

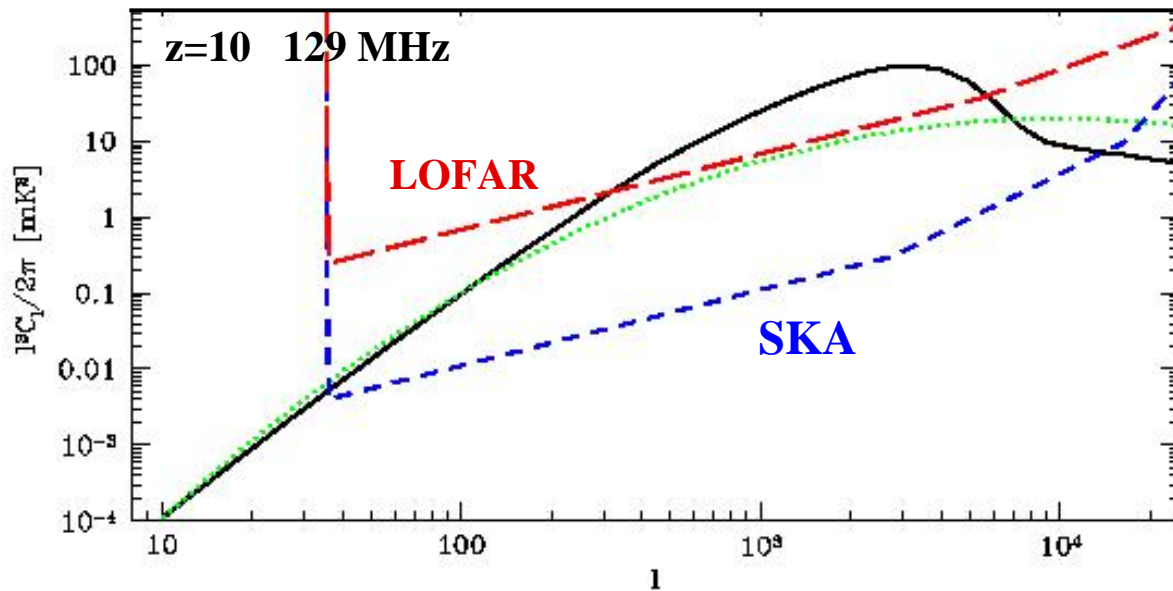
# Science Opportunities <300 MHz

- Raconteur: One who tells stories and anecdotes with skill and wit. ?
- Raconteur: SKA-style
  - Over-opinionated; off topic; too long; highly subjective & distorted view of situation;
  - Expendable: may be disregarded (or even lynched) with few resulting legal or conscience issues...

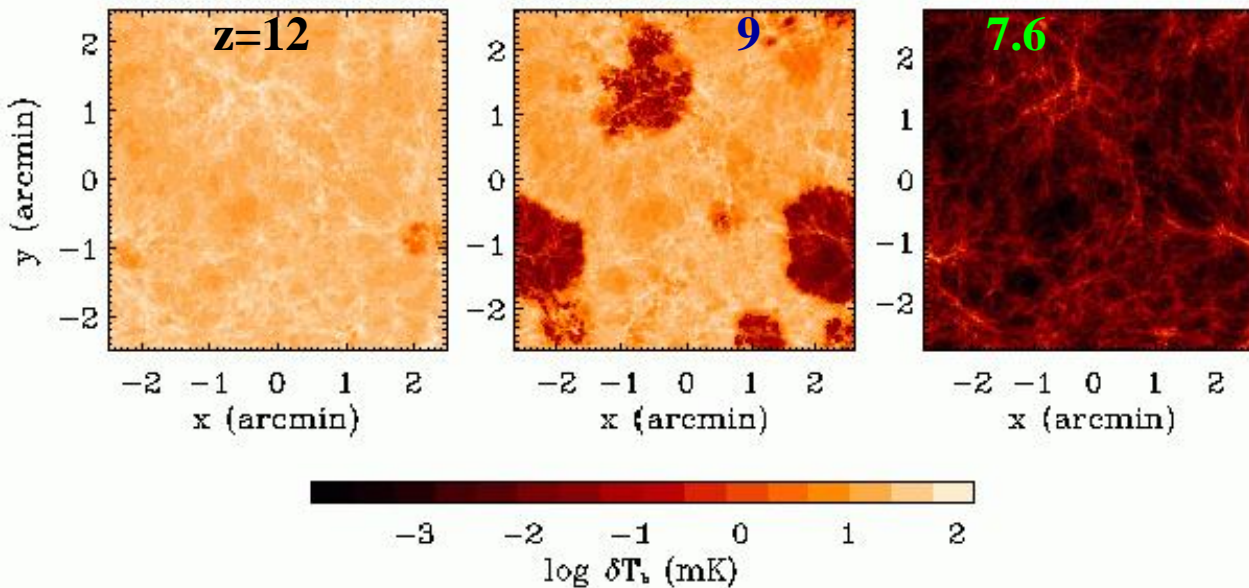
# Key SKA Science Drivers (<300MHz)

