Sileye3/Alteino results of cosmic rays on board the ISS

M. Casolino, Sileye-3 collaboration

INFN Roma2 & University of Roma Tor Vergata

Tor Vergata

INFN
Istituto Nazionale
di Fisica Nucleare

Sileye/Alteino institutions

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Experiments to study Light Flashes and cosmic ray environment

- **SilEye-1: placed on the Space Station MIR in October 1995.**

  Years 1996-97: 25 LF measurement sessions

  6 cosmonauts

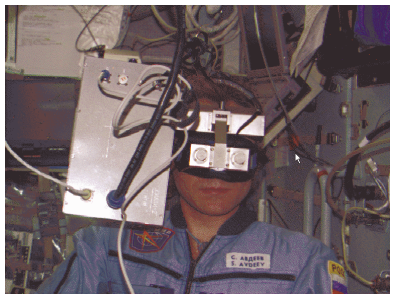
  90 LFs recorded

- **SilEye-2: placed on the Space Station MIR in 1997**

  Years 1998-2000: 24 LF Sessions

  4 cosmonauts

  130 LF recorded



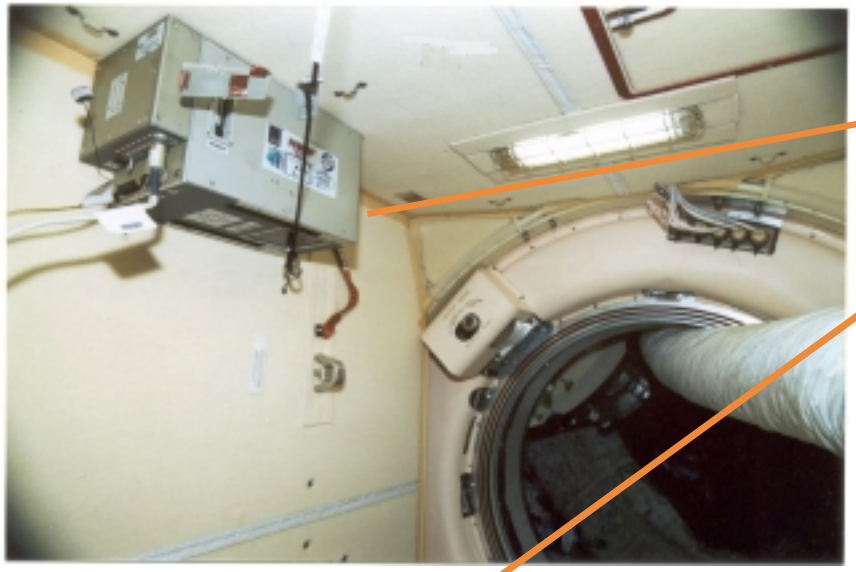
- **SilEye-3/Alteino:**

  placed on the International Space Station on 27th April 2002

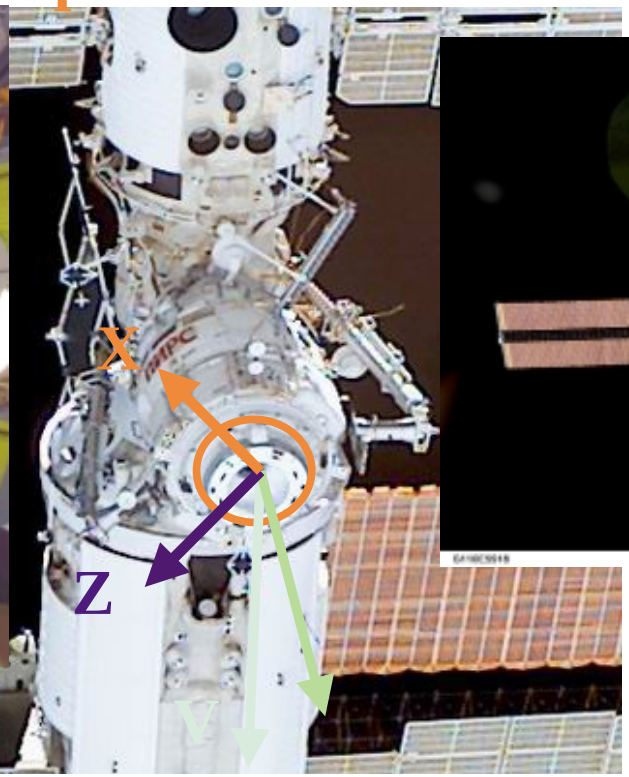
  9 LF sessions

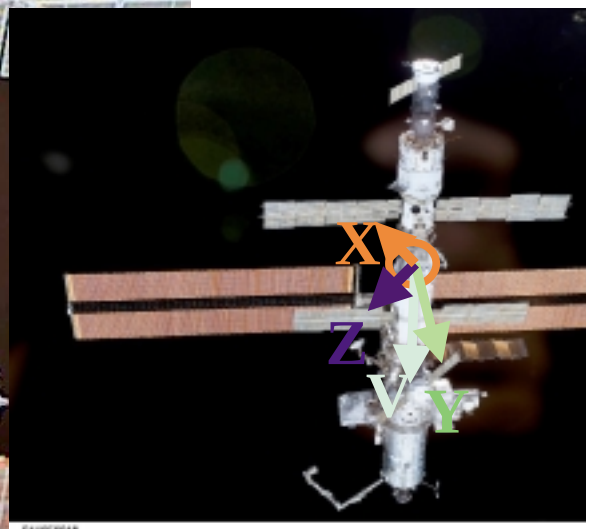
  10 days continuous monitoring of cosmic rays

  scheduled work for 1 year



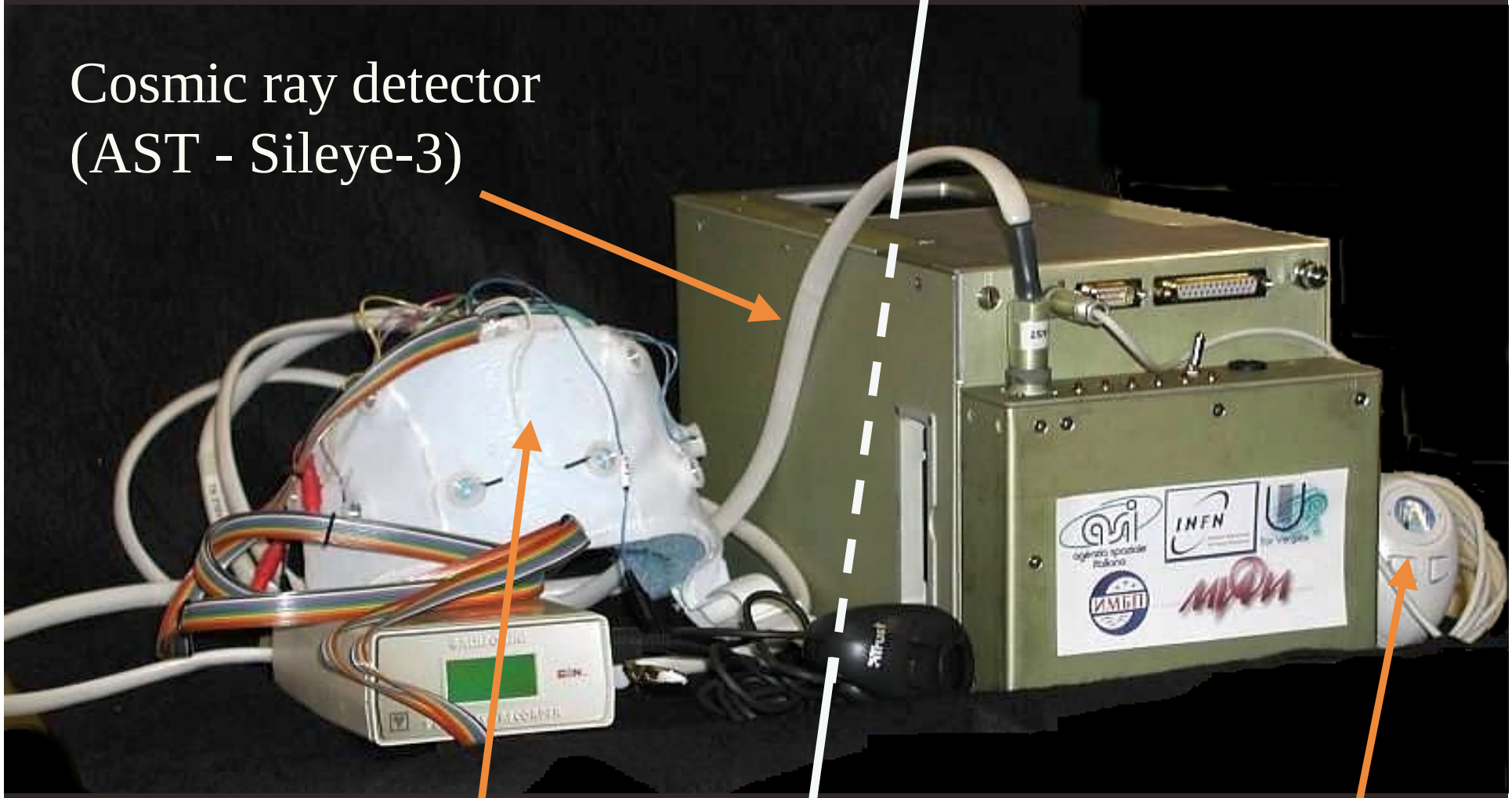
Sileye-3/Alteino & Light Flash experiments in PIRS module



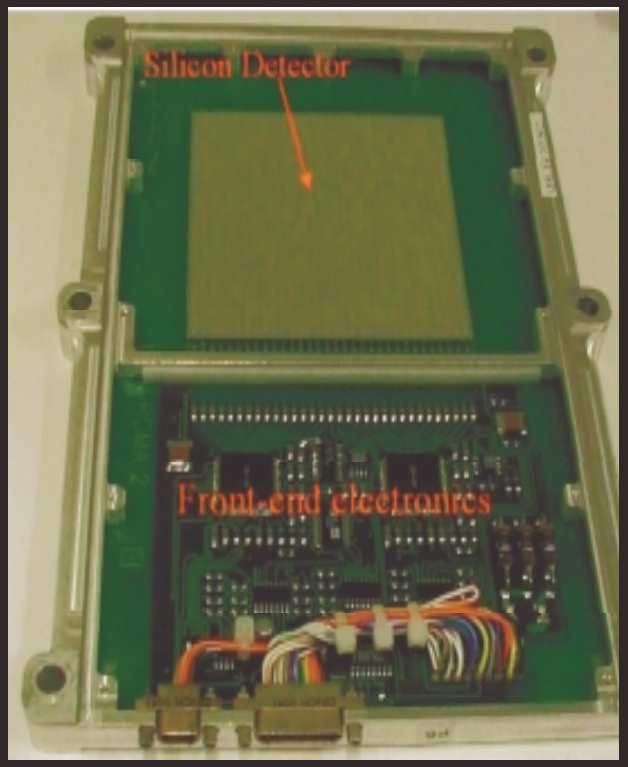


Sileye-3/Alteino

Detection of cosmic ray nuclei crossing ISS

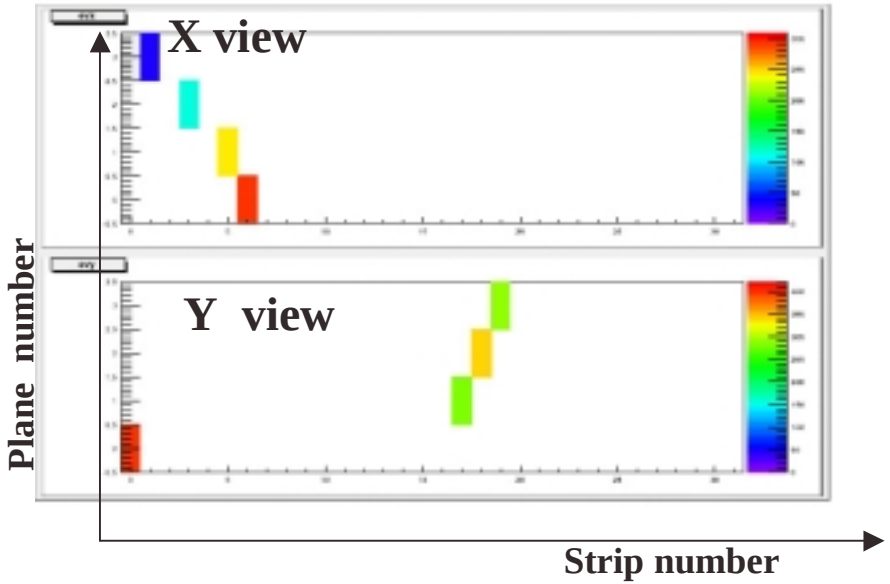


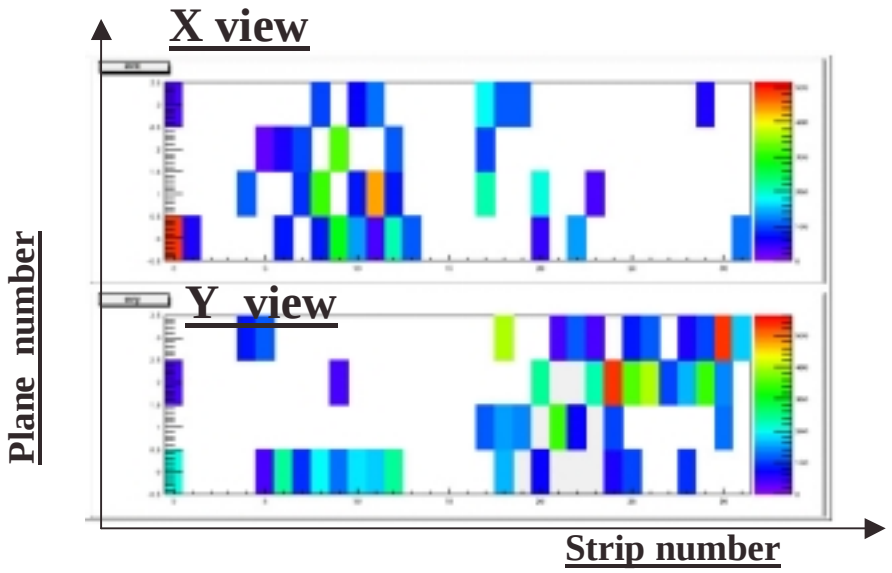
Silicon detector:

