



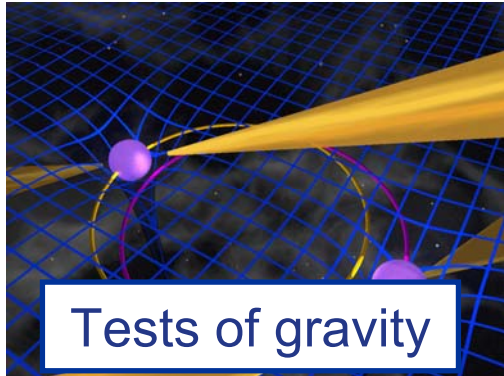
Science Drivers for the Square Kilometre Array

Steve Torchinsky
USN/GEPI
SKADS Project Scientist

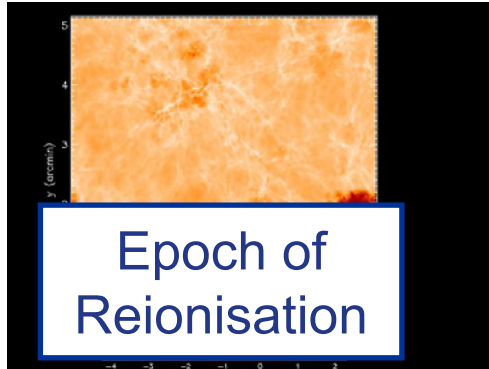
www.skads-eu.org



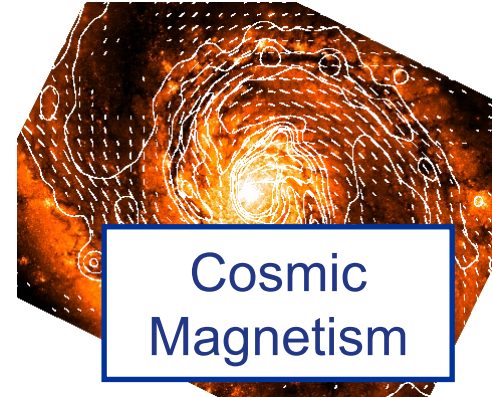
SKA Key Science



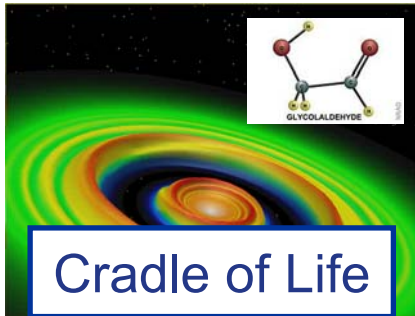
Tests of gravity



Epoch of Reionisation



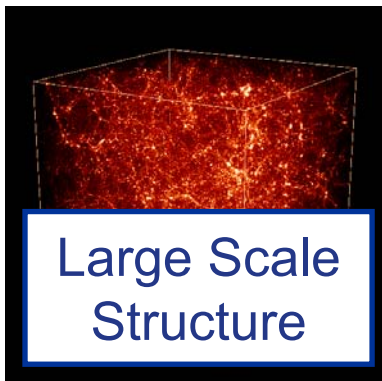
Cosmic Magnetism



Cradle of Life



Transient Universe



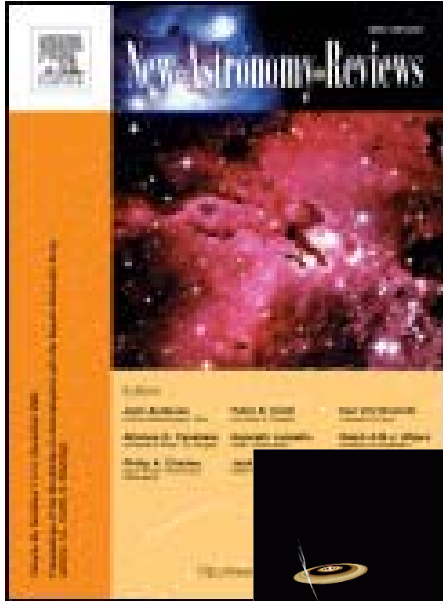
Large Scale Structure



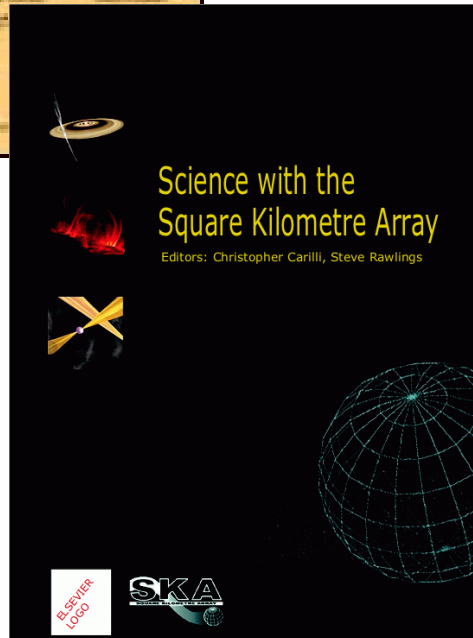
The Unknown



SKA Science Book



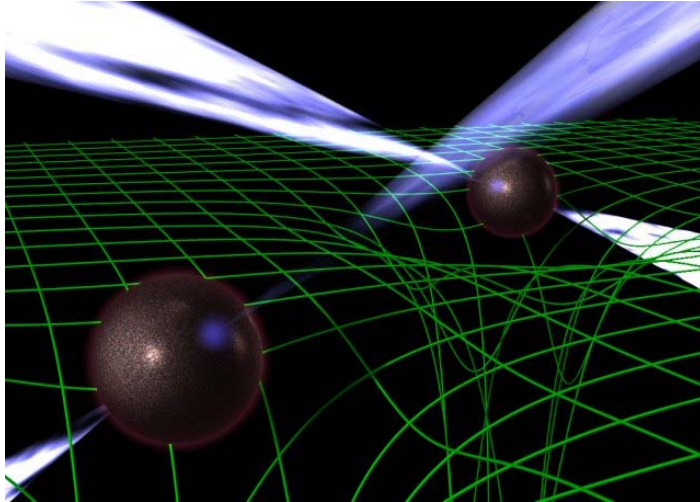
Chris Carilli & Steve Rawlings,
New Astronomy Reviews,
Vol.48, Elsevier, Dec. 2004



http://www.skads-eu.org/p/SKA_SciBook.php



Strong Field Tests of Gravity

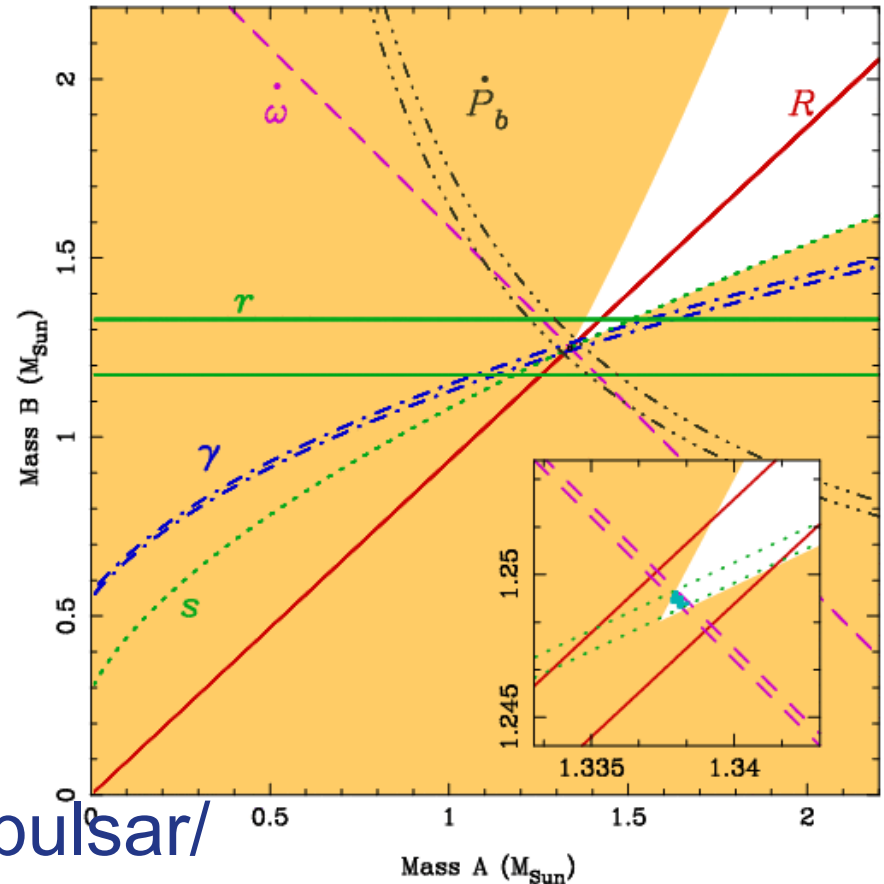


Binary orbit permits determination of masses

Relativistic effects permit (re) determination of masses.

