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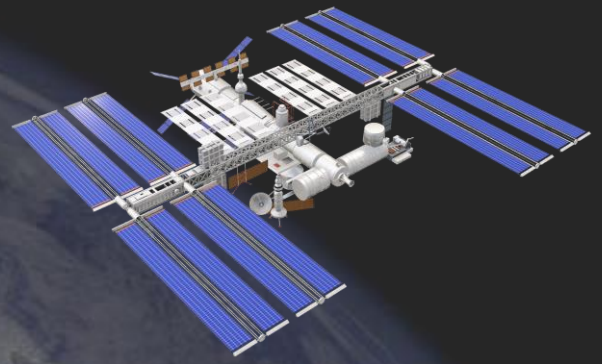
UNIVERSITÀ DEGLI STUDI DI ROMA
Dipartimento di Fisica

HSERLAB
Human Space Exploration Radiation LAB



LIDAL: Nuclear Discrimination

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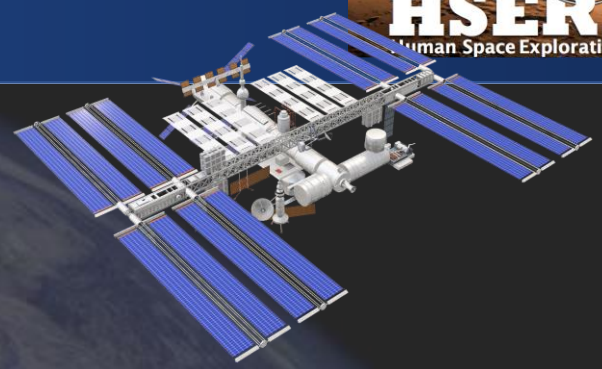
Overview



- LIDAL Introduction
- Goal: Minimization of Astronauts' Radiation Risk
- How: Nuclear Discrimination
- Current Results
- Future Perspective

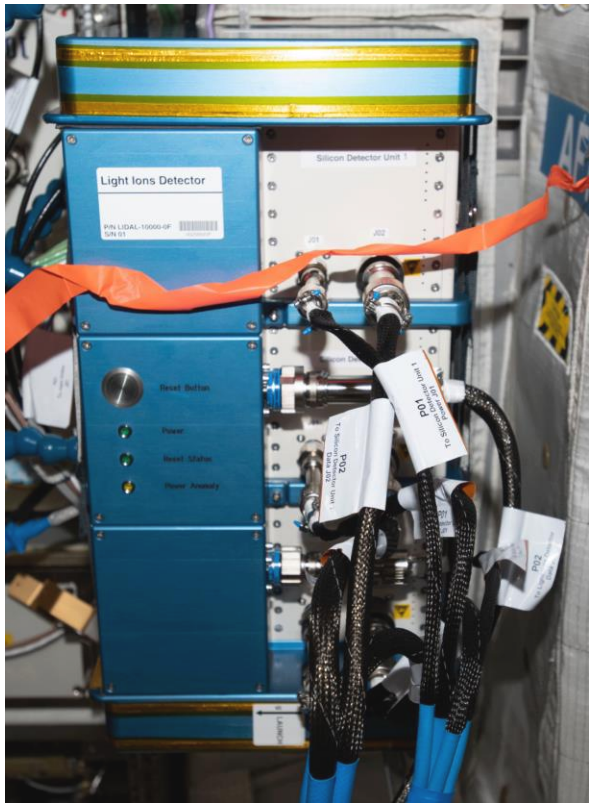
Astronauts' Radiation Risk

To understand the risks for astronauts, particle track-structure and energy deposition in biomolecules, cells, and tissues are described by the parameter $\frac{Z^2}{\beta^2}$

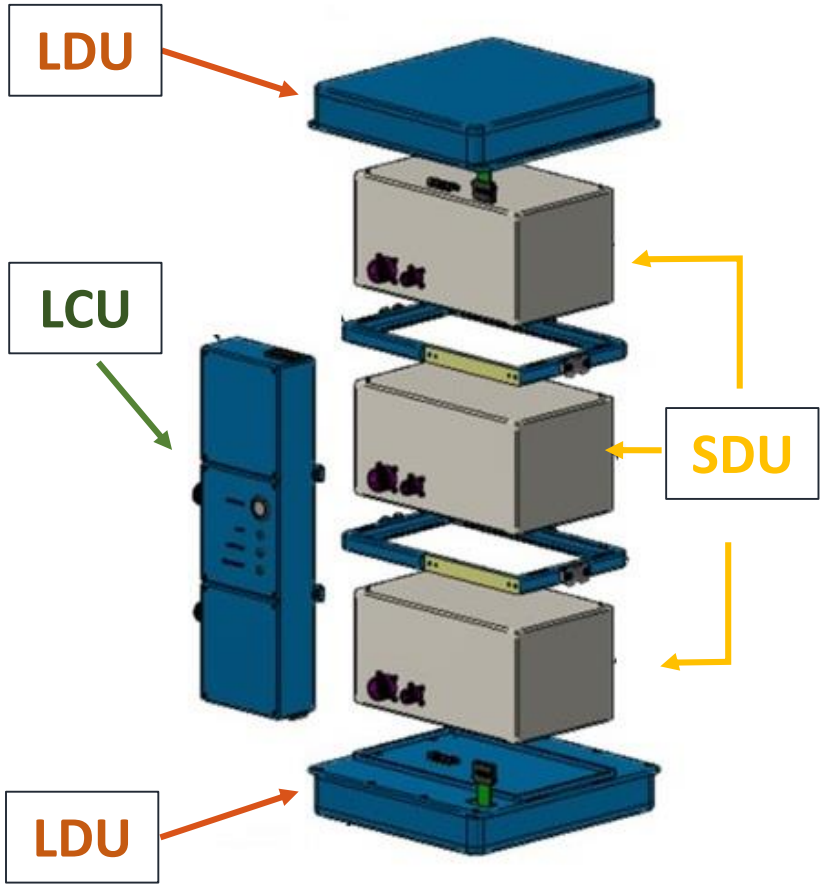
SPE

GCR

LIDAL - Light Ion Detector for ALtea



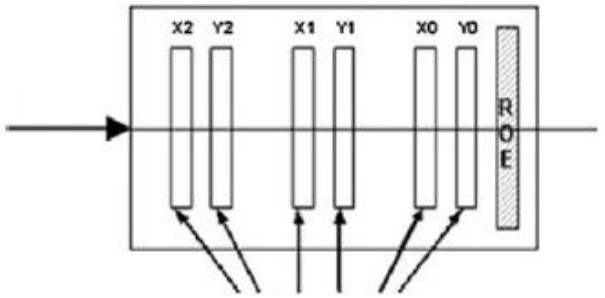
LIDAL detector on board the ISS



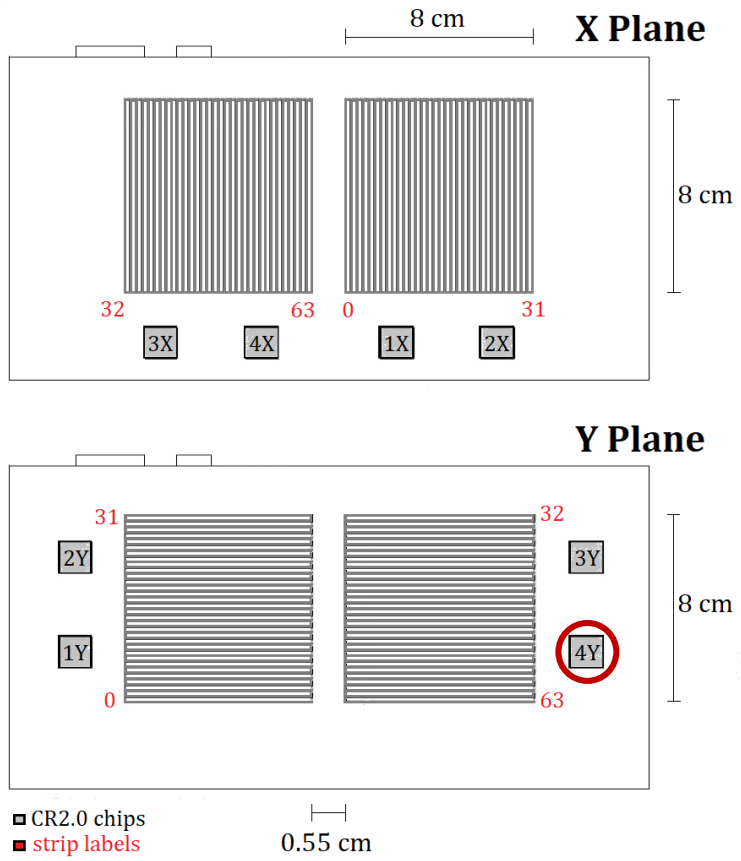
LDU: LIDAL Detector Unit
LCU: LIDAL Control Unit
SDU: Silicon Detector Unit
DAU: Data Acquisition Unit

Scheme of LIDAL system

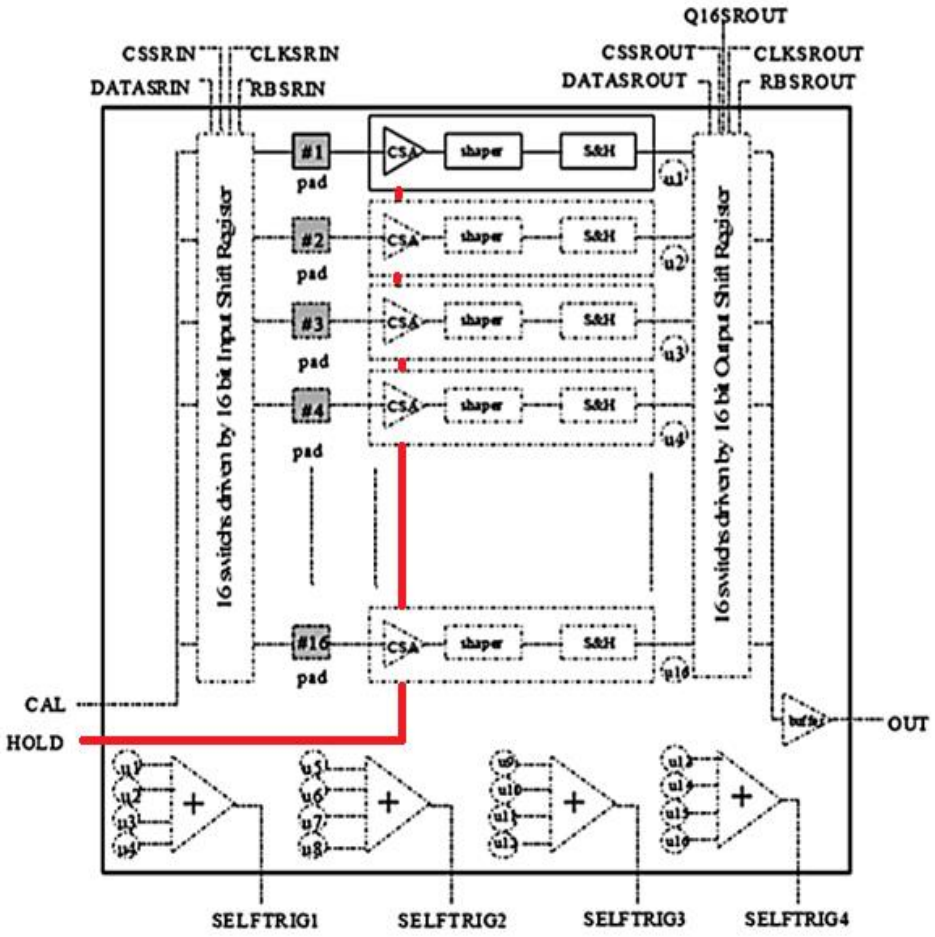
SDU



$8 \times 8\ cm^2$ silicon chips
380 µm thick
segmented in **32 strips**
strips' pitch of 2.5 mm



