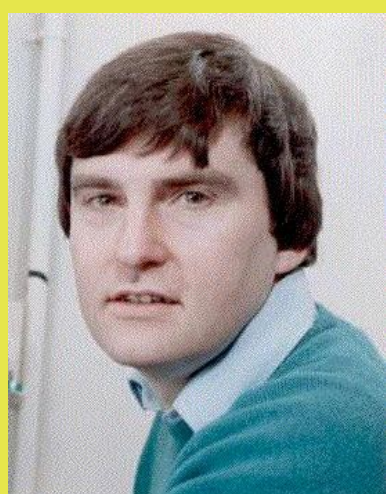


# Starlink Software Developments

Malcolm J. Currie<sup>1</sup>,

David S. Berry<sup>2</sup>, Brad Cavanagh<sup>3</sup>, Peter W. Draper<sup>4</sup>, Tim Jenness<sup>3</sup>, Frossie Economou<sup>3</sup>

<sup>1</sup>Rutherford Appleton Laboratory, UK; <sup>2</sup>University of Central Lancashire, UK; <sup>3</sup>Joint Astronomy Centre, Hawaii; <sup>4</sup>Durham University, UK



mjc@star.rl.ac.uk

## Introduction

In 2005 Starlink software came under the auspices of the Joint Astronomy Centre, Hawaii, where it plays a vital role in real-time data-reduction pipelines. The software has continued to be developed for the data reduction and analysis for new instruments at JAC, particularly for spectral cubes from the James Clerk Maxwell Telescope. This poster outlines the changes made since 2005, but not presented in other posters or at earlier ADASS conferences.

## KAPPA – Kernel Package

Three-dimensional support:

- CHANMAP** plots a two-dimensional tiled map of channels from a cube
- CLINPLOT** draws a spatial grid of line plots for an axis of a cube
- COLLAPSE** many new estimators targetted at cube analysis
- MFITTREND** fits independent trends to data lines in a cube
- Smoothing and rotation to all planes in a cube
- SQORST** can resample to specified WCS scales per pixel

Other new tasks:

- BEAMFIT** Fits up to five Gaussians to beam features with various optional constraints such as width or separation
- INTERLEAVE** forms higher-resolution data by interleaving a set of files
- WCSMOSAIC** aligns and co-adds a group of NDFs using WCS information

Improved applications:

- REGRID** and **WCSALIGN** have optional flux conservation

Improved surface fitting:

- Support for more co-ordinate systems
- SURFIT** uses SVD to obtain polynomial-fit errors
- FITSURFACE** and **MAKESURFACE** fit and evaluate bi-cubic splines

Statistics:

- More ways to compute the mode with **HISTAT**
- Reporting of positions of extreme values in world co-ordinates
- Cumulative histogram in **HISTOGRAM**

Non-sticky changes to plotting style in some tasks

Support for AST SpecFrames and FluxFrames

Alignment of plots with old plots via any suitable co-ordinate system

## SPLAT – spectral analysis

- + Fuller support for dual-sideband spectra (see the example to the right)
- + A synopsis of the properties of the current spectrum
- + More standard sub-millimetre lines
- + Interoperate with the VO, using SSAP Version 1 queries
- + PLASTIC support for sending and receiving spectra from other PLASTIC-enabled applications
- + Support for data units, including transformations between common flux systems
- + Region statistics tool
- + New smoothing filters, Hann, Hamming, Welch and Barlett
- + Useability improvements, mostly many more keyboard interactions

## GAIA – image display and analysis

Major upgrade to support three-dimensional data presented at a Forum last year, and also see P1.067 (P.W. Draper) for further developments. Some of the non-3D enhancements include the following.

