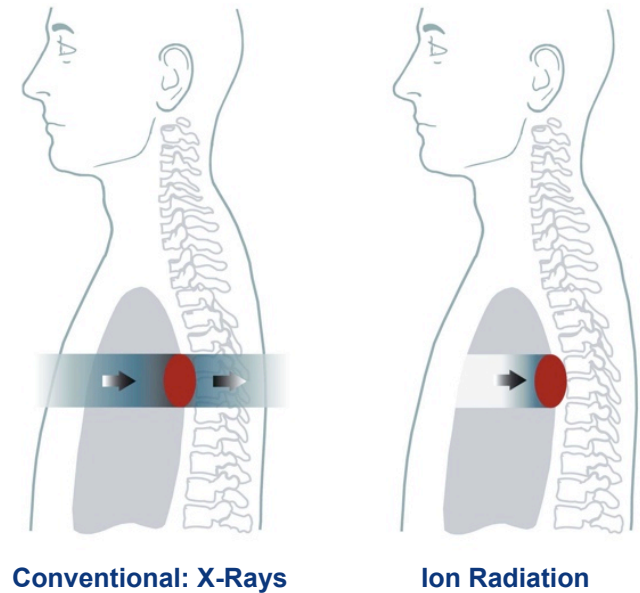
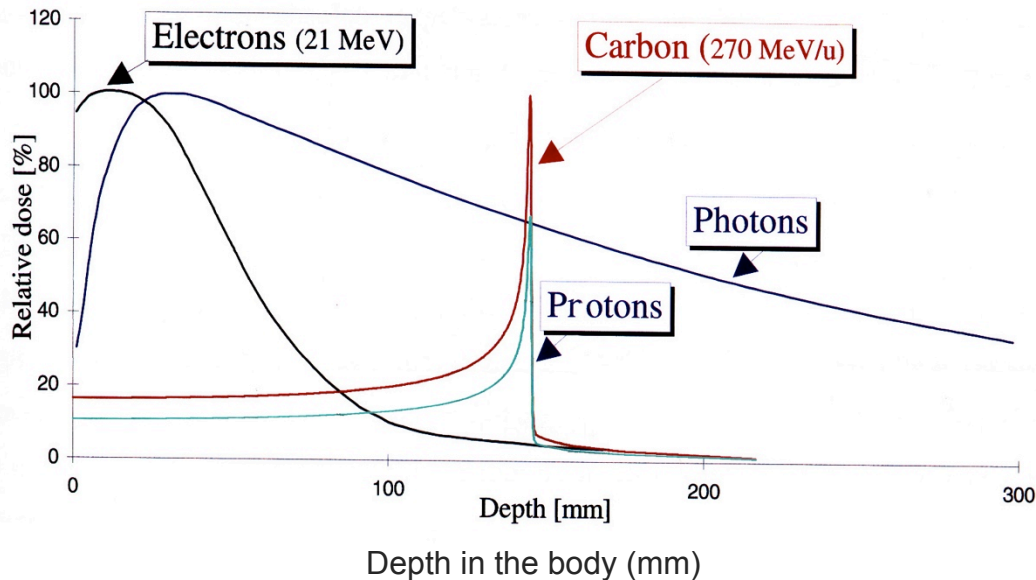
Hadrontherapy: all started in 1946



