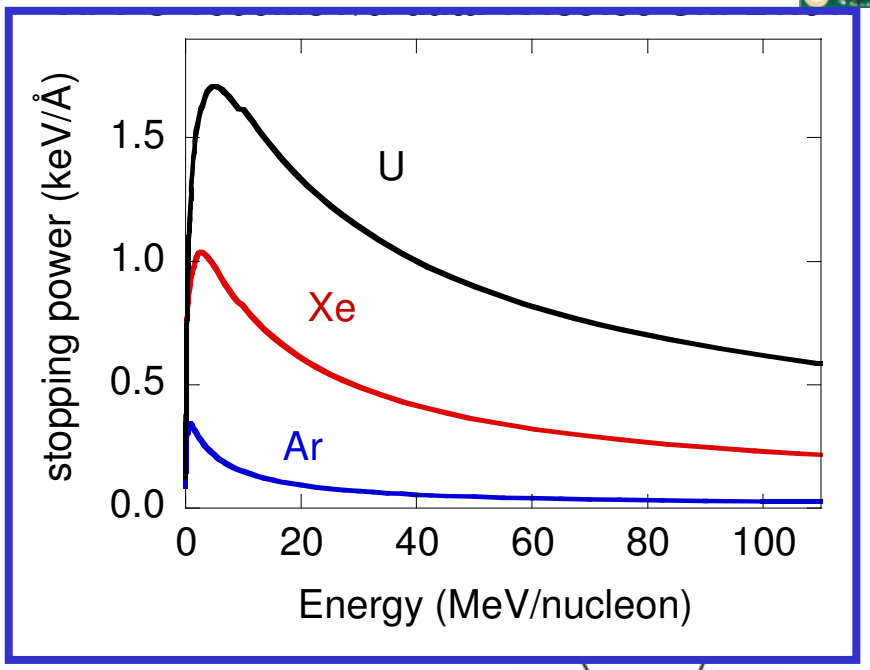
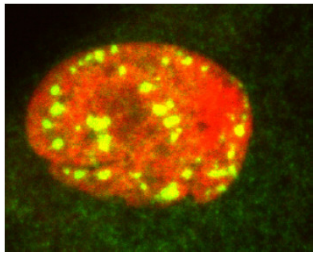
Beam requirements

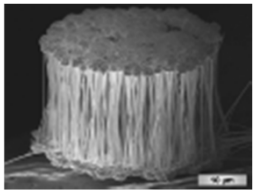
BIOMAT

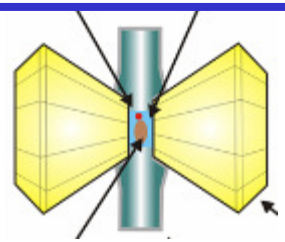
in focus: a universal user facility for irradiation experiments for Biophysics and Materials Research

