2014 CFHT Annual Report

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Front and back covers: The spiral galaxy Messier 100, as imaged by CFHT's MegaCam, is shown on the front and back covers together with CFHT atop the upper ridge of Maunakea. The front includes the Bers family who, along with many others, visited CFHT during 2014.

Director's Message


Figure 1 – CFHT celebrated its 35th anniversary in 2014. Events at the celebration started with this group photo from an overhead camera in front of the office. Photo courtesy Tom Benedict.

An important milestone quietly occurred in 2014 with the arrival of CFHT's 35th year of operations. The event was marked in Waimea with a staff party that included a number of former members of the CFHT 'ohana who remain on-island. It was a great opportunity to not only reflect on the past but consider the future of an observatory that has made so many contributions to science, the careers of engineers and astronomers worldwide, and the wellbeing of families across Hawaii Island.

Like any observatory, CFHT's role and prominence in global astronomy has evolved over time. When commissioned, the combination of CFHT's aperture, instrumentation, and exquisite site properties made it a leading astronomical research facility worldwide. That position eventually faded with the arrival of much larger telescopes and space based facilities, leading to adaptation and "retooling" to maintain CFHT's relevance and competitiveness. The willingness of CFHT's community to take some risks, cultivate a culture of innovation, and avoid being satisfied with the status quo, has been essential in CFHT's success over the years. Indeed, despite CFHT's venerable age and modest aperture, in recent years the body of research based upon CFHT data has greater science impact than most other ground based telescopes. With >150 papers based at least in part on CFHT data published in 2014, the productivity of the CFHT community has been exceptional.

How is it possible for an aging facility that spans nearly 2 generations, used 35 mm film to record its first images, and was originally designed with slide rules to have such scientific impact in the 21st century? The answer is complex and doubtless due to a confluence of circumstances and opportunities, but there are some aspects that are particularly noteworthy. First, the importance of the personal connection and sense of ownership between CFHT and its community cannot be overstated. Many of the astronomers who use CFHT today "cut their teeth" on CFHT as young researchers and are eager to share the opportunities they had with students and post-docs. I certainly remember the prominence of CFHT as a UH grad-student, and the pride I felt when I was fortunate enough to observe at what I knew was a pinnacle of astronomy. It should come as no surprise that I, like my colleagues who observed on CFHT as grad-students or post-docs, want to pass that "torch" to the next generation and perpetuate CFHT's legacy.

That community support in turn maps into the crucial grass roots support our agencies need to sustain funding for CFHT. In an era of increasing pressure on shrinking budgets, it isn't enough to excel in terms of technical capabilities, or have a lengthy publications list to point to. Communities need to voice their support for the facilities they count on to sustain their research, bolstering the cases being made by funding agencies for continued funding. Those voices are naturally amplified when they are grounded in years of experience with CFHT, reflect confidence in its future, and echo a strong desire to be part of it.

Engaged Board members and clear governance are also important to what has sustained CFHT so long. A couple of Board meetings ago, when we held the first-ever "talk story" session between the CFHT staff and Board, I asked each Board member to introduce themselves to the staff. What they provided was far more than a simple set of introductions – each Board member shared fond memories of using CFHT in prior years, in a sense transcending their roles from Board members to CFHT 'ohana members. The CFHT Board has past Directors on it, hence melds an understanding of the research community, agencies, and inner workings of CFHT which is valuable and rare. The governance of CFHT, as a non-profit corporation, makes it possible to execute decisions in a timely manner, giving us the ability to focus on "product" and not get bogged down in "process". In other words, while CFHT Corp. has all of the auditing, legal, and business safeguards in place to minimize the possibility of abuse of its independence as a corporation, it also has the organizational nimbleness to actually make things happen.

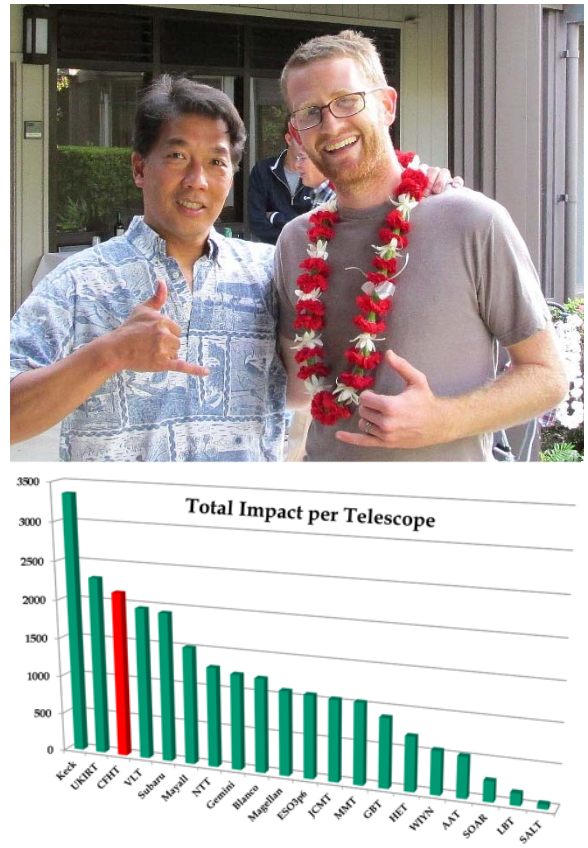


Figure 2 – Top: Part of CFHT's success has always been its exceptional staff. Brandon Metz (right) with Kevin Ho (left), our instrument group manager, during Brandon's farewell party in 2014 are shown. Bottom: Total science impact from 2008-2012 per telescope is plotted for observatories worldwide. CFHT consistently fares well in these analyses, an indication that CFHT remains scientifically competitive even 35 years into its lifetime. Plot courtesy Dennis Crabtree.

Finally, central to CFHT's success over the years has been its staff – a staunchly dedicated group that is thoroughly networked with the researchers and instrument builders that comprise our extended community. It has been rewarding to see several return to work at CFHT in recent years after multi-year stays with other organizations. Many on the staff have worked most of their professional careers at CFHT which, combined with those who have "returned for more", is a strong indication of the overall level of professional and personal satisfaction the staff enjoys. These sentiments aren't a secret and help attract ever more skilled and innovative staff over time.

In summary, no single reason can explain CFHT's success over the years and though there have been bumps in the road, our outlook remains positive, cognizant of where we have been and where we need to be. As described in the following pages, our future hinges on an expanding partnership, increasing large programs, new instruments, synergies with other facilities, and the eventual transformation of CFHT into a new facility. Being part of the CFHT community and fortunate enough to represent it on various occasions has been a tremendous honor and pleasure for me – something I shall always treasure.

Science Report

Research in 2014 conducted at CFHT spanned a huge gamut, from observations of planets in our solar system to free floating exoplanets among nearby stars. Research also featured mapping dark matter across vast regions of intergalactic space and observations of unusual galaxies called "red nuggets". CFHT's ability to observe Targets of Opportunity was nicely showcased through rare planetary occultations and a total lunar eclipse over Hawaii which was used to perfect techniques for detecting exoplanet atmospheric biomarkers.

Transmission Spectra of the Earth's Atmosphere

The 15 April 2014 lunar eclipse was observed using ESPaDOnS for Chinese astronomer Fei Yan. The goal of the observations was to better understand the detection challenges of exoplanet atmospheres measured in transmission. Yan's team obtained dozens of transmission spectra that probe the Earth's atmosphere from different altitudes. Figure 3, provided by the PI, shows the transmission spectra at 5 different atmospheric altitudes. The spectra show variations of the absorption features due to water, oxygen and ozone – all biomarkers of particular interest in exoplanet research. The results have not been published yet but observations using a similar technique have been published by the same group (http://arxiv.org/abs/1405.4780).

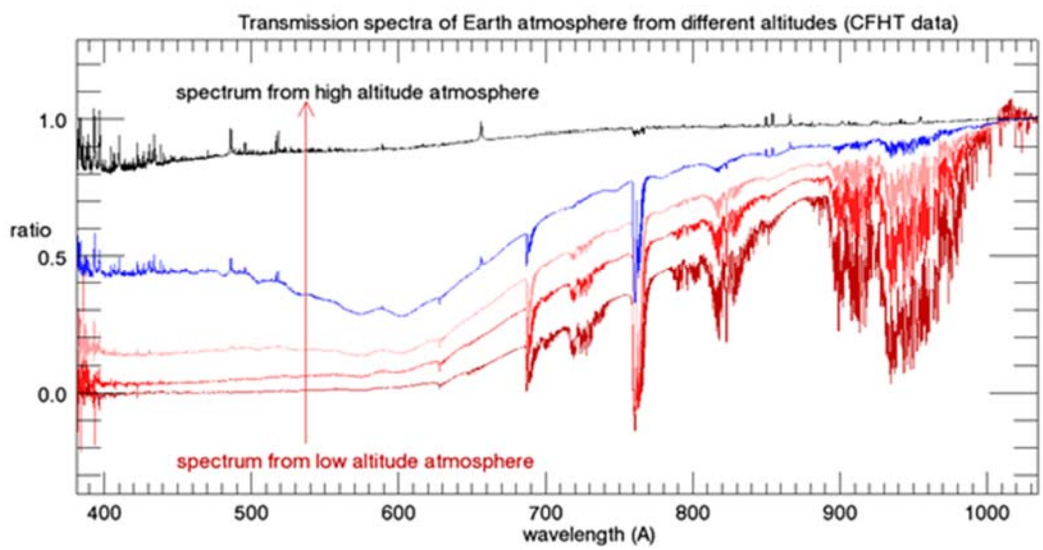


Figure 3 – An experiment using ESPaDOnS to detect biomarkers in Earth's atmosphere via light reflected from the moon during a total lunar eclipse is shown above.

Doppler Velocimetry of Venus Cloud Top Winds

From 16 - 21 April 2014, CFHT performed daytime observations of Venus with ESPaDOnS. The PI, Thomas Widemann, came to CFHT with two collaborators to help with the observations. CFHT provided a Remote Observer and one sun watcher every day of the run. The program was highly ranked by the French agency and was competing with another high priority program from France that needed observations at the end of the night. Daytime observations helped us alleviate the pressure in this region of the sky and perform more observations of two highly ranked programs.

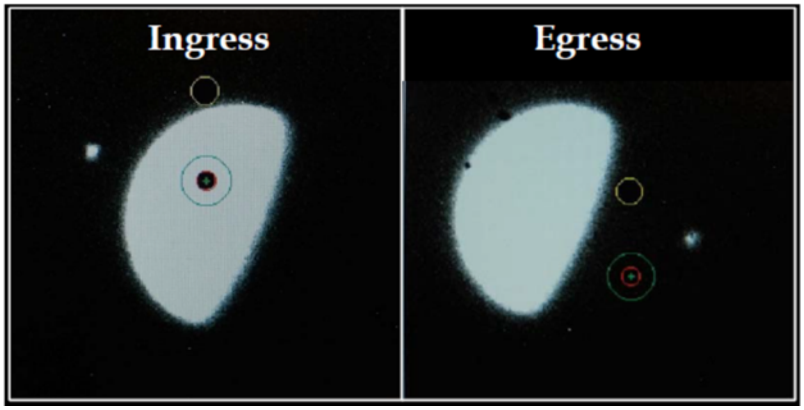


Figure 4 – The ingress and egress of the occultation of λ Aquarii by Venus, as recorded with the ESPaDOnS guide camera, is shown. This permitted measurements of the composition of Venus' upper atmosphere. Images courtesy Thomas Widemann.

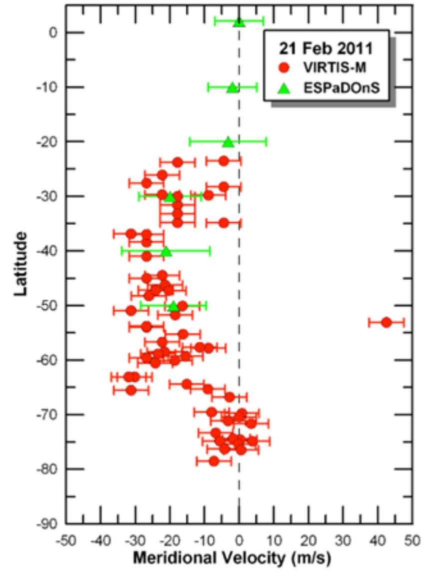


Figure 5 – Adapted from Machado et al. 2014, this plot of high altitude winds in Venus' atmosphere was generated using a combination of data from ESPaDOnS and the Venus Express orbiter.

Venus cloud top winds near 70 km in altitude were measured in the spectroscopic star-only mode with 3-sec exposures. A grand total of 864 exposures, corresponding to 288 direct wind measurements at Venus, were successfully acquired. The observations were coordinated with ESA's Venus Express' VIRTIS and VMC instrument to help constrain the background motion of the atmosphere at cloud top level.

As a coincidental event, Venus occulted a 3.7-mag star around 0800h HST on April 16. The star, lambda Aquarii, is an M0 red giant with a diameter of 8 mas. Ingress occurred on the dayside around 18:01:30 and egress on the nightside around 18:08:20 UT. Because it is a point source, the event will usefully complement the modeling of Venusian atmospheric temperature profiles in the 150-200 km altitude region. This is the brightest star occulted by Venus (and by any major planet) since Venus occulted 2.1 mag sigma Sagittarii in November 1981. The next occultations of a bright stars by Venus will be of pi Sagittarii in 2035 and Regulus in 2044. A total of 333 ESPaDOnS guider images were acquired to record in detail this rare event.

Archival Research Using CFHT Data Reveals a Missing Link

Archival research is an important tool in astronomy. More and more researchers use archived data for their research and are able to generate original, exciting and high impact results. This research, done at the Harvard-Smithsonian Center for Astrophysics by Ivana Damjanov on red nuggets, is a perfect example of what can be achieved using archival data.

