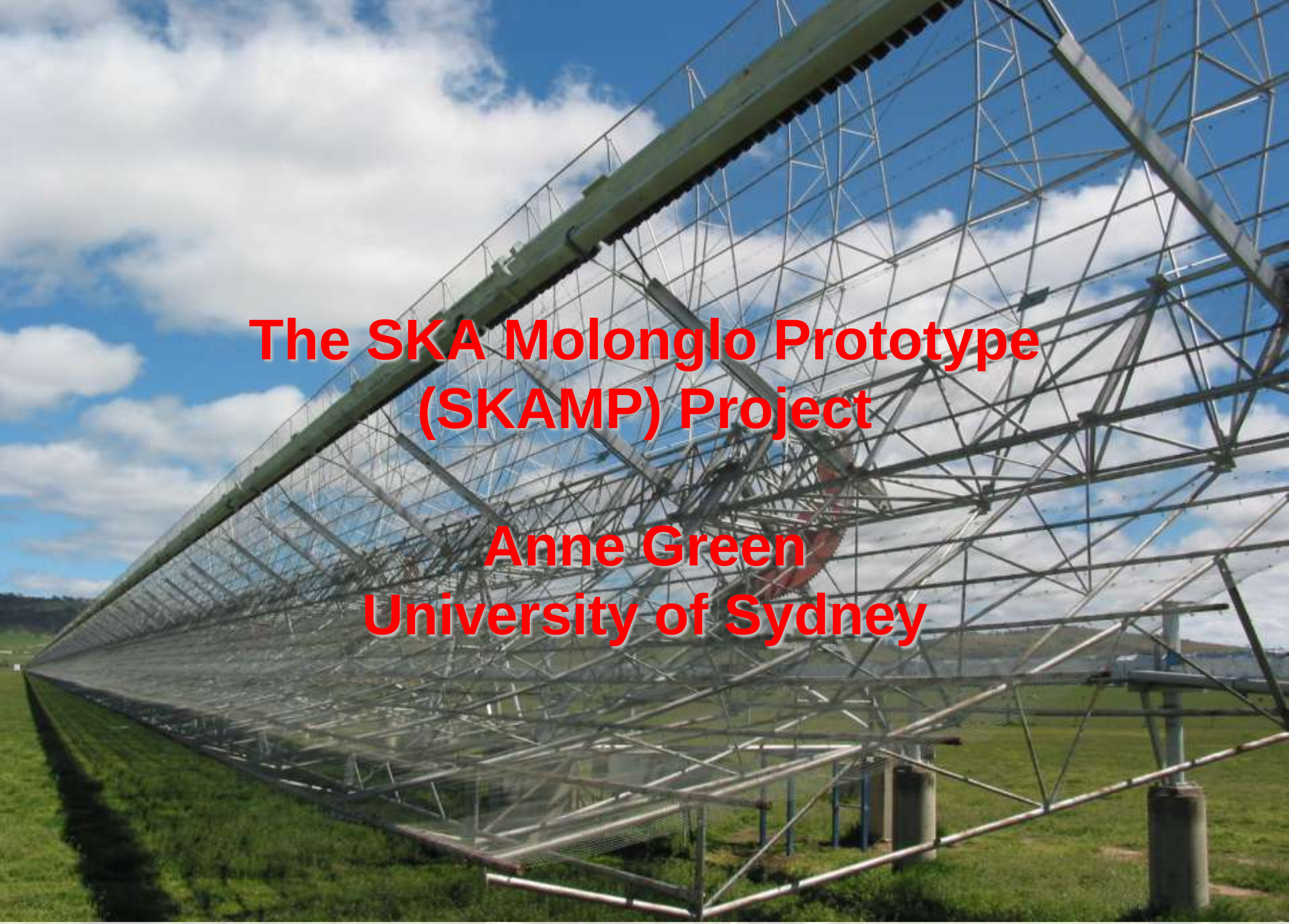


The SKA Molonglo Prototype (SKAMP) Project

Anne Green
University of Sydney

ISSC & SKA Working Groups

- Science: case for 10% SKA, memos on big questions, complementarity with other big projects
- Engineering: evaluation of RD, project cost models, project management & coordination, industry links
- Site Evaluation: advice on site proposals & RFI
- Simulations: analysis of site configurations
- Outreach: visualisations, posters, flyers & animations
- Operations: influence on construction, governance, existing facilities & resources

SKA Site Selection

- Physical Characteristics:
  * Very quiet radio site
  * Large extent (> 3000 km)
  * Low turbulence – ionosphere & troposphere
- Timeline update:
  * 4 sites proposed – Australia, Argentina, China, South Africa
  * July 2006 – SKA Site Advisory Committee evaluation
  * August 2006 – ranking of sites by ISSC
  * 2007-2008 – site decision after governmental discussions

SKA Molonglo Prototype Project (SKAMP)

- Project goal: provide a new low frequency spectral line capability to augment the national facility and contribute to the Australian SKA effort.
- Technology developments: fast digital signal processing & transport, wide-field imaging for continuum and polarisation studies, management of large data sets, RFI mitigation.
- Key science outcomes: blind survey of red-shifted HI to test predictions for mass-assembly of galaxies from CDM scenarios, direct measure of HI mass function at high red-shift, cosmic magnetism studies.
- Opportunity: test issues on 1% collecting area of SKA

SKAMP Team

University of Sydney

- Anne Green
- Duncan Campbell-Wilson
- Adrian Blake
- Tim Adams
- Martin Leung
- Sergey Vinogradov
- Elaine Sadler
- Tim Hubbard
- Greg Kingston

