ALMA-FED 2021: ALMA Front End Development (Virtual) Conference 2021

Report of Contributions

https://indico.cern.ch/e/1049946

Contribution ID: **3** Type: **Contributed Talk**

Sensitivity and a Wideband Metric for ALMA

In this talk I will present a few overview notes on the kinds of sensitivity and imaging speed improvements in the front end receivers we can expect or hope for.

Primary author: MROCZKOWSKI, Tony (ESO - European Southern Observatory)

Session Classification: Introduction/Overview

Track Classification: ALMA-FED 2021 Contributions: Contributed Talks

Contribution ID: **4** Type: **Invited Talk**

Design of optical components

Nowadays there is a considerable scientific interest in increasing the field of view of submillimeter wave observatories in order to enable a much faster wide field mapping. This would enable telescopes to survey large regions of molecular clouds and image nearby galaxies.
We present our study of multi-pixel architectures that could allow for orders of magnitude increase in mapping speeds, thus significantly expanding the capabilities of current facilities like the ALMA observatory. The results of the study will be useful also in the development of future sub-mm single dish facilities, such as AtLAST, which aims at the delivery of a new and deeper insight of the submillimeter sky. Indeed, the development of focal plane arrays would significantly enlarge the fraction of the sky covered in a single observation, thus enabling the mapping of thousands of radio sources in a reasonable time.
The purpose of our study is the design of a multipixel array horn aperture focal plane that ensures a high polarization purity, reduced aberrations for off-axis beams and as compact as possible to satisfy the technical specifications based on scientific requirements and engineering constraints on weight, size and thermal load, which represent a serious technological challenge.

Primary author: REALINI, Sabrina

Session Classification: Arrays

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **5** Type: **Invited Talk**

Development of a multiband heterodyne receiver with 49 GHz of instantaneous IF Bandwidth

Increasing the IF bandwidth in heterodyne receivers is one of the main priorities of the ALMA Development Roadmap. One alternative approach to this problem is to increase the number of IF outputs to achieve the same goal of reducing observation time. In this work, we propose the use of a multiband heterodyne receiver architecture in conjunction with digital sideband separation to achieve complete RF coverage with multiple IF outputs. The selected band to test this architecture is ALMA Band 2+ (67-116 GHz), obtaining an instantaneous IF bandwidth of 49 GHz with four IF outputs. We will present a comprehensive analysis of the proposed design, showing its advantages and limitations, as well as giving possible options of how this architecture can be implemented in the upper-frequency bands of ALMA.

Primary author: MONASTERIO, David (Universidad de Chile)

Co-author: Dr MENA, Patricio (National Radio Astronomy Observatory)

Session Classification: Beyond 2030

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **6** Type: **Invited Talk**

NRC-HAA Cryogenic Radio Receiver Development

The Radio Instrumentation Team (RIT) team at NRC Herzberg in Victoria, Canada, is developing a dual linear polarization, cryogenic radio astronomy receiver covering the frequency range of 30.5 to 50.5 GHz for the next generation Very Large Array (ngVLA) project. The specification of this receiver development is aligned with ngVLA Band 5 requirements. This receiver is designed for a noise temperature of less than 25 K over the bandwidth. The proposed receiver uses a vacuum vessel and a two-stage cryopump system for a cryogenic environment which provides 16 K and 70 K stages. The proposed receiver consists of a cryostat with a cooled feed horn, a turnstile OMT plus two integrated noise couplers for noise calibration, two mHEMT MMIC cryogenic low noise amplifiers with noise temperature lower than 14 K, IR filters, and a vacuum window to create a low-loss transmission of electromagnetic fields into the cryostat.
The RIT team is also working on designing and developing various high-efficiency and wideband feed horns, vacuum windows, and OMTs. So far, a compact, low noise octave band OMT, multiple octave band feed horns, and a vacuum window covering the frequency range of 25-50 GHz have been designed. Most of the waveguide components designed and developed for the ngVLA Band 5 and octave band receiver are scalable to higher and lower frequency bands.