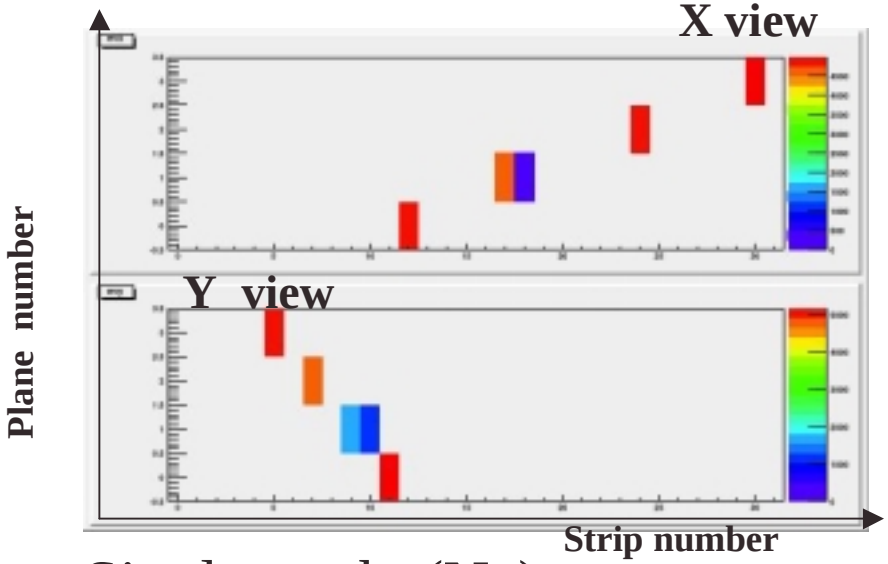


Left: AST detector tower open (without readout electronics): it is possible to see the stack of silicon detectors and the top scintillator (the detector is upside down). The bottom scintillator has been removed for clarity. Rigth: One of the 8 silicon detector boards (X view). It is possible to see the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

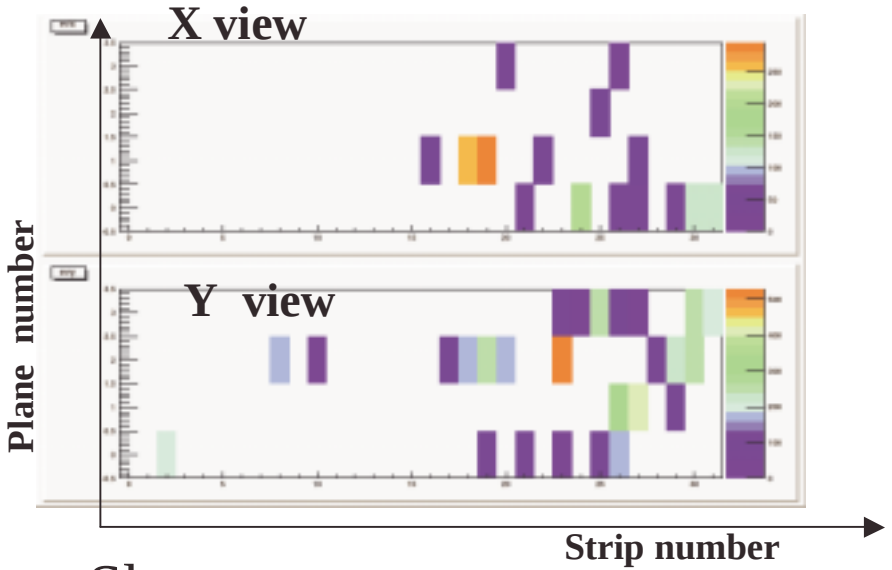
- 8 silicon planes (4x,4y)
- 32 strips strip pitch 2.5 mm, 8x 8 cm^2, thickness 380 μm
- Total 256 Independent channels
- Triggered by two scintillators (E_{min}=40MeV/n)
- Geom Fact: 24 cm^2 sr
- Bidirectional
- Max Field of view 39°
- The front-end is a developed version of two 16 channels CR1 chip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





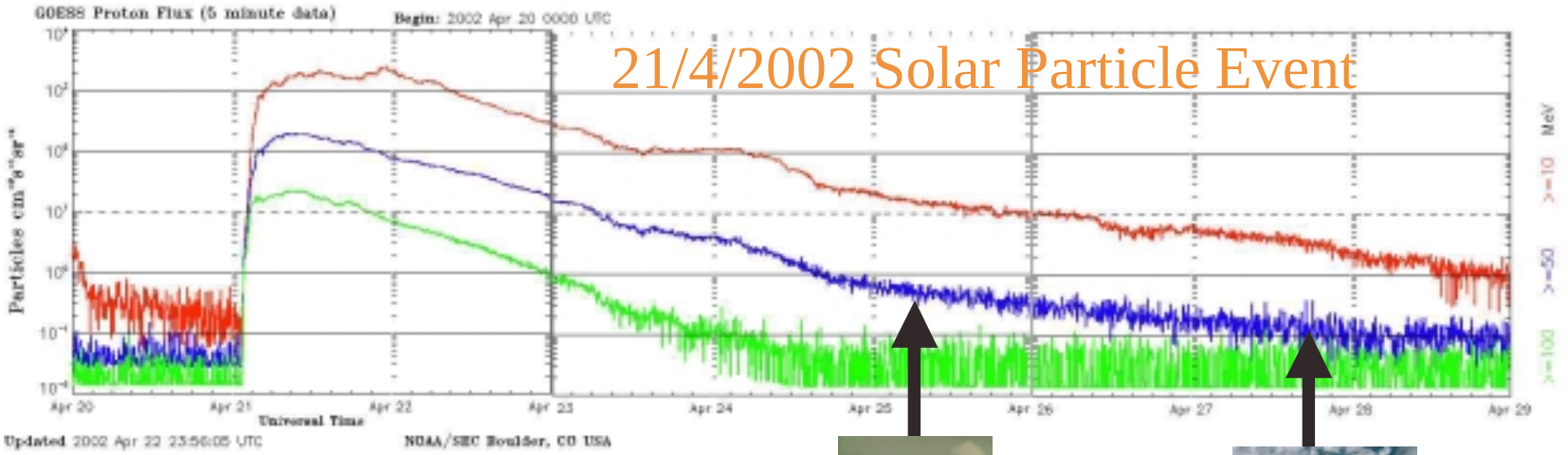


Single track (Ne) event
(ADC Channels)

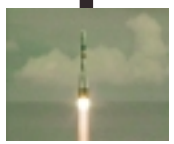


Shower event (ADC Channels)

