



The SKADS sky databases

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and the Oxford SKADS team [*]



Outline



- S-cubed databases
- Online access
- Use of S3 Tools
- Polarization
- Global Sky Model
- S-cubed by AstroGrid
- Perspectives



SKADS Simulated Skies



SEX : Semi-Empirical eXtragalactic

‘Continuum simulation’

- Observed / extrapolated luminosity functions
- Population of underlying DM density field
- Clusters identified via Press-Schechter filter
- 5 different source types

$$A = 20^\circ \times 20^\circ$$

$$0 \leq z \leq 20$$

$$S \geq 10 \text{ nJy}$$

$$N_{\text{sources}} \sim 275,000,000$$

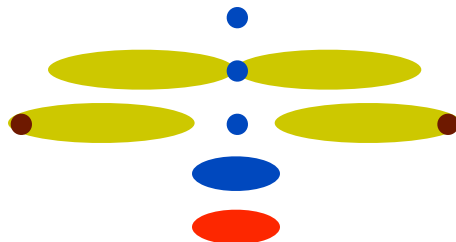
RQ-AGN

FR I

FR II

“Starburst”

“Quiescent SFG”



Wilman et al., 2008, MNRAS, 388, 1335

SAX : Semi-Analytical eXtragalactic

‘Line simulation’

- Post-processing of Millenium Simulation cubes
- SFR / AGN continua from luminosity functions
- Line properties from cold gas mass functions
- Currently contains HI and CO (J=1-0)
- Redshift cutoff determines sky area, e.g. :

$$0 \leq z \leq 4$$

$$A = 5.39^\circ \times 5.39^\circ$$

$$N_{\text{sources}} \sim 500,000,000$$

Obreschkow et al., 2008 (in prep.)



Online access to S-cubed



<http://s-cubed.physics.ox.ac.uk>

- Hosted by OeRC
- PostgreSQL databases

Current procedure

- Online query (SEX/SAX)
- Local install of S3 Tools
- Local post-processing
- Local map-making

Upcoming

- Online post-processing
- Online map-making

Common routines

UNIVERSITY OF OXFORD

S³ - The SKADS Simulated Skies

Introduction

July 8, 2008 : The S³ map-making utility now includes an option to add total intensity Galactic foregrounds from the Global Sky Model. [\[More...\]](#)

The SKADS Simulated Skies (S³) 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 emission at smaller scale, and covers a sky area of 5.2 by 5.2 degrees, out to a redshift of $z=4$. Continuum emission information at 151 MHz, 610 MHz, 1.4 GHz, 4.86 GHz and 18 GHz is yet to be added.
Status : Total intensity 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.

For any query regarding the website, databases and accompanying tools, please [contact us](#)

Credits
This project has been supported by the University of Oxford (sub-department of Astrophysics and Oxford e-Research Center) and by the European Community Framework Programme 6, Square Kilometer Array Design Study (SKADS), contract #011938.

The polarization efforts have been supported by the Cavendish Laboratory at the University of Cambridge and the Max Planck Institut für Radioastronomie in Bonn.



Querying S-cubed



Database query

How to query the S³-SEX database

- 1/ Enter a valid e-mail address.
- 2/ Select parameters to be extracted from the database.
- 3/ Choose selection criteria using the form or enter a custom SQL "WHERE" clause *[Option temporarily disabled]*.
- 4/ Press "Submit".

