

# SKAMPI

## The SKA-mid MPIfR Demonstrator Dish

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Max-Planck-Institut  
für Radioastronomie

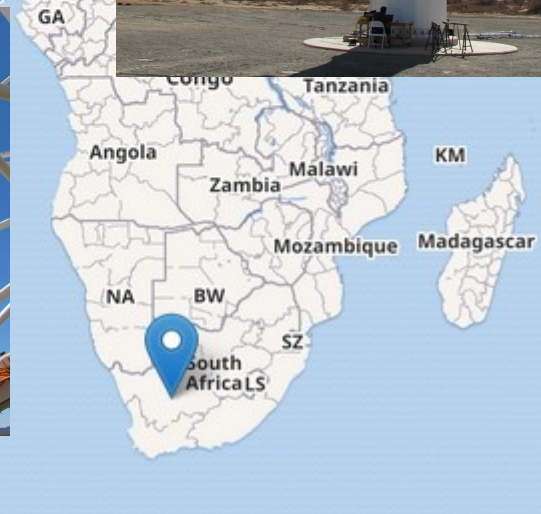
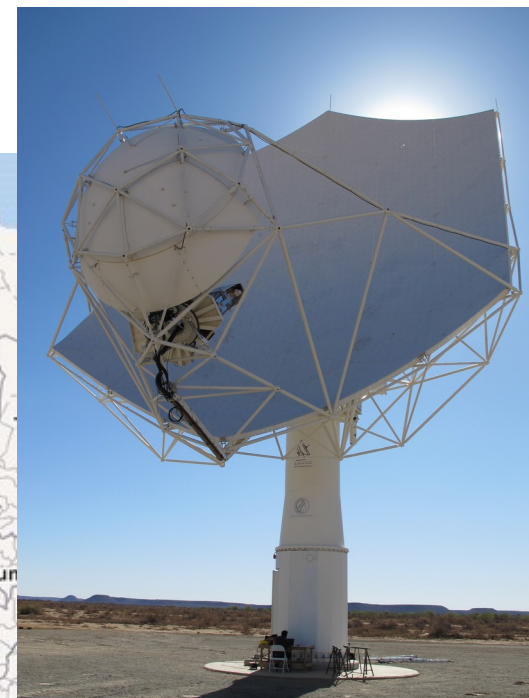


**SARAO**  
South African Radio  
Astronomy Observatory

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# SKA-MPI Dish

- 15 m x 18m telescope  
~ 15m illuminated dish
- Constructed by MPIfR and OHB in 2020
- Operated by MPIfR and SARAO
- Prototype for MeerKAT+ / SKA – MID
- Located at SKA Site in South Africa
- MPIfR EDD receivers
  - S-band, 1.75 - 3.5 GHz  
(1.75 GHz bandwidth)
  - Ku-band, 12 – 17 GHz  
(2 GHz bandwidth, tuneable)
- EDD backend



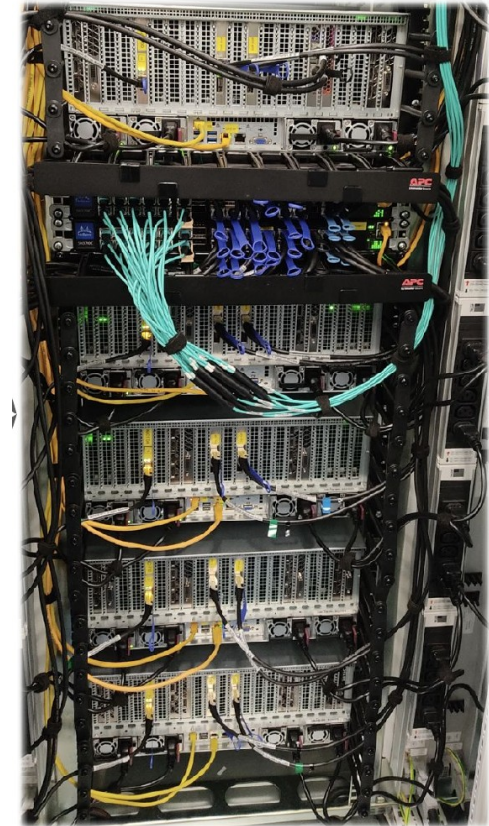
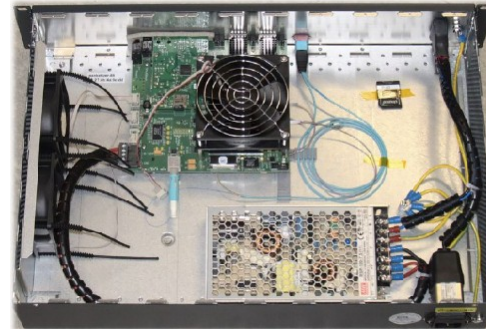
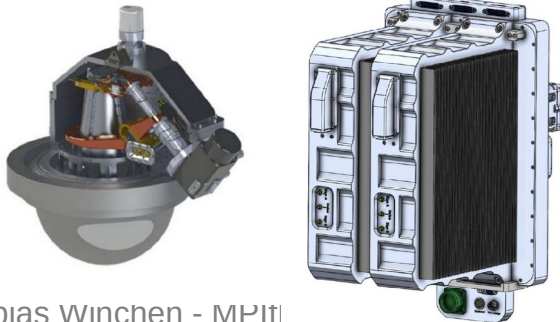
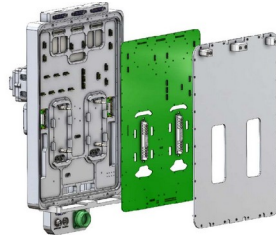
# Effelsberg Direct Digitization System (EDD)

