Queued Service Observing with MegaPrime/WIRCam:

Semester 2006A Report

08/10/06

A - Introduction

The Queued Service Observing (QSO) Project is part of a larger ensemble of software components defining the **New Observing Process** (NOP) which includes NEO (acquisition software), Elixir (data analysis) and DADS (data archiving and distribution). The semester 2006A was the first semester in the history of QSO that two instruments were fully offered in that mode: MegaPrime and WIRCam. The latter was offered as a regular instrument even if several nights in the time scheduled were used for engineering purposes. Unfortunately, the entire semester was **severely** affected by bad weather, in particular during the first 3 months when the conditions were absolutely horrible (e.g. we lost 27 QSO nights in a row at some point!). This is clearly seen in the final statistics. Again, the 2006A semester was extremely complex on the scheduling process since several programs requested time constraints. We worked really hard to make sure that everything fits as much as possible which was not an easy task with the uncooperative weather!

They are several very positive developments that occurred during this semester: 1) The efficiency on the sky for MegaCam has really been optimized with better and fast guiding acquisition and the implementation of a very reliable automated focus model; 2) WIRCam in QSO mode is working really well and produces great data, despite overheads that are still a bit larger than we would like; 3) Despite the awful weather, statistics for A programs are not bad at all: queue works! For 2006B, about 150 nights of QSO time are scheduled again... another challenge ahead!

B - General Comments

MegaPrime

The 2006A semester for MegaPrime was very severely affected by bad weather. The first three months of the semester were almost completely lost! The middle of the semester was a bit better but we had lots of cloudy periods and very unstable, mediocre seeing. The semester 2005B included very difficult scheduling issues with time critical observations from several PI programs and, of course, CFHTLS. A positive aspect of the 2006A was the continued improved observing efficiency due to reduction of the overheads by the guide probe motion and focus sequences. Due to this very high efficiency, the statistics on A programs are quite good, even for the worse semester even seen weather wise for Mauna Kea. It was, however, difficult to correctly balance the Agency time at the end since the weather affected mostly the first part of the semester and that the distribution of programs among the agencies was not uniform.

Some general remarks on QSO in general for the semester 2006A with MegaPrime:

1. *Technically, the entire chain of operation, QSO --> NEO --> TCS, is efficient and robust.* The time lost to the NOP chain is completely negligible. This is a complex system and we have worked real hard to reduce the overheads on this. The system is quite reliable and very efficient.

2. *The QSO concept is sound.* With the possibility of preparing several queues covering a wide range of possible sky conditions in advance of an observing night, a very large fraction of the observations (>90%) were done within the specifications. The ensemble of QSO tools allows also the quick preparation of queues during an observing night for adaptation to variable conditions, or in case of unexpected overheads. The introduction of the CFHTLS and several other PI programs with time constrained observations on a large-scale adds significant complexity to queue scheduling and requires much more work on planning of the runs. For 2006A, the global validation rate (validated/observed) for MegaCam was excellent (section C). For the last run of the semester, we had some RA ranges for which we had very limited options for the targets; some discretionary time was used and we had to start one program for the 2006B semester.

3. *QSO is well adapted for time constrained programs.* The Phase 2 Tool allows the PIs to specify time constraints. Two of the components of the CFHTLS have very restrictive time constraints. We can handle those easily if the weather is cooperative (of course!) although the introduction of time constrained observations on a large-scale adds up definitive complexity in the scheduling process.

4. *Very variable seeing and non-photometric nights represent the worse sky conditions for the QSO mode.* In 2006A, we were still a bit short on "shapshot" programs or regular programs requesting mediocre conditions (1" to 1.2"). As a result, we were often forced to try observing some programs in conditions worse than requested. Again, we were able to calibrate all the fields requesting photometry but originally done during non-photometric conditions. The availability of Skyprobe and real-time measurements of the transparency is extremely valuable and regularly used do decide what observations should be undertaken.