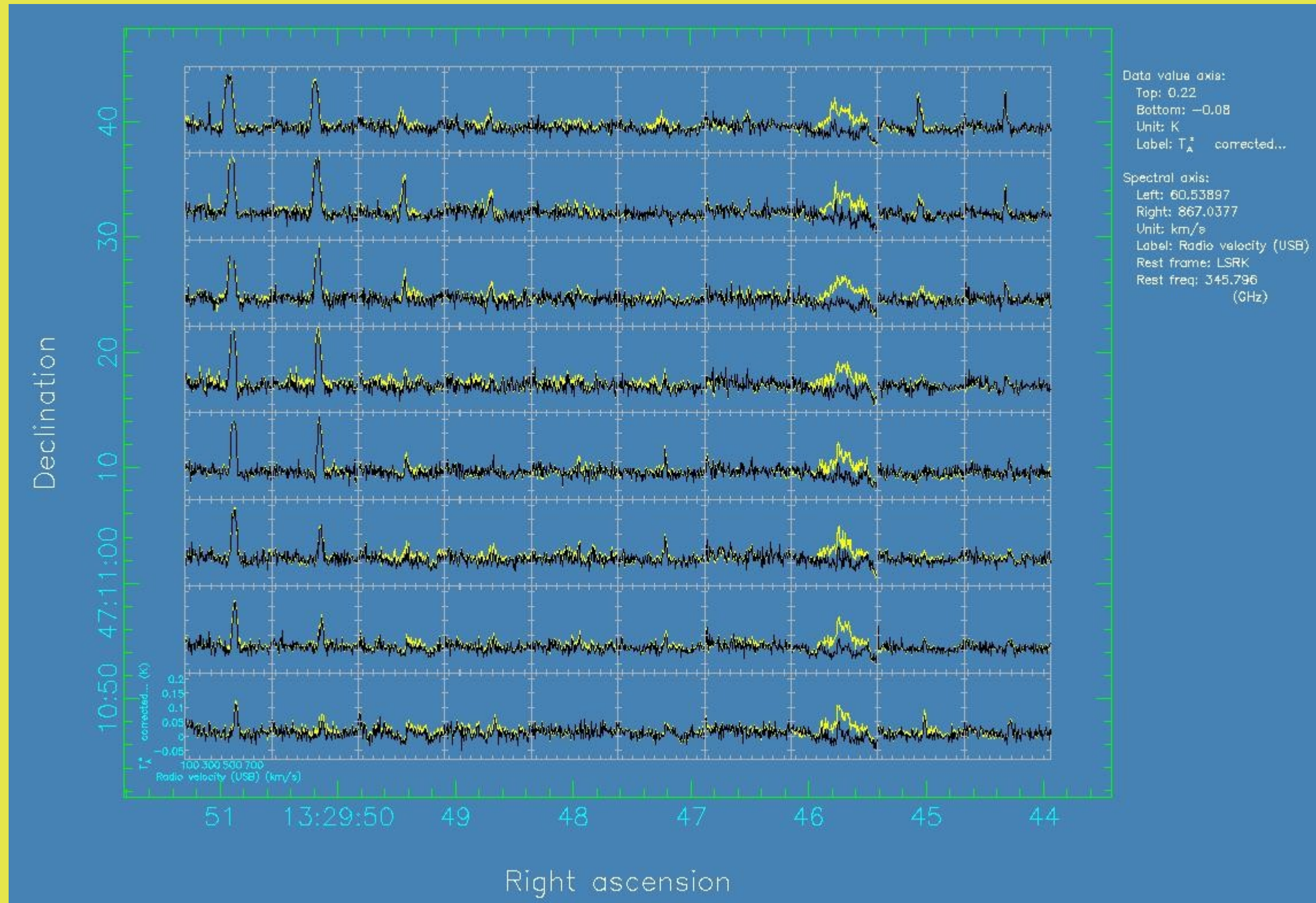
- + Display of FITS in-line compressed images
- + PLASTIC enabled so can send and receive images and receive catalogues
- + Various new default on-line catalogues available
- + Rotatable box item now available as a catalogue plotting symbol

