CAN THE TERRESTRIAL MAGNETOSPHERE MITIGATE RADIATION HAZARD ON MOON MISSIONS?

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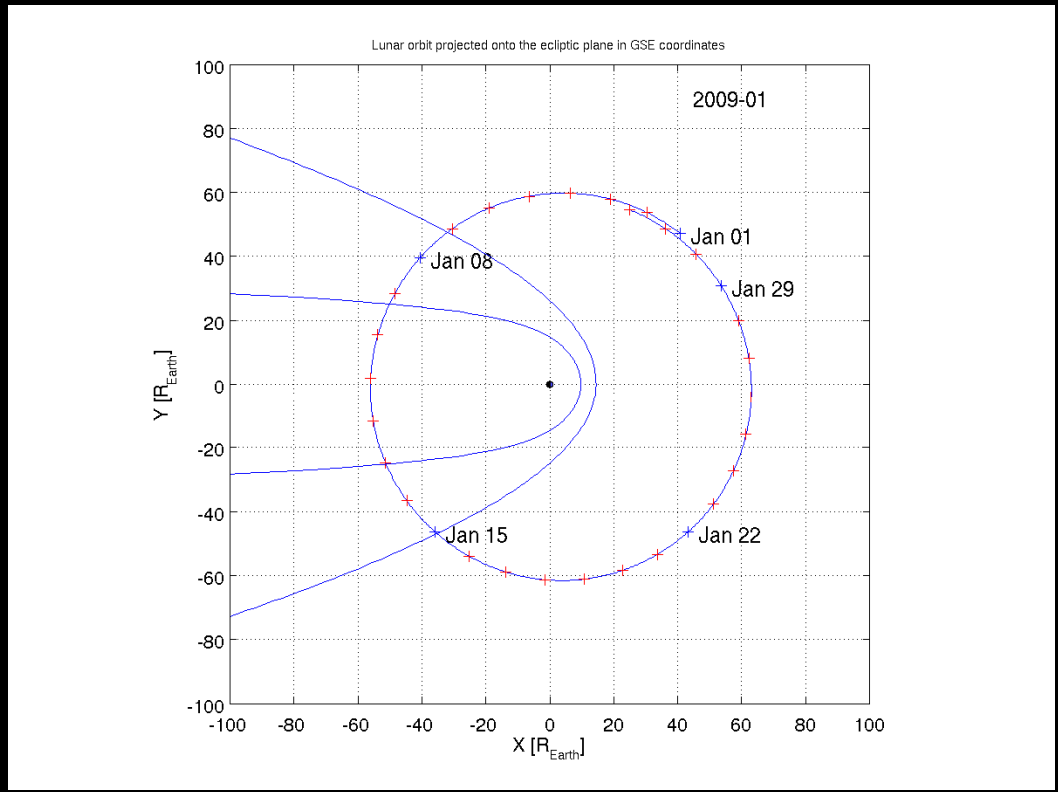
MOTIVATION

- One potential method of radiation mitigation on extra-terrestrial missions is in the form of magnetic fields
- For Moon missions the Earth magnetosphere is a source of magnetic field, as the Moon spends about 25% of its orbit inside it



Moon orbit plots in GSE are provided by the Swedish Institute of Space Physics, Kiruna

Recent modelling [*Winglee, R. M., and E. M. Harnett, GRL 2007*], suggested that the terrestrial magnetotail magnetic field can provide a significant level of shielding, the latter depending on IMF orientation and position on lunar surface.