Red nuggets are a type of galaxy which, until now, were only observed in the early Universe. Indeed, when the Universe was young and dense, these massive galaxies were quite common. They are ten times more massive than the Milky Way, but their old and red stars are packed into a volume a hundred times smaller than our Galaxy, thus the nickname "red nuggets".

Surprisingly, these galaxies have no counterpart in the local universe. Ivana and a team of researchers have attempted to address this problem using archive images from the Sloan digital sky survey, from which several hundred red nugget candidates were identified. Her team then used high quality images from CFHT and Hubble Space Telescope to show that about 200 of the candidates were galaxies very similar to their cousins in the distant, young Universe.

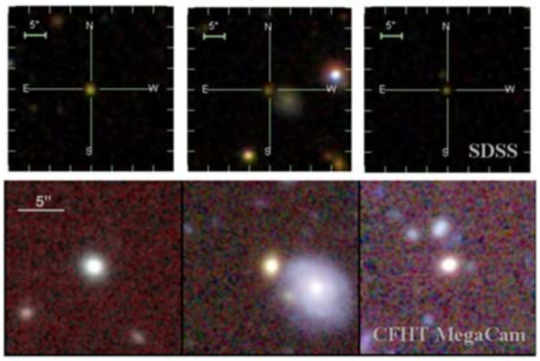


Figure 6 - Sloan Digital Sky Survey and CFHT images of three red nuggets. The Sloan survey images were used to locate candidates and the CFHT images were used to derive the physical parameters of the candidate galaxies using profile fitting software.

The large number of red nuggets discovered told the team how abundant those galaxies were in the local Universe. That number can then be compared to computer models of galaxy formation. Different models for the way galaxies grow predict very different abundances of red nuggets. The model that best matches observations is one where red nuggets begin their lives as very small objects in the young universe. During the next ten billion years some of them collide and merge with other, smaller and less massive galaxies. Some red nuggets manage to avoid collisions and remain compact as they age. The result is a variety of elliptical galaxies with different sizes and masses, some very compact and some more extended.

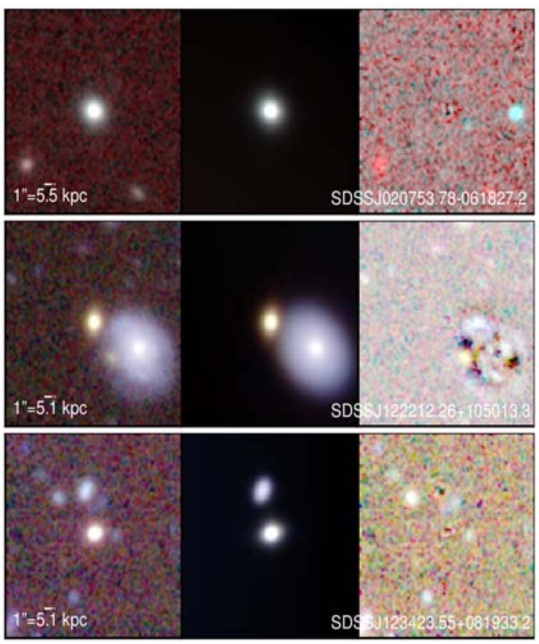


Figure 7 - Three examples of galaxy fitting results using CFHT images are shown. The panel to the left is the CFHT image, the middle panel is the fit to the data and the panel to the right shows the residuals of the fit.

A Very Lonely Planet

An international team led by Université de Montréal researchers used CFHT to discover a new planet 155 light years from our solar system. This gas giant has been added to the short list of exoplanets discovered through direct imaging. It is located around GU Psc, a star three times less massive than the Sun and located in the constellation Pisces. The international research team, led by Marie-Ève Naud, a PhD student in the Department of Physics at the Université de Montréal, was able to find and characterize this planet by combining observations from the Observatoire du Mont-Mégantic (OMM), CFHT, the W.M. Keck Observatory, and the Gemini North and South Observatories.

GU Psc b is around 2,000 times the Earth-Sun distance from its host star, a record among exoplanets. Given this distance, it takes approximately 80,000 Earth years for GU Psc b to make a complete orbit around its host star. The team used theoretical models of planetary evolution to determine its characteristics. The spectrum of GU Psc b obtained from the Gemini North Observatory on Maunakea was compared to such models to show that it has a temperature of around 800 °C. Knowing the age of this system due to its location in AB Doradus, the team was able to determine the mass of GU Psc b to be 9-13 times that of Jupiter.

The team has started a project to observe several hundred stars in an effort to detect planets with similar orbits that have even lower mass than GU Psc b. The discovery of GU Psc b, a rare object indeed, raises awareness of the potentially large distances that can exist between planets and their host stars, opening the possibility of searching for planets with powerful infrared cameras using much smaller telescopes such as Observatoire du Mont-Mégantic. The researchers also hope to learn more about the abundance of such objects in the next few years using GPI at Gemini South, CFHT's upcoming instrument SPIRou, and the James Webb Space Telescope's FGS/NIRISS.

Abundance of Dark Matter Peaks Found Using Gravitational Lensing

A number of studies have shown that dark matter is the principal mass component of the universe, making up about 80% of its mass budget. The most direct technique to reveal the distribution of dark matter is through gravitational lensing. By measuring the exact shapes of millions of these distant galaxies it is possible to map the mass distribution in the universe, including dark matter. Importantly, the number of mass peaks as a function of their amplitude constrains cosmological models. This distribution is also sensitive to the fundamental nature of gravity at large scales as well as the geometry of the universe.

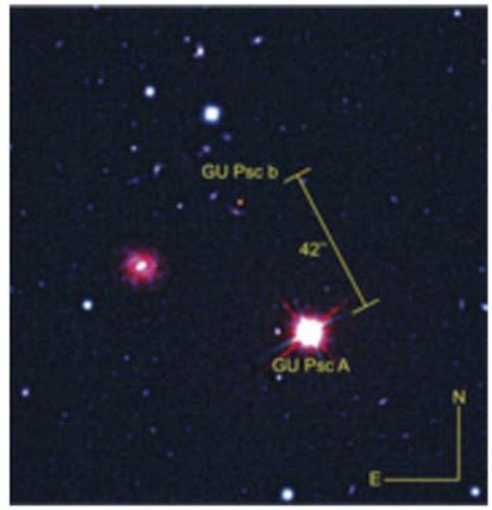


Figure 8 - The planet GU Psc b and its host star GU Psc imaged at visible (Gemini-South) and infrared (CFHT) wavelengths.

In a new publication of the Monthly Notices of the Royal Astronomical Society, an international team (Shan et al., MNRAS, 2014, 442, 2534) including researchers from Switzerland, France, Brazil, Canada, and Germany present a detailed analysis of weak lensing peaks. This work is considered a milestone given the cosmological importance of these structures. Because mass peaks are identified in two–dimensional dark matter maps directly, they can provide constraints that are free from potential selection effects and biases involved in identifying and measuring the masses of galaxy clusters. In fact a small fraction of the peaks are just mass concentration excesses along various lines-of-sight, not genuine massive clusters.

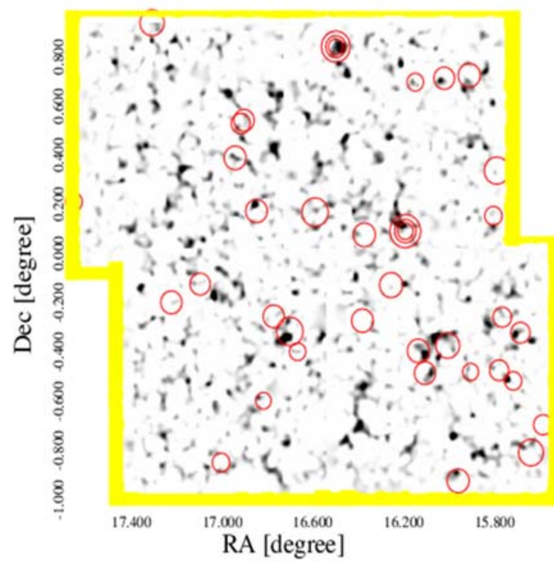


Figure 9 – This map shows the distribution of dark matter (black) in the universe, overlapping with optically measured clusters of galaxies (red circles). The mass peaks in the map contain significant cosmological information and will help provide an improved understanding about the “dark side” of the universe. The size of this map is about 4 square degrees corresponding to only 2.5% of the full CS82 survey footprint. Image credits: Dr. HuanYuan Shan, EPFL, Switzerland.

To detect weak lensing mass peaks the research team used the Stripe 82 Survey (CS82), one of the largest weak lensing surveys yet. The survey covers ~170 square degrees in an equatorial region of the south Galactic cap that has been extensively studied by the SDSS project.

With precise shape measurements for more than four million faint distant galaxies, a dark matter map was generated. This work also opens a new window to constrain cosmology with weak gravitational lensing. This work not only reveals where dark matter is located using space-time distortion, but also uses the distribution of mass peaks to better constrain and understand our universe.

The abundance of peaks in the dark matter mass map confirms certain theories of structure formation. In the near future, through various weak lensing surveys (to be conducted with DECam, LSST and EUCLID), it will be possible to further constrain the nature of dark matter and dark energy.

Fingerprinting the Formation of Giant Planets

A team of Brazilian and American astronomers used CFHT observations of the system 16 Cygni to discover evidence of how giant planets like Jupiter form (Maia et al., 2014, ApJ, 790, L25). One of the main models to form giant planets is called "core accretion". In this scenario, a rocky core forms first by aggregation of solid particles until it reaches a few Earth masses when it becomes massive enough to accrete a gaseous envelope. For the first time, astronomers have detected evidence of this rocky core, the first step in the formation of a giant planet like our own Jupiter.

The astronomers used CFHT to analyze the starlight of the binary stars 16 Cygni A and B. The system is a perfect laboratory to study the formation of giant planets because the stars formed together and are therefore very similar in most respects. They are also good solar analogues. However, observations during the last decades show that only one of the two stars, 16 Cygni B, hosts a giant planet which is about 2.4 times as massive as Jupiter. By detailed spectral analysis of the light from the two stars and looking at the differences between them, the astronomers were able to detect signatures left from the planet formation process on 16 Cygni B.

The fingerprints detected by the astronomers are twofold. First, they found that the star 16 Cygni A is enhanced in all chemical elements relative to 16 Cygni B. This means that 16 Cygni B, the star that hosts a giant planet, is metal deficient. As both stars were born from the same natal cloud, they should have the same chemical composition. However, planets and stars form at about the same time, hence the metals that are missing in 16 Cygni B (relative to 16 Cygni A) were probably removed from its protoplanetary disk to form its giant planet, so that the remaining material that was falling into 16 Cygni B in the final phases of its formation was deficient in those metals.

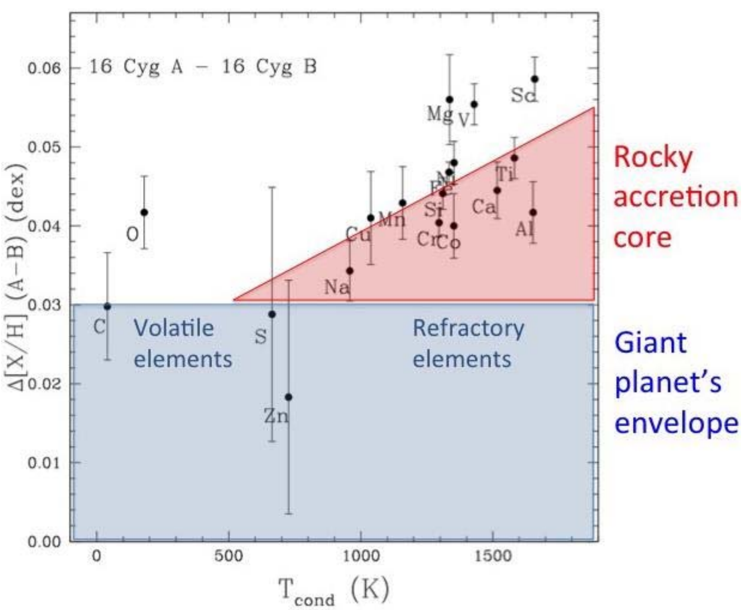


Figure 10 - Differences in chemical composition between the stars 16 Cyg A and B, versus the condensation temperature of the elements in the proto-planetary nebula is shown. If the stars had identical chemical compositions then the difference (A-B) would be zero. The star 16 Cyg A is richer in all elements relative to star 16 Cyg B. In other words, star 16 Cyg B, the host star of a giant planet, is deficient in all chemical elements, especially in the refractory elements (those with high condensation temperatures that form dust grains more easily), suggesting evidence of a rocky core in the giant planet 16 Cyg Bb. Credits: M. Tucci Maia, J. Meléndez, I. Ramírez.

The second fingerprint is that on top of an overall deficiency of all analyzed elements in 16 Cygni B, this star has a systematic deficiency in the refractory elements such as iron, aluminum, nickel, magnesium, scandium, and silicon. This is a remarkable discovery because the rocky core of a giant planet is expected to be rich in refractory elements. The formation of the rocky core seems to rob refractory material from the proto-planetary disk, so that the star 16 Cygni B ended up with a lower amount of refractories. This deficiency in refractory elements can be explained by the formation of a rocky core with a mass of about 1.5 – 6 Earth masses, which is similar to estimates of the mass of Jupiter's core.

Engineering Report

Summit Facilities Overview

After the catastrophic failure of the dome shutter system in 2012, the replacement of the dome shutter gearboxes is now complete with the last two drives installed in July and October of 2014. This major rebuild of the dome shutter assembly, which is now >35 years old, should leave the shutter assembly in a robust state for many years to come. Rework of the 26 bearings in the shutter panel upper rollers has become the main focus of remaining shutter upgrades.

Progress with the new Telescope Control System (TCS) was good in 2014, with all major hardware and software components completed and a variety of on-sky tests completed. Pointing and tracking are now at the level of or better than the previous TCS. Final on-sky stress testing and new pointing models needed as a result of relocation of some of the encoders will likely be completed in early 2015, with release for full operations expected soon thereafter. Remaining work mostly involves tidying up operator forms, testing offsets, fine tuning the system with each instrument setup, optimizing telescope balance procedures with the new TCS, etc.

