

Accessing the SKADS Simulated Skies



S³ – The SKADS Simulated Skies



Introduction

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. They form part of the Square Kilometer Array Design Studies (SKADS) programme, which is partly funded by the European Union.

Three simulations can be accessed through this portal:

- S³-SEX (Semi-Empirical eXtragalactic database)**
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. [Access]
- S³-SAX (Semi-Analytical eXtragalactic database)**
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. [Access]
- S³-PUL (PULsar database)**
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. [Access]

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 with the MapMaker, a downloadable python standalone tool whose backend routines are also implemented on our server, making it possible for users to request maps from a web-based form.

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Overview

The **SKADS Simulated Skies (S-cubed)** are a set of simulations of the radio sky performed at the University of Oxford, suitable for planning science with the Square Kilometer Array radio telescope. They form part of the SKADS program, which is partly funded by the European Union.

Their purpose is to provide the community with a common testing ground for many of the SKA key science projects, as well as for instrument design issues on the way to the SKA. Consequently, they also form an ideal set of simulated skies for SKA pathfinders.

The S-cubed simulations can be accessed freely through a web portal at

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

The current state of the simulations is the following (see left for descriptions) :

• **S-cubed SEX : Simulation finished; database, post-processing and map-making implemented**

• **S-cubed SAX : Simulation finished; database in progress**

• **S-cubed PUL : Simulation design complete**

See talks by S. Rawlings, R. Wilman, D. Obreschkow and A. Karastergiou

Make your own sky

1: Query the database

Select source types to search for :

- Radio-quiet AGN
- Radio-loud AGN (FRI)
- Radio-loud AGN (FRII)
- Quiescent star-forming galaxies
- Starbursting galaxies

Select parameters to extract :

☒ Subcomponent index	☐ Cluster index	☒ Galaxy index	☒ Star formation type	☒ AGN type
☐ Subcomponent type	☒ X position	☒ Y position	☒ Comoving distance	☒ Observed redshift
☒ Position angle	☒ Major axis	☒ Minor axis	☒ 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	☒ log ₁₀ M _{HI}	☐ Cosine of viewing angle

Sky area to search :

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

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

Redshift range to search :

0 - 20

2: Post-process (optional)

Default post-processing options :

- ☒ (1+z)^{-1.77} space density decline above z = 1.9 for Radio-quiet AGN.
- ☒ (1+z)^{-2.50} space density decline above z = 2.5 for Radio-loud AGN (FRI).
- ☐ (1+z)^{-7.00} star-formation rate decline above z = 4.8 for quiescent star-forming galaxies and starbursts. Space-density contribution 50 %

Define custom post-processing :

Luminosity decline + for z > 0.7

☒ Power-law decline (1+z)^{-α} with α = 0.5 applied to :

1: Radio-quiet AGN

2: Radio-loud AGN (FRI)

3: Radio-loud AGN (FRII)

4: Quiescent star-forming galaxies

5: Starbursting galaxies

☐ Exponential decline exp(-βz) with β = 2.0

Add

Current custom post-processing options:

Exponential space density decline [z_min=0.4; exponent=2.0] applied to source types 4

Power-law luminosity decline [z_min=0.7; exponent=0.5] applied to source types 1,2

Remove

3: Make an image

Select source types to map :

- Radio-quiet AGN
- Radio-loud AGN (FRI)
- Radio-loud AGN (FRII)
- Radio-loud AGN (GPS)
- Quiescent star-forming galaxies
- Starbursting galaxies

Sky area to map :

Minimum X [°:':"] - 0 : 30 : 0.0 Maximum X [°:':"] + 0 : 30 : 0.0

Minimum Y [°:':"] - 0 : 30 : 0.0 Maximum Y [°:':"] + 0 : 30 : 0.0

Use query window

Describe geometry of output map :

☒ Make a 2-D image ☐ Make a 3-D cube

Pixel size ["] 1.0

Start frequency [MHz] 1113.0

Channel width [kHz] 62.5

Number of channels 1

☒ Frequency axis ☐ Velocity axis ☒ Include polarization axis

Select contents of output map :

☒ Include continuum emission

☒ Include HI line emission

Specify rendition parameters :

