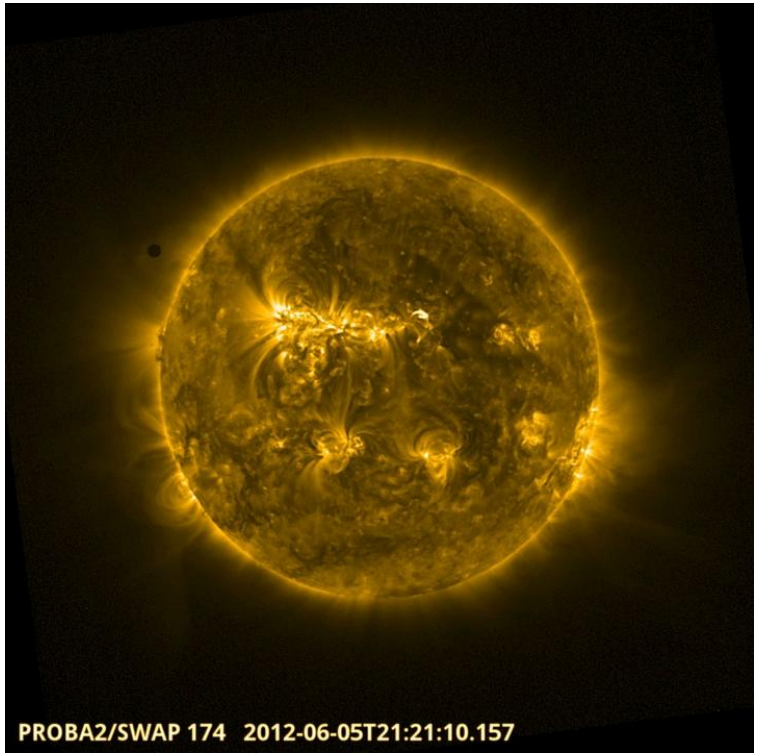
Space Weather Activities at the AIT Austrian Institute of Technology

Radiation Effects due to Cosmic Radiation and Solar Events

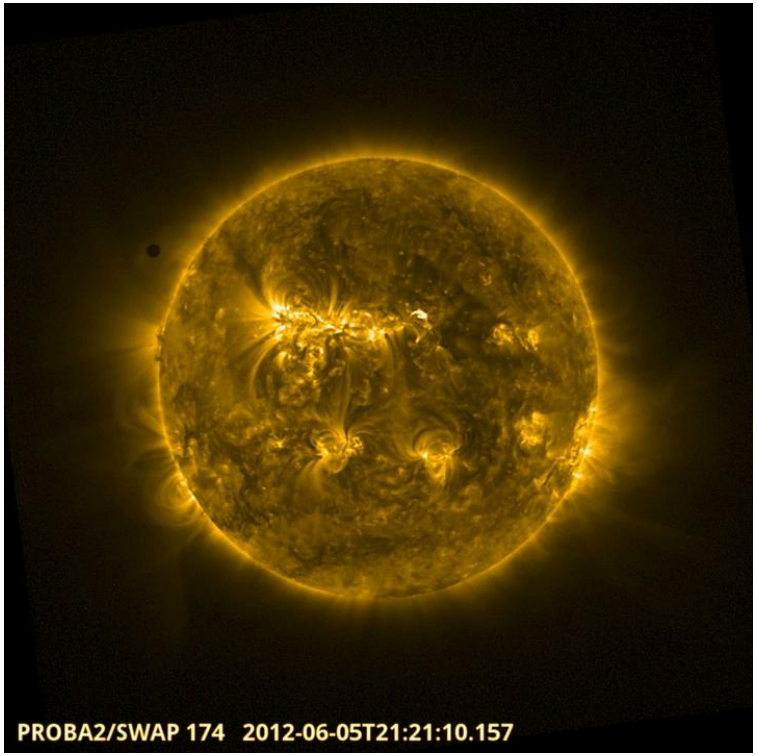
Peter Beck
Marcin Latocha, Sofia Rollet

8 June, 2012, Vienna International Center
Committee on the Peaceful Uses of Outer Space: 2012
Fifty-fifth session, (6-15 June 2012)



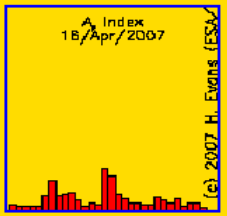
Content

- SWEETS – Space Weather and Europe an Educational Tool With The Sun
- Space Weather and Cosmic Radiation
- Effects of Ionizing Radiation to Humans and Electronics
- Space Weather Applications
- Summary and Conclusion



