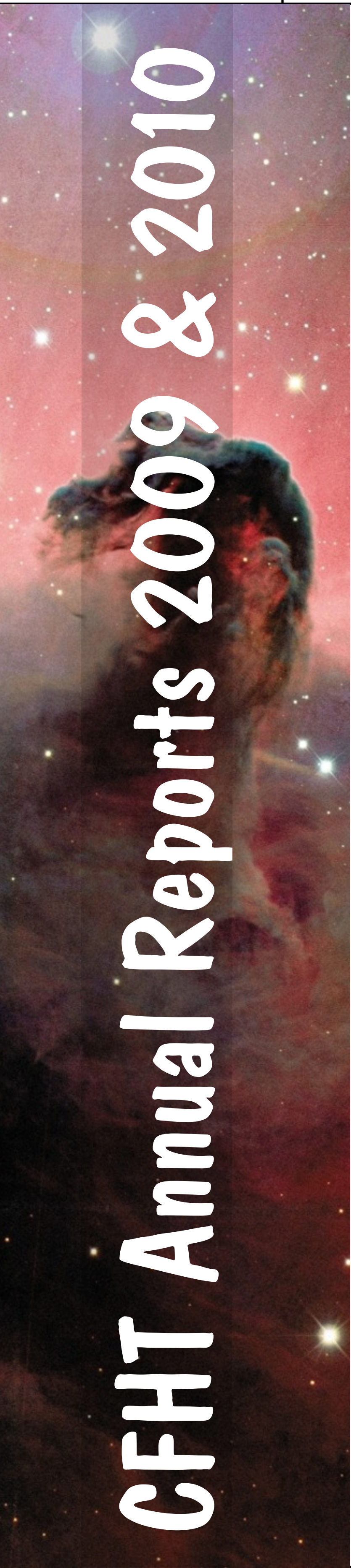
Canada-France-Hawaii Telescope

Annual Reports

2009 & 2010



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Babas, Ferdinand	Assistant System Administrator
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Barrick, Gregory	Optical Engineer
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Ho, Kevin	Instrument Manager
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Warren, DeeDee	Director of Finance & Admin.
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CFHT Executive

Christian Veillet - Executive Director
Daniel Devost - Director of Science Operations
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Director's Message

Christian Veillet
CFHT
Executive Director

Two Years in One Report! 2009 and 2010 were very busy indeed. Much work was accomplished on important in-house projects. Key decisions were made on future instrumentation. A well-attended Users' Meeting was organized for the first time outside Canada and France. The number of scientific papers based on CFHT data, as well as their impact, kept increasing. At the end of 2010, a new community decided to join the CFHT `ohana. Is being so busy a valid excuse for not publishing an Annual Report in 2009? Certainly not! My apologies go to the regular readers of the Annual Report, who missed one year, hoping that their disappointment will be compensated by reading this two-in-one issue and the many interesting news it offers.

2009 and 2010 represented a period of transition for CFHT, from the completion of the Golden Age Plan (GAP) to the preparation of the CFHT Decade Four (CD4) Plan. The GAP, implemented in 2004 to cover the period 2004-2010, was developed as a business plan and a framework in which CFHT would accomplish a well-defined set of goals: end the GAP with a balanced budget, contain the operation costs as much as possible, decrease the time lost on the sky due to failures while maintaining or even improving the quality of services rendered to the users of the telescope, and develop the users' base beyond the CFHT Member Agencies (Canada, France, and Hawaii) through collaborative agreements with new communities. At the onset of the GAP, CFHT committed to reach these goals and the Agencies committed to follow a funding plan which included a reasonable increase of their annual contribution to the operation budget of the observatory.

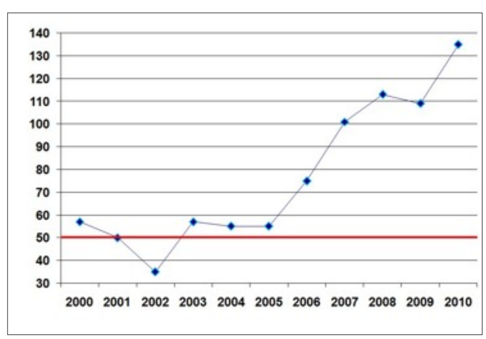
The GAP is now completed and all the goals established back in 2003/2004 have been reached:

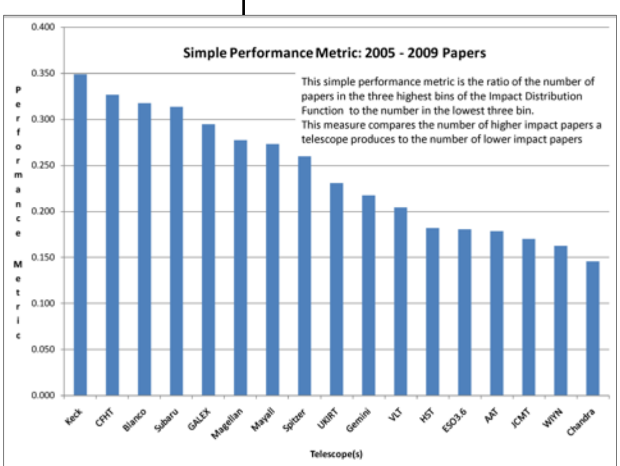
• The fraction of clear weather lost to problems has been under 2% for both 2009 and 2010, even though 2% seemed more like a dream than a reachable target six years ago. It was made possible through the amazing work of all involved in the maintenance of the observatory as a whole (telescope, dome, instruments, operations, …) and by the side effects of the Observatory Automation Project (OAP, see p. 20).

• Operating costs have been contained as much as was possible without compromising the quality of the CFHT's products. Actually, many improvements were made on the way, from moving to Queue Service Observing on the three main instruments to continuously improving the quality of the reduction pipelines (such as I`Iwi-2 for WIRCam, p. 9) and the Phase1/Phase2 process, including implementing new modes of observations to enhance the scientific outcome of the observatory (see for example the Staring Mode, p. 11).

• Over-subscription on telescope time, often called "pressure", is a measure of how much the telescope is in demand by its users. A pressure of two or more is often considered healthy, though many claim that it is more important to check if the observing programs scheduled on the telescope are of good scientific quality. At CFHT, the pressure on normal (PI) programs moved up and down with the scheduling of Large Programs, averaging 2.6 over the duration of the GAP and 2 over 2009 and 2010.

• According to the GAP goals, the number of publications based significantly on CFHT data was to stay above 50 for its duration. As can be seen on the graph on the right, this number actually increased dramatically, reaching more than 120 in 2010! In 2009, only Keck and the VLT published (per telescope) more papers than CFHT. Quantity is definitely there, but what about quality? The graph on the left shows statistics (*D. Crabtree, private communication, 2011*) on a simple performance metrics: the fraction of the number of "high impact" papers over "low impact" ones for the main observatories world-wide. Here, CFHT is second only to the Keck Observatory.





• The GAP also included goals that concern the staff of the Observatory, such as high staff retention as a measurement of staff satisfaction, and a better adequacy of the staff complement to the needs of the Corporation. Staff turnover has been very low in the recent years. Each departure has been an opportunity to assess the need for rehiring, either on the same job description or another one more critical to the future operation of the observatory, or not hiring at all. The staff complement of around 44 persons projected for the end of 2011, once OAP is fully operational (see p. 23 for details), includes nine Resident Astronomers, among them the Executive Director and the Director of Science Operations. CFHT will then be at a place at which the staff will be essential for smooth operations and an efficient participation in the ongoing or planned development of the first half of the new decade.

CFHT was recognized as one of the Best Places to Work in Hawaii in the Medium Companies category.

The ninth CFHT Users' Meeting was held in Taipei, Taiwan, in November 2010. The Academia Sinica Institute of Astronomy and Astrophysics (ASIAA) hosted the meeting. It was the first time that CFHT held its triennial Users' Meeting outside one of its three member nations, acknowledging the importance of the ongoing collaboration with ASIAA, which started in 2001 and is now in its 10th year. As with South-Korea in the past and with Brazil since 2009B, such collaborations bring to CFHT new users and many opportunities to gather a wider community around scientific projects as well as instrument design and fabrication. This Users' Meeting, nicknamed "CFHT Decade 4", came after the celebration of CFHT's 30th birthday in 2009, and at a time when users and member agencies were defining with the observatory its development plan for [2011-2020]. New instrumentation was one of the hot topics of the meeting.

The development of new instrumentation is indeed an important component of CD4. At the end of 2010, two instruments were selected for a Phase B: (1) SITELLE, an imaging FTS (Fourier Transform Spectrograph) based on a prototype operational at Mont Mégantic (Quebec), will be developed and funded mainly on Canadian funds as a guest instrument (like ESPaDOnS). (2) SPIRou, an ESPaDOnS in the near-IR, is a spectro-polarimeter covering the near-IR (up to K band), but aiming also at providing high-precision (1m/s) radial velocity measurements. The SPIRou team will have to develop a new Management Plan before moving forward to Phase B sometime in 2011. Sadly, GYES, a wide-field multi-object spectrograph, was not selected in spite of the excellent work done by an energetic team which performed a Phase A starting late in the game and without CFHT’s support. We are hopeful that the team will find opportunities to develop a similar instrument on another telescope. By the end of 2010, a decision about the future of `IMAKA was still pending, as its feasibility study was not yet completed (more on new instrumentation p. 24).

Another hot topic of the Users’ Meeting was the future of the Observatory beyond 2020, triggered by the resurgence of the old idea of replacing the current 3.6-m telescope by a 10-m dedicated to wide-field multi-object spectroscopy. This time, the idea was not just promoted by CFHT, but also by one of the CFHT communities (Canada). Nicknamed NGCFHT, this project will develop further in 2011, hopefully with much participation from the CFHT players.

The skyline of the Xinglong Observing Station of National Astronomical Observatories, Chinese Academy of Sciences.

After informal contacts with Chinese colleagues followed by a tour of some of the main astronomy institutes in Beijing, Nanjing, and Shanghai in the spring of 2010 and more talks with NAOC (National Astronomical Observatory of China) later in the year, Chinese colleagues attended the Users’ Meeting in Taipei. An announcement was made at the end of 2010 that CFHT would be part of the NAOC Telescope Access Program (TAP), a program *1) to allow Chinese astronomers to lead cutting-edge optical-IR observational programs, 2) Build the base of experienced optical-IR observers in China, 3) Facilitate collaboration between astronomers within China, and between astronomers in China and those in the user communities of telescopes participating in TAP, 4) Provide complementary observational facilities to ongoing large projects*. Beyond CFHT starting in 2011B, TAP will also give access to Palomar Hale, the MMT, and later the Magellan telescopes. Through the Collaborative Agreement with Brazil, Brazilian PIs used 7 to 8 nights of CFHT time per semester and a Brazilian Resident Astronomer joined the astronomy group in mid-2010 (see Comings and Going, p. 29).

Important in-house projects were completed in 2009 and 2010, such as the Mauna Kea Atmospheric Monitor (MKAM) or the All-Sky Infrared and Visible Analyzer (ASIVA), installed and maintained by CFHT for the benefit of all the Maunakea Observatories. `OHANA `Iki had its first fringes with the `OHANA interferometer. The dome venting project started to take shape, based on an extensive study of MegaPrime delivered image quality (more information below).

2009 and 2010 were extremely fruitful, thanks to a highly dedicated and skilled staff and very supportive communities and agencies. They laid the ground for yet another decade of CFHT’s excellence at the forefront of astronomy with exciting projects for its mid-term future and much potential for its fifth decade.

Good news for ESPaDOnS!

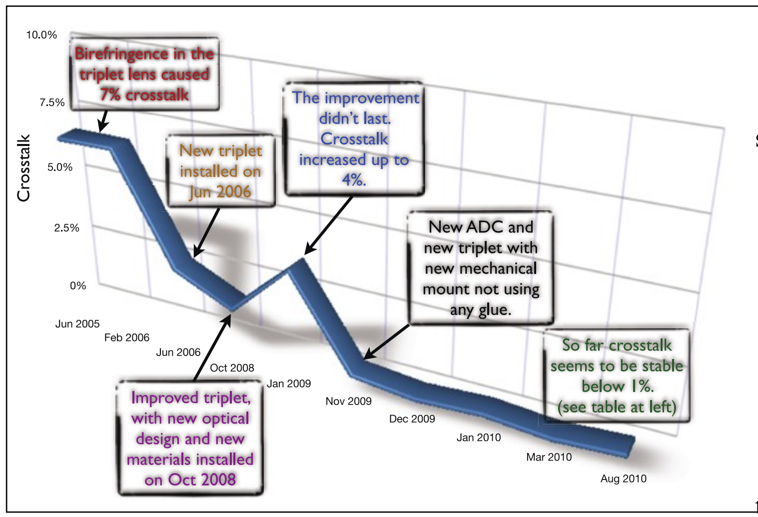
E. Martoli

ESPaDOnS is CFHT's cross-dispersed echelle spectropolarimeter, and is one of its 3 main instruments. Polarization crosstalk had been an issue since the commissioning of the instrument, and started at a level of 7%.

Replacing one triplet lens decreased the level of crosstalk to 2-4%, but it was not until the fabrication of a new triplet (with a new design, new materials, and a new mechanical mount not using any glue at all), and installation of a new ADC (Atmospheric Dispersion Corrector) that the level of crosstalk was brought below 1%, in Nov 2009. To further improve the overall performance of the instrument, CFHT has initiated the DANCE project, to replace the current EEV detector by a deep-depletion device that has much better cosmetics, better QE and less fringing in the red, and shorter read time by using its 2 amplifiers. Recent on-sky tests with this new device, called Olapa, are encouraging. In parallel with hardware improvement, CFHT has also embarked in the OPERA project, which will offer ESPaDOnS users an open-source pipeline for the reduction of its data.

Crosstalk

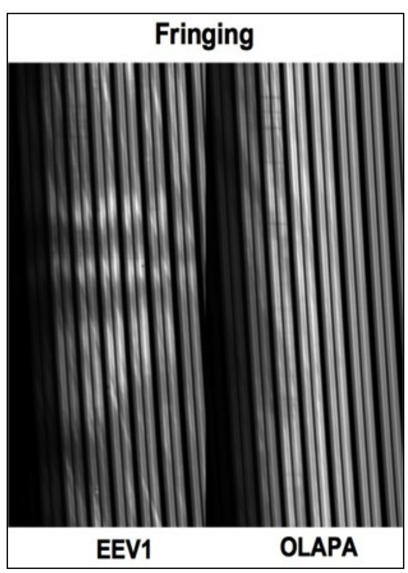
Crosstalk is the contamination of one Stokes parameter by another. In ESPaDOnS, crosstalk is caused by stress birefringence in a triplet lens and in the ADC. The evolution of CFHT developments to minimize this problem is shown on the chart below. The most recent results of on-sky tests performed with the new optical elements indicate a total crosstalk below 1% as shown in the table below. Some of the crosstalk left, along with its variation, is due to the ADC, which still exhibits stress birefringence that changes as function of telescope's position.

