La radiobiologia dell'INFN

ALTCRISS

M. Casolino

INFN Roma Tor Vergata

Trieste, 7 Febbraio 2008

ALTCRISS Collaboration

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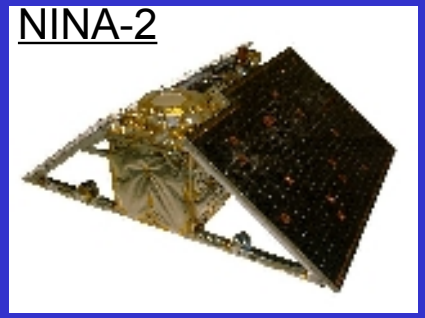
Past, Present and Future Projects

MASS-89, 91, TS-93,
CAPRICE 94-97-98

NINA-1

NINA-2



89 M 91 TS 93 C 94 C 97 C 98 PAMELA

9 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 ...

NINA-1 NINA-2

LAZIO-SIRAD

SILEYE-1 SILEYE-2 SILEYE-3 ALTEA

SILEYE-1

SILEYE-2

SILEYE-3/
ALTEINO:

LAZIO-SIRAD

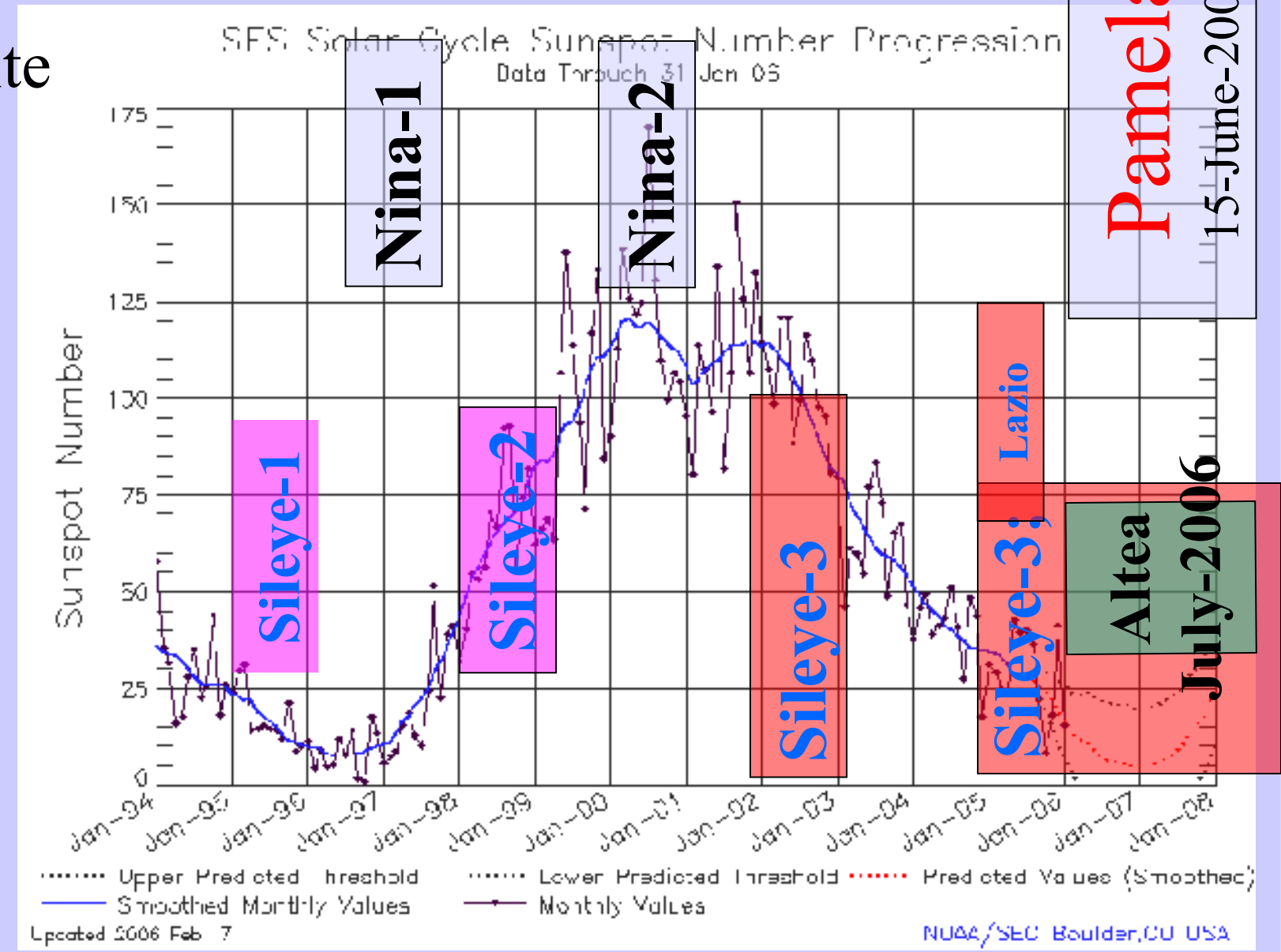
SILEYE-4/
ALTEA

Observations at the minimum of 23° solar cycle

Satellite

Mir

ISS



Altcriss

Alteino Long Term cosmic ray measurements on board the ISS

- **Selezionato dall'ESA AO 2004 ESA (AO2004-067)**
  - **Lancio, Equipaggio, Rientro materiale (circa 1 Meuro/anno)**

- **Operativo nel 2002 e senza soluzione di continuità dal 2005**

- **Missione Eneide (R. Vittori, 2005)**
- **Spedizioni dalla XII alla XVI sulla Stazione Spaziale Internazionale**
- **Long Duration Mission (T. Reiter)**
- **>10 astronauti europei, russi, statunitensi**

Obiettivi scientifici

- **Misura delle abbondanze nucleare e ambiente radioattivo sulla ISS (p-Fe >50-100MeV/n)**

- **Studio dell'efficacia di vari materiali schermanti a bordo della ISS e con Montecarlo e Test su Fascio (SPADA)**

- **Misure con dosimetri passivi (JAXA, DLR, Fed II, INFN)**

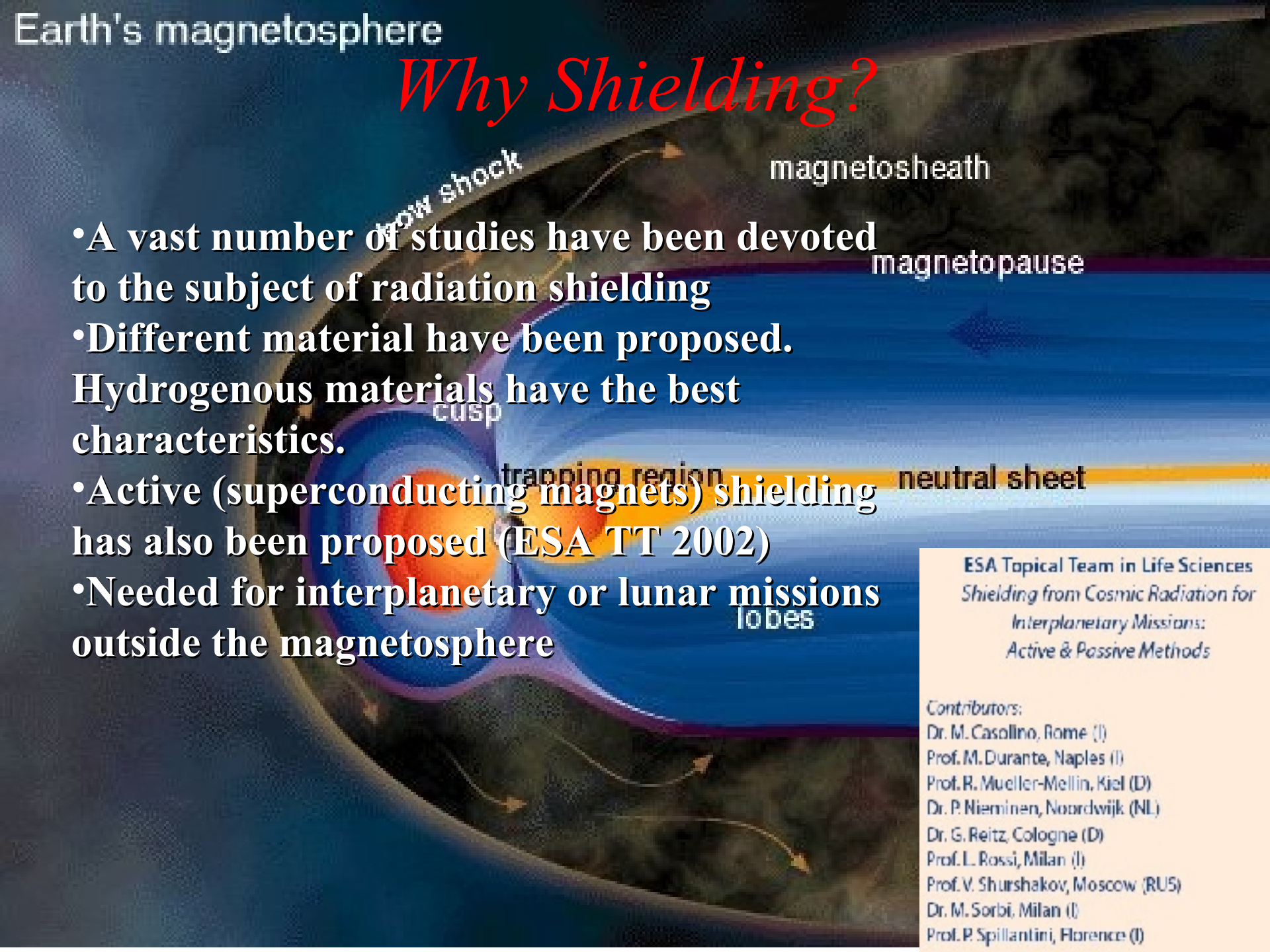
- **Misure in parallelo con Matroska, Pamela and Altea**

- **Studio della modulazione solare e di eventi di particelle solari**

L'ambiente radioattivo nello spazio

- Nello spazio, in orbita bassa, gli astronauti sono soggetti ad una dose di circa 3 ordini di grandezza maggiore che a terra
- Raggi cosmici di natura:
  - Galattica
    Il flusso di rc galattico è modulato dall'attività solare ed è massimo al minimo solare e viceversa.
  - Solare
    Gli eventi solari sono più frequenti al massimo solare ma di natura casuale
  - Intrappolata
    I rc intrappolati sono protoni della fascia interna di Van Allen
- Gli ioni pesanti sono pochi ma contribuiscono alla dose equivalente più dei protoni
  - *Difficoltà del calcolo degli ioni*
    (Geant3, Geant4,Phits, Fluka, HZTRN,….)
  - *Sezioni d'urto nucleari*

Why Shielding?



- **A vast number of studies have been devoted to the subject of radiation shielding**
- **Different material have been proposed. Hydrogenous materials have the best characteristics.**
- **Active (superconducting magnets) shielding has also been proposed (ESA TT 2002)**
- **Needed for interplanetary or lunar missions outside the magnetosphere**

ESA Topical Team in Life Sciences

Shielding from Cosmic Radiation for Interplanetary Missions: Active & Passive Methods

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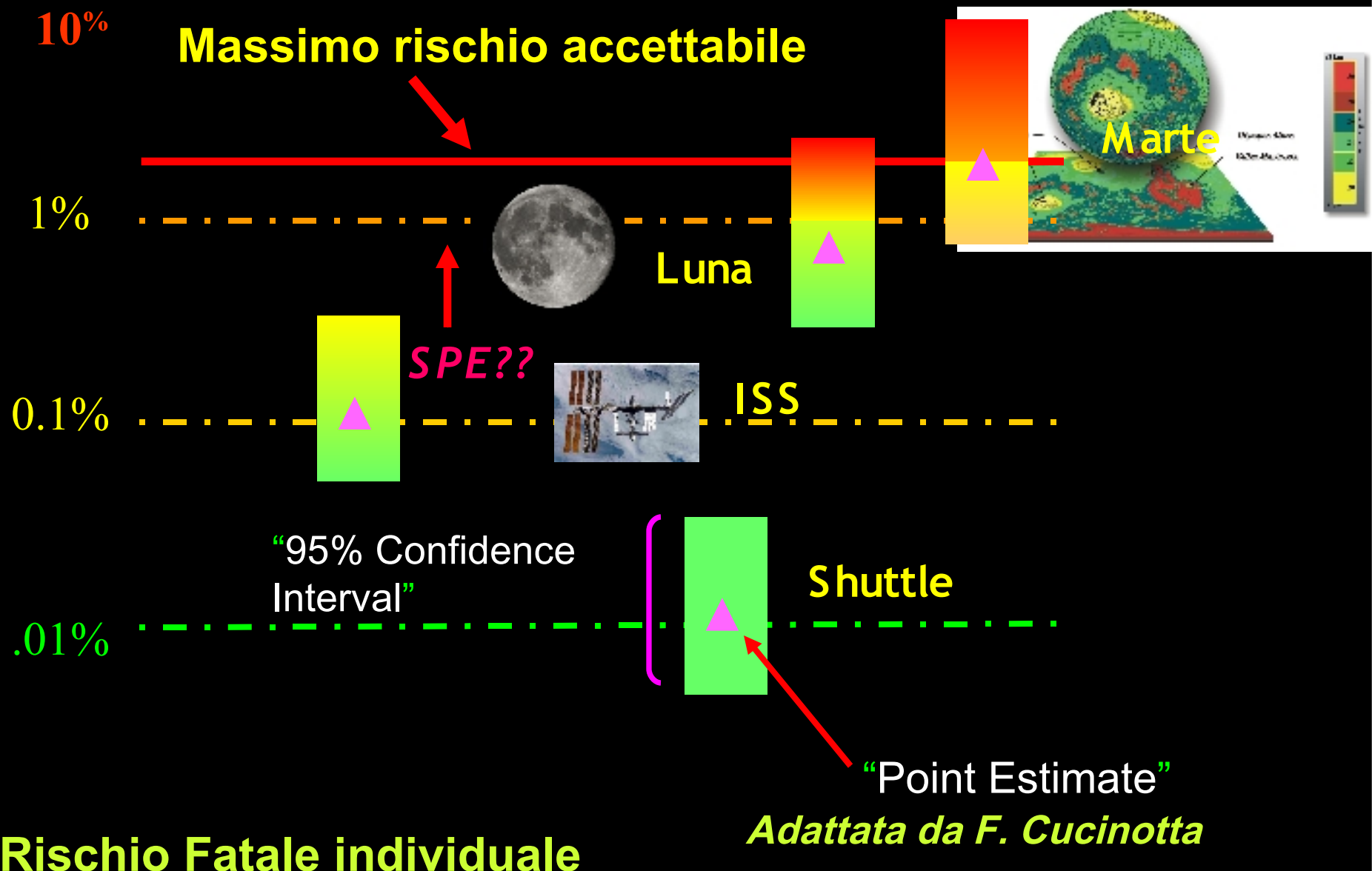
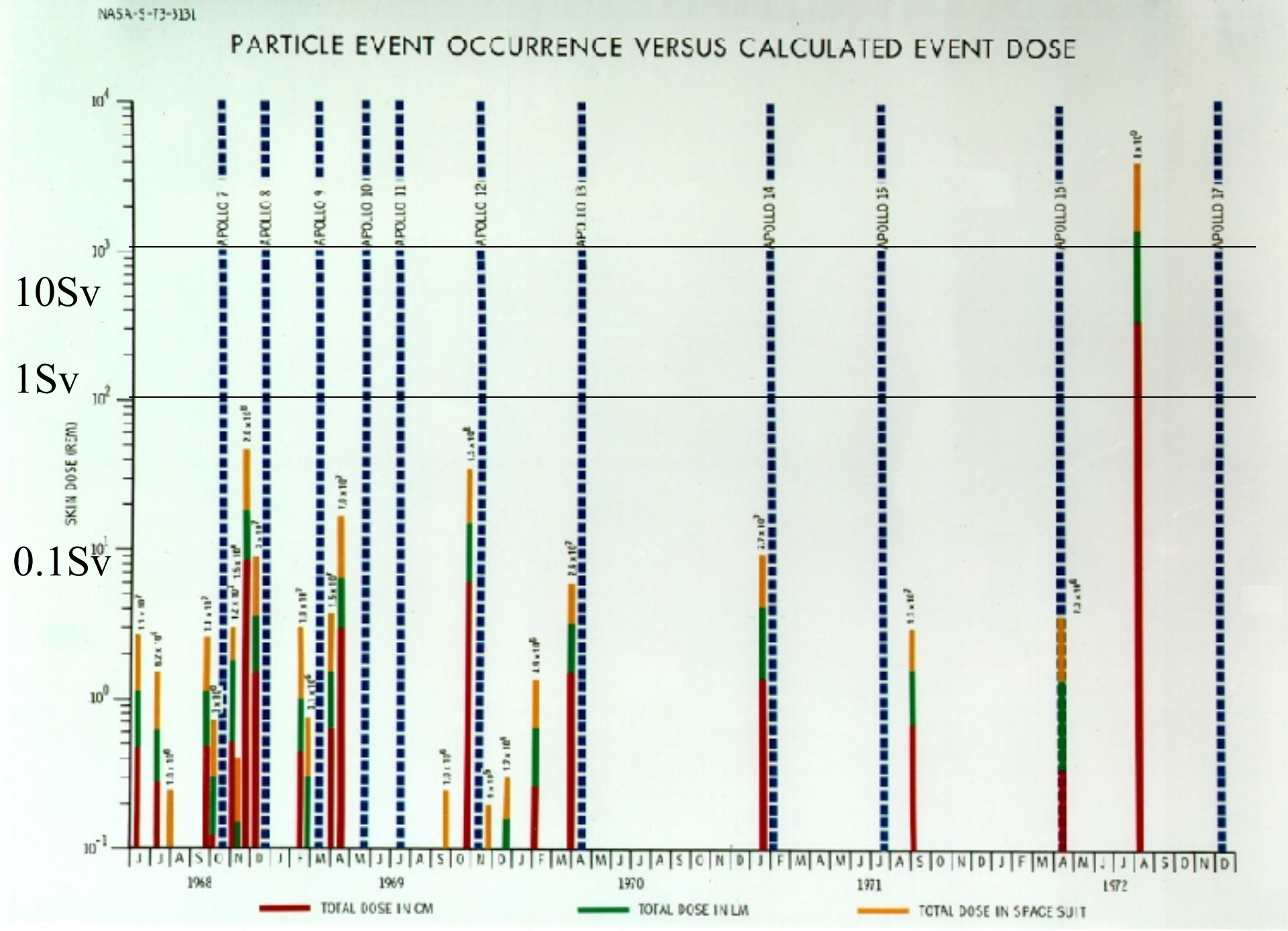
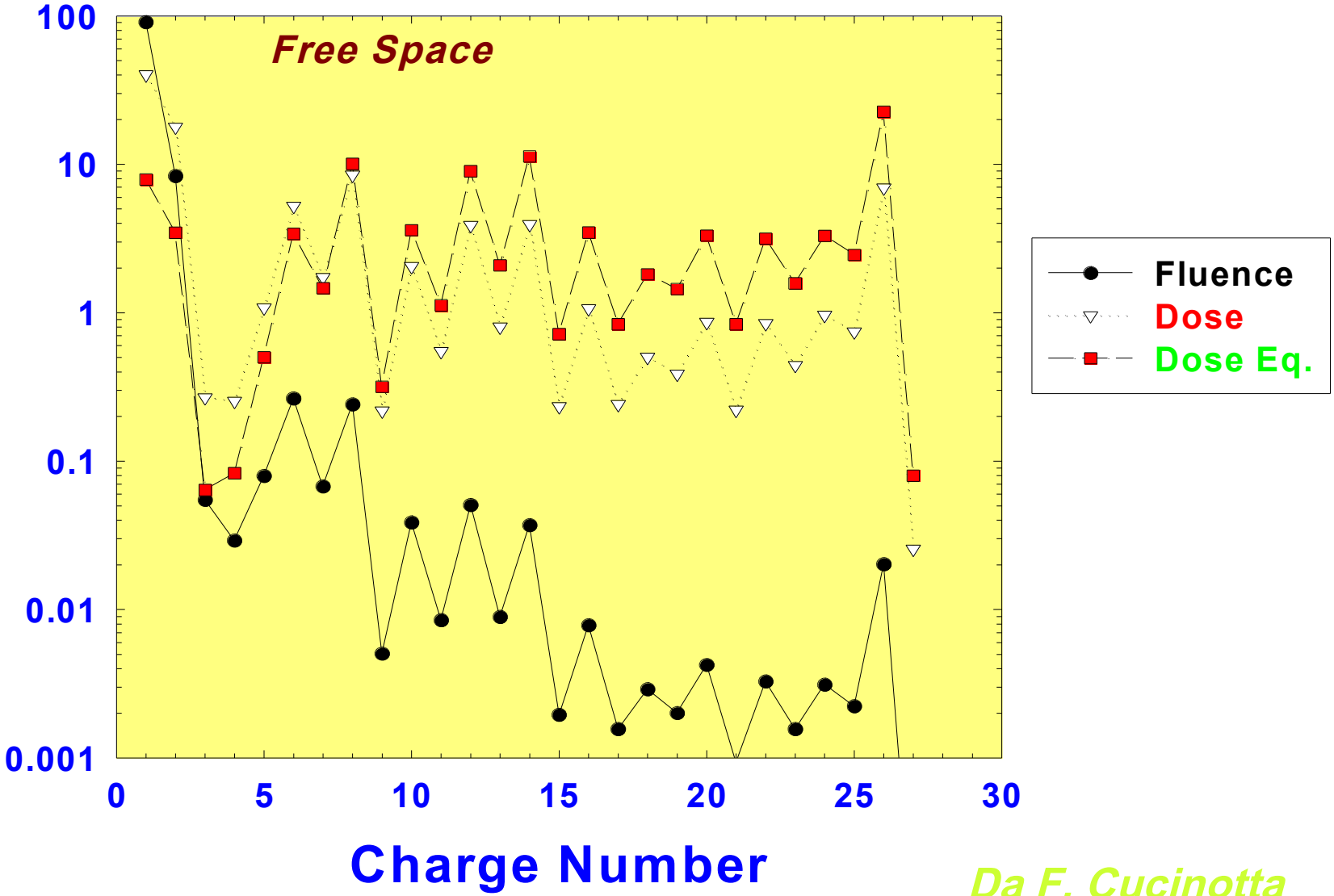
Ruolo delle incertezze nel rischio individuale




