20TH, GIFU ISTS & 11TH IAS

96-j-19

Mars Dust Counter on Board ISAS PLANET-B

Eduard Igenbergs and Ralf Münzenmayer
Fachgebiet für Raumfahrttechnik, TU-München, Germany

Sho Sasaki
Geological Institute, University of Tokyo, Japan

Georg Färber and Franz Fischer
Lehrstuhl für Prozeßrechner, TU-München, Germany

Akira Fujiwara
ISAS, Japan

Albrecht Glasmachers
Universität / GH Wuppertal, Germany

Eberhard Grün
MPI Kernphysik, Heidelberg, Germany

Heinrich Iglseder
STMS,Sittensen, Germany

Tadashi Mukai
Kobe University, Japan

Ken-ichi Nogami
Dokkyo Medical University, Japan

Hideo Ohashi
Laboratory of Physics, Tokyo University of Fisheries, Japan

Gerhard Schwehm and Håkan Svedhem
Space Science Department, ESA, The Netherlands

Kazuo Yamakoshi[1]
ICRR, University of Tokyo, Japan

20th International Symposium on Space Technology and Science
Gifu, Japan
May 19 - 25, 1996

20th ISTS Secretariat
Hamamatsu-cho Central Building, 1-29-6 Hamamatsu-cho
Minato-ku, Tokyo 105
JAPAN

[1] Deceased

MARS DUST COUNTER ON BOARD ISAS PLANET-B

Eduard Igenbergs, Ralf Münzenmayer
Fachgebiet für Raumfahrttechnik, TU-München, Richard Wagner Str.18/III, 80333 München, Germany

Sho Sasaki
Geological Institute, University of Tokyo, Hongo, Tokyo 113, Japan

Georg Färber, Franz Fischer
Lehrstuhl für Prozeßrechner, TU-München, 80333 München, Germany

Akira Fujiwara
ISAS, 3-1-1 Yoshinodai, Sagamihara 229, Japan

Albrecht Glasmachers
Universität / GH Wuppertal, FB13 Lehrstuhl für Meßtechnik, 42097 Wuppertal, Germany

Eberhard Grün
MPI Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Heinrich Iglseder
STMS-Satellite Technology and Microsystems, Amselweg 14, 27419 Sittensen, Germany

Tadashi Mukai
Kobe University, 1-1 Rokkoudai, Nada-ku, Kobe 657, Japan

Ken-ichi Nogami
Dokkyo Medical University, Mibu, Tochigi 312-02, Japan

Hideo Ohashi
Laboratory of Physics, Tokyo University of Fisheries, 4-5-7 Konan, Minato-ku, Tokyo 108, Japan

Gerhard Schwehm; Håkan Svedhem
Space Science Department, ESA, PO Box 299, 2200 AG Noordwijk, The Netherlands

Kazuo Yamakoshi*
ICRR, University of Tokyo, Midori-cho, Tanashi 188, Japan

ABSTRACT

PLANET-B is a Japanese spacecraft which will investigate the Martian upper atmosphere and its interaction with the solar wind. A dust experiment MDC will be on board PLANET-B. The primary purpose of MDC is to detect circummartian dust particles and clarify the distribution of the proposed Martian ring or torus of dust particles. MDC PLANET-B will also measure interplanetary and interstellar dust particles. The proposed instrument is an improved version of the Munich Dust Counter flown on the Japanese MUSES-A satellite (HITEN) 1,2) and on the German BREMSAT 3). MDC is a multi-coincidence impact ionization detector measuring particles with mass between 10^{-15} and more than 10^{-5} g and velocity between less than 1 and more than 70 km/s. These mass and velocity ranges cover the expected mass and impact velocity of circumplanetary, interplanetary, and interstellar dust particles. The instrument is lightweight (around 650 g) with low power consumption (4 Watt). In this paper an overview of the PLANET-B mission will be given and the MDC will be described.

phone: (+49)-89-289-16004; fax: (+49)-89-289-1603;
e-mail: ralf@asterix.lrt.tu-muenchen.de

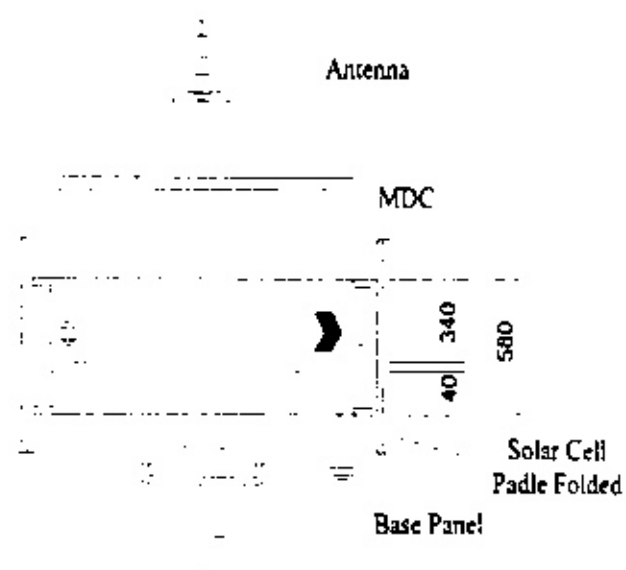

Figure 1: Outline of PLANET-B in launch configuration, with the MDC mounted at one of it's side panels.

