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DISH: The Single Dish Environment in AIPS++

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Abstract. We present a short description and update of the single dish analysis environment in AIPS++, called DISH. The focus on DISH has been to provide traditional single dish spectral line data analysis tools with support for extensibility and customization of the package. Several tools have recently been added to complete the reduction of spectral line observations; in particular, a stack-based spectral calculator has been implemented which allows direct manipulation of spectra by any general mathematical function.

DISH and AIPS++ are the primary analysis tools for data from the Green Bank Telescope and are also in use at several other observatories. We present examples of its use and outline the general features. DISH is available now with the first public release of **AIPS++** (http://aips2.nrao.edu/daily/docs/html/aips++.html).

1. Introduction

DISH is a collection of Glish scripts and clients which provide an environment within AIPS++ intended to be used for single dish radioastronomy data analysis. The focus of DISH has been to provide traditional single dish spectral line data analysis tools with support for extensibility and customization of the environment. Several tools have recently been added to complete the reduction of spectral line observations; in particular, a stack based spectral calculator has been implemented. The following is a snapshot of the features of DISH:

- Design goals: The primary goal has been to provide a graphical user interface that is intuitive, unsurprising and responsive. Users should feel that results go to obvious places and, whenever possible are displayed as they occur.
- Data: There are three types of data that DISH uses.
  1. Individual scans. These are two-dimensional data arrays plus associated information including analysis history information. The first dimension can be anything but is most typically a frequency and/or velocity axis while the second dimension is a stokes axis. These are refereed to as *SDRecords*. DISH knows how to plot these. They can also be browsed in the sense that the associated information and analysis history can be examined in the SD Record Browser.
  2. Collection of individual scans. These can be browsed. The selection operation applies a user defined selection criteria to one of these collections producing a new collection.

3. Everything else. These can neither be plotted or browsed.

- Data flow. Operations may operate on collections of scans or they may operate on individual scans. Most operations place their results in the DISH results manager. The sole exception to this rule is the Calculator which has its own stack. If the result can be displayed, it is. Operations on individual scans always operate on the most recently displayed scan so that hopefully the user is not confused as to what is being operated on.
- Data format. The primary archival format for single dish data within AIPS++ is Single Dish FITS. Single Dish FITS is a convention for storing single dish radioastronomy data in a FITS binary table. All astronomical data within AIPS++ resides in a MeasurementSet, which is the specific form of AIPS++ table. MeasurementSets can be converted to and from Single Dish FITS. DISH is planned to eventually also be able to interact with image cubes as yet another collection of individual scans.
- Saving State. Each time you exit DISH its state is saved to disk. This includes all of the values known to the results manager as well as the various settings for each GUI element and operation. When you restart DISH, this state is restored. You can also choose to save and restore the DISH state while using DISH as a way of bookmarking key steps in the data analysis.
- Scripting. Underlying each GUI operation are Glish commands which are available to the user. Users who wish to do complex tasks not available through the DISH GUI or who want to capture existing sets of operations into a Glish script will need to use this command line interface to DISH. The AIPS++ scripting tool can be used to show the underlying Glish commands as each GUI operation occurs. These can be used to simply learn how the GUI does things, or the text from that window can be copied to an editor and used as the basis for a Glish script.

2. Major Graphical Components of DISH

- Menu bar
  New data files are created and existing data files are opened through the *File* menu. The *Options* menu has two selections which can be toggled. The "Write to Script" option signals, when on, that DISH should echo the Glish behind each GUI action to the AIPS++ Scripter as each action is invoked by the user. The "Save when done" option, when on, indicates that the state of DISH should be automatically saved when the current session of DISH ends. The *Operations menu* allows one to toggle on the GUI panels for the available operations in DISH.
- Results Manager
  The *Results Manager* is the heart of DISH. All Glish results which DISH creates in response to user actions are stored in the *Results Manager* and listed in the "Results" window. These results are all available at the Glish command line for the user to interact with. DISH immediately plots the currently selected result if it can be plotted. A description is associated with each result. The user can change the description or the name of the result if they choose to do so. Certain results can also be browsed.

Pressing the "Inspect" button launches a simple GUI useful for looking at the contents of results which can not be browsed or displayed.

