HHT Instrumentation – Present and Future

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Abstract

A brief review of receiving systems for the Heinrich-Hertz-Telescope over the next few years is presented. Spectroscopic and continuum detectors will increasingly be focal-plane arrays. Two such system, a 37-element bolometer-array for operation at 350μm and a 16-element 625μm heterodyne-array, including a broadband autocorrelator, are under construction at the MPIfR.

First-Generation Facility Instrumentation

Current plans are to make the Heinrich-Hertz-Telescope (HHT) available to the astronomical community after the summer 1995 shutdown. The prime atmospheric submillimeter windows should then be covered by state-of-the-art receivers. Preliminary 'test' receivers, currently used for commissioning the telescope, will successively be replaced by the facility obligations outlined in the Memorandum of Understanding between the two partner institutes (MPIfR and Steward Observatory).

Heterodyne Detectors. Table I summarizes the facility SIS frontends expected to be operating by September 1995. All mixers are currently in full-height waveguides, with two tuning elements. Junctions have been provided by and/or produced in cooperation with the SIS laboratories of IRAM (345 & 690 GHz) and JPL (250 & 480 GHz). The upgraded dual-channel systems delivered by the MPIfR will come with newly delevoped hybrid dewars, with Helium hold-times of up to two weeks. Once the broader band spectrometers are available (see below), the bandwidth of the IF chain will be increased to 2 GHz. To ease on-site operation of the instruments, intrinsically wideband-tunerless mixers and junctions will be installed as soon as possible.

Table I. **First-Generation SIS Frontends**

Tuning Range	Polarization	IF Bandwidth	Responsibility
220–270 GHz	single	1 GHz	SO
310–370 GHz	single	1 GHz	MPIfR
	dual	1 GHz	MPIfR
450–500 GHz	single	1 GHz	SO
660–690 GHz	dual	2 GHz	MPIfR

NOTES: initial single-channel units, currently used for commissioning the telescope (T_{Rx} ~125 K at 345 GHz; T_{Rx} ~75 K across the 1.3mm band), will be replaced by dual-polarization units. To permit heterodyne observations at 350μm, prior to the completion of the SIS receivers under development at both institutes (SO, MPIfR), a Schottky-diode open-structure receiver can be made available in coordination with H.P.Röser (MPIfR/DLR).

Spectrometers. Two broadband (1 GHz, each) and one high-resolution (250 MHz) acousto-optical spectrometer will be available (Table II). The physical arrangement of the receivers in one of the Nasmyth cabins allows simultaneous observation at two different sky frequencies (with perpendicular polarizations). A Martin-Puplett interferometer will serve as single-sideband filter and for proper calibration. A *tau*meter has been installed for continuous monitoring of the atmospheric transmission at 225 GHz.

Table II. **Spectrometer Backends** (MPIfR)

Unit	Bandwidth	Channels	Resolution
AOS#1	1 GHz	2048	1.2 MHz
AOS#2	1 GHz	2048	1.2 MHz
AOS#3	240 MHz	2048	250 kHz

Bolometers (MPIfR). Two single-channel bolometers, currently operating in the 1300 and 350 μm windows for commissioning, will be replaced by a four-color instrument (with filters for 0.35, 0.45, 0.87 and 1.2 mm wavelength) in Fall 1995. The four channels will be operated in parallel, with spatially displaced beams on the sky. The multi-channel digital backend *Drumbeat* can currently handle up to 8 continuum channels simultaneously, but for operation of the future bolometer arrays the unit can easily be upgraded for up to 64 channels.

Software. The operation of the facility instruments will be remotely controlled (selection and control of receivers, thermal calibration, SSB filtering). The observer's interface is patterned after the IRAM-30m telescope; data aquisition and analysis is within the GAG-software environment. At a later date an environment similar to that of the NRAO 12-m telescope is envisaged too, and additional software packages may be provided. For processing continuum observations a NOD-based algorithm will be available.

Development Projects

The dynamical range of current submillimeter observations is seriously limited by the rather low atmospheric transmission and its temporal fluctuations. Allowing dedicated observing modes and correlation algorithms, large focal-plane arrays will make better use of rare submm observing conditions, thus providing intrinsically much improved image quality. In 1993 the SMTO Council recommended the development of coherent and incoherent focal-plane arrays for operation at the HHT. We restrict our discussion to those systems under development and with approved funding.

- At the MPIfR (PI: E.Kreysa) a large bolometer array with 37 elements for operation in the 350μm atmospheric window is being built, based on the experience gained with the 7 and 19-channel prototypes, which have been operated successfully at the IRAM 30m-telescope at 1.2mm wavelength. The beams of the diffraction limited array will be in a hexagonal packed arrangement with individual sky-pixels separated by $2\times\Theta_{\mathrm{HPFW}}$.

- Construction of a 16-element heterodyne array for operation in the 625 μm window, including a flexible spectrometer backend, commenced in 1994 (PI: R.Güsten). Details of the development will be presented elsewhere in this conference (Scherschel et al.), so we only briefly summarize the system definition:
    - the array consists of 16 elements with the closest feasible spacing of the pixels on the sky ($\sqrt{2} \times \Theta_{\mathrm{HPFW}}$),
    - the performance of the individual modules should be state-of-the-art. In particular we require:
        - mixer & junction to be 'tunerless',
        - $T_{\mathrm{Rx}} \leq 150$ K over the LO-tuning band of 455 – 495 GHz
        - minimum instantaneous bandwidth of 1.5 GHz.

  All the major phase I project goals have now been achieved: reduced-height mixers and competitive 480 GHz junctions with integrated tuning structures have been designed, manufactured and successfully tested; the layout of the system has been designed, based on detailed Gaussian optics calculations and scale-model measurements; broad-band low-noise HEMTs (IF: 2–4 GHz) have been developed. By the summer of this year, a 5-element array prototype will be constructed to test the optics and LO-distribution scheme. By the end of 1995 the array dewar with the first of the two sub-arrays will be finalized. Commissioning of the complete instrument at the telescope is foreseen for winter 96/97.

- A 2-bit hybrid-autocorrelator, based on the new correlator chips of the University of New Mexico is under development (PI: W.Wiedenhoever). The maximum bandwidth will be 2 ($\times$1) GHz for each of the 16 modules, each with 2048 effective channels. In the high-resolution mode, 500 MHz of bandwidth will be covered by 8192 channels with 61 kHz spectral resolution.