

BIOMAT@APPA Cave

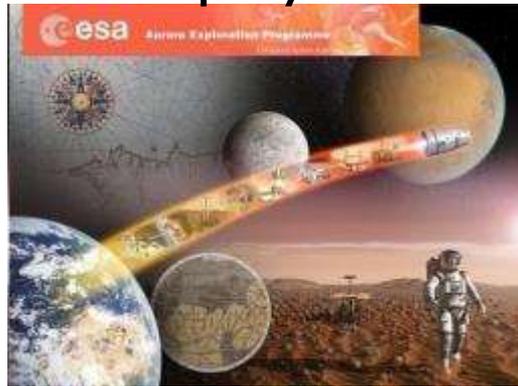


Beamline infrastructure and advanced instrumentation





Biophysics



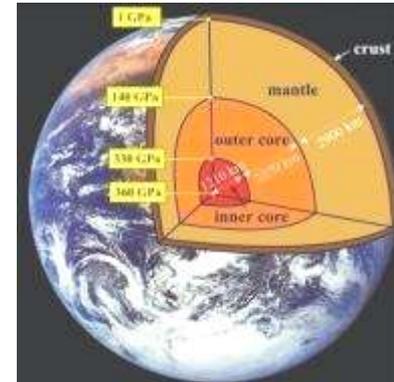
Cosmic radiation: the main hindrance toward manned space exploration

Widely unknown **biological effects** of heavy ions

NASA and ESA started a large experimental campaign in **space radiation biophysics**

Particle Therapy

Materials Research

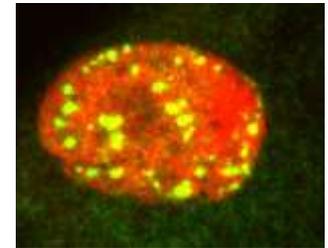
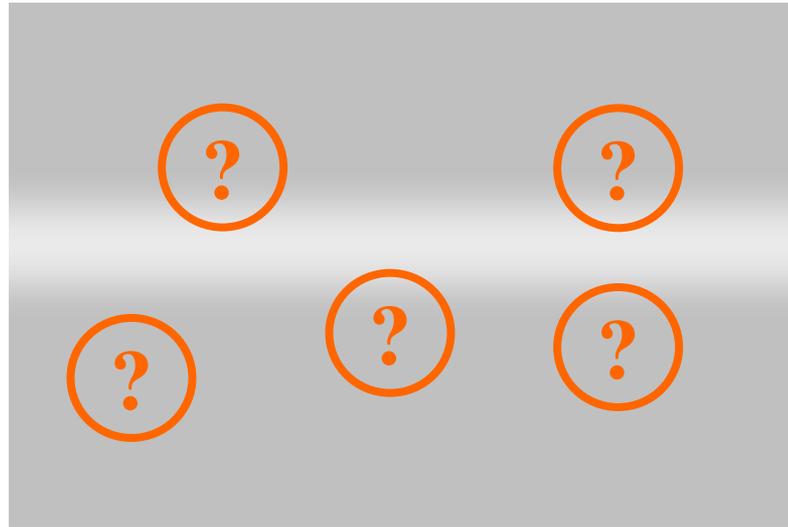


Radiation effects under high pressure: phase transitions in mineralogy and geophysics

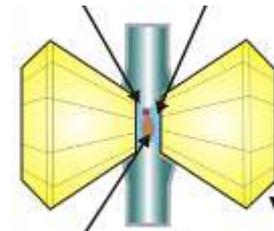
Ion-matter interaction at relativistic beam energies: **energy-deposition and short-time processes**

Radiation hardness of materials: **requirements for accelerator and spacecraft-components**

General experimental setup



Target



Existing beamlines for BIOMAT research activities

M-Branch

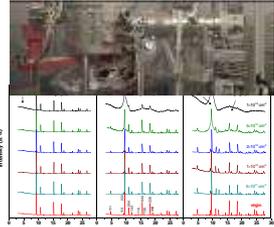
In-situ and On-line Analysis of Irradiated Material

M1
Microscopy



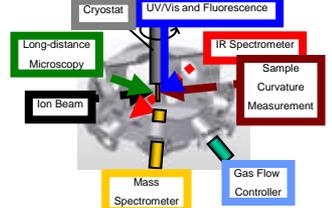
University of Stuttgart
University of Duisburg Essen

M2
X-Ray Diffraction



Helmholtzzentrum Berlin / GSI

M3
Multi-Analysis Chamber



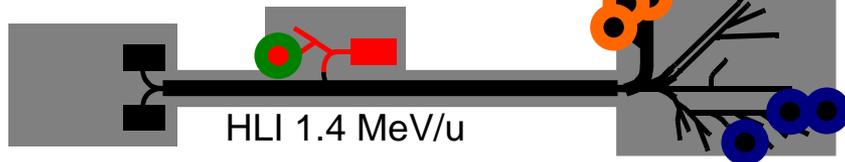
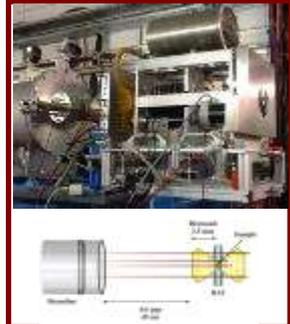
Universities of Darmstadt, Dresden
Göttingen, Jena, Heidelberg

