THE IMPORTANCE OF GROUND BASED TESTS FOR SPACE EXPERIMENTS USING LOW BACKGROUND IR PHOTODETECTORS

A. Coulais and A. Abergel

Institut d'Astrophysique Spatiale, Batiment 121, Université Paris XI, 91405 Orsay cedex, France

ABSTRACT

The four instruments of ISO have been characterized during ground based tests, at different levels. These tests have allowed a thorough investigation of the performances of the detectors but also of the complete instruments, with a special attention to the influence of high energetic particles impacts on detectors responsivity, the strategy for detectors curing, the optical properties, the influence of several parameters (electrical and temperature setups), the behavior of the transient responses and the photometry.

For well design system with good working points of the detectors, the transient effects after flux changes are predictable, and can be properly modeled and corrected. In that case, glitches due to the impacts of high energetic particles appear to be the main limitation of the final accuracy. Several design problems have been identified during the ground based tests, and in some cases corrections were applied. It appears also that several useful tests were not performed, partly because the configuration on the ground was too different from the real one.

Key words: ISO – CAM, LWS, PHT, SWS; IR photodetectors, transients, crosstalk, ground based tests, optical, high energetic particles

1. Introduction

ISO operations have demonstrated the efficiency of IR low background photodetectors, but also the high complexity of these systems. Several examples of unresolved problems or limiting factors can be found in this proceeding, 3 years after the end of the mission. A large fraction of these problems could have been avoided before the flight. Thus we describe the Ground Based Tests (GBT), which problems were identified, what was improved, and which new problems were really discovered only during the flight. This review is limited to problems concerning the optical systems, electronic, consequences of high energetic particles and transients. The main ideas are the following:

- To design the optical and electronic systems is difficult, but most of the problems encountered by ISO instruments were detectable prior to the launch (Sect. 2 for the optics, Sect. 3 for the electronics) and could have been avoided.
- The photodetectors are very sensitive to HEP (High Energetic Particles) who produce glitches (Castañeda and Klaas, 2000; Gabriel and Acosta-Pulido, 2000; Dzitko et al., 2000). Glitches rate cannot be changed, but the instruments and the detectors can be shielded and the detector working point selected in order to reduce glitches effects (Sect. 4).
- All photodetectors are affected by delay (latents, transients, drifts, ...) in the measured response after change of the incoming flux (Sect. 5). The transient response can be described by linear and non linear models[1], with two main parameters: β, related to the instantaneous jump, and λ, proportional to the time constant (See a review of physical and analytical models in Fouks (1992)). The detectors have to be set up so that their transients are reproducible. In these conditions, all effects can be characterized, modeled, and corrected. The GBT allow the characterization of the effects much more easily than during the flight.

As a consequence, for a well design system, the limiting factor during flight should be only the glitches due to HEP. Since it is actually impossible to design photodetectors without transients[2], it is necessary (1) to avoid all bias and other non linear effects in the system (optical errors, electronic non linearities and latch-ups), and (2) to correct these transients using modelization.

2. Optical Problems

Designing an optical system working in broad bands in IR at 3 K is not an easy work. Then optical properties

[1] Bolometers seem to have a much better linear behavior but they begin only now to cover the far IR region.

[2] From the physics we theoretically know how to reduce the transient effects (by decreasing the time constant λ and increasing the instantaneous jump β). To reduce λ needs good contacts quality and to increase the electrodes dopant concentration. For matrix array, the upper electrode must be transparent since light goes inside bulk trough this electrode. Unfortunately, above a given concentration, the electrode is opaque (Cesarsky et al., 1994). One way to increase β is to increase the voltage. But when the voltage is increased, a Hook response can appear, which complicates the transient correction (Vinokurov and Fouks, 1991). Furthermore, the higher the voltage, the closer the photodetectors to the avalanche breakdown, and the more sensitive the detectors to HEP (Leeks et al., 2001).

must be carefully checked during GBT to correct misconceptions. Several optical problems were identified during the GBT of ISO instruments. For CAM LW, multi reflections between filters, lenses and detectors gave ghosts. In 1992 during the GBT, the broad-band filters were slightly tilted in order to reject these ghosts out of the field of view[3]. However it was not possible to tilt the CAM LW CVF segments, thus the CVF observations are affected by a variable position ghost with ~20% of the source amplitude depending on the wavelength (Okumura, 2000). The optical tests performed on SWS (Lim, 2001) and LWS (Swinyard and Lim, 2001) were limited because the GBT optical setups were too different to the in-flight configuration[4].