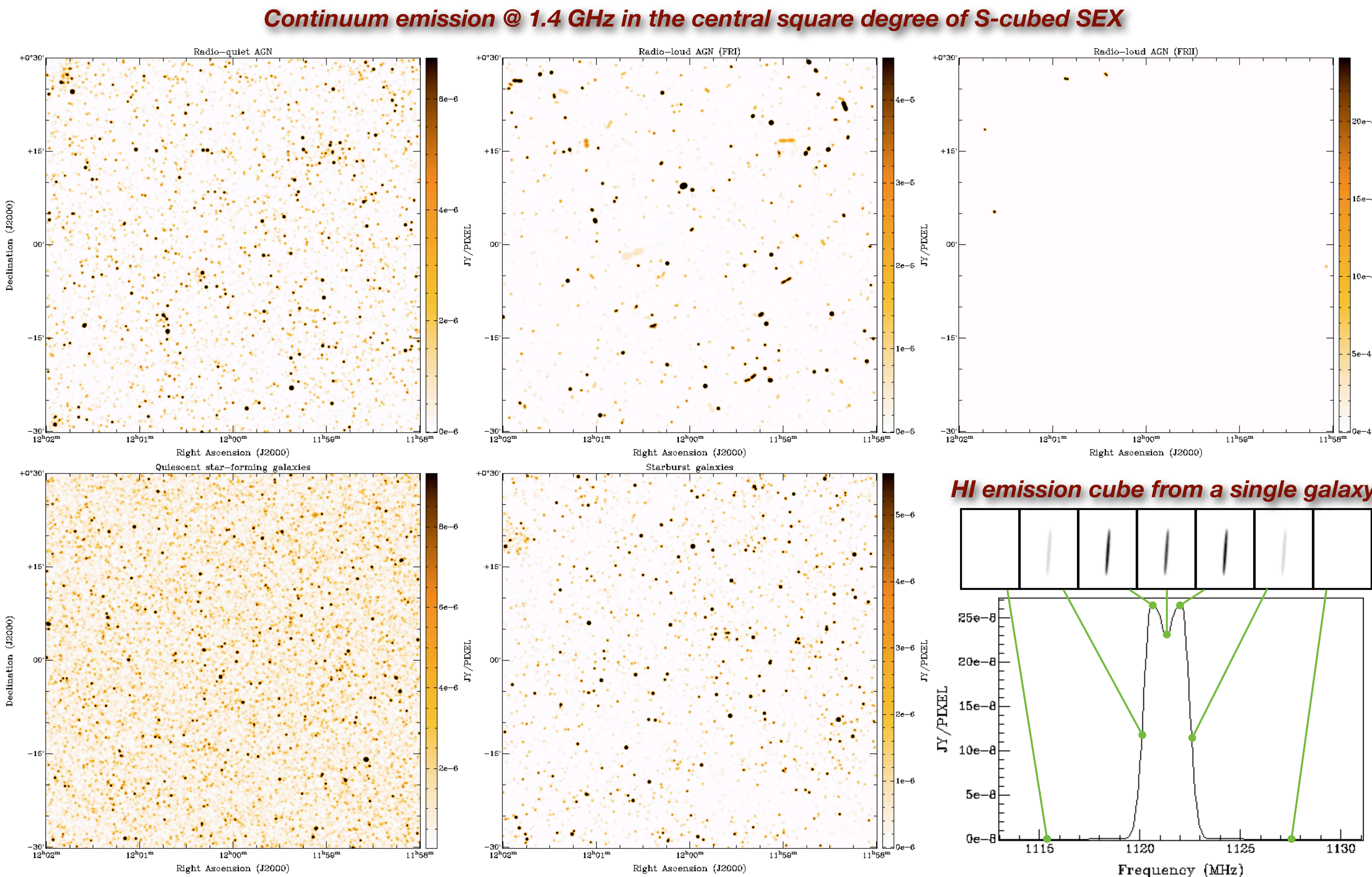
Beam FWHM ["] 2.0 Noise level 0.0

Profile accuracy 300 Image accuracy 20

Specify map center coordinates :

Right ascension [h:m:s] + 12 : 0 : 0.0

Declination [°:':"] + 0 : 0 : 0.0



Do try this at home!

