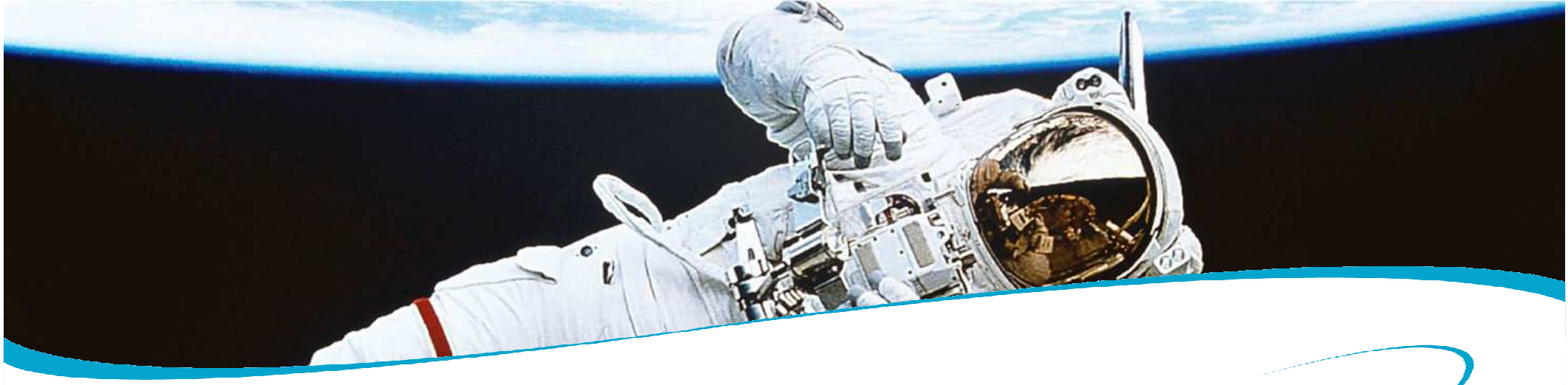


ThalesAlenia Space
A Thales / Finmeccanica Company

Environmental Quality Control in space systems: the experience of the International Space Station

C. Lobascio, P. Messidoro
A. Quaglia, E. Tracino

THALES

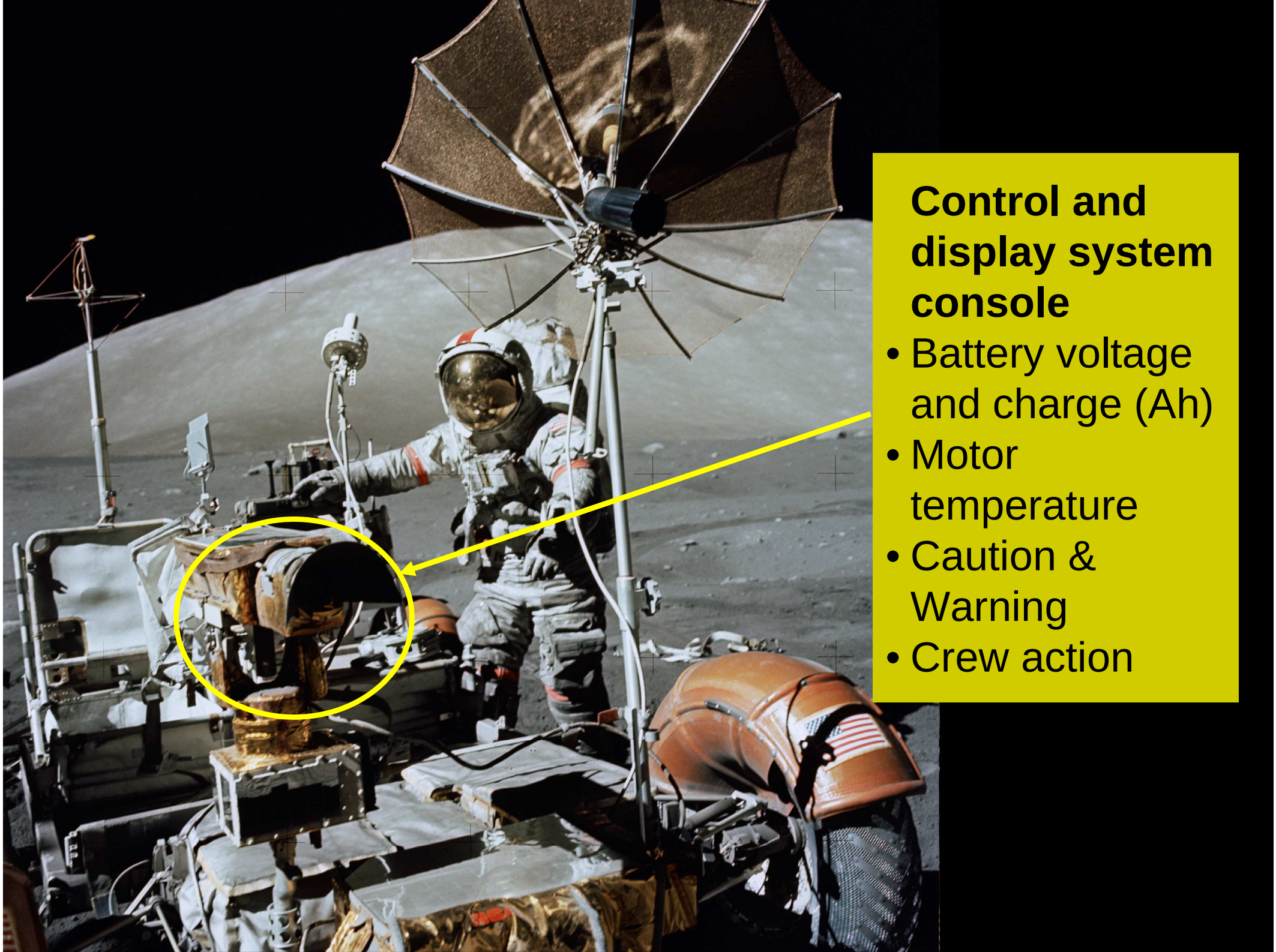
Corporate Communications

Summary

- The Human Space Frontier, yesterday, today
- Space Station Environment Diagnostics
- Astronauts Environment Diagnostics
- Future Frontiers and Needs


Yesterday: a
frontier at
400k km


Even a car!



Control and display system console

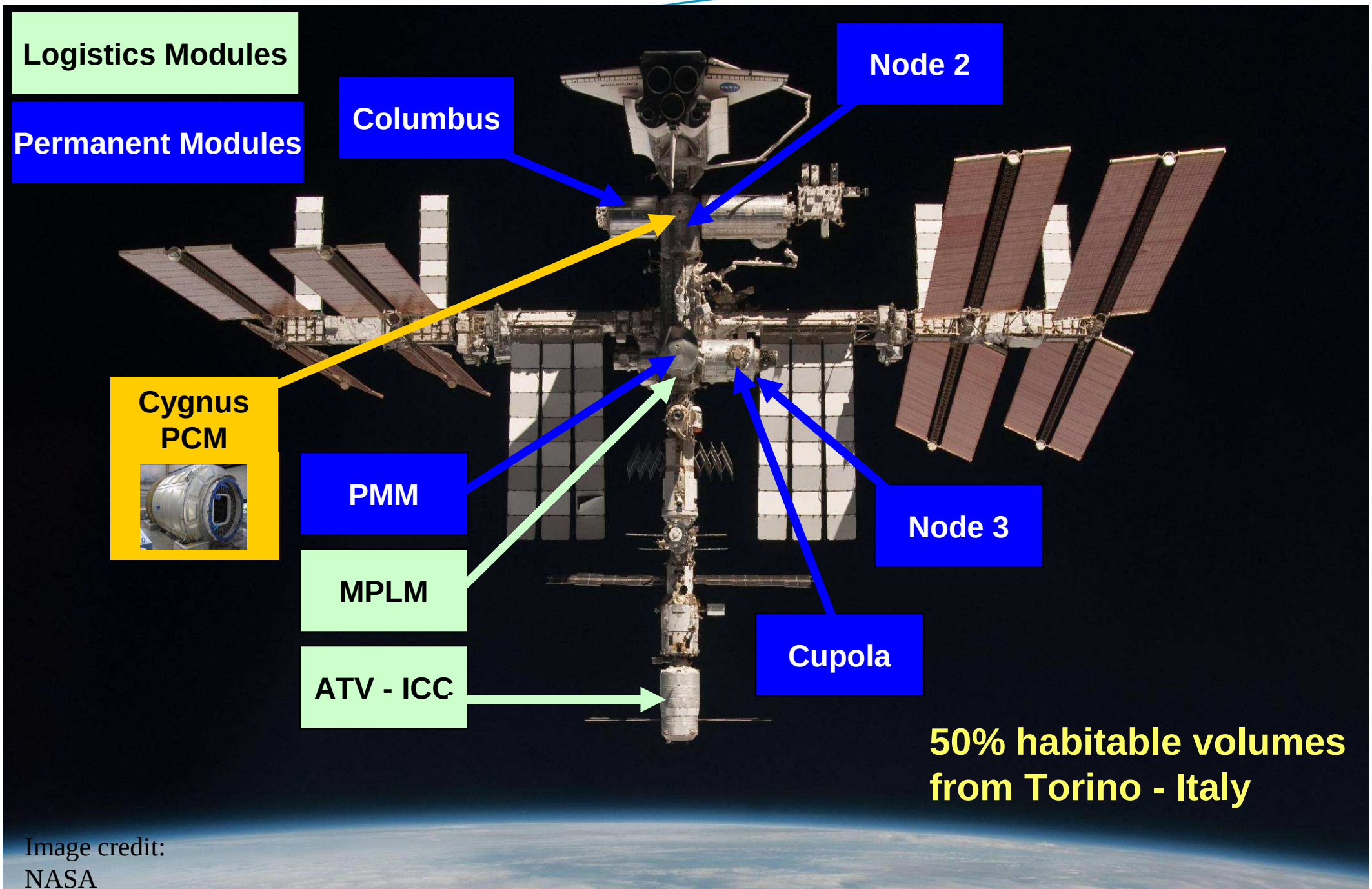
- Battery voltage and charge (Ah)
- Motor temperature
- Caution & Warning
- Crew action


Today: a beautiful frontier at 400 km

There is Italy… behind ISS

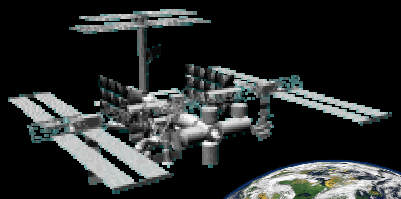
Image credit:
NASA

European / Italian contribution



A harsh environment

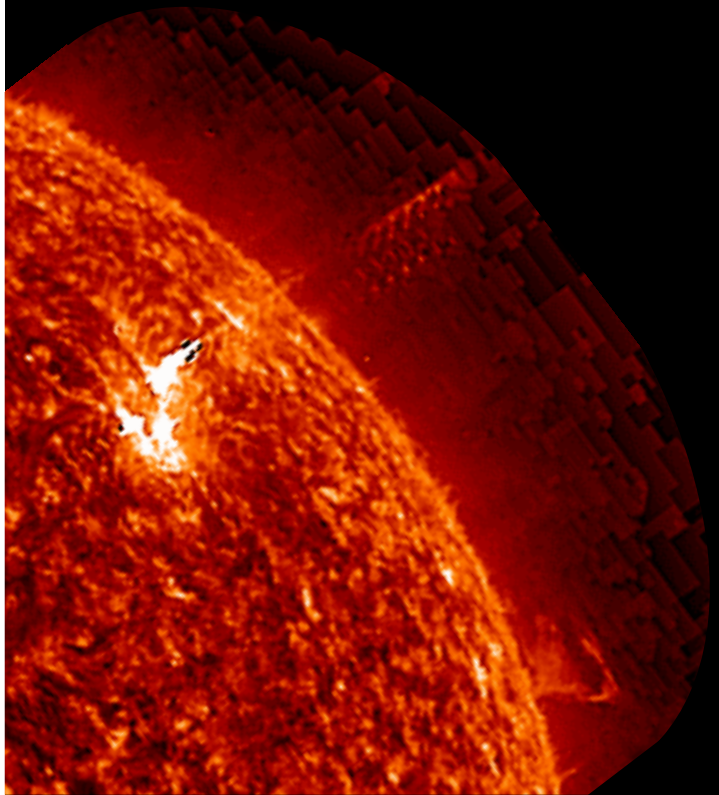
Cosmic Rays



Meteoroids
& Debris

Residual
Atmosphere

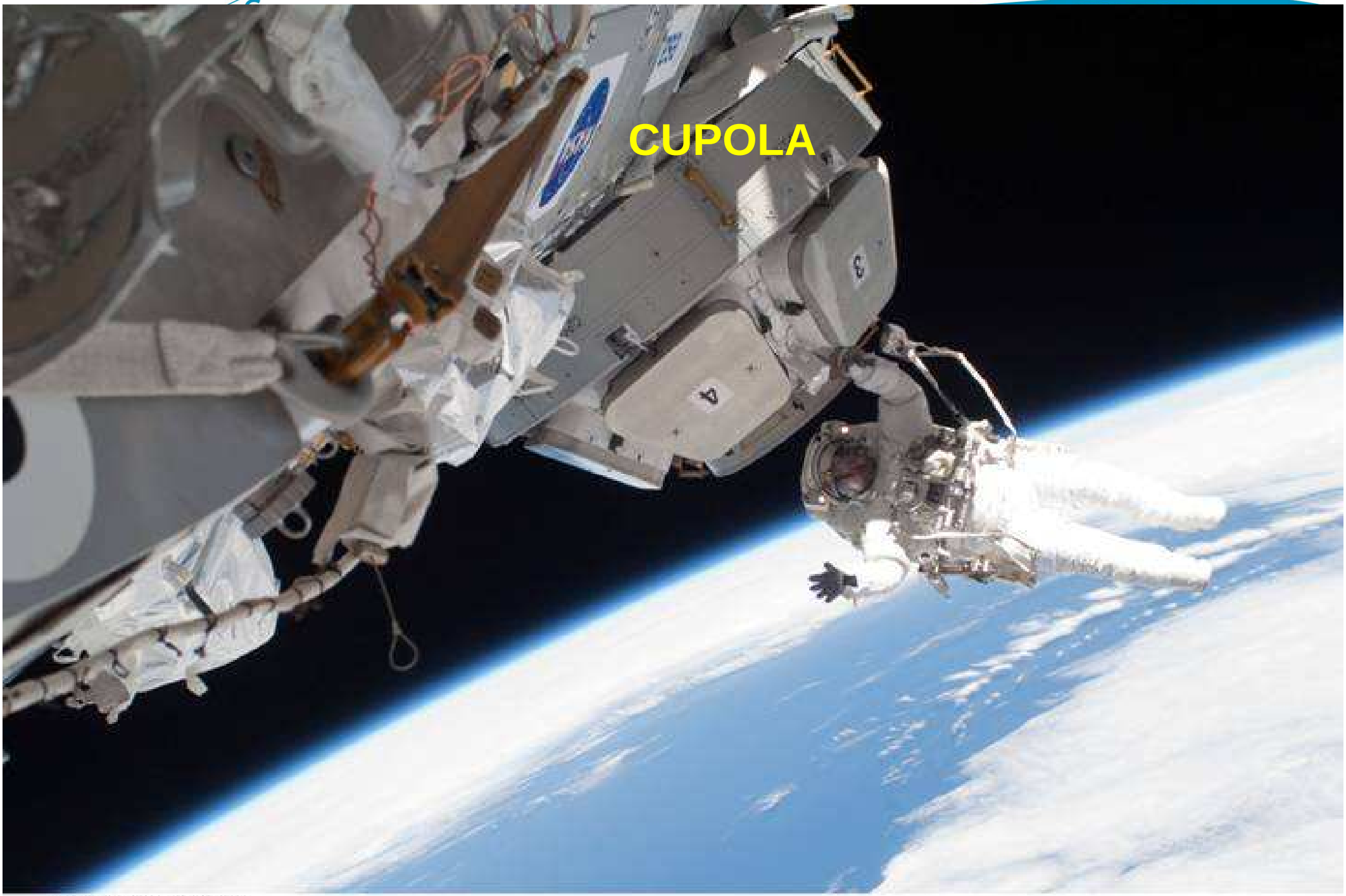
Plasma



Solar Particles

Vacuum

Astronauts in Space Environment



Space Environment Diagnostics

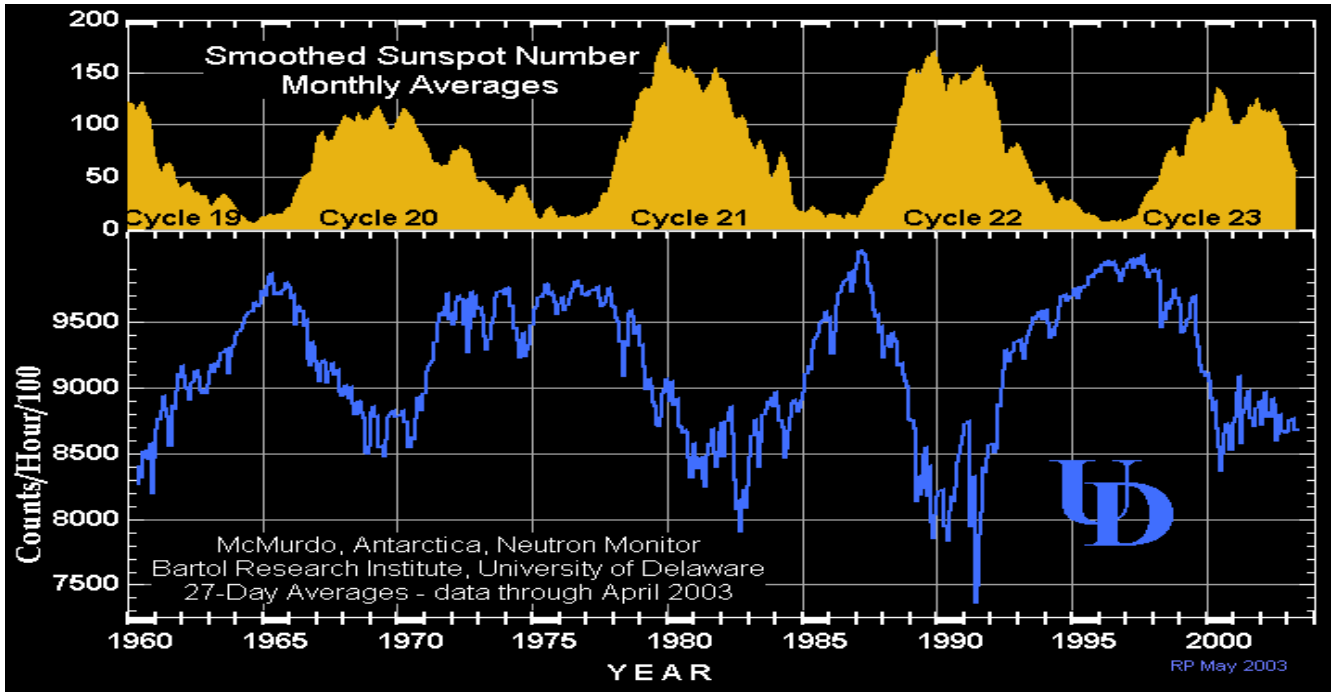
Radiation Diagnostics

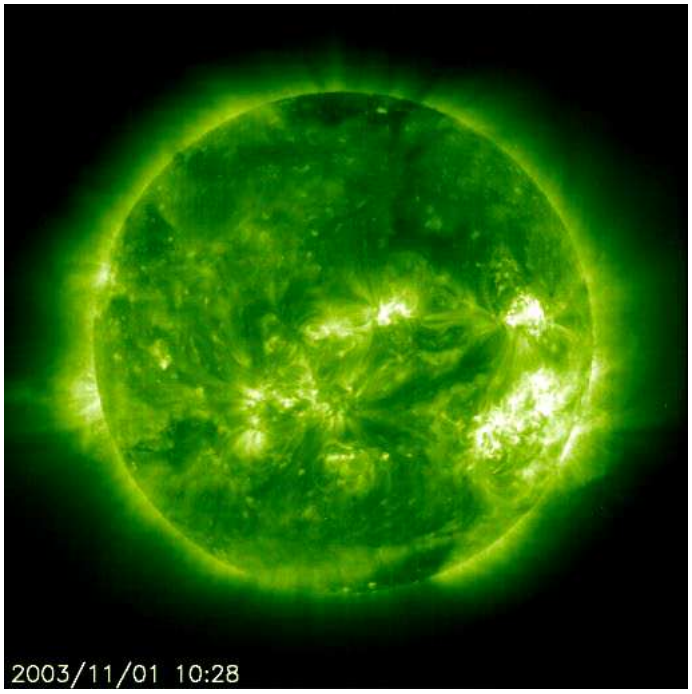
- What we monitor…
- Why?
- Where
- Radiation monitors
- Data analysis

