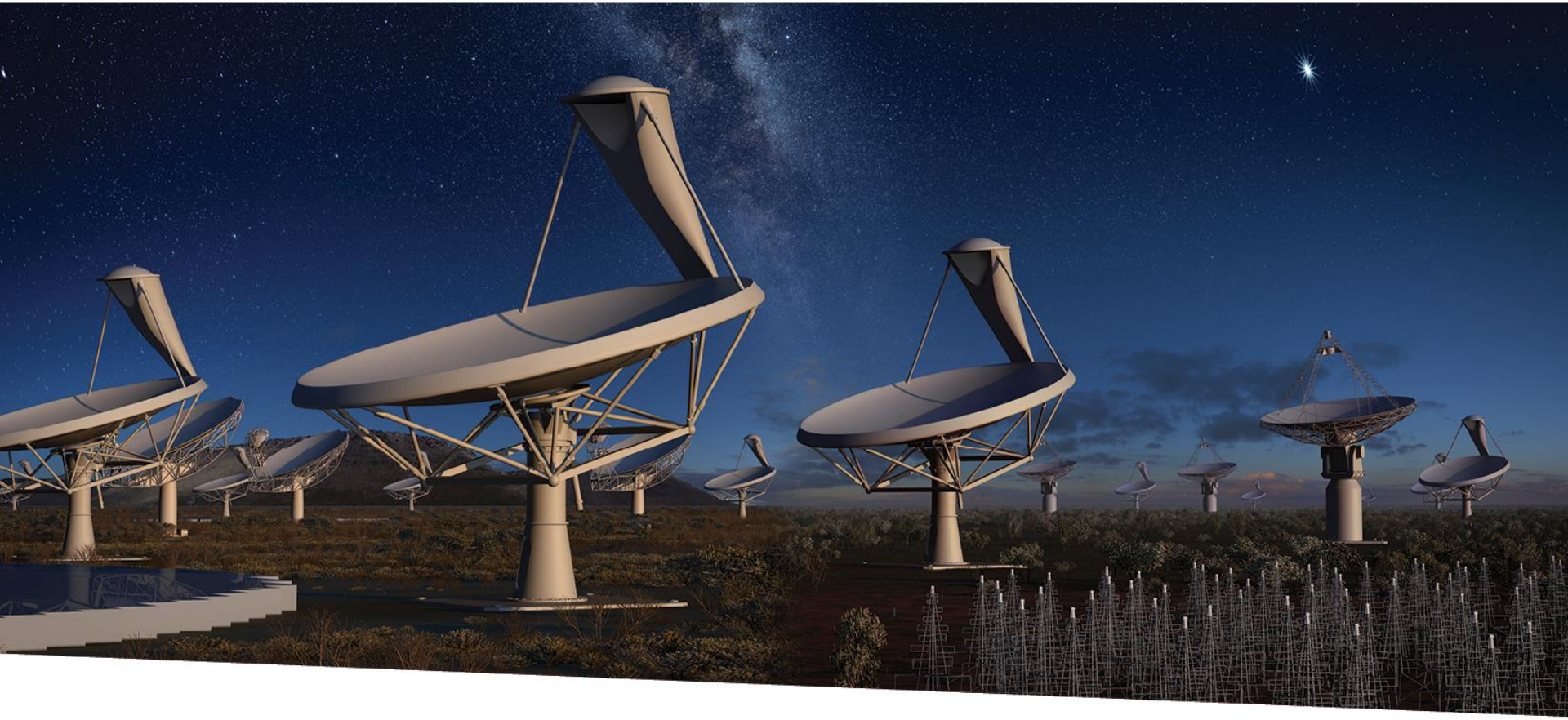
SKA



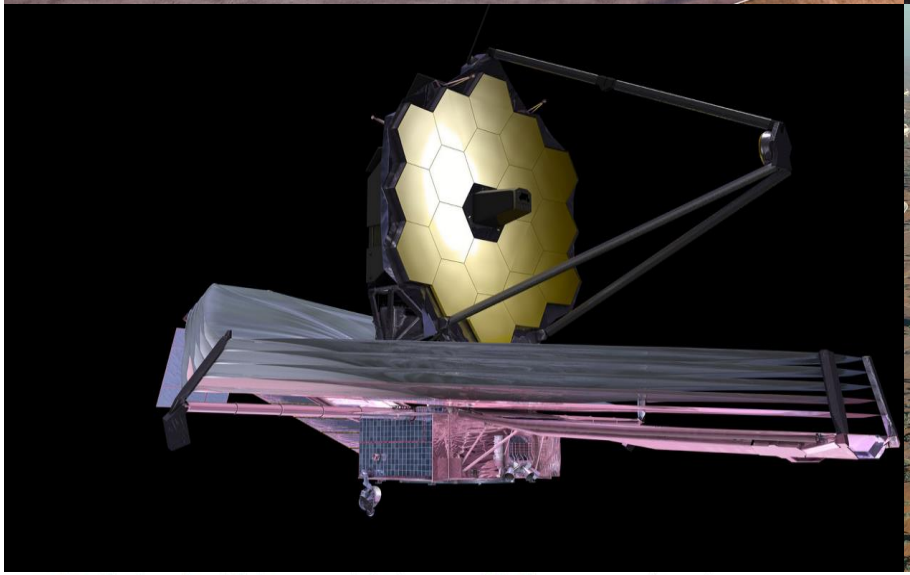
SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Kristian Zarb Adami

October 2014

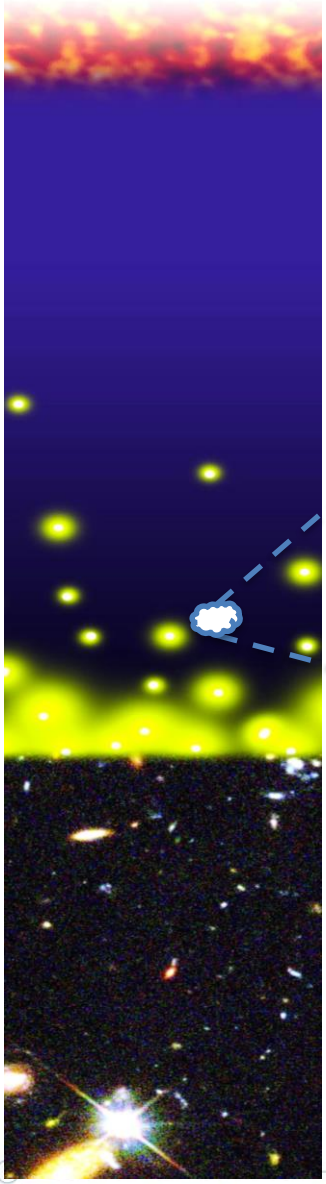
Great Observatories for the coming decades

