The Australian SKA Pathfinder

Status Update

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ASKAP OVERVIEW

Exquisite radio site (~100 people in area size of Netherlands)

Murchison Radio-Astronomy Observatory (MRO)

S26° 42′ 15″, E116° 39′ 32″

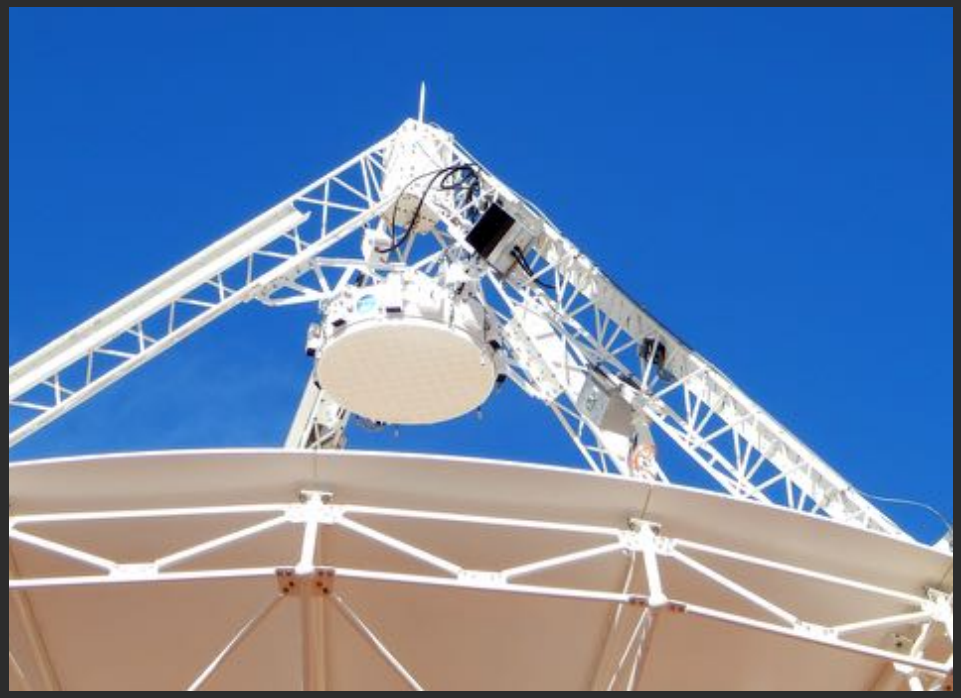
ASKAP (700 – 1800 MHz)

MWA (80 – 230 MHz)

TELESCOPE SPECIFICATIONS

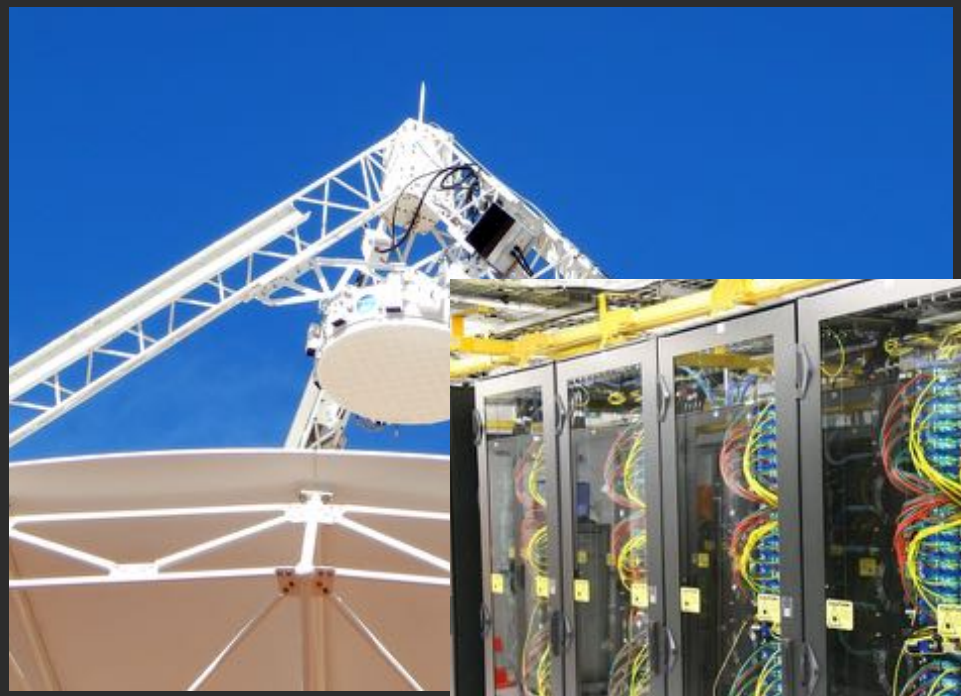
- 36 antennas with chequerboard Phased Array Feeds (PAFs)
- 30 square degree field-of-view sampled with 36 beams
- T_{sys} / η ~ 90 K (Chippendale+ 15)
- Sky frequencies between 700 and 1800 MHz
- 16,416 x 18.5kHz channels (Δv ~ 5 km/s)
- Continuum imaging resolution @ 1400MHz ~ 10 arcseconds
- Spectral imaging resolution @ 1400MHz ~ 30 arcseconds (limited by processing and data storage)

ASKAP OVERVIEW



Mark II phased array feed samples focal plane with 188 dipole elements

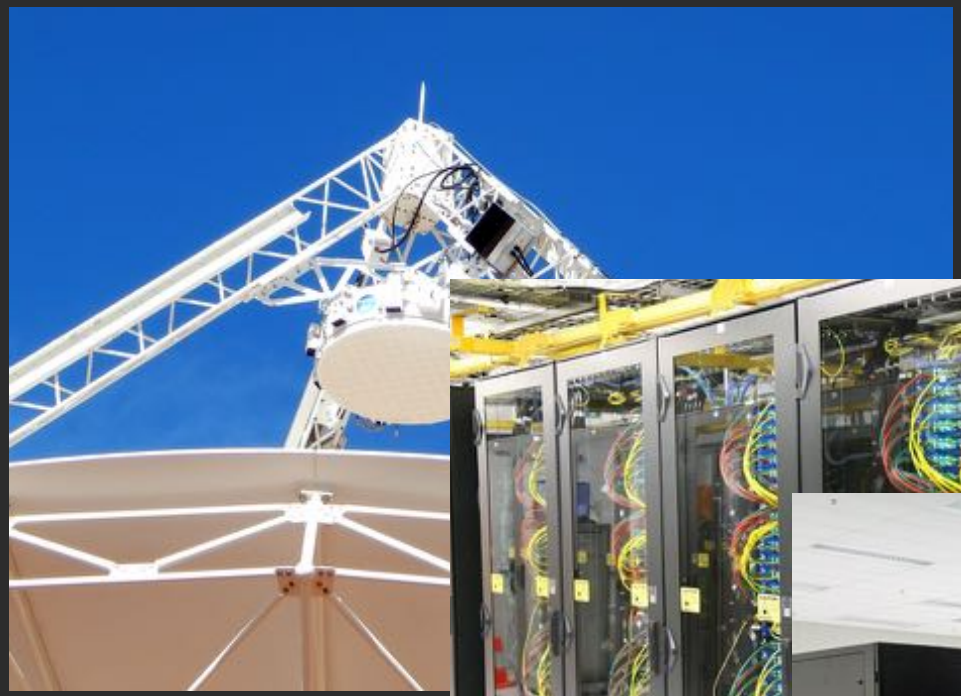
ASKAP OVERVIEW



Digital backend of field-programmable gate arrays at MRO site:

1. Form 304 x 1 MHz channels
2. Form 36 PAF beams using pre-determined weights
3. Form 16,416 x 18.5 kHz fine channels
4. Correlates to form visiblities

ASKAP OVERVIEW



Super Computer at Pawsey Centre (Perth):

1. Ingests data in Measurement Set format
2. Runs ASKAPsoft processing pipeline
3. Archives data products in CASDA
4. Users access CASDA for science

