Annex A

Viewgraphs

SPIRE Bolometer Array Group Meeting
Saclay September 29, 30 1999
AGENDA

Day 1: September 29

1	09.30	Introduction • Meeting logistics • Aims of the meeting • Review/revision of agenda • Status of FIRST and SPIRE	Vigroux Griffin
2	10.00	SPIRE Review Plan	King
3	10.20	July PDR Review Board report and SPIRE response	Griffin
4	10.40	SPIRE instrument design update	Swinyard
5	11.00	Review of actions	King
6		Progress reports	
	11.30	CEA	Rodriguez
	12.00	GSFC/NIST	Moseley
	12.30	Lunch	
	14.00	JPL/Caltech	Bock
	14.30	QMW (including Array Test Plan update)	Hargrave
7		Electronic system design updates (see note below)	
	15.00	CEA	Cara
	15.30	GSFC/NIST	Moseley
	16.00	JPL/Caltech	Bock
	16.30	Summary/discussion: Preparation for Nov. review	Cara
8	17.00	Splinter meetings: Array Test Plan Warm Electronics	Hargrave Cara
	18.00	End Day 1	

Day 2: September 30

9		Simulations	
	09.00	Beam profile and stray light modeling results	Swinyard
	09.30	Instrument operating modes	Griffin
	10.00	Simulations of telescope scanning observations	Oliver
	10.30	Other simulation activities	Vigroux Moseley
	11.30	Discussion: planning of future simulations leading up to detector selection	All
10	12.00	Summary of meeting and actions	Griffin
	12.30	End of Meeting	

1. MATT GRIFFIN

- AIMS OF THE MEETING
- STATUS OF FIRST AND SPIRE

Aims of this meeting

1. Review technical status of the array options
   - Test results
   - Readiness for final test phase
   - System design

2. Plan the final phase of the array test programme

3. Prepare for the Warm Electronics Review in early December

4. Review status of instrument modelling and simulation work
   - Major results so far
   - Agree programme leading up to detector selection meeting

This is the last meeting of the Detector Array Group before the Array Selection Meeting in January

Status of FIRST and SPIRE

FIRST

- **Available data rate (averaged over 24 hrs) per instrument is now 100 kbs (not as high as the 200 kbs that we hoped for)**

- **Dornier Cryostat Interface Study has started**

  - **Limited scope - no radical re-examination of the cryostat design**

  - **Study will examine problems with interfaces associated with the detector options Þ important that we participate**

  - **Study progress meeting in Munich October 20**

SPIRE

- **July PDR Phase 1 was a success overall**

  Review Board report has been received and SPIRE has responded to it

- **PDR plan has been revised (see Ken King's presentation)**

- **FTS options narrowed down (see Bruce Swinyard's presentation)**

- **Detailed optical design and layout now available**

- **Division of focal plane between the three FIRST instruments is now finalised**

- **Areas in need of urgent attention:**

  - **Electronic system designs of array options**

  - **Operating modes and their implications for the warm electronics**

Schedule of future meetings

• Warm Electronics Review (PDR Phase 2)	Dec. 6, 7	Rome
• Detector Array Selection Meeting	Jan. 31/Feb. 1	RAL
• PDR Phase 3	March 2000	TBD
• Detailed Design Review	Sept. 2000	RAL

Agenda Item 7
Electronic system design updates

Detailed information for

- The Warm Electronics Group and the Systems Team (preparation for the December Warm Electronics Review)

- Cryostat/instrument interfaces study.

Presentations to include all requirements on and specifications for (and as much detailed design information as possible) on:

- Cryoharness requirements
- Requirements for the grounding scheme
- RF filter box
- BAU
- Detector sampling and synchronisation
- Detector data reduction
    - What needs to be done to convert the raw data stream to the value assumed in the data-rate note?
- Glitch recognition
- Colin's "noise diagram" filled in
- Proposed/suggested warm electronics implementation (block diagrams/circuits/components to be used etc.)
- Warm electronics power
- Anything else that you think may be relevant to the work of the Warm Electronics Group (before it's too late . . .)

Note on Item 7:

The main purposes of this item are to provide as much and as detailed information as possible for:

- The Warm Electronics Group and the Systems Team to help them define the requirements and outline design for the warm electronics. It is very important to do this in preparation for the November Warm Electronics Review.

- The ESA/Industry study of the cryostat and instrument interfaces which is about to start. The requirements for the cryoharness and the BAU are important here. Much of the relevant material has already been presented at the July PDR and is incorporated into the IID-B - please provide any updates and check for any errors/inconsistencies.

Presentations should include all requirements on and specifications for (and as much detailed design information as possible) on:

- The cryoharness requirements
- Requirements for the grounding scheme
- RF filter box
- The BAU
- Detector sampling and synchronisation
- Detector data reduction
  - What needs to be done to convert the raw data stream to the value assumed in the data-rate note?
- Glitch recognition
- Colin's "noise diagram" filled in
- Proposed/suggested warm electronics implementation (block diagrams/circuits/ components to be used etc.)
- Warm electronics power
- Anything else that you think may be relevant to the work of the Warm Electronics Group (if it's not raised soon it might be too late . . .)

Some of these issues and the implications for the warm electronics will be discussed in more detail in the Systems Team meeting immediately afterwards. The agenda will be circulated later by Colin and Louis, but will include:

- Interface Definition and Control
- Warm Electronics (analysis of needs defined by FTS and Detector Groups)
- ESA's industrial study of the FIRST Cryostat
- AIV (outcome of alignment meeting)
- Clarification of subsystem deliverables
- Planning for Warm Electronics internal review in Nov.

2. SPIRE REVIEW PLAN

KEN KING

SPIRE Review Plans

Instrument review process takes place in 3 stages:

– *Design Reviews*
  - Preliminary Design Review
  - Detailed Design Review

  Design approved for manufacture of CQM and AVM

– *Development Reviews*
  - AVM Delivery Review
  - CQM Readiness Review
  - Critical Design Review

  Design approved for manufacture of PFM (and FS)

– *Flight Model Delivery Reviews*
  - PFM Delivery Review
  - FS Delivery Review

SPIRE Preliminary Design Review (1)

Purpose:

- *To review the instrument design with respect to the scientific goals of the instrument.* These goals are defined in the **Scientific Requirements Document**.
- *To verify that the design conforms to the capabilities and requirements of the mission (spacecraft and ground segment).* The requirements are defined in the **Instrument Requirements Document**
- *To review the plans for developing such an instrument by the required delivery date.* These plans are contained in the **Instrument Development Plan.**

SPIRE Preliminary Design Review (2)

The review process is split into four stages following progress in instrument definition

- *Review of Cold FPU subsystems Design (July 1999)*
  - Scientific Requirements -> Instrument requirements -> subsystem requirements
  - Subsystem designs
  - Development Plans
- *Review of Warm Electronics Design (December 1999)*
  - Warm Electronics Requirements - from IRD and subsystems -> WERD.
  - DPU, DRCU, Subsystem electronics designs.
  - Development Plan.

SPIRE Preliminary Design Review (3)

- *Detector Array Selection (Jan-Feb 2000)*
  - will act as the PDR of the selected detector option.
  - Subsystem design, electronics design confirmation

- *PDR Delta Review (March 2000)*
  - will cover items not fully covered before:
    - Structure, FTS etc.
    - On Board Software (URDs)
    - Test and Calibration Facilities
    - Support Equipment
  - **will provide a complete development plan**

SPIRE Detailed Design Review

Purpose: to approve the detailed design of the instrument and release it for manufacture of the AVM and CQM

- *Review of instrument detailed design*
  - System and Subsystems designs (documented)
  - Subsystem Interfaces (documented)
  - OBS architecture and specification
  - Development Plan

- *Date: May 2000*

  requires work to start on detailed design ASAP on subsystems as they are reviewed at PDR level.

3. PDR REPORT RESPONSE

MATT GRIFFIN

(SEE NOTE DISTRIBUTED BEFORE THE MEETING

Response to PDR Review Board Report

1. Capability to meet science goals

- **Effect of pointing errors on scanning mode observations and need for simulations of FTS observations:**

  Will include in simulations.

- **Extraction of astronomical spectra from FTS data:**

  FTS simulations must be done.

- **Need for stray light modelling and experimental measurements**
  - **Build up increasingly detailed APART model.**
  - **Possibly build ground calibration facility early and use as test bed.**

- **Data rate problems**
  - **Aim is to avoid any on-board averaging if possible**
  - **100 kbs limit may require some compromises**

- **Urgent need to make progress on the FTS design**
  - **Already being addressed**
  - **Working towards full review in March**
  - **FTS must not distract consortium attention from the photometer**

- **^{3}He cooler redundancy:**
  - **Study group set up and is working.**
  - **Assessment and report by end 99**
  - **Will present proposed scheme to establish high reliability to ESA**

2. Development Plan

- **Structural design, BSM:**

  Preparing for full PDR in Mar.

- **Thermal design:**

  Full thermal model to be established (will be discussed at Systems Team meeting)

- **Shutter:**

  - **Design can't start in detail until the workpackage has been accepted and funded.**
  - **Canada only option now; funding status uncertain**
  - **Cold cryostat lid or retroreflector MGSE should be studied by ESA.**

- **Detector selection:**

  - **Agree that it cannot be delayed.**

4. SPIRE INSTRUMENT DESIGN UPDATE

BRUCE SWINYARD

Instrument Design Update

Bruce Swinyard

Instrument Design Update

- No major changes to the opto-mechanical layout
  - Design consolidation and interface specification
  - It all still fits - just!
  - Difficult to accommodate the detector arrays (see proposed i/f drawing)
- Attention is now on the detailed design of the FTS
  - A carriage mechanism has been proposed by GSFC
  - This is presently the baseline
  - The Heidenhain Moiré fringe device is baselined for the position sensor
  - The position of the system stop is being finalised

Instrument Design Update

- FTS issues affecting the arrays
  - Decision to keep to two arrays for the FTS
  - Extension to lower wavelengths difficult - possible to achieve some sensitivity by profiling filter
  - Sensitivity at longer wavelengths (up to 670 μm) dependent on detector
  - Backup "step and integrate" operation mode will be implemented if possible
  - Envelope is very tight

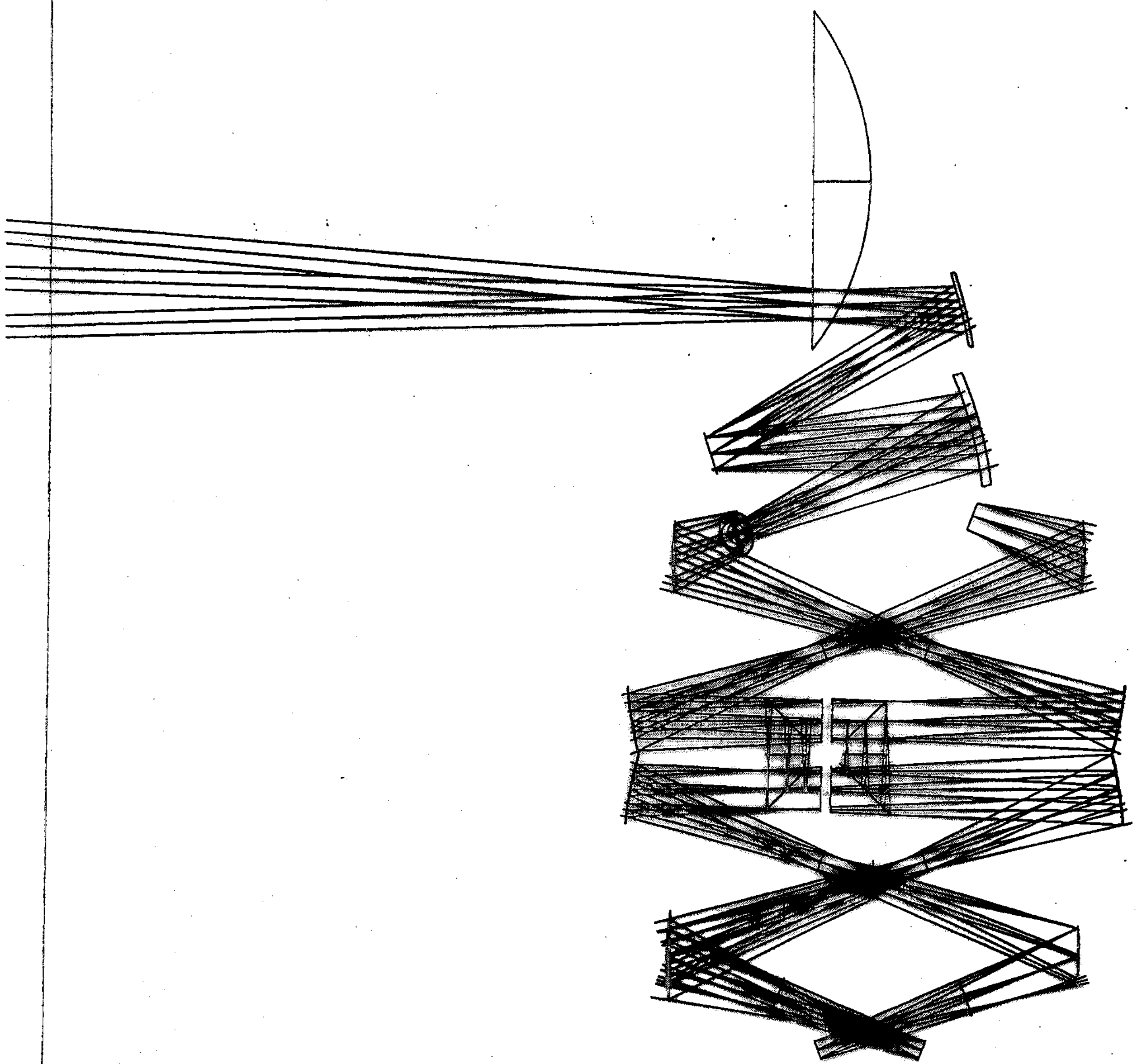
Instrument Design Changes

- "External" issues
  - Telescope design has changed - now have a thick telescope (~200 mm). F/# and focal position w.r.t. optical bench remain the same (more or less)
  - ESA have started a cryostat study with Dornier to revisit the instrument interfaces.
    - We are asking for the interface temperature to be significantly lower (<6 K) as this would very much simplify the design
    - Dornier fax indicates they won't be radically changing the design
    - They have highlighted the large thermal load from the GSFC wiring - they only want to study one detector option
    - We have responded "robustly" to this suggestion

Instrument Design Update

- Outstanding issues:
  - BAU requirements
  - JFET/Filter box requirements
  - Grounding scheme and EMC requirements
  - Interface definition
    - Electronics/operations - N kHz to 40 Hz - synchronisation - bias and control lines etc...
    - Thermal - how do the straps get/on off
    - Mechanical - MSSL concerned about the amount of space
    - Accessibility

AZIMUTH 0.000 ELEVATION 0.000 SCALE 0.200 ID SPIRE SPECTRO (BOLSP472)



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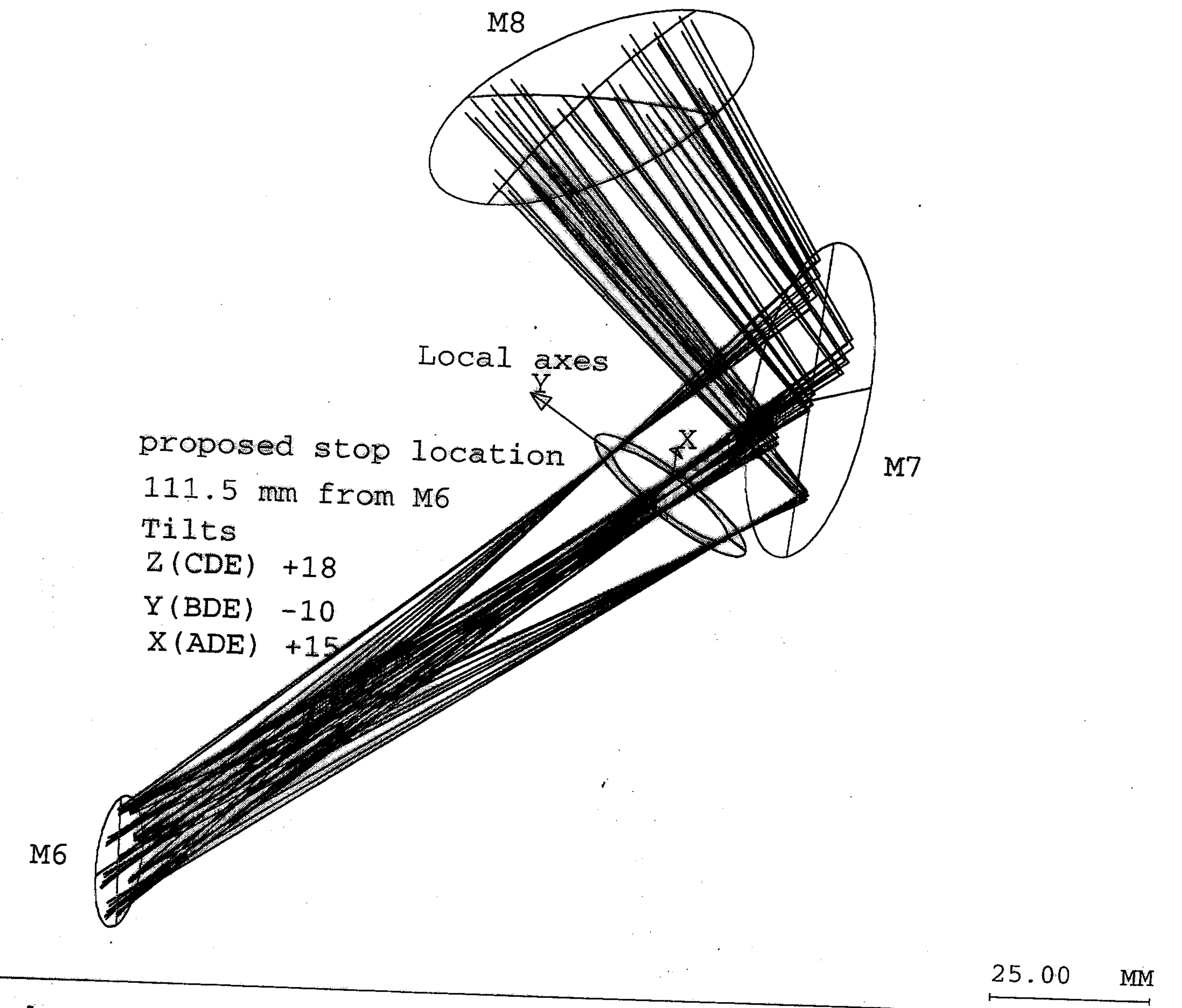
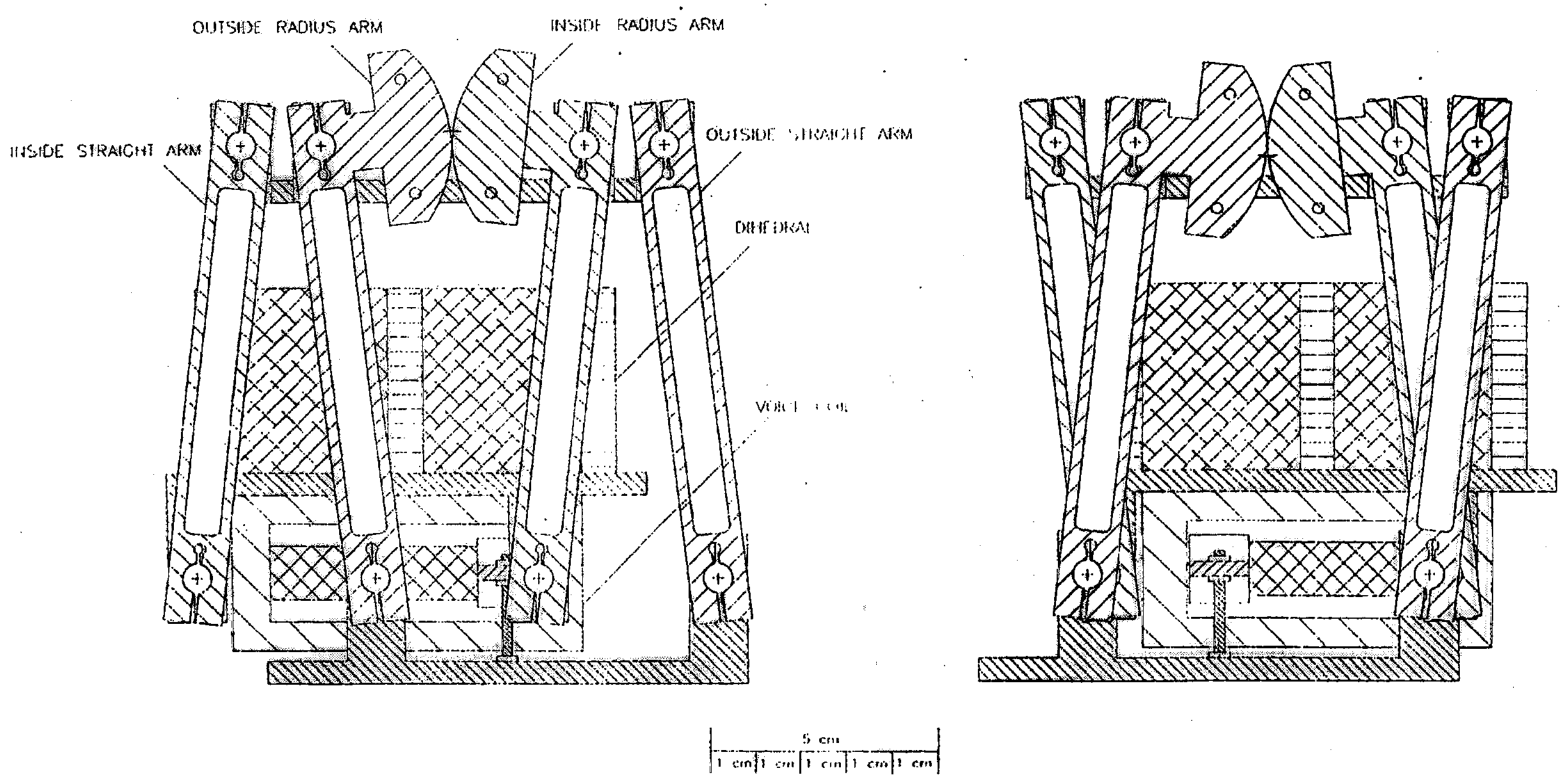


sp460c + stop between M6/M7

FULL SCALE

20-Jul-99

Carriage Mechanical Design (Side Views)



5. REVIEW OF ACTIONS

KEN KING

Actions

Action Number	Description	Responsible			Due Date	Status
AI-DET-0051-28	Investigate creation of new SPIRE workpackage for a cold shutter	MJG			09-Oct-98	~~Open~~ C
AI-DET-0051-29	Array splinter meeting actions	All				~~Open~~ C
AI-DET-0056-07	Design and build 300mK shields for other array options (to be delivered with arrays)	GSFC	JPL			~~Open~~ C
AI-DET-0210-33	Investigate availability of illuminators from Jeff Beeman	Hargrave			31/10 ~~30-Jun-99~~	Open
AI-DET-0210-41	Generate nominal beam profiles for 0.5Flambda and 2.0Flambda pixels and provide LV with input map projected through the photometer optics onto the detector focal plane	BMS		N 00297	01-Feb-99	~~Open~~ C
AI-DET-9???-44	To quantify and tabulate geometrical filling factor for ionising radiation (fraction of pixel area that can be struck) for 225, 333 and 500 um arrays	Bock	Moseley	PDR Rodriguez CLOSED	31/10 ~~14-Jun-99~~	Open
AI-DET-9???-45	To specify array filling factor (fraction of total array area which is sensitive to submm radiation) for 225, 333 and 500 um arrays	Bock	Moseley		31/10 ~~14-Jun-99~~	Open
AI-DET-9???-46	To provide Jamie Bock with the latest sensitivity models for SPIRE and discuss the assumptions and methods	MJG	model has been updated		31-May-99	~~Open~~ C
AI-DET-9???-47	To provide list of non-standard parts that they may wish to use. This will then be provided to ESA for comment.	Bock CLOSED	Moseley OPEN	J-LA CLOSED	31/10 ~~20-Jun-99~~	Open
AI-DET-9???-48	To comment on the existing draft of the Array Selection Criteria document in as much detail as possible	Bock	Moseley	Vigroux	31/10 ~~04-Jun-99~~	Open
AI-DET-9???-49	To produce a revised draft of the Array Selection Criteria document, which will be distributed as part of the PDR documentation	MJG			14-Jun-99	~~Open~~ C
AI-DET-9???-50	To specify what is required for the Development Plan.	KJK			31-May-99	~~Open~~ C

Action Number	Description	Responsible	Due Date	Status
AI-DET-9???-51	To review the list of headings for the July PDR viewgraphs/viewgraph sequences and provide Powerpoint template to all subsystem groups	BMS	31-May-99	~~Open~~ C
AI-DET-9???-52	To distribute electronmics version of Seb Oliver's viewgraph package to all participants	MJG	~~27-May-99~~ 5/10	Open
AI-DET-9???-53	To comment on Seb Oliver's presentation or any other aspect of SPIRE simulation work	Bock Moseley Vigroux (see tomorrow meeting)	10-Jun-99	~~Open~~ C
AI-DET-9???-54	To organise a meeting on simulations before the PDR in July (ideal participants: Oliver, Vigroux, Griffin, Gear, Aussel, representatives of Caltech and GSFC).	Vigroux (did not happen)	30-Jun-99	~~Open~~ C
AI-DET-9???-55	To comment on the Detector Test Document	Bock Moseley Rodriguez	31-May-99	~~Open~~ C
AI-DET-9???-56	To investigate external filter availability/definitions	Hargrave PARA	31-May-99	~~Open~~ C
AI-DET-9???-57	To send BACUS optical design/ZEMAX file to array groups	Hargrave	31-May-99	~~Open~~ C
AI-DET-9???-58	To send FTS interface details to array groups	Hargrave PARA (To be provided at mtg)	31-May-99	~~Open~~ C
AI-DET-9???-59	To send QMW shipping agent information to the US groups	Hargrave	31-May-99	~~Open~~ C
AI-DET-9???-60	To refine Letter of Agreement and circulate to GSFC	Gray	04-Jun-99	~~Open~~ C
AI-DET-9???-61	To investigate and identify any potential shipping problems	Voellmer Glenn	02-Jul-99	~~Open~~ C
AI-DET-9???-62	To provide detailed inventory, and list of QMW provided equipment	Bock Moseley Rodriguez	04-Jun-99	~~Open~~ C
AI-DET-9???-63	To send QMW email/letter stating lab/bench/office space requirements	Bock Moseley Rodriguez	31-May-99	~~Open~~ C
AI-DET-9???-64	To provide P. Hargrave with QMW test phase schedules	Bock Moseley Rodriguez	31-May-99	~~Open~~ C
AI-DET-9???-65	Revise test document and recirculate	Hargrave	~~07-Jun-99~~ 12/10	Open
AI-DET-9???-66	To clarify qualification test/deliverables/schedules at least to CQM.	BMS Moseley Rodriguez Hargrave	~~07-Jun-99~~ 22/10	Open

6. PROGRESS REPORTS

(a) CEA — LOUIS RODRIGUEZ

(b) GSFC/NIST — HARVEY MOSELEY

(c) JPL/CALTECH — JAMIE BOCK

(d) QMW — PETER HARGRAVE

CEA DETECTOR ARRAYS STATUS

Patrick Agnese, Yann Le Pennec,
Eric Doumayrou, Vincent Reveret,
Louis Rodriguez, Laurent Vigroux

During the last months we have been working mainly in four directions:

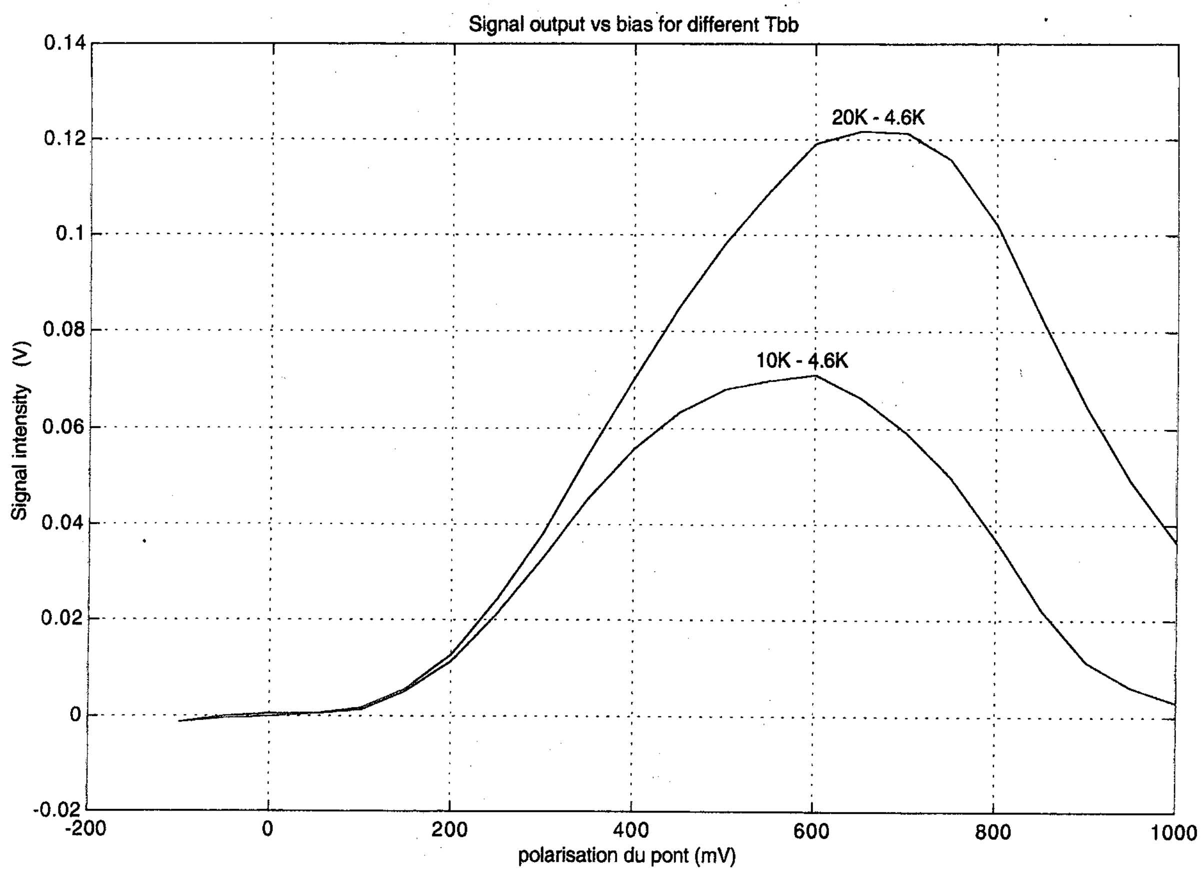
- ➡ Compare thermometers obtained by deep implantation vs mesa technology
  -We explored also the geometry influence. (I & Z shapes & channel sizes)
- ➡ Determine response to a Cold Blackbody on monopixels of 5 x10 pixels arrays built in 98 .
- ➡ Explore the Multiplexing scheme read out (levels, frequencies etc) & determine response to a Cold Blackbody on 16 x 16 arrays.
- ➡ Refine simulation Models

Of course all that noble tasks have been done once we have solved

- ➡ problems of ESD on MOS readouts.
- ➡ problems of adherence of the arrays on the copper plate at cold temperatures.
- ➡ problems of MUX & readout circuit contacts on the main chip.

DETERMINATION OF OPTICAL RESPONSE FOR MONO-BOLOMETERS

Manufacture of a "gray" cold Blackbody for responsivity evaluations (25 cm^2)
-OFHC Copper plate with pyramidal pattern front surface (2 mm step) "painted" with a multilayer Eccosorb 269 E coating (.5 mm thick), regulated in temperature between 2.5 K and 25 K.



Problem to control the parasitic flux coming from the 2K shield heated by the BB placed below

➡➡➡

we have built a new 1.5 K shield around the detector.

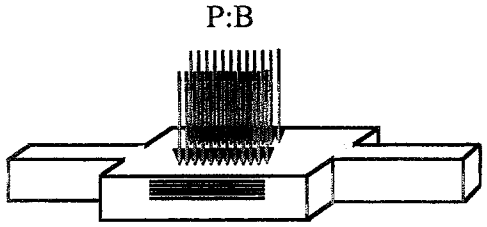
Here estimated load 70 pW

Comparison of deep implanted & mesa thermometers

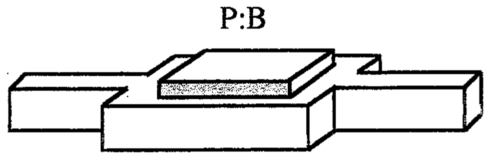
Goal:

To achieve the conduction channel profile control

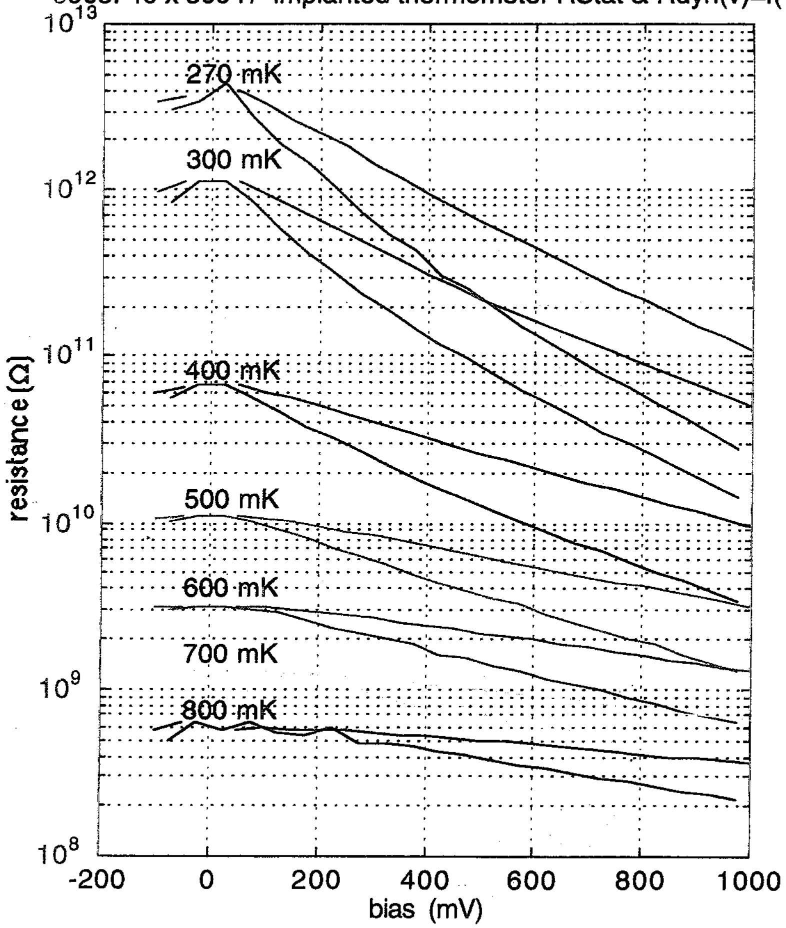
High Energy Implantation



MESA geometry



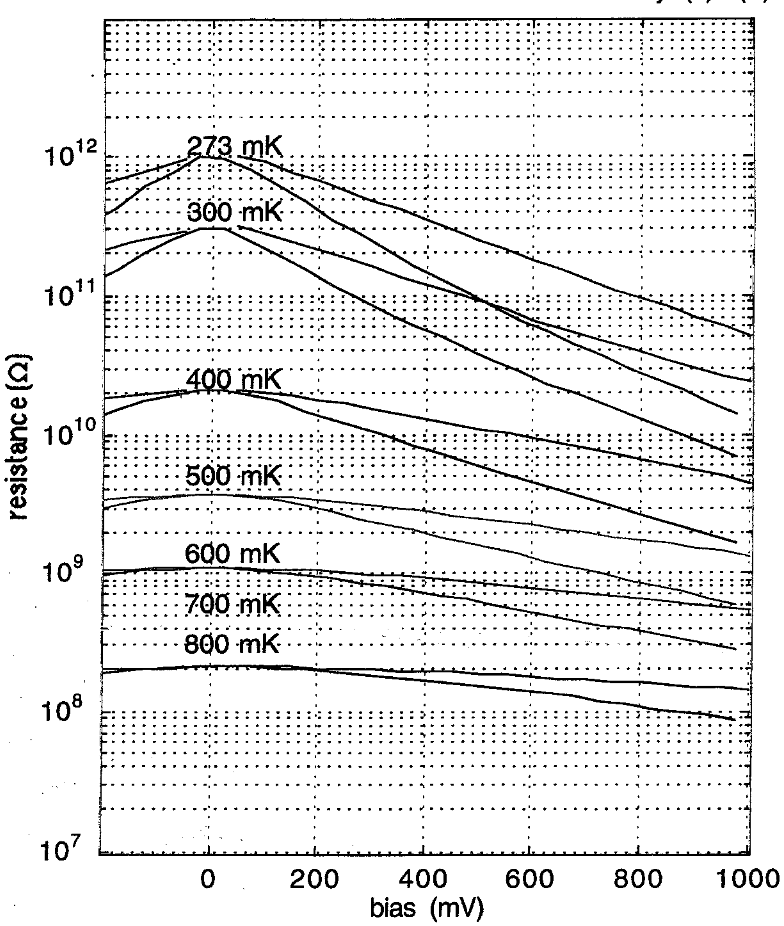
$$R(T) = R_0.\exp[\sqrt{\frac{T_0}{T}}].\exp[-\frac{qLE}{kT}]$$



and produce a sensitive sensor

Here T_0 at low bias close to 120 K then α=10 @ 300 mK

In terms of sensitivity mesa & implanted are almost identical



DETERMINATION OF PHYSICAL CARACTERISTICS OF 16 X 16 ARRAYS
Array 99-20 to be tested at QMQ early October

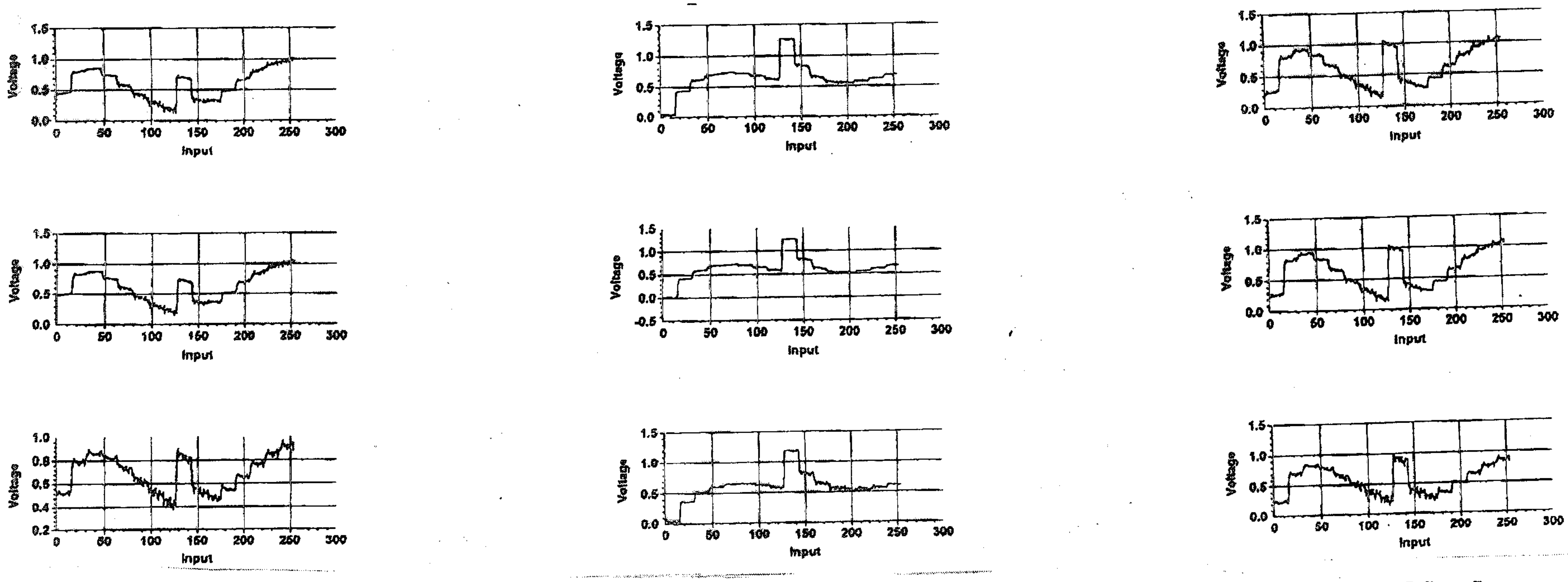
Very resistive sensors : Bridge =900 GOhm at zero Bias @300 mK R/10R configuration

Optimal bias response @1.2 Volts.

Frequency Band : 15 Hz at 1.2 V 30 Hz @1.4 V

Exemple response to a bias square waveform

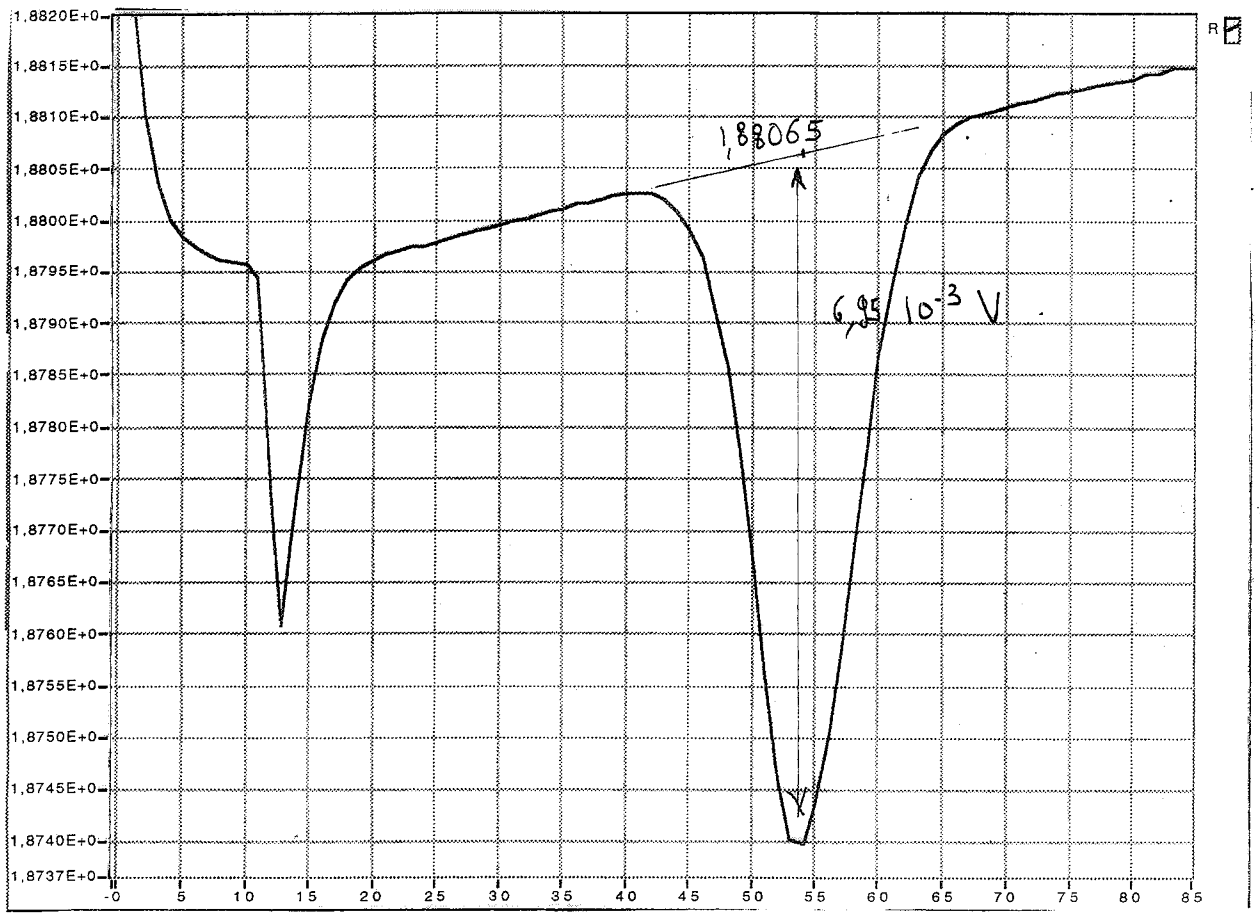
step 1.2->1.3 V@15 Hz | **step 1.2->1.3 V @30Hz** | **step 1.2->1.4 V @15 Hz**



dark conditions | **15 K blackbody** | **15 K blackbody**

DETERMINATION OF PHYSICAL CARACTERISTICS OF 16 X 16 ARRAYS: MEASURED RESPONSIVITY

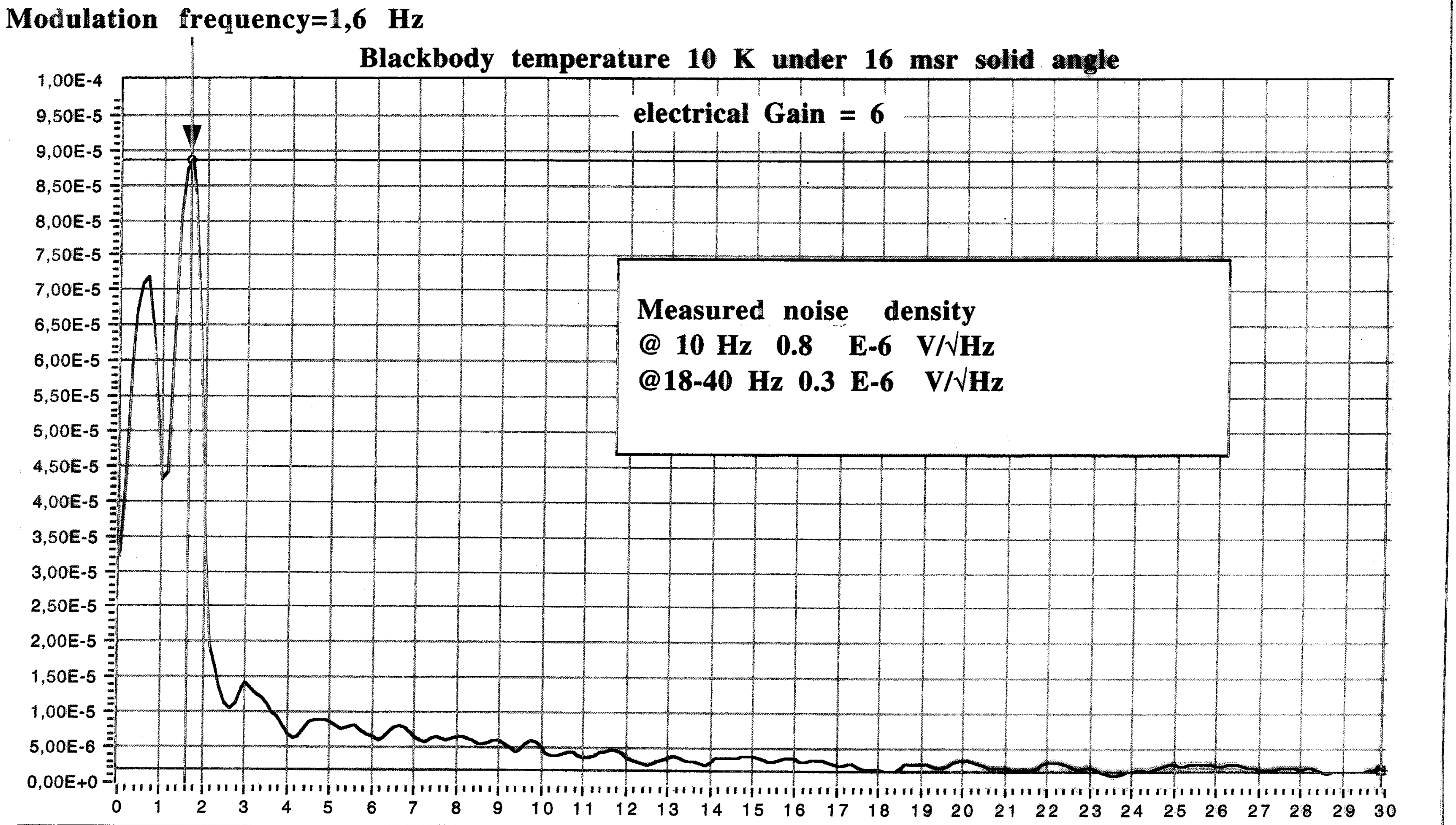
Response to different steps in Blackbody temperature



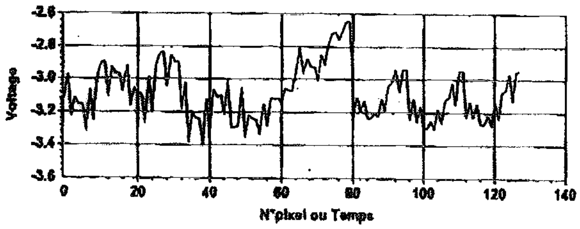
The deduced minimum responsivity is R= 1.1 E10 V/W @ 1.2 V bias.

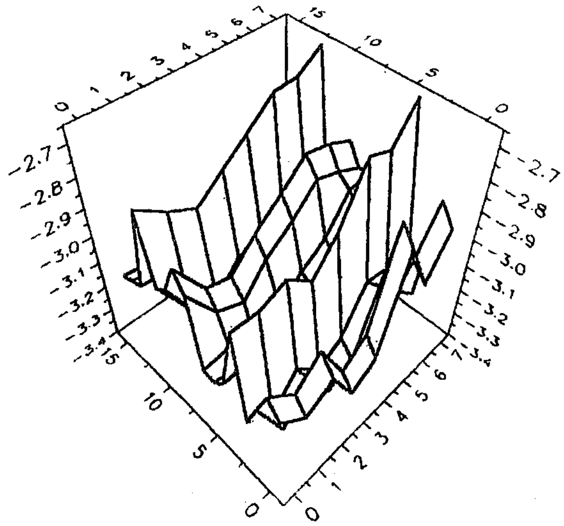
DETERMINATION OF PHYSICAL CARACTERISTICS OF 16 X 16 ARRAYS

Noise spectrum @ 1,2 V Bias
and modulated blackbody



Système ADWINPRO ; **Pré-ampli EPAS : gain**=100,BP=3.4KHz
Réf.Montage:99_ 20 /**Réf.Bolomètre:**P115_2.3
Intégré en cryostat : au SAP ; **Température** : 0.28K
Conditions particulières : Bg= CN à 9.6K pW/mm2 ; Filtre : μm - μm (non)
Commentaires: Charges externes,VI=1.,offset=2.745v, Vbias=1.2 à 1.6v
Mode Suiveur ; fréquence trame =29
Temps d'acquisition par colonne =0
Nombre de moyenne par acquisition =0
Nombre d'images successives =255
Valeur du bruit corrélé =0.0104522835903475
Filtrage coupe-bande :1
Cross_filtrage : 1
Correction d'offset :10
Nombre de défauts =0 / critère : 0.2
Fichier de sauvegarde : OffsetH:\Porte-documents\acquisition\99_20\CRYO.SAP\0.3K.25HZ\vin1.2
Fichier de sauvegarde : ImageH:\Porte-documents\acquisition\99_20\CRYO.SAP\0.3K.25HZ\vin1.2.tcn15
Fichier de sauvegarde : BruitH:\Porte-documents\acquisition\99_20\CRYO.SAP\0.3K.25HZ\vin1.2
Image de référence; Réponse sous flux; Image de bruit; Signal à bruit
Image-offset





DETERMINATION OF PHYSICAL CARACTERISTICS OF 16 X 16 ARRAYS

Figures of Merit

The first 16 X16 array tested with success at Saclay with a probabely pessimistic calibration source gives very encouraging results:
A Frequency bandpass controled through the bias input between 15 an 30 Hz.