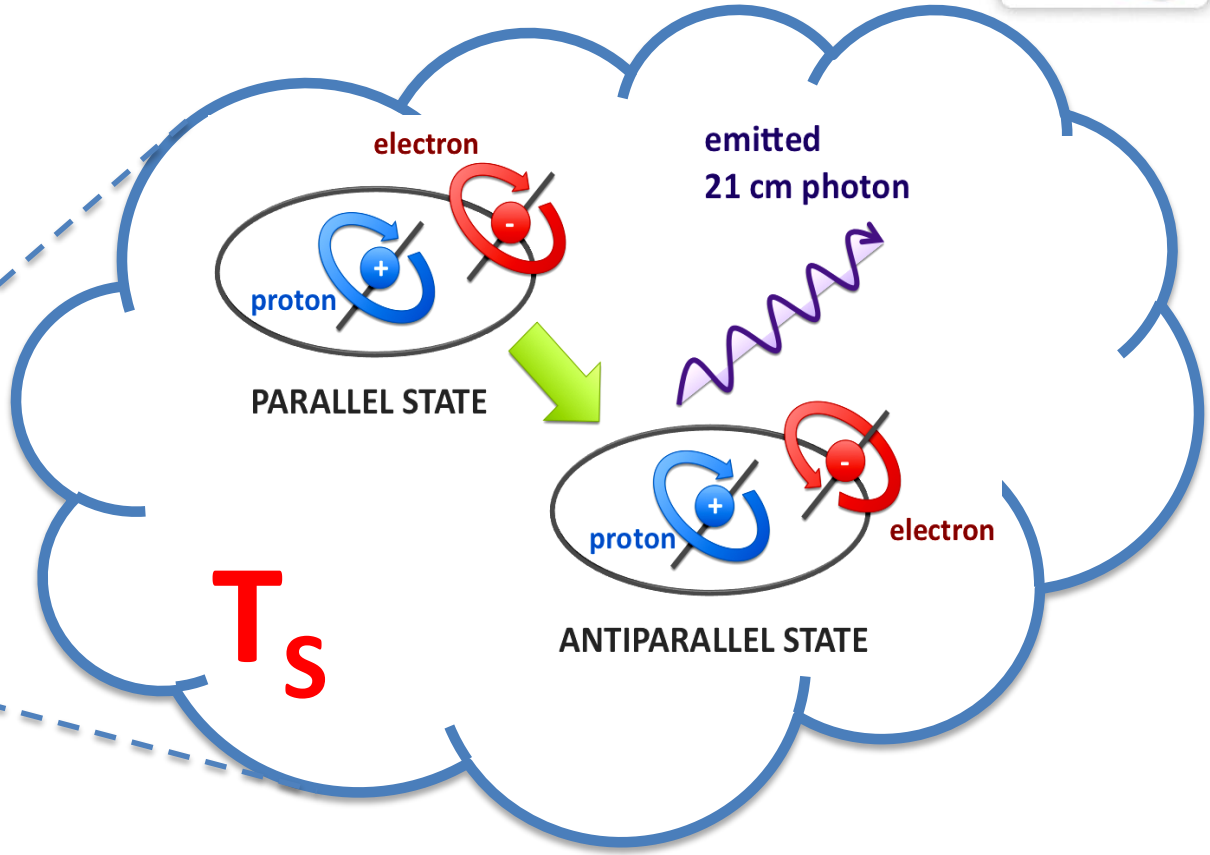


Exploring the Universe with the world's largest radio telescope

The Science

21-cm Emission Mechanism



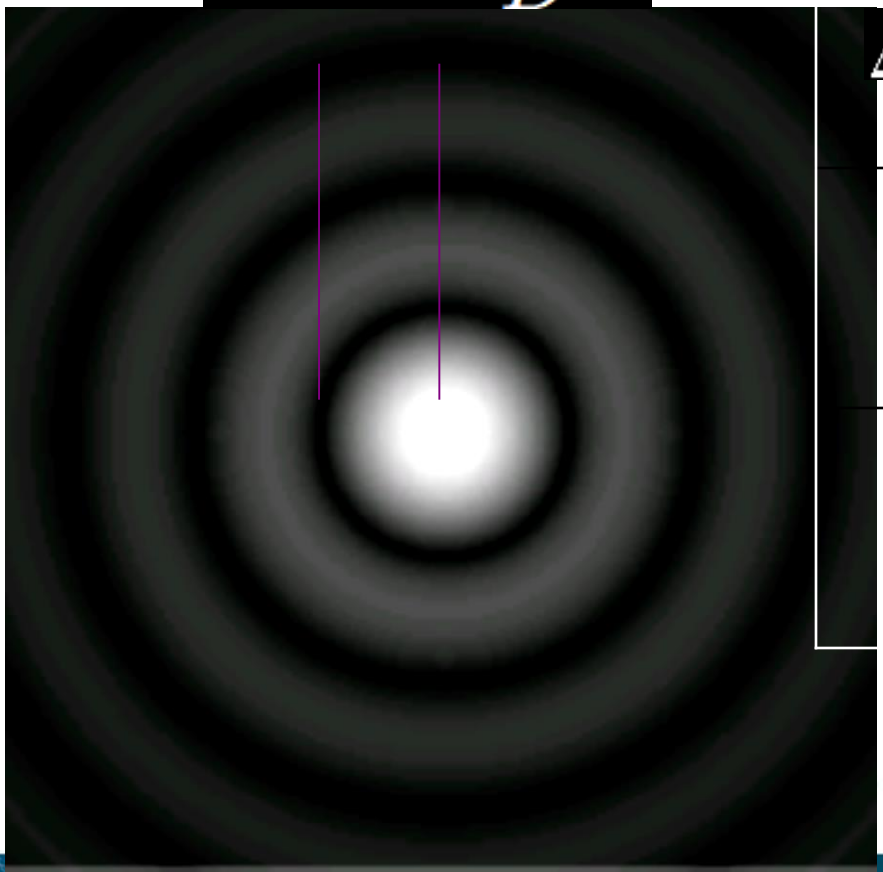


$$\frac{n_1}{n_0} \mu \exp(- E_{21cm} / k_b T_S)$$

Boltzmann distribution

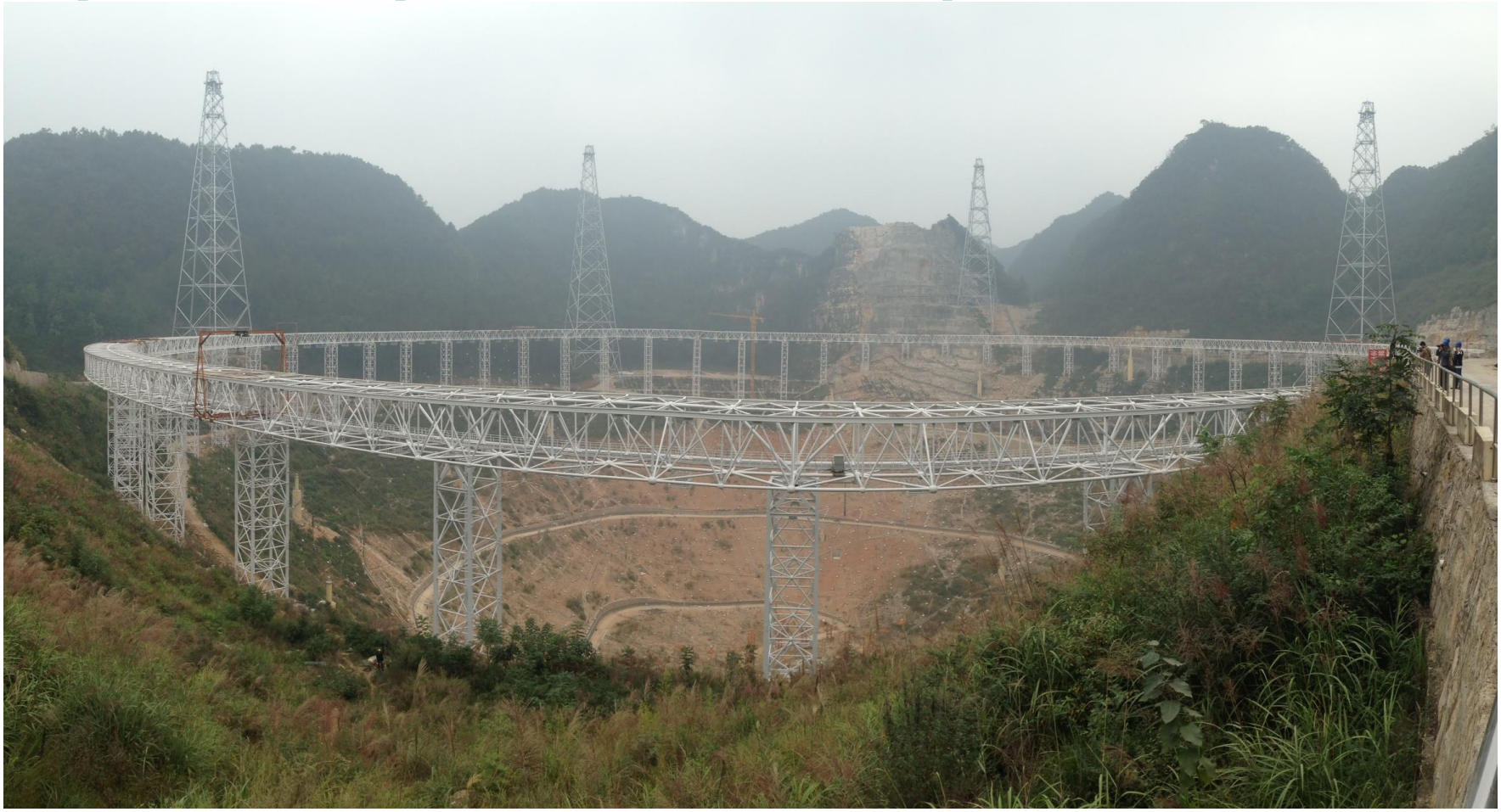
Diffraction limits

$$\Delta\theta \approx \frac{1.22\lambda}{D}$$

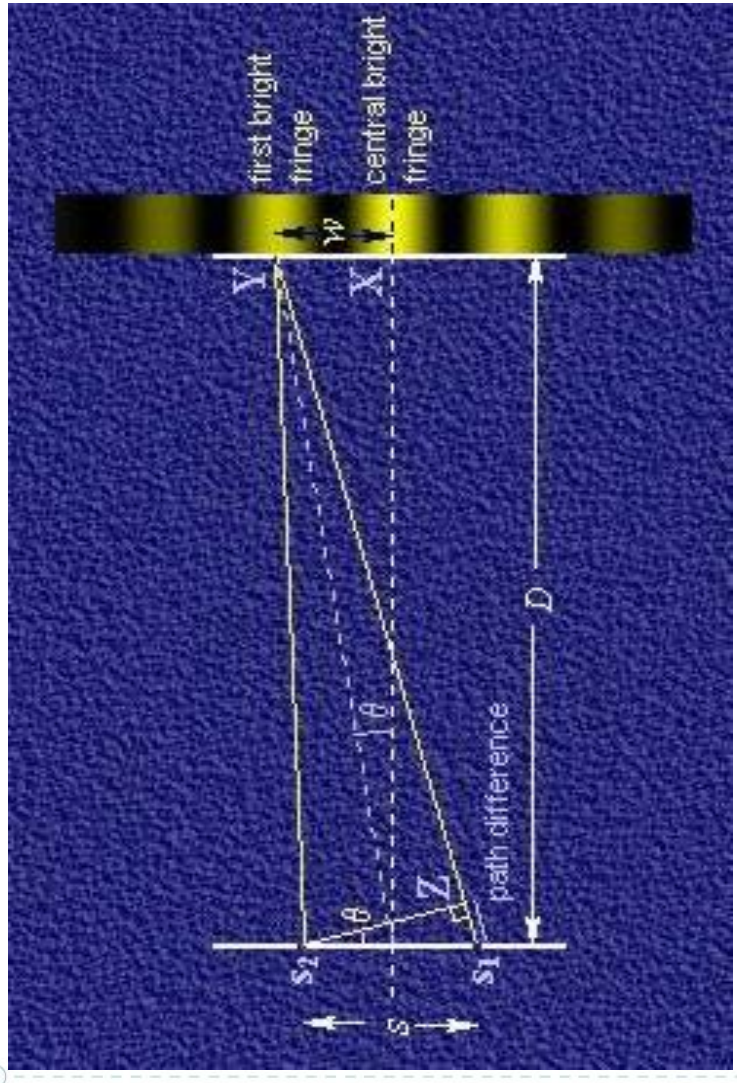


$\Delta\theta = 1''$	λ	D
Optical	500 nm	125 mm
Radio	20 cm	50 km

FAST: Five hundred metre Aperture Spherical telescope



Interferometry

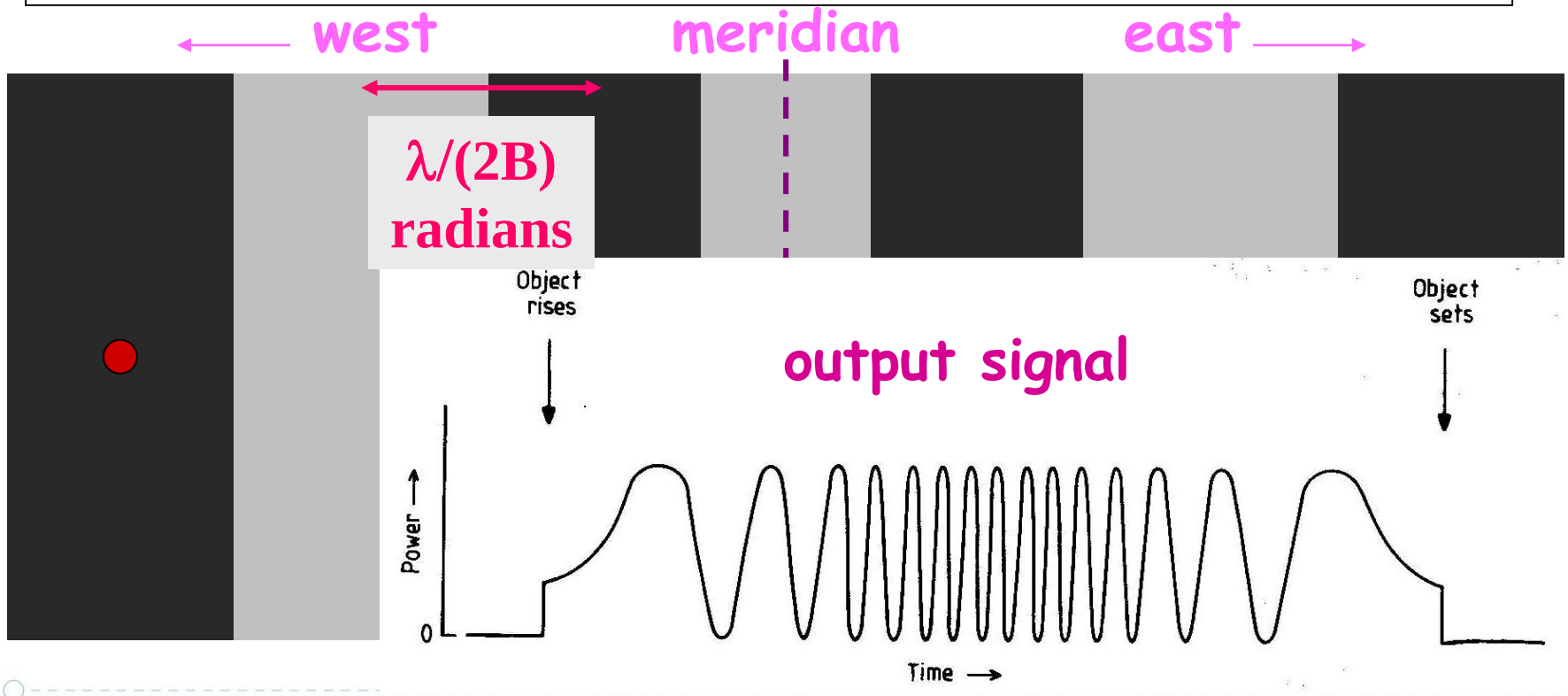


- A pair of radio antennas behaves like the double slit but receiving rather than transmitting.
- Antennas at s_1 and s_2 will receive radiation “in phase” from radio sources on the bright fringes.
- The radio interferometer will be sensitive to the fringe with angular spacing λ/s.

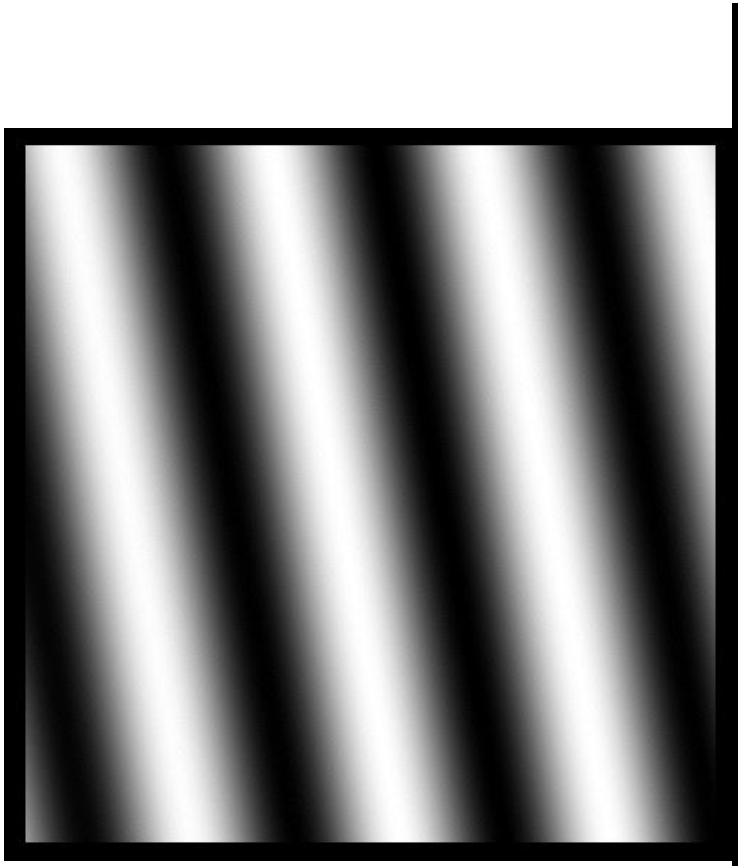
Interferometry

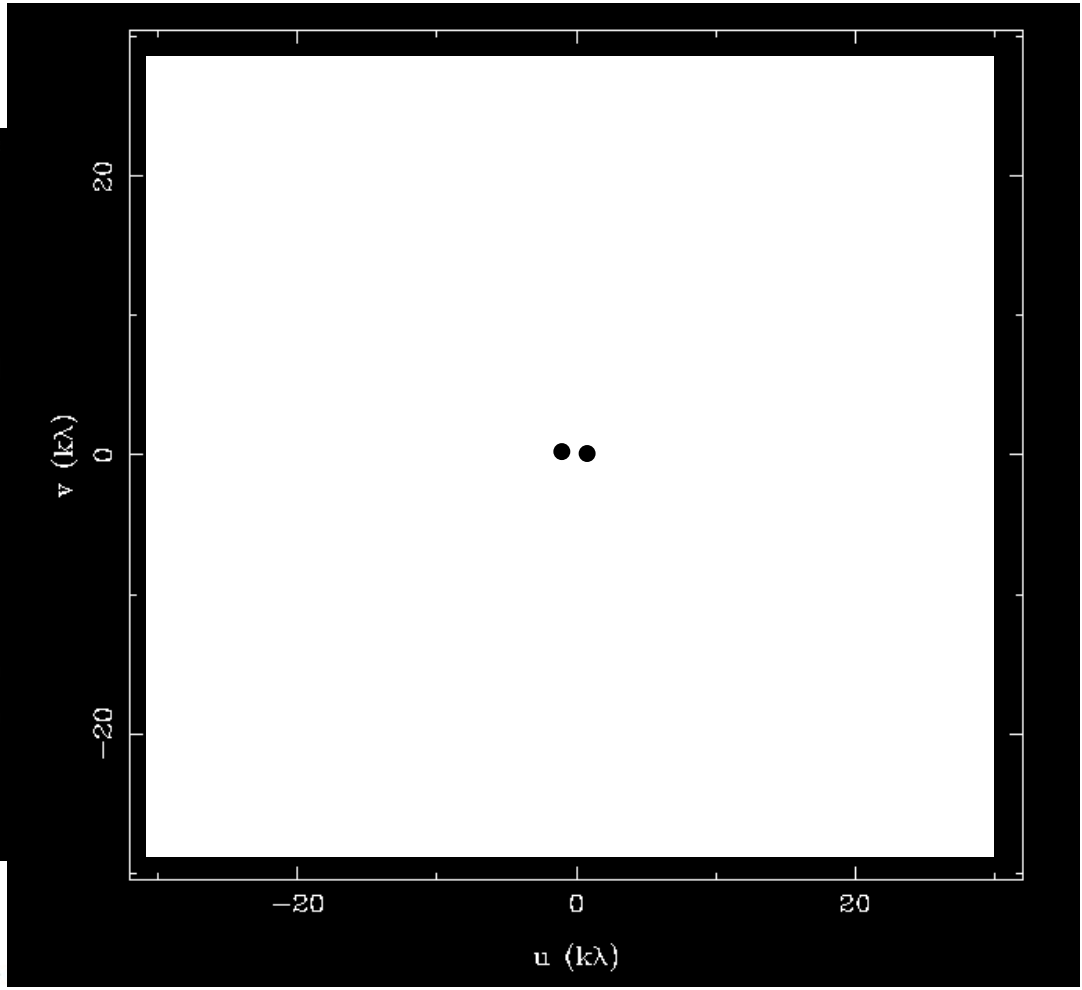
By analogy to the double slit experiment, regions which would cause constructive and destructive interference can be considered “stripes” in the sky. As the source moves through it, it produces oscillating output signal.

The **angular resolution** is now given by the **fringe half-spacing λ/2B (in radian)**.

