On the possibility to use semi-conductive hybrid pixel detectors for study of the radiation belt

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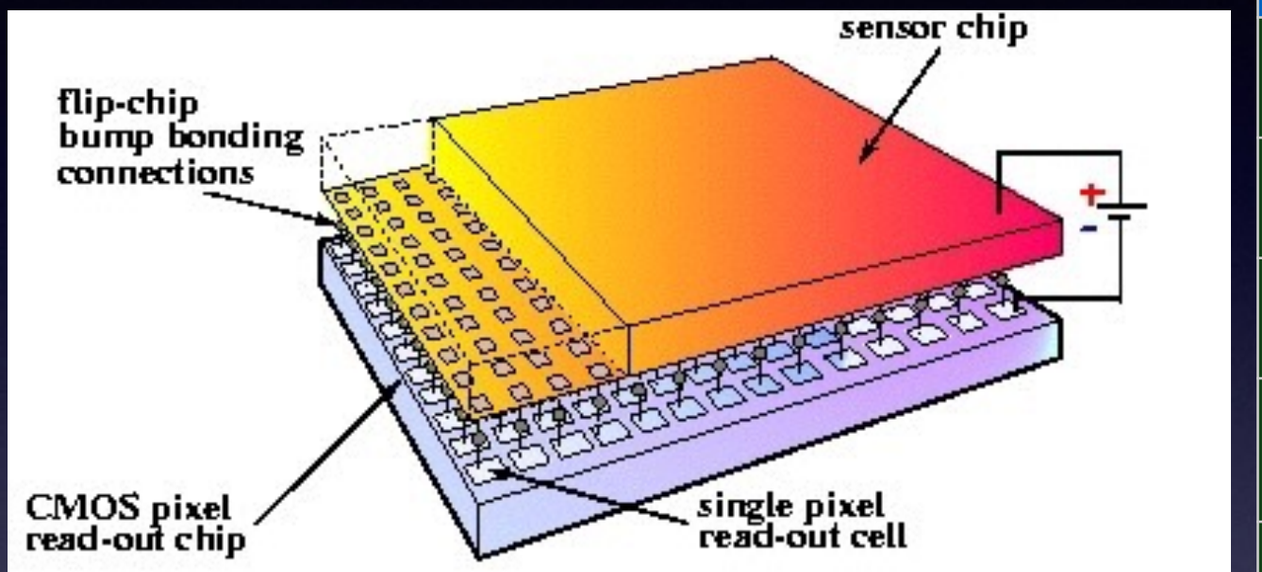
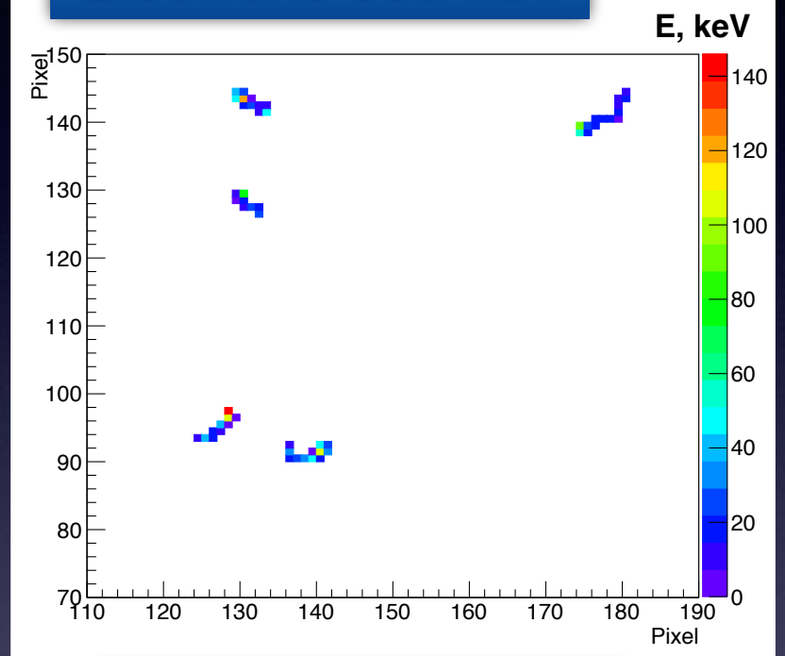
Semiconductive hybrid pixel detectors based on Timepix chip



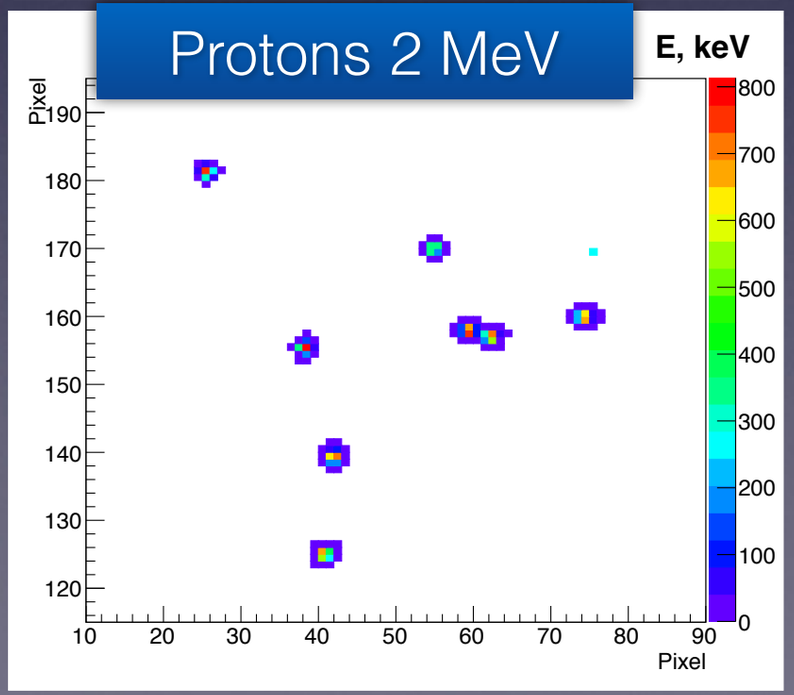
Parameter	Value
Mass, g	200
Dimensions, cm	15x5x3
Power consumption, W	2.5
Radiation hardness, MGy	4.6(chip), 0.1-0.5 (Si), 1.5 (GaAs)
Electric field strength, V/μm	0.5-1.0
Minimal frame length, ms	0.01
Amount of data, kb/frame (10% occ.)	20
Maximal frame rate, Hz	100
Sensitivity range, keV	>6(γ), >30(e), >500(p)
Working area, cm^2	2
Interface	USB

