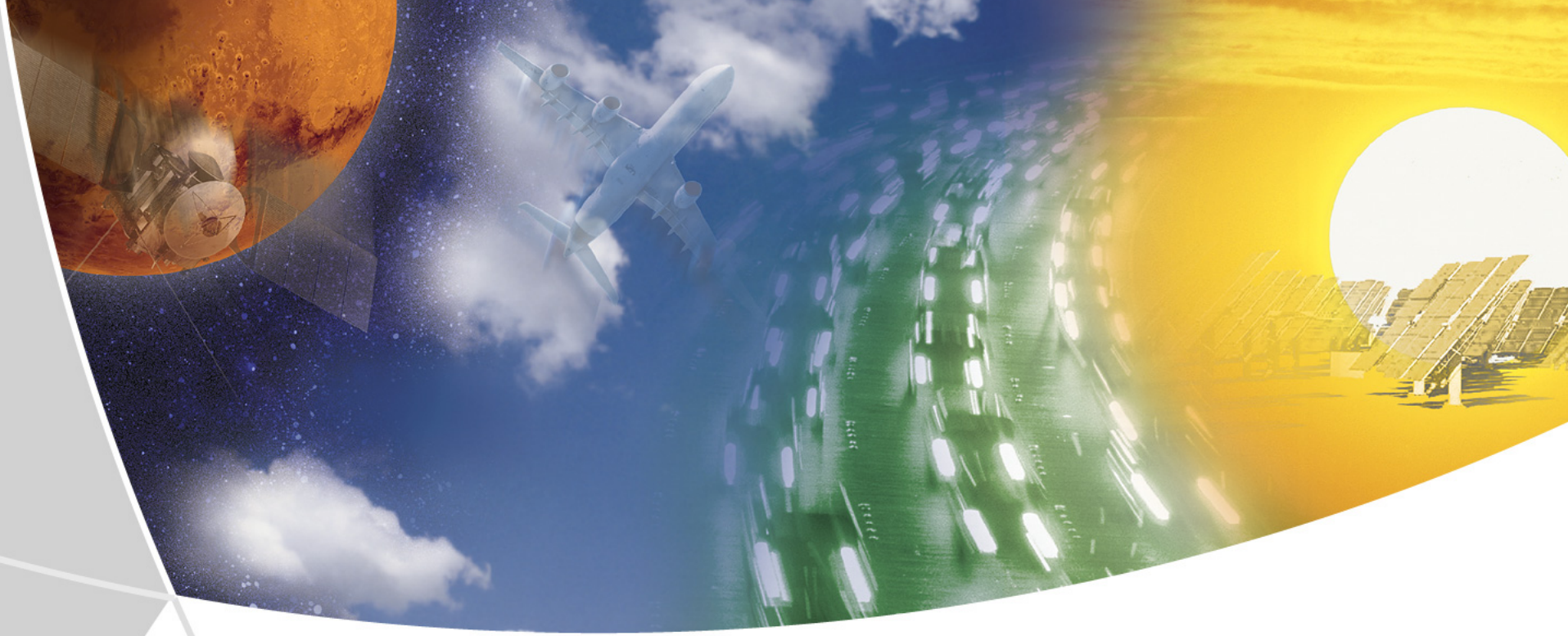

Dosimetry of Cosmic Radiation at Aviation Altitudes

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Outline

- Introduction
- Measuring Flights
- Results
- Outlook
- Summary

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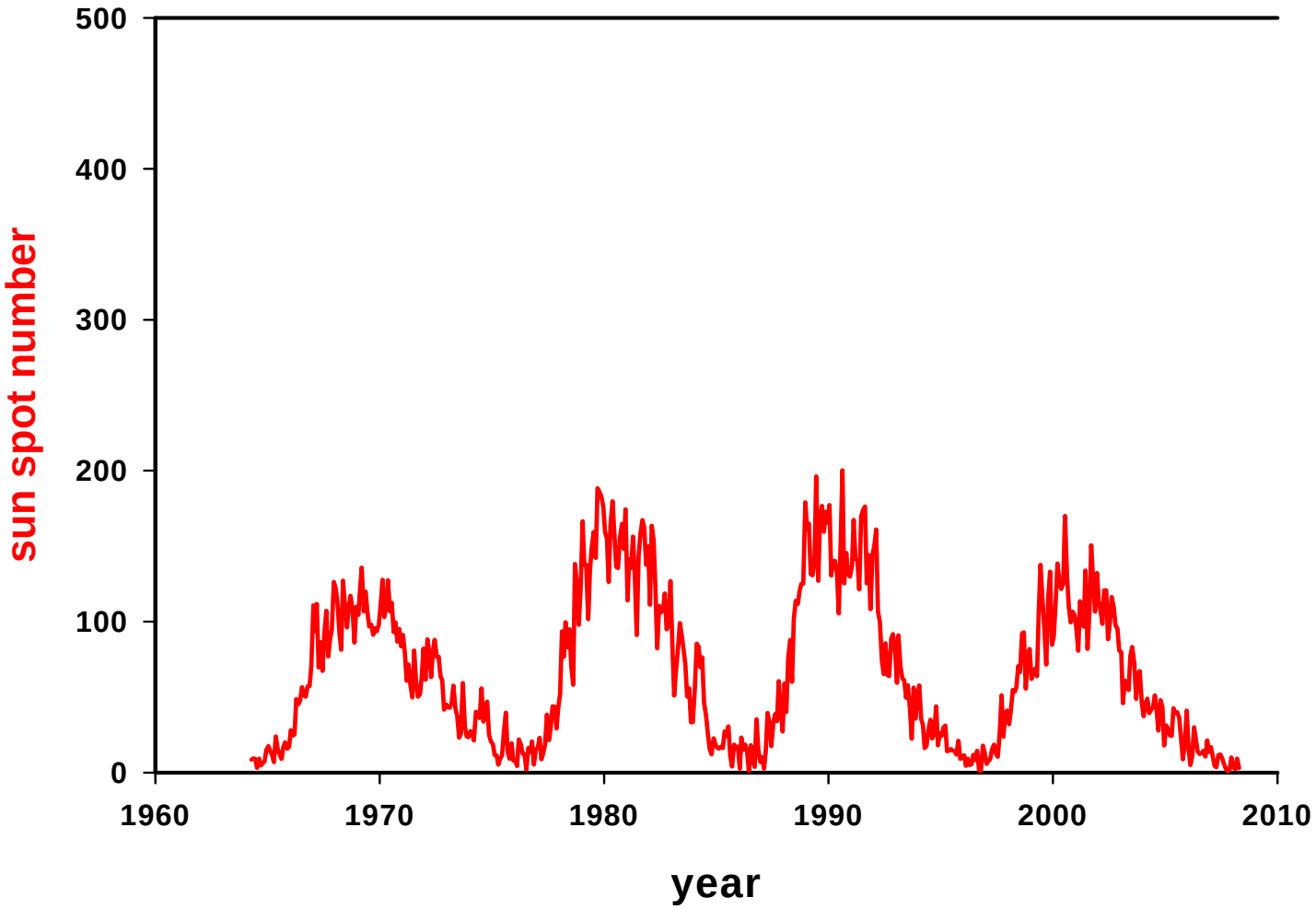
Introduction 1

