NIC-FPS 1-Year Review

Mechanisms, Instrument Control & Detector

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- **Mechanisms Overview**
  - **Remote motor control**
    - 4 moving mechanisms (3 filter wheels, F-P linear stage)
    - 2 or 3 switches per mechanism (proximity switches)
  - **Remote temperature and pressure monitoring**
    - Monitor several locations inside dewar (60-300K)
    - Monitor dewar pressure (10^{-3} to 10^{-7} Torr)
  - **Remote communication**
    - Standard protocol (Ethernet, RS232)

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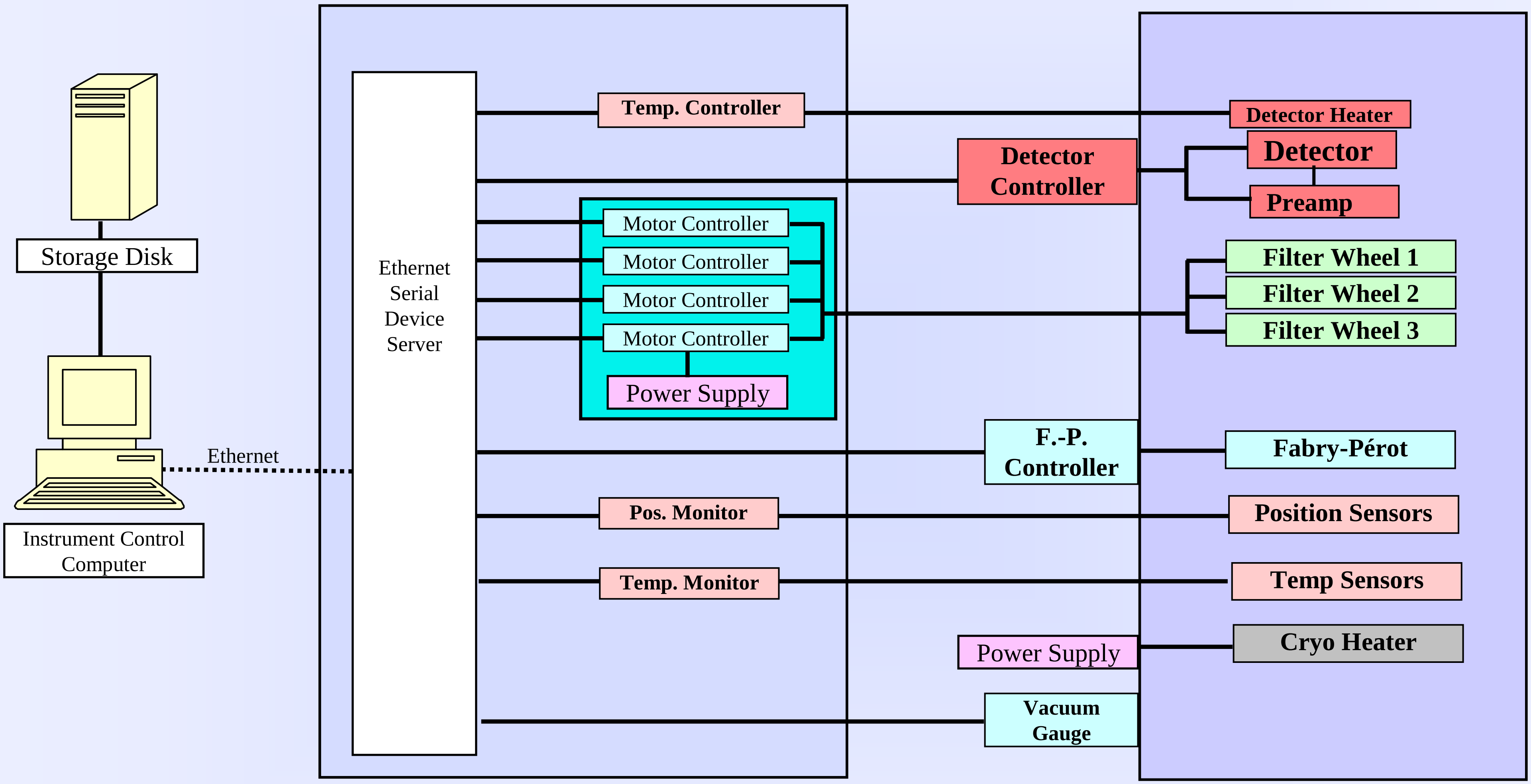

Remote Motor Control

- Serial RS232 Motor Controllers API Motion DM224i
- 4 cryogenic stepper motors

Remote Temperature and Pressure

- Temperature Sensors (Lakeshore PT-111)
- Serial RS232 temperature monitor (Lakeshore 218)
- Serial RS232 pressure monitor (Varian eyeSYS mini-BA)

Remote Communication

- Ethernet from Instrument Control Computer (ICC) to Serial Device Server
- RS232 from Serial Device Server to instrument devices (National Instrument NI ENET-232)

NIC-FPS 1-Year Review

- **Instrument Control Software**
  - Provide user-friendly control of all aspects of the instrument
    - filter wheels
    - F-P linear stage
  - Maintain and inform user of status of instrument
    - Filter wheel positions, temperatures, pressure, detector state, F-P position and spacing
  - Software under version management
  - Documentation will be provided
  - **Adhere to ARC standards (using new Python Instrument Control Interface & scripts)**
  - Observing scripts: F-P scanning, Co-adding images, Multiple Sampling Readout (to beat down read noise), Exposure Time Calculator, …

Detector:

Rockwell/Hawaii-1RG MBE 1024×1024 HgCdTe

- JWST type with several enhancements over Hawaii-1, such as reference pixels and selectable postage-stamp readout
- Under development (with JWST providing significant funding)
- Rockwell in-house testing indicates excellent QE, read noise, and dark current performance
- Cost ~$295k (incl. drive electronics and fiber link)
- Delivery Schedule:
  - April 2003: Engineering-grade array + drive electronics + basic operating S/W
  - September 2003 (possibly as early as June): Science-grade array
- "2 output channel" version [actually 2 output channels + 1 reference output channel + 1 window mode channel = 4 output channels] (may be revised)
  - 4 ADC for 16-bit SLOW (100 kHz) readout
  - 4 ADC for 14-bit FAST (5 MHz) readout
  - "Fast RS-232" for ~100k-baud rate