- The bandpass is actually the electrical bandpass.

-The mean responsivity for a 10 K BB is 1.1 E10 V/W

-The Noise density measured in dark condition & under flux (10 K BB) is
0.8 E-6 V @ 10 Hz
value of the pMOS readout transistor noise density.

Leading to a Noise Equivalent Power:

NEP mes = 7. E-17 W/√Hz
(here BLIP 0.5E-17 V/√Hz)

This value , we expect, should be decreased when applying modulation.

PERSPECTIVES FOR THE COMING MONTHS

Start Next week measurements of the first mesa array in Saclay and the 99-20 detector array at QMW.

-Integrate in our test device an InSb source for fast photonic modulation purpose

-Integrate passband filters designed by IAS and already manufactured

----

_ Test a new array type every 15 days in each device

-Test the dedicated electronics we have just received from the manufacturer (all the measurements done for this presentation are made with a commercial set up sold by Keithley, a preamp by E. Doumayrou and a manual switch box made by C.Cara).

-Analyse a lot of data produced these two last weeks and not yet exploited.

Progress Report
GSFC/NIST Detectors

H. Moseley

Sept. 29, 1999

Progress

- System development; Test facilities, hardware and software , Analysis Algorithms.
- Mechanical design, fabrication, and assembly
- TES production
- Tests of superconducting elements
- Plans for completion of downselect

BACUS

- The Bacus system has been initally configured for single array tests, but all electronics are in place for full downselect tests.
- Mark II SQUID electronics are functional at GSFC and NIST, seem to work well.
- Software has been developed which provides all required capabilities for SQUID mux operation with Mark II electronics.

BACUS

- Operation of the BACUS is cryogenically routine. Full housekeeping system makes for easy tracking of system performance.
- Several items remain to be completed:
  - 1 Paddle/shutter installation
  - 2 heat switch for faster cooldown of arrays
  - 3 complete internal wiring between downselect and breakout board.

Mechanical System

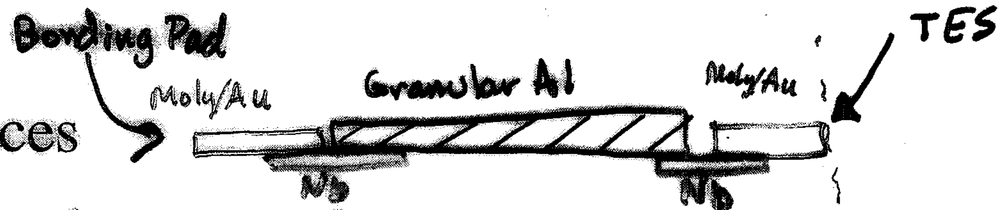
- Design and Fab are complete for the downselect system.
- Detector folding has been carried out successfully on both NIST and GSFC PUDs
- Assembly of mechanical system has been successfully carried out.

PUD/TES Production

- PUD's are mechanically reliable
  - Never break in folding unless dropped
- Procedure for achieving accurate PUD position with respect to backshort is being developed
- Folded devices are uniform
  - New wafers have resulted in better mechanical properties

Tests of Superconducting Components

- TES's: Two problems in development of photolithographic process.
  - Reliably achieving required Tc
  - Superconducting contact between bonding pads and TES
    - Many interfaces

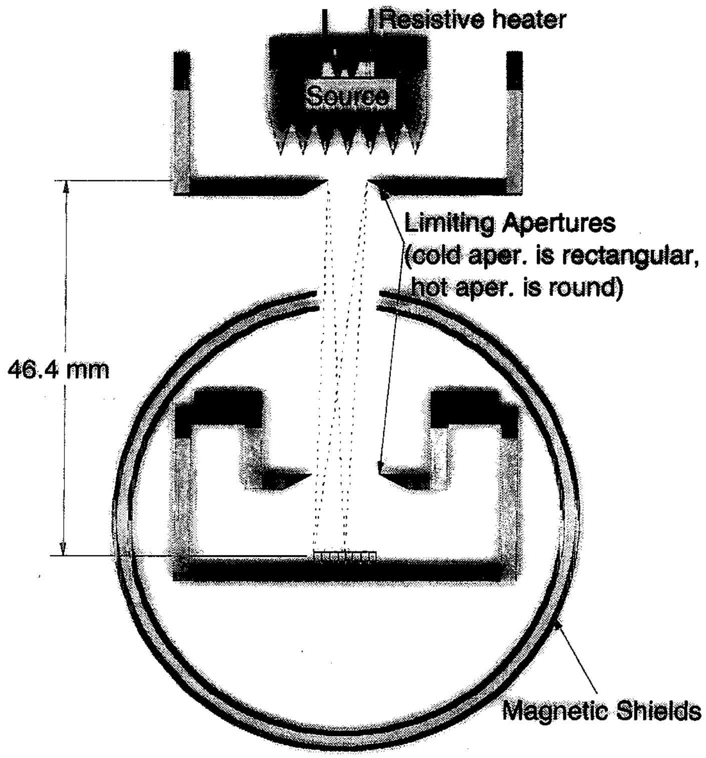


- This has been achieved for Mo/Au process

PUD/TES Production and Test

- NIST has produced 4 downselect devices, and have tested their electrical and optical characteristics.
  - Ag/Al bilayers with shadowmasks
- GSFC has produced photolithographic PUDs with Mo/Au bilayers
  - Have wafer of unetched devices with $T_c \sim .460$ K

Popup Detector Efficiency Measurement



Magenta = 4 K
Blue = T(base) = 0.3 K
Red = T(source) = 4 - 10 K

Thruput : $A^*\Omega = 0.0275\ mm^2sr$
(source diameter and 1/8 of cold aperture)

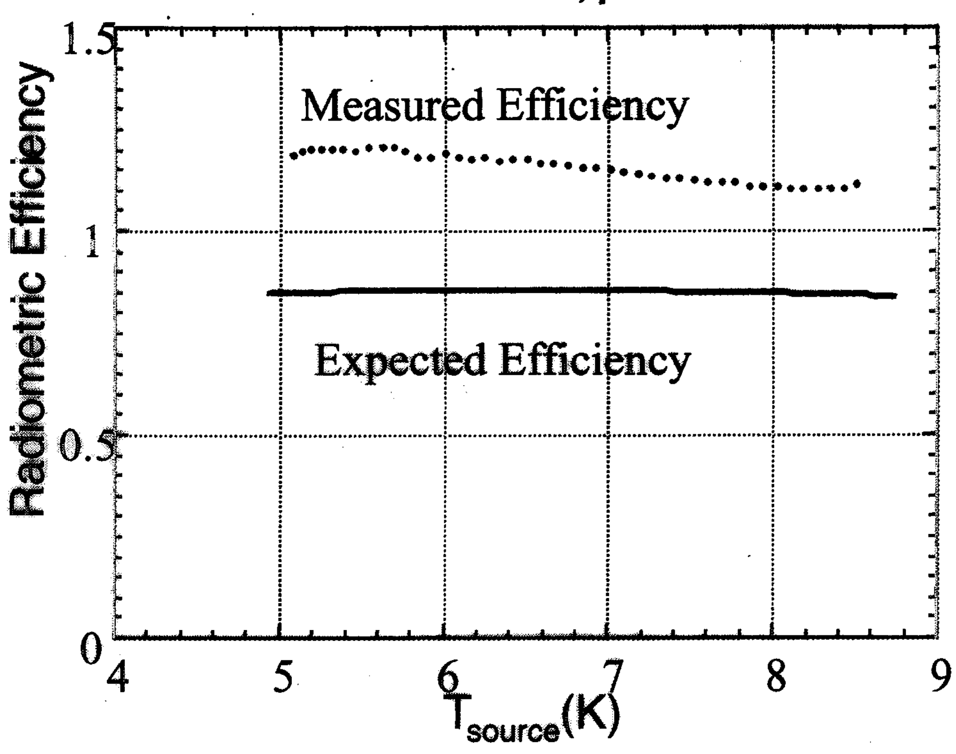
NIST Boulder

Measured Efficiency

Source geometry allows some scattered light from source to reach array, increasing measured efficiency.

Tests with redesigned source are now being conducted to improve measurement.

$$\frac{[P_{det}(T_{max}) - P_{det}(T_s))]}{[P_{inc}(T_{max}) - P_{inc}(T_s)]}$$

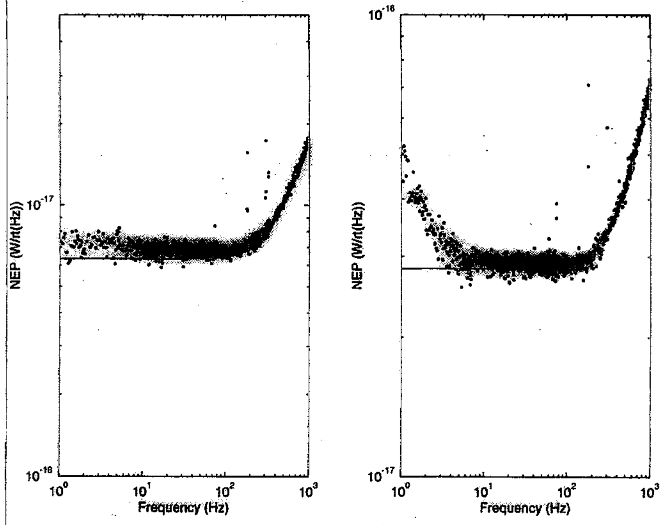


NIST Boulder

Electrical NEP from Two Tc test popup device

Tc 1: 265 mK

Tc 2: 528 mK



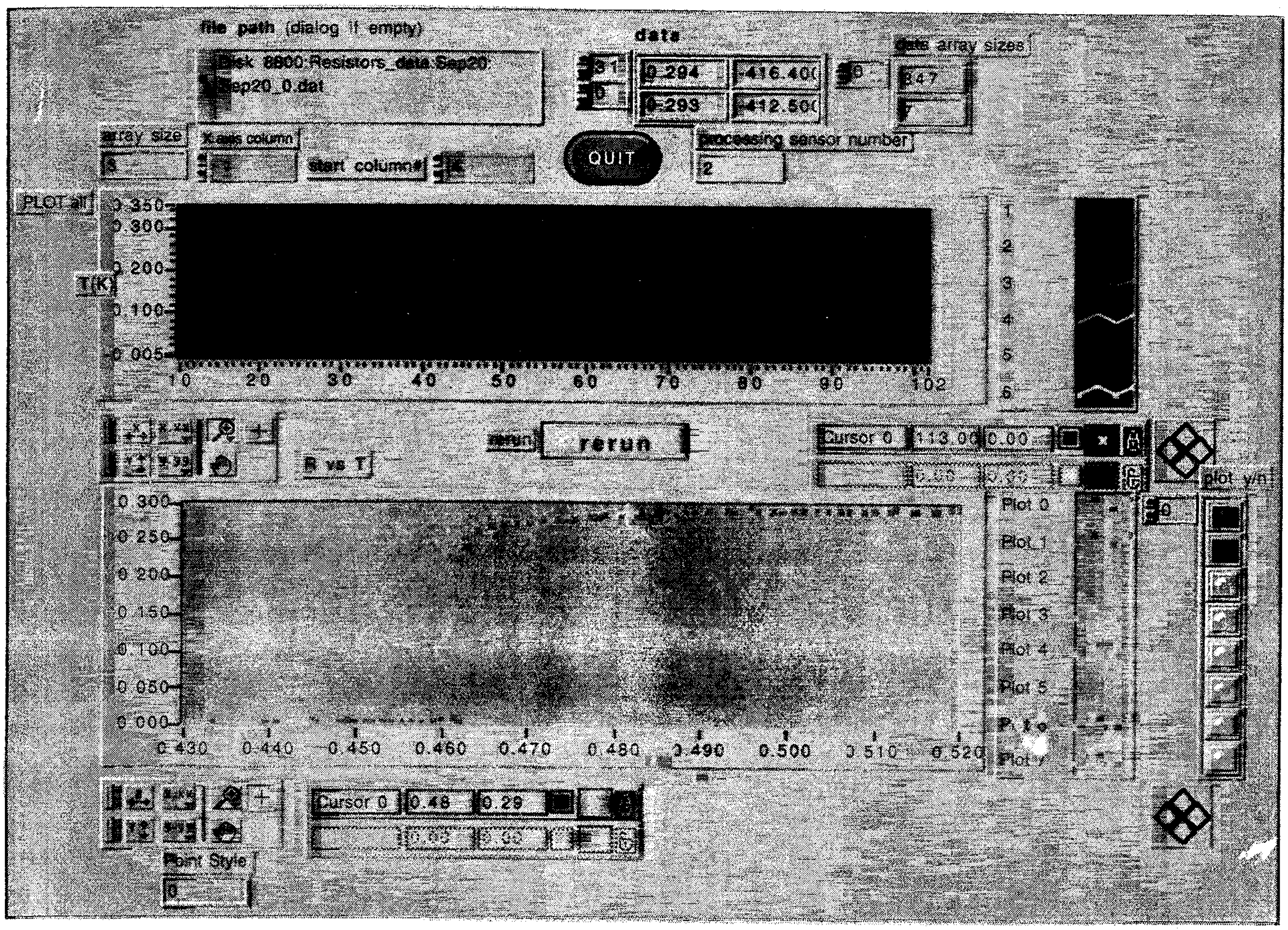
Line: theoretical phonon NEP

Line: theoretical phonon NEP

Device 1: Tc = 265 mK
Pbias = 1.4 pW
fknee = 286 Hz
NEP = 6×10^{-18} W/rt(Hz)

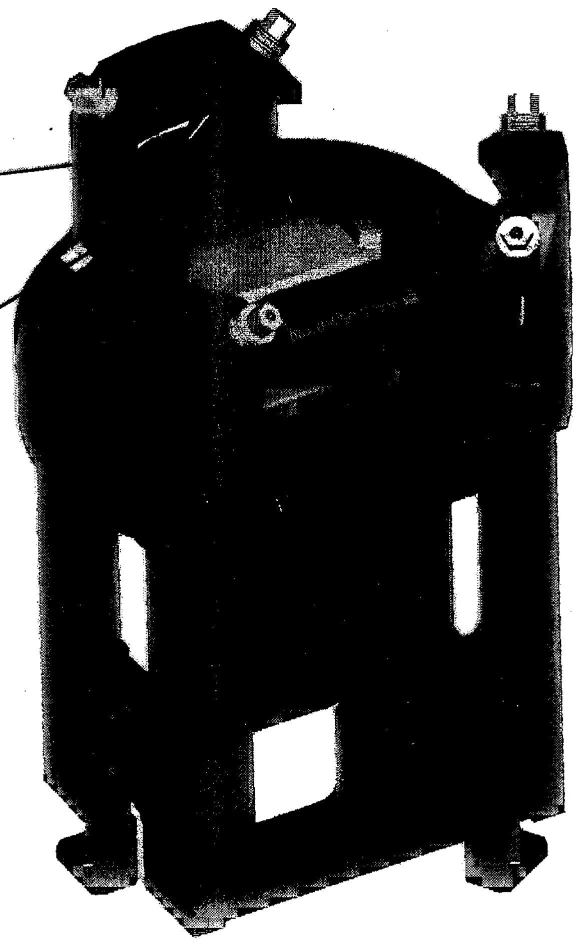
Device 2: Tc = 528 mK
Pbias = 12.6 pW
fknee = 360 Hz
NEP = 2.8×10^{-17} W/rt(Hz)

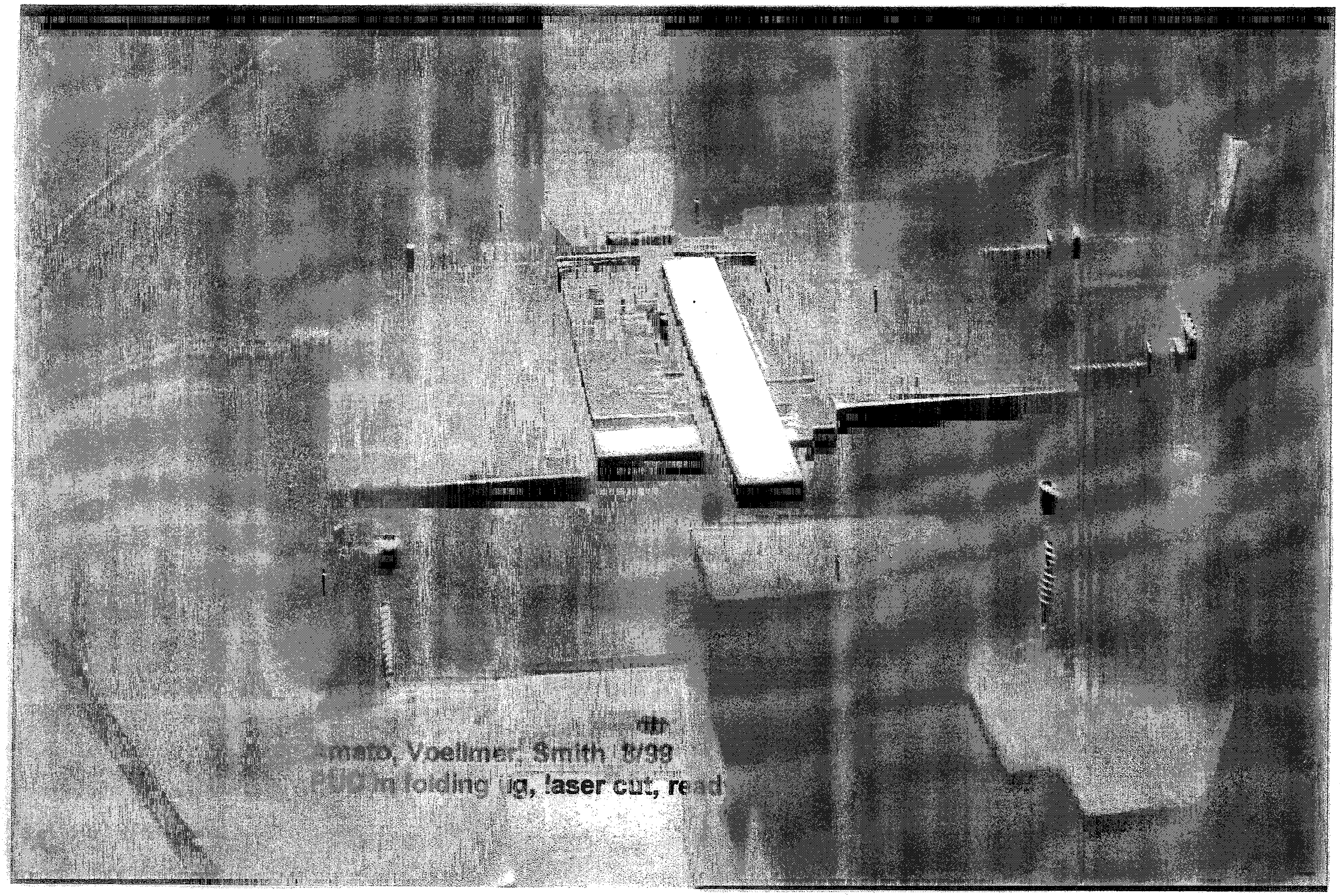
NIST Boulder

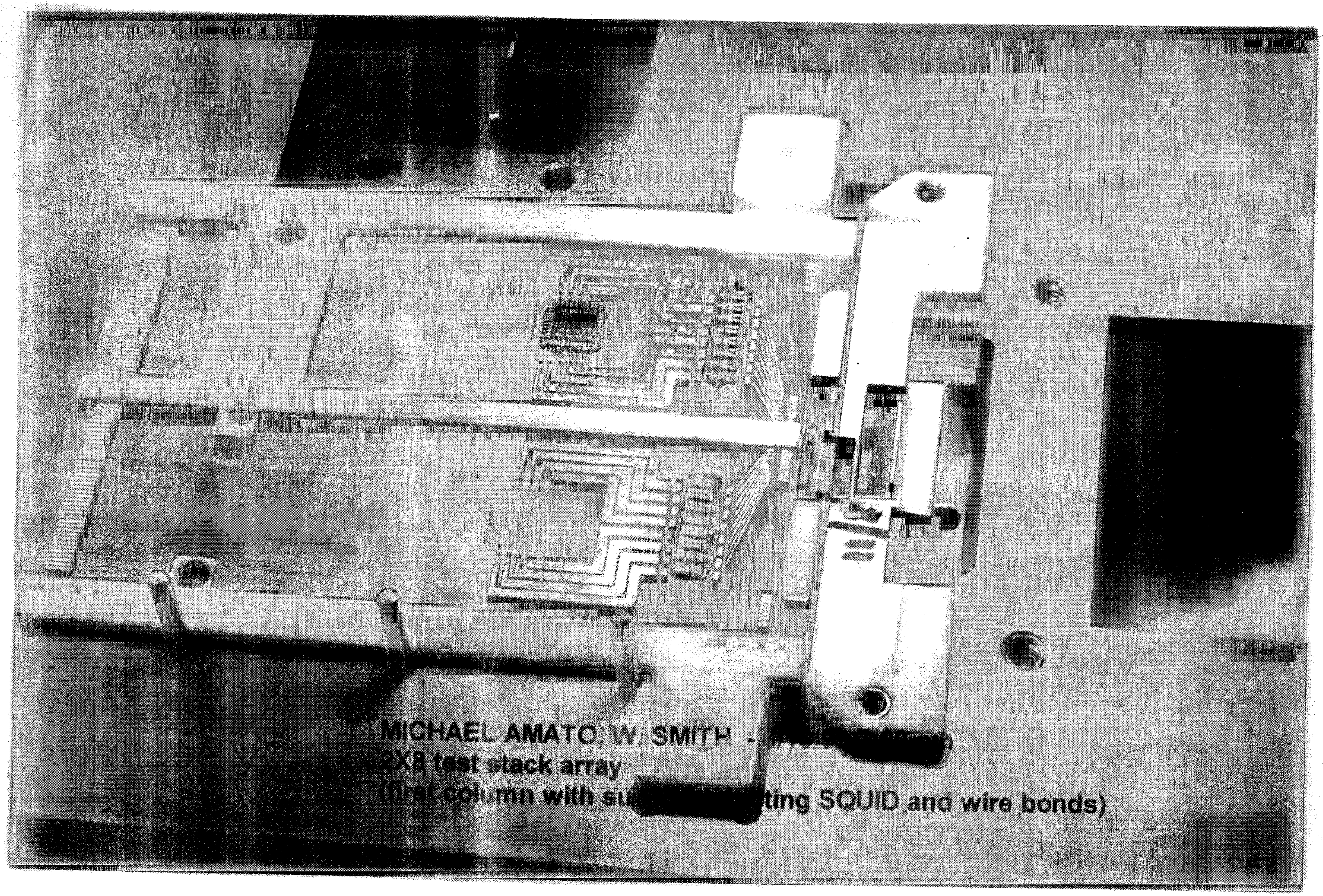

file path (dialog if empty)
Disk 8800:Resistors_data:Sep20:
Sep20_0.dat
data
data array sizes
array size
X axis column
start column#
QUIT
processing sensor number
PLOT all
T(K)
rerun
R vs T
Cursor 0
plot y/n
Plot 0
Plot 1
Plot 2
Plot 3
Plot 4
Plot 5
Point Style

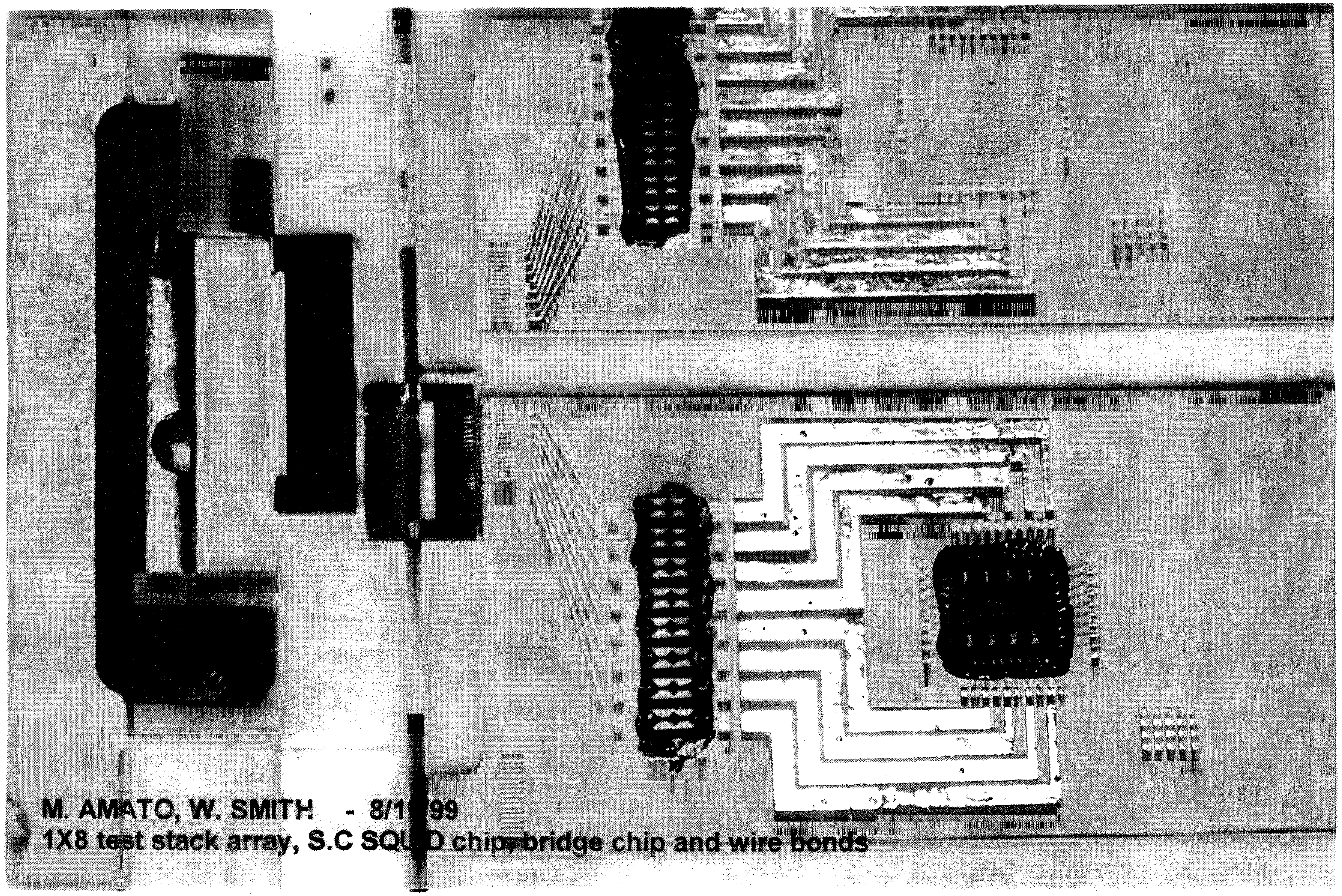
PUB Detectors

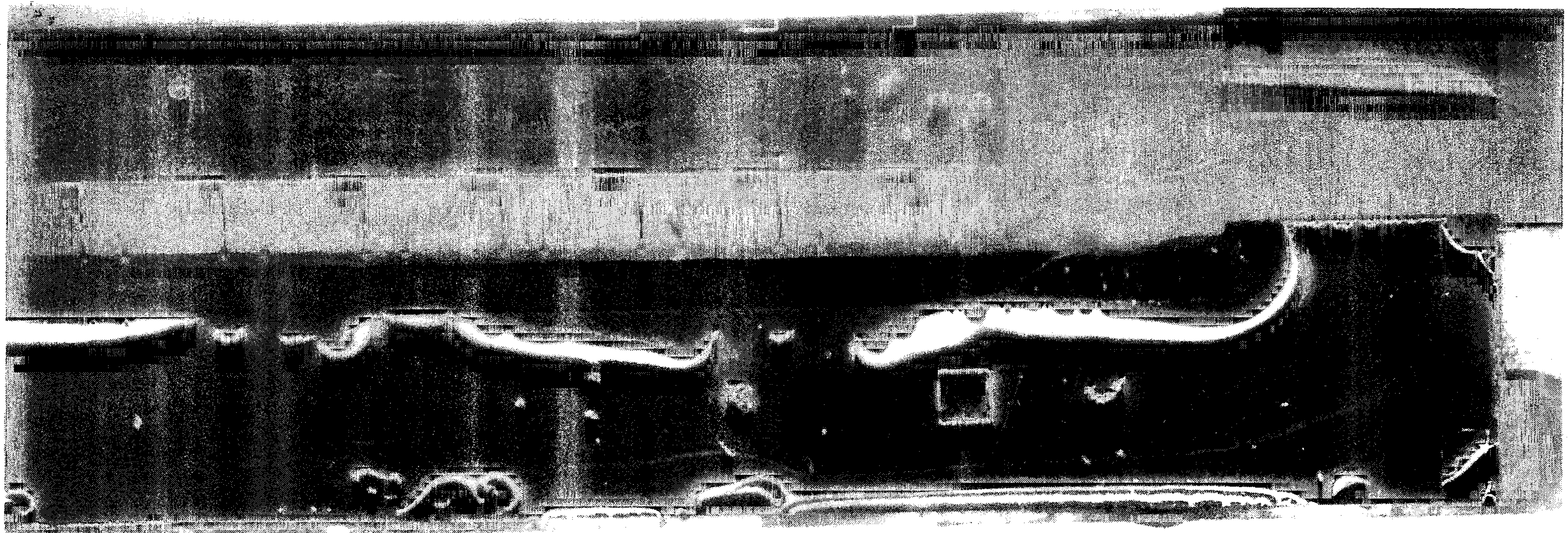
- The cold plate is lowered, twisted into position with its 'hooks' or 'grooves' at the kevlar straps, and bolted or epoxied to the upper 'C's.



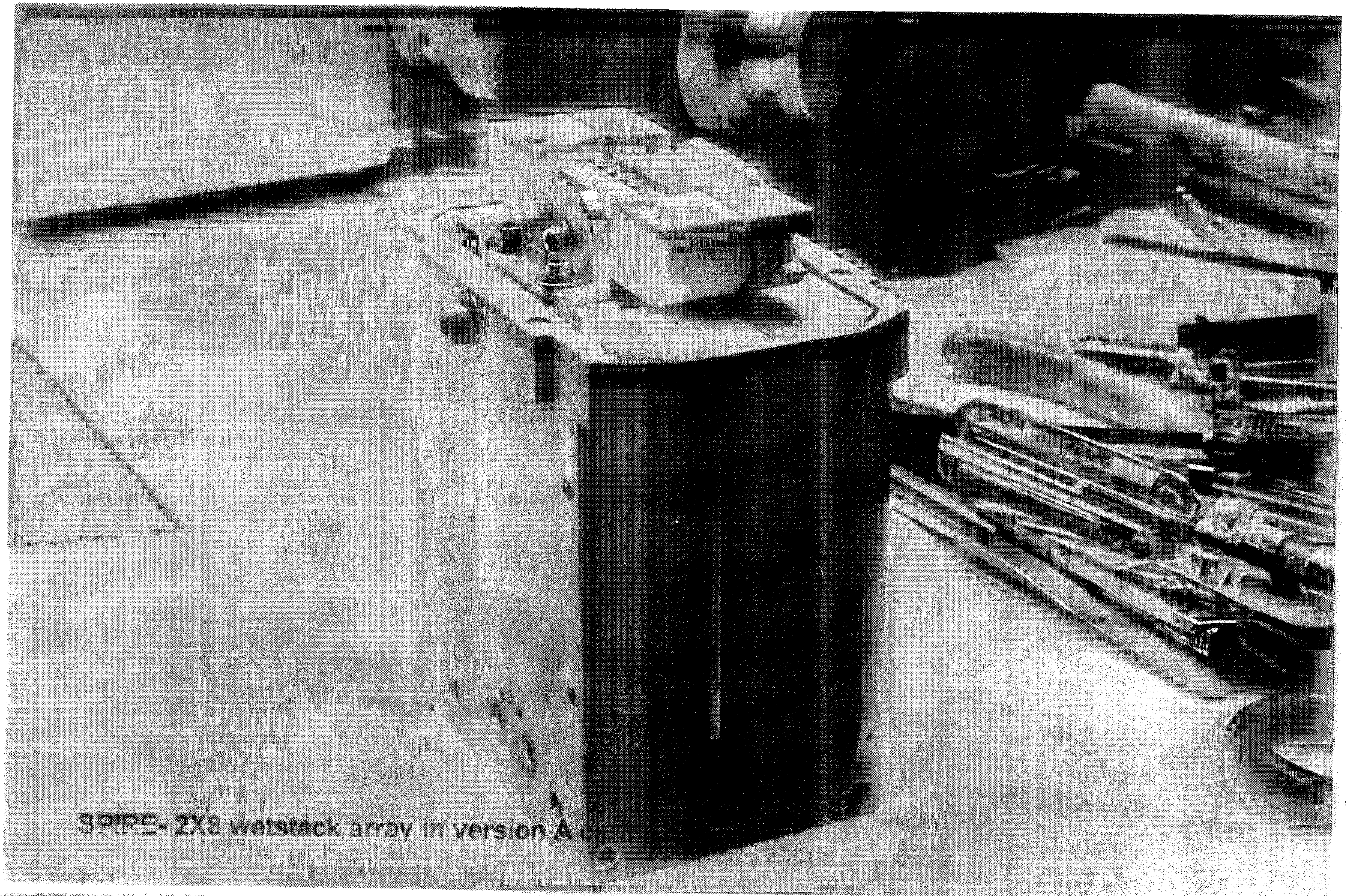

Voellmer, Smith
folding jig, laser cut,


MICHAEL AMATO, W. SMITH -
2X8 test stack array
(first column with su ting SQUID and wire bonds)

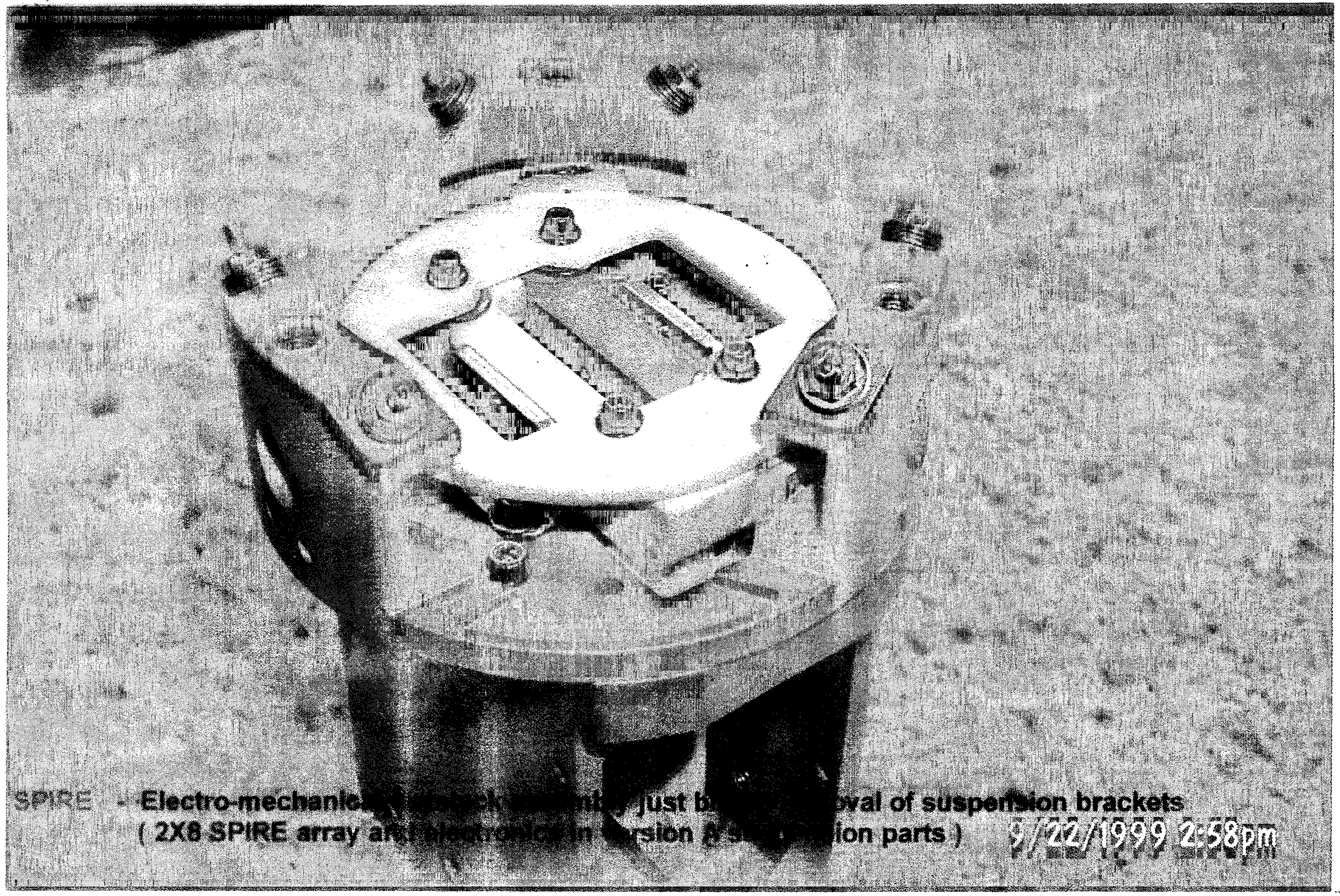

M. AMATO, W. SMITH - 8/1 99
1X8 test stack array, S.C SQUID chip, bridge chip and wire bonds



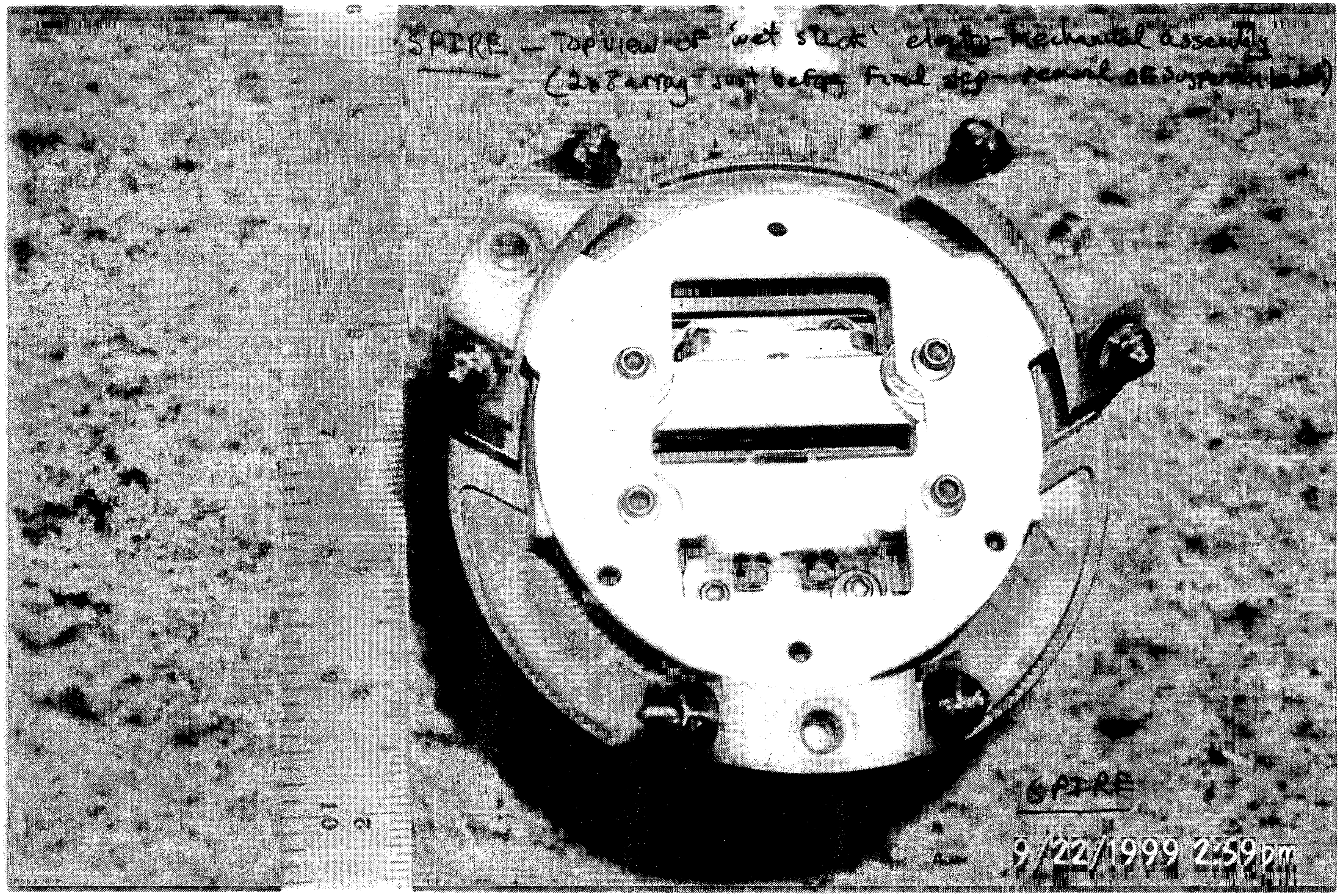
Amato, Voellmer, Smith   8/99
Epoxy on PUD in folding jig, laser cut, ready to fold (microscope)



SPIRE- 2X8 wetstack array in version A



- Electro-mechanical ... just b... oval of suspension brackets
(2X8 SPIRE array and ... parts)


SPIRE – Top view of 'wet stack' electro-mechanical assembly
(2x8 array just before final step – removal of suspension bands)
SPIRE
9/22/1999 2:59pm

Progress and Status

of the

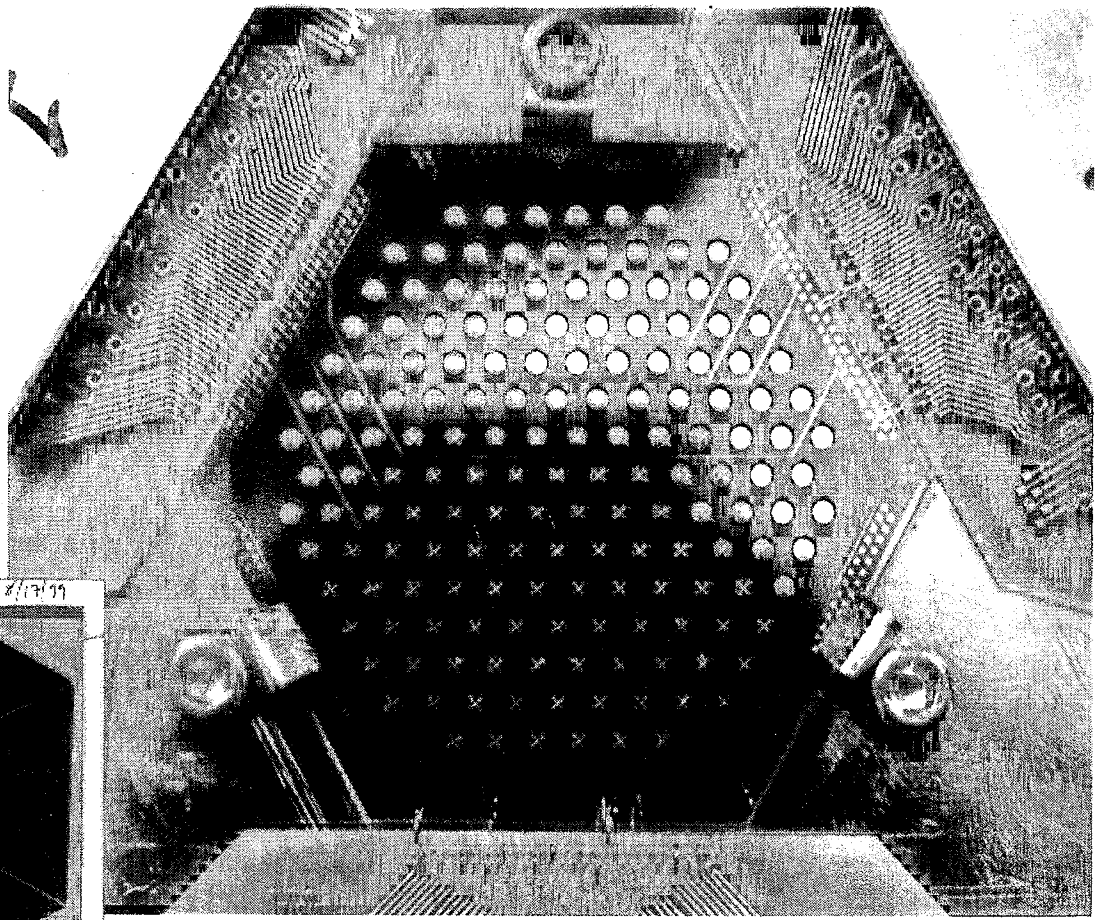
JPL/Caltech Feedhorn Option

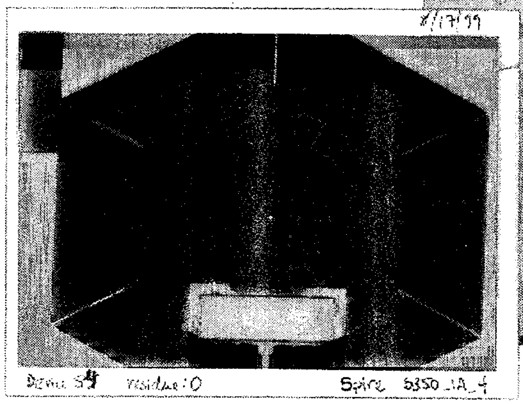
Jamie Bock

350μm Spider Bolometer Prototype Array Fabrication Status

- **Spider bolometer prototype 350μm arrays for SPIRE have achieved up to 90% working pixel yield over the central 1fλ and 2f λ areas (28/31 pixels) @ room temperature**

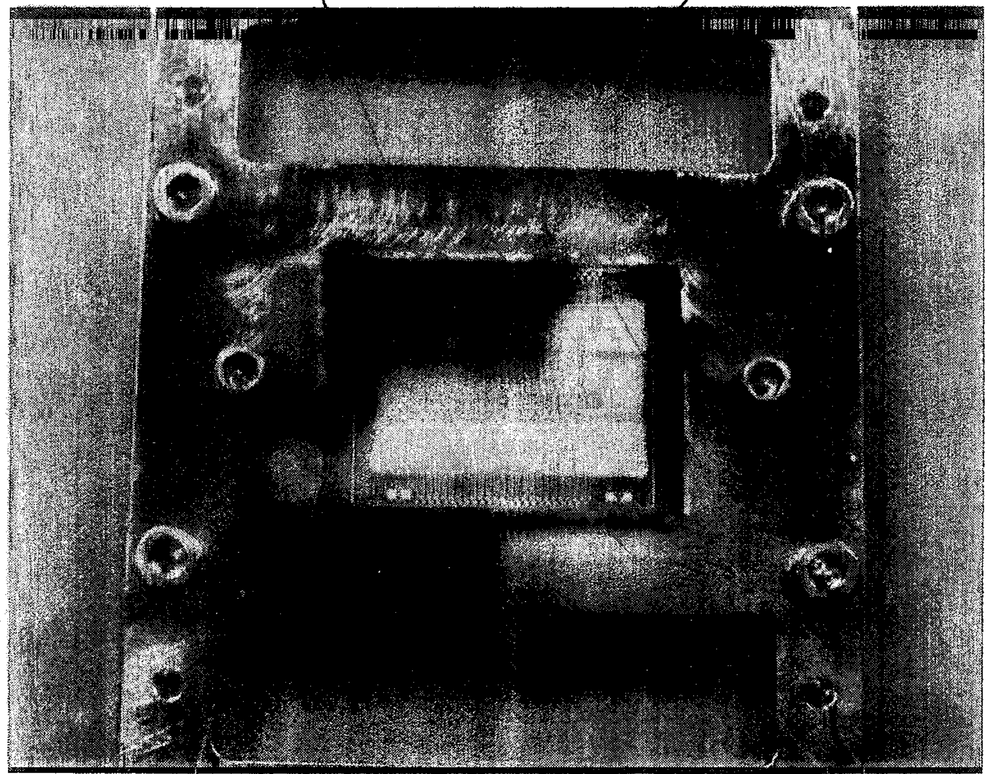
- **4 arrays have been released with 163/163 spider web pixels intact**





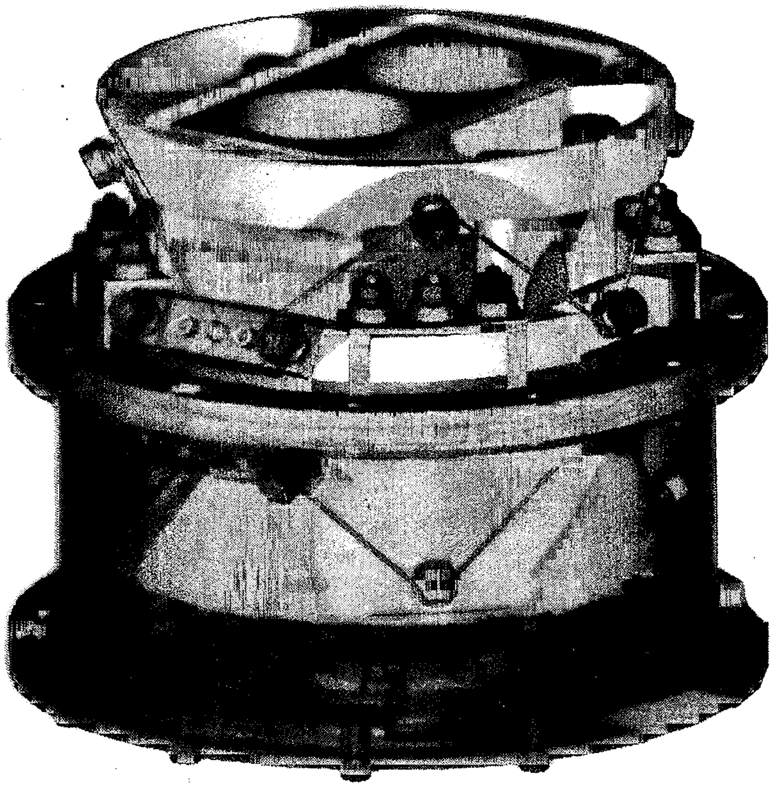
JFET Module and Mounting Structure

- Fabricated prototype membranes
  - -- thermally cycled to 4K successfully
- Now populating prototype with U401 dies