NASA-S-73-3131
PARTICLE EVENT OCCURRENCE VERSUS CALCULATED EVENT DOSE
10Sv
1Sv
0.1Sv
SKIN DOSE (REM)
APOLLO 7
APOLLO 8
APOLLO 9
APOLLO 10
APOLLO 11
APOLLO 12
APOLLO 14
APOLLO 15
APOLLO 16
APOLLO 17
1968
1969
1970
1971
1972
TOTAL DOSE IN CM
TOTAL DOSE IN LM
TOTAL DOSE IN SPACE SUIT

GCR Charge Contributions

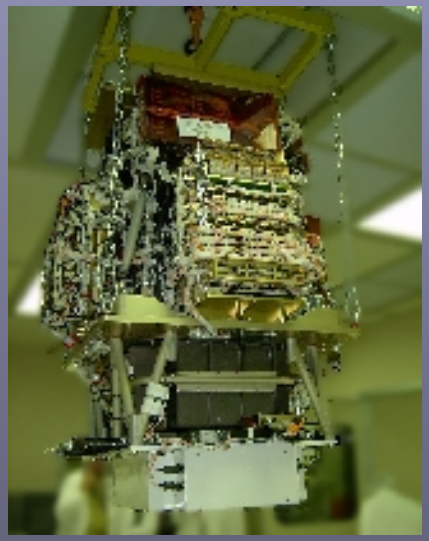


Da F. Cucinotta

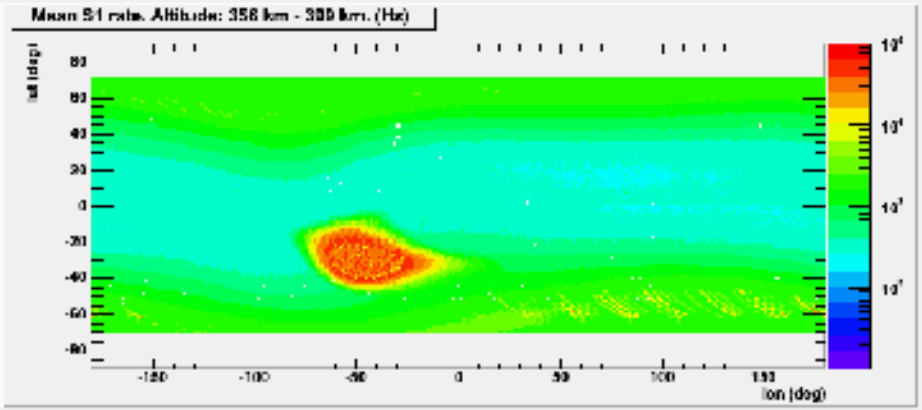
Misure comparate

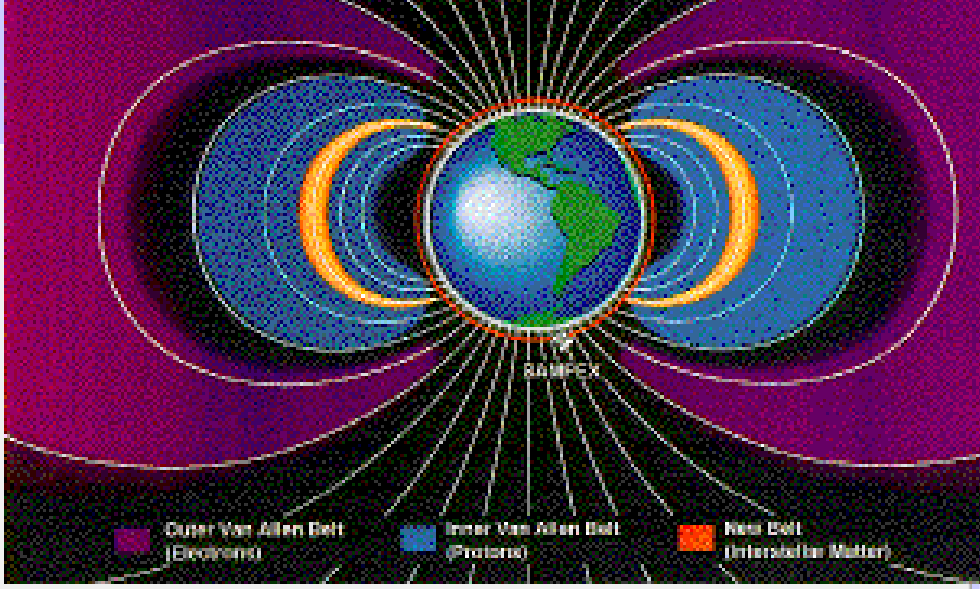
Di cruciale importanza per determinare il flusso in punti diversi della magnetosfera, all'orbita della ISS e al suo interno.
Rivelatori diversi, schermatura ecc.
Propagazione nel campo geomagnetico e nella geometria della Stazione

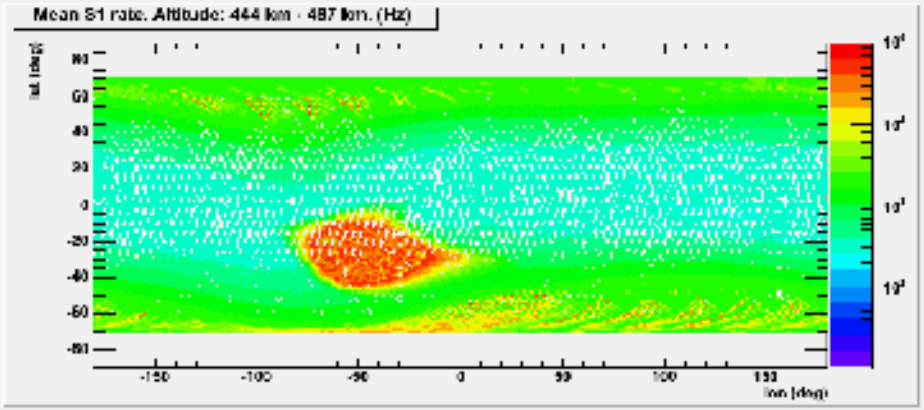
- Altea (1-7-06)
- Pamela (15-6-06)
- IV-CPDS EV/CPDS (NASA)
- Matroska-II

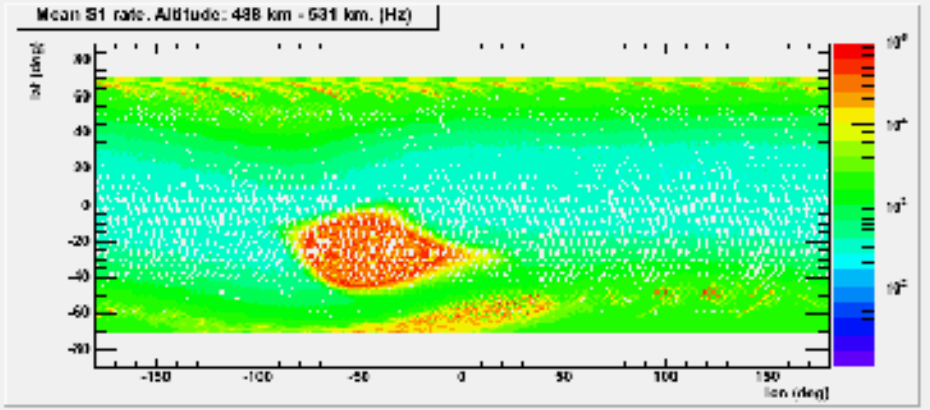


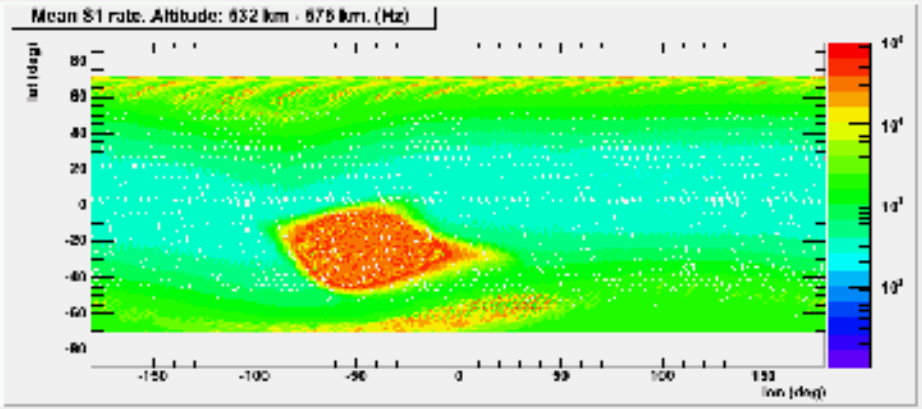
Protono 35 MeV (Pamela)

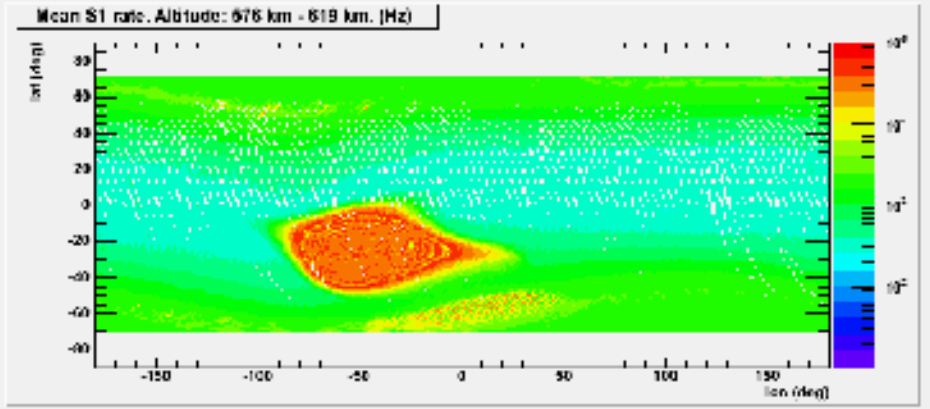




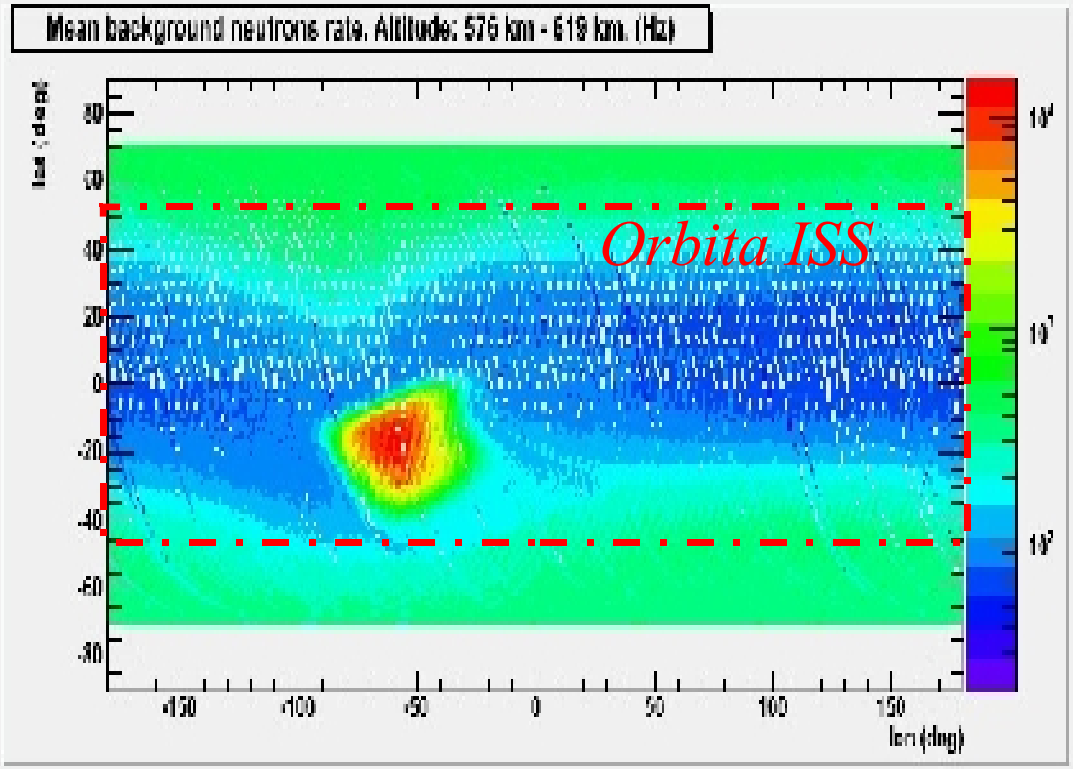


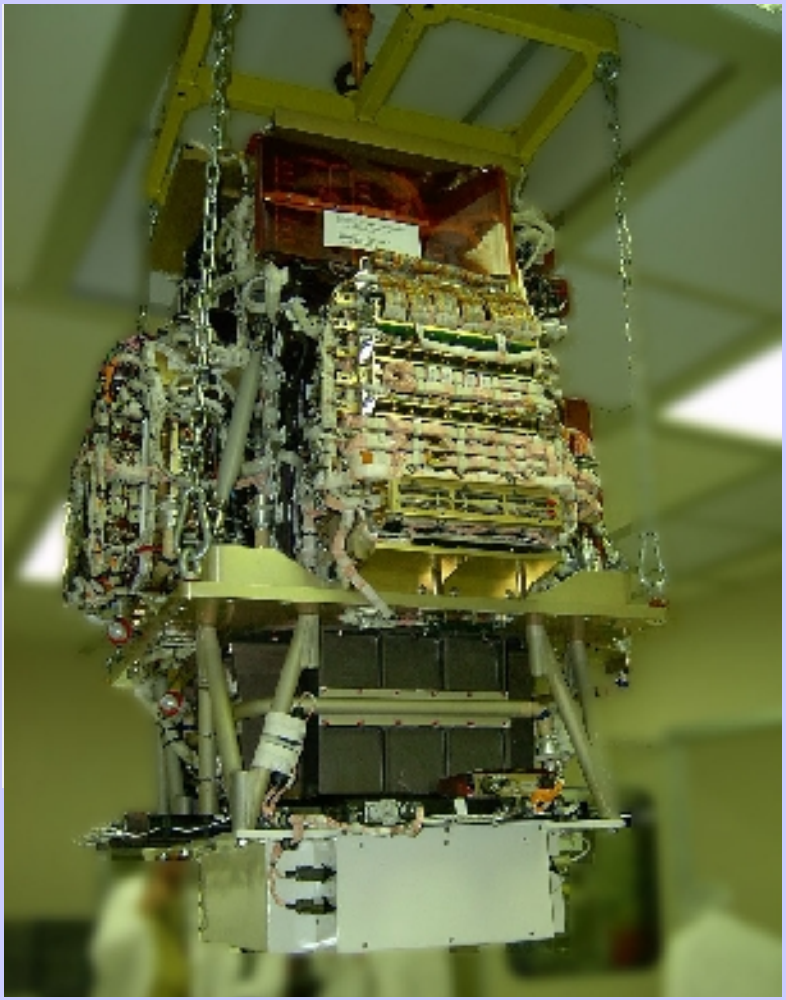


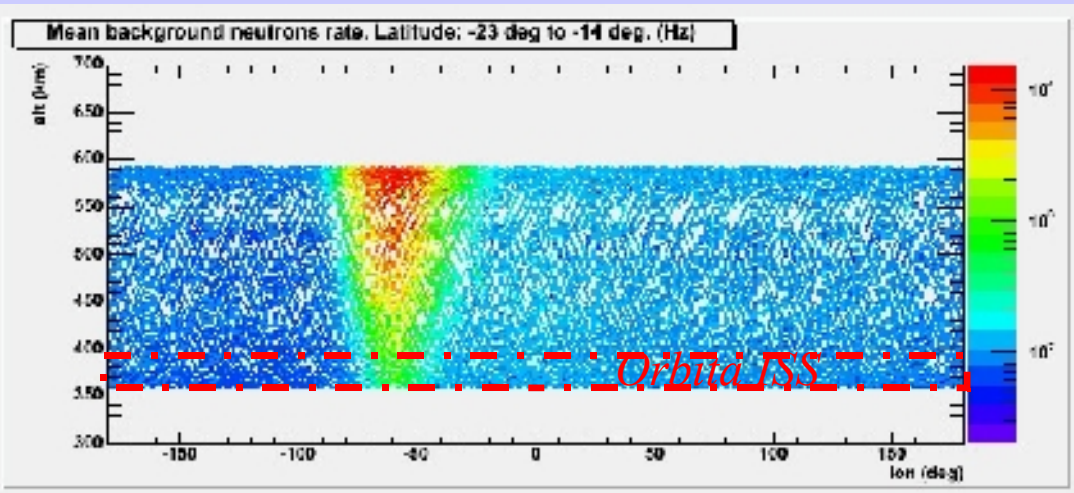




Neutroni (Pamela)