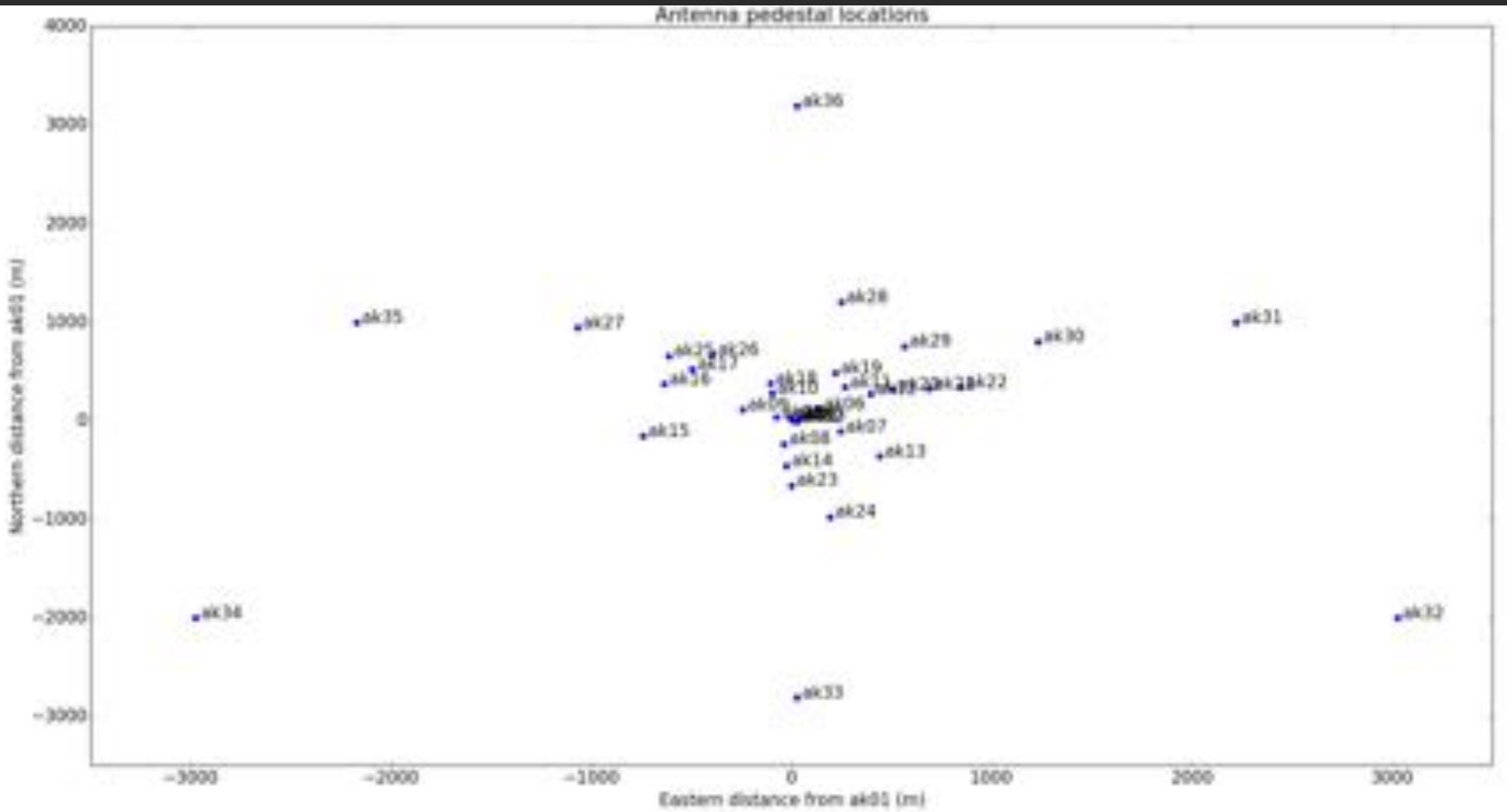
THE SCIENCE SURVEYS

- EMU (70 million radio sources, S > 10 μJy/beam)
- WALLABY (HI in 500,000 galaxies @ $z < 0.26$)
- DINGO (Deep HI in ~100,000 galaxies @ z < 0.4)
- FLASH (150,000 sight-lines for HI absorption @ $0.4 < z < 1$)
- VAST (slow variables and transients, $\Delta t > 5$s)
- GASKAP (ISM in Milky Way & Magellanic System, zooms)
- POSSUM (Rotation measure grid of the southern sky)
- CRAFT (fast transients e.g. FRBs, $\Delta t < 5$s)

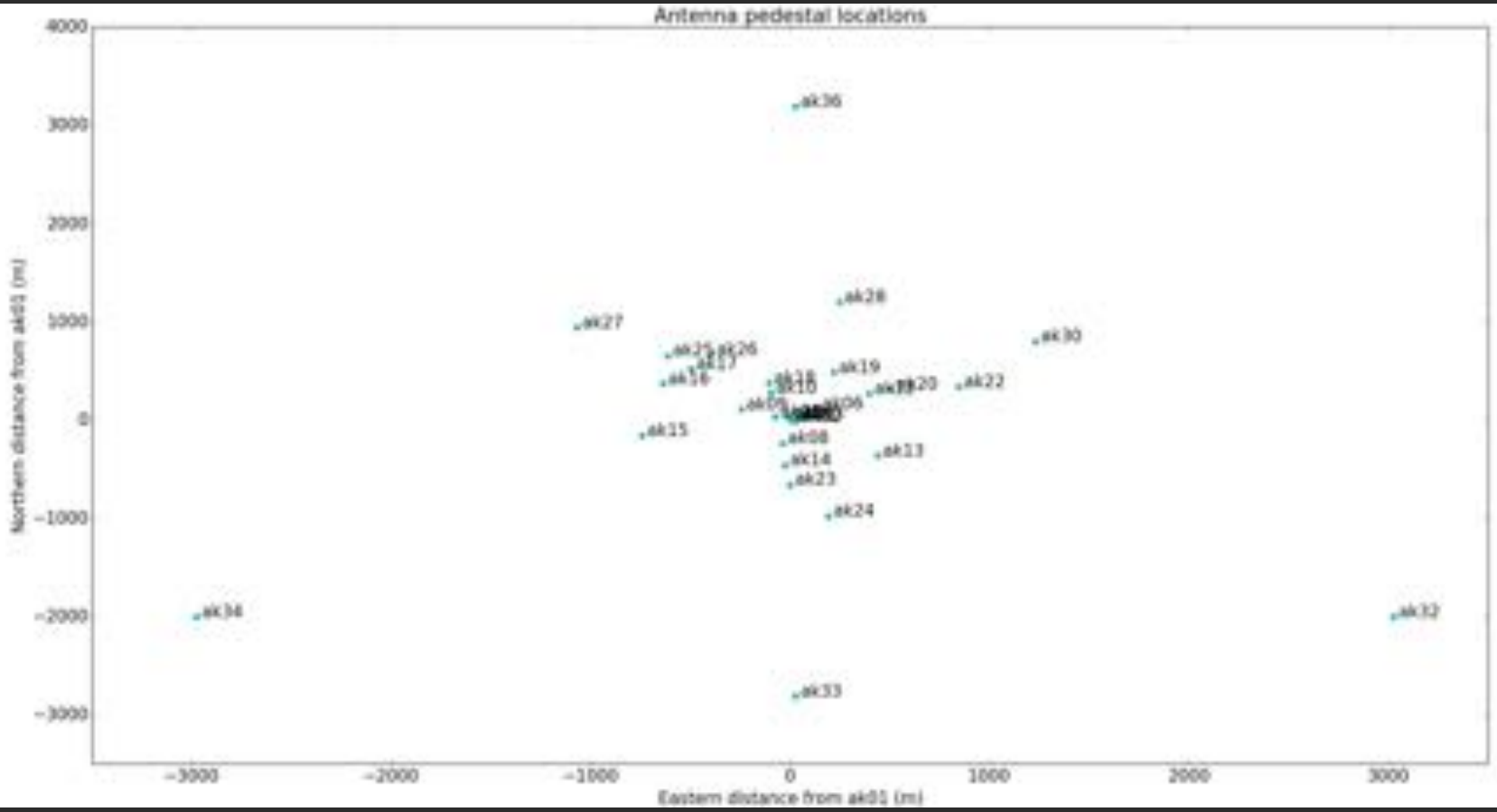
HARDWARE INSTALLATION PROGRESS

- 36 antennas: 30 have PAFs, last 6 by September 2017
- Most antennas now have an on-dish calibrator system
- 22 ants. with back ends (timing, digitizers, beam former)
- 5 correlator blocks installed each with 48MHz bandwidth

