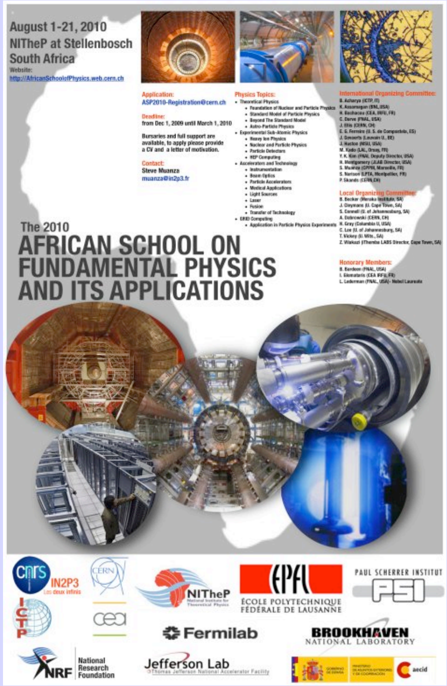
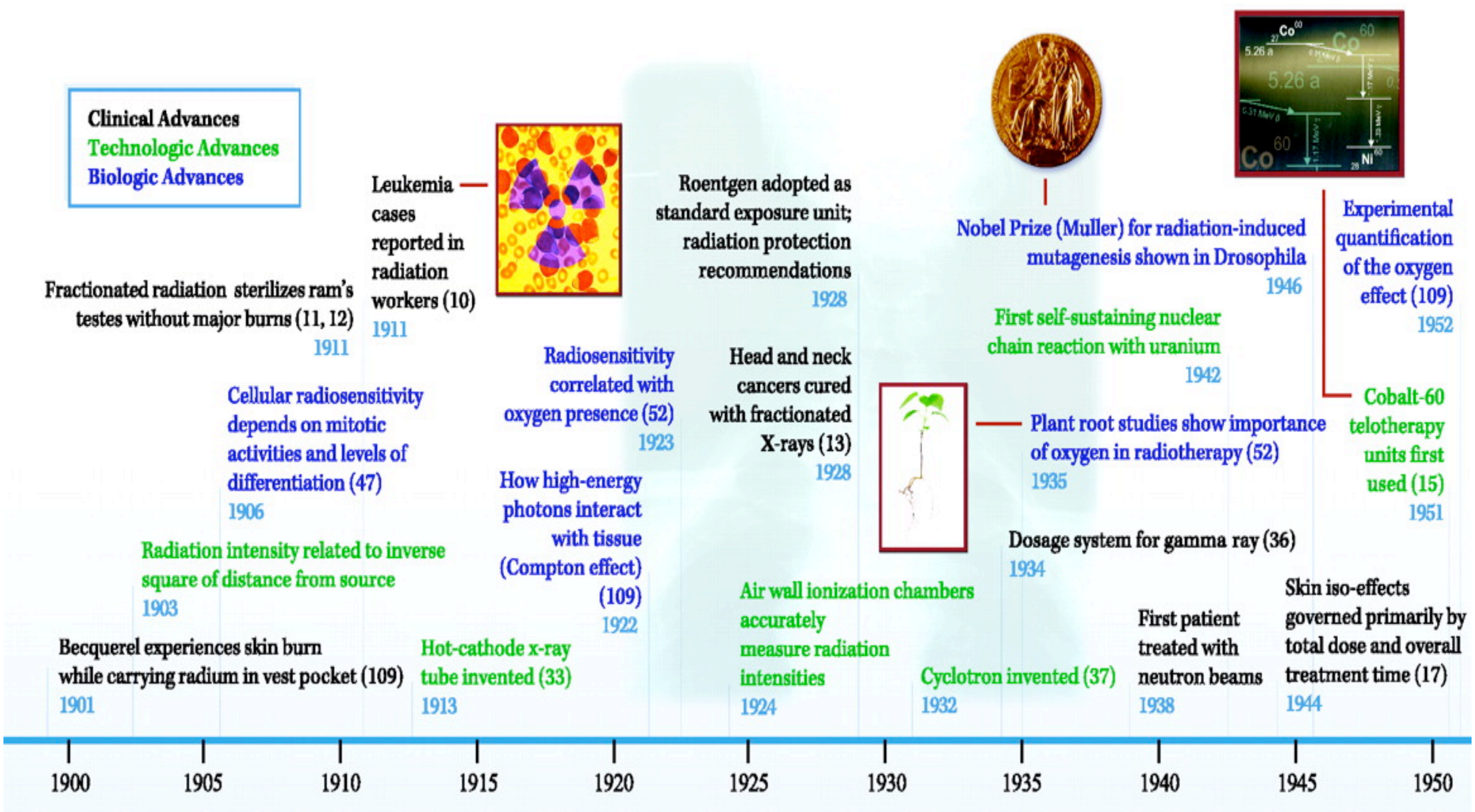


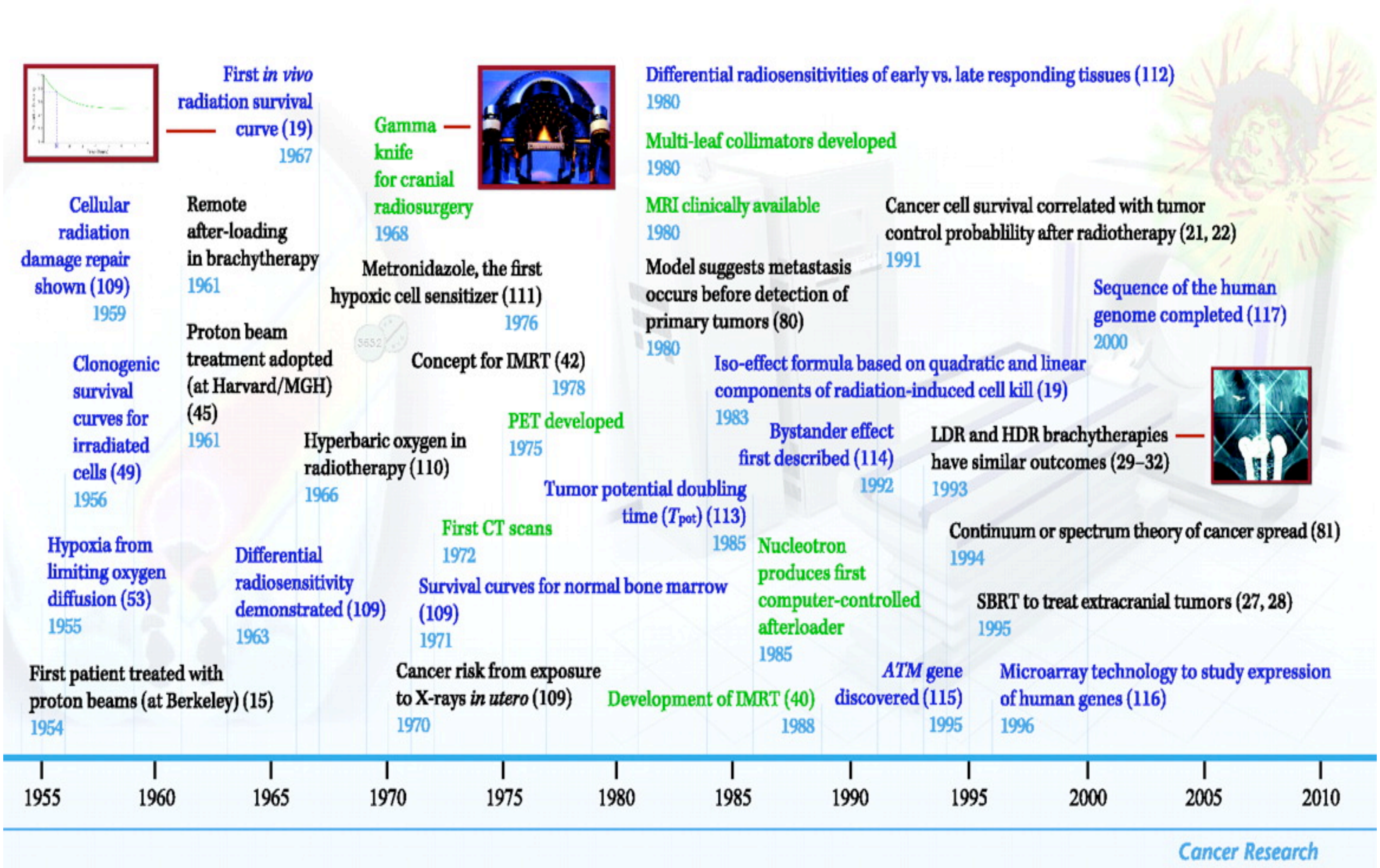

# Medical Applications from particle physics

**Manjit Dosanjh**
**Advisor for Life Sciences, CERN**

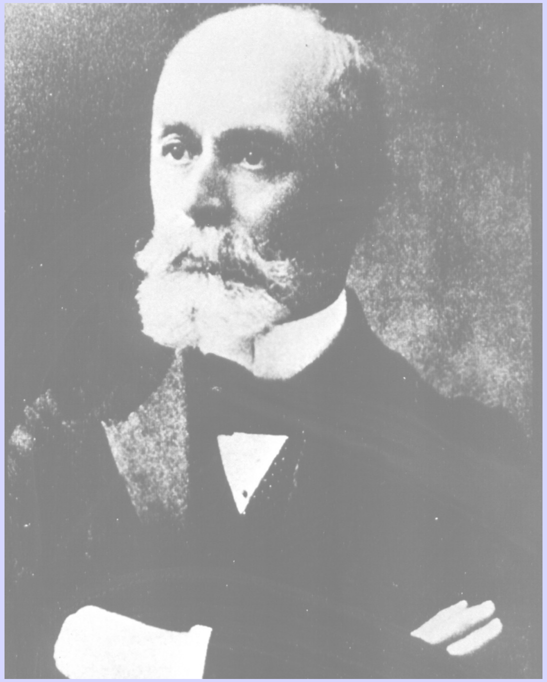
Figure 2. Advances in Radiotherapy: 1900–Present




AACR Centennial Series

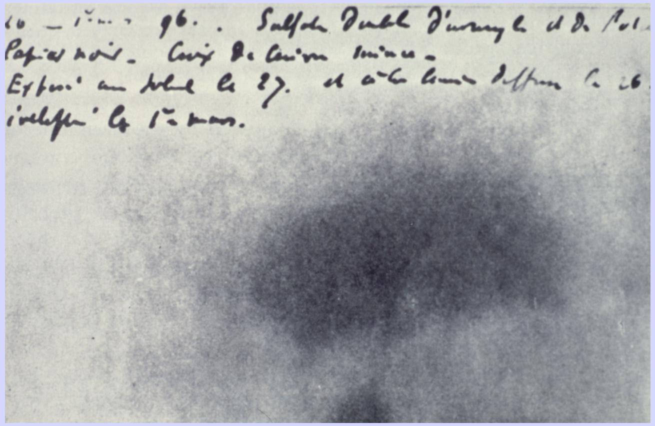

First *in vivo* radiation survival curve (19) 1967
Gamma knife for cranial radiosurgery 1968
Differential radiosensitivities of early vs. late responding tissues (112) 1980
Multi-leaf collimators developed 1980
Cellular radiation damage repair shown (109) 1959
Remote after-loading in brachytherapy 1961
MRI clinically available 1980
Cancer cell survival correlated with tumor control probablility after radiotherapy (21, 22) 1991
Metronidazole, the first hypoxic cell sensitizer (111) 1976
Model suggests metastasis occurs before detection of primary tumors (80) 1980
Sequence of the human genome completed (117) 2000
Proton beam treatment adopted (at Harvard/MGH) (45) 1961
Clonogenic survival curves for irradiated cells (49) 1956
Concept for IMRT (42) 1978
Iso-effect formula based on quadratic and linear components of radiation-induced cell kill (19) 1983
PET developed 1975
Bystander effect first described (114) 1992
LDR and HDR brachytherapies have similar outcomes (29–32) 1993
Hyperbaric oxygen in radiotherapy (110) 1966
Tumor potential doubling time ($T_{pot}$) (113) 1985
First CT scans 1972
Continuum or spectrum theory of cancer spread (81) 1994
Hypoxia from limiting oxygen diffusion (53) 1955
Differential radiosensitivity demonstrated (109) 1963
Nucleotron produces first computer-controlled afterloader 1985
Survival curves for normal bone marrow (109) 1971
SBRT to treat extracranial tumors (27, 28) 1995
First patient treated with proton beams (at Berkeley) (15) 1954
Cancer risk from exposure to X-rays *in utero* (109) 1970
Development of IMRT (40) 1988
*ATM* gene discovered (115) 1995
Microarray technology to study expression of human genes (116) 1996
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Cancer Research

# ……….beginning of medical physics

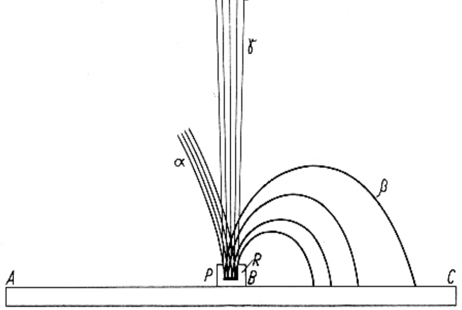


Henri Becquerel

1896:
Discovery of natural radioactivity

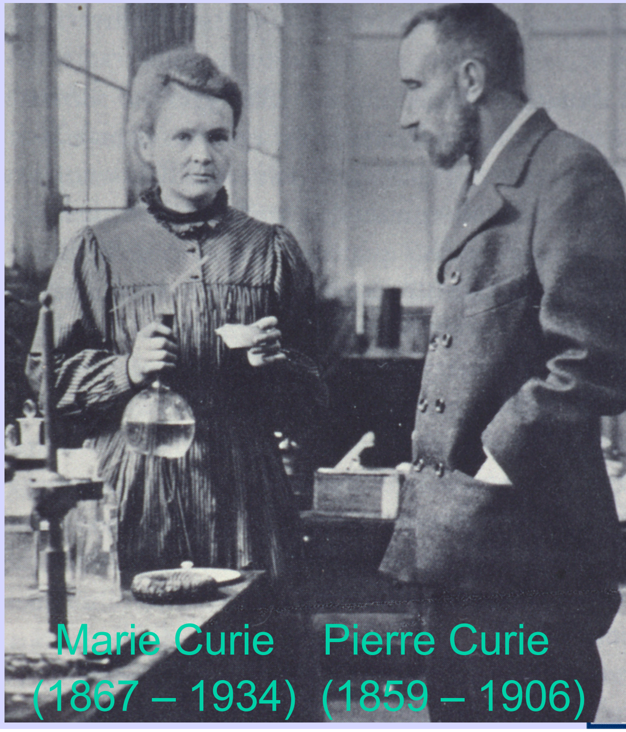


Thesis of Mme. Curie – 1904
α, β, γ in magnetic field




**1898: Discovery of radium**

**used immediately for "Brachytherapy"**



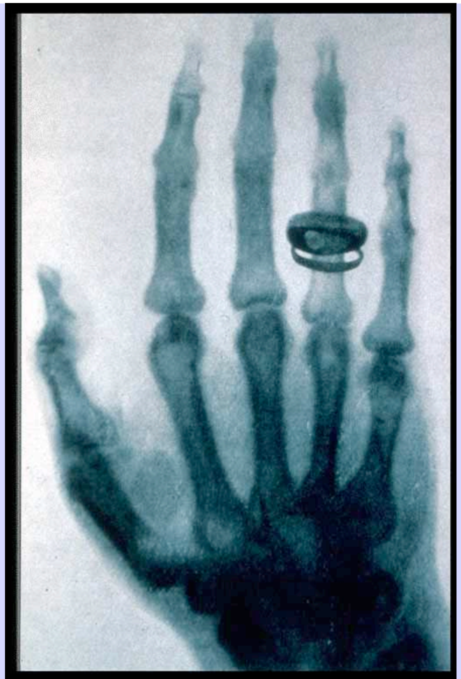
Marie Curie (1867 – 1934) Pierre Curie (1859 – 1906)

# X-Rays, the fastest technology transfer example

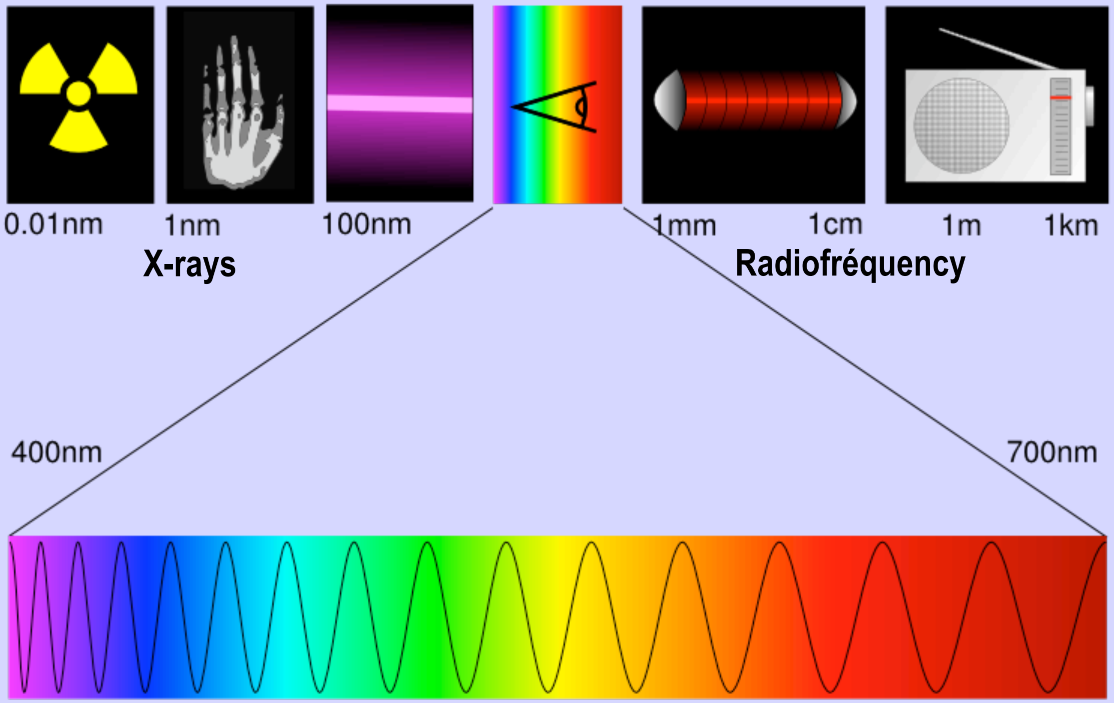
- **On November 8, 1895 Röntgen discovered X-Rays**
- **On November 22, 1895 he takes the first image of his wife's hand**

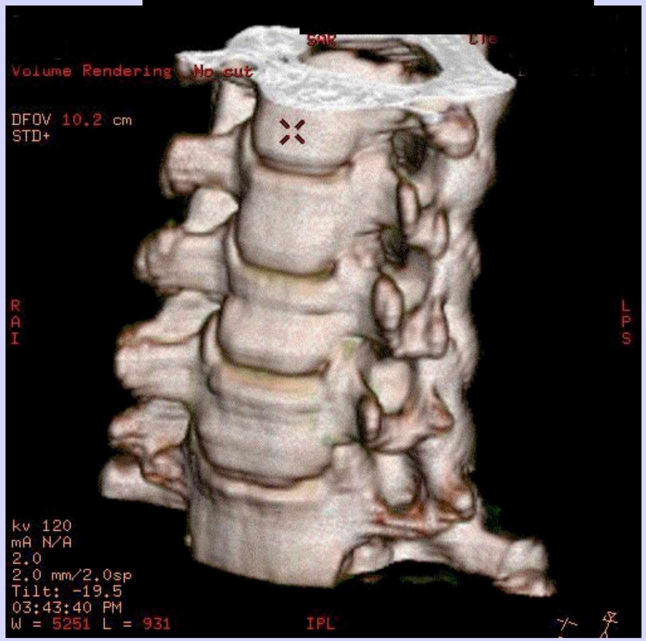
**Röntgen received the first Nobel prize in physics in 1901**

# History: Discovery of X-rays



- Since 1895, inventor Wilhelm Rötgen
- EM wave, with energy range: 30 -100 keV
- From film to digital devices

