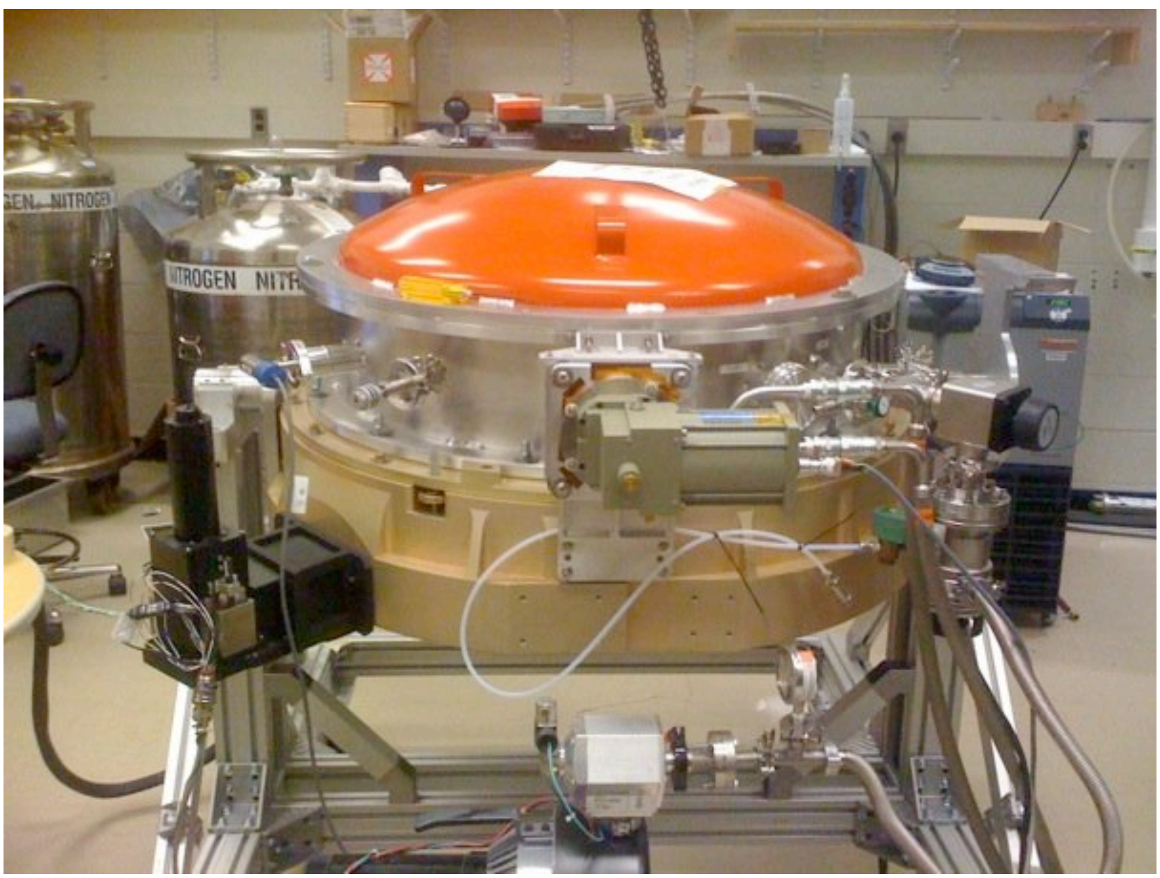
# FIRE Pre-Ship Review
# MIT - Cambridge, MA
# 11/12/2009

# Requirements Documentation



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# Section 1:
# Supplemental Support Agreement

Instrument Support Agreement for FIRE
Rev. B: 3/2/2009 (R. Simcoe)

## 1. Instrument Description

FIRE is a permanently mounted IR Echelle spectrograph, located on an f/11 auxiliary Nasmyth port. It uses an observatory rotator and guider package, but its own IR slit-viewing camera for object acquisition. It is kept cold by a closed cycle mechanical refrigerator, with cold head at the instrument and compressor mounted below the azimuth disk. The instrument will be continually powered on. It will contain a single box of electronics (including computers) mounted on-board the instrument, and a single off-instrument Mac for instrument control in the equipment room. The instrument team will provide instrument control software based on existing Magellan instruments, and also new and customized real-time data viewing and reduction software.

Throughout the rest of the document, the **Instrument Team** is understood to mean MIT, with Rob Simcoe as primary contact. Other team members are listed in the section on the instrument mailing list, but MIT is assumed to be the primary responsible institution.

## 2. Configuration

- **Intended port**: Baade FP2

- **Telescope configuration**: f/11 secondary, no ADC used

- **Guiding**: standard telescope tracking errors will be corrected using the observatory optical guide cameras. The IR slit viewer may be used for on-slit guiding if needed, or to provide less frequent corrections for flexure between the observatory guiders and the cold slit.