Several optical problems were discovered after the launch. The SWS beam profiles appeared not nominal (Beintema and Salama, 2001), while the LWS beams sizes were smaller than expected (Lloyd, 2001b). Moreover several LWS and LWS detectors were affected by fringing due to optical multi-reflection (SWS: Kester et al. (2001), LWS: Lloyd (2001a)). Some optical parameters were also revisited during the flight: CAM PSF asymmetry (Okumura, 2000), PHT beam profile (Herbstmeier et al., 2001) and PHT possible stray light (Lemke et al., 2001).

3. Electronic subsystem

Building a Cold Readout Electronic (CRE) working at few K is not trivial because of non standard behavior of Si at these low temperatures. Significant differences between CRE for the four instruments were observed. Nevertheless, most of the problems are actually known and described properly. Let us mention a surprising effect in PHT CRE discovered by Fouks (1994) during GBT study of Si:Ga PHT transients: the steps of flux were observed before they should be measured, due to electrical crosstalking between MosFets during shift of information in the CRE Si bulk. This case illustrates how such systems are complex, and how difficult it is to distinguish the true origin of a problem in between each components: detector, optical, CRE, electronic non linearities or other effects !

4. High Energetic Particles

The ISO satellite was in operations in space during a solar minimum activity period (Nieminen, 2001). The HEP rate was close to the predicted one (Nieminen and Sørensen, 2000; Claret, 2001; Leeks et al., 2001), but the rate of secondary particles was underestimated. Despite a rather accurate knowledge of the rate and the spectrum prior to the launch, most of the ISO detectors were strongly affected the impacts of HEP. Let us now discuss why and how to reduce this problem for future instruments.

HEP impacts with the bulk of photodetectors give most of the glitches observed in the electrical outputs. Some physical models of glitches in photodetectors were described by Fouks (1996b). Glitches have been classified in three categories for all detectors (Lari et al., 2001; Starck et al., 1999; Gabriel and Acosta-Pulido, 2000; Wieprecht et al., 2000; Swinyard et al., 2000):

- the *instantaneous* glitches which did not change the median level of the observation during the following readouts;
- the *fader* glitches which have a positive tail;
- the *deeper* glitches which have a negative tail.

The *faders* and *deepers* glitches modify the detector response during a long time (from seconds to hours). The impacts of HEP were dramatic for all ISO detectors, since they add some non Gaussian noise on the signal and affect on large time scales the detector responses. This problem was partially solved by a systematic curing with IR flashes at the beginning of each new orbit. Several PHT detectors have requested an extra curing procedure (Wilke et al., 2001; Castañeda and Klaas, 2000). LWS detectors were cured two times per orbit (Swinyard et al., 1996).

Glitches were a strong problem for LWS and SWS (Heras et al., 2001; Leeks et al., 2001; Valentijn and Thi, 2000), underestimated during GBT (Lim, 2001). Irradiation tests followed by curing were performed during GBT, but no test combining irradiation and variations of the illuminating source. It seems that several LWS and SWS detectors were operating close to the avalanche breakdown in order to speed up the transient response (See Footnote 2), with the secondary effect to be more sensitive to the impacts of HEP.

Except for CAM, the removal of glitches is closely related to the processing of the ramps. It seems that the ramp sampling should be as fast as possible (e.g. PHT C-100, Coulais et al. (2001)). Three years after the end of ISO operations, the ramp processing methods are still in development (SWS: Lahuis et al. (2001), PHT: Gabriel and Acosta-Pulido (2000), LWS: Swinyard et al. (2000)). The problem is that the ramps are affected by detector transients, electronic non linearities and glitches.

Four different Si:Ga detectors were used in ISO: CAM LW, SWS b2, PHT S and P. The CAM LW one appeared the less sensitive to glitches, while this matrix array has the largest volume (and surface), because of two reasons:

1. A supplementary electrode was used for CAM. The circular contacts on the lower side are surrounded by a reflective plane (Vigroux et al., 1993) setup to ~5 V. This extra electrode gives the way to sweep out the electrons[5] (the holes flow through the normal elec-

[3] This improvement was mentioned neither in Vigroux et al. (1993) nor in Pérault et al. (1994)

[4] This fact was reported at several times during this Legacy Conference.