General experimental setup



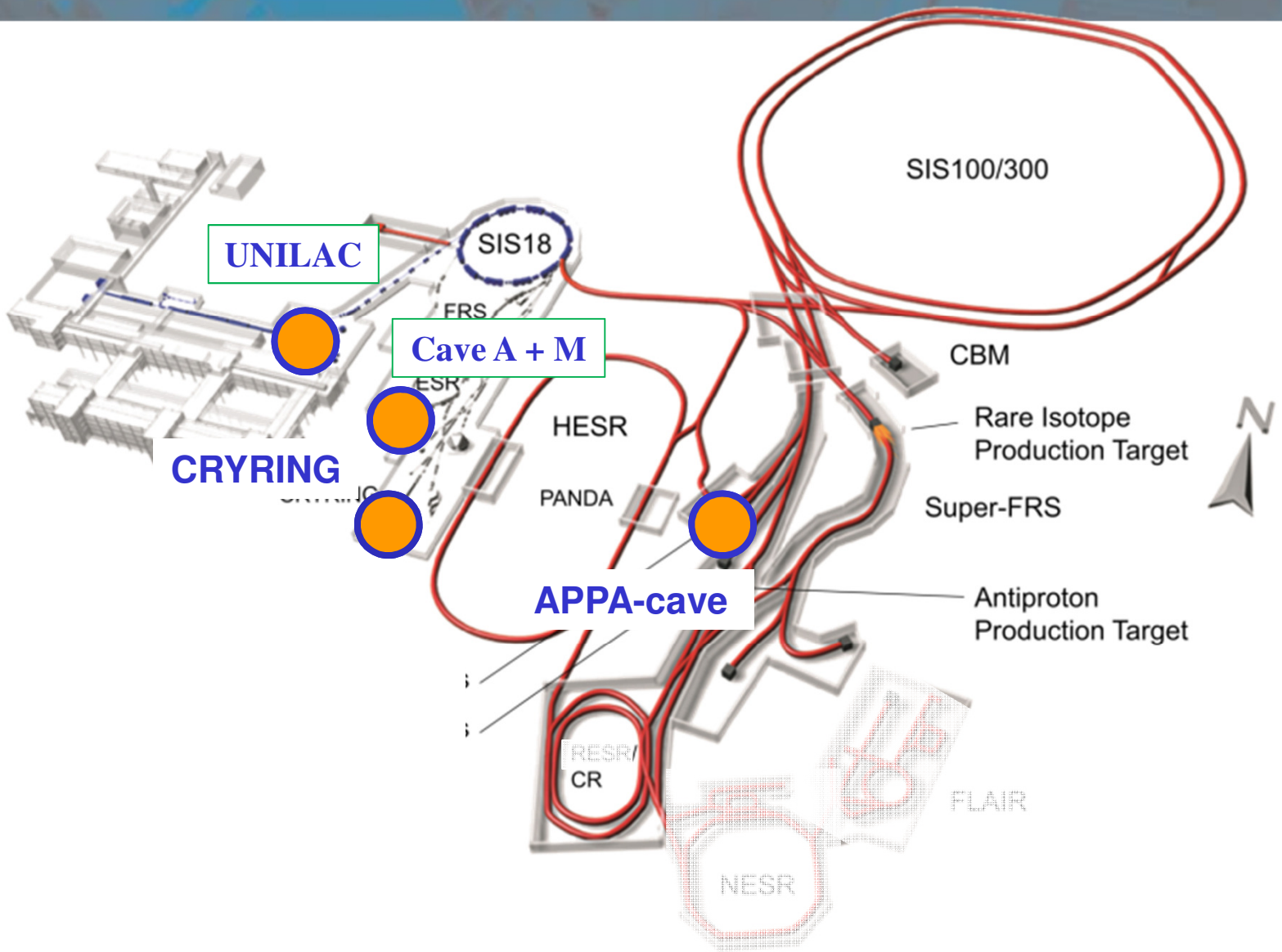






BIO*MAT FAIR

BIOMAT Facilities

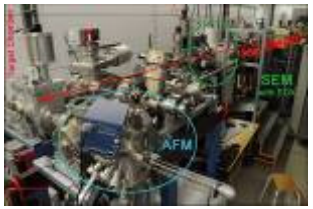


BIO*MAT FAIR

Existing beamlines for BIOMAT

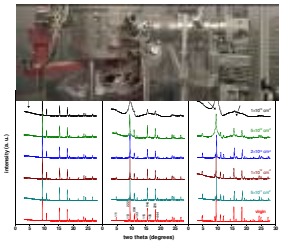
M-Branch
In-situ and On-line Analysis of Irradiated Material

M1
Microscopy



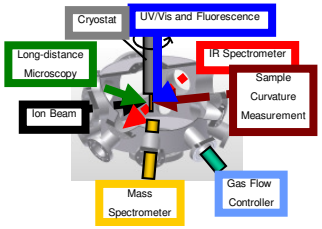
University of Stuttgart
University of Duisburg Essen