SWEETS

Space Weather and Europe - an Education Tool with the Sun



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SWEETS 2007 - Consortium

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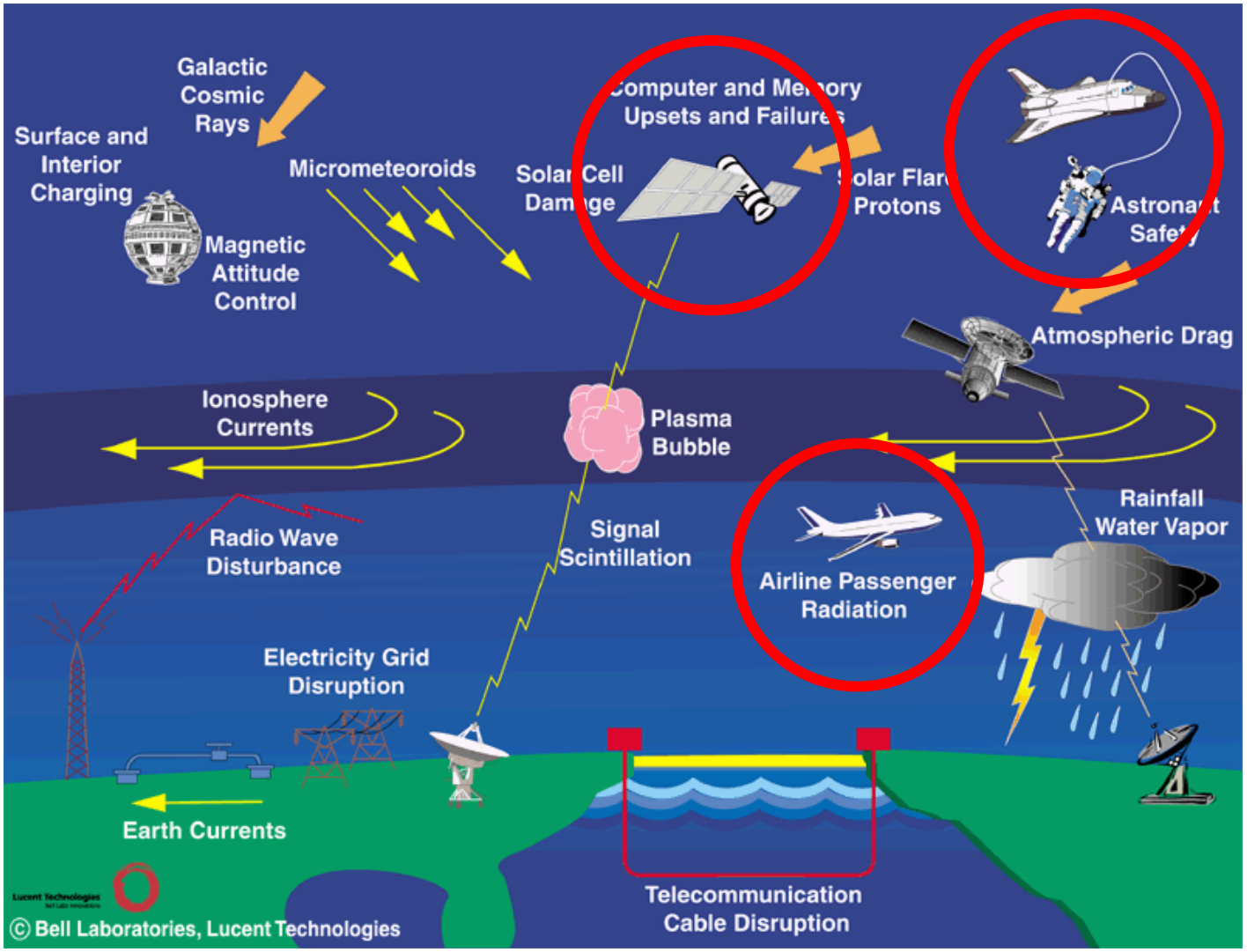
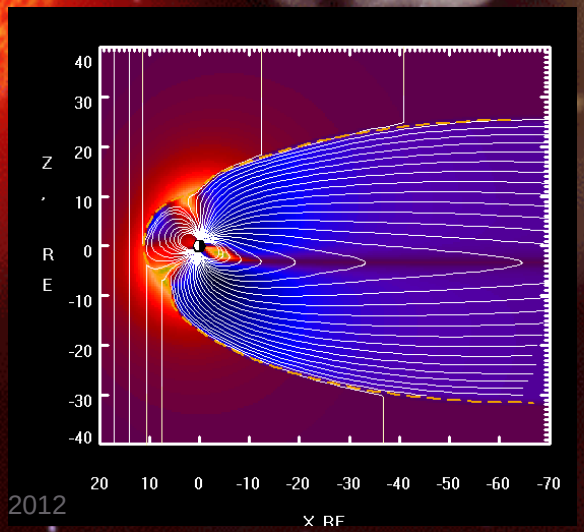
SWEETS – June 2007
50th Copuos Committee 6 – 15 June, 2007

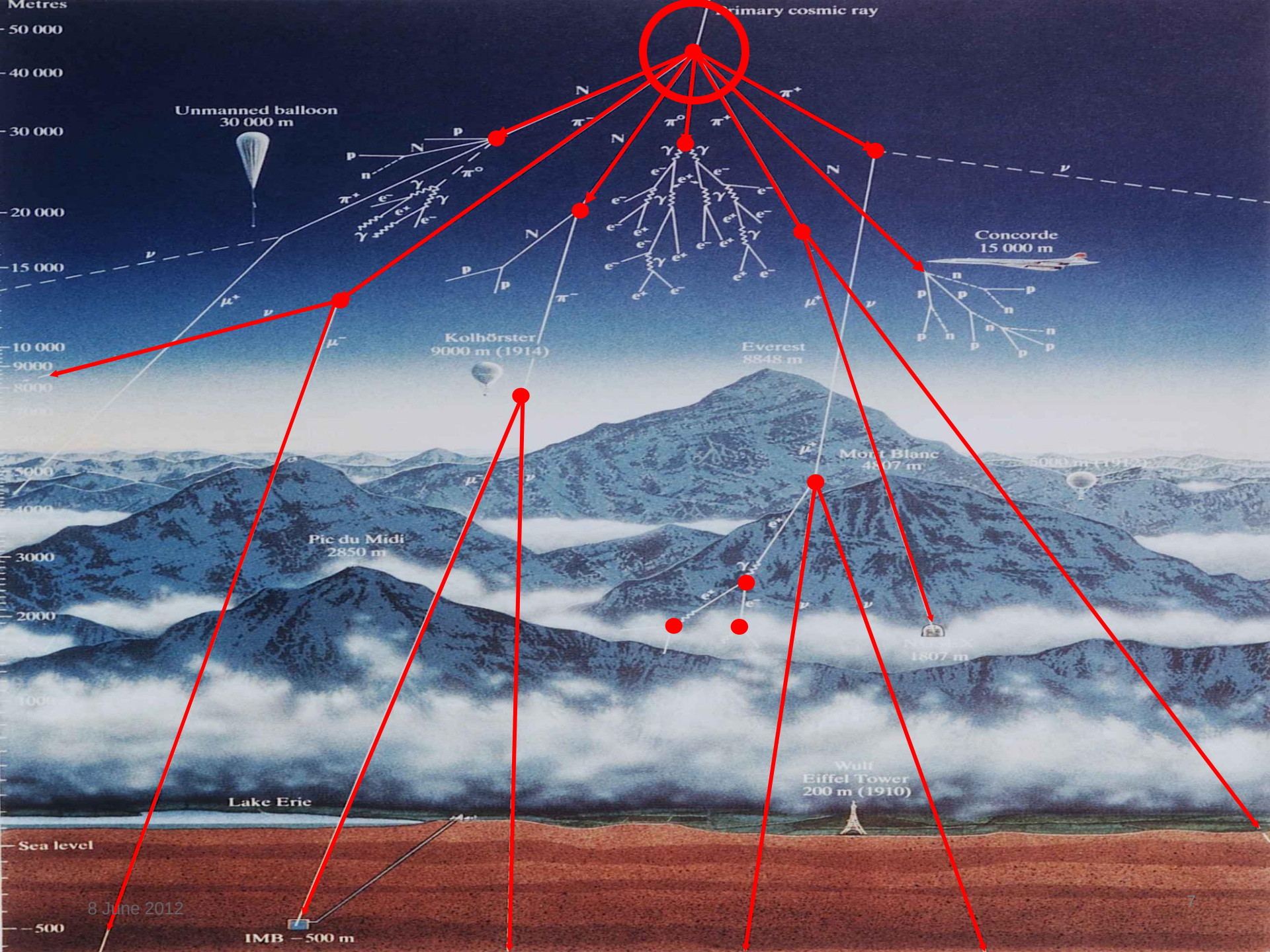
Space Situational Awareness (SSA) – Space Weather



