



# SKA – The Australian Perspective

**Peter J Hall**

**CSIRO SKA Program Leader**

*<http://www.atnf.csiro.au/SKA>*





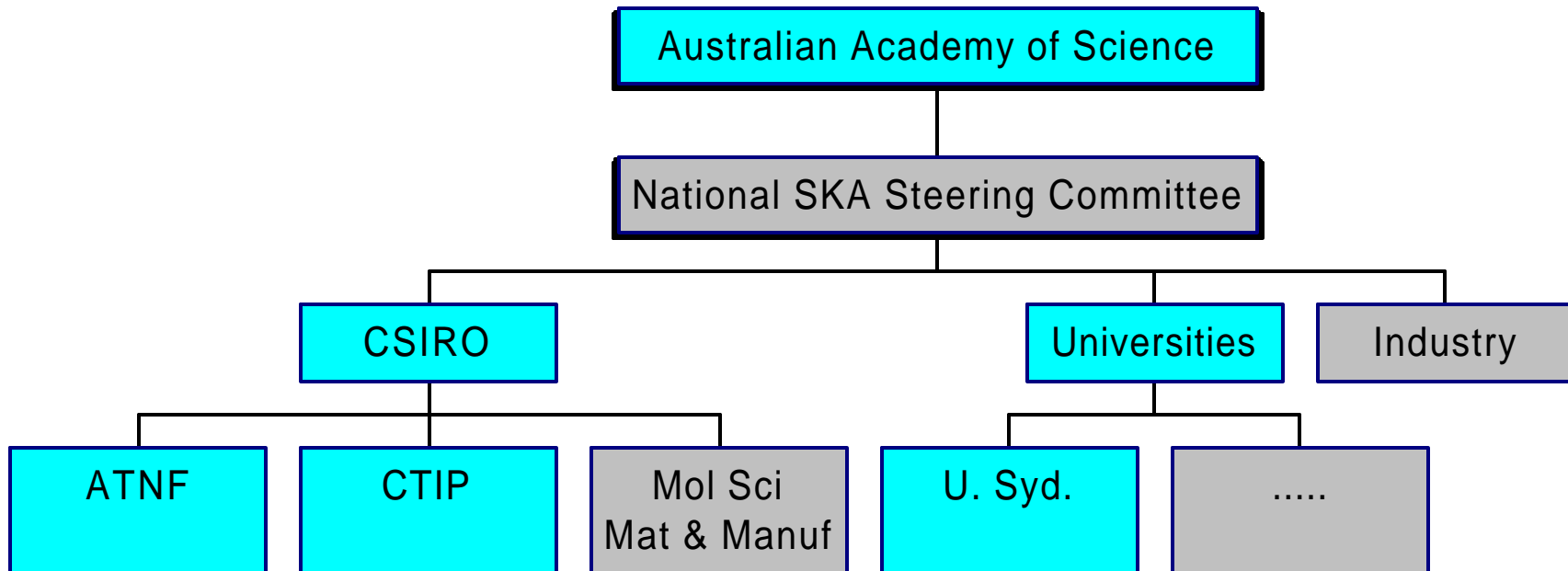
# Presentation Outline



- **Background**
- **Australia and the SKA**
  - New “seed” research program
    - » Philosophy, Working Principles, Goals
- **Activity Summaries**
  - Antennas, Interference Mitigation, Site Studies, Configurations
- **Prototyping**
- **SKA Design Evolution and Working Needs**



# Australian SKA: Who Are We?



Strategic + Commercial



# CSIRO Australia Telescope National Facility

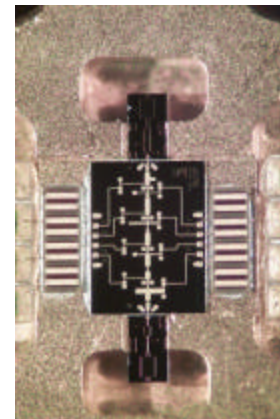
- 135 staff, annual funding \$16M
- Many links with US, European and Asian collaborators
- Manages new \$3M “seed” SKA program
- Strong background in system engineering and science
- SKA targetted as prime “long-term” organizational project