Email address :

Parameters to extract

Select all Deselect all Select for mapmaking

Source identification

☒ Component index ☐ Cluster index ☒ Galaxy index

Source type

☐ Component type ☒ Star formation type ☒ AGN type

Source position

☒ X position ☒ Y position ☒ Distance ☒ Redshift

Source geometry

☒ Major axis ☒ Minor axis ☒ Position angle ☐ Viewing angle

Continuum information

☒ $\log_{10} I$ @ 151 MHz	☐ $\log_{10} Q$ @ 151 MHz	☐ $\log_{10} U$ @ 151 MHz	☐ $\log_{10} V$ @ 151 MHz
☒ $\log_{10} I$ @ 610 MHz	☐ $\log_{10} Q$ @ 610 MHz	☐ $\log_{10} U$ @ 610 MHz	☐ $\log_{10} V$ @ 610 MHz
☒ $\log_{10} I$ @ 1.4 GHz	☐ $\log_{10} Q$ @ 1.4 GHz	☐ $\log_{10} U$ @ 1.4 GHz	☐ $\log_{10} V$ @ 1.4 GHz
☒ $\log_{10} I$ @ 4.86 GHz	☐ $\log_{10} Q$ @ 4.86 GHz	☐ $\log_{10} U$ @ 4.86 GHz	☐ $\log_{10} V$ @ 4.86 GHz
☒ $\log_{10} I$ @ 18 GHz	☐ $\log_{10} Q$ @ 18 GHz	☐ $\log_{10} U$ @ 18 GHz	☐ $\log_{10} V$ @ 18 GHz

HI information

☒ $\log_{10} M_{HI}$

Selection criteria

Spatial conditions

Minimum X [":"] - 0 : 10 : 0.0 Maximum X [":"] + 0 : 10 : 0.0

Minimum Y [":"] - 0 : 10 : 0.0 Maximum Y [":"] + 0 : 10 : 0.0

Minimum redshift 0 Maximum redshift 20

Flux conditions

☐ -8 < $\log_{10} I$ @ 151 MHz < 0	☐ Radio-quiet AGN
☐ -8 < $\log_{10} I$ @ 610 MHz < 0	☐ Radio-loud AGN (FRI)
☐ -8 < $\log_{10} I$ @ 1.4 GHz < 0	☐ Radio-loud AGN (FRII)
☐ -8 < $\log_{10} I$ @ 4.86 GHz < 0	☐ Quiescent star-forming galaxies
☐ -8 < $\log_{10} I$ @ 18 GHz < 0	☐ Starbursting galaxies

Source types

Specify your query

- Select parameters to extract from simulation
- Select spatial and redshift windows
- Select flux and source type



Submit query

- Query entered in queue
- User redirected to query result page
- E-mail sent as query completes

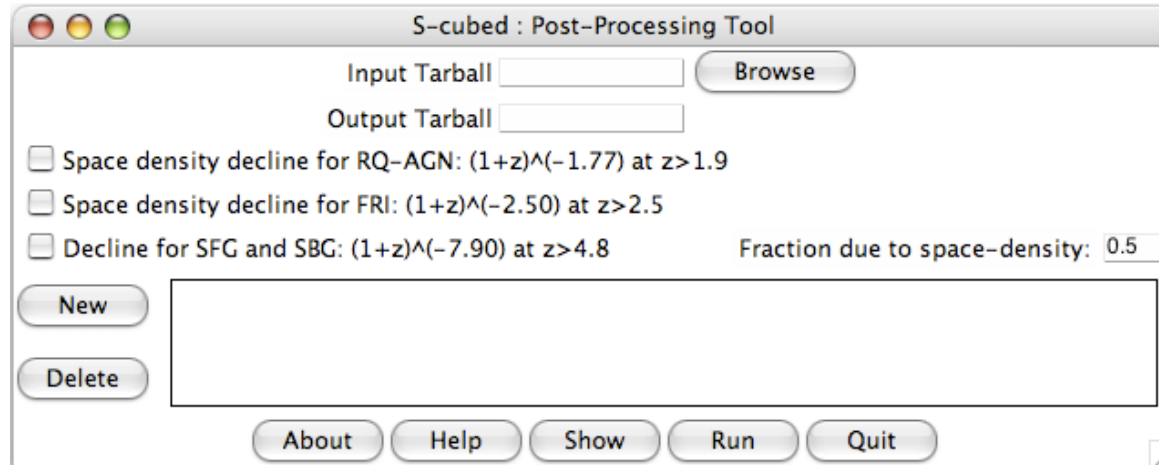


Retrieve query results

- Download tarball to local drive
- Contains query results + description file[s]