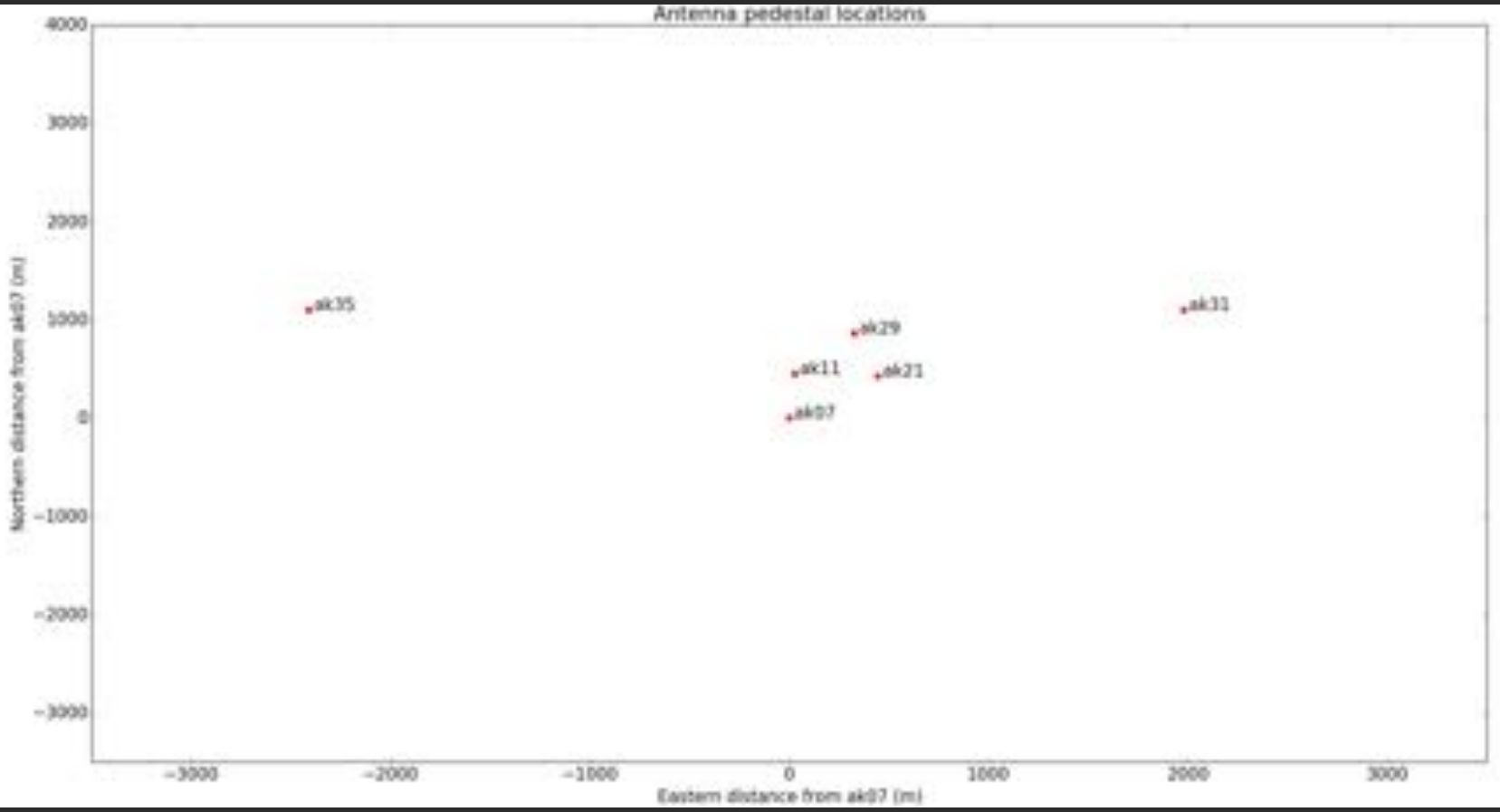
ANTENNA LOCATIONS – FULL ARRAY



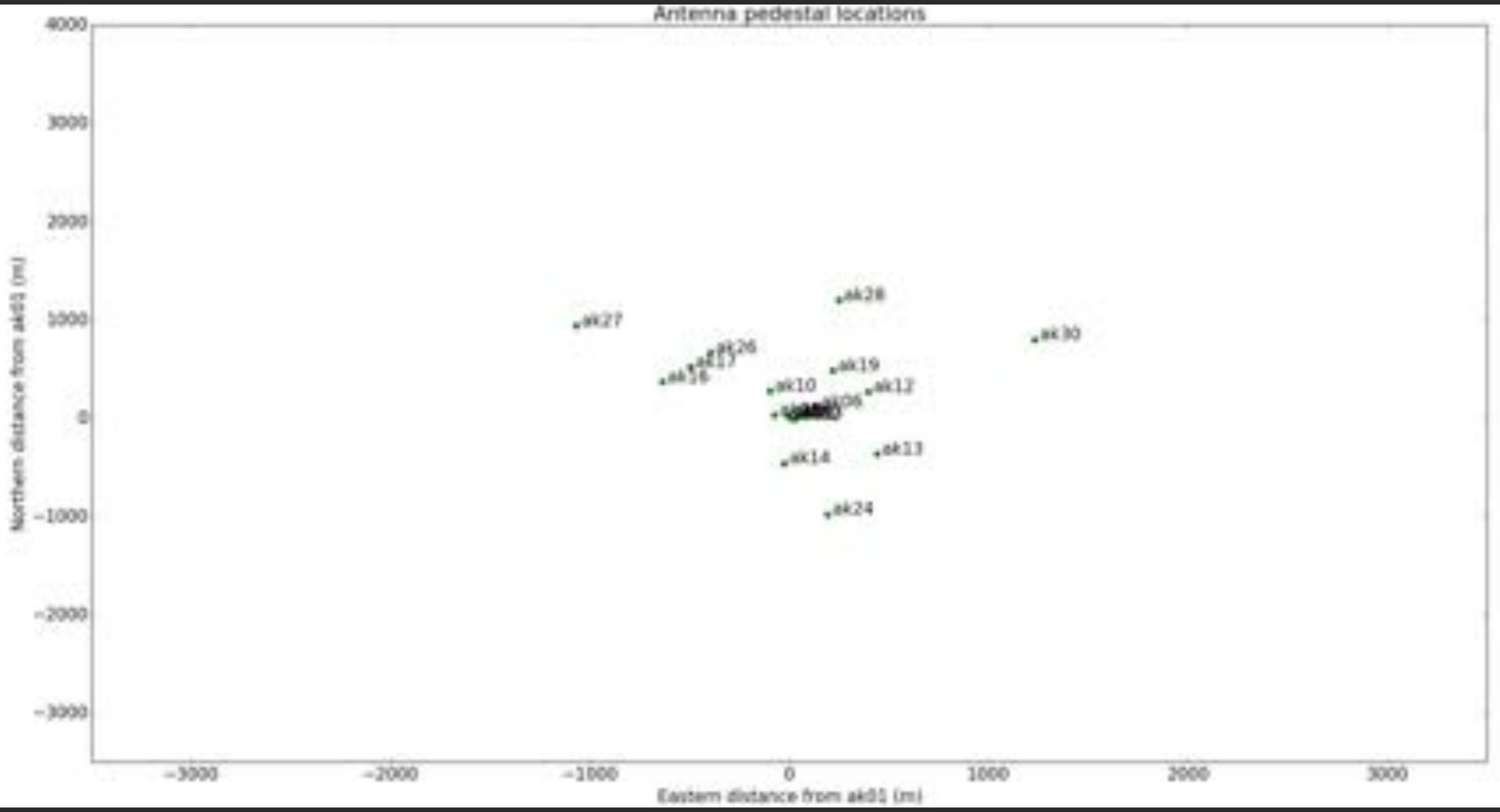
ANTENNA LOCATIONS – WITH PAFS



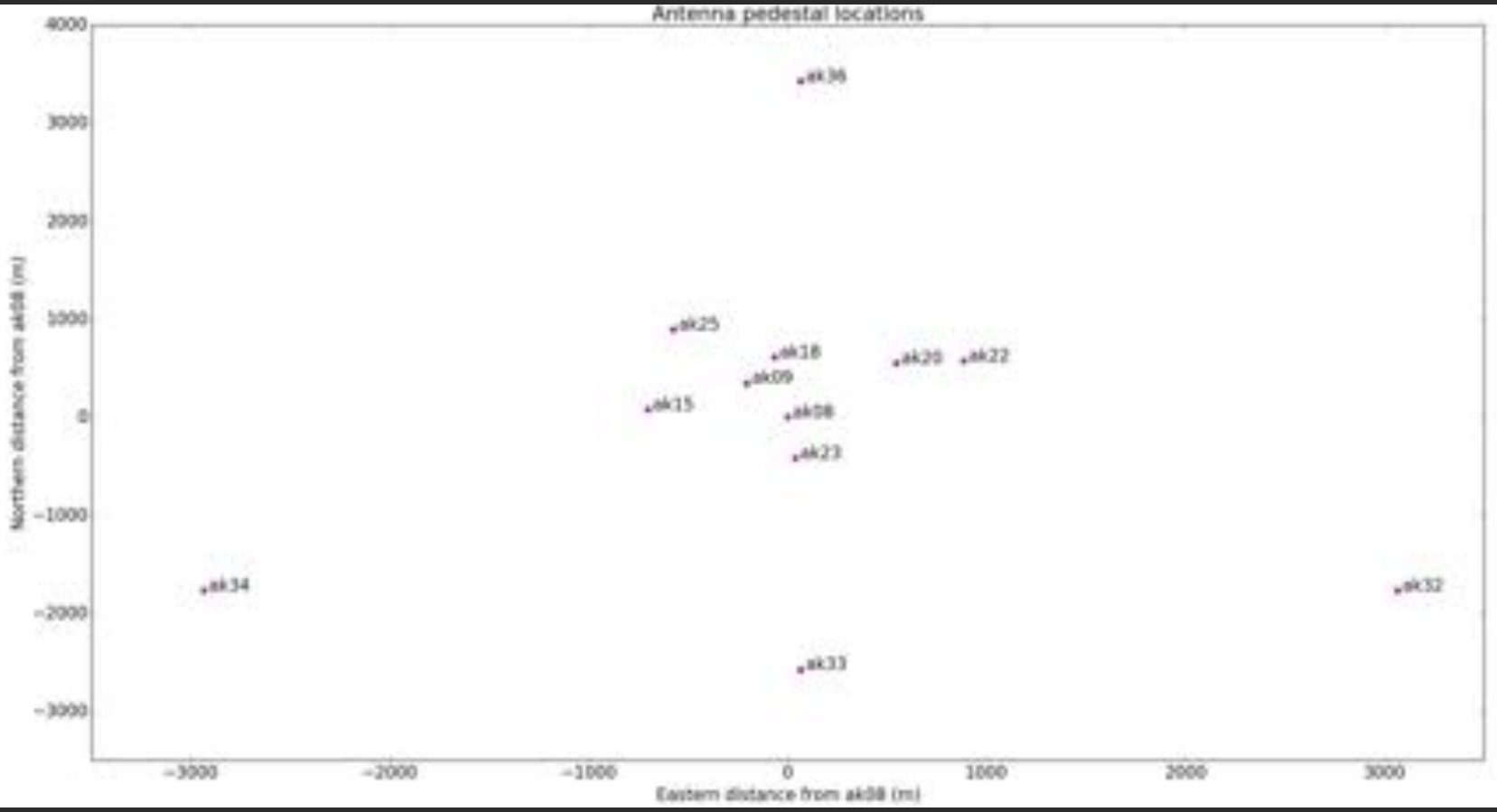
ANTENNA LOCATIONS – WITHOUT PAFS



ANTENNA LOCATIONS – OPERATIONAL



ANTENNA LOCATIONS – ACCEPTANCE TESTING



TELESCOPE TIMELINE

- Past: ASKAP-BETA (Array release 1), engineering tests, commissioning and science verification
- Present: ASKAP-12 (Array release 2), official program of early science begins
- April 2018: ASKAP-18 (Array release 3)
- Dec 2018: ASKAP-36 (Array release 4), commence full science operations with basic modes
- June 2018: Integration & verification of extended modes – full polarization, transient and zoom mode imaging

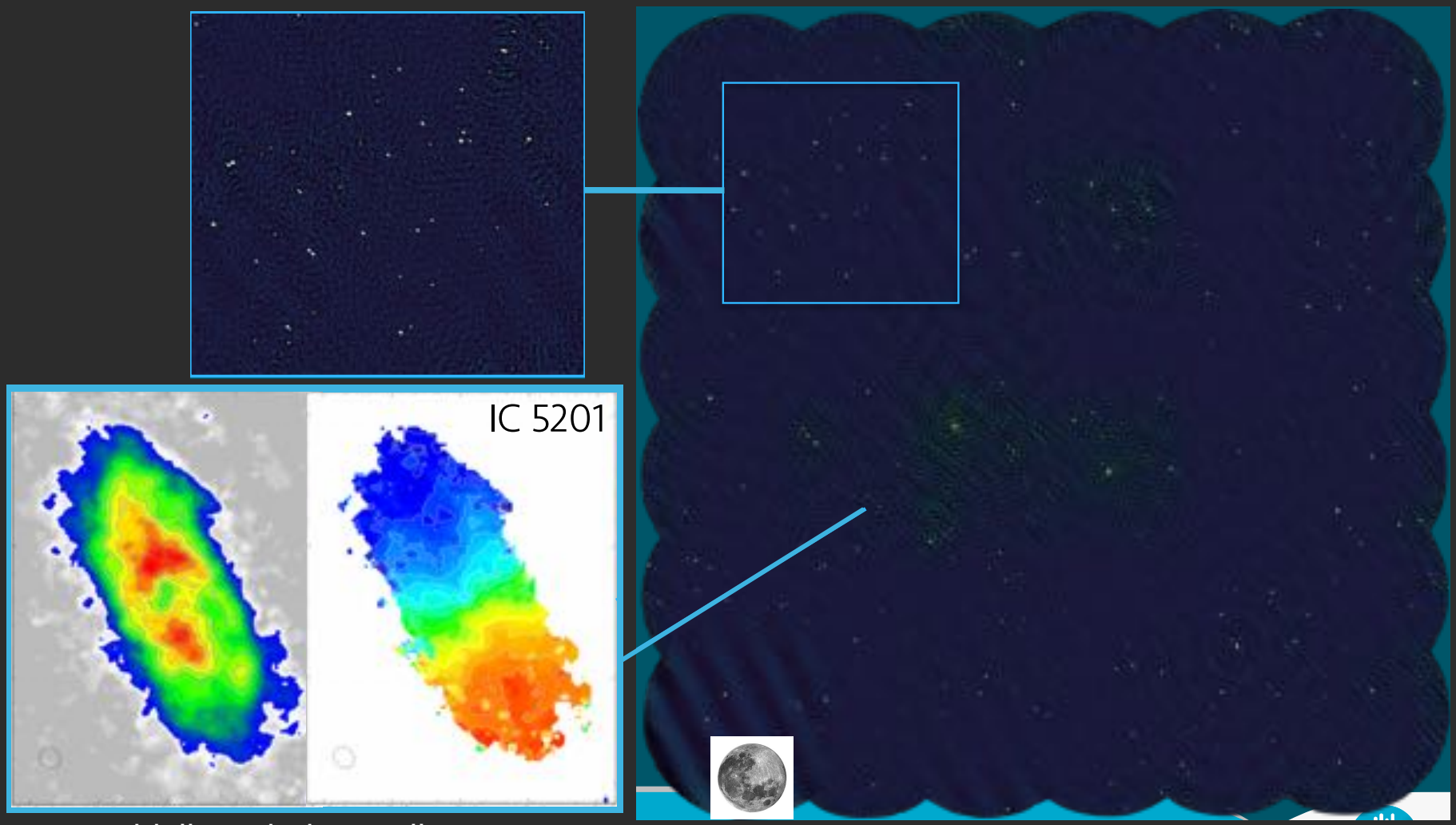
EARLY SCIENCE PROGRAM

- 12 antennas, 36 PAF beams, 300 MHz bandwidth
- Two main observing streams (~800 hrs each):
  - Wide-area survey @ 700 - 1800 MHz (4-12 hrs per field)
  - A few fields @ 1150 – 1450 MHz (120 hrs per field)
- Additional early science observations:
  - A deep (~100hr) field @ 1000 – 1300 MHz for HI stacking
  - Zoom mode observing program
  - Targeted observations of bright radio AGN for HI absorption

