

Data Pipelines for SAO's TRES Echelle Spectrograph

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Design Strategy

1. Use IRAF to take advantage of tasks written to deal with Echelle spectra
2. Adapt and re-use tasks written to process data from other SAO spectrographs such as FAST, Hectospec and Hectochelle
3. For portability, write all code in IRAF CL or SPP
4. Use same code for quick-look at the telescope and more complete reductions.
5. Make process easy enough for scientists to use and make it even harder for them to mis-use it.
6. Enforce separation of processing from raw data.

Data Setup

`trdate` yyyy.mmdd or now

Set the working directory and raw data directory based on the date.

`trsgroup`

Makes lists all of the TRES files to be processed, grouped by object name, fiber configuration and exposure time

`[obj][s m l][b if binned][fiber(s)]x[exposure in seconds].list`

Multiple groupings of exposures of the same object and configuration are split into separate lists and master lists are made of ThAr (COMP) and object data.

Quick Look

`qtres` reduces one raw spectrum image to one to three multi-order echelle spectra using `tproc`. Default flat fields and ThAr spectra can be used because night-to-night instrumental shifts are less than a pixel.

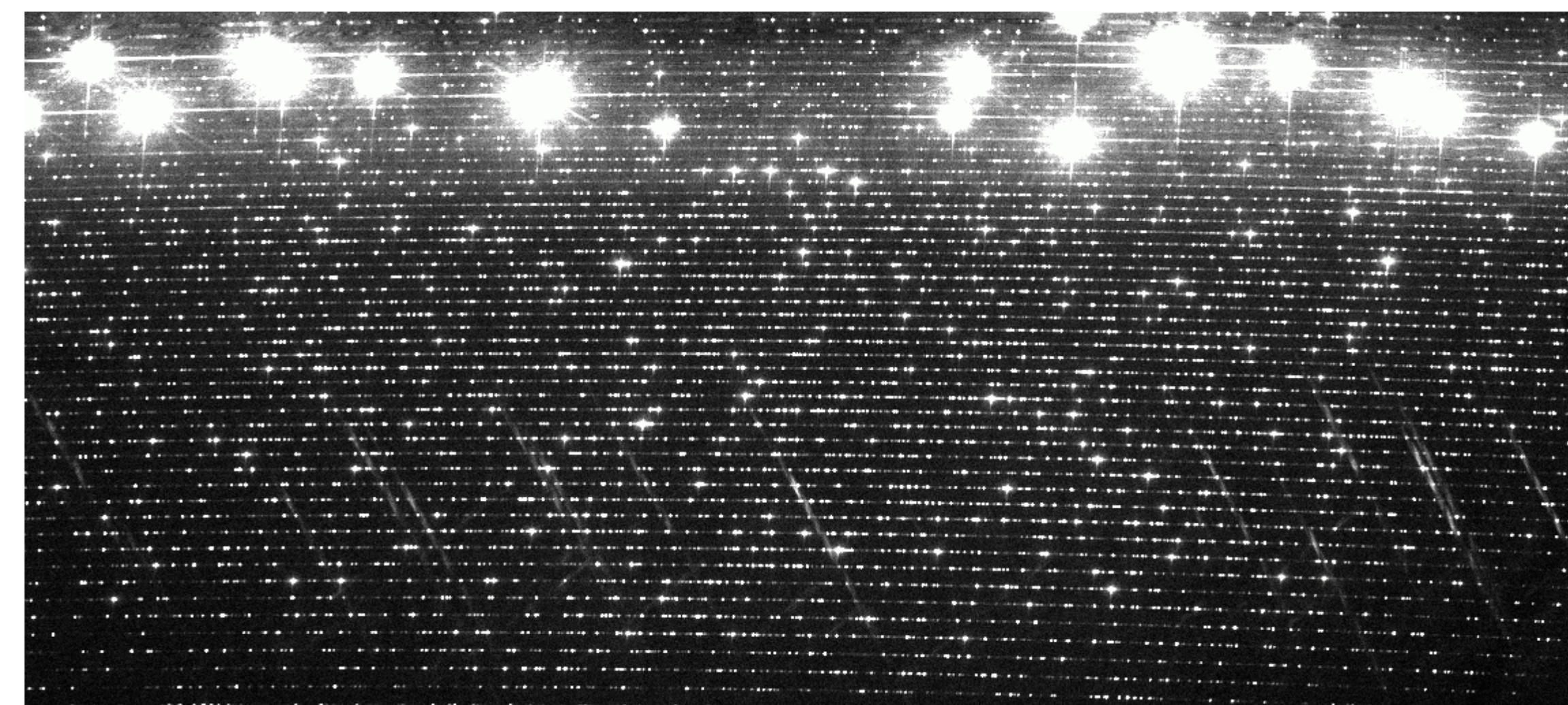
`ctres` is a quick-look task for multiple images with the same configuration reducing a list of raw spectrum images to dispersion-corrected multi-order echelle spectra with cosmic rays removed by `tcosmic`.

