Geochemical Instrument Package Facility

GIPF Summary Report

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1 Introduction

This document gives a summary of the work performed within ESA Contract No. 16854/03/NL/HB "Development of a compact Geochemistry Instrument Package Facility (GIPF)". Main objective of this study was the development and assembly of a compact instrument facility for in-situ geochemistry sample analysis in planetary research.
Several work packages listed in chapter 2 below have been performed, from the assessment of different geochemistry methods to final testing of the hardware and steps described to achieve a flight model for a given mission. The design was driven by the proposed BepiColombo mission to be used on a lander on planet Mercury. In other words BepiColombo was the "reference mission" for the presented study.

The prepared hardware was titeled as "Verification model (VM)". The VM consists of the miniaturised payloadcab, with the Moessbauer Spectrometer MIMOS, the Alpha-particle-X-ray-spectrometer APXS and the microscopic camera MIROCAM readily integrated. Overall control of the instruments facility is done through the GIPF common subsystem (CSS) and GSE software.
The box for the instruments exactly meets the formfactor of the payload cab of a miniaturised vehicle, the "Nanokhod rover", which has been developed in parallel in a second contract (MRP). The GIPF work did not cover miniaturisation and environmental testing of the CSS and the spectrometers backend electronics. Instead a major step towards a fully miniaturised instruments facility has been done by showing up a way of how to combine the overhead of the 3 instruments into a single electronics. The final hardware uses FPGA technology which has heritage in space projects whilst being the state of the art way for miniaturisation of digital circuitry. The spectrometers themselves do have heritage using their dedicated backends in NASA missions to planet Mars. This document does not go into details of spectroscopy methods of the final GIPF instruments, but an overview is given in the reports of workpackage 2000.
The study was lead by von Hoerner & Sulger GmbH, Schwetzingen. Subcontracts to built the spectrometers and the camera have been placed at University of Mainz, Max-Planck-Institut für Chemie, Mainz and DLR, Deutsches Zentrum für Luft- und Raumfahrt e.V., Berlin.

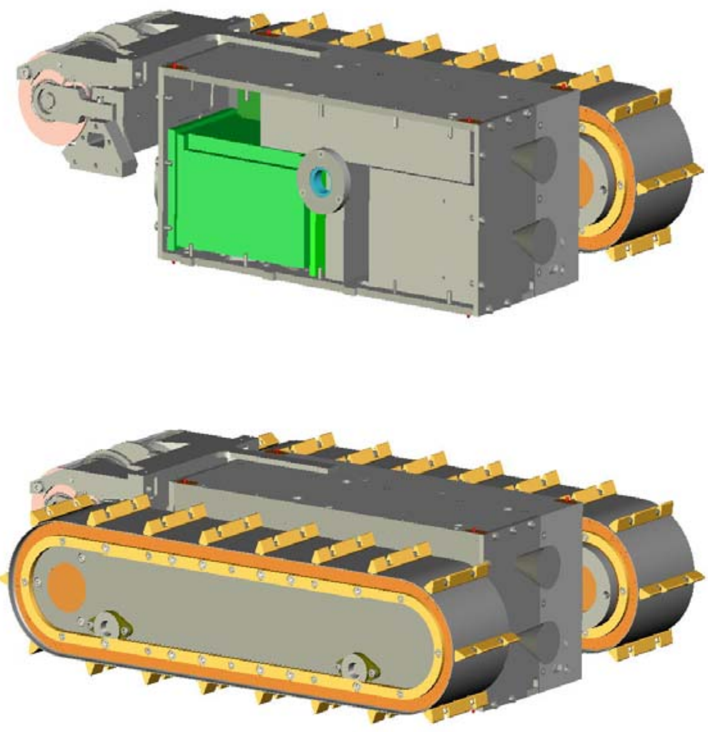


Figure 1 Nanokhod rover , top : inside view of the payload cab with the Mössbauer spectrometer MIMOS (green) , APXS and MIROCAM (grey). Field of view for the in-situ geochemistry analysis is shown (same for all 3 instruments).

2 Overview

2.1 GIPF workpackages

The following lists the work packages performed within the GIPF study and provides a quick information about the contents.

2.1.1 WP1000: Requirements Assessment

The first activity was to create and document a complete set of relevant requirements and constraints, upon which all further tasks are based. This consists of Rover Capabilities, covered in WP1100, where the NANOKHOD micro-rover resources have been taken as input (mass, volume, power, data). The scientific objectives of a geochemical exploration of the surface of planet Mercury and requirements on the choice of instrumentation are discussed in WP1200. A full and structured list of all GIPF requirements is provided as the output of WP1300.

2.1.2 WP2000: Instruments Review

This workpackage revied different methods of chemical analysis (WP2100), mineralogical analysis (WP2200), imaging instrumentation (WP2300) and additional other instruments (WP2400) to gain information on geochemistry samples, mainly by in situ exploration. All known available technologies have been considered and assessed for use in planetary missions. The collected information allowed to position the GIPF baseline instruments relative to their commercial or competing space counterparts.

2.1.3 WP3000: Verification Model Design

In this workpackage all detailed design activity towards a Verification Model (VM) of the GIPF instrument suite was covered, including Common Subsystem and GSE design, payloadcab mechanical design, as well as software concept. The result of this large activity is a complete set of documents for
fabrication of each GIPF subunit, and detailed technical specification for the entire VM. All designs had to be shown to be compliant with the requirements.

2.1.4 WP4000: GIPF Verification Model Fabrication

WP4000 covered the complete fabrication of all GIPF VM units including the Common Subsystem and the payloadcab mechanics.
In a last step, all components have been integrated to a complete functional VM. All sensors have been integrated mechanically and all electronics has been adapted to the Common Subsystem.

2.1.5 WP5000: Test & Validation

In WP5100 a complete testplan has been set up including all functional and environmental tests, to be performed on the VM. All instruments have been tested standalone and in the integrated state. Environmental tests included thermovacuum and vibration according to the requirements of the BepiColombo reference mission.

2.1.6 WP6000: GIPF FM Electronics Concept

In this workpackage a complete design concept for a future GIPF flight model has been created. Objectives are:
Integrating the complete baseline instrument set into the NANOKHOD payload cab including a unified power and data interface.
The electronics of the instruments will be highly integrated by utilizing one central FPGA plus one central digital signal processor, instead of multiple FPGAs/processors for each individual instrument. This workpackage picks up the outcome of the previous state of development and results.

2.1.7 WP7000: Programmatics

WP7100 tries to estimate and assemble an overall FM development schedule, qualification program and an estimated cost calculation. In the absence of a real mission this delivers only a rather coarse estimation. Alternative GIPF applications are presented as the outcome of WP7200.

2.1.8 WP8000: Management

WP8000 was added for formal reasons in the GIPF proposal phase. It does not deliver results to be discussed in the following.

3 Results

3.1 Results of the individual work packages

This chapter provides a quick tour through the outcome of the individual work packages. The description here is condensed. The interested reader can find the list of the original reports with all detailed information in chapter 4.