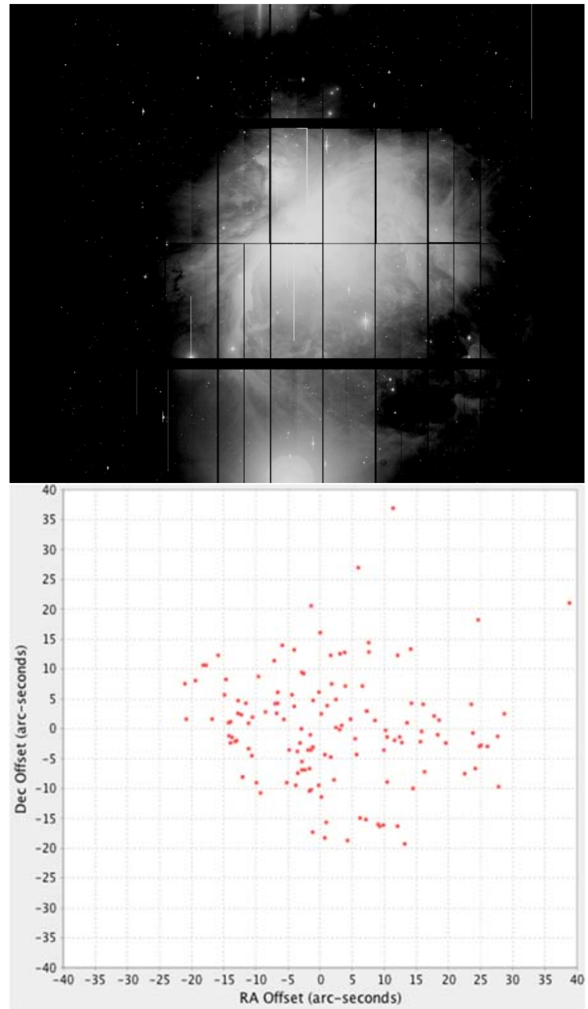


Figure 11 – Above, one of the first raw test images recorded with the new TCS was of the Orion Nebula with MegaCam. Below, a typical pointing error map generated with the current TCS is shown. One of the requirements of the new TCS is to provide at least the same level of pointing accuracy as the previous generation system.

During the summer of 2014 the f/8 secondary mirror was re-aluminized and the f/8 mirror cell was refurbished via routine maintenance on the mirror support vacuum and pressure regulators and the airlines feeding them. This effort was a first-time experience for many of the staff involved, hence demanded careful planning and execution. Soon after work on the f/8 assembly was completed the primary mirror was re-aluminized and the associated mirror support pucks serviced, all of which went well. Coating thicknesses for both the primary and secondary mirrors were well within the expected range, yielding a significant boost in throughput, particularly in the UV were coating degradation is naturally accelerated.

Other major work during the summer shutdown included upgrading the network connection of the summit facility from 1 gigabit/sec to 10 gigabit/sec. At the same time several switches and routers were upgraded and new cabling runs established throughout the building. Backup infrastructure that allows mirroring offsite system backups between the summit and Waimea was installed. In Waimea a 1 gigabit/sec wireless link with Keck was tested that is intended to provide a backup link to the summit adequate for remote observing. This collaboration with Keck is one of many between CFHT and neighboring observatories, yielding low cost efficient sharing and redundancy of key systems as essentially all of the Maunakea observatories migrate to base facility (remote) observing.

Dome Venting

After a very successful installation in the fall of 2013, and waiting for the return of favorable observing conditions after the winter of 2013/14, the new dome vents completed ~9 months of regular operation in 2014. Only two minor repairs were required, although a dozen or so slats show signs of paint flaking off. The array of seeing monitors and temperature sensors in and around CFHT permit an exceptional "before/after" assessment of the effect of dome venting on seeing. These include MKAM, the facility MASS/DIMM adjacent to CFHT on the upper ridge of Maunakea, a DIMM mounted in the dome slit at CFHT, and automated delivered image quality measurements from MegaCam. Early analyses of temperature and wind conditions inside the dome strongly suggested the vents were improving dome flushing markedly, and by the end of 2014 enough seeing data was accumulated to confirm at least a ~0.1 arcsec improvement in median image quality at 0.5 µm when the dome vents are open is achieved. As anticipated the most improvement occurs in the downwind dome slit orientation.

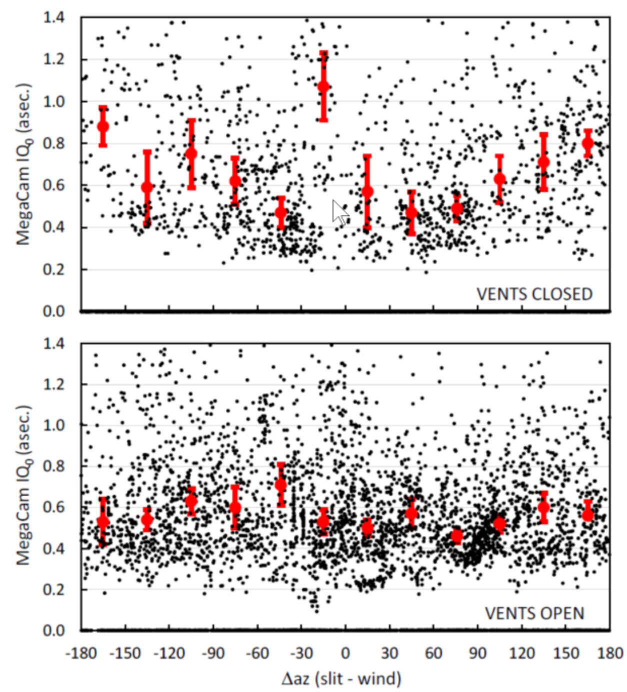


Figure 12 - MegaCam IQ measurements with the vents closed (above) and open (bottom) are plotted. Note the lower and more uniform delivered image quality as a function of Δaz with the vents open.

This important result will improve imaging programs at CFHT significantly. The combination of improved delivered image quality (point source sensitivity) and filter throughput (described below), will increase survey speeds by ~15% (private communication, Jean-Charles Cuillandre). This means the cost of these upgrades (~$2.5M) when applied to future large MegaCam surveys (e.g., ~500 nights over a ~5 year period) is roughly the same as the cost of the "extra" telescope time they generate through panoramic imaging efficiency gains.

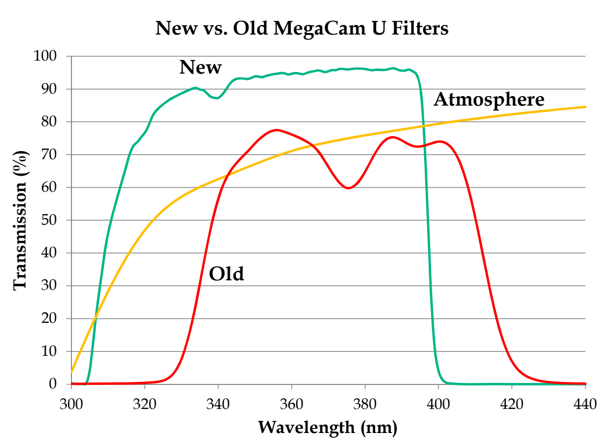


Figure 13 – As-built transmission curves for the new and previous MegaCam u-band filters are shown together with the nominal atmospheric transmission.

MegaCam

Ten new broad band and narrow band filters were delivered in 2014 as part of an upgrades program for CFHT's foremost instrument. These new larger format filters allow the use of all 40 CCDs in MegaCam instead of the 36 compatible with the original broad band filters. The new band passes include u, r, g, i, z, H-alpha, H-alpha-off, OIII, OIII-off and Ca H&K. The new u band filter's throughput is particularly noteworthy. This new filter pushes to shorter wavelengths, better matching the atmospheric cutoff at ~310 nm, while providing >90% optical throughput across much of its bandpass. Combined these filters represent a remarkable improvement in throughput over the original filters and reflect significant improvement in modern multi-layer film deposition technology in recent years. The combination of increased optical throughput, ~10% more pixels illuminated in MegaCam's detector plane, and improved image quality from the new vents (mentioned above), should accelerate a wide variety of MegaCam programs in the future.

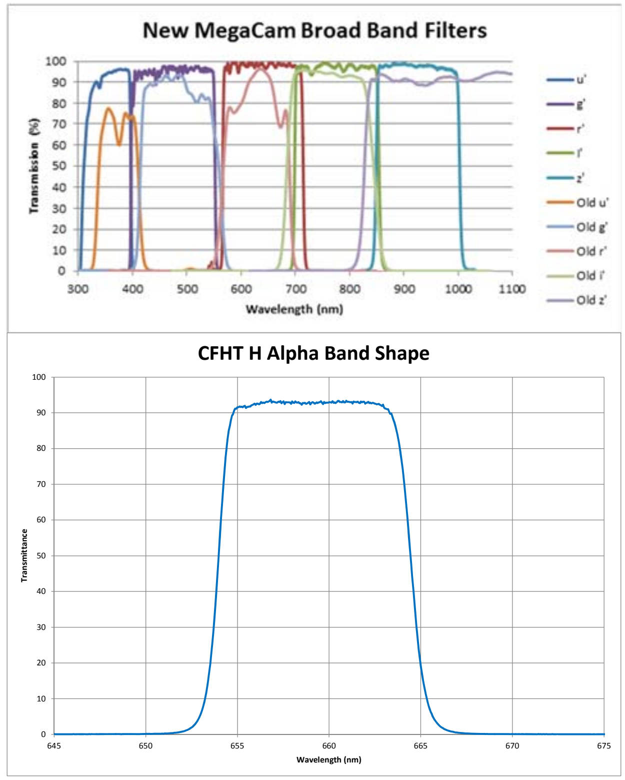


Figure 14 – Above, a comparison of the actual transmission spectra of the old and new MegaCam filters is shown. Below, a typical as-built new narrow band filter transmission plot is shown.

Other work on MegaCam centered on repairs to its filter exchange system, which suffered a major failure in 2014, demanding rework and some redesign of its jukebox assembly to ensure its reliability in the future. Some of the problems were traceable to inadequate margin in the filter insertion/extraction force, which proved important due to the thicker substrates and increased masses of the new filters. New electronics were retrofit to the jukebox assembly to ensure that the filter exchange controls have robust filter in/out-of-position sensing to avoid jamming the system. Furthermore, locking tabs on the filter frames were reoriented to improve mechanical performance.

Work in 2015 will include improvement in the readout speed of the detectors, pending various functional tests of the baseline controllers. In light of the planned use of MegaCam for many more years to support a variety of research, including large programs well into the next decade, these upgrades are seen as a valuable reinvestment in a venerable instrument that remains competitive compared to other panoramic imagers.

SITELLE

CFHT's next instrument slated for deployment continued to make good progress in 2014 toward completion and delivery to Hawaii. SITELLE is an imaging Fourier Transform Spectrometer that provides spectral imaging across its ~11 arcmin field of view from UV to red wavelengths (~350 – 950 nm). The instrument is a collaborative development effort between ABB, Université Laval, and CFHT. Delivered spectral resolutions will vary depending on source brightness and scan parameters but in general will be in the range of 3000 – 5000, with higher resolutions possible on brighter sources. Science applications include star formation, dynamics and chemistry of galaxies as measured through their luminous gas components.

Work in 2014 at ABB centered on final integration and testing of the instrument, which is a Michelson interferometer fed by a precision beam splitter suspended in a rigid carbon fiber structure. CCDs at the end of each output beam of the interferometer record fringes as a precision metrology piezo driven scan mirror is used to change the optical path difference between the two interferometer arms a small fraction of the wavelength of light at each step. A typical scan may include ~1000 steps. A sophisticated data reduction pipeline is being delivered with SITELLE that performs the necessary frame-by-frame processing, registration, sampling, interferogram extractions, Fourier inversions, and generation of a wavelength calibrated data cube, amenable to analysis by commonly available packages. In other words, while the details of imaging Fourier spectroscopy are generally not widely known across the astronomy community (though this technology has been used for many years, including in space), SITELLE is being designed and built to generate a data product that effectively removes the instrumental signature from the processed data, to facilitate scientific interpretation of SITELLE's data cubes.

Figure 15 – SITELLE is shown in the lab at ABB, where it is being built. The black carbon fiber structure supporting the embedded interferometer is evident, as well as the pair of CCD systems (gold dewars) at each end of the interferometer.

One of the most important performance metrics for an interferometer like SITELLE is the modulation efficiency (ME) delivered at its CCD focal planes. In simple terms ME is the peak-to-peak fringe contrast in delivered interferograms, with higher ME yielding greater spectral sensitivity. The ME for SITELLE was repeatedly measured at various wavelengths during 2014 and has proven to be exceptional, even at UV wavelengths where scan mirror metrology and overall system stability is pushed the hardest. This bodes well for a major component of the SITELLE science case, which centers on blue emission line work from star formation regions. This ME was achieved through careful alignment and shimming of the two CCD focal planes with respect to the SITELLE cameras. Residual field dependent ME variations across the two outputs occurs only at the ends of scans, i.e., for the highest spectral resolution observations which given typical source brightnesses will be infrequent. Other work in 2014 at ABB included the identification of a cold chamber for 2015 cold tests of the system to simulate temperatures on the summit of Maunakea. Work also progressed on proprietary circuit boards that control closed loop mirror position with the fiber fed laser used by the system to count fringes and maintain servo lock.

