FLASH —

the First Light APEX Submillimeter Heterodyne instrument

FLASH

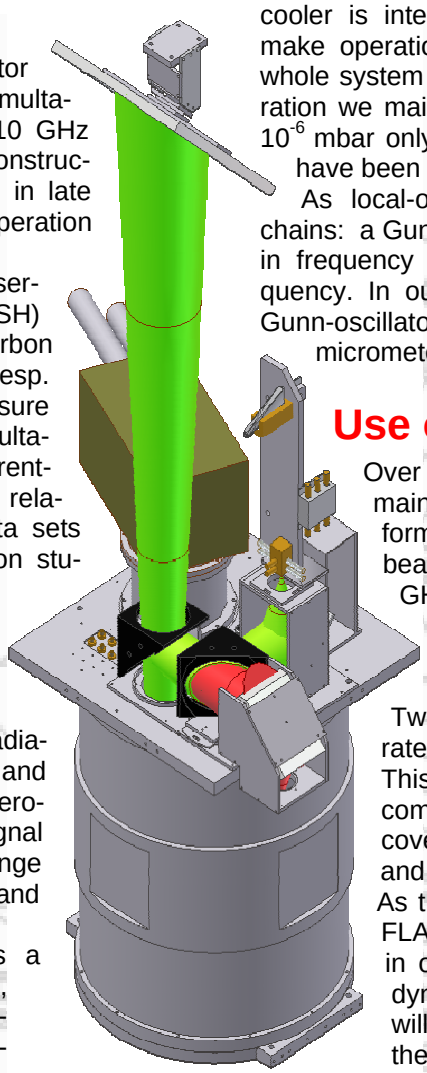
is a dual-channel principal investigator heterodyne instrument operating simultaneously in the 460 GHz and the 810 GHz atmospheric windows. Design and construction of the instrument was launched in late 2003; the receiver is in continuous operation now since June 2004.

At present, the highest frequency observation performed at APEX (with FLASH) was the J=8-7 transition of warm carbon monoxide (CO) at 881 GHz (see the resp. science flyer). The capability to measure in two different frequency bands simultaneously is extremely valuable and currently unique at APEX. This offers good relative calibration between the two data sets which is, e.g., important for excitation studies, requiring calibration accuracy.

Principle of function

The frequency of the submillimeter radiation is too high for direct detection and processing. Therefore, along the heterodyne principle, the high frequency signal is converted first into the frequency range below 10 GHz, where amplification and processing is possible.

For this so-called “mixing” process a reference source, the “local-oscillator”, is needed. The difference signal between this reference and the sky frequency still contains all the spectral information. As mixing devices we use so called SIS (superconductor-isolator-superconductor) contacts. Working near the quantum limit, the mixing device must be operated at 4 K (-269°C).



CAD-model of FLASH including the beam-path (green: 460GHz and red: 810GHz). The closed-cycle cooler is shown in brown. The mixers and big parts of the optics are inside the vacuum tube.

For cooling, a commercial two-stage closed-cycle cooler is integrated. To isolate the system (and make operation at this temperature possible) the whole system has to be evacuated. In normal operation we maintain a pressure inside the dewar of 10^{-6} mbar only. Operation times of several months have been achieved over the last year.

As local-oscillator source we use solid-state chains: a Gunn-oscillator is multiplied several times in frequency to reach the desired reference frequency. In our case the multipliers and also the Gunn-oscillator need to be tuned manually by micrometer-screws.

Use of the system

Over the last year of operation FLASH was mainly used to characterize the performance of the telescope. The small beam size of only 7 arc seconds at 810 GHz was crucial to properly characterize the telescope at the highest available frequencies.

Two months ago two FFTS (see separate flyer) as backends where installed. This made possible to launch our science commissioning, requiring wide bandwidth coverage with high spectral resolution and high reliability.

As the APEX high-frequency work horse, FLASH in its present incarnation will stay in operation until more powerful heterodyne detectors like the CHAMP+ array will become available. The receiver will then be upgraded for use at higher frequencies and with new technologies.

FLASH facts

frequency range [GHz]	420-495	780-887
noise performance [K]	200	450
IF bandwidth [GHz]	2-4	4-8
beam (FWHM) [arcsec]	13	7

We acknowledge support from Dr. U.Graf (KOSMA) who made available the design drawings for the FLASH cryostat (which made possible to manufacture the receiver on shortest possible notice). Dr. G. de Lange (SRON) provided the 800 GHz SIS mixer. These were invaluable contributions to our successful telescope commissioning.

Max-Planck-Institut
für Radioastronomie

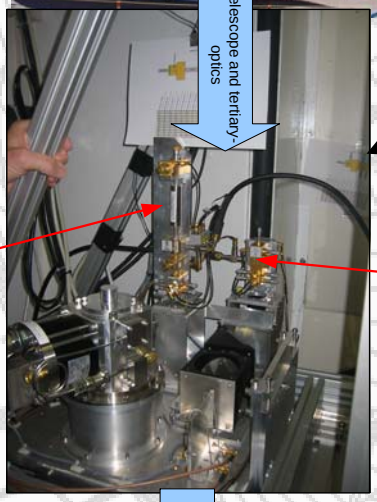
Radiation

Picture of the APEX-telescope located at the Chajnantor high-site in the Chilenean Andes

Schematics of FLASH:

From the stars to the scientific data …

Picture of FLASH installed at APEX. Visible are the local-oscillators and the cooling machine (left in the foreground)



Telescope and tertiary optics

The LO-control-electronics

Local Oscilator 1:
Reference frequency app. 464GHz

Local Oscilator 2:
Reference frequeny app. 812GHz

Matching optics

Matching optics

The mixer-control-electronics

Receiver optics

Mixer (460GHz):
(Reference frequency - Observed Frequency)

Observed Signal (460.5-461.5GHz)

Polarization splitter

Observed Signal (805.5-806.5GHz)

Mixer (810GHz):
(Reference frequency - Observed Frequency)

The IF-processor preparing the signal for the spectrometers

IF-Signal: 2.5-3.5GHz

IF-Signal: 5.5-6.5GHz

Backend 1 (FFTS)
(Spectrum analyzer with app. 16.000 independent, simultaneous working frequency-channels)

Spectra of IRC+10216: showing rotational transitions of carbon monoxide (^{12}C0) at ~461 GHz(left hand side) and ~806 GHz. The line width is due to the velocity structure of the source.

Backend 2 (FFTS)
(Spectrum analyzer with app. 16.000 independent, simultaneous working frequency-channels)

Science data

Science data