[5] HEP impacts create pair of electron-hole inside bulk. Electrons cannot left the bulk. As a result, they accumulate inside bulk which change the responsivity (Fouks, 1996b).

trodes). This very important difference in the design of similar detectors should give the way to develop a new generation of Si:Ga detectors much less sensitive to HEP. We don't know whether this improvement could be useful for Ge:Ga detectors (they are also p type).

2. Detectors electrical setup. Compared to the other Si:Ga detectors of ISO, the strength voltage of CAM LW was the lowest. The short term transient of all these detectors can be described, at first order, by the FS model[6] (See Sect. 5). The values of the two parameters of the FS model (β, λ)[7] give informations about the detector quality and setup. During the flight, the value of β was lower for CAM LW ($\beta \sim 0.5$ with V=25 V (Coulais and Abergel, 2000)[8]) than for the other Si:Ga detectors ($\beta \sim 0.8$ for PHT S (Schubert, 1995) and $\beta \sim 0.85$ for SWS b2 (Kester, 1999)[9]). Following the physics included in the FS model, for a given detector, the product $\beta \times \lambda$ is constant. Since reducing the voltage decreases β, the value of λ increases. Thus the time constant (proportional to λ) and the amplitude (1-β) of the transient response increase. It was decided during the GBT to reduce the CAM LW voltage in order to be less sensitive to glitches, with the effects to reduce the instantaneous jump (β) and to increase the time constant. The total effect was quite big, with the hope that the transients could be corrected. On the contrary, SWS and PHT detectors were setup in order to speed up the transient response, but the effects of HEP impacts were more pronounced.

Comparisons between the response on PHT C-100 and C-200 transients to glitches are very interesting (see Fig. 7 in Acosta-Pulido et al. (2000) for C-100). As reported in Coulais et al. (2001), some operating modes of C-100 were far from optimal due to the sensitivity of this detector to glitches. These limitations were not reported up to now for C-200. It seems that the intrinsic differences between the two detectors were not clearly evidenced before the launch, so some operating modes of C-100 were not optimal.

5. Transient

5.1. Conditions to have reproducible effects

All ISO detectors were affected by transient response, at different levels, which may bias the output by factors of 10–40 %. Depending on the nature and the intensity of the variations, the time constants go from 10^{-6} s to hours.

The transient response of all detectors depend on the change of the incoming flux, but also on any other changes: temperature, voltages, non-stabilized electrical crosstalking inside bulk, HEP, ... All these parameters[10] must be as constant as possible. The HEP rate cannot be changed, but the sensitivity of the detectors to HEP can be optimized (see Sect. 4). The temperature must be fixed (Fouks, 1994), and Fouks and Schubert (1995) have shown that PHT S transients were modified by temperature variations. Voltages (direct and grid) applied to the detectors must also be fixed, in order to avoid very long term drift after voltage switch on[11].

If the temperature and voltage are fixed, if the voltage is not too close to the avalanche breakdown, and for a long time after the last curing or switching on, the response to flux changes is rather simple and reproducible (see the references in the next section), even in the presence of random HEP at expected rate. Unfortunately, several detectors were not working in optimal conditions for transients: SWS and LWS detectors were too close to the avalanche breakdown, PHT detectors were affected by frequent switches off/on. In these cases the study of the transient response is strongly complicated because different non-linear effects overlap.

FS model assumes uniform illumination of the pixel surface, and that electrical crosstalks inside bulk between adjacent pixels compensate each others. Illumination profiles of the pixel surfaces should be as uniform as possible when the detector observed uniform sky in order to avoid extra non linear effects due to physical effects inside detector bulk. This condition may be difficult when cavities or light concentrator are used. We think these extra complications were encountered by PHT (cavities), SWS and LWS (beams effects).

