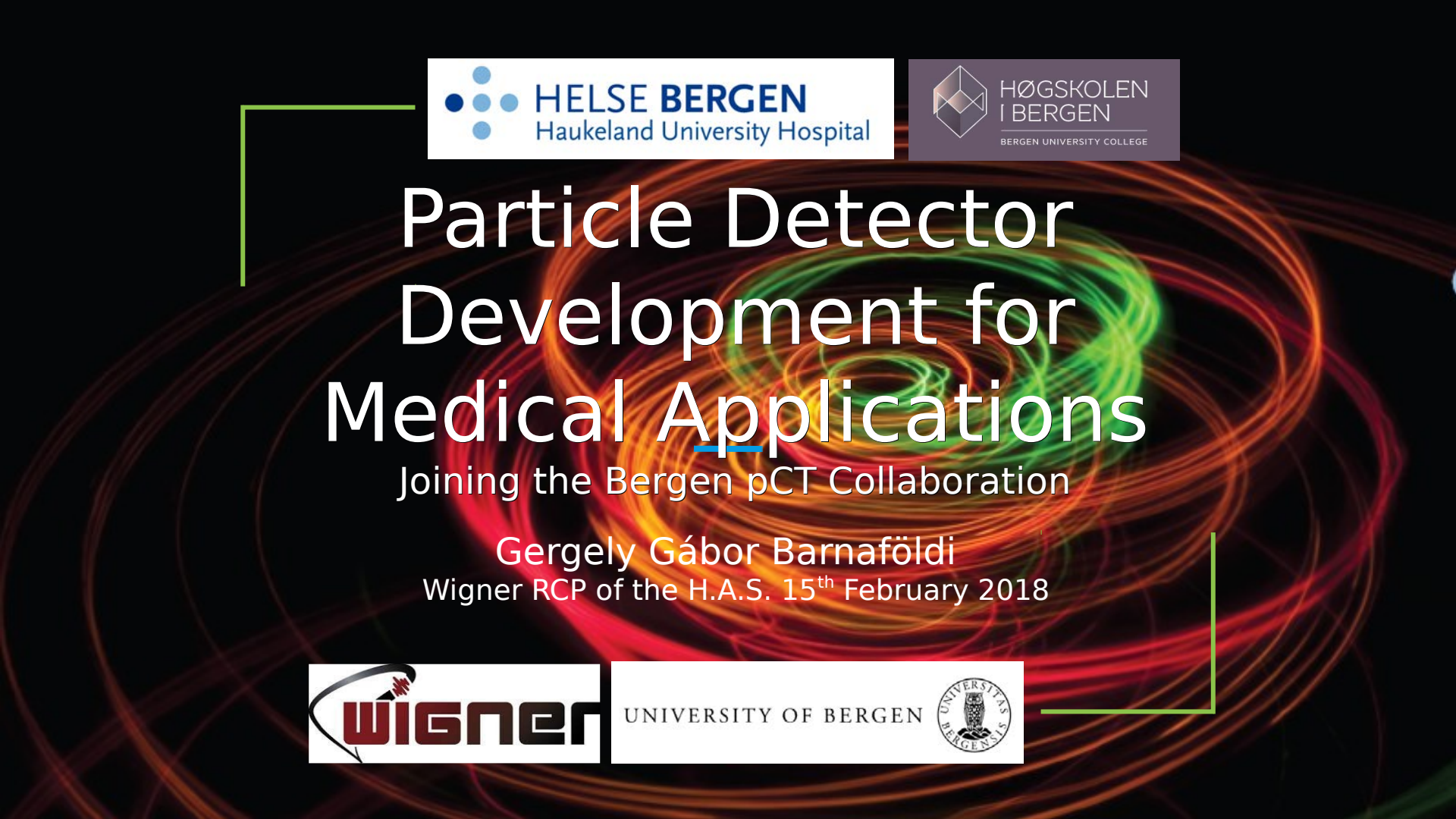
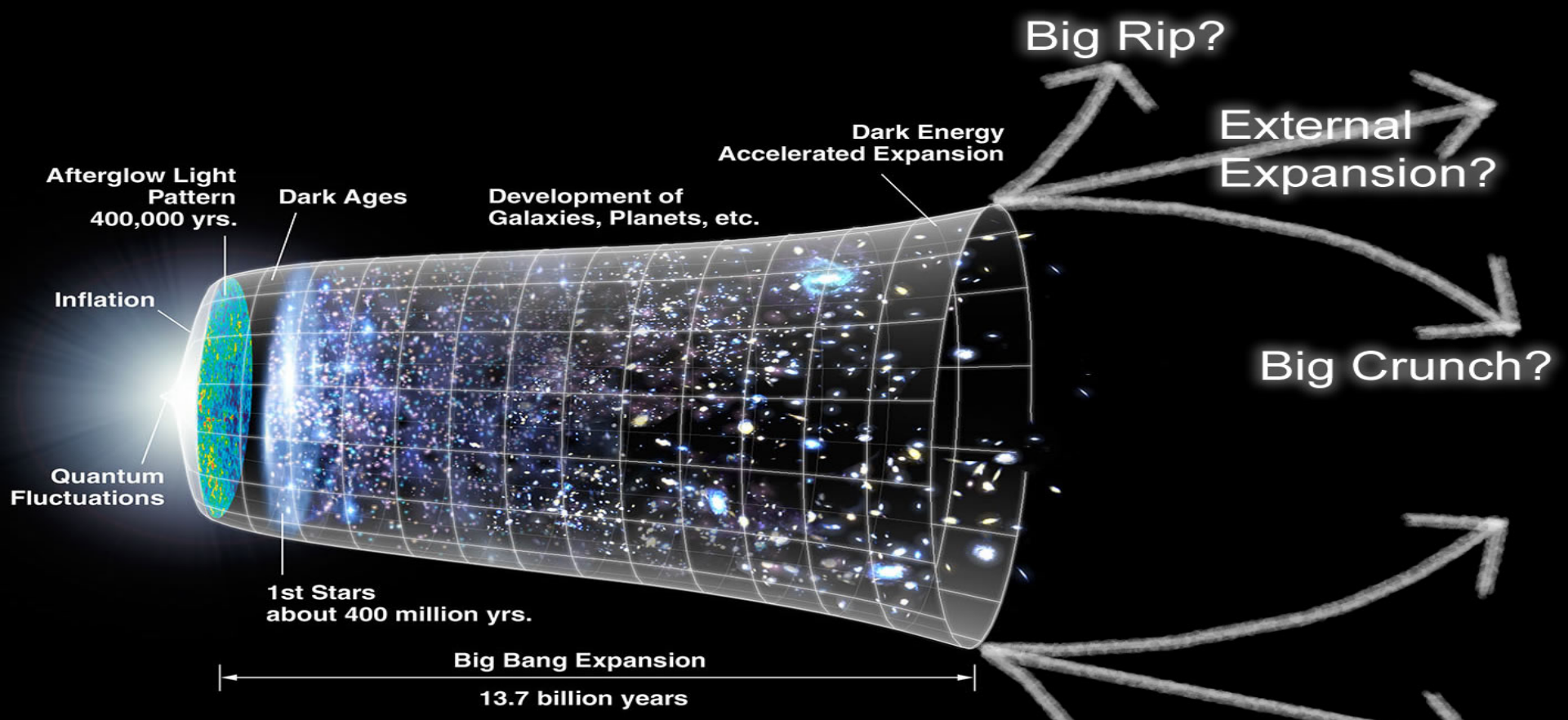

HELSE BERGEN
Haukeland University Hospital
HØGSKOLEN I BERGEN
BERGEN UNIVERSITY COLLEGE
Particle Detector Development for Medical Applications
Joining the Bergen pCT Collaboration
Gergely Gábor Barnaföldi
Wigner RCP of the H.A.S. 15th February 2018
wigner
UNIVERSITY OF BERGEN



Big things: Where are we going?

For this we use particle accelerators...

