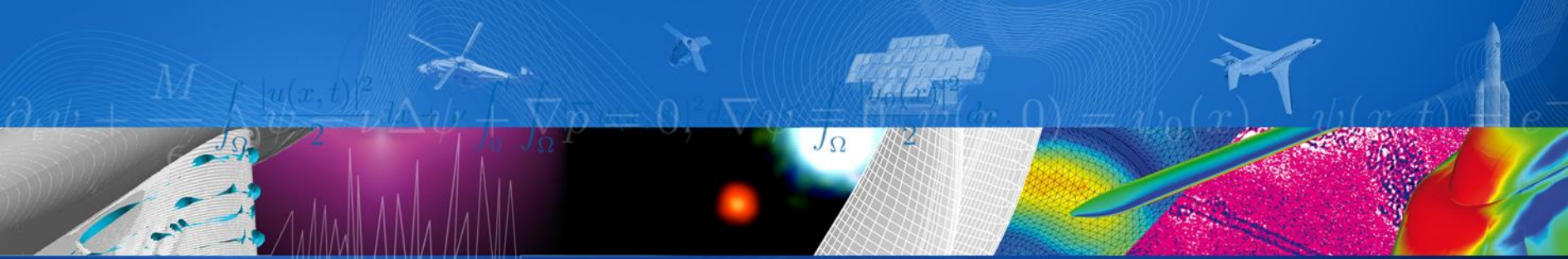

Benchmarking ionizing space environment models

S. Bourdarie, P. Calvel, M. Beaumel, F. Maloron, C. inguimbert, J.R. Vaillé, A. Sicard, D. Falguere, R. Ecoffet, D. Standarovski, E. Lorfèvre

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CENTRE NATIONAL D'ÉTUDES SPATIALES

R&T
SYSTÈMES SPATIAUX

Outline

Approach

In-flight data and comparison to proton model predictions

- TNID from OSL at 660 km altitude, 82° inclination
- SEU from EDAC counter at 719 km altitude, 82° inclination
- DCNU from Star Tracker at 960-1160 km altitude, 29.7° inclination
- TNID from OSL at 1336 km altitude, 63° inclination
- SEU from EDAC counter at 1336 km altitude , 63° inclination
- DCNU from Star Tracker at 1336 km altitude , 63° inclination
- DCNU from Star Tracker at 265-5000 km altitude, 49° inclination

Synthesis (Trapped protons)

In-flight data and comparison to electron model predictions

- Solar array power loss at GEO

Approach

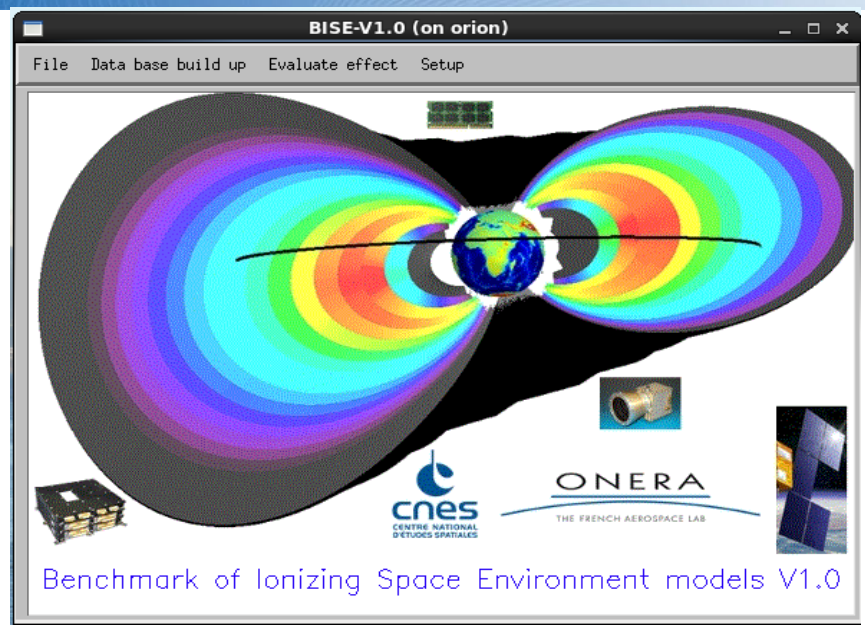
Orbit is from NORAD TLE with a 20s time step throughout the entire mission.

Trapped radiation environment is computed every 20s along the spacecraft orbit.

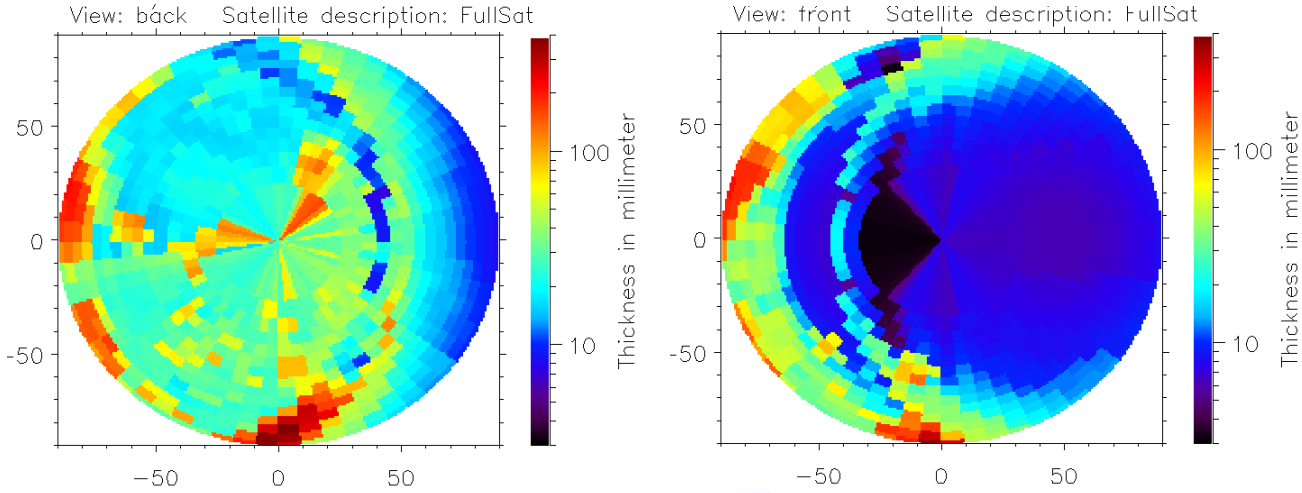
Account for 3D shielding around component of interest → sectoring analysis from FASTRAD

Response function or transmited flux are computed from Monte-Carlo run using GEANT-4 or MCNPx

Comparison of predicted degradation with in-situ measurements (TID, TNID, SEU-EDAC, DCNU, Solar array power).