WIRCam

We offered WIRCam as a fully commissioned instrument for 2006A. Several nights of the telescope time allocated to WIRCam were in fact used for engineering and commissioning, mostly for improvements made on the guiding, but we were able to get good quality data for several programs. Unfortunately, as with MegaCam, weather conditions were very bad for a good fraction of the WIRCam nights in 2006A... The statistics given in the later section clearly indicate this. As a result, the balance of agency time is also a little bit off.

For WIRCam, several conclusions regarding can already be drawn from 2006A:

1. *Technically, the entire chain of operation, QSO --> NEO --> TCS, is efficient and robust.* The time lost to the NOP chain is already quite small for WIRCam. In fact, there was a lot of optimization work done to minimize operational overheads. This is a complex system but reliable and efficient. At the moment, most of the overheads are related to guiding and dithering patterns. Certain operational modes specific to WIRCam, like nodding (target-sky-target...) and chip-to-chip dithering, have longer overheads but some of them are charged during Phase 2; those modes have been tested and work very well.

2. *The QSO concept is sound.* As with MegaCam, the possibility of preparing several queues covering a wide range of possible sky conditions in advance of an observing night result in a very large fraction of the observations done within the specifications. For WIRCam, the sky background is more of a factor although its global variation through the night in Mauna Kea is fairly well known. Seeing is of course another important parameter but variations during the night in the near-IR are generally not as brutal as in the visible.

3. *QSO is well adapted for time constrained programs.* The Phase 2 Tool allows the PIs to specify time constraints. We can handle those easily if the weather is cooperative (of course!) although the introduction of time constrained observations on a large-scale adds up definitive complexity in the scheduling process.

4. *Non-photometric nights represent the worse sky conditions for the QSO mode with WIRCam.* An important difficulty of near-IR astronomy is the removal of the sky background. Non-photometric conditions make that operation a more difficult one. Nodding for instance cannot be done. The availability of Skyprobe and real-time measurements of the transparency is extremely valuable and regularly used do decide what observations should be undertaken. Also, the real-time analysis through

Elixir provides a direct estimate of the extinction through the 2MASS catalog, helping even more the observing process.

C - Global Statistics, Program Completeness, and Overheads

1) Global Statistics

MegaPrime

The following table presents some general numbers regarding the queue observations for 2006A (C, F, H, K, L, and T, D-time, **excluding** snapshot programs). Note: 1 night is 9.5 hours.

Parameter	Number
Total number of Nights	99
Nights lost to weather	~ 41 (~41%)
Nights lost to (engineering + technical) problems	~ 5 (~5%)
QSO Programs Requested	40 (+ 4 snapshots)
QSO Programs Started	34
QSO Programs Completed	14
Total I-time requested (hr.) (A+B+C)	501
Total I-time validated (hr.) (A+B+C)	338 (67%)
Completion A+B Programs	72.7%
Queue Validation Efficiency	~ 92 %

Remarks:

- The fraction of time lost during QSO nights in 2006A due to weather and technical problems **is about 46% of the semester**. This is significantly larger than the global fraction expected (~20%). In fact, the number given above might even be a bit underestimated since we again had to observe for several nights with winds close to the acceptable limit which introduced bad wind shake and degraded the image quality.

- The time lost due to engineering and technical problems is still important this semester. The main culprit for this semester was the filter jukebox. The number given is also approximate because not everything could be taken into account (for instance, it is often difficult to untangle the time used to engineering during bad weather and count that as time lost for science).

- The global validation rate (validated/observed) is excellent ~92%. Part of this comes from the now excellent focus model with automatically adjust the focus between exposures and keep the image quality optimized. The most difficult conditions come from very rapidly changing seeing; we were faced with several nights like that during 2006A.

- The total number of hours VALIDATED during the semester is ~338 hrs. We then find [338 hrs /(99)] ~ 3.4 hours /nights of observations. This is very low and entirely due to the bad weather.