University of Tasmania

- John Russell
- Chris Wyman

CSIRO – ATNF & ICT

- Michael Kesteven
- Tony Sweetnam
- John Bunton
- Frank Briggs
- Ludi de Souza
- Diana Londish

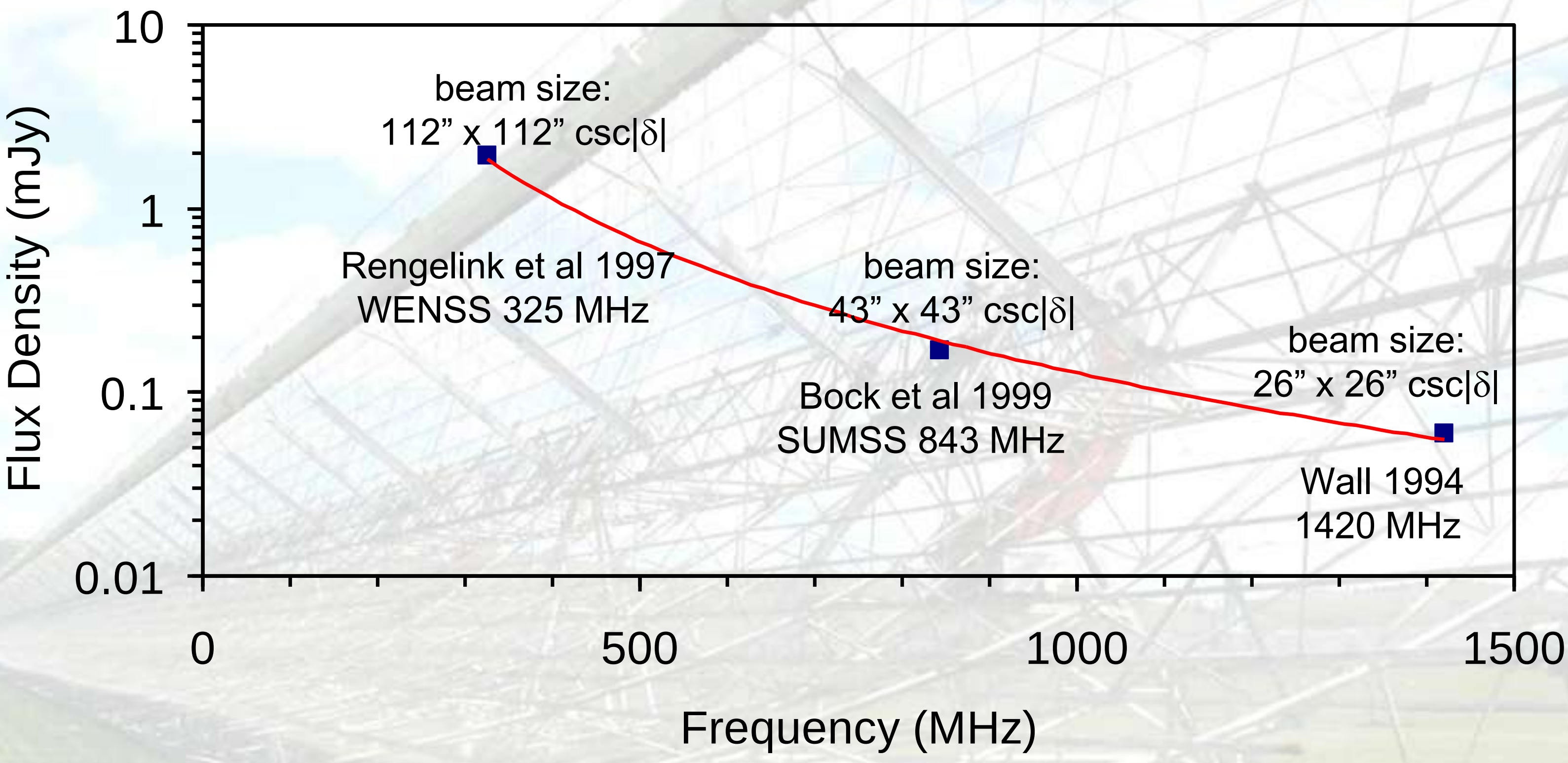
Argus Technologies

- Bevan Jones
- Martin Owen
- Peter Liversidge

SKAMP Milestones

- **STAGE 1**: 96 stations, 843 MHz continuum, Tsys 55K,BW 4 MHz, field-of-view 5 square degrees, 12 hr σ is 0.8 mJy (2006)
- **STAGE 2**: Spectral-line correlator, 830 – 860 MHz, BW 30 MHz, field-of-view 4 square degrees, 6000 channels, maximum spectral resolution 5 kHz, 12 hr σ is 0.12 mJy (early 2007)
- **STAGE 3**: Dual polarisation feed, 650 – 1100 MHz, BW 100 MHz, 6000 channels, maximum spectral resolution 5 kHz, Tsys now 40K, 12 hr σ is 0.1 mJy (late 2007 – test bay)