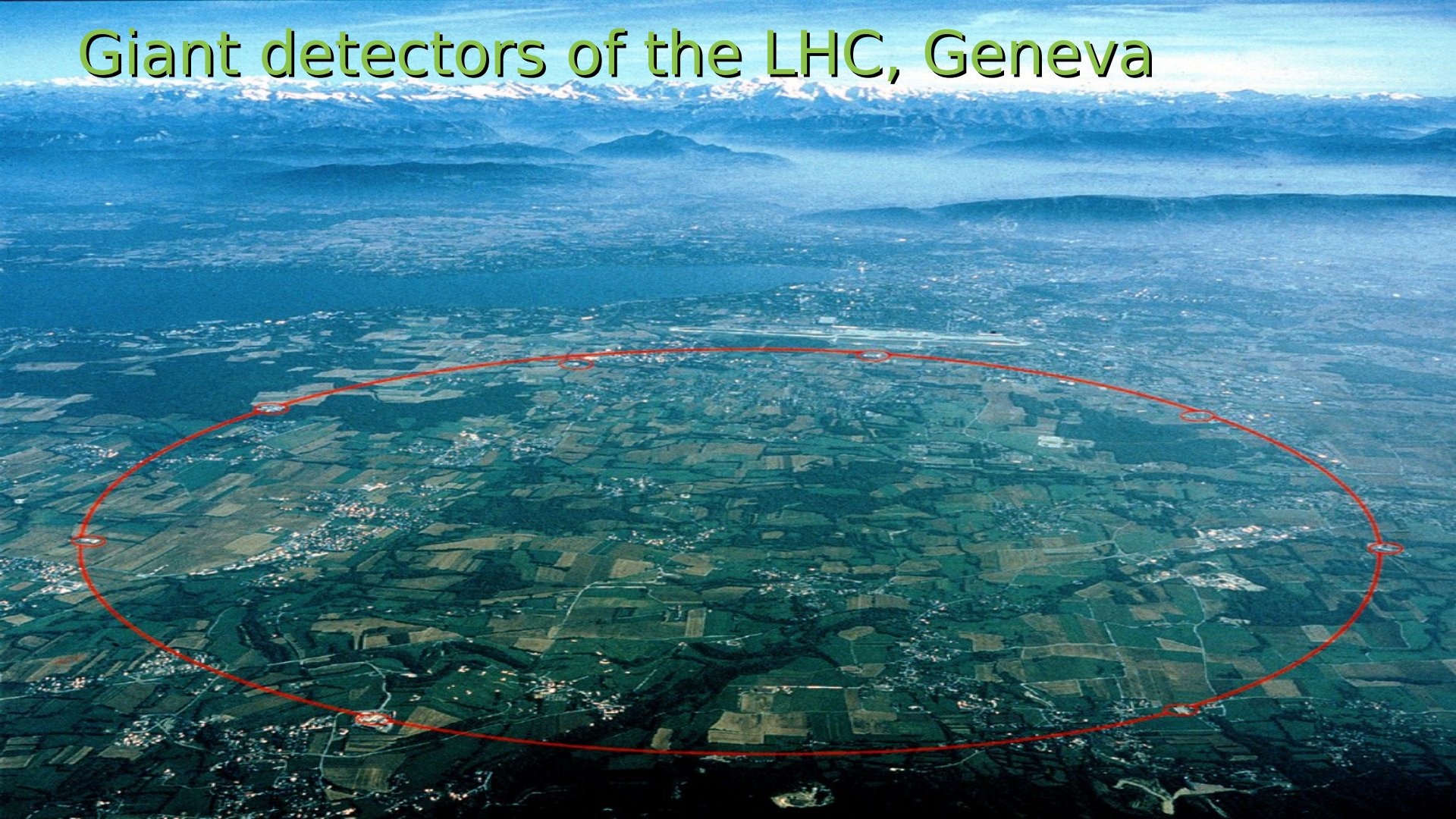
… and collide ions to answer this question

Investigating the inner structure of the matter we need

- **particle accelerators** to accelerate the matter
- to make collisions → then **kinetic energy turns to inner energy**

- bindings break to generate → **new particles, primordial matter**
- these particles are measured by the most precise **detectors** ever.

Giant detectors of the LHC, Geneva



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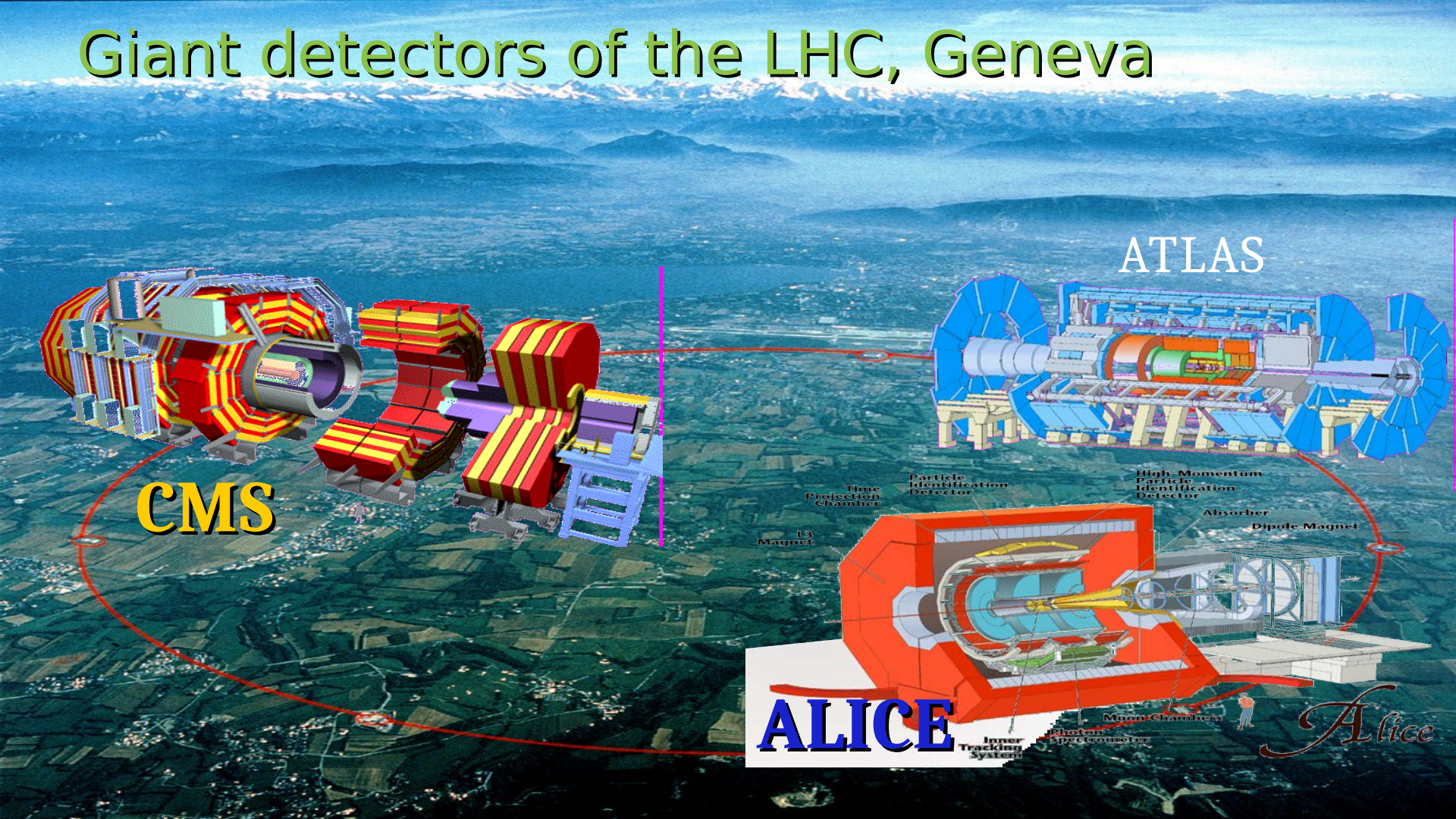
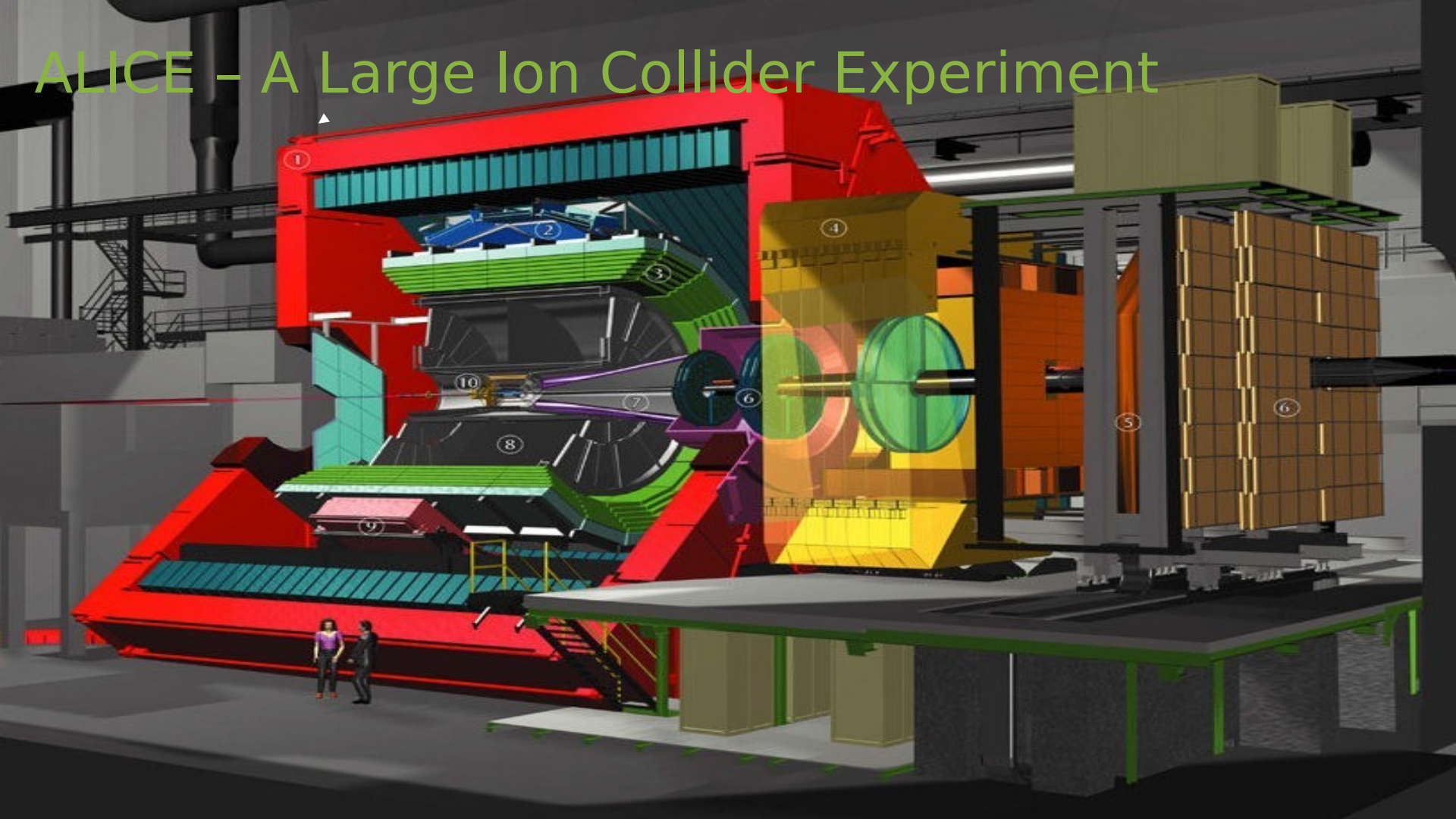


