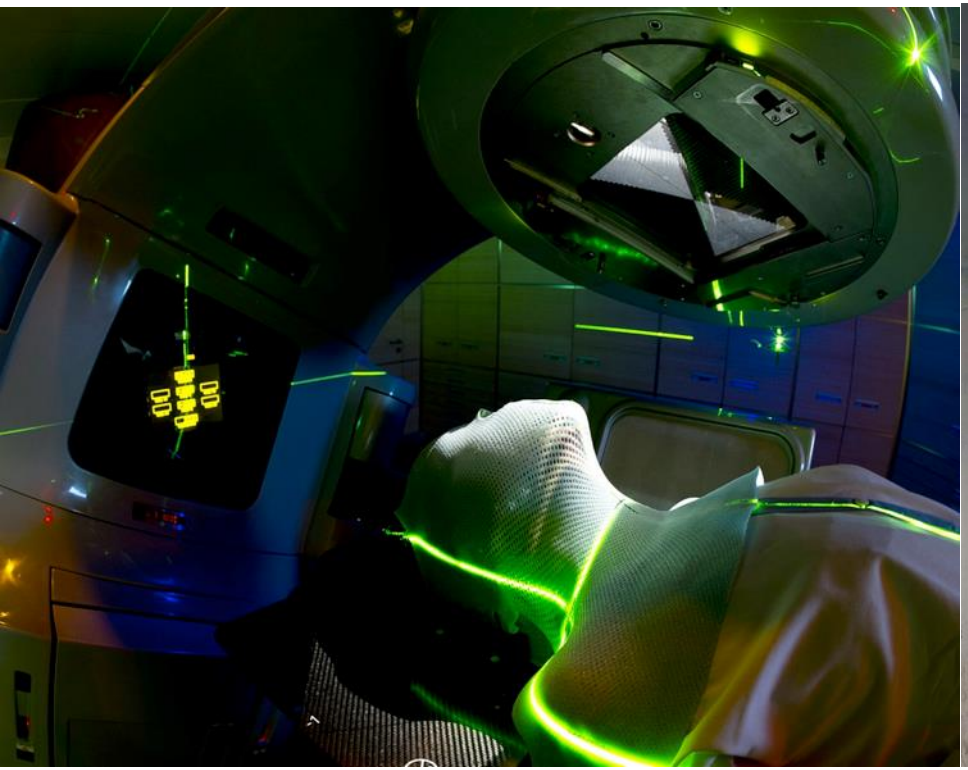
Medical Applications of Particle Physics



