# SKA – The Australian Perspective

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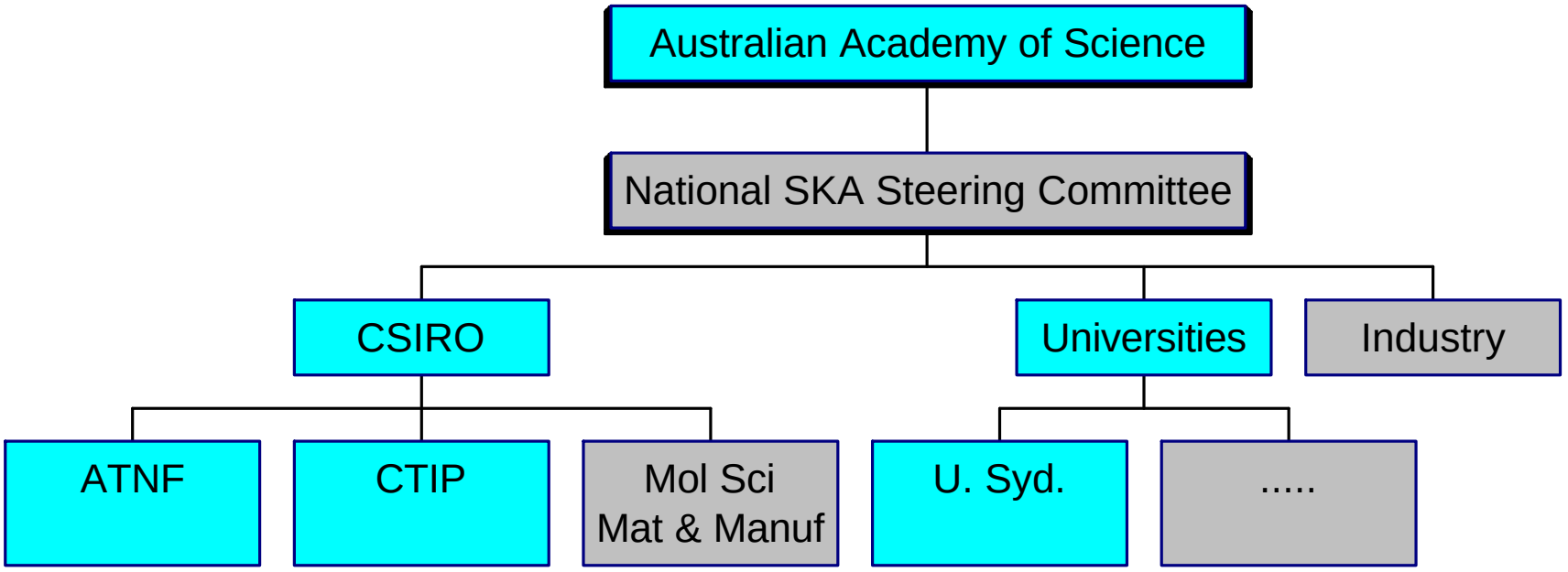
*http://www.atnf.csiro.au/SKA*