Solar environment during mission



21/4/2002 Solar Particle Event

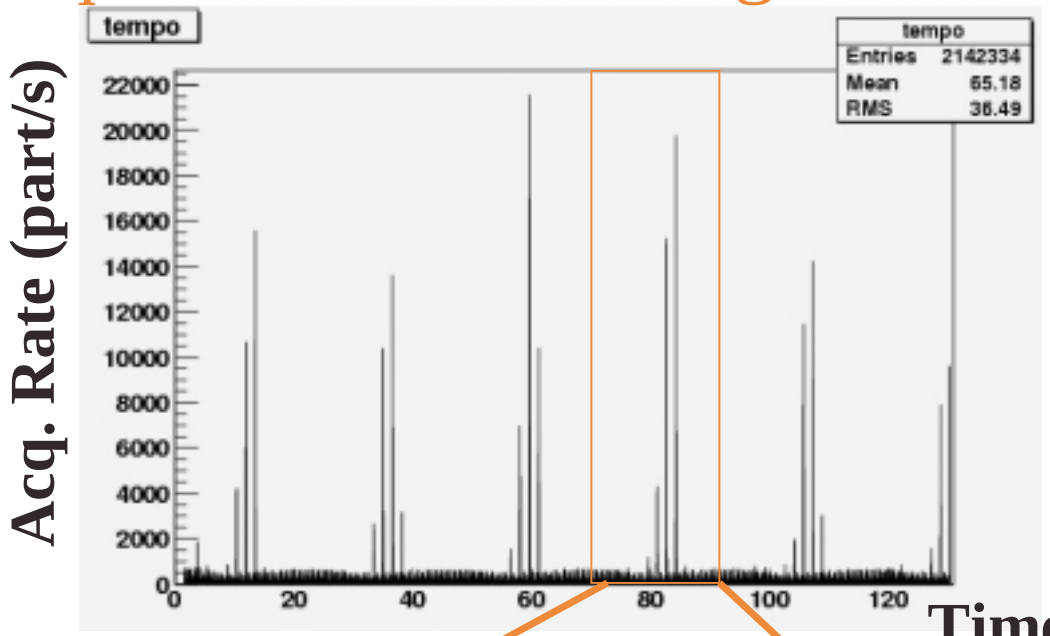


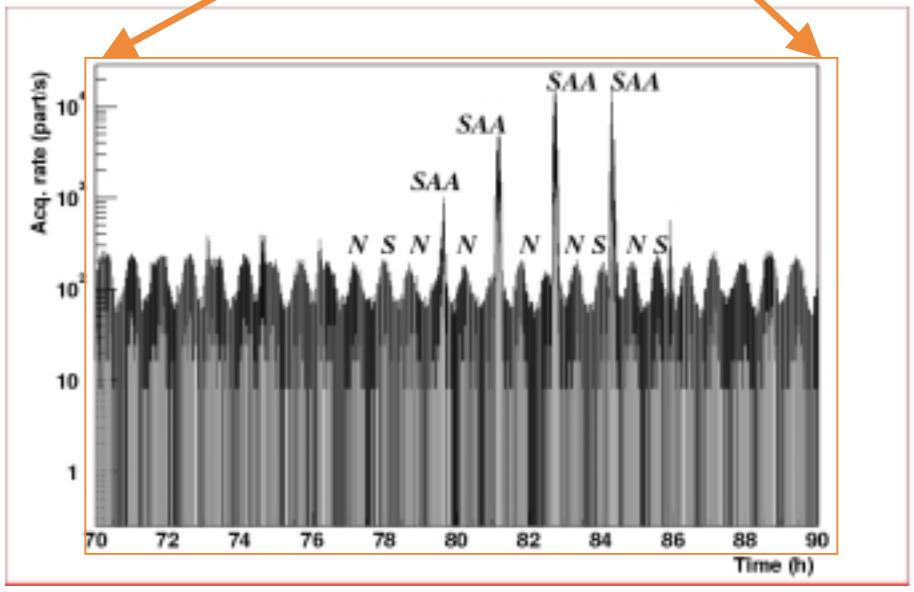
Launch

Docking with ISS

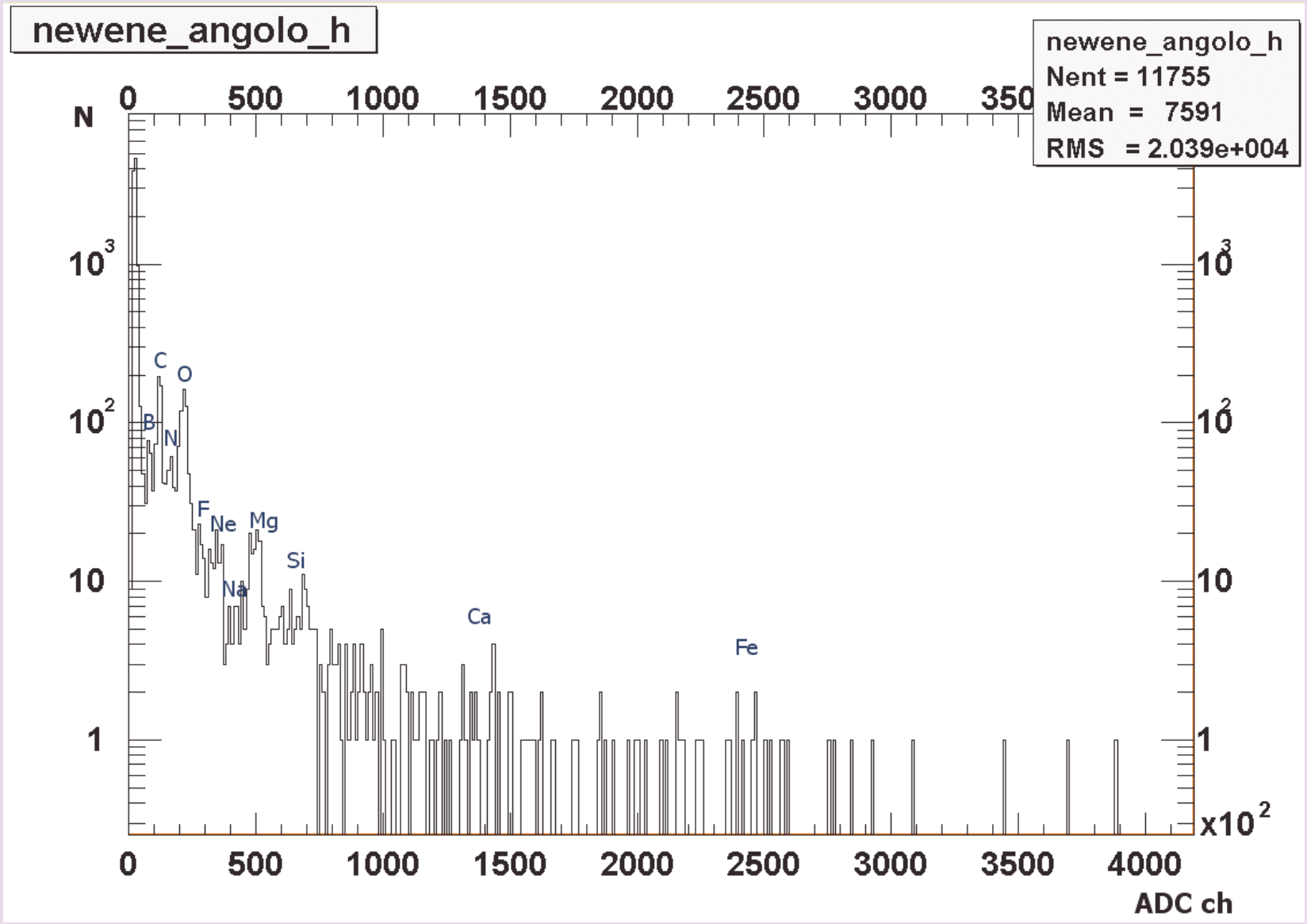
Geom. Factor 24 cm^2 sr

Acquisition Rate during mission

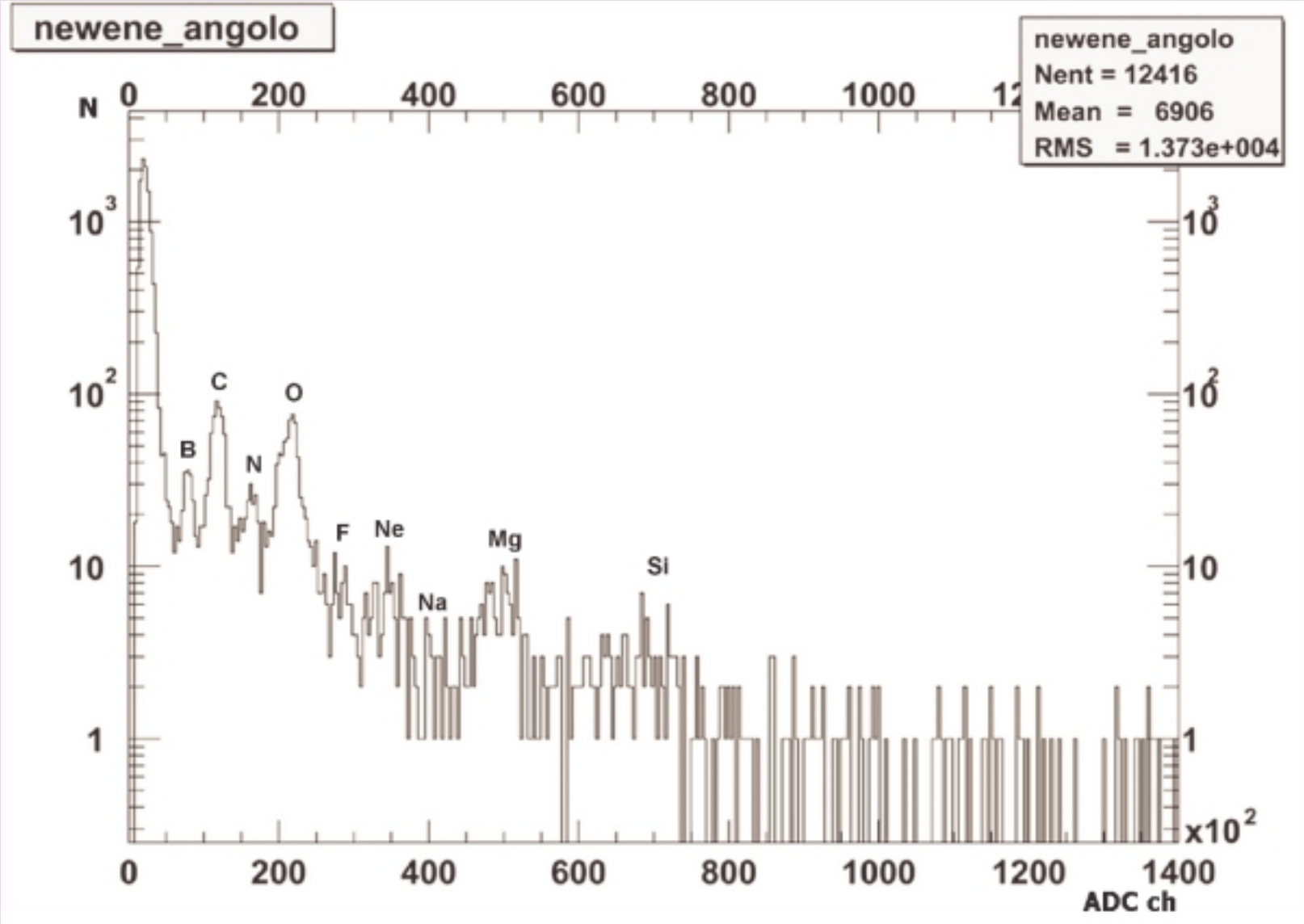




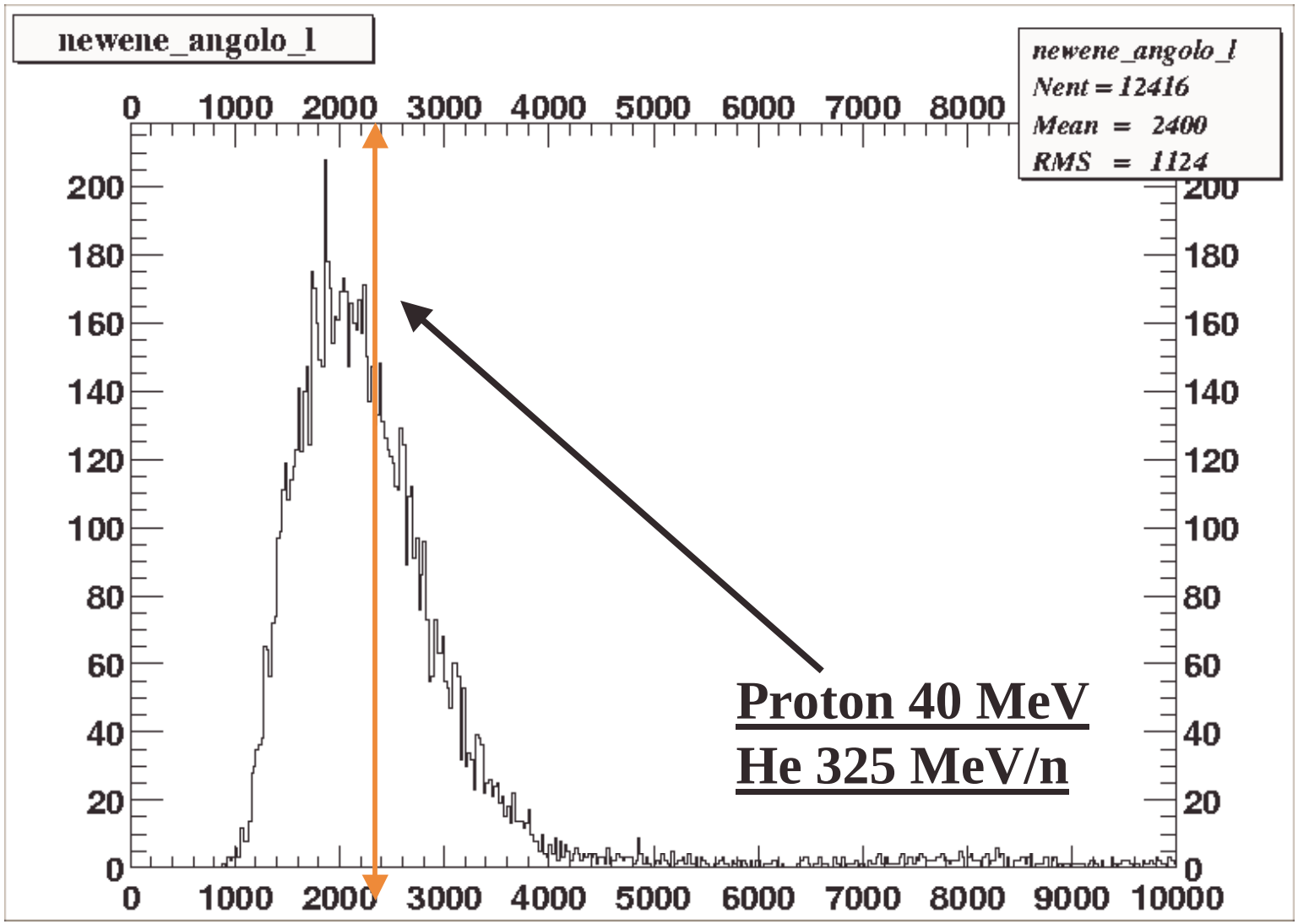
Particle Identification capabilities 1)



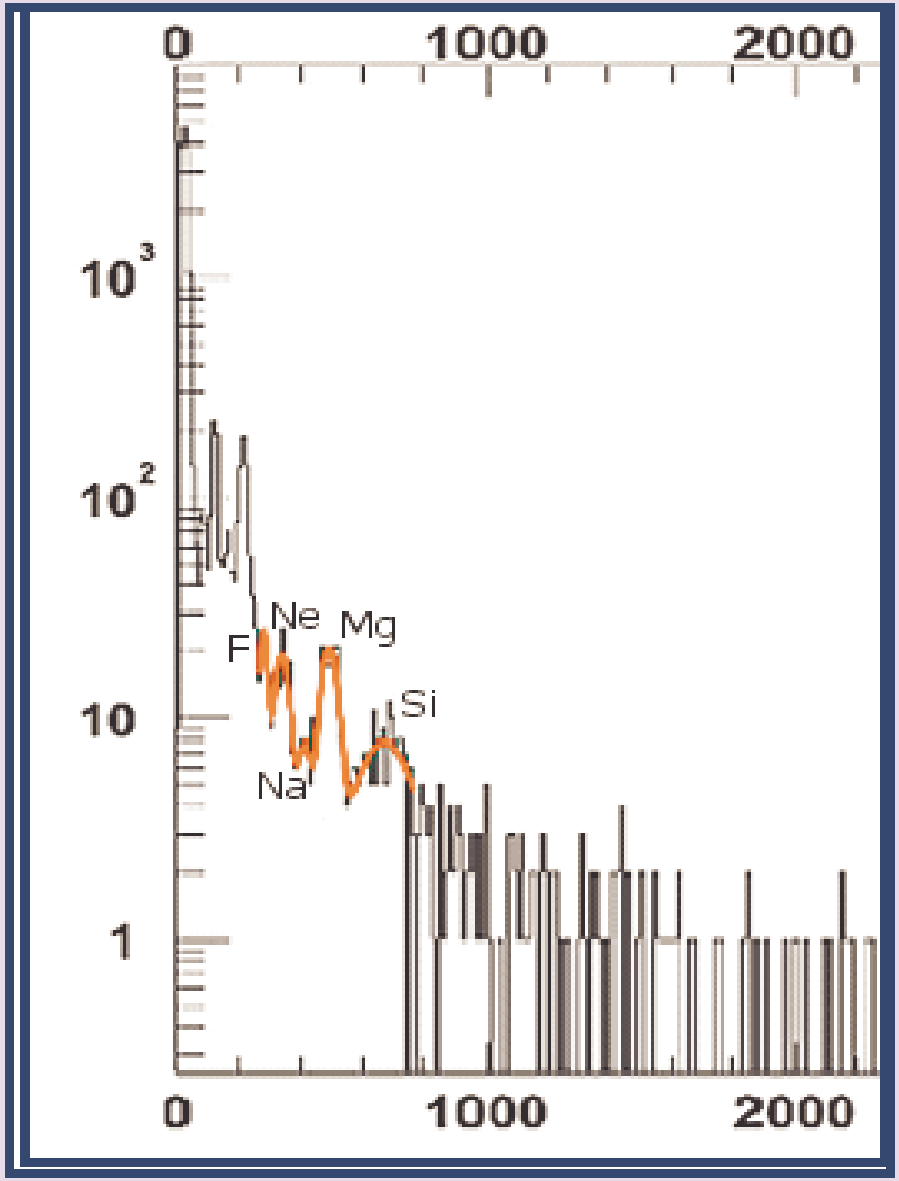
Particle Identification capabilities (Low Z) 2)



Response to low release particles



Sileye3/Alteino: analysis



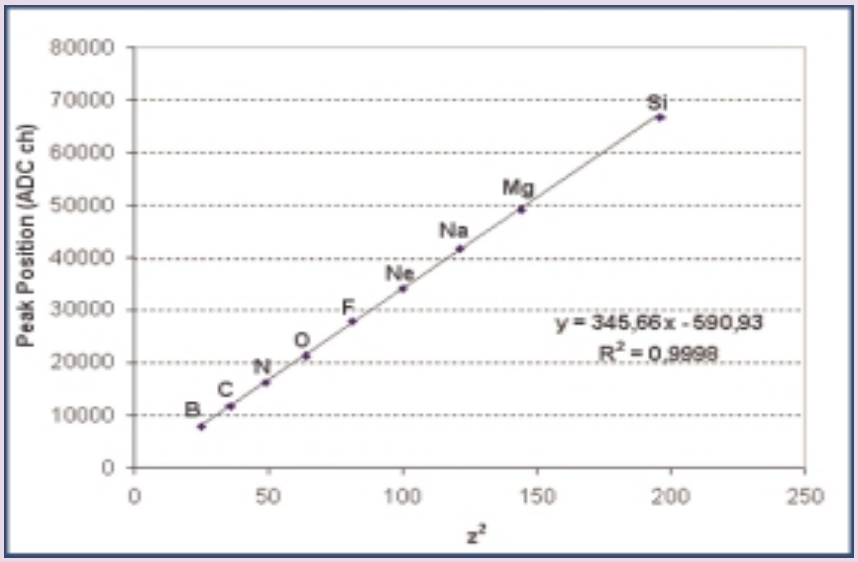
Multigaussian Fit
(root/minuit)
BCNO – FNeNa – Mg Al Si