- First stars – reionization ✓
- Large scale structure – Dark Energy
- Cosmic magnetism ?
- Strong-field gravity ?
- Cradle of Life
- .... Transients ✓ , ...

# EOR: HI 21cm signal from the IGM



Power spectrum:  
pathfinders are critical



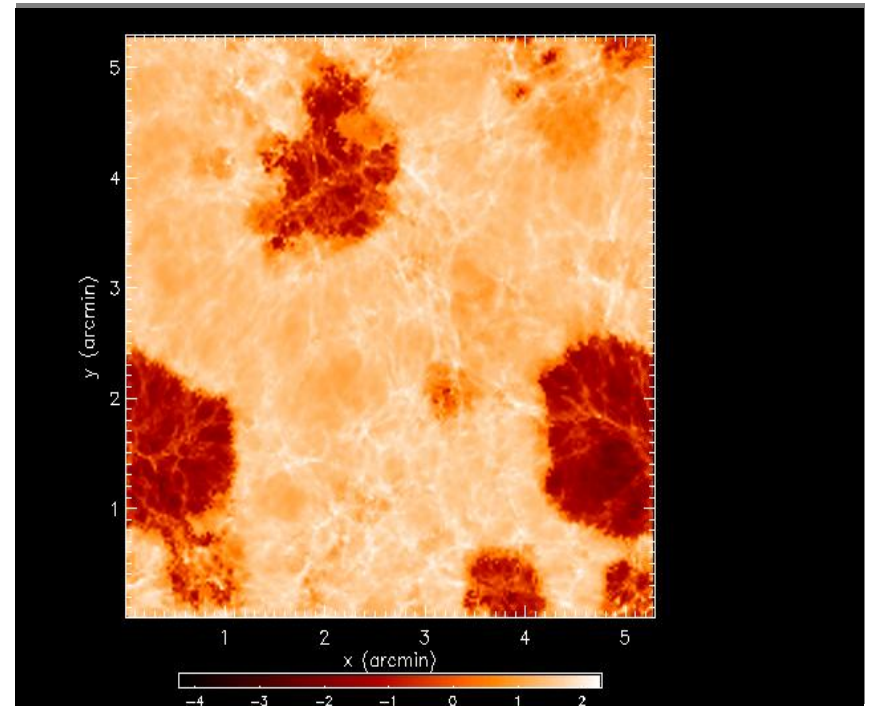
Tomography: only SKA

- $\Delta T_B(2') = 10's \text{ mK}$
- SKA rms (100hr) = 4mK
- LOFAR (1000hr) = 80mK

# The 21 cm Transition

- Map emission (or absorption) from IGM gas
  - Spectral line: measure entire history
  - Direct measurement of IGM properties

