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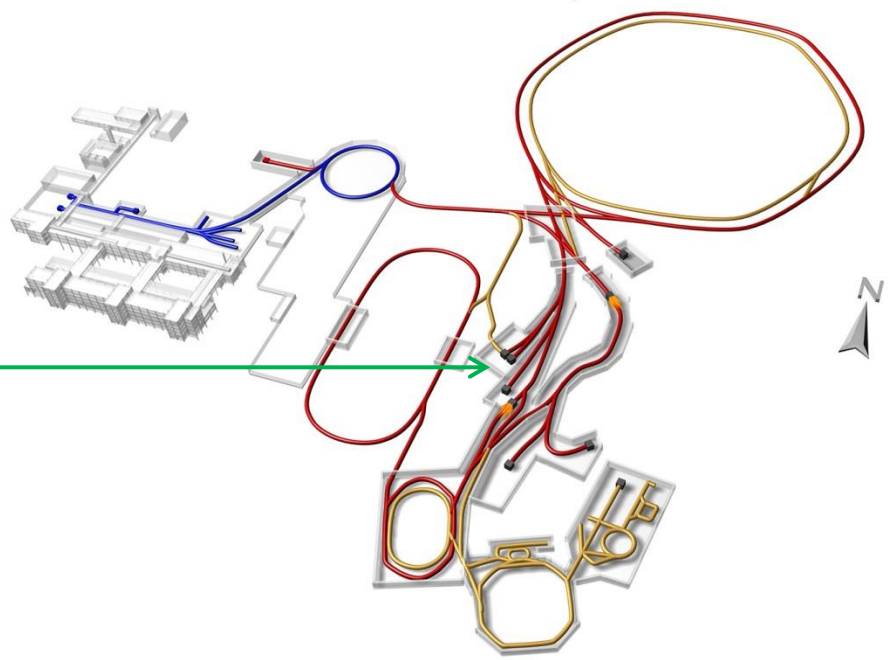
# Biophysics at BIOMAT

APPA Cave – including
BIOMAT target station




Marco Durante

GSI, Biophysics Department

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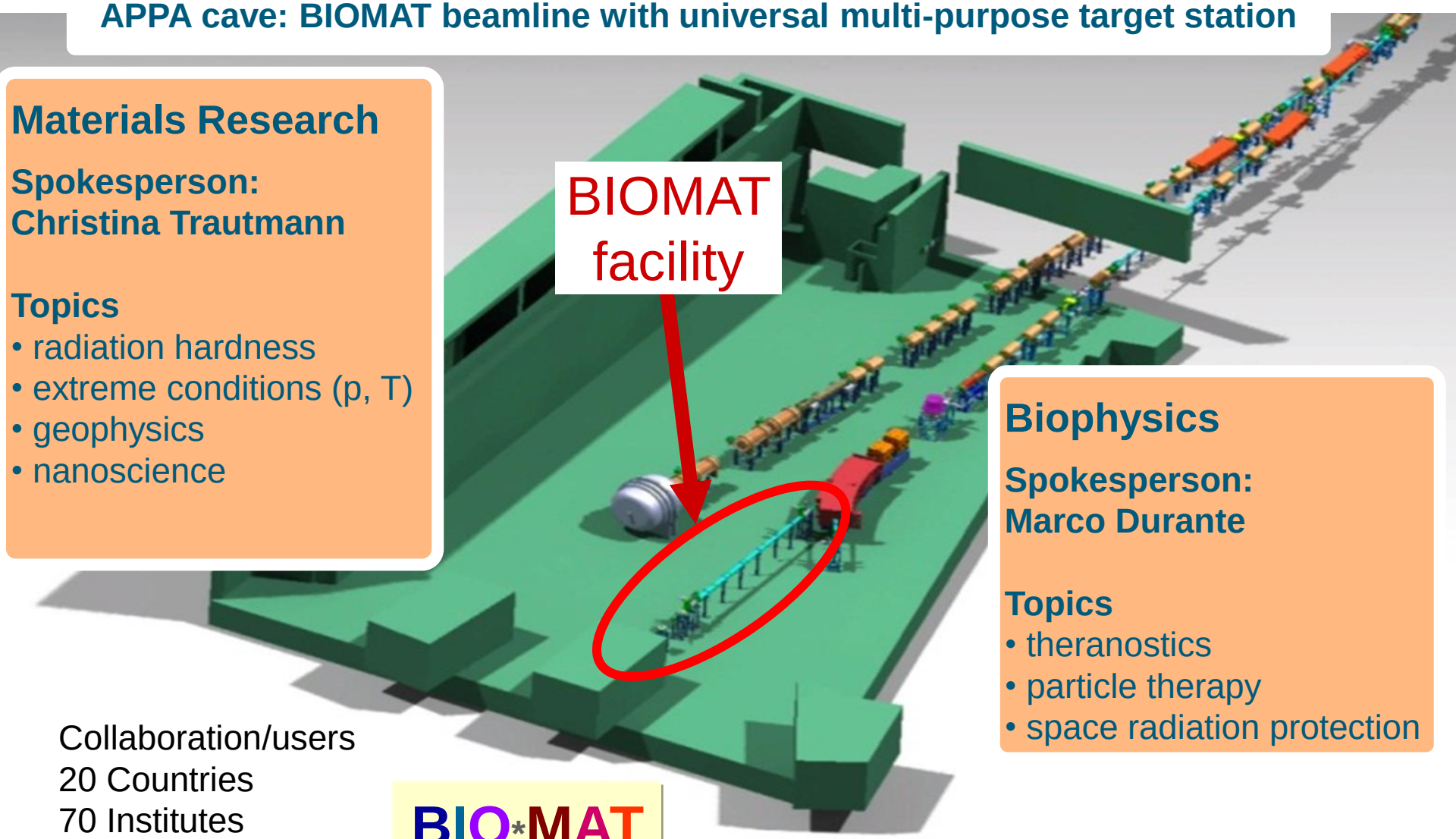
# BIOMAT User Facility and Collaborations

