DOSIMETRY ON THE FOTON M2/BIOPAN-5 SATELLITE

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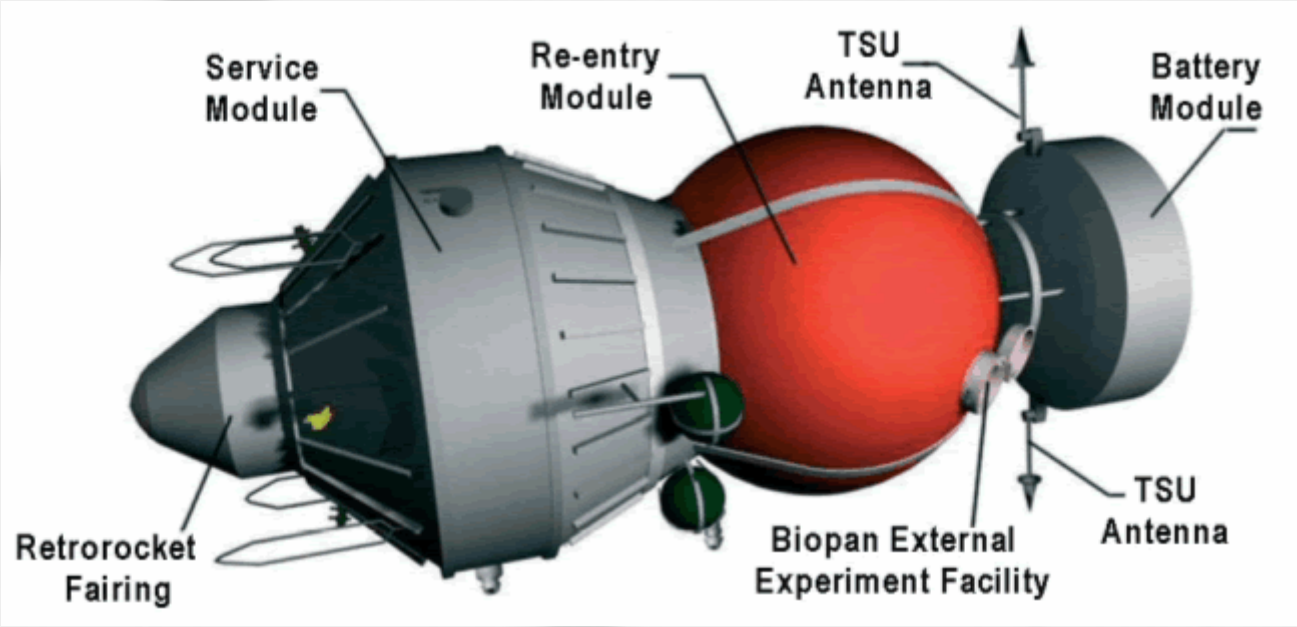
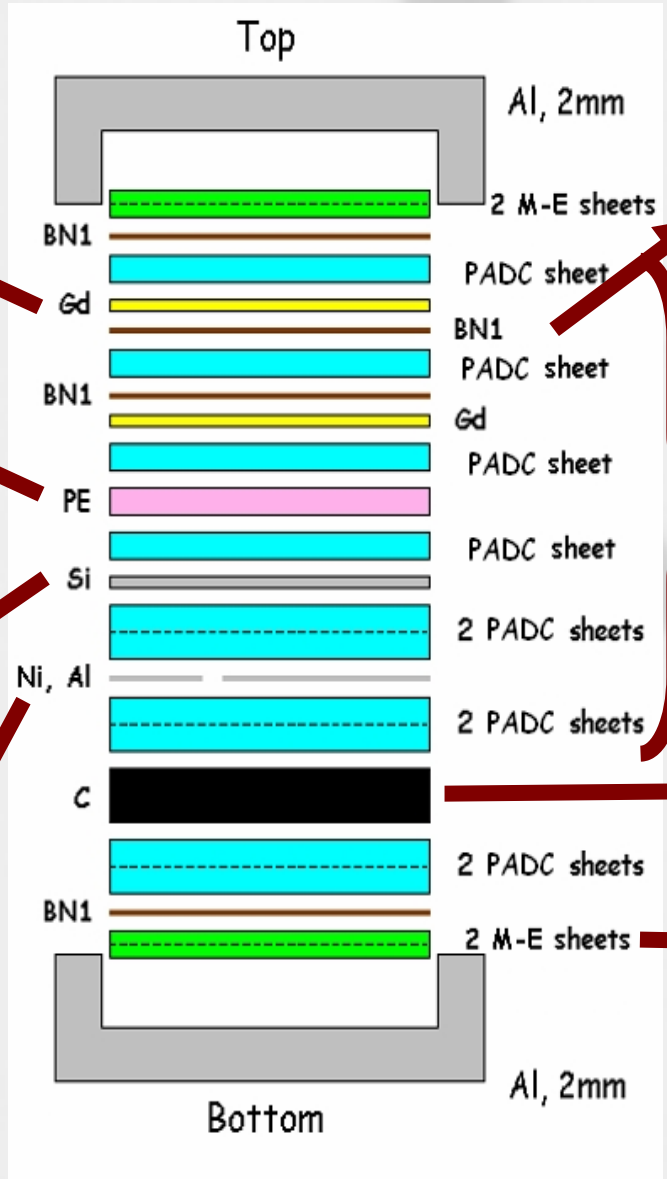
INTRODUCTION

