

# Radiation dosimetry in the Nuclear Physics Institute of the CAS



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EUROPEAN UNION  
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Operational Programme Research,  
Development and Education





- News
- People
- Research
  - Radiation biophysics
  - Mixed radiation fields
  - Radioecology
- Education
- Resources
  - Microscope HSP-1000
  - Equipment for detector etching
- Contacts

The research activities of the department lie at the border of basic and applied research in the domain of dosimetry and microdosimetry of ionizing radiation and their applications in radiation protection, radiotherapy and radioecology. Research studies are often interdisciplinary and include physics, chemistry and biology, for more details please see **Research**. Several available unique equipments are summarized in **Resources**.

The founder and the first director of our institute was well known Czech physicist Frantisek Behounek. It has been established in 1953 as an independent institute; since 1994 it has become a part of Nuclear Physics Institute AS CR as the Department of Radiation Dosimetry. In the same year Frantisek Spurny has been appointed as the new director and had held the role until his death in 2010. The department headed by Marie Davidkova is located within the premises of Bulovka Hospital; currently the building undergoes an extensive reconstruction. Some of us are lectures on Department of Dosimetry and Application of Ionizing Radiation at the Faculty of Nuclear Sciences and Physical Engineering, CTU in Prague. We are also engaged in supervising of bachelor's, master's, and doctoral research projects (more you find in **Education**).



### News

**4.6. 2014**  
We are pleased to invite you to the lecture "Charged Particle Transport Simulations for Radiotherapy and Space Dosimetry" by Prof. Lembit Sihver from Chalmers University of Technology. The lecture will be held on Wednesday at 3 p.m.

**3.6. 2014**  
Martin Seifl succeeded to defend his diploma theses, congratulation!

**18.6. 2014**  
Jan Kubancak succeeded as well to defend his PhD thesis. Congratulation!

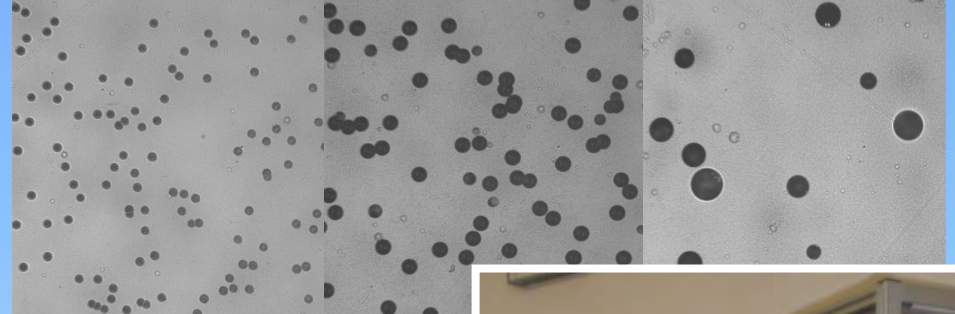
# František Běhounek (1898 - 1973)



# Development of new dosimetric methods for

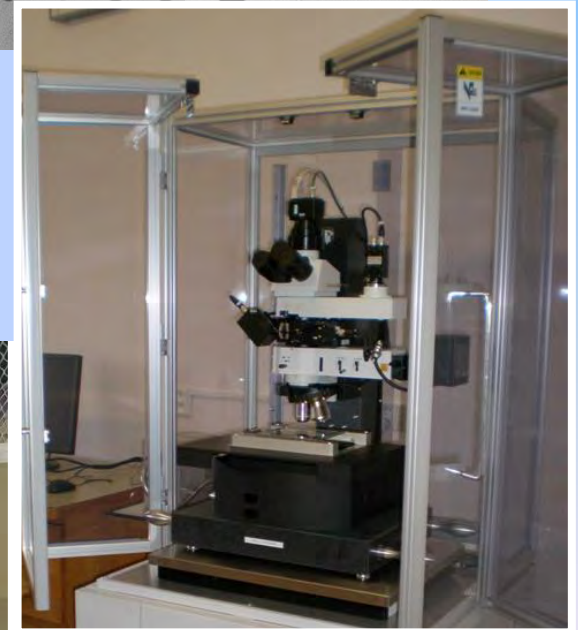


- LET spectrometry (track-etched and semiconductor detectors)
- measurements in mixed radiation fields



## Monitoring of cosmic radiation in space and at mountain observatories for research on

- space weather
- aircraft and spacecraft crew dosimetry
  
- TEPC, Liulin, Timepix, Bubble detectors, ....