*Parkes  
13-beam  
HI  
Receiver  
(with  
CTIP)*



*SEST  
2 GHz  
Correlator*



*100 GHz  
Mounted  
MMIC  
LNA*



# Australia and the SKA

- **Pre-1999 ‘ad hoc’ work**
  
- **Late 1999: CSIRO \$3M ‘seed’ program over 4 yrs**
  - Earlier activities integrated into new structure
  - Framework set for enhanced contribution over coming years
  - About 26 m-yr effort
    - » Includes 13 m-yr from ATNF/CTIP matching contributions
    - » Includes 2 postdocs, 2 postgrads, 1 new SKA support engineer
  - Primarily engineering and system science, but framed to stimulate astronomy discussions and design interactions



# Australian SKA: Some Pictorial Philosophy



Widely separated multi-beaming  
Wide field-of-view  
Active interference mitigation



# Australian SKA: Some Goals

- **Contribute effectively to international SKA effort**
  - Explore areas not well-addressed by others
  - Establish some boundaries in design space
- **Use existing instruments intelligently in SKA design**
  - e.g. software radio telescope
- **Produce engineering prototypes of key systems (Dec 2002)**
  - Prepare path for 2005 astronomical demonstrator
- **Help establish SKA site selection criteria**
- **Build SKA briefing, training and outreach programs**
  - High-level national and international
  - University and mainstream professional
  - Public



# Australian SKA Program: Technical Activities



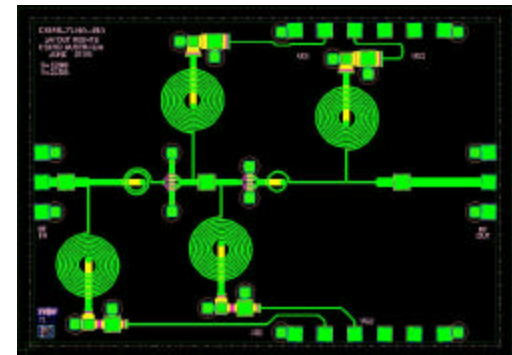
- **Antennas and RF**
- **RFI mitigation techniques and components**
- **Site selection**
- **SKA configurations and imaging**





# Antennas & RF Systems

- **Strong ATNF & CTIP background in “conventional” systems to >100 GHz**
  - Efficient feeds and reflectors; low-noise, cooled, electronics
  - Some continuing SKA efforts (e.g. doublet cylindrical reflector)
- **Investigate refracting concentrator – quickly establish viability**
  - Focus SKA community on determining REAL value of multi-beaming
- **Recognize that this DOES imply a different design path**
  - e.g. other considerations than minimizing  $T_{\text{sys}}$
- **Use MMIC capabilities to produce integrated feeds and receivers**
  - First 1-10 GHz indium phosphide LNAs under test
  - Prime area for collaboration





# Luneburg Lenses



## ■ Offer:

- Widely separated, full-sensitivity, multibeaming
- Ability to mix and match feed arrangements e.g.
  - » High sensitivity single feeds
    - 1 feed per beam
  - » “Patch” focal plane arrays
- Natural upgrade path in  $N_{\text{beam}}$  direction

## ■ Challenges:

- Materials and manufacturing to give
  - » Low cost
  - » Low RF loss
  - » Durable, easily-assembled, structures
- Feed arrangements

## ■ Synergies:

- Feed elements and arrays (Dutch planar arrays, 1 hT log periodics)
- RF, signal distribution etc (1 hT, DSN)



# Luneburg Lens SKA





# KONKUR Commercial Luneburg Lens



## Specifications – Multisat 1M

Diameter: 900 mm

Gain: 39 dB

(implies ~50% efficiency)

First sidelobe: -17 dB

No. beams: up to 10

Mass: 150 kg

Band: to Ku (12 GHz)

Loss: < 0.5 dB at 12 GHz

Estimated cost: \$US 3500

*Also advertise 1.5 - 4 m “Post” lenses for satellite up/down link (8 beams)*

*<http://www.com2com.ru/konkur/>*



# SKA - Interference Mitigation



## ■ Why?

- SKA needs to observe outside (small) designated astronomy bands to meet its scientific objectives
- SKA sensitivity is unprecedented
- Terrestrial transmissions will be a challenge for all but a few sites on Earth
- Satellite transmissions are now globally pervasive (intentional constellation coverage for many LEOs)

## ■ How?

- No single IM solution; need a hierarchy of techniques
- Toxicity and robustness are major concerns

