GBTIDL: A New Package for Reduction and Analysis of GBT Spectral Line Data

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Abstract. GBTIDL[1] is an interactive package for the reduction and analysis of spectral line data taken with the Green Bank Telescope (GBT). The software is written entirely in IDL. The top level user interface (the GUIDE layer) consists of a set of straightforward and flexible calibration, averaging, and analysis procedures modeled after the UniPOPS[2] and CLASS data reduction philosophies and command-line interface styles. In addition, GBTIDL provides a customized plotter with many built-in visualization features, and data I/O and toolbox functions that can be used for more advanced tasks. GBTIDL makes use of data structures that represent calibrated or uncalibrated spectra, and the package operates on these structures as a straightforward calculator. SDFITS data are used for I/O. GBTIDL can be run online, giving users access to the most recent data coming off the telescope, or it can be run offline.

1. Introduction

In 2004, NRAO decided to leverage the rapid development capabilities of Interactive Data Language (IDL), a commercial product of Research Systems, Inc., to provide a new package for interactive GBT spectral line data analysis. There were several key requirements:

- Adapt easily to new or updated import and export data formats.

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[1] http://gbtidl.sourceforge.net

[2] http://www.cv.nrao.edu/unipops

- Provide lossless data I/O; that is, the observer should be able to move data in and out of GBTIDL at any stage of data reduction with no loss of information.
- Provide a user interface in the style of UniPOPS so that observers familiar with that package can quickly learn GBTIDL.
- Provide a concise command line interface that uses common defaults to minimize typing
- Use global parameters to simplify and customize the user interface. For example, color settings for plot components, and plot styles should be configurable.
- Ensure the capability to produce publication quality plots.
- Make it straightforward to incorporate data from other telescopes (e.g. the NRAO 12-m).
- Provide easy access to the source code.
- Allow the user to add or modify modules at runtime to apply alternative analysis procedures.

2.   Architecture

GBTIDL was designed with the layered approach shown in Figure 1. The top layer, called GUIDE, provides flexible yet powerful data access, calibration, and analysis procedures developed with ease-of-use in mind. Following the UniPOPS model, GUIDE makes use of global settings and 16 global memory buffers called "data containers" to simplify the interface. A data container is simply a structure that describes a spectrum, including header and data values. GUIDE is built on a lower-level function library (the toolbox) that is also available directly for expert users.

The foundational Data I/O module allows clients (not end users) to store spectral line and continuum data to disk and retrieve it back again. The primary client is the GUIDE layer itself. Currently, the input and output formats are compatible with the SDFITS convention, where the input is usually a GBT SDFITS file generated automatically during the course of observing in Green Bank. Data I/O has been isolated from the body of GUIDE, plotter, and toolbox functions. Thus, new or different import/export data formats can be supported by changing only the Data I/O module, with no changes to the data processing algorithms. In addition to opening up the possibility to use GBTIDL with other telescopes, this architecture also minimizes the possibility of introducing new errors when the GBT data format itself is updated or changed.

The index file contains a map of where the data is located in order to improve I/O efficiency. Because the data files can be many gigabytes in size, the index file makes data queries and retrievals much faster. The index file can be regenerated from the raw data, so no unique information is lost if the index file is removed.