**APPA cave: BIOMAT beamline with universal multi-purpose target station**




## Materials Research

**Spokesperson:**
**Christina Trautmann**

**Topics**
- radiation hardness
- extreme conditions (p, T)
- geophysics
- nanoscience

## Biophysics

**Spokesperson:**
**Marco Durante**

**Topics**
- theranostics
- particle therapy
- space radiation protection

Collaboration/users
20 Countries
70 Institutes

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# Health in Deep Space

ROUGH GUIDES

1. Protection from space radiation
2. Psychosocial and behavioural problems
3. Physiological changes caused by microgravity

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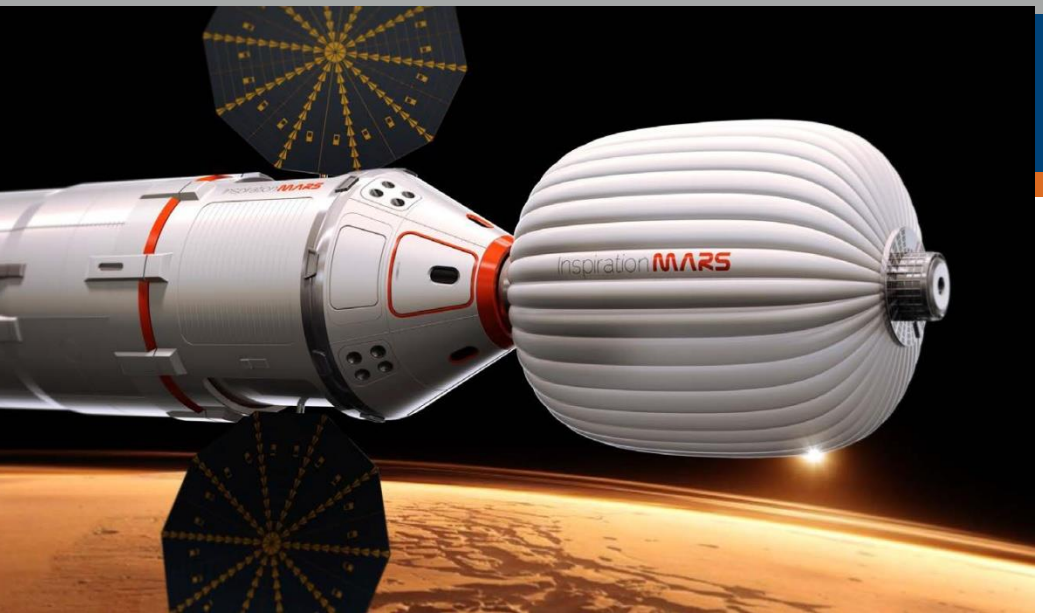
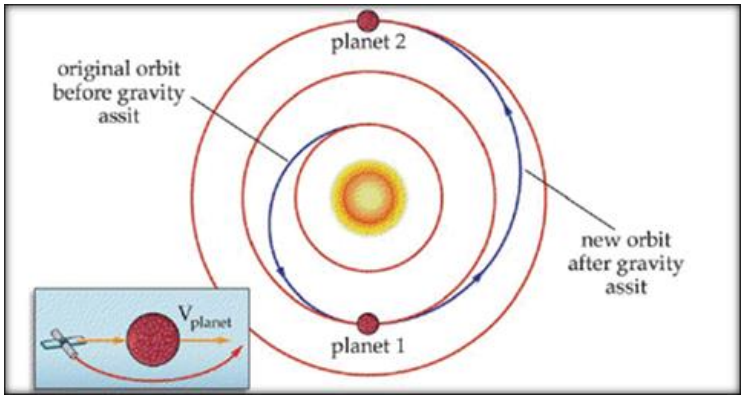



**Dennis Tito after his ISS mission in 2001**

Selected crew members for the 1-year mission (2015) aboard the International Space Station, U.S. Astronaut Scott Kelly (pictured top) and Russian Cosmonaut Mikhail Kornienko (pictured bottom).




2021 Mars flyby exploiting Venus gravity-assist

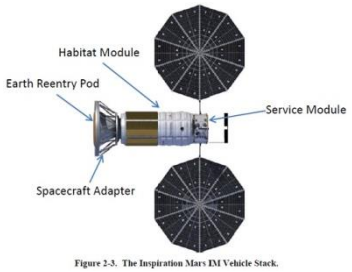


Figure 2-3. The Inspiration Mars IM Vehicle Stack.

