Large M
Survey Pr

ASSA Symposium

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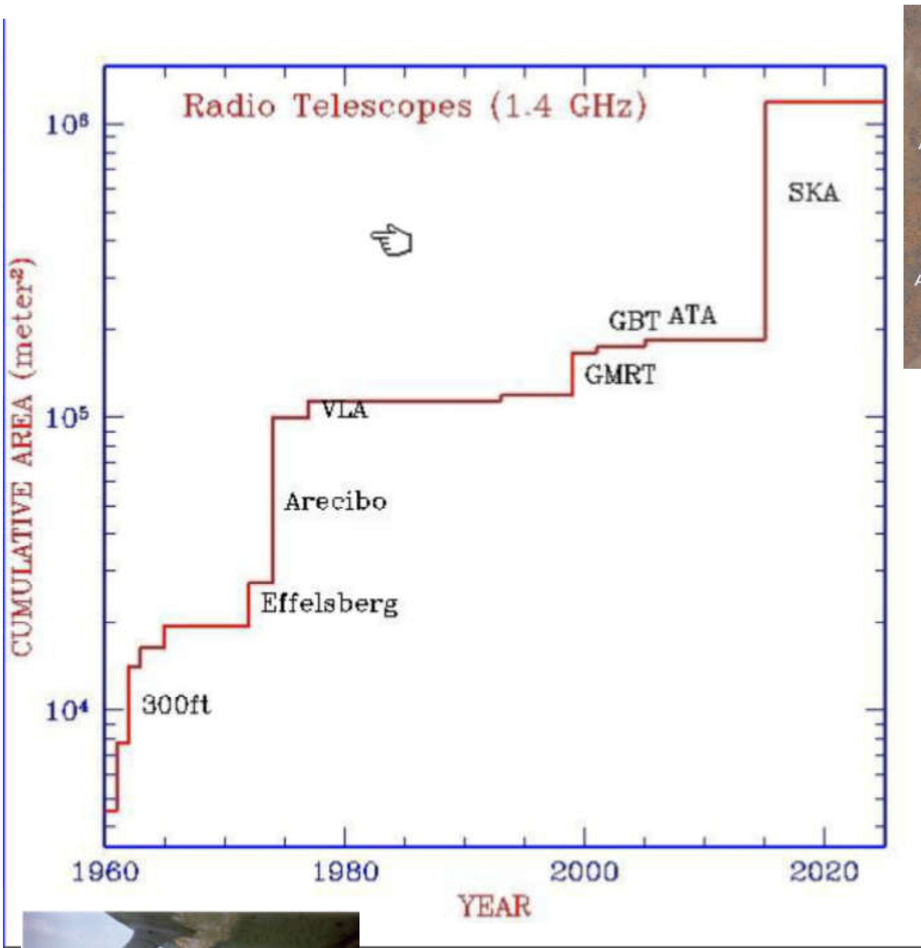
Overview

- The SKA: main science cases
- MeerKAT: rollout and large surveys
  - UCT led large surveys: *Laduma*
    Mhongoose
    MIGHTEE
    ThunderKAT
  - First results from KAT7

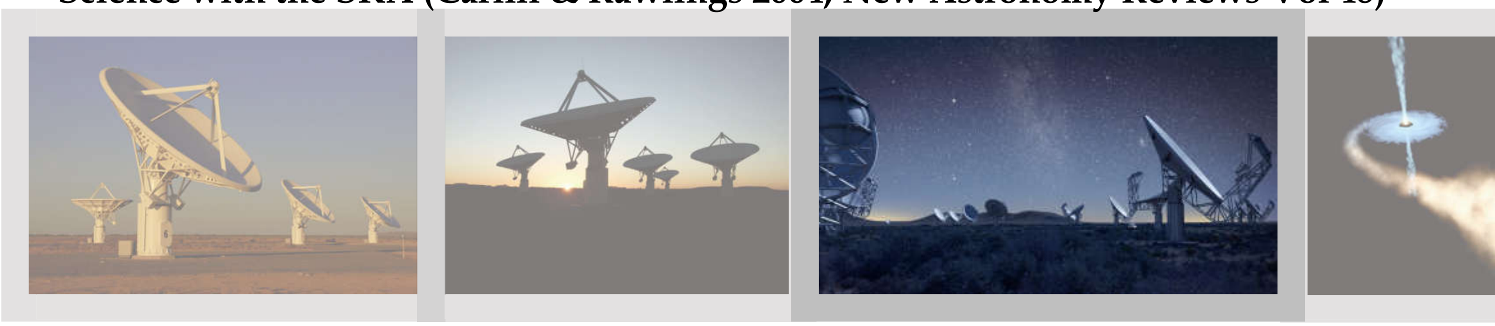
From the first radio telescopes t



The SKA science

http://www.skatelescope.org/the-science/

Science with the SKA (Carilli & Rawlings 2004, New Astronomy Reviews Vol 48)