CURRENT STATUS

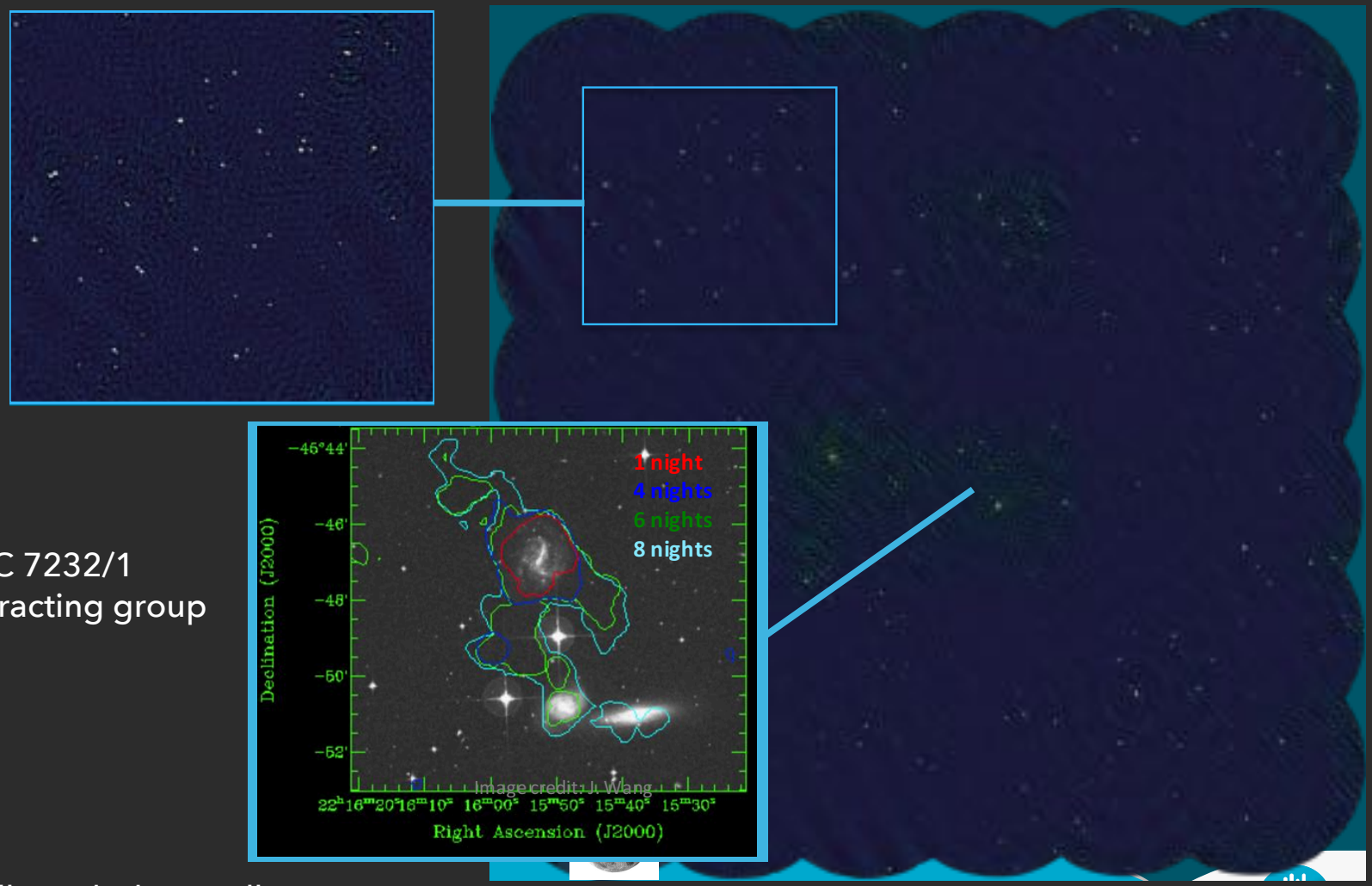
- Available bandwidth and no. PAF beams currently limited by digital backend hardware and ingest pipeline
- Several fields observed so far in early science program:
  - LMC: 48 MHz bwidth & 30 beams (12hrs)
  - GAMA 23: 144-192 MHz bwidth & 36 beams (12hrs)
  - NGC 7232: 48 MHz bwidth & 36 beams (140hrs)
  - Fornax, Dorado, M83: 192 MHz & 36 beams (70 - 160hrs)
- Good progress in building ASKAPsoft data processing pipeline

RECENT RESULTS – NGC 7232 FIELD



Lee-Waddell, Madrid, Marvill +

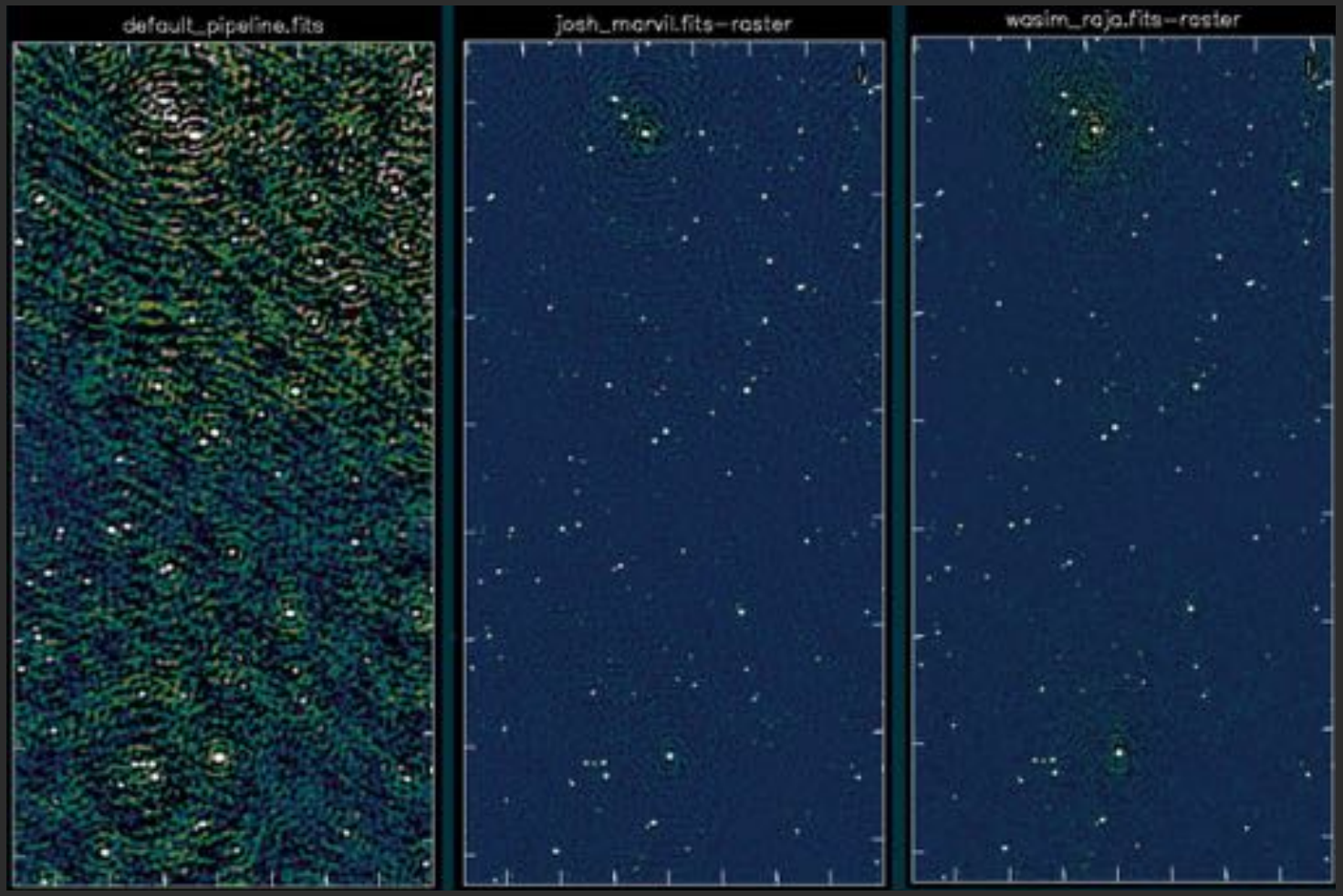
RECENT RESULTS – NGC 7232 FIELD



NGC 7232/1
Interacting group

Lee-Waddell, Madrid, Marvill +

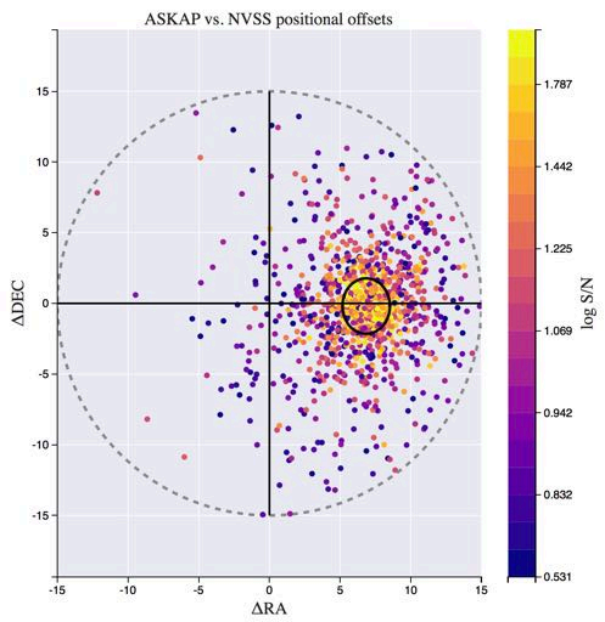
RECENT RESULTS – FINE TUNING ASKAPSOFT IMAGING

