Space Radiation Dosimetry - Recent Measurements and Future Tasks

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Radiation Environment in Low Earth Orbits

Radiation Sources

- Galactic Cosmic Radiation (protons and heavier ions)
- Solar Particle Events (protons, low contribution of heavier ions)
- Radiation belts (protons and electrons)

Magnetic Field Effects

- Solar modulation
- Geomagnetic shielding

Altitude Effect

Production of Secondaries in Interactions with Shielding Material

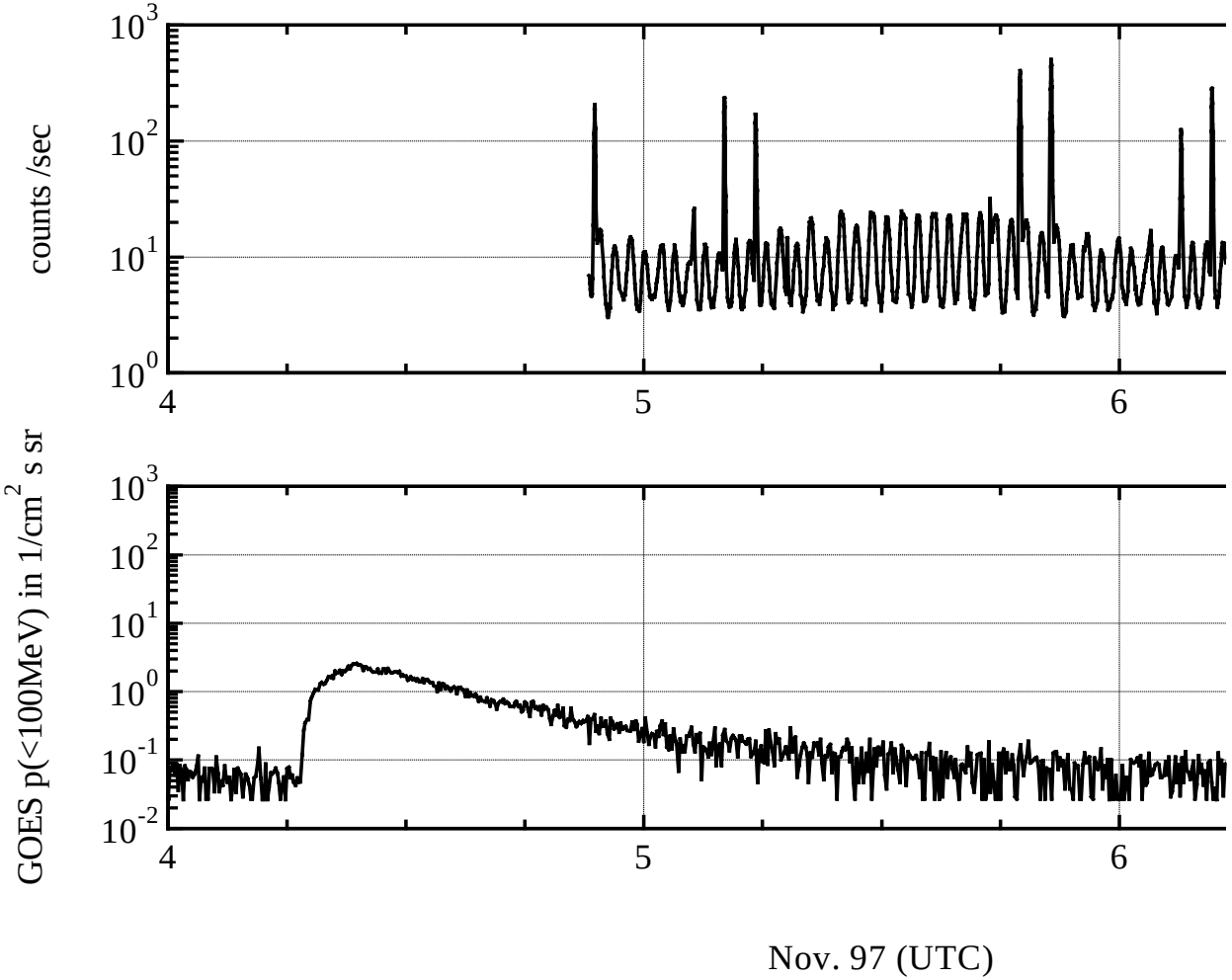
- Projectile fragments
- Target fragments
- Neutrons
- Protons
- Electrons
- Bremsstrahlung

