Joint NASA/ESA Inc13 Science Symposium

Results and perspectives from Alteino and Si-Rad experiments

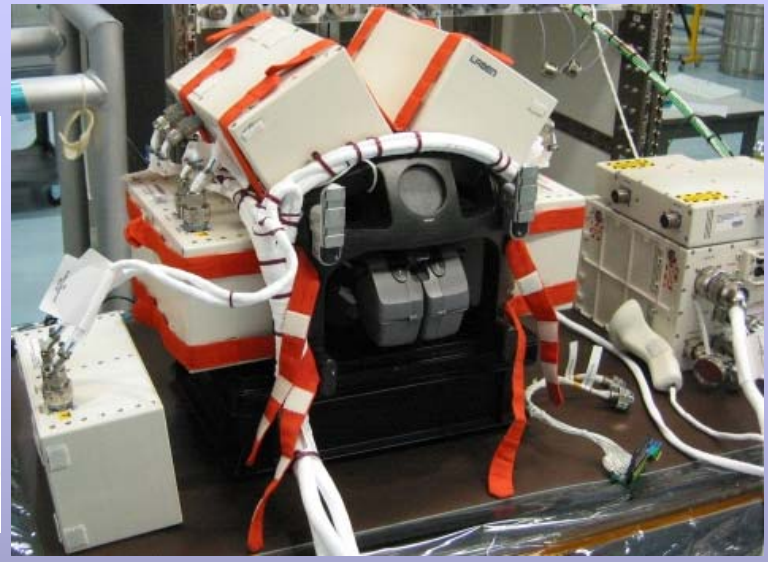
M. Casolino

INFN Roma Tor Vergata

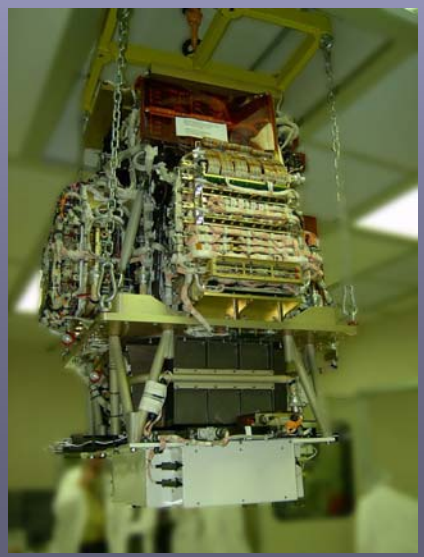
Current and future detectors

Sileye-3/Alteino

Lazio



Altea



Pamela

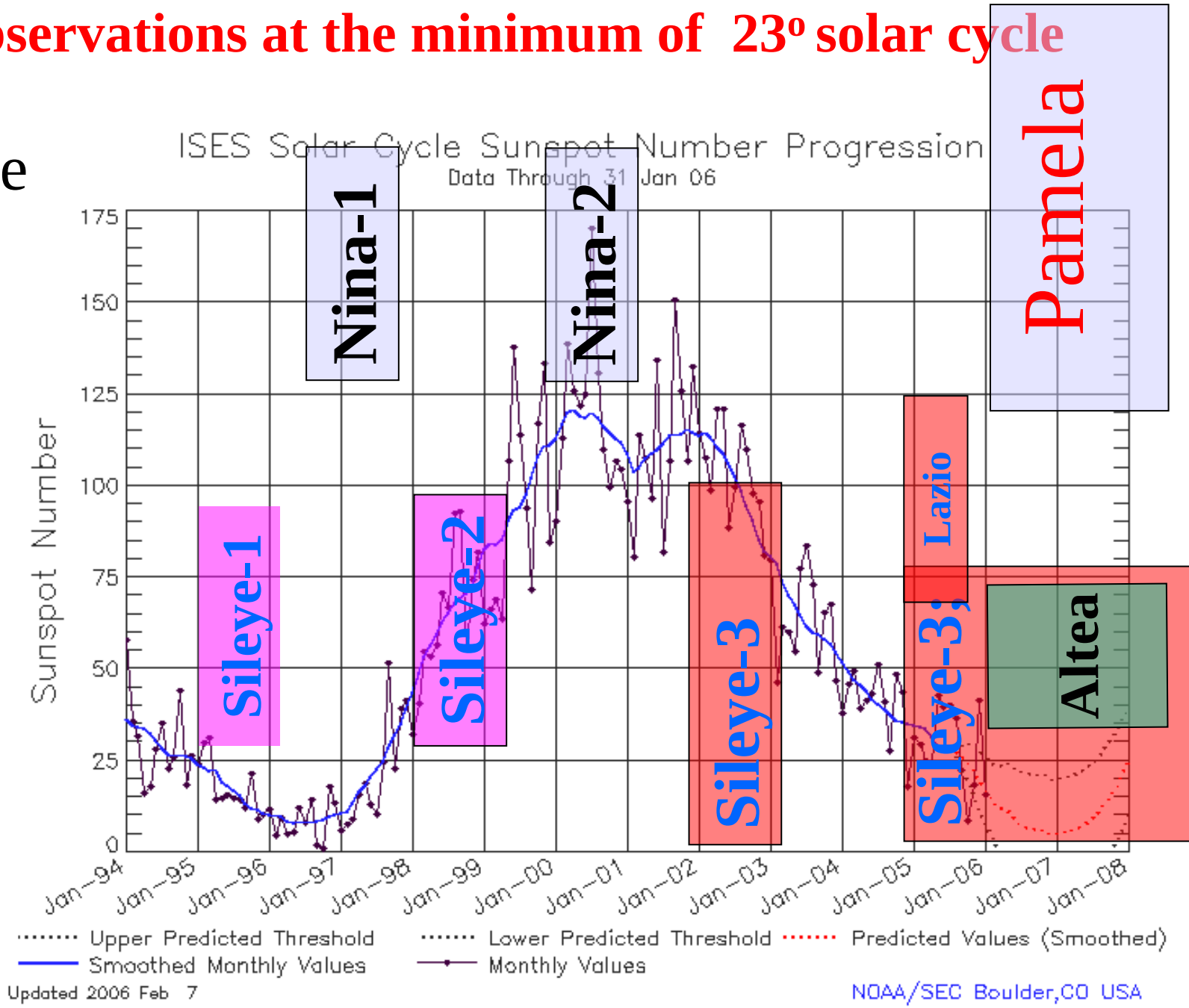
Sirad→

Observations at the minimum of 23º solar cycle

Satellite

Mir

ISS



Altcriss

Alteino Long Term cosmic ray measurements on board the ISS

- **In response to AO 2004 ESA (AO2004-067)**
- **ESA opportunity to start operations in the framewol of th ESA LDM (Long Duration Mission) – 4/5/2005**
- **Replanned on increment 12 (Dic 2005-Mar 2006)**
- **Next operations on increment 13 (Apr 2006 – Oct 2006)**

ALTCRISS Collaboration

Dr. Francis Cucinotta, NASA
Prof. Marco Durante, University of Napoli
Dr. Christer Fuglesang, EAC
Dr. Cesare Lobascio, Aleniaspazio
Dr. Aiko Nagamatsu (JAXA)
Prof. Livio Narici, University of Roma Tor Vergata
Prof. Piergiorgio Picozza, University of Roma Tor Vergata
Dr. Guenther Reitz (DLR)
Prof. Lembit Sihver,University of Chalmers (SE)
Prof. Piero Spillantini, University of Florence
Dr. V. Bengin (IBMP)

Sileye/Alteino institutions

V. Bidoli[1], M. Casolino[1], M. P. De Pascale[1], M. Minori[1], A., L. Narici[1], P. Picozza[1], E. Reali[1], R. Sparvoli[1], V. Zaconte, A. Galper[2], A. Popov[2], S. Avdeev[3], M. Boezio[4], W. Bonvicini[4], A. Vacchi[4], G. Zampa[4], N. Zampa[4], G. Mazzenga[5], M. Ricci[5], P. Spillantini[6],G. Castellini[7], P. Carlson[8], C. Fuglesang[8], V. Benghin[9], V. P. Salnitskii[9], O. I. Shevchenko[9], V. Shurshakov[9], V. P. Petrov[9], K.A.Trukhanov[9]

[1] Dept. of Physics, Univ. of Rome "Tor Vergata" and INFN Sez. Rome2 , Italy; [2] Moscow State Engineering Physics Institute, Moscow, Russia;[3] Russian Space Corporation "Energia" by name Korolev, Korolev, Moscow region, Russia [4] Dept. of Physics of Univ. and Sez. INFN of Trieste, Italy; [8] Dept. of Physics of Univ. and Sez. INFN of Perugia, Italy; [5] L.N.F. - INFN, Frascati (Rome), Italy; [6] Dept. of Physics of Univ. and Sez. INFN of Florence, Italy; [7] IROE of CNR, Florence, Italy; [8] Royal Institute of Technology, Stockholm, Sweden;
[9]IMBP, Institute of BioMedical Problems,Moscow, Russia

Scientific Objectives

- **Measure of cosmic ray abundances and radiation environment on board the ISS (p-Fe >50-100MeV/n)**

- **Long term monitoring of solar modulation and solar particle events.**

- **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)**

- **Joint measures with Matroska, Pamela and Altea**

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

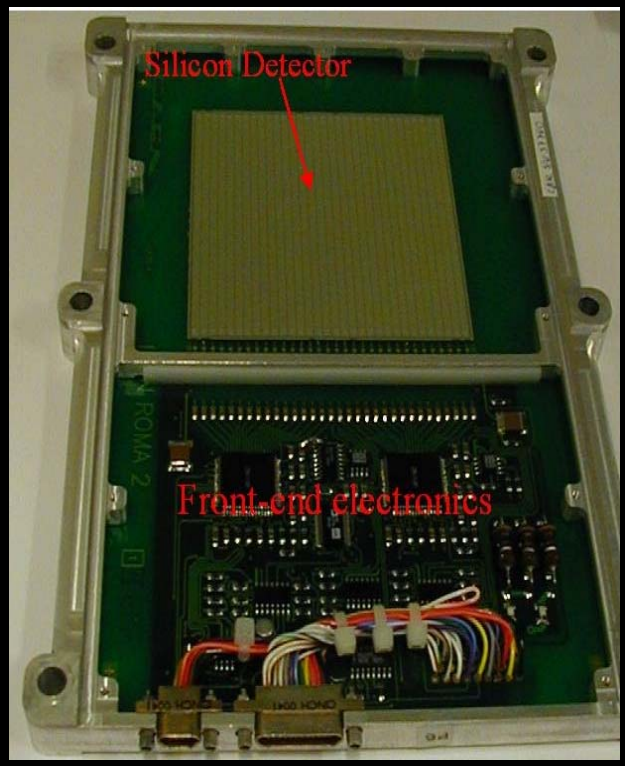
Contributors:

Dr. M. Casolino, Rome (I)
Prof. M. Durante, Naples (I)
Prof. R. Mueller-Mellin, Kiel (D)
Dr. P. Nieminen, Noordwijk (NL)
Dr. G. Reitz, Cologne (D)
Prof. L. Rossi, Milan (I)
Prof. V. Shurshakov, Moscow (RUS)
Dr. M. Sorbi, Milan (I)
Prof. P. Spillantini, Florence (I)

Sileye-3 Alteino

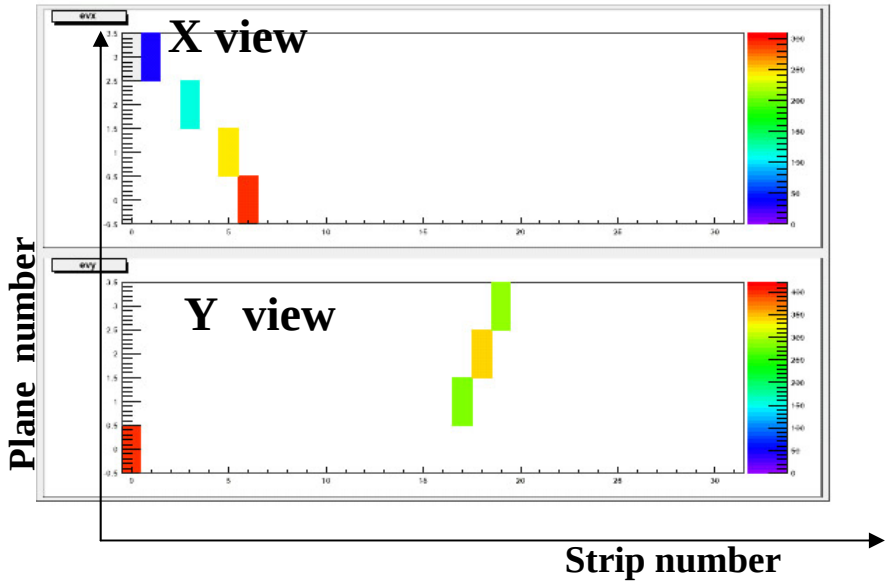
- **Placed on ISS in 2002 (ISM-1):operational for 6 days**
- **Reswitched on in 2005 (ISM-2): operational for 4 days**
- **Long term measurements (ALTCRISS): 3 months untill now**

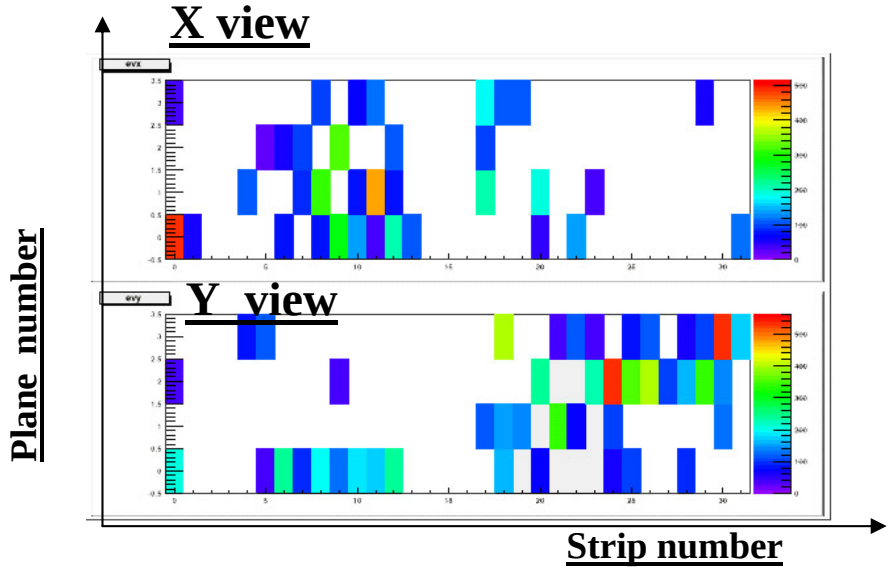
Silicon detector:

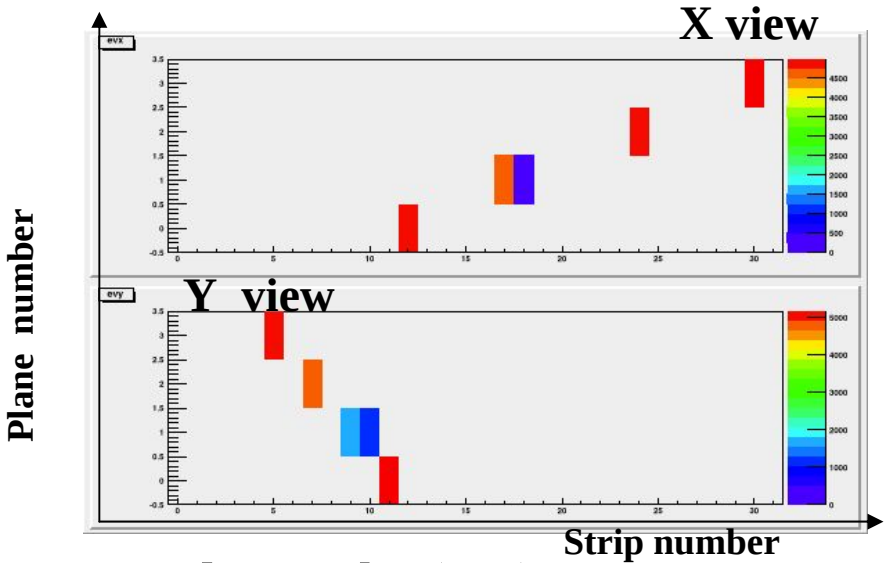


Left: AST detector tower open (without readout electronics): it is possible to see the stack of silicon detectors and the top scintillator (the detector is upside down). The bottom scintillator has been removed for clarity. Rigth: One of the 8 silicon detector boards (X view). It is possible to see the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

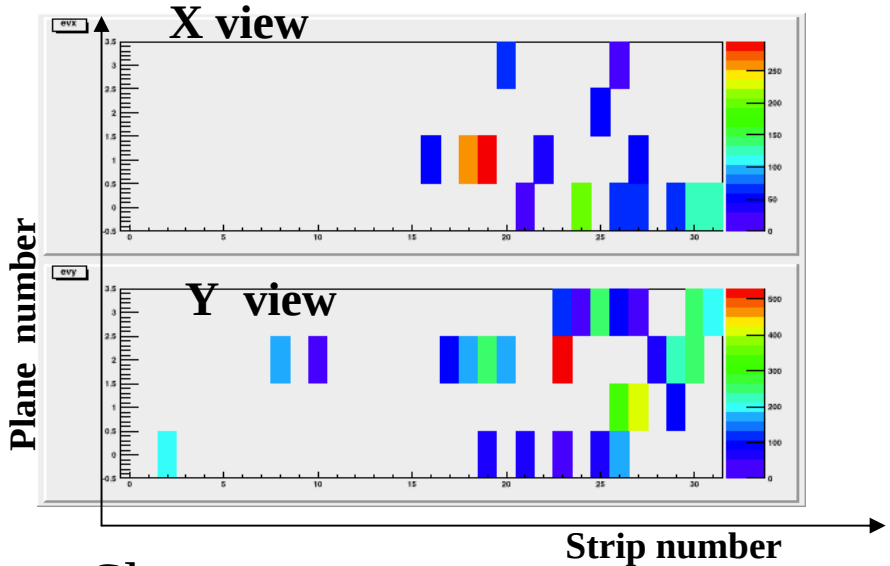
- 8 silicon planes (4x,4y)
- 32 strips strip pitch 2.5 mm, 8x 8 cm^2, thickness 380 μm
- Total 256 Independent channels
- Triggered by two scintillators (E_{min}=40MeV/n)
- Geom Fact: 24 cm^2 sr
- Bidirectional
- Max Field of view 39°
- The front-end is a developed version of two 16 channels CR1 chip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







Single track (Ne) event
(ADC Channels)



Shower event (ADC Channels)