- Modular framework for radio astronomy observing systems

- Receiver
- Analog signal conditioning
- Time distribution
- Digitization
- Packetization
- Backend

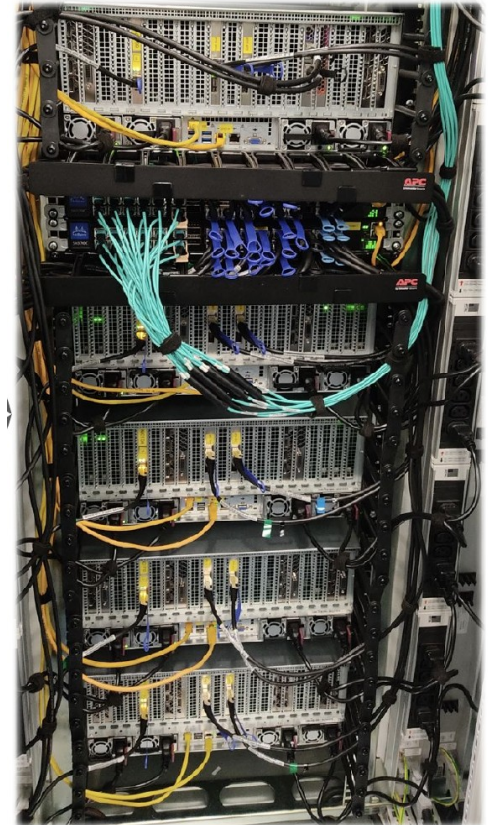
- Modularization and standardization

→ Maximize science / €



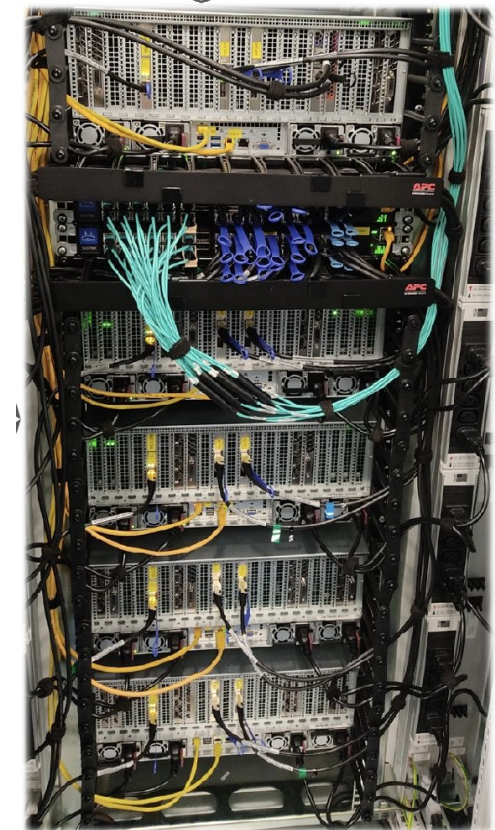
# The EDD Multi – Science Backend

- Commercial-Off-The-Shelf Computing Hardware
    - Number crunching on GPUs + PCIe Mounted FPGAs
    - Data transport via multicast on 100+ Gb Ethernet
  - Modular system designed to include new processing pipelines for new / rare science cases
  - Data processing components provisioned on per – observation basis in  $O(1 \text{ min})$
  - Industry standard open-source software
  - Monitoring / logging / alerting
  - Automated deployment
  - Configuration-as-Code
  - Versioned and reproduceable setups
- High level of provenance!