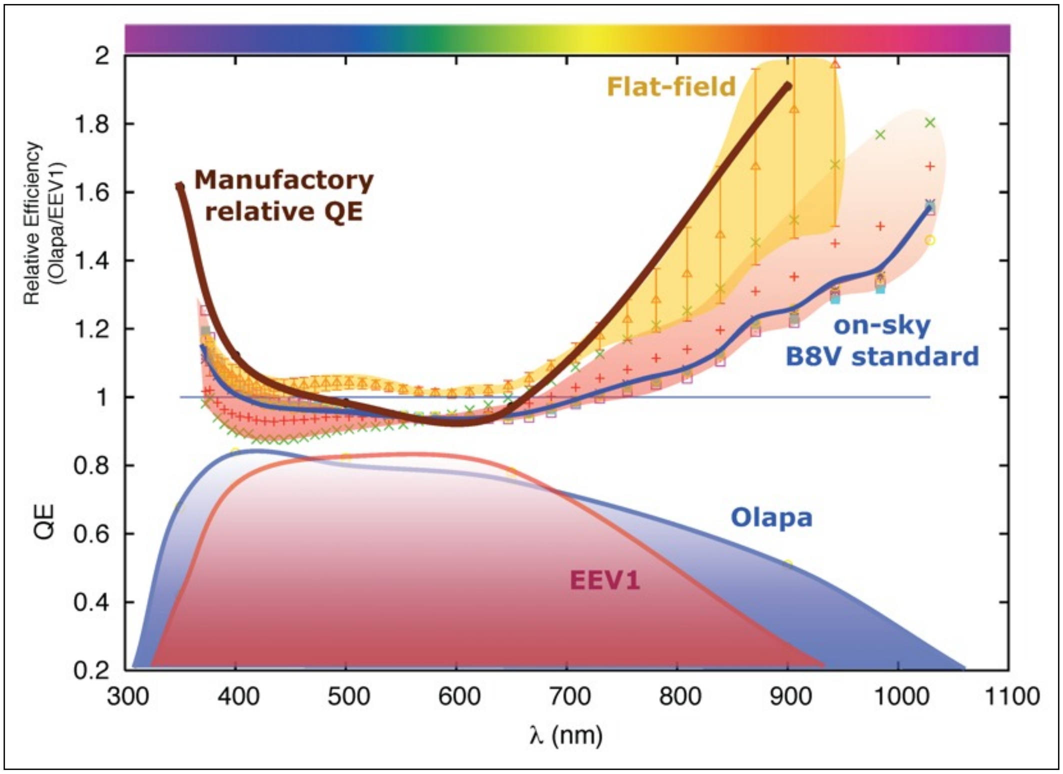


Date	Nov 2009	Dec 2009	Jan 2010	Mar 2010	Aug 2010
X-talk	0.70%	0.46%	0.59%	0.40%	0.55%

Dance Project

DANCE (Dual Amplifier New CCD for ESPaDOnS) is one of CFHT's in-house instrument projects that aim to provide an improved and faster CCD for ESPaDOnS. The new chip is called Olapa and it has the same physical characteristics as the previous CCD, but with an improved performance and less overhead time. We have recently performed lab and on-sky tests with Olapa, which showed significant improvements like read-out noise reduction, better sensitivity in the red, less fringing, and faster read-out. The comparative results between Olapa and the old EEV1 chip are presented on the left and below. Olapa is expected to be offered, in one amplifier mode, for semester 2011A.

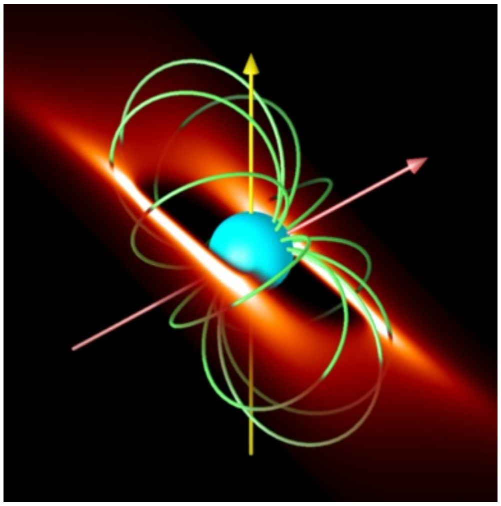




OPERA Pipeline

OPERA (Open-source Pipeline for ESPaDOnS Reduction and Analysis) will be an open-source software reduction pipeline for ESPaDOnS. The idea of OPERA is that CFHT will host an open-source project to build a reduction and analysis tool for echelle spectrograph data, such as ESPaDOnS. This will be an alternative option to the current system, which is not available for distribution and thus can not be accessed by CFHT users. With OPERA, the scientists will be able to modify and build tools to complement the standard reduction system as well as to tune down the system for their own scientific needs. For more information please visit our *souceforge* project site: http://sourceforge.net/projects/opera-pipeline/

Magnetism in Massive Stars (MiMeS)



A theoretical model for the glowing plasma in the magnetosphere of a magnetic massive star.

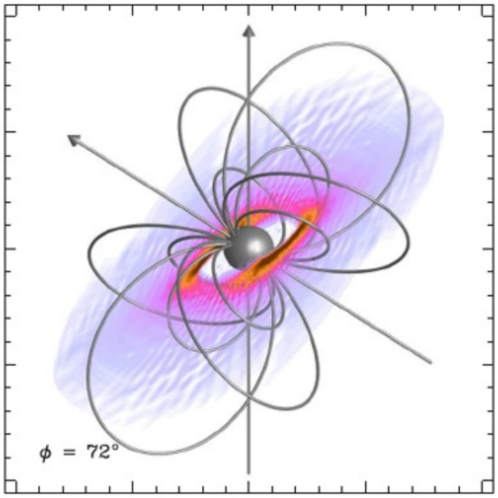
Credit: R. Townsend.

N. Manset

The magnetic fields of hot, high mass stars which have initial masses above about 8 times that of the sun are qualitatively different from those of cool, low-mass stars similar to our Sun. Those fields are detected in only a small fraction of stars, and they are structurally much simpler, and frequently much stronger, than the fields of cool stars.

The Magnetism in Massive Stars (MiMeS) Large Program conducted with ESPaDOnS employs two strategies to help improve our knowledge of magnetic fields in massive stars. First of all, about half of the observing time is spent observing known magnetic stars in detail, getting snapshots of their magnetic field strength and configuration.

This Targeted Component of the large program is following over 2 dozens stars over time in order to get high-precision and high-resolution sampling of the rotationally-modulated circular, and sometimes linear, polarization line pro-



Sigma Ori E is a young star with a very strong magnetic field in a tilted dipole configuration. Material blown away from the star in a wind is confined by the magnetic field, builds up, and periodically breaks out of the magnetosphere. The mass loss slows down the rotation of the star, by 7 ms per year.

Credit: R. Cohen.

files. The information is used to reconstruct maps of the magnetic field.

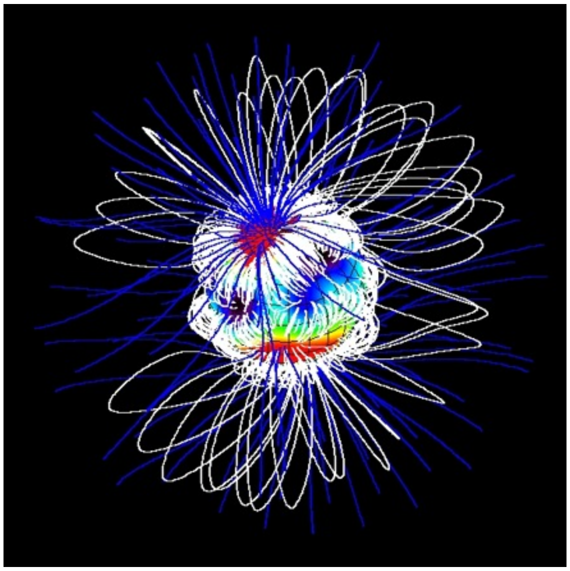
The second part of the LP is a Survey Component which looks for previously unknown magnetic massive stars from an initial list of about 200 stars.

A little over halfway through the 9 semester program, the international collaboration has acquired over 1250 high-resolution polarized spectra of about 150 individual stars, and discovered new magnetic fields in over a dozen hot and massive stars, out of the hundred or so which have been observed so far. Other notable results include the detection of magnetic fields in the 2 most rapidly-rotating known magnetic stars, which rotate in about only half a day, and in the most massive known magnetic star.

MAgnetic Protostars and Planets (MaPP)

N. Manset

MaPP (MAgnetic Protostars and Planets) is a CFHT Large Program that investigates the role of magnetic fields in the formation of stars and planetary systems, especially stars with a mass similar to that of our Sun. MaPP focusses especially on the core regions of protostellar accretion discs - including the newly born star.



Magnetosphere of the cTTS V2129 Oph, extrapolated from the surface magnetic map derived from spectropolarimetry of both photospheric lines and accretion proxies. Open and closed field lines are in blue and white, respectively; colors at the surface depict the radial field component, with red and blue corresponding to positive and negative polarities (from Donati et al. 2007; Jardine et al.i2008)

Started during semester 2008B, this large program has already followed 15 of the 20 or so young stars on its list. By the time it ends during semester 2012B, all targets will have been followed closely, sometimes at two different epochs separated by a few years. Typically, each star is observed one or more times each night for 10-16 consecutive nights, with the spectropolarimeter ESPaDOnS, allowing astronomers to map the magnetic fields as the star rotates on itself from night to night.

By comparing the observations and maps of magnetic fields with the predictions of new theoretical models and magnetohydrodynamic simulations,MaPP will answer several major open questions on star formation and produce updated models incorporating the effect of magnetic fields. Already, MaPP has found a non-stationary magnetic field configuration on V2129 Oph, with changes noticeable within only 4 years. The magnetic field is poloidal and axisymetric, and the observations show a dark photospheric spot and a localized area of accretion-powered emission, in agreement with recent 3D magnetohydrodynamic simulations specific to this star.

Variability on a timescale of one only year was also observed on AA Tau, which also has a mostly poloidal magnetic field. The circular polarization data suggest that the accreting material in the inner disk regions is mostly being expelled outward instead of getting to the surface of the star. This phenomenon in the end slows down the spin on the star.

The MaPP Large Program is confirming that magnetic fields indeed play a key role in the formation and early evolution of stars, through accretion and ejection processes.

I'iwi 2, the CFHT data processing and calibration pipeline for WIRCam

K. Thanjavur, D. Teeple, C-H. Yan, D. Devost, K. Withington, S. Arnouts, and E. Martioli

1. Introduction

During semester 2010A, we upgraded the WIRCam data processing and calibration pipeline, *I'iwi*, current version 2, with significant enhancements to the data quality and processing speed. Due to the enormous WIRCam data volume, we have replaced the sequential processing of the earlier pipeline with multi-machine parallel computation to achieve a reduction ~30% in calibration and data processing times, compared to the earlier I'iwi version. I'iwi 2 is driven by distinct goals (creation of each data product and all associated dependencies), and thus incorporates in its design the important property of being able to abort and restart the process at any point. For optimal near infrared (NIR) sky estimation, in addition to the standard dither pattern (DP), we have incorporated several new strategies (Nodding DP, Wide DP, User DP) in response to PI demands. Zero point calibration is done with both standard stars and 2MASS stars in every camera run. Weight maps and masks are generated and used in the reductions for each exposure. Six data products and the complete set of calibrations are distributed to the PIs in an easy-to-use web interface. Here we present the salient features and advantages of I'iwi 2.

2. Data processing with I'iwi 2

Each exposure of a PI program undergoes a consistent series of processing steps, illustrated with the flowchart in Fig 1. The input raw image (*o.fits) is first detrended to remove all instrumental signatures using the appropriate calibrations, namely the master twilight flat field for that filter, a dark current frame for the corresponding exposure time, and a bad pixel mask to account for chip cosmetics. Three data products are generated at this step: (1) a mask image (*m.fits) with all bad pixels including saturated pixels, and guide star windows set to zero, (2) a weight map (*w.fits) to account for pixel to pixel sensitivity variations reflecting the flat field, and 3. the detrended image, (*s.fits), which has been corrected for dark current, flat fielded and masked for bad pixels (for illustration, these three data products are shown framed in yellow, magenta and green in Fig. 1). For the next step of sky subtraction, a natural sequence of images which are within a predefined time window (nominally 20min) and spatial extent (large enough to avoid overlap of extended objects) are first identified. The detrended images of this natural sequence are then median combined (with bad pixel regions and all objects masked) to construct the sky image, (*y.fits, shown in a blue frame). The sky background in each exposure is then removed by the corresponding sky image in the sky subtraction step. A first pass astrometric calibration is then applied using the 2Mass Point Source catalog. It is important to note that only linear shifts are applied and no pixel resampling is done during the astrometric calibration, in order to leave the flux in each pixel unaltered (in keeping with the policy adopted at CFHT).

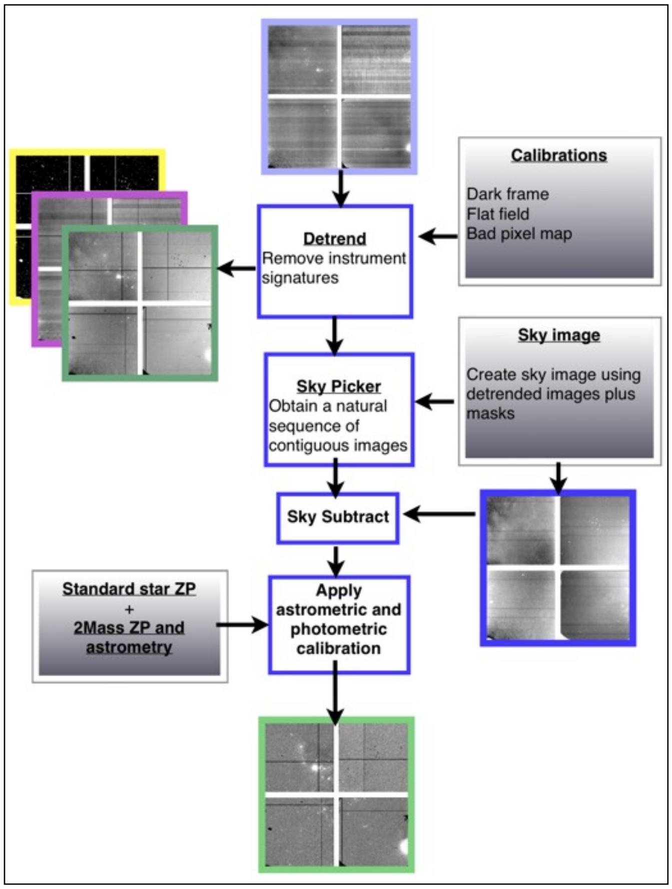
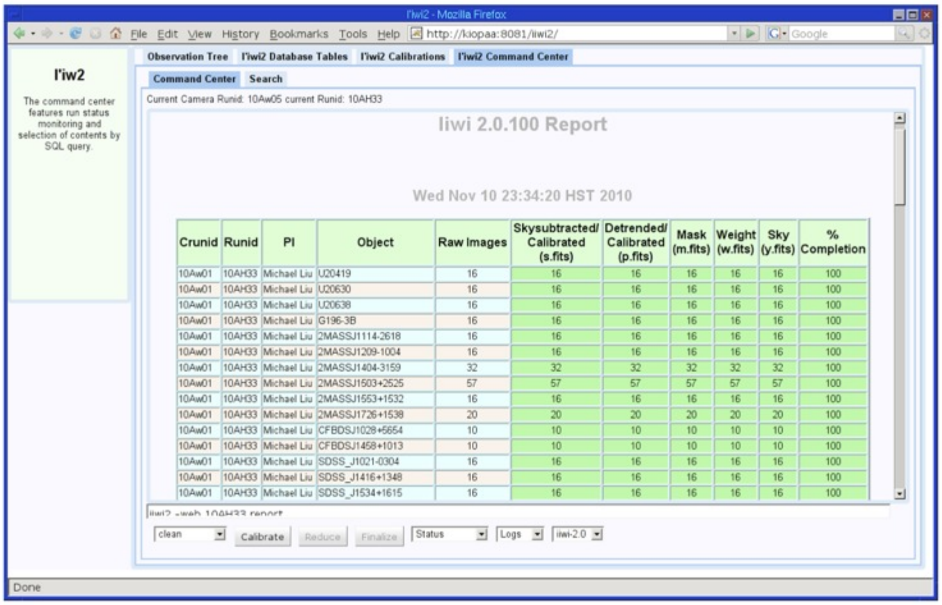


Figure 1

Flow chart illustrating the processing steps used in Iiwi 2, as well as the sixdata products, along with calibrations, which are distributed to the PIs.