*Deceased

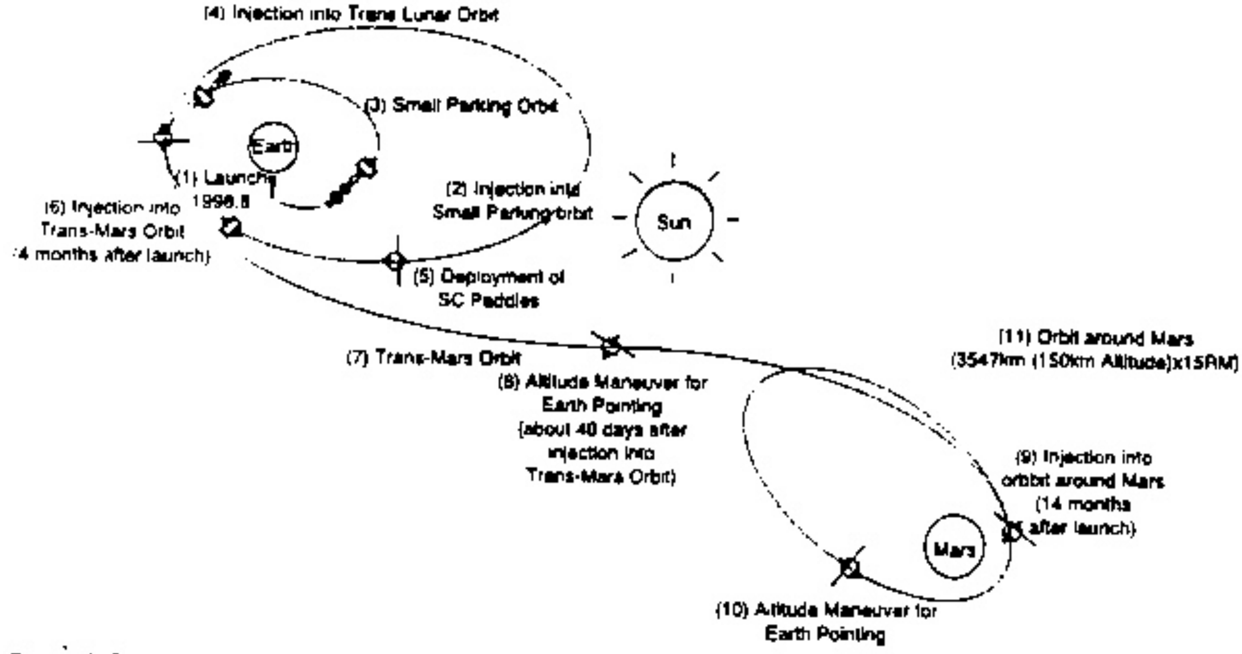

Figure 2: PLANET-B is scheduled to be launched in August 1998. After several fly-bys of the moon, it will leave the Earth on December 20, 1998 It will arrive at Mars on October 11, 1999, after which then it will execute scientific measurements around Mars for a minimum of one Martian year, which coresponds to two earth years [4].

1. Mission Overview

PLANET-B is a mission to Mars from the Institute of Space and Astronautical Science (ISAS) of Japan[4]. The primary scientific goals of the Mission are the following:

1. Investigation of the upper atmosphere
2. Observation of interaction between solar wind and upper atmosphere
3. Meteorological observation of lower atmosphere
4. Observation of intrinsic magnetic field and induced magnetic field

The launch of the mission is planed with the 3rd flight of the M-V rocket in summer 1998. The mission is divided in 3 Phases:

1. **Parking Phase (4 months):** launch; coasting; trans-lunar orbit (400000 km × 7000 km; 4.5 orbits; 11 days); 1st lunar swing-by; trans-lunar orbit (1,710,000 km Apogee; 0.5 orbits, 80 days); 2nd lunar swing-by; OMS firing for cruising
2. **Cruising Phase (10 months):** solar pointing (40 days) →Earth pointing; OMS firing for planet Mars
3. **Planet Mars Phase (2 years):** orbit plane TBD; less than 300 km altitude x 15 RM;

2. Scientific Objectives of the MDC Project

The PLANET-B mission provides an opportunity for an investigation of the interplanetary dust complex and the Martian dust environment. The overall objective of the proposed investigation is the study of the physical and dynamical properties of ejecta from the Martian satellites and all other small dust particles (with masses between 10^{-15} and more then 10^{-5} g). The parameters to be studied include charge, mass, speed and flight direction of individual particles and the time variation of the ejecta particle flux.

The scientific objectives are related to the 3 phases of the PLANET-B mission:

1. Phase (Parking Phase; 4 months):
The first phase is similar to the orbit of the MUSES-A mission (HITEN spacecraft) which spent 3 years in the vicinity of the earth and moon [5]. Thus provides the possibility to continue the dust measurements of the MDC onboard the HITEN spacecraft and to compare the new dust measurements with the old MDC data.

2. Phase (Cruising Phase; 10 months):
During the cruise phase the MDC can measure the interplanetary and interstellar dust flux [6] and there will be the possibility to compare the data with the data of the dust experiments on board the spacecraft's of the Galileo, Ulysses and hopefully the Cassini mission. As the Zodiacal Dust Cloud expands up to a distance of 2-3 AU from the sun, there could be the possibility to contribute with the MDC measurements on the solution of the question, what role are the asteroids and comets playing in the Zodiacal Cloud.

3. Phase (Planet Mars Phase; 2 years):
Around Mars, PLANET-B will take elliptic retrograde orbits whose periapsis could be down to 130-150km above the Martian surface and apoapsis is $15R_M$ (R_M Martian radius). The orbits, which are close to the zodiacal plane, will intersect with the Phobos' and Deimos' orbits twice respectively during the first two-year operation. The detection zone with large periapsis will fully cover the expected distribution of dust particles from Phobos or Deimos. Moreover, relative velocity between retrograde PLANET-B and prograde ring dust can be larger than 1km/s, which is suitable for impact ionization detector. It would be difficult to detect ring particles by a dust detector on a spacecraft taking a prograde circular orbit around Mars because of small relative velocity.