5.2. Characterization of the transient response

It appears from all works performed on ISO detectors (PHT S and P (Fouks and Schubert, 1995) and references therein, CAM LW (Coulais and Abergel, 2000; Coulais et al., 2000), SWS b2 (Kester et al., 2001), LWS (Caux, 2001), PHT C-100 (Coulais et al., 2001), SWS b4 (AC, unachieved), see also the discussions during ISO Transient Working Group meetings (García-Lario et al., 2001)) that the characterization of transient effects can be splitted into four distinct topics:

1. The so called short term transient under uniform illumination.

[6] The so-called Fouks-Schubert (FS) model was described by Vinokurov and Fouks (1991) some time ago its use for PHT S.

[7] β is the amplitude of the instantaneous jump. The time constant τ of the transient response is calculated with $\tau = \lambda / J^{\infty}$, where J^{∞} is the stabilized photo-current.

[8] During GBT with V=28 V, $\beta \sim 0.65$ (Vigroux et al., 1993; Pérault et al., 1994).

[9] Furthermore, CAM (β, λ) parameters were remarkably stable in orbit (Coulais and Abergel, 2000), while those of PHT have changed (Wilke et al., 2001).

[10] The influence of changes in the values of these parameters was analyzed by Haegel et al. (1999) using numerical models.

[11] PHT detectors were frequently switched on and off because they share the PHT electrical power. CAM was never switched off even during the crossing of the radiations belt (6 hours without observation per 24 hours orbit) with the help of an extra system (Vigroux et al., 1993). This improvement for CAM was directly derived from GBT.

2. The Long Term Drift (LTD) and Small Amplitude Oscillations (SAO) under uniform illumination. Fortunately, some ISO detectors exhibit neither LTD nor SAO (e.g. PHT Ge:Ga C-100 and C-200 detectors) nor crosstalk (idem). Nevertheless it was not always possible to observe the effects because of observing modes (LWS and SWS) or limited transient characterization campaigns (SWS, LWS and PHT).
3. The transient response under non uniform illumination, the limit case is for point sources (Coulais and Fouks, 2001). Most of the ISO detectors are linear or matrix arrays[12] where electrical crosstalking between adjacent pixels must be taken into account.
4. The LTD and SAO under non uniform illumination.

5.3. Transient modeling

The developments of models of transient have allowed significant progresses (1) to understand the nature of transients, (2) to evidence other effects which may affect the response, (3) to define the calibration strategies both for GBT and in-orbit tests, (4) to optimize the observing strategy, (5) to process systematically the data. The adjustment of the models to the data (in order to estimate the parameters and the validity range of the models) was generally performed with steps of incoming fluxes. Then the models can be modified in order to work on continuously variable data (as CAM LW CVF observations, see explanations in Coulais and Abergel (2000)).

The basic test is made of sequences with upward and downward steps of flux. The dark level must be precisely known, because the response generally depends on the absolute level above the dark level. Moreover, the change between two levels of incoming flux must be done as fast as possible. This was a limitation during in-flight observations due to the satellite slew time. If possible, the whole range of initial and final fluxes to be detected in the sky must be covered in order to check the limits of the models. Such a work was done for PHT S and P during GBT (Schubert, 1995; Fouks and Schubert, 1995). A transient model has been derived during GBT which has strongly helped to found others problems during GBT (Fouks, 1994). Such a model was not available at the time of the CAM GBT, while a rather complete characterization of transient effects has been performed (Pérault et al., 1994). The published informations for LWS and SWS do not detail the GBT for transients.

LTD occurs after curing and switching off/on of the voltage or switching off/on of the incoming flux. The amplitude of CAM LW LTD was lower that the PHT ones, likely the because CAM voltage was never switched off. LTD was observed with CAM LW after incoming flux increases, generally at the beginning of a revolution (e.g. TDT 12900101). Basic tests for LTD and SAO are the same ones than for the short term transients, but they require much more time (5 to 10 time more), well stabilized system (temperature and voltage) and an high accurate estimate of the very low initial levels above the dark level. Some GBT data to characterize LTD and SAO are available for CAM LW. The comparison with one model provided by Vinokurov and Fouks (1991) have given interesting results but no fixed parameter could be derived, likely due to uncertainties on the initial conditions and the dark level.

Tests for point source (and non uniform illumination) transient are discussed in Coulais and Fouks (2001) for CAM LW. This approach could be generalized for other linear or matrix arrays of ISO also affected by electrical crosstalk inside detectors bulk. Only limited tests of this effect were made for linear and matrix arrays during GBT (this problem was clearly underestimated). The non-uniform illumination case is difficult, since crosstalk between adjacent pixels do not compensate each others[13]. Because of gradients inside the detector bulk, it is necessary to develop a 3D model of the detector, using the real geometry of the detector. This modelization has been done with success for CAM LW (Fouks, 2001).