- Status Line
  This is the line of text immediately below the *Results Manager* which generally describes the results of user actions or the current state of the GUI. These messages are echoed to the AIPS++ logger for longer term storage.
- Operation Windows
  Each operation has an associated panel which is toggled on and off through the *Operations* menu. They appear at the bottom of the DISH window. All operations have an "Apply" button which, when pressed, actually performs the selected operation. Currently, there are eleven predefined operations, including: data selection, averaging, baseline fitting and removal, apply a user-specified function to data, re-gridding, saving, smoothing, obtain data statistics, spectral calculator, multi-operation (allows one to tie several operations into a single command), and write to file.
- DISHPLOT
  The DISH plotter adds to the existing AIPS++ pgplotter tool. Any activity or task in DISH which produces a result which can be plotted will automatically have the result displayed in the DISH plotter. Different plotting styles (histogram, line, points, etc.) and line styles (solid, dashed, dotted, etc.) may be selected. Several levels of header information may be toggled on or off. The "Overlays" menu allows the user to toggle how the plotter behaves when DISH sends it a new record to be displayed (either clear the plotter and plot the new record or overlay the new record on the previously displayed record). There are two tools available currently: (1) a "Zoom" tool which controls the resetting of the X and Y axis limits and (2) a "LineID" tool which browses an AIPS++ table containing a molecular line catalog and plots any lines found within the frequency ranges of the displayed plot. The figure shows how these lines are indicated on a plot. The cursor position is continuously displayed in the grooved box at the bottom of the plot whenever the cursor is within the DISH plotter frame. The coordinates shown are the X and Y positions of the cursor as well as the channel number nearest to the X position and the data value at that channel number.

3. DISH Command Line Interface

All of the results in the *Results Manager* are available at the Glish command line for further manipulation (e.g. user defined functions can be applied to data arrays). The results of operations done at the Glish command line can then be placed in the *Results Manager*. As mentioned, the 'Write to Script' option is also a valuable tool to see the underlying Glish behind each GUI operation and to assemble Glish scripts to do things which DISH does not yet do.

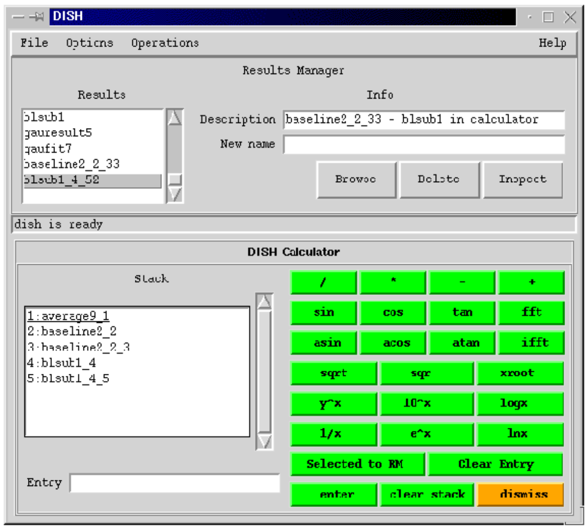

Figure 1. DISH GUI with calculator turned on. The calculator has its own stack and can function on *SDRecords*, arrays, vectors and numbers; data may be exchanged easily between the calculator and the *Results Manger*.

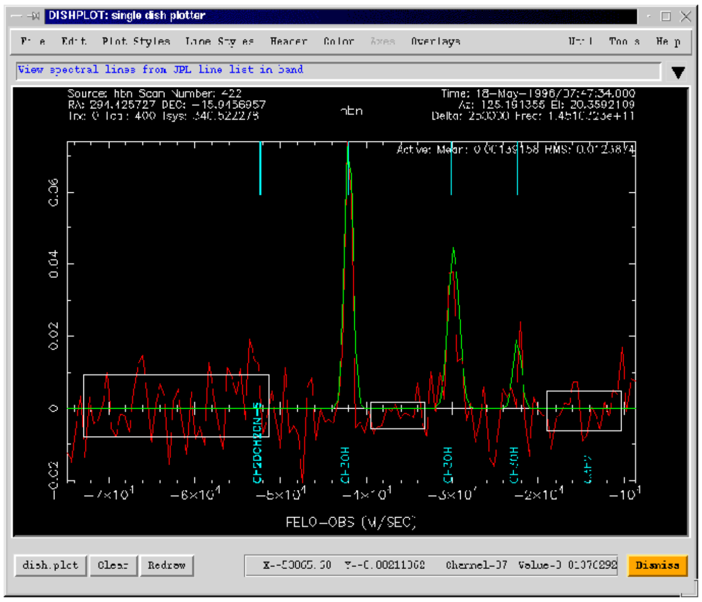

Figure 2. Example of DISHPLOT showing baseline regions, line fits, and identified molecular lines in the spectrum.