Typical frames

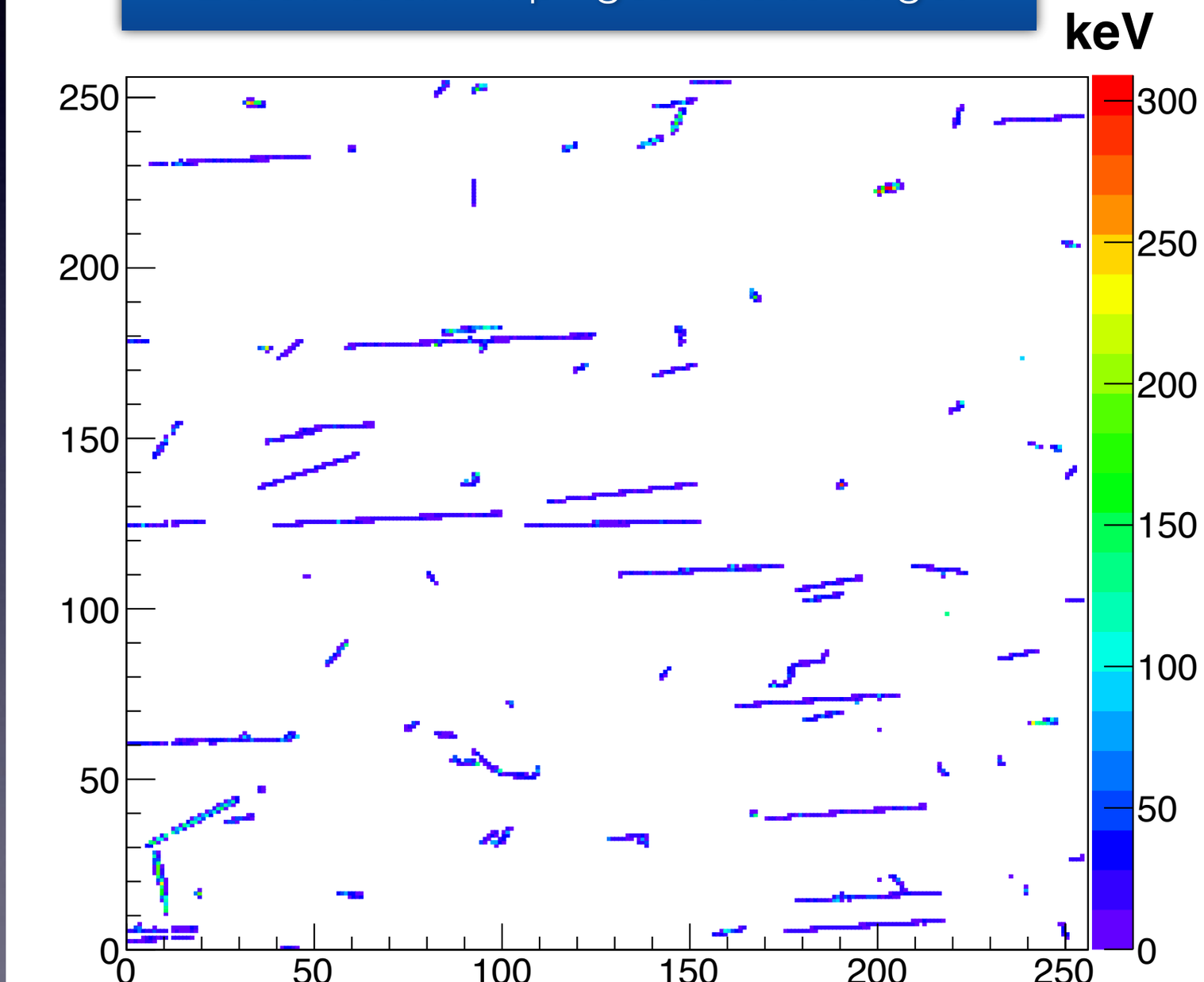
Electrons 350 keV



Protons 2 MeV



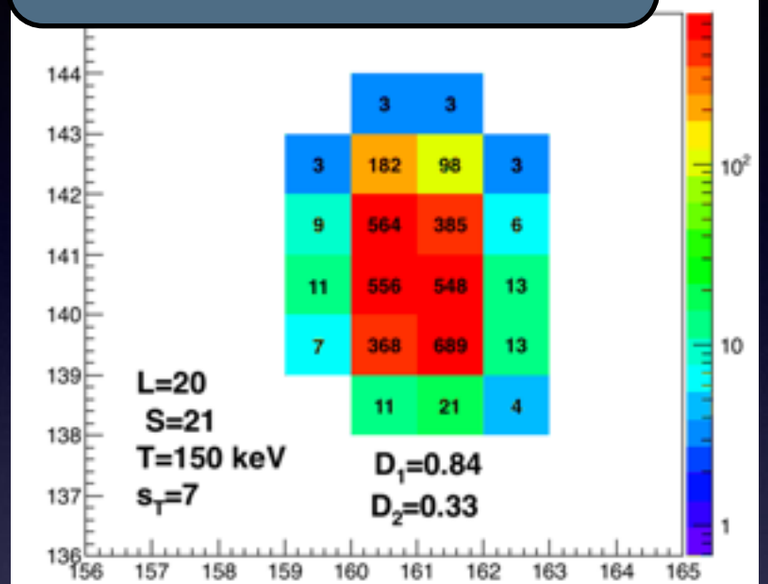
2 GeV beam impinged a lead target



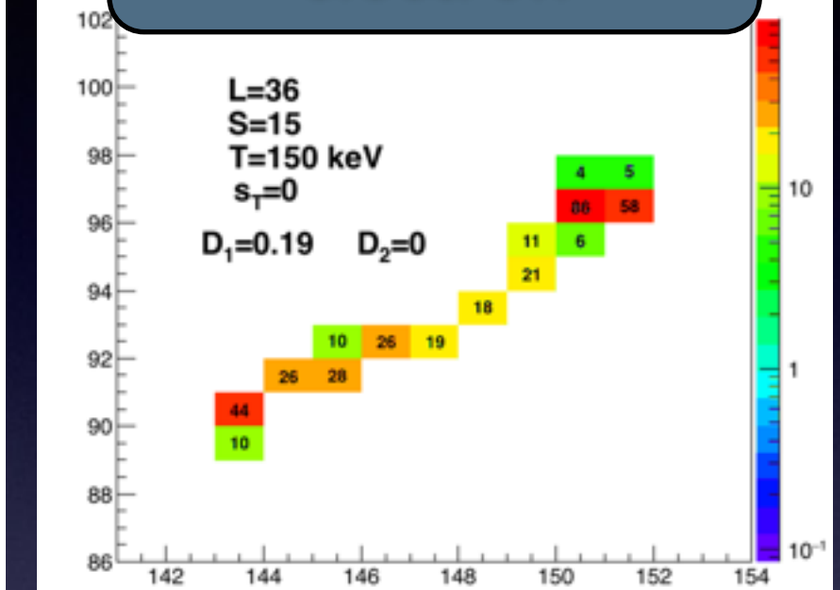