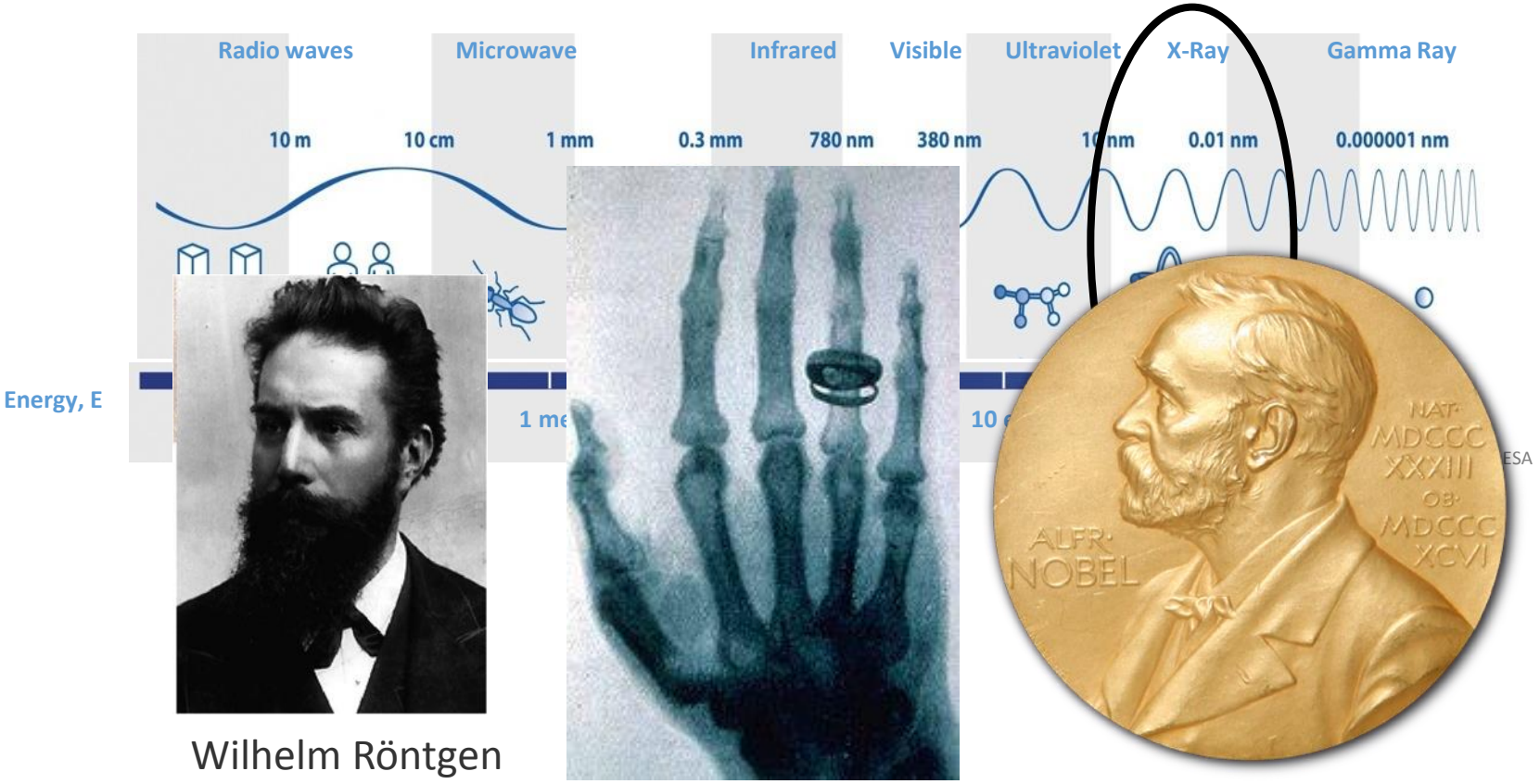
Sparsh.Navin@cern.ch

Sparsh Navin

CERN – Knowledge Transfer

Medical Applications Section

Knowledge transfer – X-rays



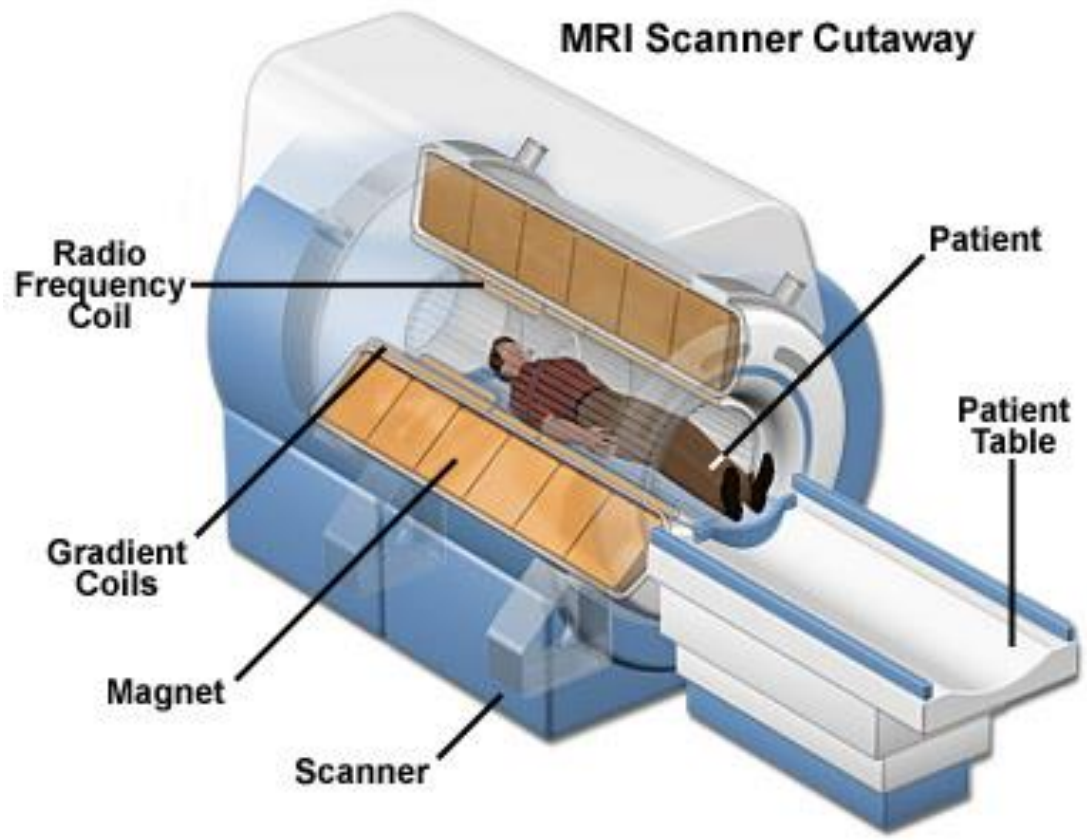
Wilhelm Röntgen

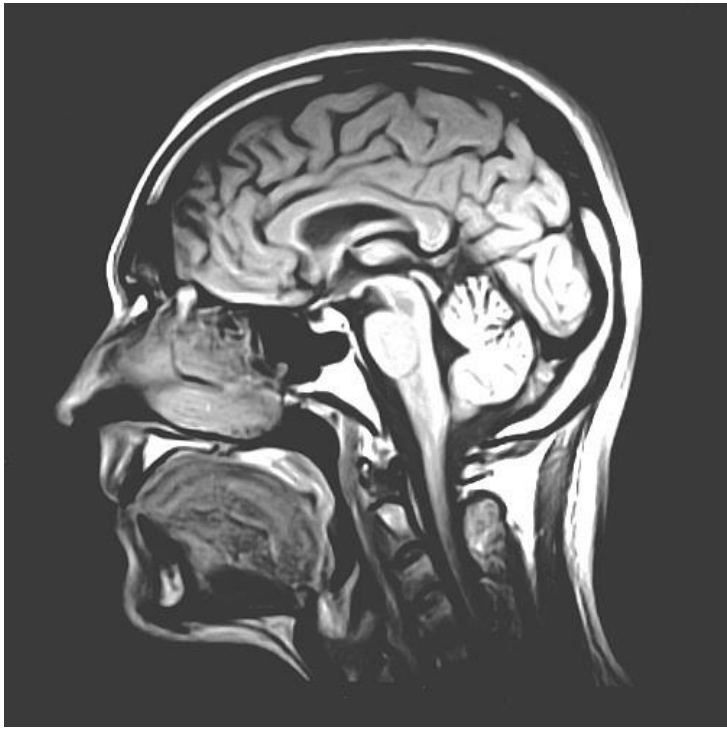
8/11/1895

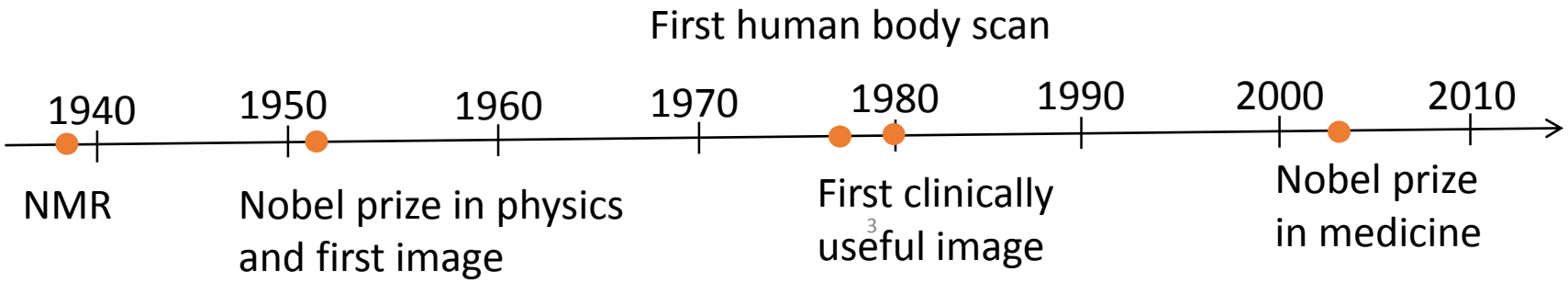
22/12/1895

1901

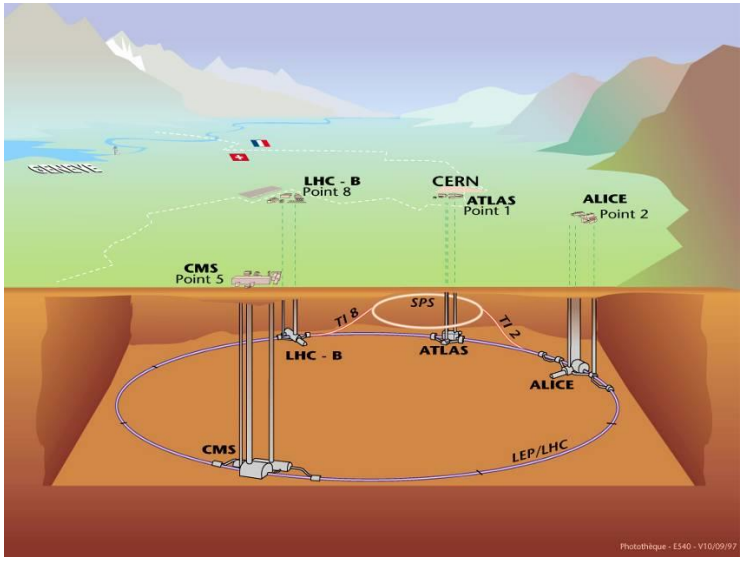
Magnetic Resonance Imaging



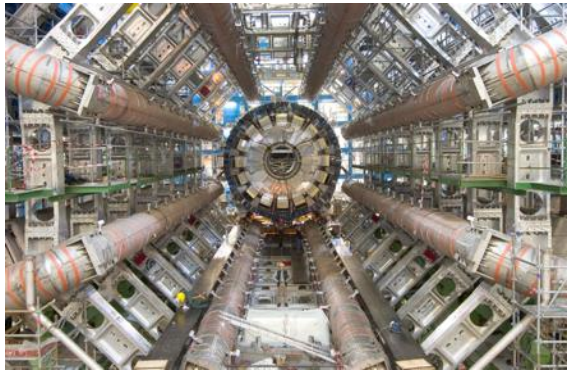




Tools of the trade



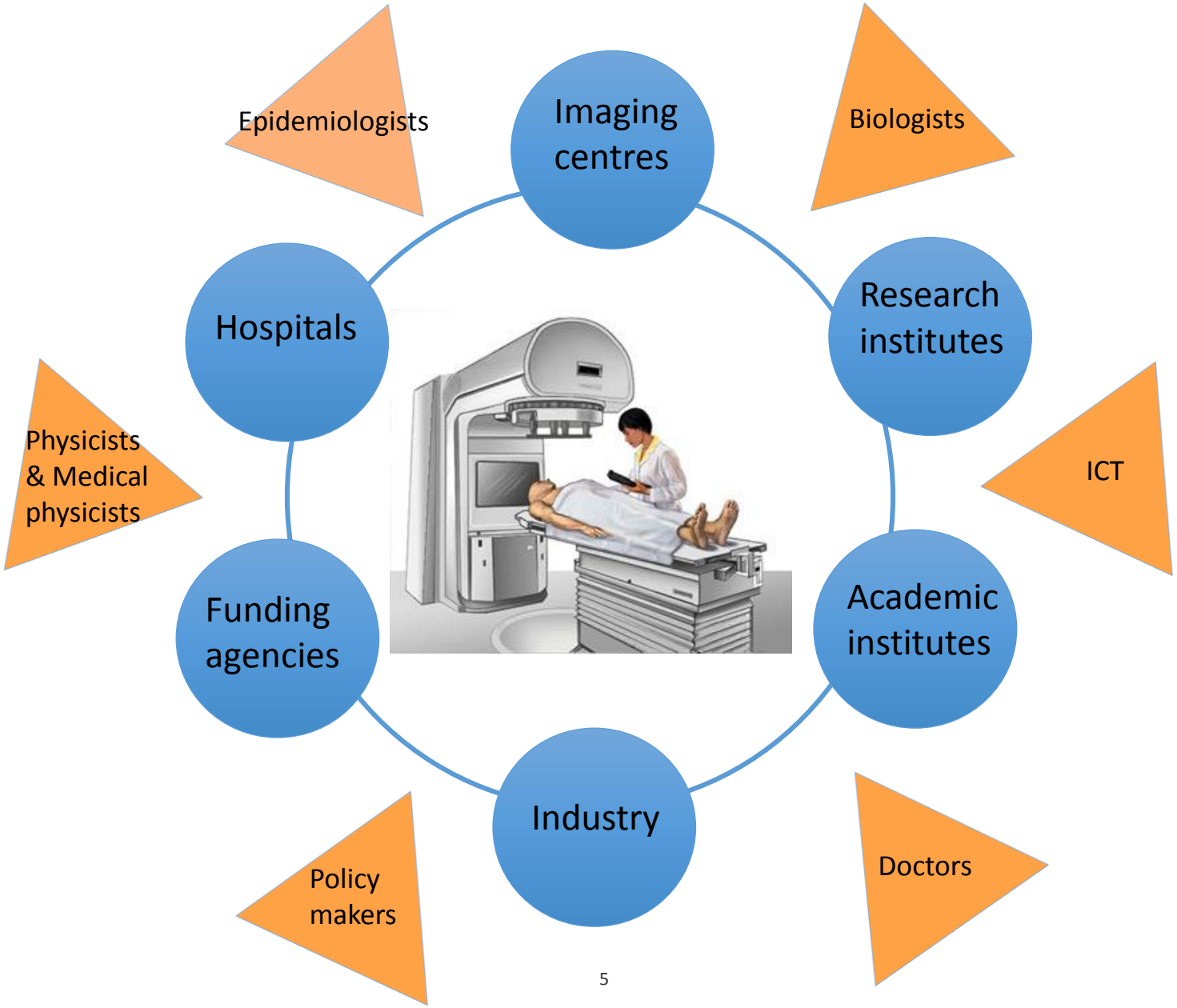
Accelerators



Detectors

Computing

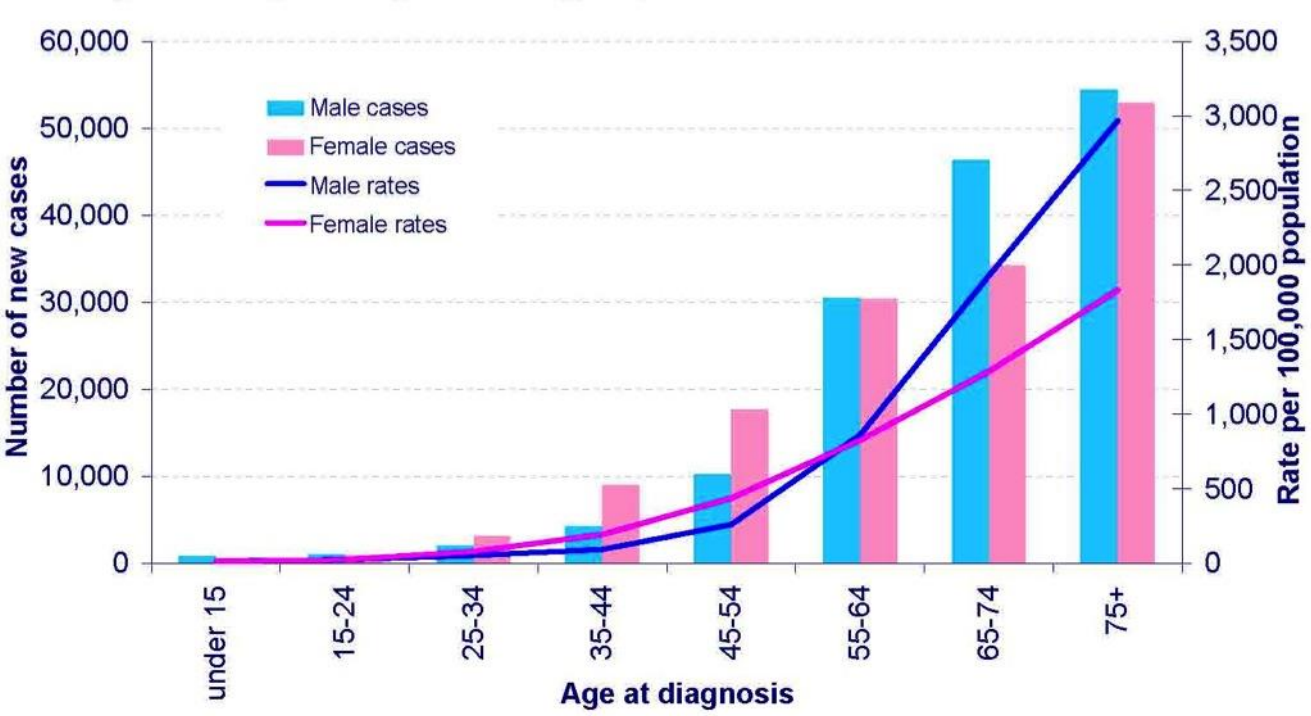
4th pillar of technology - collaboration



Cancer – a growing challenge

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

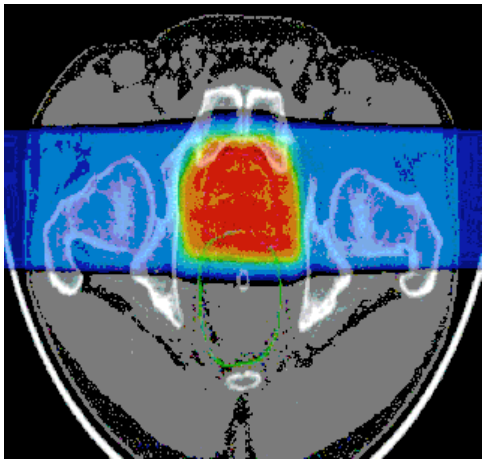
Increase by 2030: 75% in developed countries and 90% in developing countries



Treatment options

Surgery

Radiotherapy



X-ray, IMRT, Brachytherapy, Hadrontherapy

Chemotherapy (+ others)

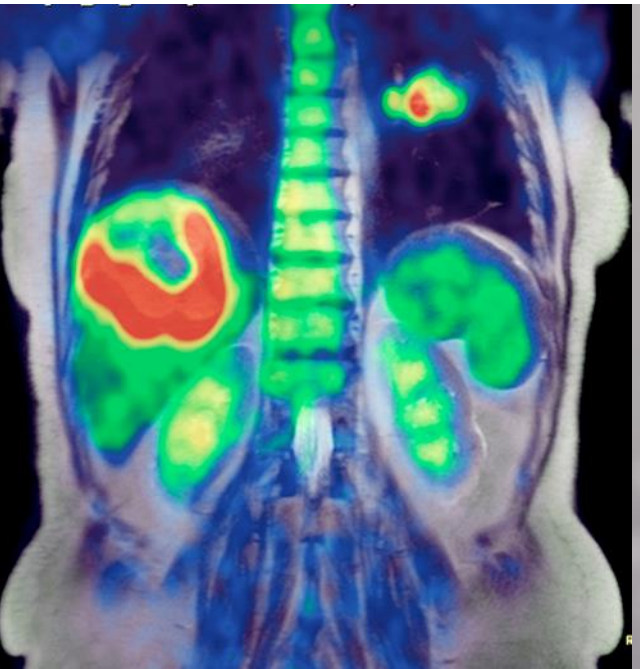
Hormones; Immunotherapy; Cell therapy; Genetic treatments; Novel specific targets (genetics..)