The New York Times

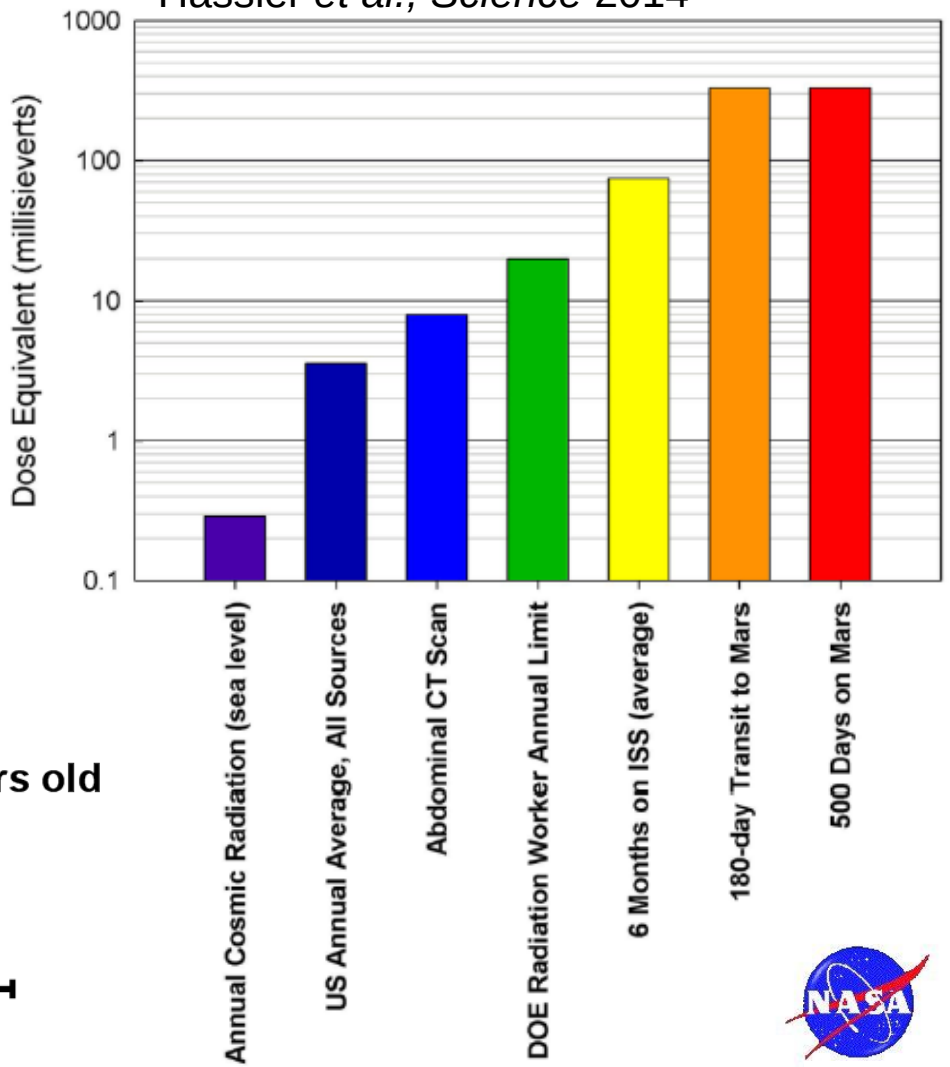
## Space & Cosmos

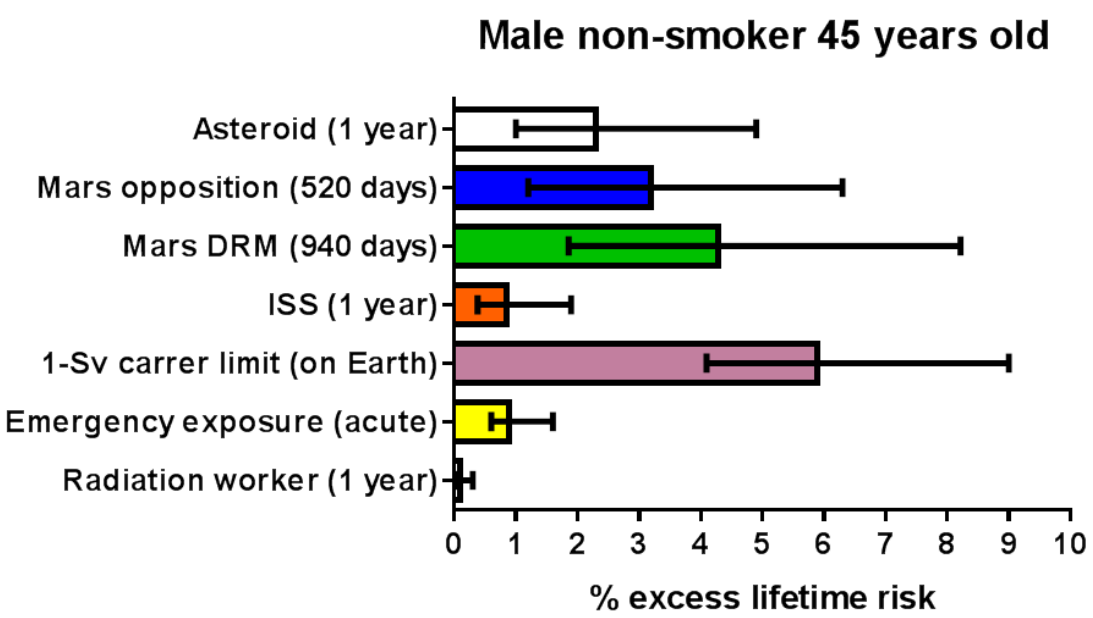
WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION

ENVIRONMENT | SPACE & COSMOS

### Data Point to Radiation Risk for Travelers to Mars

Hassler *et al.*, *Science* 2014




**NASA exposure limit: 3% lifetme excess risk within 95% CI**

# Galactic Cosmic Radiation

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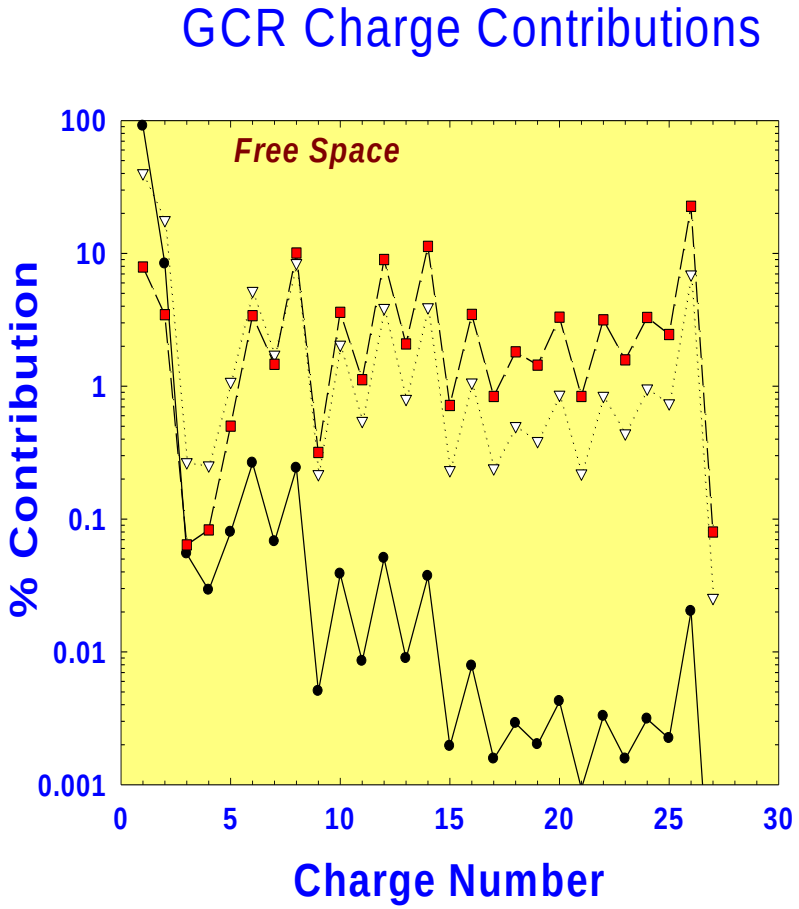