Confusion limits for Molonglo @ 843 MHz (10 beams/source) at δ = –60°

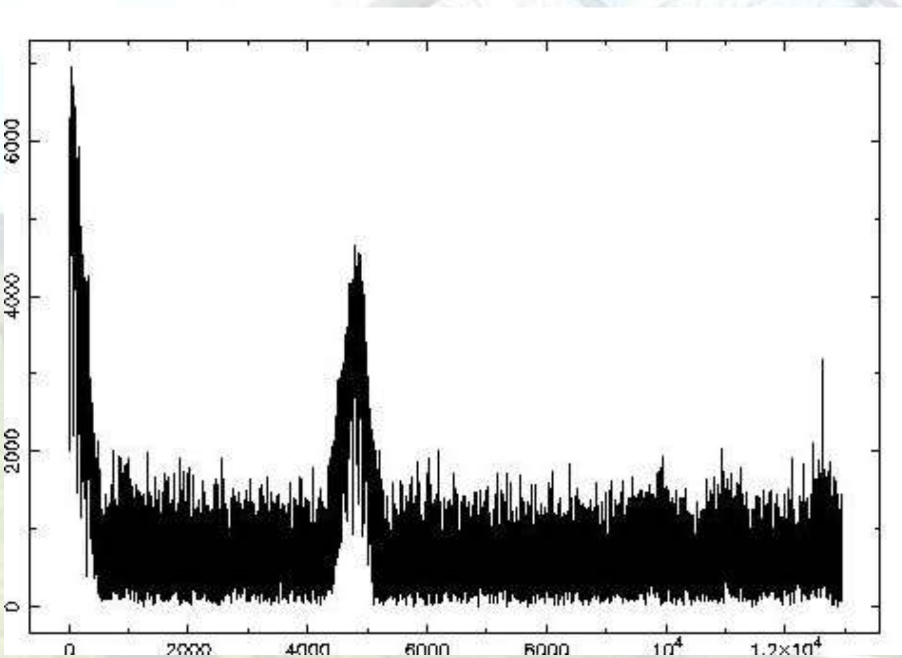


43“ spatial resolution: continuum confusion limit is 0.12 mJy

Not for spectroscopy or polarimetry – discrimination via other parameter

Narrowband continuum correlator

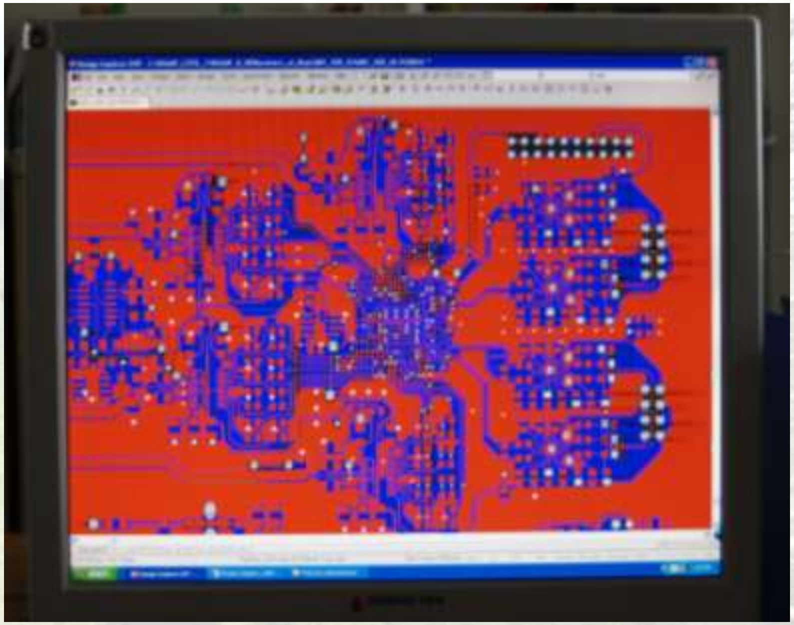
- 96 independent stations: 88 telescope stations + reference antennas
- Proof of concept complete – final debugging in progress
- Drift scan on calibrator source



Spectral-line correlator racks ready

- Racks installed for fibre patch panels, polyphase filterbanks & correlator.
- Schematics for boards nearly complete.
- For 6000 channels and 6 sec integration cycle, data rates per board will be about 0.2 Gb/s
- Total data acquisition rate for 24 ethernet connections is about 0.5 GByte/sec. Some real-time analysis and compression is essential!

Altium sponsorship - nanoboards



ADC & serializer board

- FPGA-based development board.
- Interactive implementation & debugging.
- Identical sets to be located at the telescope and CSIRO for seamless interfacing of systems.

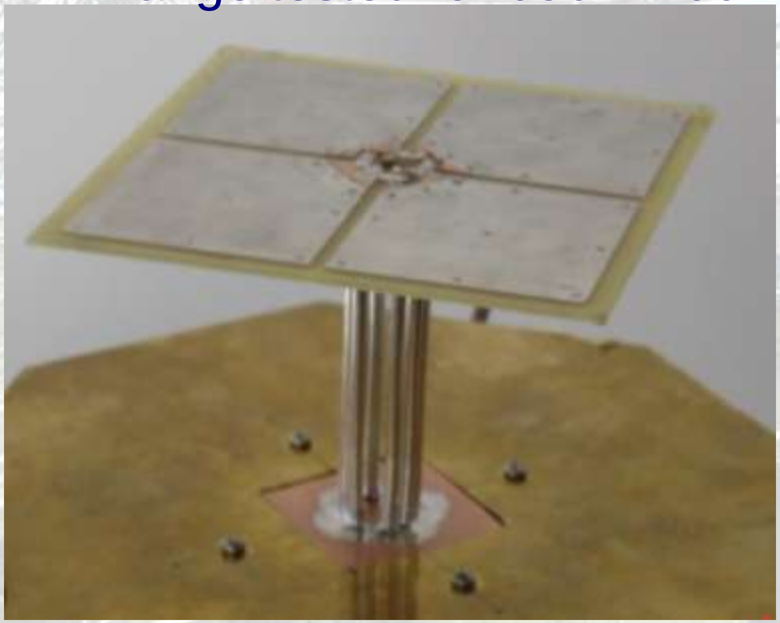
Fibre network complete – splicing under way