SIS
up to
1 GeV/u

Cave M
Medical Cave



Cave A
Irradiation Cave



UNILAC

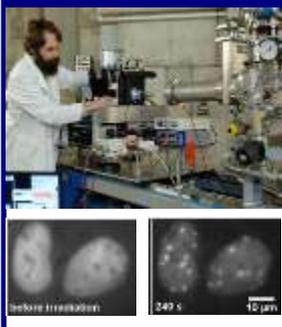
3.6-11.4 MeV/u

Range ~ 100µm

X0
Autosampler



X6
Cell irradiation



Microprobe
Single Ion Control

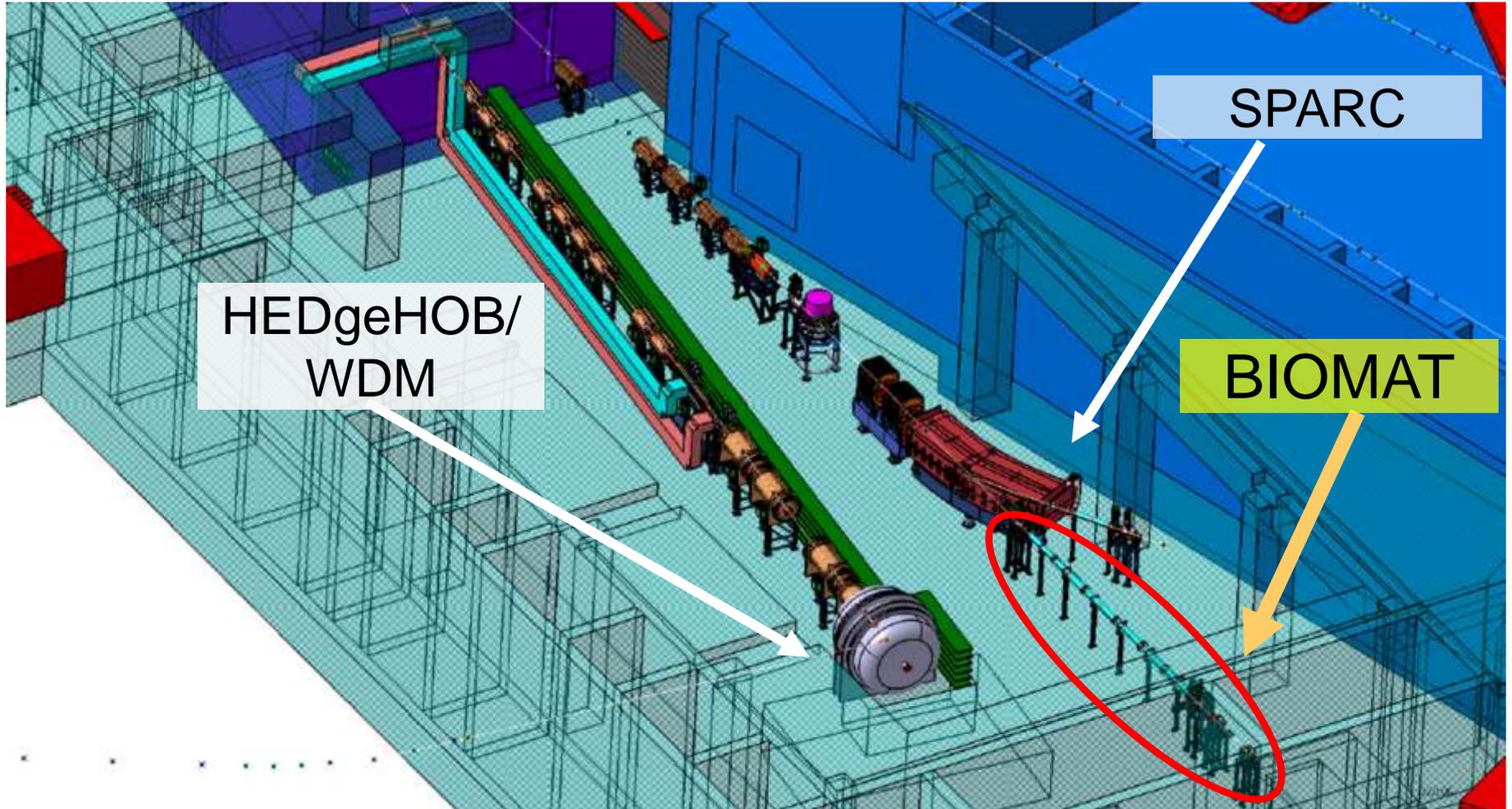


Beam requirements for future user facility



Beam parameters		
Ion type	Protons - Uranium	
Time structure	slow extraction	fast extraction
Number of ions per pulse	up to 10^9	up to 5×10^{10}
Energy range [GeV/u]	0.1-10	
Pulse length [s]	1-10	minimum
Beam spot radius [mm]	min. - 20	

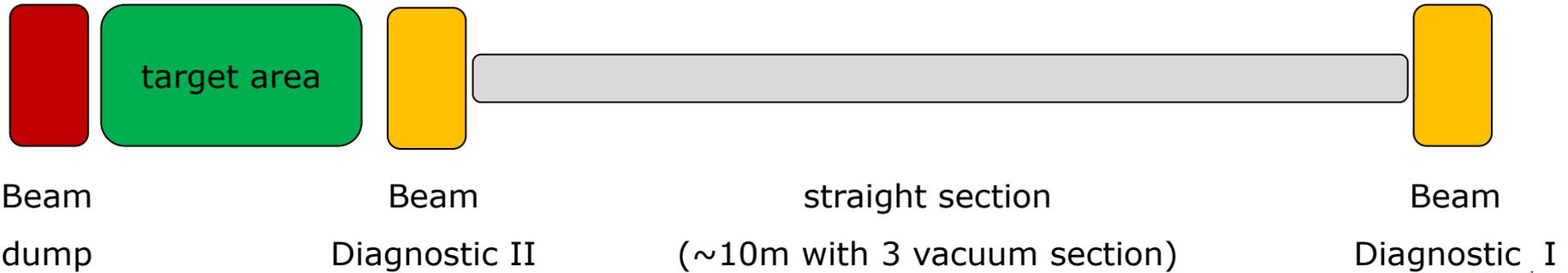
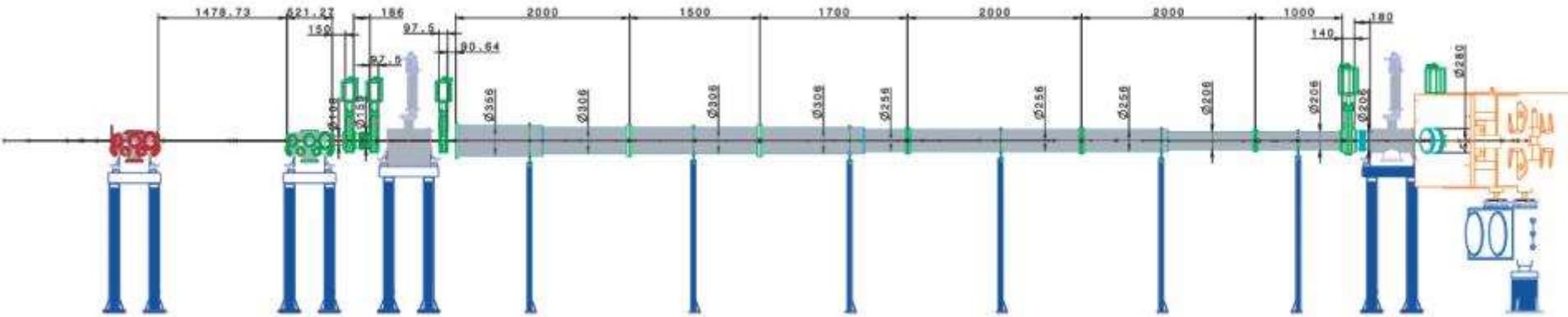
BIOMAT beamline