Post-processing



- Space density and luminosity declines
- Source type specific
- Power-law and exponential functional forms
- Default options + Possibility to define your own
- Modular scripting : New post-processing options “easy” to implement



Making maps and cubes



S3Map

Input Tarball Browse

Output Tarball ☐ Force Source List

☐ Selected Types Only

☒ S-Cubed SEX ☐ S-Cubed SAX

Source Types

X: From 0 : 0 : 0.0 [d:m:s] ☐ From Query

To 0 : 0 : 0.0 [d:m:s] ☐ From Query

Y: From 0 : 0 : 0.0 [d:m:s] ☐ From Query

To 0 : 0 : 0.0 [d:m:s] ☐ From Query

Minimum Frequency 1113.0 [MHz]

Frequency Resolution 62.5 [kHz]

Number of channels 1

Beam Major FWHM 2.0 ["]

Beam Minor FWHM 2.0 ["]

Beam Position Angle 0.0 [rad]

Pixel size 1.0 ["]

Noise level 0.0

☒ Continuum ☐ Reverse R.A. ☐ Velocity ☒ I ☐ U

☒ HI Line ☐ Include GSM ☒ Frequency ☐ Q ☐ V

☐ CO Line

Image accuracy 20

Map Center: R.A. + 12 : 0 : 0.0 [h:m:s]

Dec. + 0 : 0 : 0.0 [d:m:s]