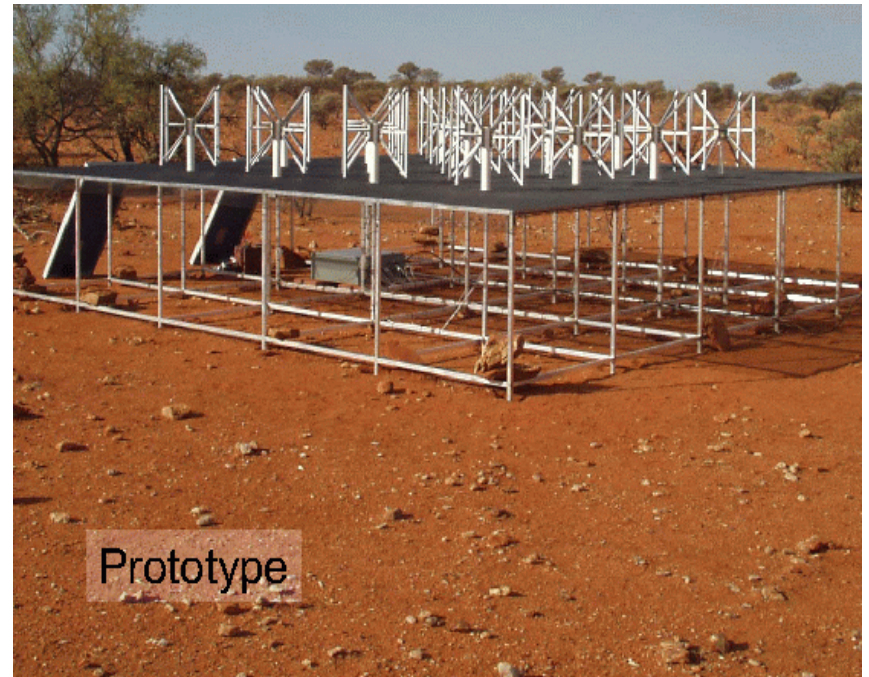
$Z = ?$



SF, AS, LH (2004)

# 21 cm Observations

- Challenges
  - Terrestrial Interference
  - Ionosphere
  - RFI
  - Astronomical Foregrounds
    - $T_b \sim 200\text{-}2000$  K
    - Galactic synchrotron
    - Extragalactic sources
    - Smooth spectra!
  - Dirty result (model-dependant) ?
  - Matching array design, brightness fluctuations
  - Redshift????
- Experiments
  - Global Signal: CoRE-ATNF
  - Fluctuations: 21CMA, LOFAR, MWA, PAPER, SKA
  - Imaging: SKA



**MWA (from C. Lonsdale)**

# R #1

- We should have a roadmap for EOR:
  - Status of existing efforts (highlighting US pathfinders).
  - More work on theory, foregrounds, systematics etc.
  - Work to detect integrated signal...
  - Plan for participation/leadership in “EOR Array” within 5-10 years – MWA → SKA...
  - More ownership, outreach in community to show EOR potential?

