https://linktr.ee/cosmicpudding

CSIRO

The quest for an autonomous ASKAP

Automating the next-generation of survey telescopes

Vanessa Moss

Head of ASKAP Science Operations

IMAGE CREDIT: A. CHERNEY

#TFOM

Wallumedegal

Dharug

Noongar

Acknowledgement of country

Ngambri

Ngunnawal

Wajarri

Overview of this talk

- **Introduction:** ASKAP and its location at MRO
- **ASKAP Surveys:** From EMU to FLASH to RACS
- **Context of ASKAP:** History and future of ATNF
- **Automating ASKAP:** Towards autonomy in ASKAP operations
  - **Coordination:** working cross-country to run ASKAP
  - **Specification:** designing ASKAP to be autonomous
  - **Initialisation:** the role of automation in setting up ASKAP
  - **Diagnosis:** identifying issues in a complex system
  - **Monitoring:** from data mining to collaborative intelligence
  - **Processing:** turning terabytes of visibilities into science
- **Summary:** The path to the future of ASKAP

Part I: Introduction

ASKAP and its location at MRO

Australian Square Kilometre Array Pathfinder
Murchison Shire, Australia

Australian Square Kilometre Array Pathfinder
Murchison Shire, Australia

Australian Square Kilometre Array Pathfinder

ASKAP

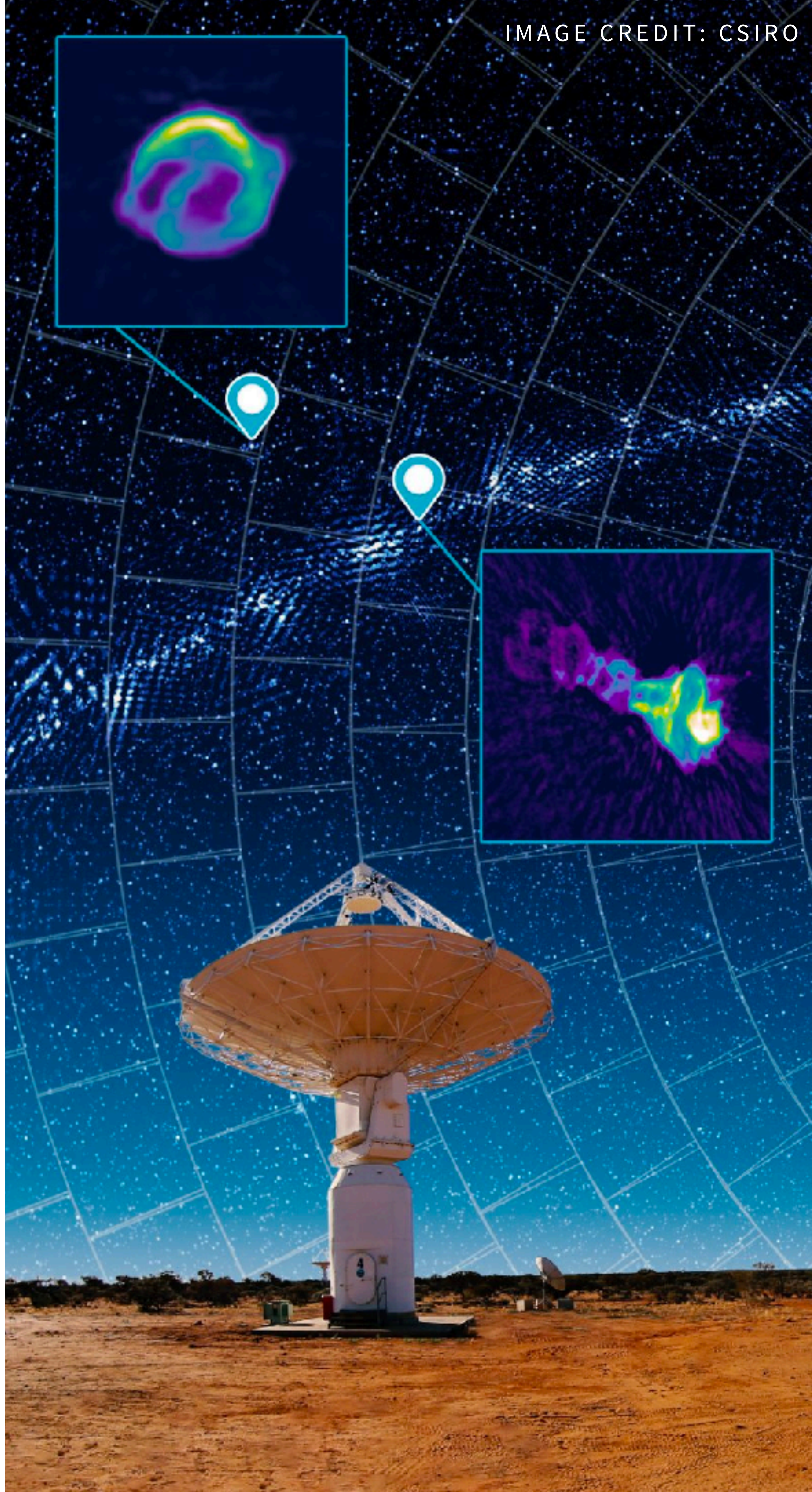
Table 1 Key parameters of the ASKAP telescope.

Number of antennas	36
Antenna diameter	12 m
Focal ratio f/D	0.5
Total collecting area	4071.5 m^2
Maximum baseline	6 km
Angular resolution	$10''$ at 1 GHz
Observing frequency	0.7 to 1.8 GHz
Processed bandwidth	288 MHz
Frequency channels	15 552
Frequency resolution	18.5 kHz to 0.58 kHz
Effective system temperature	75 K
Sensitivity	54 m^2/K
Dual-polarisation beams	36
Field of view[a] (800 MHz)	31 deg^2
Field of view[a] (1700 MHz)	15 deg^2
Survey speed[b] (800 MHz)	91 400 $m^4\,deg^2\,K^{-2}$
Survey speed[b] (1700 MHz)	44 200 $m^4\,deg^2\,K^{-2}$

See www.atnf.csiro.au/projects/askap for the latest updates!

Part II: ASKAP Surveys

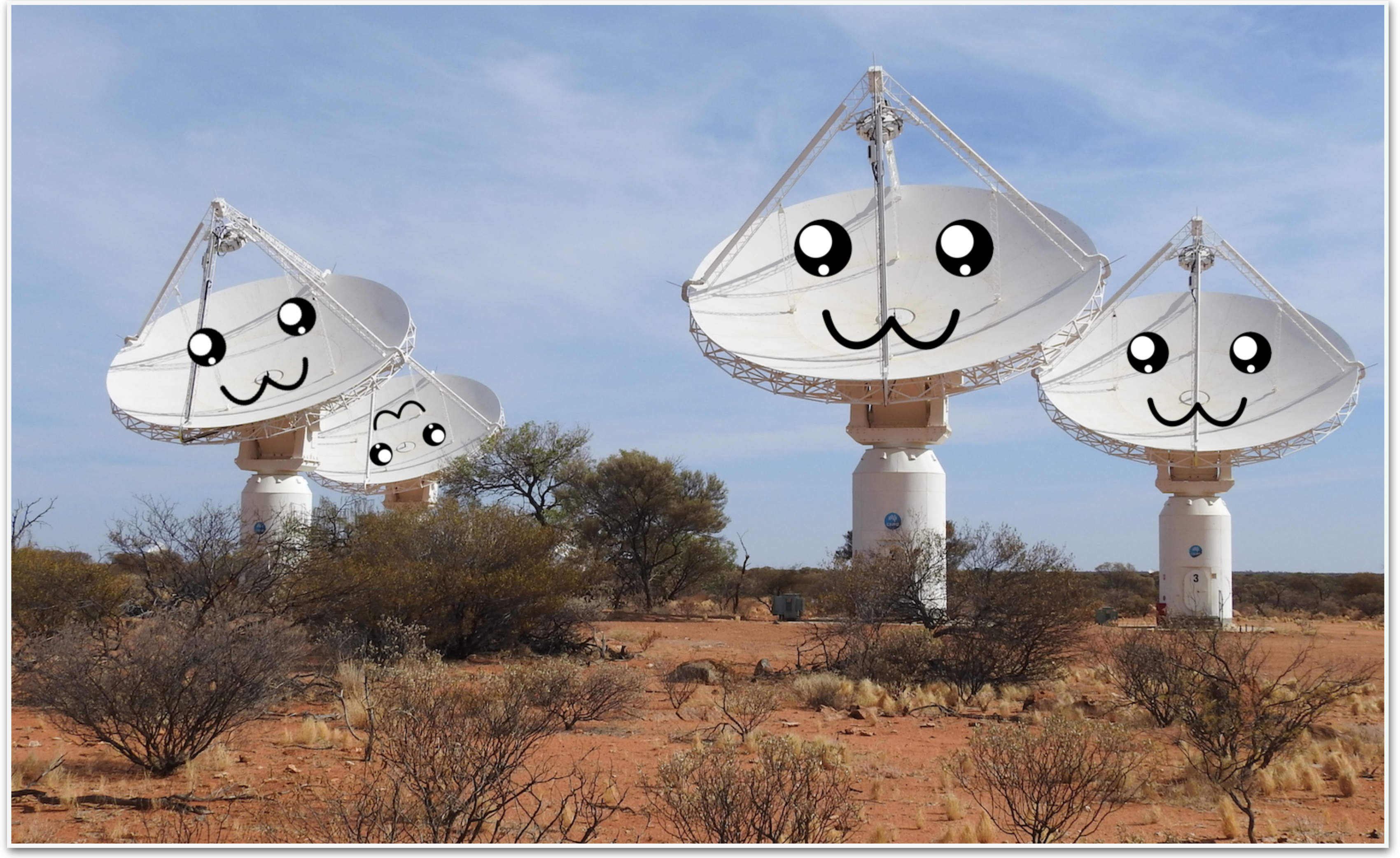
From EMU to FLASH to RACS



What are the ASKAP Surveys?

- ASKAP was conceived and designed to be a **rapid survey instrument** and will spend the majority of its time doing all-sky surveys
- Nine active **ASKAP Survey Science Projects**: EMU, WALLABY, POSSUM, DINGO, CRAFT, VAST, GASKAP-HI, GASKAP-OH and FLASH
- Two **Observatory Projects**: RACS and SWAG-X
- **Guest science time** will be capped to ~10% and become available over the next 1-2 years
- There is some limited capacity for **target-of-opportunity** observations, which are supported in collaboration with existing ASKAP SSTs

10%
guest science



What are the ASKAP Surveys?

CONTINUUM
ASKAP EMU Evolutionary Map of the Universe
Evolutionary Map of the Universe

TRANSIENTS
An ASKAP Survey for Variables and Slow Transients

HI ABSORPTION
First Large Absorption Survey in HI
The First Large Absorption Survey in HI

NEARBY HI
WALLABY
Widefield ASKAP L-Band Legacy All-Sky Blind Survey

FAINT HI
DINGO
Deep Investigations of Neutral Gas Origins (DINGO)

POLARISATION
POLARISATION SKY SURVEY OF THE UNIVERSE'S MAGNETISM
Polarization Sky Survey of the Universe's Magnetism

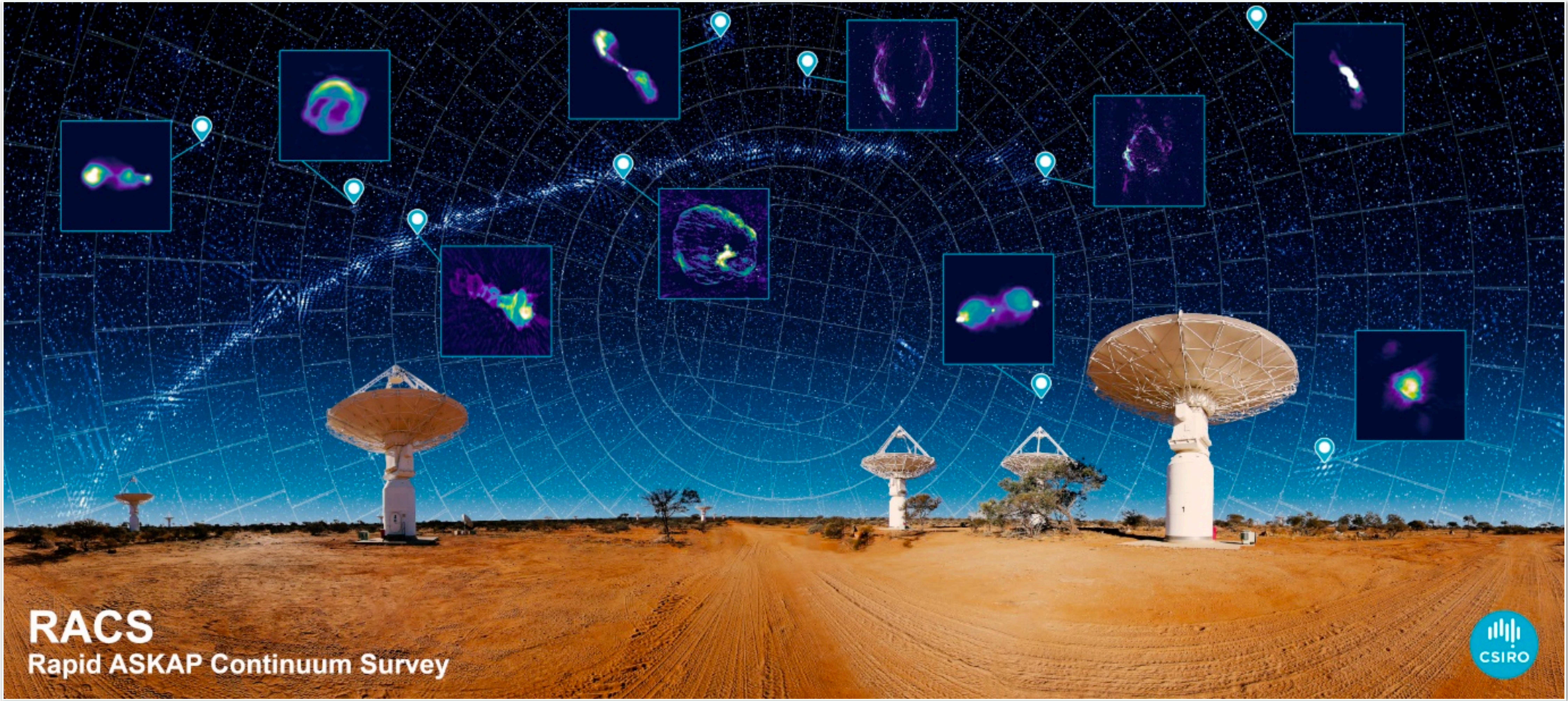
FASTER TRANSIENTS
Commensal Real-time ASKAP Fast Transients