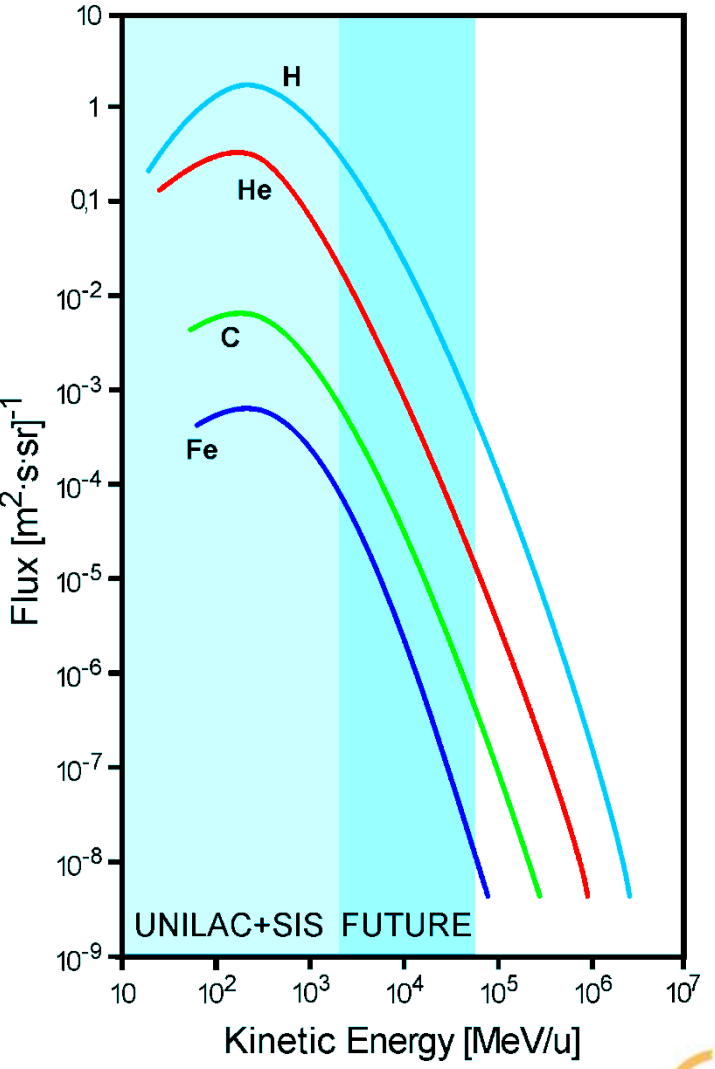


Durante & Cucinotta, *Nat. Rev. Cancer* 2008

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# Inauguration of the ESA Space Radiation Laboratory at GSI

IBER project supported by ESA – 2010-2013 at GSI future at FAIR

- Physics: shielding, fragmentation cross-sections, SEU
- Biology: cancer and noncancer late effects in cells, tissues, and animal models

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# Day-1 experiment

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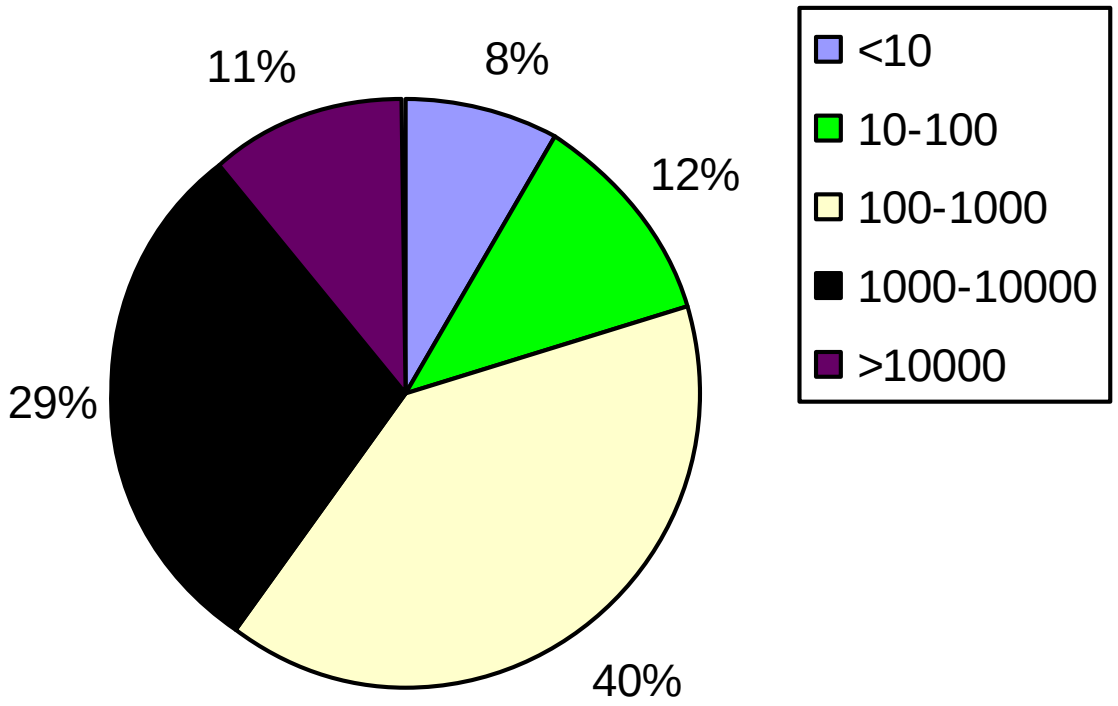


**GCR energy contributions to BFO dose equivalent in deep space behind 5 g/cm² Al (averaged over 1 year at solar minimum) – energies for all ions in MeV/n**

Day-1: irradiation of human cells/tissue and mice with 10 GeV/n H and Fe-ions – first measurements of the biological effectiveness in this energy range

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# Radiotherapy at FAIR?

