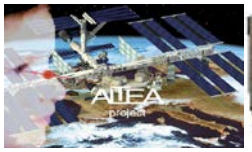

ALTEA: 2012 radiation measurements in the ISS

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Department of Physics University of Rome Tor Vergata and INFN Tor Vergata

University of Rome
"Tor Vergata"

ThalesAlenia Space

TELESPAZIO
A Finmeccanica / Thales Company

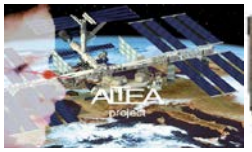
esa

ISWA
solar
heliosphere
magnetosphere
ionosphere
planetary

NASA

agenzia spaziale italiana

INFN



Content

- ALTEA
- Importance in measuring radiation in the ISS
- Considerations about the different contribution to radiation
- Different environments in USLab / Columbus – Survey measurements
- Consideration about shielding effectiveness of Polyethylene and Kevlar
- LIDAL

… work in progress, preliminary

Radiation in space

•Radiation in space is due to:

Galactic, **GCR** (*modulated by solar activity)*

Solar Particle Events, **SPE** *(more frequent at solar maximum, random in nature)*

GCR:

high-energy protons

heavy ions (HZE's)

SPE

mostly lower energy protons *(can be mitigated with Radiation Shelters)*

⇒ ***secondary*** (produced in shielding)

neutrons, protons, heavy ions

Damage to molecules, cells, tissues and possibly functional anomalies either transient or long term

WHY?

Why do we measure radiation in the ISS … ?

1) To support crew radiation **risk assessment**
2) To support **radiobiology** experiments
3) For a final validation of materials **shielding** capabilities
4) To validate radiation sources, transport and CAD **models**

…. a detailed analysis of the radiation flux in a *space habitat* is mandatory

• The ISS is the best available site to perform these radiation investigations

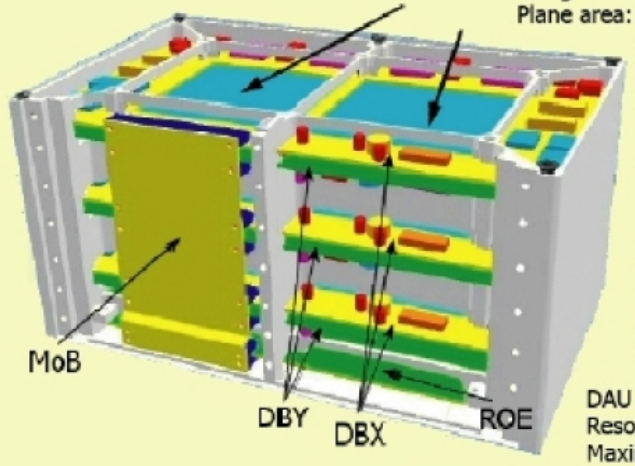
• To provide (3) and (4), aimed deep space exploration issues, the radiation detector must permit segmentation of the orbit so to select the measurements

- at high latitude (closest available replica of the deep space situation)
- without the contribution of the SAA

NOTE: A large amount of data is now available and validation in (4) should start ASAP.

ALTEA characteristics

SDU: Silicon Detector Unit

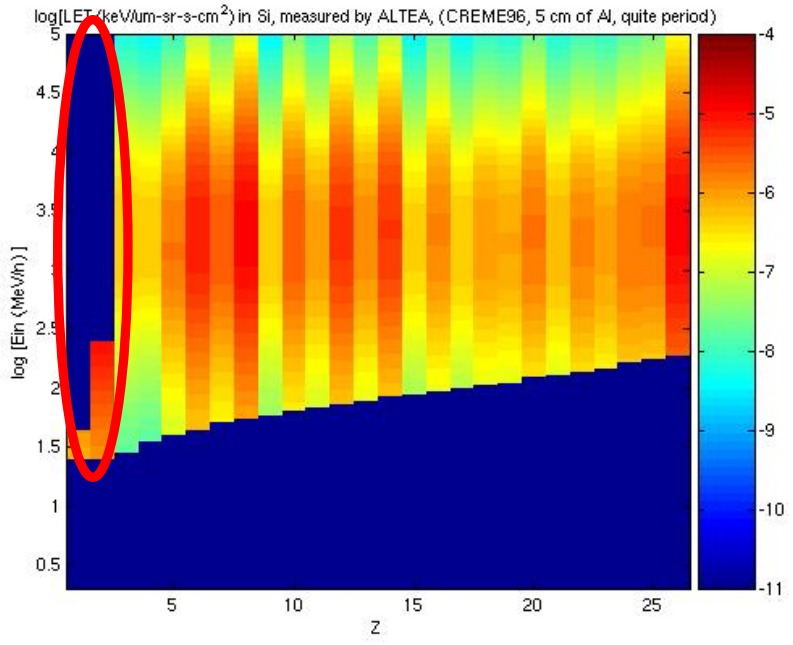


DETECTORS: 6 double strip silicon layers arranged alternately-along X and Y directions
Plane area: 2 x (8x8) cm^2
Thickness: 380 µm
Distance X-Y planes: 3.75 cm
Maximum error of angular reconstruction: 1.8°
Geometric Factor (bidirectional): 200 cm^2 sr

PERFORMANCES:
Threshold: 5 -33 MIP
Saturation: 2400 MIP
(1 MIP=109 KeV/plane)
ADC: 12 bit

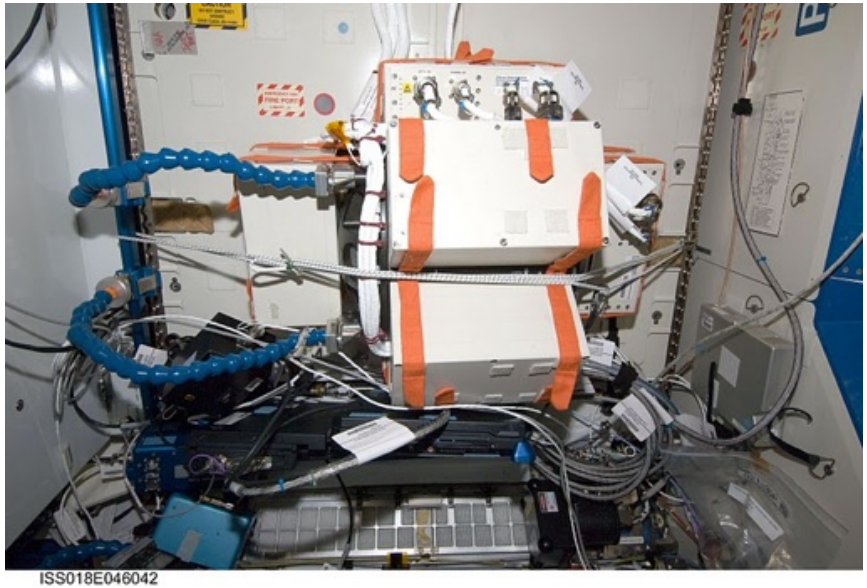
DAU SOFTWARE PARAMETERS:
Resolution: 0.64 MIP/ADC ch
Maximum Acquisition Rate: 700 Hz
Autotrigger (logic OR or logic AND of X planes, software switchable)

i) 3D – trajectories
ii) multiple measurements
iii) nuclear discrimination
iv) LET spectra
(3 keV/µm < LET_{Si} < 800 keV/µm)
v) Real Time



GCR as detected by the ALTEA system:
- Low energy ions stop in the detector
- High energy low Z ions (H and He) do not trigger the detector

ALTEA configurations



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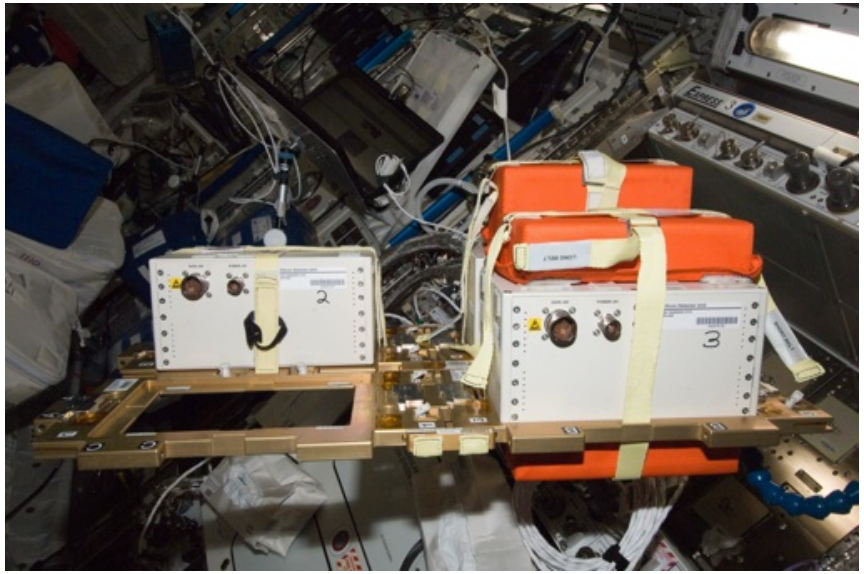
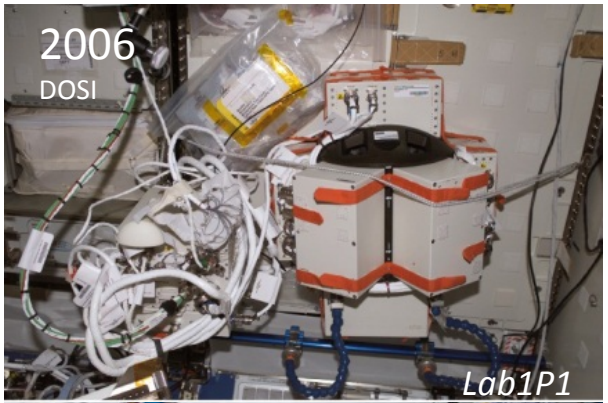