AIM:
Survival, Quality of life

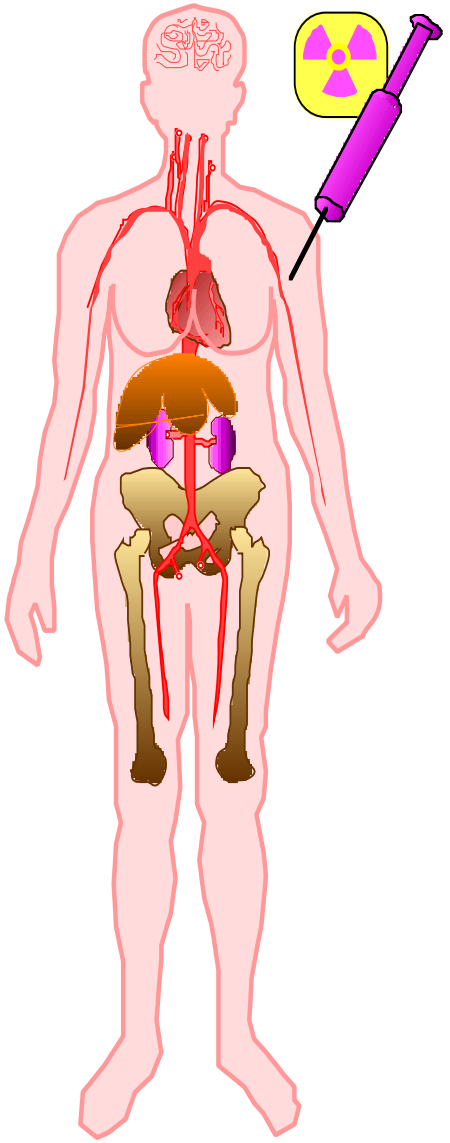
First step: Detection

Antimatter – ~~science fiction~~?

PET



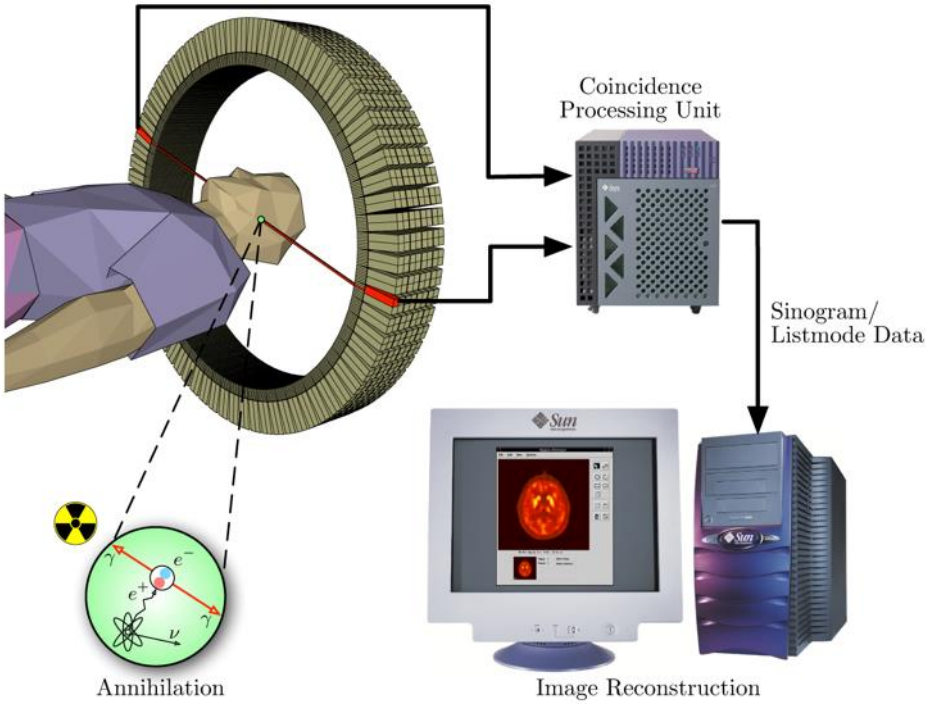
PET: how it works

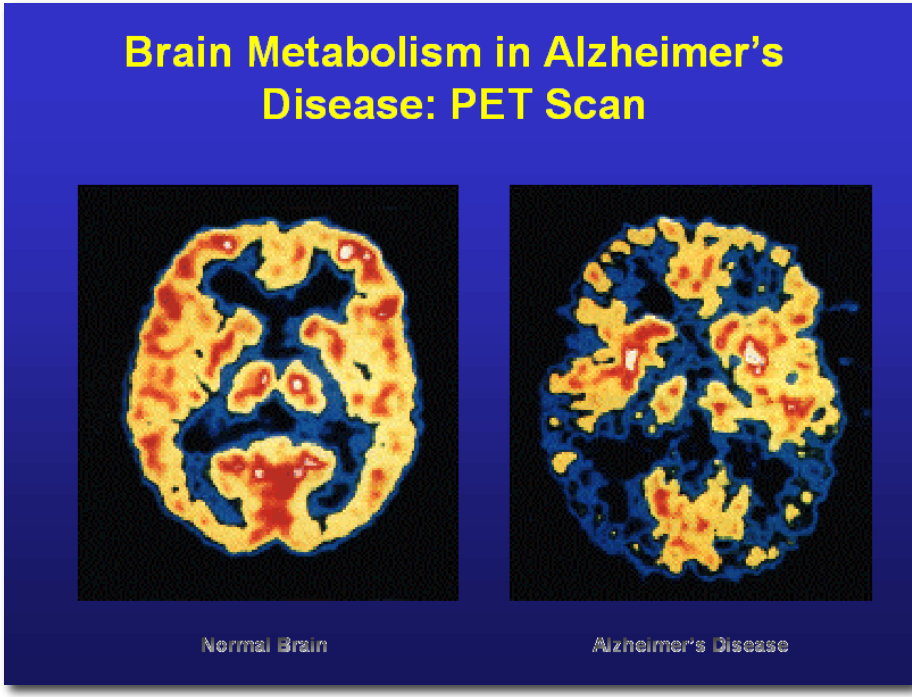


- Drug is labeled with positron (β+) emitting radionuclide.
- Drug localizes in patient according to metabolic properties of that drug.
- Trace (pico-molar) quantities of drug are sufficient.
- Radiation dose fairly small (<1 rem = 0.01 Sv).

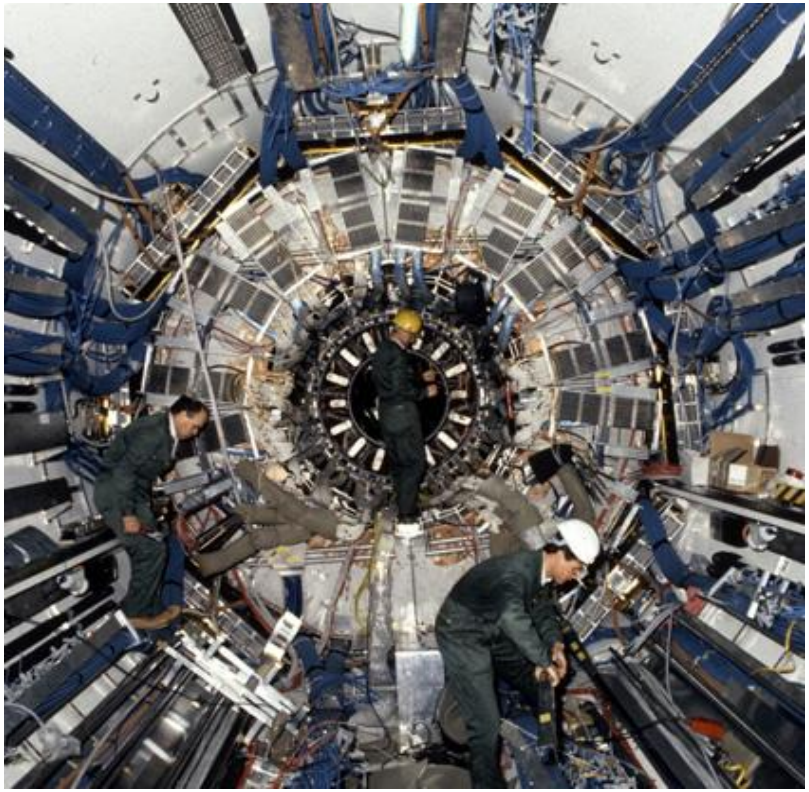
PET – How it works

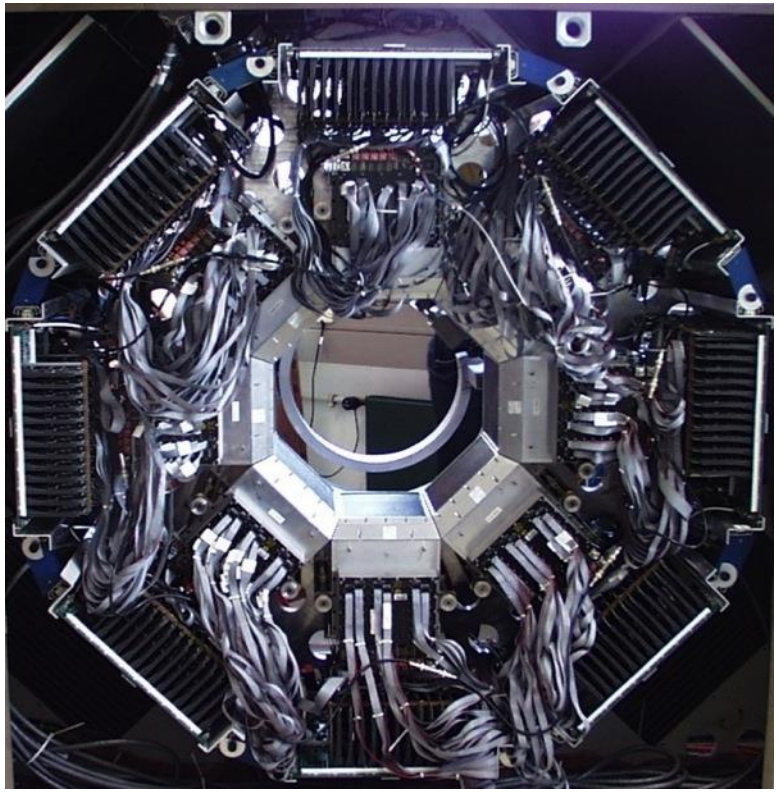
PET Scan


Coincidence
Processing Unit
Sinogram/
Listmode Data
Annihilation
Image Reconstruction


Brain Metabolism in Alzheimer's Disease: PET Scan
Normal Brain
Alzheimer's Disease

