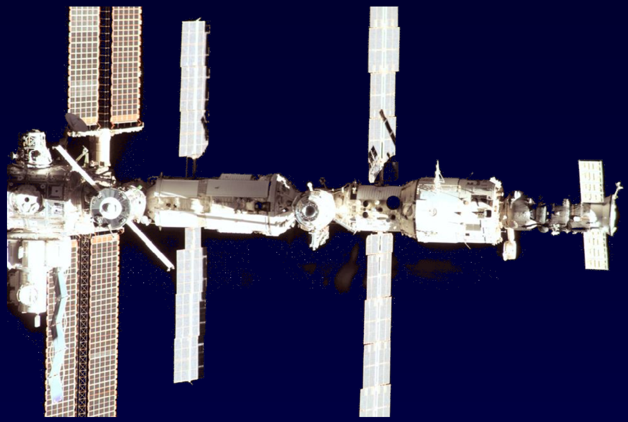

Determination of depth - dose distribution in a human phantom onboard the ISS using a particle telescope to measure radiation dose and LET

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ABSTRACT

Described is the current status of an experiment in preparation, using a particle telescope Liulin-5 for investigation of the radiation environment dynamics within the Russian spherical tissue-equivalent phantom on ISS. Liulin-5 experiment will be a part of the international project MATROSHKA-R on ISS. The aim of Liulin-5 experiment is long term investigation of the depth - dose distribution inside the phantom.

Facilities and instruments to be used in the Matroshka-R experiment

[Shurshakov et al., WRMISS, 2004]

Phase 1 - 2004

- Passive Detectors Package (IBMP- Russia)
- Spherical phantom (IBMP- Russia)
- Torso phantom (ESA, DLR)

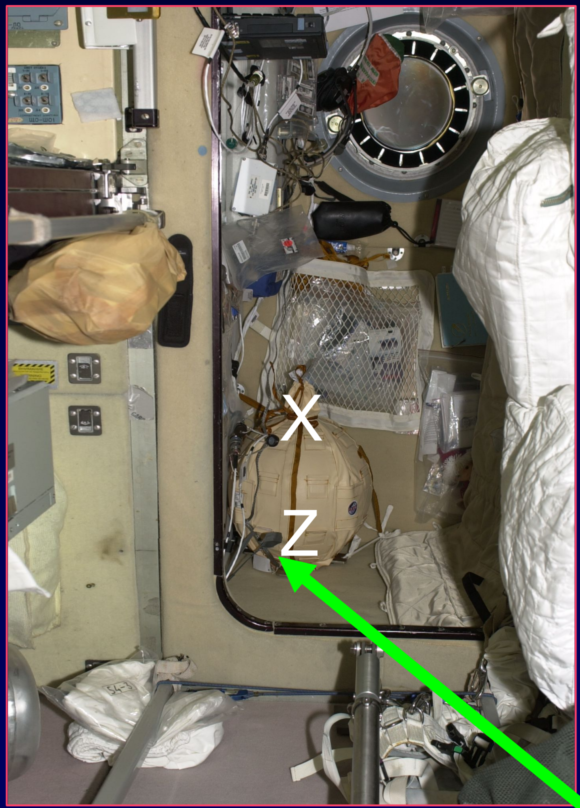
Phase 2 – 2005-2006

- + Active Detectors [Bubble + MOSFET (CSA) + Liulin-5 (STIL - BAS, Bulgaria) in the Spherical phantom

Phase 3 - 2006- …

- + TRITEL Charged Particle Directional Spectrometer (KFKI, Budapest, Hungary) on the outer surface of the ISS