About Help Show Run Quit

Input query results

Source types

Spatial region

Frequency range

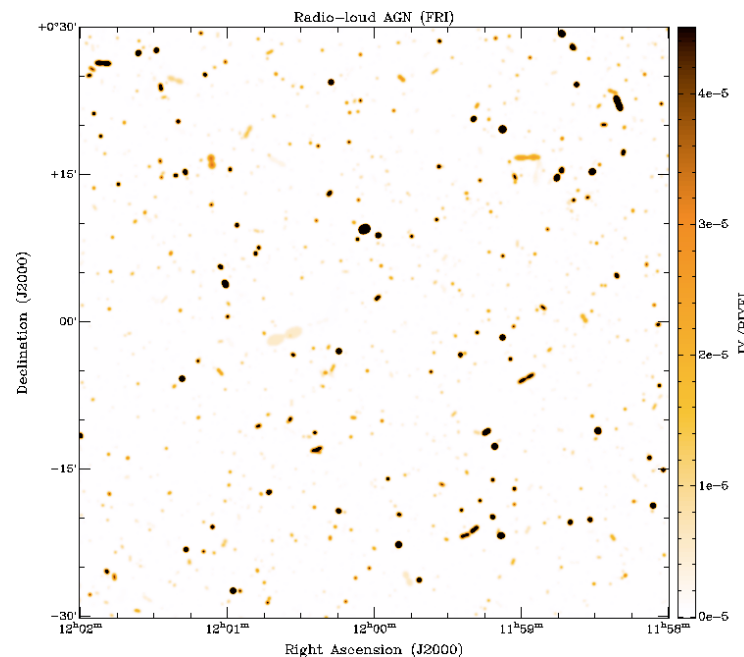
Resolution

Noise

Contents and axes

Position of output map

Central square degree of S-cubed SEX
[only FR I radio-loud AGN] @ 1.4 GHz





High-resolution HI in SAX

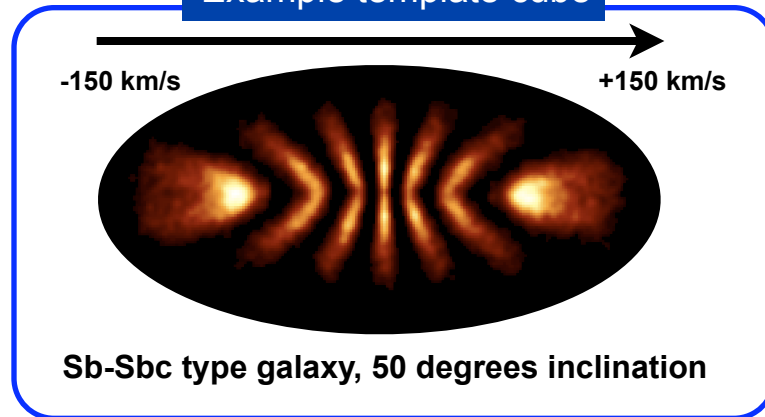


1150 Template HI cubes from
Rense Boomsma (Kapteyn)

5 Hubble types × *5 velocity scales* × *46 inclinations*

(Downloadable from the S-cubed website)

Example template cube



From template cubes to SAX cubes

SAX information

Action

- Numerical Hubble type
- Inclination angle
- HI line width



Pick template

- HI line width
- Angular size
- HI flux



Get scaling factors

- Position angle

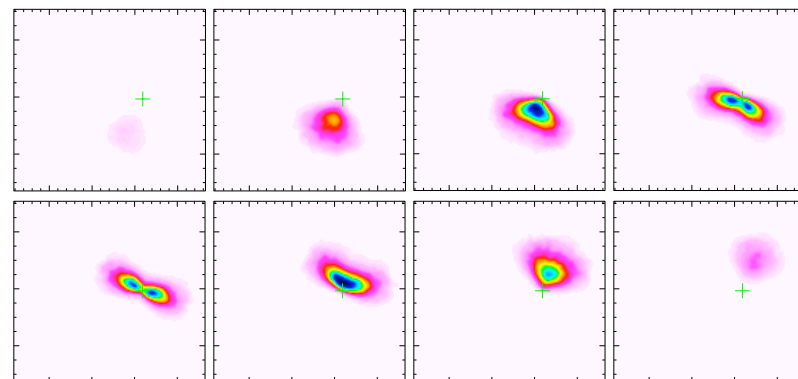


Rotate

- Sky position
- Redshift



Paste on master cube



Channel maps from sample SAX cube
[1.2419 to 1.2425 GHz]



Polarized emission



Python routines by Joern Geisbuesch, Paul Alexander [MRAO]

S3Map

Input Tarball Browse

Output Tarball ☐ Force Source List

☐ Selected Types Only

☒ S-Cubed SEX Source Types

☐ S-Cubed SAX

X: From 0 : 0 : 0.0 [d:m:s] ☐ From Query

To 0 : 0 : 0.0 [d:m:s] ☐ From Query

Y: From 0 : 0 : 0.0 [d:m:s] ☐ From Query

To 0 : 0 : 0.0 [d:m:s] ☐ From Query

Minimum Frequency 1113.0 [MHz]

Frequency Resolution 62.5 [kHz]

Number of channels 1

Beam Major FWHM 2.0 ["]

Beam Minor FWHM 2.0 ["]

Beam Position Angle 0.0 [rad]

Pixel size 1.0 ["]

Noise level 0.0

☒ Continuum ☐ Reverse R.A. ☐ Velocity ☒ I ☐ U

☒ HI Line ☐ Include GSM ☒ Frequency ☐ Q ☐ V

☐ CO Line

Image accuracy 20

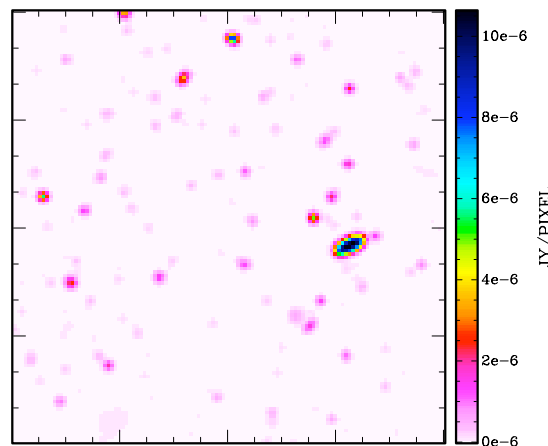
Map Center: R.A. + 12 : 0 : 0.0 [h:m:s]