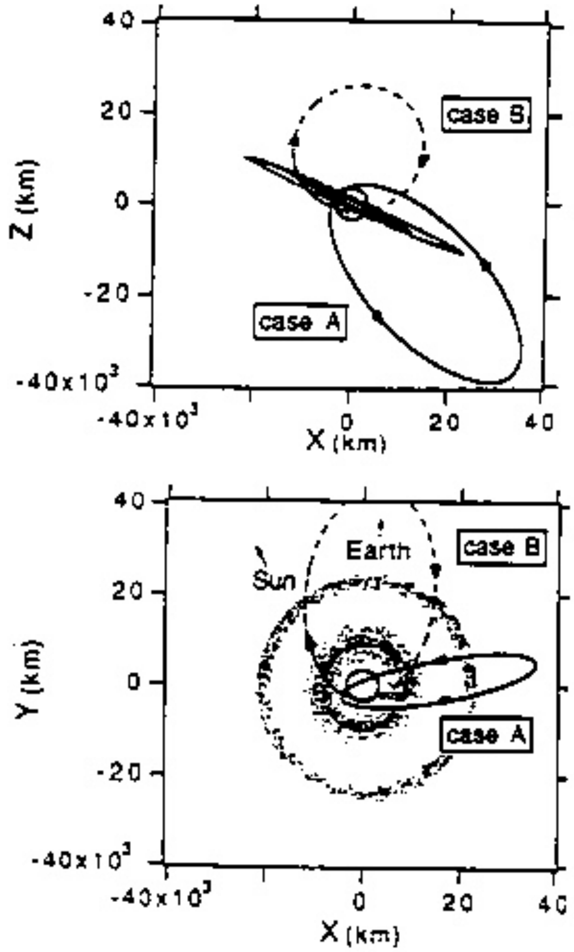

Figure 3: These drawings show two possible orbits of the PLANET-B mission. Case A represents an polar orbit and case B corresponds to an ecliptic orbit. In the lower drawing results from the calculations of the dust distribution due to the satellites Phobos and Deimos displayed [7].

Impacts on the surface of Phobos and Deimos generate ejecta particles which will mainly leave the satellites. There are some questions which could be investigated with help of the MDC.

- How much ejected particles are in orbits around Mars?
- Are there dust rings?
- What is the consistence of the possible dust rings (mass and velocity distribution)?
- How many particles are recaptured by the satellites?
- What are the loss mechanisms?

Concerning the loss mechanisms is very interesting to investigate the interaction of charged particles. As Mars has no significant magnetosphere the solar wind interacts with the atmosphere. Around Mars is only a low energetic plasma like on earth. Therefore the surface potential (equilibrium potential) of small particles could be app. 1 volt. It will be very difficult to measure the influence charge of such small charged particles as the noise level of the MDC electronic is probably higher than the charge of the particles, but there are some changes of the MDC compared to the MUSES-A MDC in order to decreases the noise level. With a more sensitive new MDC it could be possible to determine the surface charge, at least of the bigger particles.

The martian atmosphere is more enlarged than on earth due to the lower gravity. The density at an altitude of 150 km will be higher then on earth. Its known that there are small dust particles in the Martian atmosphere up to 50 km or may be more. We don't know whether there could be particles up to the altitude of the spacecraft (150 km). The MDC could proof whether there are such dust particles, if the periapsis of the spacecraft will be not increased from 150 km to a much higher value (due to safety considerations).

3. THE MARS DUST COUNTER

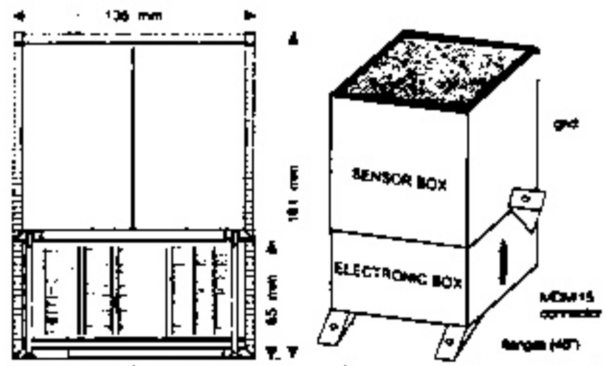

Figure 4: The MDC consists of an sensorbox which is fixed on top of electronic box. The inside of the sensorbox is gold plated in order to give a high charge yield due to particle impacts.

The Mars Dust Counter (MDC) is an impact ionization detector which is based on the Munich Dust Counter (MDC) which was flown sucessfuly on board of the HITEN Satellite of the MUSES-A mission (MDC-MU) of the Institute of Space and Astronautical Science (ISAS) and on board the German BREM-SAT (MDC-BS) in a Low Earth Orbit. The MDC is being developed by the Fachgebiet Raumfarttechnik at the Technische Universität München (TUM) of Germany and by the Space Science Department of ESA, with support by the German Space Agency (DARA) and the German industry. The MDC has been designed to determine mass and velocity of cosmic dust particles by measuring the impact charges generated by high velocity impacts (v>1 km/s) of those particles on a gold target [4]. The mass of the MDC flight unit is 0.65 kg, its power consumption is around 4 W. The dimensions of the MDC are 126 x 135 x 181 mm. The actual sensor area is 116 mm x 125 mm.

The general outline of the mechanical design of the MDC is shown in figure 4. The instrument consists of two boxes made of lightweight honeycomb structure. The lower box houses all electronics and is fixed to the satellite side panel. The upper box serves as particle detector or sensor box. The open front is covered by two grounded steel grids in order to reduce the electromagnetic noise from outside. The inside is gold plated, all five inner sides serve as target area for particle impacts, including the collector plates. The MDC is mounted on the side panel of the spacecraft looking 45° backwards in order to avoid sunlight shining directly into the sensor box (see figure 1), which otherwise would lead to noise signals due to photoionization.