3.1.1 WP1000: Requirements Assessment

The NANOKHOD rover requirements assessment reserved a mass of 620g for payload instrument cores (sensors) and another 605g for the payloadcab overhead. The distribution of individual instrument masses can be taken from the tables in GIPF-TN-110-VHS-0. Except for the spectrometers backends, which are placed outside the cab for the VM the numbers meet the final values of the hardware. Volumewise the 3 sensors did meet the rover requirements. Nevertheless the numbers given in GIPF-TN-110-VHS-0 are to small with respect to the final MIROCAM and MIMOS sensors. The original idea of integrating a fourth instrument into the volume can not be supported in the present state. GIPF-TN-110-VHS-0 also provides power and data volume estimations.
GIPF-TN-120-MPC-0 as outcome of WP1200 describes the advantages of surface measurements over the existing data gathered by spacecrafts from the orbit.

Remote determination of chemical composition can be done by gamma-ray and x-ray spectroscopy, in-situ determination of chemistry by gamma-ray, x-ray, alpha, or laser plasma spectroscopy, in-situ determination of mineralogy by Mössbauer, Raman, or thermal emission spectroscopy, and identification of surface texture and granularity by close-up or microscopic multispectral photography. GIPF-TN-120-MPC-0 also gives an overview on Mercury facts. This workpackage consolidates the baseline instrument choice for the mission.

GIPF-TN-130-VHS-1 establishes a structure for the set of requirements relevant for this project. A matrix is presented which lists all crosslinks between requirements and subsystems. All requirements listed in this document are strictly imposed from some external entity *towards GIPF* and its subunits, and not the other way around. This shall help to avoid any ambiguities as to which party has to be compliant with a requirement. The presented requirements structure has also been applied to the companion project of the rover development. Both projects share the same requirements database. In case of any FM development this system provides an optimal overview of the dependancies within the project.

3.1.2 WP2000: Instruments Review

The work done in this workpackage also consolidates the baseline instrument choice. Several different approaches for chemical, mineralogical and imaging analysis are presented. Within the limited resources the instruments chosen for GIPF seem to provide an optimal solution to gain maximum geochemistry information from remote in-situ measurements.

3.1.3 WP3000: Verification Model Design

3.1.3.1 WP3100 APXS VM Design

One of the new aspects of both spectrometers used in this study is the digital filtering of X-ray pulse amplifiers. This method becomes more and more popular in spectroscopy electronics and should now be applied to miniaturised instruments for planetary exploration in this study. After carefully assessing the existing systems of digital pulse amplifiers, the APXS team decided to go for a digital electronics developed by *X-ray Instrumentation Associates,* (XIA).
As there where only minor modifications of the APXS sensorhead with respect to the version used in the NASA Mars Exploration mission, the main effort for GIPF concentrated on the digital spectroscopy aspect.

3.1.3.2 WP3200 MIMOS VM Design

Also for the Miniaturised Mössbauer Spectrometer the main effort concentrated on setting up a digital filter channel as proof of concept. Therefore some effort has been taken to built a breadboard version of a digital filter and connecting it to one MIMOS detector and preamplifier. Some general introduction to digital signal processing in spectroscopy is provided in GIPF-TN-320-UMZ-0. It also describes the breadboard in detail and show the path to a common GIPF unit for both spectrometers, that can be combined in a common digital circuit for possible flight units. As the work for the MIMOS digital filter has been performed at vH&S GmbH, there was already a strong interest in using plain FPGA technology for the digital filter. This technology allows lateron easily combining the different digital tasks of the GIPF instruments and rover overhead for a possible FM development. The MIMOS digital filter shares the same electronics board as the GIPF Common Subsystem.

3.1.3.3 WP3300 MIROCAM VM Design

The main goal of MIROCAM is to provide close-up images of the same field of view as covered by APXS and MIMOS. In close-up mode the distance between MIROCAM and the rock sample is of the order of a few tens of millimetres. Considering the uncertainty in the distance estimate and the surface roughness of the samples it becomes clear that a fix-focus camera solution would provide unsatisfactory results in terms of resolution and contrast. Therefore, an auto-focus system has been developed that can operate at very close distances. Furthermore, the goal was to change the focus from close distances to infinity in order to support navigation and orientation of the rover. The system has been accommodated in a very small package of 19mm(H) x 40mm(W) x 96mm (L).
The goal MIROCAM VM was to verify the design of a micro-rover- camera model that could be the baseline for a future FM-design. It will be used for verification and further investigations in laboratory. In order to do so, the following design goals have been applied for the VM:

1. the design concept has to be as similar or as close as possible to the flight unit
2. all main components shall be accommodated in a volume that is very close to a flight unit
3. it shall be possible to qualify the VM components or it shall be possible to procure the VM-components in a standard that is compatible to use in space environment.
4. Some relaxation can be made in respect of performance (e.g. optics) and in the miniaturization level of electronics.

The relaxations were mainly necessary because of cost reasons. Therefore, it is possible to improve the performance, the hardness of the components and their miniaturization level if higher financial resources are available. An evaluation has to be made for all key-components for their FM-readiness. The VM design is based on existing (off-the-shelf) components that come as close as possible to the FM design but at low cost. The key subsystems and components of the MIROCAM are optics, sensor, opto-mechanical subsystem and sensor control electronics.