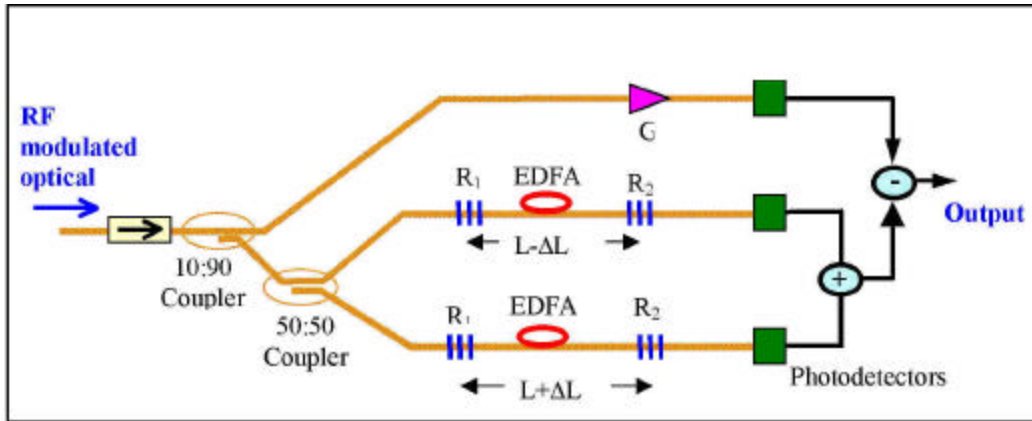


# ATNF Interference Mitigation

- **SKA location (esp. central cluster)**
- **Stations, array configurations**
  - Maximise natural RFI rejection; optimise IM effectiveness
- **High-intercept MMIC receivers**
- **Fixed or tunable RF/IF filters for high-level RFI**
  - Photonic fibre (CSIRO/U. Sydney)
  - HTS microwave (CSIRO/U. Qld)
- **Active IM techniques**
  - Software radio telescope
  - Pre and post-correlation techniques
  - New data processing algorithms (excision, robust statistics....)



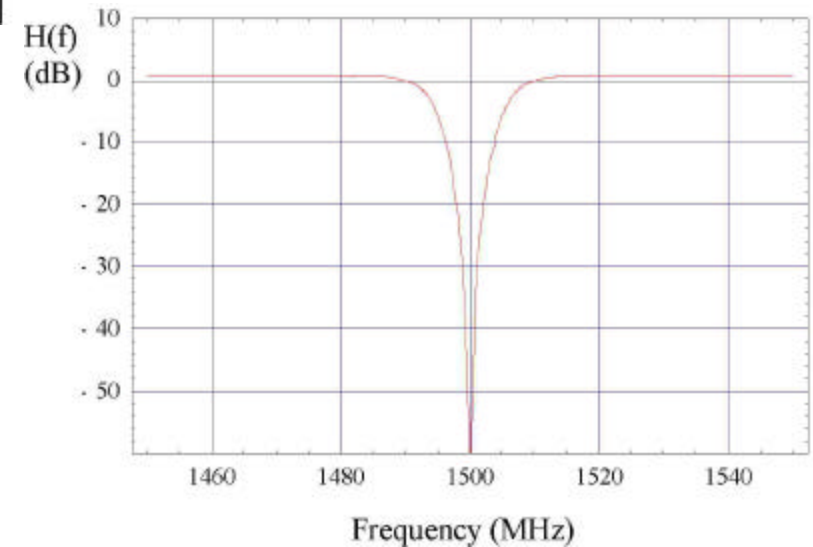
# Interference Mitigation: Photonic Fibre Processing



Robust, commercial elements

## Dual-Cavity Topology Fibre Filter

6/40 dB shape factor  $\sim 7.8$



(R. Minasian & K. Alameh, University of Sydney)