# 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?



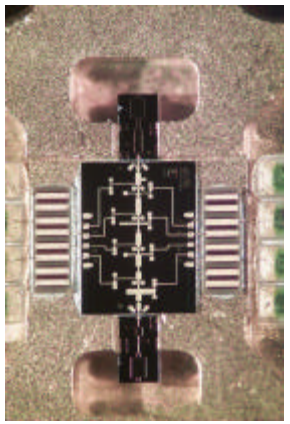

Strategic + Commercial

# 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*



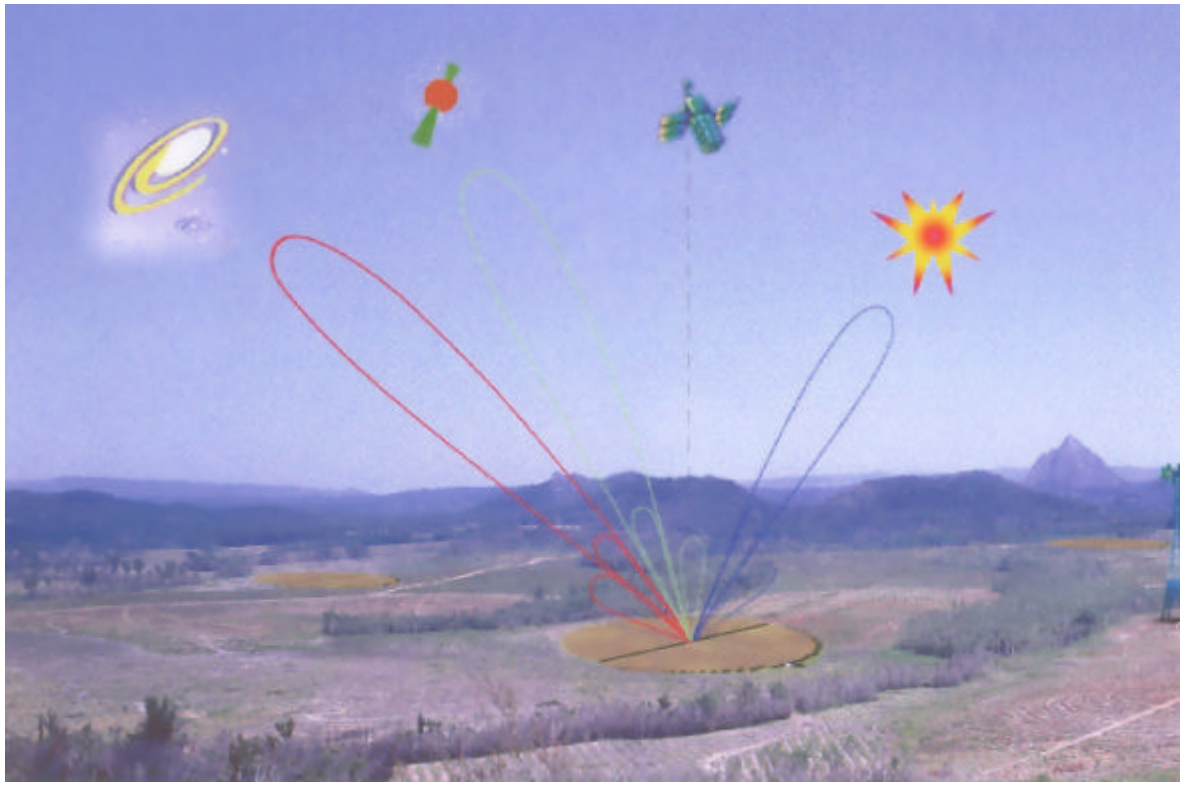
*100 GHz Mounted MMIC LNA*

# 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

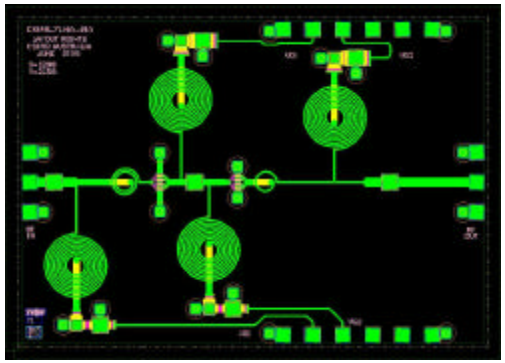
- **Contribute effectively to international SKA effort**
  - Explore areas not well-addressed by others
  - Establish some boundaries in design space
- **Use existing instruments intelligently in SKA design**
  - e.g. software radio telescope
- **Produce engineering prototypes of key systems (Dec 2002)**
  - 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 $T_{sys}$
- **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 $N_{beam}$ 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/*