10% guest science

TOOs

MILKY WAY
The Galactic ASKAP Spectral Line Survey

Rapid ASKAP Continuum Survey

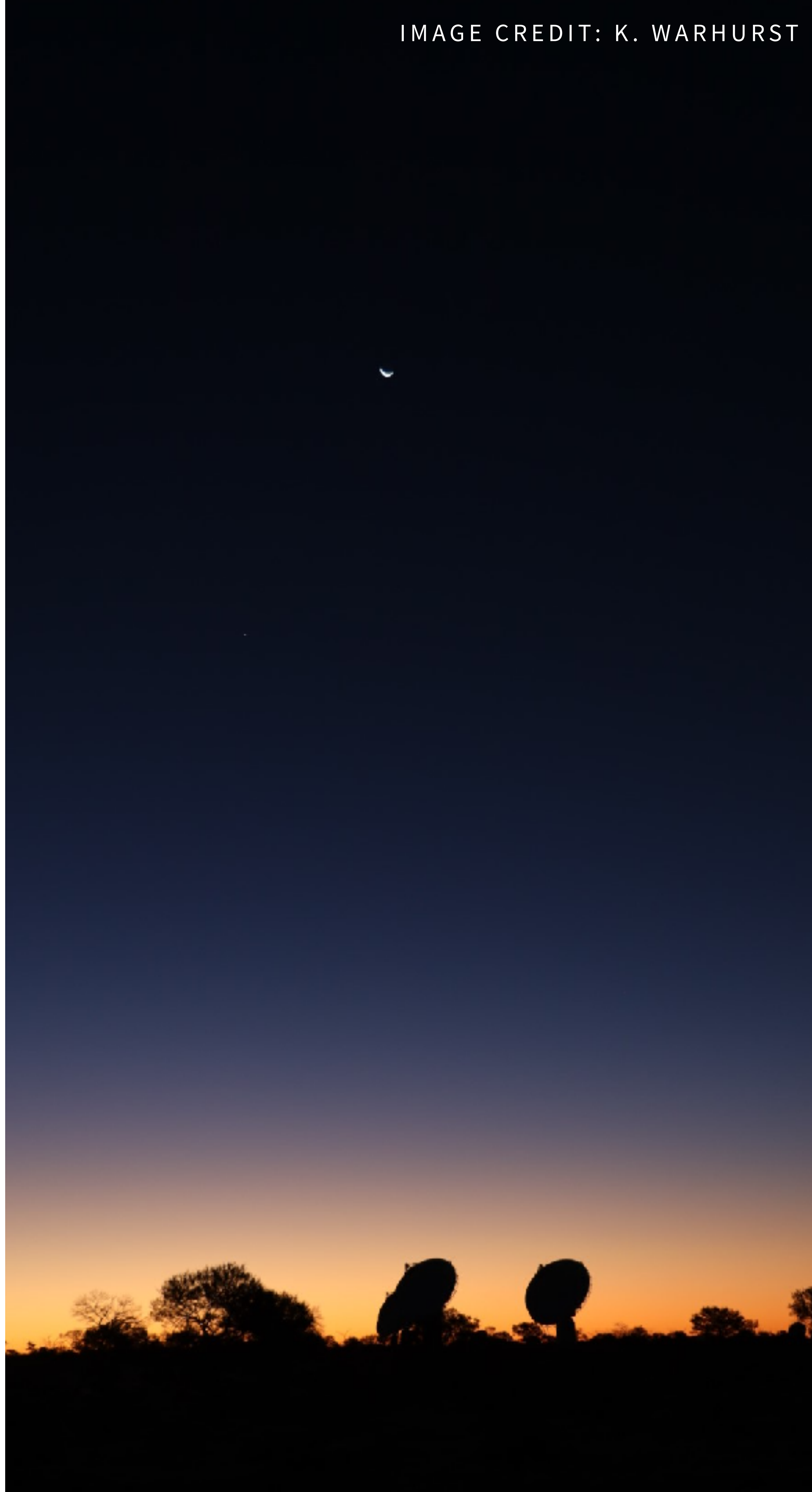


SEE: HTTPS://RESEARCH.CSIRO.AU/RACS

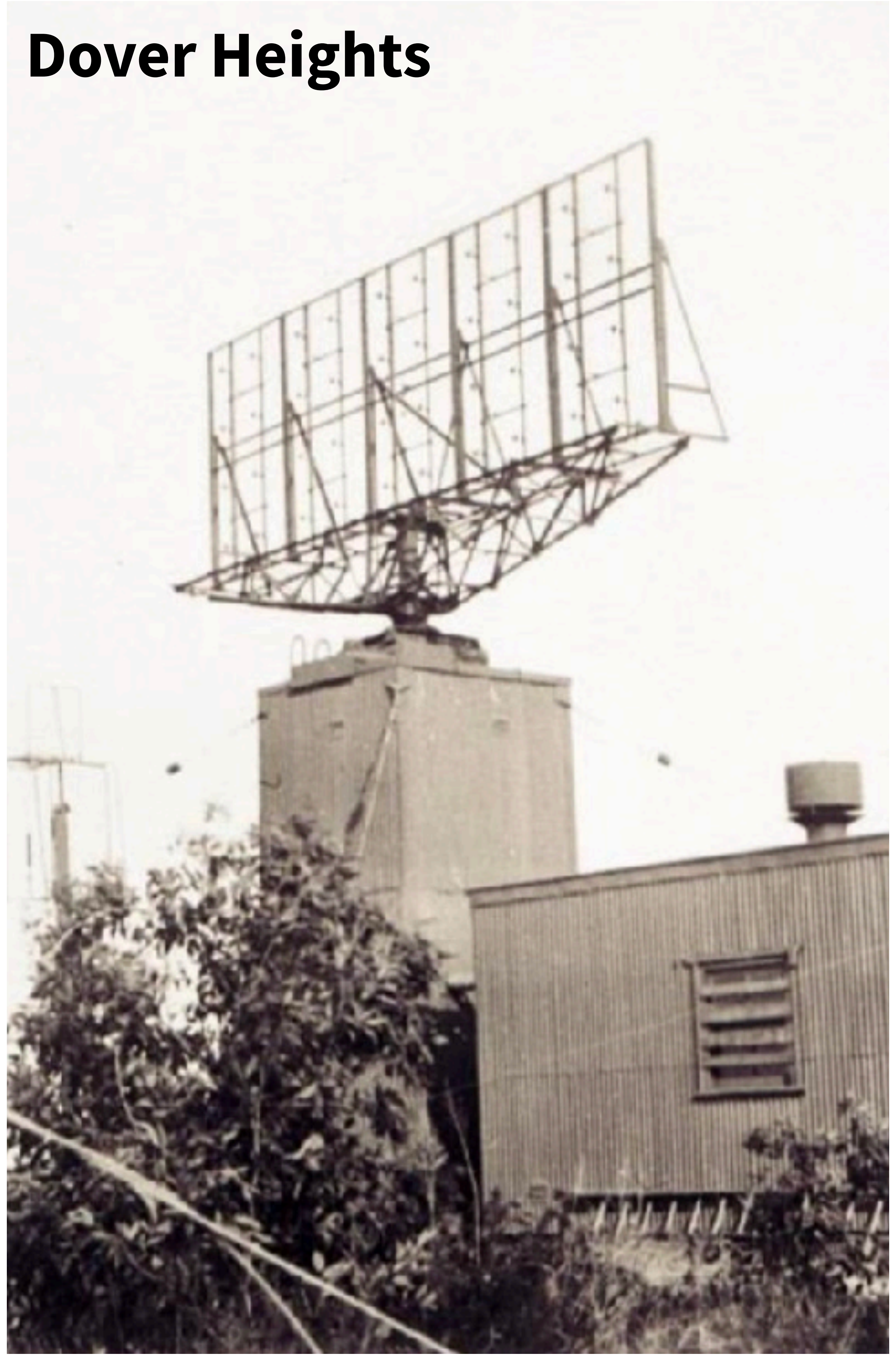

IMAGE: CSIRO
CSIRO
Counting down to the launch of ASKAP 36 full survey science
csiro.au/ASKAP
01
FRINGES BETWEEN ALL ANTENNAS
Verify that all antennas function as an interferometer
02
SINGLE-BEAM IMAGE
Test phase stability and array calibration
03
MULTI-BEAM IMAGE
Test ASKAP's processing pipeline
04
IMAGE OF A COMPLEX FIELD
Test ASKAP on a challenging part of the sky
05
OBSERVE SCIENCE TEST FIELDS
Demonstrate performance using fields of scientific interest
06
COMPLETE A RAPID ALL-SKY SURVEY
Release data from the Rapid ASKAP Continuum Survey project
07
COMPLETE PHASE I PILOT SURVEYS
Release data that meets international science team standards
08
COMPLETE PHASE II PILOT SURVEYS
Test a combined survey strategy that maximises efficiency
09
ASKAP SURVEYS COMMENCE
Launch multi-year observing campaigns based on pilot surveys
COMPLETE
NEARLY THERE
JUST STARTED
NOT STARTED