ALICE – A Large Ion Collider Experiment



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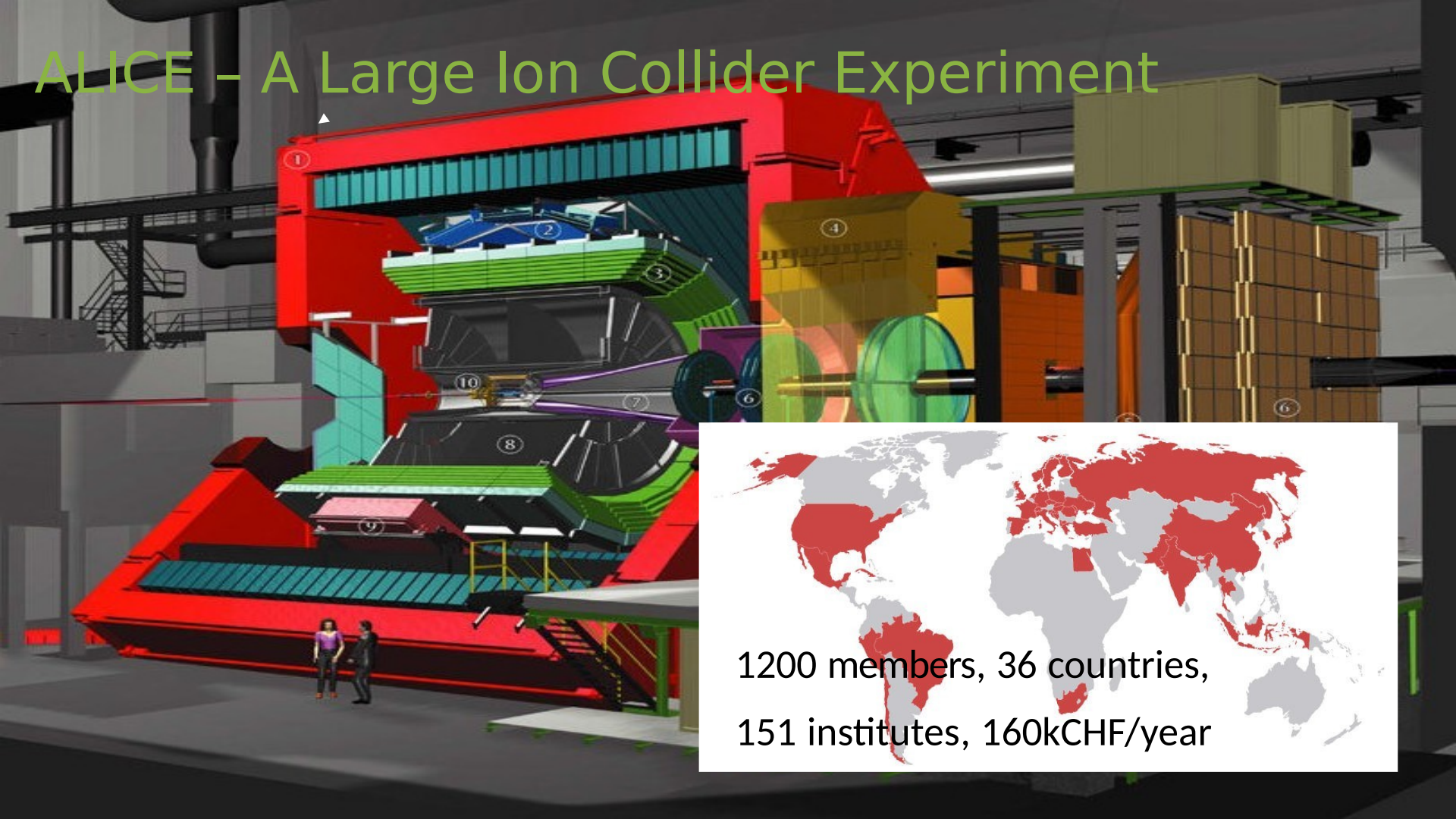


1200 members, 36 countries,

151 institutes, 160kCHF/year

ALICE upgrade: R&D for Run3 after 2020

ALICE Upgrade

New Inner Tracking System (ITS)
- improved pointing precision
- less material -> thinnest tracker at the LHC

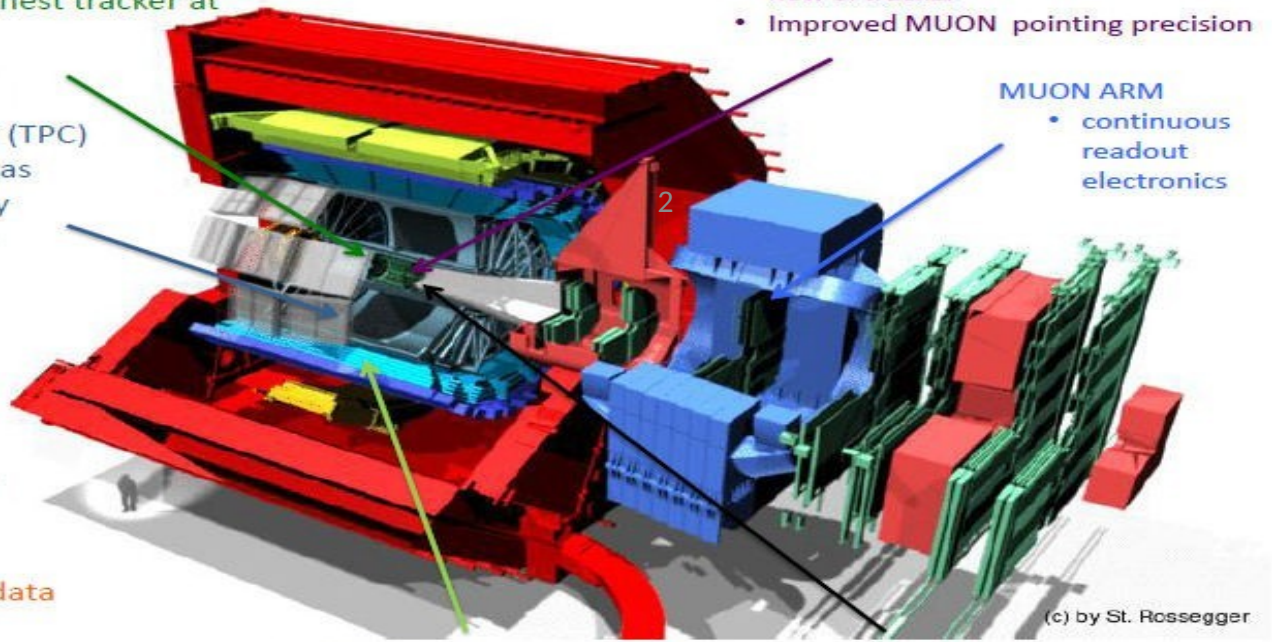
Muon Forward Tracker (MFT)
- new Si tracker
- Improved MUON pointing precision

MUON ARM
- continuous readout electronics

Time Projection Chamber (TPC)
- New Micropattern gas detector technology
- continuous readout

New Central Trigger Processor (CTP)

Data Acquisition (DAQ)/ High Level Trigger (HLT)
- new architecture
- on line tracking & data compression
- 50kHz Pbb event rate



TOF, TRD
- Faster readout

New Trigger Detectors (FIT)

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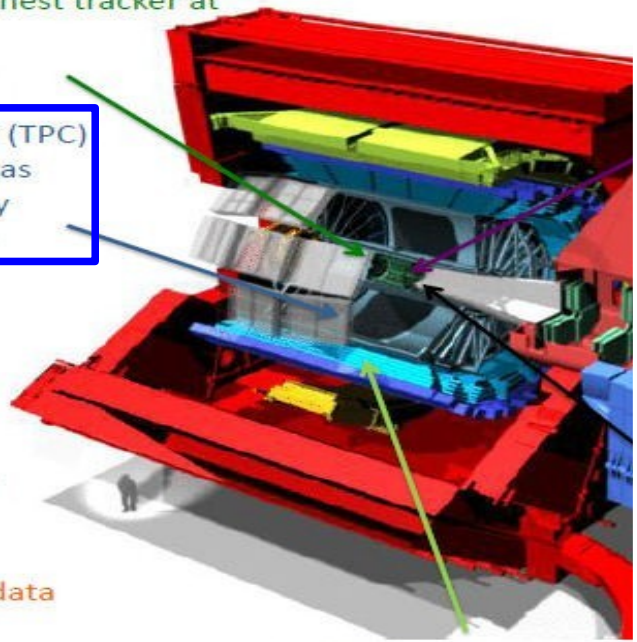