Mission timeline

- 24 Dec 2005 Begin measurements – PIRS module – no shield
- 26 Dec 2005 Data sample received
- 06 Gen 2006 Poliethilene shielding inserted
- 08 Gen 2006 Data sample received
- 26 Gen 2006 Moved in the Service Module – no shield
- Feb 2006 Shielding in the Service Module

- Mar 2006 Rotate Instrument
- Apr 2006: End increment 12 Rientro dati e dosimetri con Soyuz 11S
- Apr 2006: Launch new dosimeters with Progress 21P
  - *New orientation in crew cabin,*
  - *New position close to DB-8 (IBMP) detector*
  - *Command module?*
- Autumn 2006: Joint measurements within Matroshka-2

Shielding and radiation measurements with active and passive detectors

Alteino

TLD, CR39 to measure charged particle and neutron dose

Jaxa

DLR

Napoli Fed. II

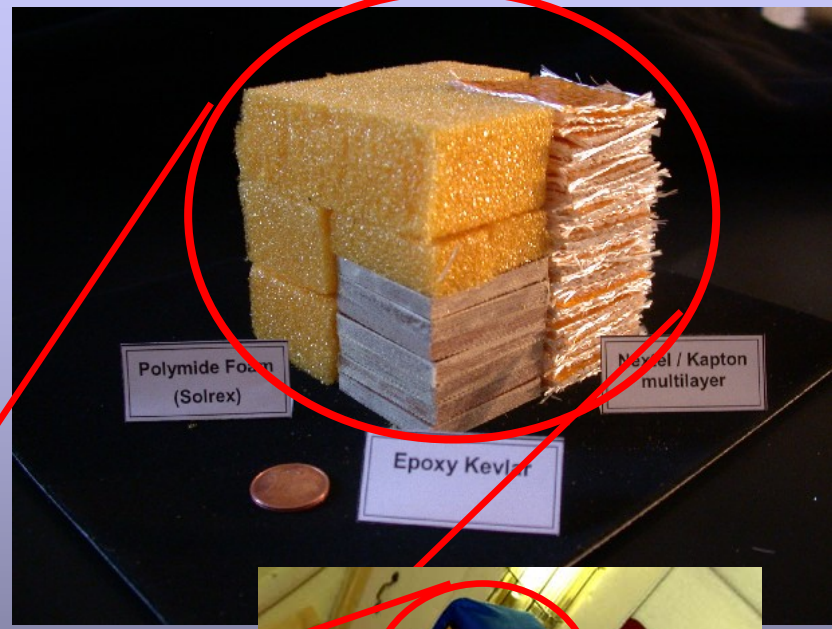
INFN-LNF

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



Shielding bag

Polietilene shielding: (5g/cm^2):

(Same thickness of the US section of the station)

Dosimeter arrangement

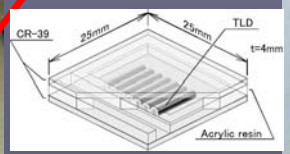
Each Package:
2 Napoli TLD
6 DLR TLD (diff. Material)
1 Napoli CR-39
2 DLR CR-39
1 JAXA Padles

SHIELD1

SHIELD2

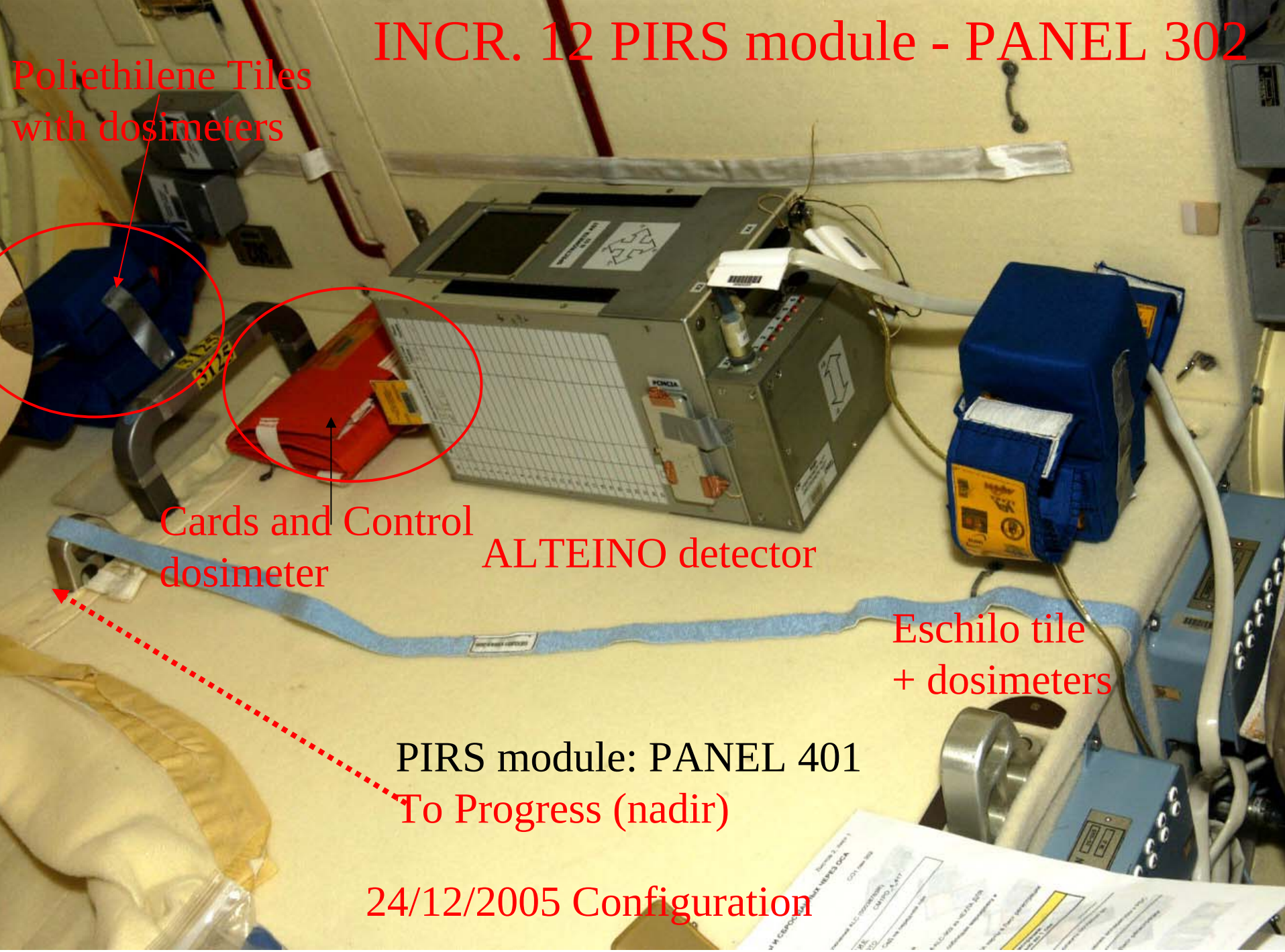
CNTRL (SPACE)

ESCHILO (SPACE



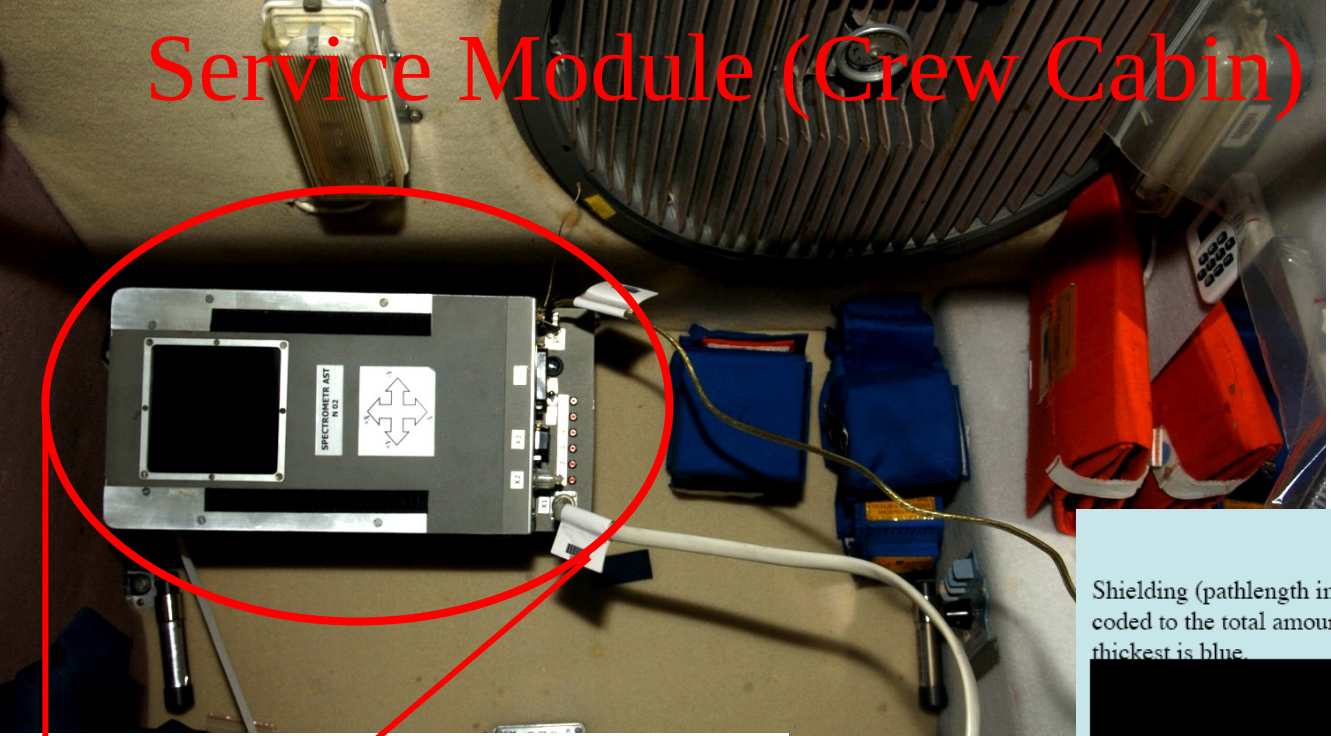
CNTRL GROUND

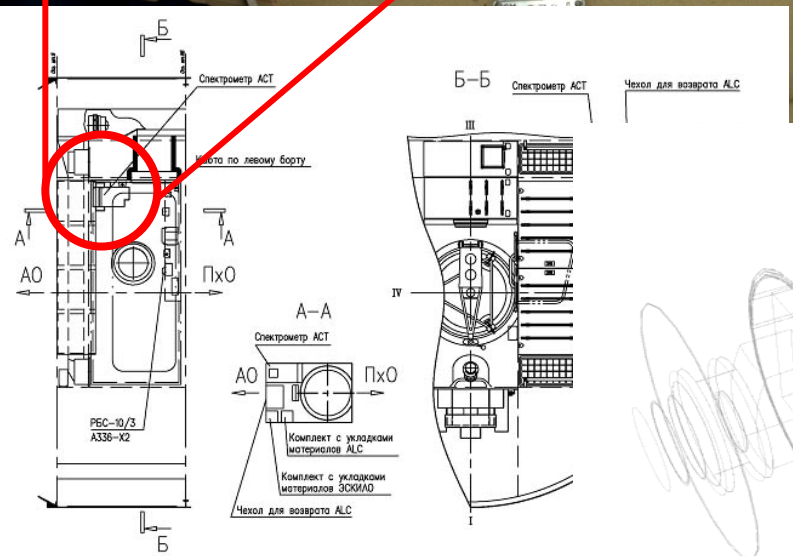
Brasilian As
Marcos Pon
5/4/2006

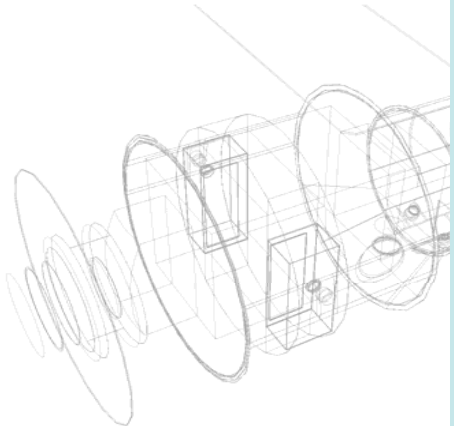

INCR. 12 PIRS module - PANEL 302
Poliethilene Tiles
with dosimeters
Cards and Control
dosimeter
ALTEINO detector
Eschilo tile
+ dosimeters
PIRS module: PANEL 401
To Progress (nadir)
24/12/2005 Configuration

6/1/2006 Configuration: same location - with shielding tiles

Service Module (Crew Cabin)

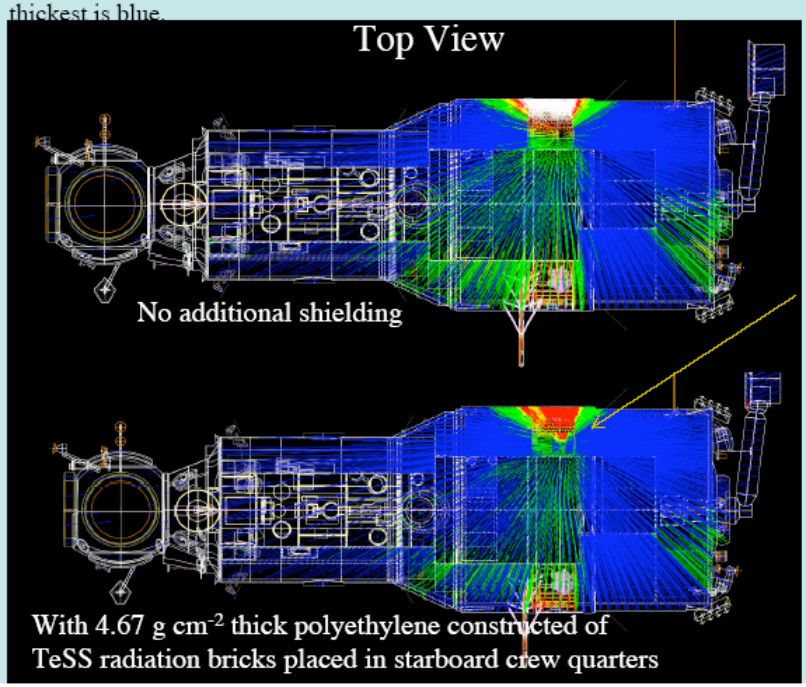






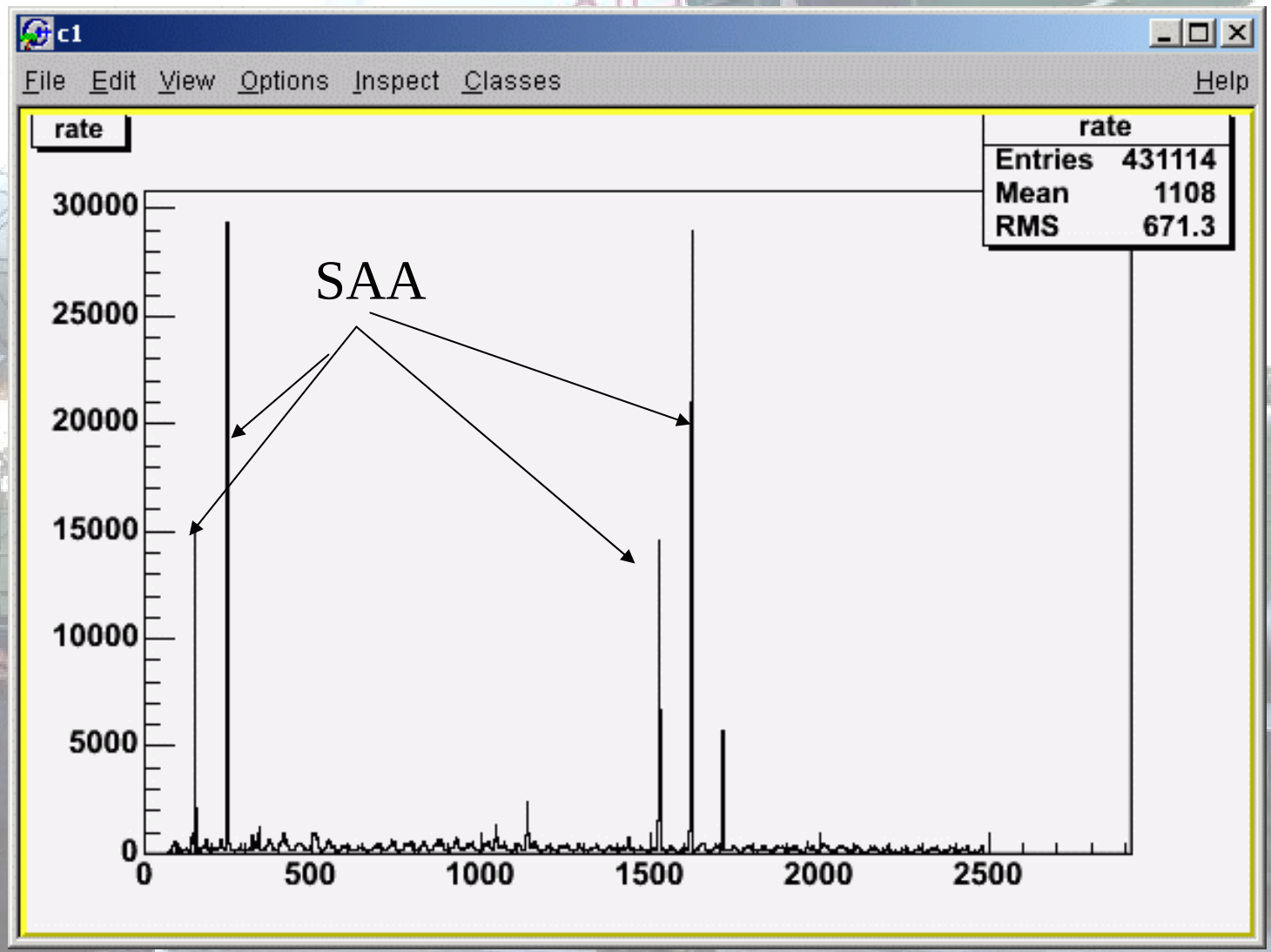
Ray Tracing Results

Shielding (pathlength in assigned material) along each of 5000 rays is color-coded to the total amount of shielding [g cm^{-2}]; thinnest shielding is white, thickest is blue.