Finally, the flux in the sky subtracted image is scaled using standard star zeropoint, and chip-to-chip variations are accounted using the magnitudes of 2Mass objects in each exposure. The astrometric solution and the zeropoint values are provided as fits header keywords in the detrended, sky subtracted, and astrometrically and photometrically calibrated image, *p.fits (shown in the green frame in Fig 1).

3. Automation and parallel processing



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.

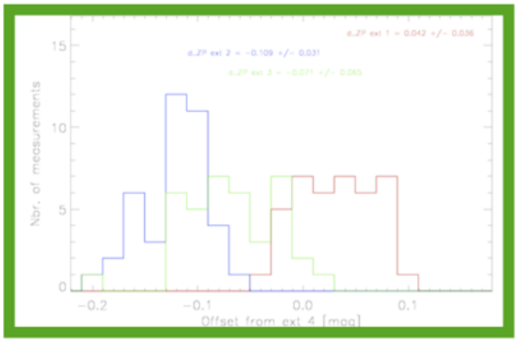
By incorporating a multi-machine parallel driver, I'iwi 2 automates and optimizes all aspects of WIRCam data processing and calibration for maximum throughput. Computing resources to use (CPUs, storage disks, etc) may be easily set based on availability.

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 the status and generate reports of ongoing reductions.

4. Photometric and astrometric calibrations



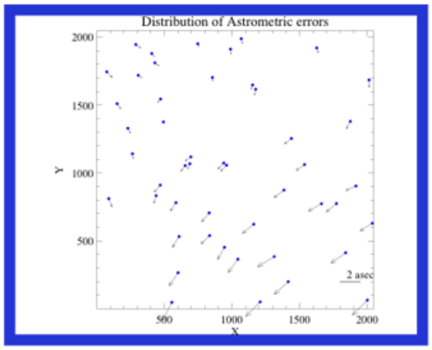


Figure 3a (left)

The relative chip-to-chip offset in photometric zeropoints computed with 2MASS catalog.

Figure 3b (right).

The distribution of astrometric errors along the chip in second quadrant. The mosaic center is the top-left corner.

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 the 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 with trends across the mosaic (Fig 3b).

5. 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.

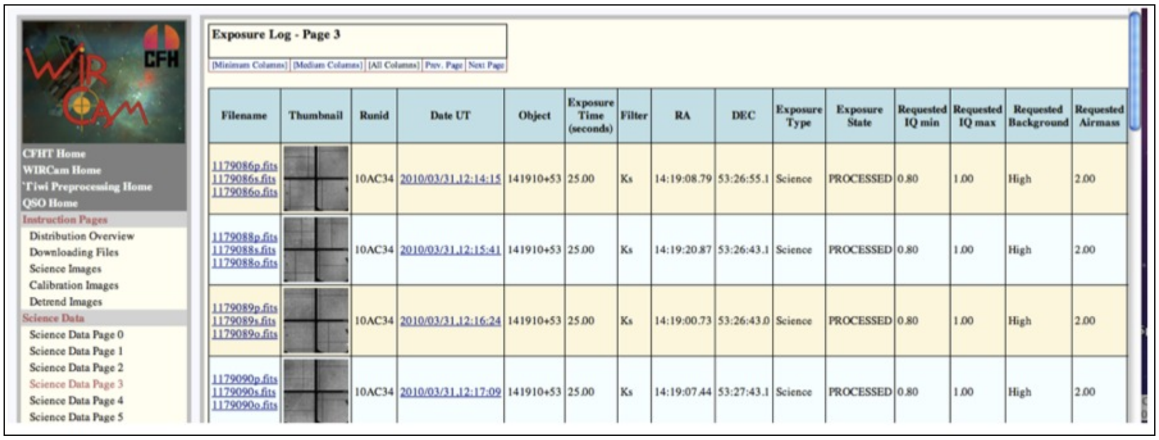


Figure 4

A sample metadata page used for processed data distribution to PIs. Each PI is provided with a unique key to access their proprietary data.

6. Summary and future development

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.

WIRCam staring mode & exoplanet studies

D. Devost

Introduction

High-precision differential photometry for time-series observations lasting up to several hours is key for the success of several astrophysical programs. In the past at the Canada-France-Hawaii Telescope (CFHT), submillimagnitude photometry was achieved with a specialized photometer operating in visible light mounted in visitor mode (Billeres 1997). With Queue Service Observations (QSO; Martin 2001) now in operation almost all-year round, it became apparent that similar performances could be achieved with a general-purpose instrument such as WIRCam but needed the implementation of a new service mode: the WIRCam Staring Mode.

The WIRCam Staring Mode consists in taking short exposures using the full detector mosaic while guiding to keep the target on the same pixel of the detector, keeping the telescope defocused at a constant defocus amount to prevent saturation. The challenges of this observing strategy are: 1) Guiding on defocused stars; 2) Keeping the defocus amount fixed over the entire observing sequence; 3) Integrating specific requirements into the highly automated QSO model, i.e. positioning the target and setting the defocus amount at the start of the observing sequence. The staring mode with WIRCam can thus observe a target for several hours on the same pixels of the array. This allows for characterization of the photometric variations of the target to less than 0.02%, or to a signal-to-Noise Ratio ~5000.

Exoplanet characterisation at CFHT

The discovery hundreds of exoplanets in the last 5 years has opened new avenues of scientific discoveries. New techniques are being developed to understand the physics of these new systems. Transit photometry is used to observe the signal resulting from the eclipse of the secondary component of a system. The signal is much fainter then that of an eclipse of the primary and thus more challenging to observe and needs very precise measurements.

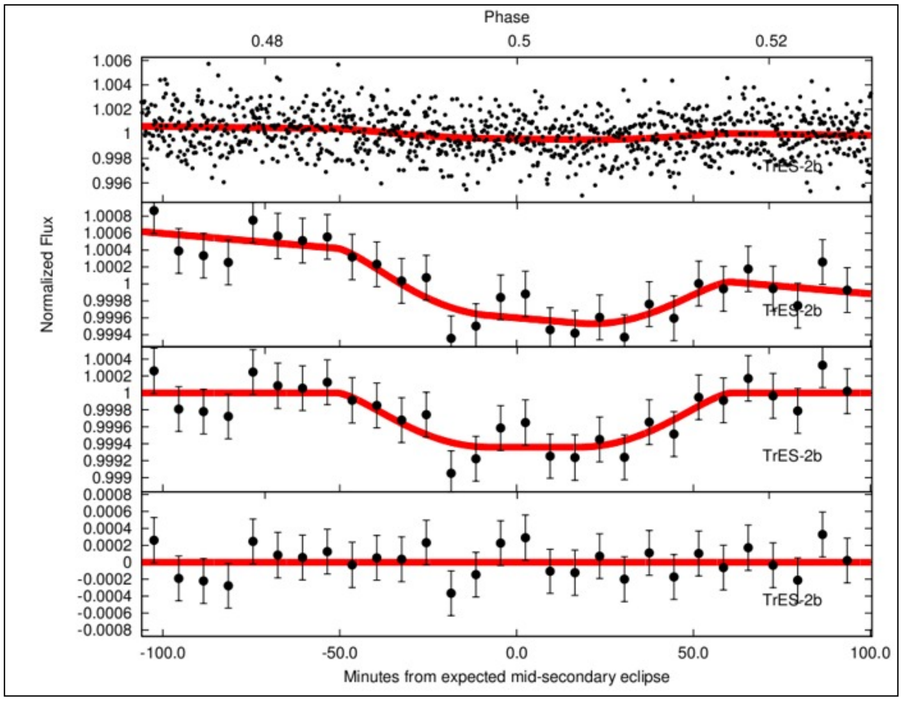


Figure 1

CFHT/WIRCam Ks-band photometry of the secondary eclipse of TrES-2b. The top panel shows the unbinned lightcurve, while the panel that is the second from the top shows the lightcurve with the data binned every 7.0 minutes. The panel that is the second from the bottom shows the binned data after the subtraction of the best-fit background, while the bottom panel shows the binned residuals from the best-fit model. In each one of the panels the best-fit best-fit secondary eclipse and background, Bf , is shown with the red line. The expected mid-secondary eclipse is if TrES-2b has zero eccentricity. Figure and caption from Croll et al (2010b).

TrES-2b

A team from the University of Toronto (UT) targeted the eclipse of the hot Jupiter TrES-2b (Croll etal 2010b) with staring mode observations.

TrES-2b's primary has a Ks magnitude of 9.846 and eclipsed the planet on the night of June 10 to June 11 2009. The observations were conducted for ~3.5 hours. The thermal emission of the planet was detected to a 5 sigma level (Figure 1). The observations, processing and analysis of the data lead to a stunning 1 sigma error bars on the order of 0.012%. They combined their CFHT WIRCam data to previous Spitzer/IRAC data and found that TrES-2b likely features a modest redistribution of heat from the nightside to the dayside of the planet. Their Ks detection also helped determined that the spectral energy distribution of TrES-2b could be fit by a blackbody curve thus indicating a fairly isothermal dayside temperature structure.

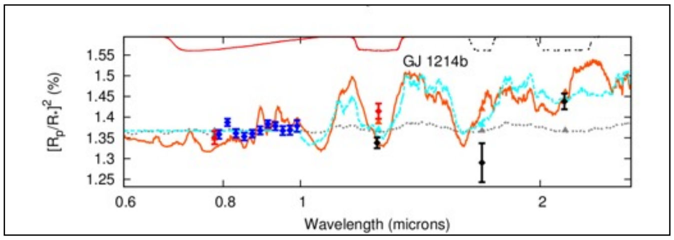


Figure 2

Transit observations of GJ 1214b. Black diamonds are the weighted mean of WIRCam J- & Ks-band and CH4 On filter data. Red diamonds are the MEarth (Charbonneau et al. 2009), and the Kitt-peak Sada et al. (2010) transit depth, blue diamonds are VLT/FORS2 points (Bean et al. 2010) Grey dotted curve line is GJ 1214b atmospheric model, orange a solar-metallicity model, cyan a solar-metallicity no methane model (Miller-Ricci 2010) for $\lambda > 1\mu m$. For $\lambda < 1\mu m$, the predicted absoprtion is cut of to simulate the impact of putative hazes. Figures and caption from Croll et al (2011).

GJ 1214b

Since then, the UT team has performed observations on other planets. The latest one being GJ 1214b, a transiting exoplanet whose radius lies midway between that of the Earth and Neptune (Croll et all 2011). For these observations, they used three WIRCam bands thus observing the broad band spectrum of the planet in the near-infrared. In June and August 2010, they used WIRCam staring mode to perform observations in the J, Ks and CH4On with the goal of determining if GJ1214b is a scaled down Neptune or a Super Earth.

To do this, one needs to determine the composition of the exoplanet's atmosphere. An atmosphere dominated by Hydrogen and Helium like Neptune will have a large scale height thus making the detection of molecular species like water and methane possible. On the other hand, an atmosphere like Earth dominated by heavier molecules, implies a lower scale height which flattens the spectra and makes it featureless when observed using this technique.

Figure 2 shows their results. The lines in this plot are the different model atmospheres while the black diamonds are the WIRCam data points. The other data points are from other observations. The WIRCam data seems to indicate that the near-infrared spectrum of GJ 1214b is not featureless thus pointing toward an atmosphere with a low molecular weight, dominated by Hydrogen and Helium, more like Neptune then Earth. However, their analysis cannot rule out that the atmosphere has a high molecular weight and that there is absorption by a haze layer at high altitude. This haze could be made of sub-micron size particles that absorbs light from the optical up to 1 microns thus flattening the spectra in the bluer parts of the near-infrared spectrum and starting to show features in the CH4On and Ks bands.

Conclusion

The WIRCam staring mode has been operating at CFHT for a little more then two years and has already produced significant scientific results. Despite the technical challenges related to the implementation of this mode of observation, submillimagnitude precision photometry over several hours of observing can be reached reliably thus opening a new window of scientific opportunities for our observatory.

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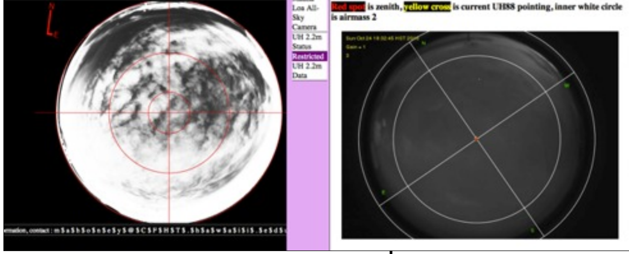
MKAM & ASIVA

***MKAM** integrated in the Waimea shop.*

MKAM (Mauna Kea Atmospheric Monitor) is a collaborative project between IfA, CFHT and W.M. Keck. Its goal is to make available a seeing monitor on the CFHT site for use by all the observatories on the summit. The project is funded through infrastructure money managed by IFA and operating funds come from the participating observatories. After months of integration in Waimea in 2009, it was installed on the concrete pad of the weather tower, which was dismounted and removed from the summit. It operated smoothly for several months until February 2010 when an ice storm resulted in a catastrophic failure of its enclosure. Ice froze one of two motors which caused the enclosure to twist and eventually a weld on the enclosure to fail. The enclosure was repaired in short order. The telescope azimuth encoder also failed during this period. Replacing it was not trivial and required disassembly of the telescope mount in order to gain access. The MASS unit overestimated the seeing when the scintillation index is high (a known issue) and new processing software were obtained to correct the problem and data verified before releasing it to the community. A new weather arm for the anemometer and wind vane was designed, fabricated, and installed by the end of 2010, replacing the original one at the enclosure platform that had significant vibration problems. It is seen on the picture on the left.

In spite of these issues, MKAM has successfully operated for more than a year, offering a long-awaited provided the Maunakea observatories and the Maunakea Weather Center with reliable seeing data

ASIVA (All-Sky Infrared Visible Analyzer) is a multipurpose visible and infrared sky imagine and analysis instrument that will be used to obtain a real-time census of the clouds and water vapor structure in the night sky. ASIVA is an IfA-CFHT collaboration, developed and operated by CFHT for all the observatories in the same way as MKAM. ASIVA has been installed on the summit at the end of 2010. Some issues with the unit were identified and addressed in the testing in Waimea prior to installation on the summit. These included issues with serial communications, the hatch motor controller, and weatherproofing of the hatch. The unit ran successfully in Waimea for 2 weeks before moving to the summit. ASIVA is using the weather information from the CFHT weather system to automatically close when precipitation is sensed. Preliminary data looks very promising, and more data will be gathered to characterize the instrument and prepare the user interface. Data release to CFHT and other observatories will happen as soon as data are well understood and the system is operational.



*Images received from **ASIVA** (IR, left) and the All-Sky Optical Camera (visible, right). The infrared image reveals cloud structure that is not easily identified in the optical all-sky image.*

Closing the CFHTLS

The last images taken for the CFHT Legacy Survey were taken in early 2009. Nearly two years later, many results have been already published, even though the final public release is scheduled for mid-2011.

The SNLS 3rd year sample

The SuperNova Legacy Survey team has updated their constraints on cosmological parameters based on their 3-year sample. It includes 252 high redshift Type Ia supernovae up to z=1.1, four times larger than the original SNLS paper by Astier et al. (2006). The new analysis include a complete characterization of the systematic uncertainties which appear to be due first to the calibration of the four CFHTLS fields and next to the modeling of the SN light curves. The constraints on the cosmological parameters based on the SNLS sample alone are presented in Guy et al. (2010, see Fig 1, left) and lead to Ω_M=0.211 +/-0.034(stat)+/-0.069(sys).