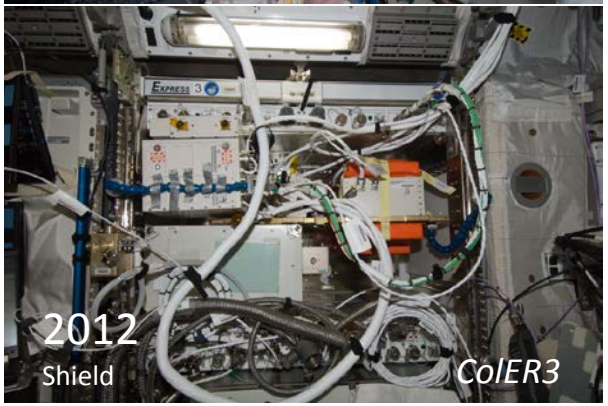
Many other configurations are possible with the plate-mounting system

ALTEA runs

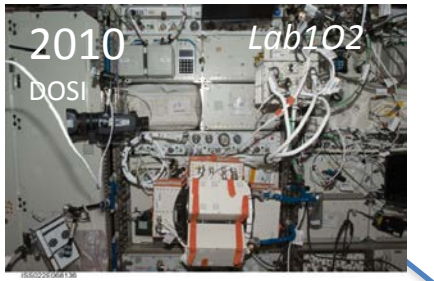
≈ 7 years of space ≈ 3.6 years of measurements

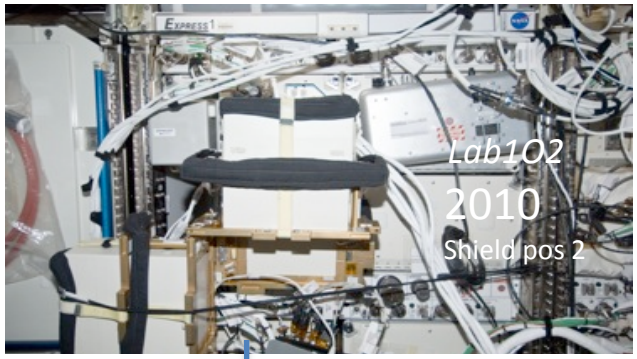
year	*location*	*experiment*
2006	Lab1P1	ALTEA-DOSI (ASI)
2007	Lab1P2	ALTEA-DOSI (ASI)
2009	Lab1P1	ALTEA-DOSI (ASI-NASA)
2010	Lab1O2	ALTEA-DOSI (ASI-NASA)
2010	Lab1S1	ALTEA-shield/survey pos 1 (ESA)
2010	Lab1O2	ALTEA-shield/survey pos 2 (ESA)
2011	Lab1P4	ALTEA-shield/survey pos 3 (ESA)
2011	Lab1S6	ALTEA-shield/survey pos 4 (ESA)
2012	Lab1S6	ALTEA (ASI-NASA)
2012	ColER3	ALTEA-shield/shield (ESA)