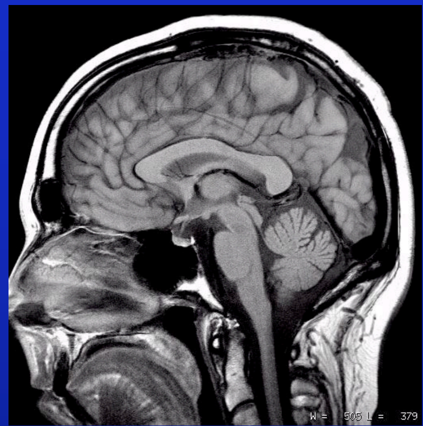


# MRI, Magnetic Resonance Imaging

## The Nobel Prize in Physics 1952

Felix Bloch
Physicist Stanford



Edward M. Purcell
Physicist Harvard

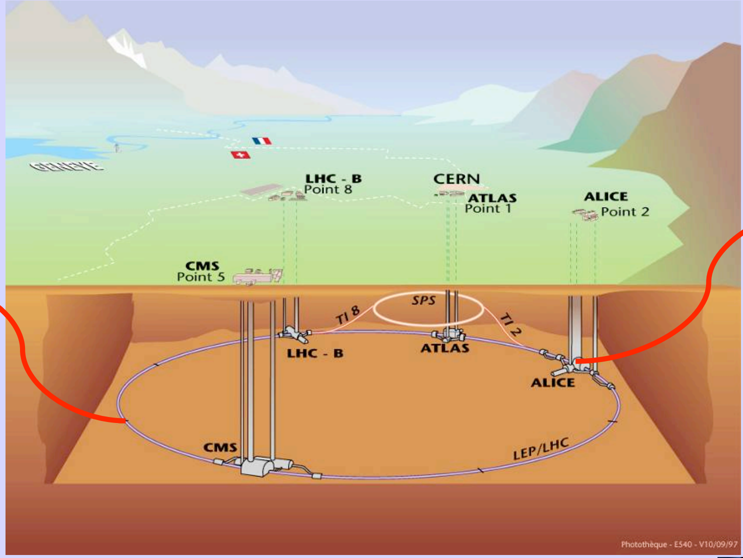
## The Nobel Prize in Physiology or Medicine 2003


Sir Peter **Mansfield**
Physicist Nottingham

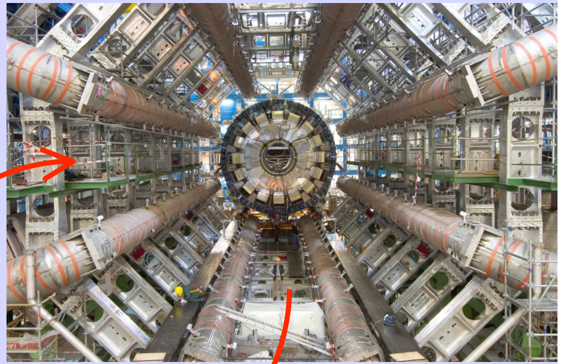

Paul C.
**Lauterbur**
Chemist Uni.
Illinois

# The tools of the trade ……….

Accelerators




Detectors

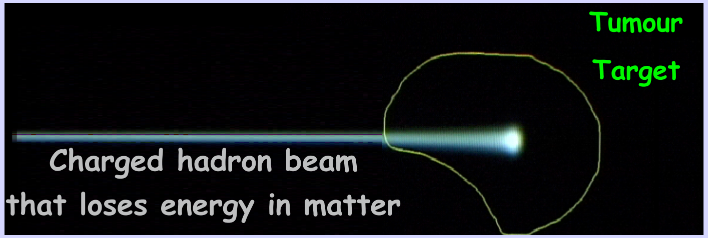


Computers

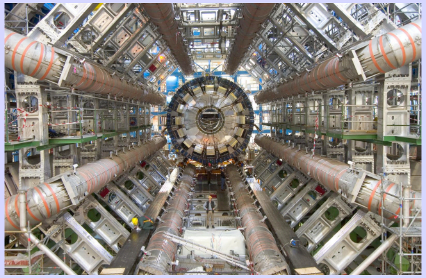
Brain behind the web

# Medical Applications

Particle beams for cancer treatment

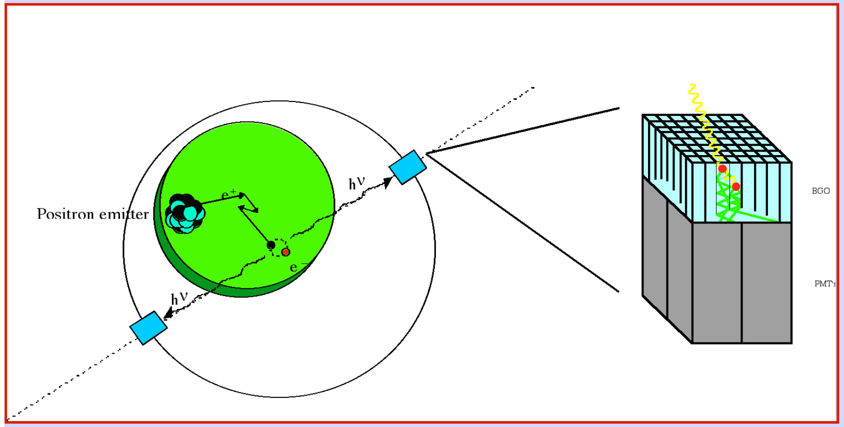



Particle detector technologies for medical imaging

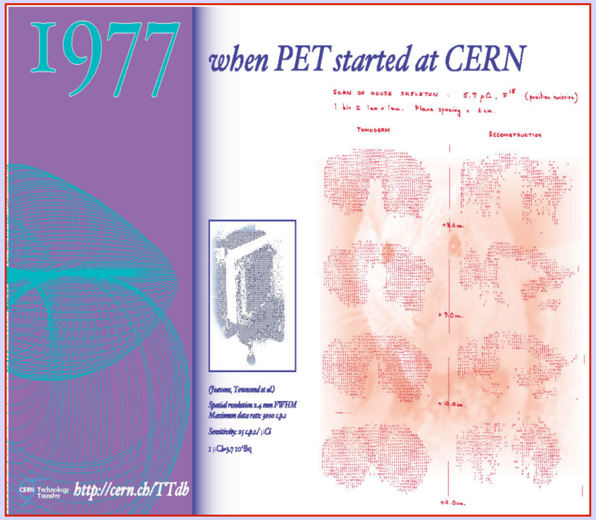


Grid computing for medical data management and analysis

# Physics to medicine

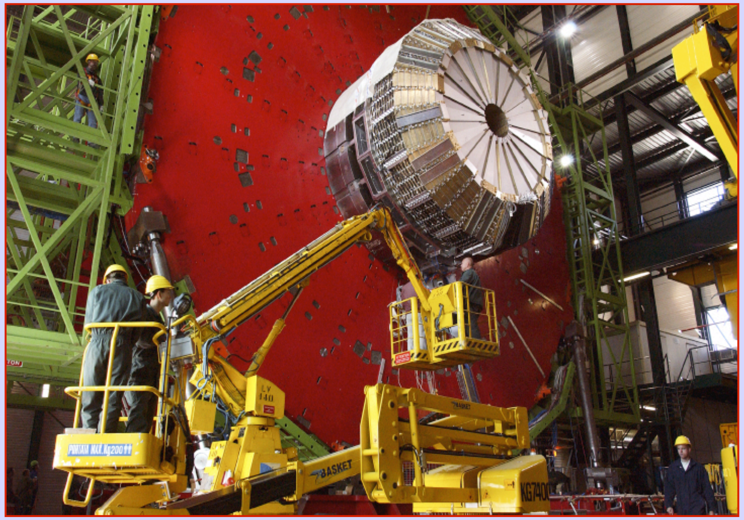



**Idea of PET**

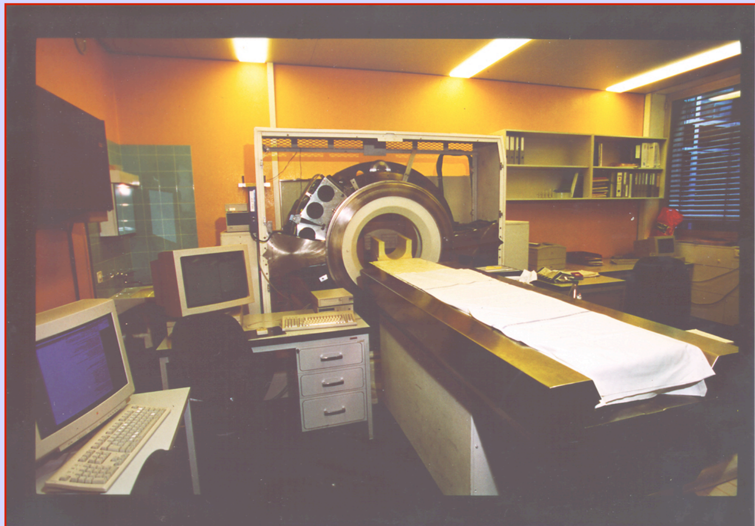



**PET today**

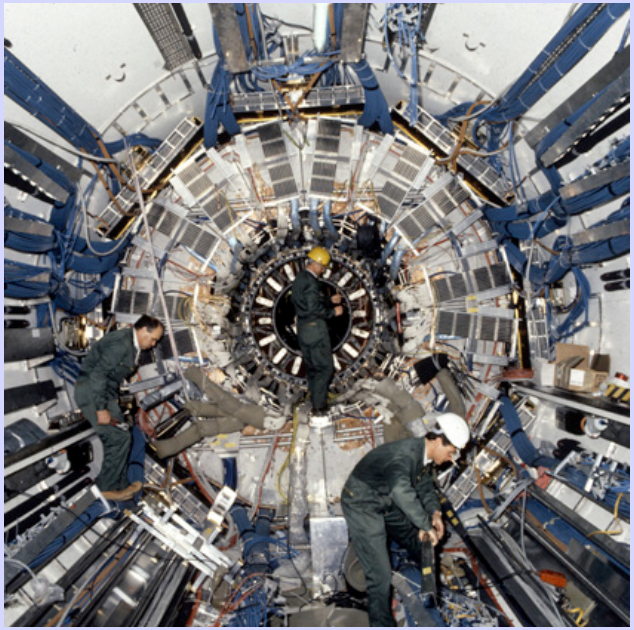
**Photon detection used for calorimetry**

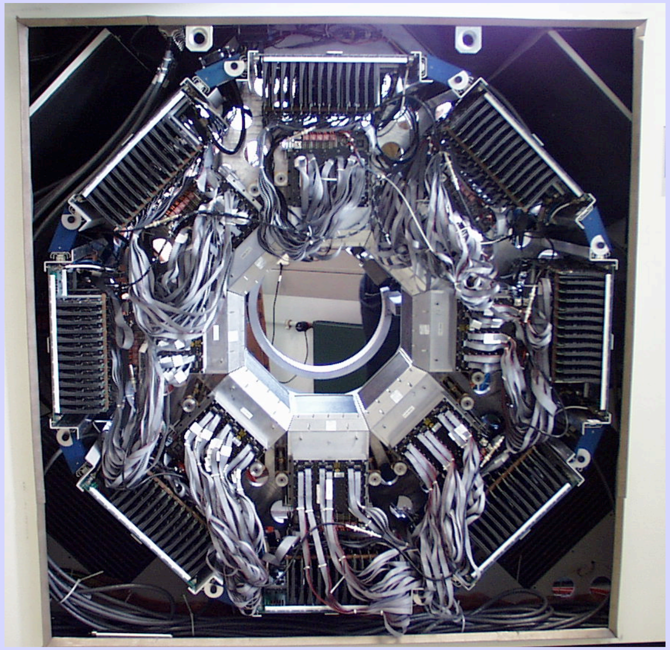


**CMS calorimeter**



# Similar challenges detectors

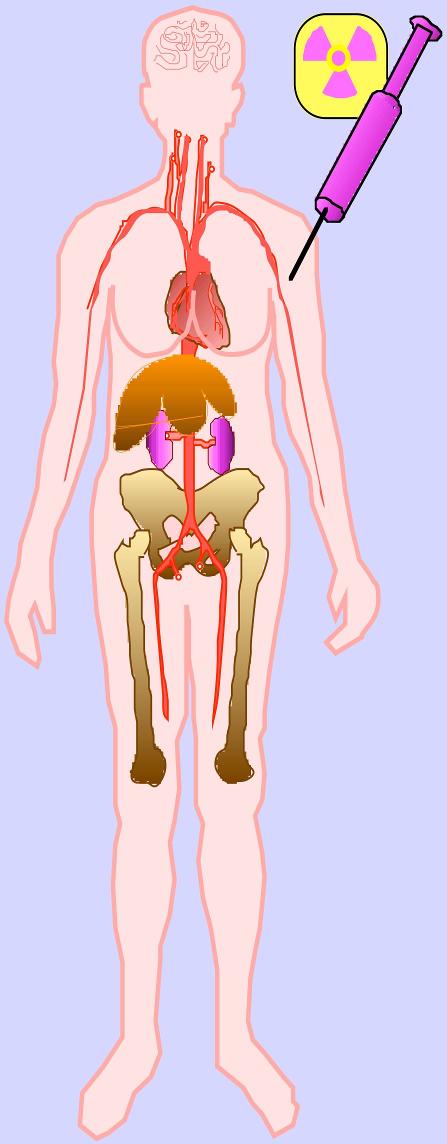




# Similar challenges for PET and HEP detectors

- New scintillating crystals and detection materials
- Compact photo-detectors
- Highly integrated and low noise electronics
- High level of parallelism and event filtering algorithms in DAQ
- Modern and modular simulation software using worldwide recognized standards (GATE)

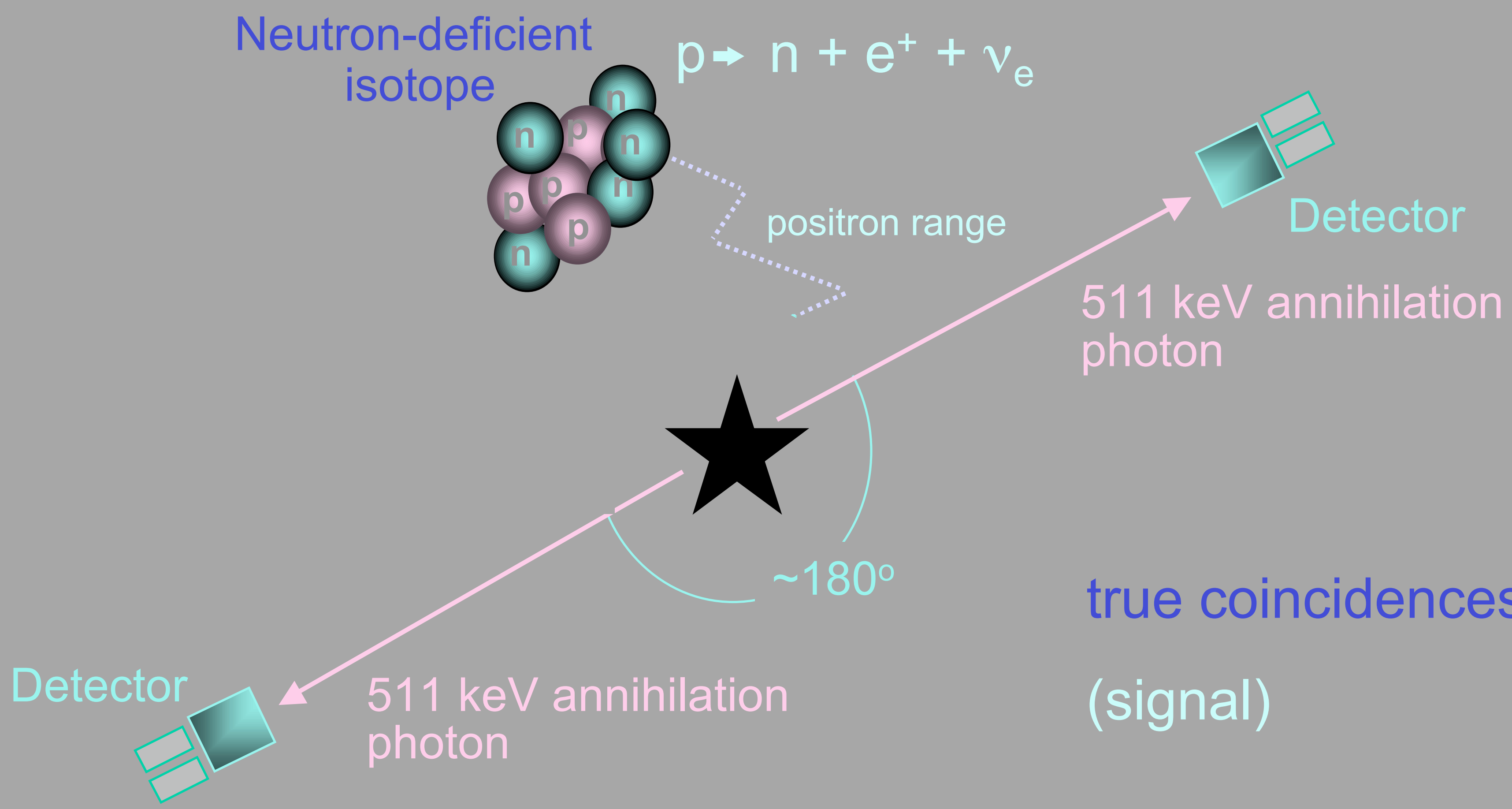

# Inject Patient with Radioactive Drug



- Drug is labeled with positron ($\beta^+$) 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).

Drug Distributes in Body

# PET: true events




true coincidences (T)

(signal)

# Crystal Clear Collaboration

-New scintillators :

- LuAP, phoswich LuAP-LSO (CERN patent)
- other crystals

- new photodetectors (Avalanche PhotoDiodes)

-new low noise front end electronics

-new intelligent DAQ systems with pipeline and parallelized architecture

-better simulation GEANT 4

-- better reconstruction algorithms

# The ClearPET™
# LYSO/LuYAP Phoswich Scanner

## A high Performance Small Animal PET System

Higher e[illegible] spatial resolution

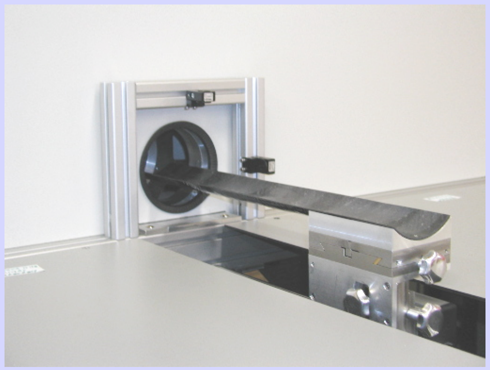

**The Design**

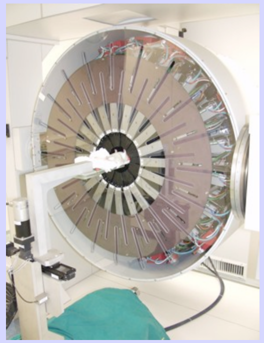
- 20 detector cassettes on the ring
- each cassette has 4 PM in line
- each PM has 64 photocathodes
- each photocathode reads 1 phoswich
- each phoswich has 2 crystals LYSO and LuYAP
- each crystal is 2 x 2 x 10mm³
- open gantry diameter adjustable 120 - 240mm
- rotation 360 degree

$T_{cosine}$ resolution 2 ns FWHN

Spatial resolution 1.5 mm at centre

Peak sensitivity >4%





By Courtesy of Raytest, Germany

# Introduction: Breast Cancer

- **1 women in 8** will develop cancer throughout her life
- **2nd cause of cancer death** amongst women
- **Very good survival rates** if detected at an early stage (> 75% of patients have a 10-yr disease-free survival if tumor < 5cm)

→ **Breast cancer screening is now standard technique:**

- **Palpation**: low sensitivity and specificity
- **X-ray Mammography**: high sensitivity and specificity BUT less reliable for dense breasts, unsuited for young, pregnant women and implants
- **Ultrasound**: complementary to X-ray
- **Biopsy**: only to confirm previous indication

If possible:

- **MRI**: very high sensitivity BUT low specificity and high costs
- **Whole-body PET**: only technique with metabolic information BUT low resolution and high costs

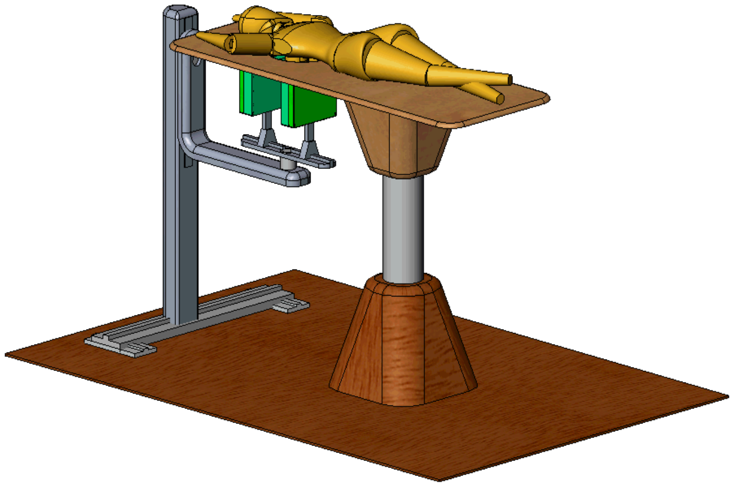
→ **Room for a new technique**

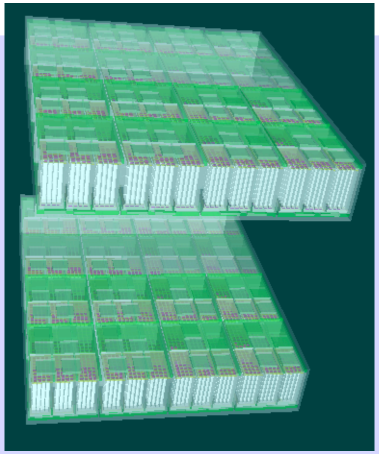
**The Pink Ribbon – the international sign for breast cancer awareness**