# EDD Backend Capabilities

- Spectroscopy / Spectropolarimetry:
  - Dual polarization FFT Spectrometer
    - » 2k - 32M Channels, up to 3 GHz Input Bandwidth,
    - » Gated: with high-speed noise diode switching [ $\sim$  kHz]
  - Full Stokes Spectrometer
    - » 4k - 8M Channels, up to 3 GHz Input Bandwidth
    - » Gated: with high-speed noise diode switching [ $\sim$  kHz]
  - Output to Alma Fits Writer + HDF5
- Channelizer
  - PFB on GPU
  - PFB on FPGA
- Pulsar pipelines
  - Pulsar timing
  - Pulsar search
  - Baseband recording
- VLBI mode (Under commissioning)
- Processing for PAFs and interferometer (under development)
- Outreach: Moonbounce
- ...



# Instruments Operating with the EDD

## Current Instruments



**Effelsberg**

4 EDD Receivers  
+ more to come  
+ 11 existing with analog tap

Processing Nodes: 72



**SKAMPI**

2 EDD Receivers

Processing Nodes: 4



**Thai National Radio Telescope**

2 EDD Receivers  
+1 Planned

Processing Nodes: 8

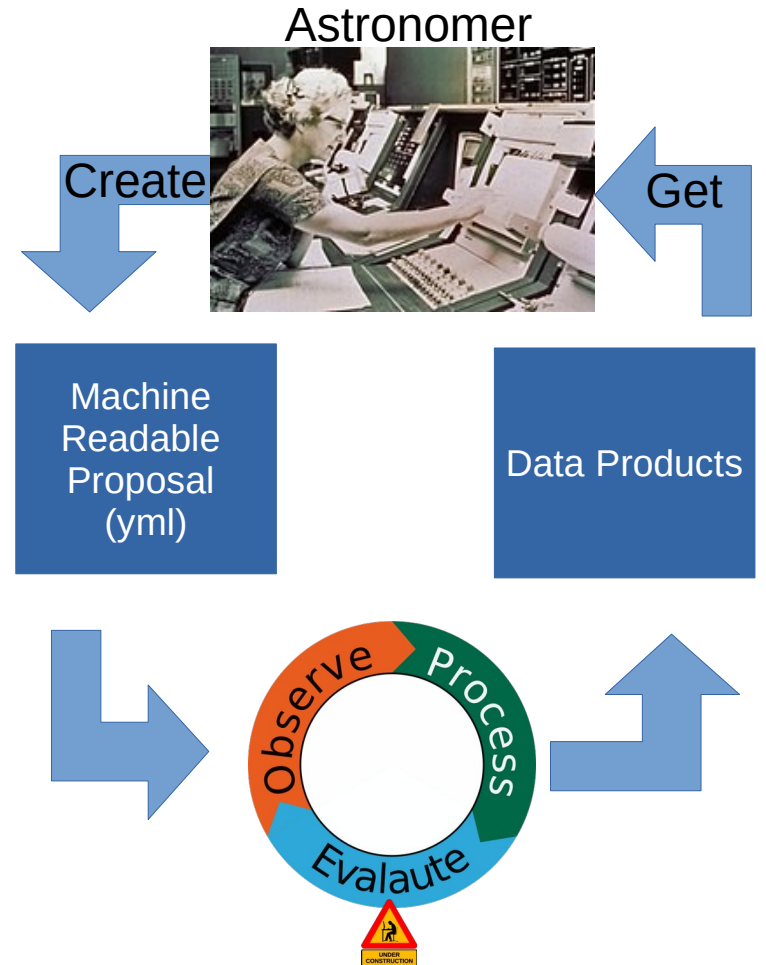
## Planned Instruments

**Botswana Telescope (BOSS)**  
SKAMPI Sibling  
2 EDD Receivers

**Argos**  
Interferometer  
Prototype 5 Antennas

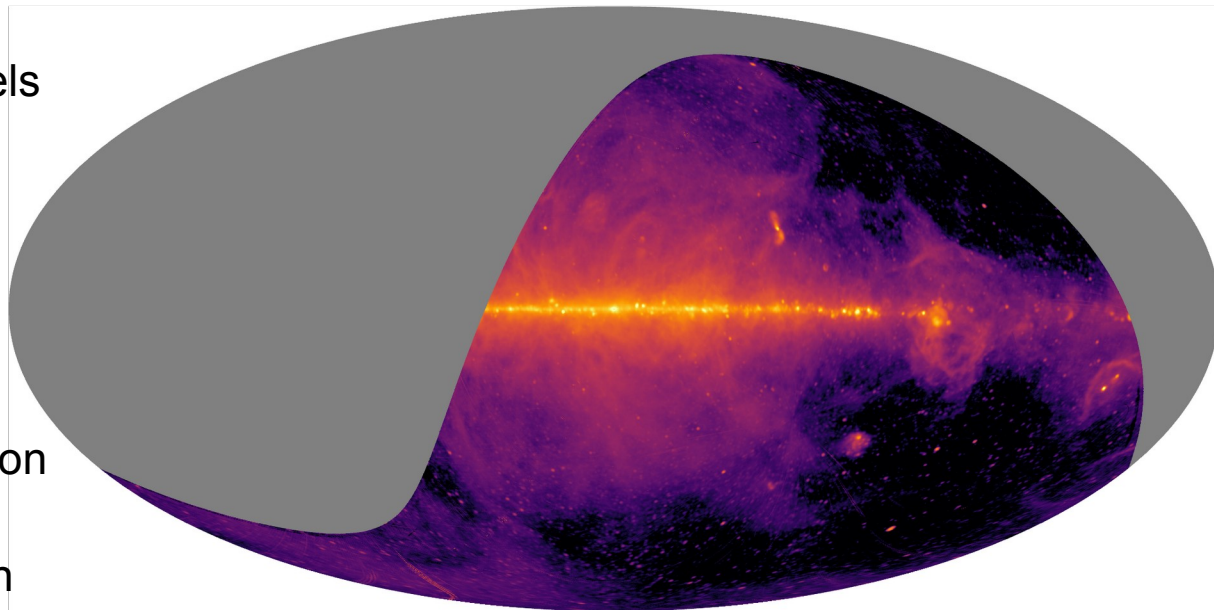
# SKAMPI: Highly Automated Observation System

- Telescope control system on top of the EDD backend