We have considered up to now only detectors with transients which can be modeled with the most simple memory effect, summarized in one term (the J_{n-1}^{end} parameter in the never stabilized version of the FS model, see Coulais and Abergel (2000) for discussion). This applies for all the Si:Ga detectors on-board ISO. In theory, this is not be the case for Ge:Ga detectors, which need a full knowledge of whole prehistory. However no evident example has been observed with the Ge:Ga detectors of ISO, but very interesting ones are presented in Kaneda et al. (2001) for ASTRO-F detectors.

5.4. Detector parameters

For CAM LW detector, it has been shown that β dispersion is $\sim 5\%$ and λ dispersion is $\sim 20\%$ (Coulais and Abergel, 2000). Following physics in FS model, that means that the quality of the bulk is good but not the contact one. Controlling (β, λ) values and their uniformity as soon as possible (if possible during the detector fabrication) will ensure to receive high quality, close to optimal, fast response and easier to model detectors. Such a study was done *a posteriori* by Fouks (2001) for CAM LW.

6. Conclusions

Despite ISO was a successful mission, the four instruments have encountered several problems during the flight (op-

[12] CAM LW 32×32, SWS 4 bands in 1×12, PHT S 1×12, PHT C-100 3×3, PHT C-200 2×2.

[13] First studies on crosstalk were done by Fouks' team (Vinokurov and Fouks, 1988; Fouks et al., 1994), specific studies for CAM LW can be found in Coulais and Fouks (2001) and in Coulais et al. (2000).

tics, fringing, CRE, drift, transients, glitches, ...). Most of these problems (not all) were identified during the GBT, and in some cases strong improvements were done before the launch (e.g. for CAM LW the tilting of the broad-band filters and the change of the detector polarization).

Several optical problems were not fully characterized during the GBT, because the GBT setups were too different from the in-flight configurations. Thus several optical problems were discovered only after the launch (e.g. beams and fringing for SWS and LWS).

Glitches due to HEP impacts changed the detectors responsivity and strongly affect the statistical properties of the noise, especially for boosted detectors. The glitch rate and spectrum during the GBT were significantly different than in the sky (as expected), and it was difficult to estimate from GBT the real impact on the noise in orbit, and to develop efficient processing methods (especially to process the ramps). It seems that the ramp sampling should be as fast as possible. Actually, glitches are one of the main limitations of the final accuracy of ISO: except for CAM LW, the noise figure increases by factors 3 to 10 (de Graauw, 2000; Leeks et al., 2001) depending on detectors technology and design, voltage strength and ramp sampling rate. For several ISO detectors, curing was used to partially restore the initial parameters. But this operation is not a panacea and can induce LTD and transient effects. Moreover, the detectors working close to the avalanche breakdown were more sensitive to glitches. The experience of ISO shows that it is better to increase the amplitude of transient effects (which are predictable so can be corrected) in order to reduce the effects of HEP (which are not predictable) and the need of curing. During the processing of in-orbit data, glitches can also be identified and systematically corrected at the level of the map making using the spatial or the spectral redundancy (e.g. Miville-Deschênes et al. (2000)). Due to the technological progress, future detectors should be less sensitive to glitches (BIB technology[14], thiner bulk). However the next missions will be launched just after the solar maximum activity period, and glitches problems must not be underestimated. Technological solutions (shielding, extra electrode ?) can also be considered to reduce the effects. The rate and the spectrum of the HEP during the GBT should be as close as possible to the in-flight ones, which can now be easily predicted.

All ISO detectors were affected at different levels by transient effects. However, these effects do not limit the performance of the instruments if the detectors are made of a good bulk with good contacts, are not too much sensitive to HEP (e.g. not working too close to the avalanche breakdown), and work in well controlled conditions (no change of temperature and voltage). In that cases (1) the transient response is perfectly reproducible, (2) it is possible to perform a detailed characterization of transient effects, (3) accurate physical or empirical models (generally non-linear) can be developed and (4) the data can be systematically corrected using the models. An important point is that the detectors must have a good setup and should not be affected by other effects than changes of incoming IR flux and HEP.

