National Optical Astronomy Observatories

# NEWFIRM

## SYSTEM DESIGN NOTE

| **Title:** NFM-AD-02-1104 Array to Dewar Wall Wiring Concept | | | | | |
|---|---|---|---|---|---|
| **Prepared by** | **Date** | **Approved by** | **Date** | **Rev.** | **Rev Date** |
| Probst, Penegor, Andrew | 9/30/03 | | | | |
| **Related documents:** | | | | | |
| Related documents are SDN 1102 Array Mosaic Baseplate Requirements, and SDN 3103 Instrument Baffle Requirements. | | | | | |

**Summary/Description:** (attach additional sheets as required)

This SDN describes the concept for the electrical wiring that goes from the 2K x 2K array elements, through intervening connectors and stations, to connectors on the Dewar wall. The concept addresses connector sizes and locations, cabling, thermal stationing, and support for signal buffering electronics. It places requirements and restrictions on detailed mechanical, electrical, and thermal design, including the array mount assembly, wiring harness, active and passive shielding, and custom made printed circuit boards.

# NEWFIRM

## SYSTEM DESIGN NOTE

## NFM-AD-02-1104 Array to Dewar Wall Wiring Concept

| Prepared by | Date | Approved by | Date | Rev. | Rev. Date |
|---|---|---|---|---|---|
| Ron Probst, Jerry Penegor, and John Andrew | 9/30/03 | | | | |

### 1. Introduction

This SDN describes the concept for the electrical wiring that goes from the 2K x 2K array elements, through intervening connectors and stations, to connectors on the Dewar wall. The concept addresses connector sizes and locations, cabling, thermal stationing, and support for signal buffering electronics. It places requirements and restrictions on detailed mechanical, electrical, and thermal design, including the array mount assembly, wiring harness, active and passive shielding, and custom made printed circuit boards.

Related documents are SDN 1102 Array Mosaic Baseplate Requirements, and SDN 3103 Instrument Baffle Requirements. The concept presented here meets, or is consistent with, requirements in these SDN's. Subsequent detailed design shall be consistent with this concept.

In the following sections we list requirements, describe the concept including a schematic figure, and evaluate the concept against the requirements. Restrictions on subsequent detailed design are noted. An alternative, rejected concept is described briefly since it might be useful in other circumstances.

### 2. Design requirements

The wiring concept must address these general requirements, in no particular order:

1. Tight and redundant light shielding of the focal plane
2. Low heat load on cold cycle cooler second stage, i.e. at the nominal 30 K array mount
3. High efficiency heat sinking at the cold end of cables from warm environment
4. Warm ( > 65 K ) location for signal conditioning (preamplifier) electronics inside the Dewar
5. Short wiring length from arrays to signal conditioning boards
6. Easy access to cables, connectors, and PC boards for installation and troubleshooting
7. Electrical decoupling of focal plane for removal as close to the arrays as possible
8. Robust focal plane/connector subassembly to avoid damage when out of the instrument
9. Least possible number of connectors along the path
10. Least possible number of cables along the path
11. Simple and direct cable-connector relationships

Inevitably there are some compromises in the final concept. It is evaluated against requirements in Sec. 4.

### 3. The design concept

# NEWFIRM

## SYSTEM DESIGN NOTE

The concept is shown schematically in Figure 1. Explanatory notes here match labels in Figure 1.

A. Arrays and their cables are isolated on one side of a solid Invar baseplate for best light shielding.

B. Double 30 K light shield; inner forms focal plane mask above array, outer fits into groove in 65 K Optical Support Structure (OSS).

C. 65 K light shield extending downward from OSS.

D. Signals pass through baseplate via connector savers installed in it: 3 per array, 12 in all.

E. Pre-wired connector soldered directly to fanout board, three per board.

F. Mechanical protection/ light shield for pigtails.

G. Fanout board splits one incoming ~110-wire cable to 3 connectors out, matching 3 array cables. Fanout board also provides heat sinking of 70 K incoming signal lines to 30 K array mount. The four boards required for the array mosaic are mounted on the inside of a box, which is mounted in turn behind the baseplate on the stationary portion of the array mount.

H. Not shown: ribbon cables around the inside perimeter of the box connect each fanout board with its nearest neighbor. This distributes common biases and common clocks to all arrays.

I. Loose connectorless pass through of radiation shield / mechanical protection for rear connections.

J. Single ~110-wire cable per array, ~30 cm long, from array mount to active shield. There are four cables in all.

K. PC board on active shield does triple duty: (1) fanout from ~110-wire cable to two 2 x 17 connector headers for video signals and three 2 x 7connector headers for clock and bias lines; (2) heat sinking of 300 K incoming signal lines to 70 K active shield; (3) optional installation of video buffering electronics on daughter board. PC board is mounted from the inside of the active shield, with copper cladding facing the shield. There are four of these boards total.

L. The optional buffer boards use the same 2 x 17 headers and sockets and map outputs to the same inputs as found on the cold station board. The same cabling can be used either with or without these boards added.

M. Each group of 32 videos goes to a single 41-pin circular hermetic connector in the Dewar wall, using a single 34-conductor ribbon cable. The two video cables from one cold station board require two hermetic connectors, for a total of eight 41-pin connectors.

N. A total of seven 14-conductor ribbon cables are used to carry biases, clocks, and ±5 VDC buffer power to the cold buffer boards and to the cold station boards for distribution to the arrays. These terminate at the Dewar wall on two 55-pin hermetic connectors.