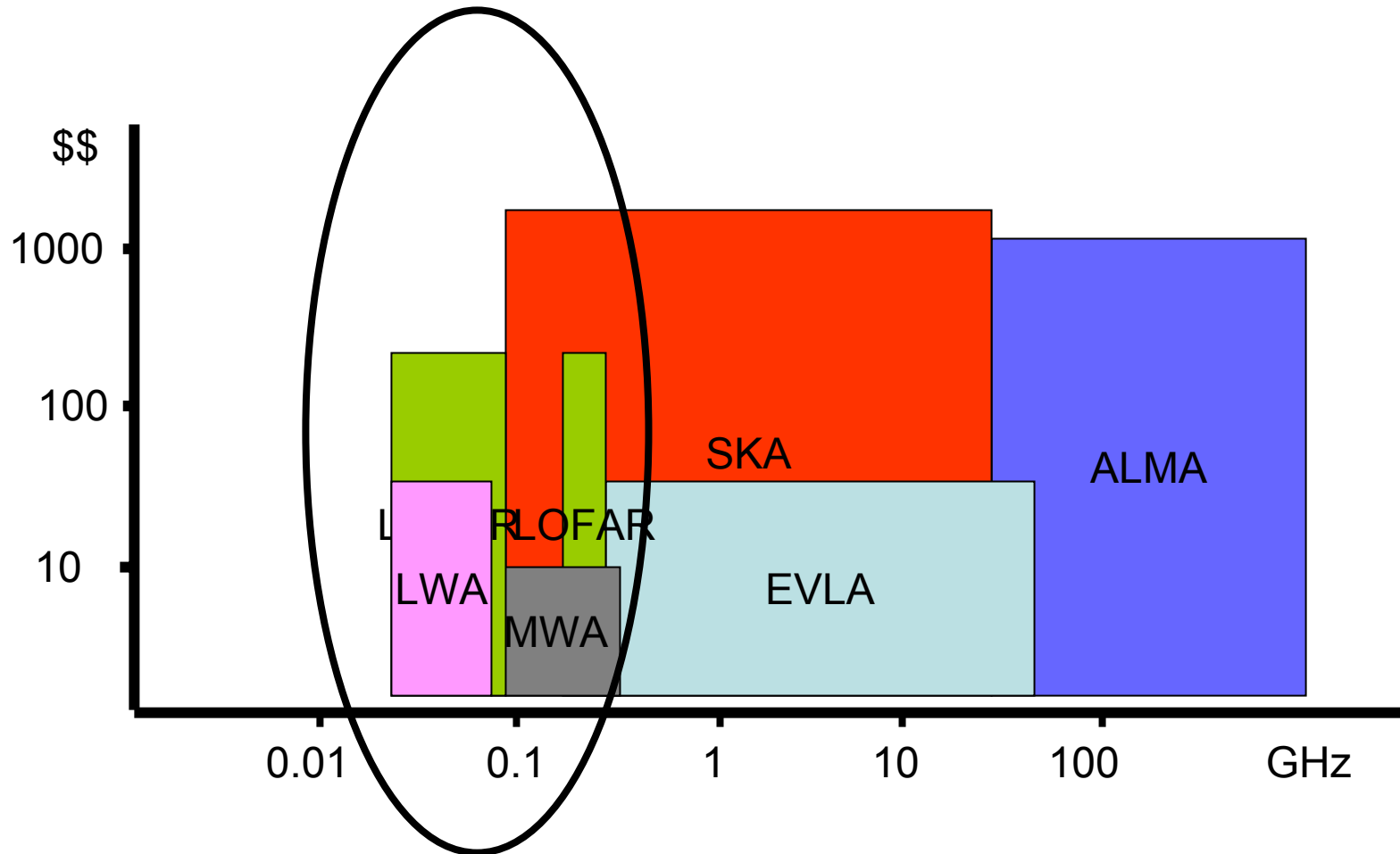
***Not controversial result... EOR is transformational  
May require full effort of our community in future?  
CMB 90's... EOR 10's...***