ALL MUST AGREE

<http://www.jb.man.ac.uk/~pulsar/>

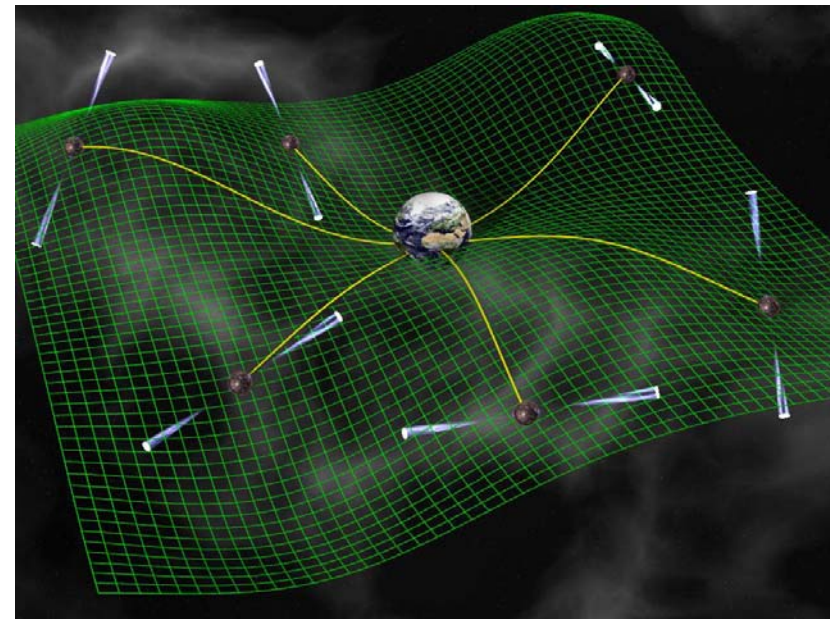




Strong Field Tests of Gravity



- Large surveys will find exotic binaries
 - ~20 000 pulsars in the galaxy
 - Nearly edge-on Pulsar – Black-hole binary (at least one)
 - Probe eg. Frame dragging, cosmic censorship, no hair theorem
- Pulsar timing array
 - Gravitational wave background

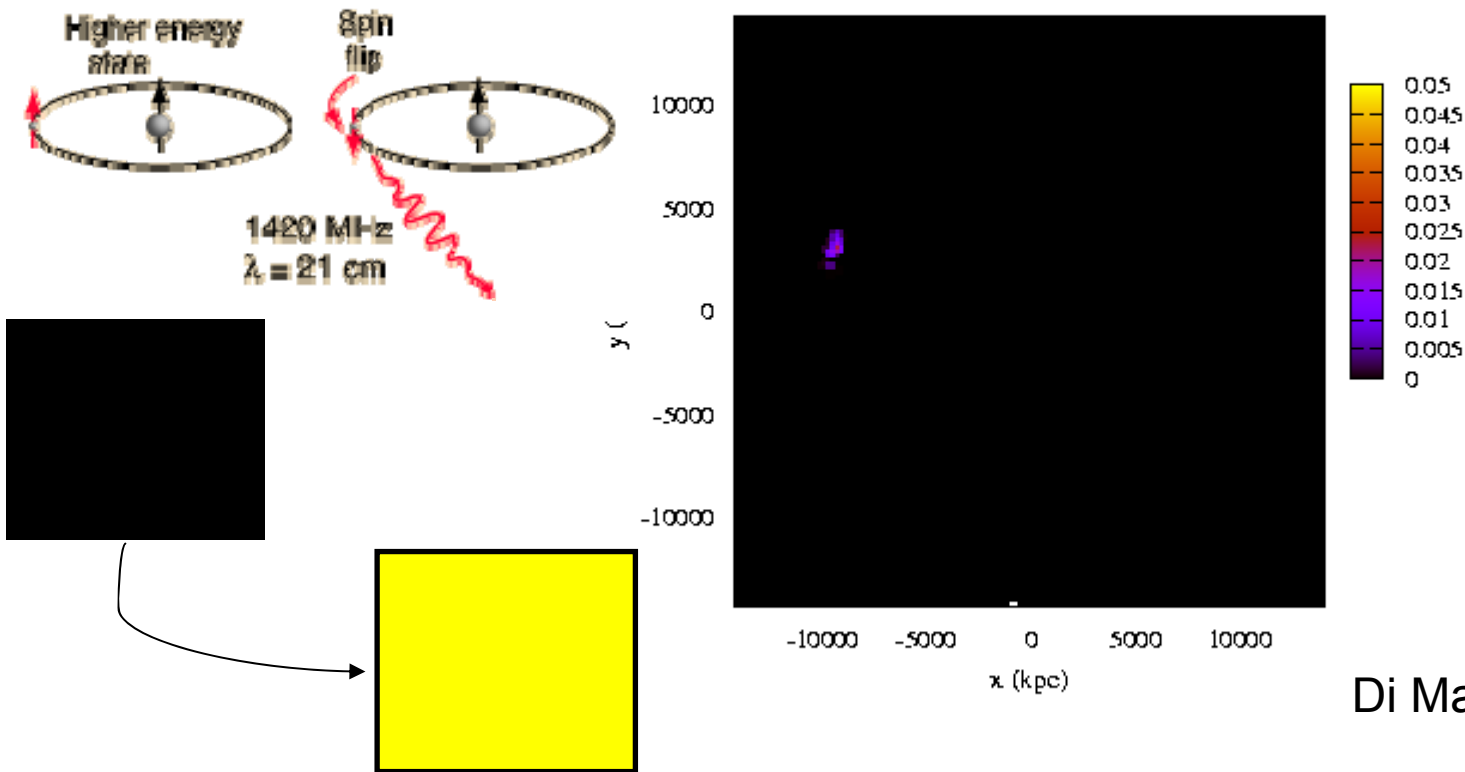




Probing the Dark Ages

- When did the first luminous objects form?
- How did they form and over what period of time?
- SKA will detect the **Epoch of Reionisation** and map the evolution history of the first luminous objects

$z = 14.4$



Di Matteo et al



Cosmic Magnetism

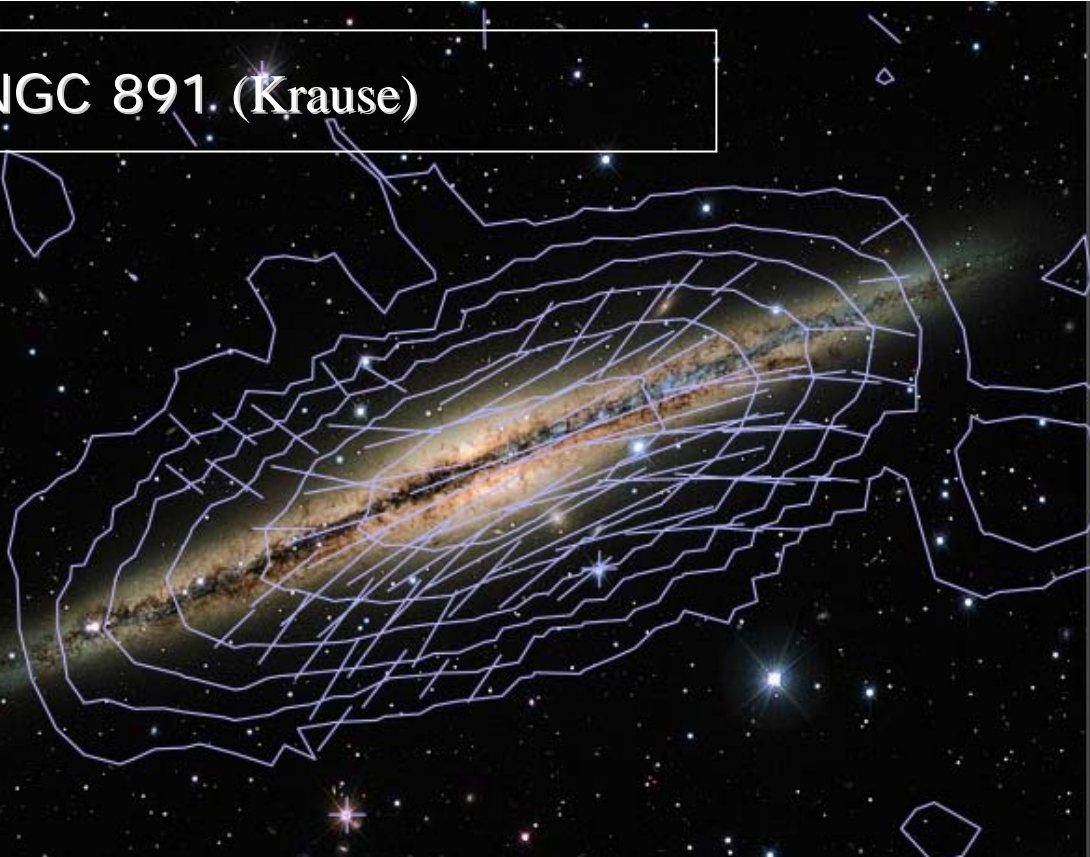


Faraday rotation of $> 10^7$ polarised background sources

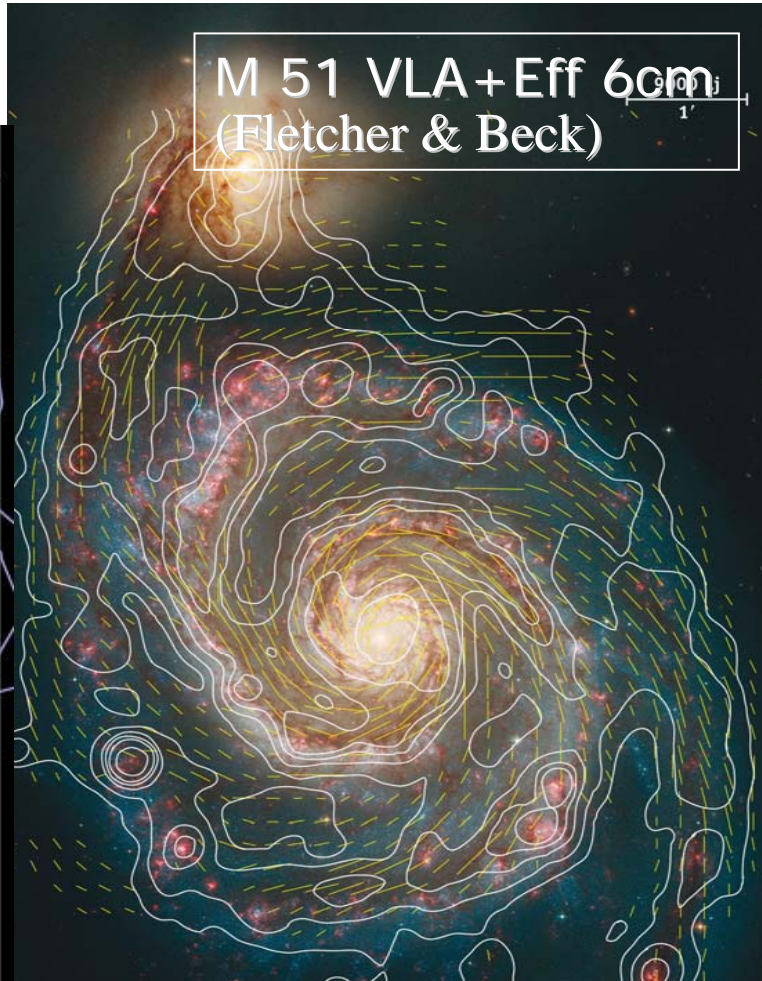
Origin of magnetic fields

- Dynamo?
- Primordial?