# Eurados WG11 High Energy Radiation Fields

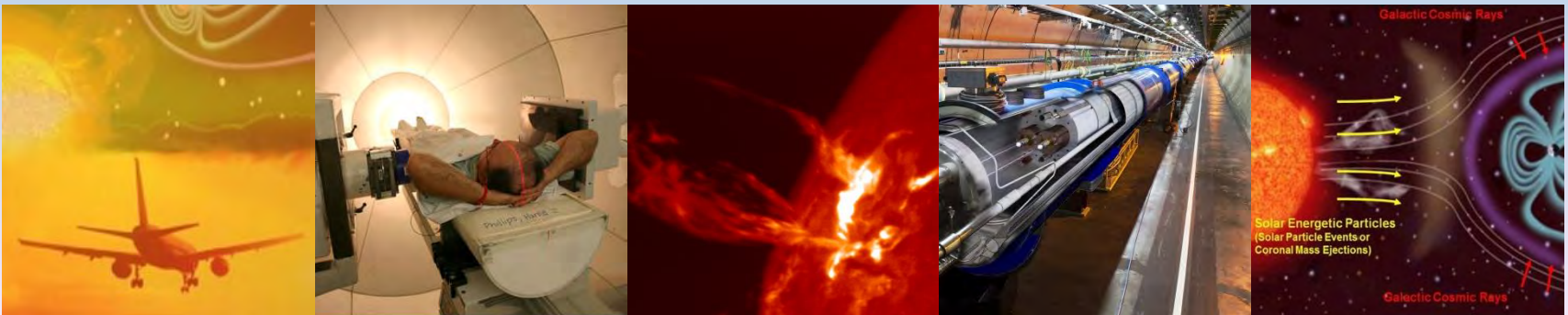
- Expertise regarding field characterisation and dose assessment in various activities where **high energy radiation, complex and pulsed fields** are used, like medicine, research accelerators, civil aviation, and space.
- WG contributes to the development of international standards and recommendations (e.g. ISO, ICRU, ICRP).

## Iva Ambrožová

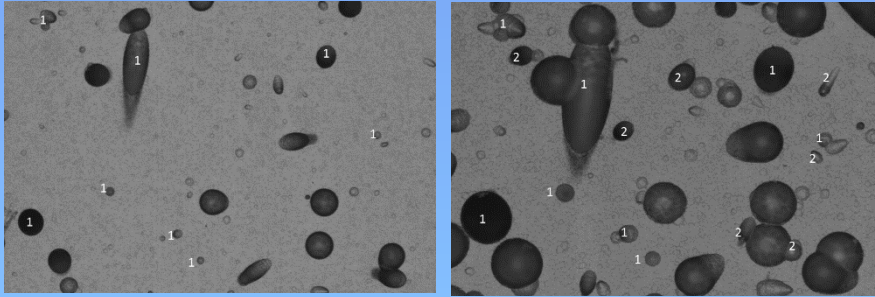
Leader of the Task 4 – Solar particle events (SPE) measurements onboard aircrafts and ground-based

## Ondřej Ploc

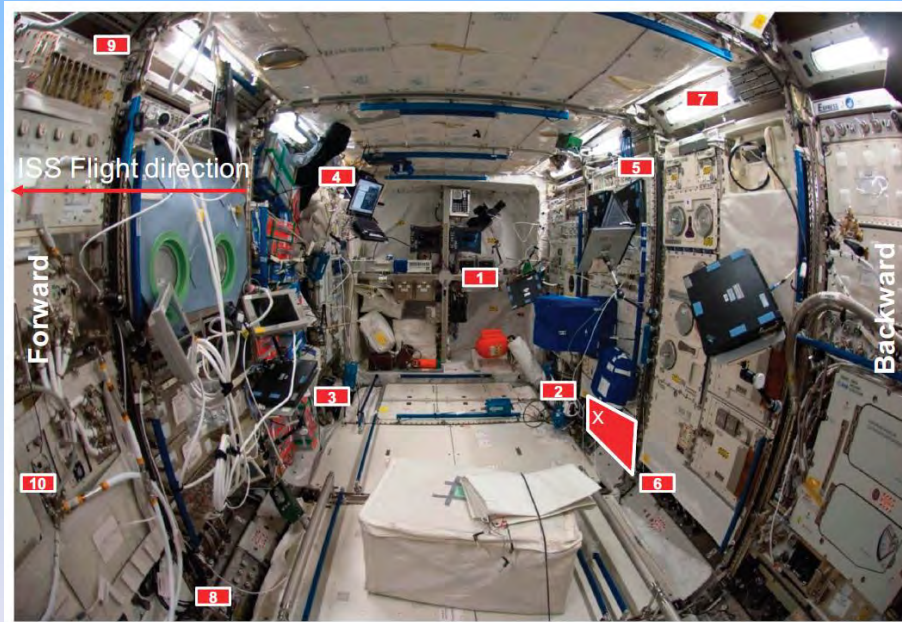
Leader of the Task 8 - Radiation dose induced by natural electric discharge in the atmosphere