- In the EU aircrew members are legally treated as radiaton workers.
- Individual dose monitoring for aircrew members for compliance with dose limits.
- The German Commission on Radiological Protection has recommended the use of calculation programs for operational dose monitoring.
- The calculation programs have to be regularly verified by experimental data.

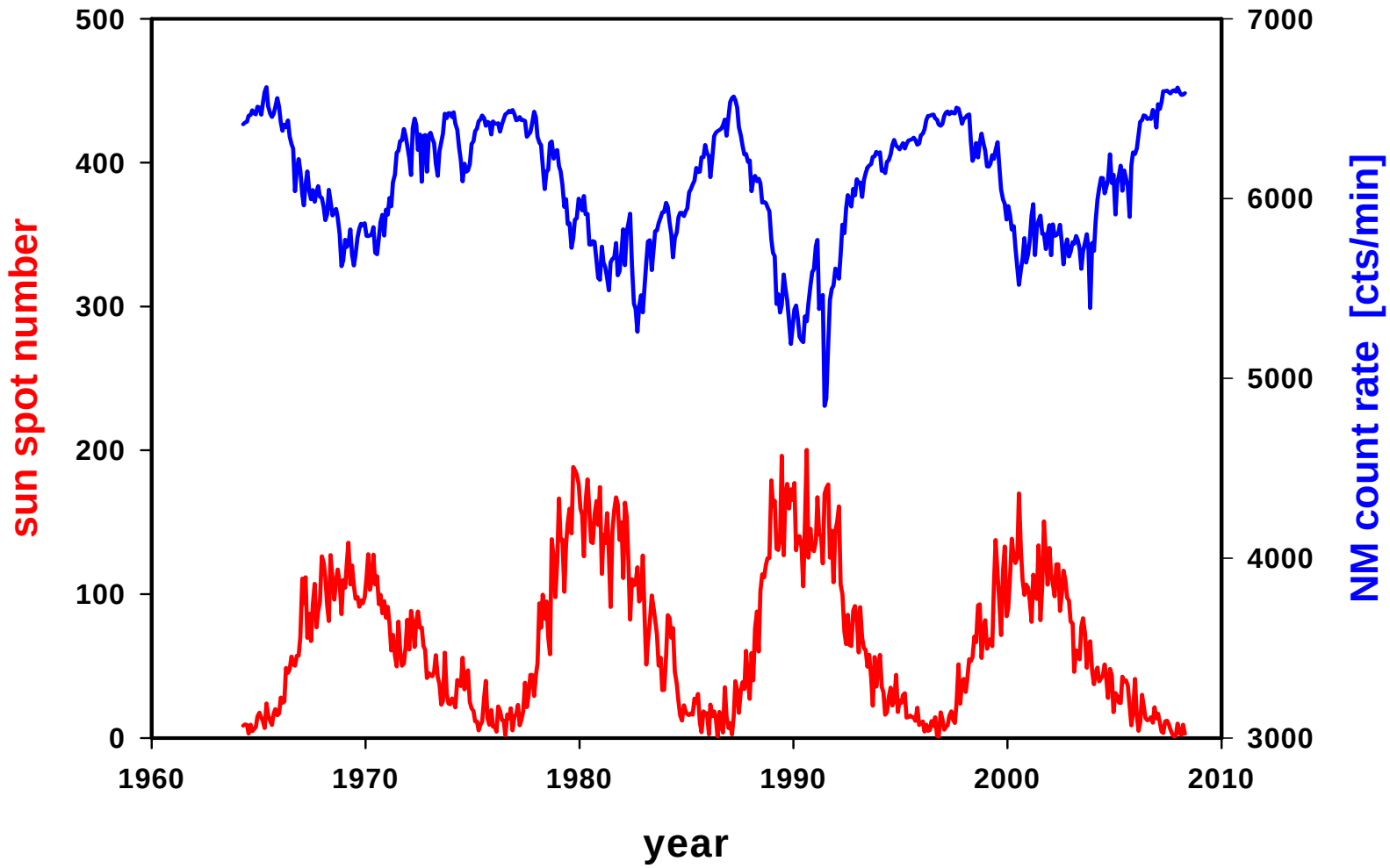
Introduction 2

- The radiation field in aviation depends on:
  - The solar activity (Space Weather)
  - The magnetic latitude
  - The altitude

