



**HZE MEASUREMENTS BY
PADC TRACK ETCH
DETECTORS DURING THE
FOTON M2 AND FOTON M3
MISSIONS (BIOPAN-5 and
BIOPAN-6 results)**

B. Dudás, J. Pálfalvi and J. Szabó



**HAS KFKI Atomic Energy Research Institute (AERI), Budapest
Hungary**



INTRODUCTION



In the frame of the two Foton M space missions external containers called BIOPAN were loaded with facilities for biology and dosimetry



ORBITAL PARAMETERS

Foton M2

- orbital period of 90 min
- apogee of 304 km and perigee of 262 km
- the inclination of 63°
- BIOPAN-5 in orbit for 15 days and 19 hours and 26 minutes
- The lid of BIOPAN-5 open for 14 days and 14 hours and 57 minutes

Foton M3

- orbital period of 90 min
- apogee of 280 km and perigee of 258 km
- the inclination of 63°
- BIOPAN-6 in orbit for 11 days and 20 hours and 25 minutes
- The lid of BIOPAN-6 open for 10 days



Comparison of the two BIOPAN boxes





RADO - EXPERIMENT (AERI)

- The aim of the RADO - experiments was to investigate the dose of the high LET components of the radiation field at LEO applying SSNTDs.

(--> PADC track etch detectors)

- Primaries

- trapped protons (from the Sun)
- GCR (87 % proton, 12 % Helium and only 1 % heavy ions)

- Secondaries

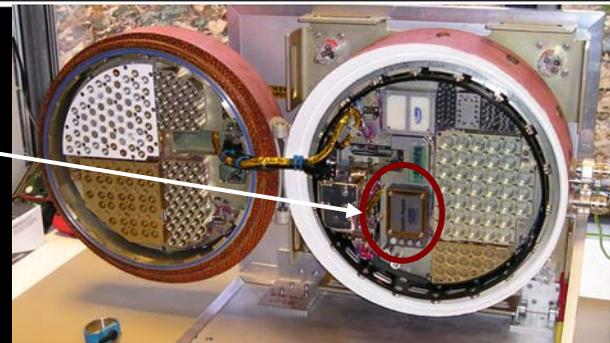
- neutrons
- fragments

- The high charge and energy particles (HZE) from galactic origin can damage the electronic devices.

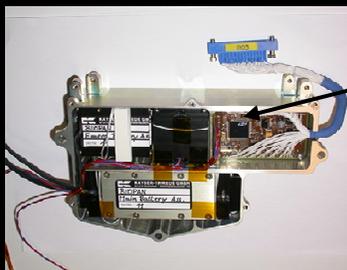


RADO - EXPERIMENT (AERI)

- In Biopan-6 experiment:
 - the RADO-plastic placed on the top of the R3D-B data acquisition system



- the RADO-galactic assembly mounted inside the microcontroller instrument



microcontroller



lid of houses

- more information about the distribution of HZE particles



STEPS OF THE METHOD

- After the etching method (6 n NaOH at 70 °C for 15 hours, bulk etch rate (V_b): 1.34 $\mu\text{m}/\text{h}$) the PADC detectors were investigated manually by an optical microscope.
- From the track parameters the linear energy transfer (LET) spectra were determined.
- Based on the LET spectra above 12 keV/ μm the **HZE particle absorbed dose** and **dose equivalent** were deduced.



RESULTS (track densities)

The fluence of HZE particles was much higher during the BIOPAN-5 than the BIOPAN-6 experiment !!!!

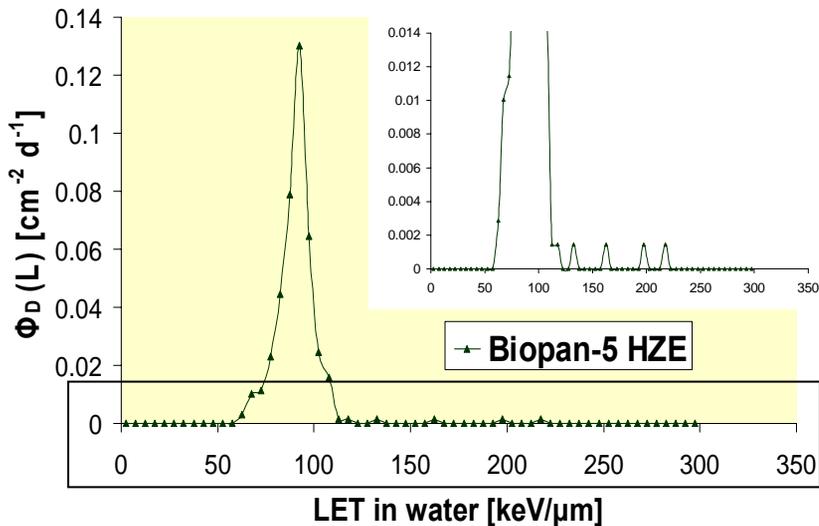
| HZE track densities [cm^{-2}] | | |
|--|--------------------|------------------------|
| Experiments | BIOPAN-6 (10 d) | BIOPAN-5 (14.625 d) |
| After 15 h etching | 8 | 130 |

| Area [cm^2] | BIOPAN-6 (10 days) | | | BIOPAN-5 (14.625 days) |
|---------------------------|---|------------------|-------------------|---------------------------|
| | RADO- neutron | RADO -plastic | RADO- galactic | RADO- neutron |
| 10 | Number of long range HZE tracks ($Z \geq 26$) | | | |
| | 8-10 | 11 | 8 | 18-30 |