# ESA projects: Dobies, Dosis, Dosis 3D



Detector's surface after 18h and 18+18h etching.



The positions of the Passive Detector Packages within the Columbus Laboratory of the ISS.

Source: NASA/ESA.

## Collaborations:

- German Aerospace Center, Institute of Aerospace Medicine, Germany
- Christian Albrechts Universität zu Kiel, Germany
- Institute of Nuclear Physics, Polish Academy of Sciences, Poland
- IAEA, Division of Radiation, Transport and Waste Safety, Austria
- Technische Universität Wien, Atominstitut, Austria
- EGB MedAustron, Austria
- Centre for Energy Research, Hungary
- Belgian Nuclear Research Center (SCK-CEN), Belgium
- NASA, Space Radiation Analysis Group, USA
- National Institute of Radiological Sciences (NIRS), Japan

# Project CRREAT (2016 – 2022)

## Research Center of Cosmic Rays and Radiation Events in the Atmosphere



- Excelent team of 15 researchers led by prof. Karel Kudela (Nuclear Physics Institute of the CAS, Institute of Atmospheric Physics of the CAS and the Faculty of Electrical Engineering CTU in Prague)
- Operational Programme Research, Development and Education
- contribute to improvement of space weather models, air transport safety and global navigation systems reliability.



# Radioecology and radiocarbon dating

- Radiocarbon dating laboratory CRL (in co-operation with Archaeological Institute CAS)
- Fossil fuel combustion and atmospheric  $^{14}\text{CO}_2$  and  $\text{CO}_2$
- Past environmental changes and  $^{14}\text{C}$
- $^{14}\text{C}$  in the vicinity of NPPs and in reference areas

Sampling in the vicinity of NPP Temelín



Low background liquid scintillation spectrometers  
QUANTULUS 1220

Monitoring of atmospheric  $^{14}\text{CO}_2$

- Development of new analytical methods
- Theory of formation of liquid scintillation pulse spectra



# $^{14}\text{C}$ - treatment of microsamples for AMS measurement

- Processing of microsamples extends substantially possibilities of all  $^{14}\text{C}$  applications, including radiocarbon dating.
- In the Czech Republic, the Accelerator Mass Spectrometry system (AMS) is not available. Our laboratory implemented and developed routines of microsamples processing.
- Nowadays, all sample processing routines are performed in the CRL. Final graphitized samples are being submitted for AMS measurements abroad.