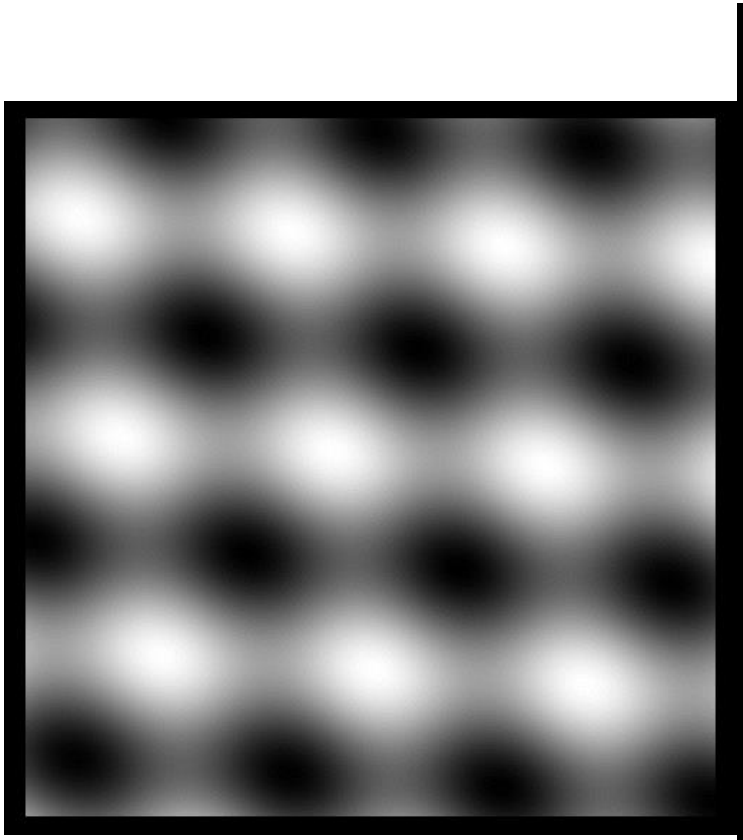


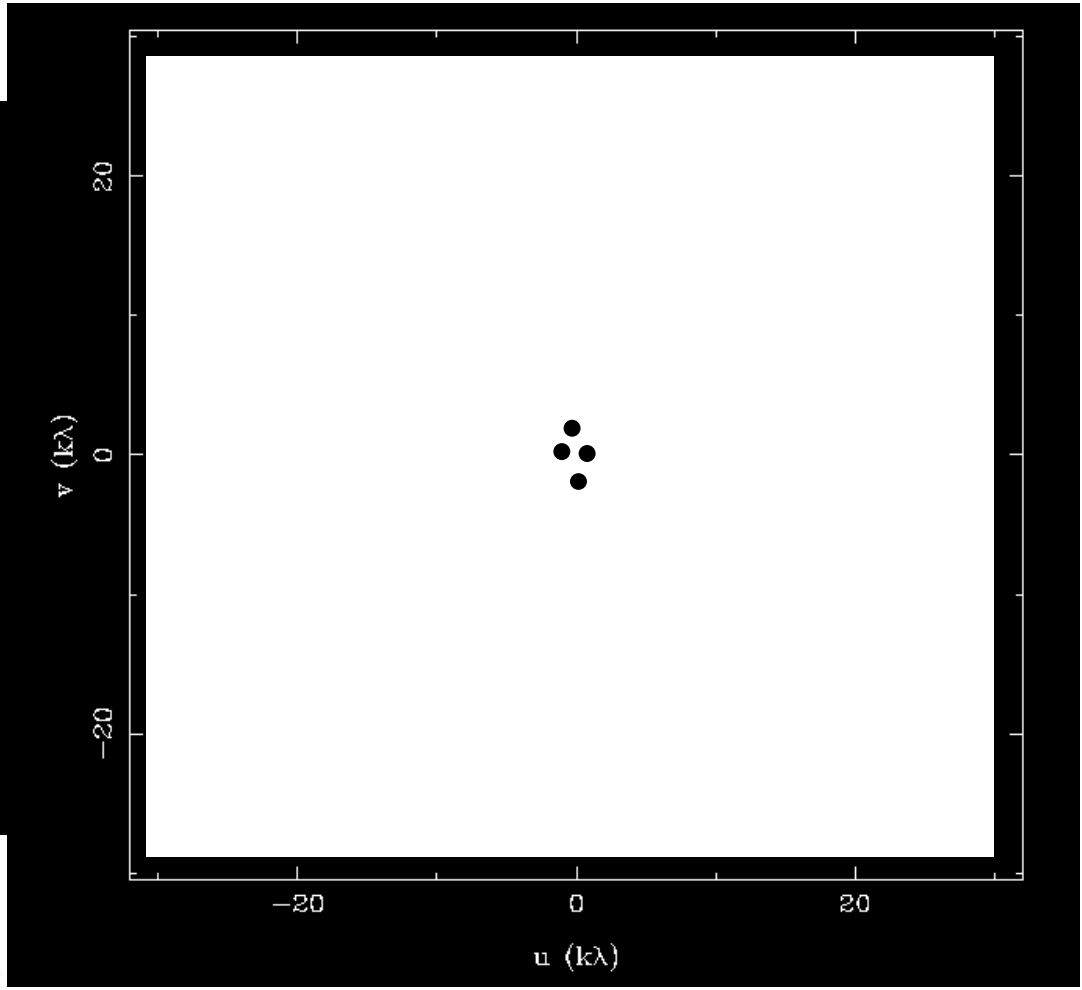
Synthesis imaging



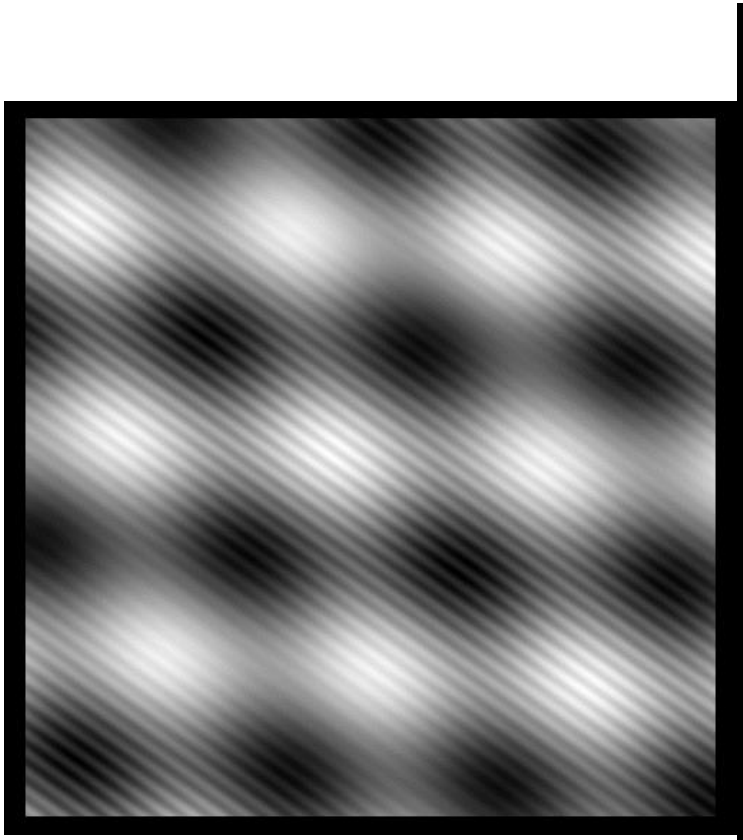


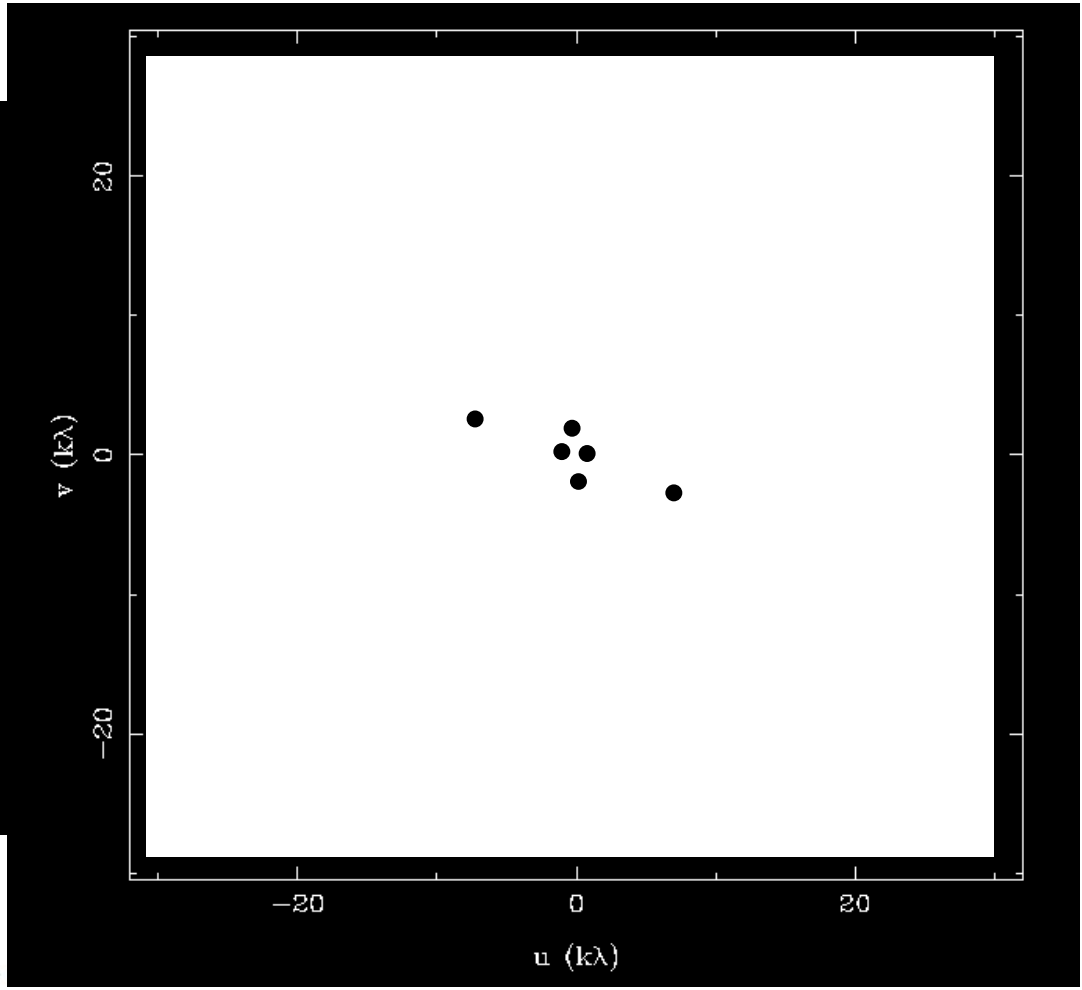
Synthesis imaging



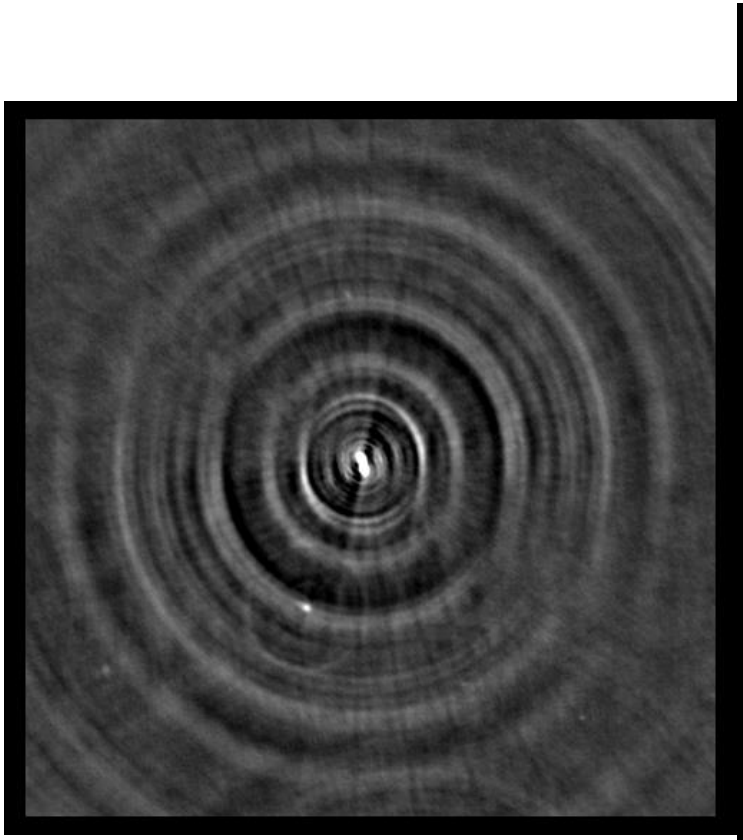


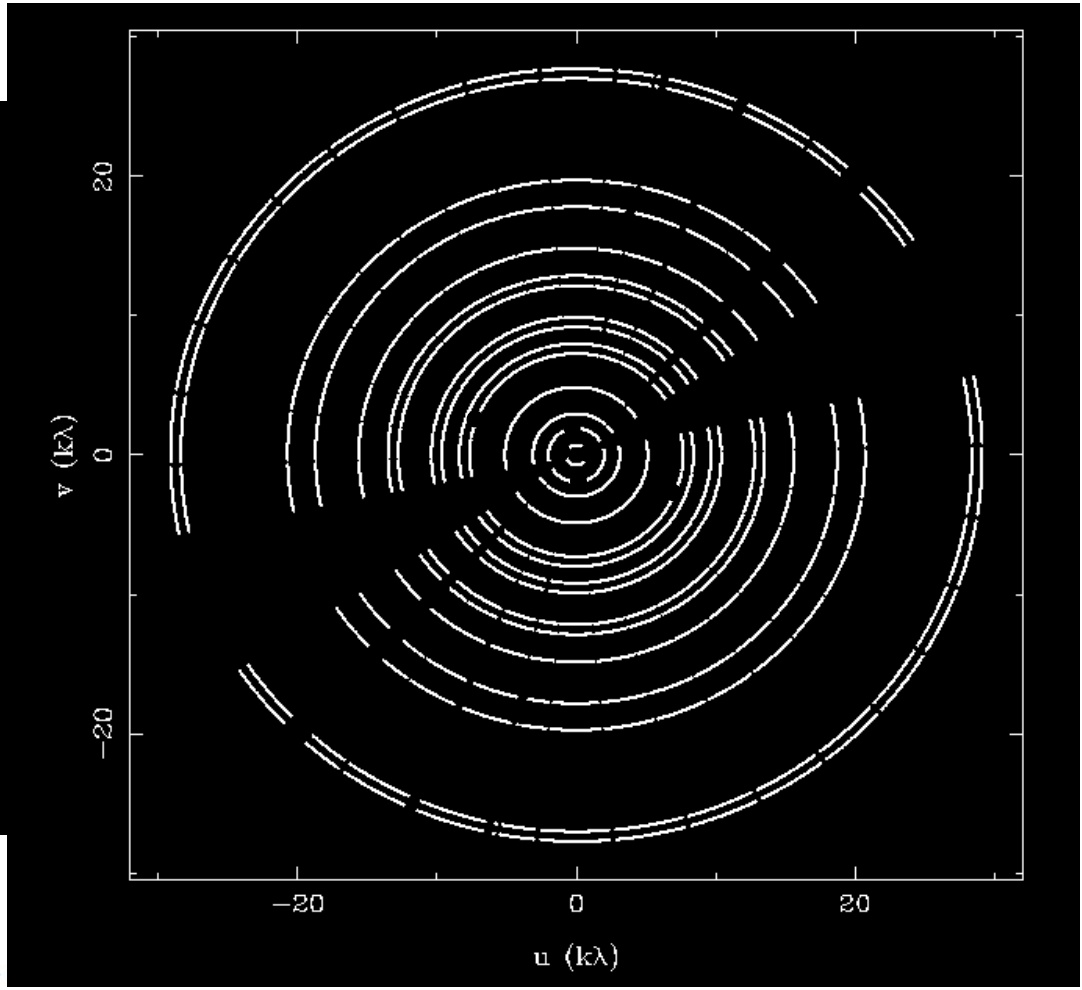
Synthesis imaging





Synthesis imaging





The project

International Design Team

- Project Management and System Engineering Team based at Jodrell Bank Observatory, Manchester, UK
- ~500 scientists & engineers in institutes and industry in 11 Member countries of the SKA