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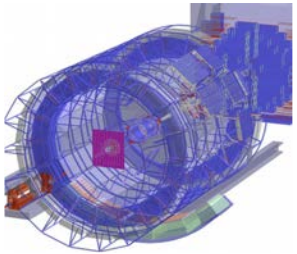

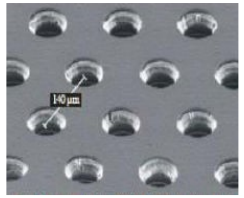

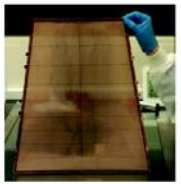

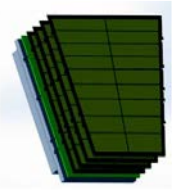

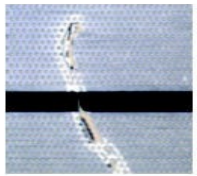

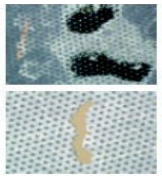

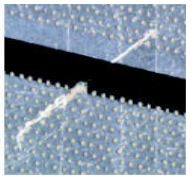

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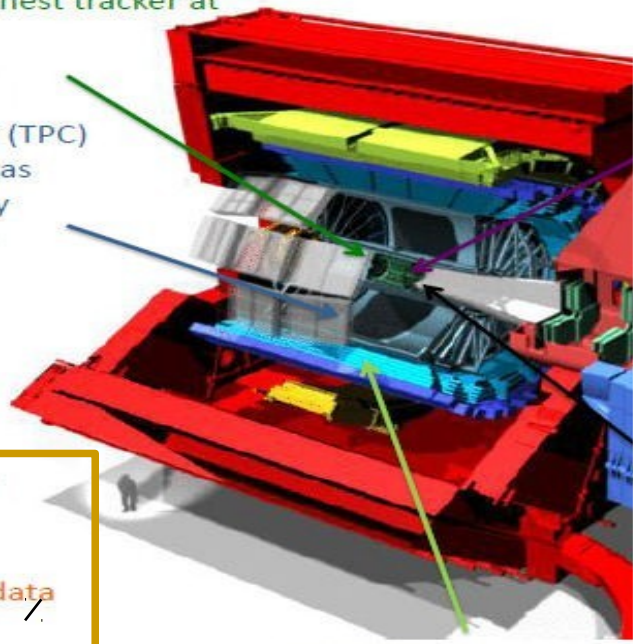

TOF, TRD
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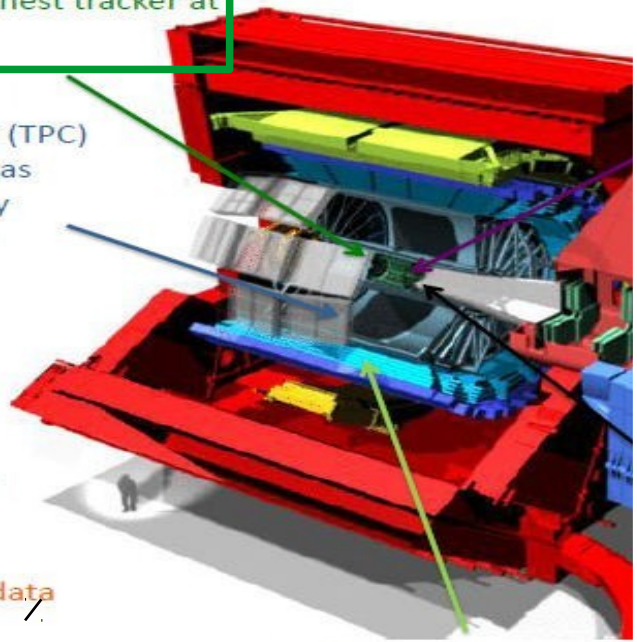

TOF, TRD
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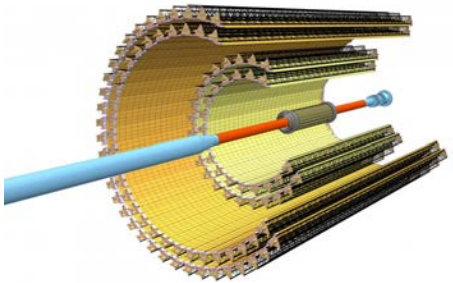
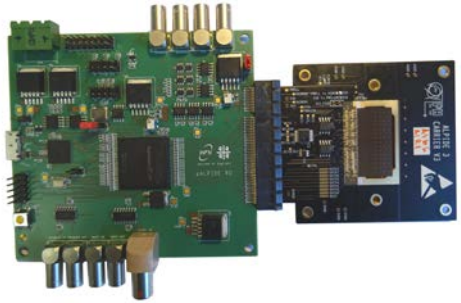




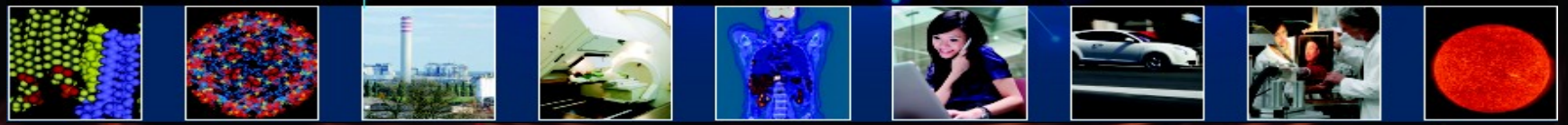
Particle accelerators are good investments!

We have 24 000 particle accelerator working on the Earth ever day.

Only 1% of these, 200, which is in scientific (base science) use.

Accelerators produce 400 billion€ value products per year.

Yearly 75 000 patients are treated by hadron therapy particle accelerators.



Where are we using particle accelerators?

health, epidemiology

food industry, virology

chemistry, material sciences

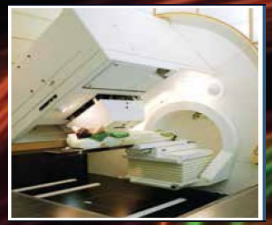
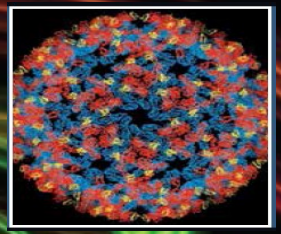
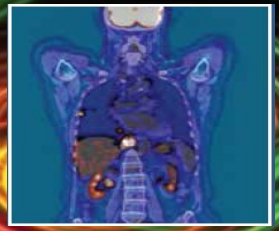
vehicles, space technology

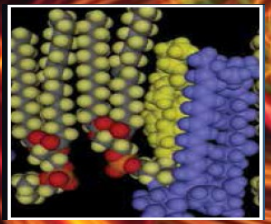
micro-electronics, energetics

semiconductors, defense,

environment protection, cultural

heritage, homeland security




Particle accelerators in medical applications

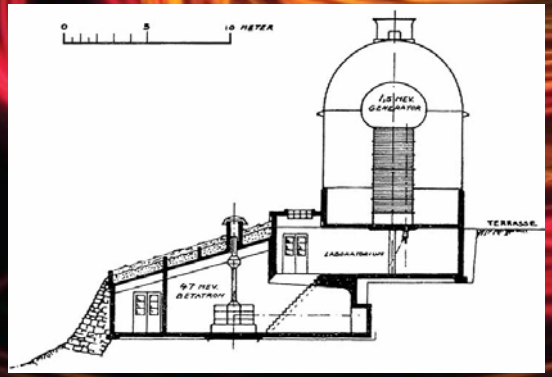
History

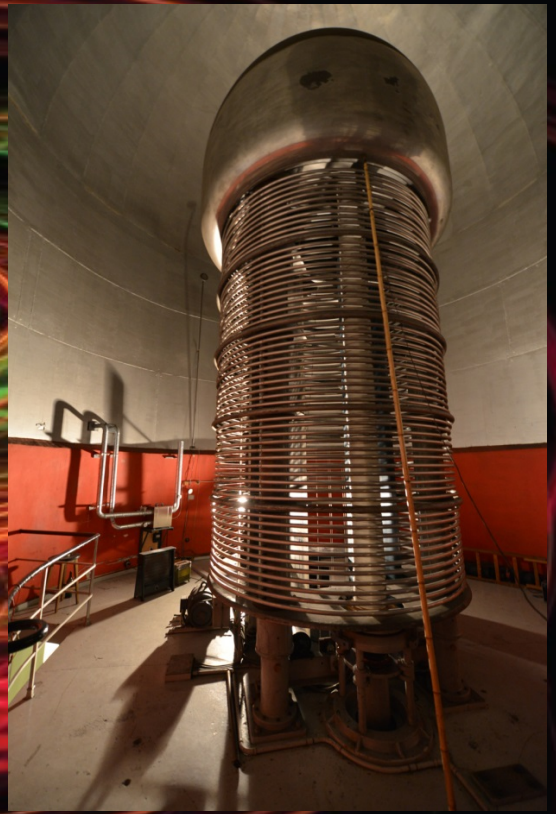
1939 Van de Graaf, Bergen (NO)

1975-1986 LBL, Berkeley (USA)

1994- NIRS Gunma (Japan)

1997- GSI, HIT, (Germany)





Where are we using particle accelerators?