PARAMETER	SPECIFICATION	COMMENT
Wavelength range	0.9-2.5um	2.5um MBE HgCdTe
Format	1024x1024	HAWAII-1RG readout
Active pixels	1016x1016	4 rows/columns of embedded ref. pix
Pixel pitch	18µm	HAWAII-1RG readout
Outputs:		
Active pixels	1, 2, or 16	H-1RG selectable
Reference	1	Simultaneous w/ other out
Window	1	Interleaved w/ other outputs (Can also use active pixel output)
Data rate per output:		
Slow mode	100-200 kHz	H-1RG selectable (slow/fast modes)
Fast mode	<= 5 MHz	Fast mode has selectable gains, x1-16
Min. integration time		
Slow mode	2.62 sec	2 outputs at 200 kHz
Fast mode	105 msec	2 outputs at 5 MHz
Window frame size	Arbitrary	Any rectangular frame
Window frame location	Arbitrary	Anywhere within the 1024x1024
Window frame readout	Interleaved	User defined duty cycle
Operating Temp	77K	Set by Idark requirements
Gain conversion	250-380 e-/mV	Typical. Cdet & Vbias dependent
Quantum efficiency	> 65%	1-2.45um; Goal > 80%
Mean Well depth	> 60,000 e-	Goal > 1.0E5 e- (Vbias ~250mV)
Mean Idk	< 0.1 e-/sec	Goal < 0.01 e-/sec
Mean Nread		
100 kHz mode	< 20 e-rms CDS	Goal < 10 e-rms CDS
5 MHz mode	< 100 e-rms CDS	Goal < 50 e-rms CDS
Operability	> 95%	(QEpix > 0.5*mean QE); Goal >98%
Uniformity	<= 10%	1 sigma; Goal < 5%
Linearity	<= 1% (10-90%)	Calibratable linearity
Power dissipation	< 2mW (22mW)	Slow (Fast) mode; 2 outputs additional 2mW (5mW) for Ref+Window

Recent changes for the H-1RG procurement:

- RWSC is shipping an array configured for 16-output channels [+ 1 reference + 1 window = 18 output channels total], though drive electronics only use 2+1+1 output channels (may drop ref pixel and window outputs; add bias line)
  - Additional electronics boxes to accommodate all 16+1+1 output channel = $62k
- Added 4th mounting post for “thermal symmetry”
- Switch from Invar to Copper-Tungsten for stud/pin material
- Cavity to accommodate future on-chip ASIC
- Some changes to wirebond pin-grid array