Rapid Prototype Telescope (RPT)

- Double mesh – reduces leakage
- Predict Tsys to improve by 15K
- Crimp added to reduce surface distortions
- Separate 17m bay to test feeds in realistic environment

Wideband feed prototype module

1. 8-element module, 1.4 m length
2. Wide-band dipoles – no moving parts
3. Polarisation axes oriented along & across axis of feed – better performance than dual-slant feeds
4. Range tested for 650 -1100 MHz



Leung

Feedline prototype support manufactured

Analogue Beam-forming prototypes designed:
Stage 1 combines the 8 elements of a module
Stage 2 combines 6 modules, gives 4 outputs per bay

Summary of SKAMP Project status

- Complete signal pathway from front-end to correlator is specified & designed – several sections in prototype or nearing completion.
- Major digital systems designed & layout almost complete (filterbanks & correlator).
- Integration of dual polarisation feed module and RPT has been planned.
- Optic fibre network laid & LO system in prototype.
- Planning for data acquisition software and analysis algorithms under way – expected data rates of 0.5 GByte/sec mean some real-time analysis essential

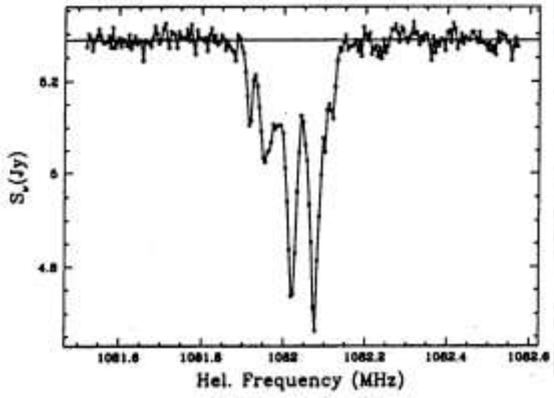
Science with spectral-line capability

Stage 2: 830-860 MHz range and 6000 spectral channel FX correlator enables:

Measurements of HI absorption at z ~ 0.75 that capitalise on the large collecting area of MOST

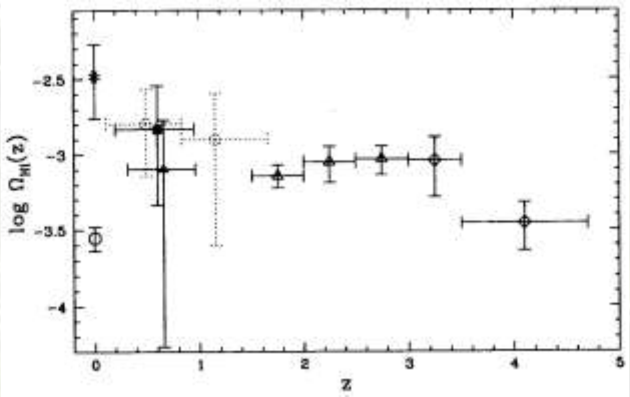
>10,000 sightlines to search for HI absorption – expect to detect ~50 sources in limited redshift range in 2000 sq deg

OH megamaser emission surveys at z~1



(Lane 2000)

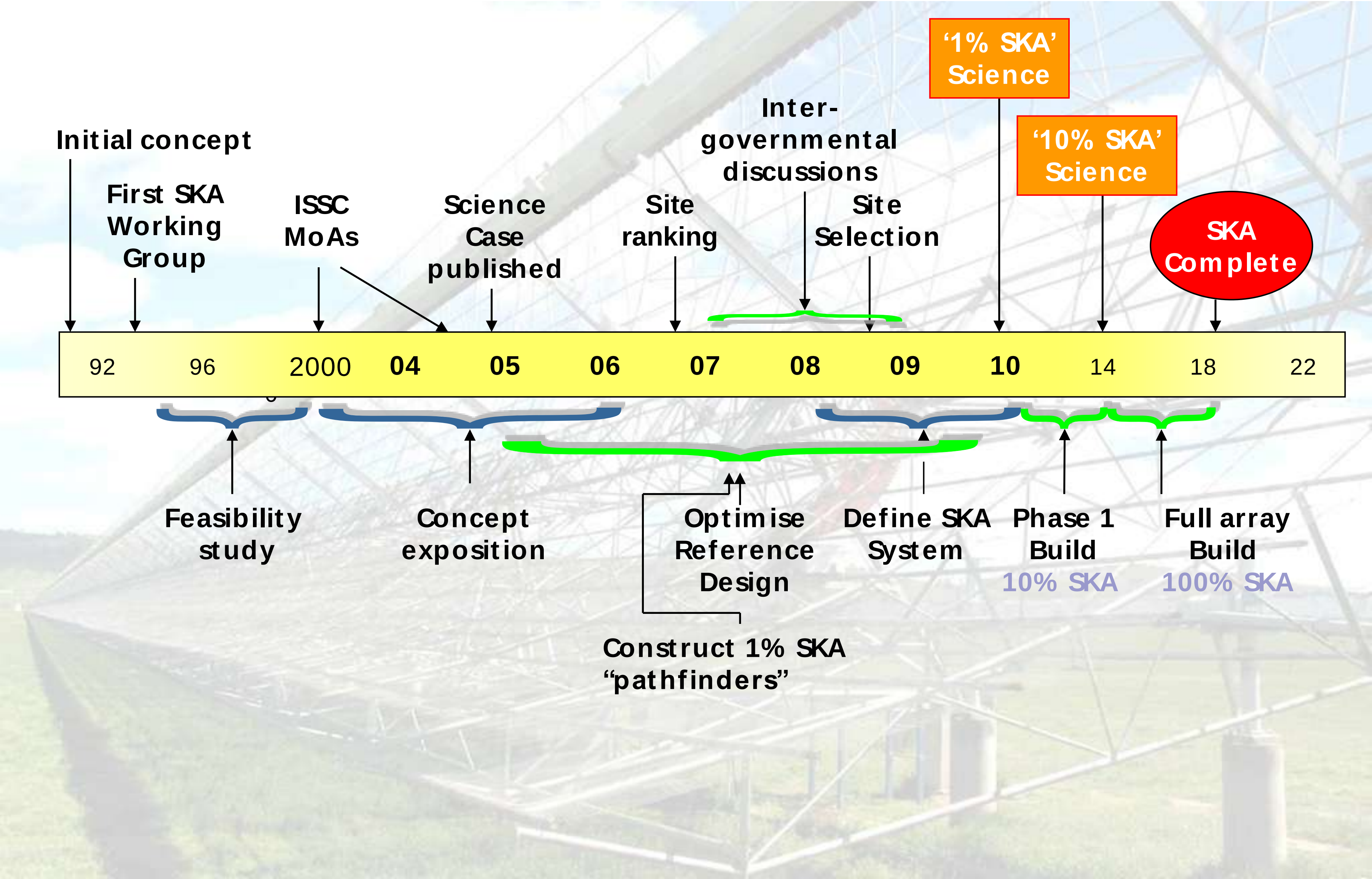
Stage 2: enables Ω_{HI} measurements at z ~ 0.75, where existing results are not well constrained



