

# XIII WRMISS

Krakow, 8-11/9/2008

## Status of Altcriss experiment + Pamela results on radiation environment

M. Casolino,  
on behalf of the ALTCRISS/Pamela collaboration

INFN & University Roma Tor Vergata





# ALTCRISS Collaboration

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Prof. Lembit Sihver, University of Chalmers (SE)

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# Altcriss

## *Alteino Long Term cosmic ray measurements on board the ISS*

- **In response to AO 2004 ESA (AO2004-067)**
- **Measure of cosmic ray abundances and radiation environment on board the ISS (p-Fe >50-100MeV/n)**
- **Study of the effectiveness of different shielding materials on board the ISS – in parallel to Montecarlo and Beam Test studies**
- **Measures with passive dosimeters (JAXA, DLR, Fed II, INFN, INFN-LNF)**
- **Joint measures with Matroska, Pamela, Altea, CPDS**
- **Long term monitoring (>2005) of solar modulation and solar particle events.**
- **Operational since end 2005 up to now (Exp 12- 17)**

# Shielding and radiation measurements on ISS with active and passive detectors

- In Space: ISS, global measurements
- On Ground: Beam tests, controlled conditions, single ions
- On Computer: Montecarlo Simulations, Cross check of codes



Alteino

TLD, CR39 to measure charged particle and neutron dose



Jaxa



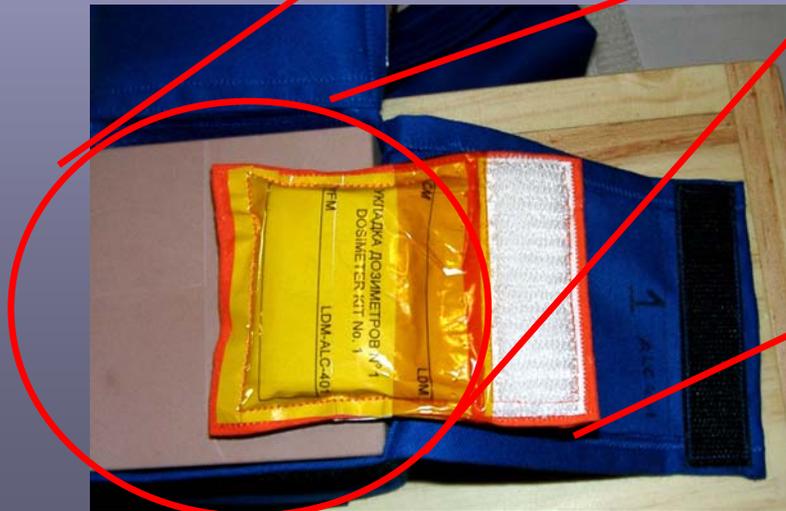
DLR



Napoli Fed. II INFN-LNF

# Shielding bag

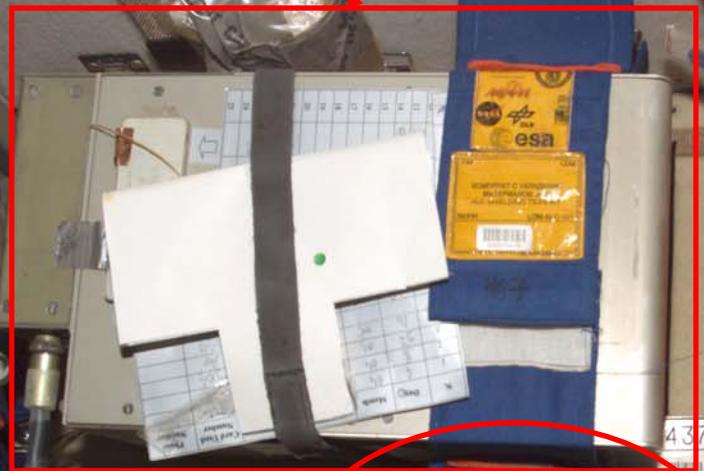
Polietilene shielding: ( $5\text{g}/\text{cm}^2$ ):  
*(Same thickness of the US section of the station)*



**25 September 2006**

Multimaterial Shielding  
And dosimeters

Alteino detector



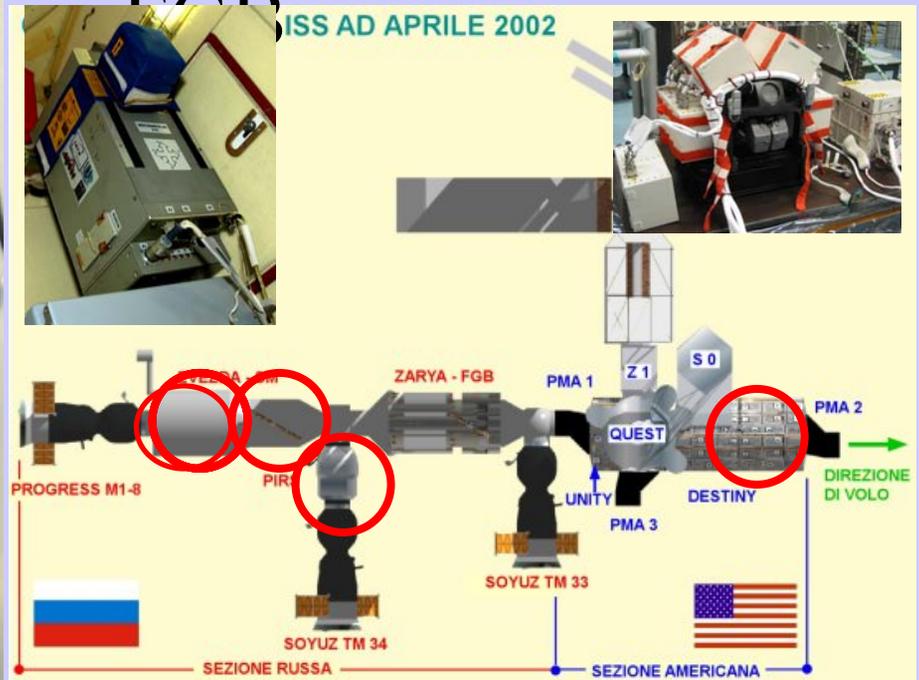
Data cards and control dosimeters

Poliethylene shielding  
And dosimeters



# Sileye-3 locations

- Service module
  - Main body
  - Cabins
  - Forward Section
- Pirs docking module





Brasileiro  
Marcos Pontes  
5/4/2006



**Christer Fuglesang, STS-116 Dec, 2006**

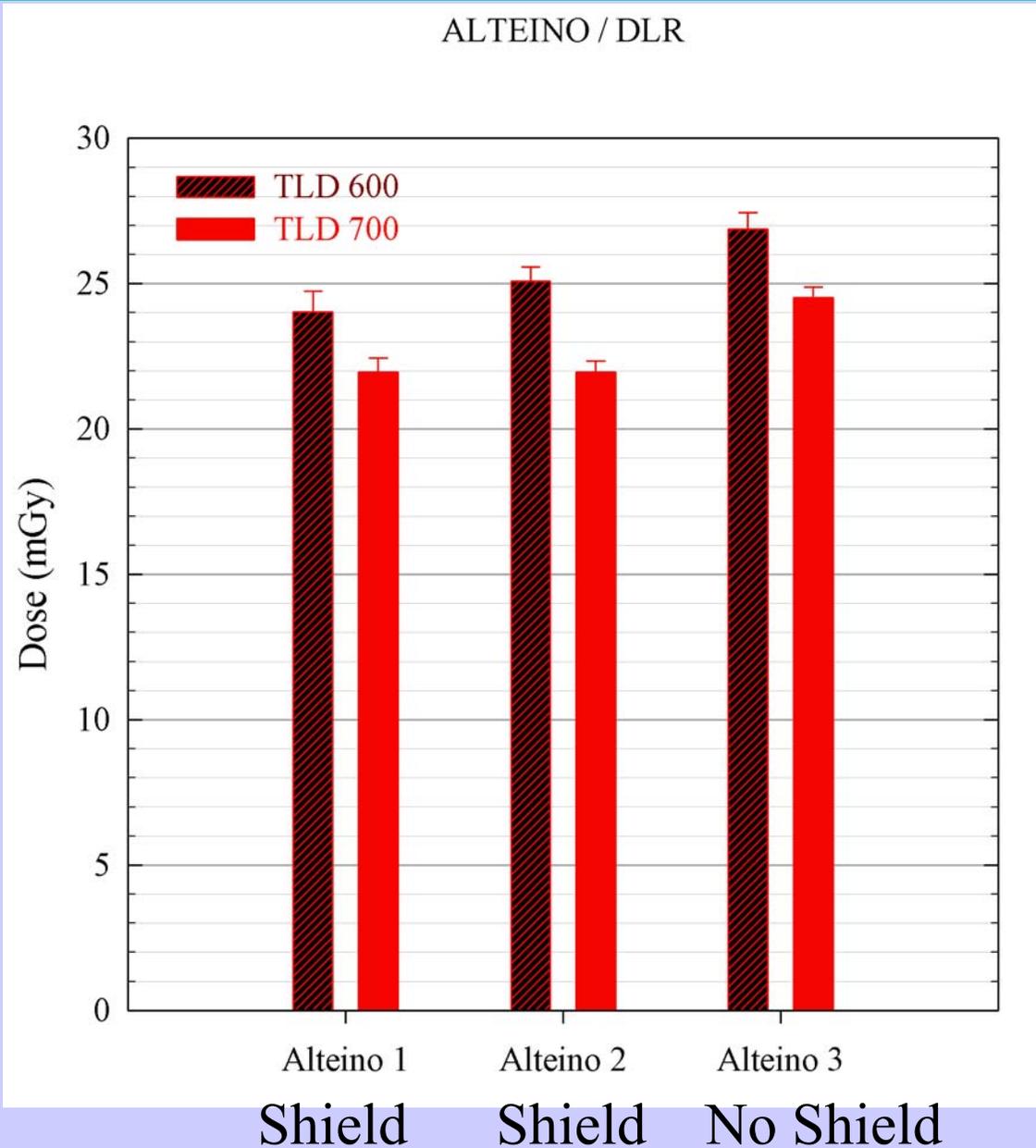
# PASSIVE DETECTOR RESULTS: JAXA CR-39+TLD results

Package No.	D <sub>TOTAL</sub> (TLD+CR-39) mGy			H <sub>TOTAL</sub> (TLD+CR-39) mSv			Mean QF		
		±			±			±	
Shielded POLY 1	26.72	±	2.04	51.80	±	2.76	1.94	±	0.18
	26.72	±	2.04	50.97	±	2.64	1.91	±	0.18
Shielded POLY 2	26.93	±	1.71	53.41	±	2.61	1.98	±	0.16
	26.84	±	1.71	50.07	±	2.48	1.87	±	0.15
SPACE CONTROL (unshielded)	28.24	±	1.73	55.01	±	2.70	1.95	±	0.15
	28.17	±	1.73	51.79	±	2.48	1.84	±	0.14
GROUND CONTROL 織等価 #4	1.38	±	0.09	2.51	±	0.13	1.82	±	0.16
	1.37	±	0.09	2.06	±	0.11	1.50	±	0.13

\* 船外・船内の線量結果は、地上コントロールを差し引いた線量を示す。

from A. Nagamatsu, JAXA

# PASSIVE RESULTS: DLR TLD



*from T. Berger, DLR*

## Polietilene shielding (ALTCRISS)

Flight Test	Dose (Polyethylene)	Dose (Space Control)
EXPEDITION 12	0,20	0,22
EXPEDITION 13	0,22	0,26
EXPEDITION 14	0,21	0,23

Dose in mGy/d

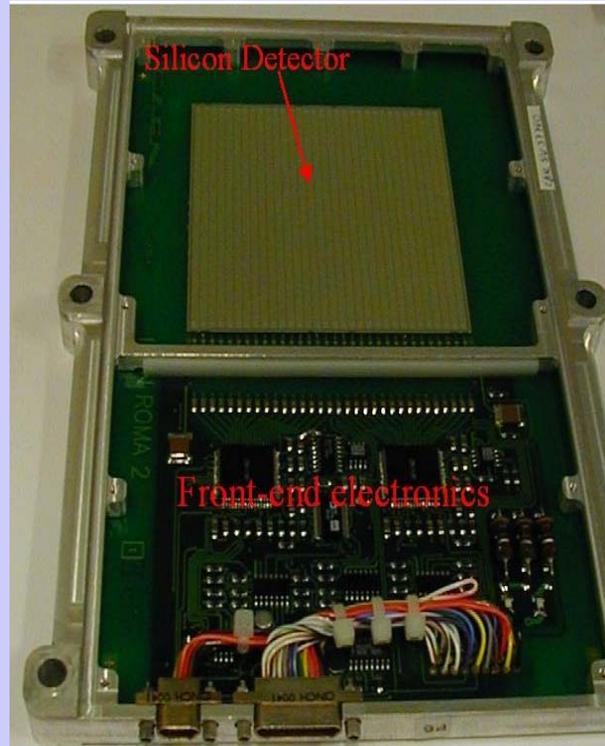
# *Conclusion for Passive shielding*

5 g/cm<sup>2</sup> poliethylene → reduction of about 10%  
(in agreement with calculations)

Continue data taking in one fixed location with/without  
shielding (Exp 18 – 1 year)