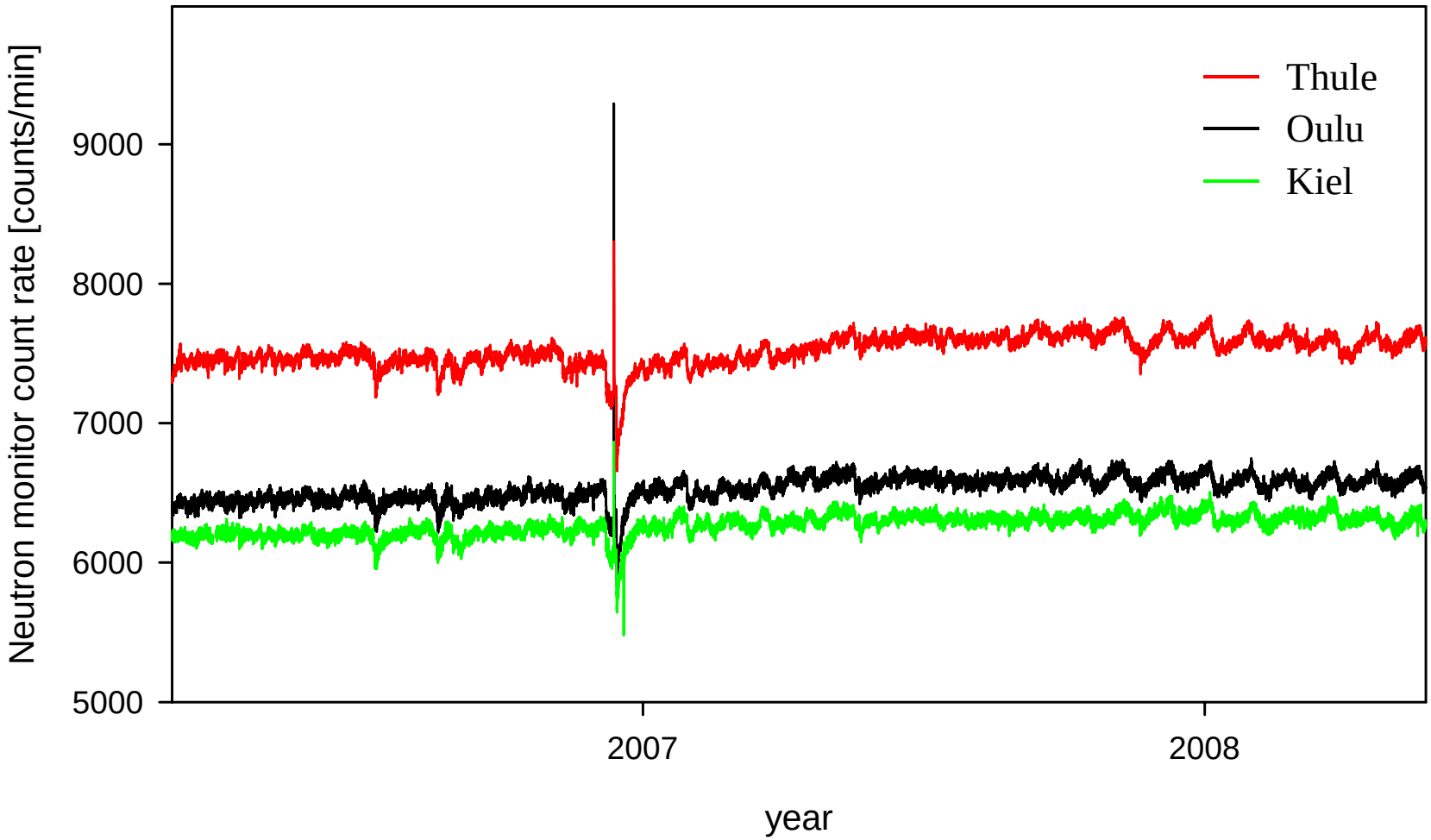
Space Weather: Temporal variation



Space Weather: Temporal variation



Space Weather during the measuring period (solar minimum)



Dosimetric Quantities 1

Absorbed dose: $$D = \frac{\mathrm{d\,energy}}{\mathrm{d\,mass}}$$ [Gy]

Effective dose: $$E_D = \sum_{T,R} w_T \cdot w_R \cdot D_{T,R}$$ [Sv]

Dose equivalent: $$H = Q_{(LET)} \cdot D$$ [Sv]

Dosimetric Quantities 2

Approximation: $$H^*(10) \approx E_D$$

Ambient dose equivalent rate: $$\dot{H}^*(10) = \frac{dH^*(10)}{dt}$$ [Sv/h]

Flight dose (dep t_0, dest t_1): $$H^*(10) = \int_{t_0}^{t_1} \dot{H}^*(10)_{(\vec{r}(t),t)}\, dt$$ [Sv]

radiation field

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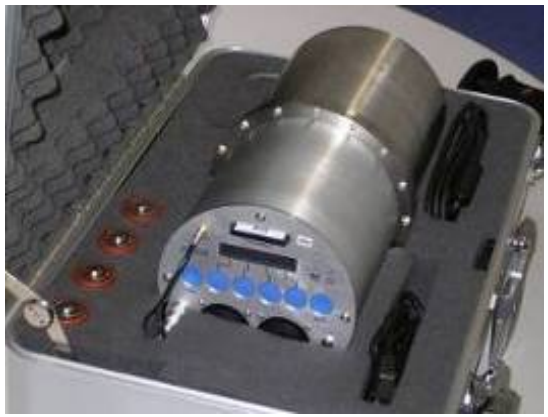
Equipment 1



- TEPC:

+ tissue equivalent material
+ temporal resolution (dose rate)
- expensive
- delicate electronics

- Bubble Detector:

+ no electronic reader required
+ sensitive to high LET only
+ inexpensive
- no temporal resolution

Equipment 2

- Liulin FM:

+ small & robust
+ temporal resolution (dose rate)
- dose conversion required
- electronic reader required

- Liulin 6G:

+ display for dose & dose rate
+ USB interface
- dose conversion required
- sensitive to shock & vibration

Aircraft:

Lufthansa Cargo AG:

McDonnel-Douglas MD-11

Altitude: FL280 – FL370

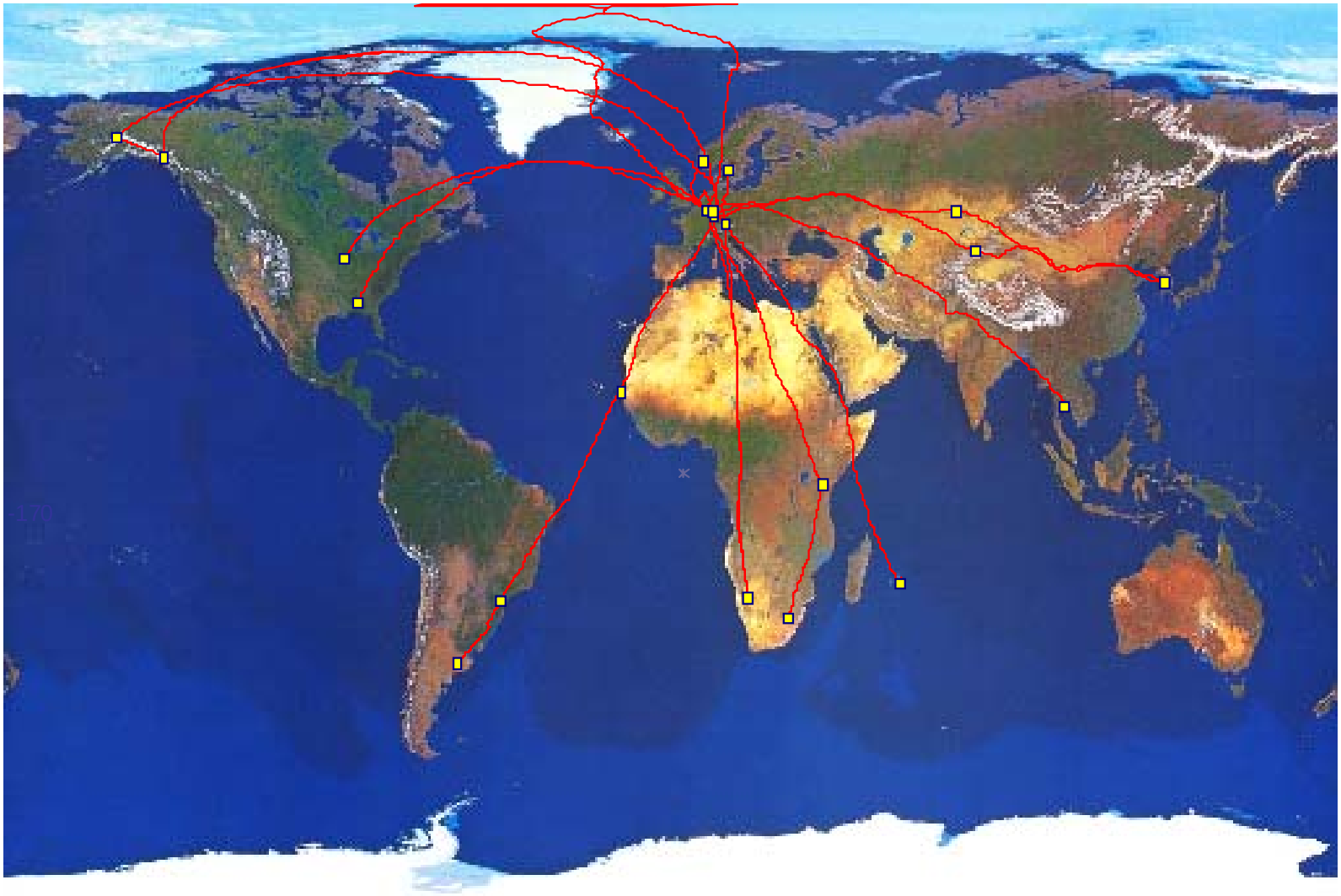
LTU International Airlines:

Airbus Industries A330

Altitude: FL350 – FL410

B-767 (Condor), CRJ-700 (CLH) and Dassault Falcon-20 (DLR)

Flight routes



Statistics

- Period: March 2006 – August 2008
- Number of flights: 35 legs
- Flight time: > 200 hours
- Geomagnetic latitudes: 27°S – 89°N
- Number of flight levels: 23

➡ a lot of data !