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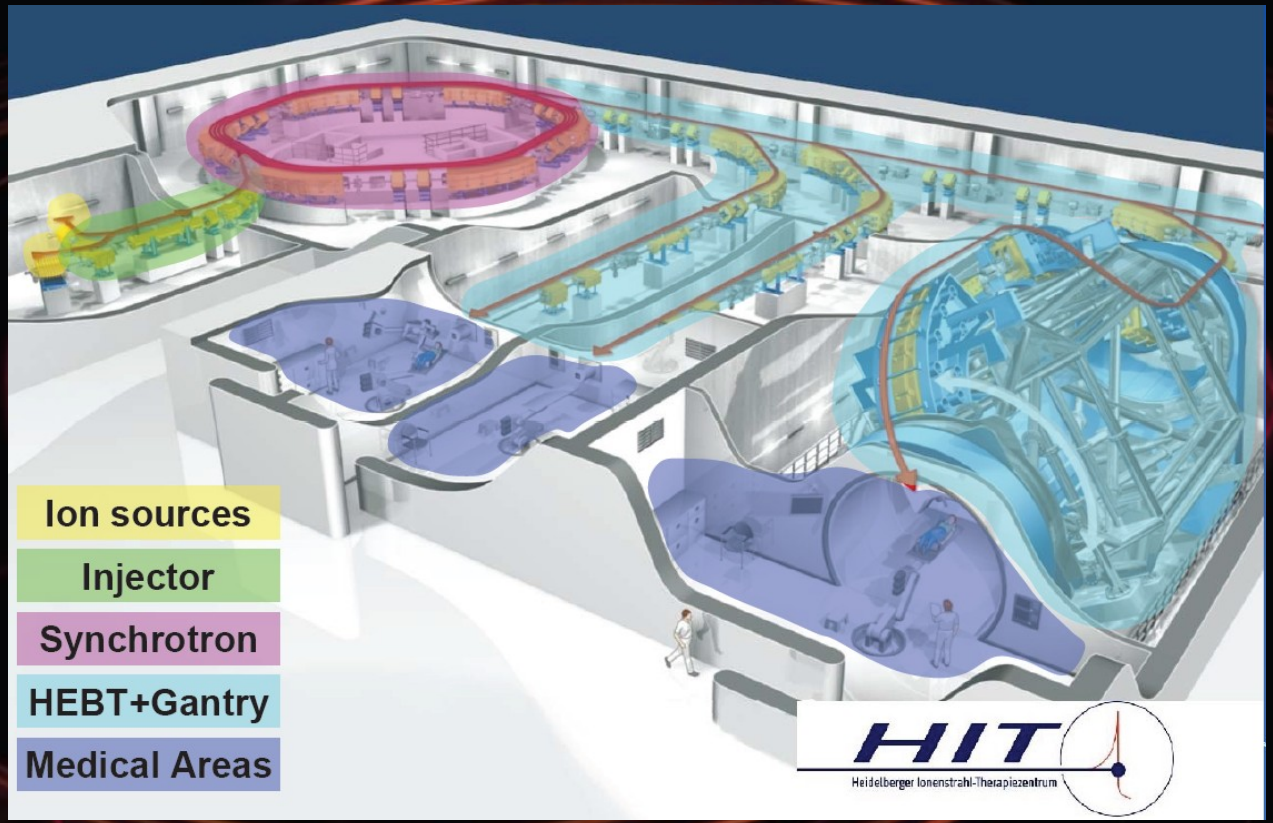
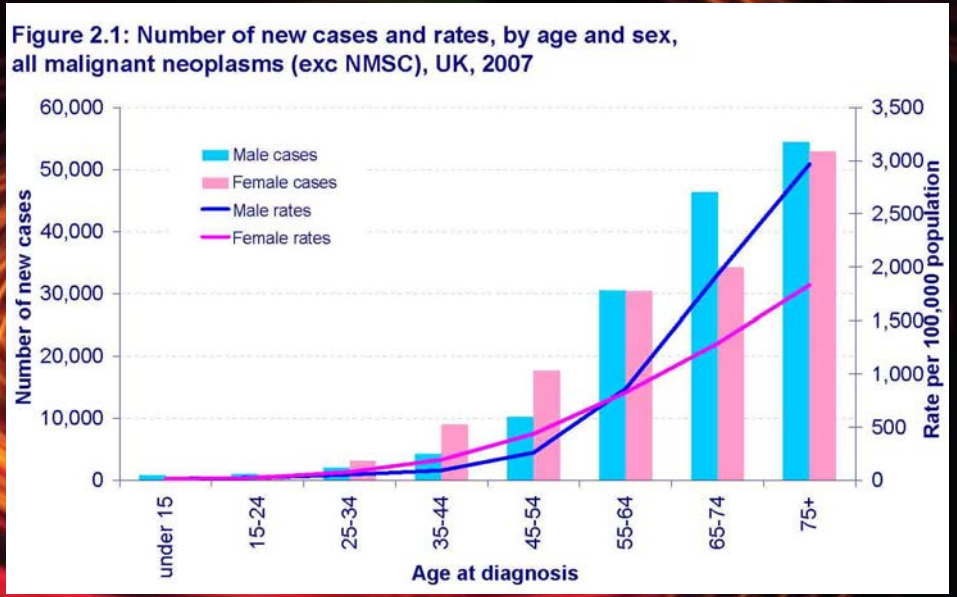


Particle physics against cancer...

Radiotherapy is an important weapon in the battle against cancer

Contributions to successful treatment of cancer

45-50% surgery
40-50% radiotherapy
10-15% chemotherapy



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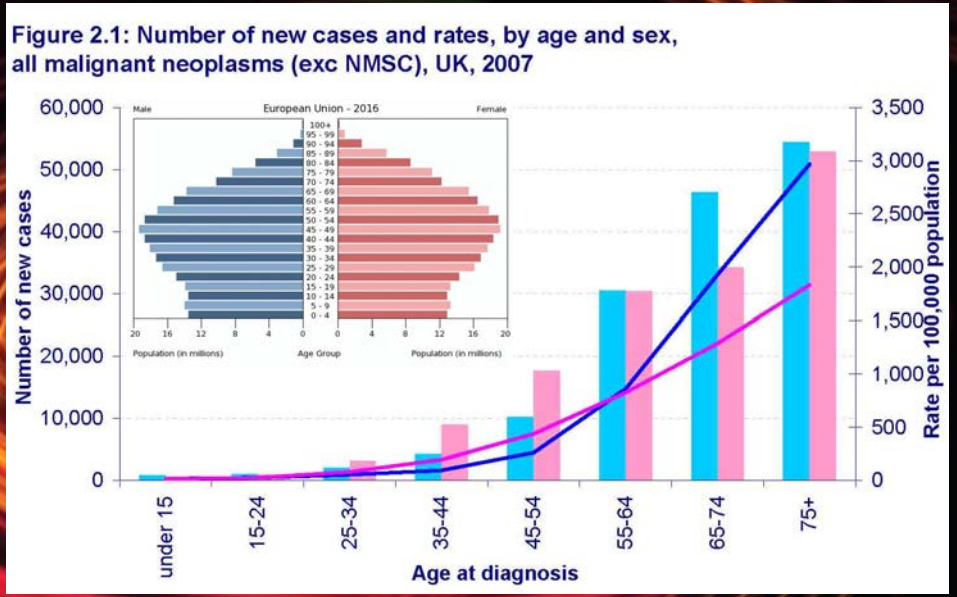
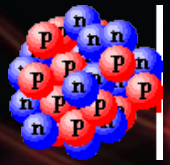


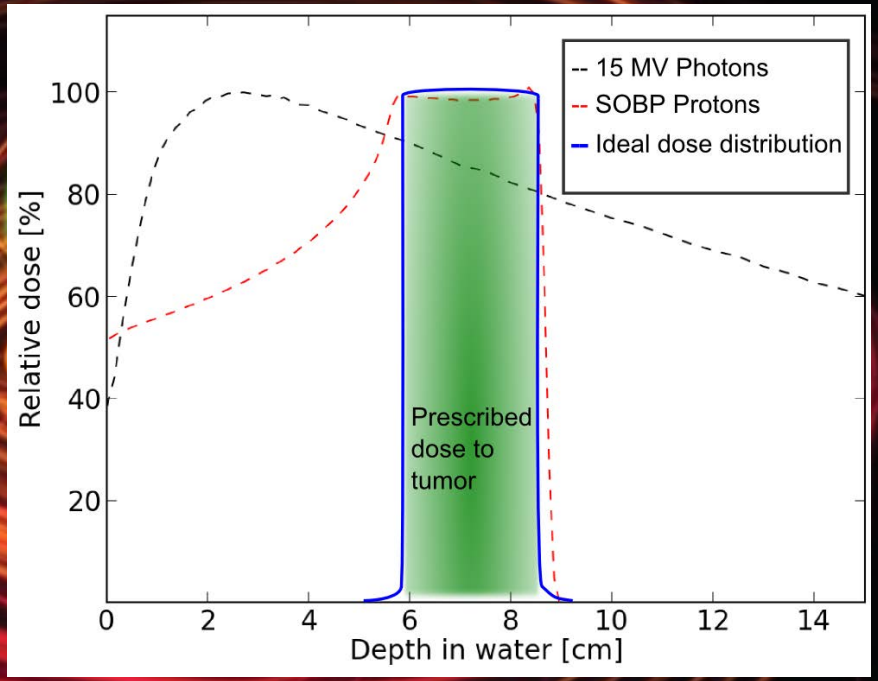
Particle physics against cancer...