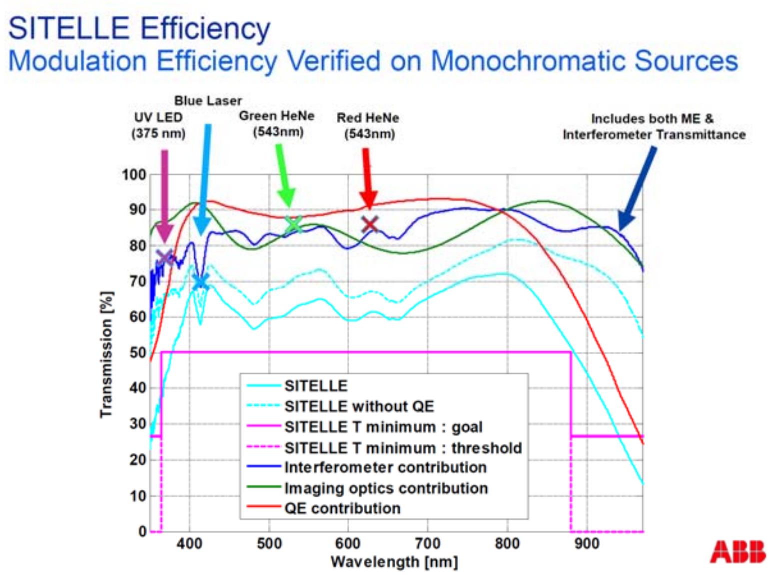


Figure 16 – Measured vs predicted SITELLE modulation efficiency is shown at several wavelengths. Plot courtesy ABB.

In Waimea, excellent progress was made in 2014 with preparations for SITELLE science operations. This included the generation of an exposure time calculator, Phase 1 and Phase 2 systems, drafting commissioning and science verification plans, and putting in place in Waimea software needed to reduce SITELLE data cubes. This work was led by CFHT in collaboration with Université Laval and staff at the University of Hawaii in Hilo. A new SITELLE webpage at CFHT will be the focal point for a myriad of information assembled to support use of this instrument. Phase 1 and 2 tools will be used during science verification to test QSO interfaces to SITELLE, providing a realistic full system test prior to releasing SITELLE for general use.

On the summit numerous modifications were completed in 2014 to get ready for SITELLE's arrival, including transforming the visitor's gallery on the 5th floor into a test and support station. Beyond remodeling the area, new glycol, power, and communication lines were added. New glycol and CCD cryo-cooler lines were also added to the telescope by CFHT staff. Key spare parts and new filters for use with SITELLE were purchased. All of this 2014 activity leaves the SITELLE team well positioned for first light in 2015. As is inevitably the case with the arrival of any new facility class instrument, excitement of the instrument team and observatory staff builds with the anticipated arrival of SITELLE in 2015. It has been about a decade since the last new instrument arrived at CFHT, and everyone involved with this unique instrument is eager to start a new "SITELLE era" at CFHT.

SPIRou

After SITELLE the next instrument slated for use at CFHT is SPIRou. This instrument is a near-infrared fiber-fed cross dispersed high resolution spectrometer optimized for spectro-polarimetric and radial velocity measurements. More specifically SPIRou is being design for single-shot YJHK R~70k measurements with ~ 1 m/s radial velocity accuracy. This combination of NIR single-shot spectral coverage and resolution is unprecedented in astronomy. It is being designed by a fairly large distributed team including IRAP/OMP (Toulouse), IPAG (Grenoble), LAM/OHP (Marseille), Observatoire de Genève (Switzerland), UdeM (Canada), ULaval (Canada), HIA (Canada), ASIAA (Taiwan), and CFHT (Hawaii).

A number of important milestones were passed in the SPIRou project in 2014, which is now well into its build phase. In mid-2014 a Final Design Review was completed, which generally yielded good results on various technical fronts but reinforced on-going concerns about cost and schedule. A follow-up review focused primarily on SPIRou programmatics will be held in Toulouse in mid-2015 to further evaluate matters and provide guidance on mitigating risks.

Current work on SPIRou is being managed through a set of contracts that have been negotiated after FDR. Accordingly much of the work at CFHT since the FDR in April 2014 has been related to finalizing the Consortium Agreement, establishing contract details between NRC-Herzberg and CFHT, developing additional ITAR-related export licenses, and the purchase of a bare multiplexer (ROIC) from Teledyne for

Figure 17 – Parts for the SPIRou Cassegrain mounted assembly begin emerging from machine shops in France.

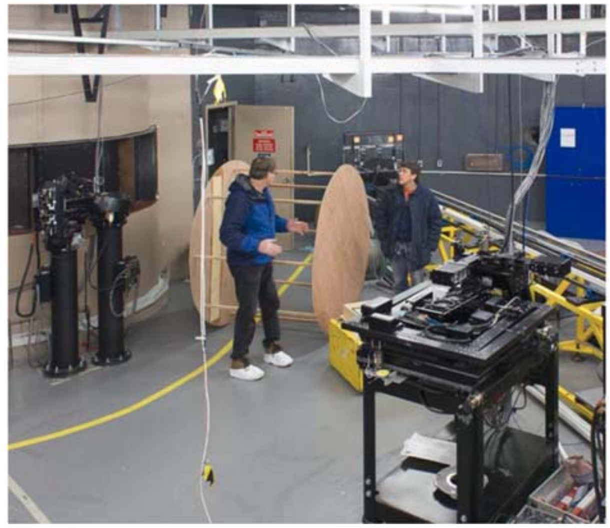


Figure 18 – Les Saddlemeyer (NRC-Herzberg) and Greg Barrick (CFHT) are seen test maneuvering mockups of major SPIRou assemblies into its future home, the CFHT Coude room, which will be cleared of unnecessary equipment before SPIRou's arrival.

Universite de Montreal (UdeM) to support their development of the SPIRou detector system. In parallel multiple agreements have been put into place since the FDR across the SPIRou collaboration, forming the basis for various parts, labor, and cash contributions to the project.

The principal science objectives of SPIRou include mapping the magnetic environments of young, embedded stars, and detecting significant numbers of terrestrial class exo-planets in the habitable zones of their low-mass host stars. Though destined for use at CFHT to conduct a range of PI and survey programs (like past and present CFHT instruments), SPIRou's scale is comparable to some of the largest and most complex instruments built for today's generation of 8-10 m telescopes. Accordingly considerable care and diligence is being given to the design and fabrication of SPIRou, which is challenging not only because of the technologies required but the highly distributed team building its various subsystems.

One of CFHT's largest contributions to the project is in the form of the detector package, which will be built by Teledyne and GL Scientific. This is also among the most critical components driving SPIRou's development schedule since the H4RG detector is unlikely to be ready until the end of 2016. The 2014 H4RG ROIC order from Teledyne will be followed by orders for engineering and science grade arrays. These will be delivered in sequence to UdeM, GL Scientific, and ultimately the team at Toulouse where the detector assembly will be integrated into the instrument.

GRACES

Phase 1 or the "experimental" phase of the Gemini Remote Access to ESPaDOnS (GRACES) project was completed in 2014 with spectacular results. This project is a collaboration between CFHT, NRC-Herzberg, OMP, and Gemini, the latter providing all the parts needed for the fiber system. Soon after the fiber bundle needed to link Gemini and CFHT was completed in Canada, under the technical leadership of NRC-Herzberg, the fibers were shipped to Hawaii and run through the existing conduit linking Gemini and CFHT. First light spectra were recorded in May and a number of engineering observations completed soon thereafter to quantify the sensitivity of the system. These measurements quickly demonstrated on-sky Focal Ratio Degradation (FRD) losses of only ~12%, well within specification and crucial to the success of the

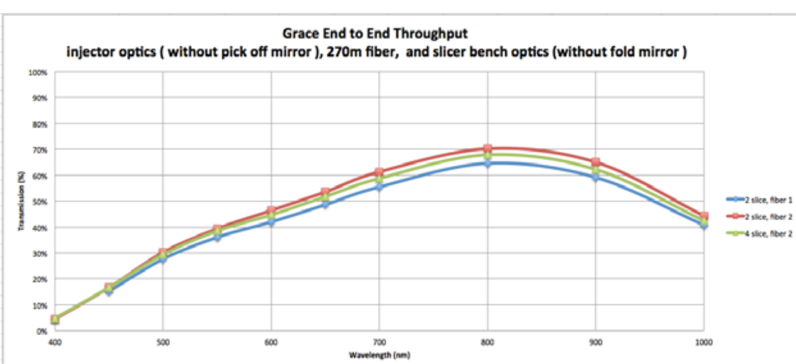


Figure 19 – The measured throughputs of the GRACES 270 m fibers is shown. This includes the injection and transfer optics at each end of the fiber. This exceptional throughput is at the core of why and how GRACES works so well.

system. Beyond those low FRD losses, the end-to-end throughput of the fiber transmission system, as shown in Figure 19, is exceptional, peaking at ~70% at ~800 nm, including losses from the injection optics at the GMOS-N side of the system and output optics at ESPaDOnS . Blue losses intrinsic to fibers were anticipated but at red wavelengths GRACES has comparable sensitivity to other high resolution optical spectrometers in use on 8-10 m class telescopes.

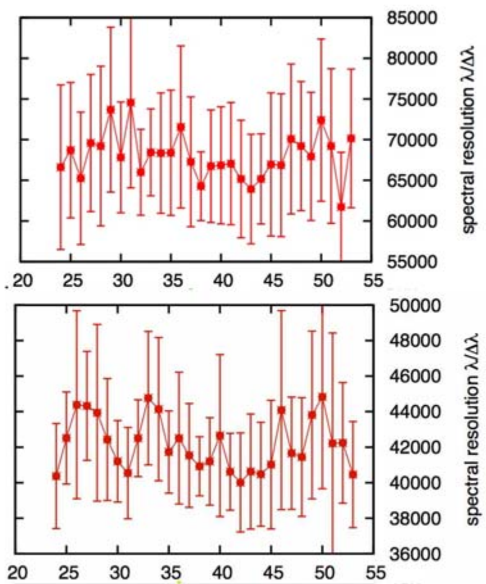


Figure 20 – The measured spectral resolution of the two GRACES modes (star+sky below, star only above) is shown as a function of spectral order. These values exceed model values and bode well for the promise of using GRACES in high-resolution spectroscopic studies.

With the successful demonstration of GRACES in mid-2014, an agreement was reached between CFHT and Gemini for the shared use of ESPaDOnS via GRACES. Gemini will have access to ESPaDOnS whenever it is not scheduled for use at CFHT. In exchange, Gemini will provide the CFHT community access to any instrument on either Gemini telescope at the rate of 3 nights for every 20 of GRACES time allocated. The main addition to the system after engineering tests is a new walk-in thermal enclosure for ESPaDOnS that makes it possible to completely seal the fibers and associated injection system which was impossible with the smaller original thermal ESPaDOnS enclosure. Once configured, it will be possible to switch the fiber feed into ESPaDOnS with the use of a simple mirror that changes the feed from the GRACES or CFHT fibers. Control of ESPaDOnS at Gemini is made possible through a remote control link provided by CFHT. Data are archived and distributed by Gemini and all science support for the GRACES mode is provided by Gemini. CFHT has made available our new OPERA reduction package for spectral extraction.

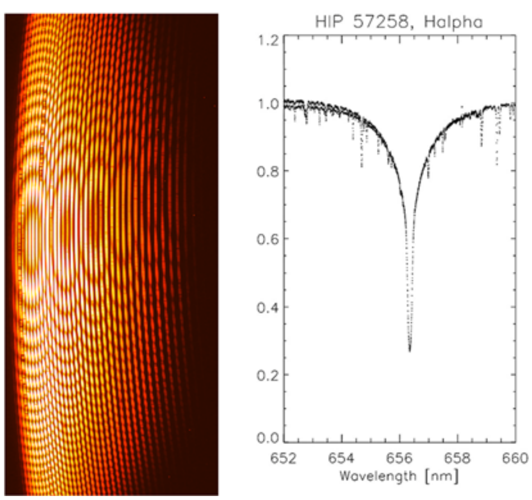


Figure 21 – On the left is a raw GRACES echellogram, capturing the many orders of a single high resolution spectrum. On the right is one of the many lines extracted from this spectrum of a star used to characterize GRACES performance.

GRACES is unique in astronomy, optically linking 2 observatories and enabling the shared use of fiber fed instrumentation. Though exceptional science is anticipated with this system, the greatest contribution of GRACES to astronomy may be as a powerful demonstration of how new technologies can enable new capabilities through inter-observatory collaboration. Longer fiber runs than the 270 m used in GRACES are certainly conceivable and it would not be surprising to see this technique used to couple other telescopes across the summit of Maunakea someday. This reduces duplication of instrumentation, costs, and builds technical and scientific collaborations across previously decoupled communities. The GRACES concept originated in the early '90's with Fred Gillett and Gordon Walker but was never pursued due to higher priorities being assigned to commissioning activity at Gemini North and the anticipation of other high-resolution optical spectroscopy capabilities at Gemini – capabilities that never materialized. Likewise, the spirit of inter-observatory collaboration across the Maunakea Observatories has steadily risen, as all of these facilities have matured, exchanged staffs, and their associated communities melded. This combination of necessity and opportunity led to GRACES.

MSE Report

Some of the first steps in 2014 towards realizing the Maunakea Spectroscopic Explorer (MSE), intended to replace CFHT early in the next decade, included the formation of an MSE Project Office that will be tasked with executing a multi-year plan to develop the MSE concept, yielding critical information necessary to ultimately support a decision to construct and operate this facility. Core objectives of the Project Office includes devising a plan for constructing MSE, preparing the technical and management systems needed to support the Project configuration, and to nurture the emerging partnership that will fund and execute the work.

Figure 22 – The new logo for the Maunakea Spectroscopic Explorer is shown, symbolizing key themes in the name of this planned facility.

Recently completed feasibility studies for a facility to replace CFHT indicate that technological advances over the past three decades make it possible to replace CFHT with a modern 10 m class facility that will not only reach ~10x fainter targets but also be able to carry out precision investigations of thousands of objects (stars or galaxies) at once. Given underlying assumptions about MSE and the technologies needed to realize it, it is unlikely that MSE will require the invention of new technology. As currently envisioned MSE is poised to exploit recent investments in technology development (e.g., high-throughput fibers, miniature fiber positioners, primary mirror segments, etc.) and merge them into a unique facility. An important thrust of the Project Office will therefore be to identify opportunities to fast-track the development and construction of MSE by using existing designs whenever possible if they offer acceptable performance levels. This philosophy is consistent with recycling much of the summit and base facilities of CFHT, should generally reduce costs, and will drive construction completion more quickly. The Project Office will focus on solutions required for integrating observatory subsystems via carefully laid out interfaces, comprehensive performance trades and a streamlined observing model.