Data from: Merck Manuals, Online Medical Library

# Positron Emission Mammography
# CRYSTAL CLEAR Collaboration

**Model of the PEM detector**





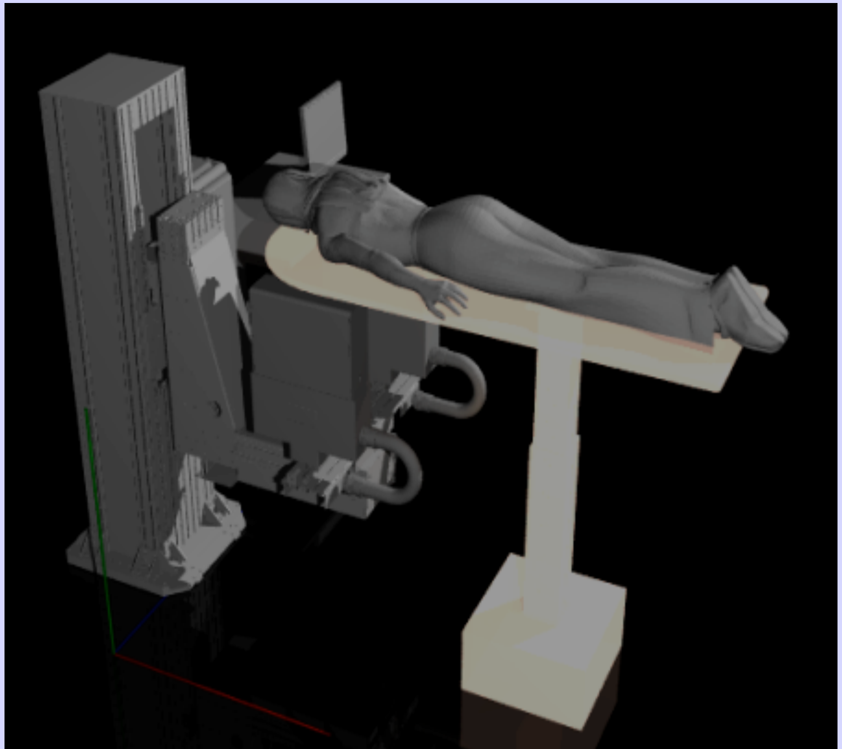
**Dedicated breast PET detector allowing high sensitivity to the small tumor detection**

- **Spatial resolution 1-2 mm**
- **High counting sensitivity**
- **Short PET exams**
- **Compatible X-Ray mammography**
- **Compatible stereotactic biopsy**

## Technical characteristics:

- 6000 crystals 2x2x20 mm
- Avalanche Photodiodes (APD)
- Low noise electronics
- High rate data acquisition
- Spatial resolution 1-2 mm
- Breast and axila region

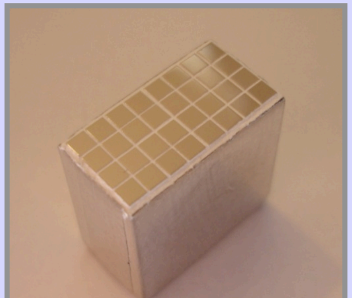
# ClearPEM: The Project

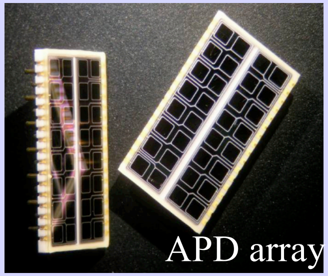


ClearPEM – 1st prototype

- **A dedicated mammography PET (Positron Emission Tomograph):**
  - Breast exams with the patient in prone position
  - The plates rotate around the breast
  - PEM plates can be rotated for axillary exams
- **Good spatial resolution : 1.4mm (FWHM)**
  - Fine crystal segmentation (2x2 mm)
  - Reduced parallax effect by optimised depth of interaction resolution: 2 mm
- **High Sensitivity:**
  - Solid angle coverage as large as possible
  - High photon interaction probability (20 mm long crystals)
  - High efficiency due to good energy resolution at 511 keV: 15.9%
- **Excellent Time Resolution:**
  - Single photon time resolution 1.5 ns (RMS)
  - Coincidence window: 5.2 ns

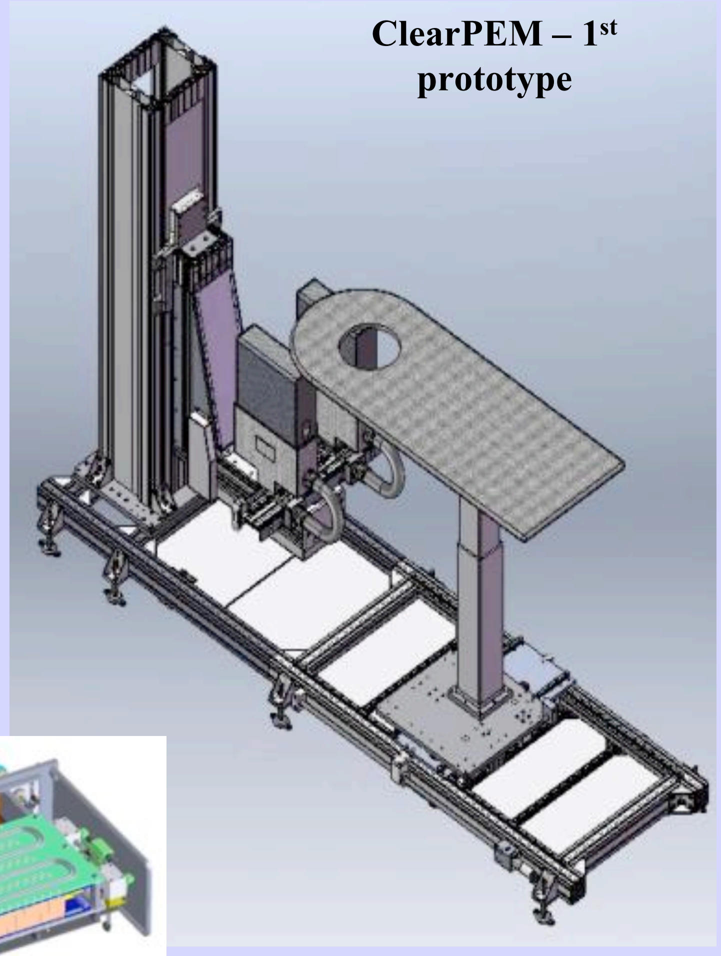
# ClearPEM: The Machine


LYSO/BaSO4 Matrix

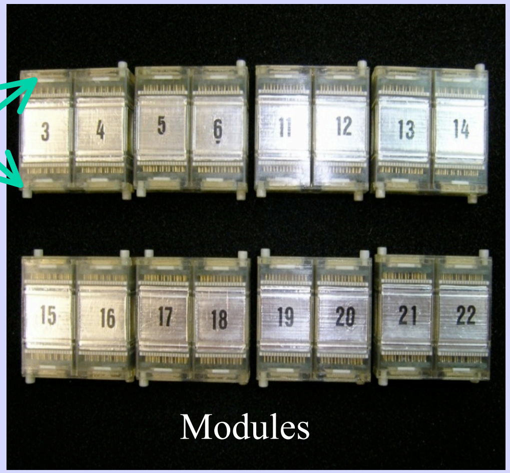

APD array

- **6144 LYSO:Ce crystals in 192 matrices**
- **APD readout on both sides of the crystal**
- **Fast Front-End readout with dedicated ASICs**
- **Two detector plates**

**→ 0.8MHz acquistion rate**


**ClearPEM – 1st prototype**

**Front-back readout**



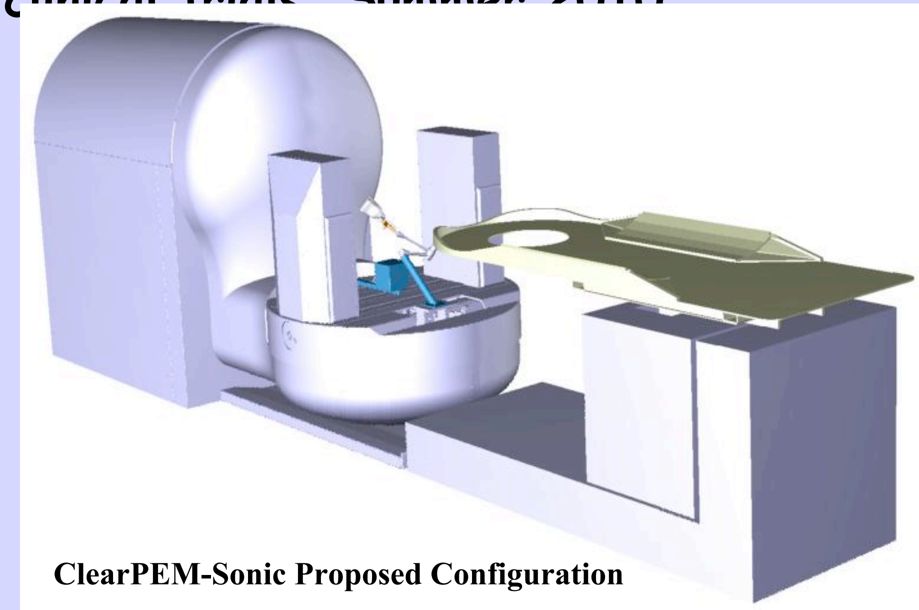
Modules


**Detector Plate**

# Outlook

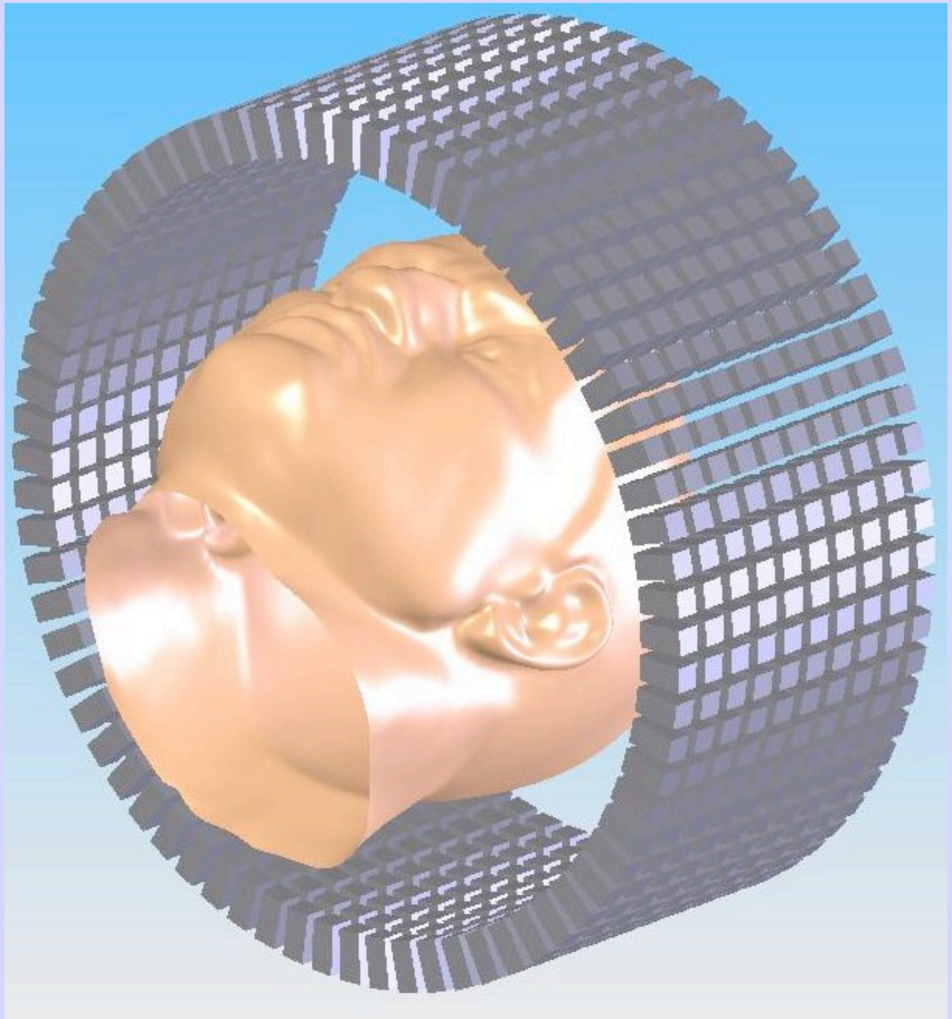
- Project status:
  - **ClearPEM** (Porto prototype): Phase 1 **clinical trials ongoing**
  - SuperSonic Imagine **Aixplorer with 3D package** : **Clinical Trials ongoing** / Commercial Release
    Spring 2010
  - **ClearPEM-Sonic** (installation at Hopital Nord, Marseille):
    - » Assembly well advanced
    - » Expected **delivery: Spring 2010**
    - » Expected Start of **clinical trials: Summer 2010**

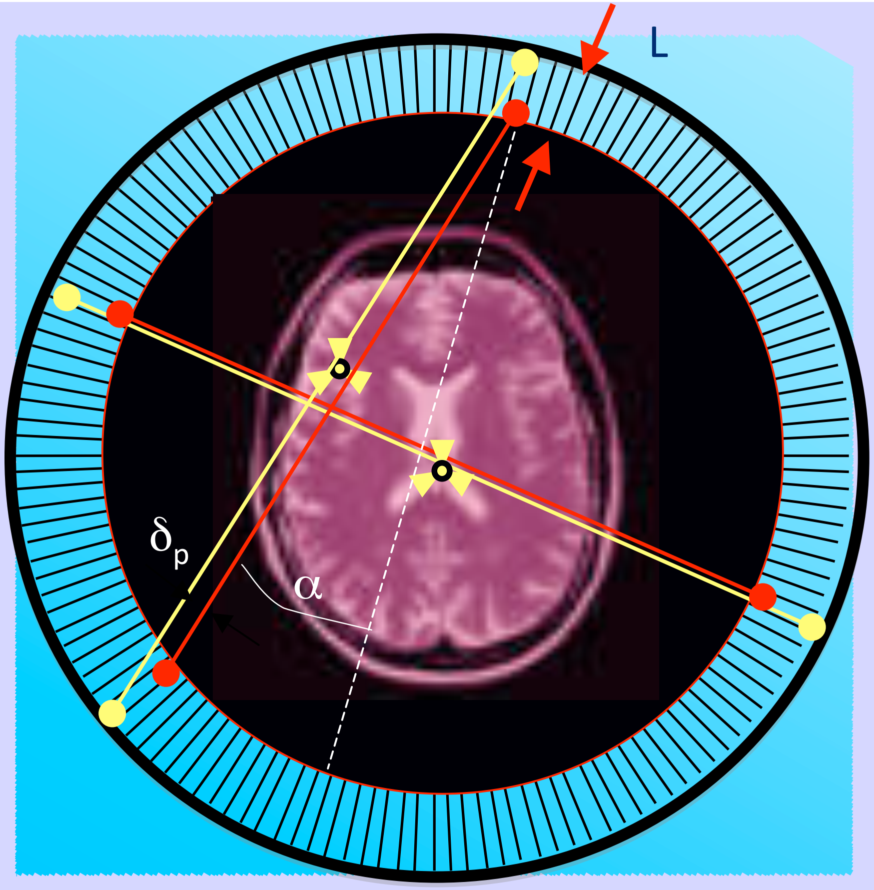
- Possible further implementations:
  - Whole-breast 3D US imaging
  - Biopsy
  - SPECT



**ClearPEM-Sonic Proposed Configuration**

# Standard PET today





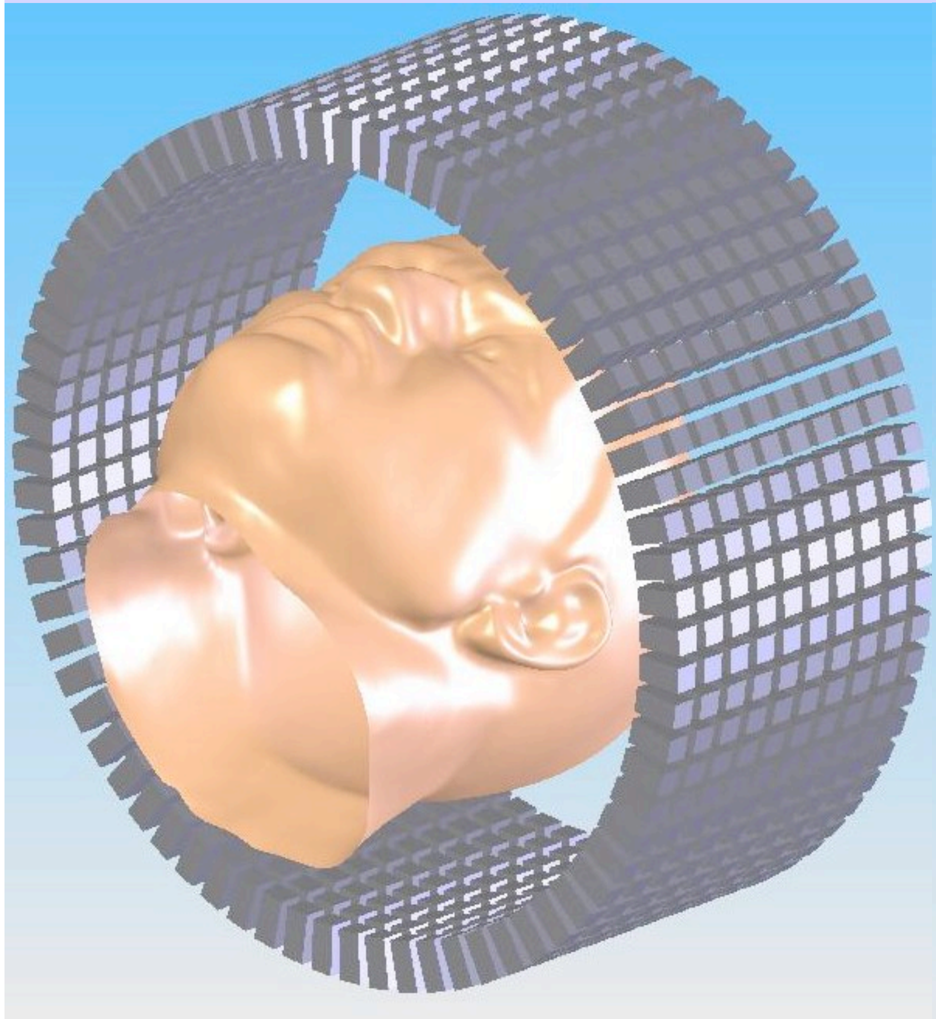

No DOI → Parallax error $\delta_p = L \cdot \sin\alpha$

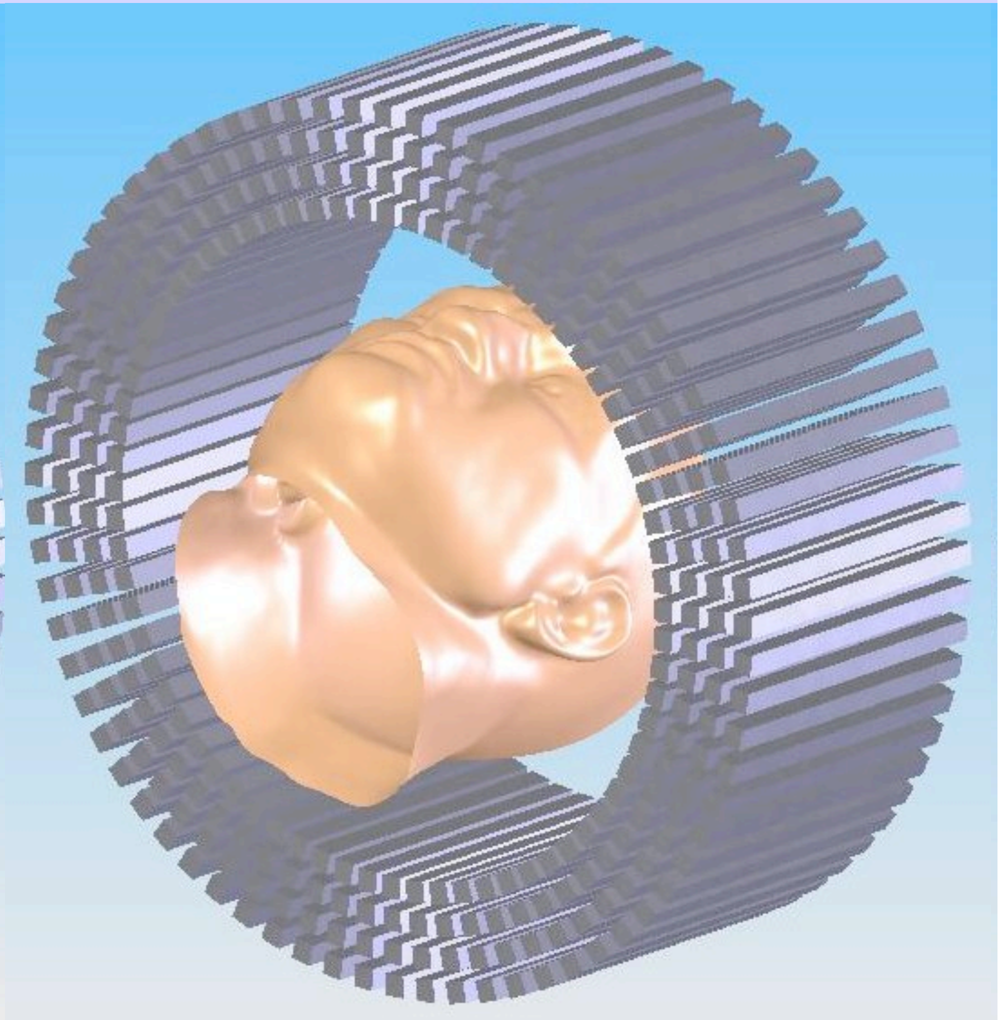
Detection efficiency $\varepsilon_2 = \left(1 - e^{-L/\lambda_a}\right)^2$