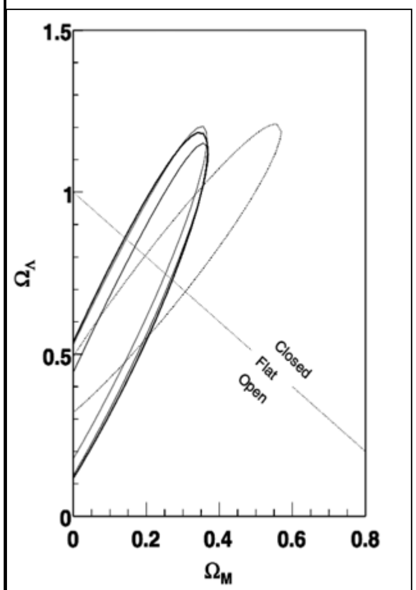


Fig 1 (Left)

68% confidence levels for (Ω_λ, Ω_M) based on 2 light curves fitters (red, blue) and the combination of the two (thick line). Astier's result is shown as dotted line. From Guy et al. (2010).

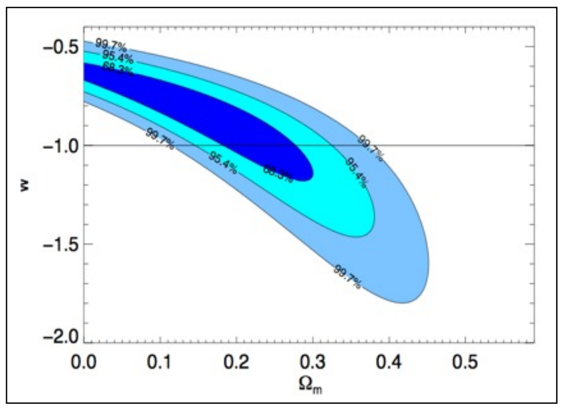


Fig 1 (Right)

Constraint on (ω, Ω_M) assuming a flat universe and including all the systematics. From Conley et al. (2011).

By combining the SNLS 3 yr sample with lower-z and higher-z samples, Conley et al. (2011) gives a constraint on the dark energy equation of state parameter $\omega = -0.91$ $^{+0.16}_{-0.20}$ (stat)$^{+0.07}_{-0.14}$ (sys) consistent with a cosmological constant.

Progenitors of Type Ia Supernovae ?

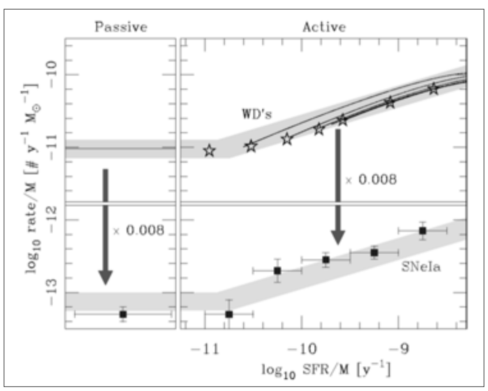


Fig 2

68% confidence levels for (Ω_Λ, Ω_M) based on 2 light curves fitters (red, blue) and the combination of the two (thick line). Astier's result is shown as dotted line. From Guy et al. (2010).

SNe Ia are widely believed to be explosion of white dwarfs (WD) whose mass has grown by accretion to the Chandrasekhar mass. WD with an evolving binary star is the accepted progenitor scenario and the presence of SNe Ia in evolved galaxies, dominated by old low mass stars, supports this picture. The increase of SNe sample and the identification of their host galaxies, allows us to characterize the occurrences of SNe Ia with the stellar activity of their hosts. By using SNLS data, Sullivan et al. (2006) have confirmed recent claims that the rate of SNe Ia depends strongly on the galaxy types. An increase of a factor 10 of the mass normalized SN Ia rate from passive galaxy to active star-forming galaxies is observed (as illustrated in Fig 2, bottom panels).

Pritchet et al. (2008) have modeled the WD formation rate for a large variety of galaxy activities and found that the WD rate matches the SNe Ia rate if an efficiency (WD exploding as SN Ia) of 1% is assumed, independently of the galaxy star formation history. Since low mass progenitors are expected to have lower conversion efficiencies than high-mass progenitors, the standard progenitor scenario of one WD with an evolving binary companion will be less efficient when dominated by low mass star systems as in the case of evolved galaxies. Therefore other progenitor scenarios are required to reproduce the constant efficiency of 1% over all galaxy types.

The rate of SNe core collapse

Using the 3yr SNLS sample, Bazin et al. (2009) have determined the rate of core collapse SNe at <z>~0.3. This rate is difficult to measure due to their faint magnitude distribution, 1.5 mag fainter than their sisters SNe Ia.

The authors used a sample of SNe detected down to i~24, and classified them according to their distinctive light curves by making use of the photometric redshift measured by Ilbert et al (2006). They identified 117 SNcc with z<0.4 and derived a SN core collapse rate of 1.42 ±0.3 (stat) ±0.3(sys) 10^{-4} yr^{-1} h^{-1} Mpc^{-3} ,which is a factor 4.5 higher than for SN Ia type.

Since the progenitors of core collapse supernovae are believed to be short-lived massive stars, this rate must reflect the redshift evolution of the cosmic star formation rate. The current result combined with previous studies shows a redshift evolution in good agreement with the expected evolution of the cosmic SFR in $(1+z)^{3.6}$.

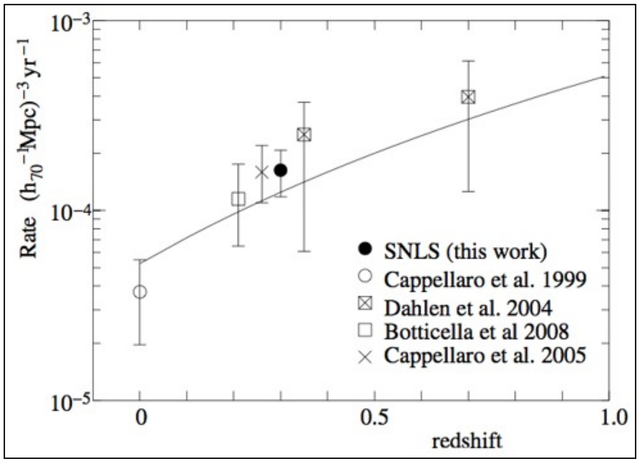


Fig 3

The measured rate of SN core-collapse as a function of redshift. The solid line shows an evolution proportional to the evolution of the cosmic SFR. (from Bazin et al., 2009).

Galaxy merger rate up to z~1.2

Galaxy interactions are a natural ingredient of the hierarchical galaxy formation scenario and can play a key role in our understanding of the global decline of the star formation activity with cosmic time. Numerous studies have estimated the redshift evolution of the merger rate providing highly discrepant results from no evolution to strong evolution yielding to an ambiguous contribution of the merger rate in the decline of the SFR.

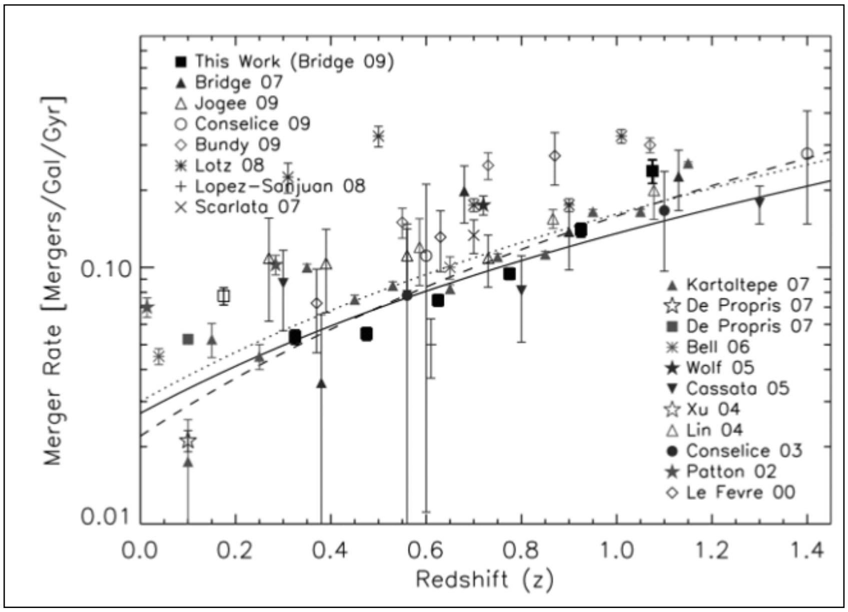


Fig 4

Evolution of the Merger rate as a function of redshift for galaxy with $M>10^{9.5}$ Mo (black squares). From Bridge et al. (2010).

The discrepancy reflects mainly the diverse definitions of a merger system and the adopted merger timescale. By using the 4 CFHTLS deep fields, Bridge et al. (2010) have developed a new classification of major mergers based on the presence of tidal tails and bridges (a clear signature of interaction), which exploits the low surface brightness reached by the i band CFHTLS data. They identified a total of 1600 merging galaxies up to z=1.2. The merger fraction increases from 4.3% at z=0.3 to 19% at z~1, implying an evolution of $(1+z)^m$, with m=2.25±0.24, strongly supportive of an evolving fraction of the galaxy mergers with time. By splitting in stellar mass, they found an higher merger fraction for less massive galaxies ($M\sim10^{10}$ Mo), consistent with the galaxy assembly downsizing picture. Finally they found that interacting galaxies have SFR twice higher than non interacting field galaxies, suggesting that the decline of the merger rate is one of the contributors to the decline of the SFR.

Galaxy structures in the CFHTLS

Cluster's counts is an alternative method to constrain the cosmological parameters but has been largely limited by either a small redshift regime or a small area. The CFHTLS provides a major step forward to contribute in this domain. By using the CFHTLS-T0004 data release,

Adami et al (2010) have analyzed 2.5 deg^2 in the CFHTLS Deep and 28 deg^2 in the CFHTLS Wide field to detect massive structures up to redshift z~1.5 - 1.2. They make use of the photometric redshifts from Ilbert el al (2006) and Coupon et al (2009) down to i=25 and 23 respectively. They constructed the galaxy density maps in narrow photometric redshift slices (Δz~0.1) and detect structures at various detection threshold (see Fig below). They end up with a list of 1200 candidates clusters increasing by a significant number previous cluster detections.

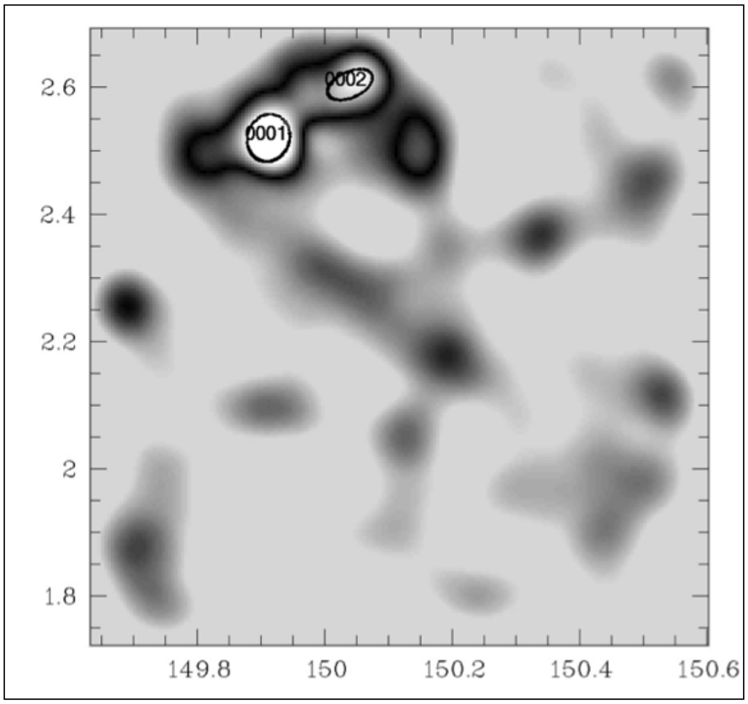


Fig 5

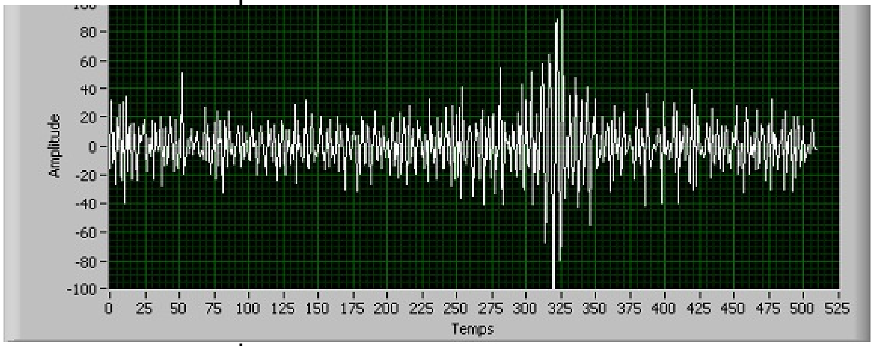
Example of two cluster detections with S/N~6 in the density map of the CFHTLS-D2 at z~0.65-0.75. From Adami et al . (2010).

In order to assess the validity of their detection rates, they have tested their method against the Millennium simulation and they also performed a clustering analysis which appears consistent with high redshift clusters measurements. These results represent the first step of this analysis. A validation and an accurate mass determination are now required to provide cosmological constraints.

\`OHANA-\`Iki

\`OHANA-\`Iki is a pair of two small telescopes (one them is shown on the right) used to feed the OHANA fibers to test the beam-combining and fringe tracking ability of the OHANA delay-line and beam combiner prior to commissioning with the CFHT and Gemini telescopes. Following the completion of the delay-line installation and in initial testing in the spring of 2009, efforts of the OHANA team for the rest of 2009 and 2010 have been aimed at obtaining internal fringes with the 300 m interferometer input fibers and then to obtain fringes on-sky with the \`OHANA-\`Iki telescopes.

Internal fringes with the interferometer set up were first obtained in April 2010 using the short (10 m) J-band fibers. Vibration of the fibers was a problem, particularly with the multi-pass setup required for auto-collimation fringes.



\`OHANA-\`Iki

Difference in the signal between the two recombination paths of the interferometer on the star Antares in J-band.

At the end of April 2010, the second \`OHANA-\`Iki telescope was commissioned. During the June run attempts were made to obtain fringes with the \`OHANA-\`Iki telescopes on the star Antares. Fringes on-sky were obtained at the end of June although the fiber injection was sub-optimal and the fringes were very noisy. Chasing vibrations and more observations are scheduled for 2011.

Cosmology Coming Closer

Alan W. McConnachie and The Pan-Andromeda Archaeological Survey

A matter of scale

When astronomers think "cosmology", the Andromeda Galaxy (M31) probably isn't at the top of the list of objects they are thinking about. Rather, high redshift galaxies, the cosmic microwave background, large-scale structures, supernovae explosions in distant galaxies…the list continues. On these largest scales, the success of the prevailing cosmological paradigm - Lambda-Cold Dark Matter (ΛCDM) - is impressive, and is now posing fascinating questions regarding the nature of dark matter and dark energy. The development of an apparently robust model for the broad evolution of the Universe means attention is now shifting to how baryonic structures – stars and galaxies – form within that model. And a detailed model of how individual galaxies form requires a detailed understanding of the structure and content of individual galaxies…

A pre-history

"Near-field cosmology" is not, despite claims to the contrary, a new field, but rather the re-emergence of a field that for a long time formed the basis of galaxy formation and evolution. Two classic papers in the Sixties and Seventies provided, with spectacular success, exactly the type of result that modern-day near-field cosmologists dream of. Olin Eggen, Donald Lynden-Bell and Alan Sandage, in 1962, noticed that 221stars in the solar neighborhood exhibited a correlation between their dynamical and chemical properties. From this, they developed a model for the formation of the Galaxy from a collapsing gas-cloud that successfully reproduced the observed chemo-dynamical correlations. Some 16 years later, Leonard Searle and Robert Zinn presented an analysis of the stellar populations of Galactic globular clusters, where they showed that the most distant clusters were consistent with exhibiting a broad range in ages, in contrast to their more tightly bound counterparts. From this, they suggested that these outer clusters had been accreted into the Galaxy from external systems over an extended period of time. Nowadays, both the collapse model and the accretion model are key components of galaxy formation theory.