↓

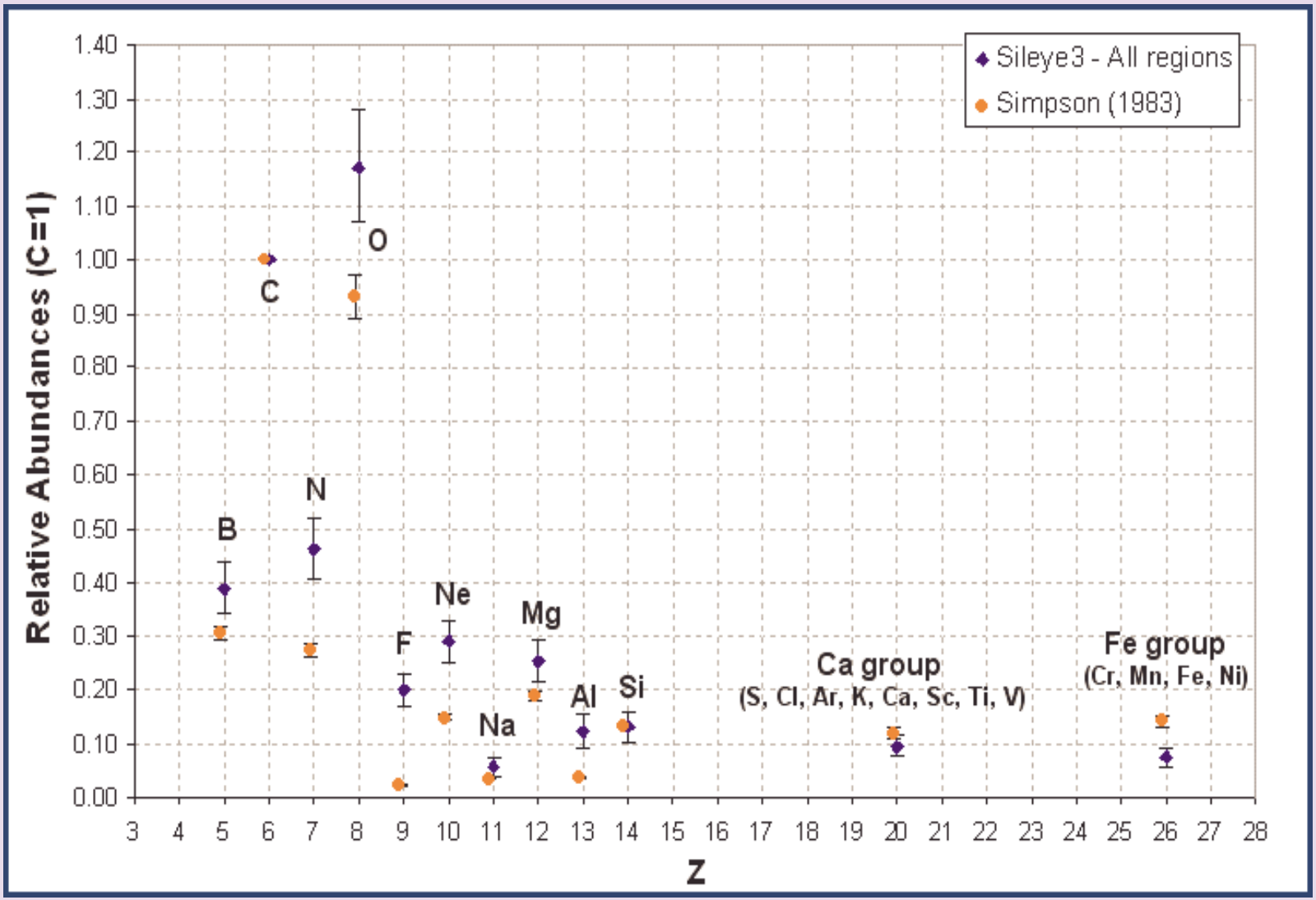
mean and sigma

↙ linearity

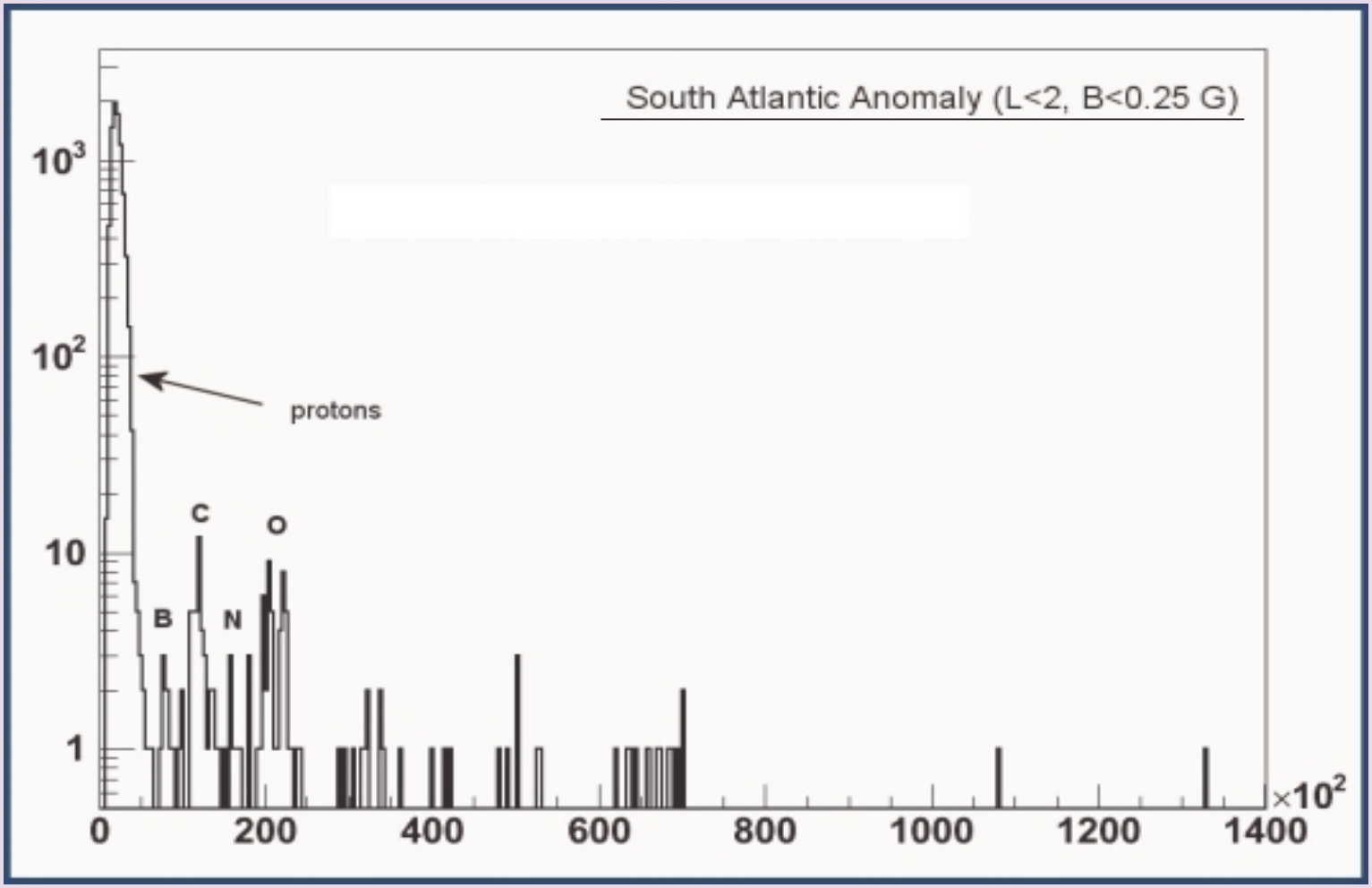
↘ abundances (integral)



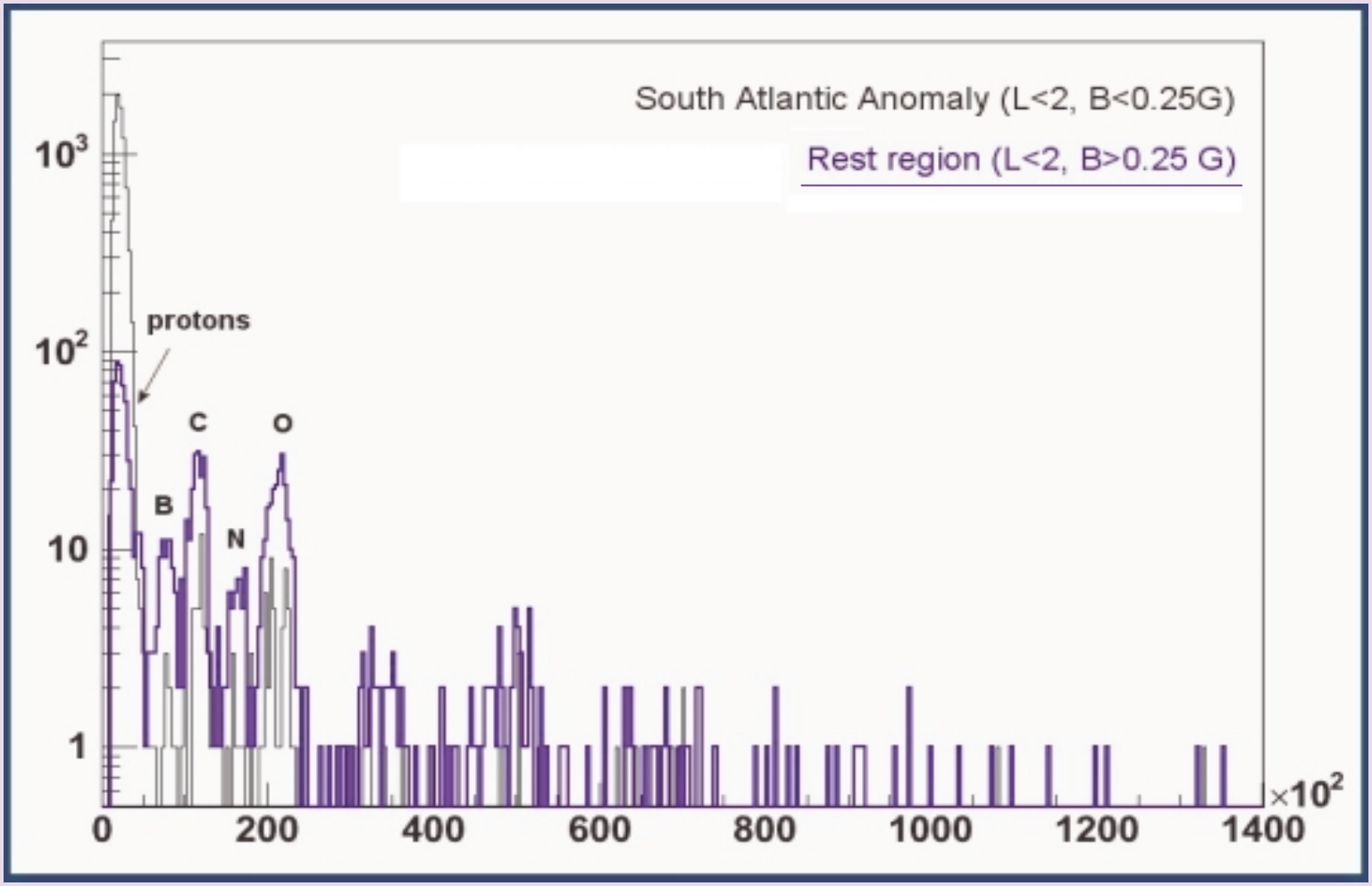
Relative Abundances (C=1)



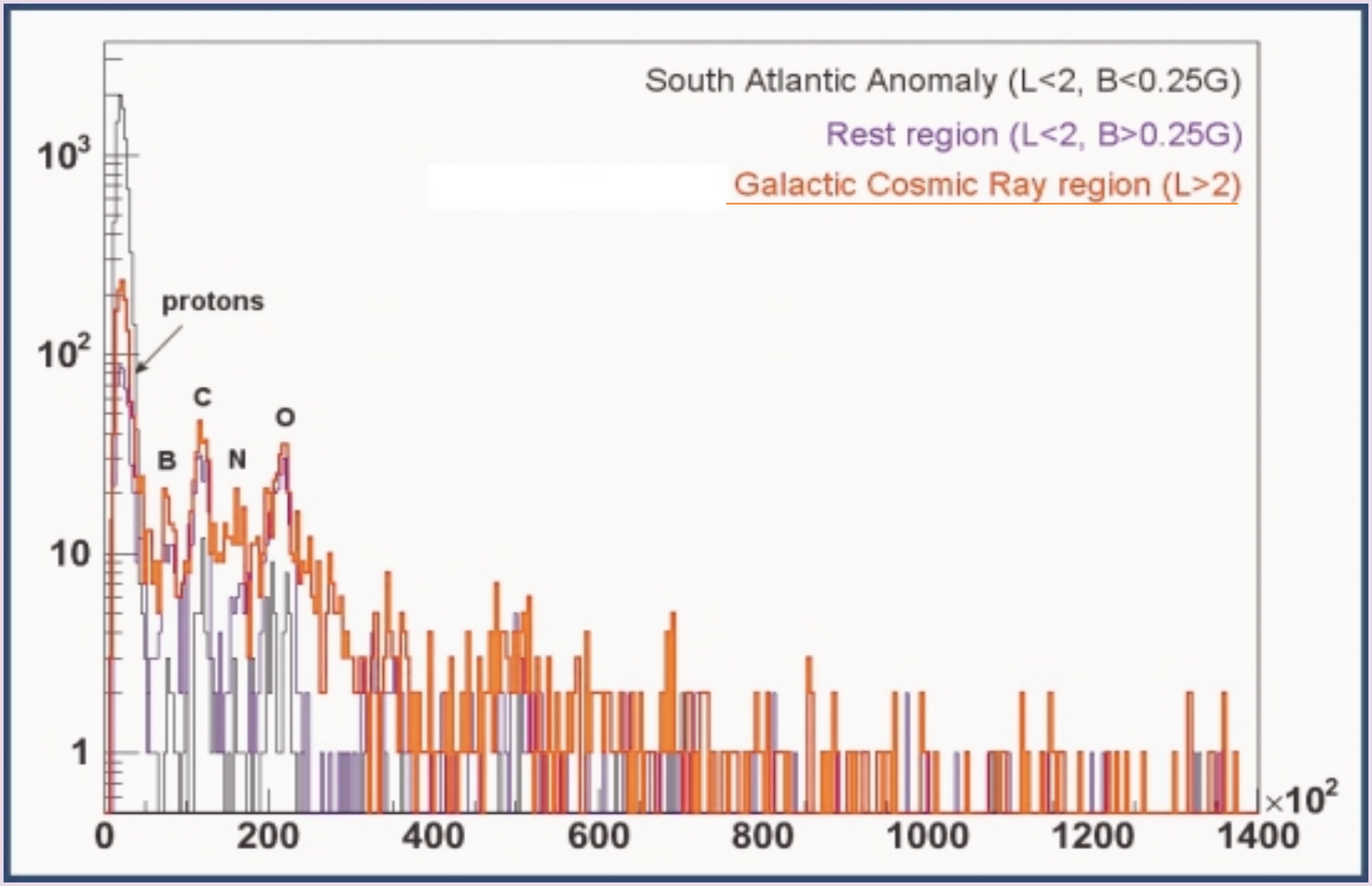
Orbit Regions:



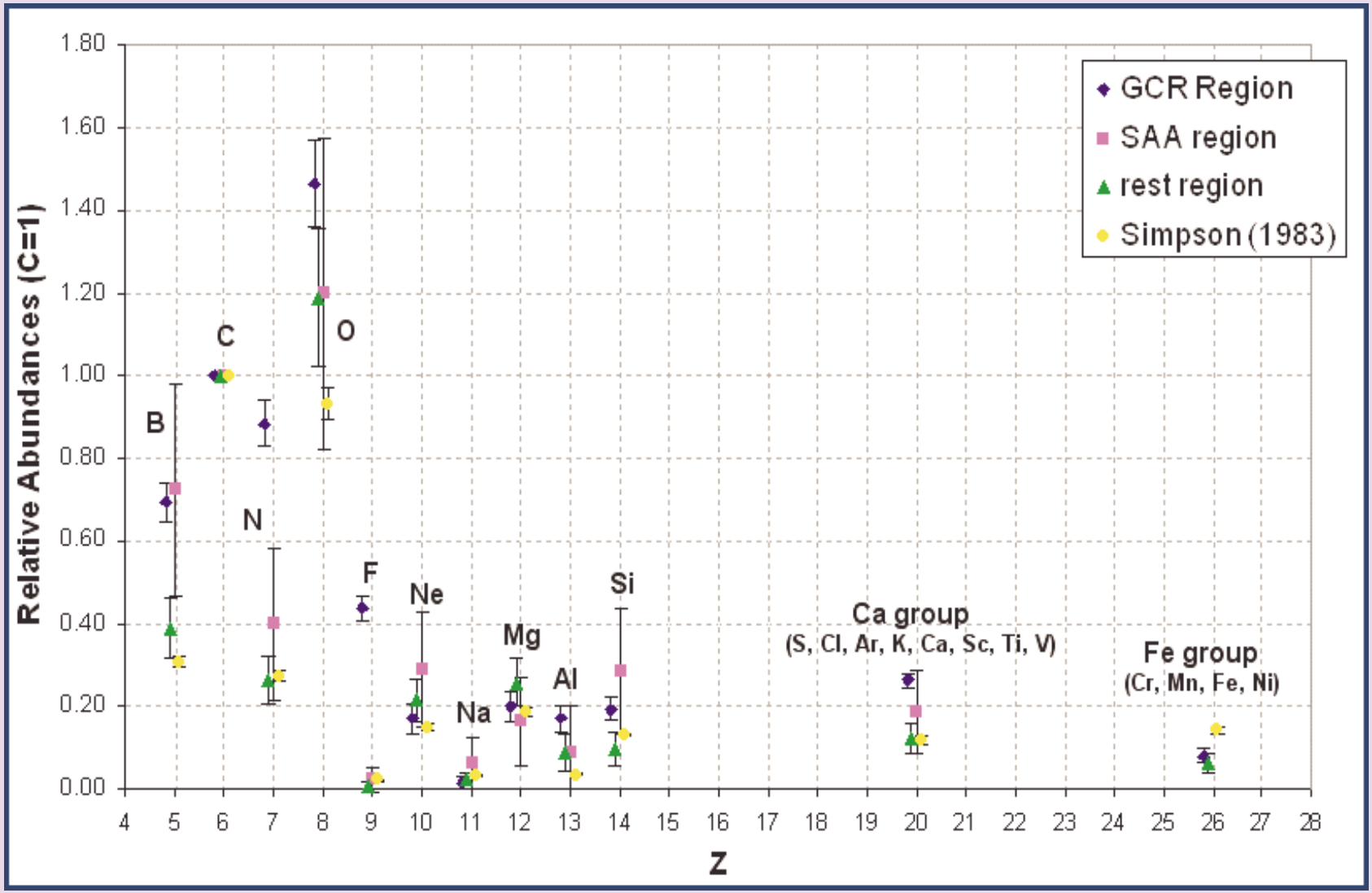
Orbit Regions:



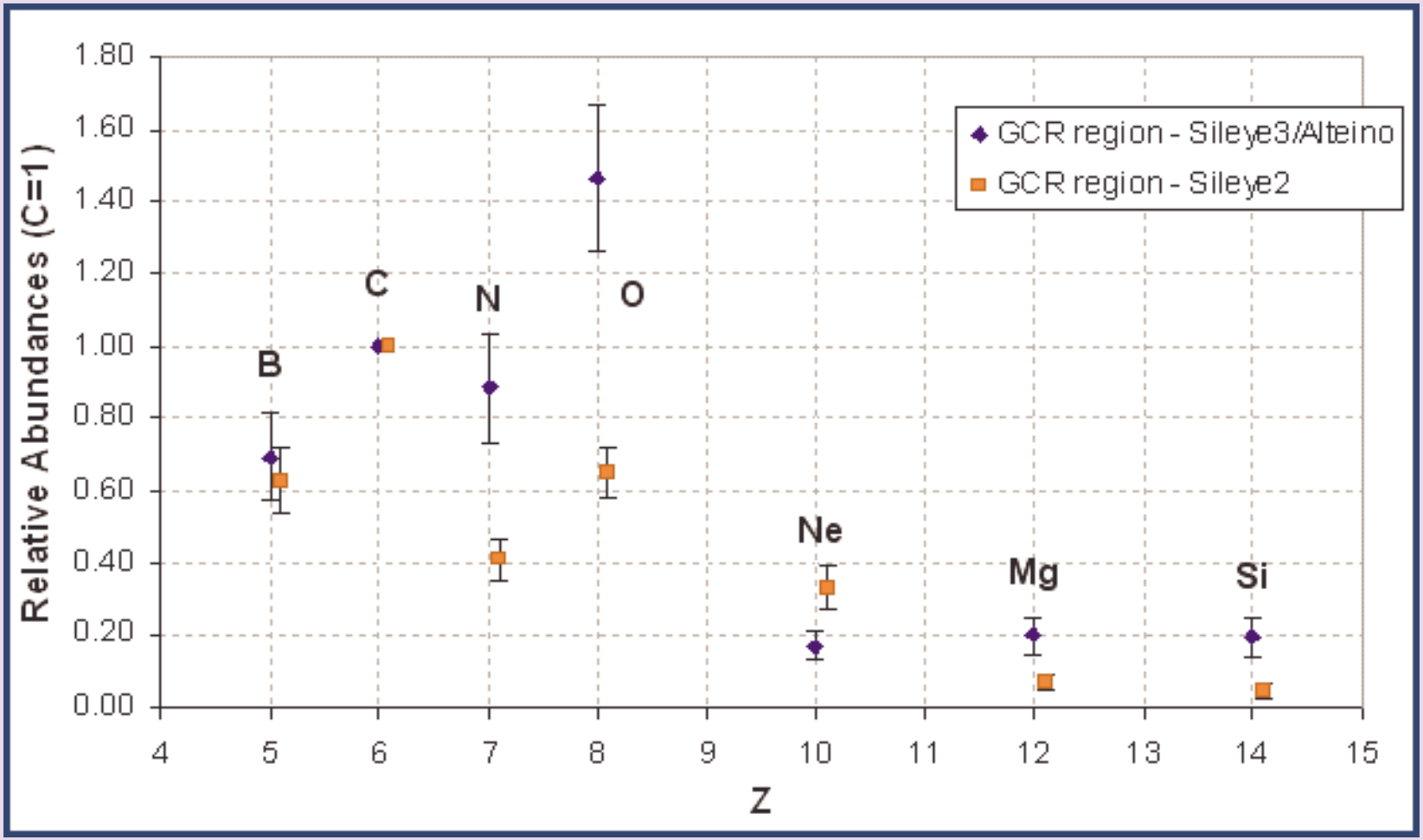
Orbit Regions:



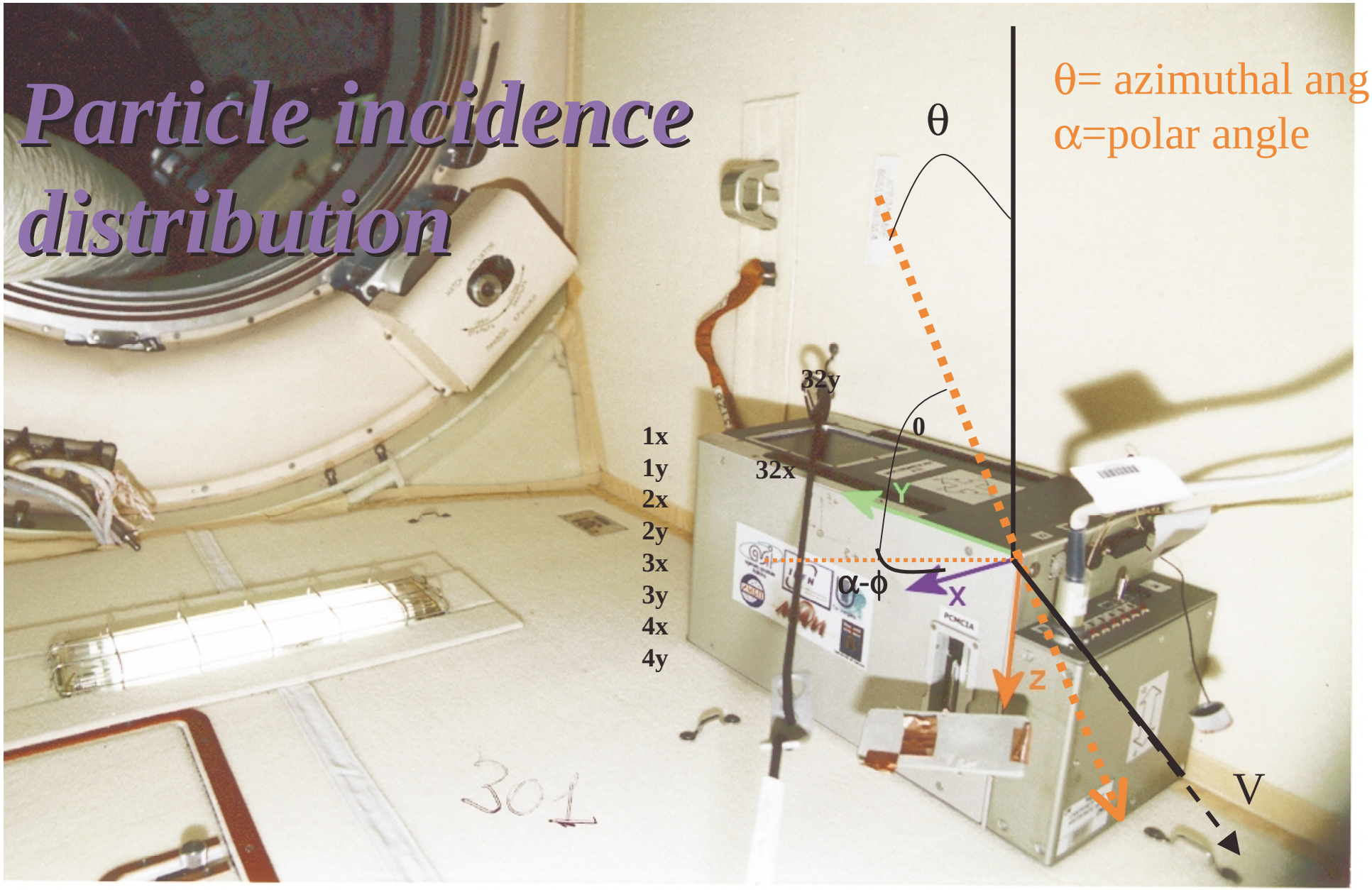
Relative Abundances Three Regions



Relative Abundances: comparison with Sileye2



Particle incidence distribution



Location & orientation within PIRS

ISS Attitude during flight:
+ZLV +XVV TEA
Yaw: 350
Pitch:350.79
Roll:0
(courtesy of M. Weyland)

Reconstruction of particle incidence

$Distx = X_1 - X_4$

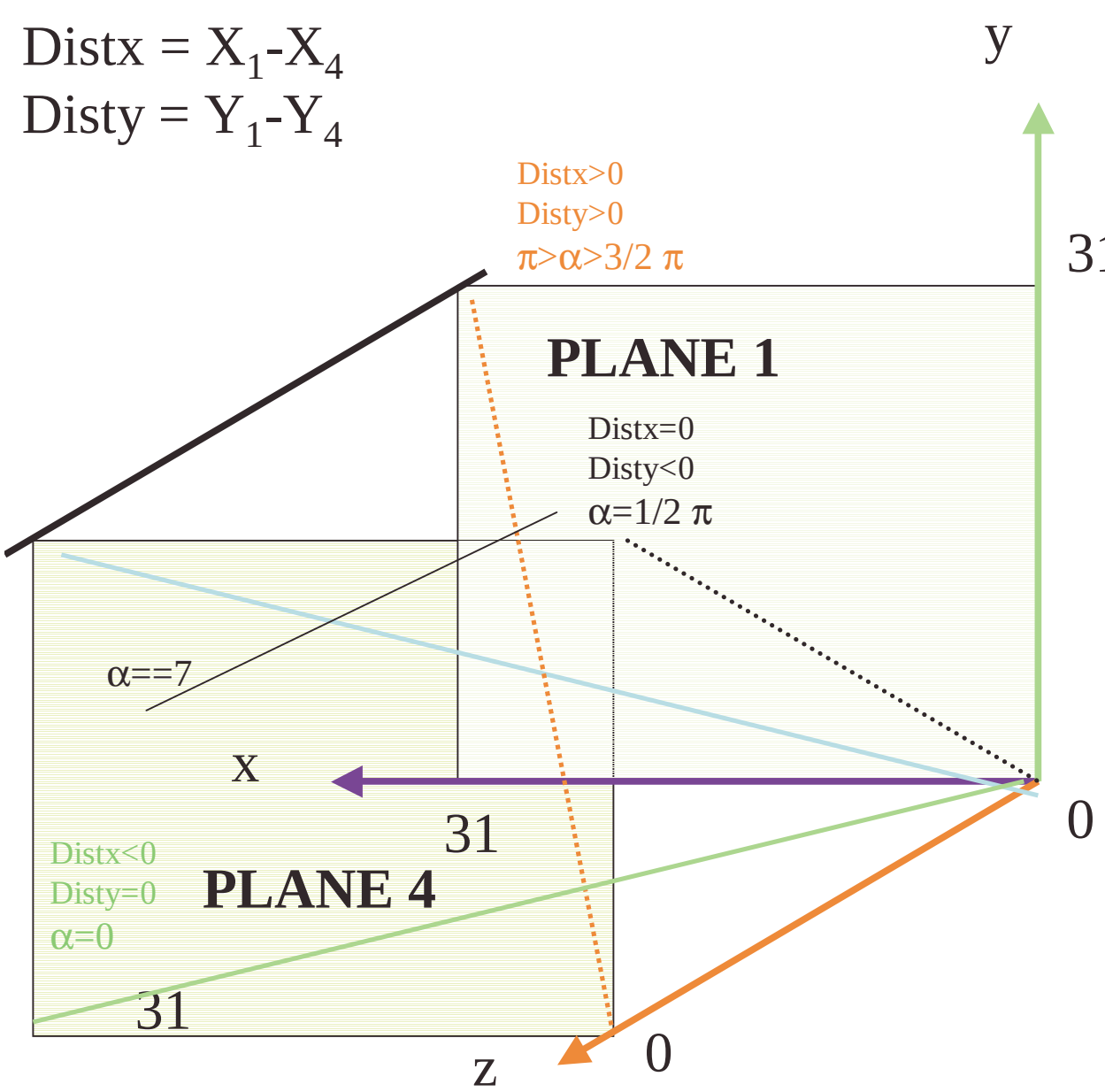
$Disty = Y_1 - Y_4$

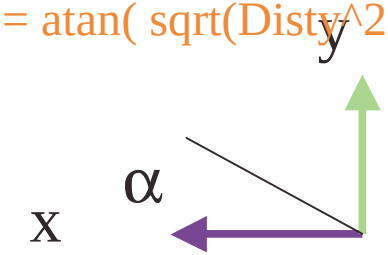
α=polar angle = atan(Disty/Distx)

