



Radiation survey in USLab and first measurements in Columbus with the ALTEA detector

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University of Rome
"Tor Vergata"





Background and rationale



Mitigation of radiation risks is a needed step for human exploration

A detailed knowledge of the radiation environment is required:

for **accurate risk assessments**

for **developing countermeasures**

to **validate models** for future extrapolations in outer space.

Detailed characteristics of the radiation are needed for all objectives



Contents



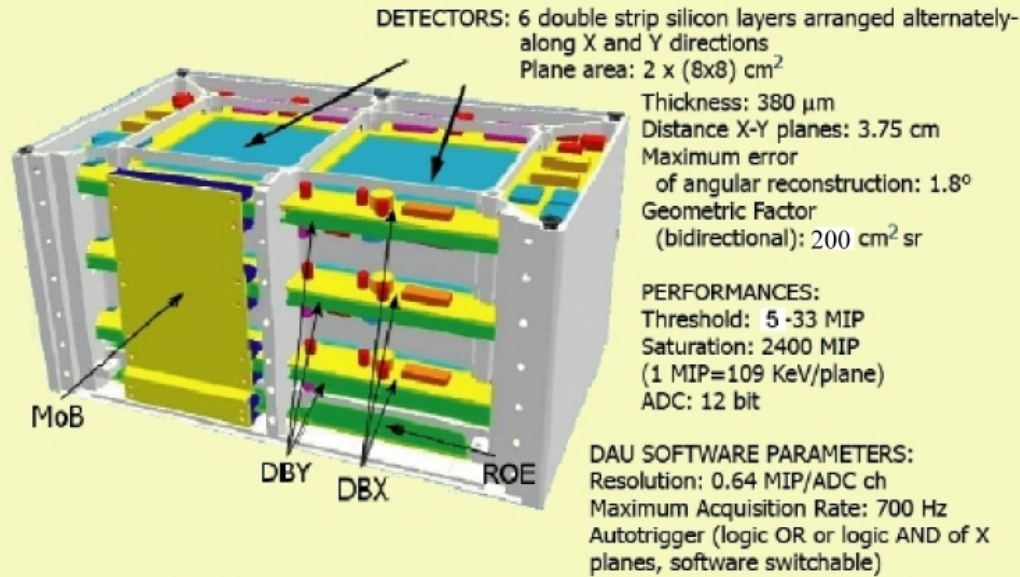
- The detector and the data handling
- New measurements:
 - 3D Survey of the USLab {ALTEA – DOSI, NASA; ALTEA – shield / survey, ESA}
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(first baselined *detailed* space measurements of Polyethylene and Kevlar radiation shielding effectiveness)



ALTEA: the detector

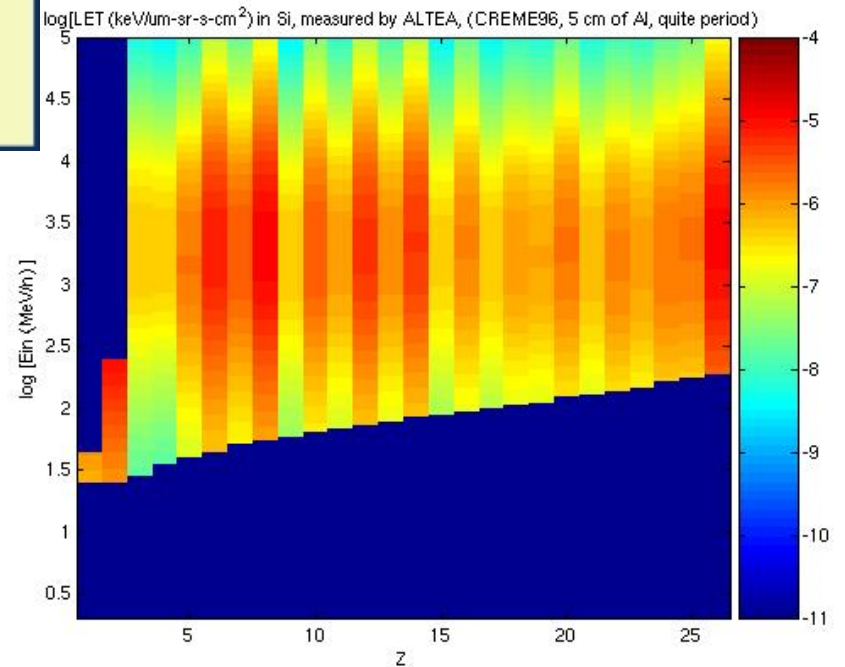


SDU: Silicon Detector Unit



With the current parameters:

$$3 \text{ keV}/\mu\text{m} < \text{LET}(\text{Si}) < 800 \text{ keV}/\mu\text{m}$$

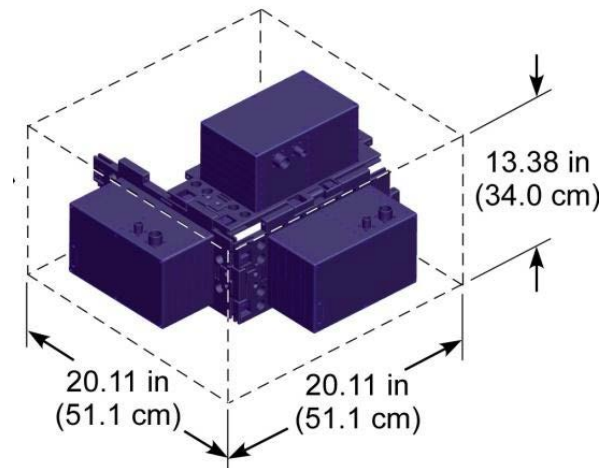
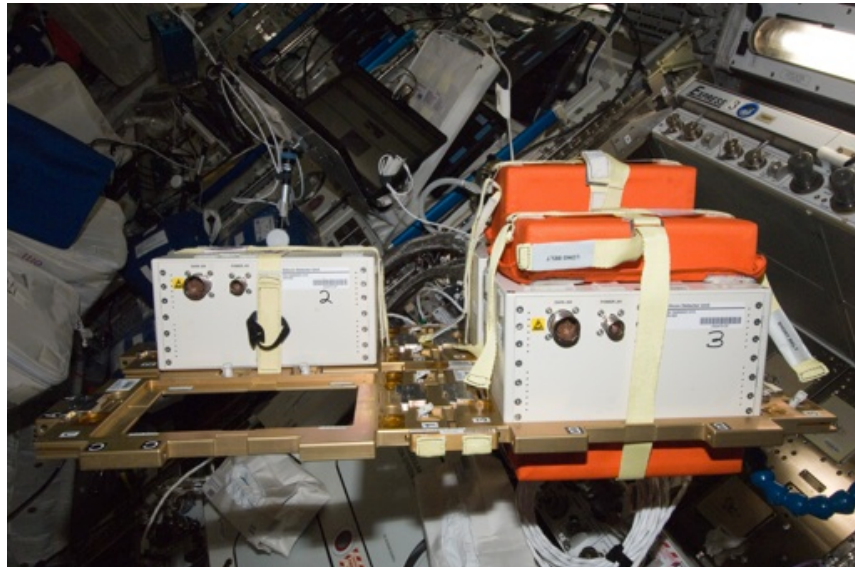