TABLE 1. Summary of dosimetric data

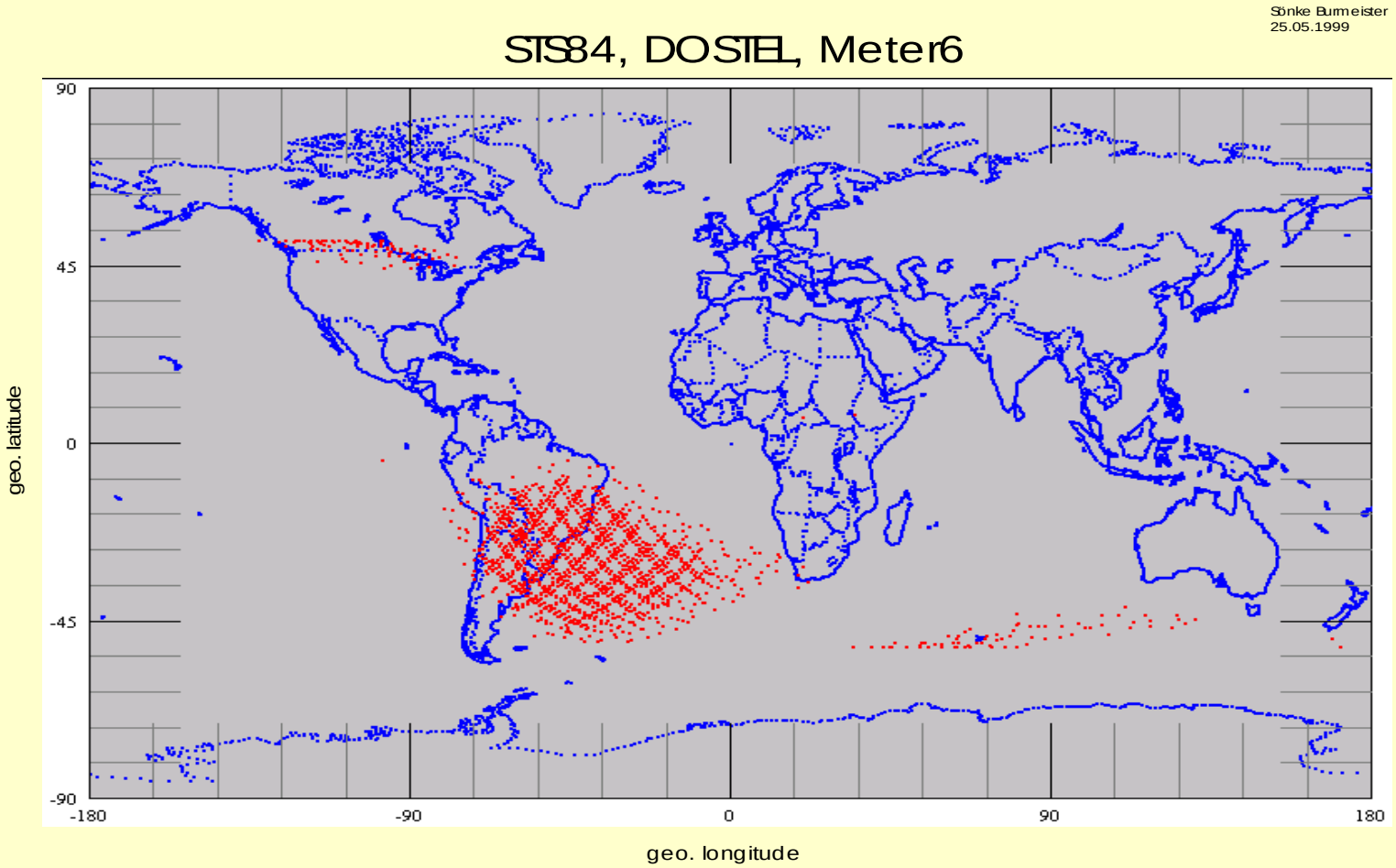
Mission	**Absorbed Dose ($\mu Gy\ d^{-1}$)**	**Neutrons ($\mu Sv\ d^{-1}$)**	**GCR particle fluence rate ($cm^{-2}d^{-1}$) [1]**
MIR92	294 ± 13	68	0.30 ± 0.05
	178 ± 6		0.19 ± 0.03
EUROMIR95	483 ± 8		1.38 ± 0.05
	236 ± 2		0.74 ± 0.03
	245 ± 8 [2)]	92 [2]	0.81 ± 0.03 [2)]
STS84	374 ± 8	228	0.58 ± 0.06
	170 ± 3	109	0.46 ± 0.05