WIDE BAND SINGLE PIXEL FEEDS


TELESCOPE MANAGER

CENTRAL SIGNAL PROCESSOR


SIGNAL AND DATA TRANSPORT

SCIENCE DATA PROCESSOR


DISH


MID-FREQUENCY APERTURE ARRAY


LOW-FREQUENCY APERTURE ARRAY


ASSEMBLY, INTEGRATION & VERIFICATION


INFRASTRUCTURE AUSTRALIA


INFRASTRUCTURE SOUTH AFRICA

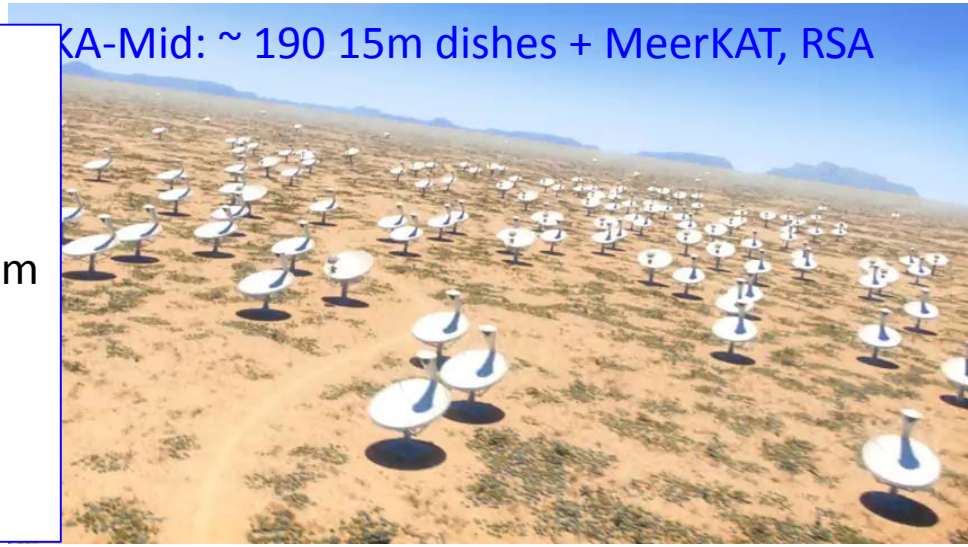
SKA Phase 1

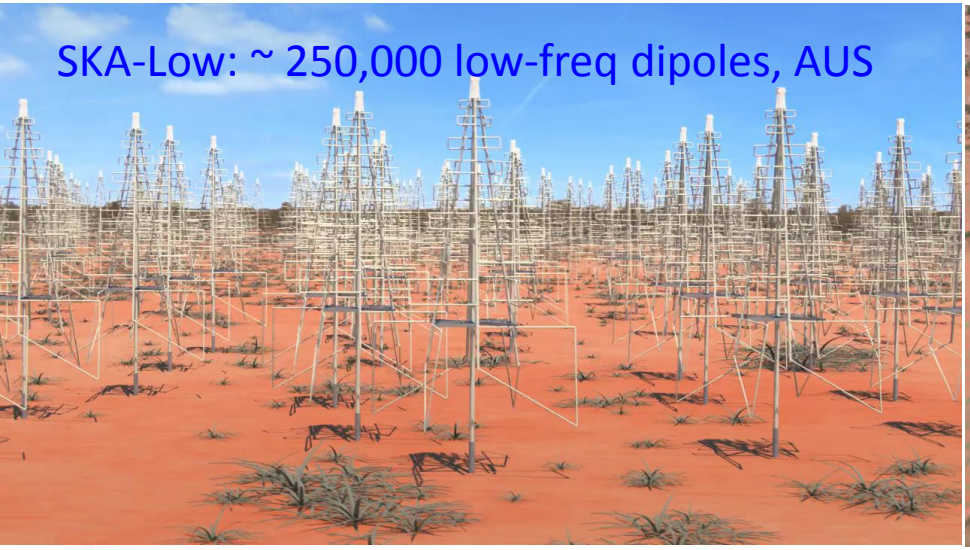
2 sites (South Africa, Australia);

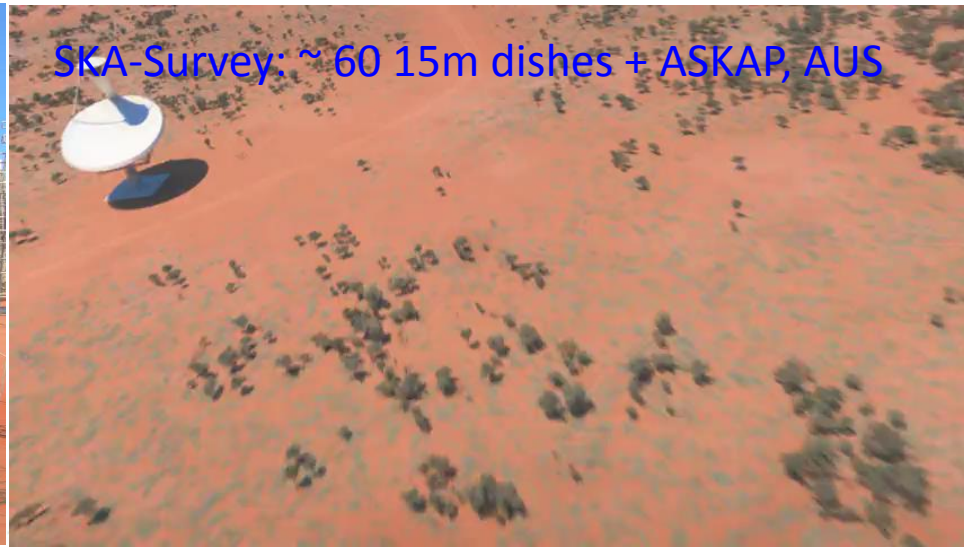
SKA Phase 2

~2500 dishes, baseline lengths up to 3500km
~10^6 dipoles, baseline lengths ~few hundred km
~250 dense aperture array stations

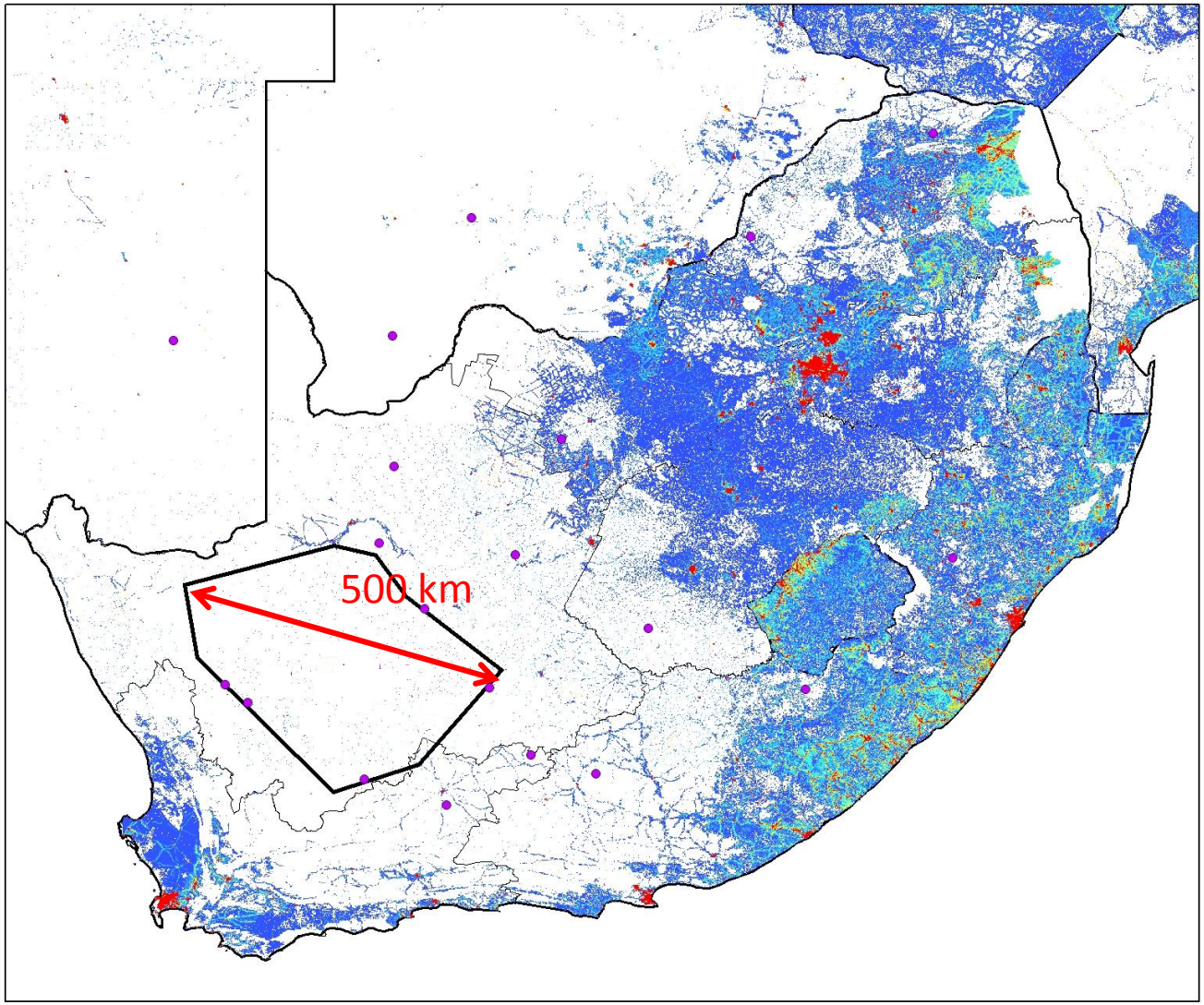
Construction: 2023 – 2030
~ LHC scale







Karoo Radio Astronomy Reserve



Legend

- SKA_Configuration_SPDO_Dish_Full
- AA1_SPDO_Version1
- AA2_SPDO_Version2
- KCAAA1

Population (per sq km)

Value

- 0 - 4
- 4.000000001 - 14
- 14.00000001 - 29
- 29.00000001 - 47
- 47.00000001 - 68
- 68.00000001 - 91
- 91.00000001 - 116
- 116.0000001 - 142
- 142.0000001 - 169
- 169.0000001 - 197
- 197.0000001 - 225
- 225.0000001 - 255

N

0 145 290 580 870 1,160 Kilometers

Contact:
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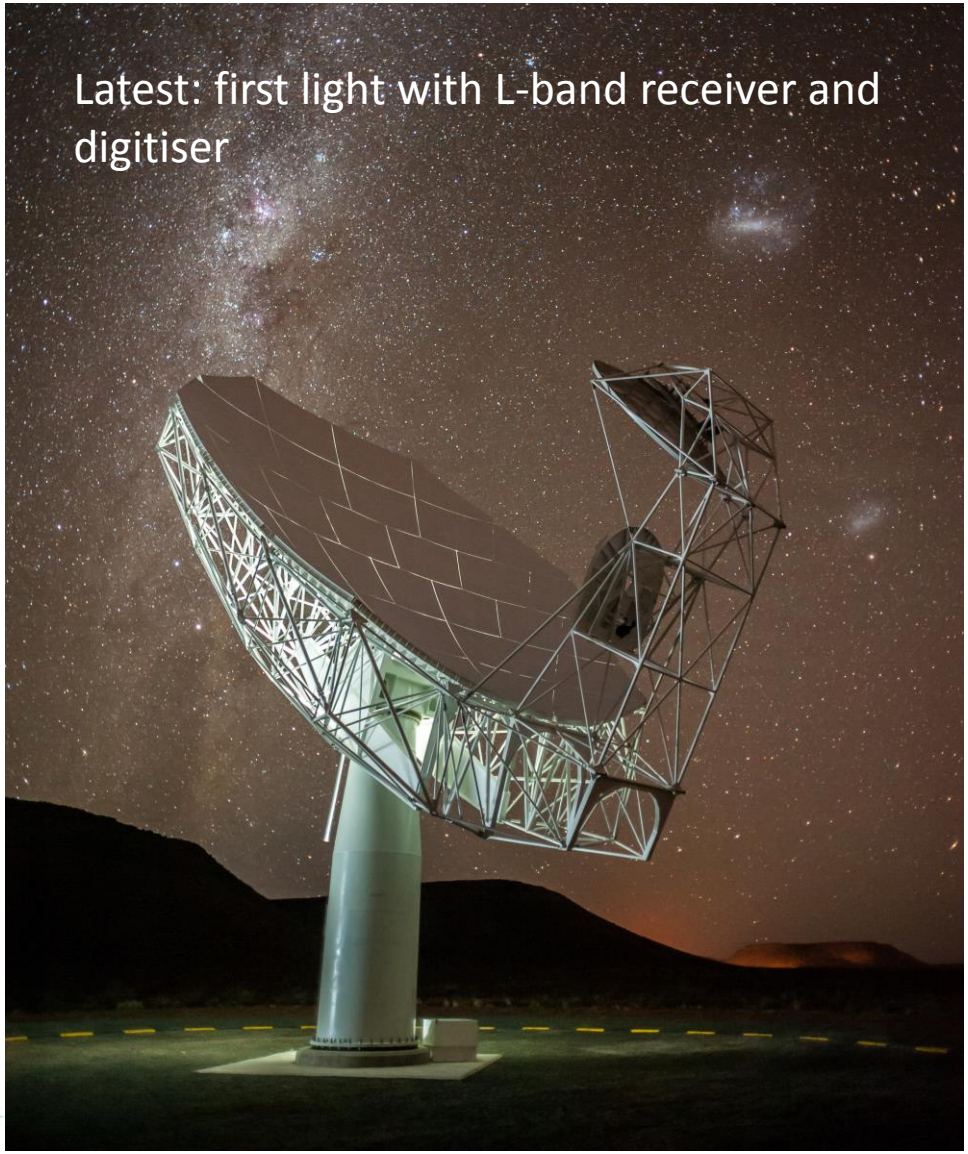
2196
South Africa
Tel: +27 11 442 2434
Fax: +27 11 442 2454
Email: atiplady@ska.ac.za

SKA Precursor: MeerKAT

64 x 13.5m offset Gregorian antennas
8km maximum baseline length
First receivers:
    0.9 – 1.67 GHz (L-band)
    0.58 – 1 GHz (UHF)
770 MHz bandwidth
Early operations 2016/7



SKA Precursor: MeerKAT

Infrastructure: dish assembly shed; bunkered and RFI shielded data processor room and power system + …..

