DUBNA

LRB

JINR

Laboratory of Radiation Biology

LRB structure

Department of Radiation Biology and Physiology:

- Molecular Radiobiology Sector;
- Radiation Cytology Sector;
- Radiation Physiology Sector;
- Radiation Neurochemistry Sector;
- Mathematical Modeling Sector;
- Lower Eukaryote Radiation Genetics Group.

Department of Radiation Research:

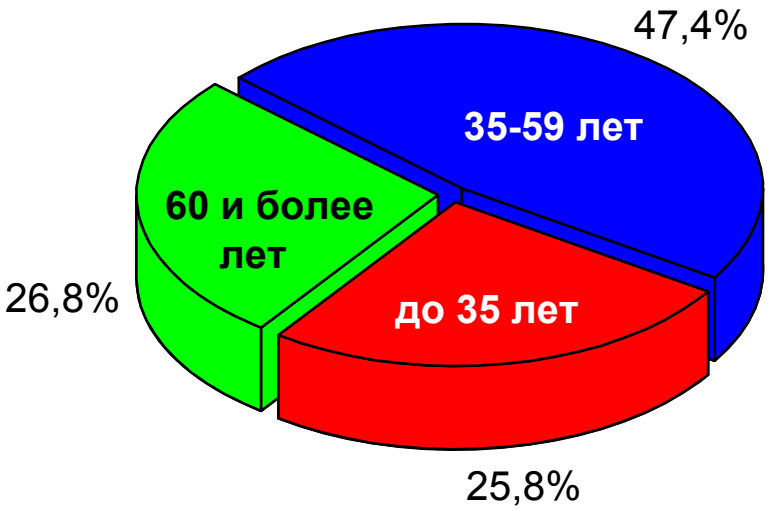
- Group for Modeling Ionizing Radiation Interaction with Matter;
- Group for Studying Radiation Fields of JINR's Basic Facilities and Environment.

❖***Astrobiology Sector***

The LRB's full-time staff is 101

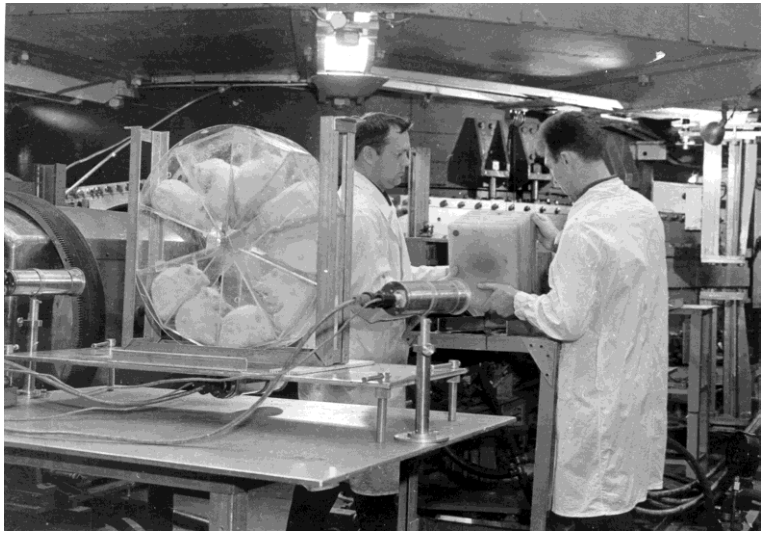
The LRB staff includes 3 Members of the Russian Academy of Sciences (RAS), 6 Doctors of Biological Sciences, 2 Doctors of Medical Sciences, 2 Doctors of Physical and Mathematical Sciences, 9 Candidates of Biological Sciences, and 8 Candidates of Physical and Mathematical Sciences.

Age distribution:



First radiobiological experiments at the Phasotron

Protons with energy up to 660 MeV



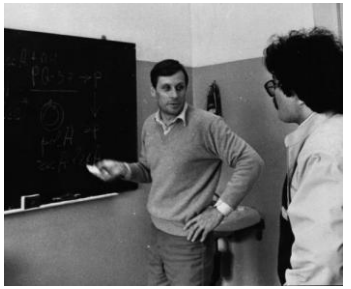
Laboratory of Radiation Biology

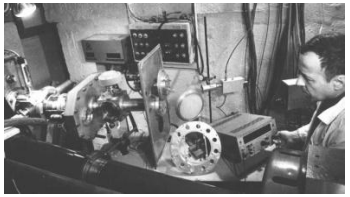
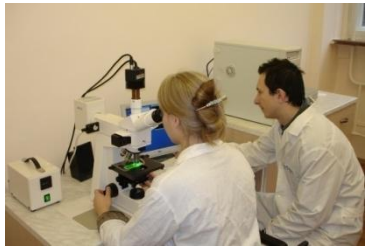
- **1978** **S**ector of biological research in LNP
- **1988** **D**ivision of biophysics in LNP
- **1995** **D**epartment of Radiation and Radiobiological Research of JINR

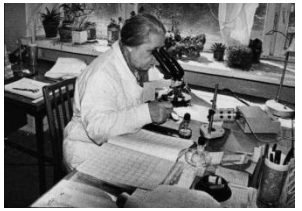
- ***2005 Laboratory of Radiation Biology*** in LNP







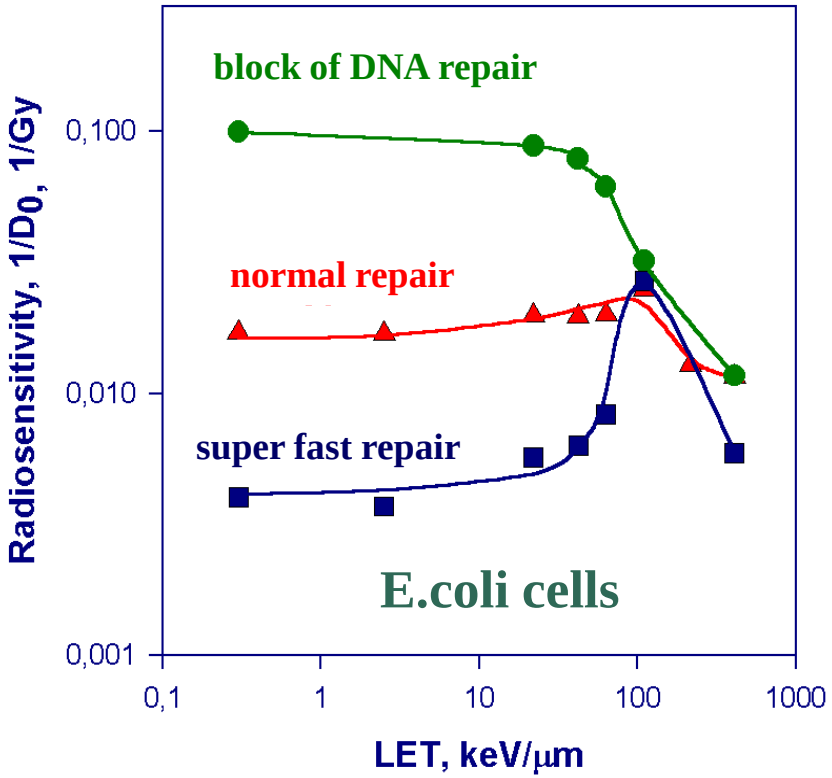
The main field of research:

THE BIOLOGICAL ACTION OF HEAVY CHARGED PARTICLES OF DIFFERENT ENERGIES

What radiobiological problems can be solved at use of accelerated heavy particles?

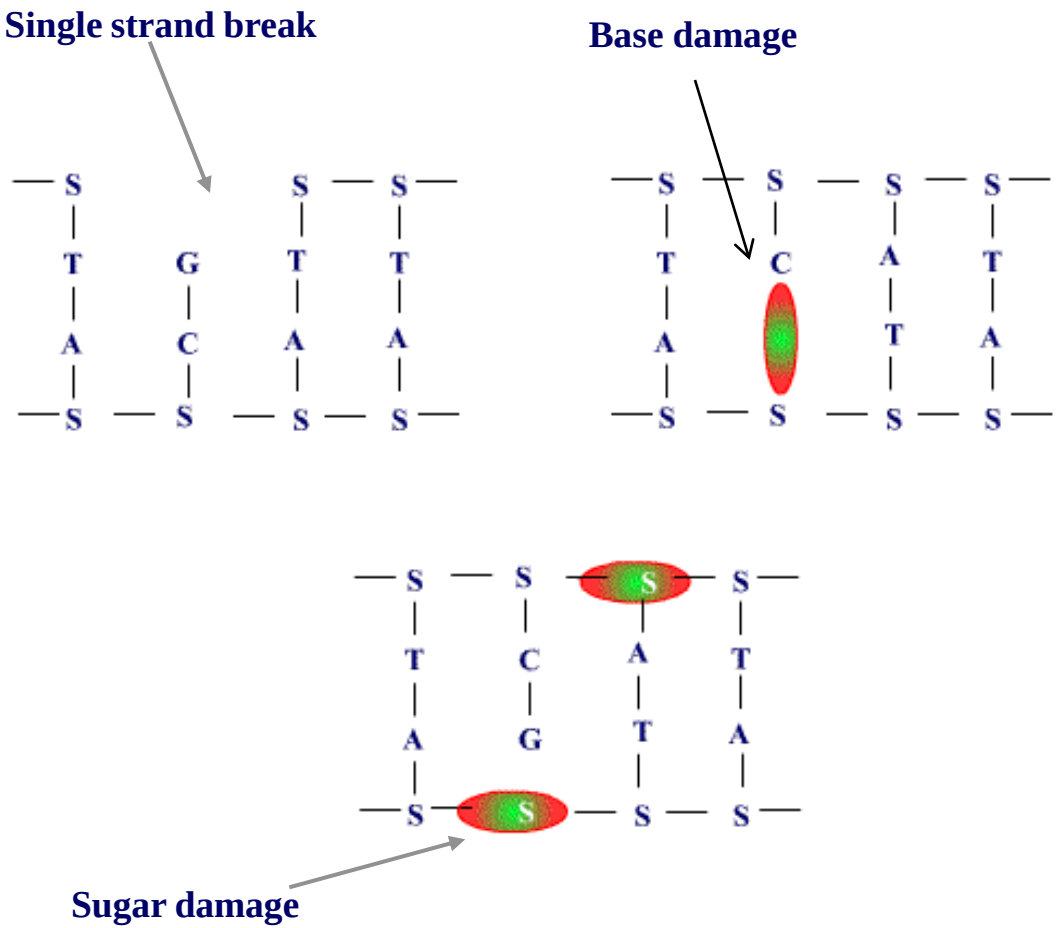
A.
Heavy ions is a powerful tool for solving problems in radiation genetics

The RBE problem

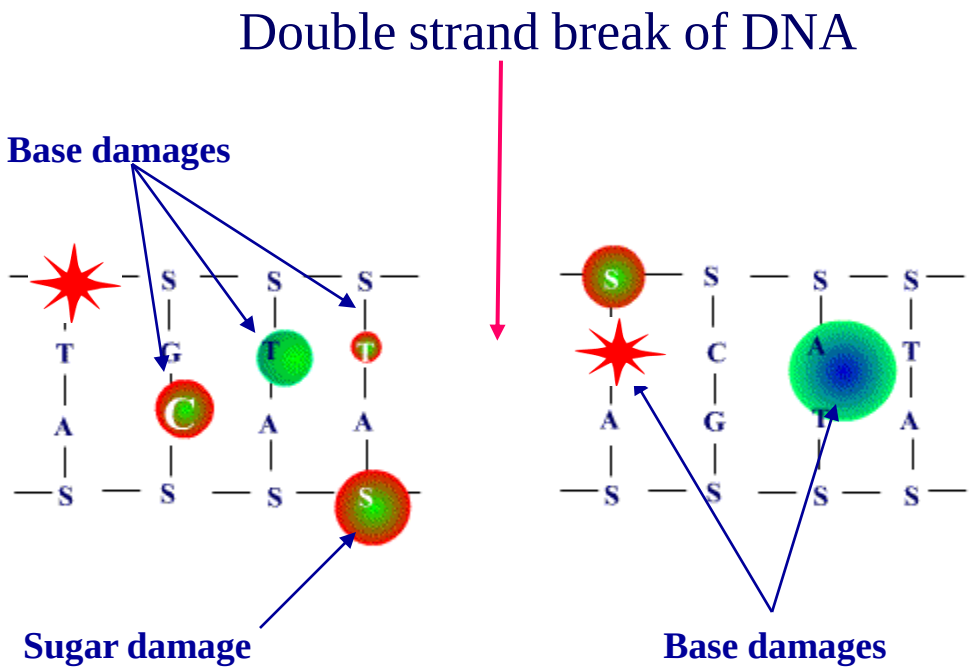


DNA repair capacity of the living cells determines the type of RBE on LET dependence

