N90-21344

ISO CAMERA ARRAY DEVELOPMENT STATUS

F. Sibille, Observatoire de Lyon
C. Cesarsky, P. Agnèse Service d'Astrophysique, DPhG, CEN Saclay
D. Rouan, Obervatoire de Meudon

Abstract

We present a short outline of the camera ISOCAM, one of the 4 instruments onboard ISO, with the current status of its two 32x32 arrays, an InSb CID and a Si:Ga DRO, and the results of the in orbit radiation simulation with gamma ray sources. A tentative technique for the evaluation of the flat fielding accuracy is also proposed.

I Outline of the camera ISOCAM

Amongst the 4 instruments onboard ISO, the task of the camera ISOCAM is to provide 32x32 pixel images in the 2,5 - 17 μm spectral range with the following characteristics :

- 4 different spatial samplings are available : 1.5, 3, 6 and 12 arc sec. per pixel, with respectively a total field of view (FOV) of 48, 96 (array size limited), 180 and 180 arc sec (ISO telescope FOV limited). With 1.5 arc sec./pixel, the spatial resolution will be limited by the spacecraft pointing jitter of 2.7 arc sec. (half cone, 2σ) with a pseudo-period of about 30 seconds.
- 21 bandpass filters, with resolutions $\lambda/\Delta\lambda$ between 2 and 30, and CVF's covering the spectral range 2.5 to 16.5 μm with a resolution of the order of 50.

An optical layout of the instrument is shown in Fig. 1. Two field mirrors mounted on the "selection wheel", at the telescope focal plane, allow to feed the beam into one or the other of the two wavelength channels, covering respectively the 2.5 - 5.5 μm and the 4 - 17 μm range. Both are optically identical, and they operate only one at a time. The filters and CVF's are mounted on a "filter wheel", in the plane of the pupil image provided by the field optics. Four lenses, mounted on a "lense wheel", allow to reimage the focal plane onto the array with a magnification matching the pixel size to the desired pixel FOV. Only 2 lenses are shown in Fig. 1 for each channel. Polarization mapping can be done using three polarizers mounted on the "entrance wheel", otherwise normally used on a free hole position. An integrating sphere mounted on the selection wheel is used as an internal calibration/flat-fielding device. In its operating position, its output port-hole matches the 3 arc min FOV of the camera in the telescope focal plane. It is illuminated through a small hole on its side by an external 1 mm^2 thin film heater element.

II The detector arrays in ISOCAM

Two arrays, with the same 32x32 pixel format and 100x100 μm^2 pixel pitch have been developed for ISOCAM.

II - 1 Short wavelength channel array : InSb CID

This array is a modified version of the CID produced by SAT (Société Annonyme des Télécommunications, France). The area filling factor is 83%, and the overall efficiency, read out electrons per incident photons, is 33 %. Below 10K, the dark current is very low and tunnel effect limited, so that the amount of dark charges is proportional to the logarithm of the integration time. For instance, one has 800 dark electrons per pixel for a 500 sec. exposure, which makes the device suitable for very long integration time. The full well capacity is bias voltage dependant, it can be adjusted in the 2 to 4 10^6 electrons range, providing an excellent linearity. With an integration time of 60 sec., the NEP(5µm) is of the order of 2.5 10^{-18} W.

A major emphasis has been put on the development of a low noise preamplifier hybrid circuit, operating at 3 K close to the focal plane temperature, located in the nearest possible vicinity of the array in order to reduce noise pick-up and cross-talk. This assembly uses G118 for reset switches and ZK111 for source follower amplifiers. The current noise level is about 1100 electrons rms, close to the design goal of 1000. The cross-talk is below 1 %.

II - 2 Long wavelength channel array : hybrid Si:Ga DRO

This array has been produced in a special development program by LETI-LIR, a division of the Atomic Energy Comission (CEA-CENG, Grenoble France).

The Si:Ga material has a dopant concentration about 6 10^{16} cm^{-3}, and a compensation level in th lower 10^{12} - 10^{13} cm^{-3} range, providing an R.A product above 10^{12} Ω cm^2, and a responsivity larger than 3 $A.W^{-1}$. Taking an input capacitance of .1 pF, which may actually be smaller than that, the full well capacity is 1.2 10^6 elect. with 2 Volt of output voltage range, and the readout noise is below 500 electrons rms. Under low background conditions, the NEP(15µm, 1sec.) is in the 2 - 4 10^{-17} W, with a linearity better than 1% when the flux is between 10 and 1000 NEP, but it shows a marked threshold effect at very low signal level. The uniformity of the response is quite good : several arrays have all their pixels within ± 20 % of the average. Different filling factors have been produced, but the value of 100 % has been selected for the final device. Measured with an f/2 beam, faster than any beam in ISOCAM, the cross-talk is less than 1 % between side by side pixels, and 2 % between corner to corner neighbour pixels.