- Short, radially oriented crystals
- readout in blocks by PMTs
- Anger logic decoding
- no depth of interaction (some exceptions)

→ Find compromise between resolution and sensitivity

# The AX-PET concept



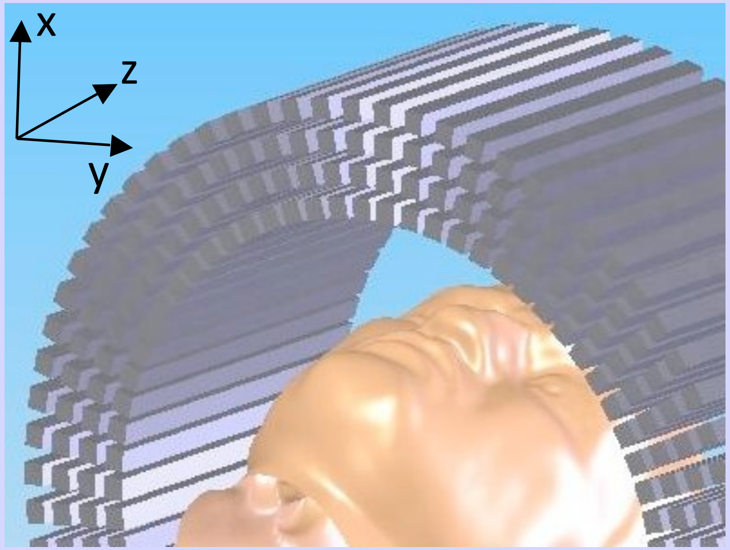


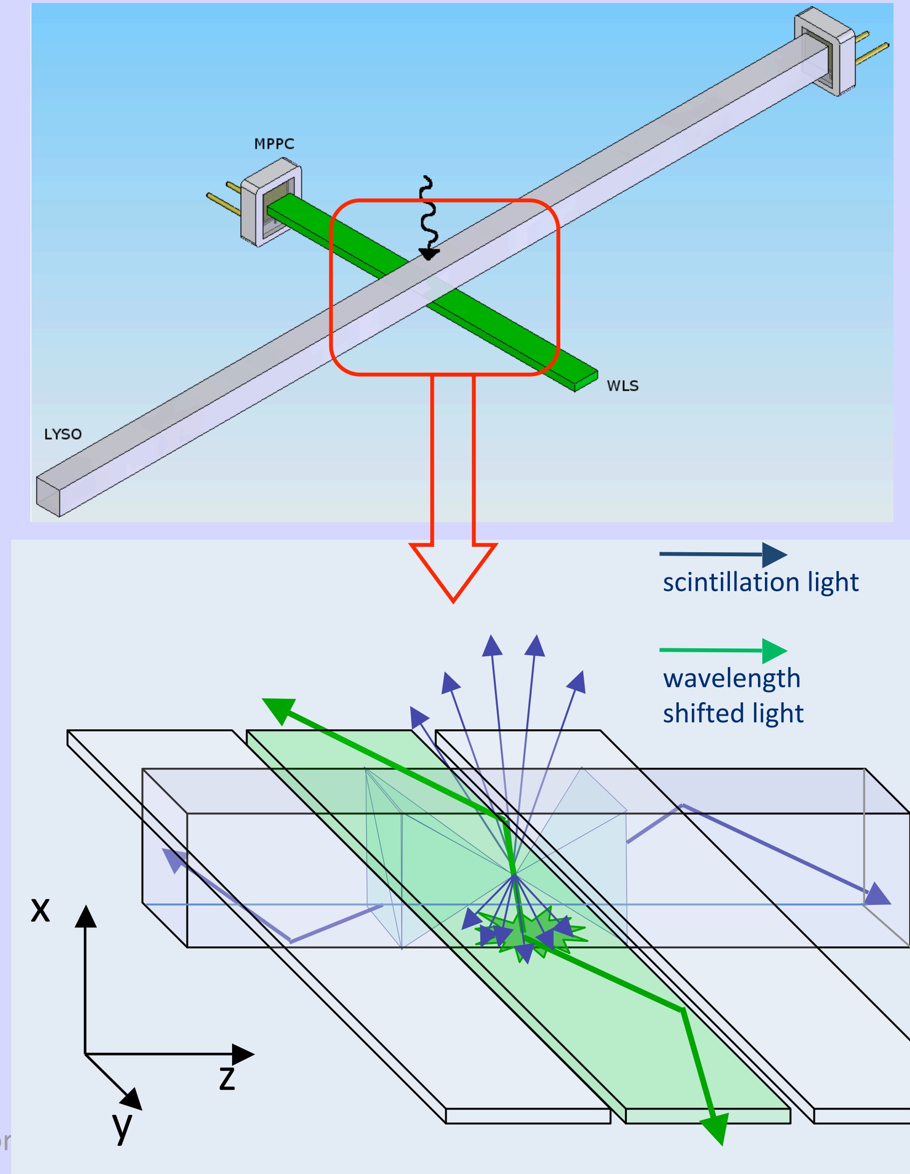
From short radially oriented, block readout crystals …

… to long, axially oriented, individually readout crystals

# Our implementation of the AX-PET concept

- How to read crystals ?
- How to measure axial coordinate ?

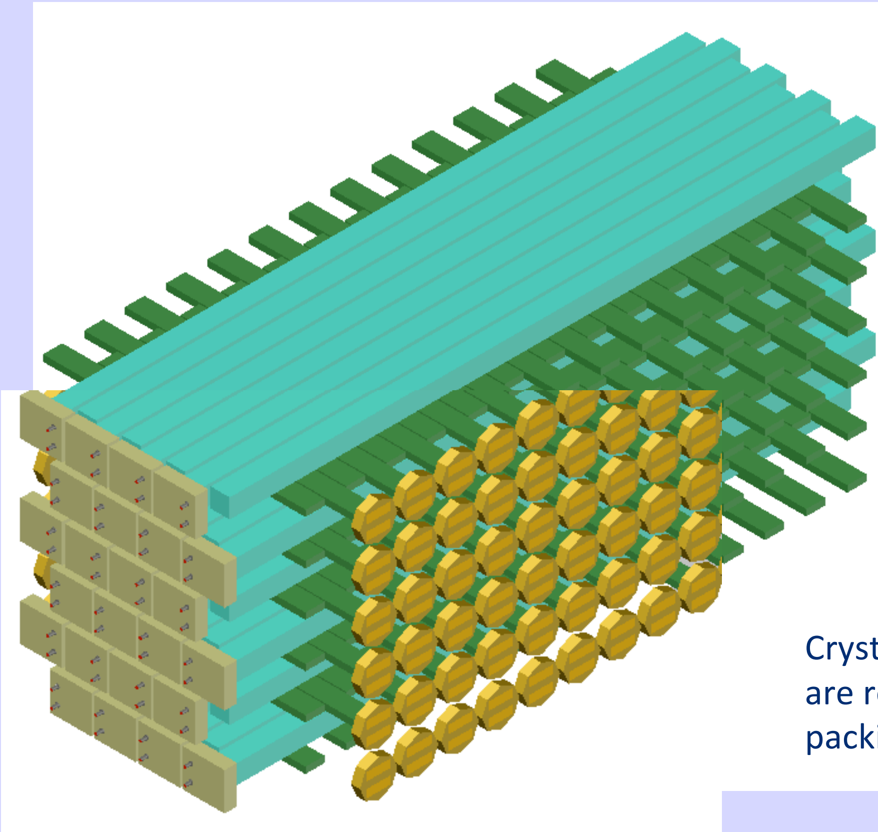


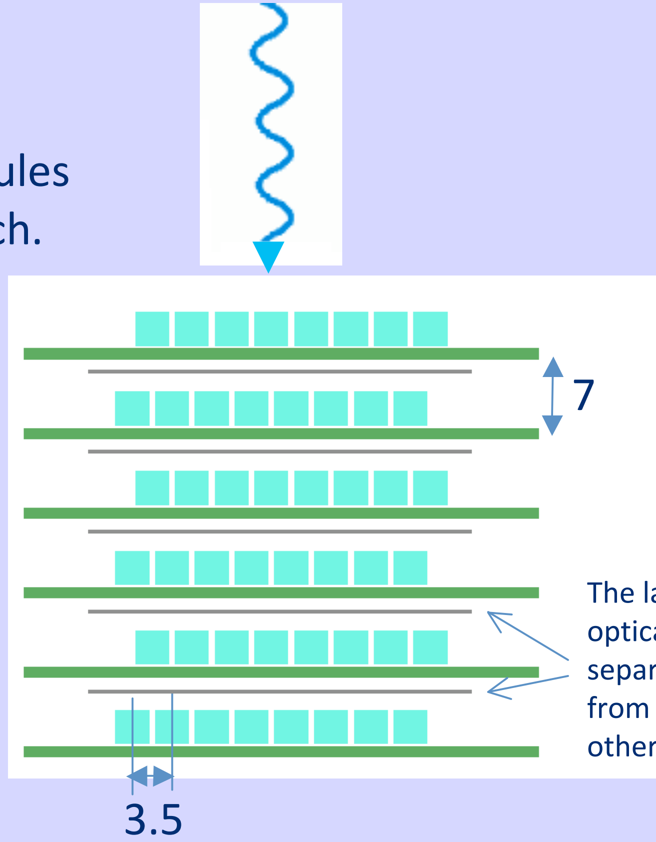



# AX-PET module geometry

- 48 crystals (6 layers x 8 crystals)
- 156 WLS strips (6 layers x 26 strips)

} 2 modules = 408 ch.



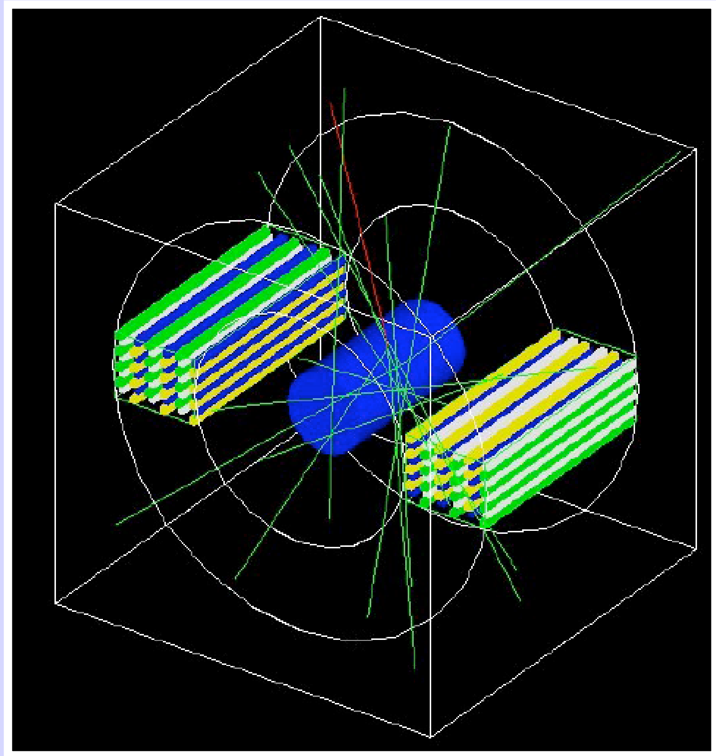



The layers are optically separated from each other.

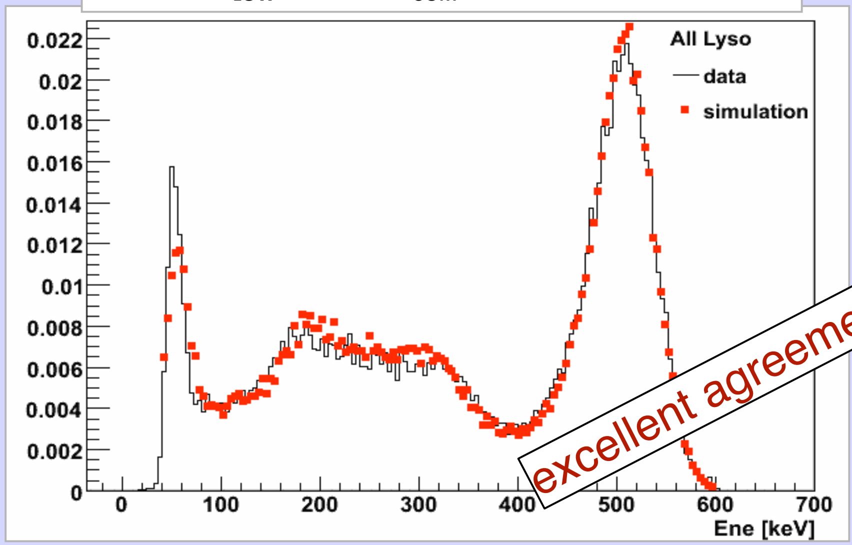
Crystals are staggered by 2 mm. Crystals and WLS strips are read out on alternate sides to allow maximum packing density.

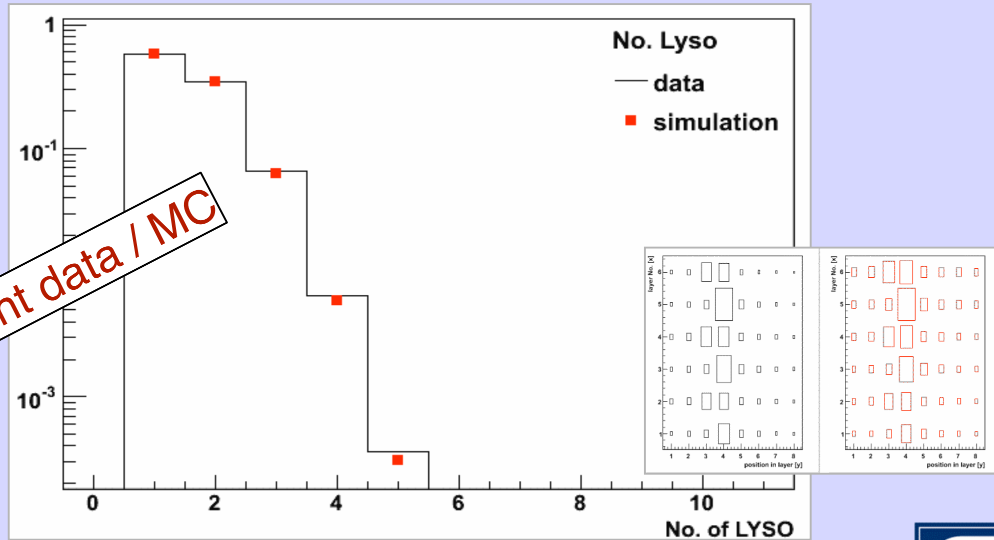
# AX-PET simulation

- **Geant4** (multi-purpose Monte Carlo tool, optical transport, dedicated geometry)
- **GATE** (PET dedicated MC, including time dependent phenomena, scanner rotation, source/phantoms...)



**Energy - $E_{LOW}$=40 keV, $E_{SUM}$=[400,600] keV**



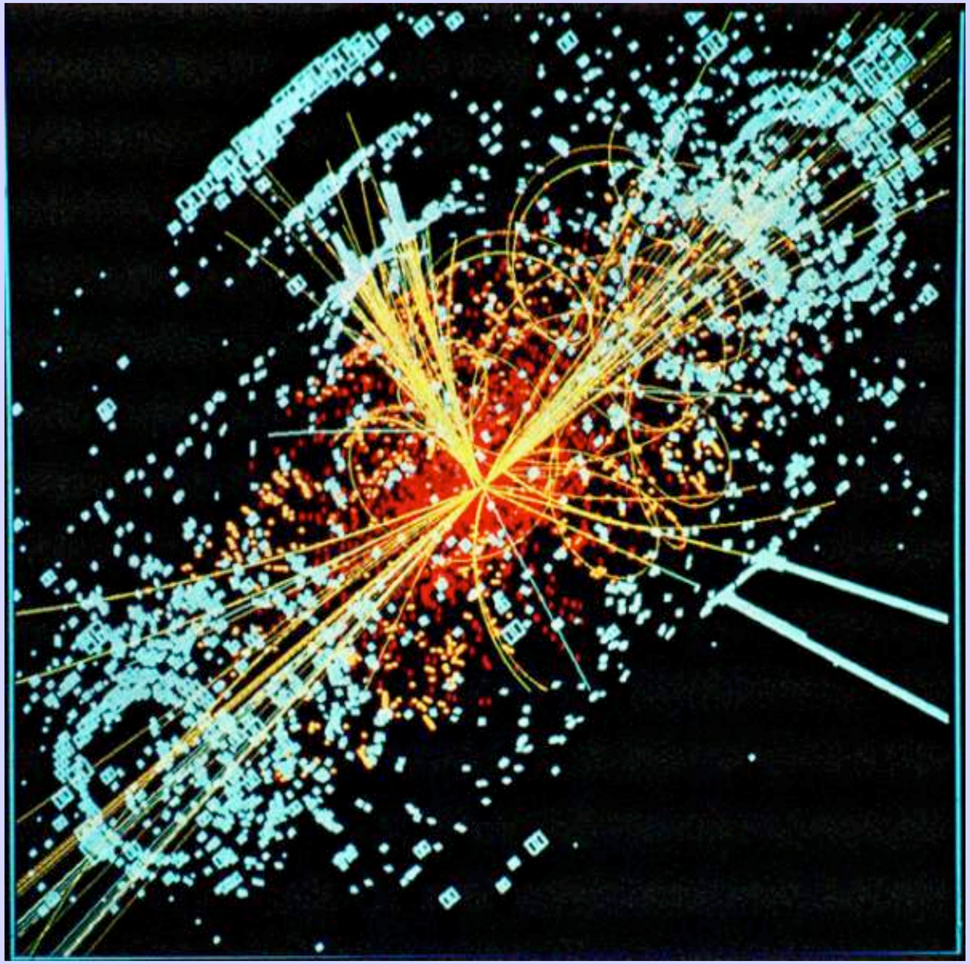

excellent agreement data / MC

# AX-PET main features

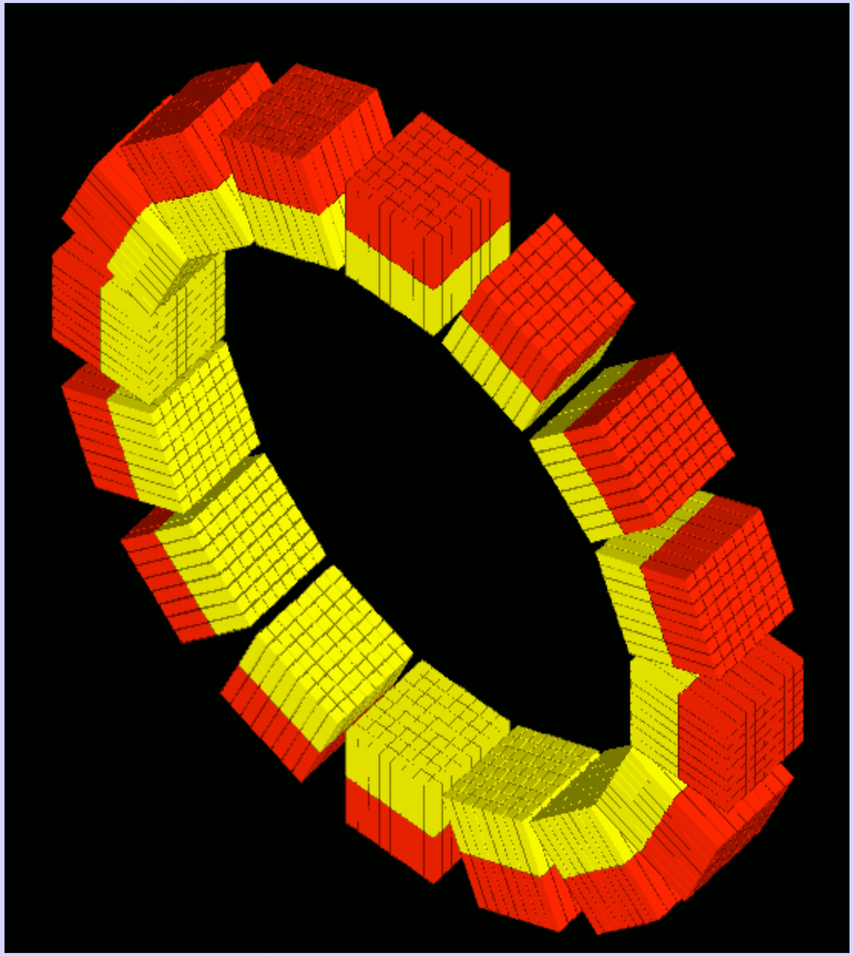
- parallax-free 3D localization of photons.
- Spatial resolution (crystal and WLS strip dimensions) and sensitivity (additional layers) can be optimized independently. Physical limits in reach.
- The 3D capability should allow to identify a significant fraction of Compton interactions (Inter Crystal Scatter).
  ICS events can either be discarded (resolution fully maintained) or reconstructed (increased sensitivity).
- AX-PET concept can be scaled in size and number of layers to match specific needs.
  → small animal PET
  → brain PET
  → full body PET
  → PEM (mammography)
- Concept and components are in principle MRI compatible and TOF extendable.

