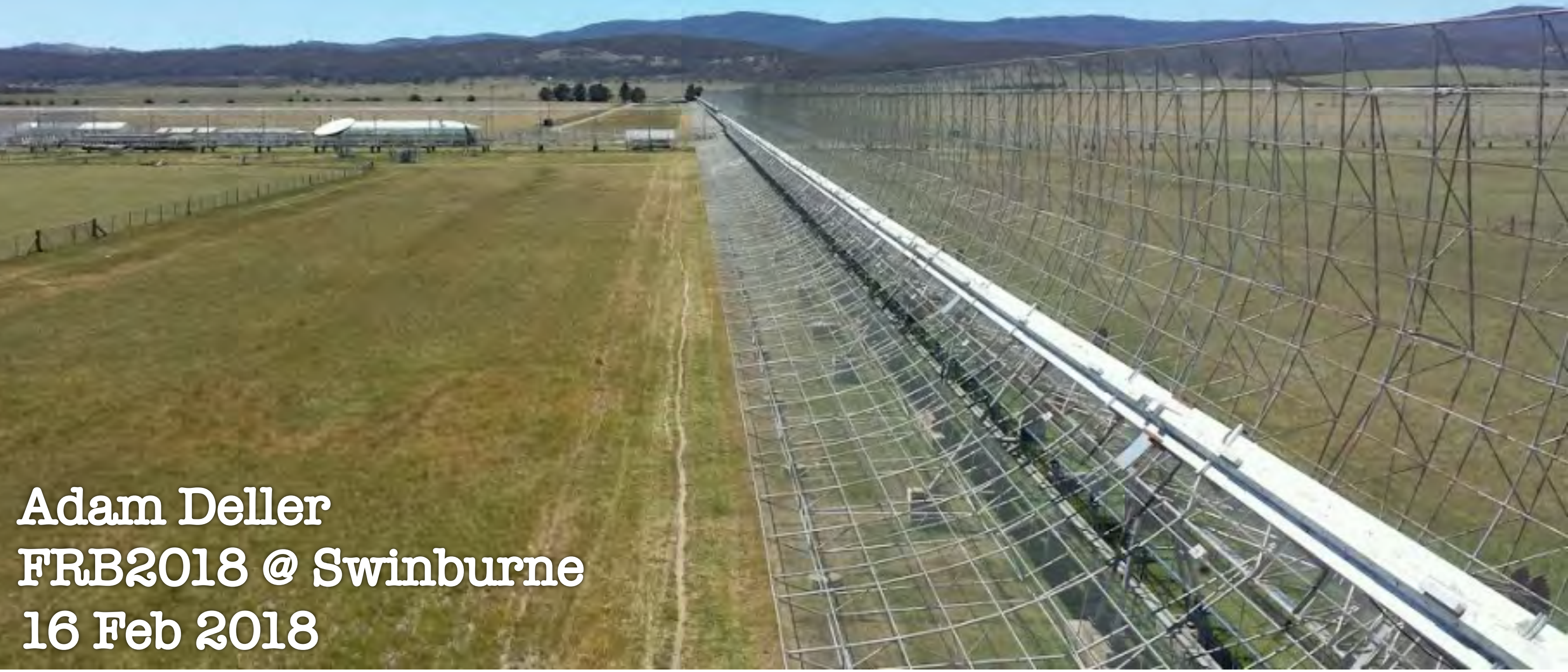
UTMOST-2D

Arcsecond-level FRB localisation with Molonglo



Adam Deller

FRB2018 @ Swinburne

16 Feb 2018

Australian National University

CAASTRO ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

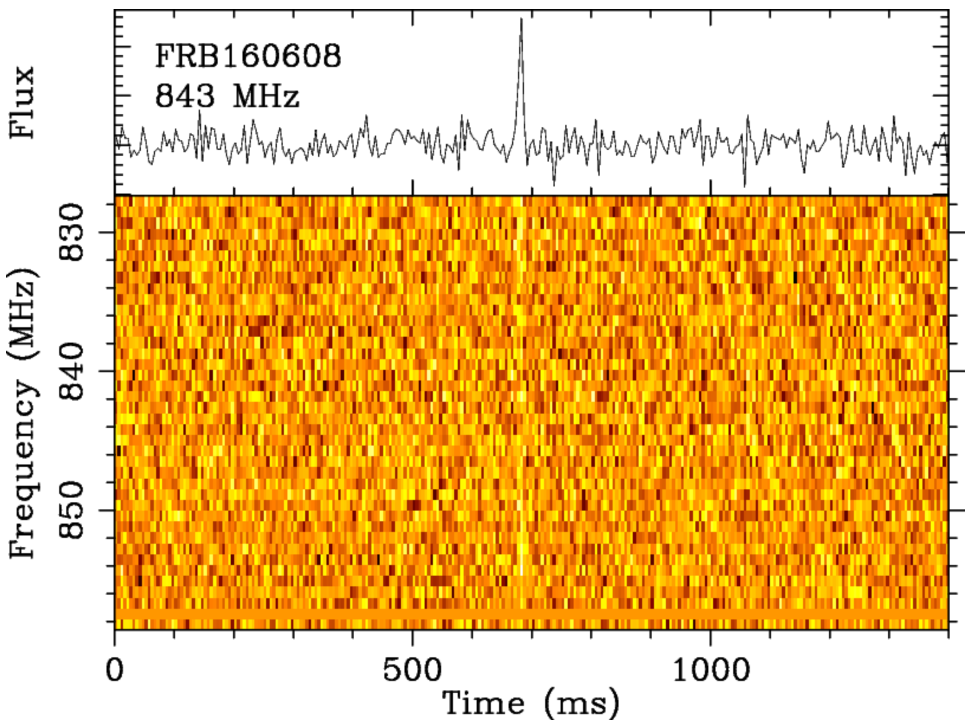
CSIRO

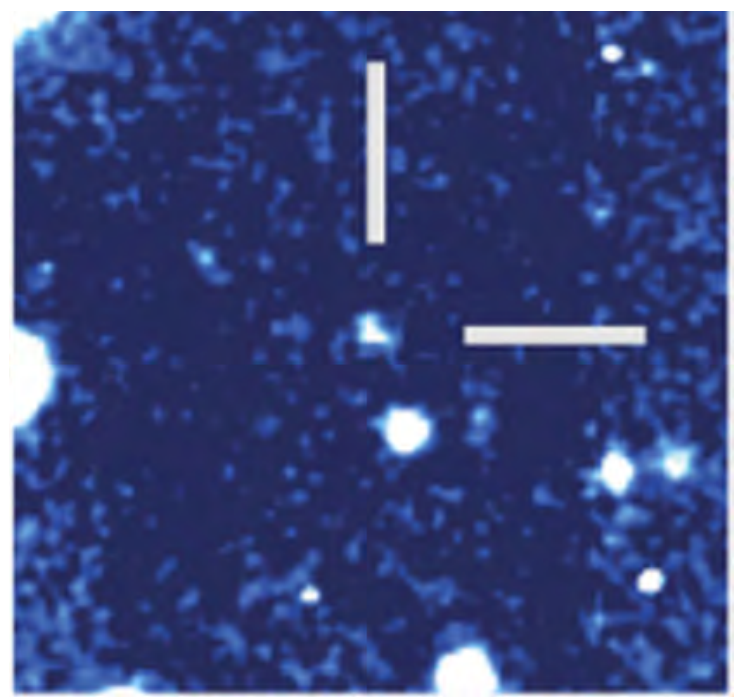
THE UNIVERSITY OF SYDNEY

SWINBURNE

UTMOST-2D: What is it?

A project to turn UTMOST from an FRB-finder to an FRB-localiser: dozens of FRB host galaxies





Who does it?