Misure di radiazione e schermatura all'interno della ISS con strumenti attivi e passivi

Alteino

TLD, CR39 to measure charged particle and neutron dose

Jaxa

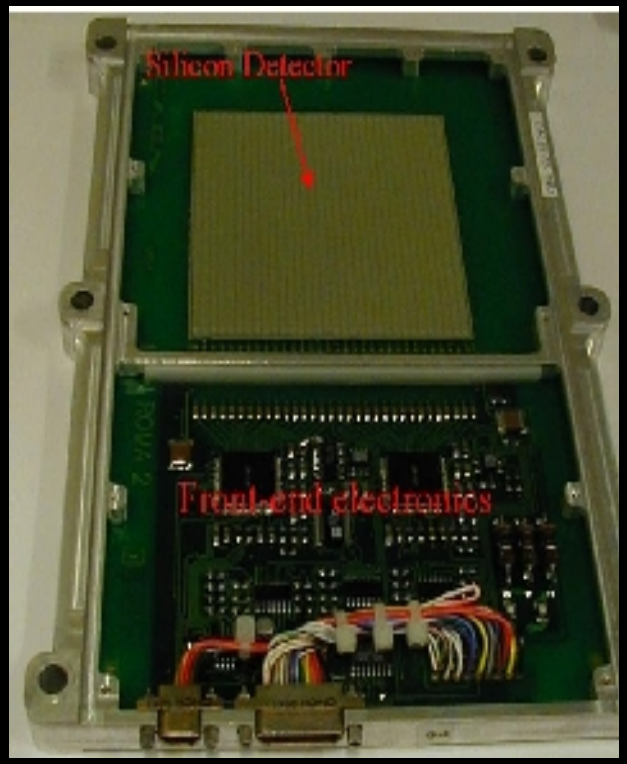
DLR

Napoli Fed. II

INFN-LNF

Sileye-3/Alteino Silicon detector:

Sulla ISS dal 2002



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. Rigth: 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 Tor Vergata.)

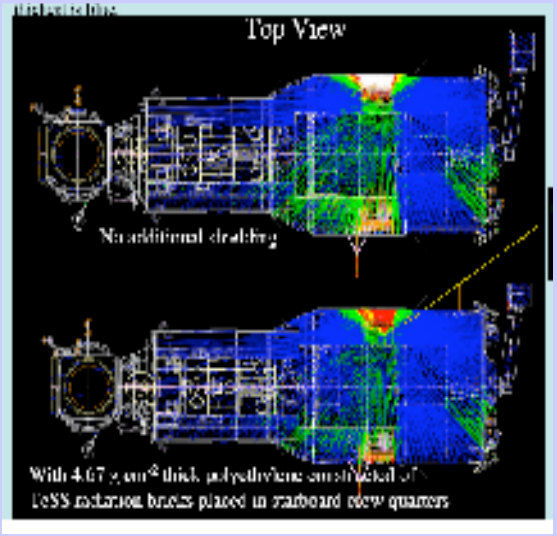
- 8 silicon planes (4x,4y)
- 32 strips strip pitch 2.5 mm, 8x 8 cm^2, thickness 380 μm
- Total 256 Independent channels
- Triggered by two scintillators (E_{min}=40MeV/n)
- Geom Fact: 24 cm^2 sr
- Bidirectional
- Max Field of view 39°
- The front-end is a developed version of two 16 channels CR1 chip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

ISS a novembre 2007

Lancio Columbus 7/2/08

http://www.heavens-above.com/

Starboard Cabin



M. Shavers et al, ASR 34 (2004) 1333


Brasilian As
Marcos Pon
5/4/2006

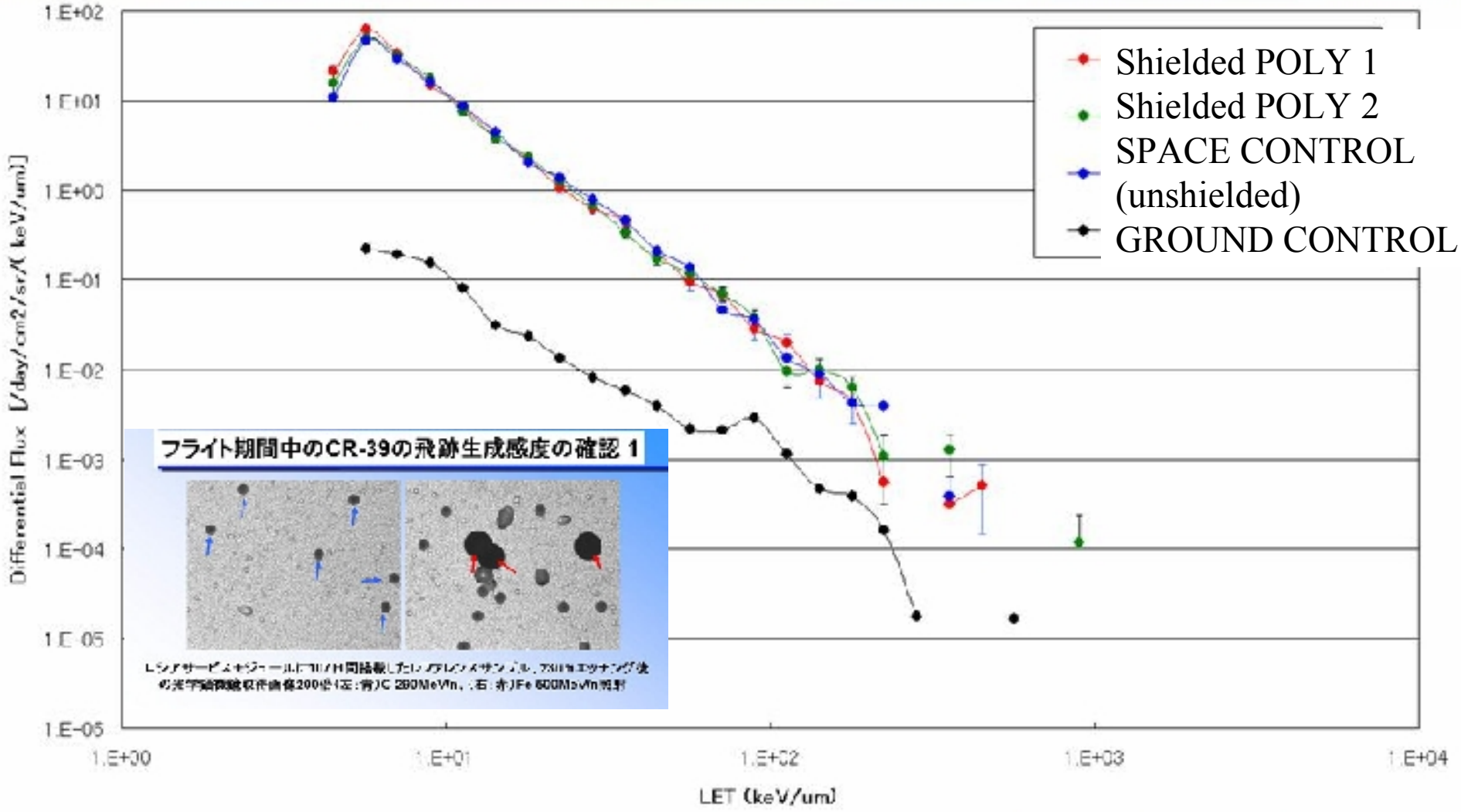
Christer Fuglesang, STS-116 Dec, 2006

S116E06539

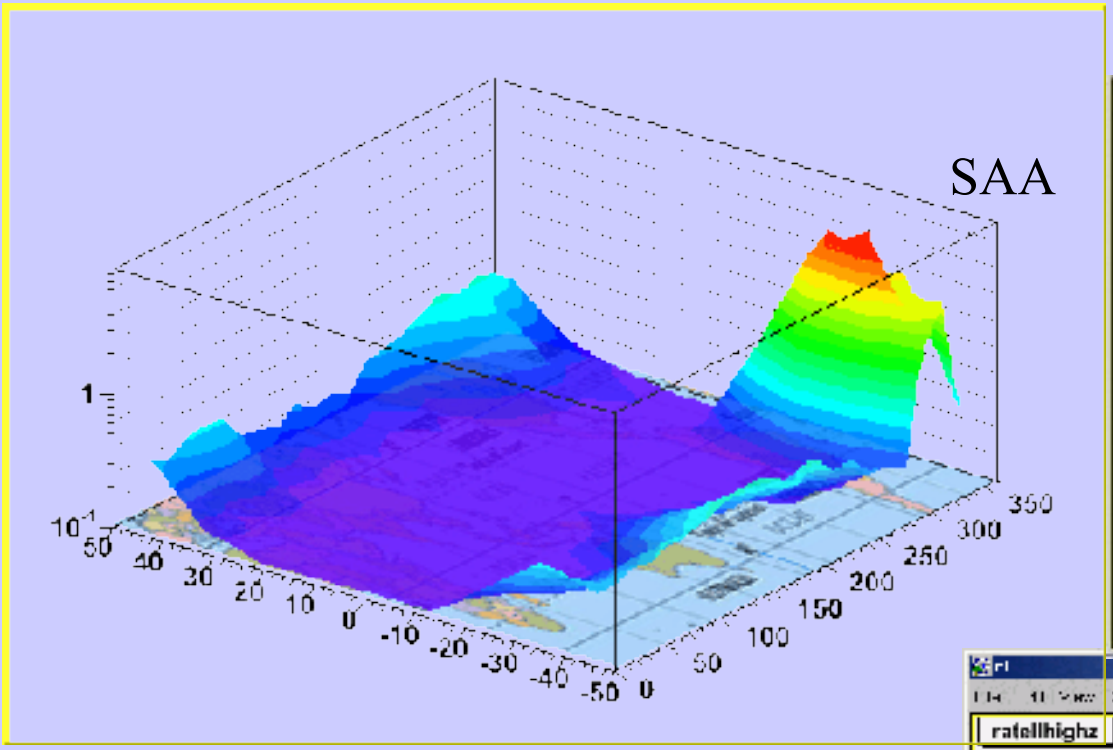

25 September 2006
Multimaterial Shielding
And dosimeters
Alteino detector
Data cards and control dosimeters
Poliethilene shielding
And dosimeters
ISS013E82688

ALTCRISSフライト実験の結果：LET分布

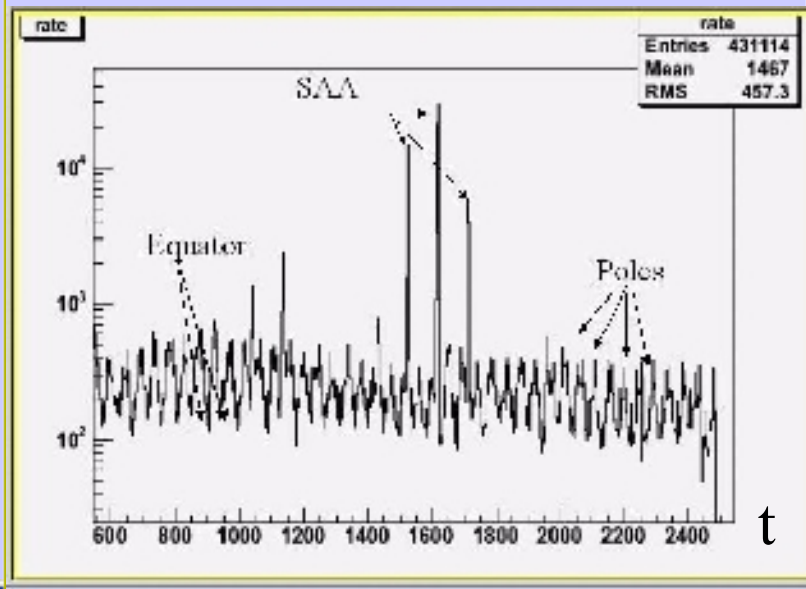
搭載から帰還　2005年12月23日～2006年4月9日　(107日間) 軌道高度：約400km 軌道傾斜角：51.6度



