CFHT Data Processing and Calibration Pipeline for WIRCam: I'iwi (near-IR imaging)

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Highlights of I'iwi 2

I'iwi 2, the current data processing pipeline for WIRCam, the wide-field near-infrared (NIR) imager at CFHT, underwent significant enhancements during semester 2010A, chief among which are:

✓ Multi-machine parallel computation to handle the enormous data volume from WIRCam, and thus achieve a speed up of ~30% compared to the earlier sequential processing pipeline.

✓ A distinct goal driven approach (each module targets the creation of only one data product and all associated dependencies)

✓ The important capability of being aborted and restarted at any point (during an abort, incomplete data products, all associated byproducts and temporary files are cleaned on all machines, and all ongoing CPU processes are terminated; this ensures 'clean' restarts).

✓ For optimal NIR sky estimation, the use of several new strategies (Nodding DP, Wide DP, User DP) in response to PI demands.

✓ Photometric zero point calibrations being done with both standard stars and 2MASS stars in every camera run.

✓ The generation and use of weight maps and pixel masks in the reductions for each exposure.

✓ Distribution of six data products (see Fig. 1), and the complete set of calibrations to the PIs in an easy-to-use web interface.

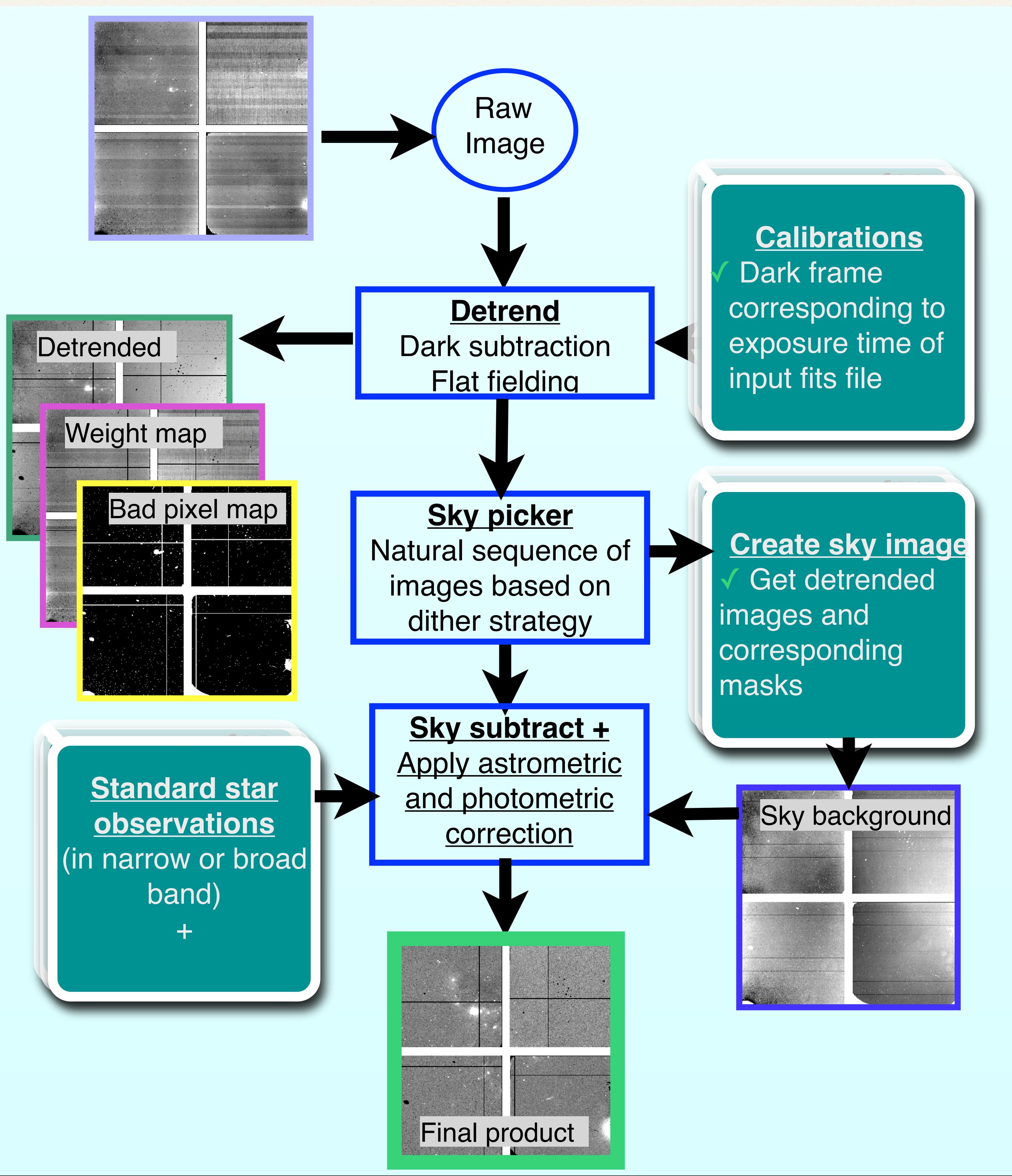
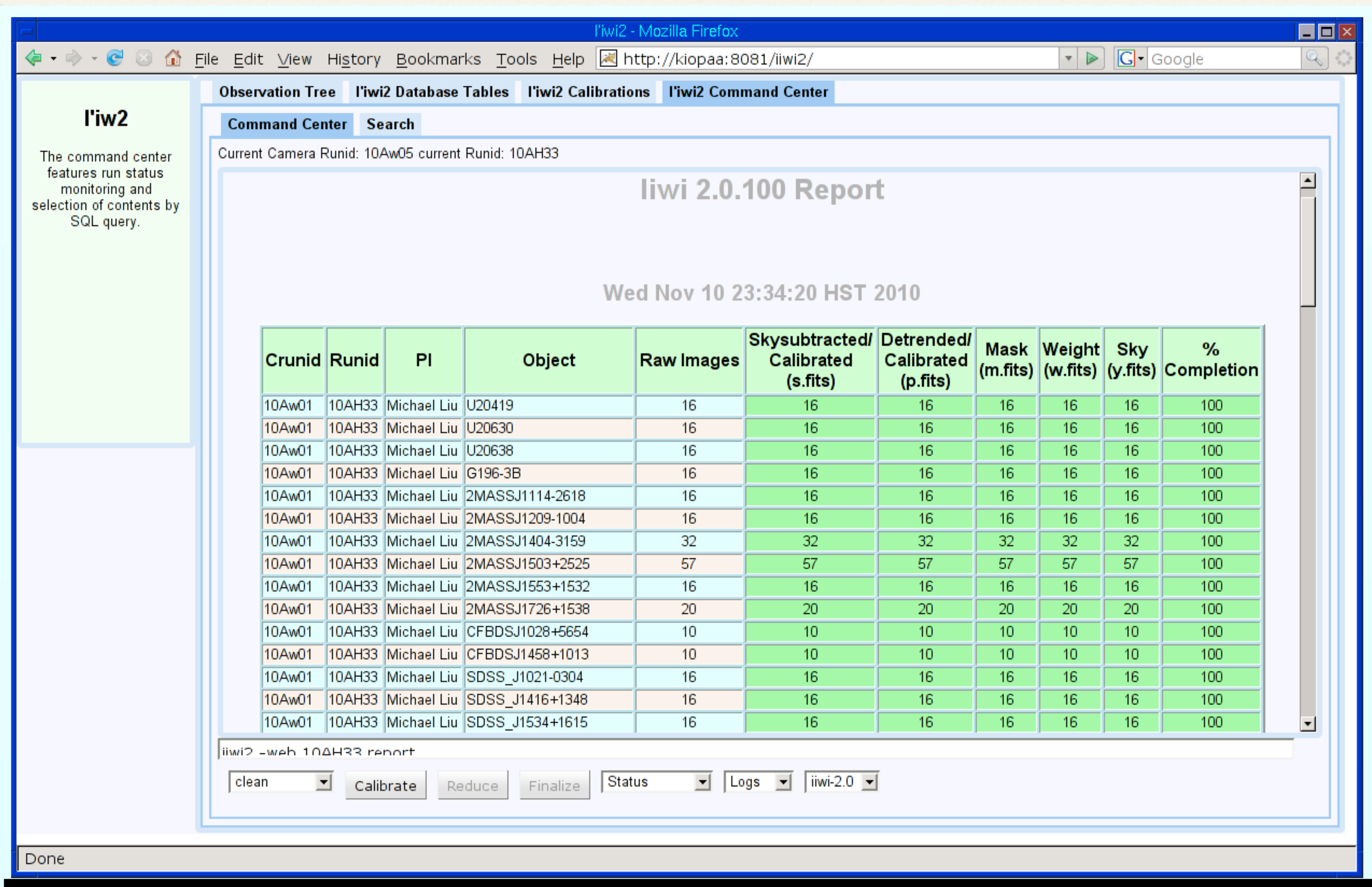