# Simulation

**Higgs event at LHC (CMS) with Geant4**



**ClearPET with GATE: Geant4 Application for Tomographic Emission**



# Task

Physics models of the Monte Carlo codes have to be validated and improved to respond to the high demand in precision for a very selected region of projectile-target combinations and energies relevant for ion therapy.

Monte Carlo particle transport systems developed at CERN:

FLUKA    Geant 4

# Hadronic Models: How accurate are they for ion therapy?

**Experimental Data**

**MC codes**

Geant 4 FLUKA

Discrepancies:
Some tens of %!
(and more)

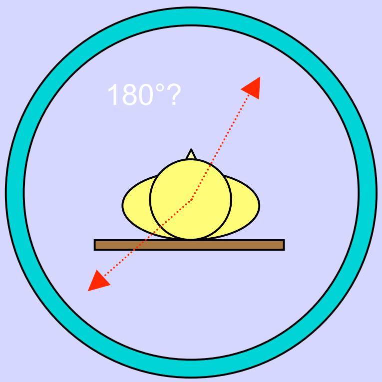
**How can we do better?**

- Work on the models!
- Experimental data is scarce and of limited precision!

# Modelling of Acollinearity for PET

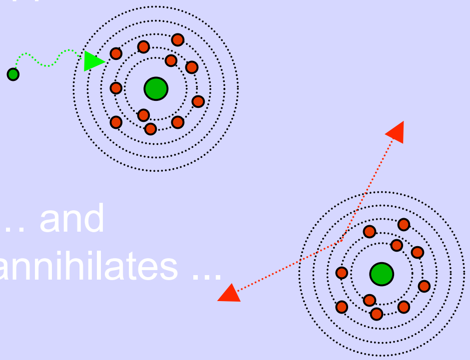
PET can be used to do dose monitoring for hadron therapy. A model describing acollinearity of the annihilation photons is being developed.

PET $e^+ + e^- \rightarrow 2\gamma$



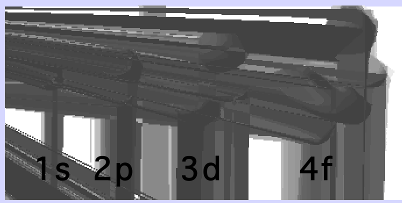

Thermalized positron (~eV) approaches atom ...

… and annihilates ...



**Model approach:**

- Calculating probability for annihilation on different shells and valence band
- Taking in account momentum distribution of atomic orbitals!



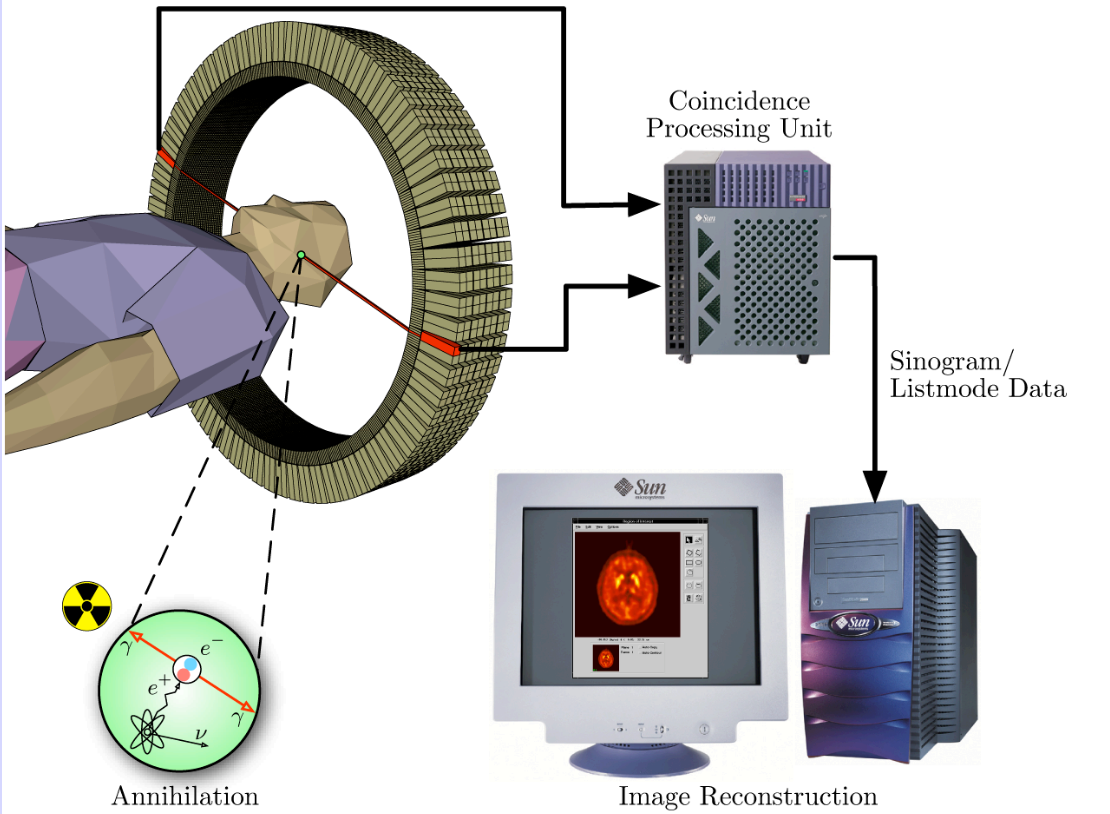
# Medical Imaging – PET (Positron Emission Tomography)

**Functional Analysis**

The system detects pairs of gamma rays emitted indirectly by a positron-emitting radionuclide (tracer), which is introduced into the body on a biologically active molecule.

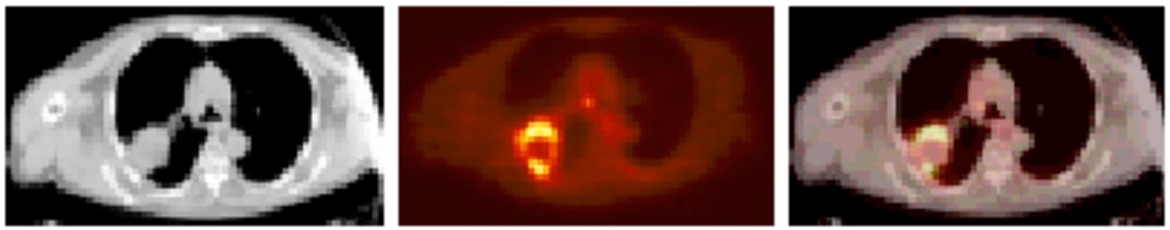
Images of tracer concentration in 3-dimensional space within the body are then reconstructed by computer analysis.

Crystals developed for LHC detectors are used in PET Scanners.

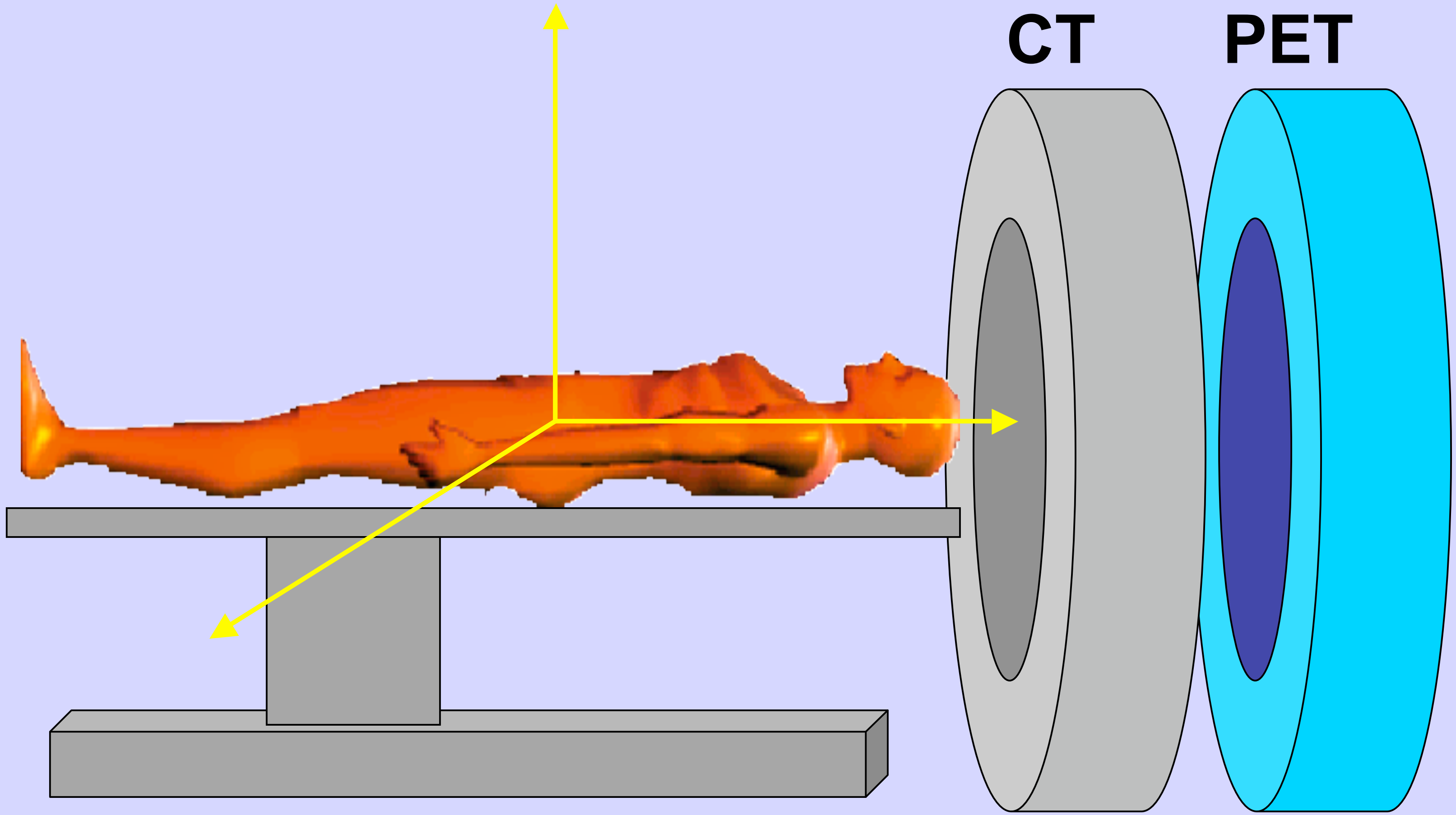


# Multi-modality imaging

Primary lung cancer imaged with the Dual/Commercial scanner. A large lung tumor, which appears on CT as a uniformly attenuating hypodense mass, has a rim of FDG activity and a necrotic center revealed by PET.



# PET/CT



# A changing tide: digital imaging

**Current**

- Limited contrast
- High dose
  - Restricted screening
  - Limited access to preventive health care

**Digital**

- High contrast
- Lower dose
  - Opportunity for screening
  - Access to preventive health care

# IMAGING WITH THE MEDIPIX CHIPS

M. Campbell
CERN
Geneva, Switzerland
8 June 2010
Imaging 2010, Stockholm

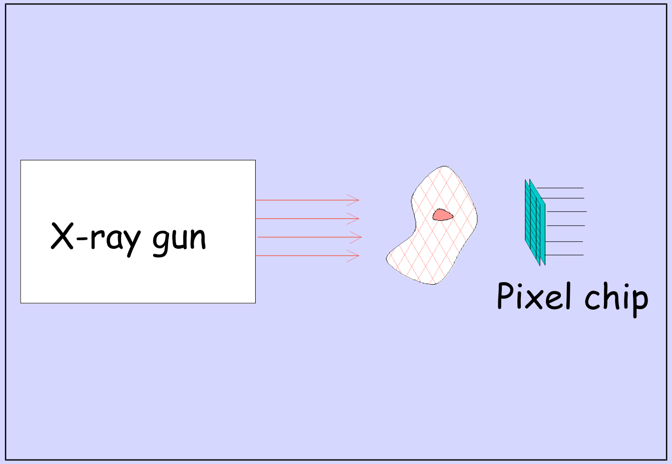
# What is Medipix?

The Medipix is an electronic chip similar to the electronic imaging chip in a digital camera. One difference is that the Medipix chip is sensitive to xrays instead of visible light. What is unique about the Medipix chip is that it can create the first true colour images with x-rays. Thus, it permits us to move from black and white x-ray images to full colour x-ray images. The chip also can be read out very rapidly. This allows the use the chip for colour x-ray digital movies or for fast colour x-ray CT scans

# Bio-medical applications of CERN technologies

## MEDIPIX2

Ga-As array detector bump bonded on a digital Silicon counter especially developed for X-rays Radiography




**High Energy Physics original development:**
Particle track detectors

**Main technologies involved:**
Micro-electronics 0.25 mm C-MOS technology
Flip chip technology
Smart electronics

**Main properties:**
Fully digital device
Very high space resolution over small areas
Very fast photon counting
Good conversion efficiency of low energy X-rays

**Status of the project:**
Design of MEDIPIX2 based on successful MEDIPIX chip in progress

# MEDIPIX: Allows counting of single photons in contrast to traditional charge integrating devices like film or CCD

- **High Energy Physics original development:**

**Particle track detectors**

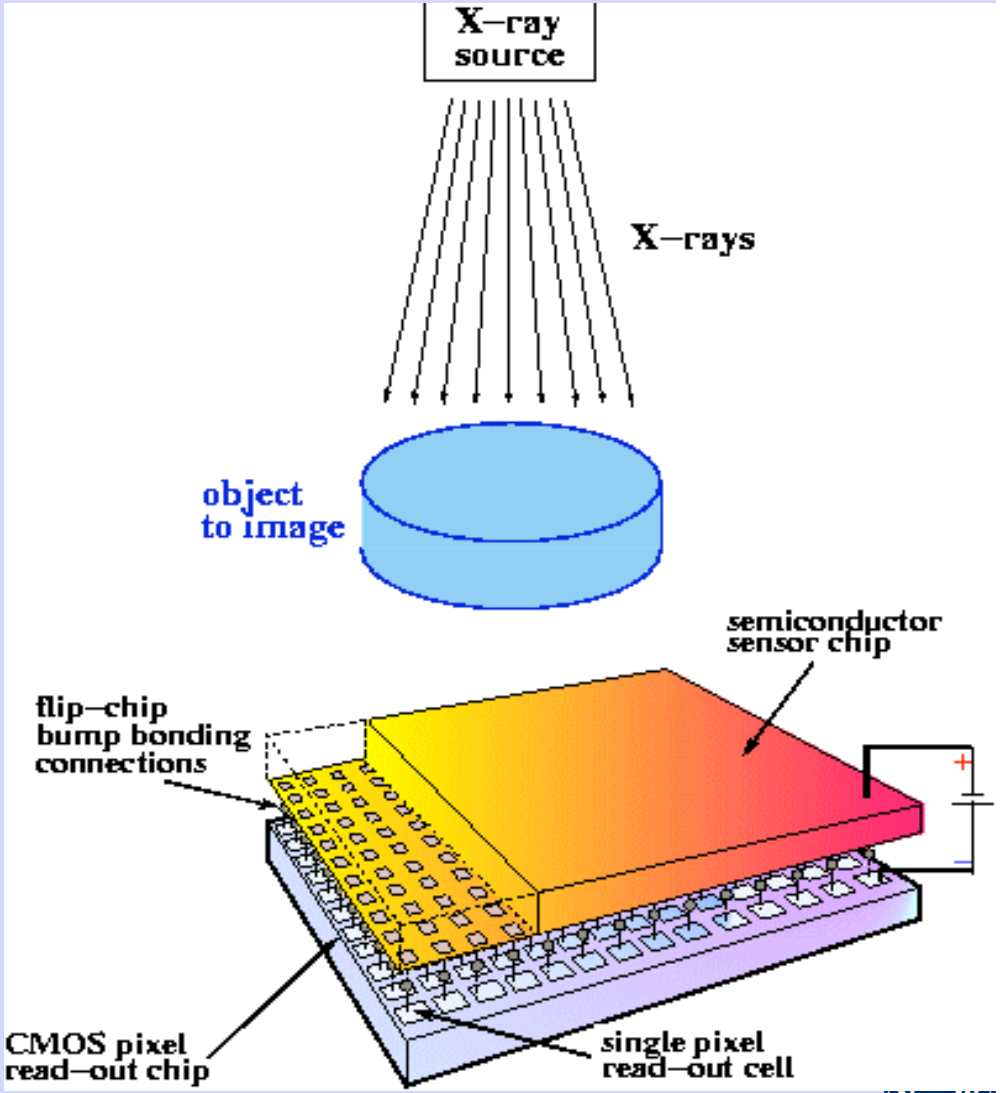
- **Main properties:**

**Fully digital device**

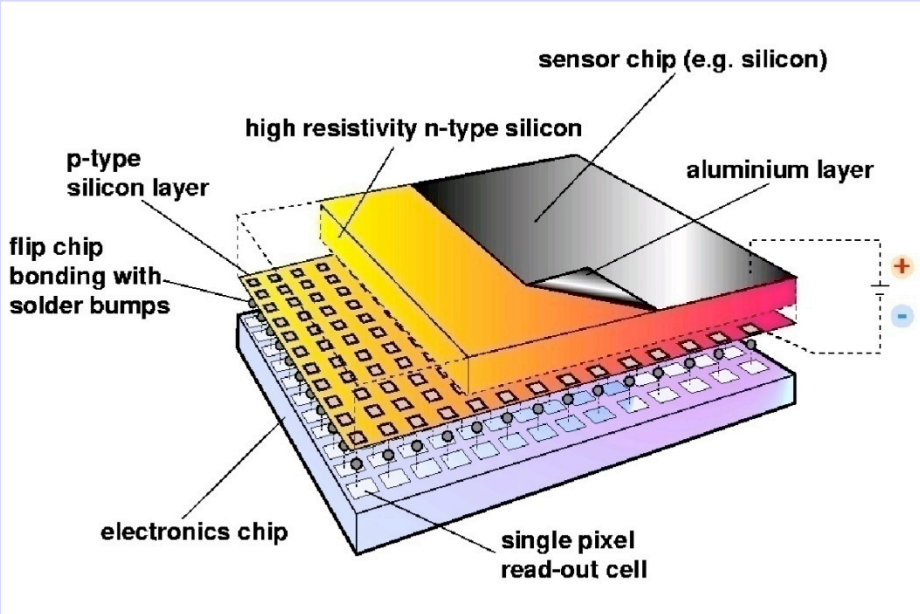
**Very high space resolution**

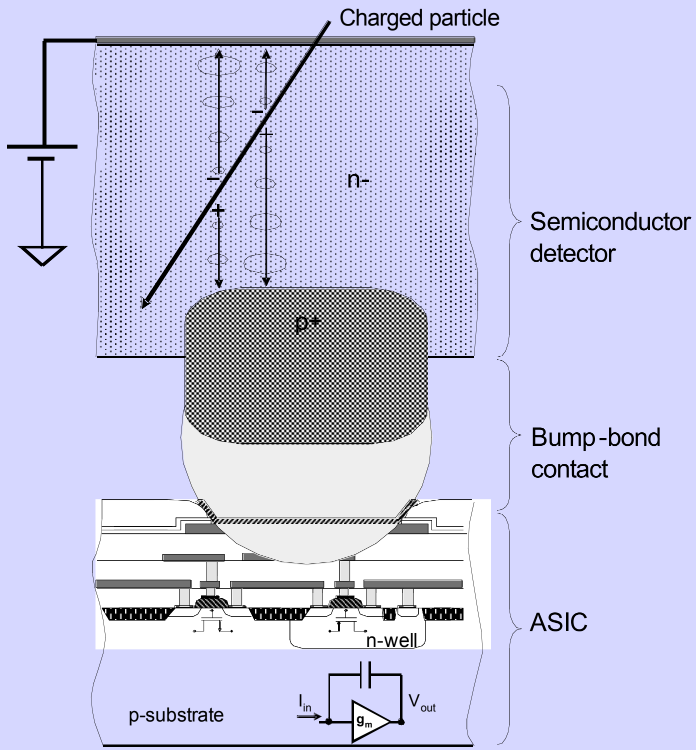
**Very fast photon counting**

**Good conversion efficiency of low energy X-rays**



# Hybrid-Pixel Detectors



# ‘Imaging’ in High Energy Physics - Summary

- Hybrid pixels offer simultaneously:
  - Practically noise free images
  - Fast ‘shutter’ times
  - On pixel event selection
- Hybrid pixels have been used as vertex tracking detectors
  - Extremely good pattern recognition performance
  - Modest material budget
- Hybrid pixels have been used as photon RICH detectors
  - Very high pattern recognition performance