The SKA science

Surveys for neutral atomi

Neutral atomic hydrogen (HI) most abur
Universe; powerful tracer of star formati
various environments; cosmic evolution

Galaxy formation and evo

Complex behaviour of baryons in contex
in dark matter halos; (supernova-driven
growth; semi-analytic models vs. observa

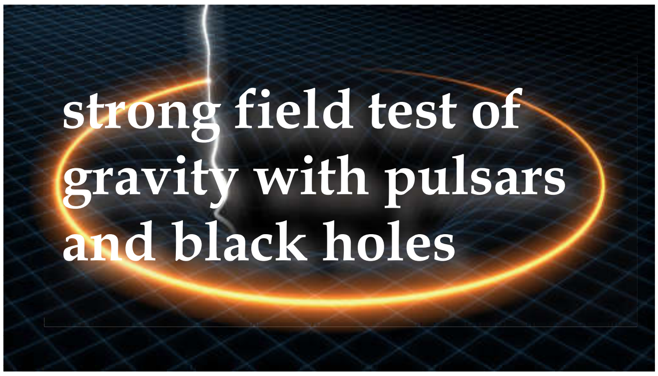
Cosmology with the SKA

Cosmological parameters (dark energy p
gravitational lensing (w as a function of r
scale of the Universe (H_0) through water

Galaxy evolution, cosmology and dark energy with the SKA (Rawlings et al. 2004, New A




The SKA science



Strong field tests of gravity

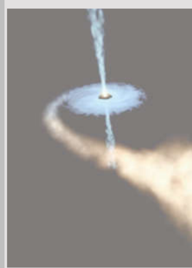
Pulsars in compact binary systems; SKA sensitivity will lead to dis
pulsars (~1000 milli-second pulsars)

Gravitational wave background

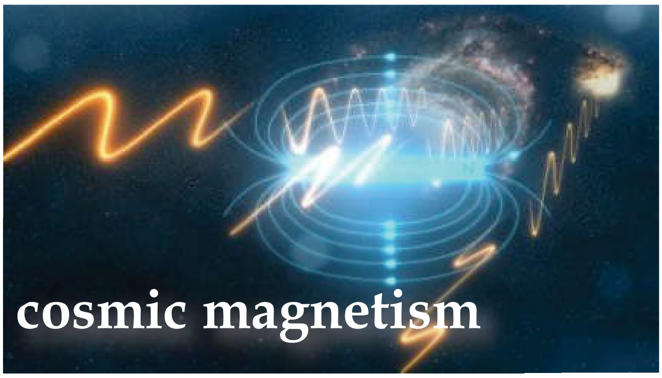
Precise timing (<100 ns) of dense array of milli-second pulsars; cos
wave detector (nHz regime); sensitive to merging massive black h
of galaxy formation - cf eLISA (mHz) or Advanced LIGO (Hz) reg

Strong-field tests of gravity using pulsars and black holes (Kramer et al. 2004, New Astro



The SKA science



Cosmic magnetism

What generates the giant magnetic
The SKA will create 3D maps of cos
(cosmic web) through Rotation Mea
studies, and try to understand their

Cradle of Life

SETI: Are we alone?
The SKA will detect weak extra-terr
and search for building blocks of lif
of proto-planetary disks; prebioptic

The Dark Ages

How and when were the first black
The SKA look back to the Dark Age
Universe lit up and of the first lumi
by observing gas at 21cm; epoch of
first metals. BH and galaxies

The SKA science

New technology

faster computing; multiplexed instrument; real-time analysis; negative time (buffering seconds to minutes of data) before triggering on an event

SKA parameter space

greater sensitivity and resolution; large instantaneous field of view (survey speed - proportional to field of view over sensitivity squared); multi-beaming

Exploration-driven observing

flexible design; comensal data access (sampling different time domains); blind searches

explo
unkn

The exploration of the unknown (Wilkinson et al. 2004, New Astronomy Reviews, 48, 15