A returning satellite - Foton-M2 - was orbiting an external container, the BIOPAN-5, loaded with facilities for dosimetry.



The galactic cosmic rays and secondary particles as neutrons were detected by a track etch detector stack.

BIOPAN-5 detector stack:



low energy neutron filter

H(n, n')p from ~200 keV up to ~ 5 MeV

(n,p) and (n,α) reactions to detect fast neutrons from different lower energy threshold up to 30-40 MeV

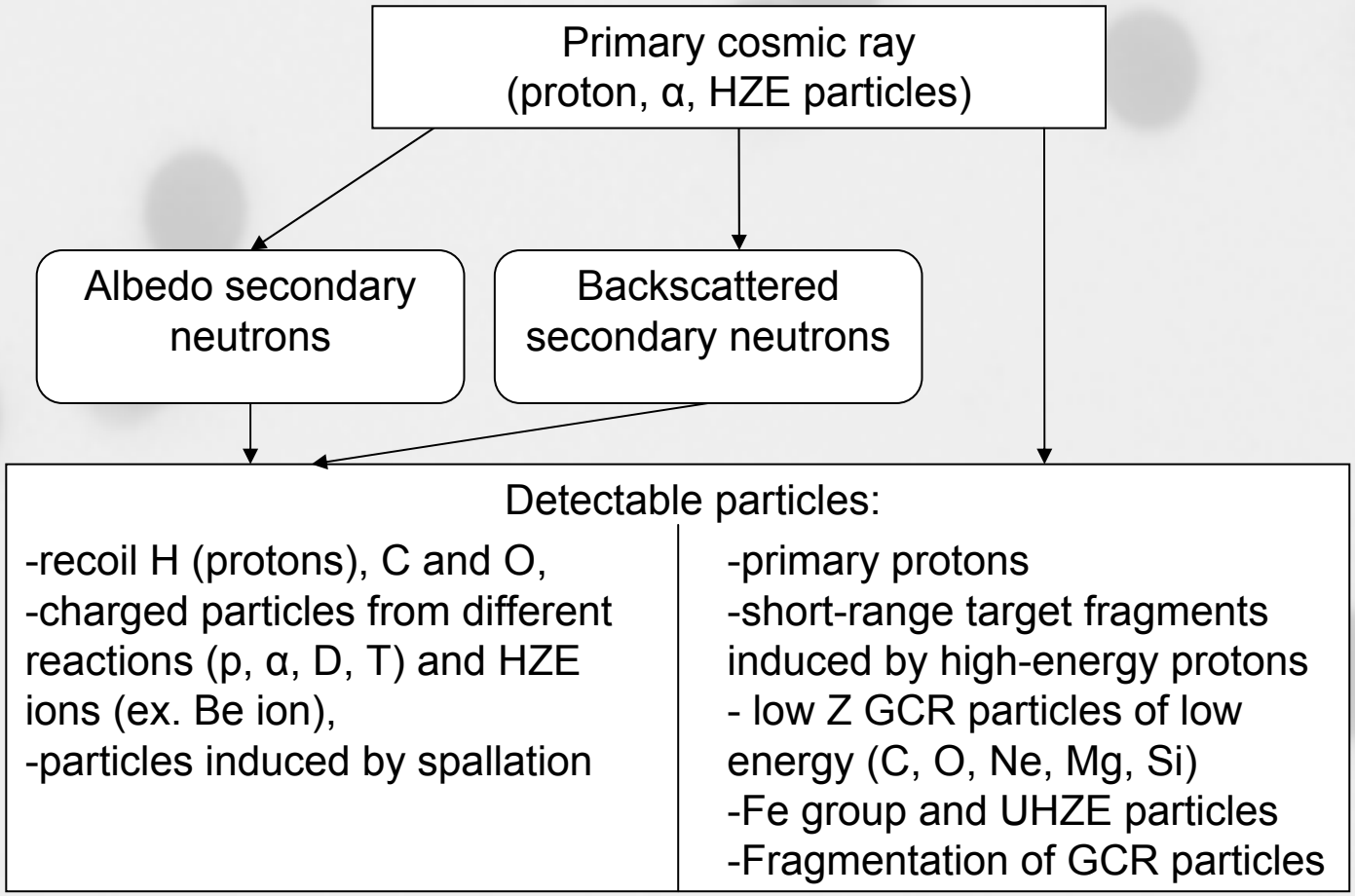
contains natural boron: thermal and epithermal (n,α) converter