During the past few years, meetings (especially the 2013 ngCFHT Workshop in Hilo, Hawaii) and working group discussions lead to the following top-level scientific requirements for MSE:

- Ability to simultaneously obtain spectra of thousands of faint sources with resolutions in the range of 2,000 – 20,000
- A large field of view and efficient target acquisition to quickly survey major areas of sky
- Ability to reach targets ~10x fainter than comparable instruments on 4 m class telescopes
- For optimum synergy with complementary facilities on the ground and in space, the upgrade should be completed ready to begin surveys early in the next decade

Arguably the most important accomplishment for the project in 2014 was the establishment of the MSE Project Office in Waimea, at the headquarters of the CFHT. As mentioned above, the MSE Project Office was charged with leading the Design Phase for MSE, for completion by the end of 2017. In parallel a new science team was formed in 2014 (and continues to accept new members) that is leading the scientific development of MSE. It currently includes 80 members from Australia, Canada, China, France, Germany, the Republic of Korea, Hawaii, Italy, India, Japan, Spain, Taiwan, the UK and the USA. The Science Executive was established to lead and coordinate the science team activities and consists of representatives (contact scientists) from the major prospective partners, as well as the leads of the major science working groups within the science team.

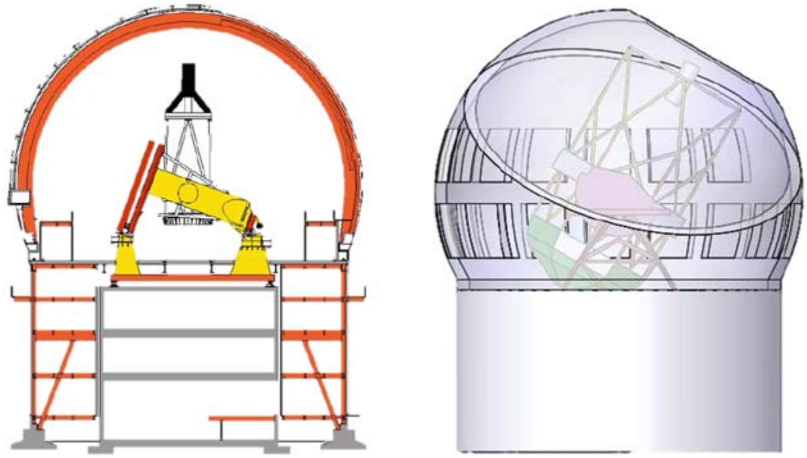


Figure 23 – On the left CFHT is shown while, on the right, a concept for MSE is shown that includes replacing the telescope and dome while preserving the underlying support structures.

Beyond technical and scientific activities, a major theme within the MSE Project Office in 2014 was to secure prominence within key national strategic planning exercises. In Australia that meant working to engage the community as part of their Decadal Planning exercise, which is expected to culminate in mid-2015. In Canada MSE is engaged in the Mid-Term Review (MTR) process of the Canadian Long Range Plan (10 year planning exercise). The MTR is expected to report late in 2015. Finally, in France, participating in the MSE design phase is now ranked as "Priority 0" (top priority) in the new 5 year "Prospective" through direct participation of the MSE Project Office team during the Design Phase.

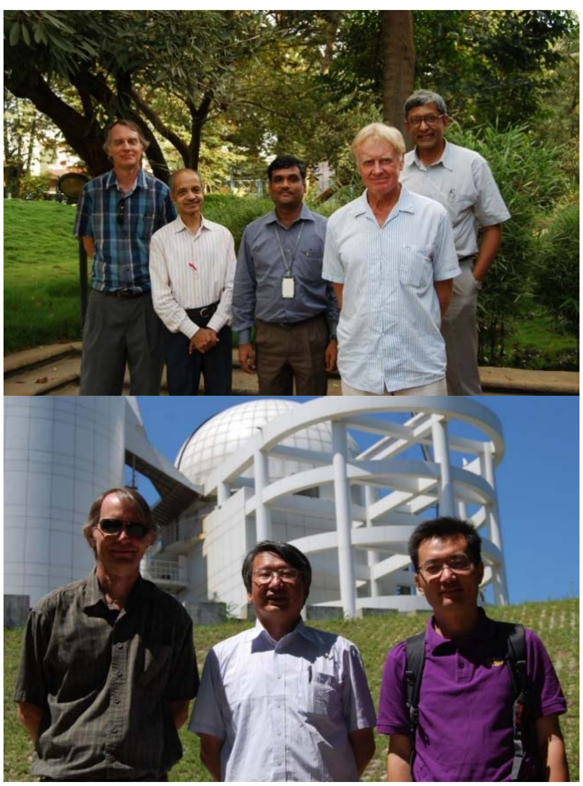


Figure 24 – MSE partnership activity included trips to China (below at LAMOST) and India (above at IIA).

Also of note is that MSE is now a joint Canada-China-France-Hawaii-India project. China signed a Memorandum of Understanding (MOU) with CFHT that extends the previous collaborative agreement and preserves their status as an Associate Partner in CFHT. That agreement includes significant contributions to the MSE project. In parallel, through the Indian Institute for Astrophysics (IIA) in Bangalore, an expression of interest to CFHT to join the MSE development team was received and the nature of their involvement in MSE will be defined in 2015. At this stage, the MSE partnership is defined as those communities that are contributing financially, or through in-kind effort, to the technical design work being led by the MSE Project Office. Partnership formation is an essential and ongoing endeavor throughout the Design Phase. MSE has established an Advisory Group that is comprised of senior representatives from the partner communities to provide oversight and strategic advice to the MSE Project Office. Matters pertaining to governance, the legal structure within which MSE will function long term, and ramping CFHT down and MSE up will all be studied in 2015 and beyond as this exciting project gains momentum.

Administration Report

Summary of 2014 Finances

The three Member Agencies supported the CFHT annual budget in 2014 at levels shown in Table 1. These contributions reflect no increase in 2014 over the prior year. Under collaborative agreements with CFHT, the Academia Sinica Institute of Astronomy and Astrophysics of Taiwan, the Brazilian Ministry of Science, Technology and Innovation, the National Astronomical Observatory of China, and the Korean Astronomy and Space Science Institute remitted $250,000, $422,250, $417,500 and $104,250, respectively, as reimbursement for costs associated with their use of the Corporation's facilities. Other sources of funds included $13,805 from mid-level facility use credits, $12,944 from distribution of educational materials, $19,365 in staffing cost reimbursements related to work done for other Maunakea facilities, and $18,326 in earned interest.

Agency Contributions (US$)	
NRC	3,211,145
CNRS	3,211,145
UH	744,610
Total	7,166,900

Table 1 – Contributions from each partner in CFHT Corp. are listed.

From the operating fund, 2014 expenditures were allocated to the areas listed in Table 2. Overall, resources from all CFHT funds were allocated to the categories of expenditures shown in Figure 25.

Operating Fund Expenditures (US$)	
Observatory facilities and operations	618,684
Base facilities and operations	620,485
Instrumentation	79,634
Science	81,215
Outreach	55,516
General administrative expenses	437,771
Staffing	4,883,595
Transfer to Reserve	390,000
Total	7,166,900

Table 2- Operating expenditures are broken down into various cost categories.

Building Renovations and Administration Activities

During 2014 we continued to tackle overdue maintenance projects to the headquarters facility. The included removing and replacing rotten wood siding and window frames on the exterior of the headquarters building. This work will continue in 2015 along with the replacement of the wood facia on the building. In addition the front lobby received a major face lift that included new wood floors, new lighting, pictures, furniture and a staff-crafted CFH logo. An updated photo montage of everyone on the CFHT staff as well as new brochures were also added to the front lobby. The choices in design, which includes local woods, warm lighting, and spectacular photographs from the summit, are intended to provide an implicit sense of "aloha" to anyone entering CFHT's office, and provide an interesting and welcoming waiting area for visitors to our office.

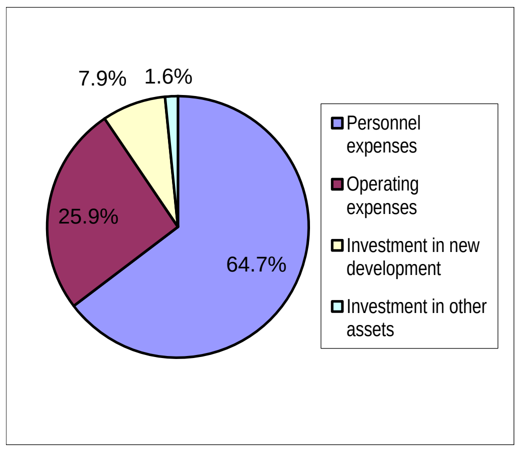


Figure 25 – The high-level distribution of expenditures across the entire observatory is plotted.

The administrative team also led in the overhaul of CFHT's annual performance evaluation system, which involved extensive consultations with the entire staff to determine what parts of the previous system worked well (and should be kept) and which parts are of little use and should be eliminated or replaced. The result is a significantly more streamlined evaluation process that is better attuned to CFHT's staff size and working culture.

The biennial staff survey was also conducted in 2014. This survey is a customized version of a survey that the Hawaii chapter of SHRM (Society for Human Resource Management) conducts. It is intended to track issues and concerns, as well as identify opportunities for improvement. The anonymous survey was completed at the 93% rate in the fall of 2014 at CFHT, with top issues identified including accountability, communication, and priority definition and alignment across a range of activity. While the survey outcome was overall quite positive, it also served as the focus for staff-wide discussions during subsequent monthly informal "talk-story" events, in which staff have the opportunity to raise any topics they feel are of general interest. Accountability and communications in particular were discussed during these get-togethers, among other topics. One change derived from those and other post-survey discussions is a new project reporting system, added to the longstanding biweekly Technical Operations Meetings, to give everyone better visibility into various activity occurring across the observatory. The intent is to provide a simple and informative means for staff to understand not only what the highest priority projects are, but the current status of their development. This structure should dovetail with semiannual SAC discussions of observatory wide task priorities, which critically link community needs and interests with effort occurring at CFHT.

Other important administrative work in 2014 included working on ITAR (International Traffic in Arms Regulations) and EAR (Export Administration Regulations) compliance through consultations, training, and executing various agreements. These included Technology Assistance Agreements (TAAs) that are essential in the use and dissemination of controlled technologies, like the detector system being developed by SPIRou. Compliance activities occurred in conjunction with various contracts the Administrative team played an important role in generating and processing. For contracts of sufficiently high value, the Director of Finance and Administration serves as CFHT's principal liaison with the Contracts Review Committee, which is tasked by the CFHT Board with reviewing from legal and administrative perspectives major contracts before they are submitted for approval.

Key policies were updated and captured in the Technical Operations Policy (TOP) in 2014, which includes a multitude of information derived from years of day-to-day operations. The TOP is expected to be particularly helpful for new staff, so they have a single source of information for the bulk of the policies and procedures used in Waimea and on the summit.

Figure 26 – Top: The front lobby of the office underwent a large upgrade with the addition of new wooden flooring, a custom 3D rendering of the CFHT logo, and new furniture to greet our guests. Bottom, Roger Wood and Joe Fehly work on replacing aging exterior panels on the office.

WORKPLACE EXCELLENCE SURVEY

for

Canada-France-Hawaii Telescope Corp

INSTRUCTIONS

For each question, choose the answer that best represents your opinion. Your responses to this survey will be kept confidential. No one from your organization or SHRM Hawaii will see your individual responses. Only an overall report based on all responses will be released to your organization.

DEFINITIONS

The term "organization" refers to Canada-France-Hawaii Telescope Corp .

The term "customer" refers to anyone who uses your work or services. This could be an outside customer, a client or another person or department within your organization.

Alignment

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Most employees understand how the work they do contributes to the overall goals of the organization	○	○	○	○	○
The goals of my department are tightly linked with the overall goals of the organization.	○	○	○	○	○
Most employees understand the overall goals of the organization and how it plans to reach them.	○	○	○	○	○
Individual performance goals are clearly linked to department performance goals.	○	○	○	○	○
My department has clear performance objectives that are tied to our customers' expectations.	○	○	○	○	○
People in this organization are held accountable for achieving high standards of job performance.	○	○	○	○	○
Communication upward from employees to management is effective.	○	○	○	○	○
There is good teamwork and cooperation between my department and other departments.	○	○	○	○	○
My immediate manager is effective at setting day-to-day priorities.	○	○	○	○	○

Figure 27 – The start of the CFHT biennial staff survey form is shown. The year 2014 marked the second time this survey was conducted, which is a means of tracking important aspects of staff morale, issues, and concerns.

A multitude of other tasks were conducted by the administrative team in 2014, many of which are of a "transactional" nature, i.e., payroll, purchasing, paying invoices, property management, fleet maintenance, etc. These are all essential aspects of CFHT's day-to-day operations and collectively drive the business systems needed behind the scenes to make the more visible aspects of operations (developing new capabilities, executing observing programs, etc.) possible.

Staff Safety

During the year two injuries occurred during work around the headquarters. Our safety specialist retired in mid-2014 and a search for a replacement was launched to replace her. The responsibility of overseeing CFHT's safety program will be transferred to the engineering group in the future, to better align safety program focus and issues with attention in CFHT's executive group.

	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005
Injuries	2	0	0	1	0	0	0	1	0	0
Illnesses	0	0	0	0	0	0	0	0	0	0
Lost work days	10.5	0	0	1	0	0	0	1	0	0

Table 3 – A decade of top-level statistics pertaining to safety are listed above.

