Nobeyama 45-m telescope:

an experimental field for next-generation technologies and astronomy with a large-aperture millimeter-wave telescope

Atsushi Nishimura (NAOJ)
Rin Yamada, Chieko Miyazawa, Tomio Kurakami, Toshikazu Takahashi, Kazuyuki Handa, Kazuhiko Miyazawa, Ken Miyato (NAOJ)



Key specifications

- **Built in** 1982
- **Altitude:** 1350 m
- **Apperture size:** 45m
- **Surface accuracy:** 100 μm (rms)
- **RF range:** 20-116 GHz (as of FY2025)
- **# of receiver ports:** 11
- **Use fees:** 30k JPY/hour (for foreign institution)
- **# of obs. projects:** 41 (/yr, FY2025)
- **# of publications:** 41 (/yr, FY2024)
- **# of visitors:** 131k (/yr, FY2025 as of 9/30)
- **# of X followers:** 26.7k (as of 2025/12)

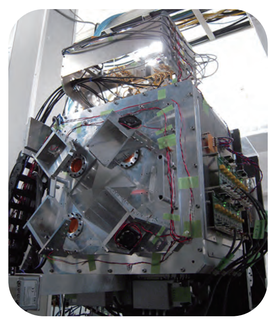
Receivers

Port	Rx	RF (GHz)	Beam	Pol	PI	Status
1	7BEE	70-116	7	2	NRO	○ Partially in-service
10	FOREST	80-116	4	2	NRO	● In-service
2	TZ	80-116	1	2	Yamaguchi U, Kagoshima U	● In-service
5	Z45	42-46	1	2	Osaka Pref. U	● In-service
4	H40	42.5-44.5	1	1	NRO	● In-service
3	H20	20-25	1	2	NRO	● In-service
11	Tsukuba-camera	100	109		U Tsukuba	◇ Under CSV
6	eQ	30-50	1	2	ASIAA	◇ Under CSV
	FMLO				Kitami Institute of Tech.	・Under development
	MAO				Nagoya U	・Under development
9	230G	230	1	2	Nagoya City U	・Budget application in progress
9	NOCTURNE	20-150	1	2	Kagoshima U	・Budget application in progress
2	TZ-230G	80-230	1	2	ISAS/JAXA	・Budget application in progress
7	ng-MultiBeam	125-163	4	2	Suwa U of Science	・Budget application in progress
11	6G	6.5-12.5	1	2	Ibaraki U	・Budget application in progress
	RFSoC Spectrometer				NRO	・Budget application in progress
	ng-analysis method				NRO	・Budget application in progress
	・HINOTORI Filter					
	H22 & H40				Kagoshima U	● In-service
	H22 & Z45				Kagoshima U	● In-service
	H22 & H40 & TZ				Kagoshima U	○ Partially in-service

Receivers: current and future

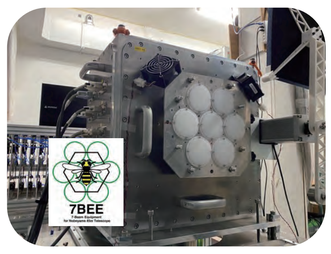
Advantages of the NRO45 are its **(1) large field of view** and **(2) large light-gathering power**. To increase its international competitiveness, developing unique receivers are crucial.

Multi-beam Rx



FOREST (Minamidani+2016)
in-operation

- **# of beams:** 4
- **Poralization:** dual (H, V)
- **Type:** SIS, Balanced-2SB
- **RF range:** 80-116 GHz
- **IF range:** 4-12 GHz

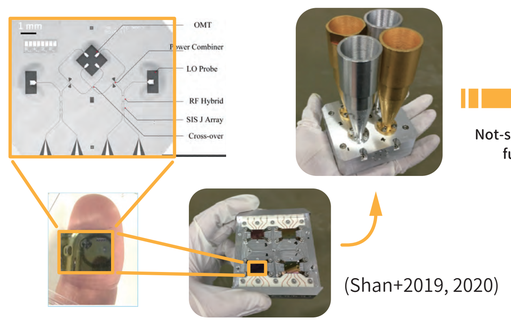


7BEE (Miyato+ in prep.)
partially in-operation

- **# of beams:** 7
- **Poralization:** dual (H, V)
- **Type:** HEMT, Waveguide SSB
- **RF range:** 72-116 GHz

ng-MultiBeam
under development

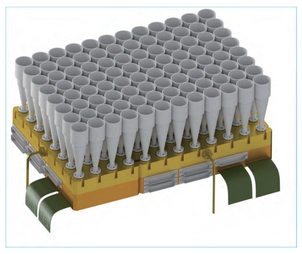
- **# of beams:** 4-100 ?
- **Poralization:** dual (H, V)
- **Type:** SIS, Balanced-2SB
  Superconducting integrated circuit
- **RF range:** TBD
- **IF range:** TBD