Robert Wilson

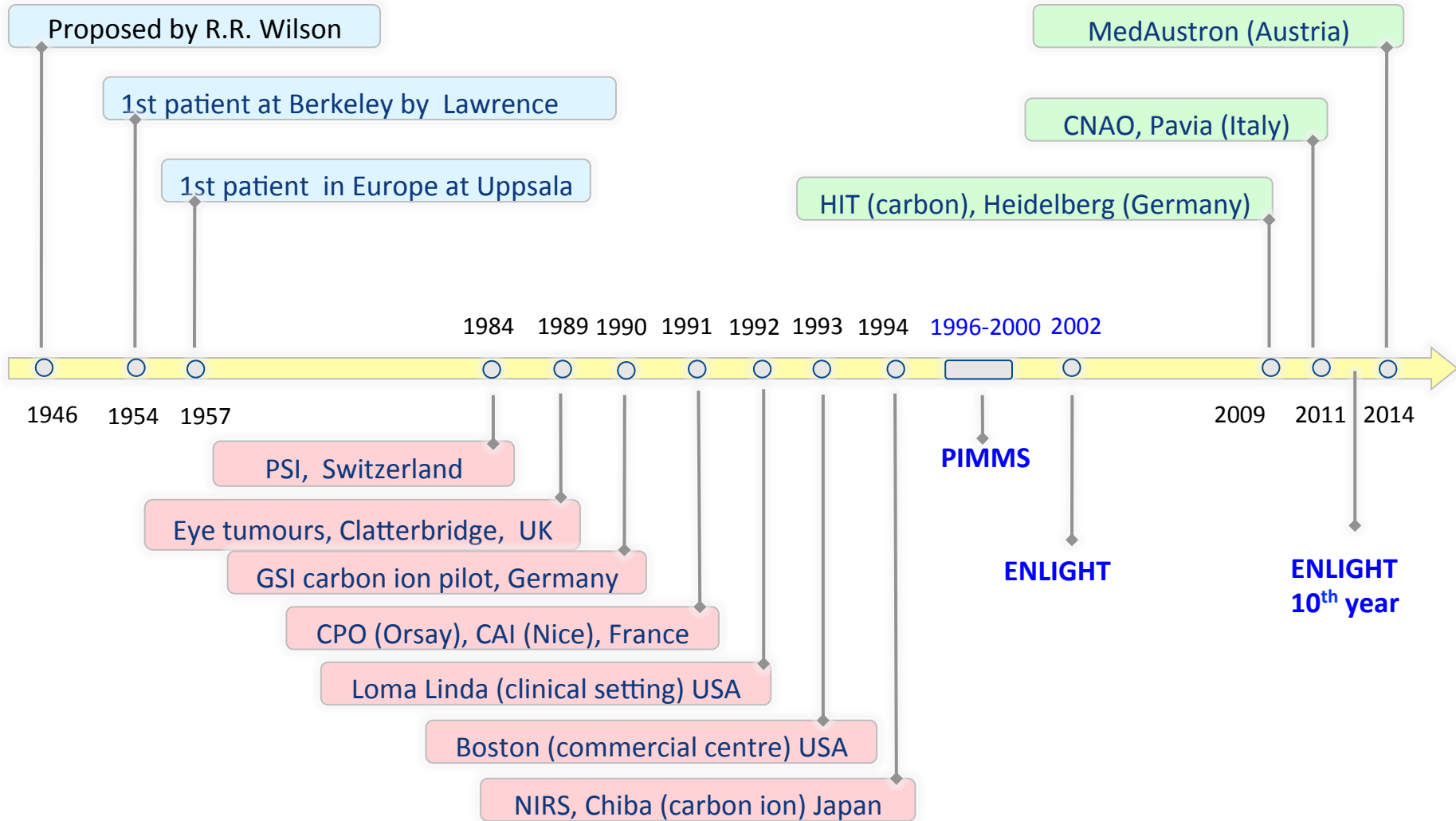
In 1946 Robert Wilson:

- Protons can be used clinically
- Accelerators are available
- Maximum radiation dose can be placed into the tumour
- Proton therapy provides sparing of normal tissues