- **Size/weight**: 1100-1150 pounds

- **Equipment / racks**:
    - One on-instrument rack containing
        - two (2) Mac-mini control computers,
        - two (2) PCs for SIDECAR control,
        - one (1) Lakeshore temperature controller and
        - one (1) Lakeshore temperature monitor units,
        - two (2) Nyden motor controllers,
        - one (1) Ethernet hub,
        - (2) power supplies for motors,
        - (1) motor controller power supply

        - (2) computer power supplies,
        - (2) ASIC power supplies,
        - (2) calibration lamp power supplies, and
        - (1) AC power distribution unit.

    - Two 1-U slots in the equipment room racks for a control Mac computer, and an Ethernet switch/firewall.

    - Closed-cycle chiller compressor, requiring 3 phase 208V AC power at 60 Hz (approx 5.5 kW nominal; but 30A min rated service), located below the azimuth bearing. MIT will supply a UPS to this unit.

- **Control console**: will be located in the observing room. The instrument software will be installed on the FIRE control computer located in the equipment room, and this machine will be accessed via VPN and/or remote desktop using the standard observing-room Macs. The console is therefore shared, but the instrument computer downstairs is not.

- **Network requirements**: FIRE will operate on its own network, behind a hardware firewall. Within the instrument network, all communications will run over an Ethernet hub. The Hardware firewall will allow connections from the control console via VPN software.

- **Balance considerations**: FIRE's center of mass is off-line from the rotator's axis, so additional balancing will be needed to counter its moment load on the rotator. Counterweights will be installed on the instrument for this purpose, and need not be engineered by the observatory.

- **Baffle requirements**: there are no special baffling requirements imposed on the telescope

- **Cable description and layout**: we have assumed that FIRE will be mounted permanently to the folded port. It will require minimal special cabling, with the major exception that helium gas line for the cryocooler (hereafter the "CCR") must be routed through the telescope structure. The instrument team will provide these lines, and the observatory will install them in the telescope. Standard cabling will include electrical service to the cold head, 110V AC (both "clean" and "dirty" varieties), fiber-Ethernet, clean N2 gas (for reducing condensation on the entrance window) and cooling glycol (for the electronics rack). Communication with the instrument will be handled via Ethernet, but we will provide Ethernet-to-fiber converters for the instrument end (not the data-room end). In principle the AC power, N2, and Ethernet could be shared with other instruments but in practice we are assuming that FIRE will occupy this port and not trade off with other instruments, because of its specialized cable wrap (see next bullet).

- **Cable wrap**: The instrument team is designing a cable wrap that will be delivered at commissioning time. MIT will fabricate this item, and the observatory will install prior to commissioning. MIT is controlling the ICD for this item and will be bringing a template to the mountain in March 2009 to test drilling patterns.

3. Service Requirements

    a. Requirements for power
        i. 110V AC power, both “clean” and “dirty” varieties at the folded port, both UPS backed. Prior to pre-ship review, the instrument team will measure the current draw on the 120V lines and convey this requirement to the observatory for proper wiring prior to commissioning.
        ii. 110V AC power at the location of the compressor
        iii. 208V, 3 phase AC (50-60Hz, 30 Amps min service) at the location of the compressor (below Azimuth bearing). MIT will supply a UPS system for the compressor.

    b. Requirements for compressed air
        i. Clean, dry N2 purge to flow across Dewar window
        ii. No mechanisms will be powered by compressed air
        iii. Occasional N2 purge of the cryostat may be required when pumping down or taking the instrument on/off the telescope. This could be accomplished via filtered boil-off from a portable LN2 can.

    c. Requirements for coolant / heat extraction
        i. Standard observatory glycol will be required at the folded port to remove heat from the electronics enclosure
        ii. A glycol or chilled water loop to the CCR compressor is mandatory. It is assumed that this would be taken from the observatory’s chilled water/glycol manifold. Lab tests on the compressor indicate that the heat load imparted to the coolant from the compressor is about 5 kW. The observatory will provide hoses to connect our system to the cooling manifold; MIT will provide regulators and gauges to control flow and pressure.

    d. Requirements for cryogens
        i. FIRE does not use any cryogens

4. Routine Support

    a. <u>Routine maintenance</u>: When observers are using the instrument the staff should monitor noise performance and stability, and make sure the software is running properly. When the instrument is offline, the instrument team will provide a set of maintenance checks, principally to make sure that the cryocooler is functioning properly. These might include monitoring temperature stability, helium gas pressure, and coolant flow. However, these routines would not be daily requirements. FIRE contains a getter with activated charcoal material and hence should not require removal and bake-out by observatory staff.