ALTEA: the configurations



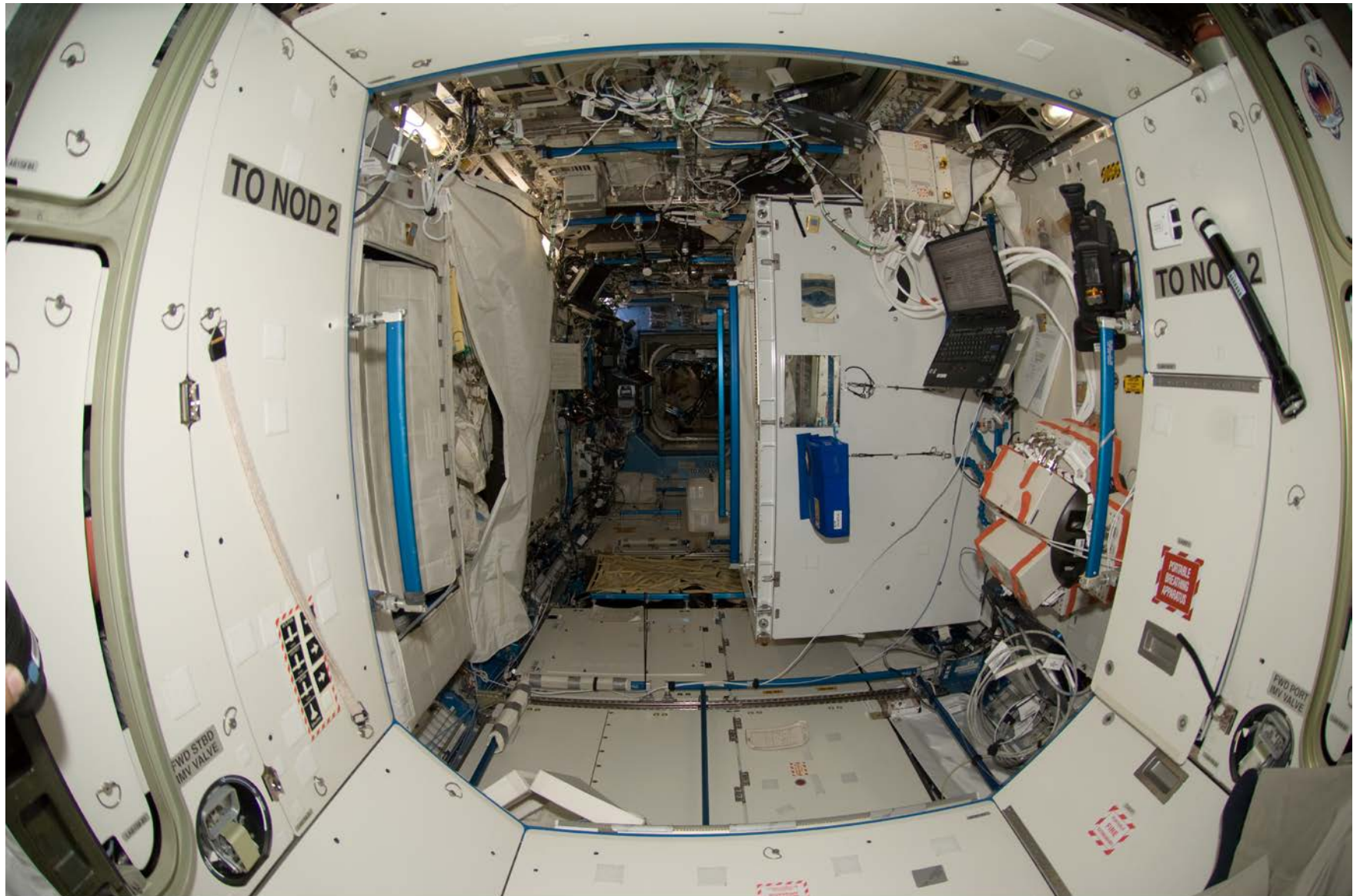
ISS018E046042



Many other configurations are possible with the new mounting system



ALTEA in 2009 (Lab1P1) {DOSI}



S127E011093

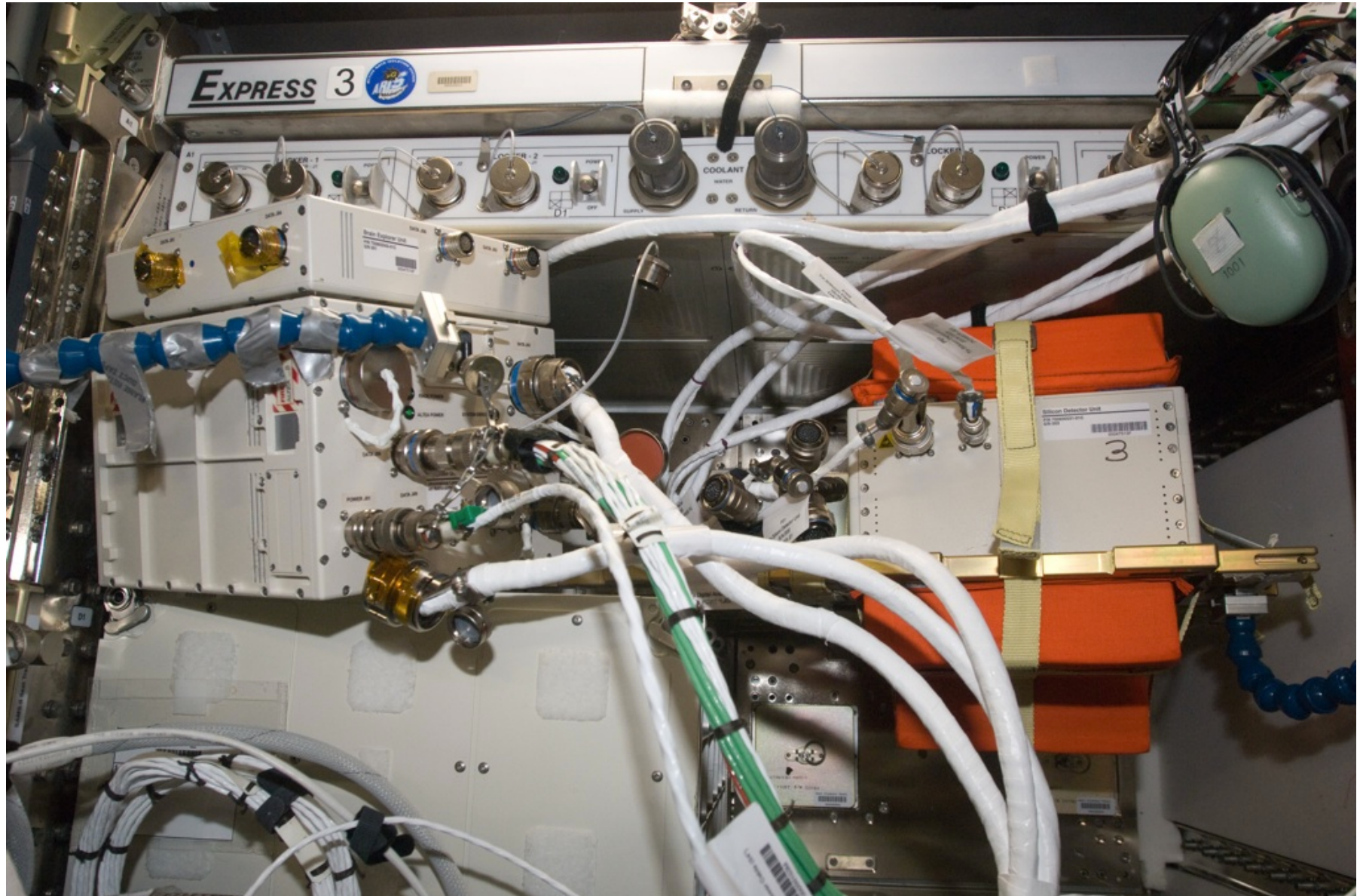


ALTEA in 2011-2012 (Lab1S6) {*shield-survey & DOSI*}



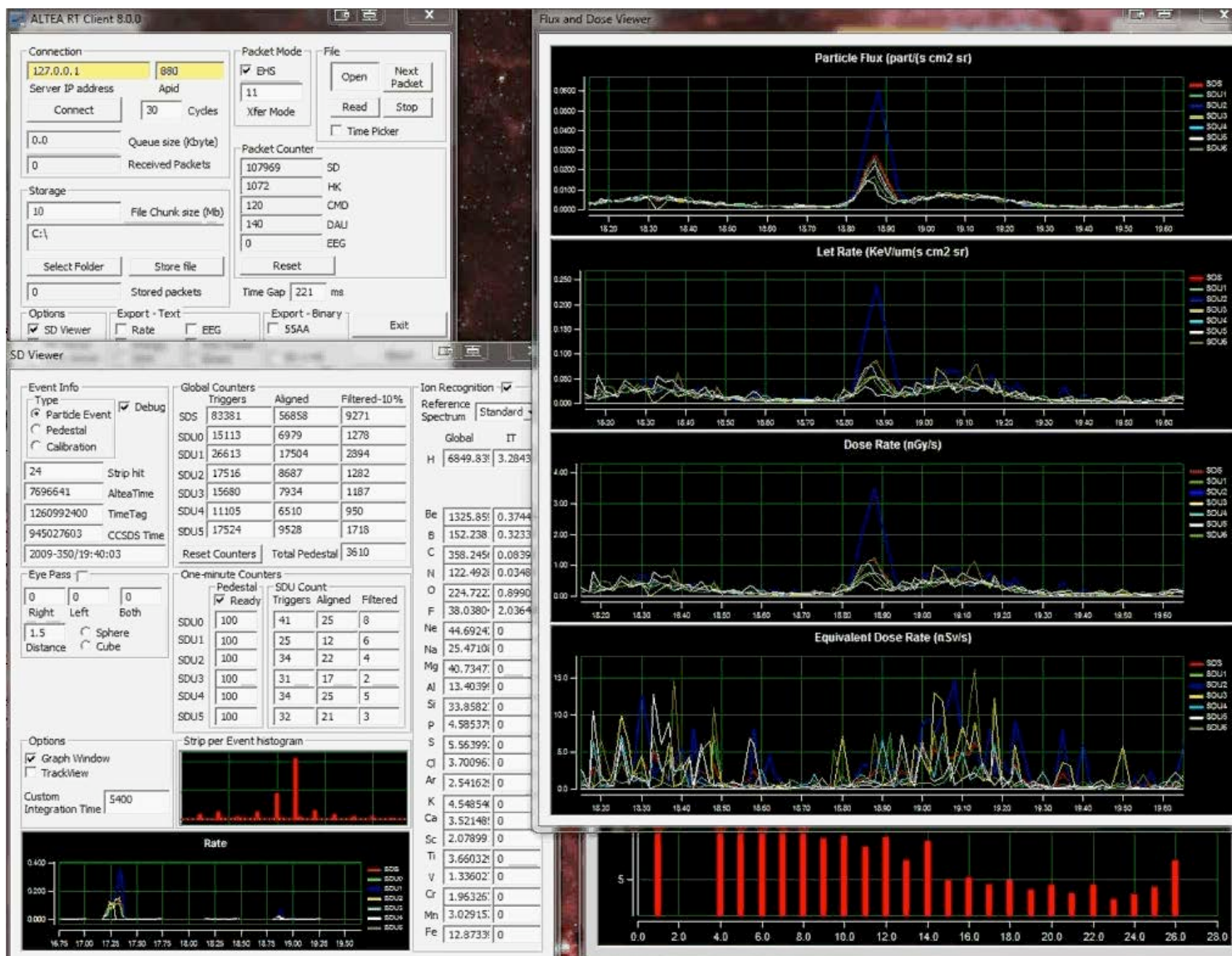


ALTEA in 2012 (Columbus) {*shield-shield*} **NOW**





ALTEA: real time in Rome DFURTV - UHB



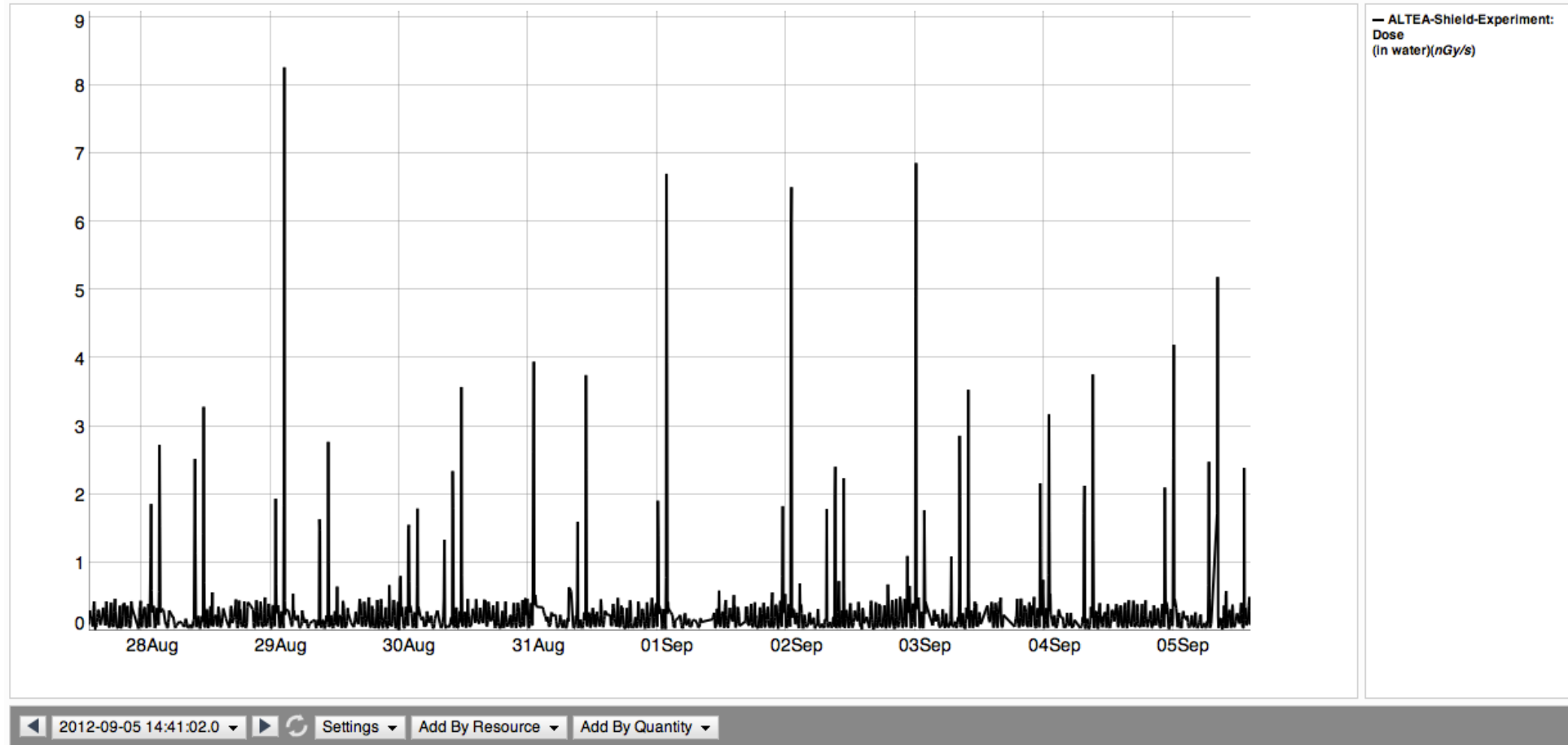


ALTEA: real time in NASA – GSFC [iSWA – web]



Data Sharing Agreement Between **ESA's** ALTEA-shield experiment and **ASI's** ALTEA experiment with **NASA GSFC** Space Weather Laboratory

iSWA Custom Timeline Cygnet



PUBLIC:

http://iswa.ccmc.gsfc.nasa.gov:8080/IswaSystemWebApp/index.jsp?i_1=388&l_1=4&t_1=27&w_1=1239&h_1=614&s_1=0



ALTEA: running times



Light Flashes sessions

2006

Aug 2006

Lab1P1

2007

Lab1P2

2008

Memorandum of AGREEMENT BETWEEN NASA AND THE
AGENZIA SPAZIALE ITALIANA (ASI)
On Ground Segment Infrastructure and Joint Operations
Support for the instrument - Anomalous Long Term Effects in
Astronauts (ALTEA)

2009

Lab1P1

2010

Lab1O2

ALTEAshield/survey (ESA sponsored)

Lab1O2

Lab1S1

Lab1O2

2011

Lab1P4

Lab1S6

2012

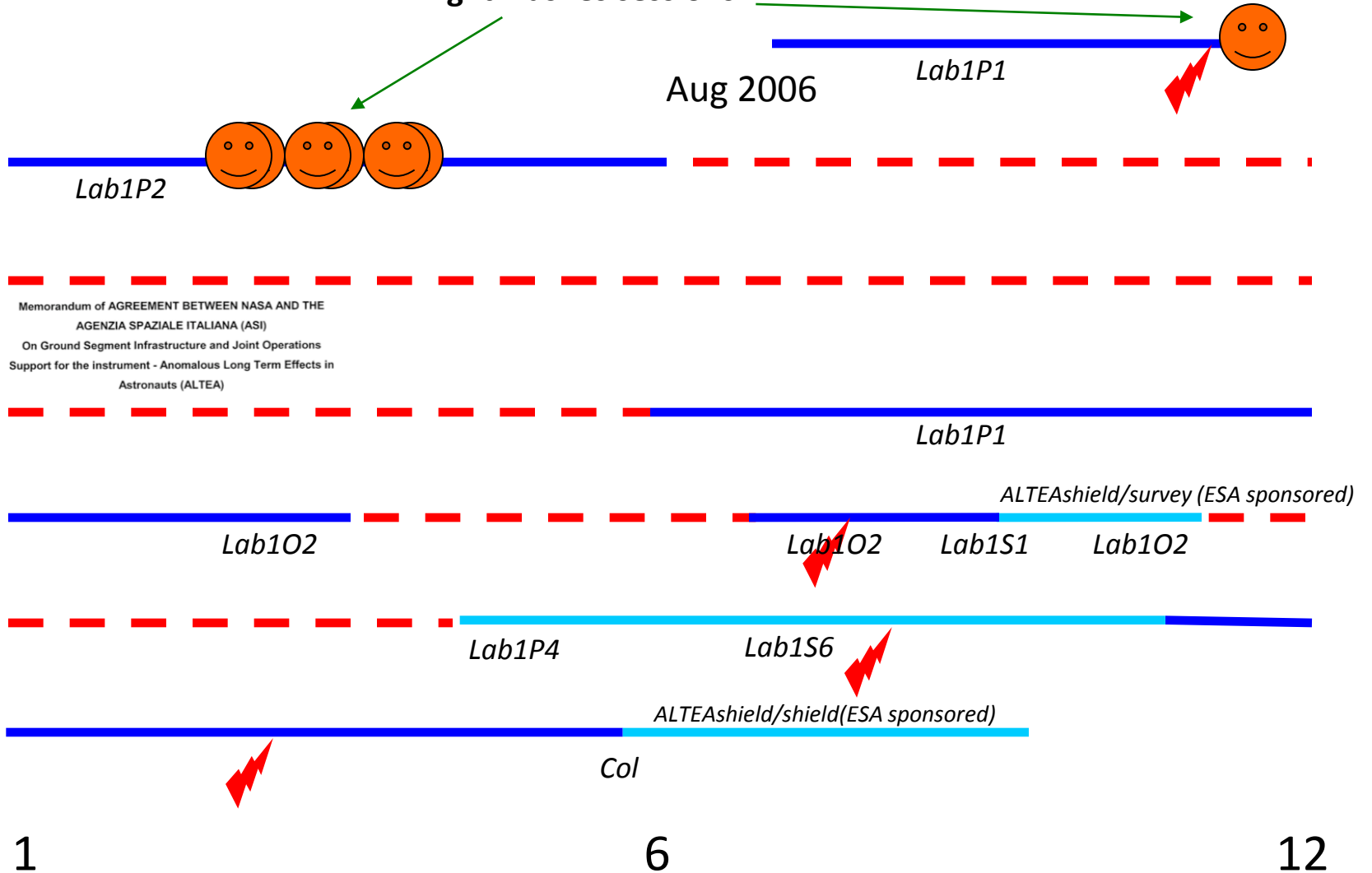
ALTEAshield/shield(ESA sponsored)

Col

1

6

12





Experiments 2006 – 2012 {*integrated results summary*}



<i>year</i>	<i>location</i>	<i>experiment</i>	<i>approximate duration (d)</i>	<i>Flux</i> <i>n/(s cm² sr)*</i>	<i>Dose rate</i> <i>nGy/s *</i>	<i>Dose Eq rate</i> <i>nSv/s*</i>
2006 – 7	Lab1P1-2	ALTEA-DOSI (ASI)	224			
2009	Lab1P1	ALTEA-DOSI (ASI-NASA)	180	0.00355	0.205	1.15
2010	Lab1P1	ALTEA-DOSI (ASI-NASA)	47	0.00347	0.199	1.08
2010	Lab1O2	ALTEA-DOSI (ASI-NASA)	23	0.00344	0.202	1.17
2010	Lab1S1	ALTEA-shield/survey pos 1 (ESA)	15	0.00390	0.239	1.47
2010	Lab1O2	ALTEA-shield/survey pos 2 (ESA)	42	0.00328	0.200	1.24
2011	Lab1P4	ALTEA-shield/survey pos 3 (ESA)	90	0.00331	0.185	0.941
2011	Lab1S6	ALTEA-shield/survey pos 4 (ESA)	136	0.00342	0.194	1.10
2012	Lab1S6	ALTEA (ASI-NASA)	128	0.00409	0.226	1.20
2012	Col	ALTEA-shield/shield [Poly] (ESA)	62	0.00373	0.225	1.70
2012	Col	ALTEA-shield/shield [Kevl] (ESA)	17	0.00383	0.229	1.71