4. MEASUREMENT PRINCIPLE

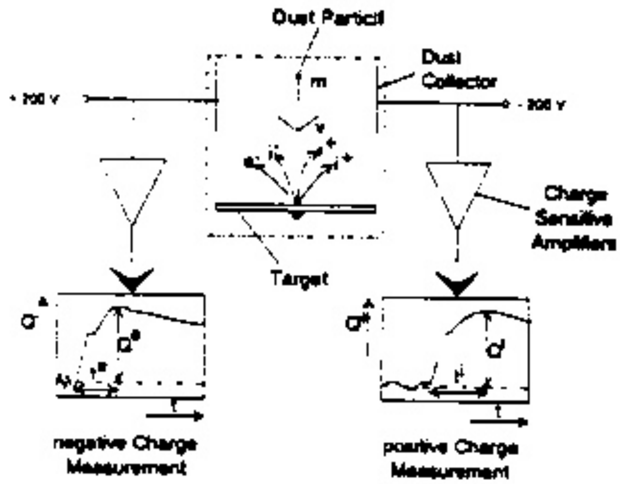

Figure 5: MDC measurement principle

The MDC experiment measures the electrical charges generated by high velocity impacts of small masses on a gold surface. The setup as shown in fig. 5 consists of a target and two charge collector plates which are biased by negative and positive voltages. The impact plasma is separated into positive ions on the negative collector and electrons and negative ions on the positive collector. The charges are measured by two independent channels. Charge sensitive amplifiers convert the impact charges of the ion and electron channels to an output voltage. This output is digitized and stored by a transient recorder consisting of two 8 bit A/D converters, clocked with 2.5 MHz each and using a FIFO memory. In order to minimize the error when converting more than four decades of input charges to 8bit data, the charge sensitive amplifiers have logarithmic response curves. A microprocessor system, 80C85 CPU with 4 KByte ROM and 56 KByte RAM, processes measured signals, controls the spacecraft interface and monitors voltages and temperatures.

Generally this design allows to record and store the whole particle impact signals of the ion and electron channel. The amount of impact data is 1 KByte per signal or 512 Byte per channel, giving a total measurement time of 200 µs. Together with the impact data calibration and housekeeping data valid for the time of impact are stored and transmitted down to ground, giving the opportunity to inspect the real signals measured in space.

During the evaluation of each charge signal, amplitude and risetime are determined. The mass m and velocity v of the dust particles can be derived from these parameters using the following empirical formulae, first found by Friichtenicht and Slattery [8] and adapted for the particular setup by Iglseder [9].

$$t = c_g * v^{\eta}$$
$$\pm Q/m = c_r * v^{\beta}$$

with: m particle mass; v particle velocity, Q maximum charge; t signal risetime; c_r, c_g, β, η calibration constants.

Iglseder showed also that the ratio of the charge of the primary impact to the charge generated due to ejecta from the dust particle impact can be determined in some cases and is also usefull for calculating the velocity of the impacting particle.

$$Q_1/Q_2 = c_{12} * v^{\delta}$$

More detailed calibration experiments showed also a dependence between the velocity and the time-difference from the begining of the rising of the two signals. This delay time is also depending on the impact location but the impact location can be determined with the typical shape and behaviour of the signals in most cases [10].

$$dt = c_{dt} * v^{\kappa}$$

There are some different possibilities to calculate the velocity, from these an average value can be calculated and the mass can then be derived.

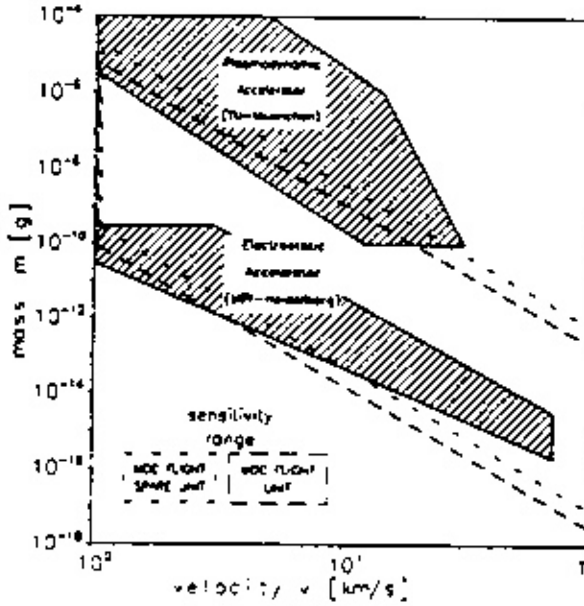

Figure 6: Sensitivity range of the MUSES-A MDC and capabiltiy of the accelerators which are used for calibration.

The used charge sensitive amplifiers are capable of measuring charges between $5*10^{-16}$ Cb and $1*10^{-11}$ Cb. The ratio of Q/m at a velocity of 10 km/s is between 0.1 and 1.0 C/g depending on the impact location. This means that at this velocity particles within a mass range of appr. $5*10^{-13}$ g to 10^{-10} g or a diameter range of appr. 0.15 µm to 10 µm could be detected. In figure 6 the sensitivity ranges of the MUSES-A MDC flight and flight spare unit is displayed. The sensitivity of these amplifiers was lower than that of the new amplifieres of the Mars Dust Counter. We can now use this higher sensitivity as the shielding of noise signals is significantly improved due to a new design of the sensor box and due some changes of the electronics.

5. CALIBRATION

For the calibration of the MDC instrument facilities are required which accelerate particles with masses between 10^{-7} and 10^{-15} g to velocities between 1 and 70 km/s. For the experiments to calibrate the MDC two such facilities were used [11,12,13]. One is the electrostatic particle accelerator of the Max-Planck-Institut für Kernphysik in Heidelberg, the other is the plasmadynamic particle accelerator of the Fachgebiet Raumfahrttechnik of Technische Universität München. Both facilities together cover the sensitivity range of the MDC instrument quite well, as can be seen from fig. 6. A few calibrations experiments were already performed with the Mars Dust Counter, but the greatest part of calibration experiments has been done now with the MDC flight spare unit of the MUSES-A project [10,14].

So fare there were not done enough experiments with the Mars Dust Counter, so only some preliminary results of the first calibration are given. The following Signals showing the impact location dependence are recorded from the old MDC but the new Mars Dust Counter shows similiar behaviour.

5.1. Impact Location Dependence

During the calibration experiments we did not only measure impacts in the center of the target area at the back side of the sensor box, but also on several other locations inside the sensor box, even on the charge collector plates. It turned out that the measured signals were quite dependent on the location of the particle impact inside the sensor box. These tests were performed at the electrostatic accelerator in Heidelberg, as the location of the particle beam is defined there within an accuracy of ±5 mm.