detect GCR HZE particles and neutron induced charged particles, detection threshold ~ 10 keV/μm

^{12}C(n, xn')Y reactions induced by fast neutrons

measure GCR HZE particles above ~ 120 keV/μm

METHODS



Particles induced by primary cosmic rays and secondary neutron radiation which can be detected in the space on the PADC sheets

STEPS OF THE METHOD

- The system was calibrated at high energy particle accelerators, at neutron generators, with 1 MeV proton (Van de Graaf) and with collimated ^{210}Po alpha source.
- After the etching method the detectors were investigated by an image analyser.
- From the track parameters the linear energy transfer (LET) spectra were determined.
- Based on the LET spectra above 15 keV/μm the total particle absorbed dose was deduced.

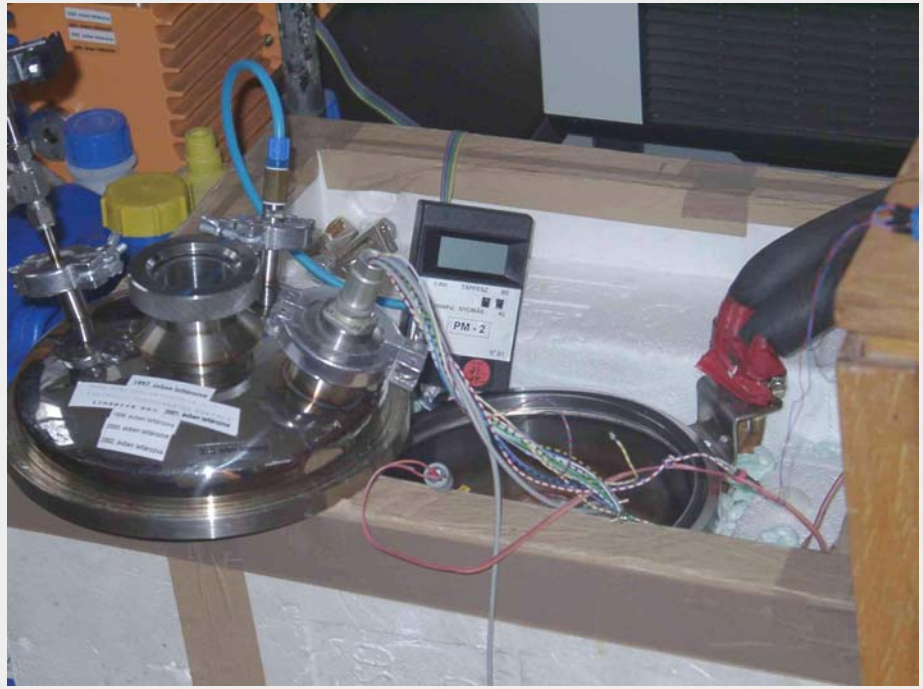
ENVIROMENTAL EFFECTS
(VACUUM AND TEMPERATURE)