b. Personnel requirements: FIRE should require roughly 1-2 hours per day of setup time while the instrument is on the observing schedule, and 1 hour every few days when it is not. There are no filters or other hardware to be maintained and configured for observers by the mountain staff.

c. Consumable supplies: The only real consumable in the instrument is the slow Nitrogen flow for the entrance window. The quantity should be very small. On very long timescales, it may be necessary to charge the CCR lines with ultrapure He gas. We expect this servicing to occur on year-like intervals.

d. Power Requirements: See 3.a.

e. Air requirements: None

f. Coolant Requirements: For the CCR compressor, we require water at approximately 20 degrees C, circulating at 3 GPM with a pressure drop of 8-10 PSID between the input and output ports of the compressor. MIT will be supplying flow and pressure regulators along with gauges to measure PSID and flow rate, but the facility supply must be able to meet these requirements. The CCR compressor deposits approximately 5 kW of heat into the water supply during normal operation. A standard glycol supply at the folded port should easily meet our (minimal) heat load requirements from the electronics enclosure.

g. Procedures for routine instrument changes

    i. Pumping procedure: A turbo pump will be mounted with the instrument at FP2, with the backing pump unit mounted offline (either on the dome floor or preferably at the port as well). The instrument should be pumped until the readout from the Convectron gauge zeroes out (indicating pressure below 1e-4 torr). At this point the cryocooler power is engaged and allowed to start cooling the dewar. Once the dewar temperature reaches a value of 10 degrees C, the pump valve is closed and the turbo unit powered off. The cryocooler will subsequently bring the instrument down to operating temperature.

ii. Cabling: The instrument will provide a single junction panel for connection of all service. This will include the following connections:
    1. Two helium gas flex lines for the cryocooler
    2. One specialty power cable for the cryocooler
    3. One input for "dirty" 110V AC power
    4. One input for "clean" 110V AC power
    5. One fiber pair for Ethernet service

iii. Power up: Powered instrument subsystems are controlled via a remote power distribution unit. This unit allows the user to address individual power supplies within the instrument over Ethernet. So, once the AC power is supplied to this PDU and the Ethernet connected, the remaining power-up procedure will all be conducted remotely. This will be done via a script run from the control computer console.

iv. Filter/mask preparation: N/A

v. Data System preparation: This only requires setting a data path in the control software, and ensuring that adequate disk space is available to contain the data. Essentially the same as all other Magellan instruments.

vi. Start-up procedures: After the power-up script has run, instrument start-up is accomplished by launching the FIRE control GUI. This will read and report the status of position mechanisms in the instrument, and prepare the detector for data taking. A separate hard-hat area will be provided in the control software, with minimal functionality. The main use for this area will involve re-homing mechanisms or power-cycling options. However, these options will not be executed by default at start-up.

h. Status Reporting

i. Instrument status reports should be sent to the instrument mailing list on every full power-up/power-down procedure when the instrument is put on or off the telescope(*not* for power cycling). The instrument team will provide procedure checklists to be included in this report, for attaching the instrument to the telescope, pumping, cooling, and power up/down. Also, the instrument mailing list members should be included on the observing run report forms filed by observers at the end of each FIRE run.

i. Instrument Team Mailing List
    i. Rob Simcoe (PI): simcoe@space.mit.edu
    ii. Adam Burgasser (co-PI): ajb@space.mit.edu
    iii. Matt Smith (Engineer): matt@space.mit.edu
    iv. Paul Schechter (co-PI): schech@achernar.mit.edu

5. Troubleshooting and Repair

**a. Subsystems serviceable by observatory staff**
    i. **Cryocooler plumbing**: He gas lines, hoses, compressor power
    ii. **Cryocooler cooling**: chilled water or glycol
    iii. **Calibration unit**: Bulb replacement, flip mirror
    iv. **Electronics rack**: Replacement of power supplies, cabling, etc
    v. **Vacuum pumping**: the observatory is authorized to perform vacuum pumping and warmup/cooldown cycles according to documented procedures provided at commissioning.
    vi. **Lifting**: The observatory staff is authorized to lift the instrument and attach/unattach it from the telescope

b. **Subsystems not serviceable by observatory staff**
    i. **Dewar interior:** Any repair requiring access to the interior of the cryostat should only be performed by instrument personnel.
    ii. **HAWAII-2RG/SIDECAR**: Any servicing of the HAWAII-2RG detectors, and the external SIDECAR electronics should only be attempted by the instrument team. This regulation is important to maintain compliance with ITAR restrictions, which prohibit non-US persons from servicing or working with these items.
    iii. **Alignment**: Observatory staff should not perform realignment of the calibration optics or dewar without consulting the instrument team.