Single DNA damage

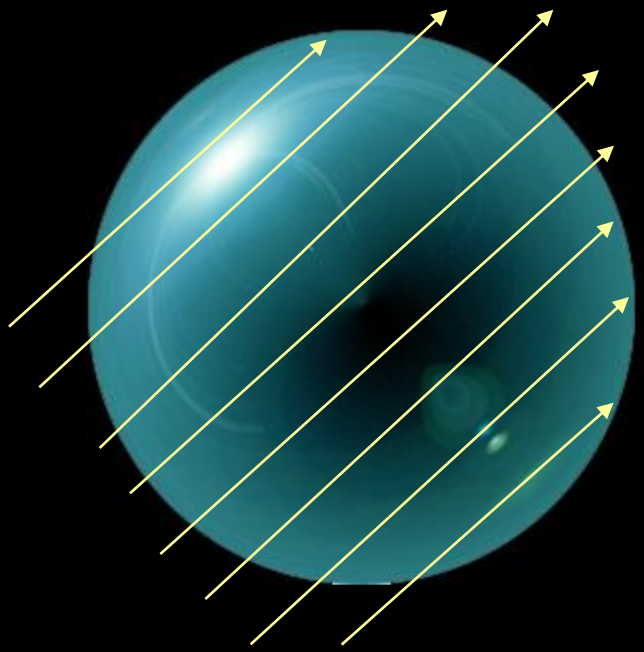


Clustered DNA damage



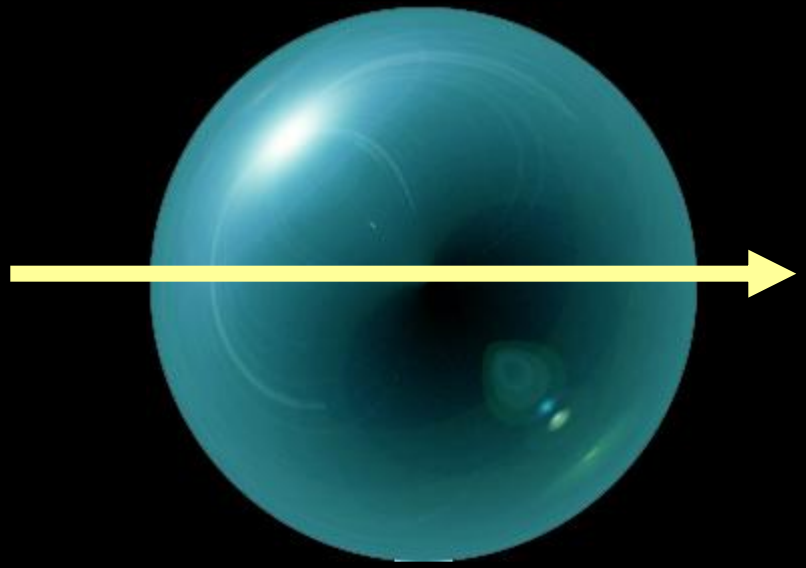
Radiation dose distribution in matter

1 unit of the dose



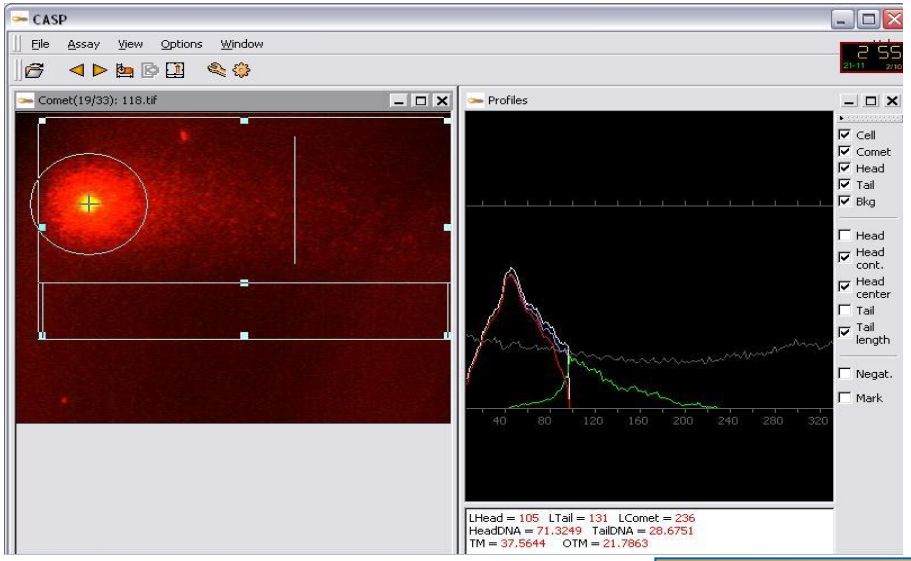
X-rays

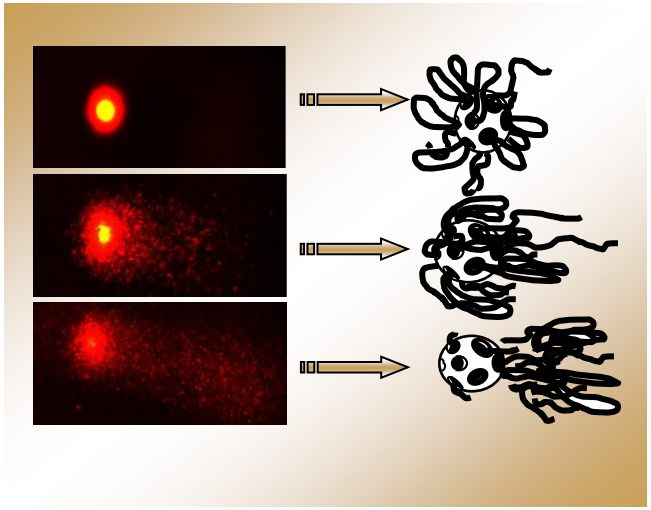
1 unit of the dose

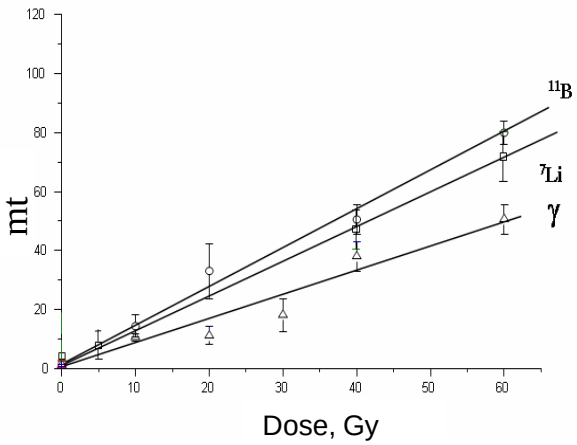