- *Swinburne:* Adam Deller, **Cherie Day**, Matthew Bailes, **Chris Flynn**, Andrew Jameson, Stefan Oslowski, Vivek V.K., Wael Farah, **Vivek Gupta**
- *Site:* **Tim Bateman, Dave Temby**, Simon Jordan, Glen Torr, Glenn Urquhart
- *Sydney:* Anne Green, Dick Hunstead
- *External:* **Duncan Campbell-Wilson**
- *CSIRO:* **Rob Shaw**

What does it look like?

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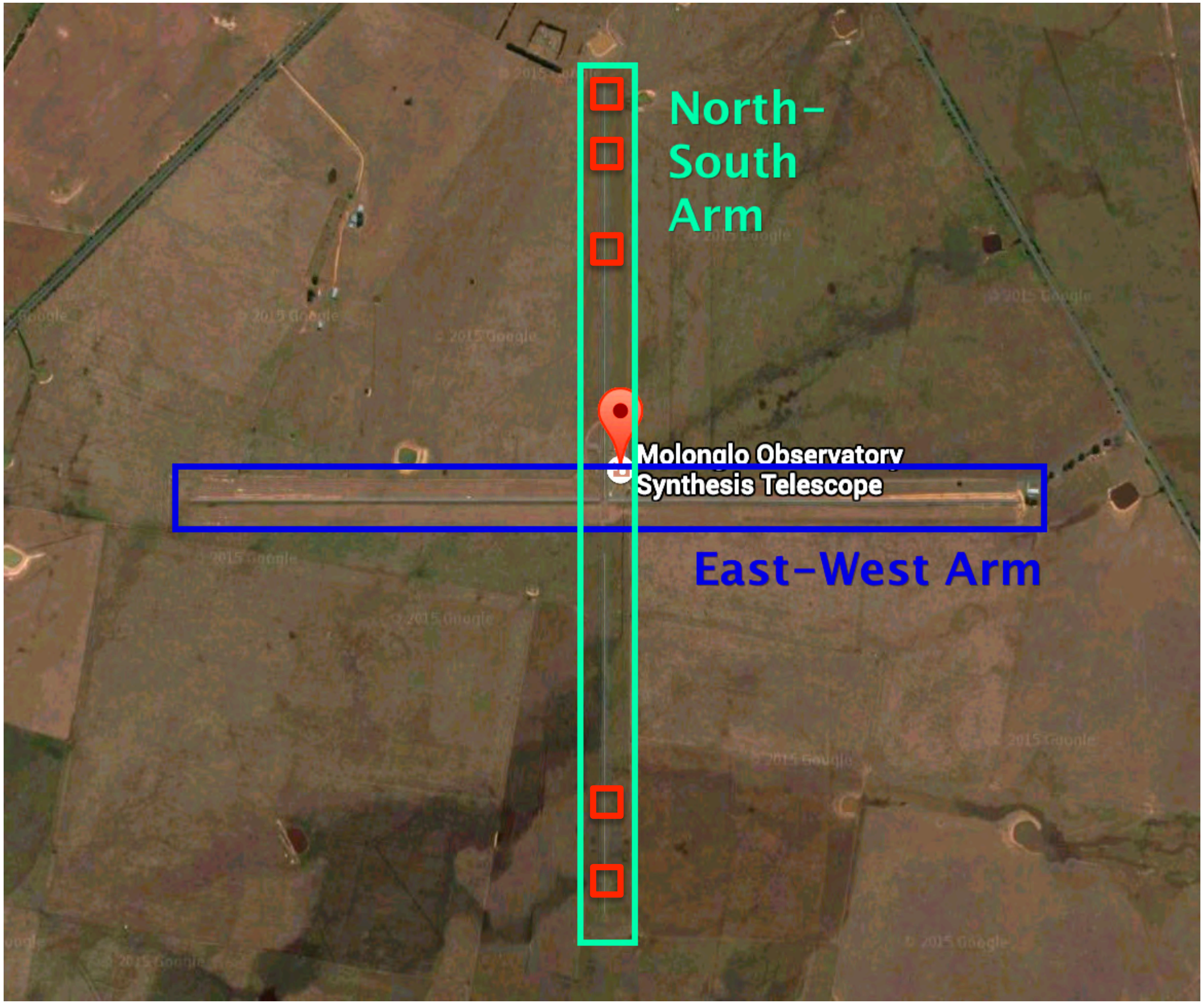
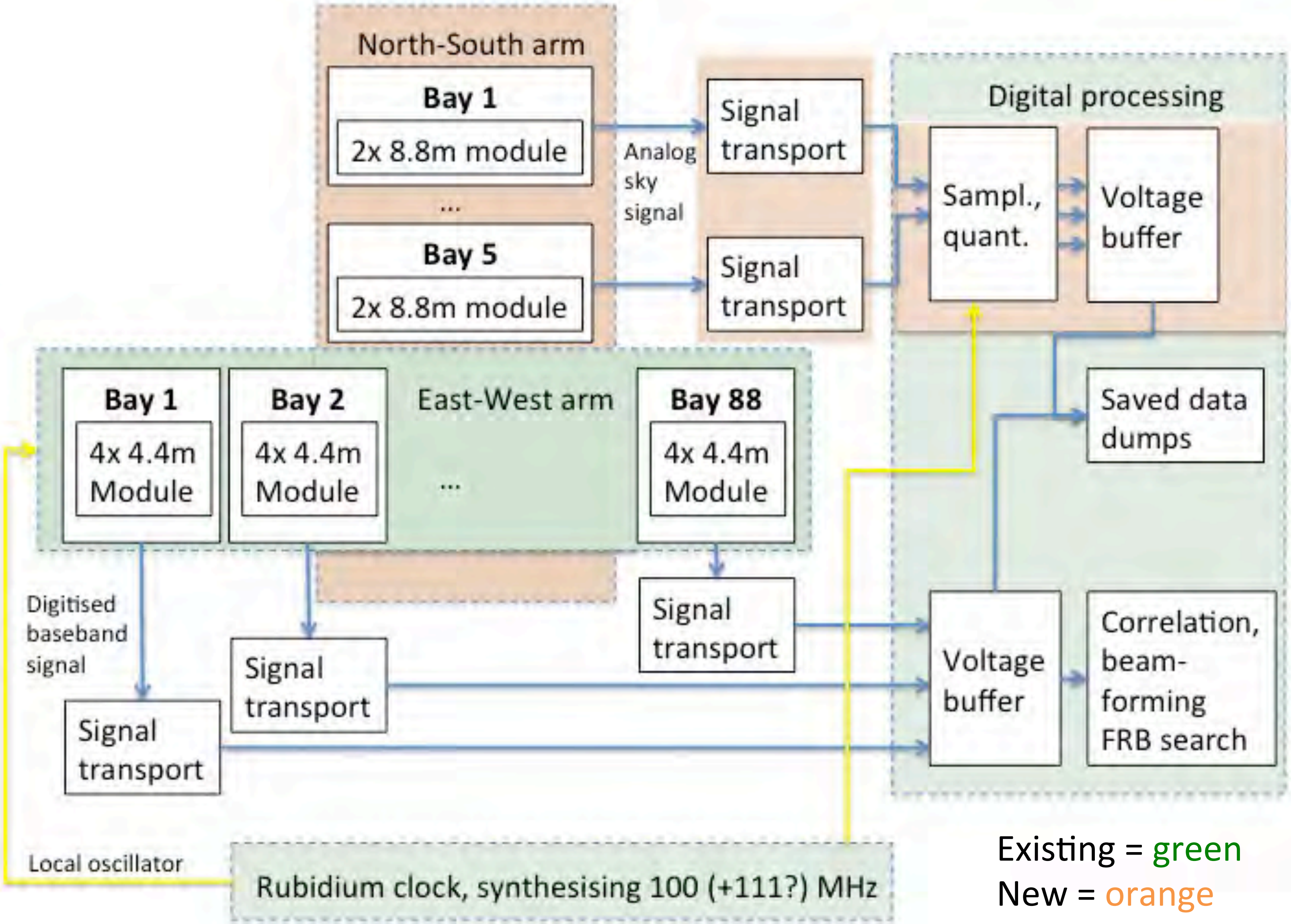