* Averaged over the three directions / whole period, errors $\approx \leq 1\%$



Contents

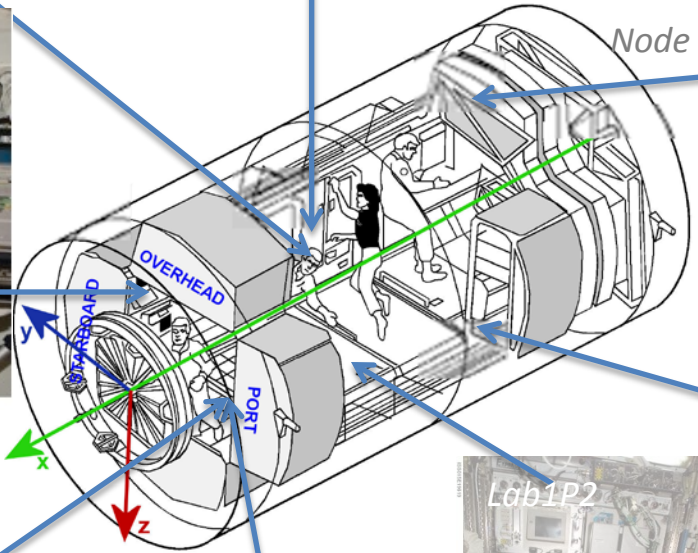
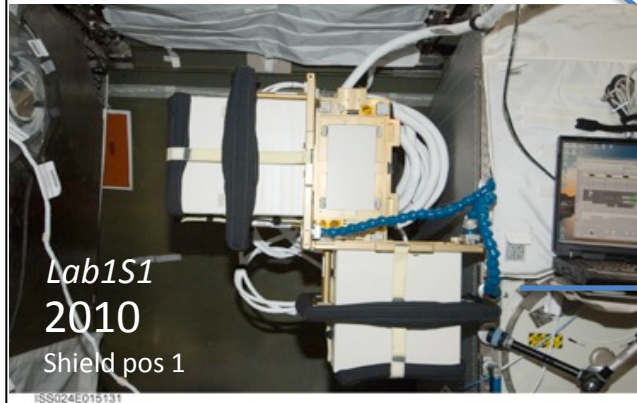
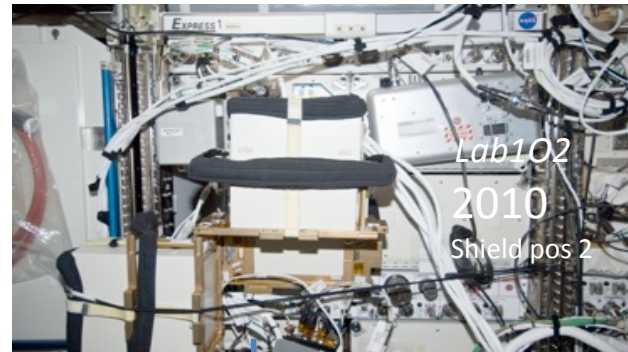
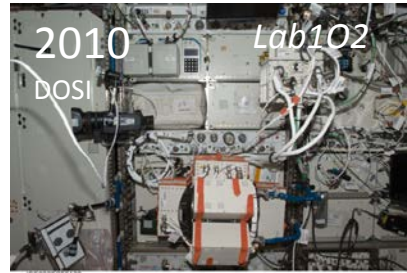


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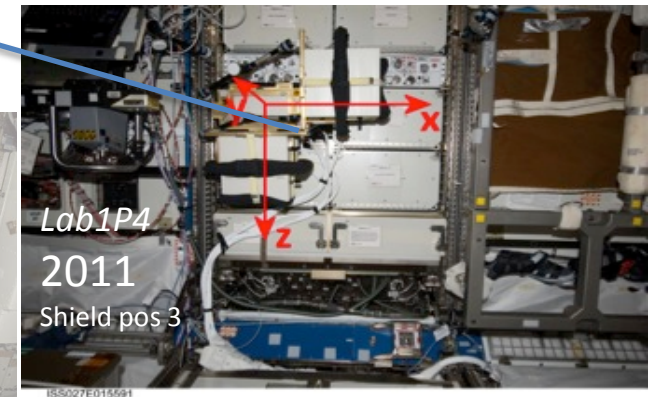
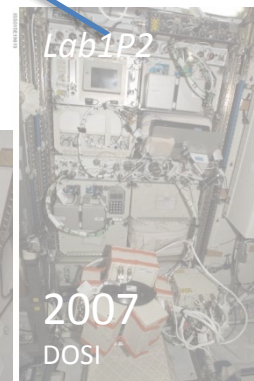
Preliminary drafted results



ALTEA: USLab survey

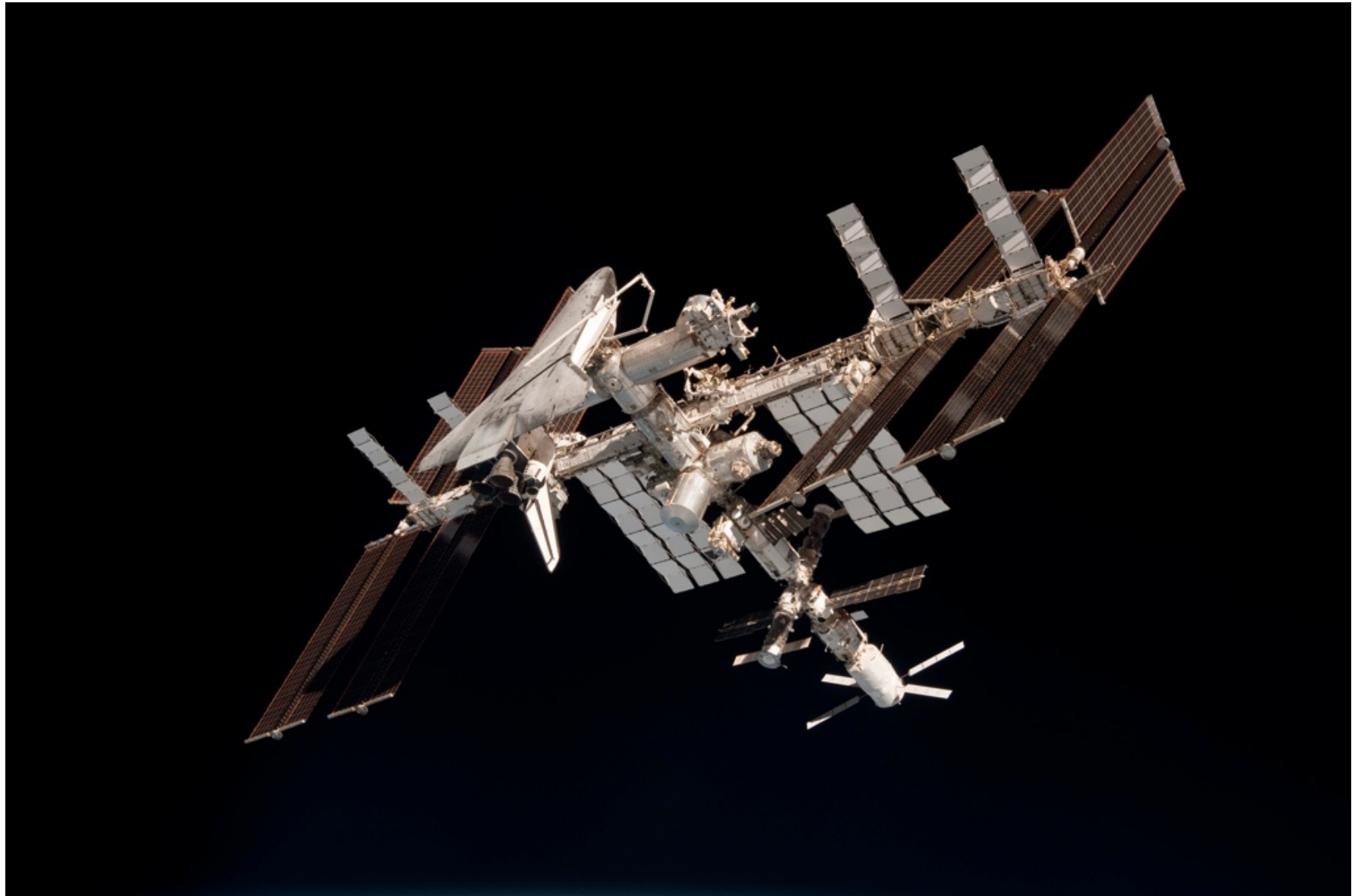


Errors on flux values along y and z: few %



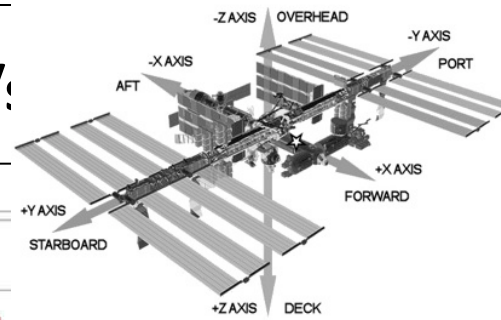


The ISS .. And its very complex shielding

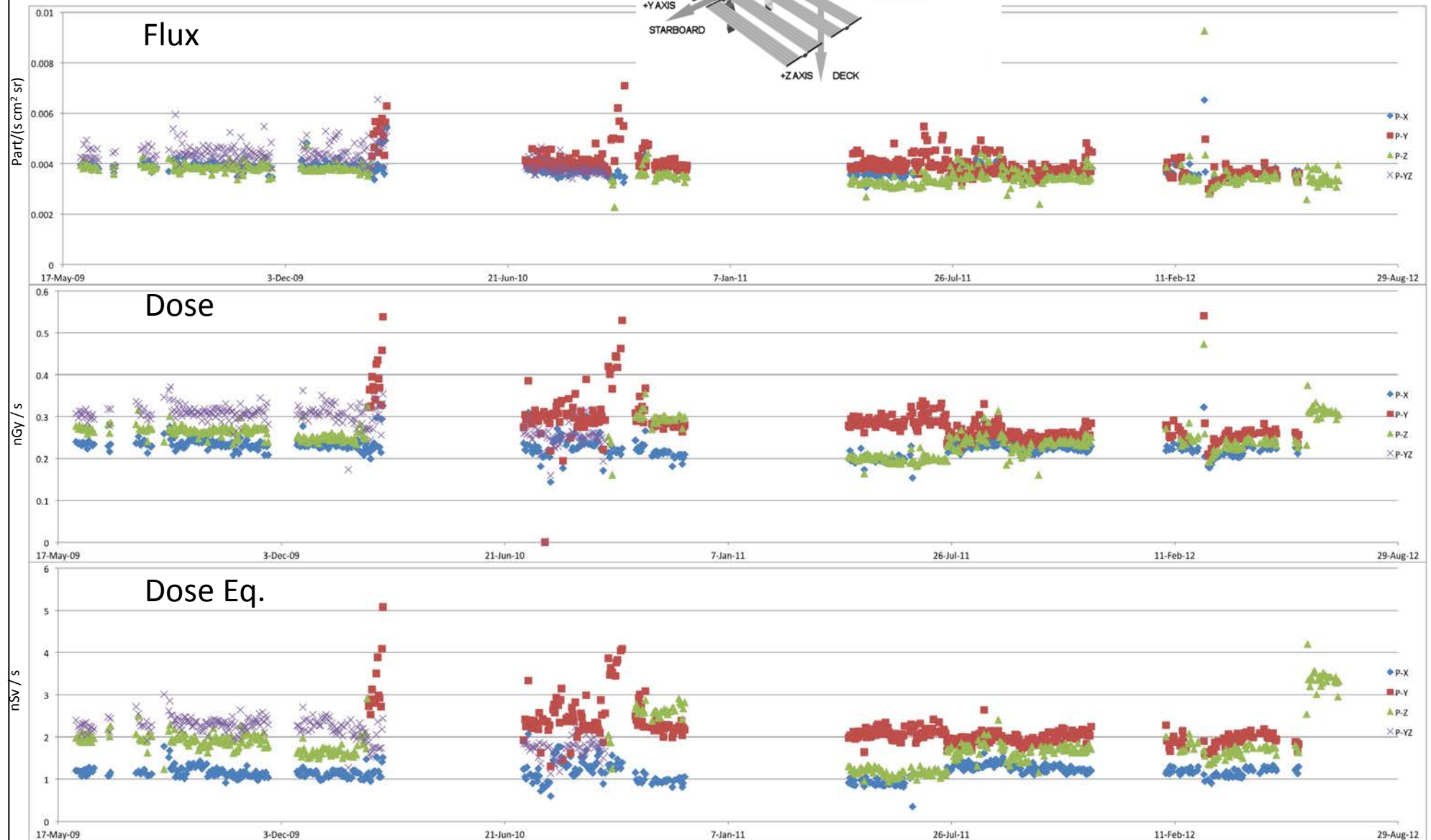




ALTEA DOSI & shield/

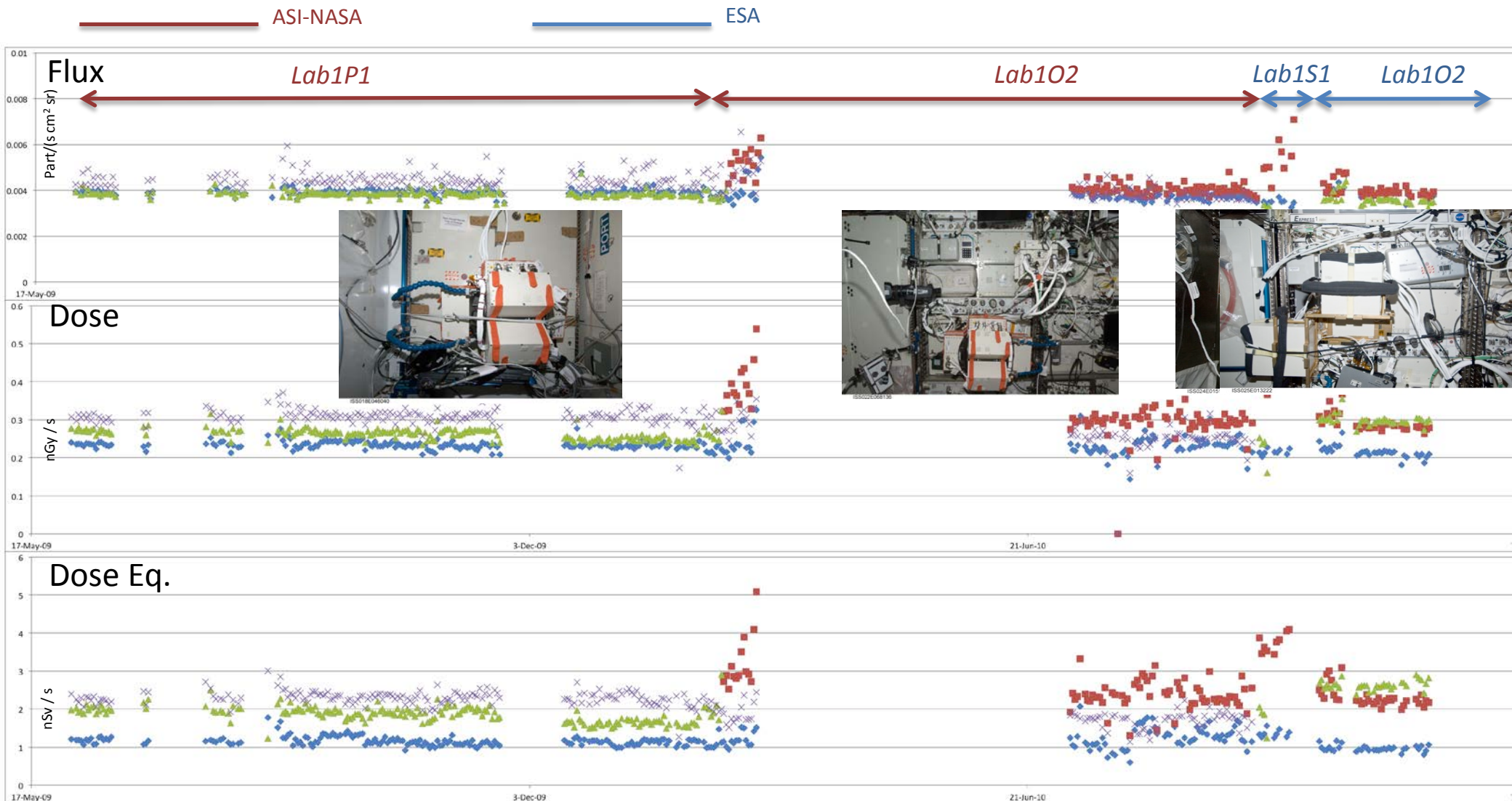


monitoring





ALTEA DOSI & shield/suvey – 3 years 3D monitoring





ALTEA DOSI & shield/survey – 3 years 3D monitoring



ASI-NASA

ESA

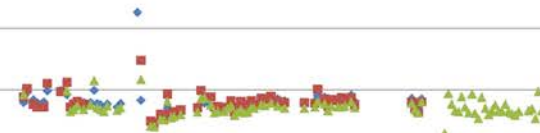
Flux

Lab1P4

Lab1S6

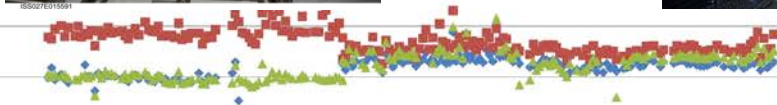
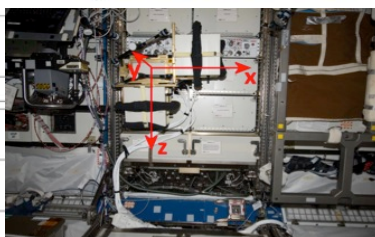
Lab1S6

