Solar Cosmic Ray monitor and surveyor in the heliosphere

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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

COSPAR 2008 – Montreal
Session F22, July 15, 2008

60s and 70s superconducting magnets for protecting from radiation in space:

several ideas were considered, no technical projects developed.

(too high E_{cut} → high B (10T) → 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) → use of very intense magnetic fields in enormous volumes → technical projects pushed very far into the future → 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 rivisited:

- 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"

2003-2004 WP "Review and development of active shielding concepts" of the contract **REMSIM** (Radiation Exposure and Mission Strategies for Interpl. Manned Missions) 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 → 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

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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.

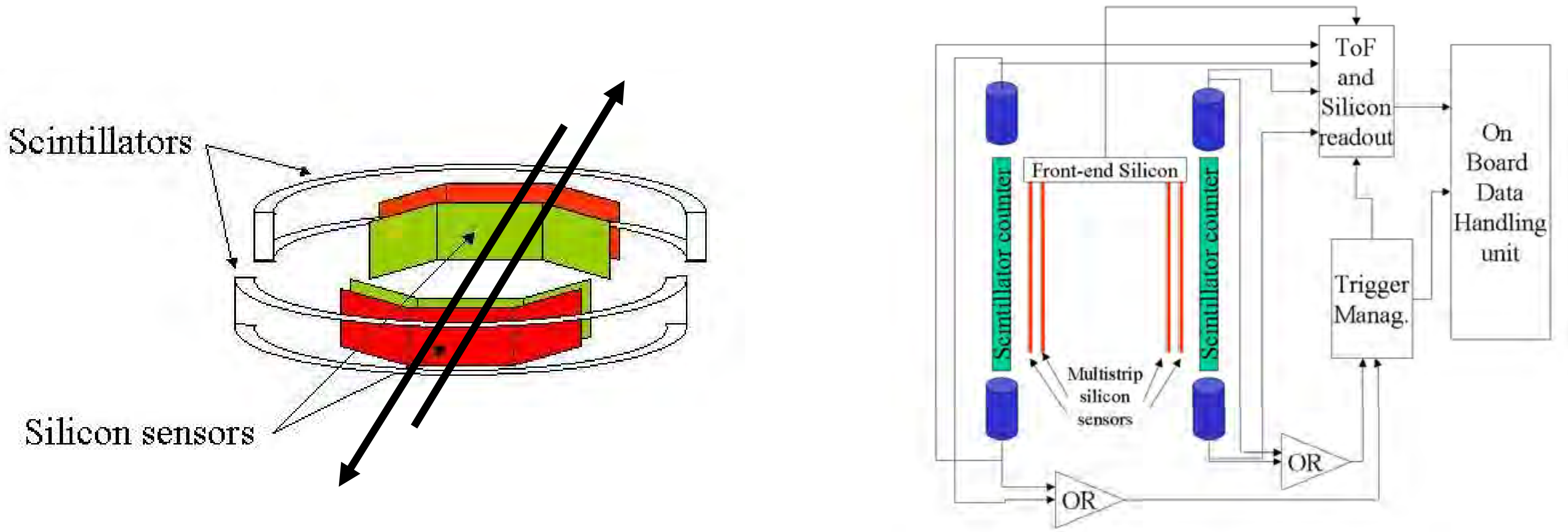


Fig.1 – Conceptual scheme of the bi-directional telescope of SPhERA and of its electronics (the sign of the ToF gives the versus of the direction)

