User needs in radio astronomy- the Square Kilometre Array

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fundamental questions in physics and astronomy

"What are the basic properties of the fundamental particles and forces?"

Neutrinos, Magnetic Fields, Gravity, Gravitational Waves, Dark Energy

"What constitutes the missing mass of the Universe?"

Cold Dark Matter (e.g. via lensing), Dark Energy, Hot Dark Matter (neutrinos)

"What is the origin of the Universe and the observed structure and how did it evolve?"

Atomic hydrogen, epoch of reionization, magnetic fields, star-formation history……

"How do planetary systems form and evolve?"

Movies of Planet Formation, Astrobiology, Radio flares from exo-planets……

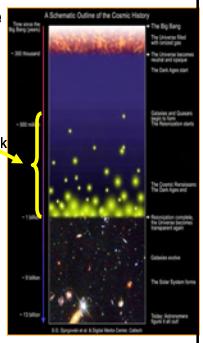
"Has life existed elsewhere in the Universe, and does it exist elsewhere now?"

SETI

CORNERSTONE OBSERVATORIES: ALMA, JWST, SKA, AND ELT

Top priorities for a new generation radio telescope

- **Detect and image neutral hydrogen in the very early phases of the universe when the first stars and galaxies appeared – "epoch of re-ionisation"**
- Locate 1 billion galaxies via their neutral hydrogen signature and measure their distribution in space – "dark energy"
- Origin and evolution of cosmic magnetic fields – "the magnetic universe"
- Time pulsars to test description of gravity in the strong field case (pulsar-Black Hole binaries), and to detect gravitational waves
- Planet formation – image Earth-sized gaps in proto-planetary disks



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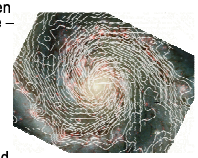

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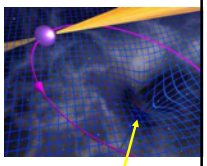

BLACK HOLE

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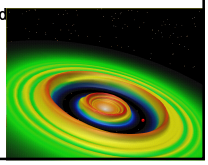


What instrument do we need?

A radio telescope with

- sensitivity to detect and image atomic hydrogen at the edge of the universe → *very large collecting area*
- fast surveying capability over the whole sky → *very large angle field of view*
- capability for detailed imaging of the structures of the planetary gaps and how they change → *large physical extent*
- *a wide frequency range* to handle the science priorities

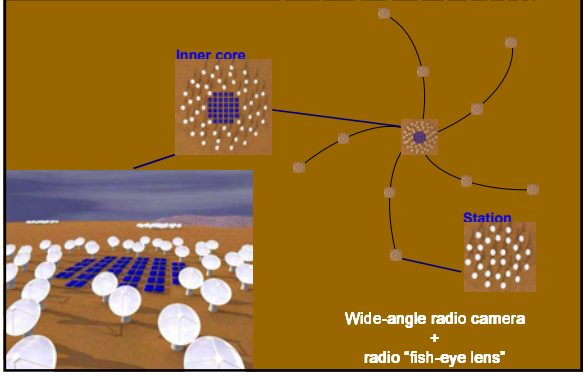
SQUARE KILOMETRE ARRAY

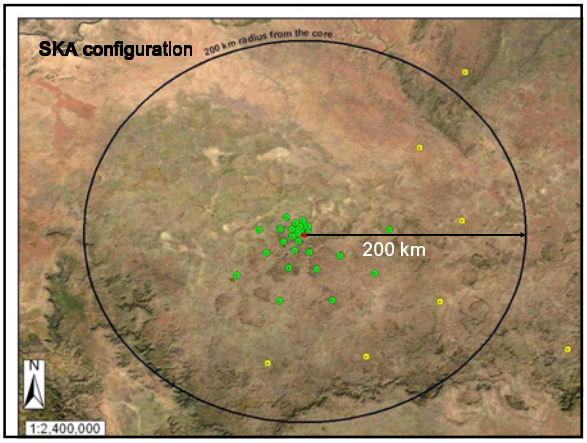
Square Kilometre Array

- **~ 1 km² collecting area** in an interferometer array
  - sensitivity ~50 x EVLA (current largest radio array)
  - survey speed >10000 x faster than EVLA

- wide frequency range: **0.1 – 25 GHz**
- configuration:
  longest baselines >3000 km; 50% collecting area<5km
- wide field of view: **50 sq. degree at <1 GHz** (250 x moon)
- total cost 1 B€; operating costs 70 M€/year

Reference Design



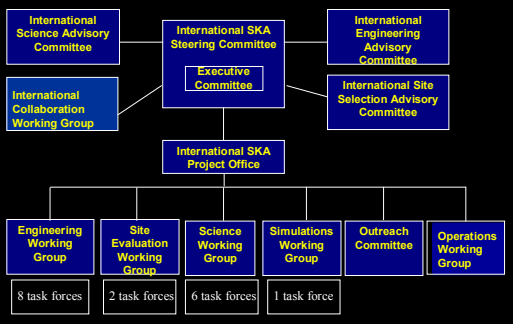


1% SKA Pathfinders – proving SKA technology

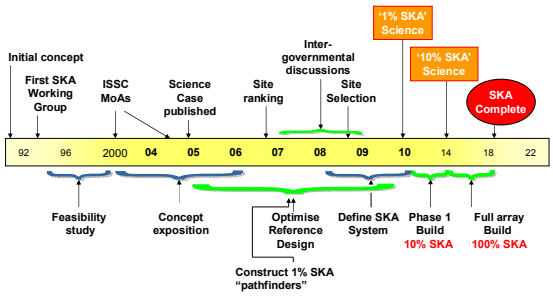
- **Radio camera: small dishes+smart feeds**
  -SKA Design Study (Europe)
  -Karoo Array Telescope (South Africa)
  -Extended New Technology Demonstrator (Australia)
  -Allen Telescope Array (USA)
- **Radio fish-eye lens: aperture array tiles**
  -SKA Design Study (Europe)
  -LOFAR (Netherlands)
- **SKADS – study of end-to-end design**
  EC-FP6, European countries, Australia, South Africa, Canada
- **RadioNet**

Current SKA governance

SKA was "born global"; >50 institutes in 17 countries actively involved



SKA timeline



Timeline to site decision

Dec 2005 – Site proposals due from Argentina+Brazil, Australia+NZ, China, South Africa+6 countries

Mar 2006 – Radio Frequency Interference reports due

July 2006 – International Advisory Committee report due

Aug 2006 – Ranking of sites by Steering Committee

2007-8 -- Final decision on site following inter-governmental discussion

summary

- **Strong science case**
- **Reference Design identified**
- **Coherent portfolio of technologies under development through funding of SKA pathfinder telescopes**
- **Site selection in progress**
- **Europe is poised to play a major role in the global project**
- **Inter-governmental discussion foreseen in 2007-8:**
  -select site
  -agree cost-sharing and procurement guidelines for SKA construction starting in 2011, and
  -establish governance structure