- Reuse backend computing resources for TCS + First stage offline processing
- Highly automated operations:
  - Observation bot software
    - » Schedules + executes proposed observations
    - » Considers weather and resource availability
    - » Commands all sub-systems (Telescope, backend, RXS)
  - Processing bot software
    - » Execute compute jobs after an observation
    - » Create high level data products
    - » Initial post processing and analysis
  - Transfer bot software
    - » To Bonn via LTO tape over airplane
    - » Mirrored long term archive in Bonn / Effelsberg
    - » Transferred to processing facilities (Jülich) via network
- 10 days of fully unsupervised operations, limited by external access to system
- Outlook: Robotic operations
  - Update of proposal pool / queue depending on evaluation of observations
    - » Data quality?
    - » Variable sources?



# Science @ SKAMPI: S-Band All Southern Sky Survey

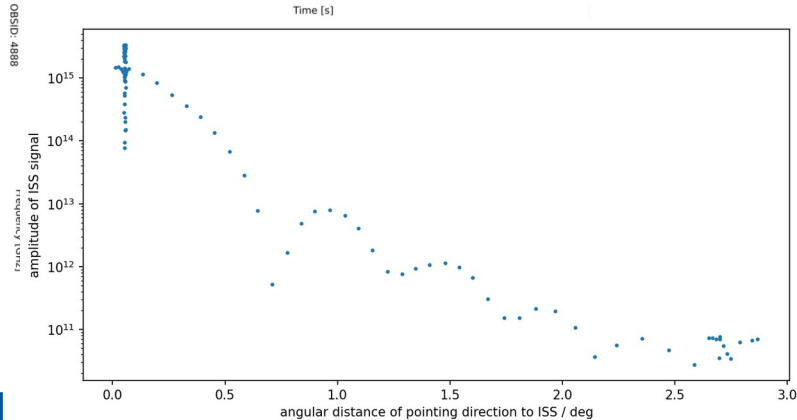
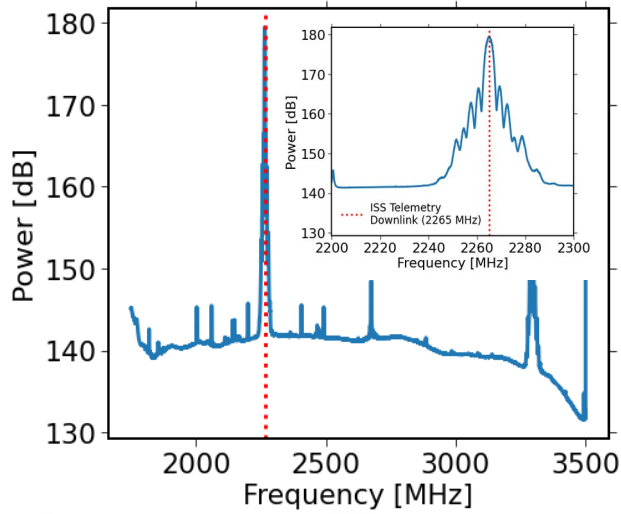
- Total intensity survey
  - Unprecedented bandwidth and resolution: 1.75 GHz, 64k channels
  - 2 x 1000 h completed, calibrated and cleaned from atmospheric emission
- Full Stokes survey
  - Ongoing
  - ~6000 h needed to reach confusion limit
  - Improved foreground subtraction for CMB maps