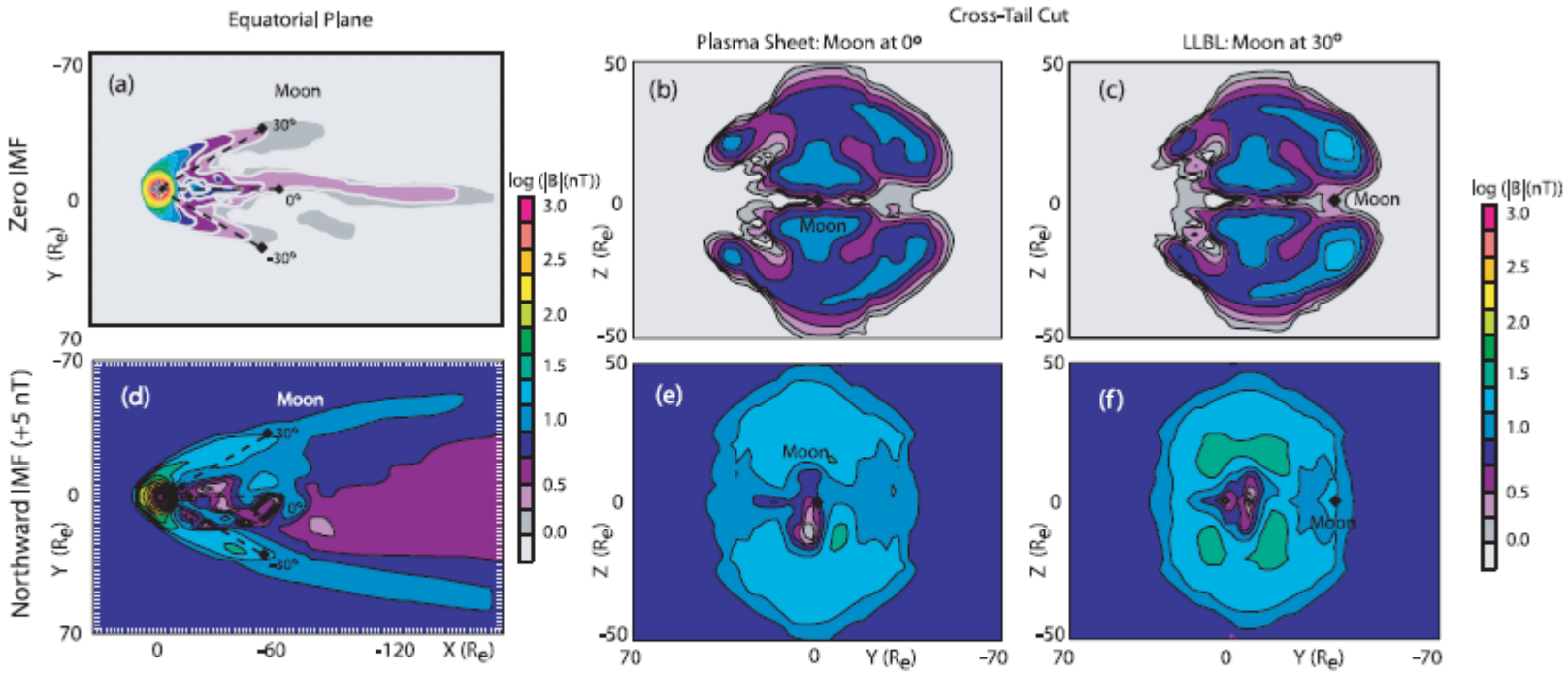


Figure 1. (a, d) The magnetic field strength within the Earth's magnetosphere along the equatorial plane and (b, c, e, f) across the tail at the Moon's orbital distance for two different IMF cases. The cross tail cuts are at the position of the Moon. For Case 1, where the Moon is in the plasmasheet, this is equal to a distance of 60 R_E downtail. For Case 2, where the Moon is in the LLBL, this corresponds to a distance of 52 R_E downtail. The radiation shielding is calculated in detail when the Moon is in the plasma sheet (Figures 1b and 1e) and the LLBL (Figures 1c and 1f).

- ✓ *"Initial calculations indicate that the quiet magnetosphere may offer some level of protections for astronauts from solar energetic particles and galactic cosmic rays, particularly for a lunar base at the Earth-facing equator.*
- ✓ *The level of the shielding and the area over which shielding occurs increases with the magnitude of the magnetic field within the solar wind.*
- ✓ *In the worse case scenario when the IMF ~ 0, the flux of GeV/nucleon particle would be reduced over most of the sky, thereby providing of shielding of SEPs, and partial GCR shielding.*
- ✓ *In the best case scenario when there is northward IMF, reduction in the flux of particles up to 5 GeV/nucleon across the entire sky is possible. In this case the terrestrial magnetosphere would provide effectively shielding for both SEPs and GCRs."*

Using RADOM data

from Chandrayaan-1 satellite

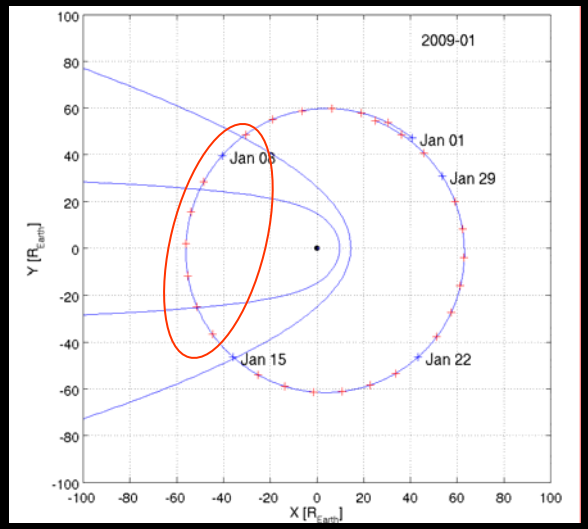
we try to check this hypothesis.

More precisely:

Does the magnetotail offer some protection in Moon orbit?