`ftres` reduces a list of raw flat, bias, or dark spectrum images taken with the same fiber size and binning by running `CCDPROC`, merging amplifiers, and removing cosmic rays with `tcosmic`.

Pipeline

The following tasks are running in order with optional interaction:

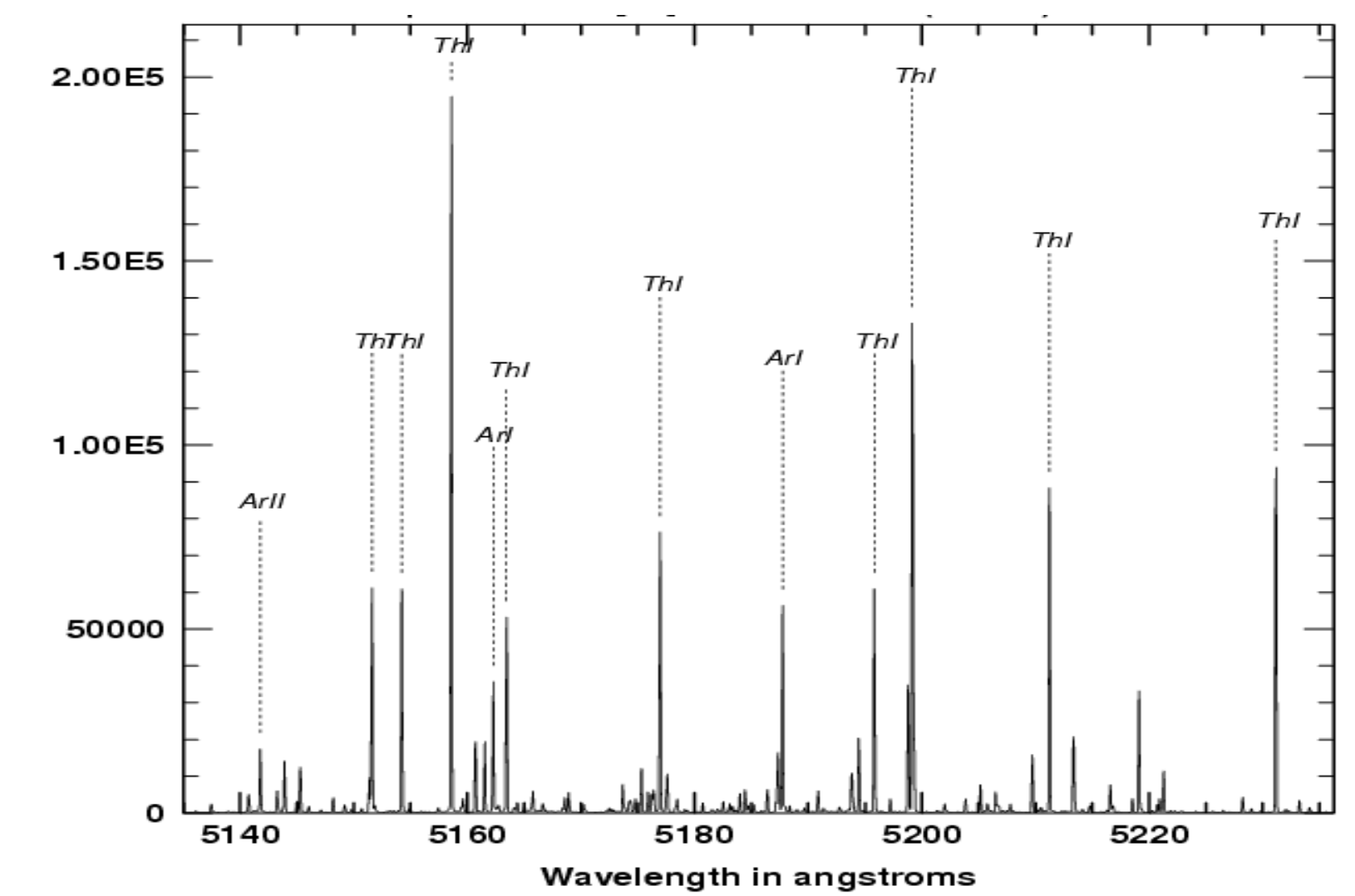
- `btres` Bias images (BIAS is object name) as an instrument check
- `dtres` Dark images (DARK is object name) as an instrument check
- `ftres` Flat field spectra (FLAT is object name) to create extraction functions, aperture flattening masks, scattered light masks, and throughput ratios
- `ttres` Thorium Argon spectra (COMP in object name)
Lists of raw ThAr spectrum images taken with the same fiber size and binning are extracted to dispersion-corrected multi-order echelle spectra by cross-correlating to a reference spectrum in pixel space, adding the resulting shift and refitting..
- `otres` Object spectra are then processed by the `trspoc` task which reads a list of lists of object observations.