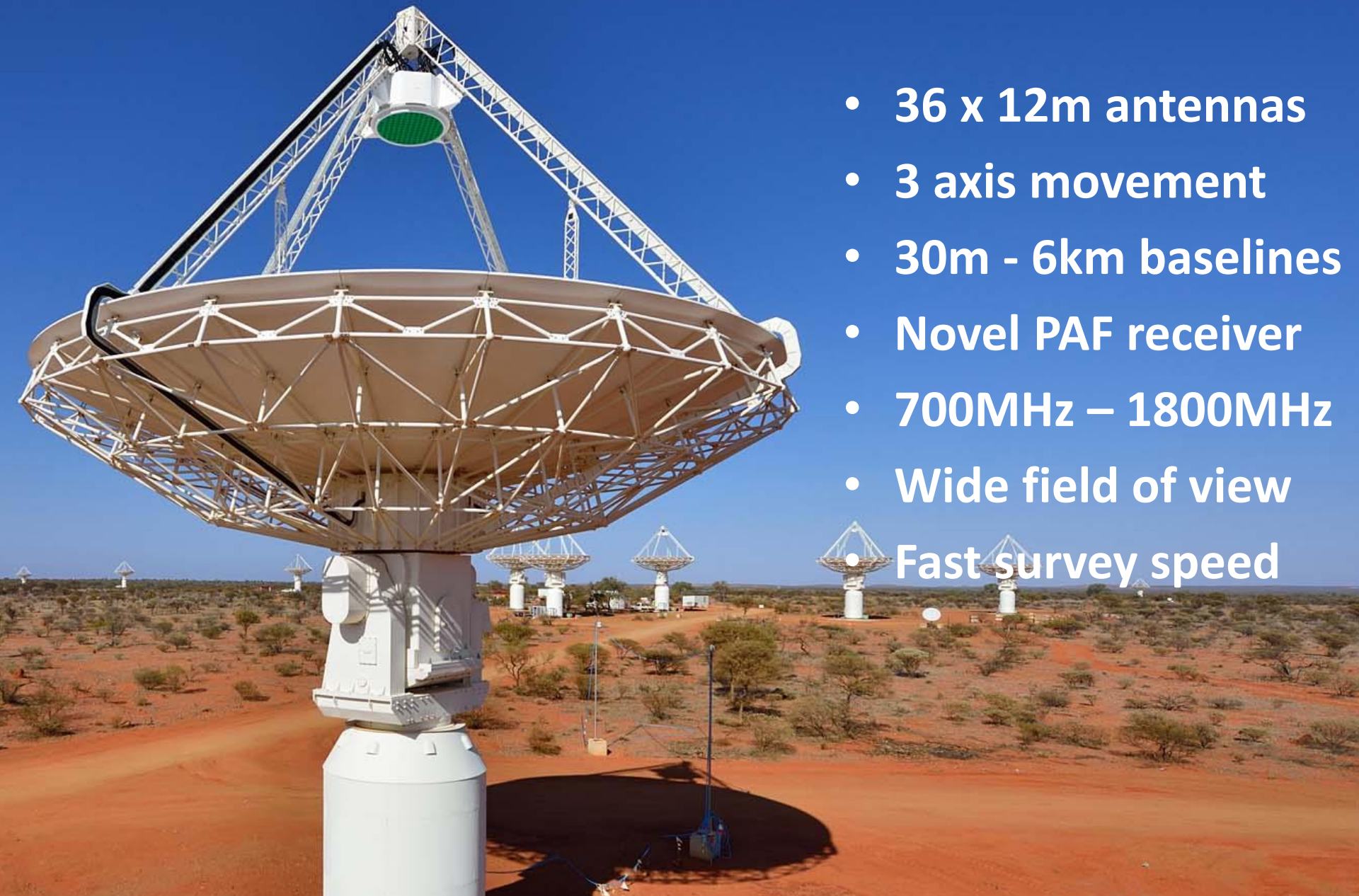
3 dish prototypes all in testing

Murchison Radio Astronomy Observatory

Shire of Murchison:

- 50,000 km² ; size of the Netherlands
- 0 gazetted towns
- 29 sheep/cattle stations
- 110 population

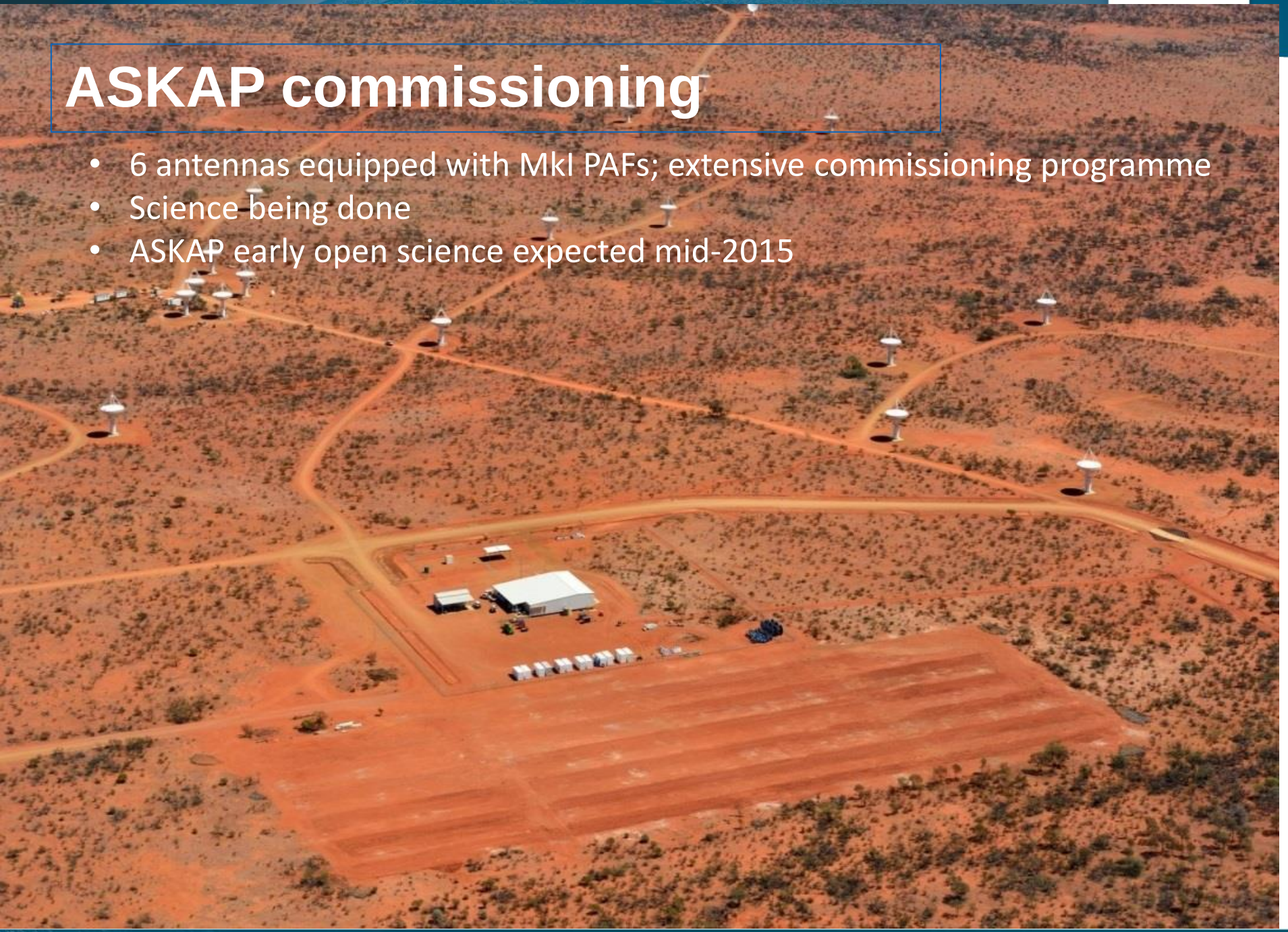
ASKAP – a new-technology survey telescope



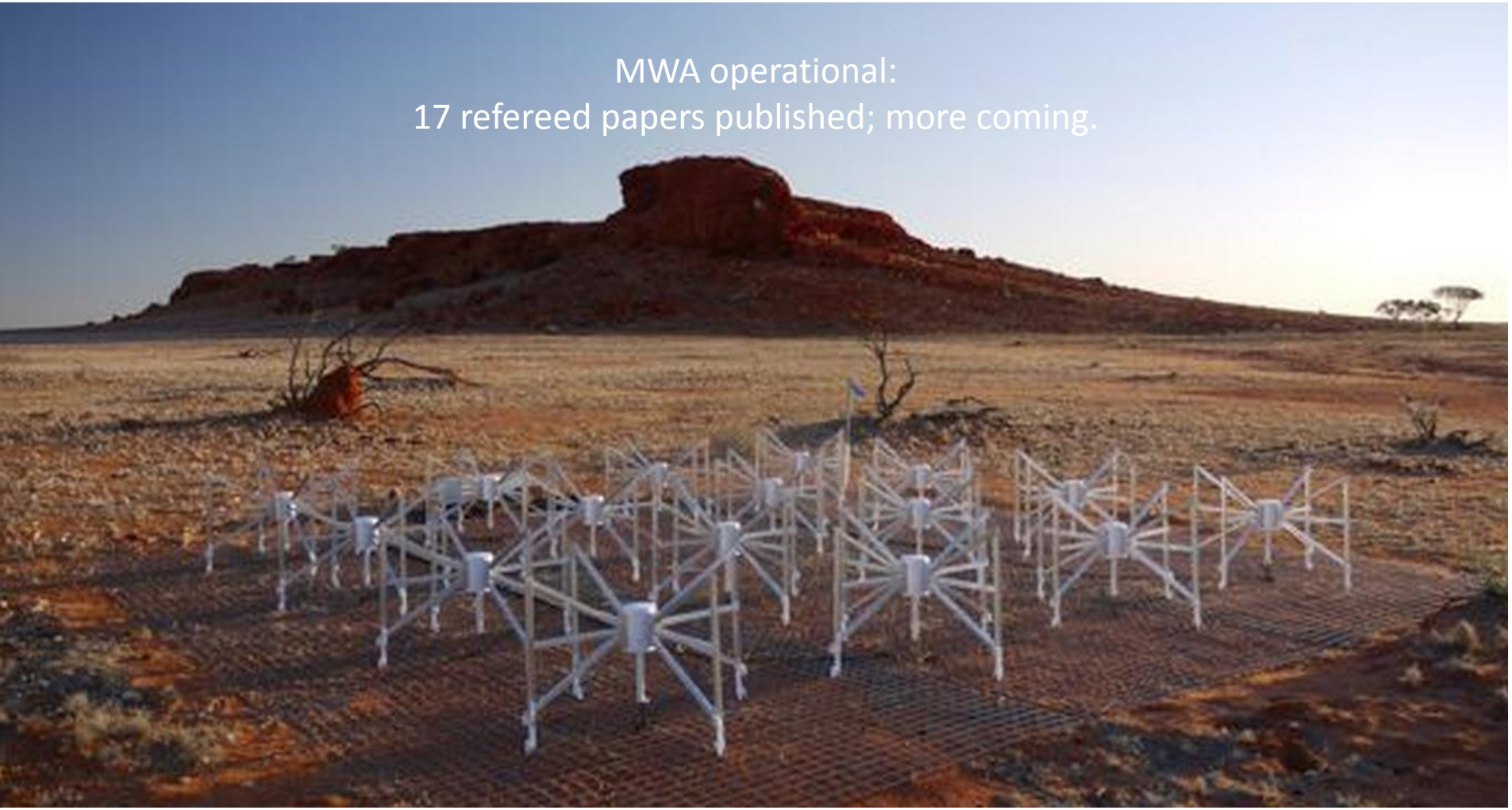
- **36 x 12m antennas**
- **3 axis movement**
- **30m - 6km baselines**
- **Novel PAF receiver**
- **700MHz – 1800MHz**
- **Wide field of view**
- **Fast survey speed**

ASKAP commissioning

- 6 antennas equipped with MkI PAFs; extensive commissioning programme
- Science being done
- ASKAP early open science expected mid-2015