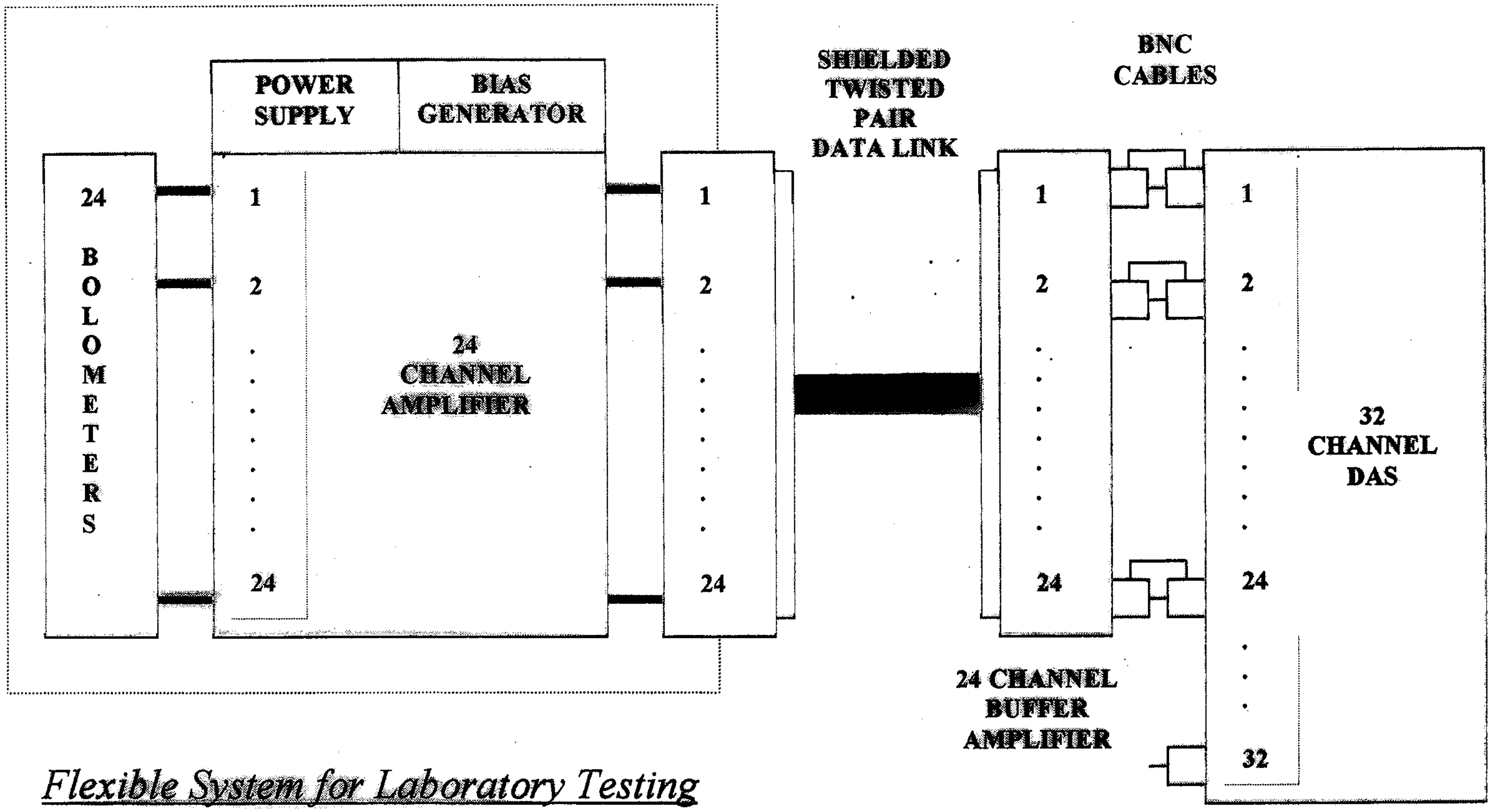


Focal Plane Structure

- Added flexture to use to interface to rest of instrument
- Completed structural analysis
- Participated in JPL internal design review
- Added alignment pins, increased spring washer stack height
- Completed fabrication drawings for suspended structure, assembly jig
- Began process of fabricating two engineering models of structure



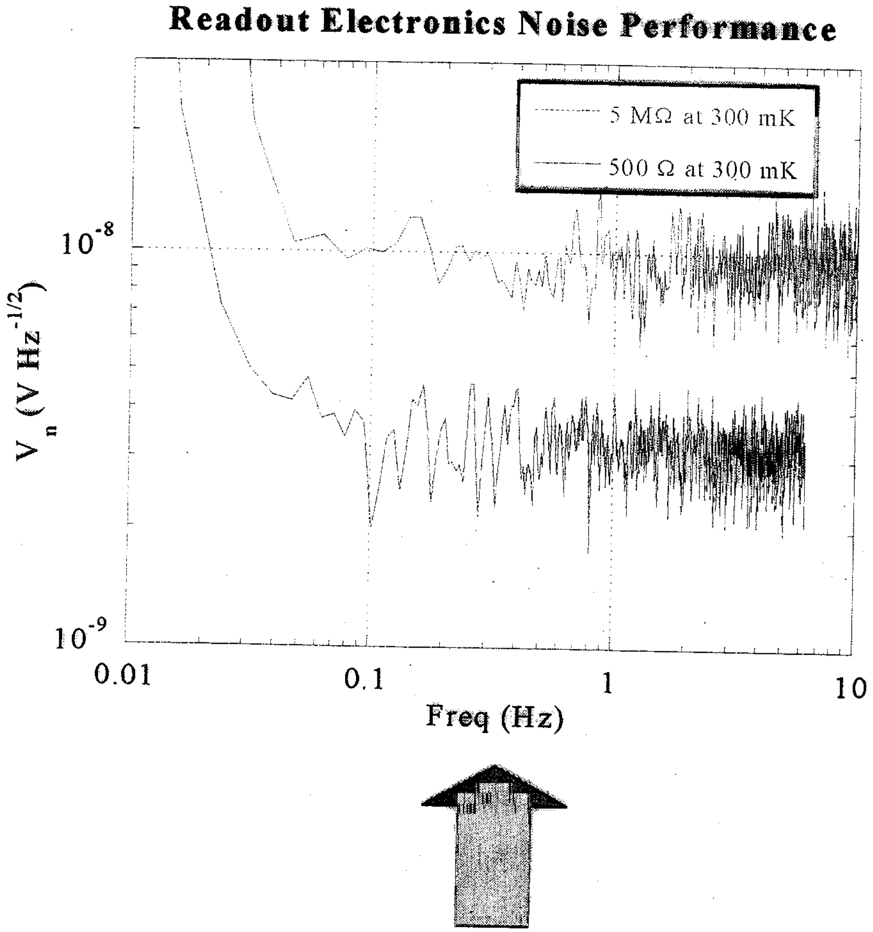
BACUS Data Acquisition System

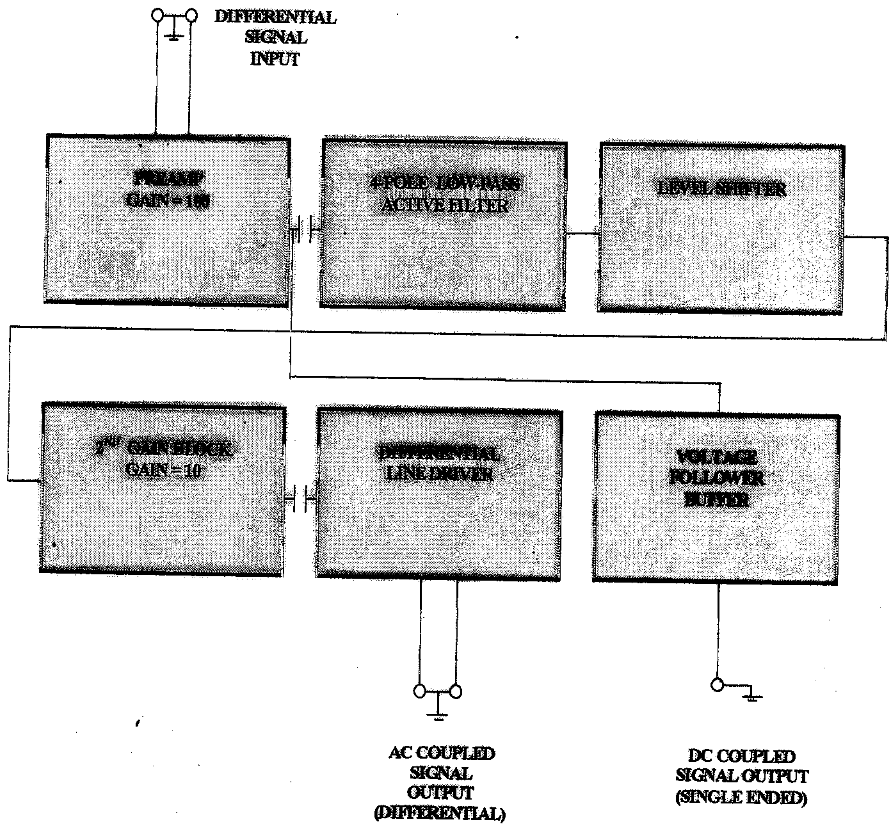


Flexible System for Laboratory Testing

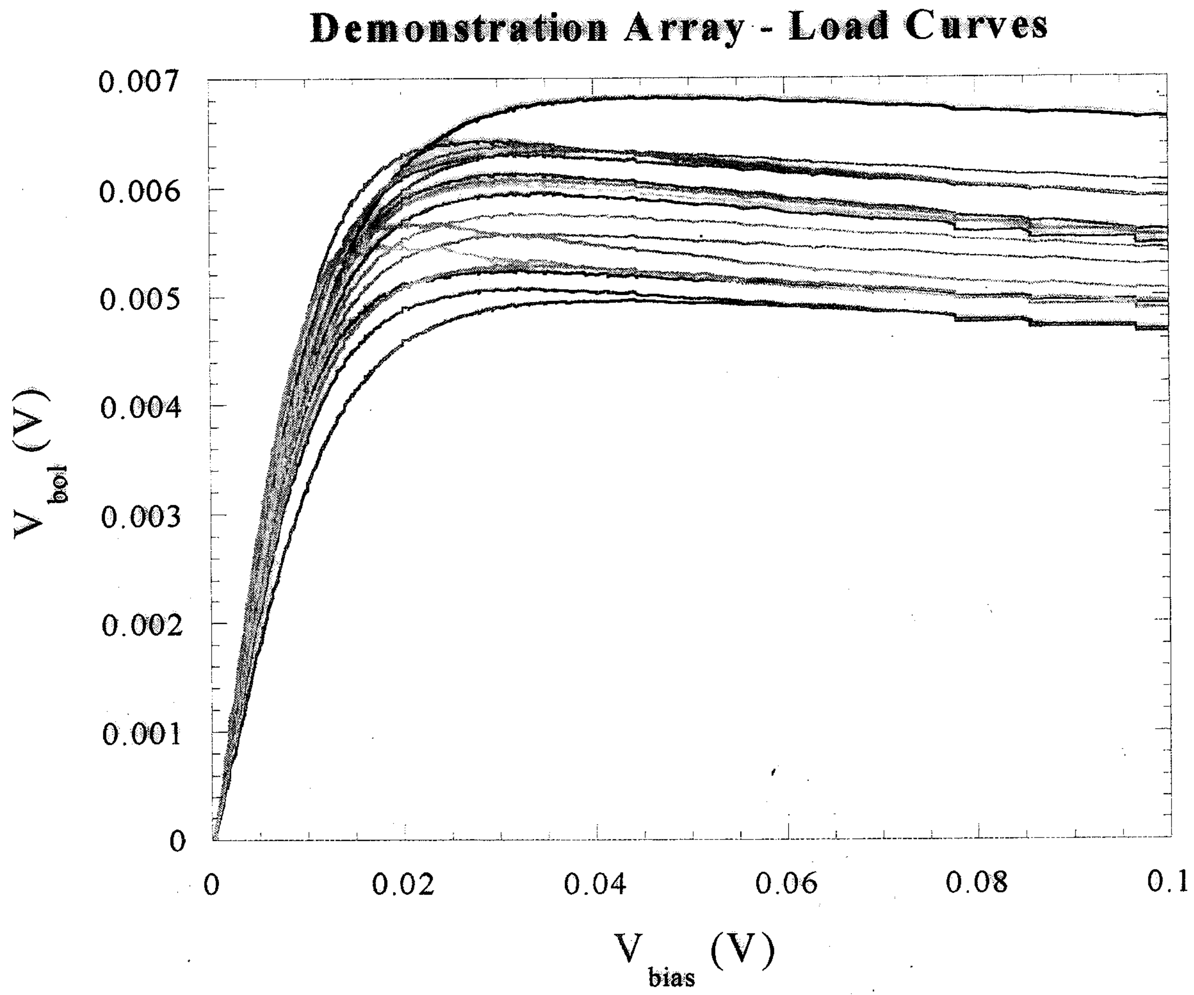
- Automated DC load curves
  - S_e(V/W), R(T), DQE
- Software demodulation for chopped sources
  - optical time constants, beam maps
- Software demodulation of AC bias
  - low frequency noise measurements

BACUS Readout Electronics

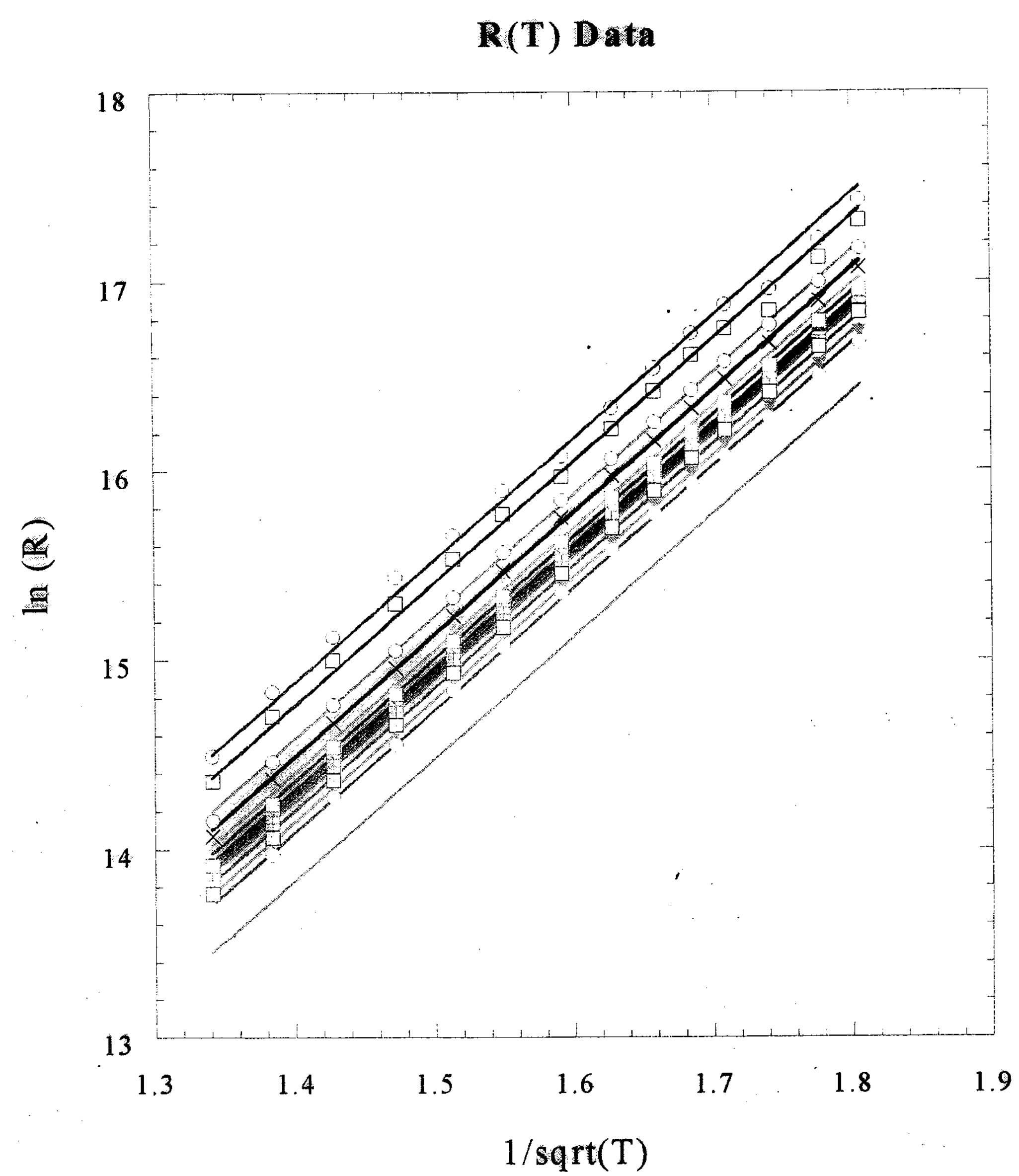


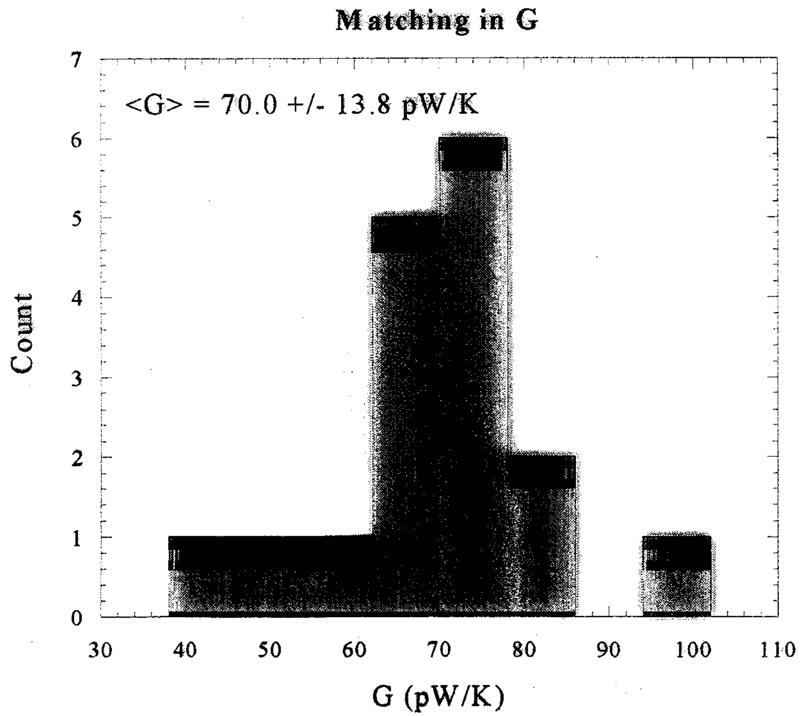


Measured end-to-end performance using 200 Hz sine-wave bias and analog lock-in for demodulation

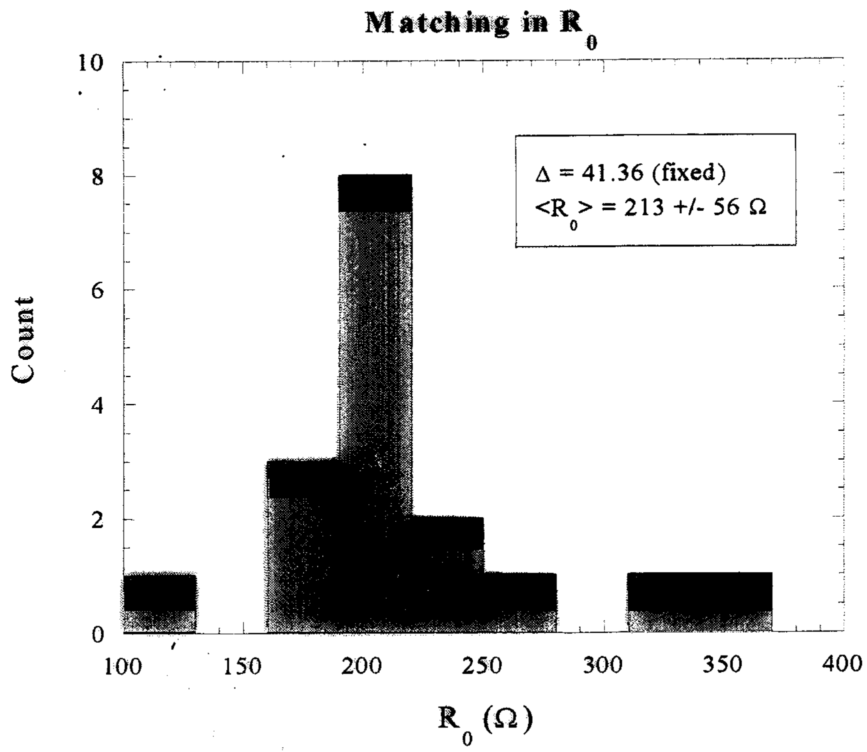


Demonstration Array - Load Curves
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0.02
0.04
0.06
0.08
0.1
V bol (V)
V bias (V)

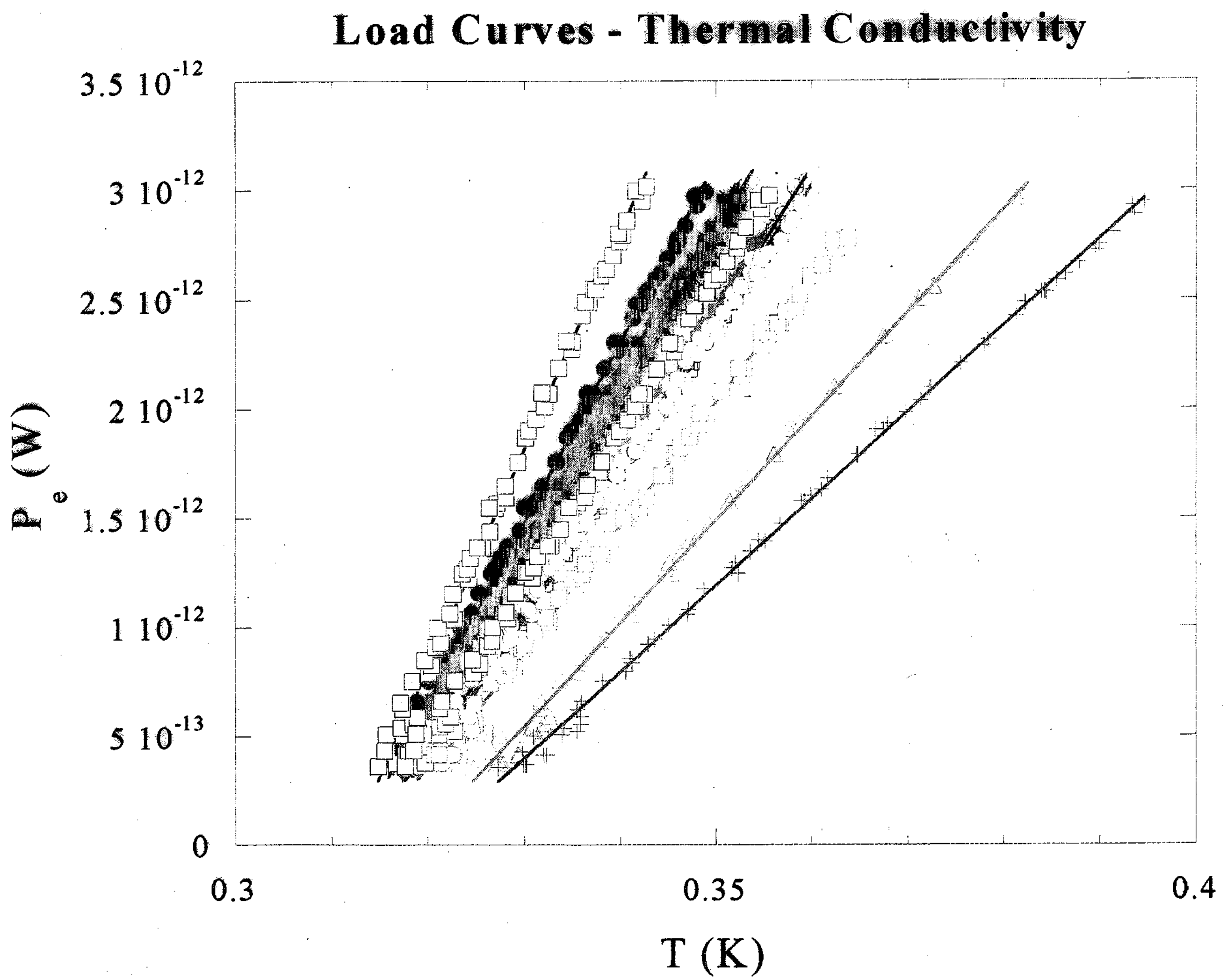

R(T) Data
ln (R)
18
17
16
15
14
13
1.3
1.4
1.5
1.6
1.7
1.8
1.9
1/sqrt(T)



Matching in G
<G> = 70.0 +/- 13.8 pW/K
Count
G (pW/K)
0
1
2
3
4
5
6
7
30
40
50
60
70
80
90
100
110



Matching in R_0
Δ = 41.36 (fixed)
<R_0> = 213 +/- 56 Ω
Count
R_0 (Ω)
0
2
4
6
8
10
100
150
200
250
300
350
400



Load Curves - Thermal Conductivity
3.5 10^-12
3 10^-12
2.5 10^-12
2 10^-12
1.5 10^-12
1 10^-12
5 10^-13
0
P_e (W)
0.3
0.35
0.4
T (K)

Bolometer Performance Summary

λ μm	τ ms	NEPblip e-17 W/√Hz	NEPdet e-17 W/√Hz	NEPtot/NEPblip
250 P	6	8.0	4.5	1.14
350 P	7	6.0	3.9	1.19
500 P	9	4.4	3.4	1.26
250 S	5	8.8	4.9	1.15
500 S	8	4.9	3.8	1.26

Assumptions:

G = Q/0.1T for margin in optical loading
Vn(amp) = 10 nV/√Hz
C = 1 pJ/K
R = 5 MΩ

- **Detectors meet speed and sensitivity requirements**
- **Photon-limited sensitivity can be achieved under lower backgrounds with a reduction in speed**

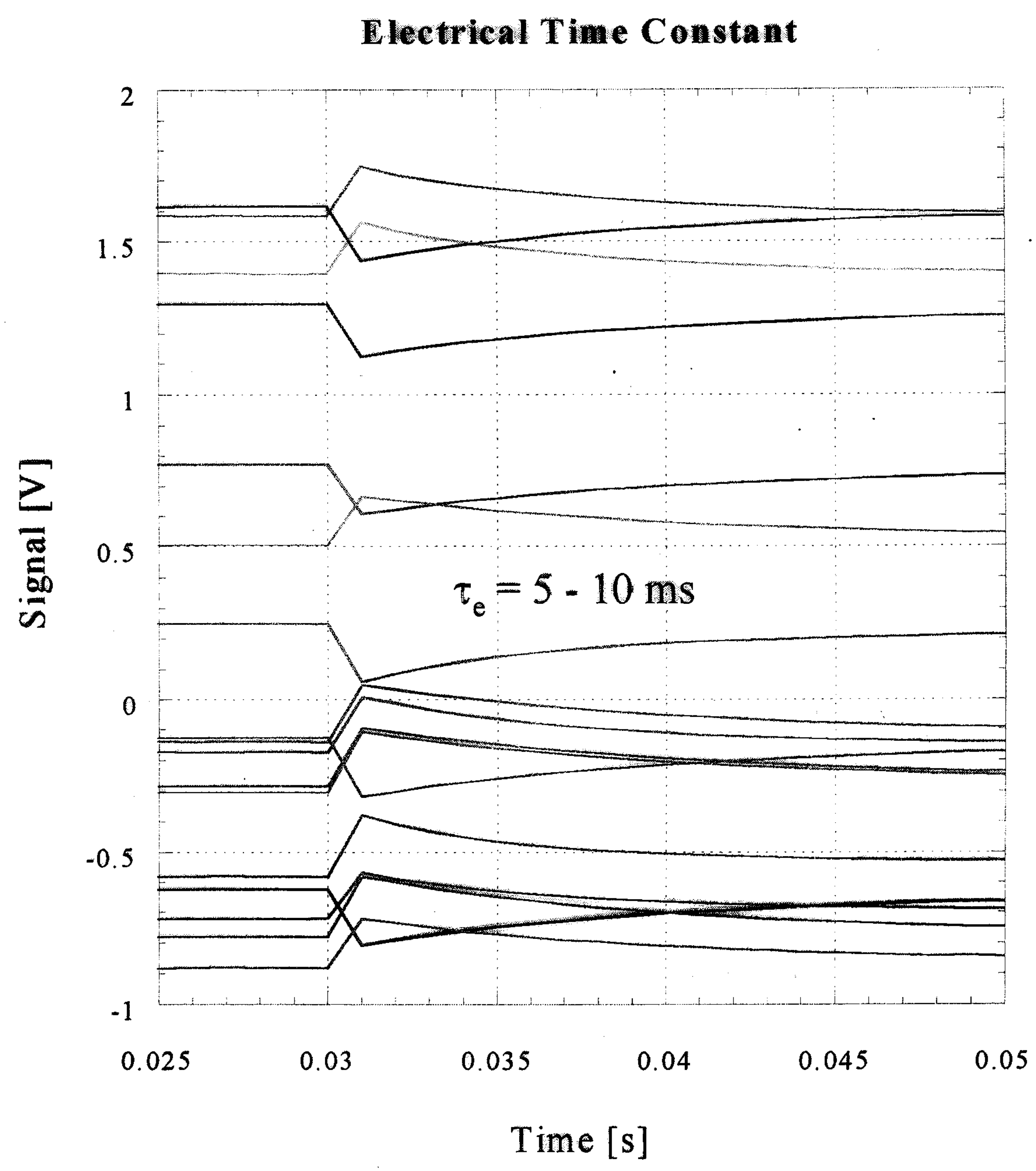
Note: NEP referred to absorbed power 0.7 coupling to telescope (assumes background flux is 0.7 times the SPIRE specification resulting in more stringent demands on the detector performance)

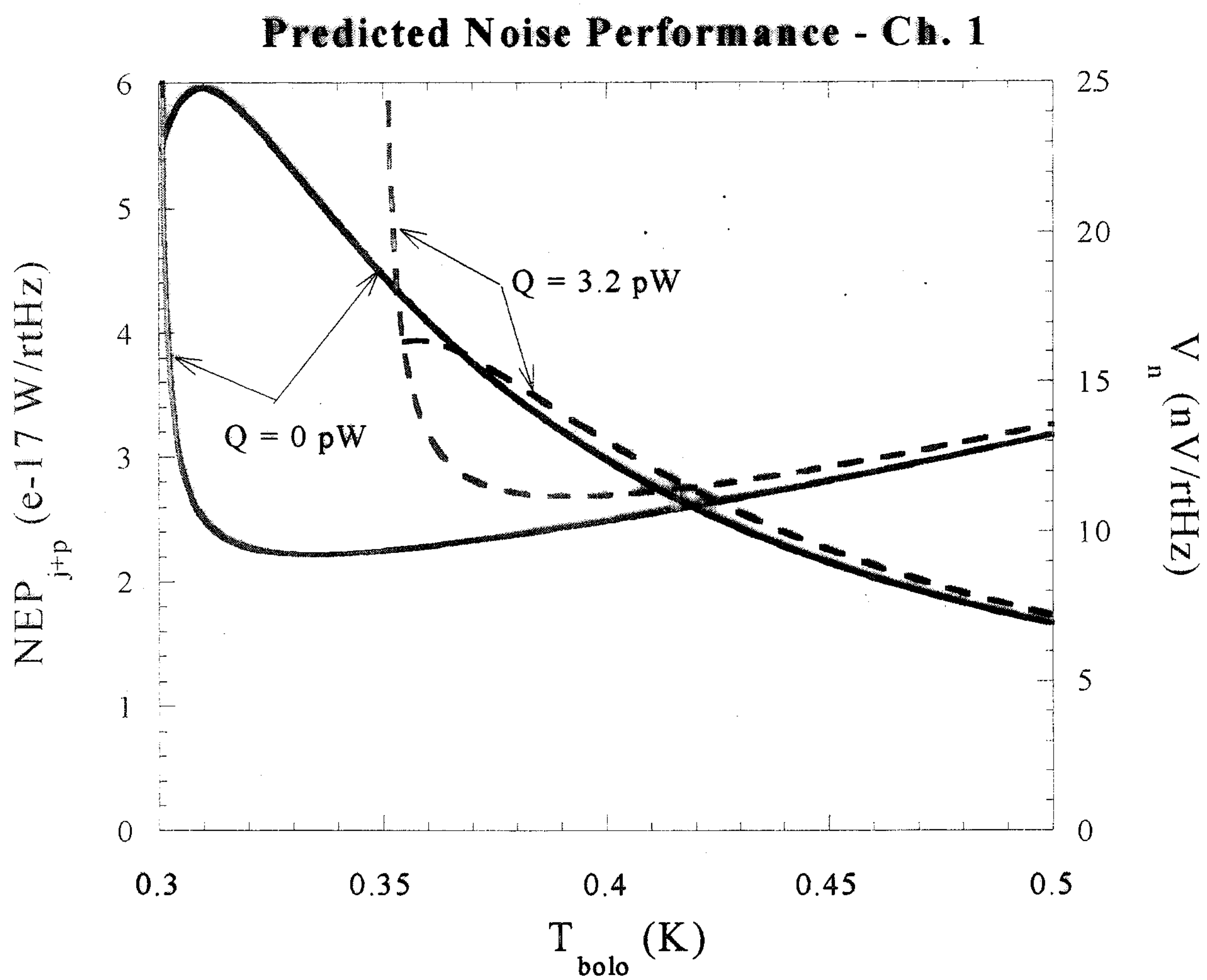
Detailed Sensitivity Spreadsheet

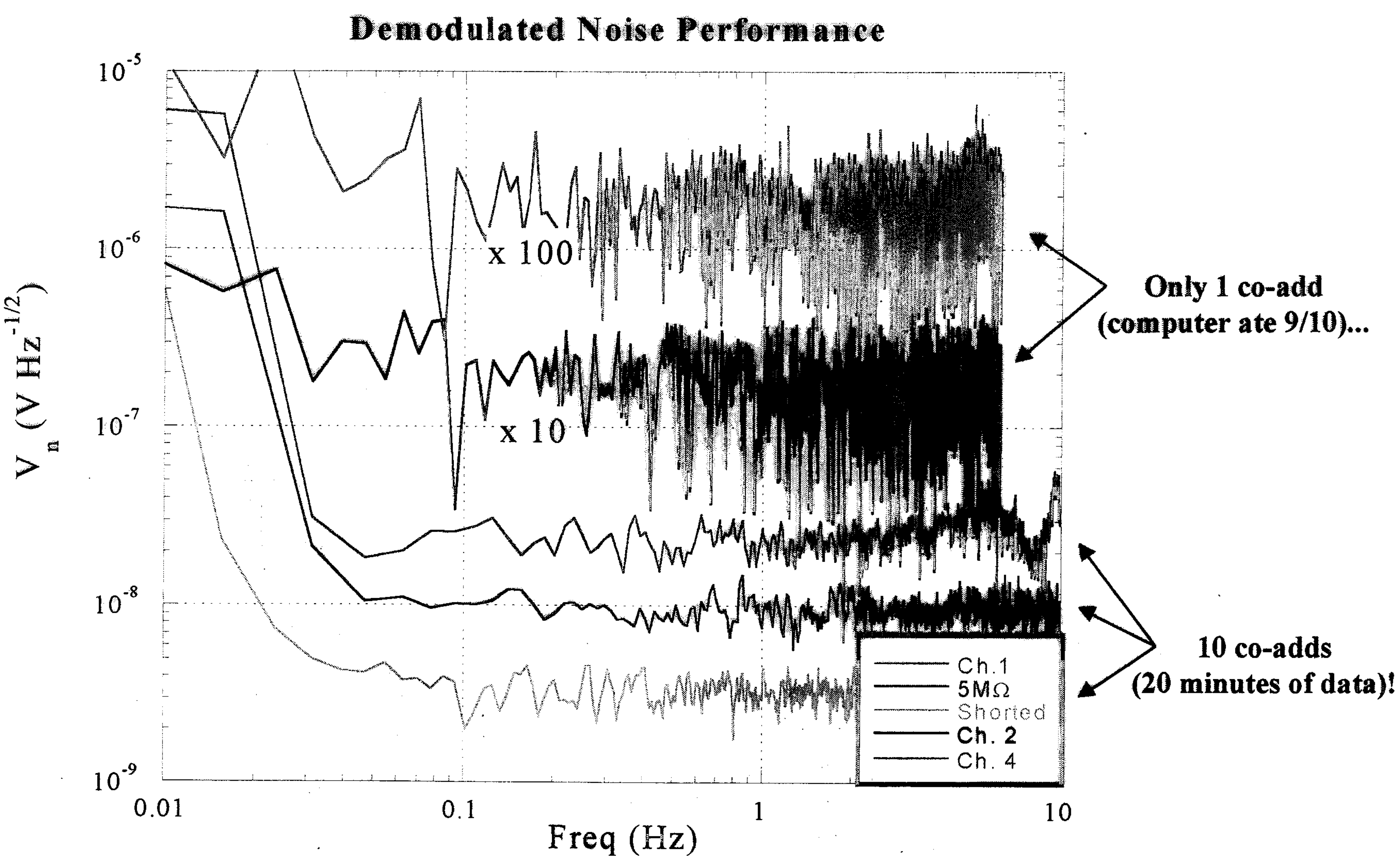
λ um	ν GHz	νBν (T) W / m^2 sr	Q pW	NEPblip W / rtHz	G pW / K	τ ms	NEPdet W / rtHz	NEPamp W / rtHz	NEPtot W / rtHz	NEPtot / NEPblip
250	1200	2.9E-02	4.0	8.0E-17	134.0	5.7	3.4E-17	2.9E-17	9.1E-17	1.14
350	857	1.2E-02	3.2	6.0E-17	107.2	7.2	3.0E-17	2.5E-17	7.2E-17	1.19
500	600	4.4E-03	2.4	4.4E-17	81.5	9.4	2.6E-17	2.2E-17	5.6E-17	1.26
250	1200	2.9E-02	4.9	8.8E-17	162.5	4.7	3.7E-17	3.2E-17	1.0E-16	1.15
500	600	4.4E-03	3.0	4.9E-17	98.8	7.8	2.9E-17	2.4E-17	6.1E-17	1.26

S V/W	Vn(phot) nV / rtHz	Vn(bol) nV / rtHz	Vn(JFET) nV / rtHz	Vn(BAU) nV / rtHz	Vn(A/D) nV / rtHz	Vn(tot) nV / rtHz	P pW	Voffset mVrms	νsample kHz	Gain	Tn nK / rtHz
3.36E+08	26.84	11.26	7.00	5.00	4.38	14.83	7.72	6.21	20.0	284.52	295.4
3.75E+08	22.68	11.26	7.00	5.00	3.92	14.70	6.18	5.56	20.0	318.11	291.1
4.30E+08	18.98	11.26	7.00	5.00	3.42	14.58	4.70	4.85	20.0	364.81	295.6
3.05E+08	26.84	11.26	7.00	5.00	4.82	14.97	9.36	6.84	20.0	258.43	268.9
3.91E+08	18.98	11.26	7.00	5.00	3.76	14.66	5.69	5.33	20.0	331.35	269.0

Notes: slightly different assumptions than in Griffin *et al.* MathCad model (e.g.: NEP referred to absorbed power 0.7 coupling to telescope)

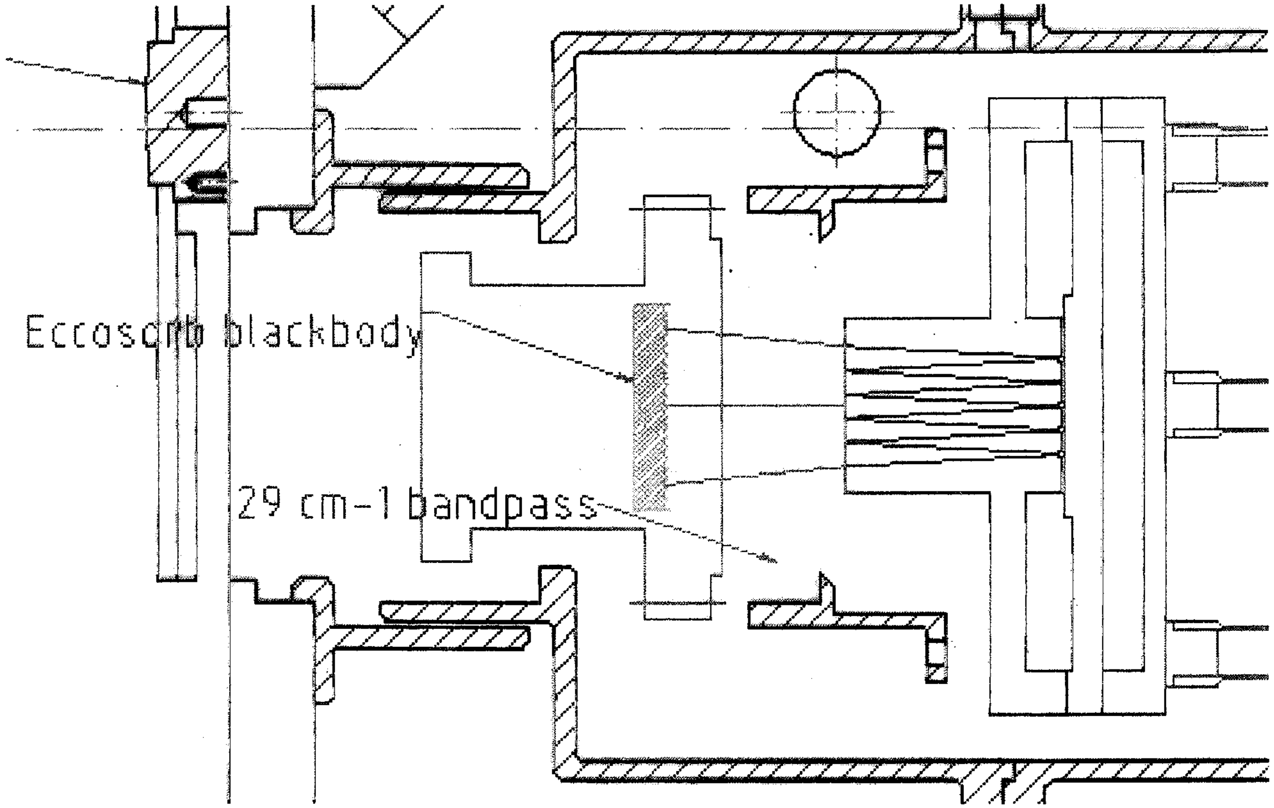

Electrical Time Constant
Signal [V]
2
1.5
1
0.5
0
-0.5
-1
0.025
0.03
0.035
0.04
0.045
0.05
Time [s]
τe = 5 - 10 ms


Predicted Noise Performance - Ch. 1
Q = 3.2 pW
Q = 0 pW
NEP_j+p (e-17 W/rtHz)
V_n (nV/rtHz)
T_bolo (K)
0
1
2
3
4
5
6
0
5
10
15
20
25
0.3
0.35
0.4
0.45
0.5



Note: unregulated 300 mK stage

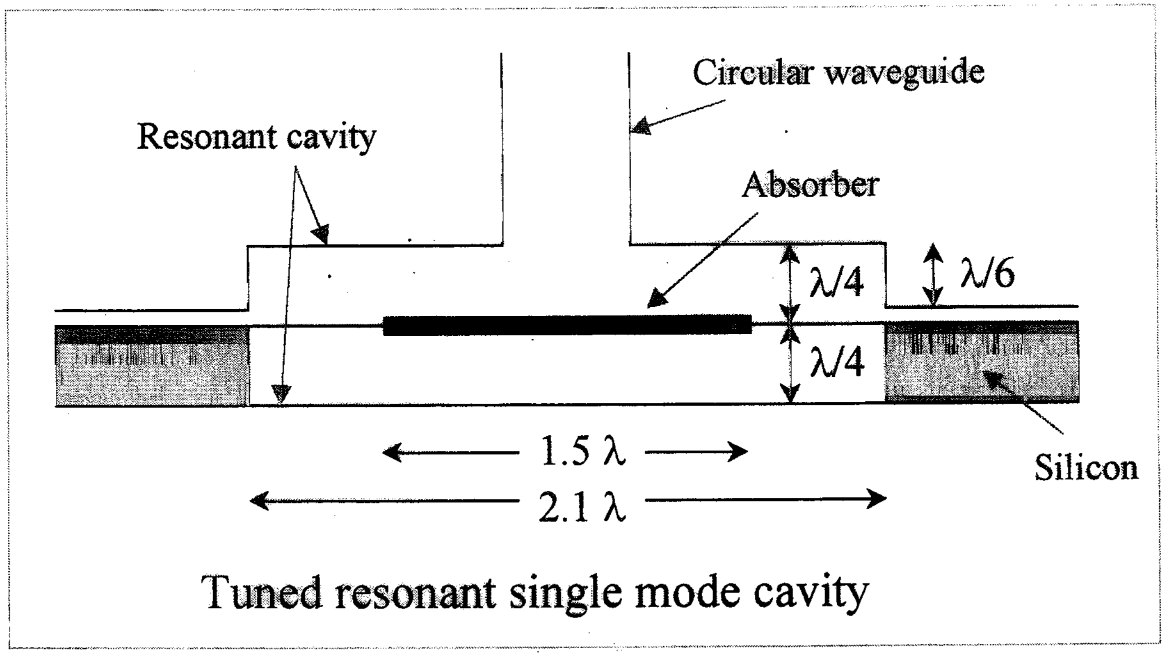
Optical Coupling Measurements with Cryogenic Blackbody

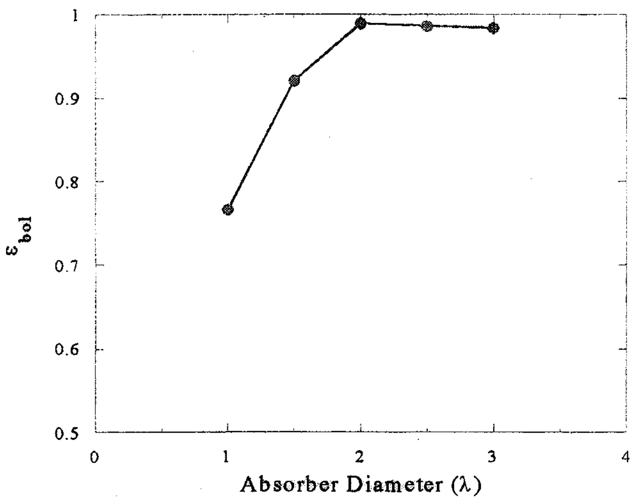


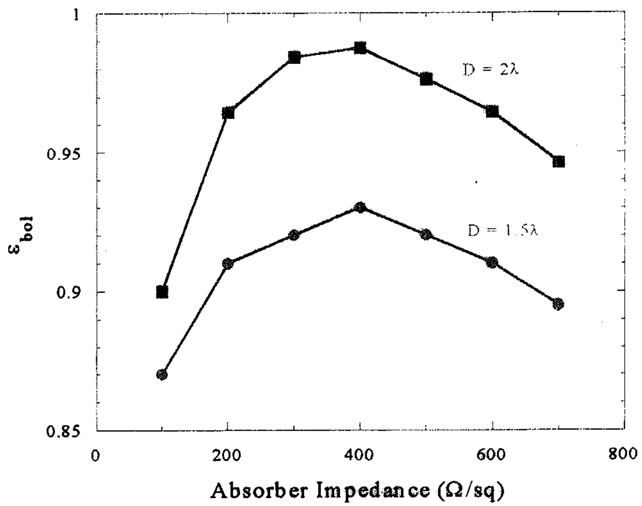
- Cryogenic blackbody may be operated between 1.6 K and 35 K using heater and GRT thermometer
- Low straylight for dark characterization
- Modest out-of-band filter requirements (no near-infrared radiation to block)

HFSS Simulations of Bolometer Optical Coupling

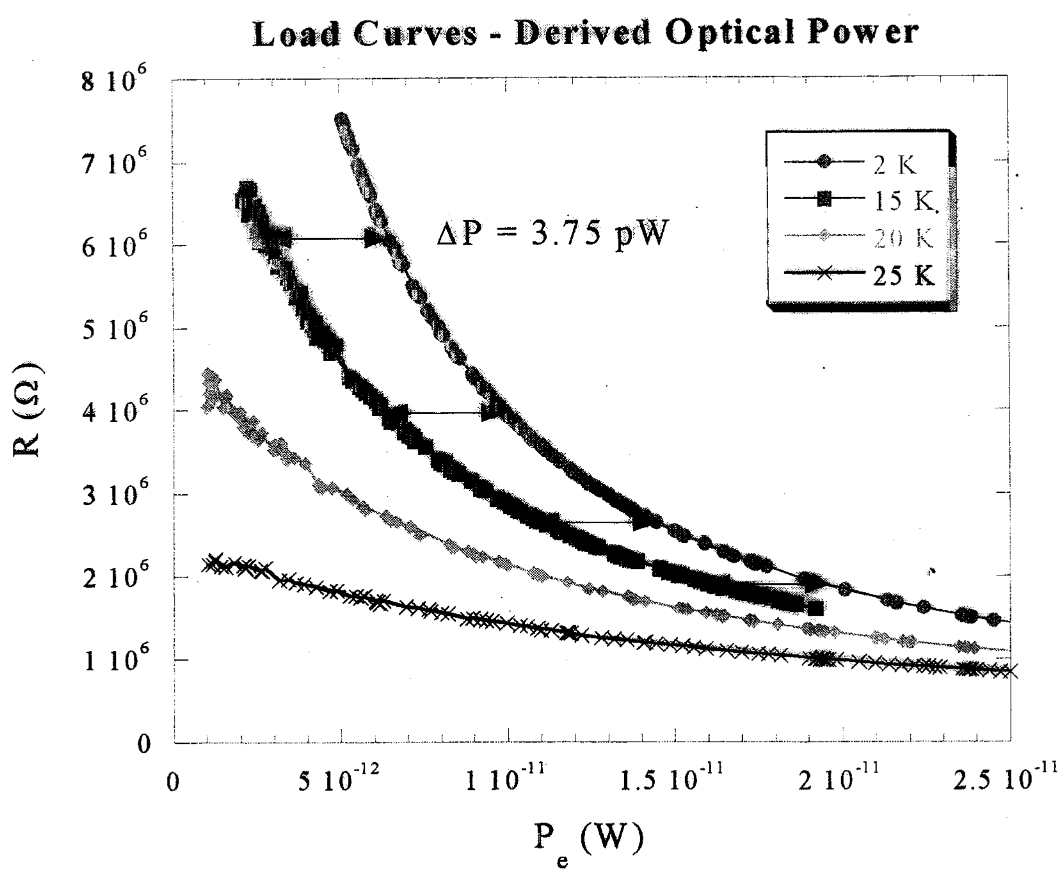
- Insensitive to absorber impedance
- Sensitive to front and backshorts
- Select D = 2.1 λ







Optical Coupling Measurements



Results so far

$\varepsilon_{bol} \sim 0.4 - 0.5$ (?!?)
$\varepsilon_{dark} \sim$ few %

$\varepsilon_{bol} * \varepsilon_{opt} = 0.5$ in BOLOCAM*
$\varepsilon_{bol} * \varepsilon_{opt} = 0.44$ in Planck feeds*

already realigned cavities feedhorns?