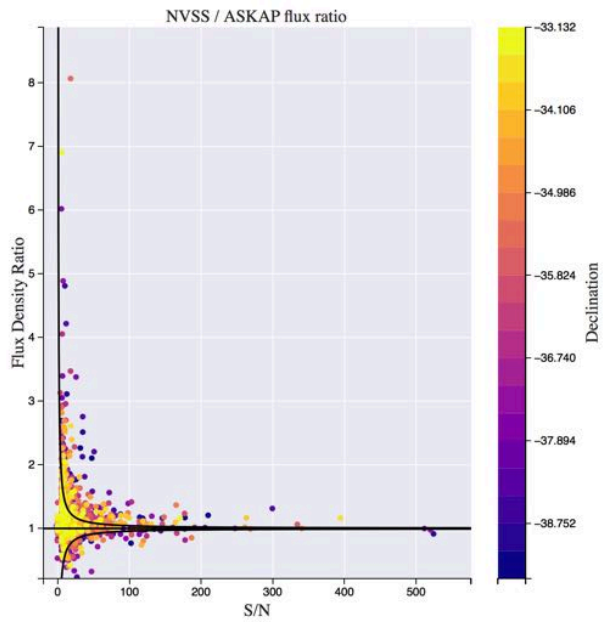


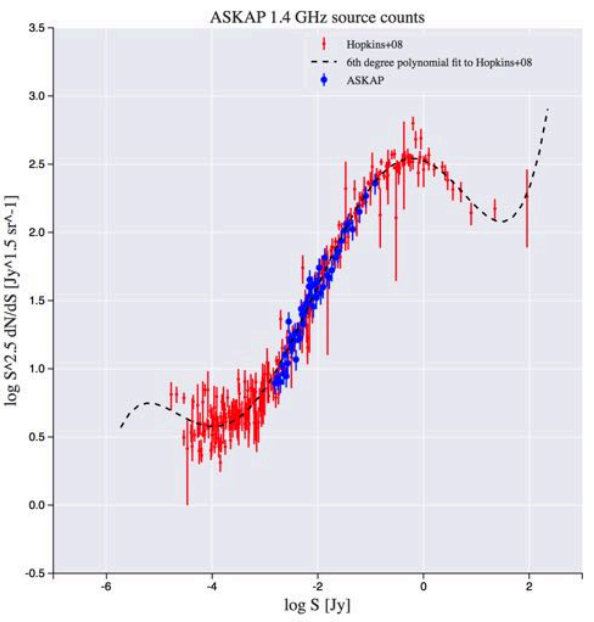
Whiting, Marvill and Raja

Credit: **Processing by Ian Heywood**

RECENT RESULTS — DATA VALIDATION TOOLS



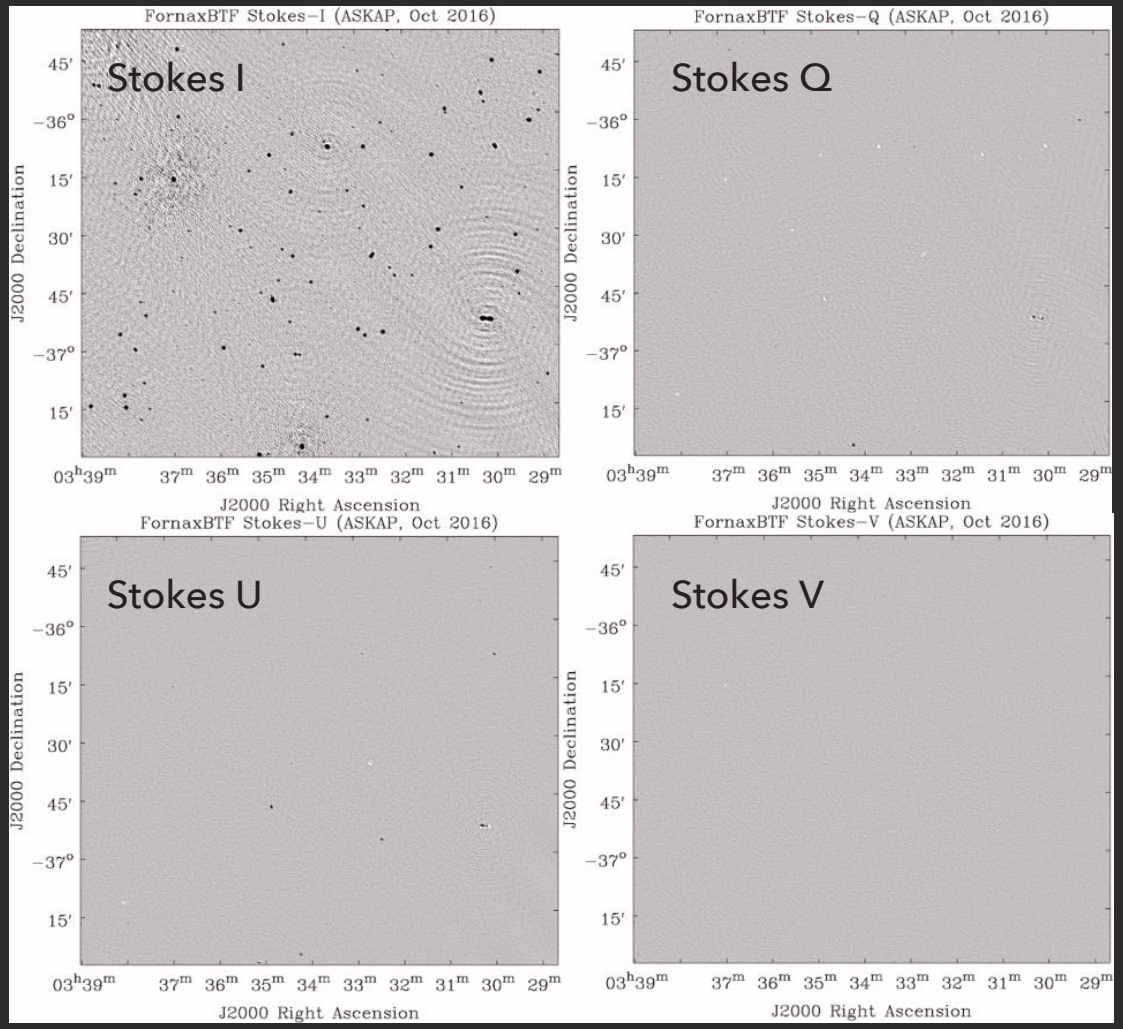




Collier, Marvil +

RECENT RESULTS – POLARIZATION IN FORNAX FIELD

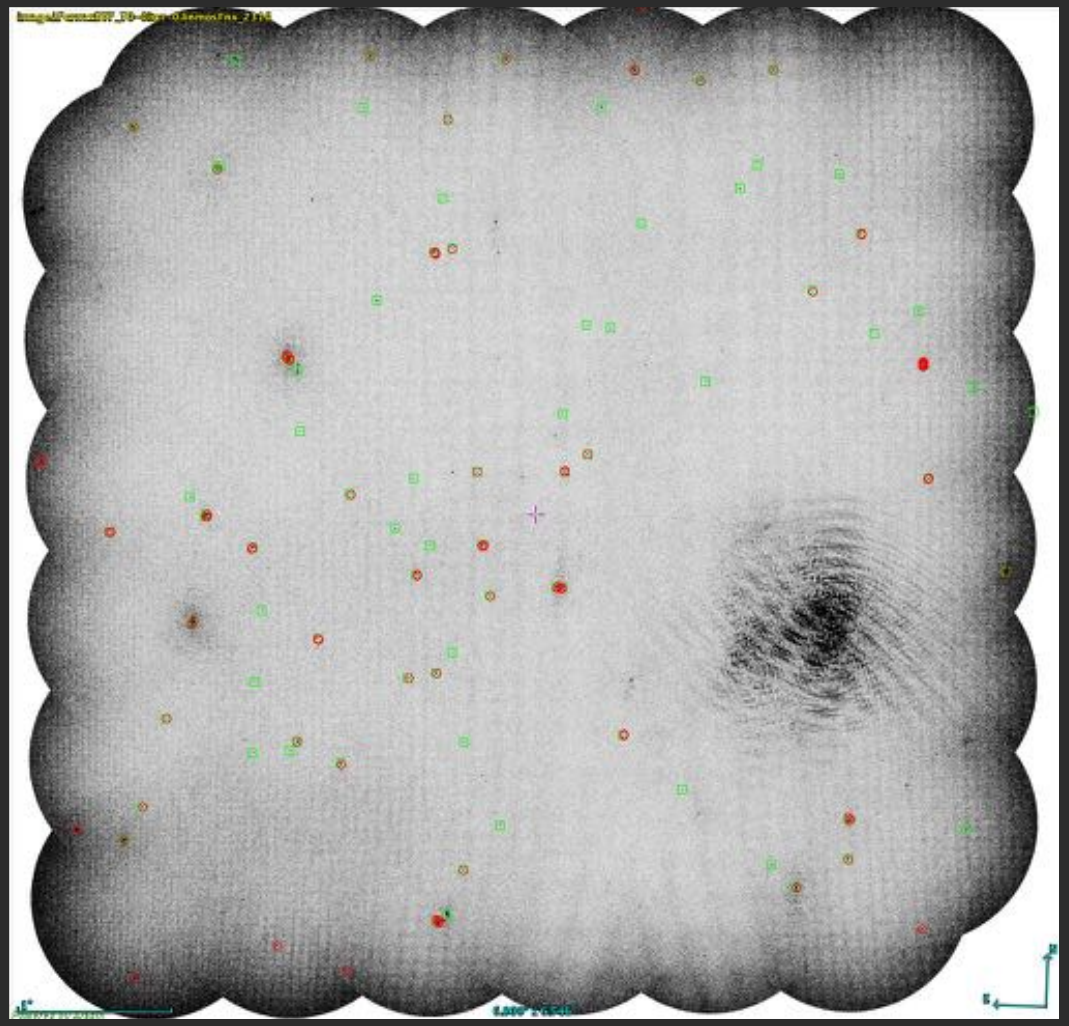
- Rotate single antenna by 5° to introduce leakage
- Calibrate XY-phase using unpolarised calibrator 1934-638
- Stokes V image of field consistent with noise