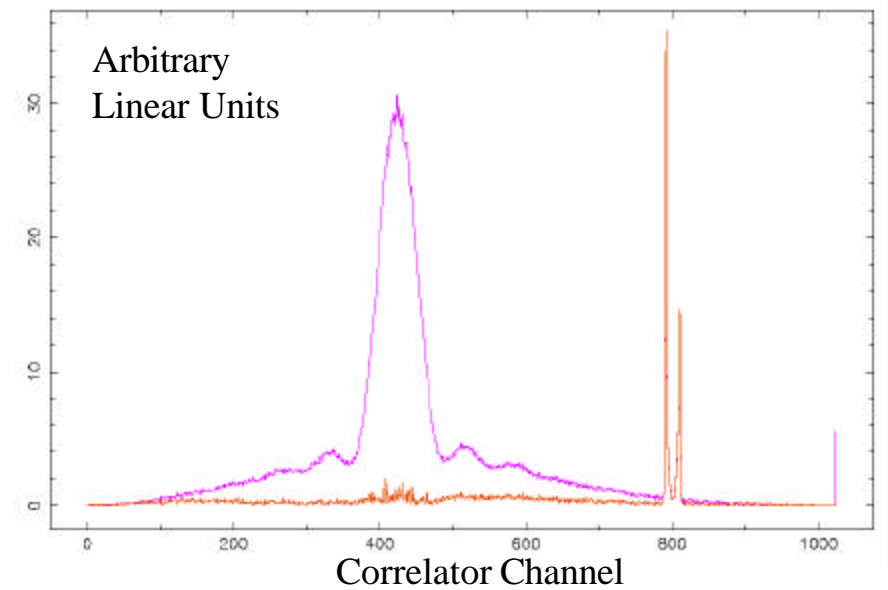
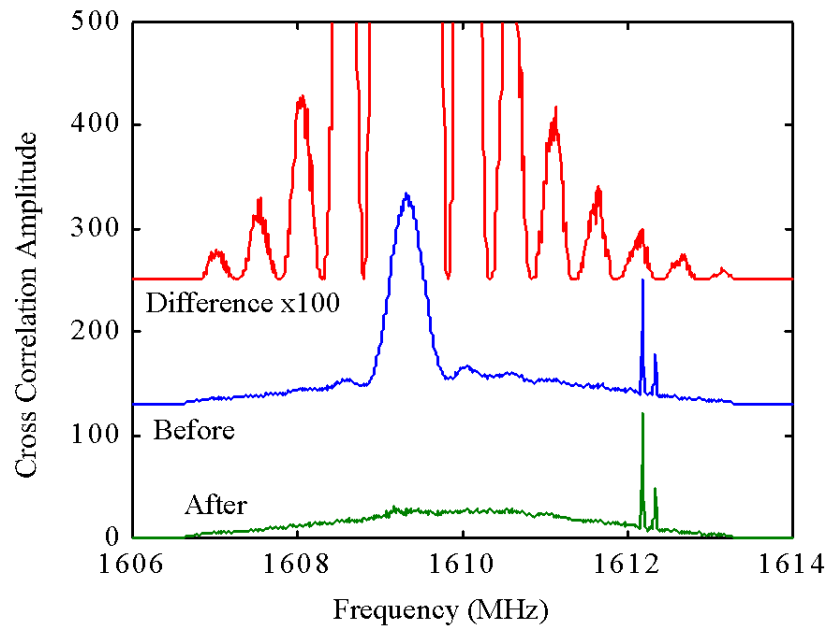