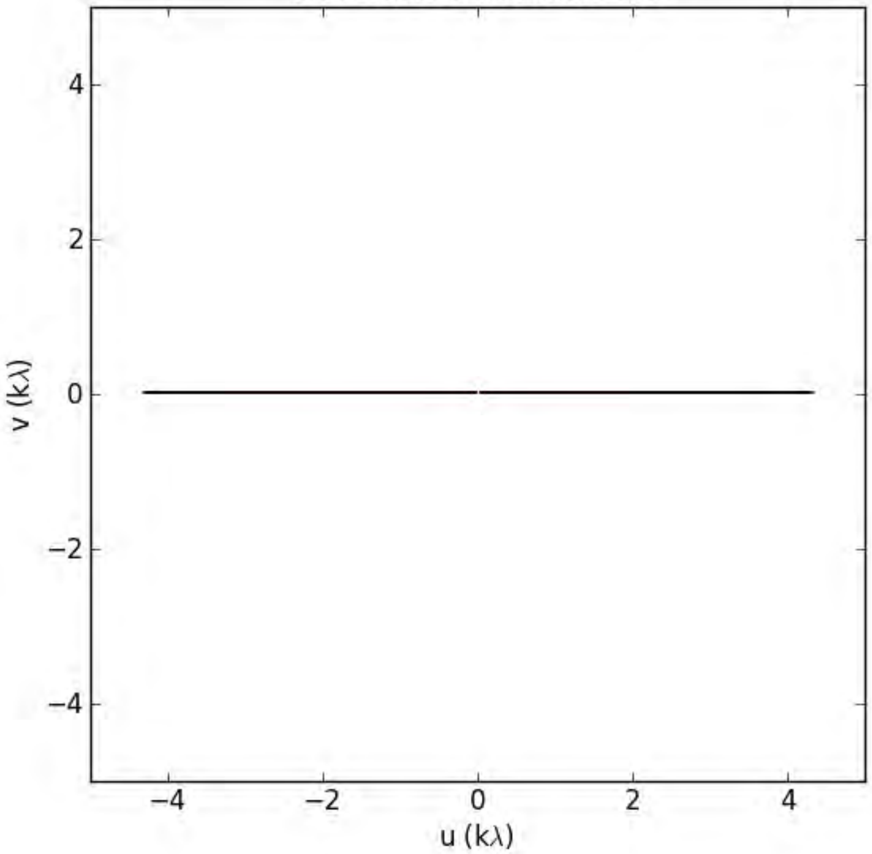
How will it localise FRBs?

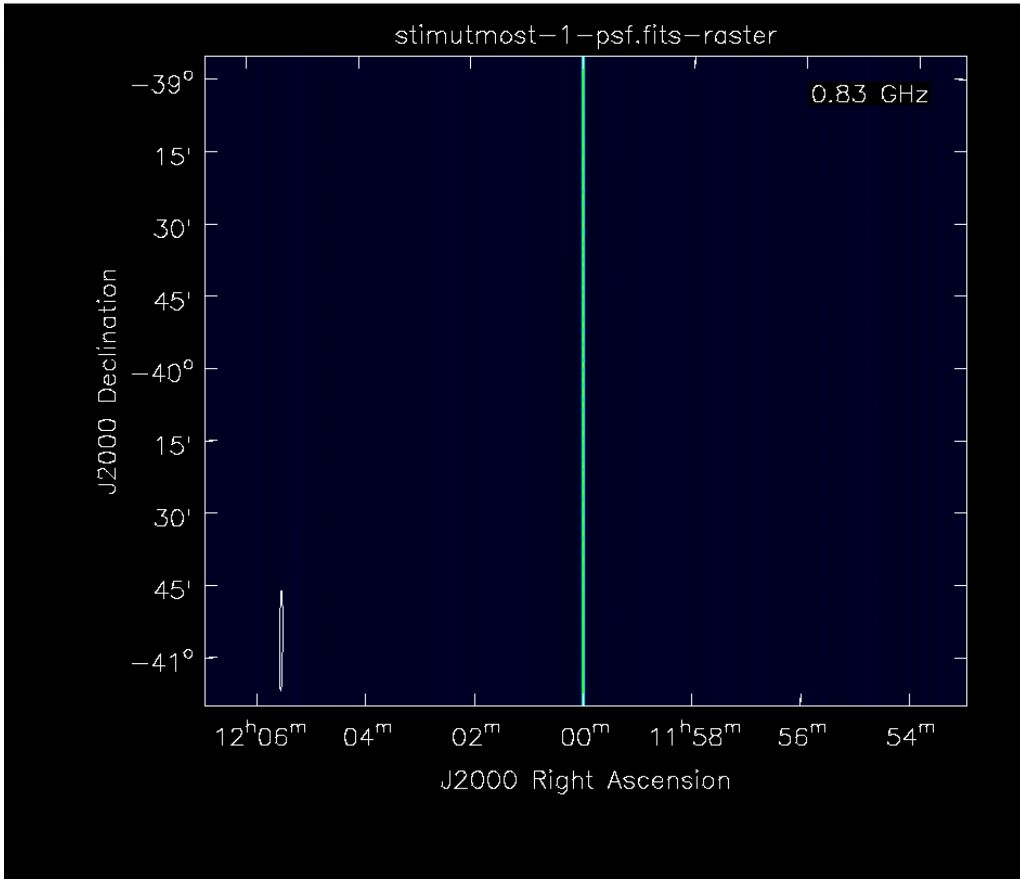


Existing = green
New = orange

What are the new capabilities?

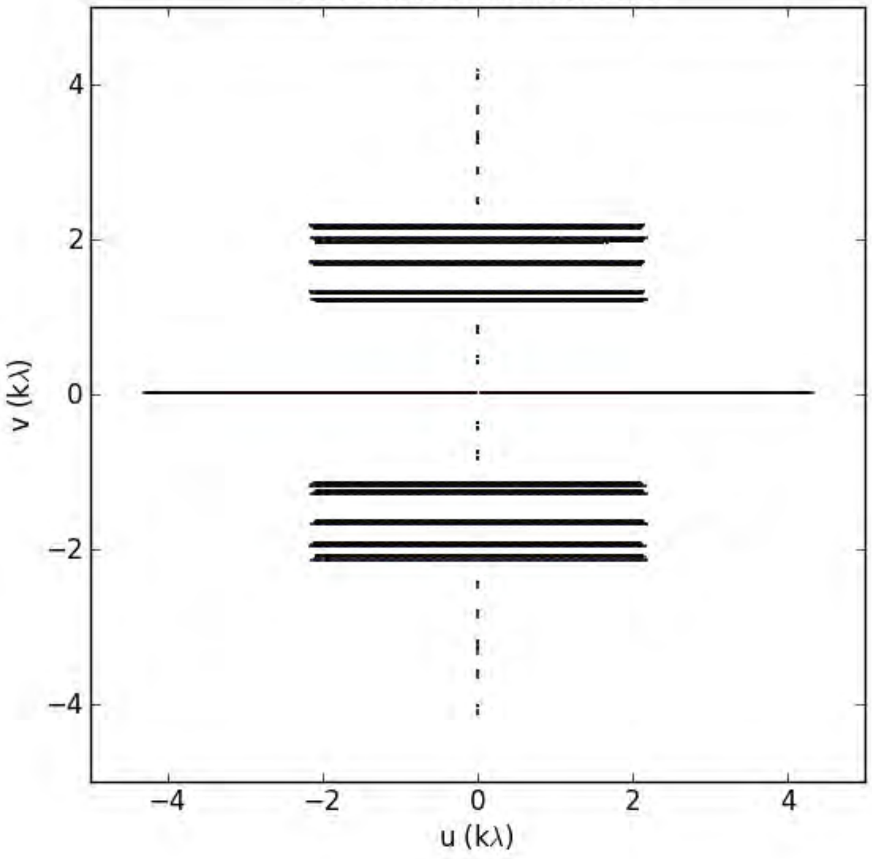
UTMOST-EW: 0 non-east/west baselines,
45” x 2.8° synthesised beam

