2013 CFHT Annual Report

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Front and back covers: The new dome vents are seen prominently in this photo of CFHT against M17 (Horseshoe Nebula), captured recently by CFHT's MegaCam.

Director's Message

Figure 1 – Top: The new dome vents, soon after installation. Each vent is independently configurable and the curved inset design beautifully matches the contours of the dome. Bottom: A photo taken from a kite-mounted DLSR showing the ~600 solar PV panels on the roof of the headquarters office and shop in Waimea.
Images courtesy Tom Benedict

If there was a theme that best describes CFHT activities in 2013, it would probably be about enhancing our base and summit facilities, in effect giving them new "faces" as we continue our longstanding mission. CFHT's new face on the summit is in the form of a dozen new dome vents, while our new face in Waimea is in the form of nearly 600 solar PV panels. These changes will provide lower costs and improved performance for many years ahead – a combination that isn't necessarily easy to achieve. Particularly noteworthy in the installation of the new dome vents is that no downtime occurred throughout the process, which is rather remarkable given the extent and complexity of such an enclosure upgrade. This a real tribute to the team that planned and conducted this major upgrade. Over the years, CFHT has acquired some of the best dome seeing data of any facility in the world, the publication of which has influenced the designs of other major facilities. I can attest to past measurements of CFHT's primary mirror temperature being factored into the Gemini telescope design nearly 20 years ago. A little known fact is that serious consideration was given to including in the Gemini primary mirror control system real time mirror coating heating, in an attempt to precisely match temperature changes between the optical surface of the primary with ambient air conditions. The concept was eventually abandoned as too complex with an expected gain that was marginal compared to simply venting the dome. Nonetheless, these design choices at Gemini were critically informed by measurements made at CFHT in the '90's. In a sense, it is only fitting that after all this time CFHT benefit from the measurements made at CFHT through the installation of new dome vents. Since installing the vents I have lost count of how many times I have been asked "how much better is your seeing?". The simple answer is, we don't know and we won't know until at least 1 or 2 semesters have transpired, allowing us to make a statistically meaningful comparison with past (non-vented) image quality. Once we do know, it will be interesting to translate that improvement into various benefits and metrics, including the theoretical additional observing time improved image quality provides using SNR QSO (see page 8), or the amount of time necessary for the venting project to pay for itself ("return on investment"), equating additional observing time for the community with nominal operations costs. Regardless of these details, improved image quality will impact nearly all research done with CFHT for many years to come, which is arguably the most important benefit of this upgrade.

Figure 1 shows the dome vents soon after installation, as well as an overhead view of the solar PV panels on our headquarters roof in Waimea. CFHT is the first Maunakea observatory to "go solar" through the installation of a system that will provide ~40% of our headquarters power needs. The cost

Figure 2 – Top: An image from the ngCFHT Workshop held at Imiloa Astronomy Center in Hilo. Center: Participants in CFHT's Triennial Users' Meeting held in British Columbia are shown. Bottom: CFHT hosted the ADASS XXIII meeting in Waikoloa. Combined, roughly 500 astronomers, engineers, students, etc. participated in these meetings which all showcased CFHT to an international community.

of the system will be recovered through reduced electricity bills in ~5 years. We are also focused on energy conservation, having replaced all of the office celling lights with energy efficient LED fixtures. Factoring in rebates for these new lights, the return on this investment is only <1 year. In addition we plan to use ambient air to cool our central computing facilities, taking advantage of Waimea's naturally cool climate and only using air conditioning as a backup. Combined all of these initiatives reflect the innovation of CFHT's staff and commitment to provide first rate data products and support for our community while keeping costs manageable.

Also noteworthy in 2013 were the 3 major conferences that CFHT either led or hosted, which allowed us to engage our growing community as options for the future of CFHT are explored. These conferences also helped foster greater collaboration between CFHT's partners and the observatories on Maunakea. The ngCFHT Workshop, which was held in March 2013 at Imiloa Astronomy Center and attended by >100 participants from all over the globe, was an excellent opportunity for science cases, strategic issues, and technical options for this project to be discussed. Subsequent to the successful workshop, a proposal to launch the ngCFHT Project Office in Waimea was considered by the SAC and Board and the decision made to launch such an Office in 2014. The main product of the ngCFHT Project Office will be a construction proposal that in a few years will help inform the Board (and community) about the merits, risks, challenges, and opportunities such a "recycling" of CFHT represents. The main goals for the Project Office in 2014 include ramping up infrastructure in Waimea to host the effort, and building the international base of support for this project.

Finally, considerable progress was made in 2014 on developing new instrumentation for CFHT. The nexus of this activity occurred through an Announcement of Opportunity to the entire CFHT community to develop new instruments and/or upgrade existing systems. The main outcomes of this activity included commitments for new filters and a CCD controller upgrade for MegaCam, the purchase of a fairly large suite of filters for SITELLE, and the support of SPIRou through a $2,000,000 contribution from CFHT, as well as considerable in-house technical resources. Combined with existing capabilities, these new instruments and upgrades to various facilities represent the near-term bridge to CFHT's future – a future that remains promising as our community continues its voyage of exploration and discovery.

Science Report

CFHT had another productive year in 2013. The year started with a CFHT image of M31 on the cover of the journal Nature and continued with the discovery of a rare magnetic transient in a massive star, the discovery of the first Uranian Trojan and finished with the publication of high precision astrometry on a free floating planet that will help shed light on the characteristics of exoplanets. These exciting discoveries were interleaved with the successful testing of the SNR queue observing mode and with the release of the CFHTLenS imaging data catalog products. These and other science highlights can be found on CFHT's web page (www.cfht.hawaii.edu), which is updated on a continual basis as exciting new observations and discoveries based upon CFHT data are published in journals worldwide.

A Rotating Disk of Dwarf Galaxies Surrounding M31

A wonderful surprise was awaiting the CFHT staff at the start of 2013. The cover of the first 2013 edition of the journal Nature featured a new MegaCam Hawaiian Starlight image of the Andromeda galaxy by CFHT/Coelum. This image was the setup for the article inside describing a remarkable discovery that shows that more than half the dwarf galaxy companions of the Andromeda Galaxy are aligned in a giant disk that appears to rotate around their bright host.

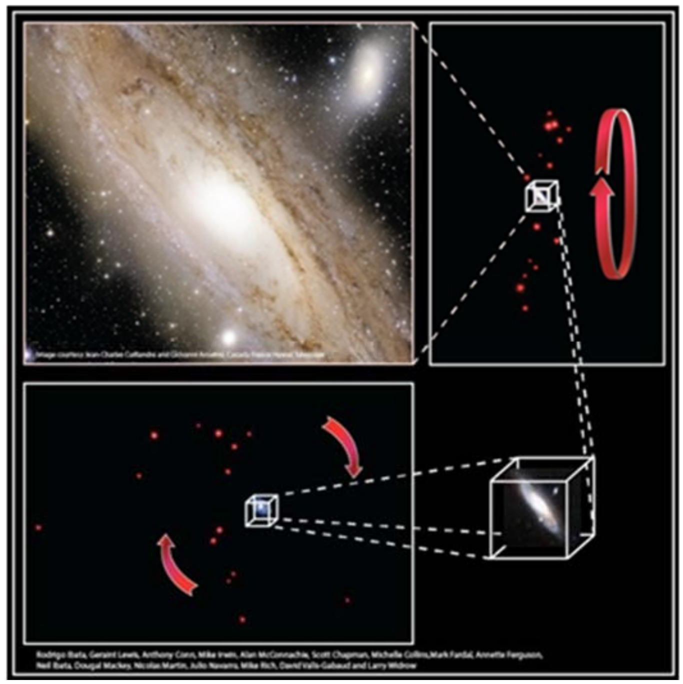


Figure 3 - The composite image to the left shows the alignment of the satellite galaxies of Andromeda, in relation to the view that we see from Earth. The top left panel shows a true color image of the center of the Andromeda galaxy taken with MegaCam. New distance measurements provide the three-dimensional positions of the satellite galaxies, which together with new velocity measurements, reveal their true nature as part of a gigantic rotating structure. Credit: R. Ibata and the PANDAS team.

Large galaxies like Andromeda and our own Milky Way have long been known to be orbited by an entourage of smaller galaxies. These systems - that are individually ten to hundreds of thousands of times fainter that their bright hosts - were thought to have distinct orbits around M31. Observations by Ibata et al. show now that a majority of these dwarf galaxies in fact constitute an immense (approximately one million light year diameter) but extremely flattened structure. Something about how these galaxies formed, or subsequently evolved, must have led them to trace out this peculiar, coherent, structure. While dwarf galaxies are not massive, they are the most numerous galaxy type in the universe, so understanding their dynamics will help shed new insight into the formation of galaxies at all masses.

The study is based on the Pan-Andromeda Archaeological Survey (PAndAS), a large project undertaken between 2008 and 2011 with MegaCam on CFHT. It culminates many years of effort by an international team of scientists who discovered a large number of the satellite galaxies, developed new techniques to measure their distances, and used Keck observatory with colleagues to measure their radial velocities. While earlier work had hinted at the existence of this structure, the new study demonstrated its existence to a high level of statistical confidence (99.998%) and revealed its coherent motion in considerable detail.

In the current understanding of galaxy formation, the first galaxies formed within large clumps of dark matter. These first galaxies must have been small, but over time giant galaxies like Andromeda and the Milky Way are thought to have evolved by cannibalizing their smaller neighbors. In this model the dwarf galaxies that we now see would be those ancient primordial galaxies that survived such violent encounters. However, nowhere in this model is there an explanation for why the surviving dwarfs should map out a large disk like we now see around our nearest neighbor M31. It appears that the smallest galaxies in the universe are intent on providing the biggest challenges to our understanding of galaxy formation.

Additional information can be found in "A vast, thin plane of co-rotating dwarf galaxies orbiting the Andromeda galaxy" Nature magazine Volume 493, Number 7430, pp62-65, 3 January 2013, or via http://www.nature.com/nature/journal/v493/n7430/full/nature11717.html.