The python routines implemented on the SKADS Simulated Skies server may be downloaded freely from the website, so that users may locally :

• **Build a MySQL database from raw ASCII data (access to this data subject to request)**

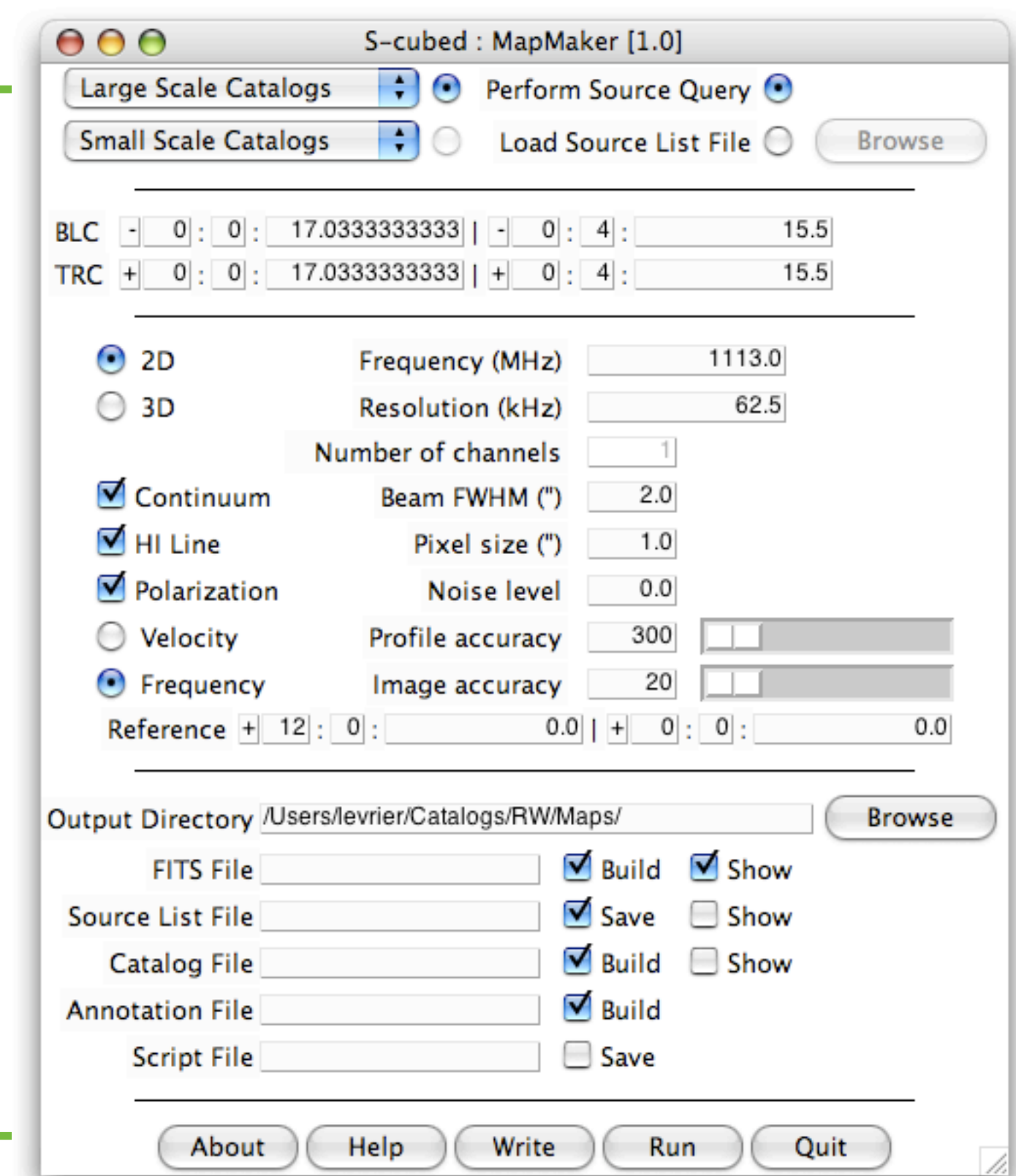
• **Query this local database**

• **Post-process query results**

• **Build maps and cubes of the resulting sky**

To facilitate the use of these routines by the end user, a set of graphical user interfaces (GUI) is being actively developed. On the right is a screenshot of the current MapMaker GUI. It essentially mimics the front-end of the website.