c. **Protocol for communicating instrument problems:** Simcoe will be registered to receive observing run reports for FIRE observations to stay up to date on instrument performance. In the event of a system failure or malfunction requiring attention, the FIRE on-site instrument scientist will notify Simcoe and P. Schechter via email. Coordination of the fix will be the joint responsibility of Simcoe and the Instrument Scientist.

d. **Replacement policies:** The observatory will pay for any consumables associated with instrument operations, including N2 gas, cooling loop fluids, and CCR helium. MIT will replace parts damaged during routine operations, provided that the staff member was following procedures authorized by the instrument team.

e. **Definition of Chronic Problems:** Although it is difficult to anticipate what chronic problems might arise, a reasonable definition is something that regularly prevents observers from consistently performing the basic tasks needed to support their science. A short list of possible failure modes for FIRE might include:

    i. Weakening of the vacuum integrity of the cryostat, requiring constant pump-downs and warm up cycles
    ii. Inability of the cooling system to maintain operating temperature consistently
    iii. Regular failure or unreliability of the cryogenic mechanisms requiring redesign
    iv. Any software failures that require power cycling or re-initialization more than once per observing run, or result in lost time > 5 minutes per restart.
    v. Problems with the science detector, including either readout failures or noise increases in excess of commissioned levels.

6. Support Provided by Instrument Group

    a. Principal point-of-contact: R. Simcoe

    b. Other contact references:

        i. Matt Smith (Mechanical Engineer),
        ii. John Bochanski (software systems),
        iii. Paul Schechter (MIT-Magellan Director).

    c. Remote help to be provided:

        i. A complete set of part and assembly drawings, as well as wiring diagrams and assembly information will be provided to the observatory via web interface at MIT
        ii. Complete procedures for instrument installation, basic servicing, and troubleshooting will also be provided over the web
        iii. The instrument team will provide complete user documentation on the FIRE webpage, and update this documentation when requested by the observatory.
        iv. The instrument team will provide complete, IDL-based data reduction software as part of the commissioning package.

v. The instrument team will arrange any purchasing of spare or replacement parts, or servicing of parts in the US. The mountain staff will be responsible for control of regular and routine maintenance schedules, alerting the instrument team when intervention is required for regular servicing (e.g. of the CCR cold head).

vi. MIT will ship any parts involved in servicing to the observatory. For non-urgent shipments, MIT will ship to Pasadena for follow-on bulk shipment to the observatory. Urgent repair items will be shipped directly from MIT to the observatory, in consultation with the Carnegie shipping clerk.

d. <u>On-site help to be provided</u>:

i. R. Simcoe and M. Smith will be the main contacts travelling to the observatory when necessary.

ii. The instrument team will make every effort to respond to requests for remote servicing consultation (e.g. via email, phone, or video conferencing) on the same day.

iii. Upon notification of on-site servicing requirements from the observatory, and work authorization from Magellan, the instrument team will schedule travel to the observatory. The timing of this travel may be subject to external schedule constraints from other commitments including teaching. However, every effort will be made to respond within 3-6 weeks for such a request.

e. Training to be provided

i. <u>During development phase</u>: We anticipate that most staff servicing will be in the replacement and debugging of problems with external units, such as the calibration lamps, motors, motor controllers, power supplies, etc. We would like to bring a member of the Magellan technical staff to MIT during the final design/implementation of this system, including its control software. We would welcome design input during this process.

ii. <u>On-site at commissioning</u>: At commissioning, we will present the staff with a series of procedure checklists for lifting and securing to the telescope, pumping, cooldown, warmup, boot-up, and software startup. We will review each of these procedures with the staff, illustrating first and then supervising the staff in the completion of these procedures. We will also instruct the staff in the architecture of the electronics enclosure and its communication with the control software, to facilitate future troubleshooting.

iii. Over the course of operation: We do not anticipate a strong demand for additional training post-commissioning. However, if there is such a demand then the instrument team could schedule extra days around observing runs to assist in this capacity on an as-needed basis.