M2
X-Ray Diffraction

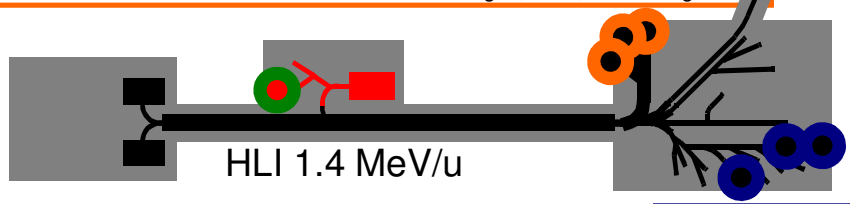


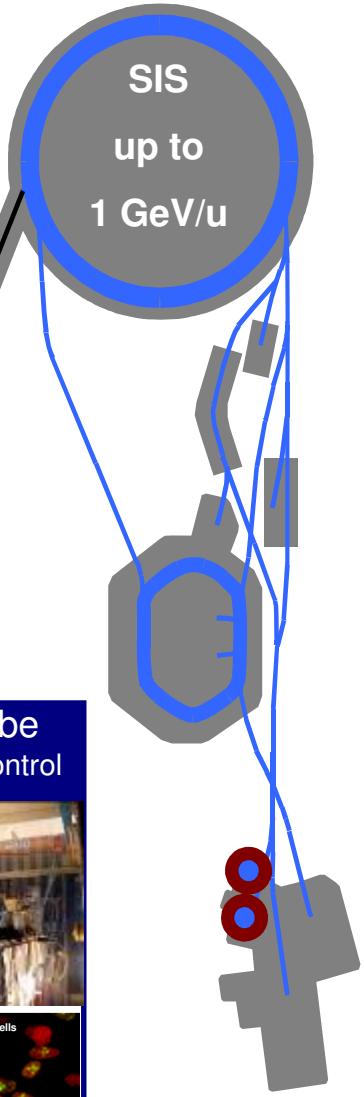
Helmholzzentrum Berlin / GSI

M3
Multi-Analysing Chamber



Universities of Darmstadt, Dresden
Göttingen, Jena, Heidelberg

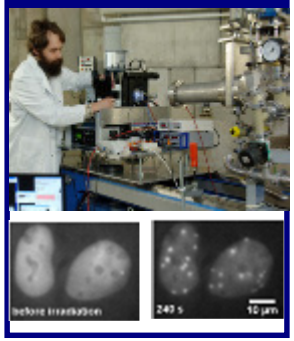




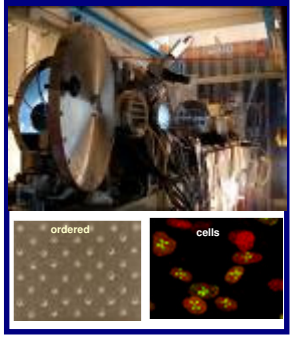
UNILAC
3.6-11.4 MeV/u
Range ~ 100µm

X0
Autosampler

X6
Cell irradiation

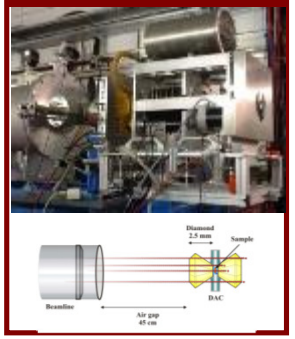


Microprobe
Single Ion Control



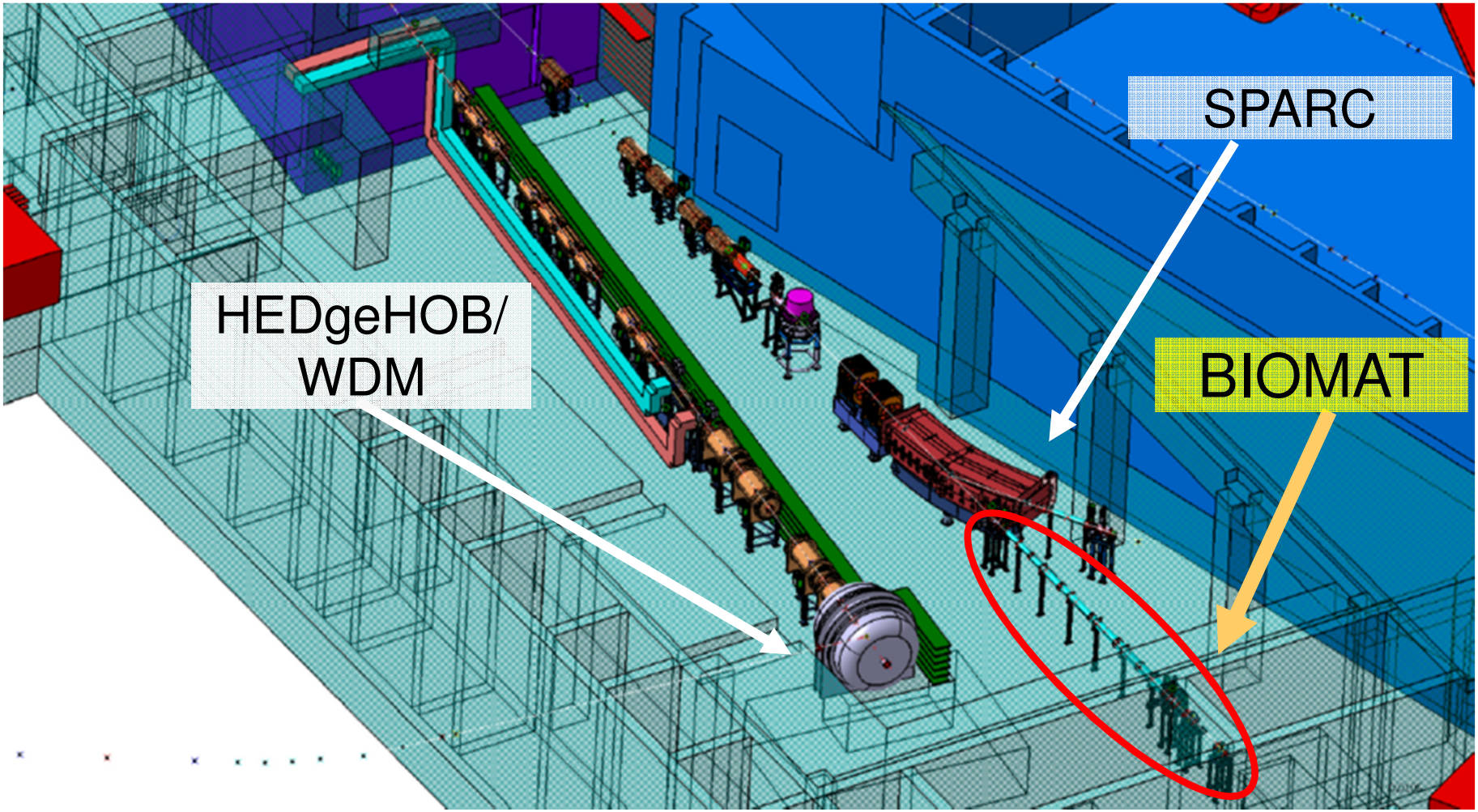
Cave M
Medical Cave

Cave A
Irradiation Cave



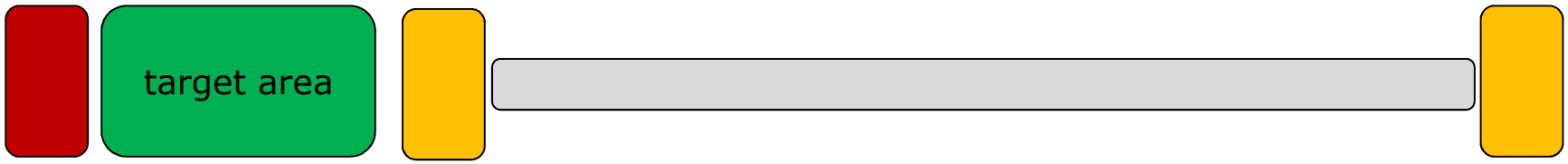
BIO*MAT FAIR

Future beamline for BIOMAT in APPA Cave



BIOMAT user facility

Experiment ← beam



Beam dump

Beam Diagnostic II

straight section (~10m with 3 vacuum section)

Beam Diagnostic I

BIOMAT Experiment requirements

Beam Parameters	Biophysics						Materials Research	
	Ion type							
	protons	He	C	Ne	Ar	Fe, Kr, Xe, U	Protons - U	
Time structure	slow extraction						slow extraction	fast extraction
Number of ions per cycle	$5x10^{10}$	$1.5 x10^{10}$	$1.5 x10^{9}$	$5x10^{8}$	$1.5 x10^{8}$	10^{8}	10^{9*}	$5x10^{10*}$
Ref. energy [GeV/u]							2	0.7
Energy range [GeV/u]	0.1-10							
Transverse emittance [mm mrad]								
Pulse length [s]	1-10						1-10	minimum
Momentum spread								
Beam spot radius RMS [mm]							minimum up to 20	

*) Values are given for an Uranium beam at ref. energy.