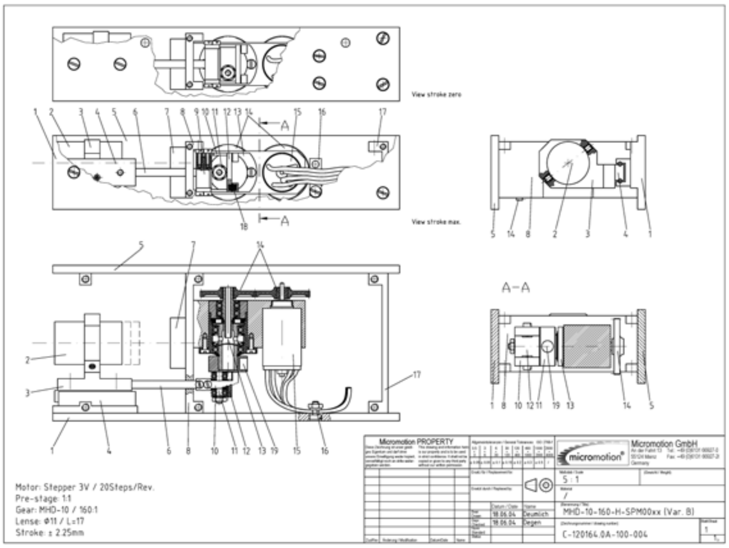
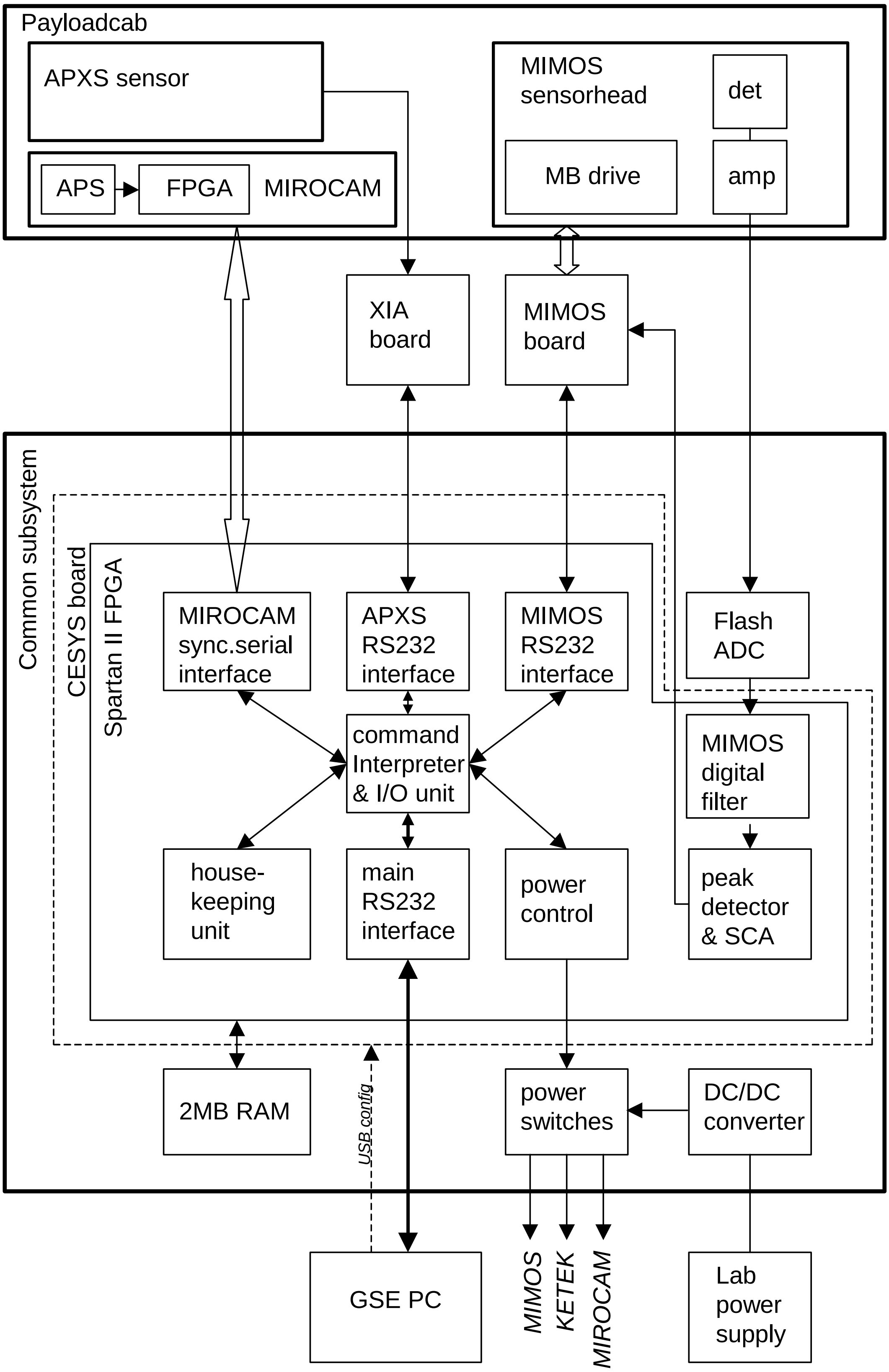


Figure 2 Mechanical design of MIROCAM

3.1.3.4 WP3400 Common Subsystem Design

Main function of the GIPF common subsystem is to connect the three instruments APXS, MIROCAM and MIMOS to a single communication line, handle their data and commands and distribute and switch power. In a later stage large portions of the instruments digital electronics and the CSS will be joined. This is possible, as all designs can make use of similar FPGA technology. In the GIPF VM stage some portions of the electronics hardware are not integrated into the payload box. The following blockdiagram gives an overview of the whole GIPF electronics, including all interfaces to the common subsystem. The upper box represents the payloadcab. The lower box stands for the common subsystem electronics. The payloadcab contains the APXS and MIMOS sensorheads and the MIROCAM sensor and electronics module. All three of them are connected by their existing standard Micro-D connectors that are fed through the cab wall. The common subsystem - shown in the lower box - makes use of a readily produced digital unit, the "CESYS board", which is a commercially available hardware module[1]. This module contains a Xilinx FPGA of type Spartan II. The Spartan-II FPGA on board the CSS is large enough to cover all communication interfaces, and memory handling. No microcontroller is needed. The MIROCAM and APXS interfaces do have high datarates which can be easily read by an FPGA wihout blocking other parallel activities. A second circuit is attached to the Cesys board by connectors and soldered wires. This one contains RAM, DC/DCconverters, and interface ICs. In case of the GIPF VM all communication to or from the CSS is done by a GSE in the form of a personal computer. This PC runs the common subsystem through a single serial interface. A direct connection to the instruments is possible for diagnostic purposes, so that they can be commanded without the CSS using their dedicated PC software.


Payloadcab
APXS sensor
APS
FPGA
MIROCAM
MIMOS
sensorhead
det
MB drive
amp
XIA
board
MIMOS
board
Common subsystem
CESYS board
Spartan II FPGA
MIROCAM
sync.serial
interface
APXS
RS232
interface
MIMOS
RS232
interface
Flash
ADC
command
Interpreter
& I/O unit
MIMOS
digital
filter
house-
keeping
unit
main
RS232
interface
power
control
peak
detector
& SCA
2MB RAM
USB config
power
switches
DC/DC
converter
GSE PC
MIMOS
KETEK
MIROCAM
Lab
power
supply

3.1.4 WP4000: GIPF Verification Model Fabrication

3.1.4.1 WP4100 APXS VM Fabrication

The reduced space in the GIPF sensor box required a reduction of the APXS sensor head size. The mechanical adaptation of the APXS sensor head for the GIPF VM was achieved by removing the external cylindrical housing used in the previous MER design, the alpha detector system (including the printed circuit board with the preamplifiers of the alpha detectors; due to the greatly improved performance of the x-ray detector system the alpha channel is of extremely little value and will be omitted in all future instruments), and the protective door mechanism (experience with both, Pathfinder and MER has shown that there is no need for "dust protection"). Measurements have been done to quantify the interference between the two spectrometers when mounted closely in the cab. The only problem was an increased background in the APXS spectra due to the MIMOS source. Finally this was reduced to an acceptable level by a Tungsten alloy shielding plate between the two spectrometers. The digital electronics has been mounted in a rigid box and directly connects to the APXS sensorhead and to the CSS data and command interface. A peltier cooler can be operated which improves the resolution when operating around roomtemperature.