Part III: Context of ASKAP

History and future of ATNF

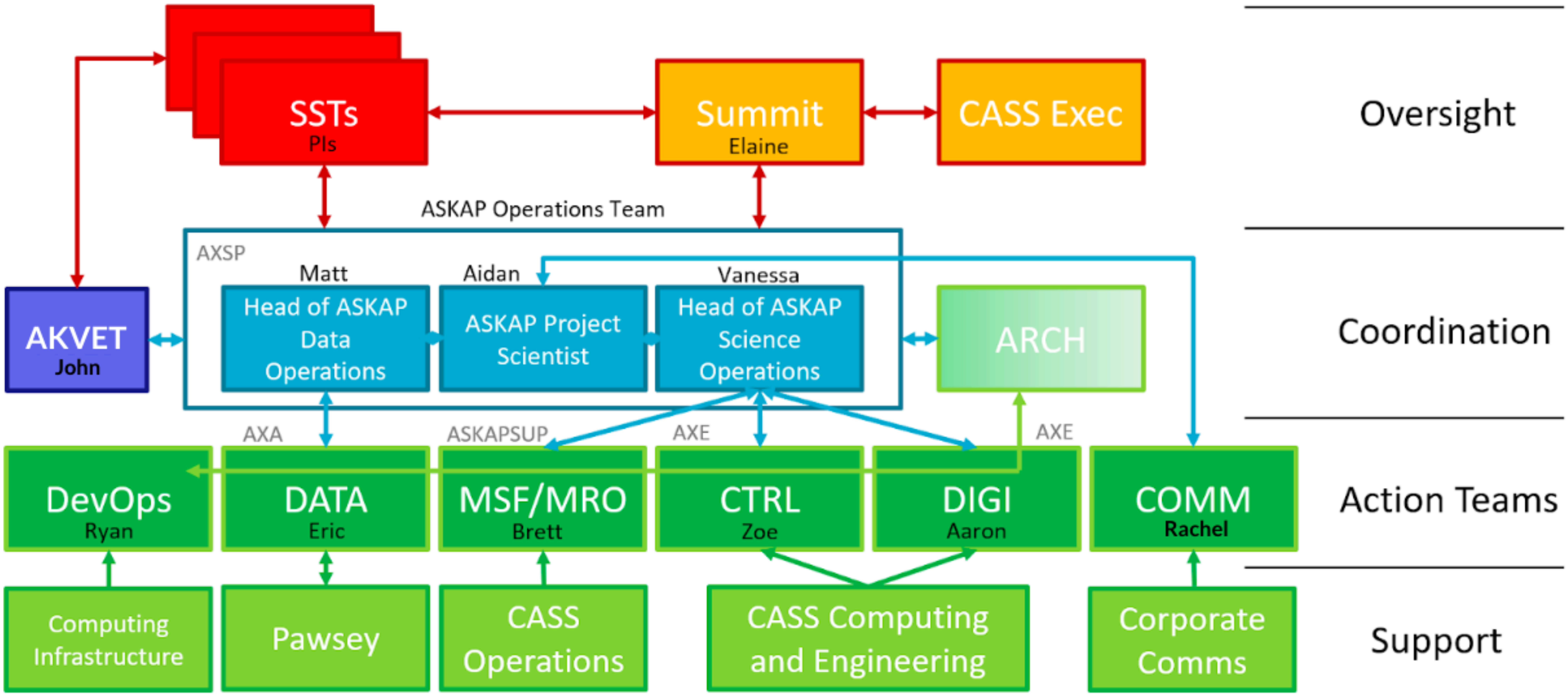


History and evolution of the ATNF

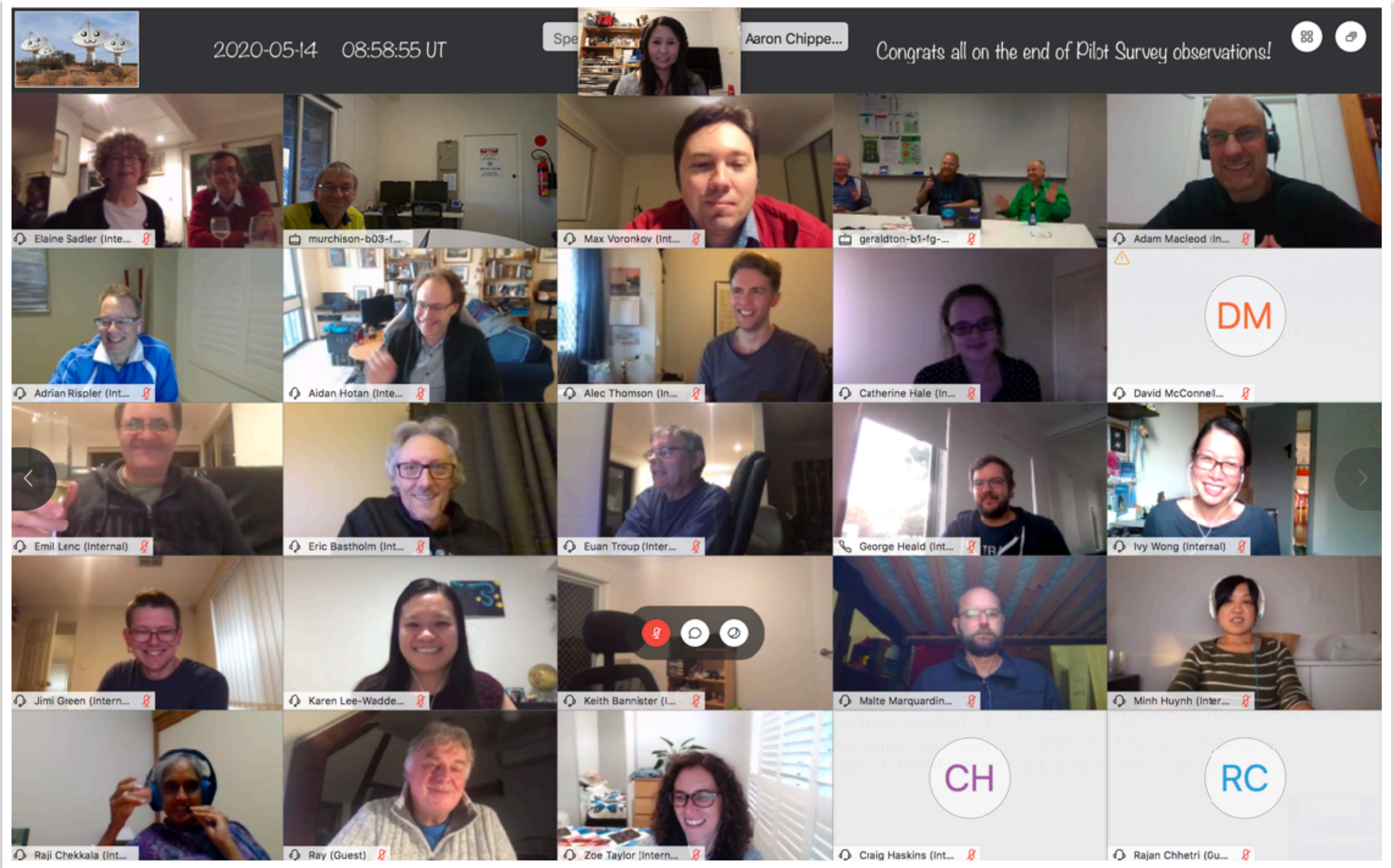


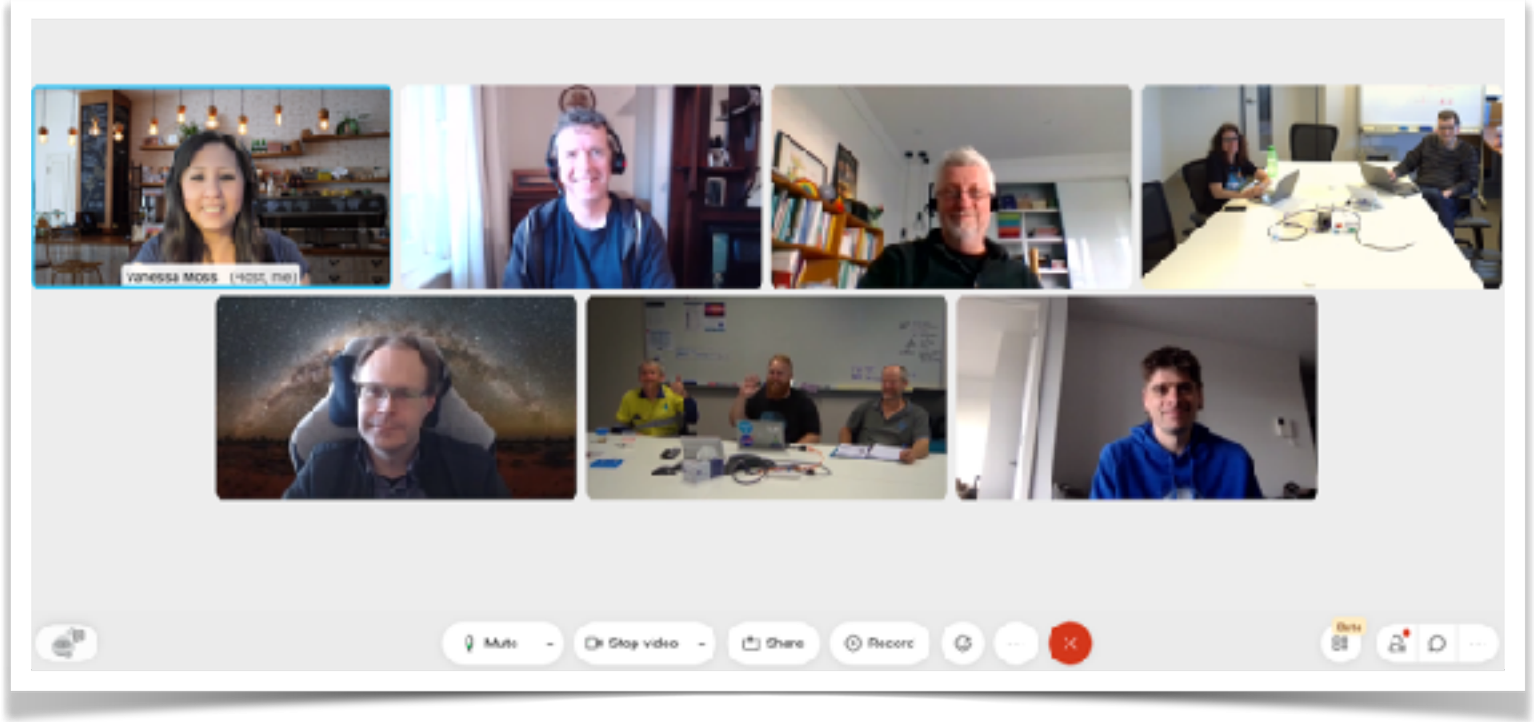
IMAGES: CSIRO, V. MOSS, S. AMY, SKAO

ASKAP Operations Model



Distributed nature of the team





Remoteness of the site

Part IV: Automating ASKAP

Towards autonomy in ASKAP operations

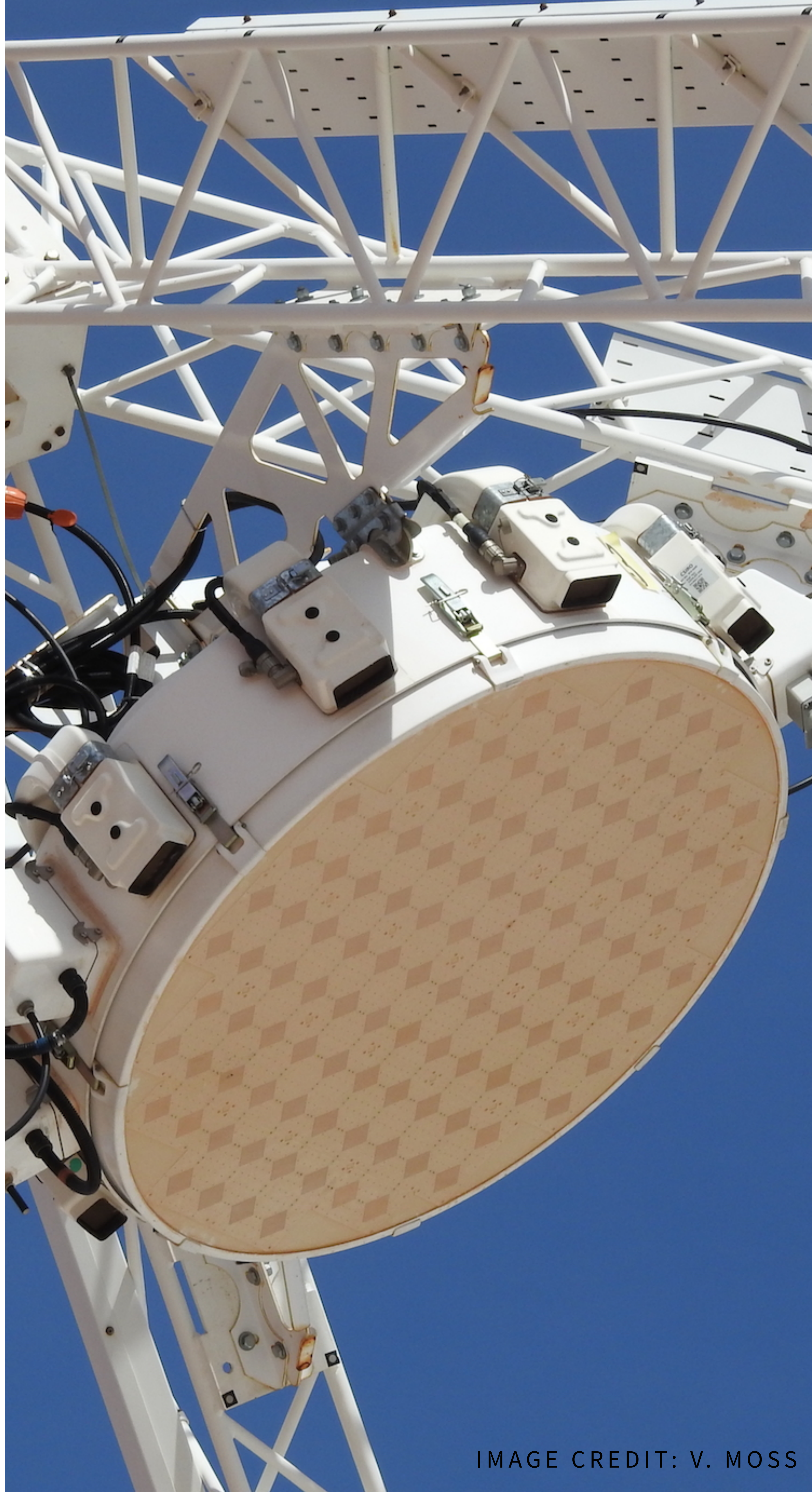
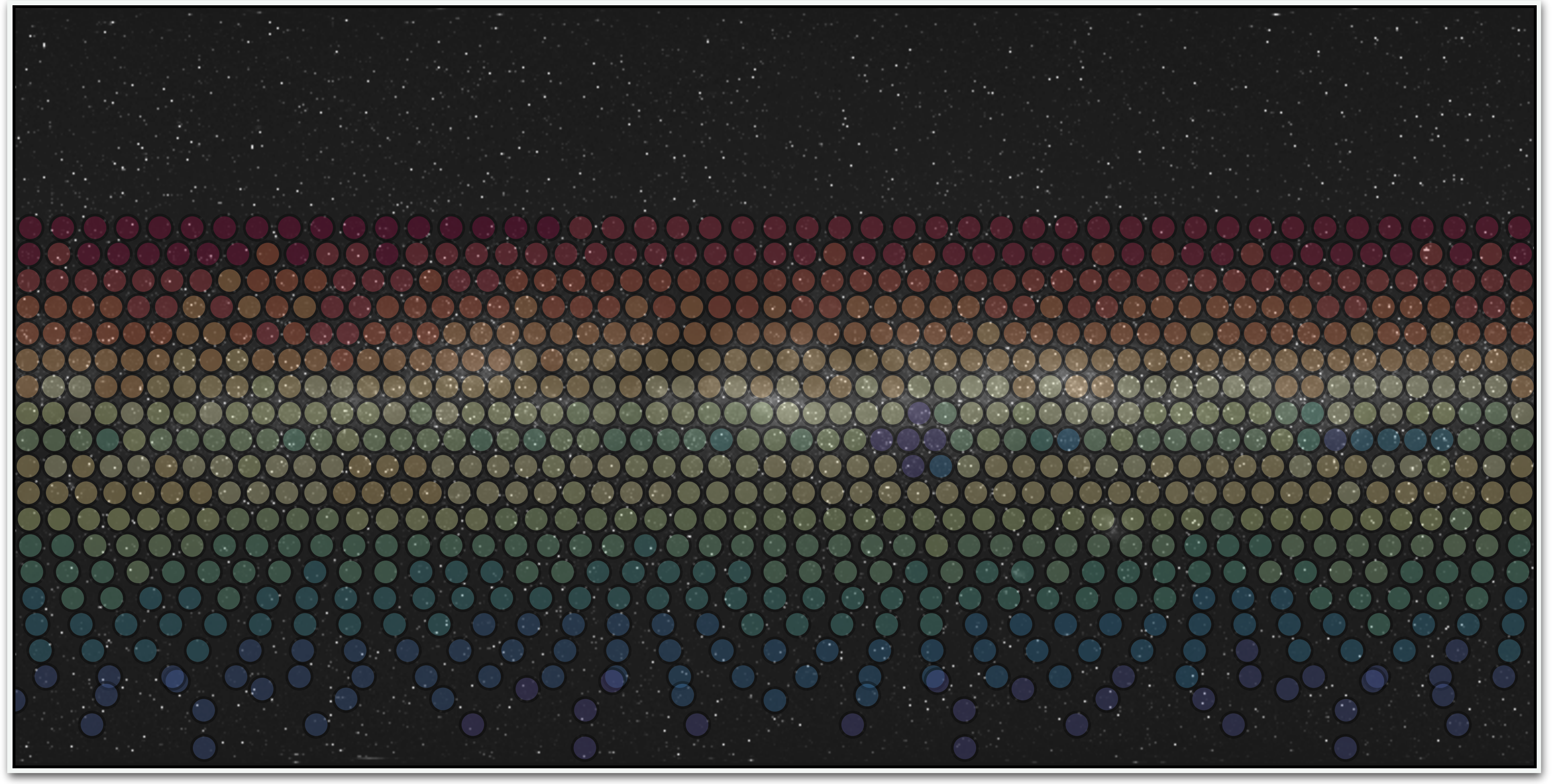
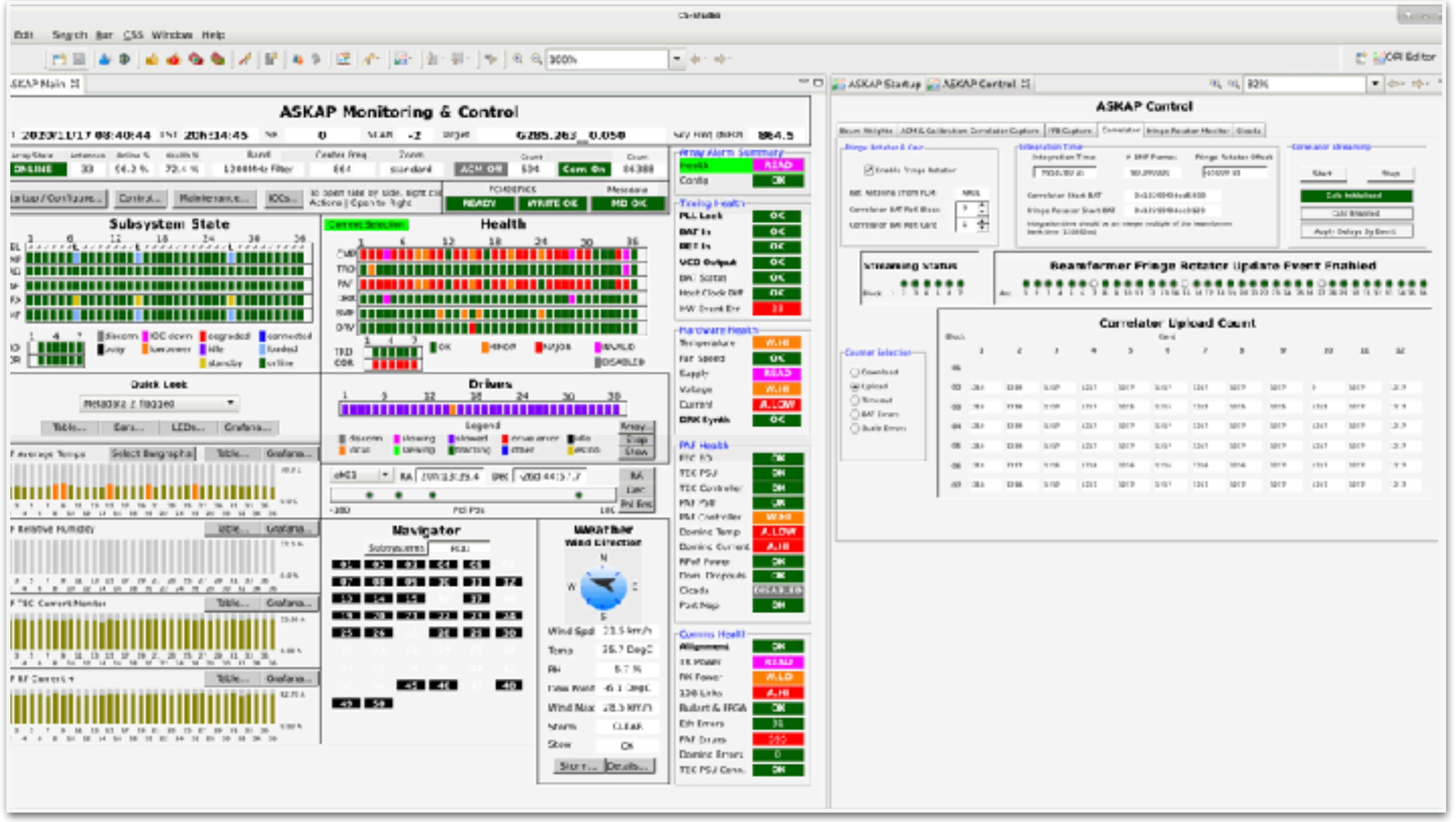