The SKA science

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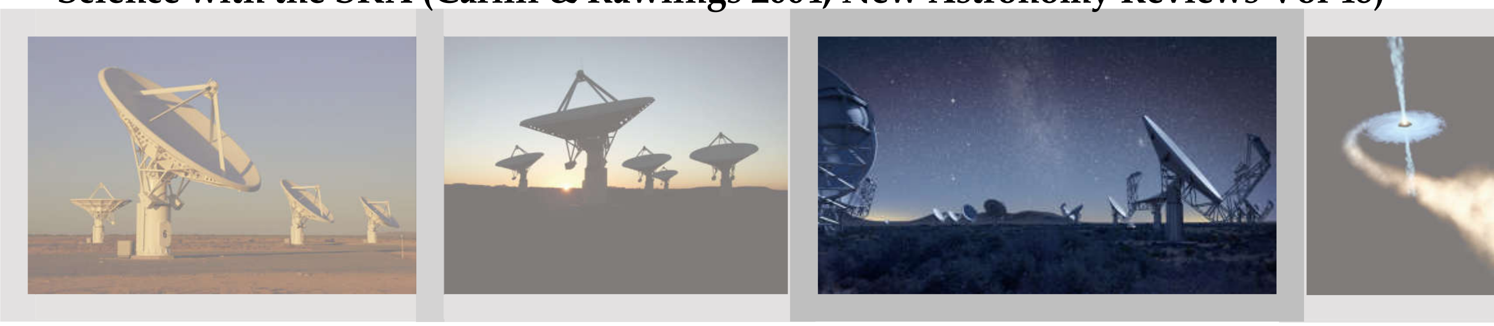

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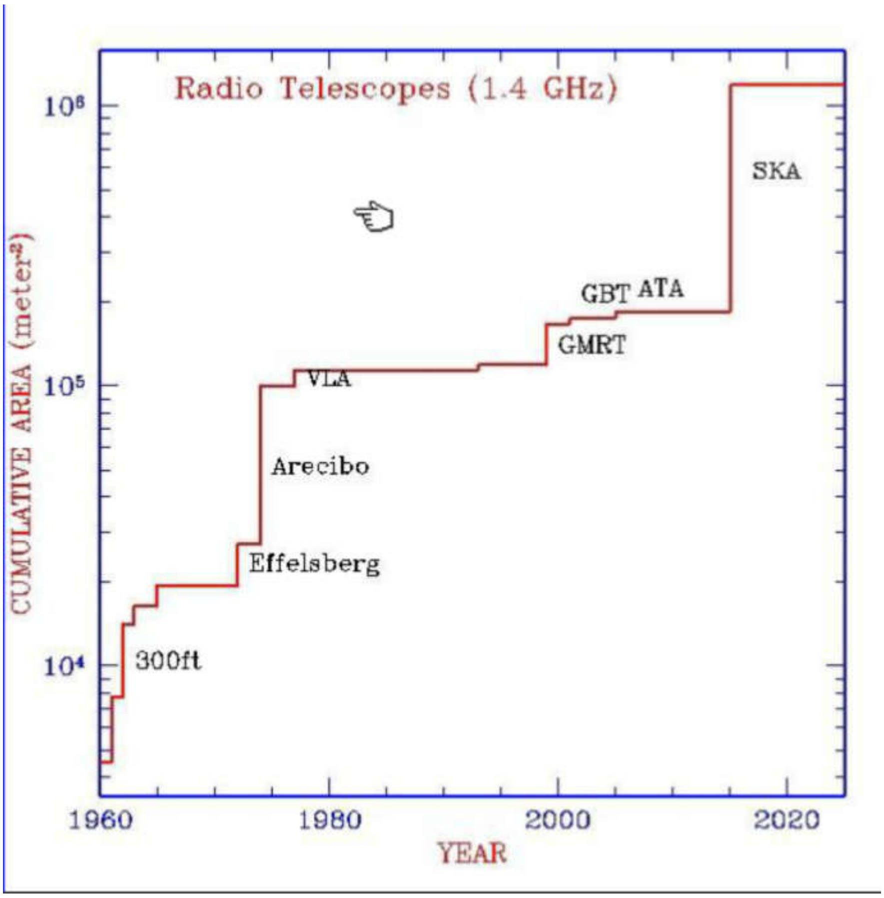


Square Kilometre Ar

A massive engineering pr

How do we get from here to there ?