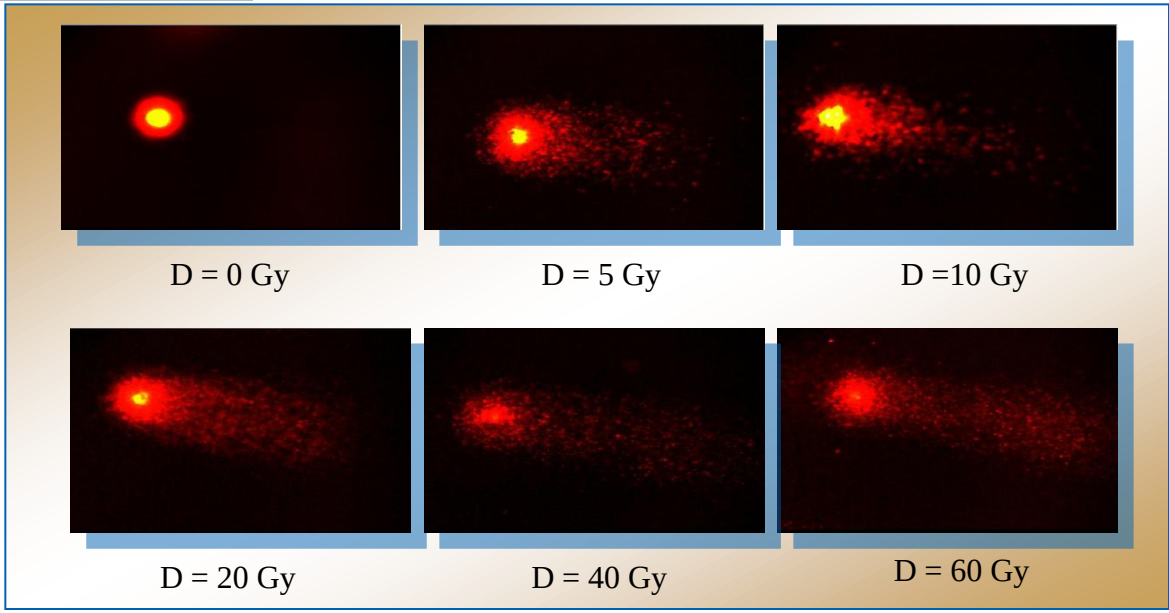
Fe ion

“Comet assay” for detection of DNA lesions









Human cells exposed to γ-rays and ^{11}B ions

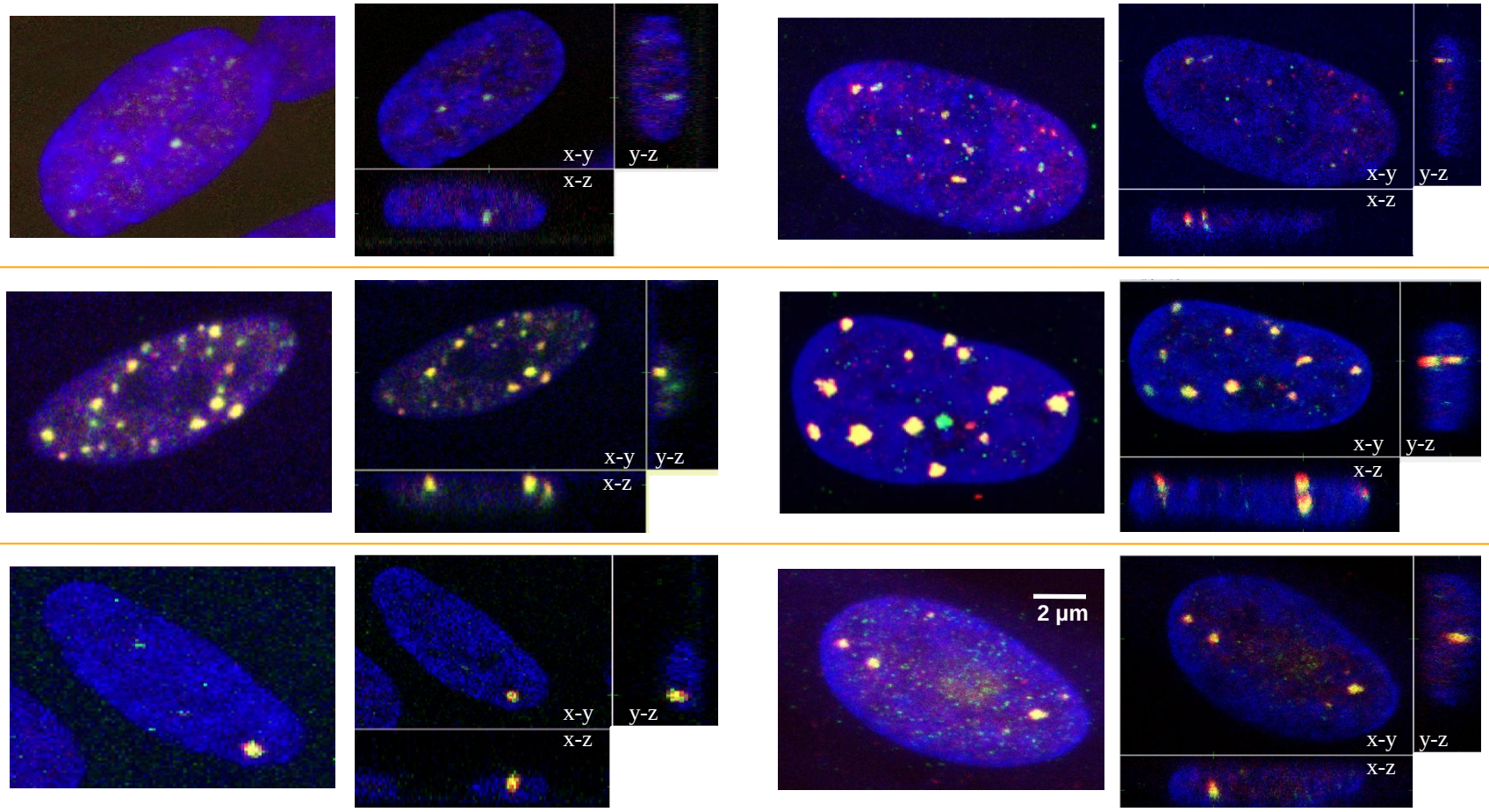
γ-rays (LET = 0.3 keV/μm)

^{11}B ions (LET = 135 keV/μm)

5 min

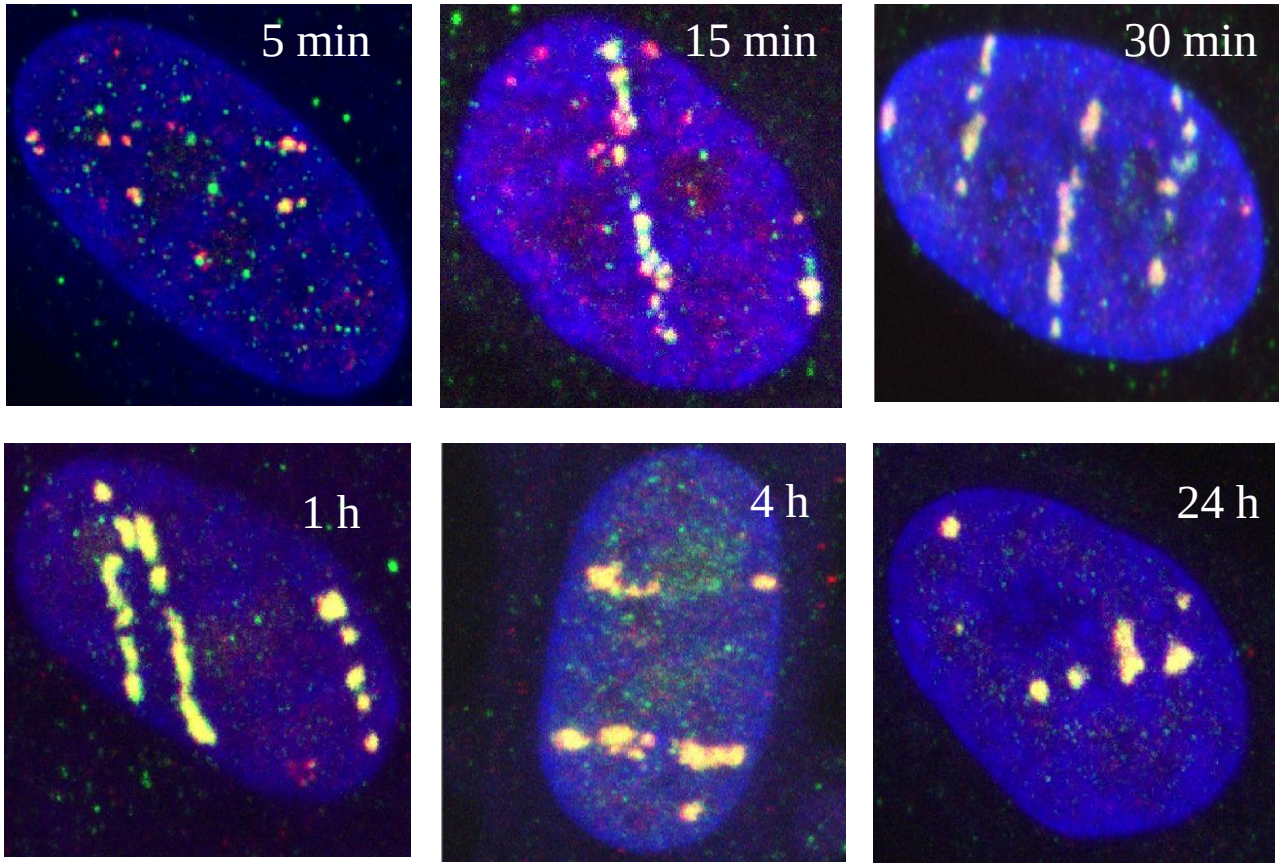
1 h

24 h



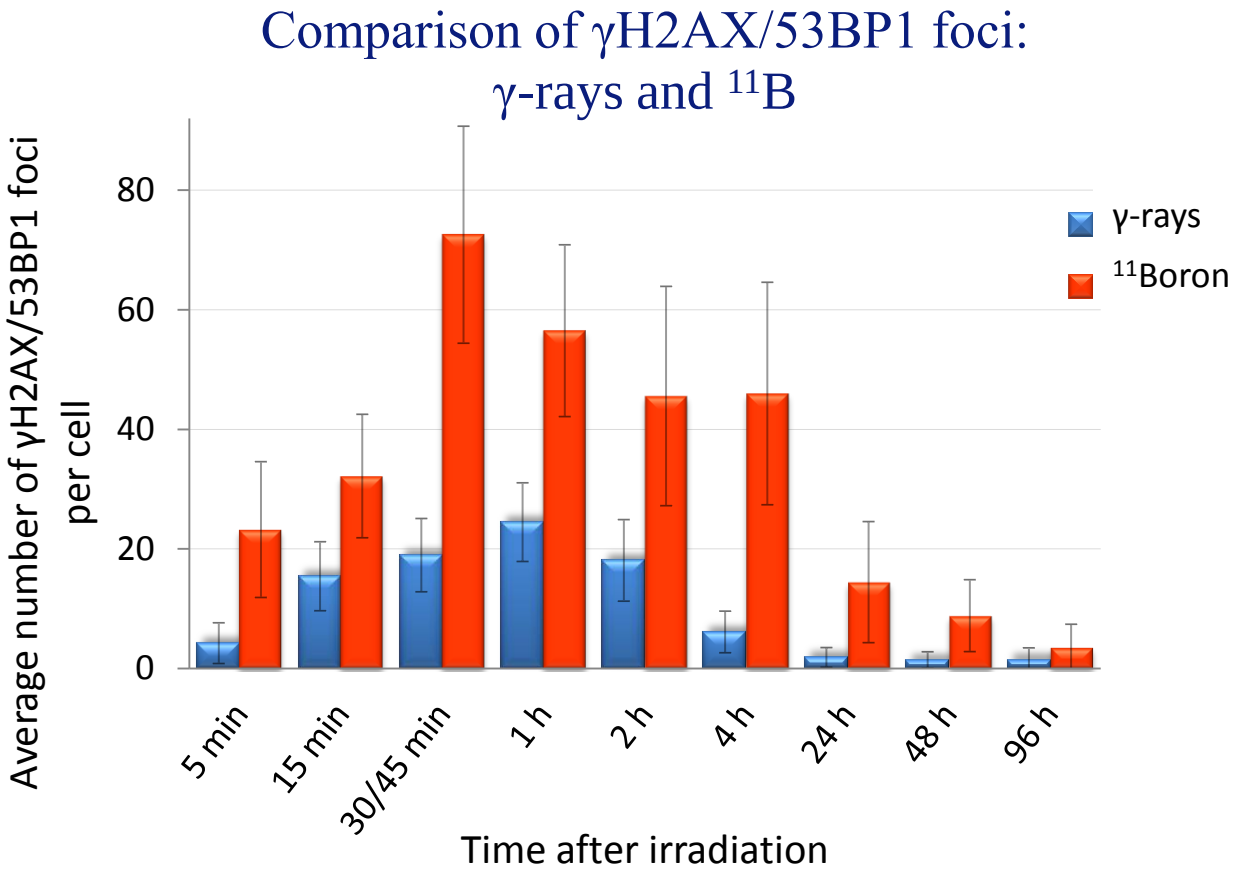
γH2AX 53BP1 Chromatin (DAPI)