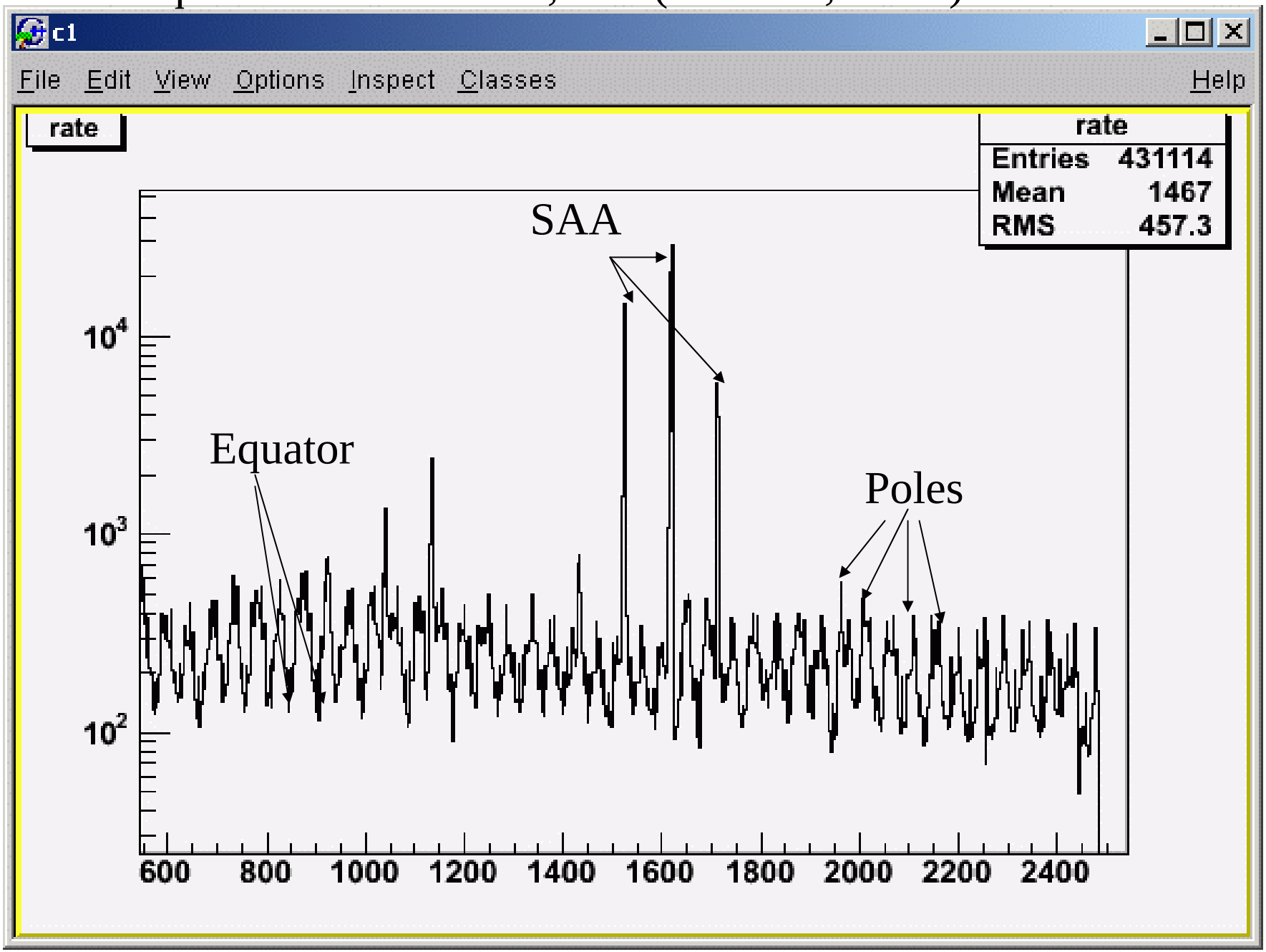


M. Shavers et al, ASR 34 (2004) 1333

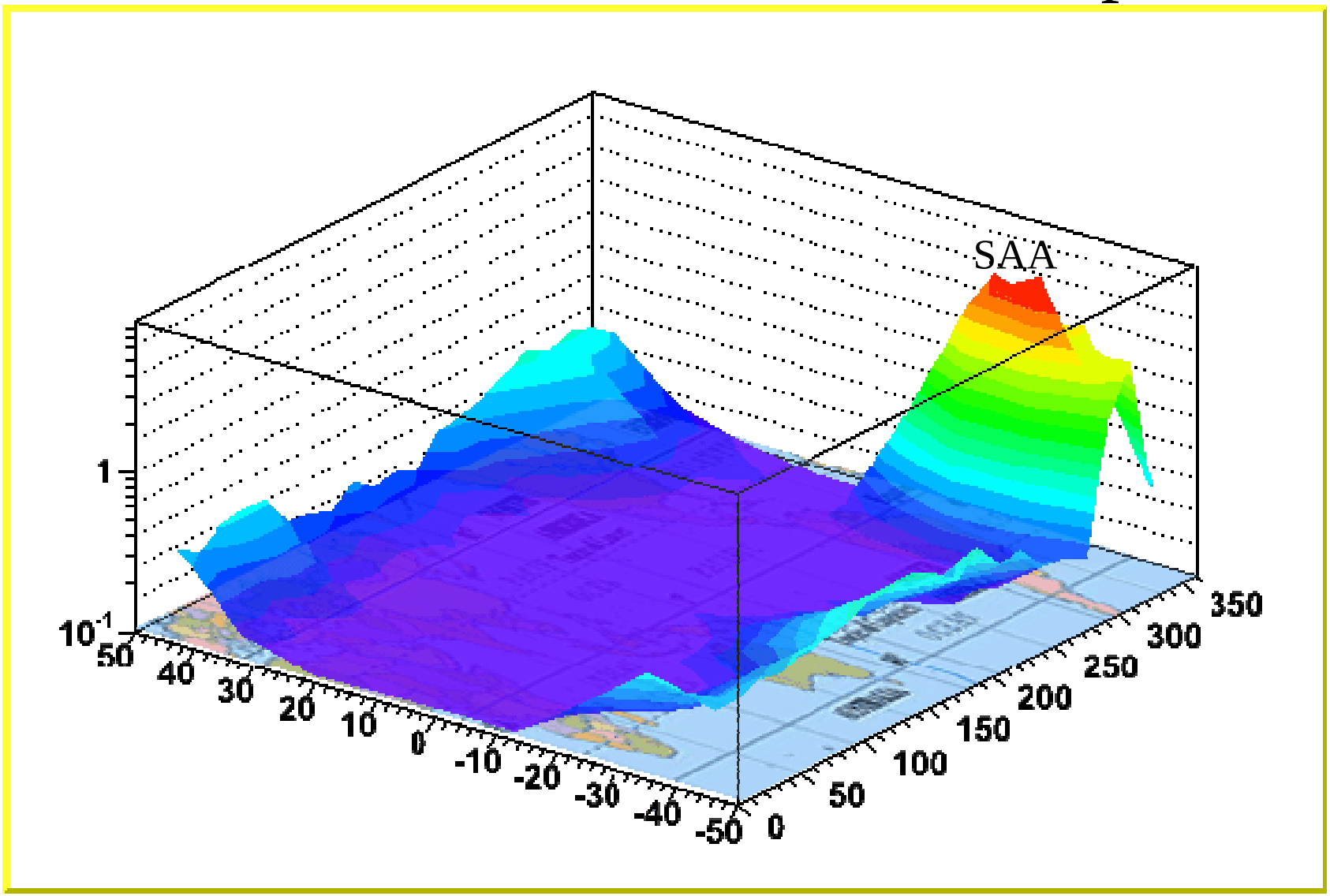
Incr. 12 preliminary data:
Acquisition rate vs time, min (raw data)



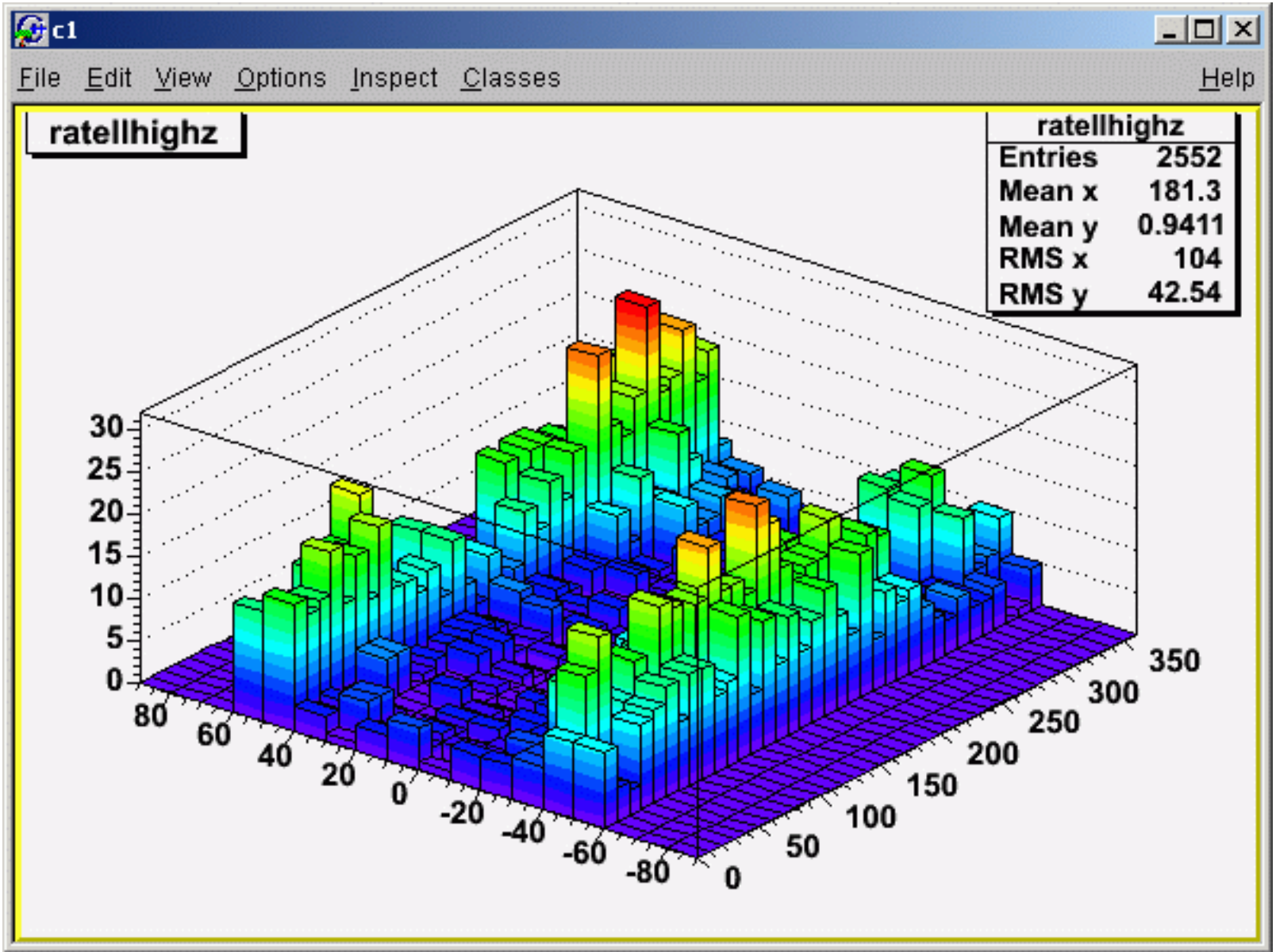
Acquisition rate vs time, min (raw data, zoom)