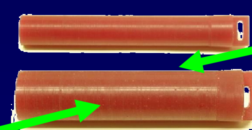
Sphere Phantom

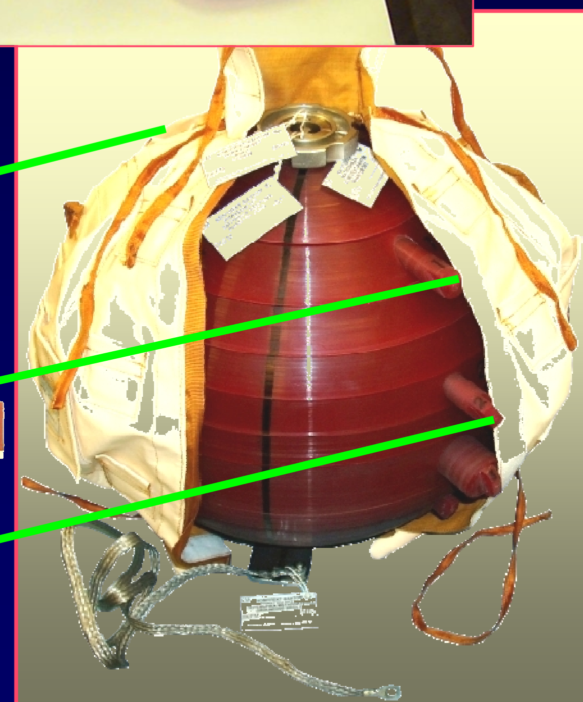


Sphere phantom in the crew cabin (right board) *[Shurshakov et al., WRMISS, 2004]*

Spherical tissue–equivalent phantom

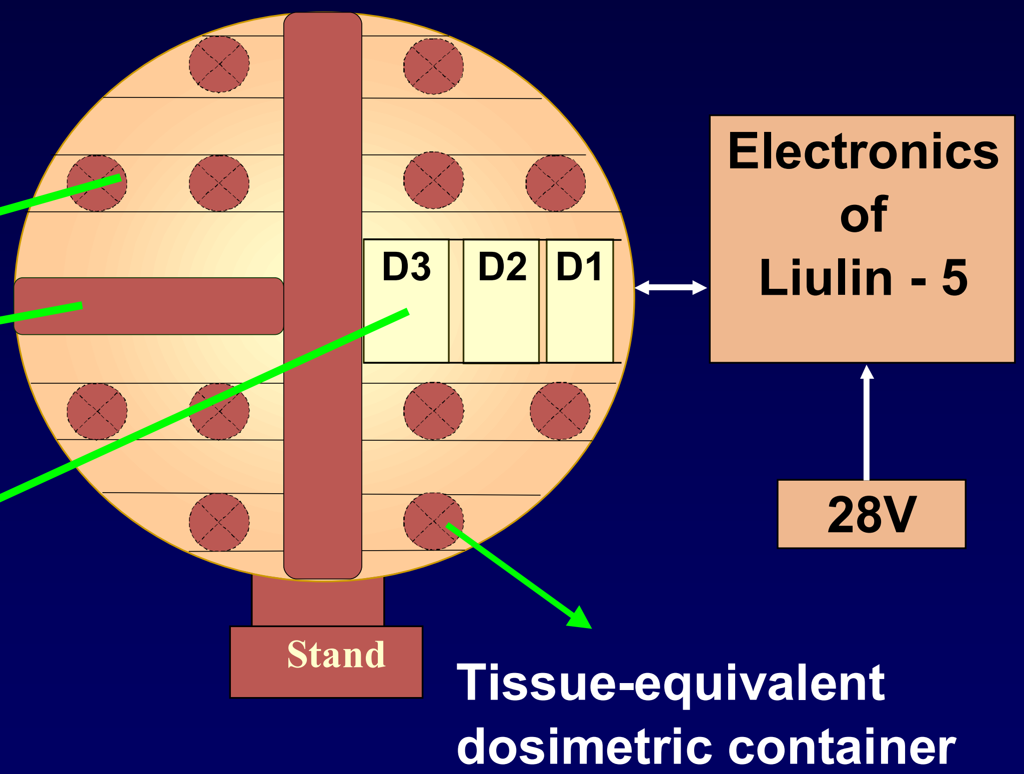
- Size: 370x370x390 mm; mass: 32kg;
- 13 tissue–equivalent slices;
- The slices, beside the central, have cylindrical openings, where passive dosimeters are placed;
- The central slice has 4 perpendicular radial channels.
- Jacket of the phantom: 32 outside pockets for Passive detectors;
- Containers for placing Passive detectors inside the phantom: 20 = 4 thick +16 thin;
- In a radial channel will be placed Liulin-5 detector module.





Radiation detectors in the spherical phantom of MATROSHKA-R experiment

- Passive detectors - TLD-100, TLD-600 and TLD- 700; SSTD (CR-39);
- Bubble + MOSFET
- Liulin-5 detector module.