# Meter-wave Science

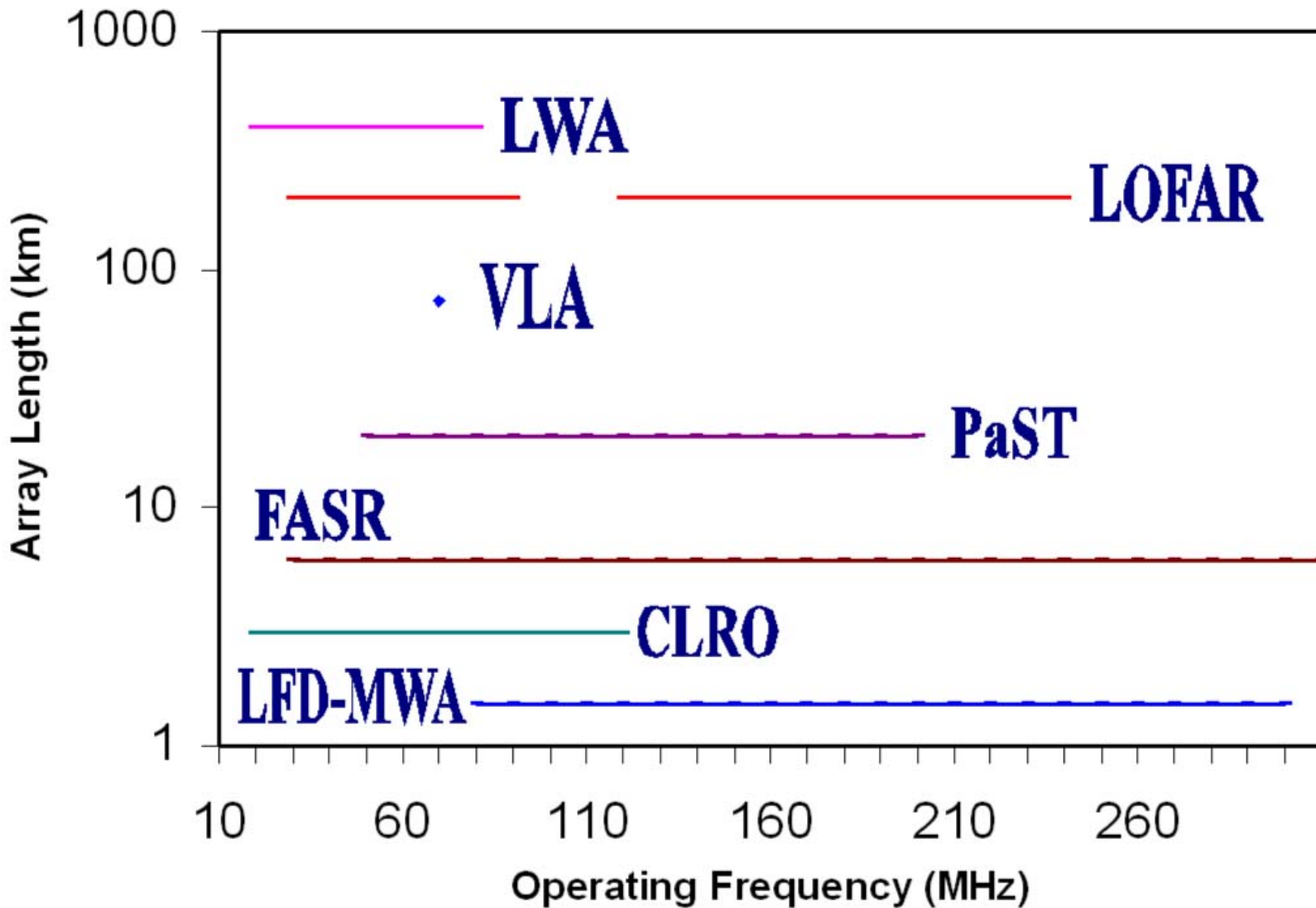
- **Cosmic Evolution & The High Redshift Universe**
  - Evolution of Dark Matter & Energy by differentiating relaxed & merging clusters
  - Study of the 1st black holes & the search for HI during the EOR & beyond
- **Acceleration of Relativistic Particles in:**
  - Hundreds of SNRs in normal galaxies at energies up to  $10^{15}$  ev.
  - In thousands of radio galaxies & clusters at energies up to  $10^{19}$  ev
  - In ultra high energy cosmic rays at energies up to  $10^{21}$  ev and beyond.
- **Plasma Astrophysics & Space Science**
  - Ionospheric waves & turbulence
  - Acceleration, Turbulence, & Propagation in the ISM of Milky Way & normal galaxies.
  - Solar, Planetary, & Space Weather, Science
- **Other, pulsars, recombination lines, “discovery science”**

LOFAR, LWA, MWA science cases...  
Dynamic range, not sensitivity, limited – techniques, fun

# Underway....



Investment & interest in m-w science apparent..