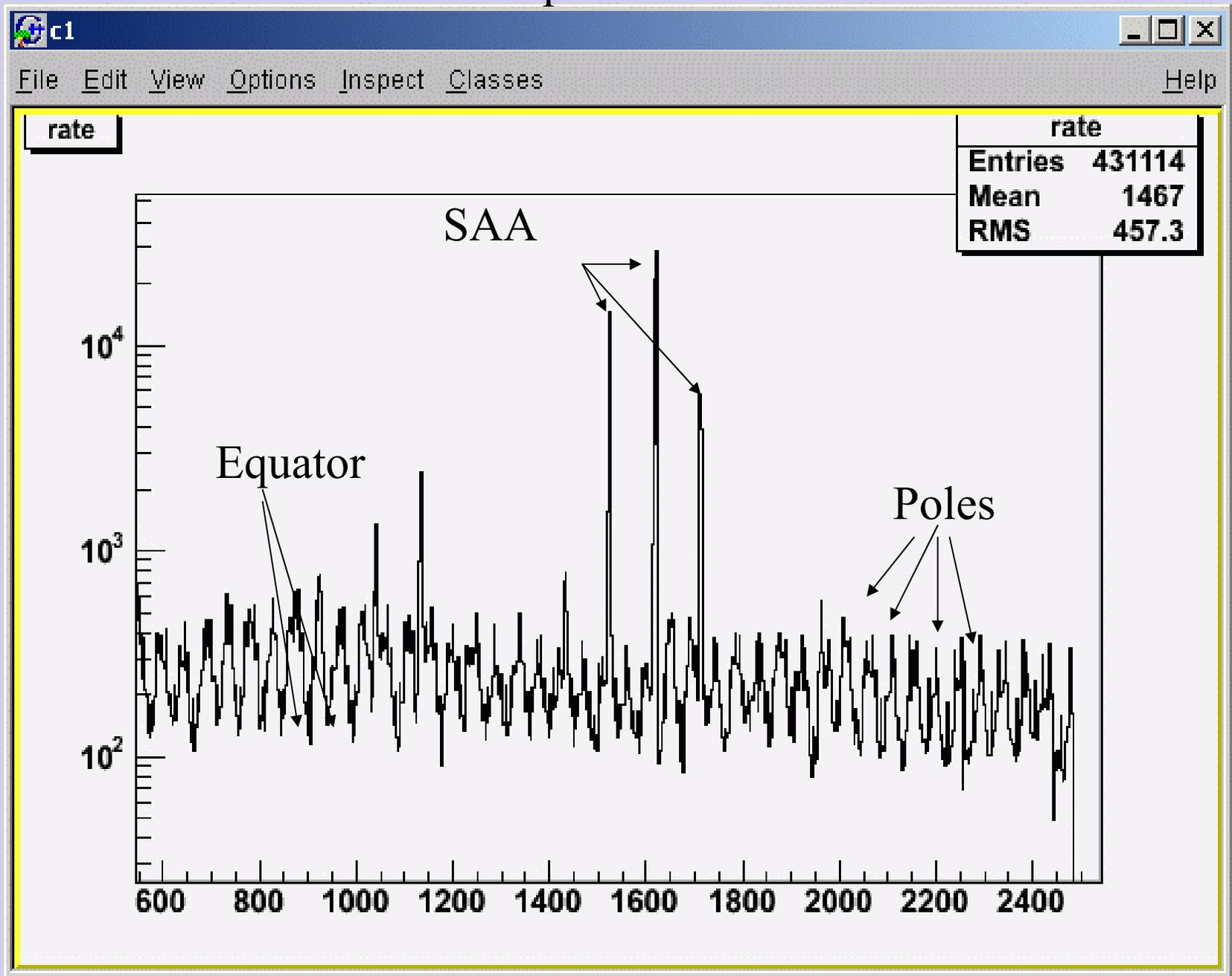
# Sileye-3 detector:

- 8 silicon planes (4x,4y)
- 32 strips strip pitch 2.5 mm, 8x 8 cm<sup>2</sup>, thickness 380 μm
- Total 256 Independent channels
- Triggered by two scintillators
- ( $E_{\min}=40\text{MeV}/n$ )
- Geom Fact: 24 cm<sup>2</sup> sr
- Bidirectional
- Max Field of view 39°
- The front-end is a developed version of two 16 channels CR1 chip with a peaking time of 2 μs; a sensitivity of 5 mV/MIP and a maximum counting rate of 30 kHz.

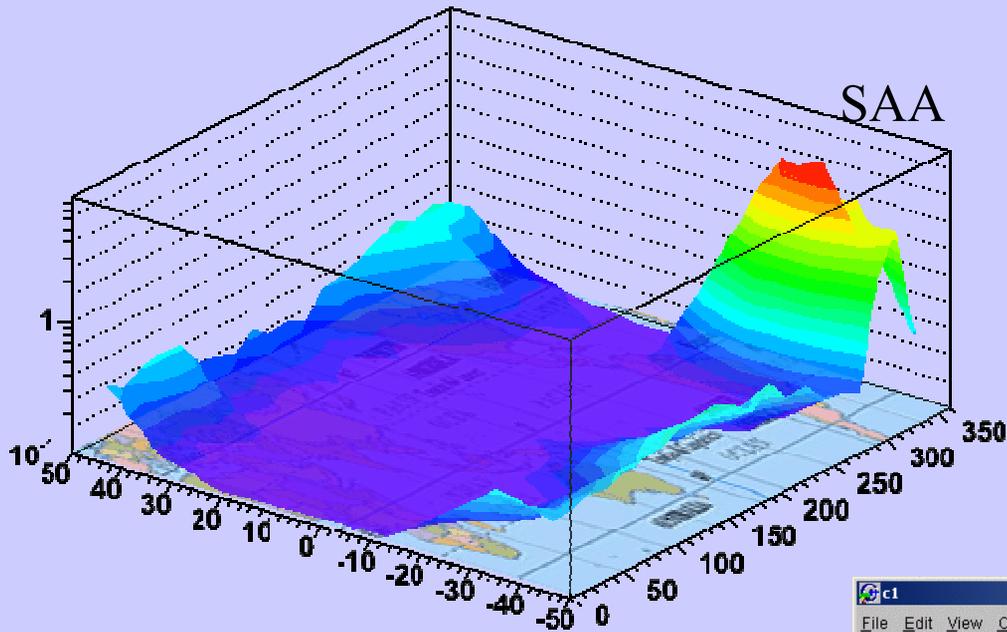


Left: AST detector tower open (without readout electronics): it is possible to see the stack of silicon detectors and the top scintillator (the detector is upside down). The bottom scintillator has been removed for clarity. Right: One of the 8 silicon detector boards (X view). It is possible to see the segmentation of the 32 strips of the detector. (Photos taken during assembly in the clean room facilities of Tsinghua University)

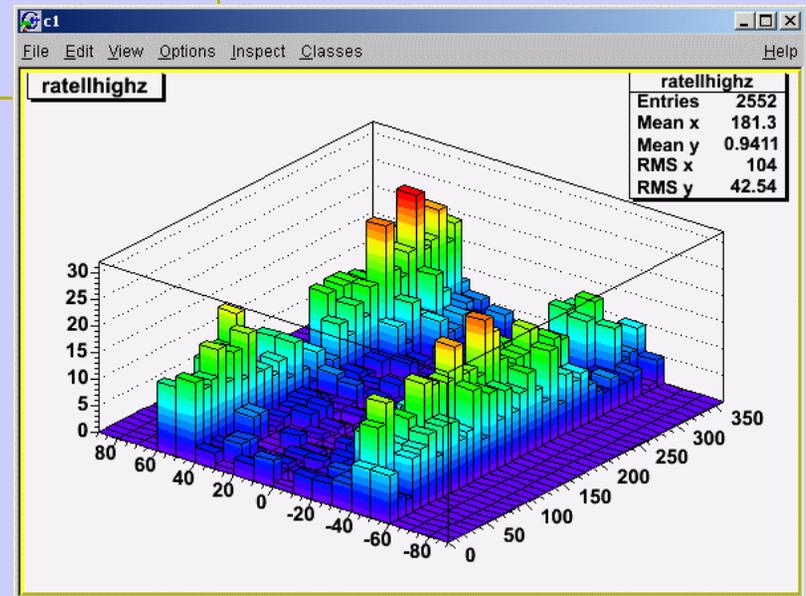
# ALTEINO Real Time Data: Acquisition rate vs time