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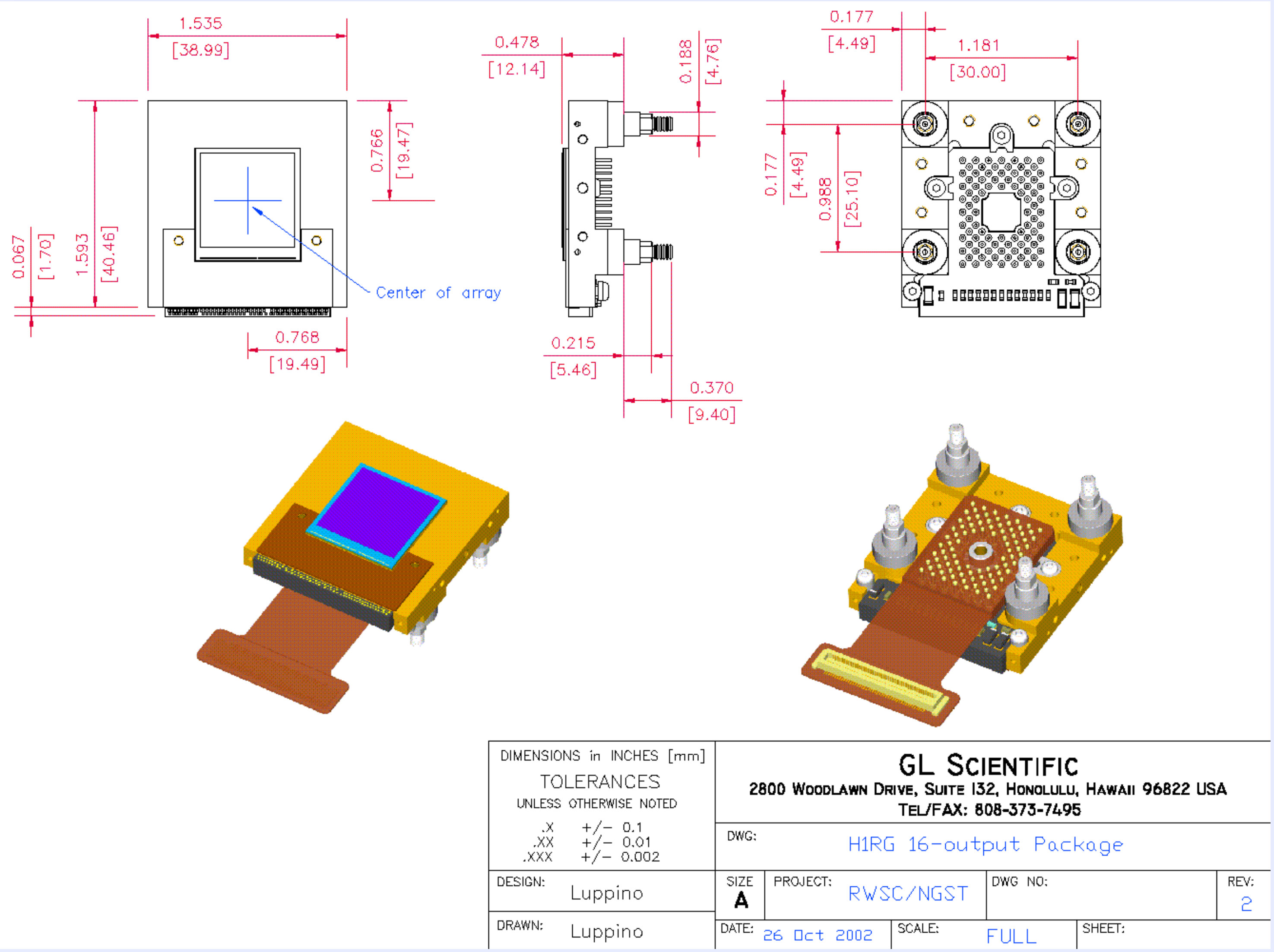
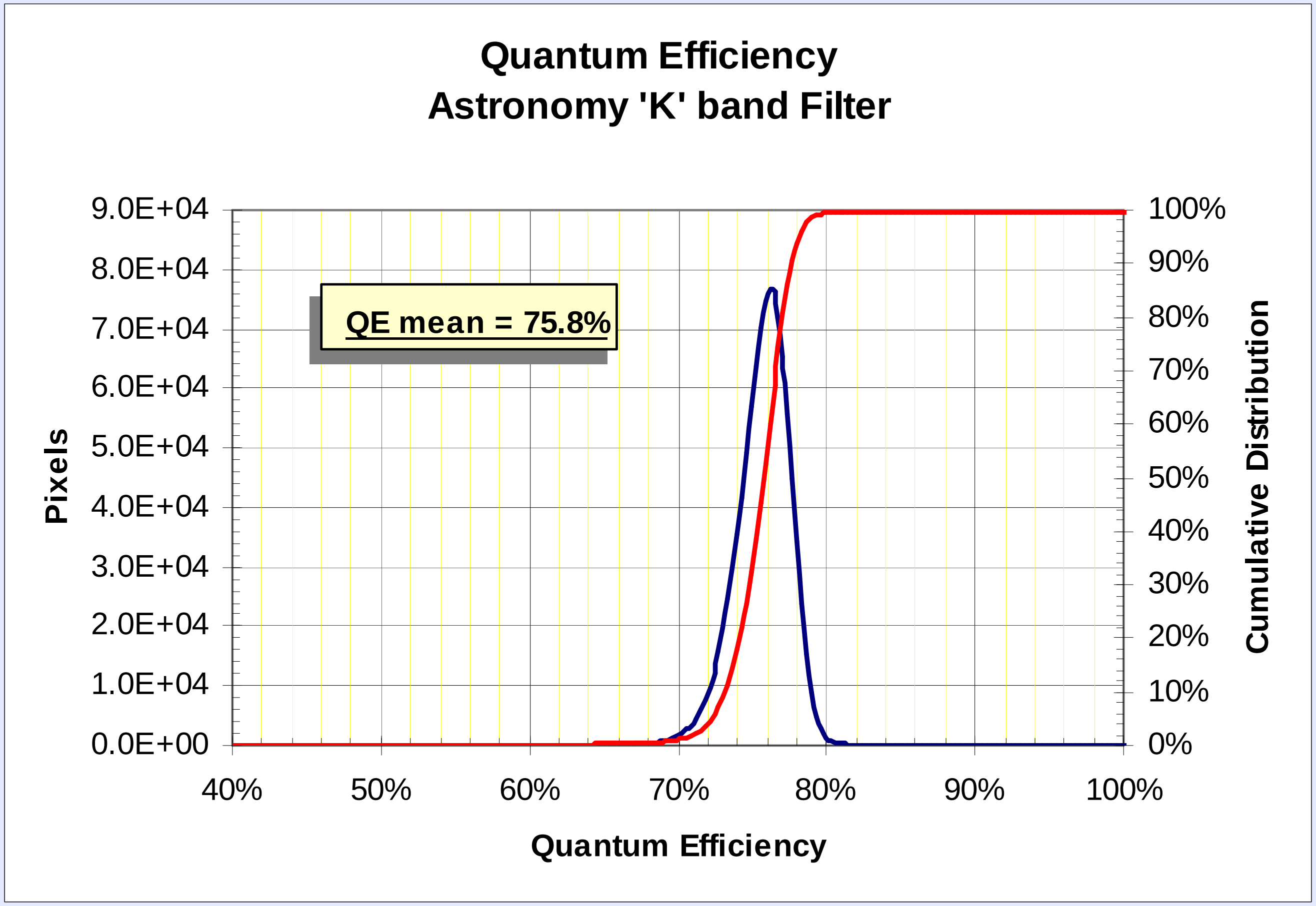
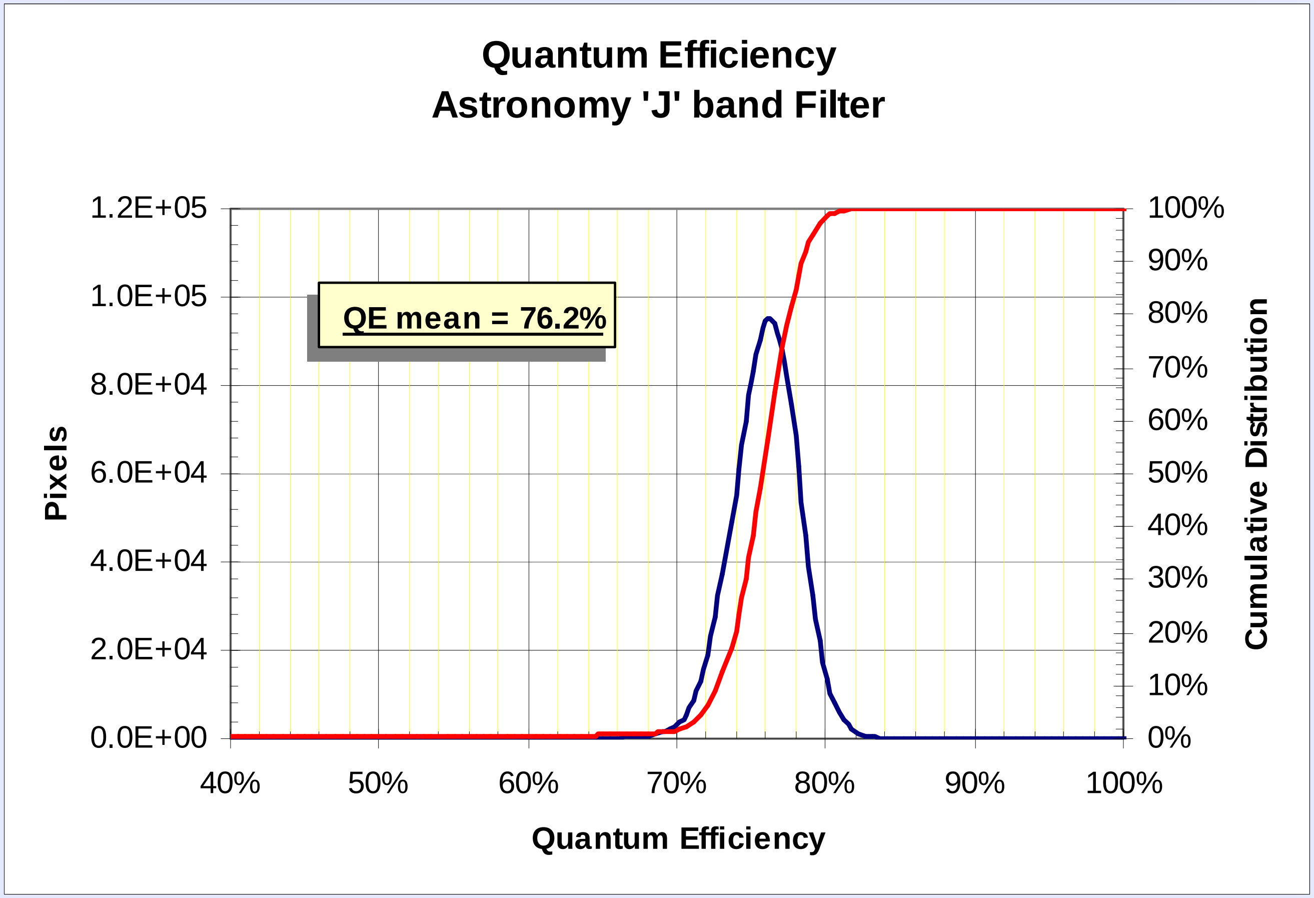