Here we present some very first result

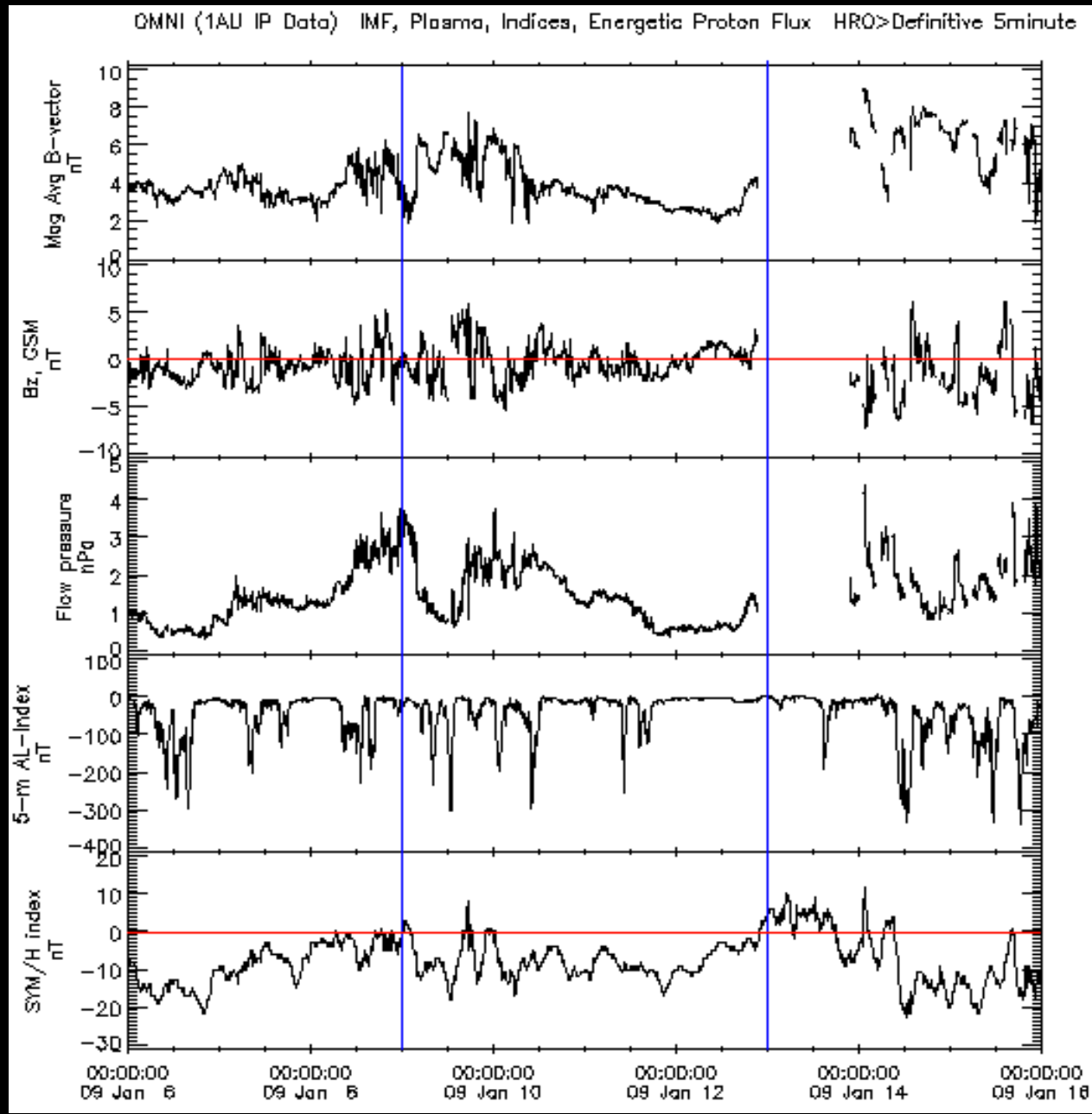
Magnetotail crossing in January 2009

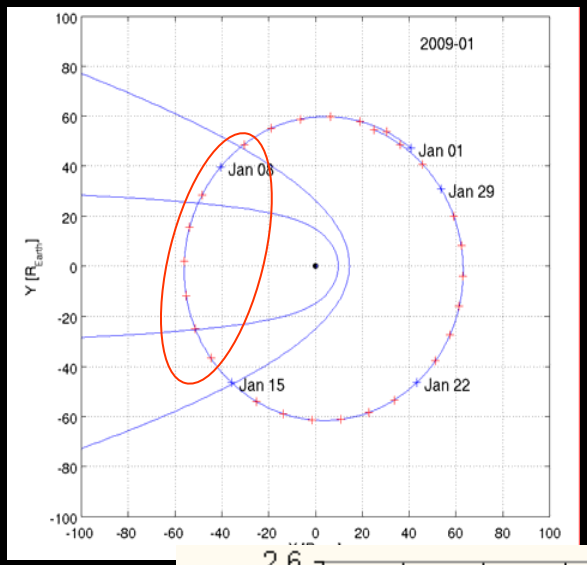


Geomagnetic conditions:

quiet.

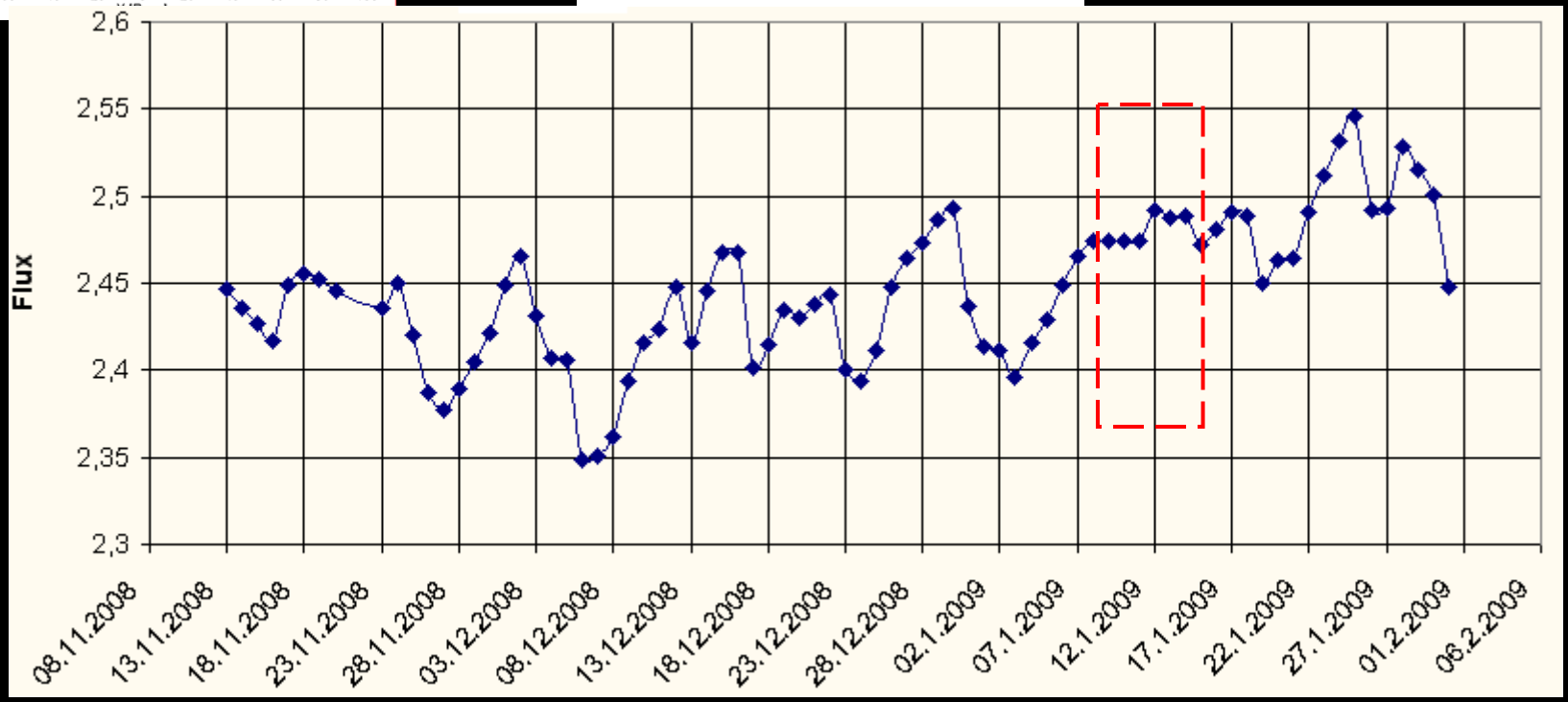
In the second half of 9 Jan IMF Bz ~ 5 nT