Anderson, Raja, Sault +

RECENT RESULTS – POLARIZATION IN FORNAX FIELD

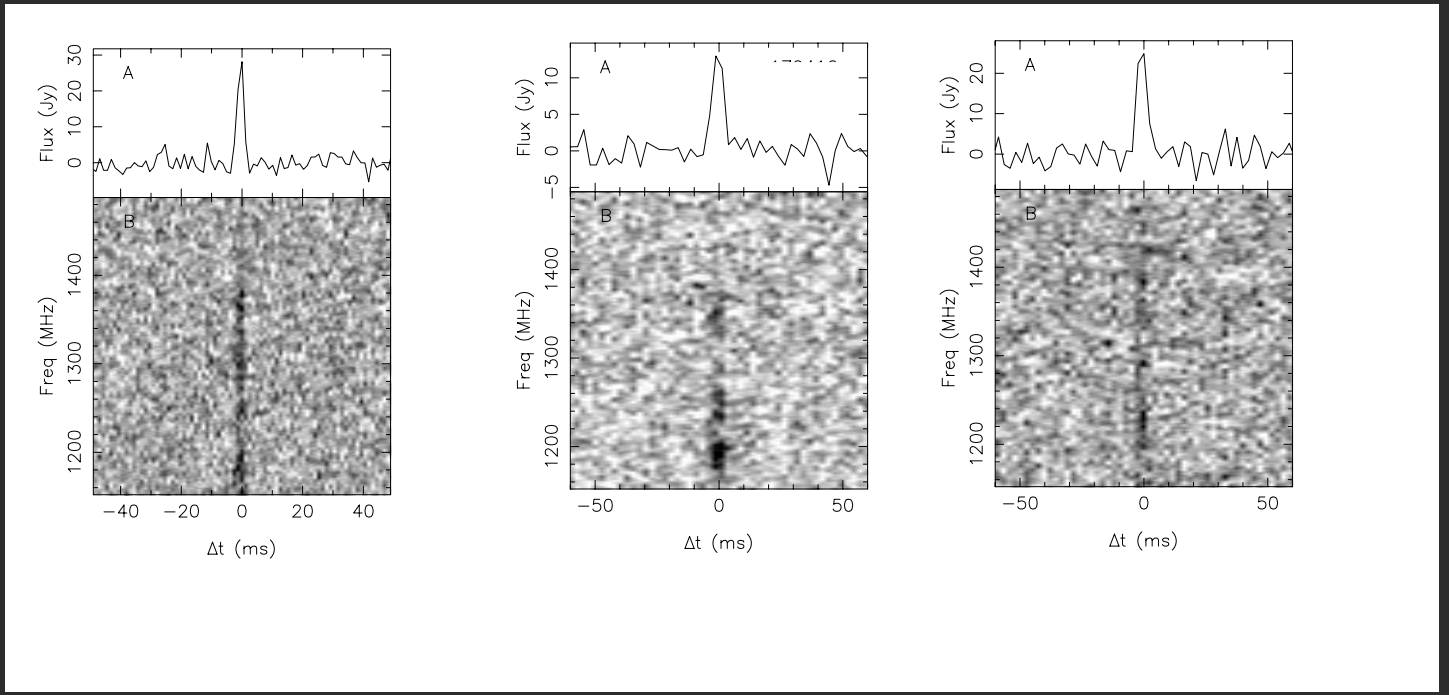
- Linear mosaic of polarized flux density
- Green – ATCA polarized sources
- Red – Taylor+ 09 catalogue
- Future improvements from ODC and shaped constrained beams



Anderson, Raja, Sault +

RECENT RESULTS – FAST RADIO BURSTS

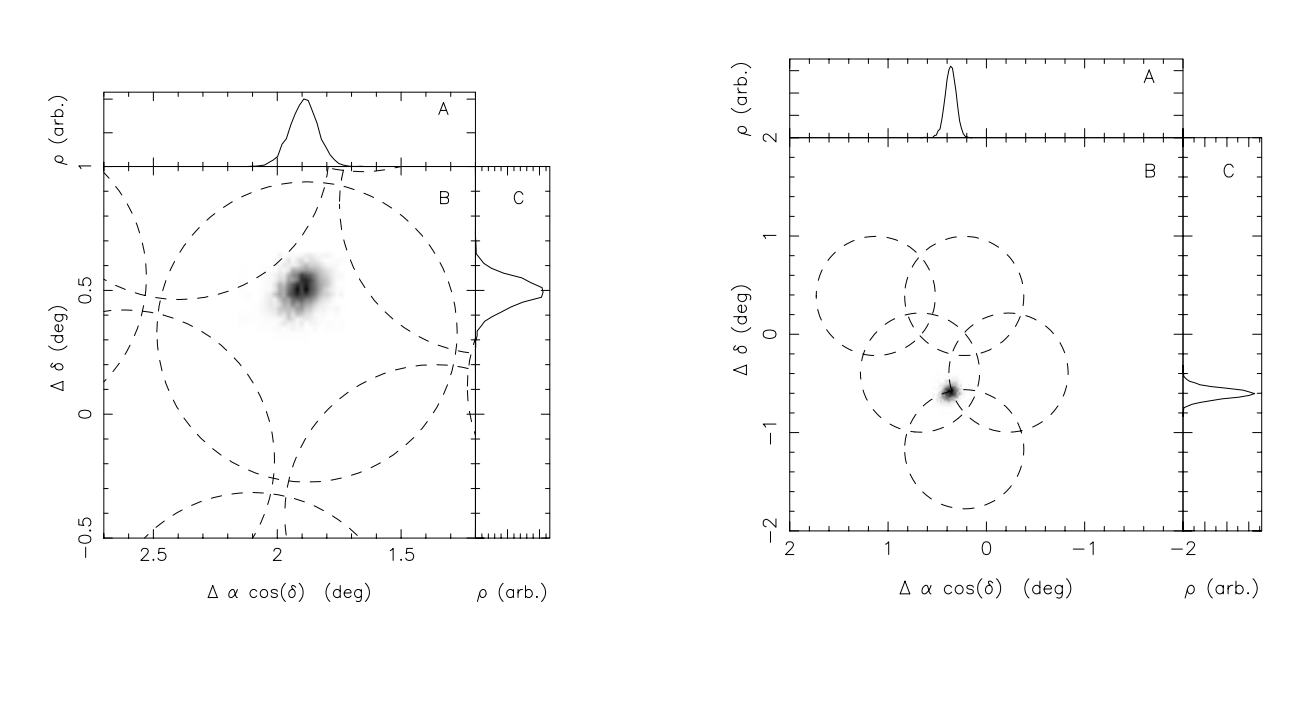
- ASKAP as “fly’s” eye: point antennas in different direction
- PAFs: very wide and shallow search
- **Bright FRBs exist (Lorimer, 150807)!**



Bannister, Macquart, Shannon +

RECENT RESULTS – FAST RADIO BURSTS

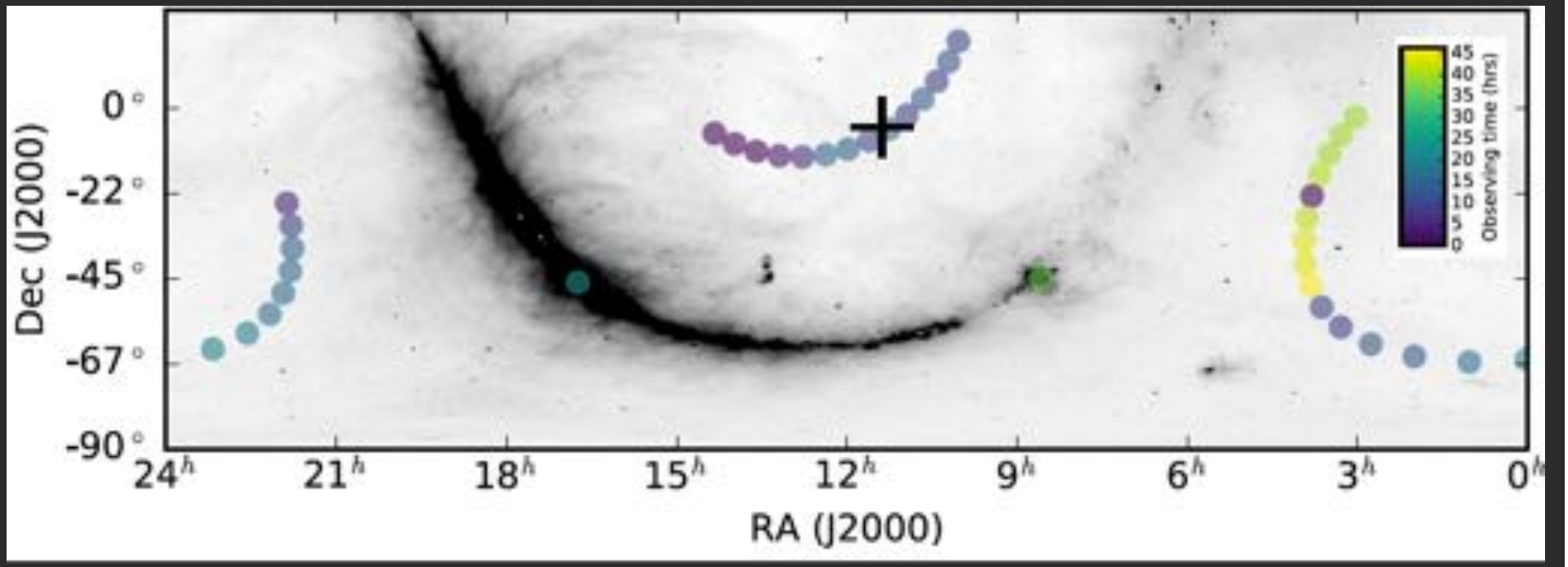
- Use multiple beam detections to determine position of burst within individual beam
- Possible because beams oversample focal plane



Bannister, Macquart, Shannon +

RECENT RESULTS — FAST RADIO BURSTS

- Next steps:
  - Find more FRBs → rates + number counts
  - Automated shadowing using Murchison Widefield Array