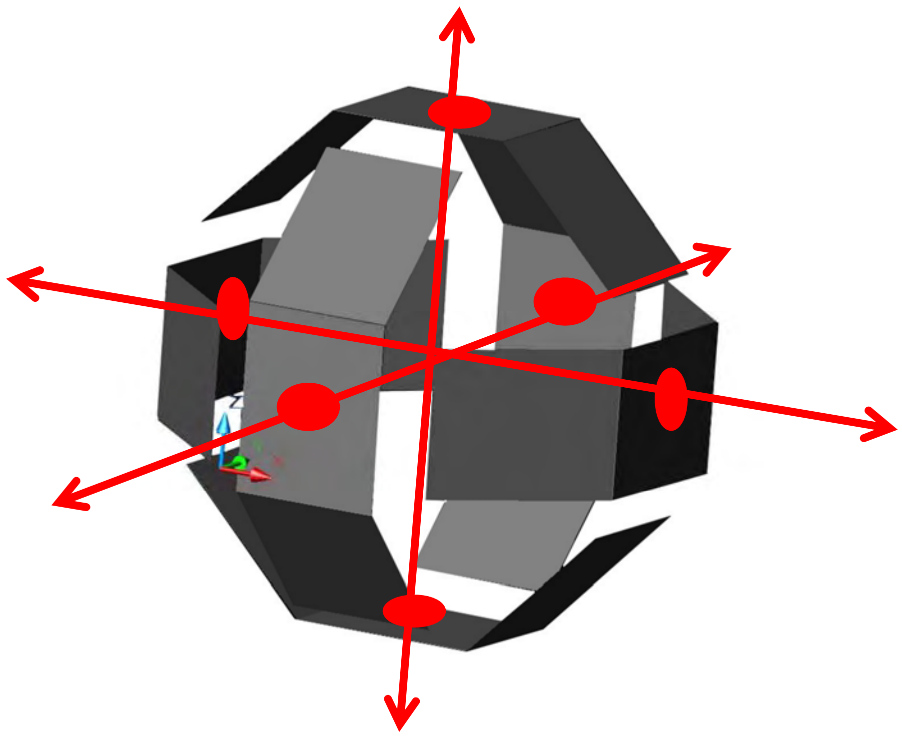


Fig.4 - The quasi-spherical structure resulting with the arrangement of three bi-directional telescopes. For sake of simplicity only the silicon sensors are shown, as they are the innermost part of the instrument.