HD190073 - A Star With a Magnetic Personality!

Researchers from the Observatoire de Paris and of the Service d'Astrophysique-Laboratoire AIM du CEA-Irfu observed an unexpected change of direction of the fossil magnetic dipole of a young massive star, the Herbig star HD 190073. Massive stars are known to possess fossil magnetic fields that are stable over tens of years and probably millions of years according to theorists. However in 2011 and 2012, as part of the MiMeS large program at CFHT, the scientists found a global change in the orientation of the magnetic field observed at the surface of the star HD 190073. The most plausible explanation is that the change of the magnetic axis of the star is due to the birth of convective movements in its core. Such an event has never been observed before and is the subject of a 2013 article published in the journal Astronomy & Astrophysics.

After its birth, a young massive star is first fully convective. As in boiling water, movements of material on large scales in the star then help to transport energy outward from the stellar core (step 1 in Figure 4). Thus, from an initial magnetic flux, the star generates a magnetic field by the motion of electric charges, through the well-known dynamo mechanism. Later, it forms a radiative stable core where convection is absent, and energy is drained by the radiation of the star (step 2 in Figure 4). This radiative core grows until the outer convective envelope has completely disappeared. The magnetic field generated in the initial convective regions is then transformed into a "fossil" magnetic field, stable and usually bipolar (step 3 in Figure 4). Finally, when the star is about to reach the main sequence it becomes stable as hydrogen is converted into helium by thermonuclear reactions and a convective core is created again in its center because of the strongly

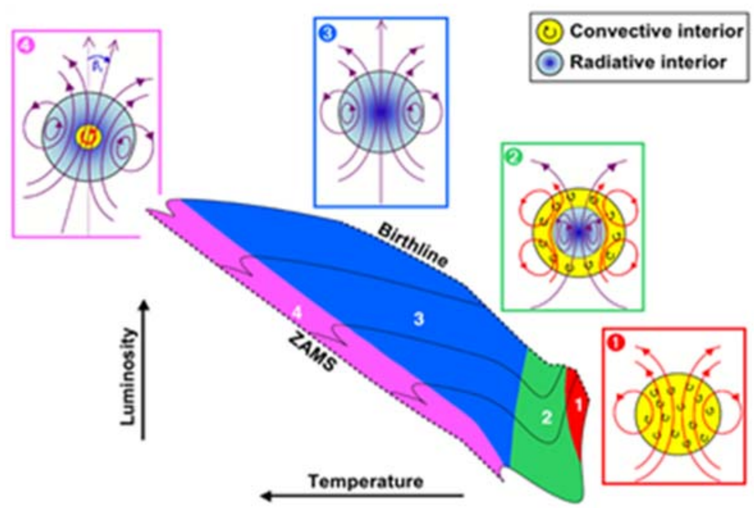


Figure 4 - In the diagram temperature-luminosity (Hertzprung-Russell diagram), for each step, the structure of the star and the type of the associated magnetic field are schematized. The star HD 190073 is located at the transition between steps 3 and 4. Credits: E. Alecian, C. Neiner

exothermic nuclear reactions that take place (step 4 in Figure 4). The appearance of a dynamo magnetic field generated in this convective central region can then disrupt the initial configuration and result in a tilting of the initial magnetic field.

The first observations of the star HD 190073, obtained at CFHT between 2004 and 2009, showed that it possessed a bipolar magnetic field, stable over this period, in agreement with the theory of the fossil field in massive stars. The surprise came in 2011 and 2012, when this star was observed once again under the large programs MiMeS at CFHT, the Bernard Lyot Telescope (TBL), Pic du Midi (France), and at the European Southern Observatory (ESO). The variation of the surface magnetic field seems to indicate that the magnetic field axis has moved. Its axis is no longer coincident with the axis of rotation of the star, but tilted, causing a periodic variation of the observed field. According to the researchers, this change can be interpreted as disruption caused by the appearance of the dynamo field produced by the formation of a convective core in the star.

Indeed, according to recent numerical simulations[1] the dynamo magnetic field generated in the convective core of massive stars and intermediate-mass stars couples with the fossil magnetic field of their radiative envelope. This coupling occurs at the boundary between the core and envelope, and causes a change of orientation of the axis of the fossil field. For the first time, this transition appears to have been observed in a star, HD 190073. To test whether the new magnetic configuration has really stabilized and to determine the precise parameters of this new configuration, additional observations will be required. HD 190073 represents a unique opportunity to witness the appearance of a convective core in a star.

For more information see http://www.obspm.fr/the-birth-of-a-convective-core-in-a-young-star.html or “The dramatic change of the fossil magnetic field of HD 190073: evidence of the birth of the convective core in a Herbig star?”, E. Alecian, C. Neiner, S. Mathis, C. Catala, O. Kochukhov, J. Landstreet, the MiMeS collaboration, A&A, 549, L8. (http://arxiv.org/abs/1301.1804)

Discovery of a Blue Supergiant Star Born in the Wild - Subaru, CFHT and GALEX

A pair of astronomers, Dr. Youichi Ohyama (Institute of Astronomy and Astrophysics, Academia Sinica or ASIAA, Taiwan) and Dr. Ananda Hota (UM-DAE Centre for Excellence in the Basic Sciences or CBS, India) have discovered a blue supergiant star located far beyond our Milky Way Galaxy in the constellation Virgo using images from the CFHT's Next Generation Virgo Cluster Survey (NGVS) in conjunction with images from GALEX and spectra from Subaru's Faint Object Camera and Spectrograph (FOCAS).

The Virgo cluster, the nearest cluster of galaxies located about 55 million light years from Earth in the constellation Virgo, is an ideal laboratory to study the fate of gas stripped from galaxies passing through the intra-cluster medium. Dr. Ohyama and Dr. Hota focused on the trail of IC 3418 to explore a potentially new mode of star formation. Dr. Hota has been collecting data from various telescopes since 2006 to understand this galaxy, which he first spotted in GALEX data during his Ph.D. research.

IC 3418 is a small galaxy falling into the Virgo cluster of galaxies at such a high speed (1000 km/s) that its blanket of relatively cool gas is being stripped off. As it speeds through the cluster, its stripped gas formed a trail ~50,000 ly long that looks like the water vapor condensation trail in a jet's path. Hot plasma in the intra-cluster medium surrounds the trail of IC 3418, and it has not been clear whether the

[1] Effects of Fossil Magnetic Fields on Convective Core Dynamos in A-type Stars, Featherstone, N., Browning, M., Brun, A., Toomre J., ApJ, 705, Issue 1, 1000

clouds of cool gas vaporize like water sprinkled on a hot frying pan or condense further to form new young massive stars. The GALEX ultraviolet image shows that new massive stars do form in the trail. How did the stripped gas form new stars in the hot plasma? This process does not conform to star formation in our Milky Way Galaxy where massive stars develop in groups inside of stellar nurseries sheltered within giant cold molecular gas clouds.

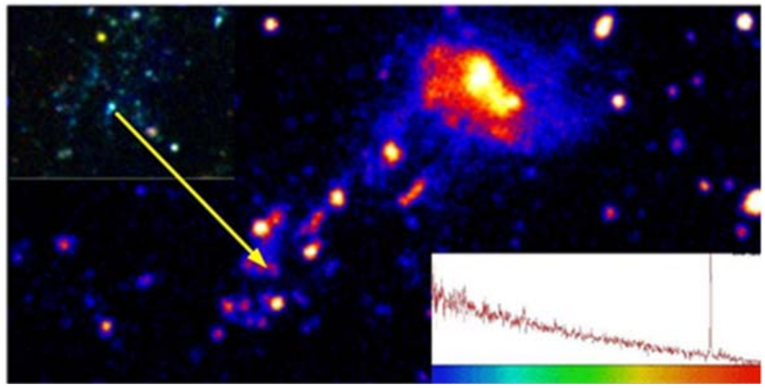


Figure 5 - Pseudo-color GALEX ultraviolet image of the galaxy IC 3418 falling into the Virgo cluster. Notice the young star-forming clumps in its 55,000 light-years-long trail, as the galaxy moves towards the top-right area. Zooming into one of the blobs, marked by the arrow, the color optical image from CFHT shows the bright blue supergiant star in the middle of the inset image in the top-left area. The optical spectrum from the same star (bottom-right area), which was obtained by Subaru Telescope's Faint Object Camera and Spectrograph (FOCAS), shows only one bright red emission line (H-alpha) due to the stellar wind and none of the other usual signs of star-forming regions. (Credit: NAOJ, CFHT, GALEX, Y. Ohyama & A. Hota)

Dr. Ohyama suspected that a tiny dot of light emission in the trail of IC 3418 seen in the NGVS images might be different from other blobs of ultraviolet light emissions in the trail. Spectroscopy of the little dot with Subaru FOCAS revealed something stunning; fast winds blowing out of the stellar atmosphere at a speed of about 160 km/s. Normally, intense ultraviolet radiation from a young star heats up and ionizes the surrounding gas soon after it is born. Comparison of the emission from this blue star with emissions from nearby stars made it clear that this massive, hot (O-type) star passed its youth and was now aging quickly. This star is now a blue supergiant and will soon face its explosive death as a supernova. This research provides unprecedented views of the star formation process in the intergalactic medium and hints at the promise of discovering new modes of star formation, unlike that within our Milky Way.

Additional information about this fascinating discovery can be found in “Discovery of a Possibly Single Blue Supergiant Star in the Intra-Cluster Region of Virgo Cluster of Galaxies” ApJL, 767, 2, or via http://iopscience.iop.org/2041-8205/767/2/L29/.

SNR Queue Observations

In order to improve the efficiency of our observing process, efforts were made in 2013 to test Signal to Noise Ratio (SNR) queue observing. In this new mode, targets are observed until the SNR required by the scientific program is reached. The motivation for this comes from the fact that PIs often calculate their point source sensitivities based upon a seeing estimate that is worse than median seeing on Maunakea. Figure 6 shows that this happens quite often in the redder MegaCam bands and also shows that the gains of SNR queued observing could be substantial at these wavelengths. In contrast, the gains of this mode are expected to be marginal in the u and g bands (the latter not shown in Figure 6).