NGC 891. (Krause)

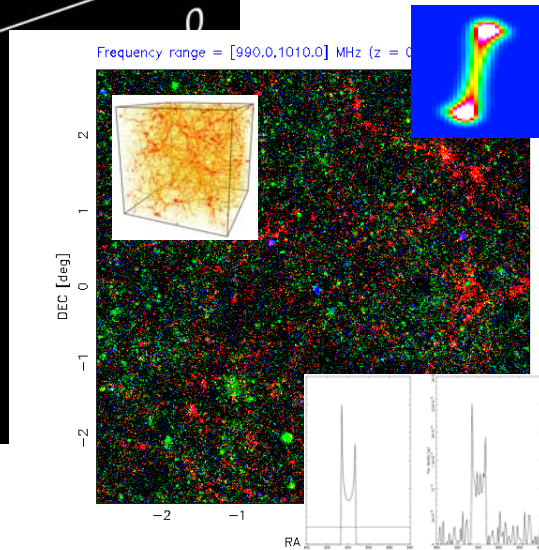
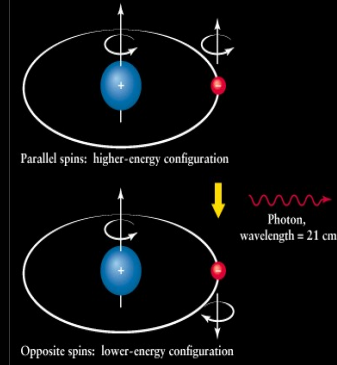
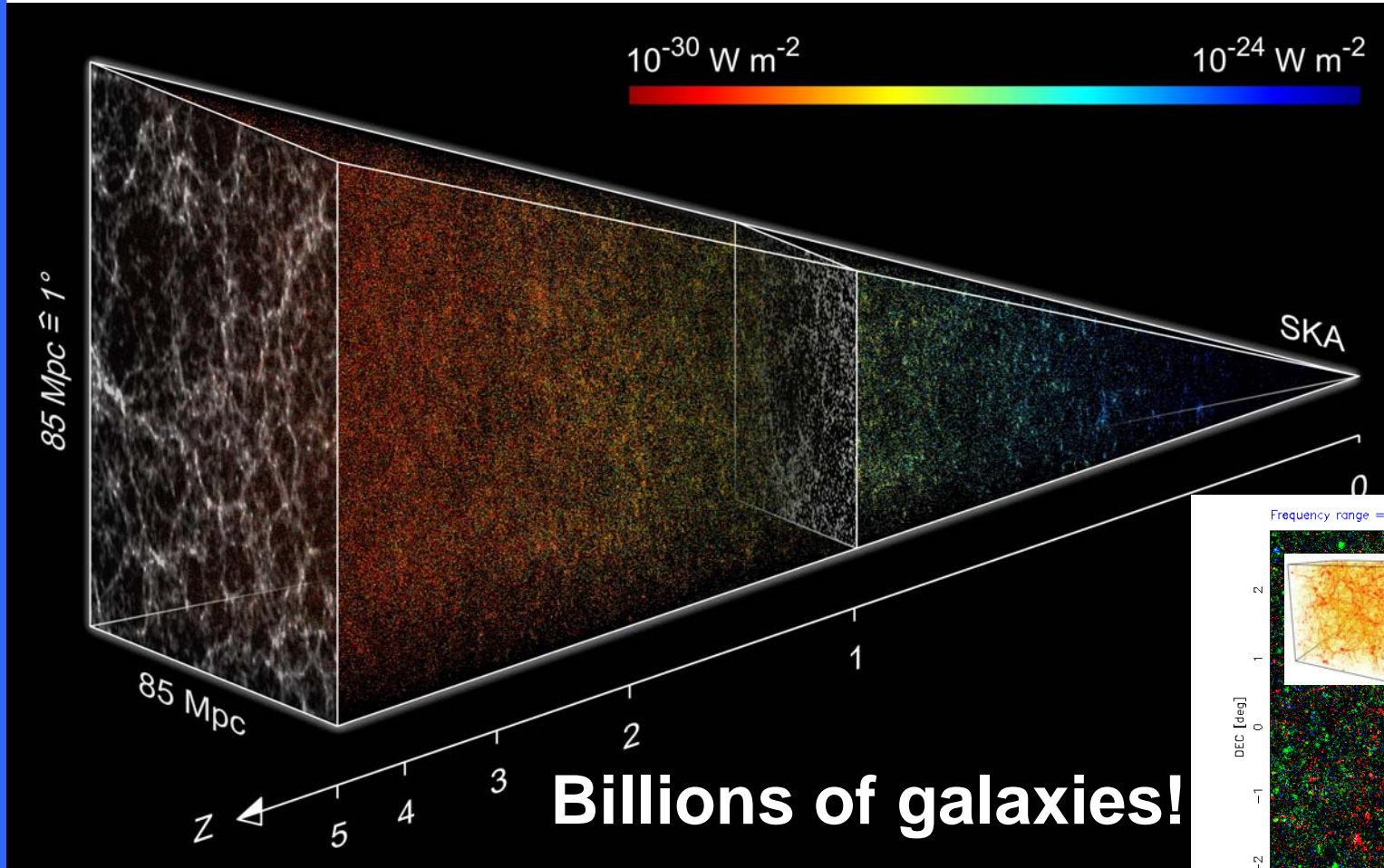


M 51 VLA+Eff 6cm
(Fletcher & Beck)



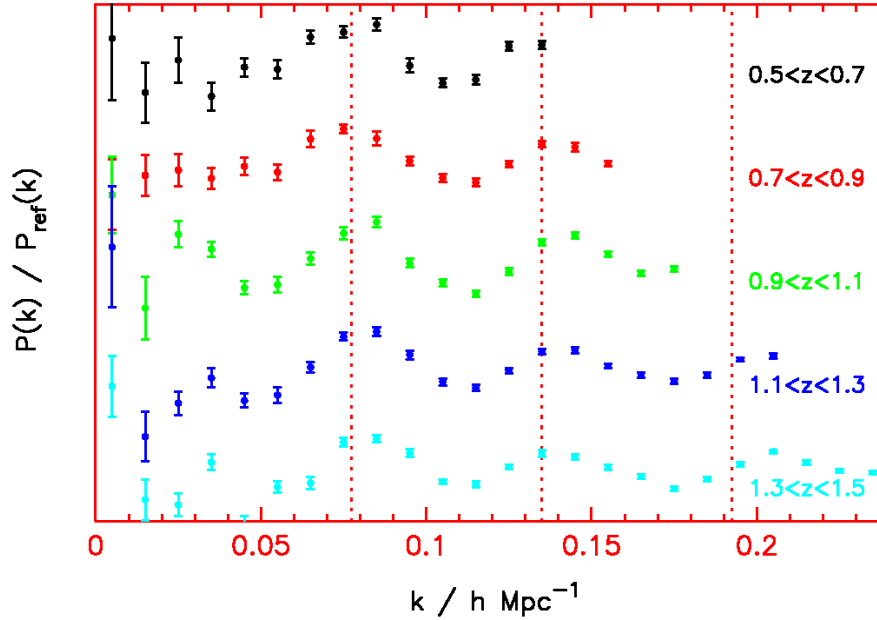


Large Scale Structure

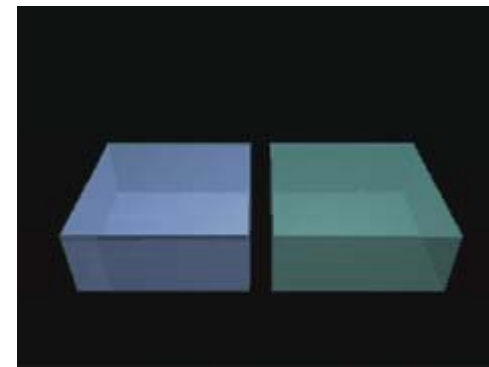
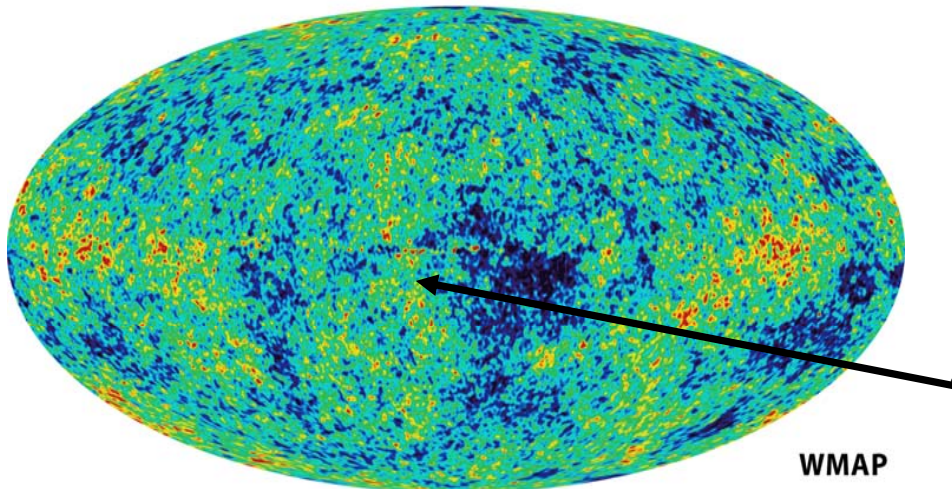