WIRCam

The following table presents some general numbers regarding the queue observations for 2006A (C, F, H, K, L, and T, D-time, **excluding** snapshot programs). Note: 1 night is 9.5 hours.

Parameter	Number
Total number of Nights	55
Nights lost to weather	~ 23.5 (~43%)
Nights lost to (engineering + technical) problems	~ 3 (~5%)
QSO Programs Requested	31 (+ 1 snapshot)
QSO Programs Started	22
QSO Programs Completed	7
Total I-time requested (hr.) (A+B+C)	310
Total I-time validated (hr.) (A+B+C)	168 (54%)
Completion A+B Programs	61%
Queue Validation Efficiency	~ 92 %

Remarks:

- The fraction of time lost during WIRCam QSO nights in 2006A due to weather and technical problems **is about 48% of the semester**. This is significantly larger than the global fraction expected (~20%). In fact, the number given above might even be a bit underestimated since we again had to observe for several nights with winds close to the acceptable limit which introduced bad wind shake and degraded the image quality. This is not the start we wanted to have for WIRCam.....

- The time lost due to engineering and technical problems is still important this semester. The main issue with WIRCam remains the on-chip guiding; it works very well but it required a lot of tweaking to make sure that science was optimized. The number given is also approximate because not everything could be taken into account (for instance, it is often difficult to untangle the time used to engineering during bad weather and count that as time lost for science).

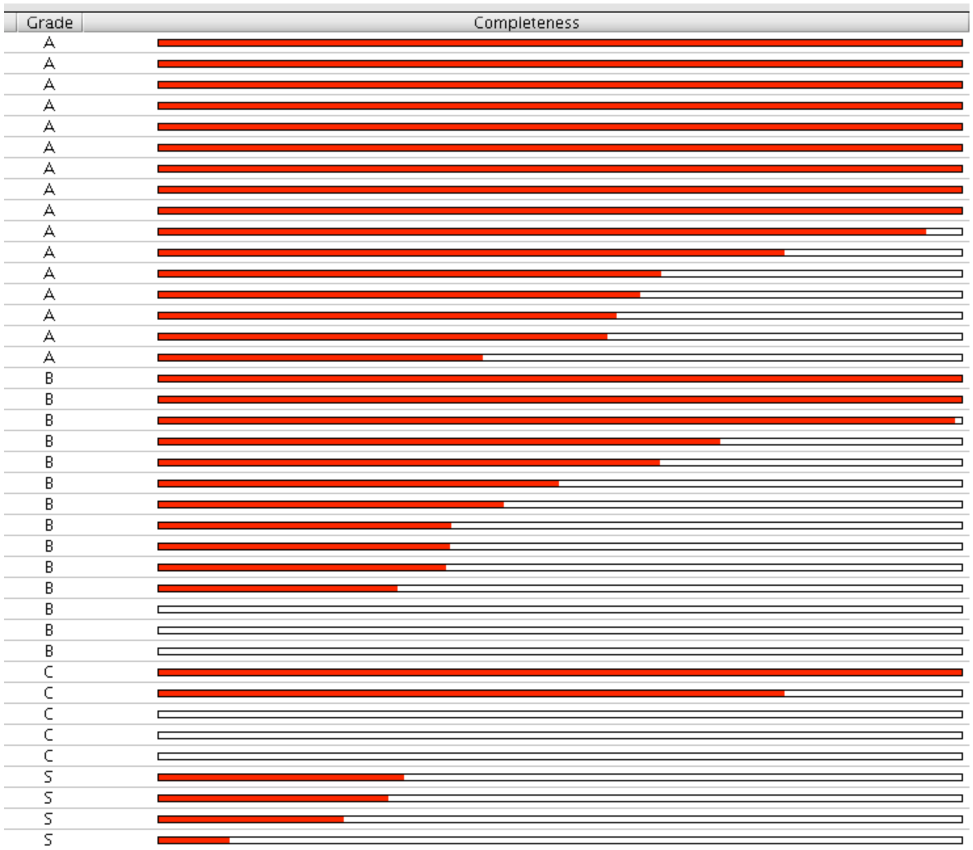
- The global validation rate (validated/observed) is excellent ~92%. The most difficult conditions for WIRCam come from clouds and higher than expected sky background. We were able to adapt quickly to these conditions.