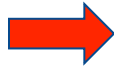
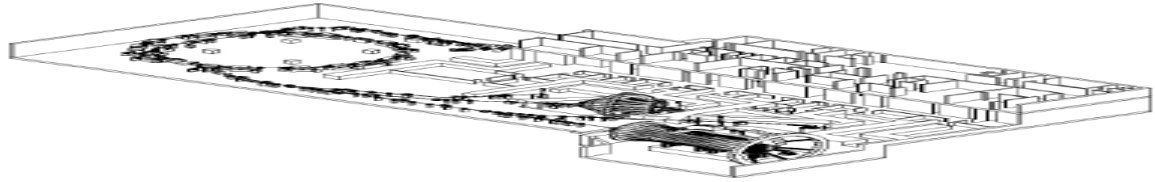
Courtesy MedAustron

Proton & Ion Beam Therapy: a short history



Accelerator technologies and KT

PIMMS 2000
(coordinated by CERN)
has led to:



fondazione CNAO

Treatment centre in Pavia, Italy.
First patient treated in Sept 2011



Treatment centre in Wiener Neustadt, Austria,
foundation stone 16 March 2011, will be ready in 2015

Looking ahead:

- LEIR facility: requested by community, see later
- Medicis (ISOLDE): exotic isotopes for future R&D
- Minicyclotron: commonly used isotopes

ENLIGHT

CERN collaboration philosophy into health field

- Common multidisciplinary platform
- Identify challenges
- Share knowledge
- Share best practices
- Harmonise data
- Provide training, education
- Innovate to improve
- Lobbying for funding



> 150 institutes

> 400 people

> 25 countries

(>80% of MS involved)

Coordinated by CERN, 80% MS involved



- Wide range of hadron therapy projects: training, R&D, infrastructures
- A total funding of ~24 M Euros
- All coordinated by CERN (except ULICE coordinated by CNAO)
- Under the umbrella of ENLIGHT