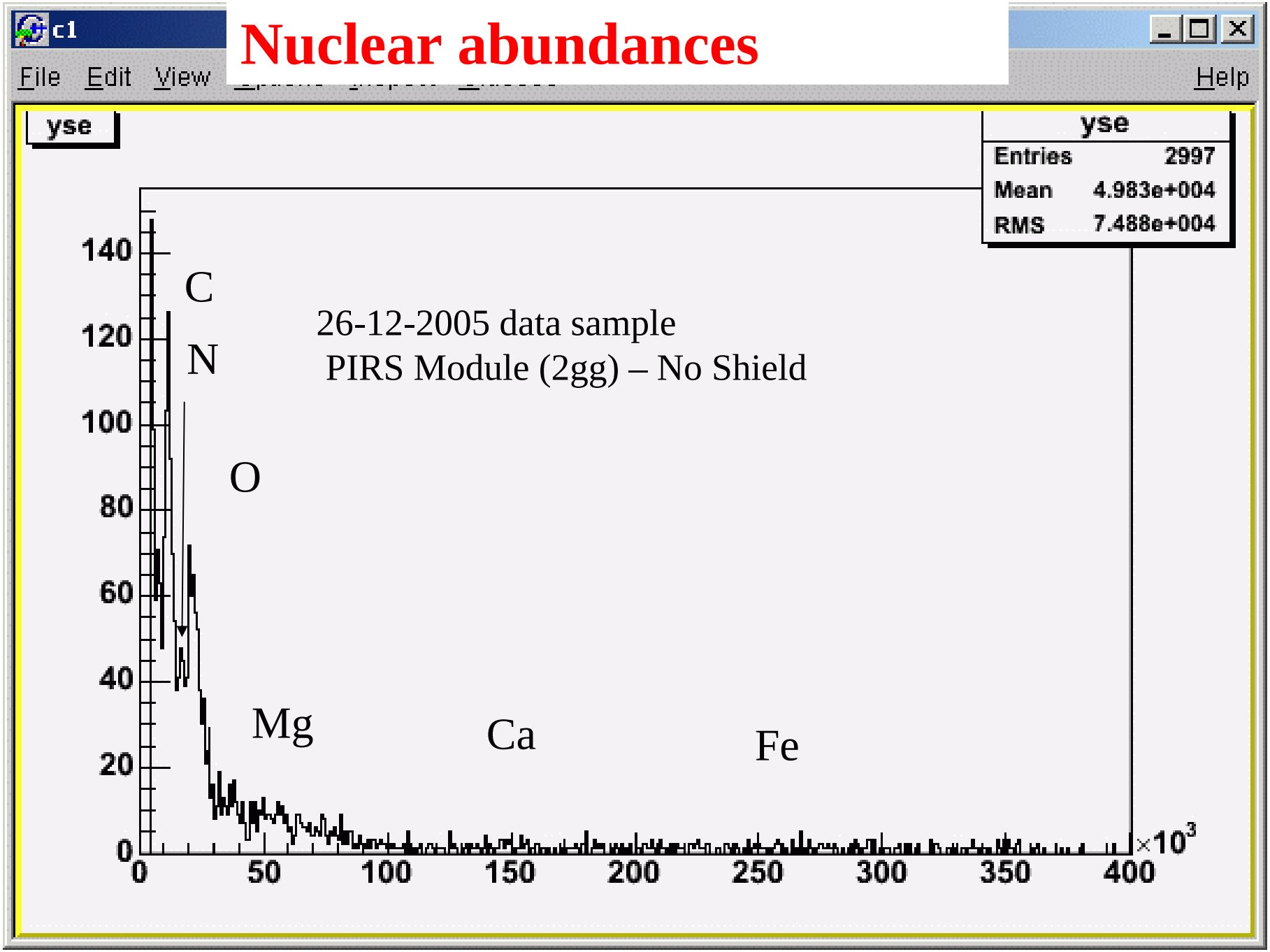
All-Particle count world map



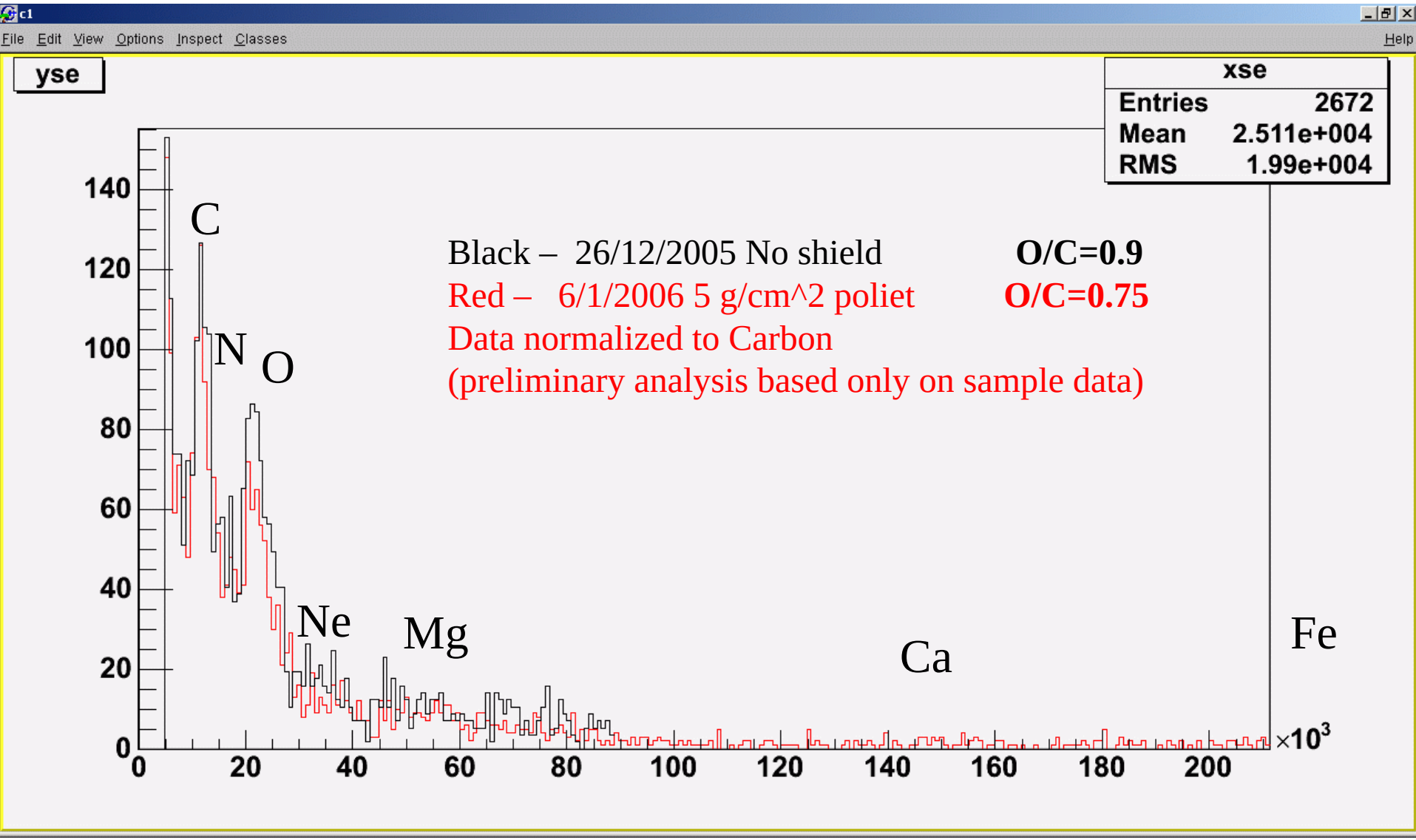
Heavy nuclei world (Z>6) world map



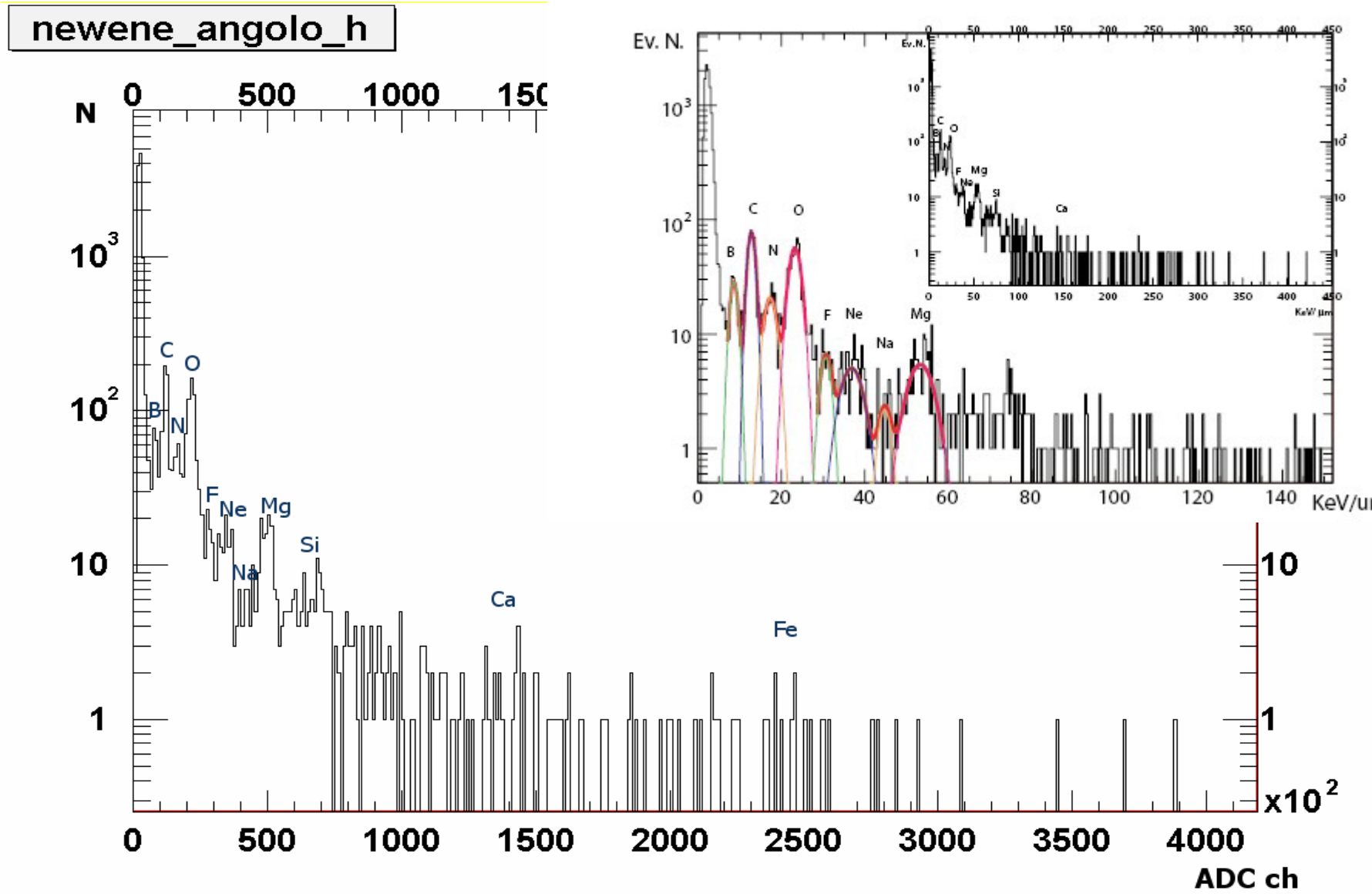
Nuclear abundances



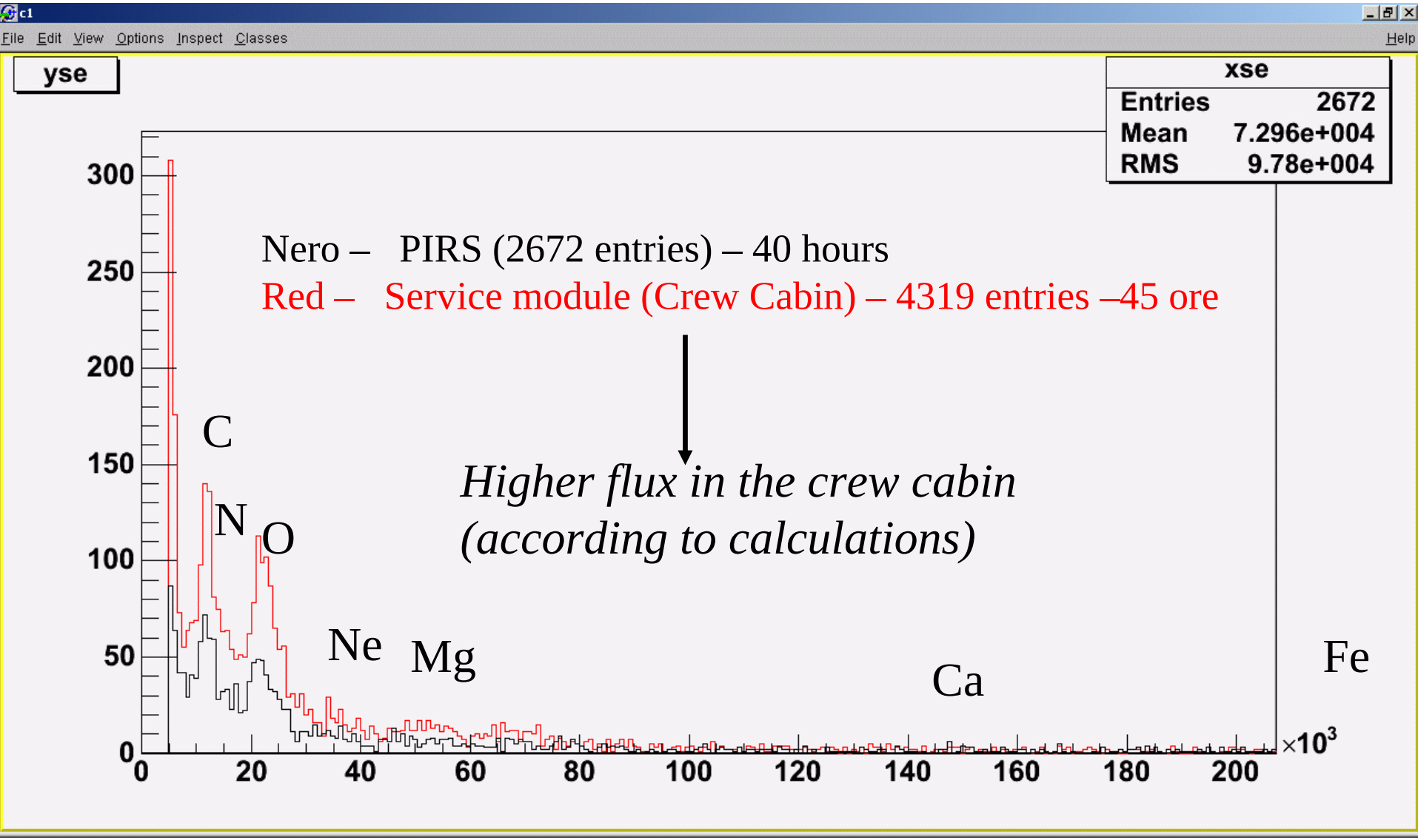
Comparison with/without shielding



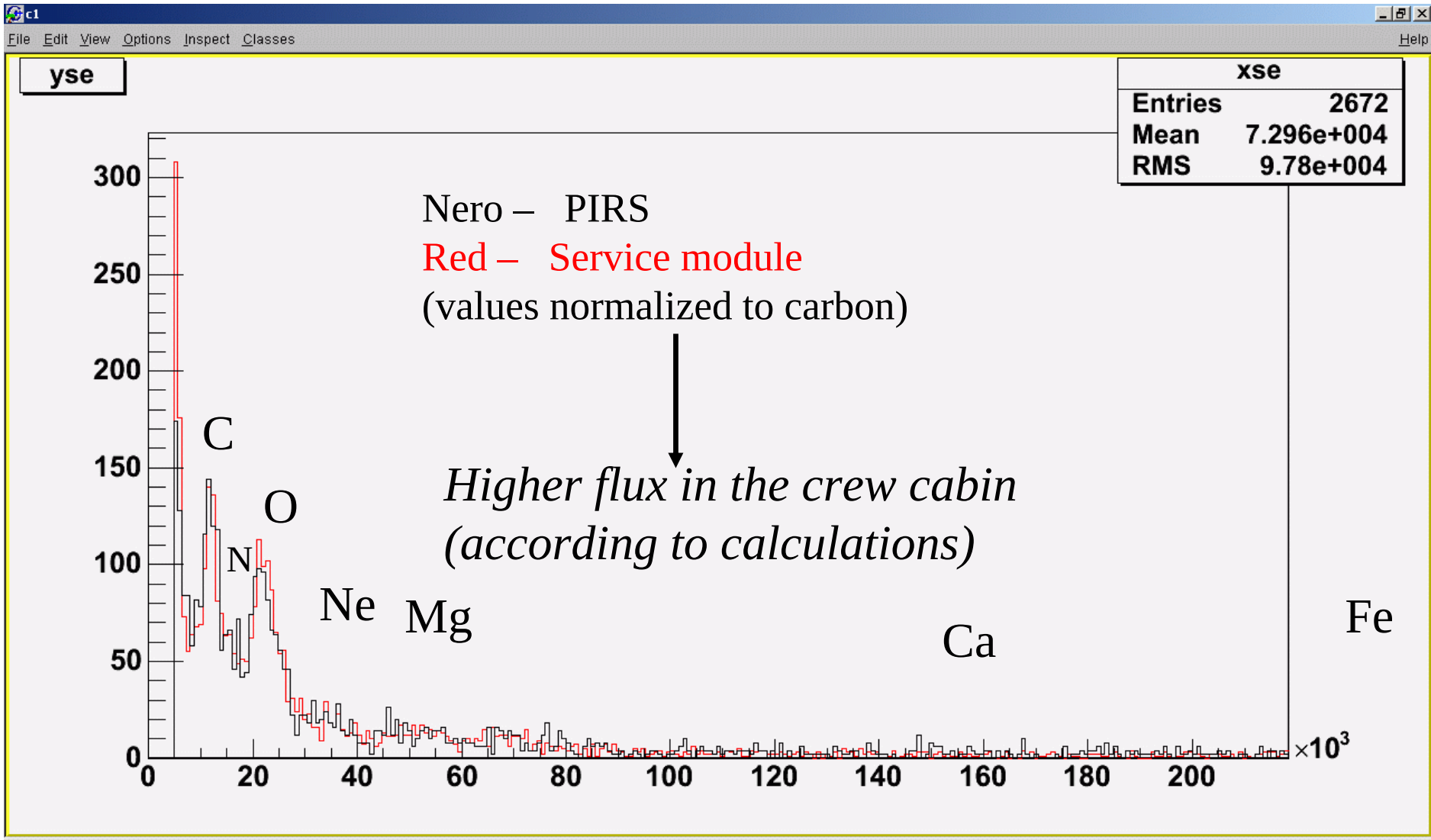
Nuclear abundances 2002



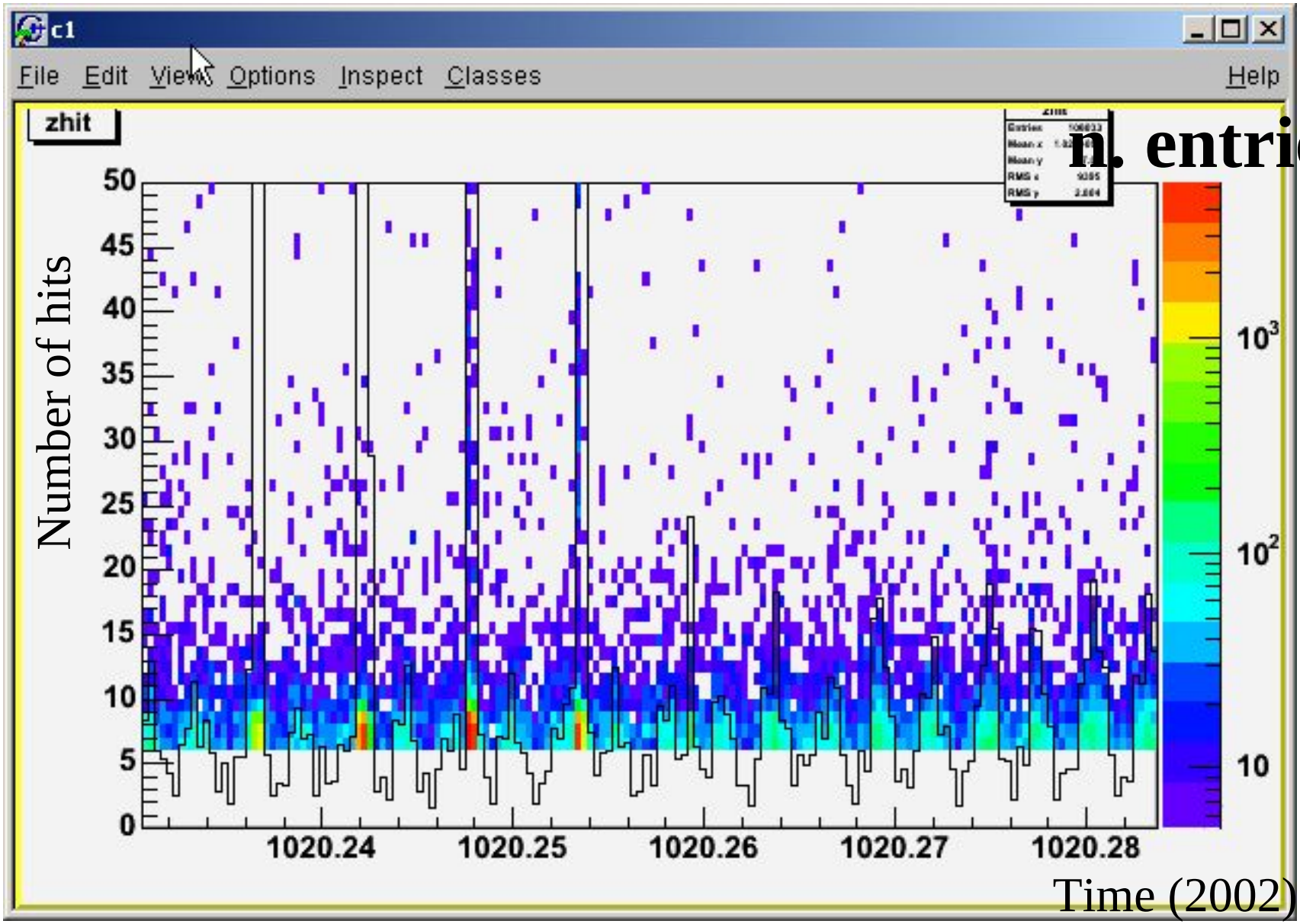
Difference PIRS – Service Module



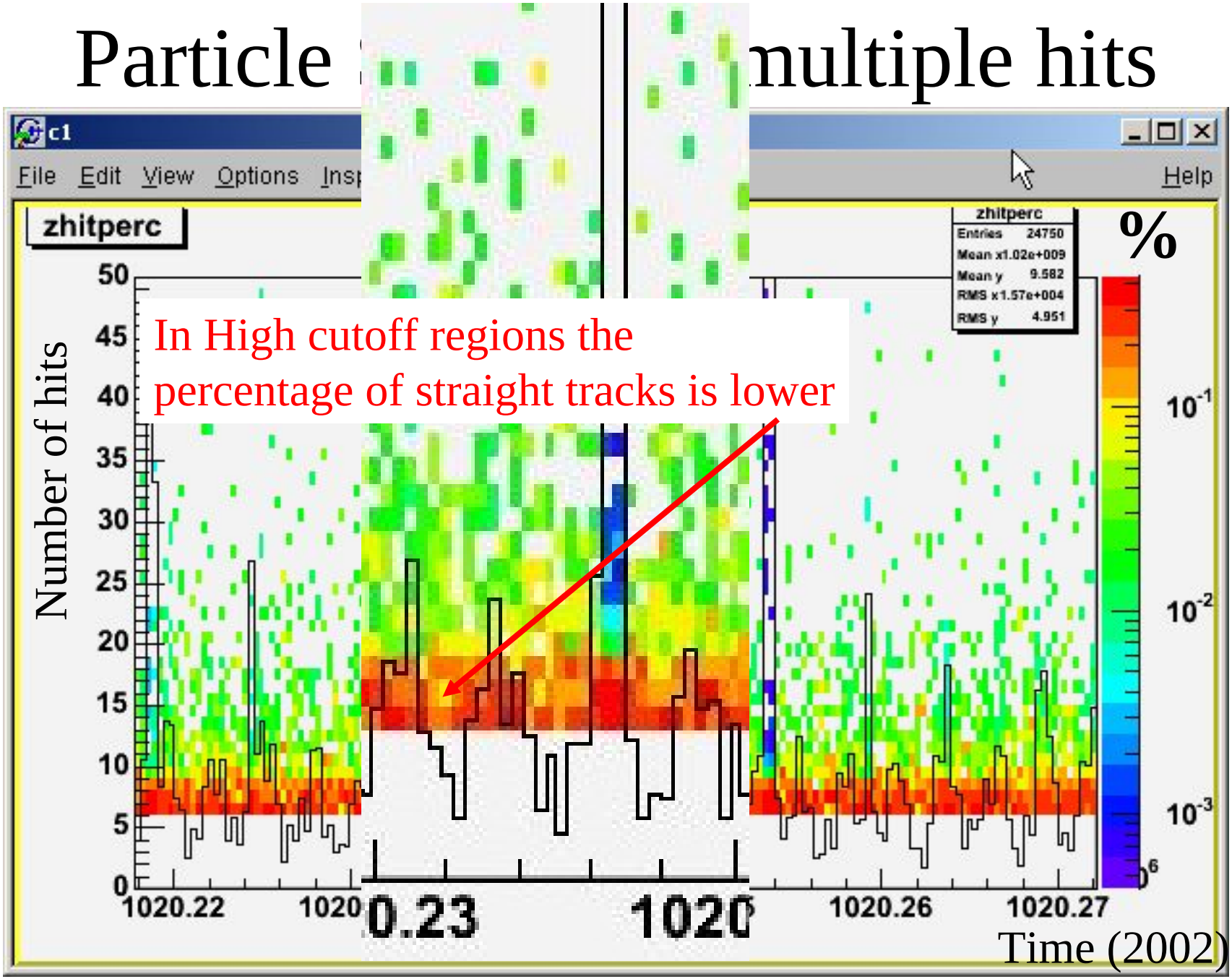
Pirs- Service Module rel. abundance



Number of hits distribution

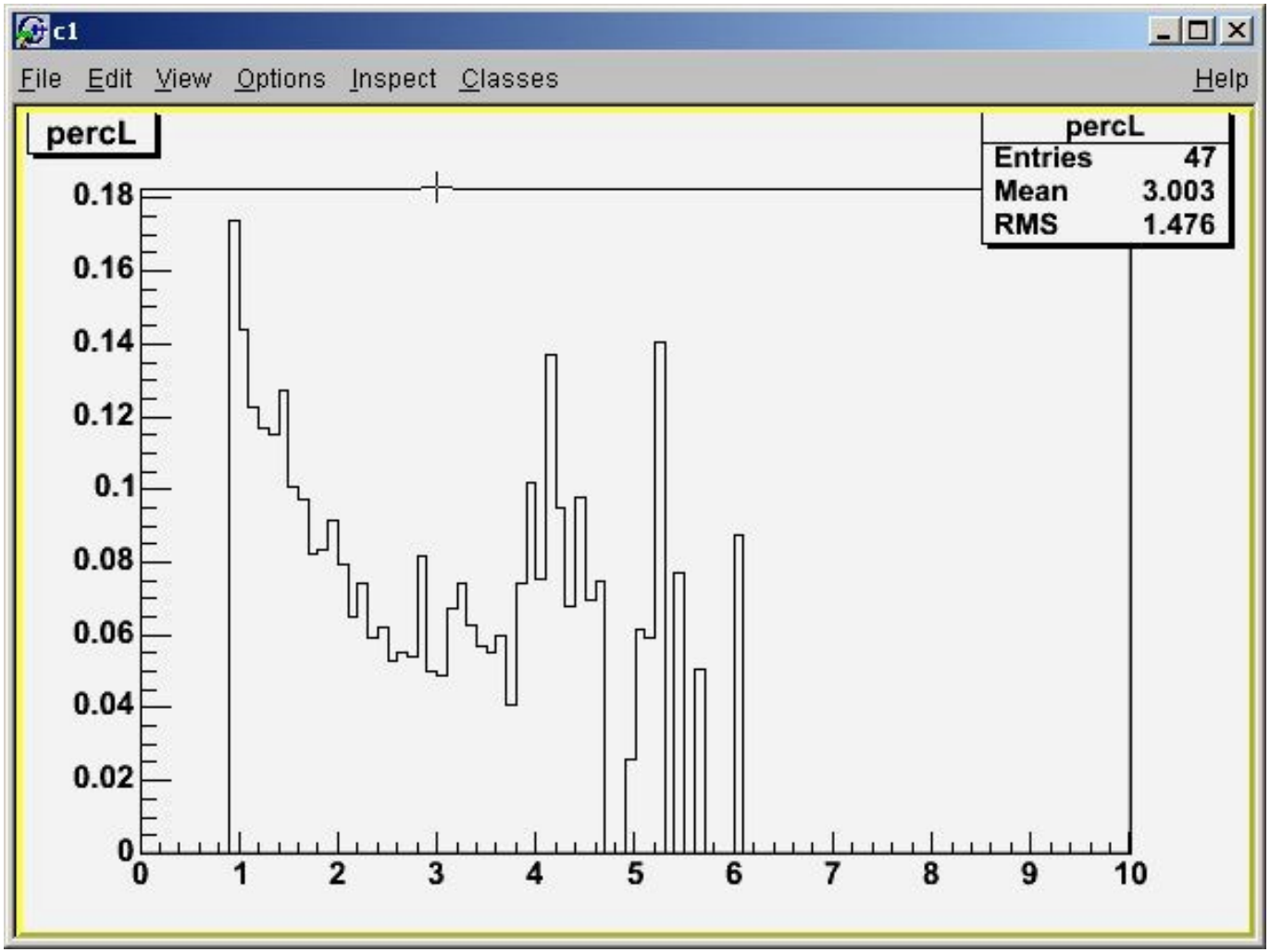


Particle multiple hits



Showers vs straight tracks

Percentage of Showers (>16 hits)



Geomagnetic shell L

