Solar Cosmic Ray monitor and surveyor in the heliosphere

P.Spillantini,
University and INFN, Firenze, Italy

Forecasting of the Radiation and Geomagnetic Storms by networks of particle detectors (FORGES-2008)
Nor Amberd, Armenia, Sep29-Oct3, 2008
Merging of two reports:

**Introduction**

Active shielding for long duration interplanetary manned missions

(COSPAR 2008)

+

Energetic Solar Cosmic Ray surveyor and monitor for EArth-Mars missions

(CREAM surveyor and monitor)

(COSPAR 2004)
Introduction

Active shielding for long duration interplanetary manned missions
**60s and 70s** superconducting magnets for protecting from radiation in space: several ideas were considered, no technical projects developed. (too high $E_{\text{cut}} \rightarrow$ high B (10T) $\rightarrow$ heavy mechanical structures (95% of mass))

**80s and 90s** no significant progress:
- passive shield for protection from the SCR (Solar Cosmic Rays);
- active shielding considered only for GCR (Galactic Cosmic Rays) $\rightarrow$ use of very intense magnetic fields in enormous volumes $\rightarrow$ technical projects pushed very far into the future $\rightarrow$ discourage further work and investments.
- technical developments in s.c. magnets:
  - 3 projects for ASTROMAG facility on Freedom SS:
    - 2 supported by NASA with various technical experiments
    - 1 by Japan, constructed and use in balloon borne experiments
  - several large s.c. solenoids constructed for experiments at accelerators

**end of 90s** active shields revisited:
- technical progress in superconductors + realization of huge s.c. magnets;
- perspective less ambitious: initially quasi-directional protons (from impulsive solar events) were considered.
2000  review of available techniques and optimization of the working point for superconducting magnets for space applications  
(INFN-Milan (L.Rossi and L. Imbasciati))

2001-2003  project of a ‘quasi-directional’ s.c. magnetic lens  
(INFN, Florence and Milan)

2002-2004  ESA international Topical Team on “Shielding from the cosmic radiation for interplanetary missions: active and passive methods”

ESA-Alenia (+EADS Astrium, REM, RxTec, INFN).
Recommendations of the ESA Topical Team:

- recommendations on SEPs knowledge:
  retrieval of the old data collected by previous probes in the interplanetary space.
  oriented analysis of the information from the presently operating instruments.
  a dedicated instrument for surveying and monitoring the SEPs.

- recommendation for the use of computer codes, in particular for evaluating the impact of active in presence of minimum realistic passive shield.

- recommendation for passive shields:
  tests at accelerators
  development and tests of new materials.

- recommendations for active shields:
  cryocooler development (CFSM concept)
  deployable current elements (larger outer radius $\rightarrow$ more bending)
  superconducting magnetic system model
  validation by prototypes
  study of hybrid solutions
The knowledge of the **SEPs arrival directions** as a function of their energy and in correspondence of the different solar phenomena is a basic input for providing an adequate protection and for planning a long duration human presence in space.
Energetic Solar Cosmic Ray surveyor and monitor for EARth-Mars missions
(CREAM surveyor and monitor)
(SPhERA surveyor and monitor)

Solar Phenomena Explorer for Radiation Assessment

+ P.G. Picozza, W. Pecorella, F. Rossitto et al.
  + JINR, MEPhI, Lavochkin

P. Spillantini, University and INFN, Firenze (Italy)
M. Casolino, University and INFN, Roma Tor Vergata (Italy)
P. Papini, INFN, Firenze (Italy)
F. Taccetti, INFN, Firenze (Italy)
SPhERA is conceived in the **plan of activities** for the realization of passive and active **shielding** systems against ionising radiation in the future manned interplanetary flights and their integration in the project of the spaceship for the first manned mission to Mars.
Fig.1 – Conceptual scheme of the bi-directional telescope of SPhERAd and of its electronics (the sign of the ToF gives the versus of the direction)
Fig.4 - The quasi-spherical structure resulting with the arrangement of three bi-directional telescopes. For sake of simplicity only the silicon sensors are shown, as they are the innermost part of the instrument.
Fig. 5 - The quasi-spherical structure resulting with the arrangement of three bi-directional telescopes with the scintillation counters outside, in case that they are read by PMs.
The **quasi-spherical layout** of the instrument allows to sample the particles coming from a large fraction of the whole solid angle and to do therefore the measurement **independent from the attitude of the spacecraft.**
Fig. 2 – Time resolution of the ToF electronics realized for the PAMELA experiment.
dp/p versus KE for protons

ToF on 10 cm

D(ToF) = 30ps
D(ToF) = 50ps
D(ToF) = 70ps
The quasi-spherical structure resulting with the arrangement of three bi-directional telescopes with the scintillation counters outside, in case that they are read by PMs.
Early arriving electron component, alarming other devices, such as other orbiters, or landers, of the soon arrival from a determined direction of the dangerous proton and nuclei storm.
Active shielding ‘progressive’ approach:

**I step**: design (based on present materials and techniques) of a *magnetic lens* for the quasi-directional SCRs

**II step**: protection from the most energetic SCRs on the whole solid angle of a *shelter* (Ø=2m, L≈3m)

**III step**: new products and new techniques promise to conceive active systems for the complete protection of the ‘living’ modules (*habitat* = ISS-like modules: Ø≈4m, L≈5m) from the SCRs at all energies and the reduction by a factor >2 of the GCRs flux
I step:
design (based on present materials and techniques) of a **magnetic lens** for the quasi-directional SCRs

Potected volume
Diameter ≈ 4 m
Length = $\infty \leq 200$ MeV
4m @ 500 MeV