Primary author: Dr SALEM HESARI, Sara (NRC HAA)

Session Classification: Receivers (MMIC/HEMT)

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **7** Type: **Invited Talk**

Development of a new wideband heterodyne receiver system (RF: 210–375 GHz, IF: 4–21 GHz) for the Osaka 1.85-mm mm-submm telescope

We report the development of a wideband receiver system using a corrugated horn covering 210–375 GHz (56% fractional bandwidth; Yamasaki et al. 2021, PASJ), wideband waveguide multiplexers (Masui et al. 2021, PASJ), and a wideband SIS-mixer with an IF (intermediate frequency) output of 4-21 GHz (Kojima et al. 2020, A&A). In the system, the RF signal from the horn is divided into two frequency bands by a wideband diplexer with a fractional bandwidth of 56%, and then each frequency band is further divided into two bands by each diplexer. One of the SIS-mixers connected has a wideband 4–21 GHz intermediate frequency (IF) output. This receiver system has been installed on the 1.85 m telescope of Osaka Prefecture University located at the Nobeyama Radio Observatory. We succeeded in simultaneous observations of six CO isotopologue lines with the transitions of J = 2–1 and J = 3–2 toward the Orion KL as well as on-the-fly mappings toward the Orion KL and W 51 with the developed system.

Primary author: ONISHI, Toshikazu (Osaka Prefecture University)

Co-authors: Mr MASUI, Sho (Osaka Prefecture University); Mr YAMASAKI, Yasumasa (Osaka Prefecture University); Prof. OGAWA, Hideo (Osaka Prefecture University); Dr KOJIMA, Takafumi (NAOJ); Dr GONZALEZ, Alvaro (NAOJ)

Session Classification: Receivers (SIS)

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **8** Type: **Invited Talk**

Preparing ALMA for the next decade and beyond

ALMA continues to provide dramatic views into our cosmic origins and yet has the opportunity to capitalize on the technological developments over the two decades since its initial design to provide deeper, clearer, and more profound insights. Having defined its upgrade path for the next decade and beyond, ALMA is in the midst of finalizing the updated system and subsystem specifications for the Wideband ALMA 2030 Sensitivity Upgrade. I will describe the fundamental goals and their motivation as well as describe the critical role that updated front ends will play in the overall upgrade plan. In the end I will outline the timeline and path toward the upgrade, highlighting the challenges and opportunities that will be presented along the way.

Primary author: CORDER, Stuartt

Session Classification: Introduction/Overview

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **10** Type: **Invited Talk**

ALMA Band 6v2 Receiver Upgrade

We report on our proposal to develop an upgrade for the existing 211-275 GHz ALMA Band 6 receiver, referred to as "Band 6v2", which complies with the strategies defined in the ALMA Development Roadmap to 2030 and with the recommendations of the ALMA Front-end & Digitizer Requirements Upgrade Working Group. The goal is to deliver an improved production-level receiver based on (i) a new Cold Cartridge Assembly (CCA) with increased sensitivity over an expanded IF band and a modestly expanded RF band, and (ii) a new low-noise Warm Cartridge Assembly (WCA) which contains a new lower AM sideband noise Local Oscillator source with a baseband YIG oscillator operating at twice the frequency of the current one. The new Band 6v2 receiver will be backward-compatible with the current Band 6 and will be able to be plugged into the ALMA FE (Front-End) cryostat as a replacement for the existing units.

We will describe the current ALMA Band 6 receiver, our plan to address its shortcomings, and the expected performance of the ALMA Band 6v2 receiver. The Band 6 receiver upgrade will result in several benefits including a reduction in integration time by a factor of ˜1.5 to as much as 3 in the worst parts of the current IF (assuming a typical sky temperature), an increase in the IF bandwidth from the present 5.5 GHz per sideband per polarization to at least 12 GHz (4-16 GHz) and potentially to 16 GHz (4-20 GHz), and an increase in RF coverage by 8 GHz, to 209-281 GHz from the present 211 275 GHz.

The project will focus on exploring several different receiver configurations for the ALMA Band 6v2 sideband separating (2SB) SIS receiver, with improvements to all the major receiver components, including optics, OMT, mixers, IF section and local oscillator. The presentation will provide a brief overview of all of the above mentioned aspects of the project.