SKA Precursor: Murchison Widefield Array



LFAA overview

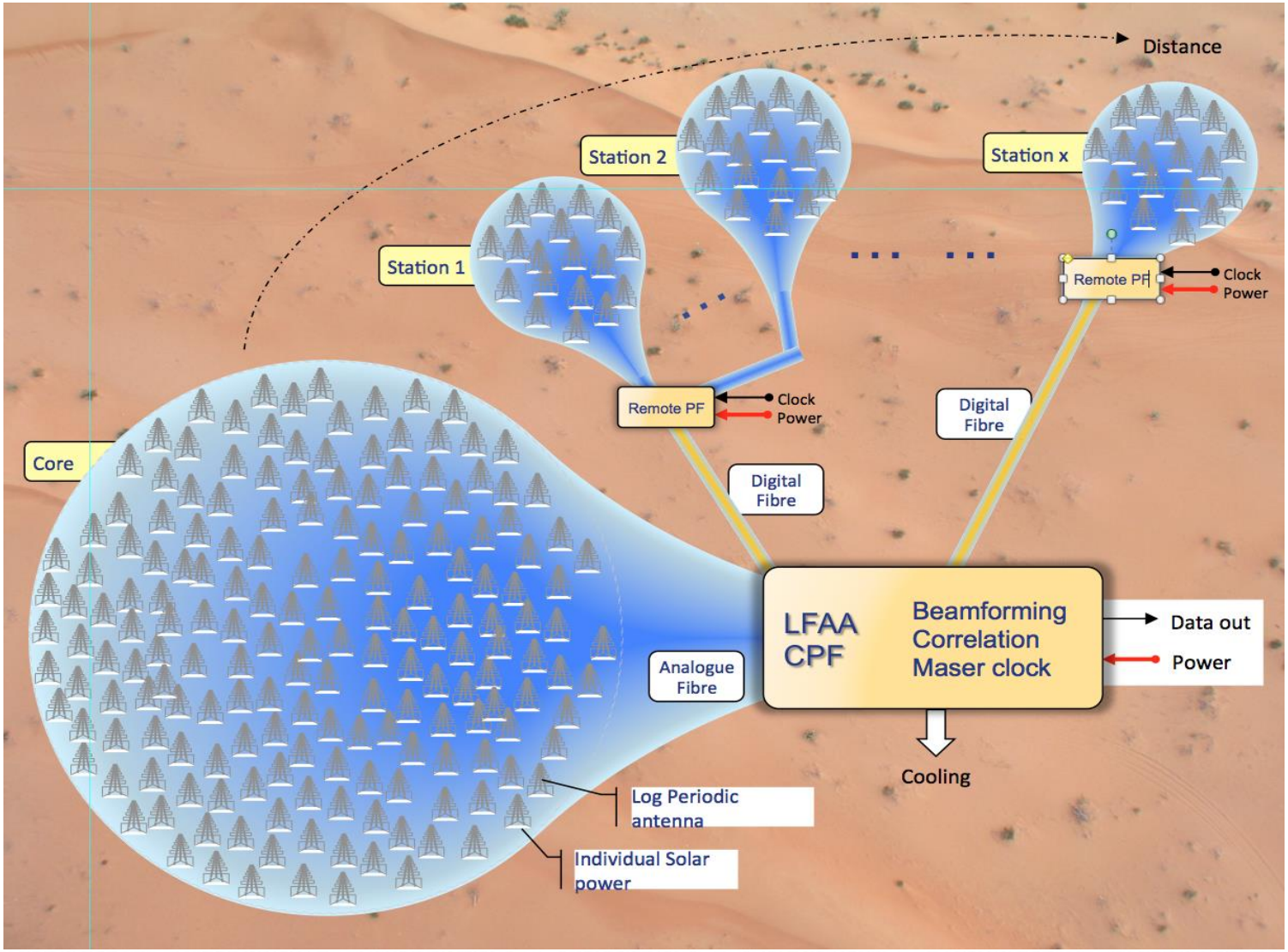
Antenna:	Log Periodic
No. of ant.:	262,144 (2^{18})
Ant. spacing:	1.5m – 2.0m
Station size:	256 ant. ~35m dia.
No. of stations:	1024

Configuration:

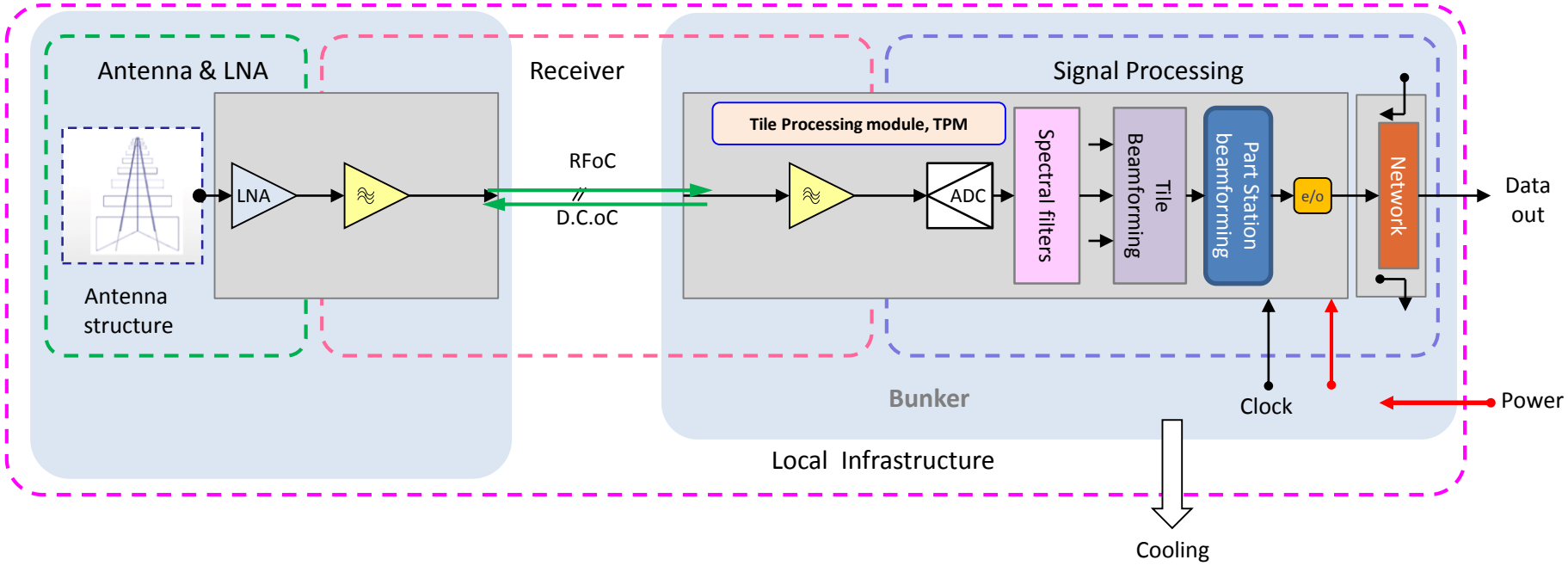
>600m:	50%	512 stns
>1000m:	75%	768 stns
>3000m:	96%	979 stns
Sp. Arms:	4%	45 stns

Ant. Sig. trans:	Analogue fibre
RPF sig trans:	Digital fibre
Processing:	Digital
Tiles:	16 ant. / “Tile”
Data routing:	Switch network
Facilities:	Central proc. Remote proc.