PC driven system for pretreatment of microsamples



A system for sealing of isolated carbon forms into quartz combustion ampoules



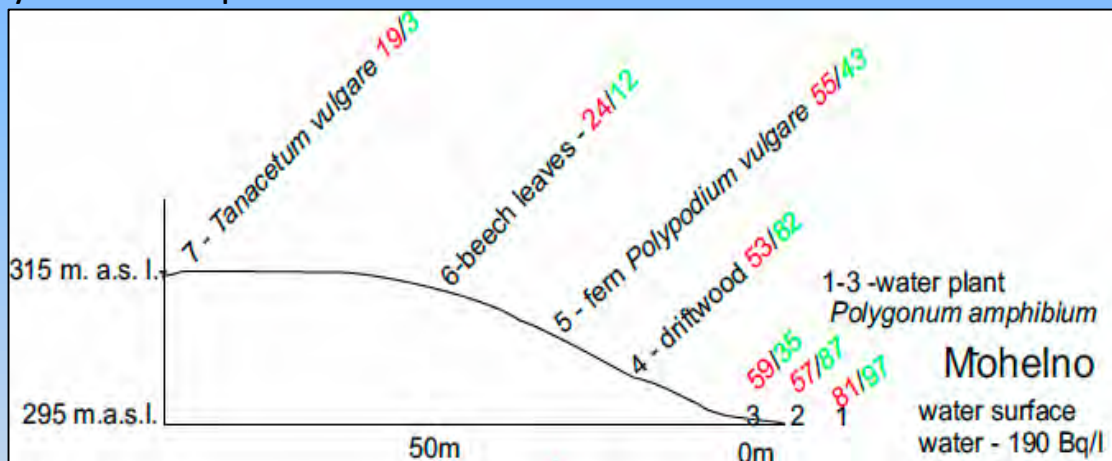
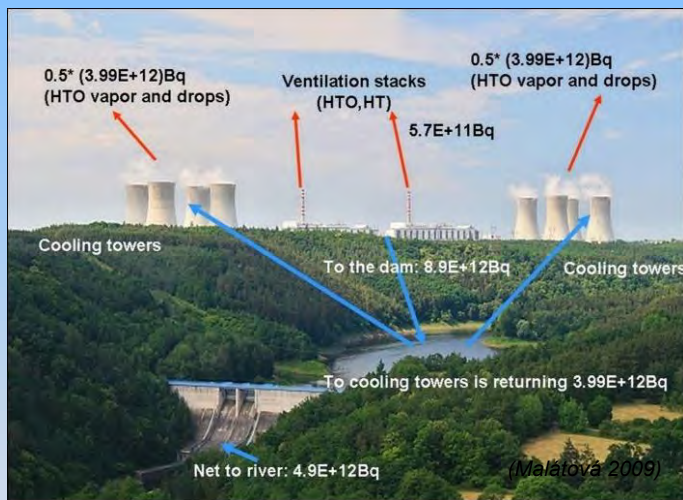
Graphitization unit



Final sample graphites, ready for AMS measurement

# Elevated activities of OBT in biota of the Mohelno reservoir

- During normal operation of nuclear power plants Temelín and Dukovany liquid releases of tritium are responsible for dominant dose load of population in the surroundings.
- We found and described elevated activities of Organically Bound Tritium in the biota of the Mohelno reservoir system, which exceed actual background level by about two magnitudes.
- Liquid effluents from the nuclear power plant Dukovany are released into the Mohelno reservoir, which is situated in a deep narrow valley with limited air exchange. Hence, both surrounding biota and water in this reservoir and connected Jihlava river which are enriched by tritium.
- This interesting system enables to study metabolic processes associated with tritium intake in natural conditions.

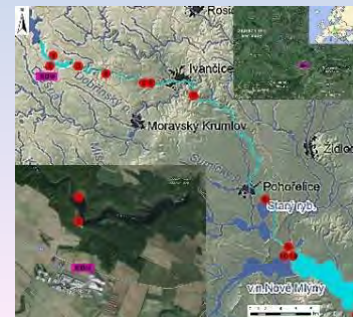


Mohelno reservoir, distribution of tritium chemical forms OBT (red), TFTW (green) in plants, and HTO in surface water (black)

To decrease tritium activities in the system of Mohelno reservoir, about 25% of the tritium liquid releases are taken by NPP Dukovany into cooling towers and evaporated (loop effect).