Magnetotail crossing in January 2009

RADOM average/day flux



No effect of the magnetotail on radiation in Moon orbiter!

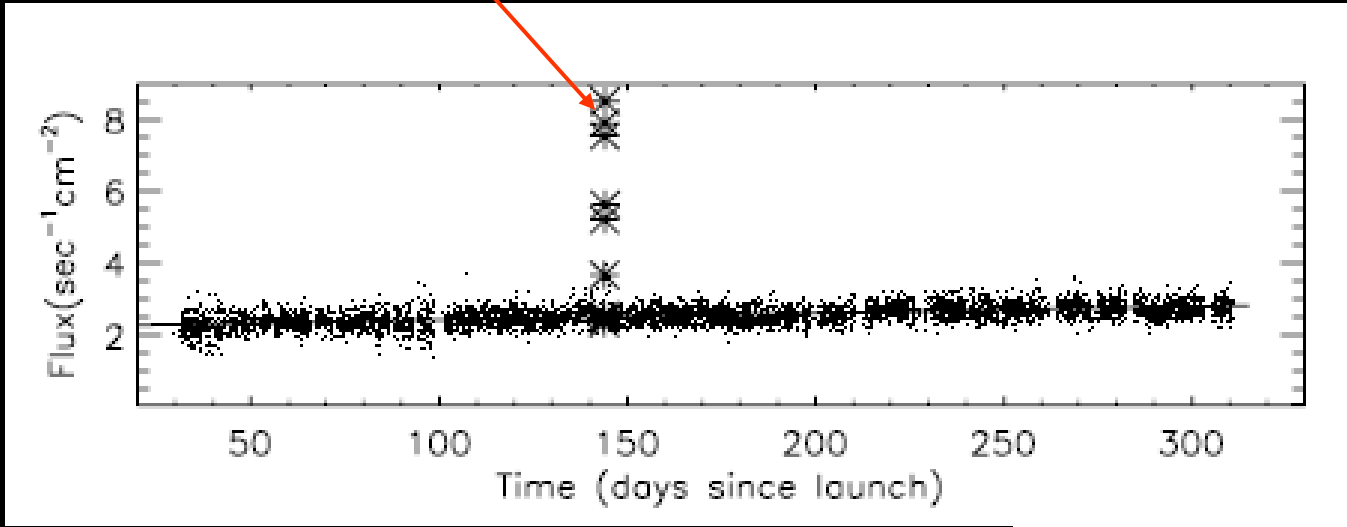
In Solar cycle minimum conditions, when there are no SPE and GCR flux is enhanced, Earth magnetosphere does not seem to provide any shielding *on Moon orbiter*.

The problem of Earth magnetosphere effect on Moon radiation environment needs more detailed investigation, because....

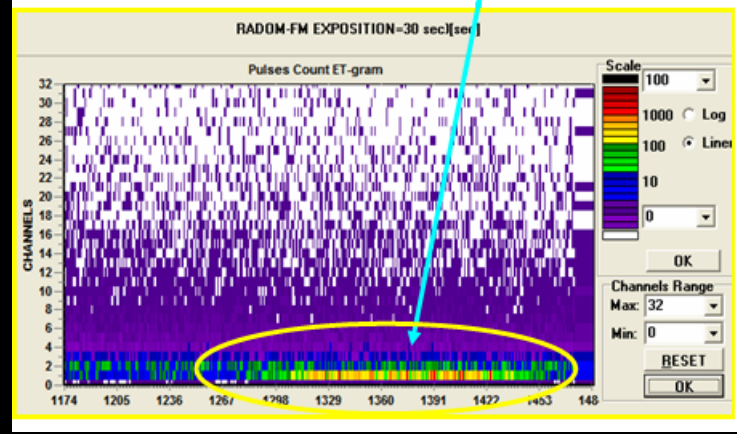
there is some suspicion that the magnetosphere can make things worse