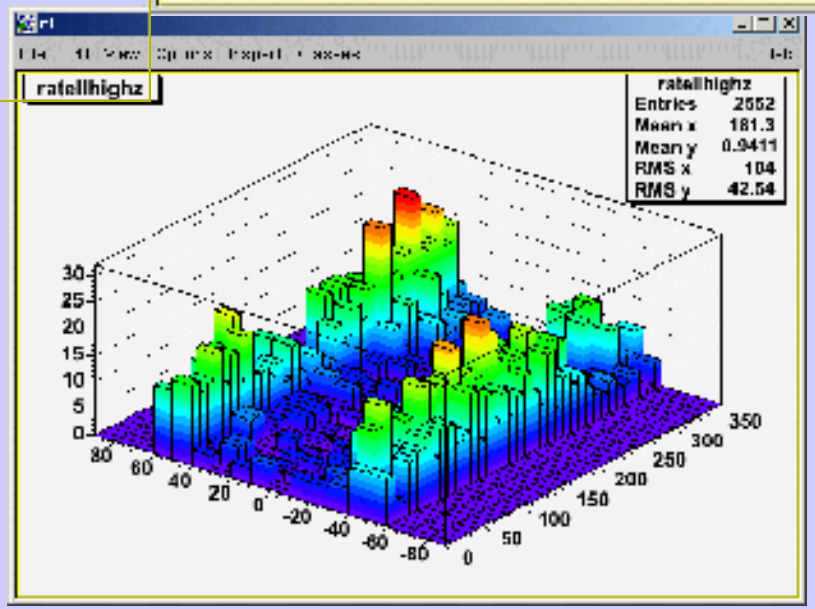
Protoni



Conteggi

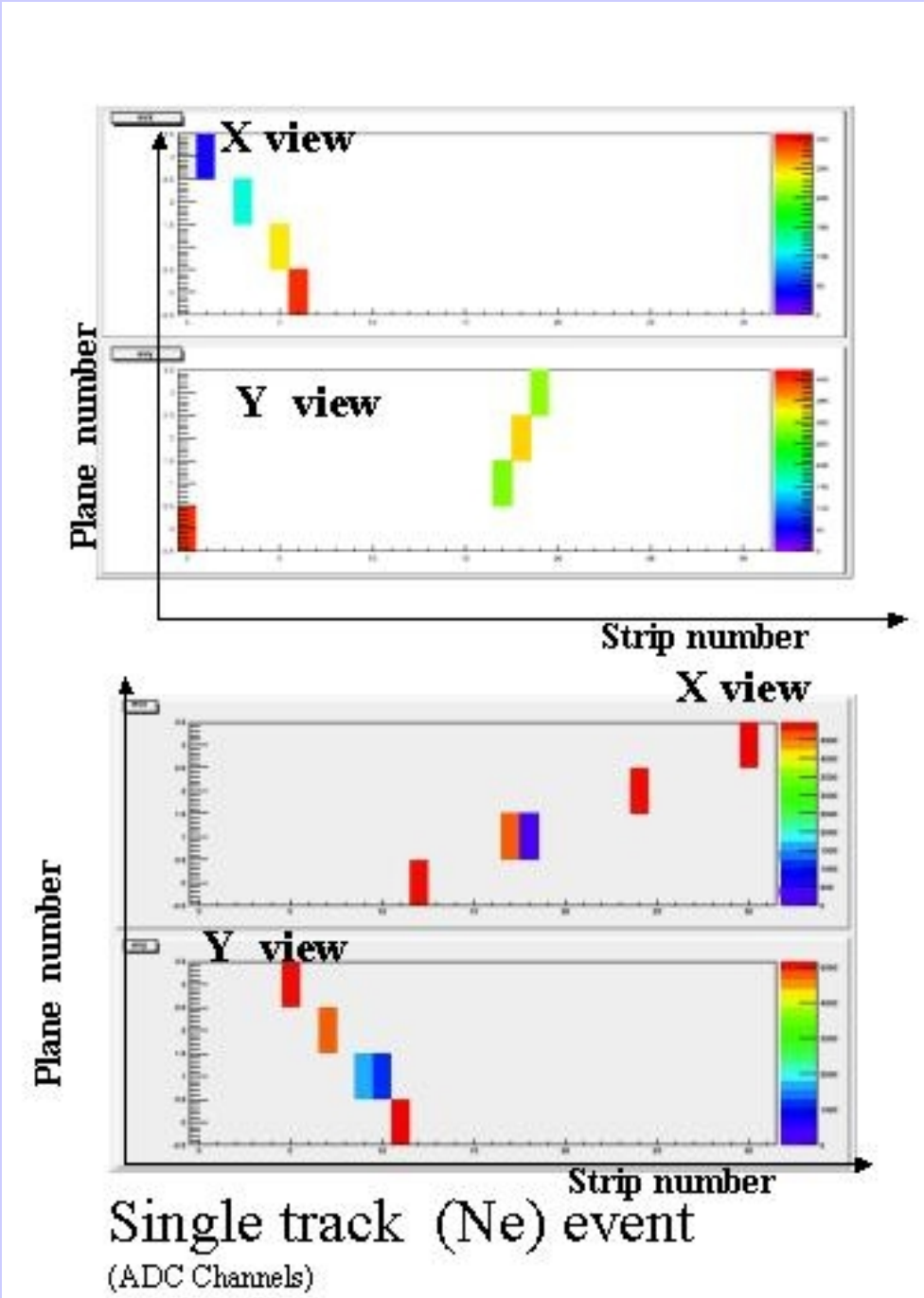


Nuclei Z>=2



Particle tracks

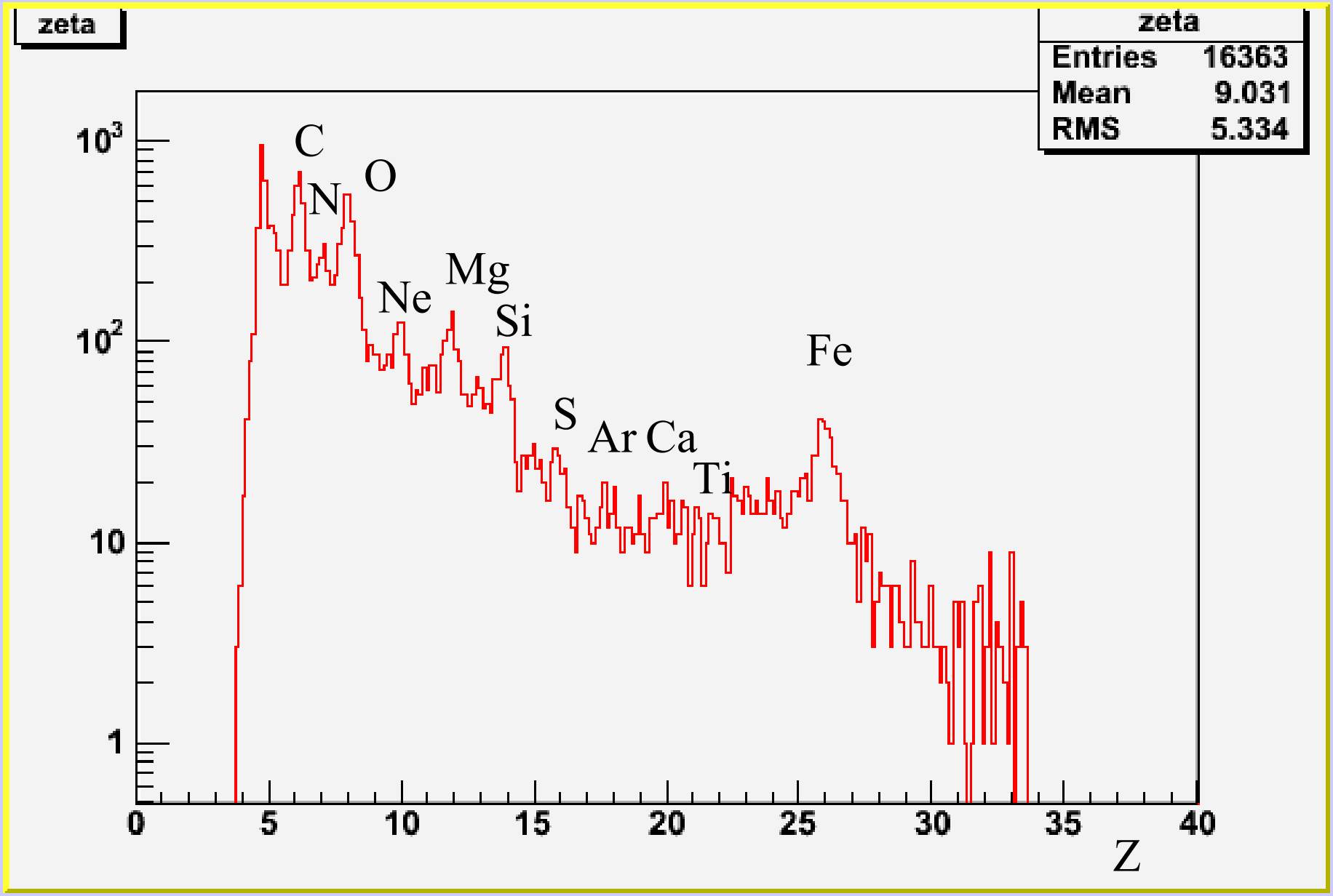
- Single and multiple track identification capabilities



Single track (Ne) event

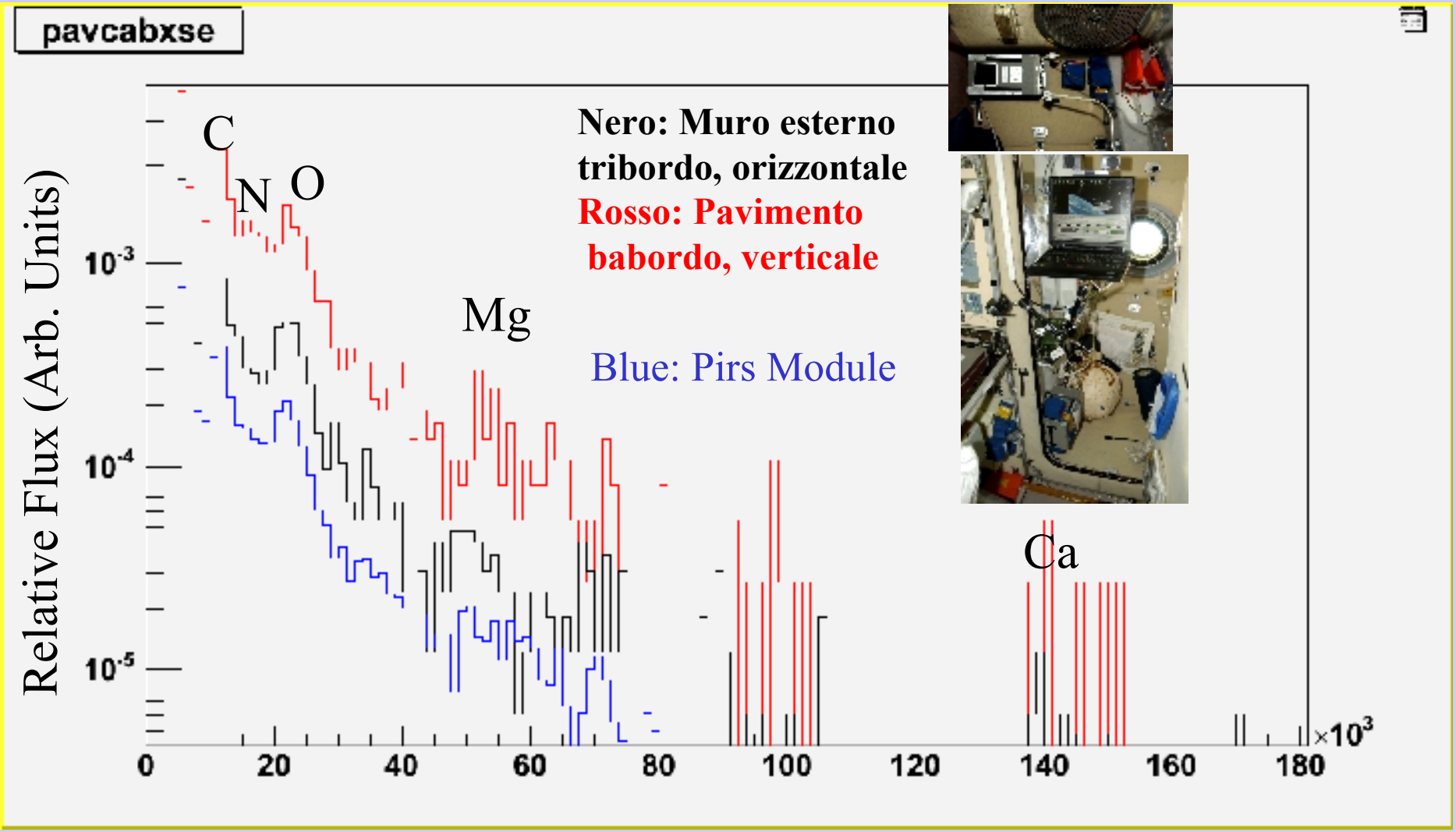
(ADC Channels)

Heavy Nuclear Charge (Pirs module)

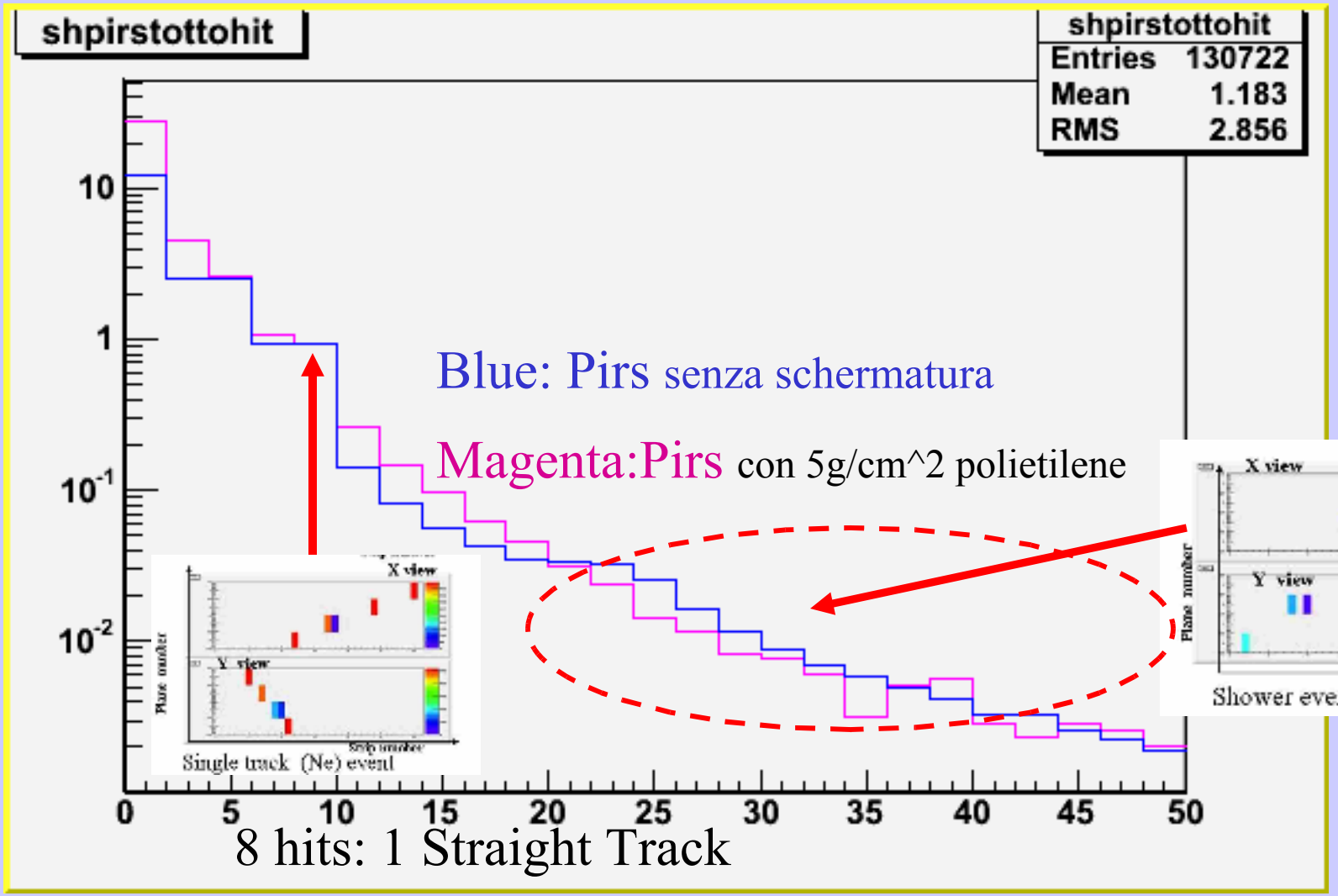


Flux Comparison: Crew Cabins – Pirs Module

(normalized by time)



Frammentazione: effetto di schermatura



Frammentazione: moduli della ISS

pavcabtottohit

pavcabtottohit	
Entries	717707
Mean	2.419
RMS	4.295

Black: Ext wall Hor.

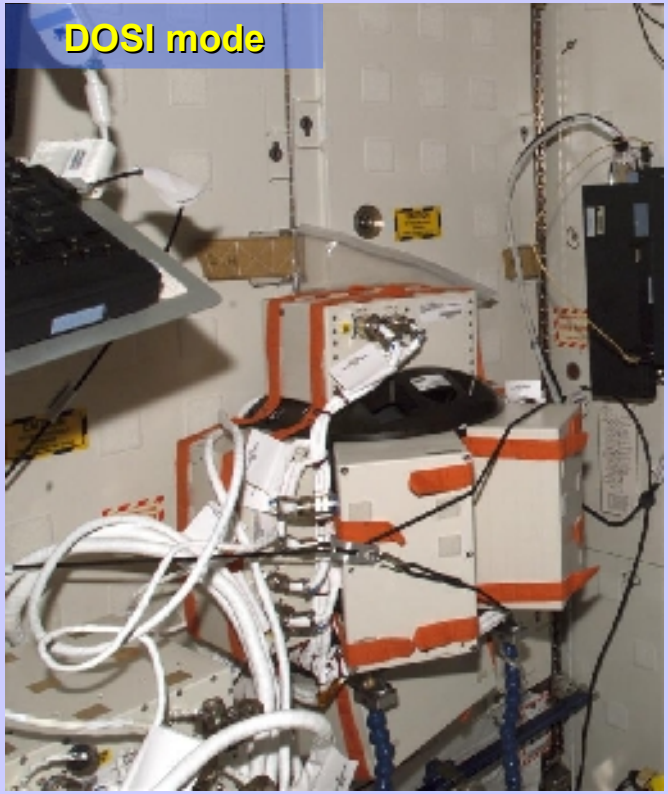
Red: Floor (Vert)

Blue: PIRS

8 hits: 1 Straight Track

Number of Hits

ALTEA

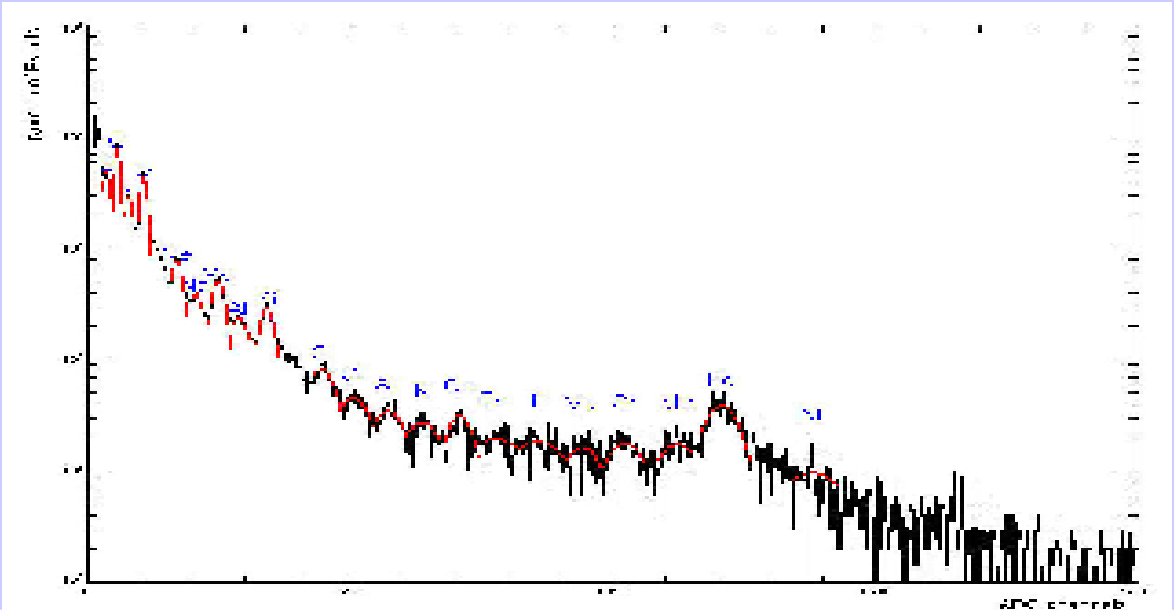


DOSI (*Dosimetry*):

- Unmanned mode
- Only SDS switched ON
- Continuous measurement of radiation flux

CNSM (*Central Nervous System Monitoring*) Light Flash:

- Manned mode
- Six 90-minute sessions (a whole orbit)
- All subsystems active (SDS, EEG,