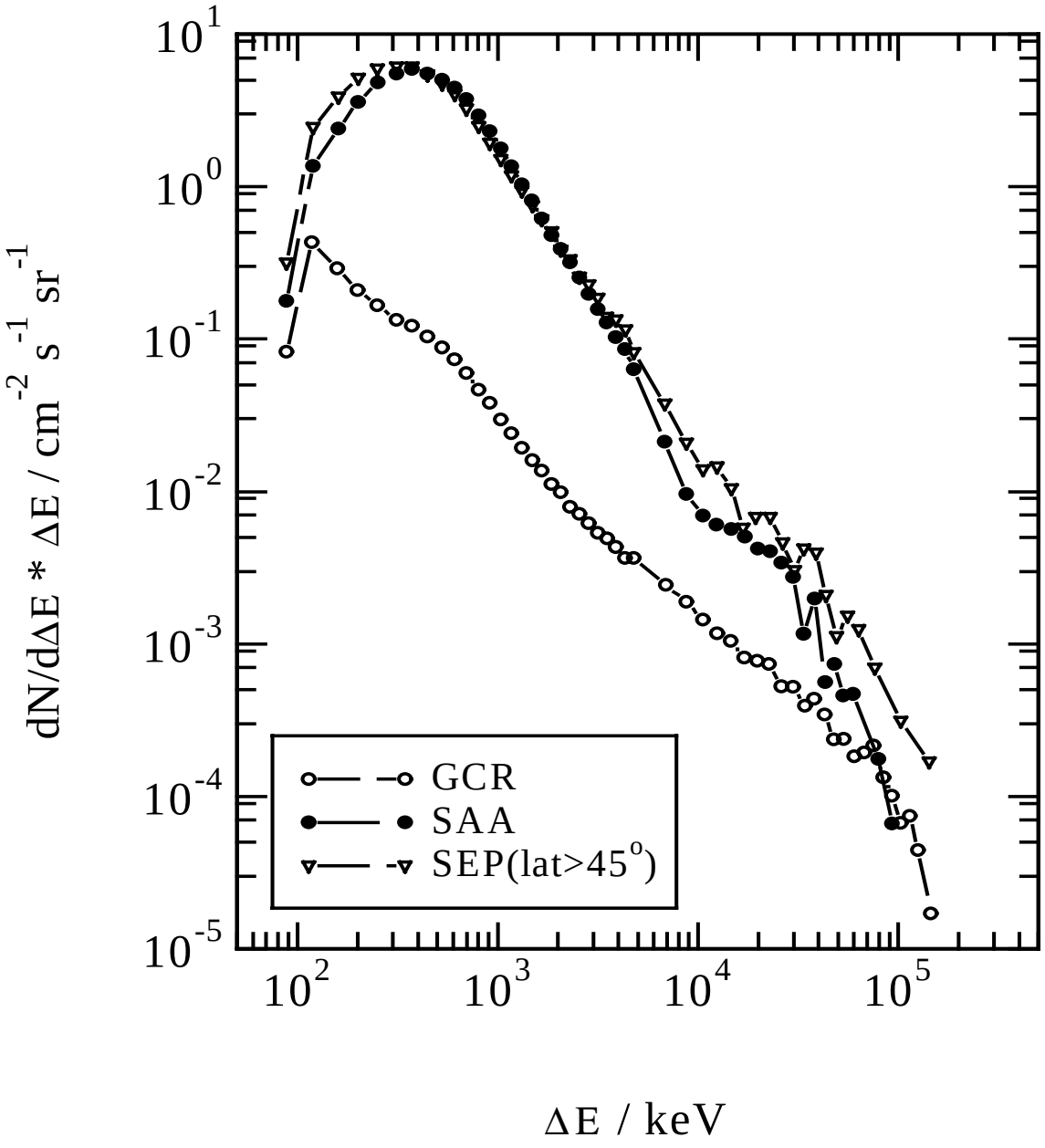
[1] Number of particles passing through an unit area of a planar surface. Measurements in CN_D
[2] Personal dosimeter readings