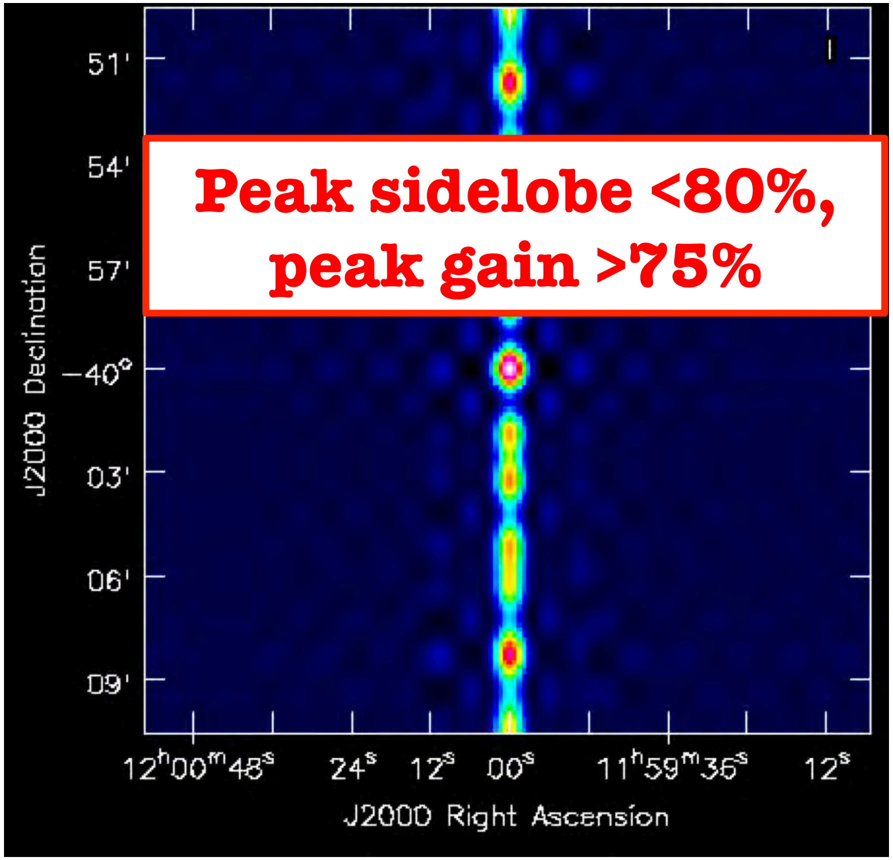




What are the new capabilities?

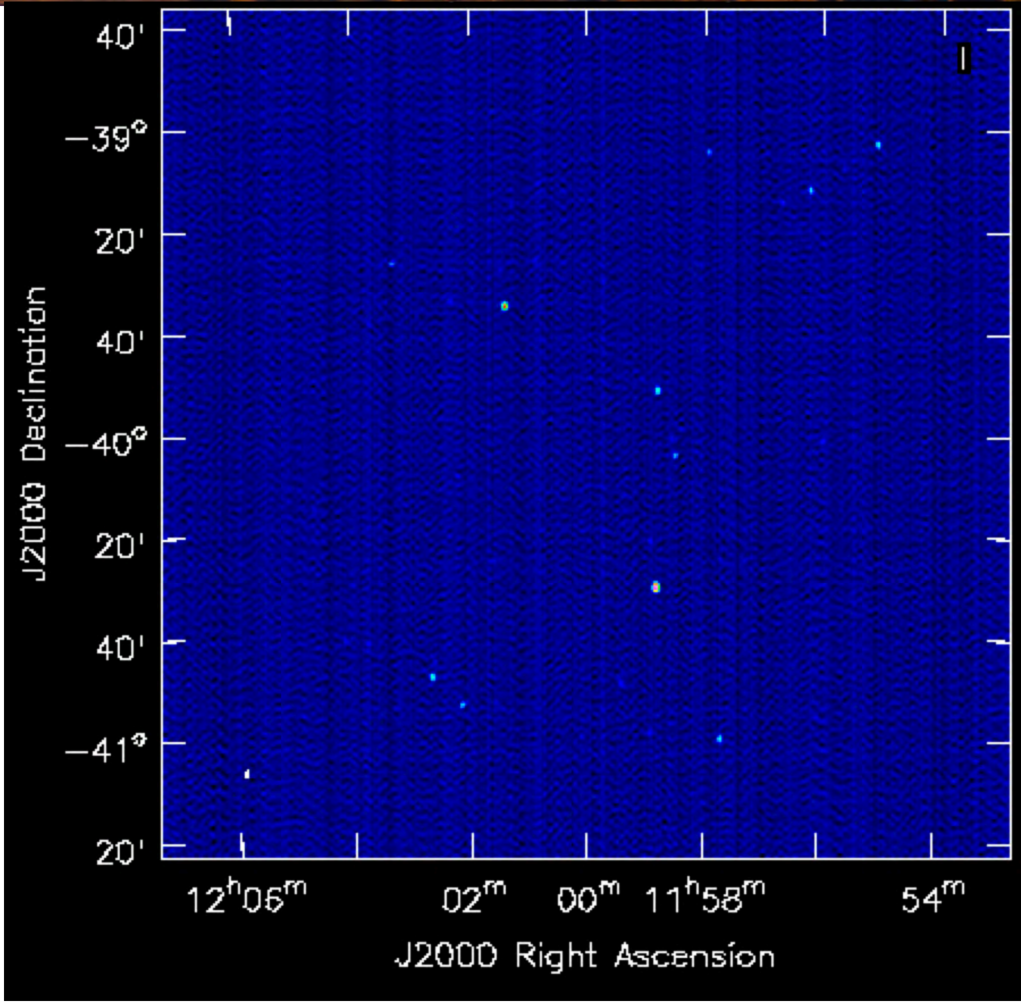
UTMOST-2D: >3500 non-east/west baselines, 60” x 45” synthesised beam





