1.1 CFHTLS Steering Group Overview: March 2005

Summary

The CFHTLS has now demonstrated that all components of the survey can meet their science goals within the full allocation of telescope time. In a number of respects the CFHTLS is already more successful than hoped and is of widespread interest in Canada, France and the world. The primary issue is that the actual CFHT observing time has only risen to 70% of its initial allocated rate in 04B, thanks to the concerted effort on the part of CFHT and the 4+4 extra nights added by the Canadian and French agencies. Anything less than 70% requires a de-scoping of the survey. The shortfall relative to expectations (perhaps unrealistic in hindsight) has a significant impact on data uniformity, survey efficiency, community support, and timeliness of completion. Something must change if the survey is to meet the high expectations for success of its many supporters. The steering group unanimously requests that the SAC and Board use the proposals and recommendations in this report to set clear priorities between the competing observational needs and provide a time allocation that allows the prioritized science to succeed. The current mandate of "equal priorities" with inadequate observing time is unworkable.

Therefore, the main survey decisions are to:

- Confirm or reset remaining time allocations to each survey component,
- Set priorities for each component of the survey (we propose the SNLS time sampling first, the g' very wide second, and the wide filter plan as laid out in the table below), and,
- Confirm that the SG manages the allocation to ensure that the primary science goals are achieved in a timely fashion, along with the legacy value over the lifetime of the survey.

To realistically implement the survey decisions time must be made, whether or not to:

- Increase the "4+4" of extra nights from Canada and France that provide the minimum of 240 hours of 2004B to significantly increase the 70% of allocation data rate.
- Guarantee a minimum allocation of 240 hours per semester,
- Extend the survey to 2010A,
- Grant the approximately extra 60 hours of "queue extender" in each of the 05B, 06B, 07B to implement the proposed "super-z" survey (Deep/SNLS), and,
- Consider whether MOS runs should be allowed to "break" MegaPrime runs.

If anything less than the 70% target data rate is awarded, it will be crucial to indicate where the survey should be cut back with clear priorities for the remainder.

1. Science Drivers and Background of the Survey

The development of the Megacam imager led to discussion of possible community-wide surveys throughout the CFHT community. The discussions fairly quickly converged on three primary goals:

- The cosmic equation of state, through supernova distance measurements,
- The dark matter power spectrum and cosmological parameters though weak lensing measurements spanning the linear to non-linear regimes, and,

- The dynamical history of the solar system through dynamics of the Kuiper Belt Objects (KBOs) of the outer solar system.

These science goals were combined with the concept that the survey should be a uniform, high quality dataset that would be valuable for additional science and unforeseen science through its "legacy value".

Meetings in Canada and France strongly advised the proponents that the survey data requirements should be broadened to include large, uniform imaging in multiple filters with time sampling to allow galactic structure and other "legacy" studies to be carried out with the data. The resulting Megacam Survey Working Group report requested 550 nights of 6.5 hours integration time distributed over 5 years to acquire the data. After review, the Very Wide component was reduced in scope by a factor of two. The resulting request was for 500 nights of 6.5 hours open shutter time. The CFHT Board provided an on-sky observing allocation of 3081 hrs (474 nights of 6.5 hours over 5 years), with 2925 hours at 0.9" or better median image quality, and 156 hours at reduced image quality to allow time critical observations to succeed. This modest de-scope was viewed by the Steering Group as undesirable but acceptable. The allocation implies a decrease in signal-to-noise of the eventual measurements of 10-20% from the initial goals.

2. Successes of the Survey

First, the CFHTLS Steering Group acknowledges the major effort that CFHT has devoted to commissioning the MegaPrime system. The support has involved training observers, resolving image quality issues, ensuring that real time and Elixir processing data is available and ultimately the timely transport of the data to CADC where users and TERAPIX are able to quickly retrieve it. The legacy survey sets demanding requirements for CFHT, which CFHT staff have gone beyond the call of duty to creatively achieve.

All three components have now demonstrated that the initial time requests were accurate. The data to meet the quantitative science goals can be achieved within the Board allocation to the survey.

- The supernova survey finds the anticipated number of supernova and has acquired the necessary 8m class telescope time to ensure adequate follow-up. In fact, the 8m class time (currently 60 hours Gemini, 60 hour VLT and 4-8 nights of Keck spectroscopic time and ~8 nights Magellan IR imaging) exceeds the approximately 110 hours of CFHT time obtained each semester. The anticipated precision of the "*w*" measurement is 0.07, sufficient to rule out a range of theories that have been proposed. A preliminary Hubble plot and derived Ω_M - Ω_Λ - *w* constraints have been produced for inclusion in a forthcoming publication.
- The wide survey has demonstrated that the image quality and error control is sufficient that the survey can eliminate the non-physical B-mode to the expected level of precision; now extending to angles up to 2 degrees spanning nonlinear and linear scales which will provide "*w*" constraints that complement the supernovae. Two papers will be submitted in the next few months.
- The very wide survey has shown that it can measure orbits with satisfactory precision that dynamical "islands" of relatively long-lived orbits will be able to be identified. Already the unbiased and well characterized nature of the survey is revealing new structures in the overall distribution of Kuiper belt object orbits. The first results of the LS-VW pre-survey will soon be submitted for publication.

