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# Mars Energetic Particles Analyzer onboard the Orbiter of China's First Mars Exploration

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## Abstract

China's Mars probe including an orbiter and a lander/rover will be launched in 2020. A Mars Energetic Particles Analyzer (MEPA) instrument has been selected as one of the payloads on the orbiter. The main scientific objective of the MEPA is to study the characteristics of energy particles in Mars space environment and Earth-Mars transfer orbits. The MEPA is an energetic particle spectrometer consisting of a solid-state detector stack and CsI scintillator with active coincidence logic to identify energetic particles using the method of dE/dx vs E. A prototype version of MEPA was designed and some experiments have been conducted to test the validity of the design.

## 1. Introduction

China's first Mars exploration mission will be performed around 2020. One scientific objective of the orbiter is to detect and analyze the Mars ionosphere and the interplanetary environment[1]. MEPA is designed based on this scientific objective. In addition to the detection of the interplanetary space and the Mars space radiation environment, MEPA is designed to provide environmental parameters for many other scientific objectives and technological objectives.

### 1.1 Scientific Objectives

The scientific objectives of the MEPA are as follows:

(1)Study the characteristics and changes of energy spectrum, elemental composition and flux of energetic particles, including electrons, protons, α-particle and heavy ions(Z≤26), in Mars space environment and Earth-Mars transfer orbit.

(2)Plot the spatial distribution maps of radiation of different energy particles by combining the time information of the acquired particles.

(3)Study the relationship between near-Mars space energy particle radiation and the atmosphere, the effect and interaction of solar energetic particle events on Mars' atmospheric escape, and the process of active particle acceleration and transport, by cooperating with Mars Ions and Neutral Particle Analyzer and Mars Magnetometer.

### 1.2 Technical Requirements

The specifications for the MEPA are listed in Table 1.

Table 1: Specifications for the MEPA

| Instrument Parameter | Characteristics |
|---|---|
| Energy Range | Electrons：0.1～12MeV;<br>Protons：2～100MeV;<br>α-Particles、Heavy Ions：25～300MeV. |
| Energy Resolution (ΔE/E) | 15% |
| Flux Range | $0\sim10^{5}cm^{-2}s^{-1}$ |
| Elementary Composition | H～Fe (1≤Z≤26) |
| Heavy Ion Mass Resolution (Δm/m) | ≤25% (Z≤9, energy range 25~300MeV);<br>≤25% (10≤Z≤26, energy range 100~300MeV);<br>≤60% (10≤Z≤26, energy range 25~100MeV). |
| Field of View (FOV) | 60° |
| Time Resolution | 4s (Electrons, Protons, α-Particles);<br>60s (Heavy Ions). |

## 2. The MEPA Instrument

MEPA is an energetic particle analyzer designed to characterize the energy particles in near-Mars space environment and Earth-Mars transfer orbit, including both charged particles ($1 \leq Z \leq 26$) and electrons. The MEPA instrument (Figure 1) consists of a solid-state detector telescope with two different thickness silicon detectors (SDs, referred to as the SD1 and SD2) for the detection of electrons and charged particles, and two scintillators for the detection charged particles. The scintillators include a CsI crystal to stop the charged particles and an anti-coincidence shield to veto charged particles entering the MEPA from the side or bottom. MEPA uses a coincidence logic system which base on the dE/dx method to identify charged particles.

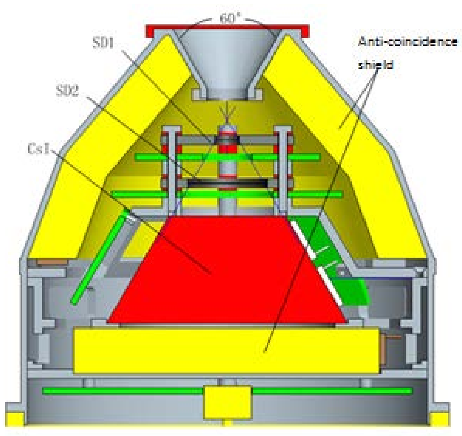


Figure 1: View of the MEPA instrument.

## 3. Test and Results

The sensor head of the MEPA prototype consists of a 30μm silicon detector, a 300μm silicon detector and a 32.5mm CsI detector. During the development of the prototype, a beam generated by a heavy ion accelerator was used to test the sensor head of the prototype. The beam test experiment used a $^{40}Ar$ beam flow of 300MeV/u to bombard a 3mm thick CH target. To detect the reaction product, the prototype was placed approximately 1m away from the target, and the angle between the beam and the prototype is around 30 degrees. The energy loss on SD2 and the energy loss on CsI are plotted in a two-dimensional spectrum (Figure 2).

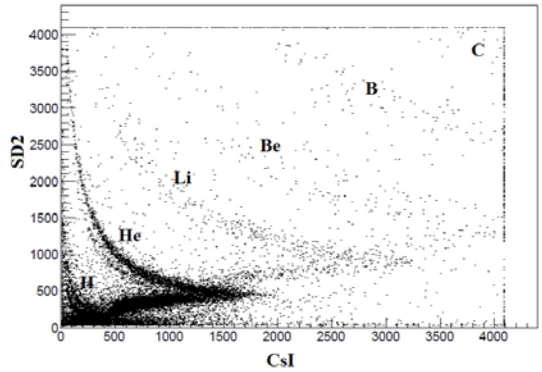


Figure 2: The particle identification spectrum of the prototype beam test.

According to the simulation parameters obtained from the prototype beam test results, the ΔE-E two-dimensional spectrum (Figure 3) of all detected particles of the MEPA was calculated using the Geant4 simulation program.

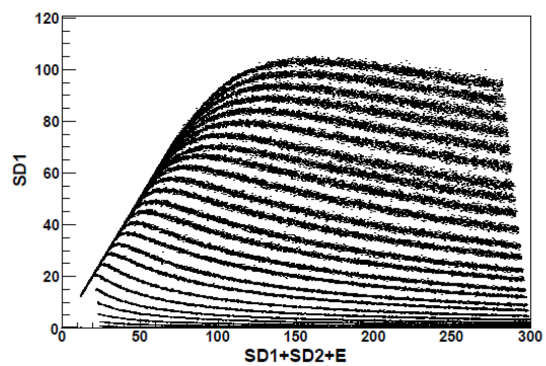


Figure 3: Simulation analysis of all detected particles using Geant4 simulation program (vertical incidence).

## 4. Summary and Conclusions

The MEPA is an important space environment exploration payload on the orbiter of China's first Mars exploration. The energy particle characteristics of near-Mars space and Earth-Mars transfer orbits can be obtained by using MEPA, which provides support for subsequent Mars scientific exploration.

## References

[1] P.J. Ye, Z.Z. Sun, W. Rao, and L.Z. Meng: Mission overview and key technologies of the first Mars probe of China, Sci. China Technol. Sci., Vol. 60,pp. 649-657, 2017.