Experiment

SIS 100 beam



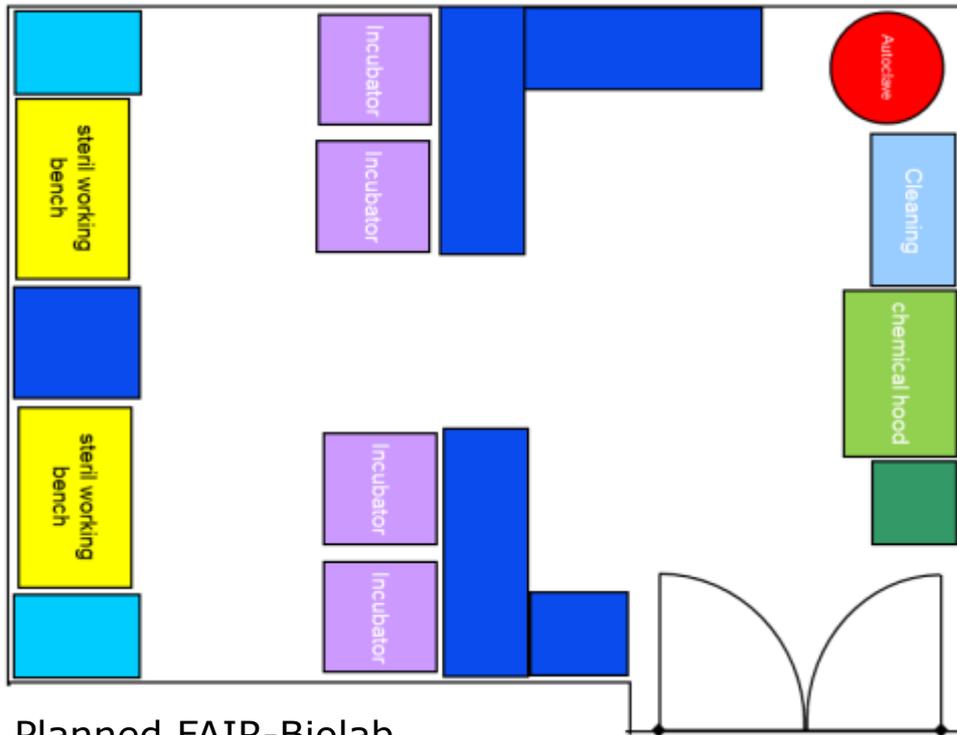
Bio-experiments require Bio-Laboratories



- very close to the irradiation facility
- preparation of biological samples before irradiation and analysis of the samples after irradiation
- equipped with incubators, laminar flow boxes, Coulter counters, microscopes, etc.



T. Reiter (ESA) visiting GSI in 2013



New ESA-Biolabs at GSI

Animal facility

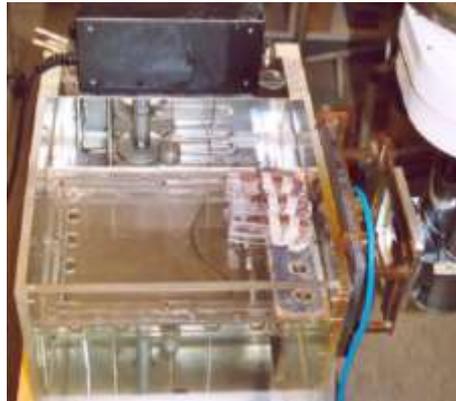
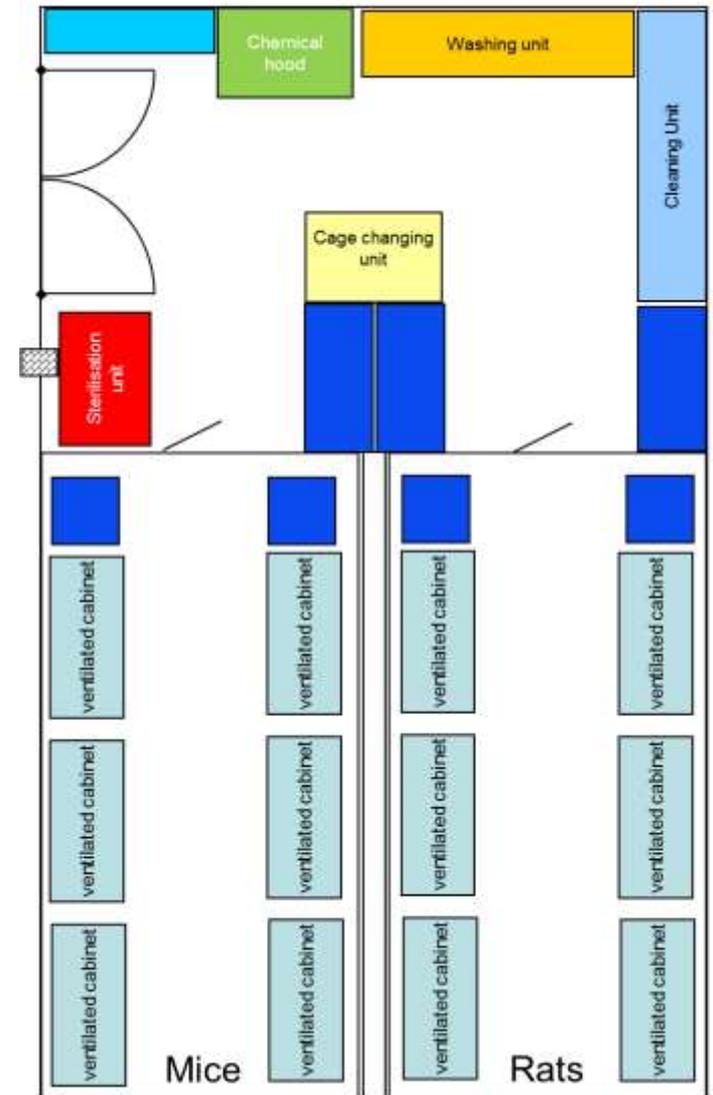