Arrivals and Departures

In 2014 we bid farewell to four staff members and welcomed three new members to CFHT's 'ohana. The roles of all involved spanned science, administration, engineering, safety, and outreach, thereby touching all facets of CFHT's team on Hawaii Island. As we do each year, below we first pay tribute to those who left CFHT in 2014, then wish a fond aloha to the new members of our staff.

Farewell

Jean-Charles Cuillandre

Jean-Charles arrived at CFHT in 1996 as a detector engineer and in 2000 joined the astronomy team. His CCD technical expertise developed over the years and included MOCAM, CFH12k, and MegaCam, all very successful optical mosaic cameras. Going beyond visible imaging, Jean-Charles made contributions to infrared cameras and curvature wavefront sensors, the data reduction pipeline Elixir used for wide-field imagers, the SkyProbe real-time sky-transparency monitor, and the CFHT Legacy Survey. This is topped off by a collection of exquisite astronomical pictures used for CFHT's public outreach efforts, in the form of posters and the ever popular calendar, produced without interruption since 2002

Brandon Metz

Brandon returned to his former employer, Jet Propulsion Lab, in Pasadena after spending a year and half at CFHT. The allure of big city life and proximity to family were too enticing. He and his wife left with an additional member who was born on island during his tenure. Brandon brought a wealth of knowledge on the latest state-of-the-art devices, electronic circuit design and servo control. He was a key member of the team developing the new TCS system. He designed all the electronic circuitry and boards as well as wrote the low level code in the commercial servo controller. He is presently working on the next generation Mars rover at JPL.

Sharon Potter

Sharon retired after 11 years of leading the safety program at CFHT and helped instill a "safety culture," which serves as the foundation for many of our activities, particularly at the summit. Sharon's safety classes were exceptional; her leadership across the other observatories' safety programs exemplary, and commitment to everyone's safety at CFHT was priceless. It was with profound regret that we said farewell to Sharon and her husband, Rick, in August 2014 when they relocated to Arizona.

Tami Jo George

Tami Jo was with CFHT for only 8 months but during this period she took on a wide range of responsibilities as an Administrative Specialist which she handled with great attention to detail, always with a smile and warmth that made her an ideal "face" for CFHT when visitors entered the front office. She was incredibly well organized and handled very complex travel arrangements for our staff. Tami Jo relocated back to Oregon to help care for grandchildren.

Welcome

Katherine Cross

After twenty five years of serving CFHT and other Big Island employers as the marketing representative for HMSA, Katherine Cross retired. However, retirement proved to be short-lived and not two weeks later in October she started working in our Administration Group where she provides recruitment, travel and other support. Katherine grew up on Oahu and moved to the Big Island twenty years ago to raise her two boys in a more rural environment. In her free time she enjoys traveling, swimming and biking and has put together the first CFHT Triathlon team, the CFHT Celestial Bodies. The team is currently training and will be ready to compete in the Waikoloa Lavaman in March.

Sidik Isani

Sidik originally worked with the CFHT Software group from 1996 to 2004 implementing control and data acquisition for the Gecko spectrograph, UH8K, CFH12K, and finally MegaCam. In September 2014 he rejoined the group after 10 years at the University of Hawaii Institute for Astronomy, where he designed and implemented software and infrastructure for the 1.4 Gigapixel CCD cameras of the Pan-STARRS 1 and 2 telescopes. Sidik has many interests and recently built a 3D printer for amusement and for learning about the technology. He also enjoys bicycling and outrigger canoe paddling.

Windell Jones

Windell joined the instrumentation group at CFHT in August of 2014 as an instrumentation engineer. Prior to joining CFHT, Windell received his Bachelors and Masters degrees from the University of Hawaiʻi at Mānoa in mechanical engineering. During his graduate studies, Windell designed and built the structural and attitude determination and control subsystems (ADCS) for a radar calibration cube satellite developed at Mānoa's Small Satellite Laboratory. He also helped develop a few radio telescopes with the High Energy Physics Group that are designed to indirectly detect high-energy neutrinos and cosmic rays. At the beginning of his appointment, Windell will be focused on the rollout of the new CFHT Telescope Control System. Windell is joined by his wife, Maryam, and son, Isaiah, and enjoys hiking with his family and diving into new hobbyist electronic projects.

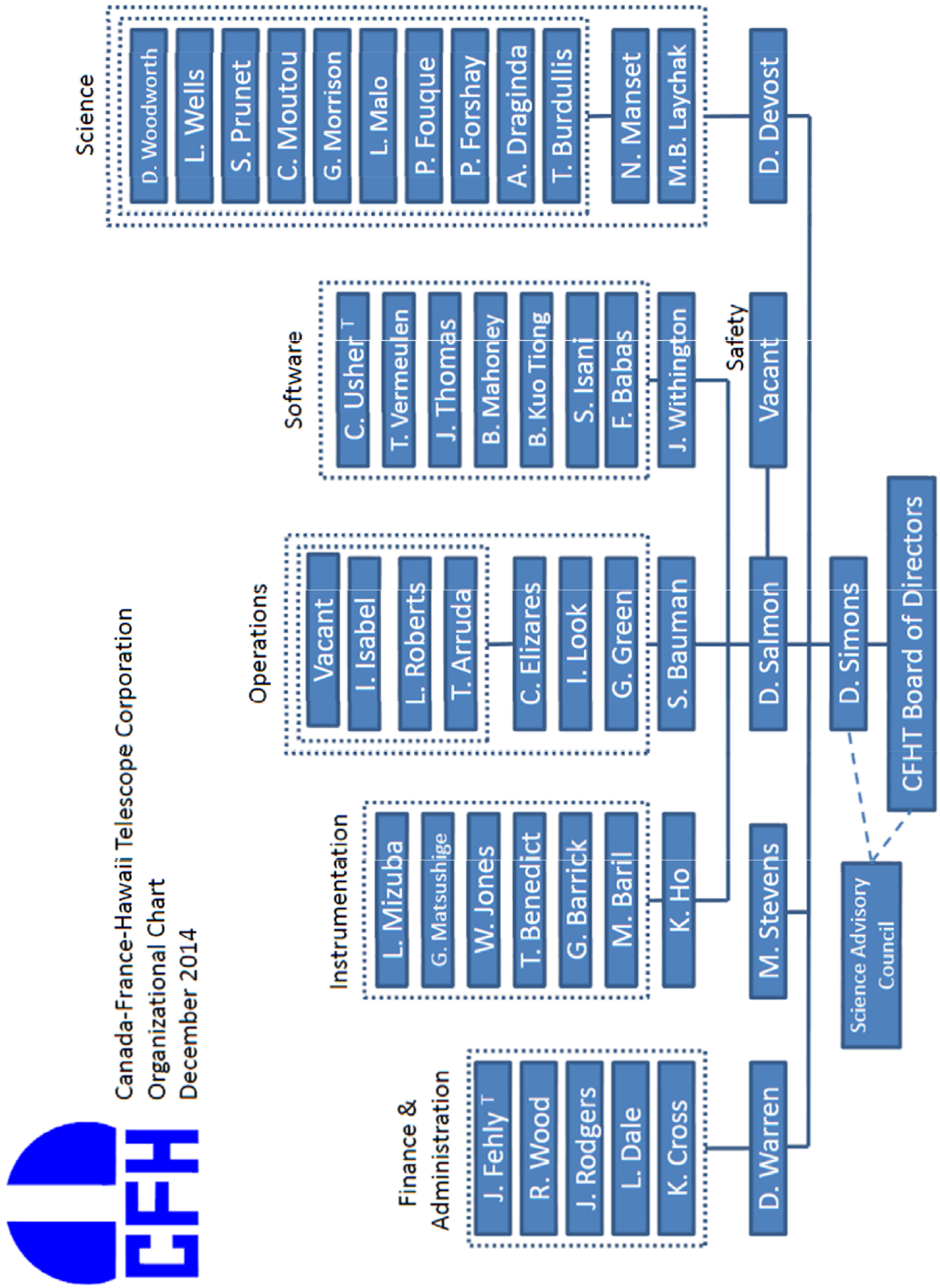
Blaise Kuo Tiong

Blaise joined the software group in April 2014 as a system administrator. Prior to joining CFHT, Blaise spent a year at South Pole Station operating the IceCube project's neutrino detector. Before that he worked for the US Antarctic Program and also for the Navigation Section at the Jet Propulsion Laboratory, mainly as a computing systems specialist with the Cassini team and multi-mission navigation. Blaise got his degree in Mathematics from UCLA and also worked for the school's Planetary and Geophysics department where he built ground stations for the THEMIS project and data systems for the DAWN spacecraft. Blaise likes hiking, traveling, snowboarding and aviation, all of which can be found on the Big Island.

Mary Beth Laychak

Mary Beth is the first outreach program manager for CFHT and this is her second time working at CFHT. Previously, Mary Beth was one of CFHT's service observers and outreach coordinator before moving to Oahu. On Oahu, she worked as the manager at the Imaginarium planetarium and astronomy lecturer at Windward Community College. Mary Beth is joined by her husband, Andrew. They're both excited to be back in Waimea, as are we to have this talented member of our ʻohana return home.

Organization Chart



Staff List

Name	Position	Name	Position
Arruda, Tyson	Mechanical Technician	Look, Ivan	Mechanical Design Engineer
Babas, Ferdinand	System Administrator	Malo, Lison	Resident Astronomer
Baril, Marc	Instrument Engineer	Mahoney, Billy	Database Specialist
Barrick, Gregory	Optical Engineer	Manset, Nadine	Resident Astronomer
Bauman, Steven	Operations Mgr/Mechanical Eng	Matsushige, Grant	Sr. Instrument Specialist
Benedict, Tom	Instrument Specialist	Mizuba, Les	Instrument Specialist
Burdullis, Todd	QSO Operations Specialist	Morrison, Glenn	Resident Astronomer
Cross, Katherine	Administrative Specialist	Moutou, Claire	Resident Astronomer
Dale, Laurie	Administrative Specialist	Prunet, Simon	Resident Astronomer
Devost, Daniel	Director of Science Operations	Roberts, Larry	Electrician
Draginda, Adam	Remote Observer	Rodgers, Jane	Finance Manager
Elizares, Casey	Summit Operations Manager	Salmon, Derrick	Director of Engineering
Fehly, Joe	Maintenance	Simons, Doug	Executive Director
Forshay, Peter	Remote Observer	Stevens, Mercédes	Assistant to the Exec Director
Fouque, Pascal	Resident Astronomer	Thomas, Jim	Computer Software Engineer
Green, Greg	Mech Designer/Instrument Maker	Usher, Christopher	Software Programmer
Ho, Kevin	Instrument Manager	Vermeulen, Tom	System Programmer
Isabel, Ilima	Custodian	Warren, DeeDee	Director of Finance & Administration
Isani, Sidik	Software Engineer	Wells, Lisa	Remote Observer
Jones, Windell	Instrument Engineer	Withington, Kanoa	Software Manager
Kuo Tiong, Blaise	Systems Administrator	Wood, Roger	Automotive Mechanic
Laychak, Mary Beth	Outreach Program Manager	Woodworth, David	Remote Observer

Outreach Report

CFHT's outreach program received a large boost with the addition of our first-ever full time outreach program manager toward the end of 2014. This new position, combined with a staff that is eager to engage CFHT's local and international community, is energizing outreach at CFHT on various fronts and will not only increase the awareness of the general public in CFHT's activities but help foster the next generation of engineers, scientists, and administrators that will someday operate CFHT/MSE.

CFHT continues to take a leadership role in several outreach areas. This includes providing judges and awards in various school science fairs including Waimea Country School and the Hawai'i District Science and Engineering Fair, which links to the State science fair in Honolulu and US National science and engineering fair on the mainland. Judging projects provides an opportunity to talk with the students individually, giving them feedback on their projects, highlighting what the students did well and offering suggestions for improvement. CFHT also hosts a number of interns from around the world and Hawaii Island, the latter principally through the Akamai Workforce Initiative – the "gold standard" for STEM internships for college students in Hawaii. Over a ~2 month immersive program these students take on projects within the Maunakea Observatories that culminate in presentations attended by observatory staff and the public. CFHT also provides support for the annual Astronaut Ellison Onizuka Day event at UH-Hilo, the AstroDay event at Prince Kuhio Mall in Hilo, participates in the annual Journey Through the Universe program organized by Gemini Observatory, participates in Office of Mauna Kea Management weed pulls and public events at Halepohaku, co-sponsored the first TEDx presentation series in Waimea, contributes to road cleanups around Waimea, and provides a public star party in the front lawn each December.

Again this year, CFHT staff gave numerous summit tours to students, astronomers, and the public. These are quite popular and invariably leave a lasting positive impression, especially for those who have not seen a major observatory, yet alone one on a spectacular site like Maunakea. Also, toward the end of the year, a summit tour and a headquarters tour was given to a class of Canadian high school students. In total, the summit tour included 18 people while ~20 people visited the CFHT headquarters.

Figure 28 – CFHT participated in the 2014 GEMS program at a Kona resort through financial support and direct participation. Seen on the right are CFHT's staff astronomers Lison Malo and Nadine Manset who led a class in crafting small functional spectroscopes from cardboard, tape, and CDROMs.

Figure 29 – Photos from CFHT's annual December star party are shown. Though the weather did not cooperate, a great time was had by numerous children and their parents from across West Hawaii Island.

The effort to expand our outreach efforts to our international partners is ongoing. The Director of Science Operations in particular provided numerous webinars and talks for Canadian schools via videocon. This innovative use of technology makes it possible for students worldwide to get a glimpse of the operations, development activity, and research being conducted with CFHT and we anticipate expanding this program in the future. CFHT's new outreach program manager is developing an international network of outreach contacts across the CFHT partnership, particularly through participation in national astronomy meetings. This network of contacts will doubtless serve as an important bridge to our international community, enabling CFHT's outreach program to extend far beyond the shores of Hawaii Island, become enriched in parallel programs in our partner countries, and hopefully catalyze new outreach opportunities in the process.

