

IFCTR IFCAI	<h1 style="text-align: center;">SAX MECS</h1>	Document: MECS Ground Calibration Report Reference: MECS_OGC_38, Issue1.1 Date: September 16, 1998 Page:
----------------	---	---

Contents

1. Introduction ..... 1

2.1. Mirror unit ..... 2

2.2. Detector unit ..... 3

2.3. Electronic unit ..... 4

2.4. Reference to industry documentation ..... 6

3. Test description ..... 9

3.1. Optics tests at PANTER ..... 9

3.2. MECS prototype tests at PANTER ..... 9

3.3. MECS final tests at LEPS ..... 9

# MECS Ground Calibration Report

MECS\_OGC\_38 Issue 1.1 - September 16, 1998

Prepared by the SAX MECS Team

L. Chiappetti <sup>(1)</sup>, G. Conti <sup>(1)</sup>, G. Cusumano <sup>(2)</sup>, S. Del Sordo <sup>(2)</sup>, G. La Rosa <sup>(2)</sup>,  
M.C. MacCarone <sup>(2)</sup>, T. Mineo <sup>(2)</sup>, S. Molendi <sup>(1)</sup>, S. Re <sup>(2)</sup>, B. Sacco <sup>(2)</sup>, M. Tripiciano <sup>(2)</sup>

Edited by M.C. MacCarone <sup>(2)</sup>

- (1) - IFCTR-CNR, Istituto di Fisica Cosmica e Tecnologie Relative, Milano, Italy  
(present denomination "Istituto di Fisica Cosmica Giuseppe Occhialini")
- (2) - IFCAI-CNR, Istituto di Fisica Cosmica e Applic. Informatica, Palermo, Italy

3.4. Optics tests at LEPS ..... 9

3.5. ESTEC tests ..... 16

3.6. Cape Canaveral tests ..... 16

4. Data reduction ..... 17

4.1. Format of archived data ..... 17

4.2. Format of archived units ..... 18

4.2.1. PANTER ..... 18

4.2.2. PANTER MK data analysis ..... 19

4.3. Package analysis ..... 19

4.4. Built in calibration source analysis ..... 20

4.5. Detector geometry ..... 20

4.6. Geometry of the detector ..... 21

4.7. Geometry of the mirrors ..... 24

4.8. Image linearization ..... 24

4.9. Gain stability ..... 25

4.9.1. Positional dependency of gain ..... 25

4.9.2. Time dependency of gain ..... 26

4.10. Point Spread Function ..... 26

4.10.1. detector ..... 26

4.10.2. mirrors ..... 28

4.10.3. detector + mirrors on axis ..... 28

4.11. Mirror effective area ..... 27

4.12. Escape fraction ..... 28

4.13. Pile-up ..... 28

4.14. Energy spectra analysis ..... 29

4.15. PL spectra analysis ..... 30

4.16. Dead time ..... 31

Document for which no computer readable source exists any longer

Partial scan of original hardcopy of 83 pag. (available on request) supplied

IFCTR IFCAI	<h1 style="text-align: center;">SAX MECS</h1>	Document: MECS Ground Calibration Report Reference: MECS_OGC_38, Issue1.1 Date: September 16, 1998 Page: i
----------------	---	---

## Contents

<b>1. Introduction</b>	<b>1</b>
2.1. Mirror unit	4
2.2. Detector unit	5
2.3. Electronic unit	8
2.4. Reference to Industry documentation	8
<b>3. Test description</b>	<b>9</b>
3.1. Optics tests at PANTER	9
3.2. MECS prototype tests at PANTER	9
3.3. MECS flight model tests at Laben	9
3.4. PANTER tests	10
3.4.1. Experimental setup	10
3.4.2. Test conduct	13
3.4.2.1. Multi-pin-hole	14
3.4.2.2. Flat field	15
3.4.2.3. Mirror units	15
3.4.2.4. PMT HV scan	16
3.4.2.5. Count rate scan	16
3.4.2.6. Miscellanea	16
3.5. ESTEC tests	16
3.6. Cape Canaveral tests	16
<b>4. Data reduction and analysis description</b>	<b>17</b>
4.1. Format of original data	17
4.1.1. PANTER and Laben scientific data	17
4.1.2. PANTER housekeeping data	17
4.1.3. ESTEC and Alenia data	17
4.2. Format of archived data	18
4.2.1. PANTER scientific data	18
4.2.2. PANTER housekeeping data	18
4.3. PANTER HK data analysis	19
4.4. Ratemeter analysis	20
4.5. Built in calibration source analysis	20
4.6. Detector geometry	20
4.6.1. from flat field runs	21
4.6.2. from multipinhole runs	23
4.7. Be window characteristics	24
4.7.1. theoretical	24
4.7.2. rib obscuration (flat field + MPH)	24
4.7.3. uniformity (MPH + flat field)	24
4.8. Image linearization	24
4.9. Gain stability	25
4.9.1. positional dependency of gain	25
4.9.1. time dependency of gain	26
4.10. Point Spread Function	26
4.10.1. detector	26
4.10.2. mirrors	26
4.10.3. detector + mirrors on axis	26
4.11. Mirror effective area	27
4.12. Escape fraction	28
4.13. Pile up	29
4.14. Energy spectra analysis	29
4.15. BL spectra analysis	30
4.16. Dead time	31