7. Handling and Storage Fixtures

a. **Description of handling and storage fixtures**: FIRE will be shipped with a handling cart and lifting fixtures. The handling cart is a modular assembly and will be used to articulate the instrument during assembly and commissioning. It is suitable for short-term storage of the instrument and transportation around the dome floor. It would also be suitable for short rolling transport to the auxiliary building at the ground level. However, it should NOT be used for vehicle transport or for rolling the instrument to the auxiliary building across the upper-level catwalk.

b. **For long term storage** and vehicle transport, FIRE should be stored in its shipping container, which will be a full, crudely dust-proofed enclosure. MIT will provide both the shipping crate and rolling cart with instrument shipment. We also request 2 cabinets of storage space for spare parts, tooling, etc.

c. **Moving/installation procedures**: FIRE will be assembled and qualified in the ASB clean room. Upon completion, the instrument will be warmed up and nitrogen purged for transport, then lifted (fully assembled) with the clean room hoist and placed in its shipping container. The container will be rolled via the loading dock onto a transport truck to bring FIRE to the summit. At the summit, a crane or fork truck will lift the shipping crate and place it onto a rolling palette. The palette will be rolled through the garage doors onto the dome's hydraulic scissor lift to the dome floor, where the assembled handling cart will be waiting. The dome crane will be used to lift FIRE out of its shipping container. From here, it can either be lowered onto the cart (if additional work is required) or lifted directly to the folded port. FIRE is lifted using the standard observatory spreader bar configuration. FIRE should NEVER be moved under cold or vacuum conditions, for safety reasons.

d. **Shipping requirements**: We anticipate FIRE will be shipped ONCE, from MIT directly to LCO, most likely via boat. We have begun researching shipping companies but do not have an estimate of the shipping cost. We do not anticipate that the instrument (or any of its subassemblies) will need to be shipped back to MIT for servicing. However, it is possible that the CCR cold heads will require servicing every 3-5 years. This would be handled by the CCR supplier, Brooks Automation/CTI Cryogenics.

e. **Requirements for testing prior to installation**: For post-shipping assembly and qualification, the FIRE team will require access to the LCO clean room (currently being built) for approximately 3 weeks. We will need a 10 x 10 foot clear floor space for our instrument cart, CCR, hoses, and personnel circulation. We will be bringing a closed-loop water chiller down to the mountain to cool the CCR compressor in this space, since the facility chilled water loop does not circulate in the ASB area. We have already discussed with A. Uomoto the power requirements to run the CCR along with its associated chiller. The CCR requires 208V 3 phase electrical service in the clean room, and the chiller requires 208V single phase service. The single phase power can be located either in the clean area, or in the "unpacking area" designated just outside of the clean room. According to Alan, the electrical installations are in queue, and a pass-through will be provided for chilled water lines between the staging and unpacking areas.

8. Special Provisions

a. **Describe any special provisions, conditions, or modifications not covered above**: Besides modifying the folded port cable wraps, we also need to add several more through holes to the guider interface plate, to accommodate fastening bolts from the back side of the instrument. These arrangements are already being discussed with the observatory.

b. **List factors that would interfere with instrument operations on other ports**: None anticipated

c. **Are there arrangements with other organizations that affect the way FIRE will be used and supported at LCO**? None in place.

# Section 2:
# FIRE Installation Plan

# <u>Installation Plan (Rev. A)</u>

**Scope**: FIRE's installation plan covers procedures leading up to, but not including on-sky observations with the instrument.

## <u>Pre-Arrival Activities</u>

In advance of the instrument team's arrival, we have made arrangements for several pieces of heavy equipment to be shipped to the mountain for early installation. These include items which are either specific to the telescope, or for which we have duplicates in the lab.

1. **<u>Cryocooler UPS</u>**: FIRE's closed cycle cooler (model CTI 9600) uses 208V 3 phase power, with maximum draw of approximately 5.5 kW. Las Campanas experiences occasional power outages of a few seconds to a few minutes; the mountain backup generators pick up power outages on timescales of a few seconds.

   120V instrument power is behing an observatory-supplied UPS. To avoid cooling lapses and/or lock-up of the compressor's rotor, we have purchased a 208V UPS for the instrument as well. This item weighs approximately 1500 lbs and is being shipped via boat to the observatory in advance of the (air freighted) spectrograph. The unit will be situated in the cooling tunnel below the dome floor, adjacent to the other observatory UPS systems and the cryocooler compressor.

   The Observatory staff has discussed this requirement with the instrument team and is ready to accept it for early installation. The install procedure will require approximately 1 person-day. A small portion of this effort goes into unpacking, lifting and locating the unit. The majority of the time will be devoted to the proper installation of electrical service, which is hard wired into the unit.

2. **<u>Cryocooler hoses</u>**: The 9600 compressor requires a pair of high-purity helium gas lines to service the cold head at the instrument port. We have purchased set of long lines (60 meters) for this purpose. The hoses will be shipped in advance of the instrument for storage at the mountain. They will be installed at the same time as the cable wrap (see below) to ensure that the proper amount of loose flex line is available at the instrument end to permit easy installation of the spectrograph. Note that the length of cable required was measured by site staff based on the projected location of the cryocooler in the cooling tunnel below deck.