FASTRAD sectoring analysis from SAC-D/ICARE-NG/OSL/LED



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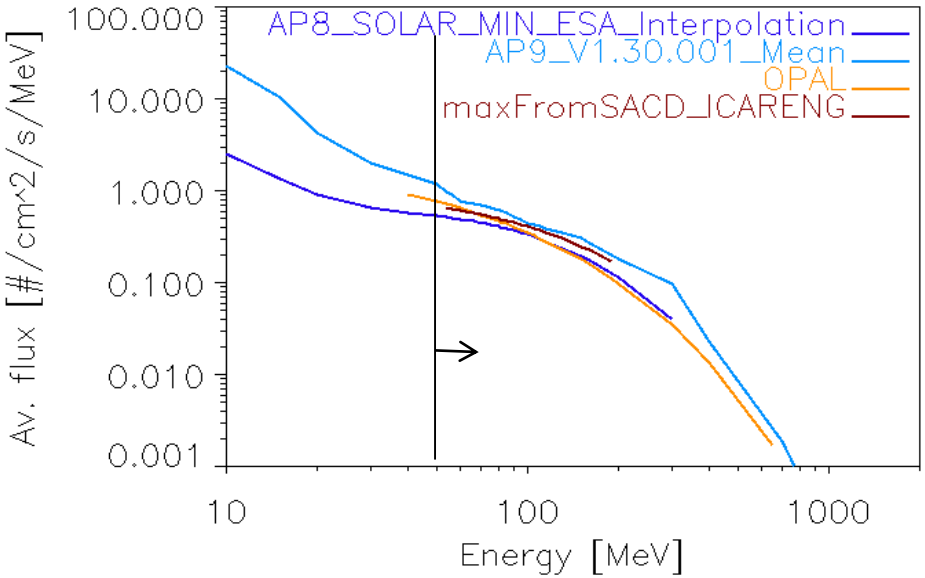
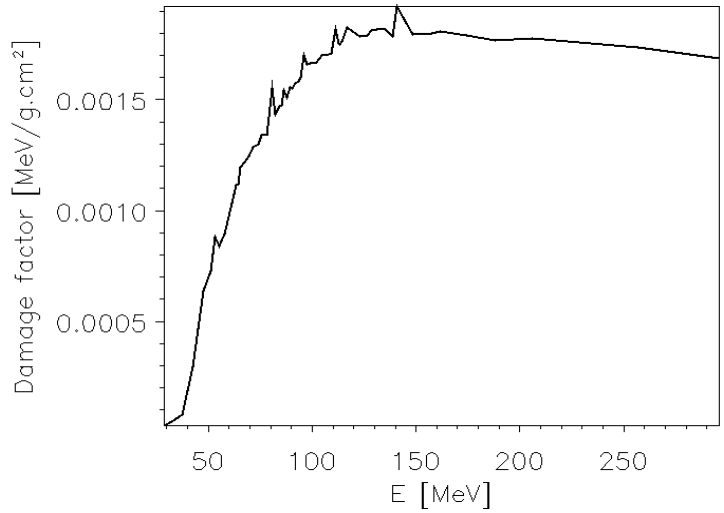
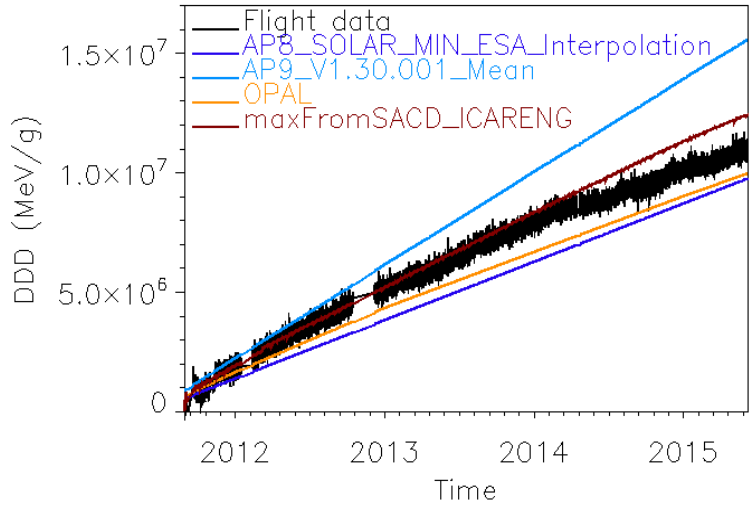
In flight data and comparison to proton model predictions

Total displacement damage (DDD) at 660 km altitude (SAC-D, 660 km, 98°)



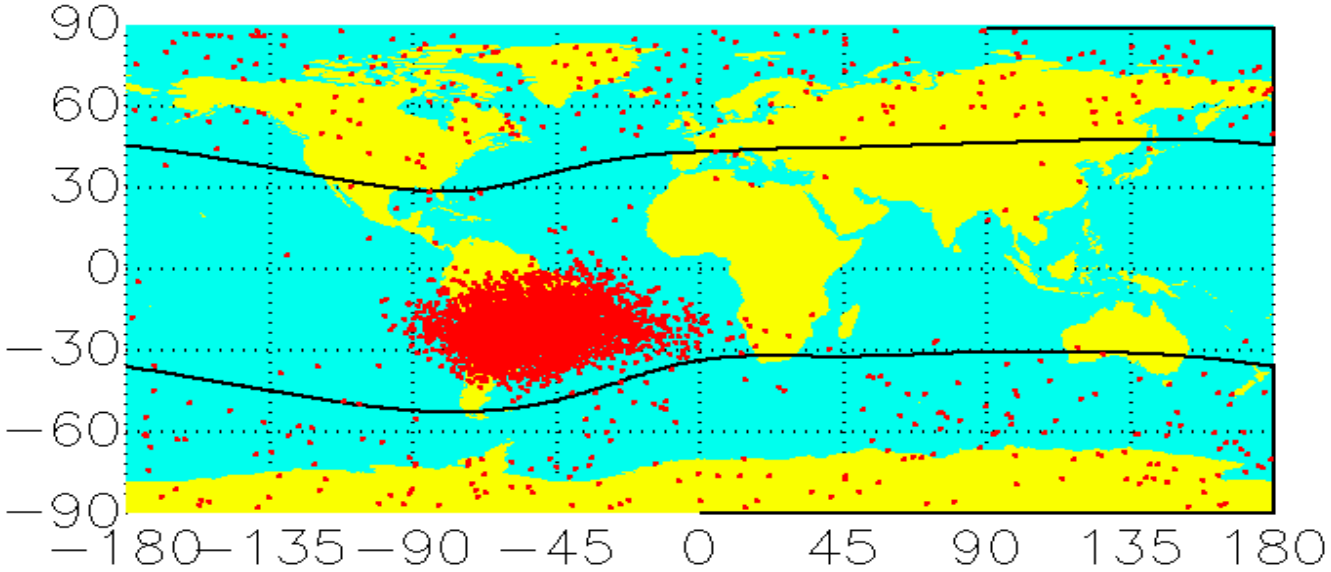




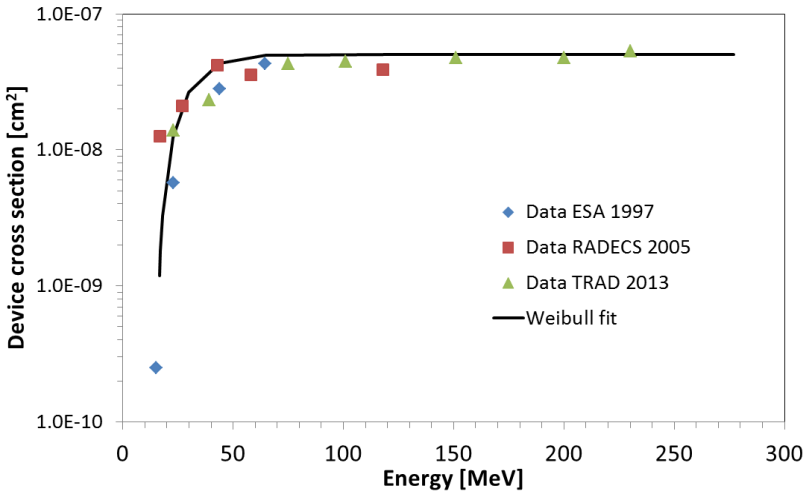
Model / data	Deviation (ratio prediction / flight data)
AP8 min	0.89
AP9 V1.30.001 Mean	1.42
OPAL	0.91
ICARE_NG	1.07