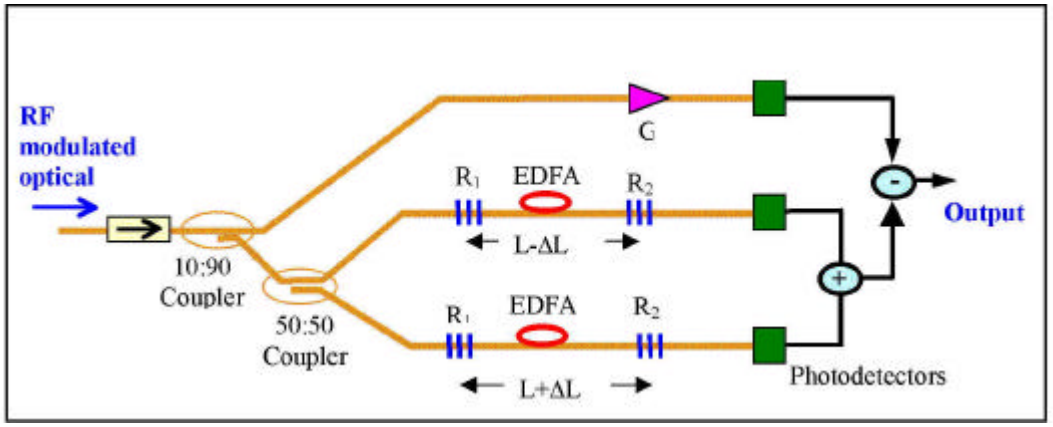
# SKA - Interference Mitigation

- **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….)

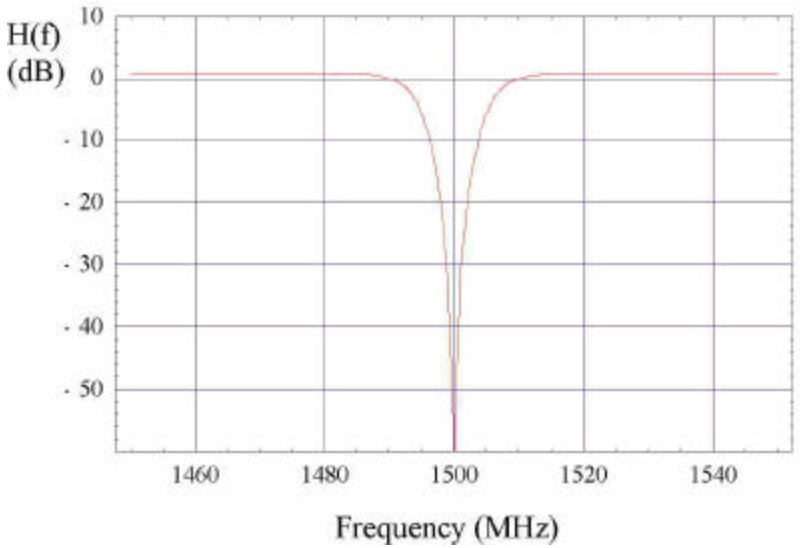
# Interference Mitigation: Photonic Fibre Processing