The goal of radiation therapy is to irradiate the tumor with the prescribed dose and minimize the dose to healthy tissue

Photons (electromagnetic):

Hadrons (proton, nuclei):





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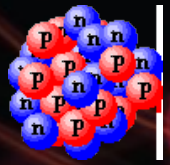
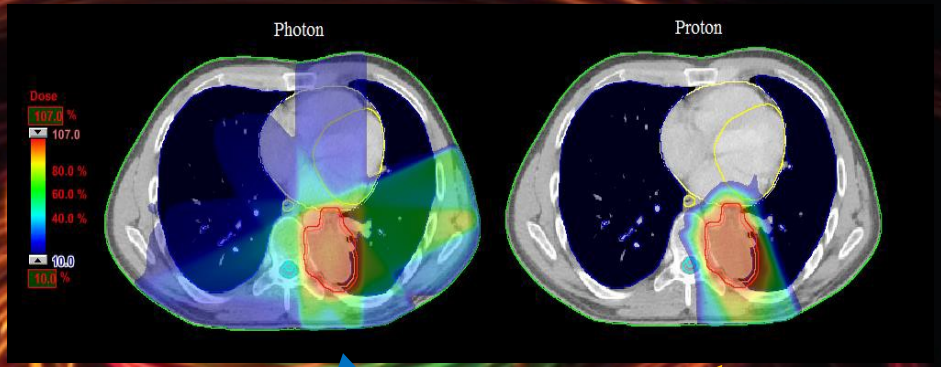
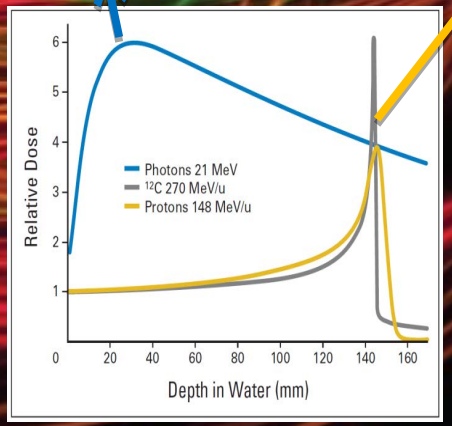
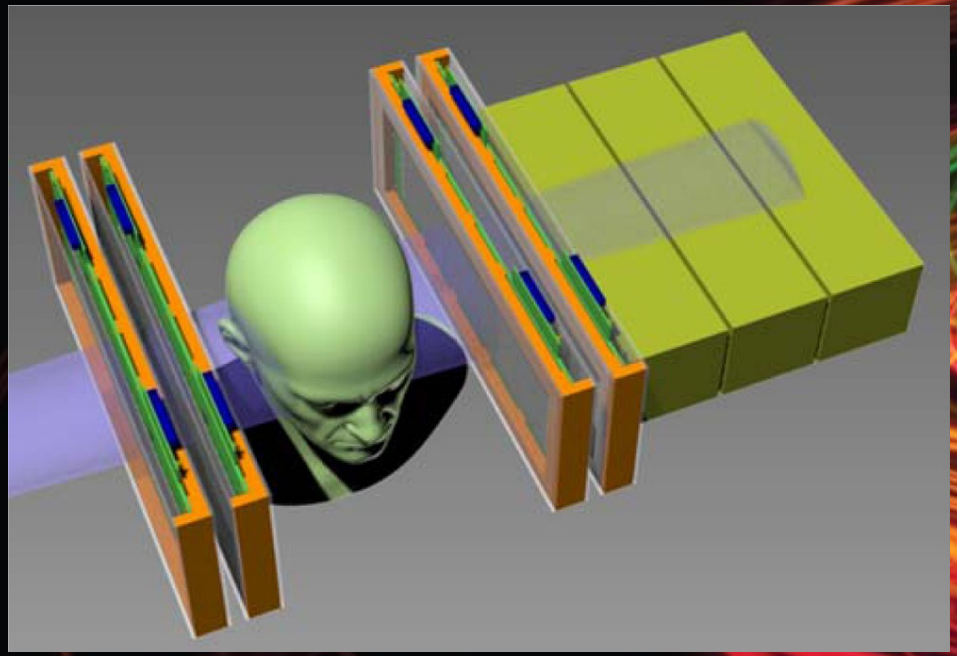


Figur fra Engeseth, GM (Haukeland)





pCT project



H.F.-W. Sadrozinski / Nuclear Instruments and Methods in Physics Research A 732 (2013) 34–39

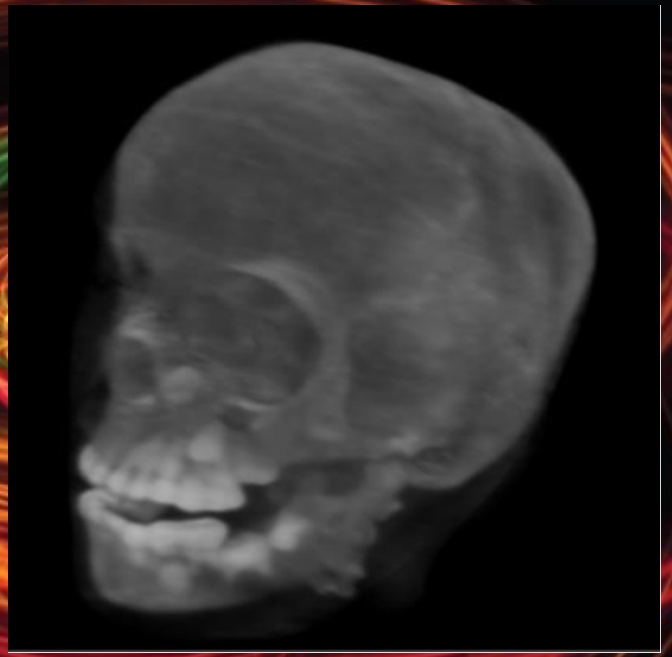
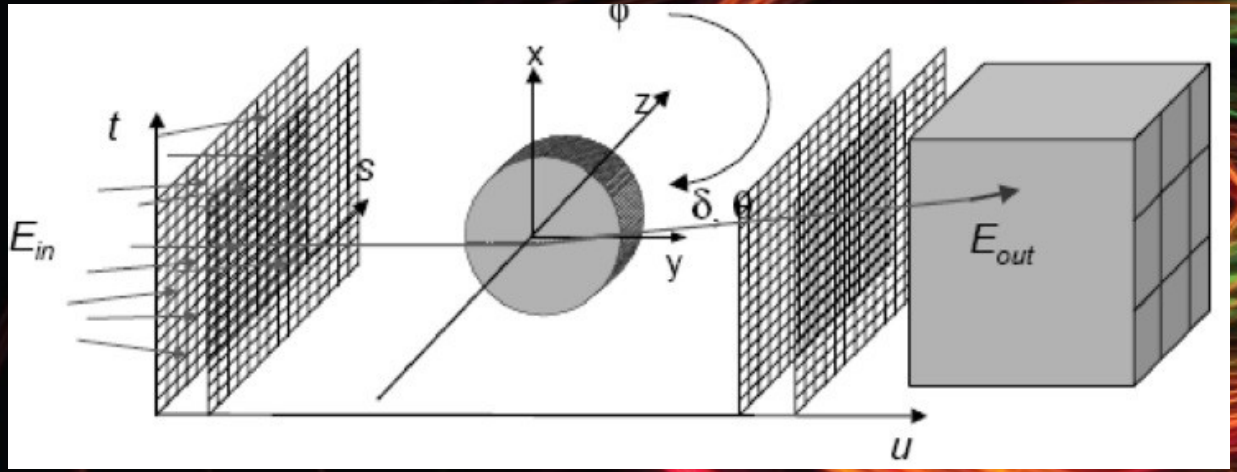
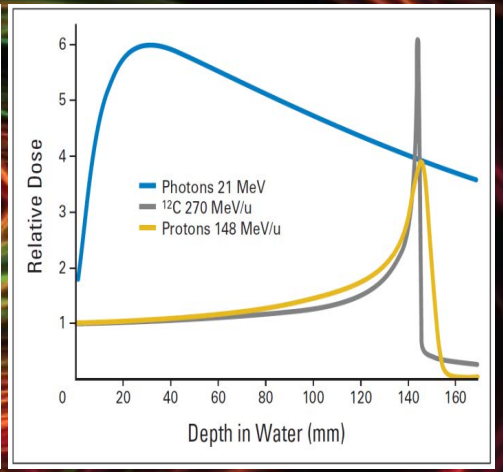


Fig. 14. 3D rendering of the pCT-reconstructed RSP map of a pediatric anthropomorphic head phantom.

