COSIMA: A High Resolution Time-of-Flight Secondary Ion Mass Spectrometer for Cometary Dust Particles on Its Way to Comet 67P/Churyumov-Gerasimenkov

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Abstract

The COmetary Secondary Ion Mass Analyser (COSIMA) is a high-resolution time-of-flight (TOF) mass spectrometer system on board ESA's ROSETTA spacecraft flying to comet 67P/Churyumov-Gerasimenkov.

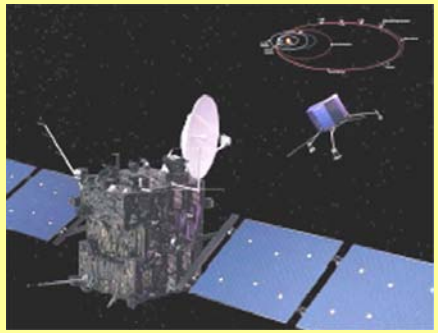
COSIMA will collect cometary dust particles on metal black targets which are exposed to space. After target exposure dust particles with sizes 10 µm and bigger are identified on the target with an optical camera. An Indium ion beam is shot onto the particle surface and material from the particle is sputtered and ionised. The secondary ions are accelerated in an electric field and from the mass- and charge-dependent flight times of the ions a time-of-flight secondary ion mass spectrum (TOF-SIMS) is measured with a mass resolution of $m/\Delta m \approx 2000$ at m = 100. During commissioning in 2004 the COSIMA flight instrument performed according to specification. The first TOF-SIMS spectra in space were obtained from one of the instrument targets.

COSIMA is now ready for the comet. The goal of the COSIMA investigation is the in-situ characterisation of the elemental, molecular, mineralogical and isotopic composition of dust particles in the coma of comet Churyumov-Gerasimenkov.

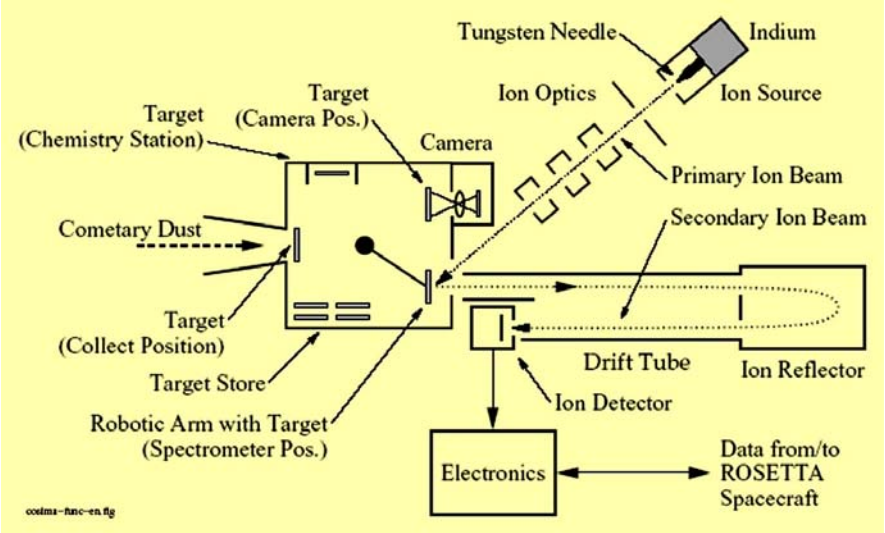
Comets are remainders from the formation of the solar system and, therefore, analysis of cometary material can give important insights into the conditions of the first stages of planetary system formation and cometary evolution.

Science Objectives

- Analysis of the elemental composition (and isotopic composition of some key elements) of cometary dust particles
- Mineralogical and petrographical characterisation of the inorganic phases – all related to solar system chemistry
- Chemical characterisation of the main organic components, homologous and functional groups
- Cosmochemical and cosmophysical processes during the evolutionary history of the comet



Functional Principle

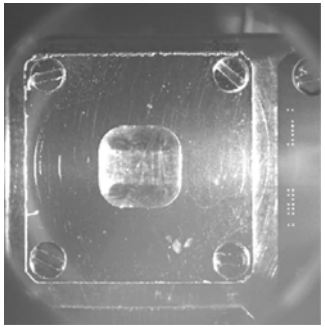


(1) Dust is collected on metal black targets which are stored in Target Manipulation Unit
(2) Dust grains are located by microscopic camera COSISCOPE
(3) A pulsed Indium ion beam partially ionizes the dust grains
(4) Secondary ions are accelerated by an electric field and travel through a drift tube with ion reflector
(5) Ions are detected by ion detector; flight times are recorded by T/D converter
(6) Mass spectra are calculated from the time-of-flight spectra