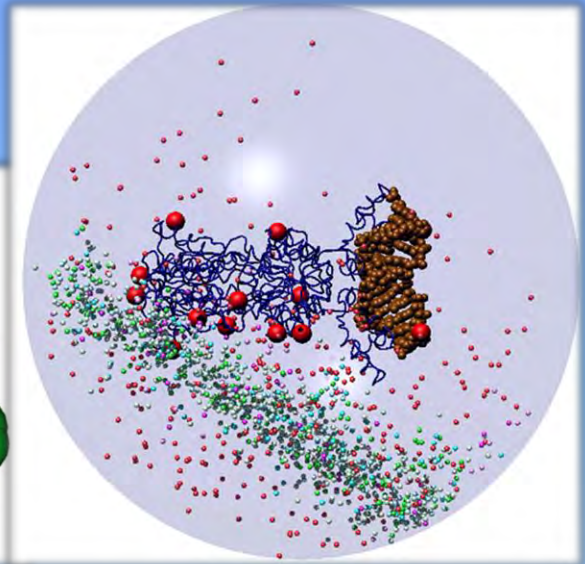
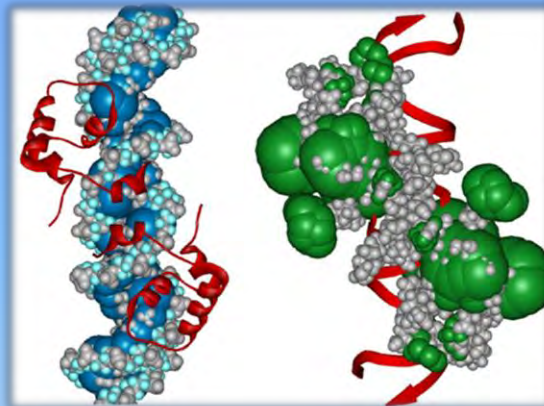
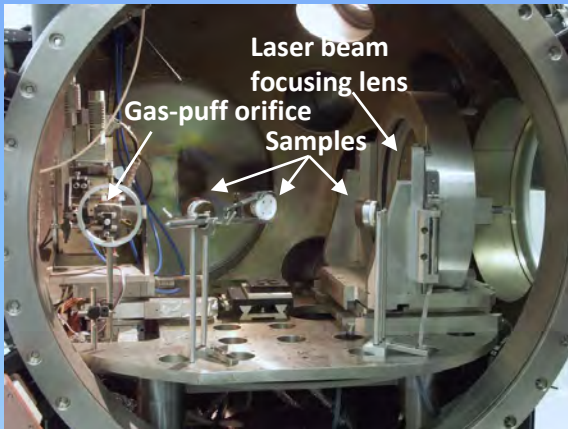


Mohelno reservoir and connected Jihlava river with elevated tritium activity



# Research on biological effects of radiation

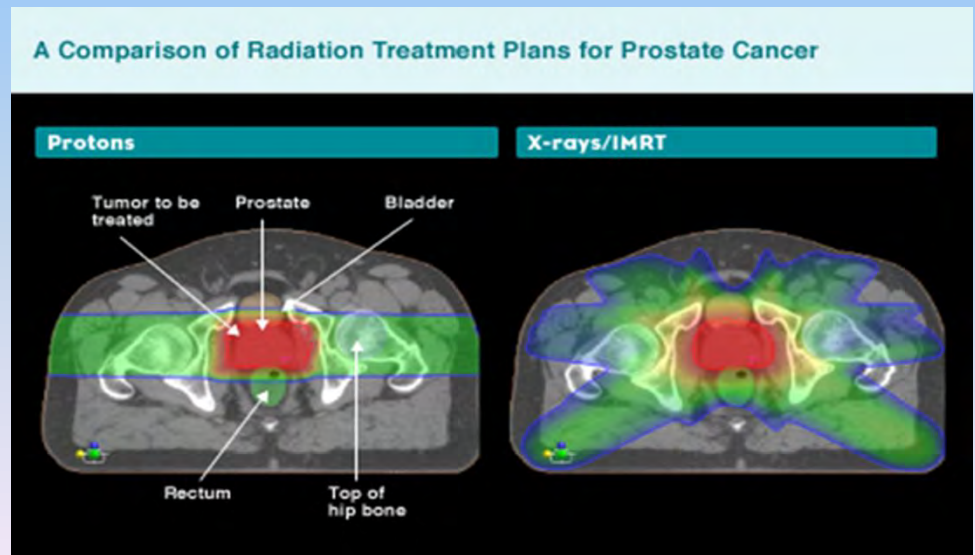
- Radiation damage to DNA and DNA-protein complexes
- Biological effects of soft X rays and XUV



- Radiation therapy of cancer:
  - Induction of secondary cancers
  - Nuclear fragmentation