Human cells exposed to ^{11}B ions at 10°

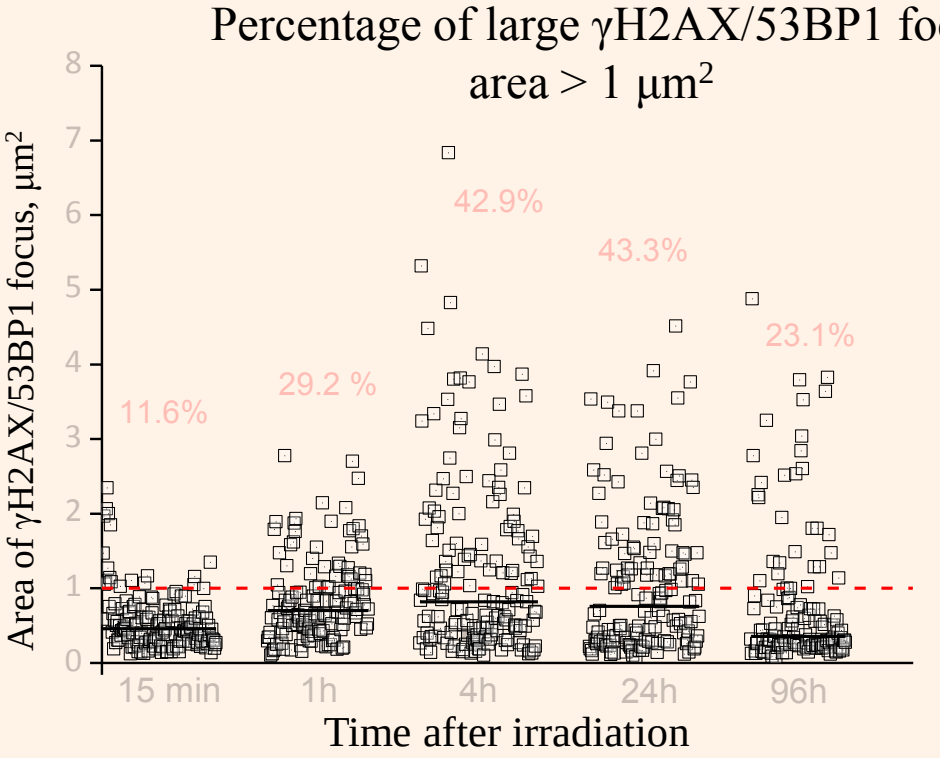


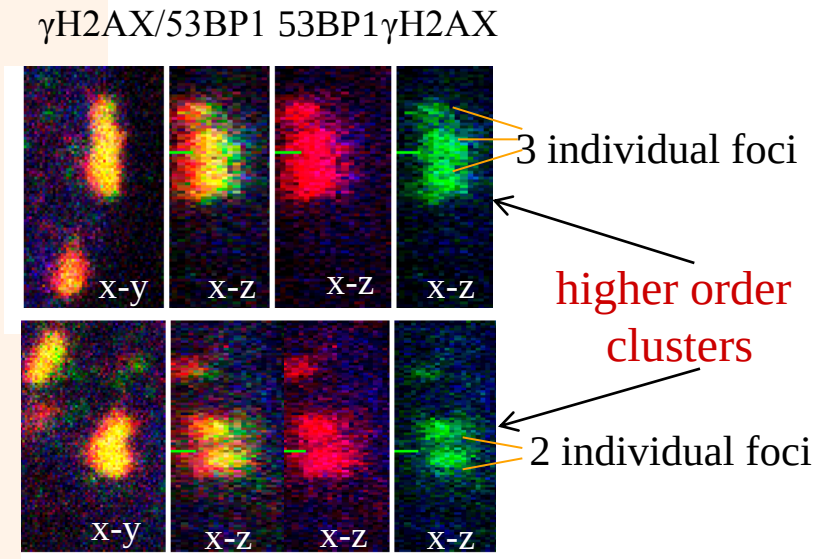
3D visualization of DNA foci streaks

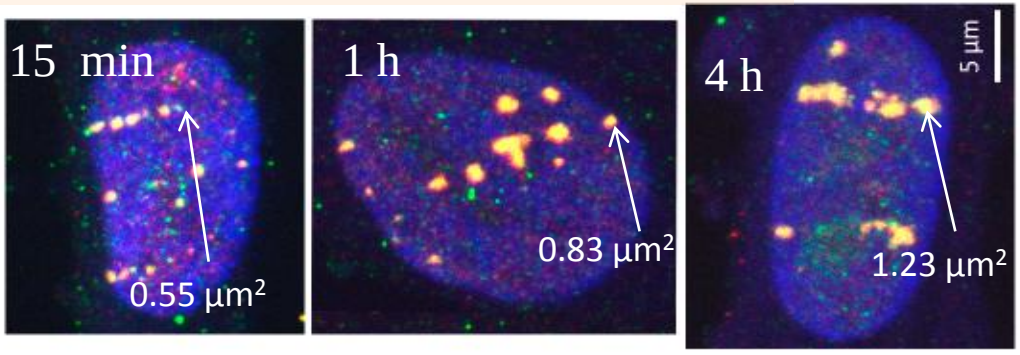
Kinetics of the formation and disappearance of γH2AX/53BP1 foci



Higher-order clustered γH2AX/53BP1 foci after ^{11}B irradiation

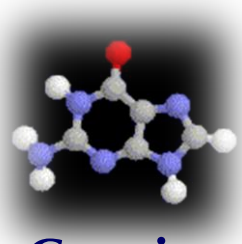




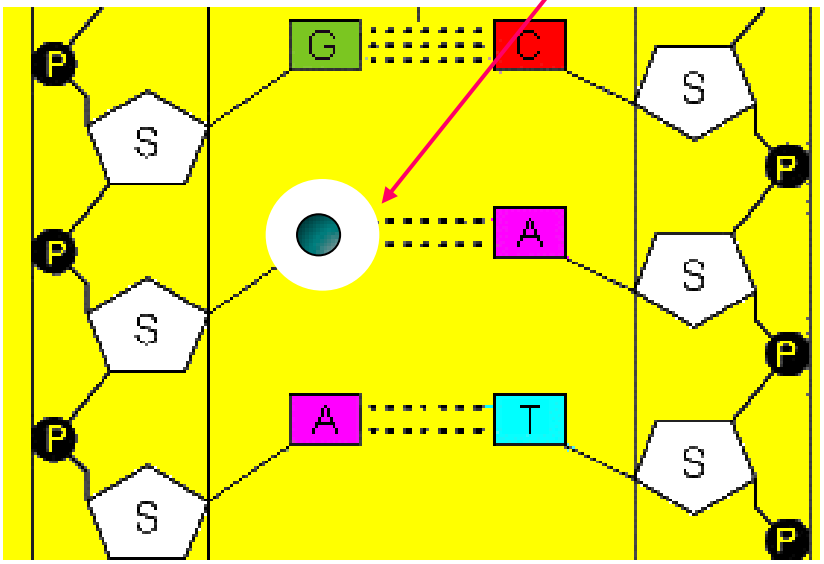


Radiation induced mutagenesis

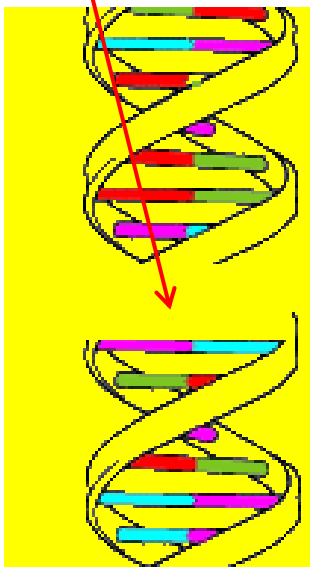
Gene mutation



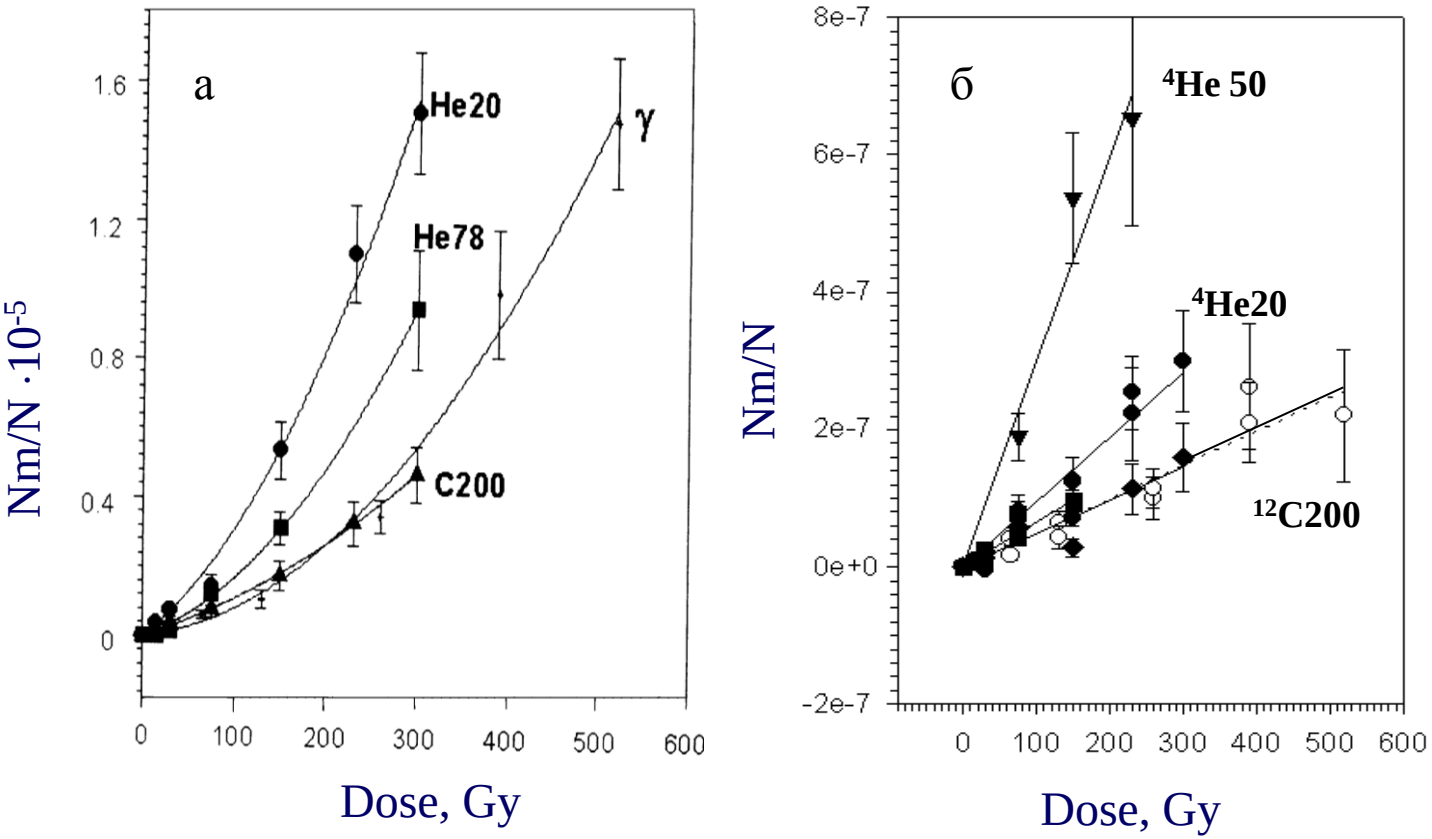
Guanine



Structural mutation

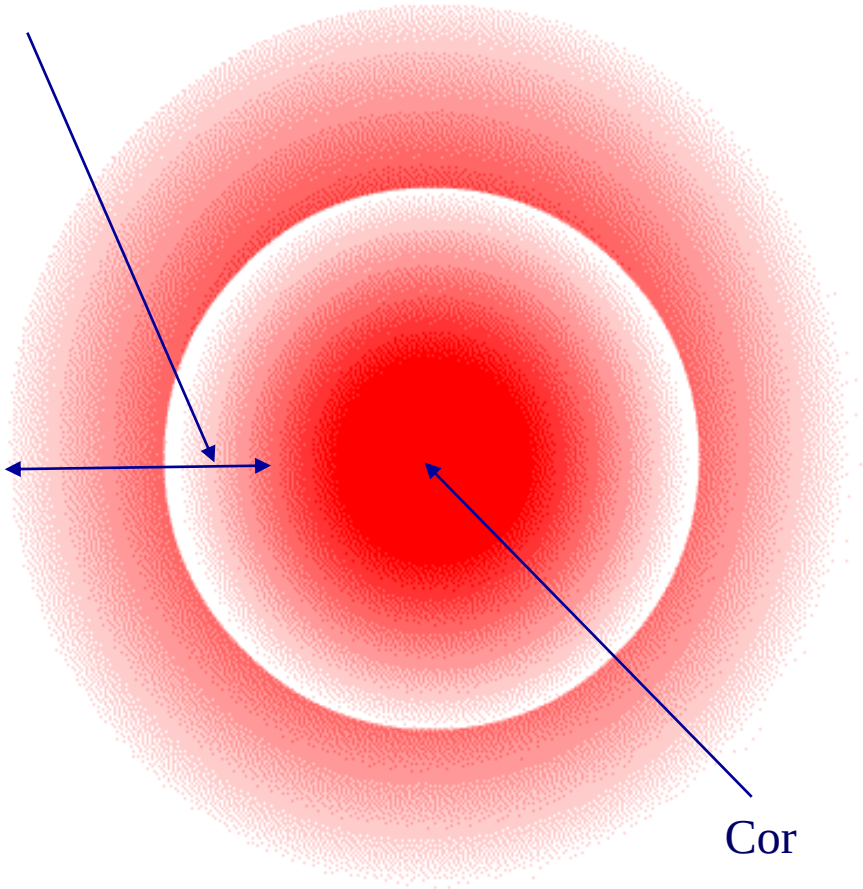


The frequency of gene and structural mutation induction after γ-ray and heavy ion irradiation



