HASPIDE

kick- off meeting

18 novembre 2021

C. Grimani

WP5 Coord. C. Grimani
In collaboration with WP3
Applications of a:Si-H detectors: Space Weather and Astronauts dosimetry

- **a:Si-H detectors:** high dynamic range, radiation resistant, adjustable geometrical shape, low weight and power consumption
- **a:Si-H detectors** are ideal for solar energetic particle monitoring (SEP; mounted outside S/C) and astronaut dosimetry (mounted inside S/C)
- Continuous monitoring, multispacecraft observations of SEP events in the interplanetary medium remain of paramount importance since in the past the majority of data have been gathered near Earth (+/- 7.25^{o} solar latitude).
- Particle interplanetary scattering and transport effects are important to set the role of serious radiation threats to human explorers living and working beyond low-Earth orbit and to technological assets such as communications and scientific satellites in space.

HASPIDE Group (confirmed with an improvement)

- Catia Grimani 20% (PA: Cosmic-ray and SEP physics)
- Mattia Villani 30% (Post-Doc: LEI Monte Carlo low-energy electromagnetic physics)
- Federico Sabbatini 50% (Models of cosmic-ray variations)
  New: Urbino PhD Student
- Michele Fabi (AT) 50% (IT support, Fluka MC simulations)
- **FTE: 1.0**

WP5: Space applications

- ***Responsible:*** **Grimani Catia**
- **Working group: (FI)**

Name	Position	FTE-WP5
Catia Grimani	Professore Associato	0.2
Federico Sabbatini	Borsista	0.5
Mattia Villani	Assegnista	0.3
	TOTAL	1.0

The activities described in this WP will be carried out in close collaboration with those of the WP3 and WP6 for the simulation of the detector performance/optimization and neutron observations, respectively.

- ***Task***

T5.1 Modeling solar energetic particle (SEP) flux evolution at 1 AU. → DONE
T5.2 FLUKA+LEI simulations
T5.3 Test of the available prototypes
T5.4 Optimization of a-Si:H devices for space weather applications: geometry, surrounding material and spacecraft positioning.
T5.5 Optimization of a-Si:H devices for human dose monitoring is space: geometry and spacecraft positioning.
T5.6 Test on final prototypes and evaluation of possible implementation in space.

- ***Milestones***

M5.1 Parametrization of the evolution of different intensity SEP events in energy, space and time.
M5.2 Monte Carlo simulations of a-Si:H device performance for space weather applications and possible implementation.
M5.3 Monte Carlo simulations of a-Si:H device performance for dose measurements in space and possible implementation.

- ***Deliverables***

D5.1 Database of the evolution of SEP fluxes at 1 AU in energy, space and time – M12
D5.2 Outcomes of Monte Carlo simulations of a-Si:H devices for space weather applications and critical comparison with other instruments in space – M24
D5.3 Outcomes of Monte Carlo simulations of a-Si:H devices for dose absorption in space and critical comparison with other instruments in space – M36