The result of these tests in general was that there are three groups of impact locations, which have very similar behaviour. They can be separated into the TOP group (close to Ion-Collector), the CENTER group and the BOTTOM group (close to Electron-Collector). In the figure 7 to 9 typical impacts of these three groups are shown as examples. All impacts have very similar parameters in terms of mass and velocity of the particle, but result in quite different sets of impact signals.

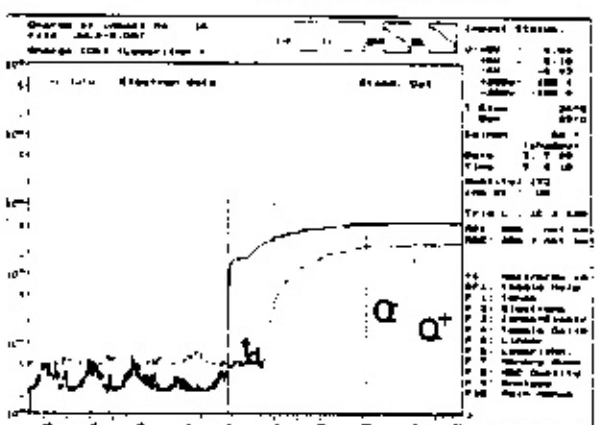

Figure 7: Center position: m = 4.1 E-12 g, v = 5.95 km/s.

The impact presented in fig. 7, measured in the CENTER, shows the expected charge signals. The ion signal rising with a short delay after the electron signal, due to the lower velocity of the ions, to about the same level as the electron signal. A typical example of an impact of the TOP group, measured at location 8, is shown in fig. 8. Here mainly the ion signal rises, while clearly less electron charges are collected during the measurement time of 100 µs. The opposite to this behaviour is encountered at the BOTTOM. (Fig. 9) In this case only the electron channel is measuring impact charges.

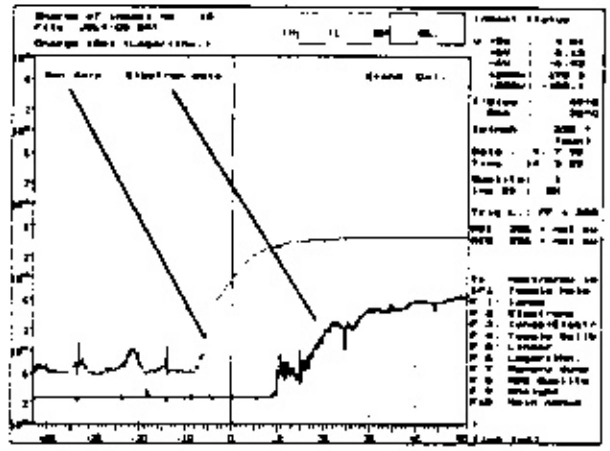

Figure 8: Top position: m = 3.8 E-12 g, v = 6.30 km/s.

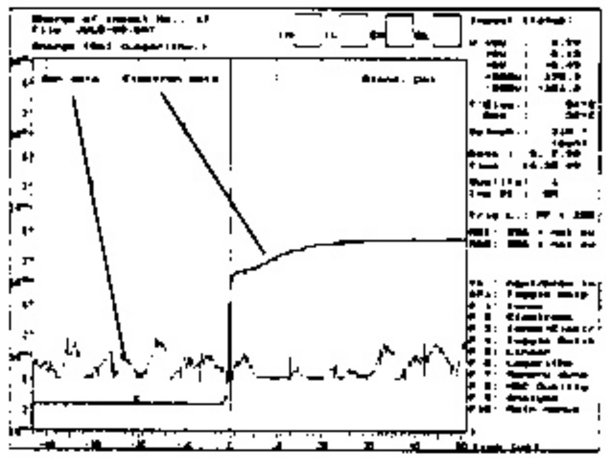

Figure 9: Bottom position: m = 2.3 E-12 g, v = 6.30 km/s.

It is often very difficult to distinguish impact signals with only one channel showing a clear visible charge signal from noise signals. Therefore it is important to have always two channels or more with a clear signal. One solution for this problem would be to have also the target area connected to a charge sensitive preamplifier. In the moment we are investigating the feasibility to implement an additional charge amplifier into the MDC electronic within the mass and power restrictions of the PLANET-B Mission.

5.2. Determination of calibration coefficients

The examples shown in figure 7 to 9 show clearly that it is not possible to use the same calibration for all impact locations. Therefore the results of the groups CENTER, TOP and BOTTOM have been to be evaluated separately in terms of rise times t+ and t- over impact velocity and in terms of charge to mass ratios Q+/m and Q-/m as a function of impact velocity for the three groups.