Cluster zoo

Si, 0.3 mm

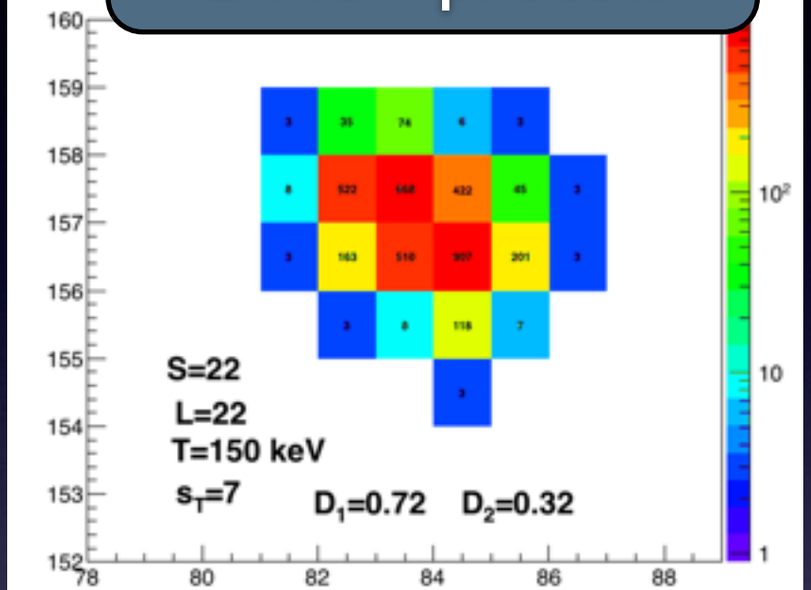
14 MeV neutron



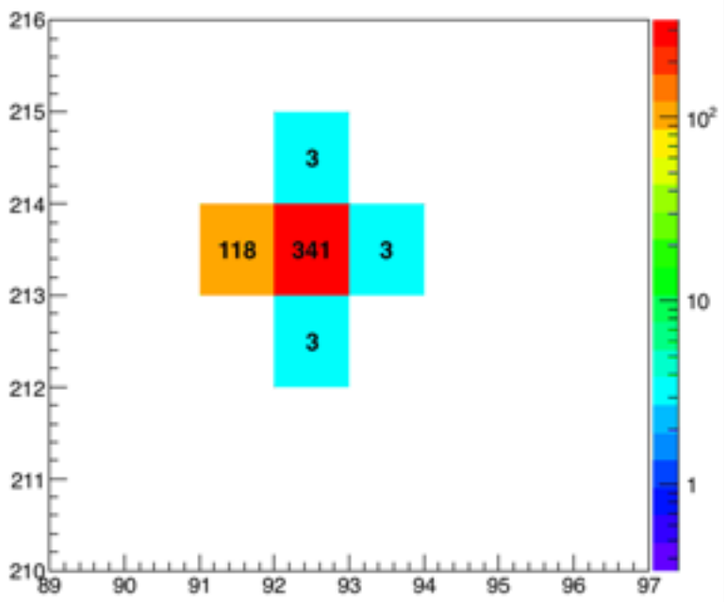
electron



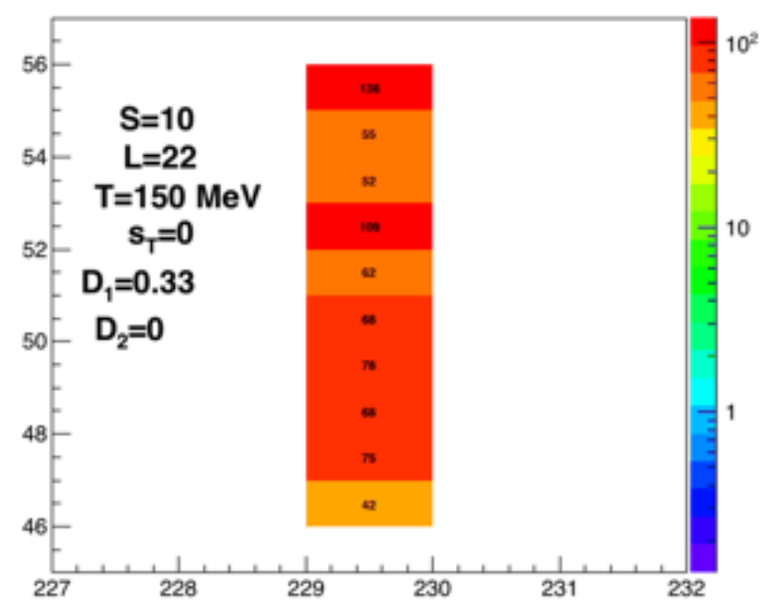