# Interference Mitigation – Real ATCA Data



■ Pre-correlation adaptive filter

■ Post-correlation processing





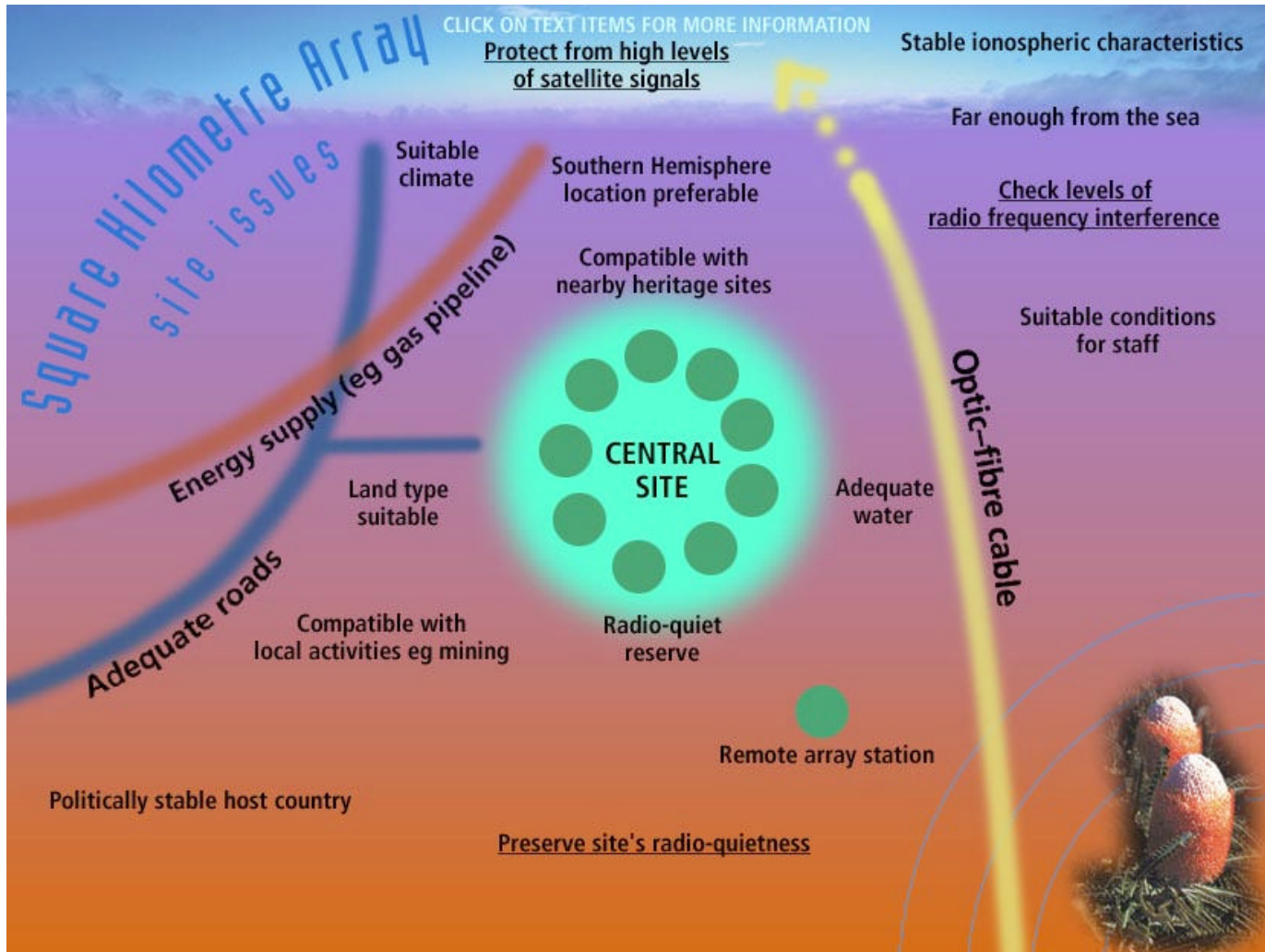


# Australian SKA Site Studies

- **Aim to use Australian case studies to illuminate general site selection issues**
  - Invaluable for emerging international working group
- **Great interest by state of Western Australia; initial CSIRO investigations in WA**
  - Negotiation with land use and native title authorities
  - Strong links with environmental remediation proposals
  - First-round RFI testing about to commence
  - Second-round site testing planned for mid-2001
- **Parallel work on establishment of radio-quiet reserve**
  - *Legislated or regulated ?*
  - More at IAU RFI standards session