Time profile of particle count rates during November 4-7 inside MIR



Radiation Belt Particle Distribution





Energy Deposit Distribution measured with DOSTEL inside MIR

Relationship between Absorbed Dose, Dose Equivalent and Effective Dose

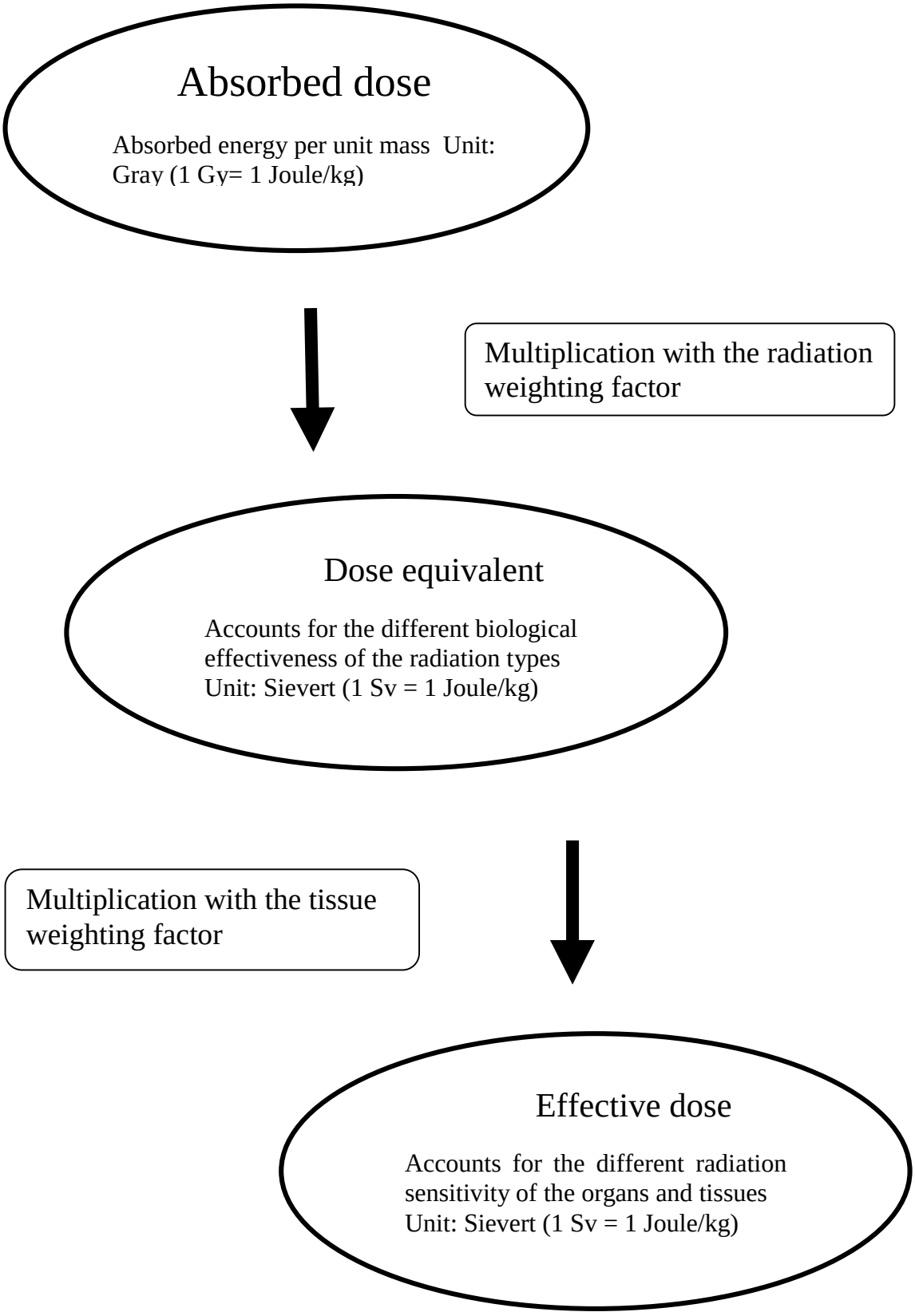


TABLE 2: Dose rates , mean quality factors and dose equivalent rates

	Mission average			**GCR average**			**SAA average**		
	μGy/d	**Q**	**μSv/d**	**μGy/d**	**Q**	**μSv/d**	**μGy/d**	**Q**	**μSv/d**
MIR92	306	2.1	640						
EUROMIR94	394	2.0	767						
EUROMIR95									
Ambient max.	510	2.0	1020						
Personal	270	22	600						
STS76	322	2.0	631	141	2.9	418	179	1.2	212
STS81	308	2.1	643	136	3.2	430	172	1.2	214
STS84	365	2.0	716	132	3.3	436	233	1.2	280

Space radiation has a major impact on all space activities.