SEP flux parameterization

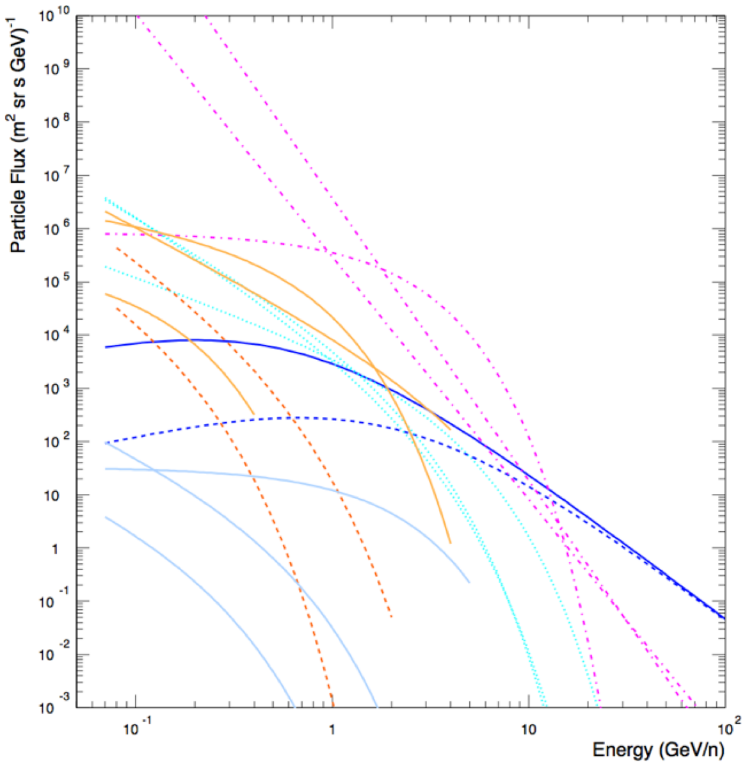


Fig. 12 Solar energetic particle fluxes observed during SEP events of different fluence. Dot-dashed lines correspond to the evolution of the February 23, 1956 event (magenta). Top continuous lines represent the dynamics of the December 13, 2006 event (orange), dotted lines show the evolution of the May 7, 1978 event (cyan), bottom continuous lines indicate the helium flux evolution during the SEP event dated December 13, 2006 downscaled by four orders of magnitude (light blue). The dashed lines represent the peak and decay phases of the December 14, 2006 SEP event (red). The continuous and dashed lines in the middle of the figure (blue) represent the GCR proton spectrum at solar minimum and maximum, respectively, for comparison.

The parameterizations of the fluxes are now available

SEP fluxes:
onset, peak and decay phase interpolation functions

$$F(E) = A\, e^{-\frac{E}{E_o}}\ Particles\ (m^2\ sr\ s\ GeV)^{-1}$$

$$F(E) = A\, E^{-\gamma}\ Particles\ (m^2\ sr\ s\ GeV)^{-1}$$

$$F(E) = A\, e^{-\frac{E}{E_o}}\ E^{-\gamma}\ Particles\ (m^2\ sr\ s\ GeV)^{-1}$$