A. Akulin

What do we monitor…

The Space Radiation Environment

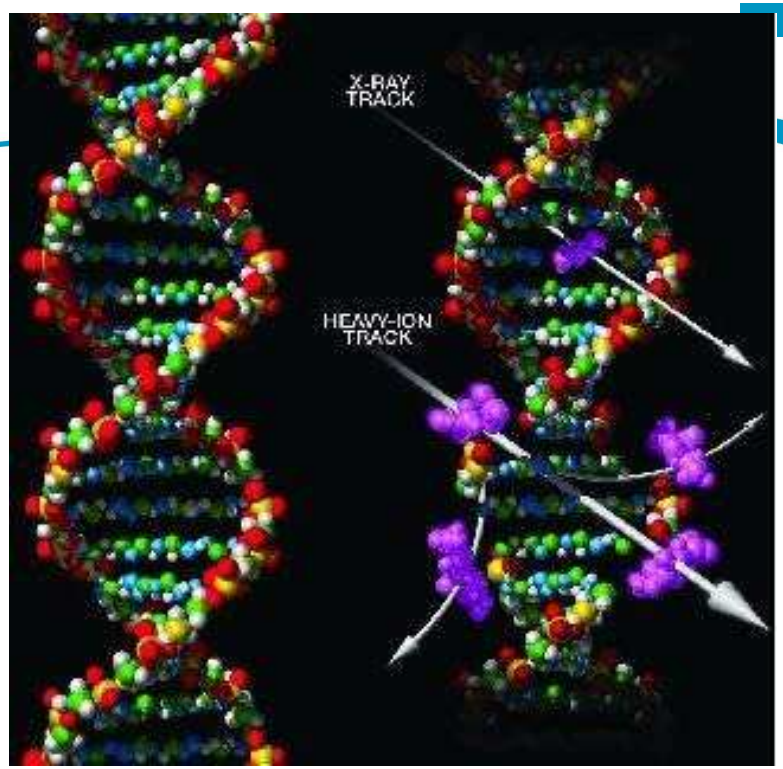




Radiation Quantities

- Fluxes, Radiation Quality, Physical Dose, Biological dose

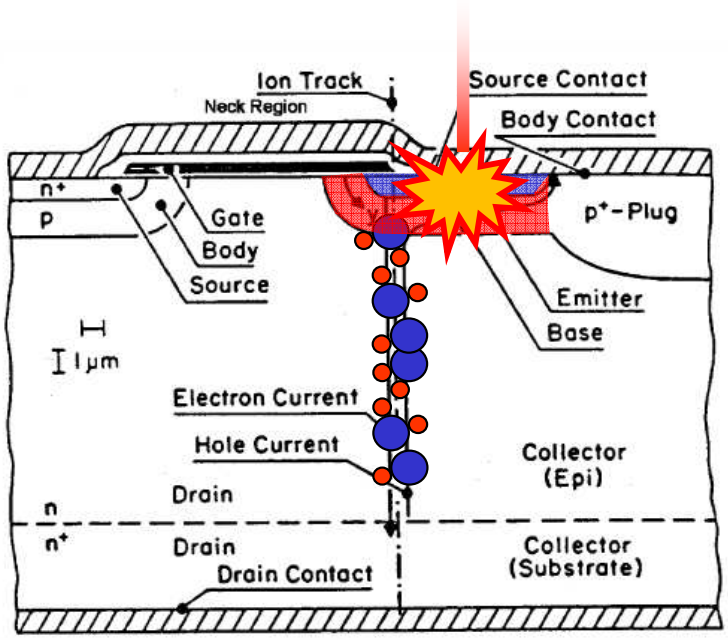
Why?

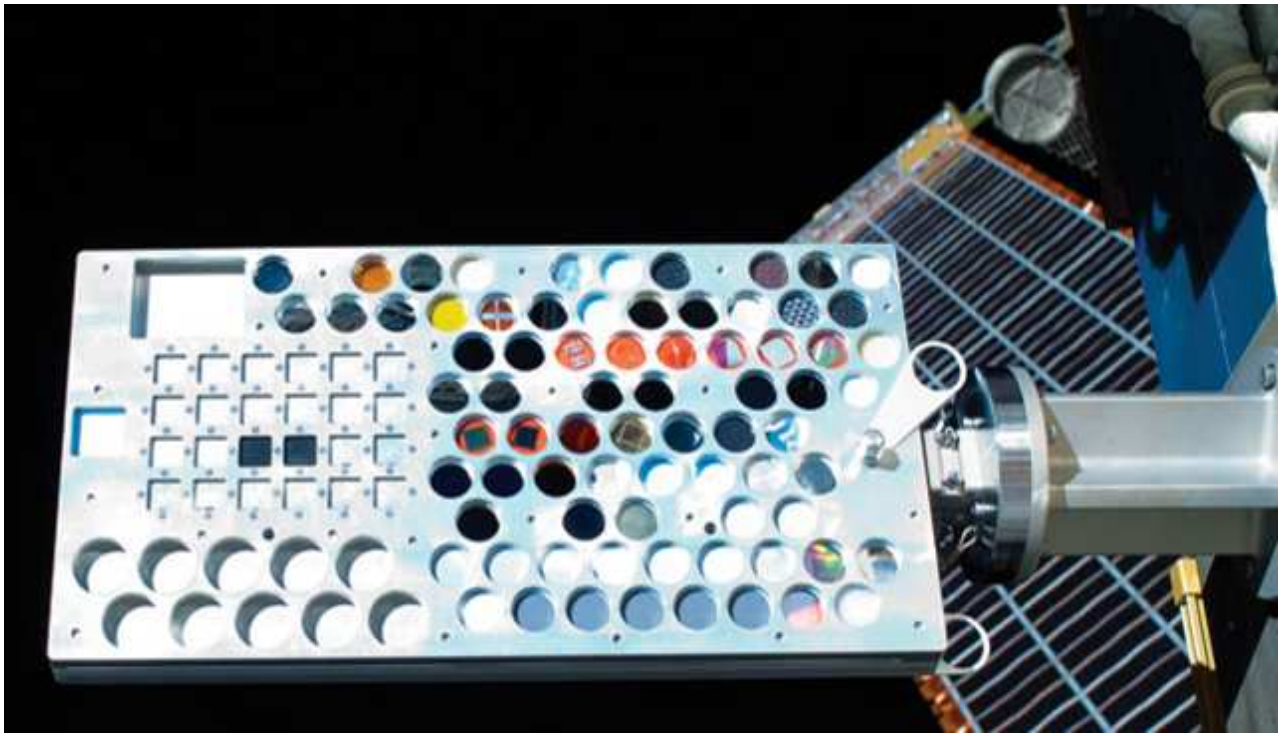


Radiation Protection of:

- Humans
- Electronics
- Materials

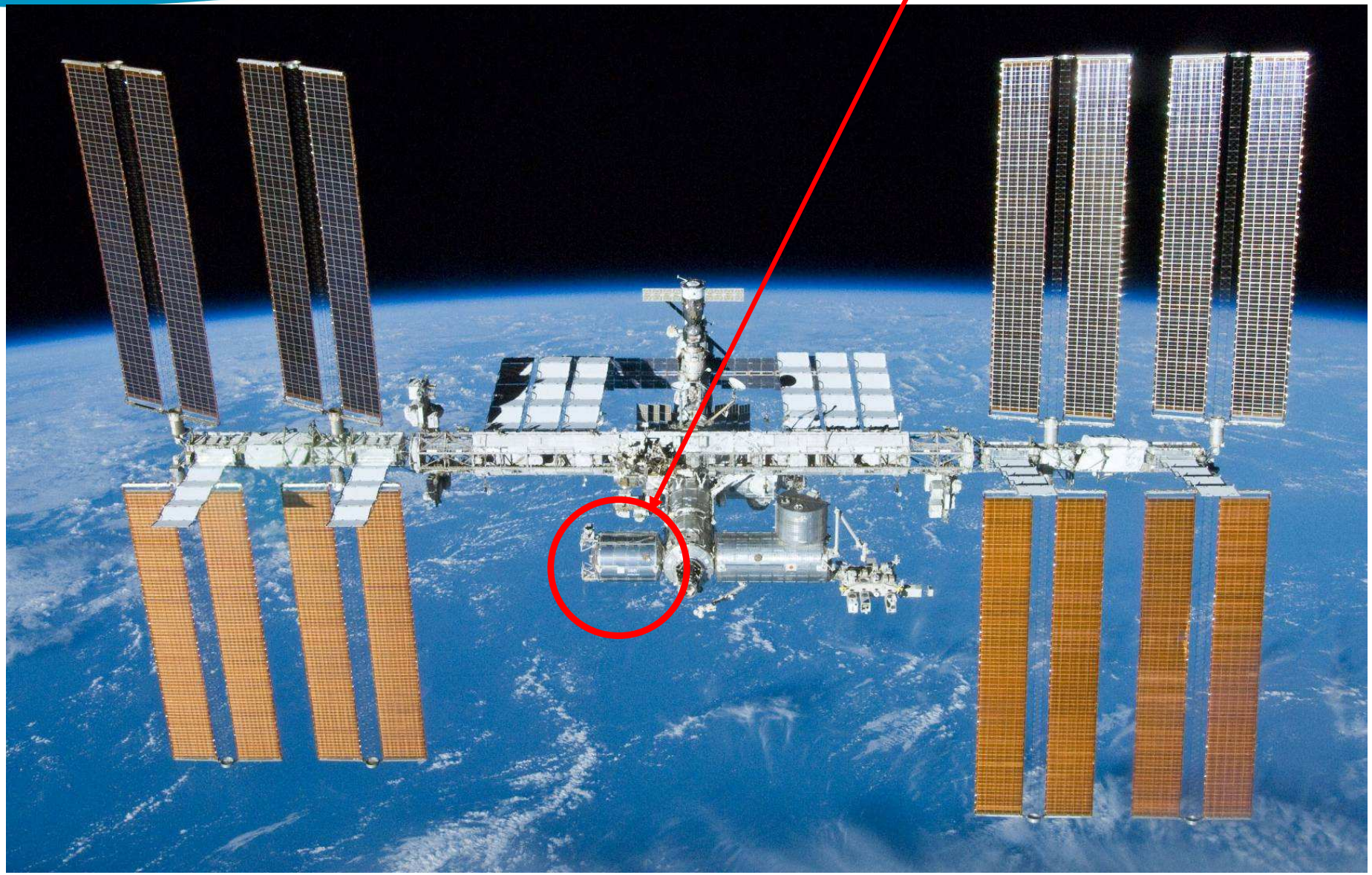
Scientific Research





Where?

Columbus



Columbus Radiation monitors

Dosemeter Equipment of DOSIS

Passive

Passive Detector Boxes

TLD Reader PILLE

Active

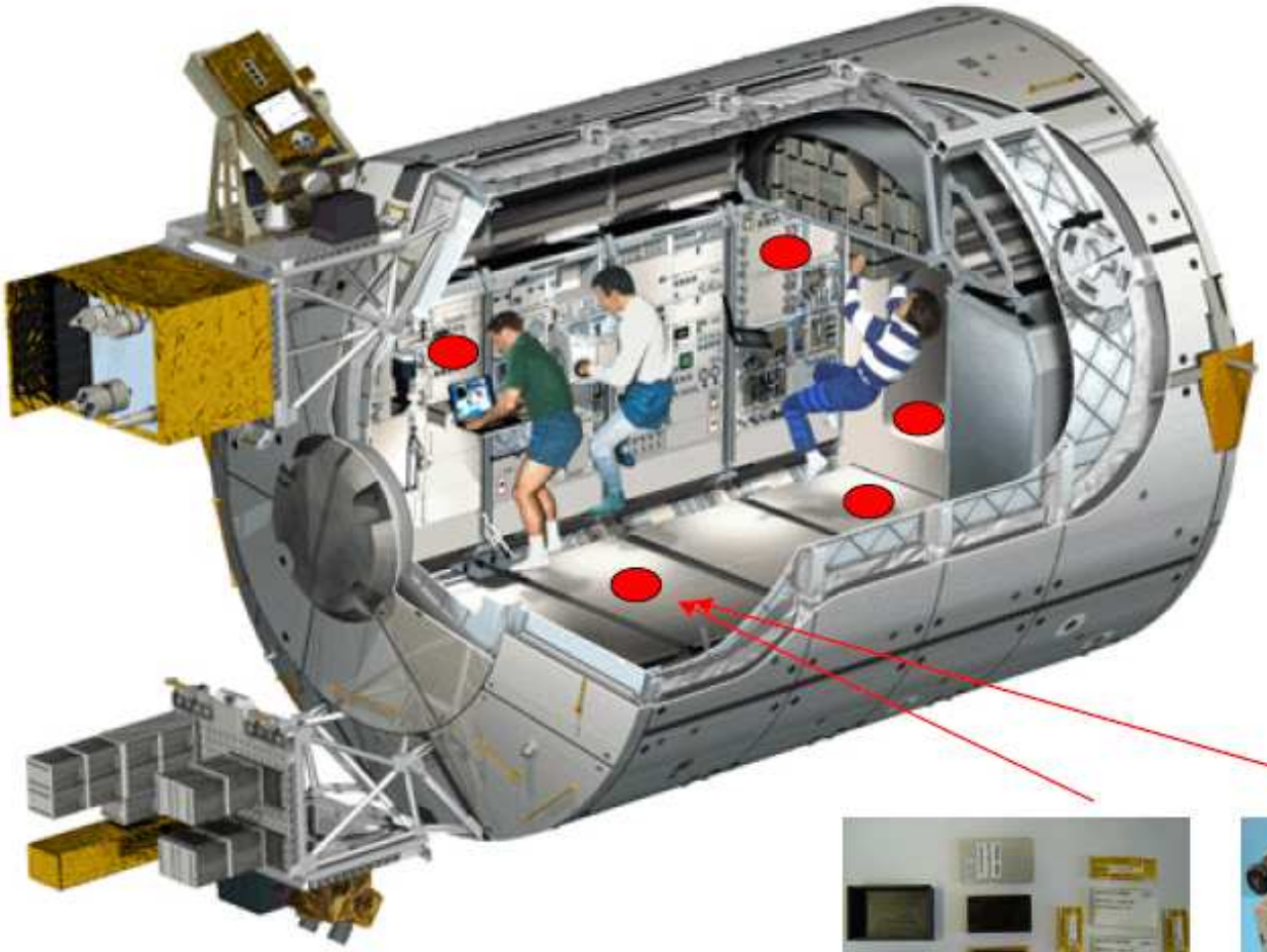
Detector Telescope DOSTEL

Alteino

Neutrondosemeter

Courtesy J. K. Pálfalvi, WRMISS 2010

Dosimeters location inside the Columbus European Laboratory (DOSIS)

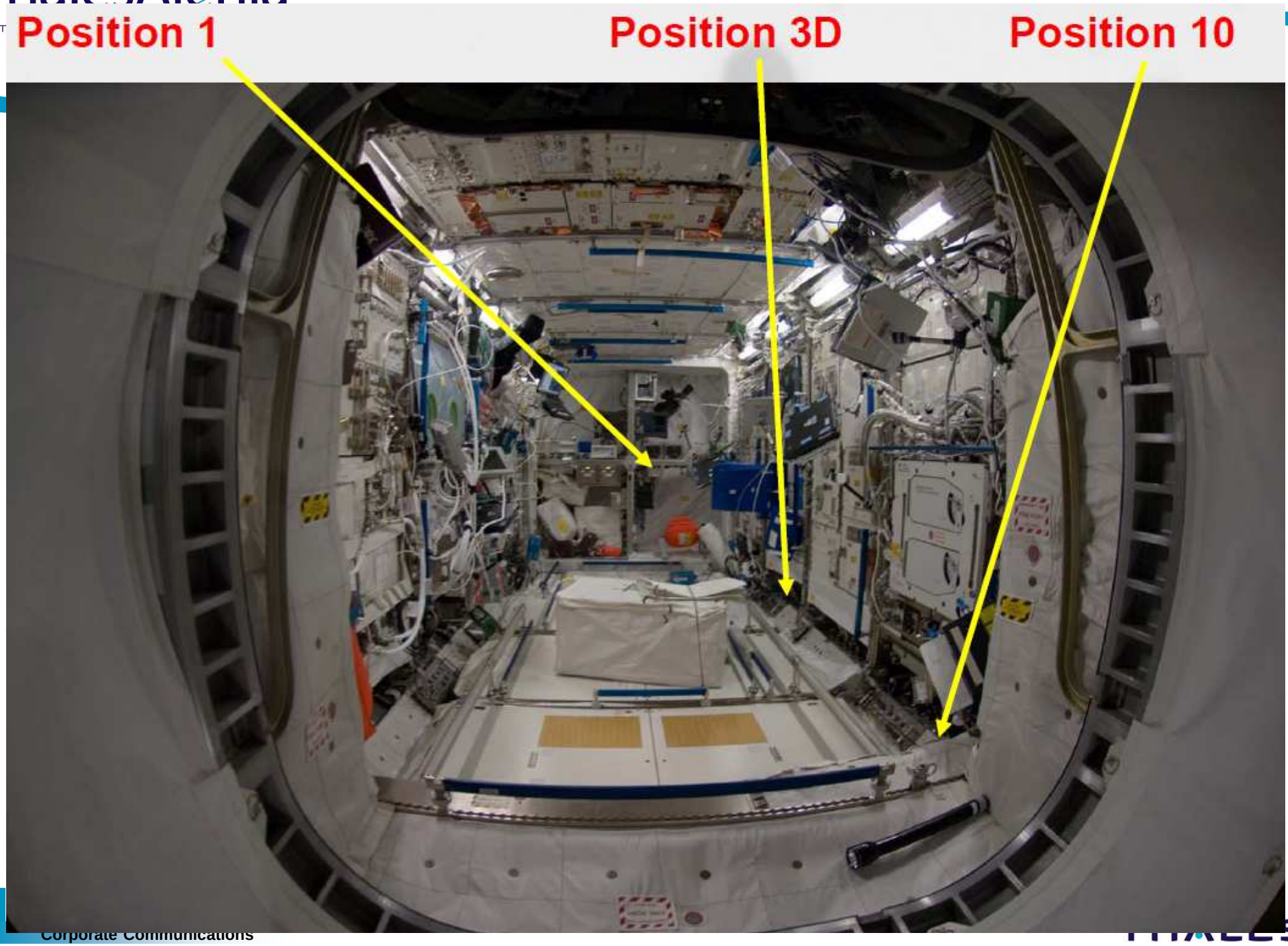


10 NTDP packages / PILLE detectors inside Columbus
→ Exchange of NTDP packages every 6 months
→ Read out of PILLE detectors every 10 days

Courtesy J. K. Pálfalvi, WRMISS 2010

THALES

Where?