Columbus



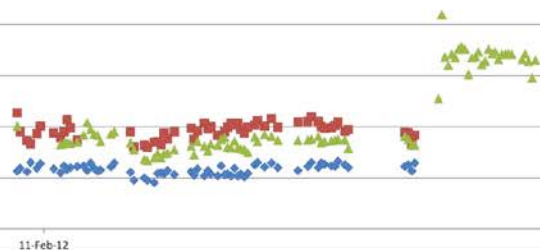
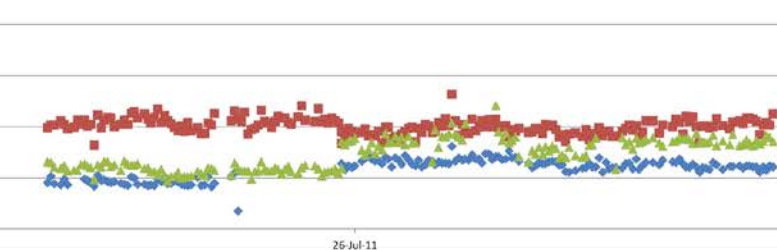
P-X
P-Y
P-Z
P-YZ

Dose



P-X
P-Y
P-Z
P-YZ

Dose Eq.



P-X
P-Y
P-Z
P-YZ

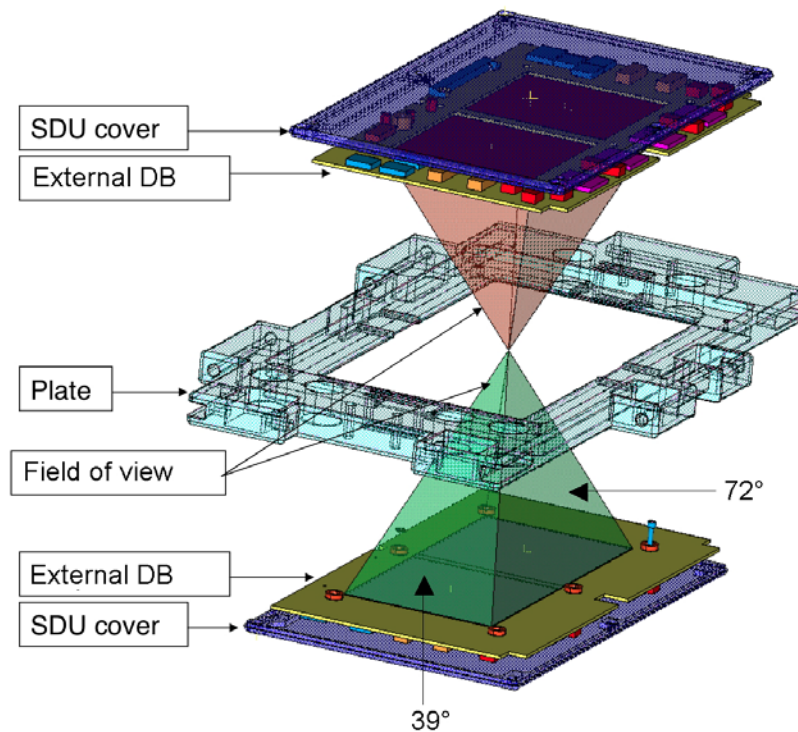


ALTEA shield/survey – 3D monitoring {small FOV}



Field Of View (FOV) with a single SDU: $90^\circ \times 129^\circ$

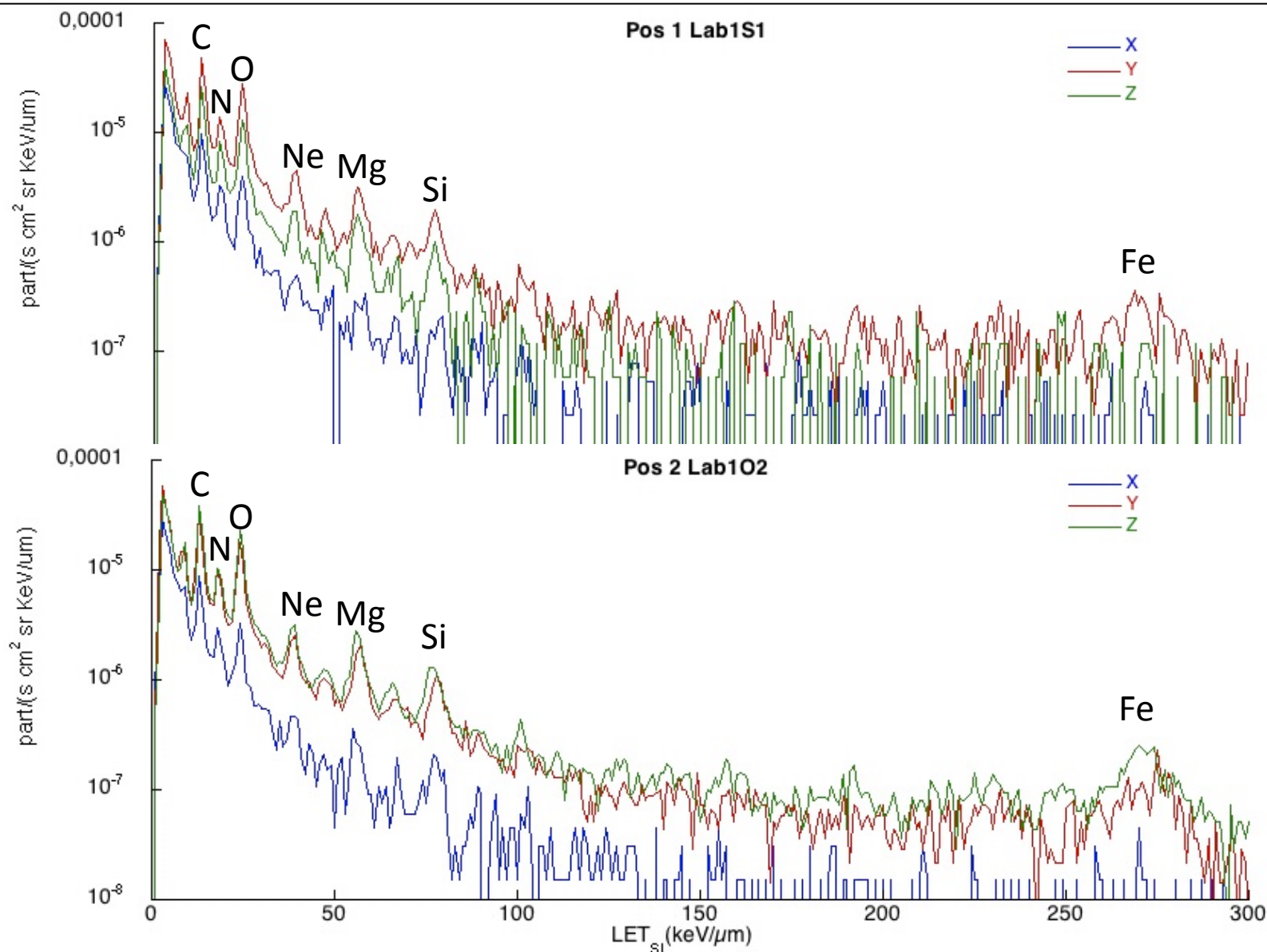
Field Of View (FOV) with a double SDU: $39^\circ \times 72^\circ$



Double SDUs
permit
better
nuclear
identification
capability
{analysis still
in progress}