Robust, commercial elements

**Dual-Cavity Topology Fibre Filter**

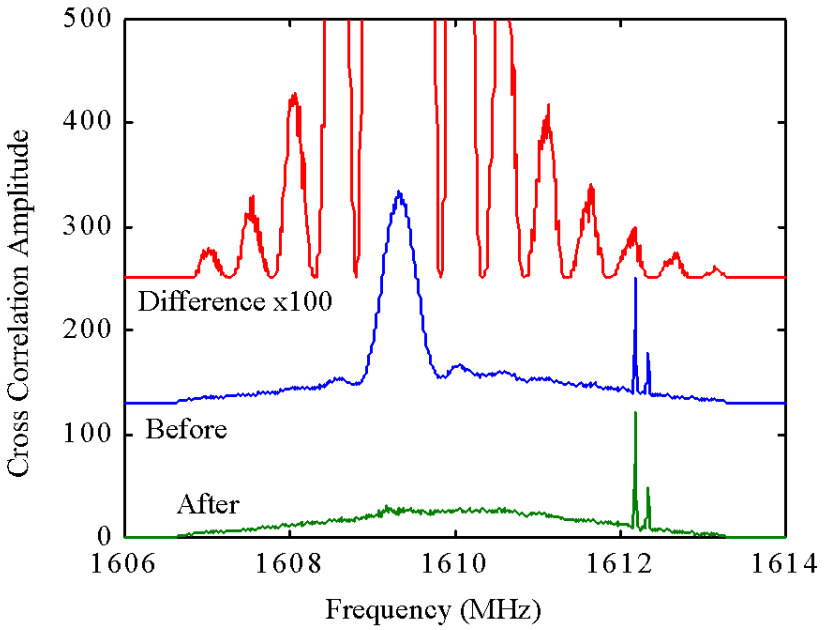
6/40 dB shape factor ~ 7.8

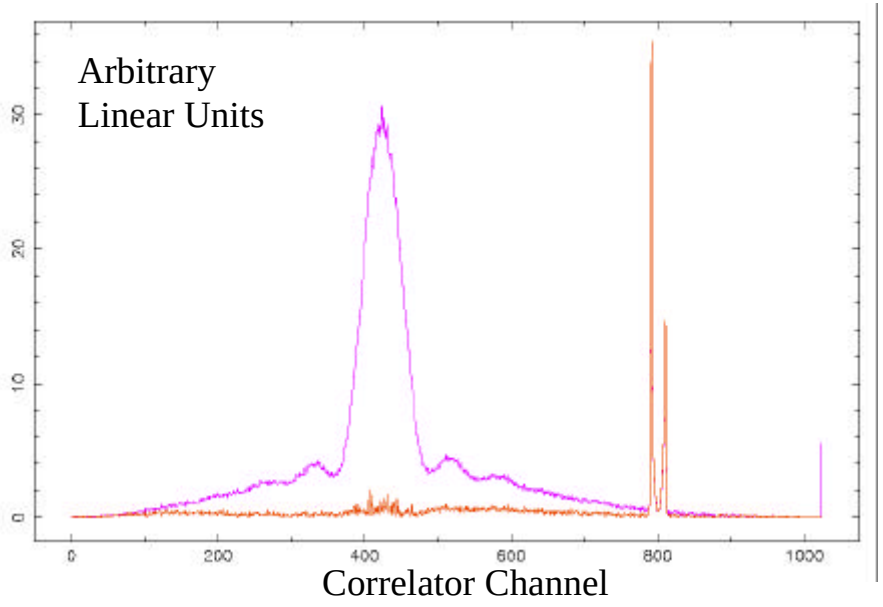



(R. Minasian & K. Alameh, University of Sydney)

