Nobeyama Development Program Meeting on 2026 July 28

From HINOTORI to NOCTURNE

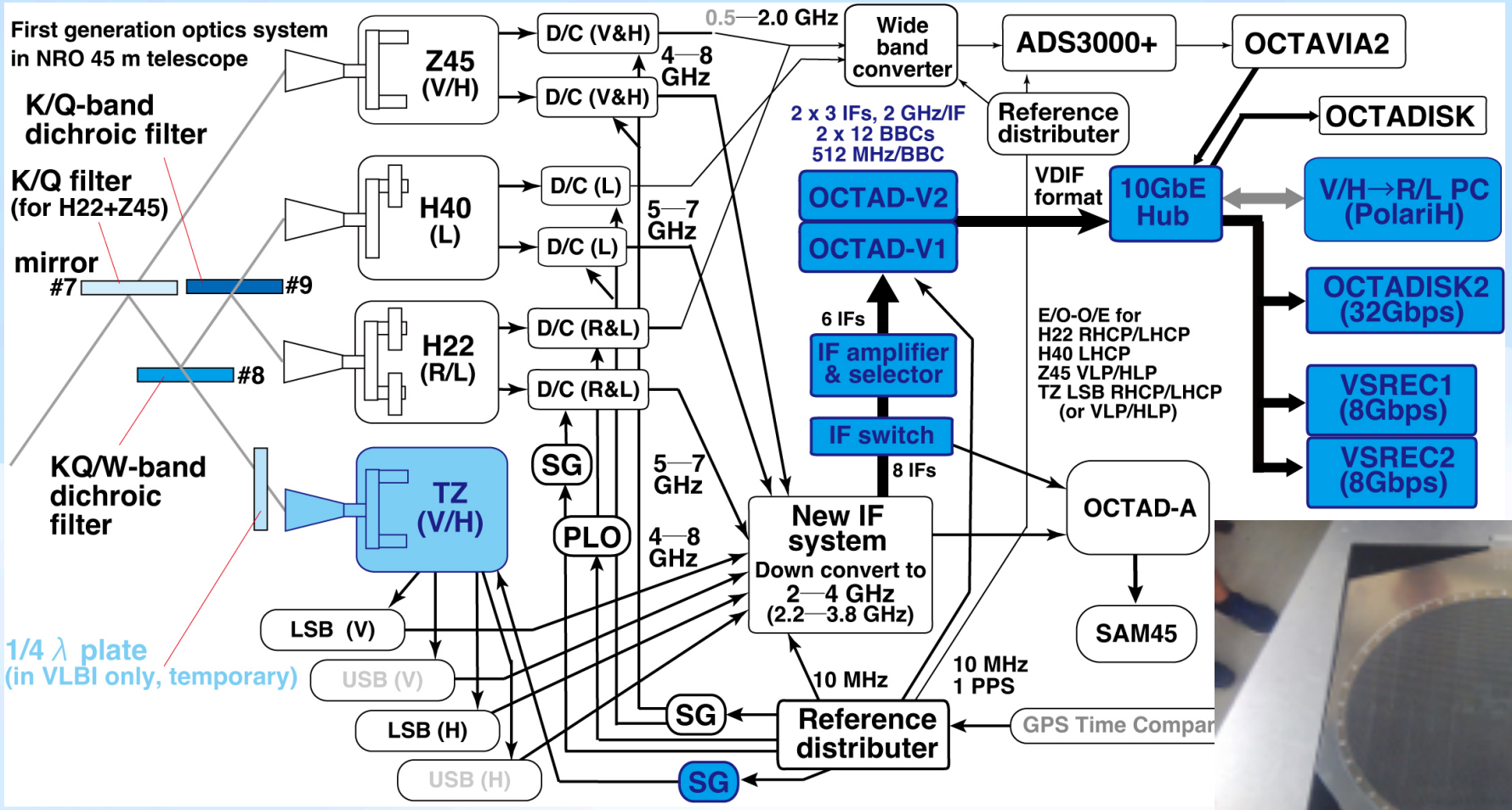
NROD:001 NROD:009

HINOTORI=
Hybrid Integration Project in Nobeyama, Triple-band Oriented
NOCTURNE=
Nobeyama Octatonic-scale bands, Unitary-frame Receivers Nexus

IMAI, Hiroshi

Amanogawa Galaxy Astronomy Research Center / Center for General Education
Kagoshima University

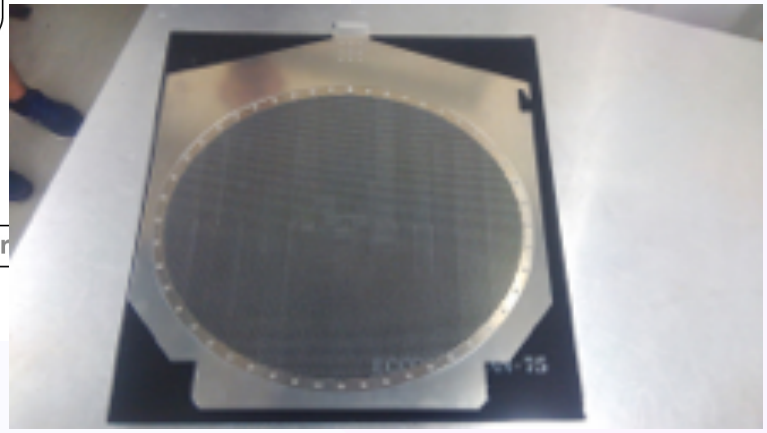
HINOTORI =**H**ybrid **I**ntegration Project in **No**beyama, **T**riple-band **Ori**ented



Now in VLBI commissioning



Perforated frequency band separation filter plate

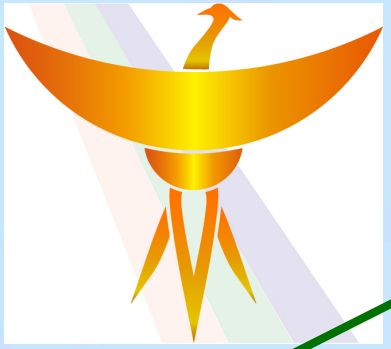


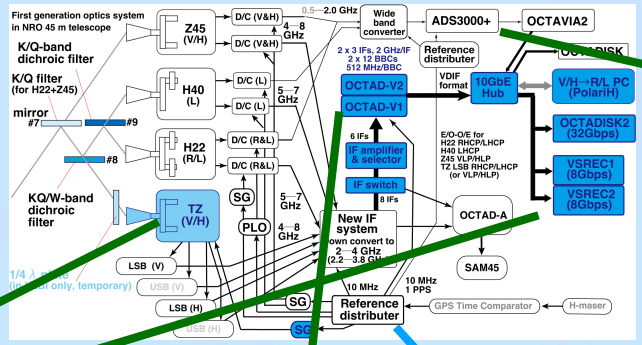
Scientific operation (single dish modes):