IMAGE CREDIT: V. MOSS

ASKAP: the role of autonomy

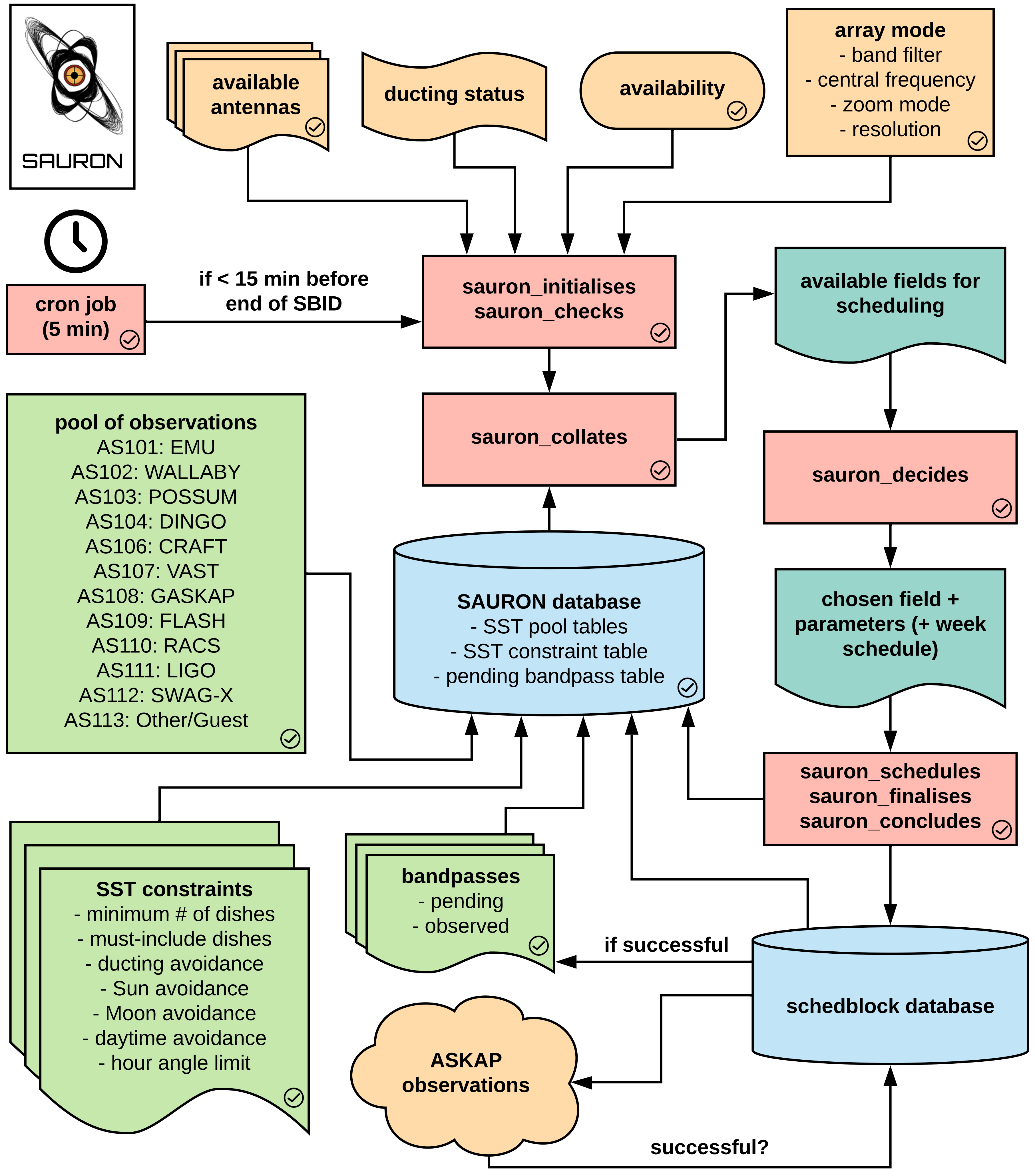
- Australia is relatively **unique** with a long history of astronomers being in charge directly of ATNF telescopes (e.g. no operator model)
- ASKAP is designed to be a **high-efficiency survey instrument**, without direct supervision and without staff on site for significant periods
- As we transition from commissioning to survey operations, we are seeking to **minimise** the role of the human to where it is best invested
- This has **parallels** with the transition from remote operations to remote management, as well as remote-controlled **robotic telescopes**



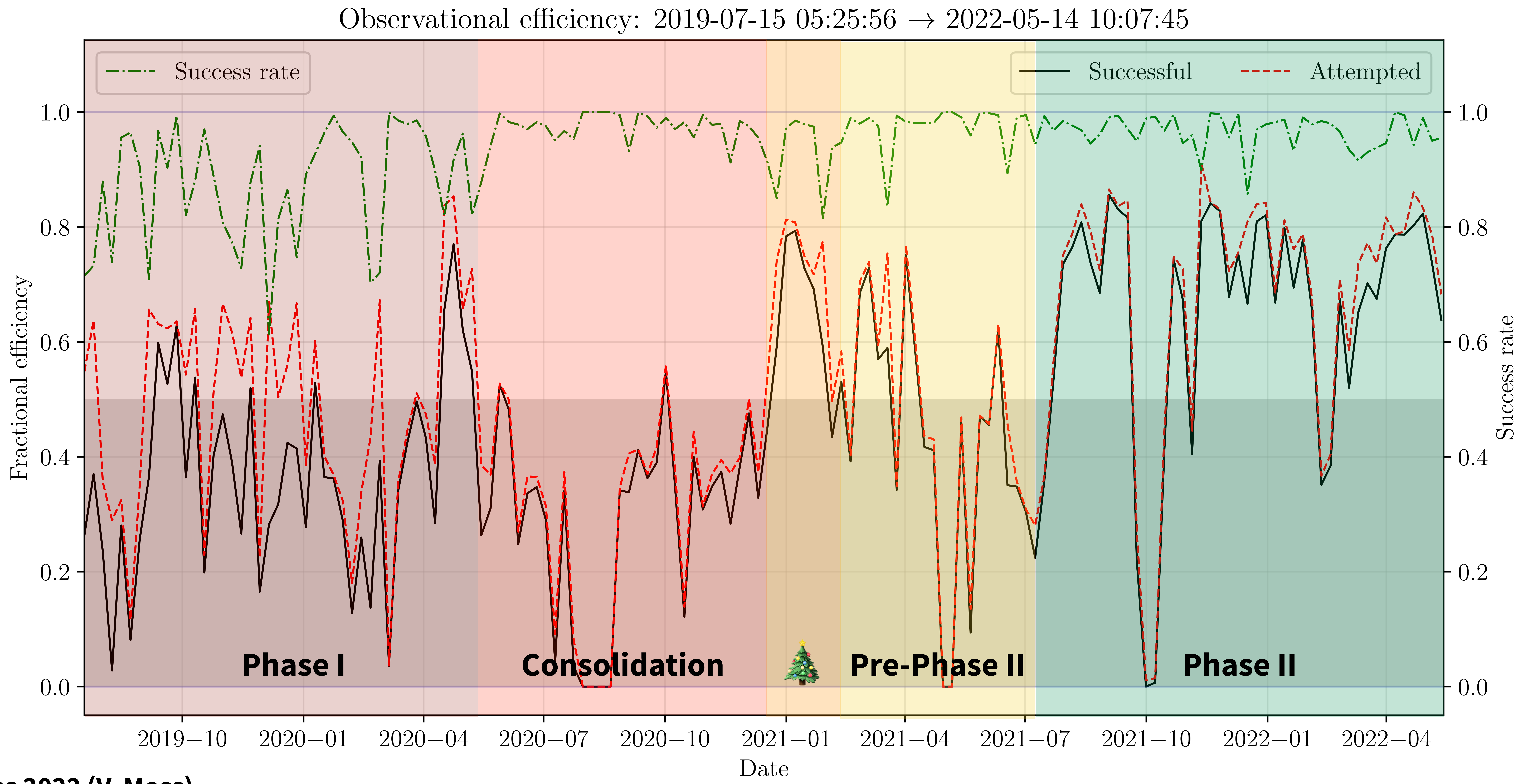


Development of SAURON

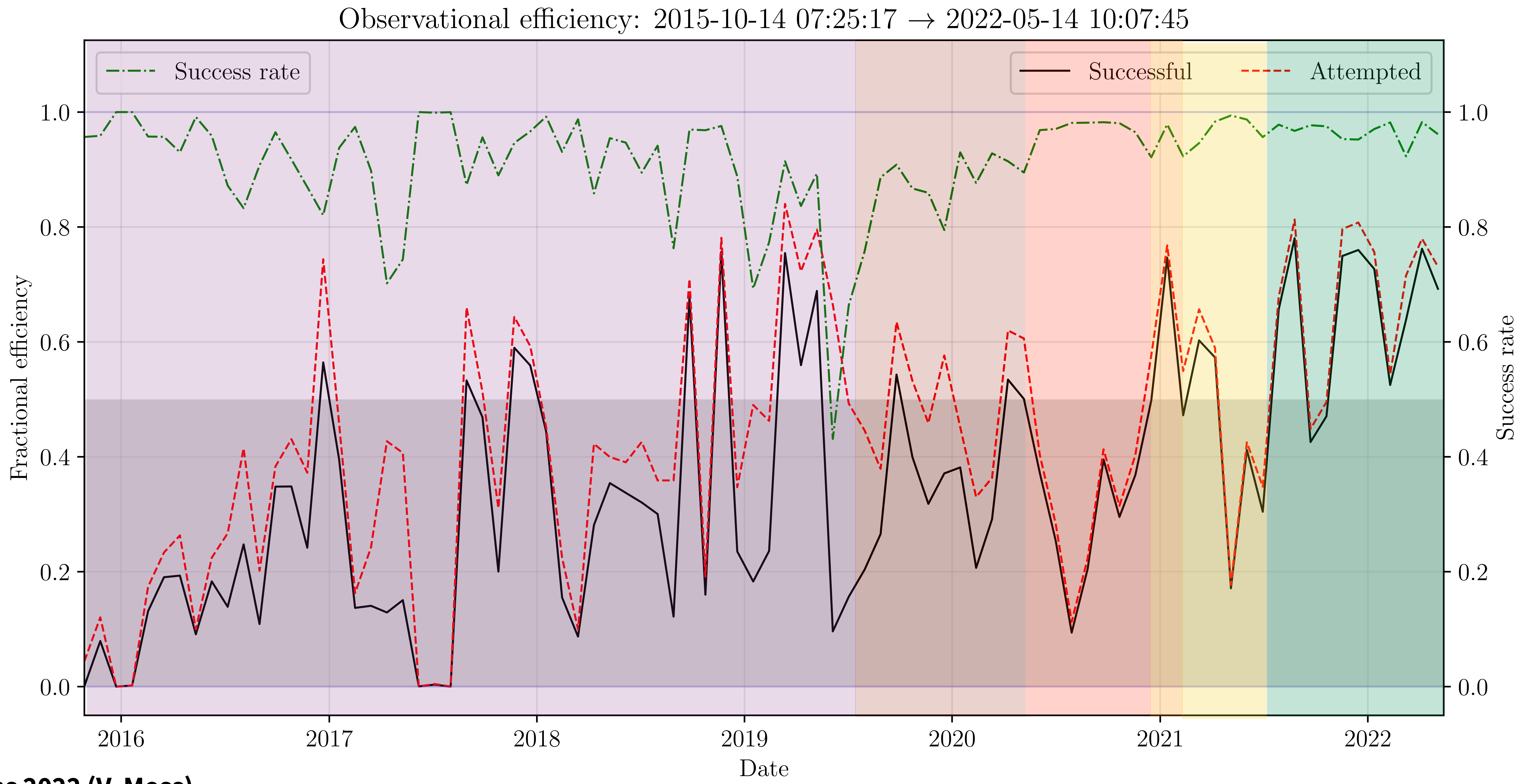
- **Scheduling** as a starting point for a broader exploration of automation possibilities for the entire ASKAP operational workflow
- **SAURON:** Scheduling Autonomously Under Reactive Observational Needs
- Operating ASKAP in this way is possible thanks to improvements in **stability**, **robustness** and **automation** as part of consolidation efforts
- **Christmas 2020** was the first road test of the initial version of SAURON, incorporating the system improvements from consolidation
- Development and improvement is **ongoing**