Courtesy J. K. Pálfalvi, WRMISS 2010

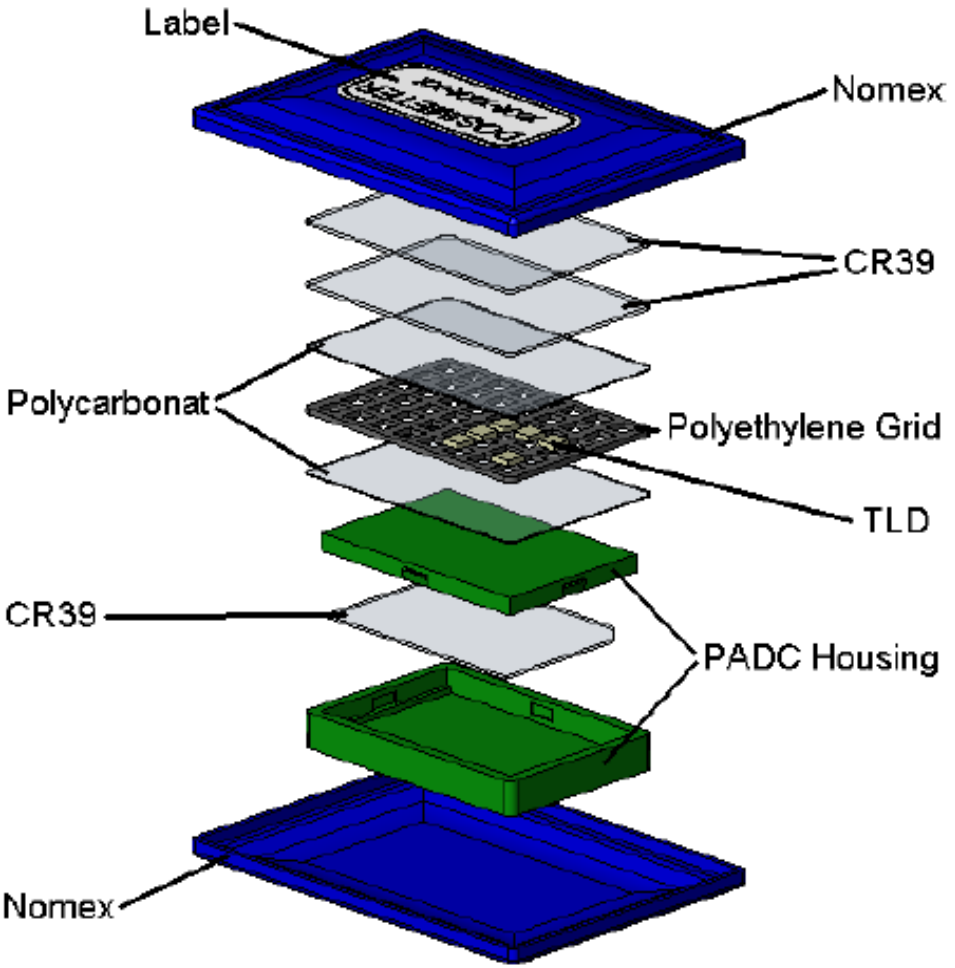
TISSUE EQUIVALENT PROPORTIONAL CHAMBER (US LAB)

Courtesy J. K. Pálfalvi, WRMISS 2010

Radiation monitors

EUROPEAN CREW PERSONAL DOSIMETER

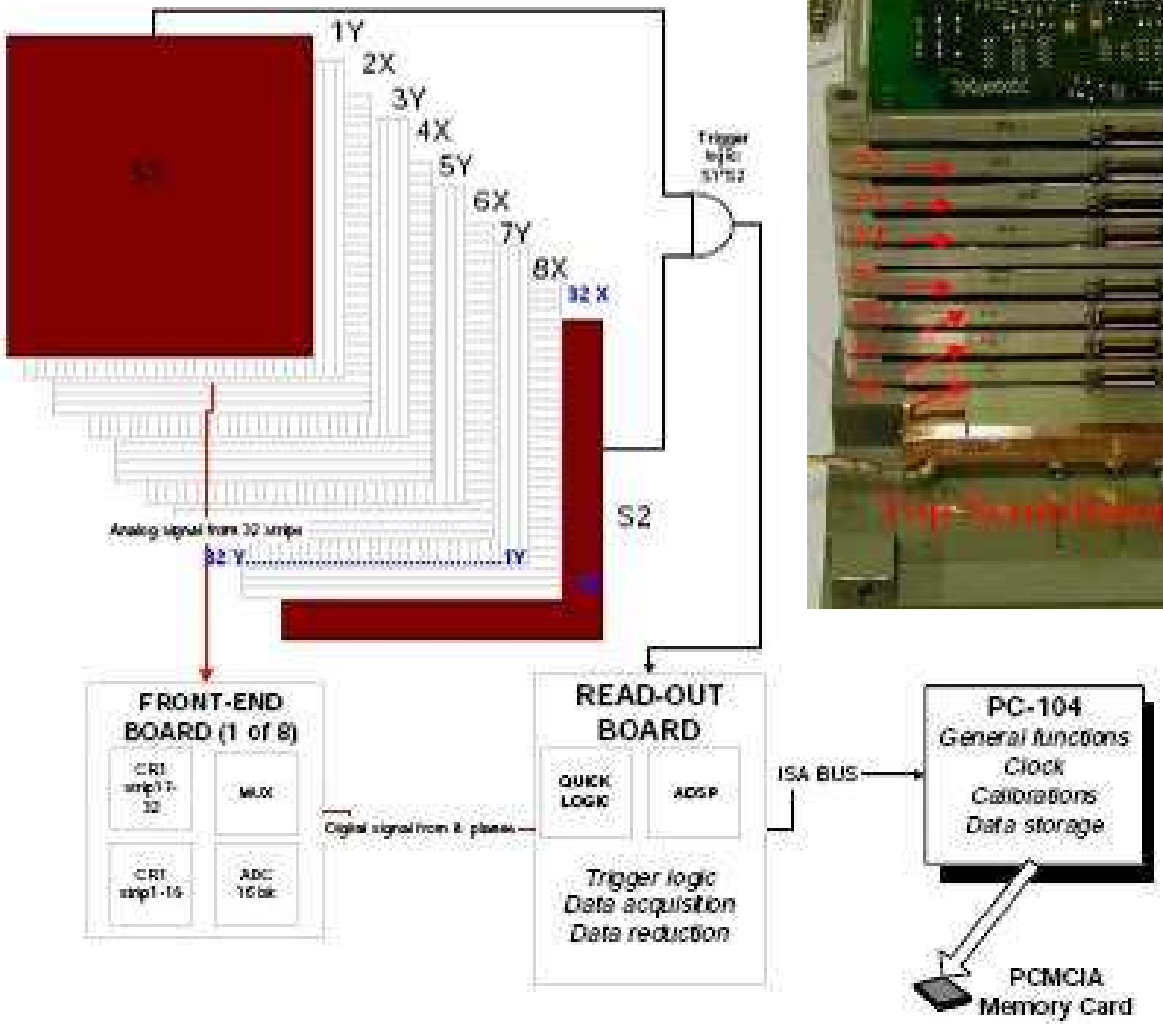
ESA
IBMP
NASA
Personal
Dosemeters

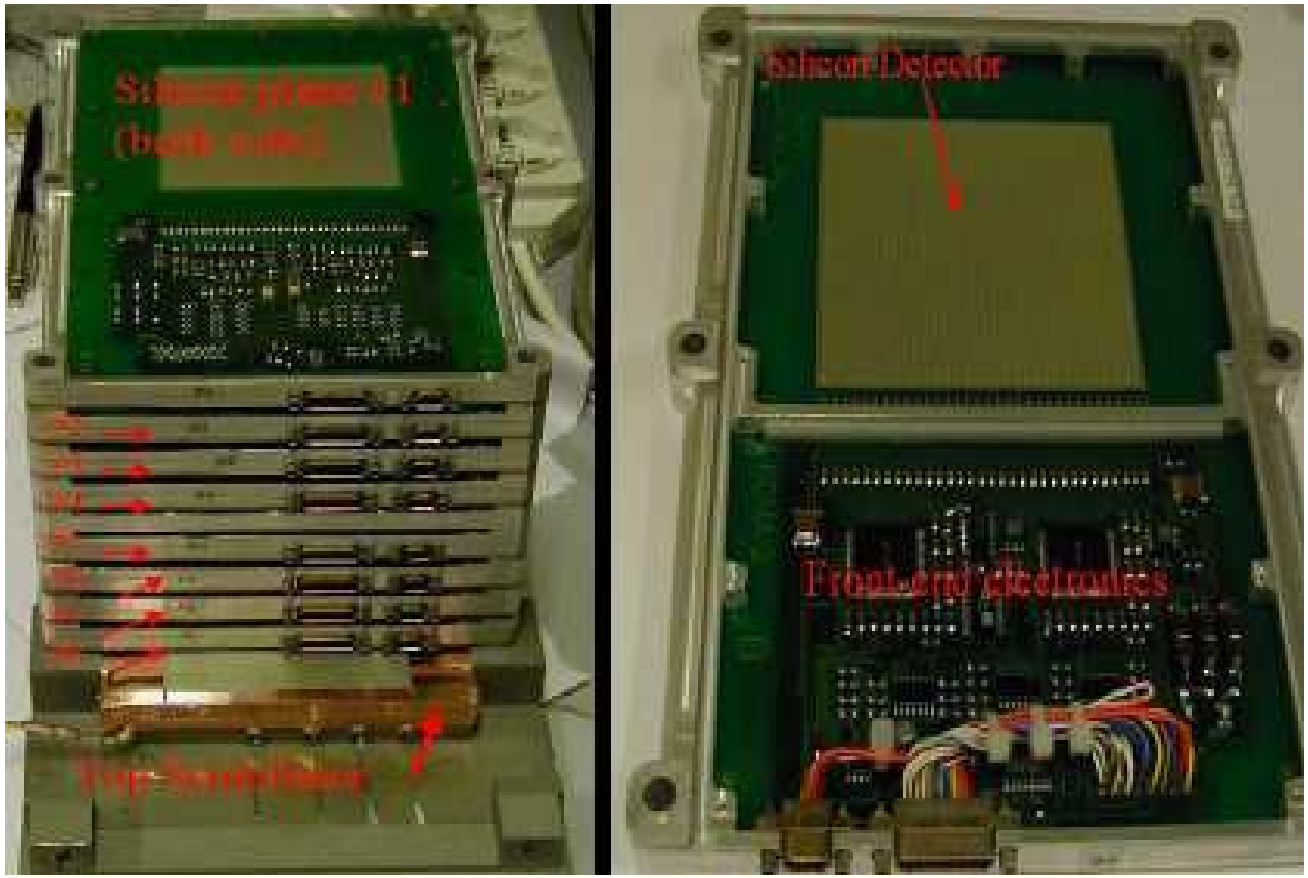


THALES

ALTEINO: Cosmic Rays

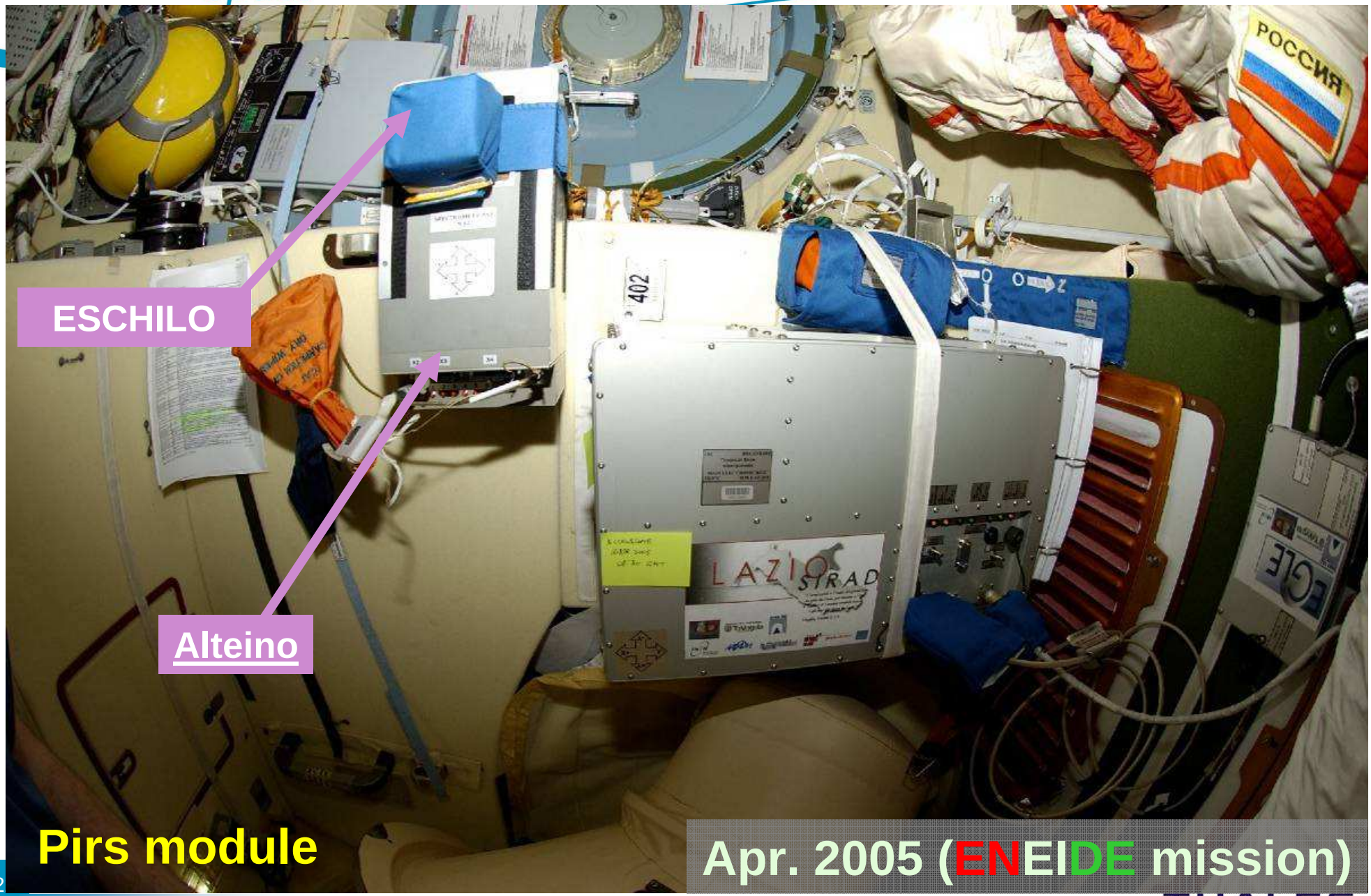
ALTEINO → stack of silicon detectors (8x8 cm)