Tools of the trade

While part of the reason that near field cosmology has been reborn can be traced to advances in our cosmological understanding (and perhaps appreciation) of galaxies, that is but half of the story. The bigger half relates to our observational capabilities. Galaxies are big, which means nearby galaxies are big in an apparent sense too. So fields of view become very important. A comprehensive view of our own Galaxy requires surveying the entire sky; the famous disk of the Andromeda galaxy spans more than four times the diameter of the full Moon; even a dwarf galaxy like Fornax or Sculptor is of the same apparent size – if not bigger! – than the full Moon. But combine their size with the fact stars in other galaxies (or the outer parts of our Galaxy) are faint, and you come up with the need for a telescope with a large aperture and a big field of view.

Enter the Canada-France-Hawaii telescope.

PAndAS

A natural consequence of galaxy formation in the hierarchical ΛCDM paradigm is that a typical galaxy like the Milky Way or Andromeda will accrete hundreds of smaller dark matter clumps, akin to the ideas proposed by Searle and Zinn. Not all these clumps are expected to contain stars, but those that do will deposit those stars in the surroundings of the galaxy, producing potentially the entire stellar halo of the galaxy. Dynamical times in the outer halo are long, and many accreted substructures will survive to the present without being totally tidally disrupted. Their number, spatial distribution and morphology provides tests of structure formation on small scales; the metal-content and ages of their stellar populations reveal how star formation proceeds at early times and in the least luminous galaxies in the Universe. In short, one can deconstruct a galaxy on a star-by-star basis, and so reconstruct its formation.

The Pan-Andromeda Archaeological Survey – one of the large programs that has just completed its primary observations on the CFHT - is designed to search for these "relics" of the galaxy formation process - fossil signatures of the chemical and dynamical origins of stellar populations present in the observed positions, velocities and colors of stars - in the closest giant galaxy to us, Andromeda.

Andromeda is, in many ways, an ideal target that neatly compliments similar studies of our own Galaxy. Whereas the precision and detail of observations that can be obtained for the Milky Way will always surpass those possible for extra-galactic targets, a clear panoramic view is unattainable due to our awkward viewing angle, extinction, crowding, and the vast area that must be surveyed. No such problems exist for Andromeda, and individual stars can still be resolved and analyzed, albeit at a lower signal-to-noise.

PAndAS has observed nearly 400 square degrees of sky in the vicinity of the Andromeda Galaxy, and its nearby neighbor, the Triangulum Galaxy (separated by 15 degrees in projection, or about 225kpc). Observations are conducted in the g and i filters, for a total of 1450 seconds in each. The resulting observations are generally sufficient to reach S/N=10 for point sources at g=25.5 and i=24.5. Relative to M31, they resolve stars in the top several magnitudes of the red giant branch. Indeed, as of the end of S09B, more than 30 million stellar sources are resolved in PAndAS data.

Unearthing fossils of formation

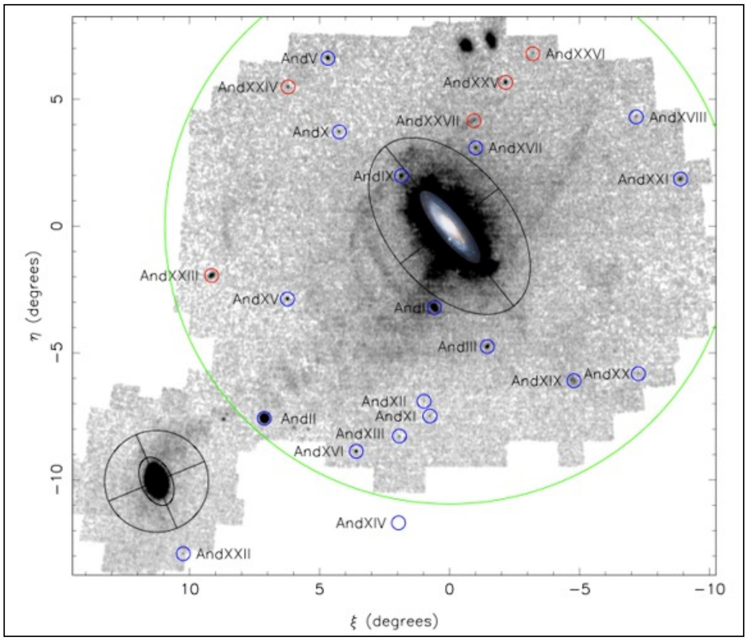


Figure 1

A tangent plane projection of the spatial density distribution of red giant branch stars across the PAndAS area (as of the end of S09B) a convenient proxy for the light distribution when dealing with very faint structures. The outermost circle corresponds to a projected radius from M31 of 150kpc. Small circles highlight dwarf galaxy companions to M31 and M33. Red circles highlight new dwarfs discovered within the past year (Richardson et al. 2011, ApJ, in press).

Figure 1 shows the spatial density distribution of red giant branch stars across the PAndAS area, a convenient proxy for the light distribution when dealing with very faint structures. The sheer scale of this image - and the fact that it isn't empty! - is surprising. The main disk of M31 is included for scale, and the presence of structures at all more than 10 degrees from the center of M31 is a startling visual confirmation of the vast (and generally unappreciated) scale of galaxies.

And what of the structures themselves? A plethora of extended streams, loops, clumps and blobs cover the entire map, extending out to projected radii in excess of 130kpc (>20 scale lengths). Many *individual* structures, such as the large loop in the north-west, are greater than 100kpc in extent. And perhaps most striking of all is the number of highlighted, concentrated, stellar over-densities: these are dwarf galaxy satellites of M31/M33, the vast majority of which were unknown prior to these observations: so far, 19 new dwarf galaxies have been uncovered by PAndAS, with more likely to be discovered.

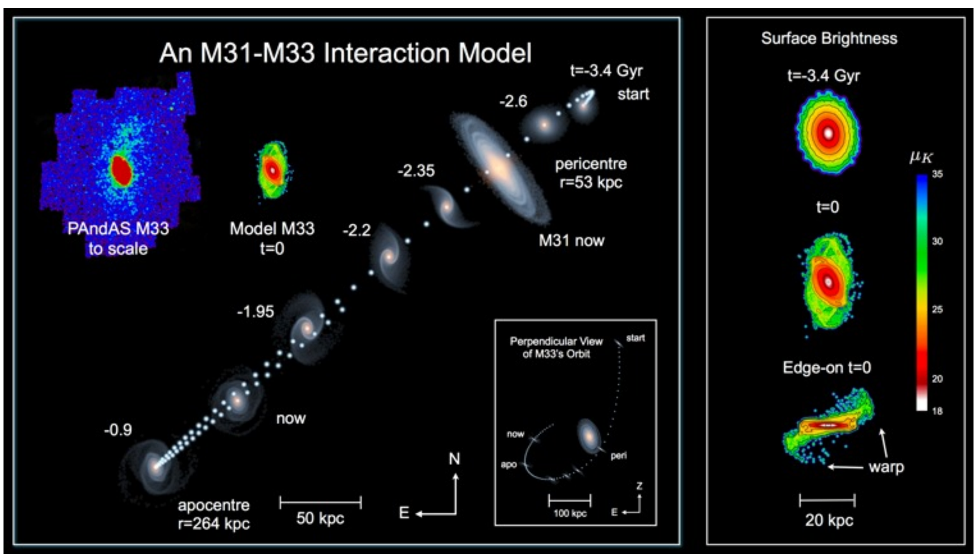


Figure 2

Projection of the orbit of M33 and M31 that best reproduces the extended structure surrounding the disk of M33 first observed in the PAndAS dataset, showing the relative position of the galaxies as a function of time in their orbit. The right panel shows the simulated stellar surface brightness distribution of the M33 disk at the present day, which closely matches the observations (McConnachie et al. 2009, Nature, 461, 66).

One of the most unexpected early results from PAndAS involved the faint, extended, structure surrounding the disk of M33. Analysis suggests that it is a result of a previous interaction with M31 as M33 orbits around its more massive companion. This finding fits with several other pieces of circumstantial evidence, in particular peculiarities in the dynamics of various tracers in M33 that until now have defied simple explanation. Using all these observational constraints, we have been able to reconstruct the orbital history of M33 and M31, and timed their most recent encounter to have been some 2.5 Gyrs ago (Figure 2).

Not all of the objects we detect are visible in these maps. Globular clusters, long regarded as stellar population beacons, are present too. Figure 3 shows a collection of these objects, exactly 100 of which have been discovered in recent years as a result of this and related surveys. All of the discoveries have been at radii greater than 1 degree from M31; that is, not likely associated with the disk. Prior to this work, only 3 clusters were known to lie beyond 30kpc, whereas now there are 79 known clusters. Of these, 15 lie at projected radii between 85 – 145 kpc. This is a virtually unexplored region in any spiral galaxy, and the Milky Way has only 2 known clusters at comparable radii.

A beautiful verification of the Searle and Zinn scenario has been made possible with these discoveries. When the spatial distribution of all the outer clusters are compared to the spatial distribution of stellar substructures, a clear correlation is present – clusters are preferentially seen wherever a stellar stream is detected (indeed, often "chains" of clusters stretch along the stellar feature; Figure 3), and clusters are preferentially absent in areas with no stellar substructures. This is arguably the most direct – and visual – confirmation of the extragalactic origin of many outer halo globular clusters since the idea was first proposed back in 1978.

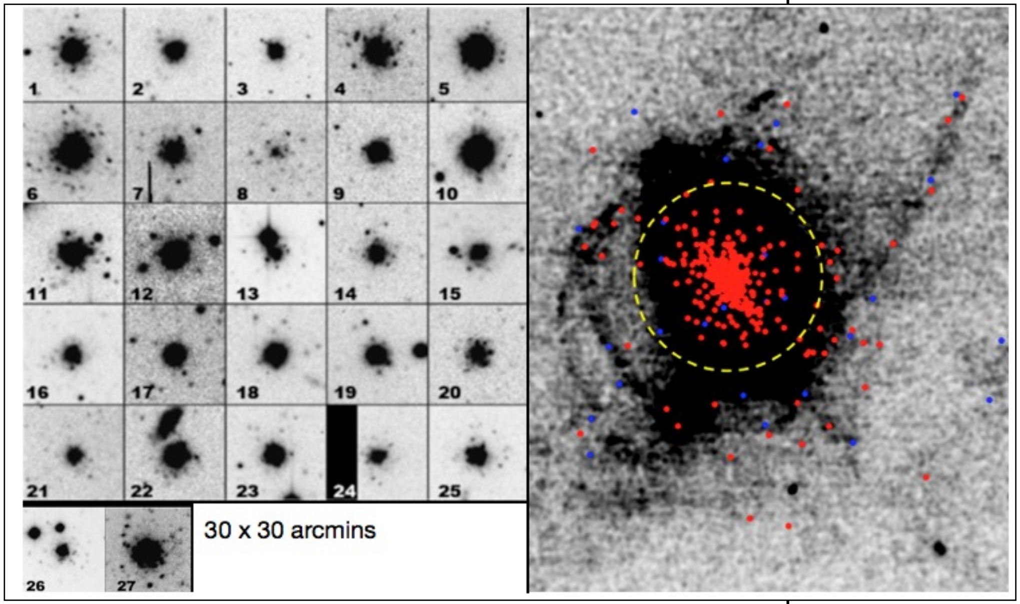


Figure 3

Left., a selection of the 100 new M31 globular clusters that have been discovered in this and related surveys, all at radii greater than 1 degree from M31. Right, a segment of the PAndAS map showing the positions of globular clusters relative to the stellar structures. The outermost clusters show a striking positional correlation with the stellar streams. This implies that these clusters were once associated with the progenitors of the streams, and are thus extragalactic in origin (Mackey et al. 2010, ApJ, 717, L11).

To infinity!

With the completion of data collection in S10B, work within PAndAS is now focusing on the final quantitative measurements of the spatial distribution, morphology and populations of the stellar halo, its substructure, the dwarf galaxies and the globular clusters. A significant number of follow-up observations on CFHT, the KPNO-4m, WHT, Subaru, Gemini and Keck have taken place too, that concentrate on deeper observations, bluer and redder bands, as well as spectroscopy of clusters and individual red giant branch stars. The latter has proven particularly interesting, but is fundamentally limited by the relatively small field of view of the present generation of multi-object spectrographs, such that the ultimate goal of obtaining chemo-dynamical information for every bright star across the PAndAS area is still some way off. But CFHT/MegaCam has ensured that PAndAS will likely remain one of the most powerful datasets for addressing the properties of stellar halos and for comparison to cosmological simulations of galaxy formation for the foreseeable future. And its not just within the PAndAS consortium that the new few years will prove interesting. Near-field cosmology is entering a decade that promises to be exceptionally rich.

As well as the (pointed) wide field imaging capabilities presented by CFHT/MegaCam, and imminently Subaru/HSC, the 3PI survey of PS1 will present a deep view of the Milky Way that will probe the stellar populations of the Milky Way halo and should in principle detect the faintest galaxies ever found. In the south, SkyMapper will likewise chart the sky, albeit not as deep as PanSTARRS, and at the end of the decade LSST will present the deepest and most comprehensive photometric view yet of the halo of the Milky Way, with the ability to examine the stellar populations of the Galaxy out to the equivalent radii probed in M31 by PAndAS.

But as great as these photometric surveys will be, the immediate future is astrometric, with the advent of GAIA in 2012. With its ability to measure three dimensional positions and velocities for all stars with V<20, as well as detailed chemical abundance analysis of all stars with V<12, it will enable full chemo-dynamical separation of the nearby Galaxy using all 6 phase-space coordinates and multi-element abundances. Astronomers are about to dig up a treasure chest of fossils to probe the history of our Galaxy.

In short, cosmology is once again coming closer…

Observatory Automation Project: Toward Remote Operation

OAP (the Observatory Automation Project) has been the major in-house project carried out by the staff over 2009-2010, following one year of brainstorming and planning. While "OAP" suggests a full automation of the observatory operation, the goal of the first phase of OAP nearing completion by the end of 2010 is to allow remote operation at night without anyone at the summit.

When Service Observers (SOs) took over the observations in the early days of QSO (Queue Service Observing), the observatory still required an Observing Assistant (OA) to man the telescope and the overall facility while the SO performed the observations. With increased computerized assistance added to the QSO mode, such as an automatic slew of the telescope once an observation is selected, or automatic field acquisition and guiding setting once on a target, the role of the OA became limited to readying the observatory for observing at the beginning of the night and closing and securing it at the end of the night. During the observing itself, the OA's role was mainly to intervene and assist in case of problems. It became clear that a single person, with appropriate training, could actually handle both the SO and OA duties. This would reduce the manpower needed for observing, therefore increasing the efficiency of the operations of the observatory. Unfortunately, at sites like Maunakea, remoteness and altitude mandates for the personnel safety requirement to have at least two people present in the building at any given time. In order to really improve the operational efficiency of the observatory, we had to think about not being at the telescope anymore during observing!