In flight data and comparison to proton model predictions

SEU rate from EDAC counter at 719 km altitude (CRYOSAT-2, 719 km, 98°)



L*<1.9 ⇒ 88.4%
L*>1.9 ⇒ 11.6%

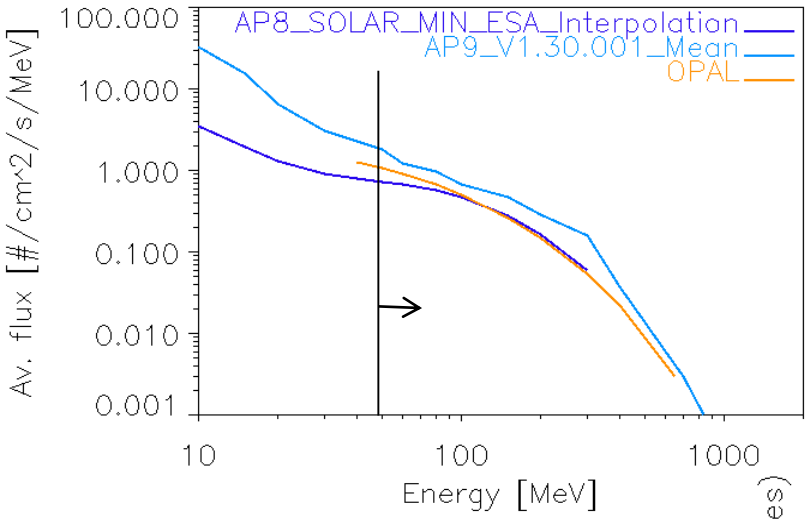


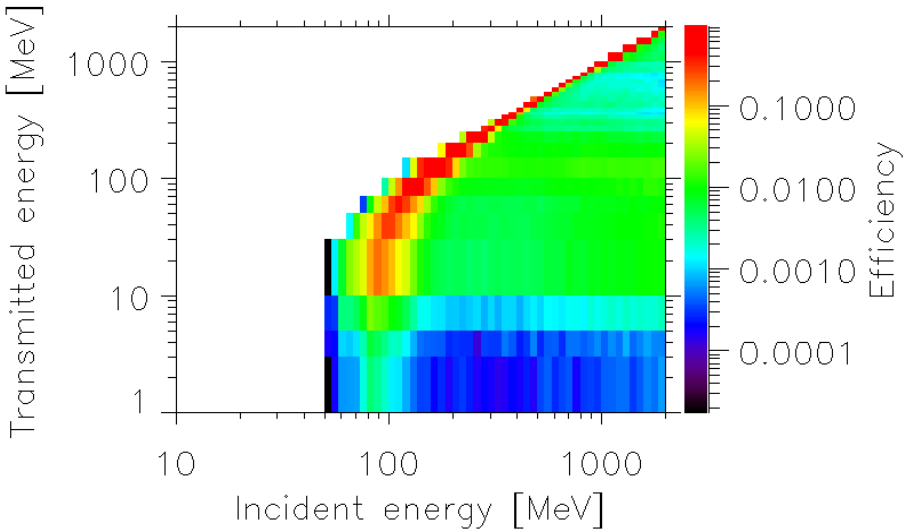
10 SRAM (1MB SRAM M65608, 0.5µm CMOS process, developed by ATMEL)

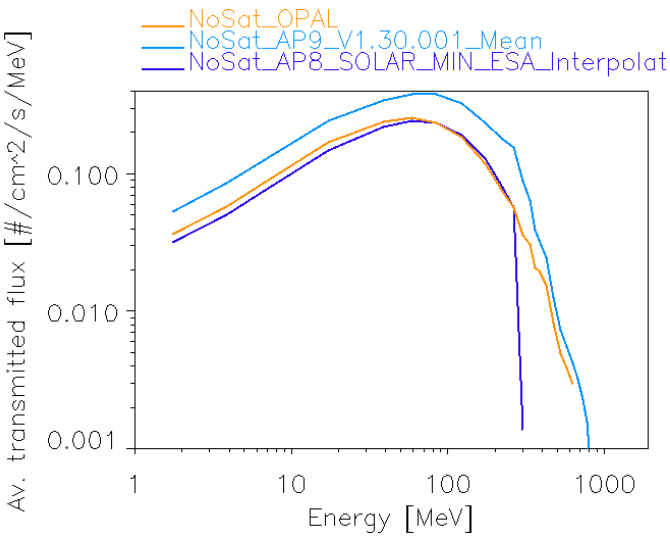
W=18
S=1.5
Eth=15 MeV
Sat=5.28 10^{-8} cm^2/device

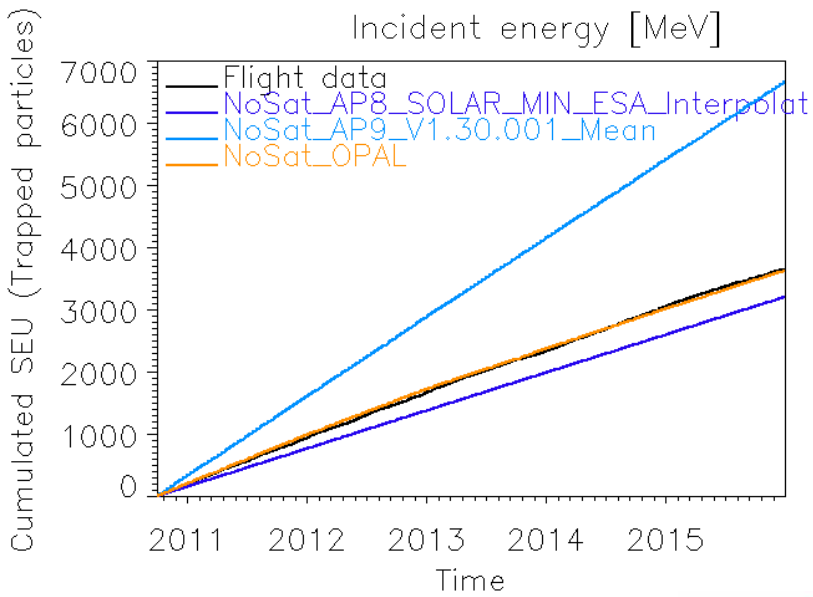
In flight data and comparison to proton model predictions

SEU rate from EDAC counter at 719 km altitude (CRYOSAT-2, 719 km, 98°)