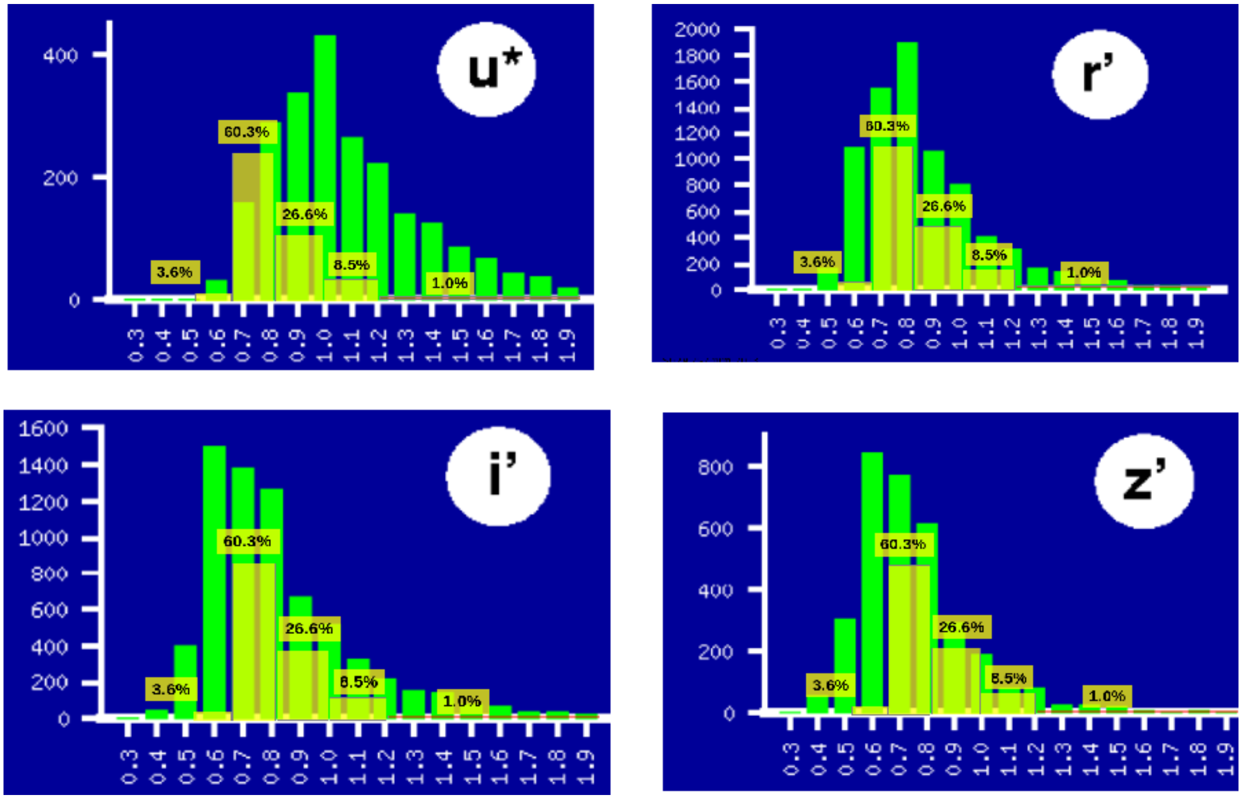


Figure 6 - Demanded seeing compared to delivered seeing on MegaCam. The yellow transparent bars show the percentage demanded by PIs for each seeing bin offered in PH2 over a three year period on MegaCam. The green bars show the median seeing as measured on MegaCam. Credits: Jean-Charles Cuillandre, Todd Burdullis and Daniel Devost.

Implementation of this mode and testing started in 2013A with the NGVS program. The PI graciously offered to let us test this mode and was fully involved in the process. A control system interface that updated the running SNR and magnitude depth after each observation was developed by CFHT's software group and successfully tested by the ROs for the first time during the April 2013 MegaCam run. Observations of NGVS in SNR mode continued afterwards, though we mainly attempted u' band SNR queue observations for the NGVS large program. Weather cooperated and seeing on the order of 0.5" in u' allowed us to complete these observations faster than conventional queue observing, allowing the completion of this portion of the NGVS large program.

First Trojan Companion of Uranus Discovered Using CFHT

Using MegaCam on CFHT, a team of astronomers from Canada and France have discovered the first known Trojan companion of the planet Uranus. The team is composed of Mike Alexandersen, Sarah Greenstreet, and Brett Gladman from the University of British Columbia in Canada, JJ Kavelaars and Stephen Gwyn of Canada's National Research Council, and Jean-Marc Petit at the Observatoire de Besançon in France. They published the discovery, and numerical studies of the object's orbit and origin, in the August 30, 2013 edition of Science magazine.

The Trojan, a 60-km wide ball of rock and ice temporarily known by the name 2011 QF99, was first identified by the team in CFHT observations from October 2011. The original program was designed to search the outer Solar System for even more-distant trans-neptunian objects beyond the planet Neptune. The comparatively fast-moving 2011 QF99 was re-observed many times during 2011 and 2012

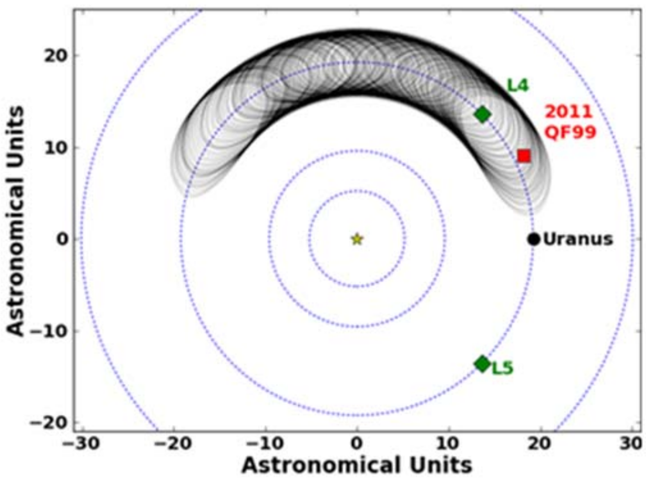


Figure 7 - The motion of the Uranian Trojan 2011 QF99. In this representation of the motion of 2011 QF99, one sees the motion over the next 59,000 years, looking down on the Solar System from above and turning at the same rate as the planet Uranus (which thus remains stationary at right). The Trojan oscillates forward and backwards, always keeping ahead of the planet. Image Credits: Mike Alexandersen, Brett Gladman, Sarah Greenstreet.

to track it across the sky, making it possible to determine with high confidence that this object is in a Uranian Trojan orbit.

2011 QF99 shares an orbit with the planet Uranus at a distance of 19 AU. In such a Trojan state, the object always remains 10-170 degrees ahead of the planet Uranus, never advancing too far ahead of, nor being caught by the planet. Although the team showed that the newly discovered object can remain in this state for many hundreds of thousands of years, they also showed that within millions of years the object will very likely escape this state and be scattered into the outer solar system. Other planets, like Earth and Neptune, have recently been shown to host similar temporarily co-orbital populations. 2011 QF99 is the first Trojan object identified for Uranus, which for now, does not have any known permanent co-orbital companions. The team used extensive computer simulations to prove that the number of non-permanent co-orbital companions of Uranus and Neptune made sense if distant trans-neptunian objects are leaking inward towards the Sun.

Information about this discovery, the tracking effort, and the orbital simulations are provided on the UBC web page referenced below[2]. Additional detailed information can be found in "A Uranian Trojan and the Frequency of Temporary Giant-Planet Co-Orbitals", Mike Alexandersen, Brett Gladman, Sarah Greenstreet, J. J. Kavelaars, Jean-Marc Petit, Stephen Gwyn, Science, Vol. 341, no. 6149, pp. 994-997 (http://www.sciencemag.org/content/341/6149/994.full).

Release of the CFHTLenS Imaging Data Catalog Products

CFHTLenS is based on the Wide component of the Canada-France-Hawaii Telescope Legacy Survey (CFHTLS). It encompasses 154 deg^2 of deep, optical, high-quality, sub-arcsecond imaging data in the five optical filters of MegaCam: u*g'r'i'z'. The scientific aims of the CFHTLenS team are weak gravitational lensing studies supported by photometric redshift estimates for the galaxies. Their paper (Erben T., et al., 2013, CFHTLenS: the Canada-France-Hawaii Telescope Lensing Survey - imaging data and catalogue products, MNRAS, 433, 2545) focuses on the presentation of the CFHTLenS data set and all the steps necessary to obtain the products required for weak lensing experiments. Such experiments require very specific data processing steps which often tend to be in conflict with a general-purpose data set.

This release was accompanied by three papers recently and, overall, nine papers were published this year using CFHTLenS data. These papers studied a whole range of subjects related to cosmology. Studies of the large scale distribution of dark matter, constraining cosmological parameters, quantifying accurate redshift distributions, determining the environmental dependence of galaxy halo masses and

[2] http://www.phas.ubc.ca/~mikea/Press/2011QF99.html

even testing the laws of gravity. This modified version of the data products of the CFHTLS W1-4 fields will most certainly increase the scientific contribution of CFHT to high redshift studies and cosmology.

A Strange Lonely Planet Without a Host Star

An international team of astronomers including Dr. Michael Liu (Institute for Astronomy, University of Hawaii), Dr. Niall Deacon (Max Planck Institute for Astronomy, Germany), Dr. Katelyn Allers (Bucknell University), Dr. Trent Dupuy (Harvard-Smithsonian Center for Astrophysics), and Michael Kotson and Kimberly Aller (Institute for Astronomy, University of Hawaii) discovered an exotic young planet that is not orbiting a star. This free-floating planet is just 80 light-years away from Earth and has a mass only six times that of Jupiter. The planet formed a mere 12 million years ago - a newborn in terms of planetary lifetimes.