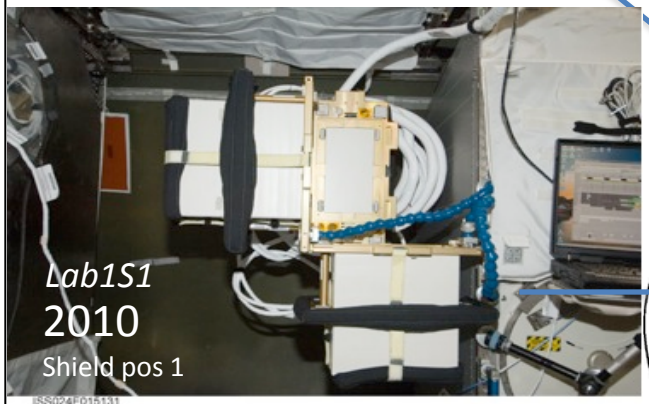


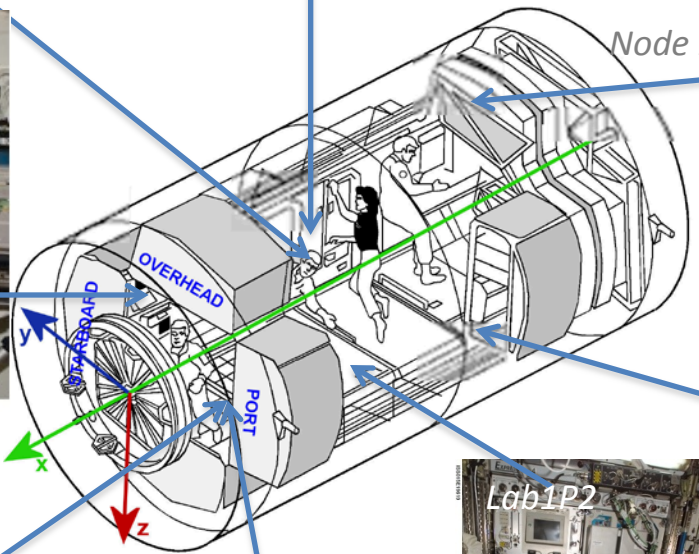


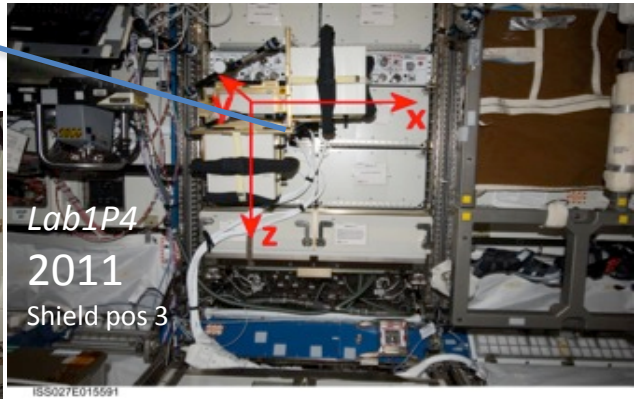
ALTEA USLab survey

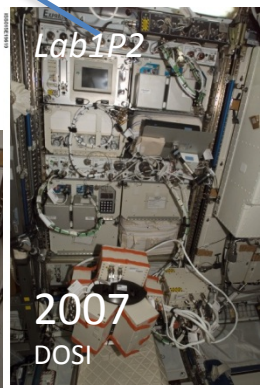






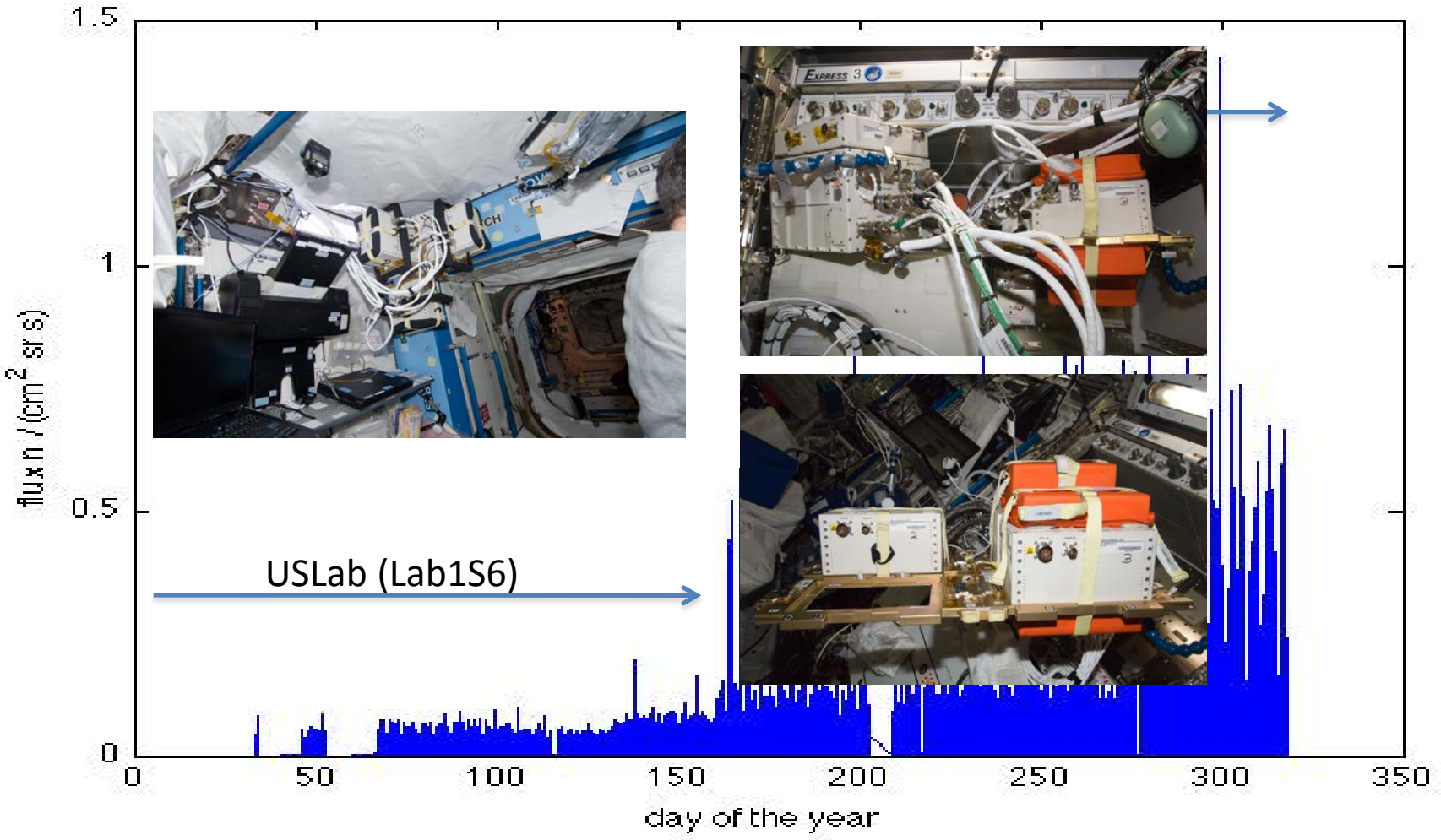




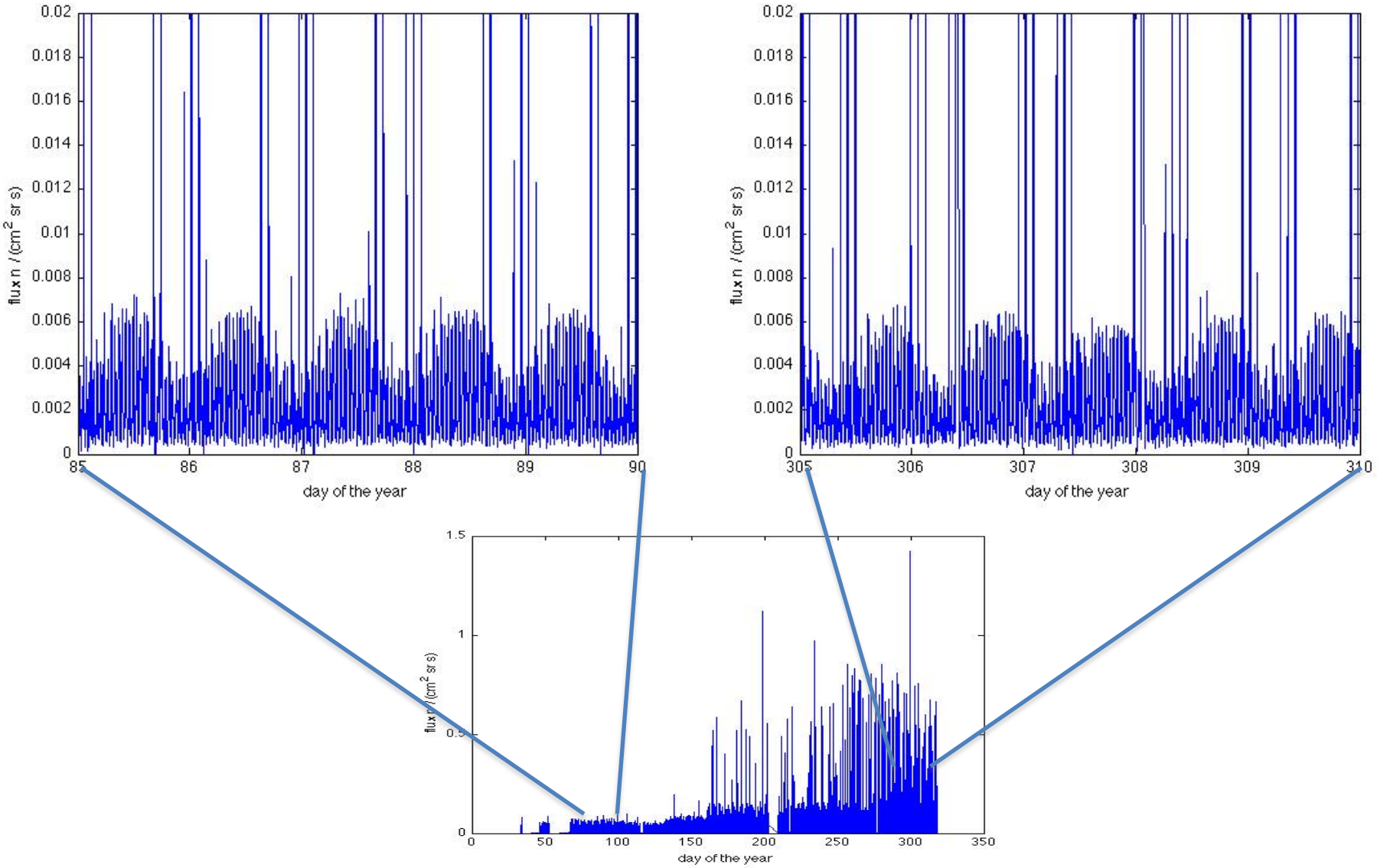


Survey measurements

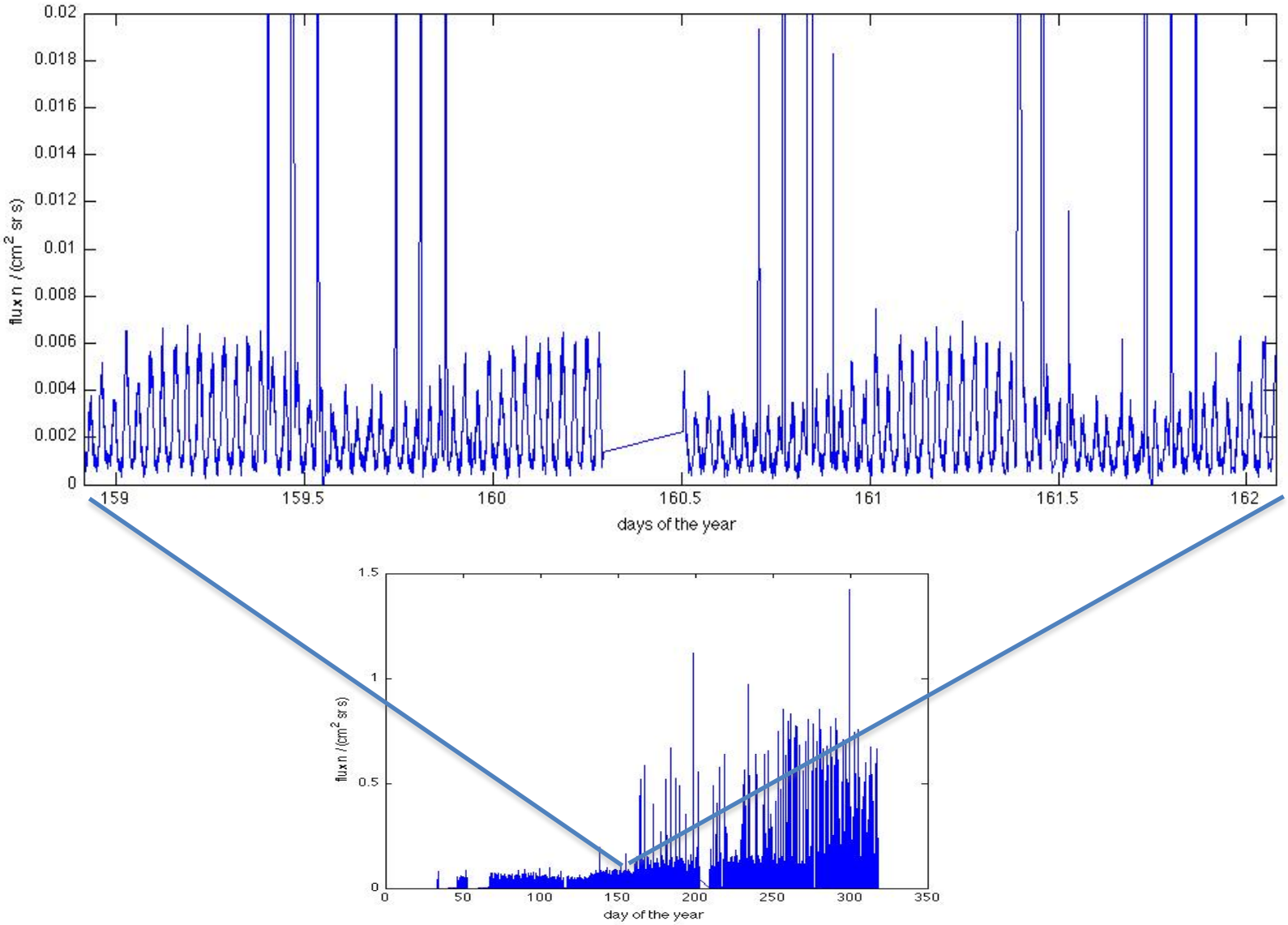
Flux in 2012 (SDU2)



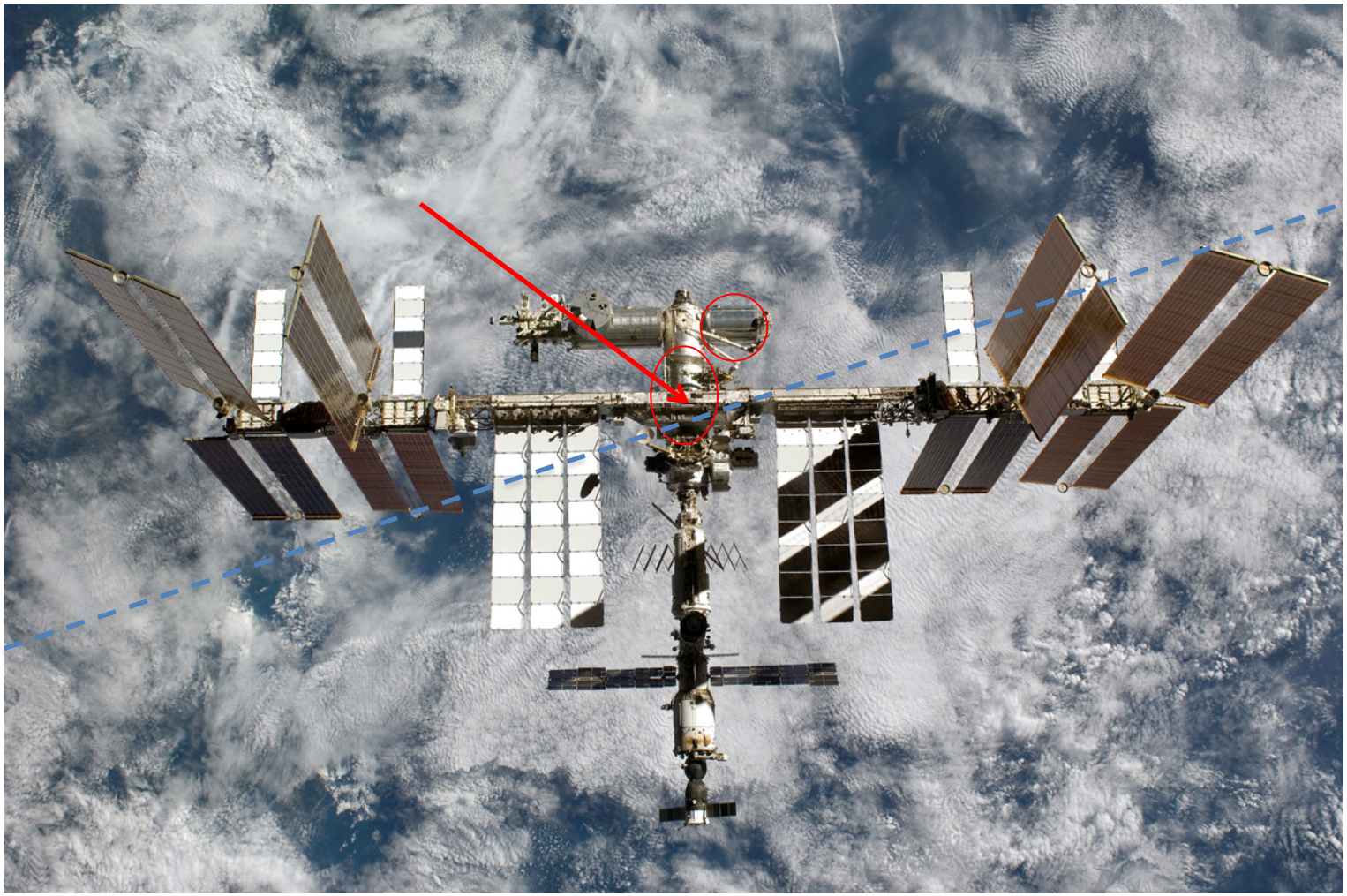
Flux in 2012 (SDU2)