# Medipix2 chip developments

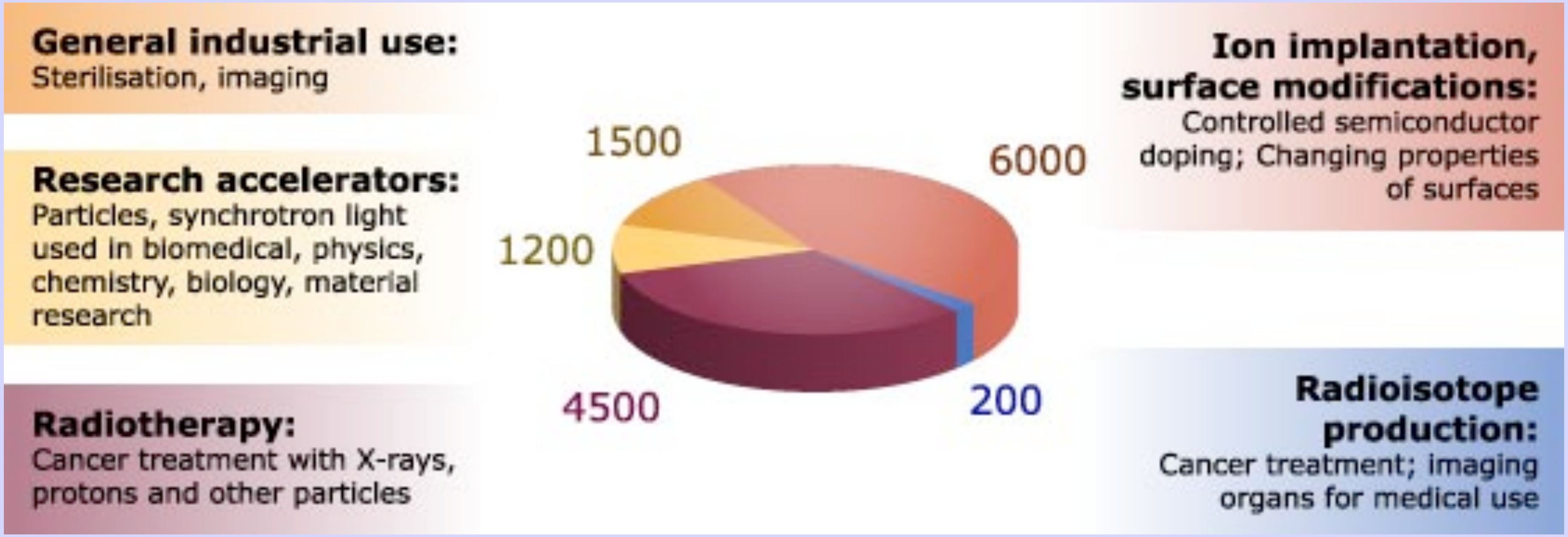
- Chip designed in same CMOS technology as Alice and LHCb
- Pixel shape now square - 55μm pitch
- Matrix of 256 x 256 pixels
- In-pixel counter with 'camera' logic
  - Externally applied shutter
  - Window discriminator
  - 14-bit counter with stop at 12000
- Very high flux capability
  - $\geq$ 3 GHits/cm$^2$
- Frame-based readout
  - All bits read out in serial (5ms @ 200MHz) or parallel (300μs @ 100MHz)

# Use of Accelerators for cancer treatment

# Accelerators: developed in physics labs are used in hospitals


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

# Use of Accelerators Today



## Cancer Incidence

- Every year about 2 million new cases in Europe
- The rate of patients treated with RT will likely increase in the years to come
- The main cause of death between the ages of 45 and 65. Second most common cause of death

# Cancer and Radiotherapy in 21st Century

- RT is, nowadays, the least expensive cancer treatment method (around 5% of cost)
- Good cure rate (30-40%)
- Conservative (non-invasive, fewer side effects)
- There is no substitute for RT in the near future

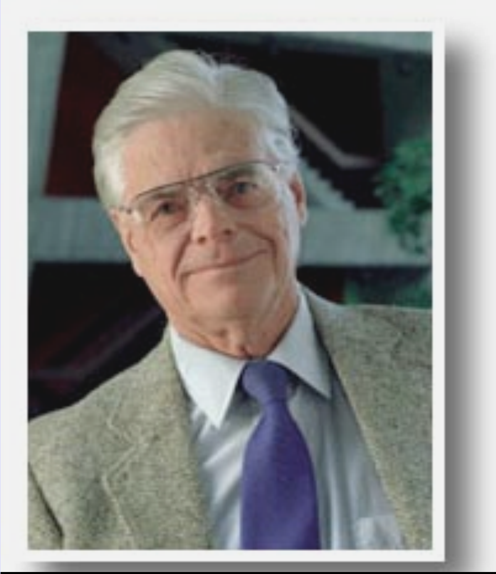
**Present Limitation of RT: 30% of patients still fail locally after RT**

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

# How to overcome failures?

- Physics & treatment technology: dose escalation
- Imaging: MRI, PET, image registration
- Biology: altered fractionation, radiosensitization

Raymond Miralbell, HUG

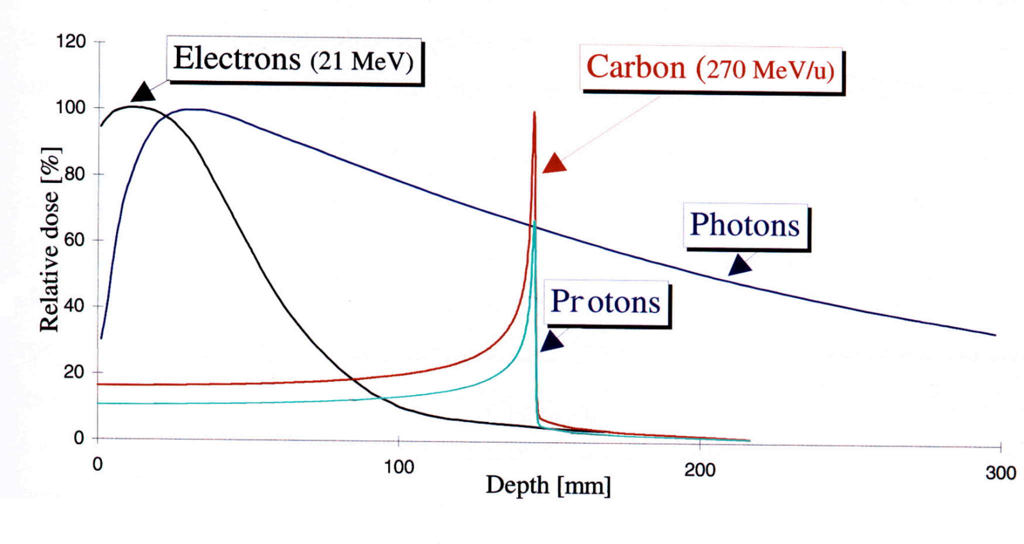


Founder and first director of Fermilab

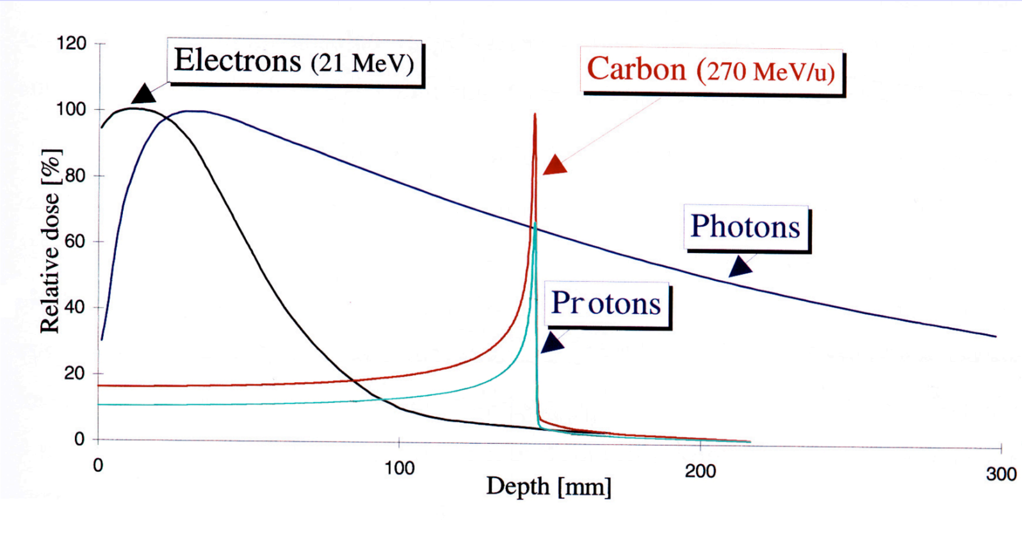
# Hadrontherapy: all started in 1946

**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**



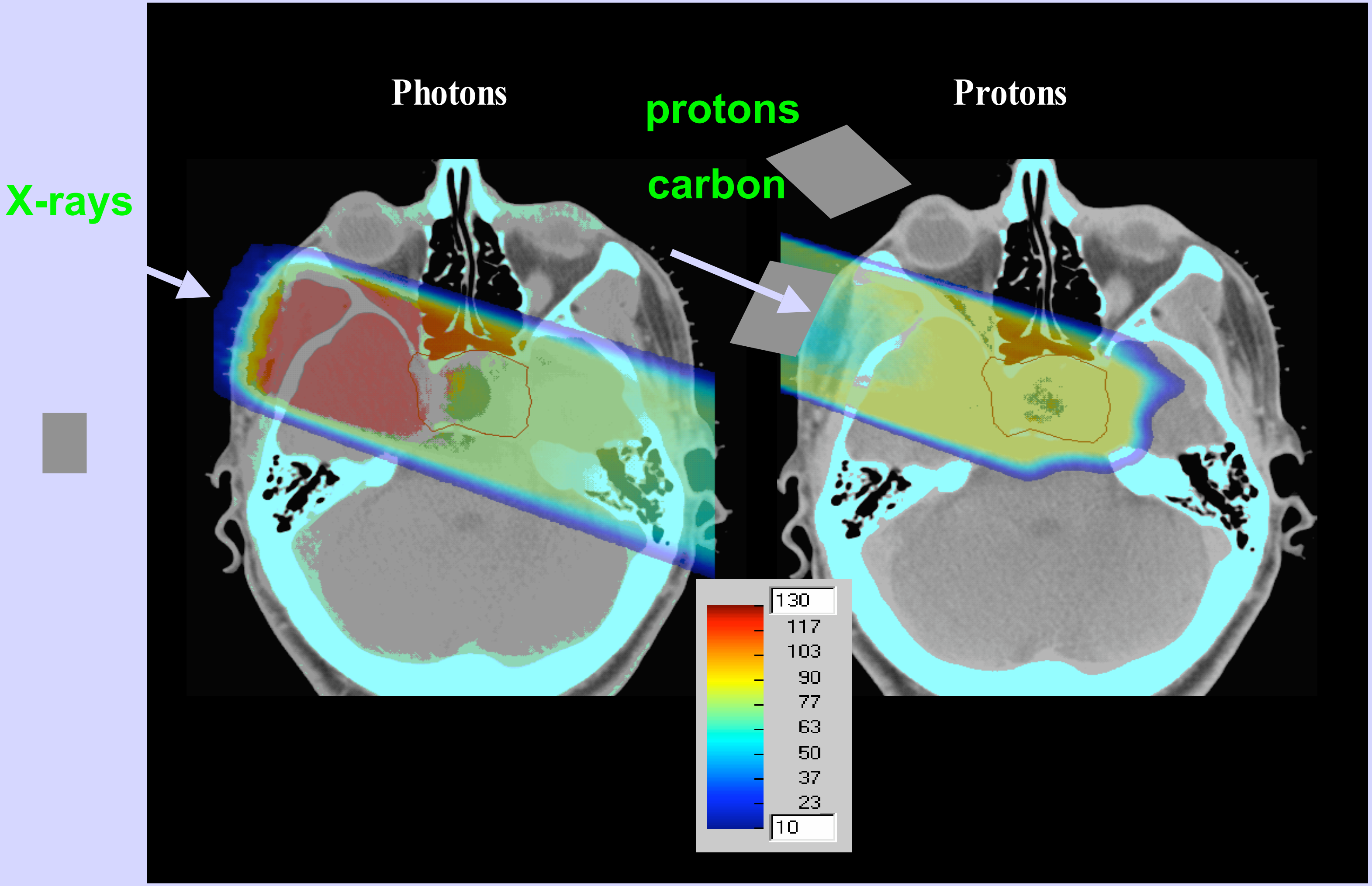
# Hadrontherapy vs. radiotherapy




- Tumours close to critical organs
- Tumours in children
- Radio-resistant tumours

| Photons and Electrons | vs. | Hadrons |
| --- | --- | --- |
| Physical dose high near surface | | Dose highest at Bragg Peak |
| DNA damage easily repaired | | DNA damage not repaired |
| Biological effect lower | | Biological effect high |
| Need presence of oxygen | | Do not need oxygen |
| Effect not localised | | Effect is localised |

# Advantage of hadrontherapy



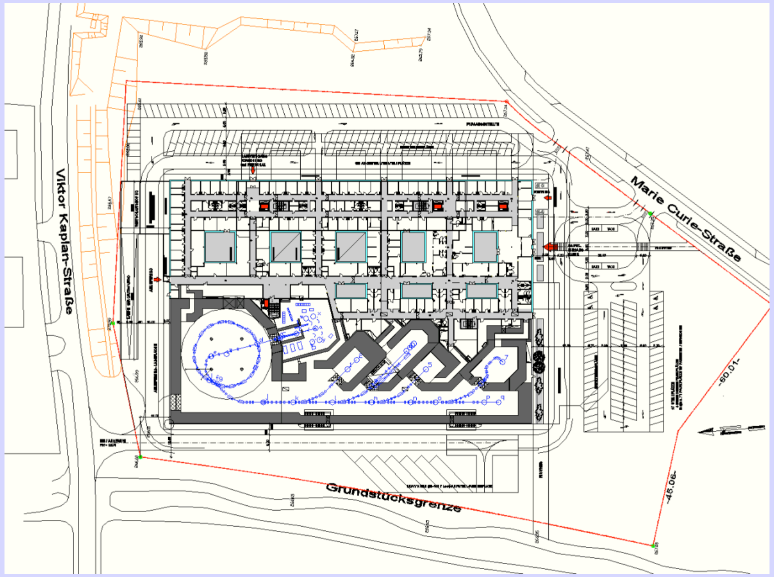
# Main Parameters

- Synchrotron based (C=76 m, cycle time > 1 second)
- Ion species: protons and carbon ions
  - Optionally and at a later stage other ions with q/m>1/3 are possible
- Energy range
  - Proton: 60-250 MeV (medical)
    - Higher proton energy provided for experimental physics: up to 800 MeV
  - Carbon: 120-400 MeV/n
- Intensities (maximum) in irradiation rooms
  - Proton: $1*10^{10}$ /cycle
  - Carbon: $4*10^{8}$ /cycle

# Tumour Therapy and Research Centre

MedAustron located in the north of Wiener Neustadt next to the future site of the new hospital

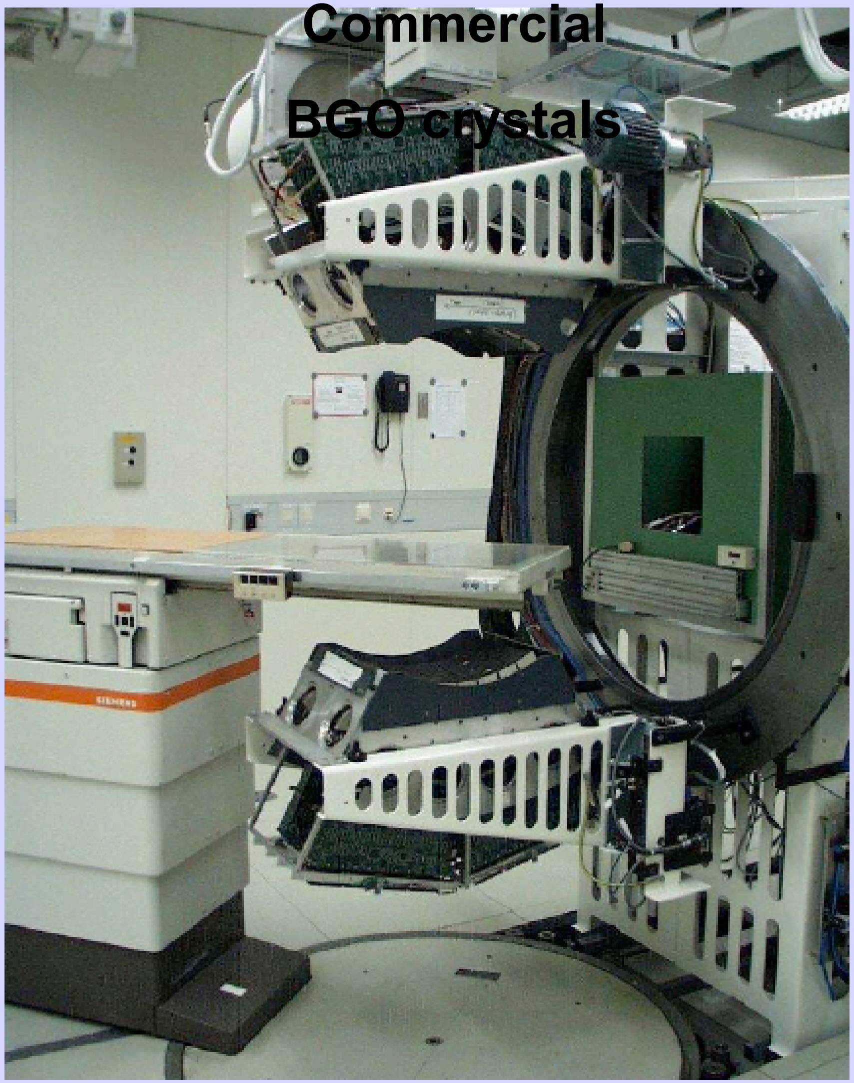
## Applications:




- Medical Treatment
  - Tumour treatment
  - Clinical research
- Non-clinical Research (NCR)
  - Medical Radiation Physics
  - Radiation biology
  - Experimental physics

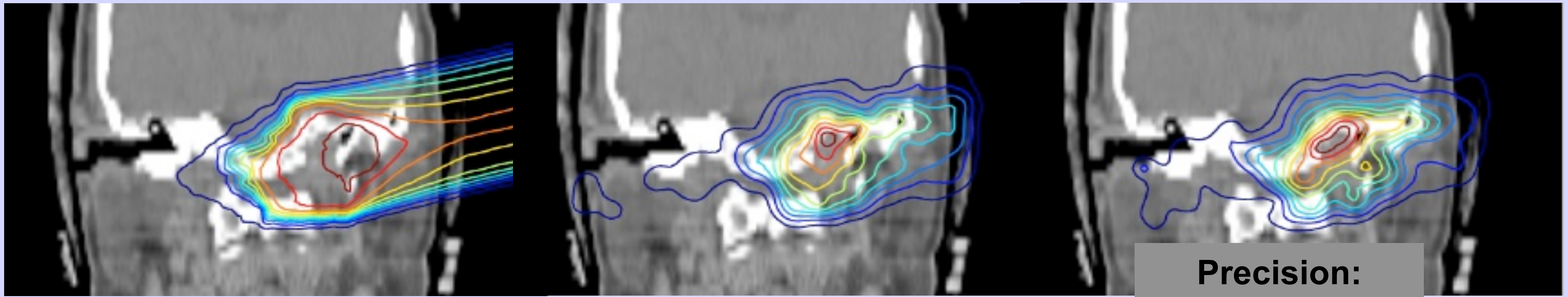
- Accelerator operates 24/7.
- Beam time split Treatment: NCR about 50:50

# In-beam-PET for range measurements with carbon ions

# Comparison with the data I

**Chondrosarcoma of the skull base**

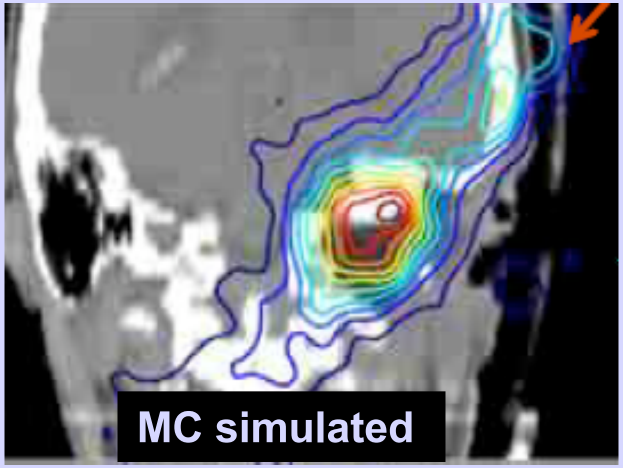


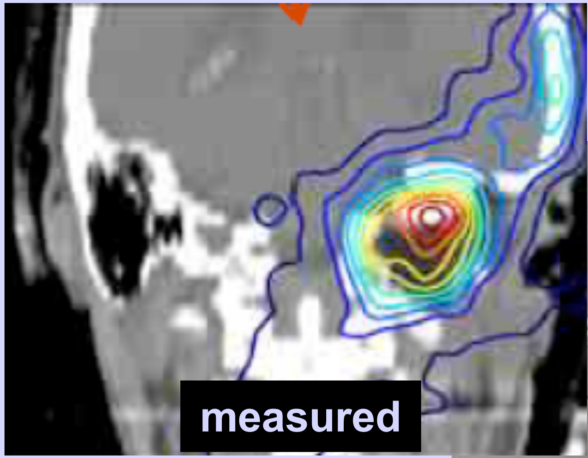
**Precision: 1mm**

**Dose distribution (left) compared with the predicted (middle) and the measured (right) positron-activity distributions brought in 1999 to a**