The readout circuit is a classical DRO made with MOS N-channel technology. The source follower MOSFET is permanently biased, and its output is sampled to a column bus with a switch. The total heat dissipation is below 5 mW. The typical frame readout time is .1 sec. and the the integration time is limited to 800 sec. by the dark current, 2 10^3 elect./pixel/sec, or by the background which depends upon the selected pixel FOV or filter. In orbit, the high energy particles will be the most severe limitation in the integration time : simulations shows that in 30 seconds there will be 8 impacts producing 60 glitched pixels. Above this value the deglitching algorithms loose efficiency, the smallest glitches beeing the most difficult ones to disentangle, and there is little gain, or even loss, in integrating further.

III <u>In orbit radiation effects</u>

The radiation environment along the ISO 24 hours orbit is sketched on Fig 2. So far simulations of the orbital conditions on the arrays have been done only with gamma rays sources with low dose rates representative of the inner and of the outer belt, or with high dose rate to study the cumulated dose effects. Simulations with protons will be performed soon.

The main conclusions are that in most of the outer belt the CID can be operated with slightly degraded, but still acceptable performances, whereas the integration time of the Si:Ga DRO is limited by the glitches to about 1 second, which severely degrades the performances. Cumulated doses did not produce any degradation on both arrays, but only a permanent drift of some MOSFET threshold voltages, still at an acceptable level.

After the perigee passage, the responsivity change of the CID is barely measurable, which makes it ready for use immediately in the outer belt. On the other hand, the Si:Ga DRO responsivity increases by about a factor of 2, and returns to normal during the crossing of the outer belt, so that it is ready for use during the radiation quiet part of the orbit. It was noticed during these tests that its recovery time is noticeably reduced when the array is exposed to a large photon flux.

IV <u>Flat fielding characterization</u>

This section is an attempt to summarize the approach currently adopted in evaluating the usefulness of an array. Most often, during the operation of ISOCAM, the performances limiting factor will be the accuracy with which one knows the "gain" matrix $|Ri|$ of the array, or the relative response of each pixel with respect to the others. Would it be perfectly stable, one could spend a long time measuring it with a high accuracy, and then just use this calibration. But real life is far from that ideal situation.

We try to characterize the changes of $|Ri|$ occuring with time, the usual temporal drifts, or with the change of a parameter which is a factor of the gain. Instead of $|Ri|$, we use $|xi| = |Ri/\langle Ri\rangle|$ where $\langle Ri\rangle$ is the spatial average of Ri over the array, and we characterize any change in $|Ri|$ by :

$\sigma = \sigma_{xi}/\langle xi\rangle$, where σ_{xi} is the standard deviation of xi.

This approach has been recently implemented in the tests of the Si/Ga DRO at Saclay. For instance, if one performs two measurements of $|Ri|$ at time t and t', σ_t characterizes the differential drifts, pixel to pixel, over the time interval (t'-t). If one changes the integration time Ti, σ_{Ti} characterizes the differential linearity of the signal with respect to Ti. If one changes the flux level, σ_W does the same with respect to the linearity with respect to the flux.

If xi = 1, then $\sigma = 0$, one find the ideal situation of a perfect photometric and imaging device. If xi is not 1 but a constant, $\sigma = 0$ again, the imaging capability is still perfect, and there is a constant bias in the photometric calibration, which is not too difficult to correct. Finally, if σ is large, the photometric calibration does not make any sense, and worse, there is a large potential for false source detection.

The followings are a few preliminary results obtained on the "scientific model" of the array :

$t' - t = 4$ hr	$\longrightarrow \sigma_t$	$= .2$ %
$.1$ sec $< Ti < 2$ sec	$\longrightarrow \sigma_{Ti}$	$= .2 \longrightarrow .7$ %
$.1\ W_{sat} < W < .8\ W_{sat}$	$\longrightarrow \sigma_W$	$= .2 \longrightarrow 1$ %

ISOCAM SCIENTIFIC CONSORTIUM

Principal Investigator :	C. CESARSKY	SAP
Co-investigators :	S. CAZES	IAS Orsay
	D. CESARSKY	IAP Paris
	A. CHEDIN	LMD Orsay
	M. COMBES	Paris Obs.
	M. GORISSE	SAP Saclay
	T. HAWARDEEN	Edinburgh Obs.
	P. LENA	Paris Obs.
	M.S. LONGAIR	Edinburgh Obs.
	R. MANDOLESI	TESRE Bologna
	L. NORDH	Stockholm Obs.
	P. PERSI	IAS Frascati
	D. ROUAN	Paris Obs.
	A. SARGENT	Caltech
	F. SIBILLE	Lyon Obs. (Proj. Scientist)
	L. VIGROUX	SAP Saclay
	R. WADE	Edinburgh Obs.