BIOMAT Experiment requirements

Further aspects:

- Intensity will vary $1x10^4$ up to $5x10^{10}$ ions/cycle in both modes (slow and fast extraction) special demands on beam diagnostics
- A possibility for switching off the beam within ms is needed
- For homogeneous irradiation experiments the beam intensity within a pulse has to be constant

Possible operation scenariaos

APPA Cave:	10 GeV/u Fe with 10^8 ions/cycle slow extraction
	300-700 MeV/u U with max. intensity ($5x10^{10}$ ions/cycle) fast extraction
(60ns)	
	200-500 MeV/u Au - U with $5x10^{10}$ ions/cycle slow extraction

Cave M:	Machine 0 up to 400 MeV/u p – O (Therapy mode)
Cave A:	up to 1 GeV/u Fe up to 10^8 ions/cycle
	200-500 MeV/u Au - U with max. intensity
	(today 10^9 ions/cycle due to radiation protection)

UNILAC:	up to 11.4 MeV/u; C – U; pulse min. 1ms; wish: DC beam (min. 10 Hz)
(X6, X0, M)	

BIOMAT user facility

High flexibility concerning irradiation conditions and target areas

- ✓ X0, X6 -UNILAC
- ✓ Mikrosonde
- ✓ M-Zweig
- ✓ Cave A + M
- ✓ Cryring
- ✓ APPA Cave

- versatile target station for materials and biological samples
- in-situ or on-line methods for beam induced effects

BIOMAT user facility

High flexibility concerning irradiation conditions and target areas

- ion species: p .... U
- energies: 100 MeV/u .... 10 GeV/u
- SIS: 10^4 ....$5x10^{10}$ ions/cycle
- extraction mode: fast and slow (60ns-10 s)
- beam switch off: within spill (< ~ms)

Thanks for your attention

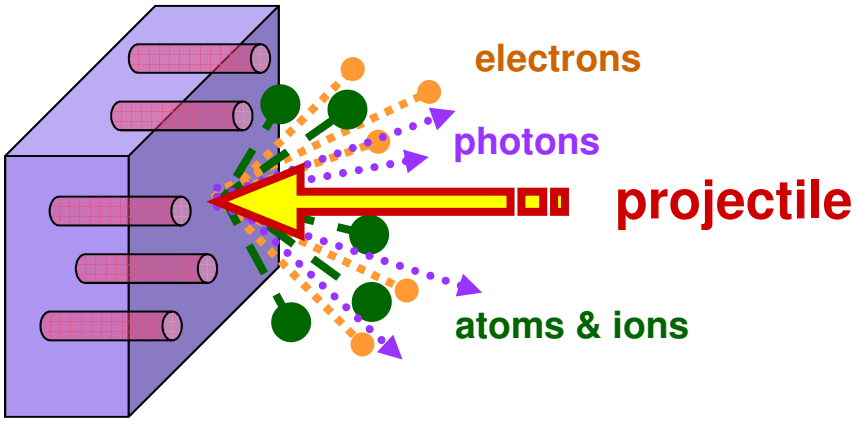
Backup slides

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 $5x10^{10}$
Energy range [GeV/u]	0.1-10	
Pulse length [s]	1-10	minimum
Beam spot radius [mm]	min. - 20	