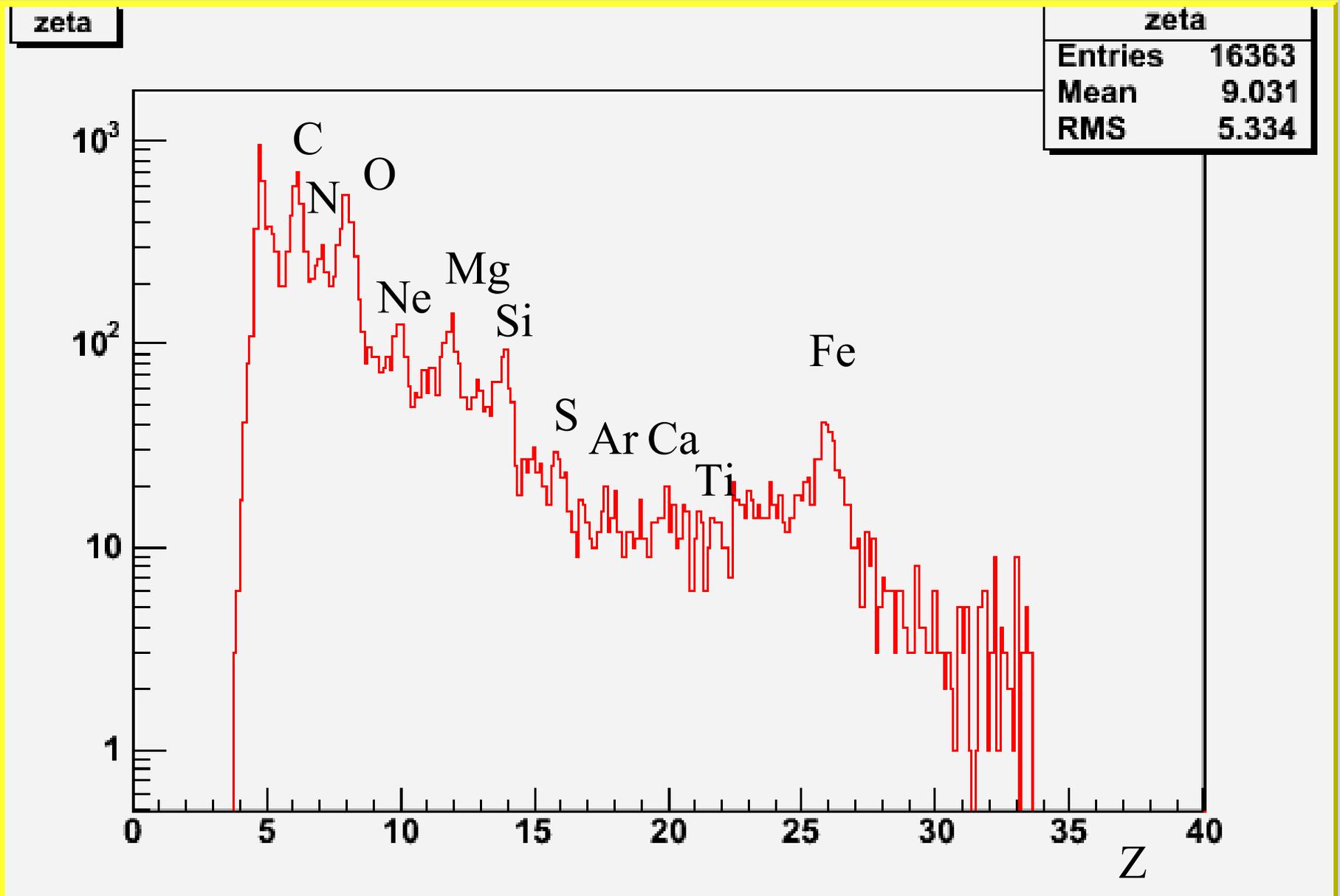
# All-Particle count world map



Heavy Nuclei



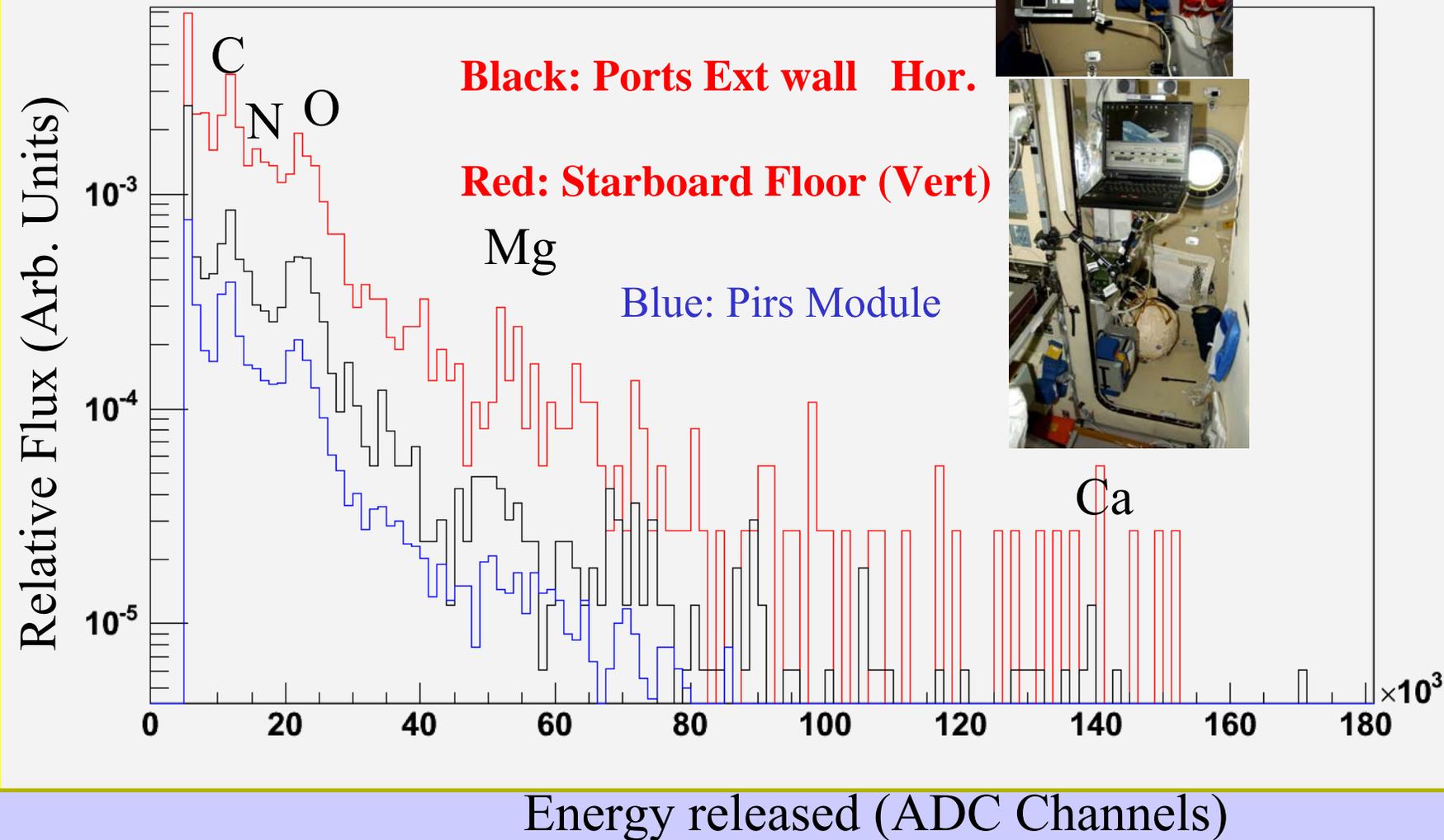
# Nuclear Aundances (Pirs module)



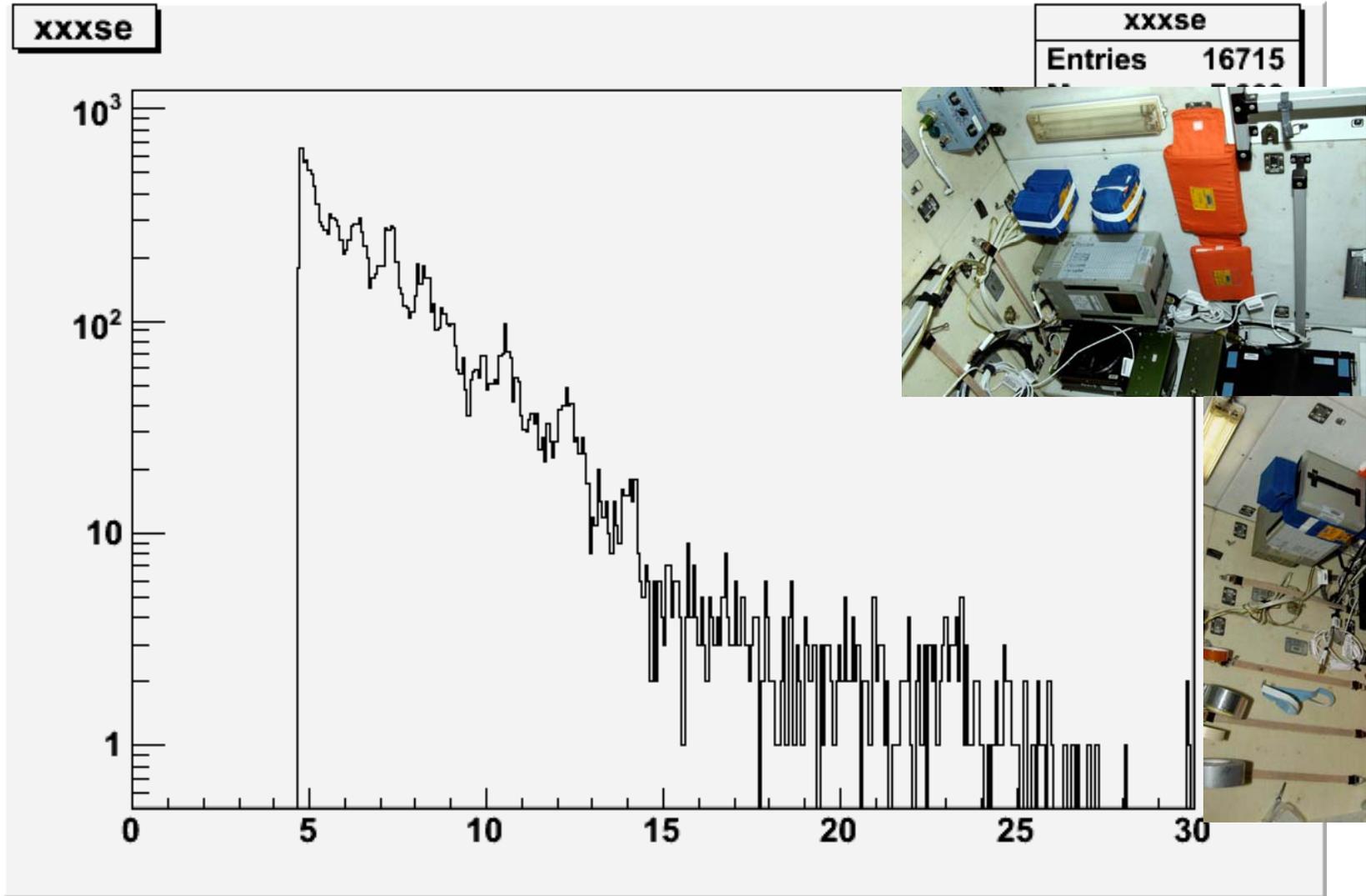
# Flux Comparison: Crew Cabins – Pirs Module