K+Q (H22+Z45) opened in single-dish mode since 2022 March

K+Q+W (H22+H40+TZ) will be opened in single-dish mode since 2026 February

Synergy of HINOTORI with other development projects





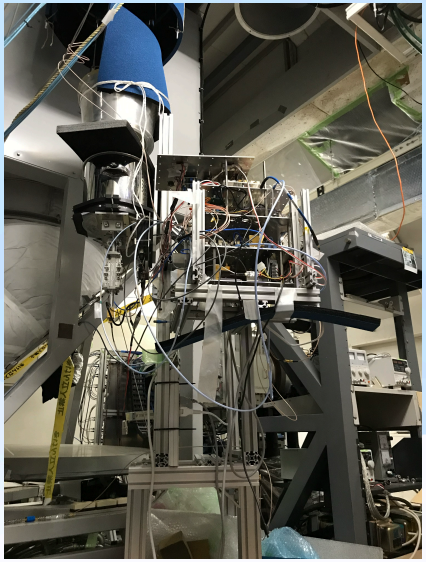
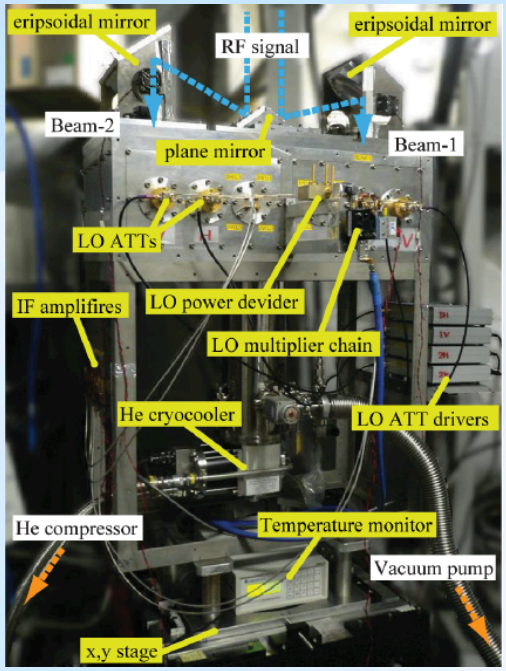


Photo by H.I.

TZ for 86&230 GHz VLBI



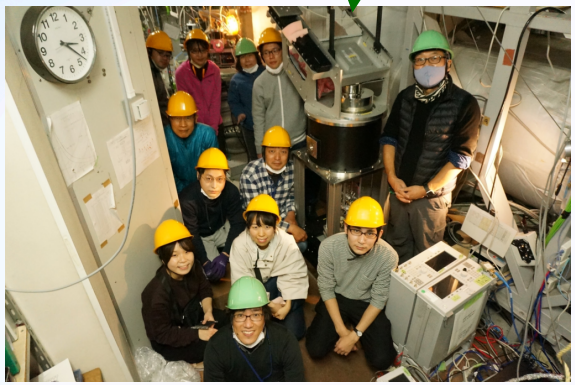
Nakajima et al. 2013

New band separation filter

eQ receiver for Zeeman effect measurement

digital signal sampling

NeCoDeS for VLBI



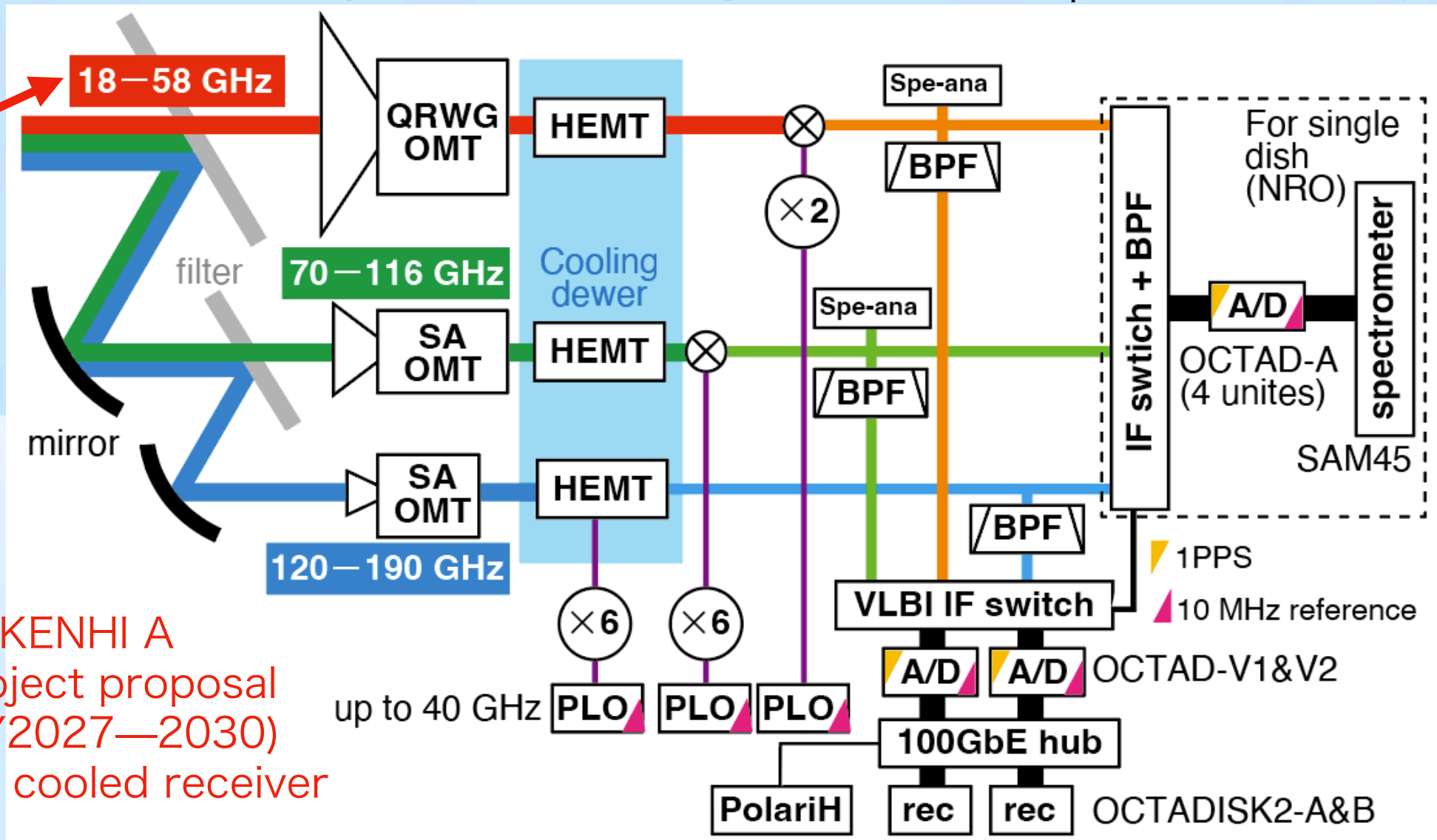
https://sci.nao.ac.jp/main/highlights/20211202