Increasing operational efficiency



Towards full survey efficiency



SciOps 2022 (V. Moss)

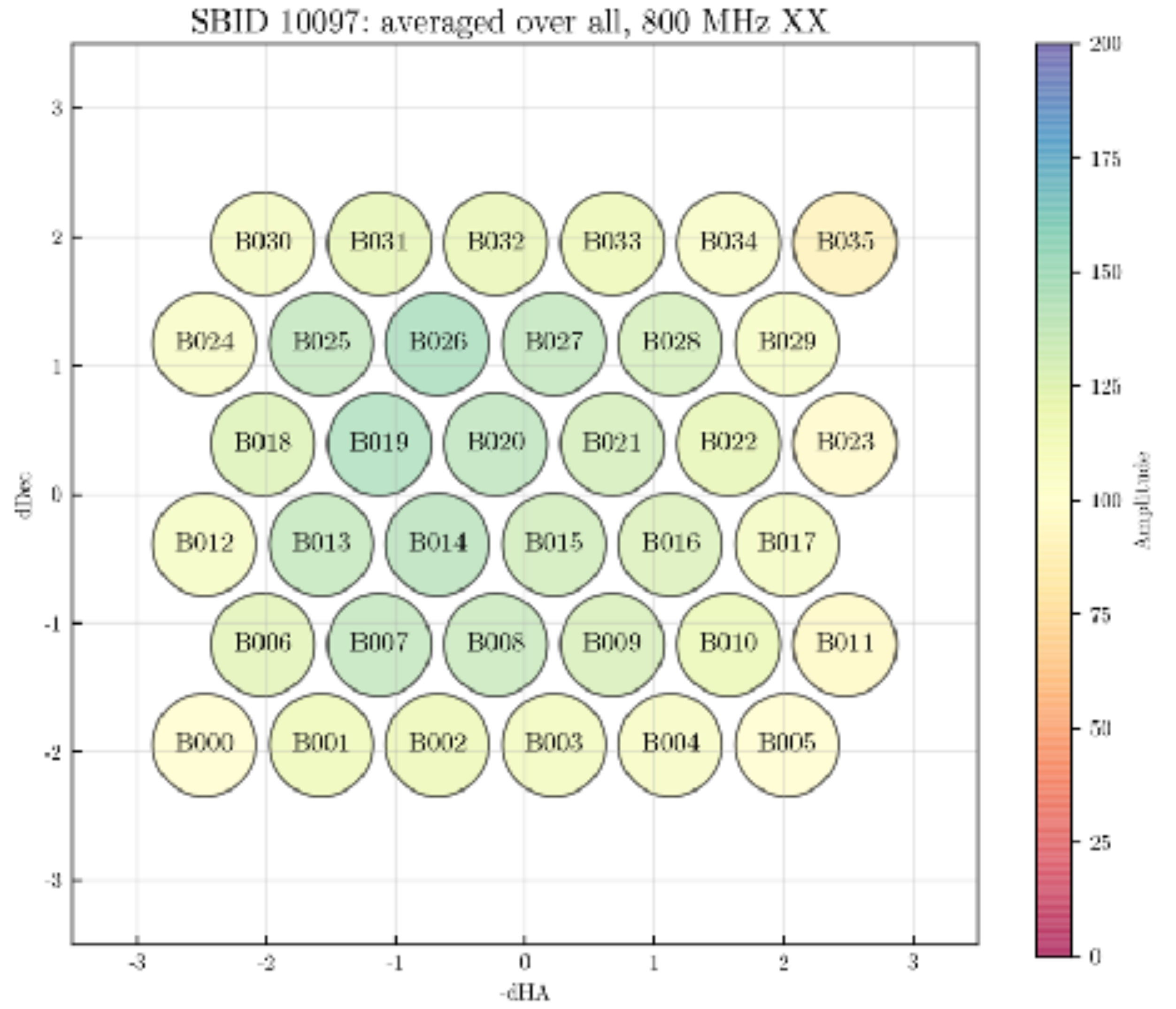
Data complexity

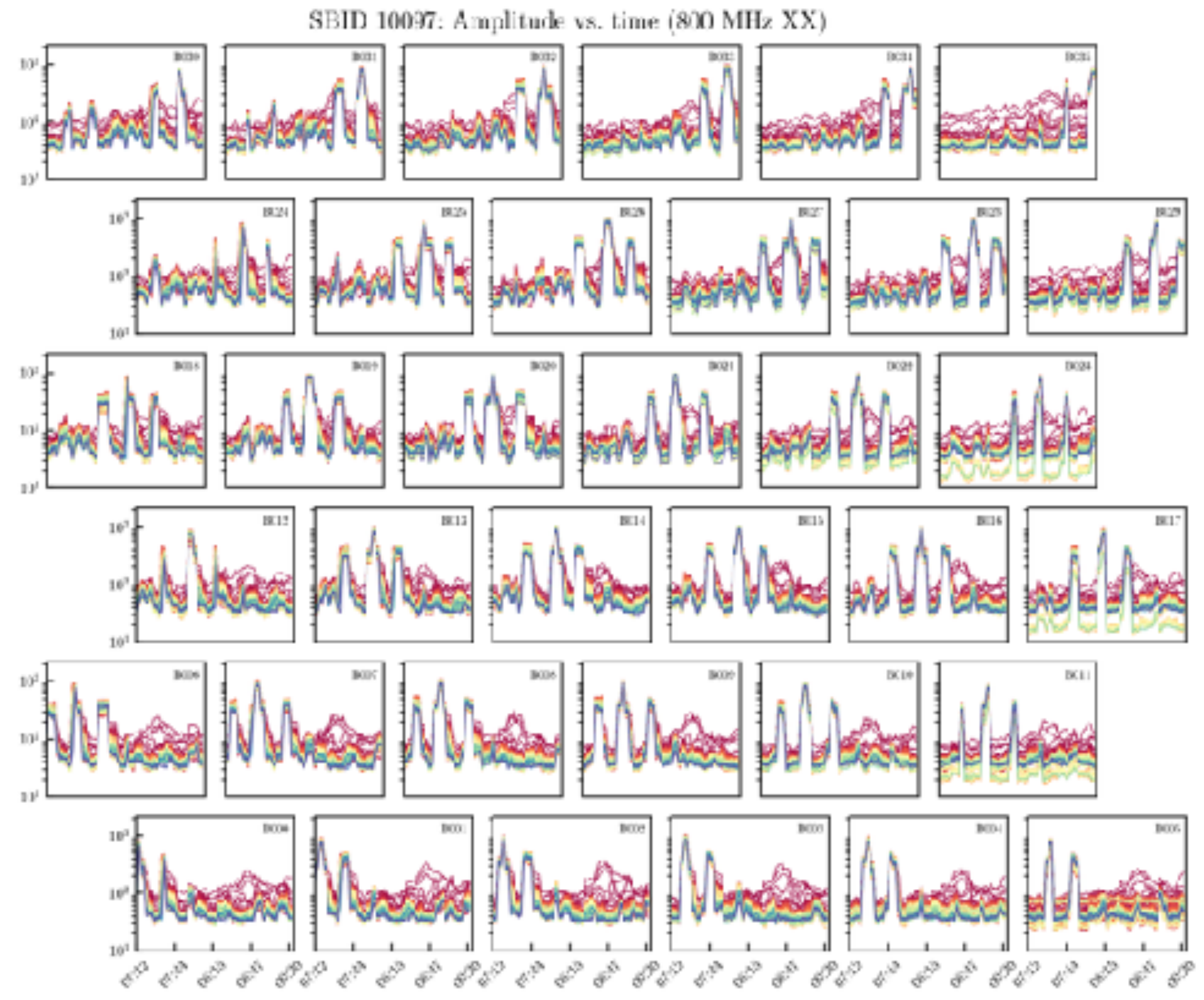
- ASKAP datasets have many **complexities** compared to **traditional** astronomical datasets
  - **36** antennas
  - **36** beams
  - **100s** of timestamps, **1000s** of channels

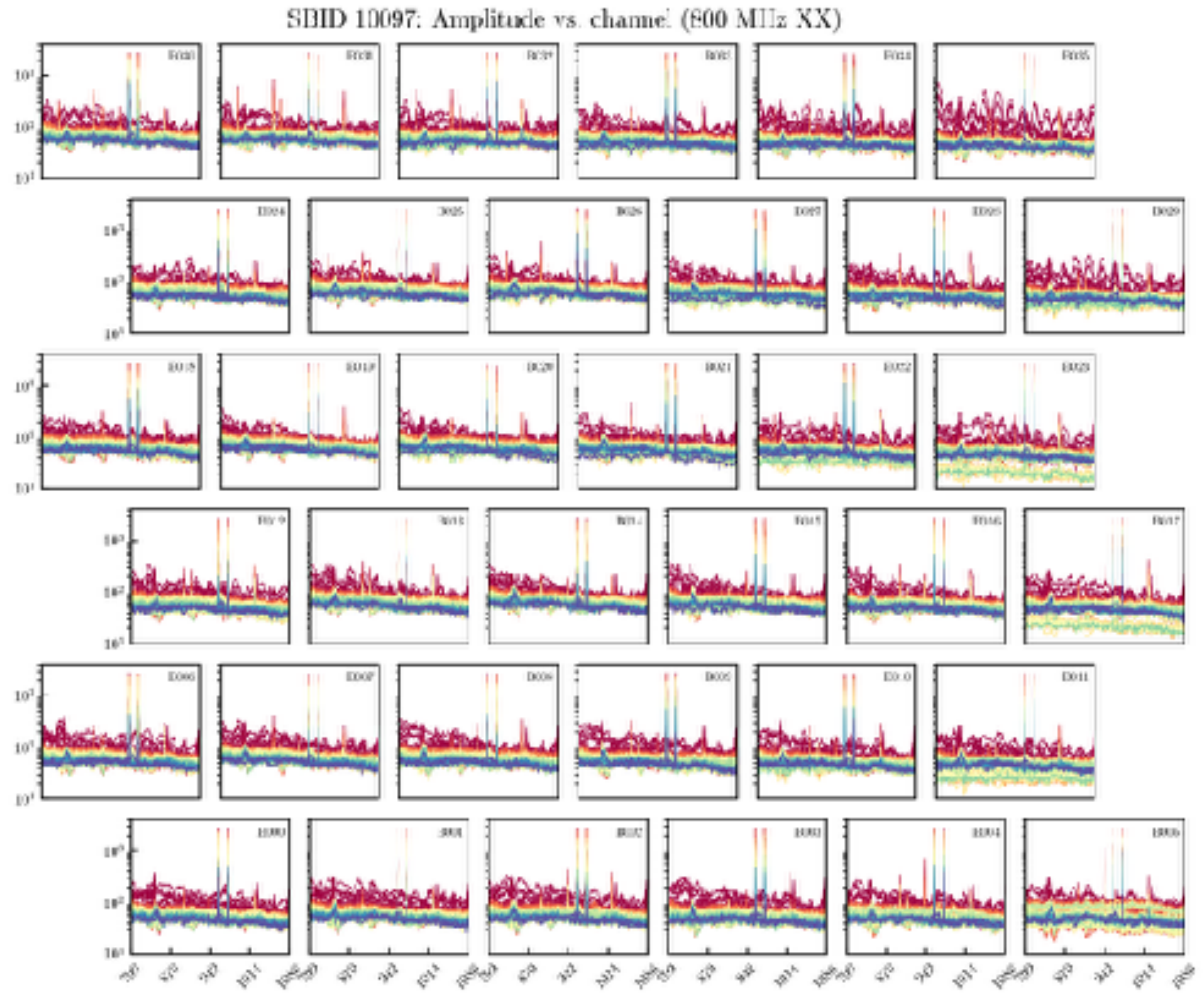
- Data sizes are also **immense**
  - continuum bandpass: 170 GB
  - continuum target: 729 GB
  - spectral bandpass: 8.7 TB
  - spectral target: 32 TB

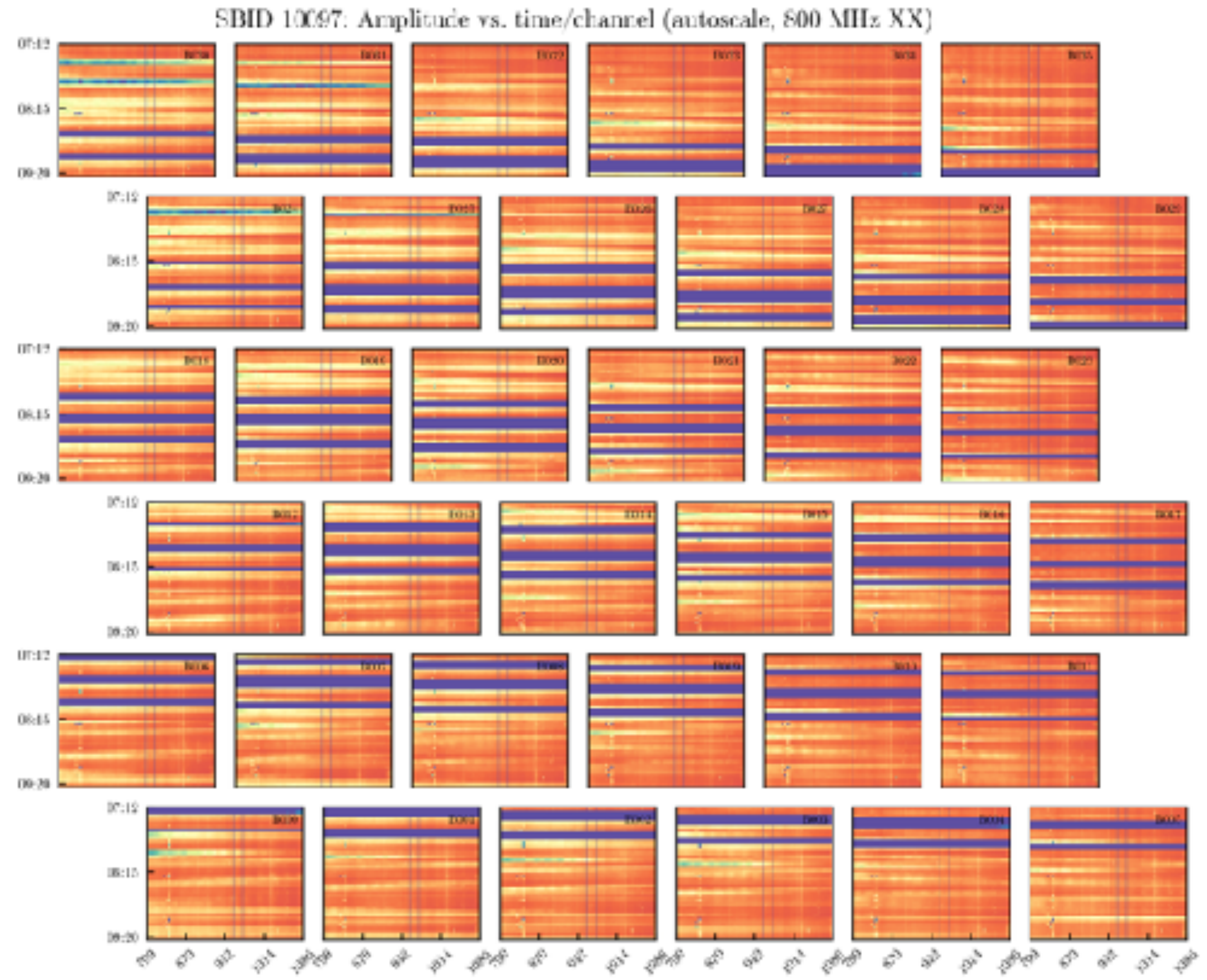
- Need a **quick way** to see data quality!