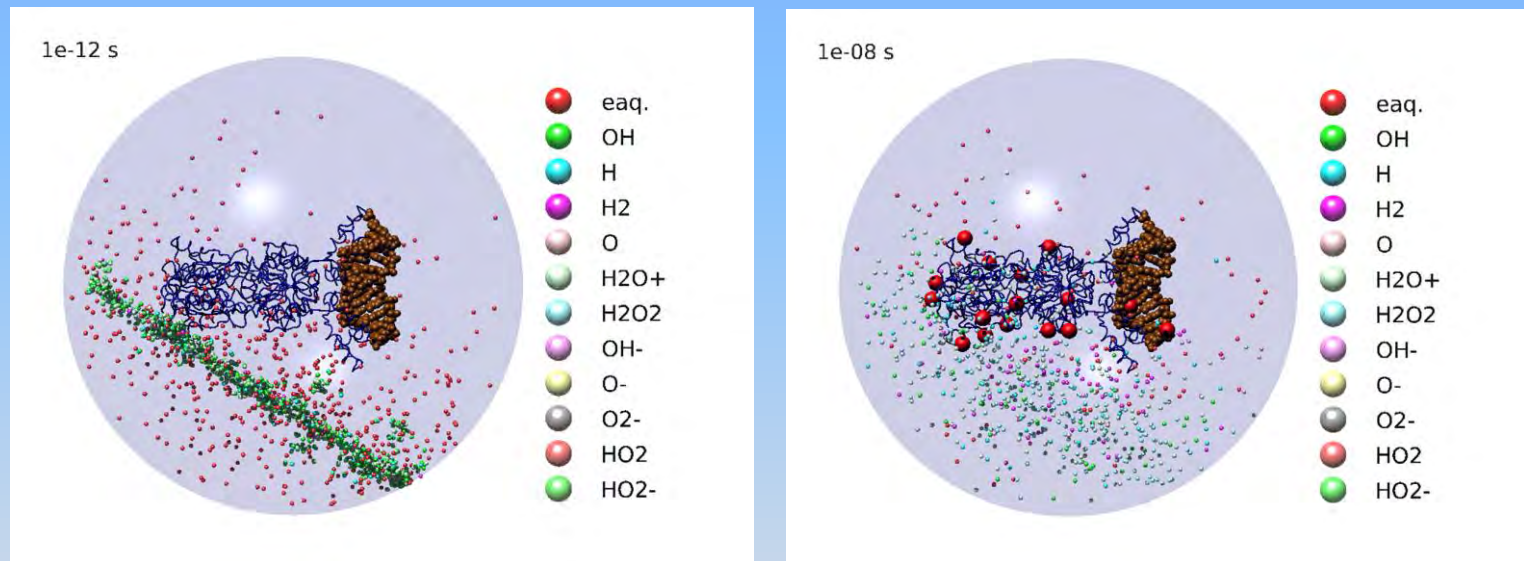


TLD and PADC in proton beam



# Theoretical modeling of initial radiation damage in biological systems

**Code RADAMOL** (RAdiation Damage to bioMOlecules) developed to model yields and distributions of primary damage to DNA and proteins induced during physical, physico-chemical and chemical stages of radiation action



**Collaborations:** Geant4-DNA project (**Václav Štěpán**)

The Geant4 general purpose particle-matter Monte Carlo simulation toolkit is being extended with processes for the modeling of early biological damage induced by ionizing radiation at the DNA scale in the framework of the Geant4-DNA project. They are fully included in Geant4.