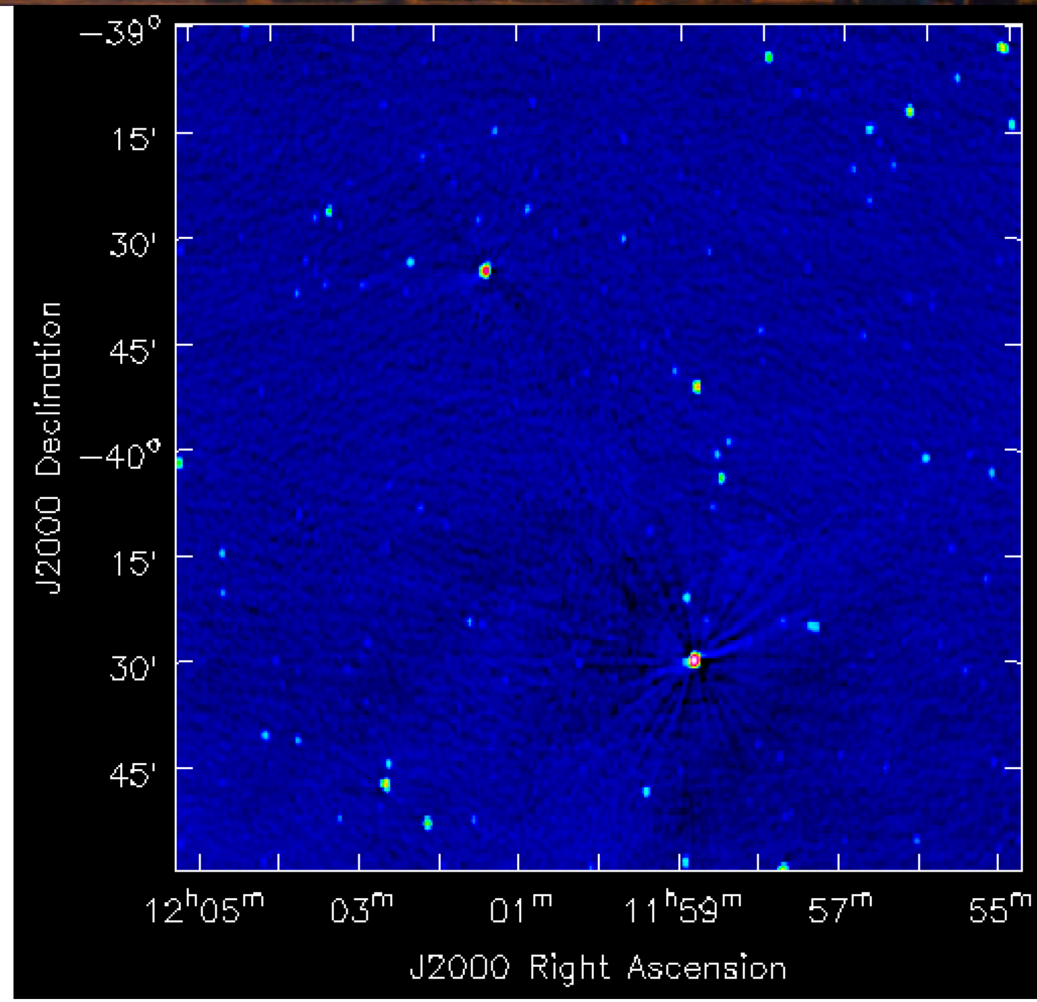
How do we get the positions?

- Image dumped visibility data (1-2s)
- Simulated image (with noise, no gain errors)



How do we get the positions?

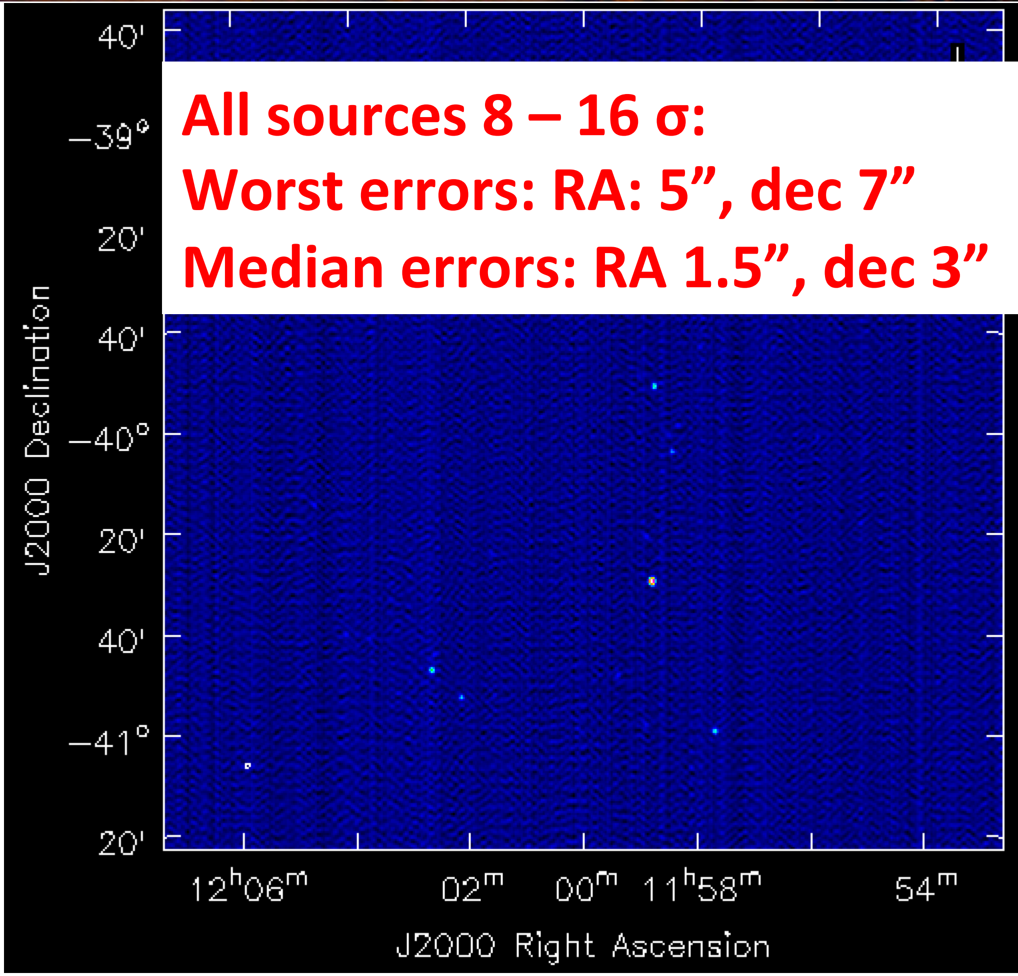
- Image dumped visibility data (1-2s)
- Calibrate using reference image (SUMSS/NVSS)



SUMSS image 12h00m00s -40d00’00”

How do we get the positions?

- Image dumped visibility data (1-2s)
- Simulated image (with noise + gain errors up to 50% and 90°, self-calibrated)



How will we build it?

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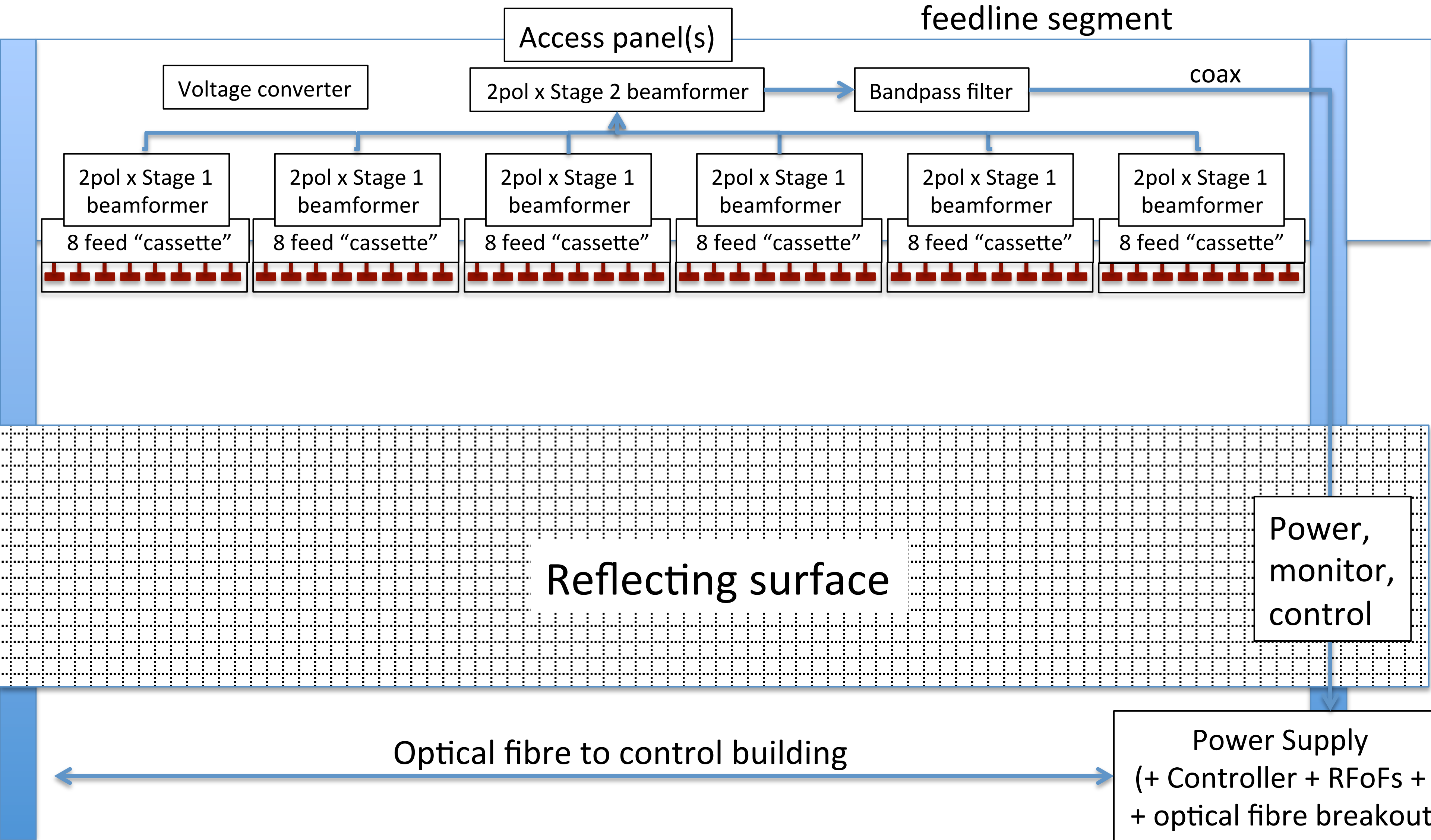