3. **Cryocooler plumbing**: The cryocooler compressor requires coolant during operation. This coolant will be supplied from the observatory's manifold for cooling fluid. A service line will need to be routed from the manifold to the compressor location. The instrument team will supply gauges and controls to monitor and maintain the proper flow rate and PSID to the unit.

4. **FIRE Cable Wrap**: A roughly "standard" cable wrap interface has been adopted for Magellan's folded port instruments. FIRE will be using an identical design concept, except that the radius of our serpentine wrap is slightly larger because of the large bend radius of the Helium flex lines (as compared with Cryotigers). We have designed a dedicated cable wrap for FIRE which is currently under fabrication at Rettig Machine in Redlands, CA.

   This item will be drop shipped to the Pasadena offices of Carnegie, for forwarding to the observatory under supervision of A. Uomoto. An IGUS guide chain to carry the service lines has been delivered to MIT and will also be shipped to Pasadena and the mountain. These items will be shipped separately and in advance of the instrument to provide the mountain staff with extra time for installation.

5. **Drilling of custom bolt holes, guide pins**: FIRE's mounting bolt circle requires a minor modification to the existing folded port mounting surface. Four thru holes must be drilled for access from the backside of the flange. The instrument team has delivered a drilling template with accompanying ICD to the observatory to aid in this procedure. Compatibility of the template with the guiders was verified during a site visit in April 2009.

   Provisions exist to install locating pins (one round, one diamond) on the Magellan guiders but no instruments have used them to date. We intend to use these as an installation aid and for stability and repeatability of alignment. The observatory already has the pins in stock. They must be ground down from a standard 1-5/16 inch length to a shorter length not to exceed 15/16.

## Arrival and Instrument Unpacking

FIRE will ship in a largely assembled state in a custom-designed wooden shipping container. The instrument team will uncrate the instrument in the clean room staging area and clean and prep the dewar for movement into the clean tent. At this time FIRE's handling and assembly cart will be reconstructed and the instrument lifted from the shipping container onto the handling fixture. Support from the site staff will be needed to lift and transport the instrument into the bay, and provide hoist/crane access. The instrument team can take over from this point.

## Instrument Reassembly

Reassembly of instrument subsystems that were broken down for shipment will take place in the clean tent. The following punch list describes items that fall under this category and their assembly order.

1. Optical Bench: FIRE's optical table is normally supported by G10 flexures. To protect these flexures during shipment, an additional set of three solid steel shipping brackets between the dewar and bench will be installed at MIT. These will be the first items for removal. [1 hour, no support required]

2. Spectrograph camera: The camera mounts on an L-bracket and stands off from the optical bench via three customized Al shims. Its X-Y location is defined by a tooling ball press-fit into the optical bench, which mates in a precision bore in the L-bracket. Rotation is defined by a second pin which inserts into a slot in the bracket. The three shims have been serialized and will ship attached to the bench in their proper locations. With this pin+shim system that has already been determined in our lab, re-installation of the camera should take a matter of minutes. Including verification with alignment telescope the process could take up to a few hours. The camera itself will ship in the Pelican case designed by Coastal Optical for shipment of the lens barrel from their factory to MIT. [2-3 hours, no support required]

3. Prisms: The prisms mount in an assembly containing leaf springs to take up differing thermal contraction of materials. It was designed to support the prisms under varying gravity loads, not to withstand a transportation vibration spectrum. For shipment FIRE's 4 prisms will be removed from this assembly and packaged individually. The fragile ZnSe prisms will ship in the pelican cases supplied by II-VI. Reassembly of this unit takes approximately 3-4 hours [no support required].

4. ESD Workstation: Prior to handling of the detector arrays, we will set up and certify an ESD working zone in the clean room or flow bench. If observatory facilities are available we will utilize them together with our own equipment. However we will bring a full set or mats, smocks, boots etc to support FIRE completely if necessary. Our lab setup consists of dissipative bench and floor mats, a continuous wrist strap monitor, personal voltage tester, ionized air flow unit, and ESD garments. We will also bring a small humidifier and temperature and humidity monitors. [3 hours, some advice and support required]

5. Detectors: FIRE's detectors and SIDECAR electronics will be removed from the instrument and shipped in the custom enclosure supplied by Teledyne. Once the ESD work zone has been established, this takes about 2 hours per detector. [4-5 hours, support from site staff discouraged!]

6. Alignment check of grating, LD mirror, collimator: These units will ship in the instrument, but their alignment will be verified using the D271 alignment telescope and optical bench reference fixture (which we used to align them at MIT). The procedure is fairly straightforward and takes 1-2 hours.