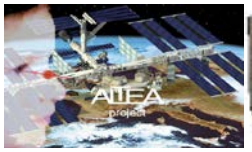


Flux in 2012 (SDU2)



The measurements sites





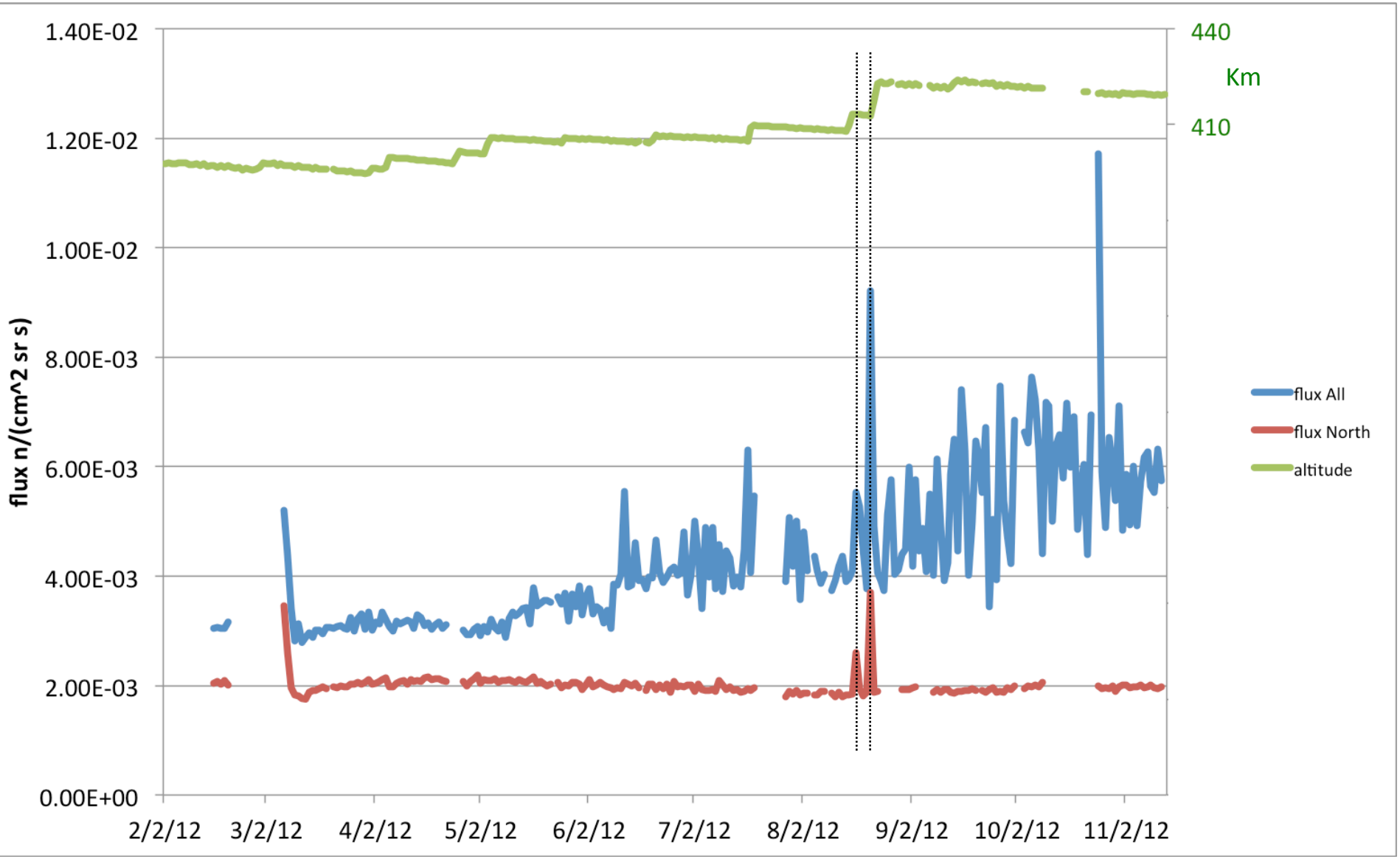
Flux in 2012 (SDU2)

- Averages over 1 day

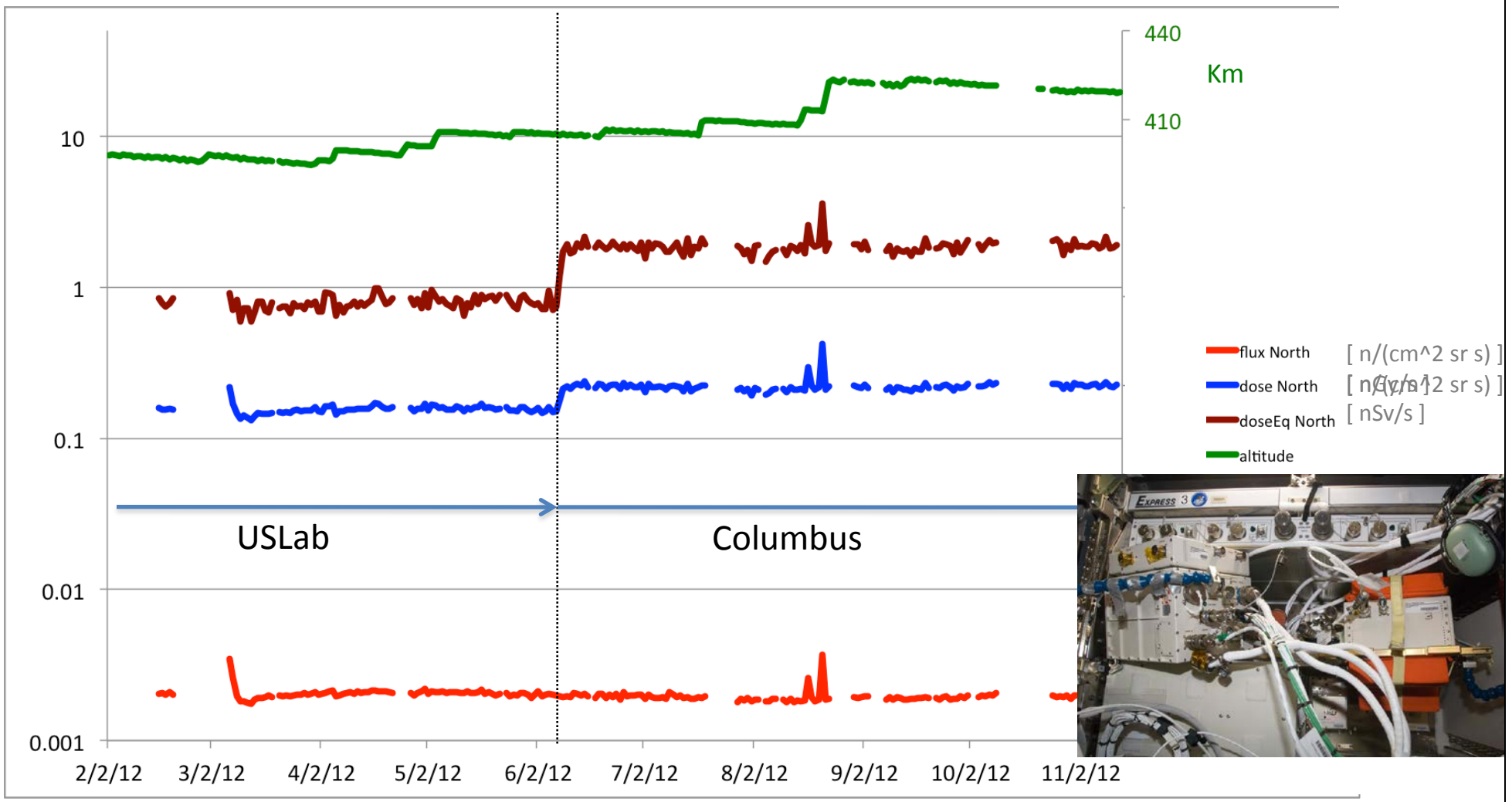
- The contribution of the SAA is important and highly variable