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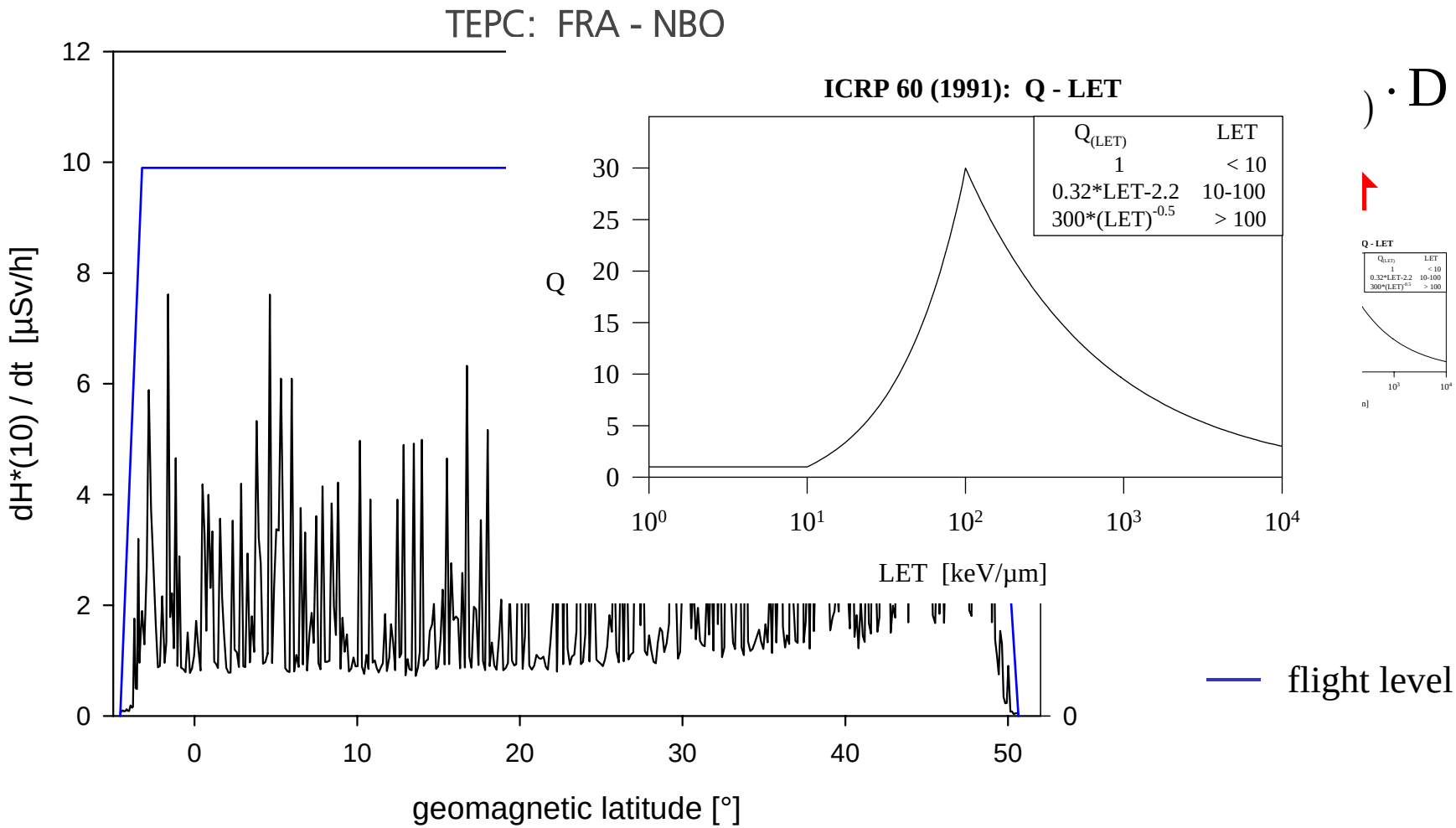
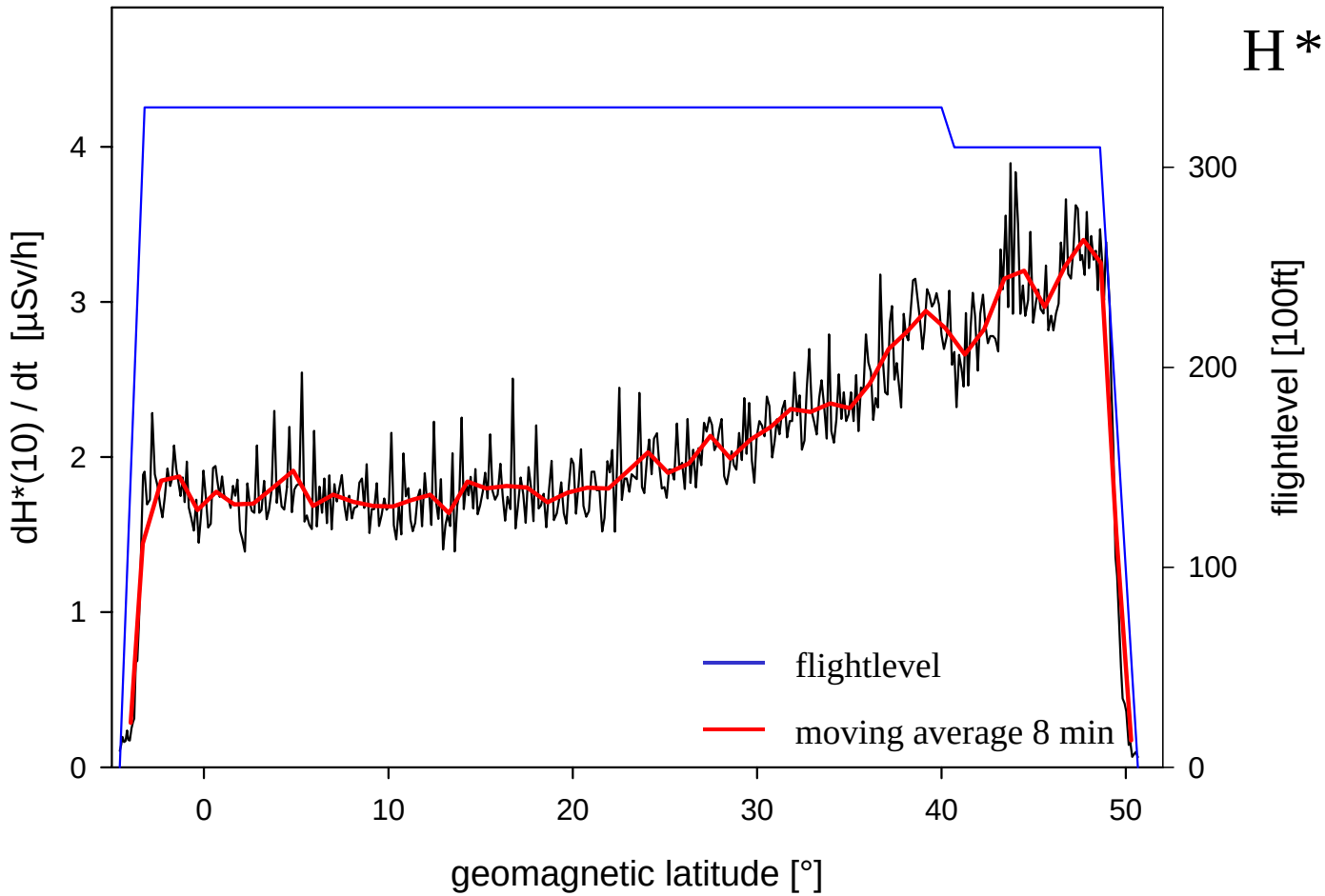
Results: Latitude effect 1