Ground Segment

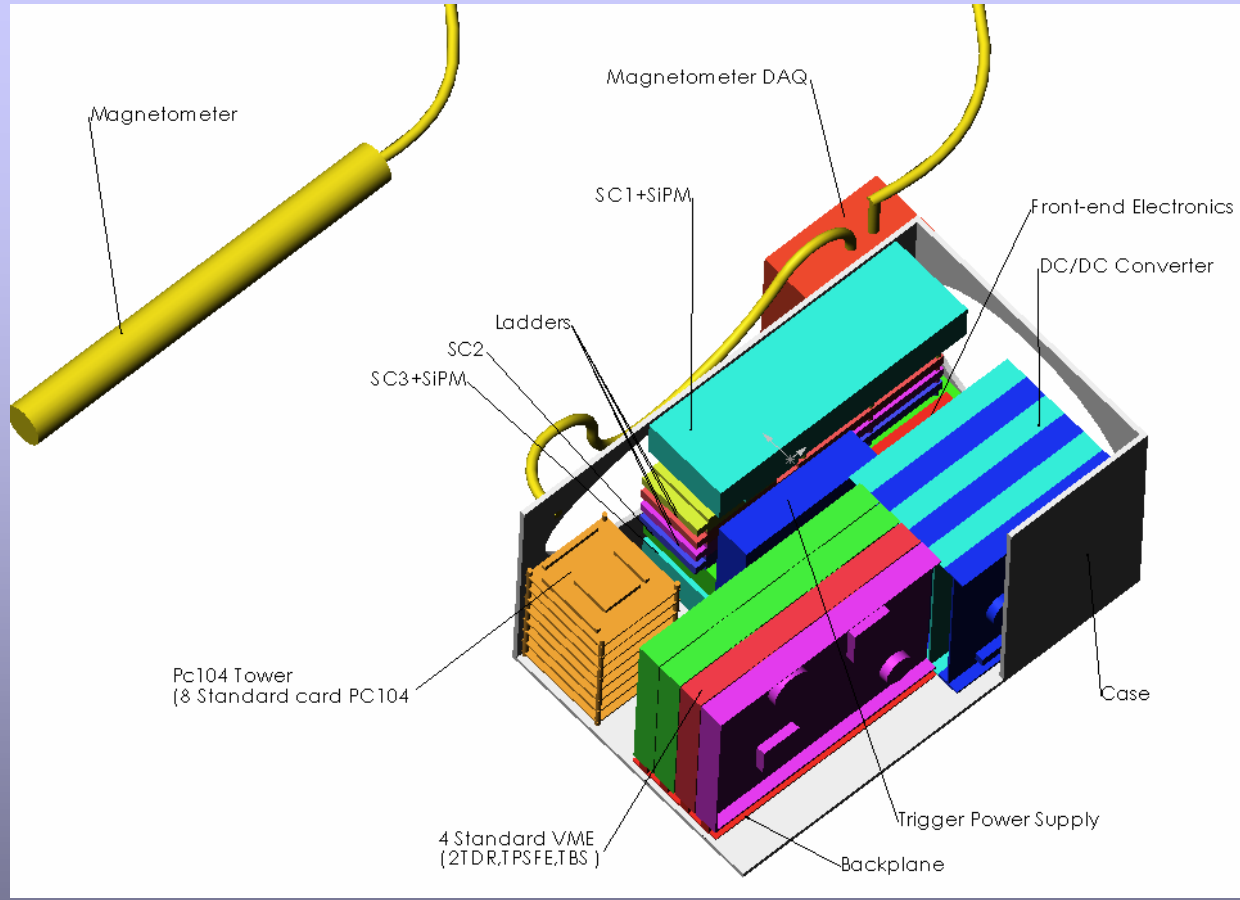
•Usoc at Mars (NA) *(Link with ESA, data reception, ISS orbital parametes) – special thanks to Dario Castagnolo and Raimondo Fortezza*

•Local Usoc in Tor Vergata *(Built for ISM-2 mission, currently shared for Altea, Pamela and Altcriss)*

Lazio-Sirad Detector

Built (in 6 months)
In response to opportunity to flight in ISM-2 (April 2005)

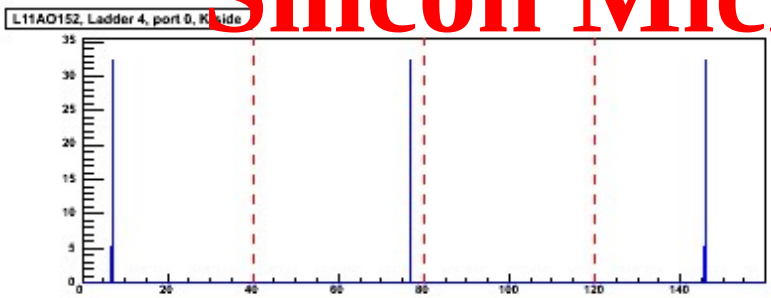
- Silicon detector
- SI-PM
- Magnetometer

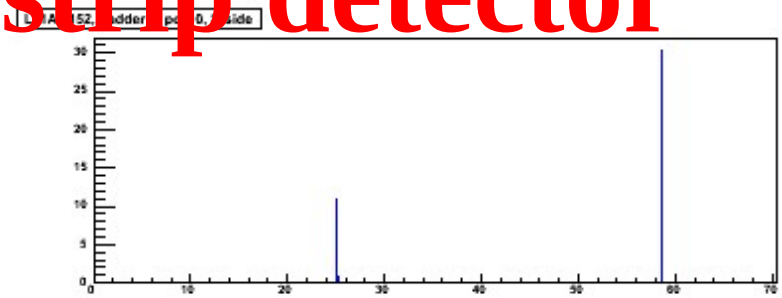


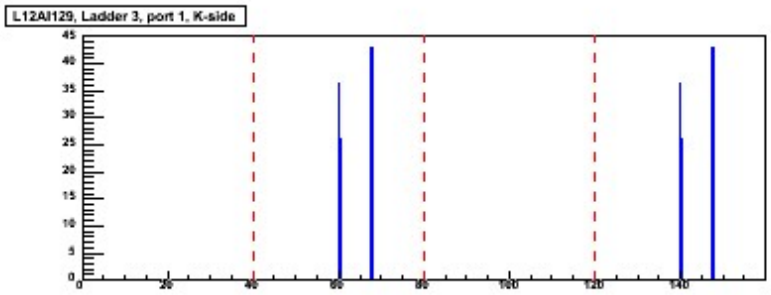
Lazio Detector assembly

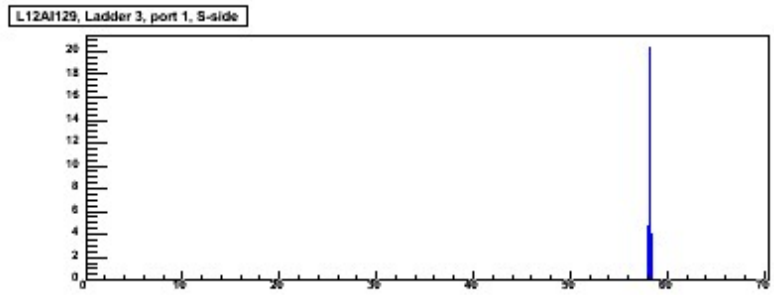
Figure 2b Alteino & Lazio detectors inside PIRS module of ISS