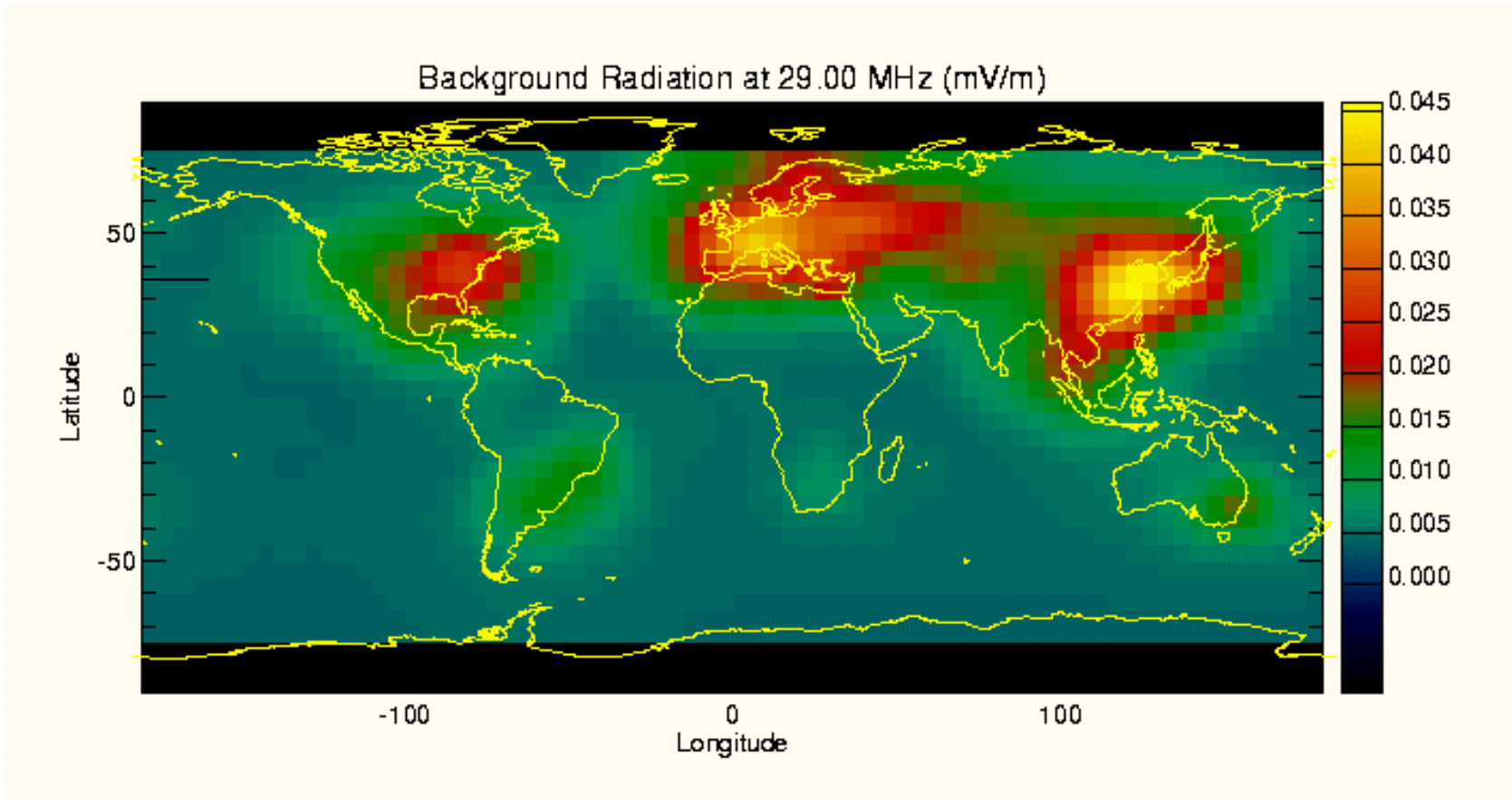


# SKA Site Selection





# Terrestrial Interference



**FORTÉ satellite**



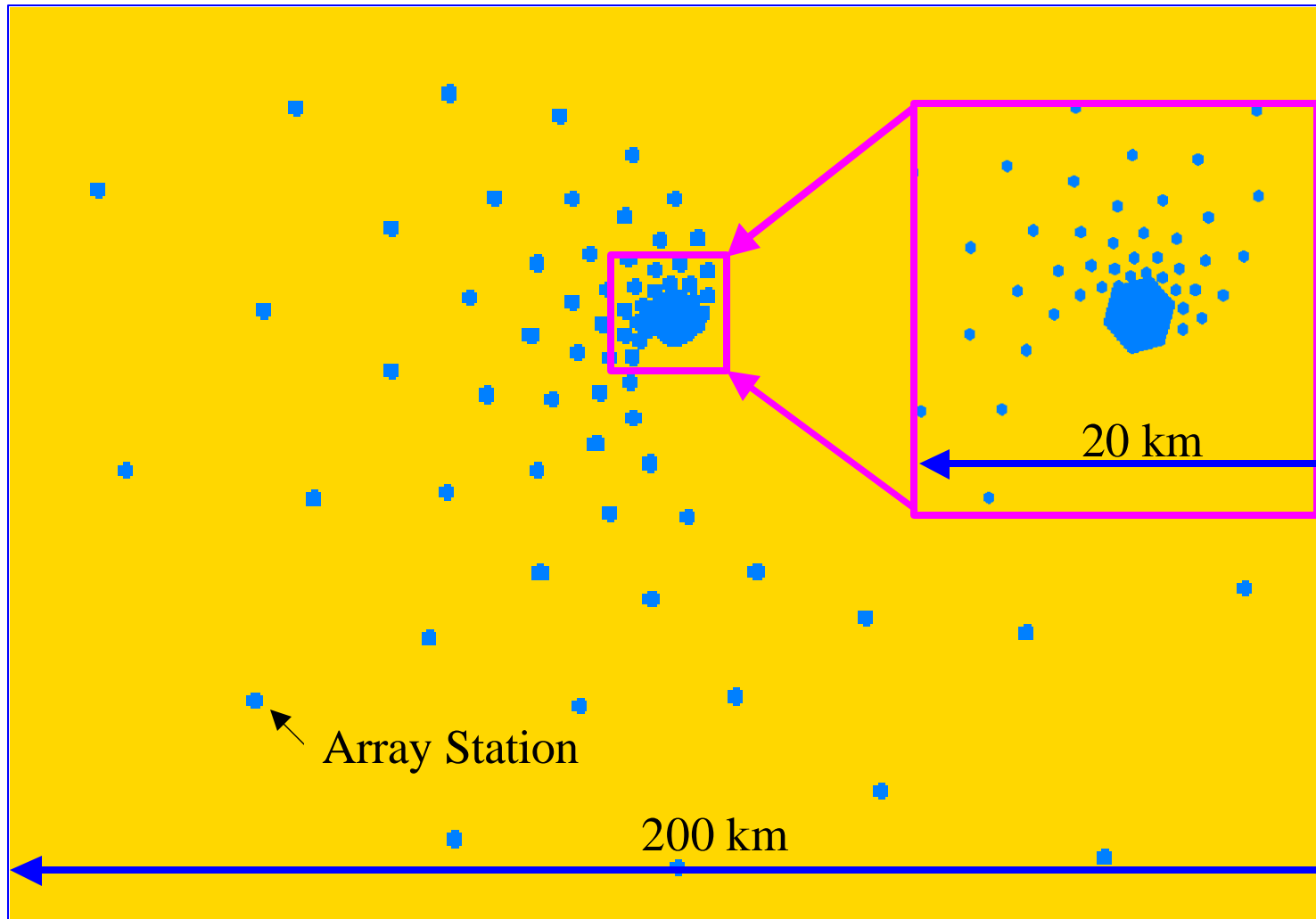
# Configurations & Imaging



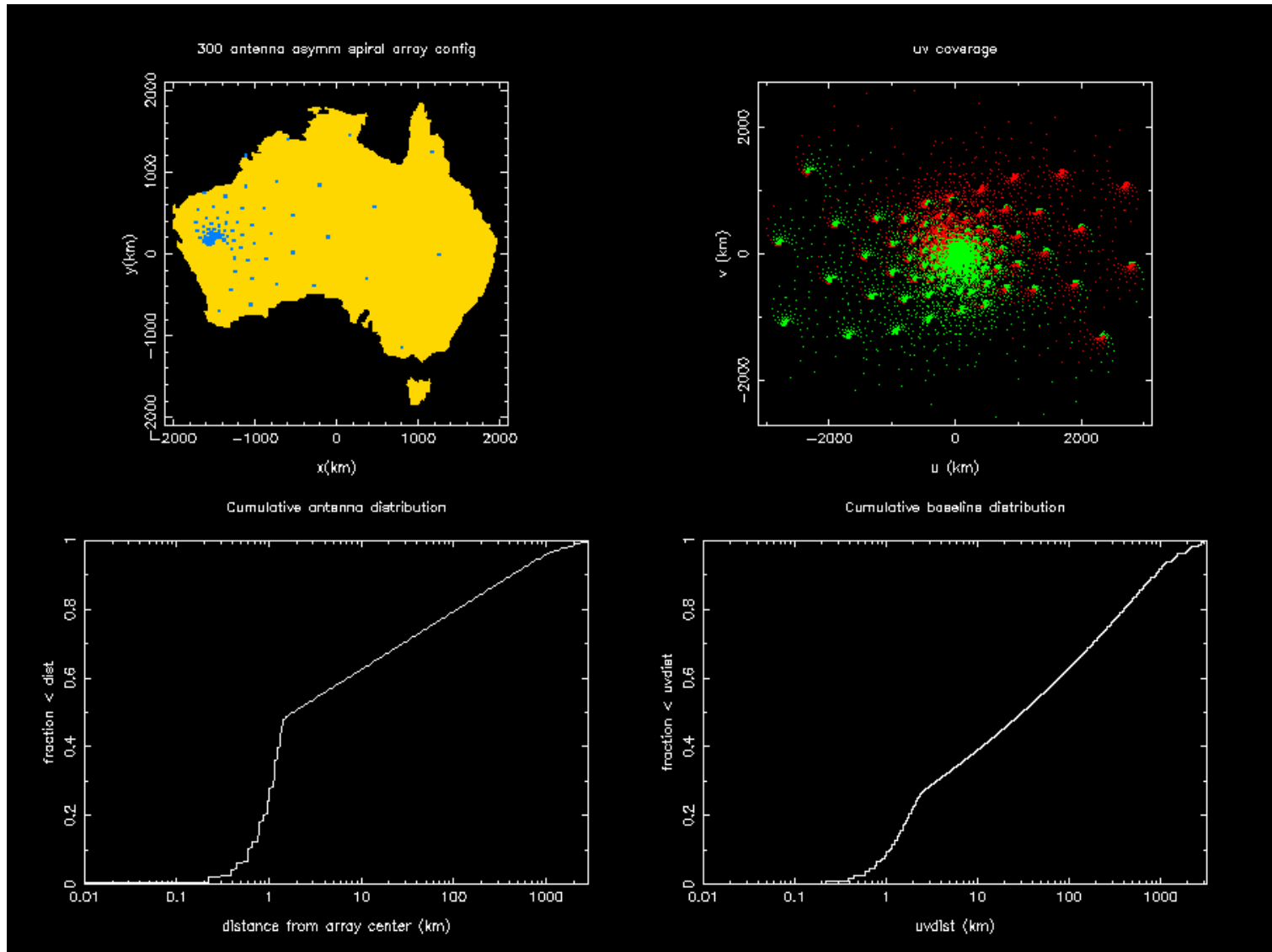
- **Aim to use ATNF AIPS++ expertise to construct simulated observations**
  - Mark Wieringa work on array configurations already on Web
  - Will extend to full simulated observing suite
  