Figure 1.Data flow during I'iwi 2 processing on a single image, with samples of all the data products

Automation & Parallel Processing

By incorporating a multi-machine parallel driver, I'iwi 2 automates and optimizes all aspects of WIRCam data processing and calibration for maximum throughput. Computing resources to use (CPUs, storage disks, etc) may be easily set based on availability. Each data product is created in an individual module (atomically). Modular design permits the processing to be aborted and restarted "cleanly" - the pipeline, though running multiple processes on multiple machines, may be safely stopped at any time (automatically cleans up incomplete products and running processes); when processing resumes, the pipeline automatically picks up where it left off. Processing is very flexible, being able to reduce an entire Camera Run with a single command, to reducing a particular PI program crossing multiple camera runs, to reducing a single image. All processing parameters are taken from a database with a flexible web interface, shown in Fig 2. The interface permits easy browsing of database tables and processed calibrations, as well as to enable/ disable use of particular data. Processing parameters may be changed as required. Thumbnails of science data product images are also available for quality evaluation purposes. In addition it is possible to monitor status and reports on ongoing reductions.

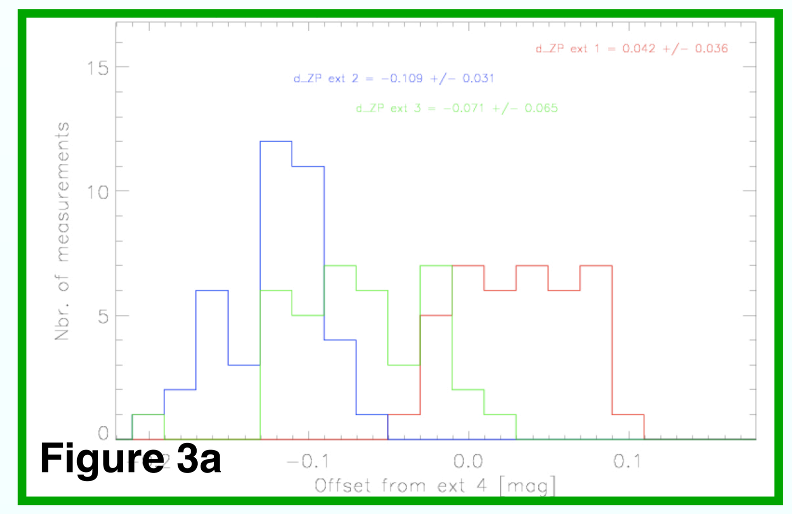


Crunid	Runid	PI	Object	Raw Images	Skysubtracted/ Calibrated (s.fits)	Detrended/ Calibrated (p.fits)	Mask (m.fits)	Weight (w.fits)	Sky (y.fits)	% Completion
10Aw01	10AH33	Michael Liu	U20419	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	U20630	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	U20638	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	G196-3B	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	2MASSJ1114-2618	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	2MASSJ1209-1004	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	2MASSJ1404-3159	32	32	32	32	32	32	100
10Aw01	10AH33	Michael Liu	2MASSJ1503+2525	57	57	57	57	57	57	100
10Aw01	10AH33	Michael Liu	2MASSJ1553+1532	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	2MASSJ1726+1538	20	20	20	20	20	20	100
10Aw01	10AH33	Michael Liu	CFBDSJ1028+5654	10	10	10	10	10	10	100
10Aw01	10AH33	Michael Liu	CFBDSJ1458+1013	10	10	10	10	10	10	100
10Aw01	10AH33	Michael Liu	SDSS_J1021-0304	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	SDSS_J1416+1348	16	16	16	16	16	16	100
10Aw01	10AH33	Michael Liu	SDSS_J1534+1615	16	16	16	16	16	16	100

Figure 2.The I'iwi 2 web interface to show the status of processed programs, for monitoring process parameters, and browsing of database tables, calibrations and data products.

Photometric and Astrometric Calibration

I'iwi 2 computes photometric zero points for each camera run instead of just once at the end of the semester. Absolute zero point calibration is obtained using broad and narrow band standard star observations, observed each night under photometric conditions. Relative zero point offsets between the four CCD chips (Fig 3a) are computed using 2MASS stars in the standard star fields; we bootstrap available JHK magnitudes from 2MASS catalog for the narrow band filters. Celestial coordinates of 2MASS stars in each science image are used for *linear* astrometric correction; as a policy, no pixel re-sampling is permitted during data processing. With the current algorithms, we estimate ~10% error in photometry, and < 2" astrometric error though there are clear trends seen across the mosaic (Fig 3b).