<b>5. Results of main analysis .....</b>	<b>35</b>
5.1. PANTER HK stability .....	35
5.2. Ratemeter stability.....	36
5.3. Calibration source position.....	36
5.4. Calibration source gain stability vs time.....	38
5.5. Calibration source gain stability vs rate .....	39
5.6. Replacement of calibration sources .....	40
5.7. Detector geometry .....	41
5.8. Be window characteristics .....	42
5.9. Position distortion corrections.....	43
5.10. Gain correction.....	45
5.10.1. positional gain correction.....	45
5.10.2. normalized gain (PHA-to-PI).....	45
5.10.3. gain vs temperature and time.....	46
5.11. Point Spread Function .....	46
5.11.1. on axis .....	46
5.11.2. off axis .....	48
5.12. Mirror effective area.....	48
5.13. Escape fraction.....	50
5.14. Energy to channel conversion .....	50
5.15. Energy resolution .....	51
5.16. Low energy tail.....	52
5.17. Burst Length centroid vs time .....	52
5.18. Burst Length selection.....	54
<b>6. Analysis of special measurements.....</b>	<b>55</b>
6.1. Background.....	55
6.2. Far off axis & off-Field-Of-View.....	57
6.3. Count rate scan.....	57
6.4. PMT HV scan.....	57
<b>7 Response matrix.....</b>	<b>61</b>
7.1. Total effective area .....	64
7.1.1 Mirror efficiency .....	64
7.1.2 Plasma grid transmission .....	65
7.1.3 Passive ion shield transmission.....	65
7.1.4 Beryllium window transmission.....	66
7.1.5 Detector quantum efficiency.....	67
7.1.6 Burst Length selection.....	68
7.1.7 Position selection.....	68
7.2. Re-distribution matrix.....	68
7.2.1 Energy resolution.....	68
7.2.2 Gain calibration .....	69
7.2.3 Escape peaks.....	69
7.2.4 Low energy tail .....	69
<b>References .....</b>	<b>71</b>
<b>List of figures .....</b>	<b>75</b>
<b>List of tables.....</b>	<b>77</b>
<b>List of acronyms.....</b>	<b>79</b>
<b>Annex A. The 'refhkud' library.....</b>	<b>A-I</b>
<b>Annex B. The 'mecsutil' library .....</b>	<b>B-I</b>
<b>Annex C. Calibration files.....</b>	<b>C-I</b>

## 1. Introduction

The Medium Energy Concentrator Spectrometer (MECS), one of the four narrow field instruments on-board the SAX observatory, is operating in the medium X-ray energy band. Its main scientific objectives are: spectroscopy in the energy range from 1.3 to 10 keV ( $E/\Delta E$  in the range 6-16); imaging with angular resolution at the arcmin level; timing variability on time scales down to the millisecond.

The present report describes the pre-launch calibrations of the MECS instrument, mainly performed at the 130-meter long X-ray PANTER facility of the Max-Planck-Institut für Extraterrestrische Physik in Munich, Germany, in the period October/November 1994; other calibration tests, performed during the satellite integration at ESTEC, are also reported. The paper is organized as follows: Sect. 2 outlines aspects of the MECS instrument; Sect. 3 describes the experimental setup and the calibrations which have been done; Sect. 4 details the calibration data reduction and analysis procedures; Sect. 5 shows the calibration results and the derived scientific capabilities of MECS; Sect. 6 gives results from special calibration tests; and Sect.7 describes the MECS response matrix. Some software utilities are reported in annex.

### Remarks:

- PANTER calibration (and related data analysis) was performed on the MECS flight model having a METOREX anti-ion grid. Unfortunately, after vibration tests, one of the METOREX filters was found to be destroyed and in the final flight configuration each detector was newly protected by LEXAN or KAPTON filters. For this reason, the MECS effective area (necessary to define the MECS response matrix) has been computed based on these new filters.
- After PANTER tests, the  $^{55}\text{Fe}$  inner calibration sources were replaced on the MECS flight model to fulfill the requirement of 1 cts/s at the launch time. Consequently, their position in flight could be different.
- All the results of the on ground calibrations have been checked and updated (whenever necessary) during the in-flight Science Calibration and Verification Phase. The MECS in-flight calibration results will be the subject of a further report; nevertheless, the main updating obtained during the in-flight calibrations are mentioned in this report as "Note".