Holding rooms

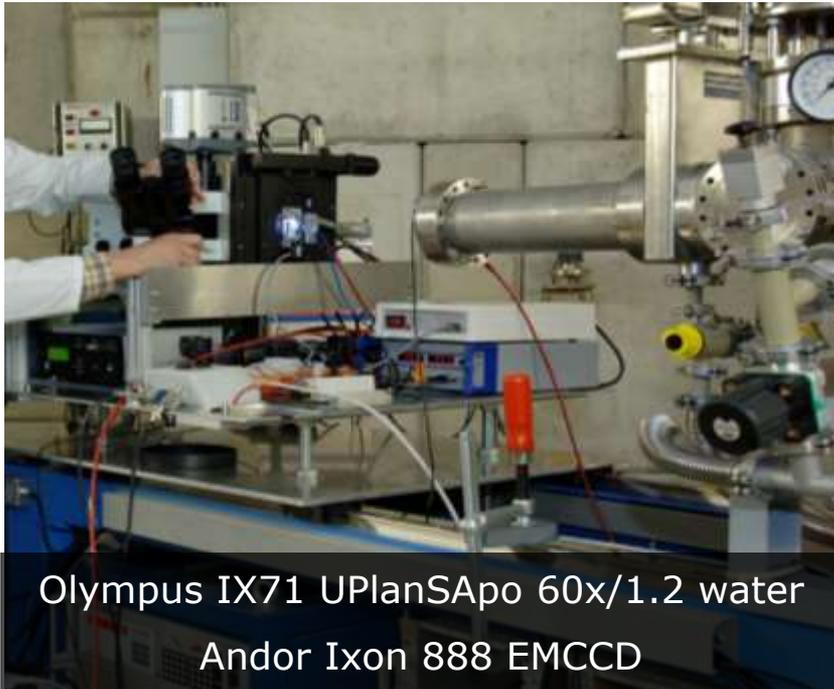
- Keeping of animals – planned 2 rooms (mice/rats)
- located very close to the irradiation facility and biological labs
- equipped with ventilated and independent lighted holding cabinets to keep mice or rats

Preparation room

- Care-taking unit for prearrangement before and post-processing after irradiation
- including cage changing stations and cage cleaning facility