- To minimize unwanted fluctuation: consider only the north hemisphere

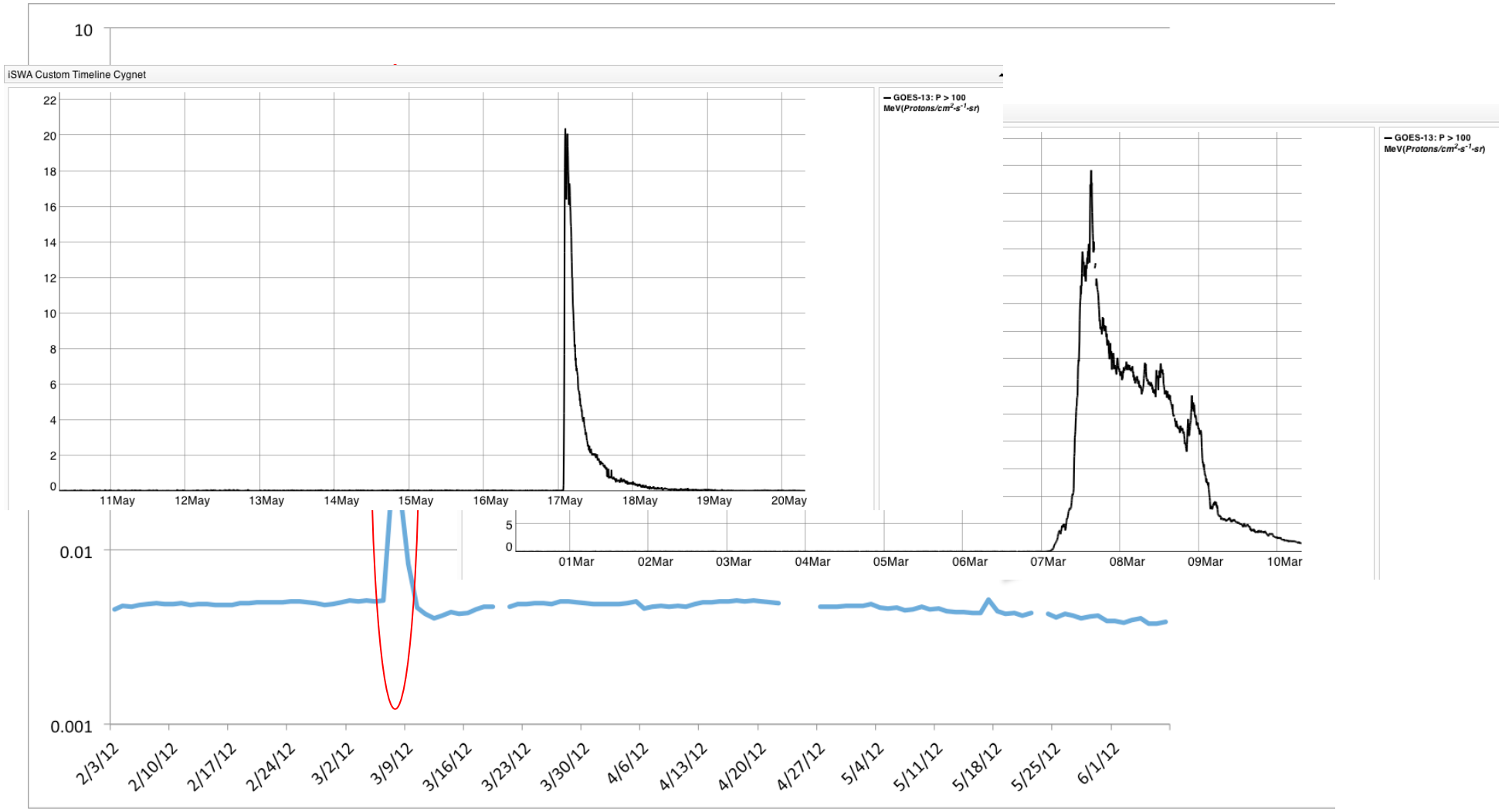
Flux in 2012 (SDU2)