Detectors setup and transient behavior must be carefully checked during the GBT in order to optimize the working point of the detector. Transient characterization and modeling must start as soon as possible. Models are very helpful (even first order ones), since they allow systematic data corrections, which can evidence other effects to be also analyzed during the GBT. For PHT S, with the help of FS model, two problems were identified during GBT (thermal heating in CRE and electrical crosstalk between MosFet transistors in CRE (Fouks, 1994)). Some electrical glitches became evident after the use of FS model on SWS b2. For CAM LW, LTD and point source transients became specific transient problems only after the use of FS model developed for uniform illumination.

Long Term Drift (LTD) and Small Amplitude Oscillations (SAO) have affected several detectors of ISO, after curing, switching off/on of the voltage, or increasing of the incoming flux. Actually no model has been developed. The lesson from ISO is that, if it is possible, it is always better to avoid frequent switches on/off.

The transient effects may strongly affect the observation strategy. Thus a proper characterization before the flight can save a lot of observing time. Accurate transient response characterization and modeling is much more easy to perform during GBT than during the flight, since most of the key parameters (voltage, temperature, levels of incoming flux) can be properly controlled and their stability monitored. Moreover GBT are not affected by satellite jitter and HEP glitches. After the end of the ISO mission, several data sets from these GBT are still used to study the behavior of the detectors and to optimize the transient models.

Finally, the necessity to maintain updated documentation appears crucial for long term projects as ISO. The instrument team members have changed during the project (the design phase started in 1984). Several important informations were lost[15] or forgotten[16] and several technical choices appeared no more understandable once ISO was in orbit.

We hope this review will be useful for the teams involved in the development of future IR projects (SIRTF and ASTRO-F). GBT could be the way to confirm the de-

[14] Nevertheless the BIB Si:As was the SWS detector with the highest increase of r.m.s. noise level between GBT and flight (Valentijn and Thi, 2000).

[15] For CAM, it was learned years after launch that the industrial contractor has made a study of optical paths. This study was unknown for people involved later with optical problems.

[16] Since it was not specified that no radioactive material should be used, one lens of CAM was coated with low radioactivity material, which produced extra glitches on the detector.

sign pertinence and the performance of the instruments, and the last chance to change and improve any parts of the instruments. A huge among of *a posteriori* corrections can be avoided for a limited initial extra cost.

ACKNOWLEDGEMENTS

AC thanks CNES, CEA SAP and IAS for financial support. AC thanks K. Okumura for useful discussions about ISO optical problems. AC thanks all the ISO Legacy Conference speakers who described the behavior of their detectors and systems.

AC would like to remind that a huge amount of informations and advices on space operation of low background IR photodetectors can be found in the papers of B. Fouks. New in-flight operating modes are also proposed (Fouks, 1996a).

References

Acosta-Pulido, J. A., Gabriel, C., and Castañeda, H. O.: 2000, *Exp. Astro.* **10**, 333

Beintema, D. A. and Salama, A.: 2001, in *this volume*, pp E40–+

Castañeda, H. O. and Klaas, U.: 2000, *Exp. Astro.* **10**, 369

Caux, E.: 2001, in *this volume*, pp E47–+

Cesarsky, C. J. et al.: 1994, *Optical Engineering* **33**, 751

Claret, A.: 2001, in *this volume*, pp E38–+

Coulais, A. and Abergel, A.: 2000, *A.&A. Suppl. Ser.* **141**, 533

Coulais, A. and Fouks, B.: 2001, in *this volume*, pp E73–+

Coulais, A., Fouks, B. I., Giovannelli, J.-F., Abergel, A., and Sée, J.: 2000, in M. Strojnik and B. Andresen (eds.), *Infrared Spaceborne Remote Sensing VIII*, Vol. 4131, pp 205–217, SPIE, San Diego, USA

Coulais, A., Sée, J., Giovannelli, J. ., Stepnik, B., Balleux, F., Lagache, G., and Abergel, A.: 2001, in *this volume*, pp E71–+

de Graauw, T.: 2000, *Advances in Space Research* **25**, 2145

Dzitko, H., Claret, A., and Engelmann, J.: 2000, *Exp. Astro.* **10**, 279

Fouks, B. I.: 1992, in *ESA SP-356 Photon Detectors for Space Instrumentation*, pp 167–174