Cooling

NOCTURNE

NOCTURNE system concept

updated on 2025/7/6



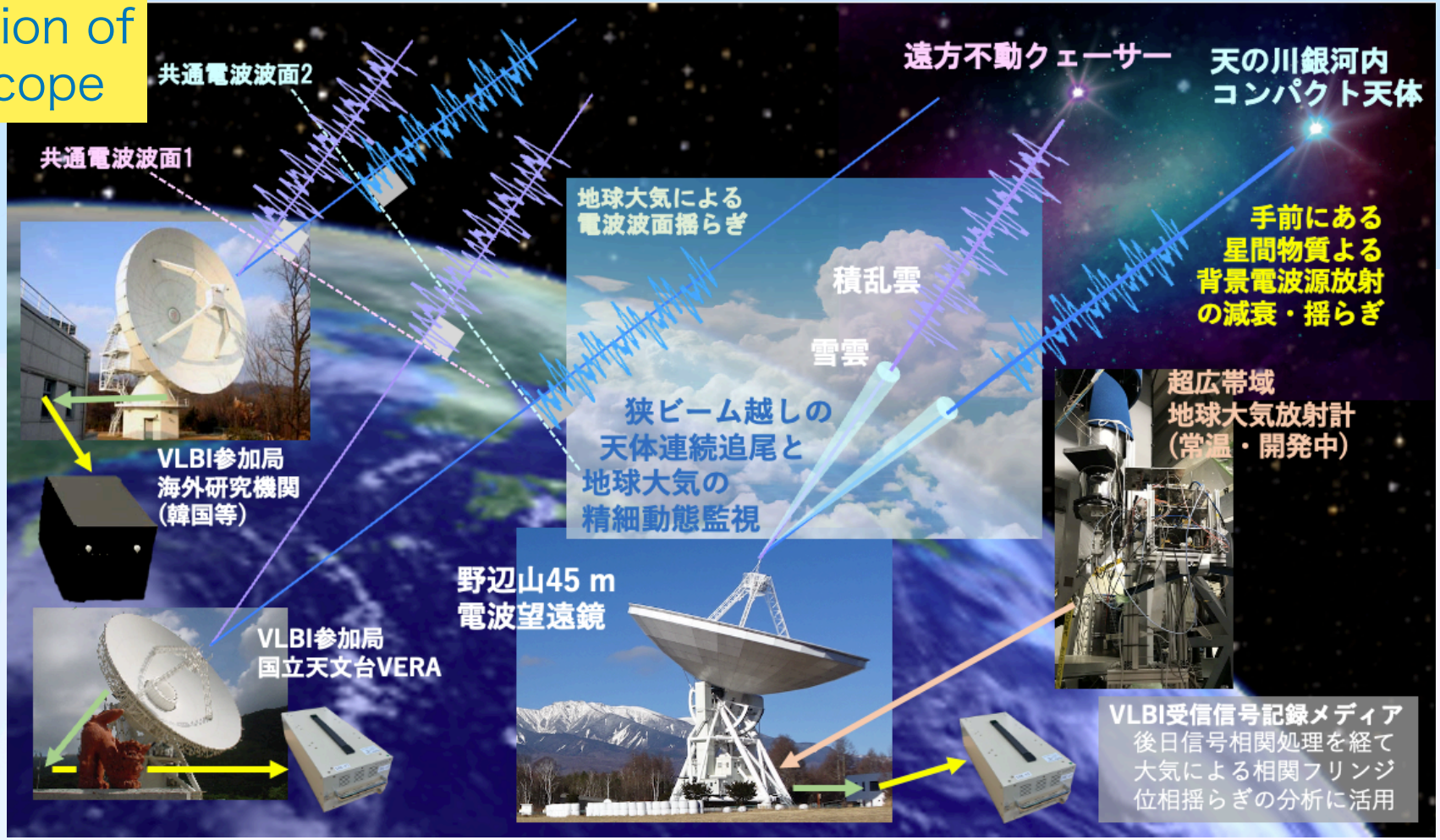
KAKENHI A
project proposal
(FY2027—2030)
for cooled receiver

Proposal background

- Ultra-wide band, single-pixel receiving system for next generation of NRO 45 m telescope

令和8年度科研費申請調書より

18—190 GHz
(18—58,
70—116,
120—190)
~~**(up to 230 GHz in future)**~~



Proposal background

- Microscopic structure in Earth's troposphere and interstellar medium

in Earth's troposphere and interstellar medium exhibiting rapid and random variation

- Astrophysical masers
- Interstellar tiny-scale molecular structure (~1 au)
- Water vapor clumps on Earth (< 1 km)
- Blackholes and jets
- Basic data for ultra-precise optical/IR photometry