*(normalized by time)*

pavcabxse

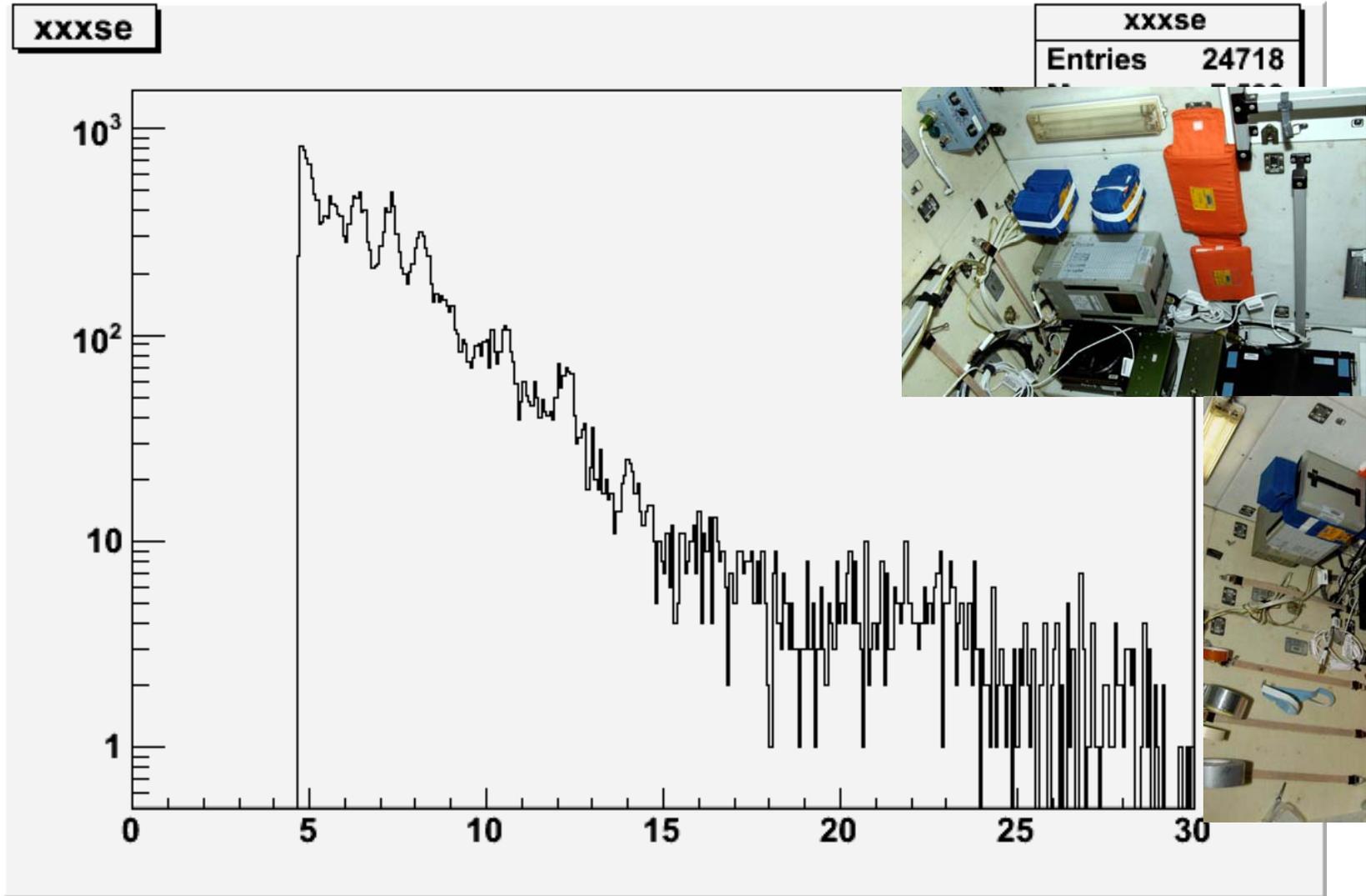


# Nuclear Aundances (Service Module)



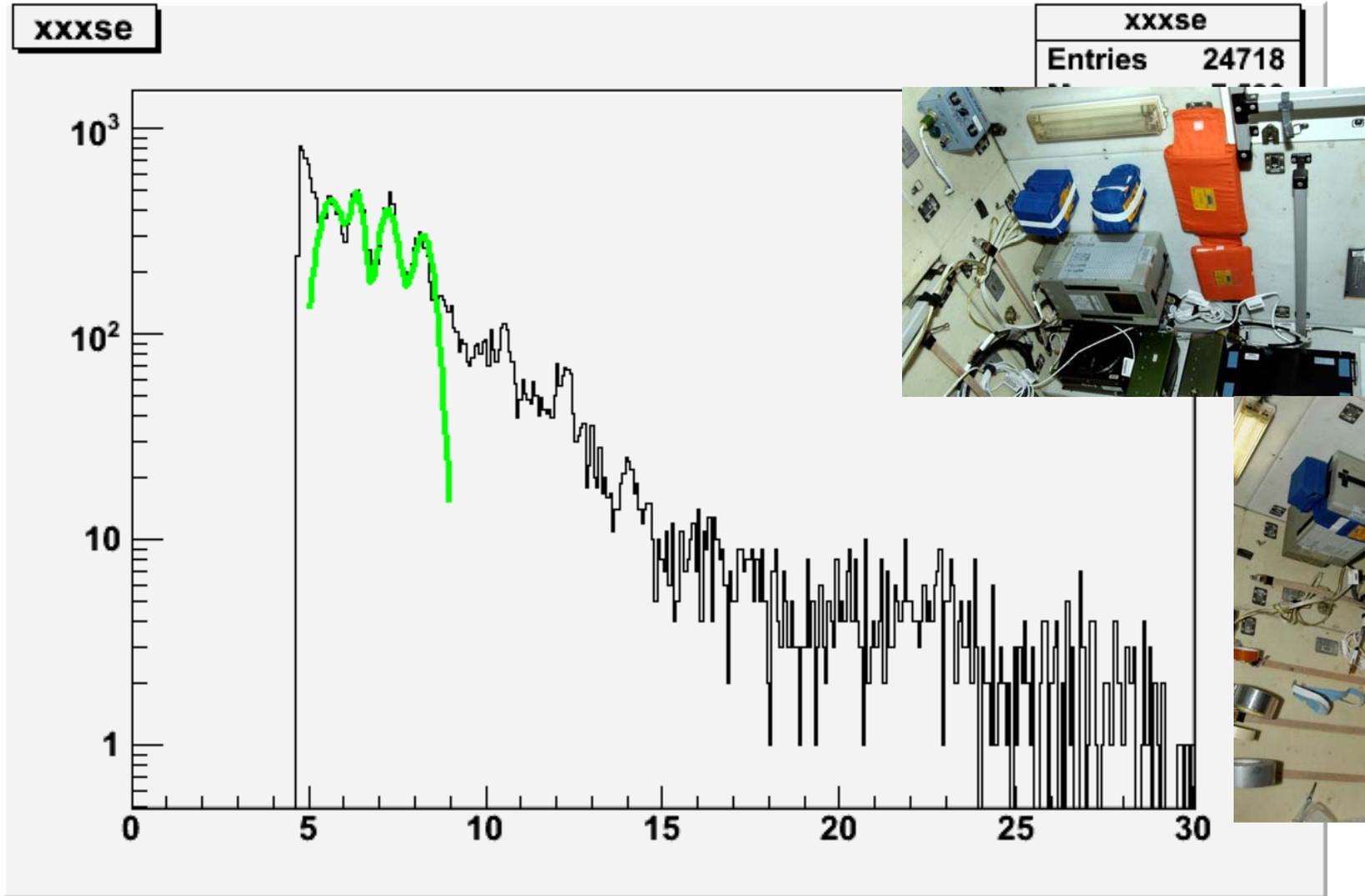
Card 925 – November 2006 – Panel 326

# Nuclear Aundances (Service Module)

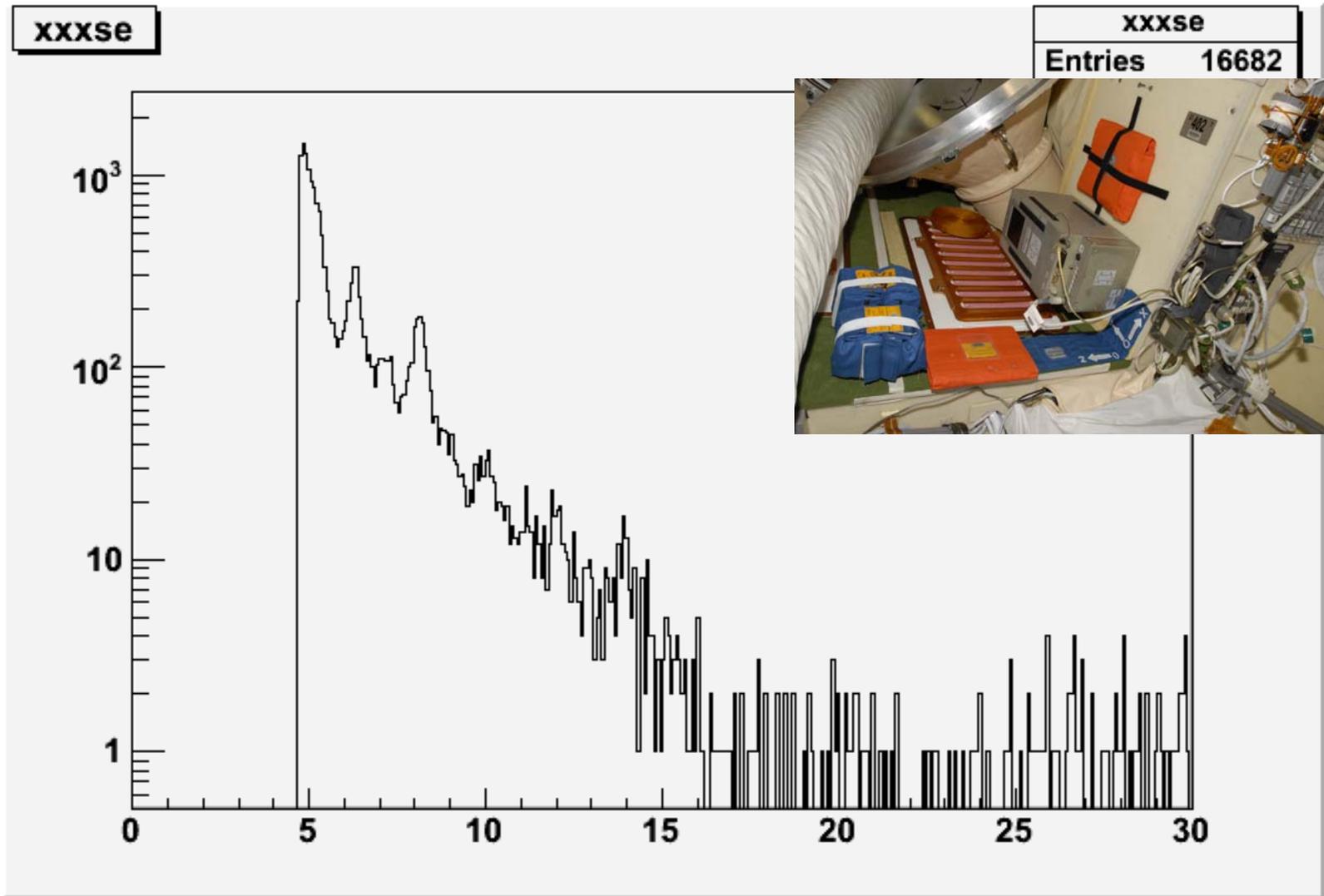


Card 933 – August 2007 – Panel 326

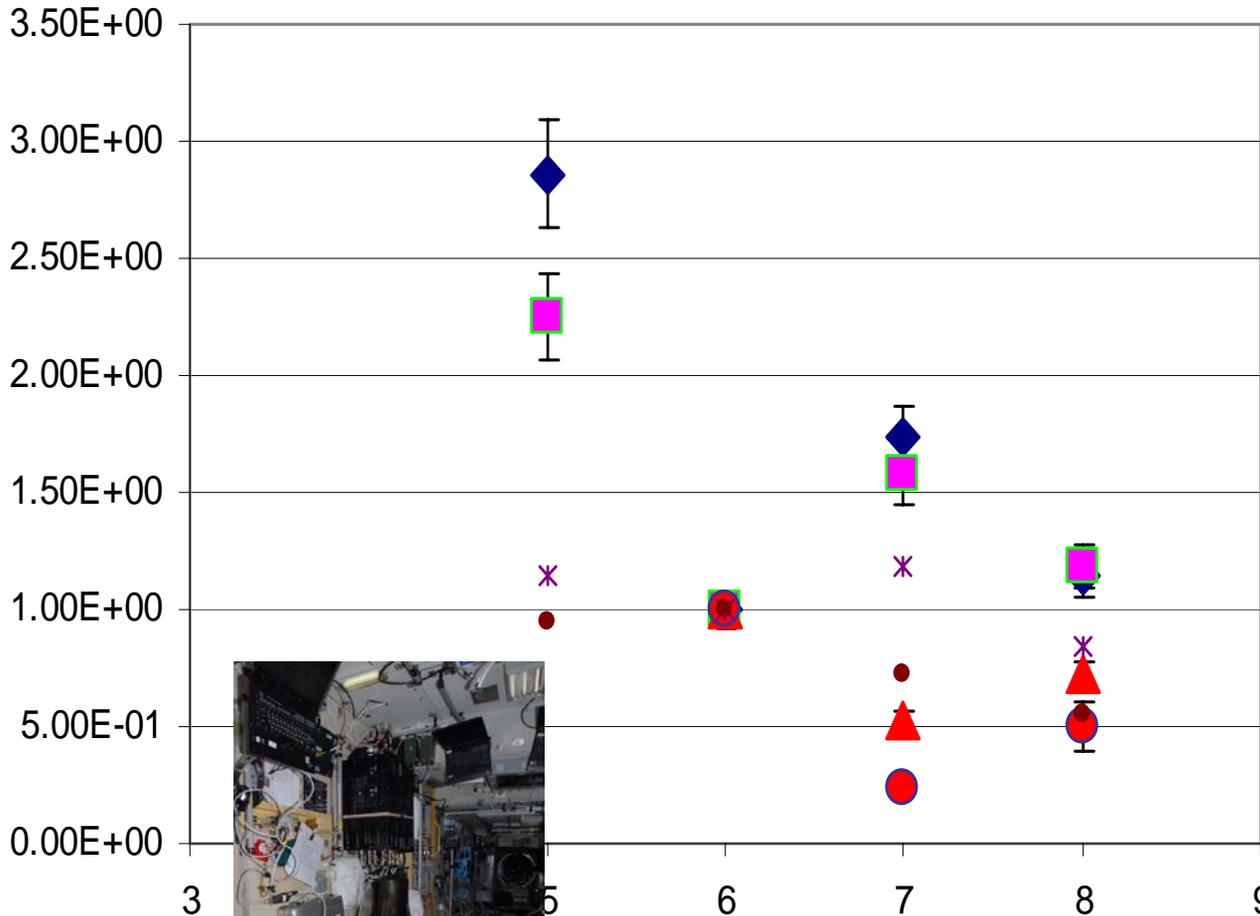
# Nuclear Aundances (Service Module)



# Nuclear Aundances (Pirs Module)



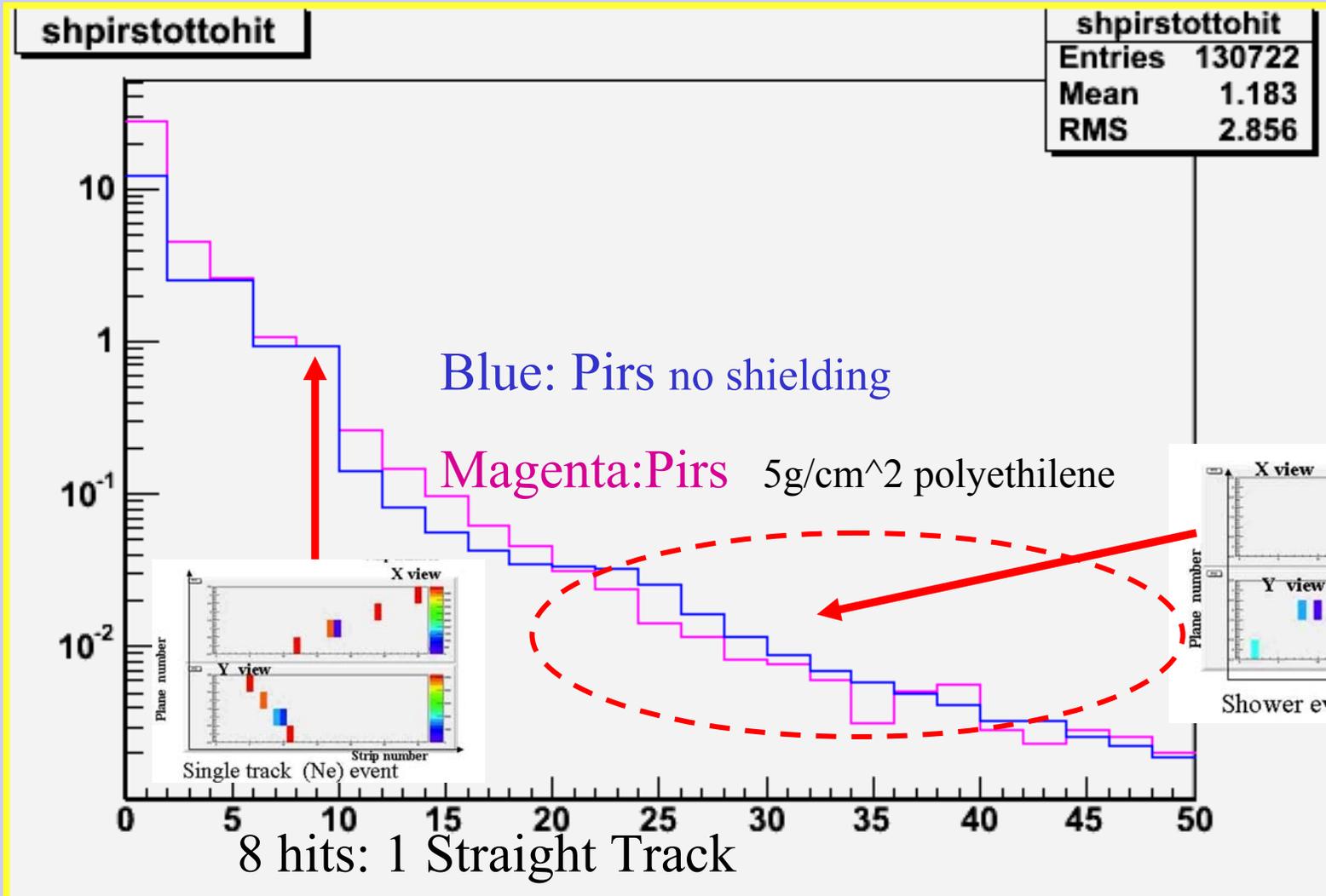
# Comparison BCNO – Service Module (Matroska location)/ Pirs



- ◆ 925 - SM Panel 326
- Sm Panel 326 - 933 -
- ▲ Pirs module - 94
- SM panel 123 - 924bis
- \* SM Panel 326 coaxial to ISS - shield
- SM panel 126 zpar x entr 920

