Development of the 30-50 GHz Receiver for Nobeyama 45-m Telescope

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The proposal to install 30-50 GHz receiver at Nobeyama 45-m telescope **has been approved** by NRO, and a Japan-Taiwan development team is coordinated aiming to install the receiver in **2-year time**. The primary goal of this receiver is to provide an powerful tool to detect the magnetic field strengths via Zeeman measurements. New development items on optics, feedhorn and OMT will be carried out to meet the large RF frequency range (50% relative bandwidth). First on-site discussion at NRO was held in November and the receiver is expected to be installed in **winter 2019/2020**.

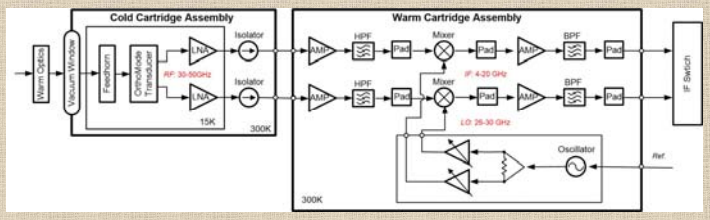
Unique Tool for Efficient Zeeman Survey

With wide RF and wide IF bandwidth, 3 Zeeman transitions between 30 and 46 GHz can be **observed simultaneously**. They are supposed to probe different region of the pre-protostellar cores, and thus provide us a more complete picture of its magnetic field strengths and distribution with single observation.

Species	Transition	Frequency (GHz)	A_{mol} (km s^{-1} G^{-1})	Note
SO	$J_k=1_0$-0_1	30.0015	12.425	Widely found in shock region and dense core $n(H_2) \sim 10^{4-6}$ (cm^{-3})
CCS	$J_k=3_2$-2_1	33.7514	4.409	Found in early stage star-less molecular core $n(H_2) \sim 10^{4-6}$ (cm^{-3})
CCS	$J_k=4_3$-3_2	45.3790	2.938	

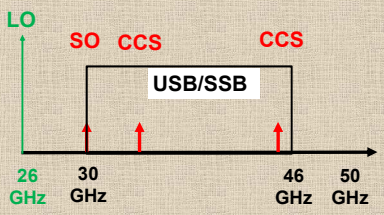
Receiver Configuration

SSB/USB Receiver



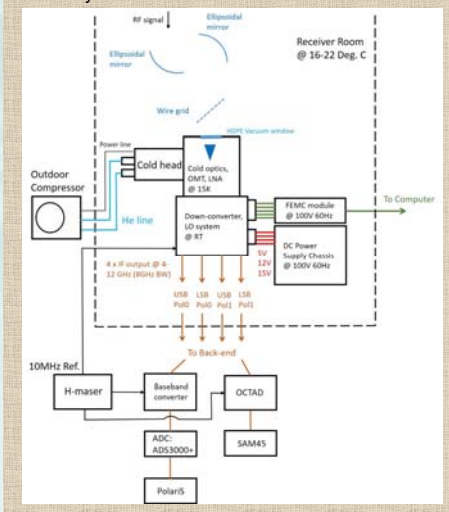
Pros:
- Compact receiver layout
- No image band contamination

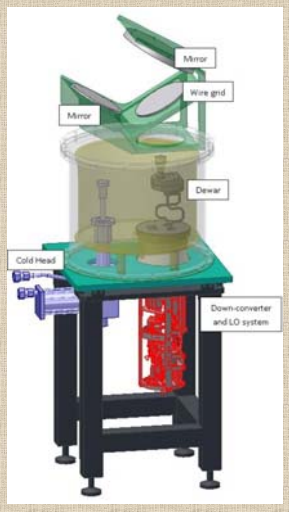
Cons:
- Wide (16 GHz) IF bandwidth currently not supported by NRO IF system



Receiver Layout

ASIAA will be responsible for the down-converter and system integration. Following NRO's constrain on the dimension of the receiver (no more than 70cm x 75 cm) and on the total weight (500 kg), preliminary receiver layout is shown below. A lot of efforts are needed to fit the ALMA-based monitor and control (M&C) system at ASIAA to the NRO system.