From L. Di Fino

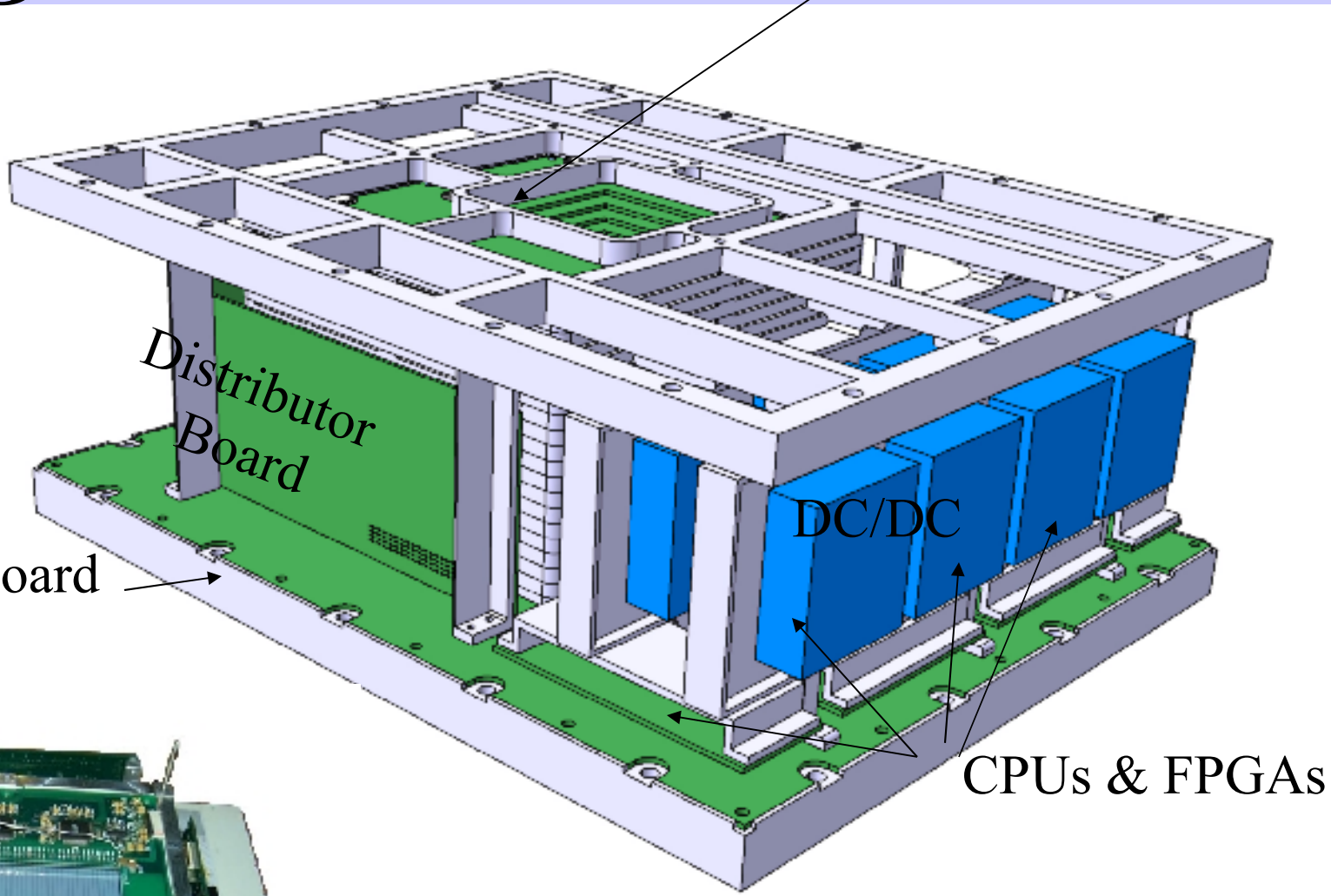
Si-rad detector

32 Silicon Planes,
1024 channels 8*8cm^2
100 cm^2 sr
H-Fe identification
Energy resolution in 30-2000 MeV/n

In/out ISS measurement

Risoluzione angolare	Scintillatori		Risoluzion	SILICI piano 1 2 3	
Strip Pitch	0.25	cm	*Strip Pitch*	0.25	cm
Max angle (one module)			Max angle (one module)		
rad	0.6896467		rad	1.446441	
deg	39.513844		deg	82.87498	
Max angle side strip			Max angle side strip		
(Angolo per la strip accanto)			(Angolo per la strip accanto)		
rad	0.674112		rad	1.442473	
deg	38.623773		deg	82.64762	
Error for inclination part	-0.89007	deg	Error for in	-0.22736	deg
Error for orthogonal parts	0.0257675	rad	Error for or	0.244979	rad
	1.4763685	deg		14.03624	deg

SIRAD

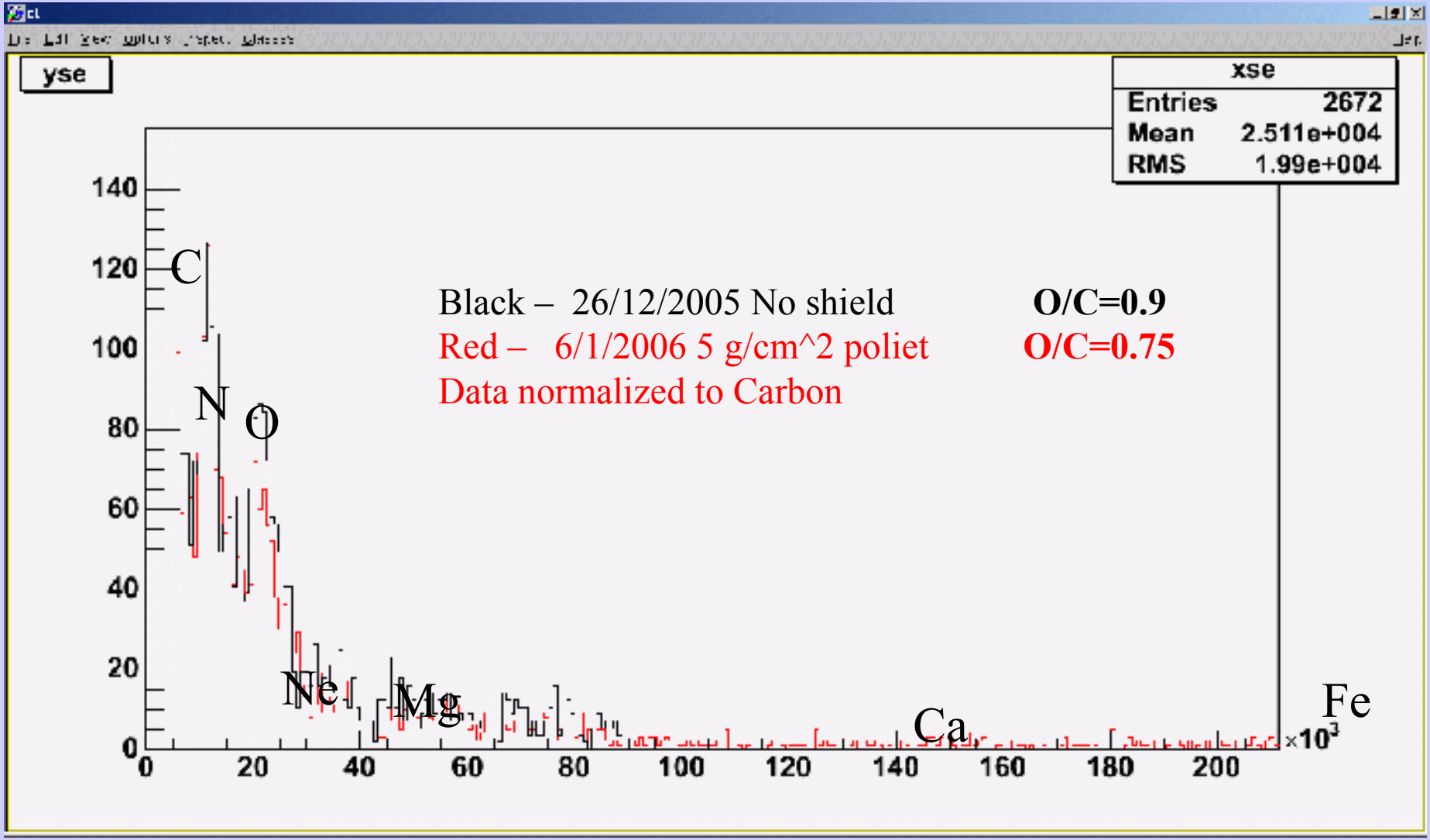


384*304*120 cm 35 kg (esterno) + 10 kg (interno) Power: 30 W

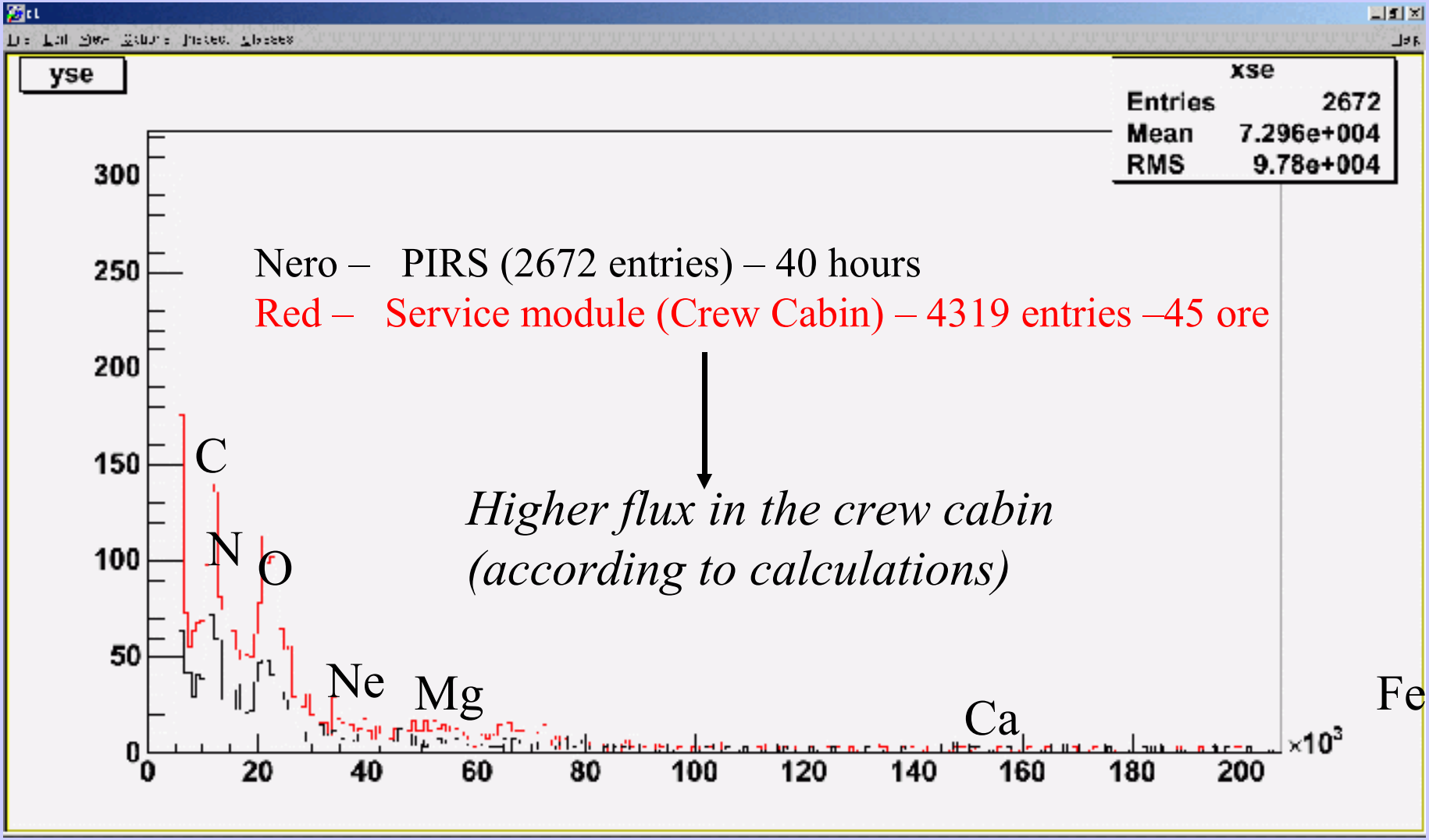
Risultati / Conclusioni

- Schermatura necessaria in future missioni sulla Luna e/o Marte
- Polietilene (5g/cm^2) nello spazio:
  - 10% in media, dosimetri passivi (vedi SPADA)
  - 25% sulle abb. nucleari in particolari condizioni di schermatura
- Sciami:
  - Polietilene riduce eventi ad alta molteplicità, aumenta media molt.
  - Schermatura passiva ISS modifica fortemente la molteplicità
- Pirs maggiormente schermato del modulo di servizio
- Cabine hanno forte asimmetria della fluenza.
  - ϕ (cabina) / ϕ (modulo attracco)= 10
  - ϕ (verticale) / ϕ (orizzontale)=4
- Nuclei pesanti ridotti da schermatura O/C da .9 a .75
- Lampi di luce poco frequenti nel modulo americano
  - Maggiore schermatura, Forte soggettività
- Misure correlate con Pamela – Altea
- Sirad in fase di completamento

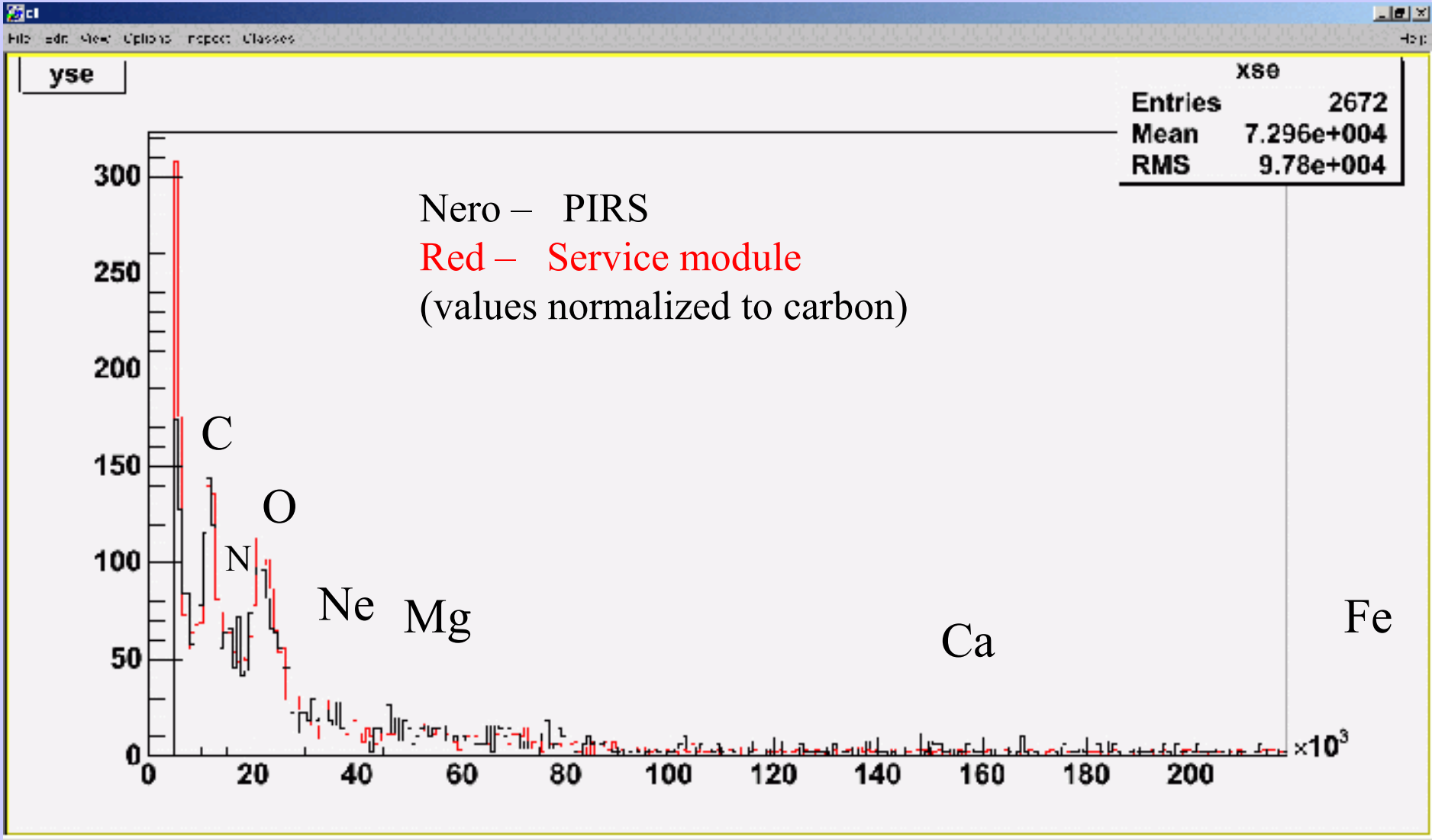
Comparison with/without shielding



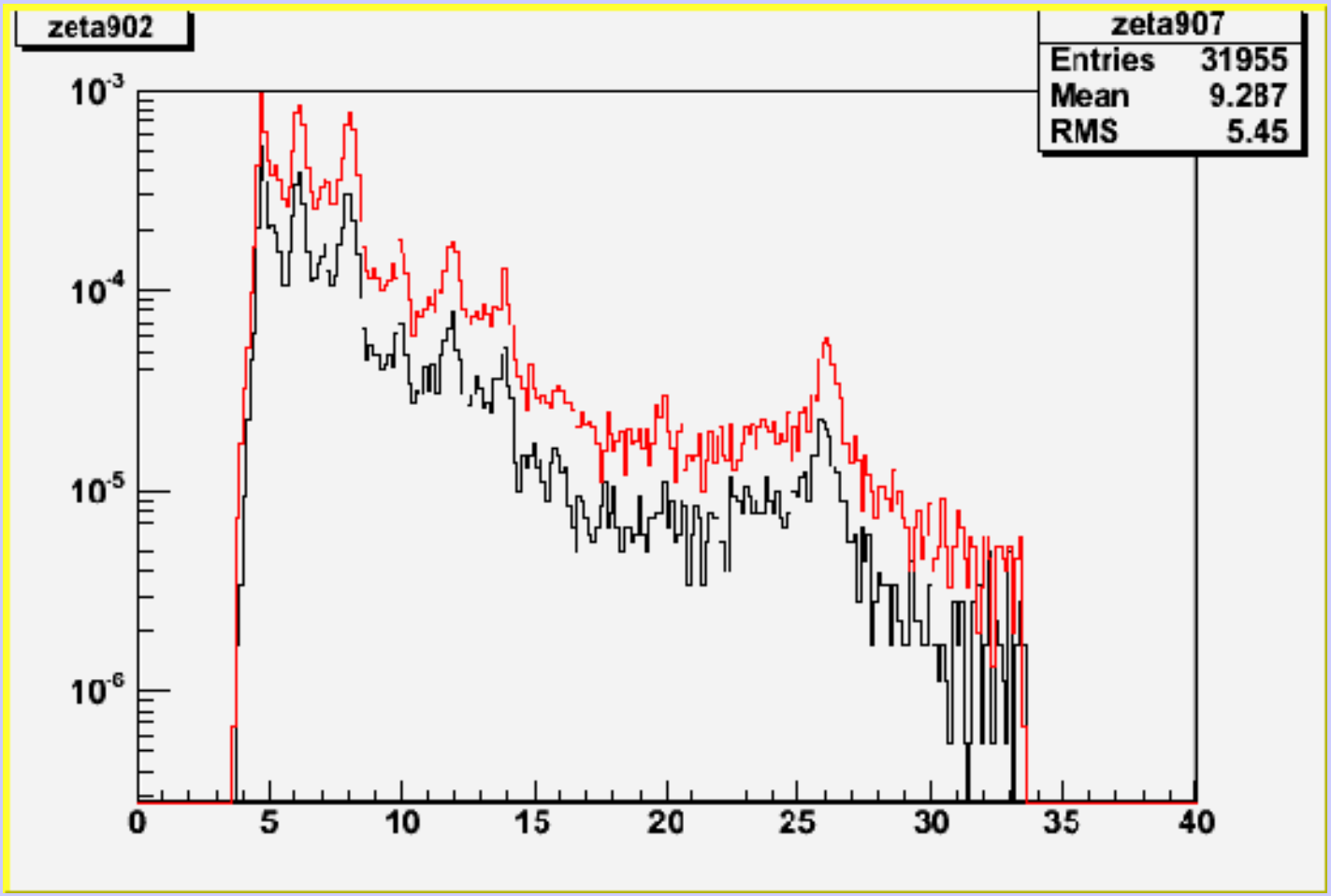
Difference PIRS – Service Module



Pirs- Service Module rel. abundance



Heavy Nuclear Charge (Pirs – Service module)