Pivotal SKA technology is being demonstrated w
studies and a suite of precursor and pathfinder te
by SKA groups around the world.

→ SKA Pathfinders

Science-grade Testbed Facilities

- MeerKAT (South Africa)
- ASKAP (Australia)
- LOFAR & APERTIF (Netherlands)

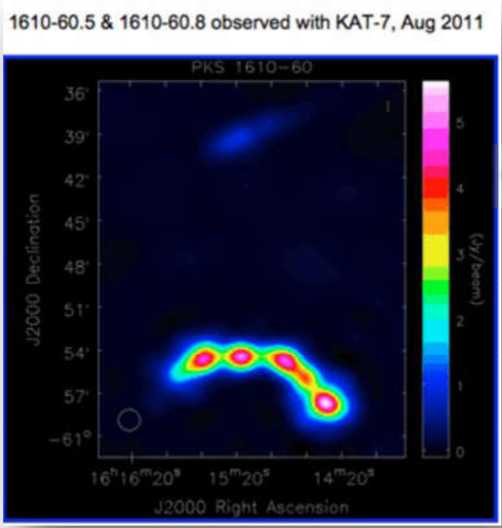
MeerKAT

64 dishes over 8 km baseline
13.5-m Gregorian offset
Single pixel receiver (0.9-1.7 GHz)
Compact core, extended baseline

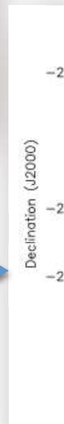
Will be most sensitive cm-wavelength instrument in southern hemisphere

MeerKAT precursor: KAT-7

- Completed Dec. 2010
- Science verification started: mid 2011
- First radio telescope array consisting of composite (fibre glass) antenna structures
- First results: continuum & line mode



Line 03/12
NGC 3109



KAT-7→ MeerKAT → SKA

SQUARE KILOMETRE ARRAY: TIME I

Year	KAT-7	MeerKAT
2012	commissioning	design studies
2013	Science operations	1st dish constructed
2014		16 dishes completed
2015		64 dishes completed
2016		Science operations
2017		
2018		
2019		
2020		
2020+		




MeerKAT Science

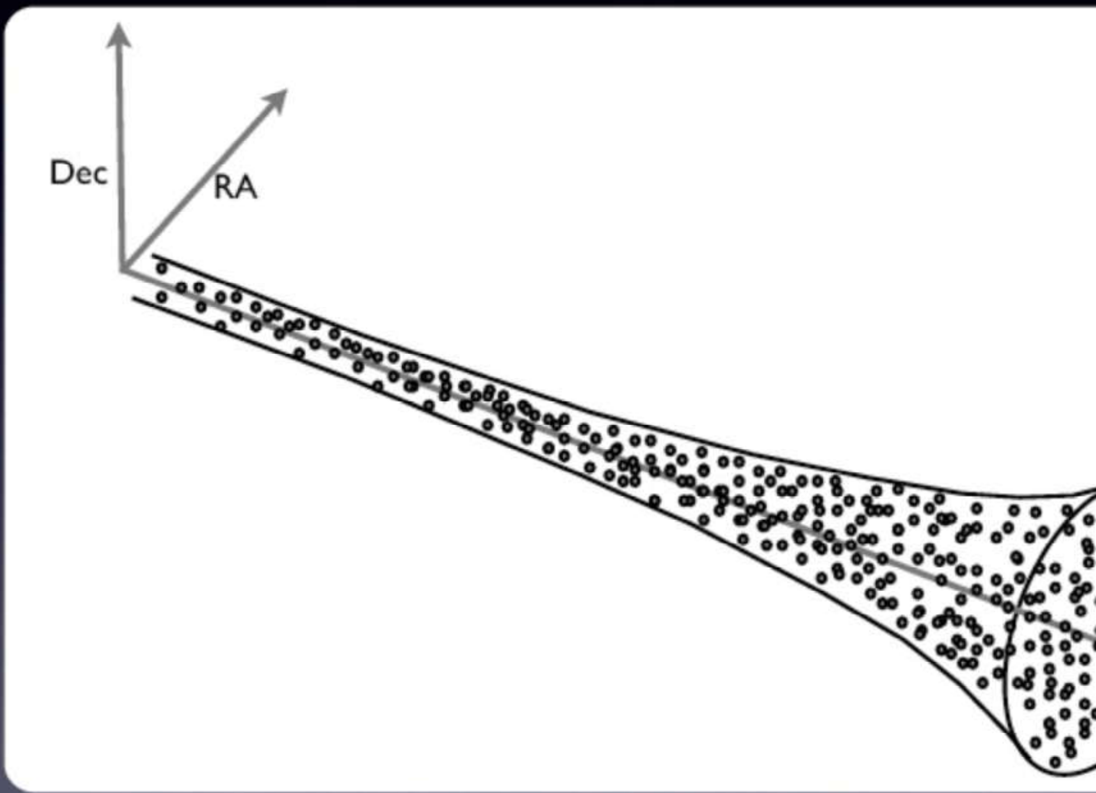
- Call for large survey projects: end 200
- 21 proposals from 500 astronomers fr the world (~60 SA)
- 43 000 hours (~5 years) allocated to 1 survey projects (5 with SA PIs)
- The science objectives of the selected consistent with the prime science driv SKA, confirming MeerKat as an SKA