(Shan+2019, 2020)

Not-so-distant future

>100 beam receiver



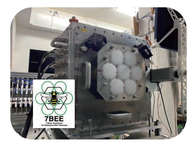
(Shan+2023)

Wide-band Rx



eQ (Chiong+2022)
under CSV

- **Poralization:** dual (H, V)
- **Type:** HEMT, Balanced 2SB
- **RF range:** 30-50 GHz

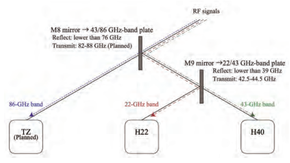


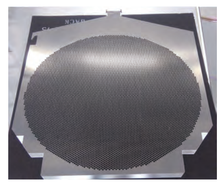
7BEE (Miyato+ in prep.)
partially in-operation

- **Poralization:** dual (H, V)
- **Type:** HEMT, Waveguide SSB
- **RF range:** 72-116 GHz

HINOTORI (Okada+2020)
in-operation

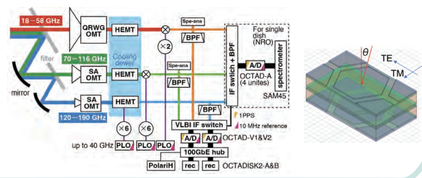
- **Type:** quasi-optical filter
- **RF range:** 22, 43, 86 GHz





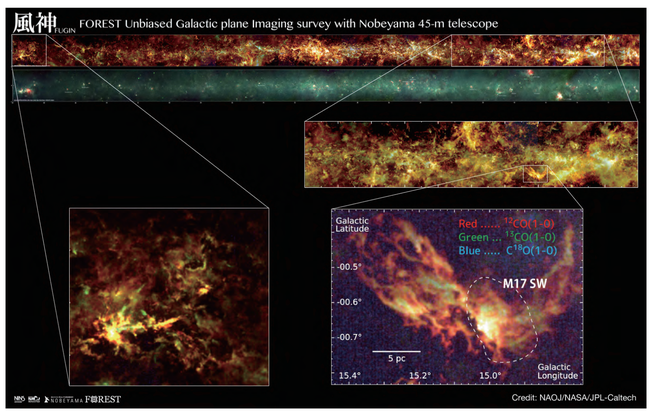
NOCTURNE
under development

- **Type:** quasi-optical filter, HEMT
- **RF range:** 18-58, 70-116, 120-150 GHz



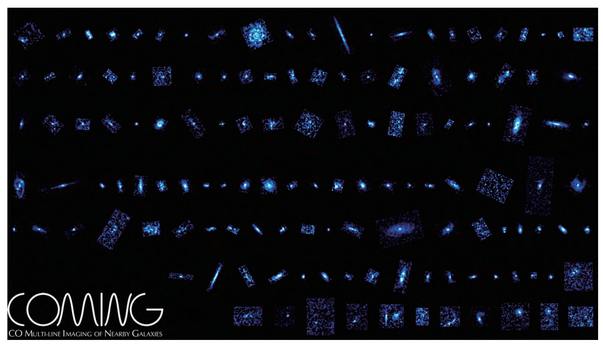
Science cases

Large scale mapping of molecular lines are NRO45's areas of speciality. NRO Legacy Projects were carried out and its data is publicly available.