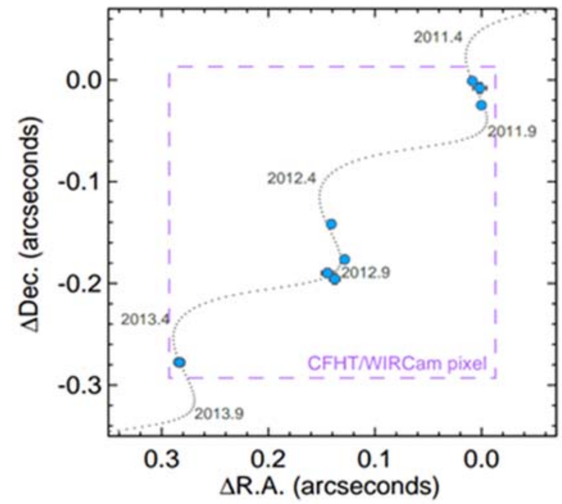


Figure 8 - Proper motion and parallax plot of PSO J318.5-22. The tiny dots are evenly spaced in time showing the predicted motion with the dates of the parallax maximum/minimum labeled. The measurements of the astrometric position are in blue, with error bars. For reference, the dashed purple line shows the size of a WIRCam pixel (~0.3 arcseconds). Credits: Dr. Trent Dupuy, Harvard-Smithsonian Center for Astrophysics.

During the past decade, extrasolar planets have been discovered at an incredible pace, with about a thousand found by indirect methods such as radial velocity wobbling or dimming of their host stars by a transiting planet. However, only a handful of planets have been directly imaged, all of which are around young stars, less than 200 million years old. These planets are hard to study because they are right next to their bright host star. In order to understand the physical properties of these planets, astronomers compare them to cold and low mass brown dwarfs that are isolated and much easier to study. The idea is that the smallest and coldest dwarf stars will have similar properties to those of giant planets. However, efforts to link these two classes of objects together have so far been substantially unsuccessful.

Using the Pan-STARRS1 (PS1) wide-field survey telescope on Haleakala, Maui, an international team of astronomers identified an object with a faint and unique heat signature. Follow-up observations using IRTF, Gemini, UKIRT and CFHT on Maunakea show that it has properties similar to those of gas-giant planets found orbiting young stars. This free-floating planet, dubbed PSO J318.5-22, is just 80 light-years away from Earth and has a mass only six times that of Jupiter. PSO J318.5-22 is one of the lowest-mass free-floating objects known, perhaps the very lowest. But its most unique aspect is its similar mass, color, and energy output to directly imaged planets.

The team performed astrometric monitoring of PSO J318.5-22 obtaining 9 epochs over two years using WIRCam on CFHT. The resulting median astrometric precision per epoch is 4.0 milliarcseconds, a stunningly precise measurement for such a faint, cool object. These measurements are shown in Figure 8. From this, the team was able to make a direct determination of the distance to PSO J318.5-22 and its absolute J band magnitude, essential parameters for this type of study. Also, using the high precision astrometry provided by WIRCam, the team was able to conclude that PSO J318.5-22 belongs to a collection of young stars called the Beta Pictoris moving group that formed about 12 million years ago thus determining the age of PSO J318.5-22. The 2013 discovery paper of PSO J318.5-22 appears in Astrophysical Journal Letters, Volume 777, Issue 2, L20.

Engineering Report

Dome Shutter

The on-going efforts to refurbish the dome shutter drive progressed, although more slowly than planned, mainly as a result of staffing issues and discovery and partial repair of additional mechanical problems. In early 2013 the shutter drive system jammed in an open state for several weeks, triggering an intensive effort to restore basic shutter functionality in the face of winter weather. Nighttime operations continued during this period, impacted marginally by the need to weatherize sensitive equipment inside the dome to protect it from precipitation. By the end of 2013, 7 of the 8 drives were in operation with 3 new speed reducers still to be mounted. In the meantime the sources of episodic noises heard during shutter motion for many years were identified and partially solved. In one case, steel ice 'wipers' (see Figure 9) that surround the shutter rails on either side (and are well hidden) were identified as the culprits and modified. They had been riding in contact with the dome rail and had worn by several millimeters. The reason for the contact appears to be a long-standing problem with the adjustment of lateral constraint rollers. While addressing the lateral roller issue, a problem with some of the shutter panel upper support rollers was identified as another source of episodic operational noises. Replacement of these roller bearing assemblies resolved the immediate problem and led to the decision to replace many (26) of the remaining assemblies as well, given their age and likelihood of failing in a similar manner. Experts from Climb Aloha (Figure 10) also spent two days grinding bevels on shutter rack bolt heads to minimize the potential for previously identified contact between these and the upper roller mount brackets. With the replacement of the rollers completed, work in 2014 will once again focus on refurbishing the remaining drive units, leaving all 8 in excellent mechanical shape, capable of many years of reliable service.

Figure 9 – This close up view of an "ice wiper", deep within the shutter assembly, was found to be in contact with shutter rail, contributing the shutter jamming for several weeks in early 2013.

Figure 10 – Staff from Climb Aloha are seen repelling down the CFHT dome as part of the on-going repairs to the dome shutter drive system.

Dome Venting

All 12 dome vent units were installed on the dome in 2013 by a commercial contractor working closely with CFHT staff, enabling routine remote operation of the dome vents starting in early 2014. On-site work began with the installation of a prototype vent in April which experienced a number of "teething problems" after installation that resulted in jamming of the outer door and several bent door slats. Design problems identified were addressed by the fabricator and were the subject of on-site acceptance tests by CFHT staff in Tucson in early September prior to shipment to Hawaii of the remaining 11 vents. As a result of these changes, the installation schedule slipped to October, but still before winter weather settled in. The removal of insulation panels on the dome inner skin needed for vent installation was completed by CFHT staff prior to the arrival of the vents, as was the installation of cable conduit runs, pulling of electrical cables, installation of control boxes for each vent, and the installation of an upgraded power transformer relocated between the inner and outer dome skins.

The installation of the 11 remaining vent units, followed by upgrades of the prototype unit went very smoothly with no nighttime lost on the sky. Individual units were offloaded at Hale Pohaku and transported to the summit as needed. The contractors maintained the summit site in near pristine condition throughout and were commended by the Office of Mauna Kea Management for their efforts in this regard.

The impact of the use of these vents on delivered image quality will be determined through continued methodic measurements and take 1-2 semesters to evaluate in a statistically meaningful sense.

Telescope Control System Upgrade

The final design review (FDR) for the TCS upgrade was held on April 29. Two external reviewers from W.M. Keck observatory participated in the review. Two sets of new hardware were completed, one installed at the summit while the other remained in Waimea and served as a test bench for the new control system. The new TCS servo system is similar to the present TCS with the new absolute encoders providing feedback for telescope pointing and slewing and incremental encoders used for tracking. Custom software is used to seamlessly switch between these two encoder systems.

New hardware also included a encoders on both axes of the telescope, requiring custom mechanical interfaces (Figure 12). The interface software between the existing TCS IV command processor and the new mount control subsystem (MCS) which is the interface between the i/o computer (IOC) and PMAC controller was nearly complete by the end of the

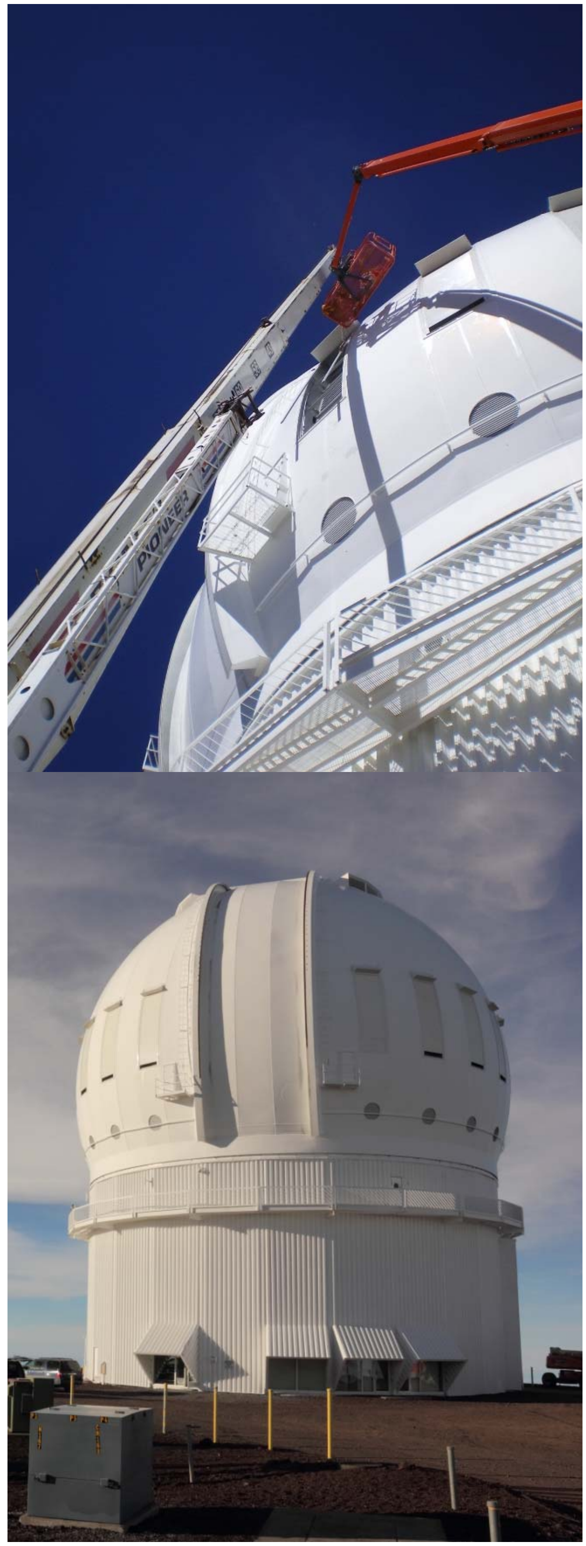


Figure 11: Top" Installation of one of the dome vents, as seen from ground level outside CFHT. Cranes and man lifts were used throughout the process. Bottom: A view from outside CFHT soon after all the new vents were installed.

year. The MCS provides the 20 Hz communication interface, sequencing of commands and feedback to and from the PMAC. The software will be tested on the test bench in Waimea before being deployed to the summit. Tests of the new TCS are anticipated in early 2014, ending a long and complex process to modernize CFHT's TCS, yielding a modern pointing and tracking system that is much more easily maintained with increased reliability.