- probably not?

filter/feedhorn interaction?

- edge pixels have best coupling

*BOLOCAM and Planck have filters at large effective distance

Summary of Problems and Progress

Cryogenics

- 12-hour LHe hold time
  - *removed all superinsulation from He stage*
- Slow cooldowns, 340 mK from ^{3}He fridge
  - *lightweighted focal plane*
  - *replaced Chase ^{3}He fridge with Duband lab fridge*

Detectors

- Prototype array demonstrated slow optical time constants (but still in spec)
  - *improved release process for demonstration array*
- Lower-than-expected DQE with cryogenic blackbody
  - *carefully checked cavity dimensions*
  - *interaction with BP filter?*

Schedule

- FP structure and JFET prototypes are ~1 month behind schedule
- Haven't yet measured optical performance in BACUS

Detectors

- G, R(T) and $V_n(\nu)$ satisfactory
- Reasonable yield, optical crosstalk level

Readout Electronics

- Excellent noise performance
- Temperature control electronics not required

QMW Progress & Array Test Update

Progress

- 3 CEA devices tested so far
- Heat switch designed & integrated
- BACUS cool-down cycle well characterised
- Dewar reconfigured for stray light tests
  - Blanked VI's as F(temp.) & noise as F(bias)
  - ISO illuminator tests
  - Stray light tests - next week

Progress (2)

- Building parts for testing stray light from FTS position sensor (Moire fringe)
- All filters, windows & mounts now built & distributed to groups
- Ruthenium oxide thermometers mounted & calibrated
- Blanking plates complete & distributed - test data to be distributed by Raul Hermoso

Progress (3)

- QMW lab almost completely equipped
- Illuminator tests
  - Stalled due to NASA admin. - Four devices were sent 2 months ago, but they are still held up in the shipping dept. - problems with ITAR regulations
  - Ready for integration in BACUS - test with NTD pixel.

Test Plan Update

- CEA tests continue at QMW
  - Next device to be tested 4/10/99
- GSFC
  - Shipping to QMW 8/11/99
  - Campaign starts 10/11/99 - ending 19/12/99
- JPL/Caltech
  - Arriving 1/11/99 for 1 month campaign

Test Plan Update (2)

- All dewars now have correct filters/windows to allow “open” operation
- FTS & telescope simulator interfaces & operational modes will be finalised at the splinter meeting

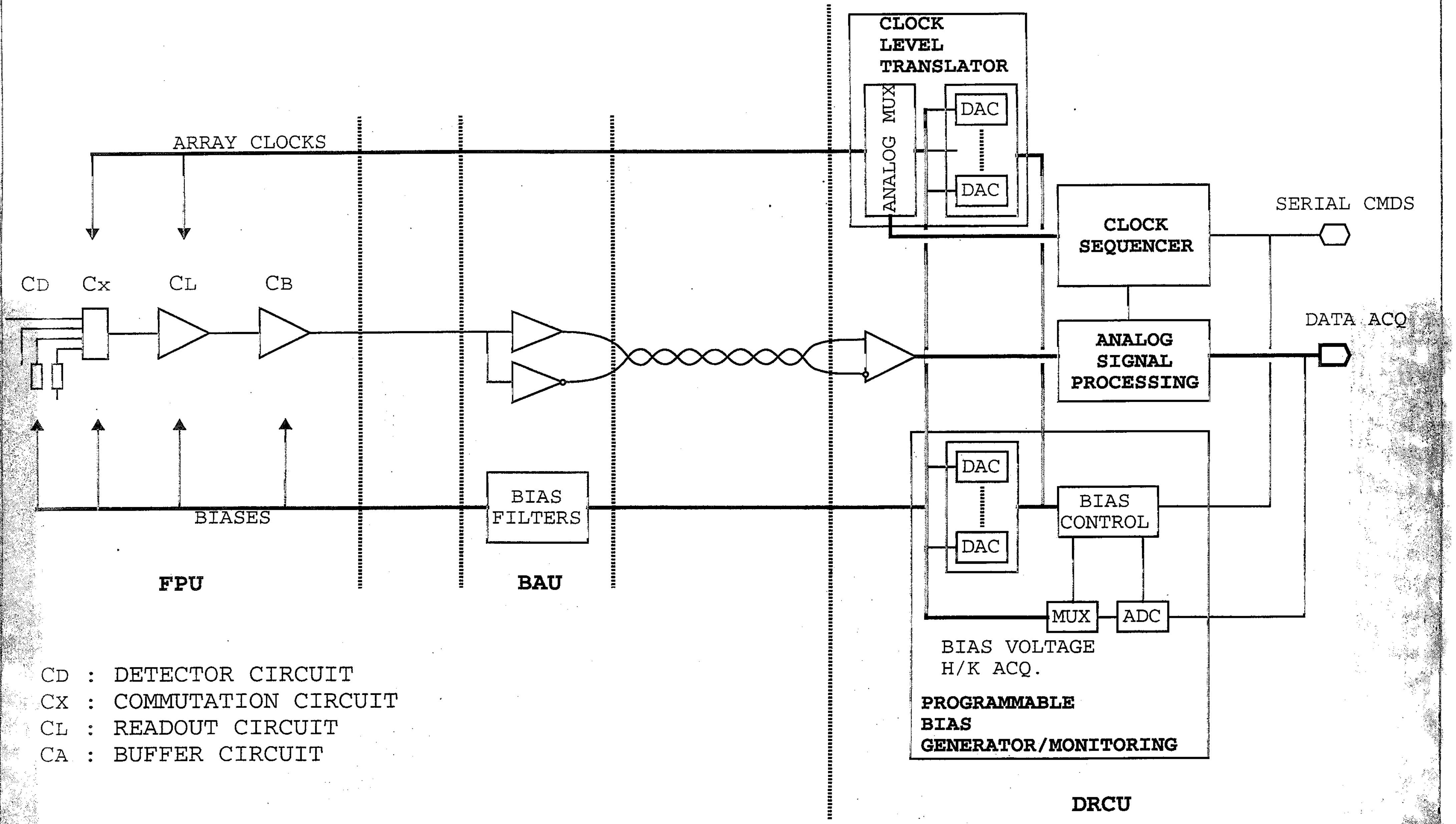
6. Electronic System Design Updates

(a) CEA — Christophe Cara

(b) GSFC/NIST — Jim Caldwell

(c) JPL/Caltech — Viktor Hristov

CEA OPTION
ARRAY CONROLLER ELECTRONICS BLOCK DIAGRAM



CD : DETECTOR CIRCUIT
CX : COMMUTATION CIRCUIT
CL : READOUT CIRCUIT
CA : BUFFER CIRCUIT

DETECTOR SAMPLING AND SYNCHRONISATION

- DETECTOR SAMPLING IS DONE BY SELECTING COLUMNS OF THE ARRAY

- PIXEL OVERSAMPLING IS ACHIEVED BY SWITCHING BUFFER INPUT BETWEEN BOLOMETER SIGNAL AND A REFERENCE BIAS

→ THE WARM ELECTRONICS INCLUDES **CLOCK SEQUENCERS** :

• THE SEQUENCER DESIGN IS COMMON TO PHOTOMETER AND SPECTROMETER SUB-SYSTEMS

• CLOCK SEQUENCES (SIMILAR TO TINY PROGRAMS) ARE SPECIFIC OF SUB-SYSTEM AND ARRAY READOUT MODE (E.G. FRAME RATE)

• SEQUENCER GENERATES TEST PATTERN ON REQUEST (TBC)

• H/W PROVIDES :
  - LOAD/DUMP FEATURES
  - EXTERNAL SYNCHRONISATION (INPUT LINE)
  - ON/OFF COMMAND (FROM DRCU CONTROLLER)

  - IMPLEMENTED ON ANTIFUSE FPGA + RAM

NOTE : ALL THE SEQUENCERS ARE RUNNING SYNCHRONOUSLY WITH A MASTER CLOCK.

DETETOR ARRAY AND WARM ELECTRONICS CONNECTION

→ EACH DETECTOR SUB-ARRAY (16x16 PIXELS) HAS THE FOLLOWING INPUTS/OUTPUTS :

- 5 BIASES
- 5 SUPPLIES
- 9 CLOCKS
- 16 SIGNAL OUTPUTS

→ EACH ARRAY (3 FOR PHOTOMETER AND 2 FOR SPECTROMETER) HAS ITS OWN COLD REDUNDED CLOCK SEQUENCER.

--> EACH SUB-ARRAY HAS ITS OWN BIAS VOLTAGE GENERATOR (THIS ENABLES TO OPTIMIZE EACH SUB-ARRAY FUNCTIONNAL PARAMETERS)

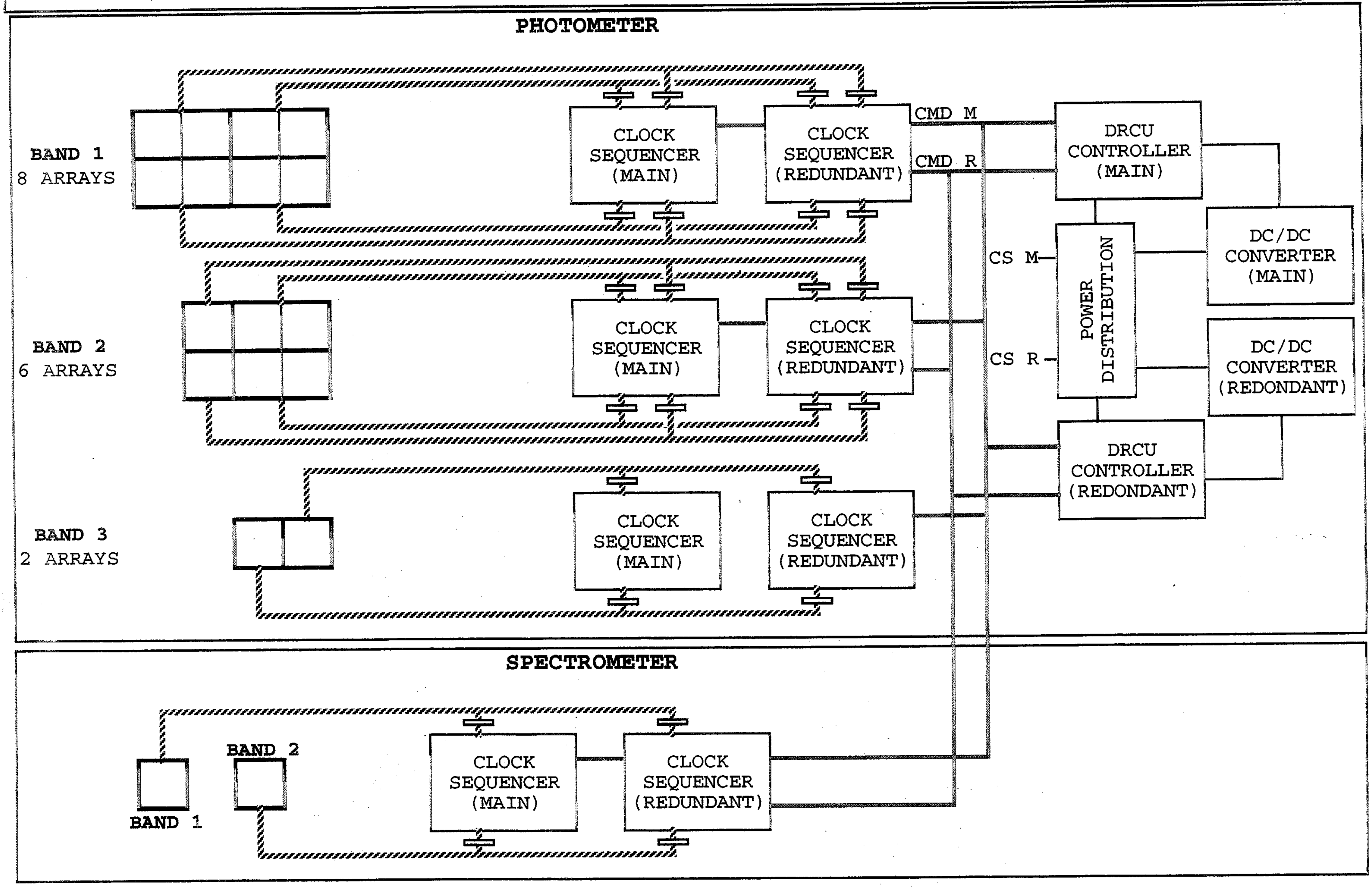
→ IN ORDER TO REDUCE THE WIRING COMPLEXITY 2 SUB-ARRAYS SHARE :

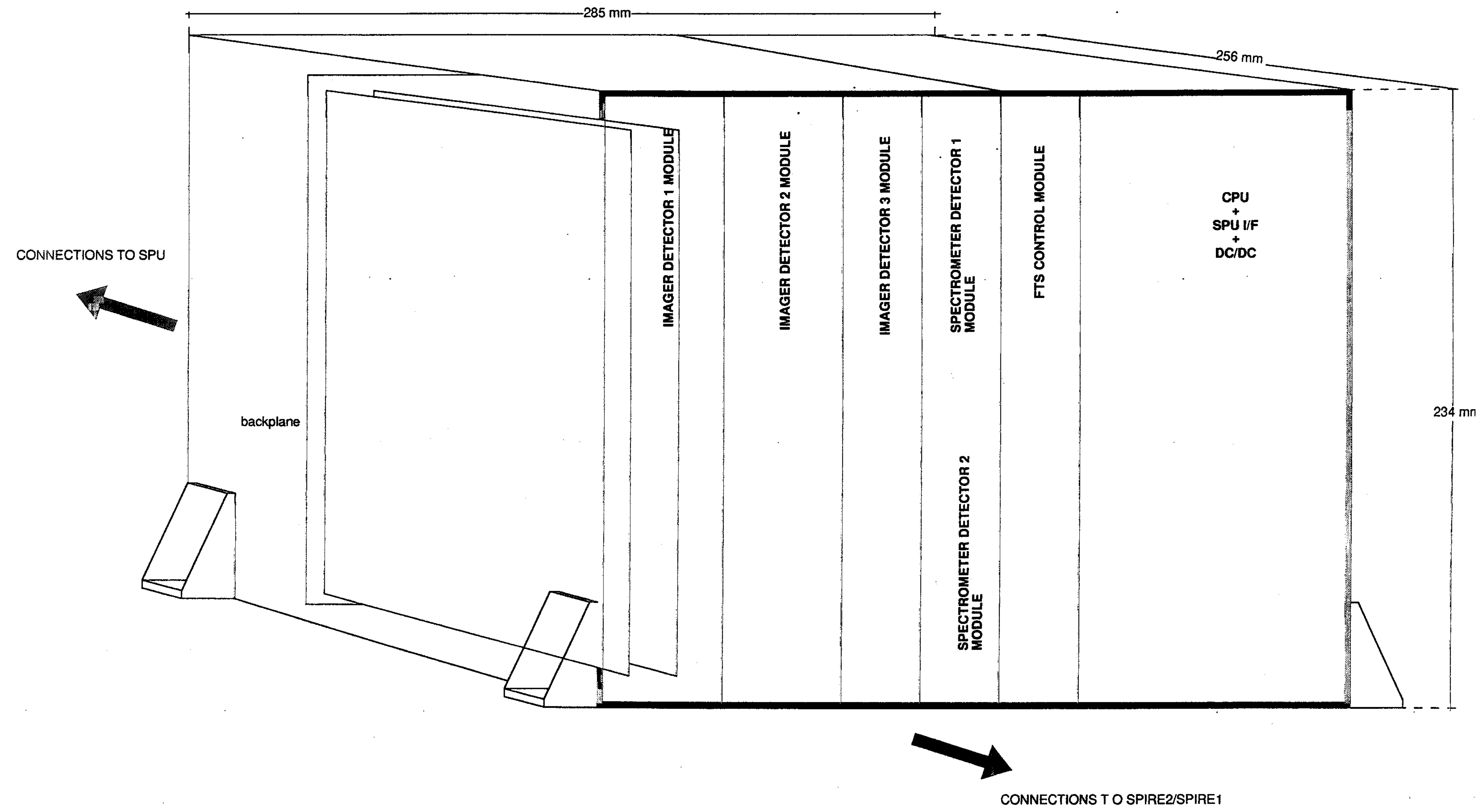
- THE CLOCK LINES
- THE SUPPLY LINES → TOTAL GAIN : 126 LINES !

RELIABILITY CONSIDERATION :

FAILURE TYPE :	SOLUTION	COMMENT
CLOCK SEQUENCER	SWITCH TO REDUNDANT	
SUB-ARRAY (INTERNAL)		NO FAILURE PROPAGATION
COMMON LINE SHORTENED	MODIFY CLOCK SEQUENCE	1 SUB-ARRAY LOST SUPLLY LINES ARE PROTECTED
BIAS OPENED OR BIAS GENE FAILS		1 SUB-ARRAY LOST
CLOCK OR SUPPLY OPENED OR GENE FAILS		2 SUB-ARRAYS LOST
DRCU CONTROLLER	SWITCH TO REDUNDANT	

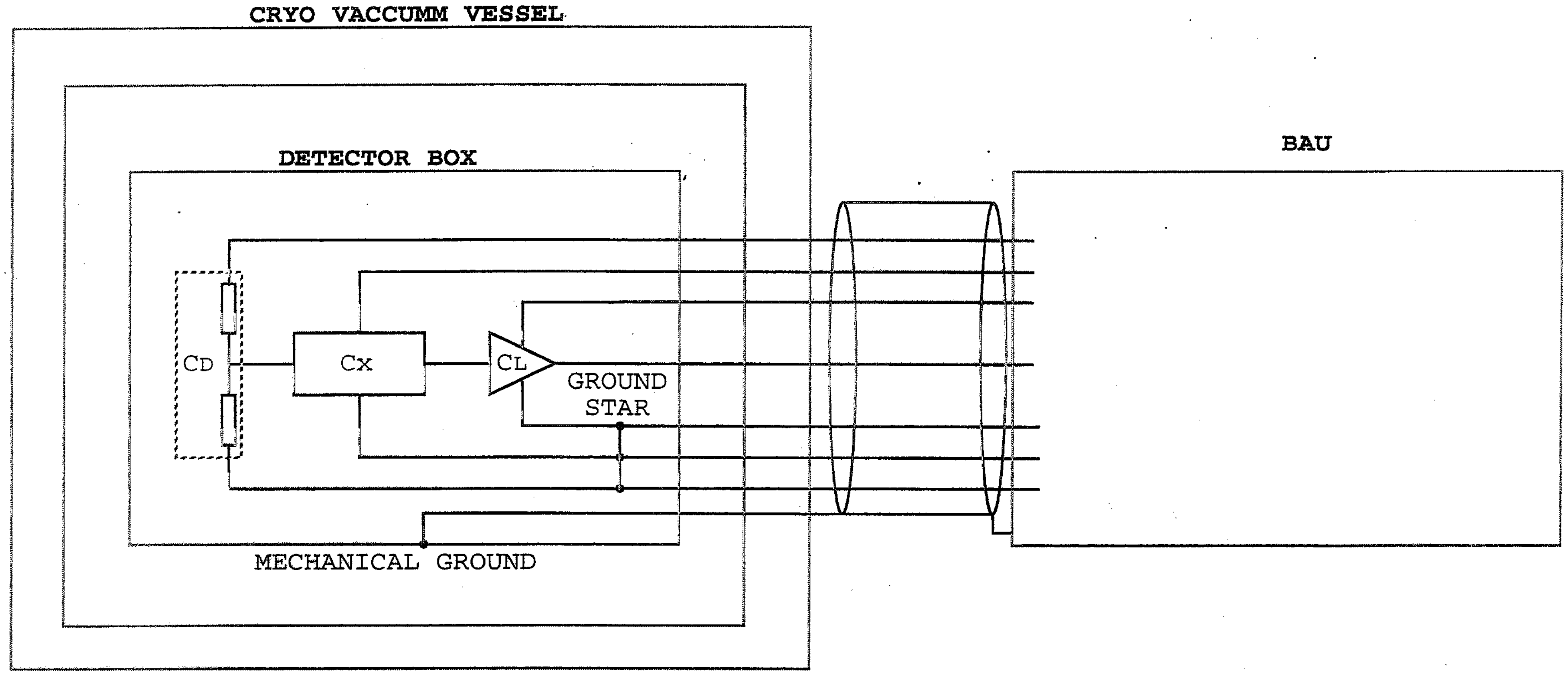
ARRAY CLOCK SEQUENCERS CONFIGURATION





285 mm
256 mm
234 mn
CONNECTIONS TO SPU
backplane
IMAGER DETECTOR 1 MODULE
IMAGER DETECTOR 2 MODULE
IMAGER DETECTOR 3 MODULE
SPECTROMETER DETECTOR 1 MODULE
SPECTROMETER DETECTOR 2 MODULE
FTS CONTROL MODULE
CPU + SPU I/F + DC/DC
CONNECTIONS T O SPIRE2/SPIRE1

CEA DETECTOR OPTION
DETECTOR WIRING AND GROUNDING



Detector Arrays

Design Status of the GSFC Electronics

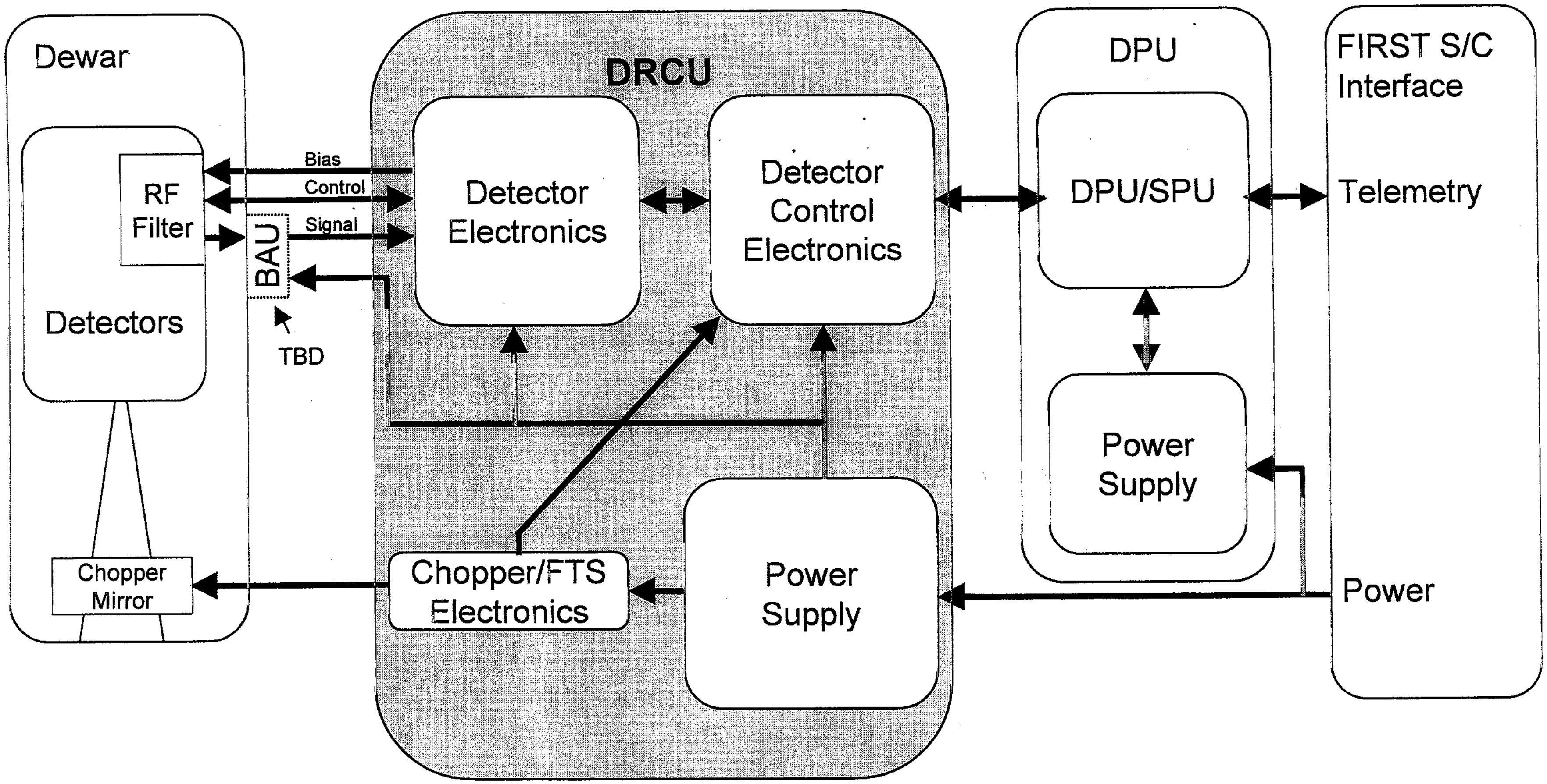
J. Caldwell

Main Design Features

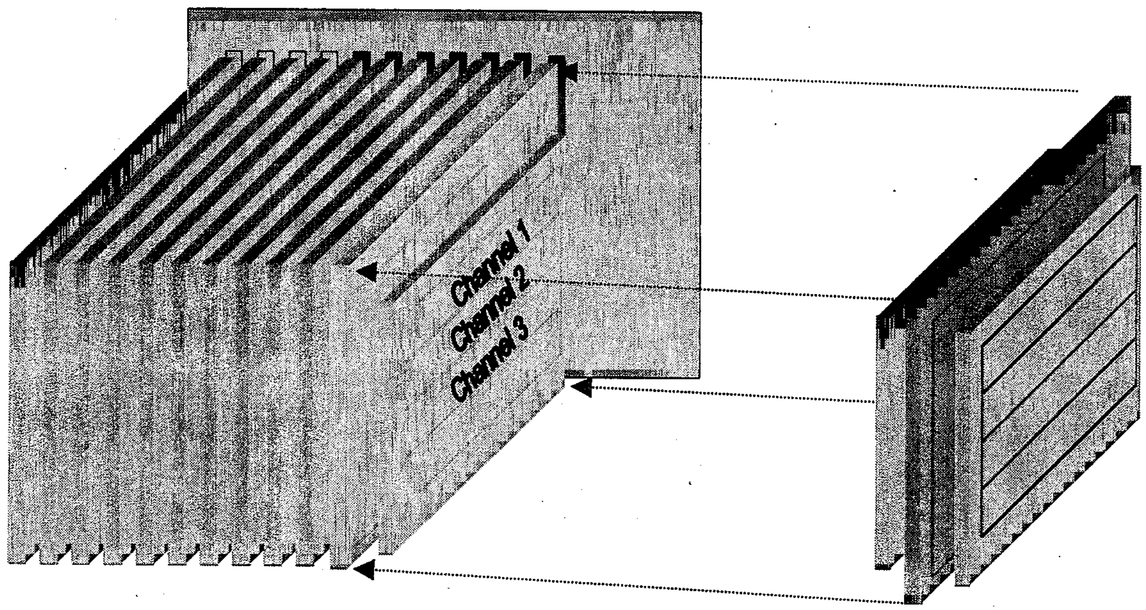
Functional Description

- Description of the Warm Electronics operation and physical constraints.
  - The GSFC/NIST detector system employs SQUIDS to multiplex the data into pairs of wires.
  - The system samples each detector at 20,000 frames per second. These data are co-added into a single image. During the co-adding, the pixels are examined for glitches and the data is flagged in the frames which are corrupted. The sampling of the data is coordinated with the position of the FTS and Chopper.
  - For both and Photometer and the FTS, the system is synchronized to the start of scan pulses produced by the scan control electronics and to the mirror position sync pulses.

SPIRE TES Block Diagram -- Top Level



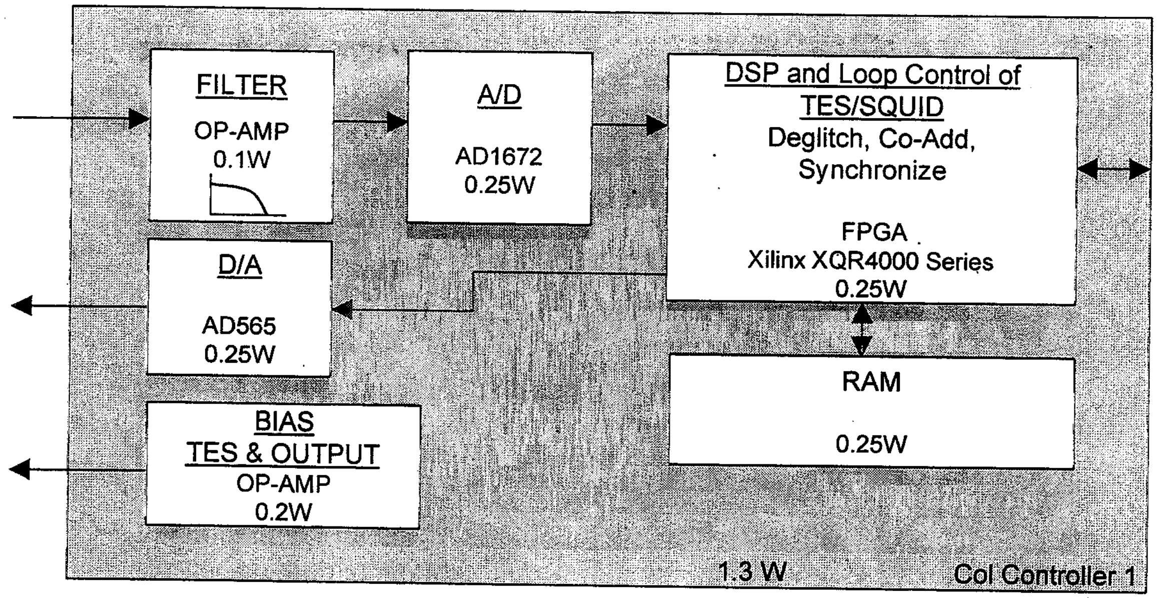
SPIRE TES Package Concept -- Warm Electronics boards



53 Column Controllers Needed

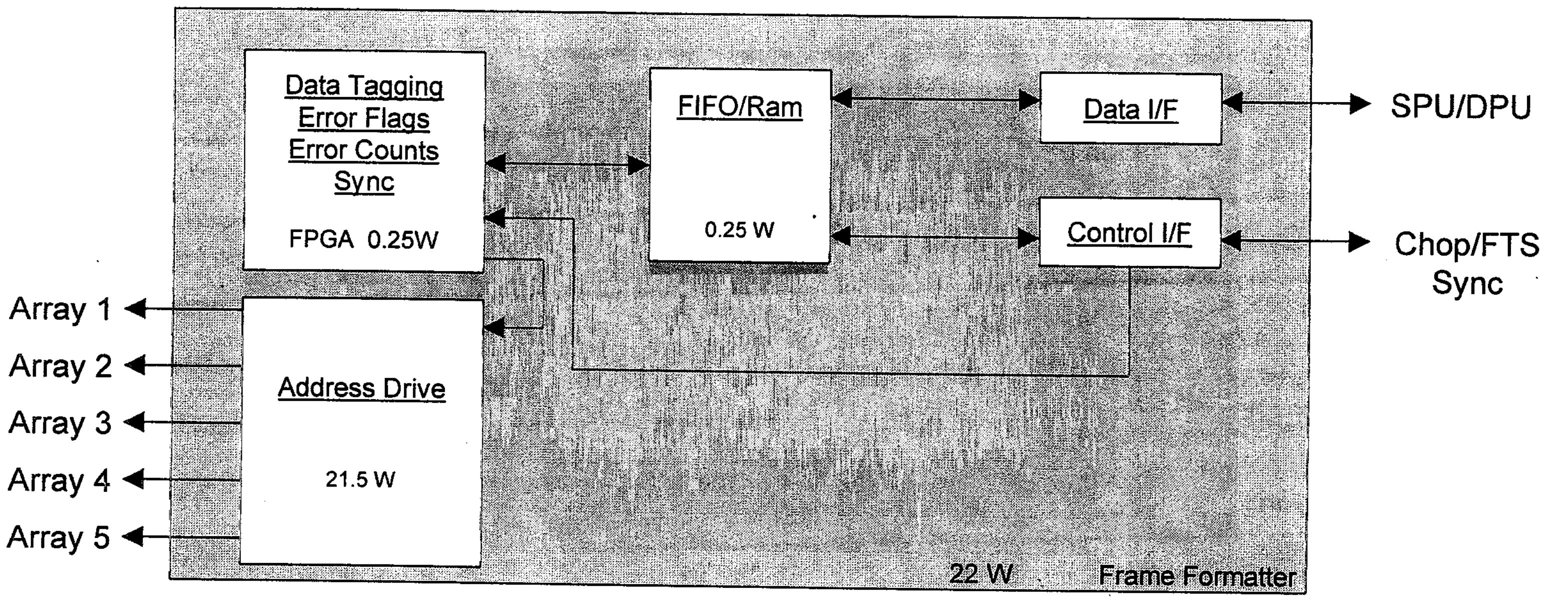
- **3 per Side of 9 Double Sided Circuit Boards**
- **2 Double Sided Circuit Boards for all other functions**

Column Controller Block Diagram



- System requires 53 Controller Modules (8 + 14 + 31)
- Functions contained within each Column Controller Module
  - Passive Input Filter
  - 1 to 2 FPGA's required for each controller
  - Loop control is in firmware of the FPGA
  - RAM contains the co-added data arrays and A/D and D/A Linearization Tables
  - Bias for TES Detectors.
  - Bias for Output Series Array

Frame Formatter Controller

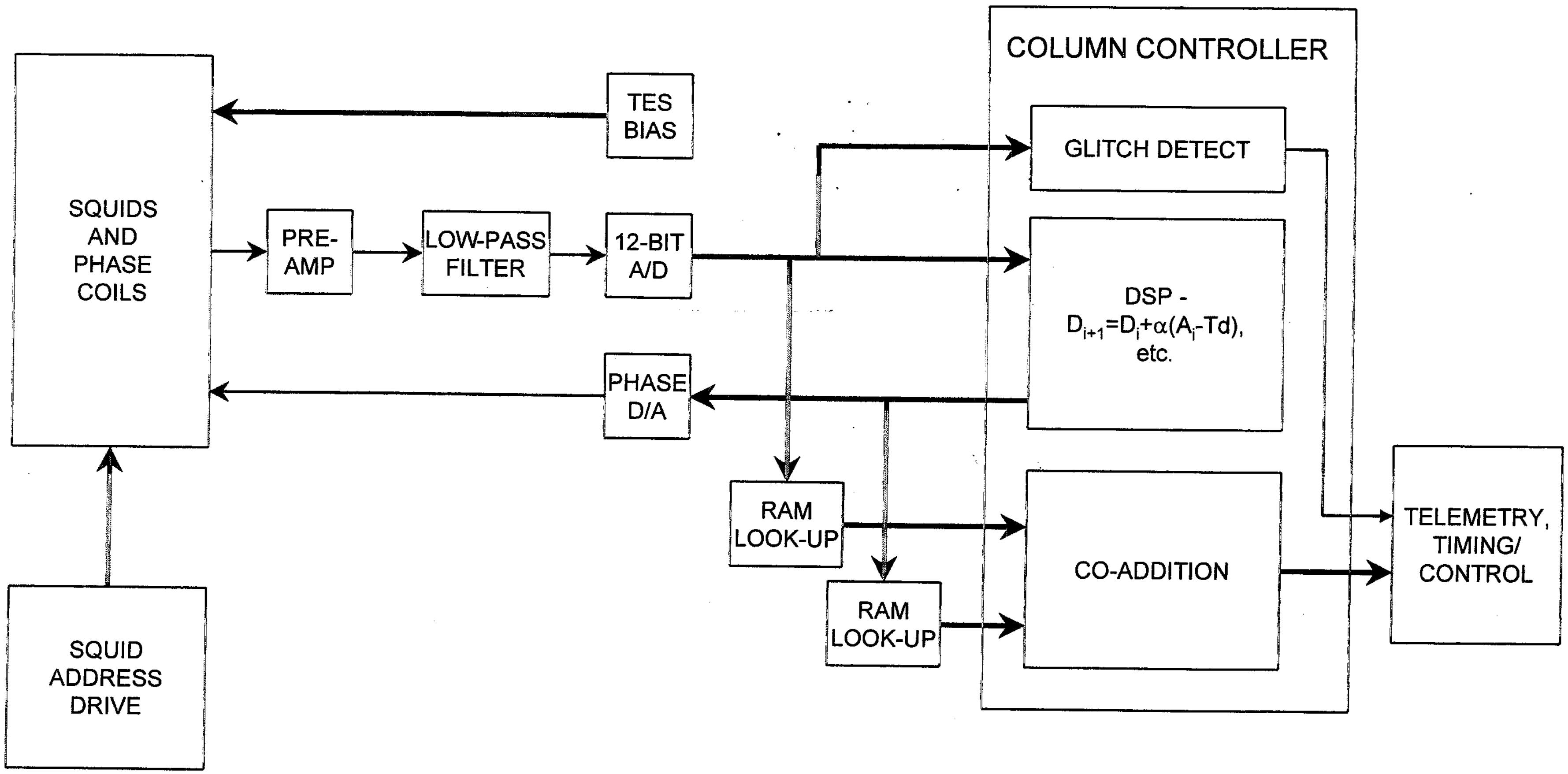


- System requires 1 to 2 FFC Modules
- Functions contained within each Module
  - Data Tagging -- Error Flags, Error Counts
  - 1 FPGA required for each controller
  - Data and Sync Control Interfaces
  - Data Storage is Ram or FIFO
  - Address Drive for three arrays

POWER ESTIMATE

	Address Drivers	Column Controller	Bias	BAU (TBD)
Array 1	65 ea OP467 @10 V and 11 mA = 7.15 W	1.3 W per CC x 8 CC = 10.4 W	1 W	8 ea OP467 @10V and 11 mA = 0.88 W
Array 2	65 ea OP467 @10 V and 11 mA = 7.15 W	1.3 W per CC x 14 CC = 18.2 W	1 W	14 ea OP467 @10V and 11 mA = 1.54 W
Array 3	65 ea OP467 @10 V and 11 mA = 7.15 W	1.3 W per CC x 31 CC = 40.3 W	1 W	31 ea OP467 @10V and 11 mA = 3.41 W
SubTotal	21.45 W	68.9 W	3 W	5.83 W
Total	**99.18 W**			

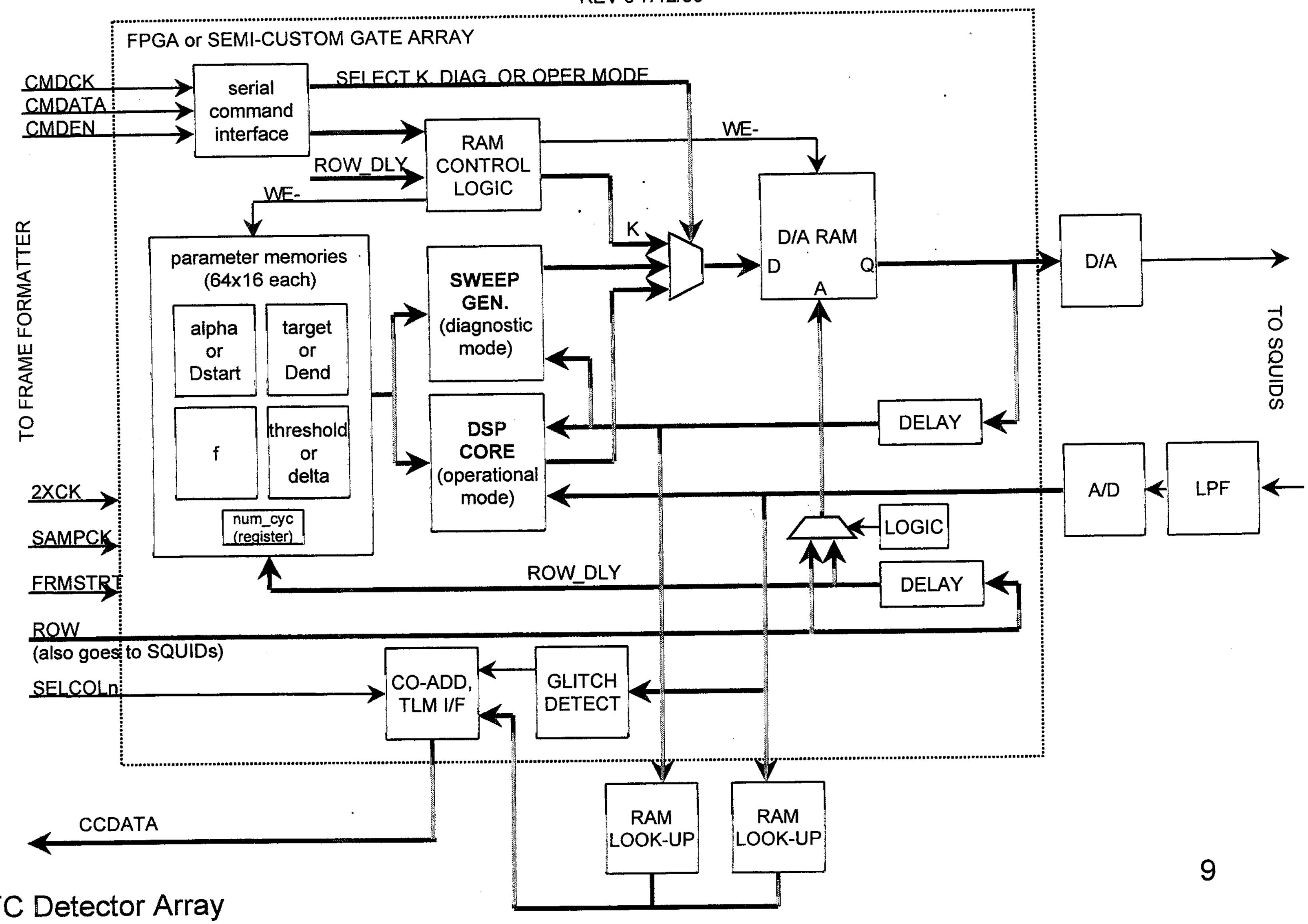
SPIRE - COLUMN CONTROLLER FLIGHT ELECTRONICS
1 COLUMN
REV 0 7/12/99



SPIRE Sep 99 Systems Meeting
30 Sep 1999 Saclay

SPIRE - COLUMN CONTROLLER BLOCK DIAGRAM

REV 0 7/12/99

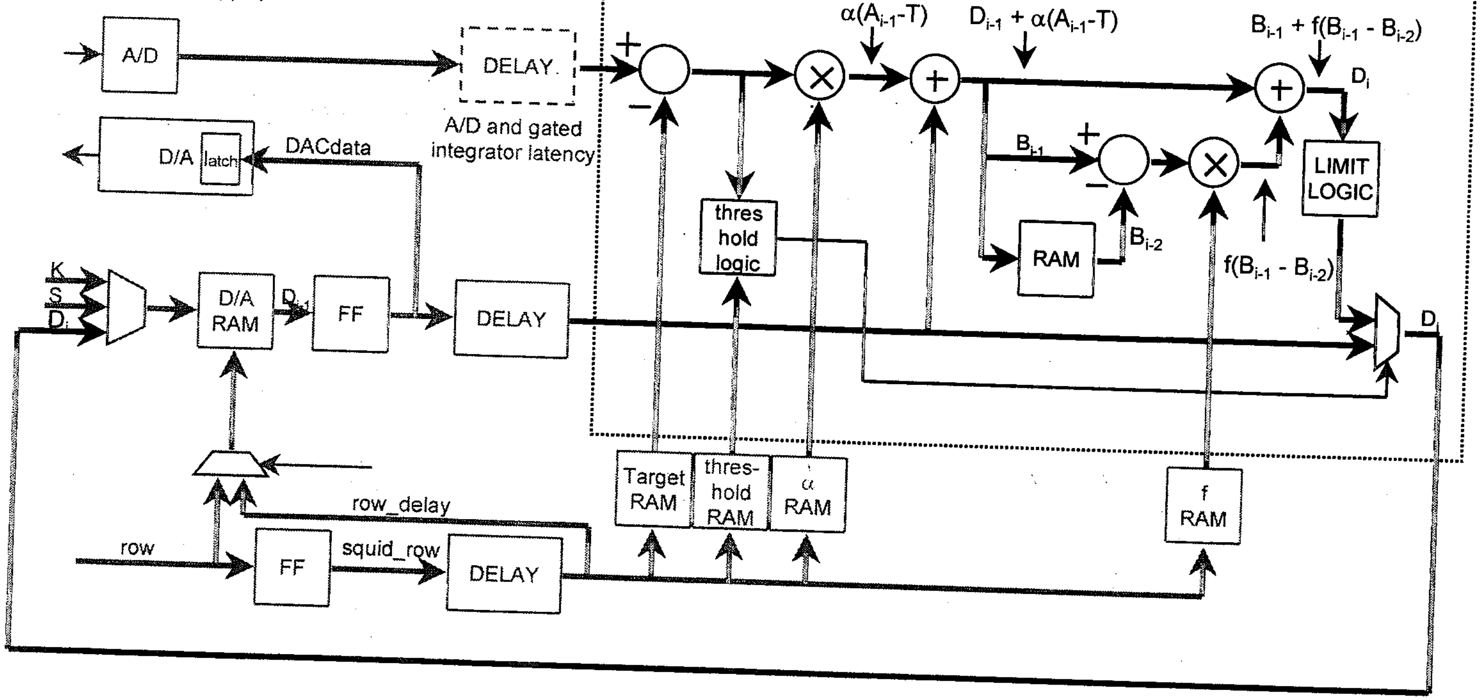


GSFC Detector Array

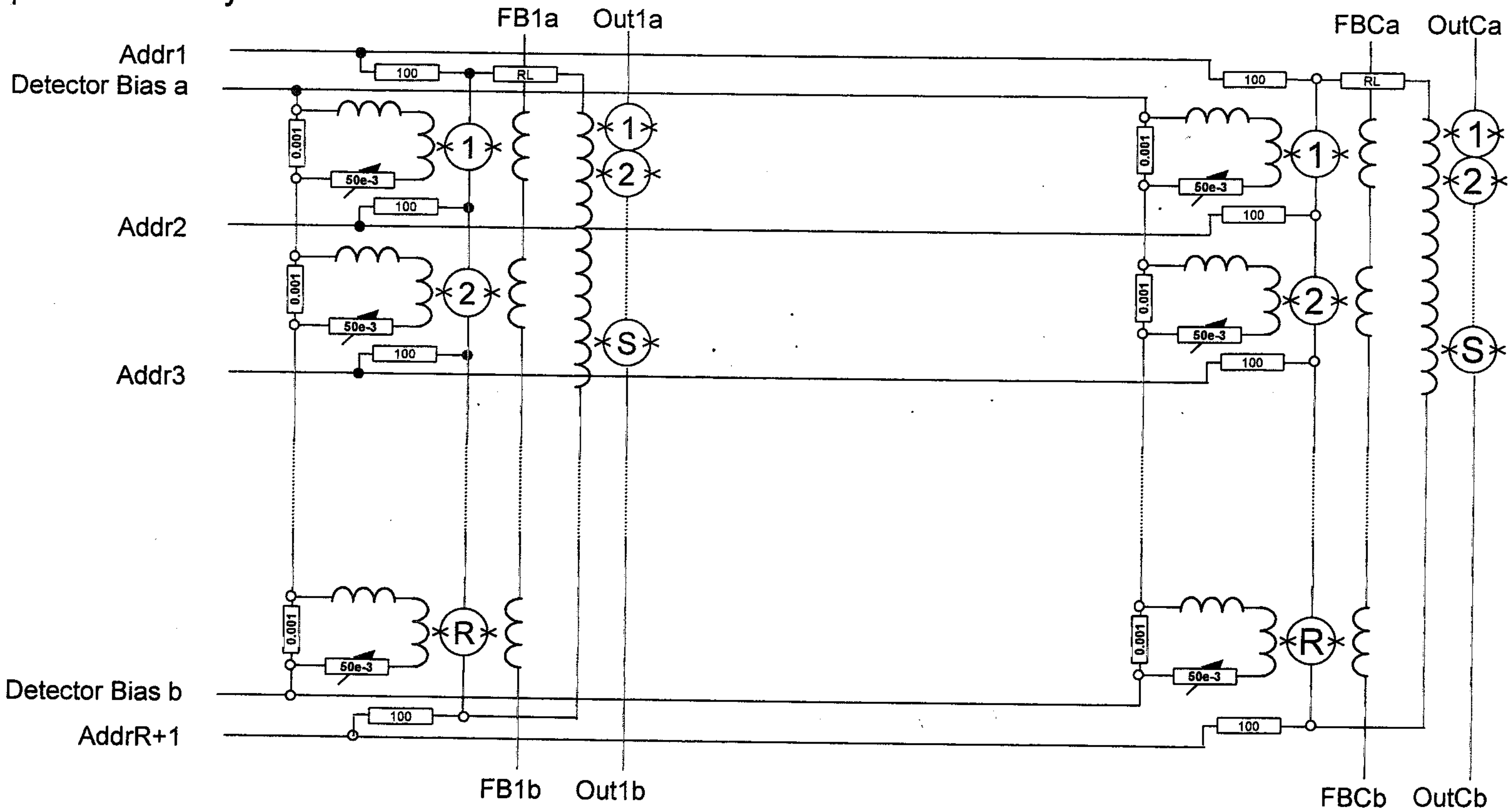
SPIRE - COLUMN CONTROLLER DSP CORE ARCHITECTURE