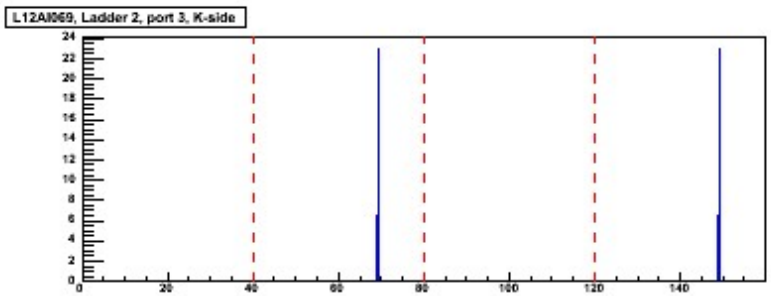
Silicon Microstrip detector

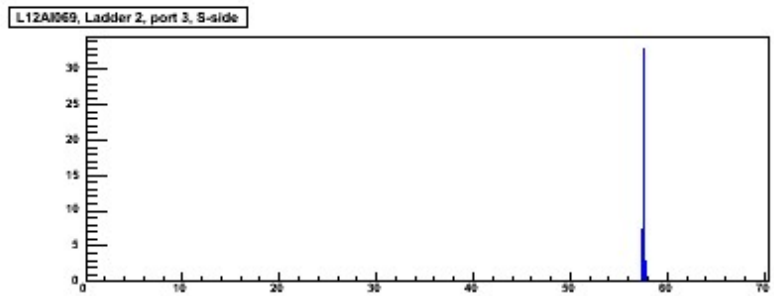


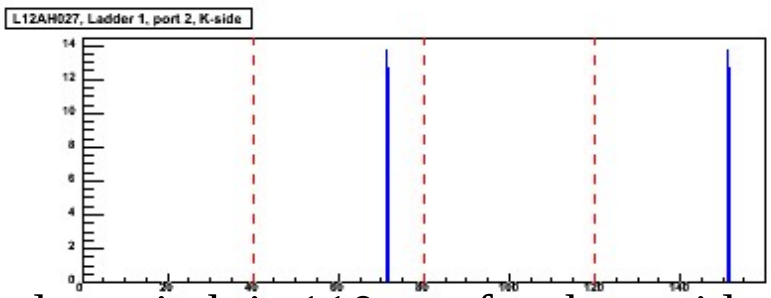


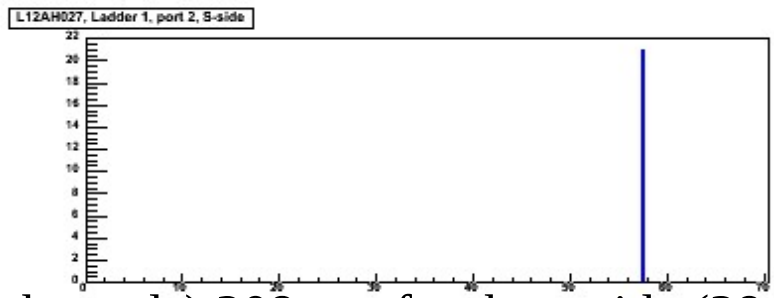






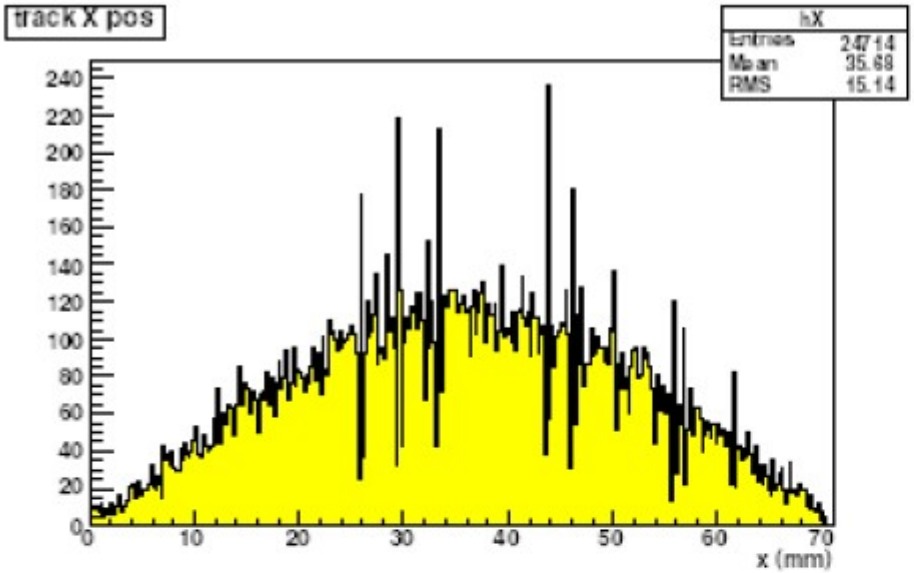


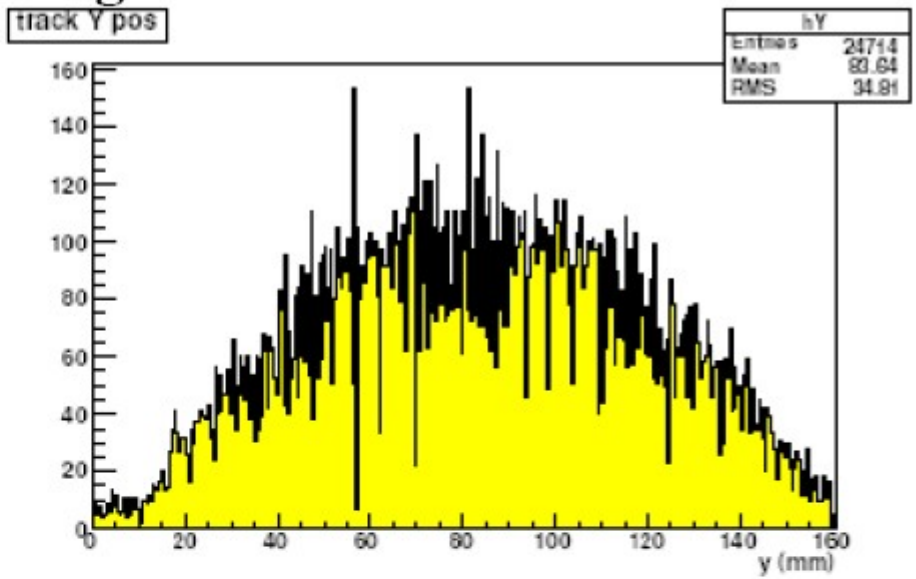


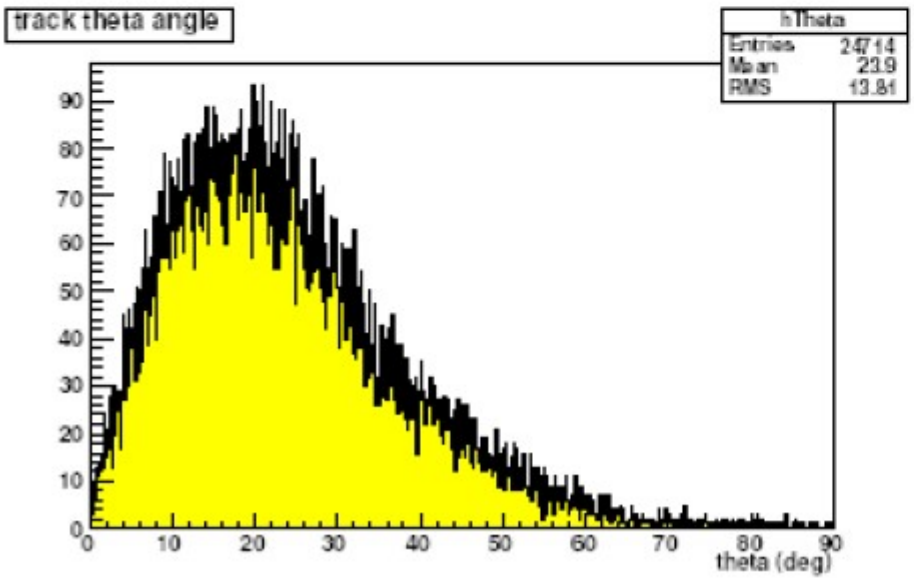


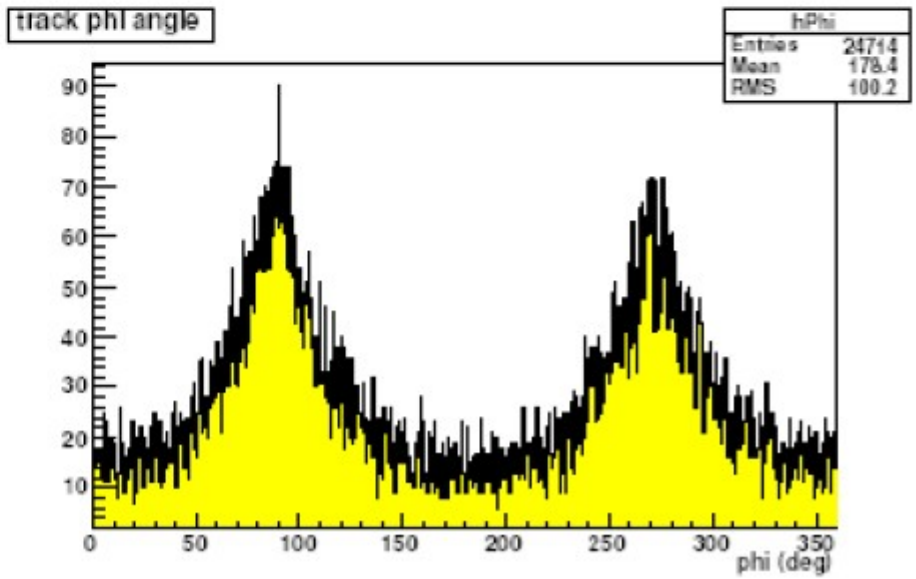
Readout pitch is 110 μm for the p-side (640 channels) 208 μm for the n-side (384 ch)

LAZIO-SiRad flight data

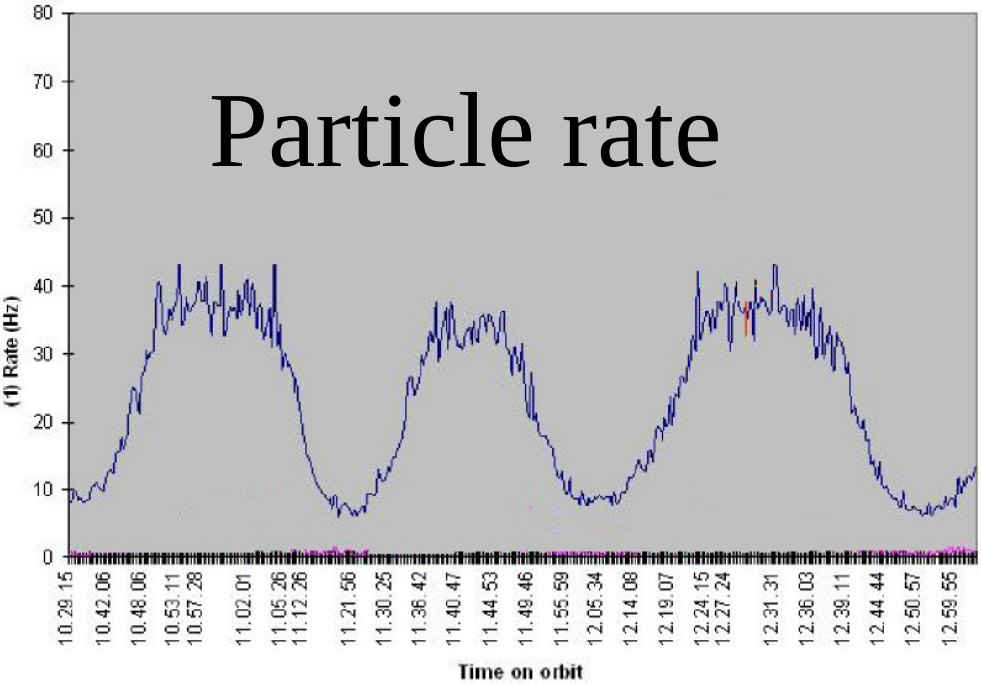








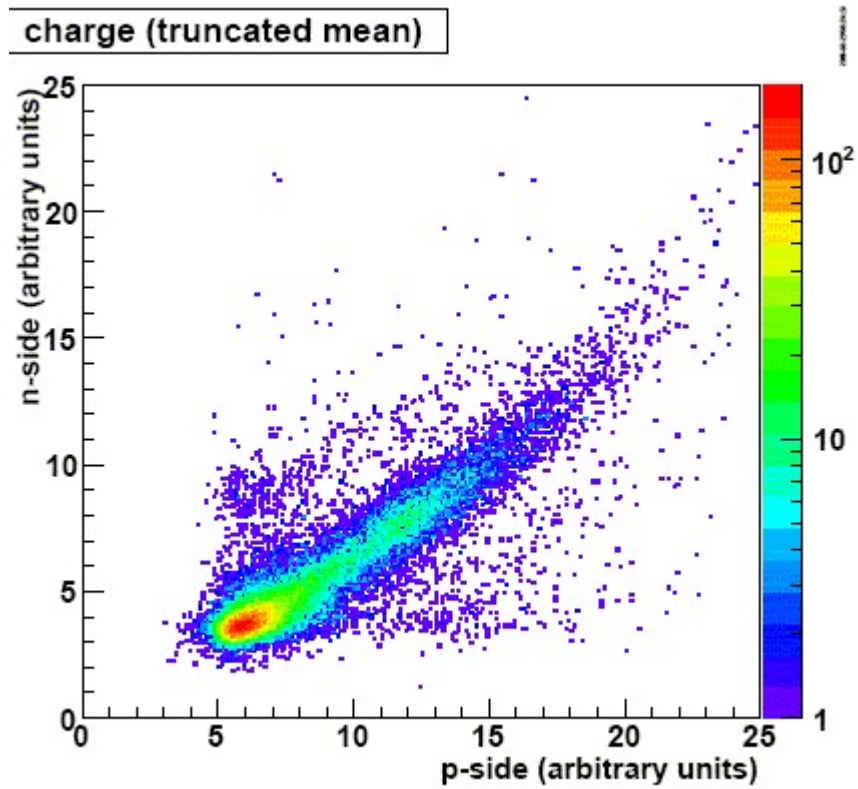
Particle rate



2.5 hours data

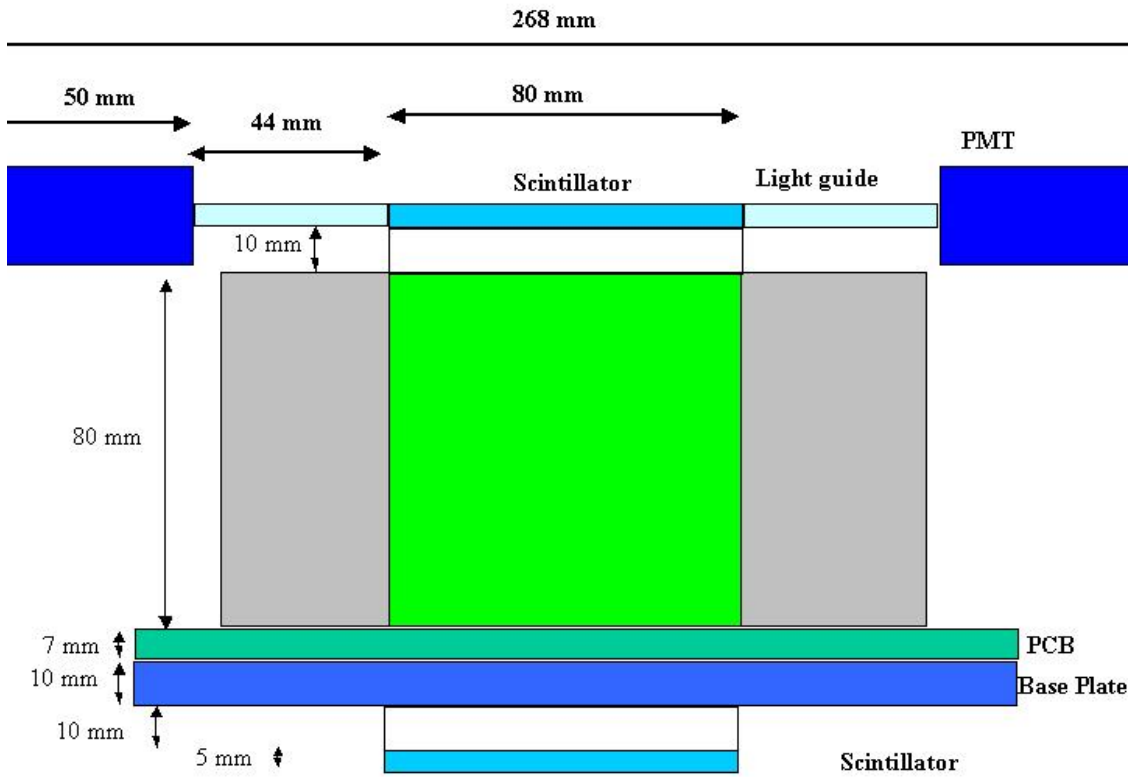
Energy release

- Good linearity between two channels
- Proton peak evident



SIRAD

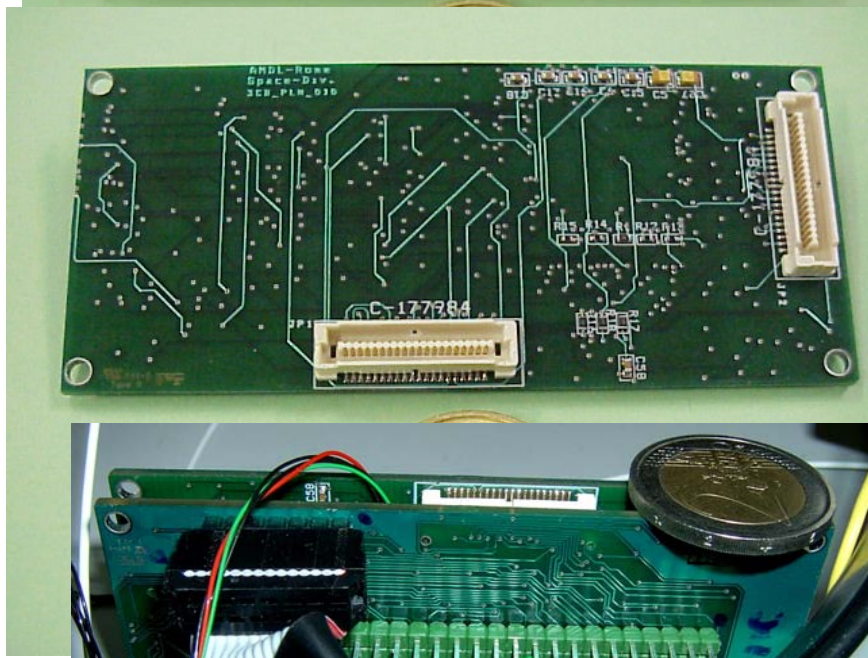
- Under construction
- 16 double silicon planes
- Trigger with scintillator
- Self Trigger
- Calorimeter on bottom

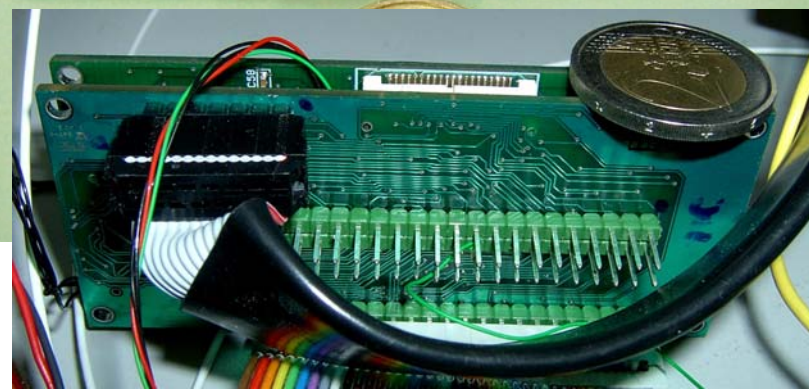


CPU

•Prototype integrated with FPGA and front-end
•CPU 144 Mhz, 280 Mips
•2 Mbyte flash 4 RAM
•2 usb
•1 bus esterno 16 bit indirizzamento esterno 14 bit

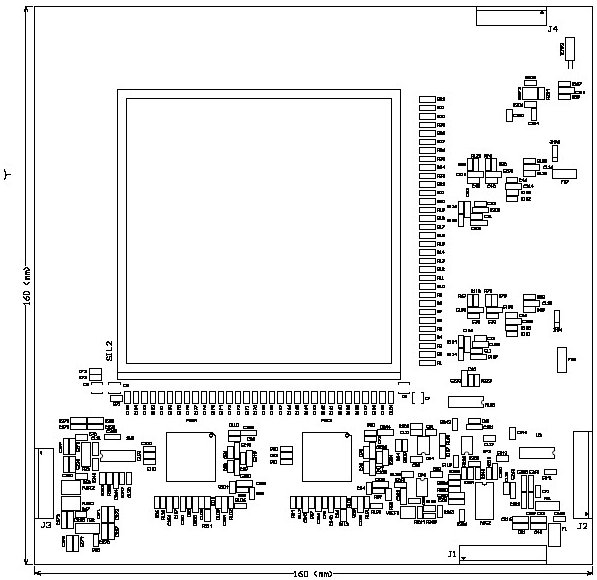
•FPGA actel reprogrammable 80kGate 208 pin:
•I/F frontend, alarms reading housekeeping