Dec. + 0 : 0 : 0.0 [d:m:s]

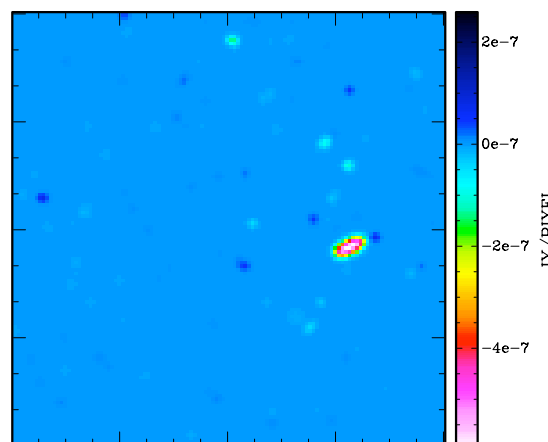
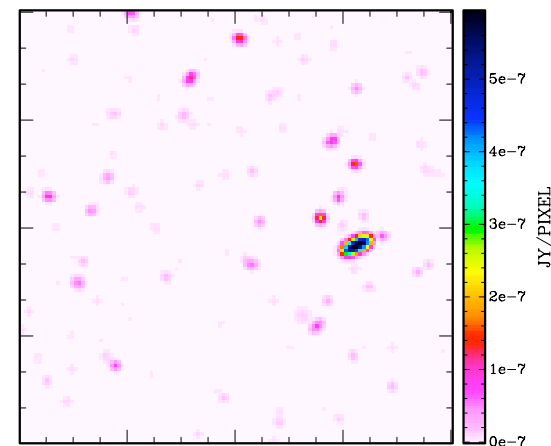
About Help Show Run Quit