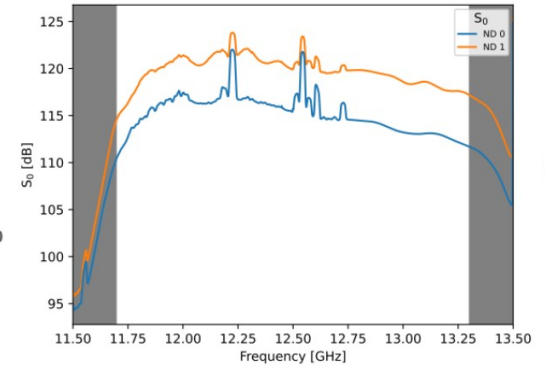
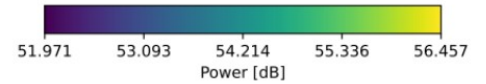
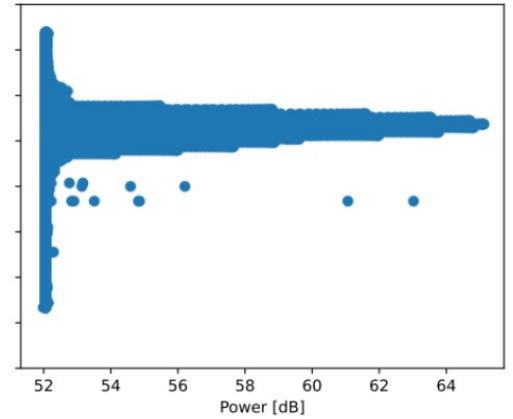
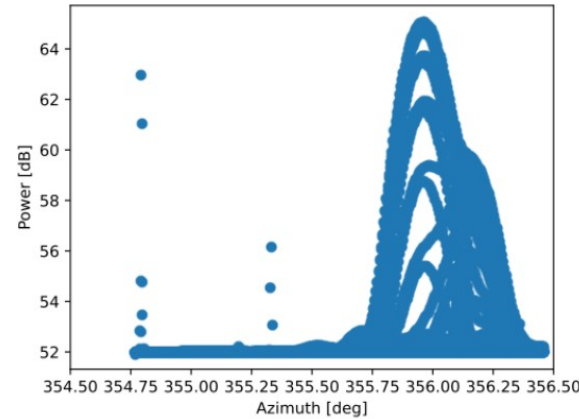
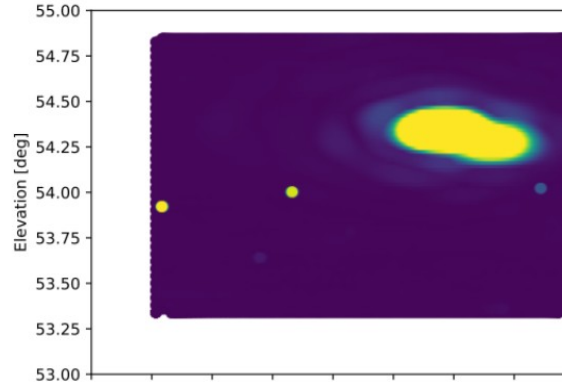