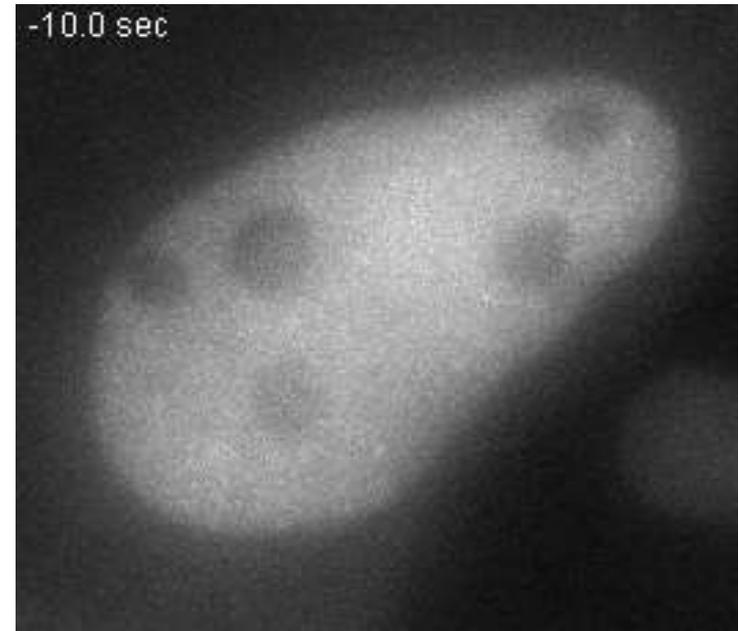


Real time repair protein recruitment in living cells: Beamline Microscopy



Olympus IX71 UPlanSApo 60x/1.2 water
Andor Ixon 888 EMCCD

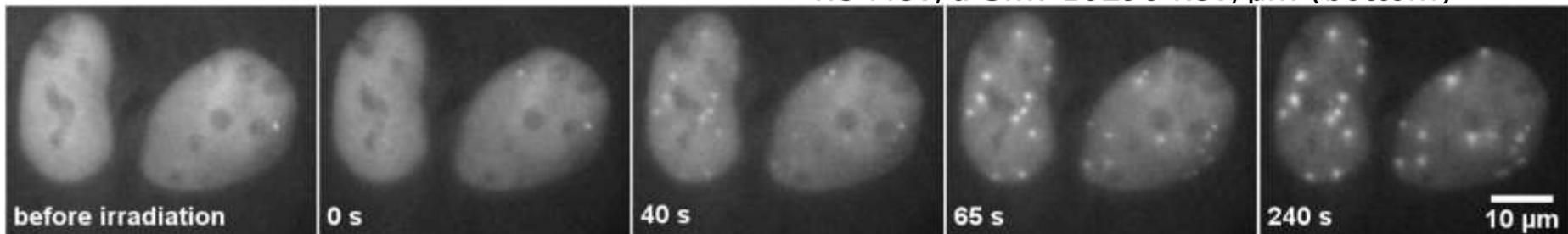
B. Jakob GBS/DNA-Repair , Sept 2012



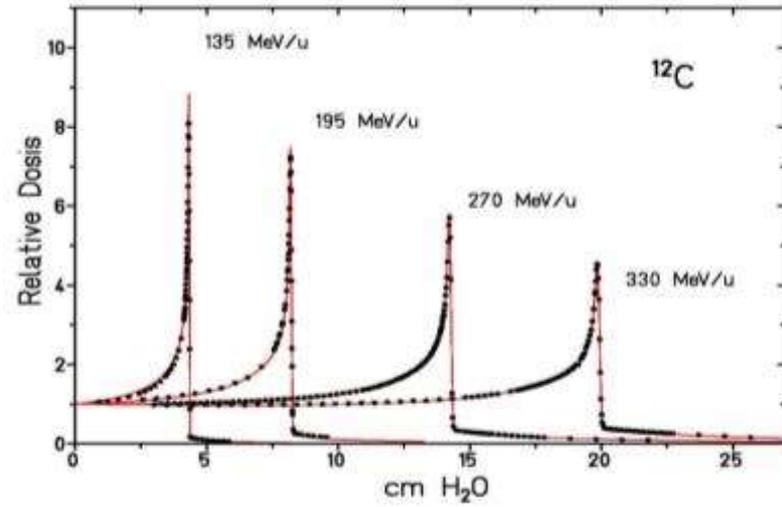
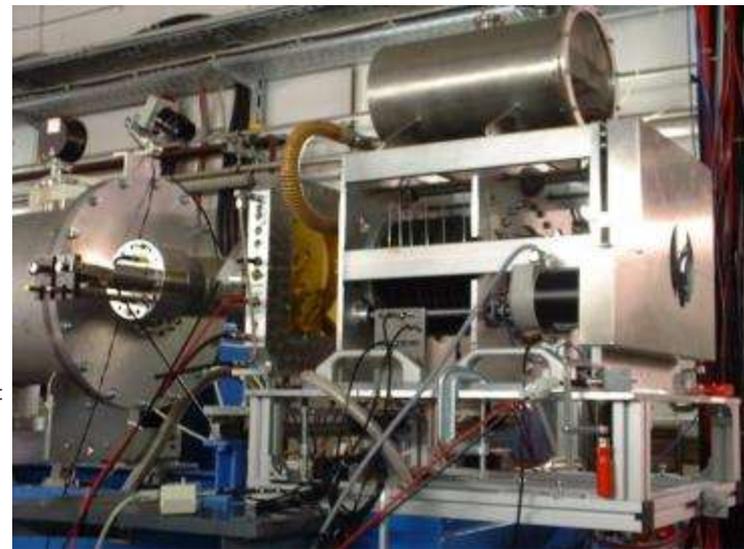
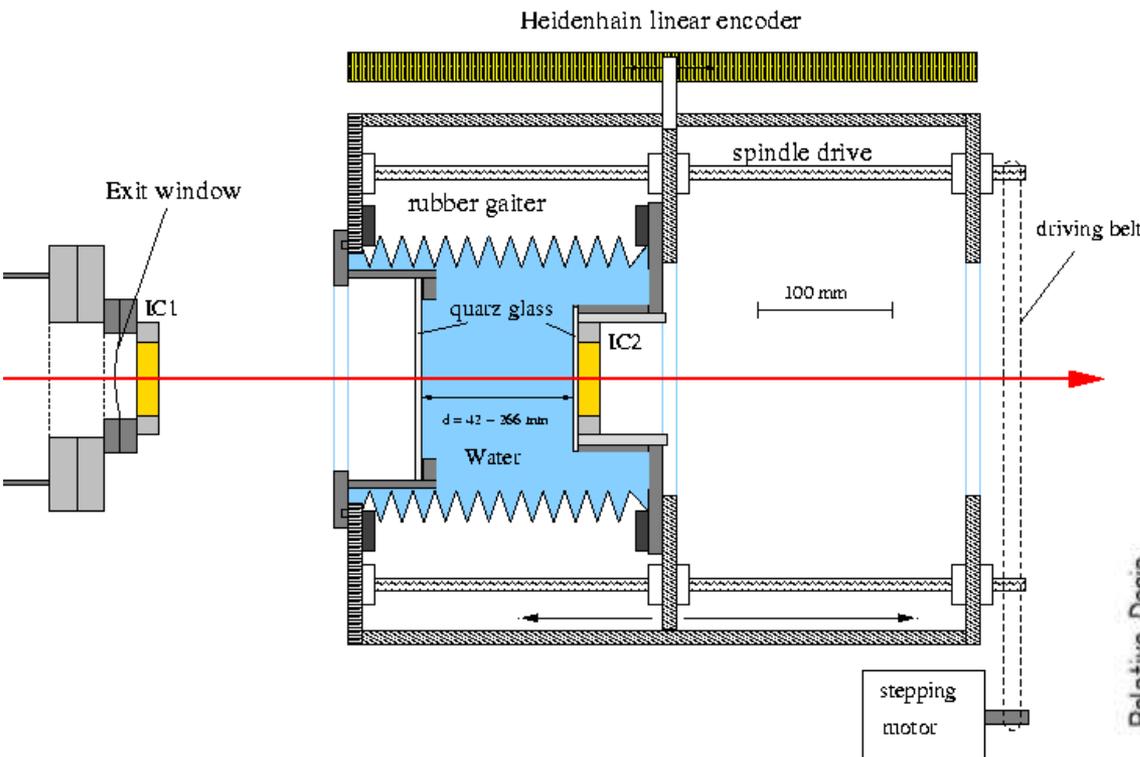
U2O2-NBS1-GFP

1GeV/u Fe: 150 keV/ μm (top)

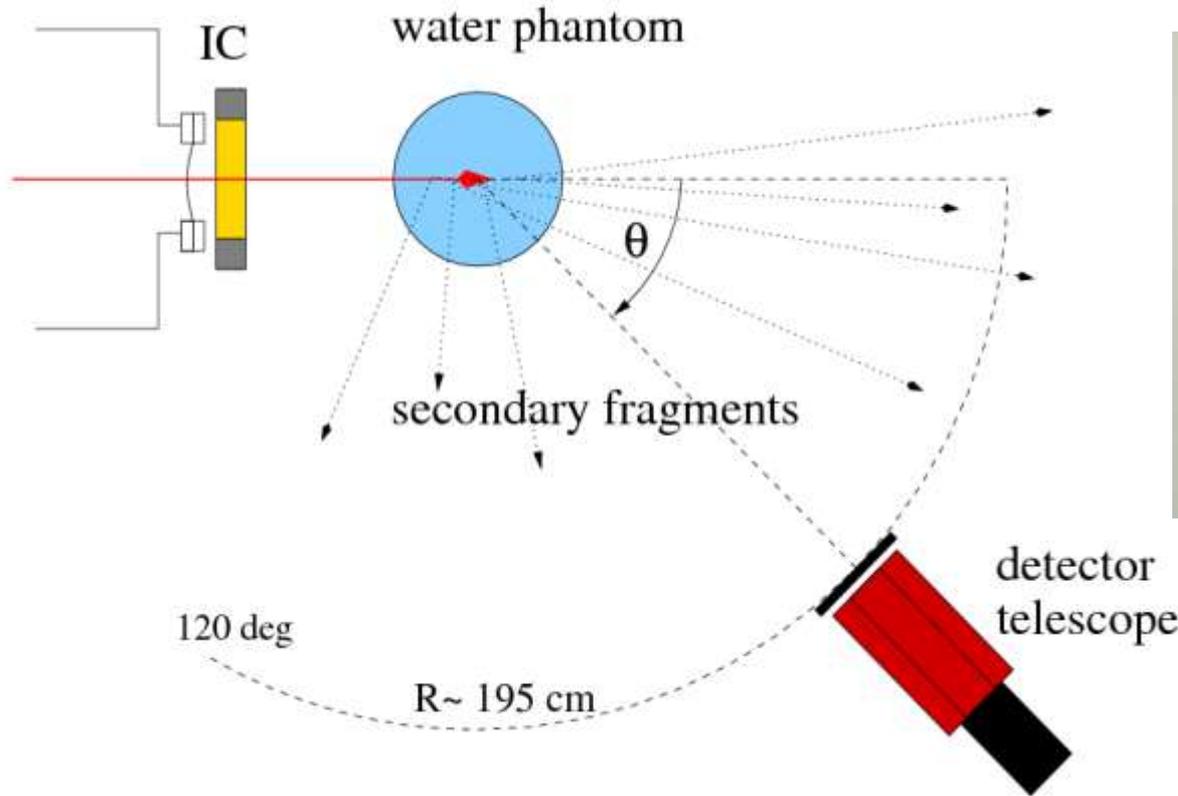
4.5 MeV/u Sm: 10290 keV/ μm (bottom)