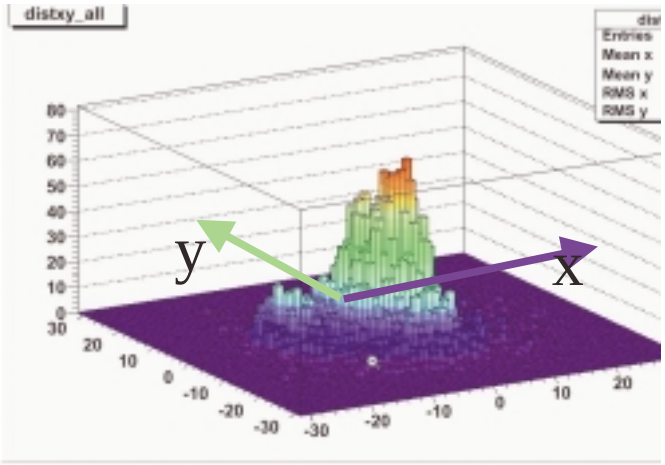
α=7 = vertical particles

θ= azimuthal angle

θ = atan(sqrt(Disty^2+Distx^2)/H



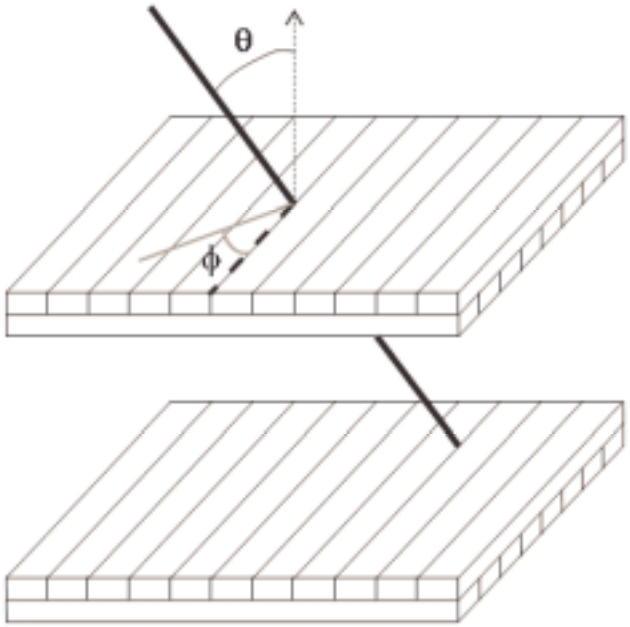




Angle of incidence

$$E = \frac{dE}{dx}\Delta x = \frac{dE}{dx}\frac{\Delta l}{\cos\theta} = \frac{E_0}{\cos\theta}$$

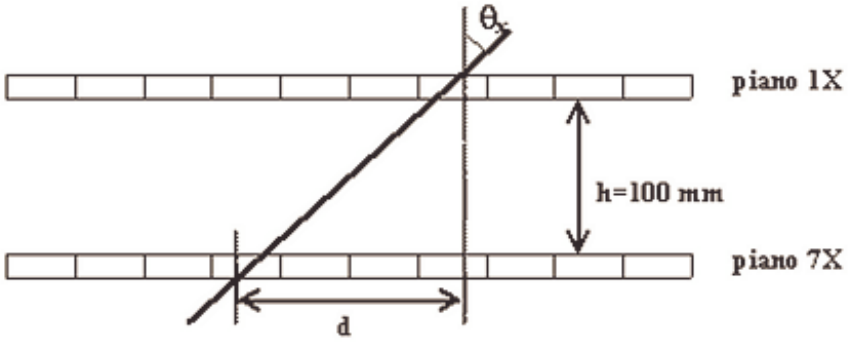
- Necessary for energy loss correction
- Directional instrument
- Non uniform response distribution



$\theta_{x\ -\ max\ incidence} = 39^o$

$\theta_{xy\ max\ incidende} = 48^o$

$\theta_{max\ probability} \cong 12^o$

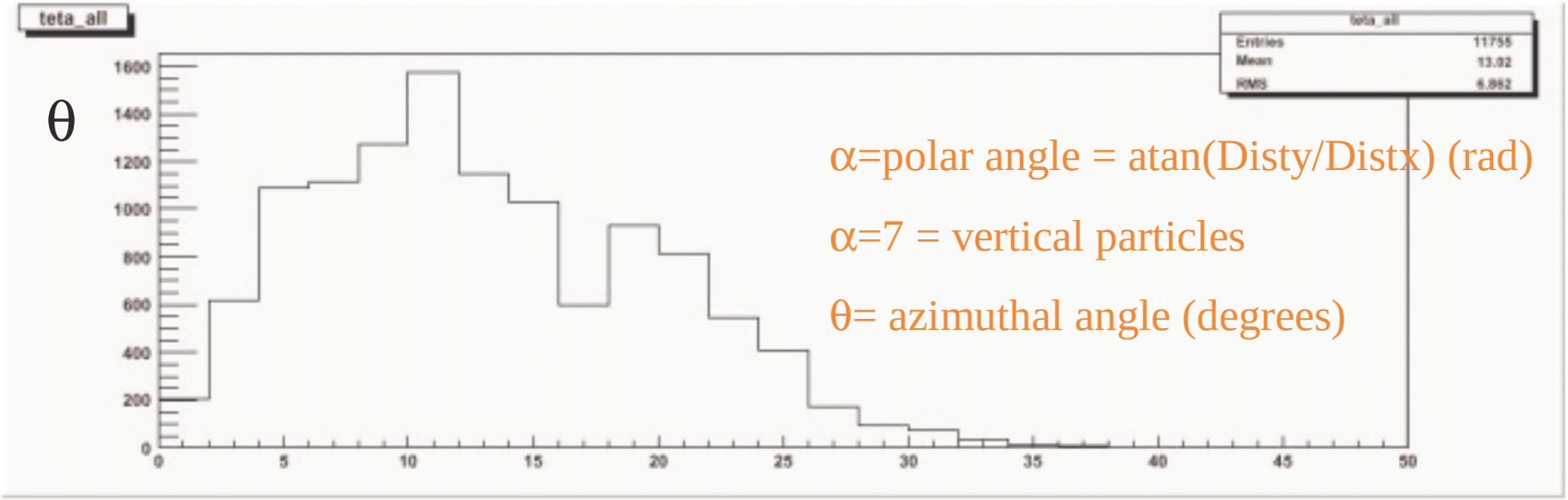


$$\theta_x = arctg\left(\frac{d}{h}\right)$$

$$\theta = arctg\left[\sqrt{tg^2\theta_x + tg^2\theta_y}\right]$$

$$\varphi = arctg\left(\frac{\sin\theta_x}{\sin\theta_y}\right)$$

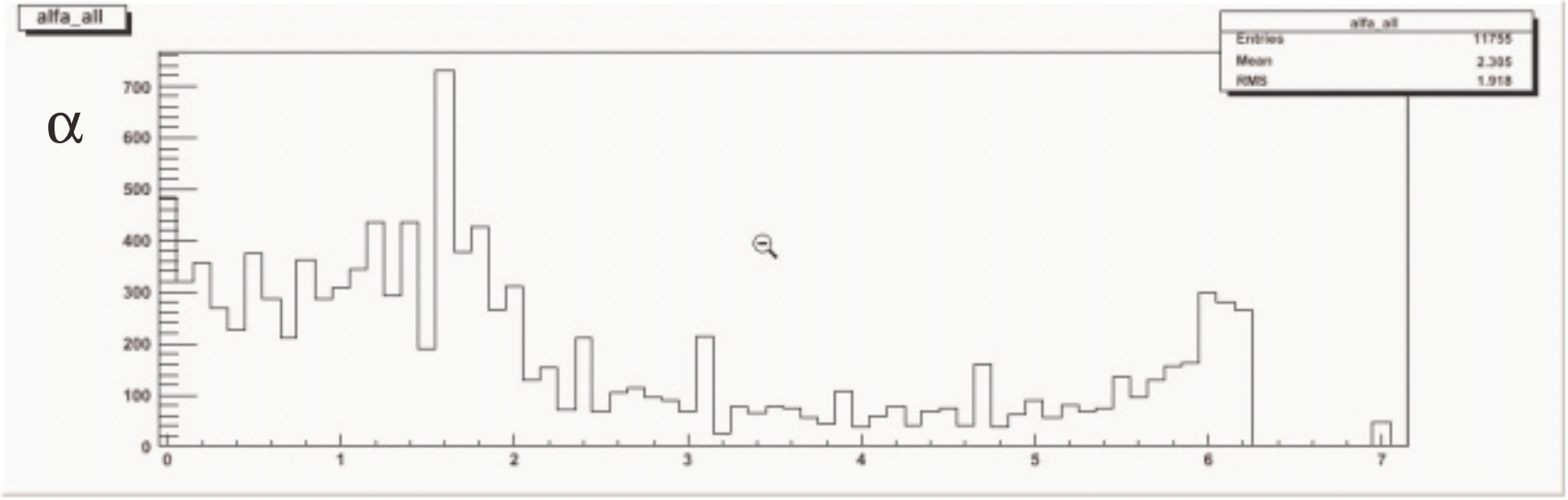
Angle of incidence: histogram of α and θ



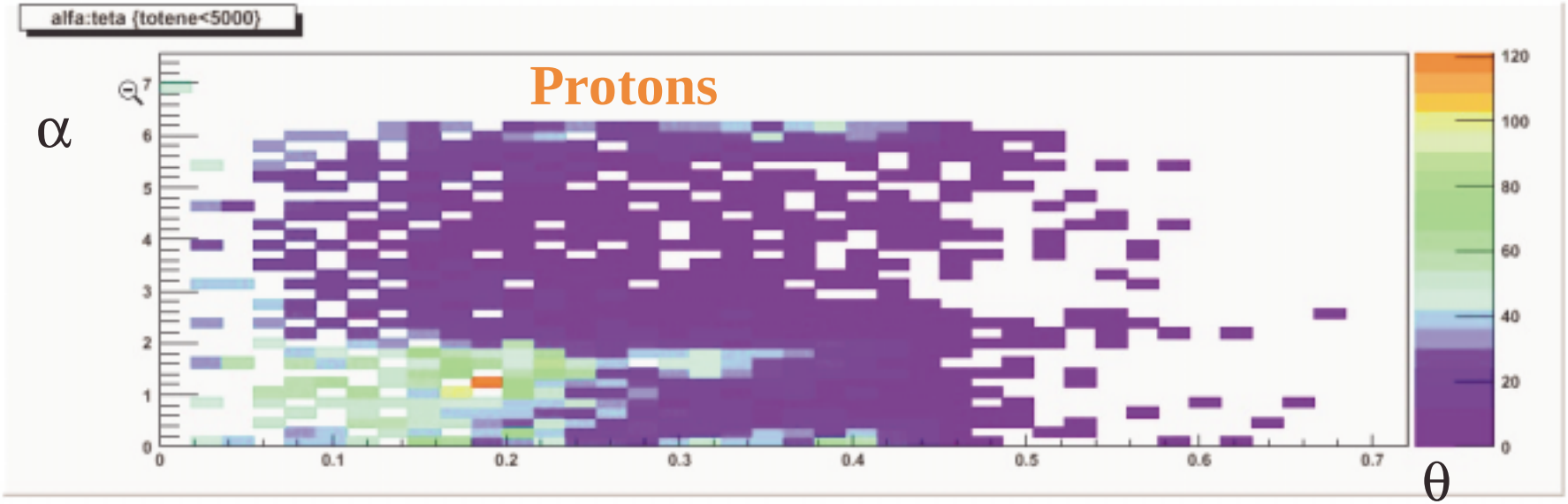
α=polar angle = atan(Disty/Distx) (rad)