Module specifications

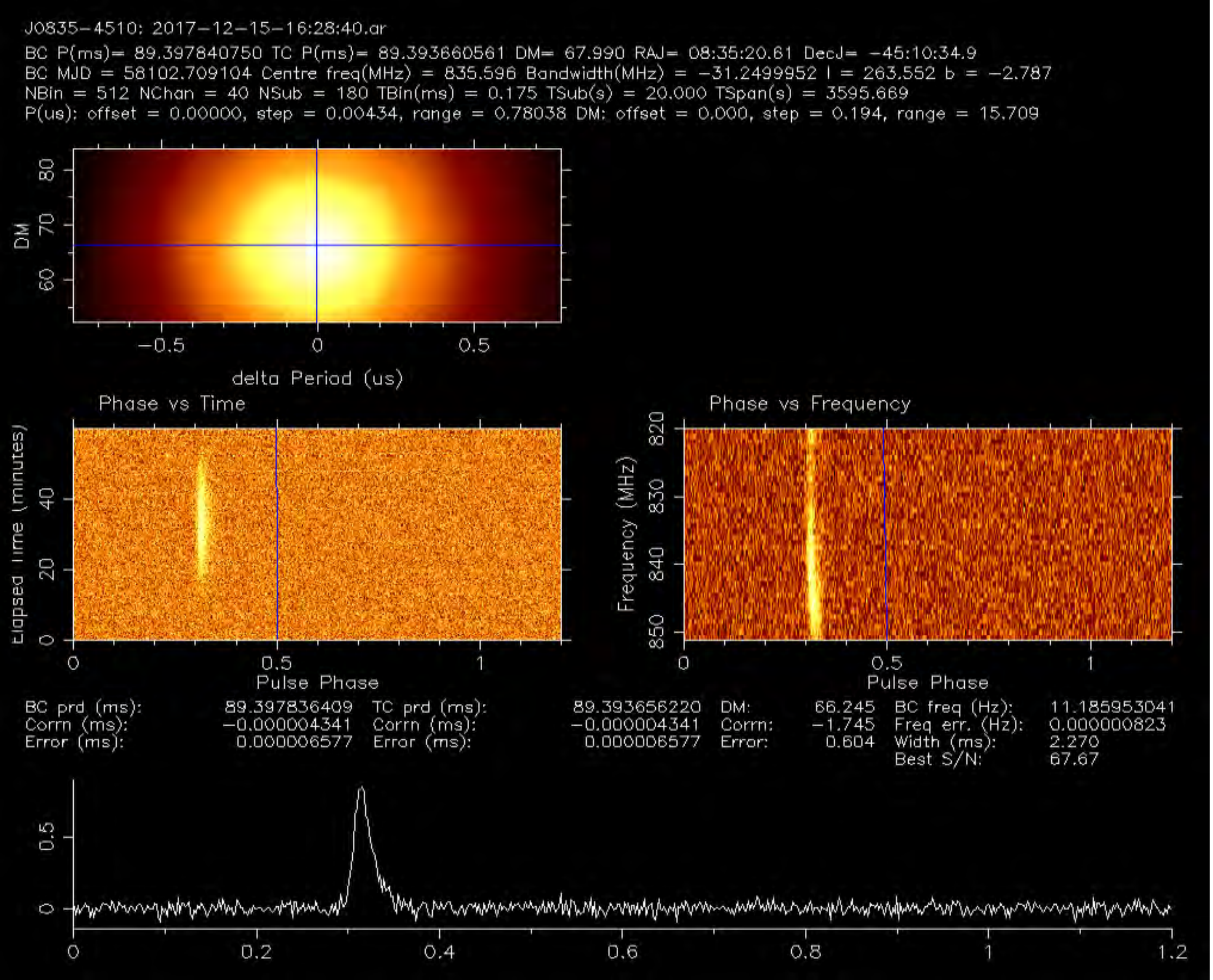
- Target Tsys: 80 K
- Size: 8.8 x 11.6 m
- FoV: 2.8 x 2.2 °
- Target SEFD: 4500 Jy
- Polarisation: dual linear
- Sampled bandwidth: 780 – 877.5 MHz
- Recorded bandwidth: 795 – 856 MHz
- Pass band: 800 – 850 MHz
- Zenith angle coverage: >45°

Cassette testing

- Single cassette (1.44m, 1/3rd of an E-W module, 1/60th of final system) on the Rapid Prototyping Telescope
  - Using legacy backend (same recorded bandwidth)
  - But used narrower 25 MHz filter