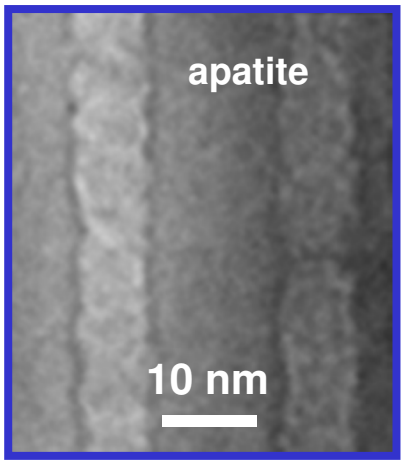
Materials Science and Swift Heavy Ions

destructive power



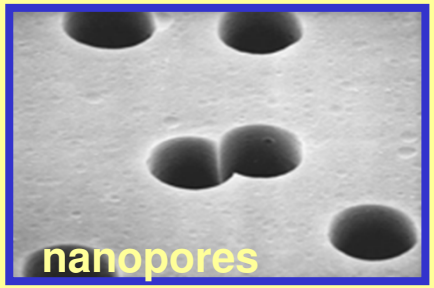
degradation

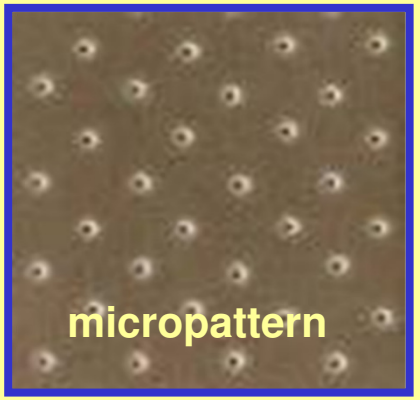
microscopic

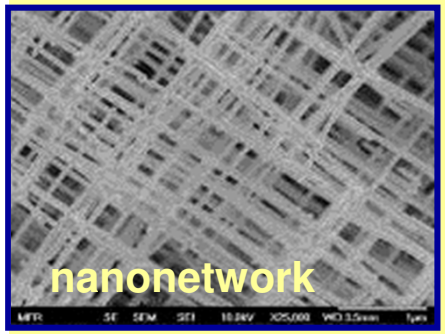


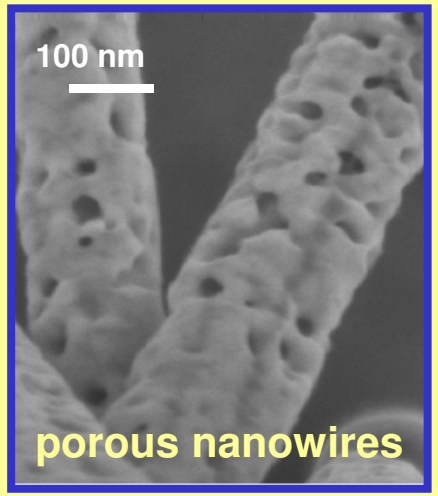
macroscopic

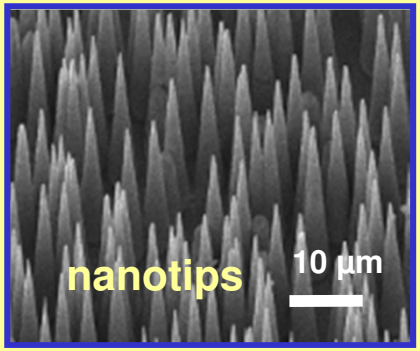
structuring tool



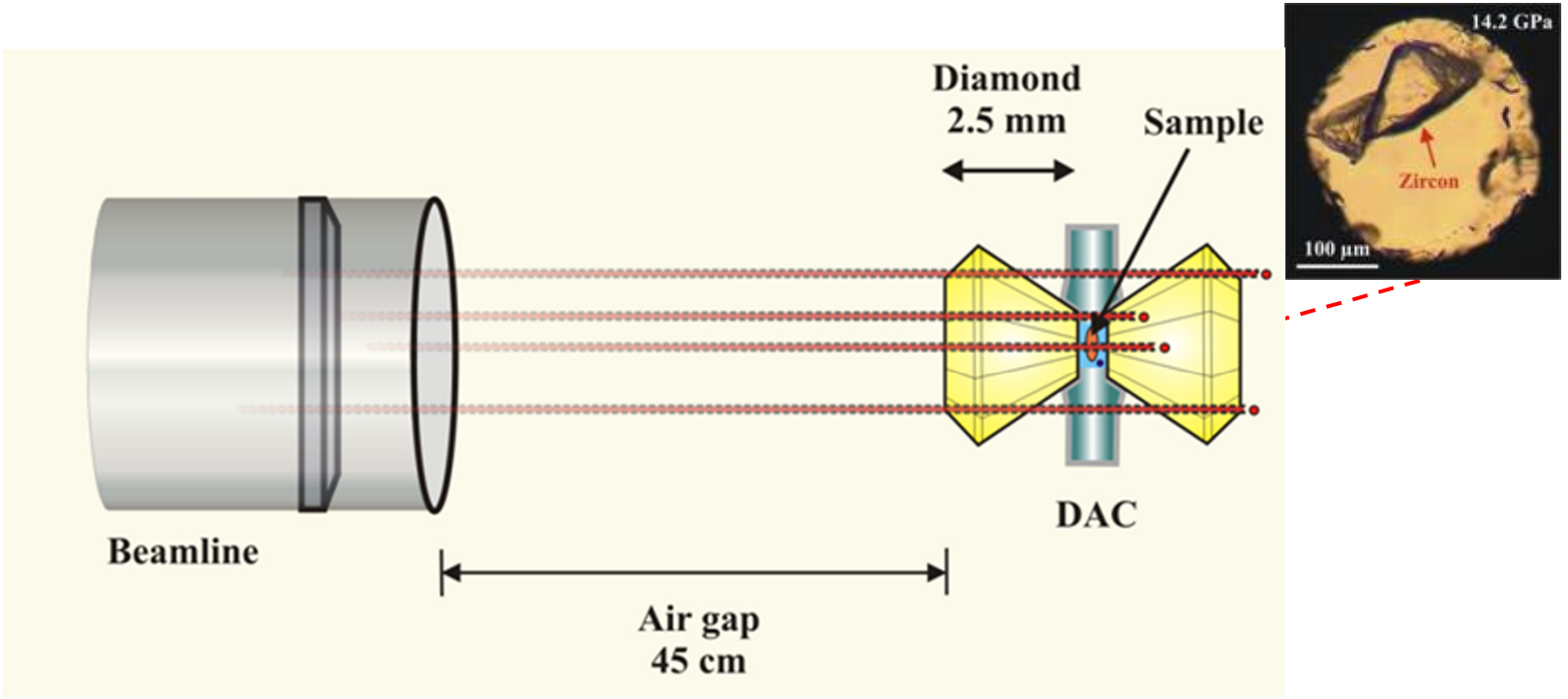


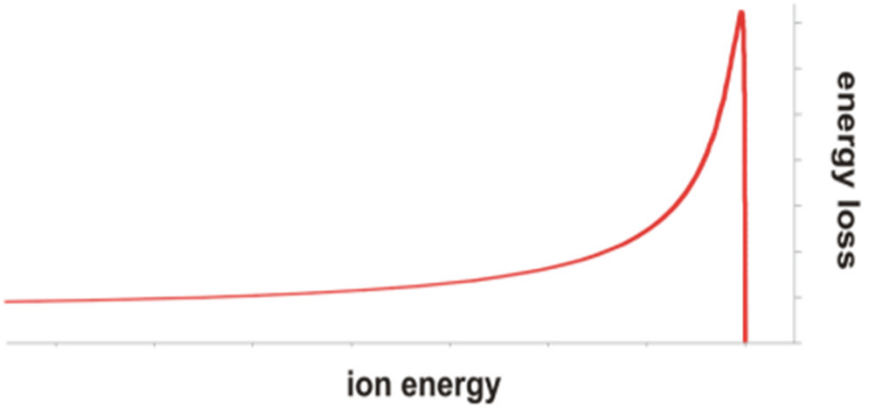






Irradiation of material under extreme pressure





