A CXC goal is to provide a programmable analysis system for grating spectroscopy. ISIS has been serving as a stand-alone research and development package as well as an important pathfinder for features now appearing in Sherpa in CIAO 3.0.

There are two CXC-software options for grating spectroscopic analysis:
1. ISIS (plus optional Xspec module; CIAO 3 provides optional sherpa module).
2. Sherpa (including ISIS module for CIAO 2.3 on).
ISIS:

- Designed specifically for grating spectroscopy, for fitting list of 1D spectral histograms;
- Interface to AtomDB for atomic data, line, and continuum emissivities, browsing the database and computing plasma models;
- Slang interface only, designed for fully programmable control, but also with reasonably simple interactive commands.

Sherpa (CIAO 3.0)

- Generalized fitting, modeling; e.g. 1D, 2D, histogram, spatial, spectral.
- Designed as command-line-interpreter; SLang parser now coexists.
- S-Lang interfaces to Sherpa added starting in CIAO 3.0 (S-Lang parser and some functions in CIAO 2.0)
Important Features

- **ISIS**
  - AtomDB interface, for line data, emissivities, plasma models;
  - Modular design (slang, cfitsio, pgplot); small source code volume (20,000 lines of C, 5,000 lines of S-Lang (including cfitsio and xspec modules).
  - Extensible, even at very low levels: kernel (entire “RMF” integrand; e.g., for pileup), slang or C user models, slang or C user statistic; “hook” functions;
  - Two optimization methods built-in; user method via C interface;
  - Two statistics built in; slang interface for user statistic;
  - Plotting (via pgplot);
  - A few key built in fit functions for spectroscopy (∼10)
  - Xspec module, with all xspec models (including local and convolution);
  - Well documented (Introduction and Reference manual)
  - Dynamic binning and grouping (including rsp regridding)
  - Generic Monte-Carlo wrapper (for fitting or statistic)
– Basic math functions (rebinning, interpolation, histograms, 1D FFT, random numbers);
– Easy to maintain, build, enhance;
– Portable (Linux, Sun Solaris, SunOS, DEC, FreeBSD, IBM AIX; MacOSX)
– Stable core; used for ~ 4 years;
– Maintained and developed by a single architect, with enhancements based on input from a small group conducting grating analysis.
– Low-resolution or other spectroscopic analysis automatically supported by hi-res functionality (ACIS imaging, RXTE, XMM, HST).
• Sherpa

- Large volume of source code (100,000 lines)
- Extensible via S-Lang, optimization method and statistic via C interface;
- 12 built-in optimization methods;
- 9 built-in statistics; three statistical tests
- Portable (Solaris, Linux, MacOSX)
- Inherently multi-mission/discipline (no axis assumptions; Data-Model i/o)
- Multi-dimensional fitting.
- Access to AtomDB plasma models (via ISIS or Xspec modules)
- Xpsec models included (except local or convolution; Sherpa’s convolution is more general)
- Well tested, documented (manuals, ahelp, threads), consistent.
- Long development cycle, improved by 3.0 infrastructure release
- Hybrid parser (command line interpreter plus slang); context sensitive commands
- Plotting (via SM, Chips)
- ~ 6 years development;
Example Scripts, Documentation

Some ISIS and Sherpa scripts are printed in a separate handout. Many examples are available on the web:

- **ISIS examples**: [http://space.mit.edu/CXC/ISIS/examples.html](http://space.mit.edu/CXC/ISIS/examples.html) — single-ion spectrum, fake data with line broadening, monte-carlo line profile analysis, continuum modeling.

- **Sherpa command-line threads**: [http://cxc.harvard.edu/ciao/threads/sherpa_grating/](http://cxc.harvard.edu/ciao/threads/sherpa_grating/)


- **WebGUIDE**: [http://obsvis.harvard.edu/WebGUIDE](http://obsvis.harvard.edu/WebGUIDE)

- **Sherpa on-line help (“ahelp”)**: [http://cxc.harvard.edu/ciao/ahelp](http://cxc.harvard.edu/ciao/ahelp)

Other Uses of ISIS as a prototyping & development platform

Pileup models via ISIS module; (imaging-mode now in sherpa, Xspec)
cfitsio S-Lang interface (now in ciao)
contamarf: rapid implementation of new calibration effect - high-resolution contamination function.

Bayesian blocks light curves

$kT$ map modeling - dynamic binning, individually fitting a spectra in a thousand regions in extended sources.

“PI-on-the-fly” for ACIS RMF regridding.

ACIS time-dependent gain prototype

Distributed processing.

Emission measure modeling
These “Other Uses” (mostly non-grating specific) demonstrate the power of a programmable scripting language combined with function-based data and model access.

Some have been possible in CIAO 2.3, and CIAO 3.0 S-Lang infrastructure provides greatly enhanced scripted modeling support for such:


ChAMPs Spectra, perl-driven-sherpa for hundreds of spectral fits (to be converted to CIAO 3 perl-S-Lang interface).
Plans

With the CIAO 3 release we are in a position to look at integrated approaches for sharing and coordinating technologies and lessons-learned from Sherpa and ISIS. We recognize the value in a global approach, and also the value in limited-scope applications. We are beginning to explore in detail divergence/convergence pros and cons, as well as common bases for future enhancements.

- ISIS
  - No major development plans for the core system.
  - Enhance, bugfix as per user request.
  - Apply to research; automate repetitive tasks.
  - Prototype new applications (e.g., emission measure modeling support; interactive event browsing)
  - Develop/test new slang modules (such as GSL, PVM, GTK).
  - Improve documentation.
  - Improve/add measurement tabulation/output — e.g., use Sherpa’s “MDL”.

CXC
• Sherpa
  – Support a wide range of users.
  – Continue adding S-Lang functions useful for library access, common tasks, or automation.
  – Implement sophisticated plasma modelling codes based on AtomDB.
  – Improve interactive plotting, GUls, scatter data, “MDL” (see other talks).