Scheme of X-Y planes from above

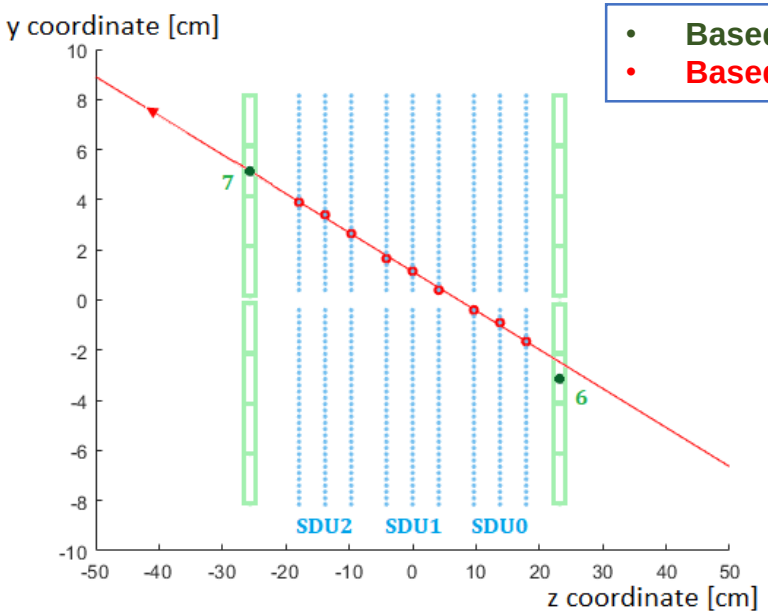


Schematic of the integrated chip CR2.0

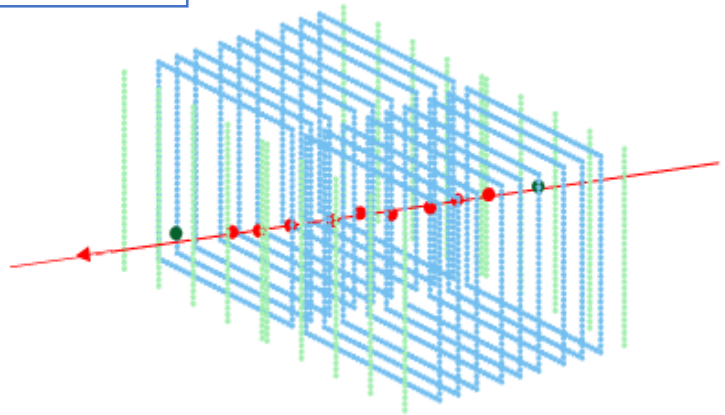
LIDAL Particle Discrimination

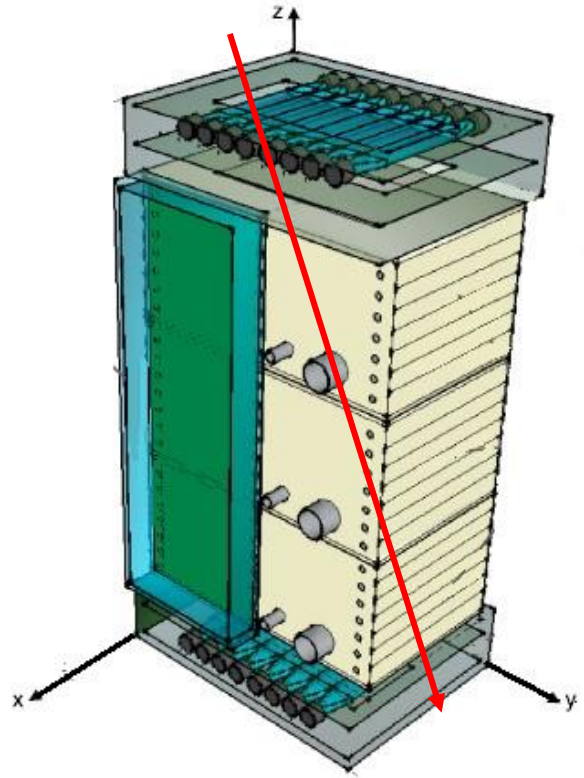
LIDAL allows measurement of the energy released by the particle passing through the detector and measurement of Time of Flight (ToF)

$$\frac{Z^2}{\beta^2}$$



- **Based on LCUs data**
- **Based on SDUs data**





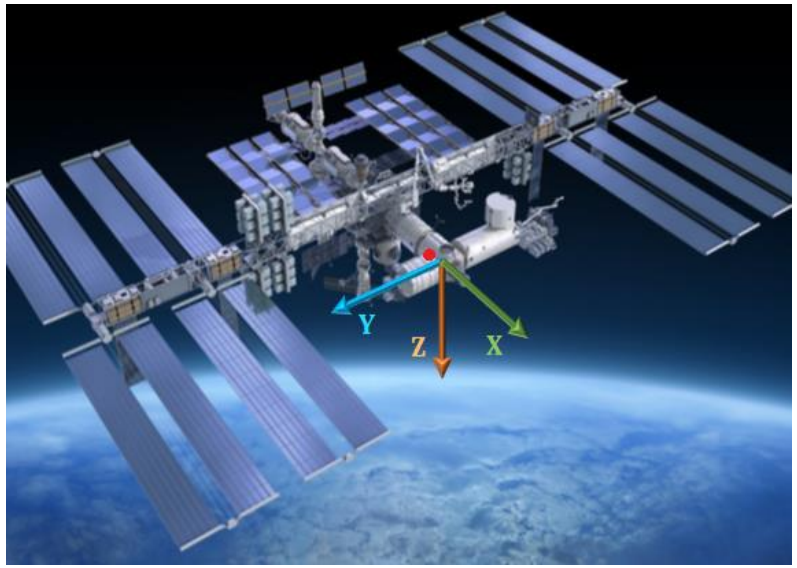
Real trajectory of a particle through the several layers of **LIDAL**

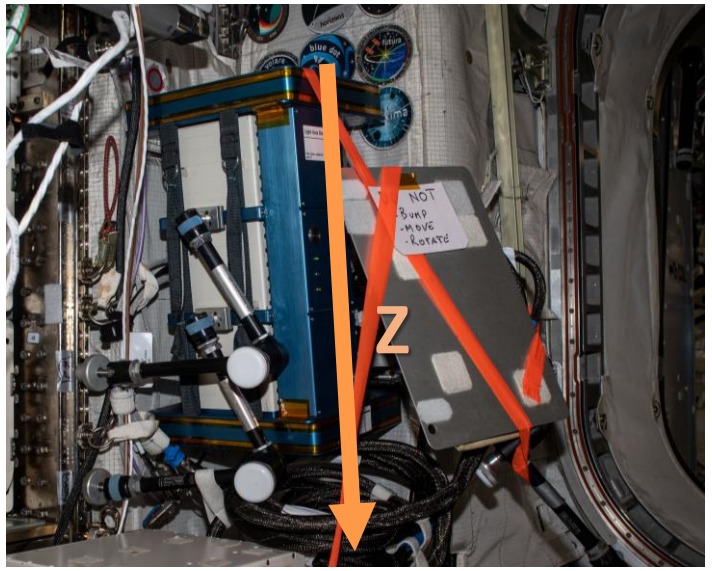
LIDAL Positions

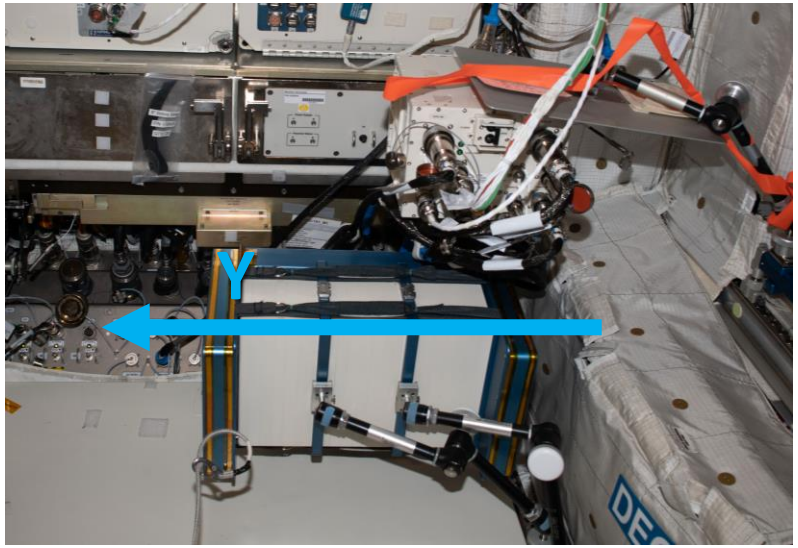
LIDAL in the three positions in **Columbus** module.

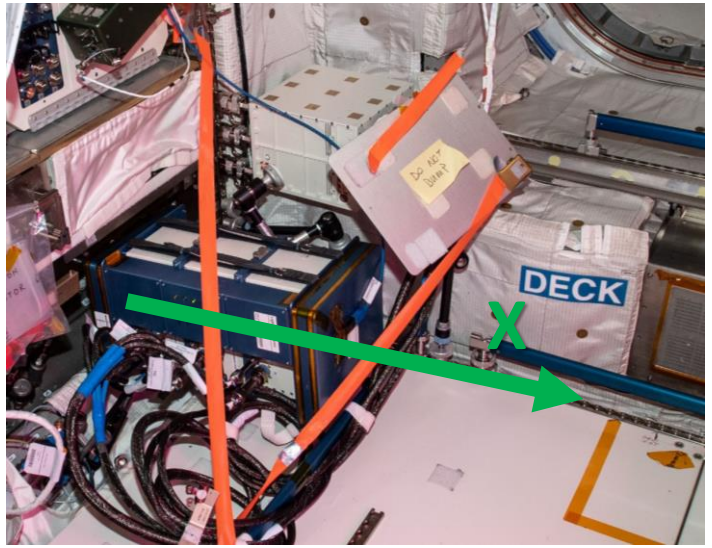
Position	date	Approximate duration (months)
Z	Start 19/01/2020	
Z	End 12/02/2021	13
Y	Start 12/02/2021	
Y	End 16/09/2021	7
X	Start 16/09/2021	
X	End 05/06/2022	6