Courtesy Marco Casolino

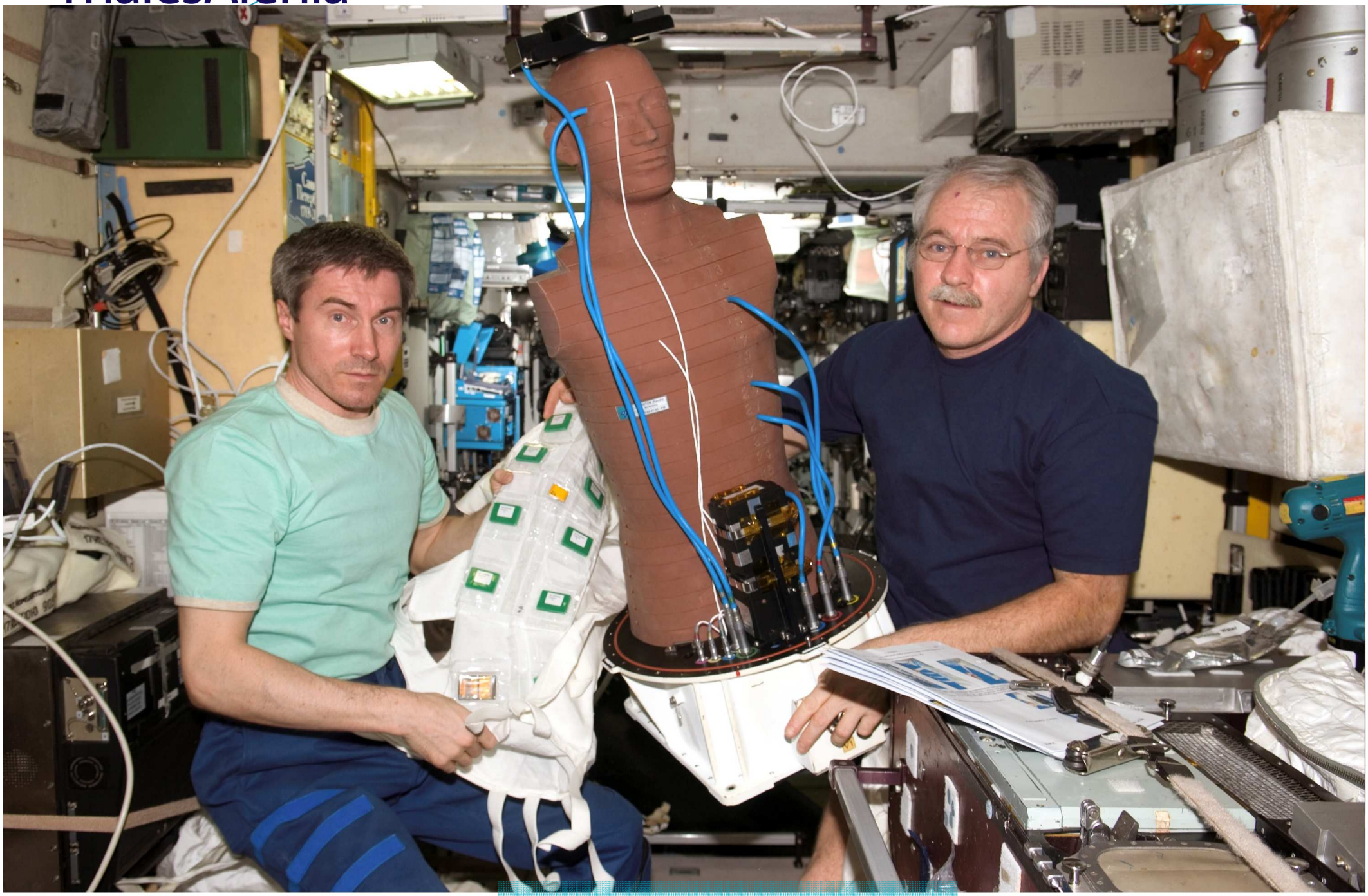
ALTEINO + ESCHILO = Shielding



Courtesy Marco Casolino

ThalesAlenia

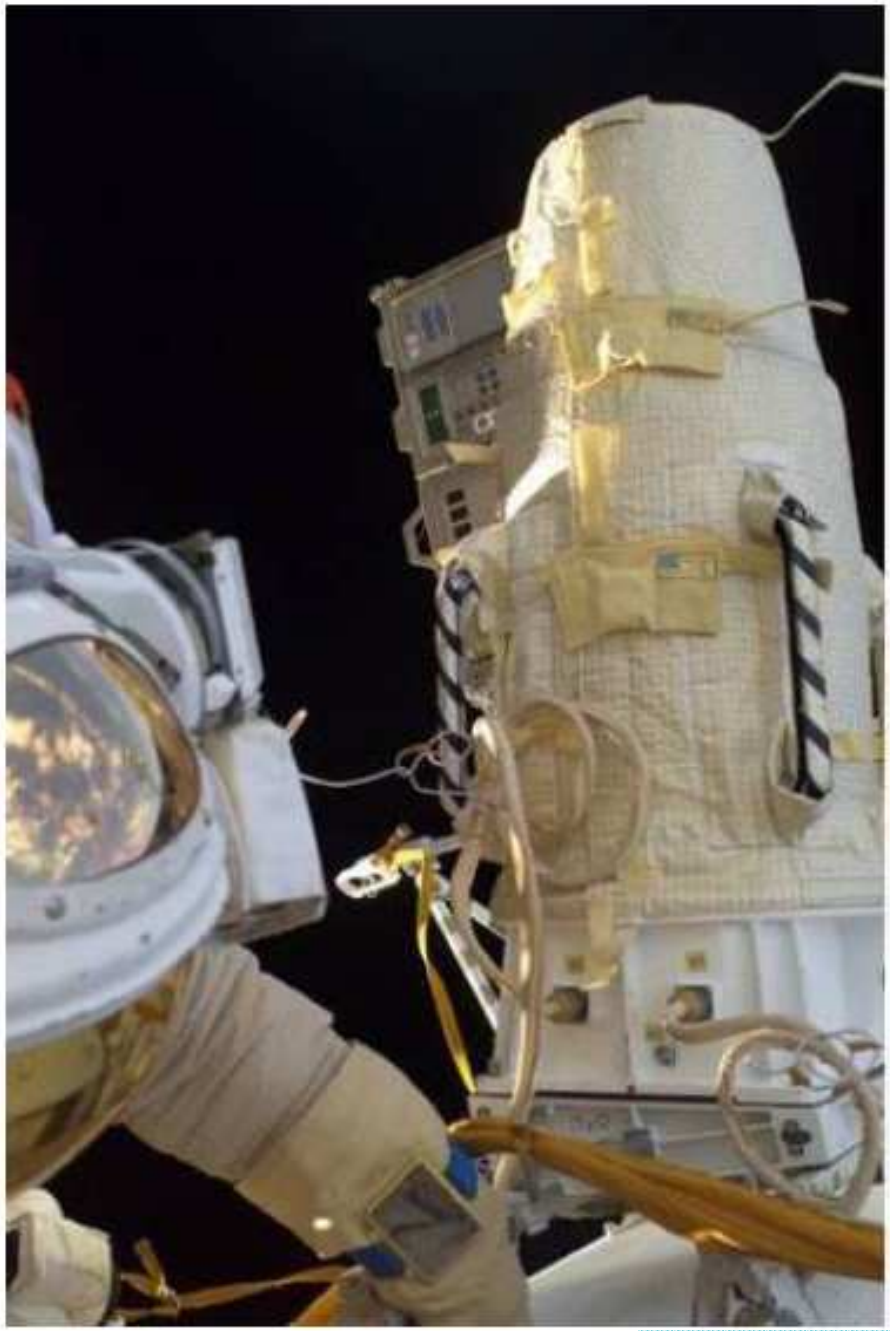
MATROSHKA

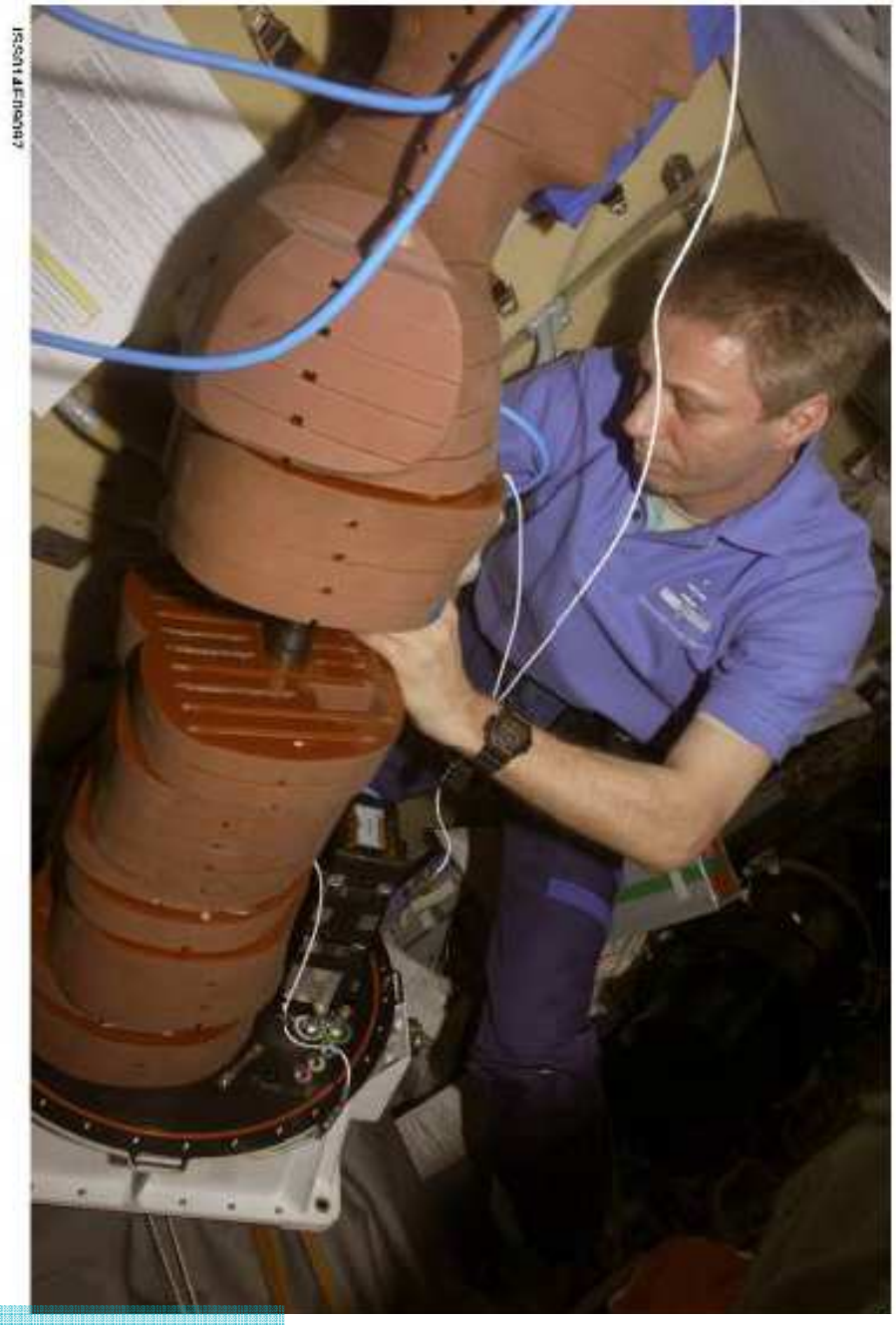


ISS011E13025

Courtesy DLR

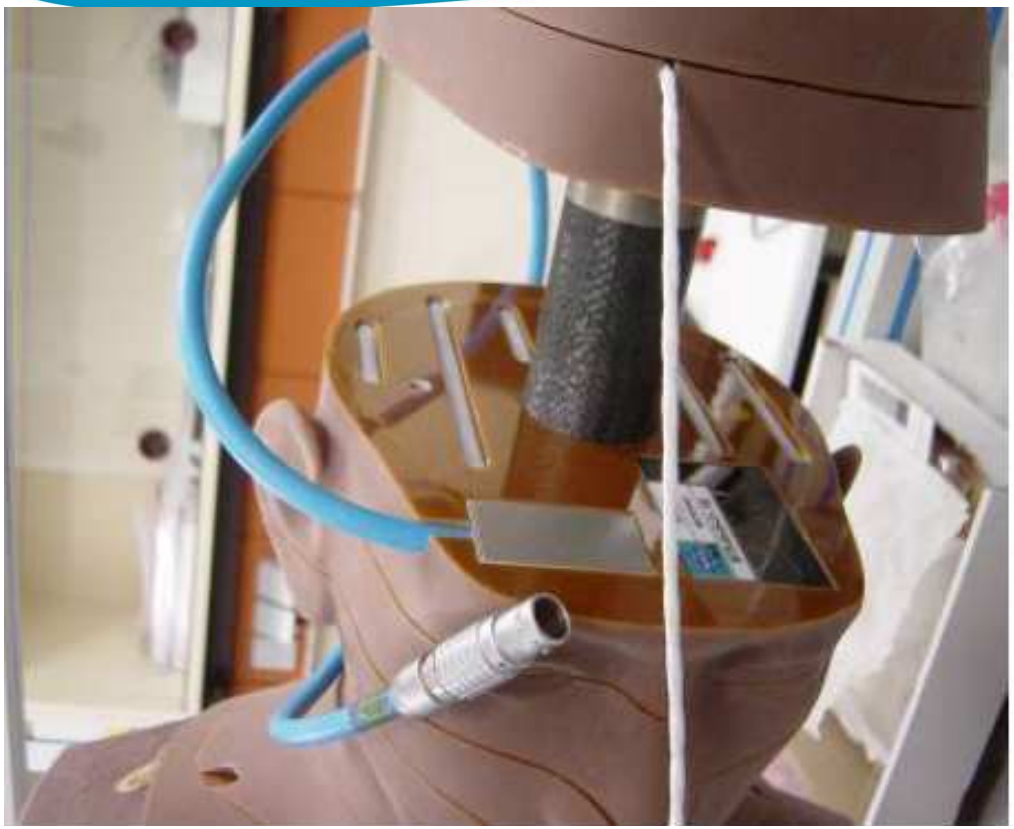
MATROSHKA





Courtesy DLR

MATROSHKA

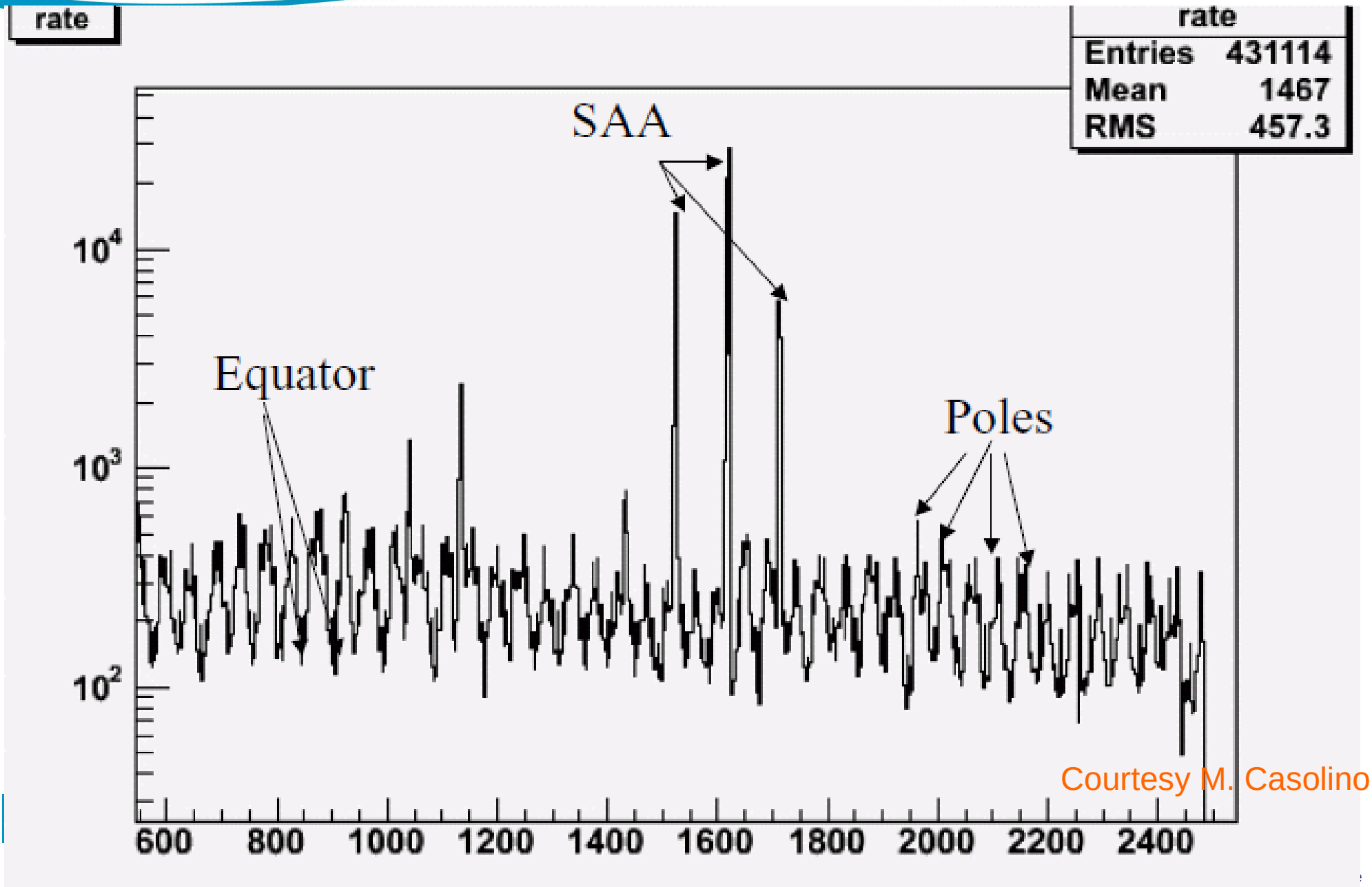


Thermoluminescence detectors (TLDs) and Nuclear Track Etch detectors, Scintillator/Silicon detectors, silicon telescope, tissue equivalent proportional counter (TEPC)

Courtesy G. Reitz

Results – radiation rate in time

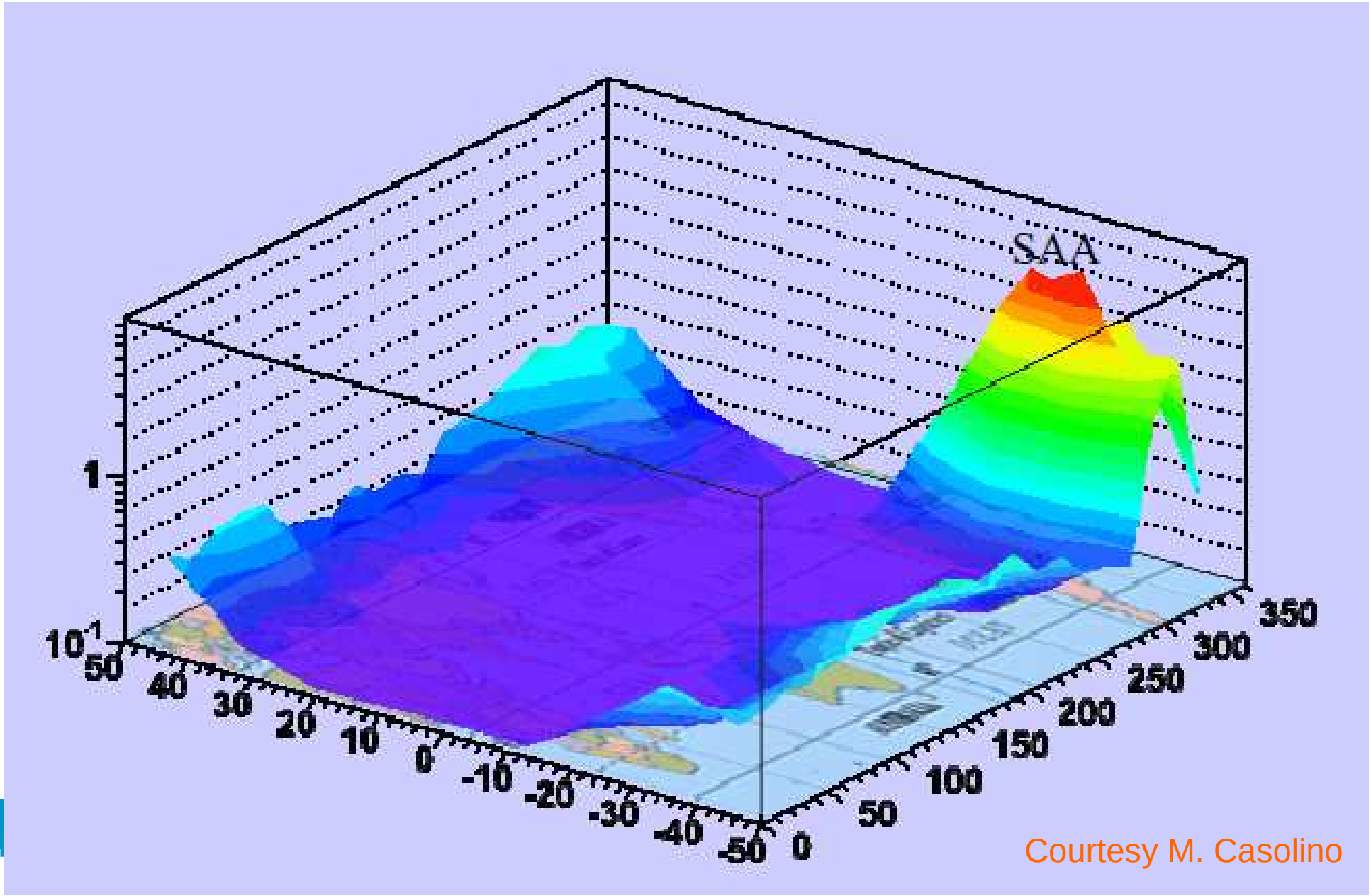
ALTEINO



Courtesy M. Casolino

Results – world map

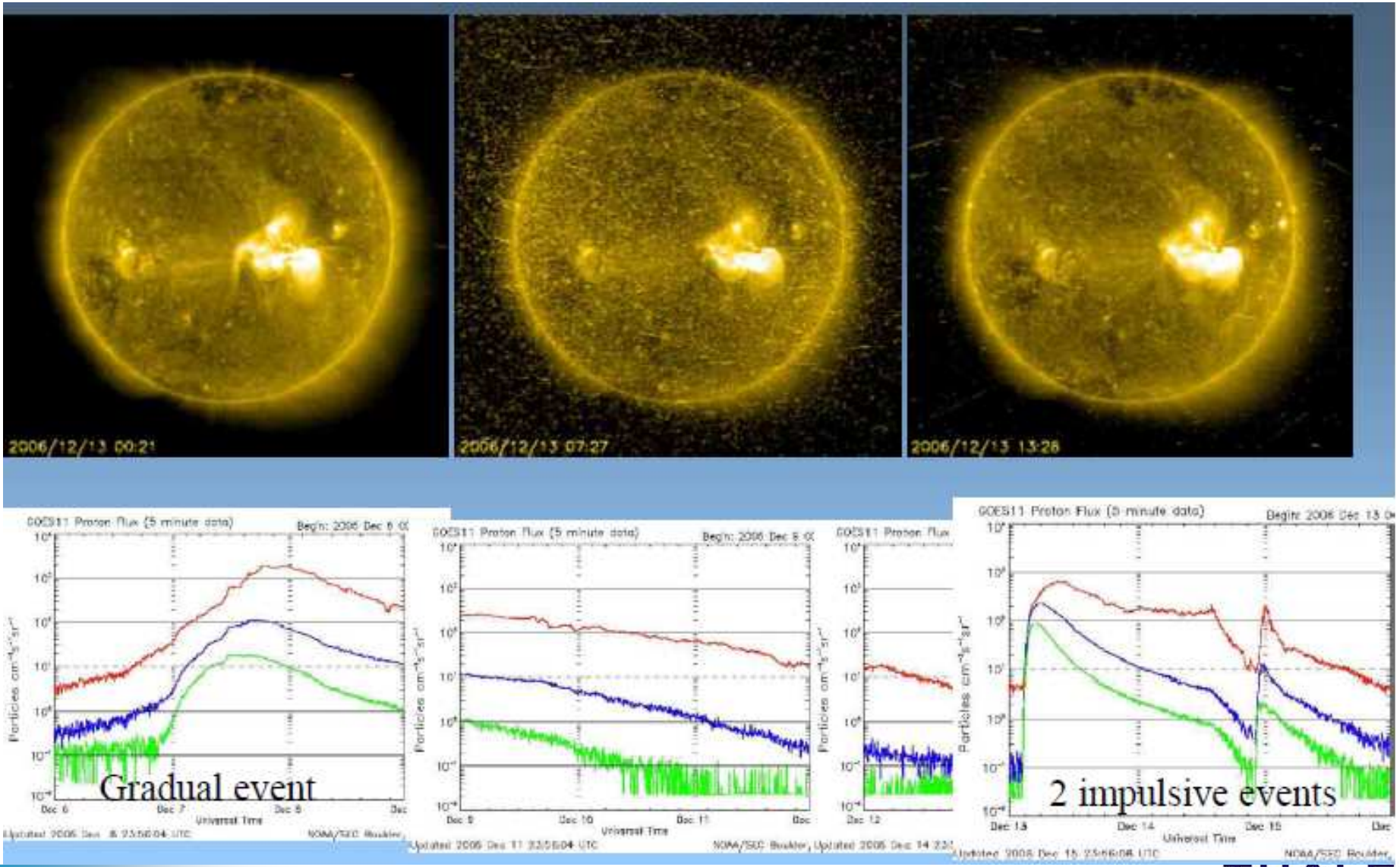
ALTEINO



Courtesy M. Casolino

Results – solar particle events

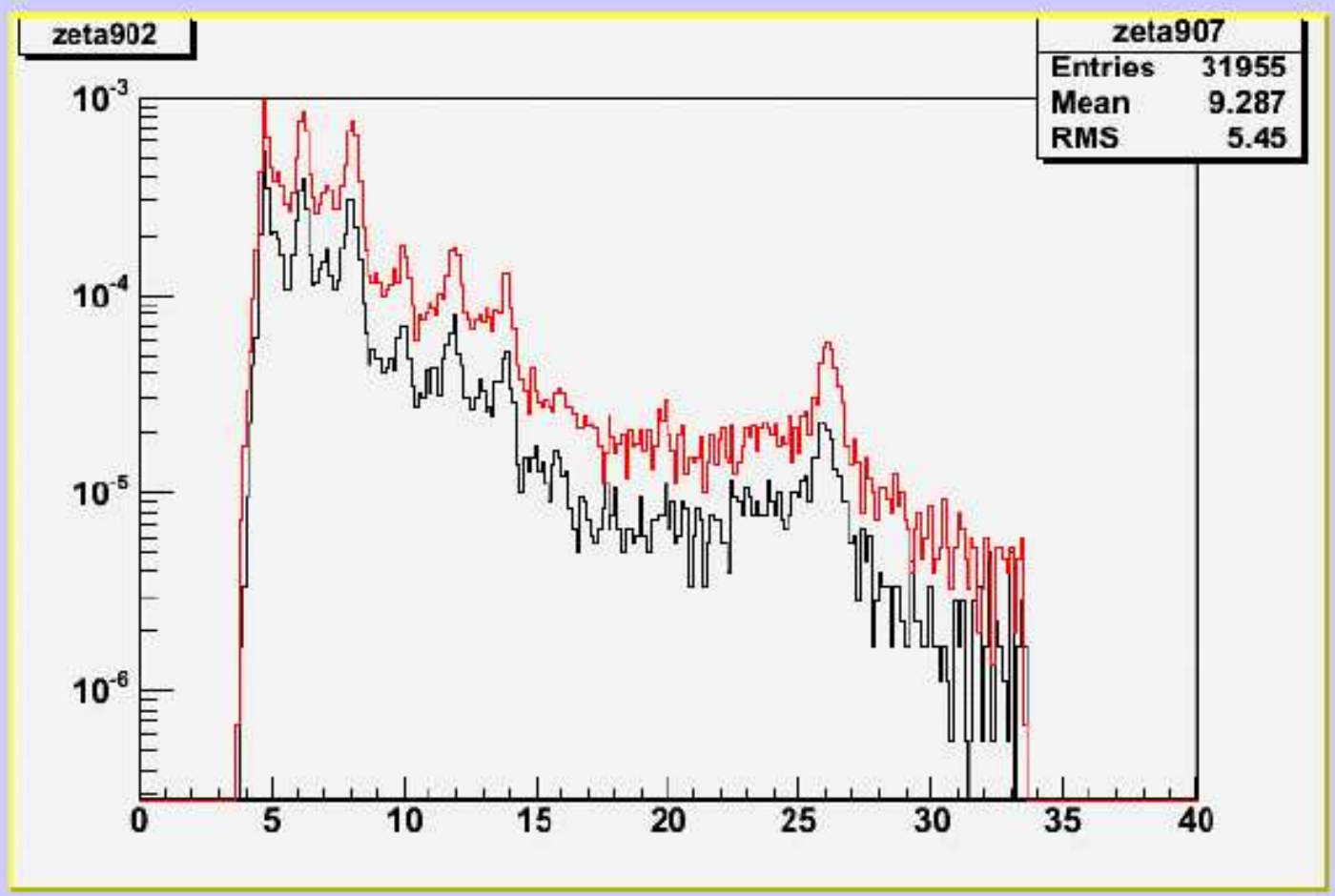
December 2006 Solar Particle Event



Courtesy M. Casolino

Results and lesson learned

Comparison with/without shielding (ALTEINO)