Baryonic Acoustic Oscillations



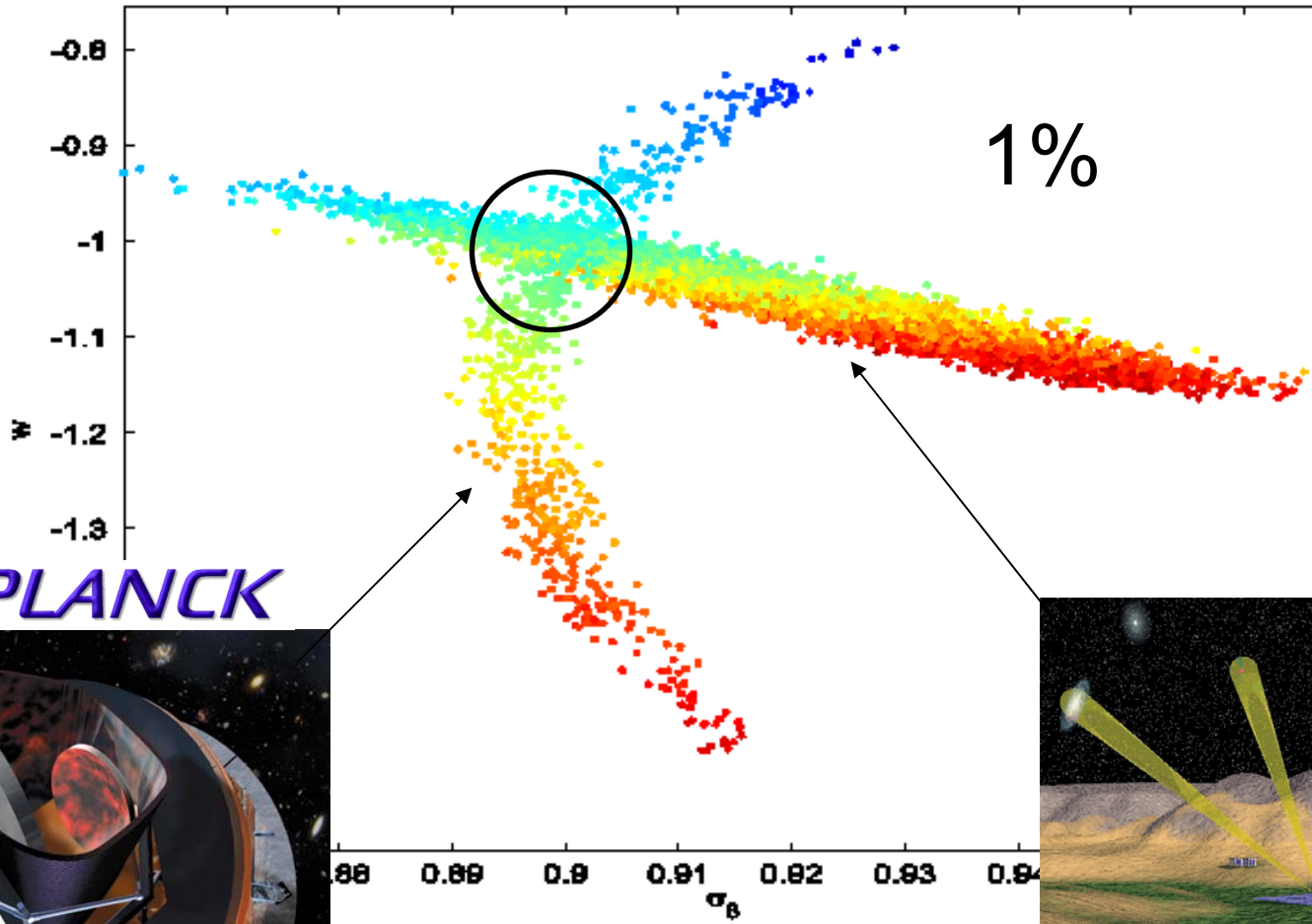
- Improve signal confidence by measuring wiggles in separate redshift bins
- A catalog of a billion galaxies
- Position and redshift measured simultaneously



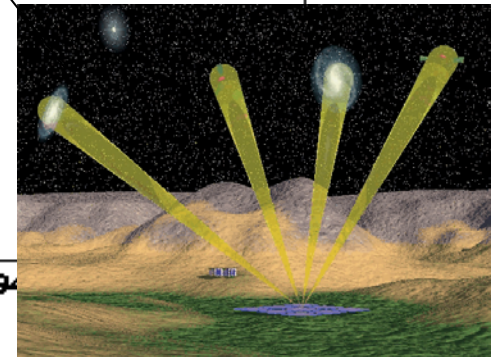
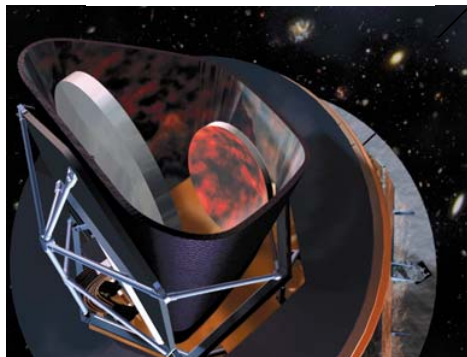
There are fluctuations at all scales but there is a preferred scale of around 1 deg.



Complementarity with Planck



PLANCK

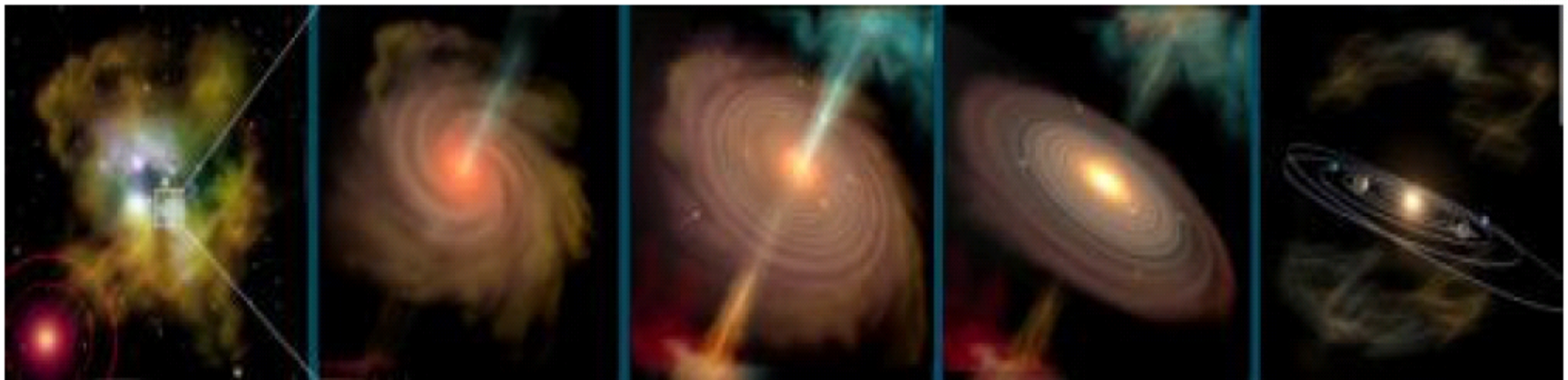
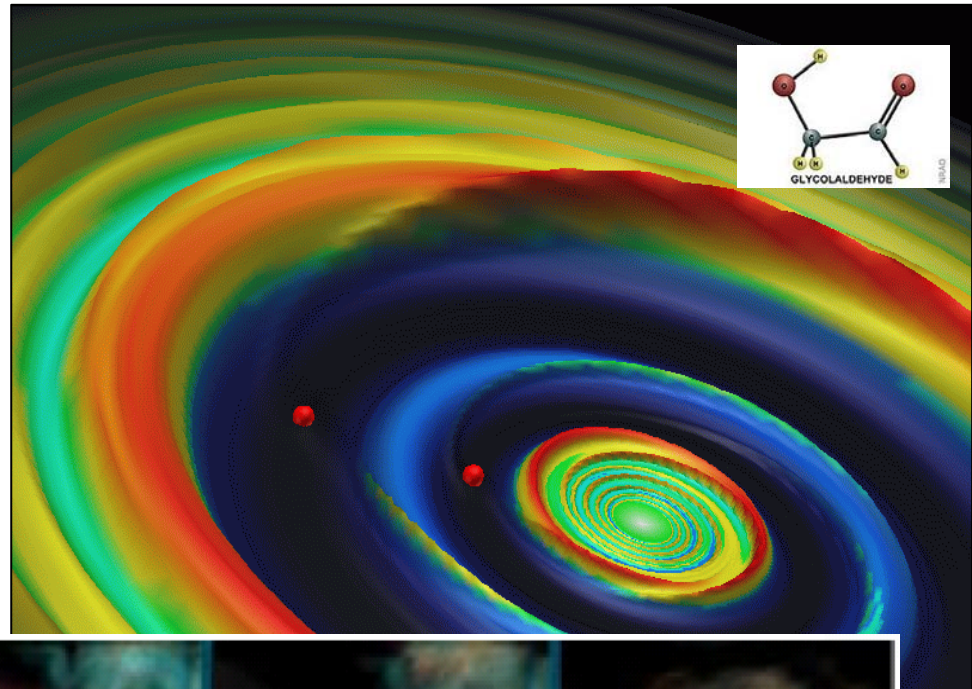




Cradle of Life



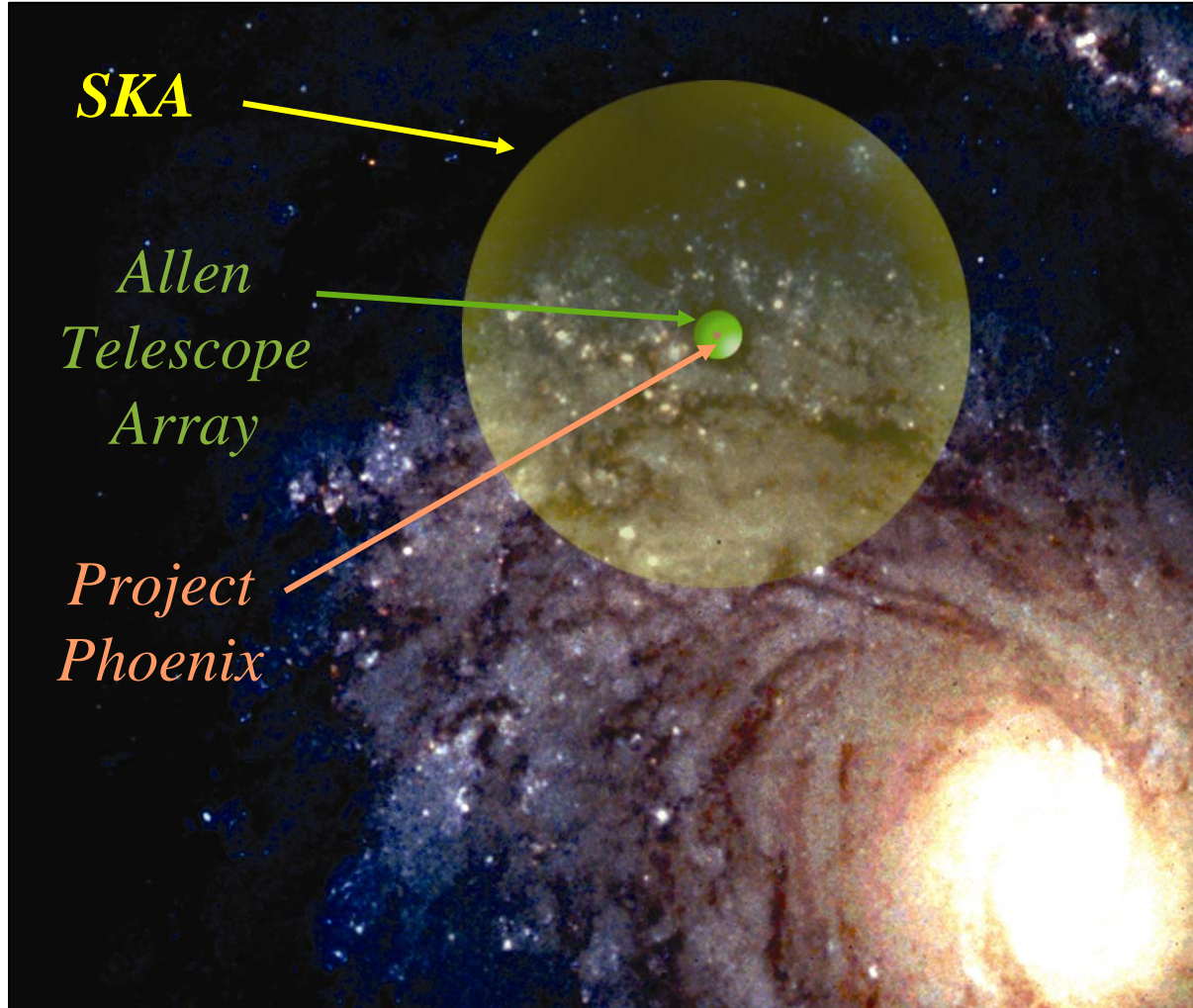
- Protoplanetary disks resolved to Earth-like orbits
- Organic molecules
 - methanol (834 MHz)
 - acetaldehyde (1.1 GHz)
 - acetamide (9.2 GHz)
 - cyclopropenone (9.3 GHz)
 - propenal (26 GHz)
- Extrasolar planets