- 1x10x20 mm PADC solid state track detectors
- Collimated ^{210}Po α source

Study:

- Area distribution of the α tracks ⟶

Change in the charged particle registration sensitivity of the track detectors



ENVIROMENTAL EFFECTS
(VACUUM AND TEMPERATURE)

CONCLUSIONS:

- It was found that after an outgassing time before and after irradiation in vacuum (80 mbar) the area of alpha tracks decreased drastically

- The low temperature (- 60 ºC) applied during the irradiation increased the registration sensitivity, as the area of alpha tracks increased.

- By applying vacuum and low temperature together, low temperature compansates the effect of vacuum.

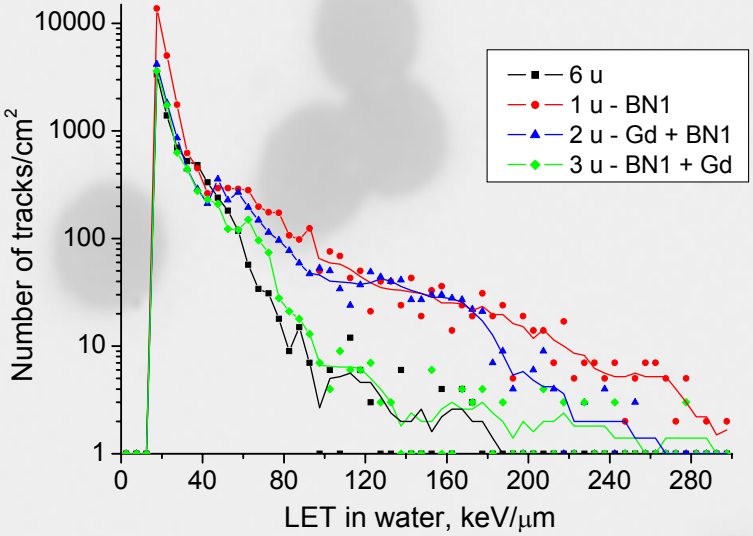
Etching methods:

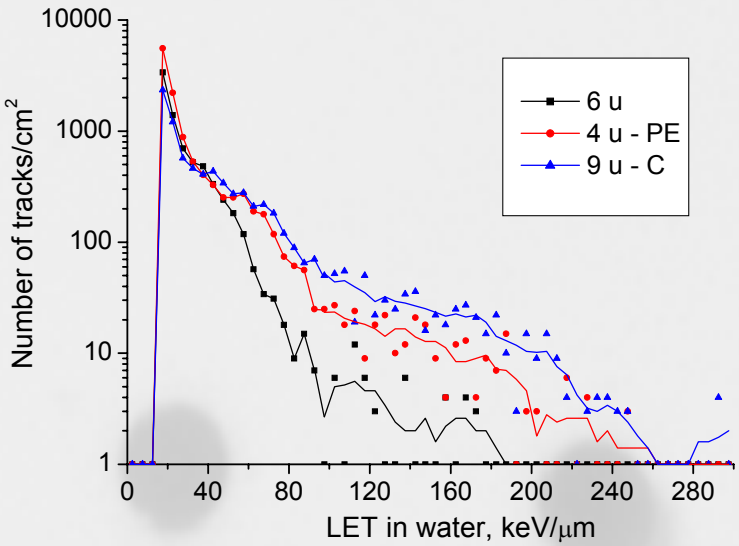
- 6 n NaOH at 70 °C
- Bulk etch rate (V_b): 1.34 µm/h
- 3 - step etching procedure applied:
  - 2 h : looking for very high LET particles of any origin
    Very few tracks (< 0.1 %)
  - 6 h : lots of tracks induced by neutron and cosmic ray particles with high LET above 15 keV/µm on each detector side; standard evaluation
  - 15 h : detecting particles above 10 keV/µm; forgetting very short range particles