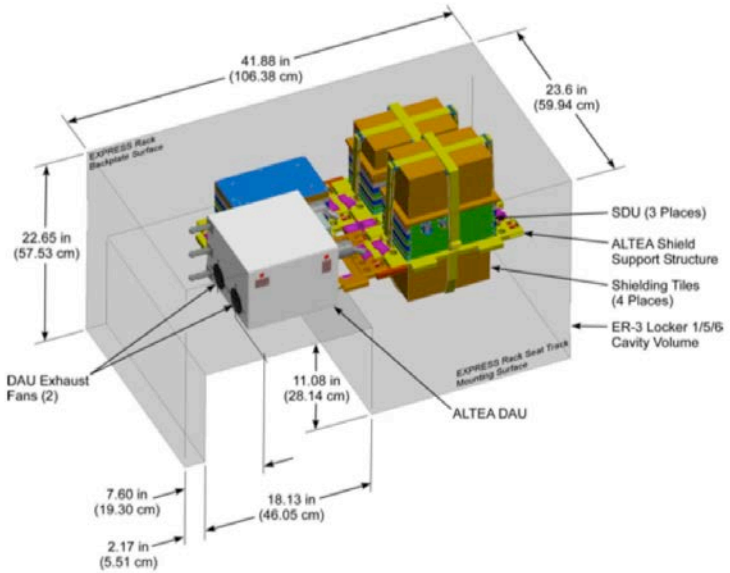
Dose, Dose Equivalent

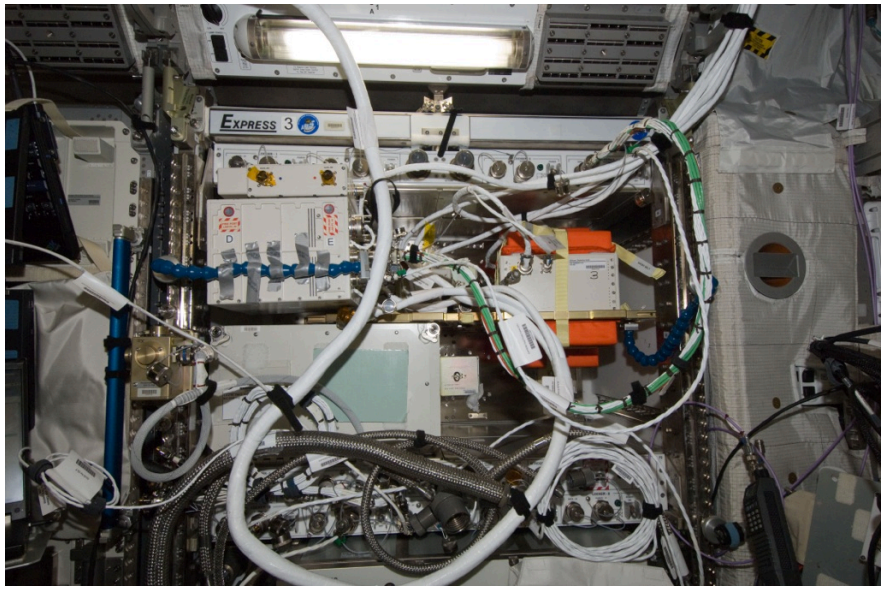


Poles measurements

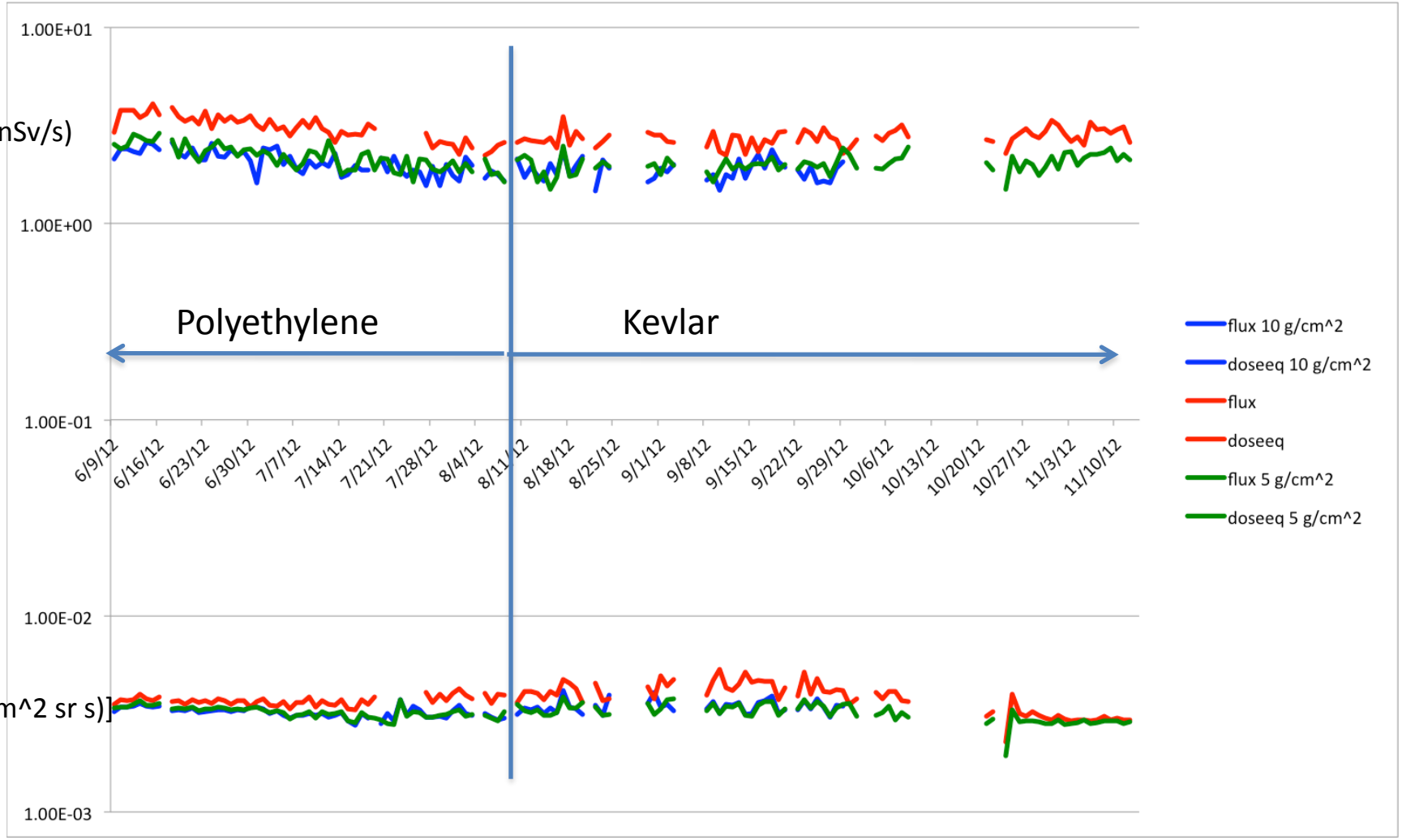


Shielding measurements

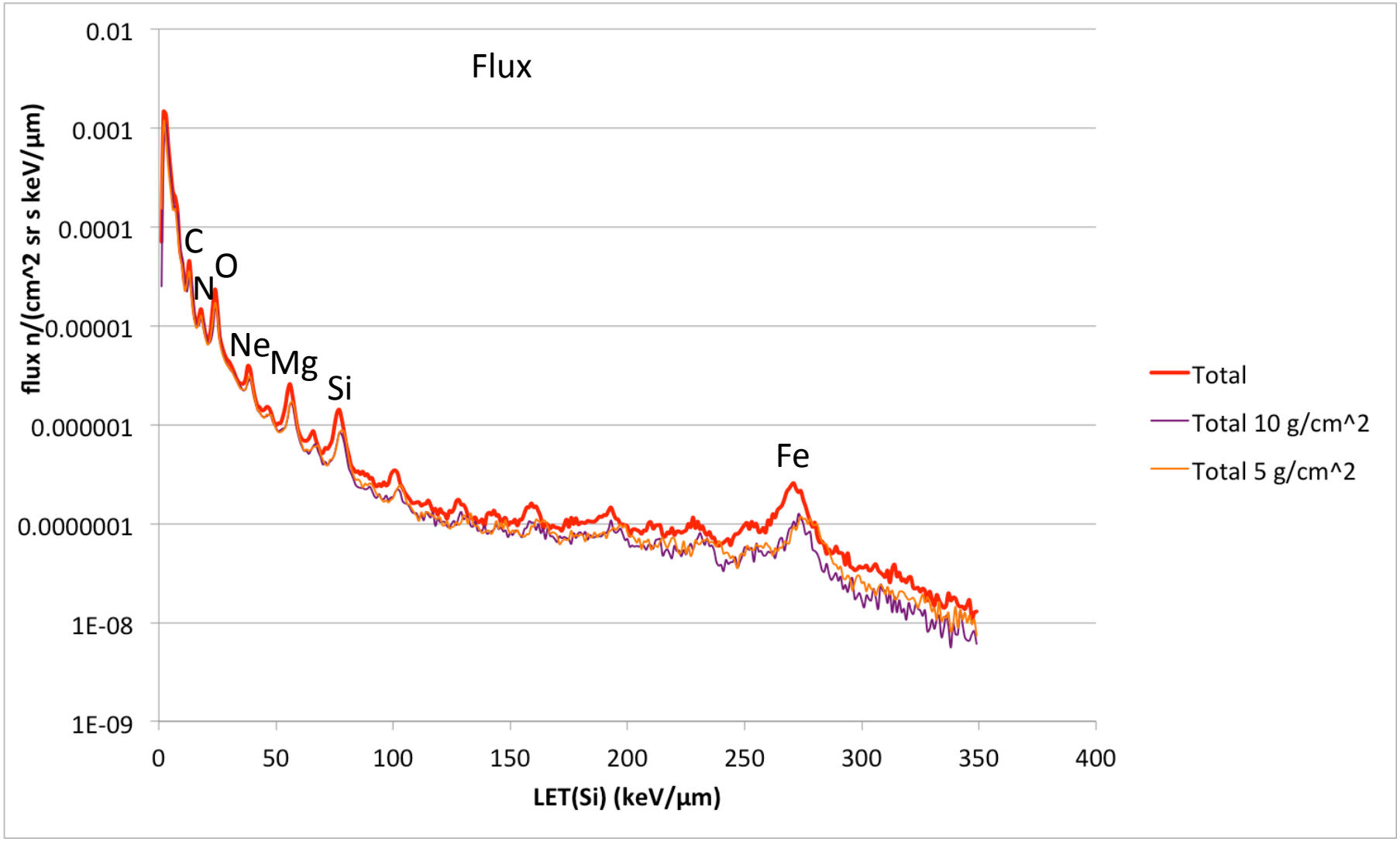




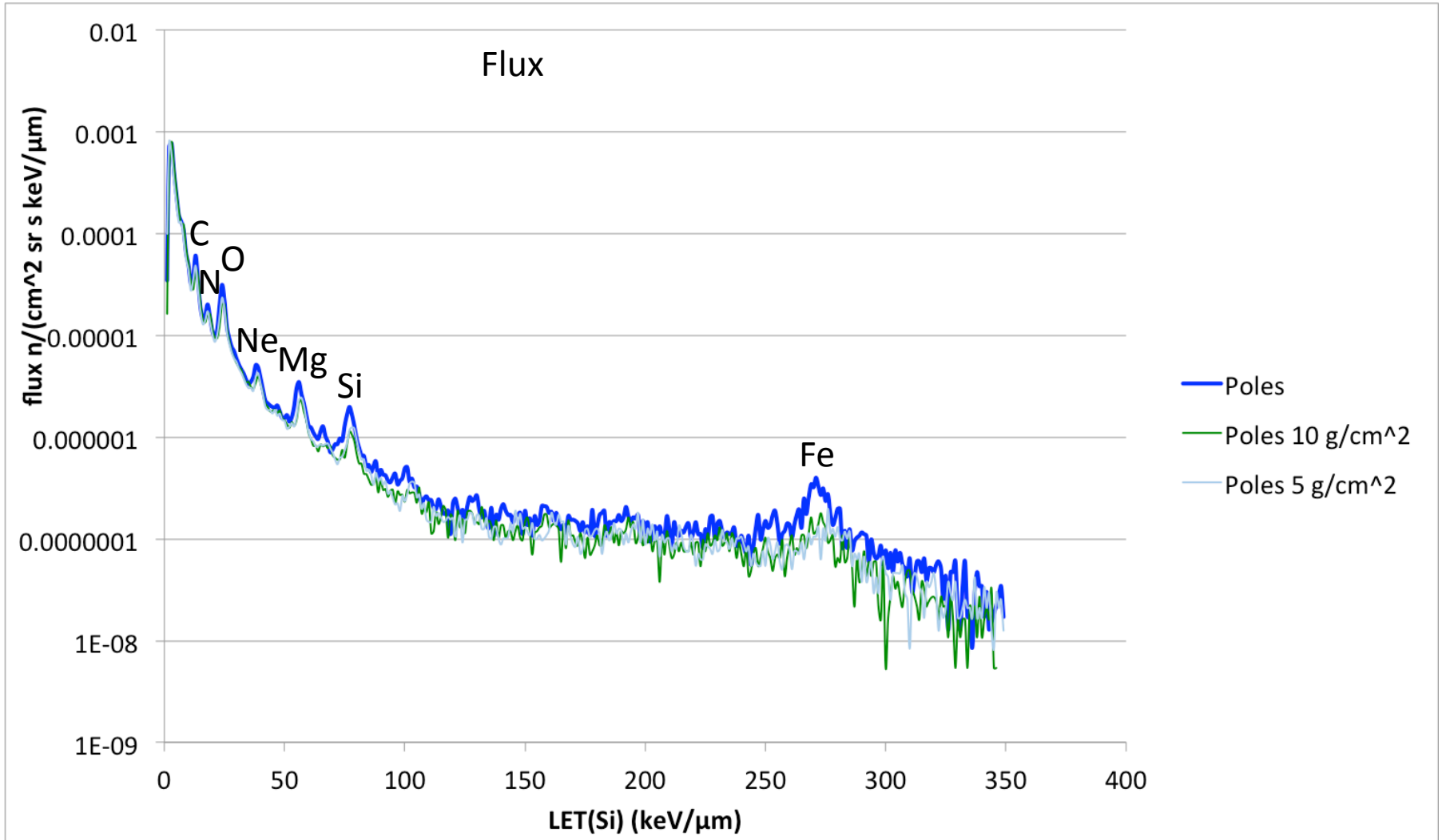
Shielding (Poles)