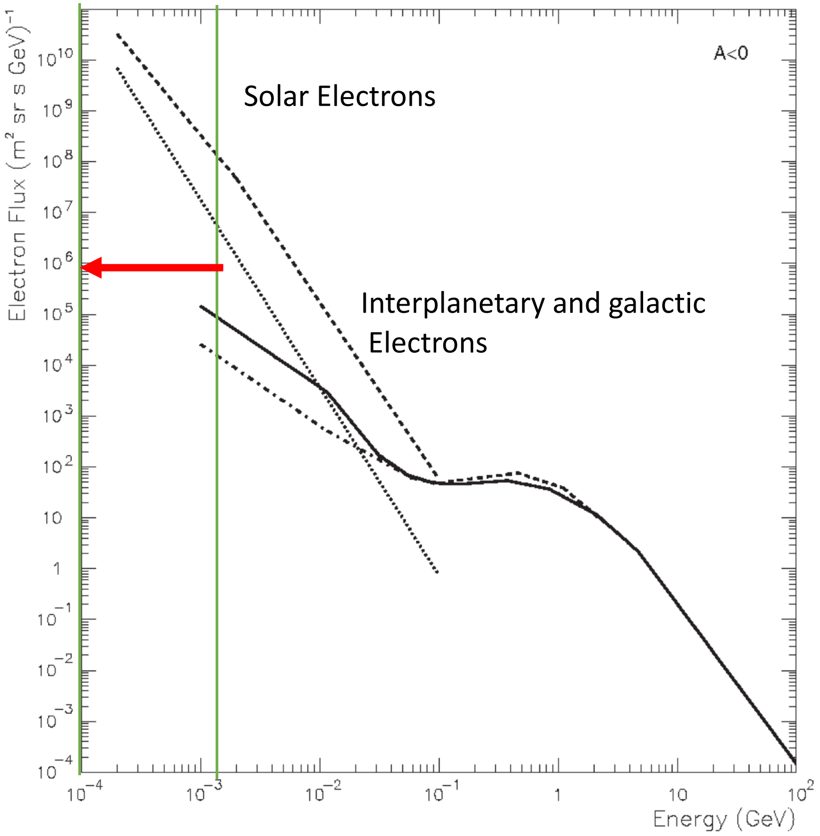
Event	Protons Particles $(m^2\ sr\ s\ GeV)^{-1}$	Helium Particles $(m^2\ sr\ s\ GeV)^{-1}$
February 23rd 1956		
0400 UT	$850880\ e^{-\frac{E}{1.13}}$	
0430 UT	$3688100\ E^{-5.30}$	
0500 UT	$1026400\ E^{-5.24}$	
0600 UT	$295420\ E^{-4.56}$	
December 13th 2006		
0318-0349 UT	$446900\ e^{-\frac{E}{0.33}}\ E^{-0.51}$	$51079\ e^{-\frac{E}{0.155}}$
0349-0433 UT	$535000\ e^{-\frac{E}{0.20}}\ E^{-1.02}$	$1122\ e^{-\frac{E}{0.28}}\ E^{-1.77}$
0433-0459 UT	$12038\ e^{-\frac{E}{2.53}}\ E^{-1.95}$	$3117\ e^{-\frac{E}{0.19}}\ E^{-1.58}$
0818-0917 UT	$1057\ E^{-3.60}$	$675\ e^{-\frac{E}{0.13}}\ E^{-1.72}$
1650-2235 UT	$58718\ e^{-\frac{E}{0.072}}\ E^{-0.37}$	
December 14th-15th 2006		
2305-0235 UT	$1155\ e^{-\frac{E}{0.24}}\ E^{-2.48}$	
0305-0455 UT	$463\ e^{-\frac{E}{0.27}}\ E^{-2.68}$	
0525-0630 UT	$23005\ e^{-\frac{E}{0.089}}\ E^{-1.13}$	
0750-0800 UT	$400900\ e^{-\frac{E}{0.054}}\ E^{-0.095}$	
1540-1930 UT	$15909\ e^{-\frac{E}{0.056}}\ E^{-0.96}$	
1930-2335 UT	$435\ e^{-\frac{E}{0.079}}\ E^{-2.10}$	

CG+, J. Ph. Conf. Ser. ,31, 045018, 2014

a:Si-H detectors

- Actual performance?
- Any possibility for SEP forecasting?

CG et al., JPCS 409 (1), 012159, 2013



Instrument performance for SEP detection

- FLAIR Geometries + FLUKA for particle arrival direction estimates
- SEP physics and doses
- OPEN POINT: detector performance?

SEP event occurrence predictions

The yearly SEP-event occurrence in the fluence range **10^6-10^{11} protons/cm^2 above 30 MeV** can be estimted according to the **Nymmik [1999a,b] model** on the basis of the number of the yearly predicted sunspot number:

$$N_{SEPs}\,[N_{SSmin}, N_{SSavg}, N_{SSmax}]=0.0694\,N_{SS}[min, avg, max]$$

Nymmik has found that the SEP event fluence (ϕ) distribution shows a power-law trend with an exponential cut-off

$$dN_{SEPs}=C\,\phi^{-1.41}\,e^{-\phi/\phi_x}\,d\phi$$

where $\phi_x=4\times10^9$

and **C** can be determined on the basis of the total number of expected SEP events

Occurrence of strong SEP events

Single event fluences of protons above 10 MeV larger than **1.5×10^9 protons/cm^2** are very rare. Only **14** have been observed **since 1963**. Between August 1972 and October 1989 there were no events larger than 10^{10} protons/cm^2.