LIULIN – 5 EXPERIMENT

Goals

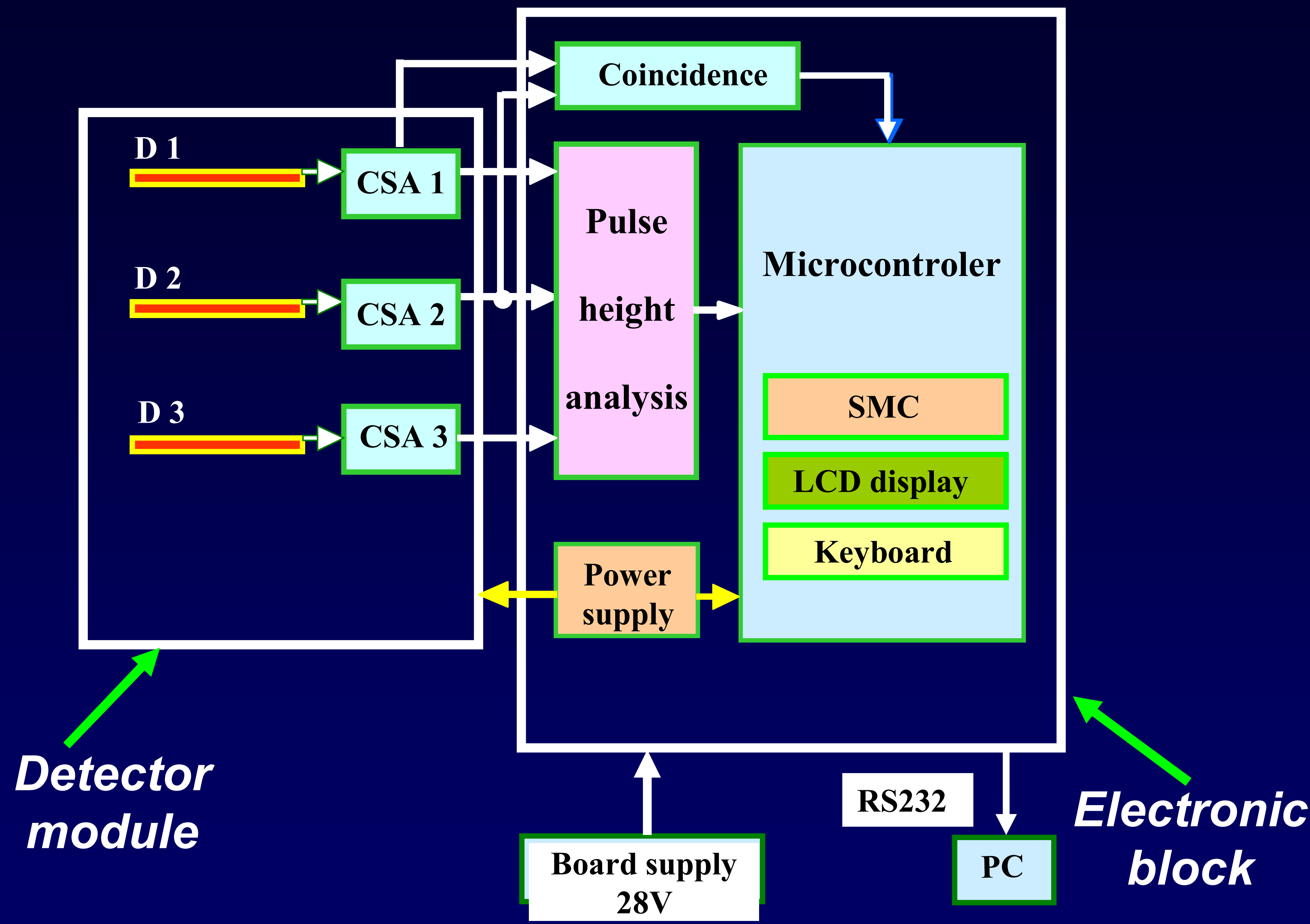
- Liulin-5 will measure simultaneously at 3 different depths of the radial channel of the spherical phantom:
  Energy Deposition Spectra, Dose Rate and Particle flux - then Absorbed Dose D;

  The doses and flux in intermediate points will be determined by interpolation.

- Measurement the Linear Energy Transfer (LET) Spectra – then assessment of Q=f(LET) and Dose Equivalent H; H=DxQ.