Primary authors: Dr NAVARRINI, Alessandro (INAF and NRAO Adjunct); Dr KERR, Anthony R. (NRAO); Mr DINDO, Philip (NRAO); Dr EFFLAND, John (NRAO); Dr LAMBERT, Joseph (NRAO); Prof. LICHTENBERGER, Arthur (IFAB University of Virginia); Dr SAINI, Kamaljeet (NRAO); Dr SRIKANTH, Sivasankaran (NRAO); Mr VASELAAR, Dustin (NRAO); Dr HAWKINS, Bert (NRAO)

Session Classification: Receivers (SIS)

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **11** Type: **Invited Talk**

Development of receiver optics components using AM technology

NAOJ is performing R&D studies related to additive manufacturing (AM) technologies based on metal 3D printing. This technology is evolving day by day in the world, both instruments and methods, and is used for diverse industries, e.g., aerospace, medical, automotive, ISS. Benefits of AM are rapid prototyping, design optimization with topology methods, cost and lead time reductions. We have focused this research on the development of receiver optics component, especially the ALMA Band1 corrugated horn. Through these studies, we have also learned some practical disadvantages of additive manufacturing, which need to be compensated by other existing technologies. In addition, the material/physical properties of components produced by AM should be checked carefully because they may change during the manufacturing process and through aging. We will present the current status of this research and would like to discuss the usefulness of AM for the development of future receivers.

Primary author: KANEKO, Keiko (National Astronomical Observatory of Japan)

Session Classification: Receiver optics

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **13** Type: **Invited Talk**

Heterodyne Array Receivers for Space and Ground Based Applications

Heterodyne array receivers have been successfully built for ground-based telescopes. Here we will present the first detailed design for a space application, the Heterodyne Receiver for the Origins Space Telescope (HERO). HERO follows the traditional design, but limited cooling power and the limited electrical power of the satellite pose major challenges. Minor challenges are limited availability of space and weight. For the eight 3x3 pixel arrays of which 4 can operate simultaneously we attributed 20mW at 4.5K, 35mW at 35K and 205 W at the satellite temperature. Therefore we propose to use SiGe cryogenic low noise amplifiers, with a dissipation of about 0.5mW for 6 GHz bandwidth. The power of the backends also needs to be reduced drastically to about 1 W for 6 GHz bandwidth. CMOS ASIC backends are one option, ADC, followed by FFTs and ACCs another. To reduce the volume and mass, we propose the cover the RF bandwidth of 486 GHz to 2700 GHz in only 4 bands, each with about 50% relative width.
The design might not only be a helpful starting point for any heterodyne array on a satellite, but the low heat and power consumption might be also an essential first step for large (100 to 1000 pixels) heterodyne arrays for ground based telescopes or simply a more energy efficient alternative for any ALMA single pixel or array receiver.

Primary author: WIEDNER, Martina

Session Classification: Arrays

Track Classification: ALMA-FED 2021 Contributions: Invited Talks

Contribution ID: **15** Type: **Invited Talk**

Broad IF band vs. Broad RF Band

Day 3: Receivers (SIS)
11:00 Wideband Technology development for ALMA receiver upgrades at NAOJ Takafumi Kojima invited
11:05 SIS based mixers development for radio astronomy Kirill Rudakov 6 contributed
11:10 On Extending the IF Bandwidth of ALMA Band # 6 SIS Mixers Marian Pospieszalski 6 invited
11:15 ALMA Band 6v2 Receiver Upgrade Alessandro Navarrini 6 invited
11:20 ALMA Band 6 Local Oscillator Noise Improvement Kamaljeet Saini 6 contributed
11:25 The status of SIS Process Development at GARD Alexey Pavolotsky 5-9 contributed
11:30 The development of low-noise, wide-band SIS mixer receivers based on a zero-IF architecture. Ray Blundell 5-8 invited
11:35 Discussion Neil Phillips
12:00
Development of a new wideband heterodyne receiver system (RF: 210–375 GHz, IF: 4–21 GHz) for the Osaka 1.85-mm
mm-submm telescope Toshikazu Onishi 6-7 invited
12:05 Development of Band 7+8 Cartridge Receiver Jung-Won Lee 7-8 contributed
12:10 On-going mixer developments at IRAM Doris Maier 2-7 invited
12:15 Dual Band upgrade of NOEMA Receivers Anne-Laure Fontana 2-7 contributed
12:20 Developing for ALMA's future at NOVA Ronald Hesper 9 invited
12:25 Calculation and Analysis software for SIS-Mixers Daniele Ronso Lima 9 contributed
12:30 Discussion Kamaljeet Saini

Presenter: BELITSKY, Victor