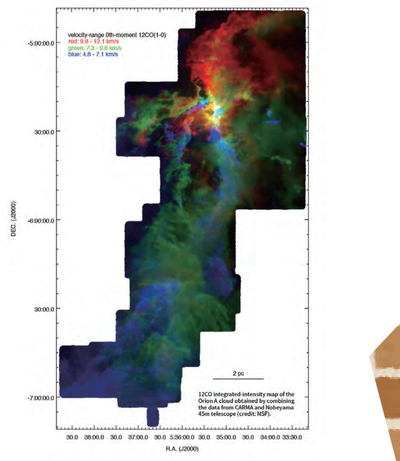
FUGIN (Umemoto+2017)
highest angular resolution galactic plane survey

The mapping area extends over a large parts in the first quadrant (10° <= l <= 50°, |b| <= 1°) and the third quadrant (198° <= l <= 236°, |b| <= 1°) of the Galactic plane, which include spiral arms, the bar structure, and the molecular ring of the Milky Way.



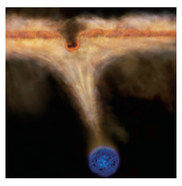
COMING (Sorai+2019)
147 nearby galaxies mapping survey

The project has observed nearby galaxies with the Nobeyama 45-m radio telescope in 12CO J=1-0 in On-The-Fly mode. The final observed sample consists of 147 galaxies to understand where and how did stars form in galaxies.

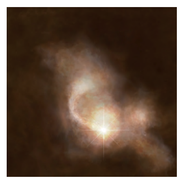


Star Formation (Nakamura+2019)
nearby star-forming regions mapping survey

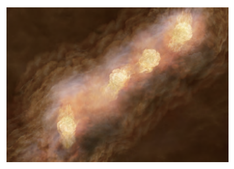
The NRO Star Formation Legacy Project is a large project to make wide-field molecular line maps of nearby star-forming regions. The target regions are (1) Orion A, (2) Aquila Rift, and (3) M17 SWex molecular cloud complexes.



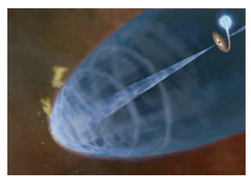
Possible detection of dark matter sub-halo
(Yokozuka+2024)



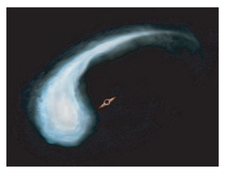
Mass flow to star forming core through streamer
(Taniguchi+2024)



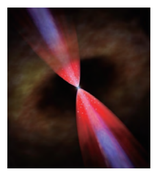
Filament flagmentation to star forming cores
(Shimajiri+2023)



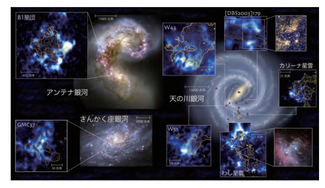
Molecular clouds swept up by the jets (Sakemi+2023)



Molecular clouds being captured by inter-mediate mass blackhole (Kaneko+2023)



Discovery of SiO Masers in the "Water Fountain" Source (Amada+2022)



Cloud-cloud collision triggering high-mass star formation
(Nishimura+2018,2021; Fujita+2019; Kohno+2021)

Future

NRO45 is expected to remain the world's largest millimeter-wave telescope over the coming decade. NRO have been collecting community input through science and technology workshops to shape our future vision and priorities. As the results, key sciences are set to be (1) extending galactic plane survey especially toward higher latitude, (2) multi-line survey to reveal physical and chemical evolution of the ISM, and (3) mm-wave VLBI.



NRO45 science workshop (Dec 2024)







NRO45 developer meeting

Roadmap

↓ Plan / Year→	4th midterm plan				5th midterm plan						6th midterm plan						
	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Operation under charged telescope time	Countermeasures against deterioration will be conducted as needed																Consider whether continue or not
7BEE receiver (7 pixels) [3mm]	Development	Open use							Decommission								
Next generation multi-beam (20 pixels) [3mm]		Concept design		Preliminary design		Integration, Qualification		Open use								Decommission	
Next generation multi-beam (100 pixels) [3mm]								Concept design		Preliminary design		Integration, Qualification		Open use			Relocation to LST/AtLAST
New radio spectrometer		Development		Open use													
Ultra-wide mm-wave receiver (20-150 GHz; 2mm)		Development			Open use・VLBI use												
Ultra-wide mm-wave receiver (20-230 GHz; 1mm)								Development			Open use・VLBI use						
Improvement of surface accuracy by dynamic control of the surface	Development				Partially implementation		Test and upgrade		Full implementation		Open use						Relocation to LST/AtLAST
LST/AtLAST (reference)																	Start operation?
ATT30m (reference)	Development and observations of MKID camera using NRO45m										Construction?						Start operation?