NIFS Python Data Reduction Pipeline

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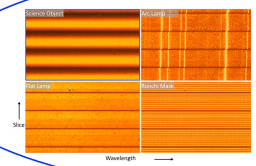
The NIFS Python Data Reduction Pipeline was developed to provide a complete package that reduce NIFS raw data and produce a final flux and wavelength calibrate science cube with the full Signal/Noise needed for science analysis. Most of the routine uses tasks that are inherent in the Gemini IRAF package for NIFS data reduction. The Pipeline is a set of python scripts that run under UREKA (http://ssb.stsci.edu/ureka/). Ureka is a collection of useful astronomy software that is generally centered around Python and IRAF. UREKA provides everything needed to run the data reduction packages provided by STScI and Gemini. The NIFS Python Data Reduction Pipeline runs from a simple command line and offers various option like :

- performing or not various steps (e. g. Telluric correction, flux calibration)
- Stop and start a specific step or the data reduction (e. g. stopping after all calibrations has been reduce, after the sky subtraction during science reduction)
- provide input for task like flux calibration or cube merging (e. g. spectral type, already shifted individual science cubes).

The pipeline can be found on the GEMINI Data Reduction User Forum (http://drforum.gemini.edu)!

Typical NIFS Data

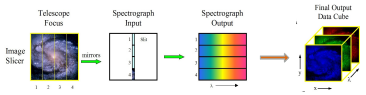


Files sorting tree

TARGET NAME/
- YYYYMMDD/ - date of observation
  - Calibrations/ - All baseline daytime calibrations from a specific date
  - Science Band/ - e.g. 'K' (if using multiple configs)
    - Acquisitions/ - acquisition frame taken on that date
    - obsID/- science data of that date (if split over >1 OT observation ID) and subsequent analysis
    - Telluric/
      - obsID/ - telluric data for this science obs of that date (if split over >1 OT obsID) and subsequent analysis
  - Merged/
    - YYYYMMDD_obsID - all science cubes and merged science cubes for a specific obsID
    - Target_Name_merged.fits - Final combined 3D cube

NIFS

Near-infrared Integral Field Spectrograph
Cryogenic slicer design
Z,J,H,K bands, R~5,000
One spatial setting: 3"x3" FoV & 0.1"x0.04" sampling
Optimized for use with AO
Science: young stars, exo-planets, solar system, black holes, jets, stellar populations, high-z galaxies....

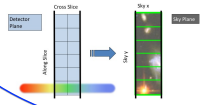


Typical NIFS Observation

- 'Before' telluric star
  - –NGS-AO
  - –Acquire star
  - –Sequence of on/off exposures
  - –Same instrument config as science (inc. e.g. field lens for LGS)
- Science observation
  - –Acquisition
  - –Observation sequence:
    - –Arc (grating position is not 100% repeatable)
    - –'After' telluric (if science >~1.5hr)
- Daytime calibrations:
  - –Baseline set: Flat-lamps (with darks), Ronchi mask' flats (with dark) and Darks for the arc
  - –Darks for science (if sky emission to be used for wavelength calibration)

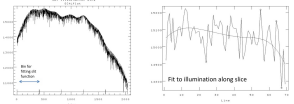
Rectangular Pixels

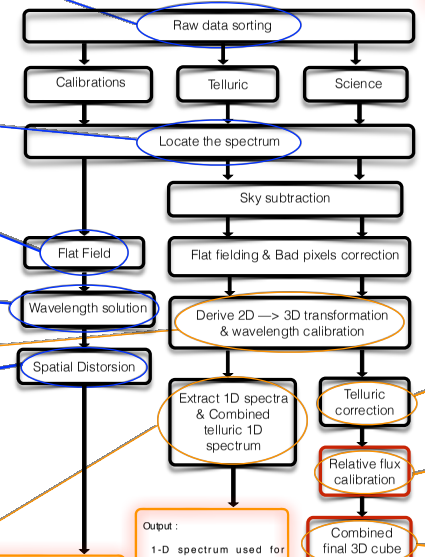
- NIFS has different (x,y) spatial sampling
- ***Along the slice*** is sampled by the ***detector***
- ***Across the slice*** is sampled by the ***slicer***
- Cross-slice sets spectral PSF - should be sampled on ~2 pixels
- Gives rectangular spaxels on the sky



Purpose : Locate the spectra on the detector and Correct for transmission and illumination. **Uses Gemini iraf tasks** (nfprepare, gemcombine, extract slices using nsreduce, nsflat and nsslitfunction for renormalization that account for slice-to-slice variations)