Raw data diagnostics









ASKAP Inspection Plots 2019-11-24_061040_EMU_2205-51

METADATA FOR 2019-11-24_061040_EMU_2205-51 (SBID 10635)

Source:	EMU_2205-51	**Bandwidth:**	288.000 MHz
RA:	22:15:21.432	**Channels:**	288
Dec:	-53:04:08.811	**Frequency resolution:**	1000.000 kHz
Start (UT):	2019-11-24 06:10:19.297	**Start frequency:**	799.991 MHz
End (UT):	2019-11-24 16:10:30.264	**Central frequency:**	943.491 MHz
Duration:	10:00:00	**End frequency:**	1086.991 MHz

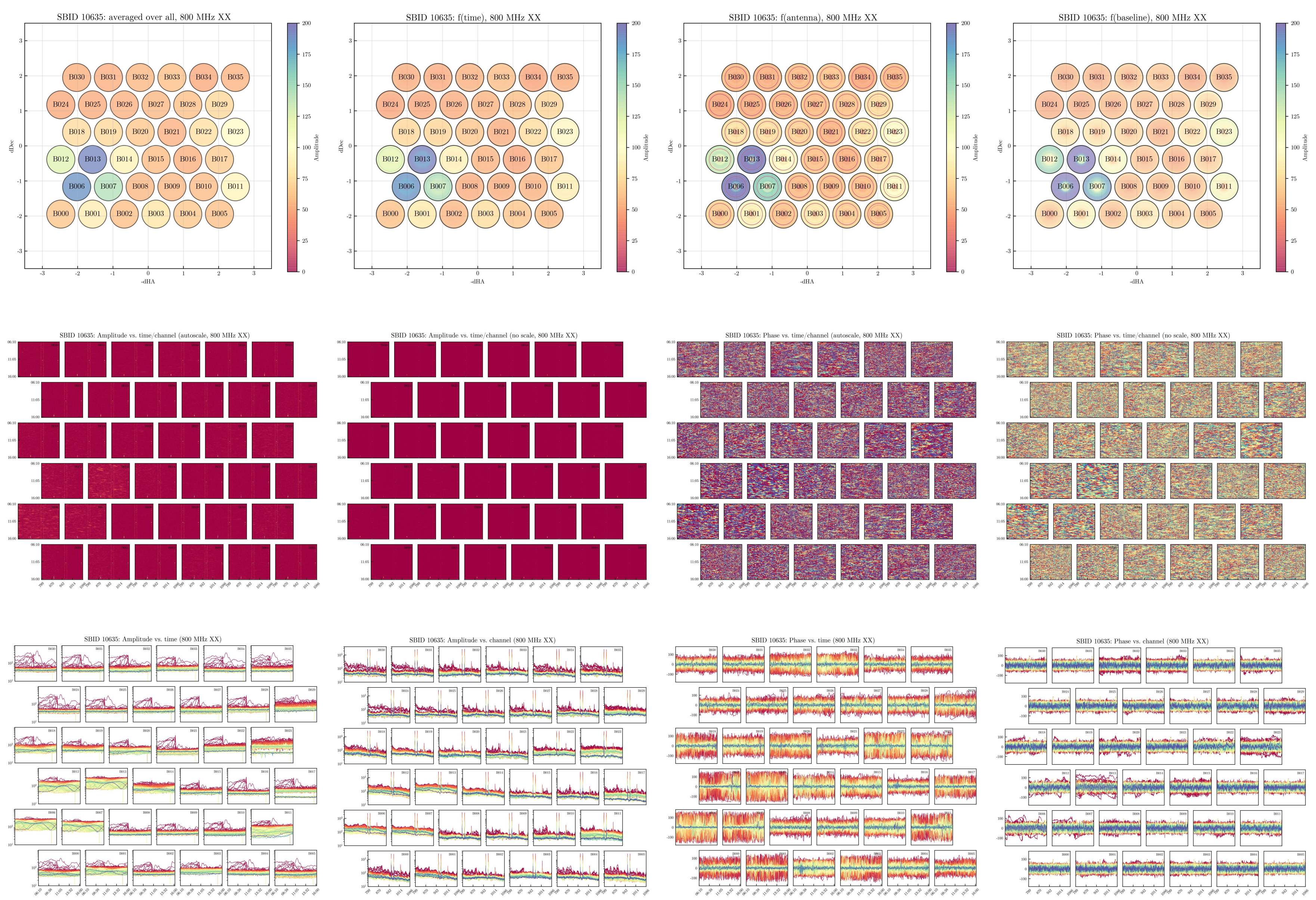
Array: ak01, ak02, ak03, ak04, ak05, ak06, ak07, ak08, ak09, ak10, ak11, ak12, ak13, ak14, ak15, ak16, ak17, ak18, ak19, ak20, ak21, ak22, ak23, ak24, ak25, ak26, ak27, ak28, ak29, ak30, ak31, ak32, ak33, ak34, ak35, ak36

PREDICTIONS FOR 2019-11-24_061040_EMU_2205-51

Data assessment: BAD (LOW)

Bad telescopes: ak09, ak32

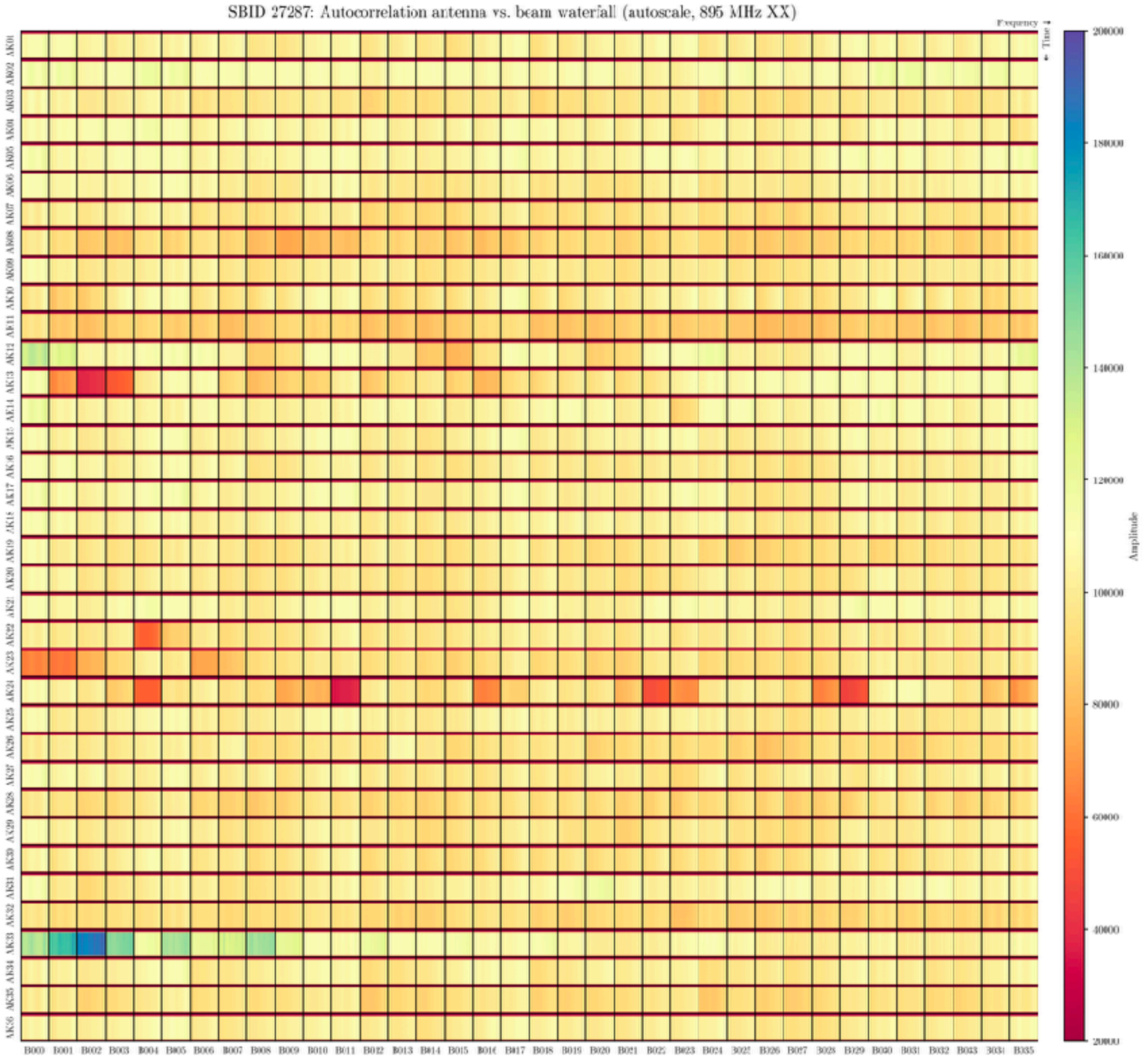
XX polarisation:

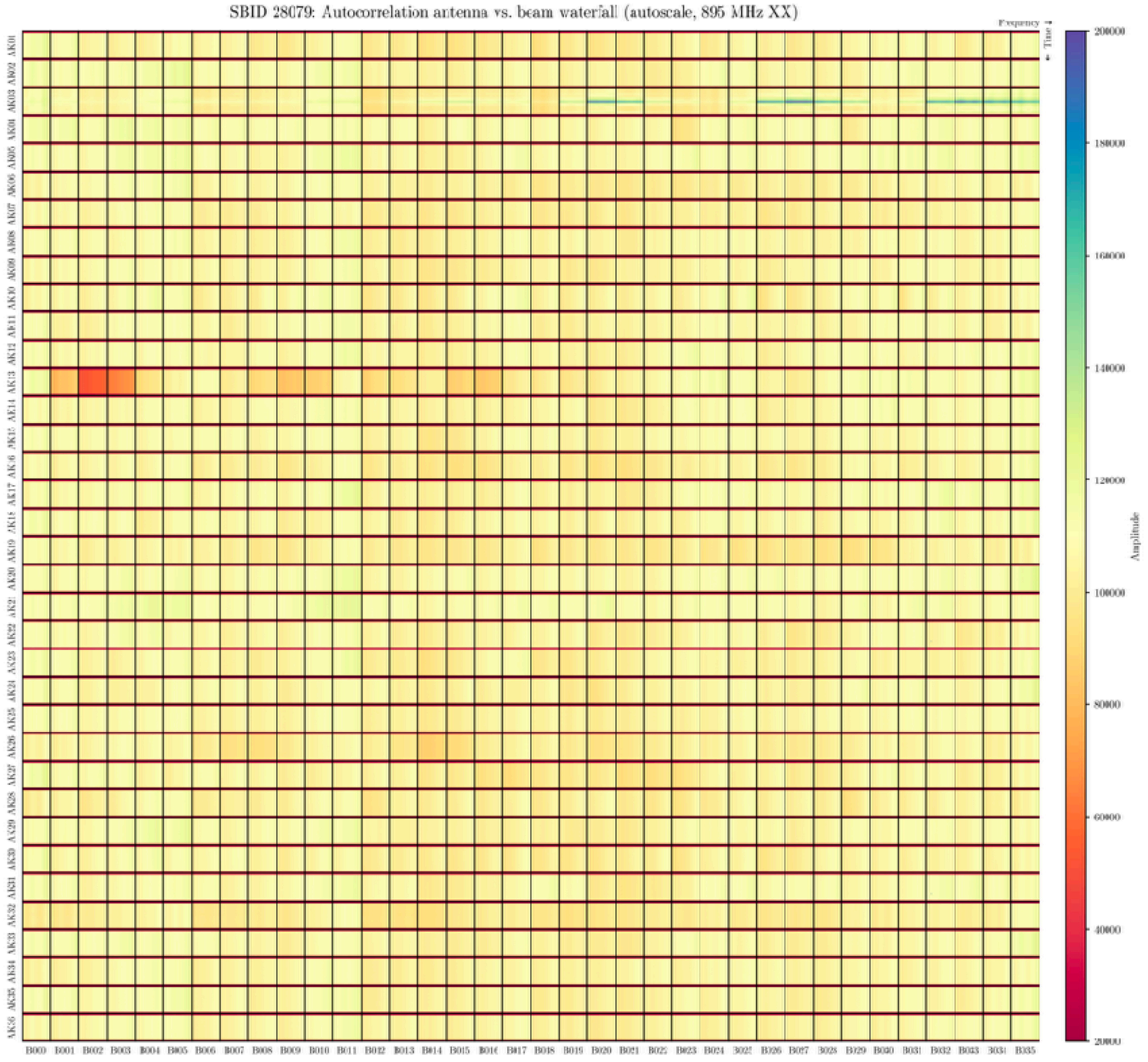


SciOps 2022 (V. Moss)