- The use of the survey to measure photometric redshifts for galaxy evolution, to identify stars in the galactic halo (a paper will be submitted soon), to find clusters of galaxies, to find strong lensing arcs and to attract the interest of other surveys is now getting underway as stacked images have become available to users in the Canadian and French communities. The deep survey has laid the basis for WIRCam follow-up.

3. Issues and Concerns

The overwhelming issue facing the survey is that the allocated time is not being realized in observational data. Observational efficiency has improved substantially over the last three semesters with the survey now running at about 70% of the allocation. This is comparable to the 67% completion of B programs. *That is, the CFHTLS, which was conceived as a set of complementary units, has a completeness rate comparable to or lower than C-F-H-K-T agencies B programs.* These B programs are meant only as secondary priorities to the allocated A programs which are guaranteed an almost 100% completion level by CFHT's service observing: the full completion level we assumed would be achieved for the CFHTLS, based on the initial definition of the time allocation. The situation is summarized in Table 1 below. As noted in the CFHT report, the weather has been unusually poor and the camera had problems during 04A.

The supernova and Kuiper belt work require carefully timed observations. Once a field is started it must continue to be observed otherwise supernovae and KBO's are "scientifically lost" due to poor quality light curves or orbits, respectively. The wide survey has only weak time constraints, which means that it has often been sacrificed in order to allow the time critical observations to be done.

Semester	03B	04A	04B
Number of QSO nights [a]	104.0	118.0	116.0
Total Validated Exposure Time (hrs) [a]	340.0	282.0	500.4
Queue Efficiency (hrs/night) [b]	3.3	2.4	4.3
CFHTLS Validated (hrs) [c]	158.5	122.4	247.0
CFHTLS Allocated fraction [d]	45.0%	44.0%	50.3%
CFHTLS Validated fraction [e]	46.6%	43.4%	49.4%

Table 1: The queue efficiency of the CFHTLS Wide per semester.
Notes:
a: from http://www.cfht.hawaii.edu/Instruments/Queue/2004a_report.html
b: equal (3) / (2)
c: from CFHTLS-Deep.log, CFHTLS-Wide.log and CFHTLS-VeryWide.log available at http://www.cfht.hawaii.edu/Science/CFHTLS-DATA/exposureslogs.html
d: from http://www.cfht.hawaii.edu/Instruments/Queue/statistics/

Some further improvement in overall efficiency is expected as auto-focus becomes operational (up to 40 minutes in a 360 minute open-shutter night, hence 10-12%). At the same time there is a risk that the camera will fail as the instrument ages and requires more attention to preventive maintenance.

The quality of the science returns declines much more quickly than a naïve "square root of the amount of the data" approach. For instance, if the data rate had remained at about 50% of the allocation, as in January-June 2003, the survey would not have been worth continuing. That is, no element of the survey was collecting data with adequate sampling rate or filter coverage to be distinctive relative to competing work, often competing for the same follow-up resources. The rise to 70% has preserved the basic competitive position of the survey. But, doing the same science over a longer time simply increases costs and diminishes impact. A number of important decisions must be made.

4. Ensuring Success

The following actions should allow the survey to completely succeed and create a high quality dataset with legacy value.

- Increase the current allocation of an additional 8 nights (4 Canada, 4 France) to the LS queue. Experience indicates that 8 nights lead to about 240 hours of "phase 2" time (220 hours on sky) time per semester, which is below the minimum we need. Table1 shows that the allocation needed is about 320 hours per semester.
- Extend the survey to end 2010A (except SNLS – see below). At the end of 05A the survey will have about 640 hours in hand. The allocation (474 nights of 6.5 hours) was 3080 hours. From 05B to 10A there are 10 semesters which will have about the minimum requested of 240 hours each, raising the total time observed to at least 3000 hours.
- At the same time, ramp-down the supernova survey after 2008A, terminating with the D1 field in 08B along with a guarantee that it will have highest observing priority on the nights when fields need to be observed as in the plan proposed above. The "timed priority" is currently the policy of the Steering Group and works well.
- Once the SNLS is completed, ramp-up the Wide and Very Wide surveys, keeping the survey allocation time to 240 hours and complete the other survey components as fast as possible.
- The proposed deep "super-z" plan adds a night of z' at the beginning and end of a queue run to improve cosmological constraints through improved control of dust extinction, improve the constraints on variable *w*, deepens the important z' filter for both stellar and distant galaxy studies, and complement the deep WIRCam observations of widespread interest in France and Canada. The CCD QE defines the z' filter red end, and has turned out to be a little less sensitive than hoped during the survey design. The extra time will restore the original, better balanced, depth.
- Guarantee 17 night (or longer) MegaPrime queue runs up to and including 2008B. Shorter runs greatly diminish the supernova light curve quality. If the observing efficiency rises, it will allow all programs to be done more quickly.