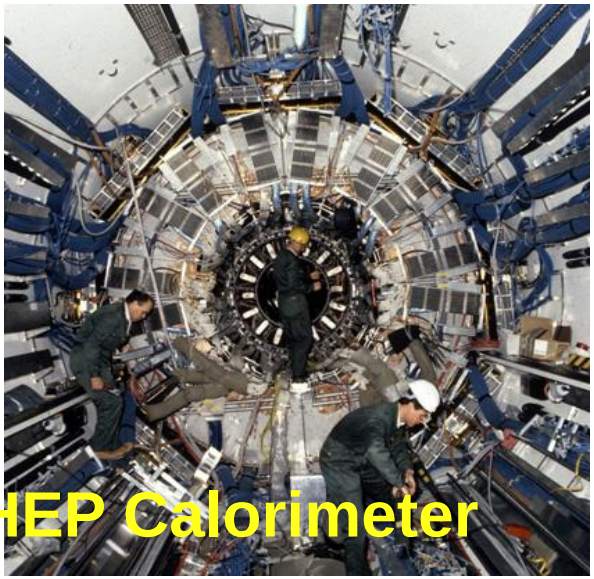
The detector challenge





Similar challenges

- New materials
- Compact
- low noise electronics
- Algorithms



Multimodal imaging

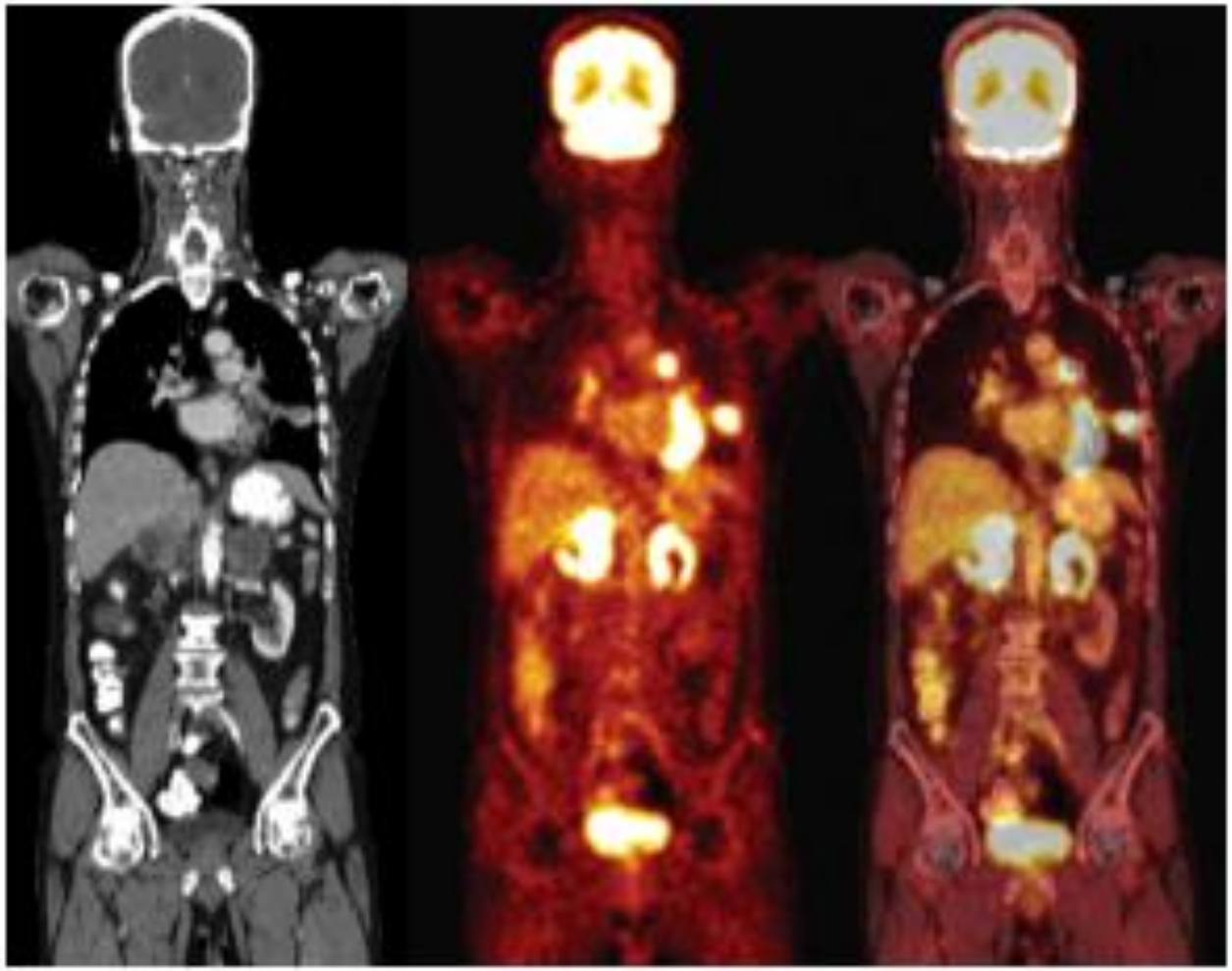
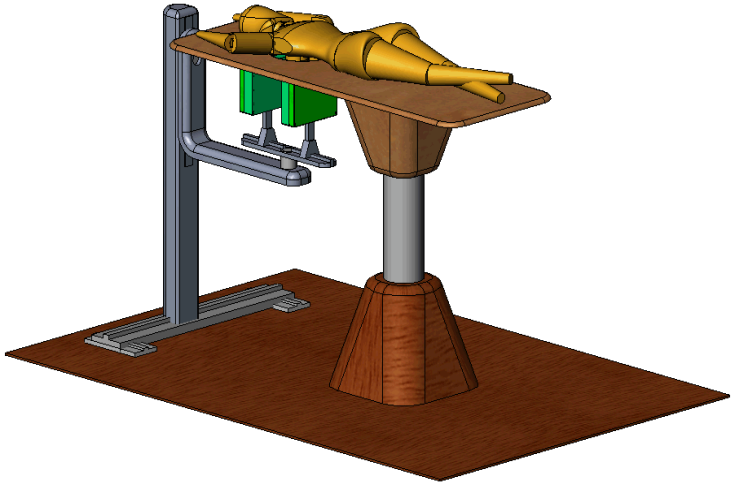


FIGURE 1. CT, PET, and PET/CT of lung cancer with adrenal metastases.

