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IR ARRAY INSTRUMENTS FOR THE ESO VLT

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Abstract. The four infrared instruments currently planned for the ESO VLT are briefly described and their collective infrared array requirements are summarized and discussed in the light of recent advances in this area.

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1. The ESO VLT

ESO's Very Large Telescope (VLT) consists of a fixed array of four 8m diameter telescopes equipped with Cassegrain, Nasmyth and coude focii plus an interferometric sub-array of three $\simeq$1.8m moveable telescopes. An intrinsic optical quality $\sim$0.2 arcsec will be achieved by active optics and diffraction limited images at $\geq 2\mu$m will be delivered at the coude focus by an adaptive optics system which will also be used together with interferometric combination of the 8m telescopes. Of particular interest here is the fact that the pupils are located at the secondary mirrors, which also provide for chopping and tip-tilt correction, and that the site of Cerro Paranal in Northern Chile promises excellent conditions for infrared work. Instrumentation effort at present is mainly directed towards the development of $\sim$ 10 facility instruments which will be permanently installed at different focii to maximize reliabilty and calibration stability, facilitate flexible scheduling and minimize the required on-site maintenance staff.

2. Overview of Infrared Instrument Status

2.1. Infrared Spectrometer and Array Camera (ISAAC)

ESO is developing this instrument in-house for one of the Nasmyth focii of unit telescope 1 where it will provide for 1-5μm imaging over a $\simeq$ 2.5x2.5 arcmin f.o.v and long slit spectroscopy at resolving powers between $\sim$500 and 10000. Additionally, polarizing analysers and grisms (e.g to provide a cross-dispersed echelle format) could be mounted in the filter wheels in the pupil plane and partial seeing correction would also be possible using the tip-tilt secondary mirror. The instrument design is based on the use of two cameras within the same cryogenic/vacuum environment which are optimized separately for the 1-2.5μm and 2.5-5μm regions and can each be used to either re-image the telescope focal plane or the intermediate spectrum produced

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by a grating spectrometer. Each camera contains two filter wheels, an objective wheel providing a range of magnifications and an array detector. The spectrometer employs a compact, wide field, 3 mirror collimator and two back to back Littrow mounted gratings (Moorwood, 1993).

2.2. Coude Near Infrared Camera (CONICA)

This is being developed under contract to ESO by a consortium led by the Max Planck Institut für Astronomie, Heidelberg with the Max Planck Institut für Extraterrestrische Physik, Garching and the Osservatorio Astronomico di Torino as partners. It is intended primarily for 1-5μm diffraction limited imaging, polarimetry and low resolution grism spectroscopy in combination with the adaptive optics sytem at the coude focus of unit telescope 1. High speed readout and a comprehensive software package are also being provided to support speckle and other high resolution imaging techniques which may be necessary at the shorter wavelengths or in the absence of suitable reference stars for the adaptive optics system (Lenzen, 1993).

2.3. Cryogenic Infrared Echelle Spectrometer (CRIRES)

The highest priority option for high resolution ($\geq$100.000) spectroscopy being studied at ESO is a cryogenic echelle spectrometer based on the use of immersion gratings. Following the promising results obtained at ESO with a small immersion grating (Wiedemann, Dave and Jennings, 1993) both optical designs of a (1)2-5μm instrument and a development programme of the larger immersion gratings required are now in progress.

2.4. Mid-Infrared Imager/Spectrometer (MIIS)

Following pre-design studies at ESO a phase A study contract has recently been let to a consortium led by the Service d'Astrophysique, Saclay with the Institute d'Astrophysique Spatiale, Orsay and the Space Research Group, Groningen as partners. The baseline requirements are for diffraction limited imaging in the 10μm and short wavelength end of the 20μm windows, low and medium resolution spectroscopy in the 10μm window and medium resolution spectroscopy in the 20μm window. There is additional scientific interest in higher resolution spectroscopy ($\sim$ 50.000) and 20μm imaging. One possible design has been presented by Käufl and Delabre(1992) and a modified ISAAC design is also being considered. The final specification will only be established after the on-going phase A study which includes a trade-off of the options, more detailed design work and a cost analysis.