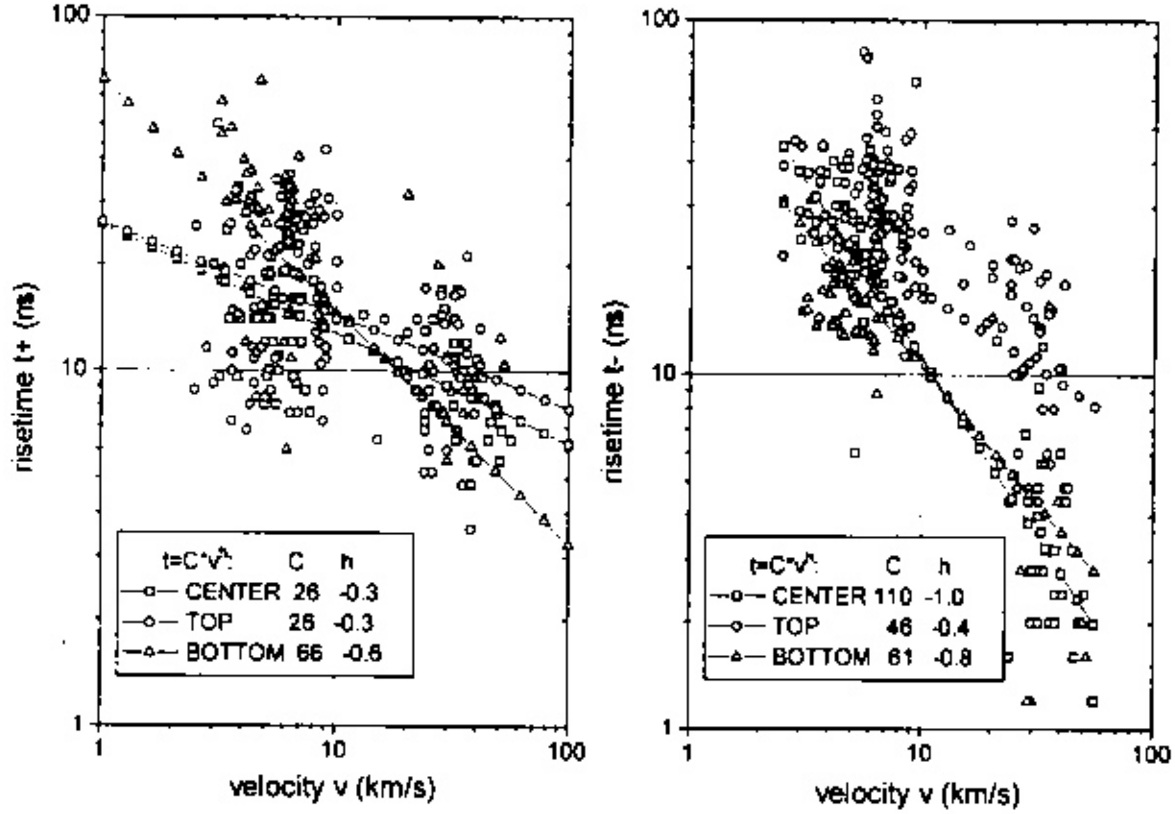

Figure 10: The velocity of the dust particles can be calculated from the risetime of the charge signals, but there are significant differences at the different impact locations. Therefore the impact location has to be known.

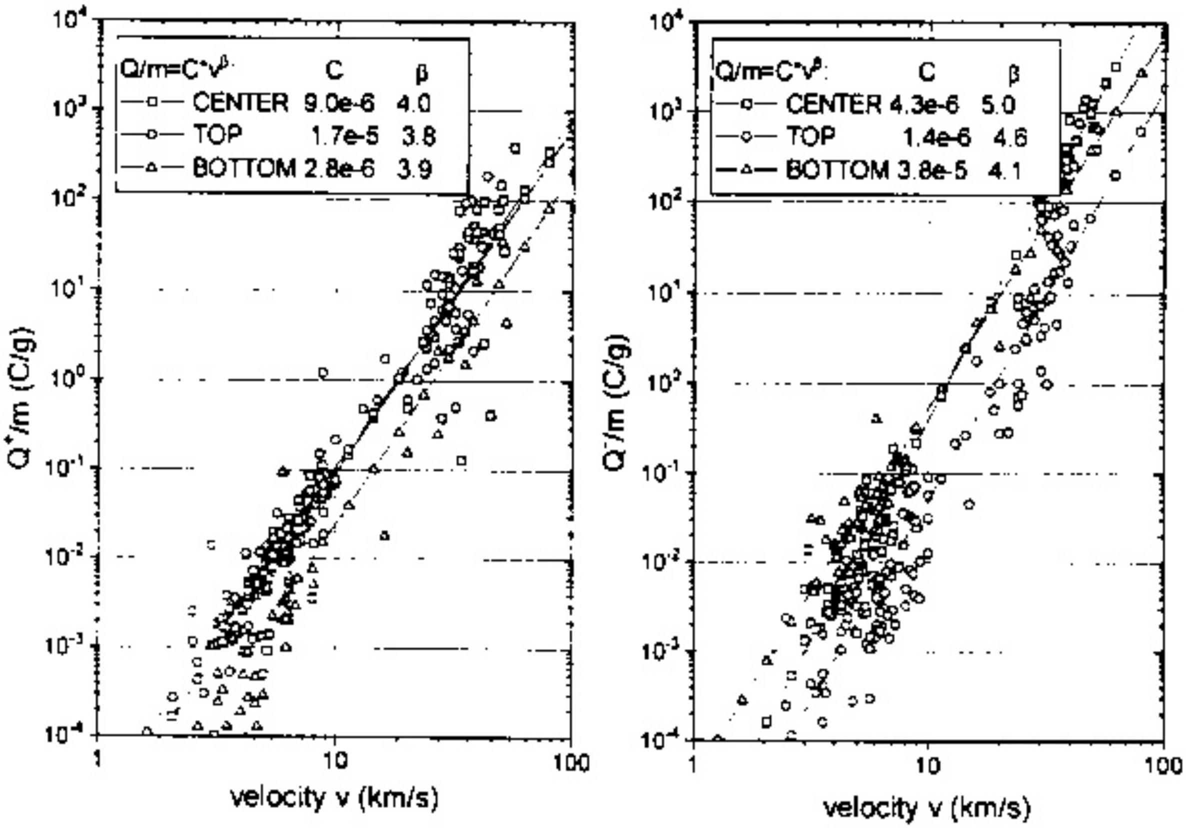

Figure 11: The overall impact charge normalized to the mass of the impacting particle shows a strong velocity dependence. If the velocity of the particle is known and the charge is measured, the mass can be calculated. At impact near to the center of the box the amounts of positive and negative charges are about the same, but at impacts close to the Ion Collector (TOP) the positive charges are dominating and at impacts in the part of the sensorbox near to the Elcectron Collector (Bottom) the negative charges are dominating.