GBTIDL includes a custom plotter that is one of the most powerful aspects of the package. The plotter, built around the standard IDL plot widget, includes visualization tools such as flexible zoom controls, data readouts, interactive plot markers, and overlays. The plotter also includes many functions specific to working with astronomical spectroscopy, such as changing the x-axis type to
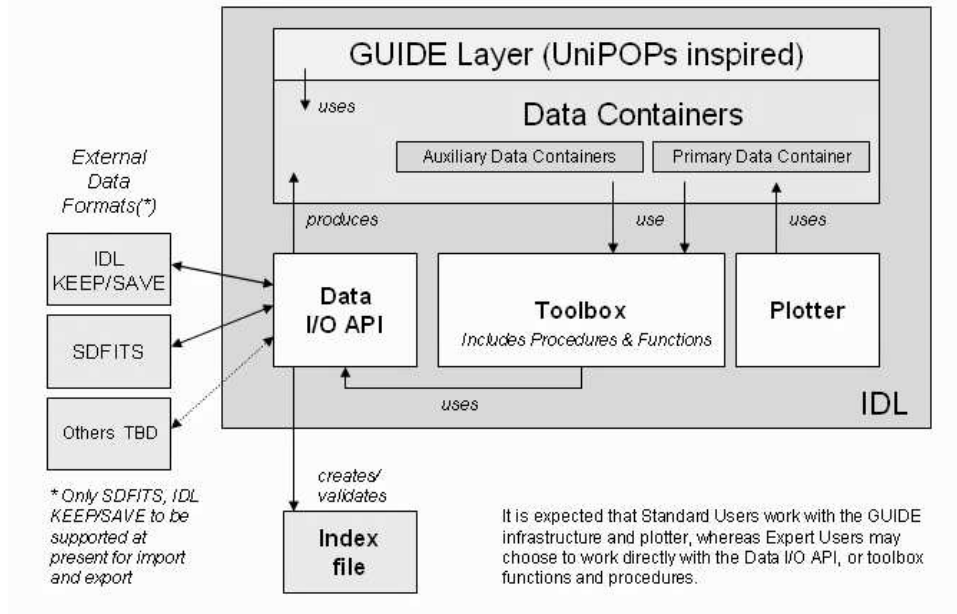
Figure 1.   Application architecture for GBTIDL.
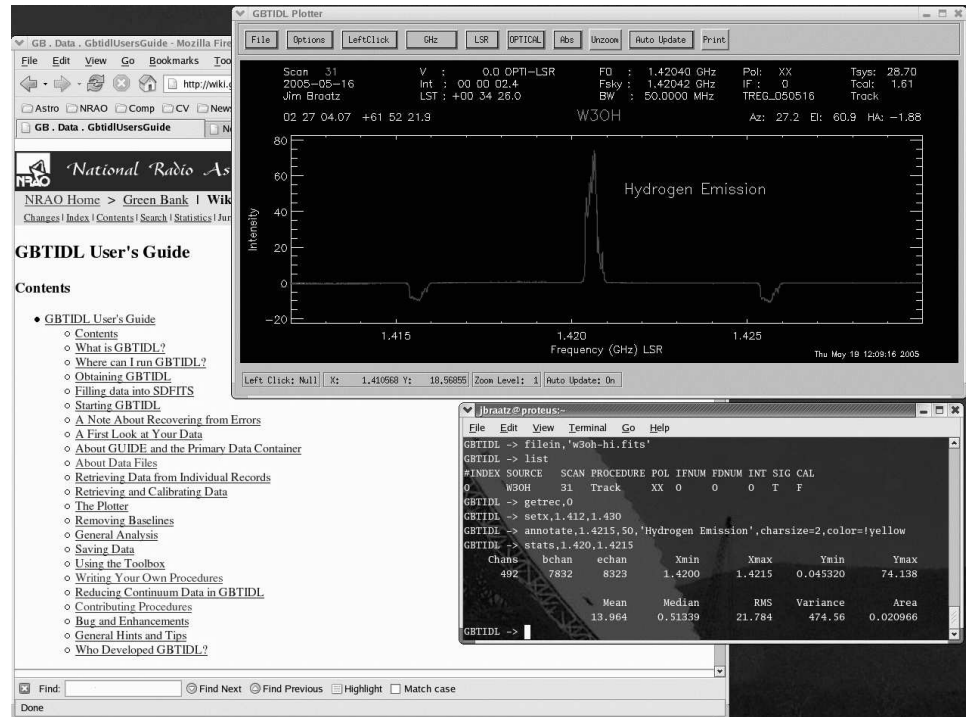

Figure 2.   A typical desktop showing GBTIDL.

frequency or velocity units, setting the velocity convention and reference frame, and setting x-offsets to match the source velocity frame. The usual IDL plotting tools, and all IDL functions, remain available to the user as well.

2.1. Unique and Defining Features

The product has the following defining features:

- GBTIDL is the recommended package for reducing GBT spectral line data.
- The interactive plotter incorporates flexible data visualization controls and command line procedures that match user interface controls.
- High quality postscript files (not bitmaps) can be generated easily, with just one click from the plotter
- The program can be used as a calculator to operate on spectra, making it easy to explore alternative calibration, compare spectra, and apply unique operations.
- The package is designed to incorporate and distribute user-contributed code. Users can also add their own modules and replace existing ones, as desired.
- GBTIDL can be run online, giving immediate access to the most recent data coming off the telescope, or it can be run offline using existing SDFITS files.
- The package uses an index file, which is a data map that improves the performance of data I/O and algorithms.
- The package is designed so that new layers can be added to enhance the existing interface or mimic a different interface. For example, a set of command abbreviations could be added trivially.
- Data I/O is well isolated within the package so additional data formats can be supported.
- Command line access to the documentation is provided via the "usage" procedure.
- Full documentation is available online.
- Sourceforge is being used to communicate with users and distribute the software.

2.2. Future Work

After the current release (version 1.2), efforts will focus on making basic continuum data processing more robust and and on implementing a flagging scheme that is consistent with the GBT science data model. User contributions are actively being solicited for integration into future releases, especially for spectral line imaging.