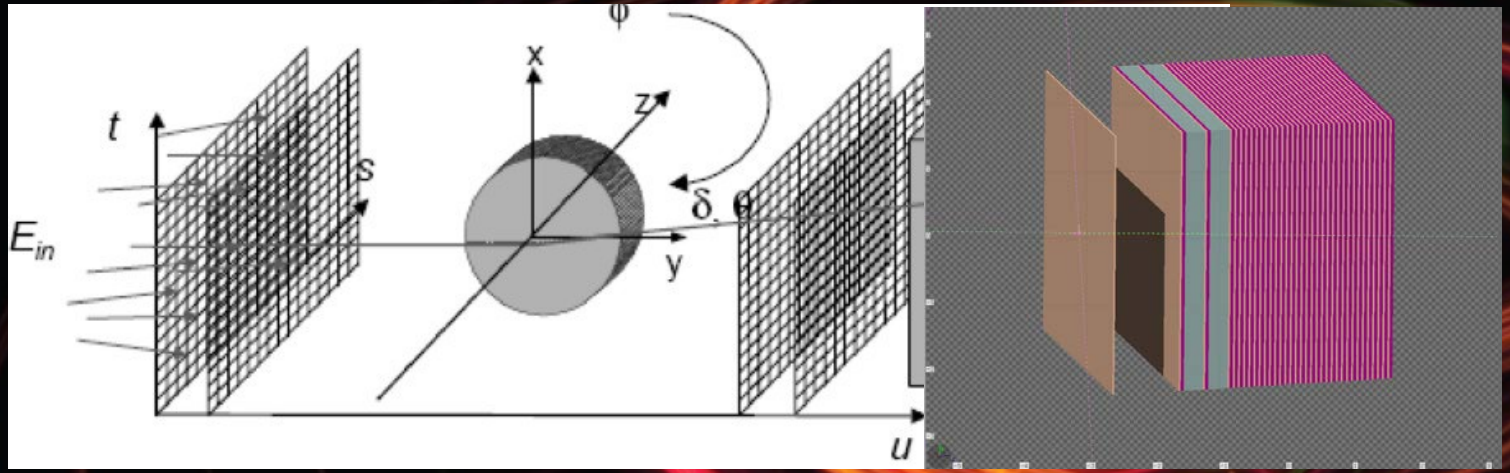
V.A. Bashkirov et al. / Nuclear Instruments and Methods in Physics Research A 809 (2016) 120–129

pCT project

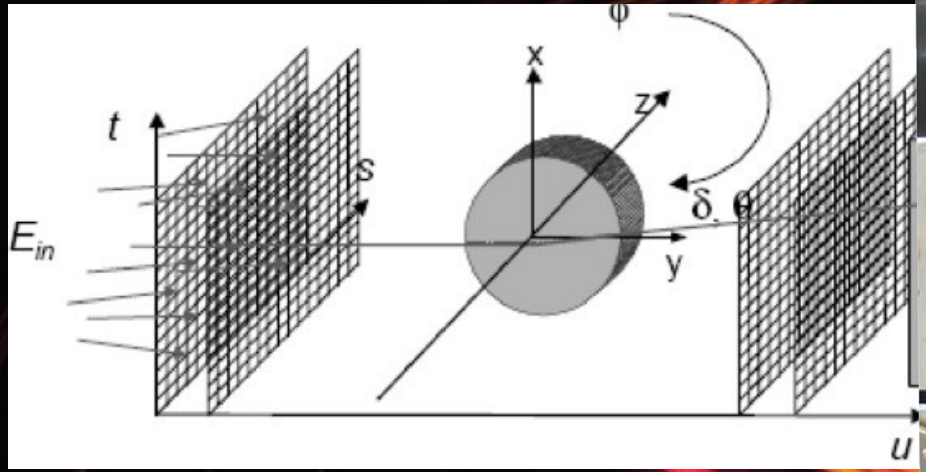

t
s
x
z
y
ϕ
δ, θ
E_{in}
E_{out}
u

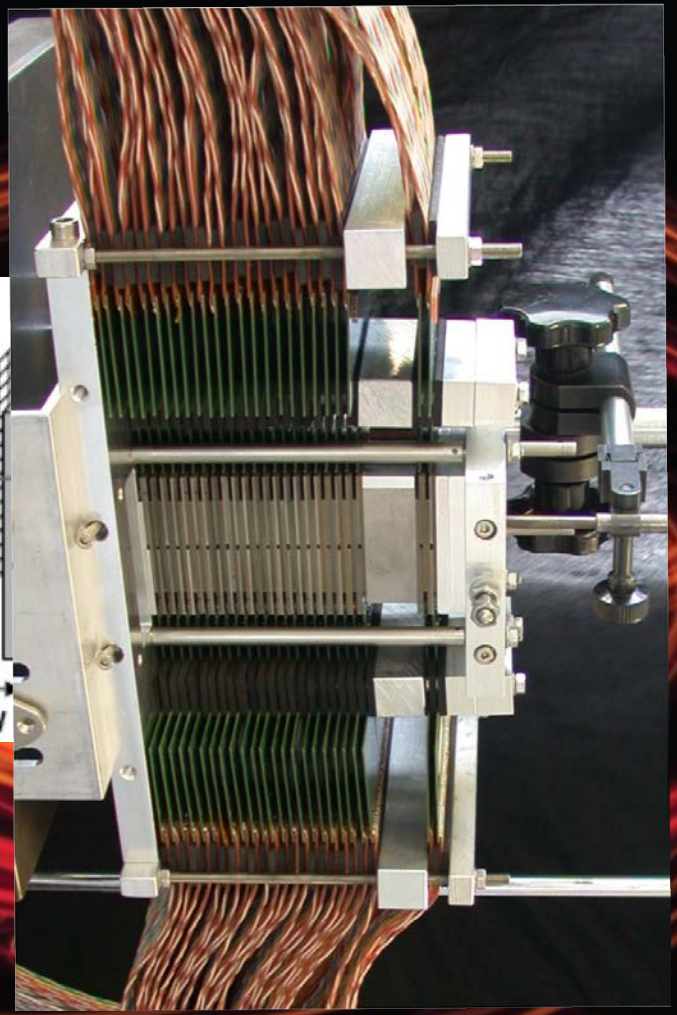

Relative Dose
Photons 21 MeV
^{12}C 270 MeV/u
Protons 148 MeV/u
Depth in Water (mm)
0
20
40
60
80
100
120
140
160
1
2
3
4
5
6