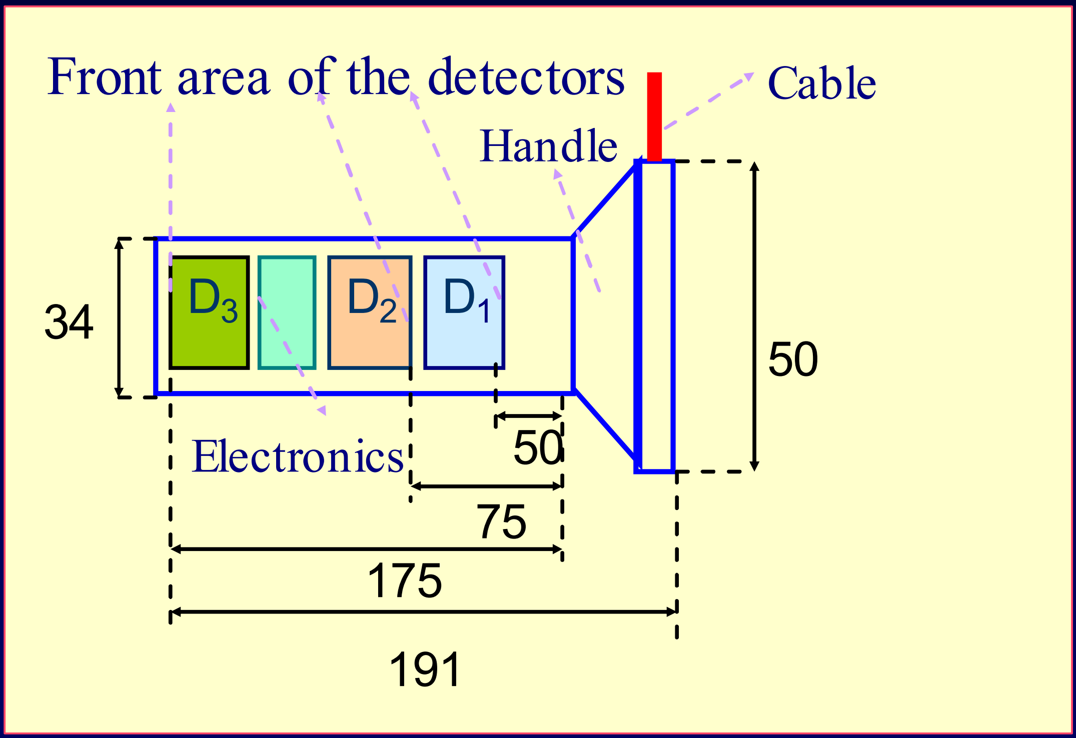
Liulin-5 particle telescope description

- Two units: a detector module in the phantom channel and an electronic block outside it.
- Weight 1,2kg;
- Power consumption 1,4W;
- Display and keyboard for control;
- Data are stored on smart media cards (SMC).