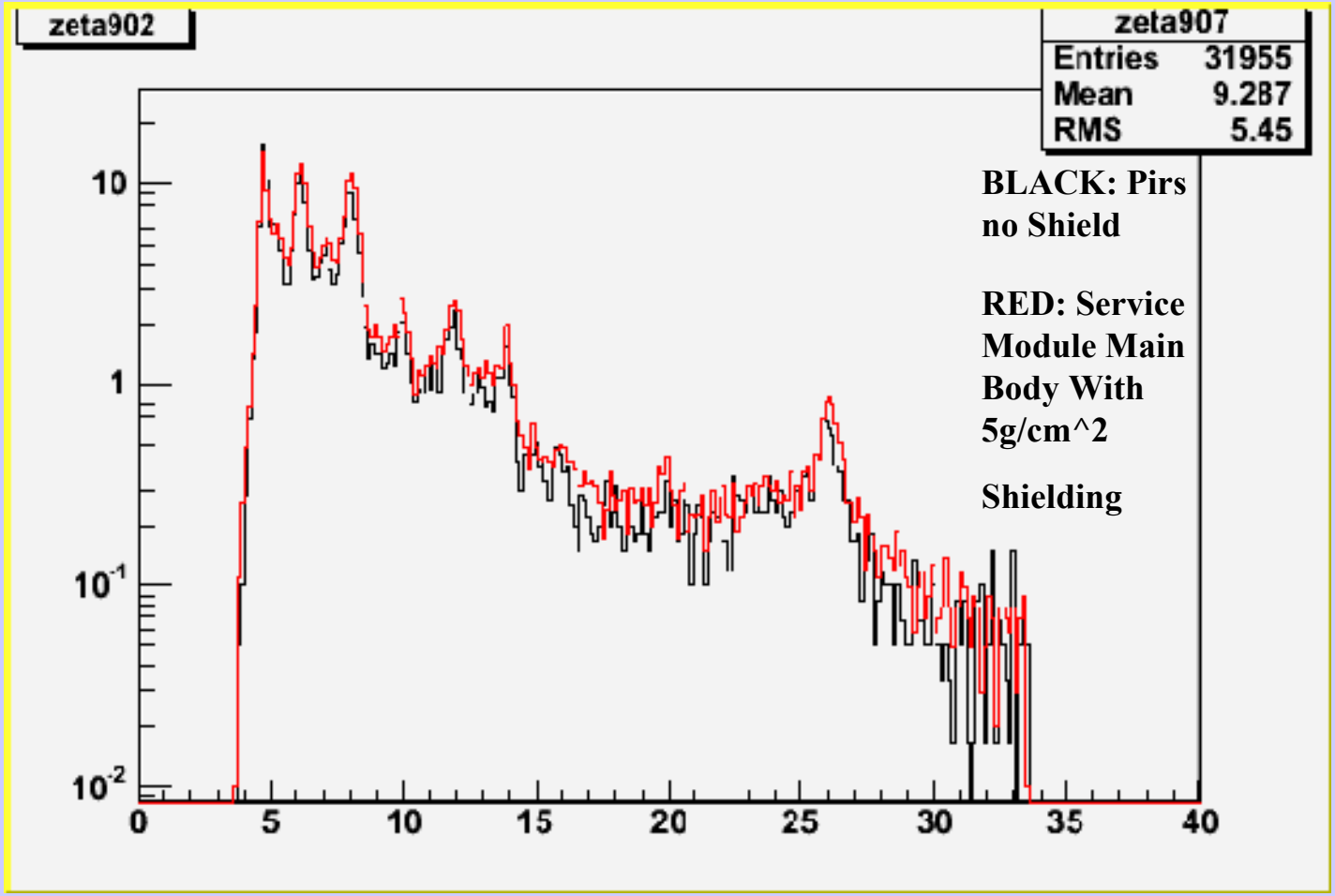


BLACK: Pirs no Shield

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

Relative abundances comp.

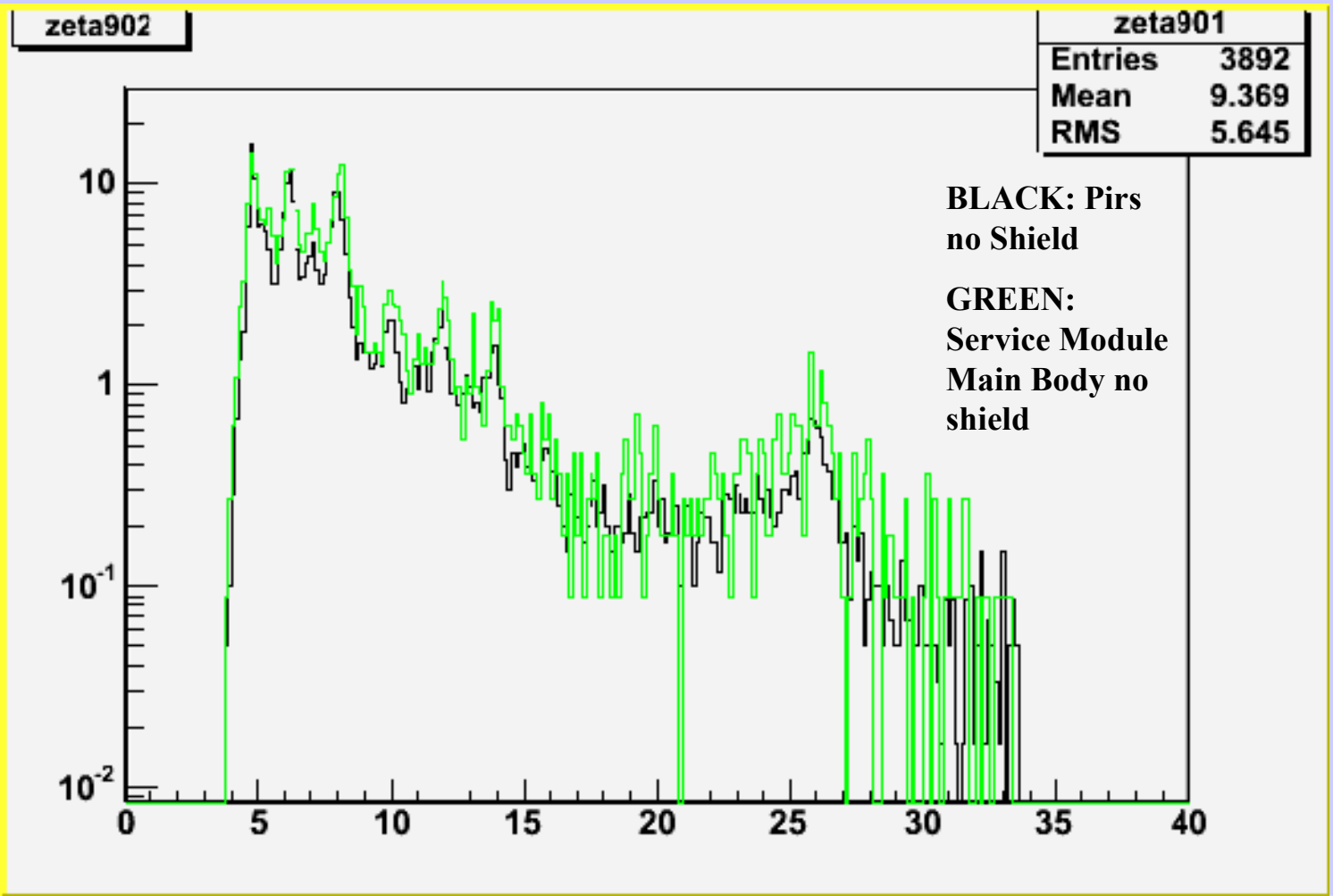
(preliminary)



Normalized to C=10

- **More heavies in Service module**

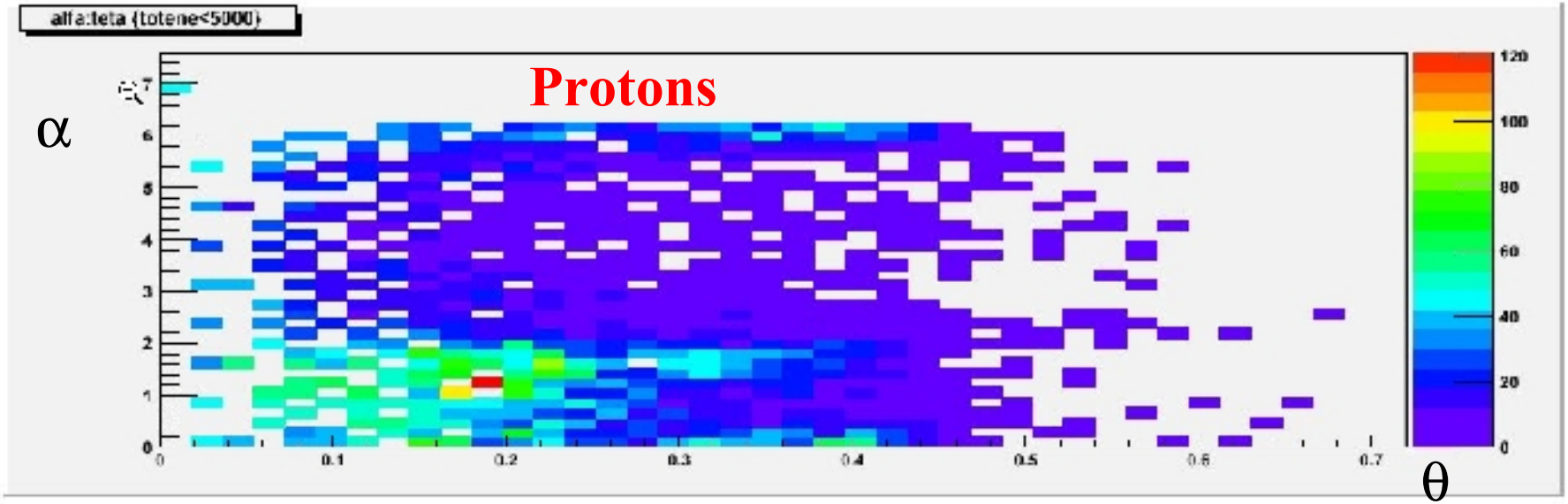
Relative abundances comparison (2)

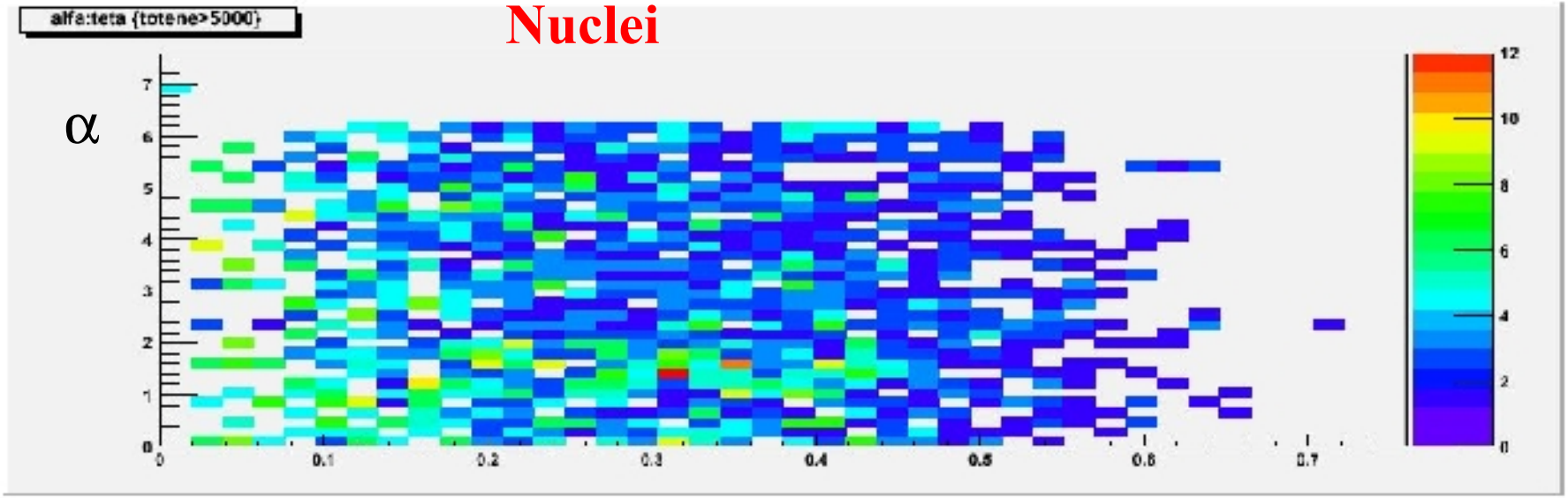


Normalized to C=10

All Z>6are suppressed with shielding *(surprise!)*

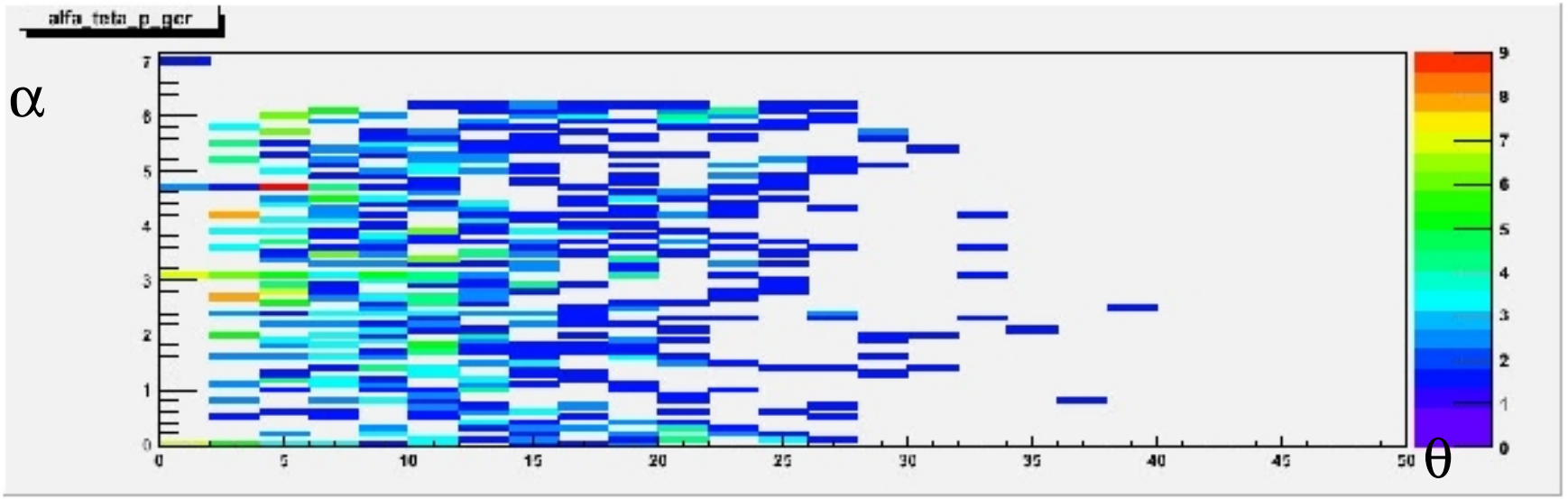
Angle of incidence:
Histogram of α - θ for proton and nuclei