- The total number of hours VALIDATED during the semester is ~168 hrs. We then find [168 hrs /(55)] ~ 3.1 hours /nights of observations. This is very low and mostly entirely due to the bad weather. WIRCam is also a young instrument; overheads are still a bit larger than we would like to have. For instance, we do not have an automated focus model as with MegaCam yet (data have been accumulated to that effect). Efficiency got better and better during the semester due to constant improvements made on the observing system and the camera.

2) Program Completeness

MegaPrime

The figure below presents the completion level for all of the programs in 2006A, according to their grade:



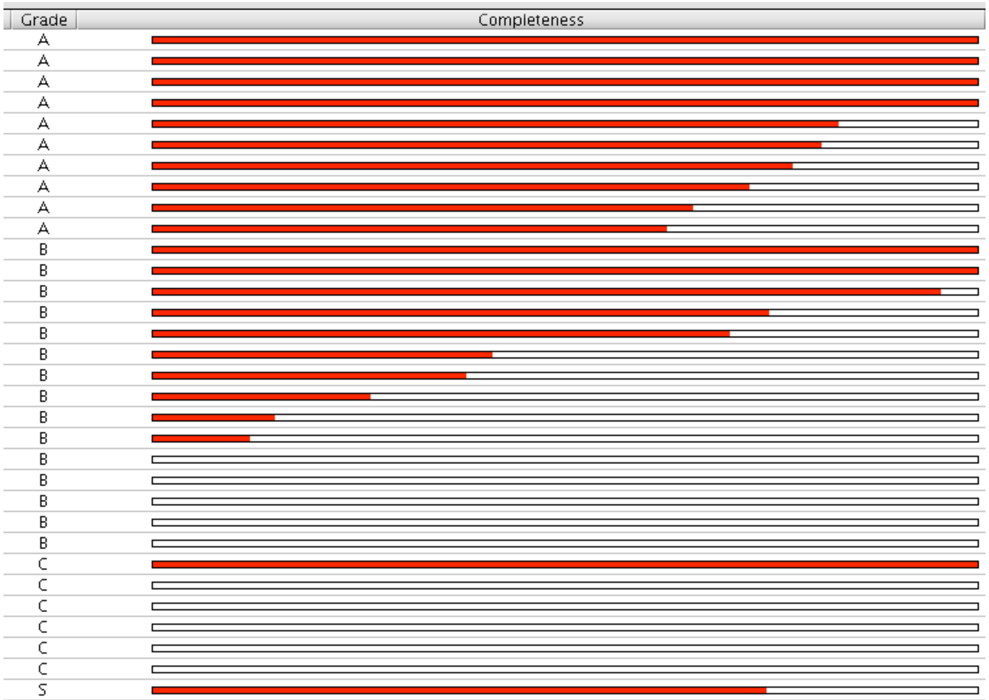
Remarks:

- The global completion level with MegaCam for A programs is ~88% while B programs were done at ~48% . These values are not bad but below our objectives of > 90% for A programs and > 65% for B programs. Unfortunately, two A programs with targets highly concentrated in the first part of the semester (so when weather was horrendous) only got about 60% of their observations done. Note, however, that with close to half of the semester lost, the global completion level for A programs is excellent. Moreover it demonstrates clearly that by concentrating on the top scientific priorities as defined by the TACs, the best science can be accomplished even when weather is mediocre. The queue model works!

- Note: The completion programs for certain C program is not bad at all for 2006A. C programs are very useful for QSO when they require modest conditions and when the targets are not located in RA ranges too populated by other highly ranked programs.