# RFI Monitoring and Satellite Tracking

## Track ISS

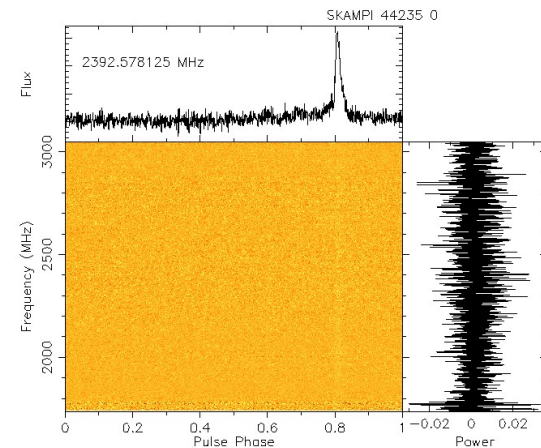
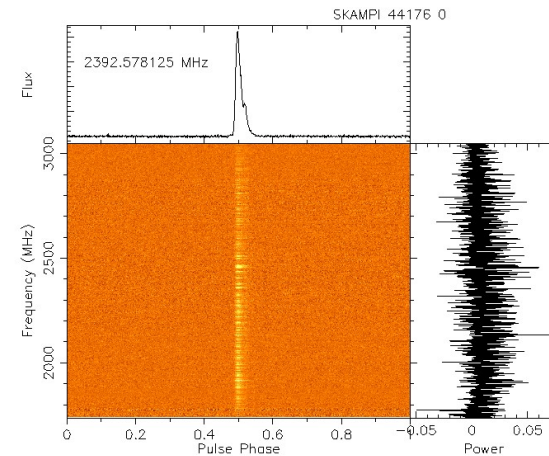
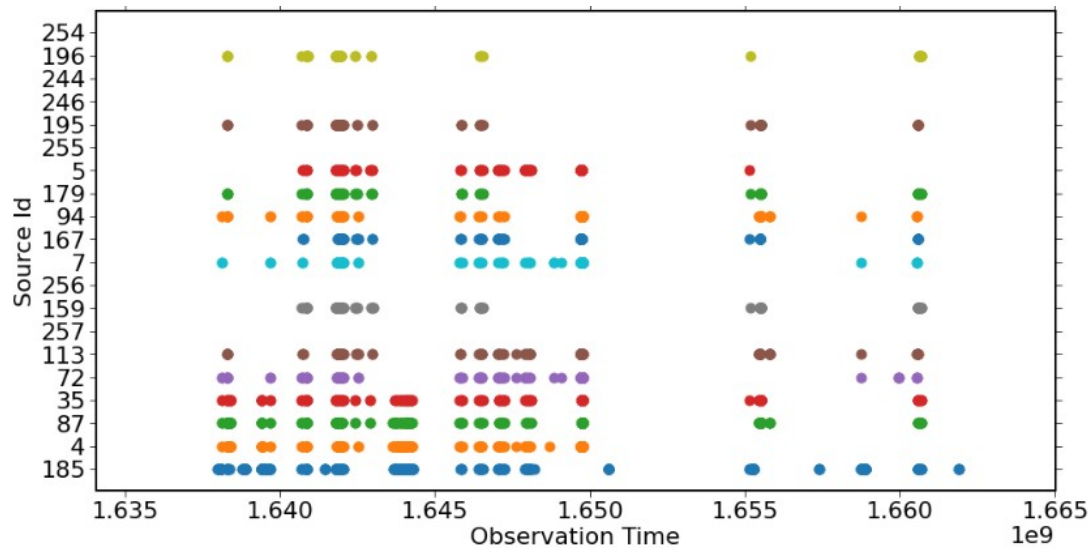


## Map Astra Satellite



# Science @ SKAMPI: Long Term Monitoring of Sources

- Periodically observe sources with high cadence (e.g. common calibrators, pulsars)
- Monitor for variability