The "everything" plot

→ increasing antennas





→ increasing beams

SciOps 2022 (V. Moss)

SAMWISE for outlier detection

SAMWISE

- Currently prototyping options for identifying bad data based on **raw data diagnostics**
- **SAMWISE:** Selecting Anomalous Matter With Intelligent Semi-unsupervised Encoders
- **Outlier detection** on autocorrelation waterfalls does relatively well at identifying correctly which data to flag, based on early tests
- We also are looking into **ML classification of data** (as opposed to **images** used above)
- Goal: determine feasibility in **producing flagging directives** that can be fed to pipeline

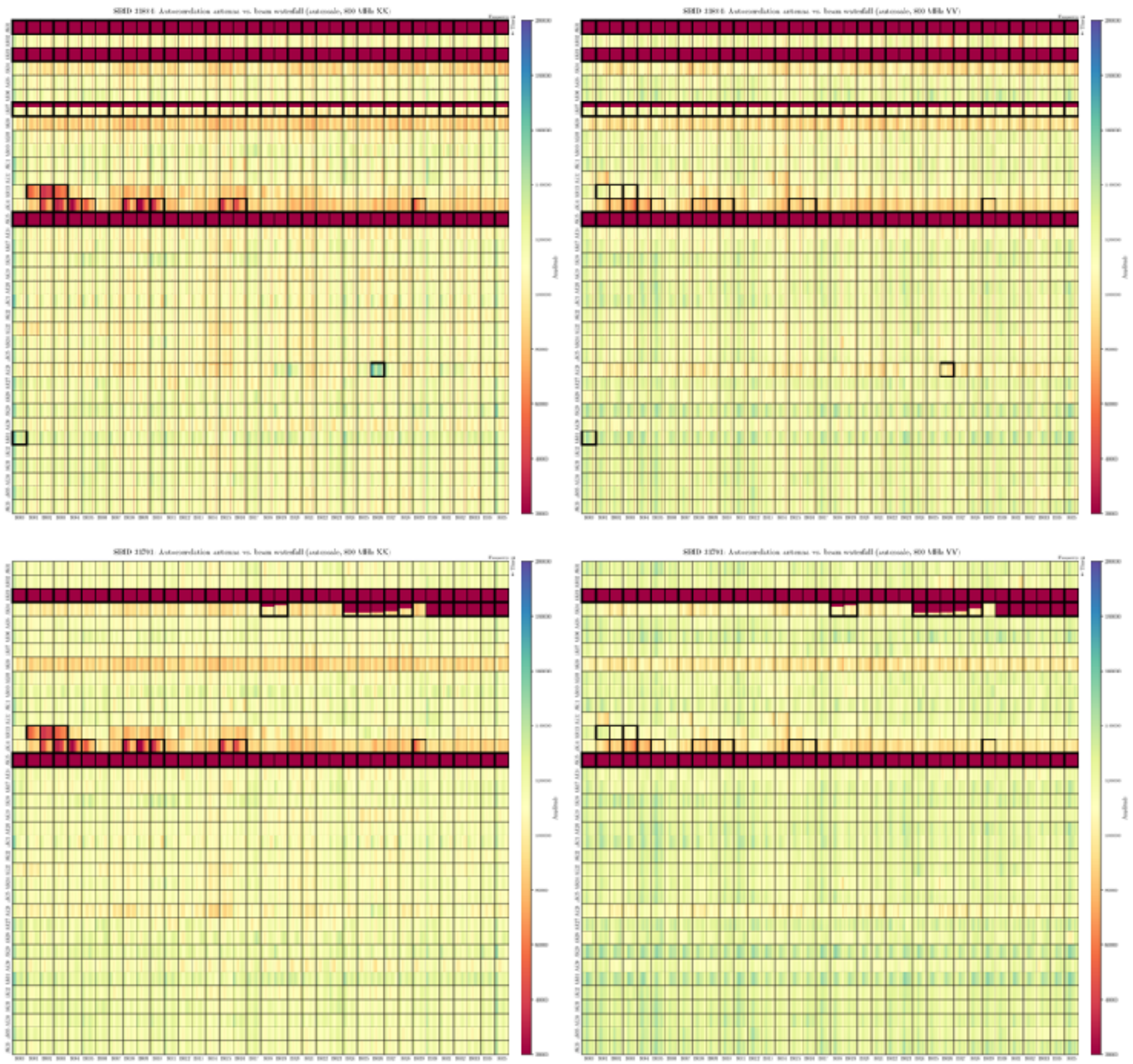
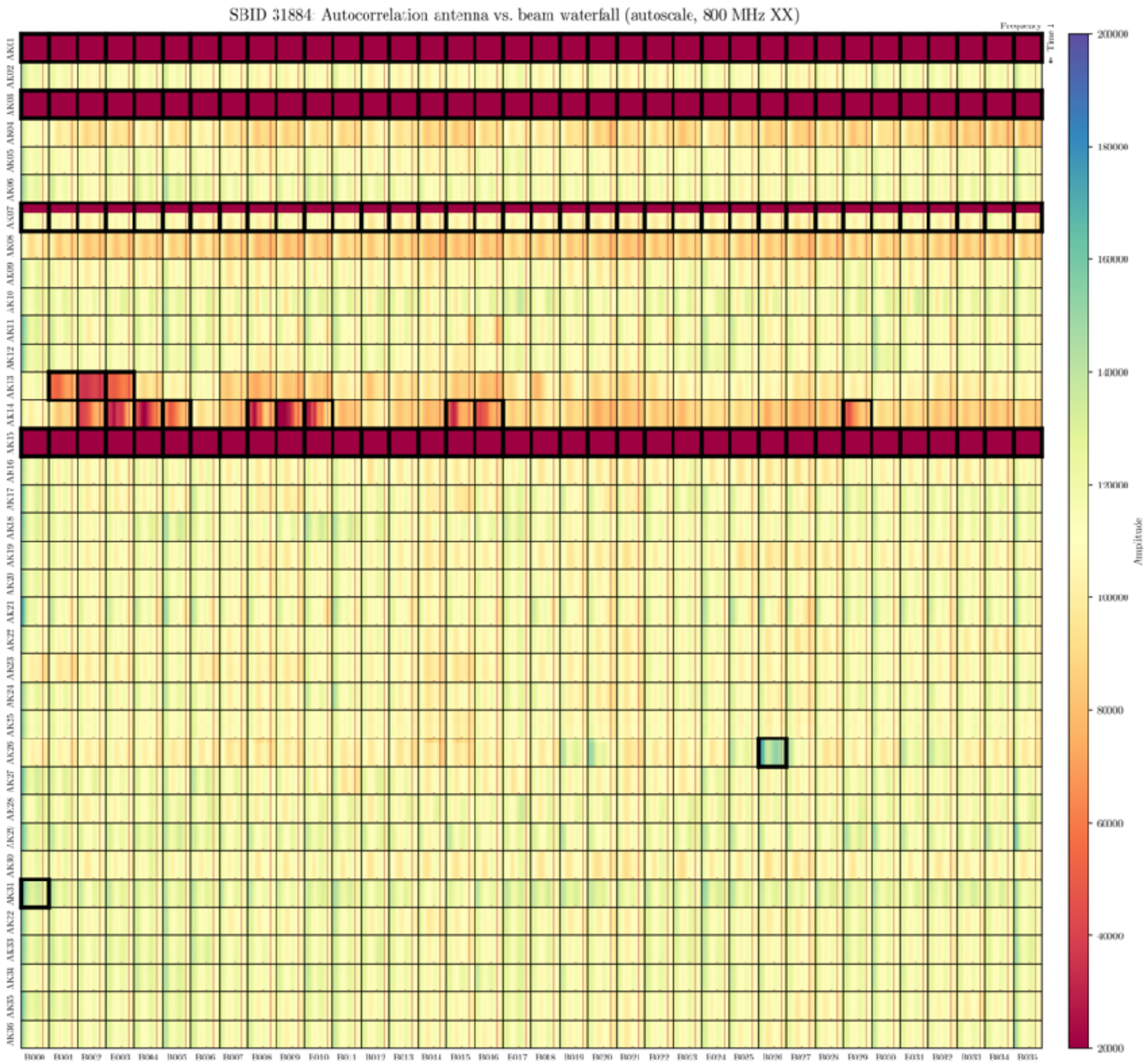


IMAGE: SAMWISE

SAMWISE example



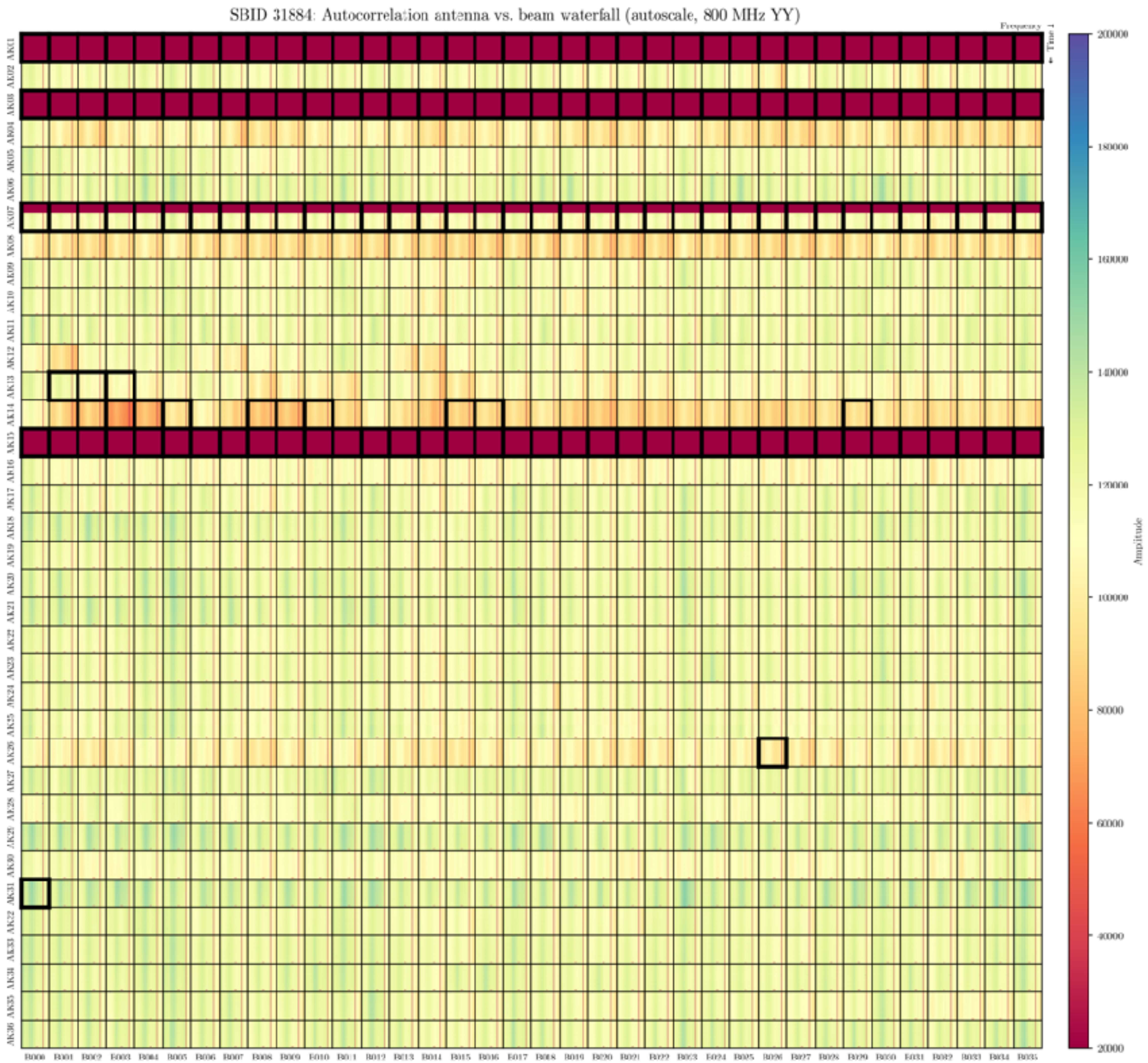
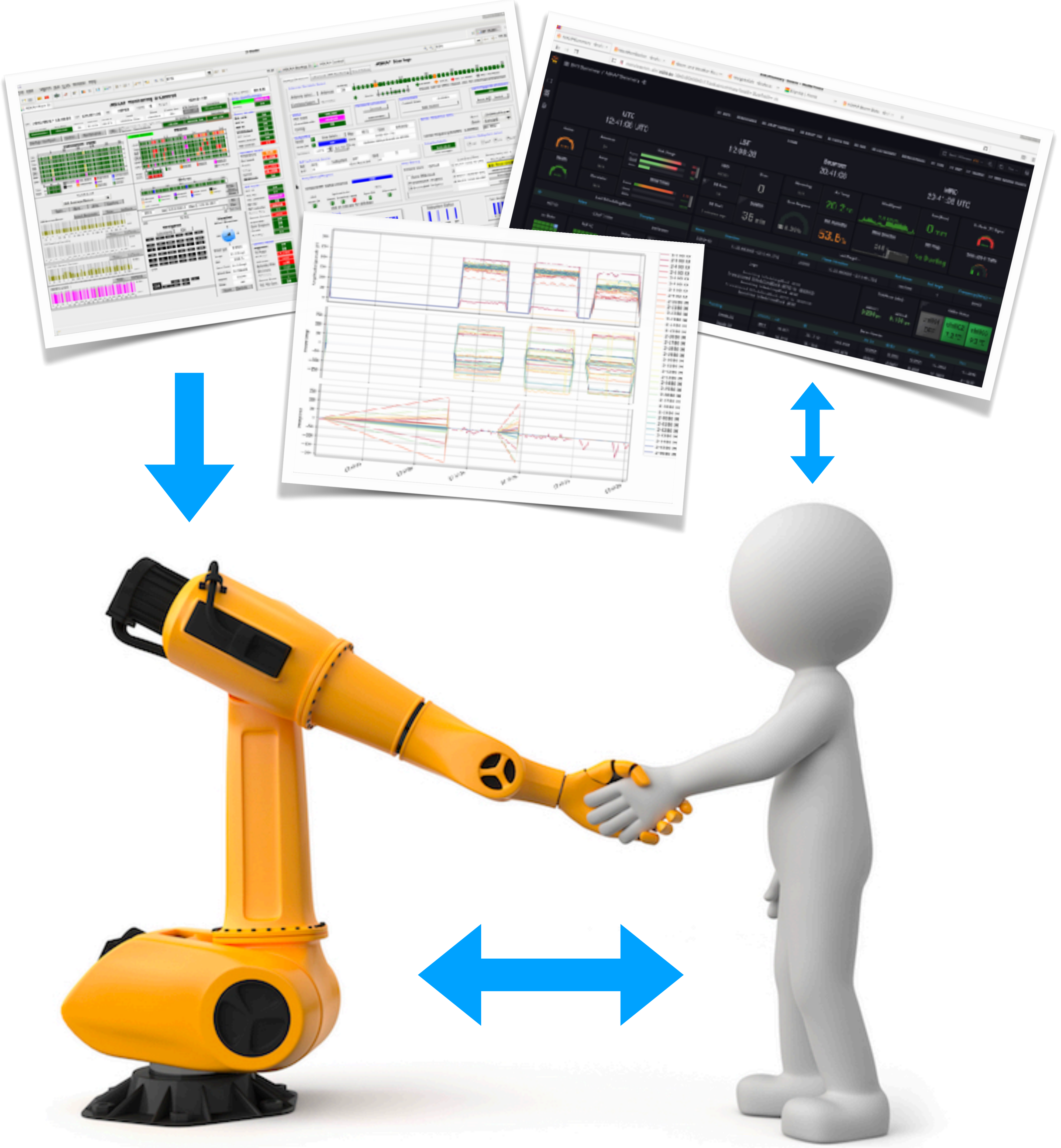