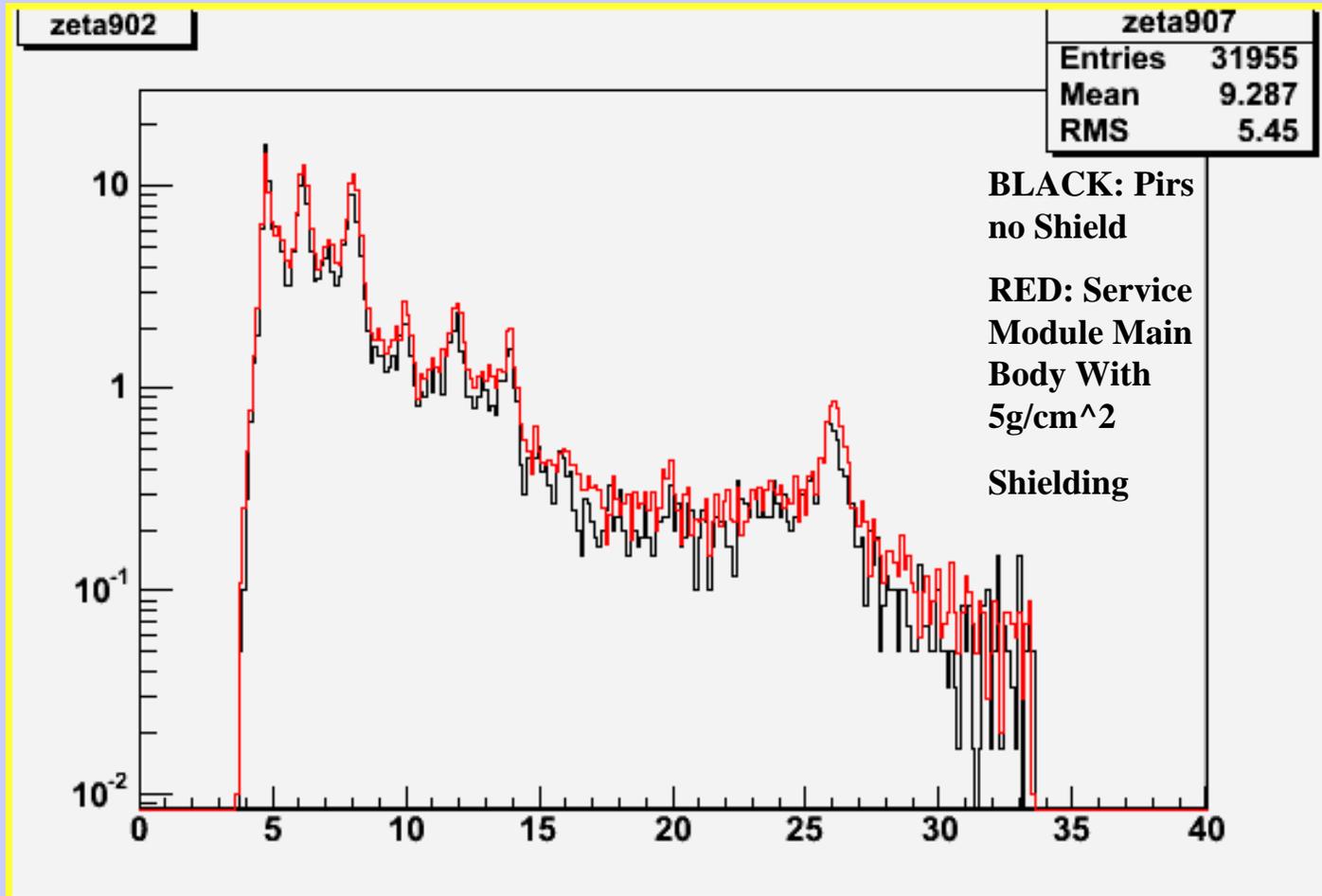
# Shielding effects on fragmentation

Normalized to 1 for straight tracks

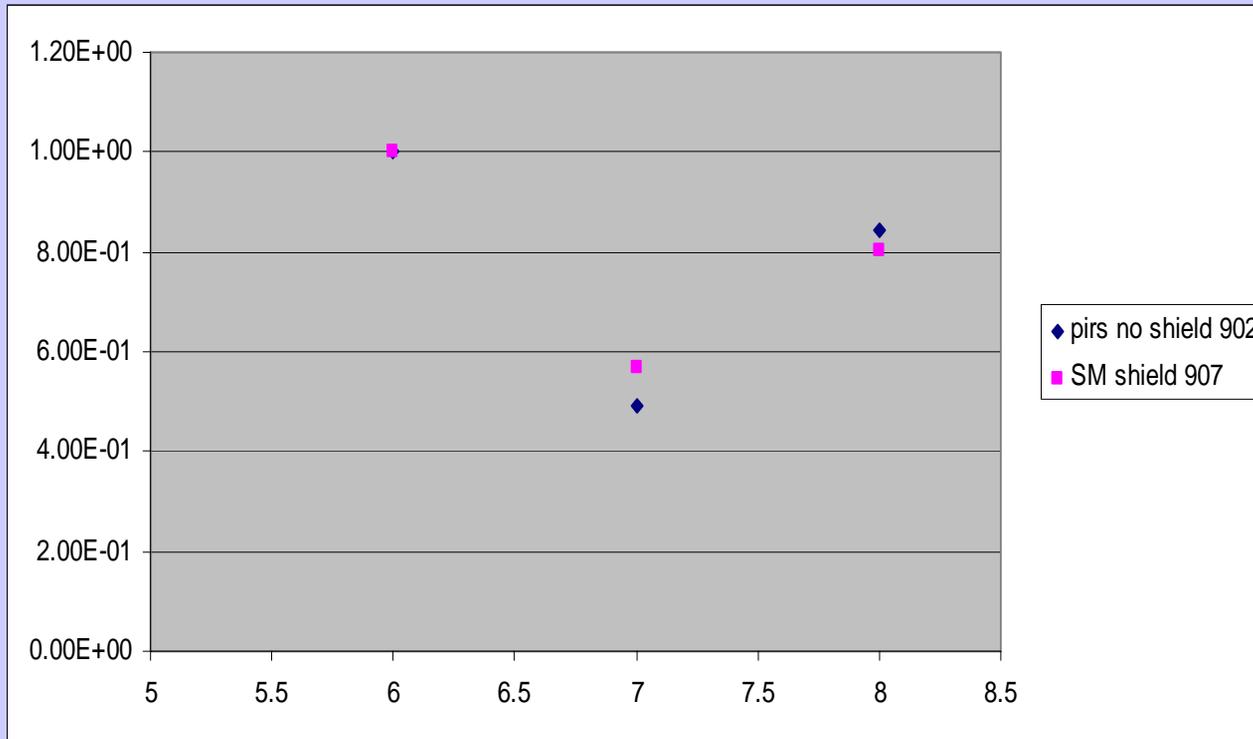


Number of Hits

# Relative abundances comp.



# Relative abundances comp.

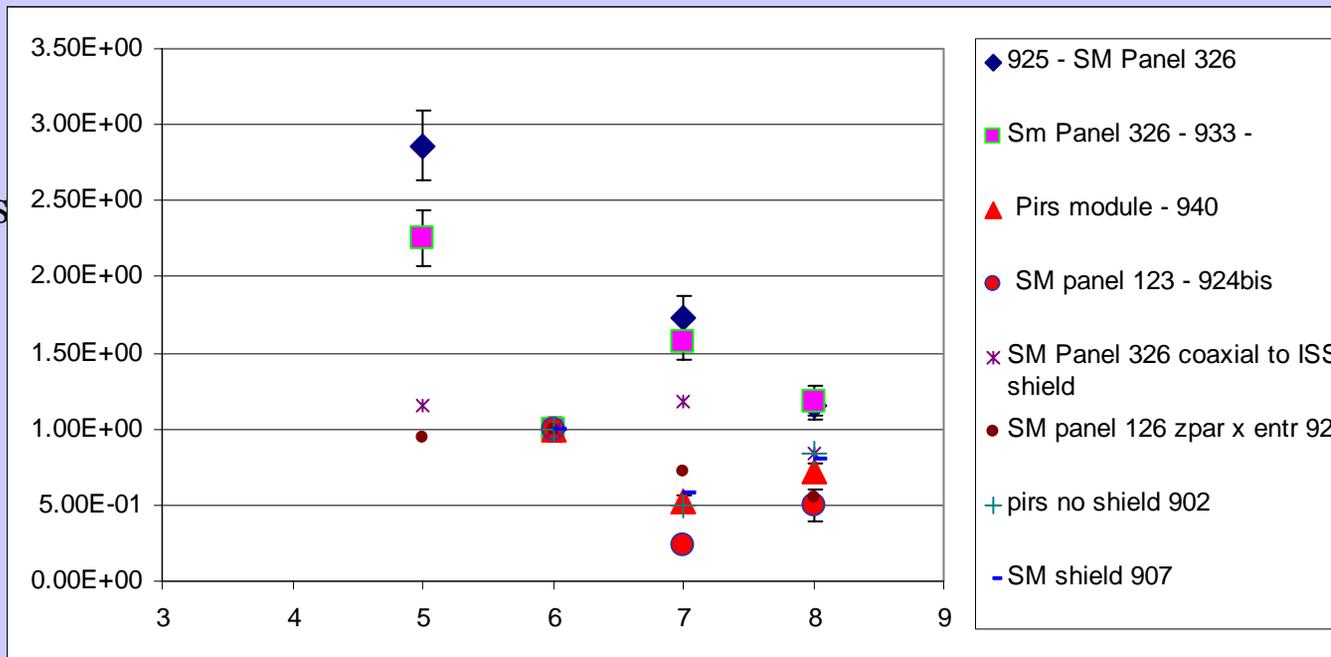


# Conclusion for Active measurements

Strong flux variation in different region  
Strong relative abundance variation between regions

Shielding affects nuclear abundances  
Fragmentation distribution

Continue data taking in one fixed location mostly without shielding (Exp 18)



# Compared Measurements

Of crucial importance to determine particle flux variation in different points of the magnetosphere and ISS.

Different detector response, shielding ecc.

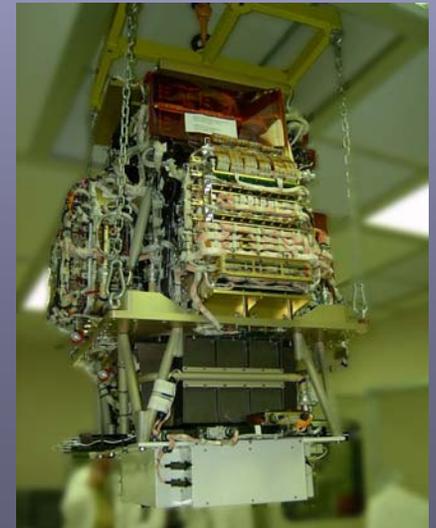
Particle propagation in geomagnetic field and inside ISS

- Altea (1-7-06)

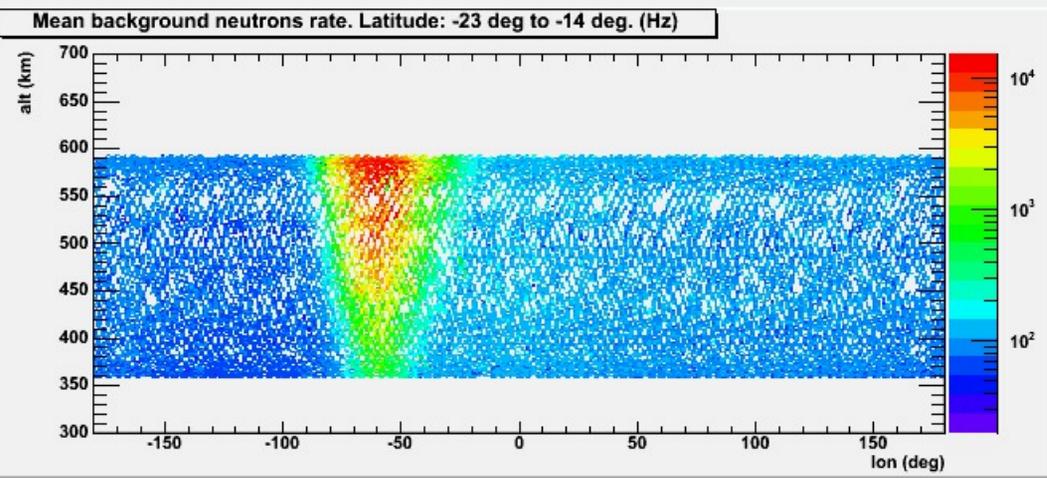
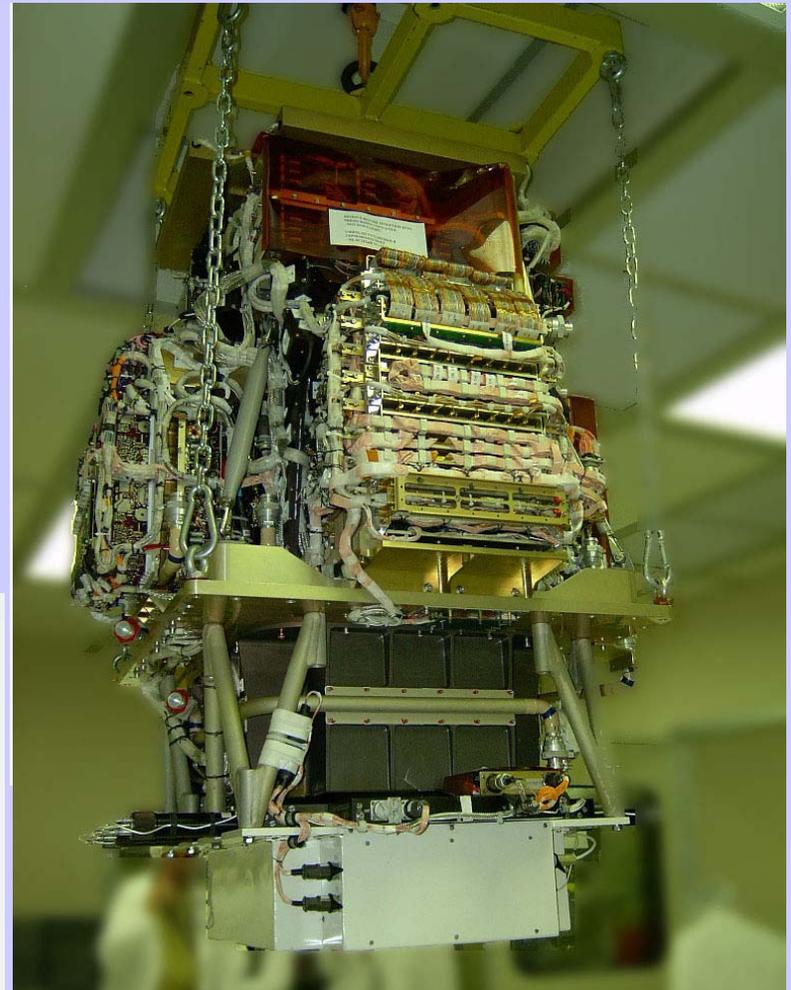
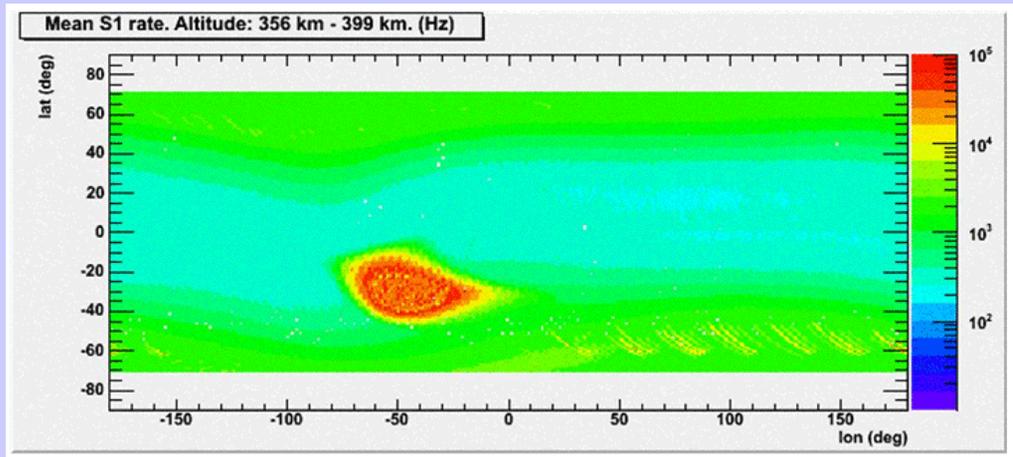
- Pamela (15-6-06)