- **Will incorporate**
  - Earlier work on sky modelling (Hopkins et al.)
  - Recent work on adaptive sub-arrays and dynamic range (Cram)



# SKA Log-Spiral Configuration



# A Possible SKA Layout





# SKA Prototyping & Astronomical Demonstrator

## ■ Engineering prototypes of key systems by Dec 2002.

- 1- 3 m diameter Luneburg Lens antenna, broadband feed structure with integral wideband MMIC low-noise receiver
- Operational IM systems
  - » Integrated post-correlation software for ATCA and Parkes observers
  - » Wideband (>32 MHz) hardware coherent processor?

## ■ Astronomical demonstrator by 2005

- Vehicle to test system design ideas
- Requires ~\$10M additional funding
- Could be done in collaboration with other international groups
- Luneburg (?) array; integrated receivers with photonic connectivity
- ATCA augmentation?



# SKA Design Evolution



- **First science specifications in place...ball is with the engineers**
- **Establish ways of fostering science/engineering iteration**
- **Decouple science politics (however worthy) from design process**





# What the SKAworld needs.....

(\*apart from cheap, efficient, decade-bandwidth antennas; broadband LNAs; low-cost photonics; real-time interference mitigation; ultra-high fidelity imaging; ...)



## ■ An evolving technical summary, incorporating:

- Design goals
- Strawman arrays (case studies)
  - » Rough cost expressions for each
  - » Scores for critical parameters (→FOM?)
- Issues emerging from case studies (e.g. extensibility...)

## ■ To help decide:

- What value do we place on new capability (e.g. multi-beaming)?
  - » Critical in establishing SKA design directions
- Is there one SKA?
  - » Cost of being all things to many people may be too high



# Some Working Needs



- **A “Technical Overview Committee” to distill and promulgate important technical and system developments**
- **A web-based repository for an “SKA Memo” series, or other publications**
  - Web links to national sites
- **A web-based discussion forum**
  - Issues, comments and preliminary results
    - » Spontaneous, as well as TOC-prompted
- **Mechanisms to grow multi-national collaborations**
  - Working groups, bench-level interactions and exchanges



# Australian SKA People

<http://www.atnf.csiro.au/SKA>



<b>Activity</b>	<b>Leader</b>	<b>Team</b>
<b>Science, Overall Direction</b>	Ron Ekers	ATNF Astrophysics, Ray Norris, Others
<b>Technology, Program Leadership</b>	Peter Hall	ATNF Engineering
<b>Interference Mitigation</b>	Bob Sault	Michael Kesteven, Jon Bell, John Bunton, Steve Ellingson (OSU), Peter Hall, Ron Ekers, Warwick Wilson, Daniel Mitchell (U Syd), Lisa Kewley (ANU), Robert Minasian (U Syd), Don McClean
<b>Antennas</b>	Graeme James (CTIP)	Andrew Parfitt (CTIP), John Kot (CTIP), Peter Hall, John Bunton (CTIP), Bruce Thomas, Michael Large, Mark Walker
<b>Configurations &amp; Imaging</b>	Mark Wieringa	Ravi Subrahmanyam, Ron Ekers, Bob Sault, Bruce Thomas, Lawrence Cram (U Syd), Wim Brouw, John Bunton
<b>Site Studies</b>	Bruce Thomas	Michelle Storey