## Transportation from Clean Room to Summit

Once re-assembly and verification is complete, the clean room hoist will be used to lift FIRE off its handling cart and place it back on the shipping platform. The shipping unit will be used to transport the instrument to the summit by truck. A hand-pulled fork truck will be used to transport the instrument to the clean room loading dock and onto the vehicle. At the summit, a forklift will be used to lower the instrument package back onto the hand cart. The cart is raised to the dome floor on the dome lift, and prepared for instrument hoisting to the folded port. [2 hours]

## Lifting Procedure

FIRE will be lifted to the folded port using the standard Magellan lifting fixture. The instrument lifting cylinders intersect the CG, and the total weight can be measured prior to lift for the purposes of telescope balancing. This is also useful for pre-loading the crane when FIRE is taken off the telescope.

Pre-installed bullpins will guide placement of the instrument on the folded port rotator and ensure repeatability upon subsequent removal/reinstallation.

After torquing down the bolt circle, electrical and cryocooler connections can be made from the service lines pre-installed in the cable wrap. Telescope balancing procedures can follow. [3 hours, 2-3 site staff needed for support]

## Pumping Procedure

FIRE will be pumped on the folded port using a turbo pump integrated into the instrument dewar. The backing pump is not integrated into the dewar so it will only be connected during pump down. When FIRE is cold the vacuum is maintained by a cryopumping getter and ion pump, so the turbo pump is disengaged. [12-16 hours, occasional monitoring by instrument team and staff].

## Computing, Network Integration, and Control Software

FIRE's instrument control is handled over a private network which sits behind a hardware firewall. Single point access to the control computer (pele) is achieved via VNC connection from the Magellan control room computers. FIRE's data taking software is installed on Pele, which will command the instrument's motor controllers and also command the two PCs running the SIDECAR ASIC electronics.

While the mechanical team members are re-assembling the instrument in the clean room, the software team will work to integrate FIRE's computing system into the mountain network, and establish communication with the TCS.  The TCS link is needed both to control small telescope pointing offsets, and also to obtain image header data.

# Section 3:
# Scientific Commissioning Plan

# FIRE Scientific Commissioning Plan (Rev A)

**Scope**: The scientific commissioning plan includes items which require open-mirror/on-sky access to complete.

The majority of these will be completed during the initial engineering and instrument installation run. Remaining items will be completed using commissioning time drawn from MIT's institutional allocation of Magellan nights during 2010A.

## Alignment of Telescope Pupil with Cold Stop

FIRE's cold stop is located in front of the slit, as the second element of its Offner Relay. Alignment of the cold stop with respect to the telescope pupil is achieved by adjusting the tilt of FIRE's optical axis with respect to the telescope.

The instrument design includes an "optical bench interface plate" (OBIF) which indexes the cold optical bench directly to the warm telescope mount, through a spacing riser. The optical bench is pre-aligned in the lab on a granite table, to be precisely parallel to the telescope mounting surface. Fine adjustment of the tilt will be done at the telescope after installation. When FIRE is mounted on the folded port, the tilt of the OBIF may be adjusted by a set of spring-loaded nuts on 3/8-40 rods. The weight of the dewar is supported by a set of jack stands integral to the instrument during this procedure, since the bolt circle attaching the OBIF to the instrument will be loose.

Once final tilt has been achieved, we will measure the OBIF-instrument spacing at each bolt location using a feeler gauge, insert aluminum motor-mount shims of the proper thickness, and torque down the OBIF bolt circle.

Alignment of the pupil will be verified in two ways. First, since the slit-viewing acquisition camera sits behind the cold stop, we can use it to examine the symmetry of defocused telescope images. This may be done in the afternoon using scattered dome light with the mirror covers open. We piston the telescope secondary out of focus and take images with the slit viewer. If the telescope pupil is not aligned with the stop, the usual "donut" shape will be lopsided. We then adjust the tilt of the instrument until the out of focus image appears once again symmetric.

Fine adjustment of the tilt will be verified by measuring the thermal background in the spectrograph when the telescope is in focus. A series of small adjustments will be made to the tilt and the background in K band recorded until the lowest background is achieved. A set of depth gauges measures the height of the OBIF at three locations so that this procedure is deterministic and repeatable.

**Determination of Shack-Hartmann Focus Offsets**

Baade will be focused on the spectrograph slit in the usual fashion, using images from the slit viewing camera. The telescope operator will piston the secondary to obtain a visual focus on the slit. Then, the Shack-Hartmann camera will be run through an offset sequence so that the primary mirror can be settled at each probe location. For each offset the image quality at the slit is recorded, and used at the end of each sequence.

**Alignment of Pointing Center**

Since FIRE's field of view is small (max +/- 30 arcseconds on the guider) we expect that the telescope's image quality will be excellent across the whole field. For this reason, if there is any slight offset between the pointing center of FIRE versus Baade, we expect to take this up by simply introducing a small offset into the telescope pointing model. This offset should be limited to the 5-10 arcsecond range at most.