2 MeV proton



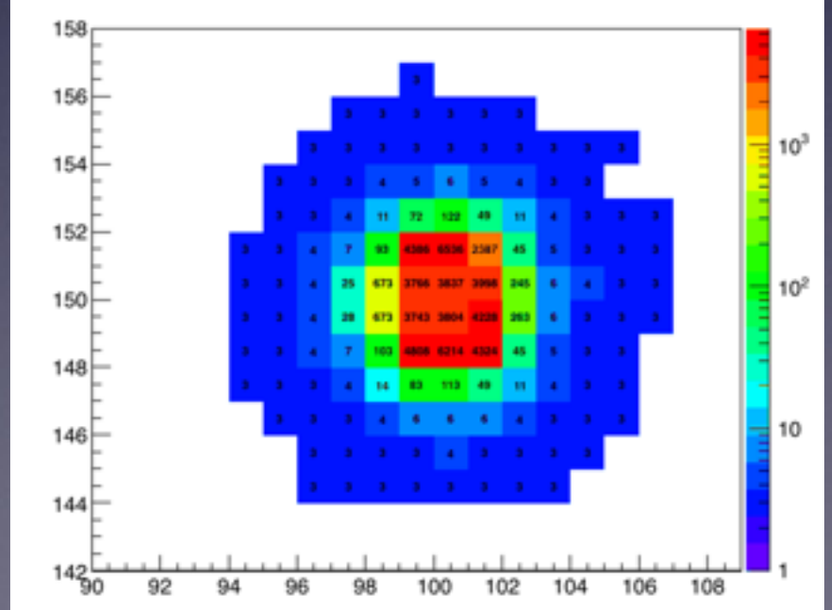
150 MeV proton 0°



150 MeV proton 60°

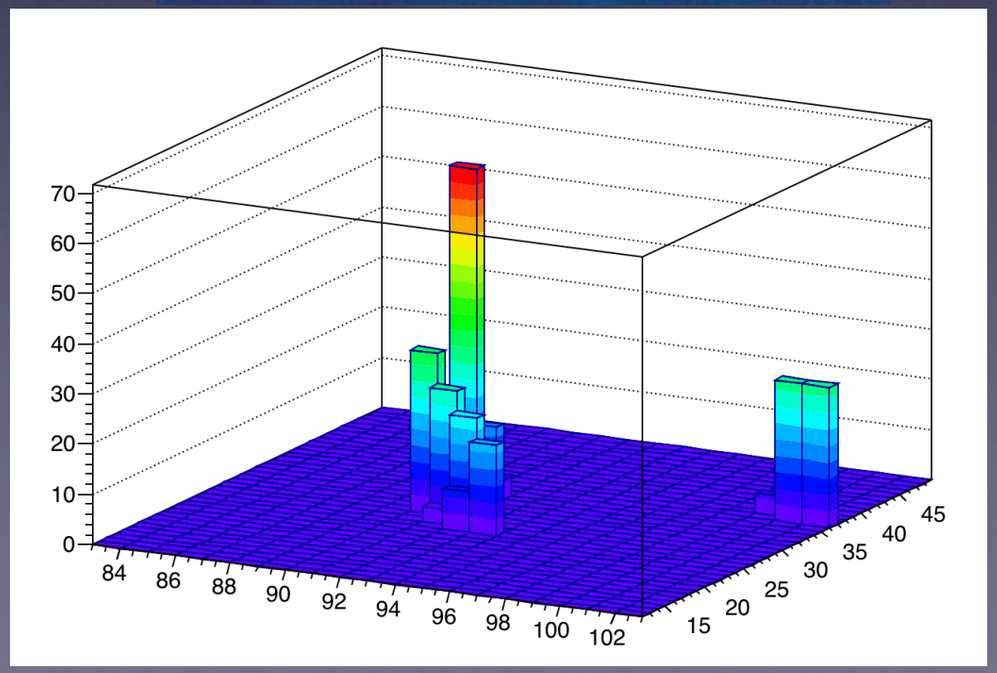


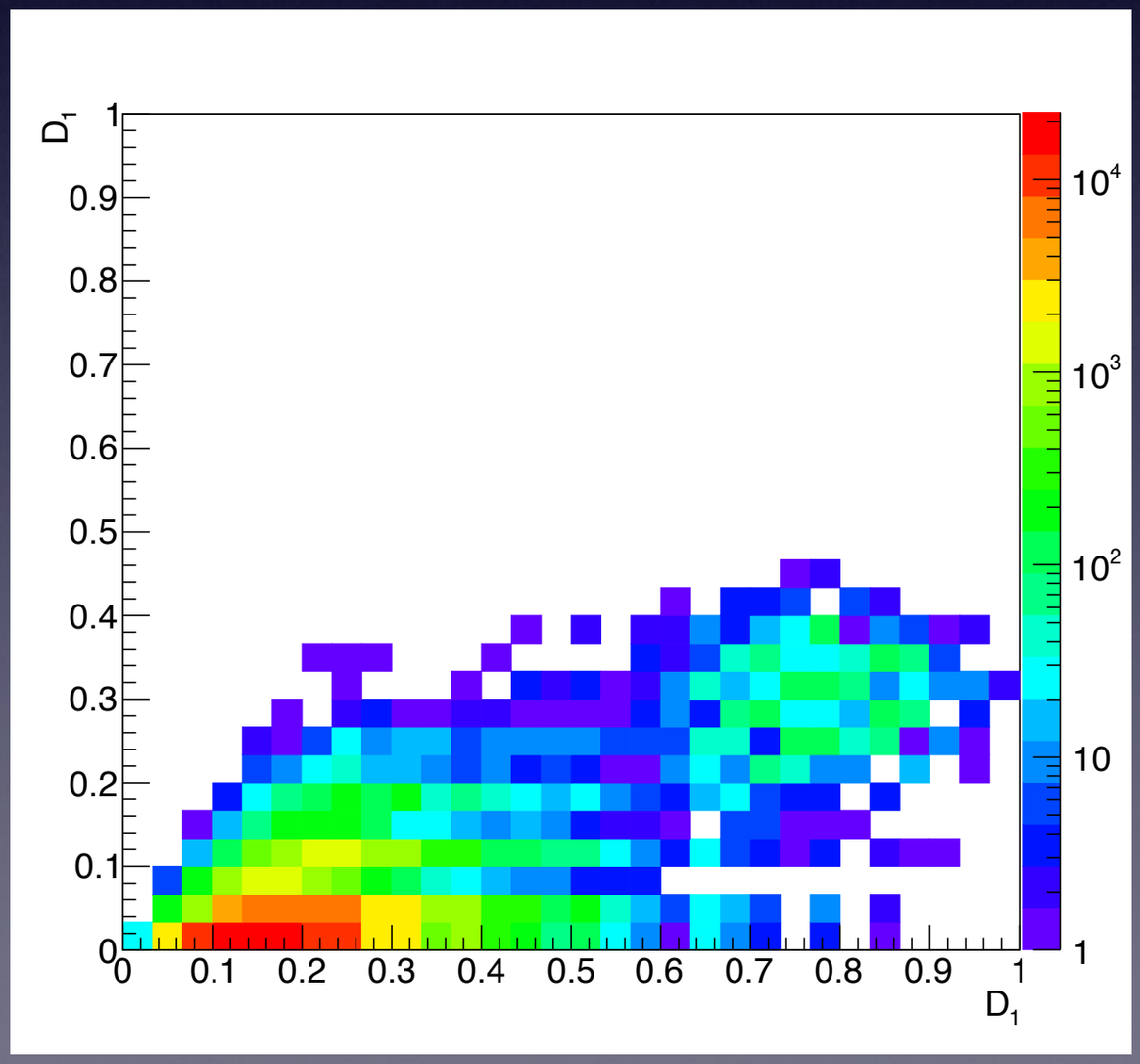
^{22}Ne 3.5 MeV/N