O. Loose connectorless pass-through of double passive shields. Pass-throughs are slotted into removable plates on the shields, and are staggered. Note service loops. Tape may be used to close up the slots after cable installation.

P. PC board with one 2 x 17 connector header wired to 41-pin hermetic connector.

Q. PC board with four 2 x 7 connector headers wired to 55-pin hermetic connector.

#### 4. Comments on concept vs. requirements

We examine here how well the concept does in terms of meeting requirements, at least qualitatively.

1. Light shielding: The focal plane is surrounded with a triple layer of labyrinthine light shielding at 30 K and 65 K. Outside the science beam, the arrays see only 30 K surfaces.

2. Heat load at 30 K: The heat load on the array mount from ~400 wires, including both the thermal drop from 70 K to 30 K and the resistive heating of 20 mA current per wire, is 2 W with 28 gauge copper wire. This is 2/3 of the (conservative) wiring heat load budget for the second stage cold heads.

3. Heat sinking: We are using a concept borrowed from GNIRS, copper cladding on a thin PC board in bolted contact with a radiation shield. The GNIRS implementation was compromised by a design change that required standing the PC boards off the shield with screws. We will maintain large area mechanical contact of this interface in NEWFIRM.

4. Warm location for signal conditioning boards: These daughter boards are attached through connectors to the heat sunk (70 K) fanout boards, but also face the inner passive shield (245 K) and are not particularly low emissivity. So they will run somewhat warmer than 70 K.

5. Wiring length from arrays to signal conditioning boards: This is estimated at 30 cm including service loop, longer than we would like but still ~3 X shorter than the total run to MONSOON electronics. The environment is also well shielded electrically by the Dewar. We regard this as a satisfactory compromise.

6. Access: There is mechanical room for installation, dressing service loops, and insertion of hands and probes for signal testing at key points. Two areas need to be monitored in detailed design: adequate space between the Dewar wall and the outer passive shield for folding cable service loops, and adequate space between the inner passive shield and the active shield for the mother board-daughter board-cable loop stackup. The latter could be dealt with locally, i.e. by insetting the portion of the active shield that holds the cold stationing boards.

7. Focal plane removal, and

8. Focal plane protection: The focal plane assembly is decoupled electrically at the four, ~110-wire cable connectors. Once decoupled, the cold stationing / fanout boards and perimeter interconnects are protected inside the cold stationing box with its lid re-installed. Wires and connectors to the arrays are protected by the radiation shields. Provision for a storage cover plate needs to be made in the focal plane baffle. We expect this assembly will be stored in a dry N2 gas environment or in a small vacuum chamber.

9. Number of connectors: A video signal passes through eight connectors from the Dewar wall to the array if the signal conditioning boards are used. This is more than we would like but is necessary to provide adequate heat sinking and light shielding. See also Sec. 5 below.

10. Number of cables, and

11. Cable-connector relationships: By doing fanouts on PC boards, we minimize the number of cables. In every case a cable runs from a single connector at one end to a single connector at the other end. The 41-pin hermetics at the Dewar wall are under-utilized in order to have a single video cable running from a cold stationing board to a hermetic assembly. This greatly reduced the number of cables and connectors at the hermetics compared to the GNIRS implementation (which has generally served as our baseline for the NEWFIRM concept).

**5. Alternative concept to reduce connector count**

We describe this briefly in order to document it for possible future use. This alternative was suggested by Paul Schmitt and has been employed in compact CCD camera heads produced by Photometrics, Inc. and running at –40 ºC.

In lieu of the multiple stations and fanout of a ~110-wire cable from 30 K array mount to 300 K, 41-pin hermetic connectors, we considered a cable passing from a hermetic, connectorless through all shields, to a board at the array mount. (This board would be cabled to two hermetics for video lines and a third for bias and clock signals.) The board would be split, with a cold side heat sunk to the array mount and a floating warm side connected to it by narrow fiberglass struts for mechanical support. A signal conditioning board would be mounted on the warm side, and temperature isolation to 30 K would be provided by 1 cm jumper loops of Constantan. There would be four such boards in all. Compared to the chosen concept, we found that:

1. The heat load at 30 K is excessive, ~10-15 W depending on the radiative cooling assumed for cables once inside the 70 K active shield.

2. ~400 Constantan loops have to be installed on the fanout boards inside the array mount box, on the array side of the disconnect (and final signal verification). Given their location, they are perhaps more prone to damage than PC boards plus connectors alone.

3. The connector savings is two out of eight, an advantage but not an overwhelming one.

4. Connectorless penetration (i.e. slotting) of the active shield is likely to be less effective, more troublesome, or both in terms of radiation shielding at this interface.

5. A much larger number of cables penetrates the active shield. Alternatively, one-to-one connection is violated on the warm end by splitting a single large cable out to multiple hermetic connections.

While points 2-5 can be addressed or accepted as compromises in the detail stage, point 1 is fatal. The heat load reduces inversely with loop length, so a 5 cm loop is needed to get down to 2-3 W load. But ~400 two inch long loops would be unacceptable per point 2. In our chosen concept, the ~30 cm cable run from 70 K to 30 K is what reduces the cold load substantially, even with copper wire, and it is not possible to shorten this run for layout reasons. While short Constantan jumpers provide a substantial temperature drop over a very short length, that is not a driver for present purposes. Use of Constantan[1] jumpers could be an excellent solution for a different problem.

[1] ConstanTAN, or ConstanTIN ? It's Constantin in Constantinople but it's Constantan in Istanbul.

National Optical Astronomy Observatories

# NEWFIRM

## SYSTEM DESIGN NOTE