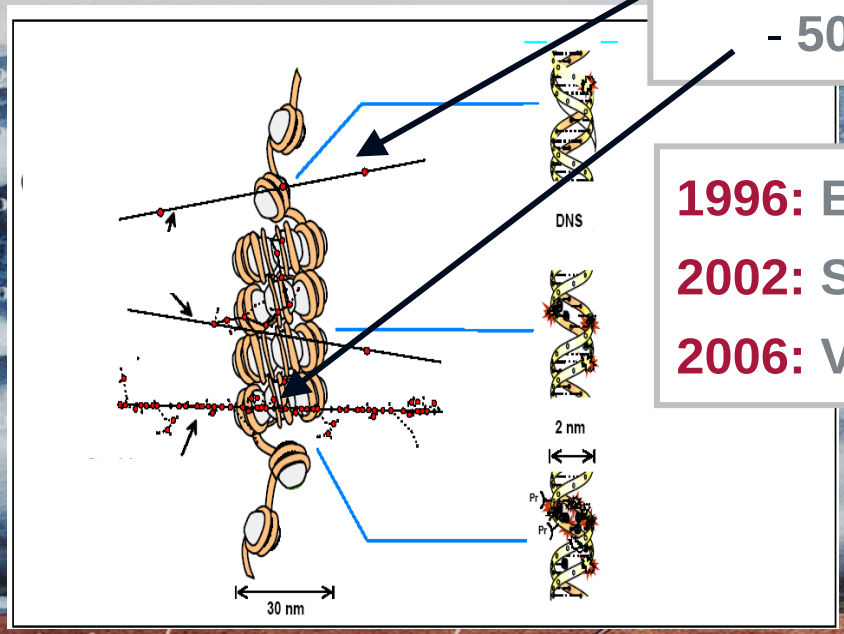
Courtesy: Bell Laboratories



Credit: ESA/NASA


Metres
50 000
40 000
30 000
20 000
15 000
10 000
9000
8000
4000
3000
2000
1000
500
Sea level
Primary cosmic ray
Unmanned balloon
30 000 m
Concorde
15 000 m
Kolhörster
9000 m (1914)
Everest
8848 m
Mont Blanc
4807 m
Pic du Midi
2850 m
1807 m
Wulf
Eiffel Tower
200 m (1910)
Lake Erie
IMB — 500 m

- Exposure due to cosmic radiation
  - 50% **low-LET** (γ, e^-, μ, …)
  - 50% **high-LET** (p, n, HZE, …)



1996: EU-Directive 96/29/EURATOM, Article 42

2002: Strahlenschutzgesetz Österreich (§ 36k)

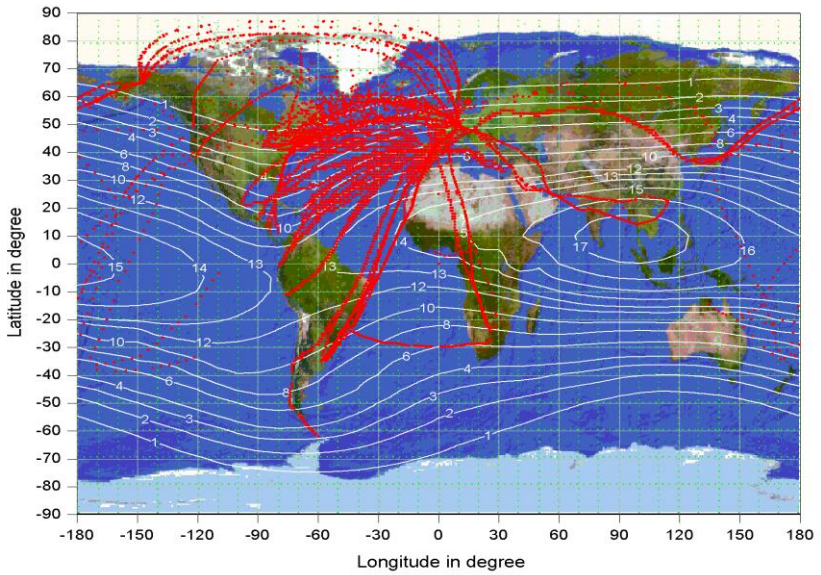
2006: Verordnung FlP-StrSchV

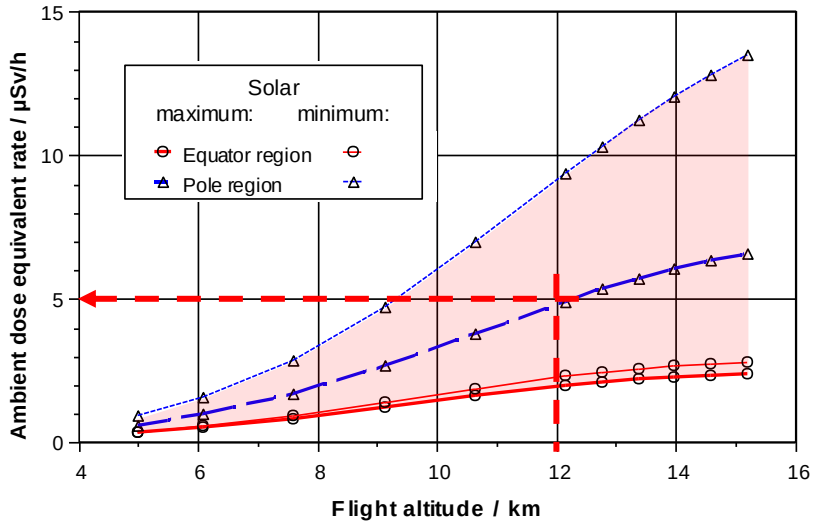
National and European Research
1995-2012: ACREM, DOSMAX, SOLARDOS

- ANPA / Italy
- ARCS / Austria
- AUA / Austria
- Brazilian Airforce / Brazil
- CERN /Swiss
- DIAS / Ireland
- DLH AG / Germany
- GSF / Germany
- INFN / Italy
- IPSN / France
- NPI / Czech
- NRPB / UK
- PTB / Germany
- SSI / Sweden
- TU - Graz / Austria
- Uni München / Germany
- University of Siegen / Germany
- VARIG / Brazil