Mutagenic belt

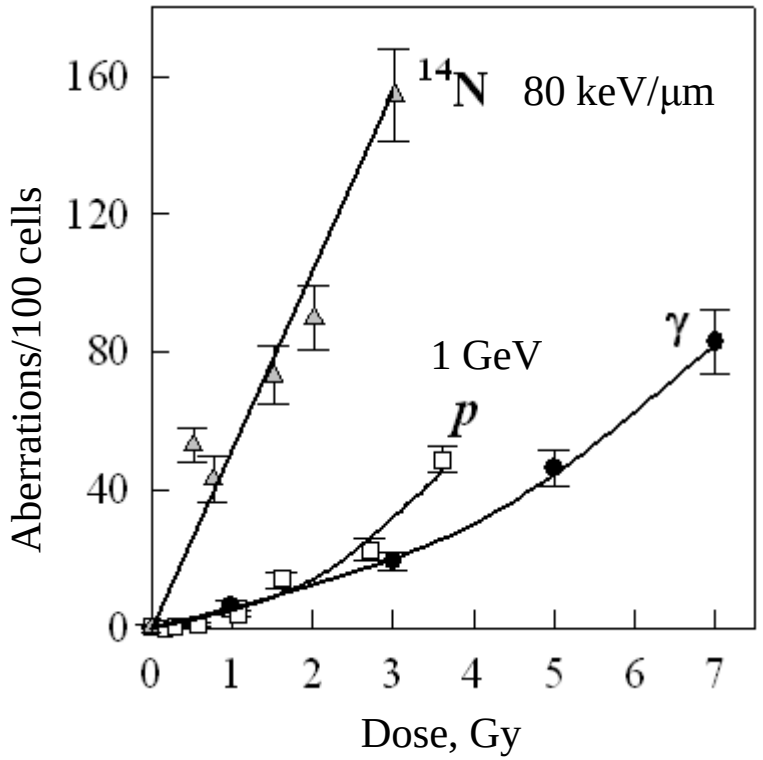
Mutagenic belt of heavy particle track



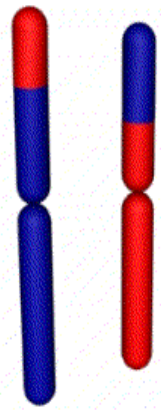
Formation of unstable chromosomal aberration in human cells after heavy ion irradiation

Cell division blocking

Unstable
chromosomal aberration



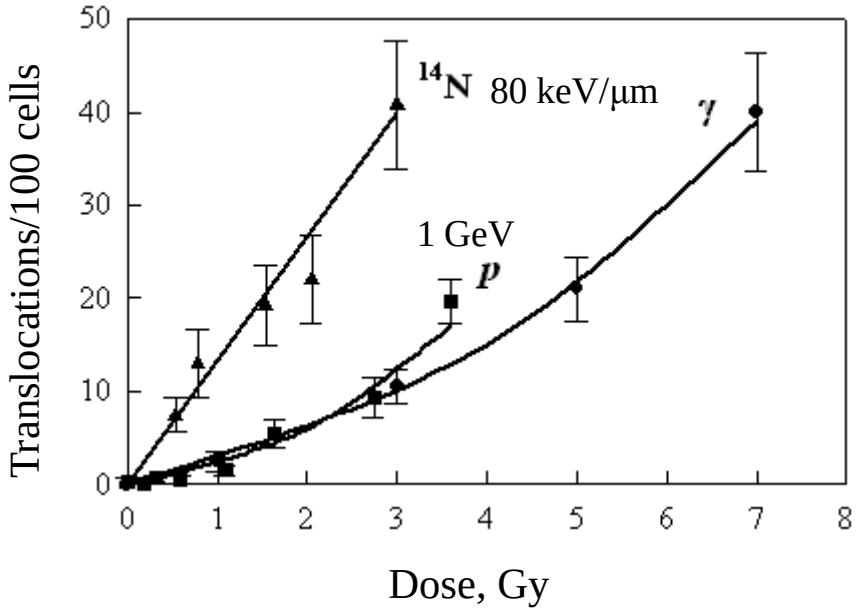
Formation of stable chromosomal aberrations in human cells after heavy ion irradiation



Stable
chromosomal aberration

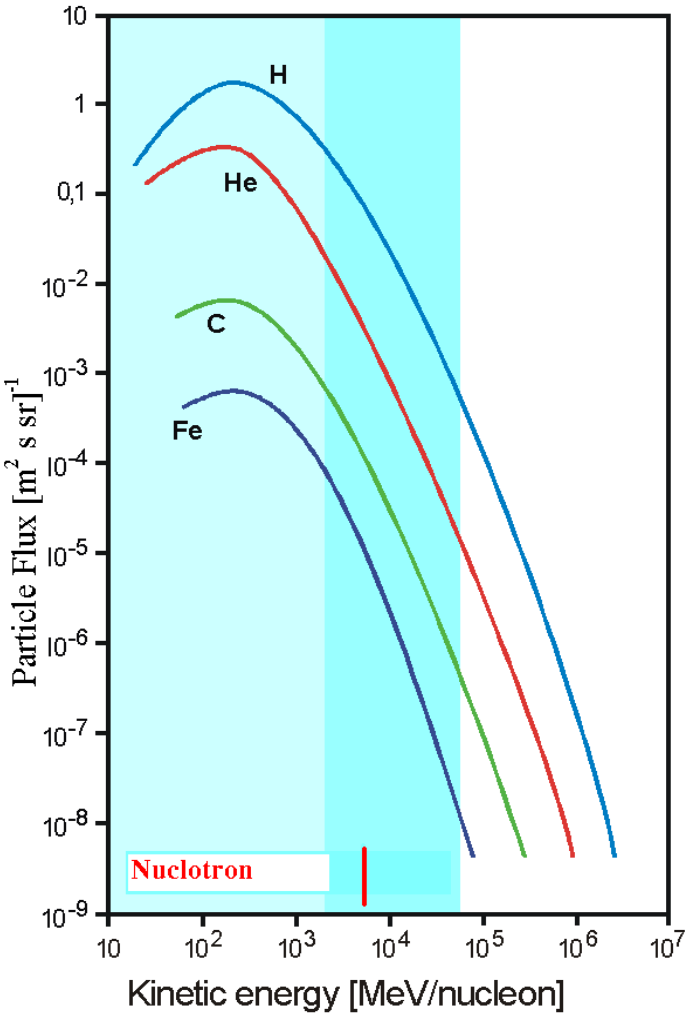
Successful cell division

Chromosome № 1



B.
Accelerated heavy ions as a tool for modeling of biological action of space radiation

The GCR energy spectrum



The integral flux of GCR particles of carbon and iron groups equals to

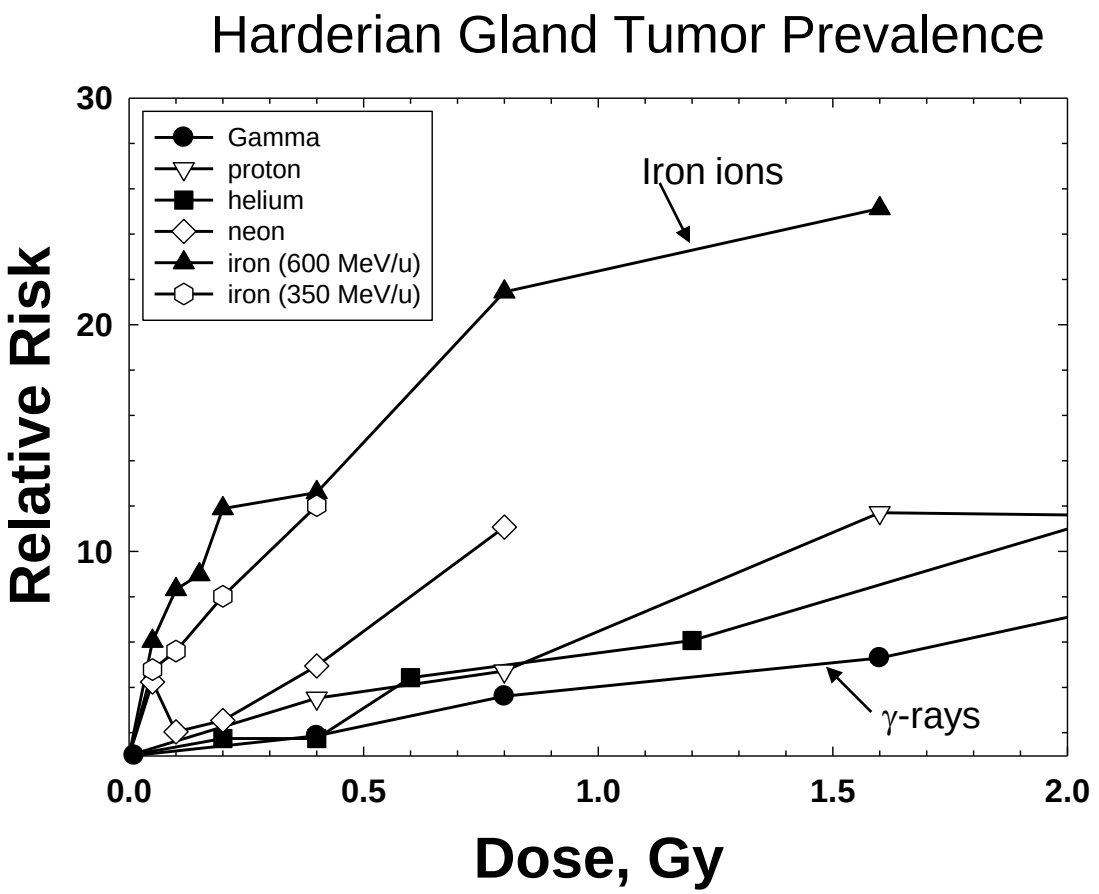
~10^5 part/cm^2 per year

Particle flux density interplanetary space Z≥20 160 per day per cm^2

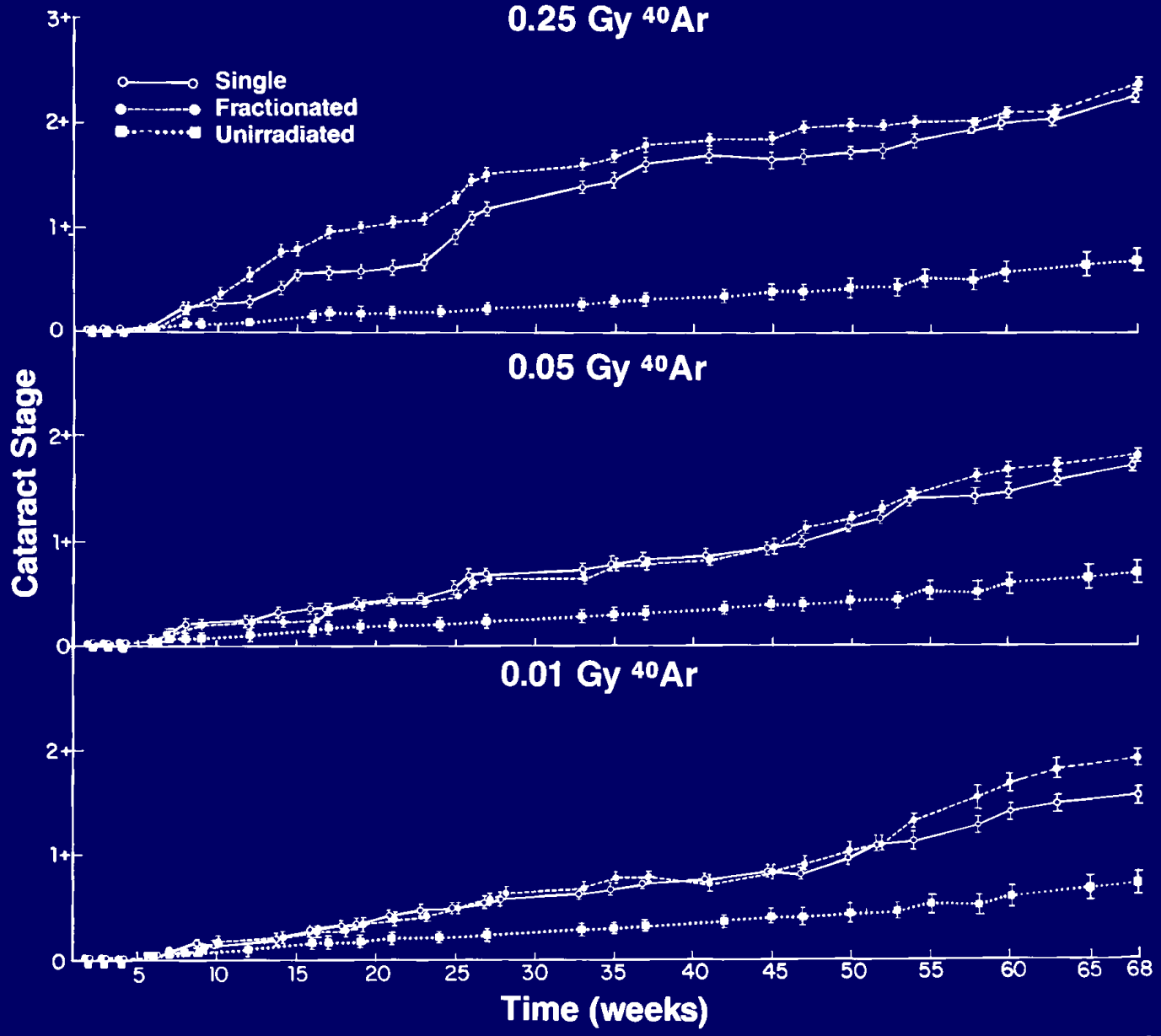
Consequences of Galactic heavy ion action