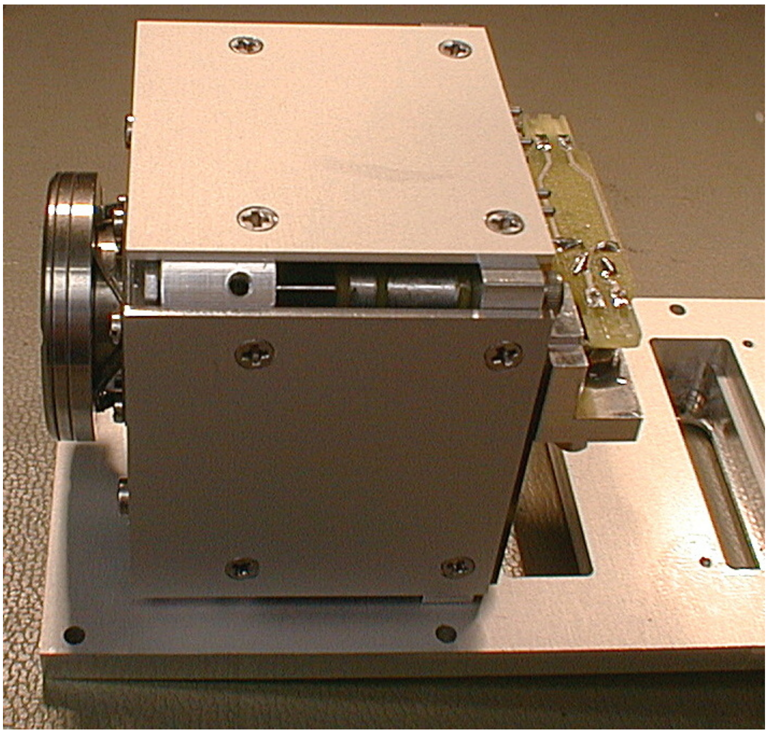


Figure 3 APXS mounted on payloadcab baseplate, side view

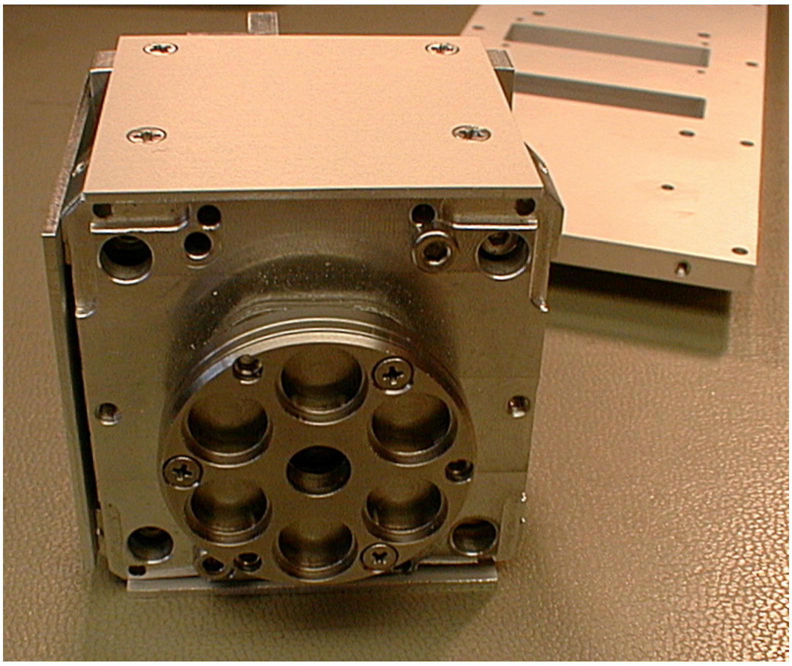


Figure 4 APXS front view

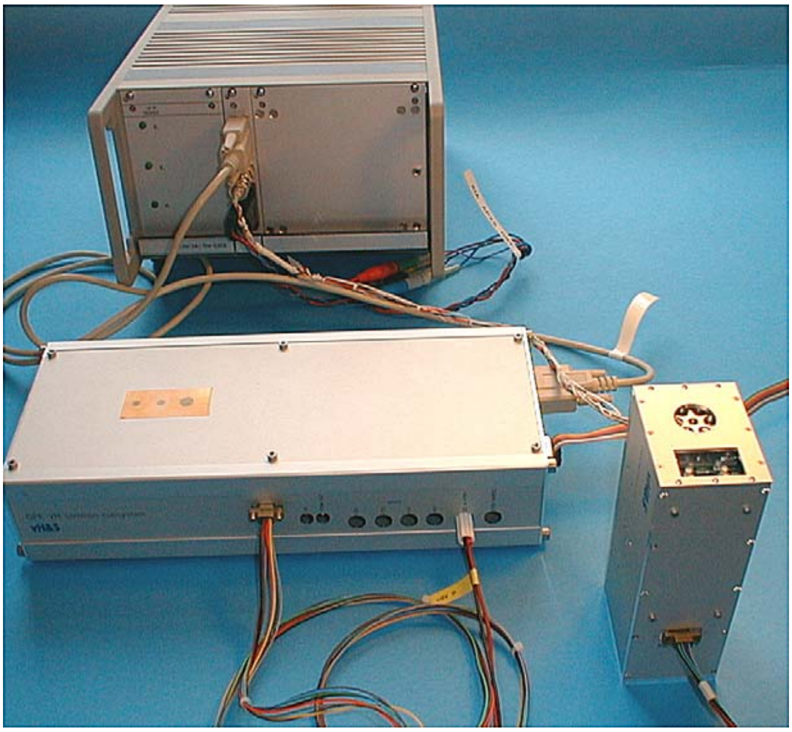


Figure 5 Setup to operate GIPF APXS: payloadcab with APXS visible (right), CSS box (left) and APXS digital electronics with XIA board (background)

3.1.4.2 WP4200 MIMOS VM Fabrication

MIMOS for GIPF consists of the sensorhead, mounted inside the payloadcab, the digital electronics board for data aquisition and the digital filter for one detector. The MIMOS digital filter has been fabricated according to the precursing design studies of WP3200. A trapezoidal filter has been implemented into the FPGA. The necessary circuitry to drive the analog to digital converter has been built in small formfactor and with low power consumption. For practical reasons the filter hardware has been built on the same PCB as the GIPF common subsystem. The FPGA that was necessary for the common subsystem tasks also contains the digital filter logic. Anyway all hardware can be used independently from the GIPF CSS overhead.

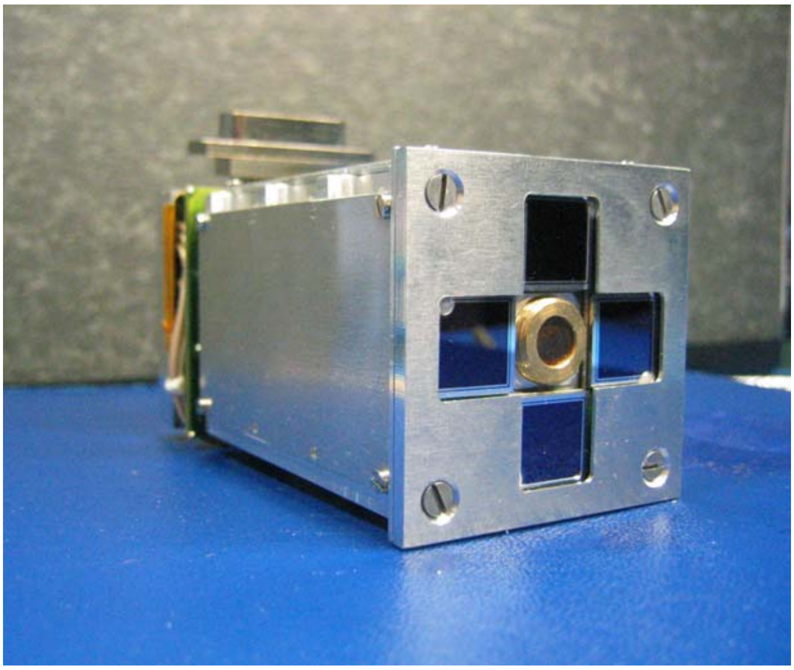


Figure 6 MIMOS sensorhead (detectors visible)