pCT project



pCT project





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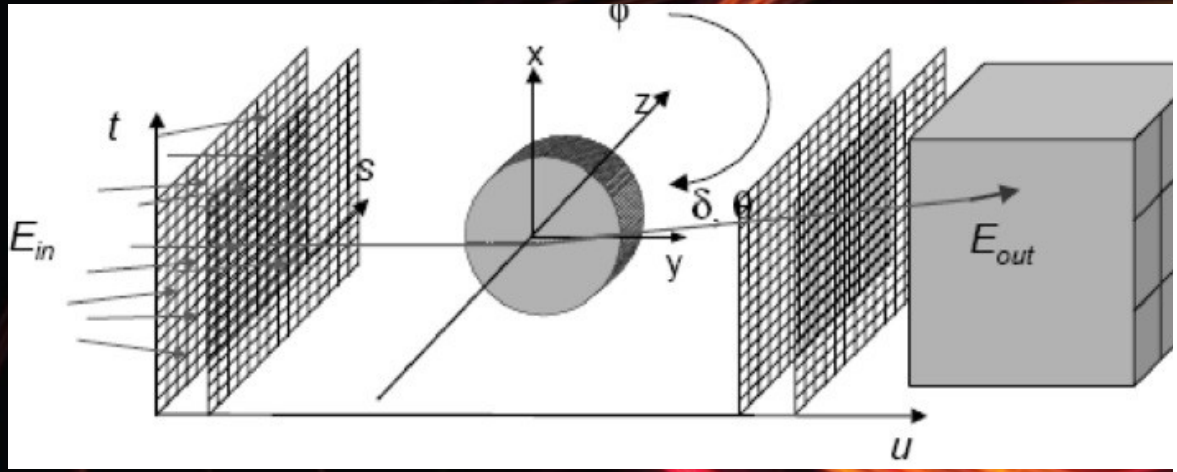
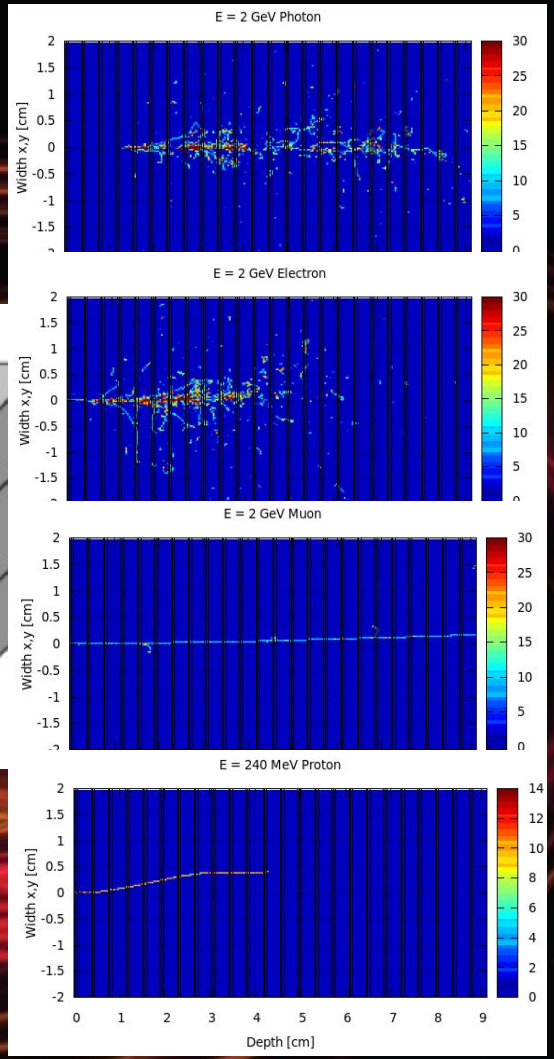
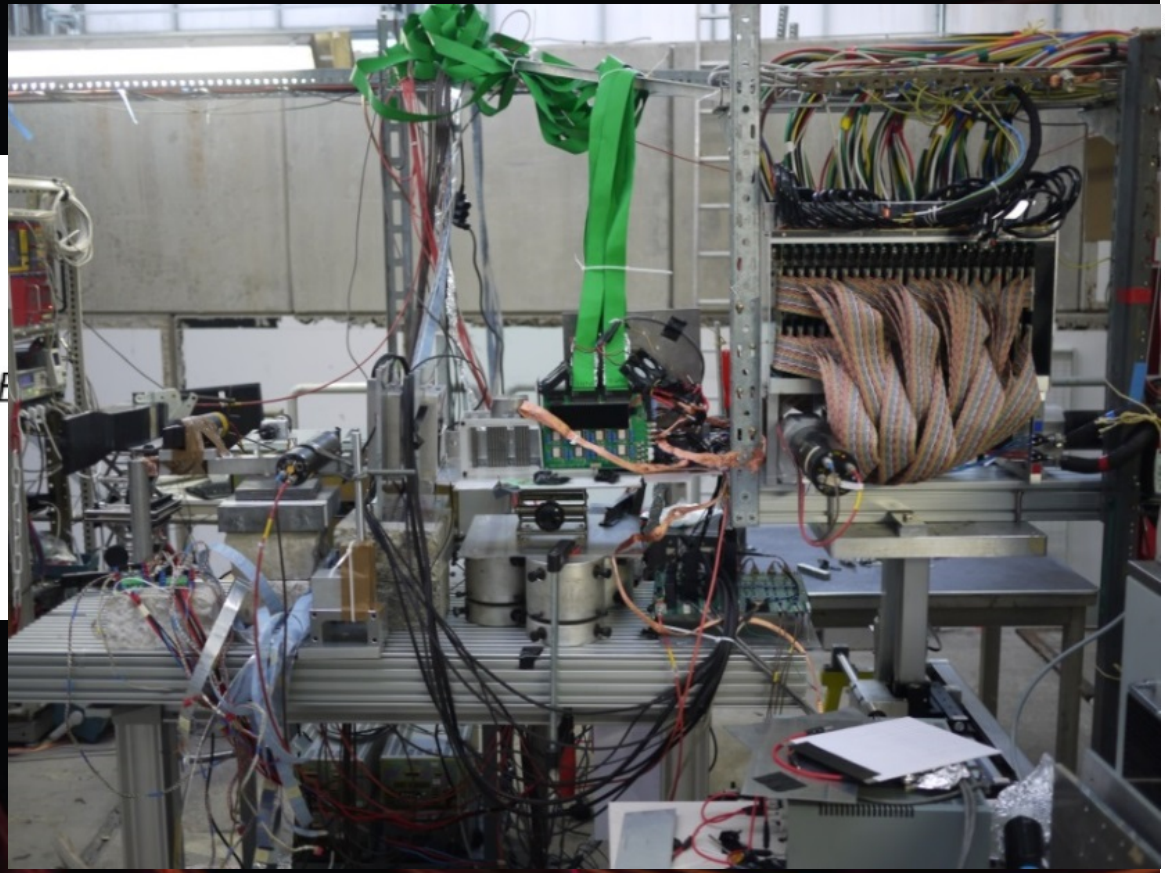
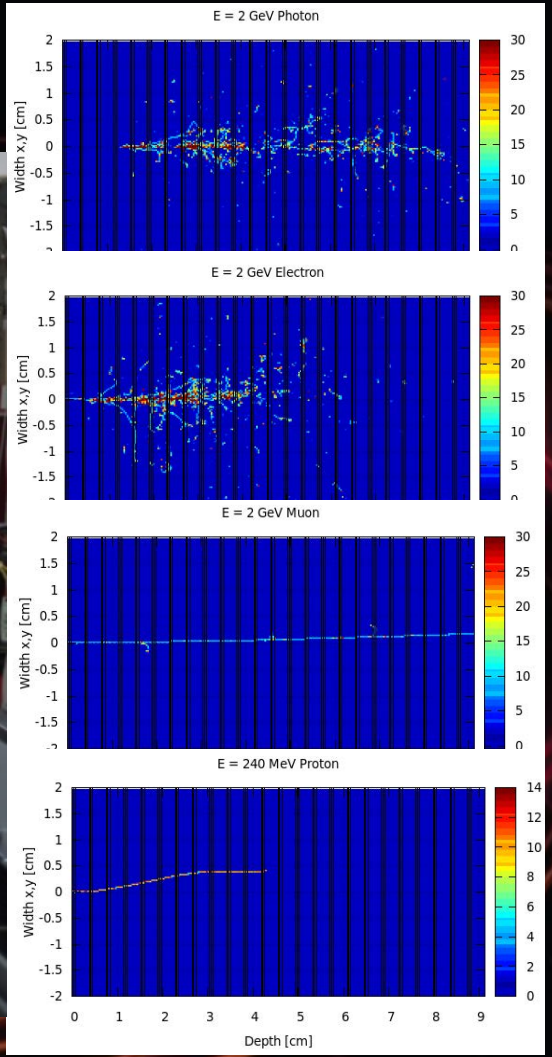

t
s
x
z
y
u
φ
δ, θ
E_{in}
E_{out}


E = 2 GeV Photon
E = 2 GeV Electron
E = 2 GeV Muon
E = 240 MeV Proton
Width x,y [cm]
Depth [cm]

pCT project

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Width x,y [cm]
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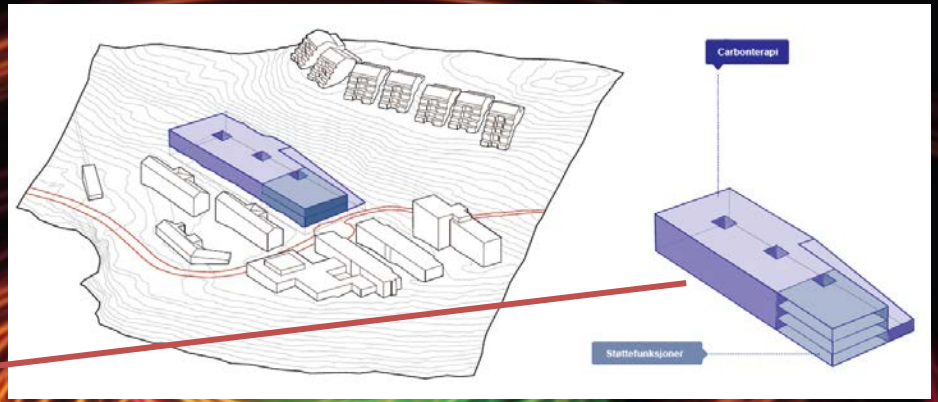
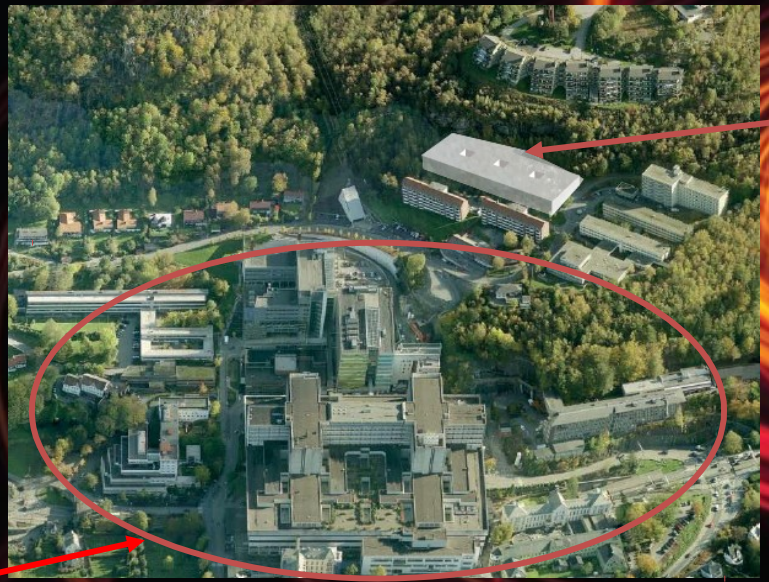
Hadron therapy center in Bergen





University Hospital

- Bergen UiB: Prof. Dieter Röhrich

- Budapest Wigner RCP:

  GG Barnaföldi, PhD

  Mónika Varga-Kőfaragó, PhD*

  Prof. Gábor Papp (ELTE)

  Ákos Sudár (BSc*, ELTE)