- Marie Curie ITN
- 12 institutions



- Infrastructures for hadron therapy
- 20 institutions



- R&D on medical imaging for hadron therapy
- 16 institutions



- Marie Curie ITN
- 12 institutions

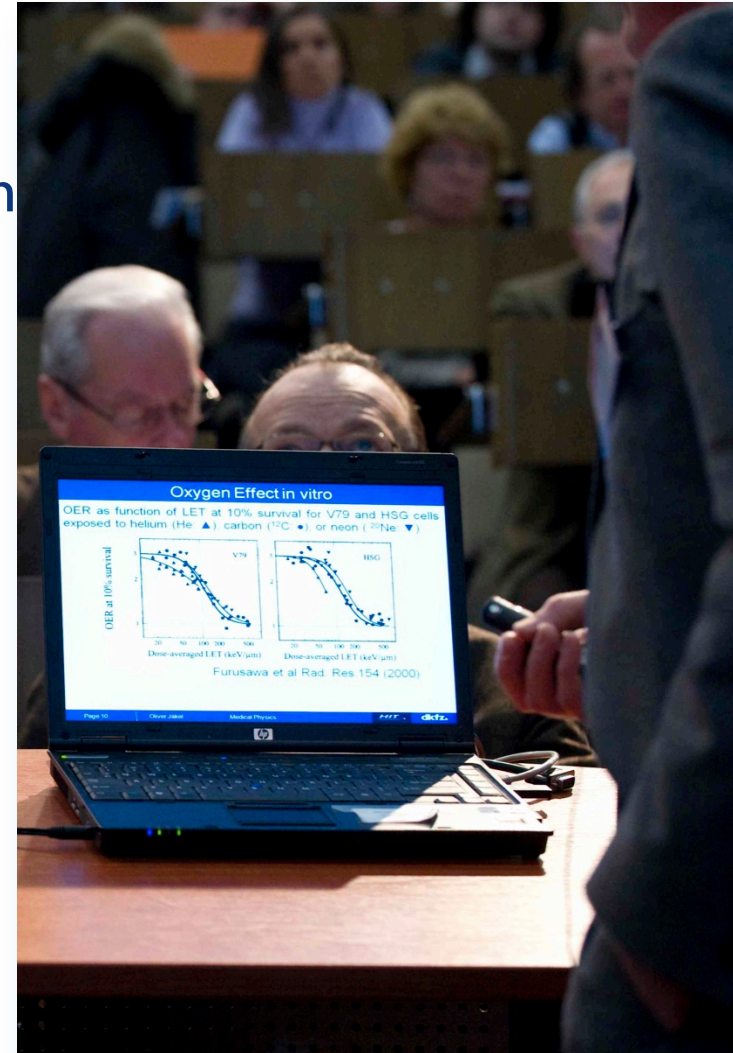
Preparing for the Future

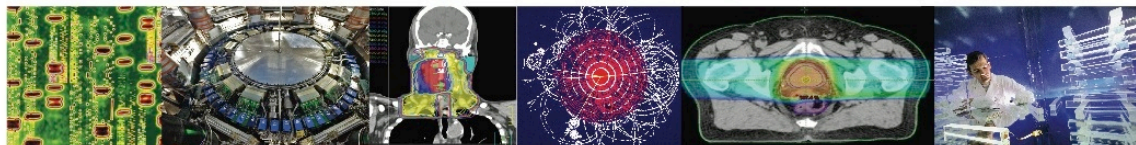
Objective

- Review progress in physics for health
- Identify areas for development
- Explore synergies
 - physics and health
- Catalyse dialogue
 - doctors, physicists, medical physicists.....

Result:

**First workshop on Physics for Health
@CERN in Feb 2010**





February 27 – March 2, 2012 at CICG, Geneva

- 2 days devoted to physics, 2 days to medicine, 1 common day
- Over 600 people registered, nearly 400 Abstracts
- Chairs: Jacques Bernier (Genolier) and Manjit Dosanjh (CERN)

Four physics subjects :

- Radiobiology in therapy and space
- Detectors and medical imaging
- Radioisotopes in diagnostics and therapy
- Novel technologies

1) Radiobiology in therapy and space :

- Particle therapy on the rise
(100 000 patients treated from 1954-2012)
- Carbon ions have higher radiobiological effectiveness (RBE) than protons
- Which is THE ion?

2) Radioisotopes in diagnostics and therapy

- Lutetium – ^{177}Lu : The rising star for therapy
- The Theranostic approach: Terbium isotopes in therapy and diagnostics

3) Prospects in detectors and medical imaging:

- The holy grail: 10-picosecond PET
- Hybrid systems: PET/CT to PET/MR

4) Novel technologies in radiation therapy:

- New accelerators, beams
- Organ motion: fast rescanning, gating
- Simulation: Geant4
- Beam transport & gantry