NASA



Indicators of Extra Terrestrial Intelligence



SETI at leakage levels from nearby stars

eg:

- planetary radar
- Interplanetary communication
- Interstellar communication

Jill Tarter



Transients

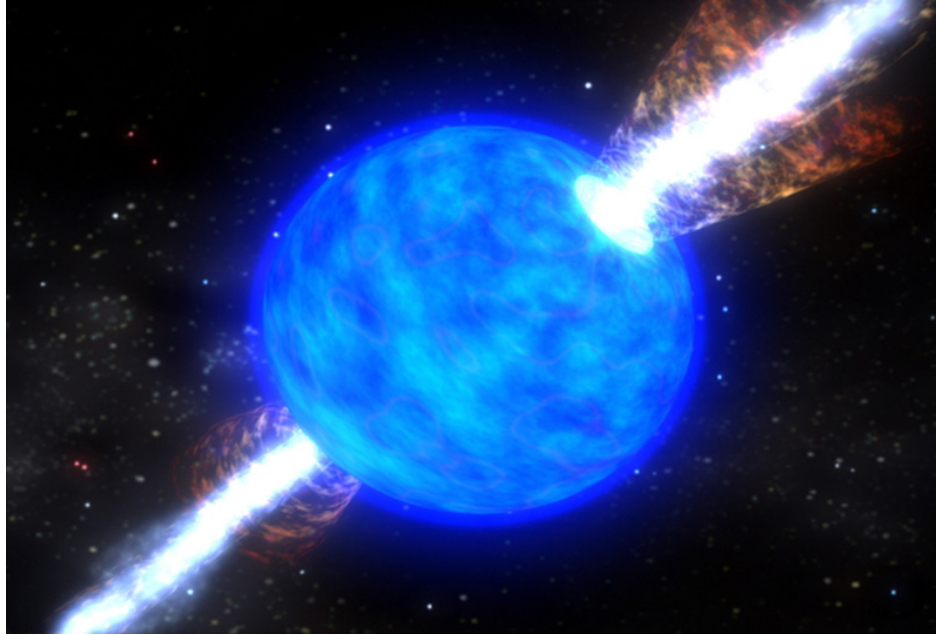
Start recording...





Transients





- Pulsar is a special case of transient phenomena (periodic)
- Giant pulses
- Supernova
- Bursters
- ETI

requires:

- fast time constant
- memory buffer for post analysis
- wide instantaneous, fully-sampled FoV





The Unknown

- New discoveries always result from observations in new parameter space
 - sensitivity
 - spatial resolution
 - spectral resolution
 - polarisation
 - time domain
 - observing speed (multibeaming)
- eg. CMB, pulsars, extra solar planets,...

**SKA
improves
all of
these**

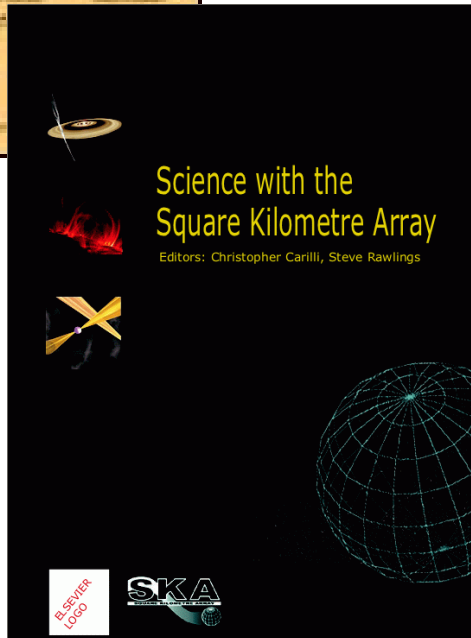
SKA is designed for the Key Projects but with an overriding design philosophy of flexibility to maximise the likelihood of new discoveries



SKA Science Book



Chris Carilli & Steve Rawlings,
New Astronomy Reviews,
Vol.48, Elsevier, Dec. 2004

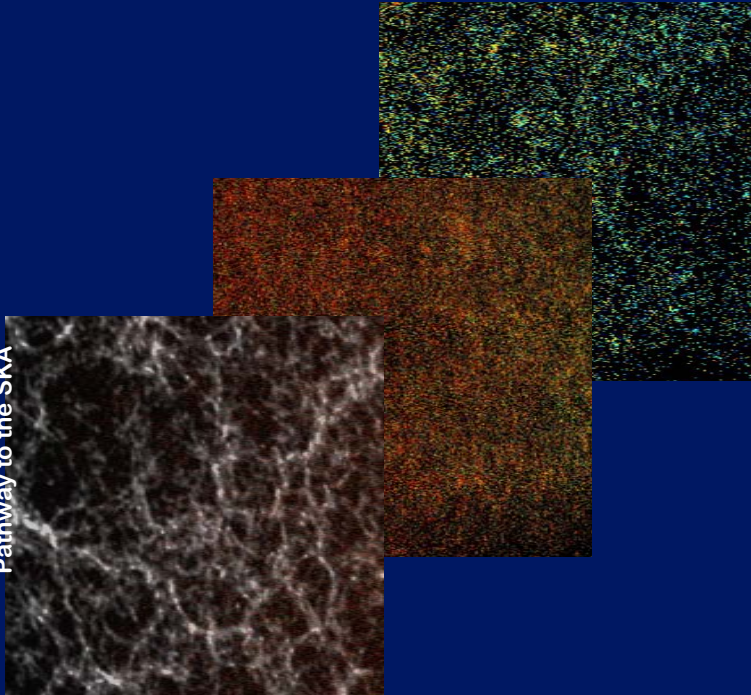


http://www.skads-eu.org/p/SKA_SciBook.php



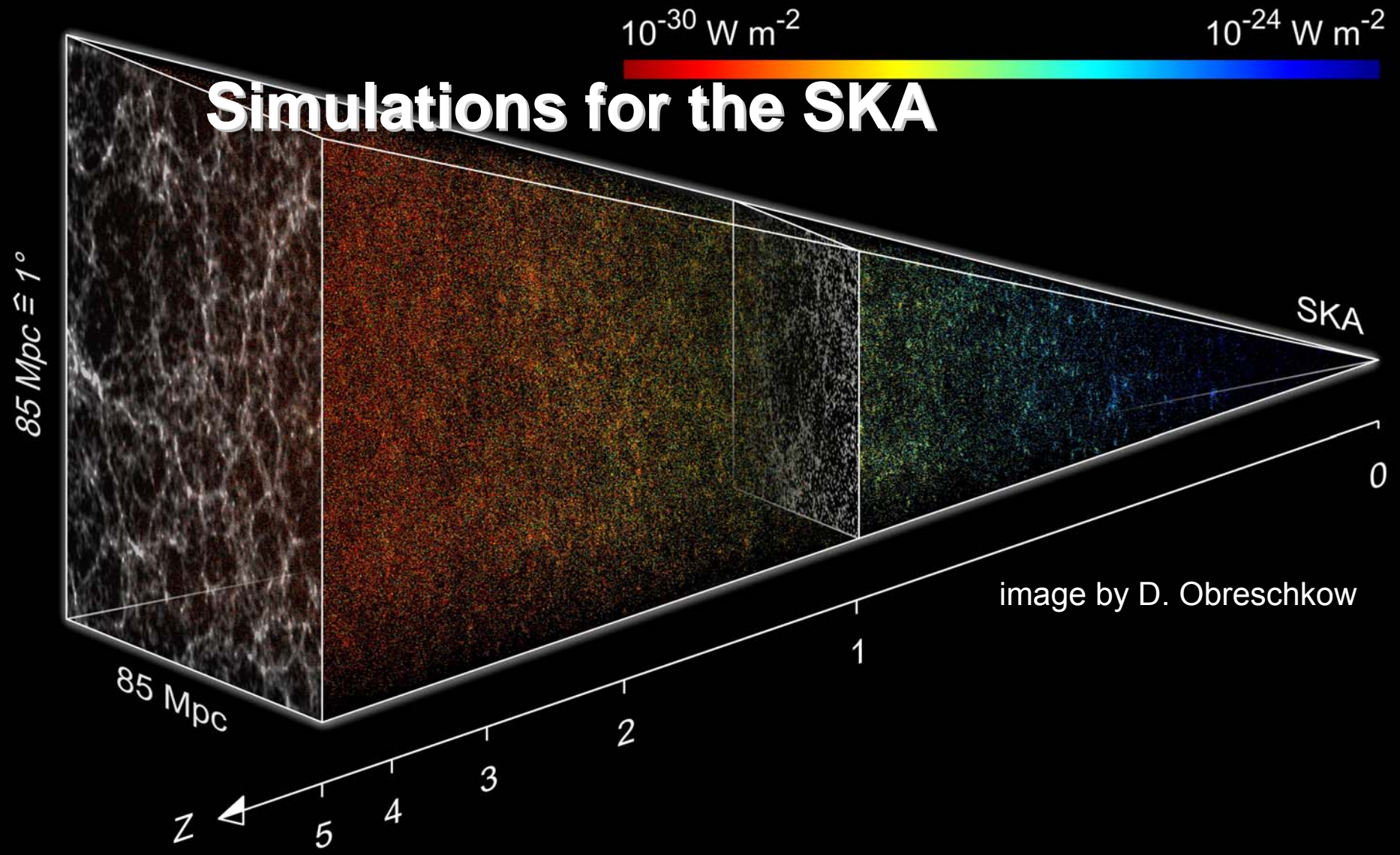
Cosmology, Galaxy Formation and Astroparticle Physics on the Pathway to the SKA

Cosmology, Galaxy Formation and Astroparticle Physics on the Pathway to the SKA



Hans-Rainer Klöckner, Steve Rawlings,
Matt Jarvis, Angela Taylor (eds.)

