FYST CCAT Heterodyne Array Instrument Precursor

K. Vynokurova[1], U.U. Graf[1], I. Barrueto[1], N. Honingh[1], M. Justen[1], B. Klein[2], H. Krüger[1], A. Mahmood[1], B. Schmidt[1], J. Stutzki[1], S. Varghese[1,2], L. Weikert[1]

***Abstract*—This abstract offers an overview of the FYST CCAT Heterodyne Array Instrument Precursor, underlining its practical dual-frequency capabilities, intricate optics path design, and potential for incremental advancements in our understanding of celestial phenomena.**

***Keywords*—Heterodyne receiver, dual-frequency, optics path.**

I. INTRODUCTION

SPECTROSCOPY holds significant importance in improving our understanding of the Universe, offering a window into celestial bodies' composition, temperature, and dynamics. In the microwave range, it allows astronomers to probe, among other things, molecular clouds, providing insights into the star formation processes, and the physics of the interstellar medium (ISM) through detailed mapping of molecular transitions, its distribution, and properties.

The aforementioned phenomena will be observed by the Fred Young Submillimeter Telescope (FYST), a future 6m diameter telescope working in the millimeter and submillimeter wavelength regions. It is being built in the Parque Astronomico de Atacama in northern Chile, at 5600m elevation [1]. The telescope is being created as a versatile platform, allowing multiple instruments to be used for observations. One of them is the CCAT Heterodyne Array Instrument (CHAI), which will operate within 455 – 495 GHz (LFA) and 800-820 GHz (HFA) frequency ranges. In its final configuration, CHAI will feature 64 pixels in each frequency band, totalling 128 pixels (TABLE 1). The receiver allows simultaneous observations of neutral atomic carbon fine structure lines ([CI] $^3P_1 \rightarrow {}^3P_0$ in LFA and $^3P_2 \rightarrow {}^3P_1$ in HFA) and rotational lines of carbon monoxide (CO J=4→3 and J=7→6 respectively). [2].

TABLE I. MAIN SPECIFICATIONS OF CHAI

	LFA	**HFA**
RF range [GHz]	455-495	800-820
Noise temperature [K]	<100	<200
IF band [GHz]	4 – 8	4 - 8
Resolution [kHz] /[km/s]	100 / 0.06	100 / 0.04
Velocity coverage [km/s]	2500	1500
Beam size ["]	26	15
Field of View [' x ']	7.5 x 7.5	4.5 x 4.5

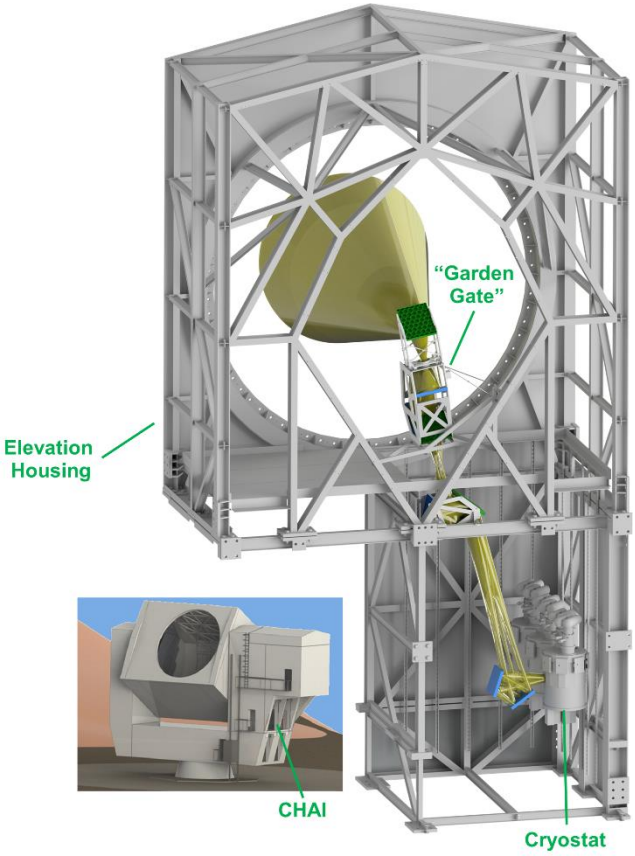

Fig. 1. The Optics path from FYST elevation bearing (large round opening), where the "Garden gate" component is located, down to the instrument space, where the instrument's cryostat is placed.

However, during preliminary tests and commissioning of the telescope, namely, holography measurements, as well as for the first light of the FYST, a less complex precursor of CHAI will be used, a dual-frequency single-pixel receiver (mini-CHAI).

II. CONFIGURATION OF THE INSTRUMENT

The instrument's location within the FYST introduces a unique optics path complexity, featuring a retractable

[1] I. Physikalisches Institut der Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany, email: vynokurova@ph1.uni-koeln.de & graf@ph1.uni-koeln.de & barrueto@ph1.uni-koeln.de & honingh@ph1.uni-koeln.de & justen@ph1.uni-koeln.de & krueger@ph1.uni-koeln.de & mahmood@ph1.uni-koeln.de & bschmidt@ph1.uni-koeln.de & stutzki@ph1.uni-koeln.de & varghese@ph1.uni-koeln.de & weikert@ph1.uni-koeln.de; [2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany, email: bklein@mpifr-bonn.mpg.de .

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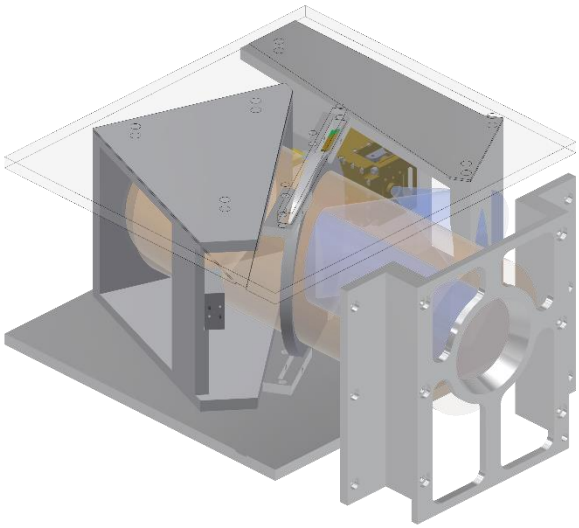

Fig. 2. CHAI precursor optics inside the cryostat. 475 GHz (orange) and 807 GHz (blue) beam paths lead from the cryostat window to the balanced SIS CHAI mixer and band 2 SIS Nb-AL2O3-Nb HIFI mixer respectively. The beams are split using polarising filter foil.

component used to direct the sky signal to our device's cryostat or enable observations with other instruments (Fig.1) [3].

Within the mini-CHAI cryostat, the double-frequency sky signal is split by a polarising filter foil. The transmitted component of the signal is then fed through the 475 GHz spline-profile diagonal horn [4] to the SIS-balanced mixer (Fig.2).

The reflected component (with polarization perpendicular to the orientation of the foil) is then fed to a second, single-ended SIS mixer, identical to the band 2 Heterodyne Instrument for the Far-Infrared (HIFI) mixer, launched onboard ESA's Herschel Space Observatory in May 2009 [5].

This single-pixel instrument not only simplifies the commissioning and initial operation of the FYST telescope but also offers a platform for field verification of CHAI components.

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