Retrofitting an old facility like CFHT to enable its remote operation is not a simple endeavor: after all, we are talking about a telescope with a 250-ton moving mass , or a 580-ton dome, with their hydraulic drives and high-pressure oil running from the basement to the dome floor, hundreds of meters of hoses carrying glycol running all over the telescope and its instrumentation. Is it really feasible to replace all the hands-on monitoring carried out by an OA and all the manual interventions a person could do at night by remotely-controlled functions accessible on a screen and through the click of a mouse?

Actually, not only it is feasible, but it brings much more than just the possibility of remotely operating the facility! An example: An old-style dial gauge, looked at by the OA to check if a pressure is nominal at the beginning of the night, has to be replaced by a sensor remotely accessible. It opens the possibility of continuous control of the pressure through a script reading the value, sending a warning when significant increase, decrease, or change rate, are detected, therefore preventing a failure before it occurs! Add to the script an automatic notification through text messages on smart phones, write as many scripts for as many sensors as you deem necessary for safe operations, and you end up with technical staff made aware in advance of potential failures: the operations move from fighting fires to well-informed preventive maintenance and preemptive actions.

The following items outline some of the various sub-projects related to the whole OAP.

- New monitoring and remote control of the telescope hydraulic system
- Monitoring of personnel entry to the 5th floor (a safety issue)
- Sensing the location of the solar sail
- Sensing the location of the mirror cooling duct
- New monitoring capabilities for the secondary mirror support system
- Coordinated alert system that includes slew tones, pop-up messages, warnings, alerts, and broadcasted messages in the dome and the remote operations room
- Monitoring of the summit UPS(s)
- Removal of the telescope key
- Installation of a light source by one of the catwalk cameras to assist in monitoring the environmental conditions (fog detection)
- Implementation of an autonomous shutdown protocol
- Additional functionality in the OAP Control GUI
- Modifications to the summit control room and the remote operations room
- Summit fire alarm system upgrade

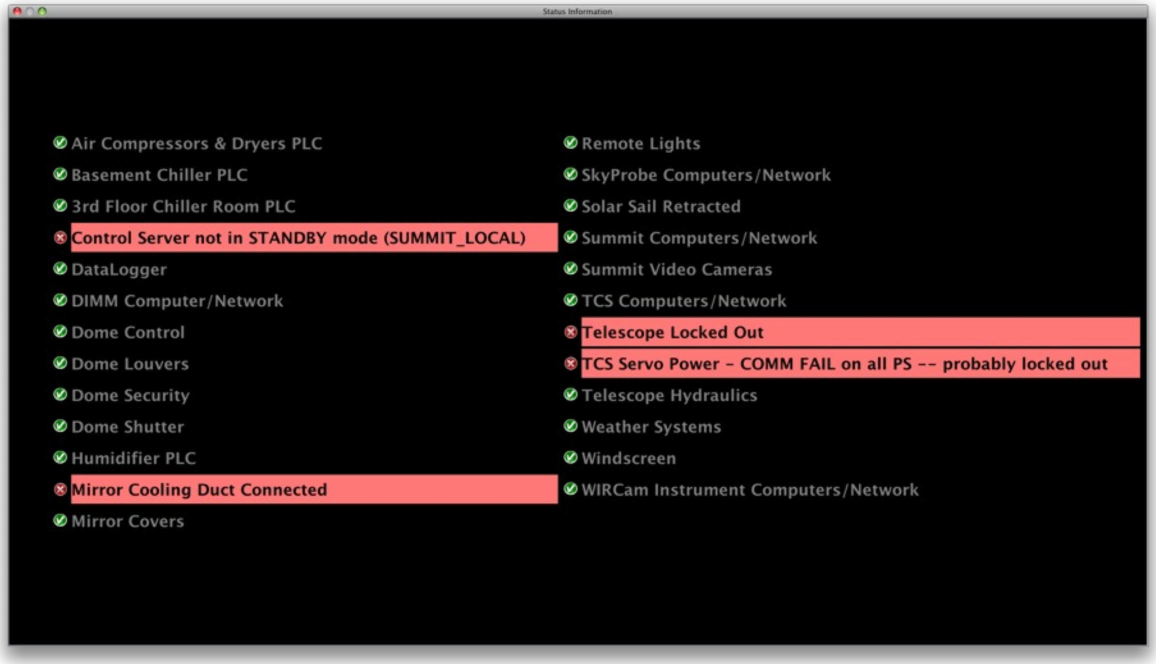
- Windscreen monitoring and remote control implementation
- Remote operations room UPS upgrade
- End-to-end testing of all technical requirements
- Review of remote operating procedures

Figure 1

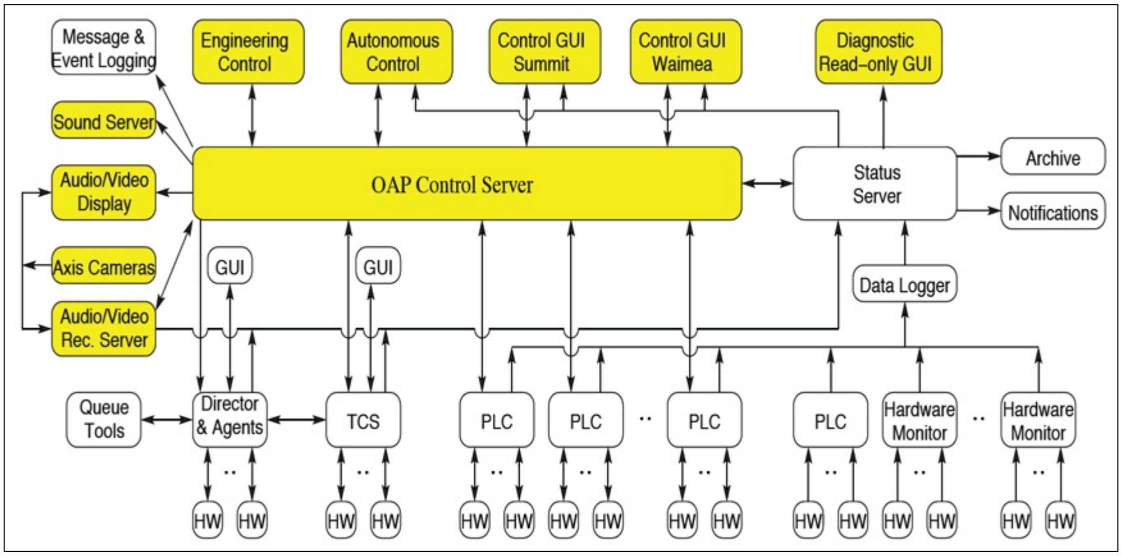
Replacing the eyes and ears of the Observing Assistant is one of the key-components of the OAP environment. Fixed or remotely controlled cameras at strategic locations offer enough information for a close look at the critical components of the observatory and for well-informed decisions from remote location (from the Waimea headquarters to mobile devices).

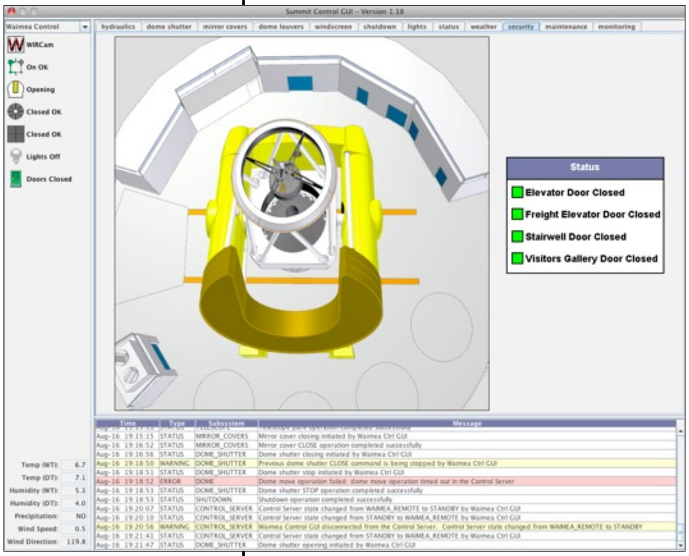
Monitoring the environment is another area where being away from the summit represents difficulties: it is not easy to replace all the information an observer can grasp from simply walking out on the catwalk! Reliably sensing the temperature, humidity, wind, precipitation (rain or snow) can be done through the implementation of robust weather sensing instruments with enough redundancy to avoid false alarms or miss bad conditions. The night vision goggles used to check faint clouds coming from afar have to be replaced with low light cameras. A good complement is an infrared all-sky camera to detect the cloud cover, ASIVA, now installed by CFHT at the summit for the benefit of all the observatories. Skyprobe, used for years, is one more important piece of observation to check the extinction of the sky where the telescope is pointing.

As various maintenance and improvement work is done during the day on the dome, the telescope, the instruments and the various subsystems of the observing environment, it is paramount to assure that the facility is left ready for night remote operation. A simple status screen is installed close to the summit front door building, providing in one glance the appropriate information on all the systems critical to the remote observations from Waimea. Below is a snapshot of how this status screen will look like once remote operations will be CFHT's regular mode of observing.



On the software side, the choice was made to centralize the control into a single software component, which simplifies the business rules and the interactions between systems. Three control modes (Summit, Standby, Waimea) help moderate the execution of the commands and insure that actions cannot be "accidentally" initiated remotely. The overall architecture is outlined in the graph below.





GUI windows

A typical GUI window, showing the telescope floor and the status of the doors. No red should be seen in night- time operation.

In developing the Graphical User Interfaces (GUIs) for all the sub-systems to be remotely operated, much attention was given to delivering a consistent look and feel, from opening the shutter to moving the windscreen, opening the mirror, checking the doors on the dome floor or controlling the louvers.

An autonomous closing procedure has been implemented, which will park the telescope, turn the telescope hydraulics off, close the mirror covers and the dome shutter. In order to protect the observatory, such an autonomous closing is triggered when certain conditions are met, like high humidity, precipitation, high wind, or daytime. Losing the connection between Waimea and the summit is not enough to shut-down the facility immediately. However, after a given time without connection (currently set at 15 min), an autonomous closing sequence will be automatically generated.

Another important project, related to OAP, is moving the dome from hydraulic drives to electric motors. Implementation has begun and the system will likely be in place in early Spring 2011. In addition to significant savings in energy consumption, the new system will eliminate the risk of leaks related to the dome motion. It will leave only the telescope as a potential source of oil leak, for which protection measures have been taken to avoid any spill in the environment (soil underneath the building or outside).

All the changes and additions made to enable CFHT to operate remotely have been incrementally integrated during observing from the summit. Their implementation did not cause any loss of observing time and will ultimately allow a smooth transition to remote observing mode.

The impact of OAP on the operational reliability of the entire facility has already been significant. Thanks to an improved monitoring of the summit sub-systems and to the ease of remote access to most of the parameters, prevention of failures and remote diagnostic have made a substantial difference on the down-time of the telescope and its instrumentation. The amount of time lost to technical problems, which is now well below 2% of the clear weather observing time, demonstrates an excellent reliability for an old facility equipped with complex high-tech instrumentation. Last, but not least, the technical staff is already enjoying a welcome peace of mind, as a result of the remote sensing capabilities offered by the Observatory Automation Project..

Queued Service Observing at CFHT: Two years of transition

The main goal of the Observatory Automation Project was to bring modifications and improvements to CFHT's systems so that only one person could operate the telescope and instrument remotely from CFHT's headquarters in Waimea.

Since its first light in 1979, CFHT has been operating under the Classical observing mode. This mode is still used a few nights per year. In Classical observing mode from the summit of Maunakea, two people are required to be present together for safety reasons. A Telescope Operator and one or more visiting astronomers perform the observations.

A little over 10 years ago, on January 29, 2001, CFHT reached a milestone with its first Queued Service Observations. Under this observing mode, the Observing Assistant (OA) performs the duties of a telescope operator while the Service Observer (SO), essentially takes the role of the visiting astronomer.

The SOs are hired and trained by CFHT to operate instruments, determine which observation to carry out based on priorities and sky conditions, and perform the data acquisition and preliminary quality assessment. By 2008, CFHT had its three main instruments operated under the QSO mode. CFHT will perform its first remote queued service observations in early 2011, with no personnel at the summit and only one Remote Observer (RO) performing all the necessary duties from the CFHT headquarters in Waimea.

In order to ensure an efficient and smooth transition from a 2-person on-site operation to a single-person remote operation, a training program was carefully designed. After defining the goals of the training, OAs and SOs completed modules covering every aspect of telescope control, dome and windscreen operation, weather monitoring, instrument functionality and operation, evaluation of scientific programs, astronomical techniques, principles of QSO as used at CFHT, data quality evaluation, etc. After two years, four candidates were hired as CFHT's Remote Observers.

At the summit

In the observing room, the left desk (2- and 4-screen panels) are for the SO, and the right desk is for the OA, operating the telescope. The environment has been modified to handle remote operations: hands on mice or keyboards only !

In Waimea

The remote observing room is ready! The environment is very similar to the summit setup. The 2-screen and 4-screen panels on the left take care of the control of the summit facility and of the instrument, while the next two screens on the desk are used for the control of the telescope.

Two years of development in a nutshell

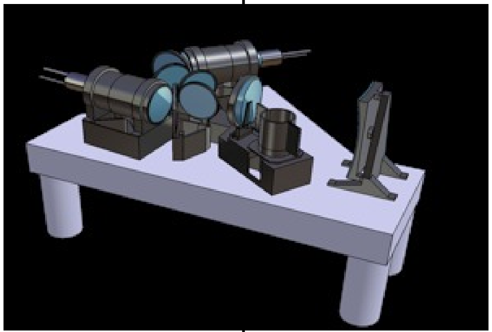
Following the call for ideas for new instruments for 2013 and beyond, the submission of four concepts of instruments and their review by CFHT and its Scientific Advisory Council (SAC), the Board of Directors decided at its 2008 fall meeting to move one instrument, SPIRou, to a Phase A study to be completed mid-201 and to support further studies on the `IMAKA concept. The proposers of a third instrument, SITELLE, were encouraged to seek appropriate funding and develop SITELLE as guest instrument in collaboration with CFHT staff. A fourth instrument, GYES, joined the game at the end of 2009, deciding to prepare a Phase A study after initiating contact with CFHT early that year. After revising the Phase A schedule for both projects, review projects were held for both GYES and SPIRou at CFHT in October 2010, with the assistance of external reviewers. The review committees concluded in both cases that the instrument concepts were very interesting as well as quite challenging. In spite of their Phase A not being fully completed, GYES and SPIRou were considered studied well enough to move ahead. Clear advice and guidance on steps to be taken prior to the real start of a Phase B were also given by the reviewers. It was then up to the Scientific Advisory Committee which followed immediately the Users' Meeting to choose between them. SAC recommended to the Board to favor SPIRou over GYES, a recommendation the Board endorsed. SPIRou will move to Phase B in 2011, after a mandatory reorganization of its Management Plan.

Meanwhile, the Canadian SITELLE team moved forward funding-wise, as requested by the Board at the end of 2008, securing the funding of the instrument through a CFI grant. CFHT helped an early start of the project by providing seed funding while Université Laval awaited the availability of CFI funding, enabling the main contractor for the instrument, ABB-Baumen, to move forward.

Following a first feasibility study report presented to SAC in May 2010, the `IMAKA team continued to work and more simulation studies concluded that the performances of the instrument were potentially not as good as previously thought, leading to a low-key presentation at the Users' Meeting and more work to be done. The Board acknowledged the situation by asking for a new Feasibility Study Report to be presented at the May 2011 SAC meeting.

GYES

GYES was proposed by a team led at Paris Observatory (GEPI) by Piercarlo Bonifacio. The instrument is a 500-fibers wide-field multi-object spectrograph to be installed at the prime focus of CFHT, using the "old" CFHT wide-field corrector which used to be in the prime-focus cage and fed the wide-field imagers from photographic plates up to CFH12K. It offers a resolution of around 30,000 in two spectral ranges [390nm-450nm] and [587nm-673nm]. The preliminary design of the fiber positioner is based on the AAO 2dF positioner design.