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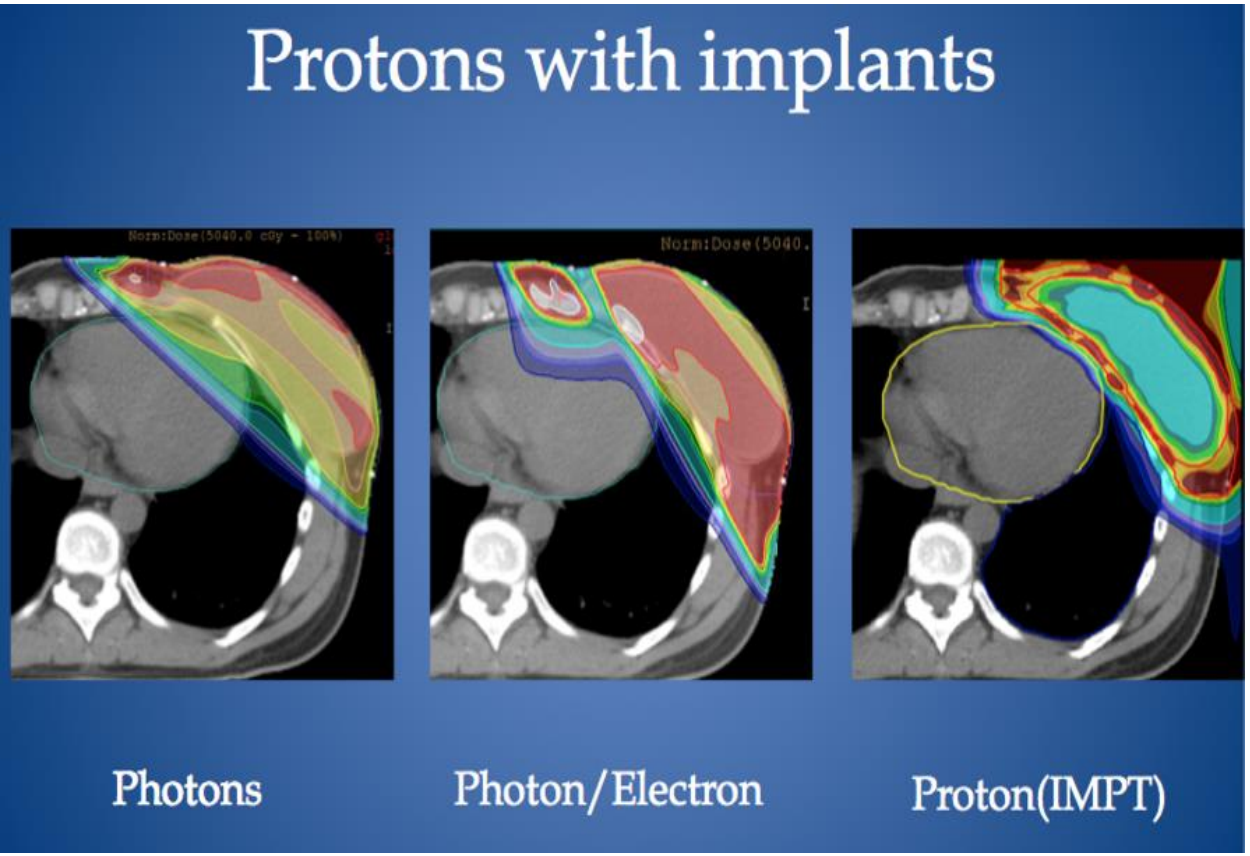
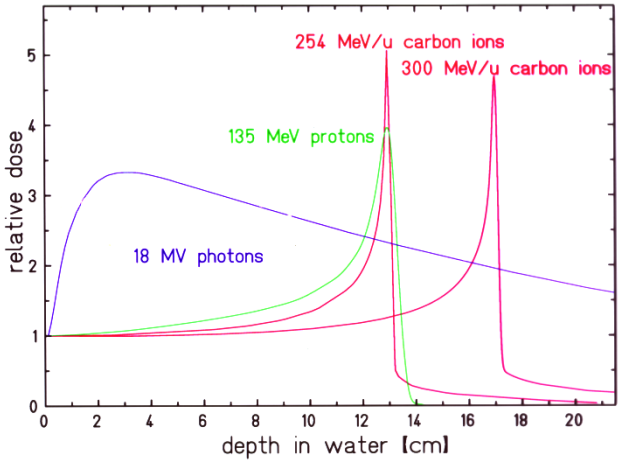
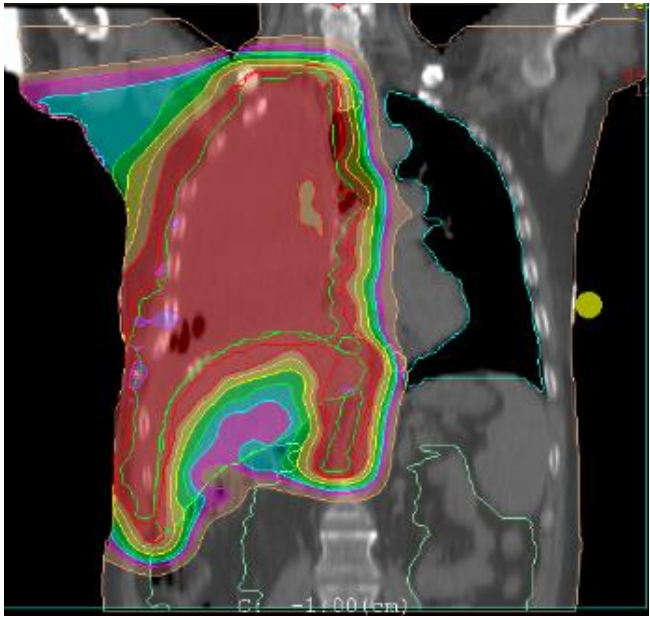
13.12.2007 – last patient treated at GSI