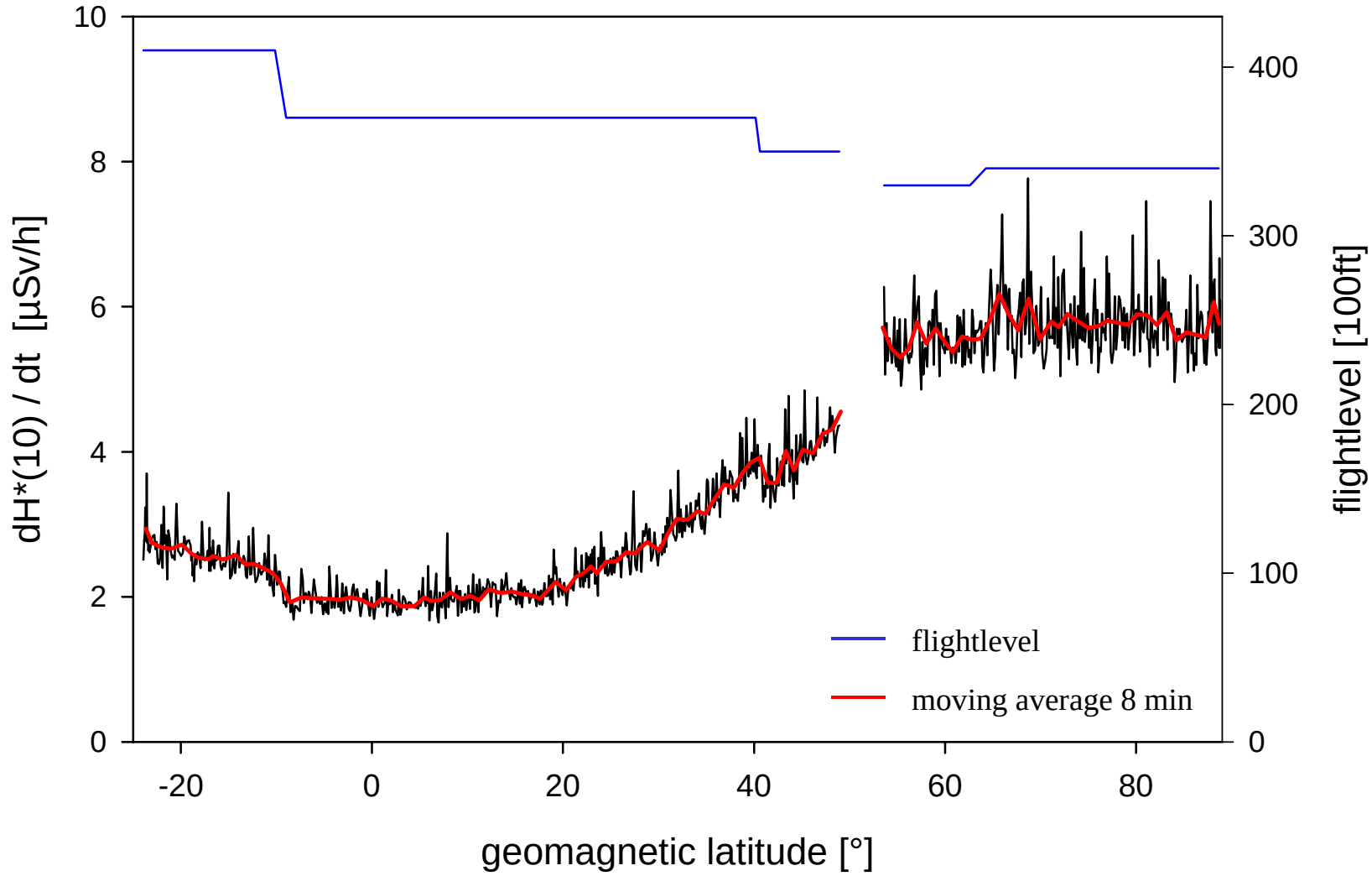


Results: Latitude effect 2

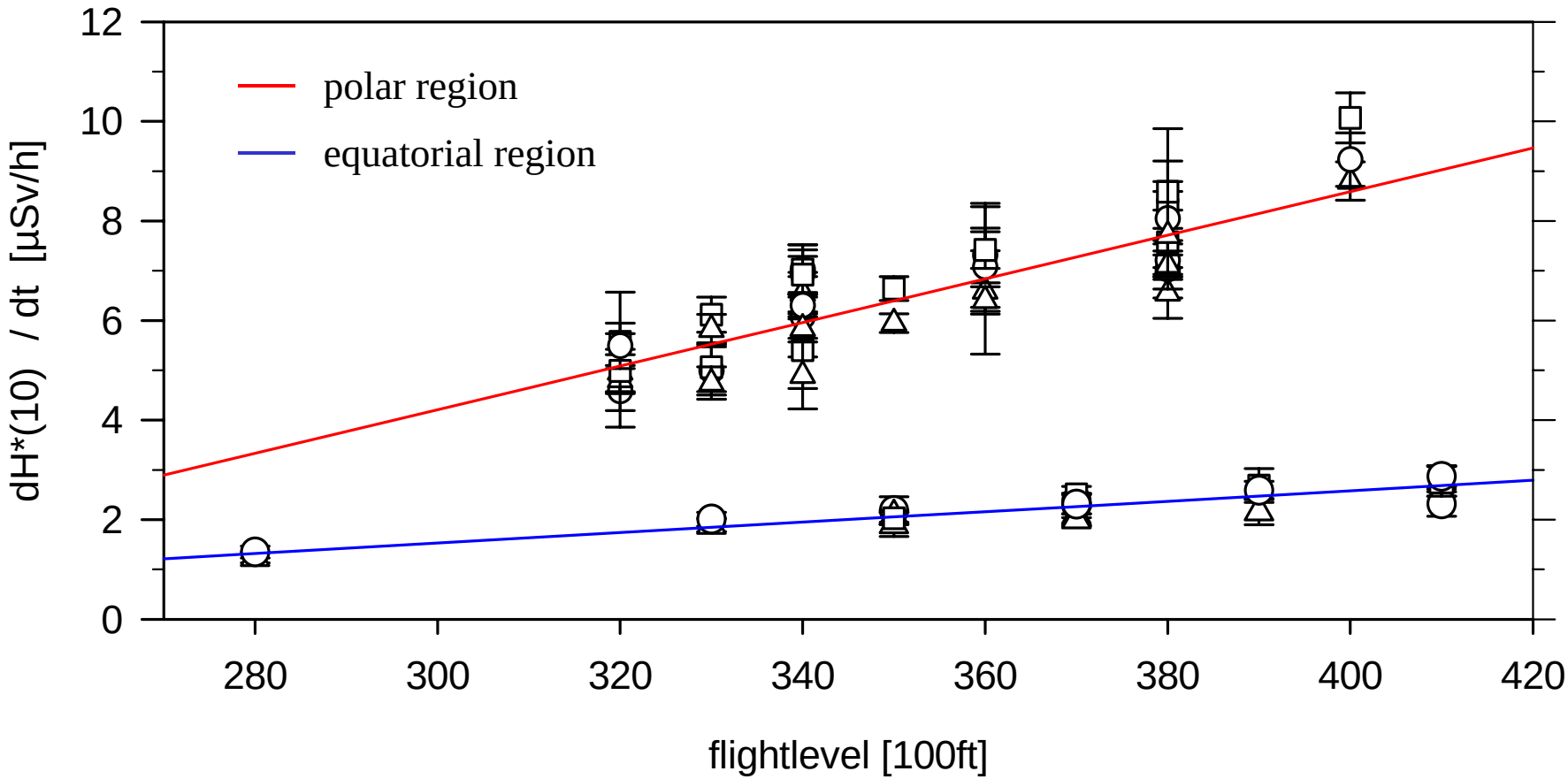


$$H^*(10) \approx \overline{Q} \cdot D_{cal.}$$

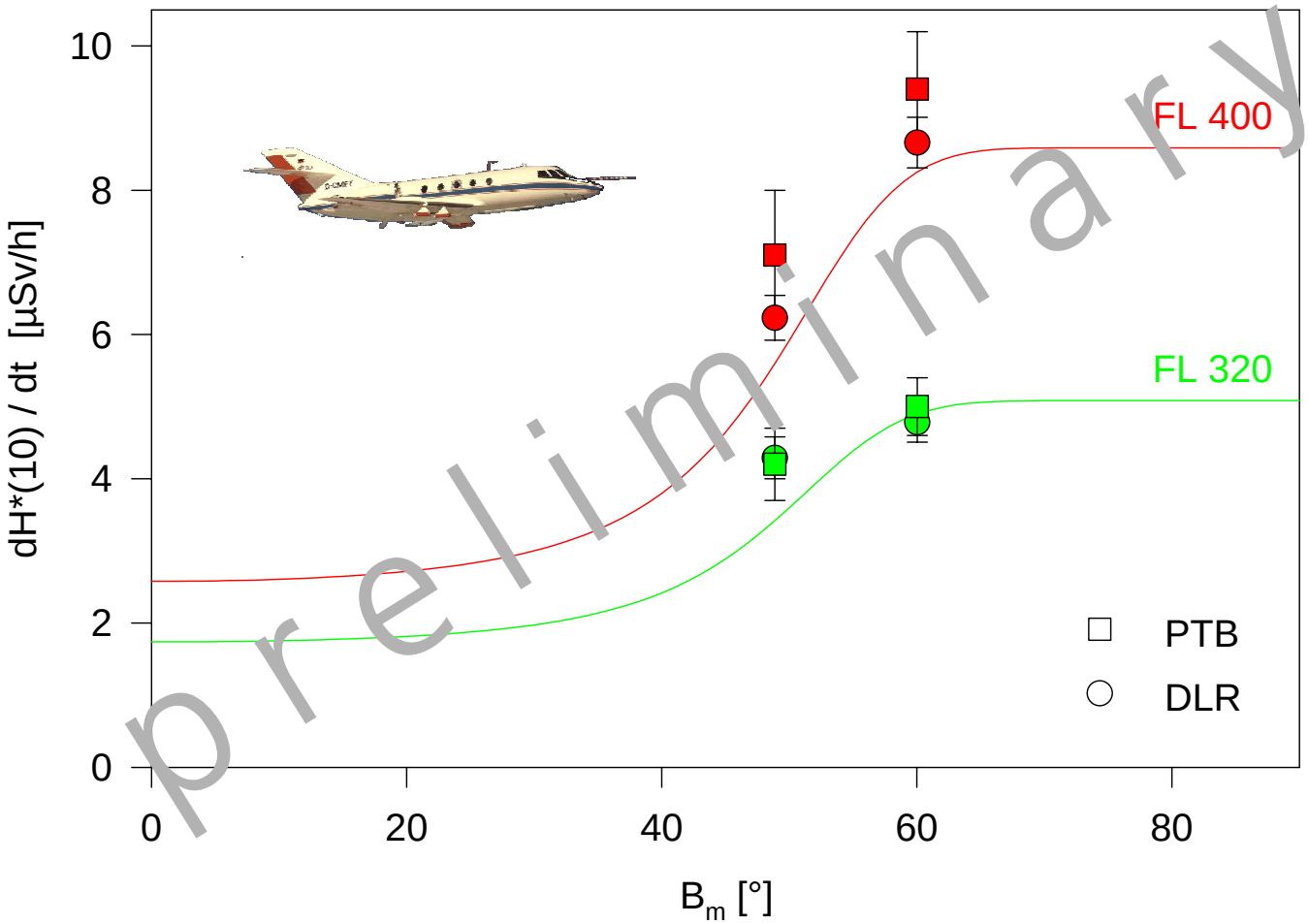
Results: Latitude effect 3



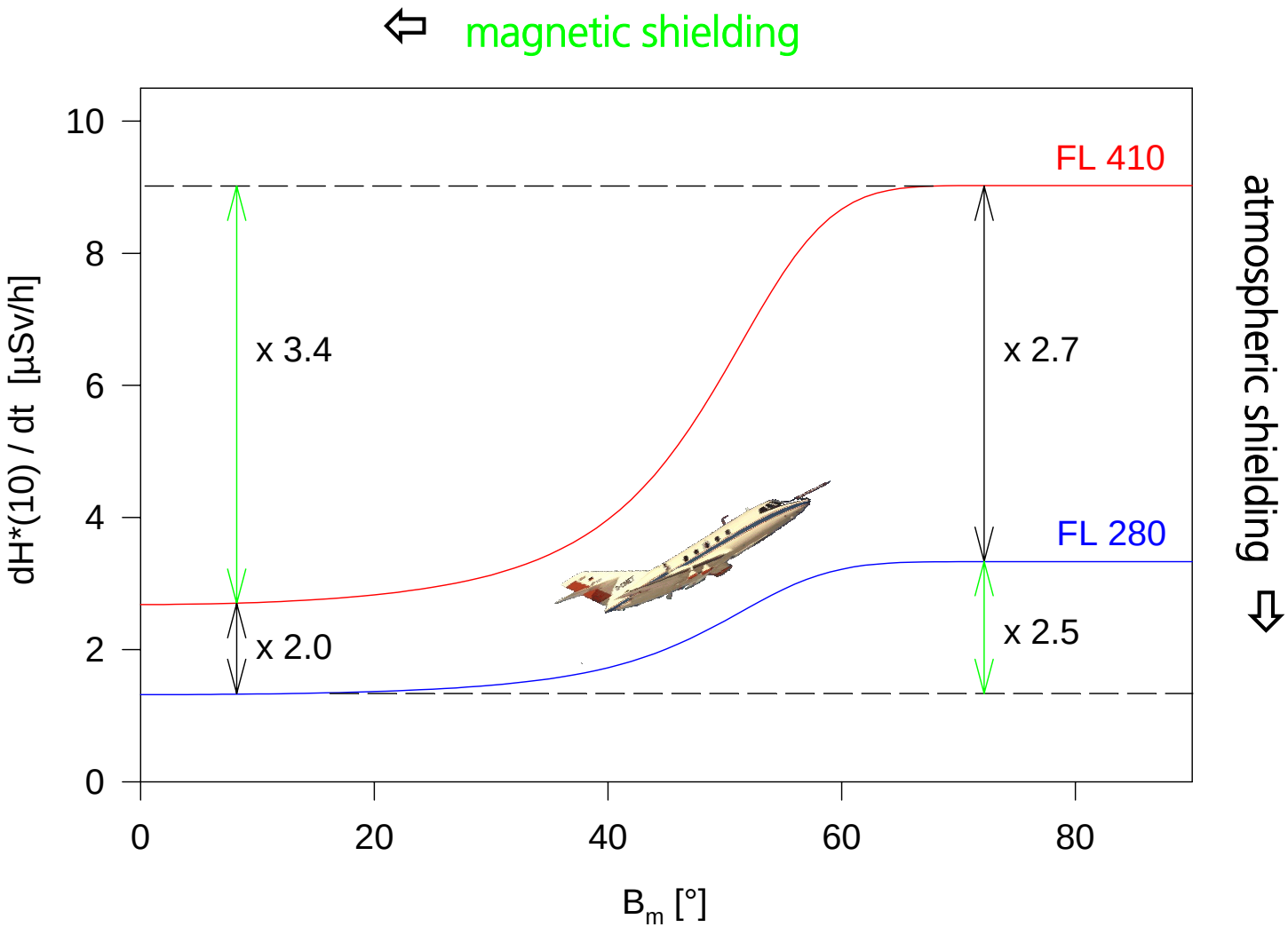
Results: Dependence on altitude



Results: Comparison with the PTB reference instrument



Results: Characteristics of the radiation field