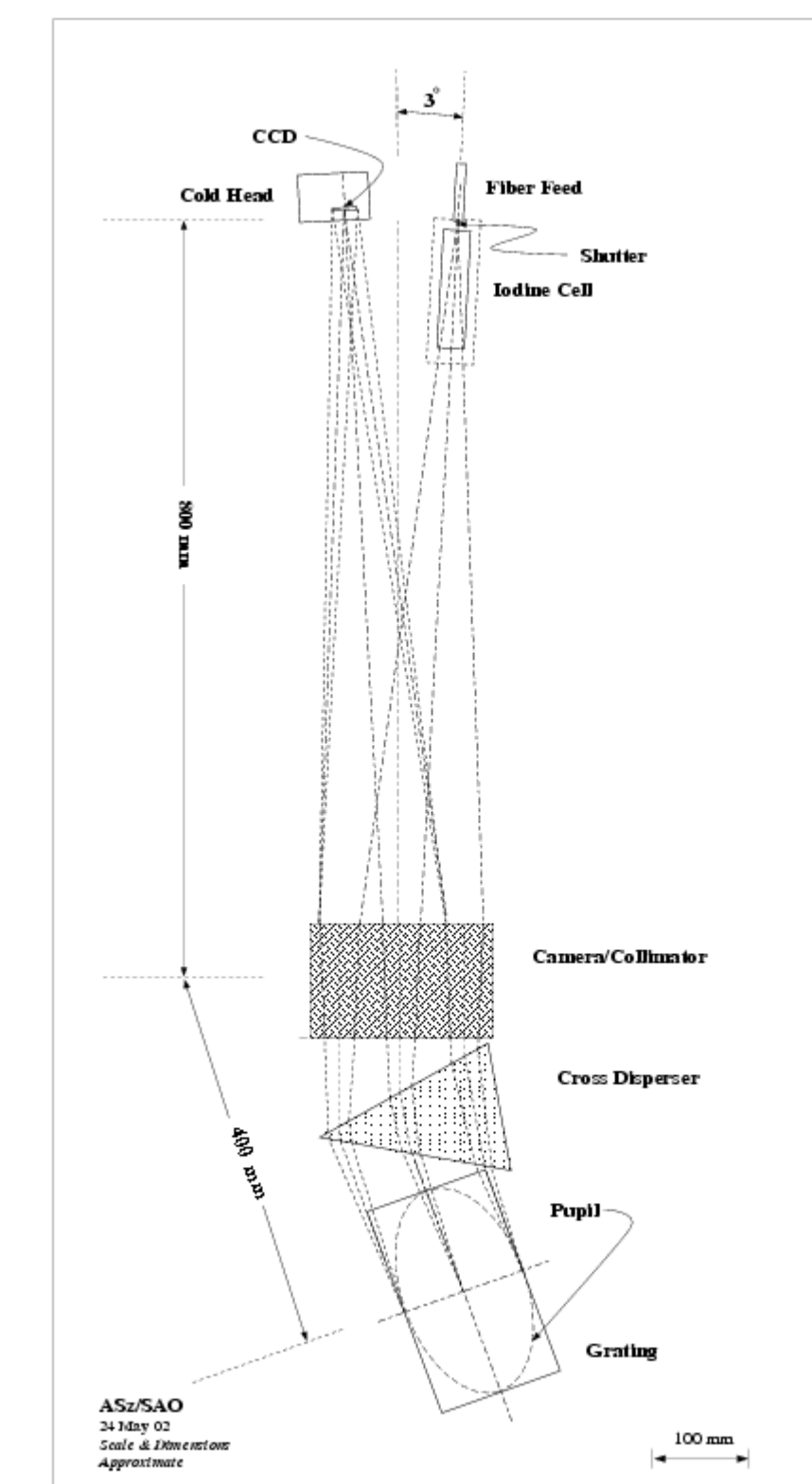
1024x2304 pixel Object Fiber 51-order ThAr Processed image

The Tillinghast Reflector Echelle Spectrograph (TRES) is a fiber-fed (object+sky and sky spectra) optical echelle spectrograph on the 1.5-meter Tillinghast telescope at the Smithsonian Astrophysical Observatory's Fred L. Whipple Observatory on Mt. Hopkins in Arizona.