Fouks, B. I.: 1994, *On improvement of ISOPHOT detector operation, results of the visit at MPIA in 1994*, Technical report, MPIA

Fouks, B. I.: 1996a, *Proc. of SPIE* **2790**, 38

Fouks, B. I.: 1996b, *Proc. of SPIE* **2817**, 160

Fouks, B. I.: 2001, *Transient processes in high-field low-background IR detectors under inhomogeneous irradiation. I General statement of the problem, II Application to the ISOCAM detector array*, Technical report, IAS

Fouks, B. I., Kocherov, V. F. et al.: 1994, *Proc. of SPIE* **2269**, 727

Fouks, B. I. and Schubert, J.: 1995, *Proc. of SPIE* **2475**, 487

Gabriel, C. and Acosta-Pulido, J. A.: 2000, *Exp. Astro.* **10**, 319

García-Lario, P., Coulais, A., Kester, D., and Caux, E.: 2001, *Transients Working Group Final Report*, ESA

Haegel, N. M., Simoes, J. C., White, A. M., and Beeman, J. W.: 1999, *Applied Optics* **38(10)**, 1910

Heras, A. M., Wieprecht, E. et al.: 2001, in *this volume*, pp E37–+

Herbstmeier, U., Abrahám, P. et al.: 2001, in *this volume*, pp E41–+

Kaneda, H., Akazaki, M. et al.: 2001, in *this volume*, pp E78–+

Kester, D.: 1999, *The impact of memory effects correction on SWS data*, Technical report, SRON, Netherlands

Kester, D., Beintema, D. A., and Lutz, D.: 2001, in *this volume*, pp E79–+

Lahuis, F., Feuchtgruber, H. et al.: 2001, in *this volume*, pp E82–+

Lari, C. et al.: 2001, *MNRAS* **325**, 1173

Leeks, S. J., Swinyard, B. M., Lim, T. L., and Clegg, P. E.: 2001, in *this volume*, pp E48–+

Lemke, D., Klaas, U., and Kranz, T.: 2001, in *this volume*, pp E42–+

Lim, T. L.: 2001, in *this volume*, pp E8–+

Lloyd, C.: 2001a, in *this volume*, pp E40–+

Lloyd, C.: 2001b, in *this volume*, pp E40–+

Miville-Deschênes, M.-A., Boulanger, F., Abergel, A., and Bernard, J.-P.: 2000, *A.&A. Suppl. Ser.* **146**, 519

Nieminen, P.: 2001, in *this volume*, pp E36–+

Nieminen, P. and Sørensen, J.: 2000, *Exp. Astro.* **10**, 381

Okumura, K.: 2000, in *ISO beyound point sources; ESA SP-455, Madrid, Spain, 14–17 Sept. 1999*

Pérault, M., Désert, F.-X. et al.: 1994, *Opt. Eng.* **33**, 762

Schubert, J.: 1995, *Ph.D. thesis*, Max Planck-Institut für Astronomie, Heidelberg

Starck, J.-L. et al.: 1999, *A.&A. Suppl. Ser.* **138**, 365

Swinyard, B., Clegg, P., Leeks, S., Griffin, M., Lim, T., and Burgdorf, M.: 2000, *Exp. Astro.* **10**, 157

Swinyard, B. and Lim, T.: 2001, in *this volume*

Swinyard, B. M. et al.: 1996, *A.&A. Suppl. Ser.* **315**, L43

Valentijn, E. A. and Thi, W. F.: 2000, *Exp. Astro.* **10**, 215

Vigroux, L. G., Cesarsky, C. J. et al.: 1993, *Proc. of SPIE* **1946**, 281

Vinokurov, L. A. and Fouks, B. I.: 1988, *Sov. Phys. Semicond.* **22(11)**, 1258

Vinokurov, L. A. and Fouks, B. I.: 1991, *Sov. Phys. Semicond.* **25(11)**, 1207

Wieprecht, E., Wiezorrek, E., and Haser, L.: 2000, *Exp. Astro.* **10**, 199

Wilke, K., Grözinger, U., Klaas, U., and Lemke, D.: 2001, in *this volume*, pp E49–+