# The adavantages (and disadvantages) of the Bragg peak




Breast cancer



Pleural mesothelioma

# Range uncertainty

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# Range verification

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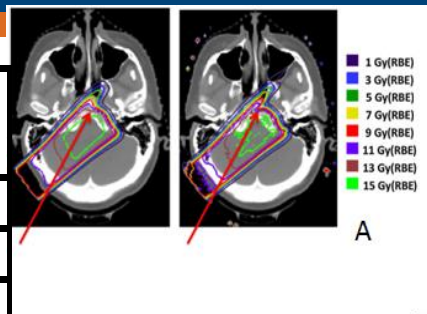
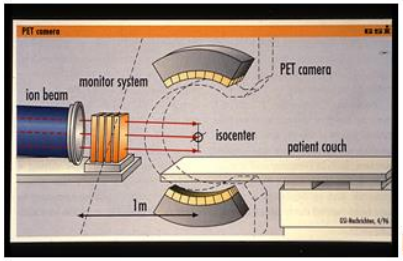
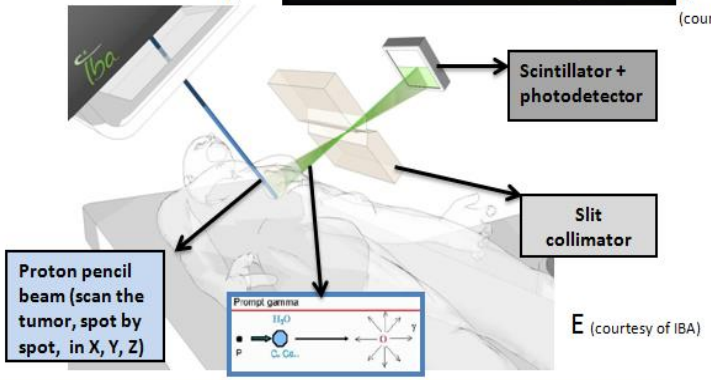
| Source of range uncertainty in the patient | Range uncertainty |
|---|---|
| **Independent of dose calculation:** | |
| Measurement uncertainty in water for commissioning | ± 0.3 mm |
| Compensator design | ± 0.2 mm |
| Beam reproducibility | ± 0.2 mm |
| Patient setup | ± 0.7 mm |
| **Dose calculation:** | |
| Biology (always positive) | + 0.8 % |
| CT imaging and calibration | ± 0.5 % |
| CT conversion to tissue (excluding I-values) | ± 0.5 % |
| CT grid size | ± 0.3 % |
| Mean excitation energies (I-values) in tissue | ± 1.5 % |
| Range degradation; complex inhomogeneities | - 0.7 % |
| Range degradation; local lateral inhomogeneities * | ± 2.5 % |
| **Total (excluding *)** | **2.7% + 1.2 mm** |
| **Total** | **4.6% + 1.2 mm** |

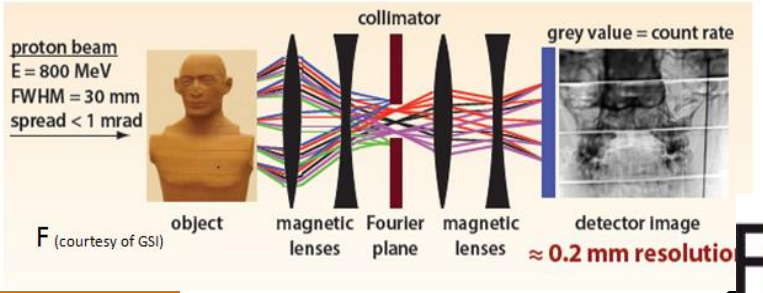
NuPECC report „Nuclear Physics in Medicine“, 2014





# Particle theranostics

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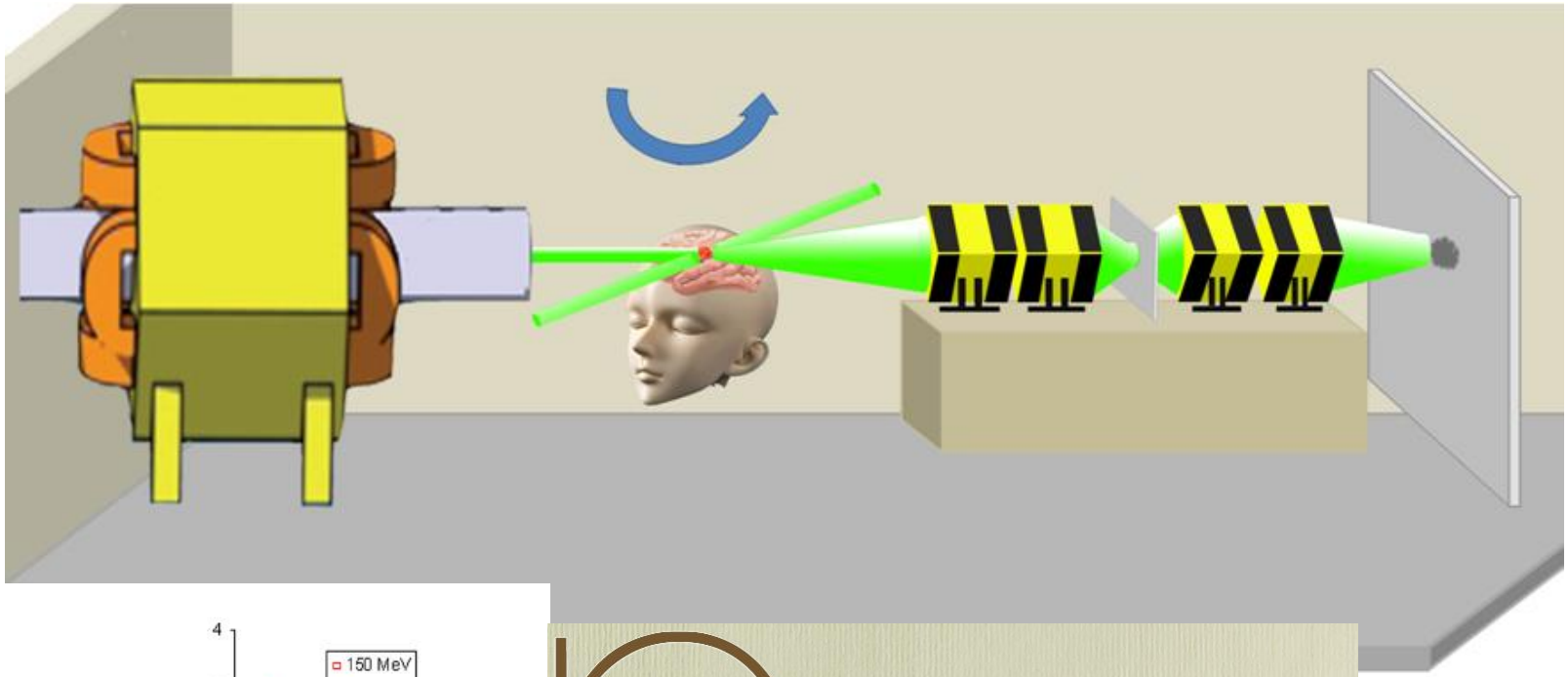