An IRAF-based processing pipeline has been written to reduce spectra keeping the maximum wavelength precision, which varies from 0.03 to 0.07 Angstroms/pixel over 51 orders covering a range of 3850 to 9100 Angstroms. The same software which is used at the telescope for quick-look real-time processing can be used with relatively few parameter changes to produce data with more accuracy for scientific processing. Important features are portability and simplicity, so that scientists can re-reduce their data in various ways to optimize its quality for their needs. The use of a legacy of relevant software from both NOAO and SAO IRAF packages has made the task easier.



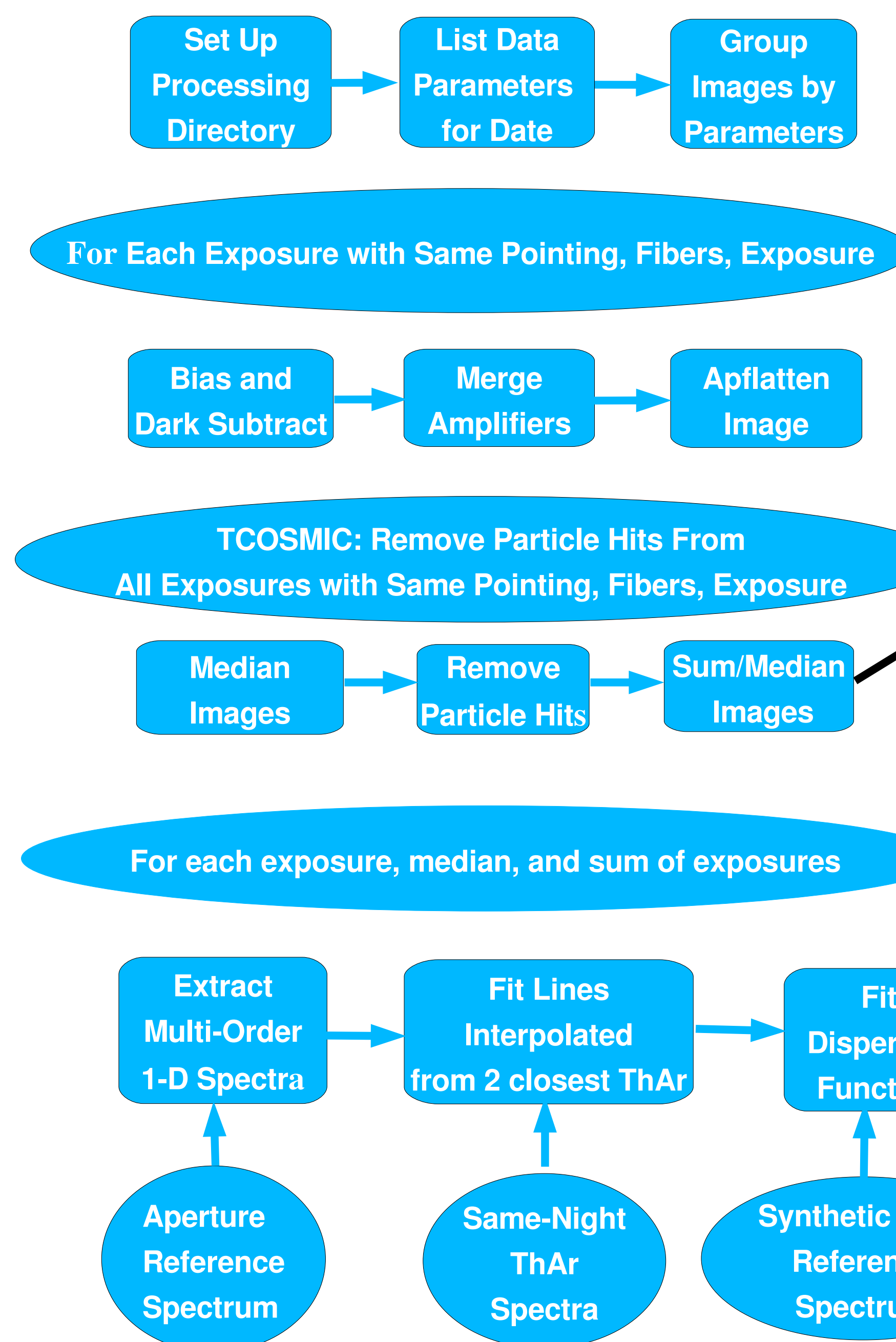
Reduced order of ThAr calibration spectrum at left