# Interference Mitigation – Real ATCA Data

- **Pre-correlation adaptive filter**
- **Post-correlation processing**

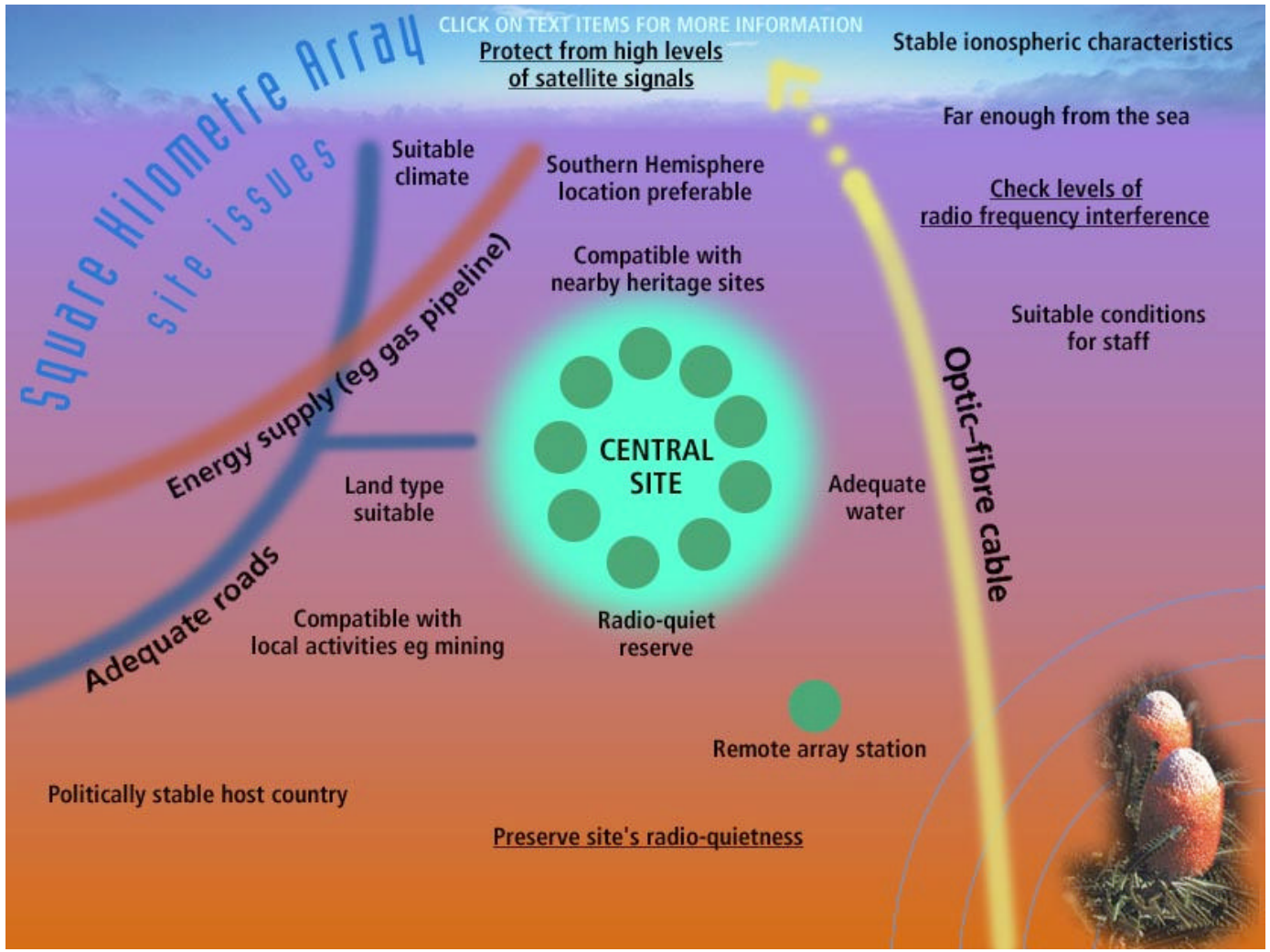


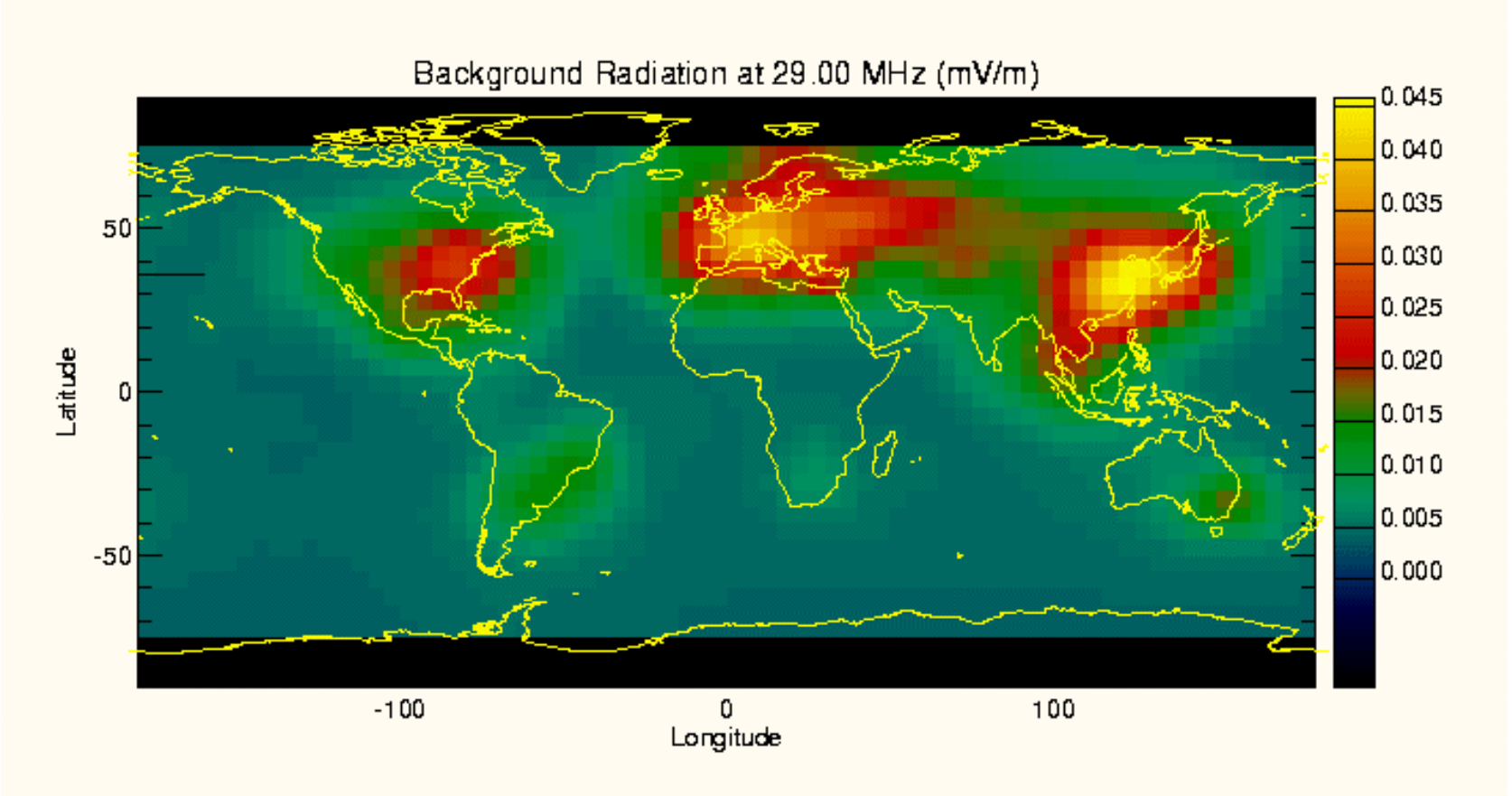
# Australian SKA Site Studies

- **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



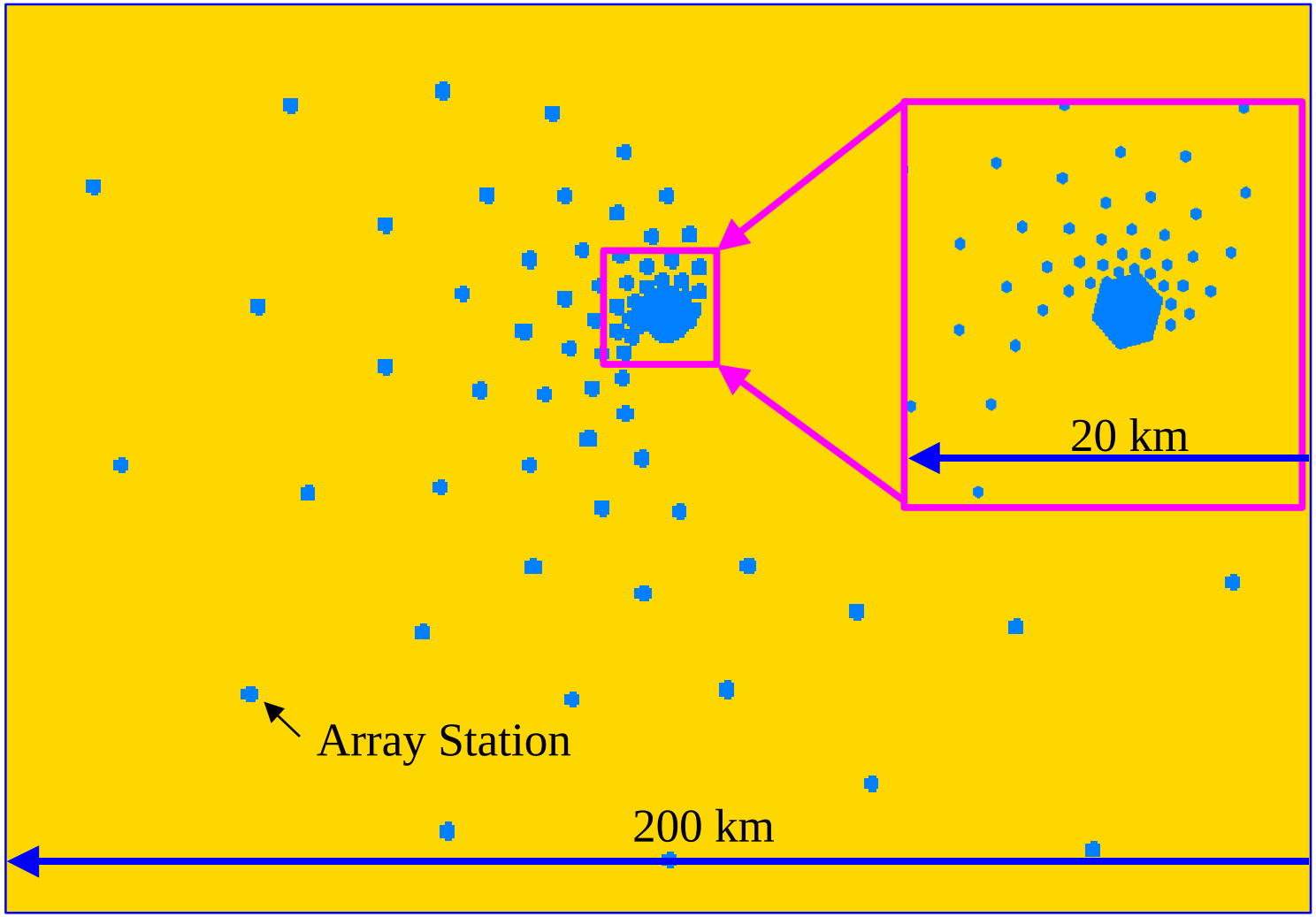