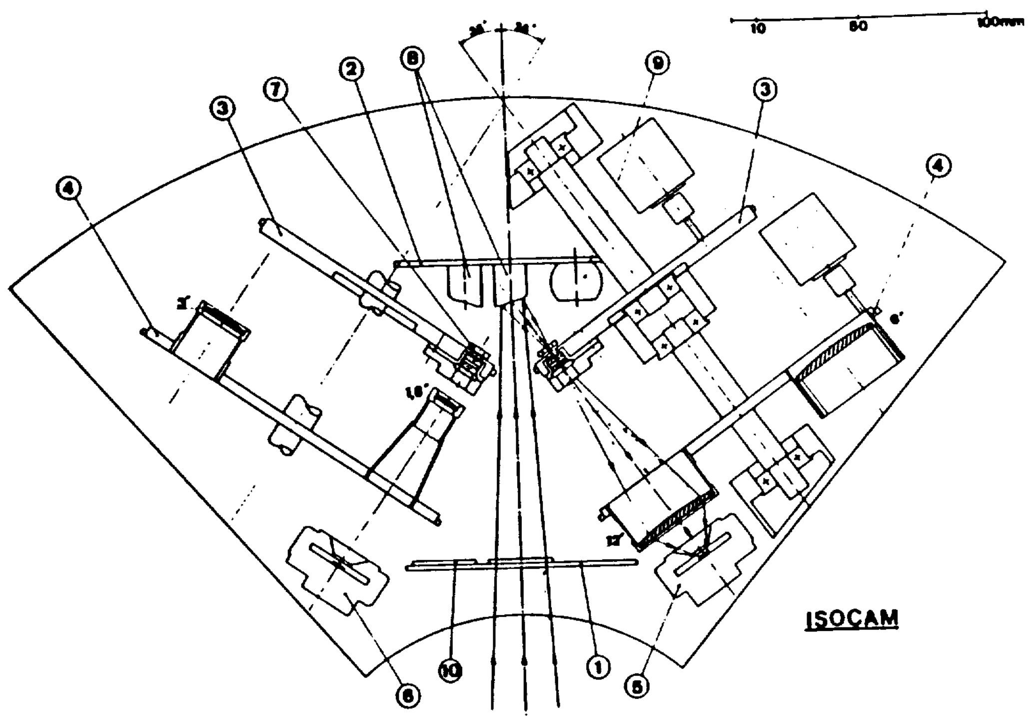
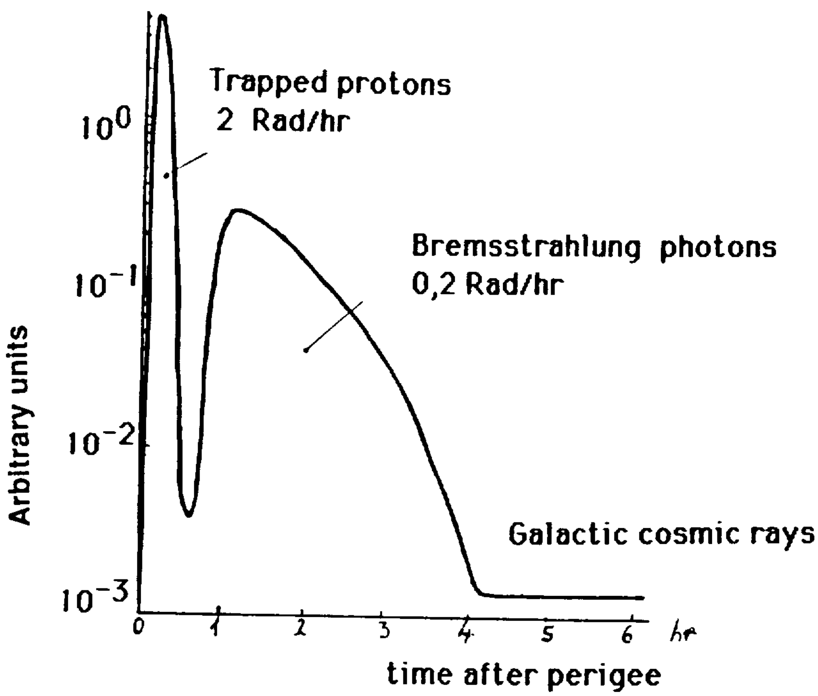


Figure 1 : ISOCAM optical lay out

1. Entrance wheel
2. Selection wheel
3. Filter wheel
4. Lens wheel
5. InSb CID
6. Si:Ga DRO
7. Aperture stop
8. Fabry mirror
9. Calibration source
10. Polarizers

Figure 2



±(0-0,5hr) Trapped protons
Experiment is OFF
dose rate < 2 Rad/hr (integrated : 1.1 Krad)

±(0.5-4hr) Bremsstrahlung photons
Experiment may be ON
dose rate < 0.2 Rad/hr (integrated : .25 Krad)

±(4-12hr) Solar/Galactic Cosmic rays
Best part of the orbit
dose rate < 10^{-3}Rad/hr (integrated : .1 Krad)

TOTAL DOSE (600 days mission) 1,5 Krad