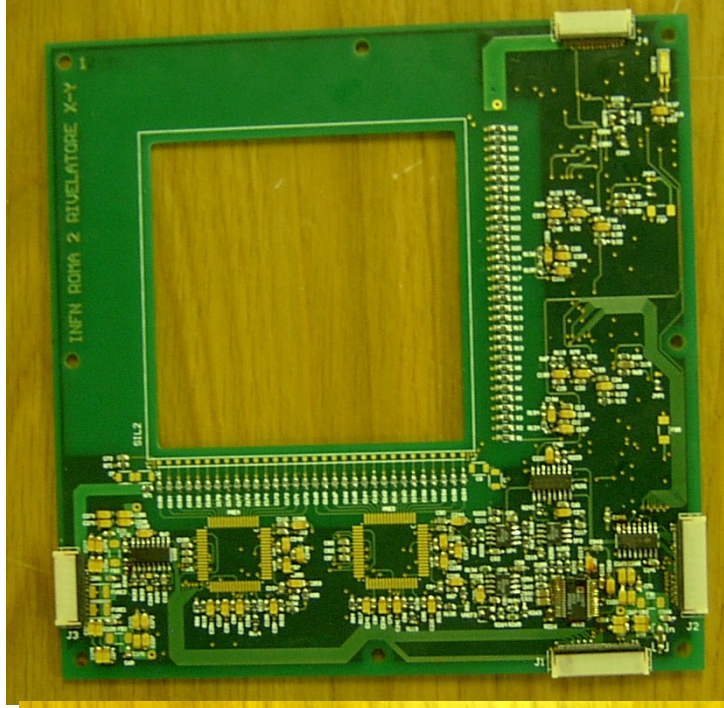


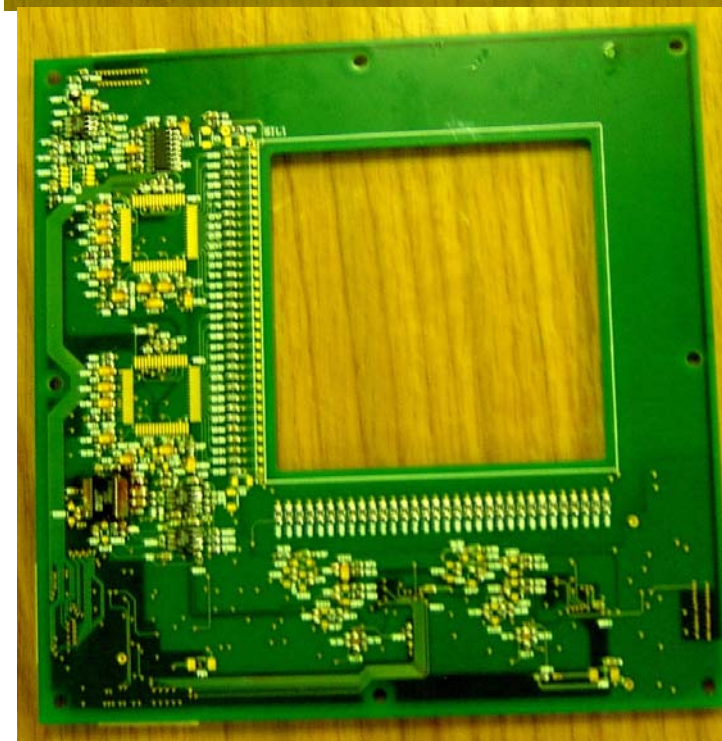


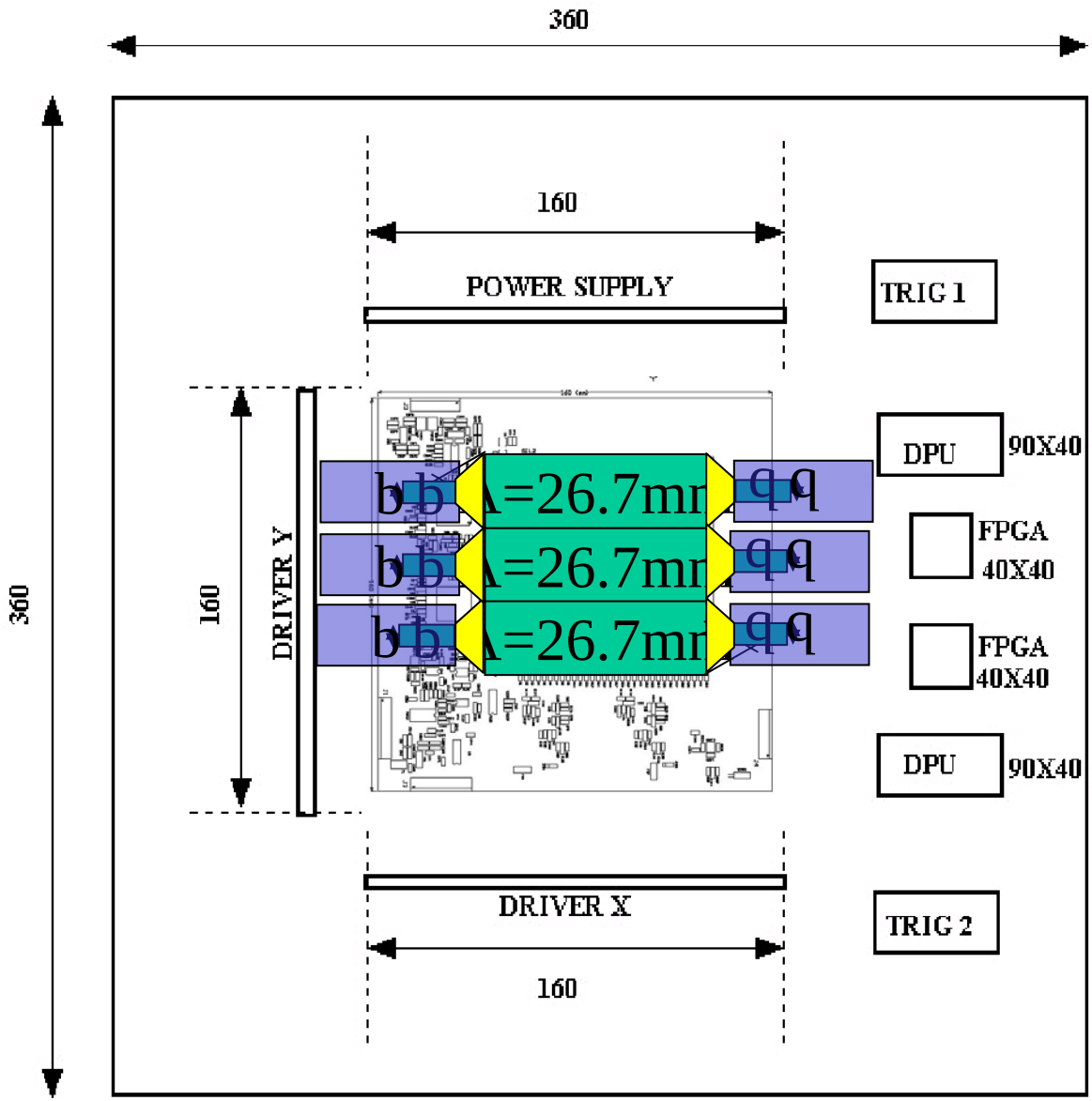
Front end

Completed ingegnerization of the boards
Low interplanar distance (5mm/2 piani vs a 3 cm/2 piani)
Under intergration with power and distribution boards

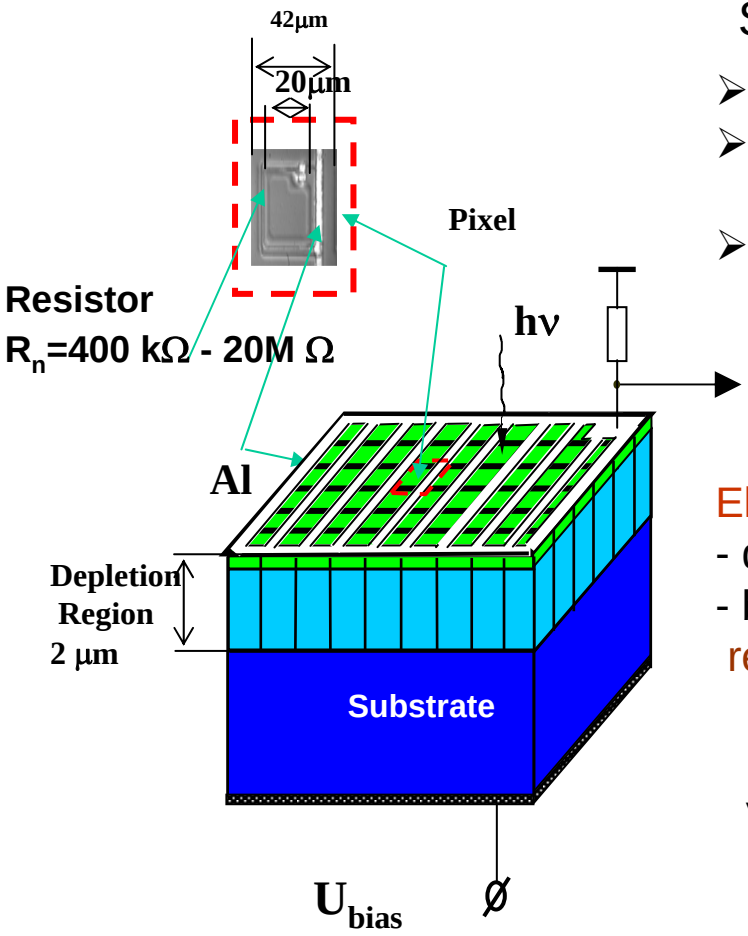







360
360
160
POWER SUPPLY
TRIG 1
DPU
90X40
FPGA
40X40
FPGA
40X40
DPU
90X40
160
DRIVER Y
DRIVER X
TRIG 2
160

SiPM's



SiPM consist of thousands pixels

- Pixel size ~(20-40) μm
- Working point: $V_{Bias} = V_{BreakDown} + Vd$ (< ~70 V)
  Vd ~ 3V above breakdown voltage
- Each pixel behaves as a Geiger counter with

$$Q_{pixel} = Vd * C_{pixel} ;$$

C_{pixel}~50fmF ➔ Q_{pixel}~150fmC=10^6e

Electrical inter-pixel cross-talk minimized by:
- decoupling quenching resistor for each pixel
- boundaries between pixels to decouple them

results: reduction of sensitive area and geometrical efficiency

Very fast Geiger discharge development < 500 ps

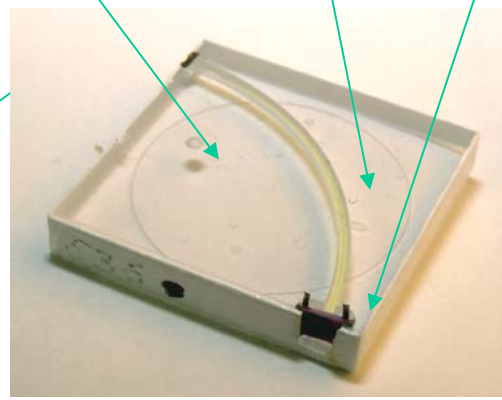
Pixel recovery time = (C_{pixel} R_{pixel}) ~ 20 ns - 1μs

Dynamic range ~ number of pixels

Scintillation detector based on SiPM for LAZIO-Sirad (1*1mm)

The scintillator + wave length sifter (WLS) + SiPM technology was used.

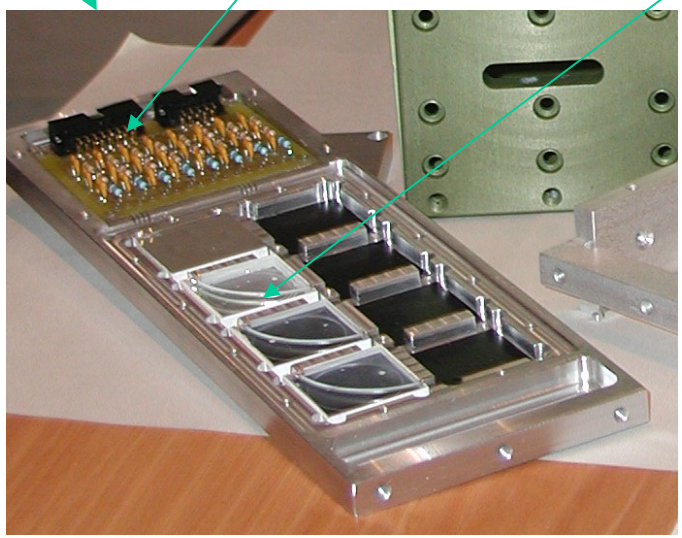
Single tile = scintillator+WLS+SiPM



Scintillation detector with SiPM's

(each detector consist of 8 tiles)

Power distributor



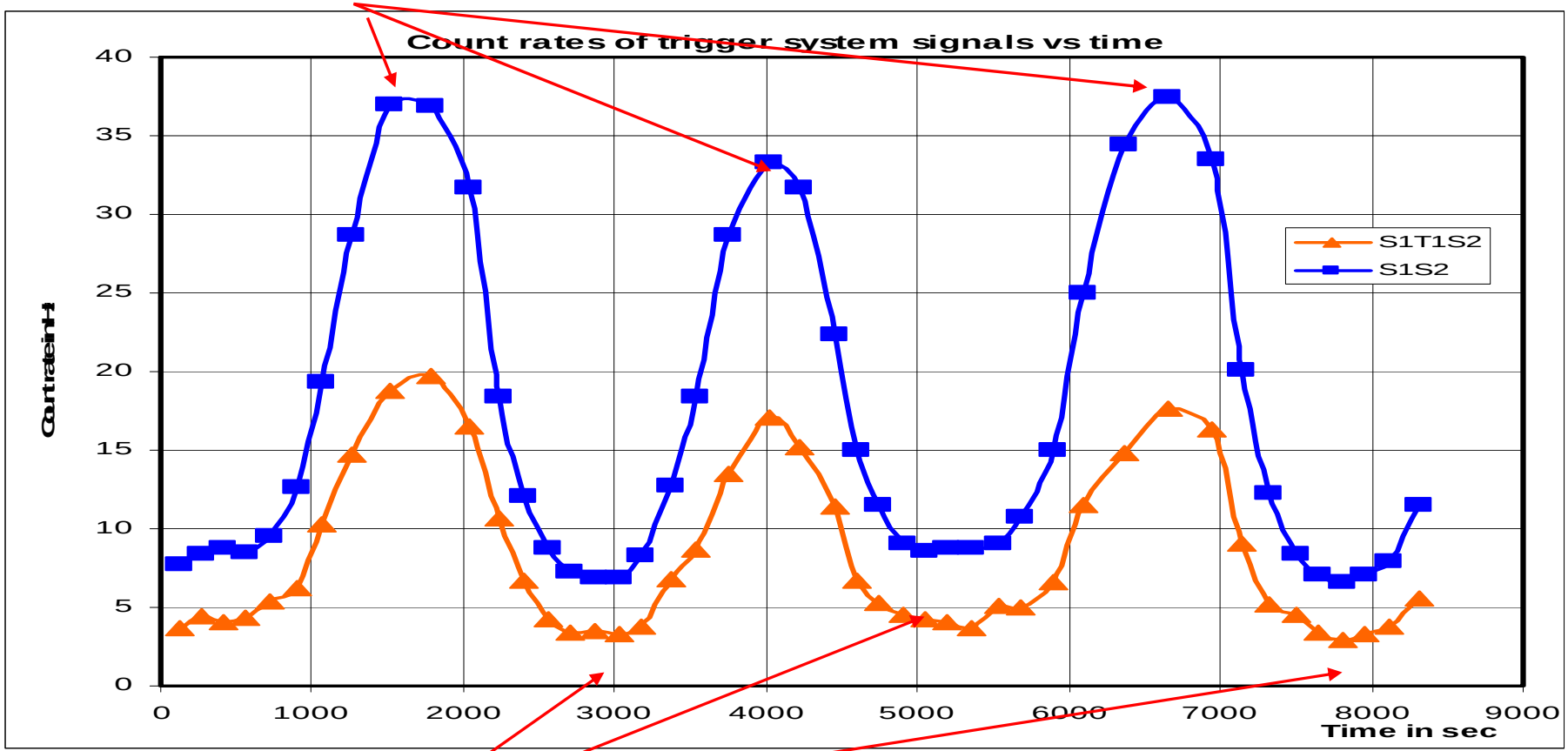
WLS used for:

- The light collection from 30x30 cm^2 scintillator to 1x1 mm^2 sensitive aria of SiPM,

- The shift of scintillation radiation spectrum to yellow-green field, where is maximum of SiPM PDE (Photon Detection Efficiency)

Silicon-Photomultiplier data

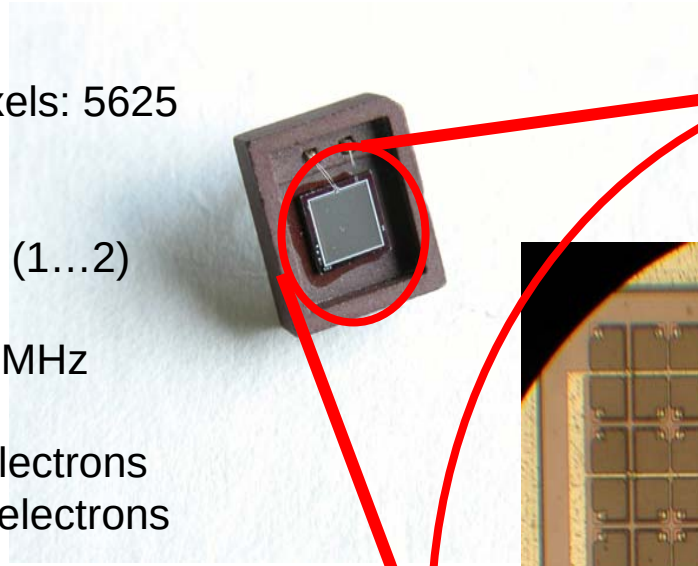
POLI

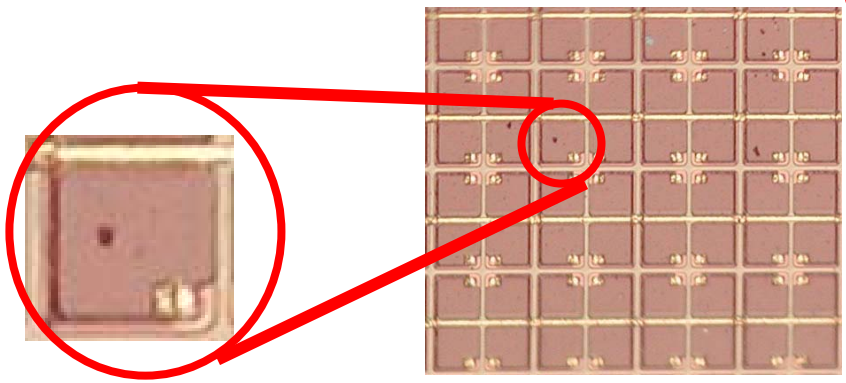


Equatore

3x3mm **SiPM,** 5625 pixels

- Sensitive area : 3x3 mm2 # of pixels: 5625
- Depletion region: ~ 1 μm
- Pixel size: 30 μmx30 μm
- Working voltage: 20…25 V Gain: (1…2) x10**6
- Dark rate.room temperature: 20 MHz
- SiPM noise(FWHM):
  room temperature 5-8 electrons
  -50 C 0.4 electrons
- Single pixel recovery time: 1us
  After pulsing probability: ~ 1%
- Optical crosstalk: ~ 30 - 50 %
  ENF: appr. 1.5-2.0 (overvoltage dependent)