H-1R July 2002



H-1R July 2002



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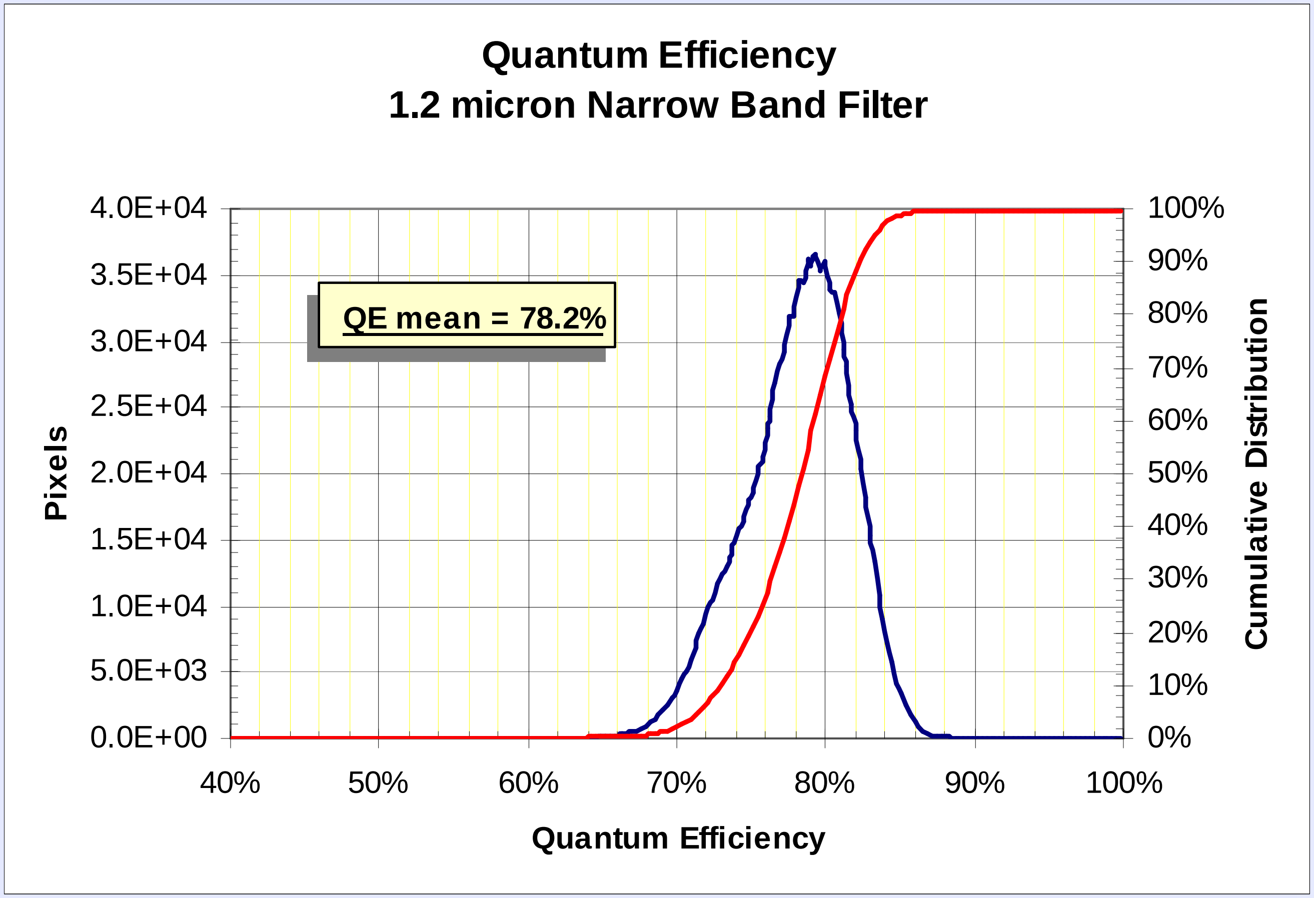

