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## Validation of Modelling the Radiation Exposure due to Solar Particle Events at Aircraft Altitudes

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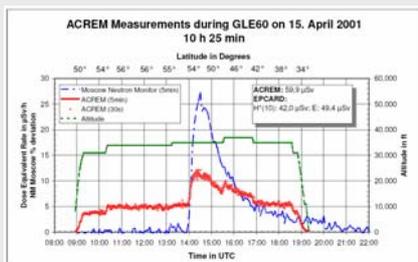
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### ABSTRACT

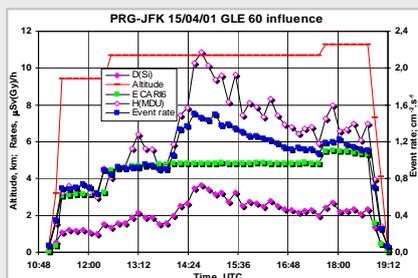
Dose assessment procedures for cosmic radiation exposure of aircraft crew have been introduced in most European countries according to the corresponding European directive and national regulations<sup>(1)</sup>. The radiation exposure due to solar particle events is still a matter of scientific research<sup>(2)</sup>. Several in-flight measurements were performed during solar storm conditions. First models to estimate the exposure due to solar particle events have been discussed. Recently EURADOS (European Radiation Dosimetry Group, <http://www.eurados.org/>) has started to coordinate research activities in model improvements for dose assessment of solar particle events. This paper describes the outline and preliminary results of a work package related to the European project CONRAD (Coordinated Network for Radiation Dosimetry) on complex mixed radiation fields at working places. The major aim of a sub-group of that work package is the validation of models for dose assessment of solar particle events, using data from neutron ground level monitors, in-flight measurement results obtained during a solar particle event and proton satellite data.

The paper describes the current status of available solar storm measurements and gives an overview of the existing models for dose assessment of the radiation exposure at flight altitudes caused by ground level events (GLEs).

### Measurements On-Board Aircraft



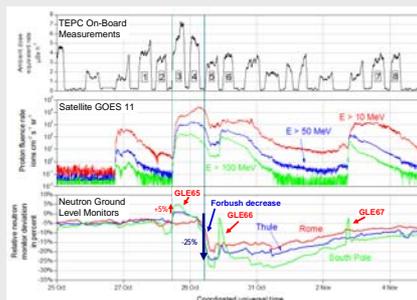
ACREM in-flight measurement of GLE 60 during Frankfurt - Dallas / Fort Worth (USA) flight and comparison with neutron monitor data from the ground station at Moscow<sup>(3)</sup>.



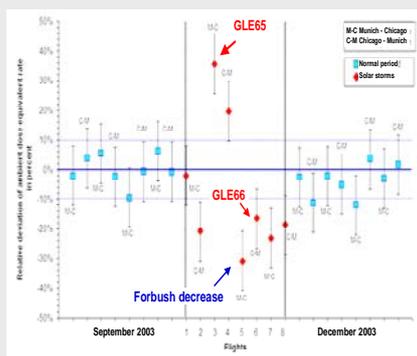
LIULIN measurements of GLE 60 during Prague – New York flight<sup>(4)</sup>.

### References

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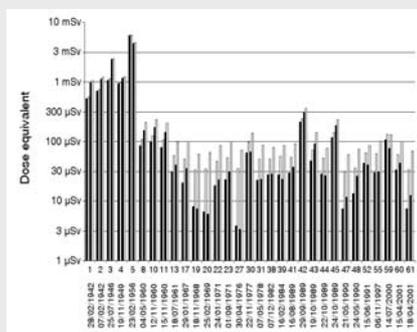


TEPC measurements during the Halloween storms between October and November 2003. GLE65, GLE66 and GLE67 occurred during these time period<sup>(5)</sup>.

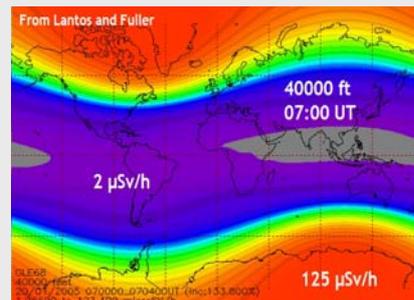


Observation of about 40% increase and 30% decreases of the radiation exposure at Munich – Chicago flights at 12 km due to GLE 65 and the following Forbush decrease<sup>(5)</sup>.

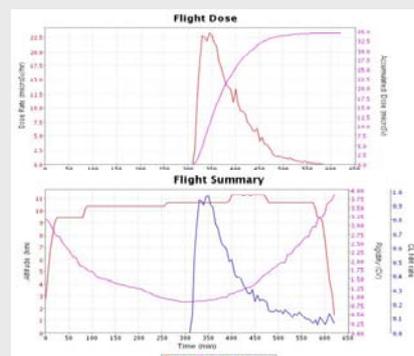
### Calculation of GLE Exposure



Worst case calculation for 31 GLEs for flights between Paris and New York with Concorde (1st and 2nd bar) and Paris to San Francisco with subsonic aircraft (3rd and 4th bar). GLE contribution (black bar), total dose (white bar). The GLEs taken into account are those significant in terms of radiation dose.



World dose map calculated for the conditions during GLE 69 on 20 January 2005 based on SiGLE model<sup>(6)</sup>.



Calculated time profile dose rate data during GLE 60 on 15 April 2001 on a flight from FRA to DFW. Radiation data were calculated by the QARM model<sup>(7)</sup>.

### Conclusions

A EURADOS working group co-ordinates current research on effects of solar energetic particles at aircraft altitudes. Calculated values of the radiation exposure due to ground level events (GLEs) range up to a total dose of some 5mSv per route on-board supersonic flights and up to some 1mSv on board subsonic flights crossing the Polar region. The occurrence of GLEs is on average one event per year with a route dose of a few tens of µSv, one event per decade with a route dose of a few hundred µSv, and perhaps one event per century with a route dose of the order of mSv. GLEs are most probable during the solar maximum, with an increased likelihood before and after the maximum of Sun's activity of the eleven year solar cycle. Several in-flight measurements have been performed during solar storm periods. Calculation methods of radiation exposure due to GLEs are at present under validation.

