**System Overview**

The observer controls the instrument via a native OS X cocoa application running on the Magellan Clay observer's workstation. The front-end application performs simple command translation and communicates with the instrument control computer via a TCP socket connection. Plate files (PERHAPS AN EXPLAINATION) and instrument logs may be copied to and from the instrument (as appropriate) via a standard network share with drag-and-drop file operations in the OS X Finder.

The instrument control computer is a Beagleboard xM (a 1GHz ARM 512MB RAM 16GB flash hard disk single-board-computer) running Angstrom Linux 3.2. This computer handles all communication with the outside world, runs the majority of the instrument control software, and controls spectrograph components (with two exceptions see following paragraph) via USB (barring the fiber imaging & illuminations subsystems; see subset XXX).

The instrument subsystems are: spectrograph table motion, slit motion, fiber imager, temperature & shock monitoring, battery backup, shutter (controlled directly by the CCD sidecar), Shack-Hartman, guider, plugging feedback, fiber illuminator, and calibration lamp unit. The calibration unit, although designed for M2FS, will be a facility component and thus not controlled in any way by the M2FS control computer.

Electronics enclosures are located on all three instrument components, with the primary electronics box mounted on one end of the spectrograph cart and connected to the conical mount and secondary cage electronics boxes via USB (conical mount) and Ethernet & TTL over multimode fiber (secondary cage).

The following systems are located within the primary electronics box or within the spectrograph enclosure.

**Spectrograph Motion** Each spectrograph uses eight axes: focus, disperser slide (used to switch between HiRes and LoRes modes), HiRes azimuth and elevation, LoRes elevation, filter exchanger (2 axes), and fiber imager pickoff. A Galil Motion Control DMC-4183 handles low-level details such as limit switches, encoders, backlash, interlocks, and calibration of these axes. We use the DMC-4183, as observatory staff is familiar with its operation.

**Slit Motion** We use a custom eight-axis stepper controller embedded in each fiber shoe to handle low level control of the tetris slits. It consists of a custom drive board mated to an Arduino Mega 2560, which is an ATMEGA based embedded microcontroller. See the associated paper for details.

**Datalogging** The instrument is equipped with three customized Arduino Pros each equipped with an Adafruit Industries Datalogger Shield, digital temperature sensors, a three-axis accelerometer and an SD card. Four “C” cell batteries should power each datalogger for the life of the instrument. Each unit records temperature readings every minute and any impact or freefall event above a certain threshold. The instrument computer downloads and collates logged automatically whenever powered.

**Battery** The battery backup system consists on an off the shelf UPS connected to the instrument control computer. In the even of a power outage, should less than a preset amount of battery life remain the instrument will safely power down.

**Shutter** M2FS uses two Uniblitz CS-90 iris shutters, both driven by a multi-channel driver from the same manufacturer. The shutter is actuated by a level transition from the CCD sidecar electronics directly to the Uniblitz controller and is not typically controlled by the instrument computer. An arduino hooked to the controller’s override provides state monitoring and the ability manually open the shutter (MARIO, THIS IS ONLY IF YOU WANT IT, I KNOW WE TALKED ABOUT IT).

**Fiber Imager** The fiber imager is a custom high-speed (18kHz) imaging system used to image the fiber ends during plugging and slit positioning. When used in conjunction with the fiber illuminator the imager allows the instrument to compare fiber plug positions against a user-supplied list. The imager is also used to monitor fiber throughput during slit positioning.

The following systems are located in the Conical Mount electronics box.

**Guider** I’m not confident enough in how this system will work to really say anything, I’m punting.

**S-H** TODO

**Plugging Feedback** M2FS uses a pair of computer speakers and a character display to provide auditory and visual feedback doffing the fiber plugging process. When used together the fiber illuminator & fiber imager provide real-time determination of any misplugged fibers. The instrument is thus able to notify the plugger as they make the mistake and, should they decide not to correct it, mark the fiber as misplugged in the FITS header.

These last two systems are in the secondary cage.

**Fiber Illuminator** TODO

**Calibration Lamp Unit** The M2FS calibration lamps consist of XXX and are controlled by the observatory software.

Control concepts

The general concepts are as follows: 1) use standardized communications and interfaces whenever practical, 2) prefer premade cables to custom wiring, 3) use USB (see 1), use open-source and hobbyist electronics solutions whenever suitable.

System status

The system architecture is completely mapped out. Wiring for the spectrograph cart is 90% finished. Barring the Guider, parts are in hand for the conical mount enclosure (S-H, plugging feedback). Shoe electronics have been fabricated and verified.

Electronic components

* Beagleboard xM
  + 1GHz 512MB DDR ARM Single-Board-Computer
* 2 Galil DMC-4183 8 axis stepper motor controller
* 2 Fiber Shoe controllers
  + custom 8 axis stepper driver mated to an Arduino Mega
* 2 Uniblitz CS-90 Shutters
* 1 Uniblitz multi-channel shutter driver
* 1 300VA UPS
* 1 Fiber Illuminator
  + 1 Microvision PicoP PDK
  + beagleboard xM + projector module
  + Controlled by main computer over 100BASE-FX ethernet
  + Projector HSync and VSync monitored by Fiber imager via TTL-to-fiber
* 1 Fiber Imager
  + 8 Hamamatsu 18kHz line rate linear CMOS arrays to image fiber ends
  + Each set of 4 connected to a custom multiplexing analog front end (AFE)
  + AFE data is captured and formatted into standard webcam format via a custom FPGA-based expansion board for the BB xM.
* 1 Pololu Simple Motor controller for the S-H
* 1 Arduino for the S-H LED
* 1 pair USB speakers for plugging feedback
* 1 20x4 character display for plugging feedback
* 3 Dataloggers
  + Analog Deviced 3axis accelerometer
  + ~5 13 bit digital temperature sensors
  + Battery powered for life of instrument
* 1 Arduino For primary electronics box monitoring
  + lights in the box when door opens
  + soft-power switch
* 1 Guider Camera thingy
  + 1 composite video usb capture adapter (ASSUMING NO OCIW GUIDER)
  + Arduino controller hobby servo for guider filter