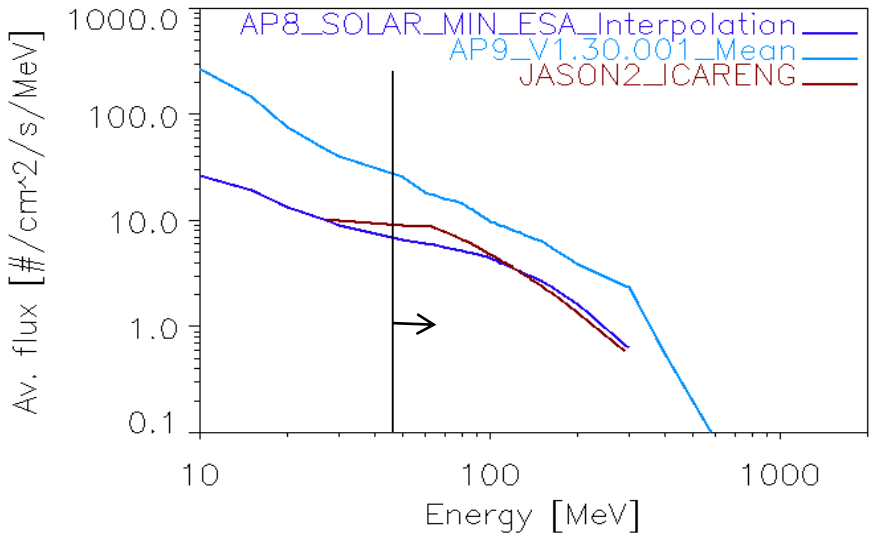
1.82

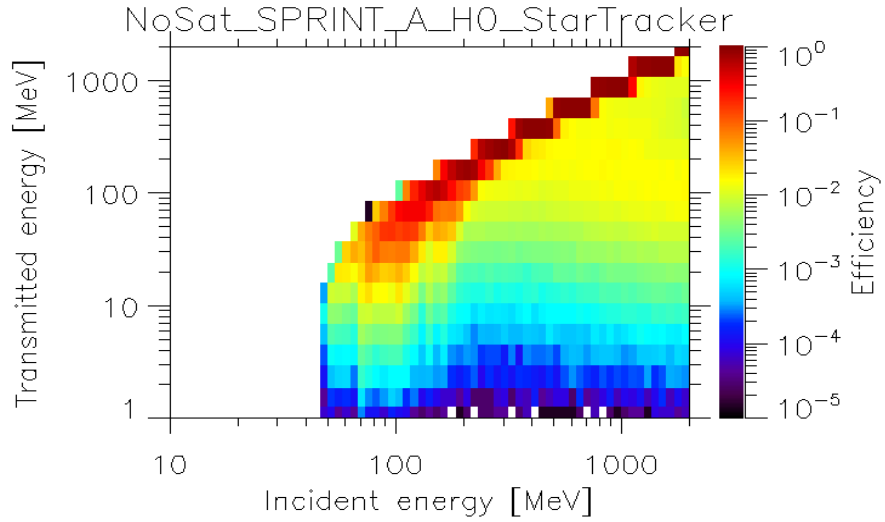
0.99

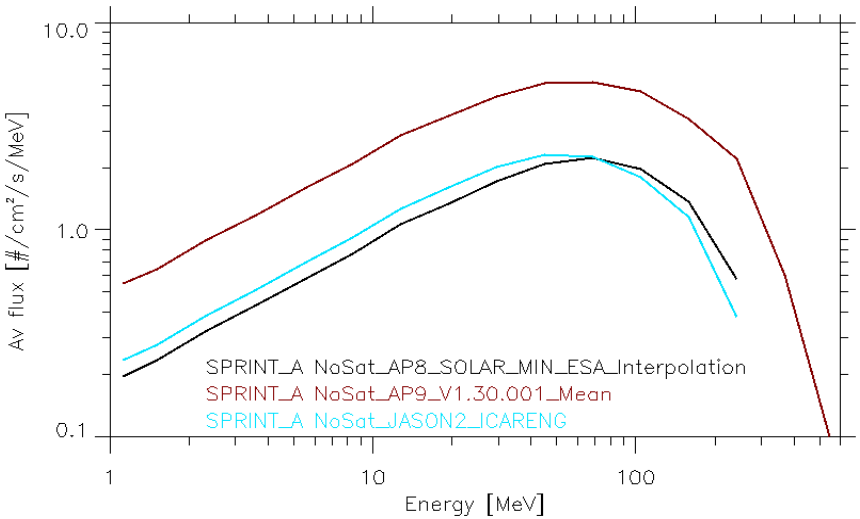
0.86

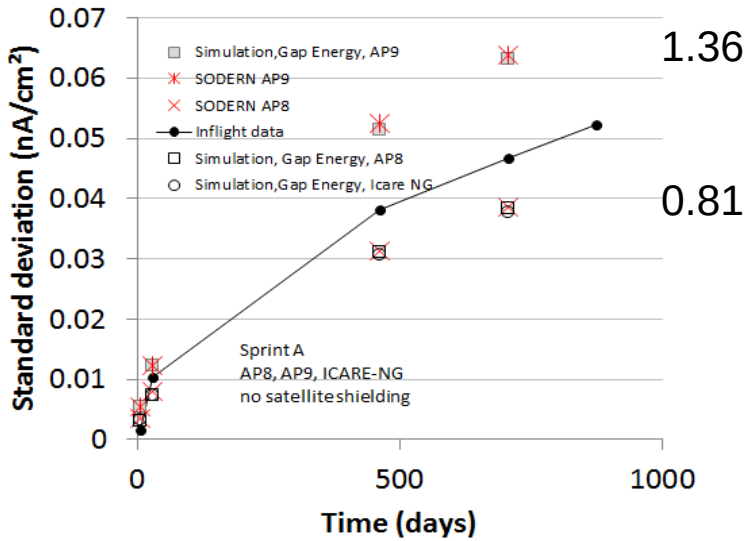
In flight data and comparison to proton model predictions

DCNU from Star Tracker at 900-1100 km altitude (SPRINT-A, 960-1160 km, 31°)