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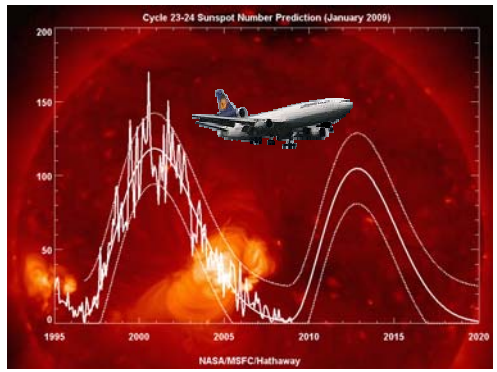
Outlook

- Investigation of solar cycle 24



- Measurements at higher altitudes (HALO)

- Continuous radiation monitoring onboard aircraft (SPEs)

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Summary

- The radiation field at aviation altitudes can be characterized by dose rates (dD/dt, dE/dt, dH*(10)/dt).
- Dose rates depend on altitude, geomagnetic latitude and solar cycle.
- The employed measuring equipment consisted of several Liulin semiconductor devices, TLDs, Bubble Detectors and a 5“-TEPC.
- The measured dose rates during the past solar minimum ranged from about 1 to 9 µSv/h.
- Future measuring activities will focus on the next solar cycle, higher flight altitudes and continuous operation of several measuring devices onboard aircraft by the next solar maximum.

How do you know you‘re flying over Africa?

Thank you for your attention !