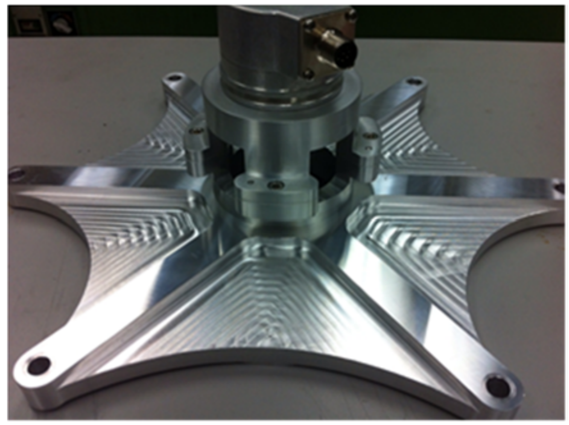


Figure 12 – The TCS upgrade project included several new components, including the encoder mount on the RA axis of the telescope shown here.

Announcement of Opportunity for New Instrumentation

In early 2013 an Announcement of Opportunity (AO) was released by CFHT soliciting proposals to develop new capabilities on a fairly rapid timescale within a $3,000,000 funding envelope. The AO specified that "new capabilities might exist in a variety of forms including upgrades to existing instruments, modest-scale new instruments, or major new instruments that are externally subsidized". A number of proposals were submitted in response to CFHT's AO in August 2013, and were reviewed by a combination of SAC and external referees with expertise unique to the proposals submitted. SAC's recommendation, which was supported by the Observatory, was then discussed and approved by the CFHT Board in October 2013 and has been carried forward by CFHT since. In summary the approved new instrumentation includes –

- CFHT will procure an extensive set of filters for use with SITELLE, to leverage the investment made in this new instrument and to help ensure its scientific success. Approximately $100,000 will be allocated to this effort.
- CFHT will collaboratively develop the high-resolution near-IR spectro-polarimeter SPIRou as a Guest Instrument. Support will be primarily in the form of providing key components with a total value of approximately $2,000,000.
- MegaCam will be upgraded to the extent possible with the remaining funds (approximately $900,000). Nominally this includes only resources for new filters and controller upgrades. CFHT leaves open the possibility of upgrading MegaCam's CCDs with higher performance devices, pending the identification of external funding.

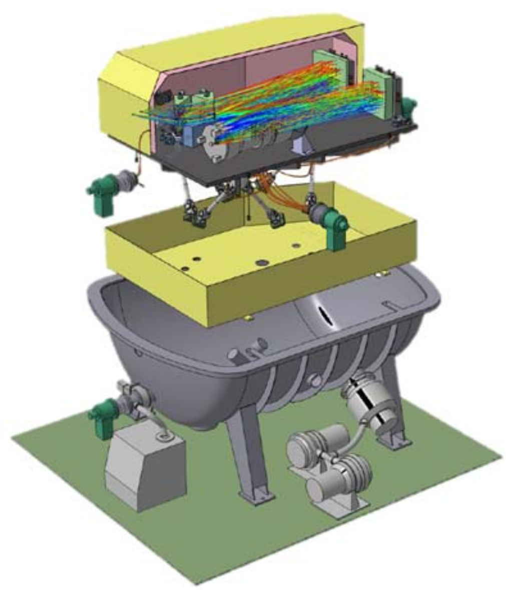


Figure 13 – A CAD rendering of the SPIRou spectrograph is shown. This will be fiber fed and located in the Coude room, next to ESPaDOnS.

This blend of capabilities was selected to maximize the scientific product possible with the funding available, leveraging external resources (e.g., the external funding used for SITELLE and SPIRou) and upgrading CFHT's most popular instrument (MegaCam) in anticipation of it being used for a range of possible applications well into the future.

Since reaching this conclusion from the AO, CFHT has been working with the leads of each of the proposals selected to implement the instrument development activity. For SITELLE and MegaCam, this meant generating technical specifications for desired filters and starting their procurement. Also, internal planned resources at CFHT for 2014 were allocated to upgrading MegaCam's CCD controller. For SPIRou, this meant engaging the SPIRou leads at IRAP/OMP in Toulouse to begin organizing CFHT technical support for the instrument and helping craft the agreements needed to support the final design, construction, commissioning, and operation of SPIRou at CFHT.

SITELLE

A well-attended and productive SITELLE workshop was hosted by U Laval at Wendake, Quebec in May, 2013. One valuable outcome was a prioritized list of narrow-band filters needed for the majority of proposed science programs. In addition the SITELLE beam-splitter was successfully manufactured, achieving the design goals. This was a critical milestone for the instrument as the beam-splitter fabrication was considered the single highest technical risk in the project. The instrument support structure and integration of the optics and CCD cameras was completed at ABB (see Figure). SITELLE's CCD cameras were delivered from CFHT to Université Laval at the end of July. Except for one amplifier with read-noise around 5 e-, the read noise with a 3 second read time and no binning is below 4 e- which meets the instrument requirement. In the case of binning, where a longer sampling time per pixel can be afforded, the read noise is close to 3 e- on all amplifiers. Vacuum and cooling performance are nominal.

Figure 14 – Top: The carbon fiber superstructure of SITELLE is shown in ABB's lab. Middle: CCD camera integration at the Universty of Laval is shown. Bottom: White light interference fringes from SITELLE's beam splitter are evident.

The optics and CCD cameras were integrated and tested at Laval in August and September. The optical image quality of the camera/collimator is as expected. Since an optical simulator to mimic telescope coma was not implemented for the tests, a pinhole grid mounted at the collimator input focus was used so the PSF at the camera focal plane contains significant "negative" coma for the off-axis pinhole images. The aberrated PSF is visually similar to what is modeled in Zemax, but a detailed analysis remains to be completed. All of the FTS components are now at ABB.

Vibrations in the interferometer in the range 8-15 Hz hampered initial interferometer testing. In addition, problems with control of the polarization along the metrology laser optical path were encountered. This problem was solved by ABB allowing work to progress to assessing the dynamic mirror assembly (DA) position control and stability.

By late 2013 the DA showed significant sensitivity to vibrations that correlated with operation of the CCD cooling system – a Joule-Thomson refrigerator made by PolyCold (formerly CryoTiger). The rms jitter specification for the DA is less than 10 nm rms path difference. When CCD cooling was not enabled jitter was measured at 7 nm rms, but spiked to over 80 nm with CCD cooling turned on, despite the fact that the CCD camera vibration requirement of less than 10 mg had successfully been demonstrated prior to delivery of the detector systems.

The over sensitivity of the DA to vibrations was hinted at during ABB's earlier tests and has been the subject of considerable analysis and rework to resolve the problem. This included changing the DA assembly drive mechanics to increase their overall stiffness by a factor of ~100, without significantly reducing the DA's dynamic range. In addition work was launched to stiffen the beam splitter support system. The outcome of these improvements in the interferometer's vibration sensitivity will be determined in 2014. Other key pre-shipment tests planned in 2014 include flexure and cold tests.

Implementation of an astrometric solution for SITELLE images similar to that used for WIRCAM will allow accurate target pointing which is required since we expect that many scans will be taken in a piece-meal fashion, often over several nights. To accommodate this, the SITELLE-specific version of the U Laval data reduction pipeline, ORBS, is being developed, while its SpIOMM version is already installed at CFHT and is working well. The real-time pipeline is currently being written at U Laval, as is work on an Exposure Time Calculator (ETC) a version of which has been delivered to CFHT. More testing is planned. A datacube-level SITELLE simulator has also been written at Laval but is currently not scalable to our ETC.

A draft On-Sky commissioning plan document is coming along and a final list of tests will be completed shortly for review at CFHT and U Laval, while the Phase 2 tools have been created but need to have the ETC webapp completed. Finally, work on preparing the storage area for the instrument at CFHT began in September and design work on the 4th floor lab needed for the CCD chiller compressors and cooling line routing on the telescope has begun. Overall, between work at ABB, Laval, and CFHT, good progress was made in 2013 on SITELLE in advance of its anticipated arrival in Hawaii in 2014.

GRACES – Phase 1

The development of GRACES, an experimental fiber link between Gemini-N and ESPaDOnS, continued throughout 2013. The main challenges were in the fabrication of the fiber cable and image slicer. Initial tests by FiberTech, the company manufacturing the fiber system, showed unacceptably high focal ratio degradation (FRD). NRC-Herzberg worked closely with FiberTech so that they can now reliably produce a fiber (not bonded into the termination) with an FRD <5%, well within the required range for GRACES. This was an important milestone in the development of the system and when reached, FiberTech moved on to

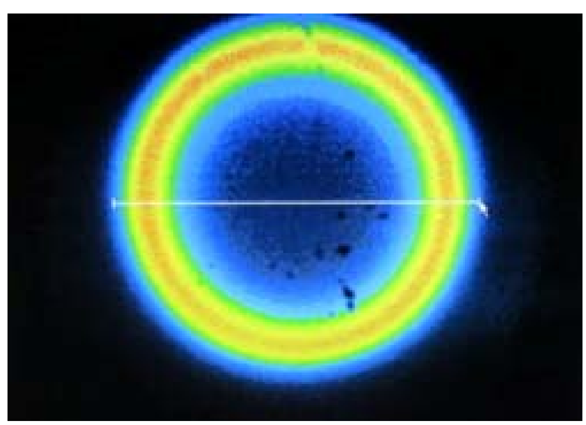


Figure 15 – An image made at the exit pupil of a test fiber as part of the extensive tests conducted to minimize FRD in the fiber system.