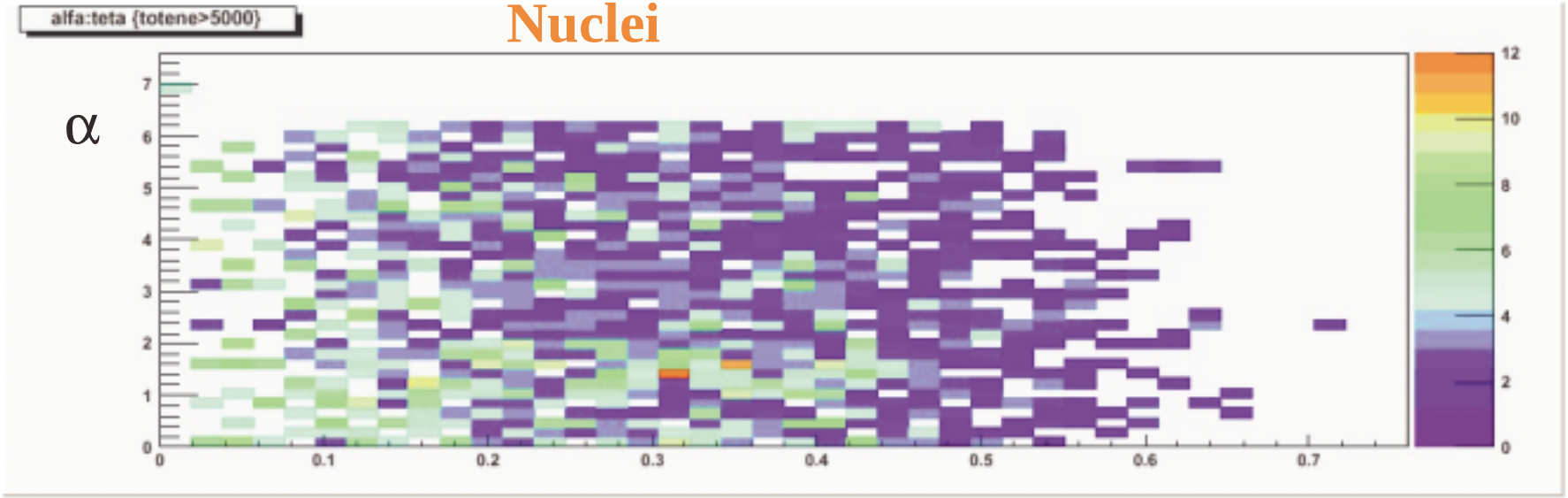
α=7 = vertical particles

θ= azimuthal angle (degrees)



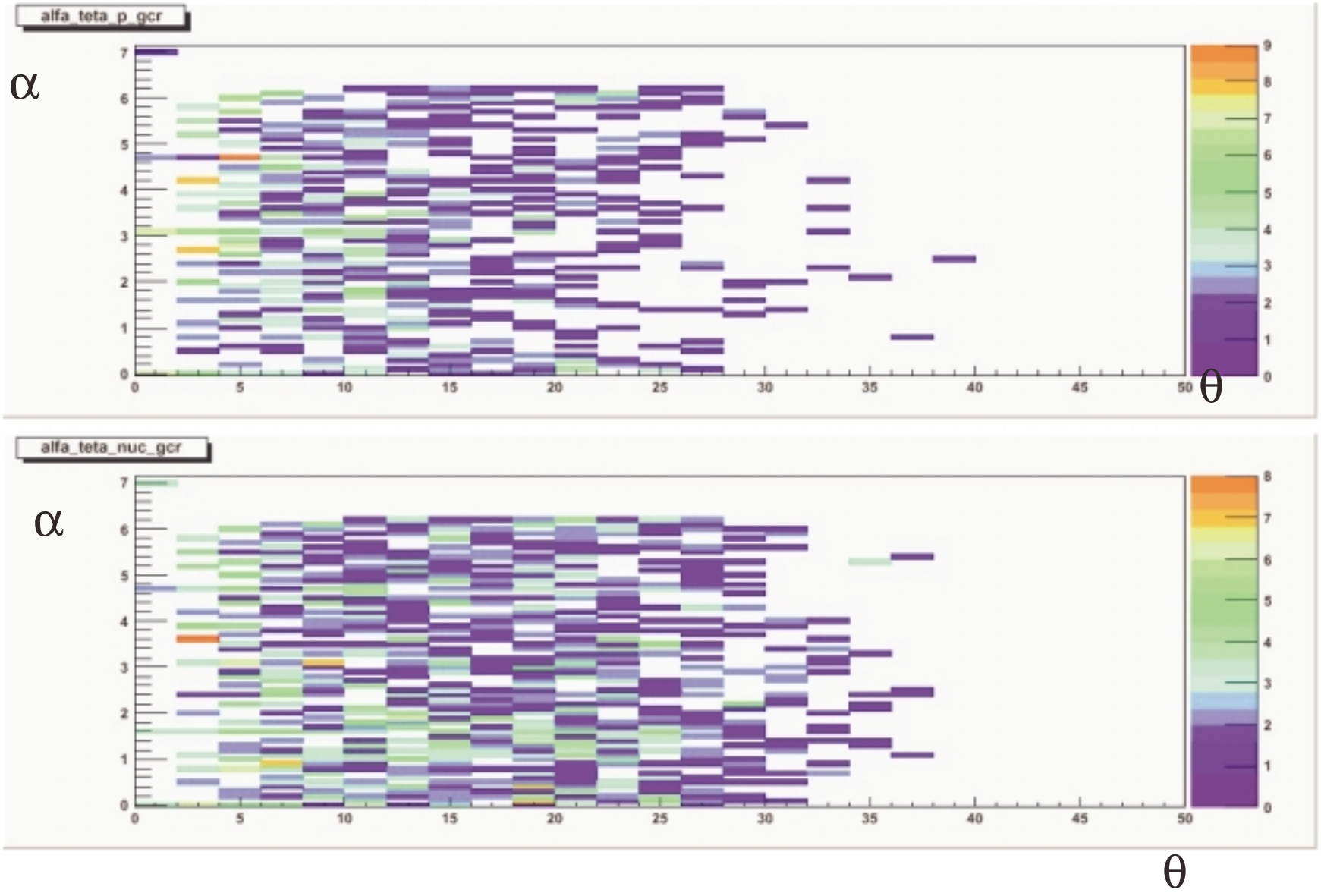
Angle of incidence:
Histogram of α - θ for proton and nuclei





GCR

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

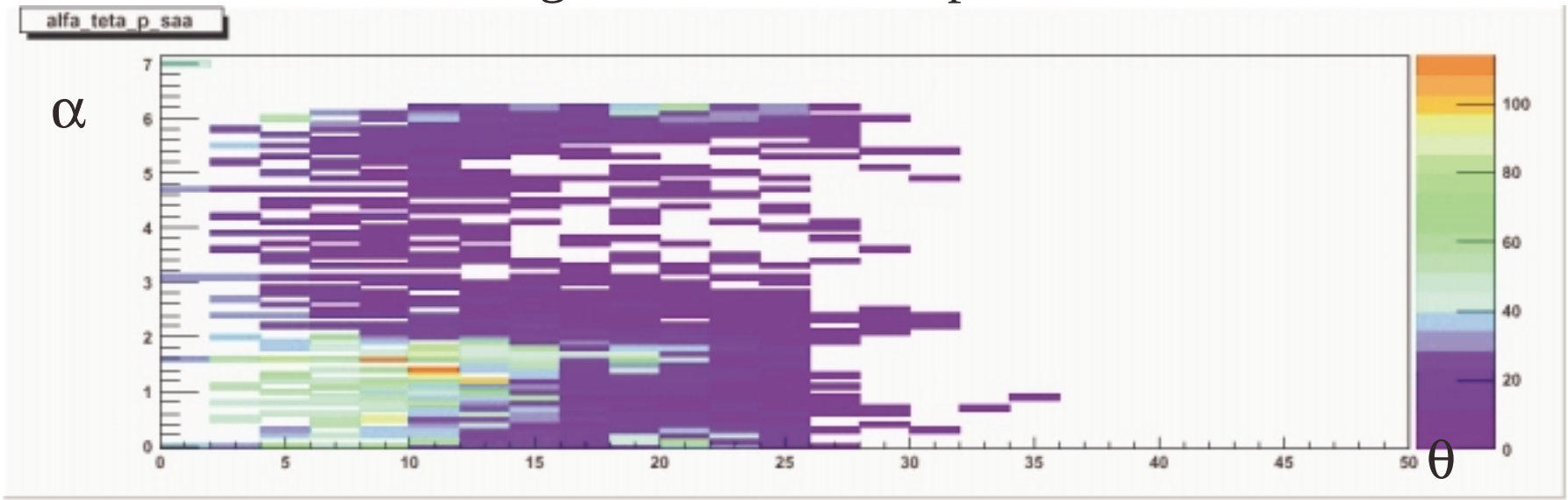


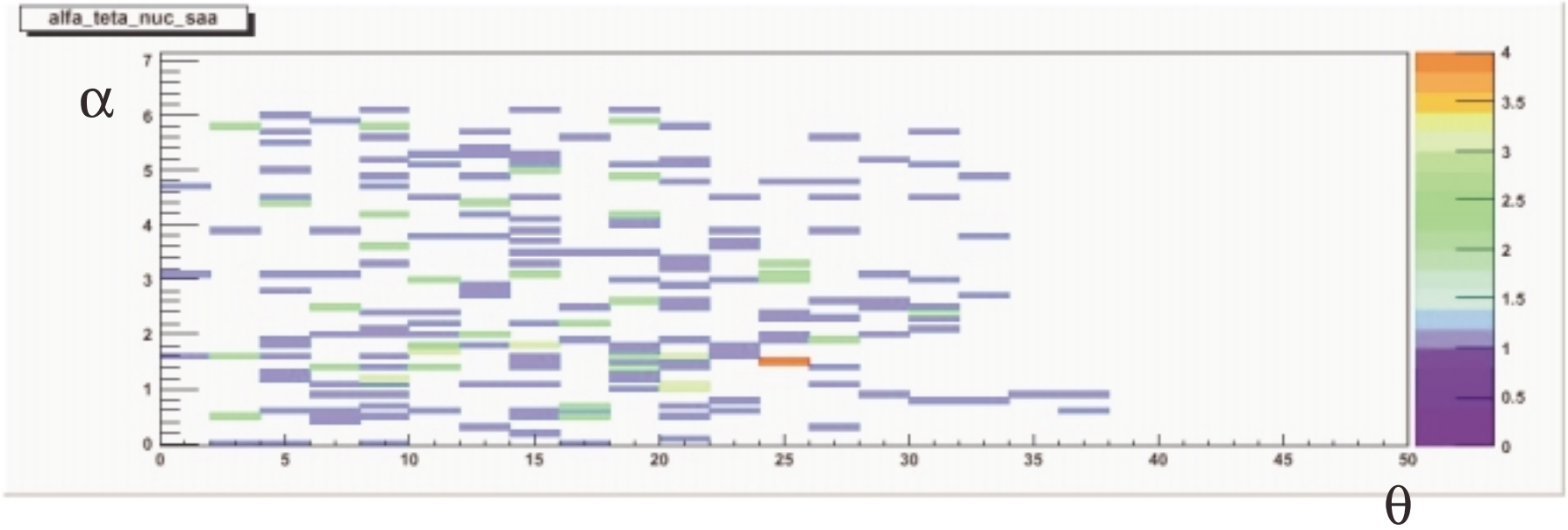
Low latitude region

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

SAA

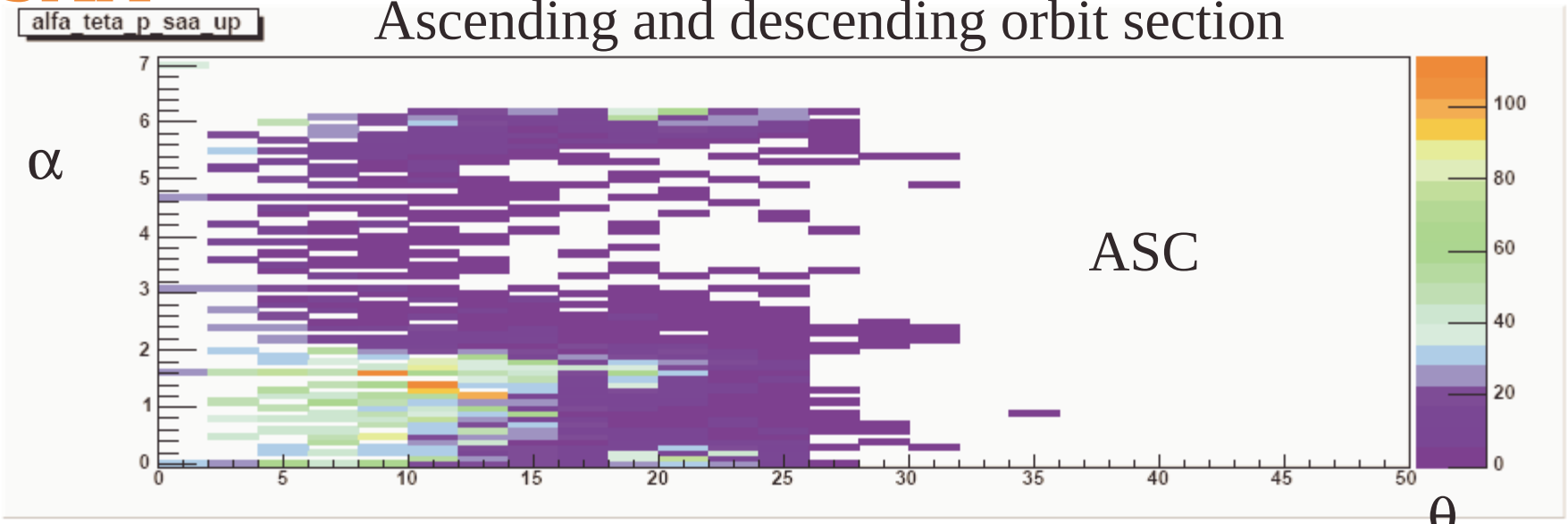
Angle of incidence:
Histogram of α - θ for proton and nuclei