**New calibration procedure of R(HU)**

# In-beam-PET for Quality Assurance of treatments



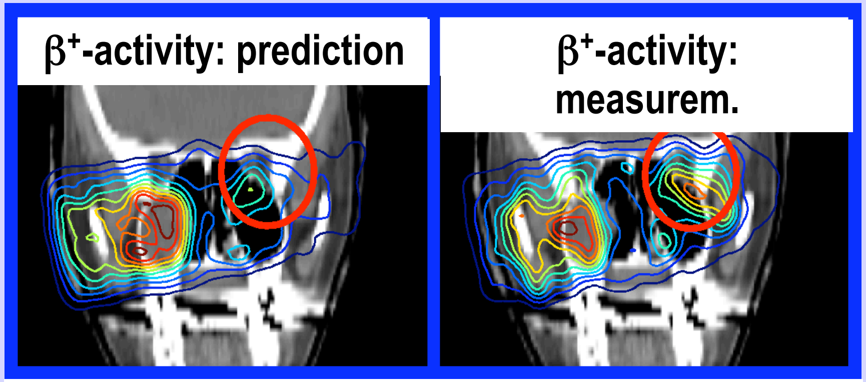




**On-line determination of the dose delivered**
**First time in 110 years!**

Modelling of beta$^+$ emitters:

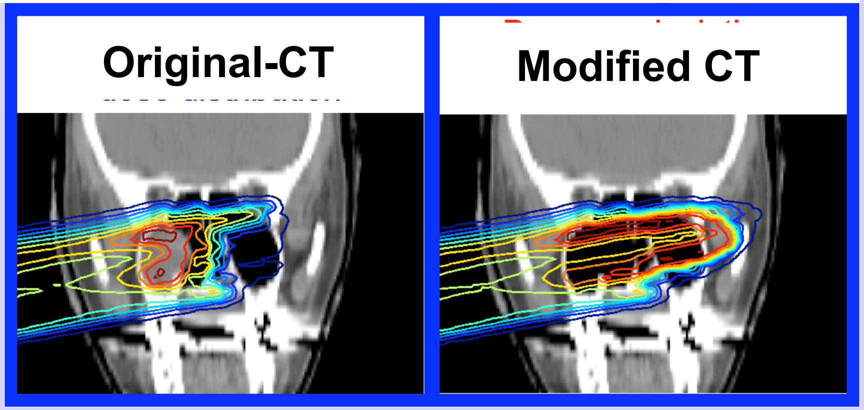
- Cross section
- Fragmentation cross section
- Prompt photon imaging
- Advance Monte Carlo codes

# Comparison with the data II

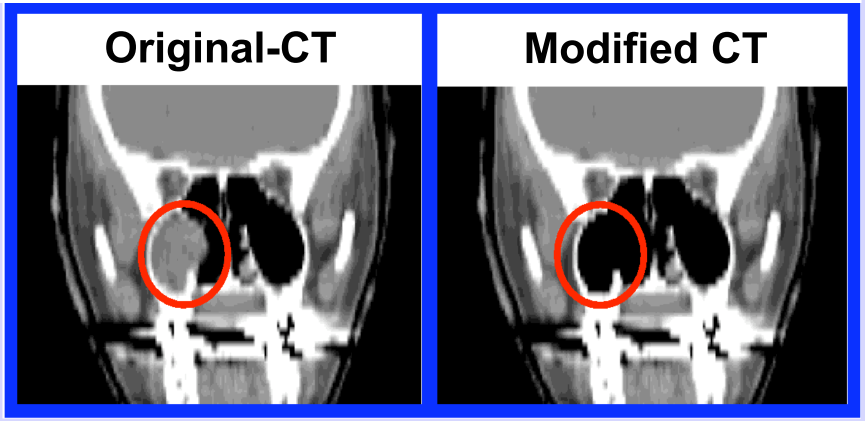


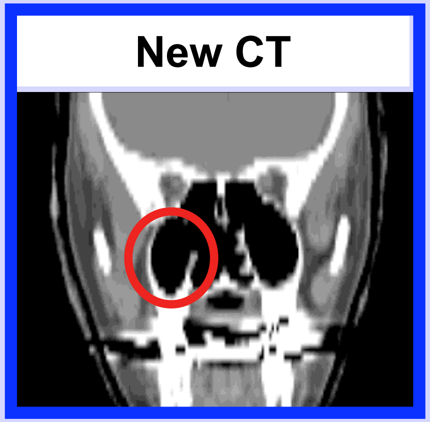

Hypothesis on the reason for the deviation from the treatment plan

**Dose recalculation**



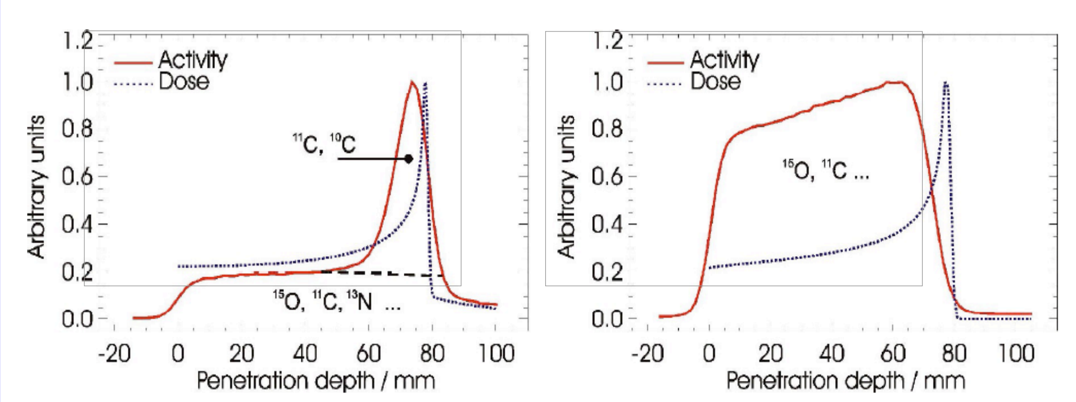

**Interactive CT manipulation**

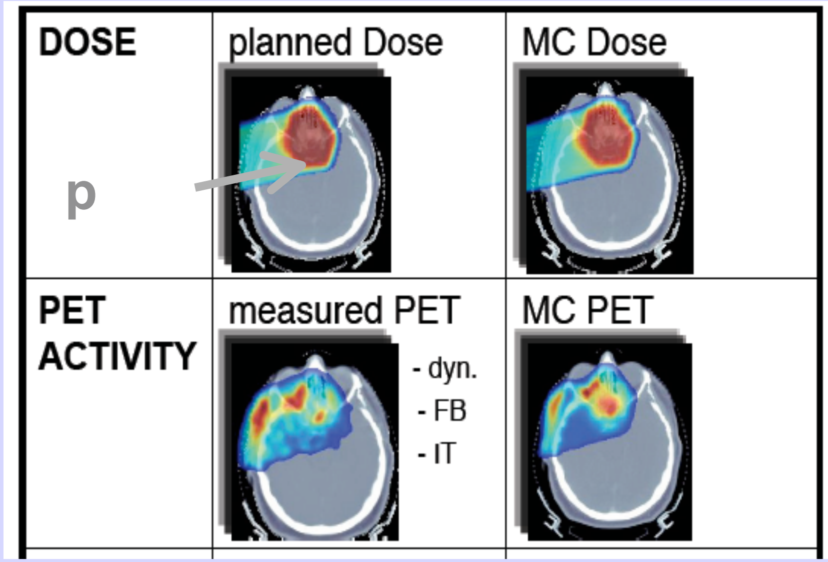



CT after PET measurent

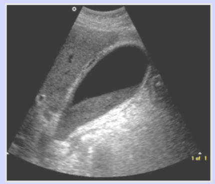
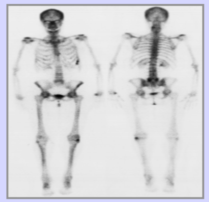
# The phenomenon is also induced by protons



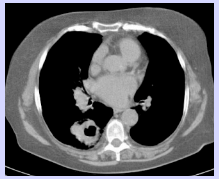
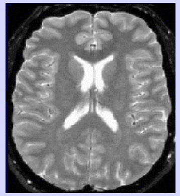
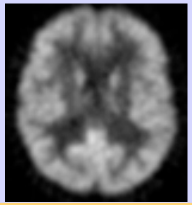




Parodi et al "**Patient study on in–vivo verification of beam delivery and range using PET/CT imaging after proton therapy**" Int. Journal of Radiation Oncology, Biology, Physics 2007

# MEDICAL IMAGING

| TECHNIQUE | | YEAR | ENERGY | PHYSICAL PROPERTY | IMAGING |
|---|---|---|---|---|---|
| RADIOLOGY | X RAYS IMAGING | **1895** | X RAYS | ABSORPTION |  |
| ECHOGRAPHY | ULTRASOUND IMAGING | 1950 | US | REFLECTION TRANSMISSION |  |
| NUCLEAR MEDICINE | RADIOISOTOPE IMAGING | 1950 | $\gamma$ RAYS | RADIATION EMISSION |  |

# COMPUTERIZED TOMOGRAPHY

| TECHNIQUE | | YEAR | ENERGY | PHYSICAL PROPERTY | IMAGING | |
|---|---|---|---|---|---|---|
| X RAYS COMPUTERIZED TOMOGRAPHY | **CT** | **1971** | X RAYS | ABSORPTION |  | MORPHOLOGY |
| MAGNETIC RESONANCE IMAGING | MRI | 1980 | RADIO WAVES | MAGNETIC RESONANCE |  | MORPHOLOGY /FUNCTION |
| POSITRON EMISSION TOMOGRAPHY | PET | 1973 | $\gamma$ RAYS | RADIATION EMISSION |  | FUNCTION |

# Grids and e-health

# LHC data challenge

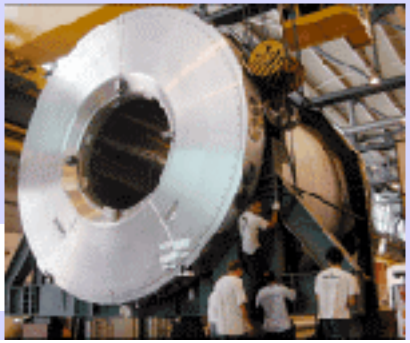
- 40 million collisions per second
- After filtering, 100 collisions of interest per second
- $10^{10}$ collisions recorded each year

~10 Petabytes/year of data
~10 000 times the world annual book production,
~20km CD stack

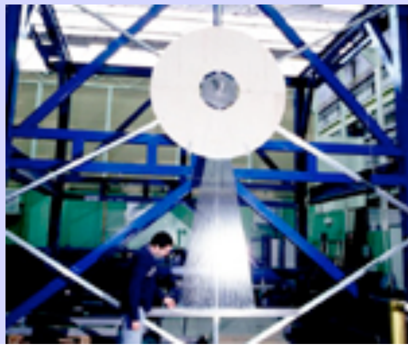

*CMS*

*LHCb*

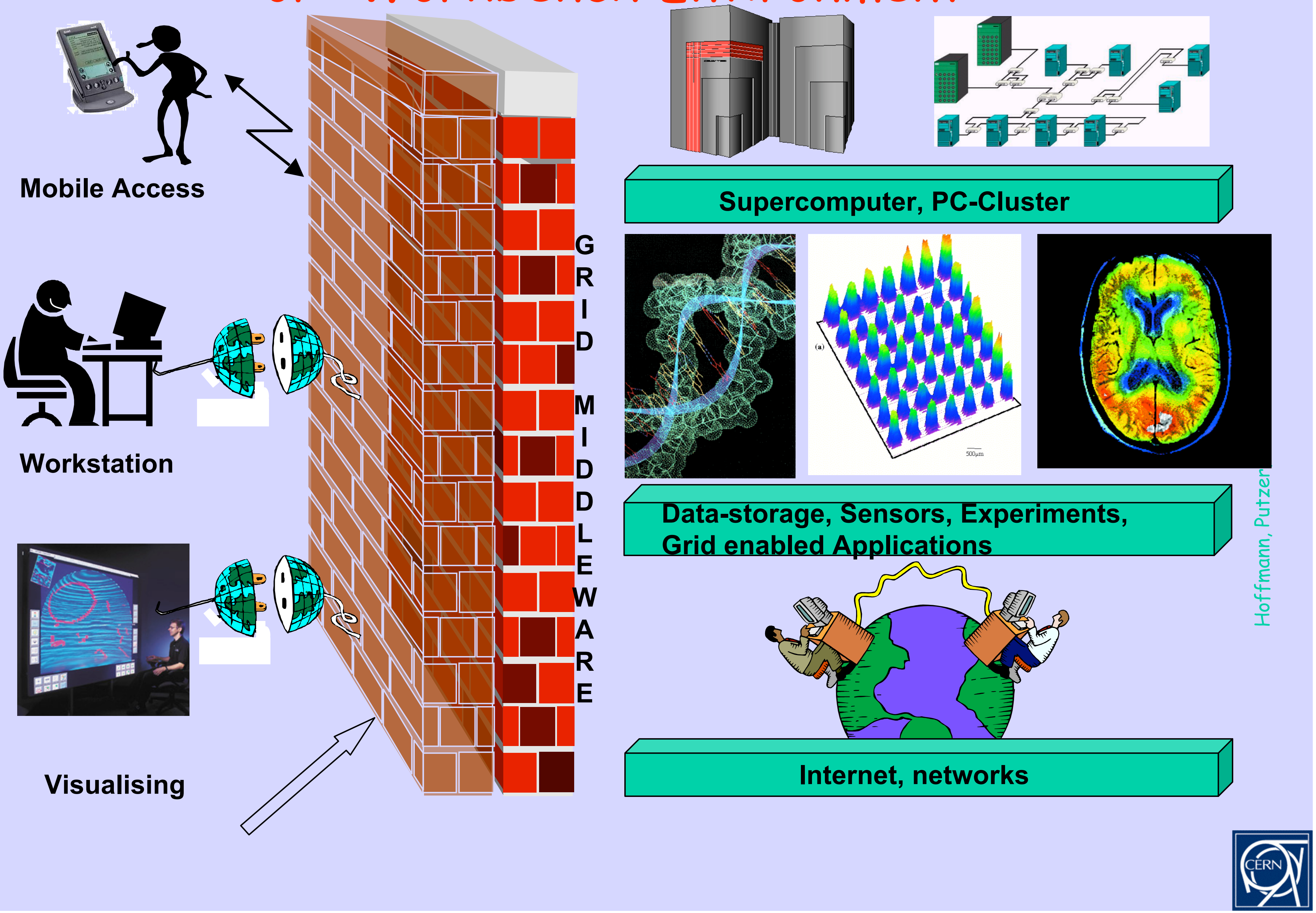
*ATLAS*



*ALICE*



# The User connects to his “Virtual Laboratory” or “Workbench Environment”



# MammoGrid Project

- To manage health care information for screening
- Acquisition of large sample of mammograms
- Standardization of mammograms
- Distributed data management system, cross-institute, cross-country queries
- Sharing of computing resources for the purpose of optimizing data storage and execution of computing-intensive algorithms\
- To assist health operators in their work environment and exchange data and practices

# Lessons Learned from MammoGrid for Integrated Biomedical Solutions


www.mammogrid.com

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

# MammoGrid in Figures

- **Addenbrookes Hospital, UK**
  - 1423 patients
  - 9713 images total (4812 - SMF)
  - Associated data size : ~14 MB
- **Udine Hospital, ITALY**
  - 1274 patients
  - 17288 images total (8636 - SMF)
  - Associated data size: ~23.5 MB

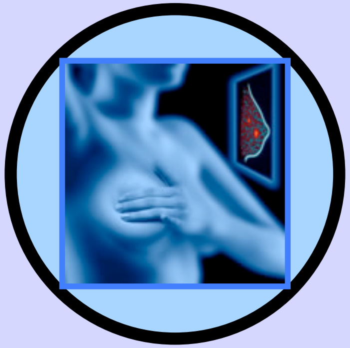
***~30'000 Images***

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

# Key Objectives

- Acquisition of ***large sample*** of mammogram images
- ***Standardization*** of mammograms (***SMF***)
- ***Annotation*** of mammograms by humans as well as ***CADe*** software
- ***Distributed*** data management system, ***cross-institute, cross-country***
- ***Sharing of computing resources***
  - *Unlimited Storage*
  - *Computing-Intensive Algorithms*

***Proof of concept*** with active clinical participation



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

# Technical Challenges

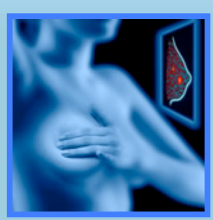
- Make Grid ***work in practice*** and ***usable*** in hospitals

  (*clinician friendly*)
- Investigate how the medical application can be isolated from the (still evolving) Grid as new Grid flavours emerge
  (e.g. OGSA→***Web/Grid Services***)

  (*grid friendly*)
- Provide a ***distributed and federated*** clinical data management system
- Deliver a ***secure system,*** which can be integrated into a hospital information system

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

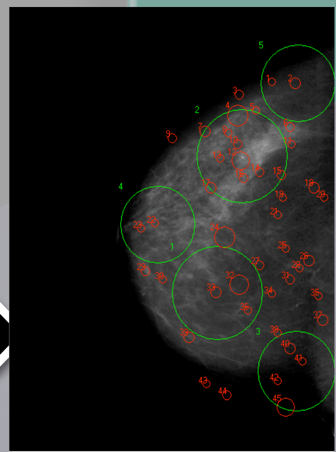
# Early example of health application on the grid

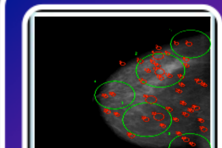


## *Mammogrid*

*A Grid-powered Mammography Database*

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



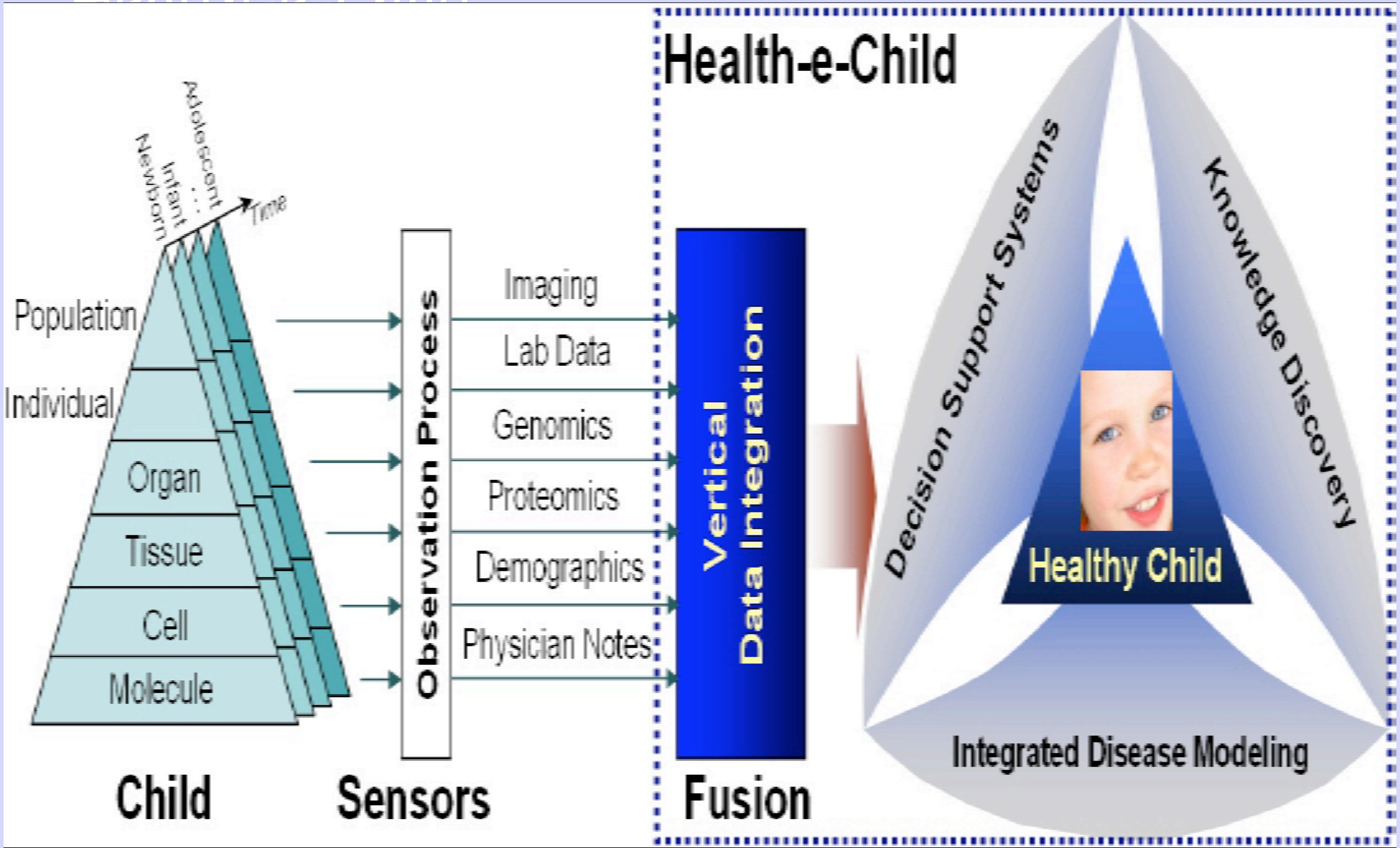


### Oncology

- Breast Cancer (micro- … ons and masses)