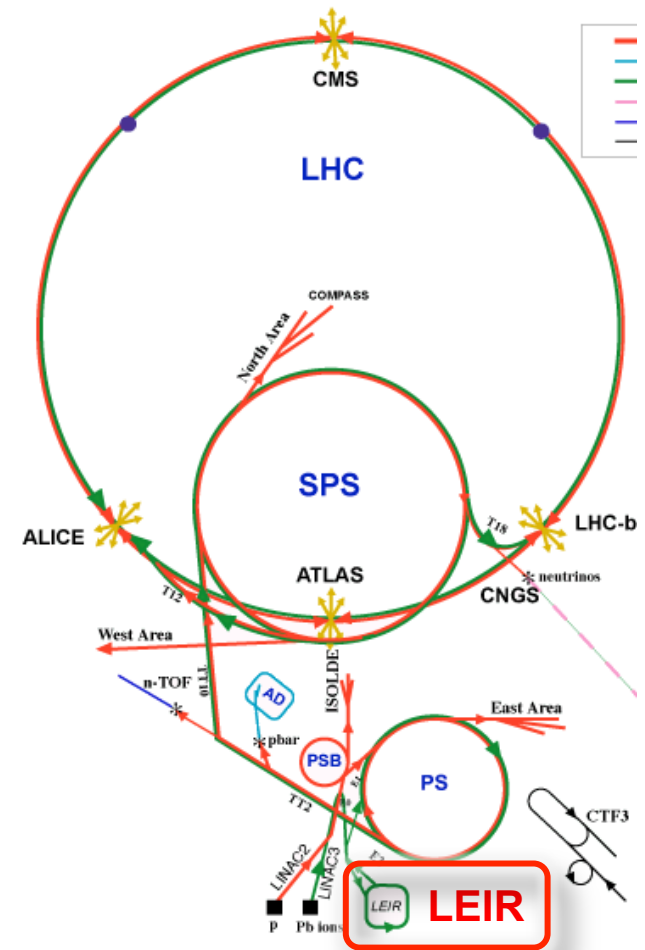
Future Biomedical Facility @ CERN

Using LEIR (low energy ionising ring) for:

European facility for radiobiology

- basic physics studies
- radiobiology
- fragmentation of ion beam
- dosimetry
- test of instrumentation

Biomedical facility requested by ENLIGHT
Community (> 20 countries, >200 people)



ICTR-PHE 2014

INTERNATIONAL CONFERENCE ON TRANSLATIONAL
RESEARCH IN RADIATION ONCOLOGY

PHYSICS FOR HEALTH IN EUROPE



February 10 – 14, 2014 at CICG Geneva

Early registration and abstract submission from June 1 to September 30

<http://cern.ch/ictr-phe14>

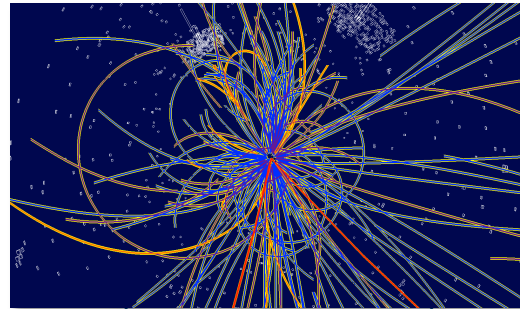
Thank you for your attention

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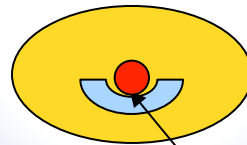
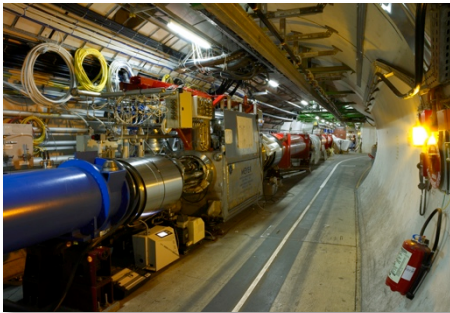
CERN Technologies and innovation

accelerators, detectors and IT to fight cancer



Detecting particles

Accelerating particle beams



CANCER

Large-scale computing (Grid)