(Lane and Briggs 2001)

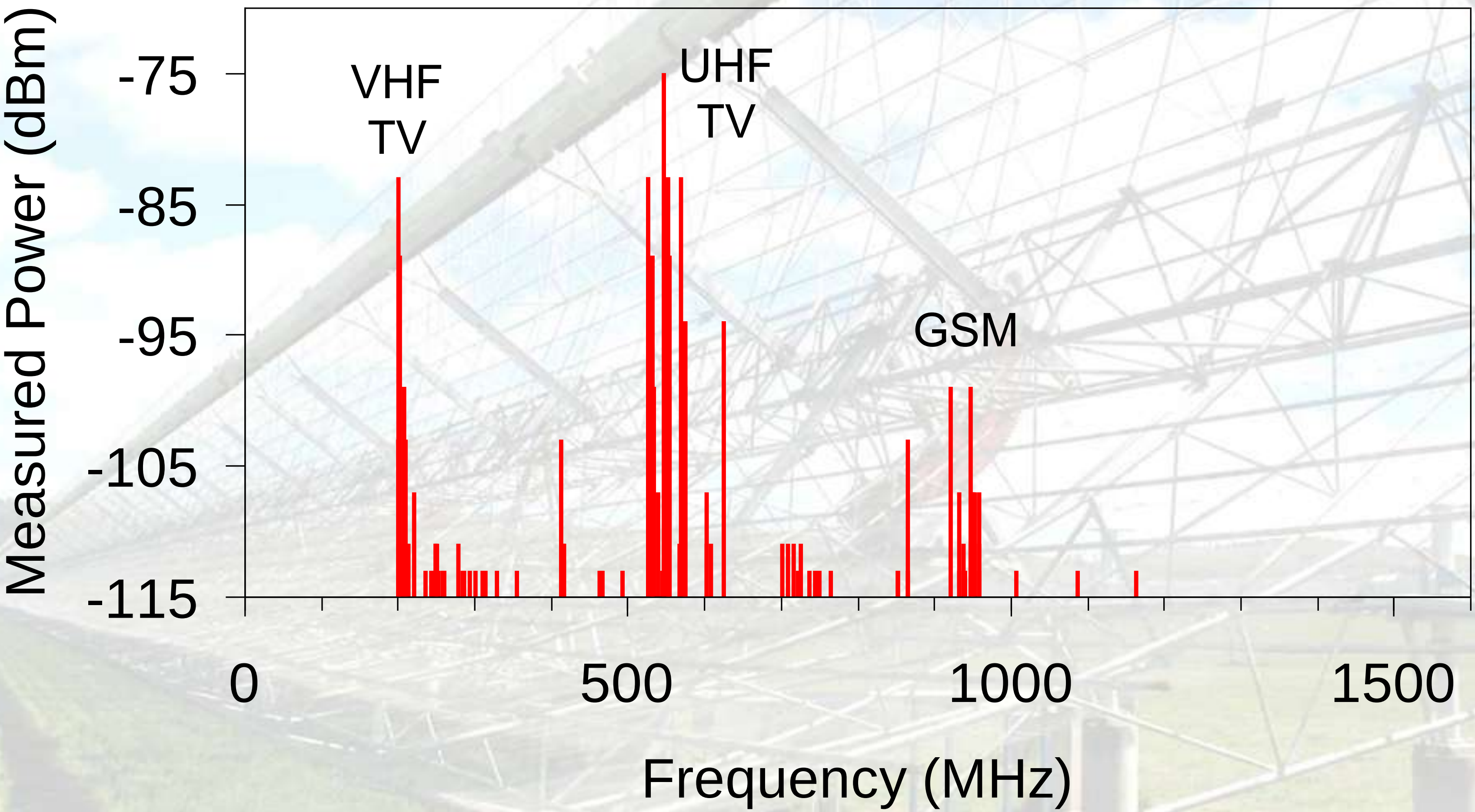
Artwork by Adrian Blake

SKA timeline

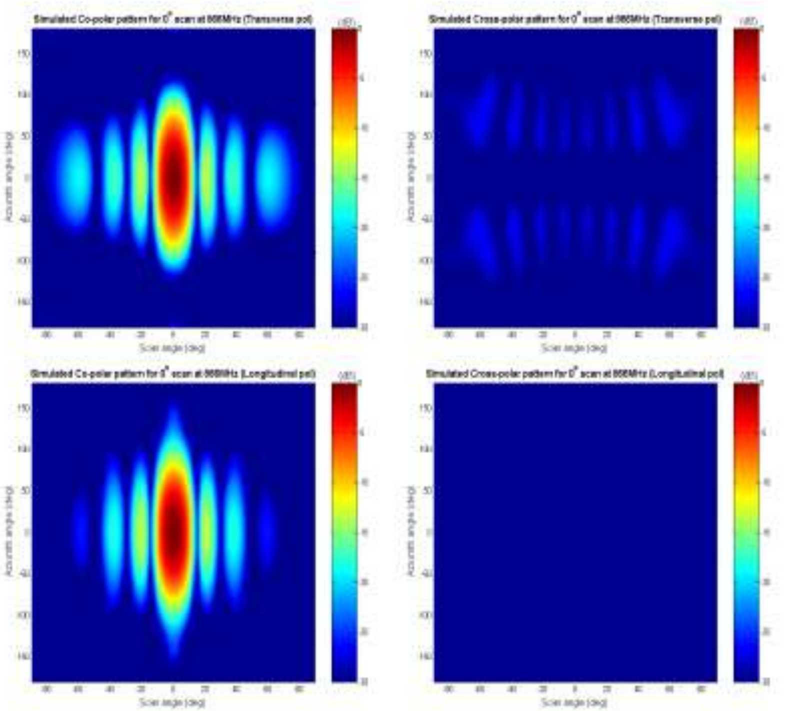



A new lease on life for a mature instrument

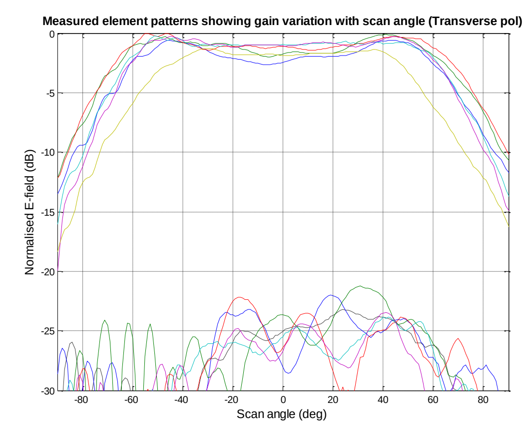
RFI at Molonglo 200-1500 MHz
(Measured 25 June 2001)

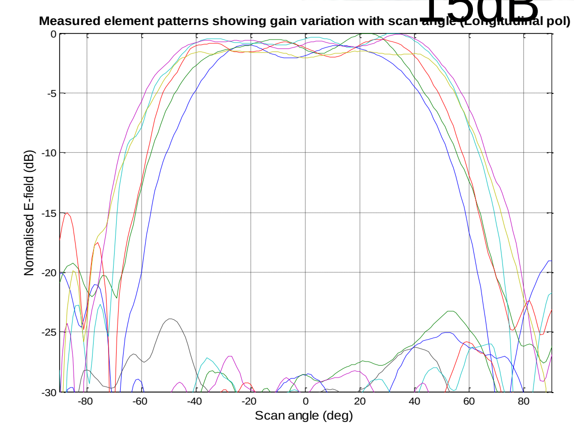


Beam & radiation patterns