Spectrograph baseline design

Two Arms (blue and red) with a VPH and a cameara for each.

GYES main scientific goals are related to the kinematic structure and chemical labeling of stars in our Galaxy, partly as a follow-up of the Gaia mission:

• Thin disc - thick disc: chemical dissection of the disc and identification of sub-structures, measure of the level of homogeneity of the elements in various environments (arms / inter-arms, outer disc, bar, etc.), interface of the thick disk with the thin disc at the metal-rich end and the halo on the metal-poor side.

• Bulge: Detailed analysis of the bulge & constraints on the bulge formation scenarios, unprecedented combination of kinematics with abundance ratios ([α/Fe])

• Halo: detailed abundance ratios of more than 10,000 halo stars and chemical evolution of the early galaxy, search for very-metal-poor stars with [Fe/H] <-4

Much more can be done with such an instrument! Here are a few of the other applications of GYES:

• Hot Stars and ISM: B/Be stars & A/Ap stars and mapping of the ISM

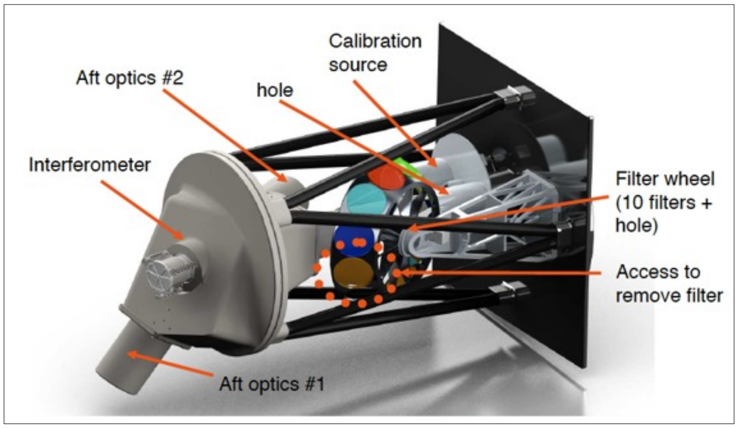
• Pulsating Stars: Cepheids, äScuti: P-L relation and galactic gradients

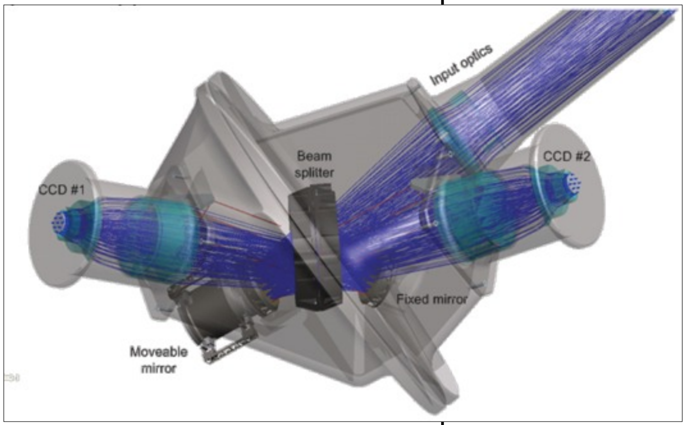
• Open Clusters (190 targets for GYES): age-metallicity relation & chemical history of the thin disk and chemical characterization of new OCs identified by Gaia

• Globular Clusters (49 targets for GYES): internal dynamics & multiple stellar populations identification

SITELLE

SITELLE is an imaging FTS (Fourier Transform Spectrograph) based on the same concept as SpIOMM, an instrument installed on the Mont Mégantic telescope. The figures on the right outline the design of the instrument: at its core is an interferometer with a friction-less scan and tip-tilt mechanism based on former Mars-mission instrument design made by ABB-Baumen, which is the main SITELLE contractor.





SITELLE Preliminary Design

On the left, the overall instrument, as it will be mounted on the Cassegrain bonnette.

On the right, the inter-ferometer and the two camera ports.

SITELLE science goals cover a wide range of fields, thanks to the size of its field (12'x12'), its wide spectral coverage [350nm-900nm], good spatial image sampling (035"/pixel), and spectral resolution (from 1 to ~20,000). Among the many topics its science case address, one can cite:
• Galactic nebulae around evolved stars (PN, WR, LBVs)
• Galactic HII regions: temperature fluctuations, internal structure, local enrichment, …
• Abundance distribution in nearby spiral galaxies
• Star-formation rate at different reshifts
• Lyman-α galaxies

Compared to SpIOMM at Mont Mégantic, SITELLE at CFHT will be 65 (15) times better at 370nm (650) respectively.

SPIRou

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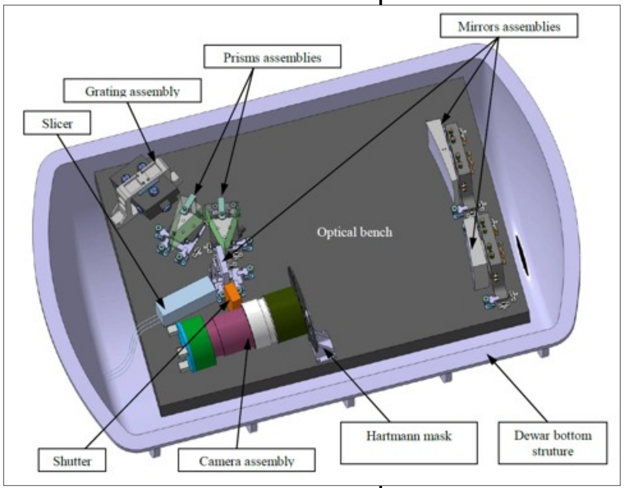
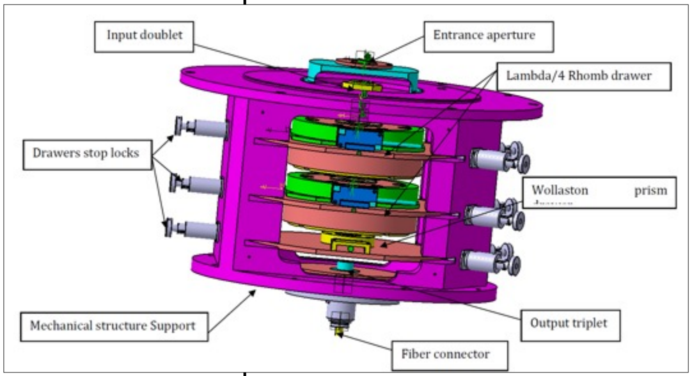
SPIRou, an near-infrared spectro-polarimeter, was proposed by Jean-François Donati (IRAP, Toulouse). It is a natural extension of the visible spectro-polarimet ESPaDOnS to the near-IR. ESPaDOnS is currently one of the three main CFHT instruments, used for two very successful Large Programs as well as by many PIs. SPIRou will be unique not only as IR spectro-polarimeter; it will also offer the possibility of measuring radial velocity accuracy, opening the possibility of Earth-size extrasolar planets around M-dwarf stars.

The science requirements of the instruments, at the end of the Phase A are as following:
• Spectral domain: 0.98-2.4μm (w/ full coverage up to at least 2μm) spectral resolution > 50,000 (70,000 if possible)
• Radial velocity accuracy < 1m/s
• S/N=150 per 3km/s pixel in 1hr @ J=12 & K=11
• Thermal instrument background < sky background, ie J>15.5, H>13.5, K>13.0
• All polarization states accessible with >99% efficiency and <1% crosstalk over full spectral domain



SPIRou spectrograh preliminary design

SPIRou plans to essentially concentrate on two main scientific goals. The first one is to search for and characterize habitable exo-Earths orbiting low-mass and very low mass stars using high-precision radial velocity spectroscopic measurements. This search will expand the initial, explorato-ry studies being carried out now with visible instruments and will survey in particular large samples of stars (e.g. late-M dwarfs) out of reach of existing instruments. SPIRou will also work in close collaboration with space- and ground- based photometric transit



Polarimetric module baseline design

The design follows the concept successfully used for ESPaDOnS.

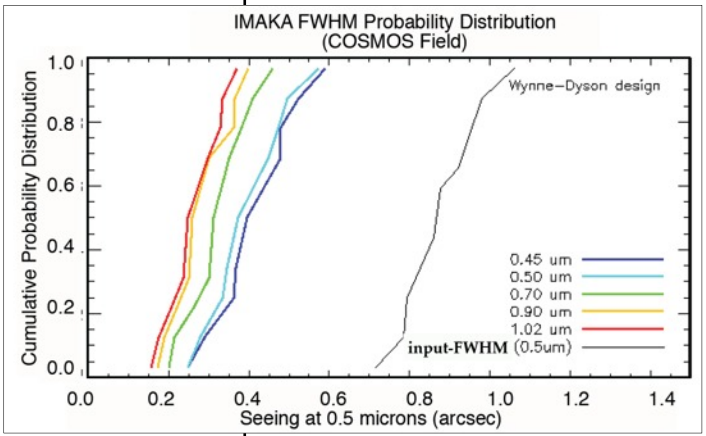
surveys to identify the true planets among the candidates they will discover.

The second main goal is to explore the impact of magnetic fields on star and planet formation, by detecting magnetic fields of various types of young stellar objects (e.g. young FUOr-like protostellar accretion discs, classical T Tauri stars) and by characterizing their large-scale topologies. SPIRou will also investigate the potential presence of giant planets in the inner regions of protostellar accretion discs and their relation with disc magnetic fields. Such studies will strongly amplify the initial exploration survey presently carried out in the visible by the MaPP (Magnetic Protostars and Planets) CFHT Large Program (LP) . It will also ideally complement the data that ALMA will start collecting soon on outer accretion discs and dense pre-stellar cores.

SPIRou will also be able to tackle many other exciting research topics in stellar physics (e.g. dynamo of fully convective stars, weather patterns at the surfaces of brown dwarfs), in planetary physics (e.g. winds and chemistry of solar-system planet atmospheres) galactic physics (e.g. stellar archeology) as well as in extragalactic astronomy.

`IMAKA

Following a series of highly successful wide-field imagers, `IMAKA is proposing an instrument which will not compete with the new generation of imagers like Hyper-Suprime-Cam, the Dark Energy Camera, or ultimately LSST in term of field size. Instead, it will focus on one of the unique characteristics of the sky over Maunakea: its turbulence profile, particularly suited to Ground Layer Adaptive Optics applications. The best image quality on a wide-field of view is the main driver for ‘IMAKA.



How good an IQ?

Preliminary simulations of `IMAKA image quality probability distribution

The science requirements of `IMAKA indeed reflect this driver:

- Field of View as large as possible, with a goal of 1° diameter
- Image Resolution 0.3 h (median seeing, r-band)
- Sensitivity/Limiting Magnitude
- Δmag ≥ 1 over MegaCam at all wavelengths (median seeing)
- Spectral Coverage/Resolution [340nm-1100nm] (at least grizY)

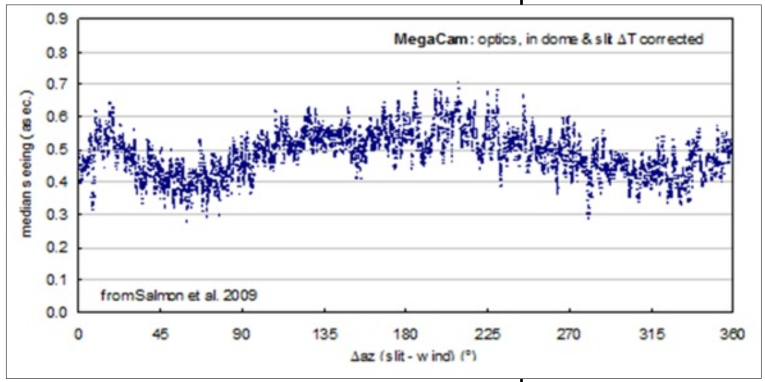
In order to meet these requirements, `IMAKA will benefit from the improvements brought by the Dome Venting Project (see next page) and from a novel approach bringing together GLAO and OTCCDs (orthogonal transfer CCDs). The GLAO component will have ~20x20 actuators, using ~6 NGS (natural guide stars) on about 1° diameter field, yielding a sky coverage > 95% ultimately limited by free-seeing. On the OTCCD side, 100-150 Tip/Tilt natural guide stars of magnitude r<~14.5 (sky coverage ~ 50% at the NGP) will be used. The spectral coverage will be [400-110nm].

Technical challenges are numerous for this project: the size of the optics makes the instrument but big and heavy for a prime-focus setup, and would require important changes at the Cassegrain focus. The identification of an optical design providing in the real world the required performances is not clear either. All these issues will have to be addressed ultimately in a Phase A if the project moves ahead in mid 2011.

Science goals are numerous, but some could be challenged by the characteristics of the PSF (point spread function) delivered by the GLAO corrections and by its changing nature with the location of the guides stars different from a field to another. At this point, it seems possible to address these issues but more simulation work is needed, helped by on-site GLAO tests. Assuming a resolution of 0.3” in r (full-width half-max) under median seeing conditions, a depth of r = 26.5 can be reached in 1 hour (5σ), and a field of at least 0.6 square degree, `IMAKA would be instrumental to the future of CFHT research ion the Kuiper Belt as well as to a wide range of applications such as resolved stellar populations, galaxy formation, or cosmology. Detailed dynamical studies in globular clusters could include search for intermediate mass black holes, dynamical signature metallicity variations, stellar orbits and evaporation rate. Similar studies in open clusters could allow to separate cluster from field, bringing information on ages and star formation history, and tackle problems like the universality of the IMF, its relationship with metallicity. Beyond our Galaxy, `IMAKA could observe Red Giants out to 10 Mpc, locating stellar streams, bringing clues to galaxy formation and test the λCDM model.

Dome Venting

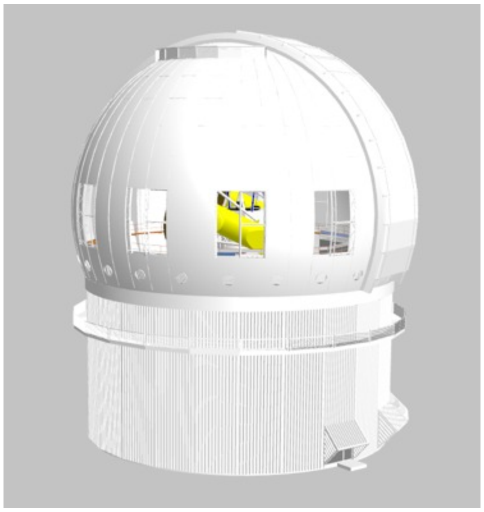
Since mid-2003 and for many years, MegaCam has been used by the CFHT Legacy Survey, followed by a few Large Programs, as well as hundreds of PI programs. As all images have been pre-processed in-house, CFHT has at its disposal an amazing database of delivered image quality (IQ) with, for each data point, a wealth of information on environment parameters. This data was thoroughly analyzed, resulting in many graphs like the one shown on the left, which provided valuable hints on how to improve the image quality seen by the instruments.



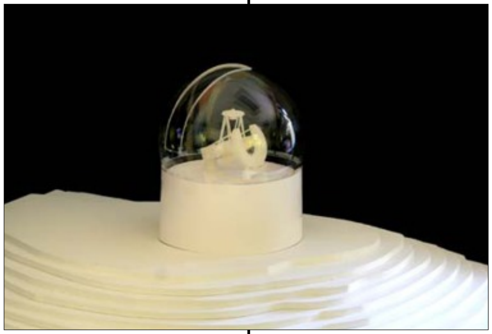
MegaCam IQ versus slit to wind angle

IQ is significantly better when the slit is oriented at 45º from the wind, thus allowing a strong flushing of the dome.