Calibration : Flat-Field

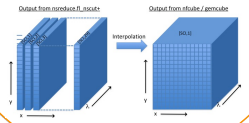




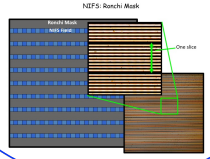
Purpose : Determine the Wavelenght solution of each slice.
Step 1: Repeat nfprepare, gemcombine and nsreduce to extracte slices
Step 2: identify the arc lines, and determine the dispersion function for each slice. Should run this interactively the first time through to ensure correct identification of lines and appropriate fit function
Result is a series of files in a 'database/' directory containing the wavelength solutions of each slice

Purpose : combines the '1D' dispersion and distortion solutions derived separately from nswavelength and nsdist into a 2D surface that is linear in wavelength and angular scale for each slice. Uses **Gemini iraf task** : nsfitcoords.
The output is essentially a data-cube (even though its not a cube...)

'Cube' = (x,y,λ) but does not have to be a rectilinear 3D array

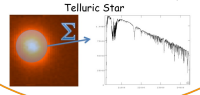


Purpose: Need to correct for distortions along the slices, and registration between slices.
This is done using the Ronchi mask as a reference. Analogous to wavelength calibration, but in spatial domain. **Uses Gemini iraf tasks** (nfprepare, gemcombine and nsreduce -> extracted slices; and nfsdist.



Purpose: Extract 1D aperture spectra from the data cube and create a final Combined 1D spectra. **Use Gemini iraf tasks**: nfextract uses a pre-defined aperture radius (centre is defined interactively) and sum spectra within it; gemcombine to create the co-added 1D spectra.

Telluric Star



Output :

-Shift reference file: "s"+calflat

-Flat field: "rn"+calflat+"_flat"

-Flat Bad Pixel Map (for DQ plane generation): "rn"+calflat +"_flat_bpm.pl"

-Wavelength referenced Arc: "wrn"+arc

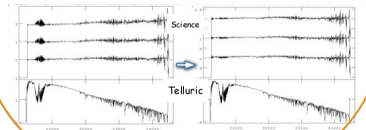
-Spatially referenced Ronchi Flat: "rn"+ronchiflat

Output :

1-D spectrum used for telluric calibration of NIFS science data. File name is "gxtfbrsn"+telluric.

The file prefixes are :
- g = gemcombined/gemarithed
- n=nfprepared
- s=skysubtracted
- r=nsreduced
- b = bad pixel corrected
- f= run through nffitcoords
- t = nftransformed
- x = extracted to a 1D spectrum

Purpose : Correct for Telluric absorption. Telluric spectrum is not only atmosphere, but also stellar spectrum: need to account for stellar absorption features (Pipeline offers to remove Hydrogen lines) and black-body continuum shape. **Uses Gemini iraf task** : nftelluric.



Output:

- A set of 3-D data cubes that have been sky subtracted, flat fielded, cleaned for bad pixels, telluric corrected and rectified into a cohesive datacube format. Files are called: catfbrgn+science
  The prefixes are similar than for the telluric reduction, plus :
  - a = corrected for telluric absorption features
  - c = rectified to a 3D datacube
- Merged cubes for each observation (ie. DATE_obsID.fits)
- Final combined cube for this target with full S/N.

Purpose : Convert flux in science cube to units of ergs/s/cm2/Å

Method: The relative flux-calibration is obtained using the telluric star which allows to take into account the throughput of the atmosphere+telescope+instrument. :

(1) Divide science cubes by the combined 1D telluric spectrum spectrum, multiply by the f-lambda BlackBody function for the temperature of the telluric, and scale by the magnitude of the Telluric.
(2) Scale by the exposure times of the target observation and the Telluric observation.

note: spectral type (e. g. A0V) and magnitude of the star can be given as input. Otherwise, the pipelie will execute a SIMBAD query to find these information.

Purpose : Produce one final combined science 3D cube from all observations.

Method :
- set the zero point p and q offsets to the p and q offsets of the first cube in each sequence (assumed to have a p and q of 0)
- find the p and q offsets of the other cubes in the sequence
- calculate the difference between the zero point offsets and the offsets of the other cubes and convert that to pixels
- write all offsets to a text file
- For bright target trim to the same dimensions and position as the zero point offset image.
- copy the merged observation sequence data cubes to the Merged directory
- merge all the individual merged observation sequence data cubes

Uses Gemini iraf tasks : gemcombine/nifcube for x axis and imcombine for y axis.
note : User can provide already shifted cubes (need name as "shif*.fits") then the pipeline just combines those shifted cubes

offsets.txt

x	y	λ
0	0	0
10	10	0
-10	10	0