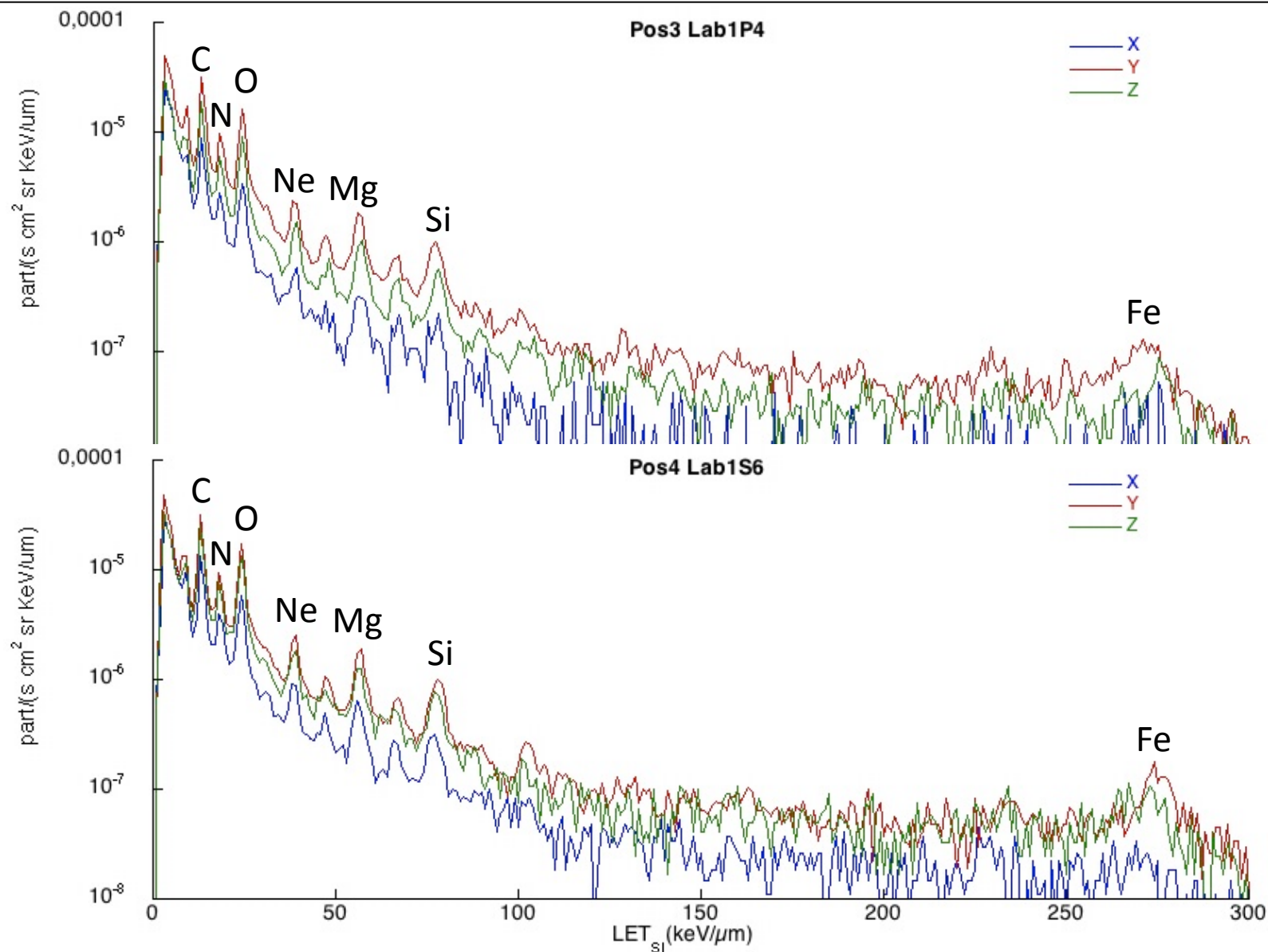


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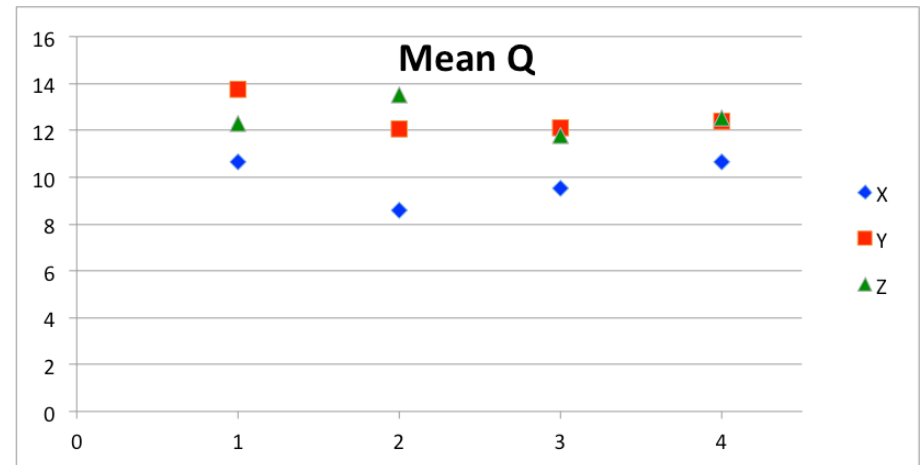
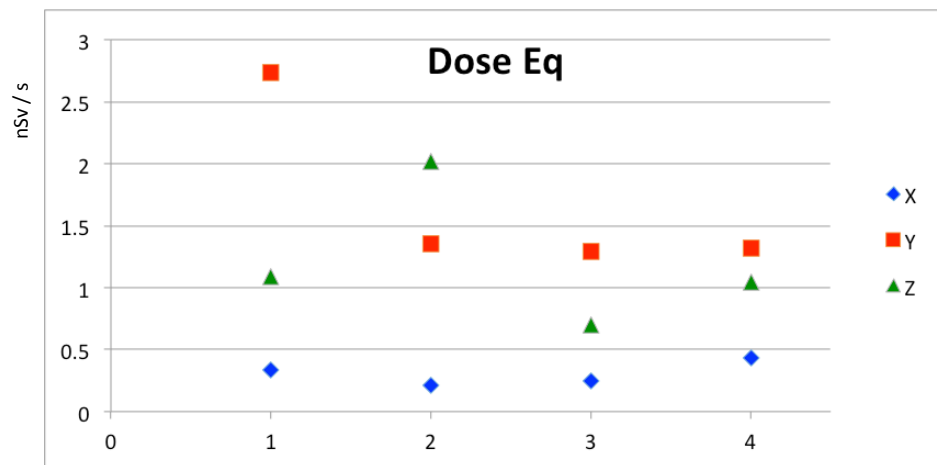
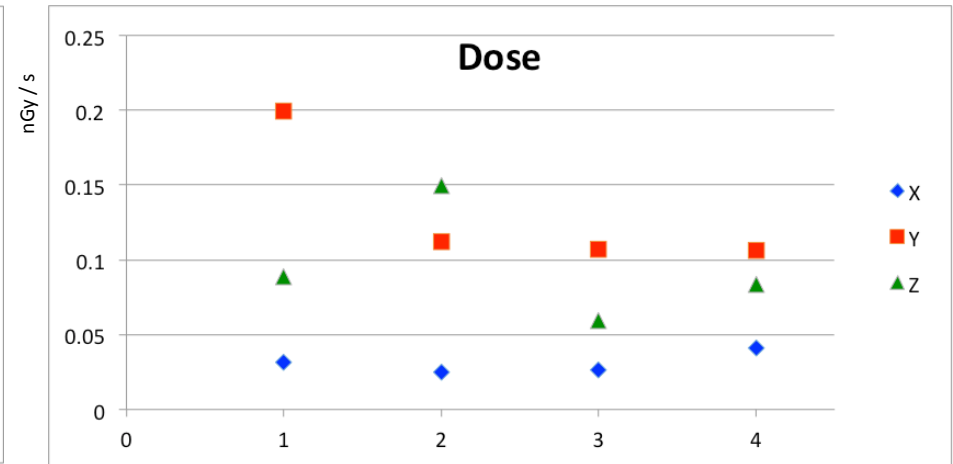
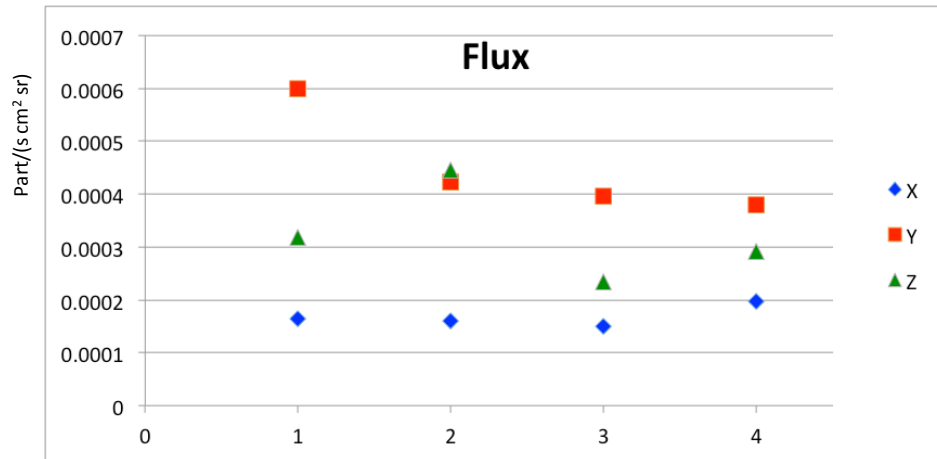


ALTEA shield/survey – 3D monitoring {small FOV}





ALTEA shield/survey – 3D monitoring {small FOV}





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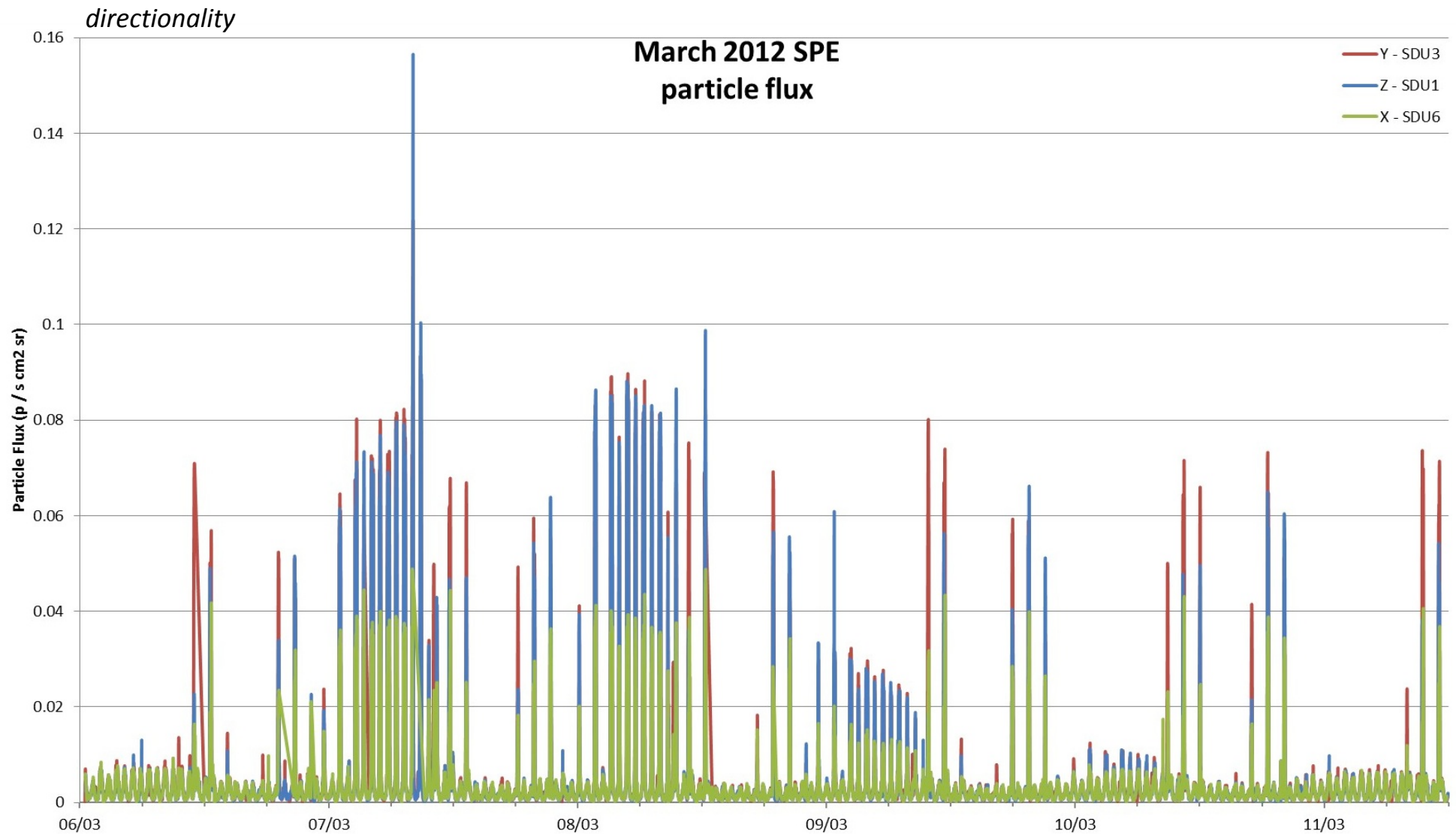


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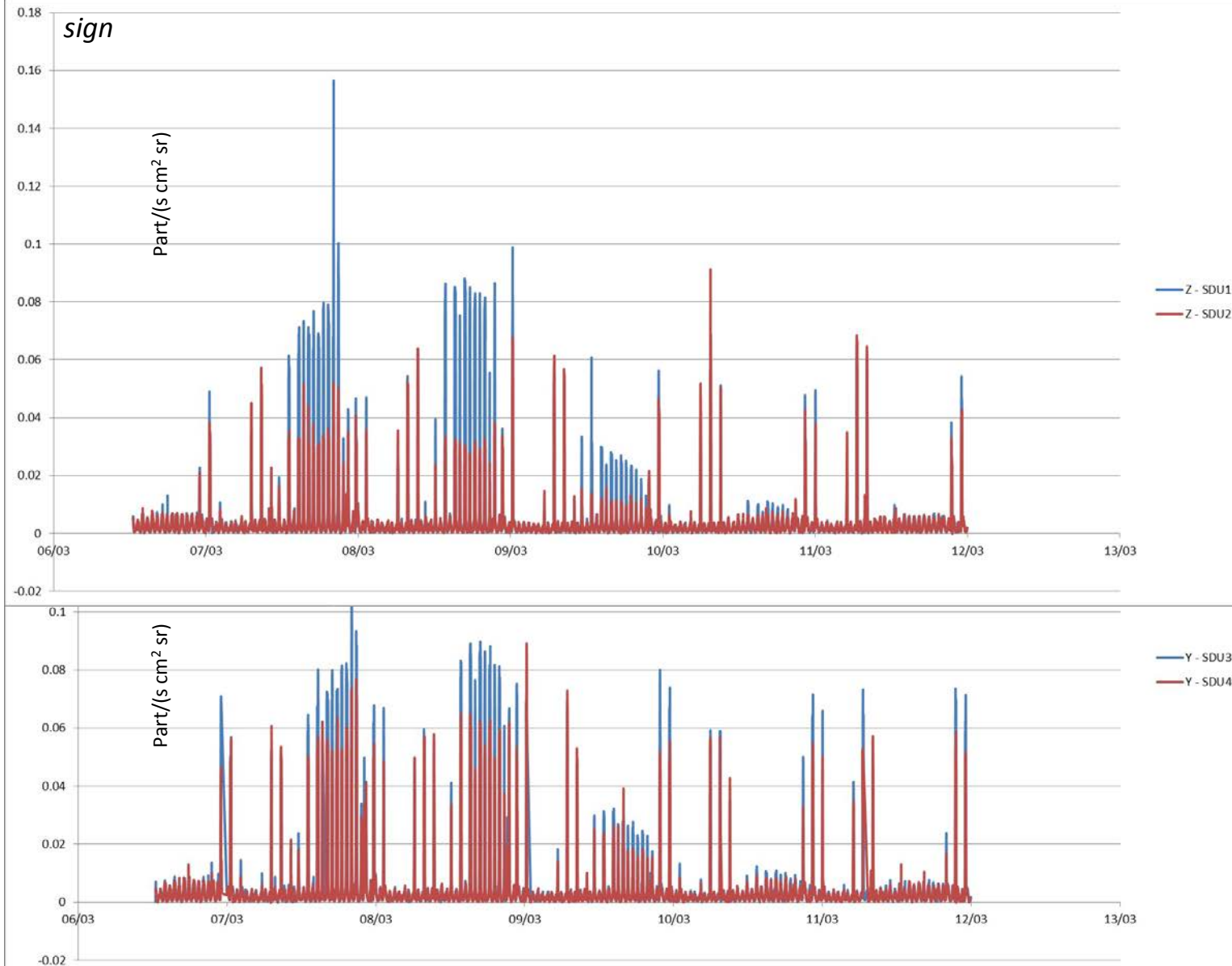