## New Packages

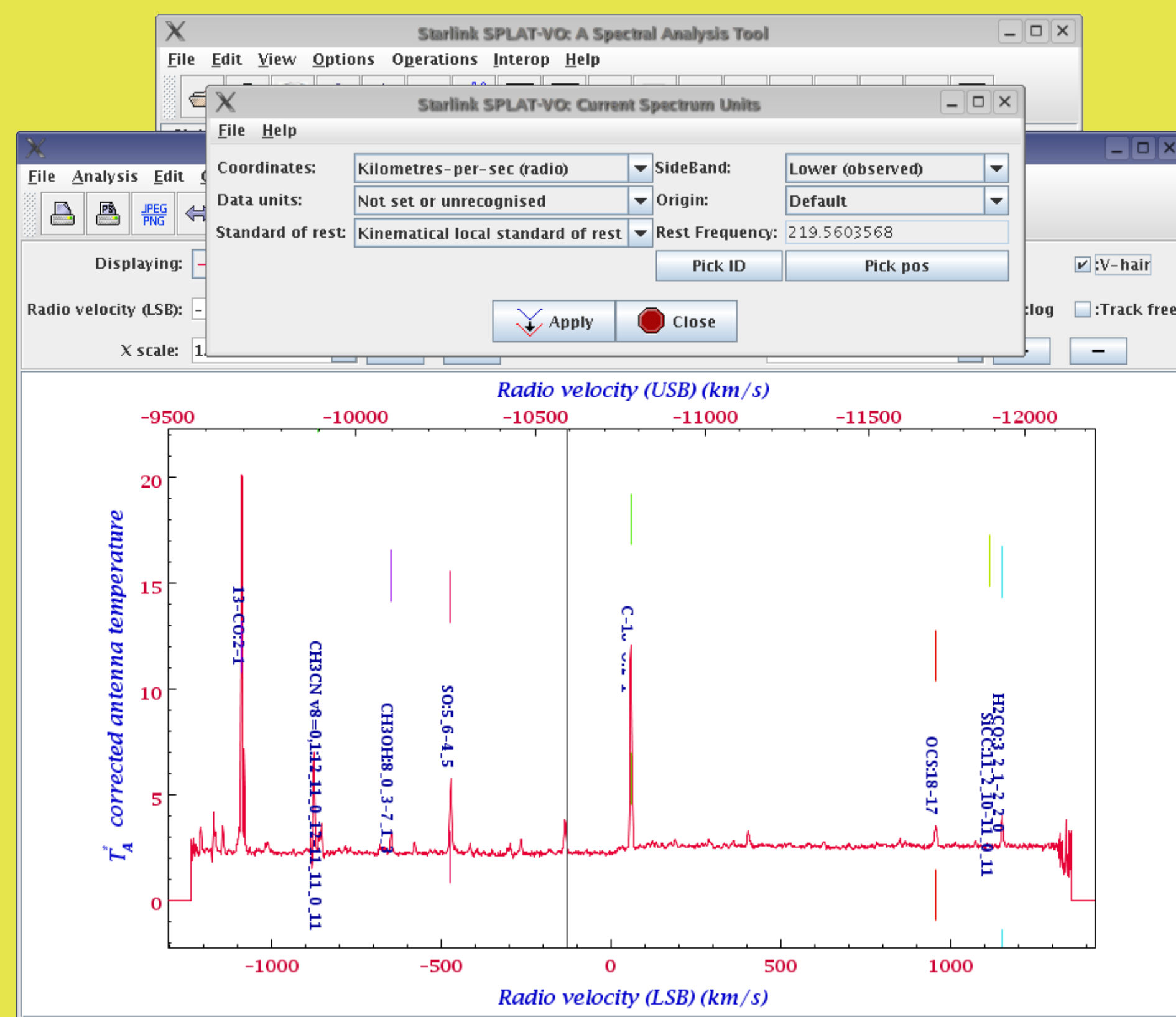
**CUPID: CIUmp IDentification** in up to three dimensions, introduced at ADASS XVI

**SMURF: Sub-Millimetre User Reduction Facility.** Its main task transforms raw time series into cubes. See P1.082 (T.Jenness *et al.*)