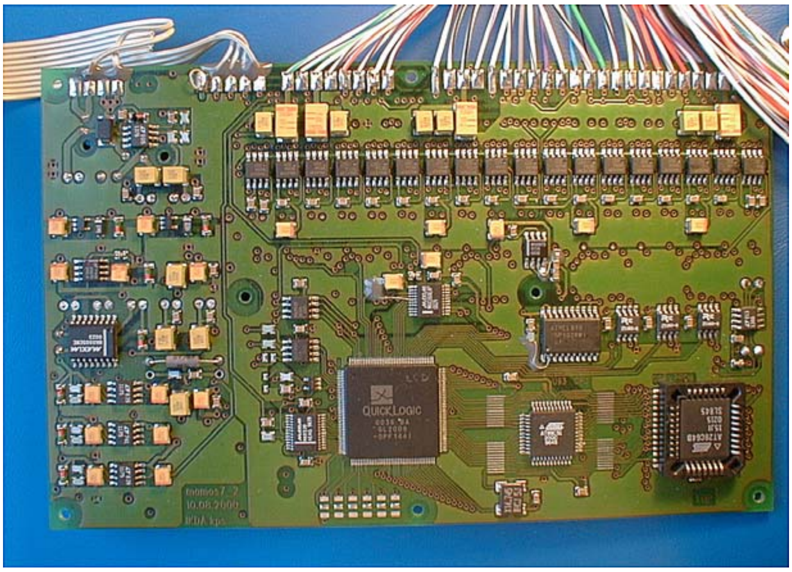


Figure 7 MIMOS digital board

3.1.4.3 WP4300 MIROCAM VM Fabrication

There are only minor modification between the VM design and the fabrication to be done due to technical reasons. These changes concern a non rad-hard optics and a commercial APS chip. They do not affect the instrument interfaces for GIPF.