Precision Bragg curve measurements



Projectile fragmentation using thick water targets



The ΔE -E telescope detector

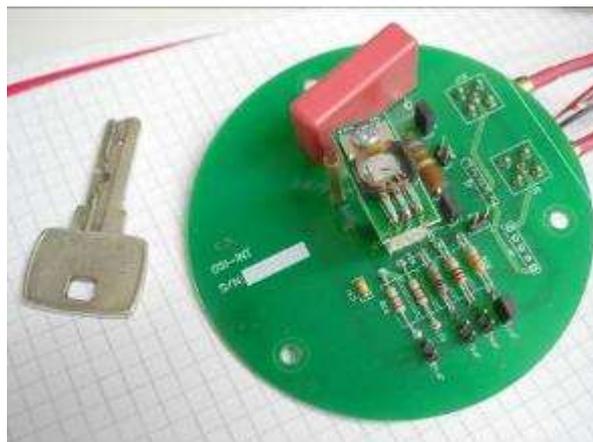
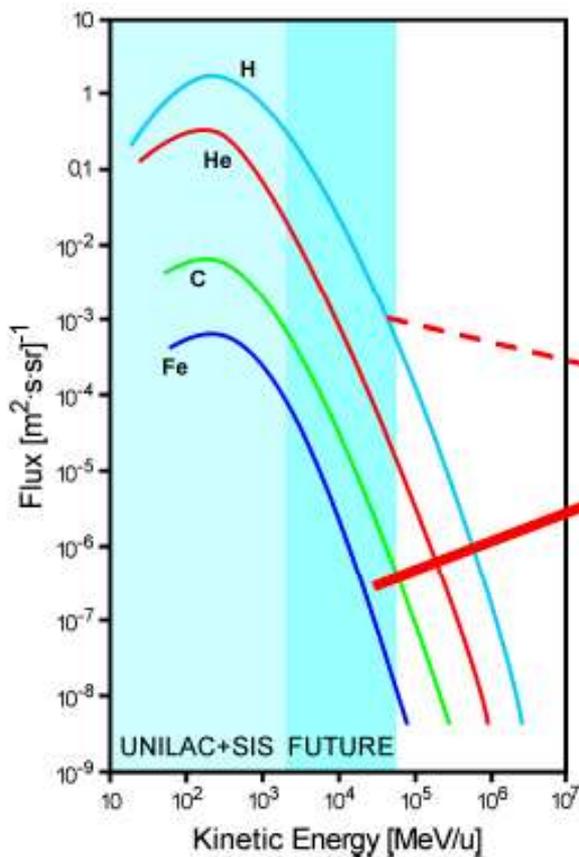
Angular distribution setup

- Cylindrical water target (adjustable water thickness)
- Telescope positioned at $0^\circ \dots 120^\circ$

Simulation of galactic cosmic rays



Single event upset tests (SEU)



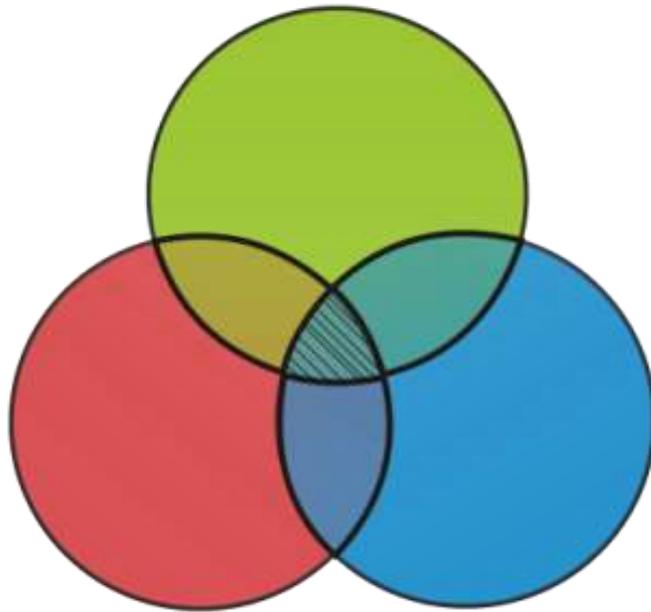
Instrument calibration



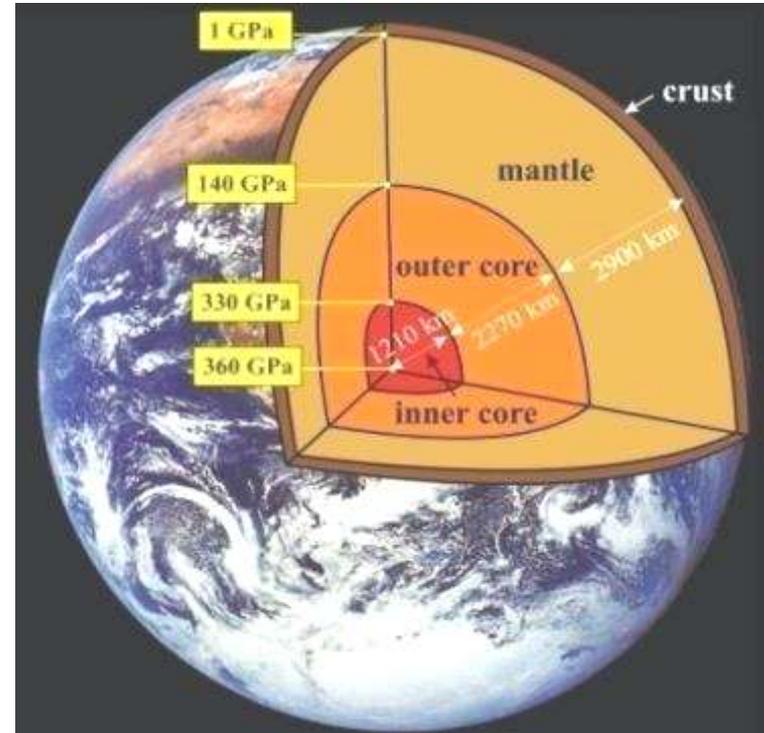
Alpha Magnetic Spectrometer (AMS)