ALTEA: March 2012 SPE





ALTEA: March 2012 SPE

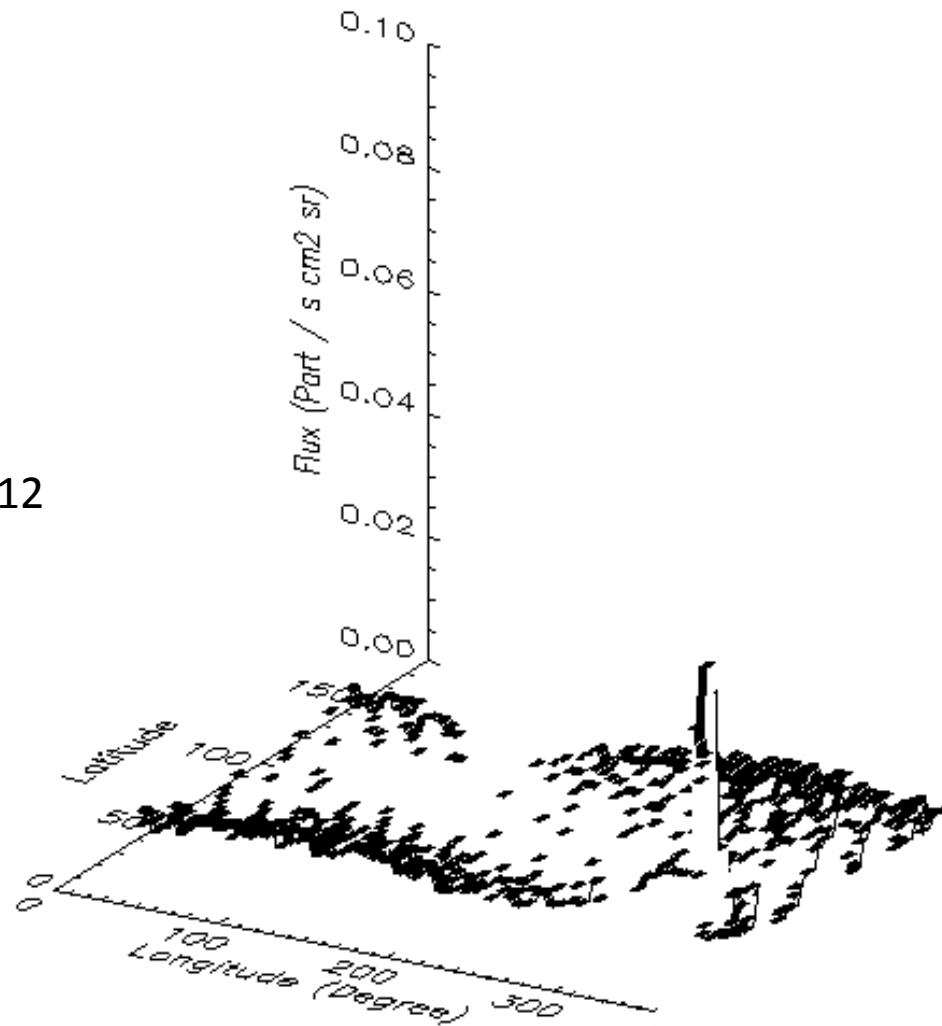




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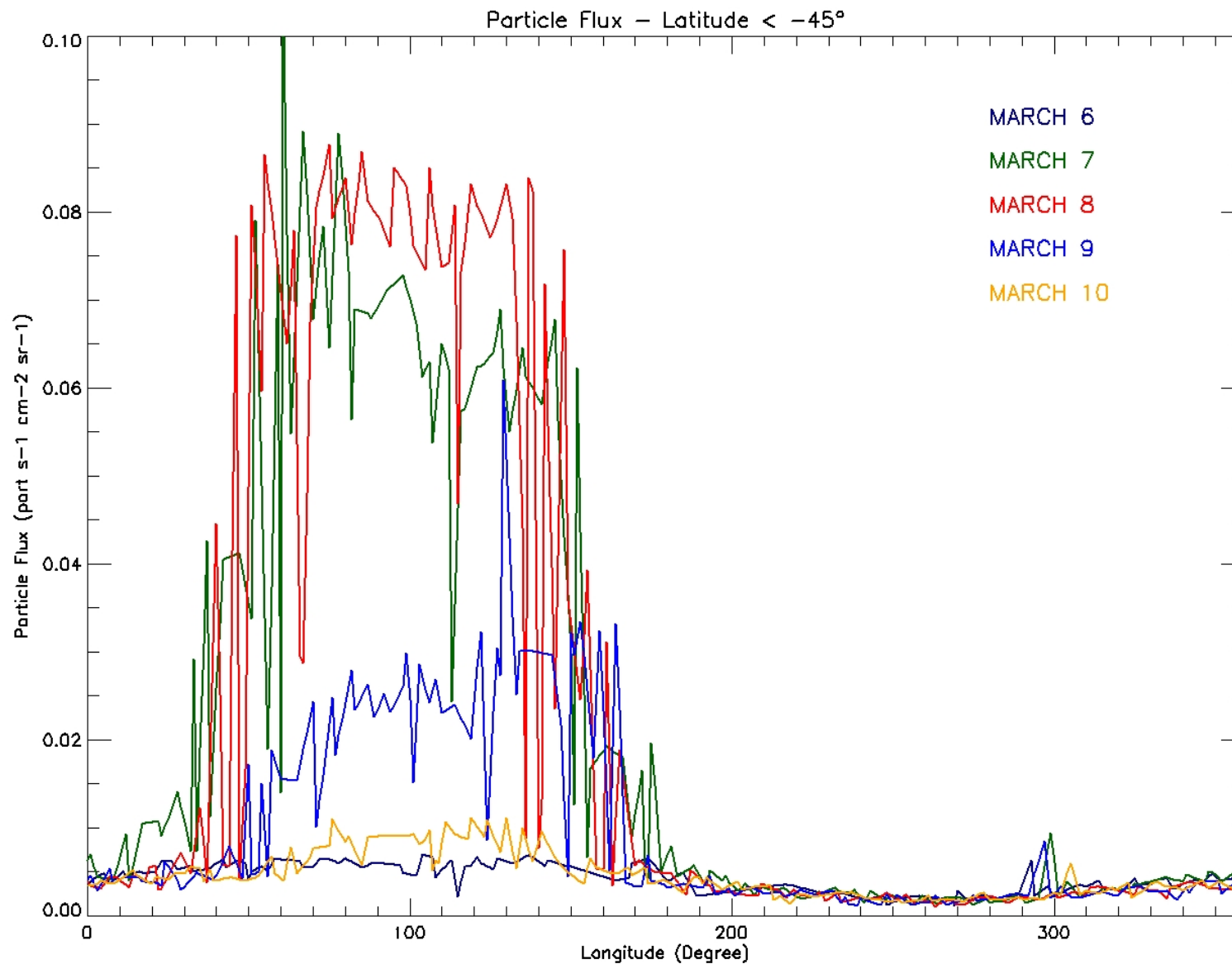


March 11 2012



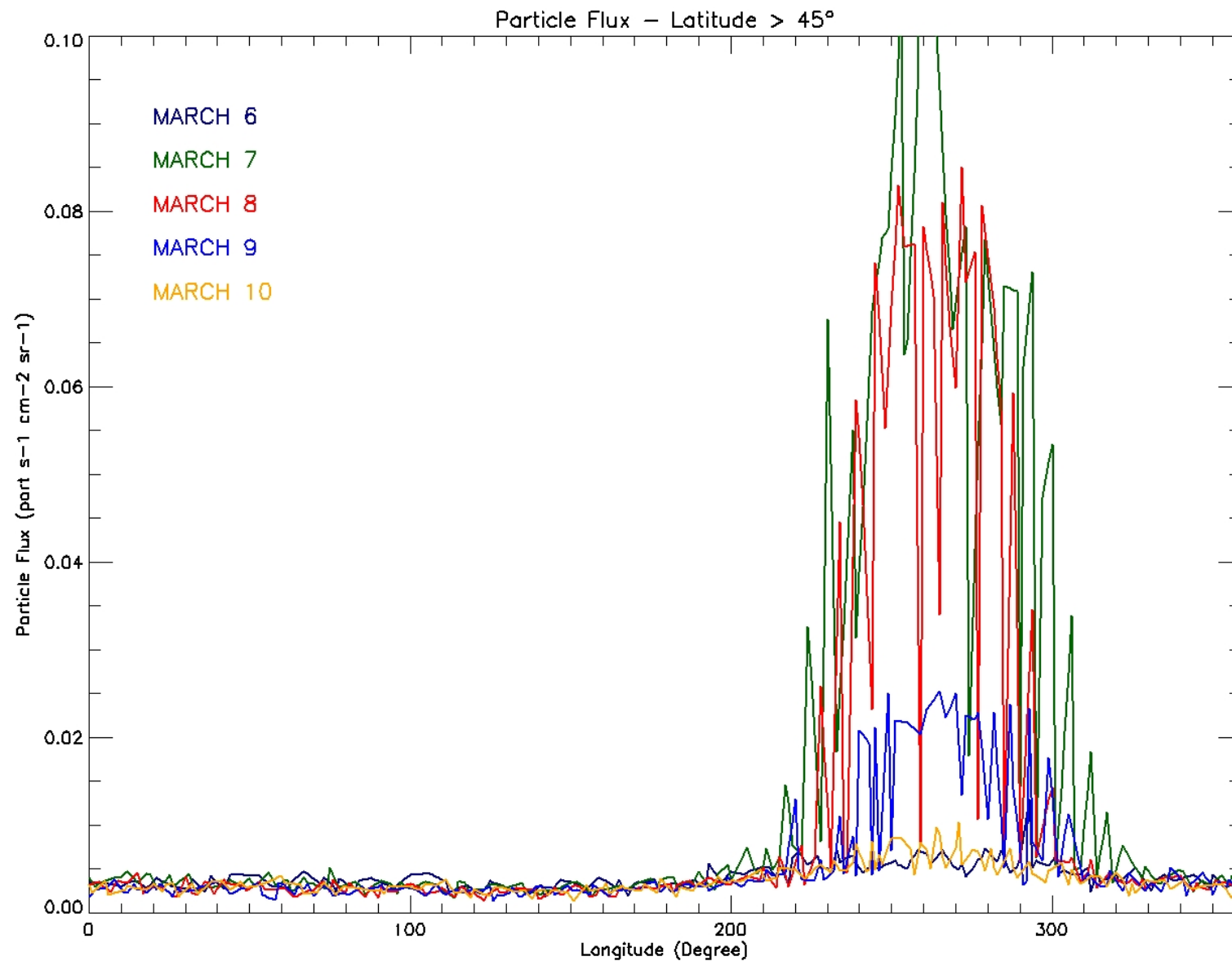


ALTEA: March 2012 SPE



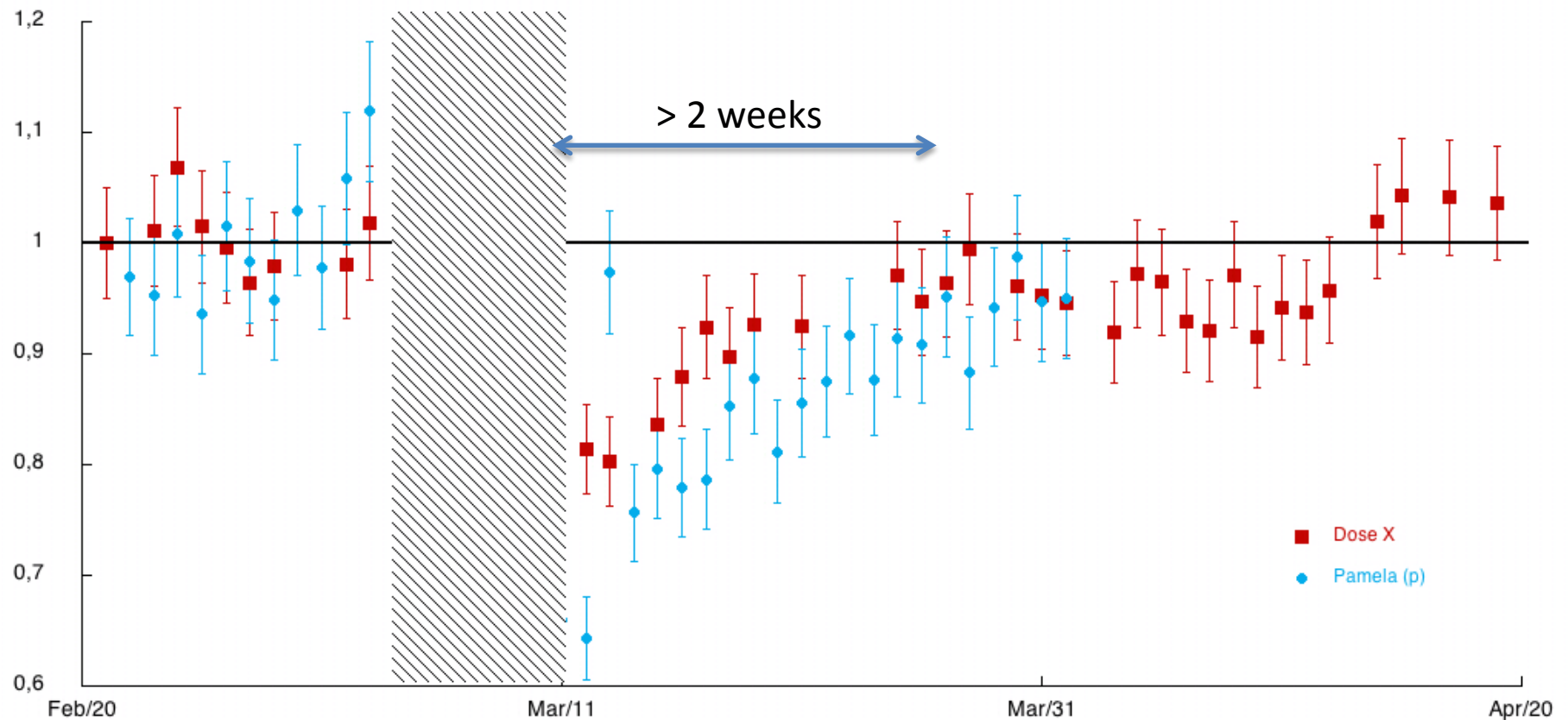


ALTEA: March 2012 SPE





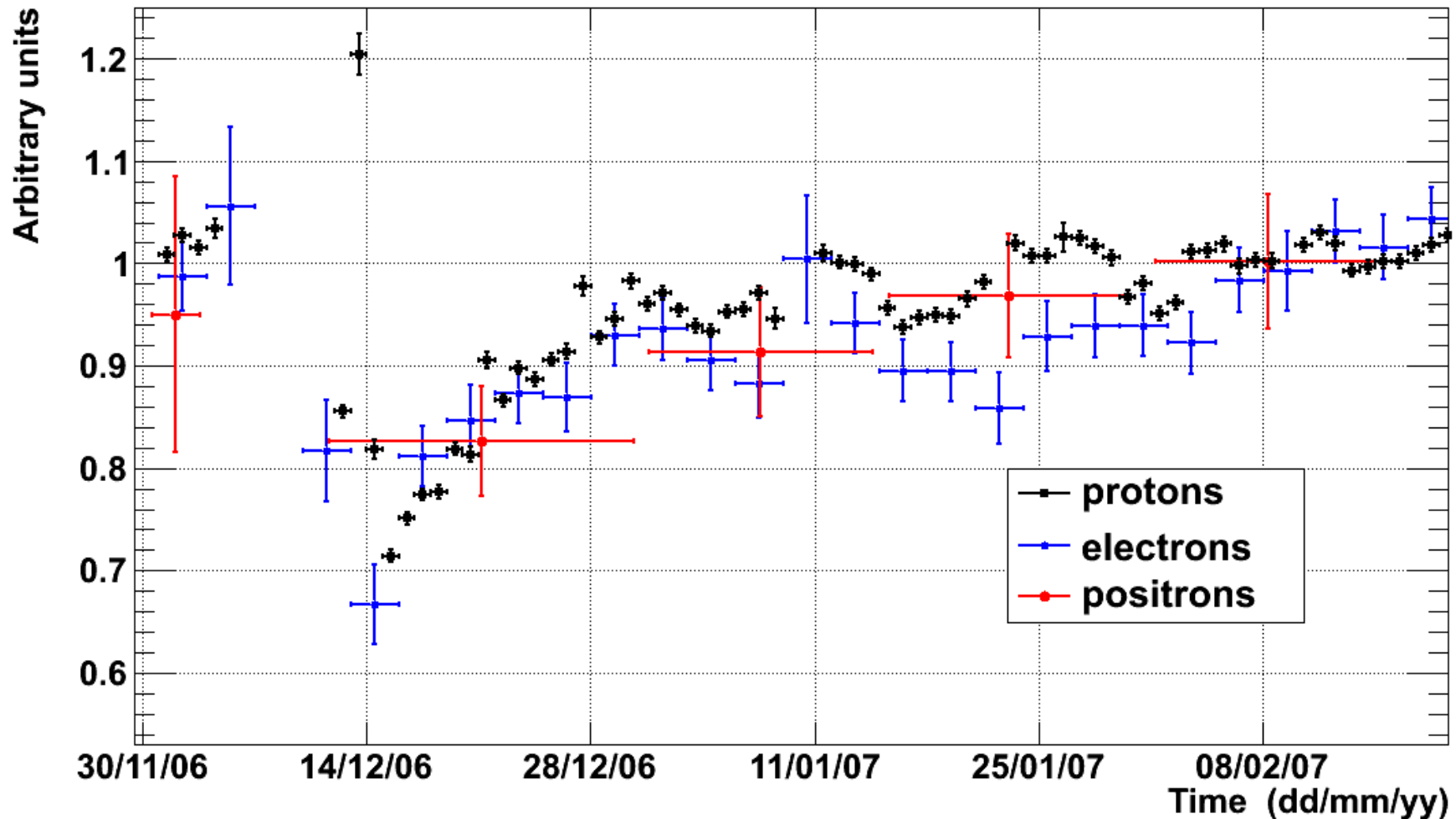
ALTEA: March 2012 SPE – Forbush decrease



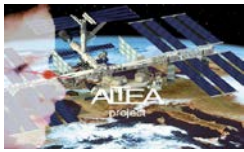
Pamela data preliminary and confidential