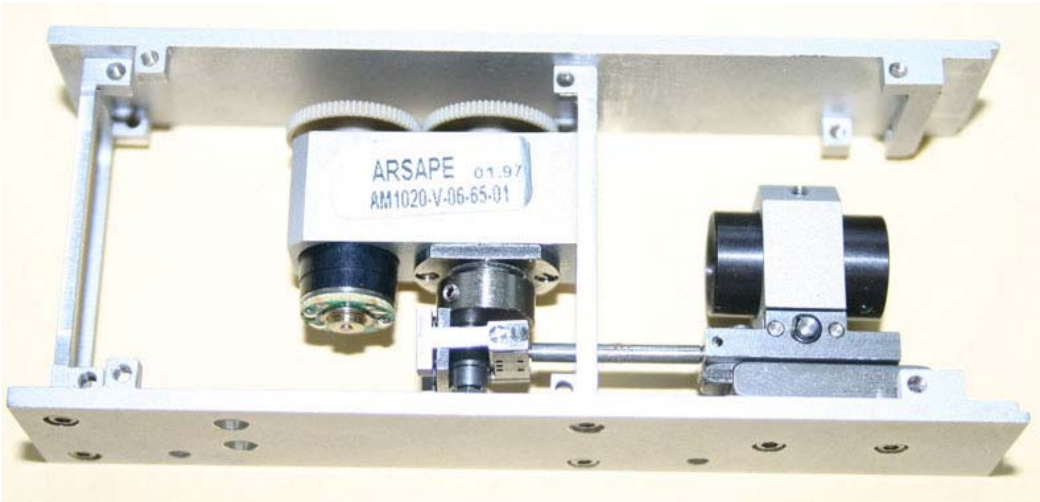


Figure 8 Photo of MIROCAM mechanics

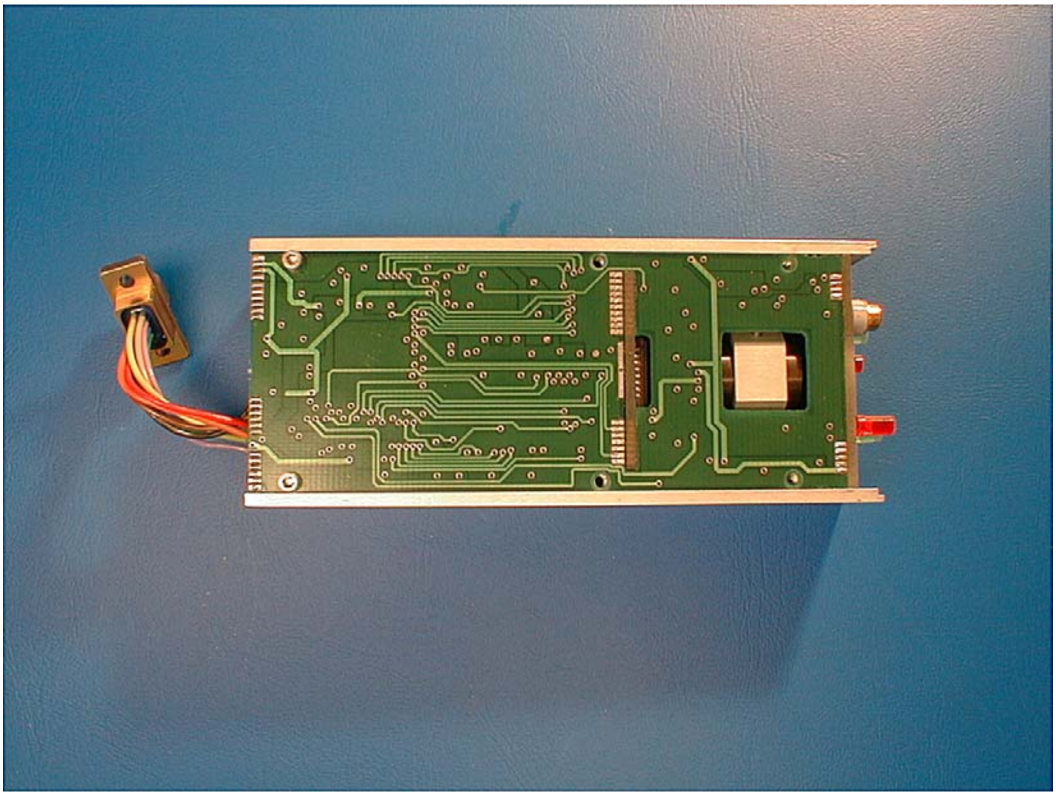


Figure 9 MIROCAM, closed

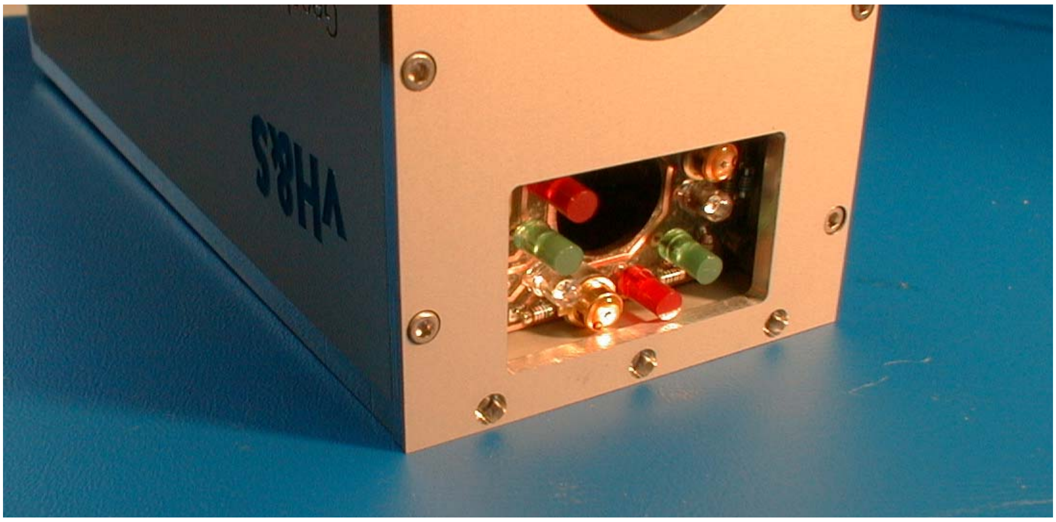


Figure 10 MIROCAM inside payloadcab, LEDs visible

3.1.4.4 WP4400 Common Subsystem Fabrication

Two joined PCBs form the GIPF common subsystem. On the lefthand side of the following

image one can see the FPGA board. On the right side one can see the dedicated CSS board. Both are connected by a 96pin VME connector.
GIPF-TN-440-VHS-0 gives a detailed tour across the electronics and the CSS software and operation. WP4400 also covered fabrication of the payloadcab.

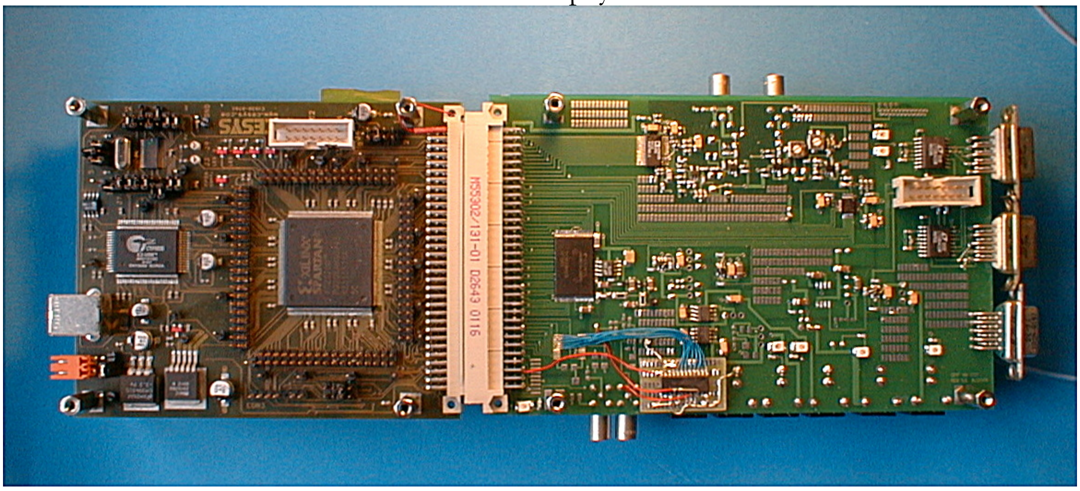


Figure 11 CSS electronics with XILINX FPGA (left)

Figure 12 Photo of CSS case and payloadcab

3.1.5 WP5000: Test & Validation

3.1.5.1 WP5100 Testplan

Outcome of WP5200 was a testplan for GIPF to

- perform functional testing of the instruments using the common subsystem and individual instrument GSE hardware and software. Examine inter-instrument cross-effects.
- perform thermovacuum tests on the payloadcab
- perform vibrational tests (shock tests excluded).

Only the VM payloadcab with its instrument sensor heads is subject to environmental testing described in GIPF-TN-510-VHS-1 as “Integrated Tests”.
The complete GIPF was forseen to be used for functional testing. Functional tests were planned to be performed on the completely integrated payloadcab.

3.1.5.2 WP5200 APXS Testing

WP5200 included APXS functional testing as well as evaluation of all spectra gathered during the thermovacuum test.
An example spectrum of a Co57 source is presented in the following. The sensor head turned out to work nominal and performs with a sufficient energy resolution of 200 eV at 6.4 keV. The test was conducted at room temperature and ~ 300 mW Peltier cooling power.
GIPF-TN-520-MPC-2 also discusses measurements of the additional background due to the Mössbauer source. Even if this cannot be completely eliminated, the finally used shielding scales the background down to acceptable levels.
During thermovacuum tests APXS operated at all temperatures down to -183°C. Any side effects like line shifts are explained in GIPF-TN-520-MPC-2.

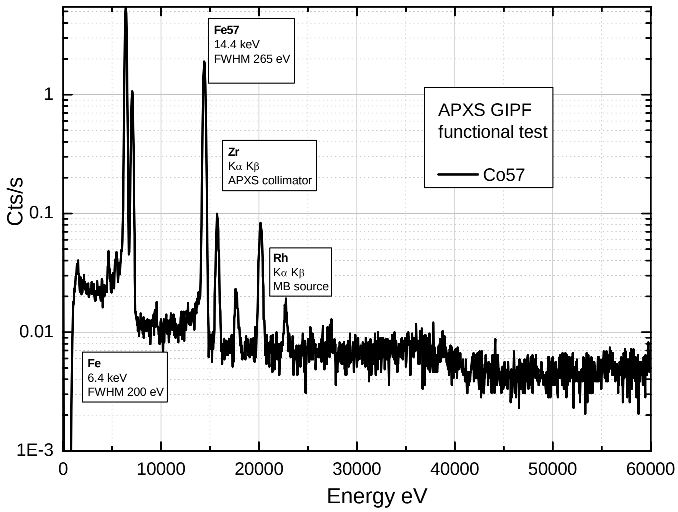


Figure 13 Example spectrum taken at a Cobalt-57 source

3.1.5.3 WP5300 MIMOS Testing

MIMOS functional test included characterization of the digital and analog amplifiers and the Mössbauer drive system. Direct comparison of the digital and analog filters could be done in simultaneous measurements. Correct command and data flow through the CSS was successfully established. The advantages of the digital filter are the much higher possible countrates, the easy simultaneous aquisition of energyspectra and Mössbauer spectra. Other technical aspects are a low amount of external components (no analog components in the chain after digitisation of the preamplifier signals) and easy software control of the filter parameters.