Materials science: Materials under extreme conditions

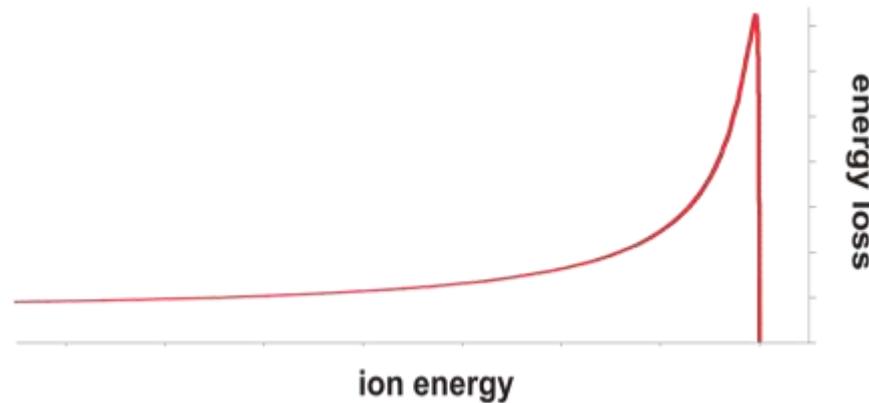
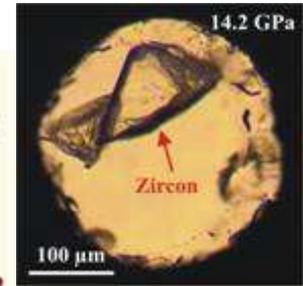
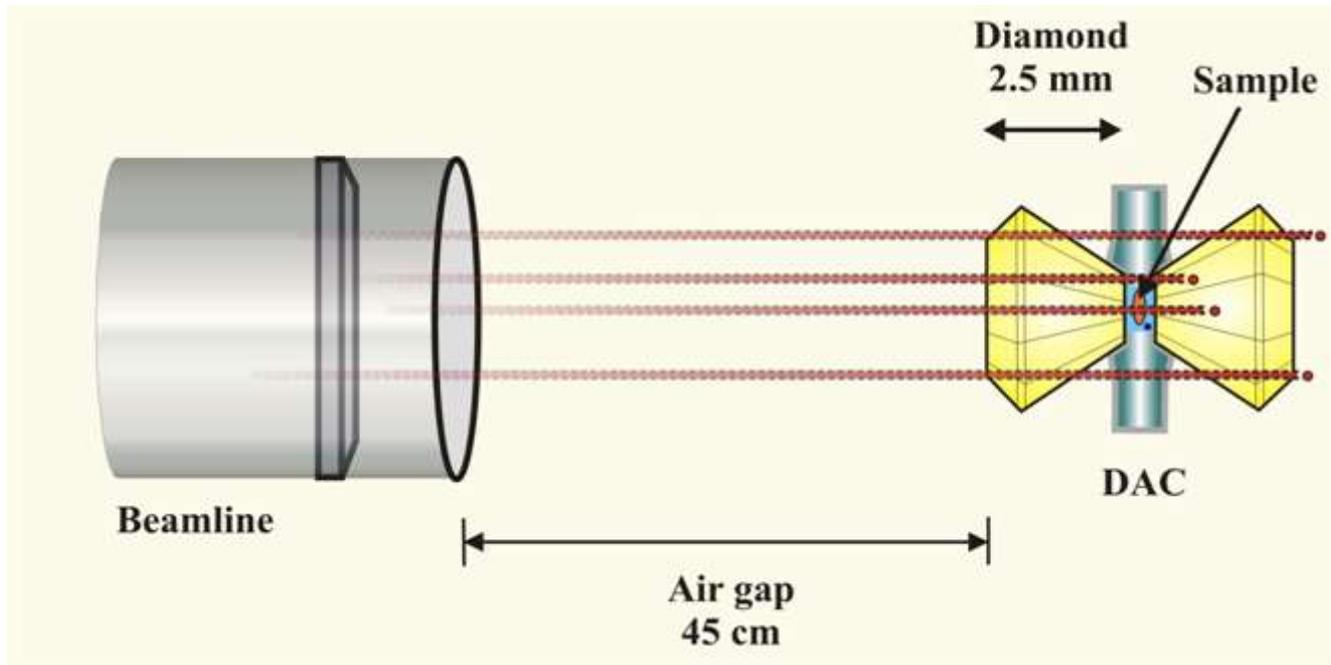
pressure