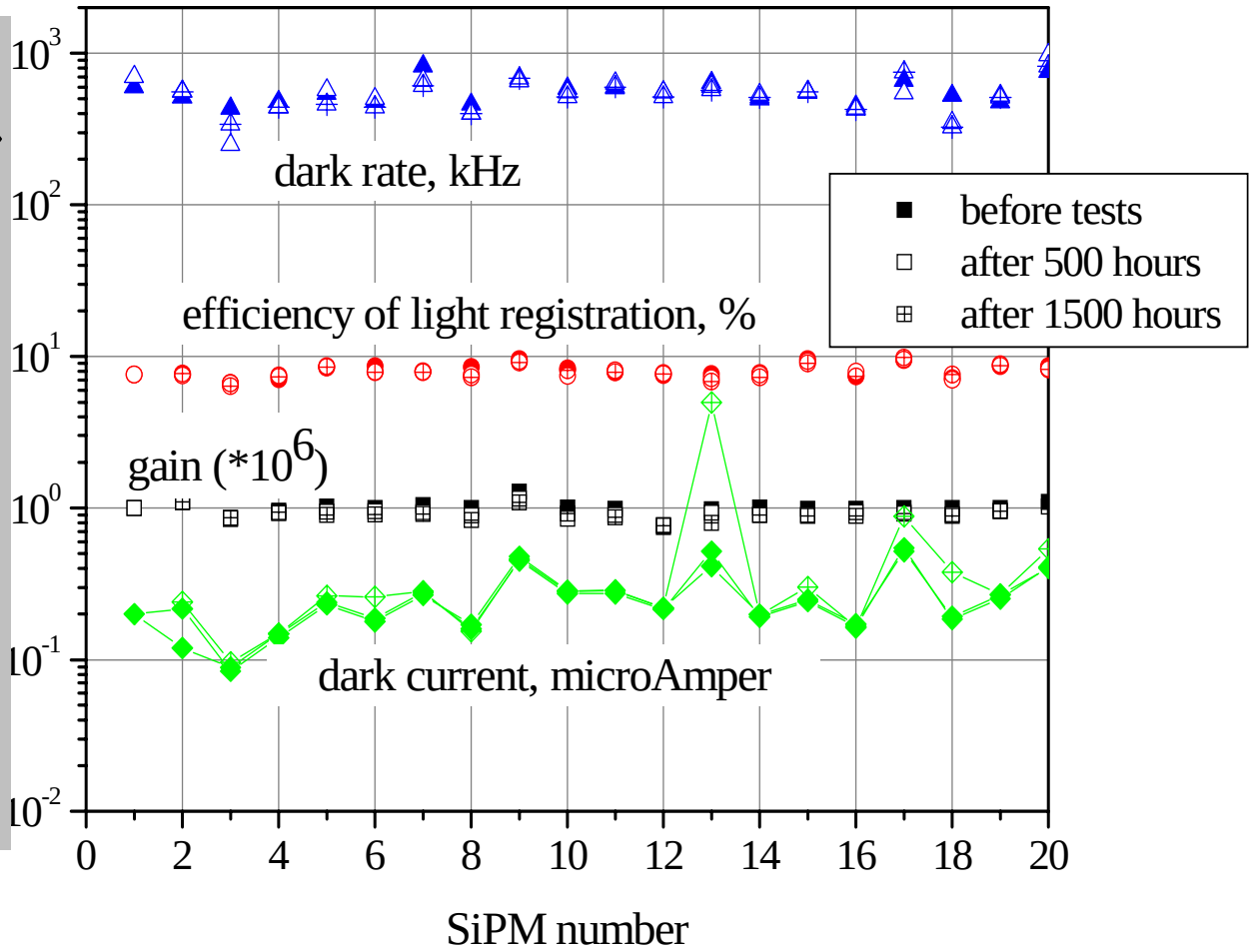


SiPM's long term stability

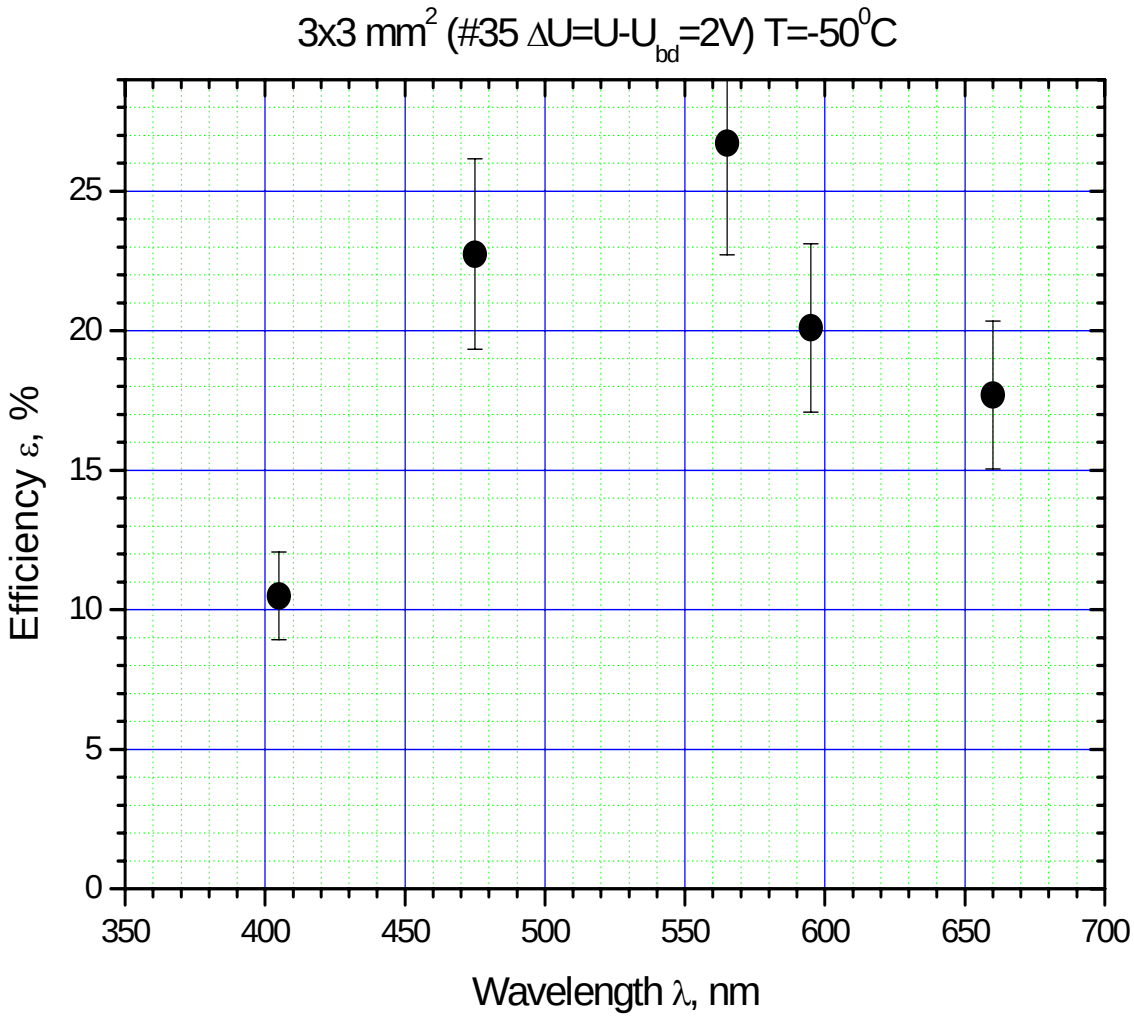
20 tested SiPM's worked during 1500 hours

Parameters under control:

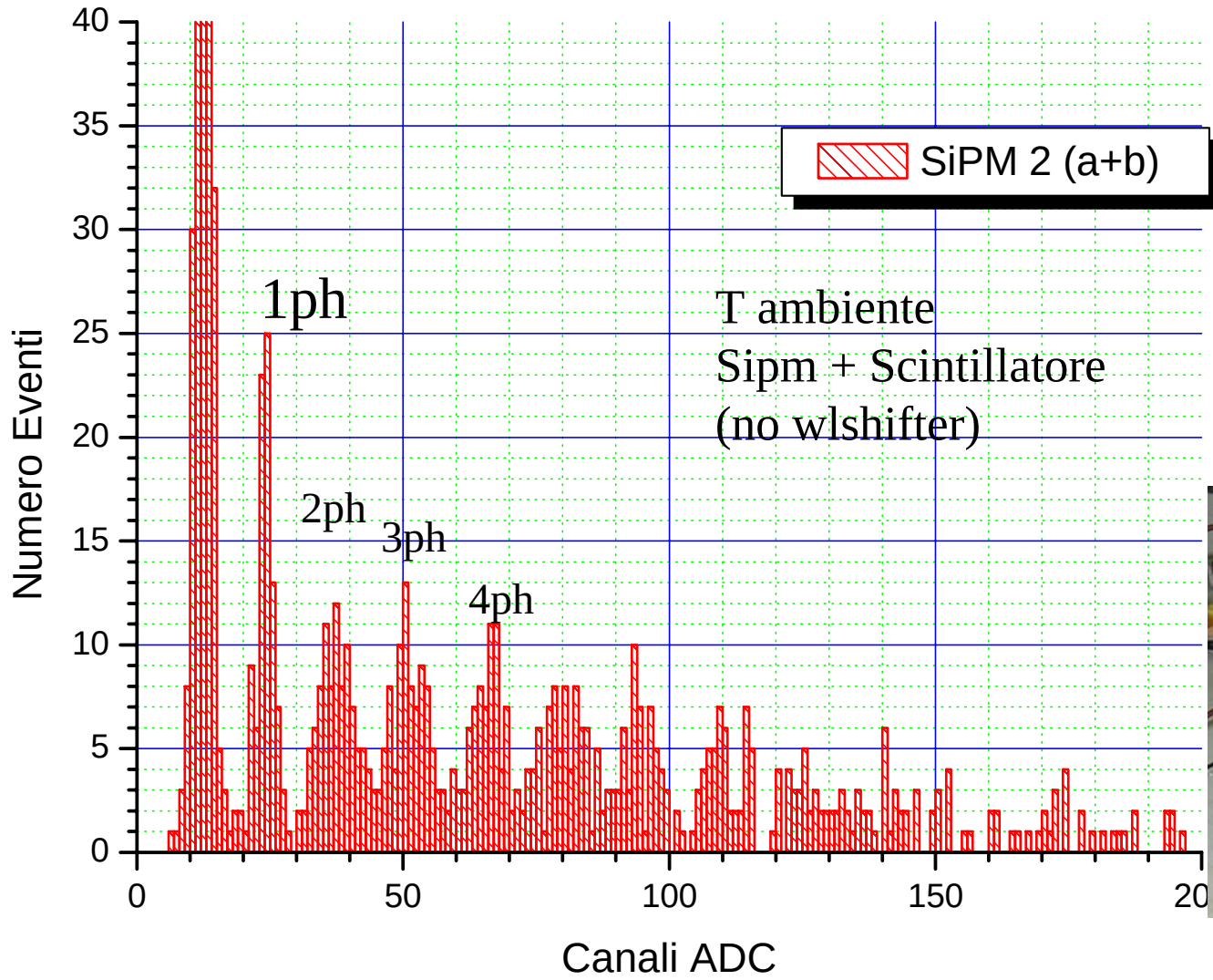
- **Dark rate**
- **Efficiency of light registration**
- **One pixel gain**
- **Dark current**

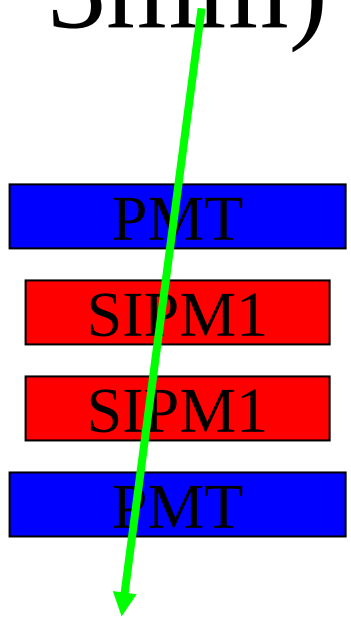


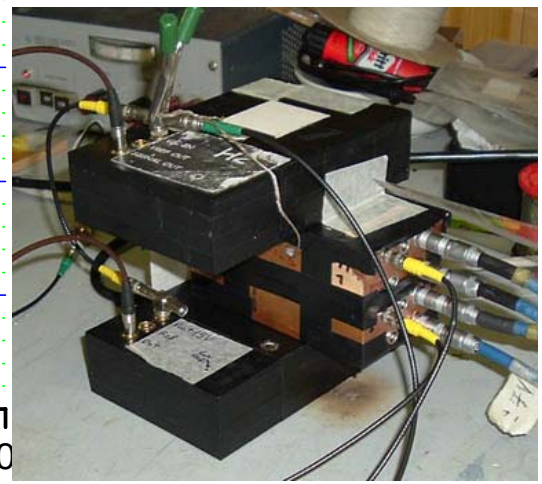
Some properties of 3x3 mm SiPM's



Cosmic Ray spectrum (3*3mm)







Pamela

Time of Flight

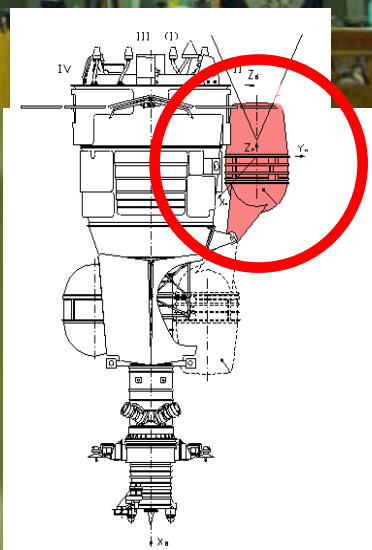
Magnetic Spectrometer Microstrip detector

Silicon Tungsten Tracking calorimeter

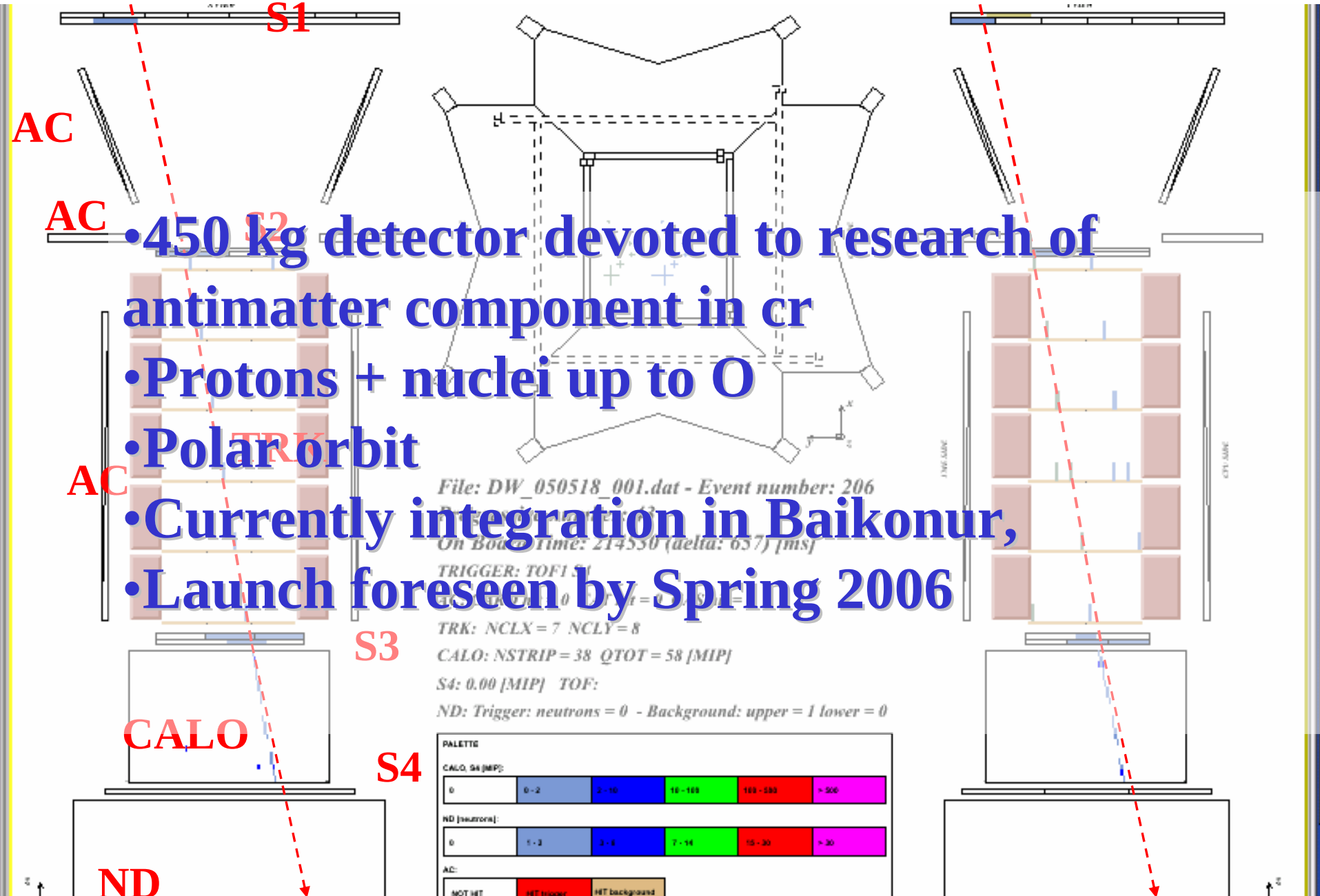
Shower Catcher Scintillator

Neutron Detector

RESURS DK1 SATELLITE (4.5T)



X View Top View Y View



- 450 kg detector devoted to research of antimatter component in cr
- Protons + nuclei up to O
- Polar orbit
- Currently integration in Baikonur,
- Launch foreseen by Spring 2006

Integration in Baikonur cosmodrome, April 2006

Conclusions: need for joint operations

- *Joint Measurements with different detectors*

Active/Passive Different detector response, shielding ecc.
Of crucial importance to determine particle flux variation in different points of the magnetosphere and ISS.

- *Ground/Space comparison/crosscorrelation*

  accelerator / shielding / calibration

- *Use of space data for operational applications*
- *Models* (trapped population, solar particle events, propagation in the magnetosphere)

- *Montecarlo Simulations* (Benchmarking / ion interactions): Geant 3.21, Geant 4, Fluka, HZTRN, Phits
More important than HE experiments

http://www.uniroma2.it/postgrad/inglese/applicazioni/instruction.htm

apply.cgi

POST-GRADUATE SCHOOL

Graduate School President

Prof. Franco Peracchi
franco.peracchi@uniroma2.it

Graduate School Office

Giovanni La Rosa
postgrad@uniroma2.it
Fax +39 06 72592565

Student assistance

Amelia Perea
amelia.perea@uniroma2.it
Fax +39 06 72592565

Policies

Regulations

HOME

Pre-selection instructions for foreign students

STEP 1: Please read the Pre-selection for foreign students announcement. Foreign citizens shall submit their [illegible] Announcement [illegible]).

STEP 2: If applying for one of the two positions described in the announcement (the positions funded by University scholarships or the supplementary positions) then please proceed to the on-line pre-selection application. The on-line application can be accessed on the previous page, www.uniroma2.it/postgrad/inglese/applications.htm.

Note: Foreign citizens may only submit one pre-selection application for the academic year.

STEP 3: Choose the faculty of which the Doctoral Program you are applying to belongs.

STEP 4: Choose the Doctoral Program which you are applying for. Click here for a translation of Doctoral Program titles from Italian to English.

STEP 5: Fill out your personal data information and click "send".

STEP 6: Click on "Add Undergraduate Degree" and then fill in relevant information. Click "send".

STEP 7: Once you have finished inserting one (or more) undergraduate degrees, click "next".

STEP 8: Click on "insert courses/exams" and make sure to insert all the names and grades of courses you took as an undergraduate. Once you have added all your courses, click on "Save inserted information".

STEP 9: Click on the appropriate link if you have any graduate degrees, publications or relevant information you would like to insert. *Remember to always save inserted information.

STEP 10: Copy down your Ctrl number and make sure to save it. Print a copy of the application and keep it for your own records.

SCHOOL
FACULTIES
SERVICES
SPONSORS
THESES ARC
APPLICATION
SITE MAP
CONTACTS

Completato

Availability of PhD positions (post-graduate) in Roma Tor Vergata University:

http://www.uniroma2.it/postgrad/inglese/applicazioni/instruction.htm

And/or contact casolino@roma2.infn.it or picozza@roma2.infn.it

Thank you!

Energy acceptance

Particle	Trigger Threshold MeV/n	Cut threshold MeV/n	Energy loss (keV/μm)
p	32	34	0.4
He	32	40	1.6
B	53	54	9.3
C	59	70	13.5
N	65	75	18.7
O	69	79	24.5
F	71	84	30.8
Ne	77	94	37.9
Na	79	95	47.2
Mg	86	104	54.4
Al	88	106	68.4
Si	94	110	75.3
Ca	114	136	152.6
Fe	126	150	254.4

Table 1
Left Minimum trigger energy of Sileye-3. *Center* Minimum energy for the data cut for various nuclear species. *Right* Minimum energy loss in silicon.