Now still running in Z Position

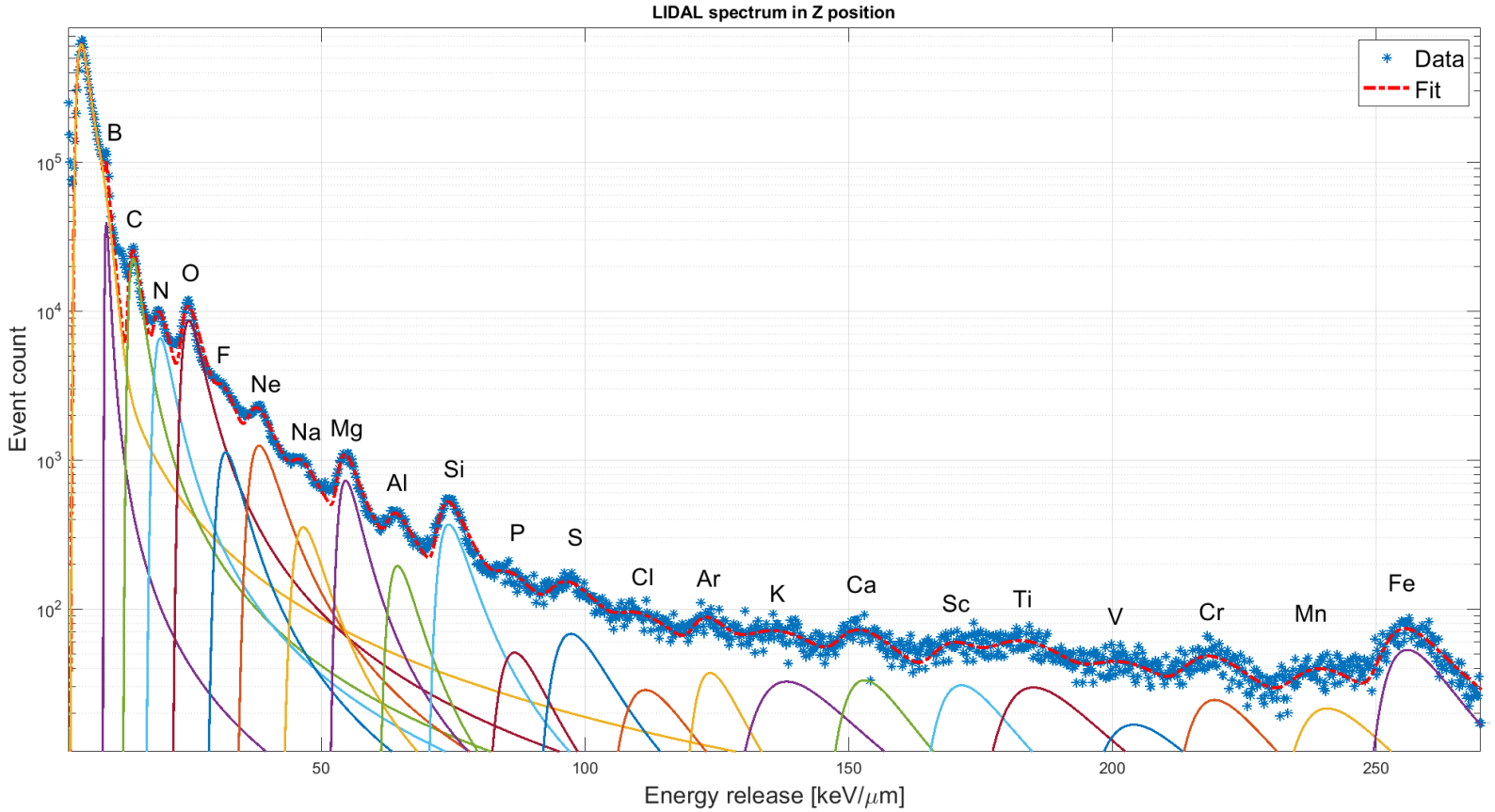


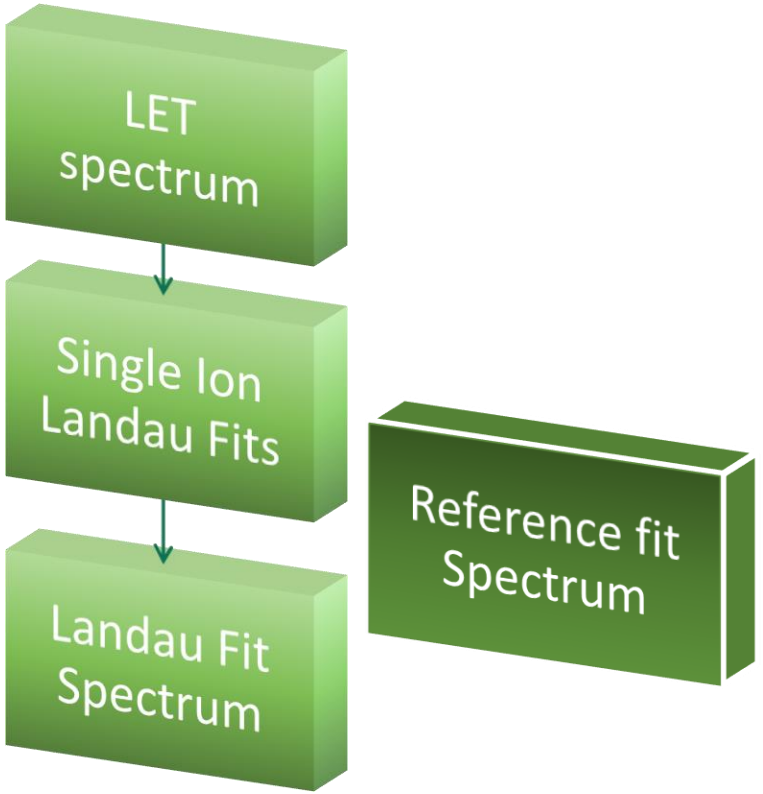




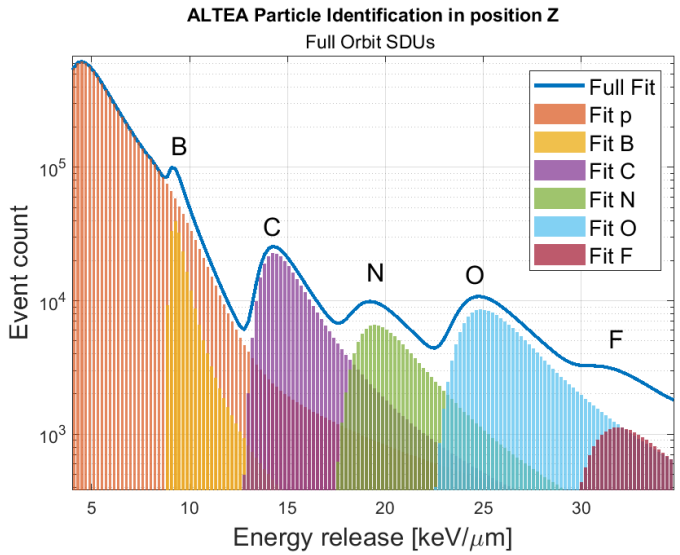


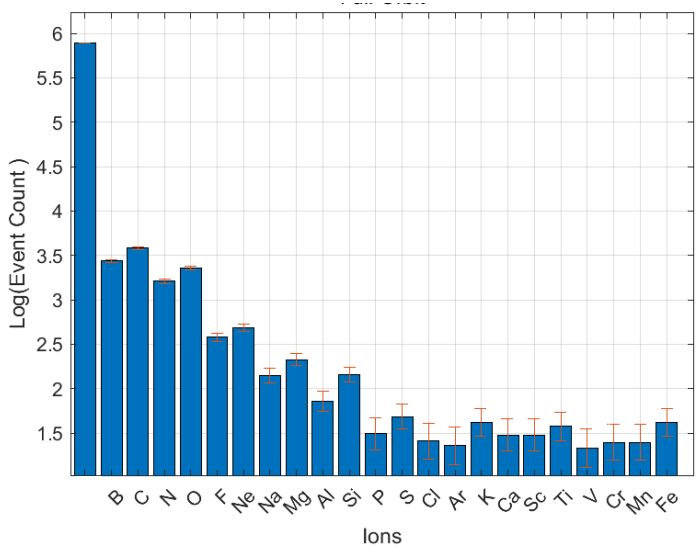
Energy Release Spectrum

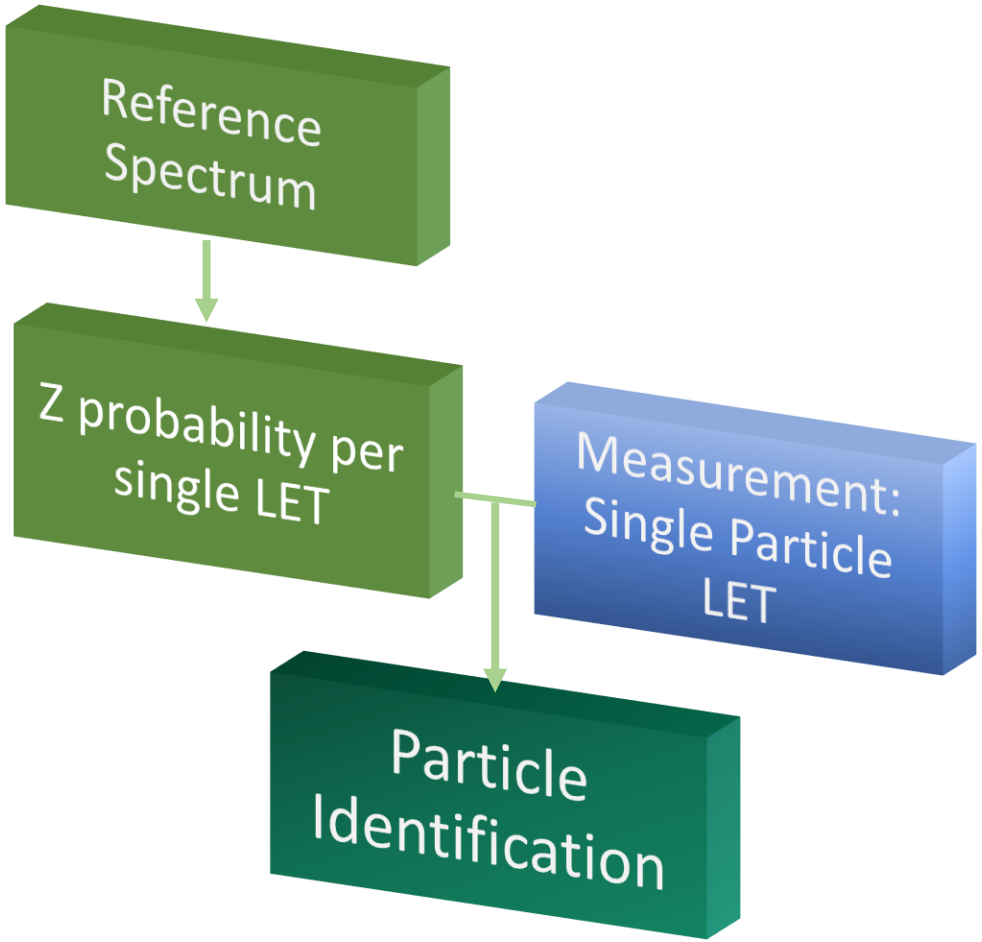




Particle Discrimination





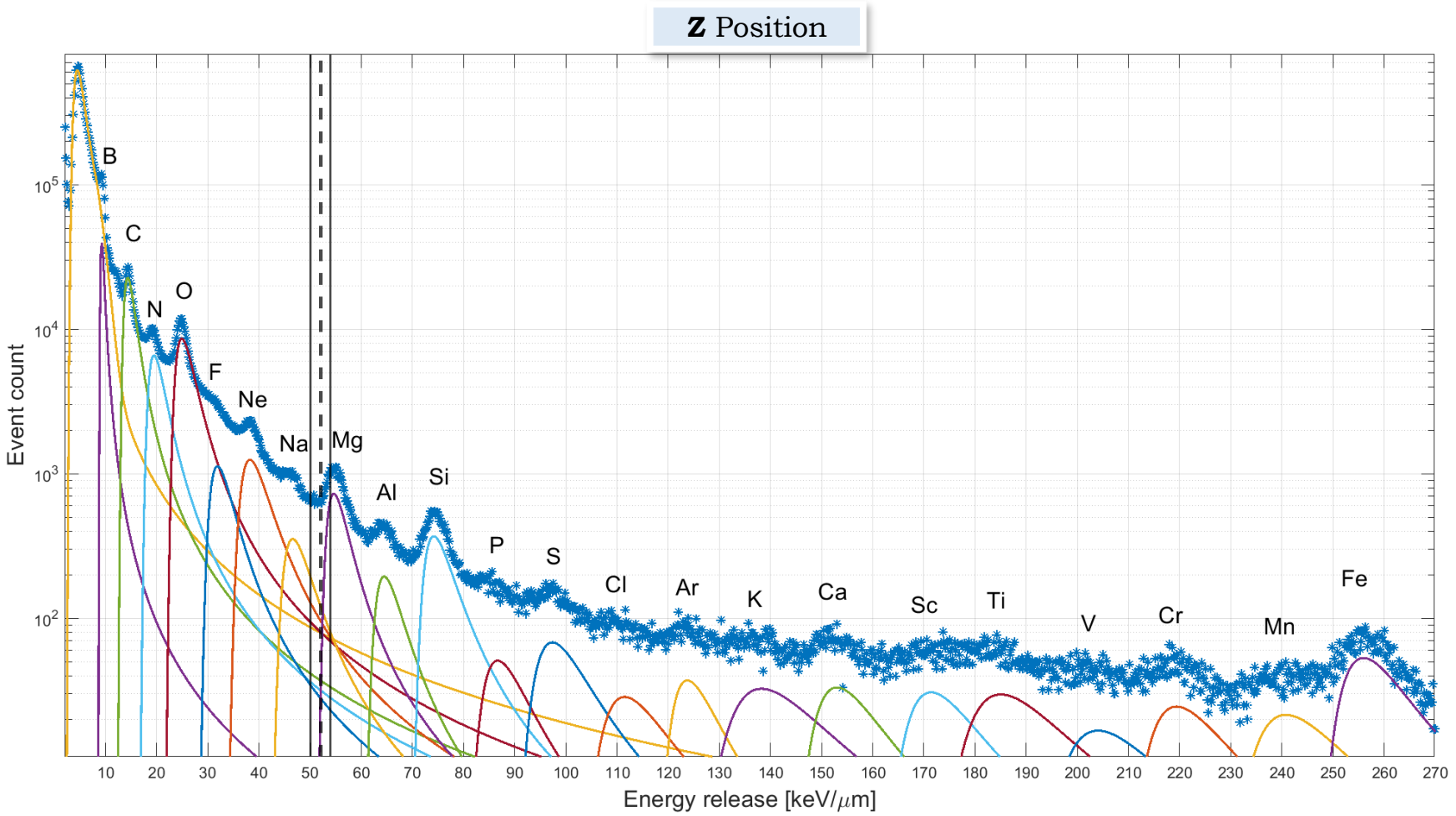


Particle Discrimination

Probability per single LET:

$$IonProb(E,Z) = \frac{Landau_z(E)}{Fit(E)}$$

ION CANDIDATES Energy Release $(52 \pm 2)\ keV/\mu m$
H or He or Li or Be (15,9 %)
B (1.1%)
C (7.5 %)
N (6.4%)
O (16.2 %)
F (5.7 %)
Ne (19.7%)
Na (25.4%)
Mg(2.0%)