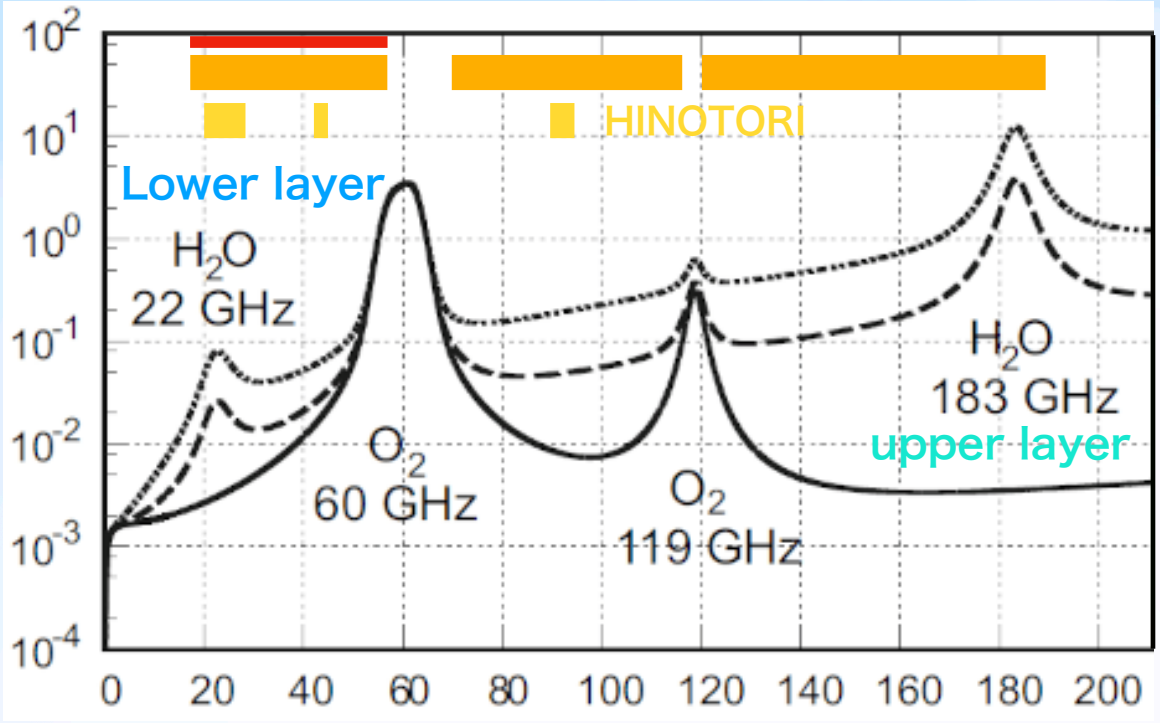
令和8年度科研費申請調書より



Wide-band atmospheric spectrum monitored for astrometry and astrophysics

- Precipitable water vapor (PWV) causes **excess path delay**
  (goal for astrometry: $\sigma_{\mathrm{EPL}}(Z, \Delta Z) < 0.5$ mm)
- PWV, liquid water, and oxygen atmosphere causes attenuation
  (goal for optical/IR photometry $\sigma_{\mathrm{photo}} < 1$ mmag : $\sigma_{\mathrm{PWV}}(Z) < 0.3$ mm)

令和9年度科研費申請
(基盤A)

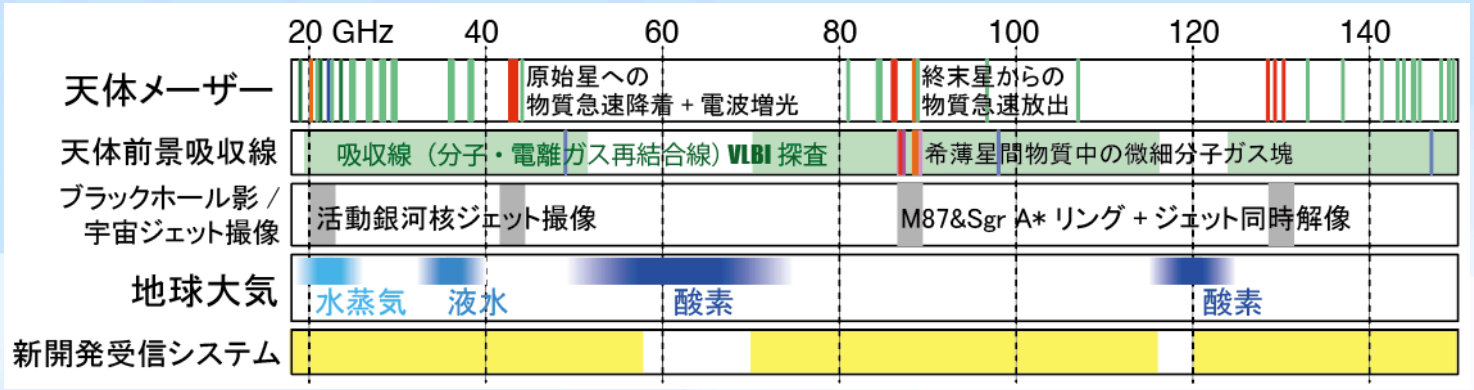


Planned receiver's frequency coverage

Masunaga 2022 (edited)

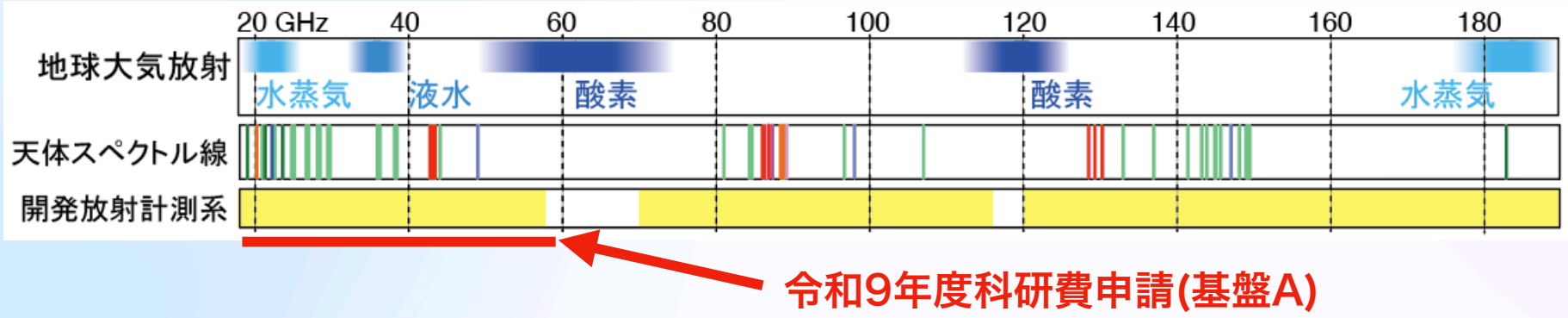
Frequency coverage and science cases

- Exploring time-domain radio astronomy on sub-daily to daily scale
- Simultaneous monitoring of interstellar medium and Earth's troposphere for data calibration in source brightness/amplitudes and VLBI fringe phases