- Induction of cancer;
- Formation of gene and structural mutations;
- Violation of visual functions:
- *lesions of retina;*
- *cataract induction;*
- CNS violation

Gardner tumors



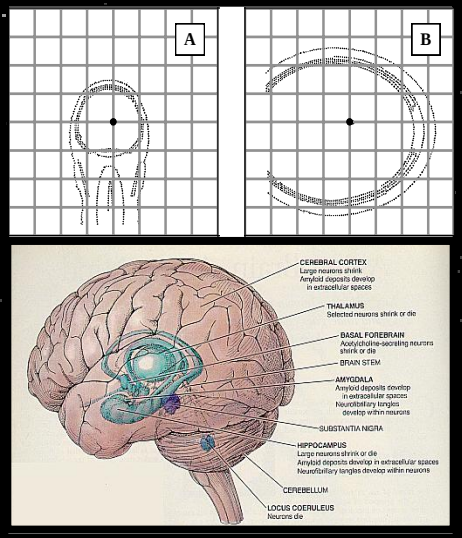
Nelson, 2006



Worgul et al., 2006

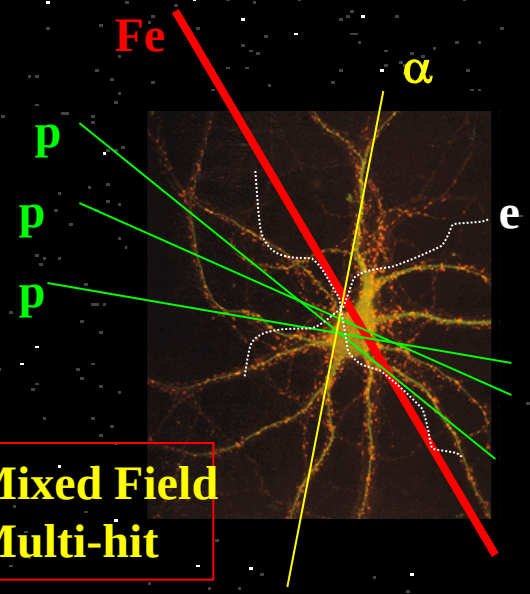
Accelerated heavy ions and CNS

Cosmic ray hit frequencies in CNS critical areas



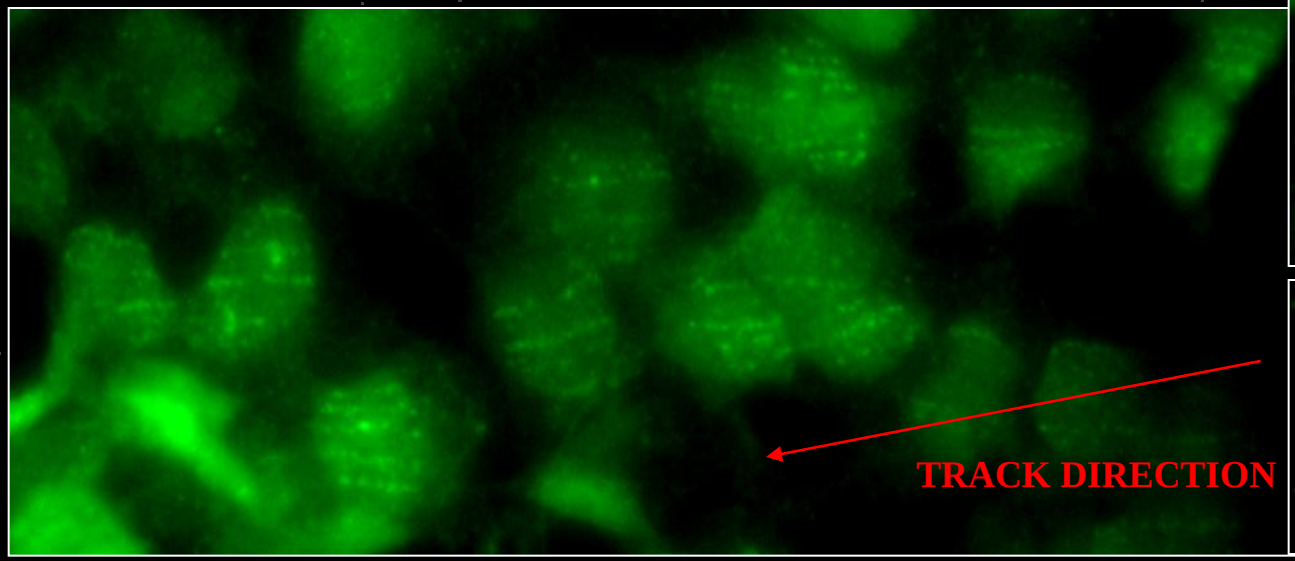
CNS in General

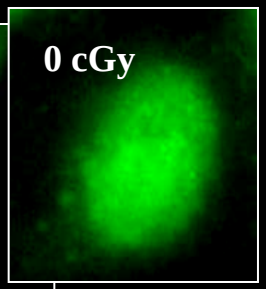
- 2 or 13% cells will be hit at least one Fe particle
- 8 or 46% would be hit by at least one particle with Z≥15
- Every nucleus will be traversed by a proton once every 3 days and a alpha particle once every 30 days.

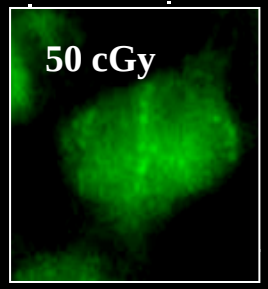


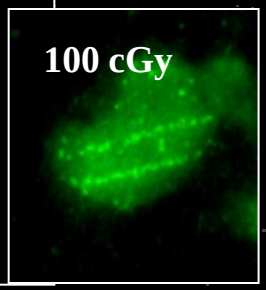
Mixed Field Multi-hit

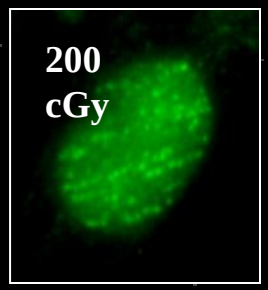
FE ION TRACKS VISUALIZED BY MARKERS OF DNA DSBs (γH2AX)