1. Beam pattern – first sidelobe -12dB; cross polarisation -30dB at meridian, worst at high scan angle, up to -12dB
2. Scanning gain curve – flat to ±45°; cross polarisation -25dB or better
3. Transverse illumination pattern – HPBW 80°; cross polarisation worst at high scan angle, about -15dB

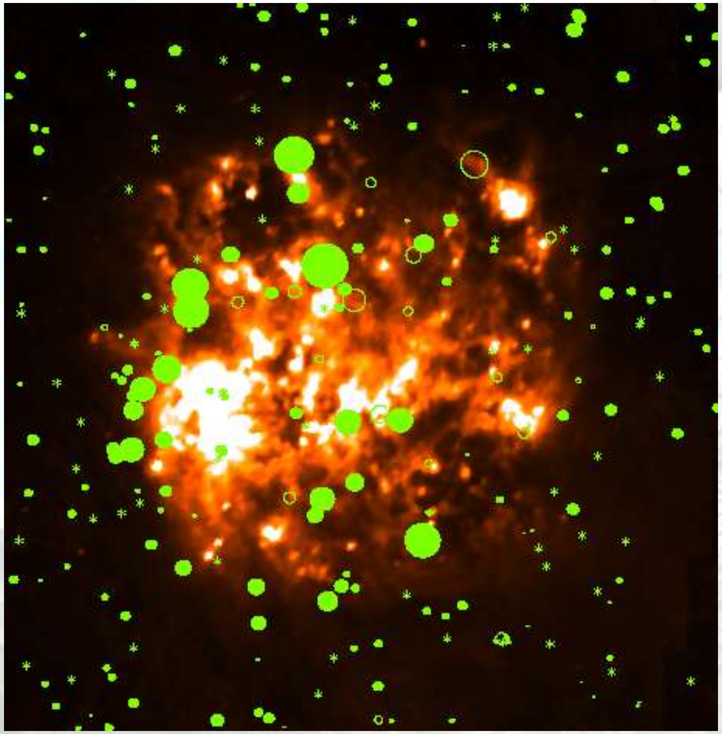




Figures show beam patterns and scanning gain variation for the two polarisations, transverse and longitudinal