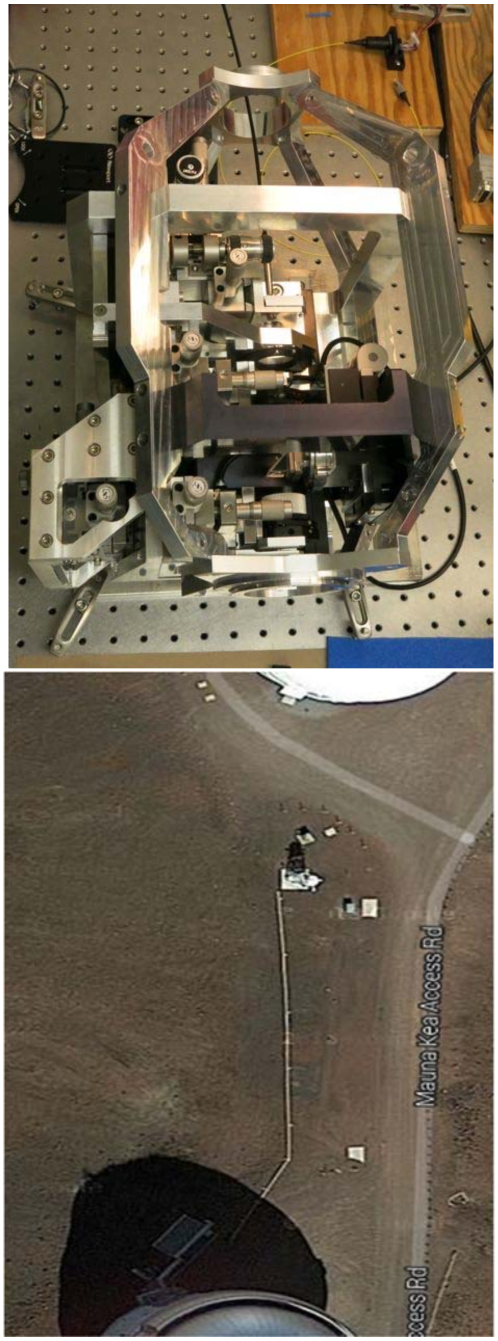


Figure 16 – Top: The GRACES fiber injection unit, which is destined to be installed in ESPaDOnS, is seen here in the lab at NRC-Herzberg, Victoria. Below: This Google satellite image of the summit of Maunakea shows CFHT at the top and Gemini at the bottom with the conduit between these observatories seen running nearly the entire distance above ground. This conduit will house the GRACES fiber.

investigating ways of bonding the fibers to the terminations and installing them within a flexible armor conduit suitable for the link between CFHT and Gemini-N. FiberTech settled upon an armor type with low interior friction and successfully pulled a 200 m fiber through it achieving a focal-ratio degradation of ~15%, still within the tolerance of 20%. By the end of 2013 most of the most risks with manufacturing the fiber system were retired as part of excellent progress in the generation of the final 270 m long fibers anticipated in early 2014.

In parallel the image slicer was been delivered from the fabricator to NRC-Herzberg, where it was demonstrated to yield good performance. Likewise, the slicer bench was completed at NRC-Herzberg (see Figure 16) and good progress was made at CFHT and Gemini with the installation of fiber trays for routing the fiber within these facilities. In December 2013 a test pull was completed, using a miniature camera, through the conduit that connects CFHT and Gemini-N on the upper ridge of Mauna Kea.

The high-level software for controlling the GRACES instrument is being written by CFHT since all controlled devices are contained within ESPaDOnS (the Gemini end of GRACES is a passive component that goes into the GMOS instrument). The interface software to Gemini is complete, as is the high-level control system. What remains is the detailed control of the 4 active slicer bench controls. This software is currently under development using ESPaDOnS devices as substitutes for the eventual GRACES devices since the GRACES hardware is not available locally yet. This will, hopefully, mean a short development time for the high-level software once the hardware gets to Hawaii.

Much anticipated on-sky tests for GRACES are planned in 2014. A decision to further develop the system into a fully supported instrument available to Gemini depends on the measured performance during these Phase 1 tests in the project. The system will deliver two spectral resolutions, between 30,000 and 34,000 in the dual fiber “star plus sky” mode, and a resolution of 50,000 to 55,000 in star-only mode. At red wavelengths (600 nm), where silica fiber transmission is high, models indicate a sensitivity comparable to competing high-resolution optical spectrometers but given the novel nature of this hybrid system, only on-sky tests can confidently determine the scientific utility of this system.

Administration Report

Summary of 2013 Finances

The three Member Agencies supported the CFHT annual budget in 2013 as shown in the table at the right, in US funds. These contributions reflect a 3.2% increase in 2013 over the prior year. Under collaborative agreements with CFHT, the Academia Sinica Institute of Astronomy and Astrophysics of Taiwan, the Brazilian Ministry Science, Technology and Innovation, the National Astronomical Observatory of China, and the Korean Astronomy and Space Science Institute remitted $250,000, 330,250, 629,583 and $154,250, respectively, as reimbursement for costs associated with its use of the Corporation's facilities. Other sources of funds included $12,518 from mid-level facility use credits, $18,097 from distribution of educational materials, $24,151 in staffing cost reimbursements related to work done for other Mauna Kea facilities, and $10,033 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, 2013 expenditures were allocated to the areas listed above in Table 2. Overall, resources from all CFHT funds were allocated to the categories of expenditures shown on the pie chart on the left.

Operating Fund Expenditures (US$)	
Observatory facilities and operations	598,362
Base facilities and operations	672,444
Instrumentation	79,769
Science	86,960
Outreach	26,680
General administrative expenses	440,683
Staffing	5,117,002
Transfer to Reserve	145,000
Total	7,166,900

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

Administrative Activities

CFHT led three conferences during 2013, including the ngCFHT Workshop in Hilo, the CFHT Users' Meeting in Campbell River, BC, and the 23rd Astronomical Data Analysis Software and Systems (ADASS) conference in Waikoloa. The number of participants approximated 100, 100 and 230, respectively.

The Admin Group implemented a new documentation management system, PaperSave. This software provides for an electronic workflow for approvals of purchase orders and invoices and eliminates countless hours of paper pushing, filing and future shredding of the documents. After all approvals are obtained, the documents are electronically saved to the specific invoice or purchase order record in the accounting system, thus eliminating the physical space used to store accounting records.

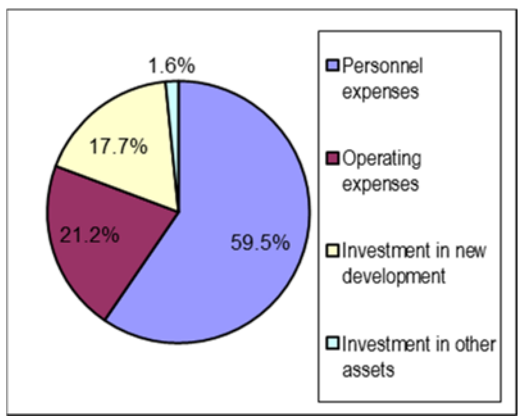


Figure 17 – The high-level distribution of expenditures across the entire observatory is plotted.

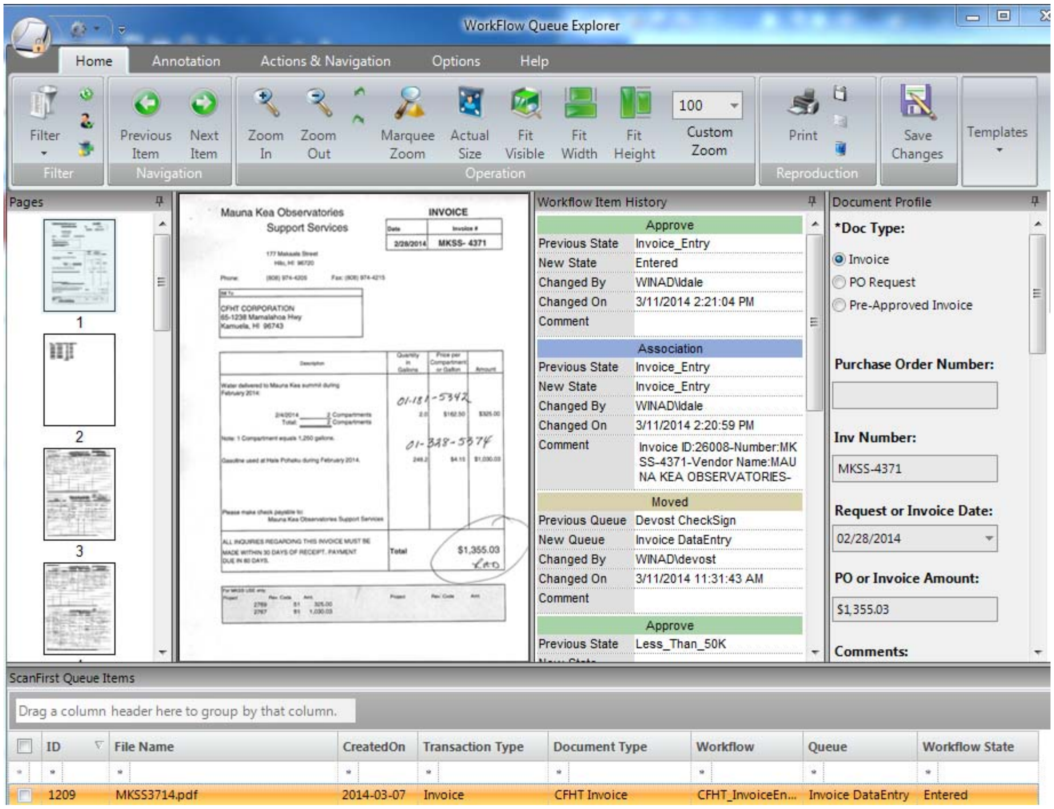


Figure 18 – A screen shot from the new PaperSave software is shown. PaperSave supports invoice management through a variety of electronic interfaces to a central database established in Waimea.