Available online:
www.skads-eu.org
(click “astronomy” and
“LOSKA2006”)





Simulations for the SKA



Effort in SKADS:

- Catalog of continuum sources (250 Million sources)
- Epoch of Reionisation (tomography from $z \approx 15$ to $z \approx 6$)
- The Cosmic Web
- Pulsars

- See SKADS Simulated Skies website
 - www.skads-eu.org/p/s-cubed.php
- See Proceedings of the Pushchino Meeting
 - www.skads-eu.org/p/memos.php
 - And others listed there, available on astro-ph



SKADS Simulated Skies



- Home
- S3-SEX
- S3-SAX
- S3-PUL
- S3-GAL
- S3-EOR
- S3 Tools
- Downloads

Introduction

The **SKADS Simulated Skies** (S^3) are a set of simulations of the radio sky performed at the University of Oxford, suitable for planning science with the Square Kilometer Array (**SKA**) radio telescope.

Three simulations can be accessed through this portal:

- **S³-SEX** (Semi-Empirical eXtragalactic database) [\[Access\]](#)
This simulation of the extragalactic radio continuum sky puts an emphasis on modelling the large-scale cosmological distribution of radio sources rather than the internal structure of individual galaxies. The simulation covers a sky area of 20 by 20 degrees, out to a cosmological redshift of $z=20$, and down to flux density limits of 10 nJy at 151 MHz, 610 MHz, 1.4 GHz, 4.86 GHz and 18 GHz.
Status : Total intensity simulation complete. Linear polarization information available.
- **S³-SAX** (Semi-Analytical eXtragalactic database) [\[Access\]](#)
This simulation of the extragalactic radio sky puts an emphasis on modelling the small-scale HI and CO emissions, and covers a sky area of 4.1 by 4.1 degrees, out to a redshift of $z=9.7$. Continuum emission information is yet to be added.
Status : Simulation complete. Database in progress.
- **S³-PUL** (PULsar database) [\[Access\]](#)
*This simulation of the Galactic population of pulsars is performed in collaboration with R. Smits (**Jodrell Bank Centre for Astrophysics**) using the **PSRPOP** package developed at **Parkes Observatory**, and an algorithm to generate synthetic high temporal resolution profiles.*
Status : Simulation design in progress.

Regarding the extragalactic simulations, query results may be subjected to post-processing algorithms described in the relevant sections, and used to build maps or data cubes.

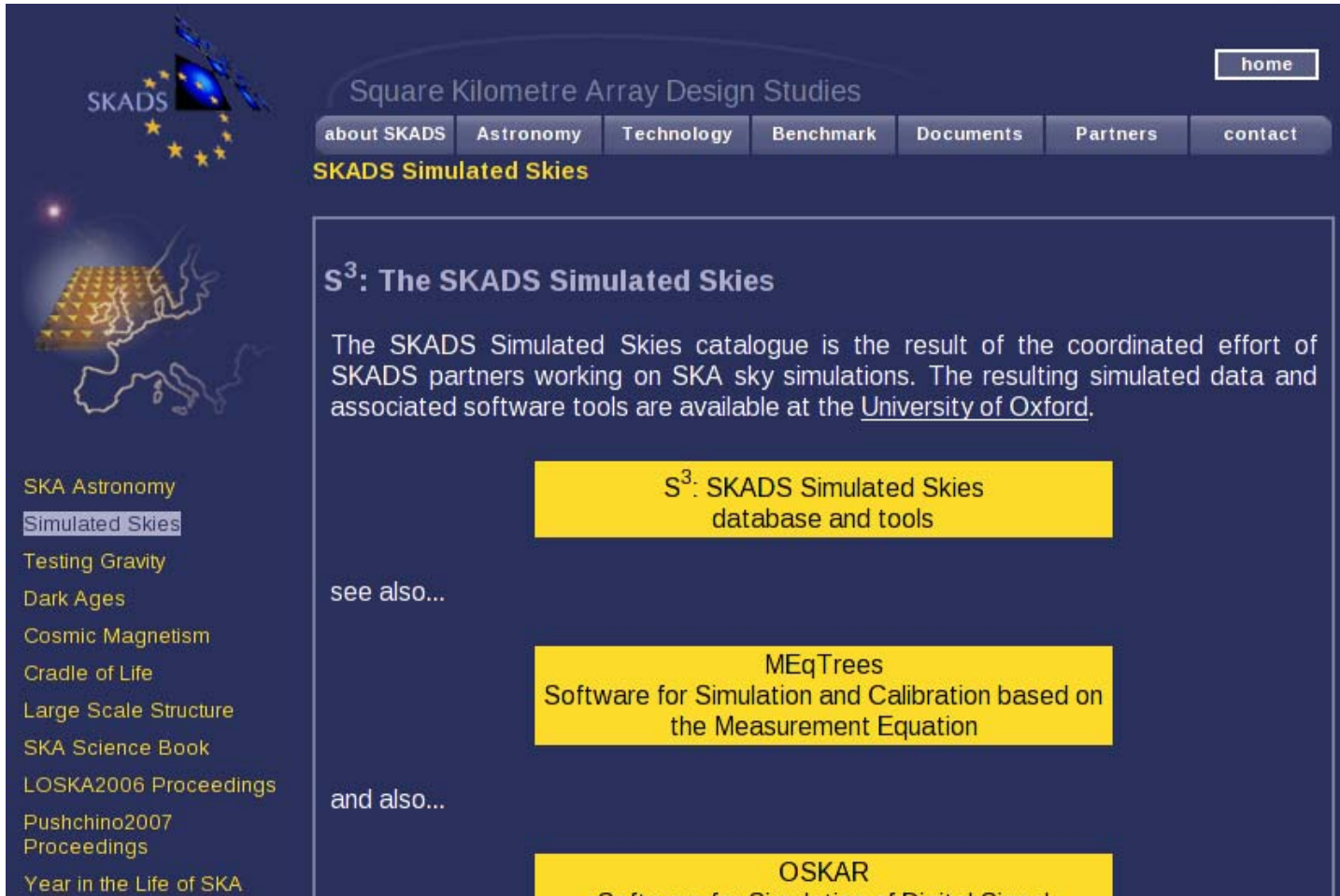
A set of standalone python tools may be used to build and query local databases, apply post-processing to query results and build maps and cubes on a local system. These SKADS Simulated Skies Interactive Tools are described [here](#) and may be downloaded [here](#). They use the same routines that are implemented on the server, so that users may for instance query the online databases, download results, and use local post-processing and map-making tools.

s-cubed.physics.ox.ac.uk

The EoR simulation efforts have been supported by the **Observatoire de Paris** and the **Instituto Superior Técnico** (Lisbon).



SKADS Simulated Skies

The screenshot shows the SKADS Simulated Skies website interface. At the top, there is a navigation bar with links for 'home', 'about SKADS', 'Astronomy', 'Technology', 'Benchmark', 'Documents', 'Partners', and 'contact'. The main heading is 'Square Kilometre Array Design Studies'. Below this, the page title is 'SKADS Simulated Skies'. The main content area features a section titled 'S³: The SKADS Simulated Skies' with a description: 'The SKADS Simulated Skies catalogue is the result of the coordinated effort of SKADS partners working on SKA sky simulations. The resulting simulated data and associated software tools are available at the [University of Oxford](#).' Below the description are three yellow buttons: 'S³: SKADS Simulated Skies database and tools', 'MEqTrees Software for Simulation and Calibration based on the Measurement Equation', and 'OSKAR'. To the left of the main content is a sidebar with a list of links: 'SKA Astronomy', 'Simulated Skies' (highlighted), 'Testing Gravity', 'Dark Ages', 'Cosmic Magnetism', 'Cradle of Life', 'Large Scale Structure', 'SKA Science Book', 'LOSKA2006 Proceedings', 'Pushchino2007 Proceedings', and 'Year in the Life of SKA'. There is also a 'see also...' and 'and also...' section.

www.skads-eu.org/p/s-cubed.php

last update 2009 June 12, 13:42 by [SKADS Management Team](#)



SKADS Publications (1/4)




home

about SKADS Astronomy Technology Benchmark Documents Partners contact

SKADS Memos

Science [\(to technology memos...\)](#)

S31	Simulation of the Polarized Sky at 1.4 GHz <i>S.P. O'Sullivan, J.M. Stil, A.R. Taylor, R. Ricci, J.K. Grant, K. Shorten</i>
S30	Simulation of the Cosmic Evolution of Atomic and Molecular Hydrogen in Galaxies <i>D. Obreschkow, D. Croton, G. De Lucia, S. Khochfar, S. Rawlings</i>
S29	The Cosmic Decline in the H2/HI-Ratio in Galaxies <i>D. Obreschkow, S. Rawlings</i>
S28	Understanding the H2/HI Ratio in Galaxies <i>D. Obreschkow, S. Rawlings</i>
S27	Simulating full-sky interferometric observations <i>J.D. McEwen, A.M.M. Scaife</i>
S26	The simulated 21 cm signal during the epoch of reionization : full modeling of the Ly-alpha pumping <i>S. Baek, P. Di Matteo, B. Semelin, F. Combes, Y. Revaz</i>
S25	A generalised Measurement Equation and van Cittert-Zernike theorem for wide-field radio astronomical interferometry <i>T.D. Carozzi, G. Woan</i>
S24	Computational Requirements for Pulsar Searches with the Square Kilometer Array <i>Roy Smits, Michael Kramer, Ben Stappers, and Andrew Faulkner</i>

memos

newsletters

annual reports

Minutes & Presentations

contracts

publication acknowledgement

presentation template

time sheet templates

technical report templates

financial report templates





SKADS Publications (2/4)