In fig. 10 the measured rise times and in fig. 11 the charge to mass ratios are shown as a function of impact velocity for the three different groups. A least square fit line has been calculated through all values with the coefficients given in each diagram. It can be seen that in the CENTER case both signals, ion and electron charges, with t+ and t- resp. Q+/m and Q-/m, can be used to determine the particle velocity and mass with reasonable accuracy. At the TOP group only the ion channel with t+ and Q+/m shows a reasonable behaviour, while the electron channel with t- and Q-/m is not useful for the determination of particle velocity and mass. At the BOTTOM group the electron channel with t- and Q-/m is the only way to determine velocity and mass of the impacting particle. There are much less data points in the t+ and Q+/m versus velocity diagrams, because there was no ion charge at all in many cases.

5.3. Determination of impact location

In the laboratory it is of course easy to associate specific sets of charge signals with given impact locations, as it has been done in the previous section. But during the operation of the MDC experiment in space, the impact location of a cosmic dust particle inside the MDC sensor box is not known a priori. To be able to select the appropriate calibration group, TOP CENTER or BOTTOM, we have to find a way to relate a given set of impact signals to one of these groups.

This can be done by analyzing both signals, ion and electron charges, and their relation to each other. The relevant parameters for this evaluation are indicated, which are the delay time between electron and ion channels, dt, and the maximum charge values Q+ and Q-. The delay time dt is defined as positive, if the ion channel is rising after the electron channel. If the charge ratio of Q+/Q-, and the delay time dt is evaluated for all particle impact measurements at all locations, the dependence of these parameters of the impact location gets evident.

The group TOP shows generally charge ratios of Q+/Q- above 1 and negative delay times. It is very cleary defined and has very little overlapping with CENTER impacts. The BOTTOM group only has charge ratios Q+/Q- of less than 0.1 and positive delay times. The CENTER group has charge ratios which are between the ratios from TOP and BOTTOM impact signals and has positive delay times in most cases.There is a small area where CENTER and BOTTOM are overlapping.

5.4 Accuracy of measurement

With the coefficients c_r, c_g, c_{12}, c_{dt}, β, η, δ and κ known, the general way to determine the particle velocity and mass by the impact charge measurement is the following:

First the impact has to be associated with one of the groups TOP, CENTER or BOTTOM by an evaluation of delay time dt and charge ratio Q+/Q-. As there will be a wide range of ground impact measurements, it is possible to confirm this by comparing the data with similar data measured on ground. Next the signal rise times t+ and t- , the rations of primary to secondary charges and the delay time are determined to calculate the particle velocity. With this velocity and by using the coefficients c_r and β the charge to mass ratios Q+/m and Q-/m can be calculated. The maximum charge values Q+ and Q- finally lead to the particle mass.

In general, using the two curves of the ion and electron channel with two different sets of coefficients (specific for the given location) some different particle velocities and two different particle masses will be obtained.

All the data of the three groups TOP, CENTER and BOTTOM has been evaluated according to the scheme described above and using the appropriate coefficients. Thus the evaluated data could be compared to the particle data measured at the accelerator facilities and the overall measurement accuracy could be determined.

For the MUSES-A MDC the standard deviation between the impact velocity and the calculated velocity was a factor of about 1.6 and between the masses the factor was below 6. The standard deviation in the case of the mass determination includes the error of the velocity determination. We expect to get the same or better accuracy with the Mars Dust Counter.

6. STATUS OF THE MDC

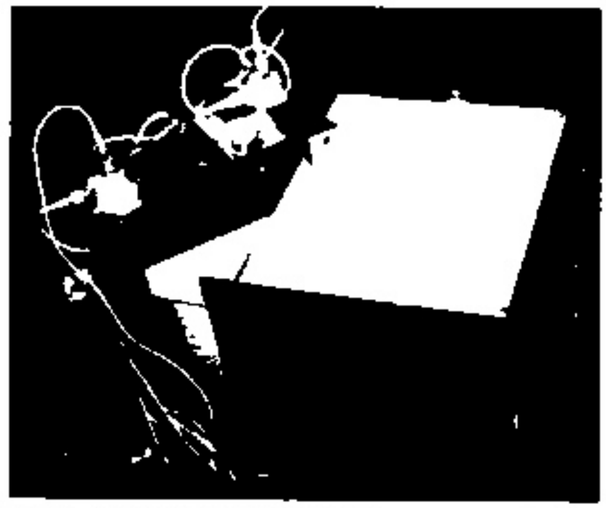

Figure 12: MDC prototype with sensors mounted for monitoring the accelerations during the vibration test

After an acoustic test with the MDC-boxes, in March 1996 the prototype of the Mars Dust Counter was completed. There were done some first calibration experiments with the electrostatic dust accelerator in Heidelberg. In April 1996 the prototype was tested in the big sun simulation chamber of IABG, Germany. The thermal conditions of the MDC together with an simple space-craft dummy were measured and evaluated in order to minimize the necessary mass for thermal insulation and thermal paint. In figure 12 the MDC prototype is displayed just before the vibration test of the experiment, which was also performed in April 1996. After some improvements of the electronics in June the manufacturing of the flight model will be started in order to be able to deliver the flight model in March 1997 for first integration and interface tests at ISAS in Japan. In Summer 1997 there will be some calibration experiments with the flight unit before the final integration of the flight unit into the spacecraft.

7. DISCUSSIONS

Recent theoretical studies show that solar radiation pressure together with Martian oblateness should enhance the amplitude of orbital eccentricity of ring particles [14]. At the Phobos' orbit, particles smaller than 20 μm are quickly trapped by Mars. If dust source should be solely the secondary ejecta from interplanetary dust collisions onto satellites, the abundance of circummartian particles would be small and the detected number of them by MDC should be much smaller than that of interplanetary particles. However, collisions of ring particles onto Phobos and Deimos may produce new dust particles because of satellite low escape velocity, and the dust ring/torus is self-sustained [15,16,17,18]. If this mechanism is efficient, dust abundance will be high enough that MDC PLANET-B can detect particles at each crossing of the ring/torus.