令和7年度科研費申請調書より
（基盤A課題として）

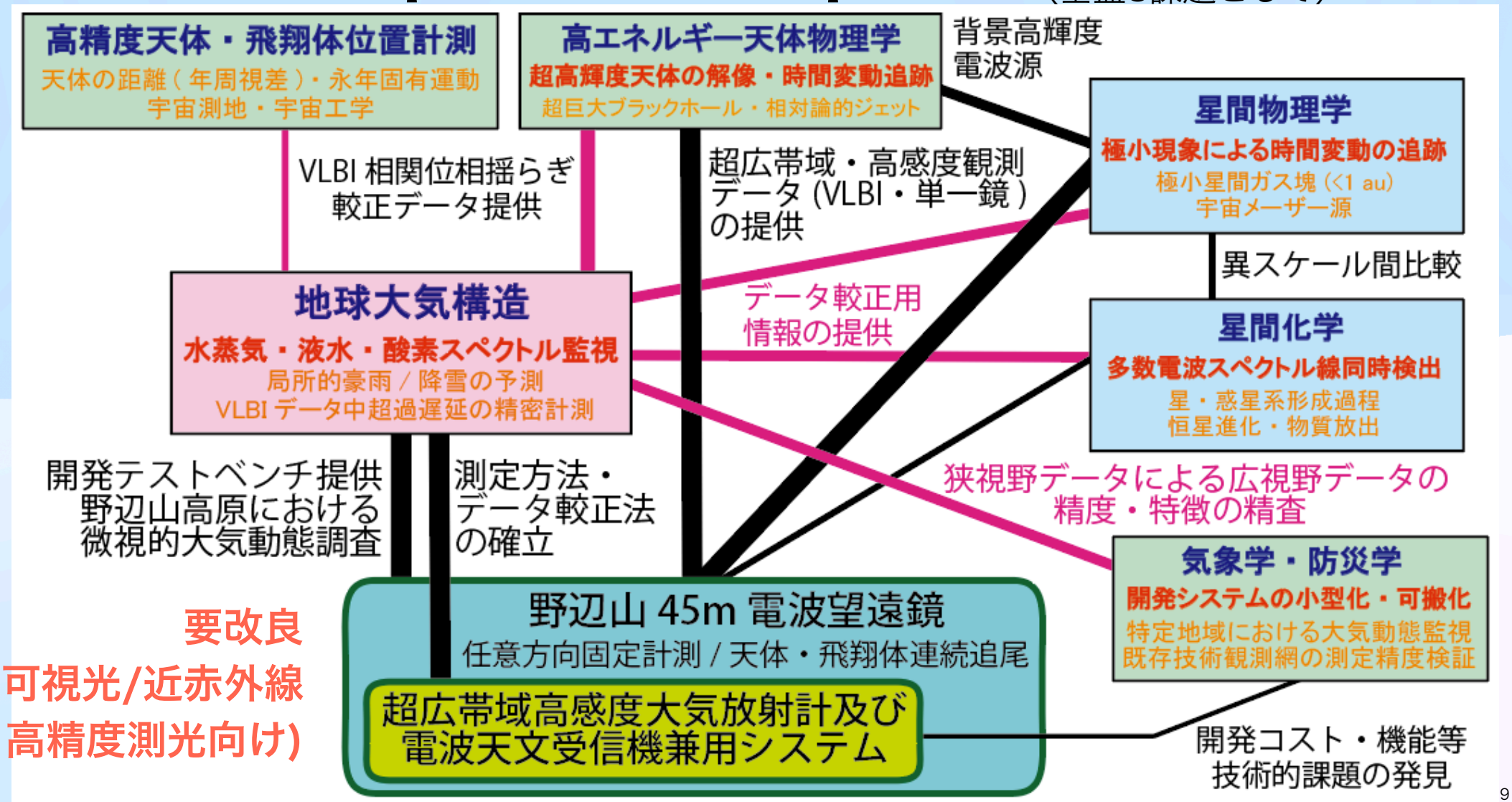
令和8年度科研費申請調書より
（基盤S課題として）

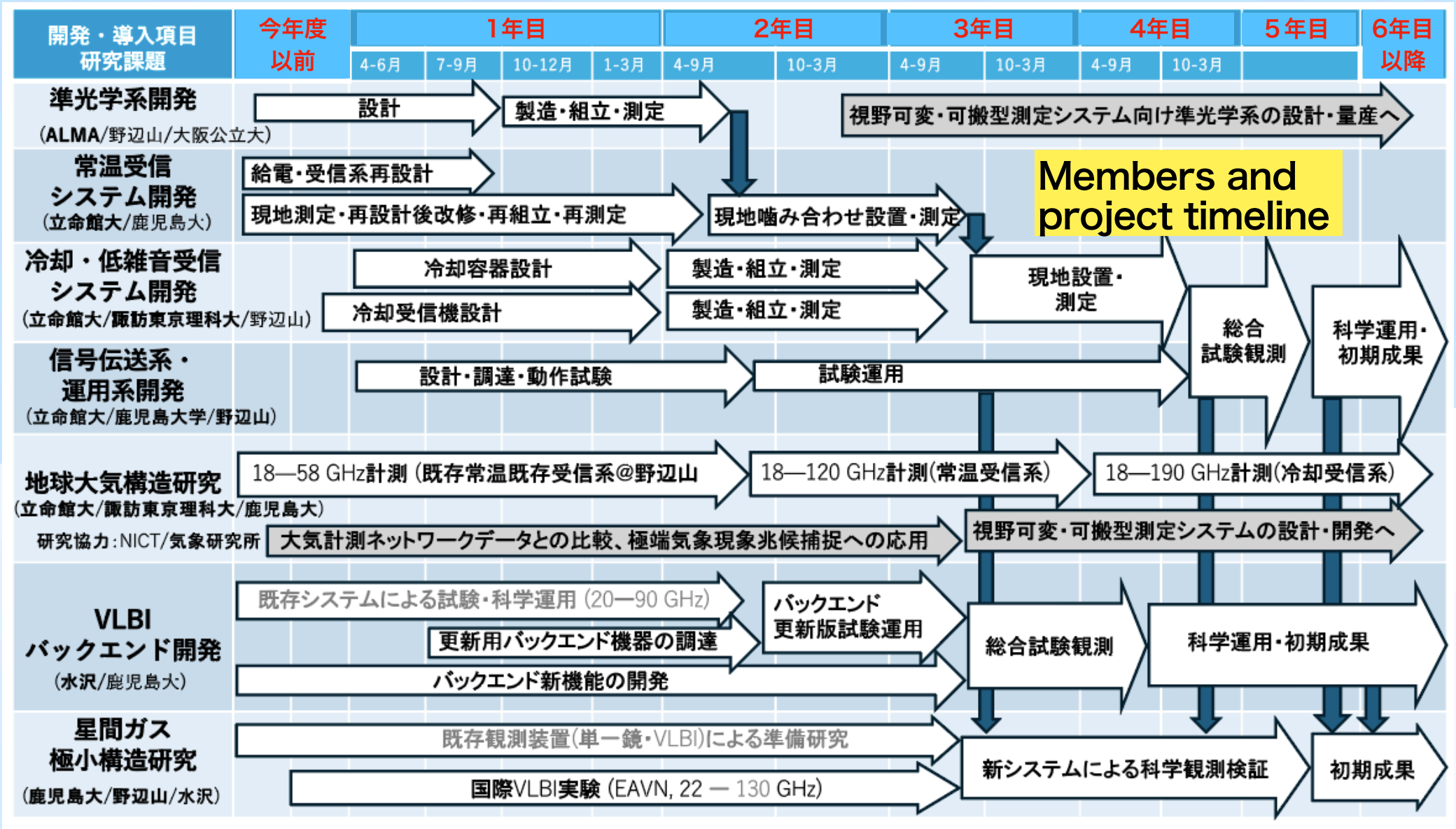


令和9年度科研費申請(基盤A)

Trans-discipline concept

令和8年度科研費申請調書より
（基盤S課題として）





令和8年度科研費申請調書より（基盤S課題として）改編

Members in KAKENHI proposal
FY2027—2030, A-project

- IMAI Hiroshi
  (PI, Kagoshima Univ.)
- UJIHARA Hideki