Staff Safety

Staff safety continues to be a high priority and we had no injuries, illnesses or lost work days in 2013 as shown in the Table 3. Some of the safety efforts undertaken during the year include:

- The development of specialized safety training for the Dome Venting project involving ~20 contractor employees working at the Observatory.
- An analysis and upgrade of a controlled descent device to allow an escape for individuals working on the top of the dome crane.
- Training on the new OSHA regulations for hazardous material communication, the Globally Harmonized System.

We were especially fortunate not to have any injuries during the year even though we suffered a flood of ~1200 gallons of water in the Observatory resulting from the bursting of a frozen pipe, a small fire in the second floor electrical vault, and a ruptured hydraulic line.

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

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

Building Renovations

The project started last year to remove the “legacy” orange ceiling grates to open up our vaulted ceilings was completed by Roger Wood and Joe Fehly. The upper windows were beautifully framed and custom valences for lights were added. In addition, a collection of photos of Maunakea taken by Jean-Charles

Cuillandre were printed and mounted on the walls. With this renovation, not only are the hall spaces more beautiful, we are now taking advantage of the natural light offered by pre-existing windows around the building.

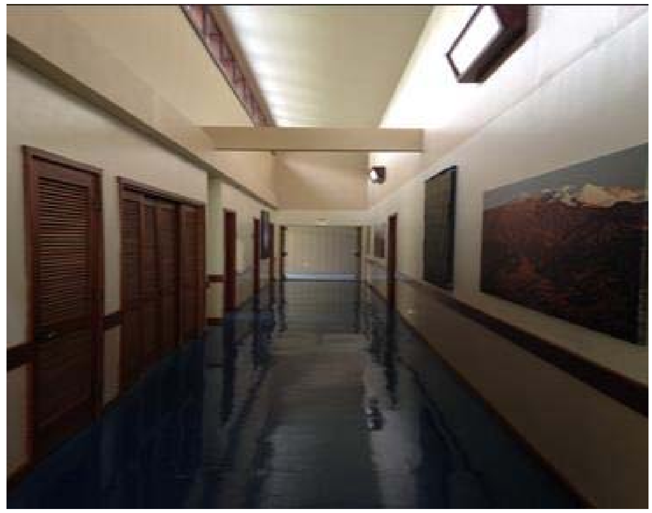


Figure 19 – The interior of the Waimea office got a major facelift by opening the vaulted ceilings, letting in much more natural lighting. New high-efficiency LED light fixtures are now used throughout the building.

Another major upgrade includes the installation of a photovoltaic system on the headquarters building roof. The system was designed to offset ~40% of the energy used in CFHT's Waimea headquarters and was financed through a bank loan that will be paid down by directing funds that would normally go to the utility company to instead make loan payments in a cash-flow neutral manner. Factoring in a 24.5% Hawaii state tax rebate, the time to recover the initial costs of the system will be ~5 years, after which CFHT will experience significantly reduced energy costs. CFHT was the first Maunakea observatory to install solar power, but is certainly not doing so in isolation as the solar power industry in Hawaii is expanding rapidly, providing commercial, county, state, and residential clients with ~250 MW of power annually. In 2012 alone nearly a half billion dollars was invested in solar power projects in Hawaii and, on a per-capita basis, Hawaii is among the top US states. CFHT's solar power initiative was therefore well timed to take advantage of this rapidly expanding industry.

Along the same lines CFHT replaced most of the conventional fluorescent lamps used throughout the offices and hallways with efficient LED lamps. The modern LED lamps with very similar form factors will pay for themselves through reduced energy bills in <1 year, the initial cost of which will be significantly offset by rebates from the local power company. In addition the consolidation of computer systems on newer, more efficient systems is also steadily lowering electric consumption. Next year we expect to use passive cooling for the Waimea based computer room, taking advantage of Waimea's relatively cool climate and using air conditioning only as a backup. Through all of these techniques, ranging from more efficient use of natural lighting, to switching to more efficient artificial light sources, to the generation of a significant fraction of our office power needs through the conversion of light to electricity, CFHT continues to tackle cost challenges through innovation.

The Personal Touch

In 2013, we bid farewell to nine people and welcomed three new staff members. Retirements accounted for the loss of nearly a century of combined service to CFHT by several longstanding members of the CFHT 'ohana. First, we pay tribute to those who left CFHT in 2013, then wish a fond aloha to the new members of our staff.

Farewell

Moani Akana

Moani retired from her position of Administrative Specialist in November 2013 after 26 years of service to CFHT. Although Moani has retired from employment, she will continue to be involved in a variety of community and cultural events, as she has done in the past years. An important and much appreciated contribution from Moani to the CFHT ’ohana was the exposure to the Hawaiian culture she shared with the entire staff. Moani helped the staff appreciate its history, depth, and richness, leading to a better work/life experience for everyone at CFHT. Moani will remain a resident of Waimea and will doubtless continue her association with CFHT through various outreach events.

Stéphane Arnouts

Stéphane went back to France in September 2013 after being with CFHT for more than 7 years. He returned to his home institution in Marseille with his wife and two children. He brought to CFHT an extensive knowledge in image stacking, photometric calibration and redshift determination. Stéphane had several outside collaborators and developed Lephare, a fortran code that computes photometric redshifts and performs SED fitting. He also provided his skills to the operation of CFHT’s wide-field imagers and the development and operation of the WIRCam reduction pipeline.

Bill Cruise

After 35 years of dedicated service , Bill decided to retire at the end of 2013. He accomplished much during his tenure at CFHT. He started in the early days and helped nurture the telescope and facilities through their growing pains. He worked on many different projects and headed up a couple of departments but in the latter half of his career, he mainly focused on maintaining and upgrading the telescope control system (TCS). Bill will remain on the Big Island and plans to spend his retirement traveling the world and riding his motorcycle.

Olivier Lai

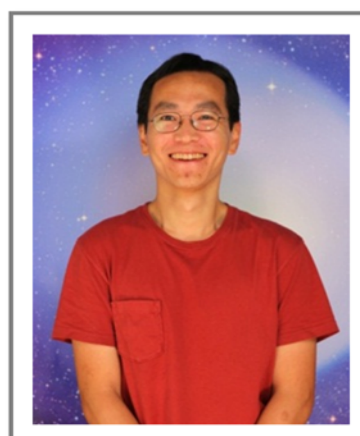
When Olivier arrived at CFHT in October 1999, he was already familiar with our observatory, having spent some time here during his PhD thesis. Olivier brought the adaptive optics expertise he had gained during his thesis and post-doc stay at the W. M. Keck Observatory, and continued his work on high resolution astronomy, adaptive optics and interferometry. His inquisitiveness and creativity showed up in the instrumentation projects (and their clever acronyms!) he contributed to, and was also revealed in pieces of visual art that were either integrated in his presentations or exhibited during special events.

Eder Martioli

Eder was CFHT's first Brazilian Resident Astronomer, and stayed with us for a little over 2 years. His relatively short stay did not prevent him from getting involved with classical and queue support for WIRCam, ESPaDOnS, and AOB, and projects such as GRACES, an instrument project between CFHT and Gemini Observatory. His enthusiasm for astronomy also went beyond research and instrumentation, and brought him to participate in science fairs, school visits, star parties, and tours of our facility. One of his major accomplishments while at CFHT was the scientific development of OPERA, which is an open-source software package to reduce spectro-polarimetric ESPaDOnS data.

Tien Nguyen

After one year with CFHT as a system administrator Tien Nyugen has returned to Seattle to be closer to his family. During his relatively short time at CFHT Tien managed to make several helpful contributions including a major consolidation of server systems to retire over a dozen aging computers, thereby simplifying support and reducing wasted electricity. He also started a project to evaluate new technologies for data storage and network monitoring. He was well liked by the CFHT staff and we wish him well on his future endeavors.



Ralph Taroma

Our long time Observatory Facility Manager, Ralph Taroma, left CFHT at the end of 2013. Ralph first joined the CFHT summit crew in 1985 as a Machinist / Millwright. He was promoted to Observatory Crew Foreman in 1999 and then to Observatory Facilities Manager in 2005. Throughout his 30 years with CFHT Ralph was known for his attention to detail and his can-do attitude. He was generally first-on-scene when facilities-related issues arose, no matter the time of day or the day of the week and earned the respect of all the CFHT staff for the obvious pride he took in keeping the observatory running in tip-top shape. Although he was unable to attend the event, the staff had a chance to toast Ralph's many years of service to CFHT at a farewell party held in honor of his and others' contributions to the observatory.

Karun Thanjavur

Karun left CFHT at the end of January 2013, almost three years after he joined CFHT in April 2010 as a Canadian Resident Astronomer. Karun was very versatile and was involved in several aspects of observatory work. He was the WIRCam Instrument Scientist and provided PI as well as in-house support for all WIRCam science issues. He also actively participated in queue coordination and other QSO duties while pursuing his science interests, with research spanning a variety of astrophysical areas extending from the early Universe to the dynamics of globular clusters and high velocity clouds in the Milky Way. Finally, Karun also performed engineering work on the observatory mechanical systems.

Christian Veillet

Christian Veillet arrived at CFHT in September 1996 from his home institution of Observatoire de la Côte d'Azur in Grasse, France, where he held the position of astronomer. In his 17 years of service to CFHT, Christian's passion and ambitiousness took him through 3 positions at CFHT: resident astronomer, Senior Resident Astronomer and ultimately, for 9 years, Executive Director of CFHT. His accomplishments as leader of CFHT were numerous, and the observatory advanced successfully through a line of new instrumentation and modes of observation during Christian's tenure. Christian moved in 2013 to Tucson, Arizona, where he began his latest adventure as Director of The Large Binocular Telescope (LBT), another international observatory that will doubtless benefit from his considerable talents, vision, and expertise.

Welcome

Pascal Fouque

Pascal Fouqué joined the astronomy group at CFHT in December 2013 as a WIRCam instrument scientist. Prior to CFHT, Pascal worked at the University of Toulouse since 2004, and previously in Chile at the La Silla Observatory for 14 years. Pascal's main scientific interests are exoplanets, Cepheids, and the extragalactic distance scale, using optical, infrared and radio-astronomy. Apart from astrophysics, Pascal is a bridge player and entertains himself looking for his roots as a genealogist. Pascal will be joined by his wife, Julia, who is a psychologist. They both hope that this new life in Hawaii will be full of new discoveries. Their three children are living in Spain and France.