Forbush decrease – protons, electrons and positrons

Rigidity from 1.57 to 5.70 GV



Confidential From Pamela Collaboration



Contents

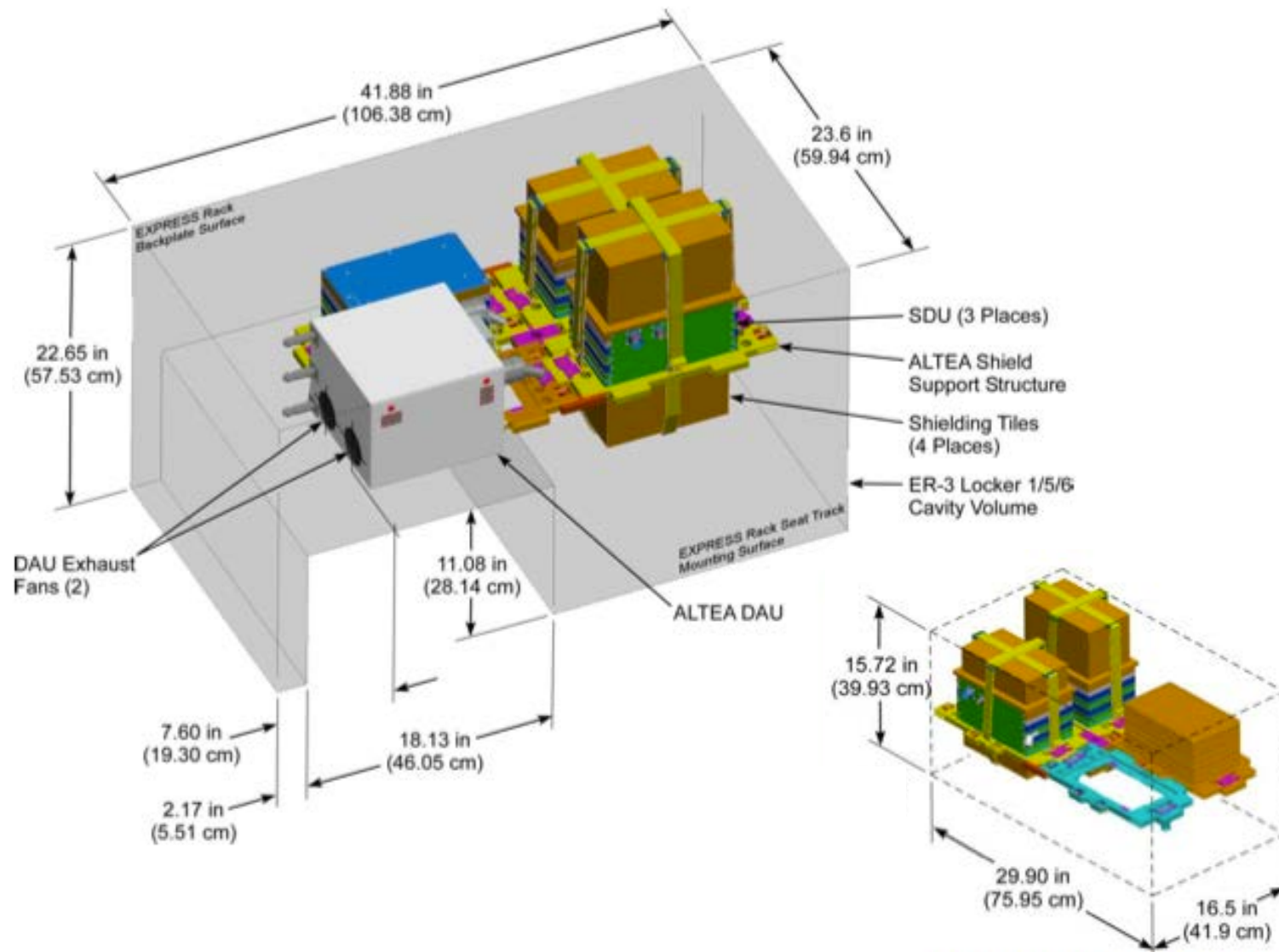


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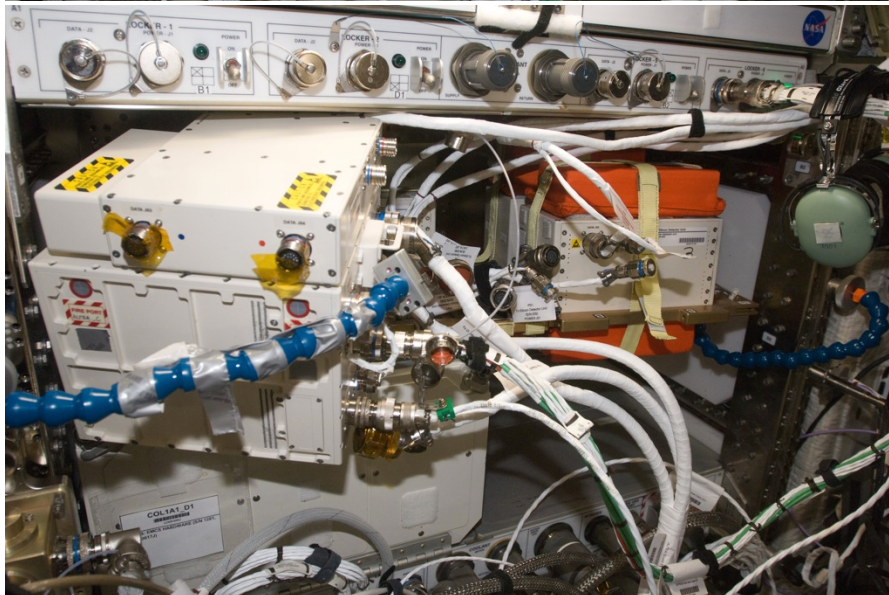
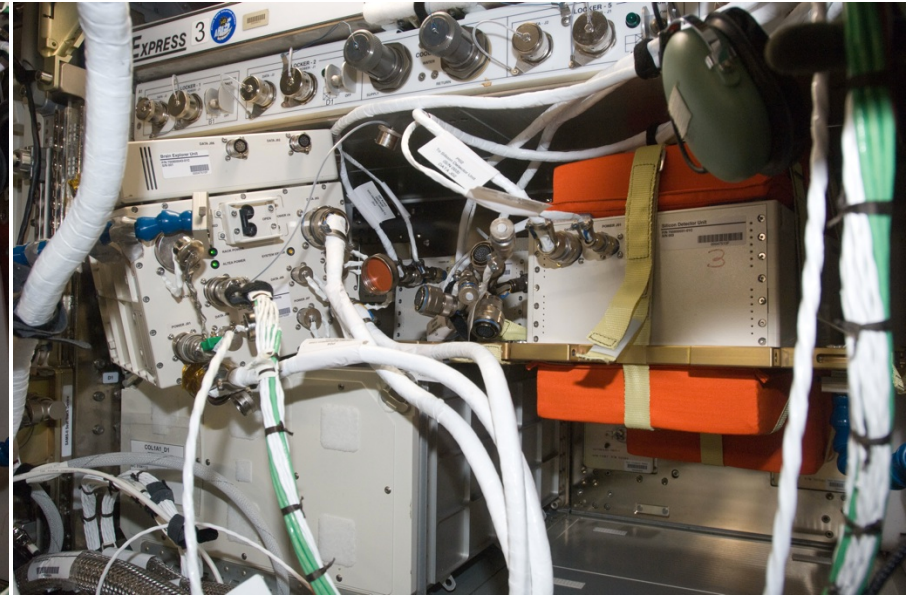
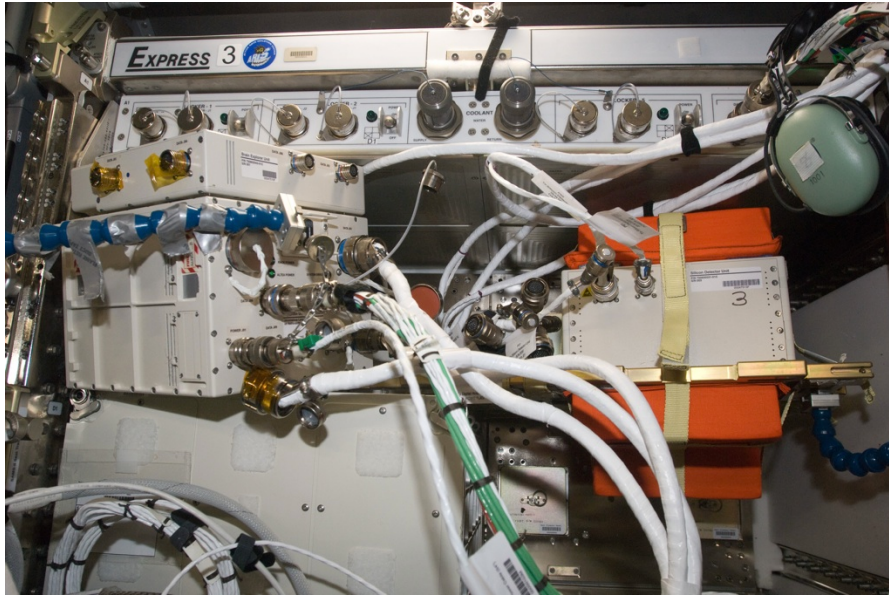


ALTEA in Columbus: shield - shield





ALTEA in Columbus: shield - shield



2012 ... *now running*

Polyethylene

Kevlar

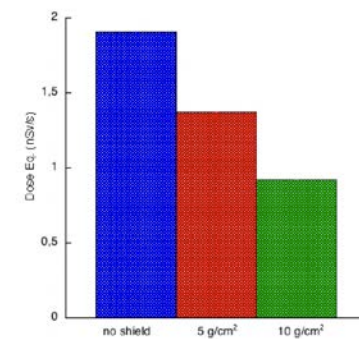
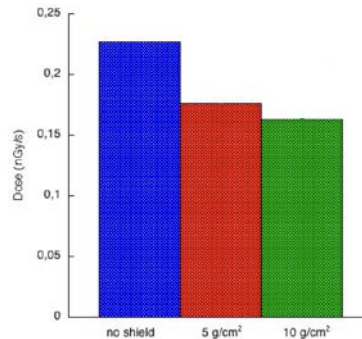
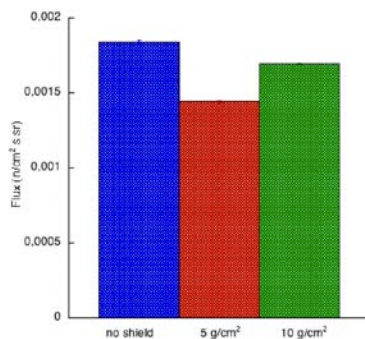
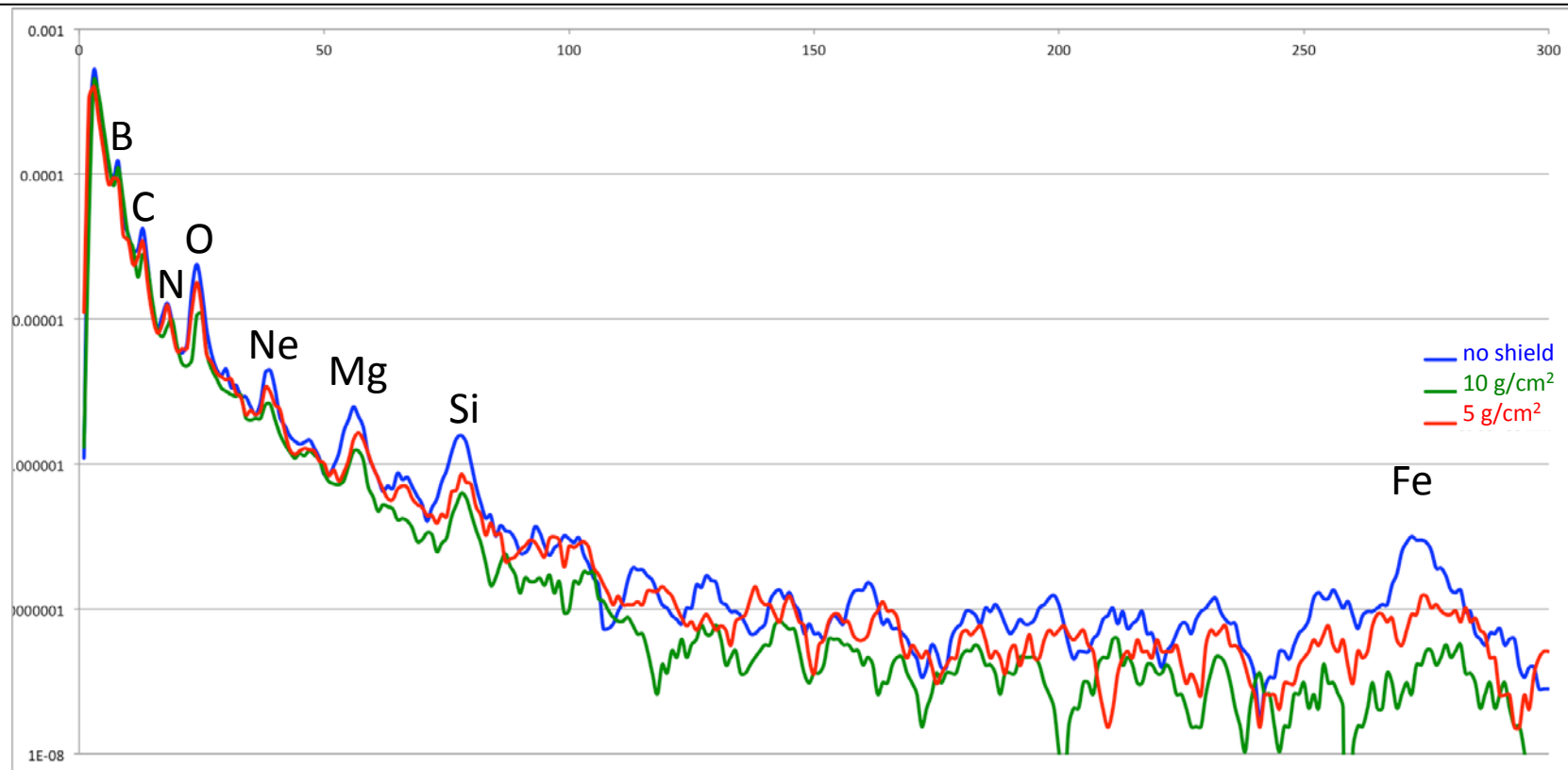
June 8th – Aug 9th