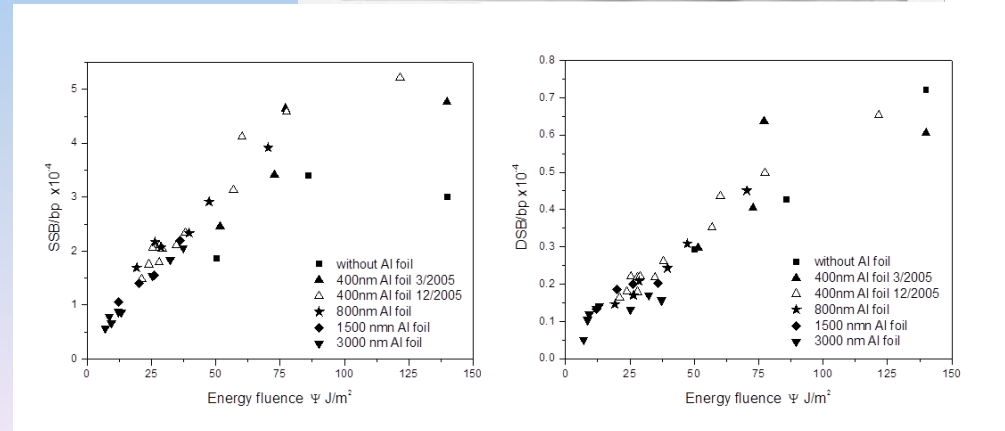
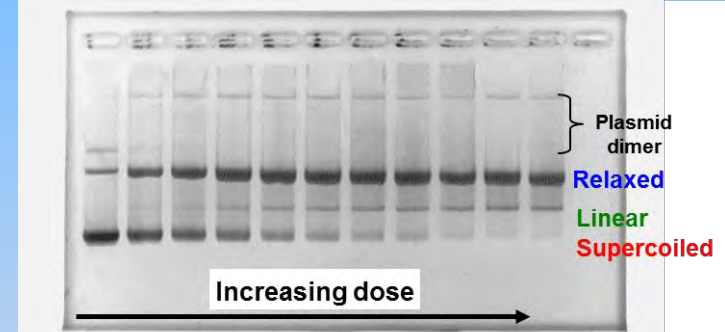
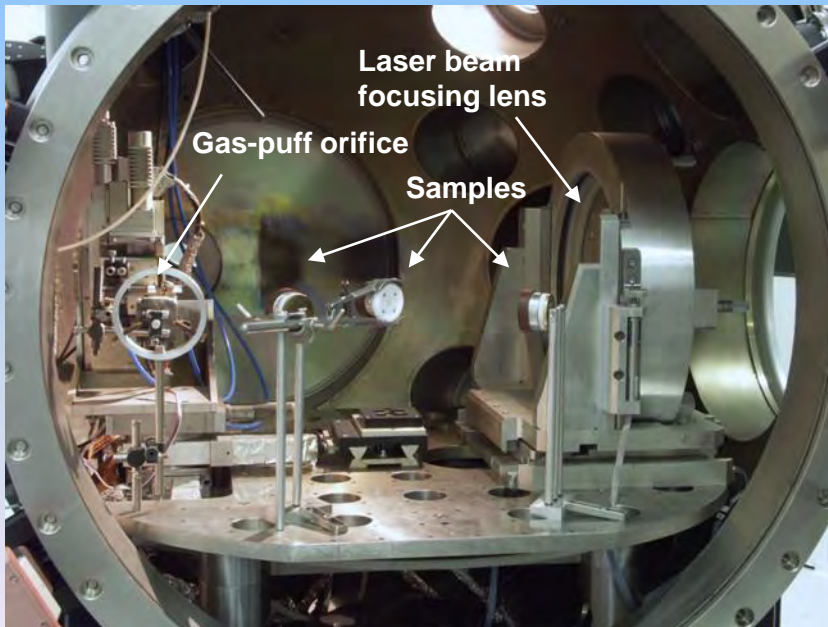
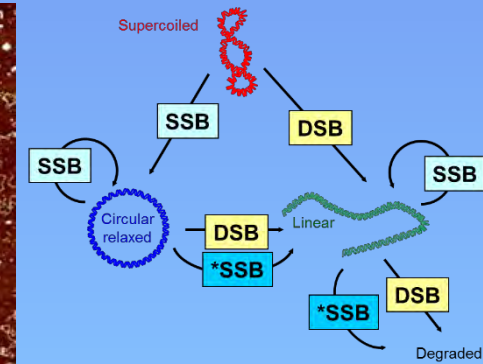
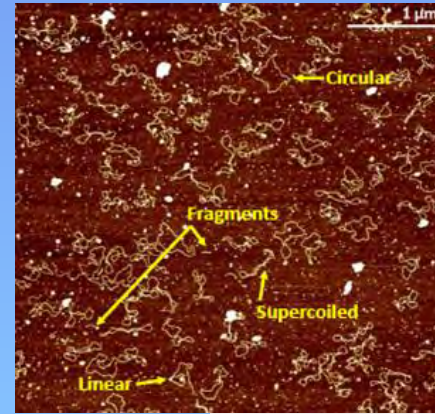
# Biological effects of soft X rays and XUV

## Collaborations:

- Institute of Physics of the CAS
- Institute of Plasma Physics of the CAS
- Institute of Optoelectronics, Military University of Technology, Warsaw, Poland

## Future perspectives:

Research at ELI Beamlines



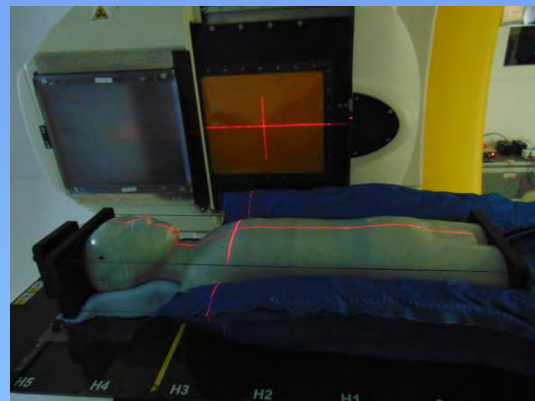
# Eurados WG9 Radiation Dosimetry in Radiotherapy