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

## Health-e-Child





From: Peter Bloodsworth, CCCS Research Centre, UWE, Bristol, UK, peter.bloodsworth@cern.ch

# Charged Particle Therapy Centres

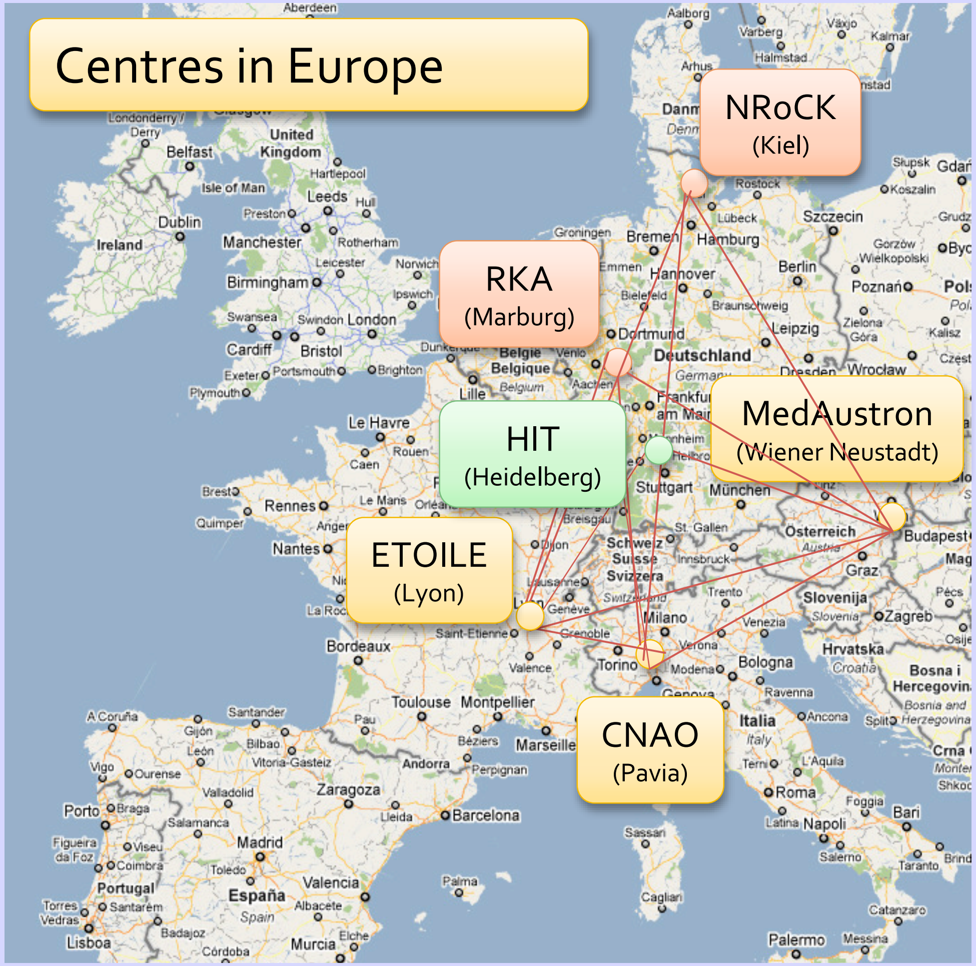
## Protons

- use of **protons** proposed 1946 by R.Wilson
- first use on patients in 1954 (Berkeley)
- in **2009: >25 proton therapy centres**

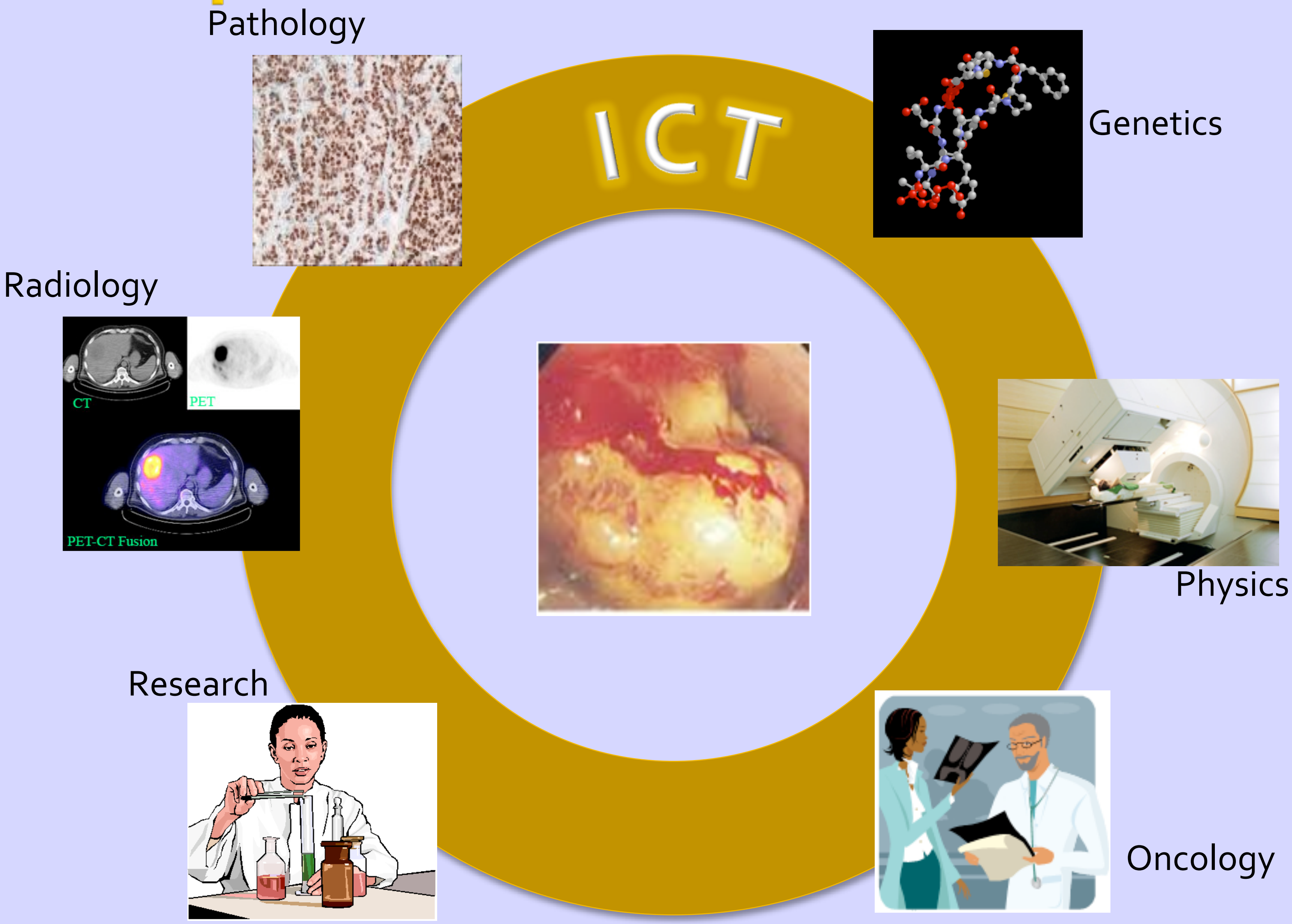
## Ions

- **only 2 clinical centres** using **carbon ions** (Japan) and physics research institutes **until 2009/11**
- **HIT** inaugurated in **November 2009**
- **CNAO** inaugurated in **February 2010**

Connect centres ...
... and make most of available data!



# Disciplines



# Challenges

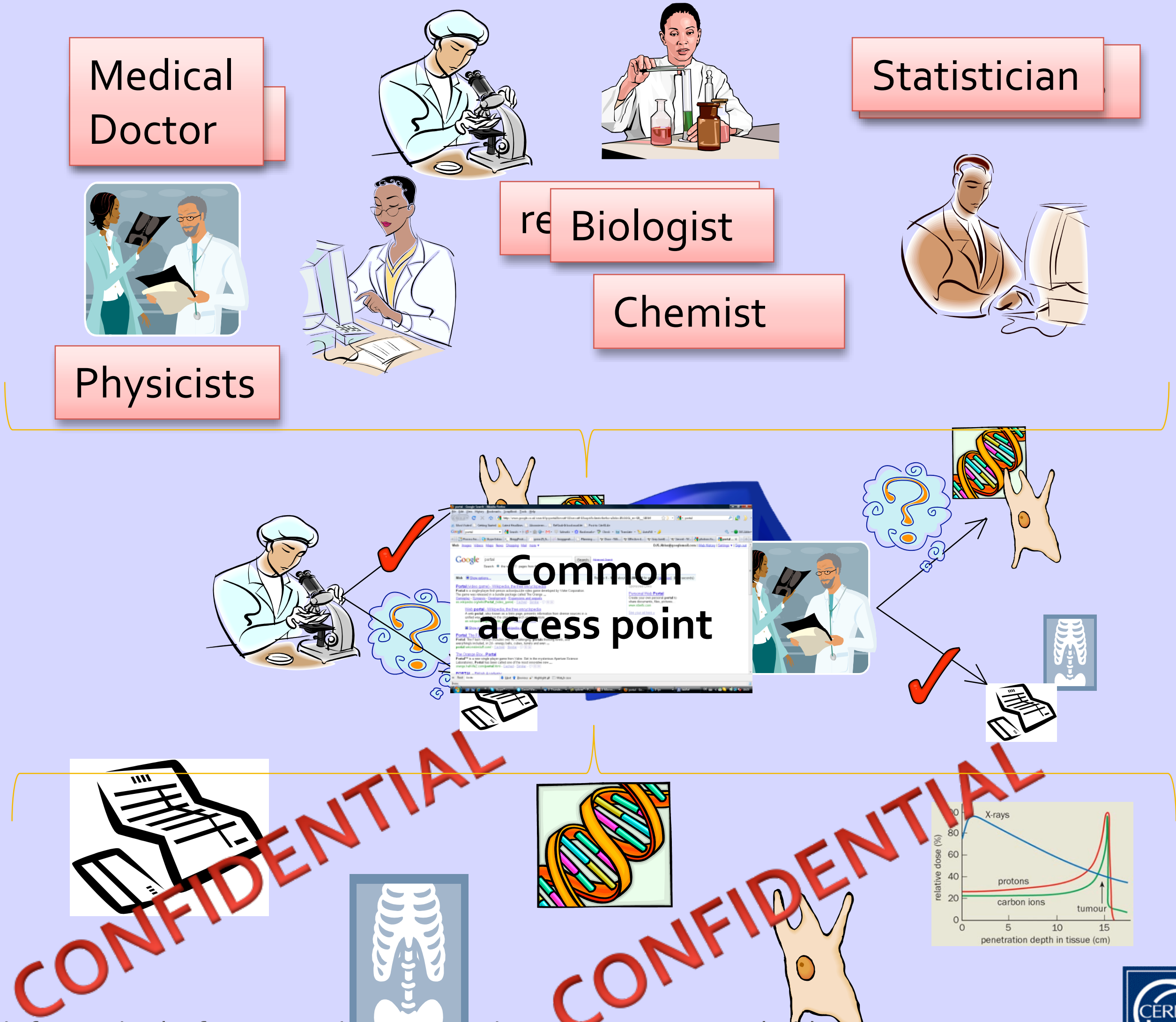
## Platform for **translational research** and **clinical practice (1/2)**

**Users**

- from **multiple disciplines** with **specific views** on data
- **across Europe**
- with **different** levels of **technical knowledge**
- with **different privileges**

**Data**

- from **multiple disciplines** with **specific terminologies**
- stored **across Europe**
- In various **independent repositories**
- with **different** ethical and legal **requirements**



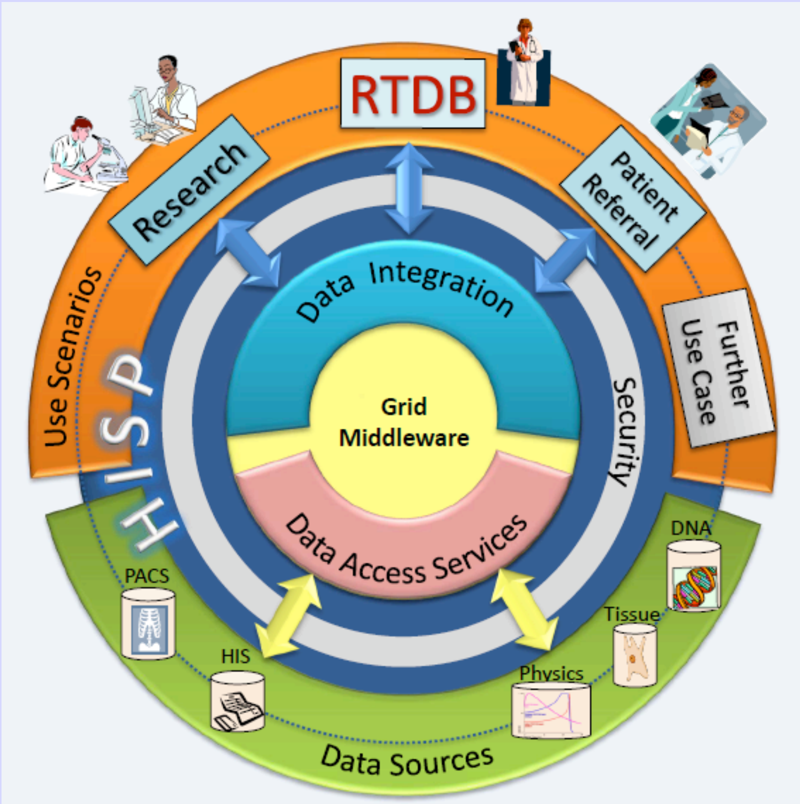
# Data standards and semantics

- Heterogeneity
  - Different disciplines have different view on subject.
  - Different  institutions have own measurement procedures and naming conventions
- Semantic Interoperability
  - Same meaning for sender and receiver
- Computer Interoperability

# The Project

Prototype for a grid-based
Hadron Therapy Information Sharing Platform (HISP)

- Technical Demonstrator
  - Scientific:
    Research Platform
  - Clinical:
    Patient Referral
- for follow-up projects
  - ULICE…





Abler, D.; Kanellopoulos, V. & Roman, F. L.
Future information sharing in Hadron Therapy
Poster at 'Physics for Health in Europe' workshop, 2-4 Feb. 2010, CERN, Geneva
https://espace.cern.ch/partnersite/workspace/abler/Shared%20Documents/ConferencePoster/PARTNER_Grid_PosterAndAbstract_PhysicsForHealthCERN2010.pdf

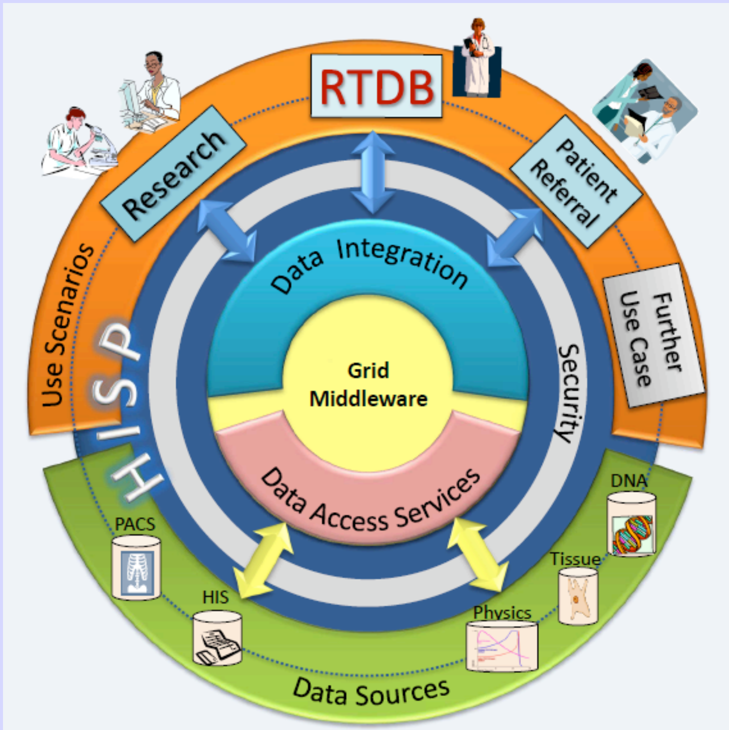
# Services in HISP

**Authentication**
- log-in

**Agreement Brokerage**
- contracts
- negotiation
- proposal submission

**Authorisation**
- general and
- custom roles
- delegation

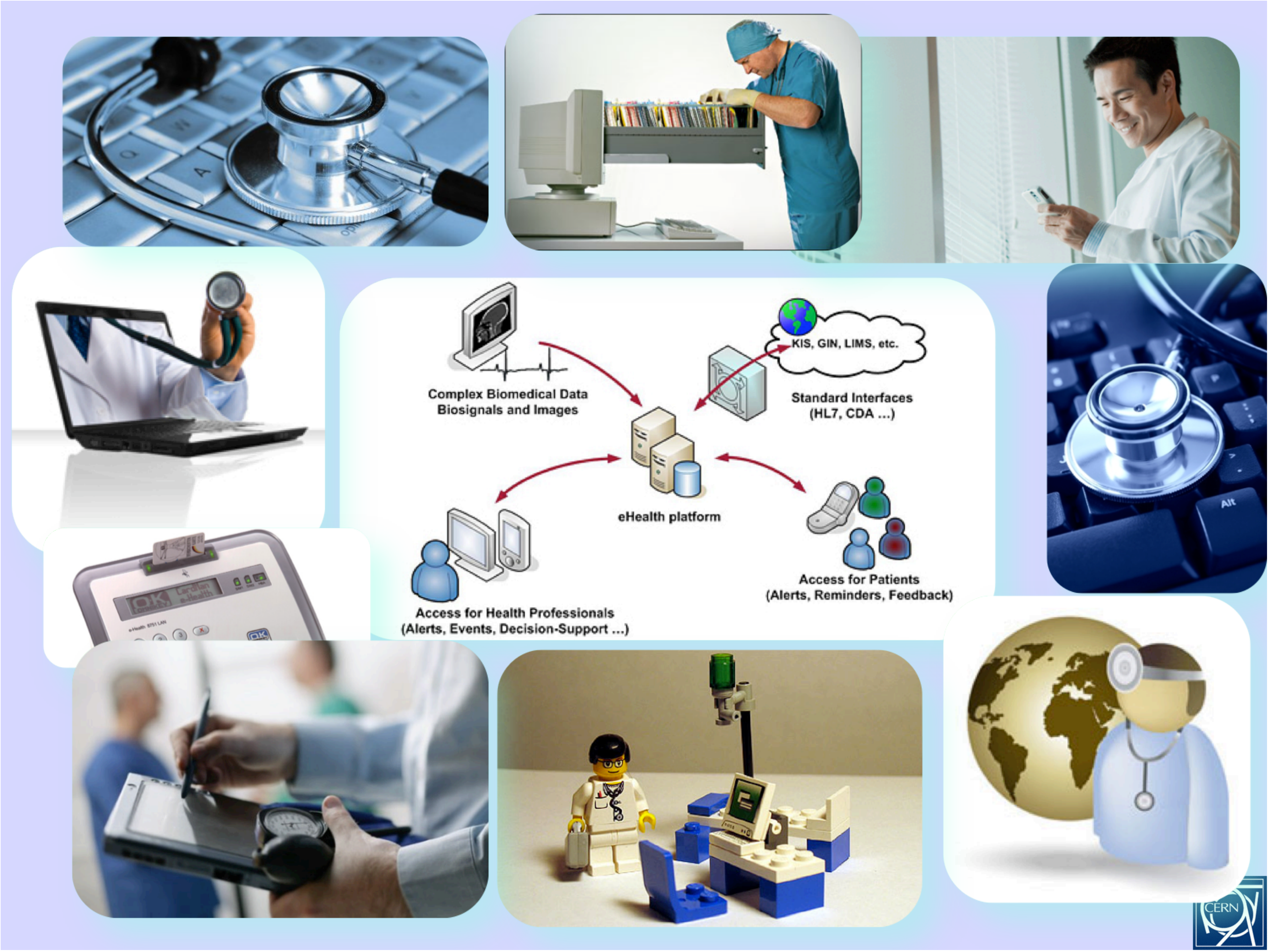
**Data Analysis**
- workflow design
- job manager
- execution




**Data Import**
- upload
- consistency check
- registration

**Data Access**
- query
- transformation
- anonymisation
- visualisation
- export
- registration

**Meta Data**
- CDE registration
- curation
- data annotation
- browsing
- mapping


Complex Biomedical Data
Biosignals and Images
KIS, GIN, LIMS, etc.
Standard Interfaces
(HL7, CDA ...)
eHealth platform
Access for Health Professionals
(Alerts, Events, Decision-Support ...)
Access for Patients
(Alerts, Reminders, Feedback)
CERN