Example :
Central 2' by 2' of S-cubed SEX
Maximum polarisation : 15%

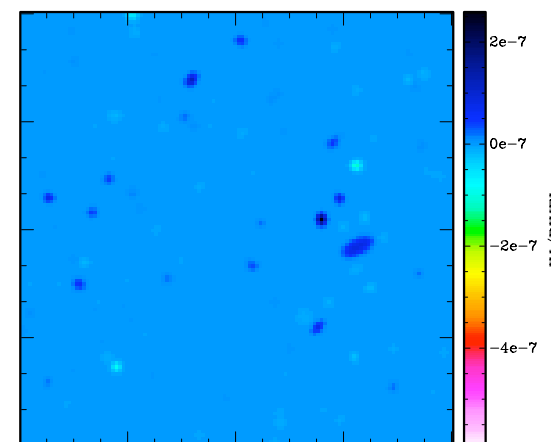
Total intensity I



Linear polarization



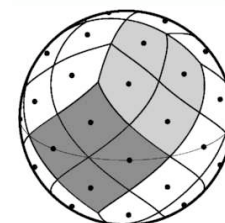
Stokes Q



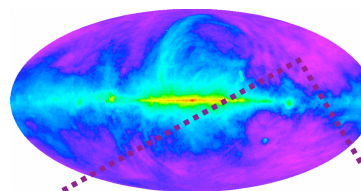
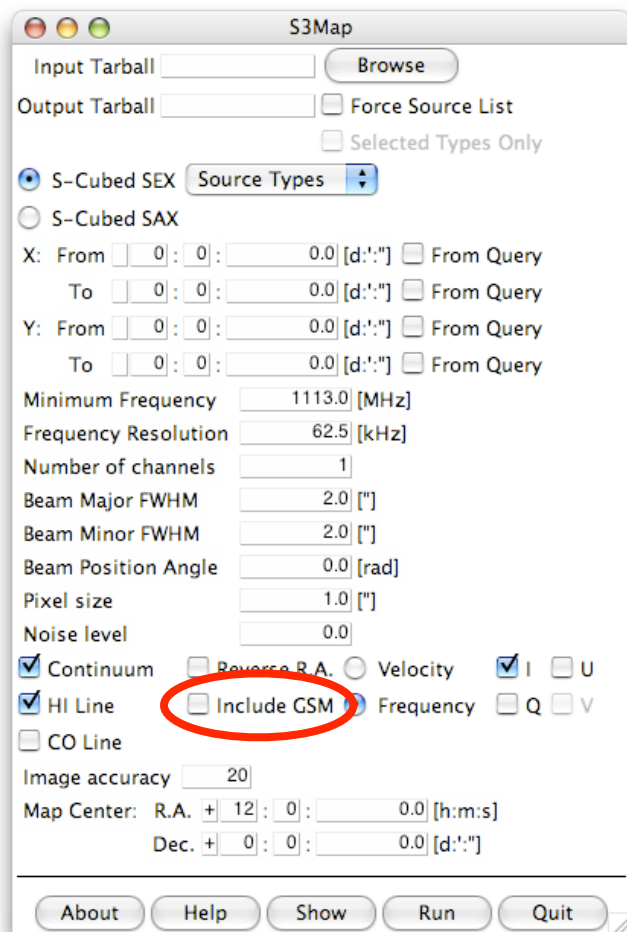
Stokes U



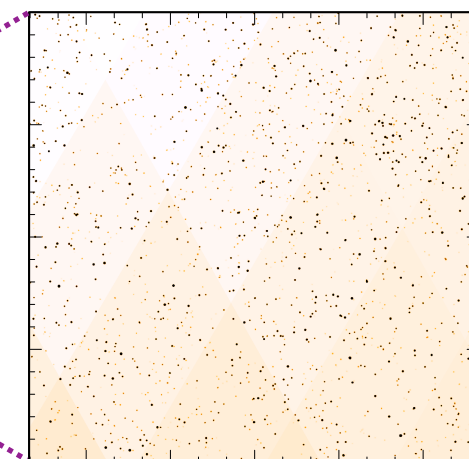
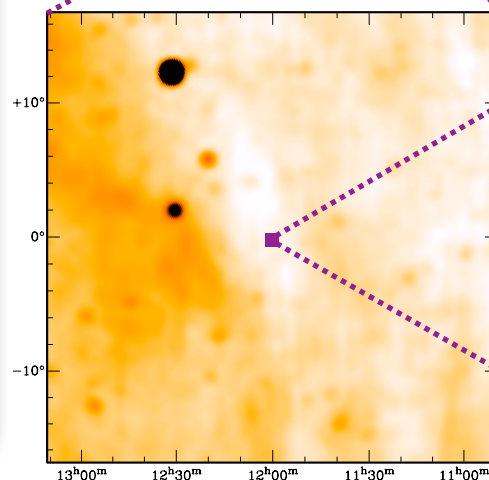
Global Sky Model



- Courtesy of Angelica de Oliveira-Costa (MIT)
- Compiles publicly available radio surveys
- Covers 10 MHz to 100 GHz
- HEALPIX format
- S3Tools adapted from available IDL routines



[Haslam et al. @ 408 MHz]



Central 20' by 20' of S-cubed SEX
[only starburst galaxies] overlaid with
GSM @ 1.113 GHz [x 1e15]