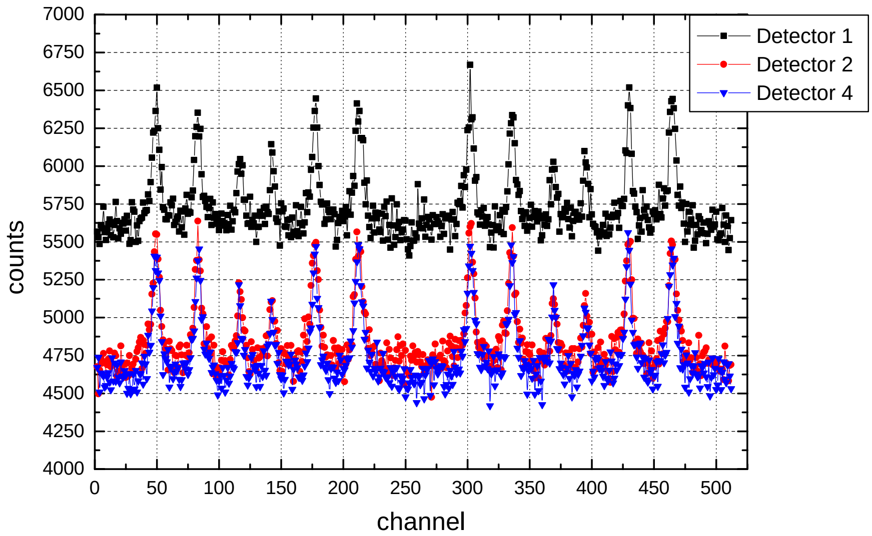


Figure 14 Example spectrum on an iron foil sample

The evaluation of the thermovacuum test showed, that the detector and amplifier system works over the full temperature range down to -183°C. The electromechanical Mössbauer drive system failed in a first attempt during this test at around -80°C with a feedback ringing problem. A new sensorhead could be provided by University of Mainz that has been tested to be working down to the limit of the Institutes climate chamber of -140°C.

3.1.5.4 WP5400 MIROCAM Testing

Functional tests of MIROCAM have been performed at DLR.
Images have been taken to verify the functionality of the camera in respect to imaging and illumination. Below is a test image of a rock sample. Because of the lack of colour in the rock-sample further laboratory images were taken which contain real electronic components with different colours (red, blue, green yellow) and a colour test target.
The images were taken with the LED-illumination of MIROCAM

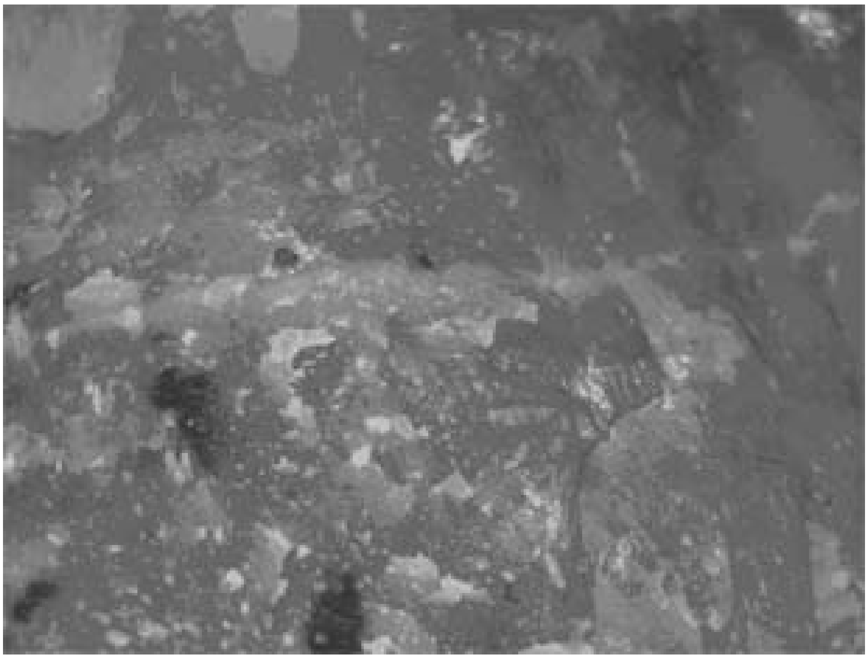


Figure 15 Rock sample image

Figure 16 Image in close-up mode with RGB- LED illumination (composit)

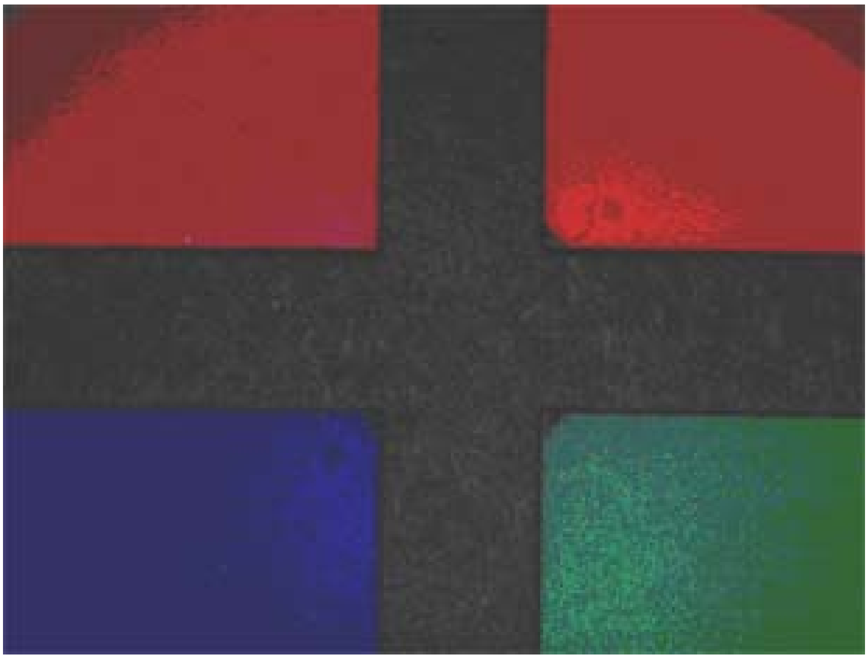


Figure 17 Image of a colour test target (Macbeth Colorchecker) FOV_H: 16mm, $T_{in}t$: 390msec

Evaluation of the thermovacuum test data showed, that the focus motor used so far did stuck already around -20°C. Also the commercial APS sensor showed some problems. Thus the camera was tested separately at DLR lateron. The (commercial-) electronics of the camera was able to operate down to about -120°C. The main EEE-component that fails was the APS. After several tests the first APS-sensor failed totally, which was probably caused by thermal-mechanical stress within the sensor. The opto-mechanics of MIROCAM (motor&gear,..) did then operate down to -145° which was the limit of the DLR test chamber. This was only possible after major modifications of the used commercially available components.

3.1.5.5 WP5500 Thermovacuum and Vibrational Test

The activity of this work package covered integrated tests of the Geochemistry Instrument Package Facility. These are the vibrational tests performed at TÜV Mannheim, Germany and thermovacuum tests done at the climate chamber laboratory at ESTEC. The results of these test are described in detail in GIPF-TN-550-VHS-1.

The vibrational tests did not show any effect on the hardware. The spectrometers designs have been tested for other missions already and no problems were expected. But also the MIROCAM worked properly after the test.

The results of the thermovacuum tests have been provided to the instruments teams. They have been mentioned already in this chapter and can be read in detail in the individual reports of WP5000. One of the astonishing results is, that the detector systems of both spectrometers even work down to -183°C satisfactorily.