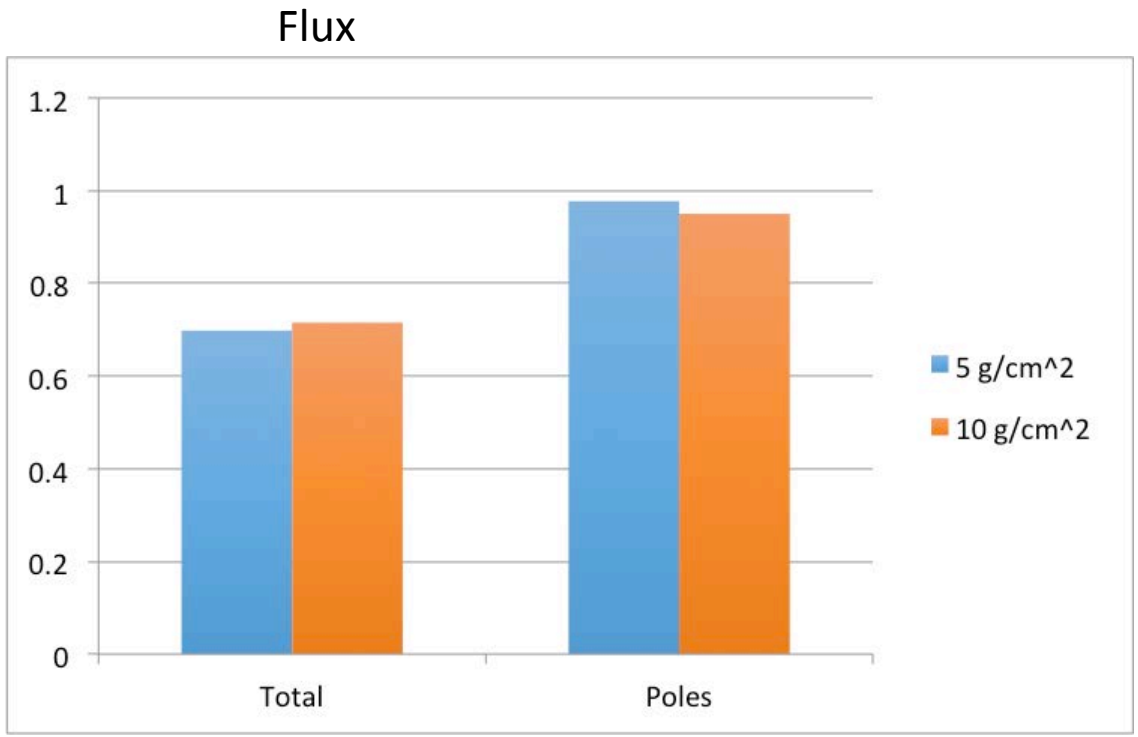
Shielding (All zones)



Shielding (Poles)

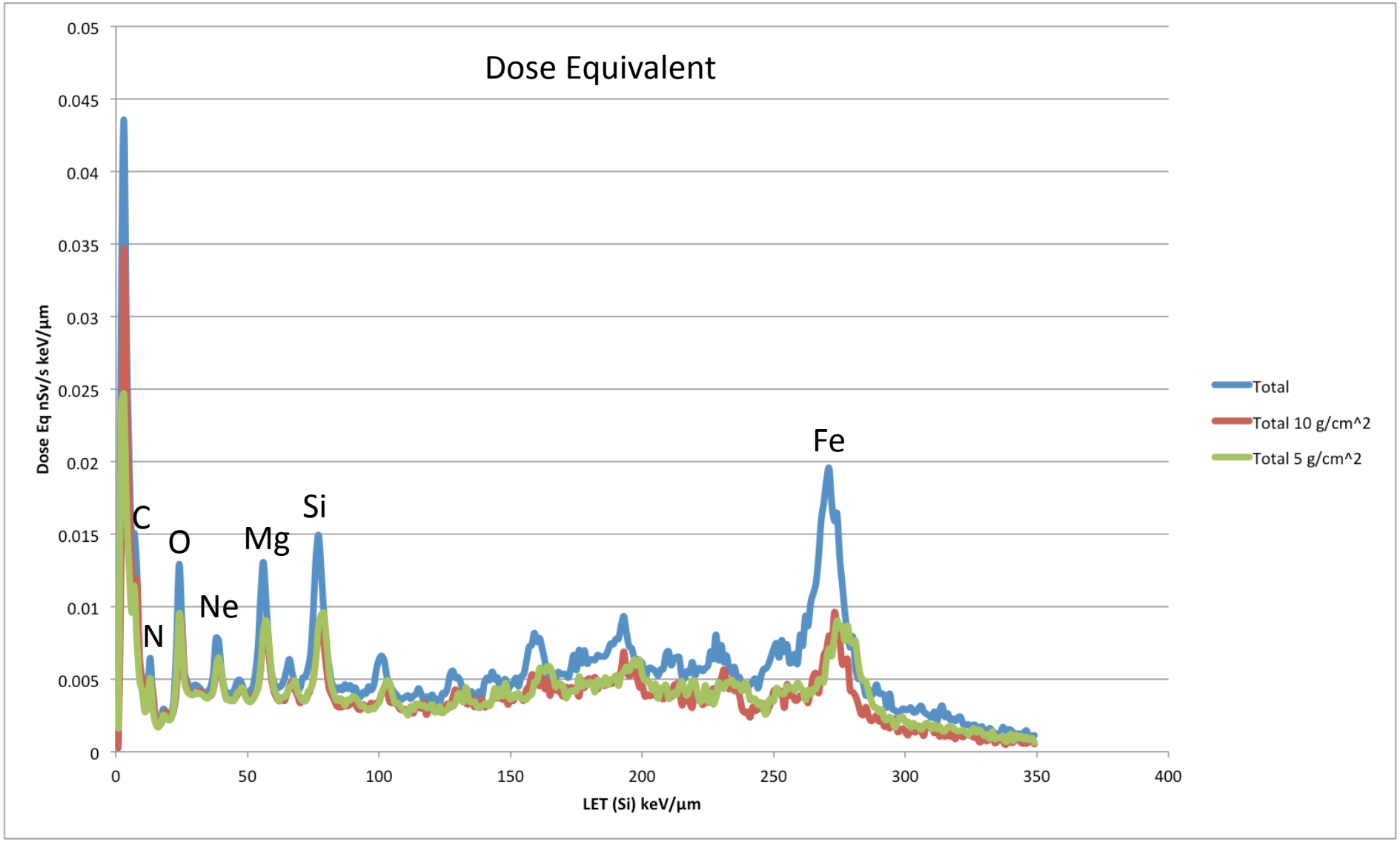


Shielding

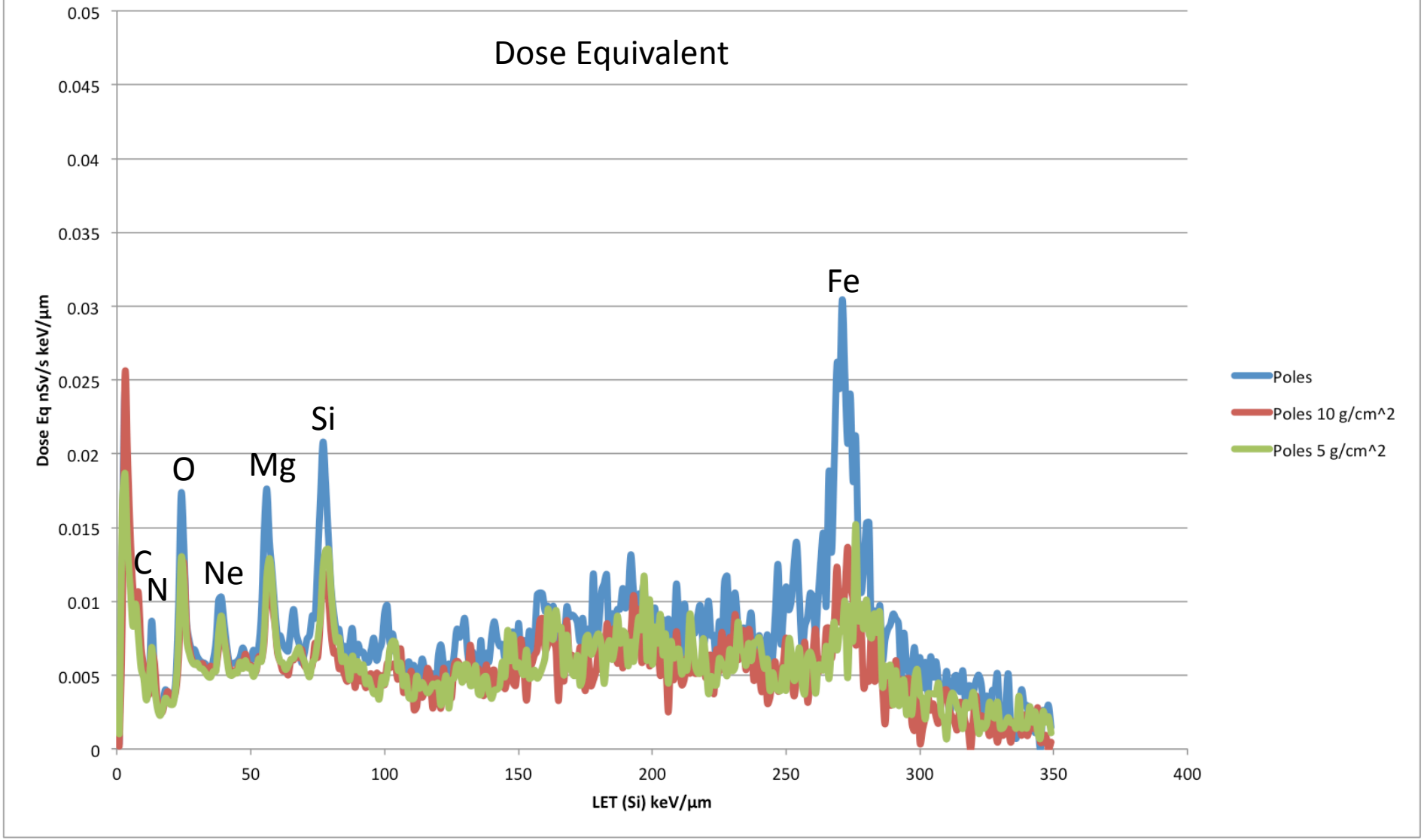


NOTE: as in the previous and following plots, to increase statistics Polyethylene and Kevlar are together

Shielding (All zones)