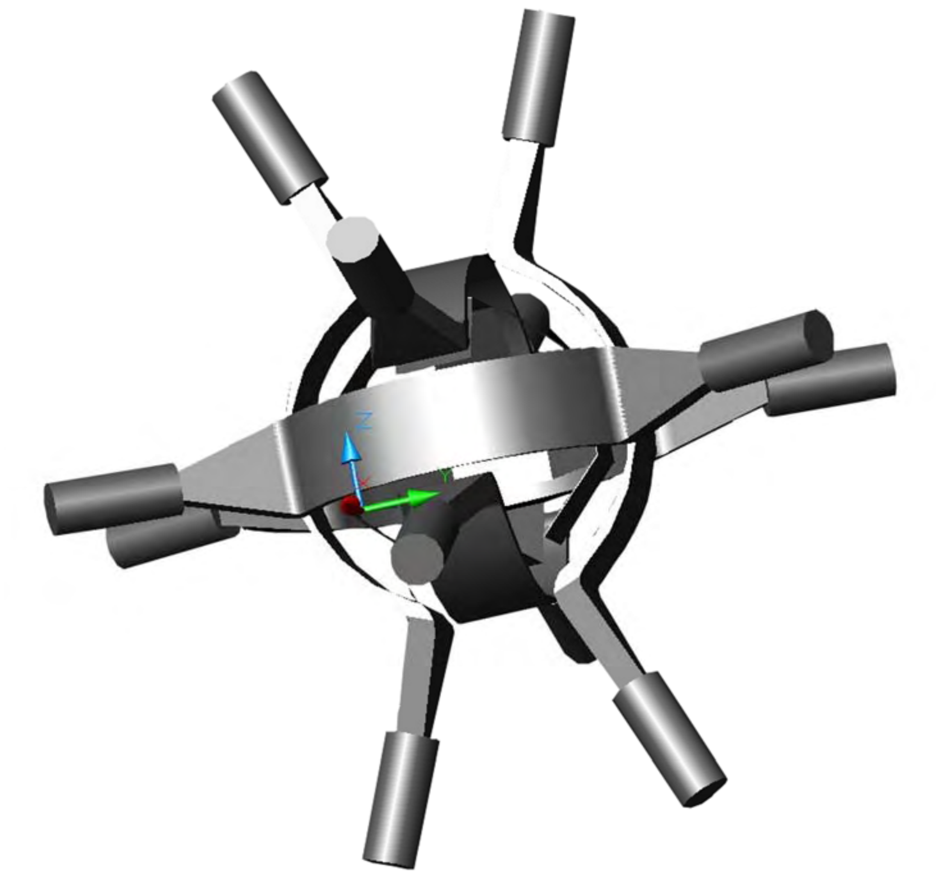
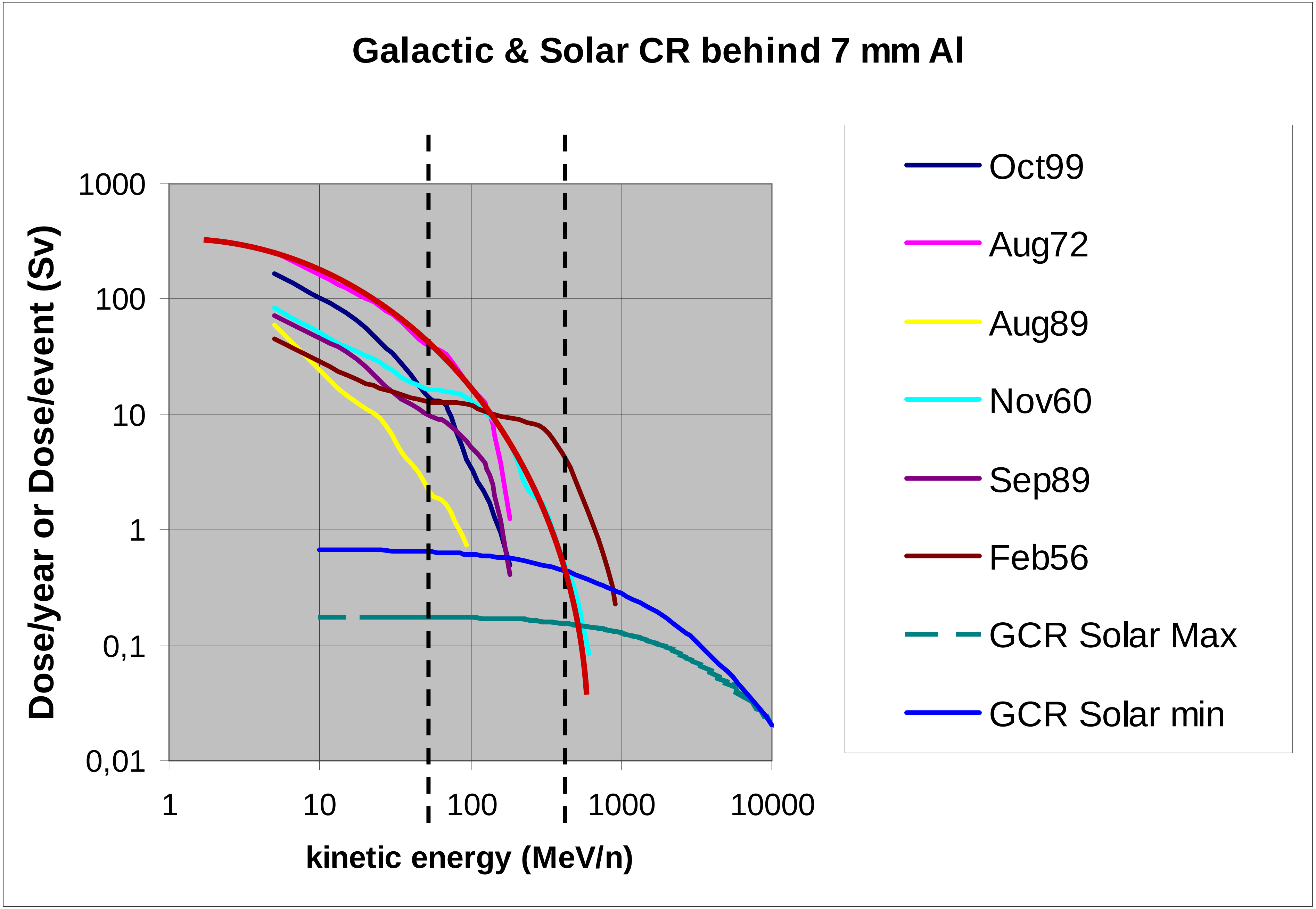


Fig.5 - The quasi-spherical structure resulting with the arrangement of three bi-directional telescopes with the scintillation counters outside, in case that they are read by PMs.