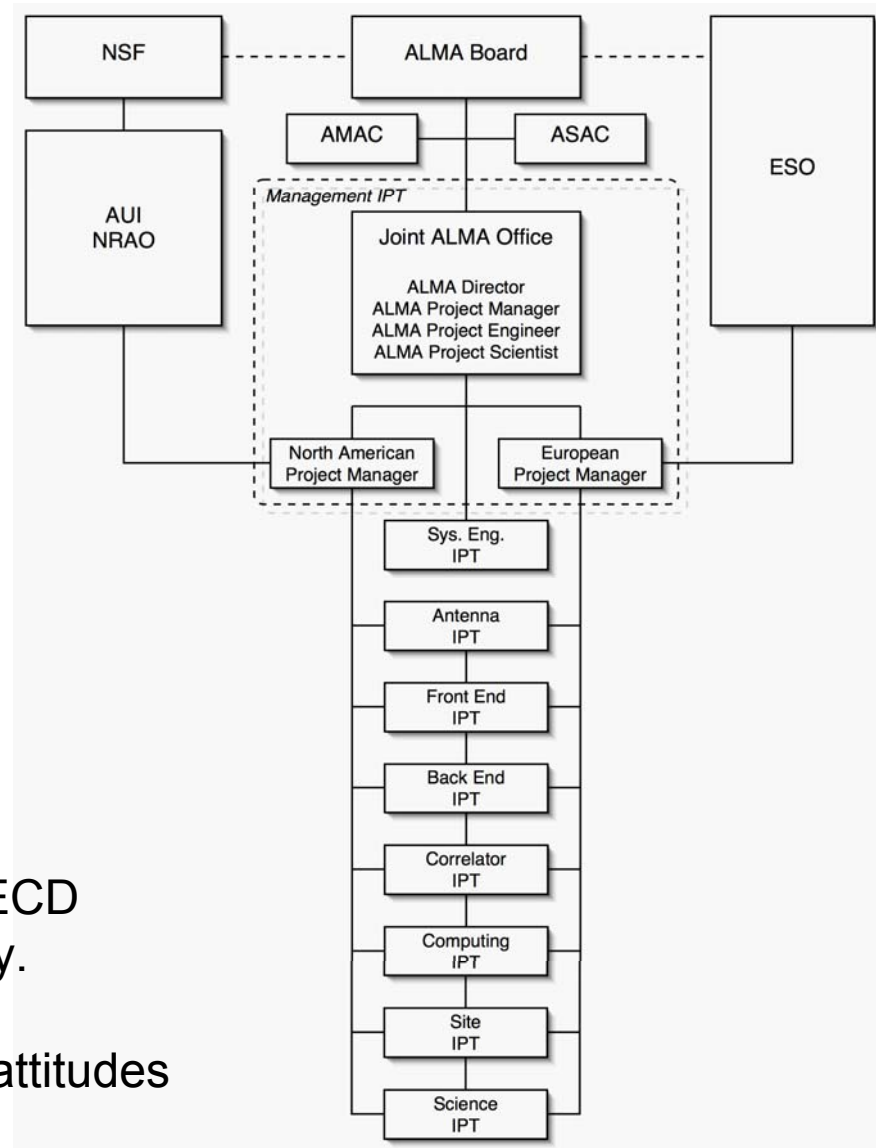


# Summary <300 MHz

- EOR !! ROADMAP... community attention, support.
- Need (and can defend) good linkage between last decadal review comments, SKA pathfinder approaches underway, and future plans ☺
- Needs ~SKA for imaging!! Warning: ownership...
- Other good meter-wave science – planned/underway efforts (MWA, LWA, LOFAR) will clean up – may eventually help justify additional large instrument (~SKA?)

# ALMA ☹️

- ALMA: \$1B radio telescope being built by an international collaboration in a remote site in the southern hemisphere.
- Science case: broad, excellent, produced in same way (international community consultation) that appears to converging very slowly here...
- Recently: long series of international reviews scrutinizing science, technical, management status; expected outcome is additional 40% in funding (in tough budgetary times).
- Poor management example?
  - First large international ground-based collaboration
  - Partners: two flagship organizations, new to “equal” collaboration
  - Result: Complex management structure



Goal: Partners retain control, responsibility for input national resources...

\$\$\$\$\$\$\$ means attention... OECD framework? "SKA Inc." not easy.