Dual feed system for 6-m Reference Antenna for adaptive noise cancellation

3. Magnetism studies – RM grid & diffuse Galactic polarisation

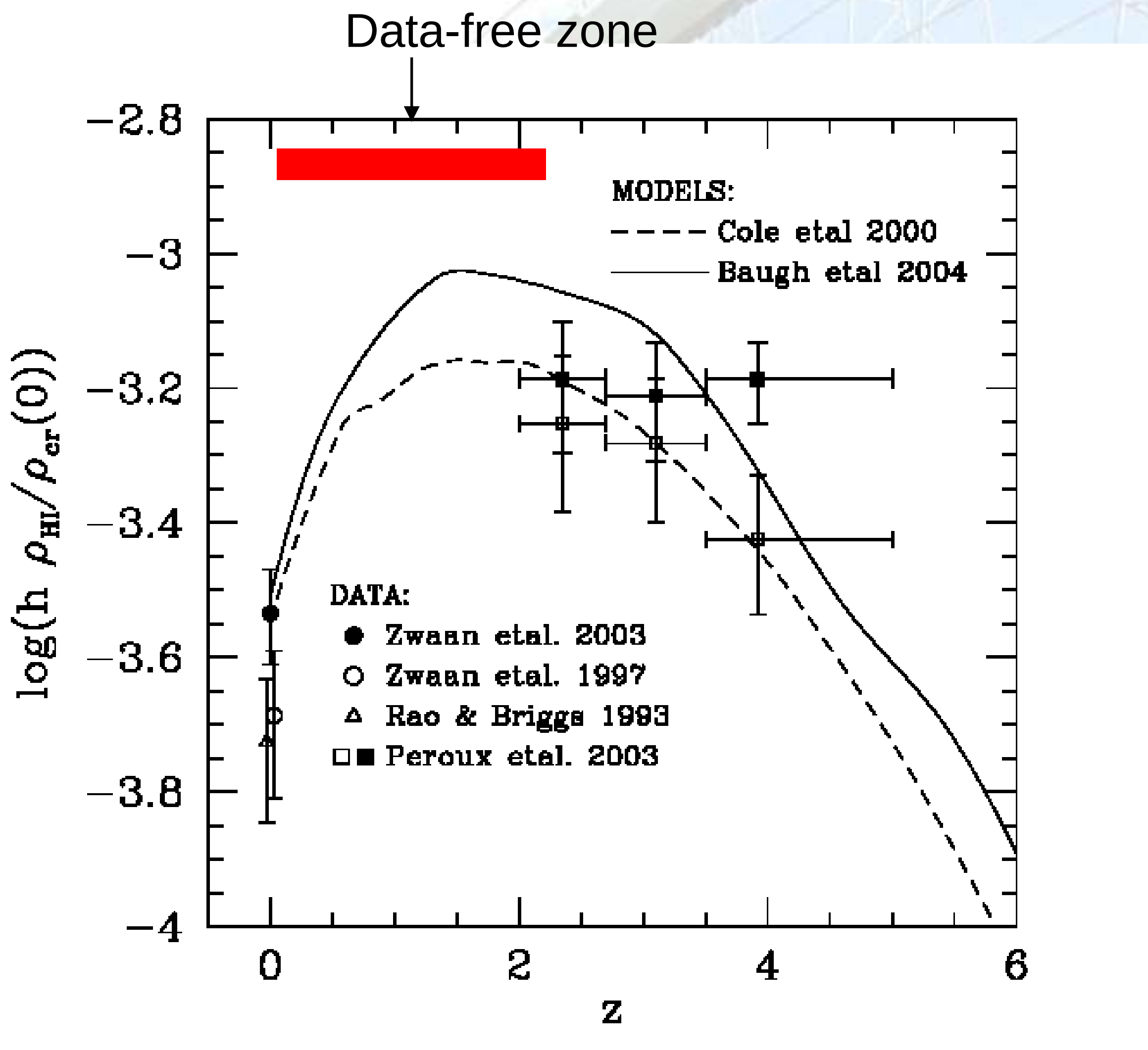


Gaensler et al (2004)
300 Rotation Measures through LMC

- Role & origin of this fundamental force largely unknown
- Crucial for studies of star formation, CRs, SNRs, jets, ISM turbulence & disk stability
- RM grid probes magnetic fields in Milky Way, galaxies & clusters – requires whole sky coverage

When & how is HI assembled into galaxies?