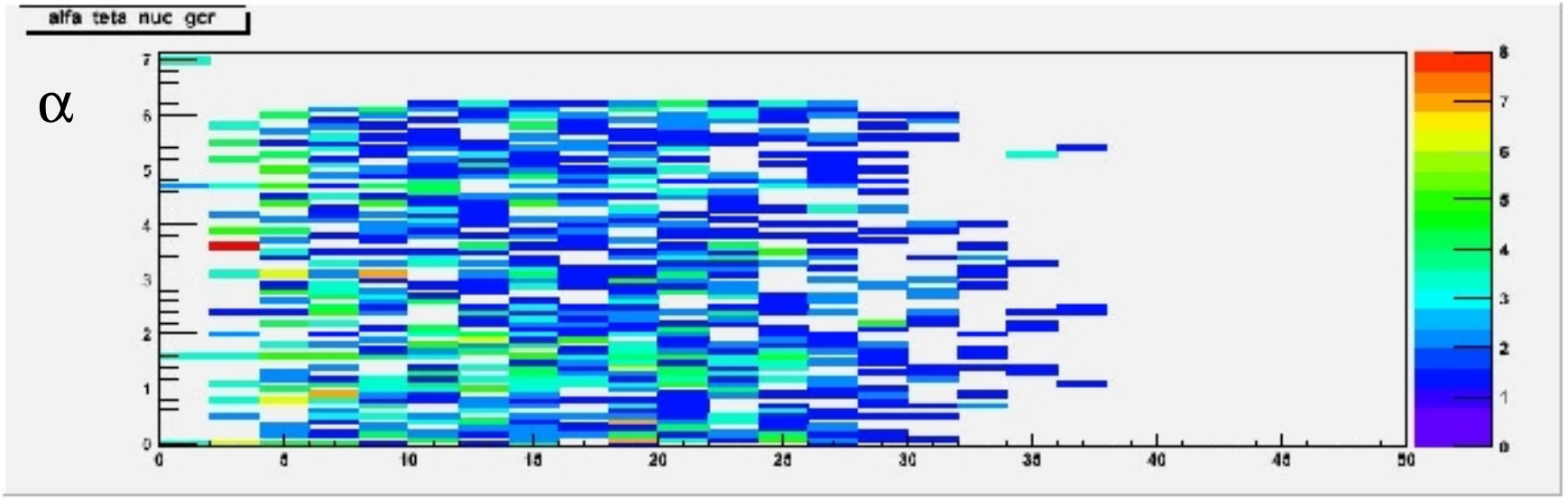




GCR

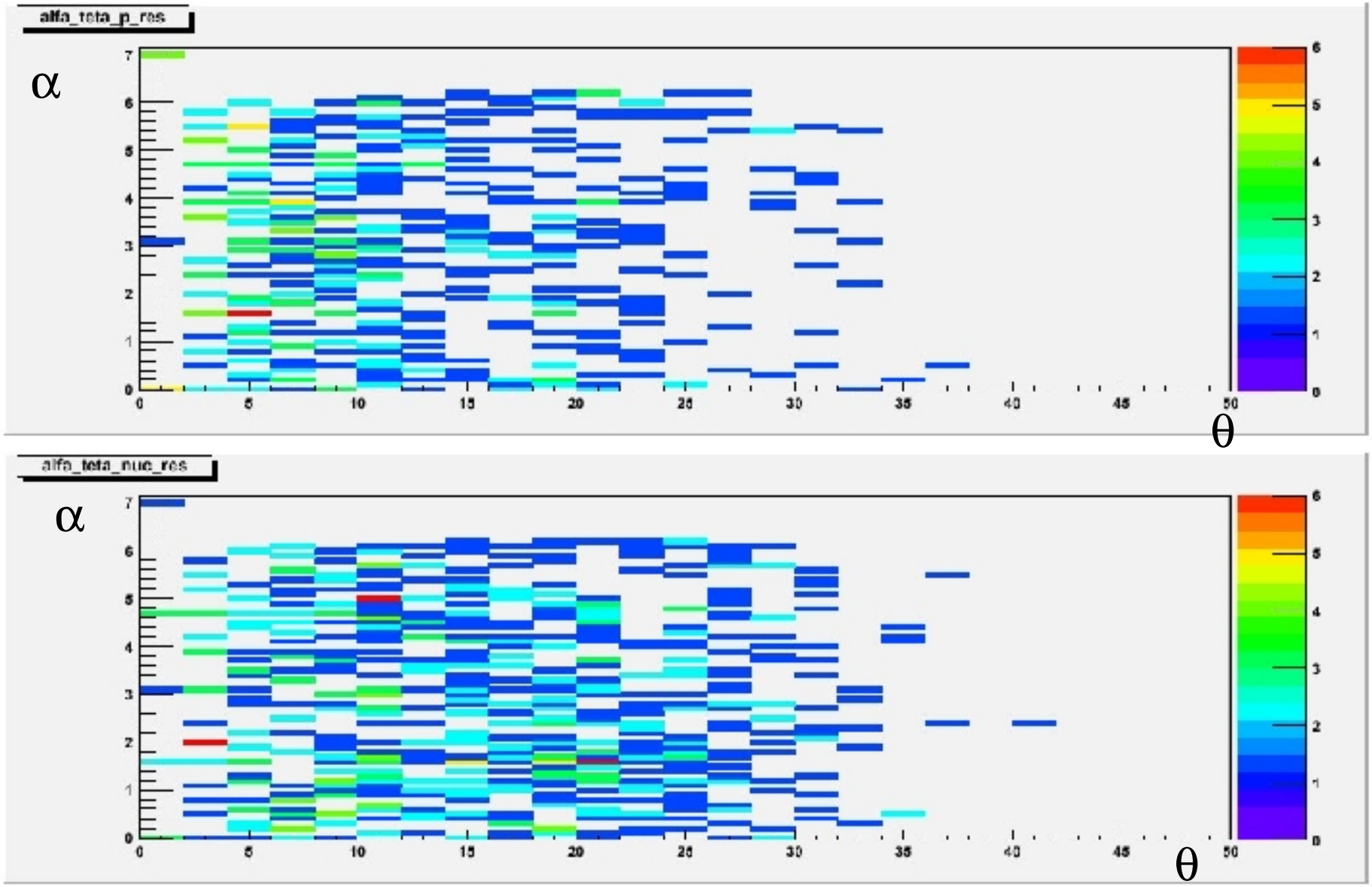
Angle of incidence:
Histogram of α - θ for proton and nuclei





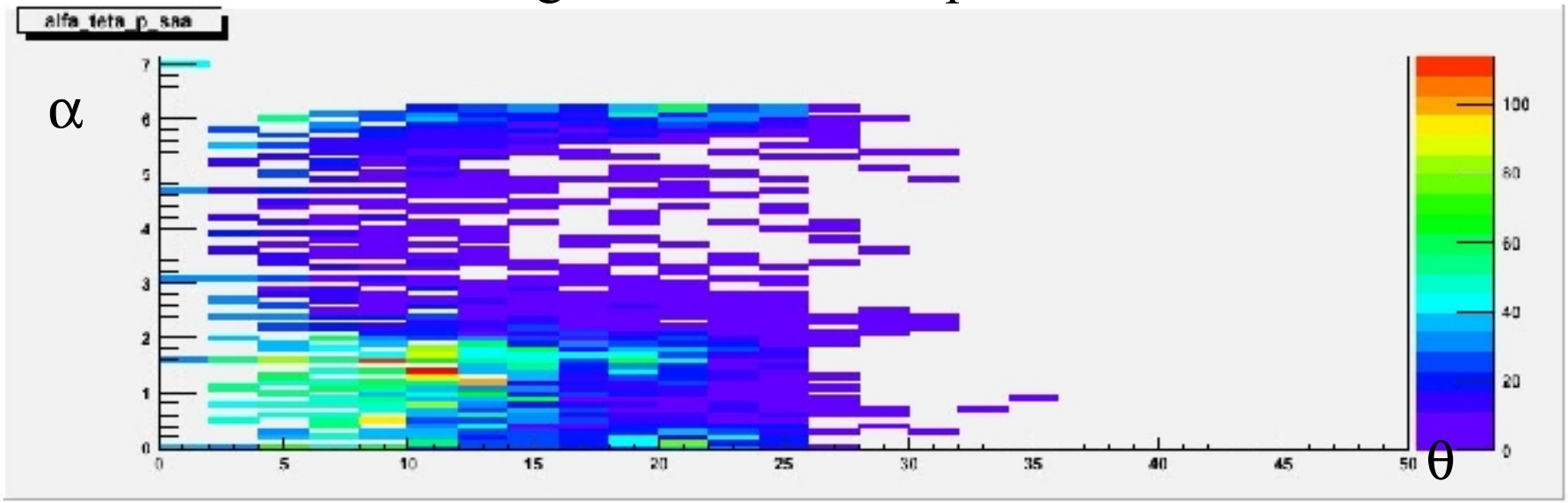
Low latitude region

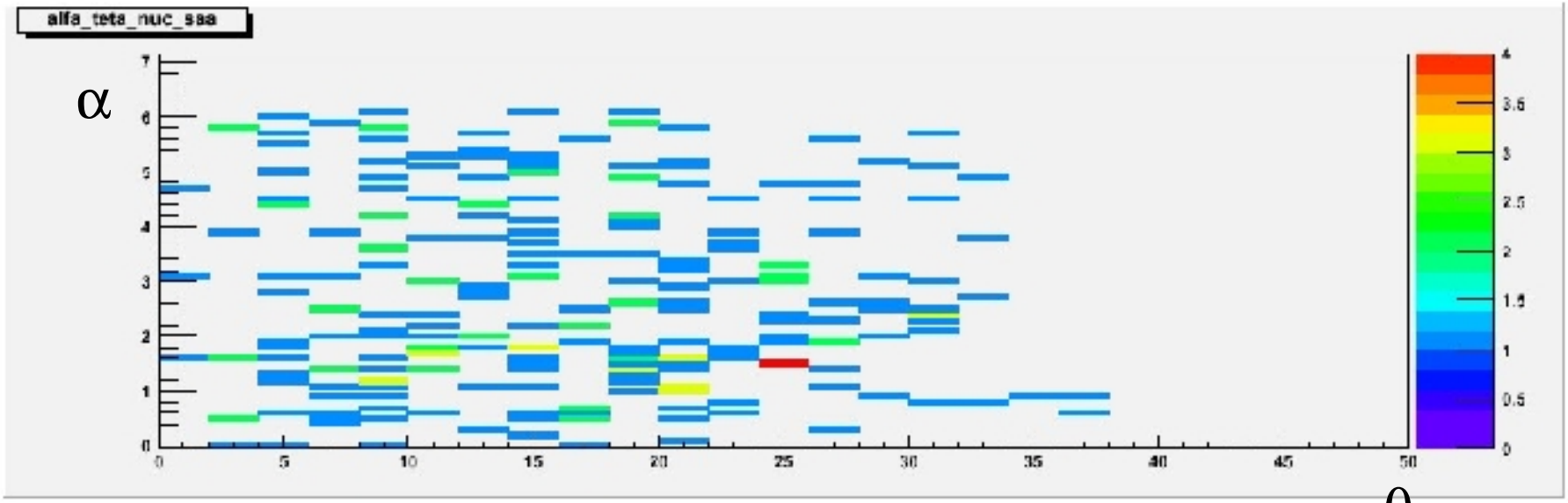
Angle of incidence:
Histogram of α - θ for proton and nuclei



SAA

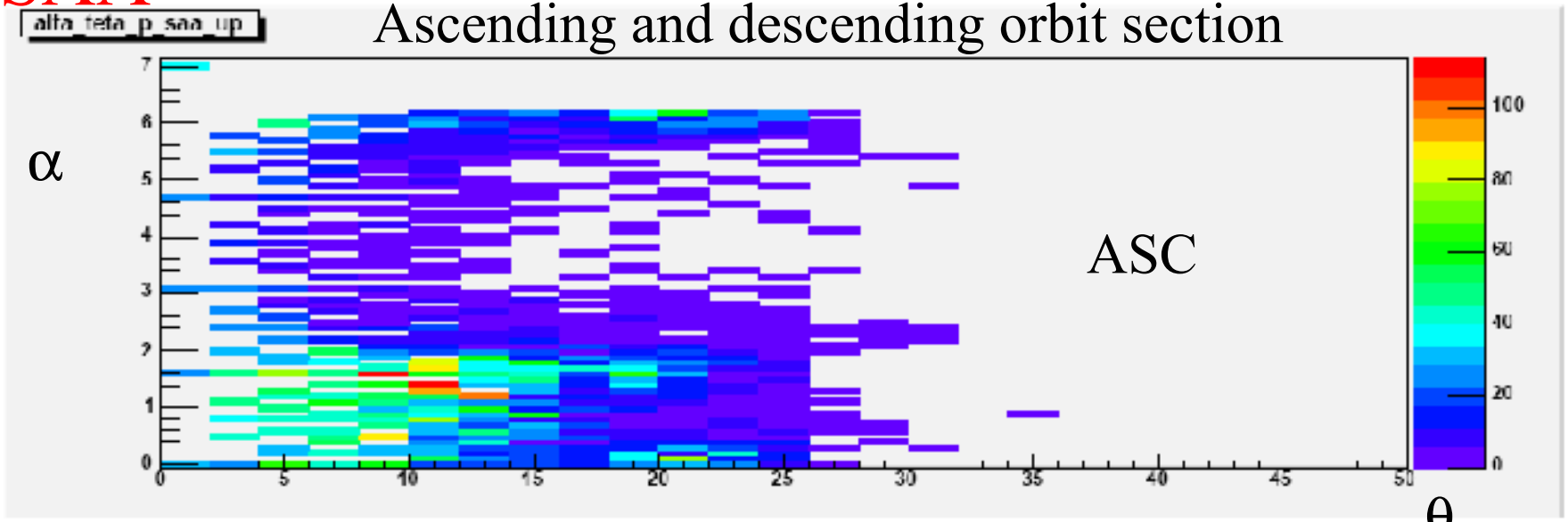
Angle of incidence: Histogram of α - θ for proton and nuclei

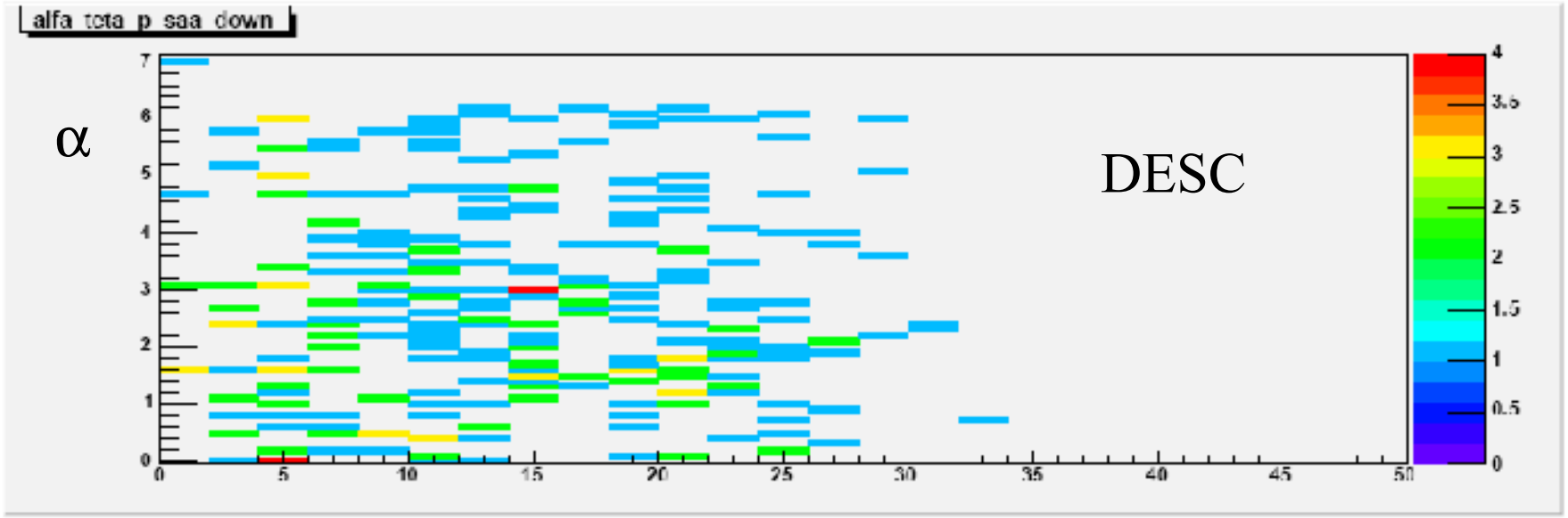




SAA

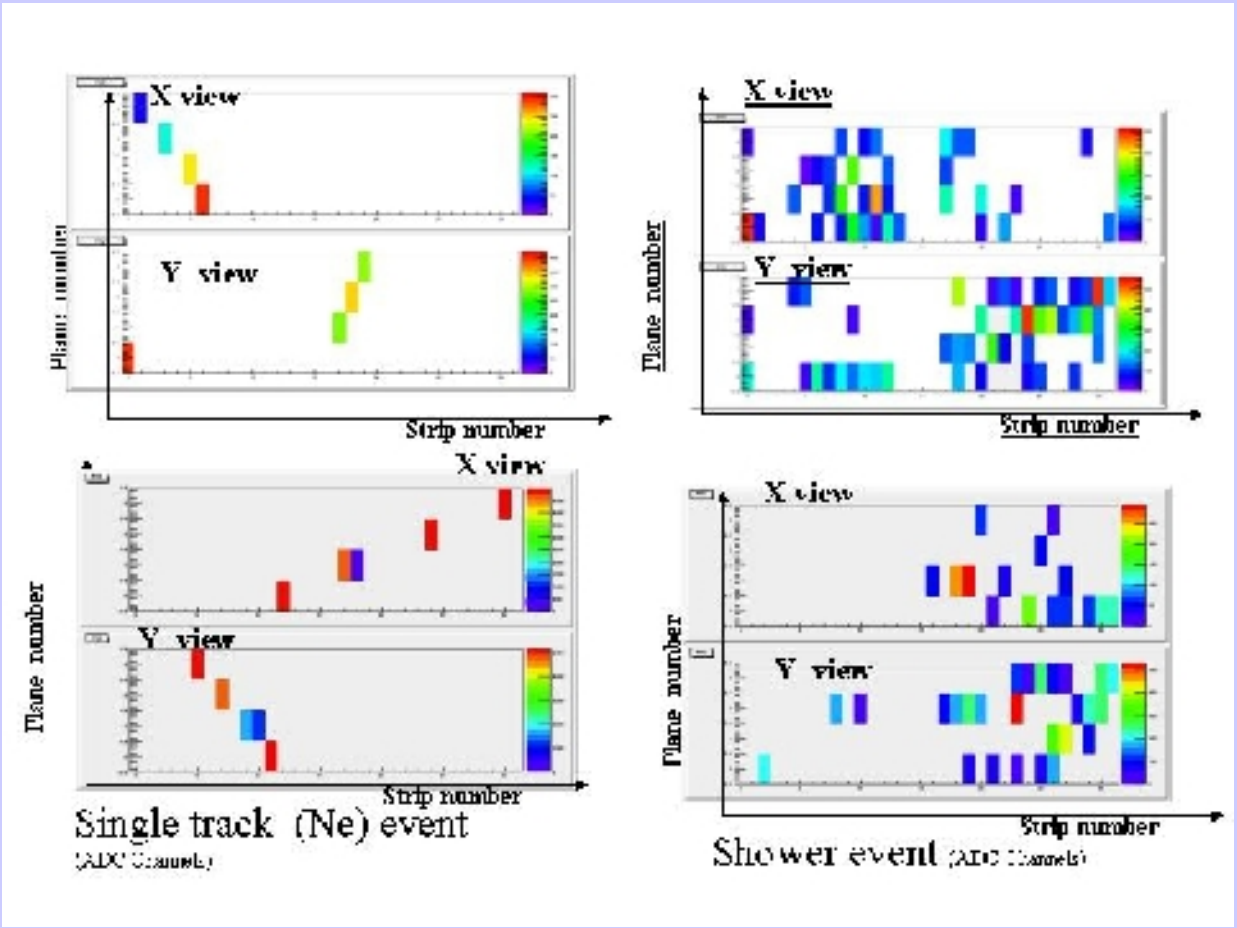
Angle of incidence:
Ascending and descending orbit section