Proposed by David Townsend

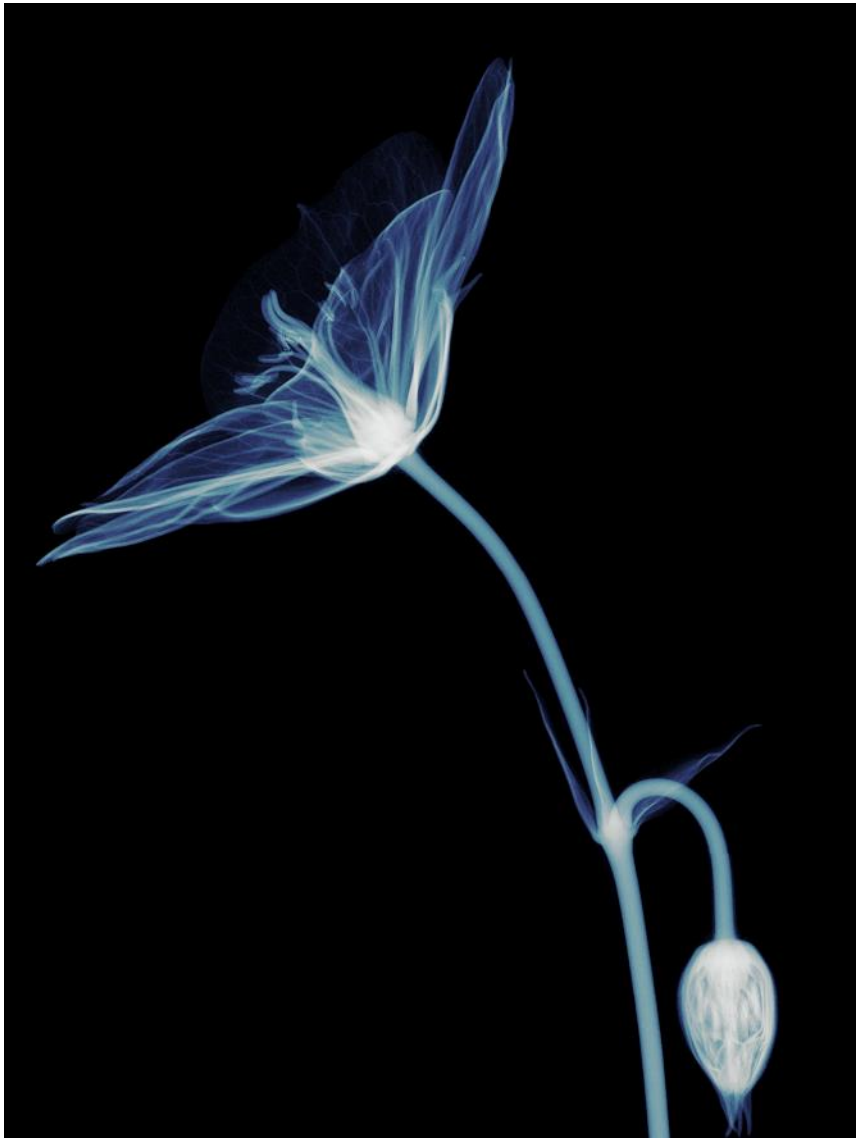
Crystal Clear

ClearPEM

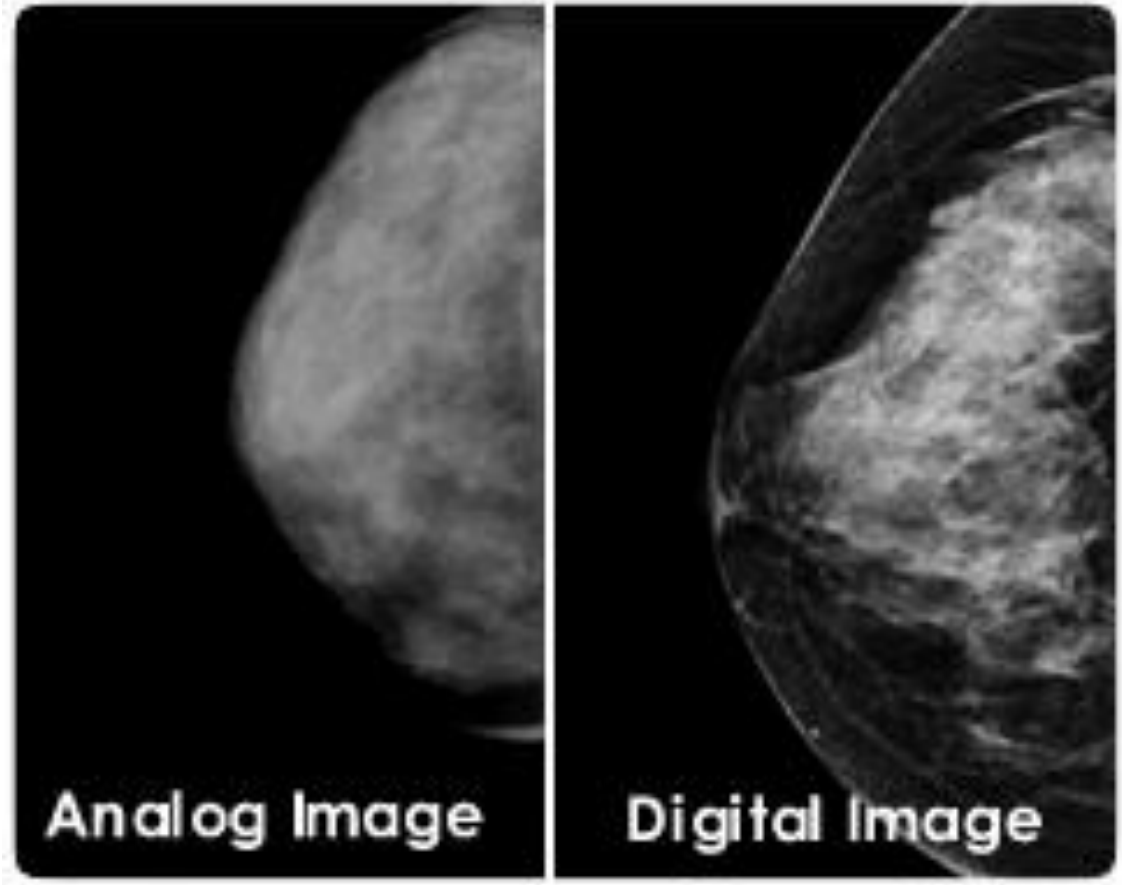


Extremely sensitive to small tumour masses

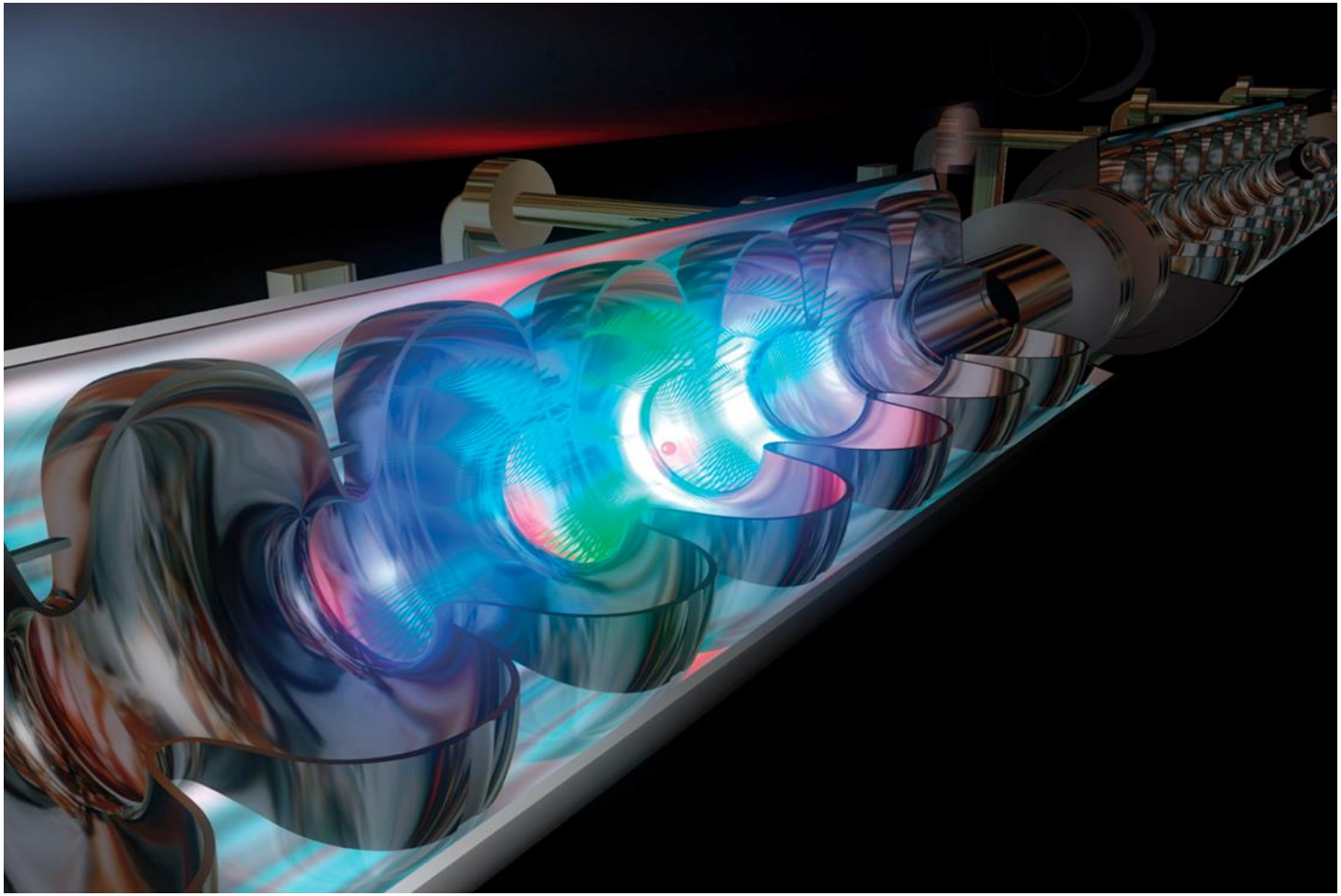
MEDIPIX



Towards digital imaging



Accelerators for cancer treatment

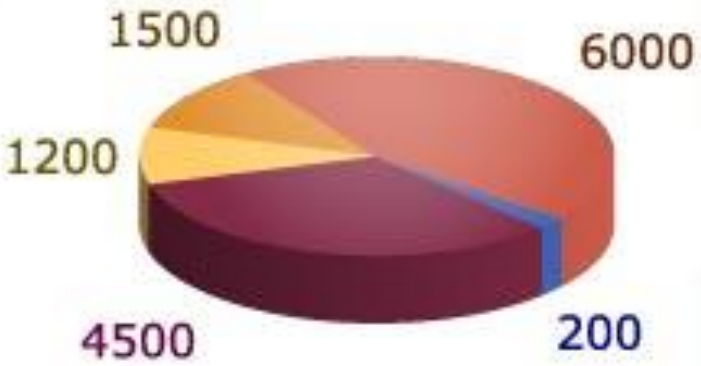


Use of accelerators today

General industrial use:
Sterilisation, imaging

Research accelerators:
Particles, synchrotron light used in biomedical, physics, chemistry, biology, material research

Radiotherapy:
Cancer treatment with X-rays, protons and other particles



Ion implantation, surface modifications:
Controlled semiconductor doping; Changing properties of surfaces

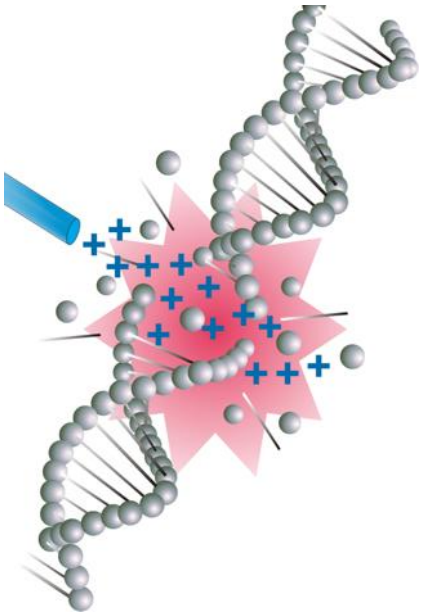
Radioisotope production:
Cancer treatment; imaging organs for medical use