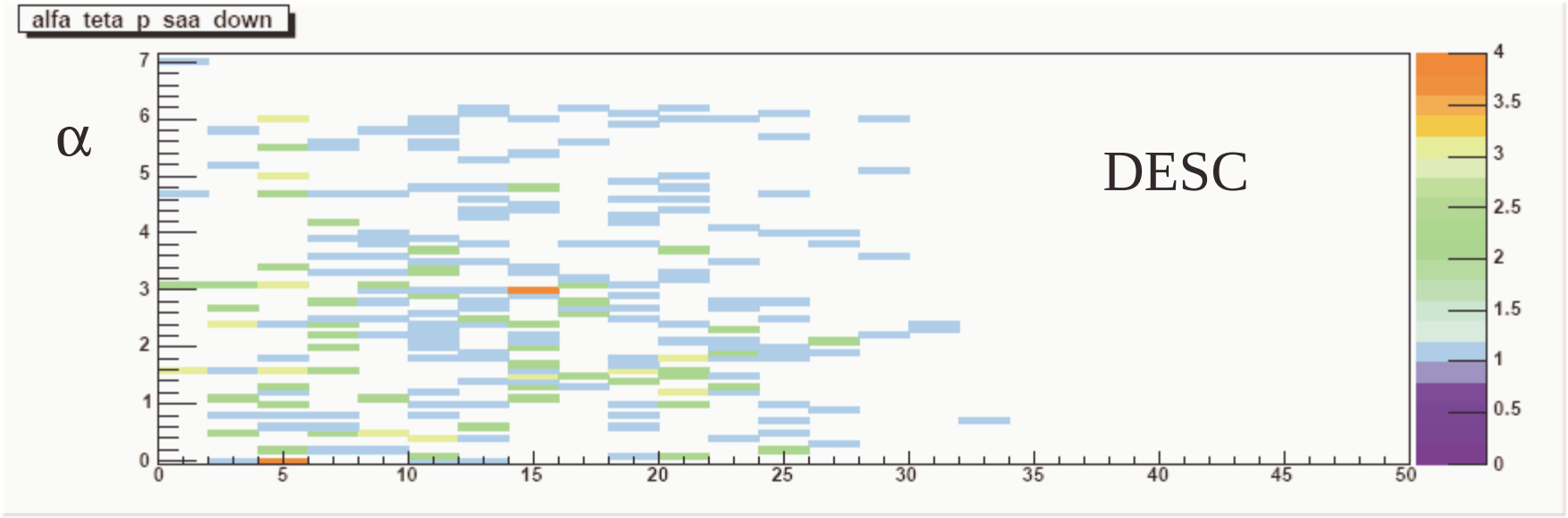




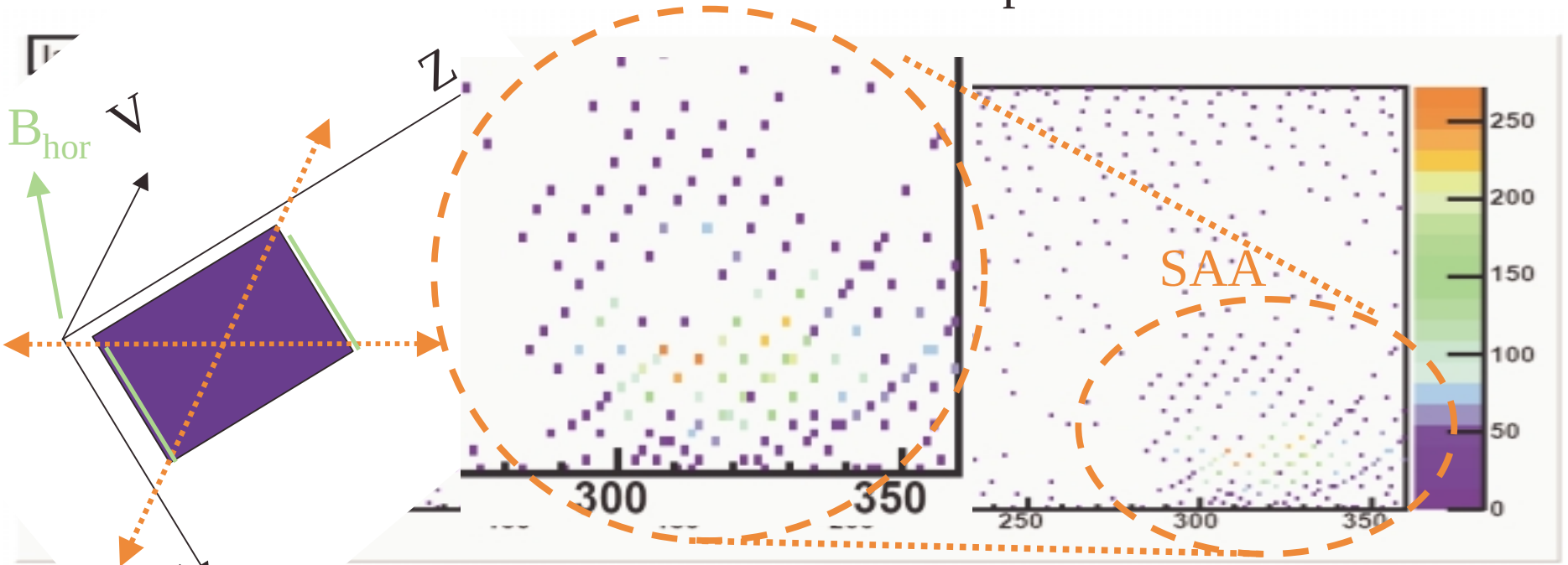
SAA

Angle of incidence:
Ascending and descending orbit section

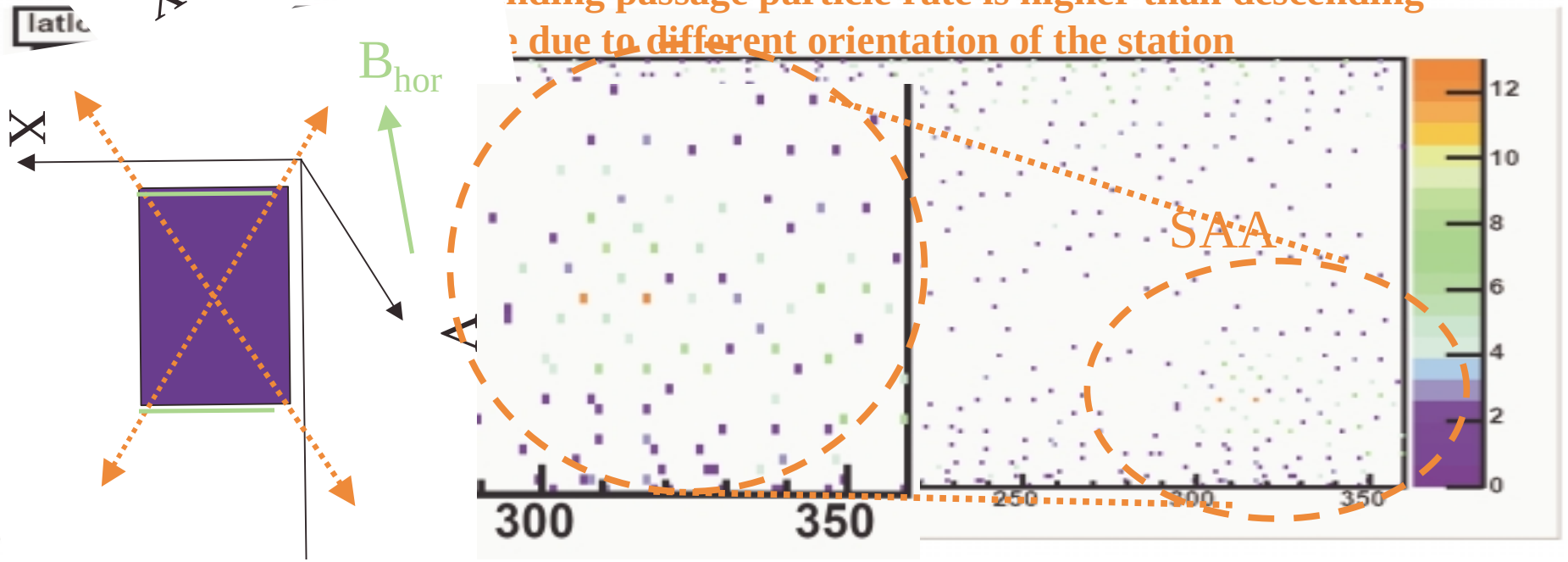




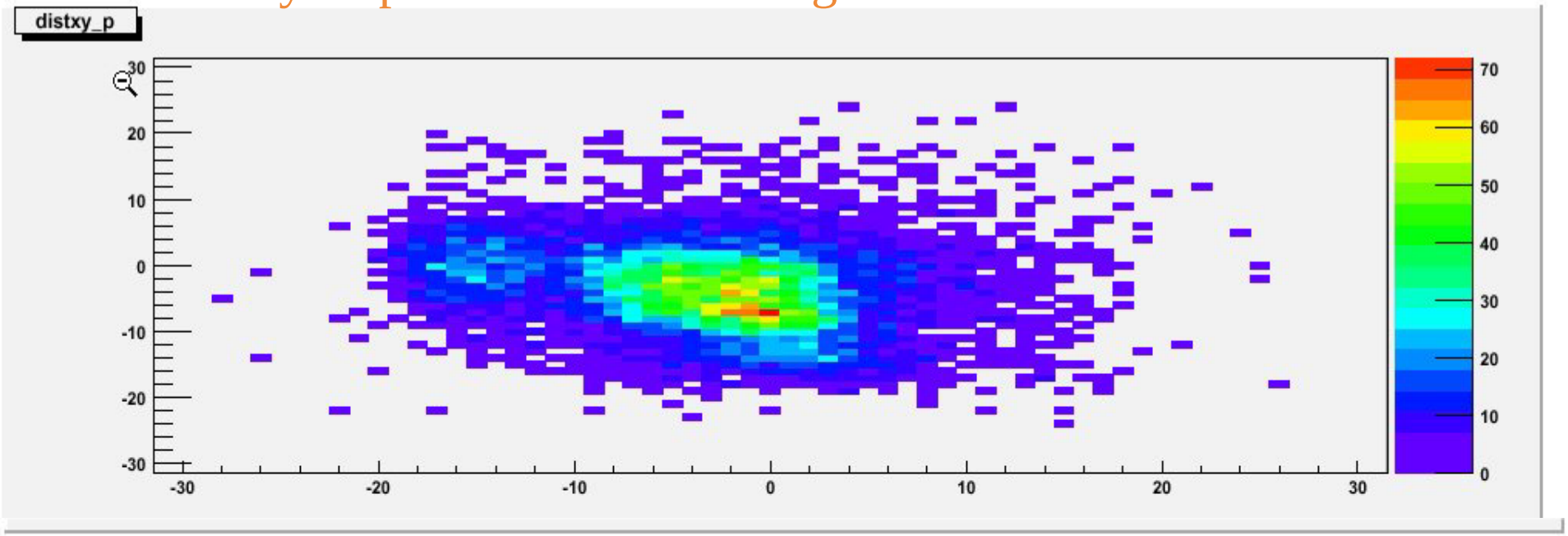
article rate as function of position



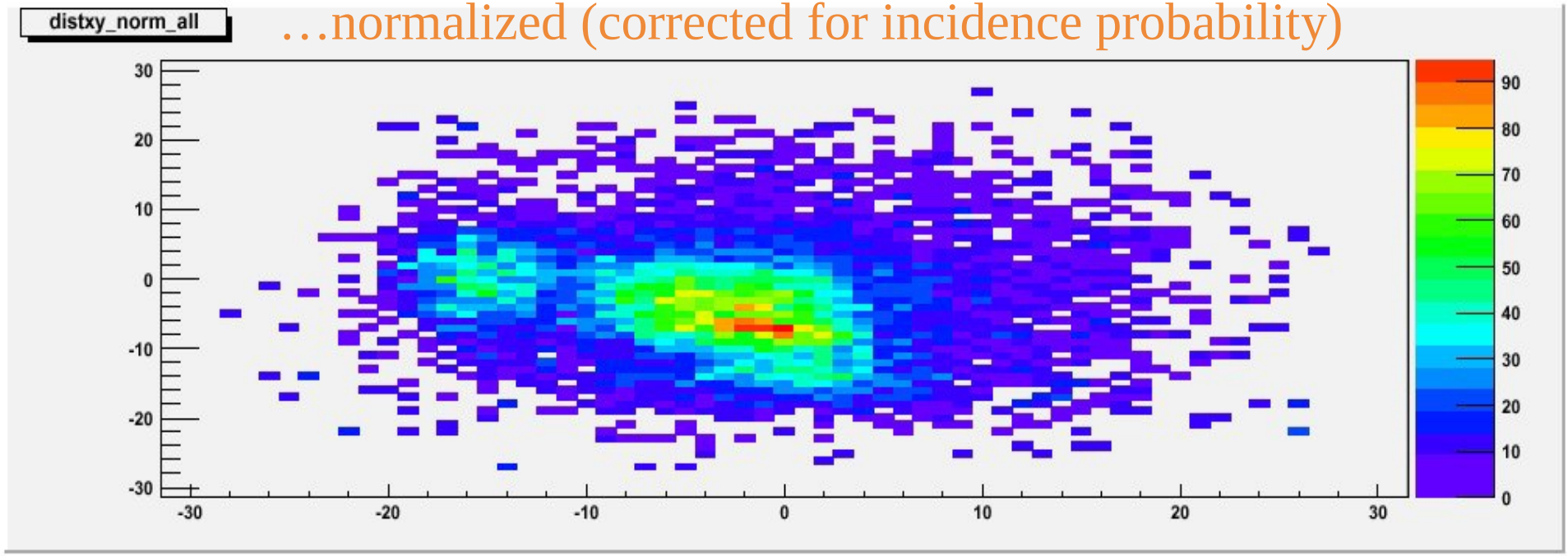
nding passage particle rate is higher than descending
e due to different orientation of the station



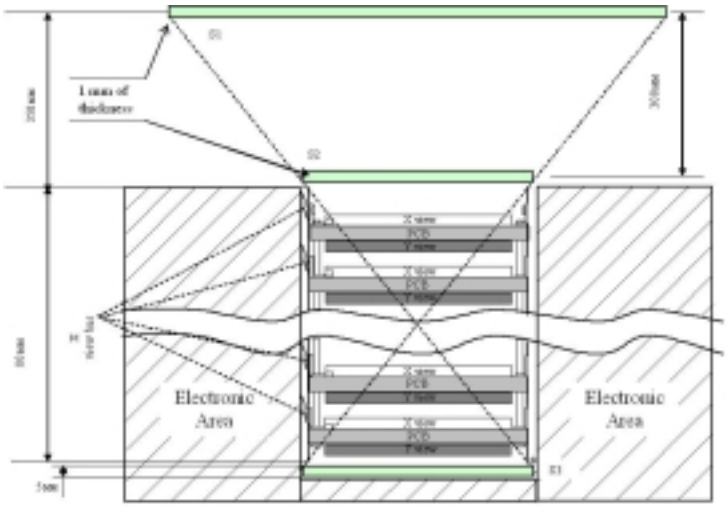
Necessary response correction Original DeltaX-DeltaY distribution…



…normalized (corrected for incidence probability)



Future Work



- Reactivation of the device

(M. Shavers, F. Cucinotta, V. Shurshakov)

- Continuation of analysis

(pitch angle and multitrack)

- Use of Neural Networks to perform particle and energy identification
- Realization of external detector (Si-rad)
- Altea