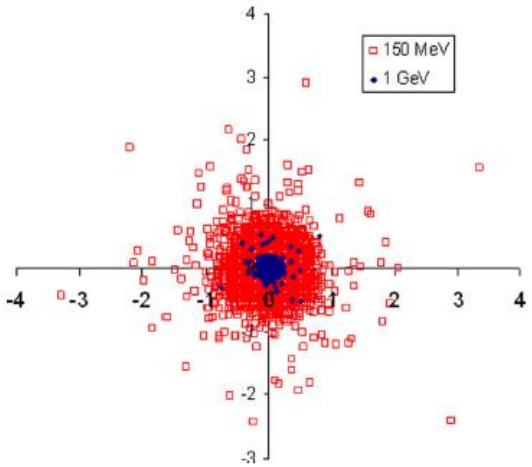


PaNTERA
Proton Therapy and Radiography

APPA

lantera

Biophysics
+
Plasma Physics

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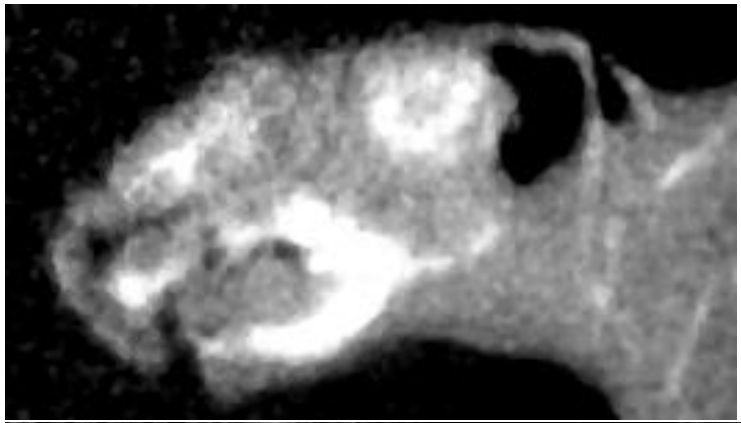
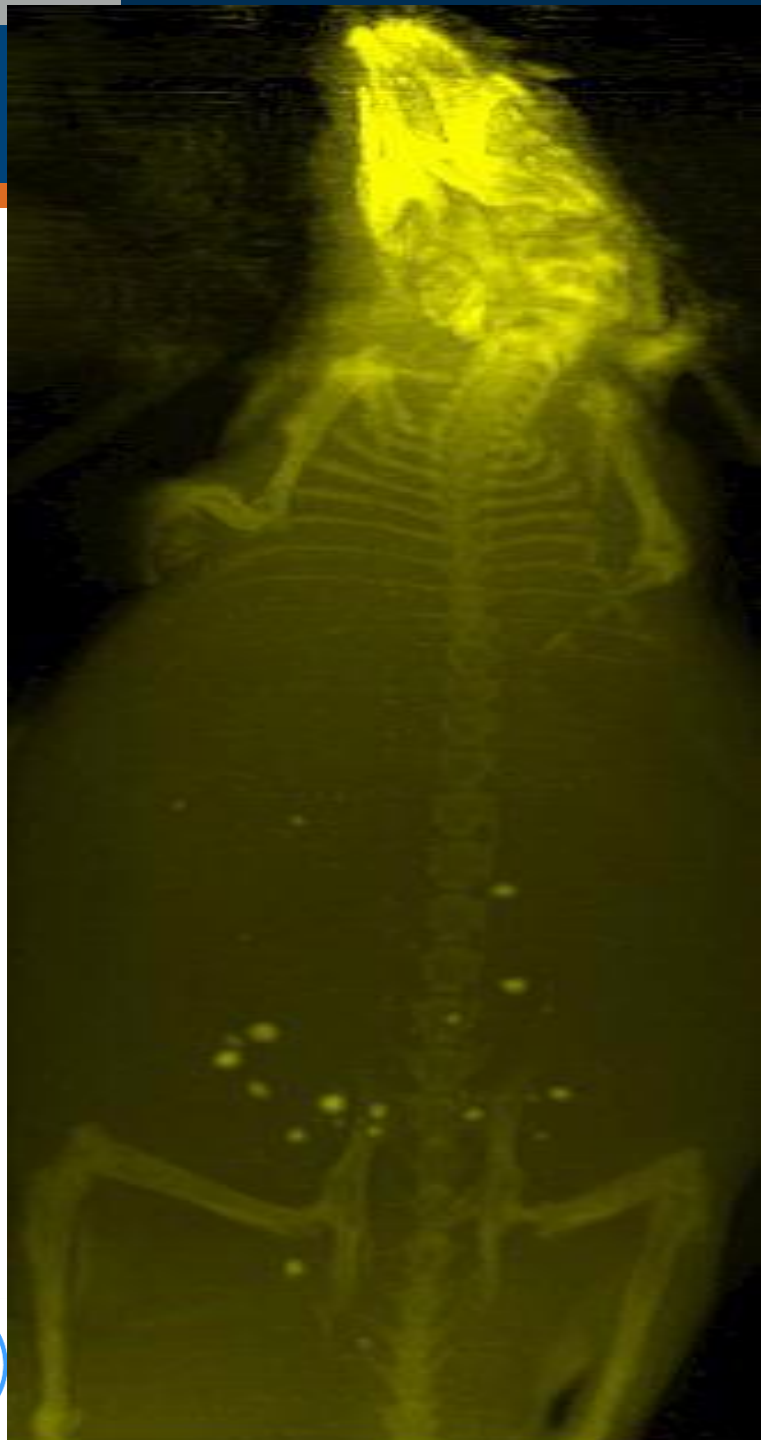
# Mouse Proton Tomography

## 800 MeV proton beam at LANL





GSI Los Alamos NATIONAL LABORATORY TECHNISCHE UNIVERSITÄT DARMSTADT FAIR

# Proton Tomography
## Comparison with state of the art X-ray CT

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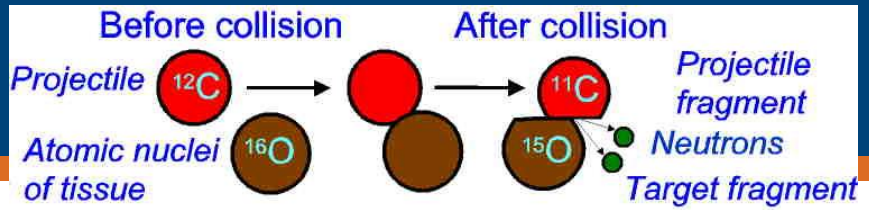
**proton CT**