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

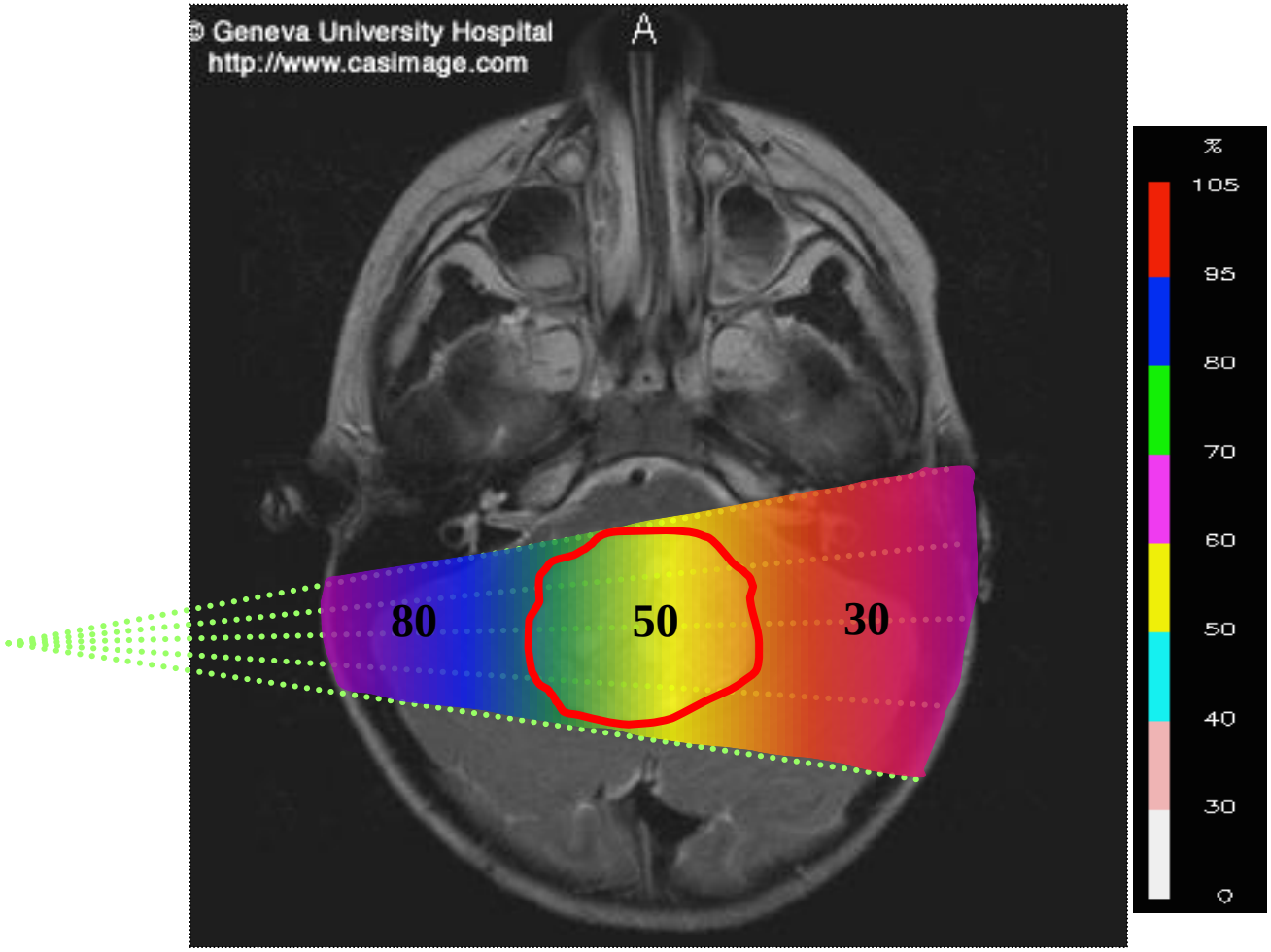
Conventional radiotherapy

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

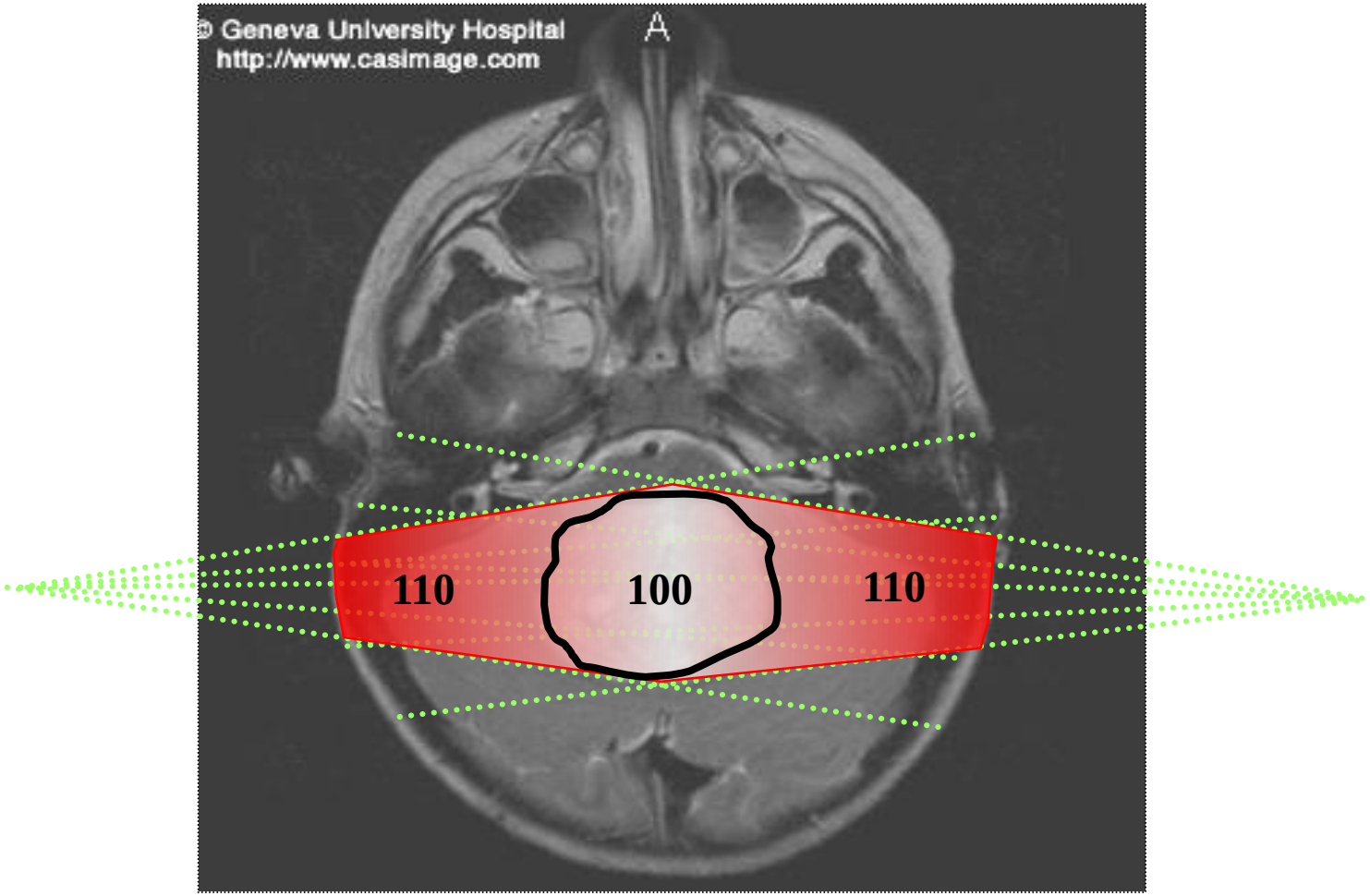
30% of patients cancer comes back in the same location after RT



Single beam of photons



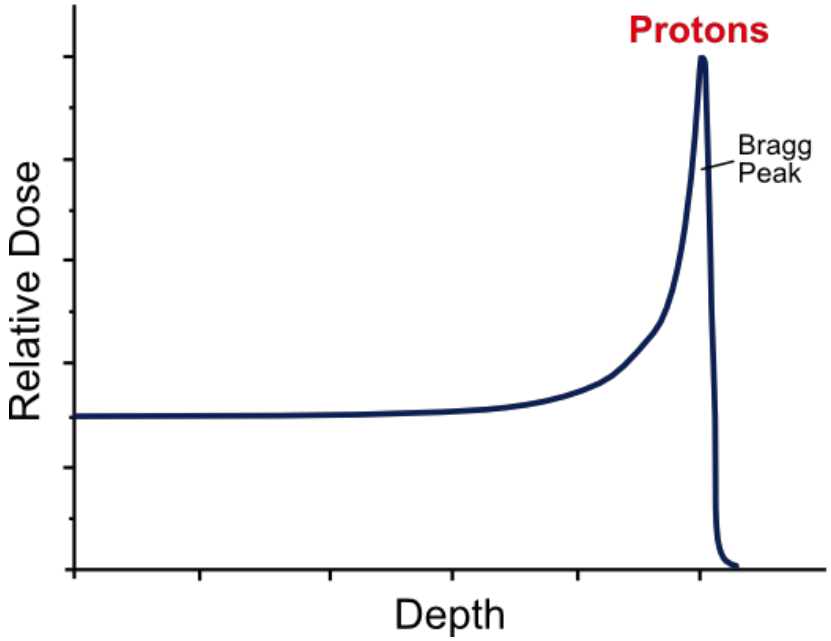
2 opposite photon beams



Alternative – Hadron Therapy

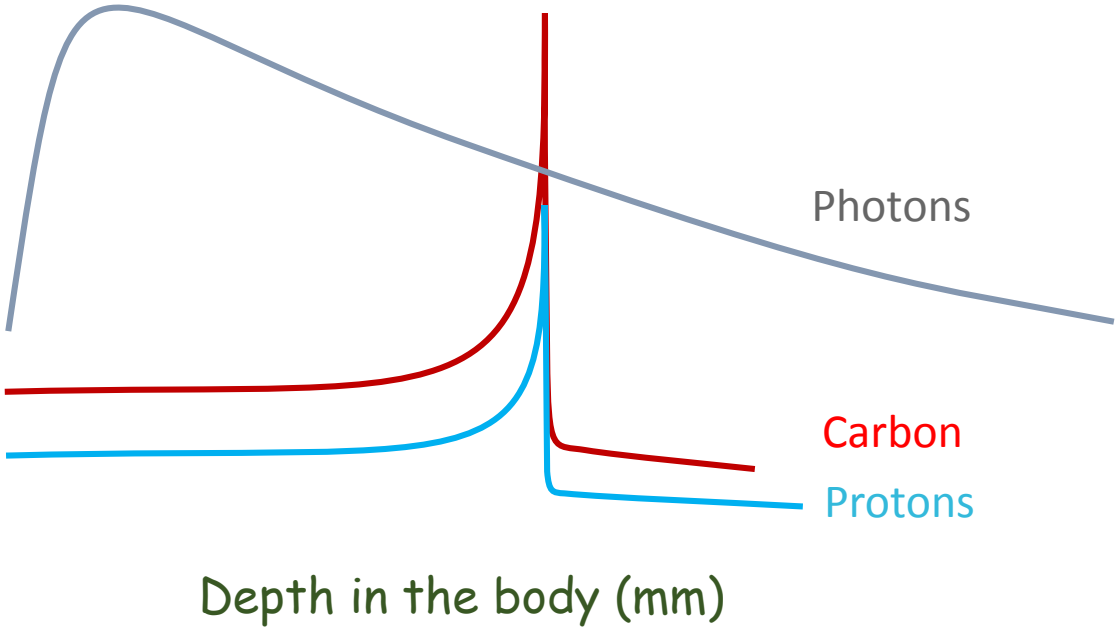
- 1946: Robert Wilson

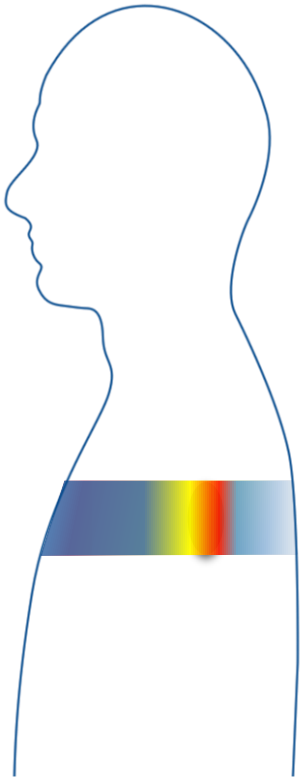
  Protons can be used clinically



Robert Wilson

Why hadron therapy





Tumours near critical organs
Tumours in children
Radio-resistant tumours

Particle therapy centres in Europe - 2002

P centres

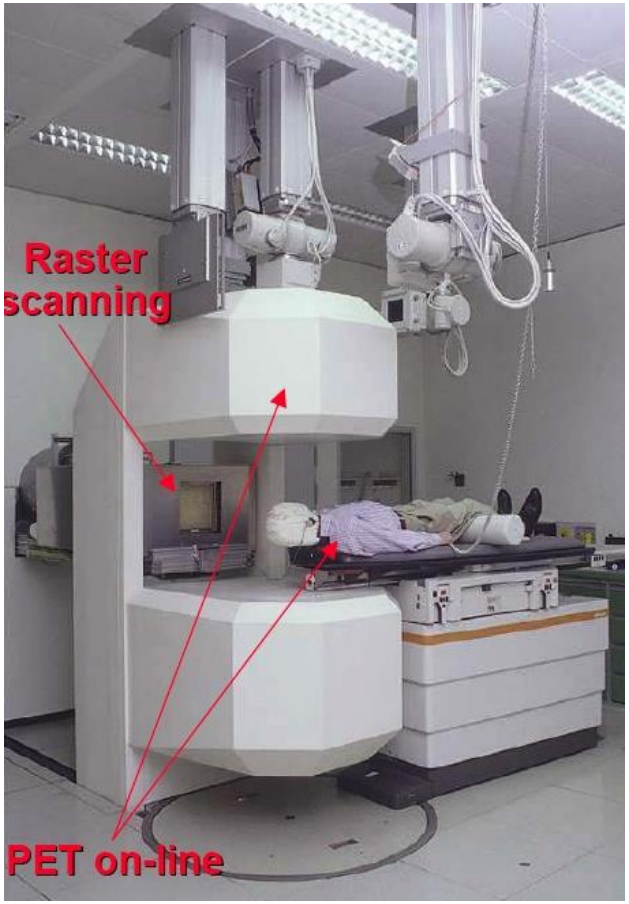
C-ion centres

Source: PTCOG, October 2015

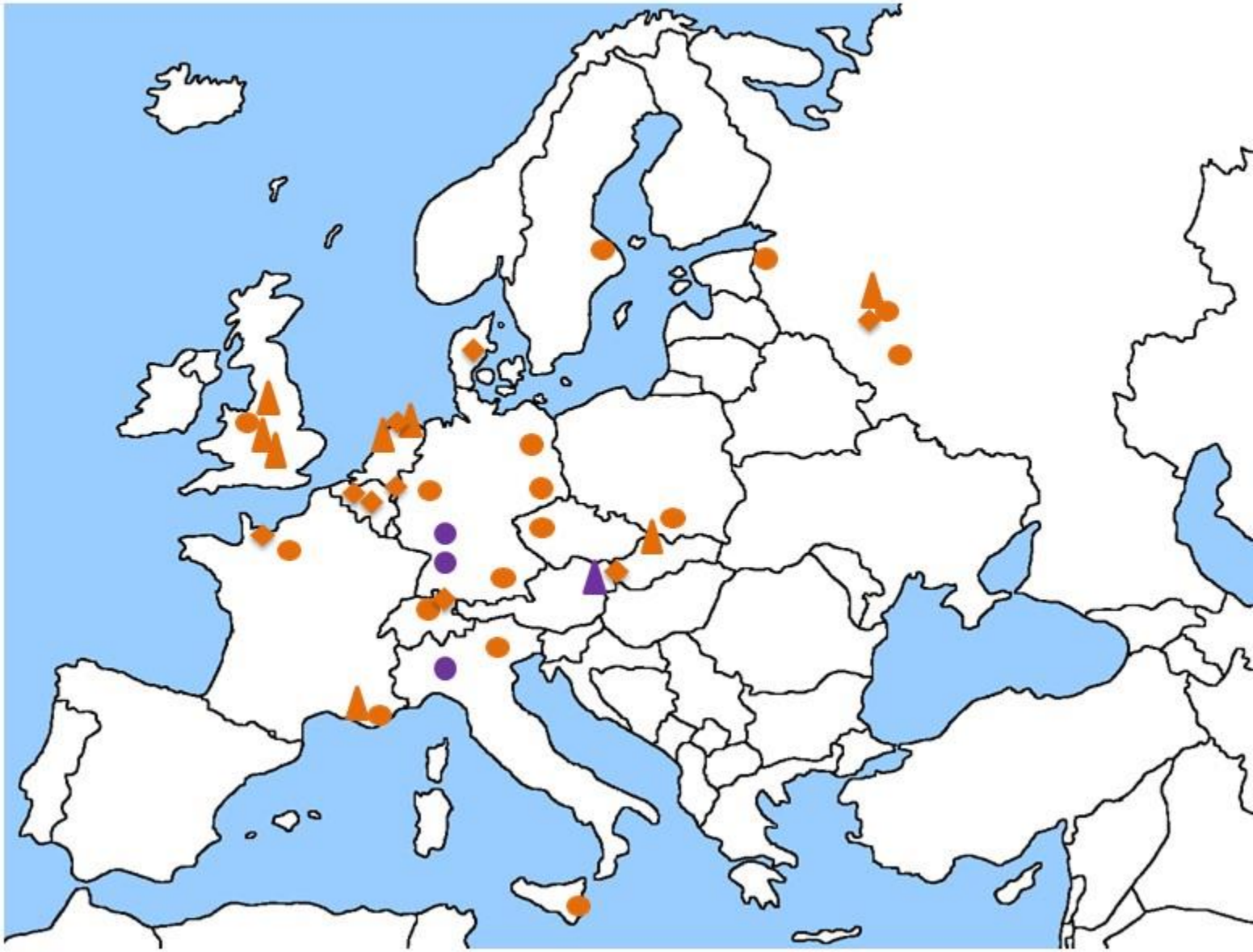
Carbon ions: pilot project in Europe

GSI & Heidelberg

– 450 patients treated



Particle therapy centres in Europe - 2015



In operation:

- Proton
- Dual Ion

Under construction:

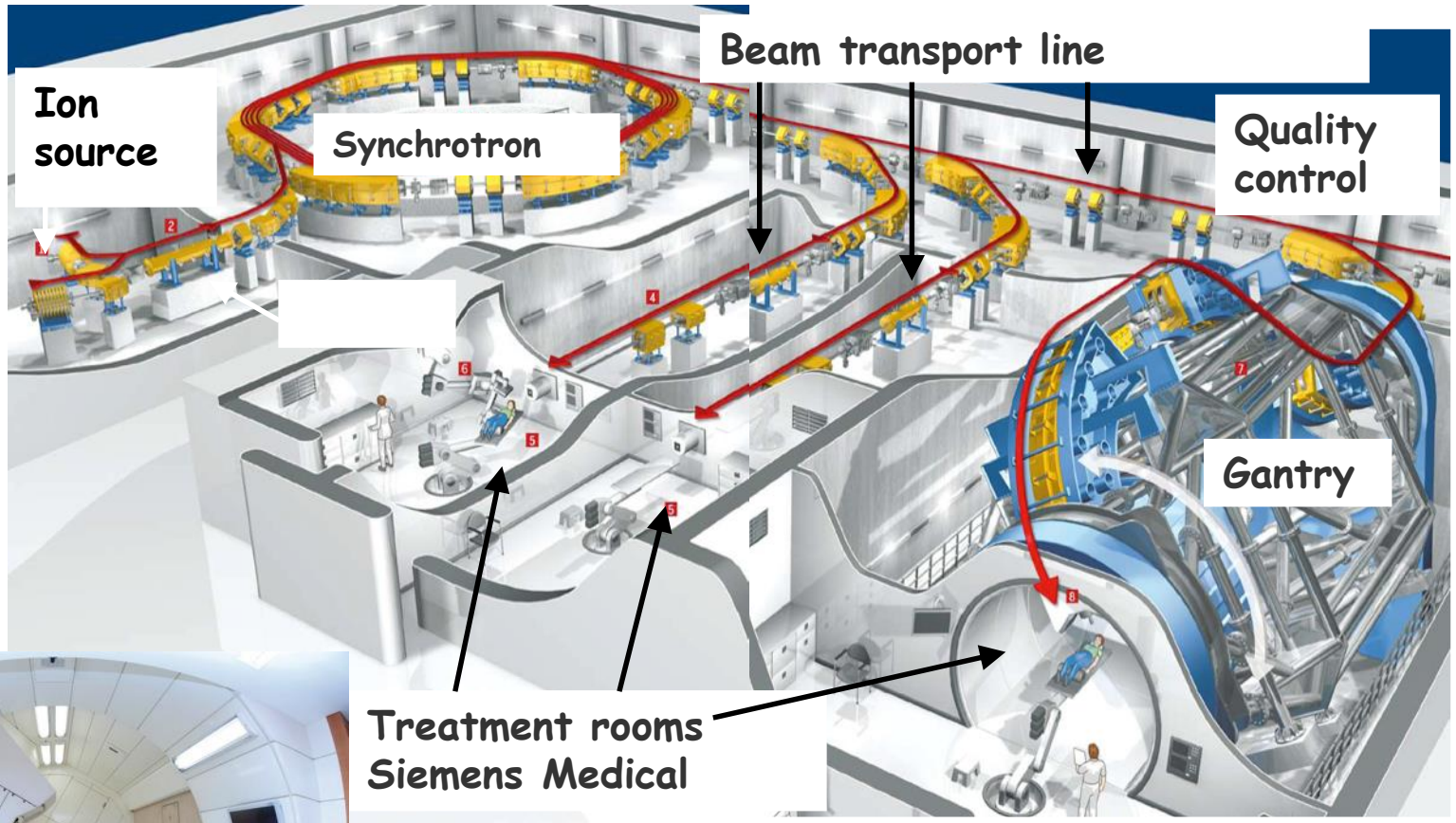
- Proton
- Dual Ion

Being planned:

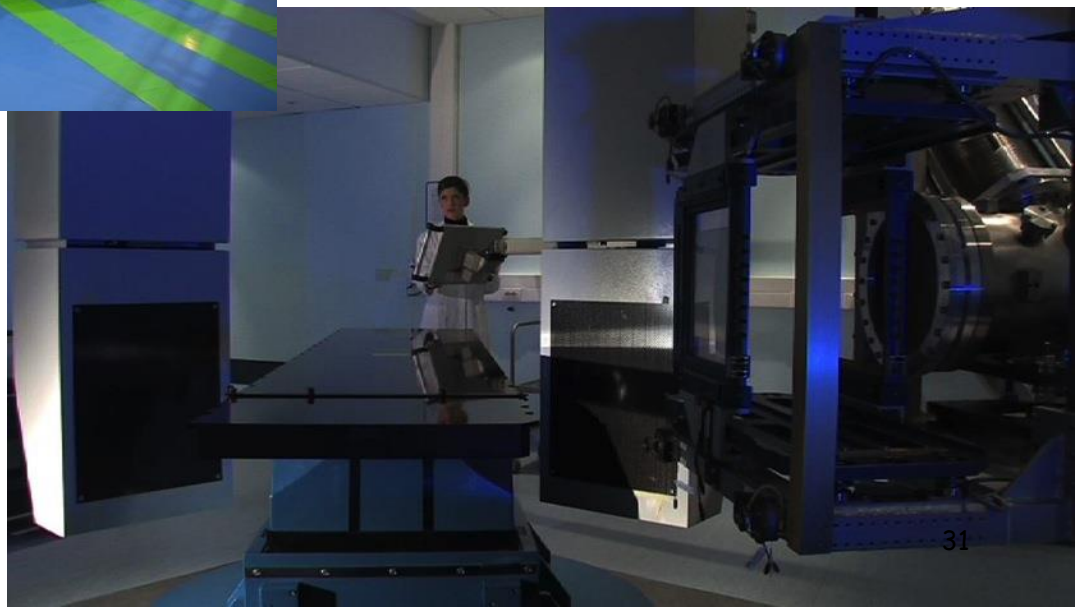
- Proton
- Dual Ion

Source: PTCOG, October 2015 and ENLIGHT

HIT - Heidelberg

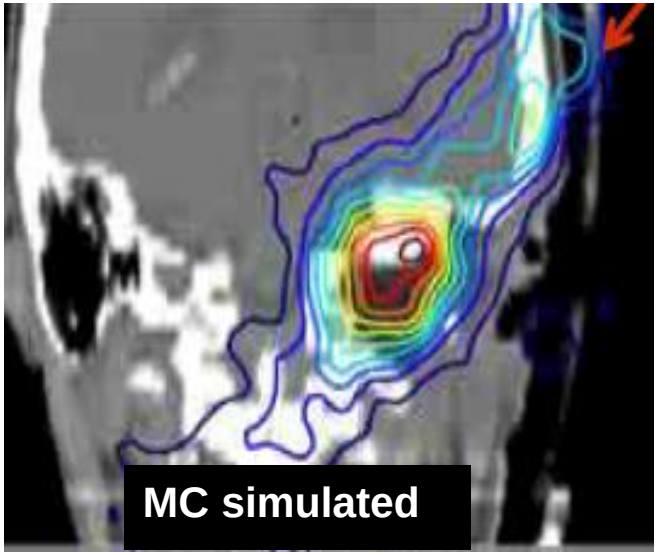


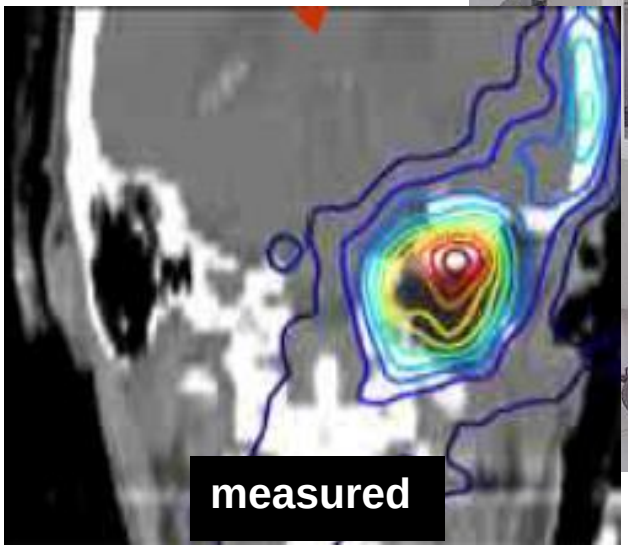
CNAO – Italy (Pavia)