Cassette testing

Cassette testing



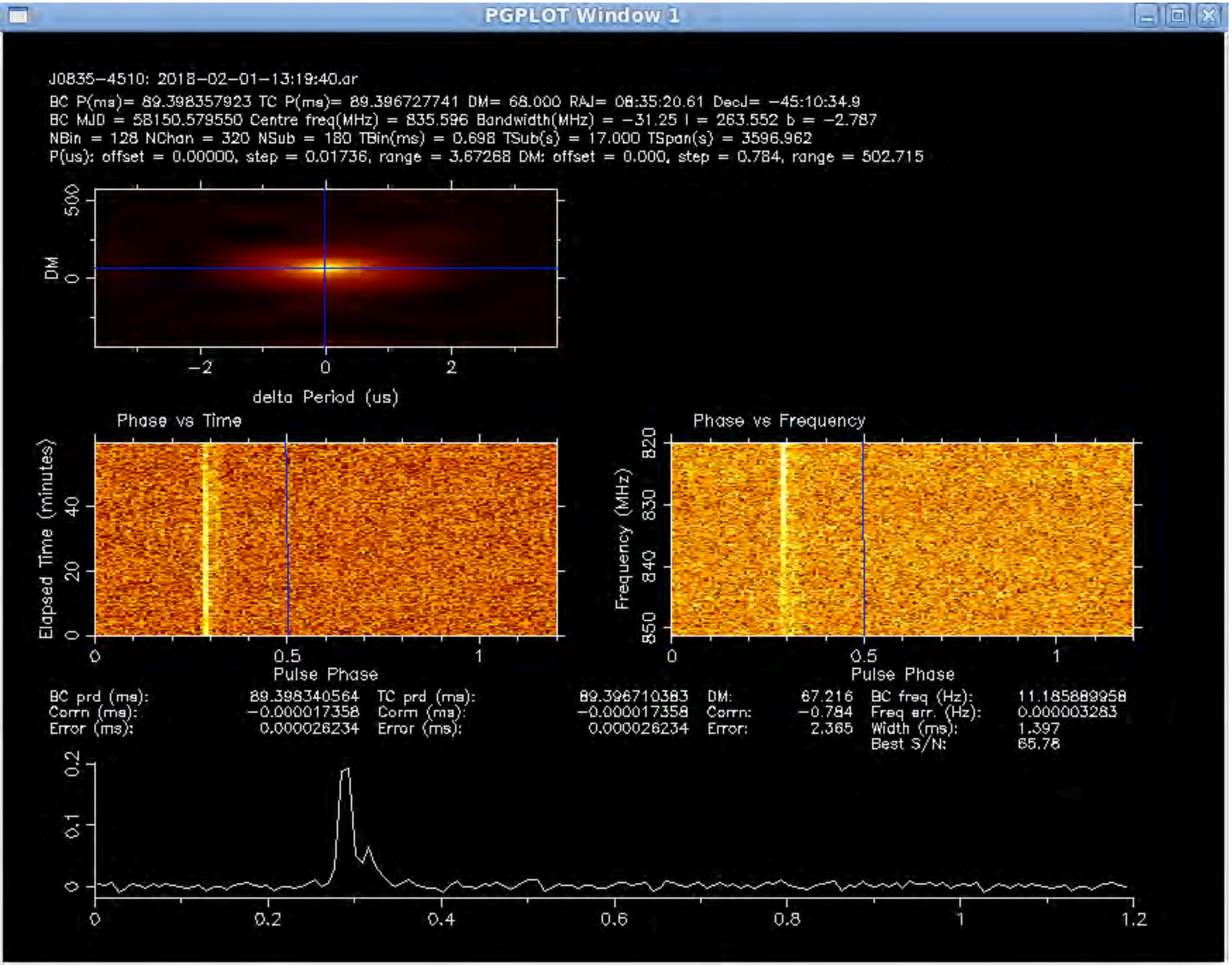
1 hr Vela transit:

E-W arm module

S/N = 67

$S/N_{20s,peak}$ = 10

Cassette testing



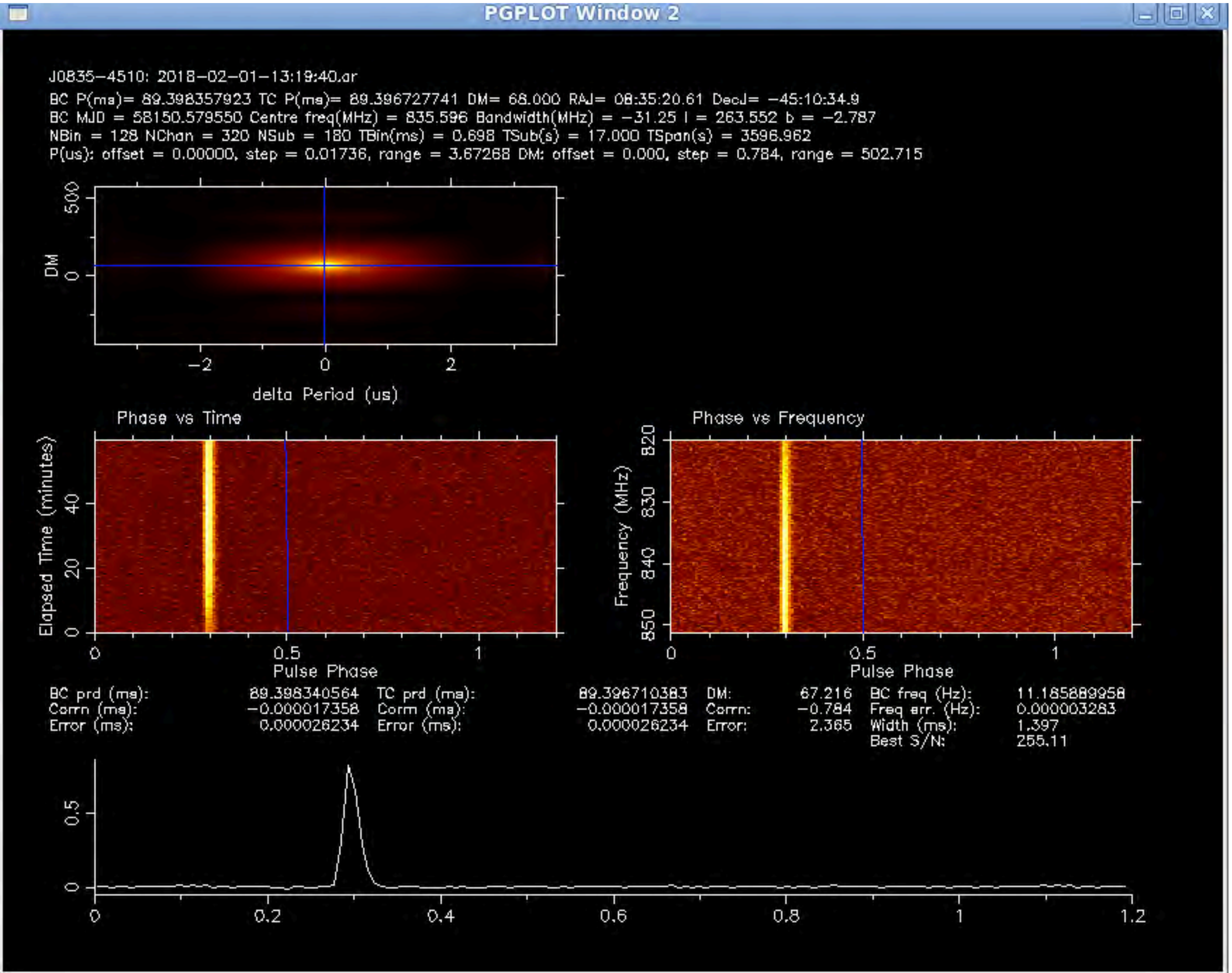
1 hr Vela transit:

Cassette, pol 1

S/N = 66

$S/N_{20s,peak}$ = 7

Cassette testing



1 hr Vela transit:

Cassette, pol 2

S/N = 255

$S/N_{20s,peak}$ = 28

Cassette testing

- Vela is highly polarised: conservatively halve the "high S/N" cassette pol^n to compare against E-W module (RR)
  - S/N 40% better, from 1/3rd of collecting area. E-W modules vary in performance; best would be comparable to the cassette
- Hence cassette A_{eff}/T_{sys} is 3x better!
  - T_{sys} around 60K

Cassette testing

- When deployed, new front-end will:
  - Have 2x50 MHz bandwidth (vs 1x15 usable on the E-W arm)
  - Have higher A_{eff} but slightly higher T_{sys} due to longer focal length on N-S arm
  - Combined, this means new system is 7-8x more sensitive than best E-W arm modules
    - 15x more sensitive than typical E-W module!
    - SEFD 3000-3500 Jy vs target of 4500 Jy