Monitoring of ion-beam effects by on-line spectroscopy

On-line Raman spectrometer

commissioned Sep. 2014 @ GSI M3

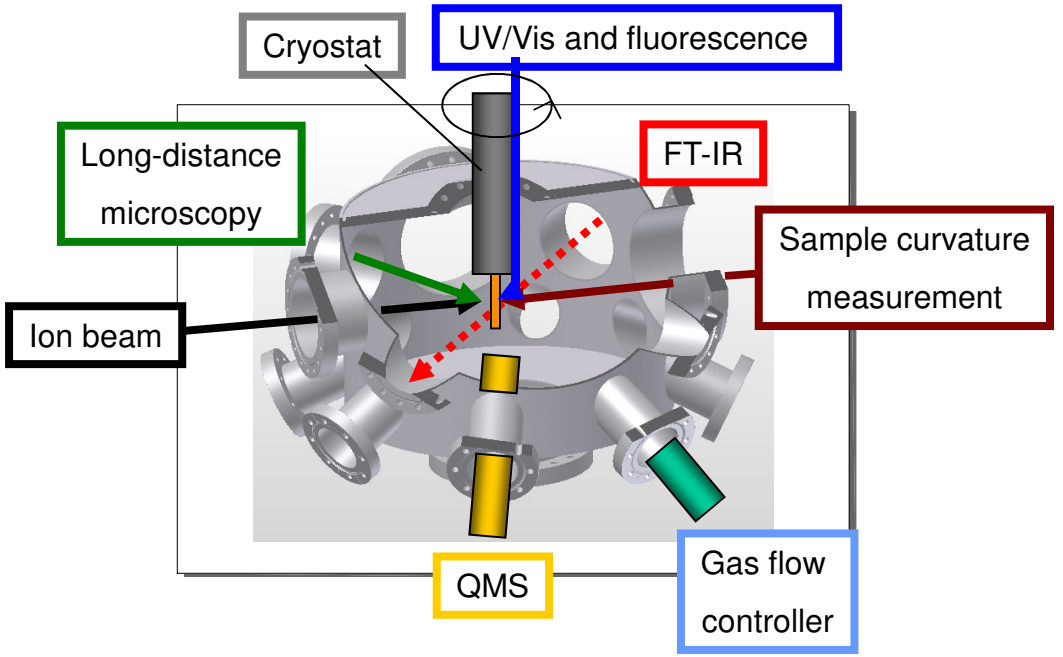
RUPRECHT-KARLS-
UNIVERSITÄT
HEIDELBERG

Prof. U. Glasmacher

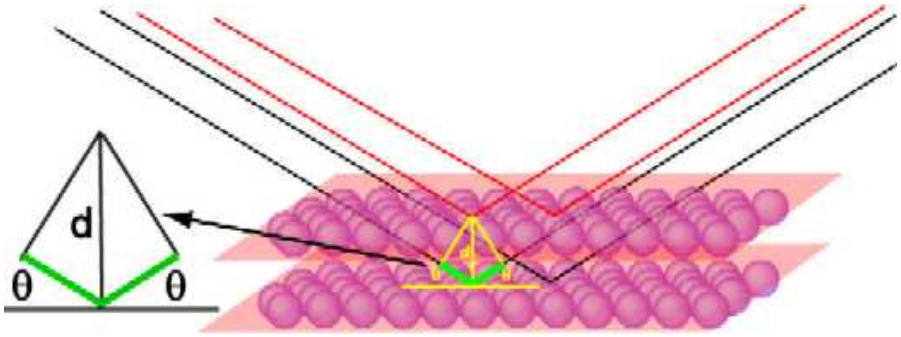
Multi-purpose setup @ UNILAC M-branch

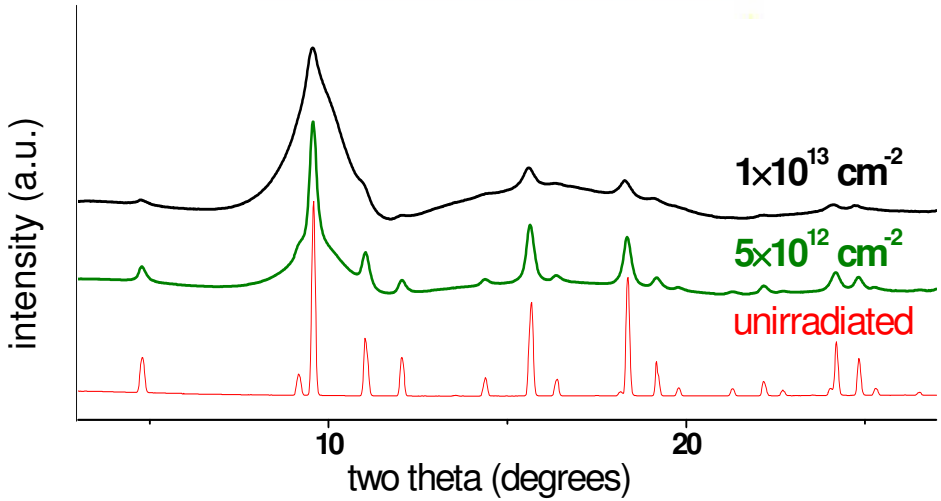
combined setup 5 Verbundforschungs projects

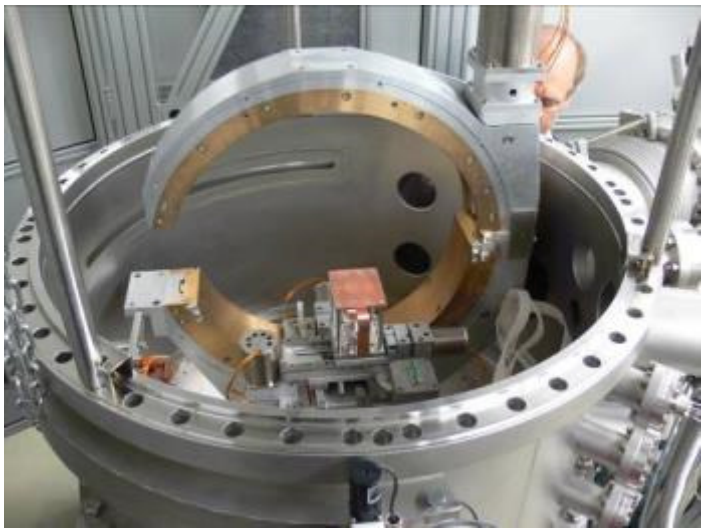
(Darmstadt, Göttingen, Heidelberg, Jena, Dresden)