Legal, moral and practical considerations require to prevent the risk of acute and to limit the risk of late effects

Radiation protection is essential to enable humans to live and work safely in space radiation limits need to be implemented

Assessing the level of risk and to determine the cancer types and the probability of their induction during a specific mission and effects of radiation on long term life support systems (plants, materials, electonics)

Adequate knowledge of the physical characteristics (type and energy of particles inside the organs) and how the cancer types vary as a function of these physical characteristics

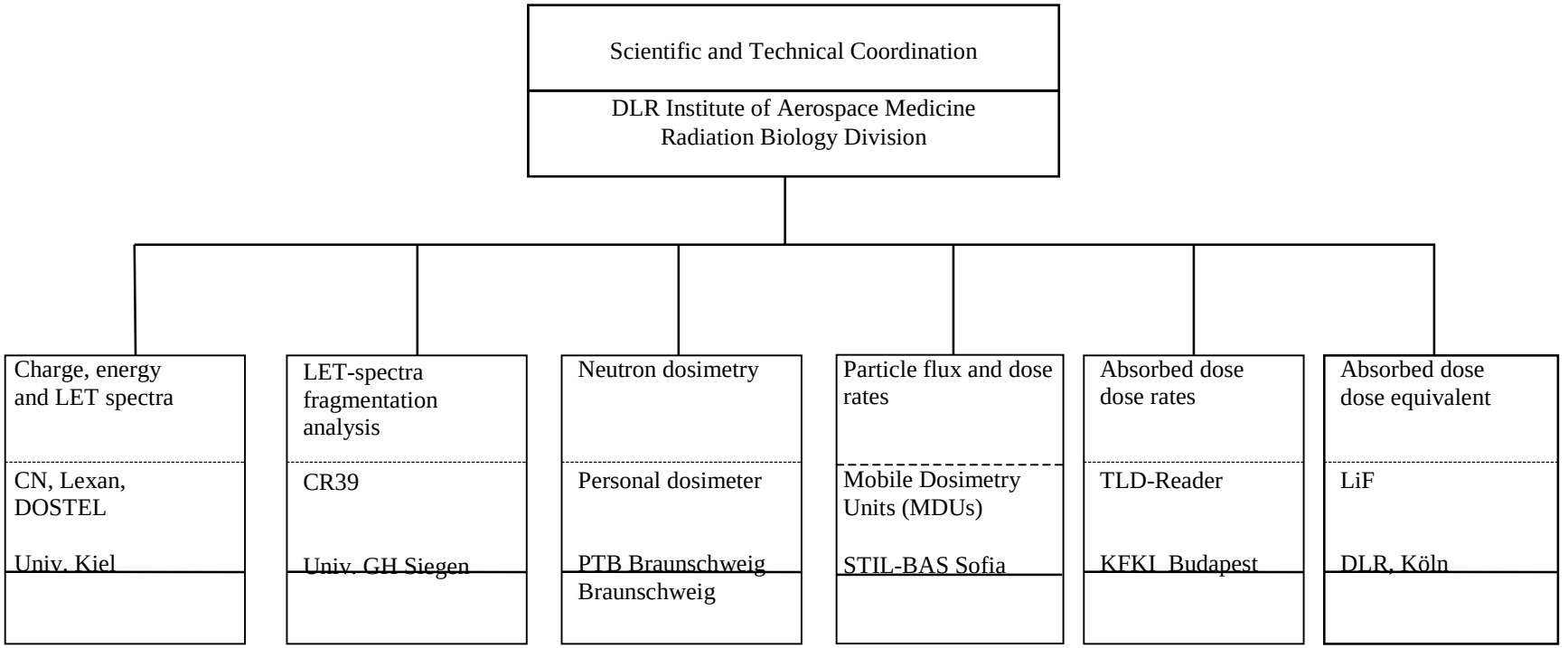
Three sets of data contribute to the variability of risk

The types of particles and their energies
The amount of radiation
The extent and timing of exposure (acute, protracted or combined exposure)