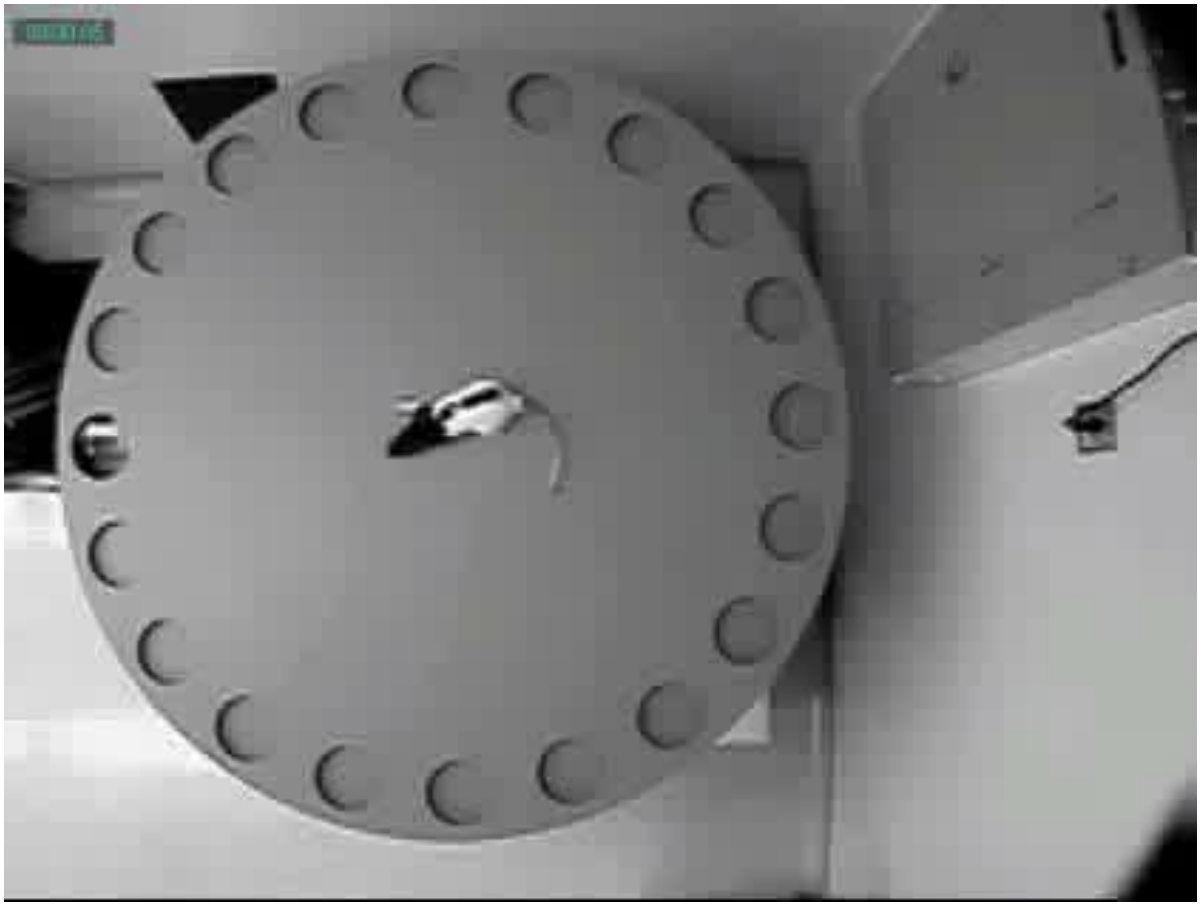








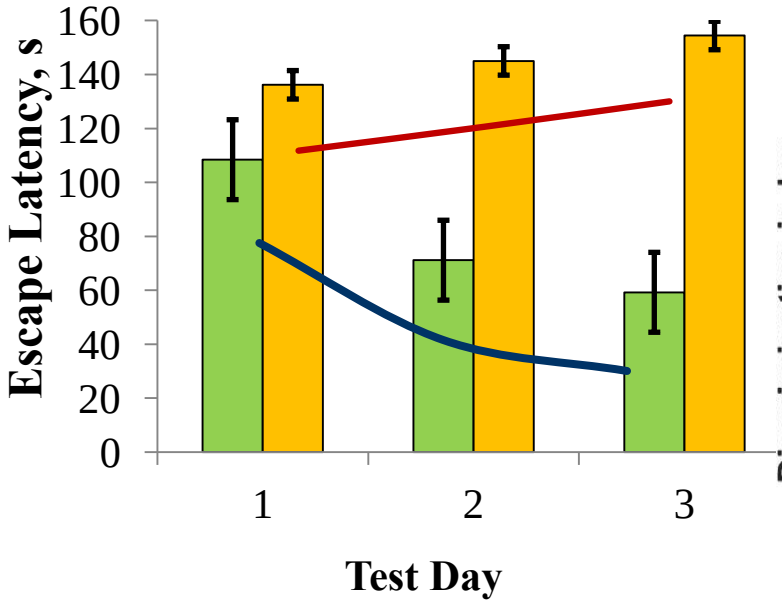
Тест К. Барнс



Behavioral deficits measured 1.5 and 3 months after charged particle exposure

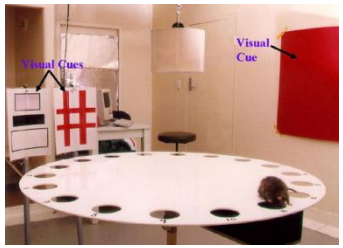
Rats

3 months after irradiation



control

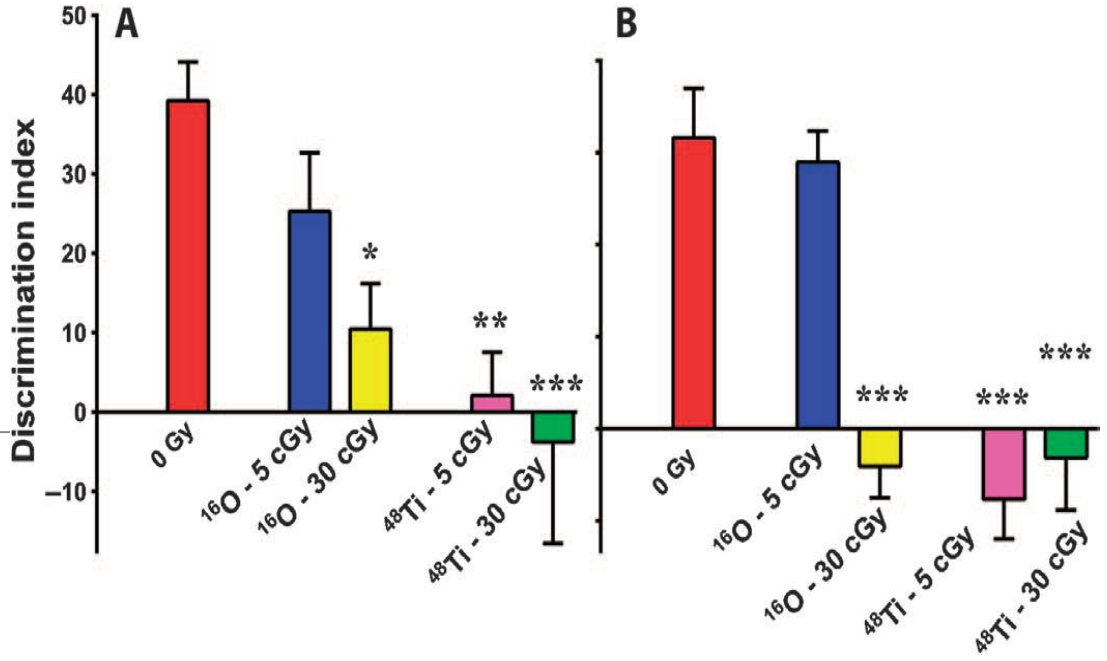
^{56}Fe ions 1 GeV/u, 20 cGy



R. Britten et al., 2012

Mice

6 weeks after irradiation



A -novel object recognition task
B - object in place task

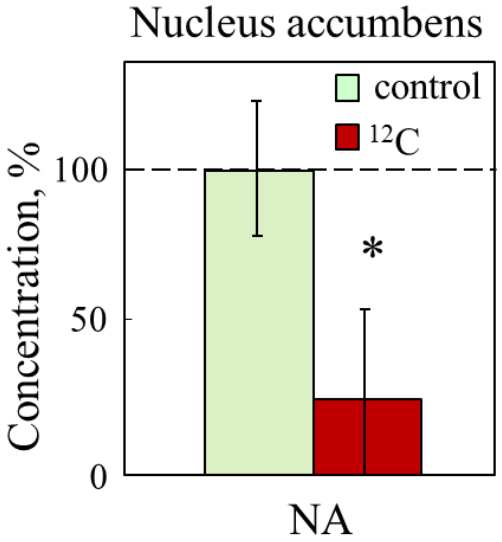
V. Parihar et al., 2015

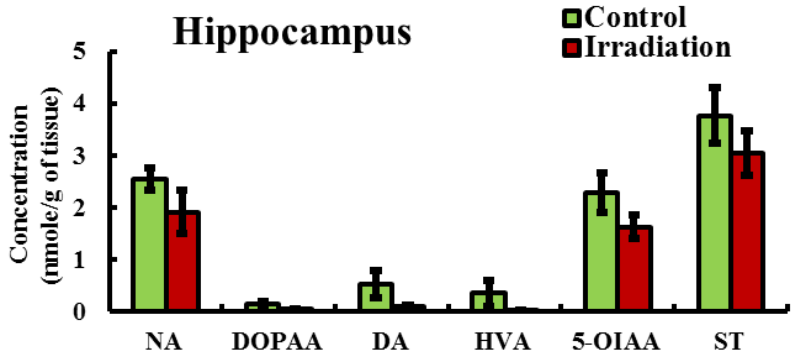
Studying the level of neurotransmitters in different rat brain areas

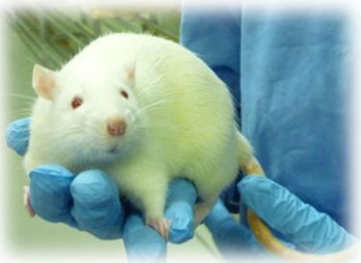
Irradiation with 1 Gy of 500 MeV/u carbon ions

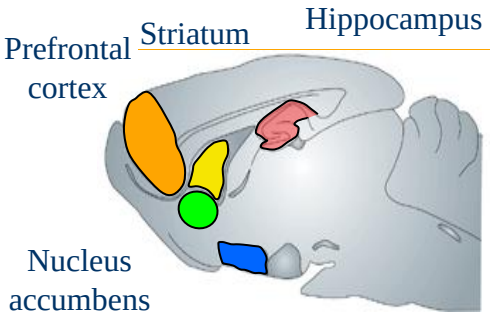
Radiation-induced decrease in the level of neurotransmitters is observed in the brain regions responsible for the *emotional and motivational state*

3 months after irradiation

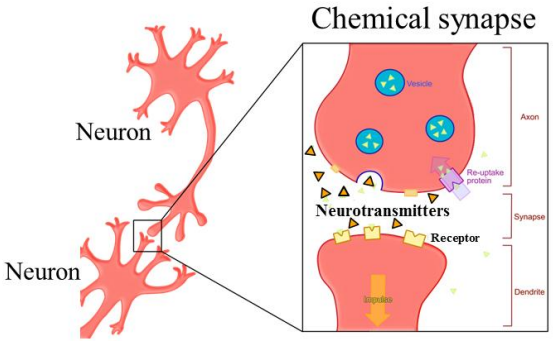






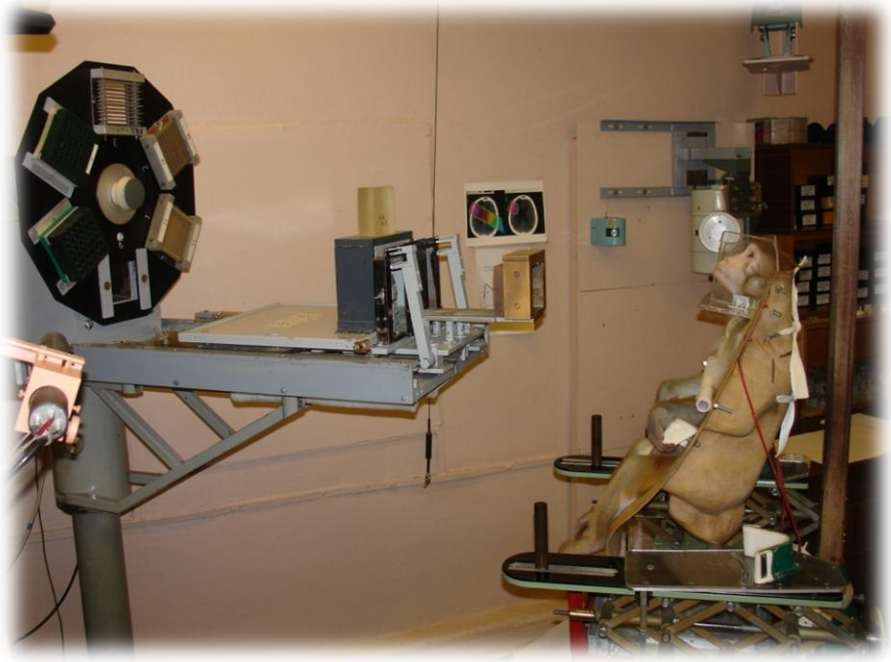


Rat brain



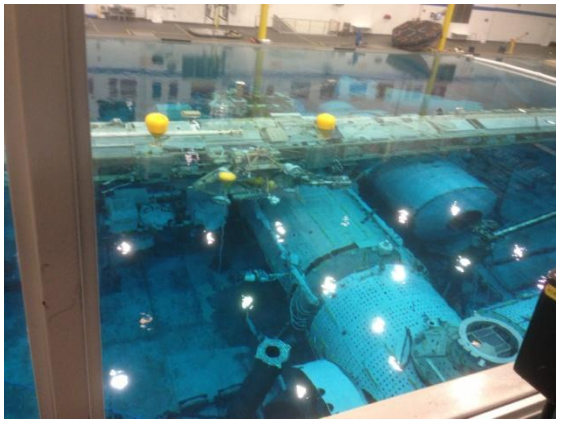
First experiments with monkeys

Irradiation with a proton medical beam, 170 MeV



Irradiation with ^{12}C ions, 500 MeV/u, at the Nuclotron

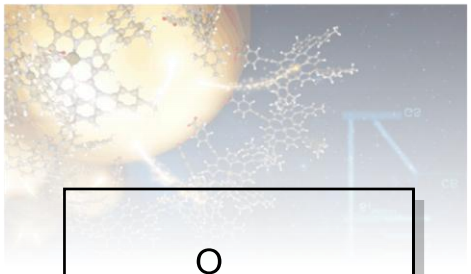
17th Meeting of the US/Russian Joint Working Group on Space Biomedical and Biological Sciences Research Houston, **NASA** (6-9 June 2015)