REV 0 7/12/99

Linear Prediction Algorithm
$D_i = (1+f)[D_{i-1} + \alpha(A_{i-1}-T)] - f[D_{i-2} + \alpha(A_{i-2}-T)]$ or
$D_i = B_{i-1} + f(B_{i-1} - B_{i-2})$ where
$B_i = D_i + \alpha(A_i-T)$
Negative Feedback Algorithm
$D_i = D_{i-1} + \alpha(A_{i-1}-T)$



OPERATION:
1st half of sample period - read D/A RAM at address 'row' to get DACdata value for next row.
2nd half of sample period- write D_i to D/A RAM at address 'row_delay' for row sampled 'delay' cycles ago. Latch DACdata for next row.
NOTES:
1. i is a sample index, not a cycle (row) index



Detector Array of C columns and R rows with S squids in the series array showing required lines in/out

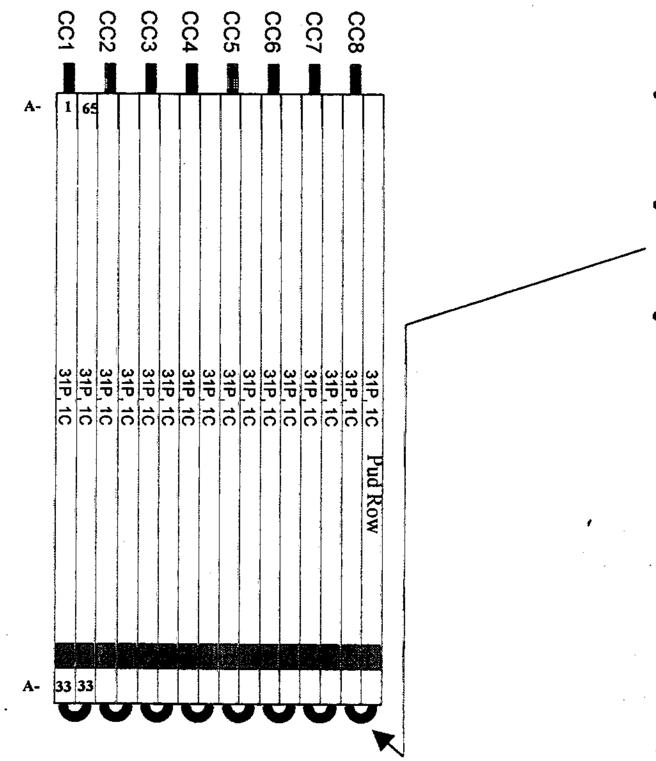
The array size can be adjusted by folding the columns associated with each column controller electronics

Squid Multiplexor

Physical Arrangement of 500 micron 16x31 Array

8 Column Controllers

TES Bias, SQUID BIAS, MOD, and OUTPUT



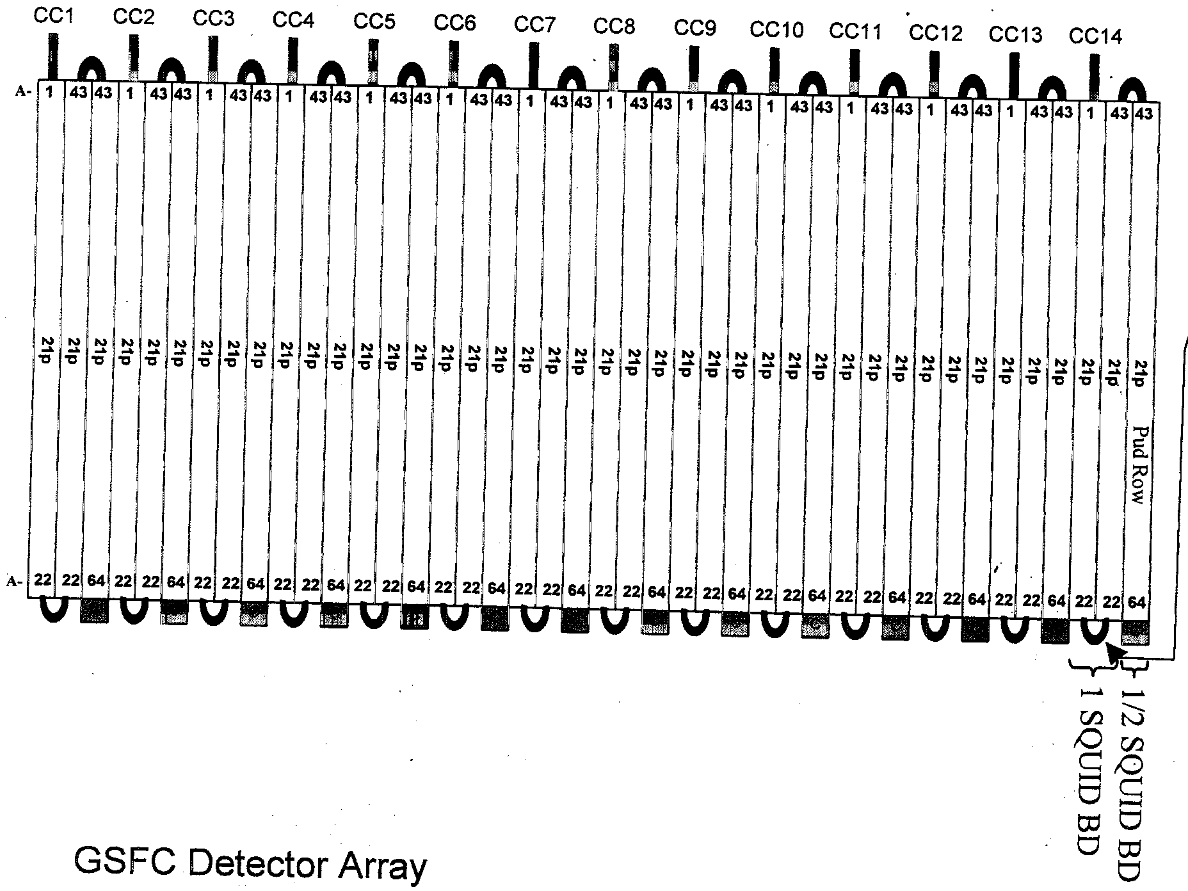
- Array has 16 PUD Rows with 31 pixel and 1 Cal SQUID circuits
- Super Conducting Wire Interconnect between Boards (where necessary)
- 65 Address Lines +1 Bundle Shield
  8 Bias Lines +1 Bundle Shield
  16 Feedback Lines +1 Bundle Shield
  16 Output Lines +1 Bundle Shield
  105 Lines +4 Bundle Shields

Squid Multiplexor

Physical Arrangement of 350 micron 21x42 Array

14 Column Controllers

TES Bias, SQUID BIAS, MOD, and OUTPUT



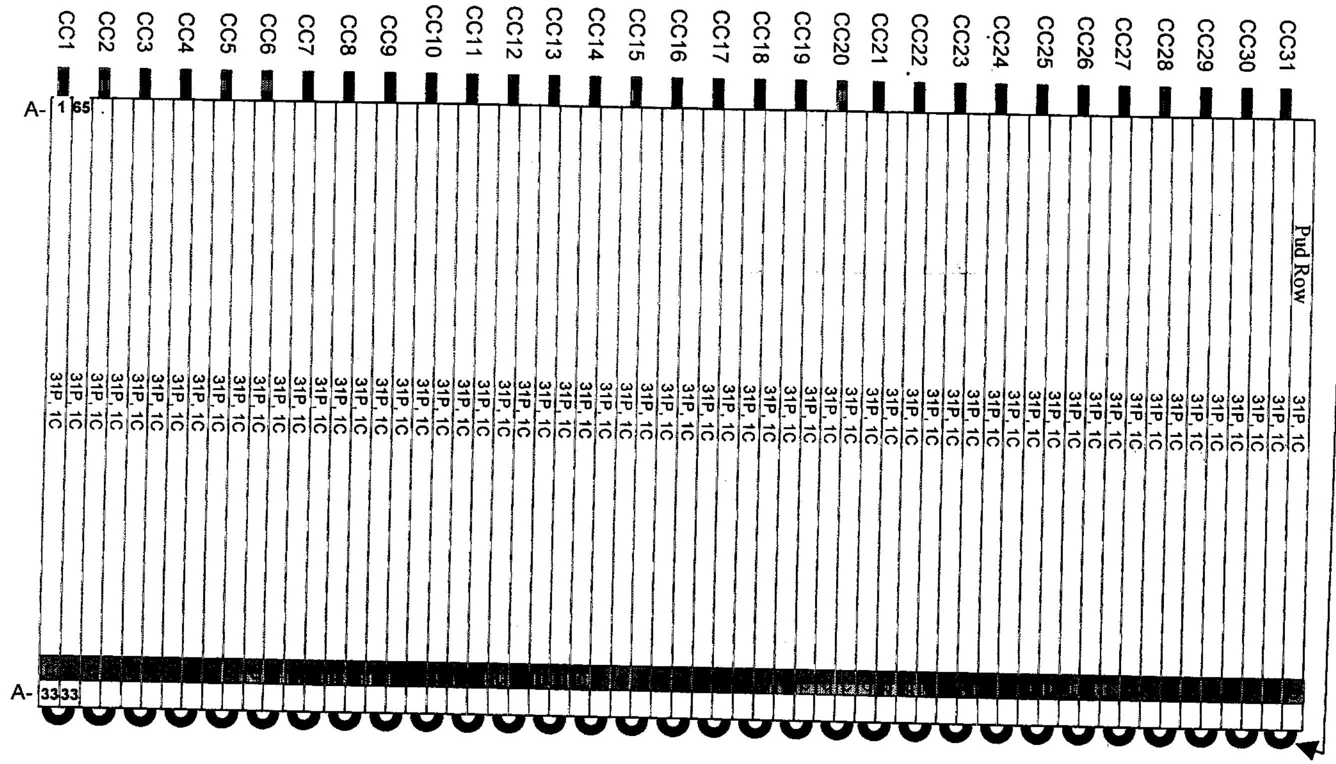
- Array has 42 PUD Rows with 21 pixel and 1 Cal SQUID circuits
- 14 Col Controllers Drive 1.5 SQUID Boards
- Super Conducting Wire Interconnect between Boards (where necessary)
- 65. Addr +1 Sh
  8. TES Bias +1 Sh
  28. Feedback +1 Sh
  28. Outputs +1 Sh
  129. Lines +4 Sh

Squid Multiplexor

Physical Arrangement of 250 micron 31x61 Array

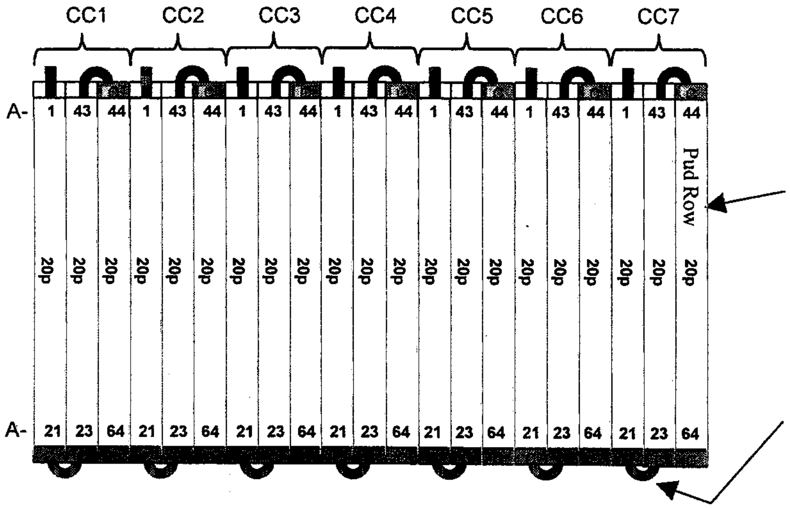
31 Column Controllers

TES Bias, SQUID BIAS, MOD, and OUTPUT



- Array has 62 PUD Rows with 31 pixel and 1 Cal SQUID circuits
- Super Conducting Wire Interconnect between Boards (where needed)
- 65. Addr +1 Sh
  8. TES Bias +1 Sh
  62. Feedback +1 Sh
  62. Outputs +1 Sh
  197. Lines +4 Sh

Squid Multiplexor



Physical Arrangement of FTS 20 x 20 array

7 Column Controllers

TES Bias, SQUID BIAS, MOD, and OUTPUT

10p 10p 10p 10p 10p 10p 10p 10p 10p10p 10p 10p 10p 10p 10p 10p 10p 10p 10p 10p

- Array has 21 PUD Rows with 20 Pixel and 1 Cal SQUID circuits
- A Column Controller Drives 1.5 SQUID Boards
- Super Conducting Wire Interconnect between Boards (where necessary)
-

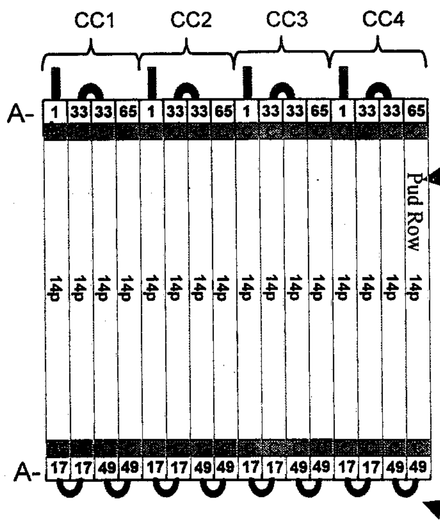
65	Address Lines	+1	Sh
8	TES Bias	+1	Sh
14	Feedback	+1	Sh
14	Output	+1	Sh
101	Lines	+4	Sh

Squid Multiplexor

Physical Arrangement of FTS 14 x 14 array

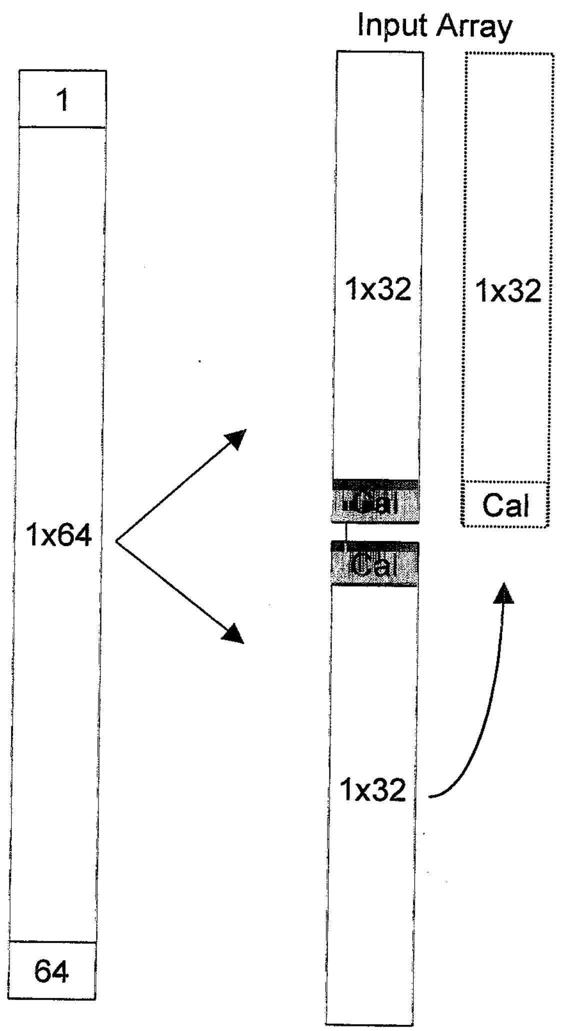
4 Column Controllers

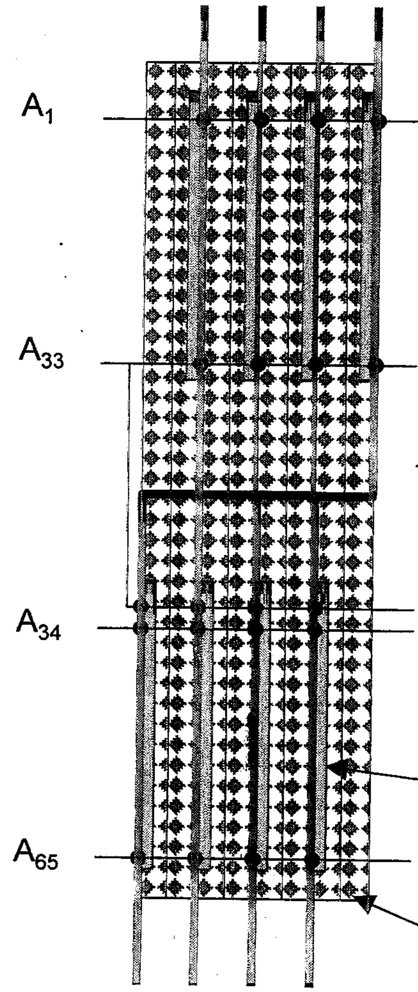
TES Bias, SQUID BIAS, MOD, and OUTPUT



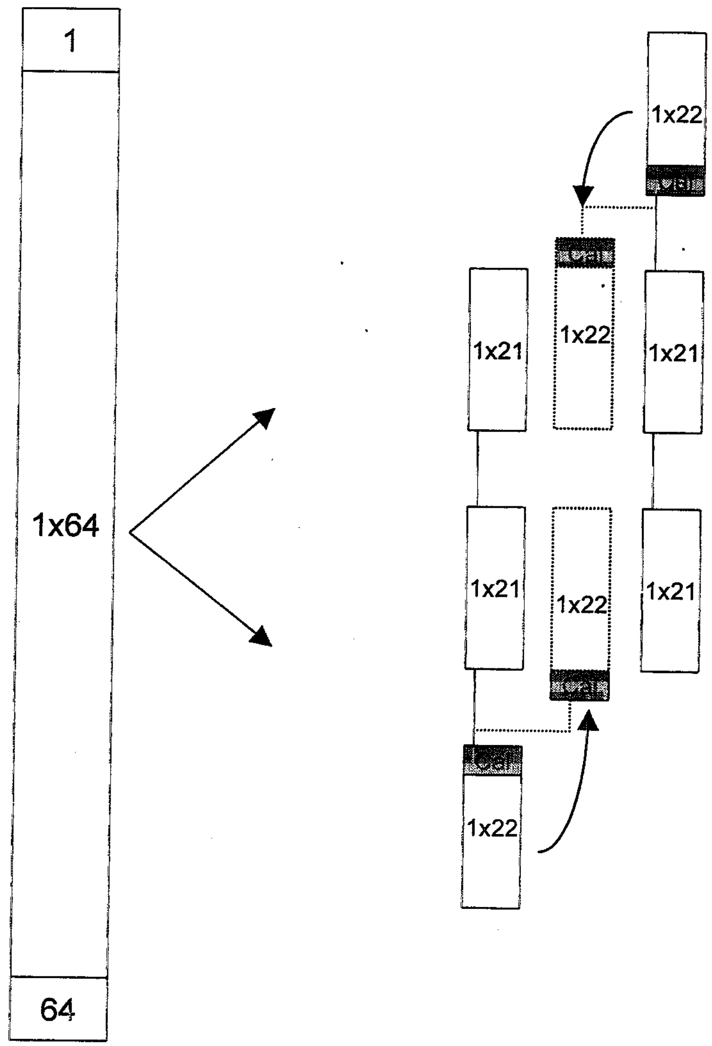
- Array has 21 PUD Rows with 20 pixel and 2 Cal SQUID Circuits (Some Cals are not used.)
- A Column Controller Drives 2 SQUID Boards.
- Super Conducting Wire Interconnect between Boards where Necessary
-

65	Address Lines	+1	Sh
8	TES Bias	+1	Sh
8	Feedback	+1	Sh
<u>8</u>	<u>Output</u>	<u>+1</u>	<u>Sh</u>
89	Lines	+4	Sh





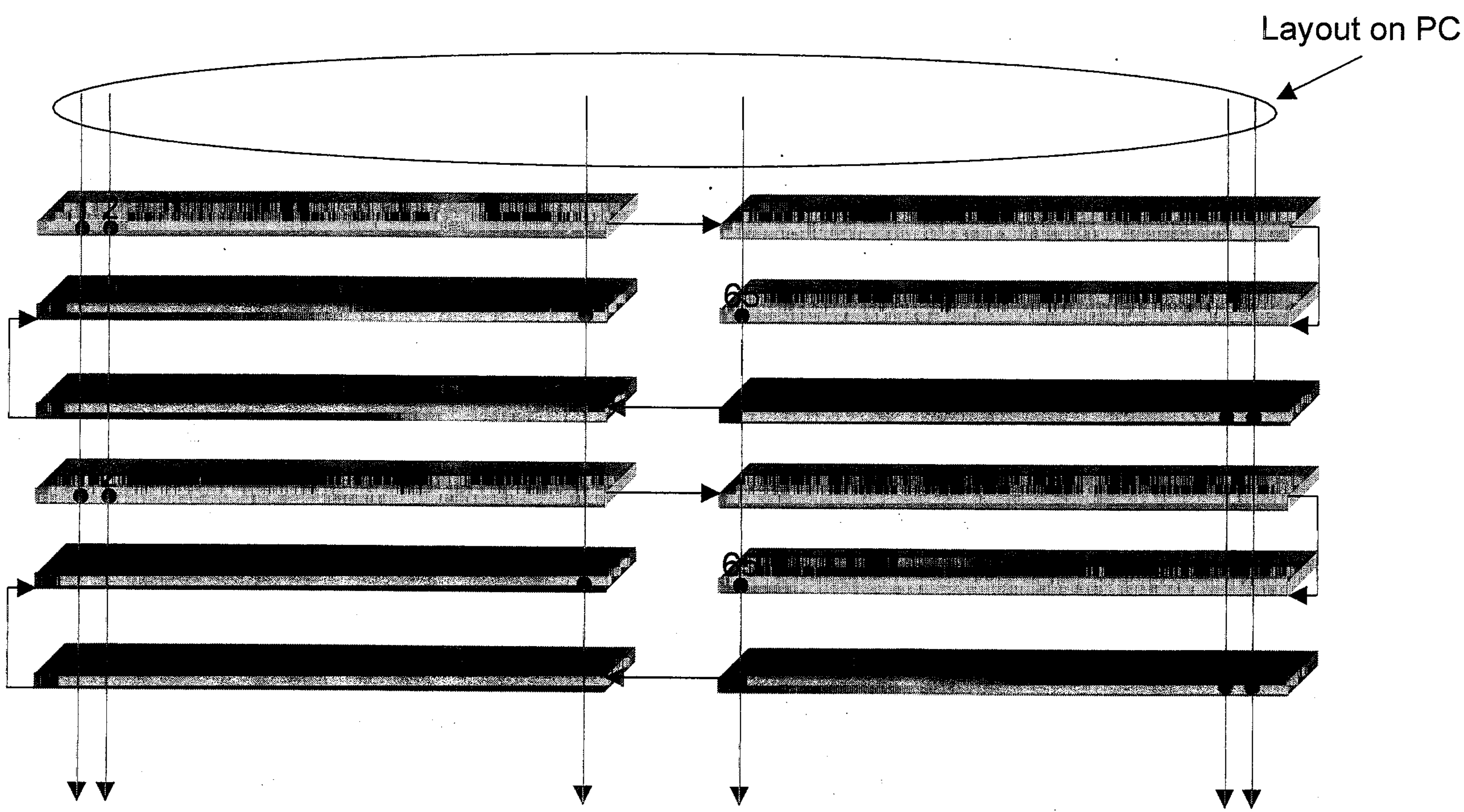
GSFC Detector Array



21 x 42 Optical

14 x 63 Electrical

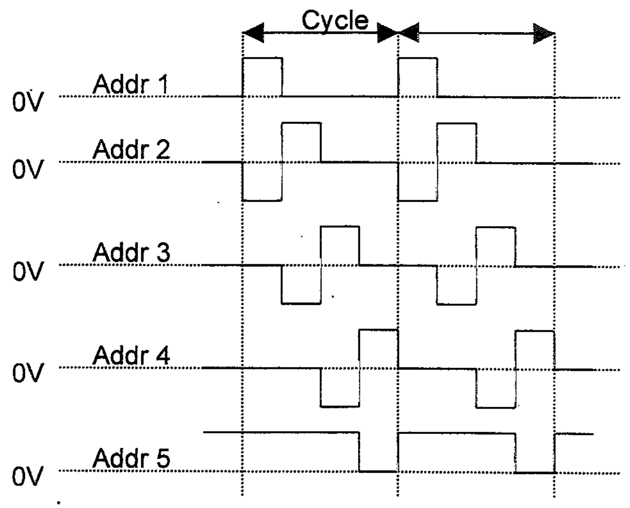
GSFC Detector Array

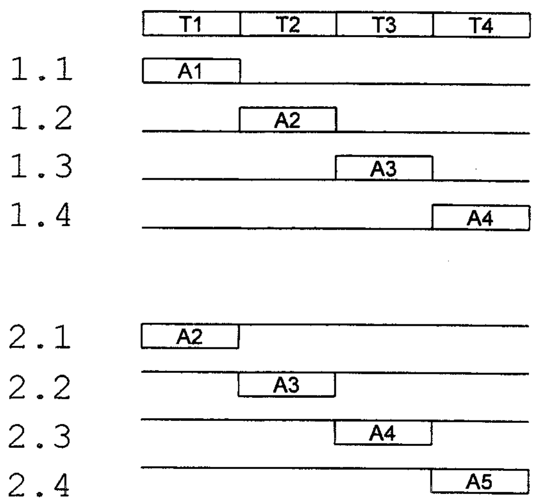

Layout on PC

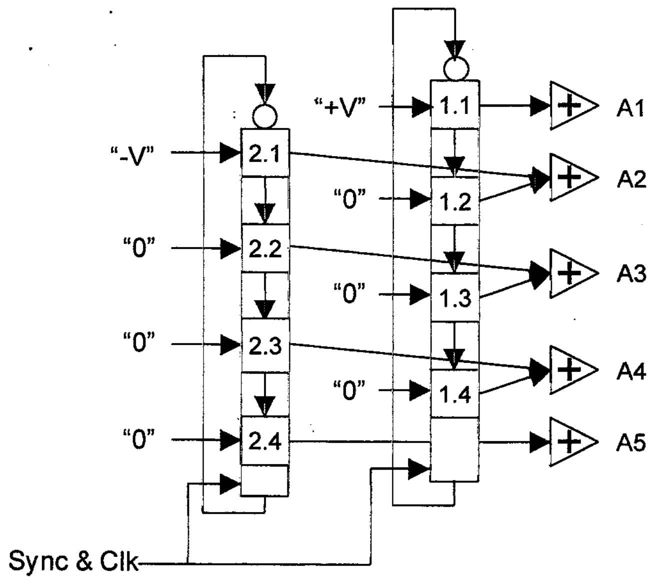
WIRE COUNT

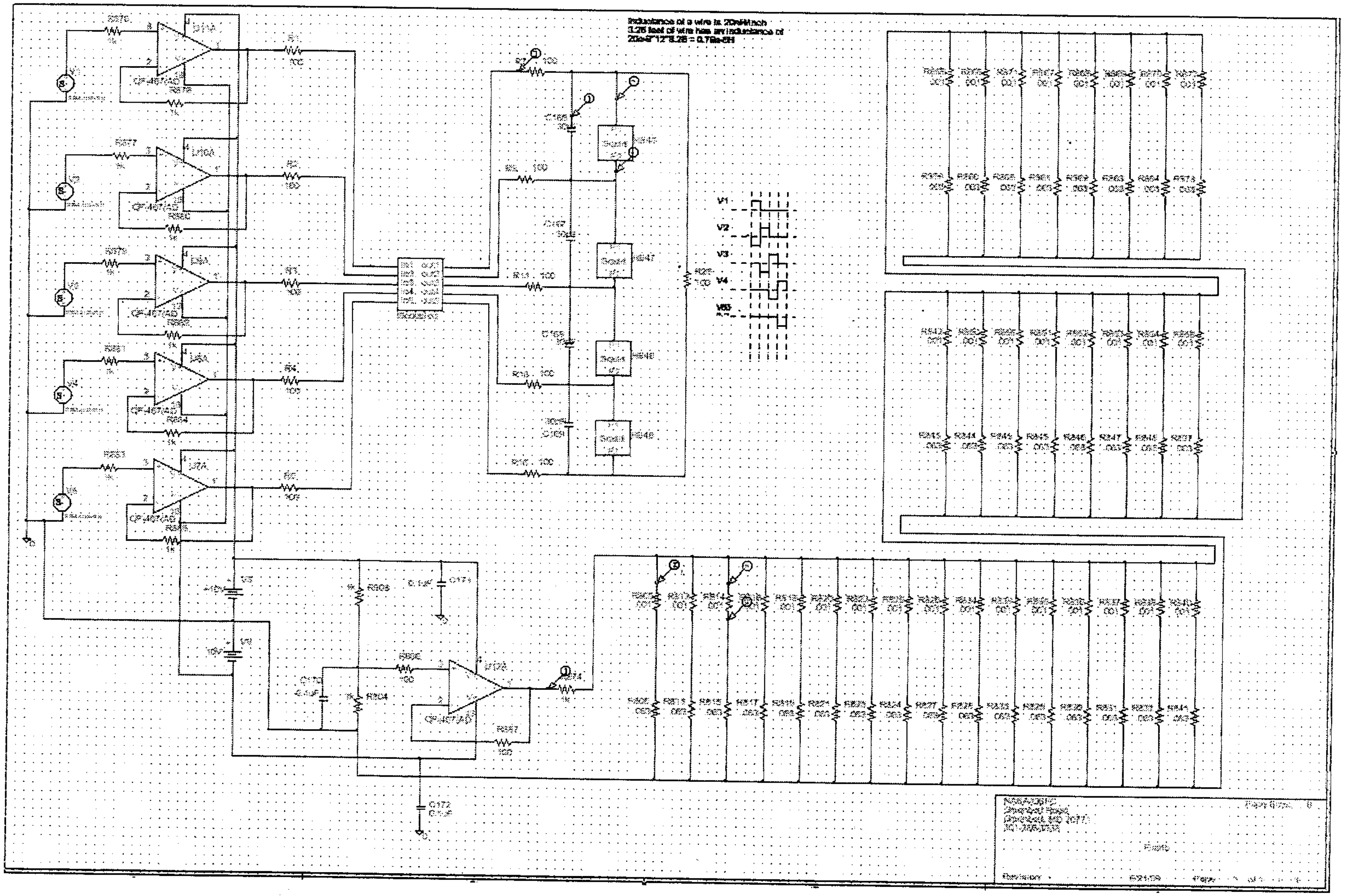
	SIGNAL	OUT		FB		ADDR		BIAS		Total	
Det	COLs	Wires	Shields	Wires	Shields	Wires	Shields	Wires	Shields	Wires	Shields
500 um	8	16	1	16	1	65	1	8	1	105	4
350 um	14	28	1	28	1	65	1	8	1	129	4
250 um	31	62	1	62	1	65	1	8	1	197	4
FTS	7	14	1	14	1	65	1	8	1	101	4
FTS	4	8	1	8	1	65	1	8	1	89	4
Totals	64	128	5	128	5	325	5	40	5	621	20

SQUID MUX ADDRESSING







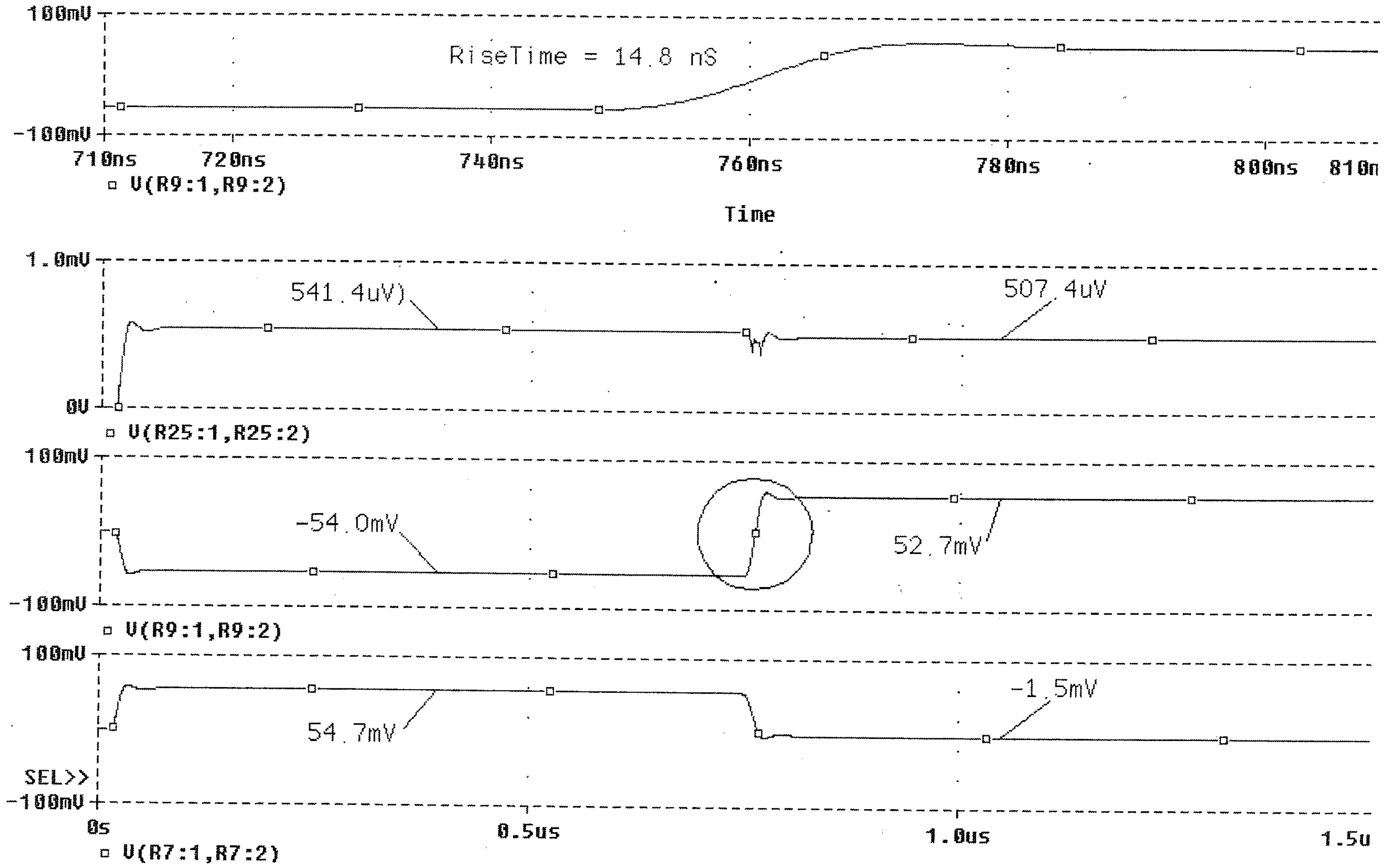


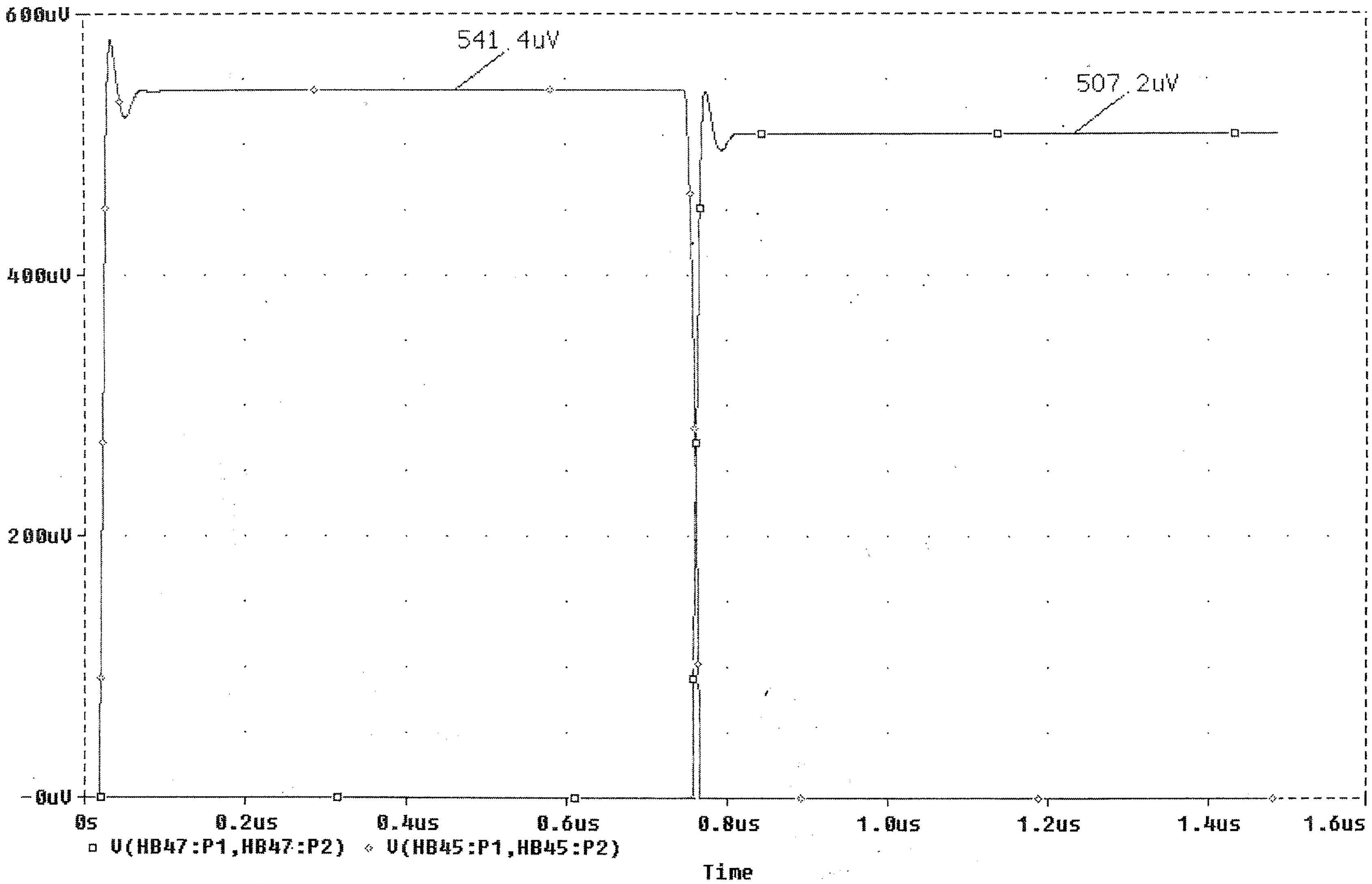
WIRE Parameters for Address Line Simulation

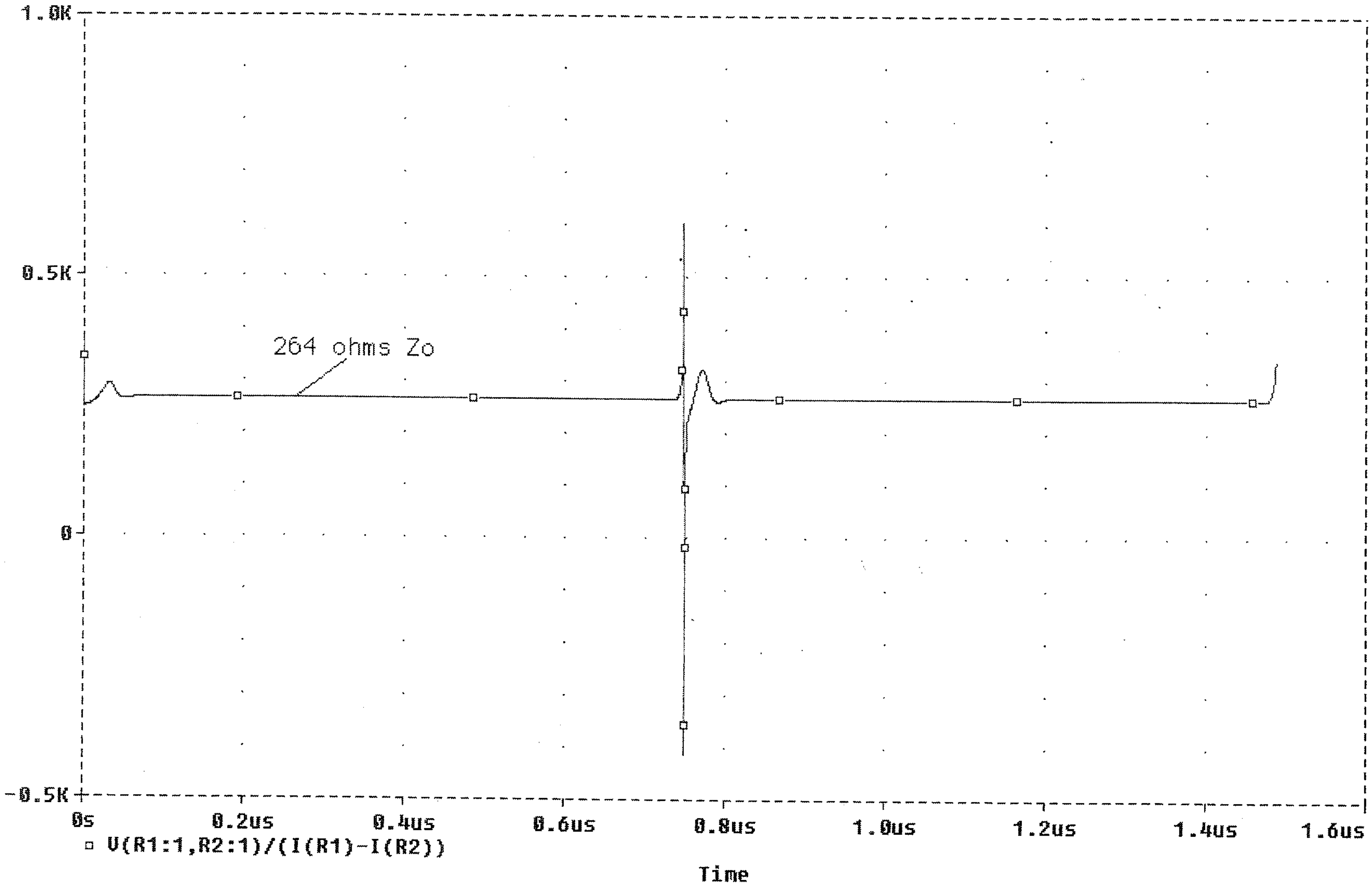
- 3 meter length simulation for worst case
- Inductance 0.79e-6H / meter
- Mutual Inductance is 0.1uH / meter
- Resistance is 26 ohms / meter
- Conductance is 0.0001 mho / meter
- Capacitance is 20 pF / meter

TES BIAS Currents

- 5 mA total current worst case for the 32 column array.
- 156.25 uA Detector bias resistor current worst case.


100mV
-100mV
RiseTime = 14.8 nS
710ns
720ns
740ns
760ns
780ns
800ns
810n
V(R9:1,R9:2)
Time
1.0mV
0V
541.4uV)
507.4uV
V(R25:1,R25:2)
100mV
-100mV
-54.0mV
52.7mV
V(R9:1,R9:2)
100mV
54.7mV
-1.5mV
SEL>>
-100mV
0s
0.5us
1.0us
1.5u
V(R7:1,R7:2)

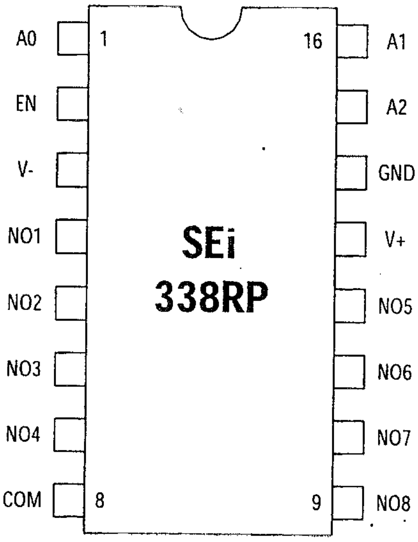

600uV
400uV
200uV
0uV
541.4uV
507.2uV
0s
0.2us
0.4us
0.6us
0.8us
1.0us
1.2us
1.4us
1.6us
□ V(HB47:P1,HB47:P2) ◇ V(HB45:P1,HB45:P2)
Time

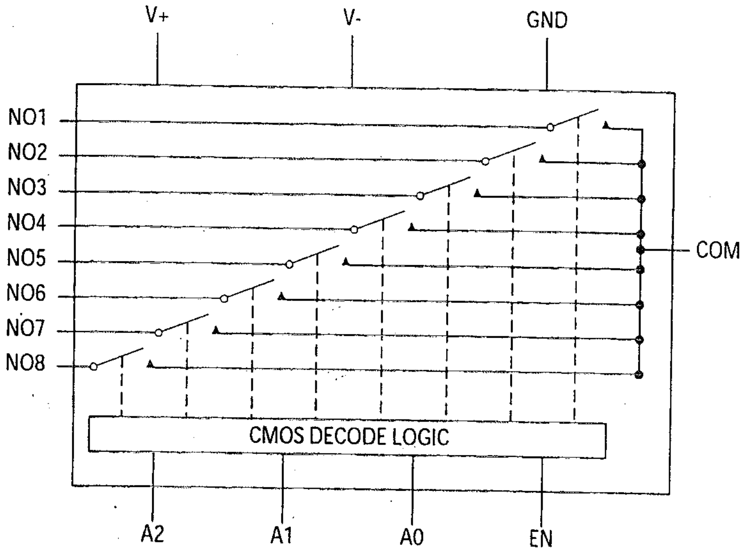

1.0K
0.5K
0
-0.5K
264 ohms Zo
0s
0.2us
0.4us
0.6us
0.8us
1.0us
1.2us
1.4us
1.6us
V(R1:1,R2:1)/(I(R1)-I(R2))
Time

Space Electronics Inc.
Space Products

8-Channel CMOS Analog Multiplexer

338RP





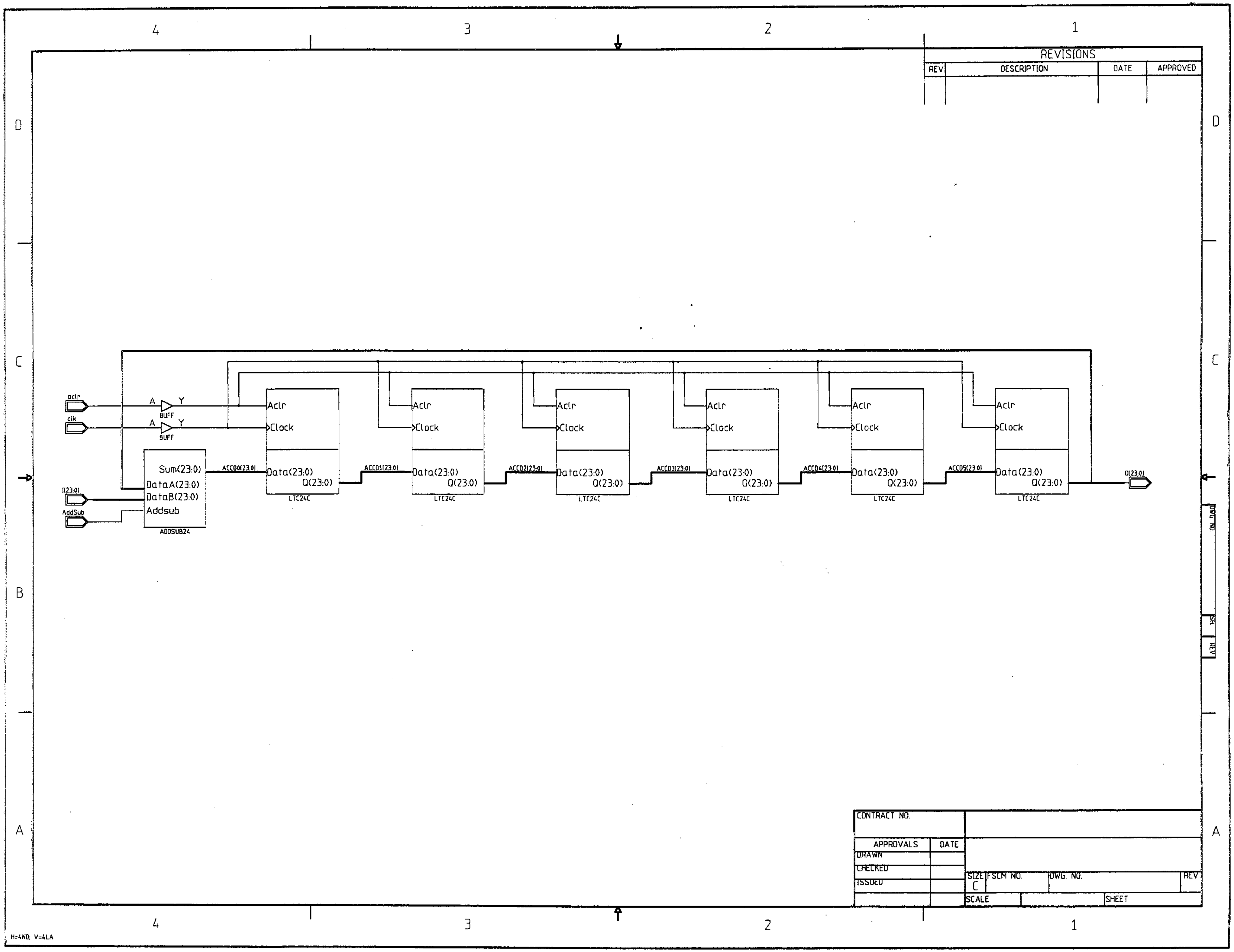
Features:

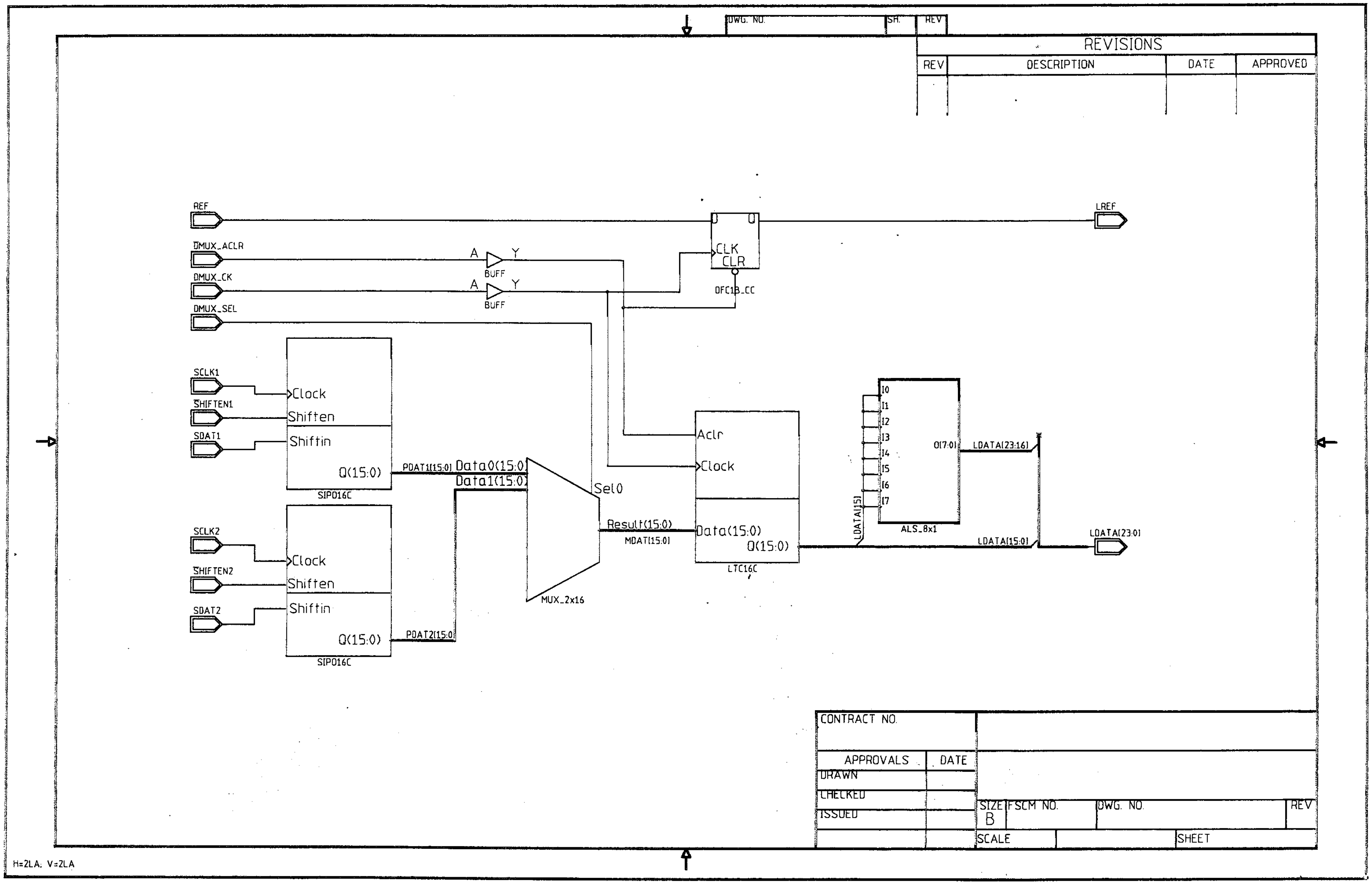
- Rad-Pak® technology hardened against natural space radiation
- Total dose hardness >100 krad (Si), dependent upon orbit
- Package:
  -16 Pin Rad-Pak® flat pack
- On-resistance, <400Ω max
- Transition time, <500ns
- On-resistance match, <10Ω
- NO-off leakage current, <20pA at +25ºC
- 1.5pC charge injection
- Single-supply operation (+4.5V to +30V) bipolar-supply operation (±4.5V to ±20V)
- Plug-in upgrade for industry-standard DG508A/DG509A
- Rail-to-rail signal handling
- TTL/CMOS-logic compatible

Description:

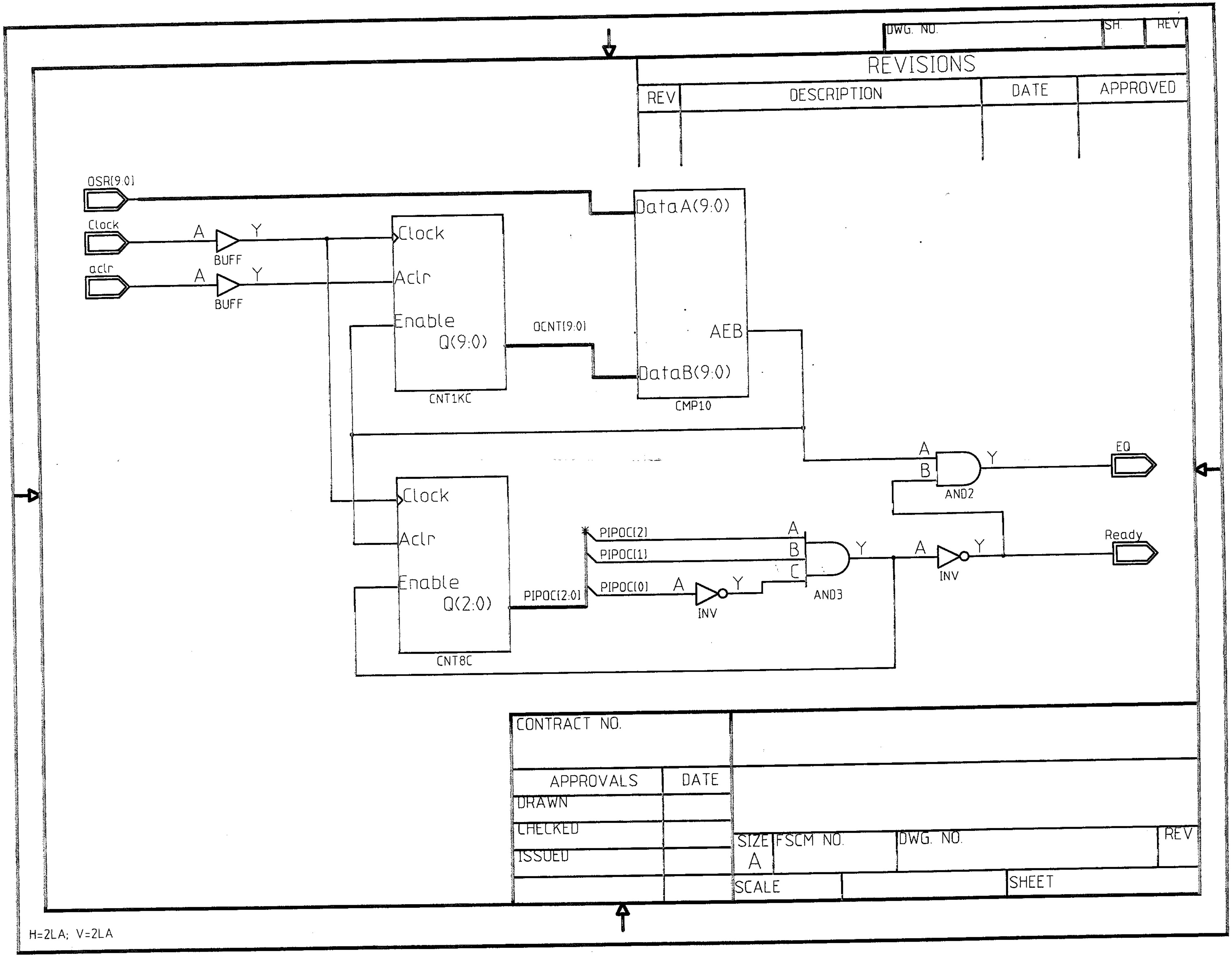
Space Electronics' 338RP (RP for Rad-Pak®) monolithic, CMOS analog multiplexer features a typical 100 kilorad (Si) total dose tolerance. Using Space Electronics' radiation-hardened Rad-Pak® packaging technology, the 338RP is designed to connect one of eight inputs to a common output by control of a 3-bit binary address, and may be used as either a mux or a demux. On-resistance is 400Ω max, and the it conducts current equally well in both directions. These muxes feature extremely low off leakages (less than 20pA at +25°C), and extremely low on-channel leakages (less than 50pA at +25°C). The new design offers guaranteed low charge injection (1.5pC typ) and electrostatic discharge (ESD) protection greater than 2000V, per method 3015.7. The 338RP operates from a single +4.5V to +30V supply or from dual supplies of ±4.5V to ±20V. All control inputs (whether address or enable) are TTL compatible (+0.8V to +2.4V) over the full specified temperature range and over the ±4.5V to ±18V supply range. Capable of surviving space environments, the 338RP is ideal for satellite, spacecraft, and space probe missions. The patented radiation-hardened Rad-Pak® technology incorporates radiation shielding in the microcircuit package. It eliminates box shielding while providing required lifetime in orbit. This product is available up to Class S packaging and screening.

(619) 452-4167 - Fax: (619) 452-5499 - www.spaceelectronics.com

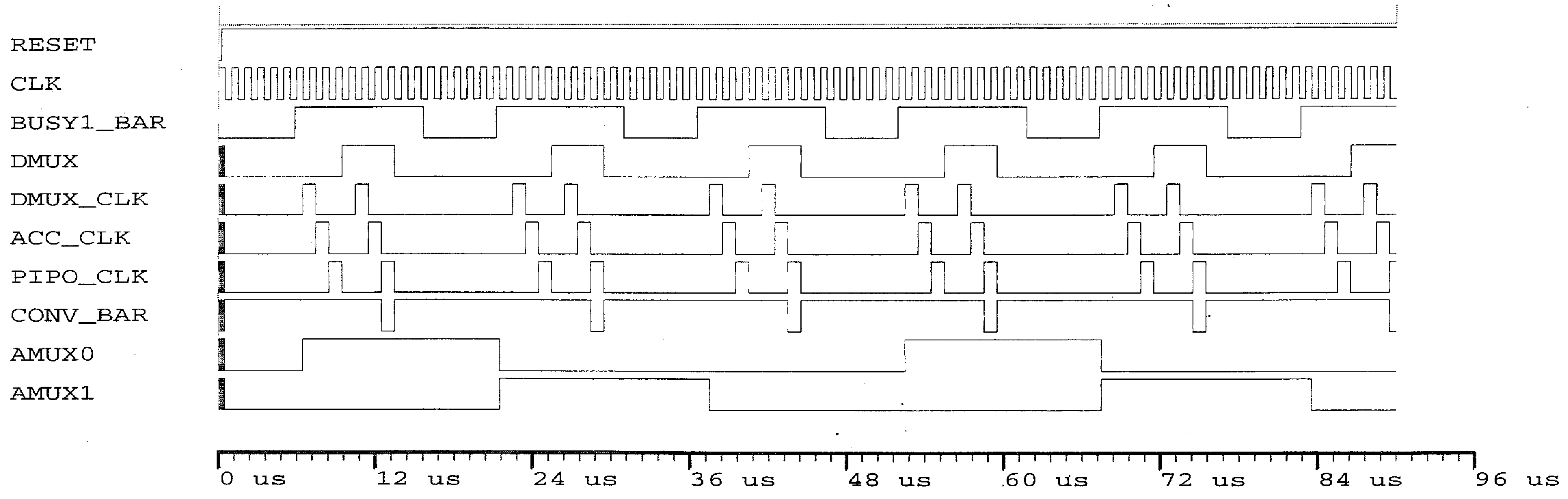

REVISIONS
REV
DESCRIPTION
DATE
APPROVED
aclr
clk
I(23:0)
AddSub
A
Y
BUFF
Sum(23:0)
DataA(23:0)
DataB(23:0)
Addsub
ADDSUB24
ACC00(23:0)
ACC01(23:0)
ACC02(23:0)
ACC03(23:0)
ACC04(23:0)
ACC05(23:0)
Aclr
Clock
Data(23:0)
Q(23:0)
LTC24C
O(23:0)
CONTRACT NO.
APPROVALS
DATE
DRAWN
CHECKED
ISSUED
SIZE C
FSCM NO.
DWG. NO.
REV
SCALE
SHEET
DWG NO
SH
H=4ND; V=4LA



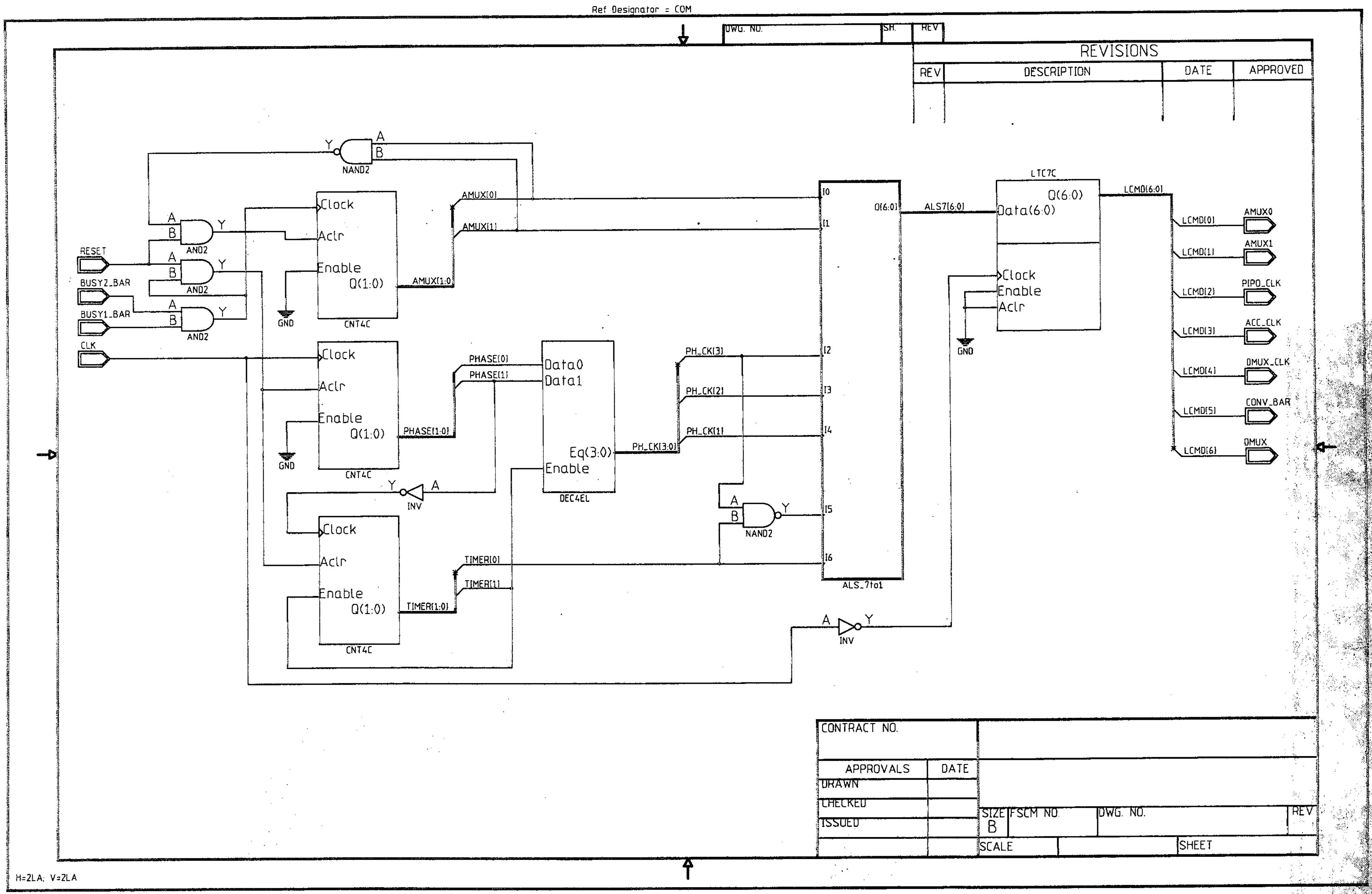
DWG. NO.
SH.
REV
REVISIONS
REV
DESCRIPTION
DATE
APPROVED
REF
LREF
DMUX_ACLR
DMUX_CK
DMUX_SEL
A
Y
BUFF
CLK
CLR
DFC1B_CC
SCLK1
SHIFTEN1
SDAT1
Clock
Shiften
Shiftin
Q(15:0)
SIPO16C
SCLK2
SHIFTEN2
SDAT2
PDAT1(15:0)
PDAT2(15:0)
Data0(15:0)
Data1(15:0)
Sel0
Result(15:0)
MDAT(15:0)
MUX_2x16
Aclr
Data(15:0)
LTC16C
I0
I1
I2
I3
I4
I5
I6
I7
O(7:0)
ALS_8x1
LDATA(15)
LDATA(23:16)
LDATA(15:0)
LDATA(23:0)
CONTRACT NO.
APPROVALS
DATE
DRAWN
CHECKED
ISSUED
SIZE
B
FSCM NO.
DWG. NO.
SCALE
SHEET
H=2LA, V=2LA



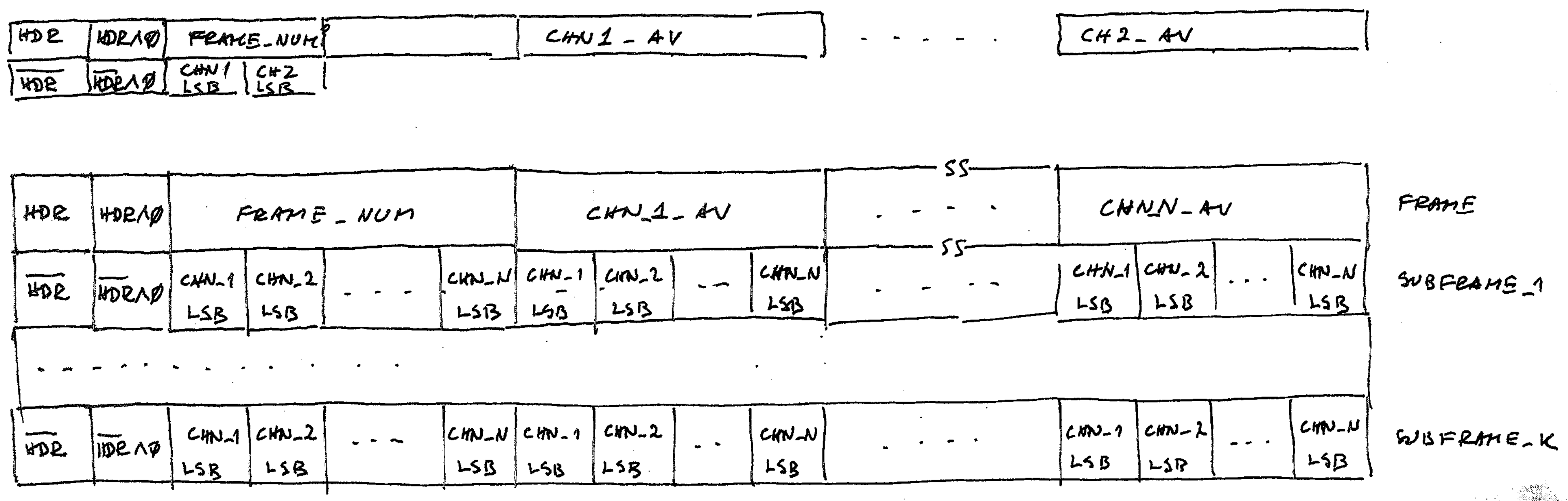
DWG. NO.
SH.
REV
REVISIONS
REV
DESCRIPTION
DATE
APPROVED
OSR[9:0]
Clock
aclr
A
Y
BUFF
A
Y
BUFF
Clock
Aclr
Enable
Q(9:0)
CNT1KC
OCNT[9:0]
DataA(9:0)
AEB
DataB(9:0)
CMP10
A
B
Y
AND2
EQ
Clock
Aclr
Enable
Q(2:0)
CNT8C
PIPOC[2:0]
PIPOC[2]
PIPOC[1]
PIPOC[0]
A
Y
INV
A
B
C
Y
AND3
A
Y
INV
Ready
CONTRACT NO.
APPROVALS
DATE
DRAWN
CHECKED
ISSUED
SIZE
A
FSCM NO.
DWG. NO.
REV
SCALE
SHEET
H=2LA; V=2LA

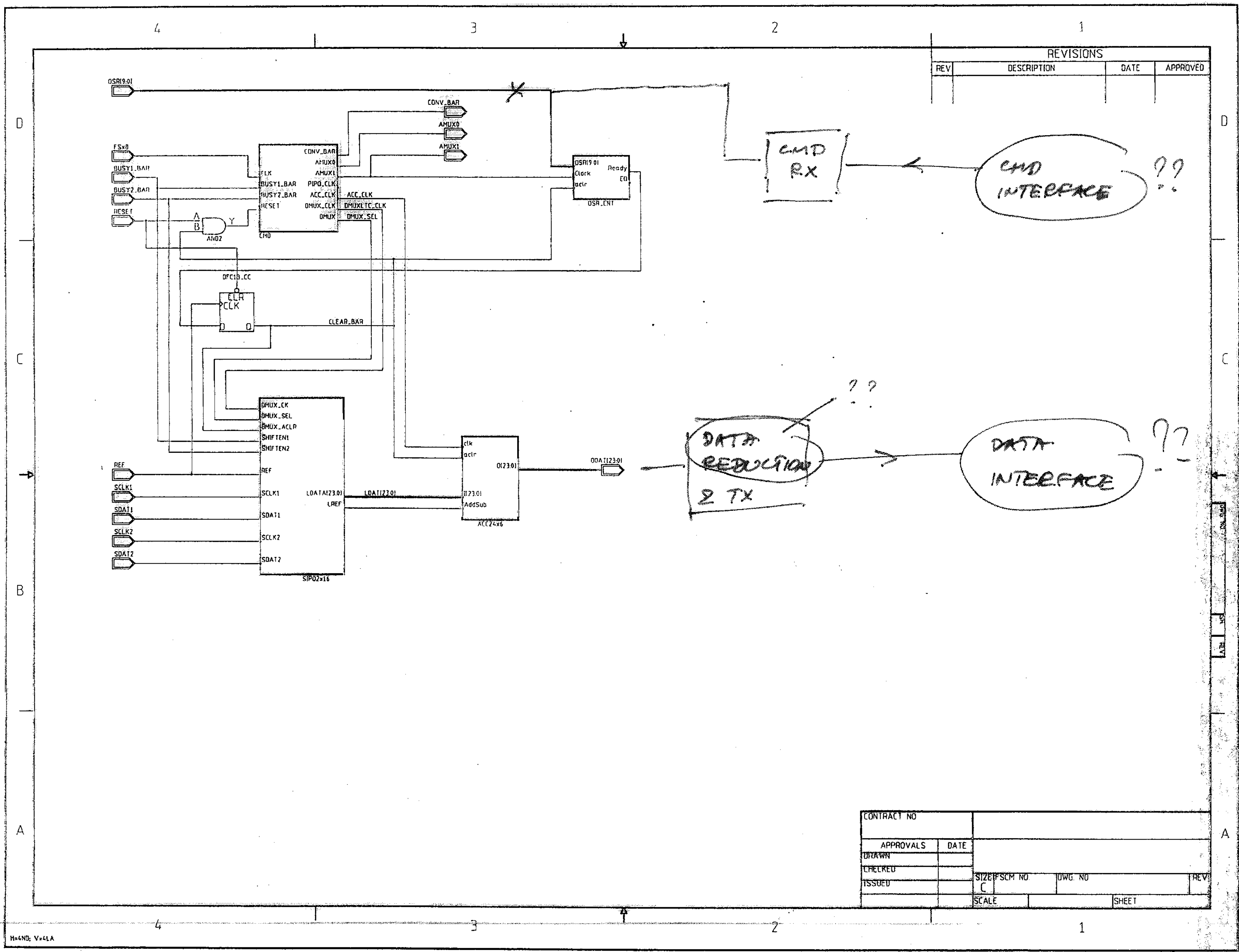


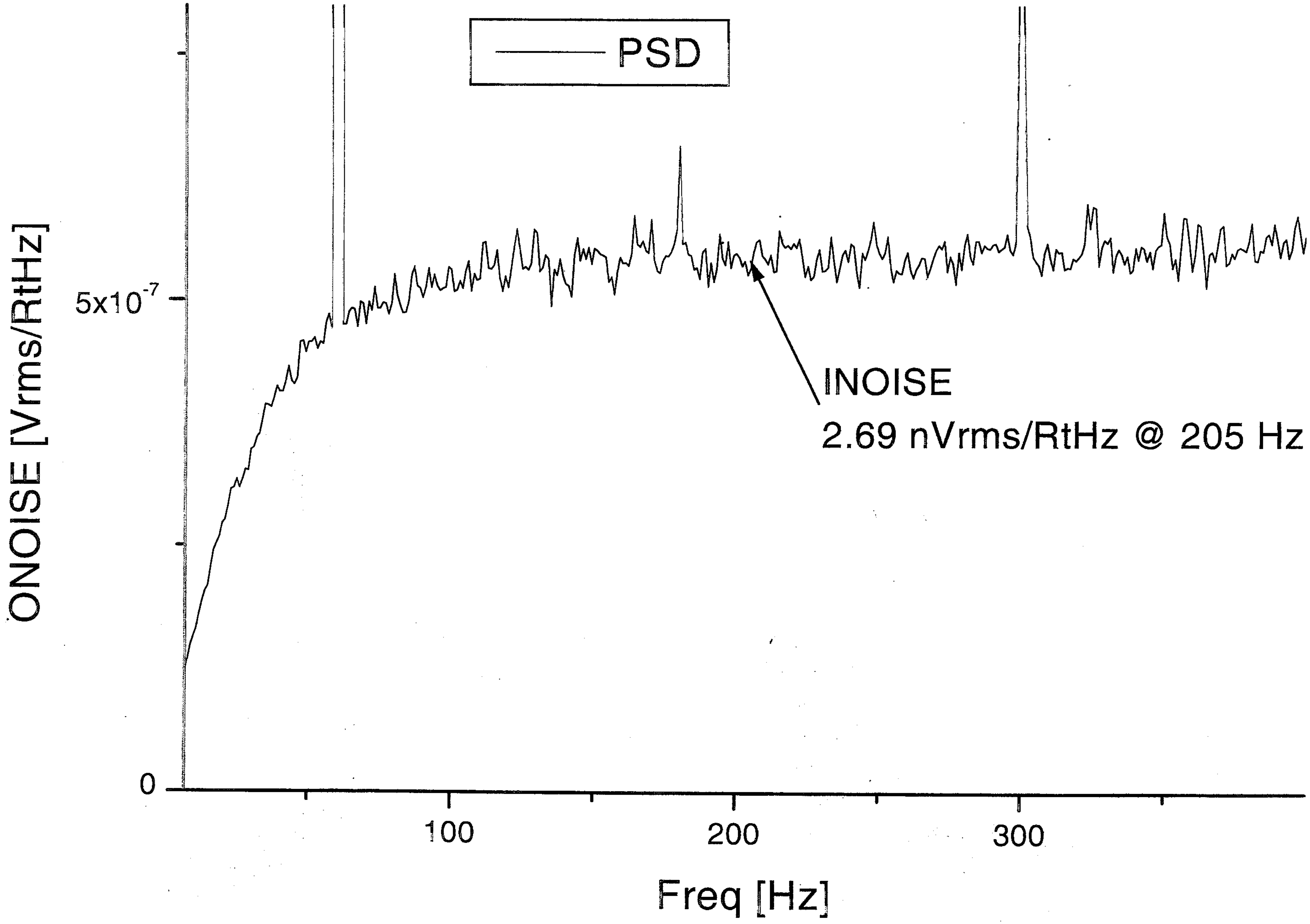
Saturday, September 25, 1999 16:12:30

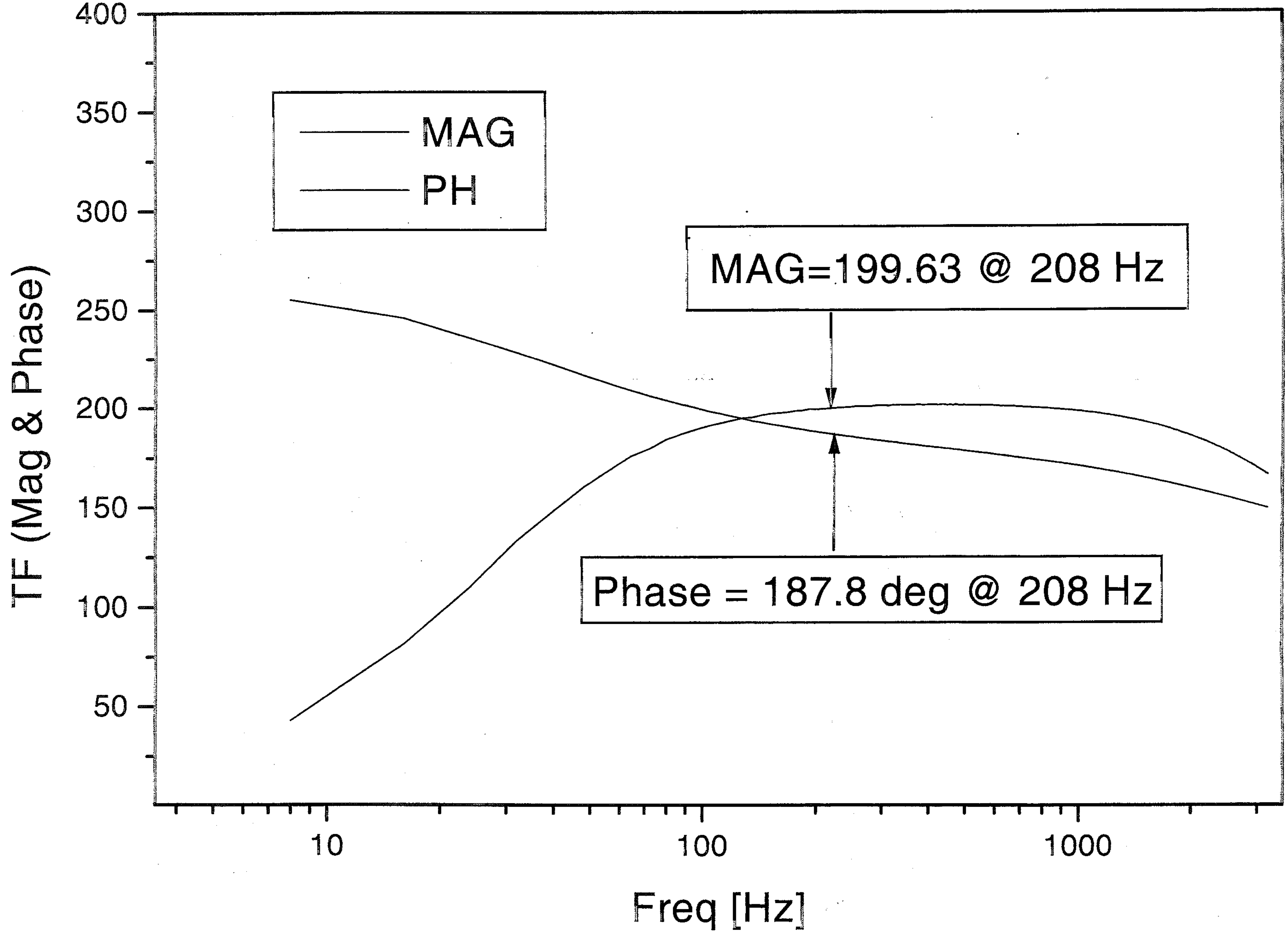


Ref Designator = COM
DWG. NO.
SH.
REV
REVISIONS
REV
DESCRIPTION
DATE
APPROVED
NAND2
AND2
AND2
AND2
RESET
BUSY2_BAR
BUSY1_BAR
CLK
Clock
Aclr
Enable
Q(1:0)
CNT4C
GND
AMUX[0]
AMUX[1]
AMUX[1:0]
PHASE[0]
PHASE[1]
PHASE[1:0]
Data0
Data1
Eq(3:0)
Enable
DEC4EL
INV
TIMER[0]
TIMER[1]
TIMER[1:0]
PH_CK[3]
PH_CK[2]
PH_CK[1]
PH_CK[3:0]
ALS_7to1
O[6:0]
ALS7[6:0]
LTC7C
Q(6:0)
Data(6:0)
Clock
Enable
Aclr
LCMD[6:0]
LCMD[0]
LCMD[1]
LCMD[2]
LCMD[3]
LCMD[4]
LCMD[5]
LCMD[6]
AMUX0
AMUX1
PIPO_CLK
ACC_CLK
DMUX_CLK
CONV_BAR
DMUX
CONTRACT NO.
APPROVALS
DATE
DRAWN
CHECKED
ISSUED
SIZE
B
FSCM NO.
DWG. NO.
REV
SCALE
SHEET
H=2LA; V=2LA


HDR
HDR∧Ø
FRAME_NUM
CHN1_AV
CH2_AV
CHN1 LSB
CH2 LSB
SS
FRAME
HDR
HDR∧Ø
FRAME_NUM
CHN_1_AV
CHNN_AV
CHN_1 LSB
CHN_2 LSB
CHN_N LSB
SUBFRAME_1
SUBFRAME_K


REVISIONS
REV
DESCRIPTION
DATE
APPROVED
OSR[9:0]
CONV_BAR
AMUX0
AMUX1
FSx8
BUSY1_BAR
BUSY2_BAR
RESET
CLK
CONV_BAR
AMUX0
AMUX1
PIPO_CLK
ACC_CLK
DMUX_CLK
DMUX
CMD
ACC_CLK
DMUXLTC_CLK
DMUX_SEL
AND2
DFC1B_CC
CLR
CLK
CLEAR_BAR
OSR[9:0]
Clock
aclr
Ready
EQ
OSR_CNT
CMD RX
CMD INTERFACE
??
DMUX_CK
DMUX_SEL
DMUX_ACLR
SHIFTEN1
SHIFTEN2
REF
SCLK1
SDAT1
SCLK2
SDAT2
LDATA[23:0]
LREF
SIPO2x16
LDAT[23:0]
clk
aclr
O[23:0]
I[23:0]
AddSub
ACC24x6
ODAT[23:0]
DATA REDUCTION & TX
DATA INTERFACE
CONTRACT NO
APPROVALS
DATE
DRAWN
CHECKED
ISSUED
SIZE
C
FSCM NO
DWG NO
REV
SCALE
SHEET
H=4N0; V=4LA


PSD
INOISE
2.69 nVrms/RtHz @ 205 Hz
5x10-7
0
100
200
300
Freq [Hz]
ONOISE [Vrms/RtHz]


MAG
PH
MAG=199.63 @ 208 Hz
Phase = 187.8 deg @ 208 Hz
TF (Mag & Phase)
Freq [Hz]
400
350
300
250
200
150
100
50
10
100
1000

Other Functions

		Electrical Grade	Pkg*	Process Level*
AD2S80A	Variable Resolution Resolver-to-Digital Converter	S	D-40	1,3
AD590	Two Terminal IC Temperature Transducer	K,L	H,F	1,2,3
AD598	LVDT Signal Conditioner	S	D-20	1
AD630	Balanced Modulator/Demodulator	S	D-20	5
AD637	Wideband RMS-to-DC Converter	S	D-14	5
AD9500	Digitally Programmable Delay Generator	S,T	D-24	1,3
ADSP2100A	12.5 MIPS DSP Microprocessor	S	G-100	1,3
MAT01	Matched Dual NPN Transistor	A	H	1,3
MAT02	Low Noise, Matched Dual NPN Transistor	A,B	H,RC	1
MAT03	Low Noise, Matched Dual PNP Transistor	A,B	H,RC	1
MAT04	Matched Quad NPN Transistor	A	Y	1

Space Products Process Level and Package Information

*** 1. Process Level Key**

1 - Qualified or qualifiable to MIL-STD-883 Level S Para. 1.2.1
2 - Qualified, or in qualification as MIL-PRF-38535 QML Level V
3 - Available processed to ESA9000 Level B
4 - Non-Compliant, Non-QML Devices per MIL-STD-883, Para. 1.2.2
SEM only is available in lieu of Wafer Lot Acceptance.
5 - Product in qualification

*** 2. Package Option Key**

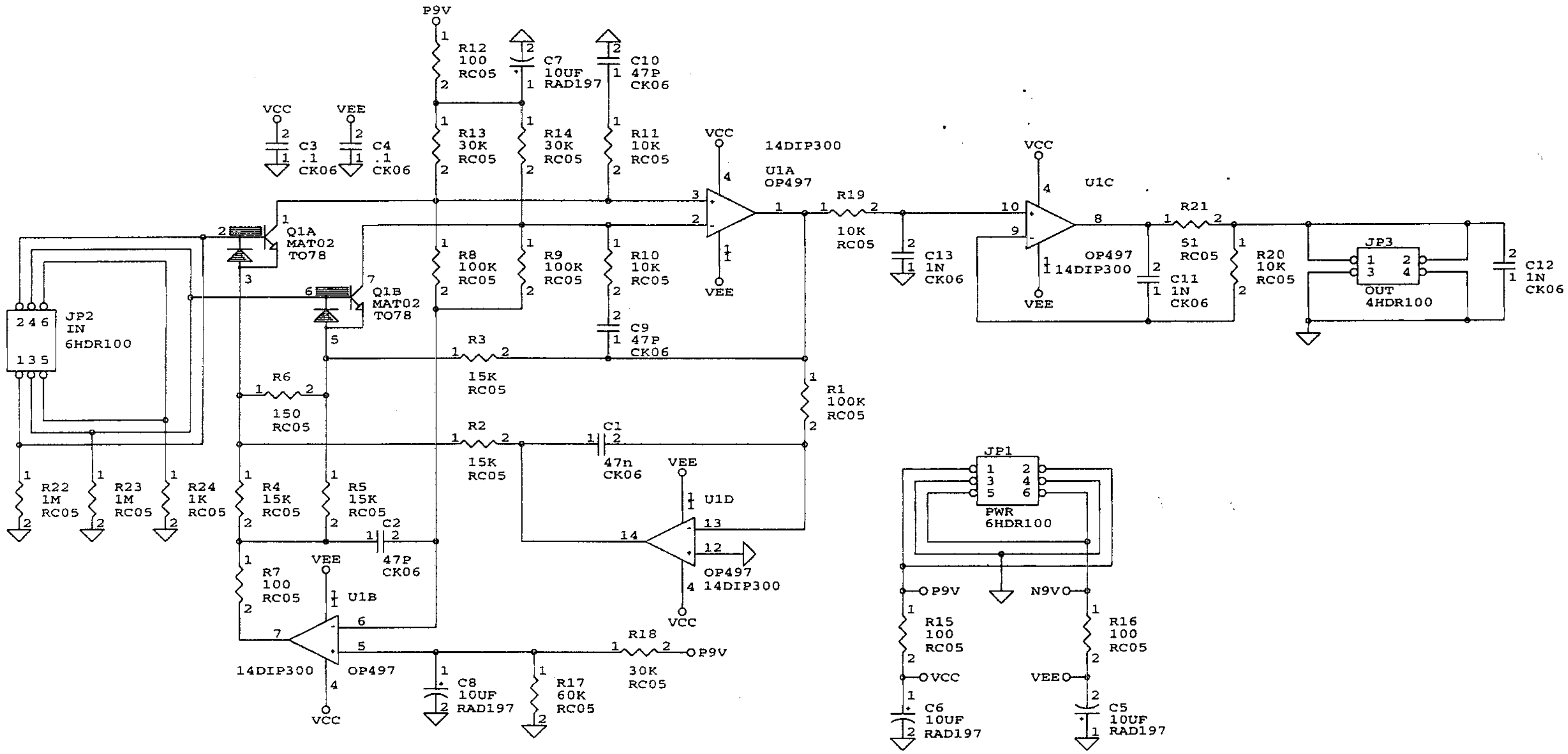
CTQFP 44 lead Ceramic Flat Pack (in development)
CSOIC Ceramic Small Outline IC Package, (in development)
D - Side Brazed Hermetic DIP
E - Ceramic Leadless Chip Carrier
F - Ceramic Flat Pack (2-Lead & 16-Lead)
G-100- Ceramic Pin Grid Array
H - Hermetic Metal Can
J - 8-Lead TO-99 Can
L - 10-Lead Flat Pack
M - 14-Lead Flat Pack
N - 24-Lead Flat Pack
F28- 28-Lead Flat Pack
Q - 16-Lead Cerdip (Santa Clara Based Product)
Q - Cerdip (Other Analog Divisions)
R - 20-Lead Ceramic Dip
RC - 20-Lead Leadless Chip Carrier
TC - 28-Lead Leadless Chip Carrier
T 28-Lead Ceramic Dip
W 24-Lead Ceramic Dip (Narrow Body)
X - 18-Lead Ceramic Dip
Y - 14 Lead Ceramic Dip
Z - 8-Lead Ceramic Dip
Z68 68 Pin Gull Wing Package

Product Deletions in 1996, Revision T, U, and Revision X in 1997 These parts are not recommended for new designs. Contact factory for availability

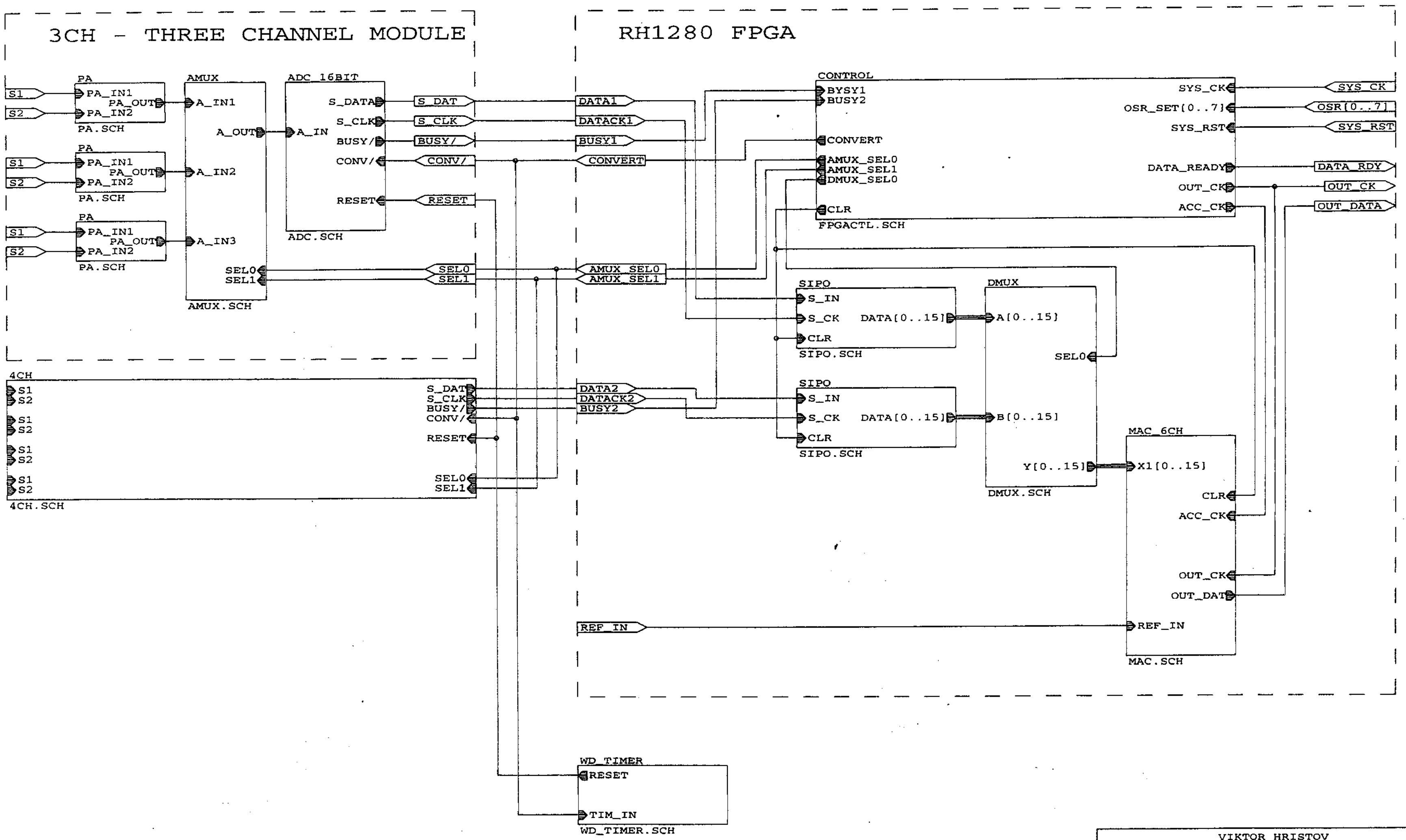
AD587SD,TD	AD9696TD	ADC912BW	OP61AJ,AZ,ARC	OP497AJ,ARC	
AD562SD	AD9022SD	AD9713BTD	AMP05BX	OP64AJ,AZ,ARC	REF08BZ
AD563SD,TD	AD9048SD	AD9720SD	DAC10BX	OP97AJ,AZ,	
AD567SD	AD973SD	AD9721SD	DAC31 2BR	OP260AJ,AZ,ARC	

Analog Devices, Inc. Space Qualified Parts List

Radiation Tolerance Category RAD(Si)	G (Data Available*)	N (Data Available*)	Product	Description
Strategic Levels 200K to 1Meg rad +			SW01	Quad SPST JFET Analog Switch
			SW02	Quad Analog Switch
	√		SW06	Quad Analog Switch
Commercial Space Level 50K to 200K rad	√		AD1671	12-Bit 1.25 MSPS ADC
	√		AD534	Precision IC Multiplier
	√		AD571	8/10-Bit ADC
	√		AD573	Complete 10-Bit ADC with μP Interface
	√		AD574	Complete 12-Bit ADC with μP Interface
			AD580	High Precision 2.5V Reference
			AD581	High Precision 10V Reference
			AD587	High Precision 10V Reference
			AD588	High Precision Voltage Reference
	√		AD589	Precision 1.2V Reference
			AD630	Balanced Modulator / Demodulator
			AD632	Internally Trimmed Precision IC Multiplier
			AD670	Low Cost Signal Conditioning 8-Bit ADC
	√		AD767	μProcessor Compatible 12-Bit DAC
	√		AD9002	High Speed Monolithic 8-Bit ADC
	√		AD9012	High Speed TTL 8-Bit ADC
	√		ADSP2100A	12.5 MIPS DSP Microprocessor
	√		AMP01	Precision Instrumentation Amp
			AMP05	Fast Settling JFET Instrumentation Amplifier
	√		CMP04	Low Power Comparator
	√		MAT01	Matched Transistor Pair
			MAT02	Low Noise, Matched Dual NPN Transistor
			MAT03	Low Noise, Matched Dual PNP Transistor
			MAT04	Matched Quad NPN Transistor
	√	√	OP08 / OP12	Low-Input-Bias-Current Op Amp
	√		OP200/400	Dual/Quad Low Offset, Low Power Op Amp
	√	√	OP249	Dual Precision High Speed Op Amp
	√		OP50	High Output Current (AVCL•5) Op Amp
	√		OP97/PM1012	Low-Power Precision Op Amp
	√		PM1008	Low-Power Precision Op Amp
	√		PM108 / PM2108	Single / Dual Low Input Bias Current Op Amp
	√		PM111	Precision Comparator
	√		PM119	Precision High-Speed Comparator
	√	√	PM139	Quad General Purpose Comparator
	√		REF43	+2.5V Low Power Precision Reference



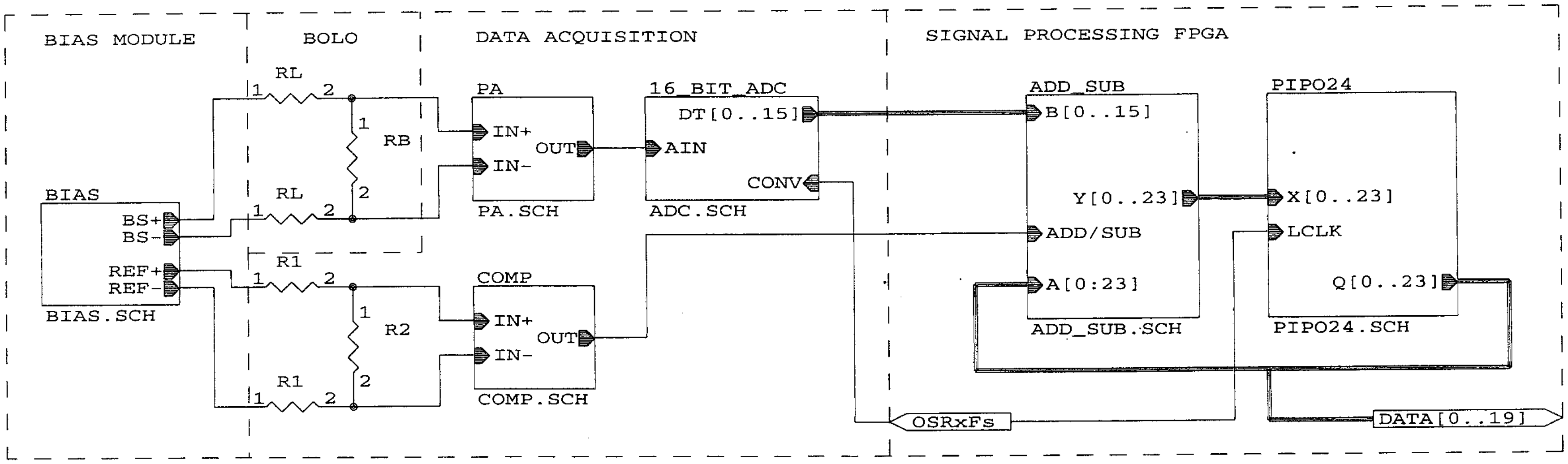
VIKTOR HRISTOV		
CALTECH		
Size B	Document Number	REV
Date: September 25, 1999	Sheet 1 of 1	



VIKTOR HRISTOV
CALTECH

Size	Document Number	REV
B		

Date: September 25, 1999 Sheet of



BASIC PARAMETERS

Bolo_noise_PSD: 20 nVrms/RtHz

Bolo_signal_bandwidth: 20 Hz

Bolo_bias_rms: 9 mV

Bolo_param_spread: 25 %

Bolo_SNR: 9.5E4

ADC_resolution: 14.5 bit

ADC_full_scale: 10 V

ADC_scale_rms: 3.5 Vrms

ADC_qnoise_rms: 125 uVrms

ADC_SNR: 2.9E4

DERIVED VALUES:

Required SNR_ADC = 3 * Bolo_SNR: 3E5

Required ADC resolution: 19 bit

Oversampling Rate: 512

ADC_sampling: 20 kHz/chn

Oversampled ADC_SNR: 6.4E5

OSR_qnoise: 5.6 uVrms

PA_GAIN: 300

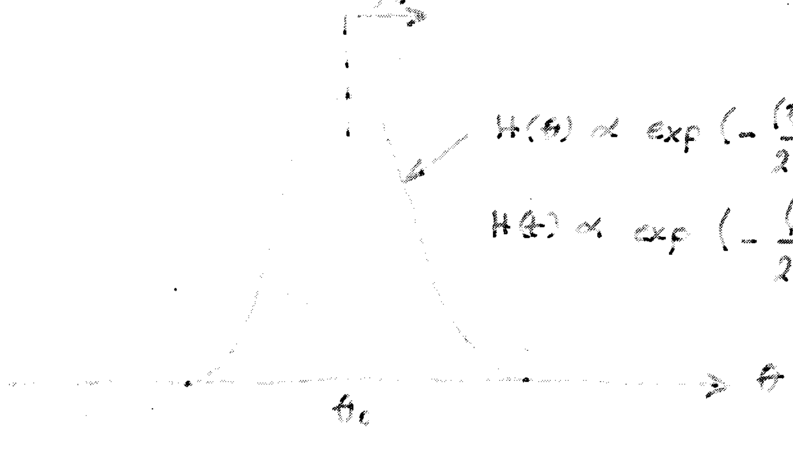
bolo_noise_rms*PA_GAIN/OSR_qnoise: 6.7

Final data sampling: 40 Hz

Final data flow: 800 baud/chn (no compression)