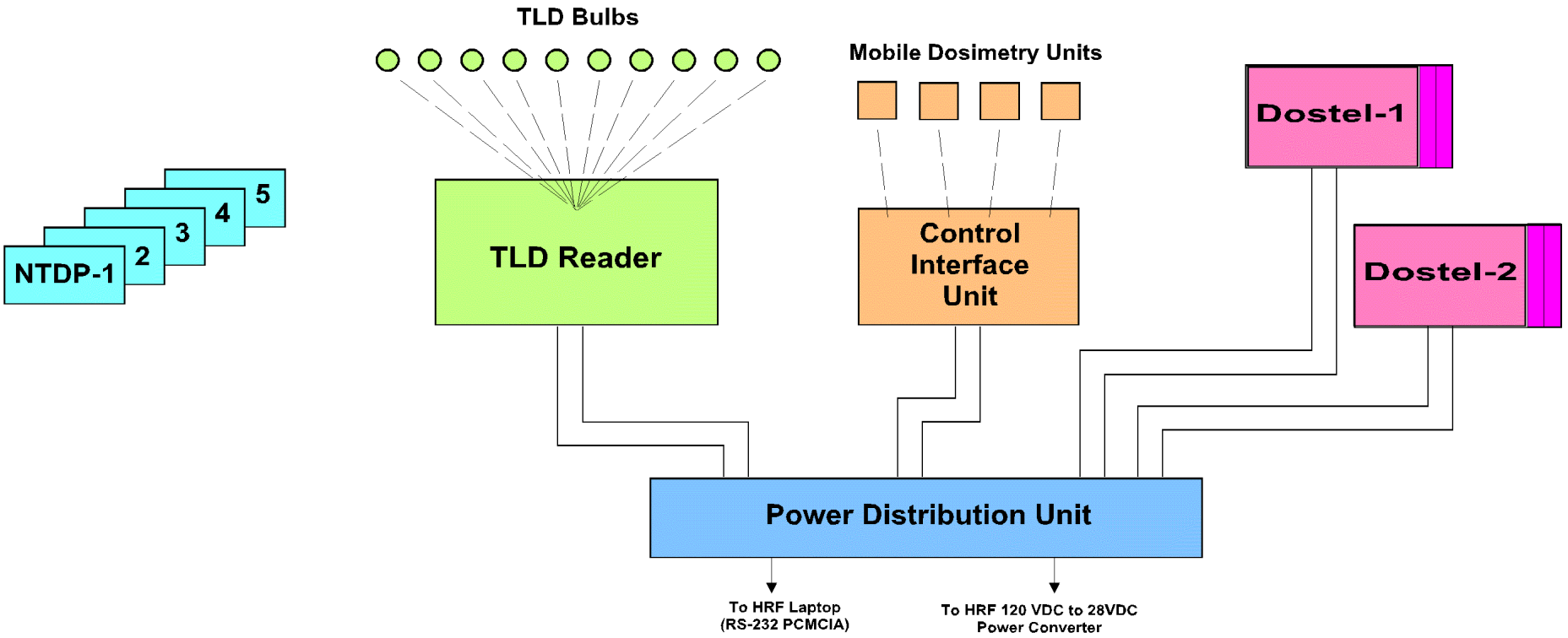
The knowledge has to be integrated into models that will provide accurate risk predictions for the ISS