Provisions exist for laterally articulating FIRE on the OBIF bolt circle. The range of motion is limited, restricted to the clearance on the bolt holes. We do not expect to make use of this feature at commissioning.

**Standard Star Observations**

Instrument sensitivity will be measured at the beginning of installation using standard stars. Unfortunately in the IR there is not a good set of true spectrophotometric standards available as in the optical. To measure the sensitivity, we will observe G stars of known magnitudes at several different airmass values. Their spectra can be matched to a Solar template, with absolute fluxed normalized to match calibrated broadband photometric magnitudes. This is a standard procedure for IR flux calibration.

A small number of white dwarfs with low hydrogen absorption have been tabulated with model atmospheres into the IR. Most of these are only visible from the North, but a few are visible. For example GD71 at 05h+15 can be seen from Magellan in the early spring and is tabulated out to 3 microns. We will observe one or more of these stars if they are up to obtain an independent measure of sensitivity.

Since FIRE will likely be used for velocity work, we will also observe a small set of radial velocity standards at commissioning. These will be used primarily to assist in the development of data reduction software during FIRE's commissioning period.

**Acquisition Camera TCS Interface and Rotation Center**

The acquisition camera interfaces with the TCS via TCP/IP link. The instrument control panel includes provisions for making small offsets along the slit and nodding for spectroscopic observations. If needed, FITS frames from the acquisition camera can also be provided to the telescope operator for use with the standard Magellan guiding software.

The communications link between the acq camera software and TCS will be established during installation (i.e. off-sky) in parallel with instrument reassembly. Once on the sky, some time will be needed to establish the parity and plate scale of images and test offset software. We will also rotate the instrument to determine where the center of rotation for the slit viewer is located in acquisition detector coordinates.

## **Flexure**

The instrument till be articulated to several positions during the afternoon to take arc lamp spectra from the dome lamps. This will be done through the full range of instrument rotator angles and for different telescope elevation angles. We note that under normal operations at the central folded port, the instrument is fixed with respect to the parallactic angle, and very few users will be rotating the instrument far from this nominal orientation.

For end to end calibration, this could also be done on the sky during twilight, using the atmospheric OH lines to measure flexure.

# Section 4:
# Institutional Commitment Letter

MIT Department of Physics
**Edmund Bertschinger, Department Head**

November 10, 2009

Dr. Wendy Freedman
Carnegie Observatories
813 Santa Barbara Street
Pasadena, CA 91101

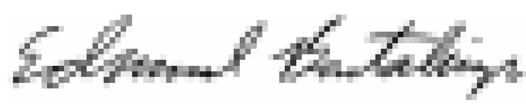
Dear Wendy:

Pending successful completion of pre-ship requirements, FIRE will be commissioned on the Baade telescope during the 2010A semester. As a planned facility instrument, FIRE will be installed during consortium engineering time, with the support of site staff to smooth its interface with the telescope. Subsequent observing time devoted to its full commissioning is furnished from MIT's institutional Magellan allotment.

Because of FIRE's relatively low complexity and compatibility with the existing folded port guiders, it is expected that a minimal amount of engineering time will be needed for installation, perhaps three nights. FIRE is under heavy demand from instrument team members, so we expect to allocate at least 5 nights from MIT's scheduled 11 in 2010A for FIRE commissioning observations, and probably more. The present plan is to install FIRE in late January, so this time would be distributed throughout the semester.

Please let me know if there are any other points which require further clarification. We are excited to see FIRE installed on Magellan and look forward to the new science it will produce.

Sincerely,



Edmund Bertschinger
Professor and Head,
MIT Department of Physics

Cc: Paul Schechter, Robert Simcoe

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# Section 5:
# List of Performance Goals

| FIRE Commissioning Performance Goals | | |
|---|---|---|
| **Item** | **Goal** | **Justification** |
| Spectral focus | 2 pixels | Nyquist sampled minimum slit of 0.3” |
| Spatial Focus | 2-3 pixels | Better than 0.3” across field, varying from anamorphic distortion |
| Throughput | SNR of 10 or better for J=18 in several hours (or throughput >20%) | Sensitivity required for observations of J>18 high-redshift QSOs |
| Detector Noise | <25 e- RMS (per CDS) | Design requirement |
| Spectral Resolution | 6000 for 0.6” slit | Design requirement |
| Residual Image | <0.2% after 5 minutes | For flat fielding, standard star observations before faint objects |
| Flexure | <0.1 pixel over 30 degree change in rotator angle | Single-exposure stability for generous maximum exposure time |