Total on-axis effective area	250 cm <sup>2</sup>
at 1.3 keV	150 cm <sup>2</sup>
at 4 keV	100 cm <sup>2</sup>
at 10 keV	50 cm <sup>2</sup>
Point resolution	20 arcmin
Image matrix	36 x 256 pixels
Image pixel dimension	20" by 20" square
Energy binning	256 channels
Time length binning	256 channels
Total maximum throughput	1000 cts/s (4 Ch)

Table 2-1. MECS overall performance

## References

- [Boella et al. 1995] G. Boella, L. Chiappetti, G. Conti, S. Molendi, G. Cusumano, S. Del Sordo, G. La Rosa, M.C. Maccarone, S. Re, B. Sacco, M. Tripiciano, H. Braüninger, and W. Burkert, "Medium Energy Spectrometer on board the X-ray Astronomy Satellite SAX. Preliminary results of ground X-ray calibrations.", 1995, Proc. SPIE Conference, San Diego, CA, USA, Paper n. 2517-14.
- [Boella et al. 1997] G. Boella, L. Chiappetti, G. Conti, G. Cusumano, S. Del Sordo, G. La Rosa, M.C. Maccarone, T. Mineo, S. Molendi, S. Re, B. Sacco, and M. Tripiciano, "The Medium-Energy Concentrator Spectrometer on board the SAX X-ray Astronomy Satellite.", *Astronomy and Astrophysics, Suppl. Series*, 122, 327-340, 1997.
- [Bonura et al. 1992] A. Bonura, S. Giarrusso, L. Lombardo, G. Manzo, S. Re, G. La Rosa, F. Celi, R. Di Raffaele, G. Conti, H. Braüninger, and W. Burkert, "Performance characteristics of the scientific model of the MECS on board the X-ray Astronomy Satellite SAX.", 1992, Proc. SPIE Conference, San Diego, CA, USA, Vol. 1743.
- [Chiappetti et al. 1997] L. Chiappetti, G. Cusumano, S. Del Sordo, M.C. Maccarone, T. Mineo, S. Molendi, "What can BeppoSAX do about the 2-10 keV cosmic background ?", in 'The Active X-Ray Sky', L. Scarsi, H. Bradt, P. Giommi, and F. Fiore (Eds), *Nuclear Physics B Proc. Suppl.*, Elsevier Science, 1998.
- [Conti et al. 1994] G. Conti, E. Mattaini, B. Sacco, G. Cusumano, O. Citterio, H. Braüninger, and W. Burkert, "X-ray characteristics of SAX flight mirror units.", 1994, Proc. SPIE Conference, San Diego, CA, USA, Vol. 2279.
- [Henke et al. 1993] B.K. Henke, E.M. Gullikson, J.C. Davis, "Atomic Data and Nuclear Data Tables", 54, 2, 1993.
- [Molendi et al. 1996] S. Molendi, L. Chiappetti, G. Boella, G. Conti, G. Cusumano, S. Del Sordo, G. La Rosa, M.C. Maccarone, S. Re, B. Sacco, and M. Tripiciano, "Ground Calibrations of the Medium Energy Experiment on board the X-ray Astronomy Satellite SAX", in 'Roentgenstrahlung from the Universe', H.U. Zimmermann, J.R. Trümper, and H. Yorke (Eds), *MPE Report* 263, pp.685-686, February 1996.

### MECS OGC reports:

(reports whose number is omitted are either meeting minutes, or obsolete or now irrelevant documents, or papers listed above)

- [1] L. Chiappetti, "Elementi per la definizione di un piano per l'analisi dei dati delle calibrazioni finali del MECS di SAX", MECS\_OGC\_1, 24 novembre 1994.
- [4] L. Chiappetti, "SAX Calibration Pipeline Processing - Istruzioni informali per l'uso", MECS\_OGC\_4, Vers. 1.0, 29 dicembre 1994.
- [5] F. Giambertone and M. Tripiciano, "Utilizzo dello shell loadrun", MECS\_OGC\_5, 19 gennaio 1995.
- [6] M.C. Maccarone, "Calibrazioni MECS a terra - Files housekeeping Panter riformattati", MECS\_OGC\_6, Vers. 2.1, 27 Febbraio 1995.