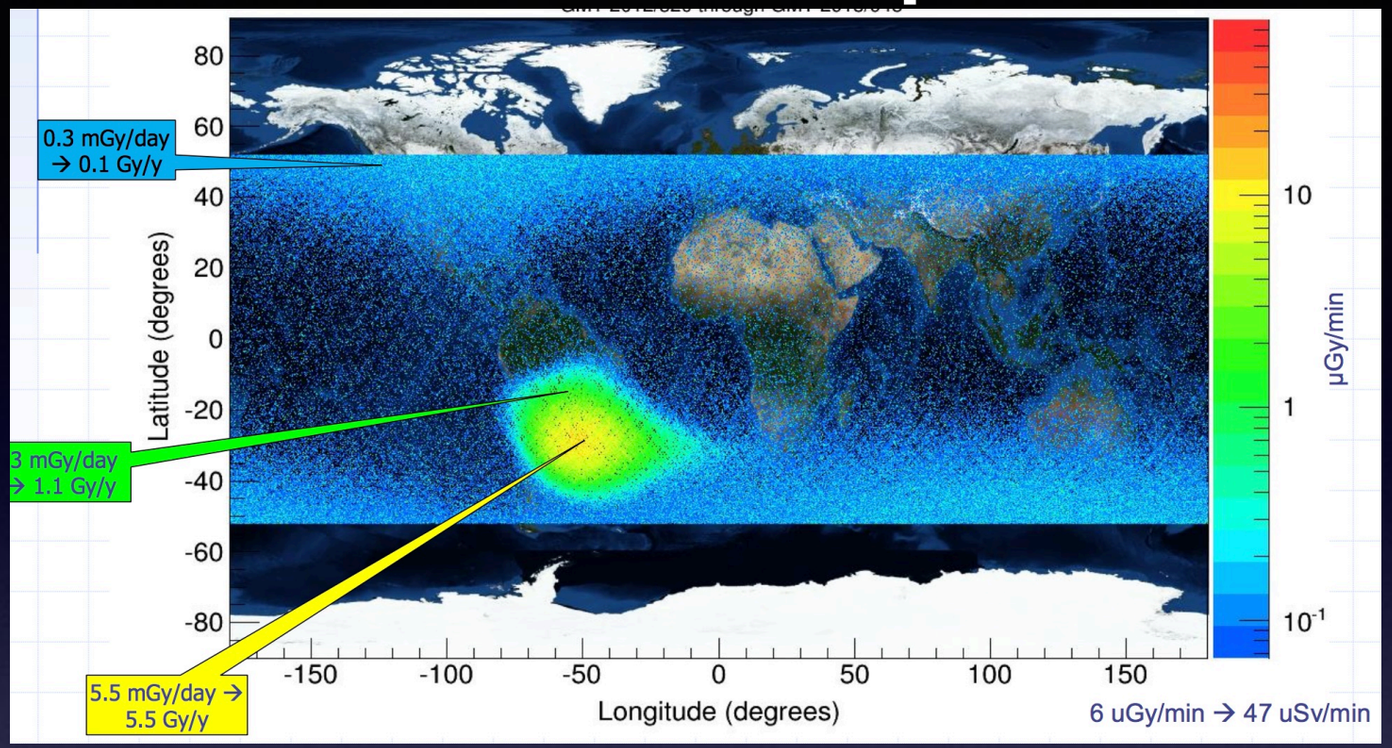
Particle identification

- Shape of the coastline
- Relief





Timepix in space



Dosimetry at ISS

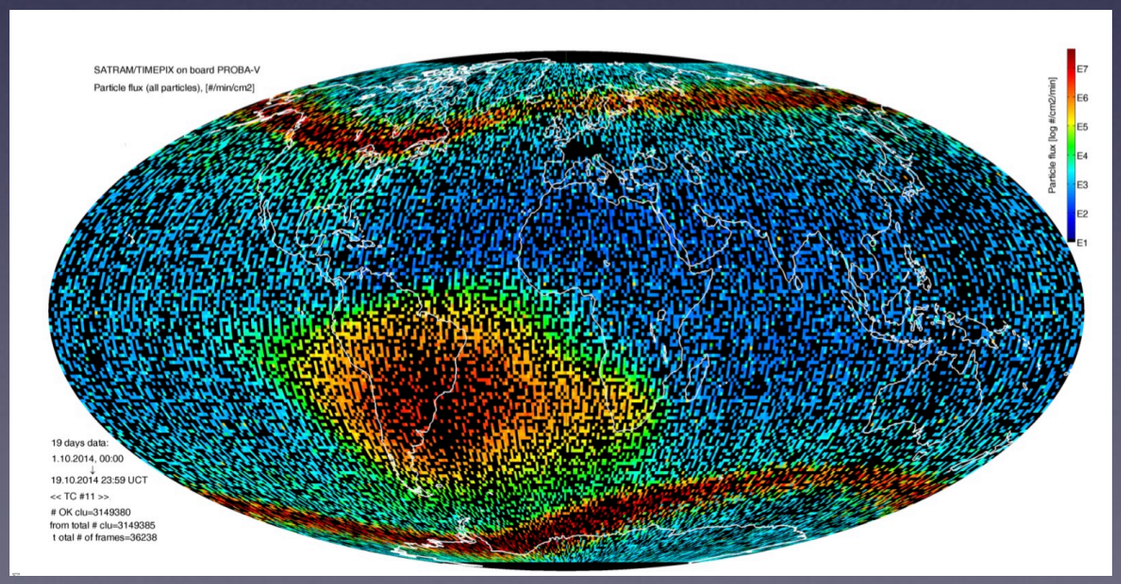
NIM A782 143 (2015)