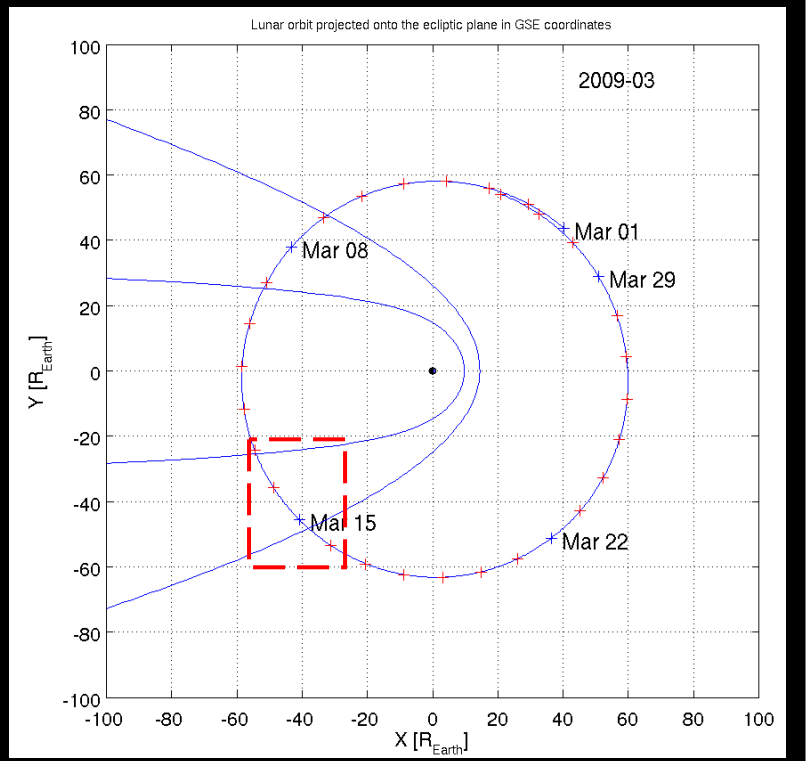
There was one interesting event in RADOM records

During the whole mission the particle flux was ~ 2.45 p/cm^2.s except on March 15 -16 2009



Only the first RADOM channel is enhanced, which means very low energy deposition

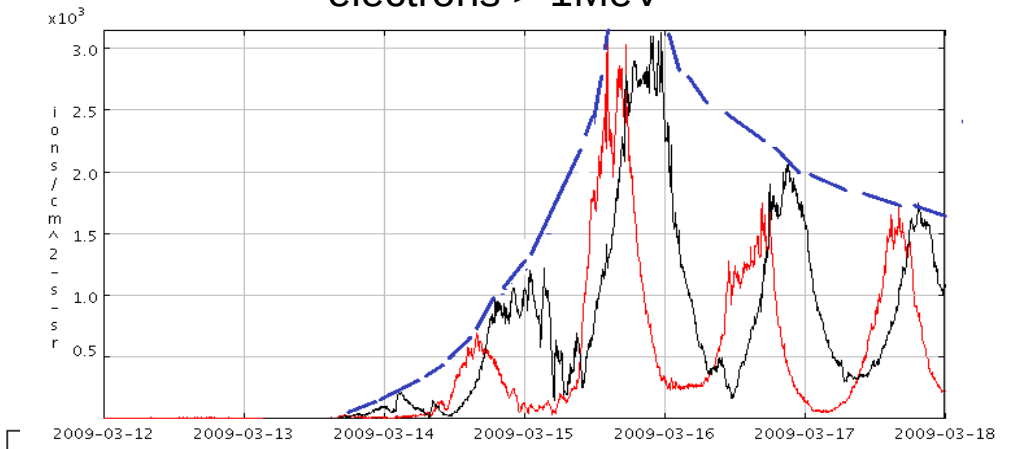


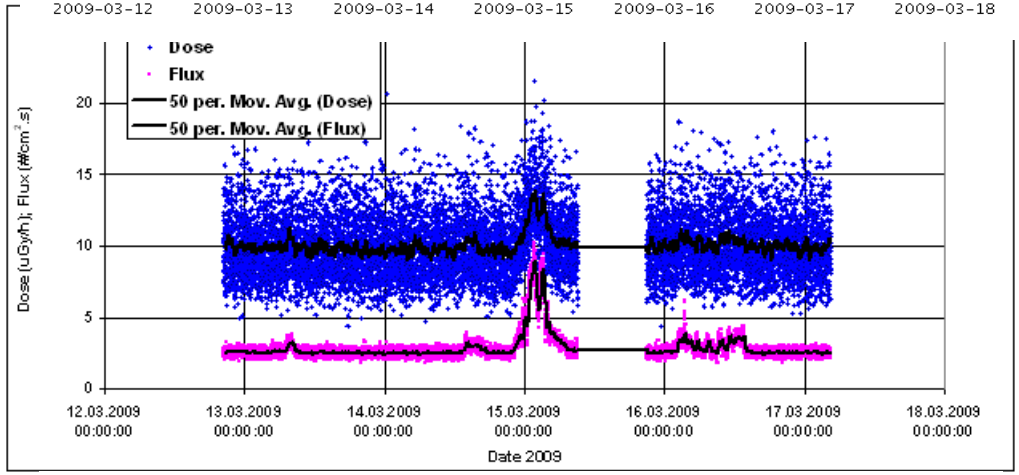


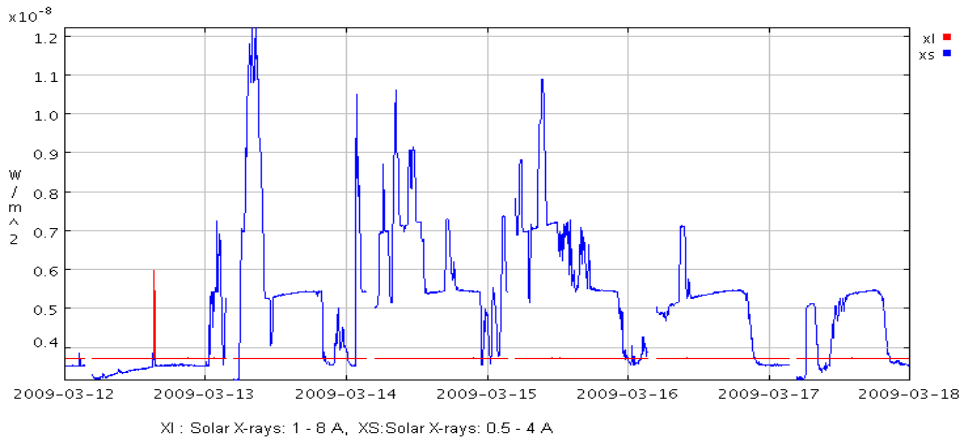
No SPE, no flares identified

GOES satellites showed increase only in electrons >1Mev flux and probably a minor enhancement in X-ray