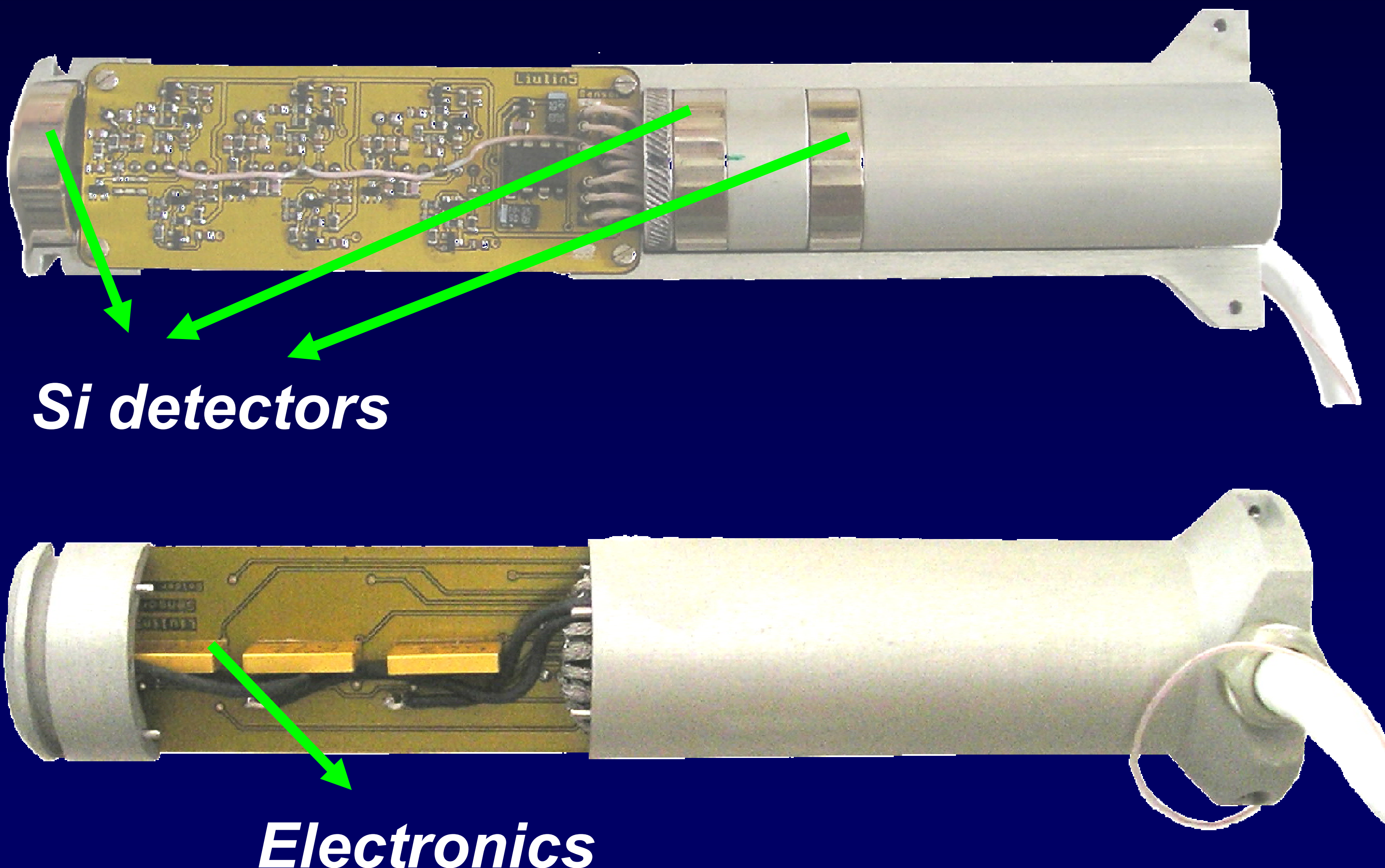
Block-diagram of LIULIN-5

Lay-out of detectors and electronics in the detector module.



- Detector's thickness - 300 μm, area 162.8 mm^2.
- Sensitive area of the D1 and D2 is in front of the aperture of the telescope, sensitive area of D3 is at the back of the telescope.
- D1 and D2 operate in coincidence mode. FOV is 88 degrees.
- Possible to move the detector module along the channel in the phantom.