S23	<u>Evolution of magnetic fields and future observational tests with the SKA</u> <i>Tigran G. Arshakian, Rainer Beck, Marita Krause, Dmitry Sokoloff</i>
S22	<u>The Square Kilometre Array as a "Direct-to-Earth" facility for deep space communications</u> <i>P.A. Fridman, L.I. Gurvits, S.V. Pogrebenko</i>
S21	<u>Pulsar searches and timing with the SKA</u> <i>R. Smits, M. Kramer, B. Stappers, D.R. Lorimer, J. Cordes, and A.J. Faulkner</i>
S20	<u>Array configuration studies for the SKA - Implementation of figures of merit based on SDR</u> <i>D.V. Lal, A.P. Lobanov</i>
S19	<u>SETI (science fiction short story featuring the SKA)</u> <i>Roy Smits</i>
S18	<u>A semi-empirical simulation of the extragalactic radio continuum sky for next generation radio telescopes</u> <i>R. J. Wilman, et al.</i>
S17	<u>Testing the magnetic field models of disk galaxies with the SKA</u> <i>T. Arshakian, et al.</i>
S16	<u>Magnetic Visions: Mapping Cosmic Magnetism with LOFAR and SKA</u> <i>R. Beck</i>
S15	<u>Galactic magnetic fields</u> <i>Rainer Beck (published on Scholarpedia)</i>



SKADS Publications (3/4)



S14	<u>Proceedings of the First MCCT-SKADS Training School, 23-29 September 2007, Medicina, Italy</u> <i>F. Mantovani, et al. (ed.)</i>
S13	<u>Simulations for the Square Kilometre Array: Proceedings of the Pushchino Meeting 30 July - 1 August 2007</u> <i>S.A. Torchinsky (ed.)</i>
S12	<u>Probing Dark Energy with the SKA</u> <i>S.A. Torchinsky & SKADS</i>
S11	<u>Radio observational constraints on Galactic 3D-emission models</u> <i>X.H.Sun, W.Reich, A.Waelkens and T.A.Ensslin</i>
S10	<u>Magnetic field structures of galaxies derived from analysis of Faraday rotation measures, and perspectives for the SKA</u> <i>R.Stepanov, T.G.Arshakian, R.Beck, P.Frick and M.Krause</i>
S9	<u>Cosmic Reionization and the 21cm signal: simulations and analytical models</u> <i>M. Santos, et al</i>
S8	<u>Lyman-alpha radiative transfer during the Epoch of Reionization: contribution to 21-cm signal fluctuations</u> <i>B. Semelin, F. Combes, S. Baek</i>
S7	<u>Cosmology, Galaxy Formation and Astroparticle Physics on the Pathway to the SKA</u> <i>Klöckner, et al (eds)</i>



SKADS Publications (4/4)



S6	<u>Is the Dynamics of Tracking Dark Energy Detectable?</u> <i>Bruce A. Bassett, Mike Brownstone, Antonio Cardoso, Marina Cortês, Yabebal Fantaye, Renée Hlozek, Jacques Kotze, Patrice Okouma</i>
S5	<u>Opportunities for maser studies with the Square Kilometre Array</u> <i>A.J. Green, W.A. Baan</i>
S4	<u>Lyman-alpha radiative transfer during the Epoch of Reionization: contribution to 21-cm signal fluctuations</u> <i>B. Semelin, F. Combes, S. Baek</i>
S3	<u>A characteristic observable signature of preferred frame effects in relativistic binary pulsars</u> <i>N. Wex, M. Kramer</i>
S2	<u>Determining Neutrino Properties using future Galaxy Redshift Surveys</u> <i>F.B. Abdalla, S.G. Rawlings</i>
S1	<u>Constraining the nature of dark energy using the Square Kilometer Array Telescope</u> <i>A. Torres-Rodriguez, C.M. Cress</i>

www.skads-eu.org/p/memos.php



SKADS Science and Technology



The Universe

↓ observations

Our understanding of the Universe

↓ brain power

Data analysis (DS2)
science goals
achievable?

Request spec
change
BENCHMARK

Sky Simulation (DS2T1)

Catalogs, images, EM fields

Simulated
telescope image

Technology
development
(DS4)

Convolution with the telescope
(DS2T2)

Data imaging
(DS2T2)

measurements
and
simulated
performance

voltages

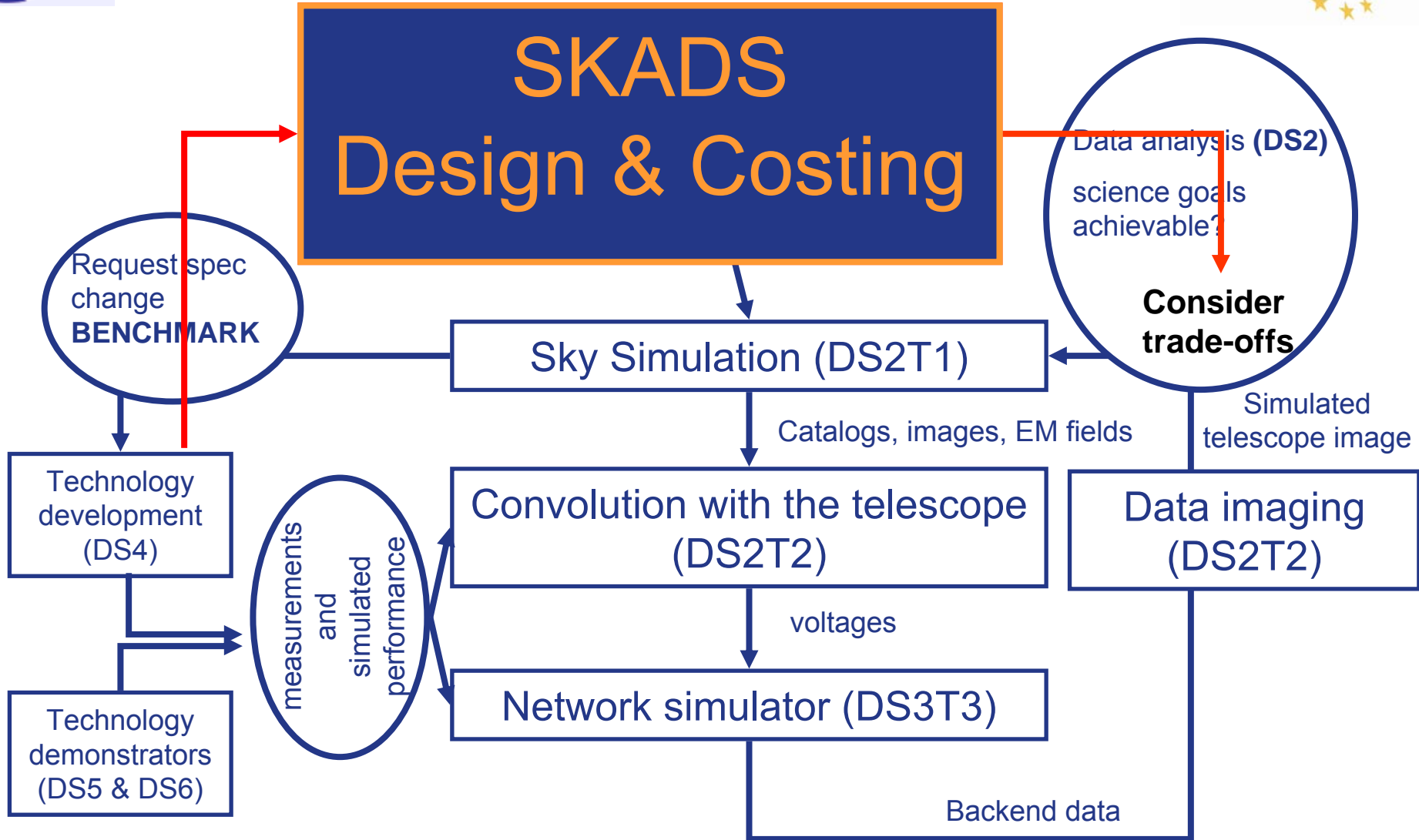
Technology
demonstrators
(DS5 & DS6)

Network simulator (DS3T3)

Backend data



SKADS Design & Costing





SKA Design and Costing



- SKADS final deliverable “Designed and Costed SKA”
- First memo: detailed design
 - www.skads-eu.org/p/memos.php
 - SKA Memo #93
 - ~1.5BEuro
- Development of costing tool: SKACost
 - Designed and costed components and subsystems
 - Data base for costing different SKA implementations
 - SKADS in collaboration with International SKA Program Office

Training the next generation

SKADS



- 1st MCCT School
Medicina 23-29 Sept 2007
- Wide field imaging and calibration
Groningen 2-7 March
- Synergies with the SKA
Bonn 14-18 April 2008
- Deep Field Imaging with SKA
Cambridge 25-29 Aug
- Radioastronomy and the New
Instruments
Siguenza 27 Aug – 4 Sept
- Multifield and multibeam science with
SKA
Oxford 15-27 March 2009
- Increasing the evolution rate in radio
astronomy
Paris 24-28 August 2009
- Towards 3rd generation calibration
Nançay 27 Sept – 10 Oct



EMBRACE



- Electronic MultiBeam Radio Astronomy ConcEpt
- Aperture-Plane phased-array
- 500MHz – 1500MHz
- Linear polarisation
- 160m² at Westerbork
- 90m² at Nançay