Table III.2: List of dose assessment methods during in-flight investigations

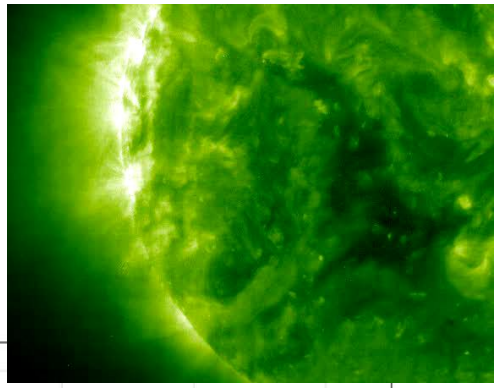
Abbreviation	Dose assessment method measurement / calculation	Measurement intervals
NM+IC (ARCS)	Combined neutron monitor (NM) LB6411 and ionization chamber (IC) RSS [BEC99a], [BEC99b]	5 min
NMX+IC (PTB)	Combined neutron monitor NE-NM2 with lead converter (NMX) and ionization chamber [SRE99a], [SRE99b]	5 - 20 min
ACREM (ARCS)	Combined GM detector and transport code calculations [BEC99a], [BEC99b]	5 min
NMX+Halle(GSF)	Combined neutron monitor NE-NM2 with lead converter (NMX) and low level scintillation detector DLM7908 [REG93], [REG96]	6 min
TEPC-log (ARCS)	TEPC detector, 12 cm sphere, logarithmic amplifier [BEC99a], [BEC99b], [BEC04]	30 – 60 min
TEPC (ARCS)	TEPC (HAWK) [BEC03], [BEC04]	30 - 60 min
TEPC (RMC)	TEPC (FAR WEST detector) [GRE00] [LEW01]	25 min
TEPC (SSI)	TEPC instruments based on the variance method [KYL01]	30 - 60 min
TEPC (CIEMAT)	TEPC (HAWK) [SAE02] [ROM04] [SAE04a] [SAE04b]	25 min
NMX+IC (CIEMAT)	Combined neutron monitor with tungsten converter (NMX) SWENDI-2 and ionization chamber (IC) RSS [SAE02] [ROM04] [SAE04a] [SAE04b]	5 min
LIULIN (NPI)	Si-Spectra-dosemeter developed originally for space (MDU-Liulin) [SPU03]	30 min
Track Detector (NRPB)	Box with 36 PADC and 30 TL dosemeters [BAR00], [BAR01], [BAR03]	16 × 120 min
TEPC (NPL-PPARC)	TEPC (HAWK) [TAY02]	30 min
EPCARDv3.2	European Program Package for the Calculation of Aviation Route Doses [SRA02]	single point calculation
TEPC (IRSN)	TEPC (HAWK) [BOT04]	30 min
TEPC (APAT)	TEPC (HANDI) [TOM99], [CUR01a], [CUR01b]	60 min
NMX+IC (APAT)	Combined neutron monitor LINUS with tungsten converter (NMX) and ionization chamber RSS (IC) [TOM99]	5 min
BSS+IC (PTB)	Bonner Spheres (BSS) and ionization chamber (IC) [WIE02], [BEC99a].	30 - 60 min

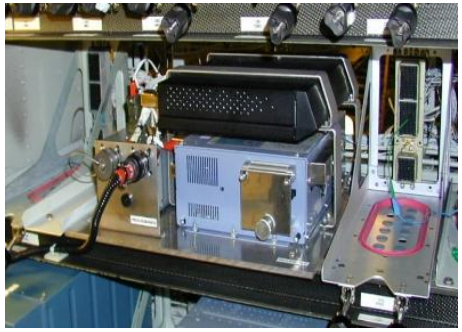


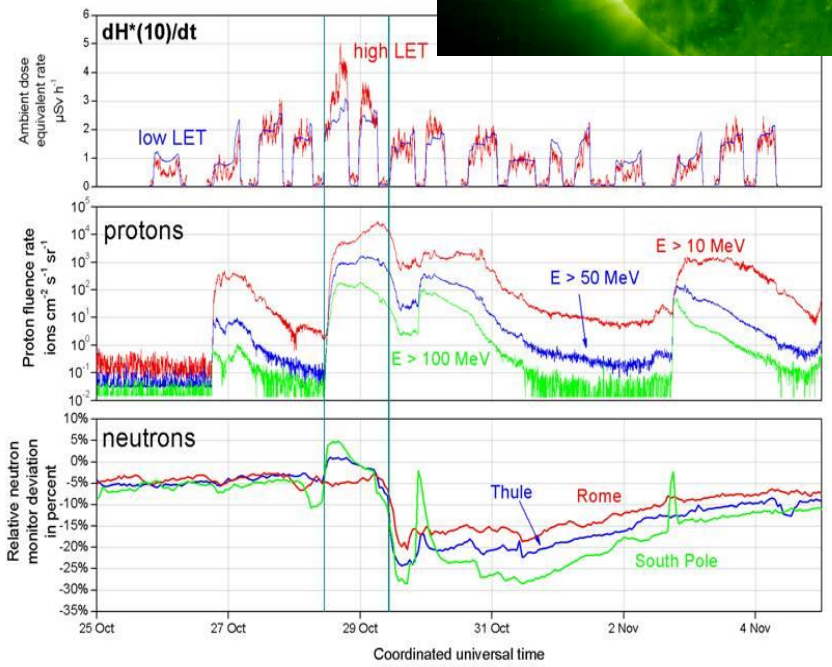


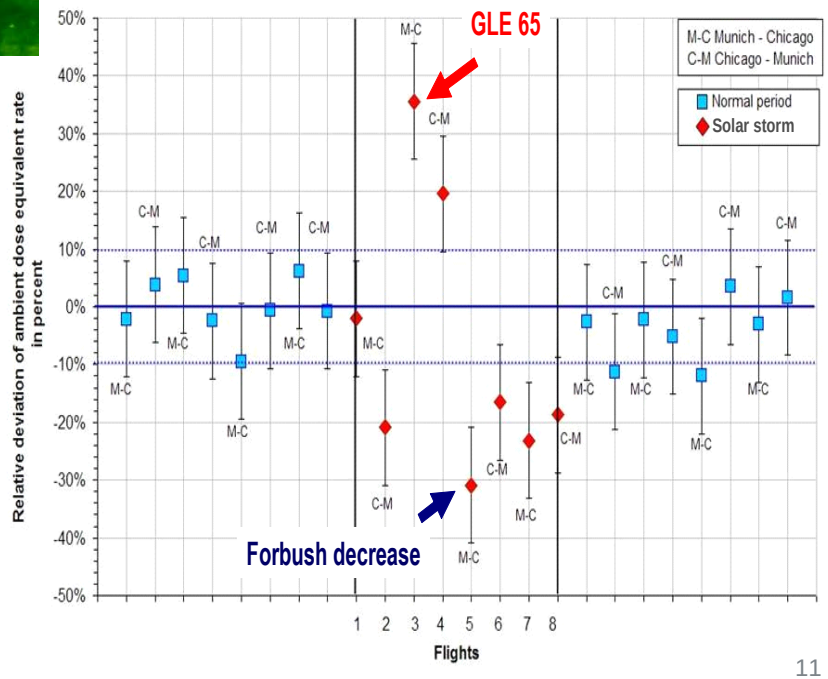
Agreement of measurements within 10% (1s)