- IV-CPDS EV/CPDS (NASA)

- Matroska-II



# Some Pamela Results



# Solar modulation at minimum of solar cycle XXIII years 2006-2008

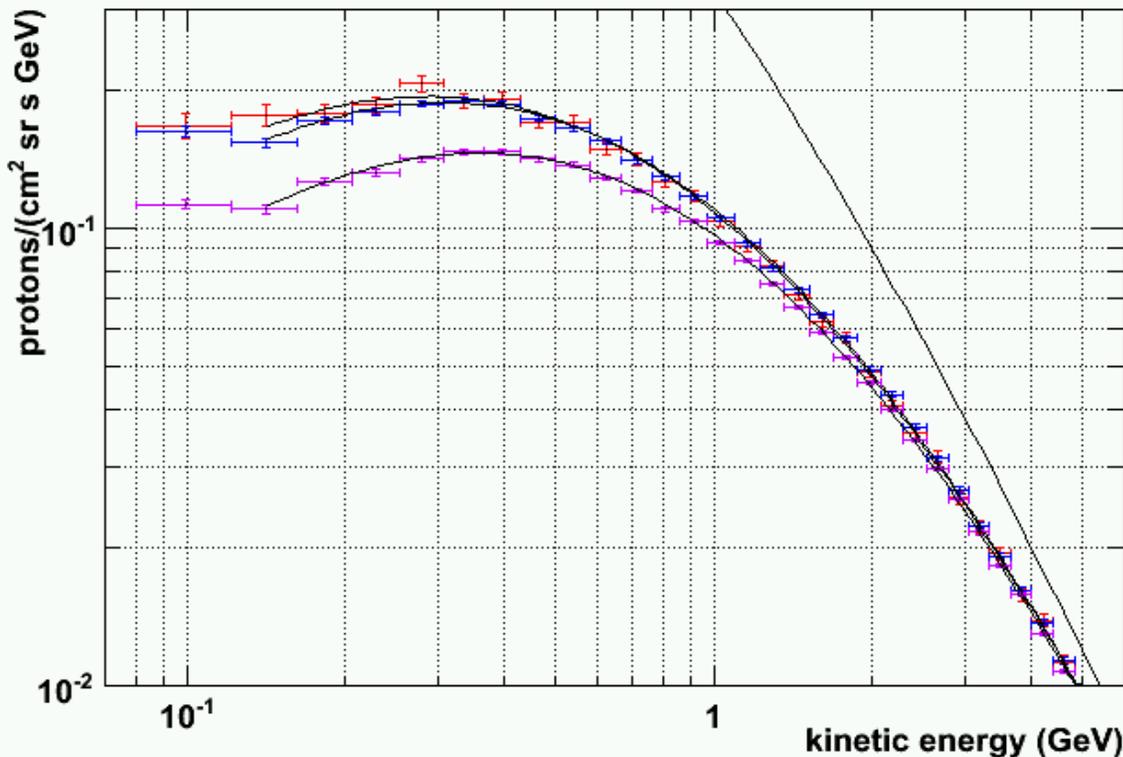
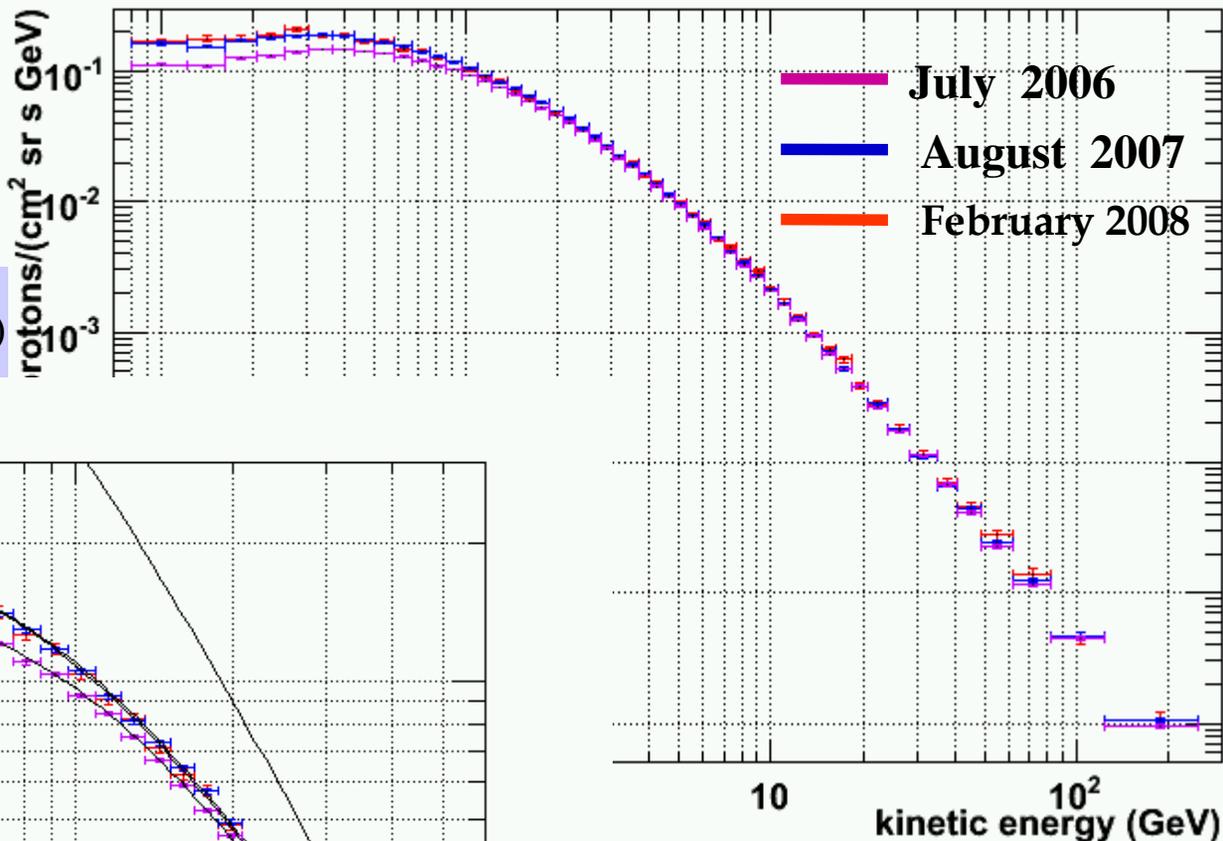
$$F_{is} = 1.54 \beta_{is}^{0.7} R_{is}^{-2.76}$$

$p/(cm^2 s sr GV)$

Spectral index

**$2.76 \pm 0.01$**

$$J(r, E, t) = \frac{E^2 - E_0^2}{(E^2 + \Phi(t))^2 - E_0^2} J(\infty, E + \Phi(t))$$



Solar modulation parameters

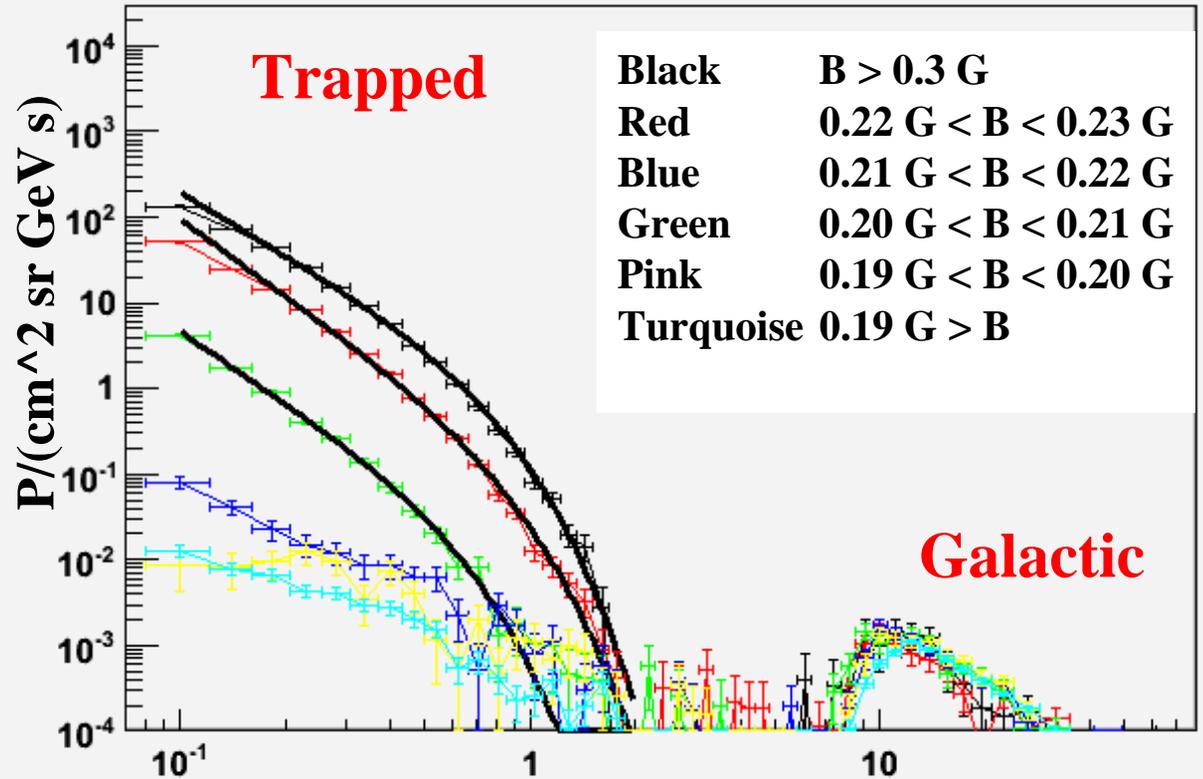
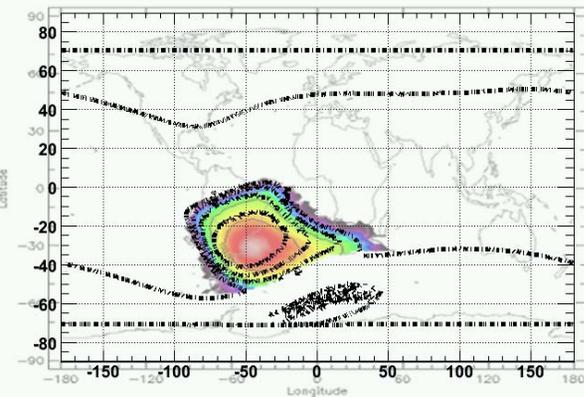
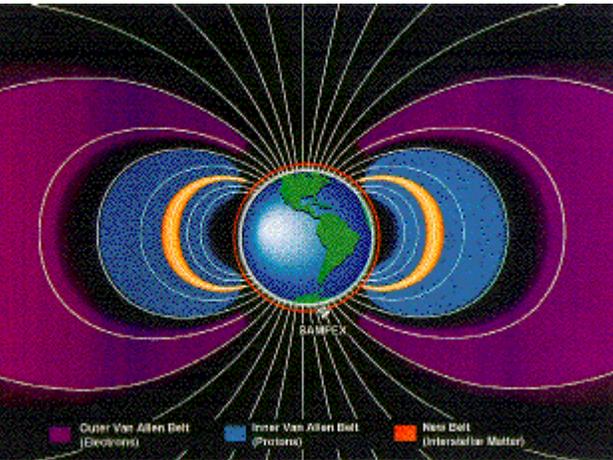
$\phi$ (GV) error