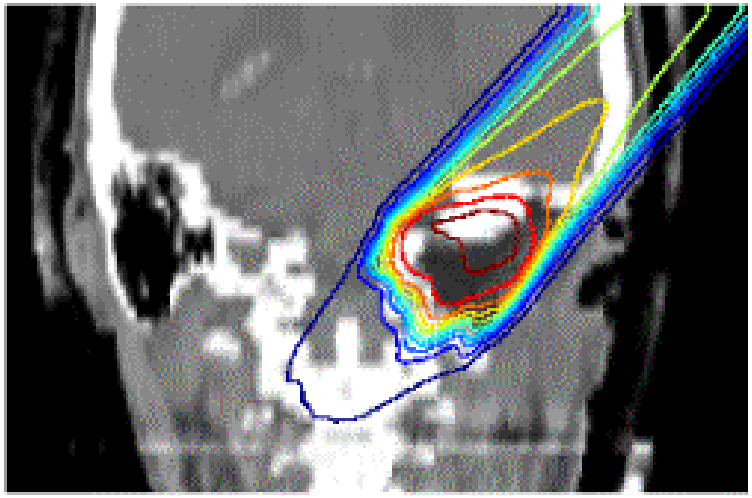
- CT algorithm from textbook
- C codes from scratch
- intermediate result

**X-ray CT**

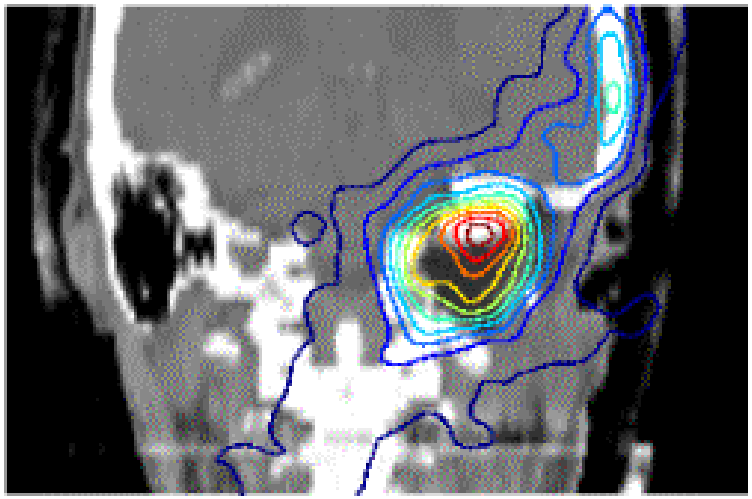
- Siemens Biograph™ TruePoint™
- > 30 years development

# In situ control with PET

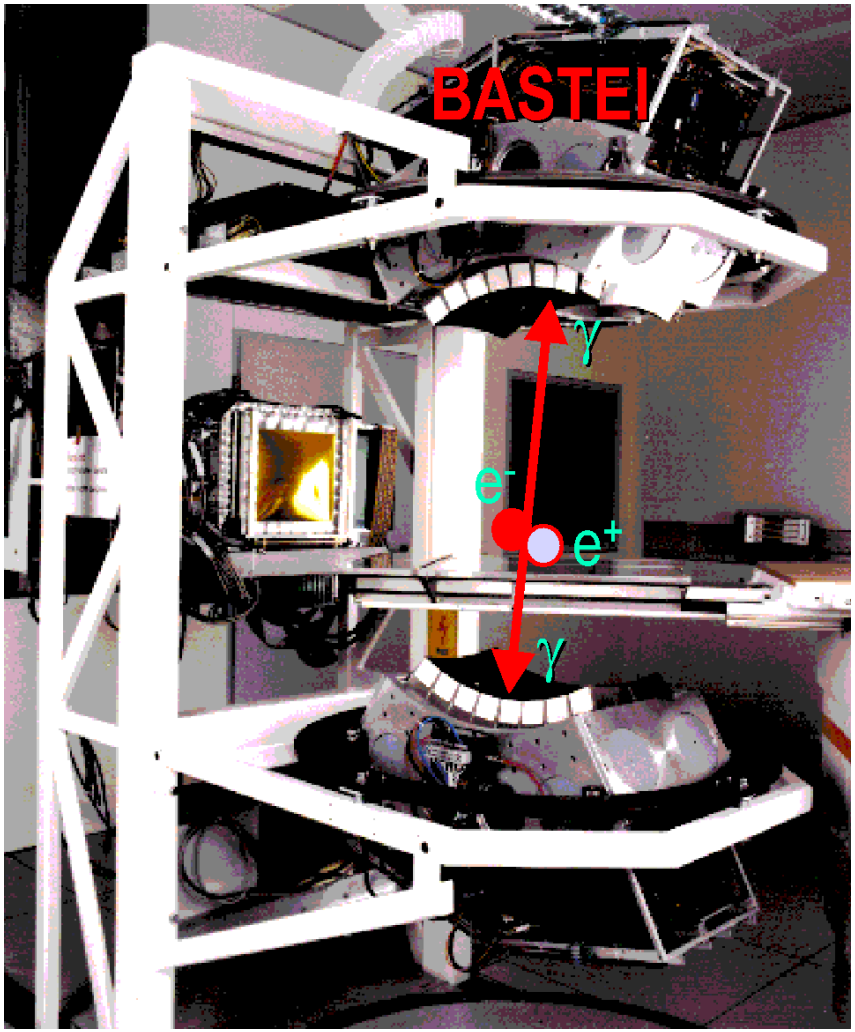


dose plan



measured




Courtesy of Wolfgang Enghardt, HZDR, Dresden

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## Biophysics Department

M. Durante (Director)

G. Kraft (Helmholtz Professor)

G. Taucher-Scholz (DNA damage)

S. Ritter (Stem cells)

C. Fournier (Late effects)

W. Kraft-Weyrather (Clinical radiobiology)

M. Scholz (Biophysical modelling)

M. Krämer (Treatment planning)

C. Bert (Moving targets)

C. La Tessa (Dosimetry)

Thank you very much!

http://www.gsi.de/biophysik/