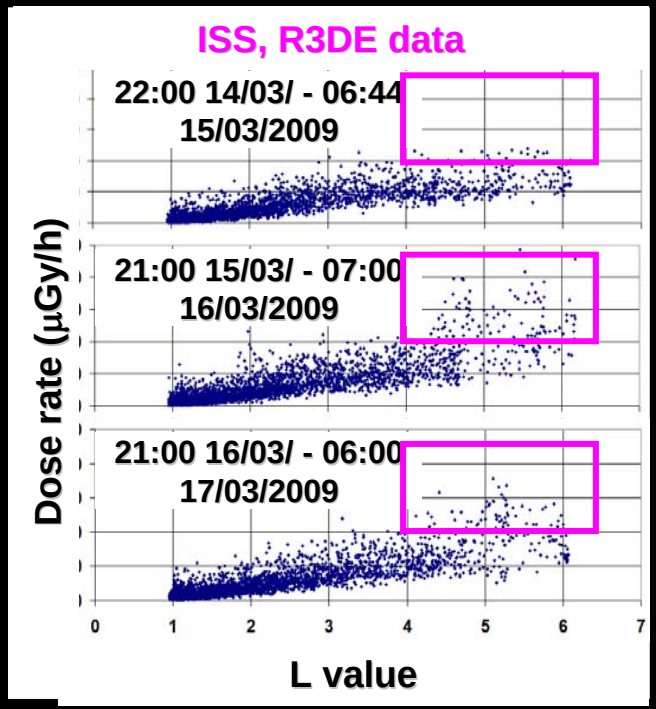
electrons > 1MeV

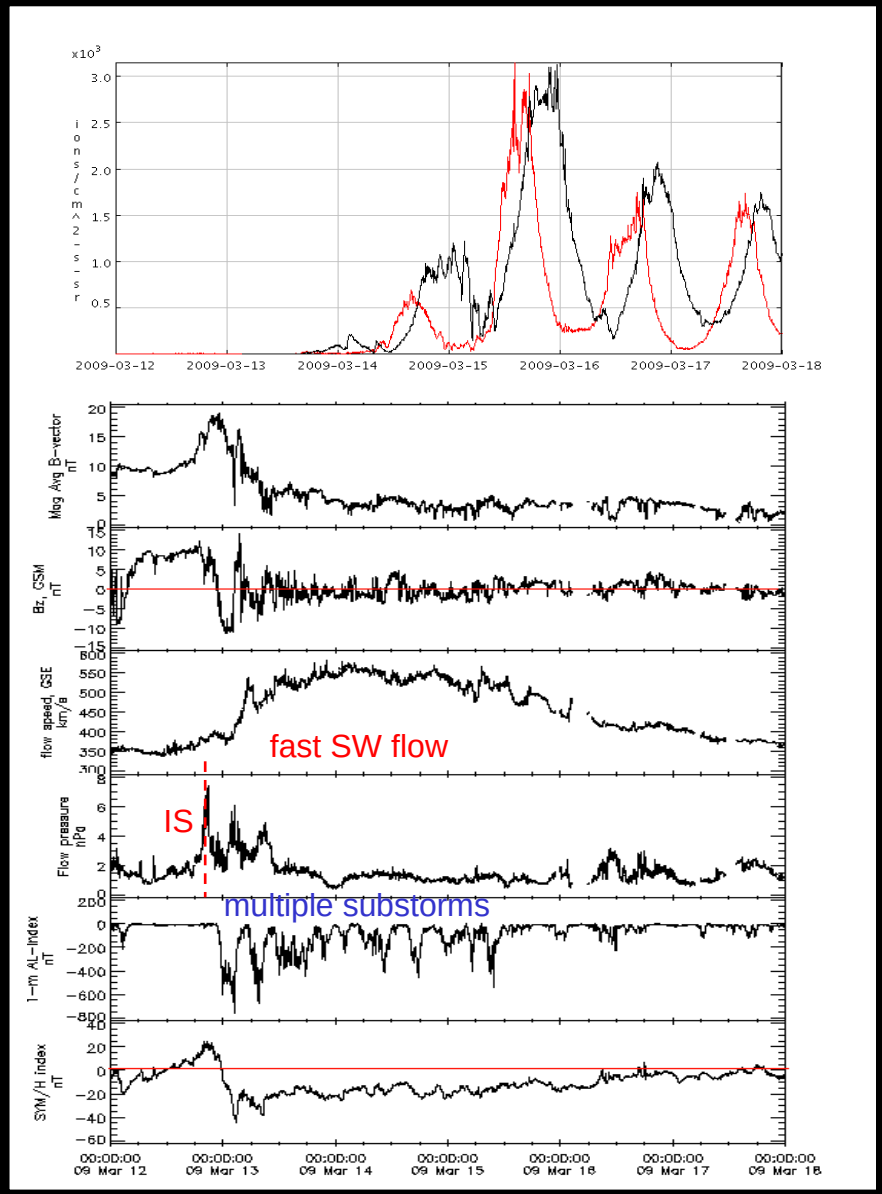






Are these elctrons from the SUN?