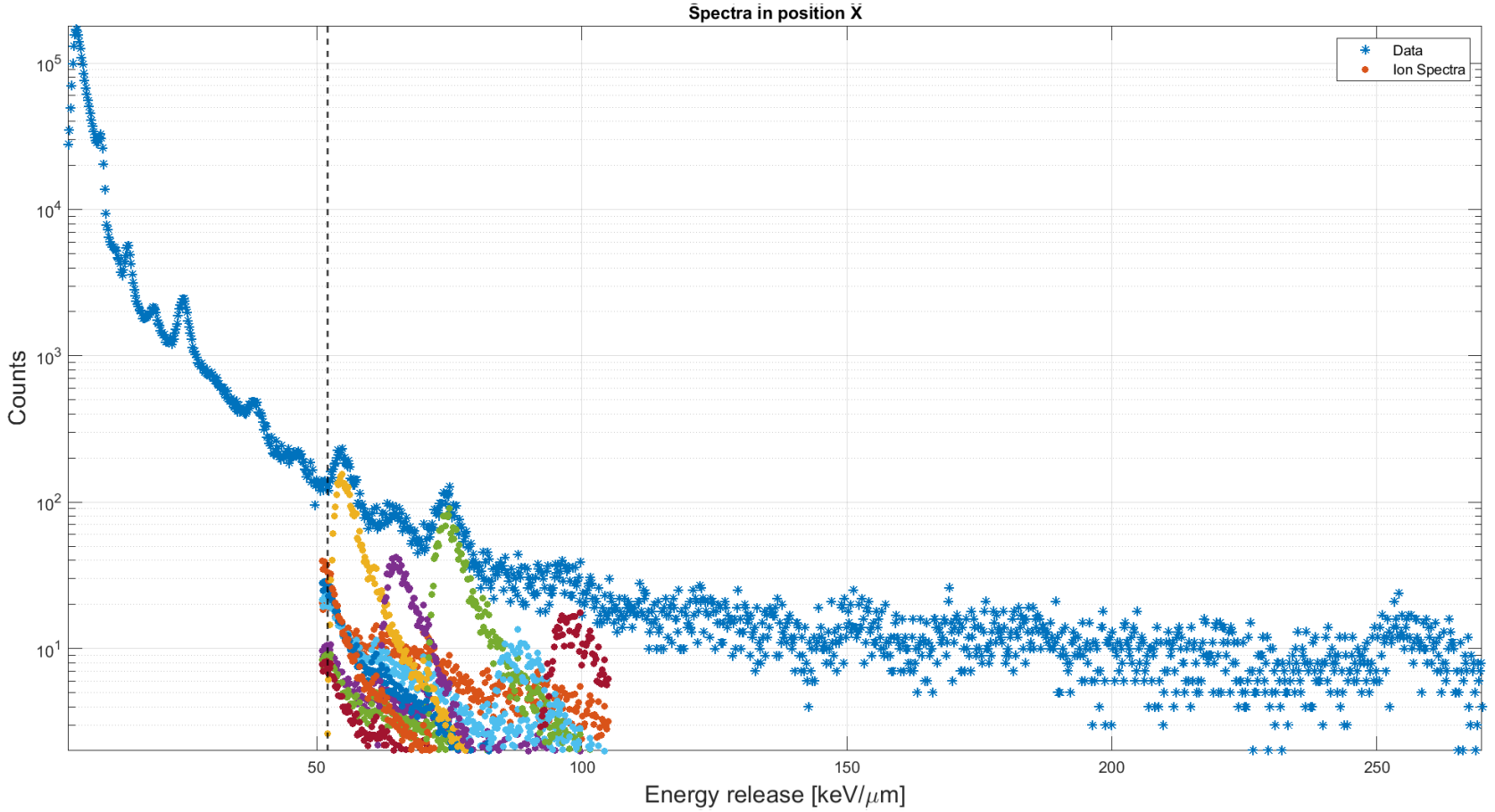
Particle Discrimination

Use the reference spectrum of LIDAL in Z direction to calculate Landau curves on spectra in X or Y direction.

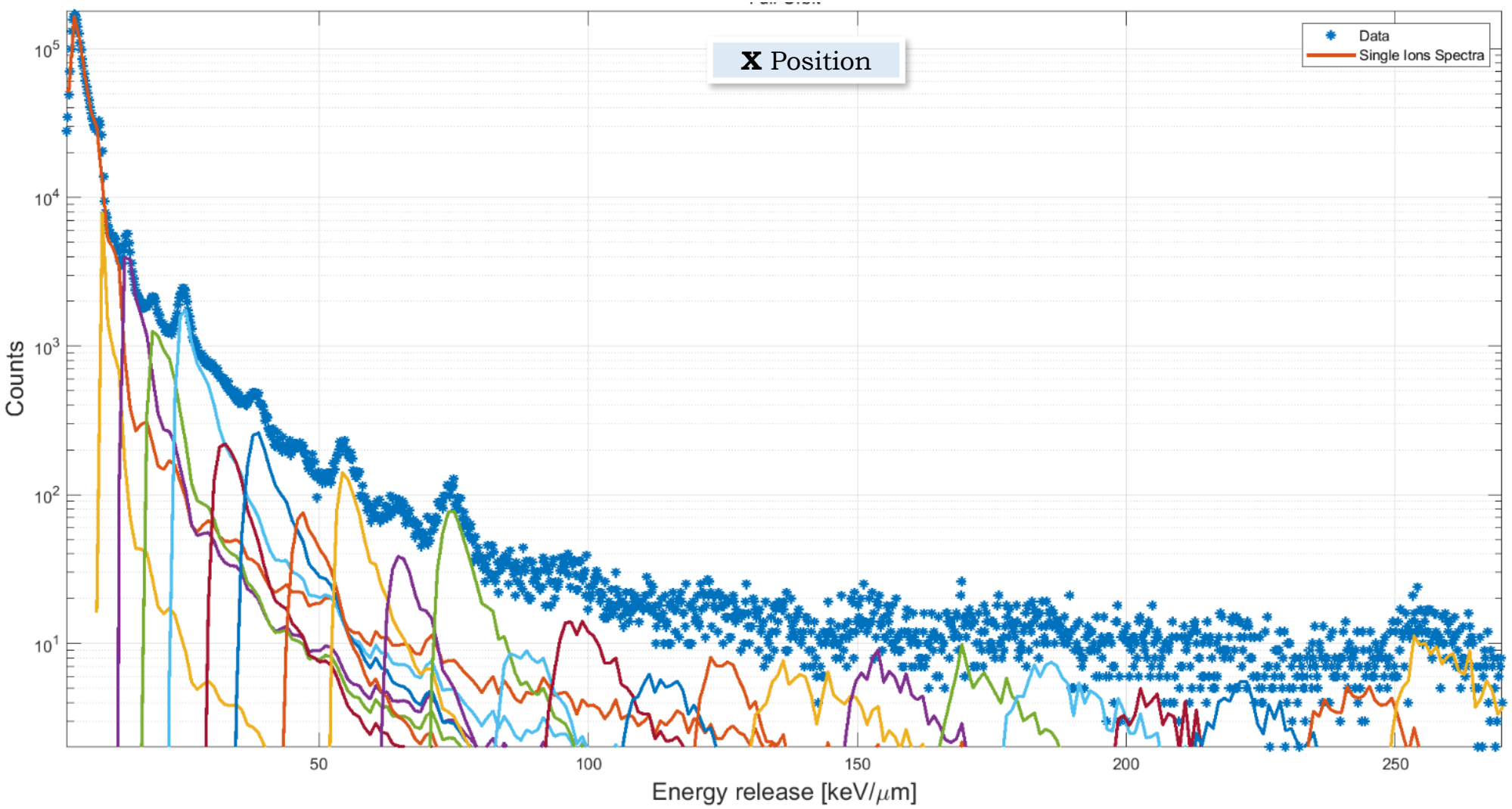
IonProb · Data X= X Ion Spectra

	Ion Probability	Ion Spectra (Counts)
< Be	15,9 %	21
B	1.1%	1
C	7.5 %	10
N	6.4%	8
O	16.2 %	21
F	5.7 %	7
Ne	19.7%	26
Na	25.4%	33
Mg	2.0%	3