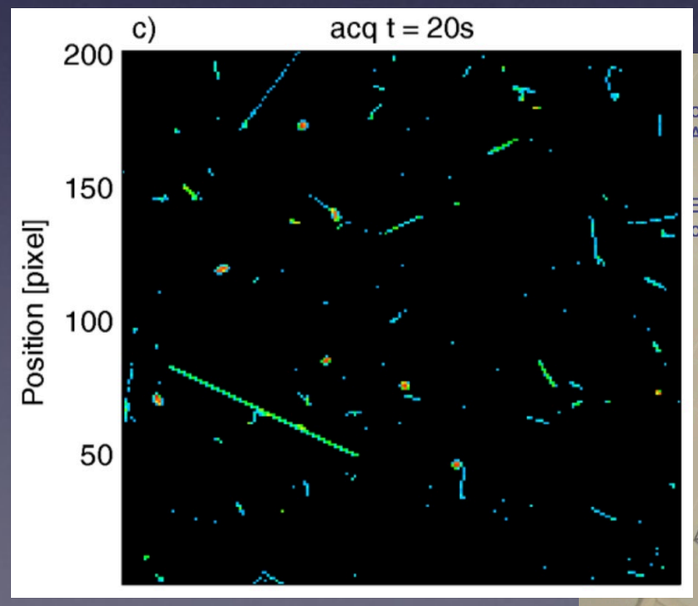
Test flight of the ”Orion module” NASA

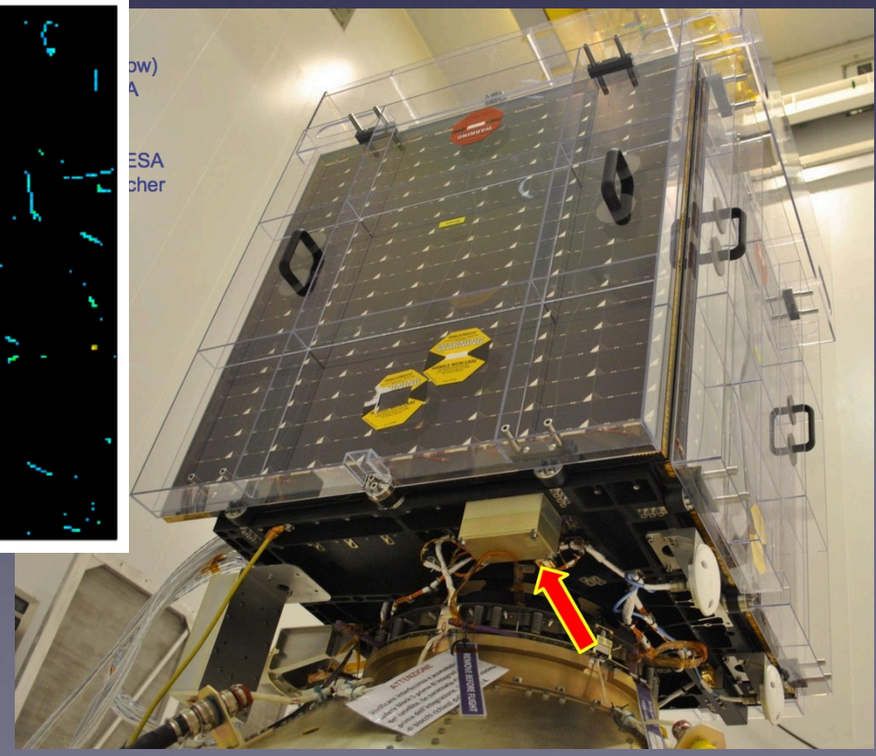
Bahadori A et al. 2015 NASA/TP-2015-218575

Proba V ESA satellite: orbit 820 km, open spase installation

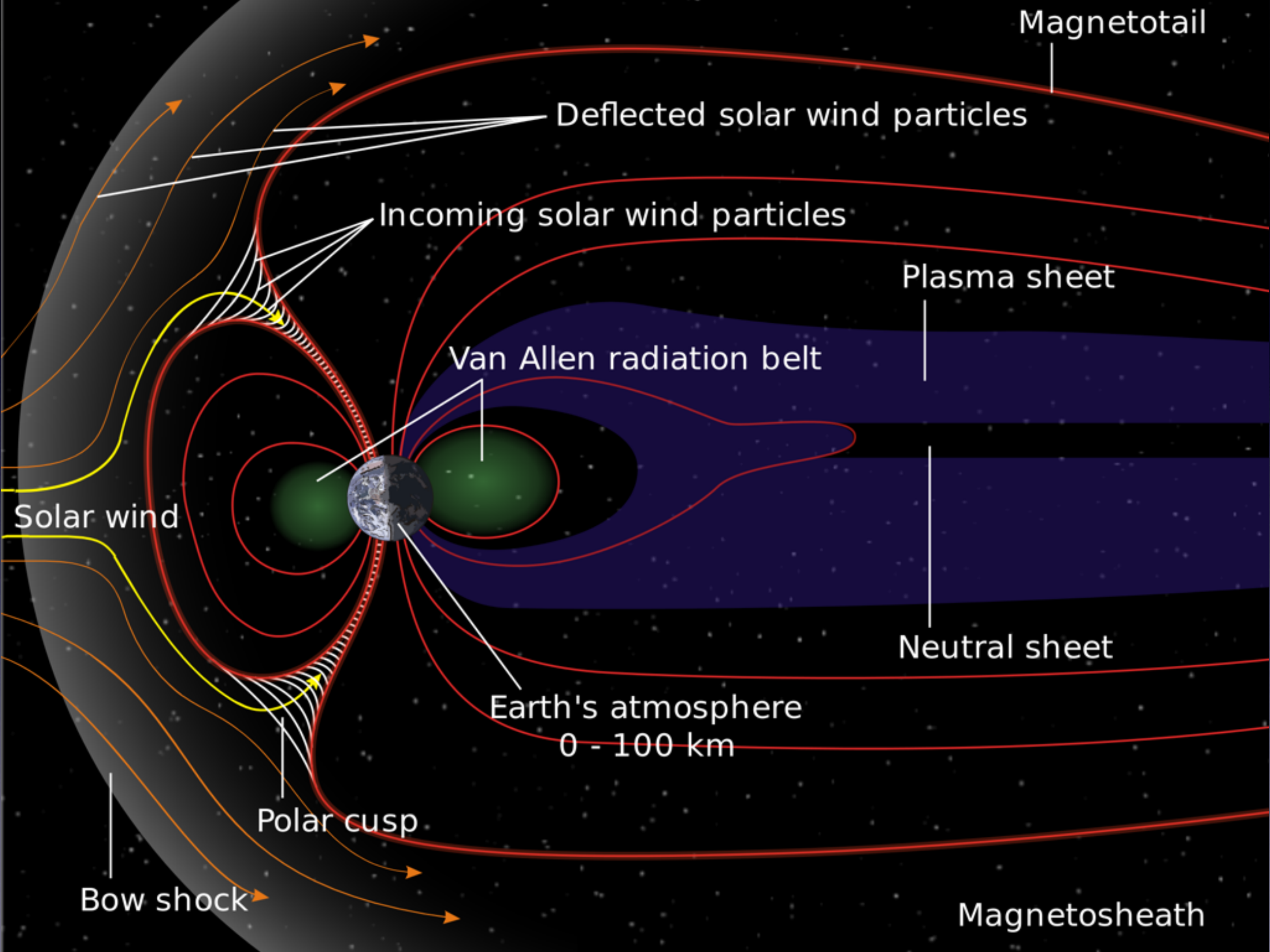
http://aladdin.utef.cvut.cz/projekty/SATRAM/