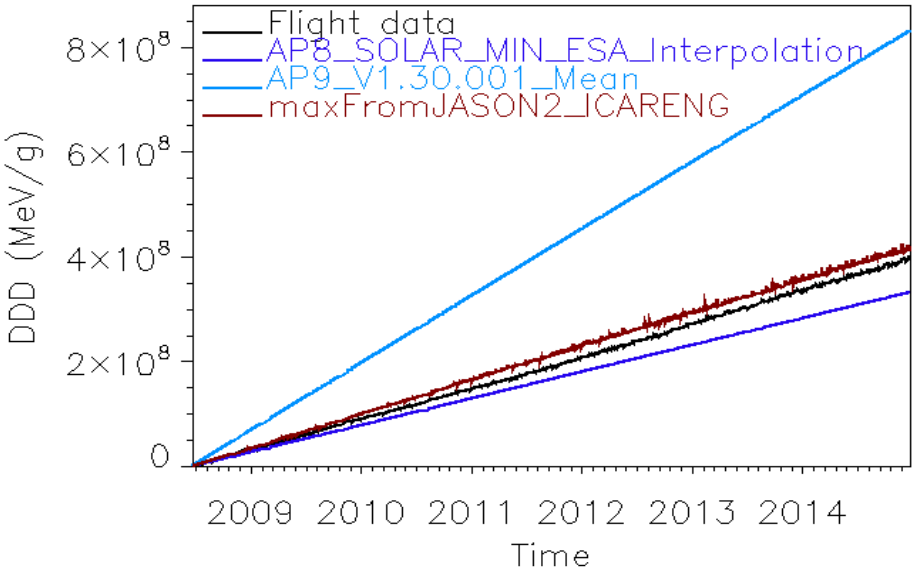






In flight data and comparison to proton model predictions

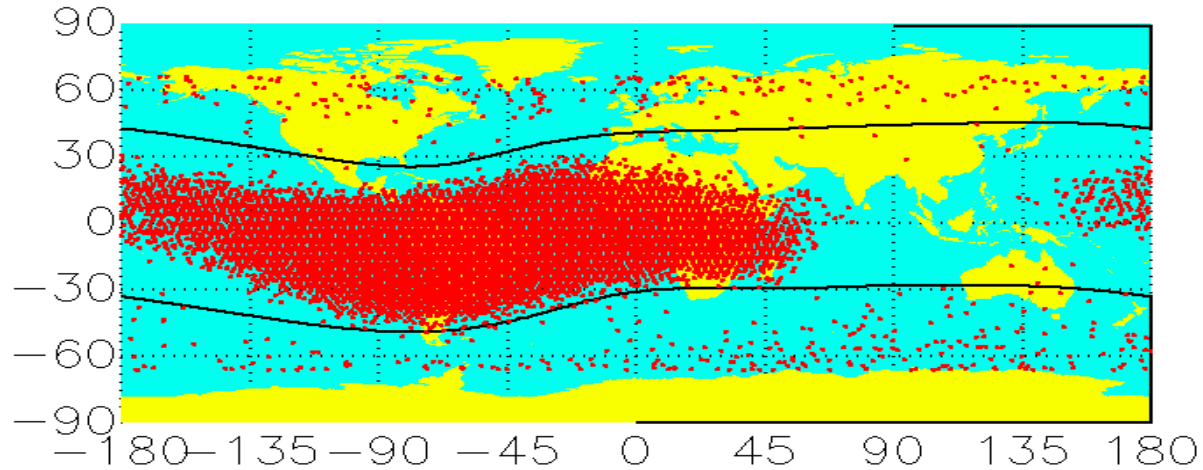
Total displacement damage (DDD) at 1336 km altitude (JASON-2, 1336 km, 63°)



Model / data	Deviation (ratio prediction / flight data)
AP8 min	0.84
AP9 V1.30.001 Mean	2.13
ICARE_NG	1.05

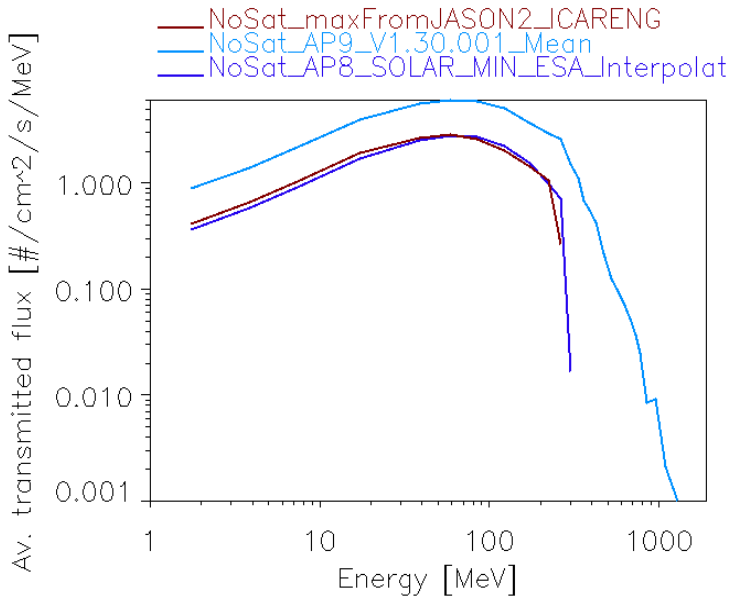
In flight data and comparison to proton model predictions

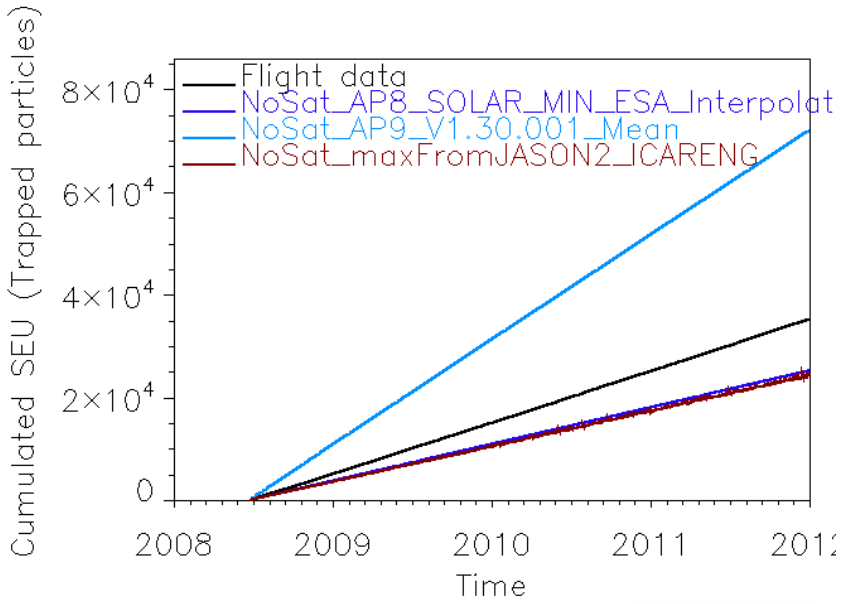
SEU rate from EDAC counter at 1336 km altitude (JASON-2, 1336 km, 63°)