VIKTOR HRISTOV CALTECH		
Title	SPIRE SIGNAL PROCESSING	
Size: A	Document Number	REV
Date: September 25, 1999	Sheet	of

$\frac{\partial \theta}{\partial t}$ = SCAN_SPEED

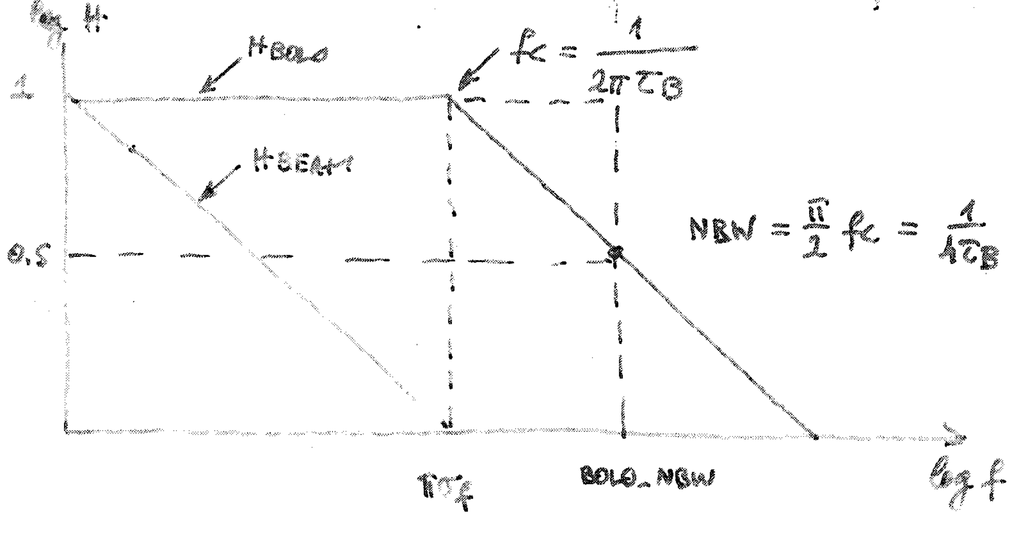


$$H(\theta) \propto \exp\left(-\frac{(\theta-\theta_c)^2}{2\pi\sigma_\theta^2}\right)$$

$$H(t) \propto \exp\left(-\frac{(t-t_c)^2}{2\pi\sigma_t^2}\right); \quad \sigma_t = \frac{\sigma_\theta}{\partial\theta/\partial t}$$

$$O(t) = I(t) \circledast H(t) \quad ; \quad H(t) \xleftarrow{\frac{\partial\theta}{\partial t}} H(\theta)$$

$$O(f) = I(f) \cdot H(f) \quad ; \quad H(f) \propto \exp\left(-\frac{f^2}{2\pi\sigma_f^2}\right), \quad \sigma_f \propto \frac{1}{\sigma_t}$$



CRITERIA 1 : $\pi\sigma_f \leq \frac{1}{2\pi\tau_B}$

CRITERIA 2.* : ELECTRONICS_SBW ≥ BOLO_NBW

HENCE NYQUIST FREQ ≥ 2 · BOLO_NBW ≥ $\frac{1}{2\tau_B}$

7(a) ARRAY MECHANICAL INTERFACES

BEREND WINTER

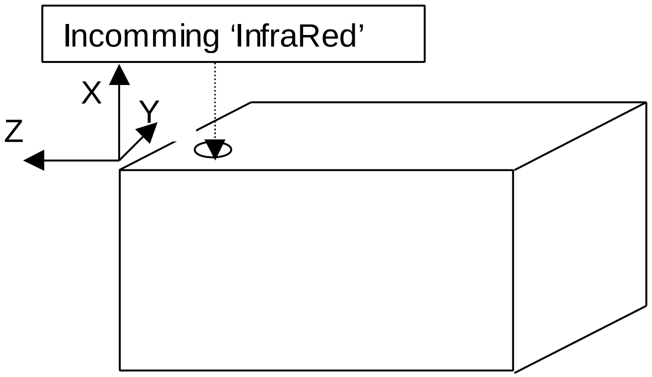
UCL MSSL

Structure-Detector

Contents:

- Mechanical requirements
- Geometrical requirements

Mechanical environment (1)



Quasi Static levels	Case 1	Case 2	Case 3	Case 4
x-direction (ref. sketch)				
Longitudinal	22.5 g	22.5 g	-	-
y-direction (ref. sketch)				
Lateral	3 g	-	6 g	-
z-direction (ref. sketch)				
Lateral	-	3 g	-	6 g

QUALIFICATION (TBC)

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MSSL

Mechanical environment (2)

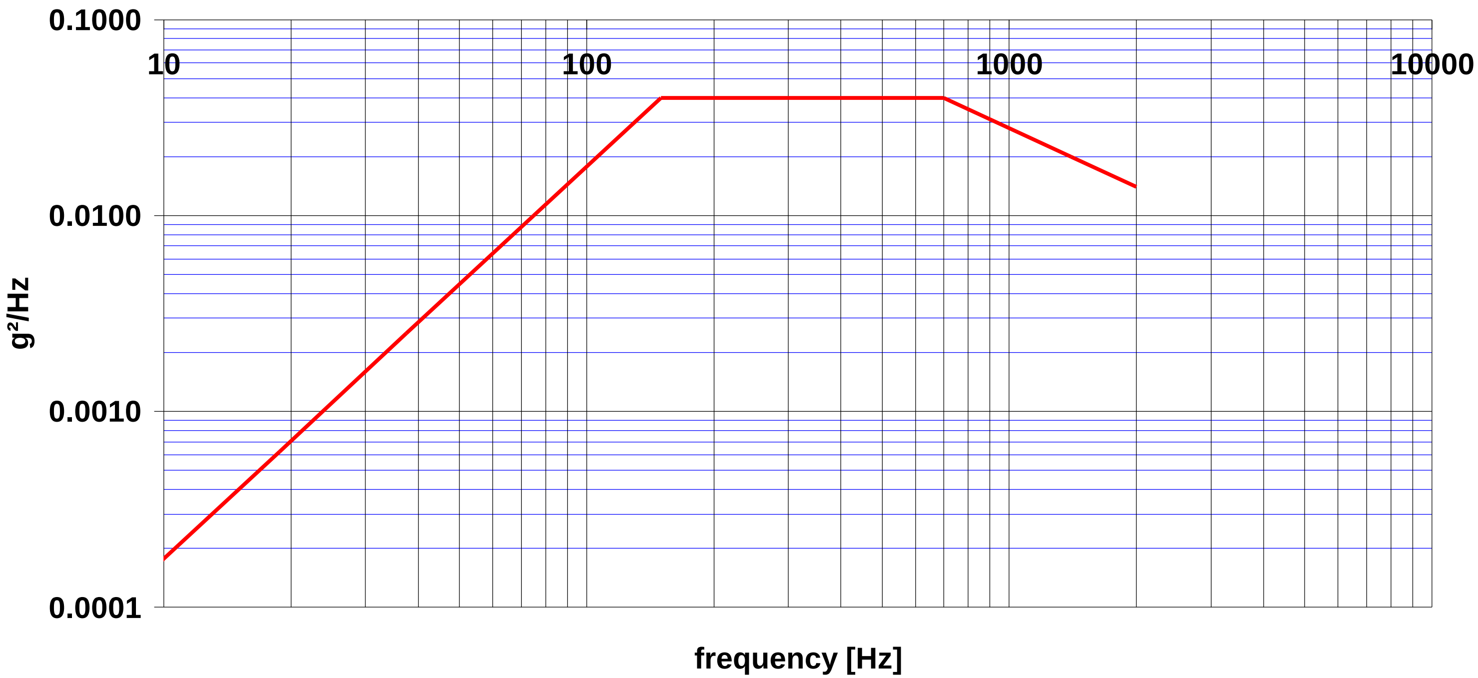
Sine vibration levels (all directions)

Frequency range	Input at base
5-18 Hz	22 mm (peak-peak)
18-100 Hz	15 g

QUALIFICATION (TBC)

Mechanical environment (3)

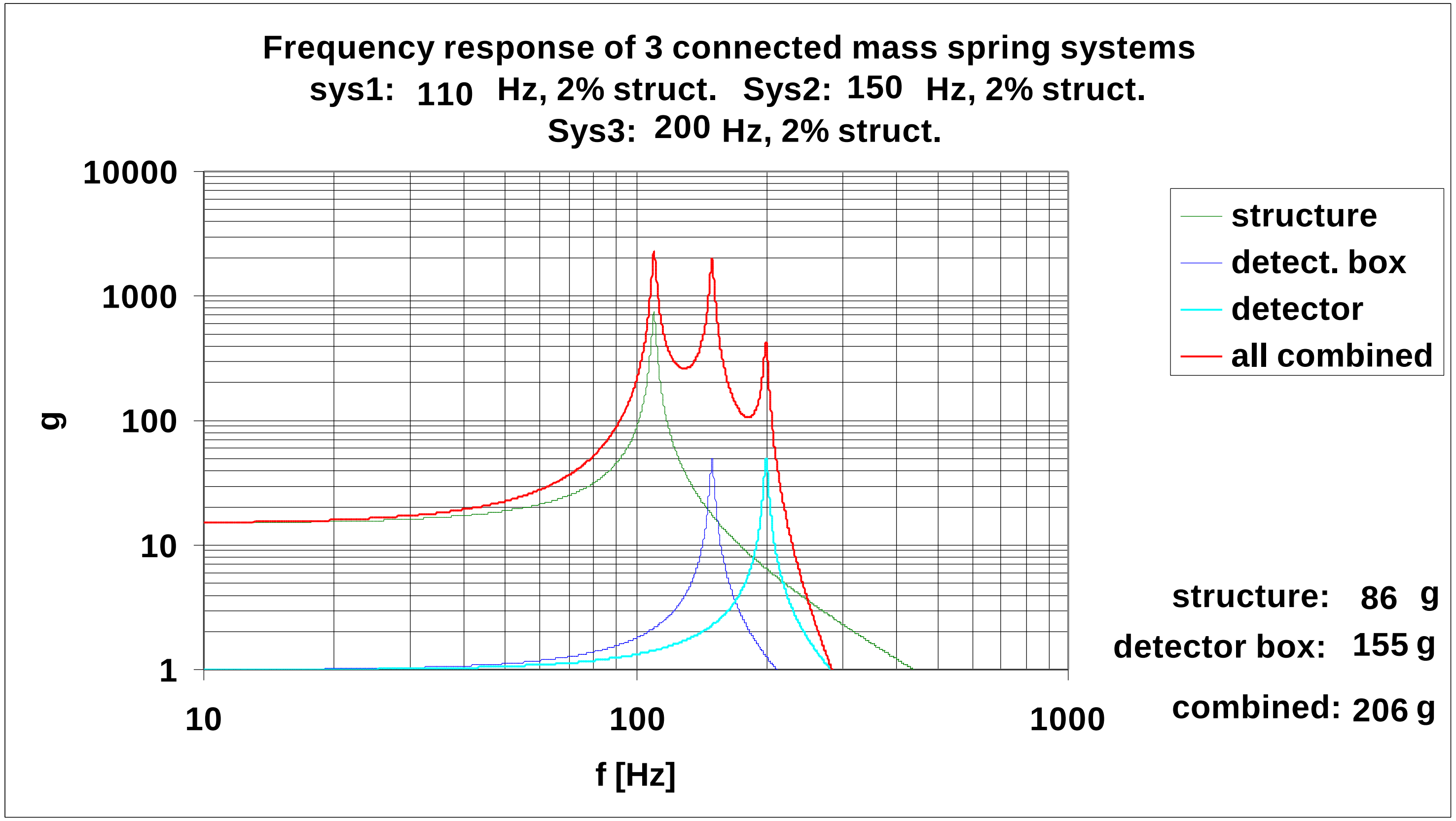
PSD input for qual. random vibration (TBC) RMS 7.4 g



QUALIFICATION (TBC)

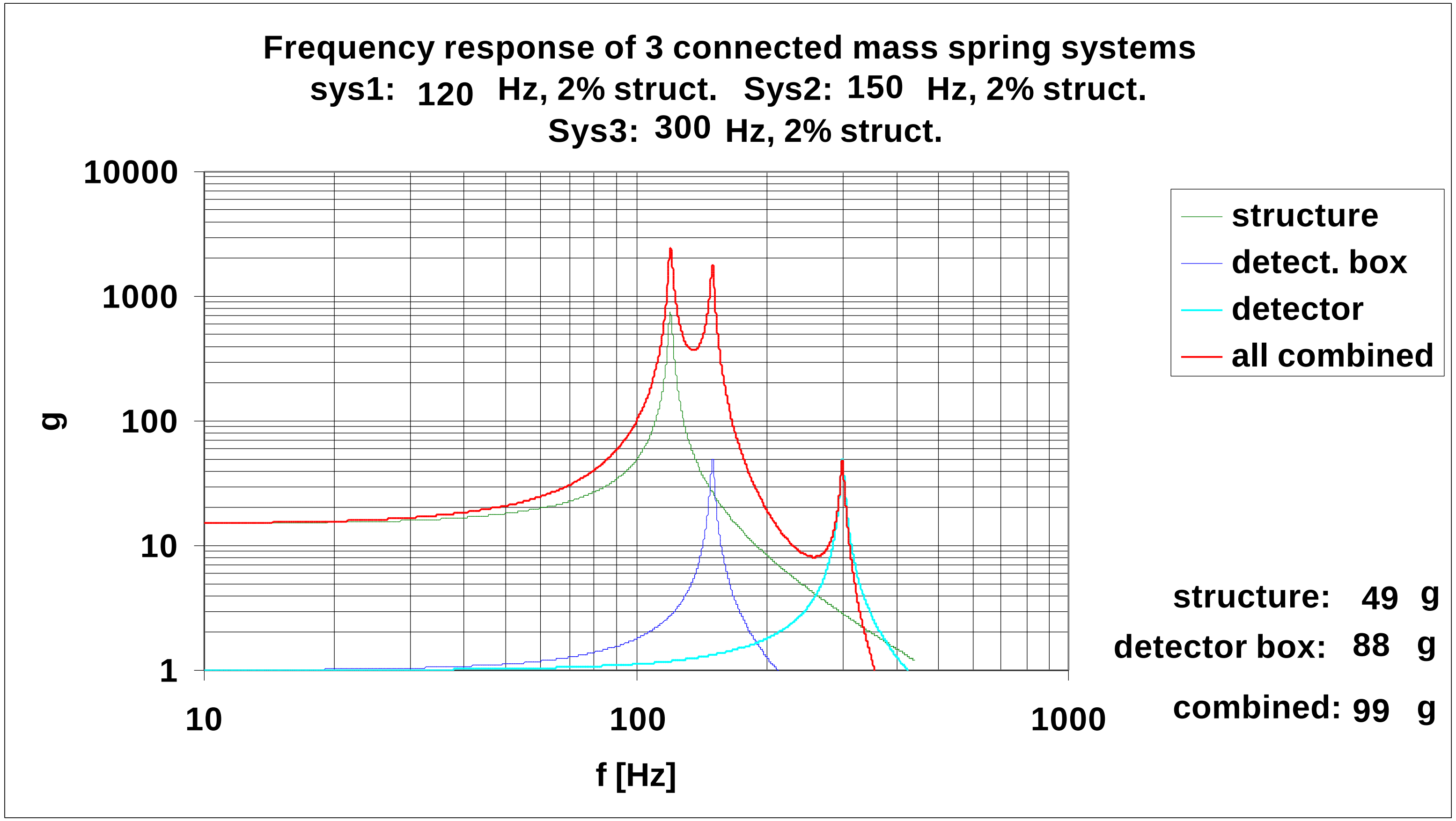
Mechanical environment (4)

MSSL



QUALIFICATION (TBC)

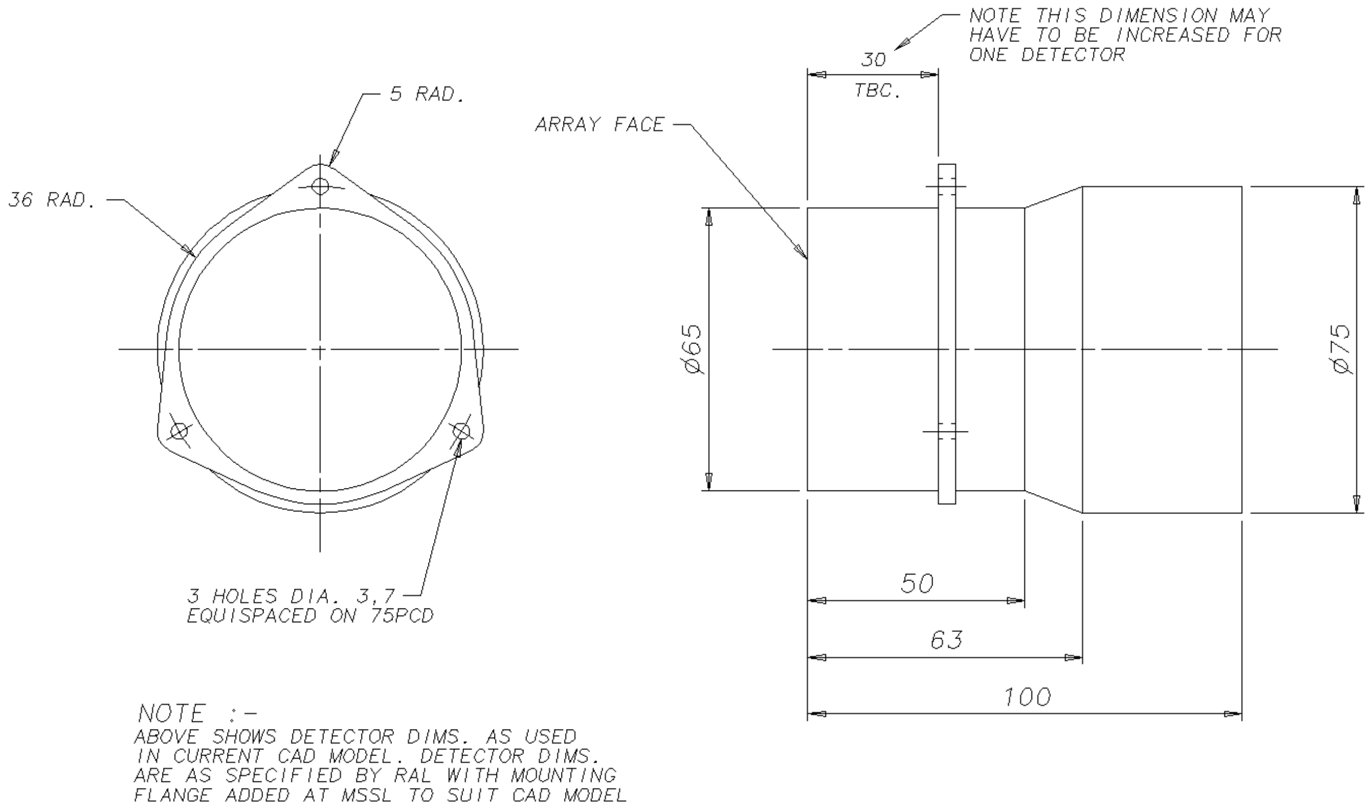
Mechanical environment (5)



QUALIFICATION (TBC)

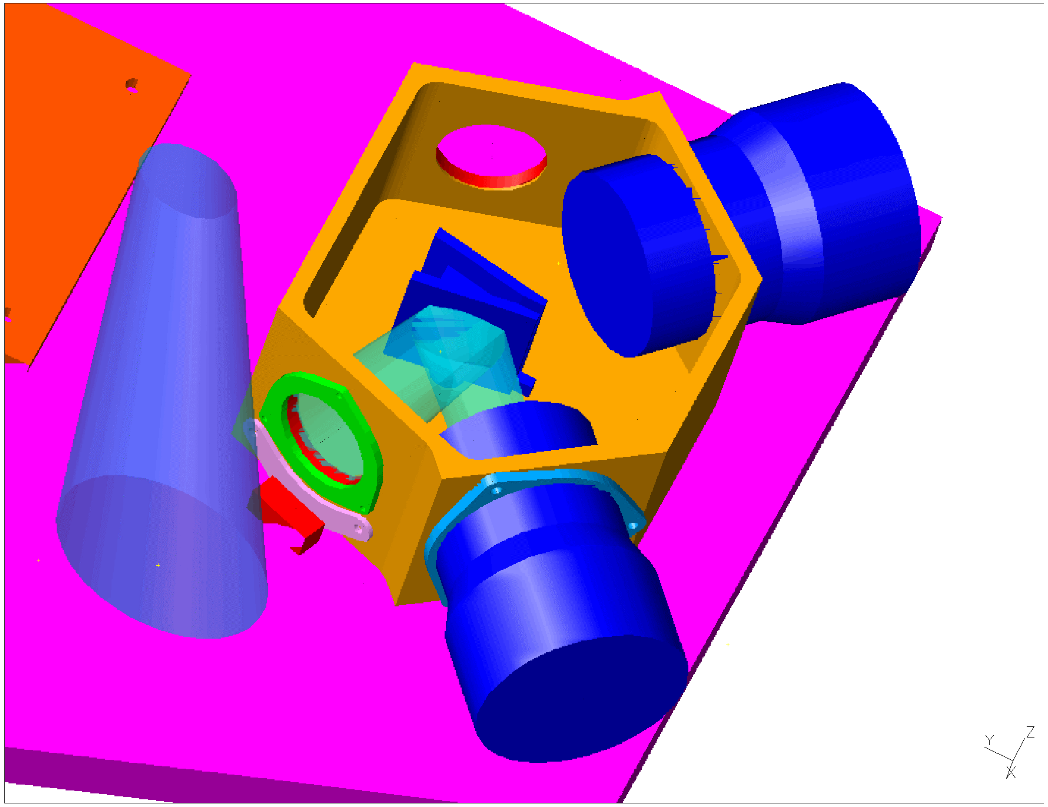
Geometrical environment

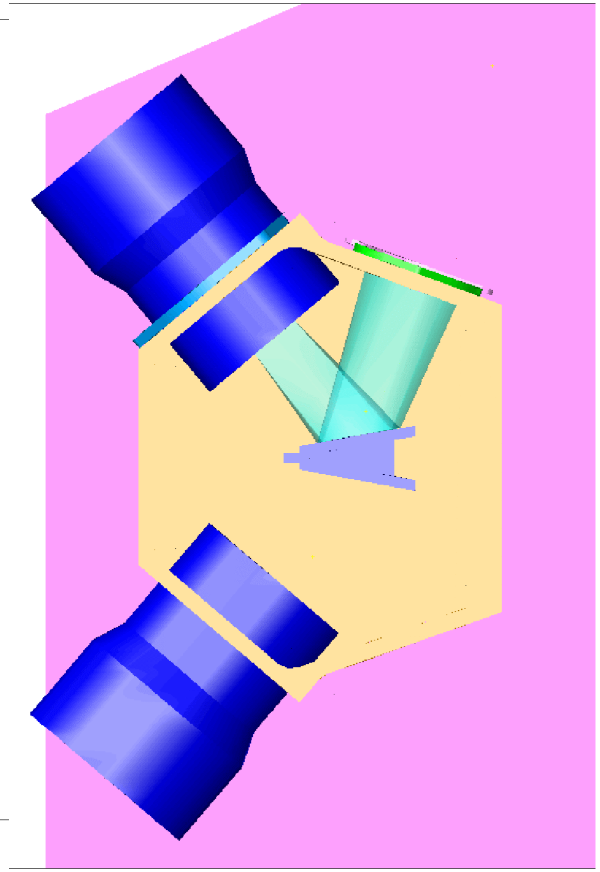
MSSL



UCL
MSSL

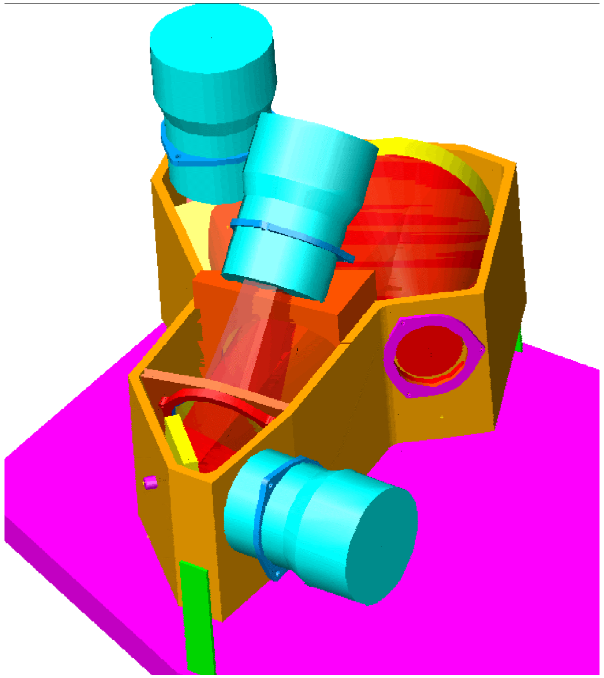
Geometrical environment

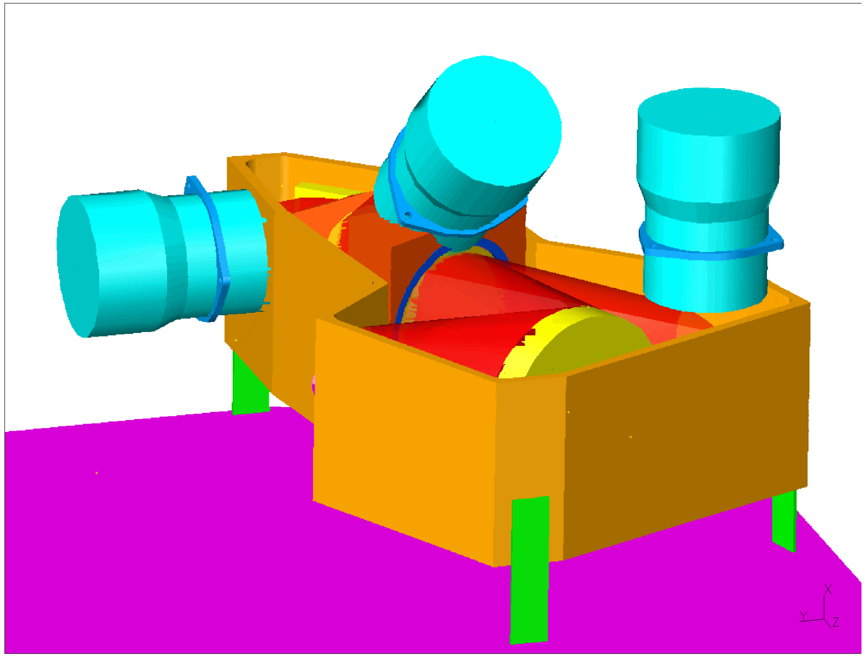




UCL MSSL

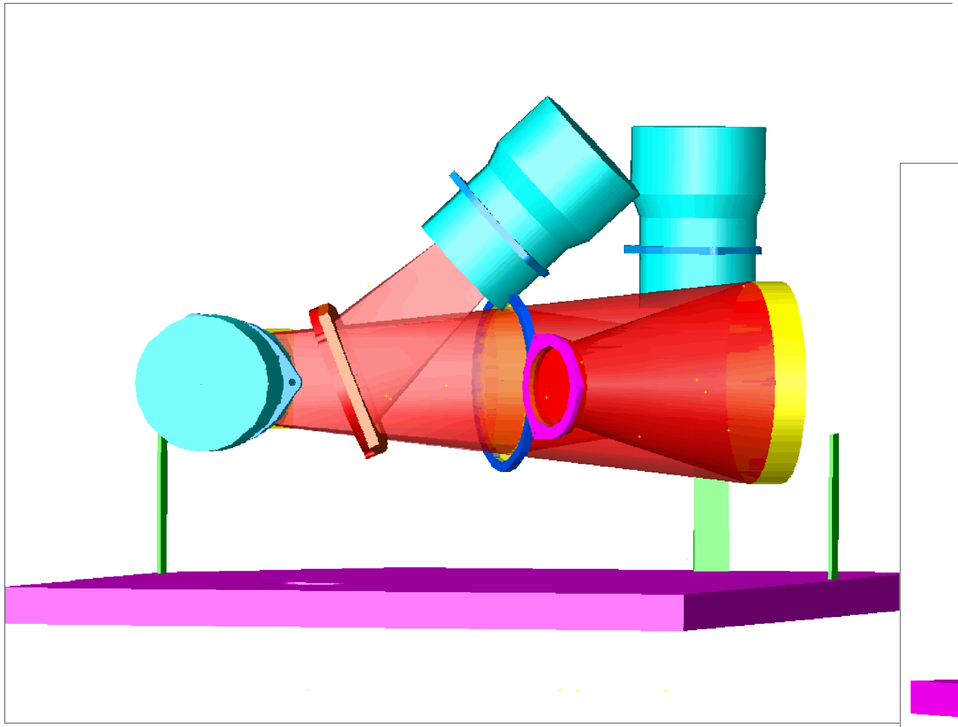
Geometrical environment

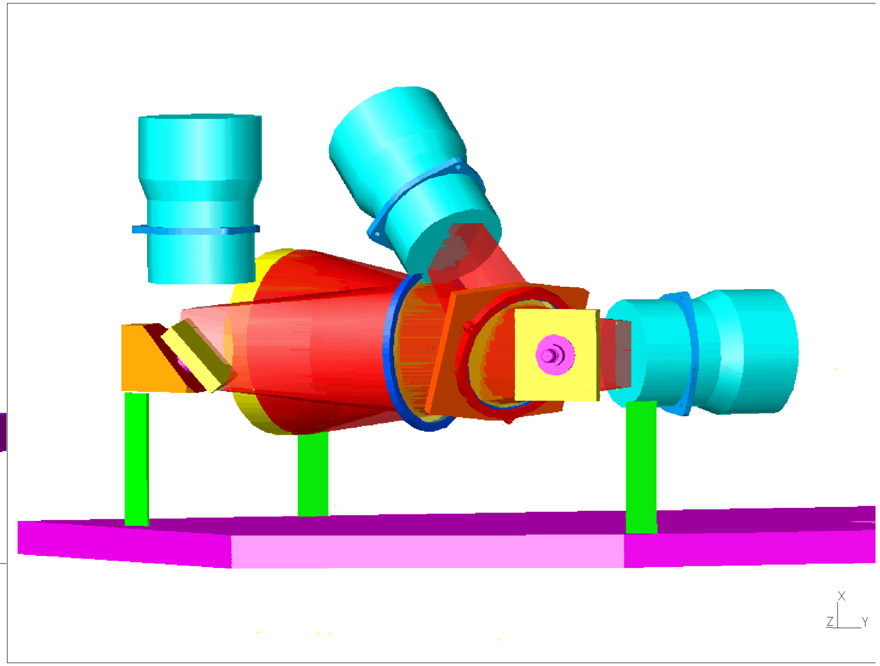




UCL
MSSL

Geometrical environment





UCL
MSSL

Conclusions

- Mechanical environment
  - – severe sine vibration spec
  - – eigenfrequency structure > 120 Hz
  - – eigenfrequency detector boxes > 150 Hz
  - – eigenfrequency detectors > 300 Hz
  - – relaxation of sine spec.

UCL MSSL

Conclusions

- Geometrical Environment
  - nose of detector < 65 mm diameter ?
  - bottom of detector < 75 mm diameter
  - mounting plane through CoG
  - mounting within this envelope !
  - HOW ABOUT ALIGNMENT
  - HOW ABOUT RF / LIGHT TIGHTNESS

→ definition focal plane

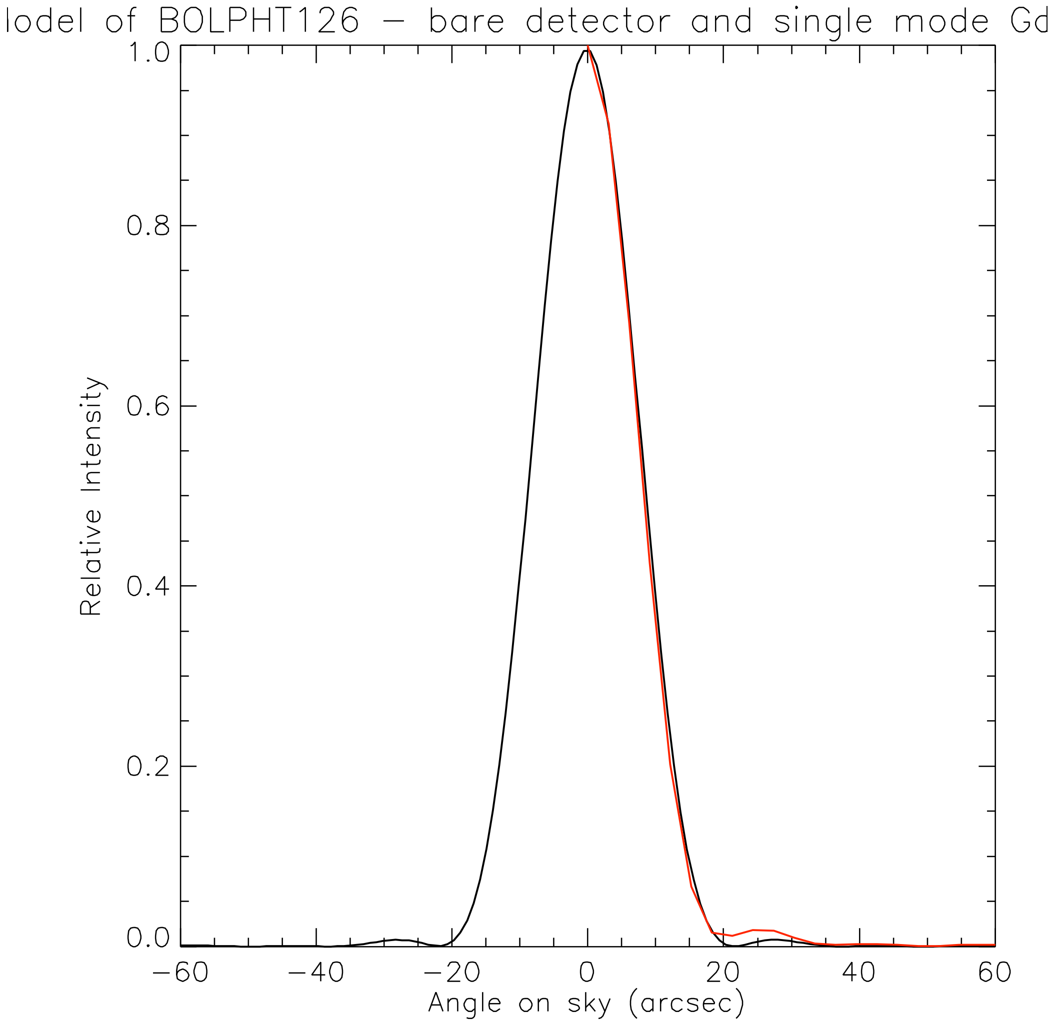
Beam Profile Modelling

Bruce Swinyard

Beam Profile Modelling

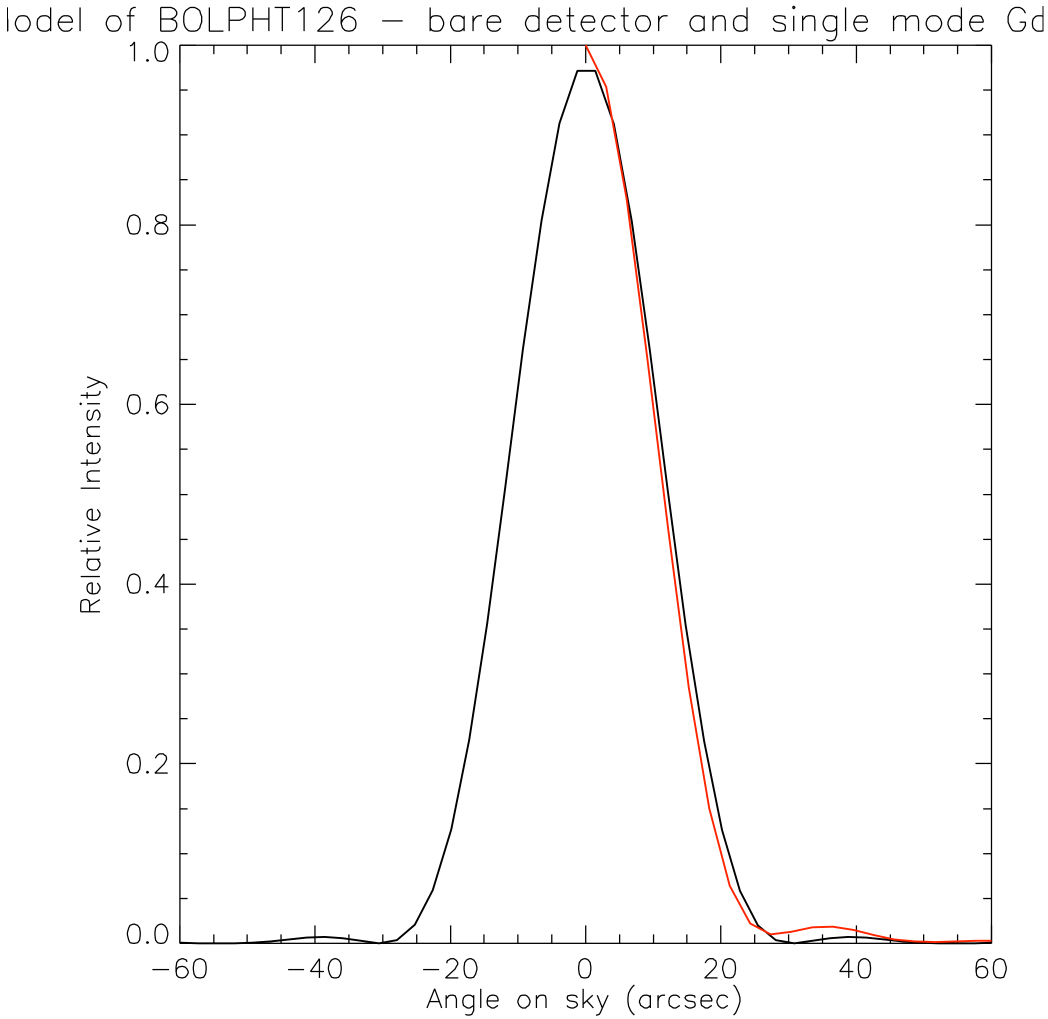
- Telescope design has changed - not included in latest model results from Martin
- Tony is concentrating on the FTS design in order to correctly size the exit apertures
- Beam sizes and distortion of field passed to simulations folk as IDL routine and table of positions
- ASAP model now includes real size of detector pixel for bare arrays
- Single Gaussian mode used for simulating feedhorns
  - FWHM
    - 250 - 17.56 arcsec
    - 350 - 24.73 arcsec
    - 500 - 35.36 arcsec

Beam Profiles



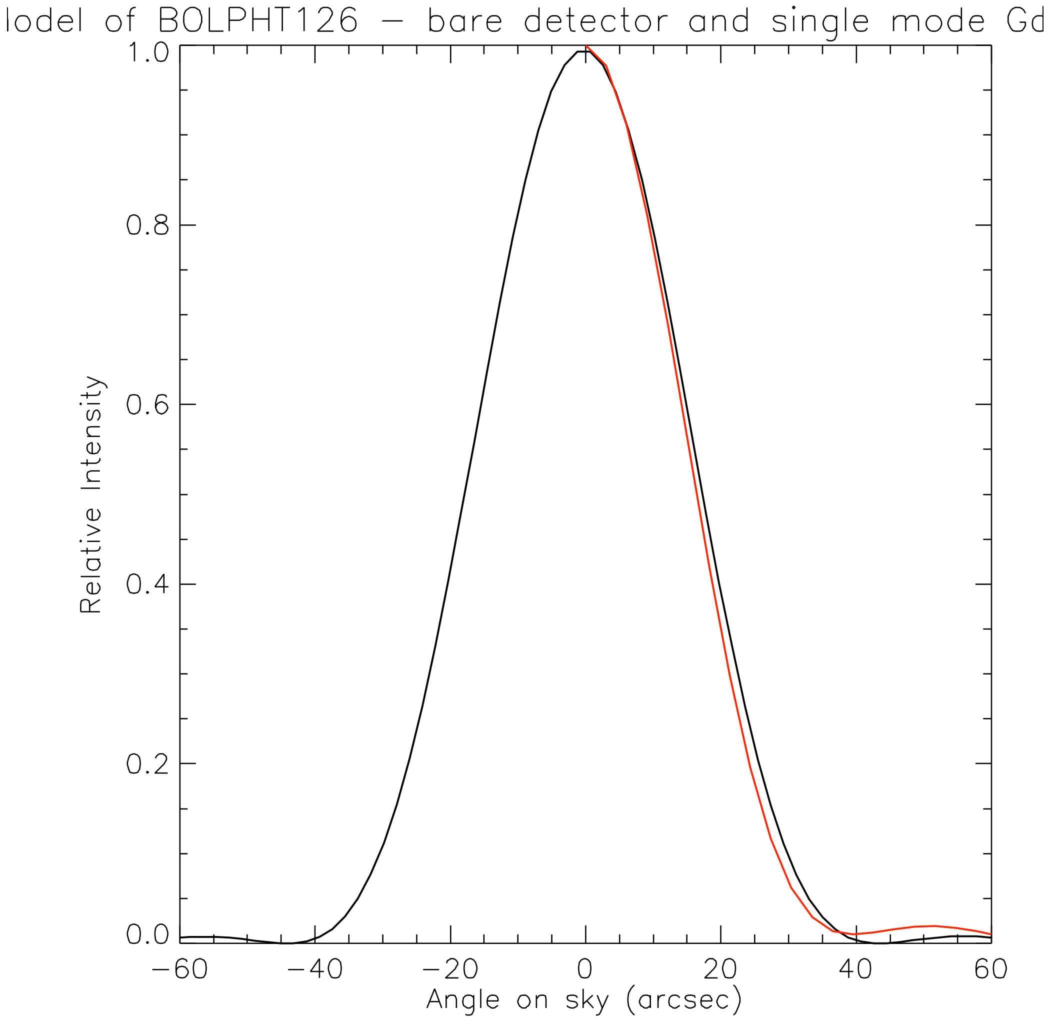
250 μm

Beam Profiles



350 μm

Beam Profiles



500 µm

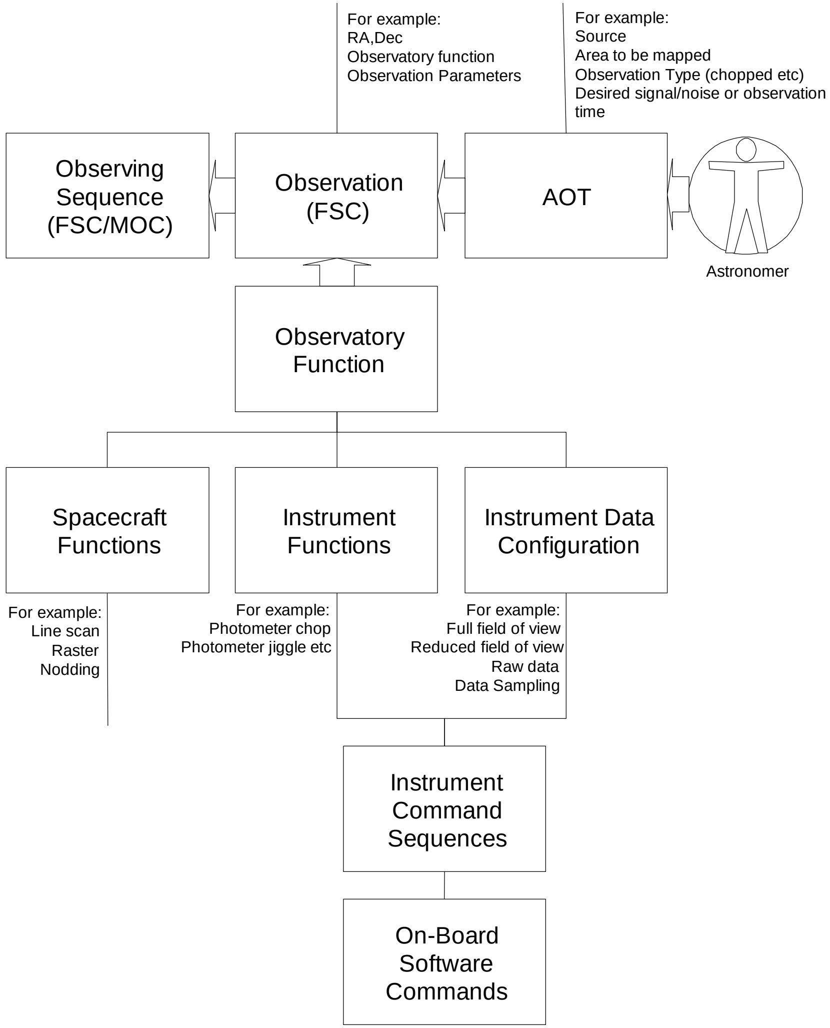
Operating Modes

Bruce Swinyard

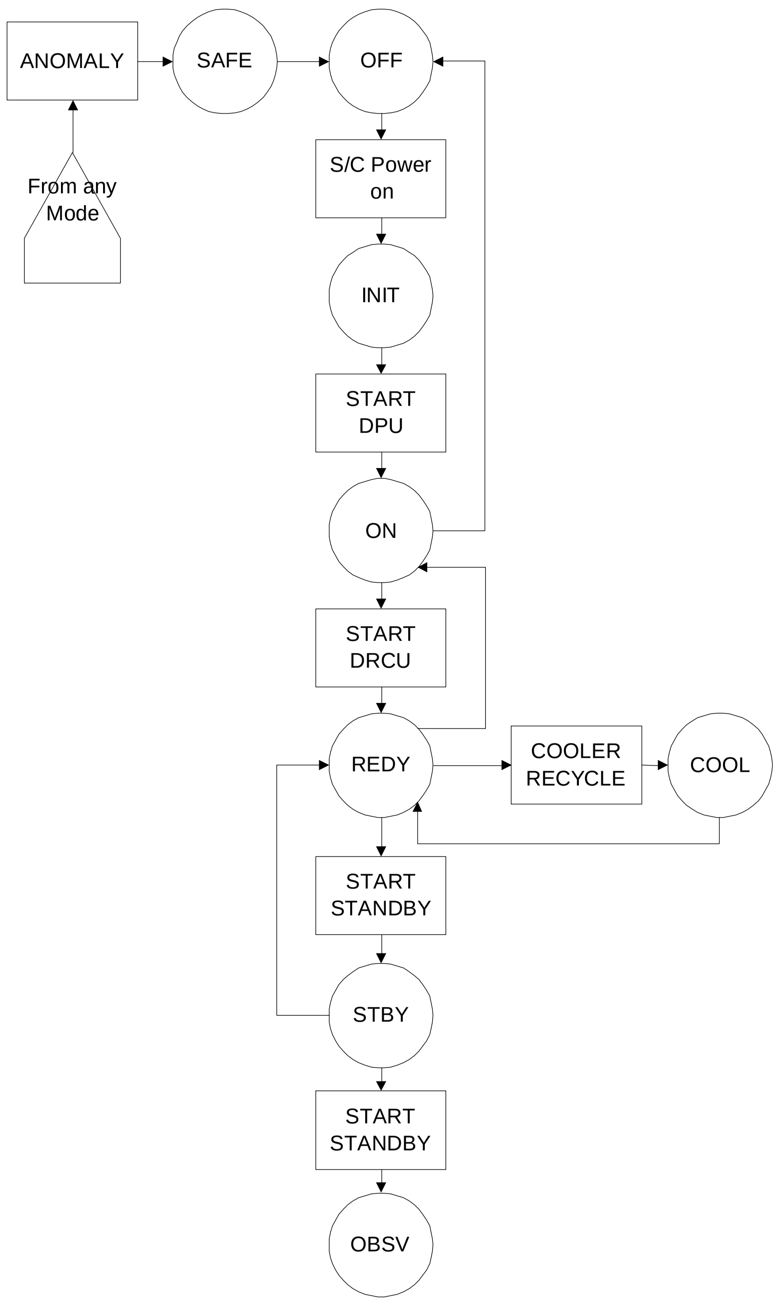
Operating Modes

- Operating Modes Document in its infancy
- It will try to define the requirements on the WE; OBS and Ground segment for all operating modes of the SPIRE instrument
- Concentration is on the Observing Mode for the time being
- First draft has 7 (ish) "Observatory Functions" defined for the feedhorn option
- Try to use these to define the "Instrument Functions" and "Data Configurations"
  - These then set the requirements on the WE; OBS and Ground segment.

Operating Modes



Operating Modes



Operating Modes

- Observatory functions - examples

  - POF1 : Chop Without Jiggling
  - POF2 : Seven-Point Jiggle Map
    POF3 : Sn-Point Jiggle Map
  - POF4 : Raster Map
  - POF5 : Scan Map Without Chopping
  - POF6 : Scan Map With Chopping
  - POF6 : Photometer Peak-Up
  - POF7 : Operate photometer internal calibrator

Operating Modes

Table TBD: Photometer Observatory Function POF2: Seven-Point Jiggle Map				
Instrument Function: Photometer Chop				
No.	**Parameter**	**Range of values**	**Nominal value**	**Comments**
1	Prime detector	One of the two triple-overlap positions in the centre of the arrays	TBD	This position on the array is aligned on-source for nod position 1. Common with POF1.
2	Chop frequency	0.3 (TBC) - 5 Hz	2 (TBC)	Common with POF1.
3	Chop direction	Any direction in the Y-Z plane	Parallel to the Y-axis	Common with POF1.
4	Chop throw	Any value within the BSM range (4 arcmin. in Y; 0.5 arcmin in z)	126" on the sky parallel to Y-axis	Common with POF1.
Instrument Function: Photometer Jiggle				
1	Jiggle pattern	7-point (central + hexagon) with separation θ	θ = 6 arcsec.	
2	Number of chop cycles/jiggle position	Min = 5 Max = TBD	Such as to give roughly 1 minute per jiggle cycle	
3	Number of jiggle cycles/nod position	N = 1 - TBD	1	
4	Total integration time	Min = 2 jiggle cycles Max = TBD	None	Only required for nodding OFF
Telescope Function: Nod				
1	Nodding	ON or OFF	ON	Nodding is optional
2	Telescope nod period	Determined by the time taken for N jiggle cycles	Set to allow one jiggle cycle per nod position	
3	Nod direction	Same as the chop direction	Parallel to the Y-axis	
4	Nod throw	Same as the chop throw	126"	
5	Total number of nod cycles	Min = 2 Max = TBD	TBD	Specifies total integration time if nodding is ON

Spire Simulations

Seb Oliver and Neal Todd

Overview

- Goals
- Overview of Simulation Method
- Current Status
- Latest Results
- Future Steps

SIMULATIONS DONE / IN PROGRESS

250 , 350 , 500 μ

½ λ	FILLED ARRAY	}	4′ × 8′ F.O.V.
2 λ	FEED HORNS		

3° × 1° MAPS @ 3″ SUBPIXEL RESOLUTION

OBSERVATIONS (SIM. DRIFTSCAN) :

1. 5040 × 8 POINTINGS (3° × 45′)
   2″.14 STEP × 4′
   (60″/s × 28Hz)

   10 day TOTAL TIME → 1 hr 15m ON EACH BIT OF SKY

2. 5040 × 1 POINTING
   WITH MAP @ 1″ SUBPIXEL RESOLUTION.