  (Ritsumeikan Univ.)
- YAMADA Takayoshi (NICT)
- ARAKI Kentaro
  (Japan Meteorological Agency)

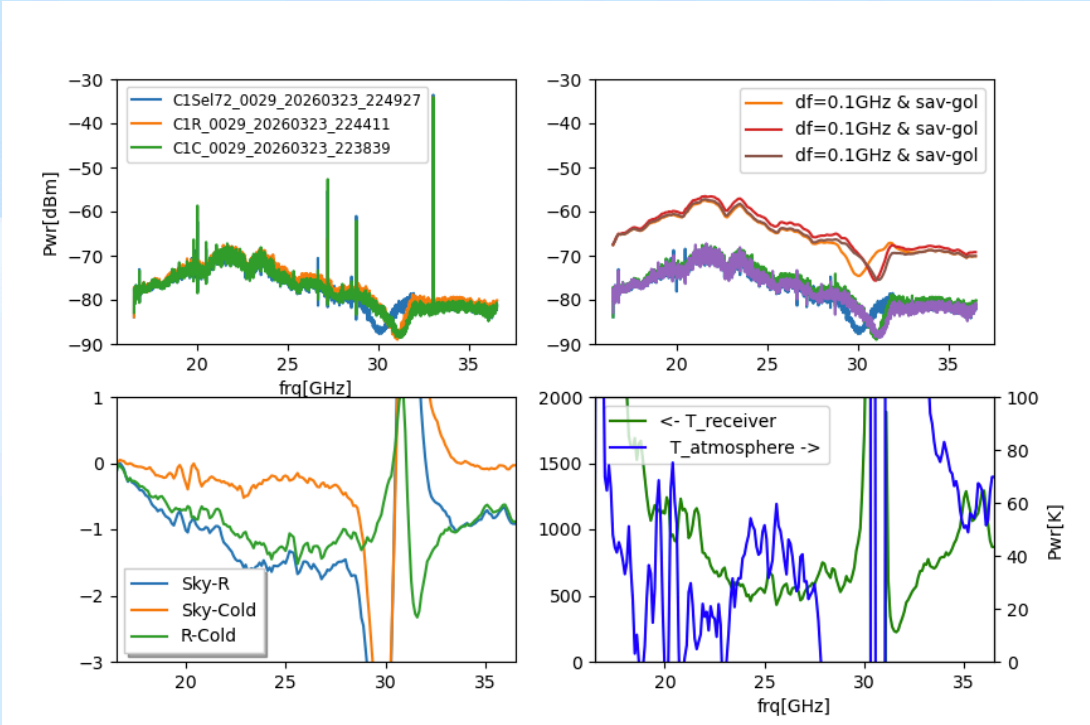
Collaborators

- NISHIMURA Atsushi (NAOJ/NRO)
- OYAMA Tomoaki (NAOJ/Mizusawa)
- NAKAJIMA Taku
  (Suwa Tokyo Univ. Science)
- ISHIKAWA Ryuichi (NICT)
- YAMASAKI Yasumasa
  (NAOJ/ALMA)
- OGAWA Hideo
  (Osaka Metropolitan Univ.)