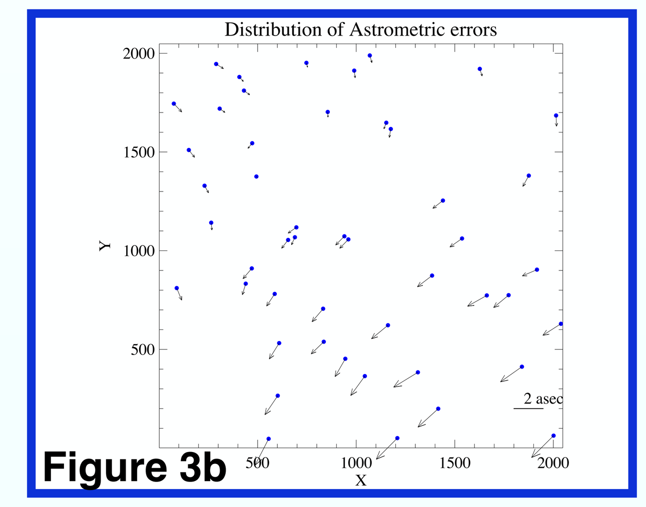


Figure 3a: The relative chip-to-chip offset in photometric zeropoints computed with 2MASS catalog. Figure 3b: The distribution of astrometric errors along the chip in second quadrant. The mosaic center is the top-left corner.

Web interface for PI data distribution

We have designed an easy-to-use web interface (Fig 4) for the distribution of data products to the PIs. For each program, a password protected webpage is created and the PI informed as soon as the observations are started and raw files are available, with regular updates as the data are processed. Once the program is complete and the data have been fully processed, the PI is again informed about the data products ready for download.

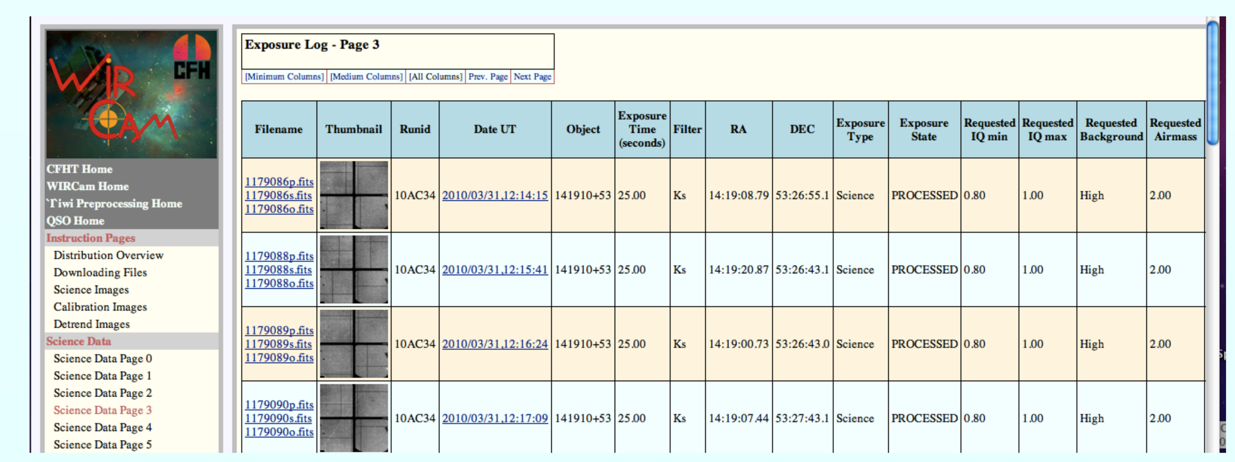


Figure 4: The distribution interface for PIs.

Summary & Future Developments

We have implemented all the major upgrades to I'iwi 2 in automation and parallel processing, sky estimation strategies and zero point calibrations. It is currently under production mode for the processing and release of the ongoing 2011A PI data.

Our I'iwi 2 experience has helped identify changes in the process which will yield further boost in speed (eg, collapsing multi-slice cubes prior to sky image construction). The complete IDL script will be replaced with a compiled programming language such as C to gain ~10x increase in speed, *and avoid licensing needs*. We plan to implement a *second pass* of sky subtraction using stacked images of the *p.fits images for constructing high S/N sky images. By mapping distortions in the WIRCam camera optics, we aim to better characterize the instrument with gains in both flat fielding efficiency and in astrometric and photometric calibrations. IDL script, we plan to use a lower level computing language to enhance the system performance as well as the accessibility and user interactions.