While these programs have been successful, with the addition of a new outreach program manager future local engagement will focus more on West Hawaii Island, where outreach has been sparse due to lack of resources (only CFHT and Keck are in Waimea) and geographic diversity. As a good example of West Hawaii outreach in 2014, CFHT co-sponsored the Girls Exploring Math and Science (GEMS) program in Kona – a program in which 5th grade girls spend a school day participating in ~1 hr classes provided by dozens of volunteers from the Hawaii business and education communities. With an eye toward preparing the community for MSE, CFHT's outreach program is also networking with the local education and business communities including roles in the Mauna Kea Management Board, THINK (The Hawaii Island New Knowledge) Fund advisory committee, participation in several workforce development committees, etc. Beyond providing an important conduit between CFHT and these sectors of the Hawaii community, the local community will doubtless gain insight into CFHT through such engagement, which hopefully is of value to them.

CFHT participated in the organization of a book about Hawaii astronomy that is being readied for the next IAU General Assembly in August 2015, in Honolulu. This "coffee table book" will be filled with spectacular images recorded from the Maunakea Observatories over the years and helps commemorate ~50 years of modern astronomy conducted in the world's most remote archipelago. While all observatories are providing images, Mike West, author of "A Gentle Rain of Starlight: The Story of Astronomy on Mauna Kea" and Director of the Maria Mitchell Observatory on Nantucket Island, is crafting words to weave all of the material together. This book is another tribute to Maunakea inter-observatory collaboration and special acknowledgement should go to UH/IfA for leading its organization, UH Press for handling the layout and mass publication, and MKAOC for coordinating the collection of material across the Big Island.

Finally, CFHT celebrated its 35th anniversary with a party at the headquarters in August that was attended by the staff and their families. A little over 100 attended, with staff providing "Canadian", "French", and "Hawaiian" cuisine, plenty of activities for all the keiki that came, and plenty of opportunities to reflect on how far CFHT has come as we look forward to a bright future.

Figure 30 – A variety of outreach events that included CFHT staff are shown including (top left) the Halepohaku weed pulls organized by the Office of Mauna Kea Management, (top right) science fairs, (bottom right) supporting amateur astronomy clubs, and (bottom left) participating in the local Adopt of Highway cleanup program.

2014 Publications

2014 Publications Including CFHT Data

Khalack V. et al., 2014, Spectral analysis and abundances of the post-HB star HD 76431, MNRAS, 445, 4086.

Crnojević D. et al., 2014, A PAndAS view of M31 dwarf elliptical satellites: NGC 147 and NGC 185, MNRAS, 445, 3862.

De Rosa R. J. et al., 2014, The VAST Survey - IV. A wide brown dwarf companion to the A3V star ζ Delphini, MNRAS, 445, 3694.

Erfanianfar G. et al., 2014, The evolution of star formation activity in galaxy groups, MNRAS, 445, 2725.

Ownsworth J. R. et al., 2014, Minor versus major mergers: the stellar mass growth of massive galaxies from z = 3 using number density selection techniques, MNRAS, 445, 2198.

Whittaker L., Brown M. L., Battye R. A., 2014, Weak lensing using only galaxy position angles, MNRAS, 445, 1836.

Raichoor A. et al., 2014, The Next Generation Virgo Cluster Survey. XV. The Photometric Redshift Estimation for Background Sources, ApJ, 797, 102.

Ye Q.-Z. et al., 2014, Where are the Mini Kreutz-family Comets?, ApJ, 796, 83.

Gilbert K. M. et al., 2014, Global Properties of M31's Stellar Halo from the SPLASH Survey. II. Metallicity Profile, ApJ, 796, 76.

Landstreet J. D., Bagnulo S., Fossati L., 2014, On the consistency of magnetic field measurements of Ap stars: lessons learned from the FORS1 archive, A&A, 572, AA113.

Lemaux B. C. et al., 2014, Hidden starbursts and active galactic nuclei at 0 < z < 4 from the Herschel-VVDS-CFHTLS-D1 field: Inferences on coevolution and feedback, A&A, 572, AA90.

Lemaux B. C. et al., 2014, VIMOS Ultra-Deep Survey (VUDS): Witnessing the assembly of a massive cluster at z ~ 3.3, A&A, 572, AA41.

Lefèvre C. et al., 2014, Dust properties inside molecular clouds from coreshine modeling and observations, A&A, 572, AA20.

Foëx G. et al., 2014, SARCS strong-lensing galaxy groups. II. Mass-concentration relation and strong-lensing bias, A&A, 572, AA19.

Deason A. J. et al., 2014, TriAnd and its siblings: satellites of satellites in the Milky Way halo, MNRAS, 444, 3975.

Marsden S. C. et al., 2014, A BCool magnetic snapshot survey of solar-type stars, MNRAS, 444, 3517.

Donati J.-F. et al., 2014, Modelling the magnetic activity and filtering radial velocity curves of young Suns : the weak-line T Tauri star LkCa 4, MNRAS, 444, 3220.

Clerc N. et al., 2014, The XMM-LSS survey: the Class 1 cluster sample over the extended 11 deg^2 and its spatial distribution, MNRAS, 444, 2723.

Wade G. A. et al., 2014, A search for weak or complex magnetic fields in the B3V star ι Herculis, MNRAS, 444, 1993.

Machado P. et al., 2014, Wind circulation regimes at Venus' cloud tops: Ground-based Doppler velocimetry using CFHT/ESPaDOnS and comparison with simultaneous cloud tracking measurements using VEx/VIRTIS in February 2011, Icar, 243, 249.

López-Cruz O. et al., 2014, The Brightest Cluster Galaxy in A85: The Largest Core Known So Far, ApJ, 795, LL31.

Umetsu K. et al., 2014, CLASH: Weak-lensing Shear-and-magnification Analysis of 20 Galaxy Clusters, ApJ, 795, 163.

Ma C.-P. et al., 2014, The MASSIVE Survey. I. A Volume-limited Integral-field Spectroscopic Study of the Most Massive Early-type Galaxies within 108 Mpc, ApJ, 795, 158.

Keenan R. C. et al., 2014, Evolution of the Major Merger Galaxy Pair Fraction at z < 1, ApJ, 795, 157.

Verdugo T. et al., 2014, Characterizing SL2S galaxy groups using the Einstein radius, A&A, 571, AA65.

Bruce V. A. et al., 2014, The decomposed bulge and disc size-mass relations of massive galaxies at 1 < z < 3 in CANDELS, MNRAS, 444, 1660.

Conselice C. J. et al., 2014, Galaxy formation as a cosmological tool - I. The galaxy merger history as a measure of cosmological parameters, MNRAS, 444, 1125.

Bruce V. A. et al., 2014, The bulge-disc decomposed evolution of massive galaxies at 1 < z < 3 in CANDELS, MNRAS, 444, 1001.

Carron J., Wolk M., Szapudi I., 2014, On fast generation of cosmological random fields, MNRAS, 444, 994.

Palau A. et al., 2014, IC 348-SMM2E: a Class 0 proto-brown dwarf candidate forming as a scaled-down version of low-mass stars, MNRAS, 444, 833.

Koprowski M. P. et al., 2014, A reassessment of the redshift distribution and physical properties of luminous (sub-)millimetre galaxies, MNRAS, 444, 117.

Lee-Waddell K. et al., 2014, An extremely optically dim tidal feature in the gas-rich interacting galaxy group NGC 871/NGC 876/NGC 877, MNRAS, 443, 3601.

Skelton R. E. et al., 2014, 3D-HST WFC3-selected Photometric Catalogs in the Five CANDELS/3D-HST Fields: Photometry, Photometric Redshifts, and Stellar Masses, ApJS, 214, 24.

Durrell P. R. et al., 2014, The Next Generation Virgo Cluster Survey. VIII. The Spatial Distribution of Globular Clusters in the Virgo Cluster, ApJ, 794, 103.

Radigan J. et al., 2014, Strong Brightness Variations Signal Cloudy-to-clear Transition of Brown Dwarfs, ApJ, 793, 75,

Eckert D. et al., 2014, The stripping of a galaxy group diving into the massive cluster A2142, A&A, 570, AA119.

Micheletti D. et al., 2014, The VIMOS Public Extragalactic Redshift Survey. Searching for cosmic voids, A&A, 570, AA106.

See V. et al., 2014, The effects of stellar winds on the magnetospheres and potential habitability of exoplanets, A&A, 570, AA99.

Venuti L. et al., 2014, Mapping accretion and its variability in the young open cluster NGC 2264: a study based on u-band photometry, A&A, 570, AA82.

Shirasaki M., Horiuchi S., Yoshida N., 2014, Cross correlation of cosmic shear and extragalactic gamma-ray background: Constraints on the dark matter annihilation cross section, PhRvD, 90, 063502.

Sato T., Sawicki M., Arcila-Osejo L., 2014, Angular clustering of z ˜ 2 star-forming and passive galaxies in 2.5 square degrees of deep CFHT imaging, MNRAS, 443, 2661.

Damjanov I. et al., 2014, The Number Density of Quiescent Compact Galaxies at Intermediate Redshift, ApJ, 793, 39.

Kacprzak G. G. et al., 2014 New Perspective on Galaxy Outflows from the First Detection of Both Intrinsic and Traverse Metal-line Absorption ApJ 792 LL12

Veyette M. J., et al. 2014, Panchromatic Hubble Andromeda Treasury. IX. A Photometric Survey of Planetary Nebulae in M31, ApJ, 792, 121.

Zhu L. et al., 2014, The Next Generation Virgo Cluster Survey. V. Modeling the Dynamics of M87 with the Made-to-measure Method, ApJ, 792, 59.

Malo L. et al., 2014, BANYAN. IV. Fundamental Parameters of Low-mass Star Candidates in Nearby Young Stellar Kinematic Groups—Isochronal Age Determination using Magnetic Evolutionary Models, ApJ, 792, 37.

Singh V. et al., 2014, Multiwavelength characterization of faint ultra steep spectrum radio sources: A search for high-redshift radio galaxies, A&A, 569, AA52.

Zwintz K. et al., 2014, Echography of young stars reveals their evolution, Sci, 345, 550.

Agnello A. et al., 2014 Dynamical models of elliptical galaxies - II. M87 and its globular clusters, MNRAS, 442, 3299.

Shan H. Y. et al., 2014, Weak lensing mass map and peak statistics in Canada-France-Hawaii Telescope Stripe 82 survey, MNRAS, 442, 2534.

Huxor A. P. et al., 2014, The outer halo globular cluster system of M31 - I. The final PAndAS catalogue, MNRAS, 442, 2165.

Gruen D. et al., 2014, Weak lensing analysis of SZ-selected clusters of galaxies from the SPT and Planck surveys, MNRAS, 442, 1507.

Davidge T. J., 2014, Seeing Red in M32: Constraints on the Stellar Content from Near- and Mid-infrared Observations and Applications for Studies of More Distant Galaxies, ApJ, 791, 66.

Tucci Maia M., Meléndez J., Ramírez I., 2014, High Precision Abundances in the 16 Cyg Binary System: A Signature of the Rocky Core in the Giant Planet, ApJ, 790, LL25.

Amorín R. et al., 2014, Discovering extremely compact and metal-poor, star-forming dwarf galaxies out to z ~ 0.9 in the VIMOS Ultra-Deep Survey, A&A, 568, LL8.

Bailey J. D., 2014, Measuring the surface magnetic fields of magnetic stars with unresolved Zeeman splitting, A&A, 568, AA38.

Bielby R. M. et al., 2014, The WIRCam Deep Survey. II. Mass selected clustering, A&A, 568, AA24.

Carrasco Kind M., Brunner R. J., 2014, Sparse representation of photometric redshift probability density functions: preparing for petascale astronomy, MNRAS, 441, 3550.

Fu L. et al., 2014, CFHTLenS: cosmological constraints from a combination of cosmic shear two-point and three-point correlations, MNRAS, 441, 2725.

Vidotto A. A. et al., 2014, Stellar magnetism: empirical trends with age and rotation, MNRAS, 441, 2361.

Yan H. et al., 2014, Optical-faint, Far-infrared-bright Herschel Sources in the CANDELS Fields: Ultra-luminous Infrared Galaxies at $z > 1$ and the Effect of Source Blending, ApJS, 213, 2.

Tal T. et al., 2014, Observations of Environmental Quenching in Groups in the 11 GYR since $z = 2.5$: Different Quenching for Central and Satellite Galaxies, ApJ, 789, 164.

Maturi M., Mizera S., Seidel G., 2014, Multi-colour detection of gravitational arcs, A&A, 567, AA111.

Koulouridis E. et al., 2014, X-ray AGN in the XMM-LSS galaxy clusters: no evidence of AGN suppression, A&A, 567, AA83.

Baldi R. D. et al., 2014, The radio-loud AGN population at $z \gtrsim 1$ in the COSMOS field. I. selection and spectral energy distributions, A&A, 56,7 AA76.

Alecian E. et al., 2014 Discovery of new magnetic early-B stars within the MiMeS HARPSpol survey, A&A, 567, AA28.

Cooke J. et al., 2014, Lyman-continuum galaxies and the escape fraction of Lyman-break galaxies, MNRAS, 441, 837.

Umehata H. et al., 2014, AzTEC/ASTE 1.1-mm survey of SSA22: Counterpart identification and photometric redshift survey of submillimetre galaxies, MNRAS, 440, 3462.

Bagchi J. et al., 2014, Megaparsec Relativistic Jets Launched from an Accreting Supermassive Black Hole in an Extreme Spiral Galaxy, ApJ, 788, 174.

Simpson J. M. et al., 2014, An ALMA Survey of Submillimeter Galaxies in the Extended Chandra Deep Field South: The Redshift Distribution and Evolution of Submillimeter Galaxies, ApJ, 788, 125.

Jian H.-Y. et al., 2014, Probability Friends-of-Friends (PFOF) Group Finder: Performance Study and Observational Data Applications on Photometric Surveys, ApJ, 788, 109.