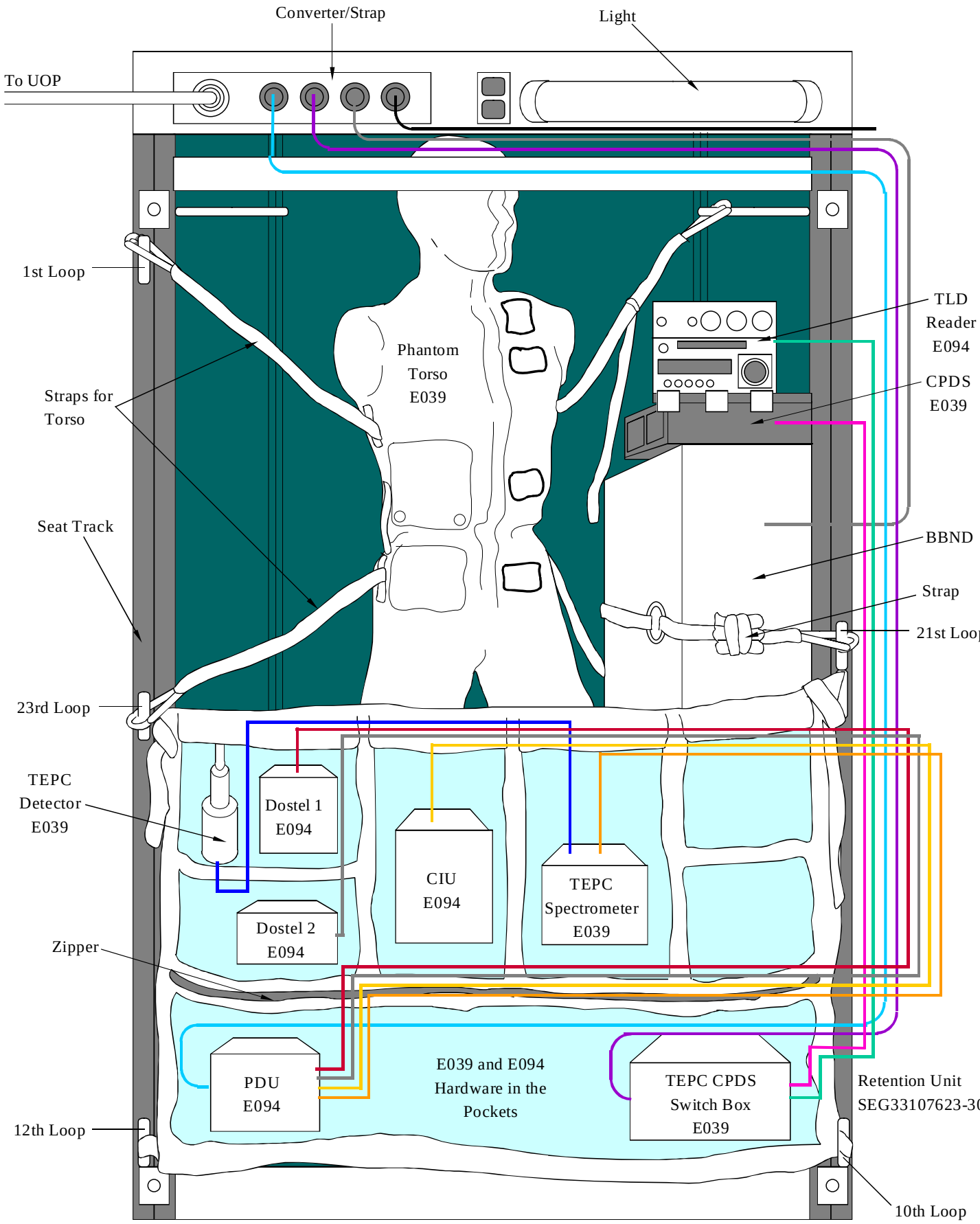
DOSMAP Experiment Objectives

- Documentation of the radiation field inside the ISS
  - Integral dose measurements for
    - ionizing radiation
      - neutrons
  - Integral measurements of energy, charge and linear energy transfer (LET) spectra of the heavy ion component
  - Measurement of dose rates
    - ionizing radiation
    - neutrons
  - Measurement of of time dependent particle flux and LET spectra
    - galactic cosmic particles
    - radiation belt particles
- Study of the anisotropy of the radiation field inside the South Atlantic Anomaly (SAA)
- Measurement of target fragmentations
- Instrument intercalibration during flight
- Environmental and individual dose records


Scientific and Technical Coordination
DLR Institute of Aerospace Medicine
Radiation Biology Division
Charge, energy and LET spectra
CN, Lexan, DOSTEL
Univ. Kiel
LET-spectra fragmentation analysis
CR39
Univ. GH Siegen
Neutron dosimetry
Personal dosimeter
PTB Braunschweig
Braunschweig
Particle flux and dose rates
Mobile Dosimetry Units (MDUs)
STIL-BAS Sofia
Absorbed dose dose rates
TLD-Reader
KFKI Budapest
Absorbed dose dose equivalent
LiF
DLR, Köln

DOSMAP BLOCK DIAGRAM





NOTE: Colored cables (shown separate for clarity) will be bundled, will run down the seat track, and will flow through the pockets of the retention unit.