COSIMA Specifications

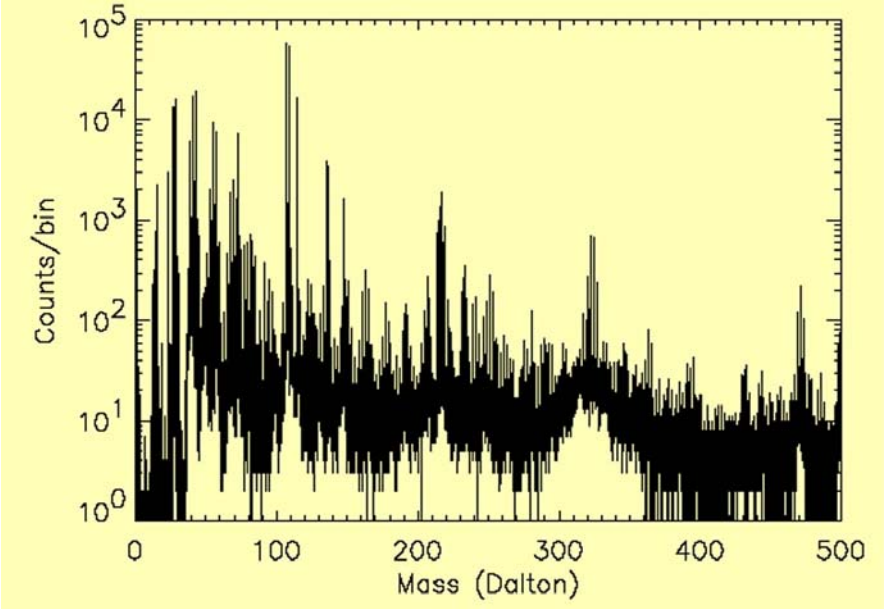
• Atomic mass range	1 ... 4000 Da
• Rel. atomic mass resolution m/Δm at m = 100	> 2000
• Mass	19.8 kg
• Indium ion pulse duration	~ 5 ns
• Indium ion energy	8 keV
• Power consumption from 28 V DC	20.4 W

COSIMA Target



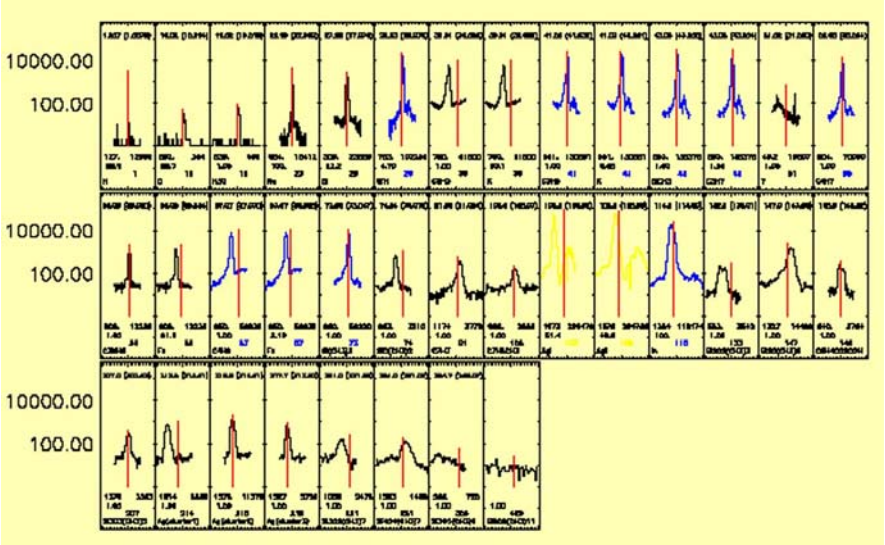
COSISCOPE image of blank silver target obtained during commissioning in September 2004. The target size is 1 cm x 1 cm.

First In-Flight COSIMA Time-of-Flight Mass Spectrum



First COSIMA in-flight spectrum (positive ion mode) measured on a blank silver target.

Detailed Time-of-Flight Mass Spectrum



Selected mass lines from first COSIMA in-flight spectrum on silver target (positive ion mode). Note that in cases where peaks due to organic and inorganic compounds are expected at the same mass number, the organic peak is shifted to the right while the inorganic peak is shifted to the left of the integer mass number. At sufficiently large masses both lines can be separated.

Commissioning

- COSIMA commissioning in March and September/October 2004
- Ion emission obtained from both ion sources
- Three good mass spectra measured (positive, negative and backup positive mode, respectively)
- Emitter 'C' worked flawlessly while emitter 'A' had unstable current. Special attention needed in the future.
- All in all, COSIMA performed according to specification