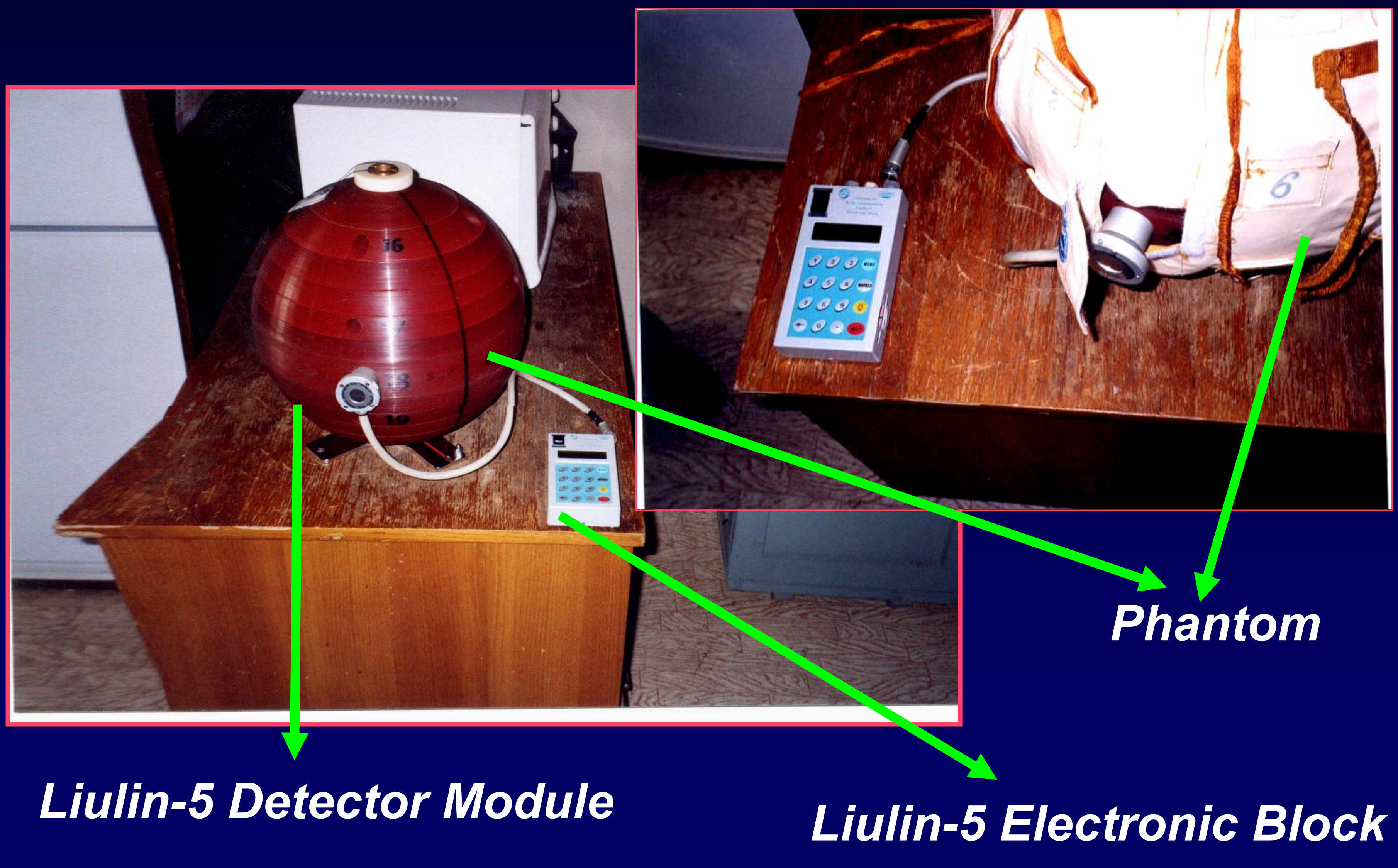
Details of Liulin-5 Detector Module



External view of Liulin-5

Electronic block ***Detector module***

Liulin-5 in the spherical phantom



Parameters to be measured (1)

- **Energy loss spectra in the range 0.09 - 72 MeV (flight model) in each of Si detectors;**
- **2 sub-ranges: LLET (0.09- 8 MeV in 255 channels) and HLET (8 - 72 MeV in 230 channels)**

Range 0.3 - 104 MeV for technological model;

- **Coincidence spectra of D1&D2 detectors–obtain LET spectra-Q(LET)**

Parameters to be measured (2)

- **Intensity of the particle flux** in each detector in the range

  0 –10^3 particle/(cm^2.sec) in LLET range;

  0 – 1.5x10^2 particle/(cm2.sec) in HLET range;

- **Absorbed dose rate** in each detector in the range 0.04 x10^{-6} Gy/h - 0.015 Gy/h;

Measurement modes

- **Standard** - Dose and flux rates measurement every 90 s, energy loss spectra and LET spectra – 90 min;

- **Fast** - for measurements in SAA, or during SPE. Dose and flux rate measurement every 20 s, energy loss and LET spectra -15 min;

- **Calibration** - for ground–based tests.

- Switching between modes – automatically or manually.

Status of Liulin-5 instrument

- **Electrical calibrations and tests with laboratory radioactive sources were performed** ***[Semkova et all., ASR, 2003].***
- **Technological model acceptance tests: April–June 2005;**
- **Intercomparison and calibration of Liulin-5 in ICCHIBAN experiment, September 2005.**
- **Flight model qualification tests in Bulgaria and Russia: October 2005 – January 2006;**
- **Launch of Liulin-5 to ISS – August 2006?**

PROPOSAL FOR FUTURE MISSION

Mission:

•Phobos-soil project

Proponents:

IMBP- RAS (Russia)
STIL –BAS (Bulgaria)

Objectives:

➢Qualitatively and quantitatively characterize the radiation environment in trans- and near-Mars space;

➢ Verify and improve methods for radiation detection and dosimetry in long-duration space flight.

➢We propose a set of dosimetric telescopes and single detectors in perpendicular directions.

➢Prototypes of proposed instruments are dosemeters and charge-particle spectrometers of Liulin family.

CONCLUSION

- A particle telescope Liulin-5 has been developed for investigation of the radiation environment dynamics within a human phantom on ISS .
- Electrical calibrations and initial tests with laboratory radioactive sources were performed to obtain the metrological and calibration characteristics *[Semkova et all., ASR, 2003].*
- We intent to participate with Liulin-5 in ICCHIBAN experiment for intercomparison of the response of space radiation dosimeters and spectrometers to heavy ion beams at the HIMAC – Japan in September 2005.
- Liulin-5 is planned to be flown on the ISS in 2006 year.

Acknowledgements

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10th WRMISS Organising Committee for Support to Attend the Workshop and Participate ICCHIBAN.