L*<1.9 ⇒ 98.8%
L*>1.9 ⇒ 1.2%

10 SRAM (1MB SRAM M65608, 0.5µm CMOS process, developed by ATMEL)



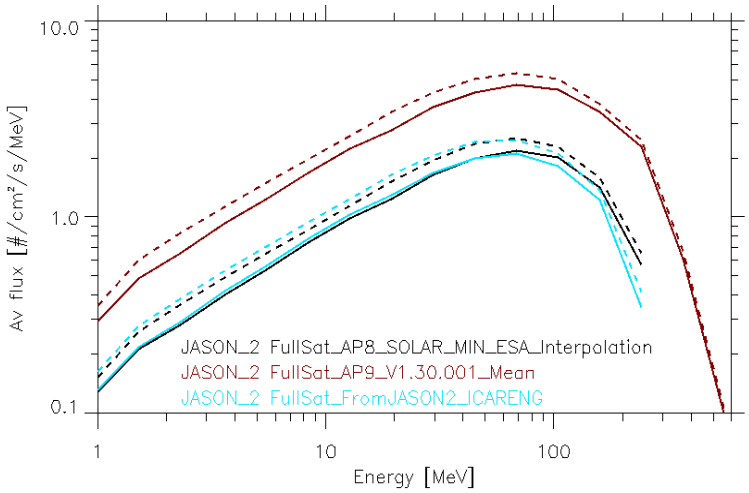


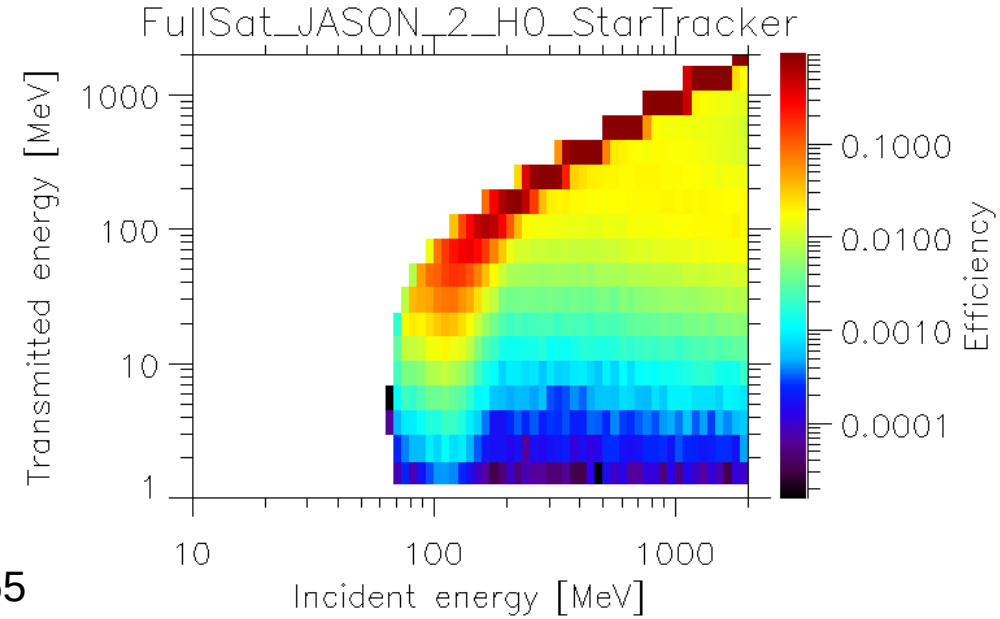
2.10

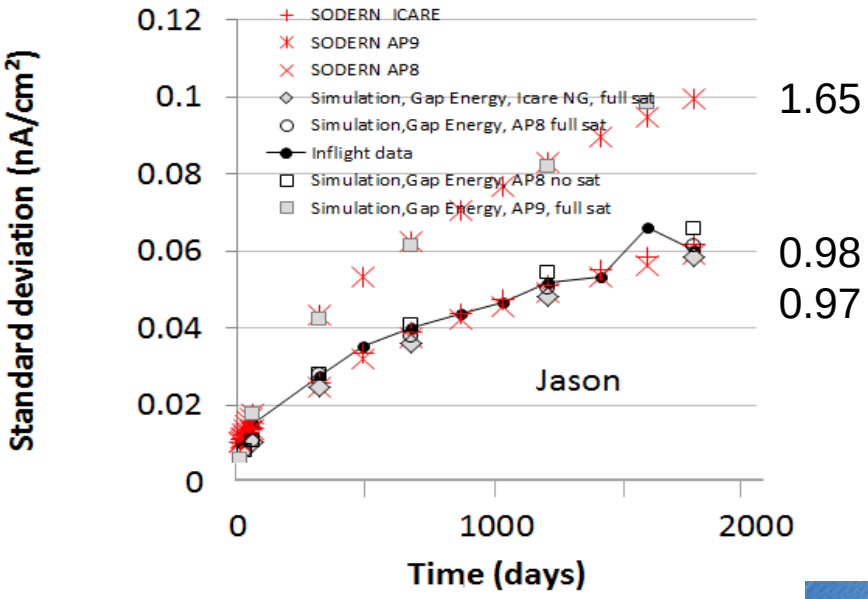
0.72
0.70

In flight data and comparison to proton model predictions

DCNU from Star Tracker at 1336 km altitude (JASON-2, 1336 km, 63°)

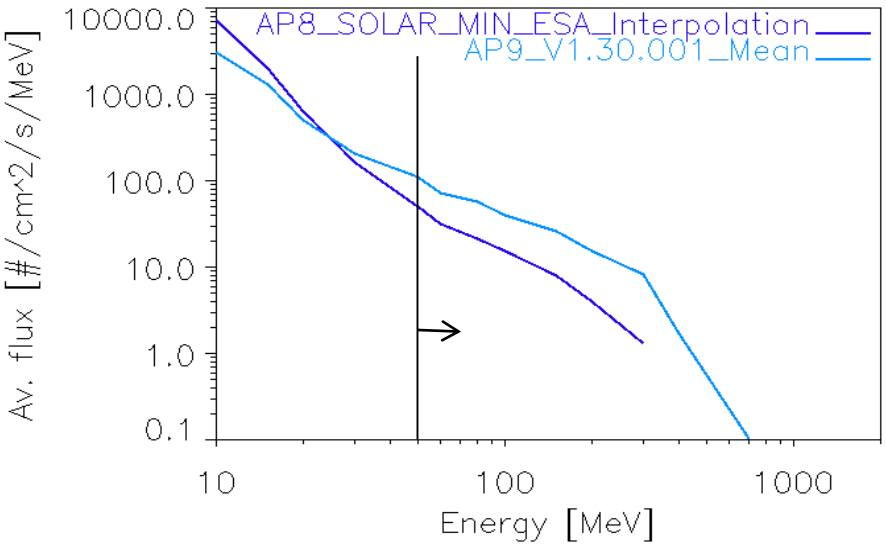


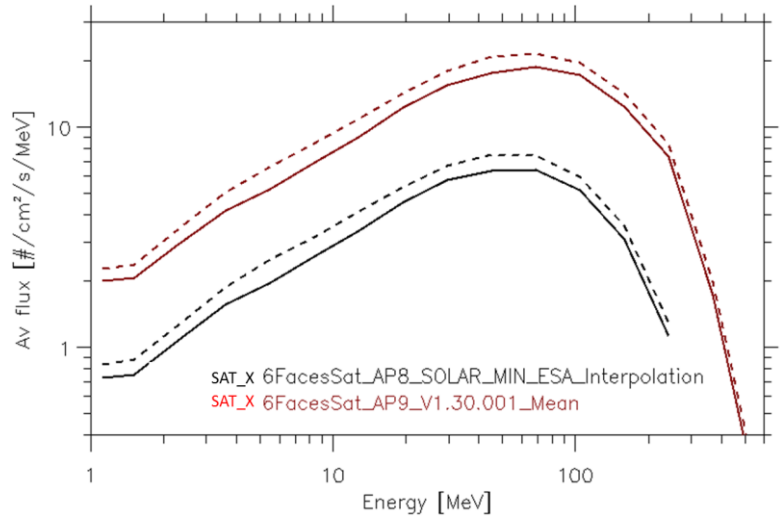


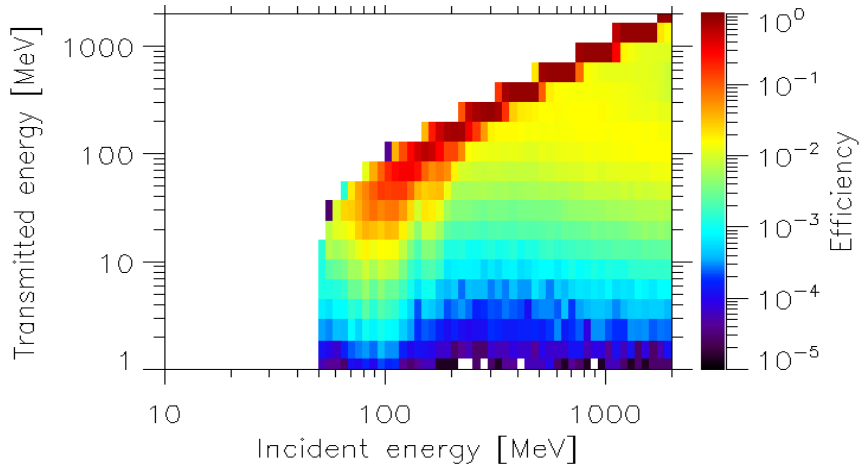


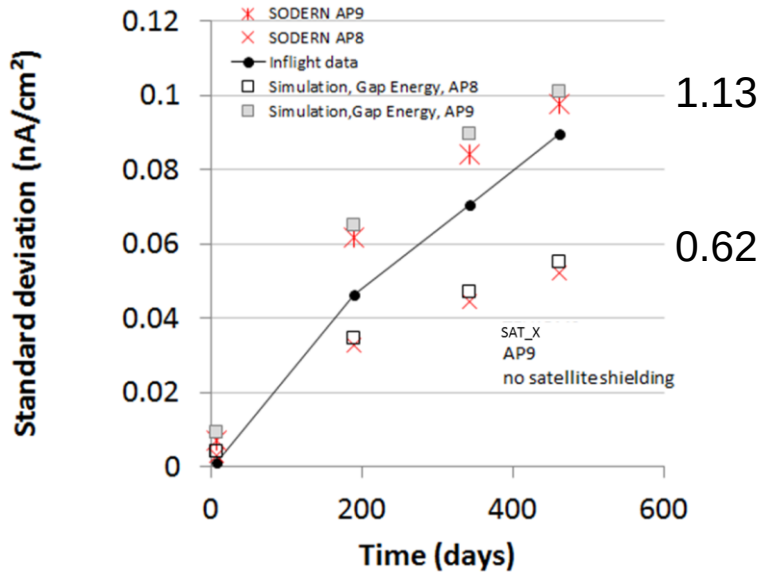
In flight data and comparison to proton model predictions