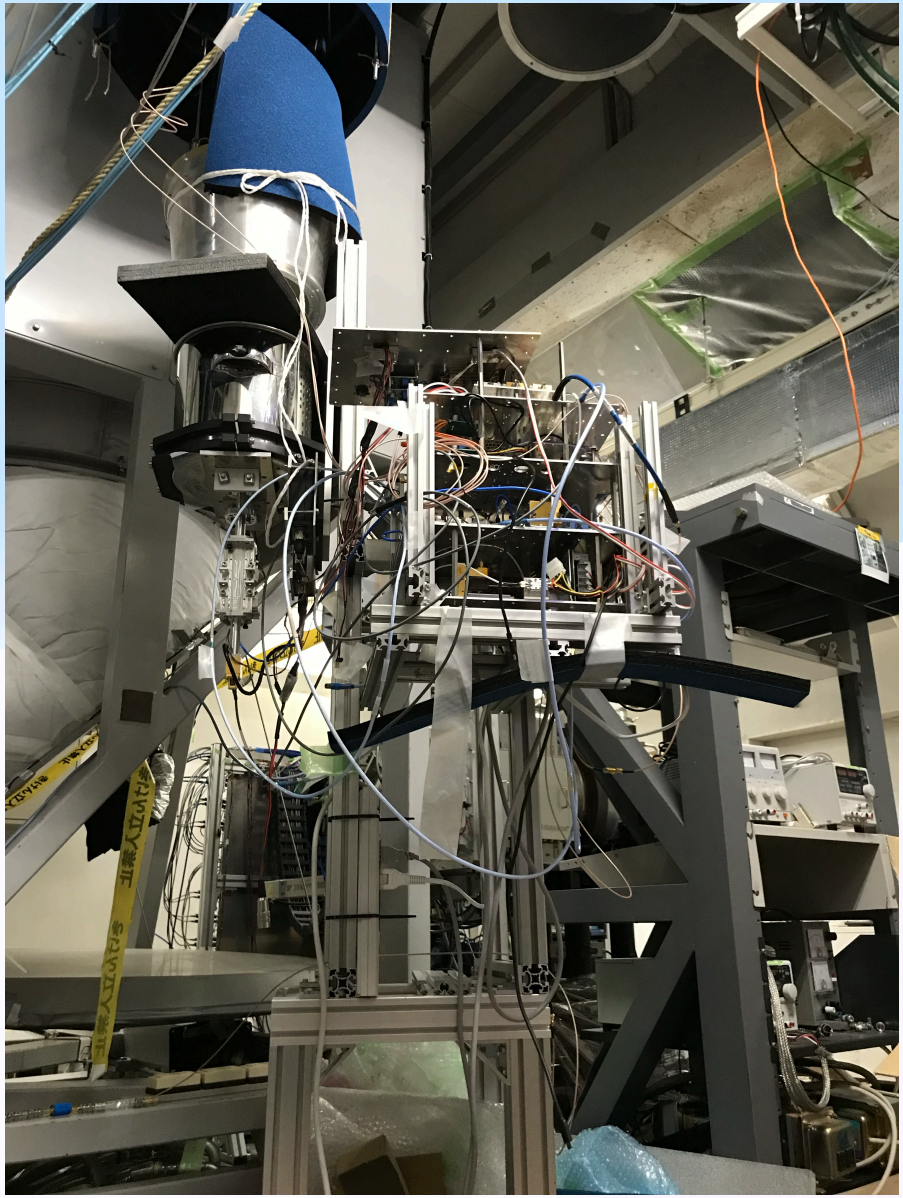
- KAWAKAMI Kaito (Kagoshima Univ.)
- NAKASHIMA Keisuke
  (Kagoshima Univ.)

Current preparations

16—58 GHz receiving system
as a water vapor radiometer
(operated in a room temperature)
(NeCoDeS by H. Ujihara)

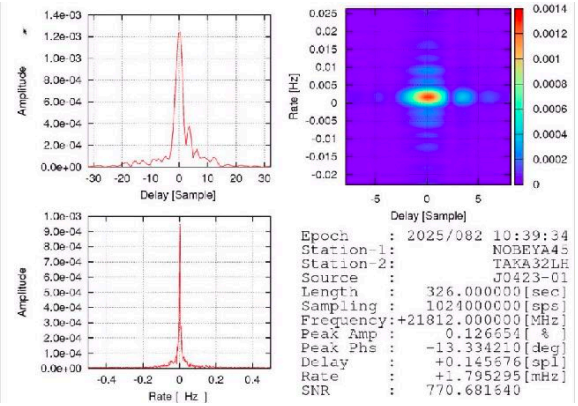


See Ujihara-san's poster

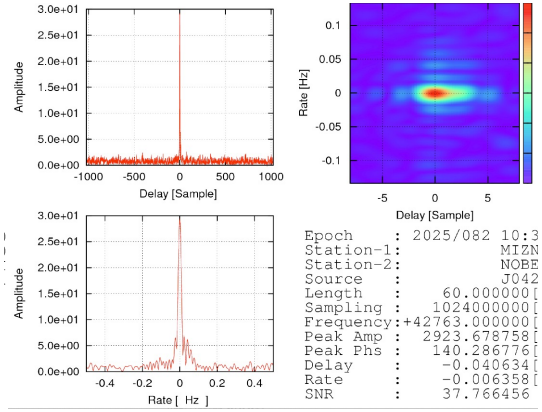


2026年度NeCoDeS侵攻計画(氏原@立命館大+今井@鹿児島大)

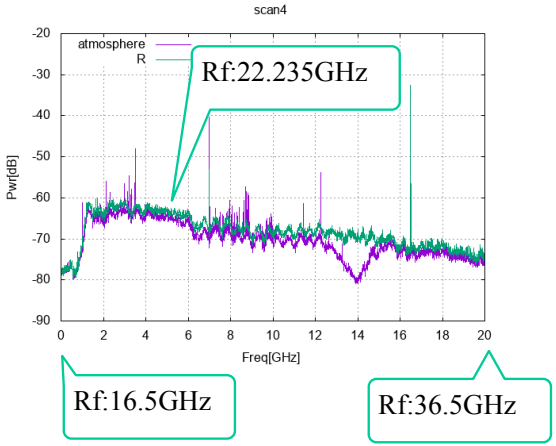
前回実験(2025/3/23)ではK/Q同時のVLBI観測ともにフリンジが得られ、同時に大気観測もできた



野辺山-高萩(K:R25082A-scan3 (J0423-01))



野辺山-水沢(Q:R25082A-scan3 (J0423-01))