EMBRACE at Nançay



image by SATorchinsky



EMBRACE at Nançay





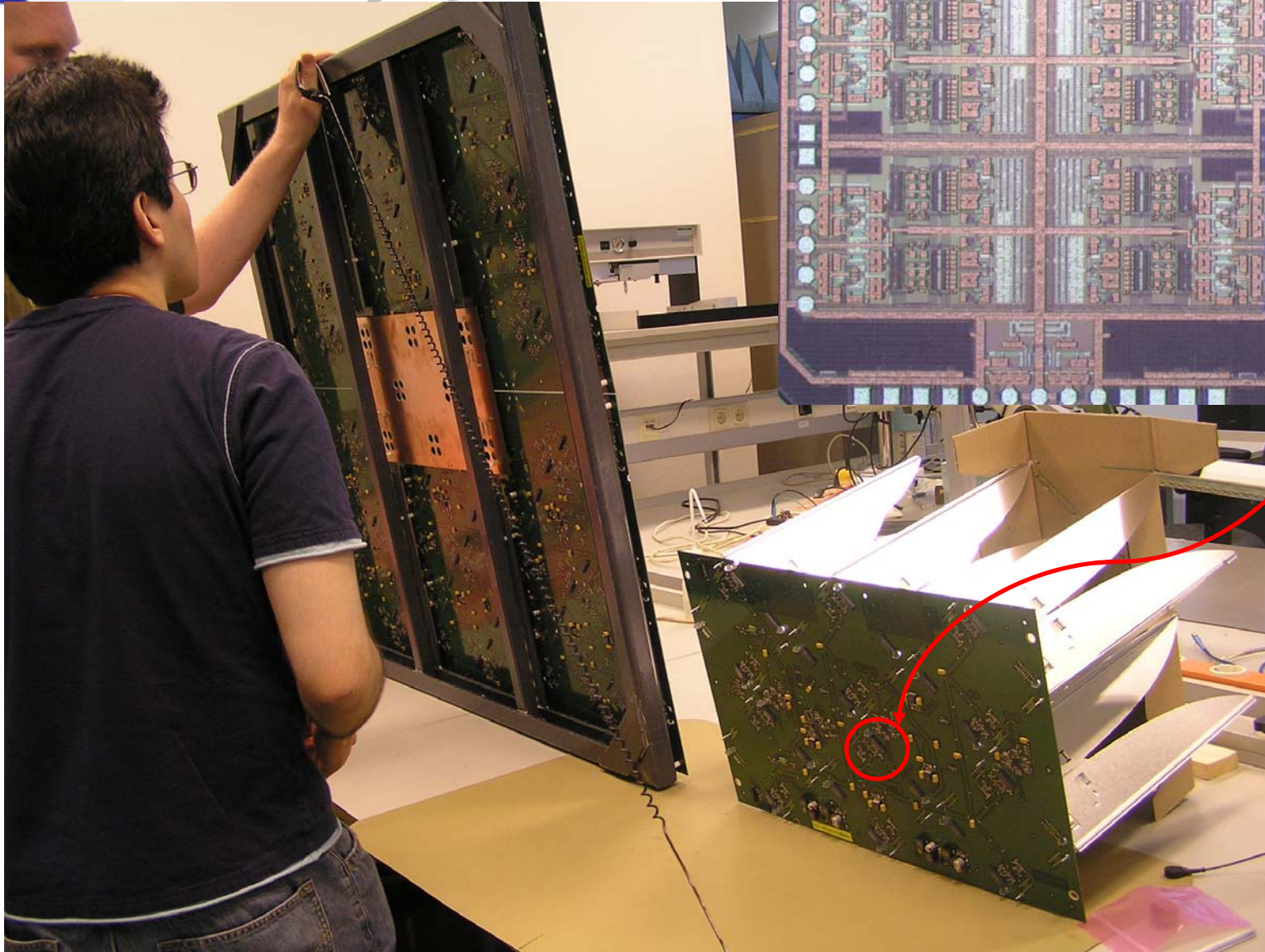
EMBRACE at Nançay



image by SATorchinsky

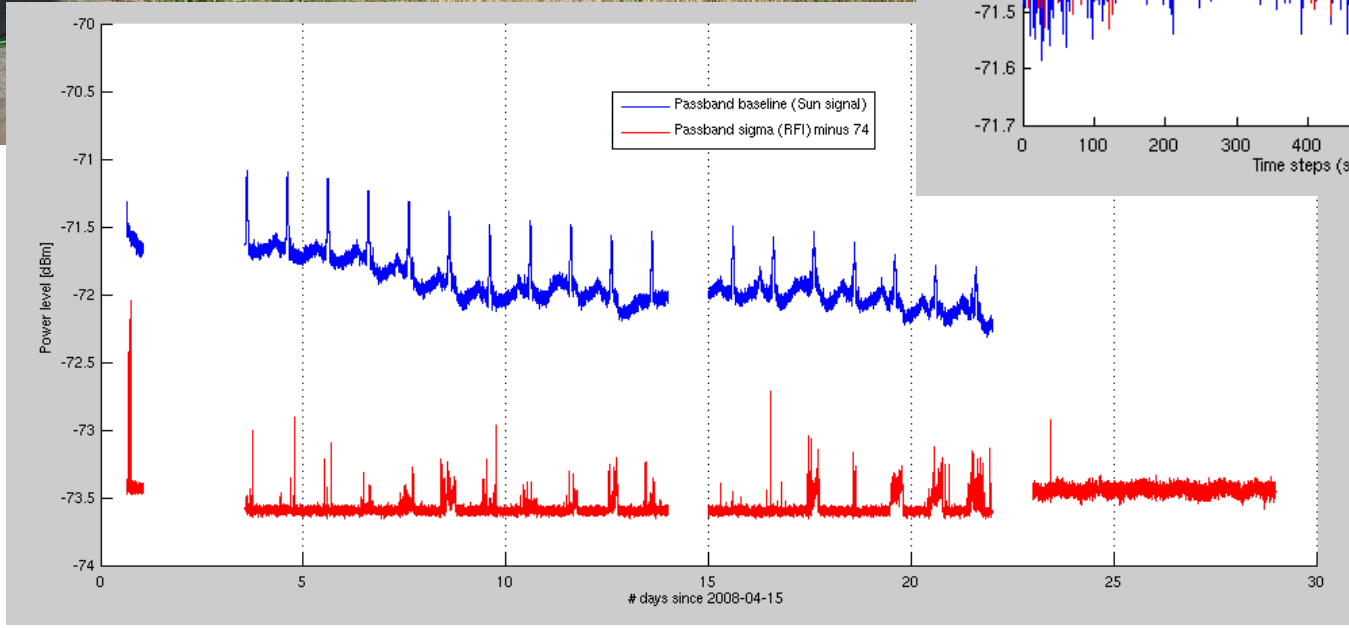
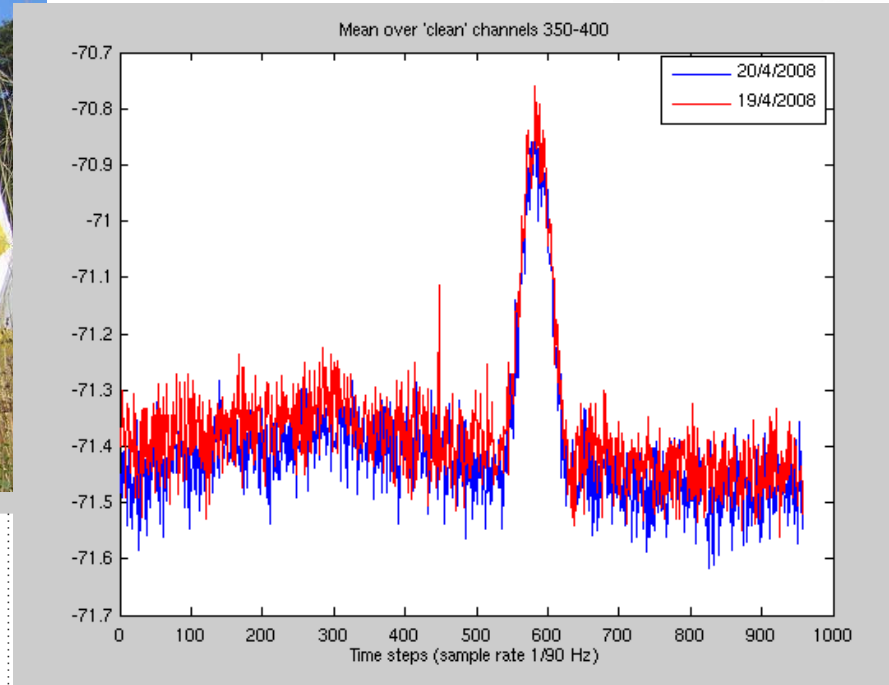


Nançay Beamformer Chip



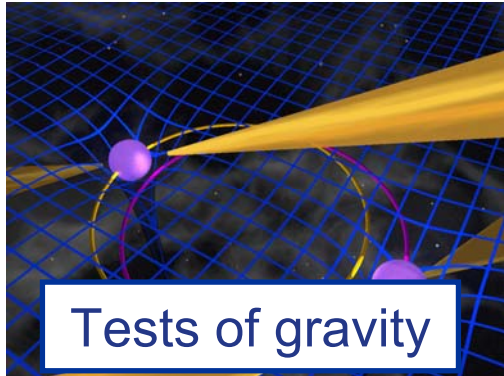


EMBRACE observations of the Sun

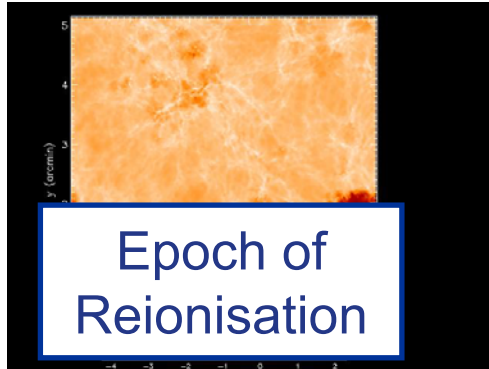




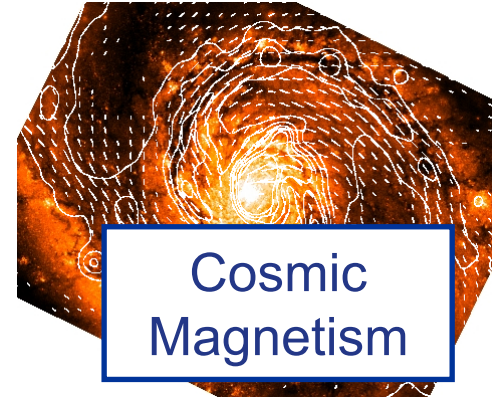
SKA Key Science



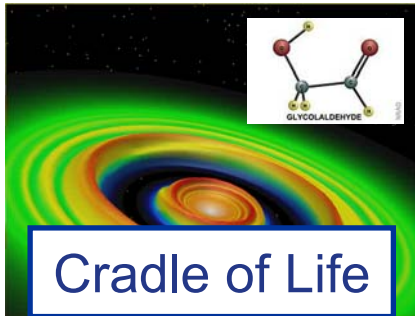
Tests of gravity



Epoch of Reionisation



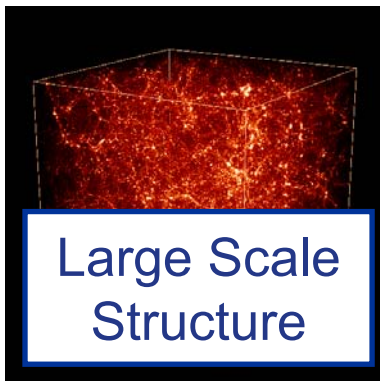
Cosmic Magnetism



Cradle of Life



Transient Universe



Large Scale Structure



The Unknown



Contact



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Phone: +33 1 45 07 75 02

Email: Steve.Torchinsky@obspm.fr

Web: <http://www.skads-eu.org>