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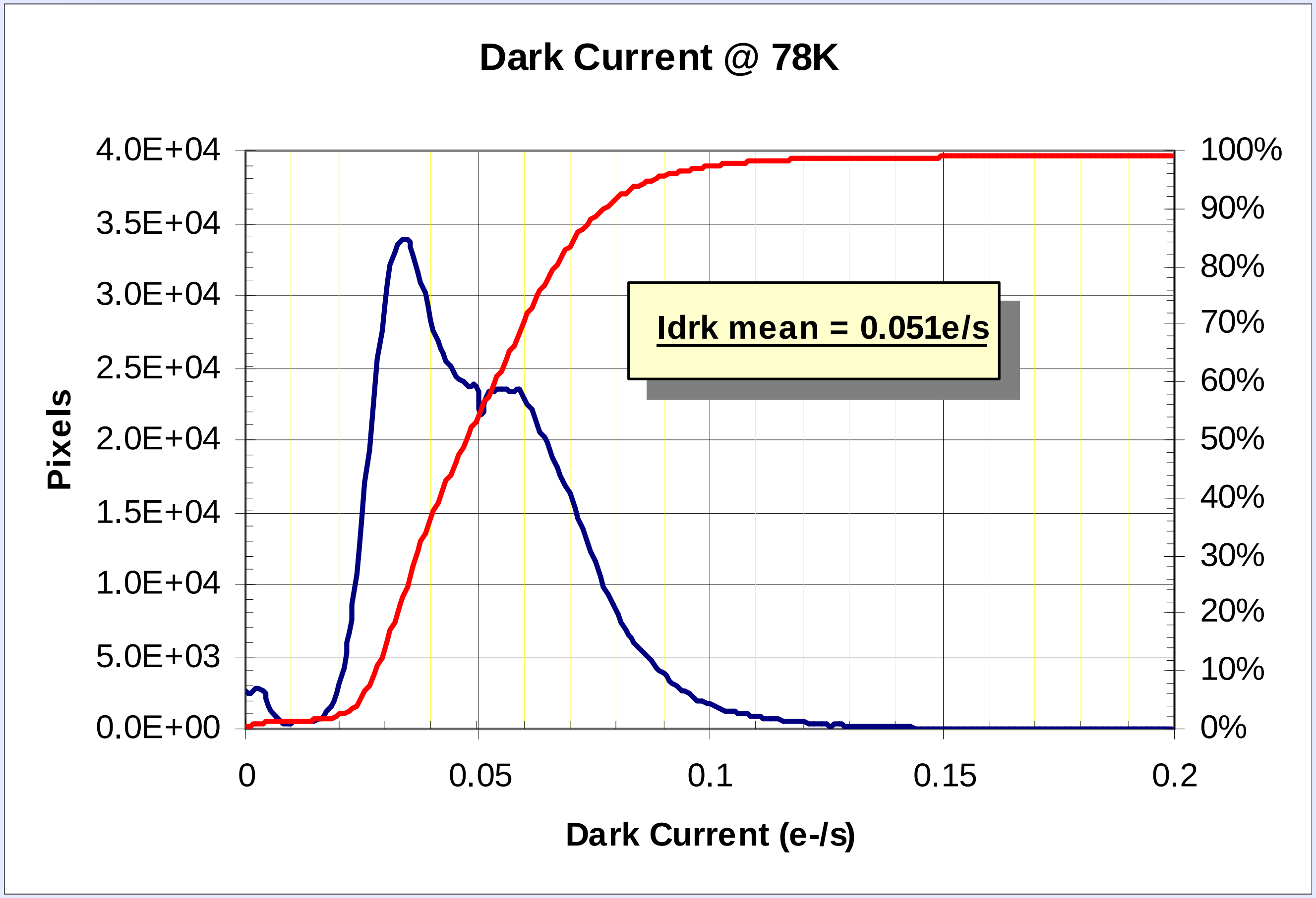


Ball Advanced Infrared Laboratory (Facilities)

Focal Plane Characterization Test Station

Focal Plane Characterization Test Station

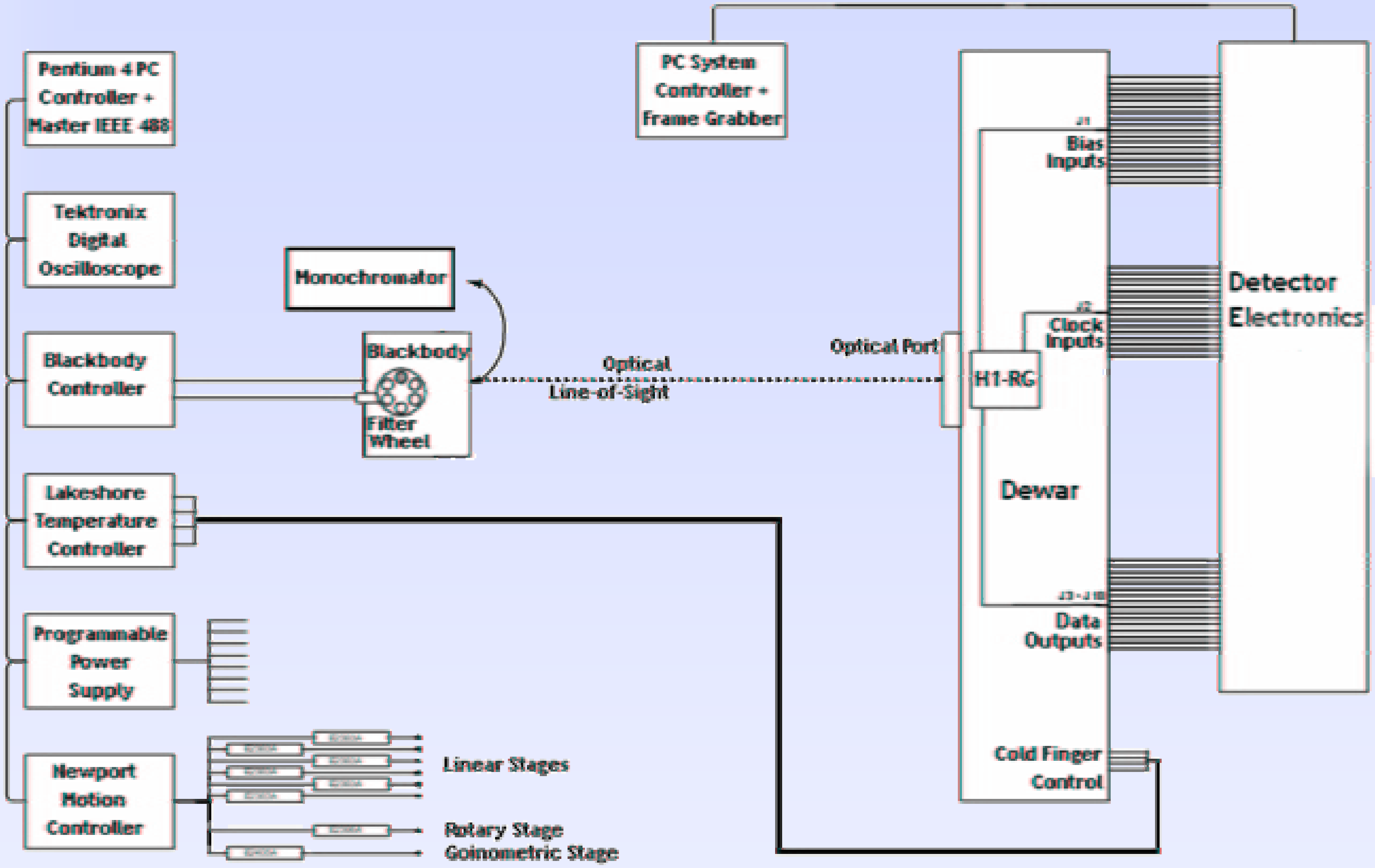
Focal Plane Characterization Test Station