# Science @ SKAMPI: VLBI

First Experiment March 2024

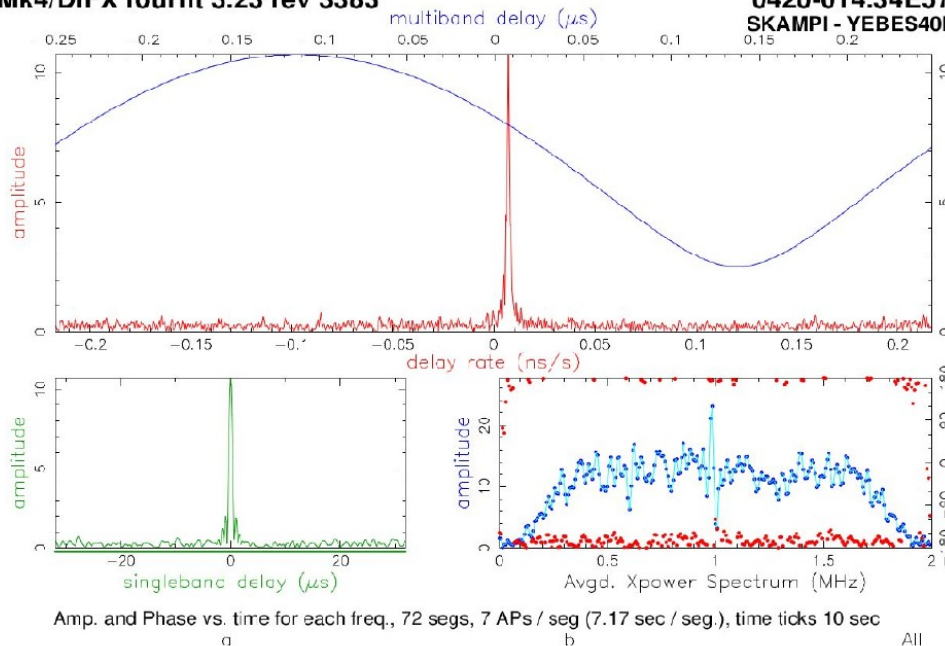
→ SKAMPI, Medicina, Yebes, Effelsberg

8800 km longest baseline

→ 2x 4 MHz @ 2.25 GHz

Mk4/DiFX fourfit 3.23 rev 3383

0420-014.34E57V, No0014, SY  
SKAMPI - YEBES40M, fgroup S, pol LL

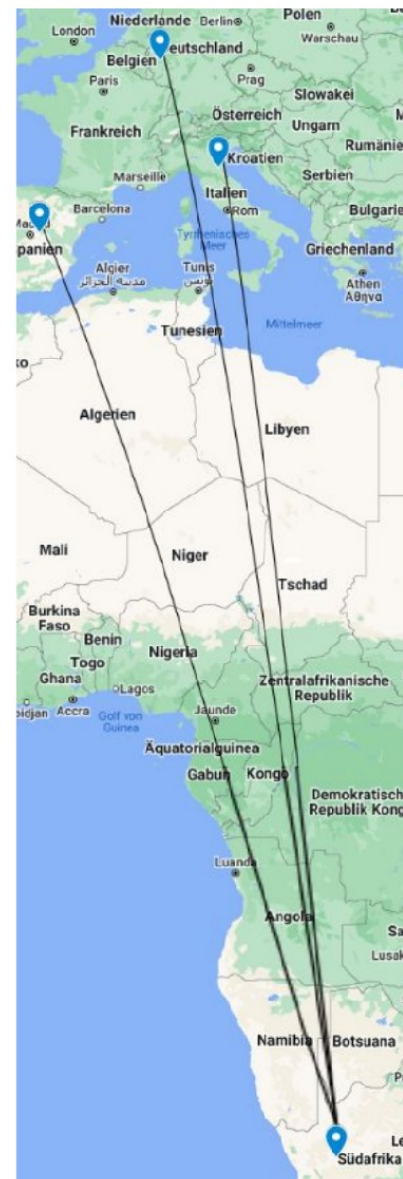


Fringe quality 7

SNR 58.4  
Int time 509.953  
Amp 10.712  
Phase -122.2  
PFD 0.0e+00  
Delays (us)  
SBD 0.016096  
MBD -0.112091  
Fringe rate (Hz)  
0.016283  
Ion TEC 0.000  
Ref freq (MHz)  
2247.0000  
AP (sec) 1.024

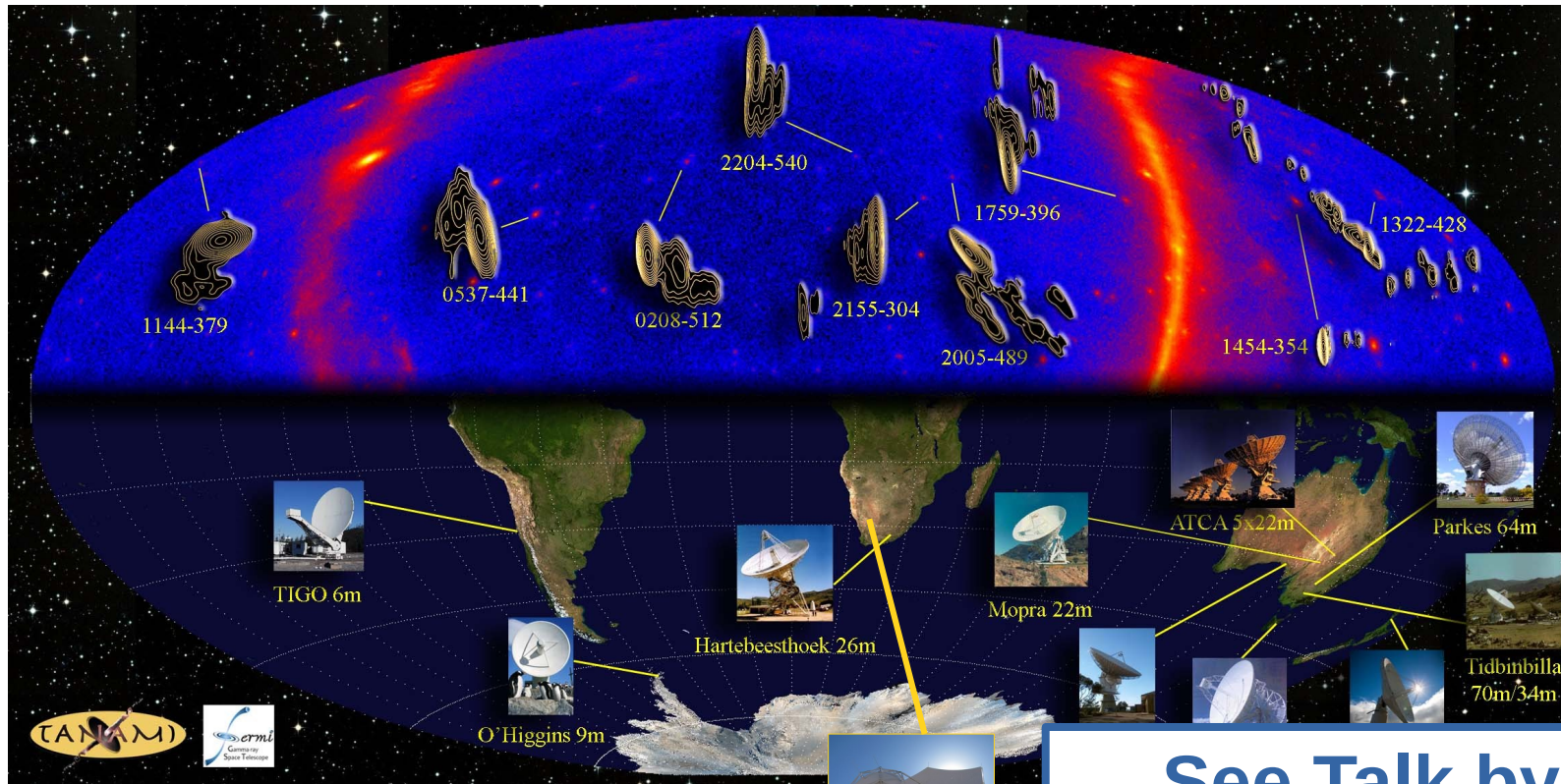
Exp. te019  
Exper # 1234  
Yr:day 2024:050  
Start 161500.00  
Stop 162330.98  
FRT 161945.00  
Corr/FF/build  
2024:051:134718  
2024:051:134727  
2023:348:201045  
RA & Dec (J2000)  
04h23m15.800724s  
-1°20'33.065613"