3.1.6 WP6000: FM Electronics Concept

In this work package, a concept has been developed for a future GIPF FM. The GIPF instruments have been split into individual frontends and commonalised back-end units, that are combined in a common subsystem, CSS. The presented miniaturisation approach of all GIPF components allows to put the complete GIPF electronics, consisting of all frontends and the CSS, into the payload cab of the NANOKHOD. The CSS provides all signal processing and support for the instruments, and does the central task of power distribution, communication, and control. All GIPF instruments, and later probably the entire system including the NANOKHOD, can be accessed through a single tether interface. The presented concept goes beyond the original proposed plan to have an FPGA plus a processor for GIPF control: The concept utilises only one FPGA with one included soft-core controller, but no separate processor IC. This leads to a further reduction of component count, while allowing easier qualification. Assessment of combining GIPF and MRP systems has been touched only roughly; a first concept has been presented, how the CSS can be interfaced to the MRP electronics (see Fig. 14). But more detailed investigations towards a commonalised system with GIPF and the NANOKHOD need to be done in future work.

3.1.7 WP7000: Programmatics

Detailed outcome of WP7100 is presented in GIPF-TN-710-VHS-0.
The WP7200 study text considers more potential applications for the GIPF package. GIPF has primarily been designed for exploration on Mercury's surface, but it can be used also on other targets. A list of alternative targets in space is presented. For these targets the changes required are discussed, to cope with the different environments. There are other possible applications of GIPF also on earth, a few of which are also presented in this workpackage. Further, the standard GIPF instrument set APXS, MIMOS, and MIROCAM can be augmented by other miniaturised instruments, to extend the range of applications for GIPF. One candidate instrument that has been proposed by DLR is the water sensor MiniHUM, which is shortly presented here.

4 List of GIPF Documents

4.1 Technical Documents

Doc. No.	Title / Description
GIPF-TN-110-VHS-0	NANOKHOD resources assessment
GIPF-TN-120-MPC-0	Scientific Objectives
GIPF-TN-130-VHS-1	Instruments Requirements
GIPF-TN-210-MPC-0	Chemical Analysis Instruments Review
GIPF-TN-220-UMZ-0	Mineralogy Instruments Assessment
GIPF-TN-230-DWP-0	Imaging Instruments Review
GIPF-TN-240-UBE-0	Additional Instruments Review
GIPF-TN-310-MPC-0	APXS VM Design
GIPF-TN-320-UMZ-0	MIMOS VM Design

GIPF-TN-330-DWP-0	MIROCAM VM Design
GIPF-TN-340-VHS-0	Common Subsystem Design
GIPF-TN-410-MPC-0	APXS VM Fabrication
GIPF-TN-420-UMZ-0	MIMOS VM Fabrication
GIPF-TN-430-DWP-0	MIROCAM VM Fabrication
GIPF-TN-440-VHS-0	Common Subsystem Fabrication
GIPF-TN-510-VHS-1	GIPF Testplan
GIPF-TN-520-MPC-2	APXS VM Test Report
GIPF-TN-530-UMZ-0	MIMOS VM Test Report
GIPF-TN-540-DWP-0	MIROCAM VM Test Report
GIPF-TN-540-DWP-1	MIROCAM final Test- and Summary Report
GIPF-TN-550-VHS-1	GIPF VM Test Report
GIPF-TN-600-VHS-0	GIPF FM Electronics Concept
GIPF-TN-710-VHS-0	GIPF FM Programmatics
GIPF-TN-720-VHS-0	GIPF Applications Assessment

4.2 Viewgraphs

GIPF-VG-030516-VHS-0	GIPF Kickoff Meeting
GIPF-VG-040324-VHS-1	GIPF Progress Meeting 2
GIPF-VG-041215	GIPF Progress Meeting 3

4.3 Progress Reports

GIPF-PR-0305-VHS-0	Progress Report
GIPF-PR-0306-VHS-0	Progress Report
GIPF-PR-0307-VHS-0	Progress Report
GIPF-PR-0308-VHS-0	Progress Report
GIPF-PR-0309-VHS-0	Progress Report
GIPF-PR-0310-VHS-0	Progress Report
GIPF-PR-0311-VHS-0	Progress Report
GIPF-PR-0312-VHS-0	Progress Report
GIPF-PR-0401-VHS-0	Progress Report
GIPF-PR-0402-VHS-0	Progress Report
GIPF-PR-0403-VHS-0	Progress Report
GIPF-PR-0404-VHS-0	Progress Report
GIPF-PR-0405-VHS-0	Progress Report
GIPF-PR-0406-VHS-0	Progress Report
GIPF-PR-0407-VHS-0	Progress Report
GIPF-PR-0408-VHS-0	Progress Report
GIPF-PR-0409-VHS-0	Progress Report
GIPF-PR-0410-VHS-0	Progress Report

GIPF-PR-0411-VHS-0	Progress Report
GIPF-PR-0412-VHS-0	Progress Report
GIPF-PR-0504-VHS-0	Progress Report
GIPF-PR-0505-VHS-0	Progress Report
GIPF-PR-0506-VHS-0	Progress Report
GIPF-PR-0507-VHS-0	Progress Report

4.4 Minutes of Meetings

GIPF-MM-040324-VHS-0	Minutes of Meeting
GIPF-MM-040702-VHS-0	Minutes of Meeting
GIPF-MM-041215-VHS-0	Minutes of Meeting
GIPF-MM-050816-VHS-0	Minutes of Meeting
GIPF-MM-051115-VHS-0	Minutes of Meeting
GIPF-MM-051124-VHS-0	Minutes of Meeting

4.5 General Documents

Some general documents can be found on the delivered GIPF CDROM.

4.6 Miscellaneous Documents

The misc folder on the GIPF CDROM contains mainly technical documentation on the instruments that was not covered by other technical notes. This includes circuit drawings, firmware and software code, some additional mechanical drawings and documentation of third party companies (XIA,CESYS).

5 Delivered Hardware

All GIPF hardware is delivered to ESTEC, Noordwijk. This is in detail:

- GIPF payloadcab assembled with APXS and MIMOS sensorheads and MIROCAM camera.
- Common subsystem electronics box
- APXS XIA digital electronic box
- MIMOS digital electronics board
- APXS sensorhead to XIA harness
- XIA to CSS RS232 cable (nullmodem)
- MIMOS electronics to CSS RS232 cable 1:1
- MIROCAM to CSS cable (9pin Micro-D)
- CSS to PC RS232 cable 1:1
- USB cable for CSS firmware upload
- 15V wall power supply

- CDROM with Documentation, software and CSS firmware

6 Conclusion

During this study a set of instruments has been assembled for "dry analysis" in geochemistry and related sciences. The selected instruments cover an X-ray fluorecence spectrometer for elementary analysis, a Mössbauer spectrometer for determination of iron bearing compounds operating in backscattering mode and a microscopical camera with illumination by different colour and infrared LEDs. All methods operate nondestructively by simply placing a sensor close to the sample material. Driving requirement was the usage in planetary research inside a remotely operated vehicle, the "NANOKHOD rover". The instruments have been adapted to the requirements of the rover. The mechanical arrangement of the instruments is done in a way, that the same target spot, e.g. on a rocksample, can be accessed by rotating the cab around a single axis. A supposed mission to planet Mercury, the originally planned but later on skipped ESA "BepiColombo Lander", has been taken as a goal for the design.
With respect to the budget available for the GIPF project, the study delivered a respectable fully functional package for many tasks of in-situ geochemistry analysis. The GIPF outcome also paved the way towards a highly integrated instrument facility for future space missions. There are no principle technical barriers when tuning the system to a flight model, even considering the harsh environmental conditions of the reference mission to planet Mercury.