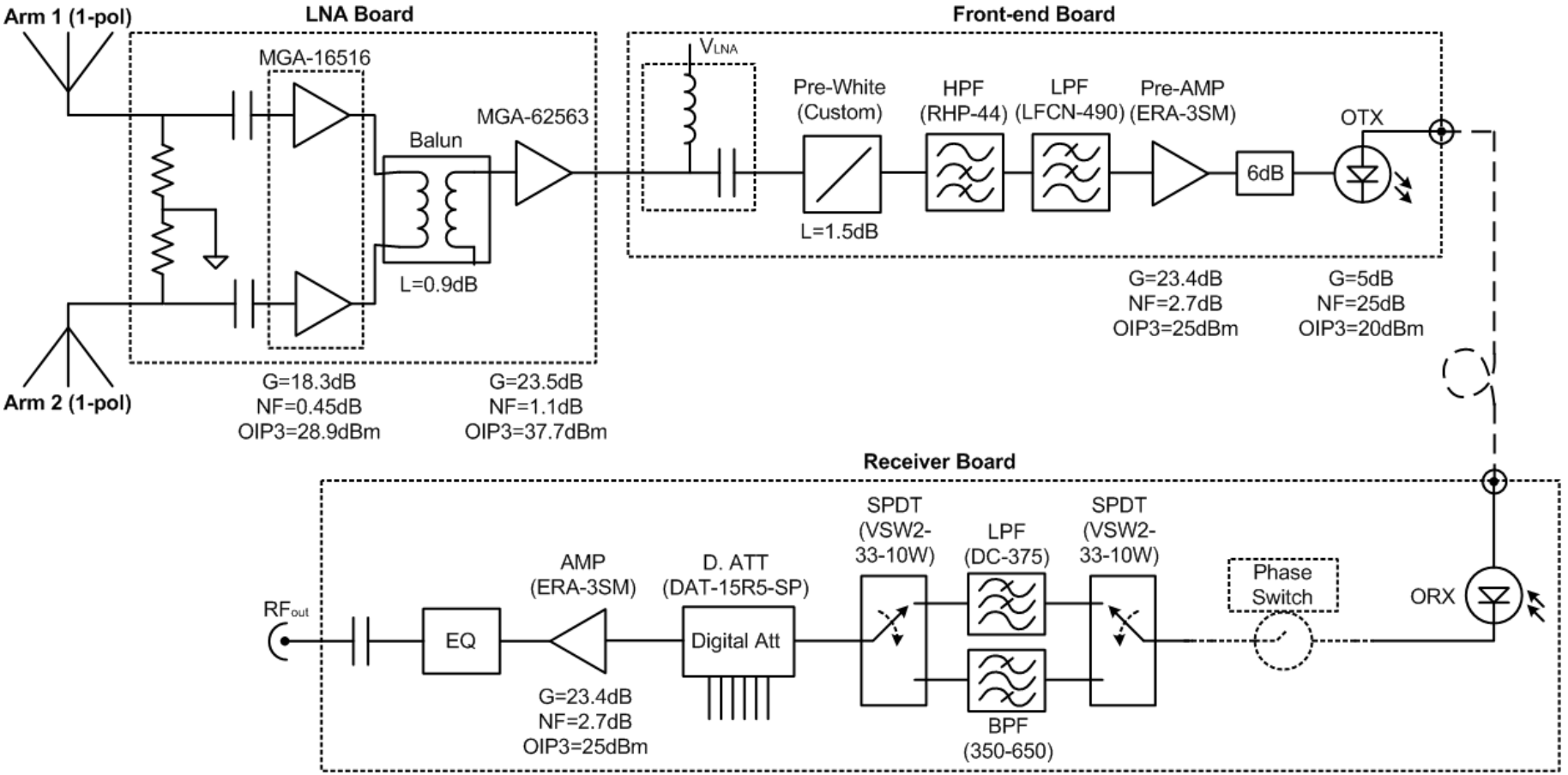
Proposed Layout



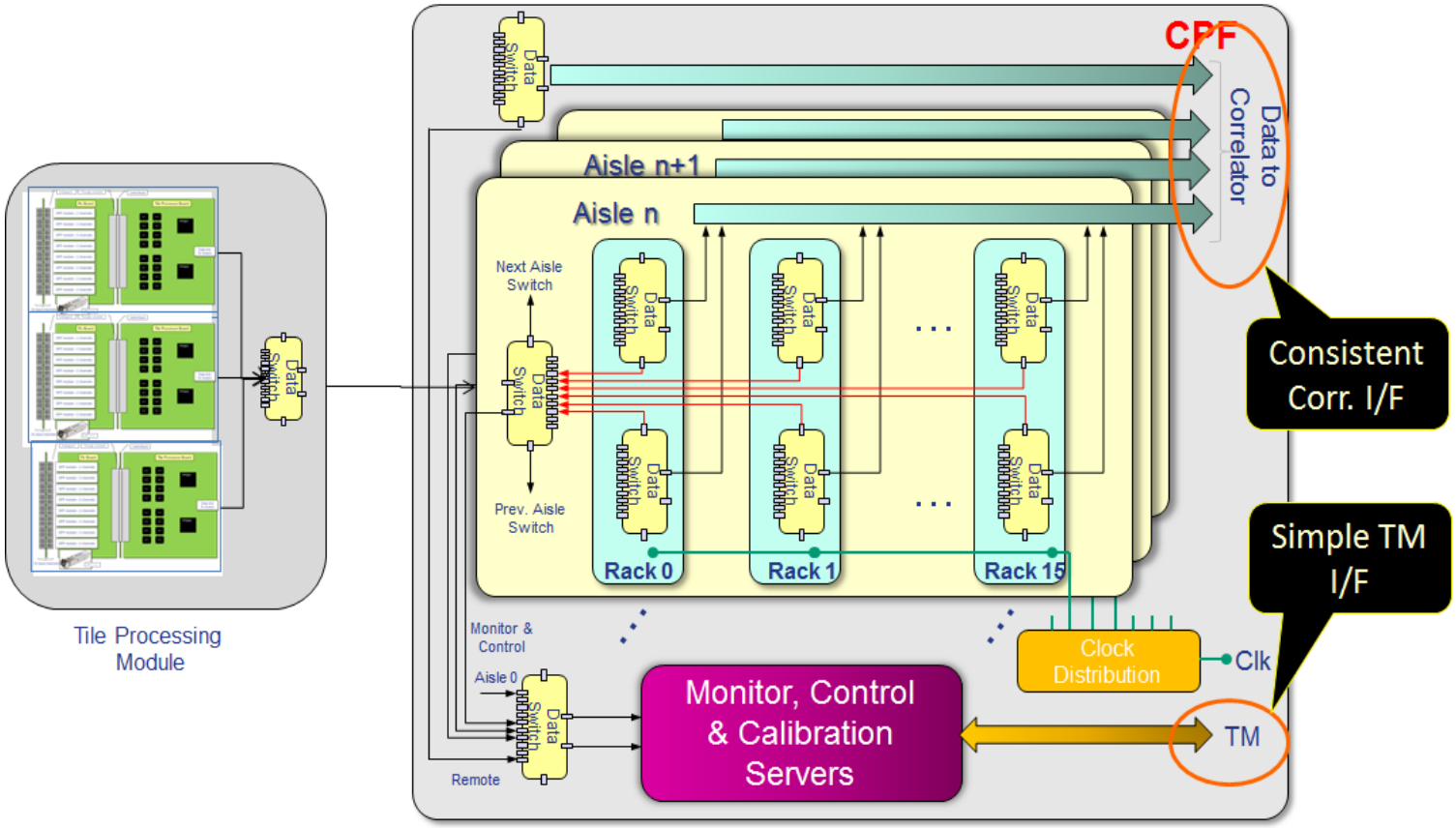
Signal flow for LFAA



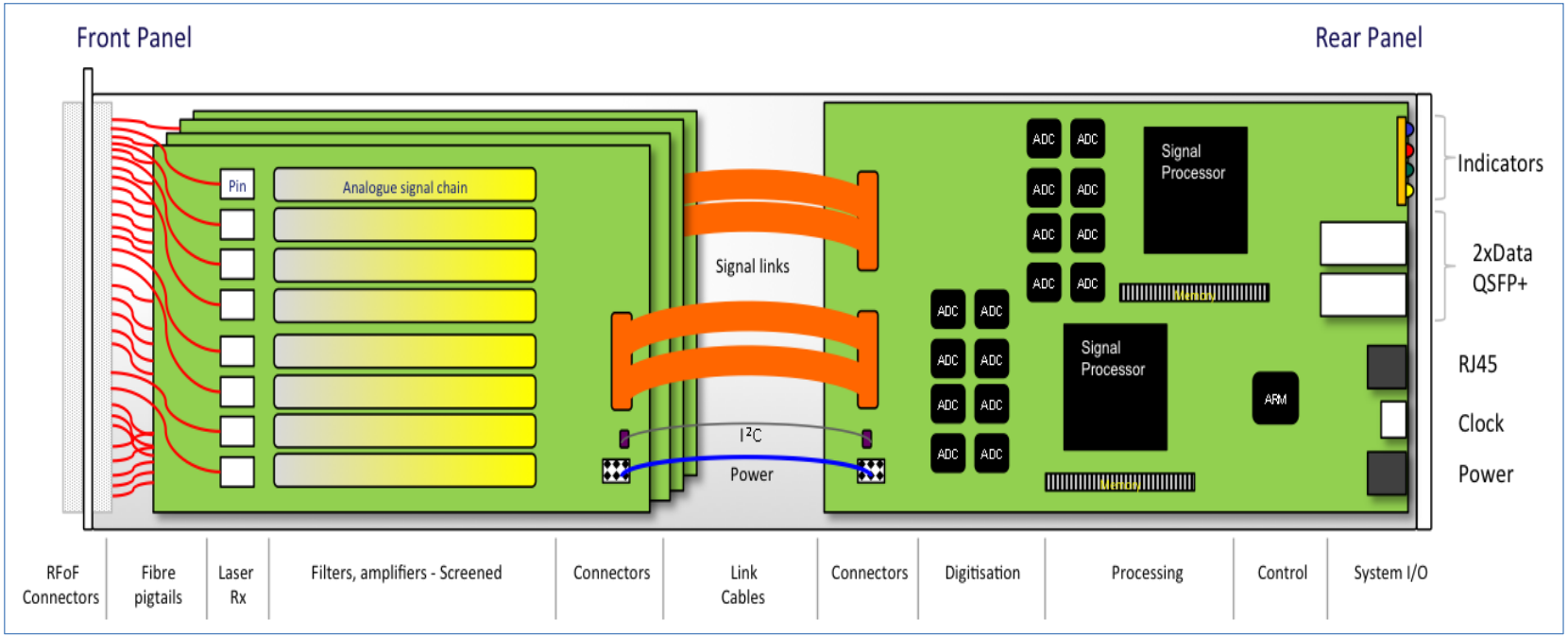
RF-components

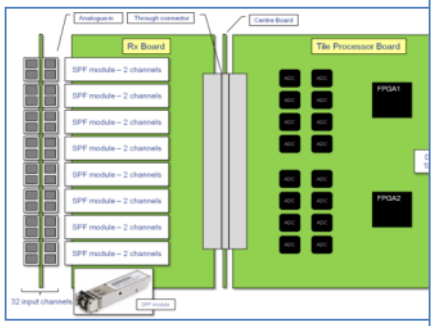


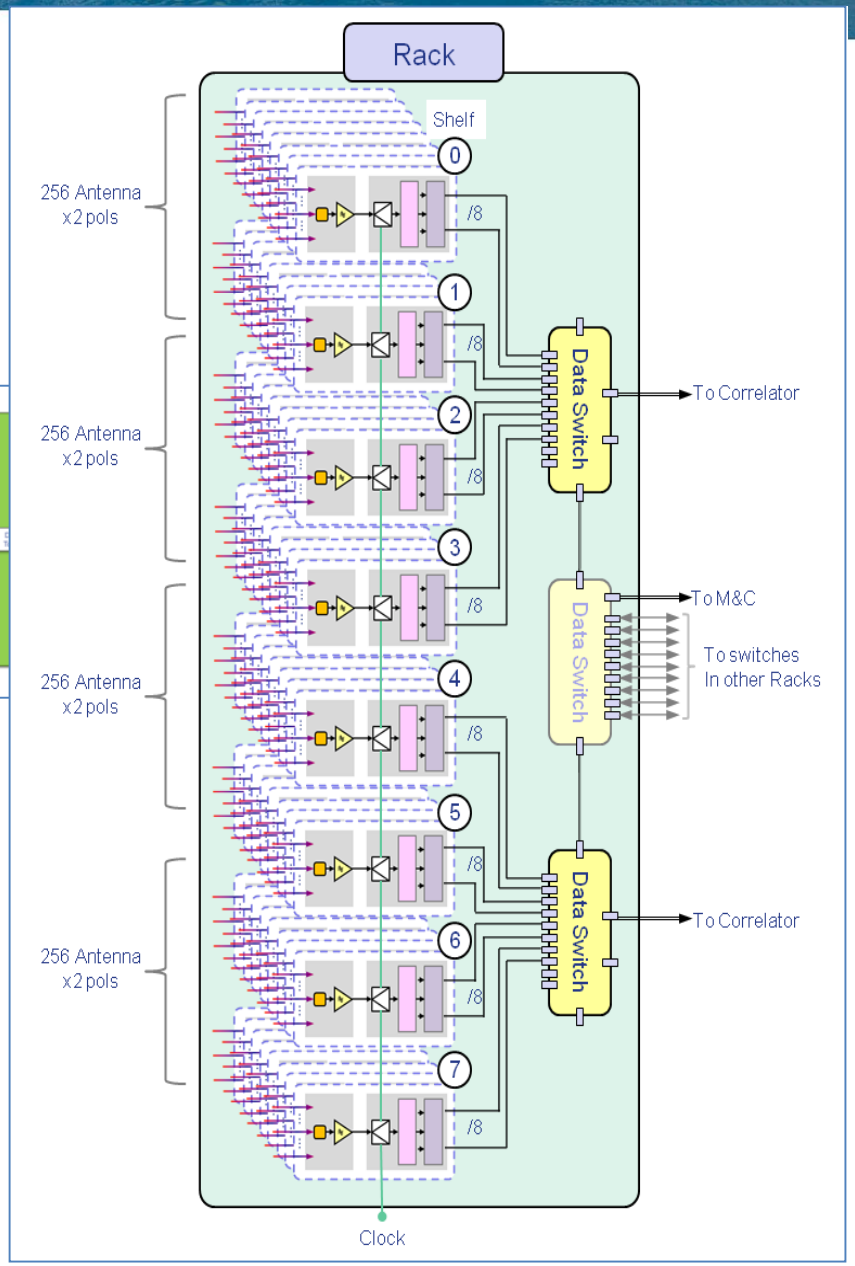
Local Processing Facility



Tile Processing Module







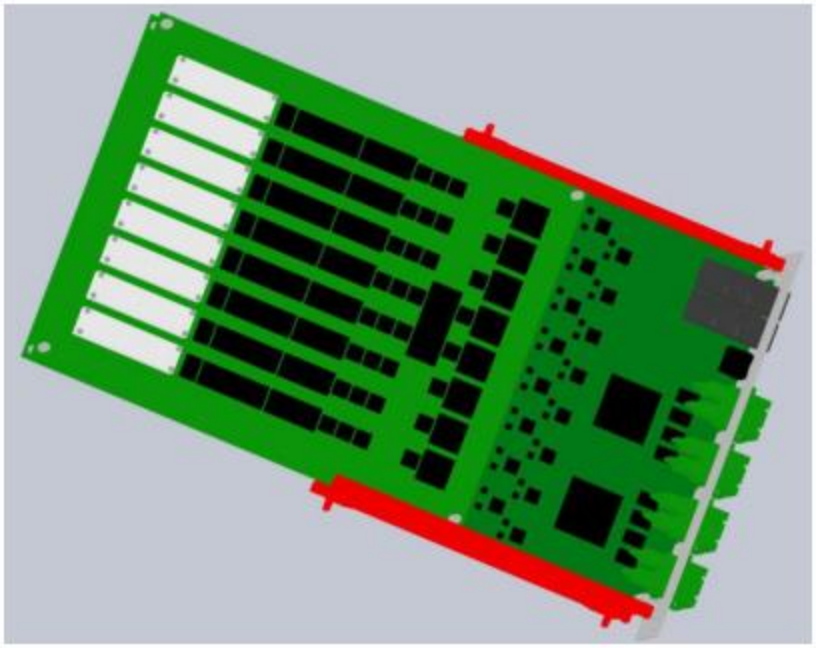
64 Tile processors in a rack

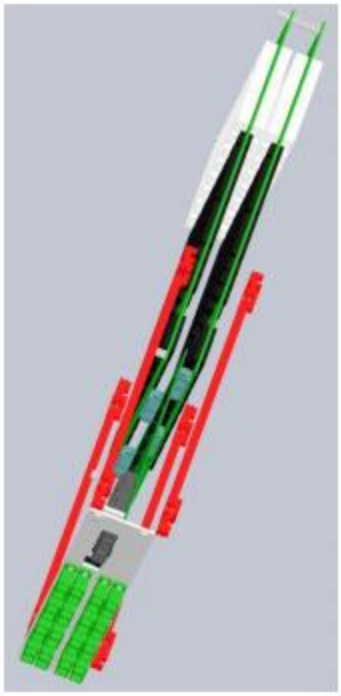
2048 fibres into each rack

Switch network to handle the data

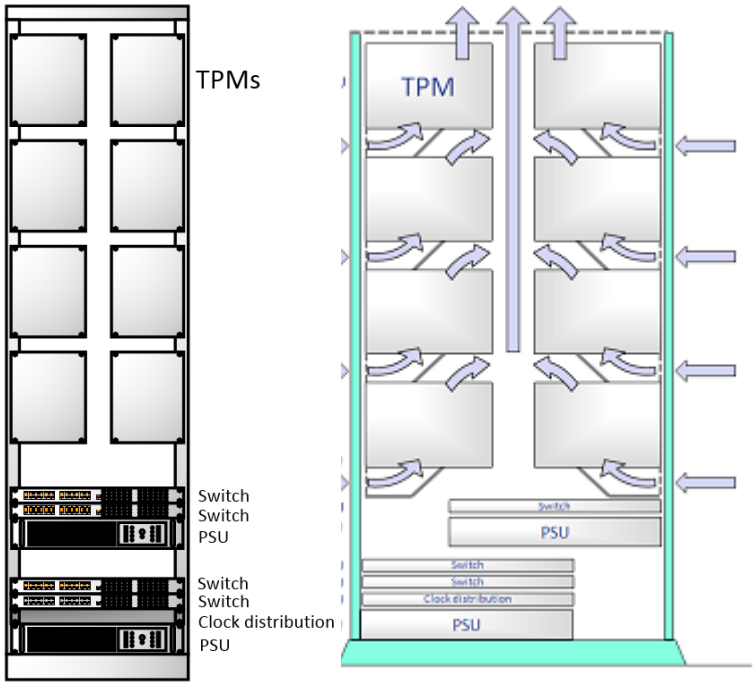
Power supplies

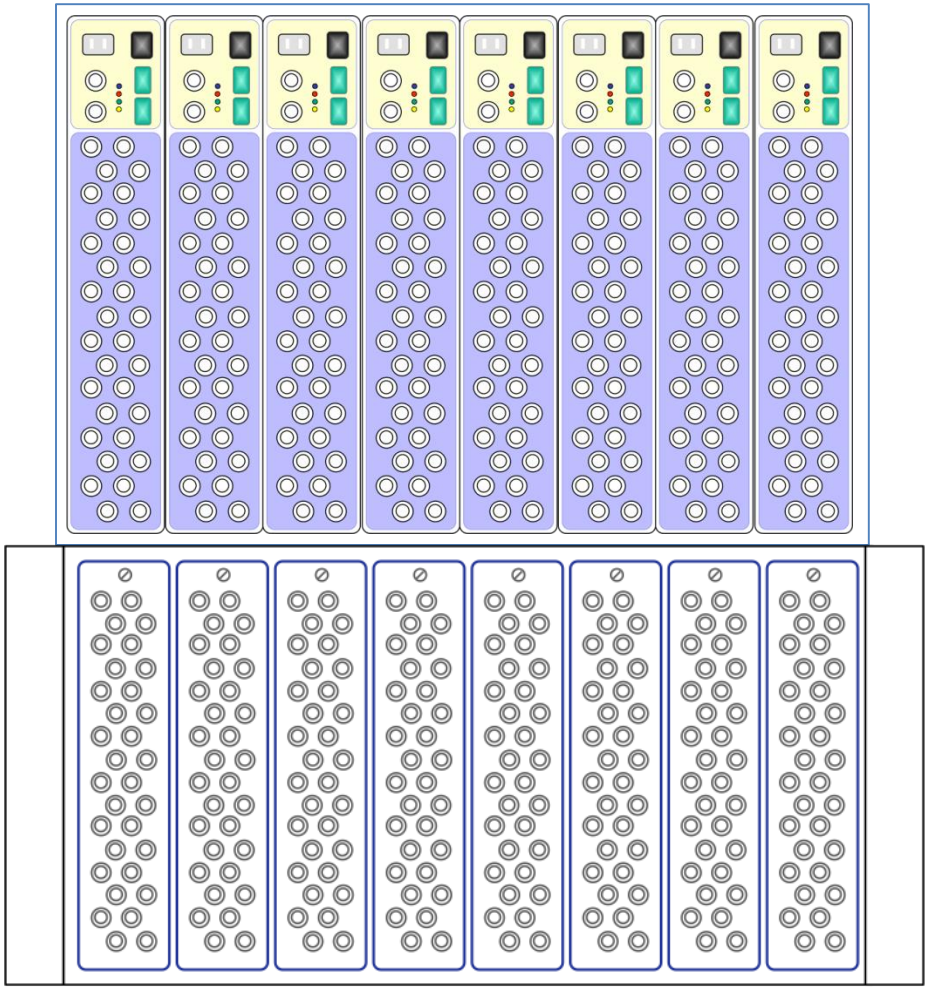
Mechanical Design



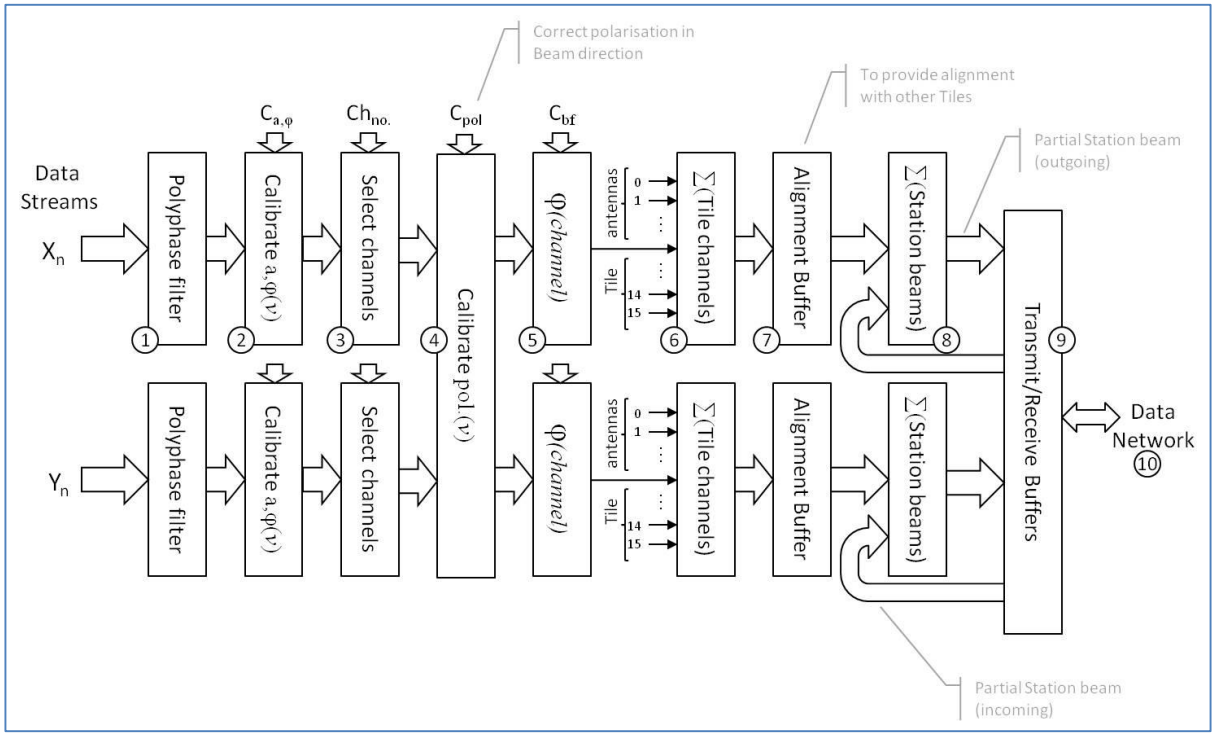


Racks and Networks

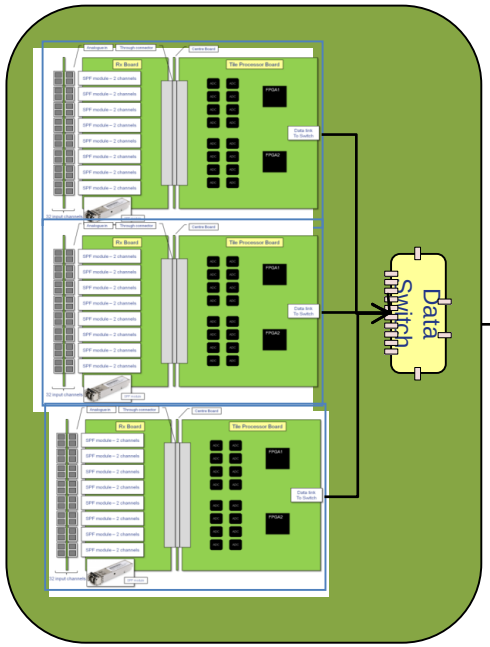




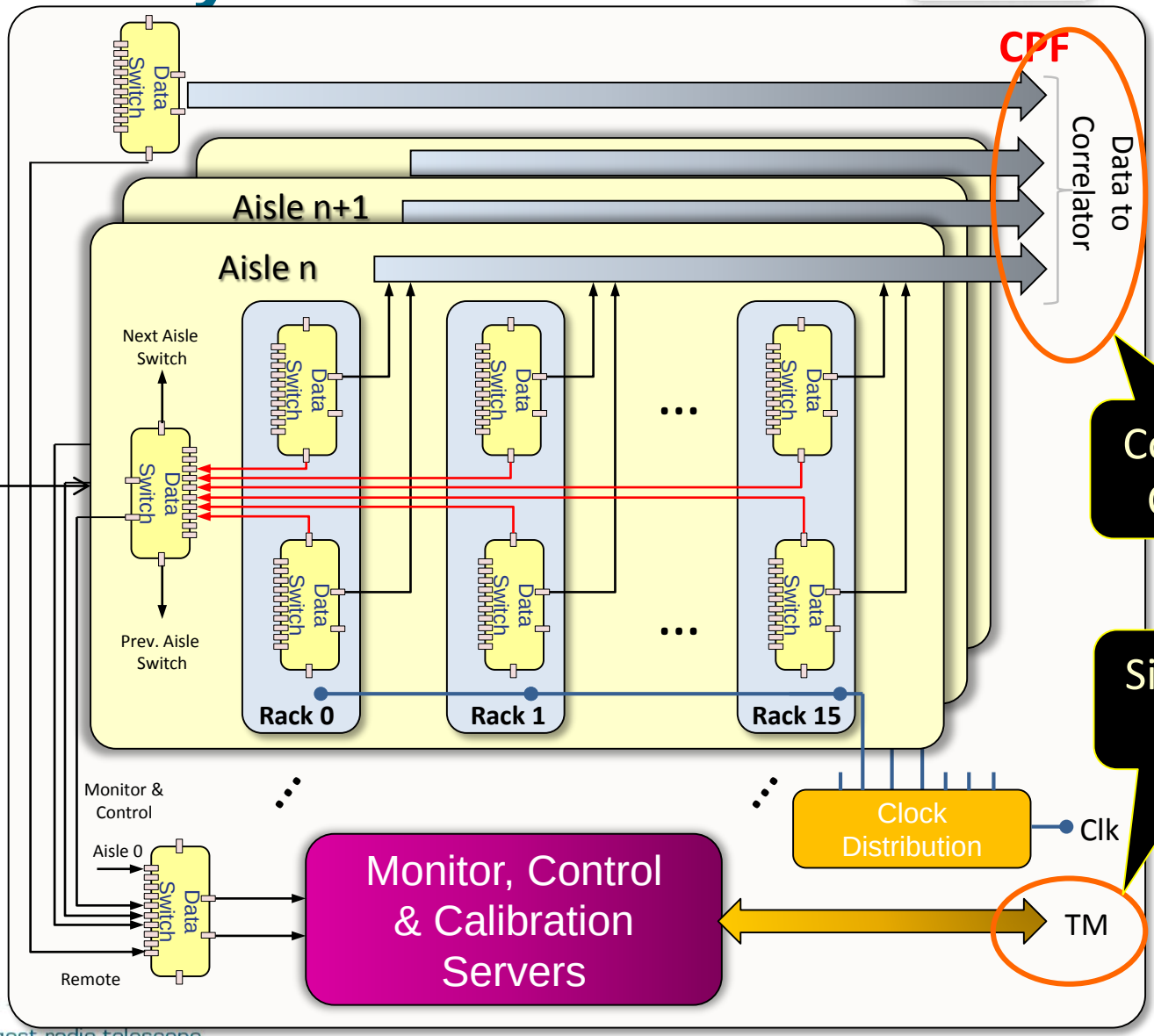
Digital Functionality



Processing Facility



Local Processing Facility



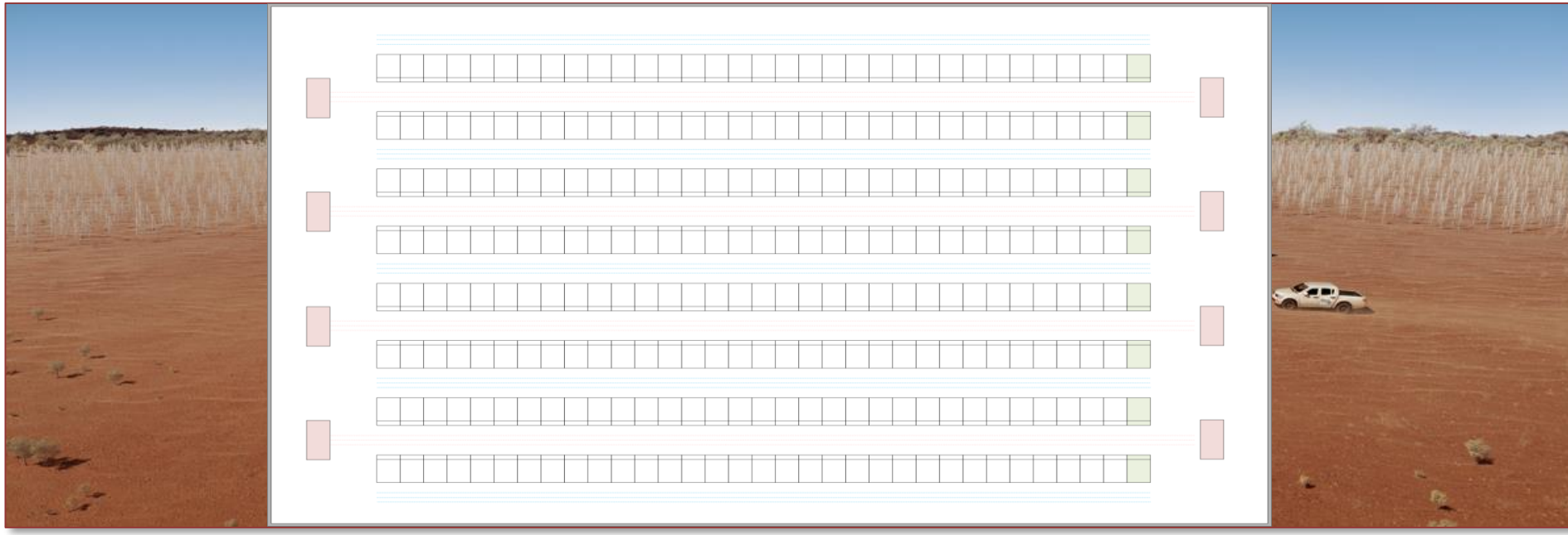
Monitor, control and calibration servers

A small cluster of processors that provide all of LFAA LMC(s).

Their role is to:

- Interface the LFAA to the Telescope manager
- Define all the LFAA stations
- Calculate all coefficients and calibrations required for all the Tile Processors
- Distribute commands to the Tile Processors
- Receive monitoring information from the Tile Processors
- Control the configuration of the LFAA switch network.

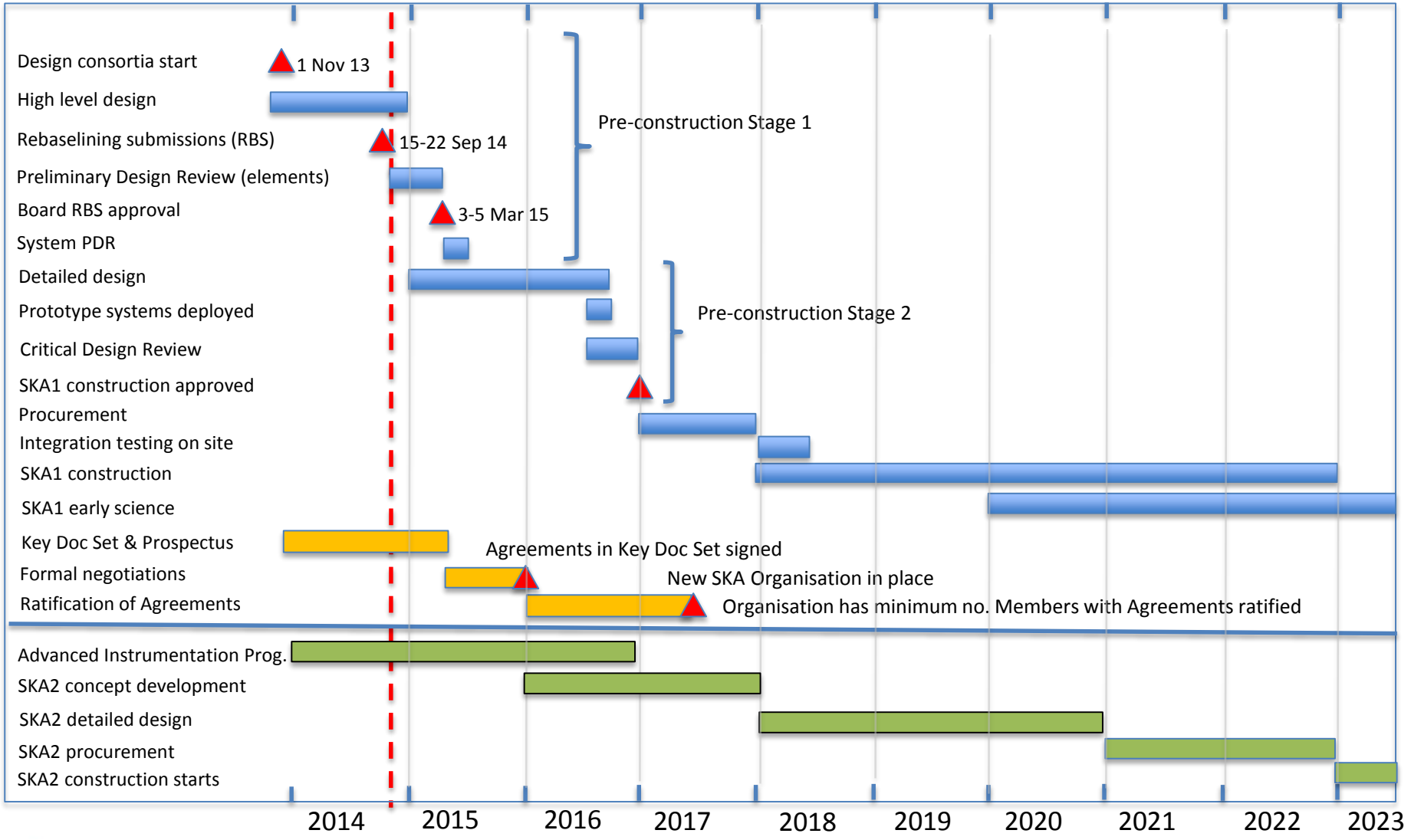
Data Centre



Status

High-level SKA1 Schedule

KEY: Blue = SKA1 science & engineering; orange = policy; green = SKA2



SKA: Driving development

- Dishes, feeds, receivers (N=250 → 2500)
- Low and mid aperture arrays (n=250k → 1000k)
- Signal transport (≈1 Pb/s → 10 Pb/s)
- Signal processing (exa-MACs)
- Software engineering and algorithm development
- High performance computing (exa-flop capability)
- Data storage (exa-byte capacity)
- (Distributed) power requirements (10 → 50MW)

Exploring the Universe with the world's largest radio telescope

SQUARE KILOMETRE ARRAY

Exploring the Universe with the world's largest radio telescope

Thank-you

www.skatelescope.org