DCNU from Star Tracker at >1000 km altitude (Sat-X, 265-5000 km, 49°)

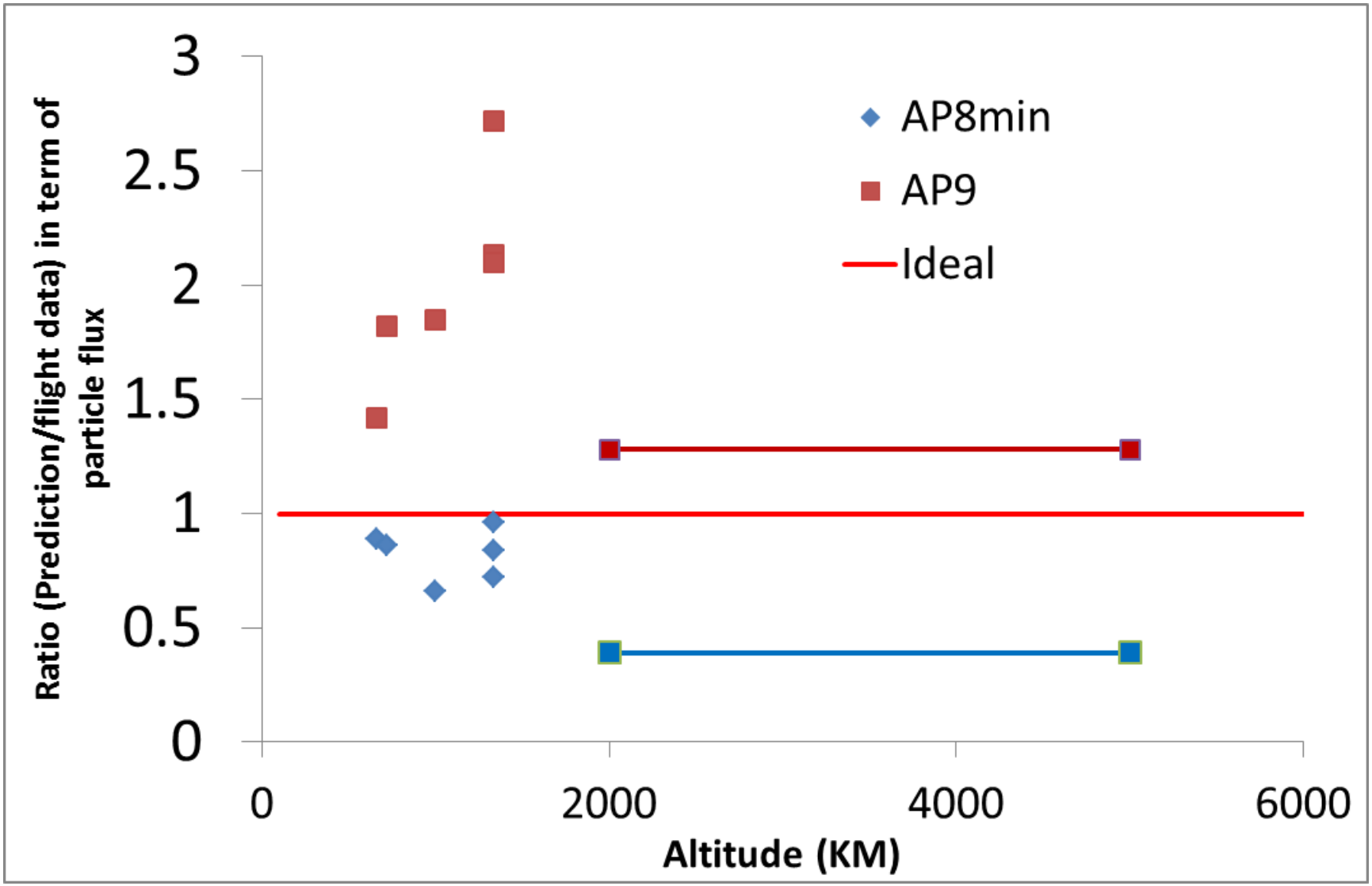






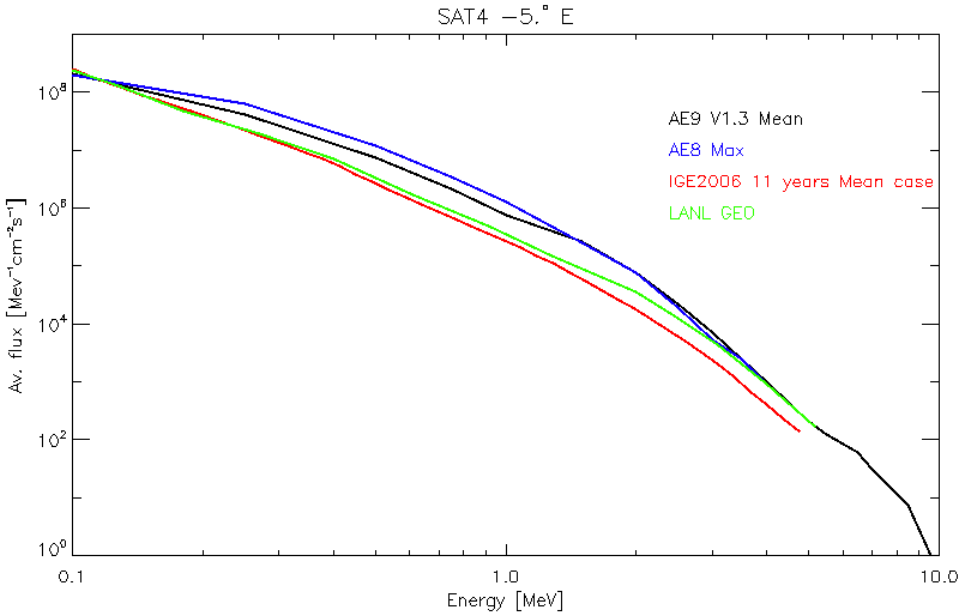


Synthesis (Trapped protons > 40 MeV)