Study of Radiation Distribution (SORD)

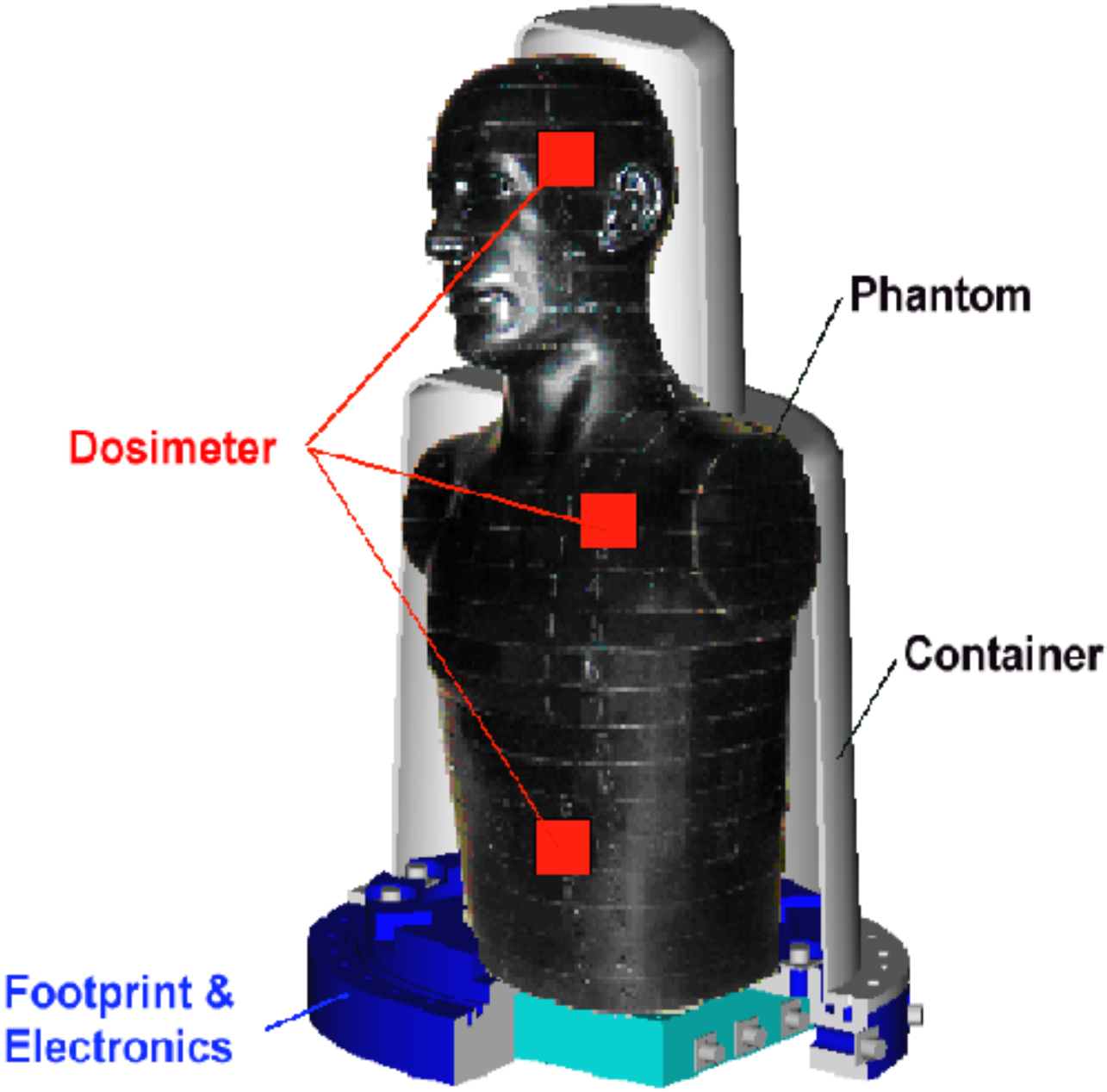
Science Objectives

In addition to the objectives of the Dosimetric Mapping experiment on STS5A:

- Measurement of flux, energy, charge and energy deposition (LET) spectra of charged particles and the corresponding dose rates at selected organ sites in a human phantom

- Measurements especially outside the ISS to gather information for EVA exposures

- Determination of the emperical relations between measurable skin doses and the required organ doses



Study of Radiation Distribution

Future Activities

- Measurement of the radiation distribution inside and outside the spacecraft
  - New spacecraft with different shielding thickness
  - Increased importance of secondary particles (especially neutrons)
  - Solar cycle influence
- Environmental and individual dose records (physical and biological dosimetry)
- Measurement of the depth dose distribution in realistic human phantoms
  - Calculate organ doses
  - Optimize risk estimates
- Development of devices for registration of the neutron component
- Radiation field studies
- Intercalibration of dosimeters in defined fields and in space