Back-end routines, GUIs and web server are concurrently developed in collaboration with the Oxford e-Research Center, to ensure cross-compatibility and thus enable users to e.g. perform an online query of the S-cubed database, download the results, apply post-processing steps locally, and upload the output for the web server to handle the map-making.



What's to come...

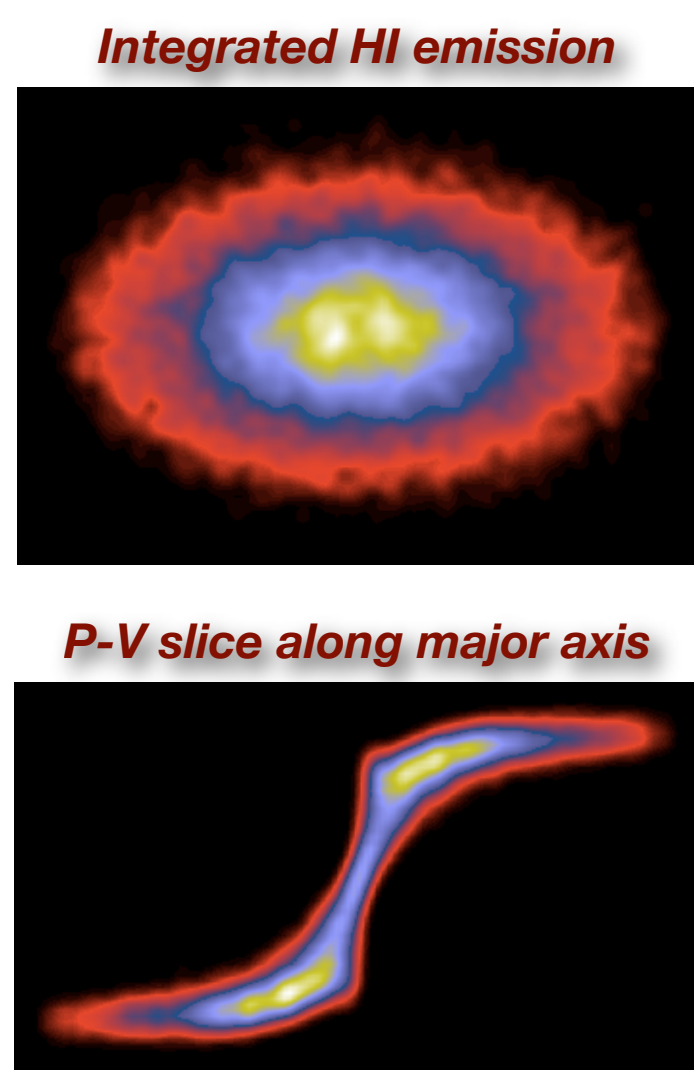
High-resolution HI emission

Currently, in S-cubed SEX :

- HI disk identified to star-formation disk
- HI emission painted uniformly

To come, in S-cubed SAX :

- HI disk distinct from star-formation disk
- Use of 1,150 HI emission template PPV cubes (spirals and irregulars, varying rotation velocity and inclination) built by Rense Boomsma (Kapteyn Institute)



Polarization

Currently, in both extragalactic databases, only total intensity values are given.

Q, U and V parameters will be implemented thanks to a collaboration with Paul Alexander (MRAO), Rainer Beck and Tigran Arshakian (MPIfR).

AstroGrid implementation

S-cubed SEX is currently being plugged into AstroGrid (www2.astrogrid.org), the UK's Virtual Observatory. Eventually, post-processing and map-making routines will be callable from the Task Launcher, to benefit from the grid's computing capabilities. This work is done in collaboration with Eduardo Gonzalez-Solares and Nicholas Walton (IoA Cambridge).

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s-cubed.physics.ox.ac.uk



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