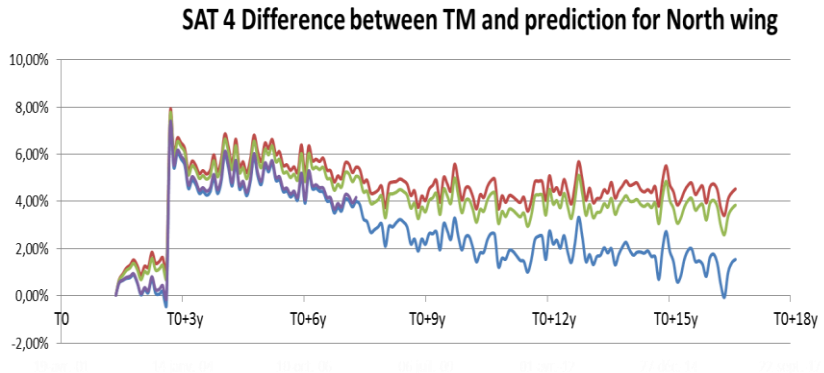
In flight data and comparison to electron model predictions

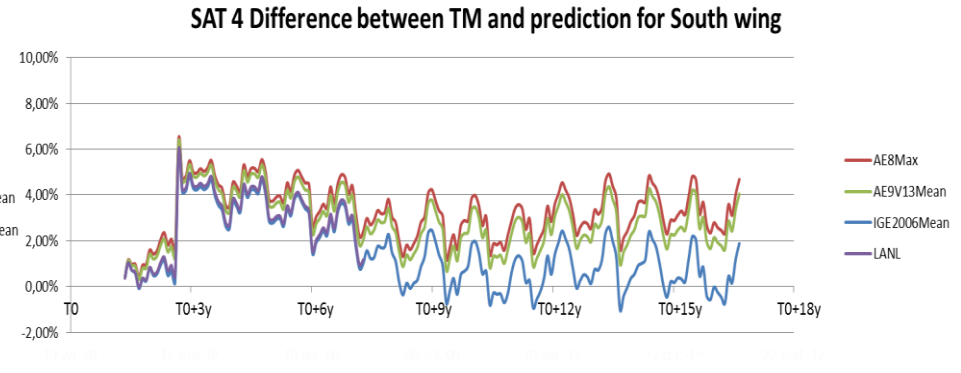
Solar array power loss at GEO



Solar protons deduced from GOES data available in IPODE (consistent results were found using SEPEM V2.0 data set).

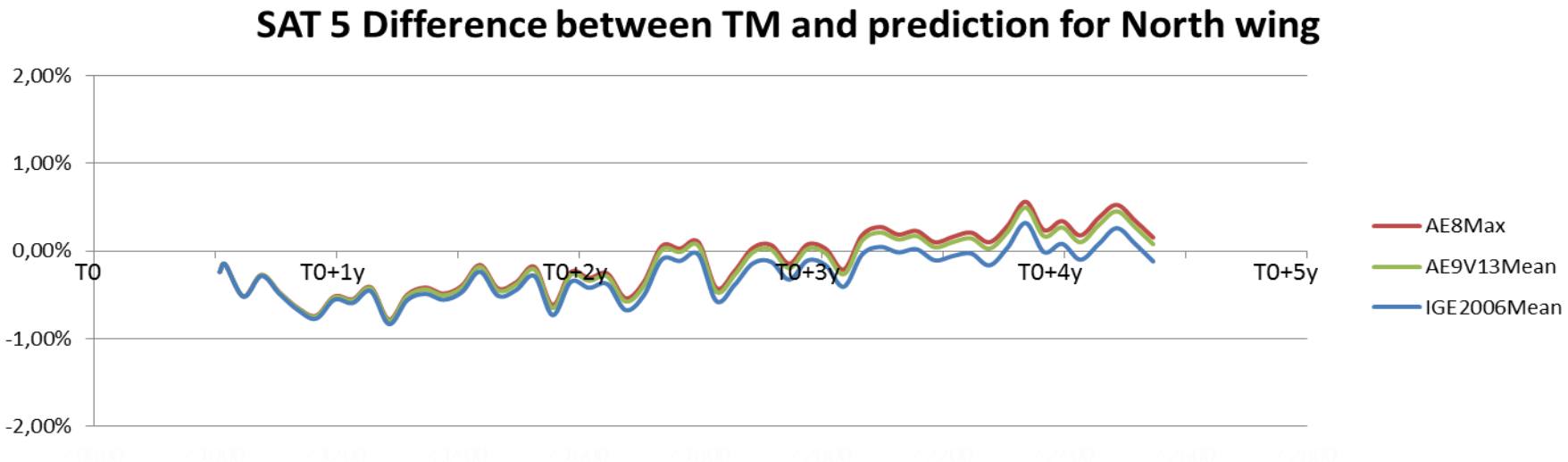
Solar cell: Si with 100 µm & 150 µm coverglass

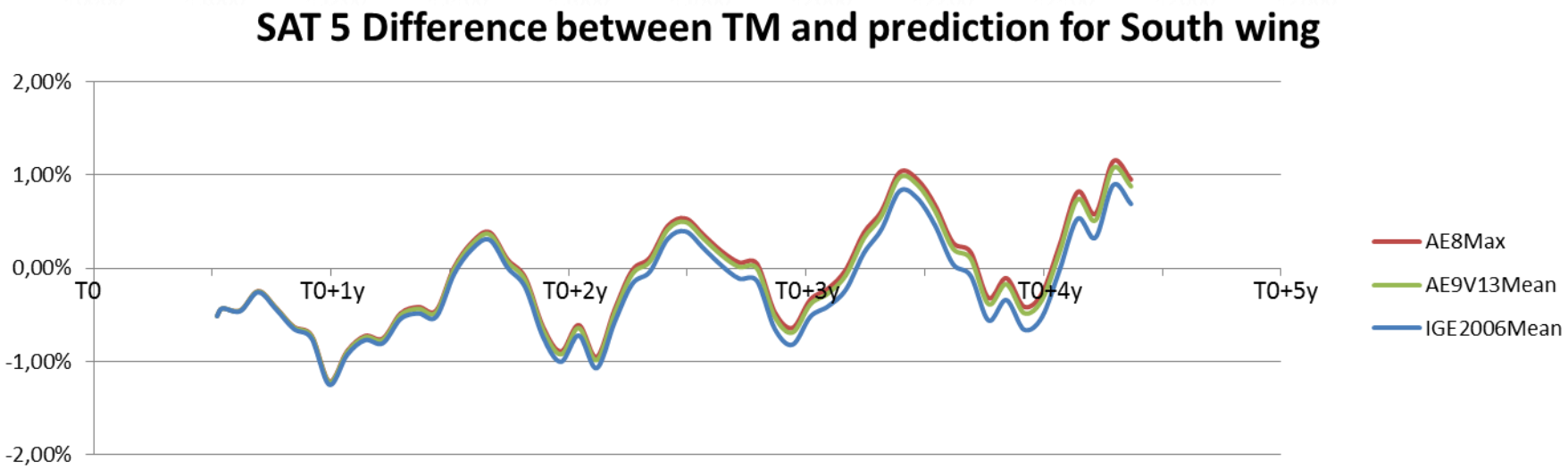




In flight data and comparison to electron model predictions

Solar cell: GaAs with 100 µm coverglass





Conclusions

1. Cumulative effects (TNID, Cumulative SEU from EDAC and DCNU) have been used to investigate uncertainties in trapped proton models

2. Investigating different types of radiation effect makes it possible to avoid any biais

3. AP8 allows for closer predictions than AP9 1.30.001 Mean (and Perturbed) except in the 2000-5000km altitude range

4. Solar arrays power loss has been used to investigate uncertainties in trapped electron models

5. Predictions from IGE2006 (+1.6%) are closer to observations than those from AE8/AE9 (+2.2%)