3. IR Array Requirements

3.1. 1-5μm

ISAAC is required to operate over a range of external backgrounds expected to range from ~0.1e/s for spectroscopy between the OH sky lines in the near infrared to ~10^7e/s for imaging in the M band. The range of backgrounds for CONICA should be comparable and both instruments therefore have separate short ($\leq$2.5μm) and long wavelength ($\geq$2.5μm) channels primarily to alleviate the problem of simultaneously requiring extremely low dark current and read noise but a high well capacity in the same detector. So far the already available Rockwell 256x256 NICMOS3 and SBRC 256x256 SBRC InSb arrays have been adopted as the baseline choices for the short and long wavelength channels respectively. The final selection is now being re-assessed, however, in view of the likely development of 1024x1024 versions of these arrays which are not only attractive because of their larger formats but also the improved performance expected e.g reduced persistence effects which are of particular concern in our case where the same arrays are used for imaging and spectroscopy. Both ISAAC and CONICA could be equipped with these arrays which would yield both larger fields and a relaxation of the present requirements for a range of selectable magnifications. For the cross dispersed cryogenic echelle instrument a 1024x1024 array is probably the minimum that one would like to have as this would still only cover typically ~ 20% of each order at a resolving power of 10^5. As regards pixel size, values around 30μm have been adopted for all the optical designs so far. The 19μm proposed by Rockwell at this meeting could pose us some problems but has not yet been fully analyzed. With regard to performance, values around 1 for the quantum efficiency and fill factor would be perfectly acceptable even if there is a bit of crosstalk! Ideally, however, for dual channel instruments we would really like a short wavelength array with $\leq$0.1e/s dark current and a few electrons read noise (even lower for the cryogenic echelle)and a long wavelength array with 10^{6-7}e well capacity but still with $\leq$100e/s dark current and $\leq$100e read noise for spectroscopy. The Rockwell 1024x1024 array might therefore be the new detector of choice for the short wavelength applications whereas the SBRC 1024x1024 array could be considered for either the short and/or long wavelength channels. (Although tempted occasionally even to drop our short wavelength channel in ISAAC we have so far always recalled in time our other major problem of achieving an instrumental background below that of the detector dark current!). With a well capacity of only ~ 3x10^5e, however, broadband L imaging with the SBRC array would already be demanding and the need for broadband M would have to be reassessed. Even using all of the 32 output channels proposed the acquisition electronics would still have to provide ~ 1μs sampling/pixel resulting in an extremely complex and expensive system. A small plea therefore for a

1024x1024 InSb array with a factor of 10 higher well capacity or a review of the importance of broadband M imaging by the potential user community!

3.2. 8-28μm

Predicted backgrounds for imaging with the MIIS instrument are in the range $\sim$ 3 10^8-1.5 10^9e/s and $\sim$5000 times lower for the highest resolution spectroscopy considered. Partially related to the Phase A study of this instrument INSU (Institut National des Sciences de l'Univers) in France has organized a consortium of interested parties, including ESO, to fund the development of a 128x192 Ga:Si photoconductor array with 75μm pixels by LETI/LIR in Grenoble (presented separately by P.O. Lagage at this conference). This follows on naturally from their 32x32 array developed for ISO and the 64x64 array used now in several groundbased cameras including TIMMI - built for ESO by the Service d'Astrophysique Saclay as a common user instrument for the 3.6m telescope. An important characteristic of the 64x64 array is its high well capacity of $\sim$3 10^7e and a novel feature of the new array is that its capacitance will be switcheable between a comparable value for imaging and an order of magnitude smaller one for spectroscopy. Being Ga:Si its long wavelength response is limited to $\sim$18μm so if more emphasis were to be placed on the 20μm window after the phase A study we would have to look to an As:Si version or one of the As:Si BIB/IBC arrays presented at this meeting assuming they become commercially available outside the USA.

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