ESD Clean Bench and Electronics Assembly

Ball Advanced Infrared Laboratory (Equipment & Capabilities)

- General Equipment
  - Optical Tables
  - Blackbody Sources
  - Test Dewars, Many Sizes
  - Vacuum Pumps, Roughing and Turbo (<10^{-6} Torr)
  - IR Monochromator
  - Lab Power Supplies
  - Precision Low Noise Power Supplies
  - ESD and Flow Benches
  - Electronics Assembly and Repair Workstation
- General Capabilities
  - IR Focal Plane Characterization
  - Cryo / Mechanical Design and Manufacturing
  - Focal Plane Drive Electronics Design and Manufacturing

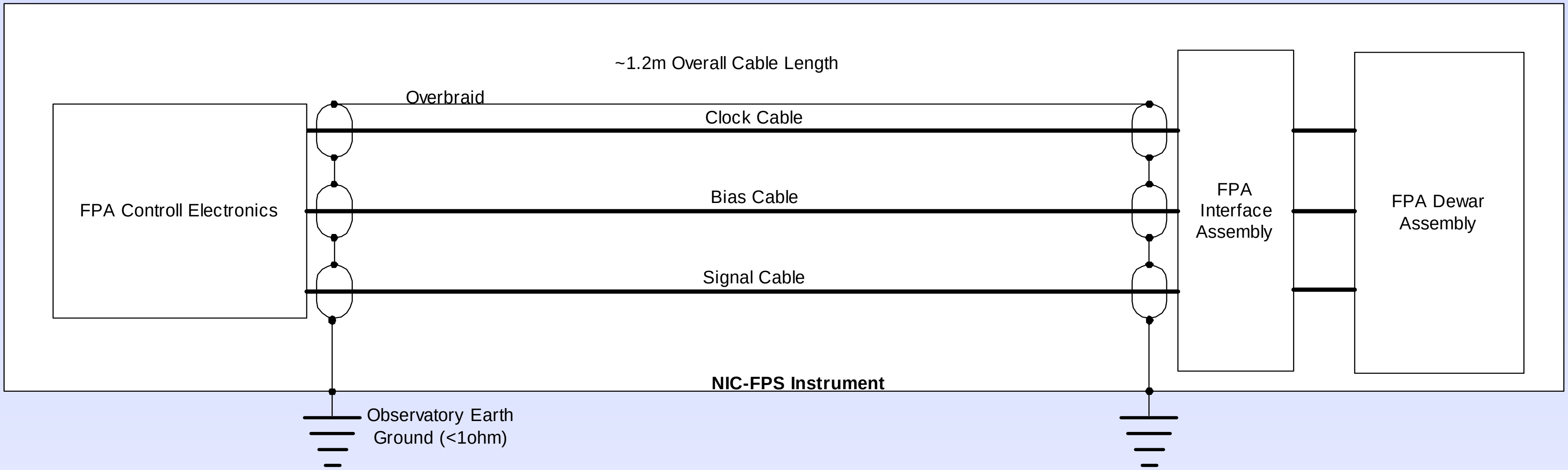
NIC-FPS H-1RG: General Test Setup Diagram



NIC-FPS H-1RG

- NIC-FPS Specific Needs
  - Mechanical
    - Cold Plate Assembly for Dewar Level Tests (Thermal Interface)
  - Electrical
    - Dewar Interface Adapter (Electrical Interface)
    - Focal Plane Electronics to Dewar Cable
  - Software
    - Image Manipulation Routines
    - Image Analysis Routines
      - Uniformity / Bad Pixel Map, etc.

NIC-FPS H-1RG: Top Level Cable Diagram



Overbraid = Faraday shield of coax/twisted pair cable bundles to mitigate noise pick-up