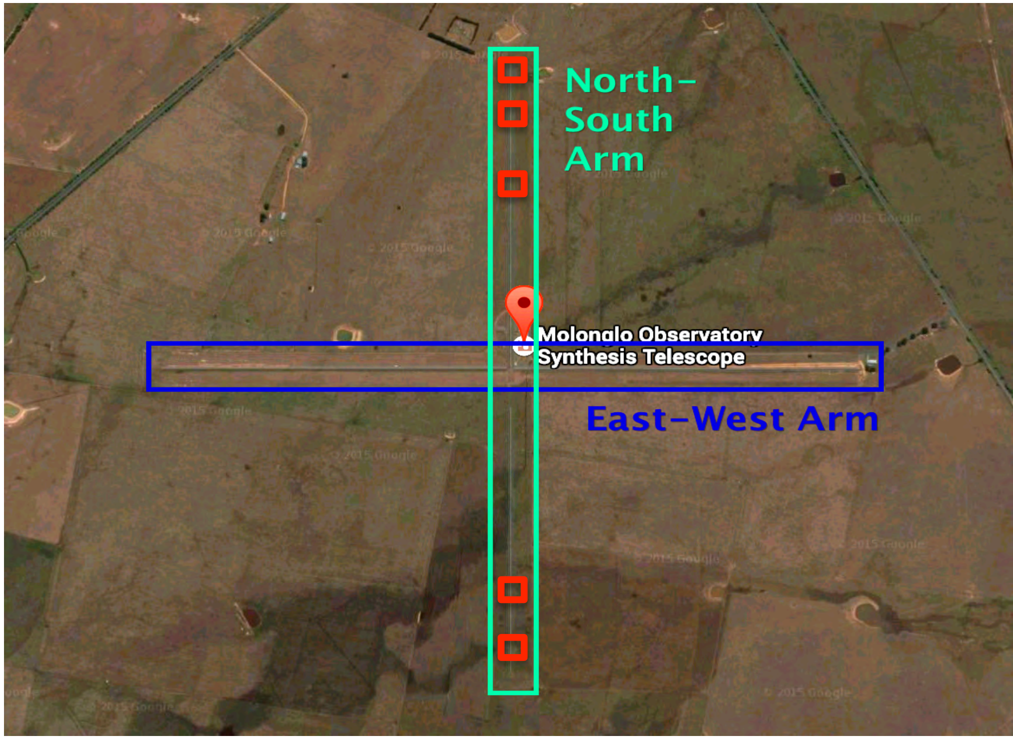
Multi-cassette testing

Multi-cassette testing

- Started last week
- Some unaccounted phase errors; combined S/N is only 60% of theoretical
- New beamformers (steerable) arriving in March, will alleviate the problem of combining different hand-built cassettes
- 2 more cassettes to be assembled in March, combine for 1st almost-complete module

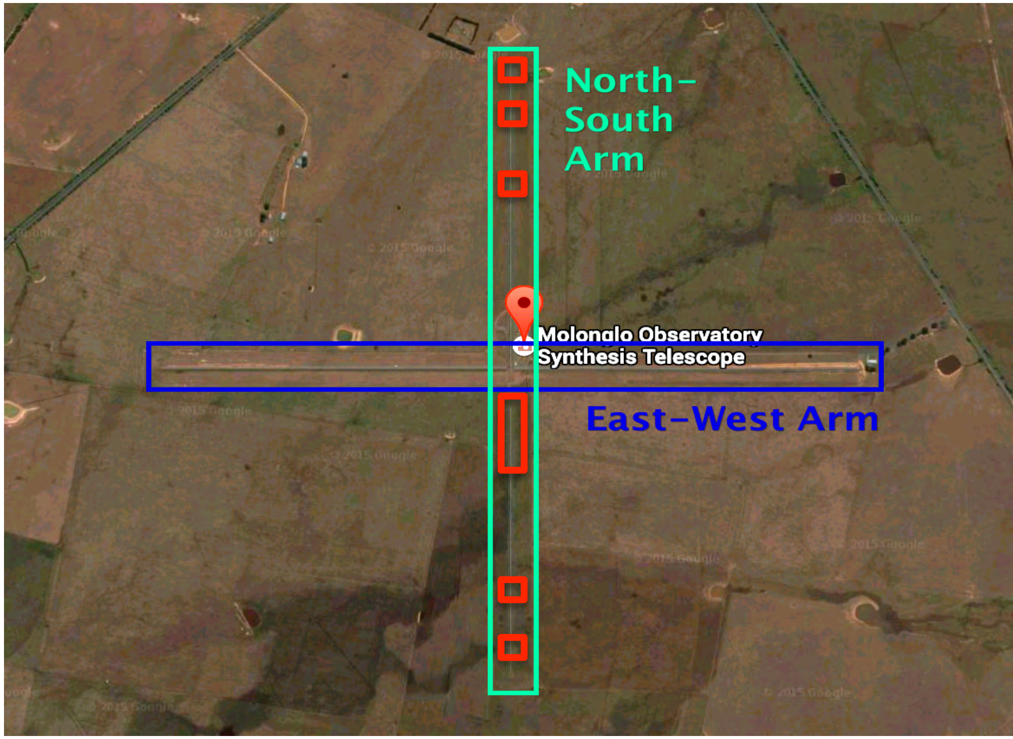
UTMOST-2D "Mark 1"

- Due to higher module sensitivity, fewer outrigger modules required for original science case
  - Deploy 5-6 individual modules rather than 5x2 module pairs



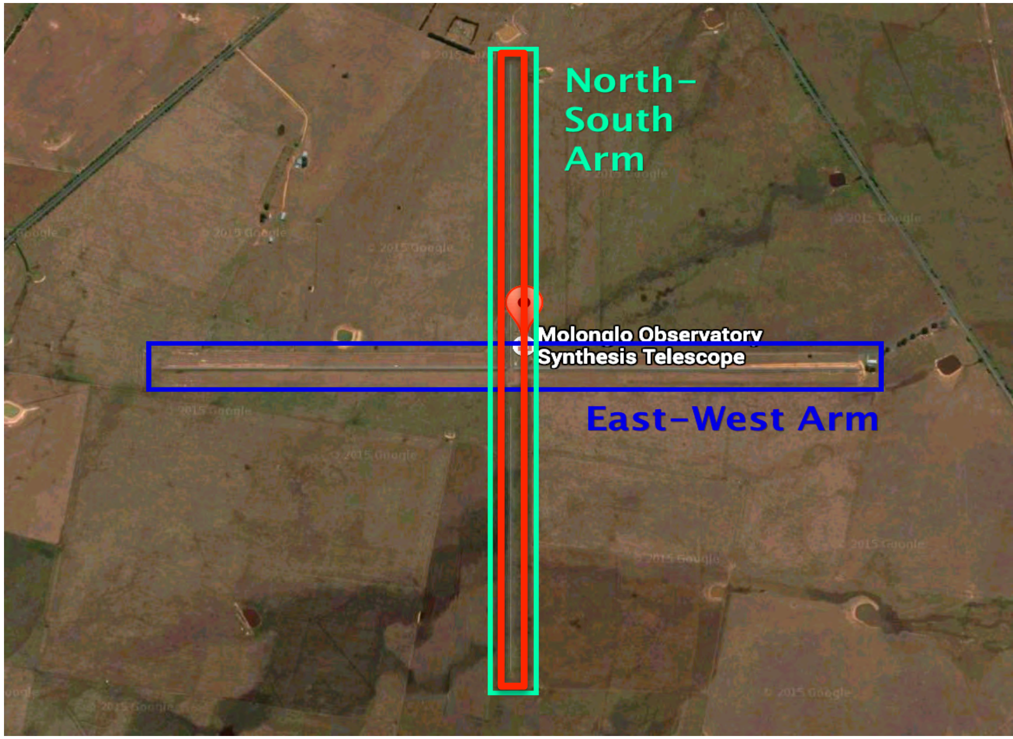
UTMOST-2D "the future"

- Use the new cassettes to build a new detector array on the N-S arm
  - Electronically steerable, no moving parts
- 12 modules: equal current detector sensitivity, far less computation



UTMOST-2D "the future"

- Use the new cassettes to build a new detector array on the N-S arm
  - Electronically steerable, no moving parts
- 12 modules: equal current detector sensitivity, far less computation
- 176 modules: Parkes+ sensitivity, 5x Parkes FoV



Timeline

- 2016 Q4: project commenced
- 2017 Q1-Q3: iterative design
- 2017 Q4: prototyping (cassettes 1, 2)
- 2018 Q1: multi-cassette validation
- 2018 Q2: full module testing (6 cassette)
- 2018 Q3-Q4: production, deployment
- 2018 Q4-onwards: science commissioning
- 2019: Build out N-S detector?