temperature irradiation



Irradiation of material under extreme pressure



Monitoring of ion-beam effects by on-line spectroscopy

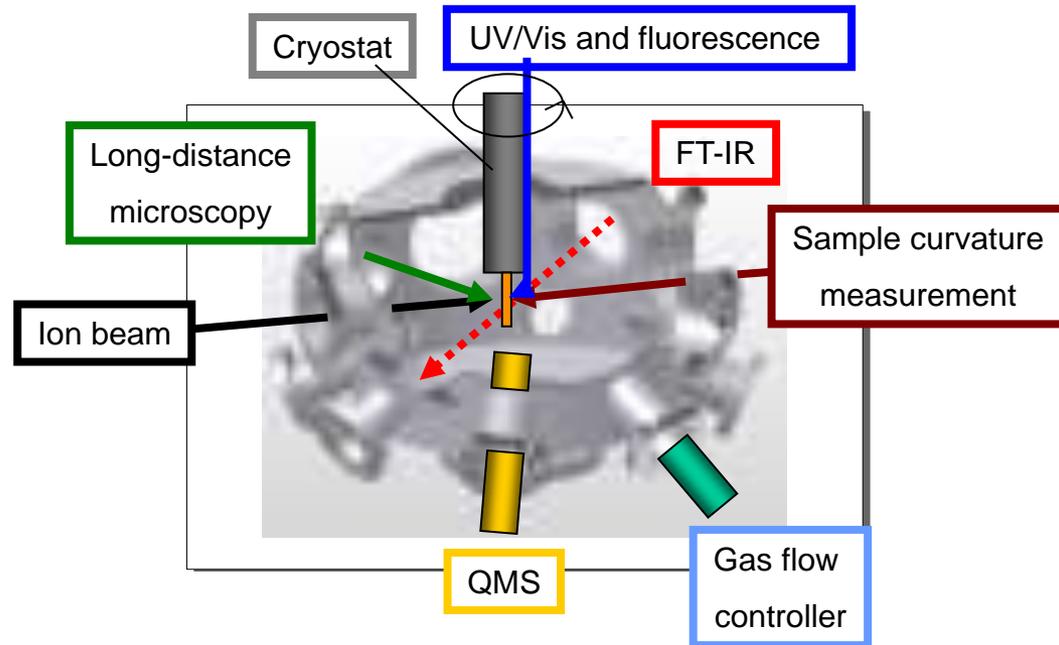
On-line Raman spectrometer

commissioned Sep. 2014 @ GSI M3



Multi-purpose setup @ UNILAC M-branch

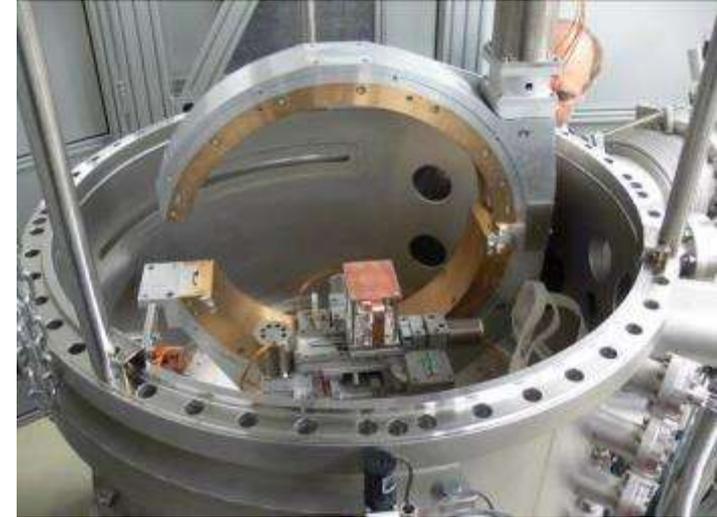
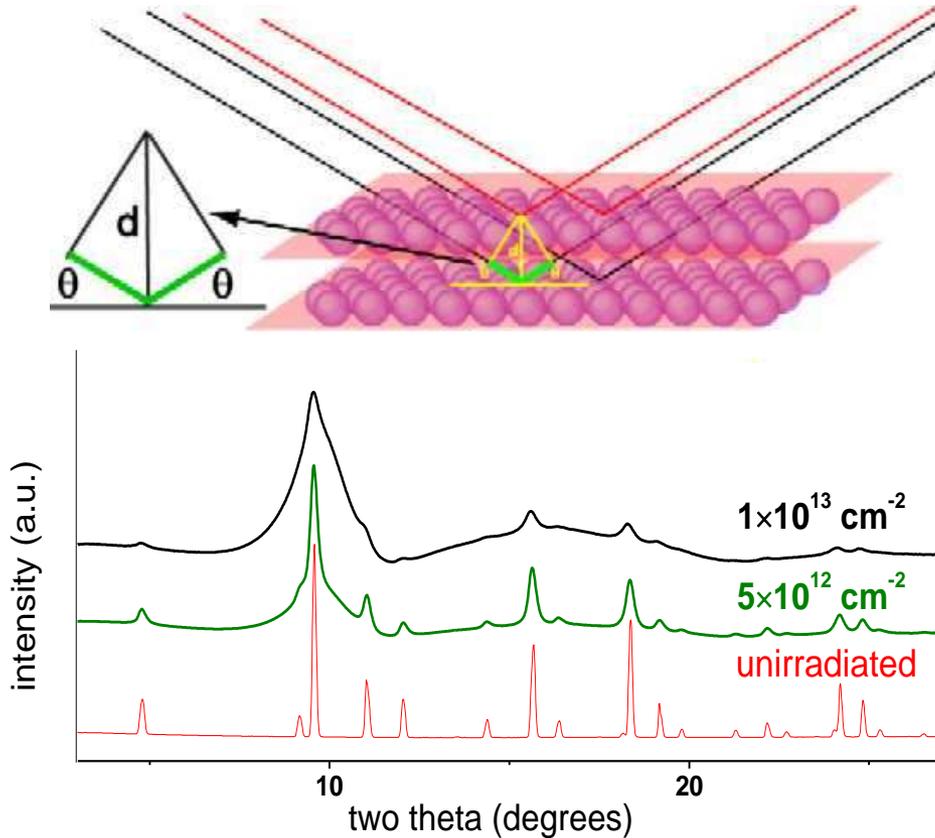
combined setup 5 Verbundforschungs projects
(Darmstadt, Göttingen, Heidelberg, Jena, Dresden)



RUPRECHT-KARLS-
UNIVERSITÄT
HEIDELBERG

Prof. U. Glasmacher

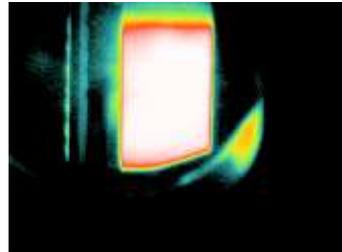
Monitoring of structural changes by x-ray diffraction



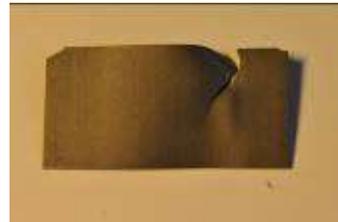
- Amorphisation
- Formation of new ion-beam induced phases
- Special orientation texturing

- SEIFERT 4-circle x-ray diffractometer (Cu-K α)
- Position sensitive detector
- Investigation under any angle of incidence enables the quantitative analysis of structural modifications

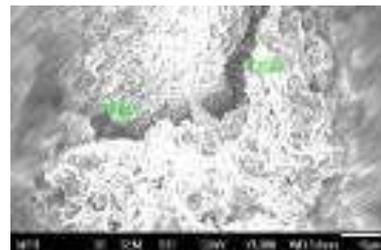
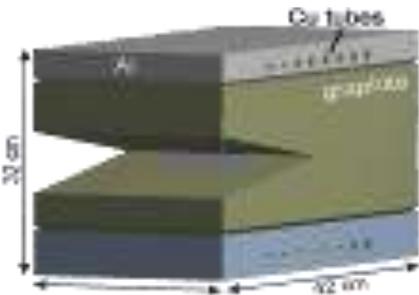
Radiation hardness of functional materials & components



In-beam thermal imaging

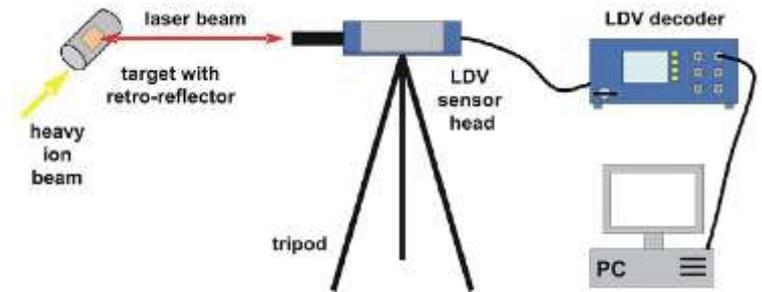


severe swelling and irradiation-induced stresses



Thermal stress induced crack

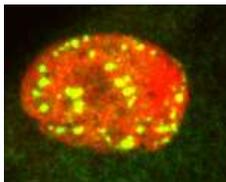
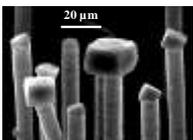
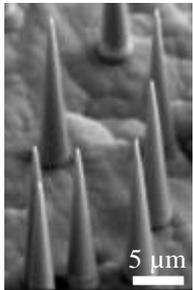
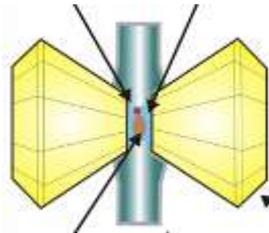
Experiment with fast-extracted beams: monitoring surface vibrations of graphite target



Summary



- world-wide **unique target station** for materials and biological samples
- **in-situ or on-line methods** for sample modifications caused by the beam
- **infrastructure** for sample preparation and post-analysis



BIOMAT Community at GSI



Biophysics department
Marco Durante



Materials Research department
Christina Trautmann