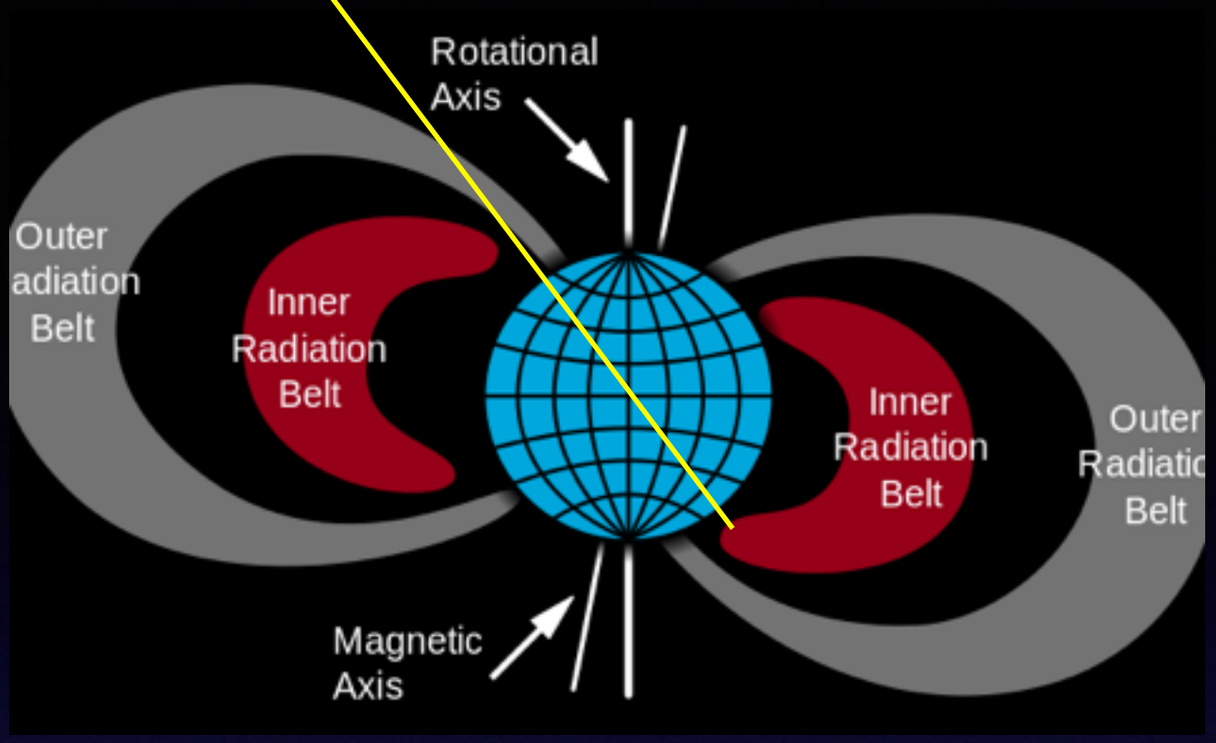




Granja C. et. al., “Directional Visualization of Space Radiation Quanta with Timepix based SATRAM Payload on-board ESA Proba-V Satellite”, Proc. of Science, X Latin American Symp. Nucl. Physics & Applications (2014) 003.

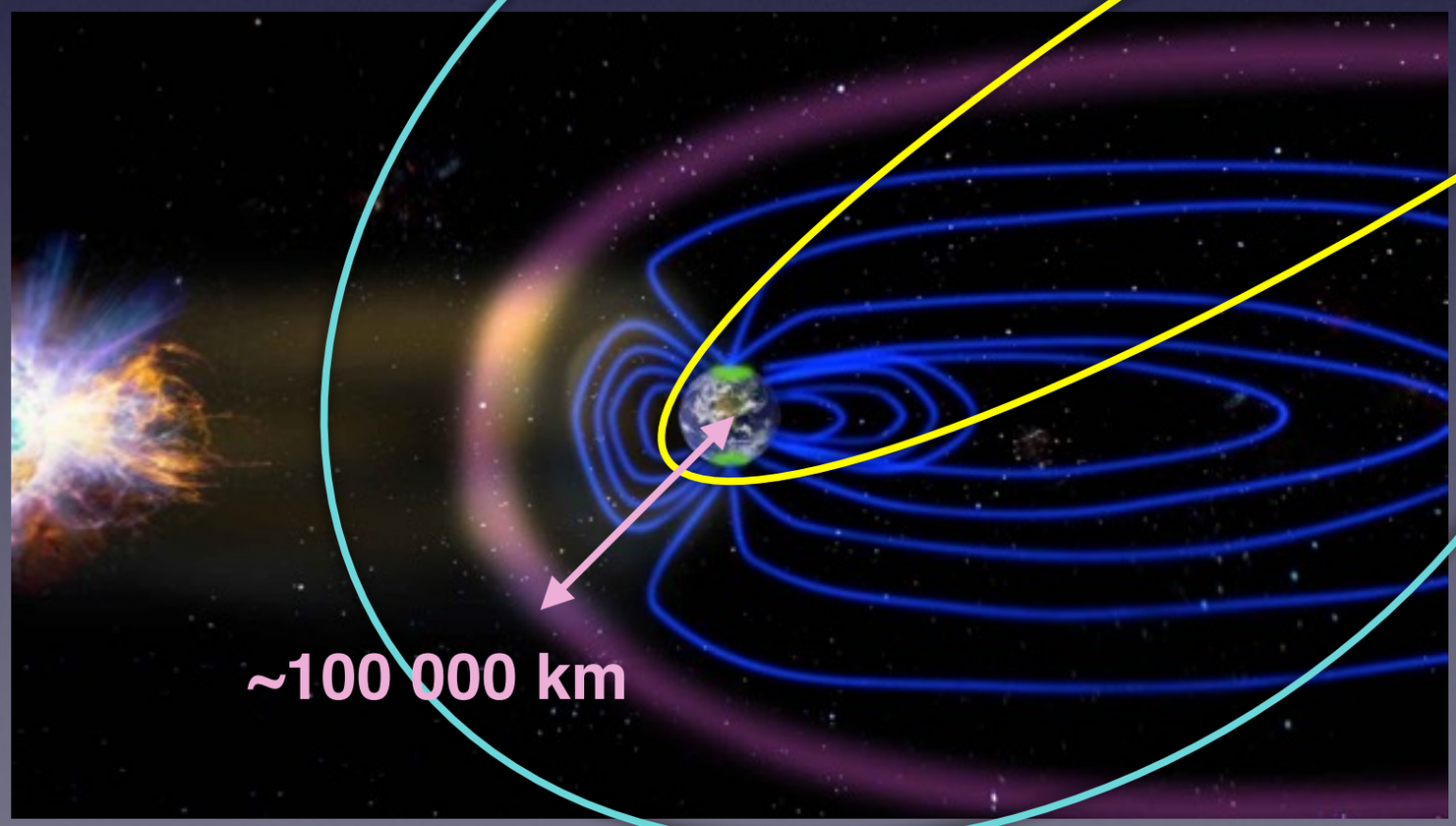

Magnetotail
Deflected solar wind particles
Incoming solar wind particles
Plasma sheet
Van Allen radiation belt
Solar wind
Neutral sheet
Earth's atmosphere
0 - 100 km
Polar cusp
Bow shock
Magnetosheath