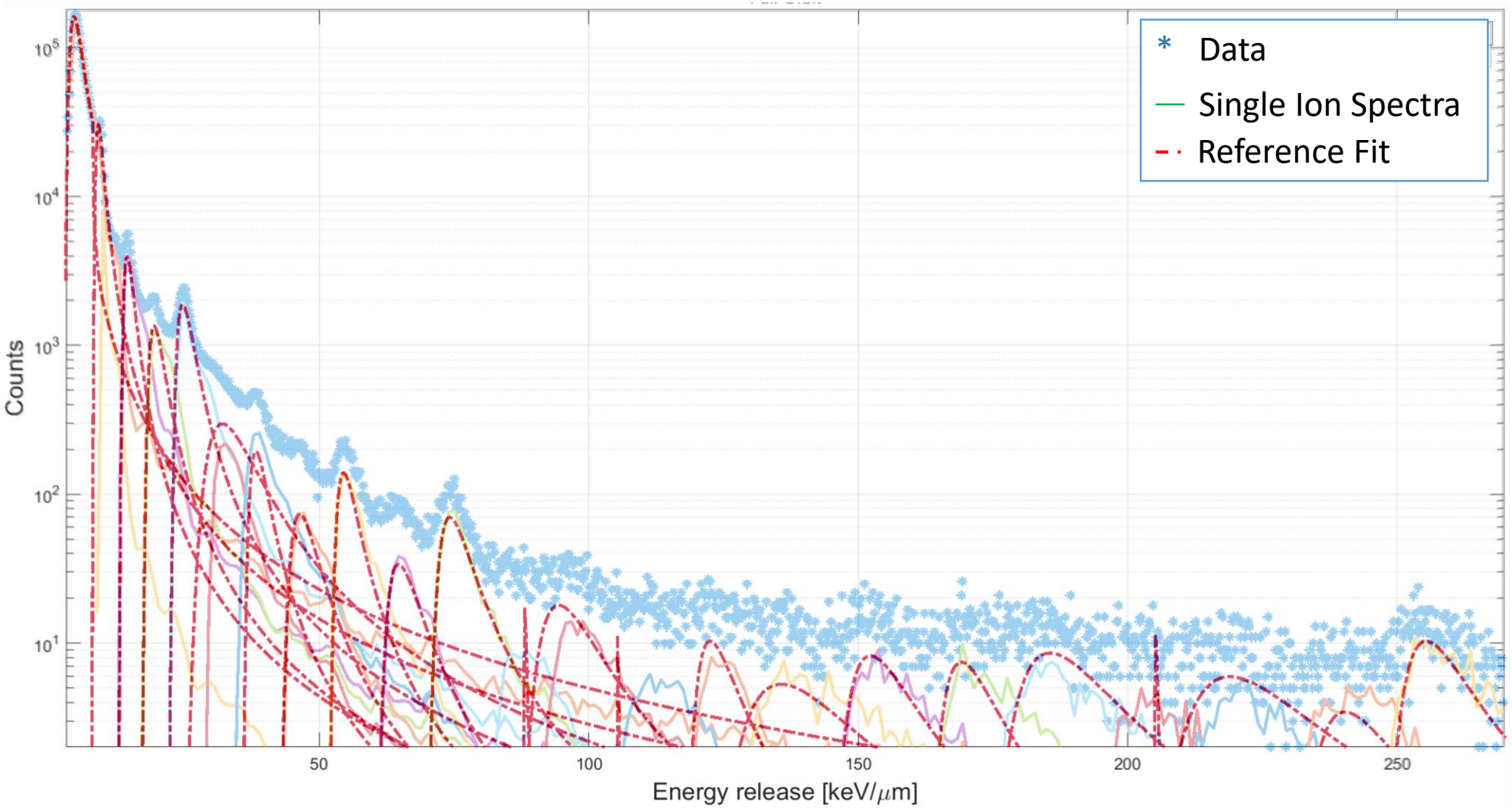
Energy Release of 52 Kev/µm



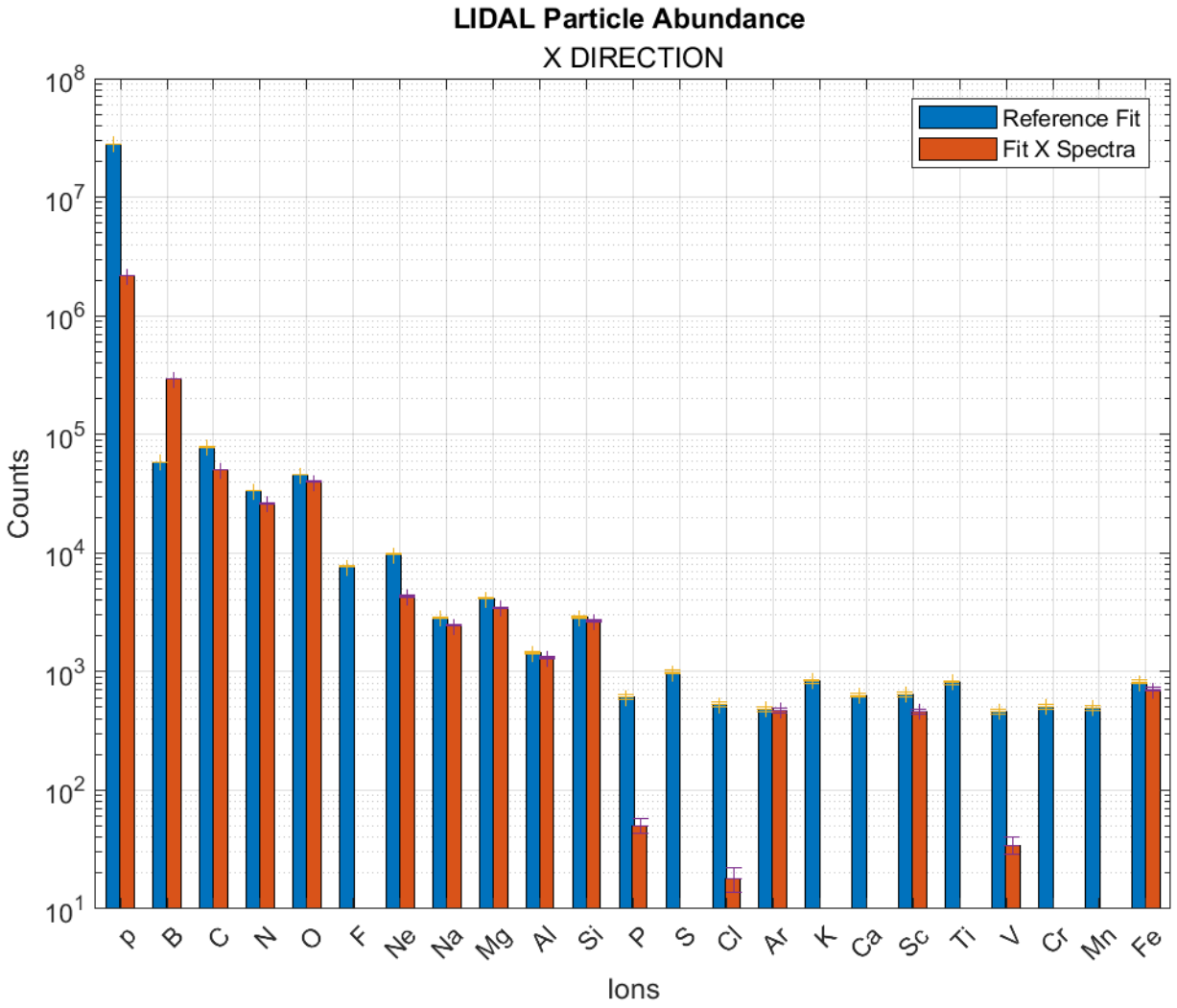
Spectra X direction

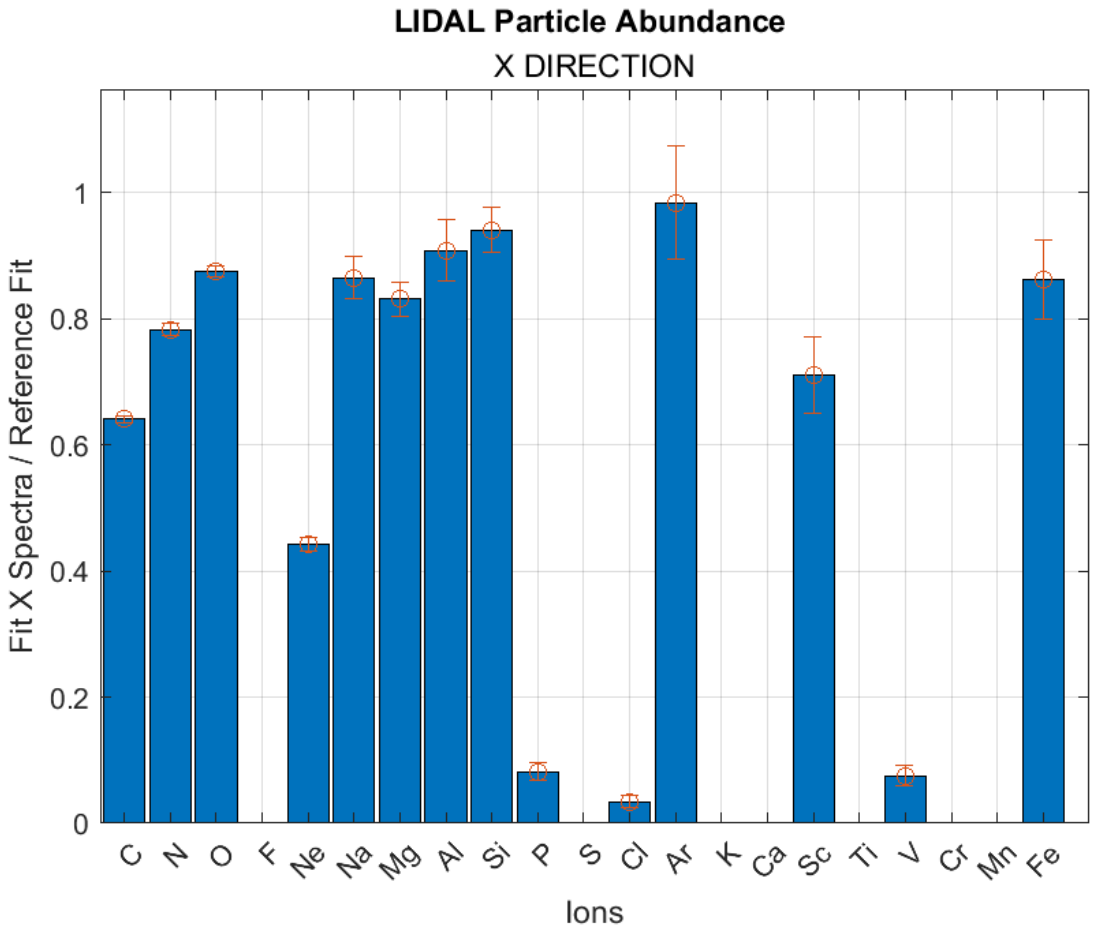


Spectra X direction

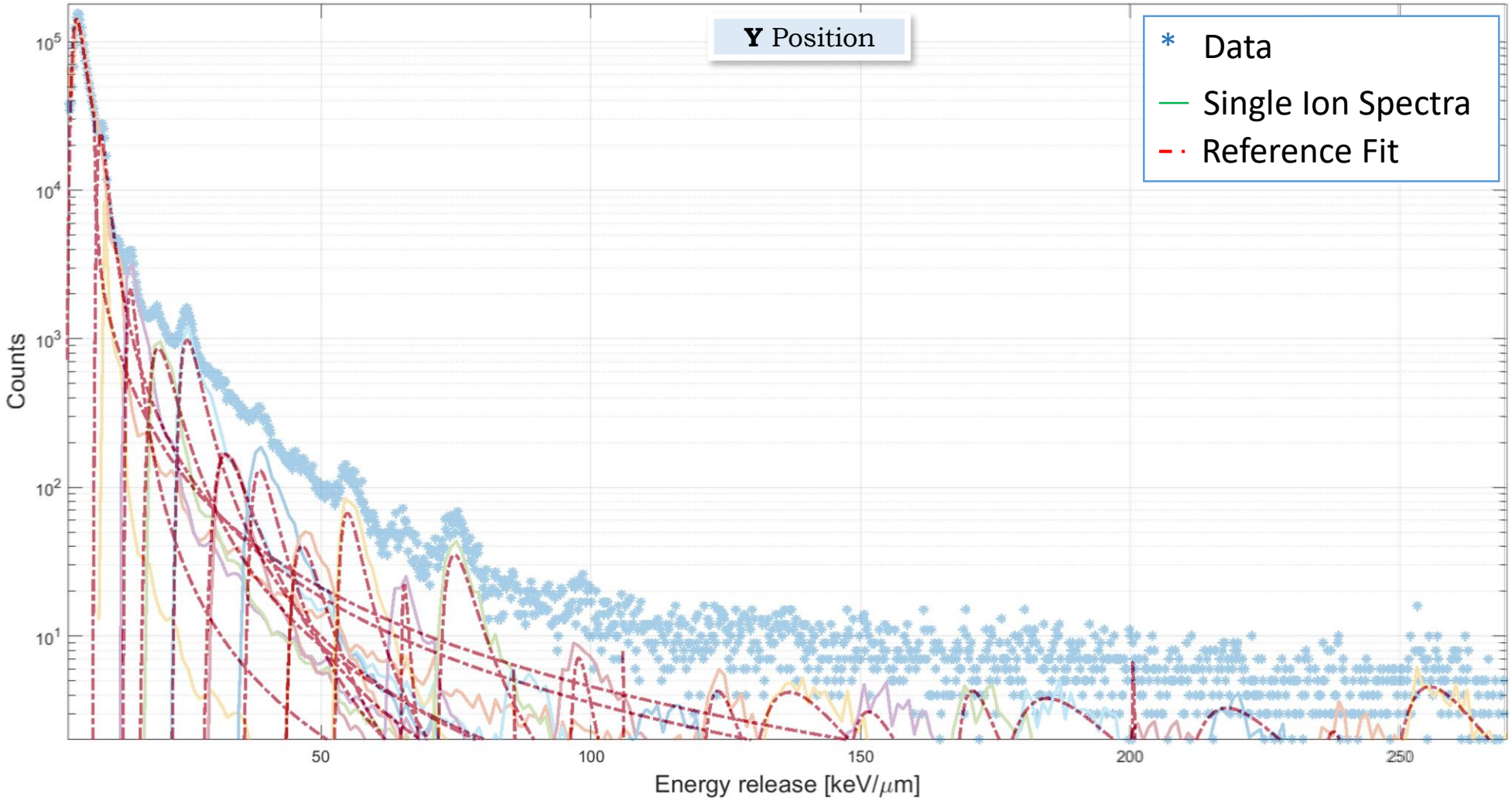


Abundance X DIRECTION

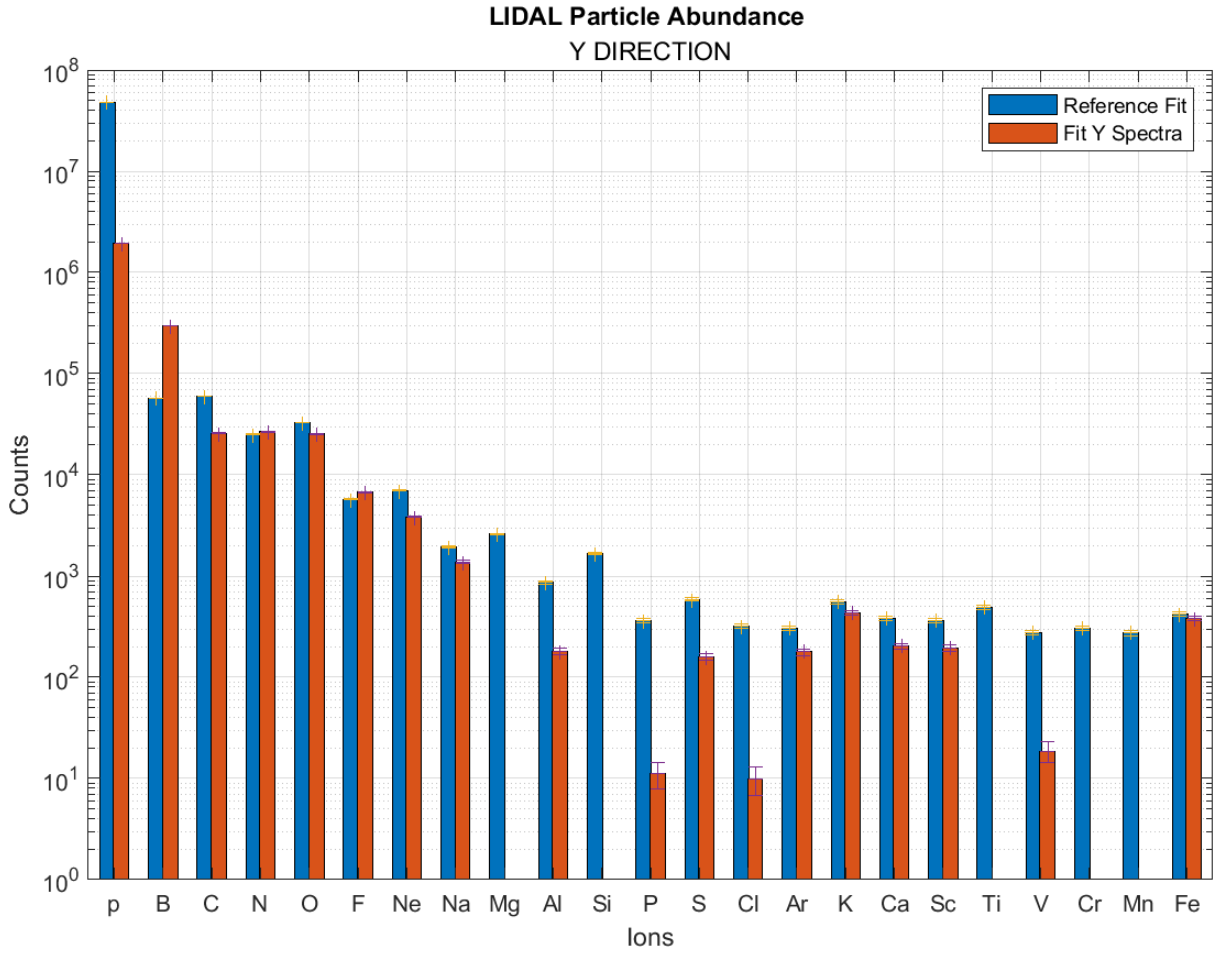