**FORTÉ satellite**

# Configurations & Imaging

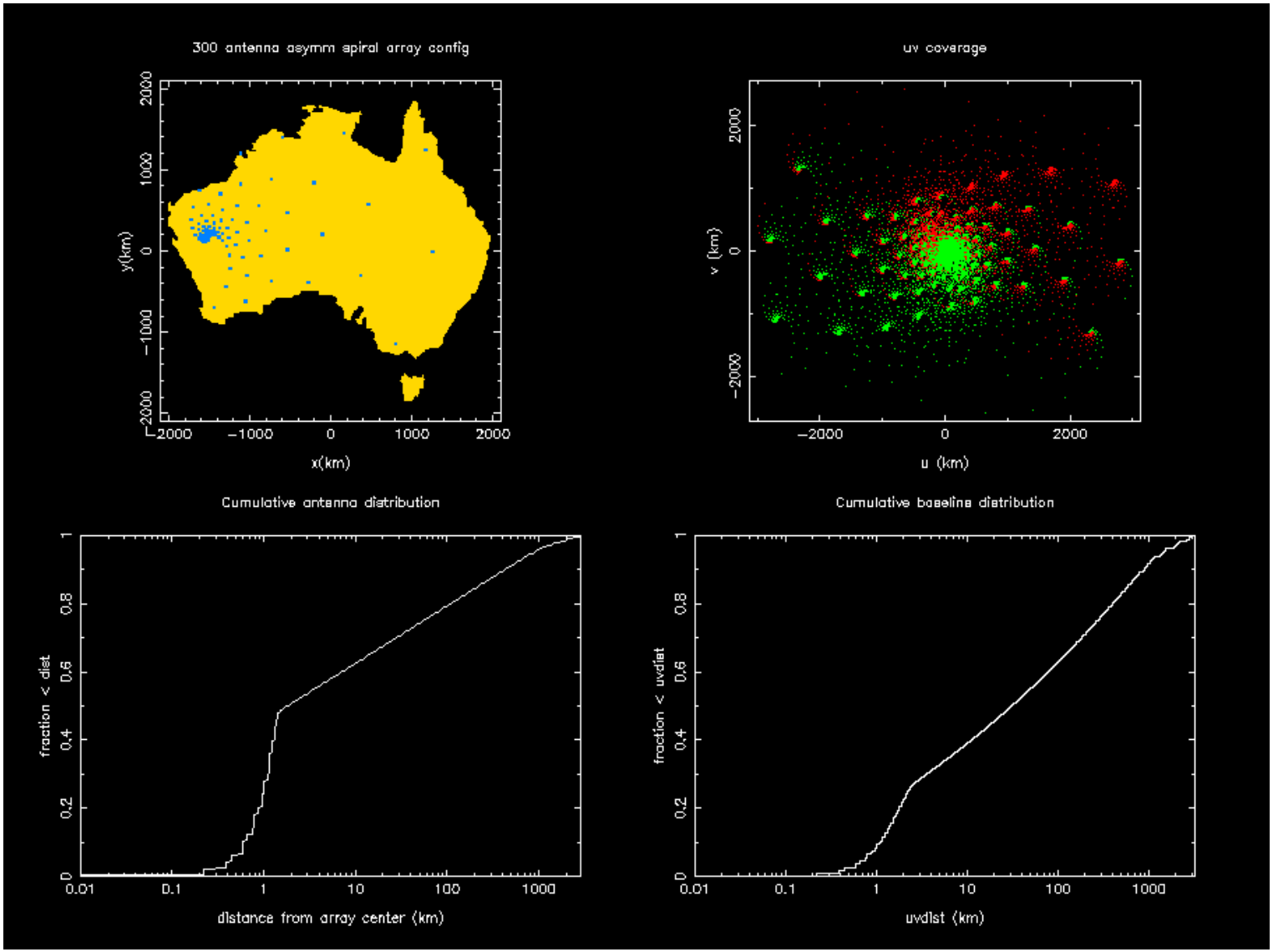
- **Aim to use ATNF AIPS++ expertise to construct simulated observations**
  - Mark Wieringa work on array configurations already on Web
  - Will extend to full simulated observing suite

- **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 <u>one</u> 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*

| Activity | Leader | Team |
|---|---|---|
| **Science, Overall Direction** | Ron Ekers | ATNF Astrophysics, Ray Norris, Others |
| **Technology, Program Leadership** | Peter Hall | ATNF Engineering |
| **Interference Mitigation** | 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 |
| **Antennas** | Graeme James (CTIP) | Andrew Parfitt (CTIP), John Kot (CTIP), Peter Hall, John Bunton (CTIP), Bruce Thomas, Michael Large, Mark Walker |
| **Configurations & Imaging** | Mark Wieringa | Ravi Subrahmanyan, Ron Ekers, Bob Sault, Bruce Thomas, Lawrence Cram (U Syd), Wim Brouw |
| **Site Studies** | Bruce Thomas | Michelle Storey |