BLACK: Pirs no Shield

RED: Service Module Main Body With 5g/cm^2 Shielding

Courtesy M. Casolino

THALES

Plasma Environment

Courtesy NASA JSC

Contributions to Plasma Physics

Original Paper

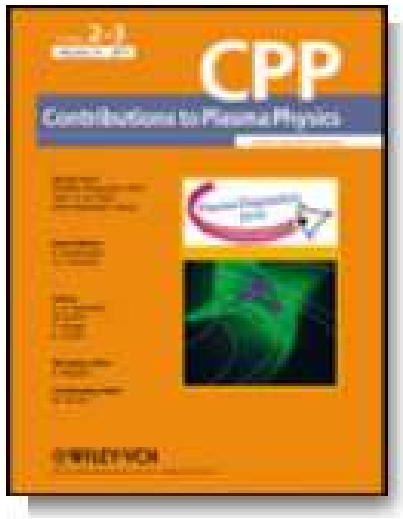
Diagnostics of Space Plasma on Board International Space Station - ISS

H. Rothkaehl[1,*], M. Morawski[1], W. Puccio[2], J. Bergman[2], S. I. Klimov[3]

Article first published online: 16 MAR 2011

DOI: 10.1002/ctpp.201000066

Issue



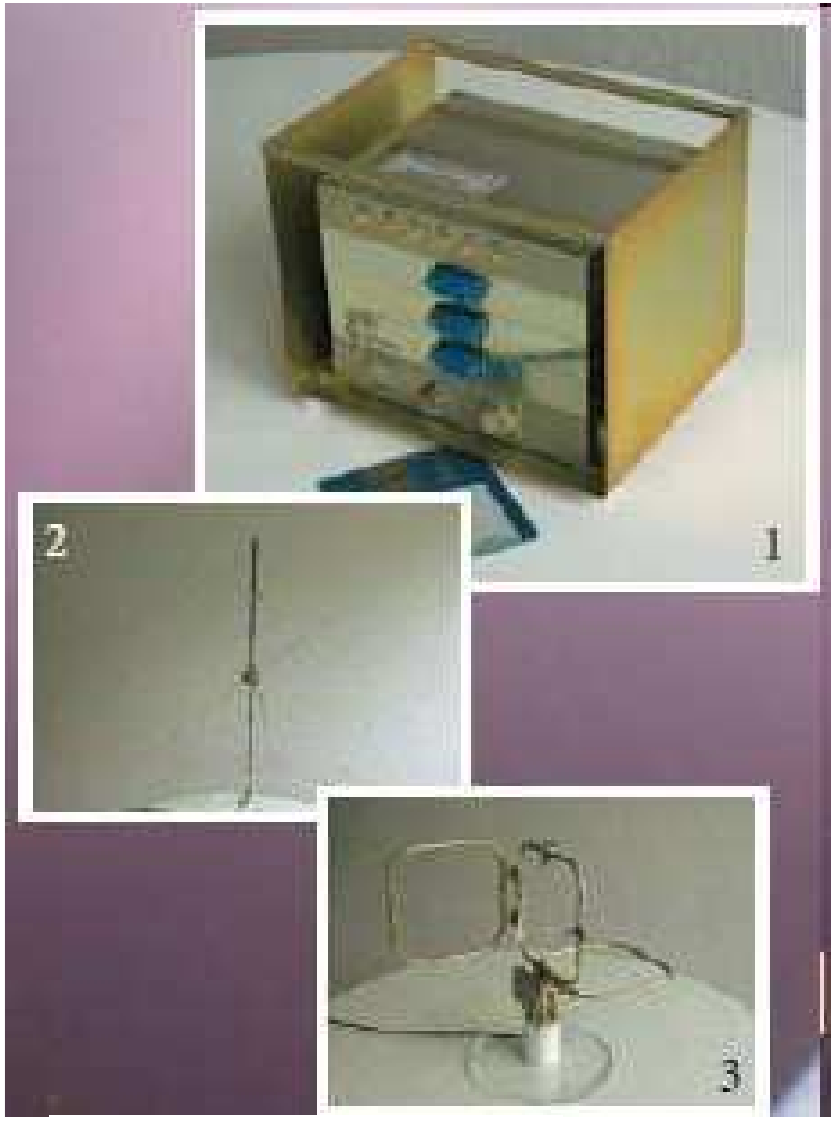
Contributions to Plasma Physics

Special Issue: PLASMA Diagnostics 2010

Volume 51, Issue 2-3, pages 158–164, March 2011

THALES

OBSTANOVKA = ENVIRONMENT



- Plasma-wave processes in near space zone (NSZ): interaction of ISS with ionosphere
- Improvement of Combined Wave Diagnostics (CWD) method of plasma flows fluctuation;
- Identification of plasma flows disturbance sources and EM fields in NSZ;
- Geophysical research of plasma-wave processes connected to solar interactions;
- Ecological monitoring of low-frequency EM radiation of anthropogenic character;
- Plasma / EM fields disturbance from ISS injection of electron and plasma beams;
- Space weather research in equatorial, middle-latitude and sub-aurora ionosphere.

ulisse.cbk.waw.pl

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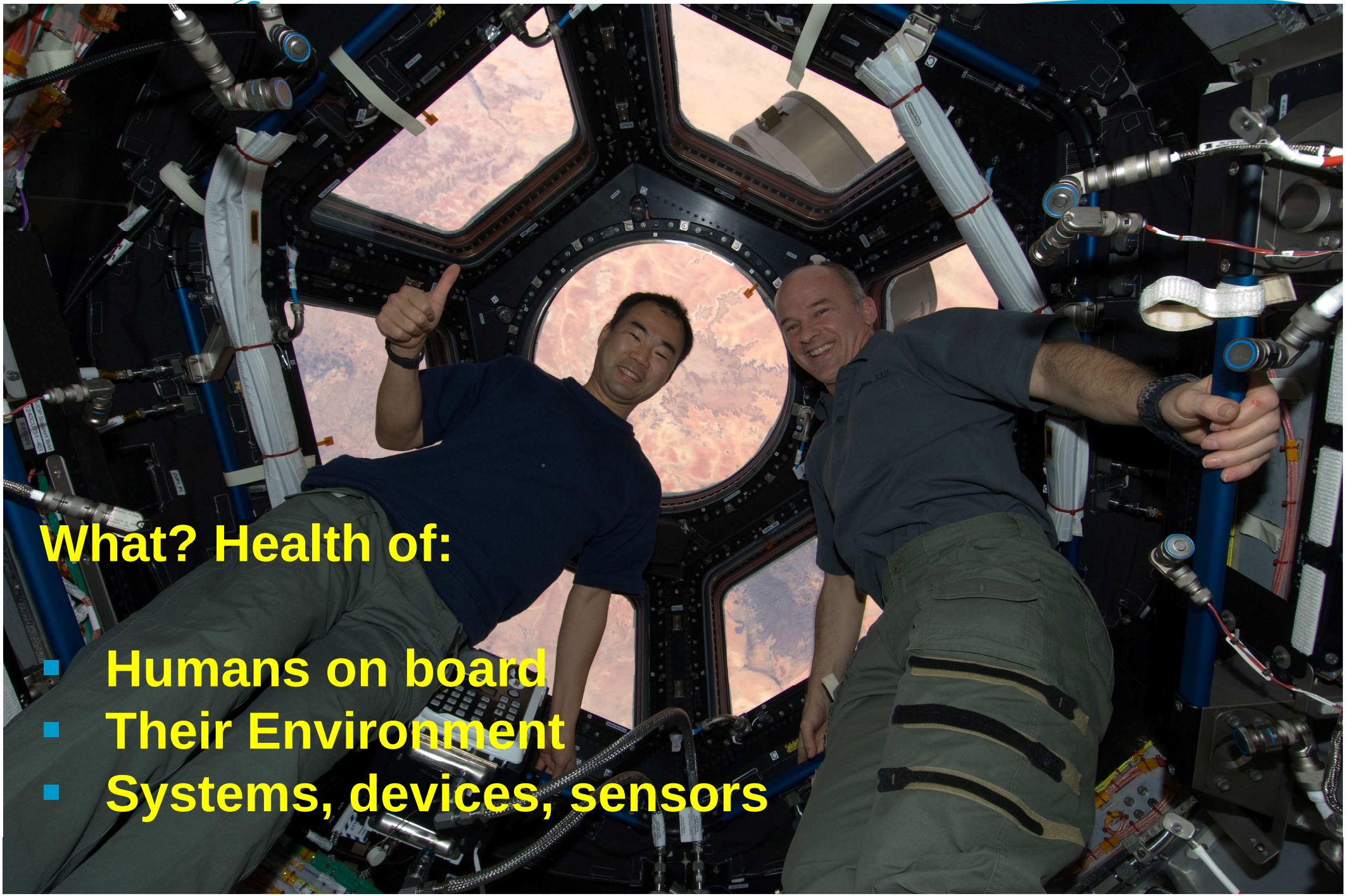
NODE 2 HARMONY, 23 ottobre 2007

ISS016E007932

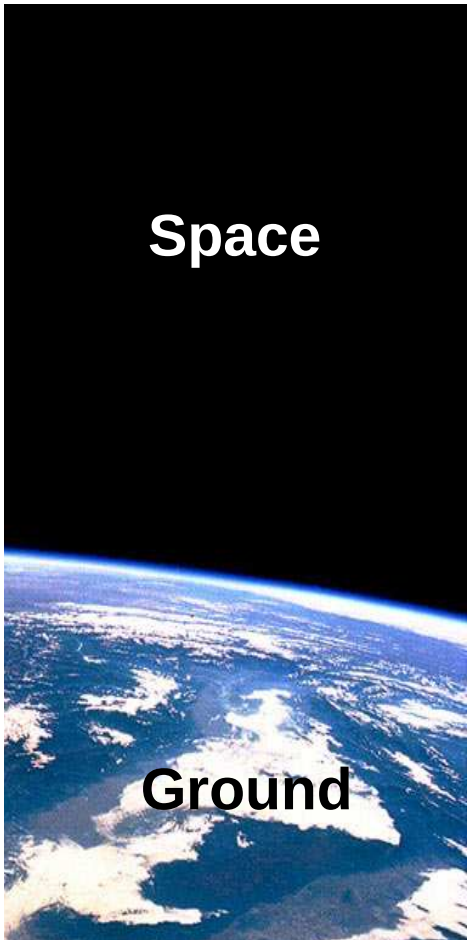
The Astronauts Environment

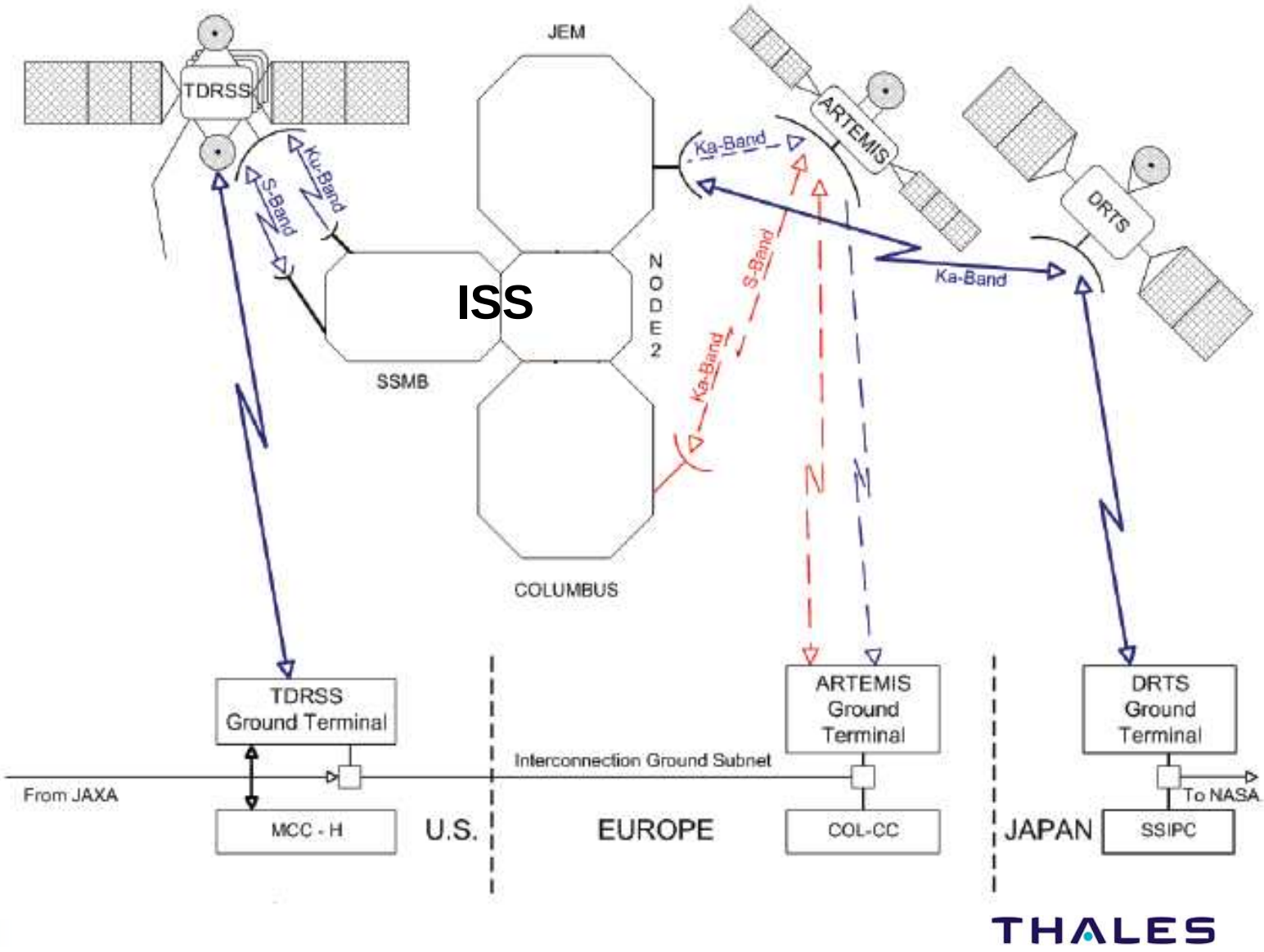
Astronaut environment diagnostics



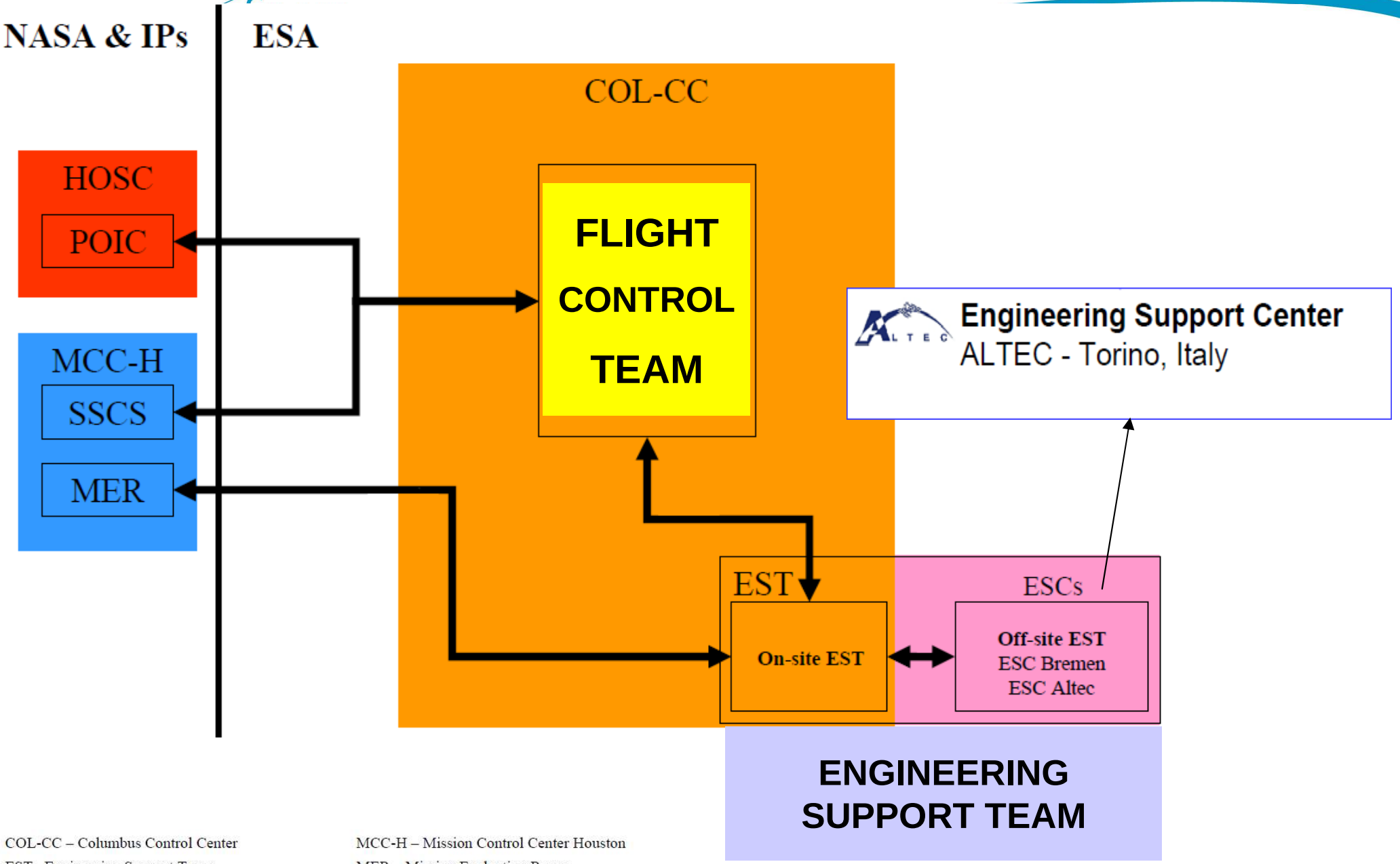
ISS / Columbus to Ground

Monitoring telemetry path





ISS / Columbus Ground Control Teams



COL-CC – Columbus Control Center
EST –Engineering Support Team
ESC – Engineering Support Center
HOSC – Huntsville Operation Support Center
POIC – Payload Operations & Integration Center
MCC-H – Mission Control Center Houston
MER – Mission Evaluation Room
IP – International Partner
SSCS – Space Station Control Center