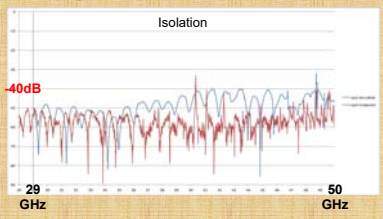




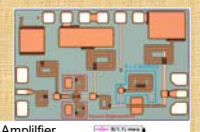
New reflective optics will be designed by Osaka Prefecture Univ. and new feedhorn will be designed by NAOJ. The ultimate goal is to optimize the cross-polarization performance at 30.0, 33.8 and 45.4 GHz. Wire grid with automation on/off will be employed for polarization calibration.

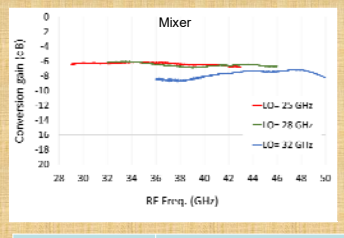
Development of New Components

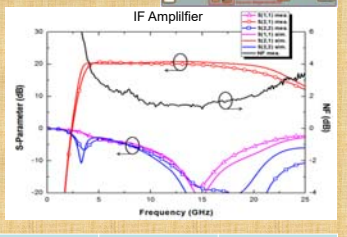
New OMT and the conceptual layout of the new receiver are carried out at ASIAA. The new **turnstile junction** OMT covers **29-50 GHz** with return loss better than 18 dB and isolation better than 40 dB.



New wide IF amplifier is also design by ASIAA with **GaAs MMIC** technology. It provides 17-20 dB gain from 4-20 GHz with large P1dB. ALMA Band 1 mixer is also tested for the new frequency range. It meets the new requirements of large IF bandwidth.







	Green Bank		Effelsberg	Nobeyama Z45	New Receiver
Diameter	100m		100m	45m	**45m**
Main Beam eff.	0.82	0.89	0.36	0.72	**TBM**
Receiver freq. coverage	Q-band (38-50 GHz)	Ka-band (26-40 GHz)	S7mm (41-45 GHz)	42-46 GHz	**30-50 GHz**
Receiver Configuration	Two-beam, each with L/R pol.	Two-beam, each with single linear pol.	Single pixel, L/R pol.	Single pixel, dual linear pol.	**Single pixel, dual linear pol.**
T_{rx} / T_{sys}	40-70 K / 67-160 K	(?) K / 50-120 K	73 K / 100-120 K	50 K / 100-150 K	**15-25 K / 50-75K**
Instantaneous IF bandwidth	4 GHz / pol.	14 GHz / pol.	Narrow (VLBI)	4 GHz / pol.	**16 GHz / pol.**
Note	Narrow IF bandwidth	Specified for high-z survey; poor spectral resolution	New Receiver underway	Narrow RF and IF bandwidth	

Status and Schedule

First on-site discussion with NRO people was held in November 2017 for overviewing the whole project. Further discussion via telecom is expected every two or three months. The receiver is expected to be installed in Oct. 2019, well before the completion of ALMA Band 1 in 2021.

Apr. 2018	Start of the project	Note
Apr. 2018	Finalize receiver architecture and work breakdown	Email and telecon
May 2018 to Mar. 2019	Component and sub-system design, fabrication and verification	Taiwan (OMT and down-converter); Japan (mirror and feedhorn)
Apr. to Aug. 2019	System integration and testing; Control software modification	Taiwan
Sept. 2019	System performance review meeting; Document review and Receiver shipment	Taiwan
Oct. to Dec. 2019	Install receiver at NRO	NRO
Jan. to Mar. 2020	Engineering time for system optimization	NRO

***Team members**:

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