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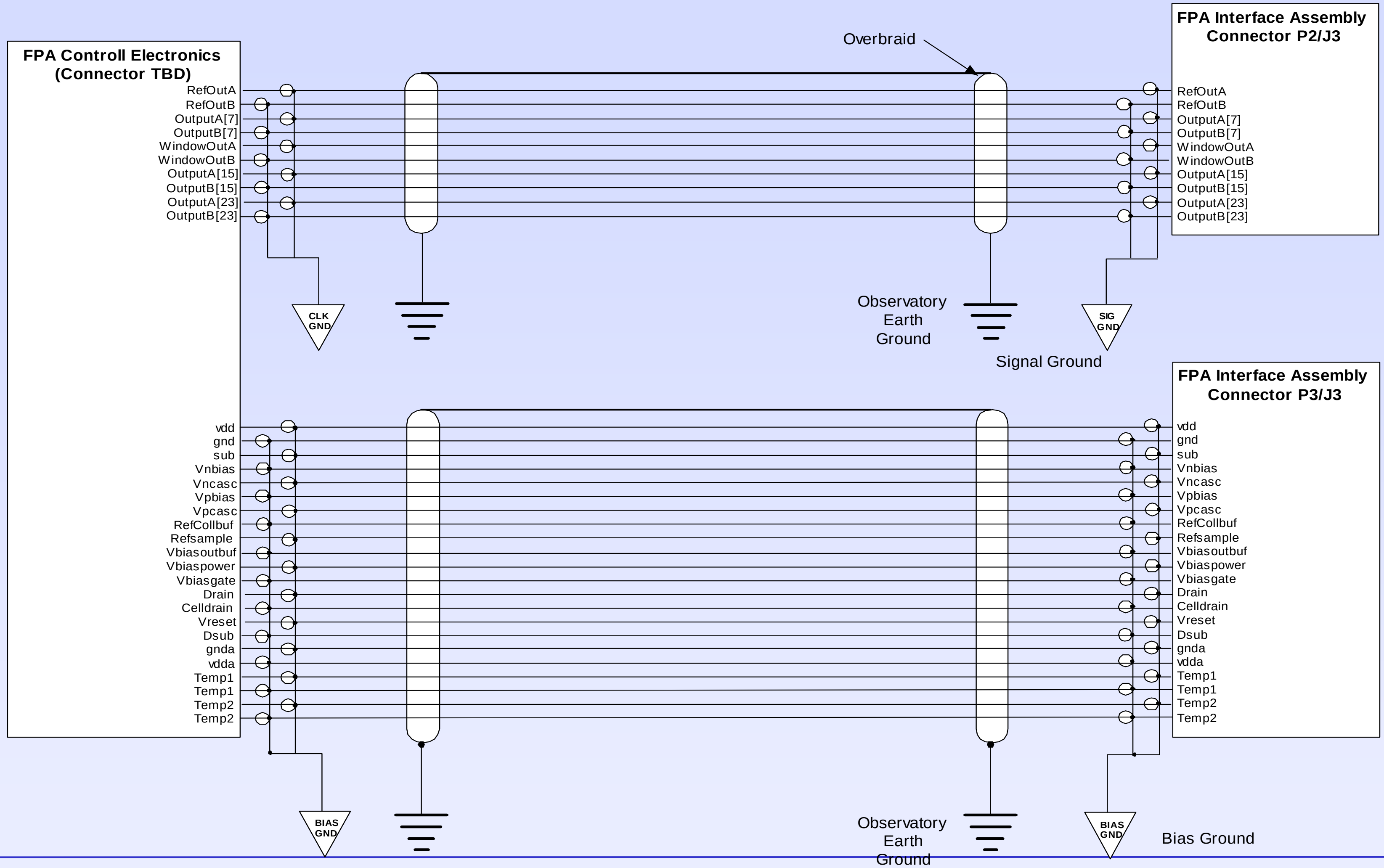
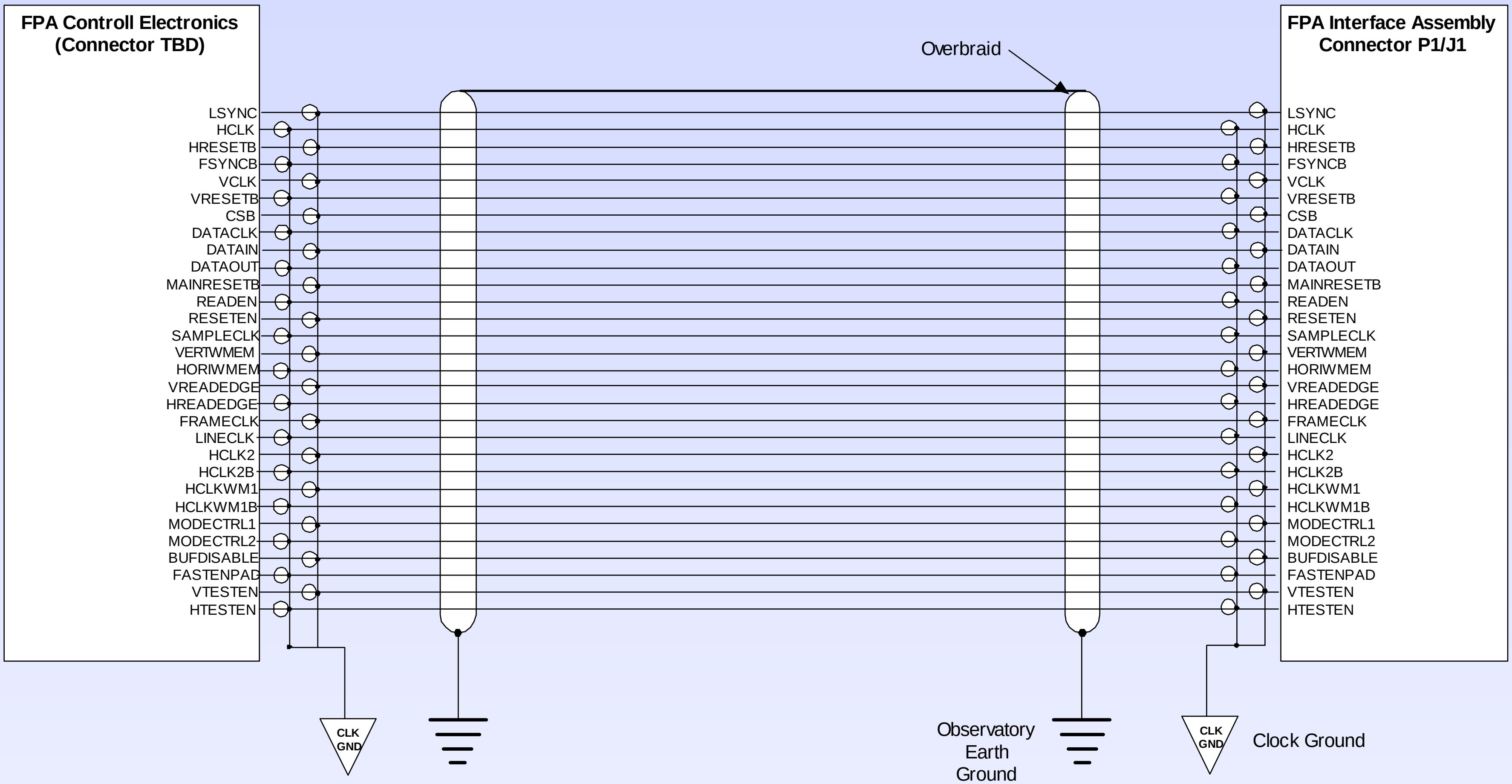
NIC-FPS H-1RG: Cable Diagram, Bias & Signals