Columbus: WE HAVE A PROBLEM

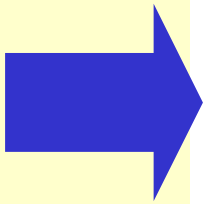
Automatic

- Alarm triggering
- Fault Detection, Isolation and Recovery (FDIR)

With human intervention

Ground - Anomaly study:

- Crew activity onboard
- Trend analysis
- Secondary parameters calculations
- Cross-check among sensors

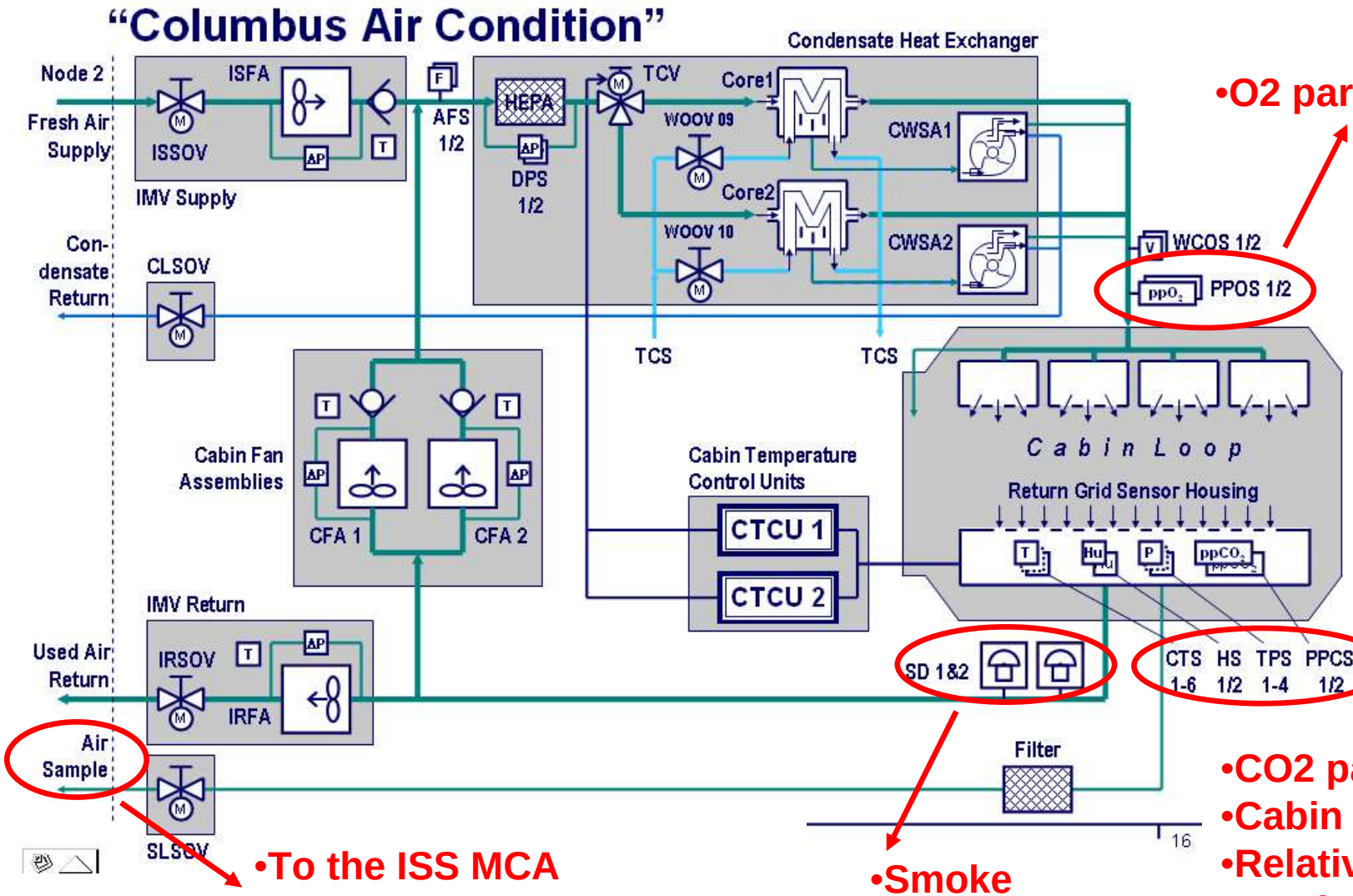


Anomaly resolution:

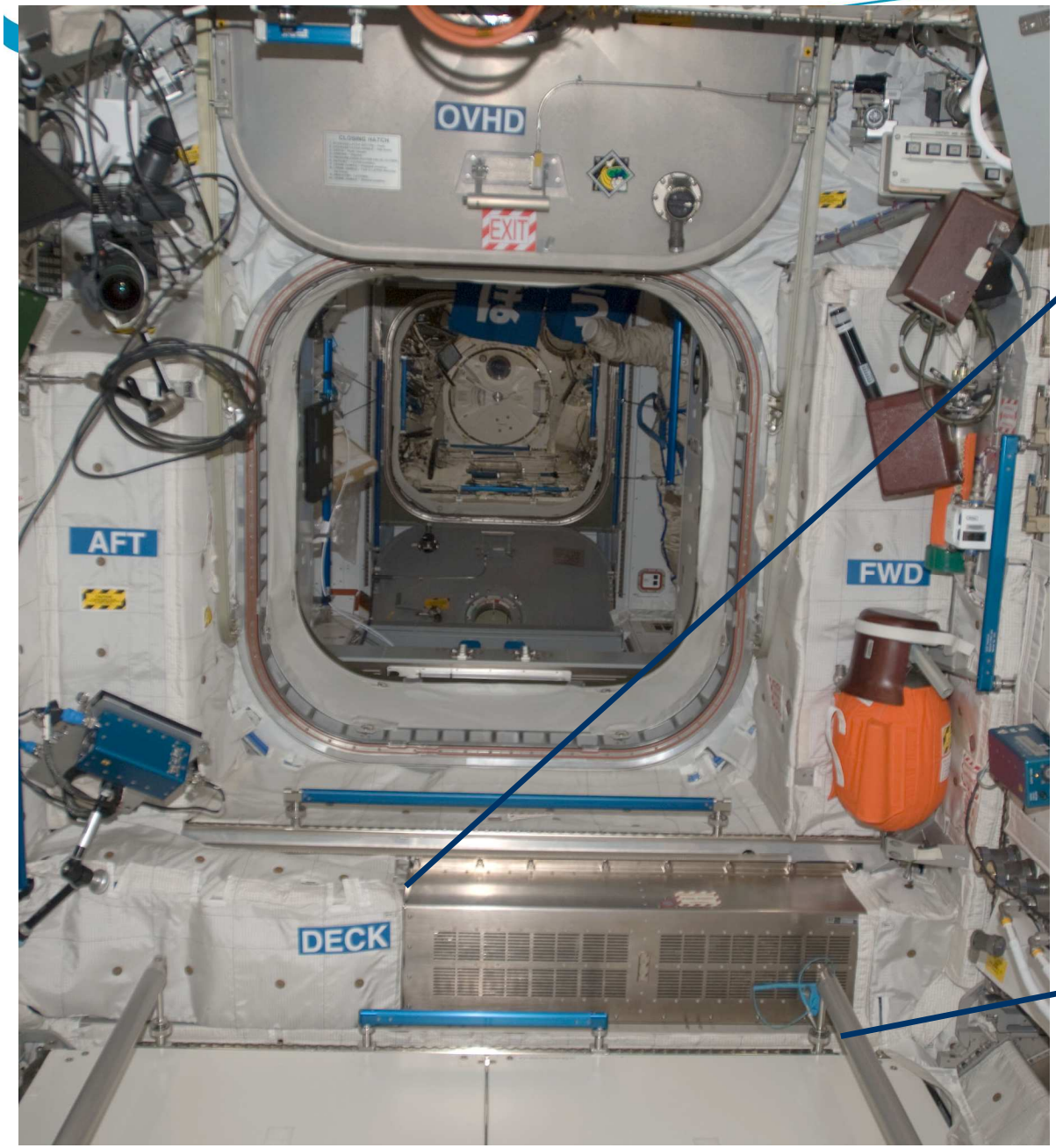
From ground

Astronauts

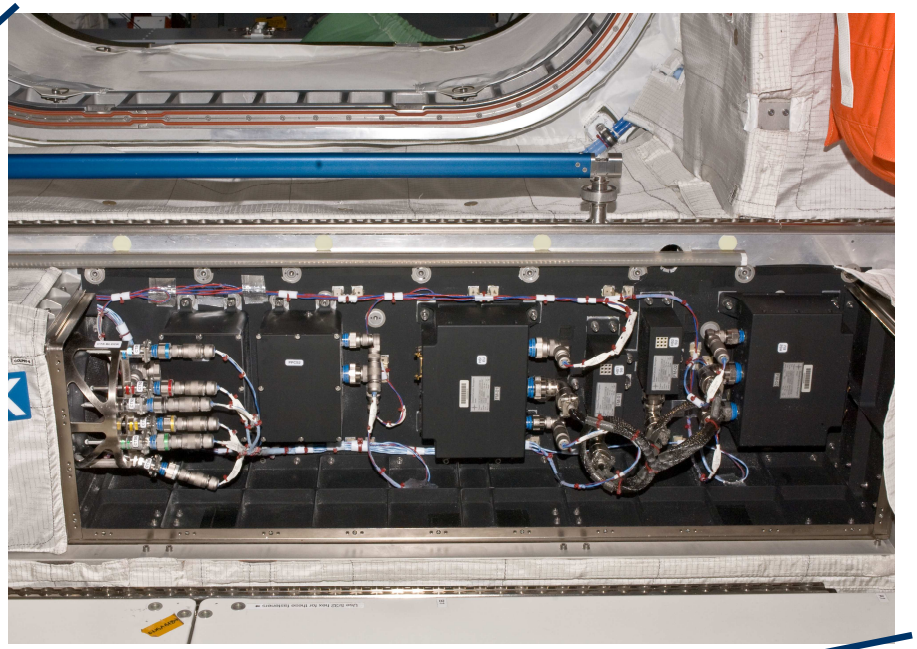
Columbus environmental monitoring



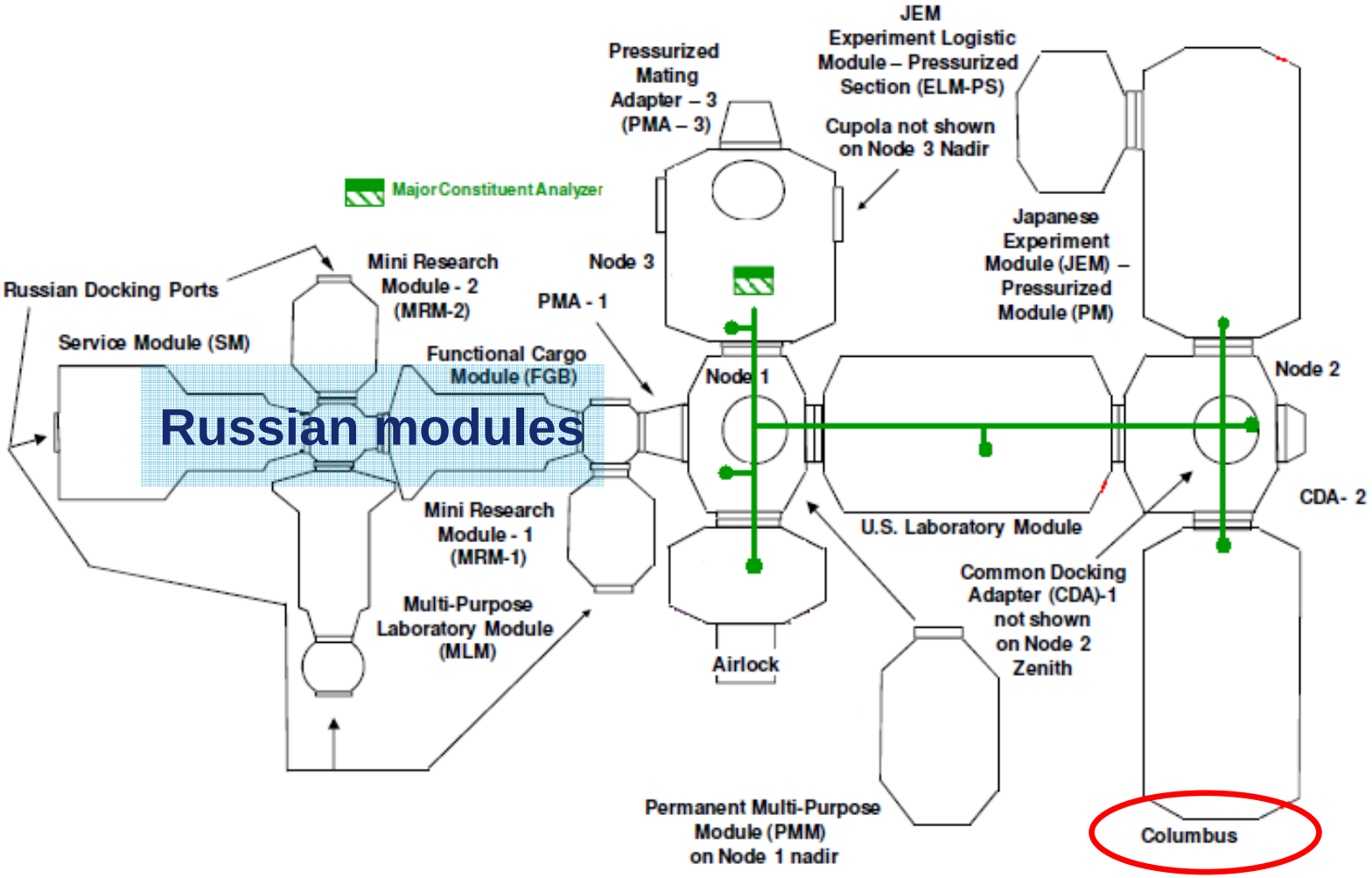
Columbus environmental monitoring



Return Grid Sensor Housing



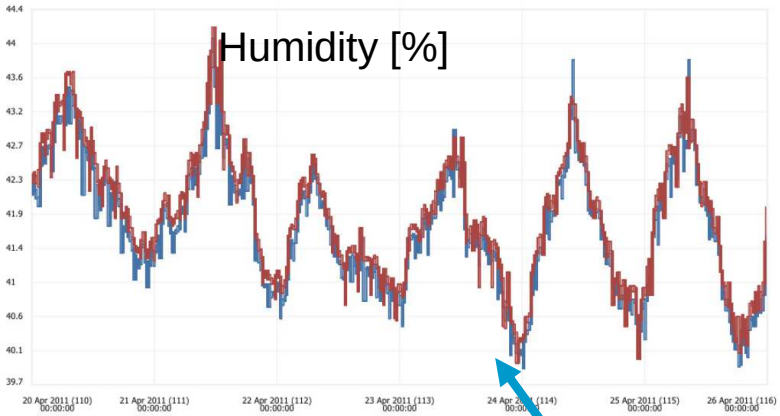
Centralized vs local monitoring

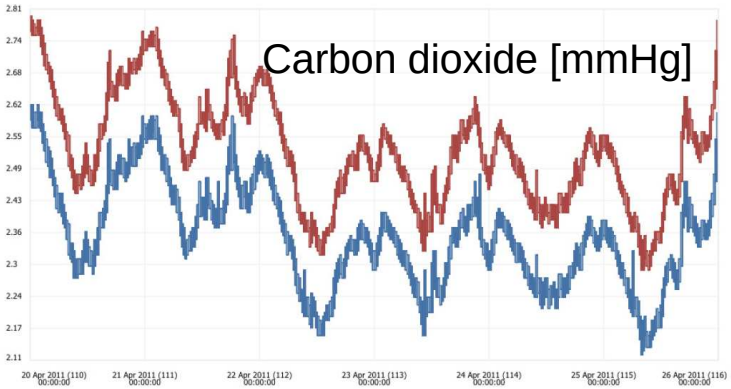


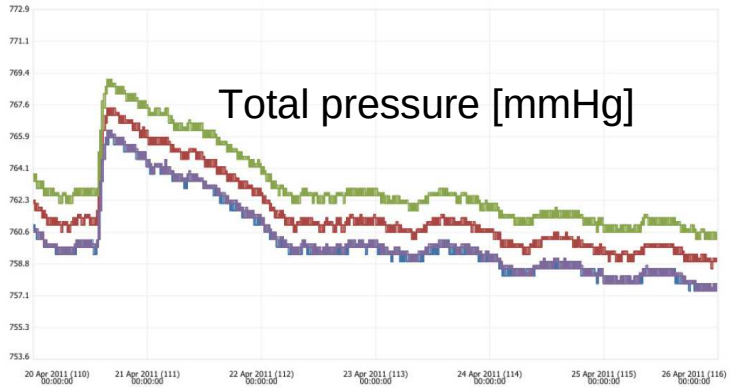
Major Constituent Analyzer

- CH4
- CO2
- O2
- H2O
- N2
- H2

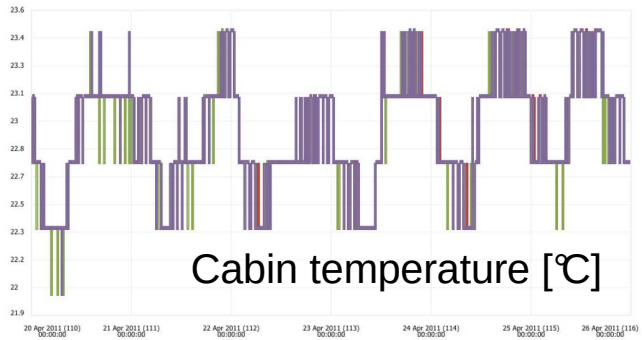
Trend Analysis

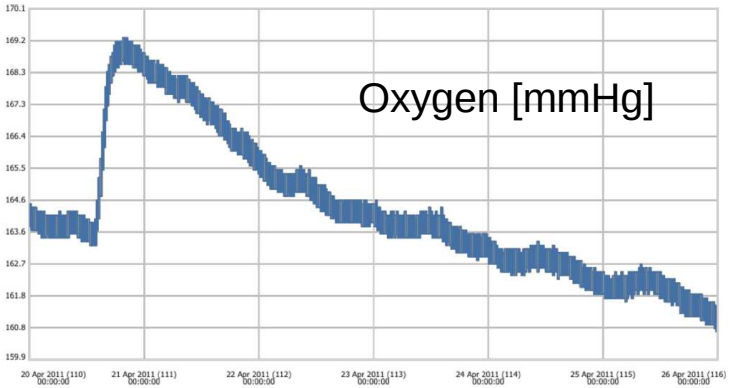




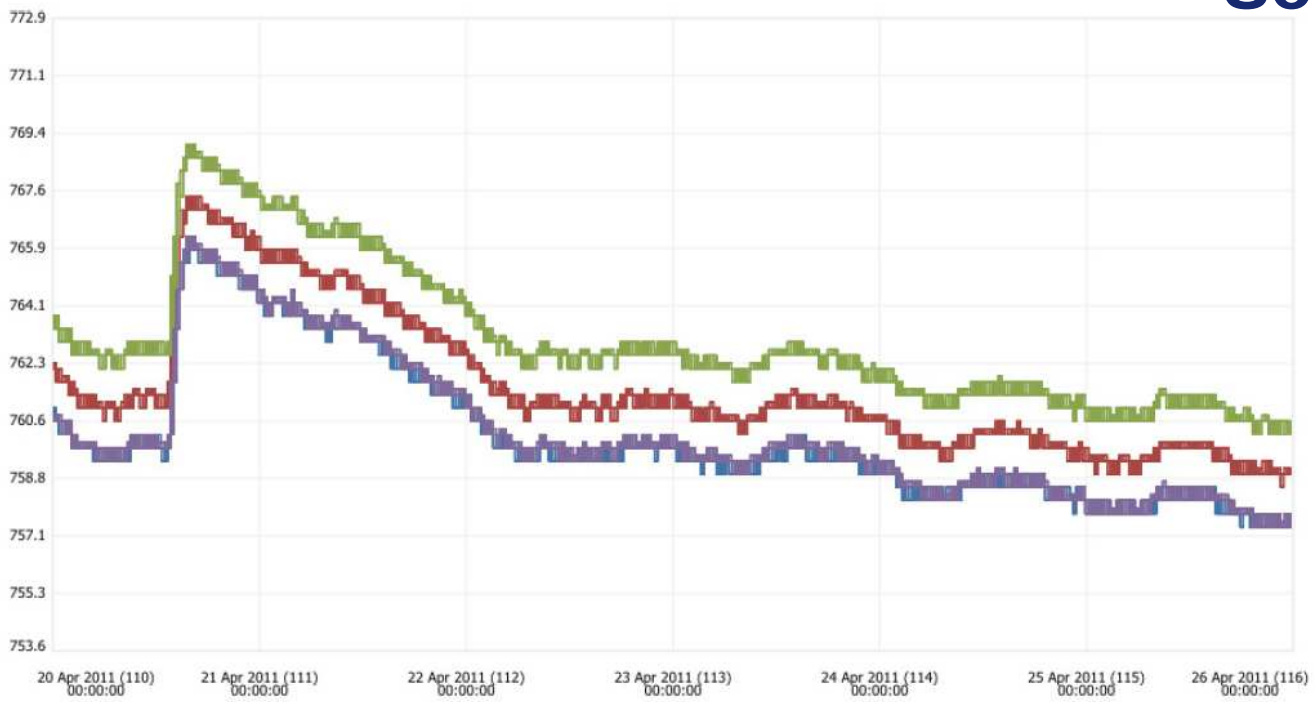


Environmental Sensors
(Telemetry from ISS to COL-CC)