JUL06 5.01-01 ± 2e-03

JAN07 4.16-01 ± 2-03

AUG07 4.02-01 ± 3-03

# Trapped proton flux in the Van Allen belt (South Atlantic Anomaly)



Integral Pamela flux  
( $E > 35 \text{ MeV}$ )

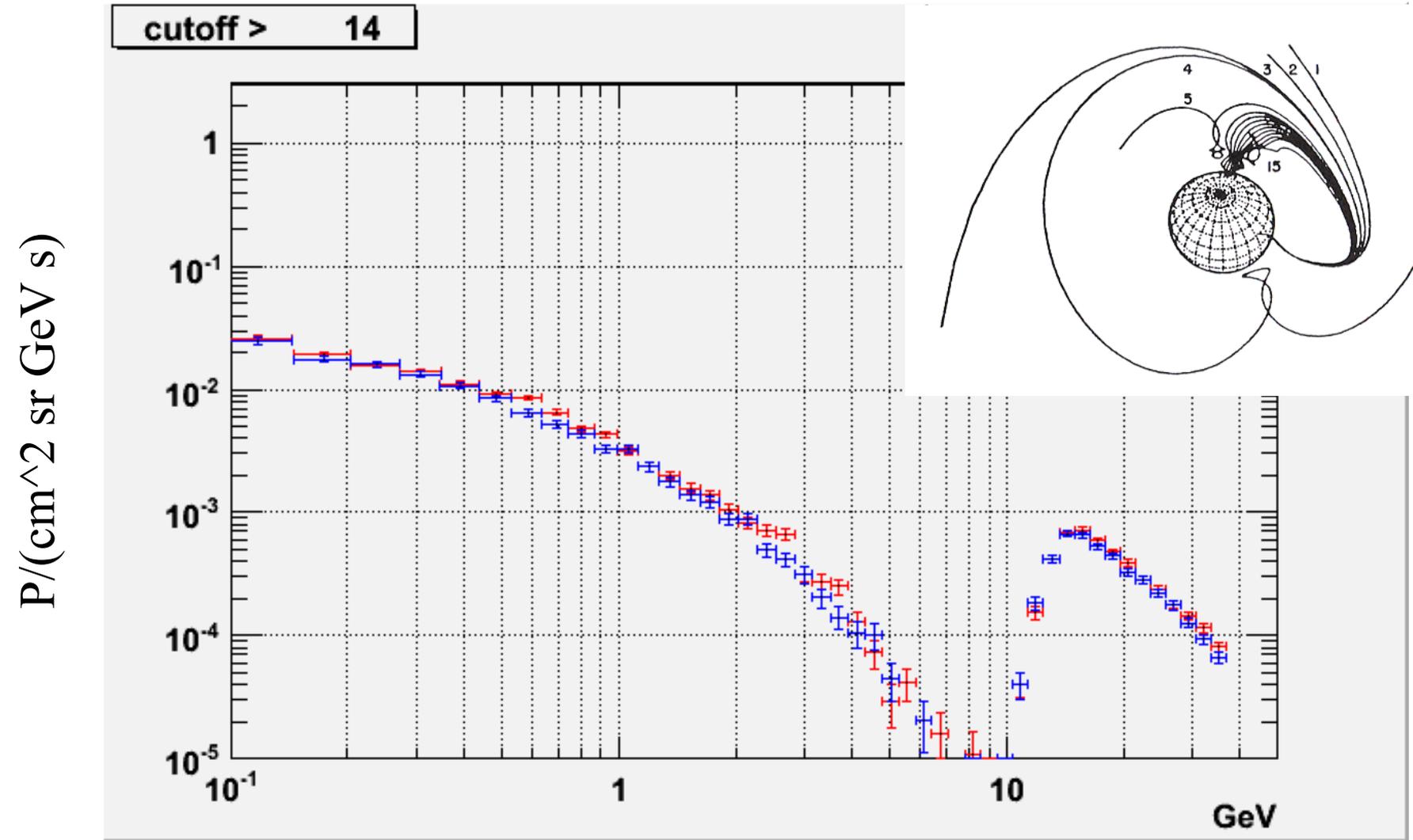
(PSB97 plot by SPENVIS  
project, model by BIRA-IASB)

$$\Phi = A E^{-(\gamma_0 + \gamma_1 E)}$$

	A	$\gamma_0$	$\gamma_1$	$\chi^2/\text{ndf}$
nero	$0.11 \pm 0.01$	$6.0 \pm 0.4$	$3.1 \pm 0.5$	7.1
rosso	$(2.3 \pm 0.3) 10^{-2}$	$5.9 \pm 0.5$	$2.6 \pm 0.6$	6.8
verde	$(5 \pm 3) 10^{-4}$	$8.1 \pm 1.8$	$4.7 \pm 1.8$	10.

# Primary and Secondary spectra

(preliminary)

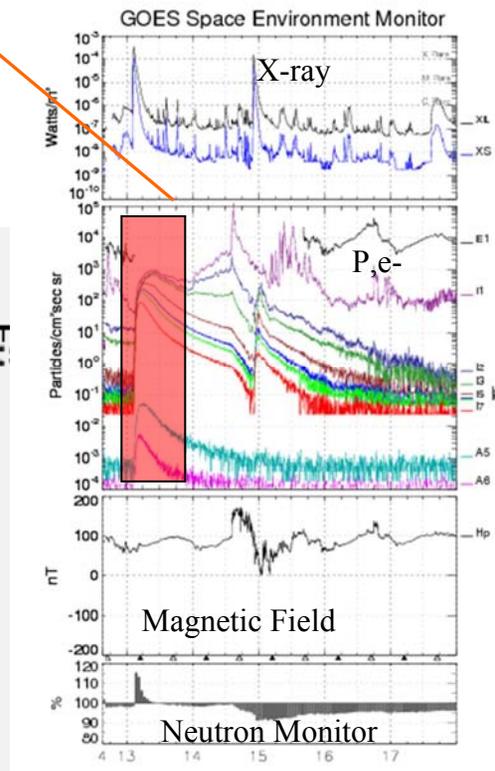
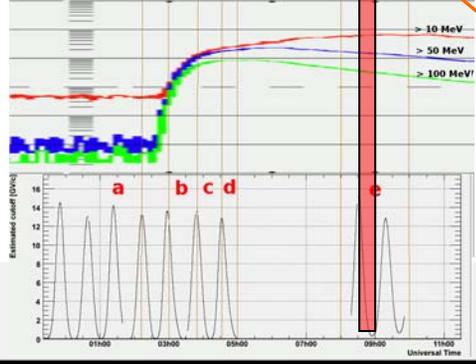