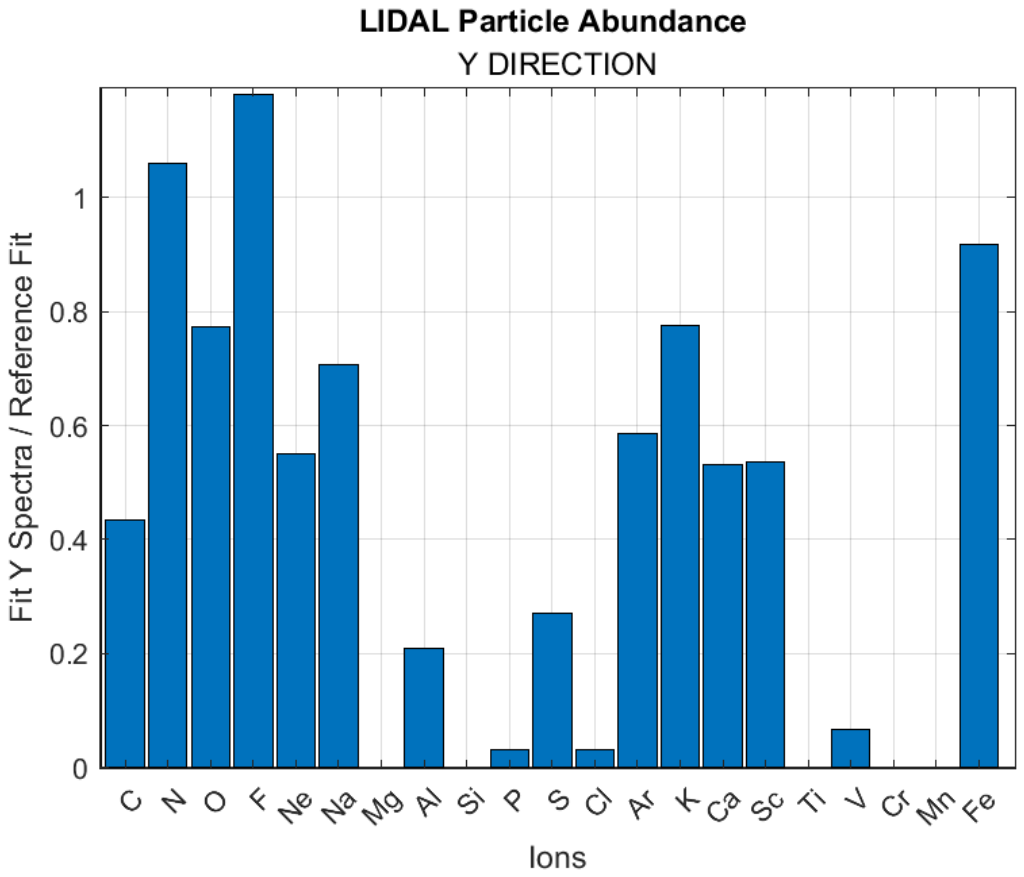


Spectra Y direction



Abundance Y DIRECTION

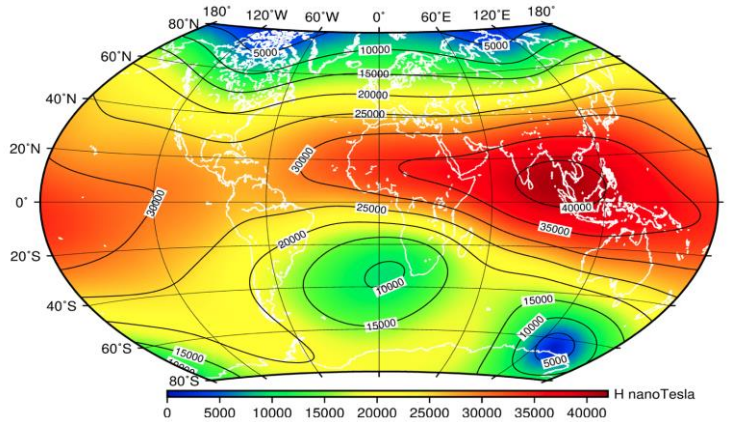


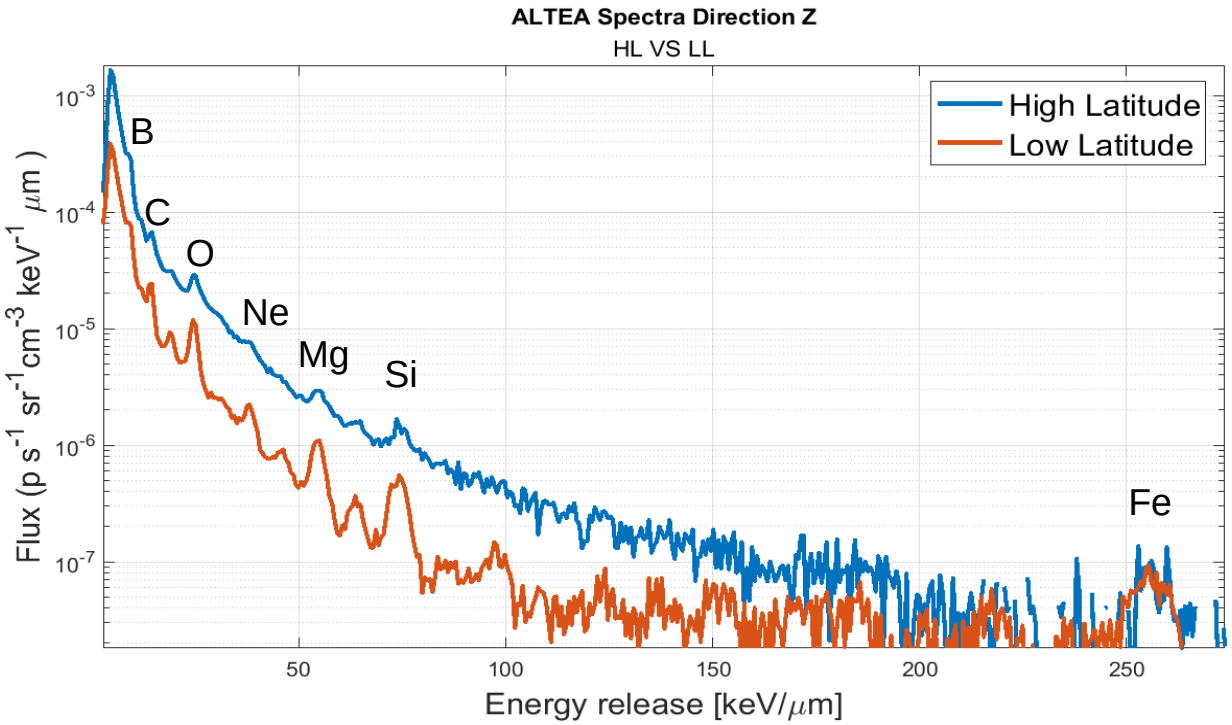


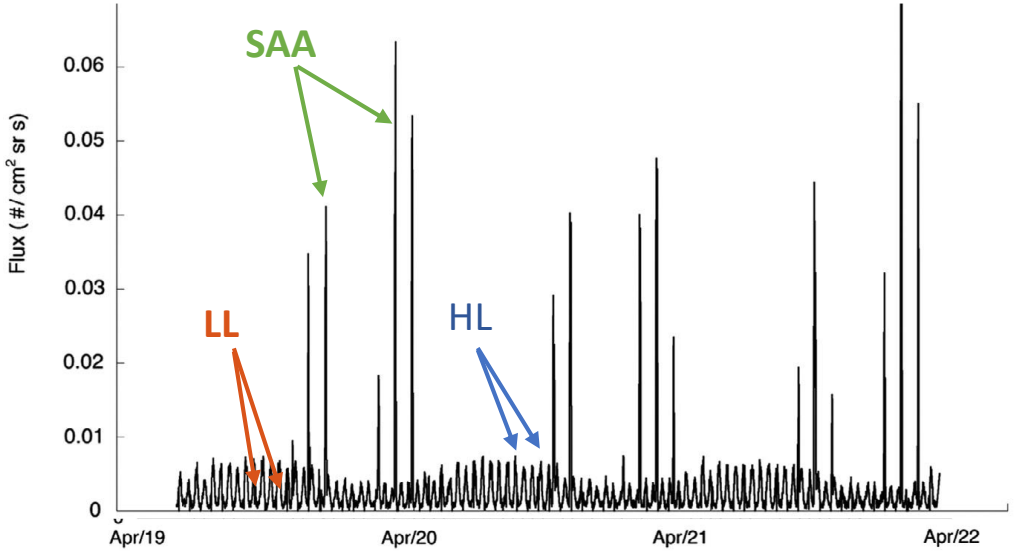
Different Geomagnetic Regions

The spectrum changes with the geographical areas.
Dividing the entire orbit into 3 regions:

- Low Latitude **LL** (equatorial regions)
- High Latitude **HL** (poles regions)
- **SAA** (South Atlantic Anomaly)





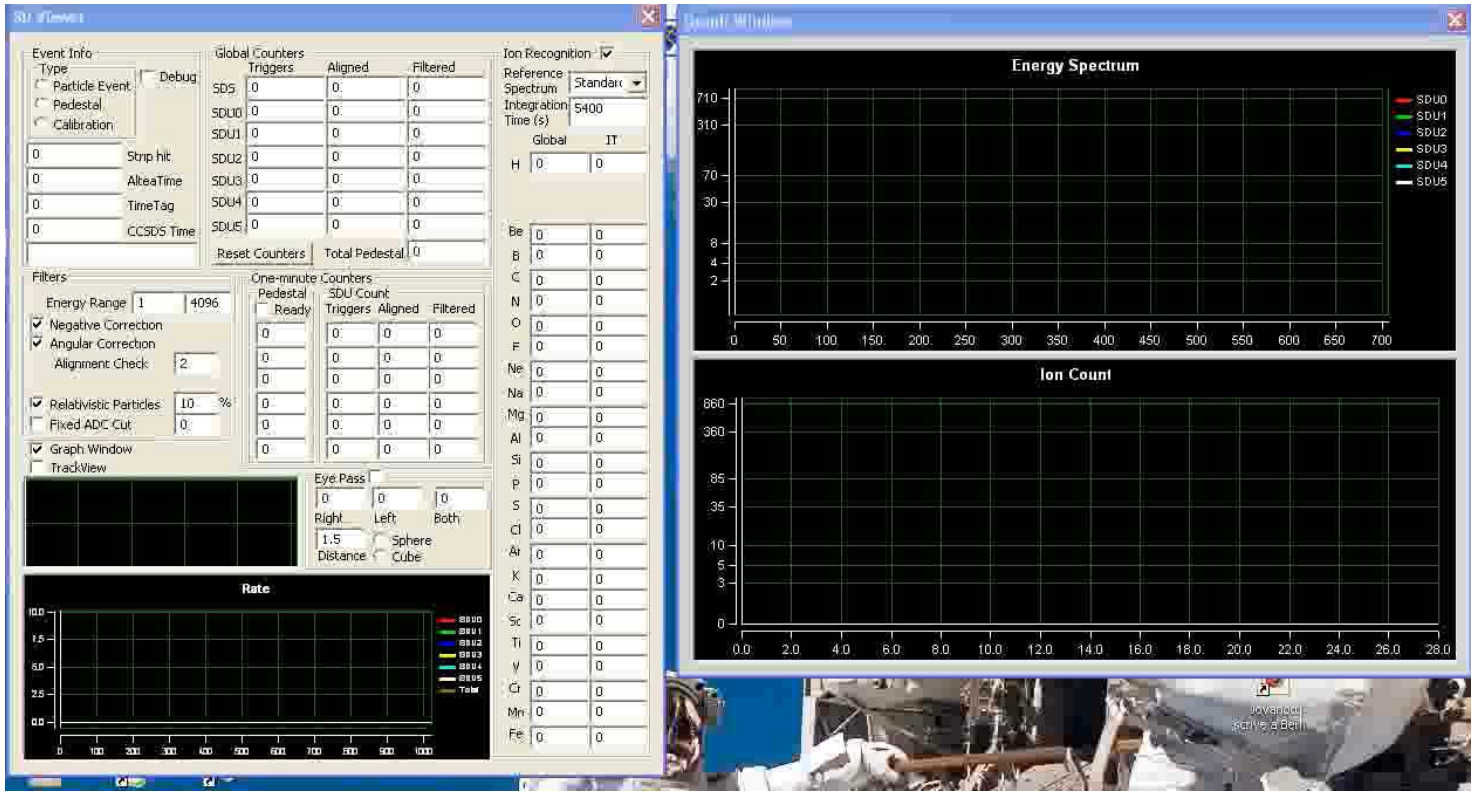


Radiation flux measured in a quiet Solar Period (April 2012).

Radiation survey in the International Space Station (2015)

Future Perspective

- **REAL TIME DISCRIMINATION**, using specific spectra for each geomagnetic zone

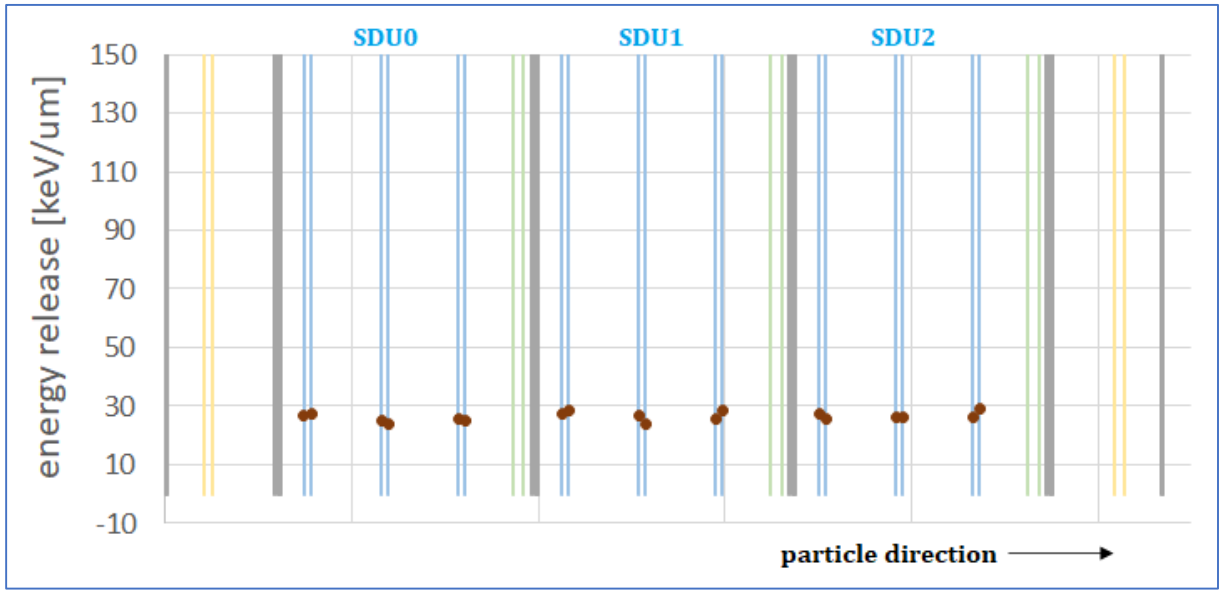


ALTEA DATA 2006

Improve Nuclear Discrimination

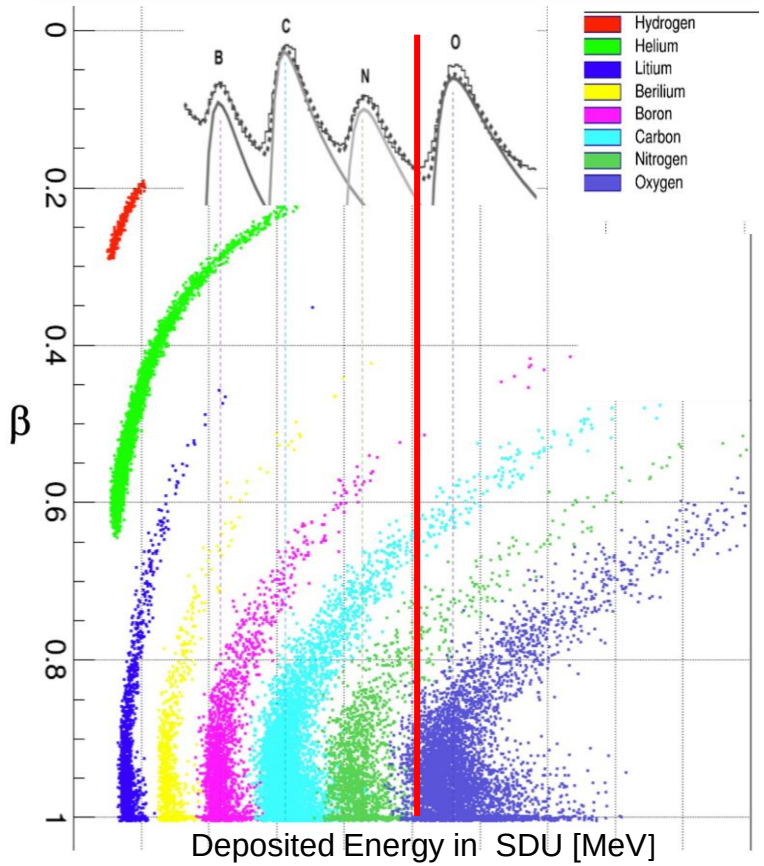
Bethe Bloch Equation

$$-\frac{dE}{dx} = 2\pi N_a r_e^2 m_e c^2 \frac{\rho Z}{A}\frac{z^2}{\beta^2}\left[ln\left(\frac{2m_e\gamma^2 v^2 W_{max}}{I^2}\right) - 2\beta^2 - \delta - 2\frac{C}{Z}\right]$$



Real trajectory of a particle through the several layers of **LIDAL**

Simulated spectrum acquired by **LIDAL** system



Improve Nuclear Discrimination

Particle with

Energy Release: $(52 \pm 2)\frac{KeV}{\mu m}$

ToF: $(2.20 \pm 0.02)\ ns$

ION CANDIDATES **Energy Release** $(52 \pm 2)\ keV/\mu m$
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B (1.1%)
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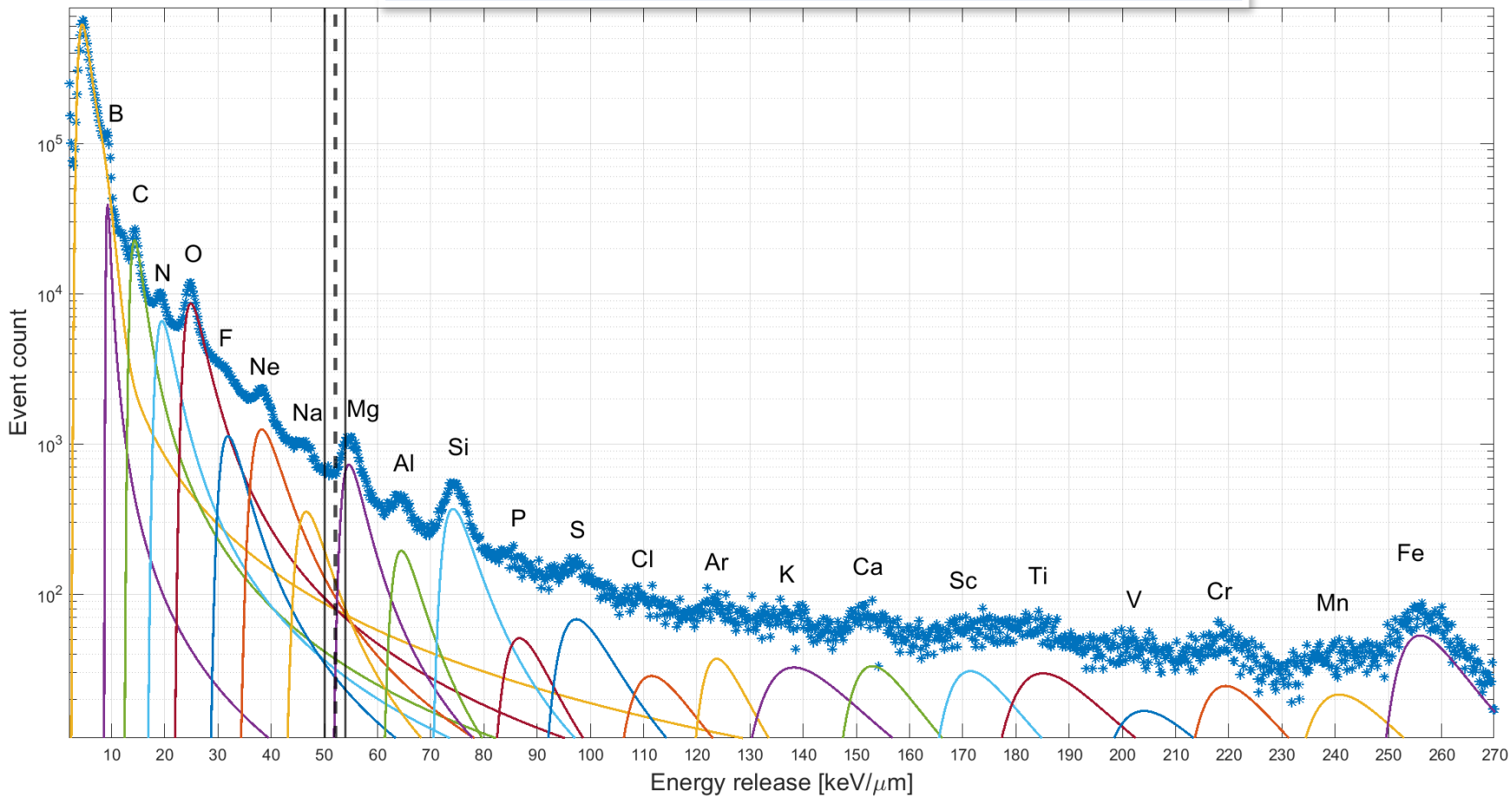