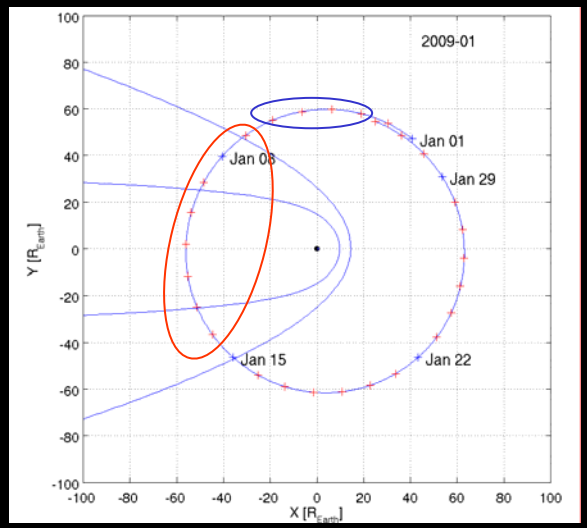




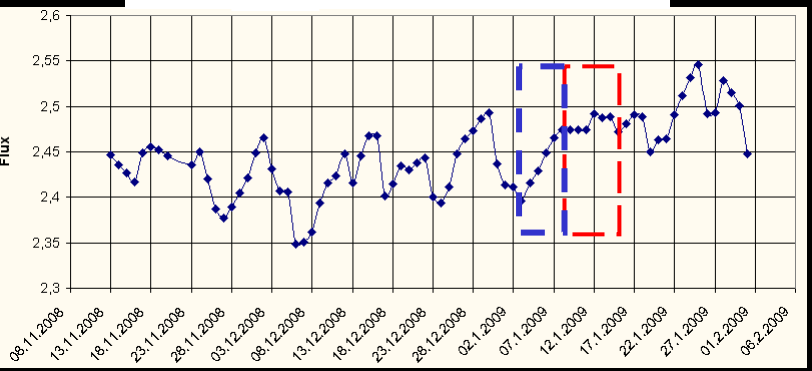
On 13 March the magnetosphere was hit by an IS caused by fast solar wind. For several days MS was under continuous driving – conditions favorable for e⁻ acceleration in the inner MS

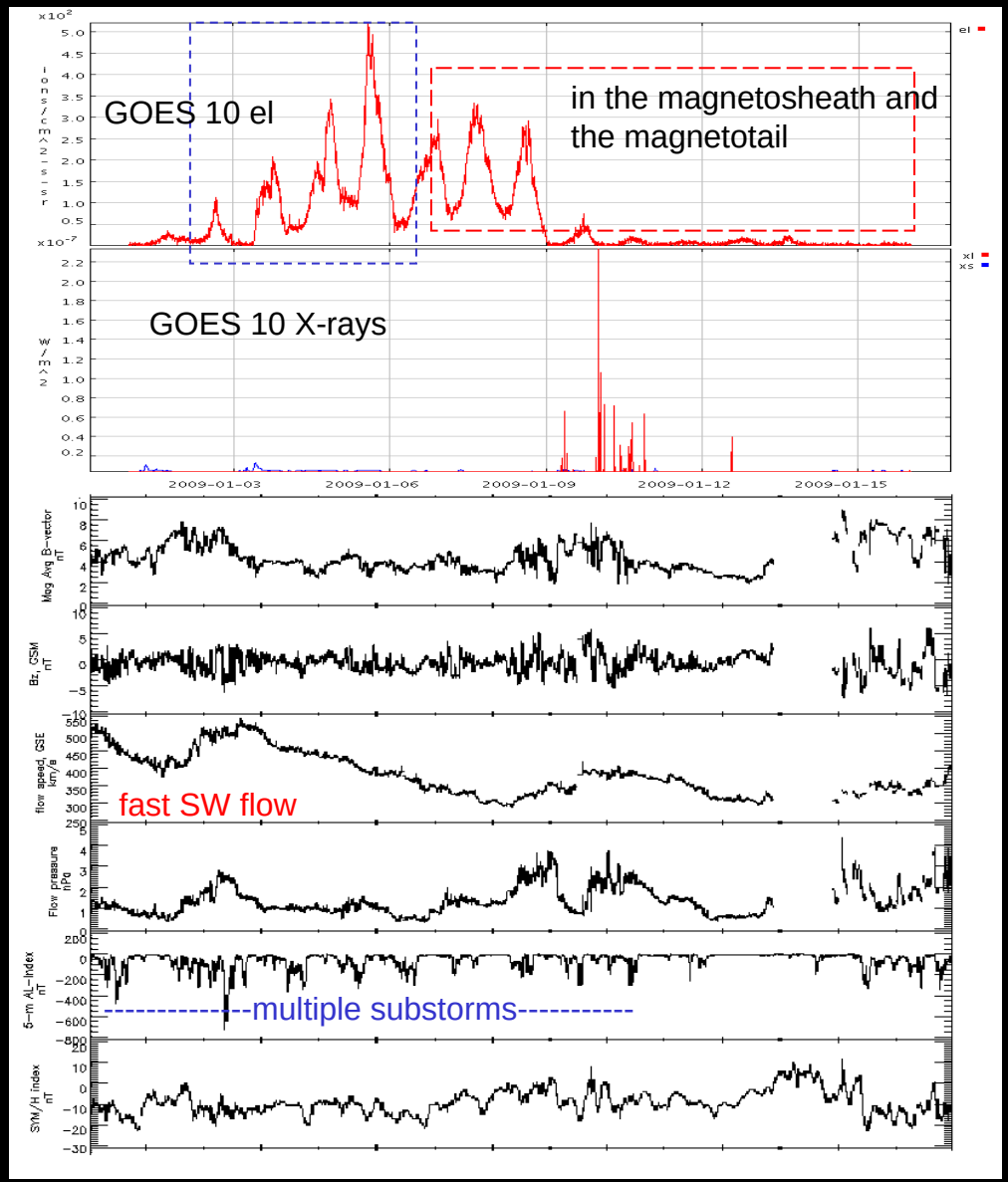
RADOM is in the magnetosheath and registers possibly e⁻ from the MS