Challenges

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

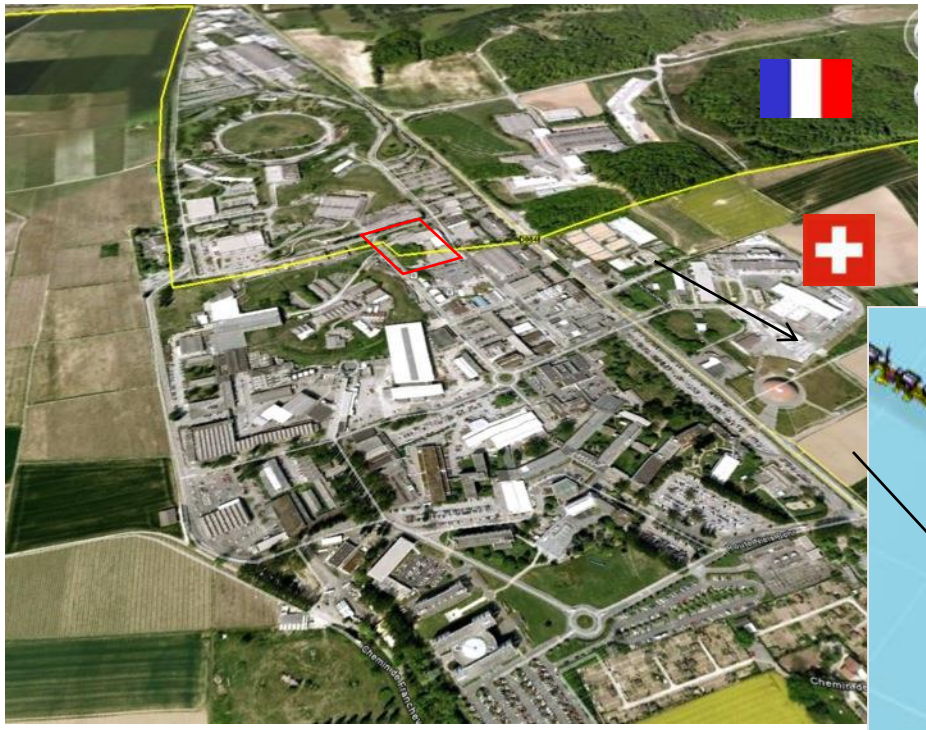


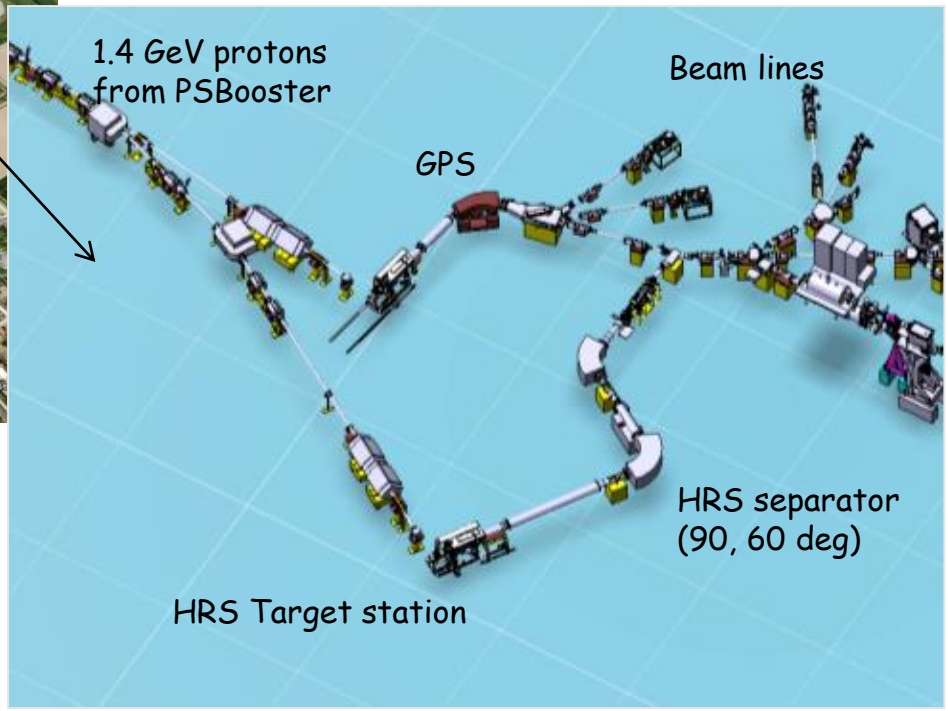



ENVISION
European NoVel Imaging Systems
for ION therapy

ISOLDE

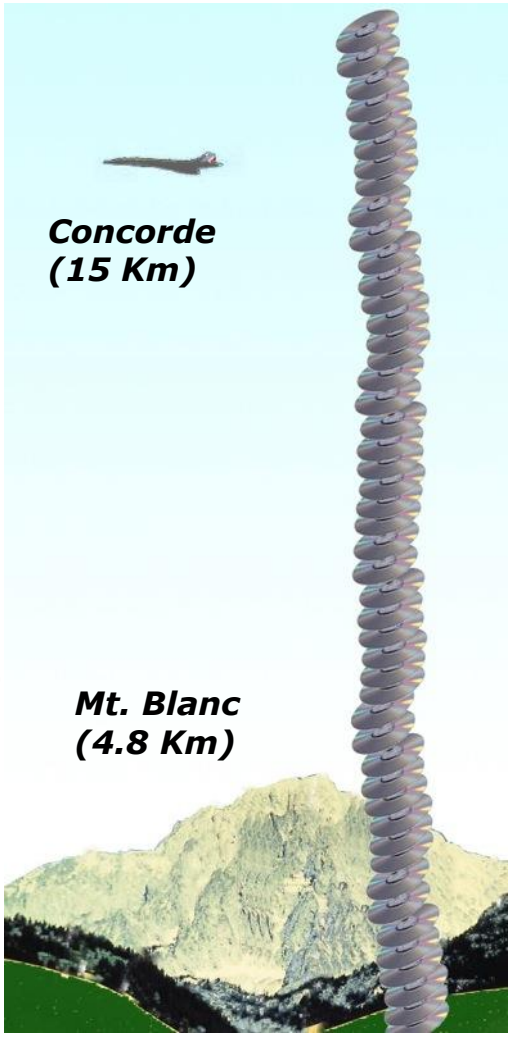
isotopes for detection & treatment



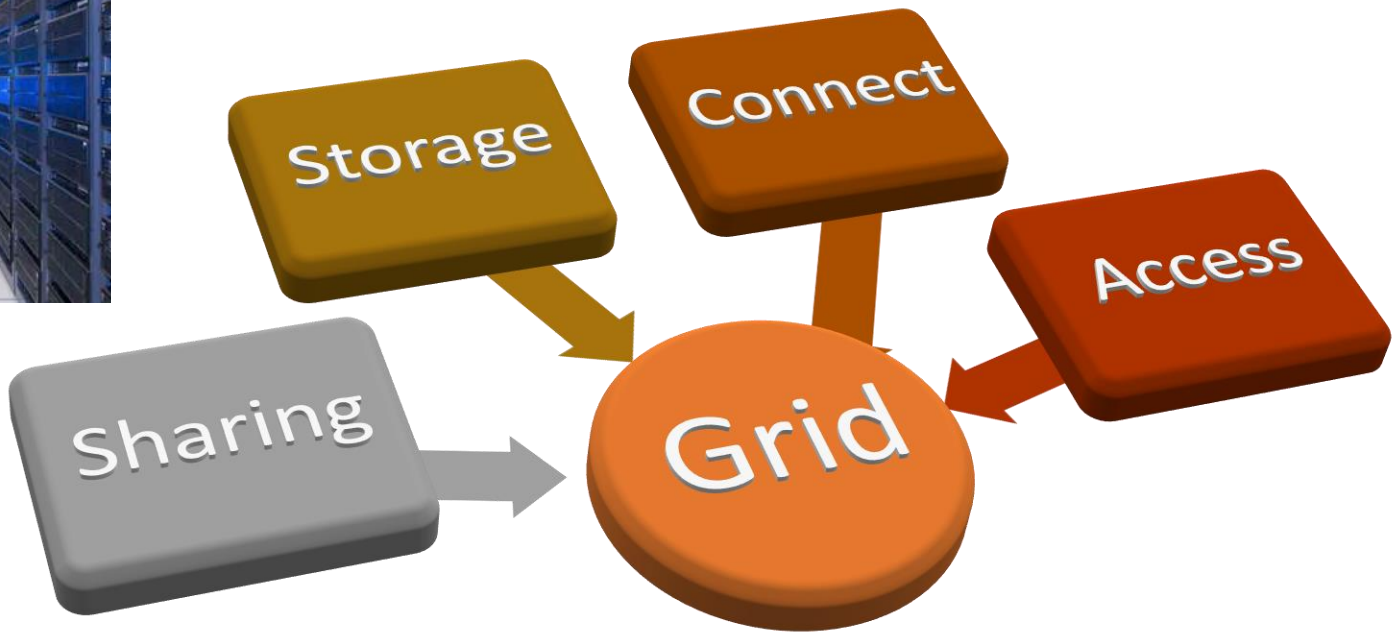


In collaboration with
University Hospital Geneva

Computing for medical applications



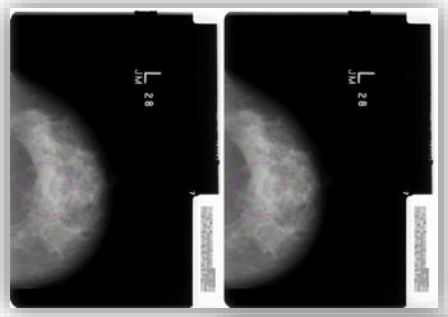
The Grid

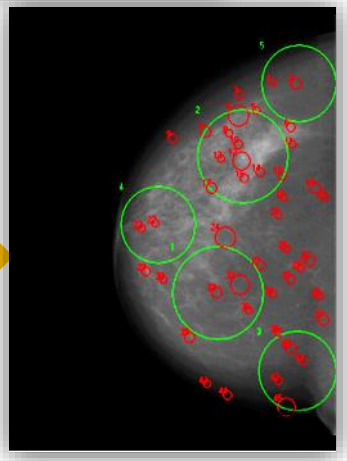


Data and Resources

Mammogrid - a grid mammography database

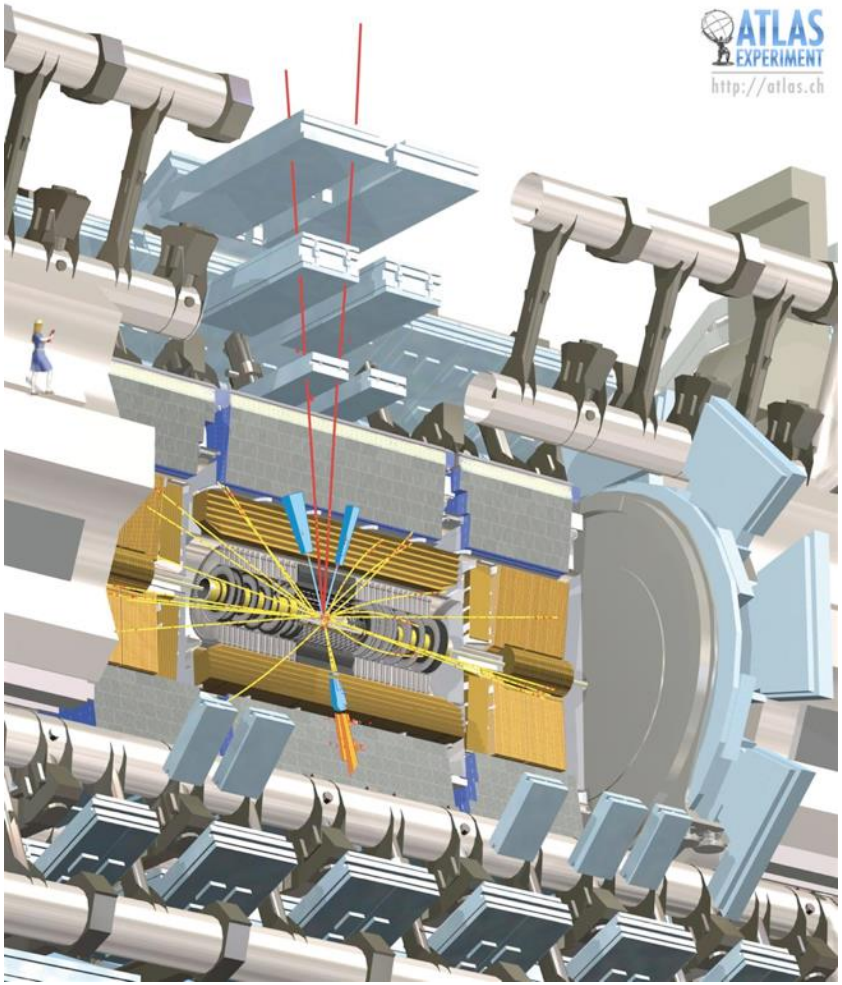
- Second Opinion
- Cancer Screening
- Education and Training
- Reference Database / Repository





From: David MANSET, CEO MAAT France, www.maat-g.com

Simulation



cern.ch/virtual-hadron-therapy-centre

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- cern.ch/wwwasd/geant
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