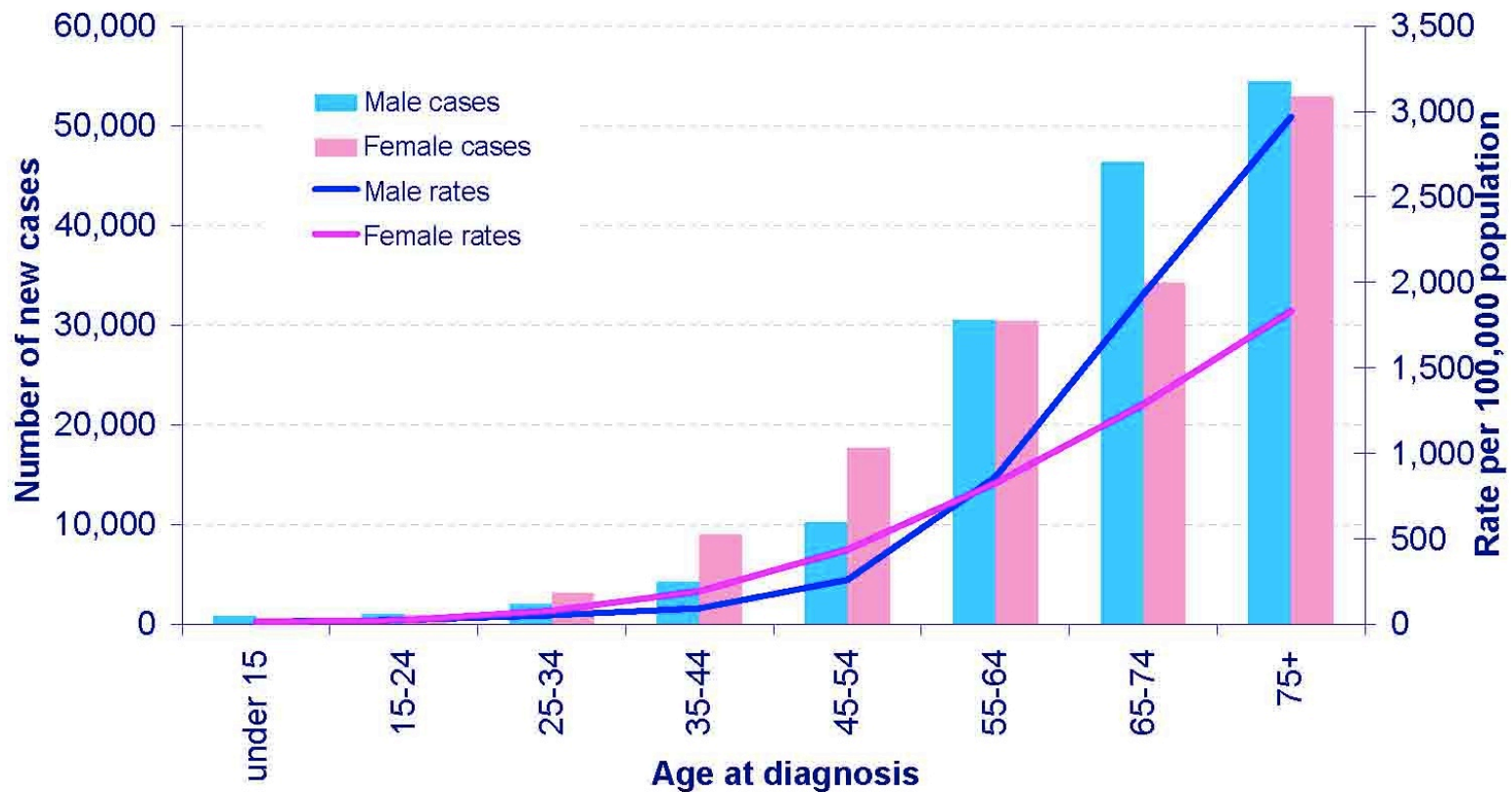


Knowledge and Technology Transfer

- KT is an integral part of CERN's mission
- PP technologies relevant to key societal issues e.g. Health
- CERN involved in the last 10-15 years
 - few CERN resources
 - attracted significant external funding (EC, MS...)
 - raises impact and profile
 - beyond the particle physics arena
 - large number of collaborating institutes
 - including medical institutes & hospitals
- Collaborators appreciate facilitation by CERN



Cancer incidence increases with age



Jean-Pierre Gerard (founder of ENLIGHT and radio-oncologist):
Physics-Clinics: collaboration is not enough, we need union



Alejandro Mazal (Chair PTCOG and Curie Institute)
Collaboration is important, “Tomorrow I will be back treating patients, but I will carry with me lots of dreams and ideas of how to work together”

Ruxandra Draghia-Akli (EC Health Director):
Horizon 2020 will focus on societal challenges (cancer is one)



José Mariano Gago:
Health research must be a driving force for the renewal of science policy: a European Council for Health Research is needed. Bringing together Medicine, Physics and Engineering Schools, across the EU.