Problem: Not R&R... cultures, attitudes

# ALMA

- Cost
  - High-frequency – difficult site, high precision equipment → high cost/m<sup>2</sup>...
  - Difficult to budget.. Design, budget by committee, email...
  - Radio community – project management, system engineering experience lacking
  - lessons learned.....

|                             | Y2002/Y2000\$ | Ratio      |
|-----------------------------|---------------|------------|
| 1 Management / Admin.       | 18            | 4.6 ←      |
| 2 Site Development          | 71            | 1.9 ←      |
| 3 Antenna Subsystem         | 230           | 1.3        |
| NA Antenna Procurement      |               |            |
| EU Antenna Procurement      |               |            |
| 4 Front End Subsystem       | 112           | 1.0        |
| 5 Backend Subsystem         | 50            | 1.1        |
| 6 Correlator                | 15            | 0.7        |
| 7 Computing Subsystem       | 36            | 1.1        |
| 8 System Eng. & Integration | 21            | 2.2 ←      |
| 9 Science / EPO             | 10            | 1.0        |
| <hr/>                       |               |            |
| <b>Total</b>                | <b>562</b>    | <b>1.4</b> |
|                             |               | avg        |

**Rebaseline project: 40% increase**

# ALMA lessons

- NOTE: with aligned science cases, medium-hard technical issues, strong international community support... 10-15 years to GO. Fact.
- Decisions will be made according to external events... e.g. political/funding agency schedule, agenda.. unavoidable, may cost you money, time, scope, credibility later. International collaboration is hard.
- SKA international project structure may be ALMA-like, or dangerously unique. Central control of resources is critical, but difficult to obtain.
- Pay attention to project management, software, system integration issues. This meeting: estimates of \$100M's tossed around.
- ALMA management: tested by evolution, SKA: proposing intelligent design. Compare ALMA, SKA in 2022?

# Timescales

- US: Decadal Review approaching – need clear priorities, aligned with US astronomy community interests, international SKA plans. 2008-2010...
- Funding agency timescales...