IMAGE: SAMWISE

ASKAP Operations and CINTEL

- **CINTEL:** Collaborative Intelligence, referring to the collaboration between AI and humans
- Cross-CSIRO Future Science Platform (FSP) bringing together researchers facing CINTEL challenges in **many disciplines**
- Within the CINTEL context, our ASKAP project will look at **merging** human analytical skill and expertise with the power and speed of machine-driven data cleaning to improve monitoring and surveillance
- Advertising for a **postdoc** to join our team will take place during 2022 - stay tuned!



SEE ALSO: HTTPS://WWW.CSIRO.AU/EN/ABOUT/STRATEGY/FUTURE-SCIENCE-PLATFORMS

ASKAP Operations and CINTEL

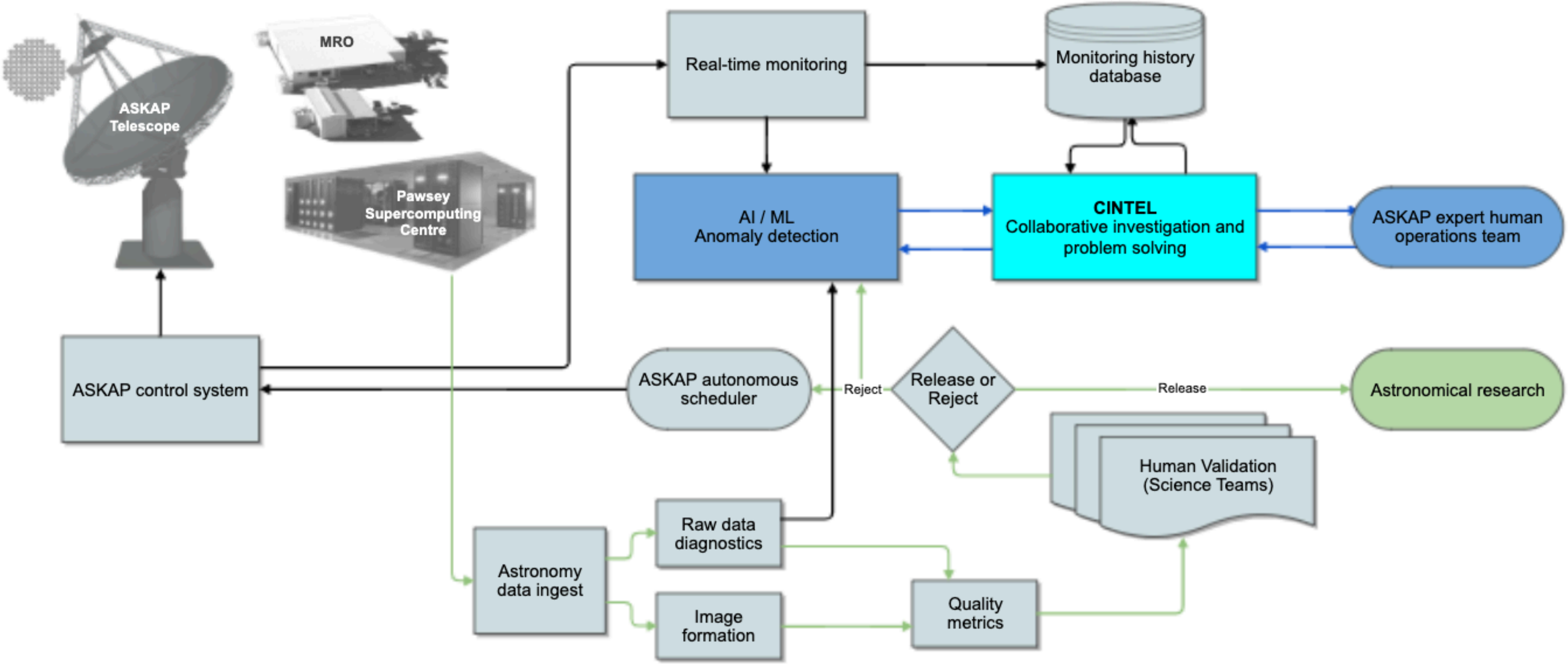


IMAGE: A. HOTAN

IMAGE: PAWSEY, ASKAPSOFT TEAM

Processing all the data

- **ASKAPsoft** is a custom pipeline designed for calibration, imaging and analysis of ASKAP data
- For **operational processing**, it is run on the Pawsey supercomputing infrastructure, specifically on Galaxy while accessing the data that is available on Payne or Scott
- Once processing is completed, data is sent to **CASDA**, the online archive for ASKAP
- Processing is currently **semi-automatic**, via scripts and slurm processes, but is intended to be automatically triggered in future
- Better **linking** of observations and processing

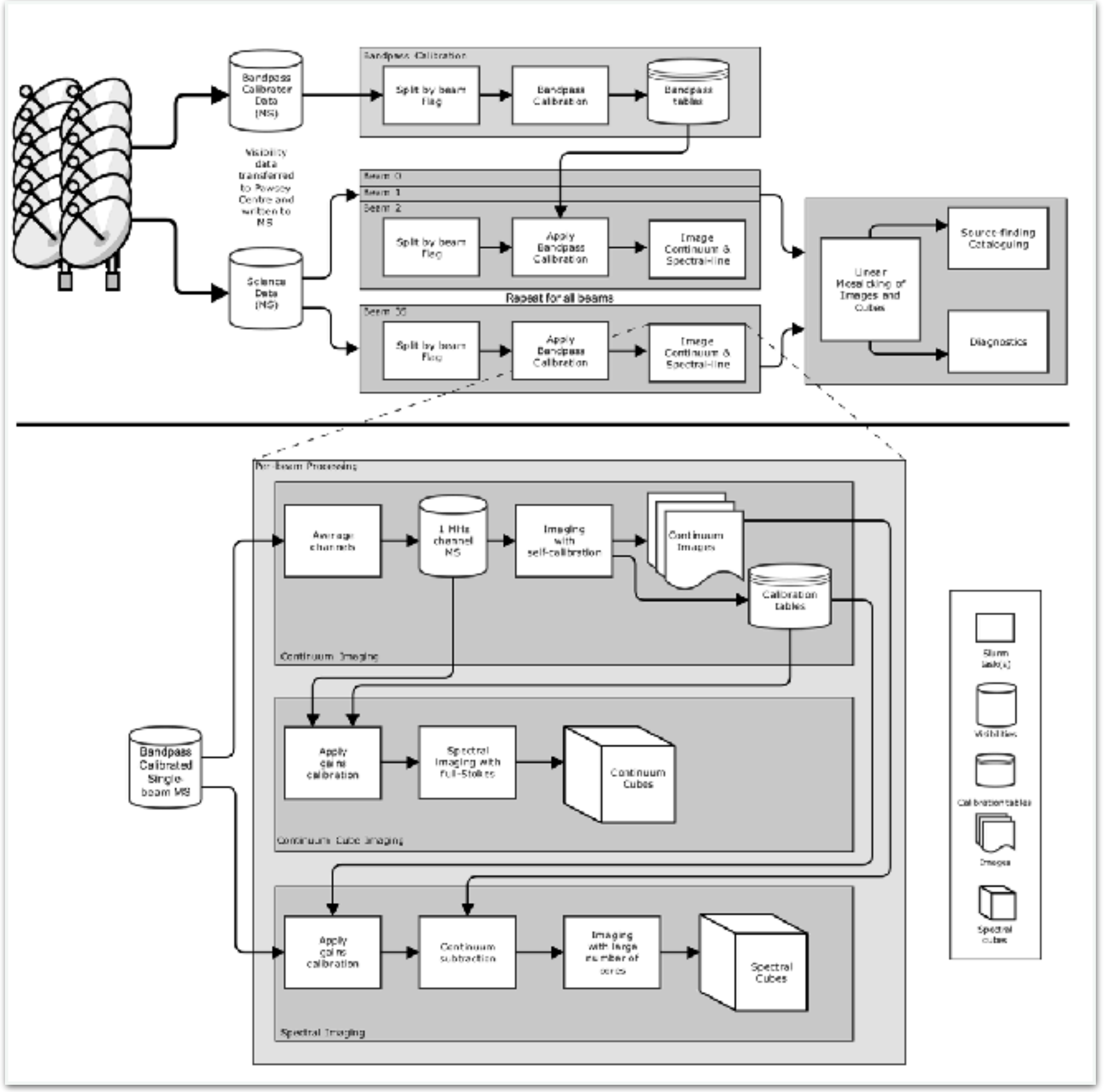
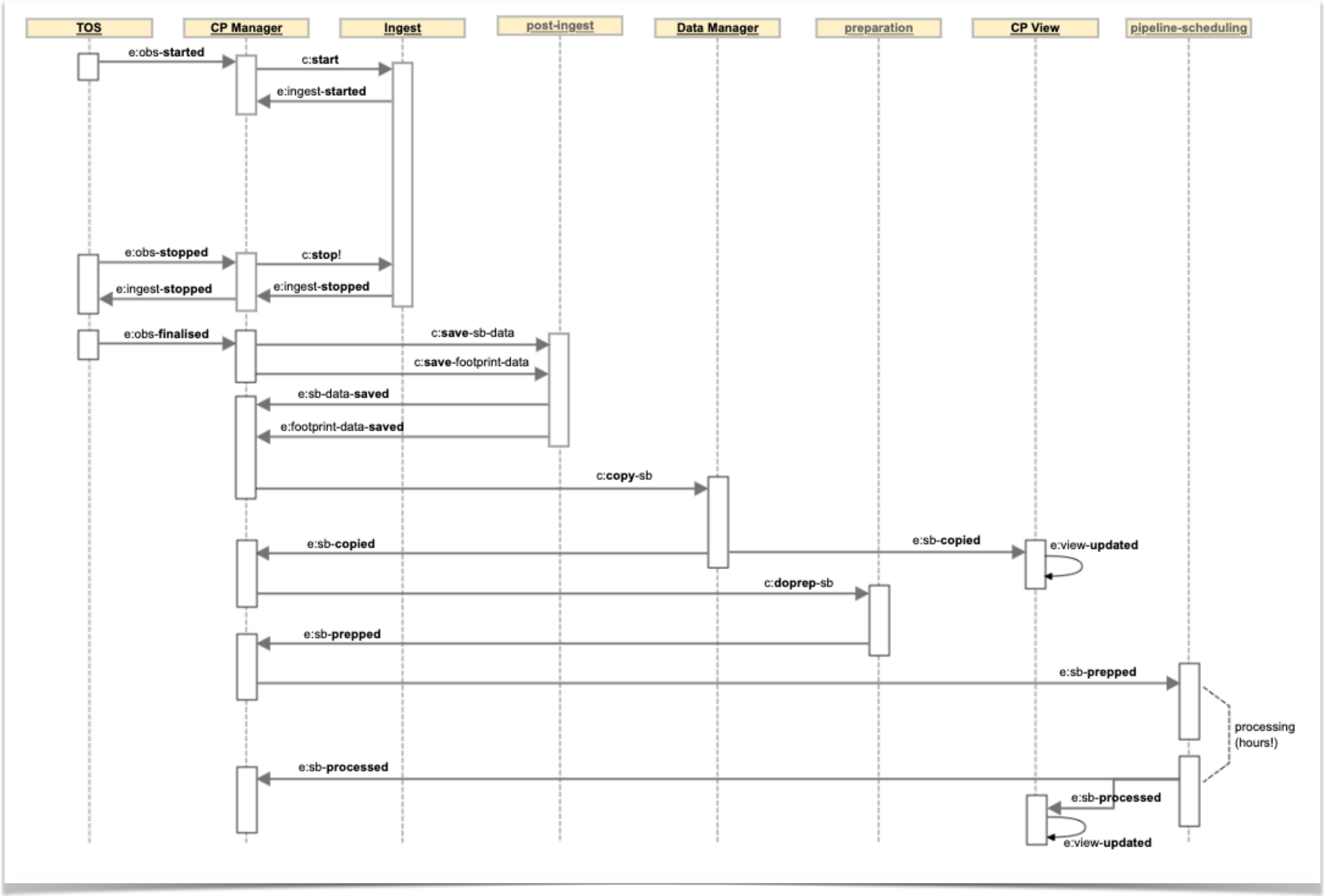


IMAGE: M. AUSTIN, E. BASTHOLM

The rise of CLINK



The path to the future of ASKAP

- ASKAP as a **remote survey instrument** is a unique context for the ATNF, encouraging us to explore a new operational regime
- The system has come a **long way** over the last few years, with big leaps in operability, stability, automation and autonomy
- So far, increasing the autonomy of ASKAP has not needed **AI in the classic sense** in order to replicate human roles - systematic logic has been sufficient for effective automation
- Our work in **CINTEL** will help us to establish collaborative human/machine workflows