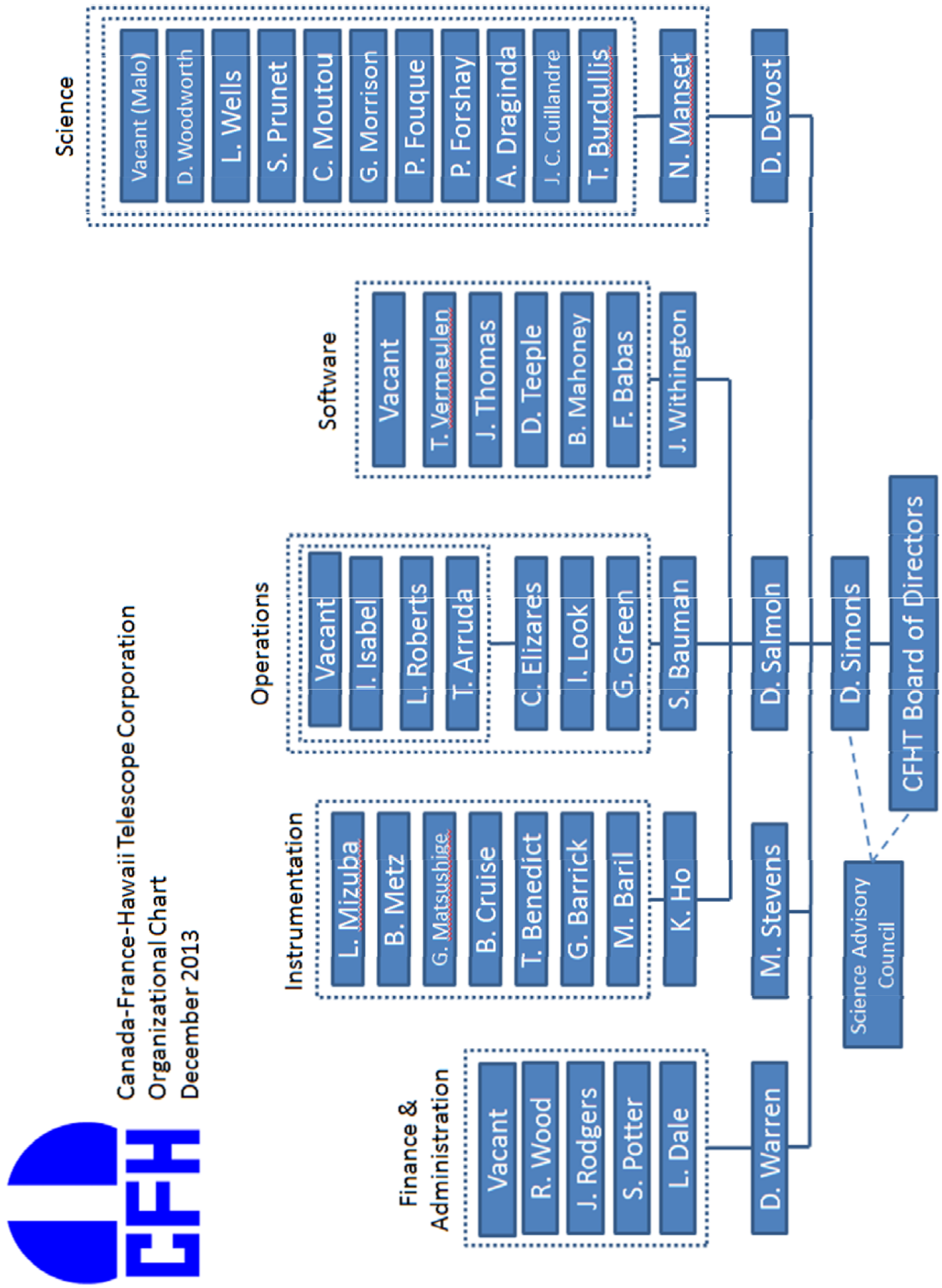
Claire Moutou

Claire Moutou arrived at CFHT in September 2013 as a resident astronomer. Prior to joining CFHT, Claire got her PhD in Astrophysics at Paris University in 1996, and then worked for the European Southern Observatory, both in Paranal and Headquarters. In 2001, she was employed by CNRS and worked for 12 years at Laboratoire d'Astrophysique de Marseille, where she participated in observational studies of extrasolar planets and the construction and operation of ground-based and space-based projects including SPHERE, SOPHIE and CoRoT. She is also a non-frequent, but long-term user of CFHT instruments. Claire likes hiking, playing music and traveling, together with her husband Robert, and their daughter, Romane.

Simon Prunet

Simon Prunet arrived at CFHT in September 2013 as the new MegaCam instrument scientist. Simon came to CFHT from the Institut d'Astrophysique de Paris where he worked since 2001, and before that he was a research associate at the Canadian Institute of Theoretical Astrophysics. He has been involved in different Cosmic Microwave Background experiments (Boomerang, Archeops, CBI, Planck), developing data processing techniques for cosmological applications. Simon likes hiking and sunbathing, both activities happily shared with his wife Suzana and their son Vincent.

Organization Chart



Staff List

Name	Position	Name	Position
Arruda, Tyson	Mechanical Technician	**Matsushige, Grant**	Sr. Instrument Specialist
Babas, Ferdinand	System Administrator	**Metz, Brandon**	Instrument Engineer
Baril, Marc	Instrument Engineer	**Mizuba, Les**	Instrument Specialist
Barrick, Gregory	Optical Engineer	**Morrison, Glenn**	Resident Astronomer
Bauman, Steven	Operations Mgr/Mechanical Eng	**Moutou, Claire**	Resident Astronomer
Benedict, Tom	Instrument Specialist	**Potter, Sharon**	Safety Specialist
Burdullis, Todd	QSO Operations Specialist	**Prunet, Simon**	Resident Astronomer
Cuillandre, Jean-Charles	Staff Astronomer	**Roberts, Larry**	Electrician
Dale, Laurie	Administrative Specialist	**Rodgers, Jane**	Finance Manager
Devost, Daniel	Director of Science Operations	**Salmon, Derrick**	Director of Engineering
Draginda, Adam	Remote Observer	**Simons, Doug**	Executive Director
Elizares, Casey	Summit Operations Manager	**Stevens, Mercédes**	Assistant to the Exec Director
Forshay, Peter	Remote Observer	**Teeple, Doug**	System Programmer
Fouque, Pascal	Resident Astronomer	**Thomas, Jim**	Computer Software Engineer
Green, Greg	Mech Designer/Instrument Maker	**Vermeulen, Tom**	System Programmer
Ho, Kevin	Instrument Manager	**Warren, DeeDee**	Director of Finance & Administration
Isabel, Ilima	Custodian	**Wells, Lisa**	Remote Observer
Look, Ivan	Mechanical Design Engineer	**Withington, Kanoa**	Software Manager
Mahoney, Billy	Database Specialist	**Wood, Roger**	Automotive Mechanic
Manset, Nadine	Resident Astronomer	**Woodworth, David**	Remote Observer

Outreach Report

CFHT's outreach activities were in full force throughout 2013, with many on the staff participating in a variety of outreach events for the local community and visiting students. Photos shown here captured activity at many of these events, which included –

- Judging at the Paauilo, Hawaii Preparatory Academy, Waimea Country School and Hilo School System science fairs
- Staffing a booth at the Astronaut Ellison Onizuka Day event at UH-Hilo
- Staffing a booth at the annual AstroDay at Prince Kuhio Mall in Hilo
- Participating in the GEMS (Girls Exploring Math and Science) program
- Engaging prospective students for the University of Hawaii graduate astronomy program and graduate students from Queens University
- Participating in the annual Journey Through the Universe program, which reaches ~7000 Big Island K-12 students each year
- Several public presentations at Imiloa Astronomy Center
- Star gazing at Honoka'a school, Waikoloa (ADASS), and at the CFHT headquarters
- Skype sessions with schools in Edmonton Canada
- Hosting Akamai interns at CFHT
- Hosting (along with Keck) the West Hawaii Astronomy Club meetings every other month

The diversity of these activities is an indication of eagerness with which many on CFHT's staff have to interact with the public through outreach events. It is linked to a number of local workforce development programs CFHT has supported which nurture employment opportunities for members of the local community in the Mauna Kea Observatories. This includes providing guidance to UH-Hilo as they develop engineering programs tailored to the needs of the Mauna Kea Observatories, supporting internships for local students, and informing at every opportunity the community that observatory staffs require a wide range of expertise and most positions do not require advanced degrees or involve independent research.

Figure 20 – CFHT participated in the 2013 annual Ellison Onizuka Day at the UH-Hilo campus (left) and AstroDay at Hilo's Prince Kuhio Mall (right).

Given the strategic importance of public outreach for observatories, need for it particularly in West Hawaii, and strong support already present at CFHT for outreach, the decision was made late in 2013 to recruit a first-ever outreach program manager (OPM) for CFHT. This position will be filled in 2014 and the new OPM will take the lead in launching various strategic outreach initiatives in West Hawaii, while working closely with the East Hawaii based observatories outreach programs, which are already well established. The OPM will also be tasked with engaging outreach opportunities in CFHT's partner countries, to help increase CFHT's visibility while stimulating international outreach program collaborations, along the lines of what has been done for years scientifically and technically.

Figure 21 – The featured outreach event during the third quarter of 2013 was a CFHT organized star party at Kohala Elementary school in June. Kanoa Withington (upper left), Lisa Wells (lower left) and David Woodworth (upper right) are shown engaging the keiki at this fun filled event. Pictured in the lower right is Tanis Mercer, a summer intern majoring in science communications who received course credit while participating in and supporting a wide range of outreach projects.

2013 Publications

2013 Publications Including CFHT Data

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