- A MOS run in the middle of a "field season" severely degrades the value of light curve data in months before and after. (Should the MOS be decommissioned now that far superior MOS instruments are available on 8m telescopes?)
- The Very Wide investigated two scenarios to preserve a large sky coverage while still doing good progress in i-band observations (see Table 3 of the Very Wide report). It proposes to acquire the necessary time constrained observations in g' and r' while achieving the desired i' coverage in the B-queue in non time-constrained mode. This means that g' data can be obtained at approximately the planned rate with about 1/3 of the time in this highly demanding, carefully timed program. Proper motion observations will be left to the end of the survey, which will increase their precision. The current approach of non-g' follow-up costs more time and increases risk that the timing will be missed if weather or other problems intervene.
- The Wide survey filters will be prioritized as shown in the Wide report. Three strategies have been discussed, the "best scenario" is summarized in the plan. The prioritized approach will maximize the science return with time through having large contiguous areas available quickly, ease the complications of multi-filter data processing, and reduce the number of filter changes at the telescope.

5. Proposed Plans

We show below two plans, one assuming that we carry on at rate of about 320 hours per semester (about 260 in A, 60 in B), the second in which we are allocated extra time to allow extra depth in the z' filter of the deep fields which improves all science and opens up an opportunity to provide a "variable *w*" constraint. B queue observations will be executed whenever possible as the survey progresses, with all completed in the last several semesters of the survey. These times include the 40 second "readout charge". The open shutter time is about 10% less on the average.

The "standard plan" can be accommodated within the current allocation rate of an average of 320 hours per semester. The priorities are as follows:

1. time critical supernova observations when needed (every 4 nights per active field),
2. time critical very wide g' and r' observations,
3. a guarantee of 65 hours per semester for the wide survey until the end of SNLS, then at least 100hrs will be guaranteed to complete the wide survey as fast as possible,
4. any time critical observations missed due to weather or other problems are "lost" and placed in the B queues for execution to balance filters,
5. wide survey, in the filter prioritized order,
6. all A queue observations will be executed before any B queue,

The super-z plan uses the same scheme but adds one element: the first and last night of a 18 night or longer queue run will be entirely used for z' imaging, which can be done with the moon up.

	Deep Survey		Wide		Very Wide		A total	B total
Queue	A	A	A	B	A	B		
	time critical		Best scenario		D/N/C	i/3yr		
	g'r'i'z'	u*			g			
est 03A-05A	350	26	232	0	100	0	708	
05B	129	18	65	40	50	20	262	60
06A	118	18	65	40	50	20	251	60
06B	128	4	65	40	50	20	247	60
07A	110	4	65	40	50	20	229	60
07B	143	4	65	40	50	20	262	60
08A	110	4	65	40	50	20	229	60
08B	108	20	65	40	50	20	243	60
09A	0	20	99	0	14	20	133	20
09B	0	20	93	0	14	20	127	20
10A	0	20	0	0	14	20	34	20
05B-10A	846	132	647	280	392	200		
03A-10A	1196	158	879	280	492	200		
total		**1354**		**1159**		**692**		
allocation		*1313*		*1053*		*715*		
difference		41		106		-23		

"Super z deep plan"

	Deep Survey		Wide		Very Wide		A total	B total
Queue	A	A	A	B	A	B		
	time critical		Best scenario		D/N/C	i/3yr		
	g'r'i'z'	u*			g			
est 03A-05A	350	26	232	0	100	0	708	
05B	185	18	65	40	50	20	318	60
06A	121	18	65	40	50	20	254	60
06B	183	4	65	40	50	20	302	60
07A	117	4	65	40	50	20	236	60
07B	202	4	65	40	50	20	321	60
08A	120	4	65	40	50	20	239	60
08B	163	20	65	40	50	20	298	60
09A	0	20	99	0	14	20	133	20
09B	0	20	93	0	14	20	127	20
10A	0	20	0	0	14	20	34	20
05B-10A	1091	132	647	280	392	200		
03A-10A	1441	158	879	280	492	200		
total		**1599**		**1159**		**692**		
allocation		*1313*		*1053*		*715*		
difference		286		106		-23		

Table1: the two plans proposed by the Steering Group for the full completion of the CFHTLS that preserve the legacy value and guarantee the success of science drivers of the three surveys. Scientific and operational justifications are detailed in each report. The last columns show that we need about 320 hours per semester.