MEERKAT LARGE SURVEY PROJECTS (70% of all available t		
Radio Pulsar Timing	Bailes (AU)	7860 h
Testing Einstein's theory of gravity and gravitational radiation - Investigating the physics of enigmatic neutron stars thr		
LADUMA	**Blyth**, Holwerda, Baker (SA,NL,US)	5000 h
An ultra-deep survey of neutral hydrogen gas in the early universe		
MESMER	Heywood (UK)	6500 h
Searching for CO at high red-shift (z>7) to investigate the role of molecular hydrogen in the early universe		
MeerKAT Absorption Line Survey	Gupta, Srianand (NL, IN)	4000 h
Survey for H and OH lines in absorption against distant continuum sources; OH line ratios may give clues about chang early universe).		
MHONGOOSE	**de Blok** (NL,SA)	6000 h
Investigations of different types of galaxies; dark matter and the cosmic web		
MeerKAT HI Survey of Fornax	Serra (NL)	2450 h
Galaxy formation and evolution in the cluster environment		
MeerGAL	Thompson, Goedhart (UK,SA)	3300 h
Galactic structure and dynamics, distribution of ionised gas, recombination lines, interstellar molecular gas and masers		
MIGHTEE	Jarvis, **van der Heyden** (UK,SA)	1950 h
Deep continuum observations of the earliest radio galaxies		
TRAPUM	Stappers, Kramer (UK, DE)	3080 h
Searching for, and investigating new and exotic pulsars		
ThunderKAT	**Woudt, Fender** (SA,UK)	3000 h +
Study of explosive radio transients with MeerKAT; accretion-induced outflow from compact stellar remnants, e.g. relati		