Orbital calculations suggest that particles from Phobos would form a thin ring (inclination $i \approx 0.01$) containing particles around 20-100 μm, whereas particles from Deimos would form a thick torus ($i \approx 0.2$) even containing smaller particles. Determination of particle mass and velocity by MDC will not only confirm circummartian particles but also discriminate particles from Phobos and those from Deimos.

8. REFERENCES

1) *Igenbergs E., Hudepohl A., Uesugi K., Hayashi T., Svedhem H. Iglseder H., Koller G., Glasmachers A., Grün E., Schwehem G., Mizutani H., Yamamoto T., Fujimura A., Ishii N., Araki H., Yamakoshi K., Nogami K.:* "The Munich Dust Counter - A Cosmic Dust Experiment on Board of the MUSES-A Mission of Japan"; *In "Origin and Evolution of Interplanetary Dust" (eds. A.C. Levasseur-Regourd and H. Hasegawa), Kluwer Tokyo, 45-48, 1991.*

2) *Igenbergs E., Hüdepohl A., Uesugi K., Hayashi T., Svedhem H. Iglseder H., Koller G., Glasmachers A., Grün E., Schwehem G., Mizutani H., Yamamoto T., Fujimura A., Ishii N., Araki H., Yamakoshi K., Nogami K.:* "The Present Status of the Munich Dust Counter Experiment on Board of the HITEN Spacecraft"; *In "Origin and Evolution of Interplanetary Dust" (eds. A.C. Levasseur-Regourd and H. Hasegawa), Kluwer Academic Publishers Tokyo, pp. 15, 1991.*

3) *Münzenmayer R., Iglseder H., Svedhem H.:* "The Munich Dust Counter MDC - an experiment for the measurement of micrometeoroids and Space Debris" *First European Conference on Space Debris, Darmstadt Germany, 5-7 April 1993, ESA SD-01, pp. 117-123, 1993.*

4) *NN:* „PLANET-B *INTERIM* REPORT", *ISAS February 1995*

5) *Hüdepohl A., Iglseder H., Grün E., Münzenmayer R., Svedhem H., Mizutani H., Yamamoto T., Fujimura A., Araki H.:* "Analysis of the results of two-year operations of the Munich Dust Counter - a Cosmic Dust Experiment on board the satellite HITEN"; *43rd Congress of the International Astronautical Federation, Washington, August 28 - September 5, 1992, IAF-92-0561.*

6) *Svedhem H., Münzenmayer R. and Iglseder H.: "Detection of possible interstellar particles by the HITEN spacecraft"; Submitted to IAU Colloquium No. 150, Physics, Chemistry and Dynamics of Interplanetary Dust, Gainesville, FL, USA, Aug. 14-18, 1995*

7) *Ishimoto H., Kimura H., Nakagawa N. and Mukai T.: "Planned observation of Phobos/Deimos Dust Rings by PLANET-B", 30th COSPAR Scientific Assembly, Hamburg, July 1994, B1.5-0/3.*

8) *Friichtenicht J. F., Slattery J. C.:* "Ionization Associated with Hypervelocity Impact", *NASA Technical Note D-2091, 1962*

9) *Iglseder H.,* "Ladungsemission beim Hochgeschwindigkeitseinschlag",. *Dissertation, Lehrstuhl für Raumfahrttechnik, TU-München, 1986*

10) *Münzenmayer R.;* "Beiträge zur experimentellen Erforschung des Staubes im Weltall", *Dissertation, Fachgebiet Raumfahrttechnik, TU-München, Herbert Utz Verlag Wissenschaft, München 1995.*

11) *Hüdepohl A., Igenbergs E. and Rott M.,* 'Coaxial Plasma Accelerator with Compressor Coil and Radial Gas Injection' *IEEE Transactions on Magnetics, Vol. 25, No. 1 (1989).*

12) *Igenbergs E., Aigner S., Hudepohl A., Iglseder H., Kuczera H., Rott M. and Weishaupt U.,* 'Launcher Technology, In-Flight Velocity Measurement and Impact Diagnostics at the TUM/LRT' *International Journal of Impact Engineering, Vol. 5, No. 1 - 4 (1987).*

13) *Fechtig H., Grün E. and Kissel J.,* 'Laboratory Simulation', *in J.A.M. McDonnell,* 'Cosmic Dust' *p.607-p.669, John Wiley & Sons in Chichester, 1978*

14) *Münzenmayer R., Iglseder H. and Svedhem H.:* "The Munich Dust Counter MDC - an experiment for the measurement of Micrometeoroids and Space Debis"; *Proceedings of the First European Conference on Space Debris, Darmastadt, Germany, 5-7 April 1993, ESA SD-01:*

15) *Igenbergs E., Sasaki S., Färber G., Fischer F., Münzenmayer R., Fujiwara A., Iglseder H., Glasmachers A., Grün E., Mukai T., Nogami K., Ohashi H., Schwehem G., Svedhem H. and Yamakoshi K.:* "Mars Dust Counter on Board ISAS PLANET-B"; *Submitted to IAU Colloquium No. 150, Physics, Chemistry and Dynamics of Interplanetary Dust, 1995.*

16) *Hamilton D. P.,* "The Asymmetric Time-Variable Rings of Mars"; *ICARUS in press, 1995*

17) **Ishimoto H.**; *Submitted to IAU Colloquium No. 150, Physics, Chemistry and Dynamics of Interplanetary Dust, 1995.*

18) **Sasaki S.**: "Martina dust tori formation: Ejecta at collision of torus particles with the satellite ca sustain dust abundance"; *Proc. 27th ISAS Lunar planet. Symp., 47, 1994.*

19) **Sasaki S.**: "Martian Self-Sustaining Dust Torus"; *Submitted to IAU Colloquium No. 150, Physics, Chemistry and Dynamics of Interplanetary Dust, 1995.*

Acknowledgements:

We would like ot acknowledge the signifigant work on the MDC electronics performed by Dieter Klinge and Jose Maria Castro and the assistance during calibration at the MPI accelerator by Gerhard Schäfer and also the support by Kurt Graf and Rainer Ondrusch at the Laboratory of LRT/TUM.