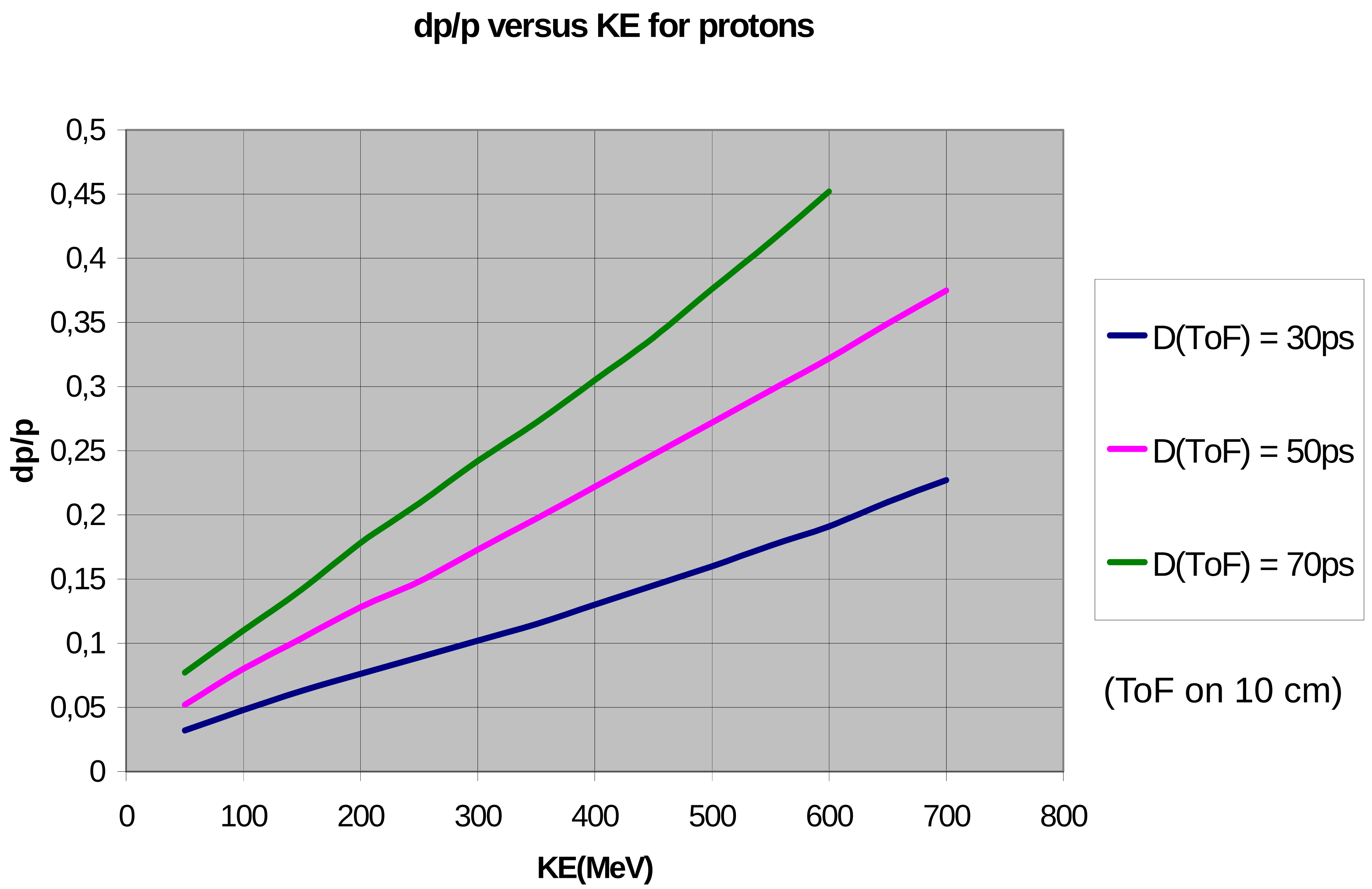
The **quasi-spherical layout** of the instrument allows to sample the particles coming from a large fraction of the whole solid angle and to do therefore the measurement **independent from the attitude of the spacecraft**.