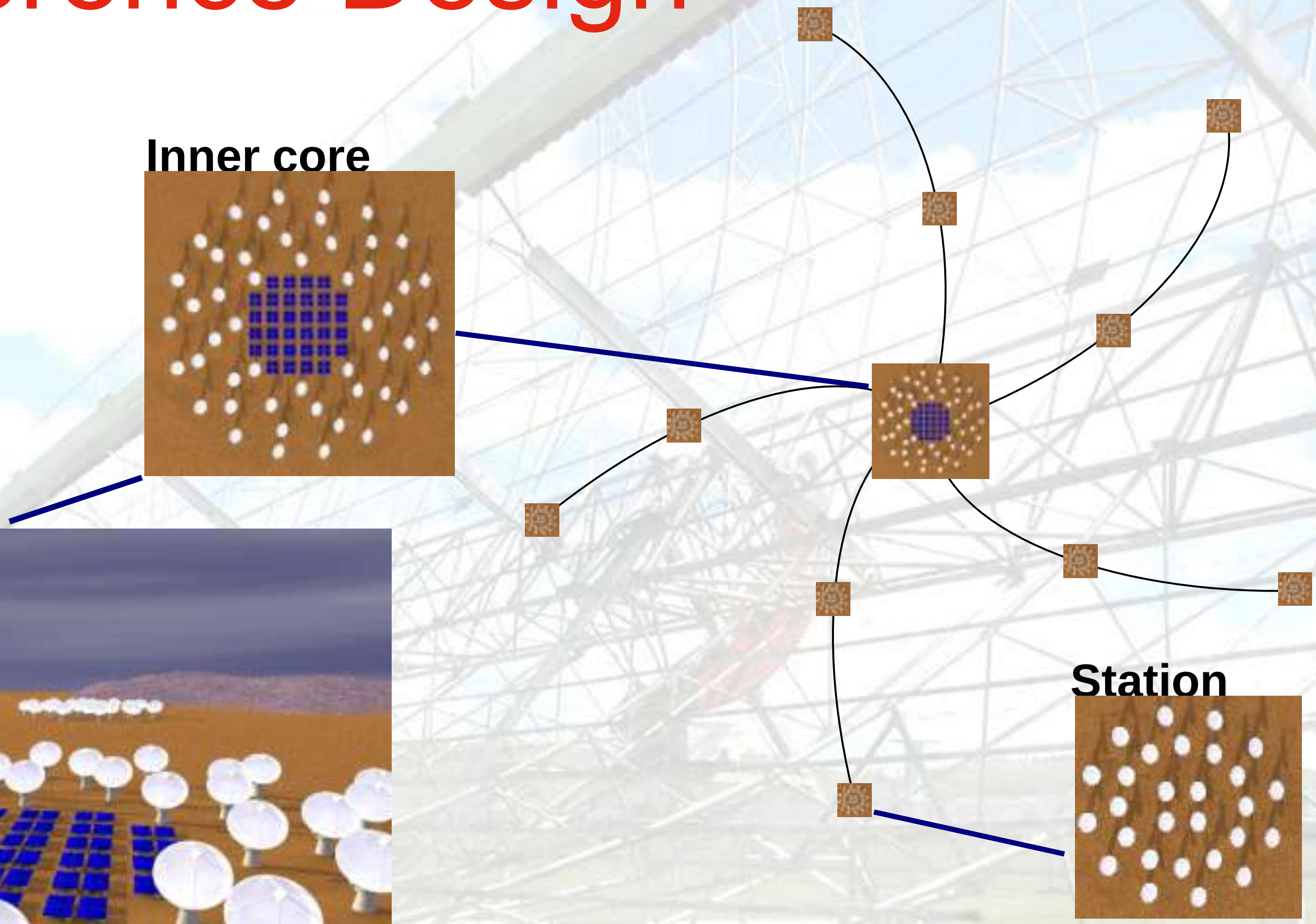
(Baugh et al 2004)

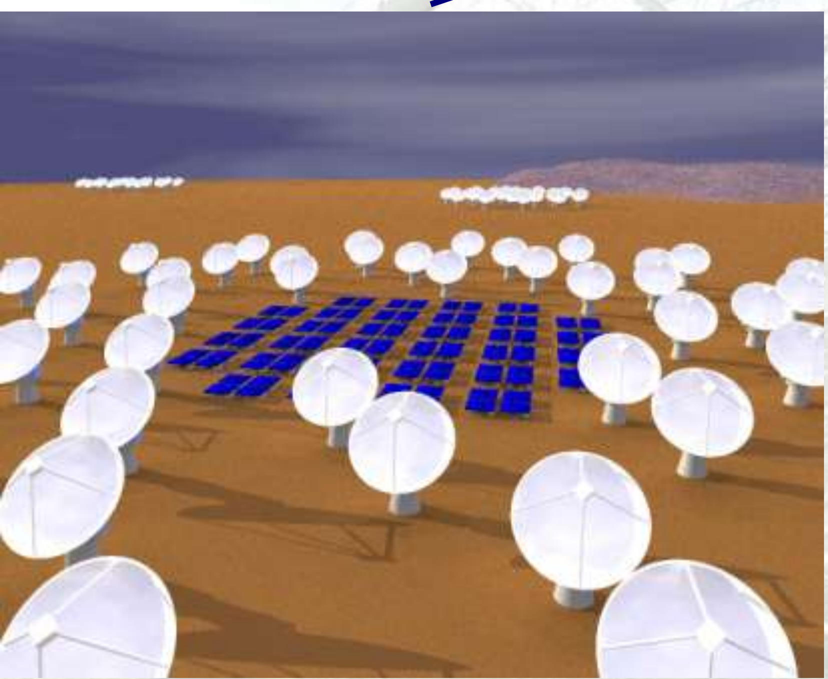


Purpose of the Reference Design

- Focus engineering and science efforts around the world
- Provide basis for detailed costing of the array
- Provide a recognizable image for the SKA

Reference Design





Wide-angle radio camera +
radio “fish-eye lens”

Reference Design for the SKA

- Data network connecting sensors of the incident electromagnetic field to a correlator → interferometer array
- Sensing antennas are highly concentrated in the central 5km, and further distributed in stations at distances up to at least 3000km
- Individual antennas and stations are connected via wide-band fibre links (100 Gbit/s) to the central data processor (10-100 Pflop/s)
- Small dishes + smart feeds and aperture arrays cover the frequency range
- Radio interferometers can be built in stages – Phase 1 will consist of 10% of the full collecting area, in array centre, and will be able to do unique science