October / November 2003:
Solar Storm Measurements with TEPC



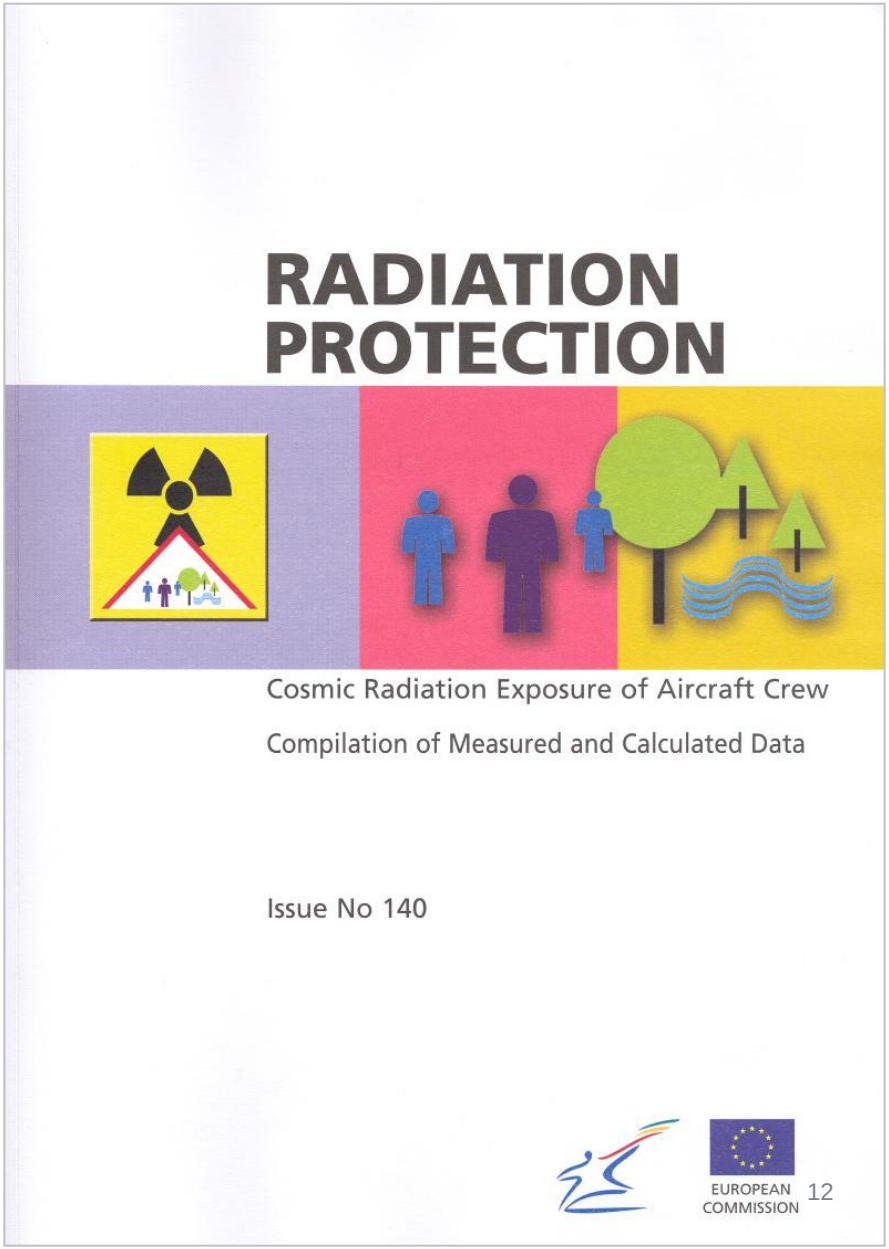




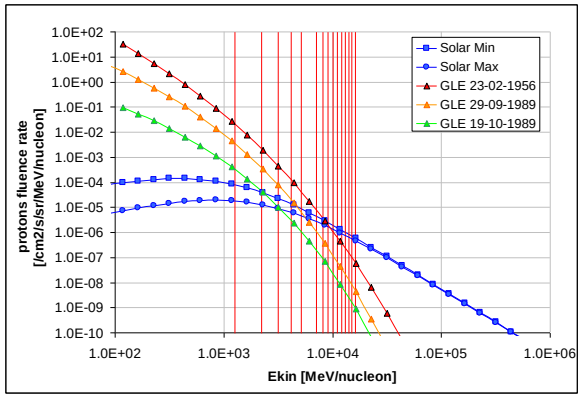


Publications, ISO, EC, ICRU-Reports

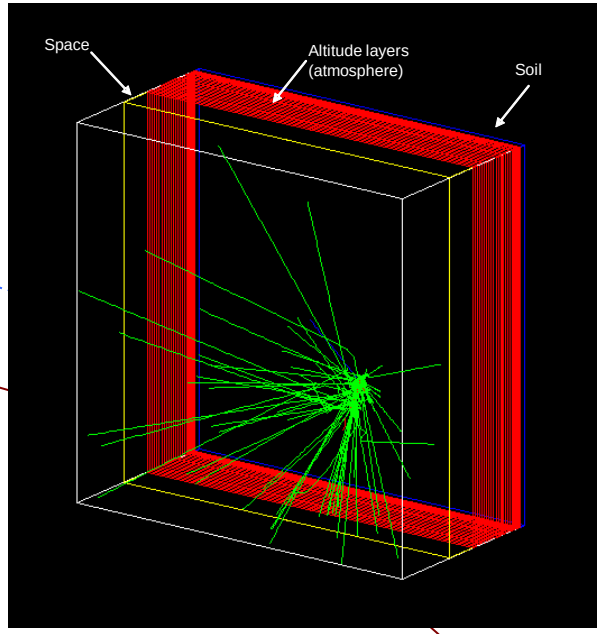
1. *Radiation Exposure of Civil Aircrew*, **RPD**, Vol.48 No.1, 1993.
2. *Exposure of Air Crew to Cosmic Radiation*, **EC-Report**, Radiation Protection Issue No. 85, 1996.
3. *Cosmic Radiation and Aircrew Exposure*, **RPD**, Vol.86 No.4, 1999.
4. *Cosmic Radiation Exposure of Aircraft Crew – Compilation of Measured and Calculated Data*, **EC-Report**, Issue No.140, 2004.
5. **ISO** Standard 20785-1:2006, Part 1
6. **ISO** Standard 20785-2:2011, Part 2
7. **ISO** Standard 20785-2, Part 3 (under preparation)
8. *Reference Data for the Validation of Doses from Cosmic-Radiation Exposure of Aircraft Crew*, **ICRU Report 84**, 2011.



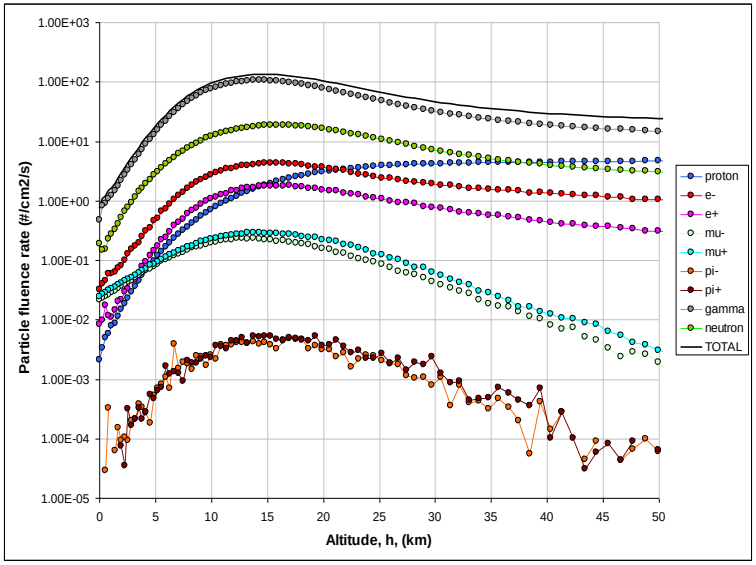
Modeling Cosmic Radiation Effects and Solar Events in der Atmosphere