Monitoring of structural changes by x-ray diffraction



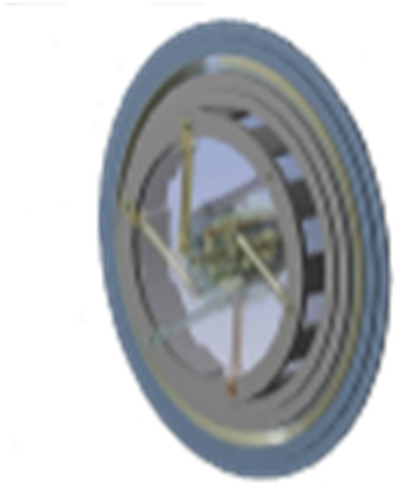


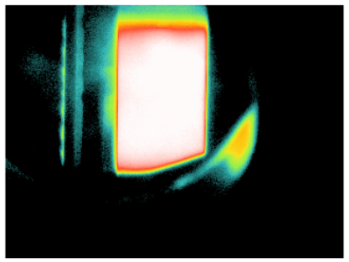


- Amorphisation
- Formation of new ion-beam induced phases
- Special orientation texturing

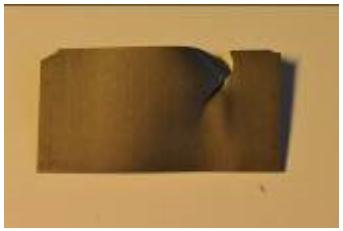
- SEIFERT 4-circle x-ray diffractometer (Cu-Kα)
- Position sensitive detector
- Investigation under any angle of incidence enables the quantitative analysis of structural modifications

Radiation hardness of functional materials & components

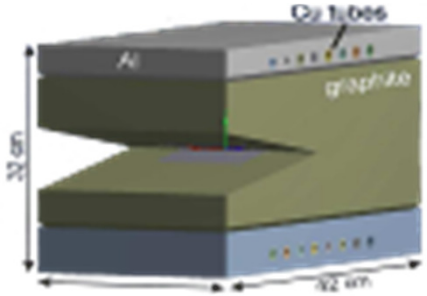


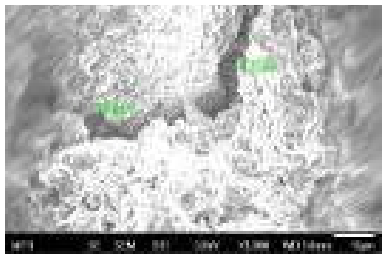


In-beam thermal imaging



severe swelling and irradiation-induced stresses

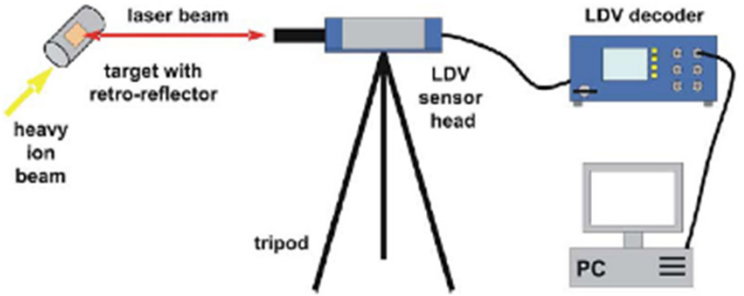




Thermal stress induced crack

Experiment with fast-extracted beams:

monitoring surface vibrations of graphite target

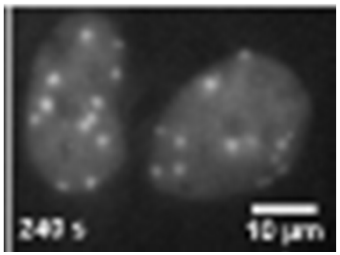


Biophysics

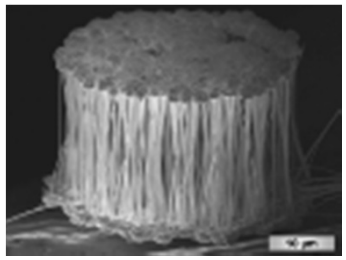
Biophysics

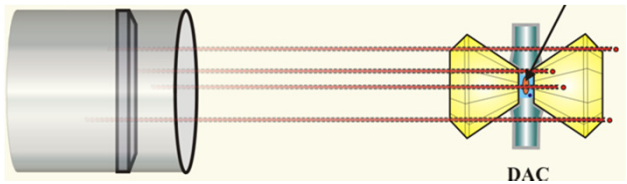
biological radiation effects

cell irradiations



Materials Research

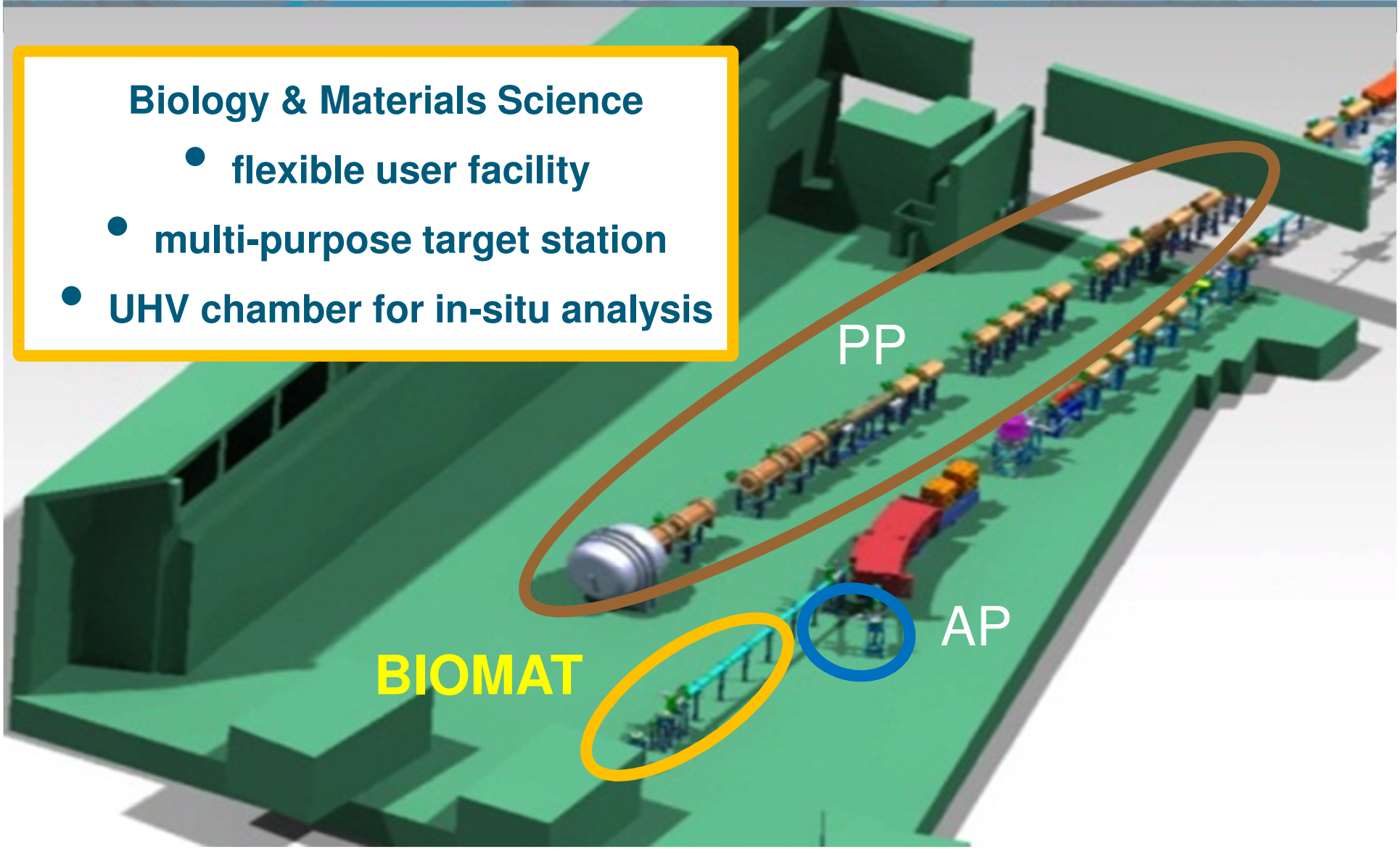




APPA Cave at FAIR

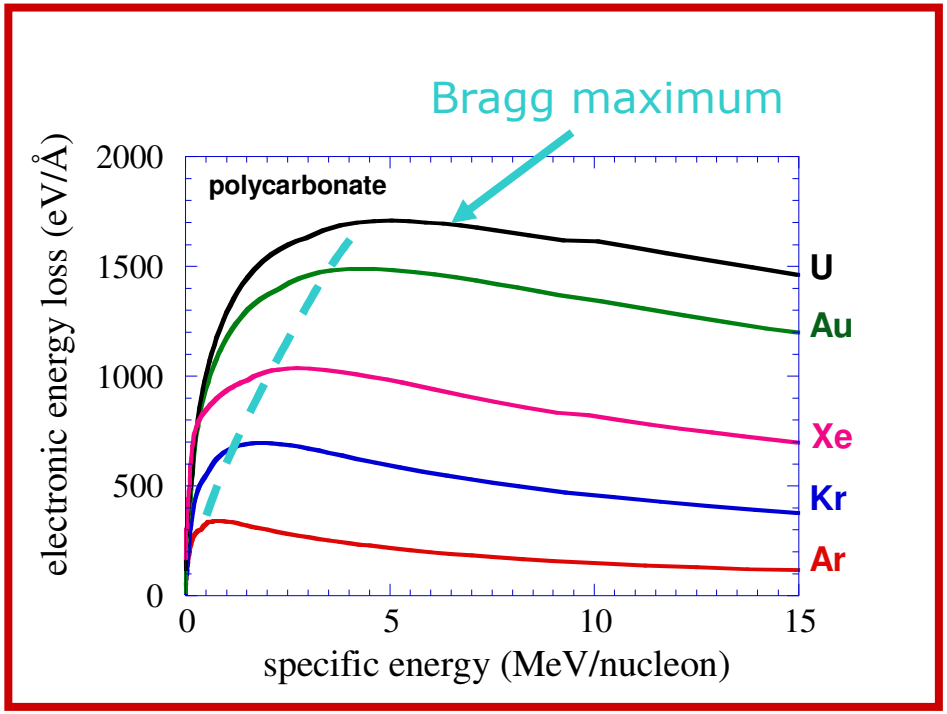
Biology & Materials Science

- flexible user facility
- multi-purpose target station
- UHV chamber for in-situ analysis



Electronic energy loss

UNILAC → max energy loss



SIS → decreasing energy loss