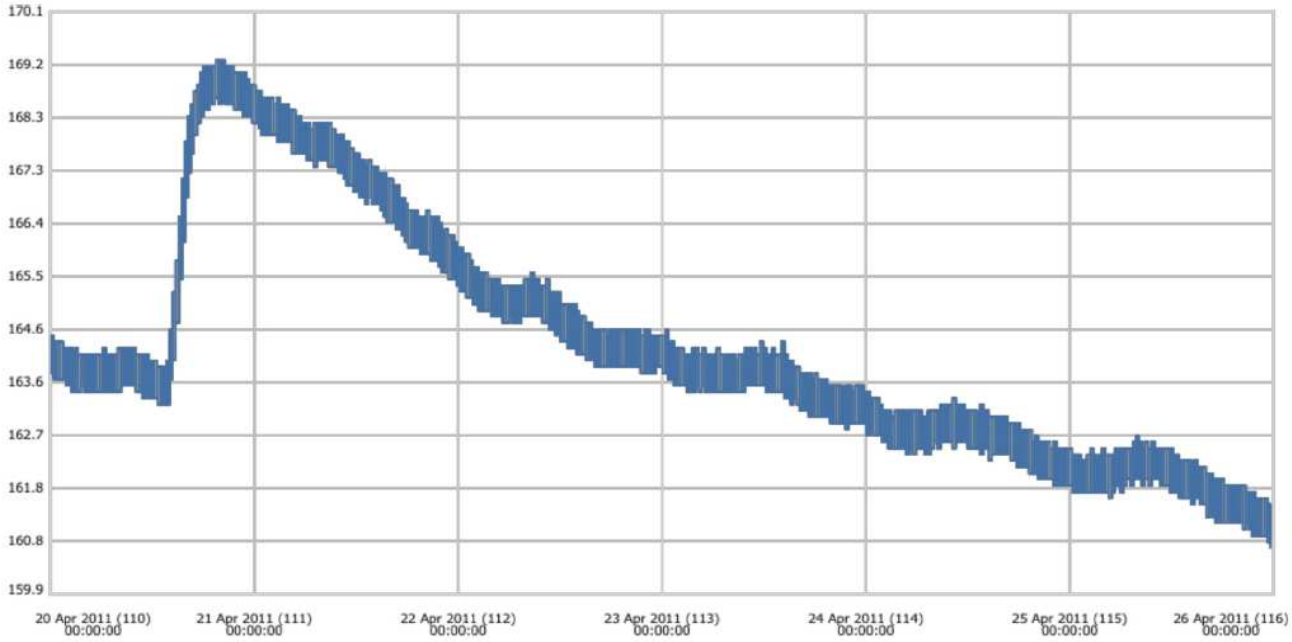




Some evident effects



Total pressure [mmHg]

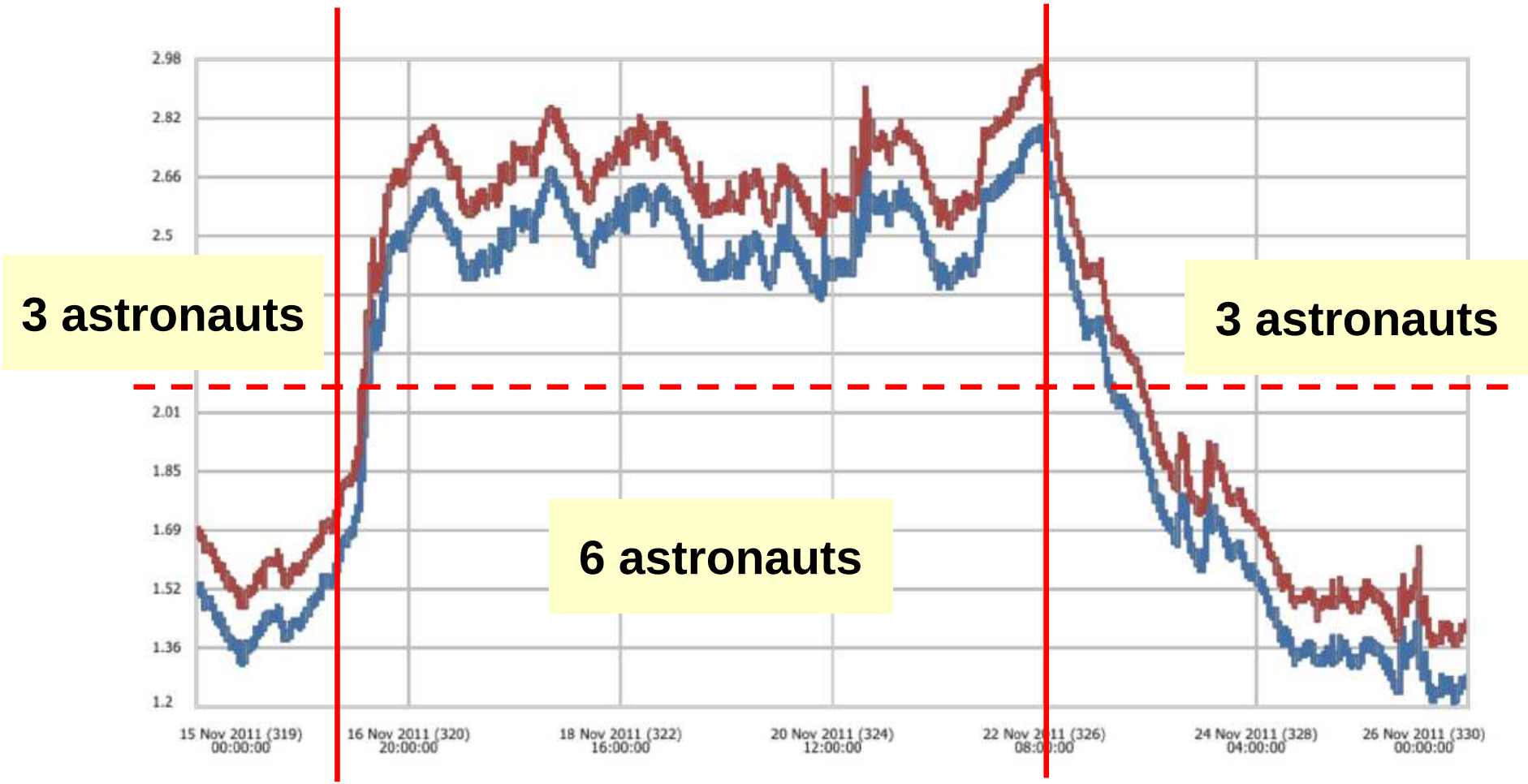


Oxygen [mmHg]

THALES

Some evident effects

CO2 Partial Pressure during crew rotations



PPCS1_Press_MVD min: 1.205 max: 2.802 unit: mmHg
PPCS2_Press_MVD min: 1.366 max: 2.970 unit: mmHg

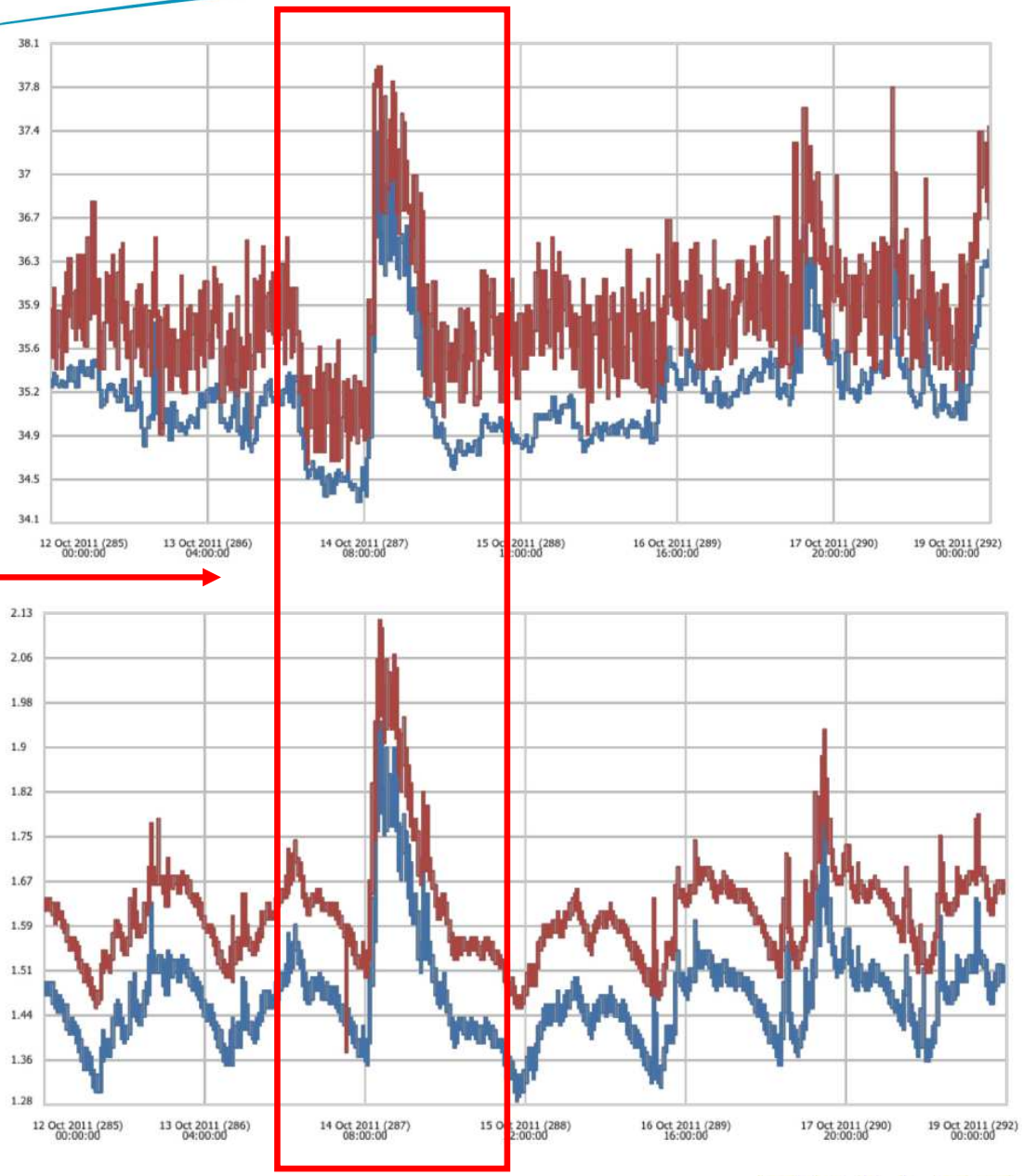
THALES

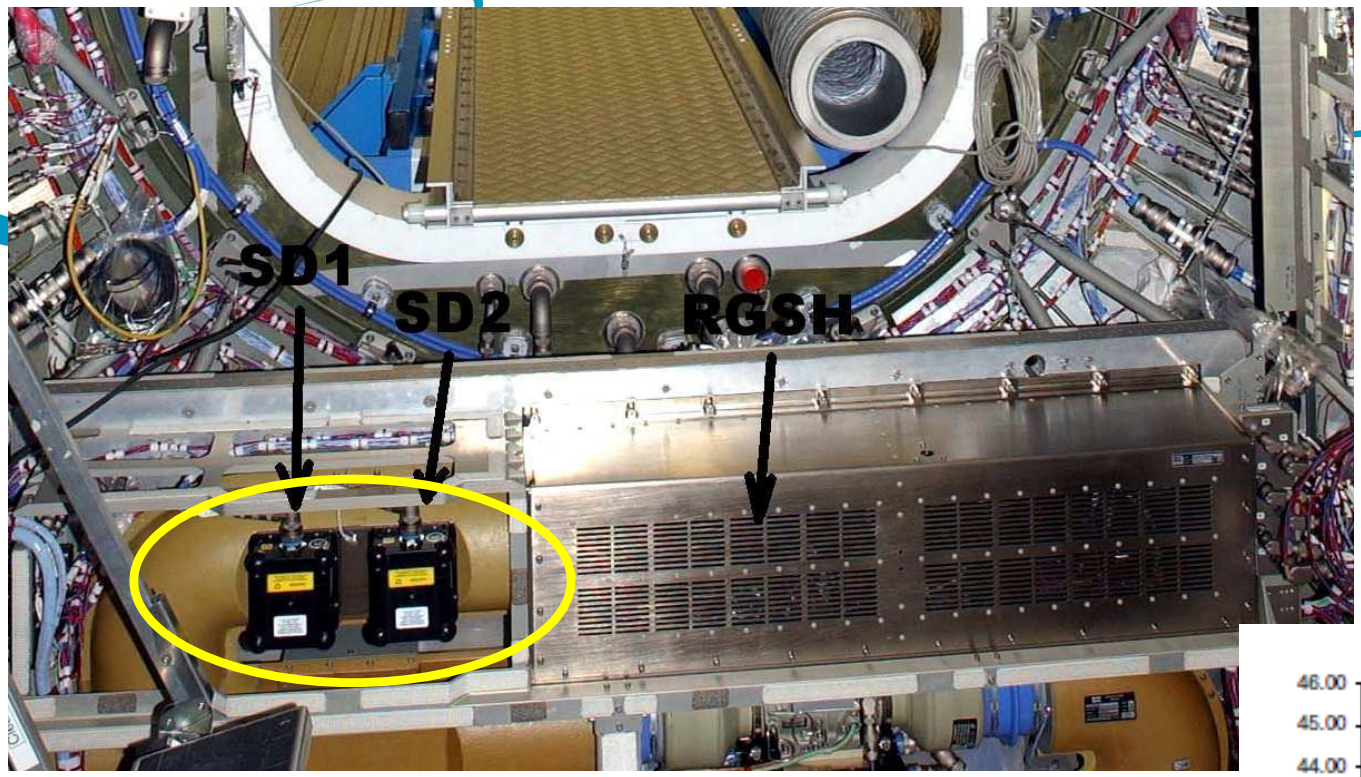
Some evident effects

Relative Humidity

Astronauts activity in Columbus with stop of air exchange with ISS

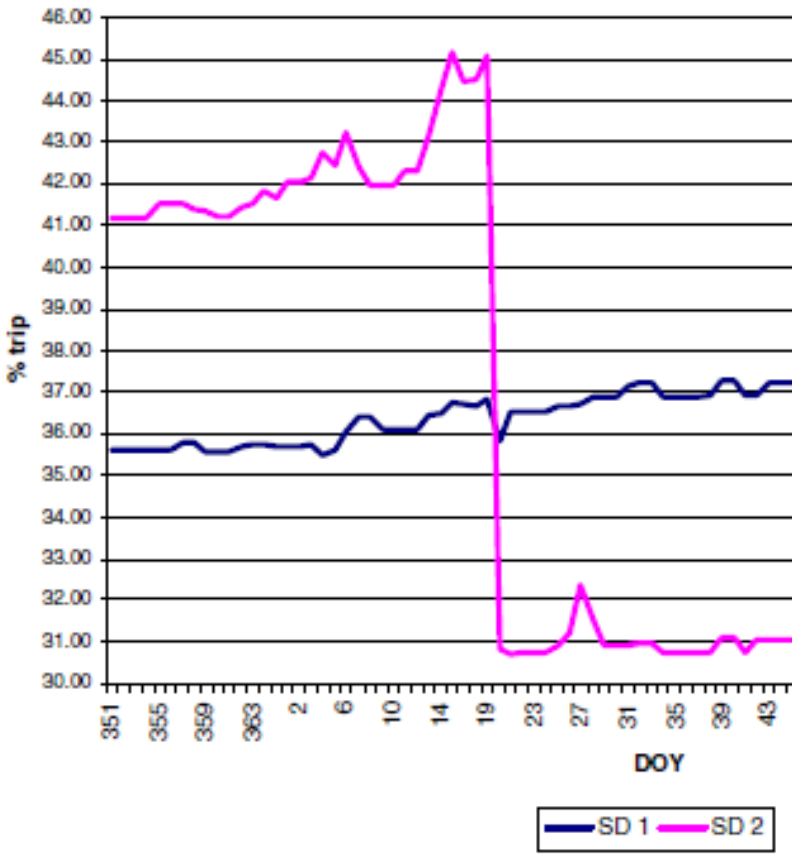
CO2 Partial Pressure





Smoke Detection

Percent Trip → scatter + obscuration = SIGN OF SMOKE PRESENCE



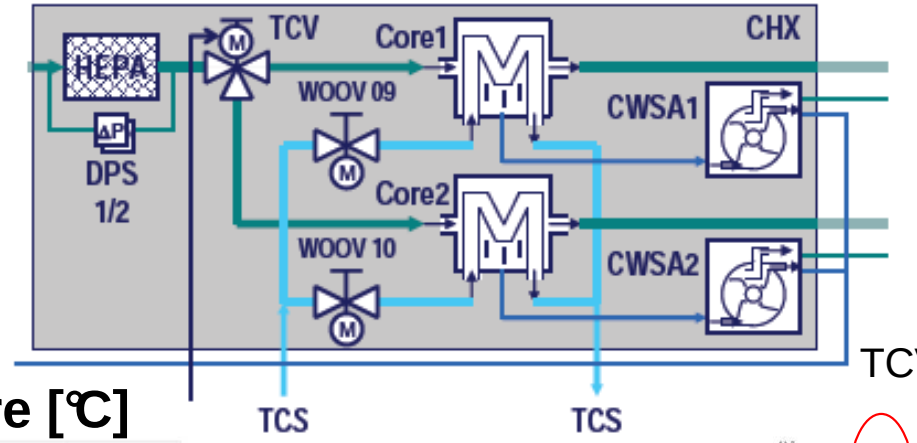
CONTAMINATION ISSUE

- PT >40% → astronauts clean sensor
- Airborne contamination can trigger it

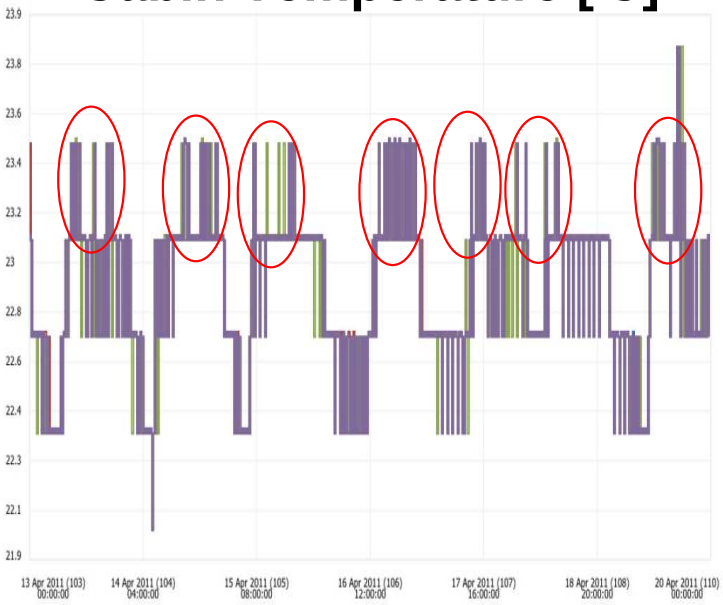
Countermeasure: new filter added

Columbus monitoring & control

Temperature Control & Dehumidification

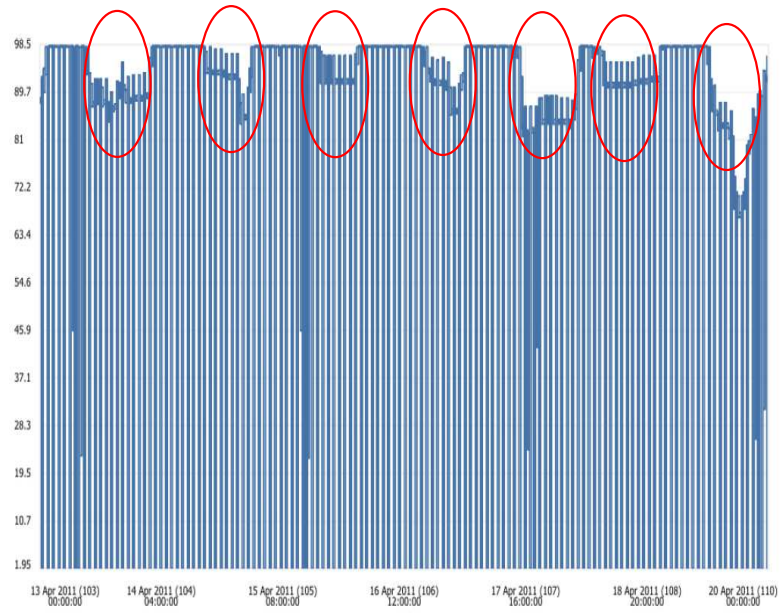


Cabin Temperature [℃]