Similar event was observed by GOES in January, but not by RADOM

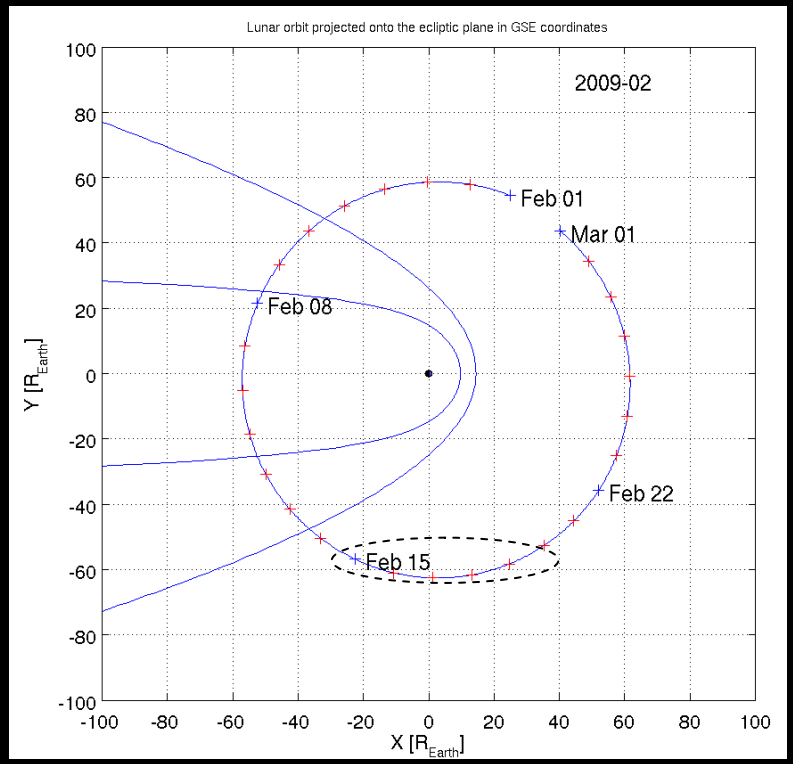


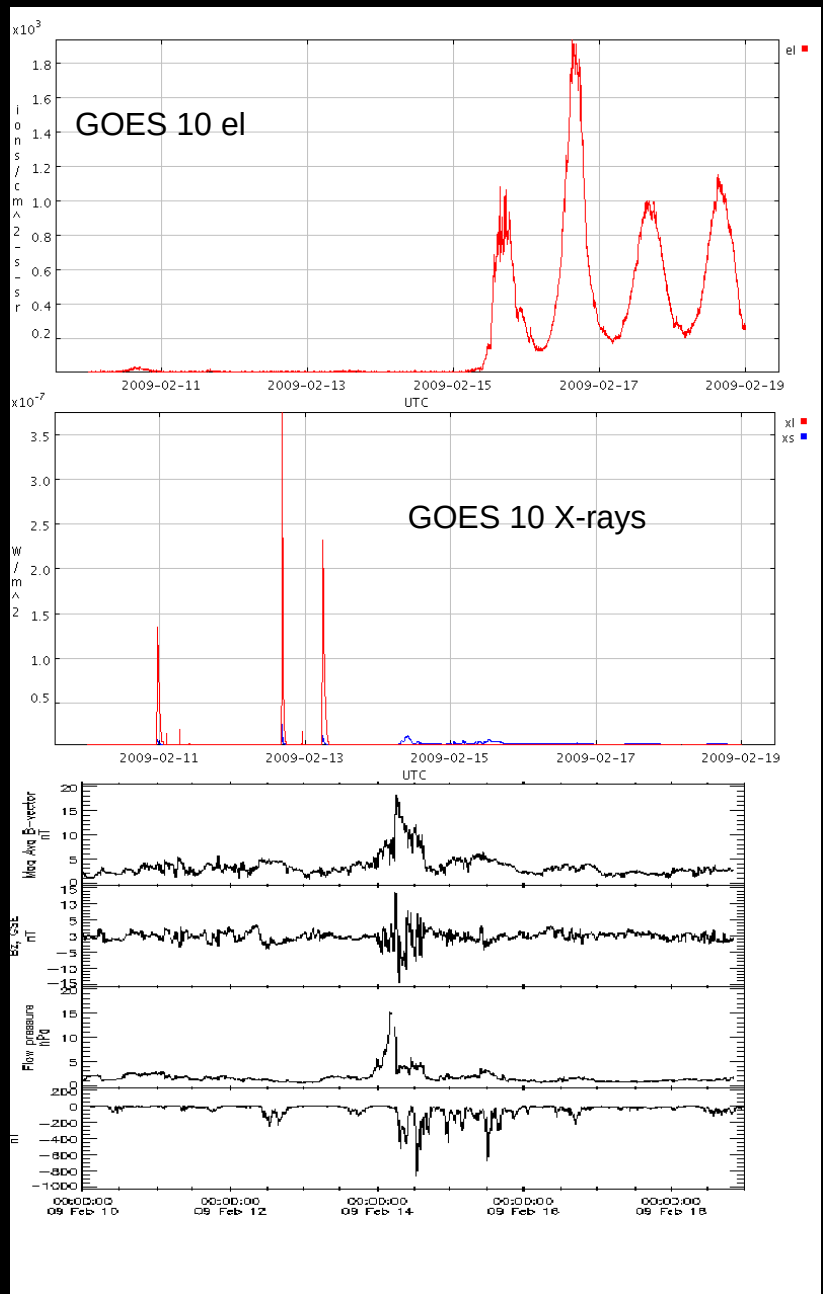
RADOM average/day flux





Similar event in February





CONCLUSION

In Solar cycle minimum conditions, when there are no SPE and GCR flux is enhanced, we could not find any indication that Earth magnetosphere can provide additional shielding *on Moon orbiter*

There are some hints that magnetospheric disturbances could affect the radiation environment on Moon orbiter, but more detailed research should be done

Thank you for your attention!