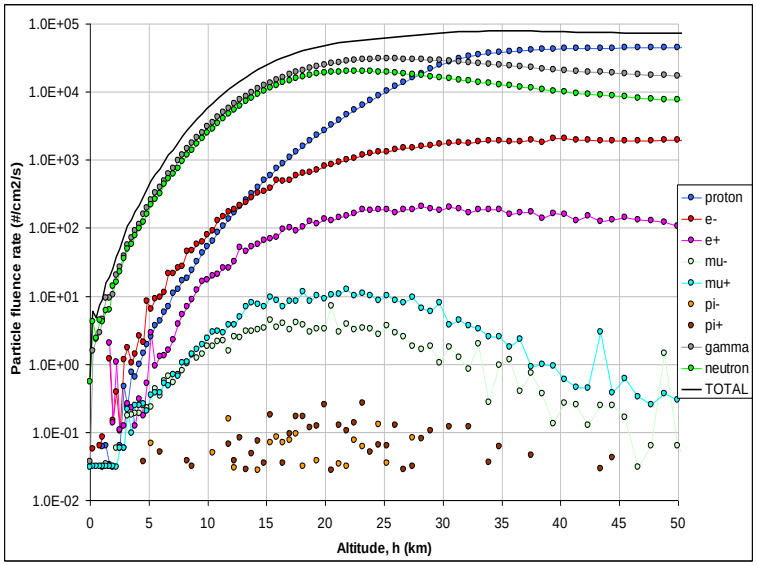
Impinging proton spectra



Particle Fluence in the Atmosphere in the Polar Region

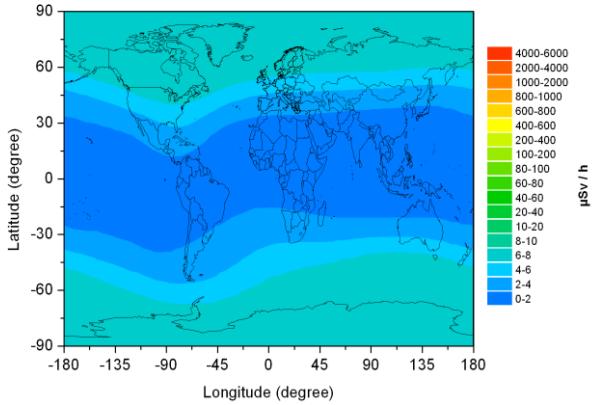


GCR, galactic cosmic radiation
(solar minimum)

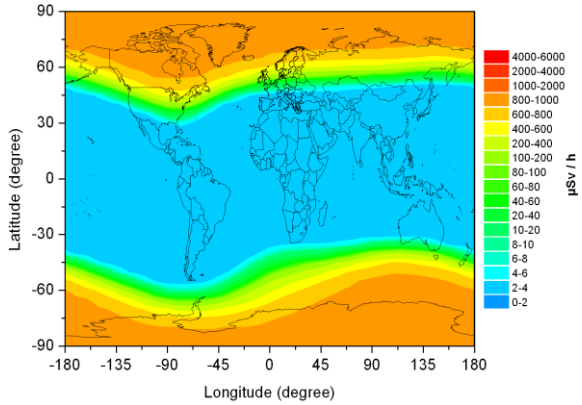


GLE5, 23. Februar 1956

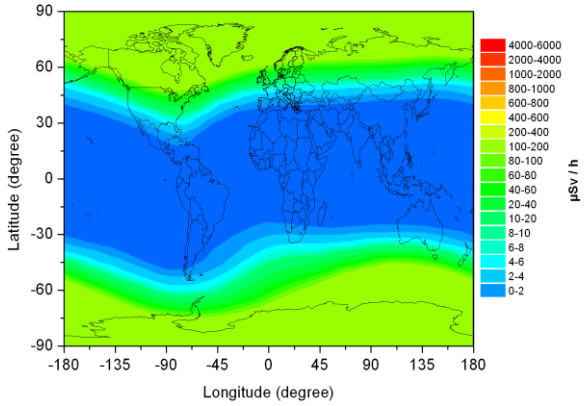
World Dose Map Effective Dose rate in µSv/h
Flight Altude10,9km (FL350)



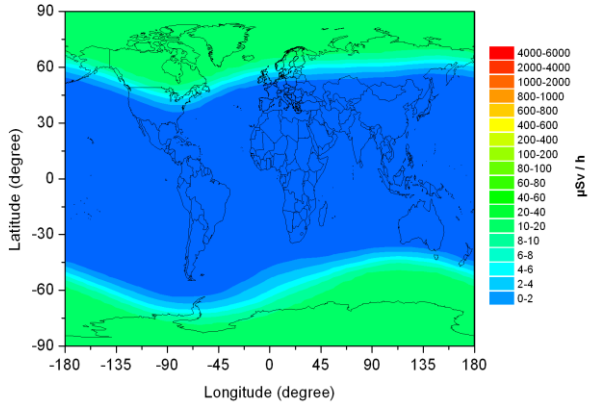
GCR, galactic cosmic radiation (solar minimum)



GLE5, 23. Februar 1956

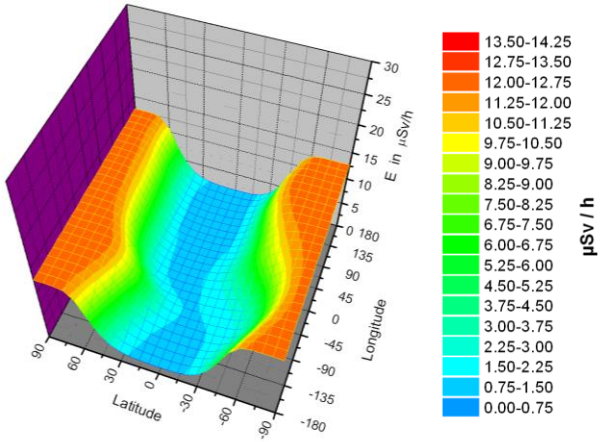


GLE42, 29. September 1989

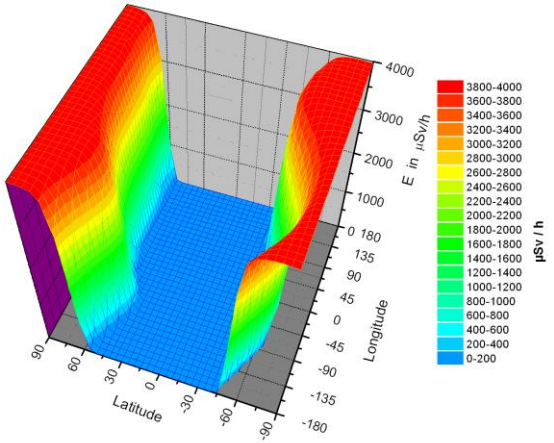


GLE43, 19. Oktober 1989

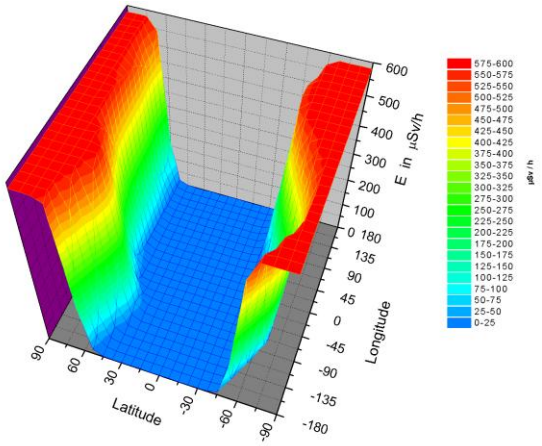
3D- World Dose Map Effective Dose rate in µSv/h
Flight Altiude 15,3 km (FL500)