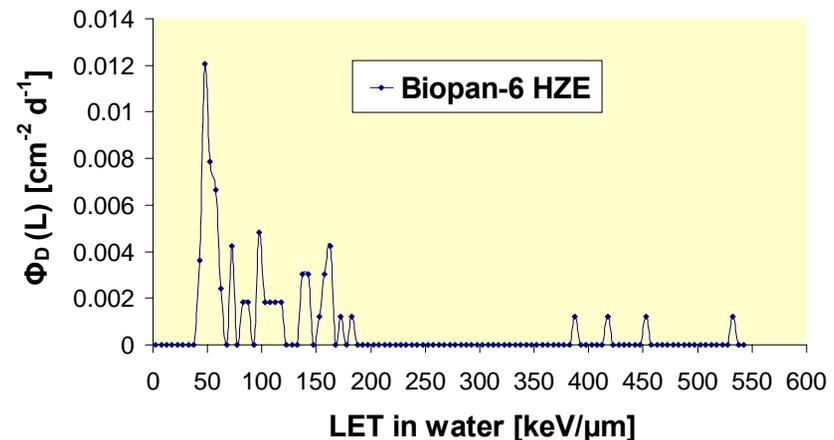
RESULTS (LET spectra)

LET spectrum of HZE particles on one PADC surface



$$\Phi_D(L) = f_c(L) \frac{dN(L)}{dLET} (d\Omega AT)^{-1}$$

LET spectrum of HZE particles on one PADC surface



$dN(L)$ - group fluence, $dLET$ - LET interval, $d\Omega$ - possible solid angle of the incident particle, A - scanned surface of the detector, T - exposure time, $f_c(L)$ - LET and dip-angle dependent correction factor



RESULTS (dose values)

$$D = \Omega \times 1.6 \times 10^{-6} \times T \times \Sigma(\Phi_D(L) \times \bar{L} \times dLET)$$

$$H = \Omega \times 1.6 \times 10^{-6} \times T \times \Sigma(\Phi_D) \times \bar{L} \times Q(L) \times dLET$$

| | | D rate [μGy/d] | Q (LET dependent quality factor) | H rate [μGy/d] |
|----------|------------|-------------------|--|-------------------|
| BIOPAN-5 | Total dose | 109 ± 19 | 6.2 ± 1.2 | 658 ± 8 |
| | HZE dose | 1.9 | 26.6 | 51 |
| BIOPAN-6 | Total dose | 15 ± 4 | 8.7 ± 0.7 | 128 ± 22 |
| | HZE dose | 0.4 | 20.2 | 9 |



CONCLUSIONS

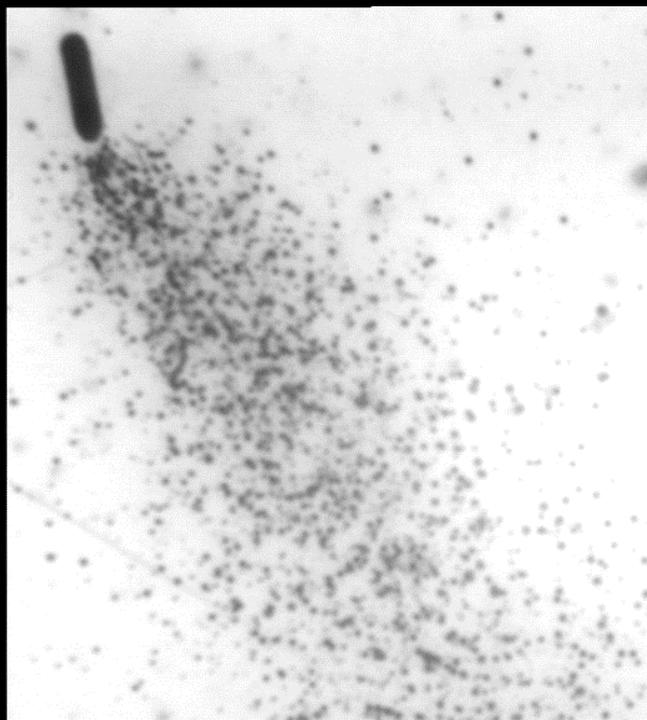
The BIOPAN-6 experiment resulted in less number of HZE tracks than the BIOPAN-5 project.

WHY?

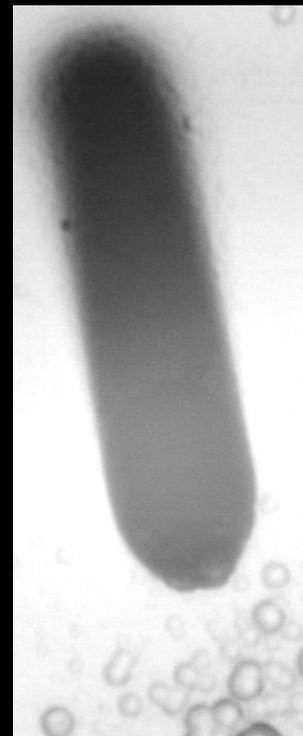
The decrease in the dose values can possibly be attributed to **some kind of shading effect**, but this hypothesis has not been proved yet.



An interesting HZE track in the RADO-galactic



**Stopping of
a heavily
ionizing Fe
particle in
RADO-
galactic**





Thanks for your
attention!