Amp. and Phase vs. time for each freq., 72 segs, 7 APs / seg (7.17 sec / seg.), time ticks 10 sec



# Science @ SKAMPI: VLBI - Participation in TANAMI

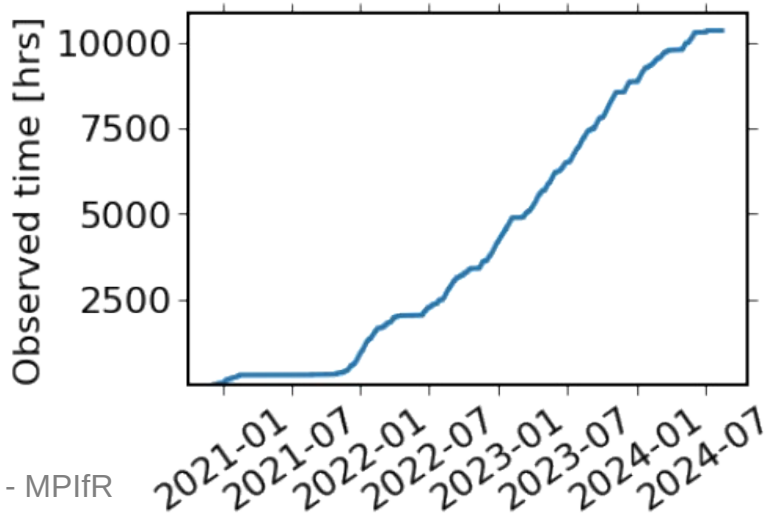
TANAMI - Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry



→ See Talk by Jompoj Wongphechauxsorn

# Conclusion

- SKAMPI: SKA MID prototype supporting independent science program
- Modular multi science backend on COTS hardware
- Robotic observation system
  - 10 Days of unsupervised observations (limited by engineering tests for SKA)
  - 10000+ hrs of observation



# Acknowledgement

SKAMPI, the SKA-MPG prototype telescope, is a facility of the Max-Planck Society (MPG) and was established with the assistance of the South African Radio Observatory (SARAO). It is jointly operated and maintained by the Max Planck Institute for Radio Astronomy (MPIfR) and SARAO. This research was made possible with the support of the MPIfR and SARAO.

# BACKUP

# Machine Readable Proposal Format

```
project:  
  title: POLARIMETRIC_SBAND_SURVEY  
  Description: >  
  [...]
```

Meta data

```
templates:  
  calibration: &calibration  
  description: X-scan on one of a list of calibrators that is up  
  select:  
    number: 1  
    choices:  
      - catalogue:  
        - file: calibrators.lst  
      scans:  
        - scan_type: cross_scan  
          tags:  
            - POINTING  
            - CALIBRATION  
          scan_type: nod_scan
```

Use yaml features to avoid repetition

```
proposed_observations:  
  - band: SBAND  
    mode: DUALPOL_STOKES  
    description: Azimuth sweep bounded by calibrator scans  
    block:  
      - *calibration  
      - scans:  
        - scan_type: azimuth_sweep  
      - *calibration
```

What the telescope should do