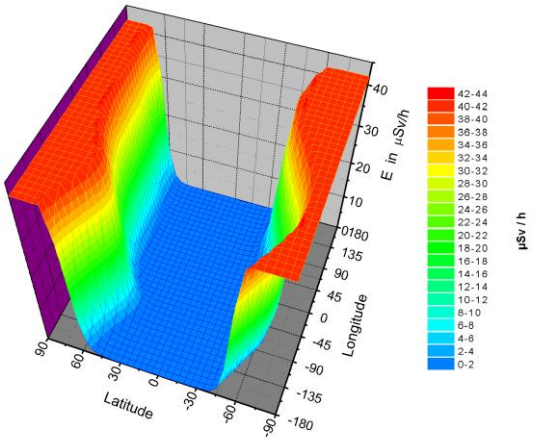
GCR, galactic cosmic radiation (solar minimum)



GLE5, 23. Februar 1956

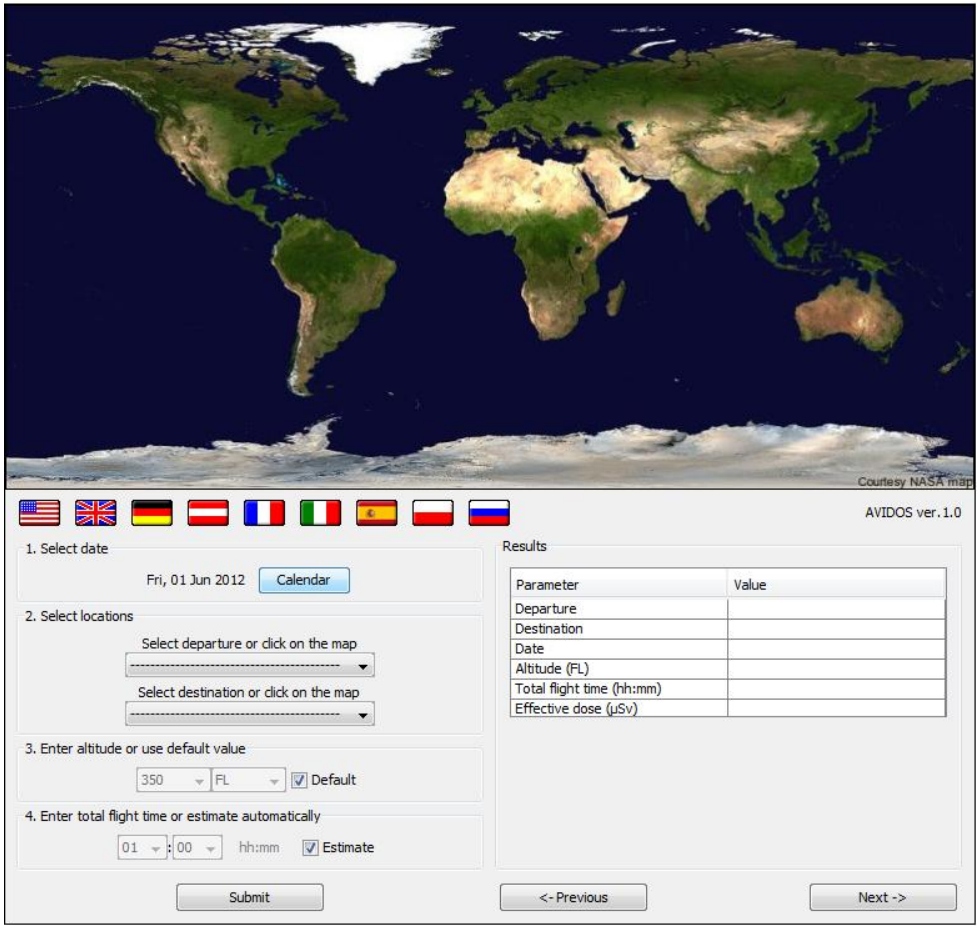


GLE42, 29. September 1989



GLE43, 19. Oktober 1989

AVIDOS – Aviation Dosimetry for Aircrew, Public Traveler, Government, Organizations, and Aviation Industry

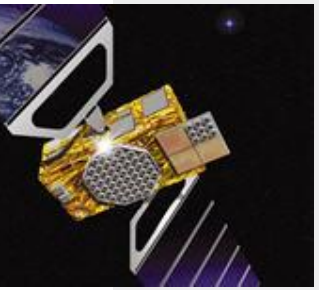


avidos.ait.ac.at

- Selection of:
  - Date
  - Departure
  - Destination
- Results:
  - Flight route dose (µSv)

AVIDOS Web User: avidos.ait.ac.at

Space Radiation Hardness Testing of Electronic Components: eldrs.net



Austrian Institute Of Techn...

eldrs.net/index.php?link=irritated_components

ELDRS

Menu

- ELDRS project
- Project overview
- The ELDRS effects
- Test method
- Test procedures
- Irritated components
- Test reports
- Publications
- Contacts & Links
- Restricted area

Irritated components

In total 10 different part types are tested to verify the switching selection are ELDRS sensitivity, availability of 70 units from o types selected are:

Operational Amplifiers:

- LM324
- LM158A
- HS-OP470 ARH
- OP470

Voltage Comparators:

- LM311
- LM339
- HS-139RH
- OP77

Voltage Regulator:

- LM317

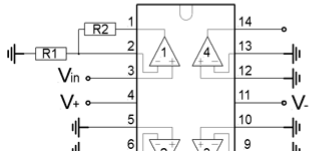
Voltage Reference:

- LM336-2.5

LM324

The LM124 (LM324) series consist of four independent, high compensated operational amplifiers which are designed to o supply over a wide range of voltages. Operation from a split p and the low power supply current drain is independent of the voltage.

Pin out and electric configuration used for the biased irradiati



ELDRS
Enhanced Low Dose Rate Sensitivity

Low Dose Rate Test Report
Date: 14/03/2011
Page : 7/11
Issue: 1
Revision: 0

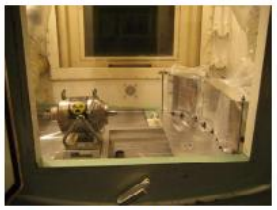


Figure 1: The set-up of the low dose rate experiment. Radiography camera and irradiation boxes hosing the irradiation boards are mounted on an Aluminum frame that is positioned inside the heavy shielded box.

Figure 2: Irradiation box; the PCB, the PMMA build-up plate and the leads for positive and negative power supply as well was as the lead for ground potential are all mounted inside the box. Only one plug is lead to the "outside".