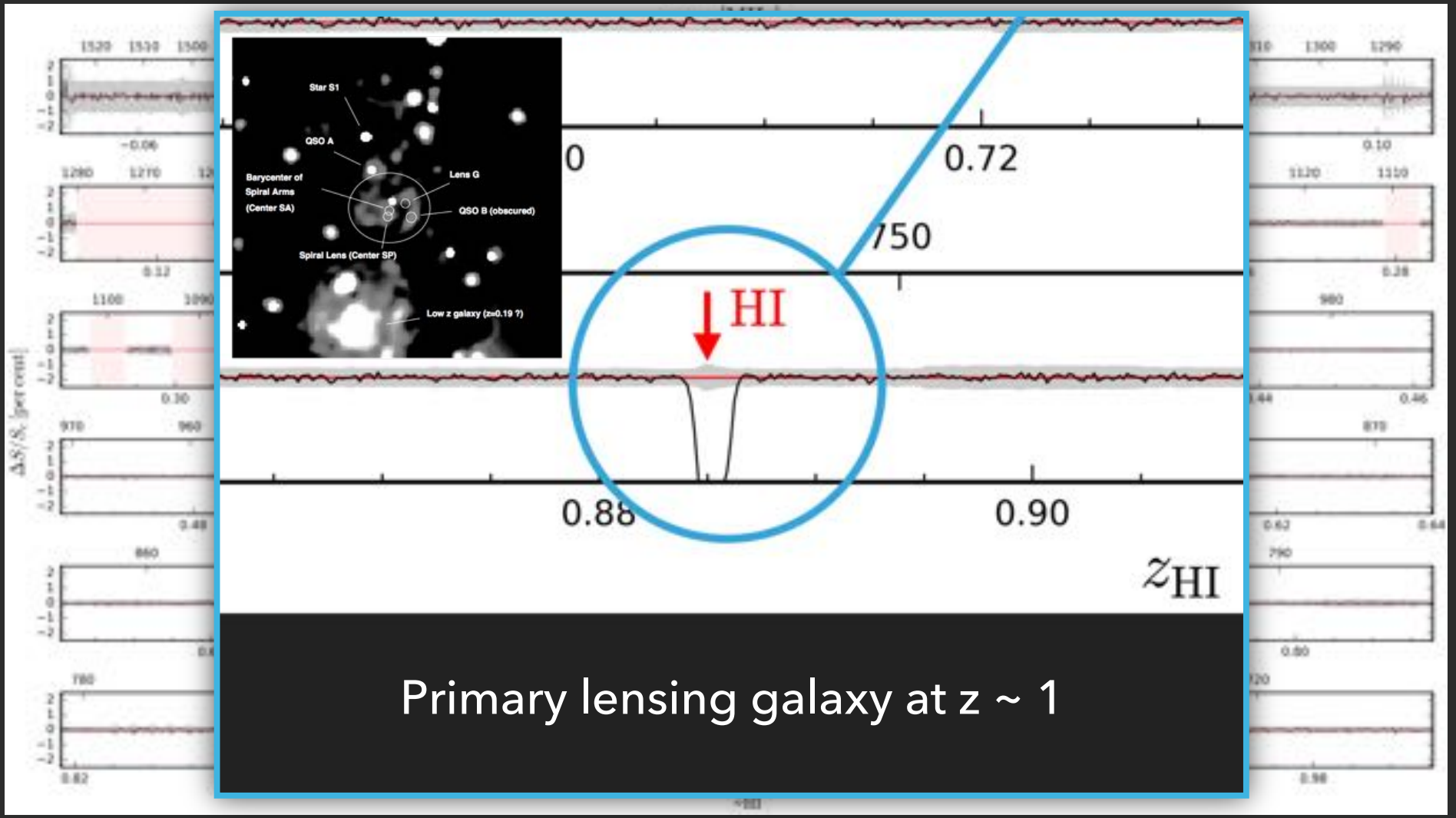


Bannister, Macquart, Shannon +

RECENT RESULTS – HI ABSORPTION

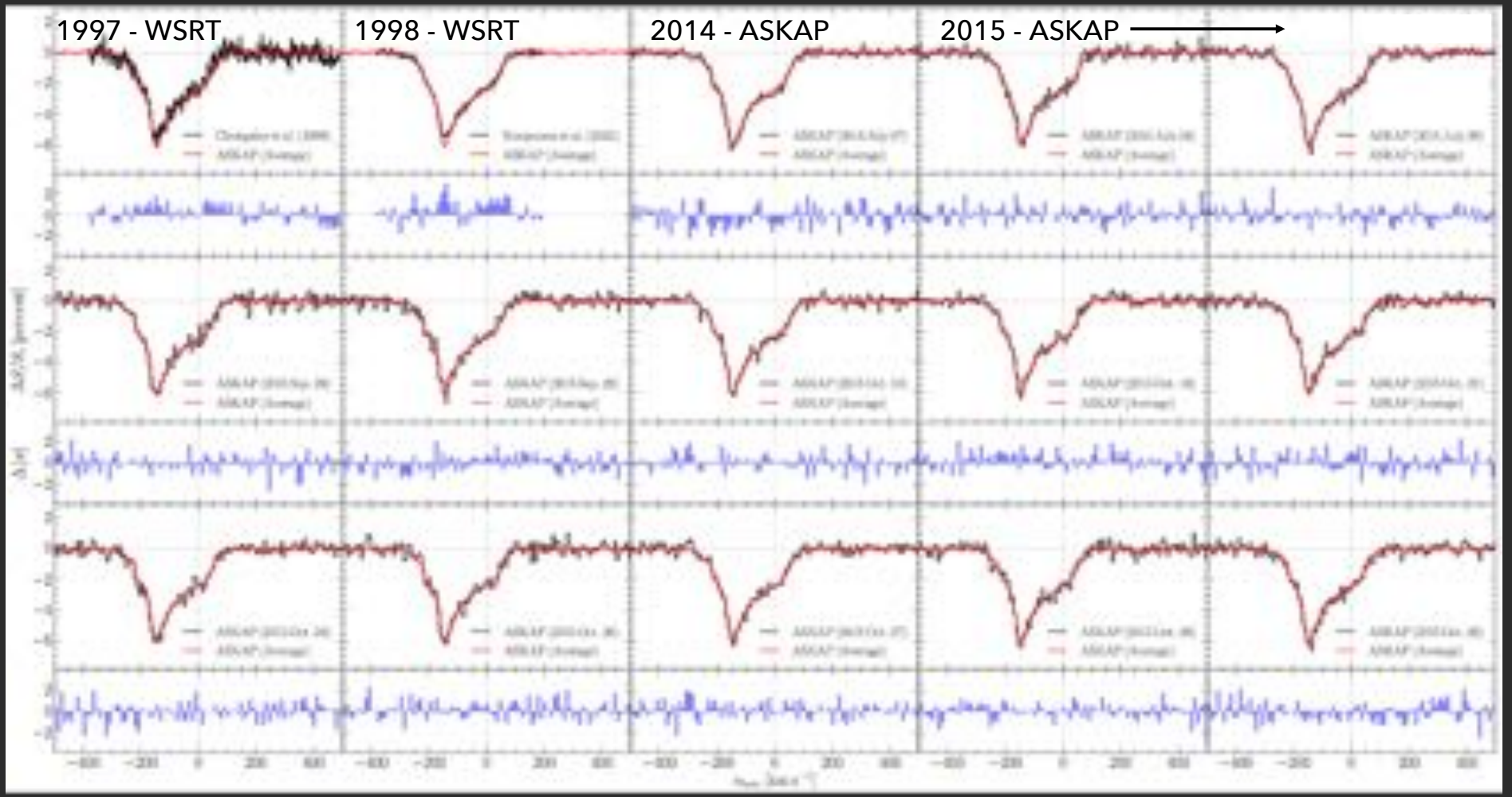
- Single-beam pointed observations towards samples of bright radio sources
- Focus on redshifts between z_{HI} = 0.4 and 1
- Samples for both intervening and associated absorption
- See talks by Elaine Sadler, Vanessa Moss and Elizabeth Mahony

RECENT RESULTS – HI ABSORPTION SPECTRUM



Allison+17

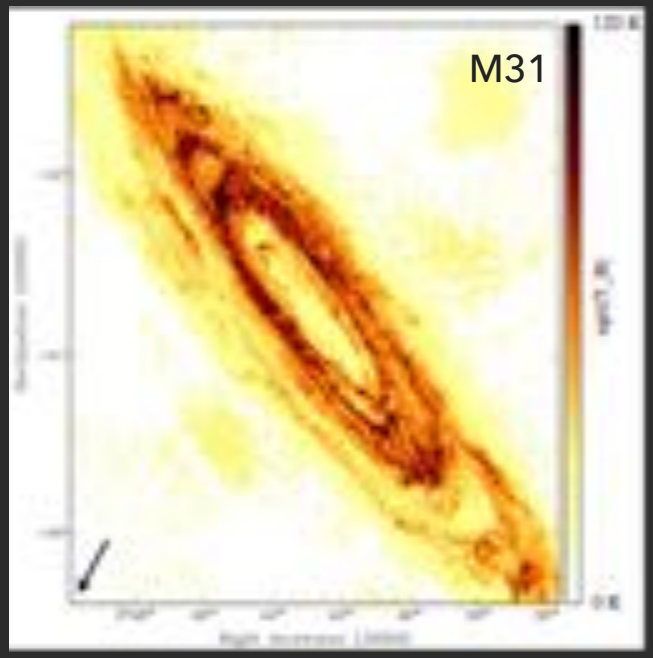
RECENT RESULTS – HI ABSORPTION VARIABILITY