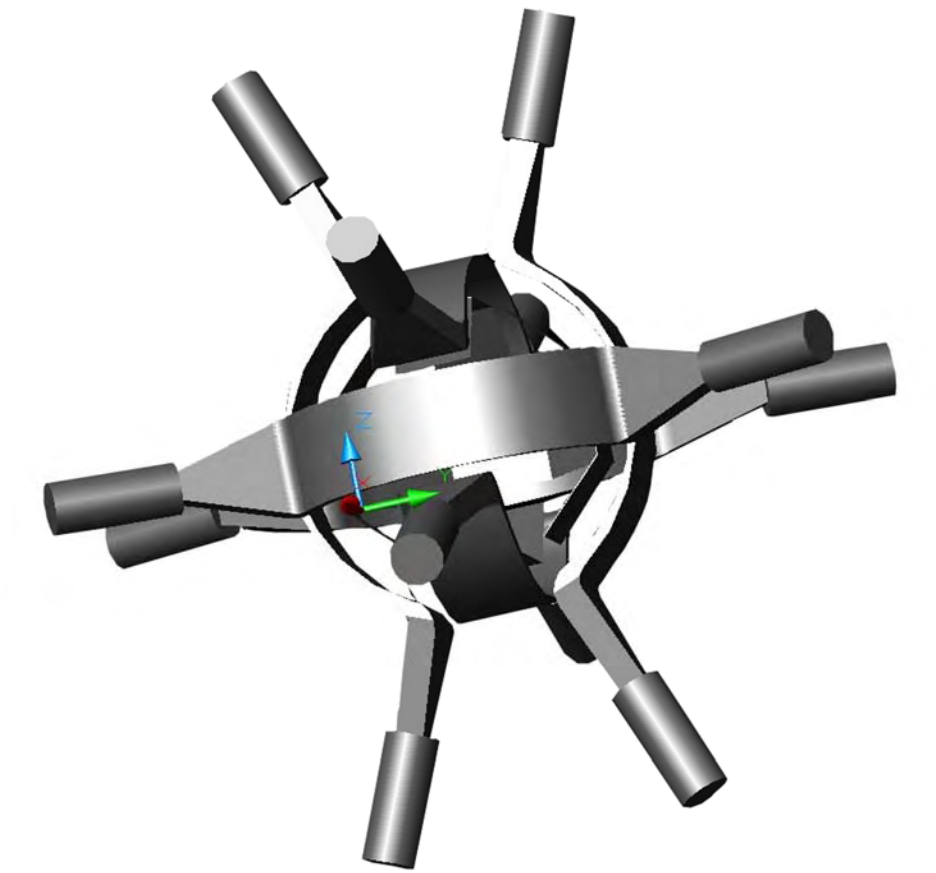


Galactic & Solar CR behind 7 mm Al
Dose/year or Dose/event (Sv)
1000
100
10
1
0,1
0,01
1
10
100
1000
10000
kinetic energy (MeV/n)
Oct99
Aug72
Aug89
Nov60
Sep89
Feb56
GCR Solar Max
GCR Solar min

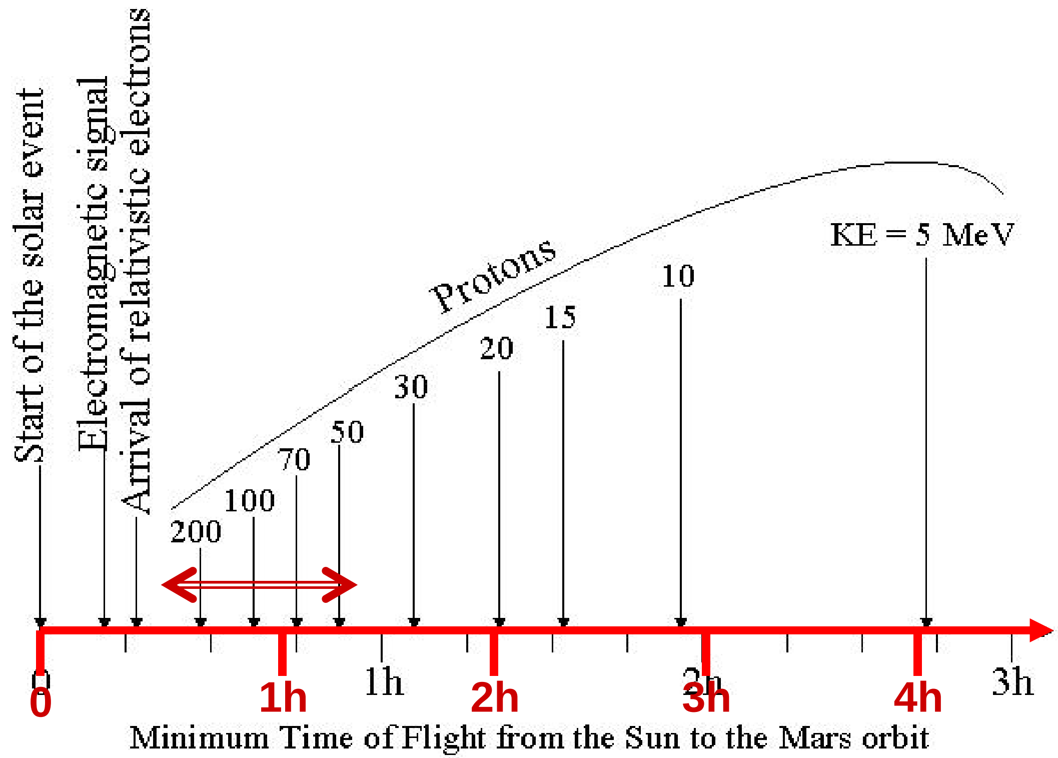
Napoli ToF board – time Resolution

Fig.2 – Time resolution of the ToF electronics realized for the PAMELA experiment.


dp/p versus KE for protons
0,5
0,45
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
dp/p
0
100
200
300
400
500
600
700
800
KE(MeV)
D(ToF) = 30ps
D(ToF) = 50ps
D(ToF) = 70ps
(ToF on 10 cm)



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** (∅=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: ∅≈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