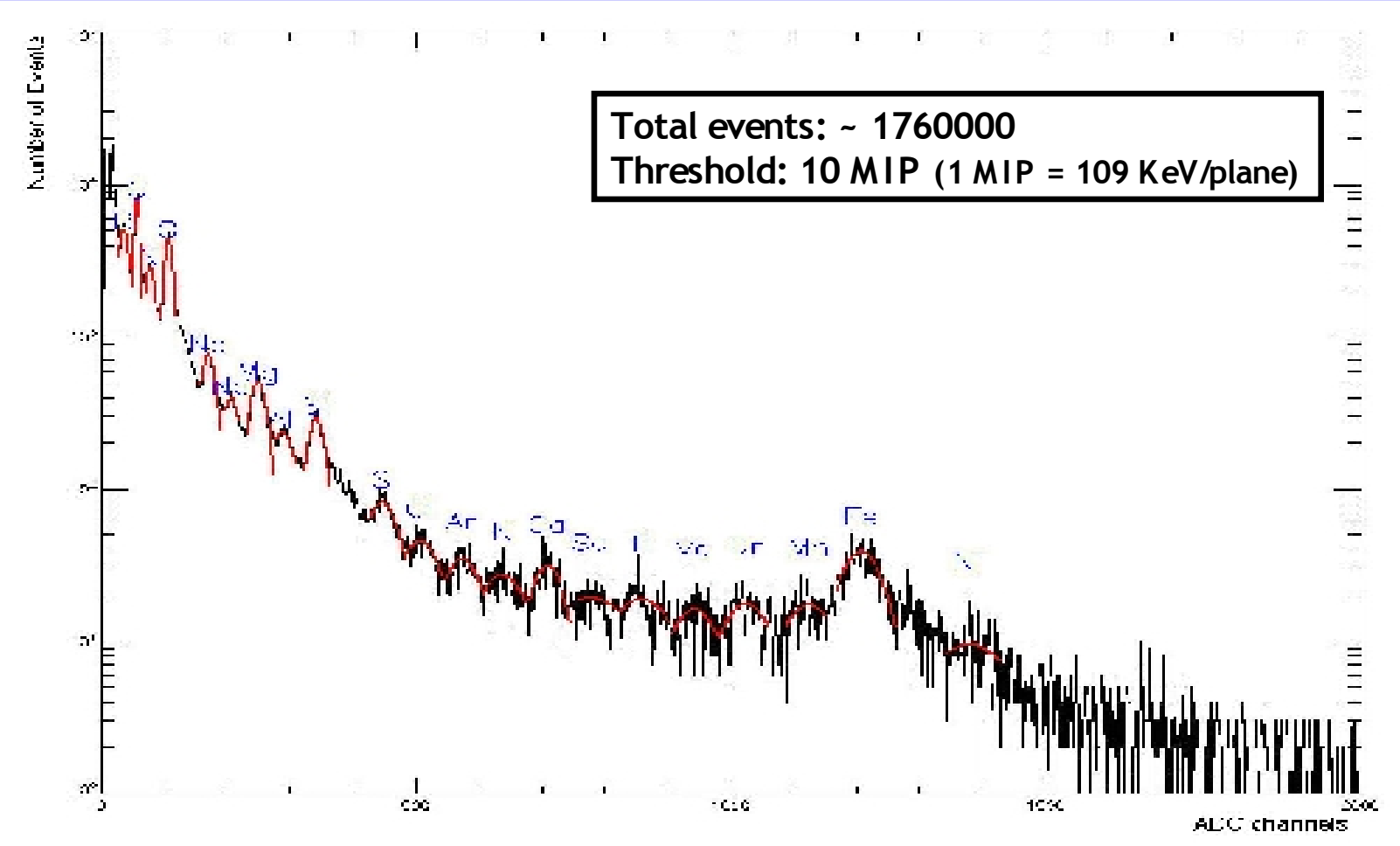


Fragmentation

- Alteino has multiple track identification capabilities
- It is therefore possible to identify showers in the detector



- Spectrum of energy released by relativistic particles (10%)
- Gaussian fits up to Ni (10 MIP, SDU2 up to December, 2nd)



From L. Di Fino

Sileye-3 Alteino

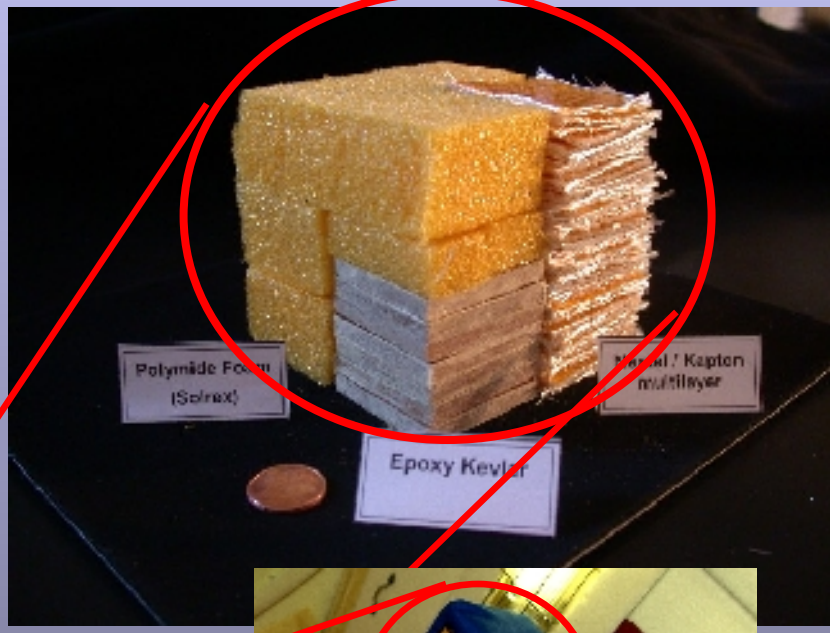
- **Placed on ISS in 2002 (ISM-1):operational for 6 days**
- **Reswitched on in 2005 (ISM-2): operational for 4 days**
- **Long term measurements (ALTCRISS): Since Dec 2005**

Precursor measurements with Lazio-Sirad (ISM-2: April 2005)

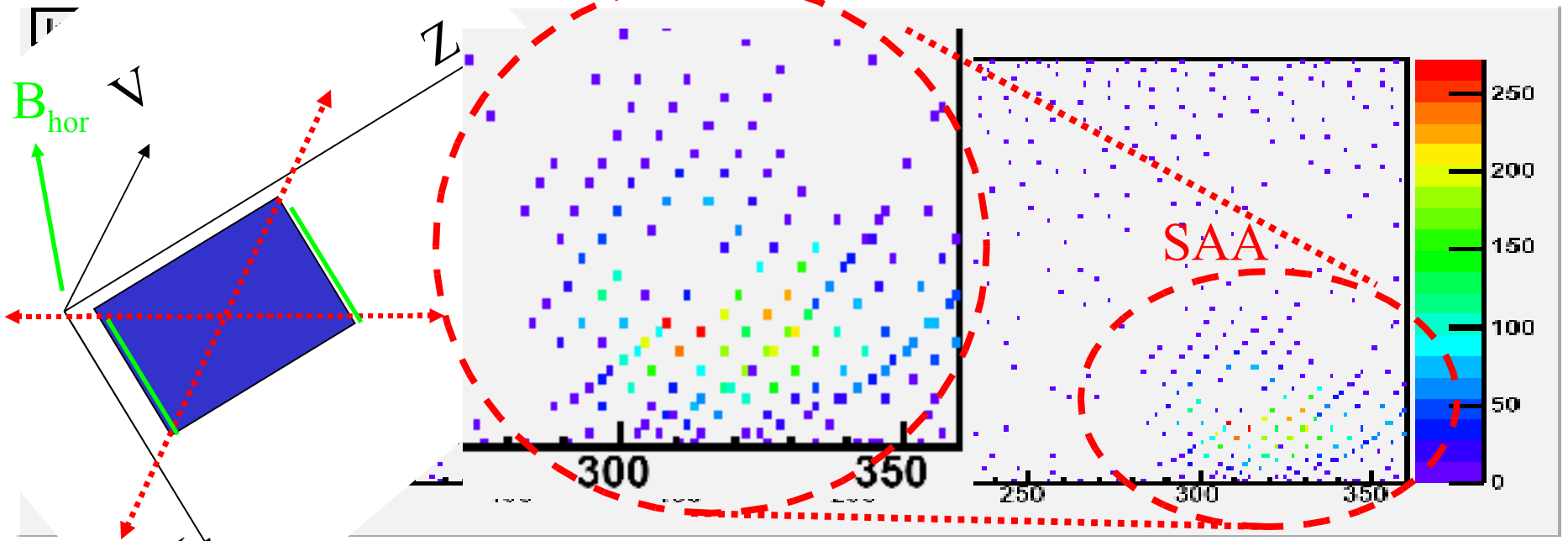
- Study of the effect of different shielding materials on the cosmic radiation
- 4 different shielding materials (5g/cm^2):

  Air, Kevlar, Poliethilene, Nextel/Kapton

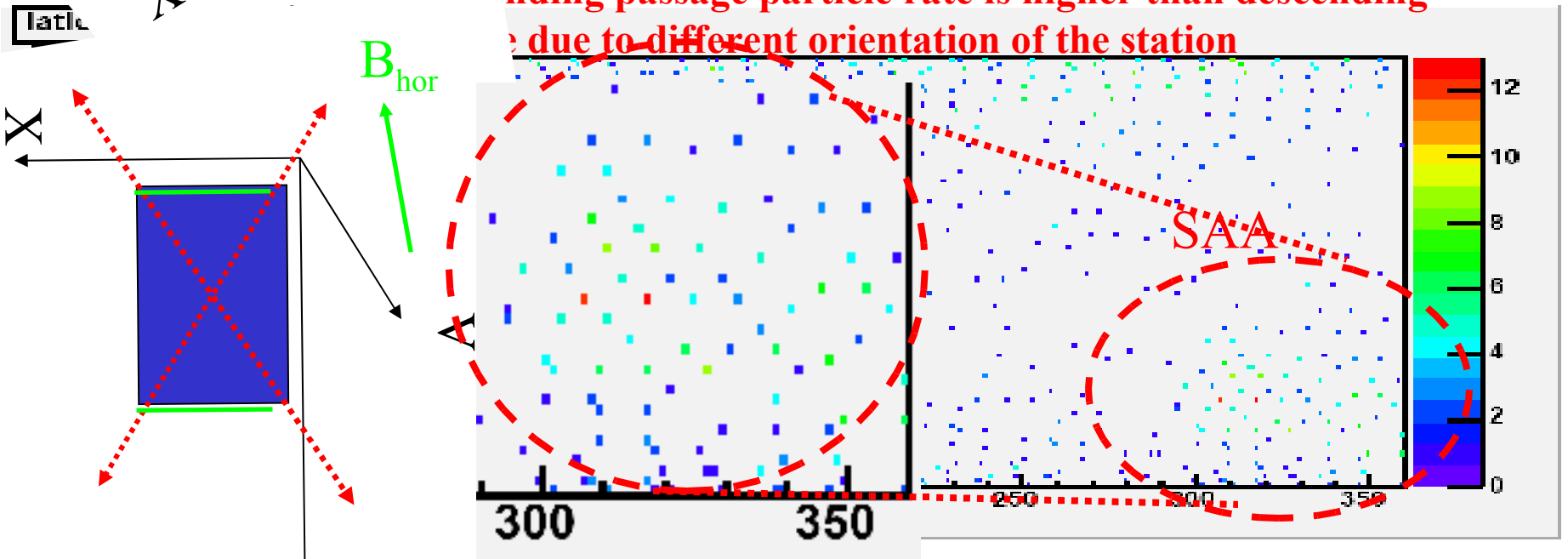
In use in ALTCRISS with passive detectors



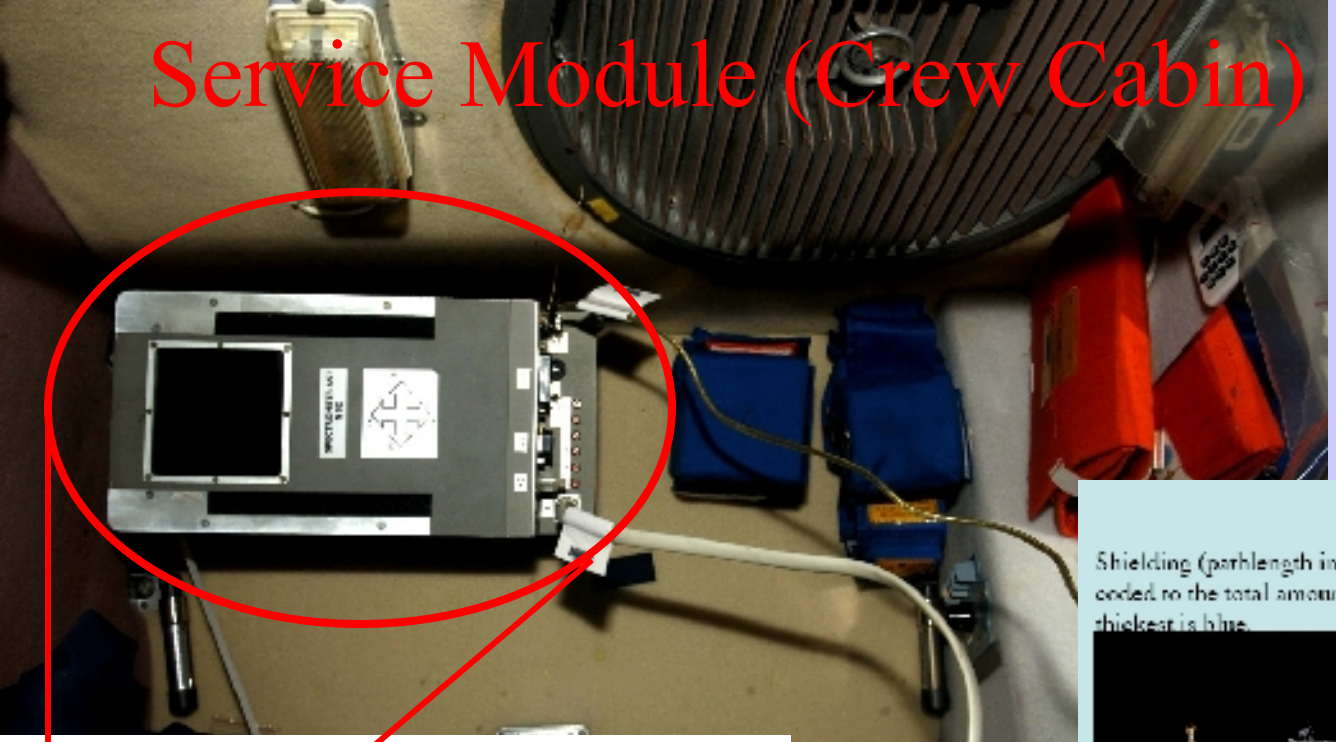
measurements and rate as function of position

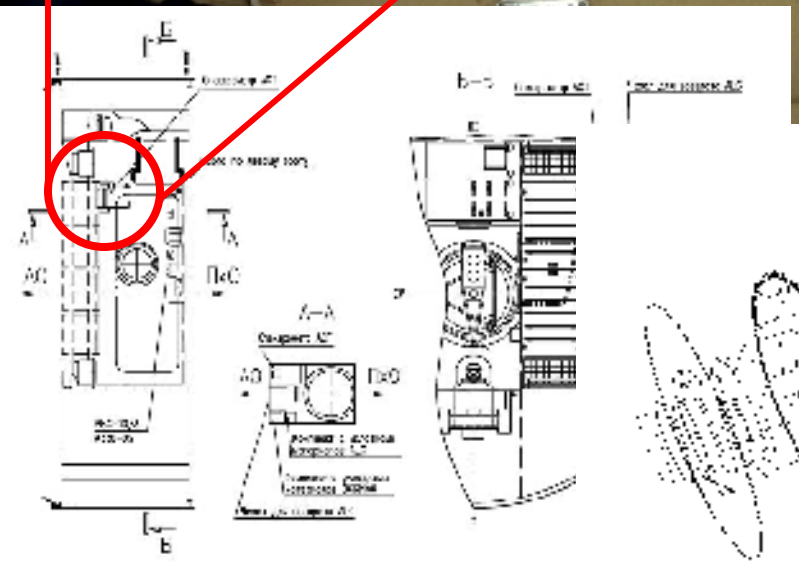


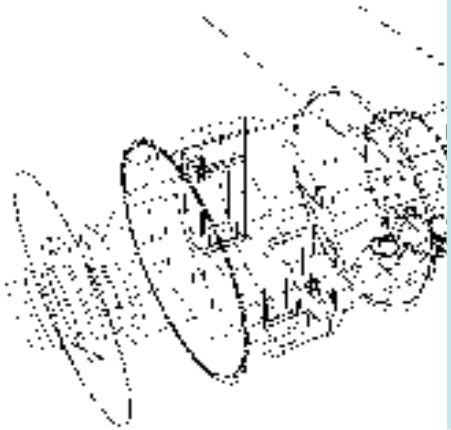
nding passage particle rate is higher than descending
e due to different orientation of the station

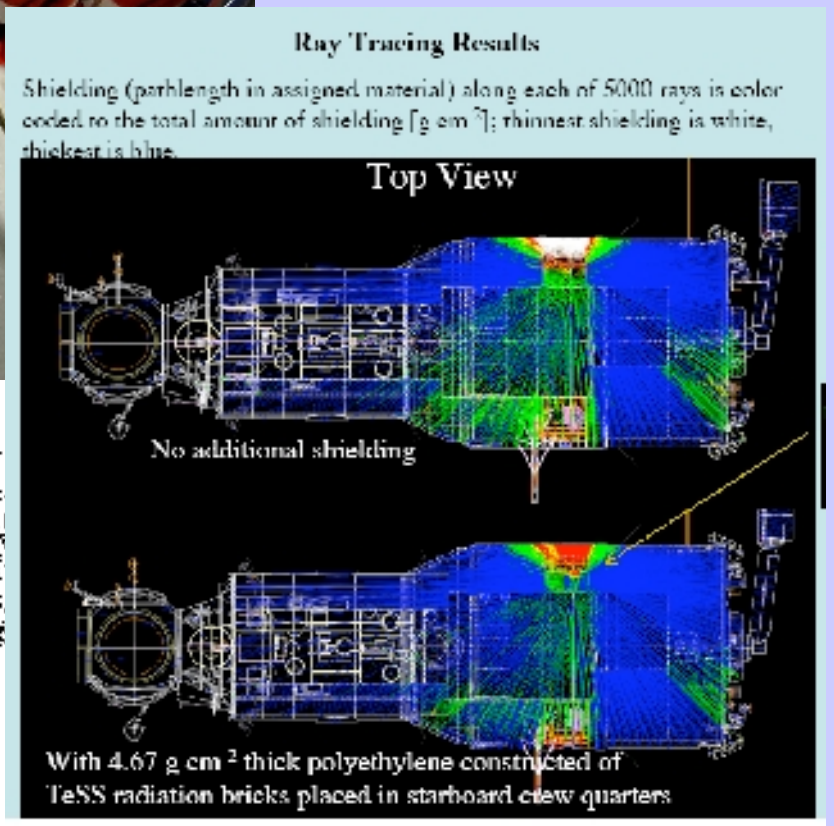


Service Module (Crew Cabin)









M. Shavers et al, ASR 34 (2004) 1333