WIRCam

The figure below presents the completion level for all of the programs in 2006A, according to their grade:



Remarks:

- The global completion level for A+B programs is not too good (~61%) but this is not at all surprising with those weather statistics. Not surprisingly, B programs highly suffered from the bad weather. Note, however, that the bad weather does not explain everything on this low completion level. Larger overheads, due mostly to focus sequences and telescope offsets overheads, are still a bit of an issue with WIRCam. Overheads have been significantly reduced later on during the semester and remain a priority for 2006B.

3) Overheads

MegaPrime

The following table include the main operational overheads (that is, other than readout time of the mosaic) with MegaPrime during **the semester 2005B**. This is given as a reference; overheads are highly variable during a given night depending on the conditions, complexity of science programs, etc. globally, the operational overheads constitute now about 10-15% of an observing night, the number originally expected before MegaPrime observations started.

Event	Events/night	Overhead	Total overhead per night
Filter Change	15 - 25/ night	90s /change	1500 - 2200 seconds
Focus Sequence	~ 0 / night	200s / seq	0 seconds
Dome Rotation > 45 d	5 ?	120s	< 600 seconds
Guide Star Acquisition	20 - 30 ?	20 s / acq	< 600 seconds

Remarks:

- Overheads to filter changes are large and constitute the main difference with CFH12K. The total time for a filter change is about 127 seconds but this is done in parallel during readout or while the telescope is moving (so, we do not always have an overhead for a filter change). The global overheads also depends strongly on the number of standard stars observed for a given night and also if switching from a queue to another is necessary (since overheads due to filter change are minimized within a specific queue). Until we have another system, this overhead will remain with us....

- Focus sequences have been almost completely removed from our operations. The auto-focus model is available and contributes to significantly increase the time we spend observing instead of focusing. We take a few sequences during the first nights of a run to confirm the zero points of the model; other than that we just operate with the focus model.

- Overheads due to dome rotation are again minimized as much as possible within a specific queue. Note that a lot of rotation is necessary to reach standards stars on the equator when we observe northern targets. Hopefully, the use of the Deep survey fields from CFHTLS as secondary standards will help on this. Rotation of the dome is now optimized and cannot be made faster.

- Guide star acquisition is fully automated and except from some rare problematic acquisitions, it works really well. Acquisition tends to take longer when the seeing is bad or cirrus are present. Programs with frequent guide star acquisition with short exposure strategy (e.g. sequences for the Very Wide survey) increase the global overheads). The main overhead related to the guide star acquisition has been reduced dramatically in 2005A by accelerating the probe motion. Dithering patterns offsets for instance are now completely hidden in the readout time, which was not the case in the past.

Note that overheads for calibrations (standard stars and Q98 short exposures for photometric purposes) are not included in this table. For 2006A, we observed about 2 standard star fields during a photometric night (12 minutes / fields due to filter changes).

WIRCam

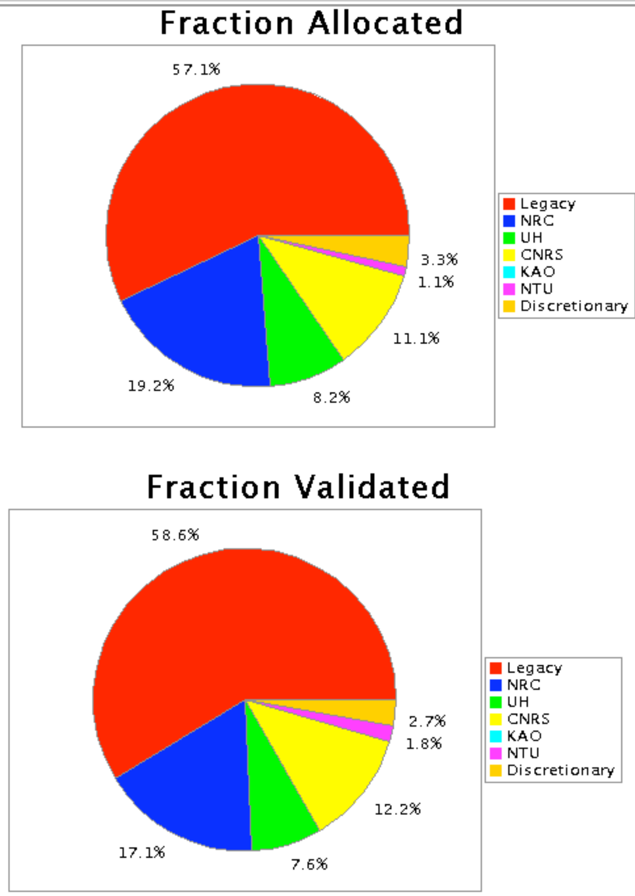
Gigantic efforts have been made to reduce the overheads for WIRCam during the runs of semester 2005B and 2006A. It is too early to give definitive numbers yet because things are still moving. The overheads are still too large but we can expect several improvements in 2006B. The main overheads include focus sequences (~ 8 per night; to be removed with focus model), guiding acquisition and pointing correction, and telescope offsets for dithering patterns.