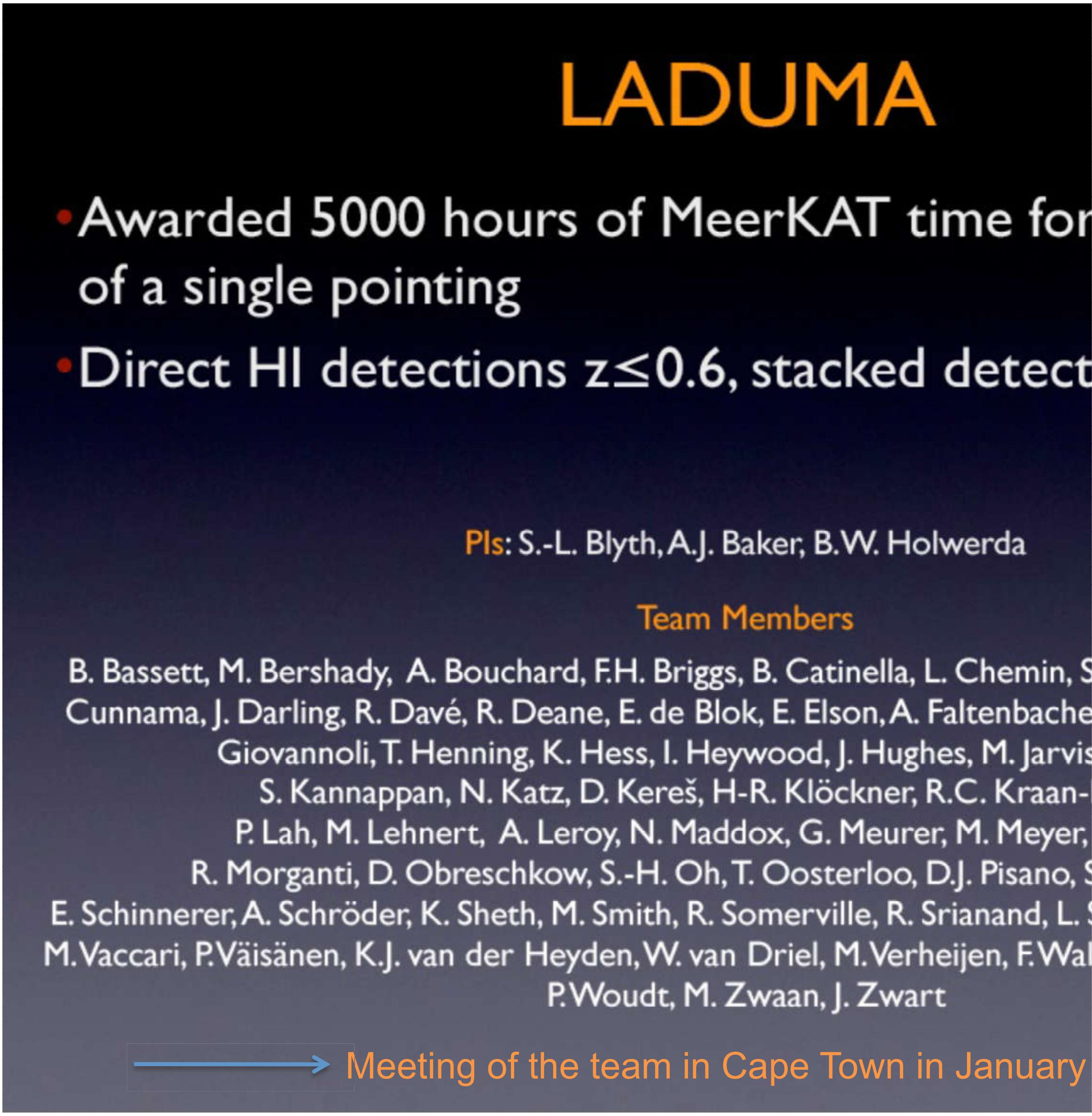



LADUMA

Looking At the Distant Universe with the Me

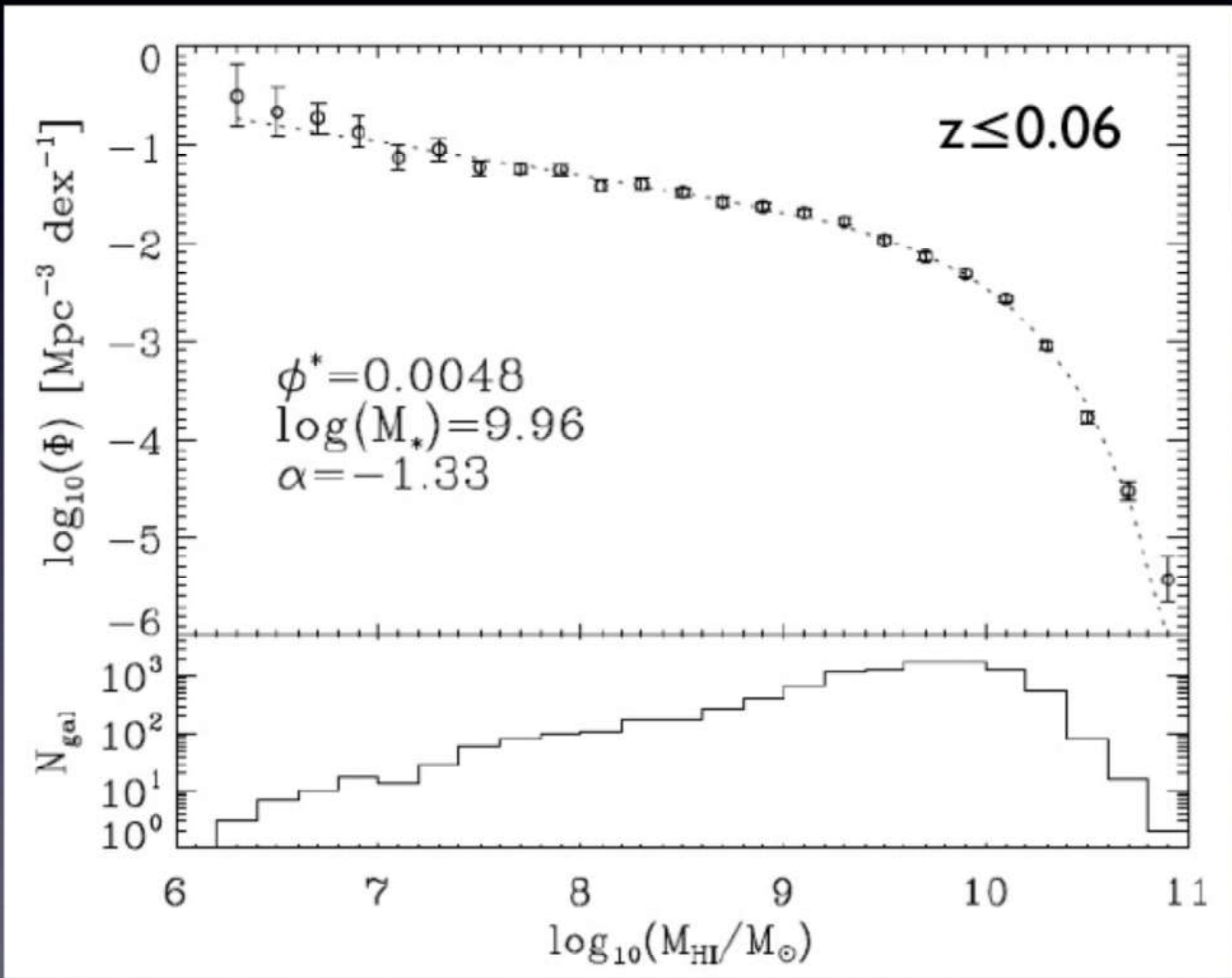


PIs: Sarah Blyth (UCT), Andrew Baker (Rutgers), Benn


LADUMA
Awarded 5000 hours of MeerKAT time for
of a single pointing
Direct HI detections z≤0.6, stacked detect
PIs: S.-L. Blyth, A.J. Baker, B.W. Holwerda
Team Members
B. Bassett, M. Bershady, A. Bouchard, F.H. Briggs, B. Catinella, L. Chemin, S
Cunnama, J. Darling, R. Davé, R. Deane, E. de Blok, E. Elson, A. Faltenbache
Giovannoli, T. Henning, K. Hess, I. Heywood, J. Hughes, M. Jarvis
S. Kannappan, N. Katz, D. Kereš, H-R. Klöckner, R.C. Kraan-
P. Lah, M. Lehnert, A. Leroy, N. Maddox, G. Meurer, M. Meyer,
R. Morganti, D. Obreschkow, S.-H. Oh, T. Oosterloo, D.J. Pisano, S
E. Schinnerer, A. Schröder, K. Sheth, M. Smith, R. Somerville, R. Srianand, L. S
M. Vaccari, P. Väisänen, K.J. van der Heyden, W. van Driel, M. Verheijen, F. Wal
P. Woudt, M. Zwaan, J. Zwart
Meeting of the team in Cape Town in January