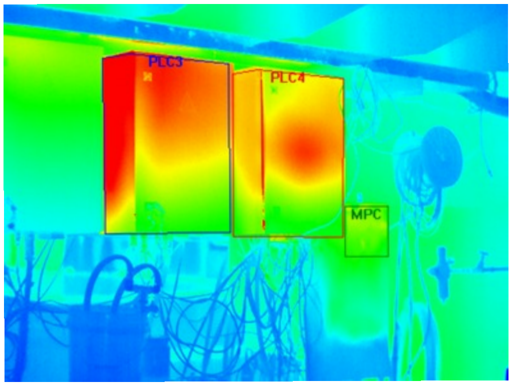
With the strong suspicion that the lack of proper venting of the dome was degrading the outside seeing, it was decided by the end of 2009 to start an in-house project, dome venting, funded using CFHT's Development Fund and aiming at (1) confirming through appropriate studies the value of venting the dome already recognized through MegaCam IQ studies, and (2) designing and implementing vents on the dome. The current schedule calls for a completion of the entire project before the end of 2013.



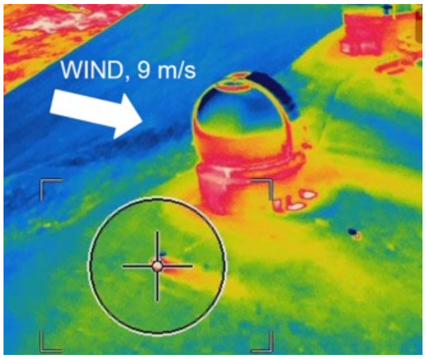
A computer model of the telescope and its enclosure were completed at the end of the summer 2010 by CFHT's mechanical designer just prior to his retirement. The model is completely articulated, allowing dome rotation, dome shutter opening and closing and telescope motions in Declination and Hour Angle. The model was used to generate three candidate vent geometries, one of which is shown on the left. The computer models of the dome and telescope have been provided to the NOAO and Taiwan CFD groups who are currently working up computer CFD models to show air flow and flushing associated with the vents at various wind-to-dome slit orientations.



As a consequence of advice from fluid dynamics labs, it was decided to undertake water tunnel tests at the University of Washington as a starting point for understanding air flow in and around the CFHT dome. A terrain model of the summit area was fabricated over the summer, a detailed physical model of the telescope at 160:1 scale was fabricated from the computer model by a commercial stereo lithography house and a transparent acrylic model of the dome has been started in-house. An image of the model, assembled with a paper mockup of the lower building, is shown on the right. Water tunnel tests are scheduled for the first half of 2011 at University of Washington and wind tests in Taiwan in summer 2011.



In parallel with the dome venting project, a thermal assay program was initiated to identify heat sources in and around the CFHT dome. On the left is a sample IR image of the PLC cabinets used for MegaPrime when in storage, taken with a FLIR SC620 camera borrowed from IfA. Night-time airplane flights over the summit captured wider views of the dome and surrounding area. The view on the right shows the building wake vortices. Mitigating heat sources in the dome and building are an important complement to the dome venting project.



Outreach

CFHT's outreach program has been again very active, emphasizing as usual activities directed toward the local community, thanks to the contribution of many staff members. The staff member at the helm of these efforts, Mary-Beth Laychack, departed in September 2010. She was replaced in this role by Nadine Manset and DeeDee Warren. One person was not enough to take over Mary-Beth's significant role, a tribute to the major contributions she dedicated to outreach over the years.

GEMS

Mary Beth Laychack at the 2009 Girls Exploring Maths and Science Day .

CFHT participated in many fairs and festivals: Onizuka Day at UH Hilo, West Hawaii Intermediate/High School Science Fair (judging), Family Science Day at 'Imiloa, East Hawaii Intermediate/High School Science Fair (judging), Girl Scouts' Women in Science Day, Healthy Keiki Fest in Waimea, Astro Day in Hilo, Girls Exploring Math and Science Day, Waimea Country School Science Fair (judging), Family Science Night at Waimea Middle School, Science Fair at Kohala Middle/High School (judging), and Family Astronomy Night at the Kona and Kohala Libraries.

Various visits of the headquarters and the summit were organized for groups and special guests. CFHT offered summit tours as silent auction items at local fundraising events for schools and non-profit groups.

Local schools were visited, bringing astronomy and its actors in the class room. Resident Astronomers gave talks for the Universe Tonight conference series at the Hale Pohaku Visitor Station.

The first Solar System Walk was organized in 2009 in partnership with the Keck Observatory, also based in Waimea. In spite of the windy and misty weather, it was well-attended and appreciated. CFHT and Keck decided to make this an annual event. The 2010 edition was also a great success!

The traditional CFHT Star Gazing Party, scheduled to immediately follow the Waimea Christmas Parade, generally held in the evening of the first Saturday of December, gathered again a good crowd. While the 2009 party was faced (again!) with yet another bout of windy-misty-cloudy Waimea weather, 2010 was blessed with clear skies, bringing joy and awe to the many visitors of all ages, as the picture on the right shows.

In addition to its usual outreach activities, CFHT marked the International Year of Astronomy (IYA 2009) through the participation of staff members in IYA activities and the organization of special events.

J.-C. Cuillandre, L. Bryson, M.B. Laychak and C. Veillet attended and spoke at the IAU/UNESCO conference "The Role of Astronomy in Society and Culture", January 19-23. In addition to a presentation of the DVD "Hawaiian Starlight", CFHT offered its 2009 Calendar to all participants. CFHT participated in the "100 Hours of Astronomy: Live from Mauna Kea" and in the Big Island Cosmic Poster Contest (judging and prizes). It also provided the Big Island IYA trading cards set four images and set up an exhibition of Hawaiian Starlight images at the 'Imiloa Center for Astronomy

D. Devost was invited to give a talk at the *AstroLab du Mont Mégantic* in Québec, Canada, as part of a conference program held every Saturday in the summer months of 2009. It was a good opportunity to talk about CFHT, its instruments and its many scientific contributions to a public that is oftentimes unaware of the involvement of Canada in an international science project located in Hawaii.

The CFHT co-produced scenic film and DVD "Hawaiian Starlight" (Exploring the Universe from Mauna Kea) was a solid vehicle for the promotion of the telescope during the International Year of Astronomy. The film was presented on several occasions in lecture halls and performance theaters, always free of charge for the audience. Jean-Charles Cuillandre, the CFHT astronomer who created the piece, introduced the film by giving a short lecture describing the story of the telescope and how the film was created over seven years. A popular questions and answers segment followed the screening.

The film was shown on four occasions on the Big Island in performance theaters offering a large screen and a powerful sound system. These showings were coupled with special afternoon sessions for schools. While the film creator had the opportunity to share such format with the public throughout 2009 (Victoria, Paris, Padova, Andorra, Maui), the film was also adopted by various groups involved in the promotion of the International Year of Astronomy in Canada and France.

Hawaiian Starlight

J.C. Cuillandre signing the DVD after a showing in the Kahilu Theatre (Waimea). The DVD has been a real asset for CFHT during IYA.

C. Veillet gave two talks for the Observatory Director's Lecture Series organized on the Big Island. In collaboration with ProScience - Te Teru 'Ihi Association and the Astronomical Society of Tahiti, and much help from the local Department of Education, he spent two weeks visiting middle and high schools, giving conferences on the Island of Tahiti and also on less visited islands, such as Raiatea and the Australes (Rurutu and Tubuai). This visit has been the major event of IYA in French Polynesia, touching 900 students through visits in class rooms in twelve different schools (Lycée Samuel Rapooto, Papeete, picture on the left), as well as university-level students in Education. Thanks to seven conferences organized at the University and in city halls in every island visited, C. Veillet was able to reach hundreds of people from the general public. A very strong support of the local media, including evening news on local TV channels (Tahiti Nui Television - picture on the right), helped in promoting the various events, giving astronomy and CFHT a wide exposure in the general public, and activating once more the historical link between Tahiti and the Hawaiian Islands.

Canada Post selected CFHT as one of the two Canadian telescopes featured on stamps issued to celebrate IYA. In addition, two images made from MegaCam data processed by Jean-Charles Cuillandre and Coelum were used for the stamps background (see front cover for the stamps, and front and back covers for the images).

Comings and Goings

RAECHEL ZELMAN left CFHT in August 2009 after being with us for a little more than 3 years. She was hired as a Service Observer at CFHT in May 2006. Rachael was a conscientious SO and provided good observations for the CFHT PIs. She also helped with distributions, always striving to provide better data to our Scientists. She did a good job! Rachael was also involved in outreach and always available to help with all aspects of CFHT's operations. Rachael and her husband have moved back to the mainland to pursue other interests.

LOIC ALBERT left CFHT in December 2009 after a tenure as Canadian Resident Astronomer for nearly five and a half years. He studies Brown Dwarfs and is heavily involved in the Canada France Brown Dwarfs Survey. This survey aims at identifying ultracool brown dwarfs (Y dwarfs) and obtain a large sample of brown dwarfs to trace their galactic distribution. During his stay at CFHT, Loïc was the WIRCam Instrument Scientist and contributed significantly to several aspects of the instrument. He also wrote the first version of the science data reduction pipeline. Most of the software Loïc wrote is still in use today in the second version of the software. Loïc remains a regular user of CFHT and recently joined the Astrophysics group at the Université de Montréal to work on the JWST guiders.

KARUN THANJAVUR joined CFHT in April 2010 as Canadian Resident Astronomer. He was appointed Instrument Scientist for WIRcam. His principal responsibilities are to provide PI as well as in-house support for all WIRCam related science issues, while actively participating in queue coordination and other QSO duties. In conjunction, Karun also pursues his science interests, with research spanning a variety of astrophysical areas extending from the early Universe, such as large scale structure formation and galaxy evolution, to the dynamics of globular clusters and high velocity clouds in the Milky Way. These explorations of the Universe come after a full career as a mechanical engineer, specializing first in combustion engineering, and later in control systems and robotics. Born and raised in a small town in South India, Karun completed his education up to a bachelors degree in mechanical engineering there, and worked as a professional engineer for several years before emigrating to Canada to pursue graduate studies first in Robotics, and later in Astrophysics. His current position at CFHT provides him the enriching experience of working with cutting-edge telescope technology while pondering on Nature's many wonders in our Universe.

MARY BETH LAYCHACK left CFHT in September 2010 after working for CFHT for more then 7 years. Mary Beth was hired as a Service Observer in June 2003. She was an excellent SO and her knowledge of astronomy and her attention to details provided high quality data to the CFHT PIs. Her contribution to the Remote Observer training was very important to the success of the program and played a major role in the early days of OAP's observing side development.

Mary Beth was also leading the Outreach program, making sure that CFHT was present to several community events and always being a participant herself to these events. Mary Beth's great communication skills makes her an effective communicator of Science to the public. She was also involved on several other aspects related to work performed at CFHT; helping with data distributions, with the library and with instrument exchanges, among others. Mary Beth has moved to Oahu where she can now enjoy the big city life and also be with her husband who started a law career.

EDER MARTIOLI joined CFHT as a Brazilian resident astronomer in September 2010. Eder received his PhD in Astrophysics from the Instituto Nacional de Pesquisas Espaciais (INPE) with collaborative period at the University of Texas at Austin. Eder's science interests are concentrated on optical and infrared astronomy. He works on the detection and characterization of exoplanets, brown dwarfs and low-mass star companions, gravitational microlensing and stellar activity. He performed his science using photometry and time series, high precision radial velocity with high resolution spectroscopy, and narrow field astrometry with the Fine Guidance Sensors on HST, optical interferometry and imaging. Eder is involved in several projects at CFHT and mainly works on ESPaDOnS. Welcome to CFHT, Eder!

DAN SABIN retired in October 2010, after 25 years of service as CFHT's machinist / mechanical designer . His knowledge of the mechanical systems of the telescope and his ability to fabricate and repair precision parts and assemblies will be greatly missed. Dan's departing accomplishment was the creation of a 3-D computer model of the telescope, dome, and building. Dan came to us from the tool and die trade as a master machinist, but over the years, with his interest in design, he became proficient in the use of modern computer design tools, starting with AutoCad when it first came out and most recently with AutoDesk Inventor.

Among his many other accomplishments, Dan designed and managed the construction of the then new MegaPrime upper end, and was instrumental in rebuilding the filter and juke box mechanisms when they failed catastrophically in the first years of MegaCam operations.

2009 & 2010 Financial Resources

The three Member Agencies supported the CFHT annual budget in 2009 and 2010 as shown in the table at the right, in US funds. These contributions reflect a 3% increase in 2009 over the prior year, and a 4% increase in 2010 over the prior year, in accordance with the Golden Age Plan.

Agency Contributions	2009	2010
NRC	3,136,126	3,261,571
CNRS	3,136,126	3,261,571
UH	727,218	756,308
Total	6,999,470	7,279,450

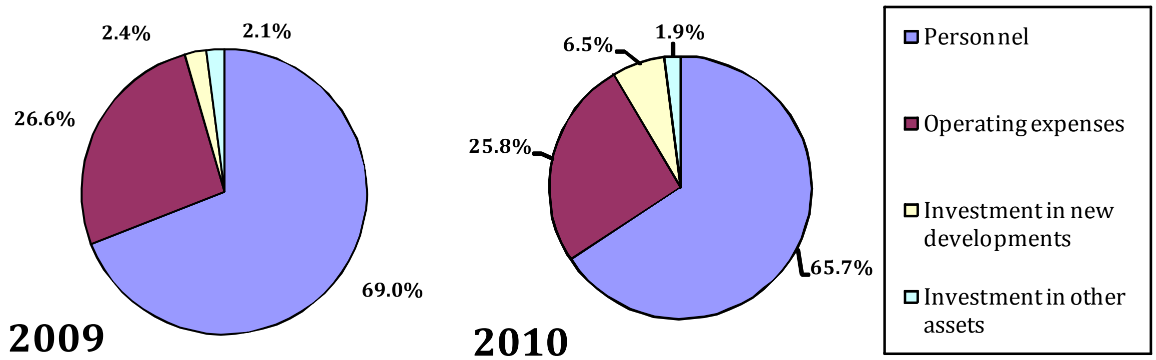
In 2009, under a collaborative agreement with CFHT, the Academia Sinica Institute of Astronomy and Astrophysics of Taiwan and the Brazilian Ministry of Science and Technology remitted $557,452 and $180,000, respectively, as reimbursement for costs associated with its use of the Corporation's facilities. Other sources of funds included $18,072 from mid-level facility use credits, $63,004 from distribution of educational materials, $63,301 in staffing cost reimbursements related to installation and maintenance of the Mauna Kea Atmospheric Monitor, and $64,489 in earned interest.

Operating Fund Expenditures	2009	2010
Observatory facilities and operations	732,435	803,303
Base facilities and operations	648,639	687,466
Instrumentation	203,284	86,628
Science	66,670	53,601
Outreach	84,956	38,660
General administrative expenses	356,788	433,133
Staffing	5,041,698	5,101,159
Transfer from Reserve	(135,000)	75,500
Total Operating Fund Expenditures	6,999,470	7,279,450

In 2010, under a collaborative agreement with CFHT, the Academia Sinica Institute of Astronomy and Astrophysics of Taiwan and the Brazilian Ministry of Science and Technology remitted $437,000 and $418,750, respectively, as reimbursement for costs associated with its use of the Corporation's facilities. Other sources of funds included $13,322 from mid-level facility use credits, $51,746 from distribution of educational materials, $39,882 in staffing cost reimbursements related to installation and maintenance of the Mauna Kea Atmospheric Monitor, and $40,221 in earned interest.

From the operating fund, expenditures in **2009** and **2010** were allocated to the areas listed in the table at left

Overall in 2009 and 2010, resources from all CFHT funds were allocated to the categories of expenditures shown in the pie chart below.



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