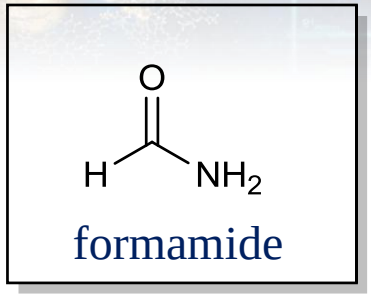


Astrobiology

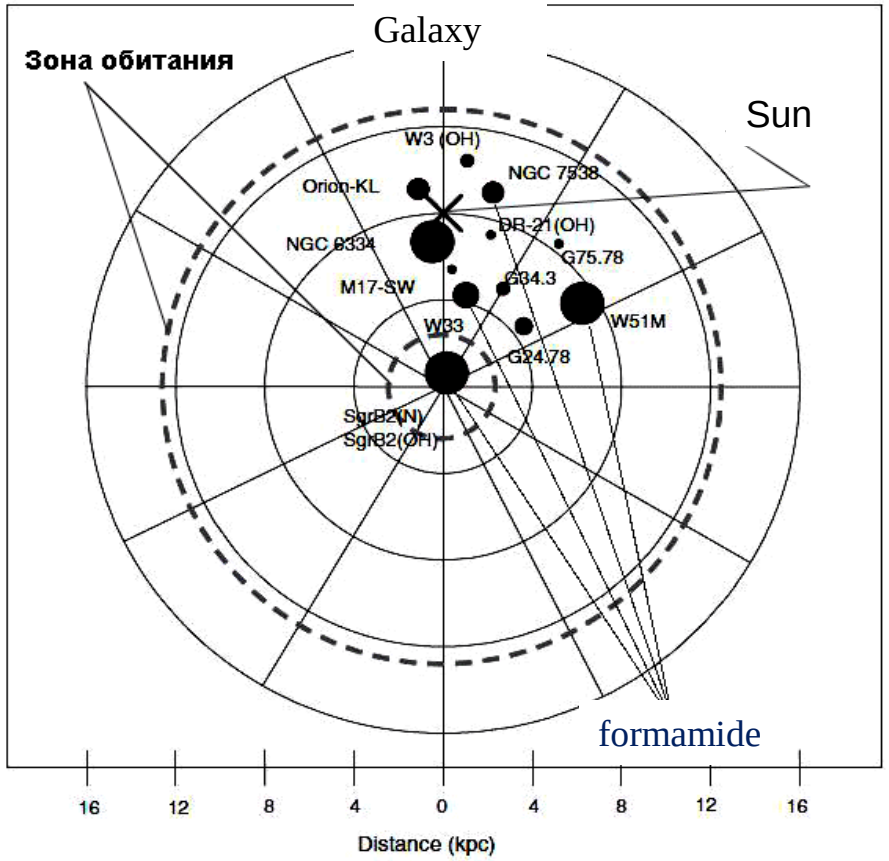
Gas-dust cloud Sagittarius B2, where formamide was found. Photo courtesy NASA

A model of the abundance and location of molecular clouds (the dotted line) containing formamide (black circles) in our Galaxy



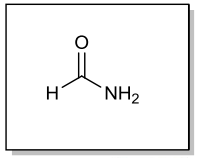


formamide

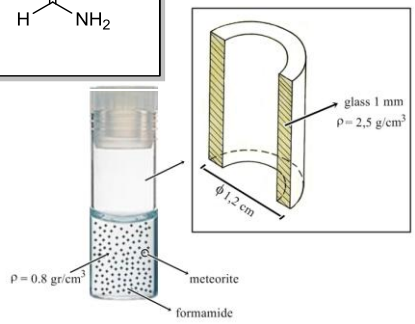


Astrobiology

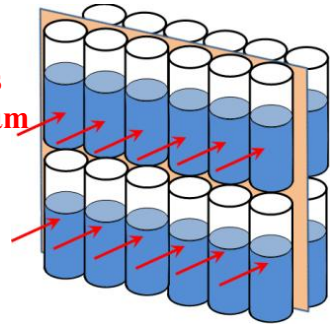
Collaboration: University of Viterbo, Sapienza University of Rome (Italy), and LRB

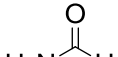


Formamide + meteorites

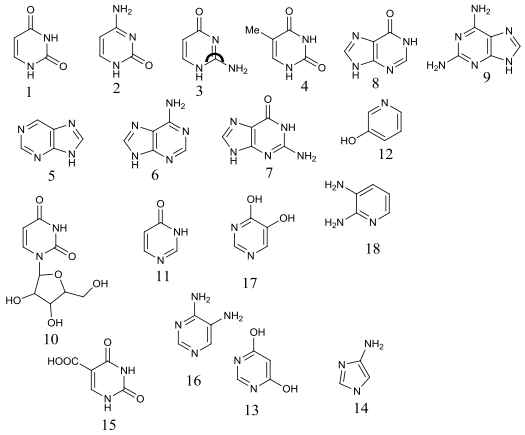


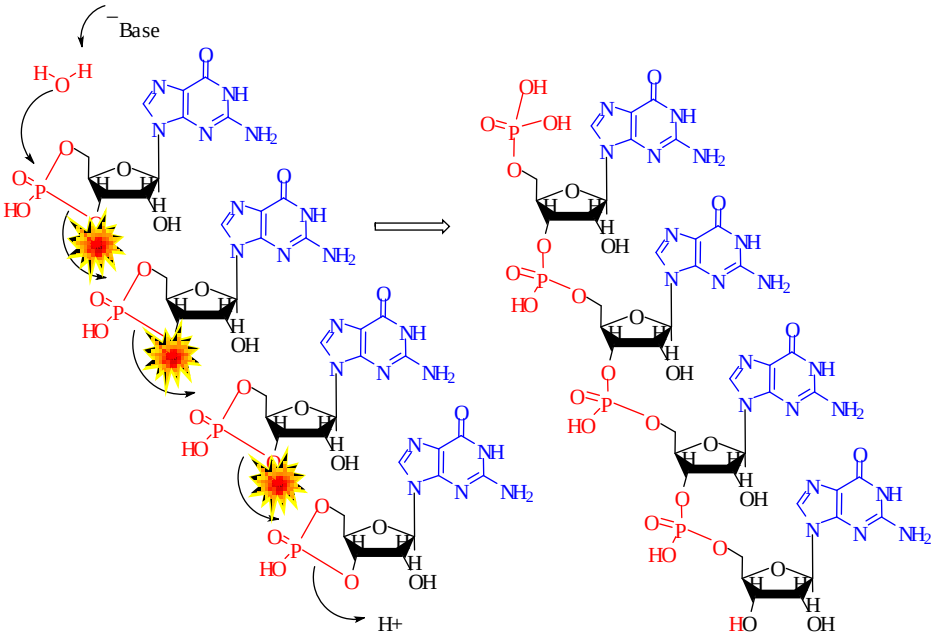
170 MeV protons
LET= 0.57 keV/µm
t= 3min
T= 25°C





Radiation





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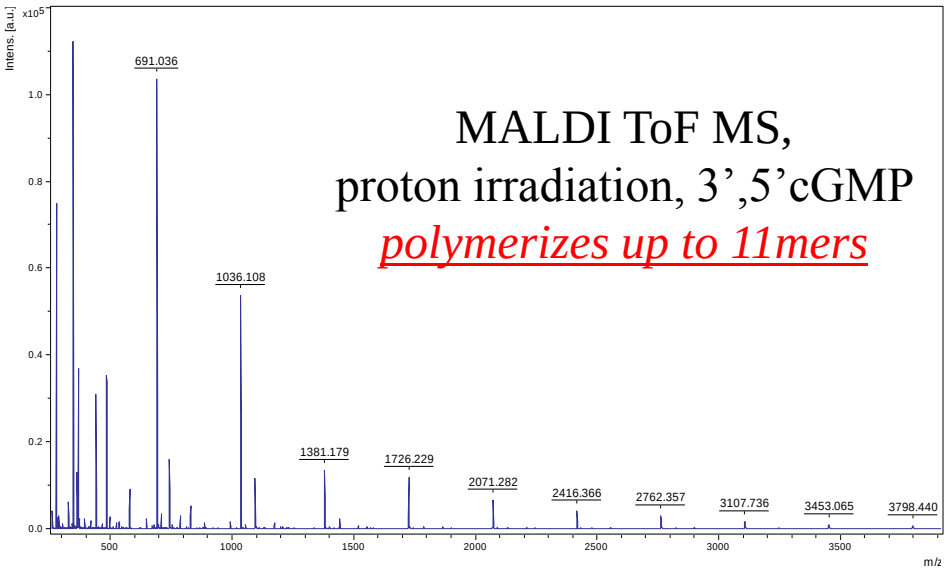
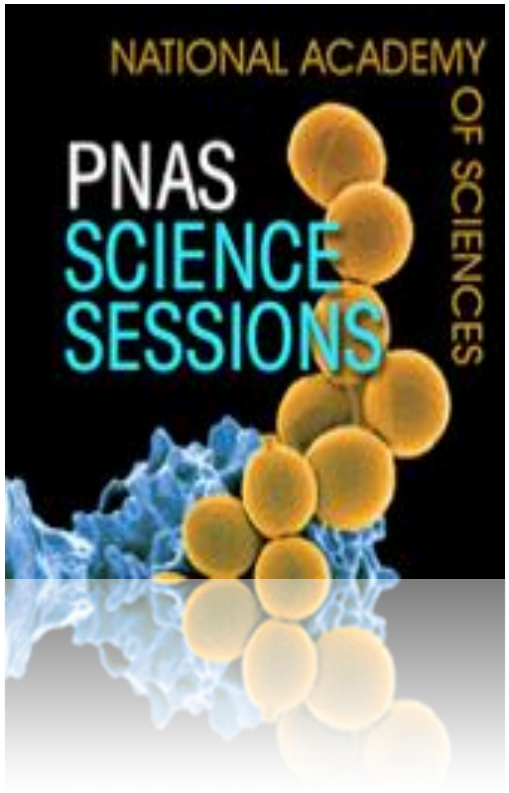


MALDI ToF MS,
proton irradiation, 3',5'cGMP
polymerizes up to 11mers

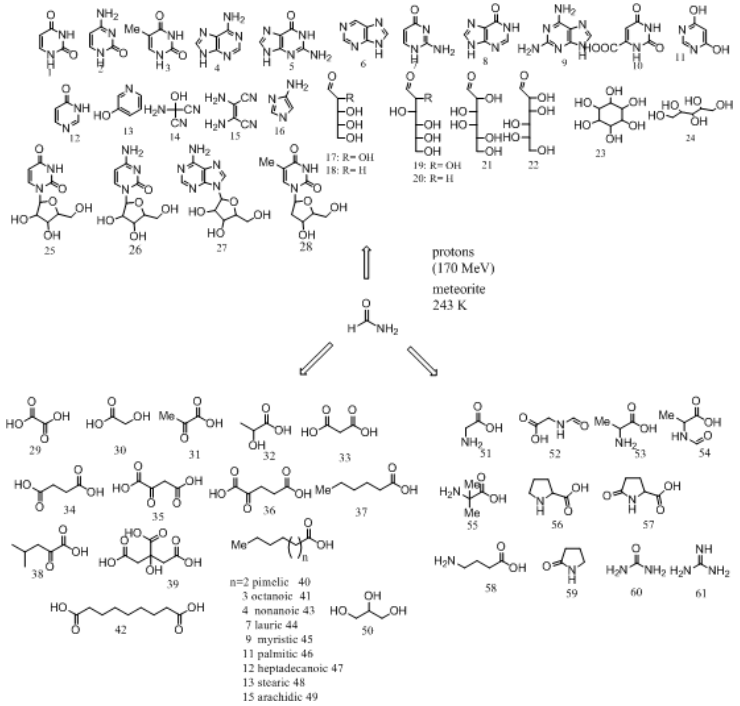
Astrobiology

The study was published in PNAS on 14.03.2015



Meteorite-catalyzed syntheses of nucleosides and of other prebiotic compounds from formamide under proton irradiation

Raffaele Saladino, Eleonora Carota, Giorgia Botta, Michail Kapralov, Gennady N. Timoshenko, Alexei Rozanov, Eugene Krasavin, and Ernesto Di Mauro. **PNAS** 10.1073/pnas.1422225112, 1-10



JINR's Accelerators for Radiobiology

U-400M: heavy ions 50 MeV/u

Phasotron: protons 660 MeV

Nuclotron: heavy ions up to 4 GeV/u

Thank you for your attention!