6 Test Results

The measurement results of the LM324AN irradiations exposing the DUTs in biased configuration are presented in the following. The parameter degradation as a function of total dose is presented in Figure 3 to Figure 11 for the biased configuration and in Figure 12 to Figure 20 for the unbiased configuration. The data points presented in the figures are calculated as the mean value of the measured data of five units treated identically. Uncertainty bars are included in the figures as well; they are calculated as the standard deviation of the result of the five samples. In case the uncertainty bars cannot be seen they are smaller than the data points.

Biased Results:

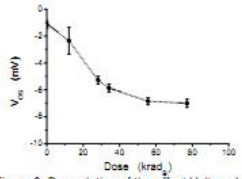


Figure 3: Degradation of the offset Voltage V_{OS} of the LM324AN microcircuit exposed in biased configuration; low dose rate response.

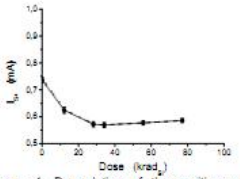
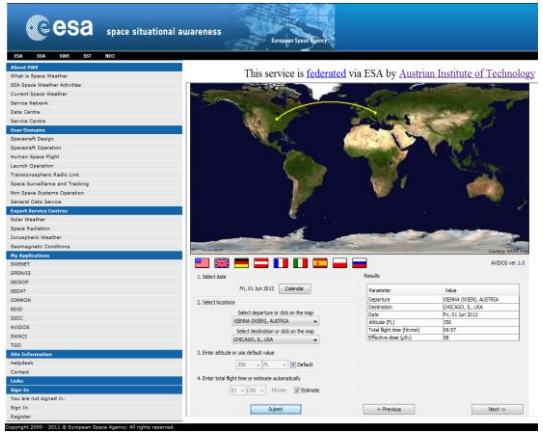


Figure 4: Degradation of the positive supply current I_{S+} of the LM324AN microcircuit exposed in biased configuration; low dose rate response.

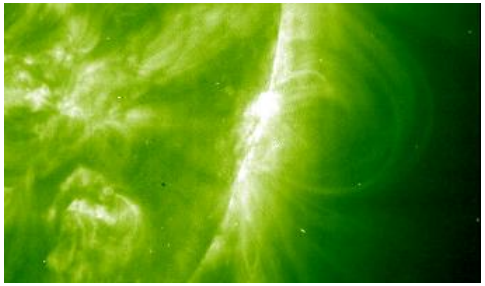
Summary - Conclusion

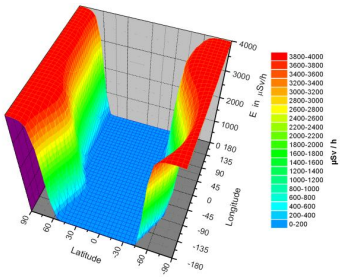
- Outstanding research projects on **air crew radiation** between **1995 – 2012**
- **Agreement** of **GCR** measurements is within **10% (1s).**
- **Dose Rate in aviation altitude:**
  - Typical **GCR** exposure: ca. **5µSv/h / BRG: 0.1 - 0.2 µSv/h**
  - Maximum **SPE** observed dose rate: ca. **1000 µSv/h / limit public: 1000µSv p.a.**
- **Several** comprehensive scientific reports published (EC-Reports, ICRU-Reports, journals)
- **ISO standard** "*Dosimetry for exposures to cosmic radiation in civilian aircraft*"
- **Modelling** of **GCR** and **GLE**
- **Agreement** of **GCR measurements** and **calculations is within 20% (1s)**
- **AVIDOS** for aviation dosimetry and the public: **avidos.ait.ac.at**
- **Microdosimeter** for the International Space Station **ISS**
- Radiation **Hardness Assurance** for electronic components
- **Transfer** science and knowledge to the **public** and industrial **applications**

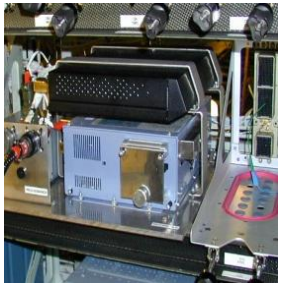


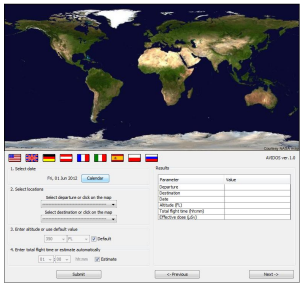
Acknowledgements

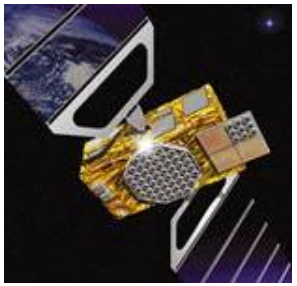
- The support by the European Commission to the projects ACREM, DOSMAX, CONRAD, CAATER within the Research Framework Program is acknowledged.
- The support by the European Space Agency, the Austrian Federal Ministry for Transport, Innovation, and Technology, and by the Austrian Space Agency, coordinated by the FFG Austrian promotion agency is acknowledged.

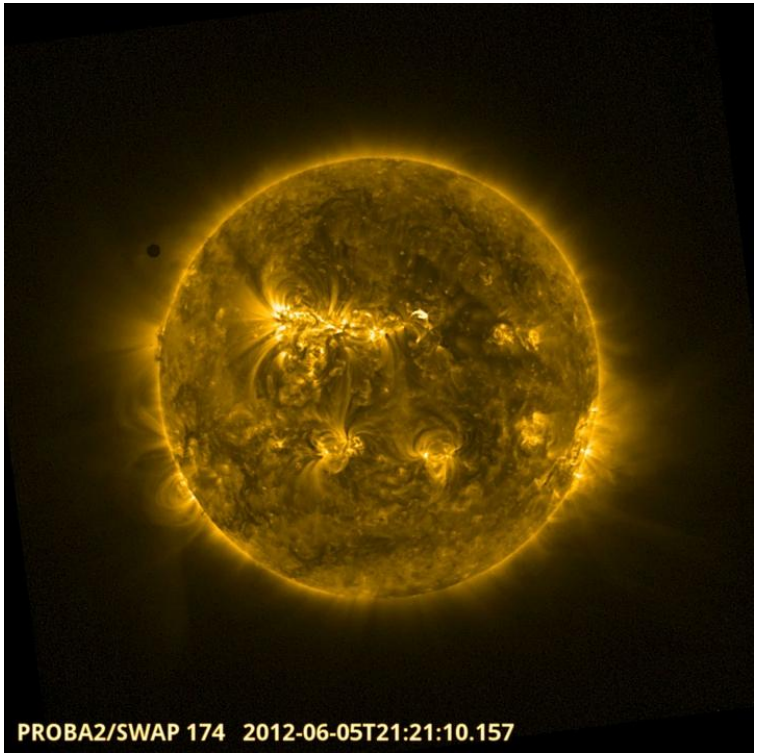












Many thanks for your attention!

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Phone: +43-50550-4305

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