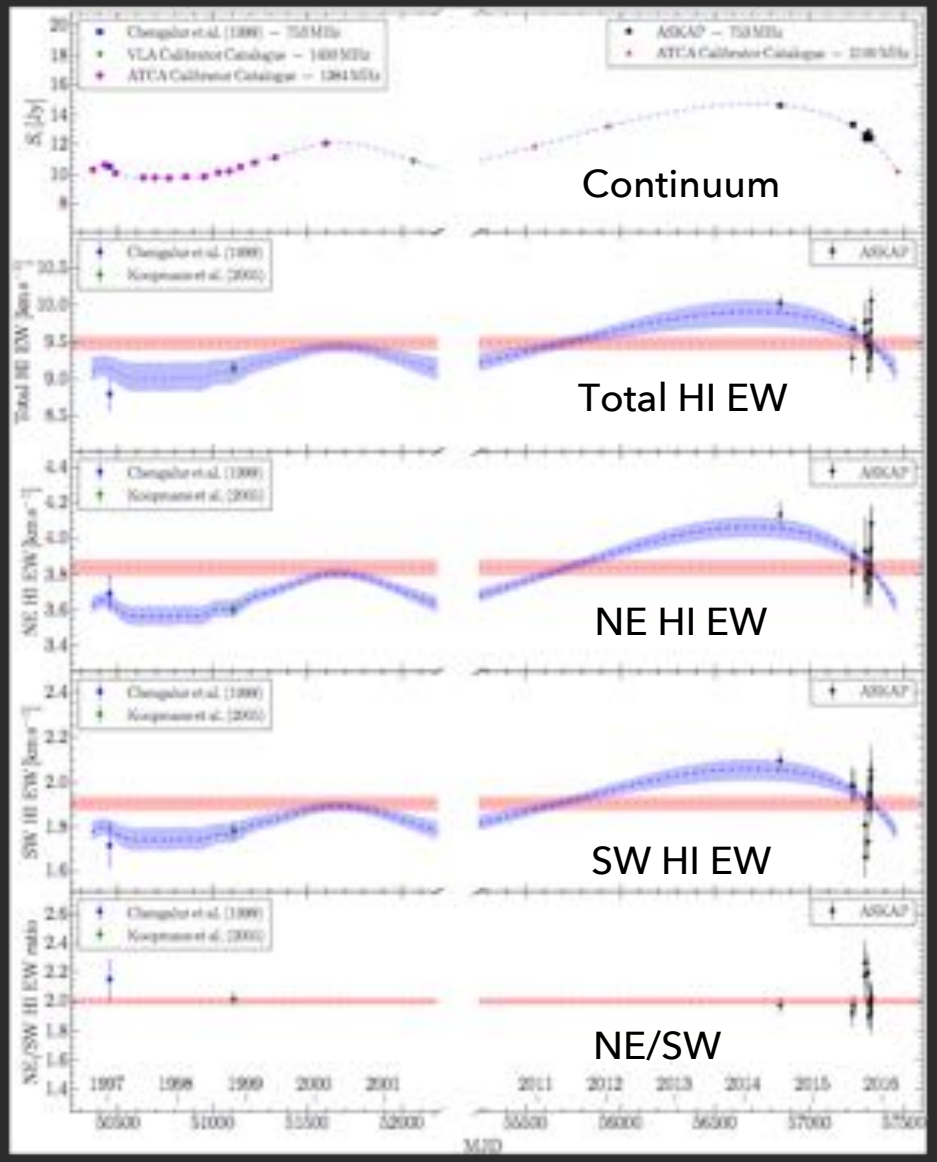
Allison+17

ASKAP EARLY SCIENCE

- Intrinsic brightening/fading of quasar core changes surface brightness distribution of source
- Drives correlated changes in the HI line
- Illuminates ~100pc self-opaque HI structures, as seen in Local Group galaxies



Braun+ 09



Allison+ 17

Early science data rates and file sizes

For 12 antennas and 192MHz bandwidth:
ingest rate ≈ **320 GB/hr**

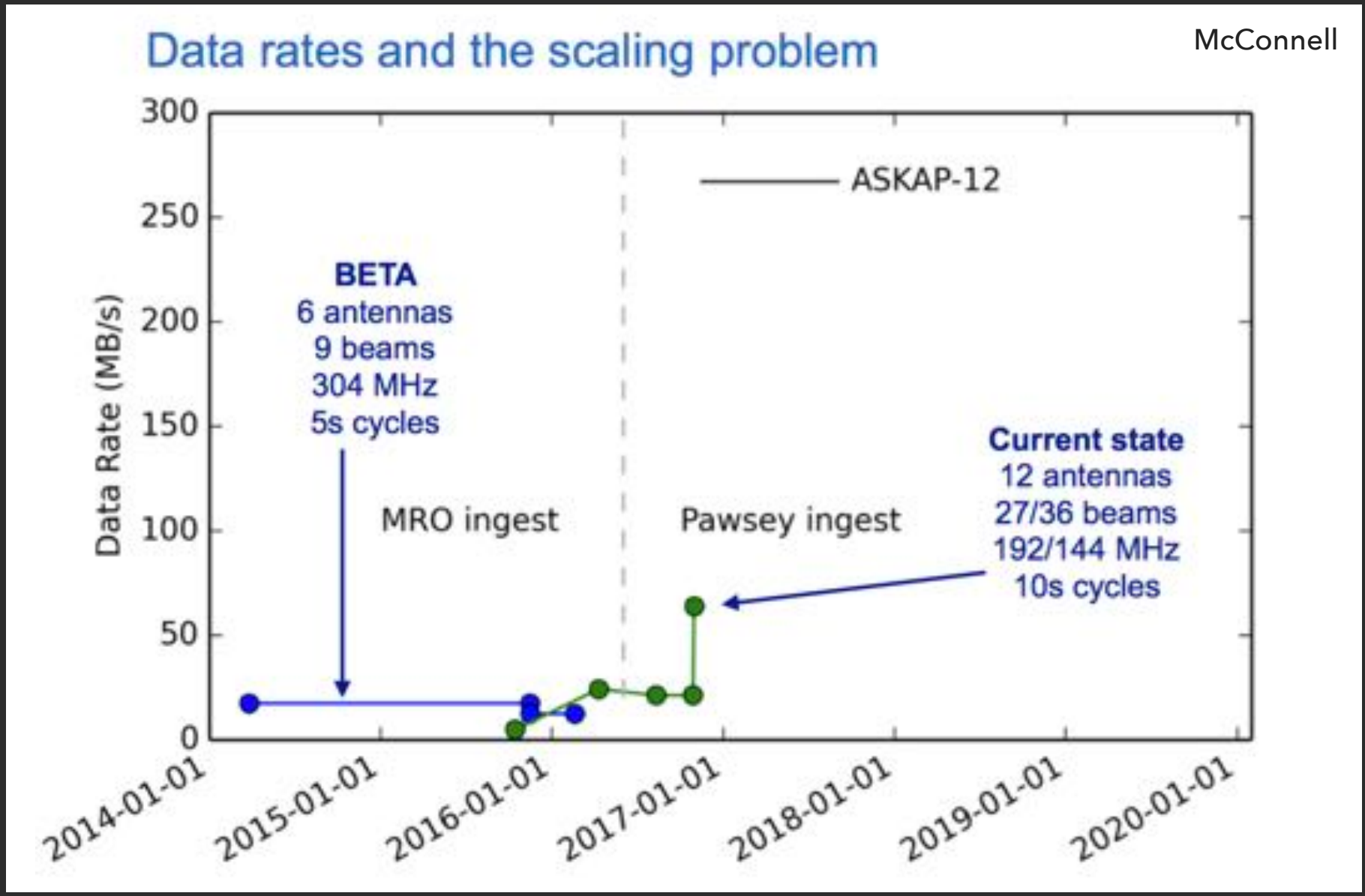
12 hours of observations ≈ **4 TB** raw data

Processing

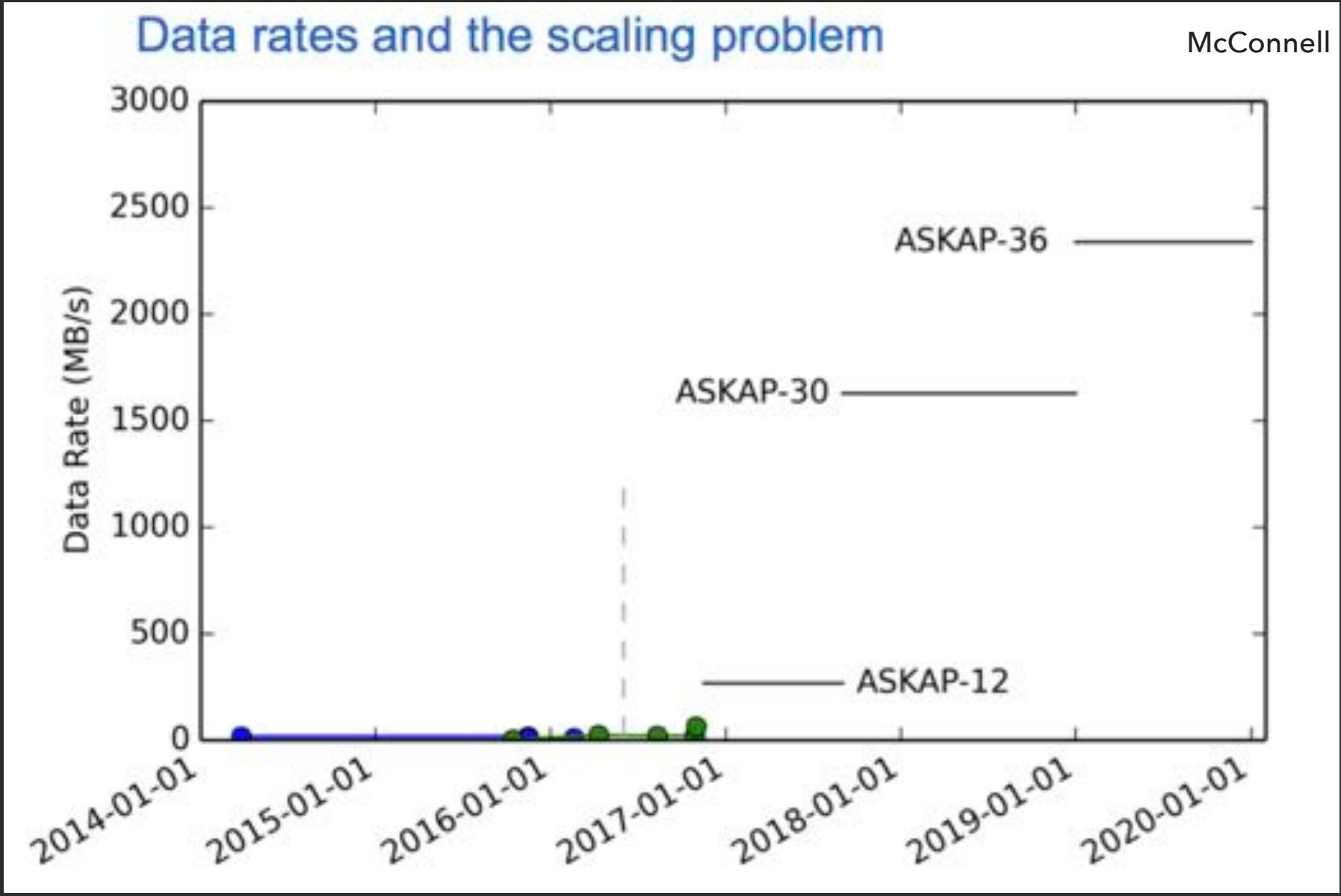
12 hours of observations ≈ **20 TB** total for Early Science

DATA RATES

McConnell



DATA RATES


Data rates and the scaling problem
McConnell
3000
2500
2000
1500
1000
500
0
Data Rate (MB/s)
ASKAP-36
ASKAP-30
ASKAP-12
2014-01-01
2015-01-01
2016-01-01
2017-01-01
2018-01-01
2019-01-01
2020-01-01

OPORTUNITIES & CHALLENGES FOR HI ABSORPTION

- PAFs offer:
  - Capability for wide-field radio-selected absorption survey
  - Better bandpass properties, reduction in standing waves
- MRO site is mostly RFI free at 700 – 1000 MHz enabling blind search on sight-lines between z_{HI} = 0.4 and 1
- Bandpass correction / residual continuum subtraction is dominated by formation of PAF beams at $\Delta\nu_{bm}$ = 1 MHz
  - Requires good calibration source or larger $\Delta\nu_{bm}$ to avoid subtracting $\Delta v > 400$ km/s lines

OPORTU

- PAFs
  - Cap
  - Bet
- MRO
  searcl
- Bandp
  domi
  - Rec
    sub

vey

ves

blind

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