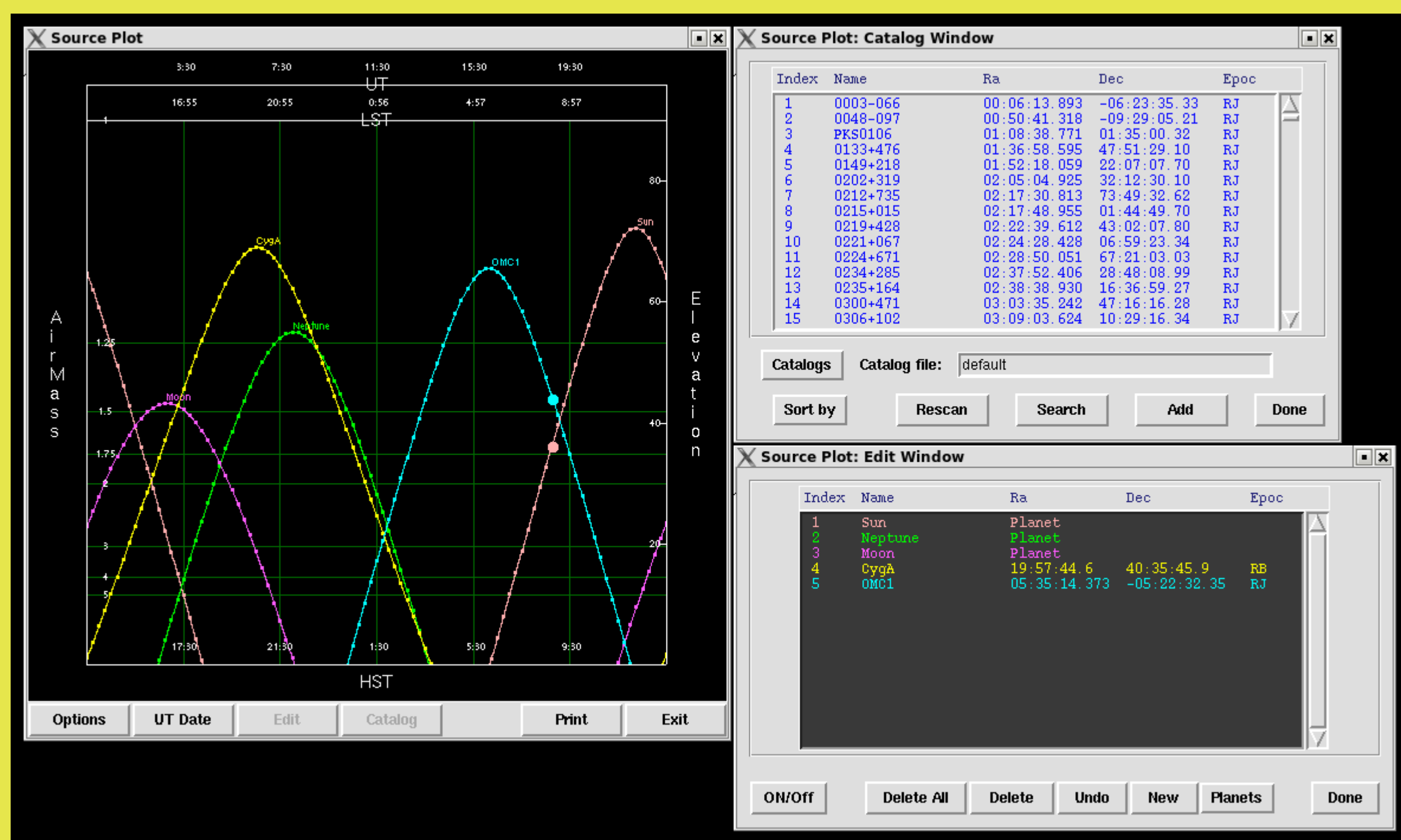
**SOURCEPLOT** plots astronomical objects in altitude and azimuth for a supplied point on the Earth (example to the right)



An example of CLINPLOT. Each box shows a raw spectrum (in yellow) at the spatial position given by the outer axes. The annotations around the lower-left spectrum are the axes for each line plot. The dark-green curves overlaid have the line trends removed automatically (algorithms still under development). The combination of WCS knowledge and a graphic database allows different datasets to be compared on the same plot.