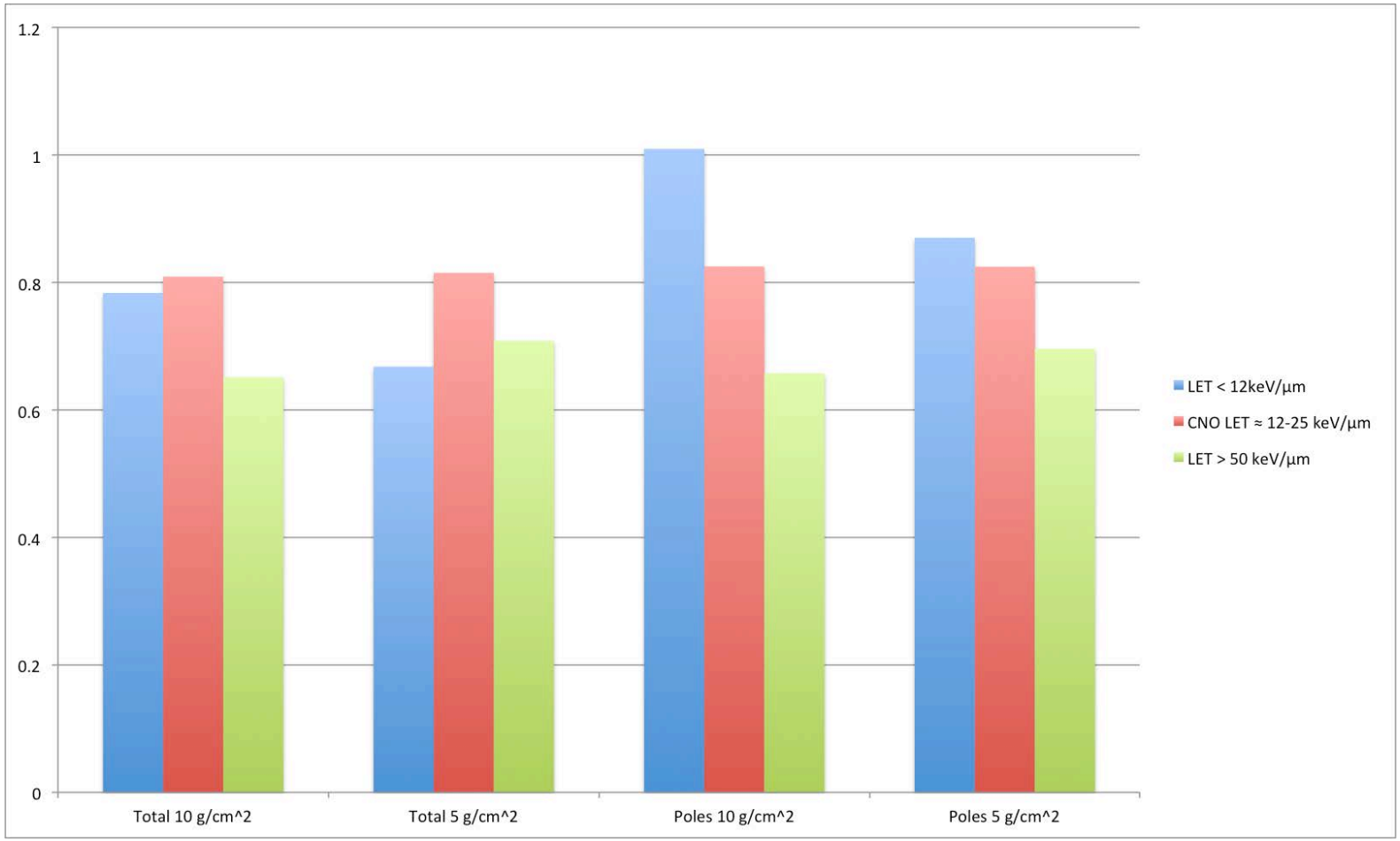


Shielding (Poles)



Shielding

Dose Equivalent



ALTEA upgrade

Light Ion Detector for ALTEA: LIDAL

Rationale:
1)expand ALTEA energy acceptance window to include all H and He
2)provide a direct measure of ions kinetic energy

Plan:
Build a system based on fast scintillator detectors to be used as ToF and as trigger for ALTEA

- Two Detector Units (DUs) to be positioned at the end of a Silicon Telescope (ST: 1 or more SDUs)
- Each DU made of thin plastic scintillators (full ST field of view covered)
- Scintillators will be segmented in the two orthogonal directions (provide first position/tracking)
- Scintillators read by Silicon Photomultiplier (SiPM)
- Resolution aimed to be better then 100 ps

-ToF measurements provide energy determination
-Signal from DUs can be used as ALTEA trigger

***STATUS**: favorable reviewing from ASI, waits for financing (probably next year). Upload NET 2016*

Final comments

A (striped) active silicon detector can be used to give answers to point 1-4

Taking care of SAA and Poles segmenting without introducing biases is still in progress

Good and clean results can be obtained using only the north hemisphere

Quite impressive dependence of quality of radiation with site (USLab / rack in Columbus)

Polyethylene and Kevlar provide quite similar shielding capabilities

<u>Need to start using data for point (4)</u>

ALTEA: the international team

Dept. di Physics, Univ. of Rome "Tor Vergata" and INFN Sect. Roma2 , Roma
Dept of Physics, Univ. of Pavia, Pavia
Dept of Physics, Univ. of Milan, Milan
DISM-Univ. of Genoa, Genoa
L.N.F. - INFN, Frascati (Rome)
CERN - INFN
Dept. of Physics,Univ. e Sect. INFN of Trieste, Perugia, Firenze
Dept. of Sc. and Chemical Tec., Univ. of Rome "Tor Vergata"
Dept. of STB - Univ. of L'Aquila, L'Aquila
Univ. Paris Sud, 91406 Orsay Cedex, France
GSI - Biophysik, Darmstadt, Germany
Royal Institute of Technology, Stockholm, Sweden
Chalmers University of Technology, Sweden

Institute for BioMedical Problems, Moscow, Russia.
Russian Space Corporation "Energia" by name Korolev, Korolev, Moscow region, Russia
Moscow State Engineering Physics Institute, Moscow, Russia

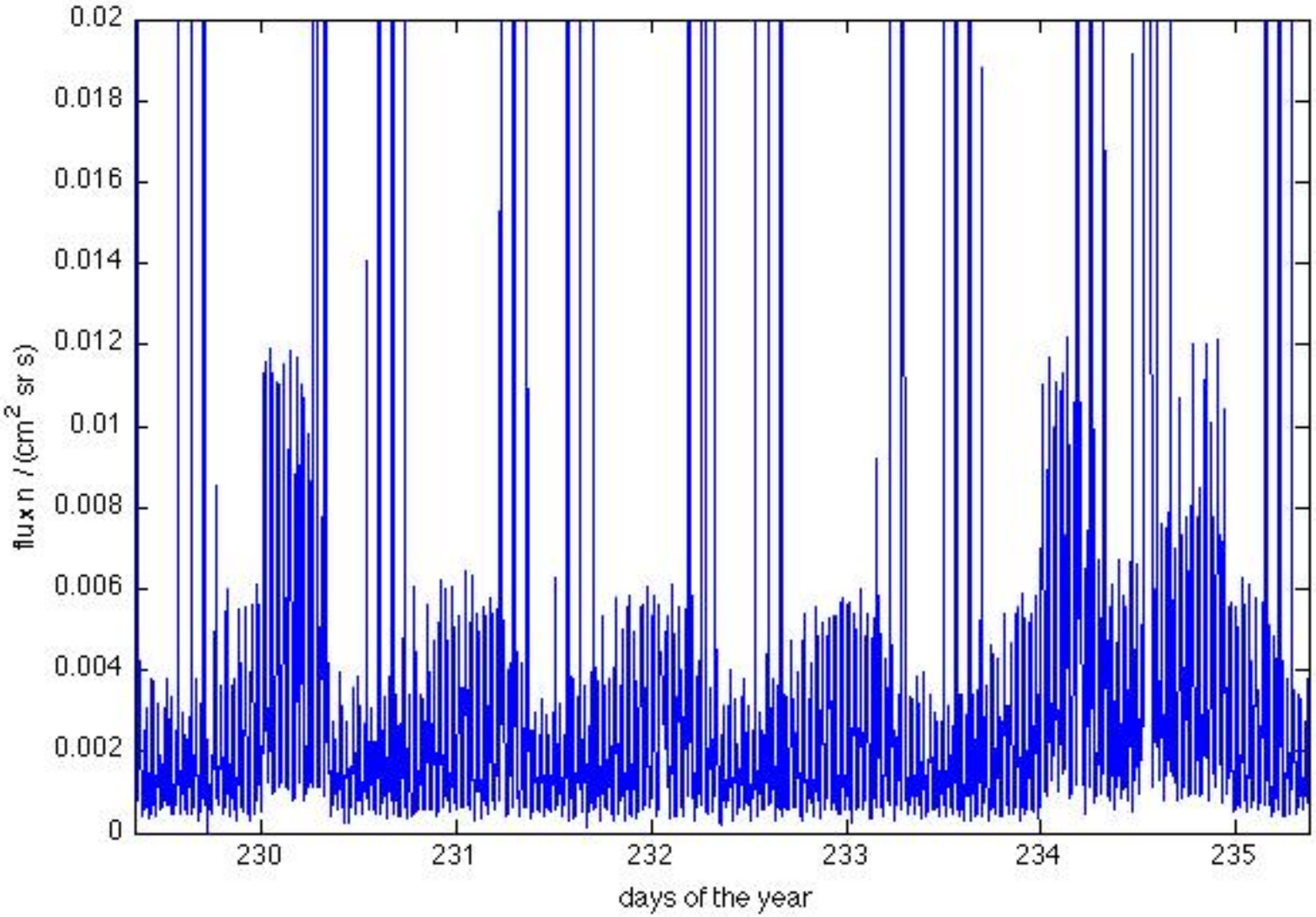
JAERI, Japan

Johnson Space Center, NASA, Houston TX, USA
Goddard Space Flight Center, NASA, USA
Brookhaven National Laboratory, NY, USA
Lawrence Berkeley National Laboratory, CA, USA
Loma Linda University, CA, USA
Cole Eye institute, The Cleveland Clinic, Cleveland, OH, USA
Wyle Laboratories, TX, USA
Eril Research, CA, USA

+ others joining in

Thanks to ESA, ASI, NASA and ISS crew!

Thank you for your attention


0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
flux n / (cm2 sr s)
230
231
232
233
234
235
days of the year