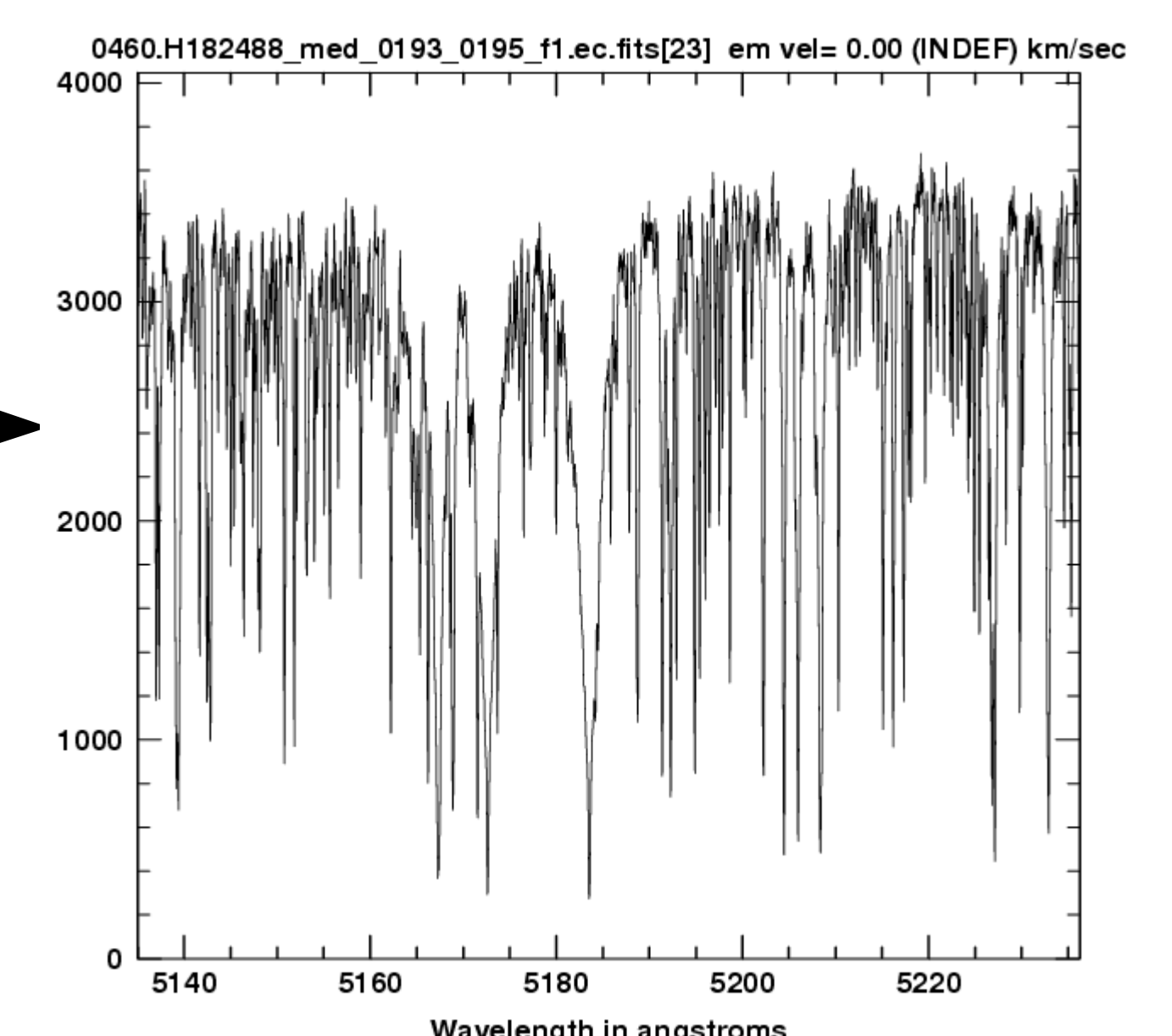
The TRES Spectrograph

The diffractive dispersion direction is out of the page at the CCD
Cross dispersion is in the plane of the page.

Processing TRES Data



Typical median processed object spectrum



One order of spectrum extracted from image above