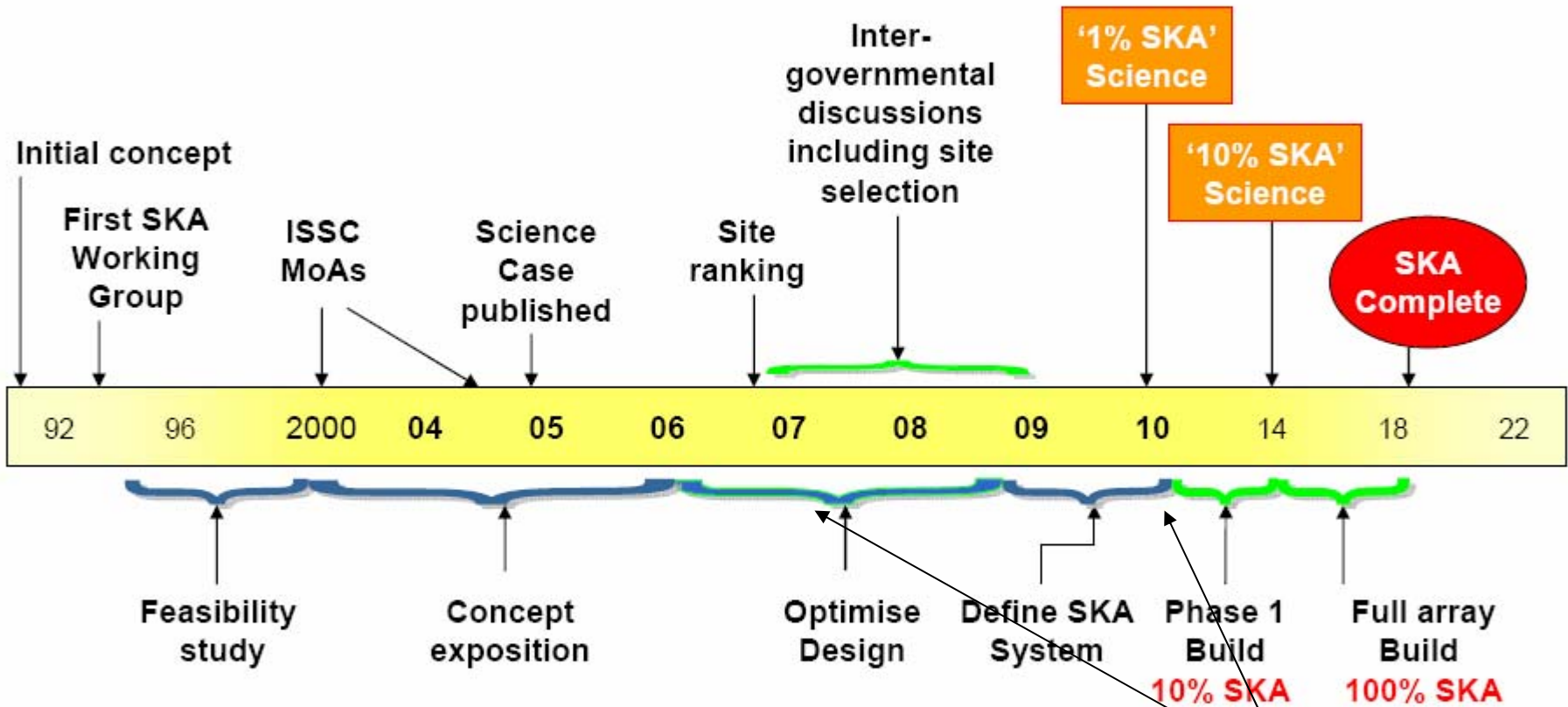
# Dickman/NSF

- *MREFC Time Frame Issues*
- *Competition for MREFC funds is fierce*
- *MREFC pipeline is massively full (~\$2.5B); many are non-astronomy projects*
- *There has been relatively little change in the annual level of the MREFC account over the years*
- *→ Difficult to predict the timing and fate of astronomy projects in the MREFC queue*
  
- *OIR/radio balance will likely be an issue in helping decide the next few large astronomy projects -- Underlying this is issue of the extent and nature of Federal support for OIR astronomy ☹*

# Timescales

- SKA/ISPO: vehicle for retaining international momentum (e.g. Site, Technology decisions), realistic??

# SKA timeline



US + International crunch time

Time is up.

# R #2

- SET PRIORITIES NOW
  - #1 EOR ← SKA, World
  - #2 HI synoptic array (+ PTA) ← SKA, World
  - #3 The rest.... ← US-oriented, self interest, TB...
  
- IMPROVE PROCESS:
  - Drive ideas, community to convergence efficiently (leadership, management issues; Ekers revival vs. endless democracy). Driving committees... e.g. this meeting...

# Goals of the Meeting—Five Desired Results

1. Statement of our vision for the key scientific objectives of US astronomy at m/cm wavelengths in the next decade and beyond.
2. Statement expressing our understanding of the multi-disciplinary context in which the *key scientific objectives of US astronomy at m/cm wavelengths* are established and a statement of the unique insight that observations at m/cm wavelengths bring in that context.
3. Concise assessment of the primary instrument requirements—parameters of the facilities required—that are necessary to address the *key scientific objectives of US astronomy at m/cm wavelengths* and the primary technological challenges they present.

# Goals of the Meeting—Five Desired Results

4. Statement of the parameters for which the widely-recognized, international, SKA project meets the primary instrument requirements. Assessment of whether alternative approaches to a monolithic SKA exist for meeting the primary instrument requirements and, if so, note the arguments for pursuing them. (That is, discuss—from a US perspective—whether the SKA is better structured as a telescope or as a program of internationally-accessible, next-generation, facilities). In all cases, discuss the technology development to be done in the US and the role of the TDP in organizing the development.
5. Assessment of the efficacy of the partnership between national centers and academic researchers in the future development of US astronomy at m/cm wavelengths.

?????????????? These goals?...

# R #2

- Clarify/empower USSKA management team to drive this process. (*DONE??*)
- LISTEN (NSF timescales; EVLA2 vs. high frequency plans vs. ALMA; SKA partners; TDP response)
- TALK (community outreach; what is SKA? political interest; etc.)

# R #2

- RISKS
  - Failure to converge community, present a strong case to Dec. Rev.
  - Failure to support existing pathfinders, develop EOR game plan.
  - Failure to link US planning with SKA, world (low, mid: OK).
  - Unrealistic international agenda, schedule. ??
  - Failure to produce coherent project plans (domestic/international).
  - Take advice from SKA-style meter-wave raconteur who spends no time thinking about SKA these days...