Juneau S. et al., 2014, Active Galactic Nuclei Emission Line Diagnostics and the Mass-Metallicity Relation up to Redshift $z \sim 2$: The Impact of Selection Effects and Evolution, ApJ, 788, 88.

Malo L. et al., 2014, BANYAN. III. Radial Velocity, Rotation, and X-Ray Emission of Low-mass Star Candidates in Nearby Young Kinematic Groups, ApJ, 788, 81.

Newman A. B. et al., 2014, Spectroscopic Confirmation of the Rich $z = 1.80$ Galaxy Cluster JKCS 041 using the WFC3 Grism: Environmental Trends in the Ages and Structure of Quiescent Galaxies, ApJ, 788, 51.

Lunnan R. et al., 2014, Hydrogen-poor Superluminous Supernovae and Long-duration Gamma-Ray Bursts Have Similar Host Galaxies, ApJ, 787, 138.

Mann A. W. et al., 2014, Prospecting in Ultracool Dwarfs: Measuring the Metallicities of Mid- and Late-M Dwarfs, AJ, 147, 160.

Murata K. et al., 2014, Polycyclic aromatic hydrocarbon feature deficit of starburst galaxies in the AKARI North Ecliptic Pole Deep field, A&A, 566, AA136.

Samal M. R. et al., 2014, The molecular complex associated with the Galactic H II region Sh2-90: a possible site of triggered star formation, A&A, 566, AA122.

Guzzo L. et al., 2014, The VIMOS Public Extragalactic Redshift Survey (VIPERS). An unprecedented view of galaxies and large-scale structure at 0.5 < z < 1.2, A&A, 566, AA108.

Joseph R. et al., 2014, A PCA-based automated finder for galaxy-scale strong lenses, A&A, 566, AA63.

Oi N. et al., 2014,, Optical - near-infrared catalog for the AKARI north ecliptic pole Deep field, A&A, 566, AA60.

Petit P. et al., 2014, PolarBase: A Database of High-Resolution Spectropolarimetric Stellar Observations, PASP, 126, 469.

Bowler R. A. A. et al., 2014, The bright end of the galaxy luminosity function at z≃7: before the onset of mass quenching?, MNRAS, 440, 2810.

Prinja R. K., Urbaneja M. A., 2014, Rummaging inside the Eskimo's parka: variable asymmetric planetary nebula fast wind and a binary nucleus?, MNRAS, 440, 2684.

Matthee J. J. A. et al., 2014, A 10 deg^2 Lyman α survey at z=8.8 with spectroscopic follow-up: strong constraints on the luminosity function and implications for other surveys, MNRAS, 440, 2375.

Lindsay S. N., Jarvis M. J., McAlpine K., 2014, Evolution in the bias of faint radio sources to z ˜ 2.2, MNRAS, 440, 2322.

Head J. T. C. G. et al., 2014, Dissecting the red sequence: the bulge and disc colours of early-type galaxies in the Coma cluster, MNRAS, 440, 1690.

Duc P.-A. et al., 2014, Identification of old tidal dwarfs near early-type galaxies from deep imaging and H I observations, MNRAS, 440, 1458.

Georgakakis A. et al., 2014, Investigating evidence for different black hole accretion modes since redshift z ˜ 1, MNRAS, 440, 339.

Caldwell N. et al., 2014, A Globular Cluster toward M87 with a Radial Velocity < - 1000 km s^{-1}: The First Hypervelocity Cluster, ApJ, 787, LL11.

Martin N. F. et al., 2014, The PAndAS Field of Streams: Stellar Structures in the Milky Way Halo toward Andromeda and Triangulum, ApJ, 787, 19.

Naud M.-E. et al., 2014, Discovery of a Wide Planetary-mass Companion to the Young M3 Star GU Psc, ApJ, 787, 5.

Croll B. et al., 2014, Multiwavelength Observations of the Candidate Disintegrating Sub-Mercury KIC 12557548b, ApJ, 786, 100.

Hagen A. et al. 2014, Spectral Energy Distribution Fitting of HETDEX Pilot Survey Lyα Emitters in COSMOS and GOODS-N, ApJ, 786, 59.

Shirasaki M., Yoshida N., 2014, Statistical and Systematic Errors in the Measurement of Weak-Lensing Minkowski Functionals: Application to the Canada-France-Hawaii Lensing Survey, ApJ, 786, 43,

Murata K. L. et al., 2014, Evolution of the Fraction of Clumpy Galaxies at 0.2 < z < 1.0 in the COSMOS Field, ApJ, 786, 15.

Sick J. et al., 2014, Andromeda (M31) Optical and Infrared Disk Survey. I. Insights in Wide-field Near-IR Surface Photometry, AJ, 147, 109.

Andreon S. et al., 2014, JKCS 041: a Coma cluster progenitor at z = 1.803, A&A, 565, AA120.

Cucciati O. et al., 2014, The VIMOS Public Extragalactic Redshift Survey (VIPERS). Never mind the gaps: comparing techniques to restore homogeneous sky coverage, A&A, 565, AA67.

Tasca L. A. M. et al., 2014 Evidence for major mergers of galaxies at $2 \lesssim z < 4$ in the VVDS and VUDS surveys, A&A, 565, AA10.

Ford J. et al., 2014, Cluster magnification and the mass-richness relation in CFHTLenS, MNRAS, 439, 3755.

Blom C. et al., 2014, The SLUGGS Survey: new evidence for a tidal interaction between the early-type galaxies NGC 4365 and NGC 4342, MNRAS, 439, 2420.

Buitrago F. et al., 2014 SINFONI/VLT 3D spectroscopy of massive galaxies: evidence of rotational support at z ˜ 1.4, MNRAS, 439, 1494.

Ebeling H., Ma C.-J., Barrett E., 2014, Spectroscopic Redshifts of Galaxies within the Frontier Fields, ApJS, 211, 21.

Gavazzi R. et al., 2014, RINGFINDER: Automated Detection of Galaxy-scale Gravitational Lenses in Ground-based Multi-filter Imaging Data, ApJ, 785, 144.

Covone G. et al., 2014, Measurement of the Halo Bias from Stacked Shear Profiles of Galaxy Clusters, ApJ, 784, LL25.

An F. X. et al., 2014, The Properties of Hα Emission-line Galaxies at Z = 2.24, ApJ, 784, 152.

Karouzos M. et al., 2014, A Tale of Two Feedbacks: Star Formation in the Host Galaxies of Radio AGNs, ApJ, 784, 137.

Riedel A. R. et al., 2014, The Solar Neighborhood. XXXIII. Parallax Results from the CTIOPI 0.9 m Program: Trigonometric Parallaxes of Nearby Low-mass Active and Young Systems, AJ, 147, 85.

Deleuil M. et al., 2014, SOPHIE velocimetry of Kepler transit candidates XI. Kepler-412 system: probing the properties of a new inflated hot Jupiter, A&A, 564, AA56.

Pila-Díez B. et al., 2014, Finding halo streams with a pencil-beam survey. New wraps in the Sagittarius stream, A&A, 564, AA18.

Karouzos M., Jarvis M. J., Bonfield D., 2014, Mergers as triggers for nuclear activity: a near-IR study of the close environment of AGN in the VISTA-VIDEO survey, MNRAS, 439, 861.

McLinden E. M. et al., 2014, Galactic winds and stellar populations in Lyman α emitting galaxies at z ˜ 3.1, MNRAS, 439, 446.

Applegate D. E. et al., 2014, Weighing the Giants - III. Methods and measurements of accurate galaxy cluster weak-lensing masses, MNRAS, 439, 48.

Kelly P. L. et al., 2014, Weighing the Giants - II. Improved calibration of photometry from stellar colours and accurate photometric redshifts, MNRAS, 439, 28.

von der Linden A. et al., 2014, Weighing the Giants - I. Weak-lensing masses for 51 massive galaxy clusters: project overview, data analysis methods and cluster images, MNRAS, 439, 2.

Sódor Á. et al., 2014, Extensive study of HD 25558, a long-period double-lined binary with two SPB components, MNRAS, 438, 3535.

Carrasco Kind M., Brunner R. J., 2014, SOMz: photometric redshift PDFs with self-organizing maps and random atlas, MNRAS, 438, 3409.

Li R. et al., 2014, First galaxy-galaxy lensing measurement of satellite halo mass in the CFHT Stripe-82 Survey, MNRAS, 438, 2864.

Santos J. S. et al., 2014, Star formation in the cluster CLG0218.3-0510 at z = 1.62 and its large-scale environment: the infrared perspective, MNRAS, 438, 2565.

Kelson D. D. et al., 2014, The Carnegie-Spitzer-IMACS Redshift Survey of Galaxy Evolution since z = 1.5. I. Description and Methodology, ApJ, 783, 110.

Jee M. J. et al., 2014, Hubble Space Telescope/Advanced Camera for Surveys Confirmation of the Dark Substructure in A520, ApJ, 783, 78.

Line M. R. et al., 2014 A Systematic Retrieval Analysis of Secondary Eclipse Spectra. II. A Uniform Analysis of Nine Planets and their C to O Ratios, ApJ, 783, 70.

Fritz A. et al., 2014, The VIMOS Public Extragalactic Redshift Survey (VIPERS): A quiescent formation of massive red-sequence galaxies over the past 9 Gyr, A&A, 563, AA92.

Hainaut O. R. et al., 2014 Continued activity in P/2013 P5 PANSTARRS. Unexpected comet, rotational break-up, or rubbing binary asteroid?, A&A, 563, AA75.

Marquez M. J., Budavári T., Sarro L. M., 2014, Improving cross-identification of galaxies using their photometry, A&A, 563, AA14.

Shultz M. et al., 2014, An observational evaluation of magnetic confinement in the winds of BA supergiants, MNRAS, 438, 1114.

Bate N. F. et al., 2014, Major substructure in the M31 outer halo: the South-West Cloud, MNRAS, 437, 3362.

Lin L. et al., 2014, The Pan-STARRS1 Medium-Deep Survey: The Role of Galaxy Group Environment in the Star Formation Rate versus Stellar Mass Relation and Quiescent Fraction out to z ~ 0.8, ApJ, 782, 33.

Bizzocchi L. et al., 2014, Bulgeless Galaxies at Intermediate Redshift: Sample Selection, Color Properties, and the Existence of Powerful Active Galactic Nuclei, ApJ, 782, 22.

Ingraham P. et al., 2014, Near-infrared (JHK) Spectroscopy of Young Stellar and Substellar Objects in Orion, ApJ, 782, 8.

Lanzuisi G. et al., 2014, Active Galactic Nucleus X-Ray Variability in the XMM-COSMOS Survey, ApJ, 781, 105.

de la Chevrotière A. et al., 2014, Searching for Magnetic Fields in 11 Wolf-Rayet Stars: Analysis of Circular Polarization Measurements from ESPaDOnS, ApJ, 781, 73.

Donato D. et al., 2014, A Tidal Disruption Event in a nearby Galaxy Hosting an Intermediate Mass Black Hole, ApJ, 781, 59.

Fossati L. et al., 2014 Two spotted and magnetic early B-type stars in the young open cluster NGC 2264 discovered by MOST and ESPaDOnS, A&A, 562, AA143.

Garilli B. et al., 2014, The VIMOS Public Extragalactic Survey (VIPERS). First Data Release of 57 204 spectroscopic measurements, A&A, 562, AA23.

Van Waerbeke L., Hinshaw G., Murray N., 2014, Detection of warm and diffuse baryons in large scale structure from the cross correlation of gravitational lensing and the thermal Sunyaev-Zeldovich effect, PhRvD, 89, 023508.

Duncan C. A. J. et al., 2014, On the complementarity of galaxy clustering with cosmic shear and flux magnification, MNRAS, 437, 2471.

Velander M. et al., 2014, CFHTLenS: the relation between galaxy dark matter haloes and baryons from weak gravitational lensing, MNRAS, 437, 2111.

Tejos N. et al., 2014, On the connection between the intergalactic medium and galaxies: the H I-galaxy cross-correlation at $z \lesssim 1$, MNRAS, 437, 2017.

De Rosa R. J. et al., 2014, The VAST Survey - III. The multiplicity of A-type stars within 75 pc, MNRAS, 437, 1216.

Cacciato M., van Uitert E., Hoekstra H., 2014, Describing galaxy weak lensing measurements from tenths to tens of Mpc and up to z ˜ 0.6 with a single model, MNRAS, 437, 377.

Kartha S. S. et al., 2014, The SLUGGS survey: the globular cluster systems of three early-type galaxies using wide-field imaging, MNRAS, 437, 273.

Muñoz R. P. et al., 2014, The Next Generation Virgo Cluster Survey-Infrared (NGVS-IR). I. A New Near-Ultraviolet, Optical, and Near-Infrared Globular Cluster Selection Tool, ApJS, 210, 4.

Ibata R. A. et al., 2014, The Large-scale Structure of the Halo of the Andromeda Galaxy. I. Global Stellar Density, Morphology and Metallicity Properties, ApJ, 780, 128.

Läsker R. et al., 2014 Supermassive Black Holes and Their Host Galaxies. II. The Correlation with Near-infrared Luminosity Revisited, ApJ, 780, 70.

Läsker R., Ferrarese L., van de Ven G., 2014, Supermassive Black Holes and Their Host Galaxies. I. Bulge Luminosities from Dedicated Near-infrared Data, ApJ, 780, 69.

Bailey J. D., Landstreet J. D., Bagnulo S., 2014, Discovery of secular variations in the atmospheric abundances of magnetic Ap stars, A&A, 561, AA147.

Guennou L. et al., 2014, Structure and substructure analysis of DAFT/FADA galaxy clusters in the [0.4-0.9] redshift range, A&A, 561, AA112.

Reylé C. et al., 2014, CFBDS J111807-064016: A new L/T transition brown dwarf in a binary system, A&A, 561, AA66.

de Oliveira C. A. et al., 2014, The Low Mass End of the IMF Unveiled by the WIRCam/CFHT Survey of Nearby Young Clusters, ASSP, 36, 351.