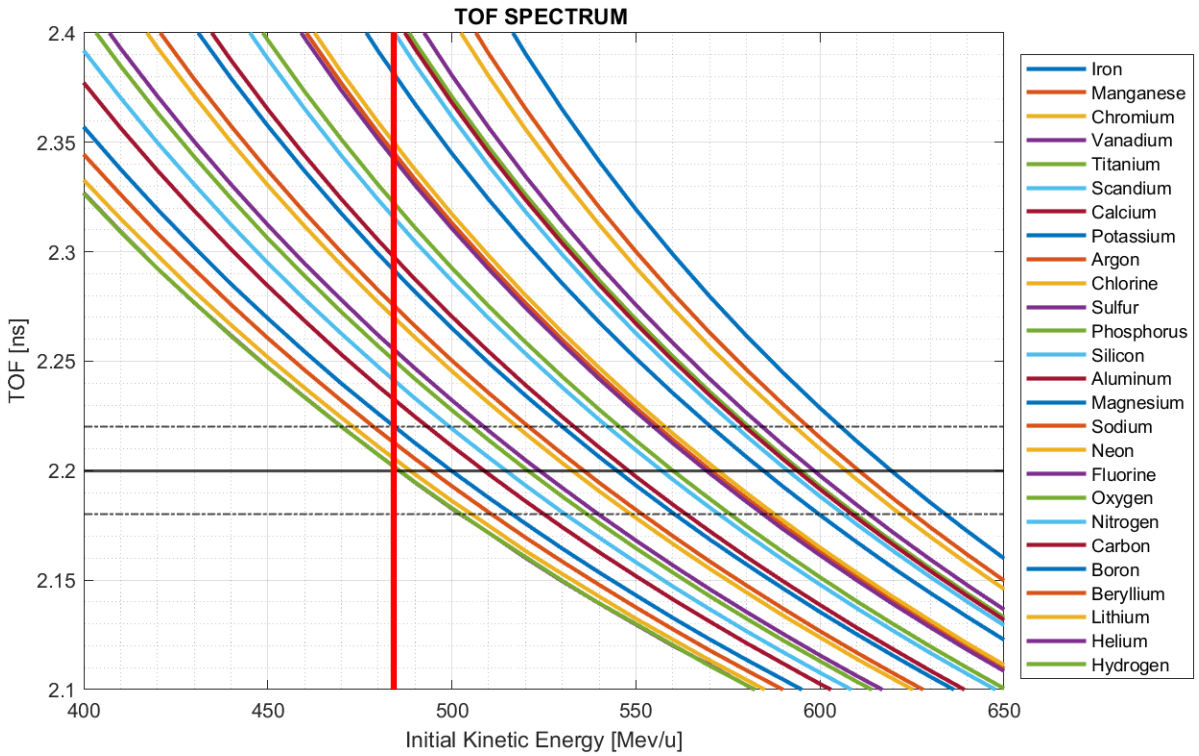
Improve Nuclear Discrimination

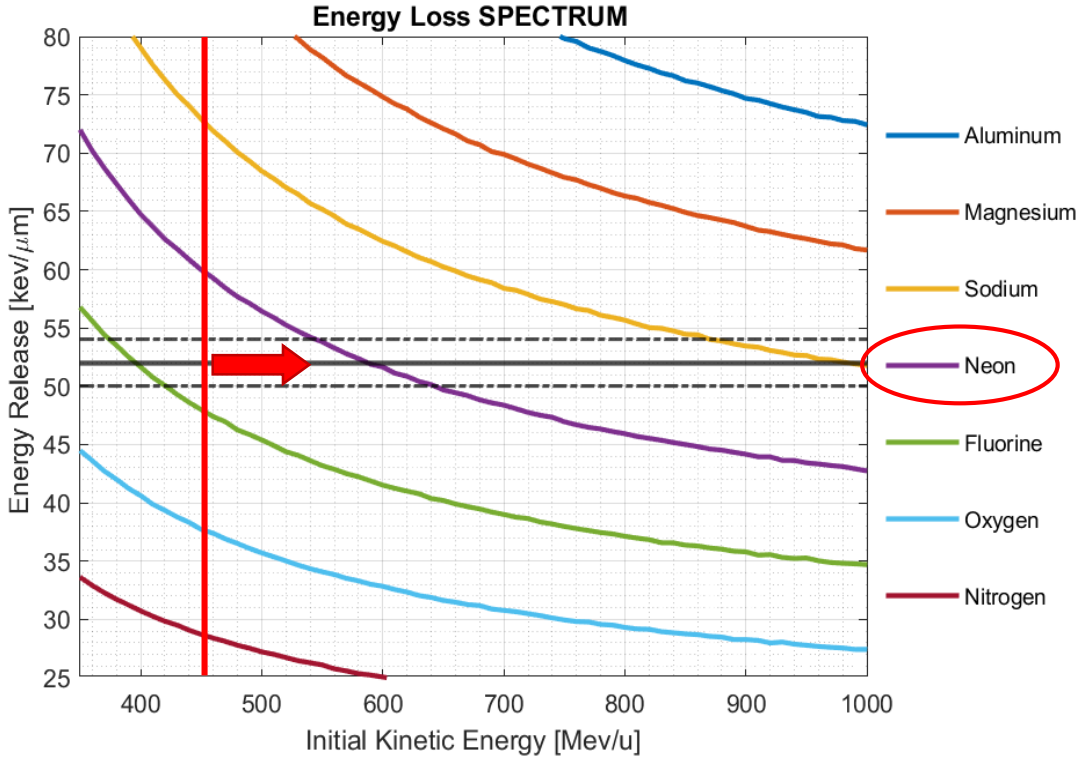
Particle with

Energy Release: $(52 \pm 2)\frac{KeV}{\mu m}$

ToF: $(2.20 \pm 0.02)\, ns$

$$\frac{Z^2}{\beta^2} = 153.8 \pm 3.5$$



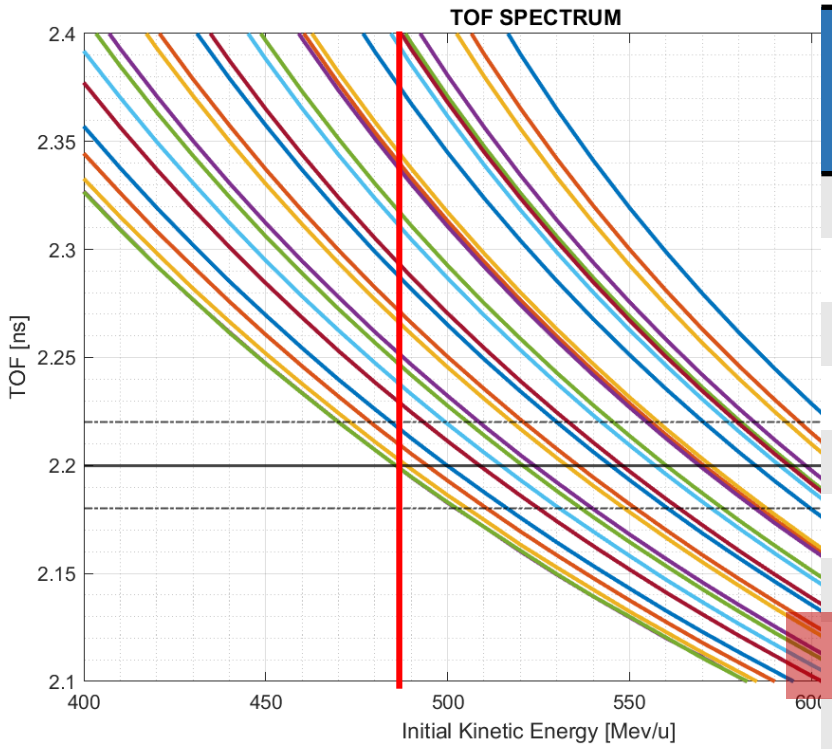


Improve Nuclear Discrimination

Particle with

Energy Release: $(52 \pm 2)\frac{KeV}{\mu m}$

ToF: $< 2.2\ ns$



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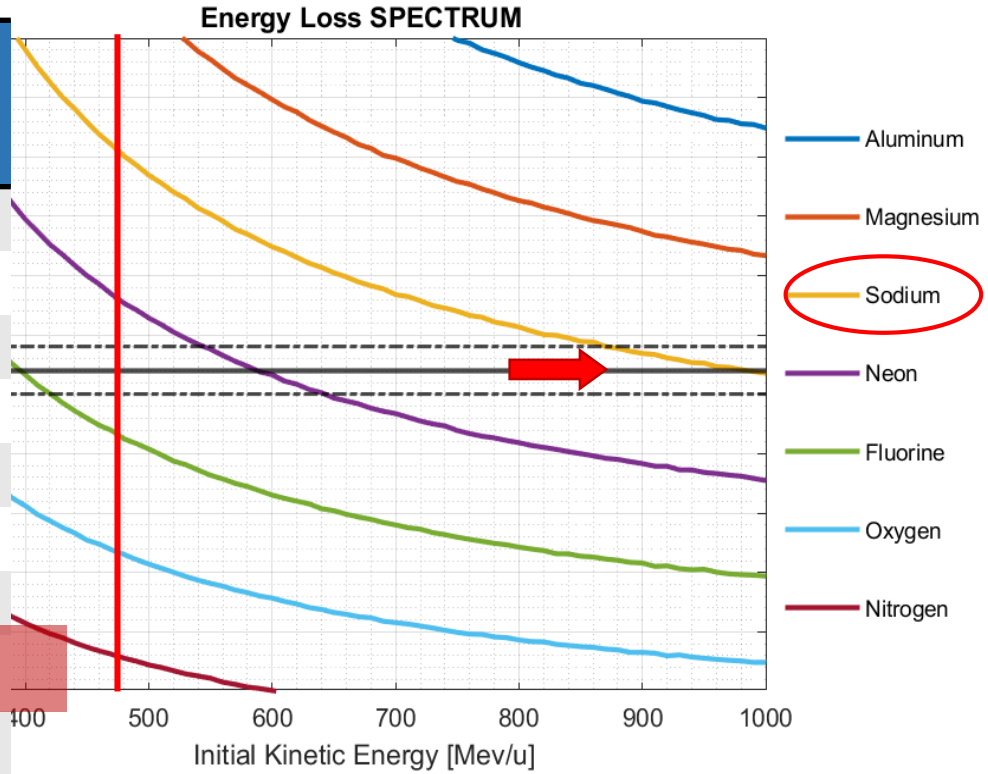

Conclusion:

- Development of algorithm to fit LET spectrum with Landau Curves
- Nuclear Discrimination on LIDAL data
- Single particle analysis eventually in real time
- This study is important for radiation risk assessment


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KAYSER
ITALIA
ASI