D - Agency Time Accounting

1) Global Accounting

MegaPrime

Balancing of the telescope time between the different Agencies is another constraint in the selection of the programs used to build the queues. The figure below presents the Agency time accounting for 2006A. The top panel presents the relative fraction allocated by the different agencies (program A + B), according to the total I-time allocated from the Phase 2 database. The bottom panel represents the fraction of observations validated (programs A+B+C) for the different Agencies, that is, [Total I-Time Validated for a given Agency]/[Total I-Time Validated]. As showed in the plots, the relative distribution of the **total integration time of validated exposures** between the different Agencies was relatively well balanced at the end of the 2006A, although not perfect due to the bad weather.



Remark:

- The global distribution between the Agencies is relatively good. CFHTLS is a bit ahead but it compensates somewhat for some lower stats during previous semesters. Both NRC and UH are a bit late due to the program targets being mostly distributed at the beginning of the semester, when weather was awful. Programs for these agencies also had somewhat most difficult constraints to be met for image quality.

WIRCam

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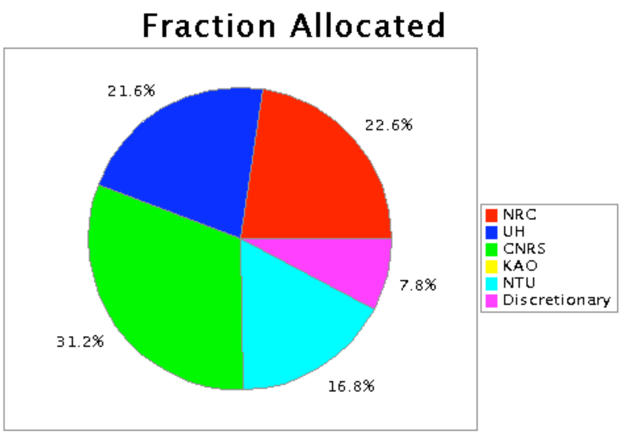