Aug 8th – Oct 10th

2 shielding values: 5 g/cm² and 10 g/cm²

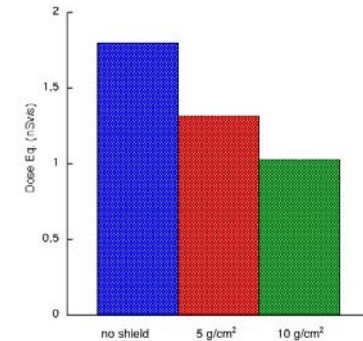
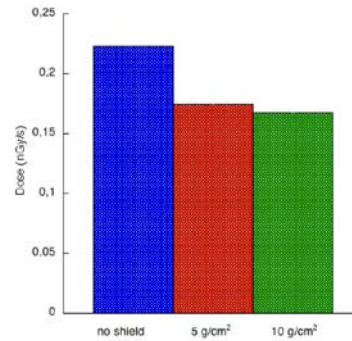
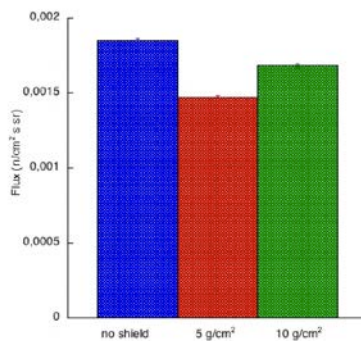
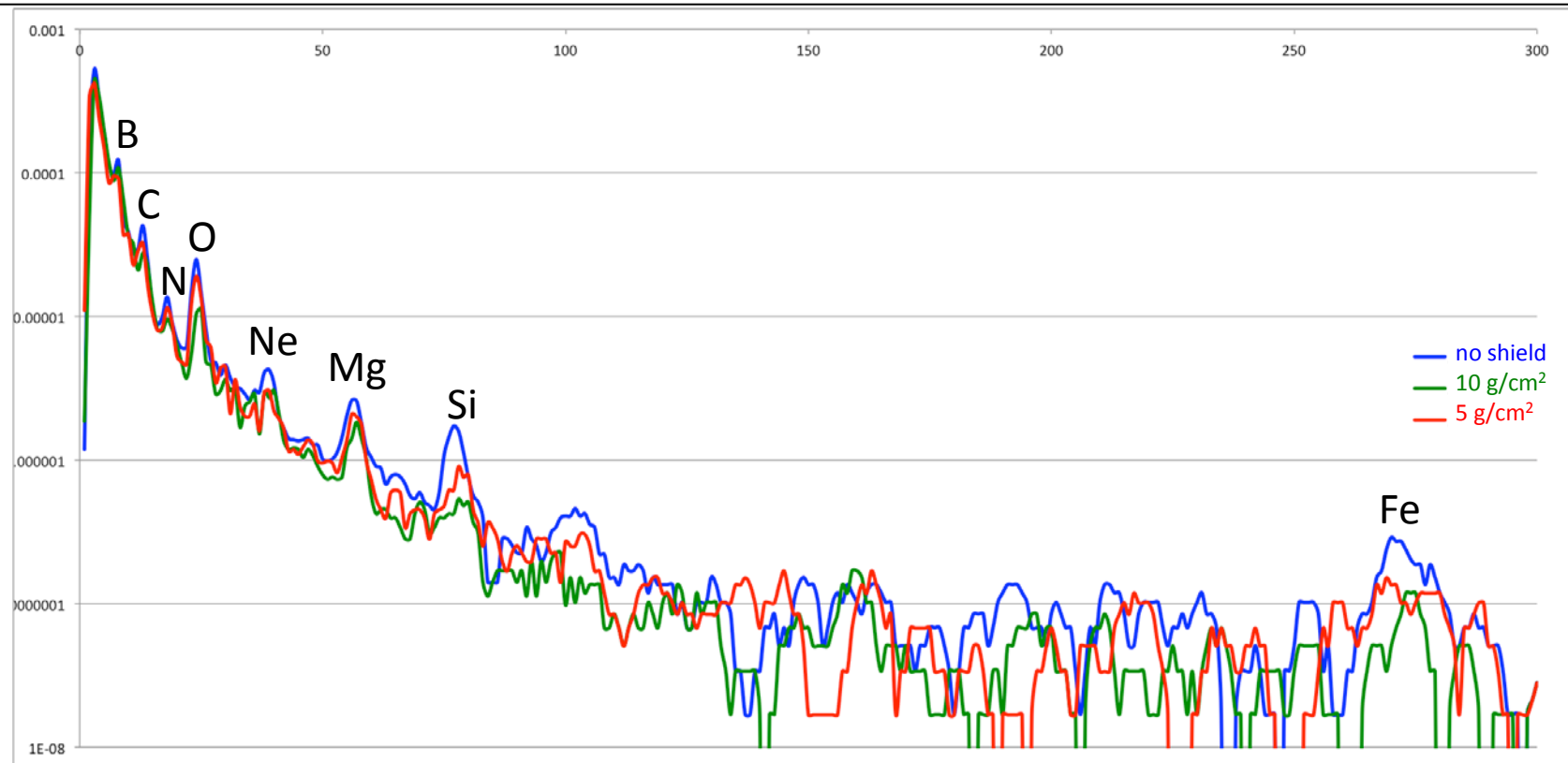


ALTEA in Columbus: shield – shield {Polyethylene}





ALTEA in Columbus: shield – shield {Kevlar, to Aug 18th}

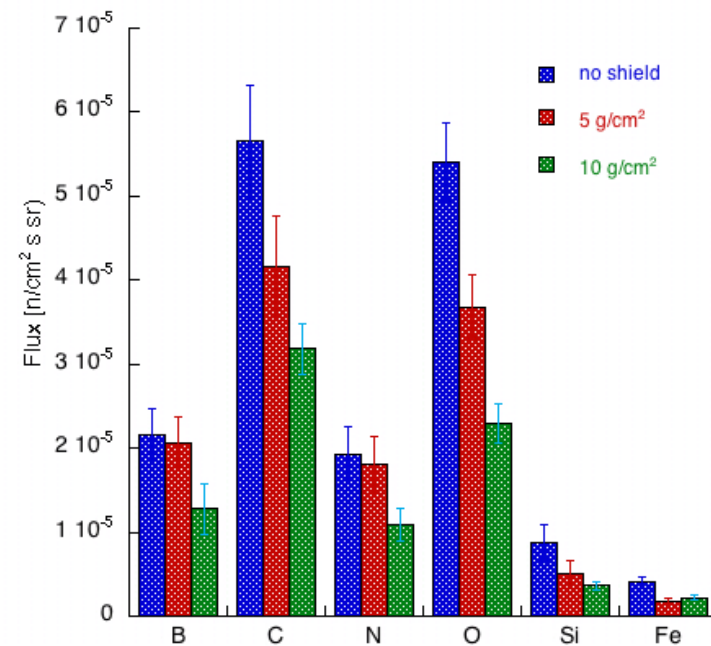




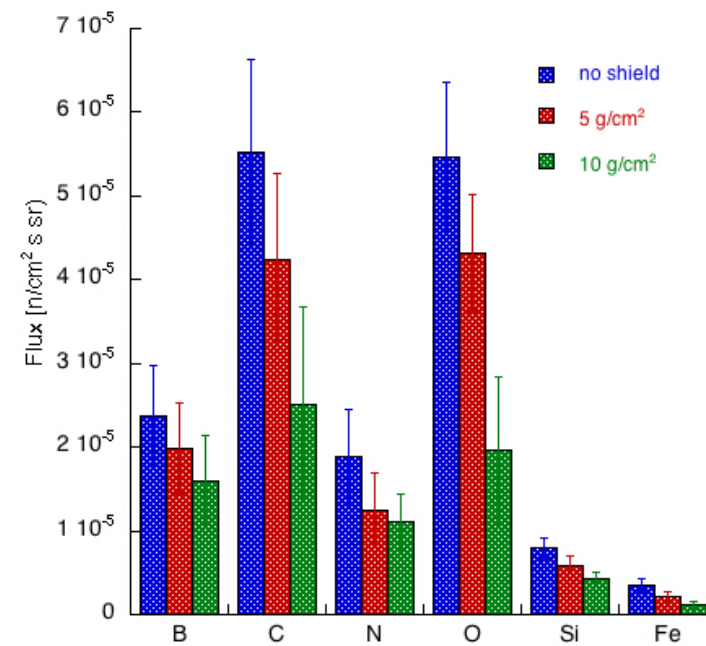
ALTEA in Columbus: shield – shield



Nuclear Identification



Polyethylene



Kevlar

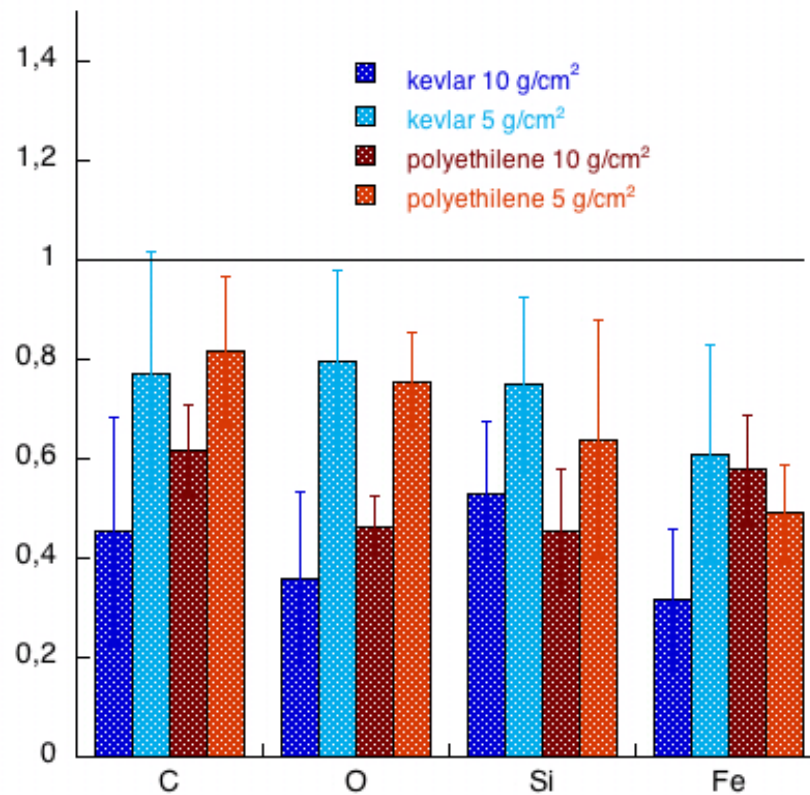


ALTEA in Columbus: shield – shield



Nuclear Identification

Compare the ratios of the measurements with the tiles to the reference measurements (no tiles)





Summary conclusions / comments



- 1) Radiation environment in the ISS depends strongly on directions and on position

Differences can be as large as one order of magnitude

Further measurements, CAD models, info on racks configurations must be used to study in detail the data

Columbus in the site and direction measured appears to have a different radiation quality then USLab (very Preliminary)

- 2) Details of the dynamics of the radiation field during the March 2012 SPE are under analysis

Clear Forbush decrease, lowering the dose for about two weeks following the March 2012 SPE, have been measured (same dynamics shown by Pamela measurements). Further analysis is in progress. Possibly more SPE in the ISS must be studied to provide information on countermeasures development

- 3) Preliminary analyses show similar effectiveness of Polyethylene and Kevlar, reaching a reduction of about 25% in Dose and almost 50% in Dose Equivalent (10 g/cm^2)

We need models to compare our data with and info from radiation biology suggesting the degree of details the data analysis (and consequently the models ..) must reach

We need to compare our data with the data coming from other available similar instrumentation

We need concurrent measurements inside – outside the ISS to correctly provide tools for model validation

Only detectors that can provide trajectory and nuclear identification (such as ALTEA) can provide the entire set of the needed experimental info



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

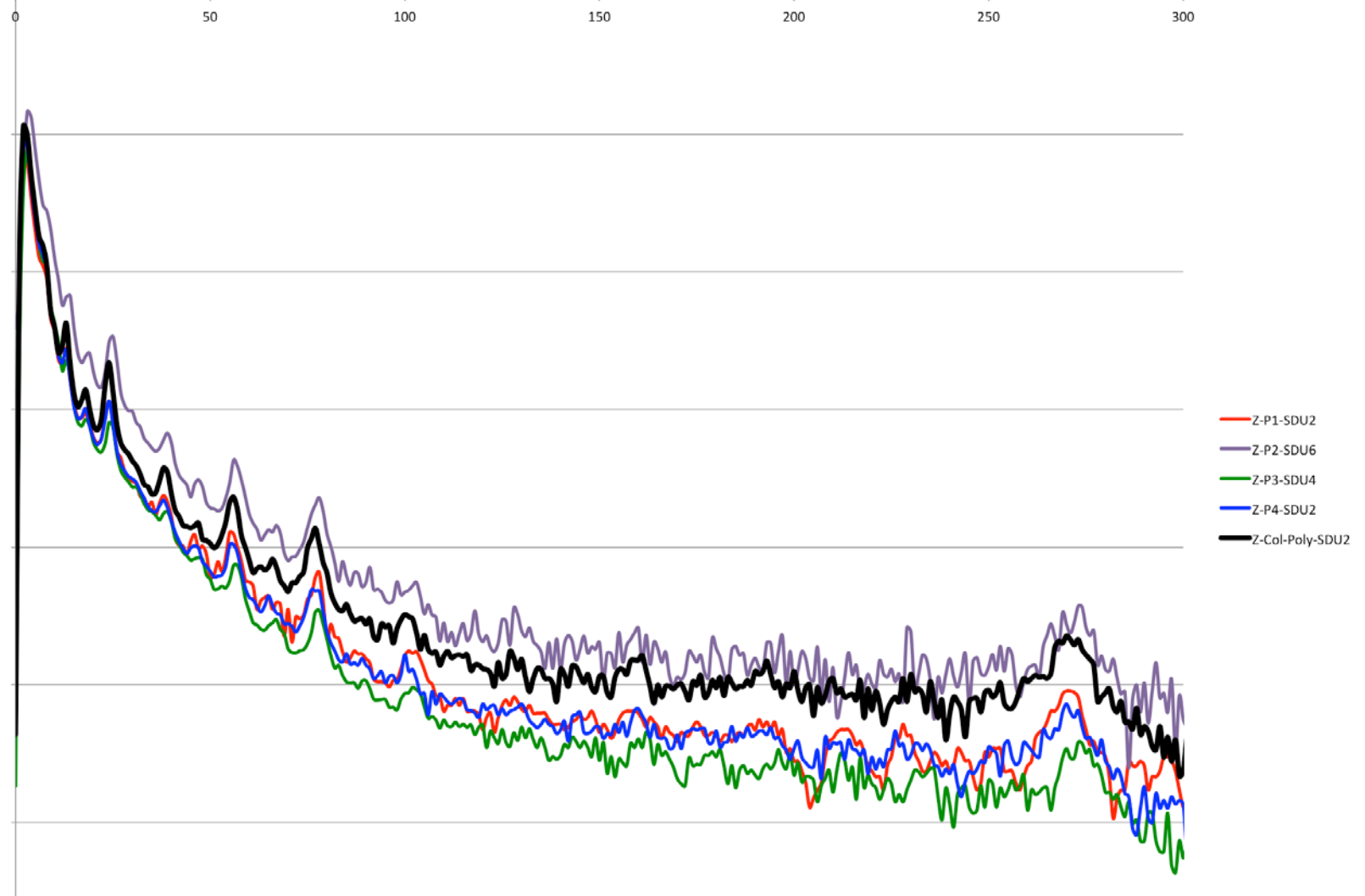
Eril Research, CA, USA



+ others joining in



Thank you for your attention





ALTEA: iron oversimulation