NIC-FPS H-1RG: Cable Diagram, Clocks



NIC-FPS H-1RG: Characterization Tests

- Tests Performed at J, H & K bands
- Detector Level Tests Performed in Dewar
  - Noise [Dark, Read, Electronics, etc.]
  - Quantum Efficiency [f(x,y), intra-pixel]
  - Quantum Efficiency Stability [f(T)]
  - Image Persistence
  - Uniformity
  - MTF / PSF [knife-edge scan to determine cross-talk]
- Instrument Level Tests (Mimic NIC-FPS Electronic Configuration)
  - Cold preamps
  - Noise [Dark, Read, Electronics, etc.]
  - QE
  - Uniformity
- Readout Modes
  - FAST, SLOW rates
  - Windowing
  - CDS, Fowler sampling, up-the-ramp sampling

NIC-FPS H-1RG: Noise Mitigation

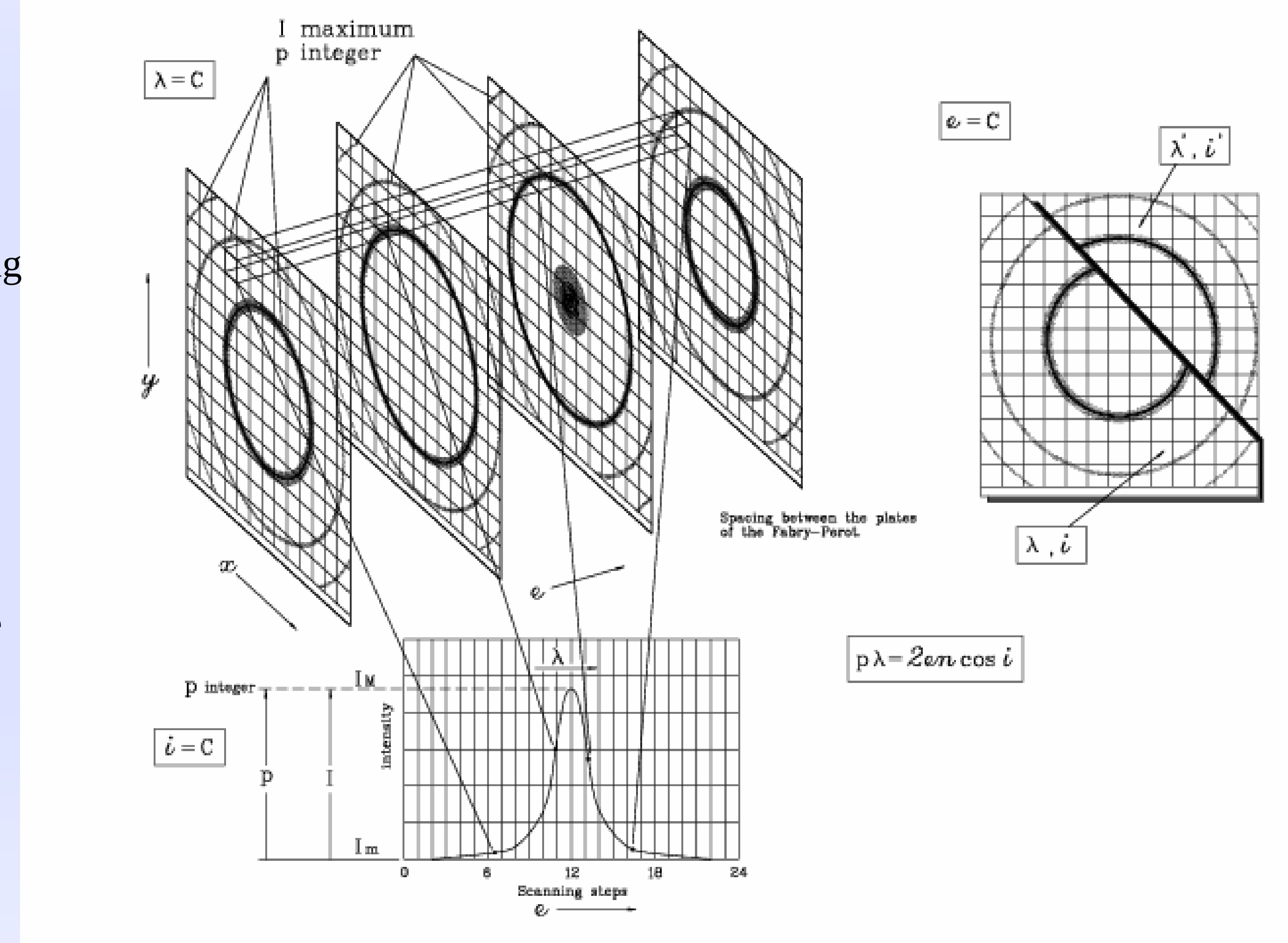
- Good Cabling Design Key to Noise Suppression for Detector Level and Instrument Level Tests.
- Instrument Cabling will be designed to minimize noise through the use of shields for all signals and a Faraday overbraid for the three main cable groups.
- Twisted-Shielded wire pairs will be used for all output channels.
- Passive or Active Termination will be used when required.
- Instrument Level Noise Reduction will use Detector Level Test Results as Baseline.

Data Reduction Software (Imaging Mode)

- Detector (non-destructive) read out: Reset, Reference Frame, Integration, Raw Frame
- Co-add N frames: in controller or computer memory or post processing with referencing
- Flat field for each filter position (“dome”, or sky)
- Bad pixel map
- Cosmic ray cleaning
- Geometric distortion map
- IRAF, IDL
- Assuming average 10sec exposure and 50% duty cycle over 10 hours (2MB per image)
  - 3.6GB per night of unprocessed data

Data Reduction Software (Fabry-Perot Spectroscopic Mode)

- Standard image processing
- Generate phase map
- Extract spectrum:
  - any region, any sampling
- Standard spectro. reduction
  - wavelength calibration
  - photometric calibration
- IRAF, IDL
  - IRAF routines available



Observing Procedures

- Imaging Mode:
  - Adjust focus (filter change, mode change)
  - Take flat fields for every filter to be used during observations
- Fabry-Perot Spectroscopic Mode:
  - Adjust focus (filter change, mode change)
  - Adjust/verify etalon’s parallelism at setup
  - Measure etalon’s scanning constant (Wavelength / Binary Coded Values)
  - Perform wavelength calibration (lamps or OH lines) at spacing to be used during observations
  - Take flat fields at every combination of spacing and filter to be used during observations (White Light Cube); good stability will mitigate need for frequent White Light cubes
  - Calibration Stars