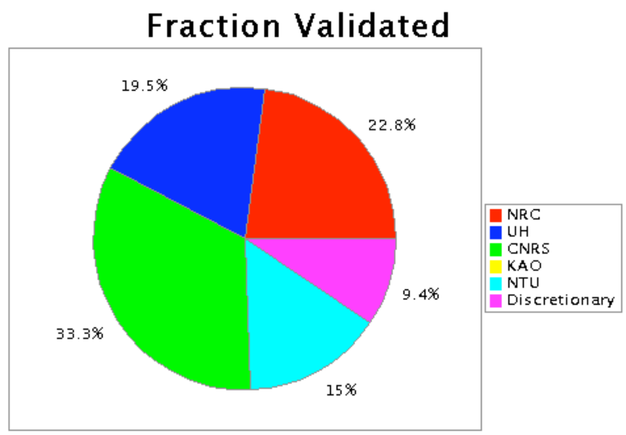

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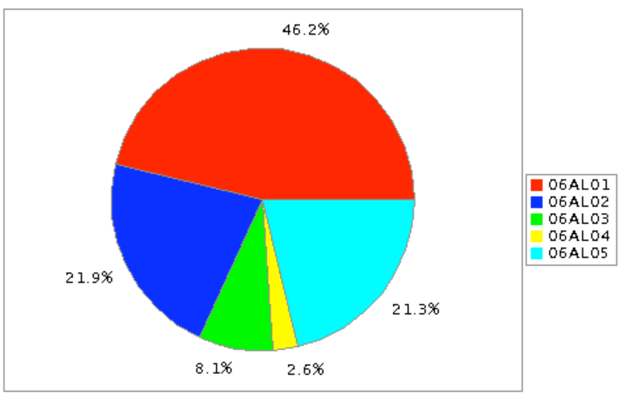
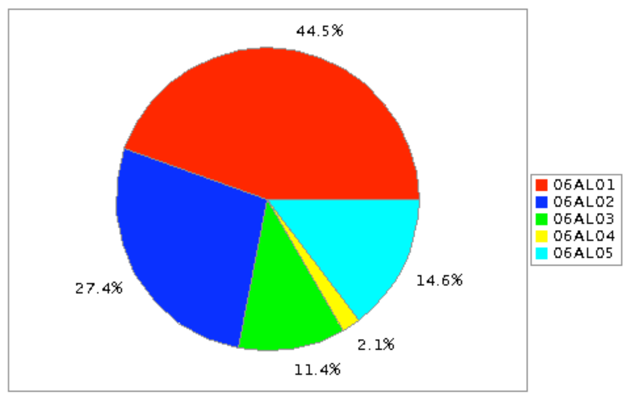
Remark:

- As showed in the plots, the relative distribution of the total I-time between the different Agencies was acceptable for WIRCam at the end of the 2006A. This is not perfect, however, since weather was so bad at the beginning of the semester, affect some agencies more than others.
- The time allocated for D programs seems a bit large. This is because we ran out of targets in certain RA ranges at the end of the semester and mostly because we badly needed programs requesting mediocre seeing (not snapshots but more in the 1" range).

2) CFHTLS Accounting

CFHTLS occupies a large fraction of the I-time allocated for QSO for MegaCam. The following figures show the time accounting for the different CFHTLS components for 2006A:





Since each component of the survey is divided into two programs, the global fractions are given in the following table:

Survey	Programs	Fraction Requested	Fraction Validated for 2006A
Deep Synoptic	L01 + L04	46.2 % + 2.6% = **48.6%**	44.5% + 2.1% = **46.6%**
Wide Synoptic	L02 + L05	21.9% + 21.3% = **43.2%**	27.4% + 14.6% = **42.0%**
Very Wide	L03	**8.1%**	**11.4%**

Remark:

- The final time distribution of validated data within CFHTLS is very close to the respective allocation of each survey before the semester. A good reason for this is that the pressure coming from the PI programs on the Very Wide W1 field was lower than usual. Also, the Wide has relaxed some airmass constraints on some filters which greatly helped in scheduling more observations. The opening of the W4 field was crucial also to maintain that balance within CFHTLS and also, between CFHTLS and the other Agencies.

E - Conclusions

MegaPrime

Our seventh semester with the queue mode with MegaPrime was very difficult. The fraction lost to bad weather was again extremely high; close to 505 of the semester was lost. Despite all that, gains in observing efficiency resulting from MegaCam improvements really helped achieving acceptable completion and validation levels. Balance of the Agencies was satisfying. The balance between the LS surveys was also quite good.

WIRCam

QSO has been ready to go with WIRCam for quite some time and 2006A was the first semester for which WIRCam was fully offered! We were able to gather good, high quality data during 2006A but weather was awful since close to 50% of the semester was entirely lost. Reducing overheads remain a major objective in the coming months, in particular the implementation of an automated focus model.