Gamma-400 in space

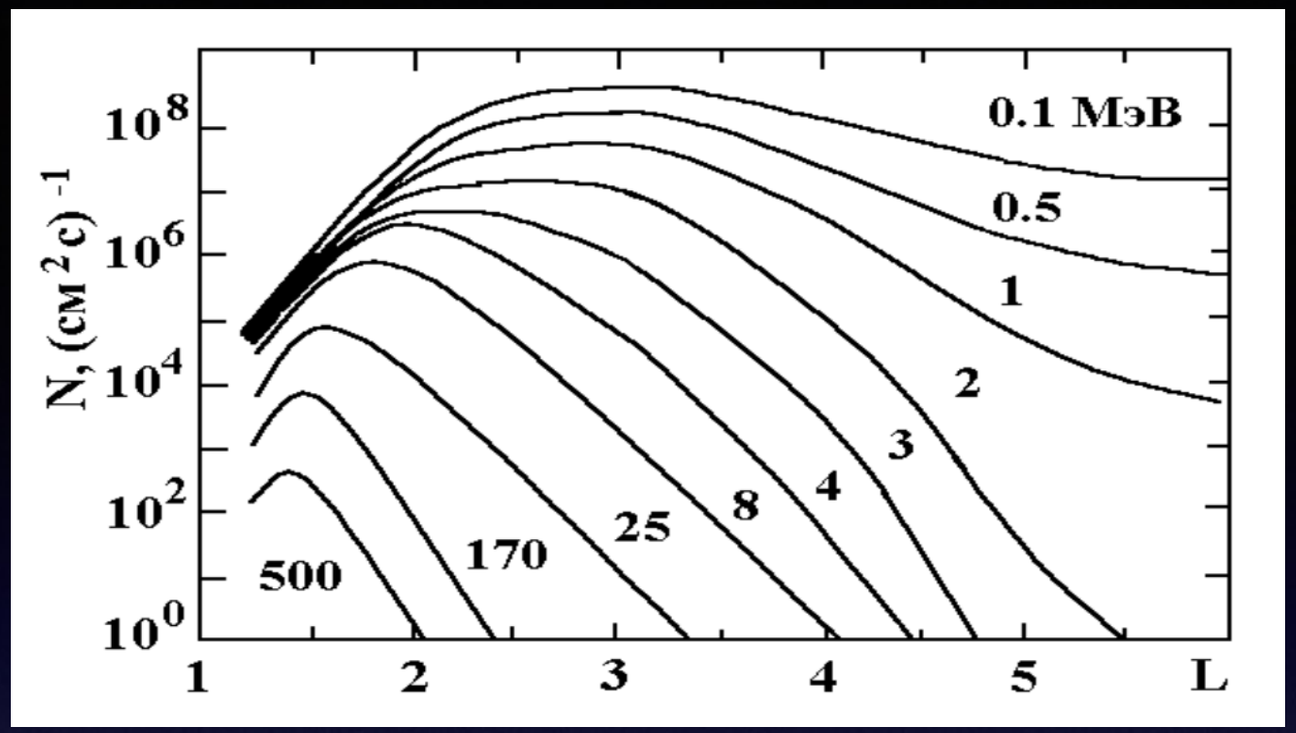


~6 months of
orbit evolution

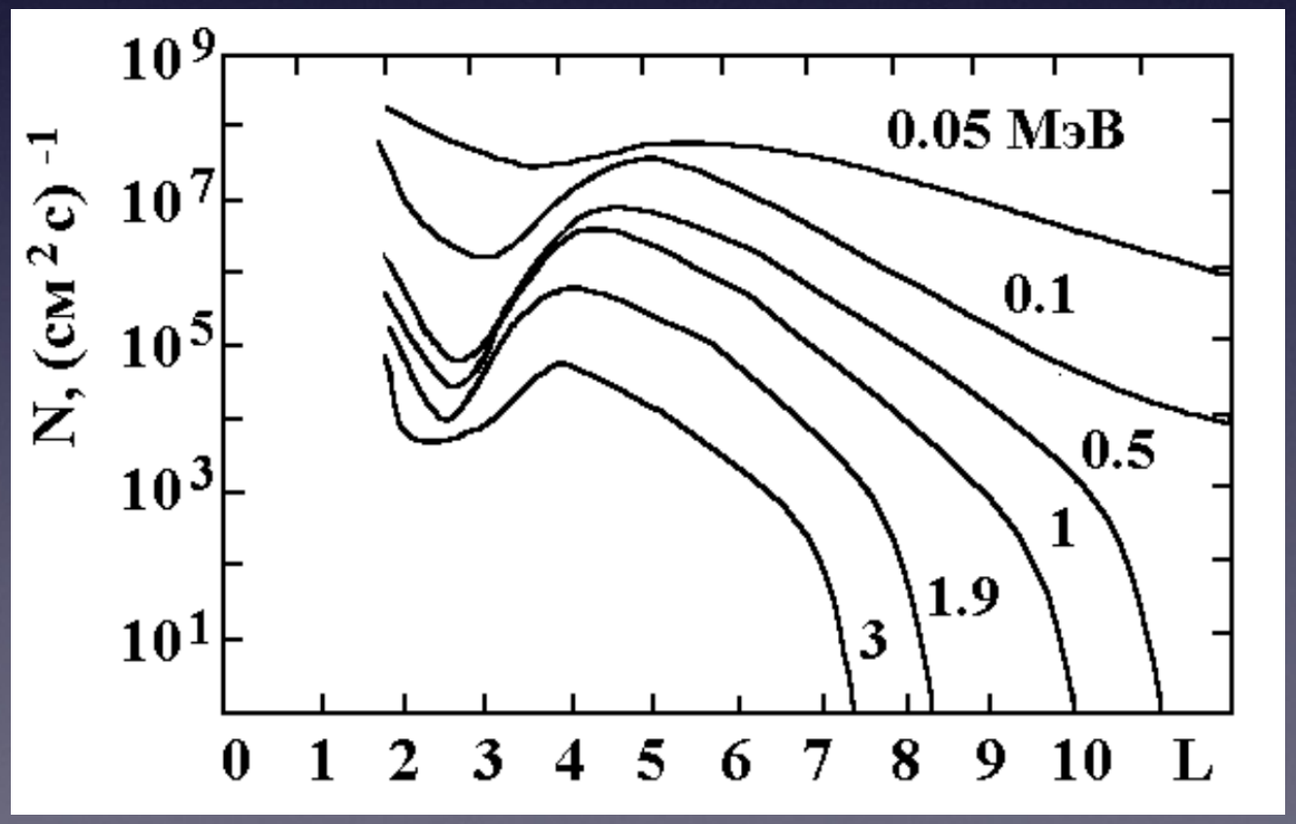
Final orbit
(after 6 months):
~200 000 km



Initial orbit:
500-300 000 km



protons



electrons

p and e fluxes as functions of L=r/R (at geomagnetic equator)

Final orbit: L~30

For minimal frame length 10 μs occupancy on the level of 5% will be reached at intensity 7×10^7 /cm^2 c

Possible tasks

- Measurement of electron and proton **fluxes** (starting from **30 keV** and **500 keV**), **energy spectra** (up to **1.4 MeV** and **17 MeV**) and **angular distribution** in the radiation belts.
- Study of configuration of the external part of magnetosphere and their interaction with solar wind (together with the magnetometer of GAMMA-400).
- Study of soft solar cosmic rays

Summary

- Such advantages of the Timepix based semiconductive detectors as compactness, light-weight, radiative hardness, high granularity and possibility to measure energy deposition in each pixel make this class of the detectors very attractive for operation in space.
- There is some experience to run such detectors in space (ISS, “Orion” module test flight, Proba V satellite (open space))
- Timepix detector installed onboard the GAMMA-400 apparatus can be used for monitoring electron and proton flux in radiation belts of the Earth, investigation of interaction of the magnetosphere with solar wind and study of soft solar cosmic rays.