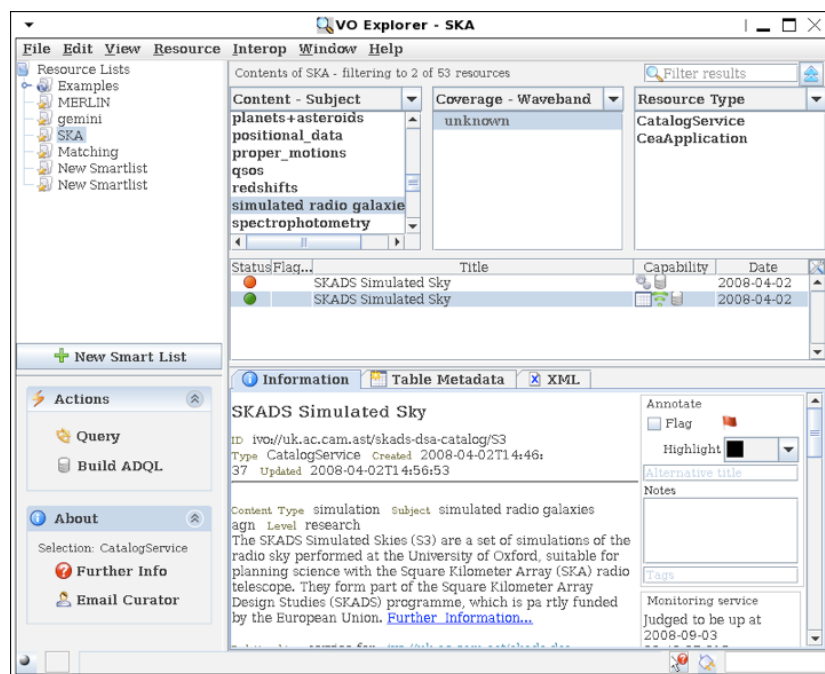
<http://space.mit.edu/home/angelica/gsm/>
<http://healpix.jpl.nasa.gov/>



S-cubed by AstroGrid



Credit goes to Eduardo Gonzalez-Solares, Nick Walton [IoA] and Anita Richards [Manchester]



VO harvests data providers' standard descriptions

- Publishing registries at Cambridge, CDS, HEASARC, ...
- VOExplorer searches Registry of resources
- Look for content description containing 'SKA' and 'simulated'

Choose SKADS Simulated Sky

- Catalogues stored on MySQL at Cambridge
- Browse / sort details of columns etc...
- User types in SQL-like ADQL or uses tree GUI

Query sent to database

- Results returned as standard xml-like VOTable
- Examine, process, convert to ascii e.g. in TopCat

Pipes to plug on the way to VO-S3 and VO-S3Tools

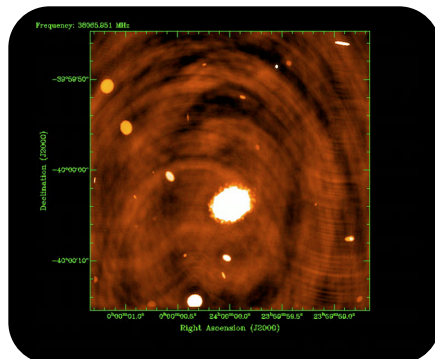
- Post-processing and map-making (already scripted)
- Update of S-cubed SEX
- Registration of S-cubed SAX



Perspectives



- Improve modularity : VO compliance, maintenance issues
- Compatibility with MeqTrees (Smirnov, Salvini)
- HI spectra banks (AGES/HIPASS) to be used in S-cubed SEX
- Epoch of Reionization signals (Combes, Santos)
- Polarized emission from the Galaxy (Reich)
- Cluster depolarization
- S-cubed PUL (Smits, Karastergiou)
- S-cubed SEX-HEMIS (Wilman)
- S-cubed beyond SKADS : high z CO observations for ALMA (Heywood)



30" x 30" x 64 channel AIPS simulation of an ALMA observation
CO source at $z \sim 2$ from SAX + Background continuum from SEX