LADUMA Key Science Goal

- Investigate the HI mass function in different enviro

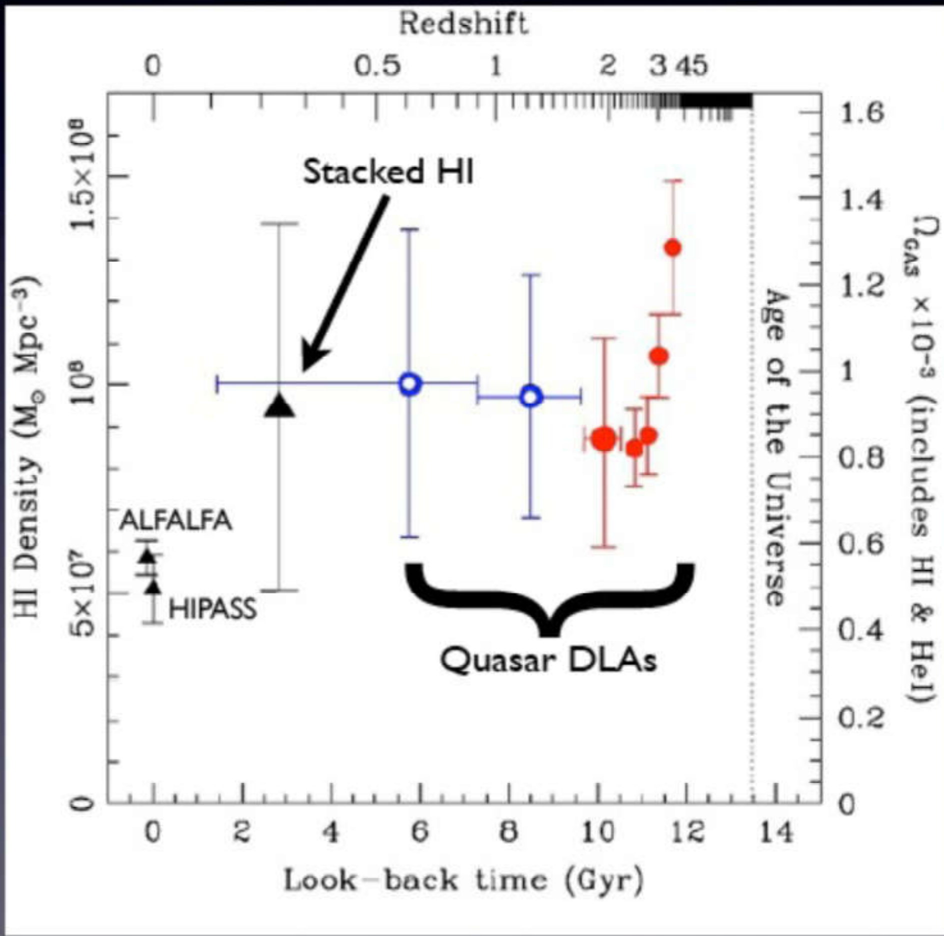


How do N
vary with

Martin et al 2010

LADUMA Key Science Goal

- Investigate the HI mass function in different enviro
- Measure the evolution of Ω_{HI} using HI emission to



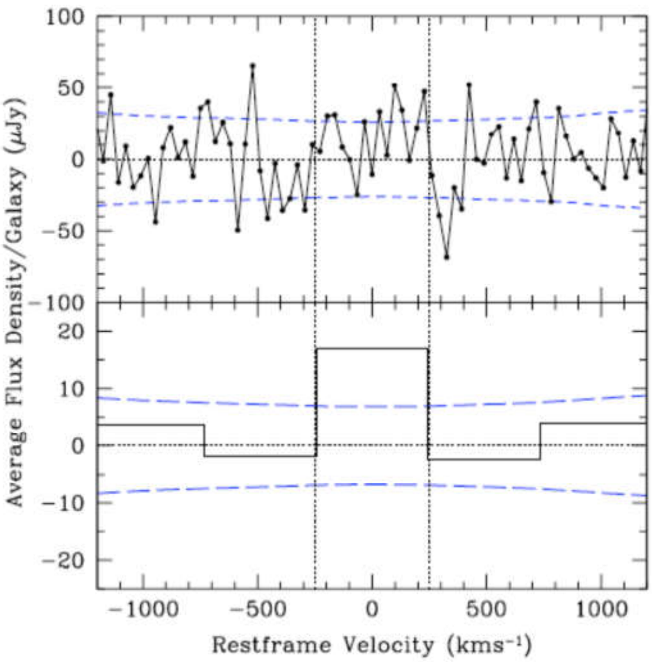
P Lah, Private Communication

State of the Art

With current telescopes, HI is hard to find at intermediate z

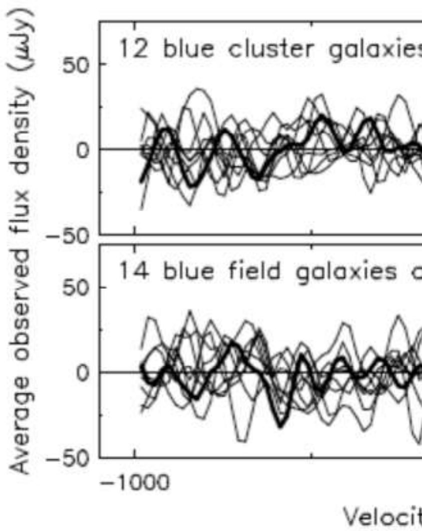
Lah et al. (2007)

z = 0.24, GMRT
signal: 2.6σ



Verheijen et al

z = 0.2



HI Stacking

Since the HI signal is weak, one uses independent measurements of galaxy z before stacking:

- **STEP 1: extract spectra using known positions and z**

- **STEP 2: Using known z values, shift all lines to common channel**

- **STEP 3: Co-add spectra**