## Research topics:

- To identify a list of clinical situations and treatment protocols which lead to healthy tissue doses of concern.
- To evaluate the characteristics of dosimeters for out-of-field measurements and in vivo dosimetry.
- **The determination of out-of-field doses in paediatric radiotherapy treatments, using various photon and proton radiotherapy techniques.**
- To develop appropriate phantoms for out-of-field dosimetry.
- To investigate and develop combined techniques for out-of-field dosimetry (e.g. combinations of measured and calculated doses, using experimental data to test and verify analytical dose models).
- Starting from the measured organ doses, to select the models that will be used to estimate the risk of developing second cancers.

## Future perspectives:

- Dosimetry in small irradiated volumes and high gradients (tomotherapy, gamma knife, Cyber knife, ...)



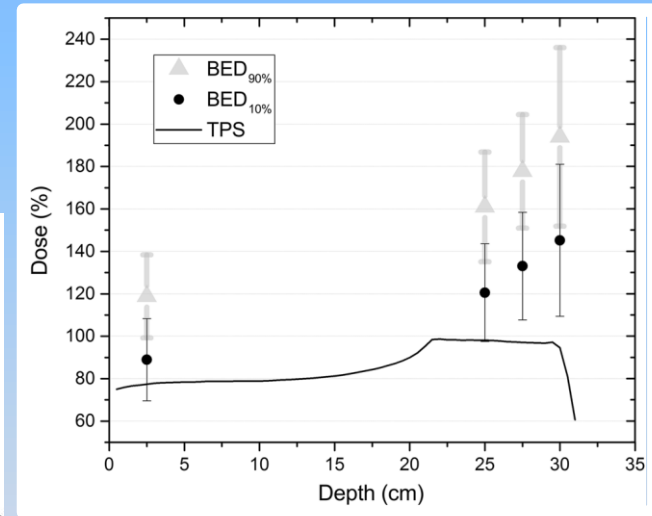
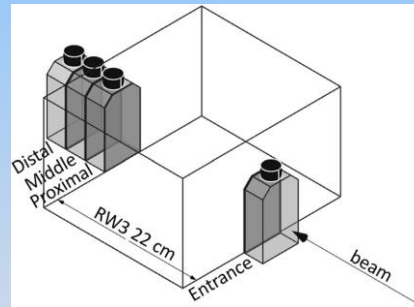
# Radiation biology of proton beams

## Research topics:

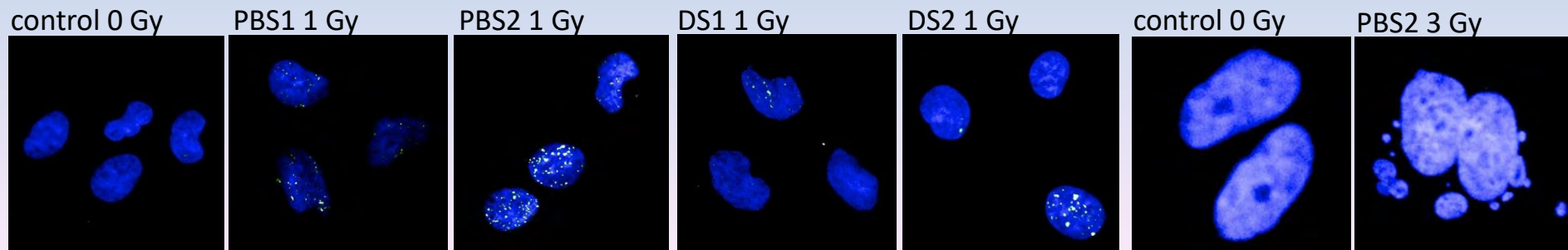
- Radiobiological efficiency of therapeutic ion beams
- Effect of metallic implants on dose distribution in radiotherapy

## Collaborations:

- Proton Therapy Center Czech
- Institute of Biophysics of the CAS
- Centre for Cancer Research and Cell Biology, Queen's University, Belfast, UK



Michaelidesová et al. *Australas Phys Eng Sci Med* (2017)



**Thank you for your attention**