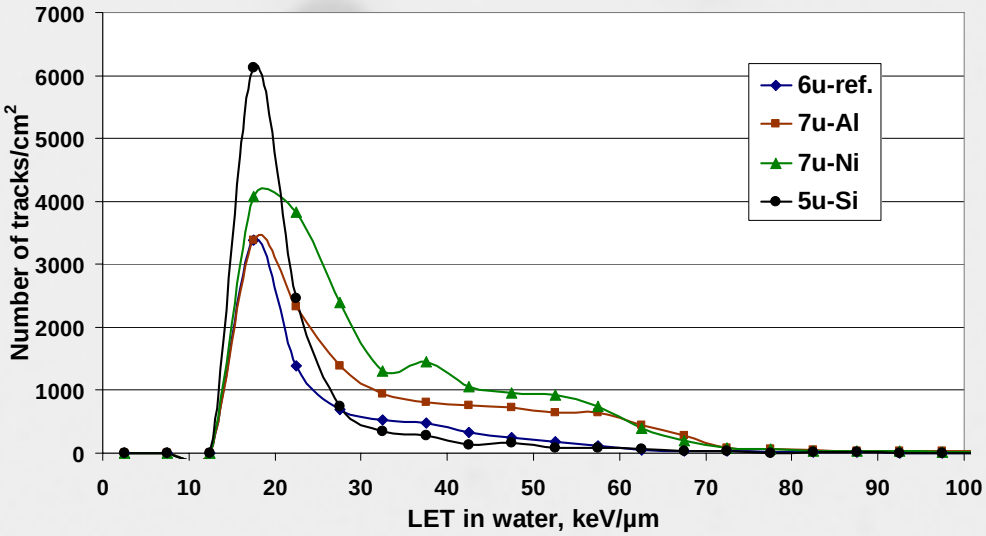
RESULTS

Evaluation of the BIOPAN detectors:

- LET spectra on the upper sides of detectors







RESULTS

Utilising the CERF CT neutron spectrum and the track density measured under the BIOPAN-5 PE converter the secondary neutron flux could be obtained below ~ 5 MeV

→ 2.41 cm^{-2} s^{-1}

and the calculated absorbed dose

→ 2.5 µGy/d.

This is ~10 % of the total dose (see next slide) calculated from the distribution of LET.

RESULTS

Evaluation of the BIOPAN detectors :

$$H = \frac{1}{\rho} \times 1.602 \times 10^{-6} \times \sum_i \Phi_i(LET_i) \times \overline{LET}_i \times Q_i(LET_i) \times \Delta LET_i$$

ρ is the density of the tissue, g/cm^3

$\Phi_i(LET_i)$ is the total group fluence per cm^2 per keV/µm measured in the ΔLET_i interval

$Q_i(LET_i)$ is the quality factor in that interval

BIOPAN-5	$\dot{D}$ D [µGy] dose rate [µGy/day]			**MEAN (S D)**
On upper sides of detectors 6, 8, 10	335 23	361 25	436 30	377 26 (± 14 %)
On lower sides of detectors 5, 7, 9	478 33*	437 30	705 48*	540 37 (± 27 %)

BIOPAN-5	$\dot{H}$ H [µSv] dose equivalent rate [µSv/day]			**MEAN (S D)**
On upper sides of detectors 6, 8, 10	2970 203	3403 233	3979 272	3451 236 (± 15 %)
On lower sides of detectors 5, 7, 9	4272 292*	3774 258	5906 404*	4651 318 (± 24 %)

$\overline{LET_i}$ is the mean LET

1.602×10^{-6} :

it harmonises the units to obtain the dose in mSv

CONCLUSIONS

- The applied TASTRAK detectors were appropriate for the BIOPAN-5 experiment because the low temperature reduced the registration sensitivity decreasing effect of vacuum.

- The flux obtained from the BIOPAN results was found somewhat higher from the direction of the carrying satellite.

- From the distribution of LET it can be concluded that our stack was able to differentiate between the primary protons and the protons induced by secondary neutrons (the secondary neutron flux = 2.41 cm^{-2} s-1 and the dose rate = 2.5 μGy/d).

- The LET spectra provided the total particle absorbed dose rate, which was found 26-37 μGy/d (for $Z \geq 1$ above 15 keV/μm).

Thanks for your attention!