Proton selection in Stormer Vertical Cutoff bands

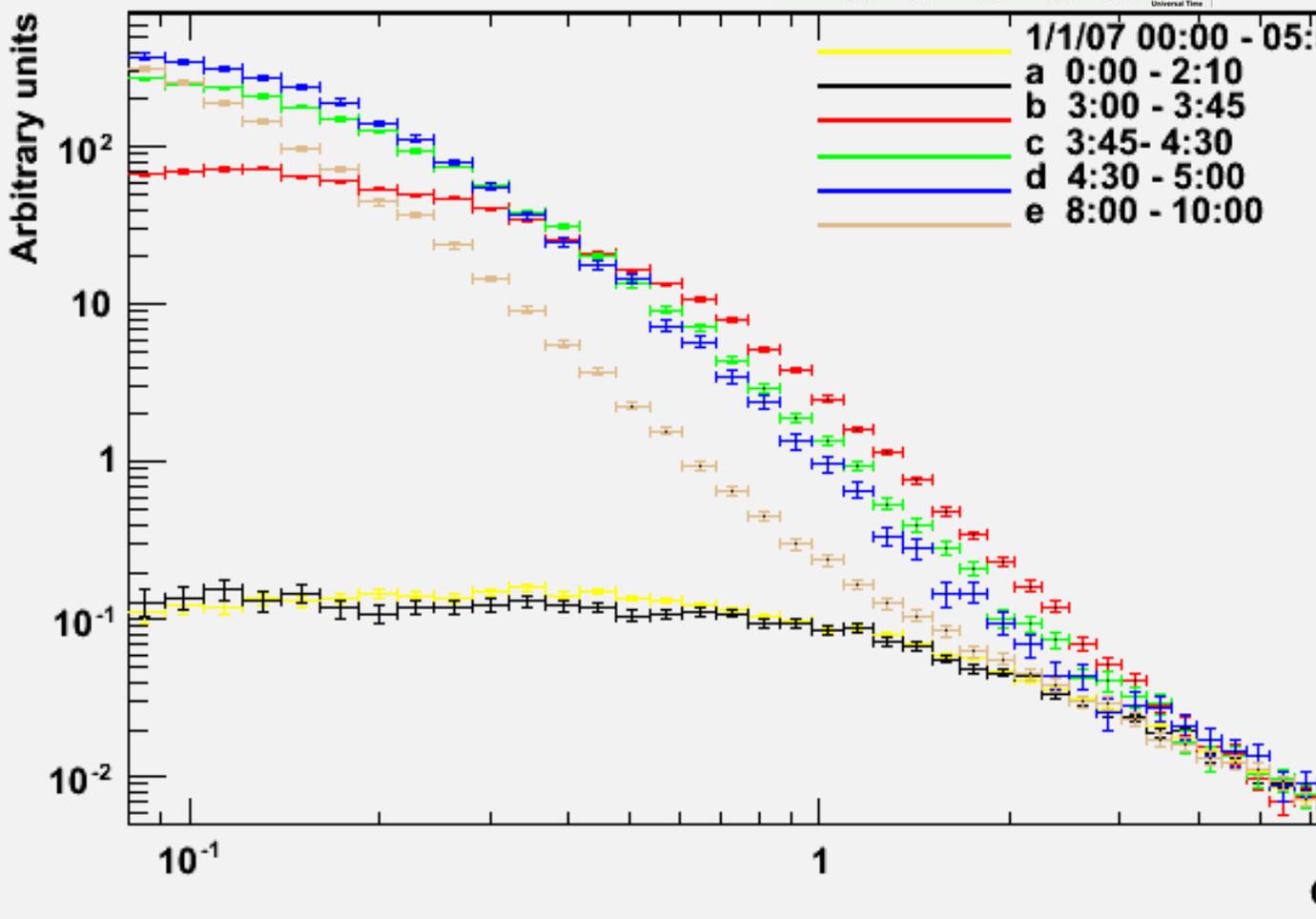
**RED: JULY 2006**

**BLUE: AUGUST 2007**

# December 13th 2006 event

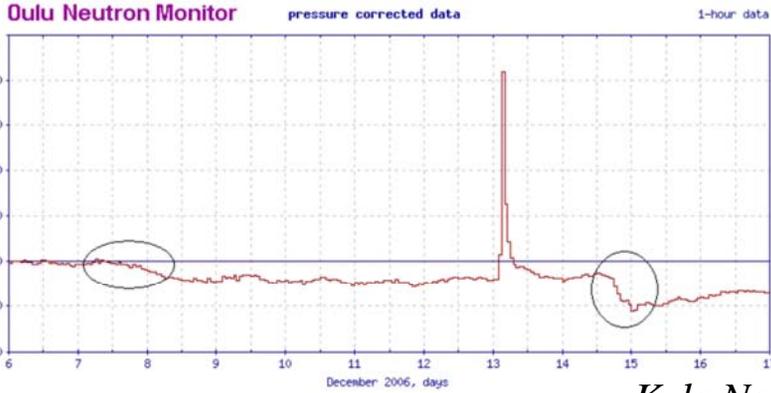


## Protons



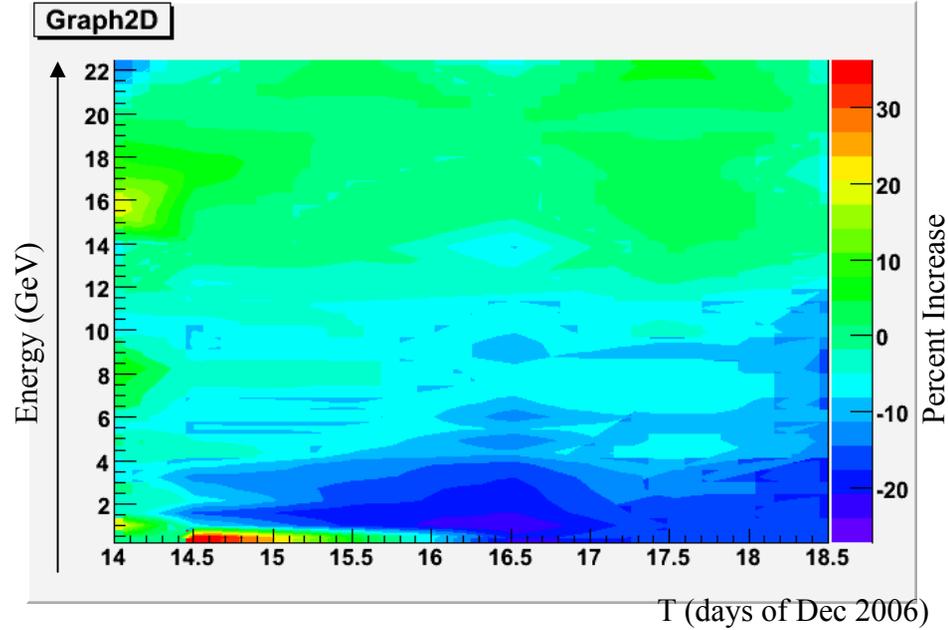
*Preliminary!*

# Forbush Decrease from space



Kyle Neary

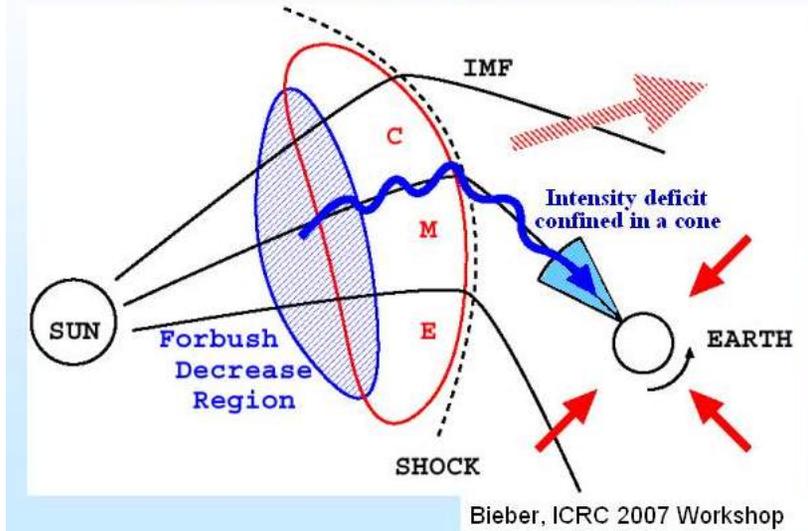
Figure 2: Circled are the Forbush decreases that occurred directly before and after the GLE. [2]



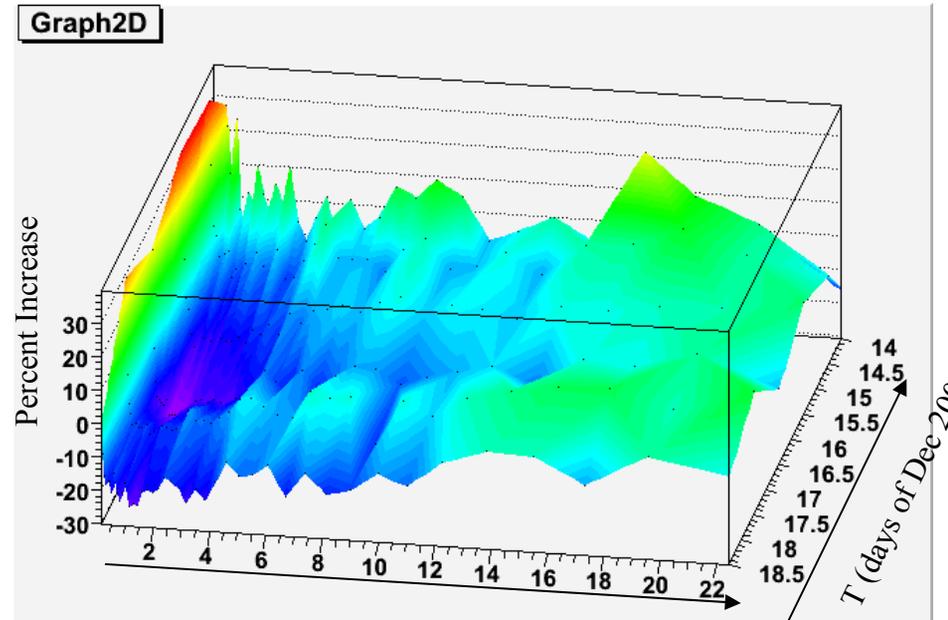
## Muon Diagnostics

### Loss-cone Precursors

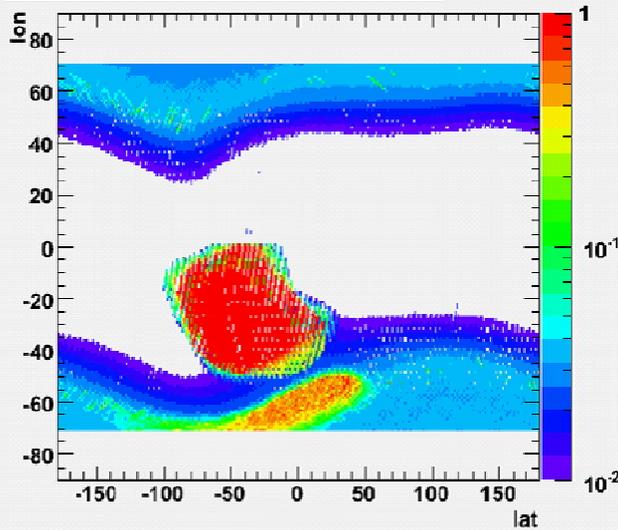
Nagashima et al. [1992], Ruffolo [1999]



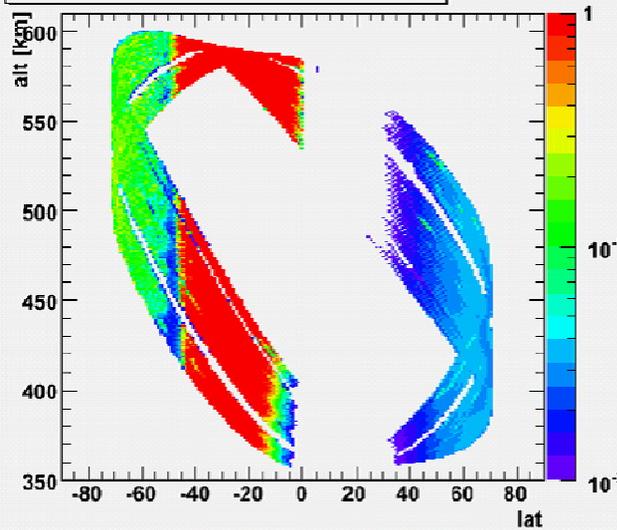
Bieber, ICRC 2007 Workshop



Flux on S1 [particles / (cm<sup>2</sup> sr s)]. Jan 2007.

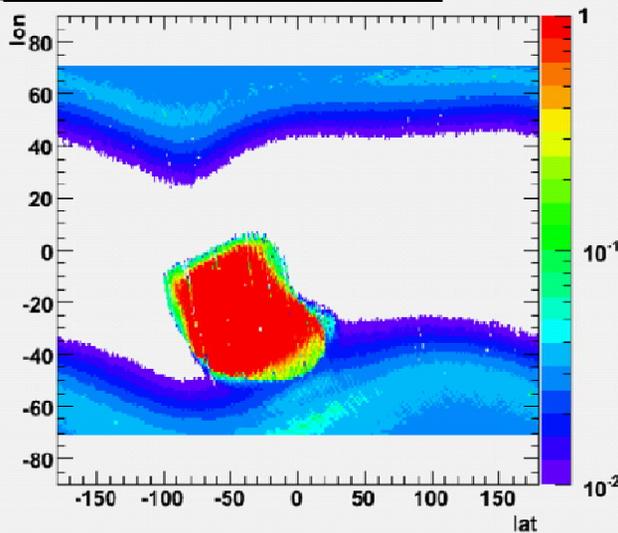


Flux on S1 [particles / (cm<sup>2</sup> sr s)]. lon < 30°. Jan 2007.

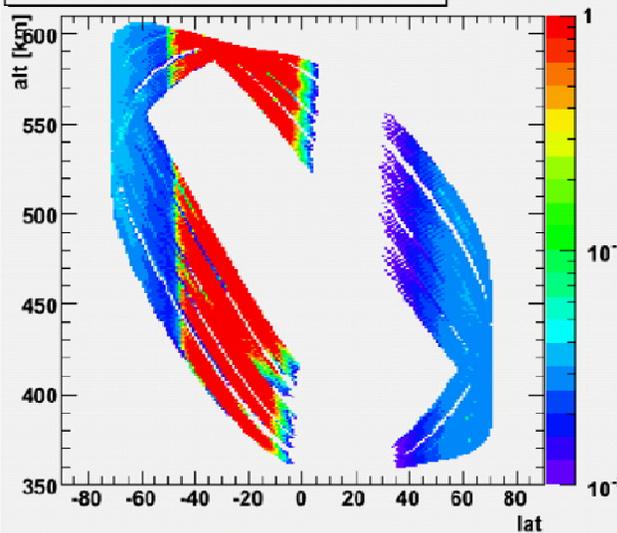


*Increase of  
Trapped electrons  
in Dec- Jan  
Due to electron  
immission by  
solar particle  
event*

Flux on S1 [particles / (cm<sup>2</sup> sr s)]. Aug 2006.

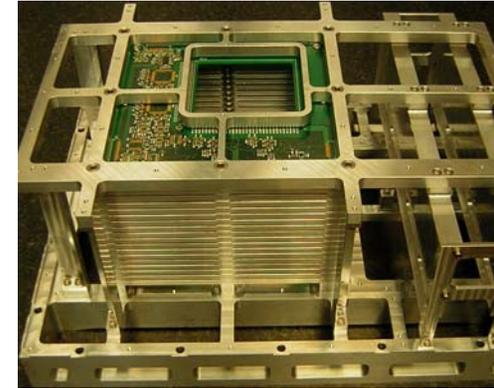
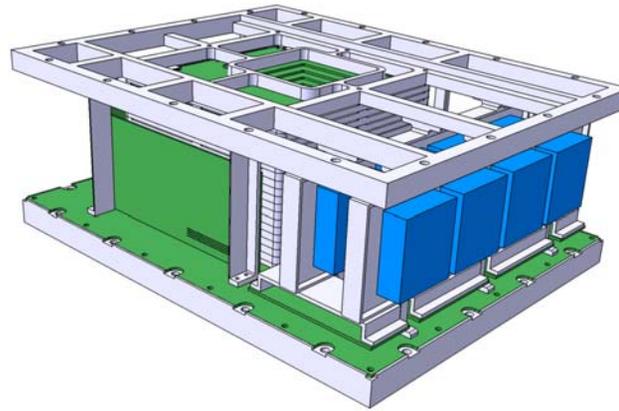


Flux on S1 [particles / (cm<sup>2</sup> sr s)]. lon < 30°. Aug 2006.

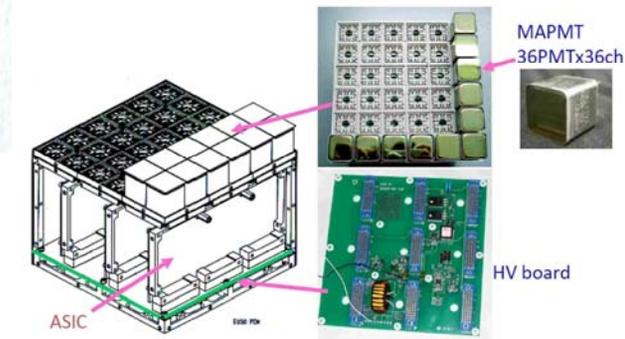
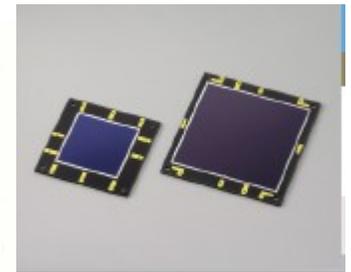
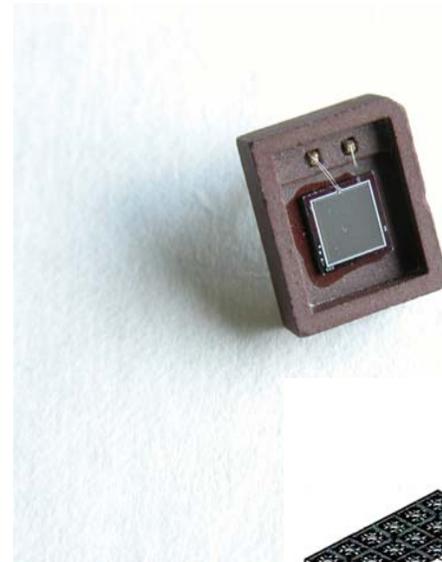


# Febo/Sirad

1. Phase A of mission of opportunity ASI
2. Express Pallet (out)
3. Internal device (small



- LET tiraxial measurement
- Low energy cosmic rays with SiPM
- UV background measurement
- Silicon detector stack
- 32 planes





# PIRS – Service Module comparison