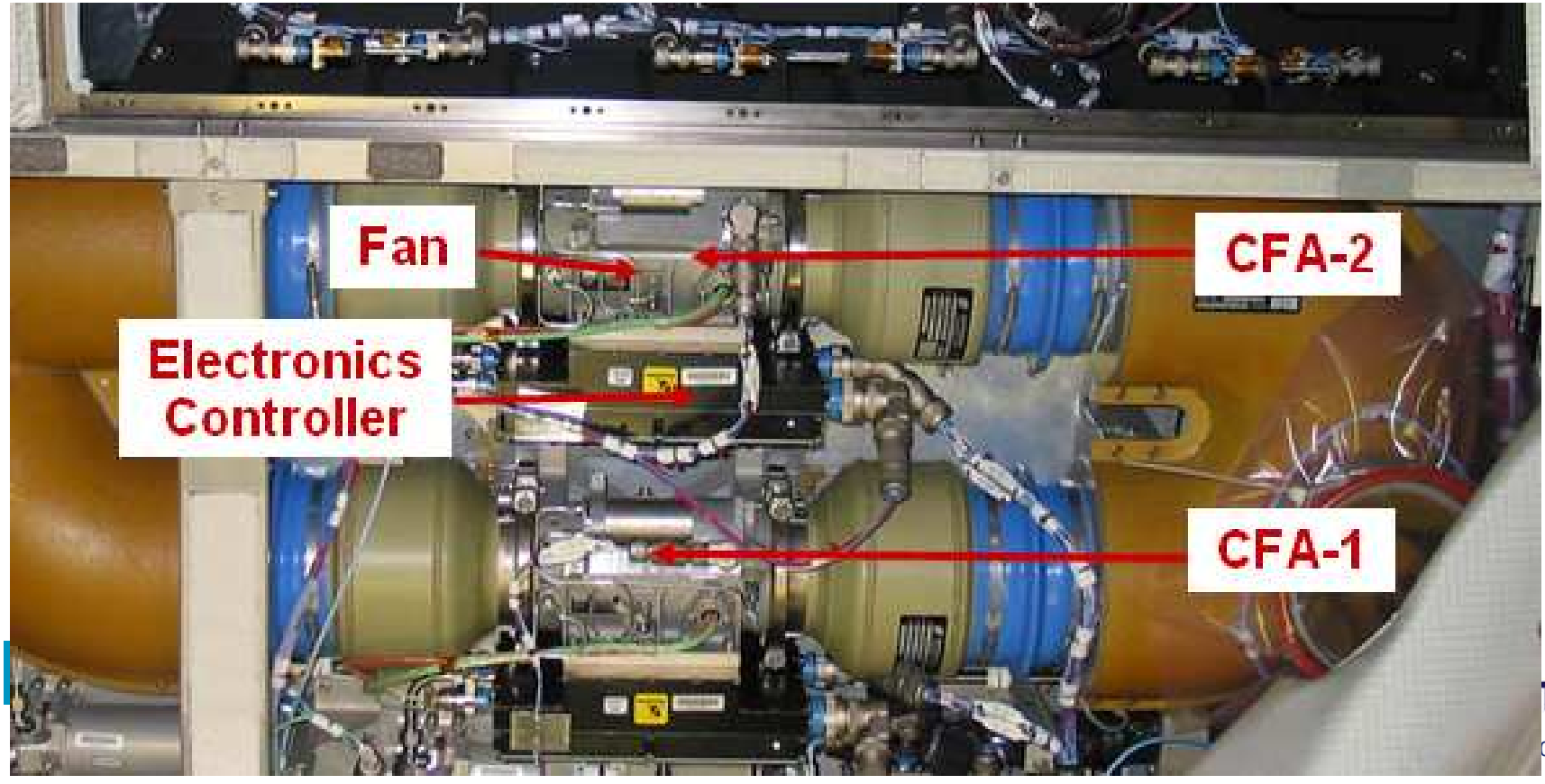
Temperature control law

TCV opening on the active core [%]

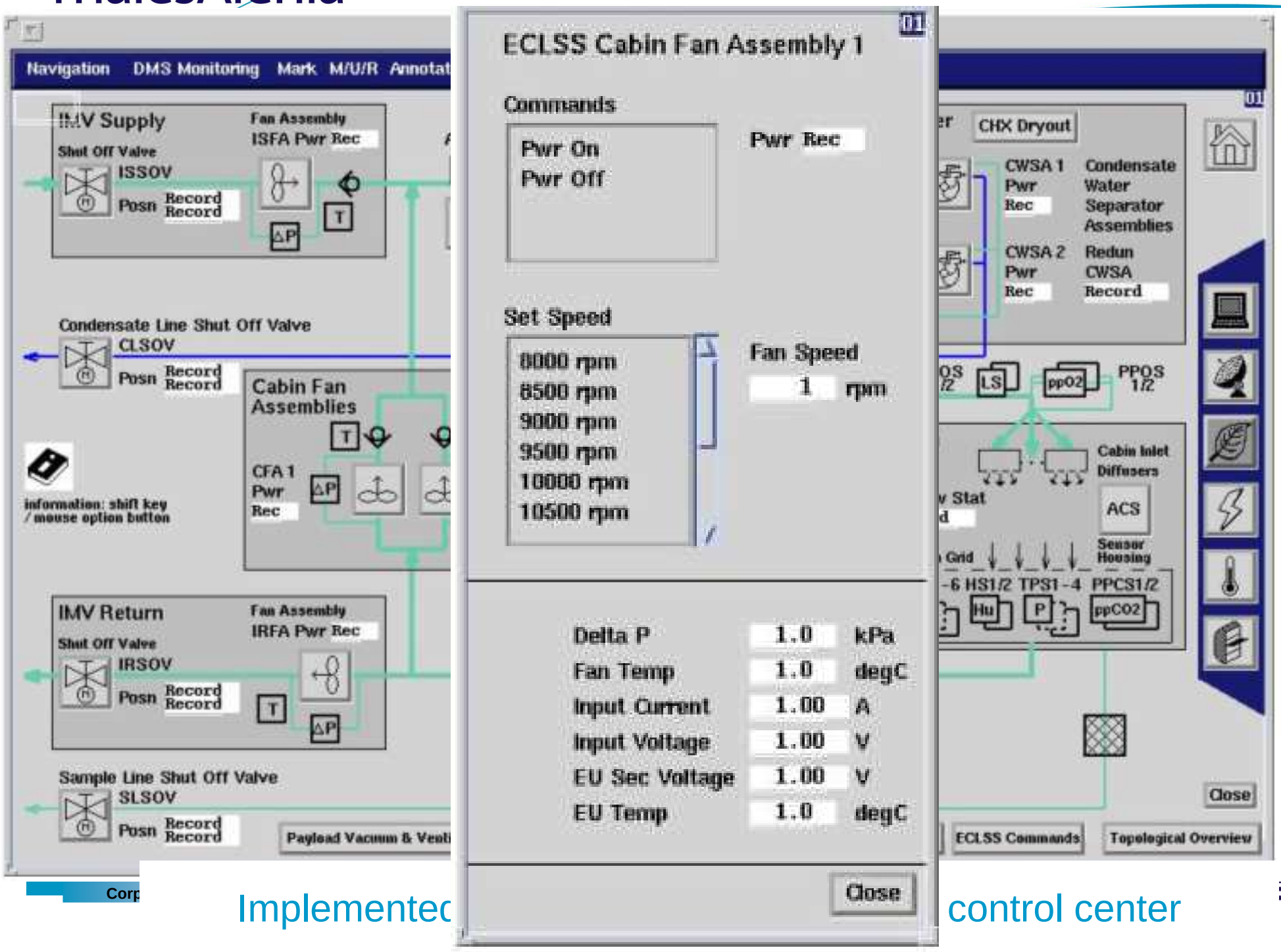


Devices and sensors health monitoring

- Health status (Built In Test)
- Active Status
- Electronic Unit temperature
- Input Current
- Motor temperature



Portable Work Station display



Implemented control center

Failure Detection Isolation & Recovery (FDIR)

Approach: to concentrate the FDIR activities on the lowest affected levels

SCOPE

- contain faults at equipment level

- avoid failures propagating to the higher level subsystem functions, impacting on its performance

Failure Detection

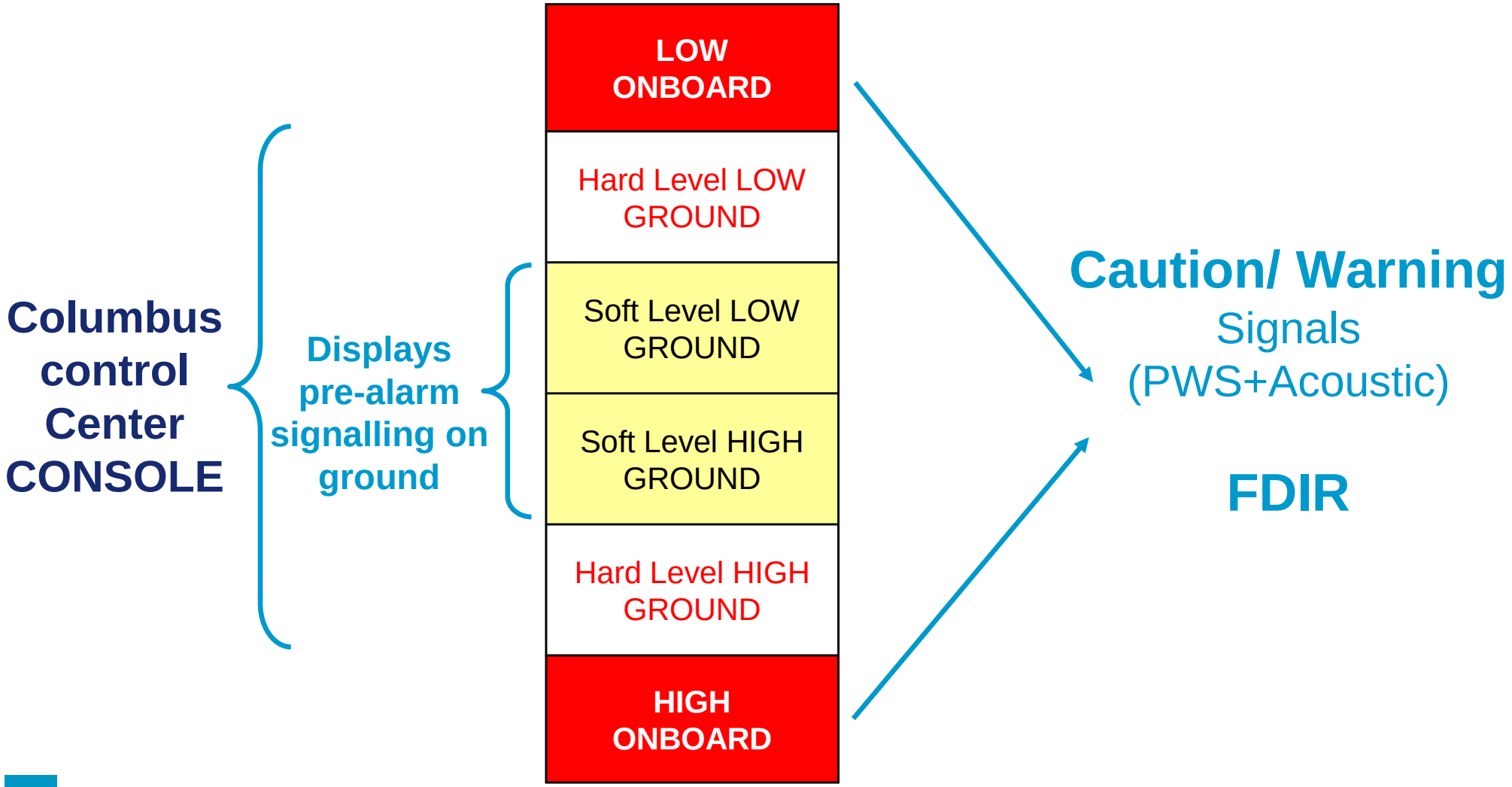
Failure DETECTION Isolation & Recovery

Identification

- Monitored parameter out of limits
- Monitored parameter exceeding its delta limit wrt a redundant one
- Monitored parameter out of its safe range
- Monitored discrete item not in one of its expected states

- Identification of valid symptom set from monitoring data
- Mapping of symptom set to potential failure
- Mapping of identified failure(s) onto one or more equipment

Detection → Caution & Warning



Failure Isolation

Failure Detection ISOLATION & Recovery

Containement

Identify faulty equipment down to equipment level, compatible with recovery capabilities

To avoid propagation

- ✓ **Capability to switch-off automatically**
- ✓ **Capability to switch-off via DMS instructions**

Failure Recovery

Failure Detection Isolation & RECOVERY

Allow nominal operations to occur continuously and safely

Achieved by selecting redundant functional paths or alternative operating mode (functional redundancy).

Automated procedures implemented for different failures via FDIR FLAPS

FLight
APplication
Software

Radisens Diagnostics win €1m International Space Station contract

Share Tweet

October 31, 2011

By Laura McGuigan

Cork firm Radisens Diagnostics has been awarded a €1 million contract by the European Space Agency, to develop an innovative blood testing device for use by astronauts on board the International Space Station and on various human spaceflight missions.

"Radisens Diagnostics' success is the most recent example of an Irish company reaping significant benefits from Ireland's membership of the European Space Agency (ESA) through Enterprise Ireland," said Sean Sherlock T.D. Minister for Research and Innovation.

Finger-prick of blood to test patients for diabetes, heart disease, liver and kidney damage and thyroid conditions, with instant results.

Credits: insideireland.ie

Future Frontier

MARS

Radiation issue

Mars travel dose ~ 0.8 Sv/y vs 0.5 Sv/y limit for ISS astronauts

Every year 1/3 of astronauts DNA would be damaged by Cosmic Rays

THALES

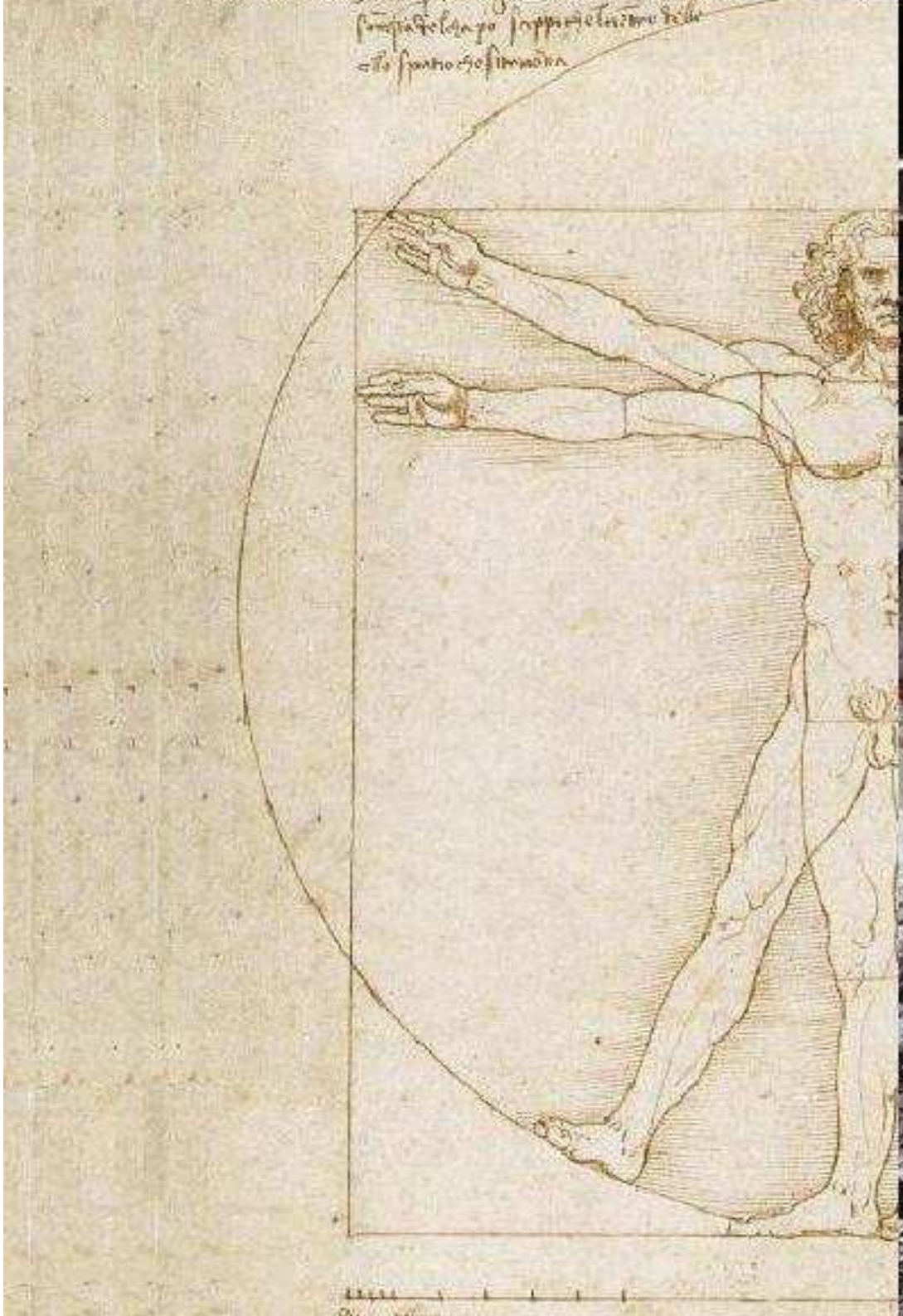
Impossible resupply → Reliability

Earth From Mars - From Rover Spirit, one hour before sunrise, 63rd Martian day of its mission. Credit NASA

ThalesAlenia

Challenges for diagnostics

Lessons will be learned!



Thanks for your attention!

Questions?

Final notes

Contact mail

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Credits

Unless otherwise indicated all picture credits are NASA