SPLAT displaying a dual-sideband (see P1.054) sub-millimetre spectrum from the JCMT, with the two sideband velocity systems shown. Standard lines have been overlaid and corrected for the source velocity. Note that the rest frequency can be trivially changed to that of one of the lines, or a picked velocity, as can the co-ordinate system and selected sideband.



Example SOURCEPLOT graphics that shows the positions of the Sun, Neptune, the Moon, Cygnus A, and OMC-1 from the JCMT for 2007 September 19. Also shown is the default source catalogue, which includes 383 astronomical sources. All of the planets, the Sun, and the Moon are available for plotting as well, and you can add your own sources or import your own catalogue.



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## General

- + GPL licence
- + Builds with standard GNU autotools from an SVN repository
- + Works on 64-bit systems
- + Builds with g95 (GCC4.0+) and gfortran (GCC4.3)
- + Builds on Solaris 10 with the Studio 11 compilers (Intel and Sparc)

## Data System

- + HDS supports files >2GB on 32-bit machines, and individual arrays >2GB on 64-bit systems
- + 64-bit files created by default
- + Can include ".sdf" file extension when supplying the name of an HDS (such as an NDF) file
- + Scaled NDFs for compression
- + NDF sections can be specified using world co-ordinates, for example  
cube(12:34:56.7,-41:52:09,400.0;650.0)  
might extract a spectrum from a cube at the given sky position between 400 and 650 km/s, and  
ifu(1h34m10.1s:1h34m12.4s,2d35m:2d35.5m,656.3)  
specify a region of sky 2.3s by 0.5 arcminutes at Halpha from an IFU.

## CONVERT – format conversion to and from NDFs

- + On-the-fly conversion of compressed FITS
- + **NDF2FITS** supports
  - \* multi-NDF files
  - \* writes CHECKSUM and DATASUM keywords
  - \* converts in-line compressed images (RICE, GZIP, PLIO)
- + FITS converters:
  - Have AIPS++ and CLASS encodings
  - Scaled arrays are converted without loss of compression
- + **SPECX2NDF** can create NDFs with dual-sideband SpecFrame

## DATAcube – scripts for automating spectral cube analysis

- Major overhaul and update including User Guide and Cookbook documentation reflecting the state of 3-D tools in early 2006.
- + Generalised to work for arbitrary datacubes not just optical IFUs
- + Support for NDF sections
- + All scripts improved and enhanced, notably **VELMAP**. Improvements include the map output in one of four velocity systems, recognition of dual-sideband spectra and an optional velocity key
- + Addition **GRIDSPEC** averages and plots groups of neighbouring spectra
- + Addition **VELMOMENT** builds a velocity map from collapsed intensity-weighted spectra, it also has optional spatial compression
- + Clearer spectral plots, and more control of contouring

## ORAC-DR Data reduction pipeline

- + Support for infrared spectropolarimetry
- + Support for WFCAM, including automated astrometry correction
- + Support for ACSIS

## Subroutine Libraries

- AST:** Major developments. See poster P1.054 (D.S.Berry)
- ARD:** Can refer to regions within time or spectral co-ordinate systems
- GRP, HDS, and NDG** have official C interfaces

For further details, and how to obtain the software, please visit  
<http://starlink.jach.hawaii.edu/>

The puana release is available pre-built for the following operating systems:

- + 32-bit Linux glibc 2.3.4 (434MB .tar.gz)
- + 32-bit Linux glibc 2.5 (438MB .tar.gz)
- + 64-bit Linux (420MB .tar.gz)
- + PPC OS X Tiger (348MB .tar.gz)
- + Intel OS X Tiger (335MB .tar.gz)

Other systems, such as Solaris, may be provided given sufficient demand.