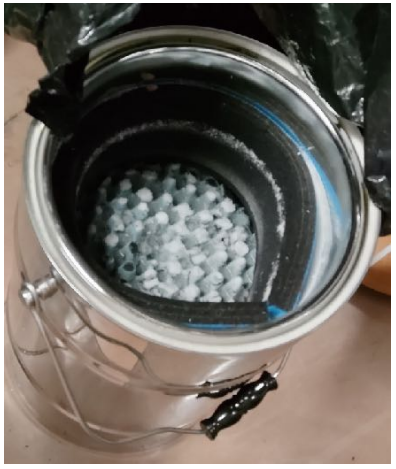
2025年度実験(2026/3/23)ではQのフリンジは出なかったが、下記の改良をおこなった

- 初段LNAを常温アンプに変更して、回路を単純化
- 受信帯域の分割が不要になったので、OMTをダブルリッジ導波管に変更して損失を低減
- スケジュールを修正して大気観測と受信機の較正頻度を向上
- データ処理ソフトをPythonに移行して機能向上(周波数分解能の事後変更機能、平滑化など)
- ローカル信号の漏れ込みやRFIなど「鋭い」雑音をソフトで除去

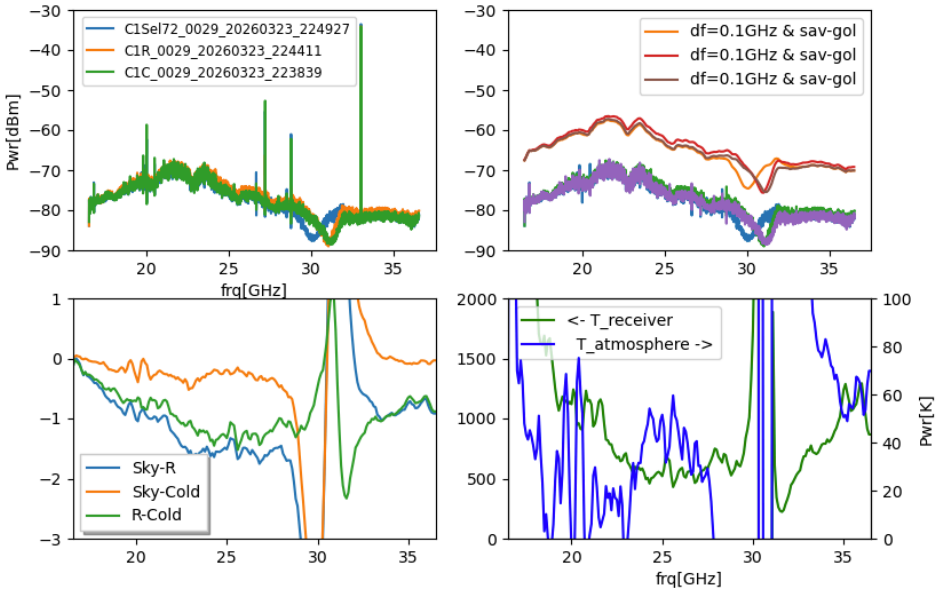
今年度予定

- フィードの改良による感度向上(できればOMTも改良して2偏波化)
- Coldポートの性能検証(実際の温度は77 Kより暖かく、周波数で異なっている印象)
- ソフトウエアの機能向上(現場処理、時間変動の算出、スペアナ入力切り替え用I/OやGUIの実装など)
- 甲南大から借りたスペアナの修理(たぶんbios電池切れ)とリモート制御化
- 受信機を野辺山用と移動局に分離して(瀬戸内海が見える)甲南大屋上でも実験したい
- 挑戦的(萌芽)が採択されたので広帯域スペアナやRFSoC 4x2を購入予定

観測アイデア実現基金エントリー#5



液体窒素を充填されたColdポート中の電波吸収体
実際は冷えてないとこも見えてるのかも…



試作したデータ処理ソフトの試験画面

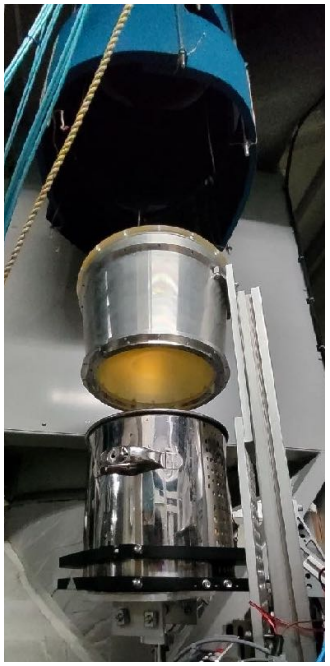
RFI除去

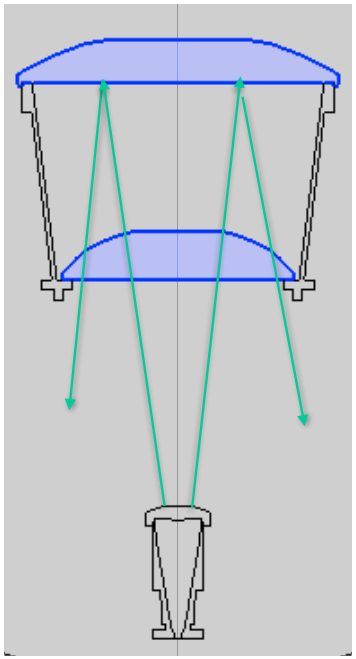
・できるだけ細かい周波数分解能でデータをとっておく
・Savitzky-Golay filterで極端な外れ値を検出、近傍値で置換
・適当な周波数幅で切り直し(~0.1GHz?)

大気放射の計算

・適当なウインドウ幅のSavitzky-Golay filterで再度平滑化
・Hot/Coldの雑音温度からシステム雑音や大気放射を計算

特にColdの誤差は受信機や大気の雑音温度に大きく響く
→特に23GHz以下がおかしいので、秋以降に調査予定





RFI対策で貼りまくった吸収体をサイドローブでひっかけるとColdポートの電波吸収体の温度が高く見えるのでは？
→フィード直近で比較してみたい

レンズの反射による「迷光」も誤差要因
→やはり野辺山45m専用フィードが必要

NICTで内製できるかどうかは不透明

Other related development items

- Wide-band receivers using new wide-band OMT and LNA
- Quasi-optics such as band separation filters for ultra-wide bands
- Wide-band spectrometer using RFSoC
- Linear to circular polarization conversion in A/D sampler (OCTAD) for VLBI
- Extracting precipitable water vapor (PWV) content and corresponding excess pass delay length from spectra of water vapor radiometer for astrometric calibration