REQUIREMENTS

450 MHz PII 256 Mb RAM (128 Mb SWAP)

3° × 1° MAP PRODUCTION (@ 3″/pix) : 30 MINS.
OBSERVATION + 1ST STAGE REDUCTION : 40 MINS.
(UNLOADED MACHINE)

MAP PRODUCTION REQUIRES MINIMUM OF 100Mb
∴ NEED 256Mb RAM MINIMUM (IE 128Mb TOO SMALL)

DATA REDUCTION ⇒ MAPS, OPTIMISED FOR PS EXTRACTION

$\times\, s(\underline{r})$

ISOLATED POINT SOURCE at $\underline{r}_0$ $\qquad \cdot\ \underline{r}_0$

$$\overline{s(\underline{r})} = f(\underline{r}_0)\, P(\underline{r} - \underline{r}_0)$$

$$f(\underline{r}_0) = s(\underline{r}) / P(\underline{r} - \underline{r}_0)$$

$$\hat{f}(\underline{r}_0) = \frac{\sum w(\underline{r}, \underline{r}_0)\, s(\underline{r}) / P(\underline{r} - \underline{r}_0)}{\sum w(\underline{r}, \underline{r}_0)}$$

case of noise $= \sigma(\underline{r})$

Min Variance $\quad w(\underline{r}, \underline{r}_0) = P^2(\underline{r} - \underline{r}_0) / \sigma^2(\underline{r})$

$$\Rightarrow \quad \hat{f}(\underline{r}) = \frac{P \otimes s/\sigma^2}{P^2 \otimes 1/\sigma^2}$$

case $\frac{1}{\sigma^2(\underline{r})} \propto \delta(\underline{r})$

$$= \frac{P \otimes s}{P^2 \otimes \delta}$$

But could choose ...

$$w(\underline{r}, \underline{r}_0) = w'(\underline{r} - \underline{r}_0) / \sigma^2(\underline{r})$$

eg. $\quad w'(\underline{r} - \underline{r}_0) = P^2((\underline{r} - \underline{r}_0)/2)$

or $\quad w'(\underline{r} - \underline{r}_0) = \begin{cases} P^2(\underline{r} - \underline{r}_0) & |\underline{r} - \underline{r}_0| \le r_{max} \\ 0 & |\underline{r} - \underline{r}_0| > r_{max} \end{cases}$

Goals of SPIRE Simulations

- Assess Instrument Design Options e.g.
  - Filled Arrays vs. Feed Horns
    - Impact on confusion noise
    - Impact on mapping speed
  - Filter choice
- Assess Observation modes & Strategies
- Assess Data Reduction Methods and Quality of Data Products

Simulation Ingredients

- Synthetic Sky
- Instrument Model
- Observing Modes
- Data Reduction
  - Maps
  - Source lists
- Data Assessment

Synthetic Sky

- Point Sources
  - Model Counts — full range of valid models
  - Model Colours — to test multiλ capabilities
  - Model N(z) & P(k) — to assess clustering
  - Real Sources — for observation planning
- Background
  - Cirrus Emission — espec. near Galactic plane
  - Zodiacal Light — probably unimportant

Instrument Model

- Beam profile of detector on sky
  - includes coupling of detector to telescope

$$f(x,y) = I_n(a, d) * B_n$$

- Power absorbed by detector

$$P = fA_{\mathrm{tel}} \Delta_n h_{\mathrm{opt}} h_{\mathrm{det}}$$

- Noise Addition

$$s_p = \frac{NEP_{TOT}}{\sqrt{2t}}$$

Current Status

- Sky Model
  - N(S) models independent across bands
  - Low resolution Cirrus
- Instrument/Observing Modes
  - 3 filters 250, 350, 500μm
  - Feed Horn & Filled arrays
  - Single NEP & 2 detector Q. Efficiencies
  - Raster & 64 pt. Jiggle Map
  - Chopped & Un-chopped
  - Scan mapping

Current Status (ctd.)

- Data Reduction & Analysis
  - Arbitrary map weighting function
  - Statistics of intensity map, P(D)
    - Gaussian Fit → [illegible] & sigma
    - RMS trimmed at fixed "classical" confusion level
    - FWHM
    - Itterative Condon

$$s = \sqrt{\int_0^{3s} S^2 dN \Big/ \int_0^{3s} dN}$$

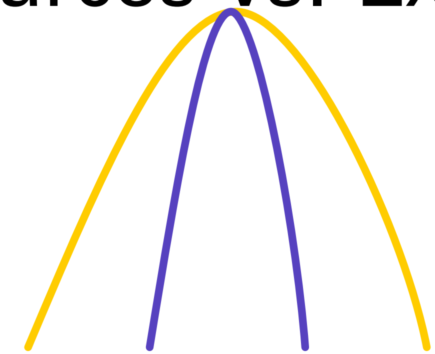
  - Intensity in map at position of input sources
  - Source extraction, reliability and completeness

Limits to Super-Resolution

- With no noise & infinite sampling it is possible to recover infinite resolution
- In practice noise & finte sampling provide constraints
- Leon Lucy has calculated theoretical limits to Super Resolution from photon counting
  - Perfect Instrument: records exact possition of ν
  - Ideal reconstruction:

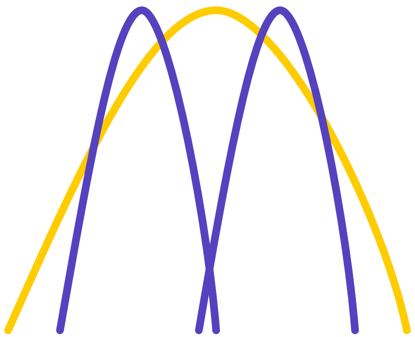
Limits to Super-Resolution (ctd.)

- Point Sources vs. Extended Sources



$$\frac{s_{Natural}}{s_{Super}} \propto N^4$$

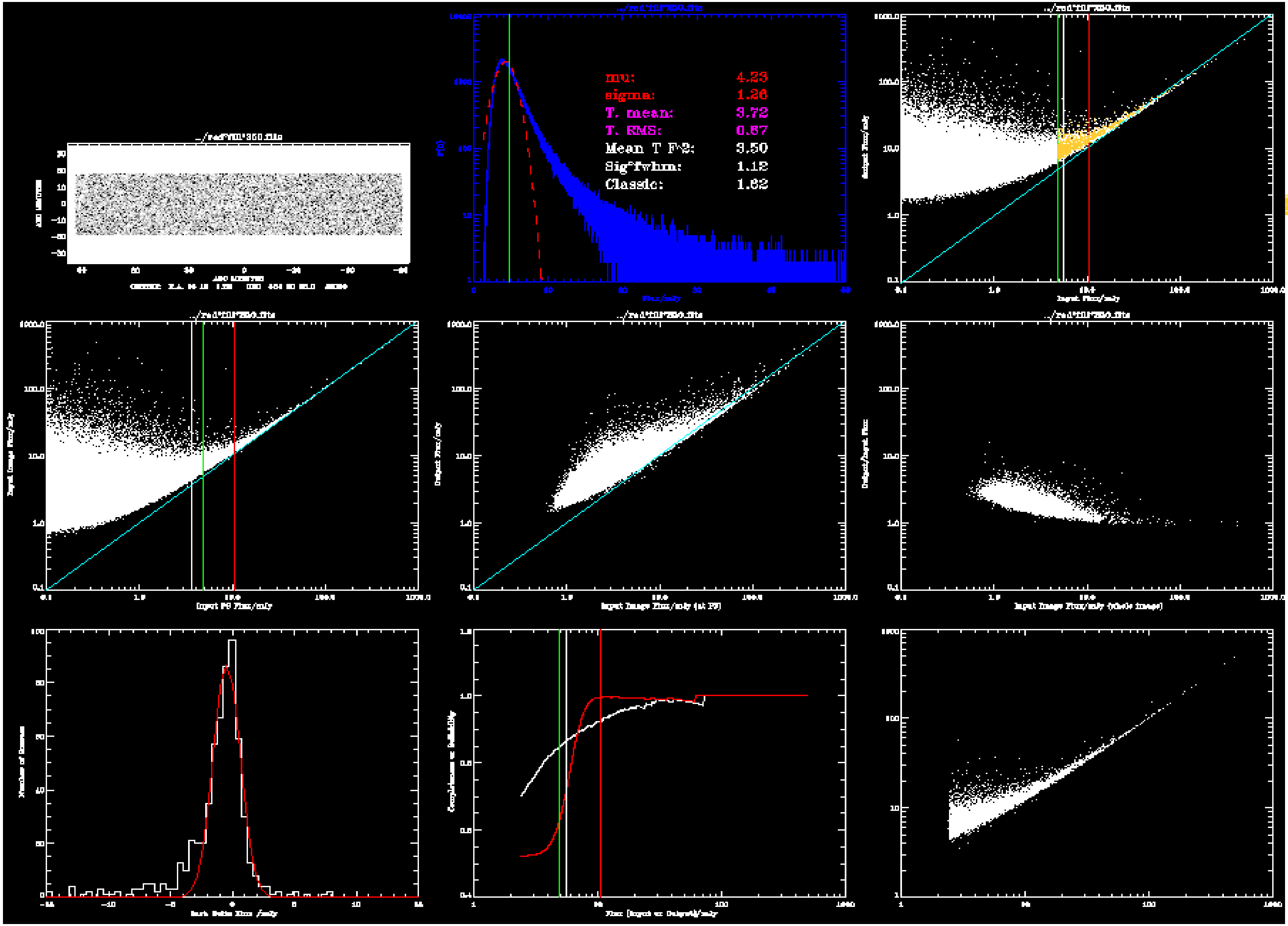
- 2 Point Sources vs. Extendended Source



$$\frac{s_{Natural}}{s_{Super}} \propto N^8$$

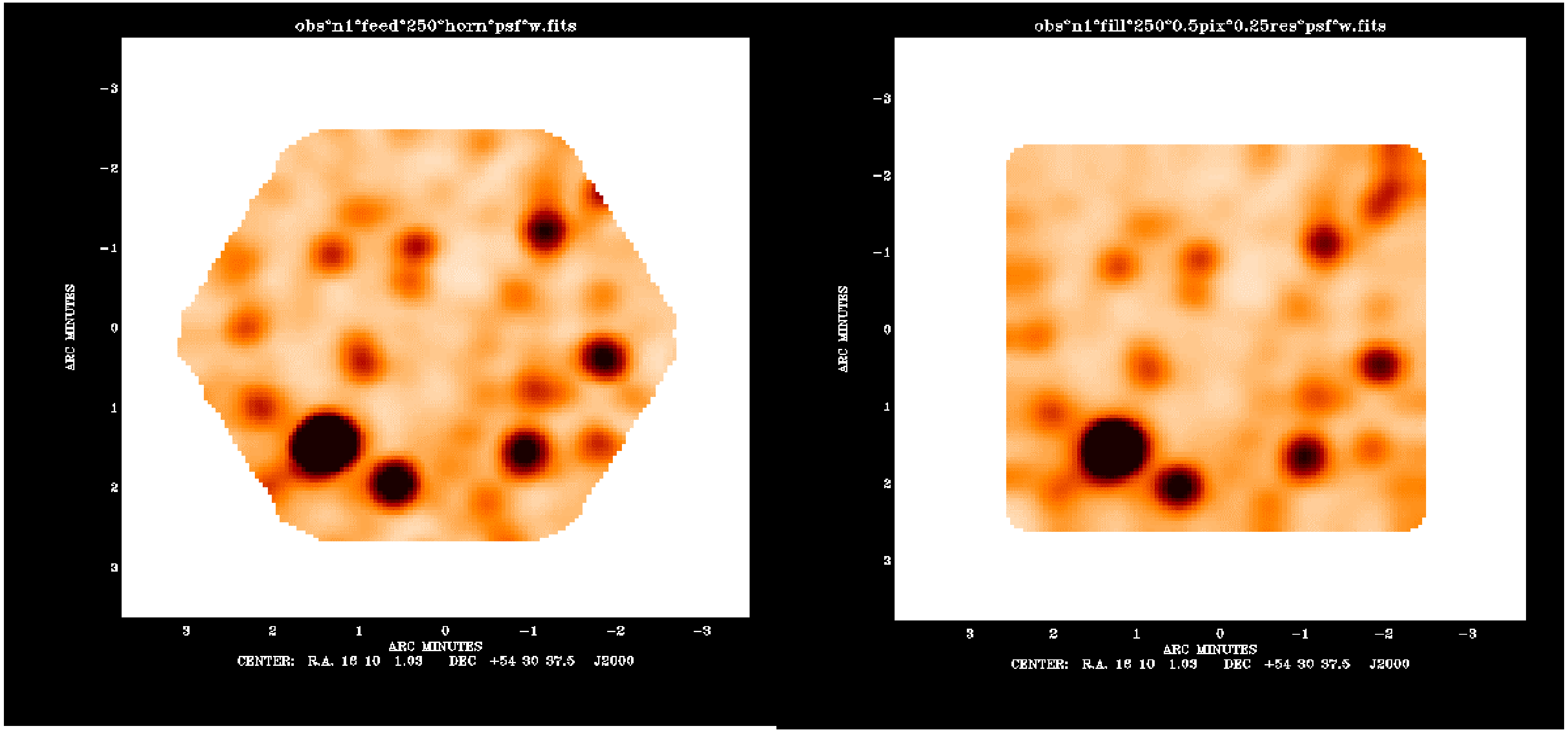
Figures of Merit

- Images
  - Measure of dispersion in P(D)
  - Must be robhust
  - Must be intuative
  - Must measure confusion
- Catalogues
  - Completeness
  - Reliability
  - Photometric accuracy
  - Astrometric accuracy

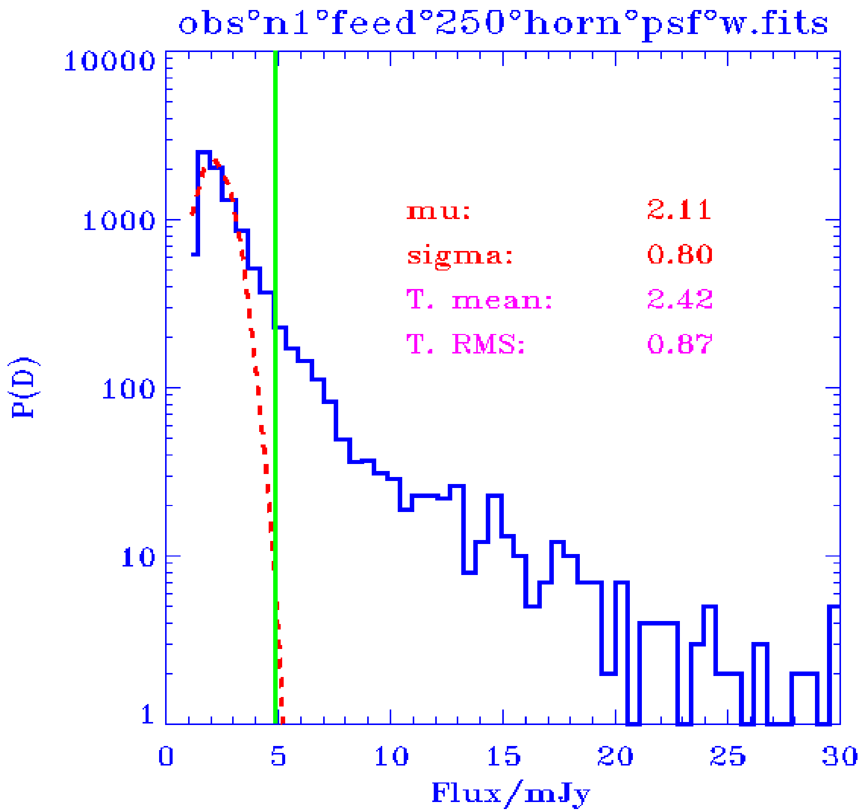


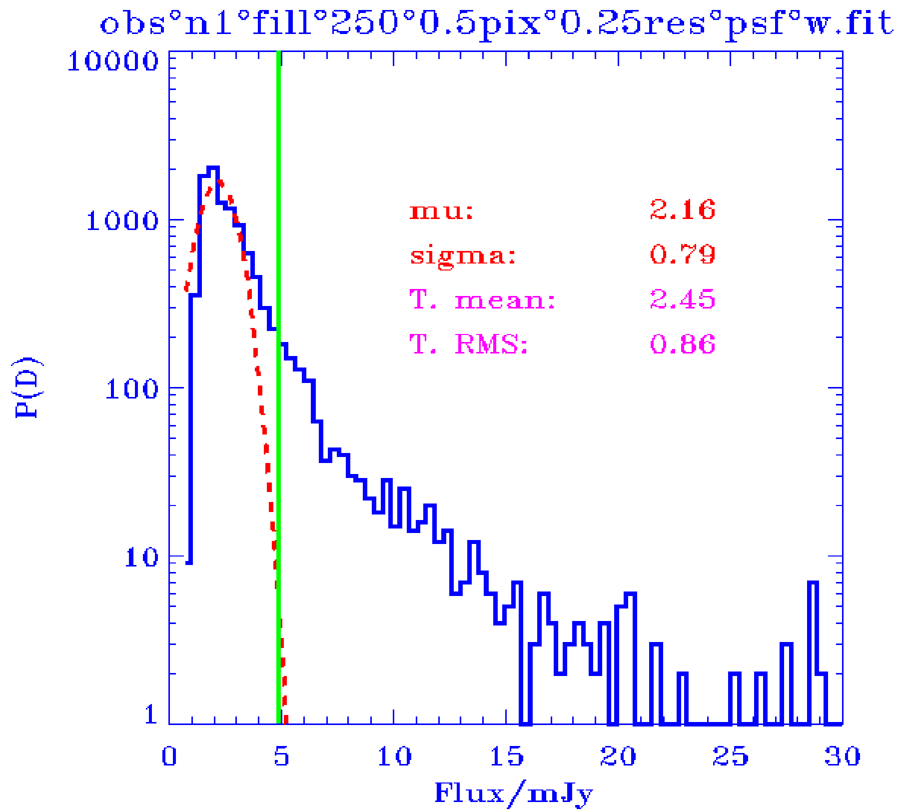
mu: 4.23
sigma: 1.26
T. mean: 3.72
T. RMS: 0.87
Mean T F^2: 3.50
Sig*fwhm: 1.12
Classic: 1.82

250µm Horn vs Filled Array

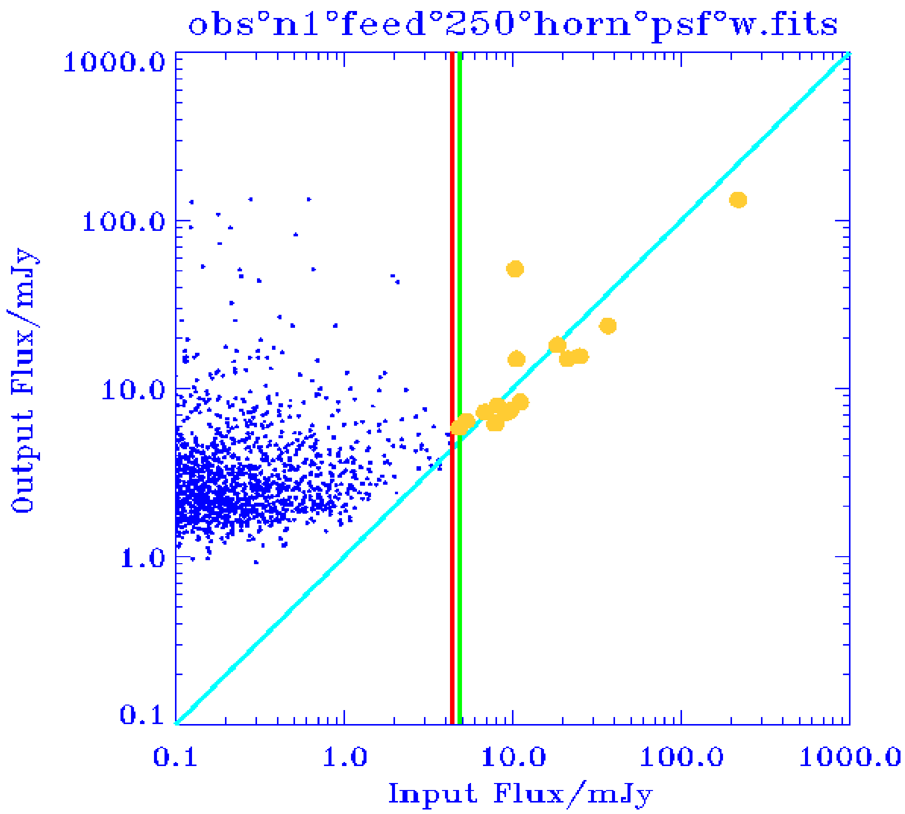


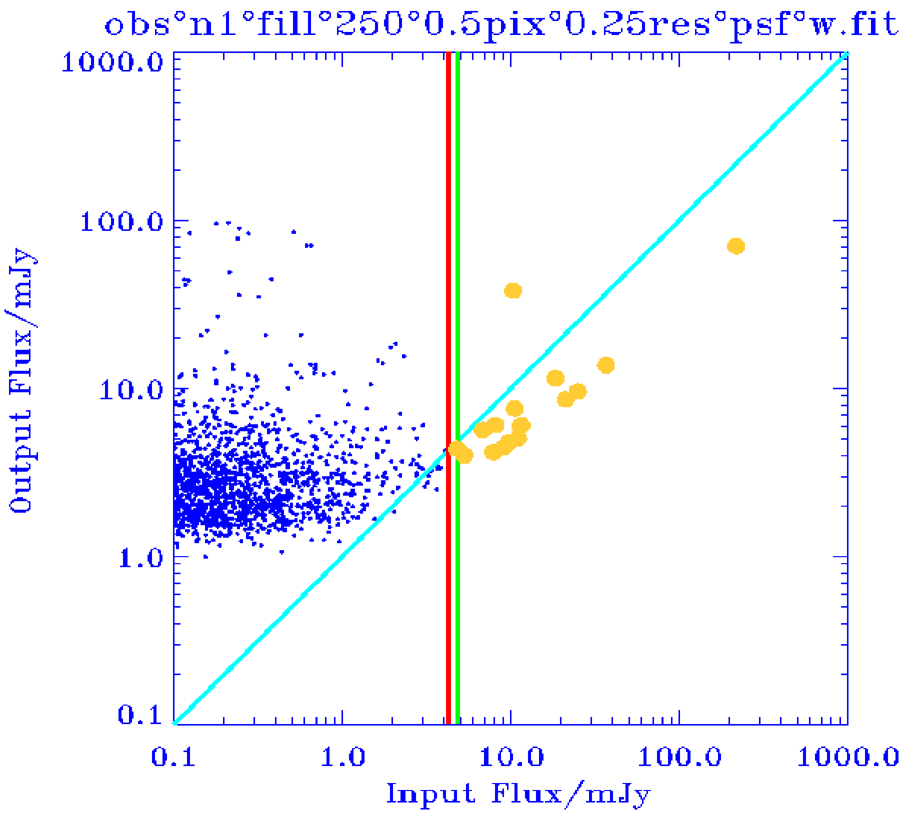
250μm Horn Vs Filled Array



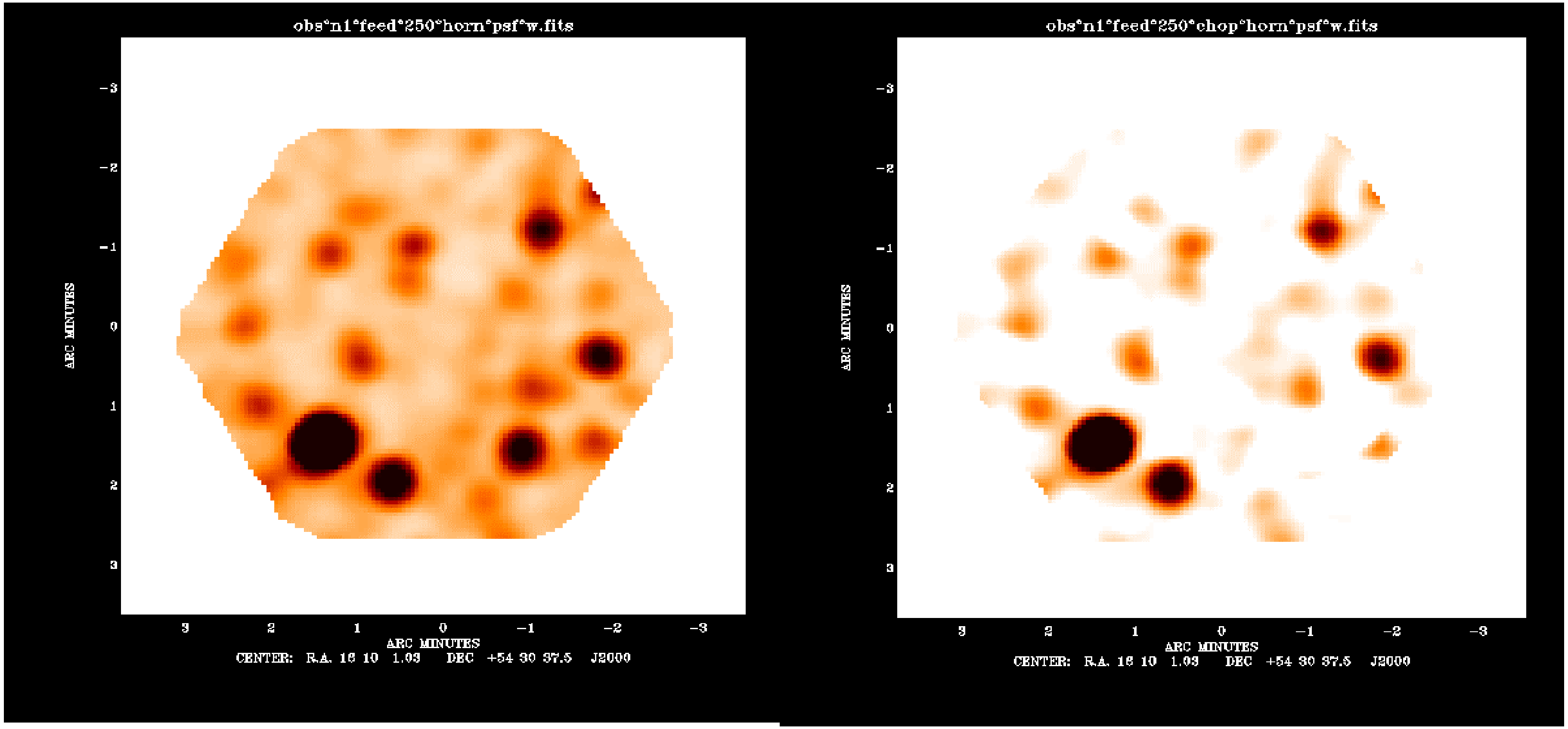


250μm Horn Vs Filled Array

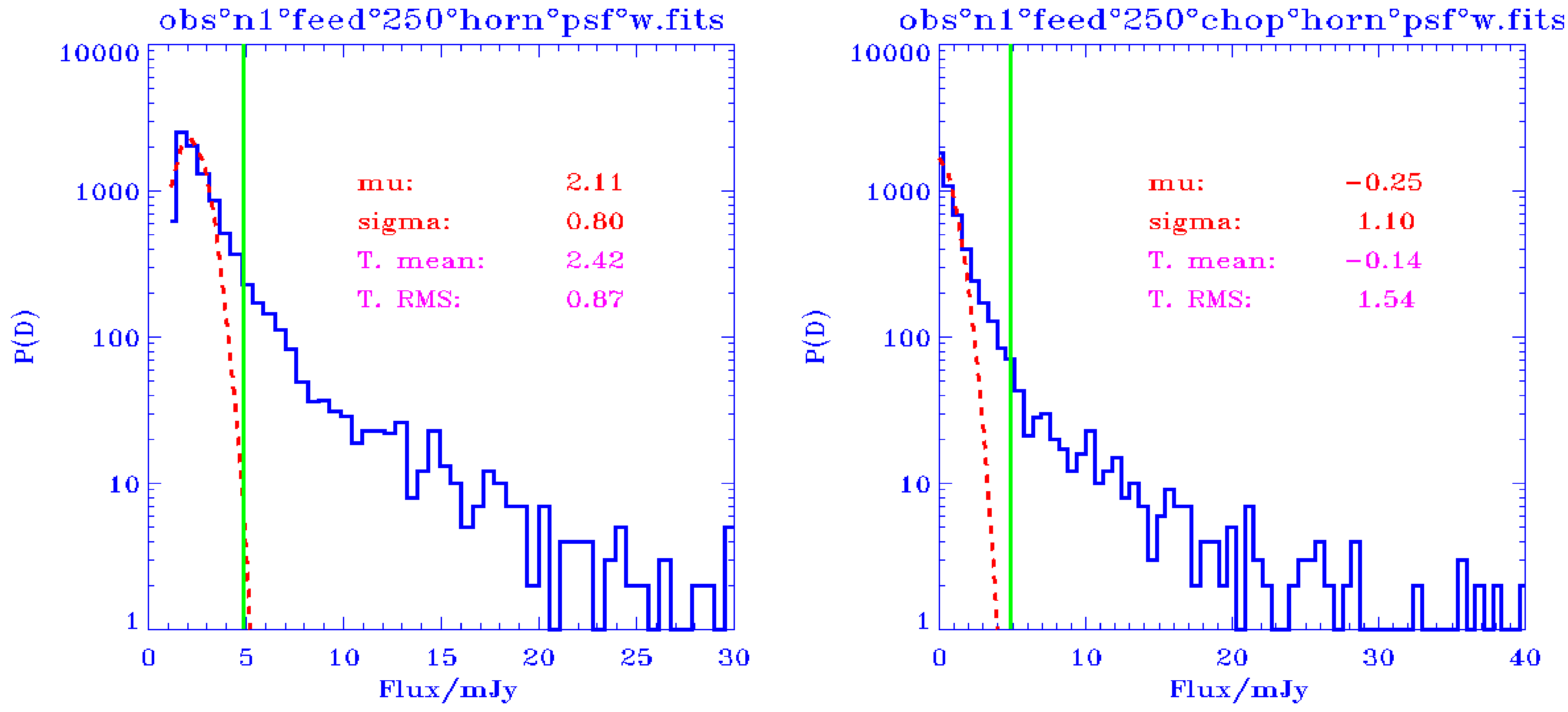




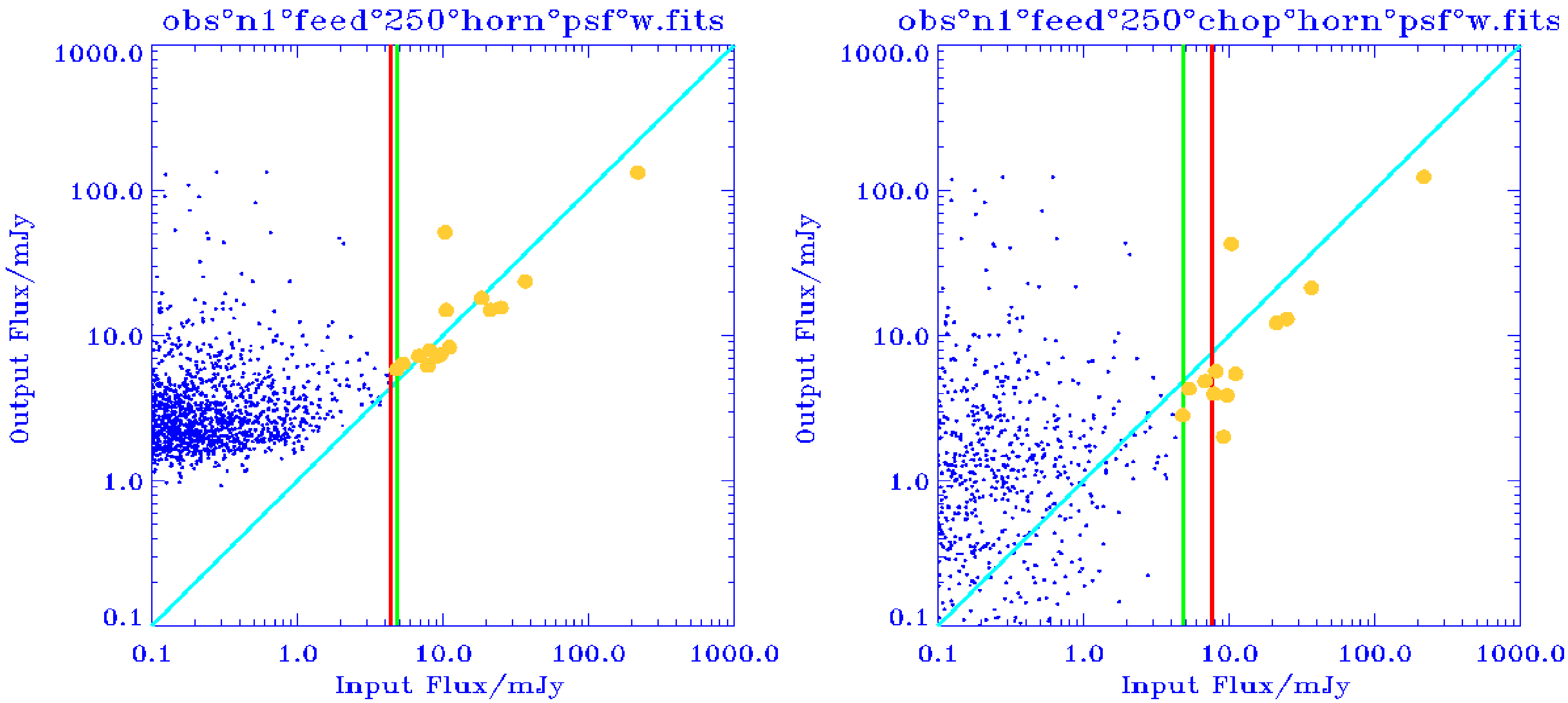
250μm Un-chopped Vs Chopped



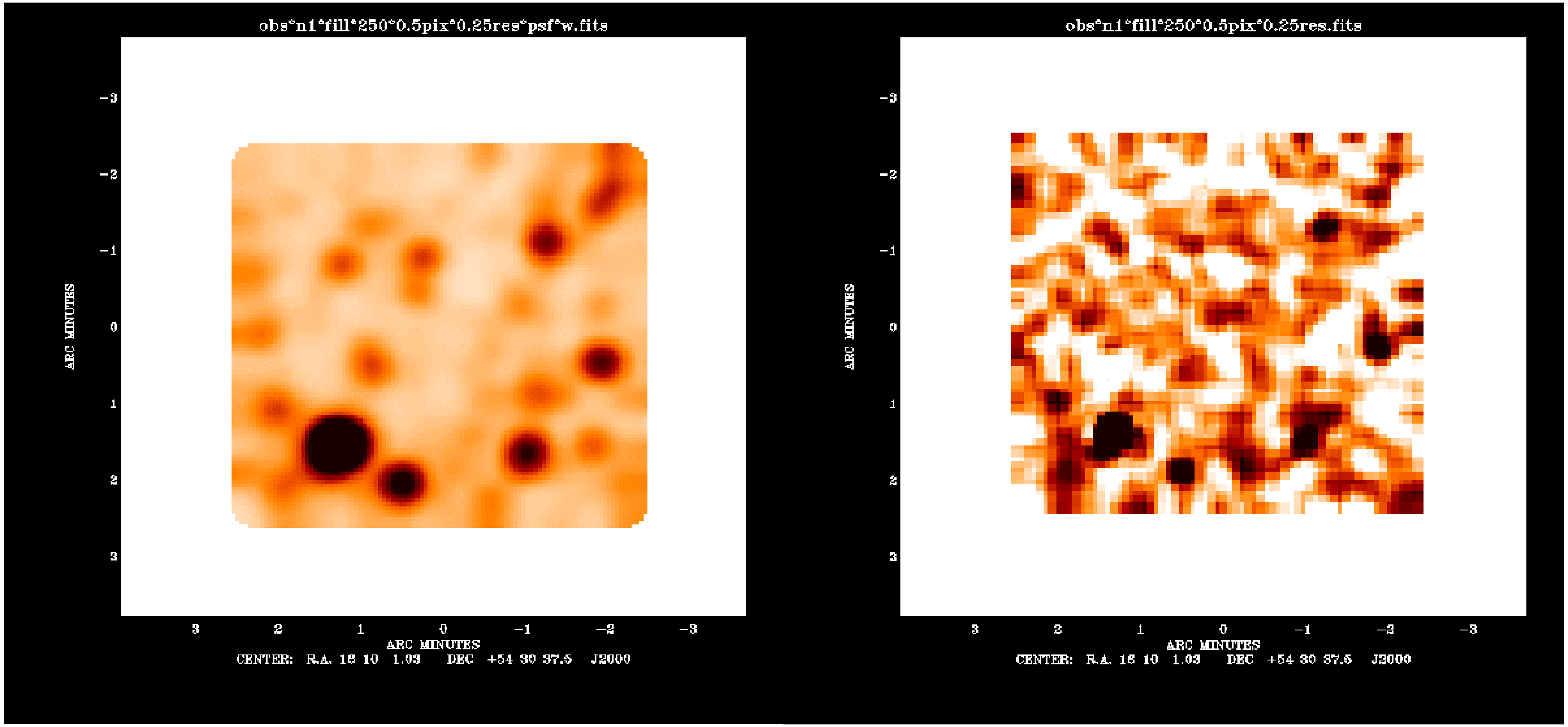
250μm Un-chopped Vs Chopped



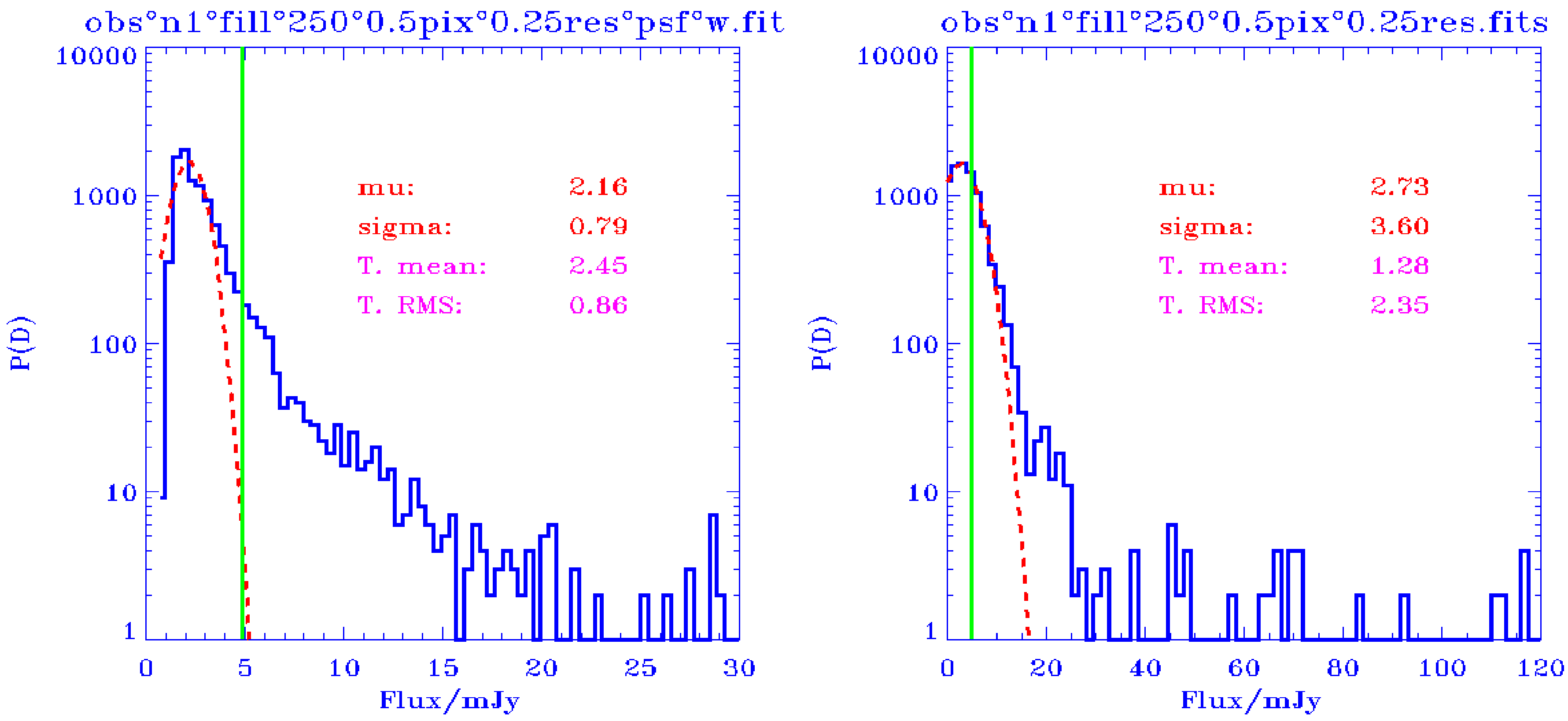
250μm Un-chopped Vs Chopped



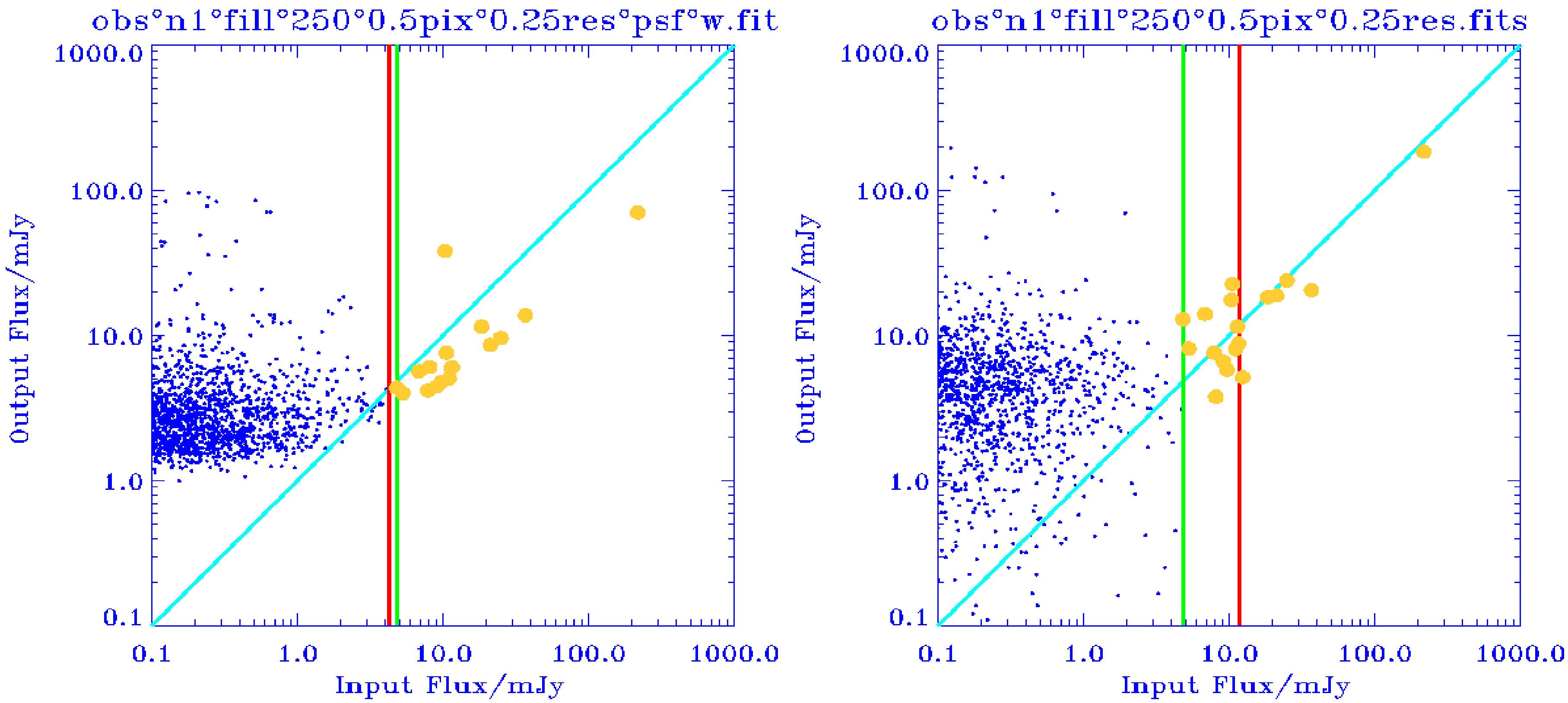
250μm Beam Vs Square Footprint



250μm Beam Vs Square Footprint



250μm Beam Vs Square Footprint



Conclusions

- Little Difference between horns & filled arrays w.r.t. confusion noise
- Chopping significantly worsens confusion noise
- Data reduction techniques crucial
- Trimmed RMS appears to be a reasonable "figure of merit" for confusion noise

Future Improvements

- Sky Model
  - Coherent Source lists at multi-λ
  - Generalised Source count models
  - Clustering of point sources
  - High-resolution Cirrus maps
- Instrument/Observing modes
  - More bands (including PACS)
  - Finer details...

Future Improvements (Ctd.)

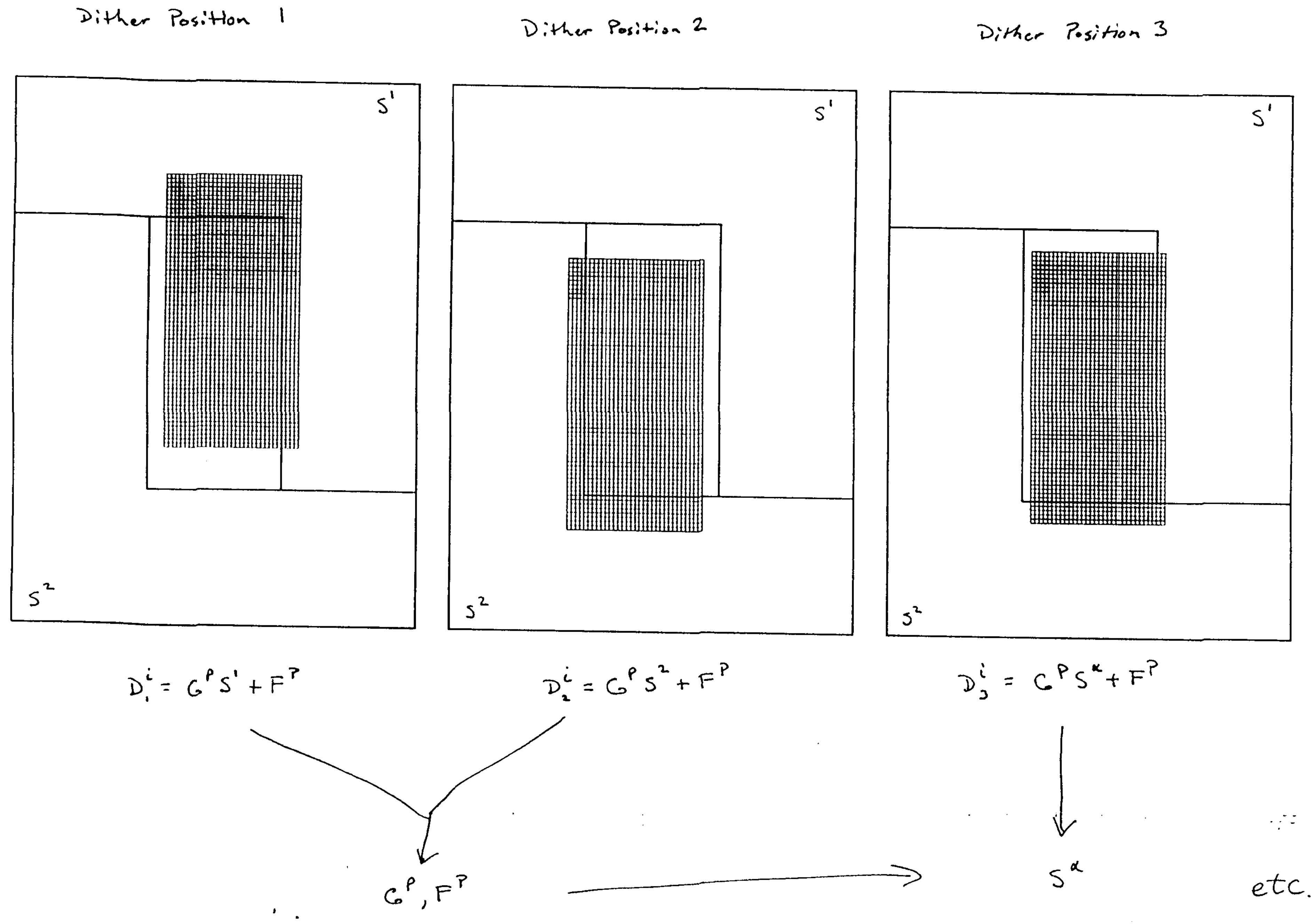
- Data Reduction & Analysis
  - Hyper-resolution reduction techniques (e.g. CLEAN)
  - Assess completeness & reliability of extracted sources
  - Refine quality criteria

Simulations of filled array observations

Harvey Moseley

Sampling + Dithering.

- Spatial dither patters controls spatial correlation of noise in extracted images
- We are working on developing best scan pattern combining scanning and dithering with scan mirror.


Dither Position 1
Dither Position 2
Dither Position 3
S^1
S^2
S^1
S^2
S^1
S^2
$D_1^i = G^p S^1 + F^p$
$D_2^i = G^p S^2 + F^p$
$D_3^i = G^p S^\alpha + F^p$
G^p, F^p
S^α
etc.

Thick Crust

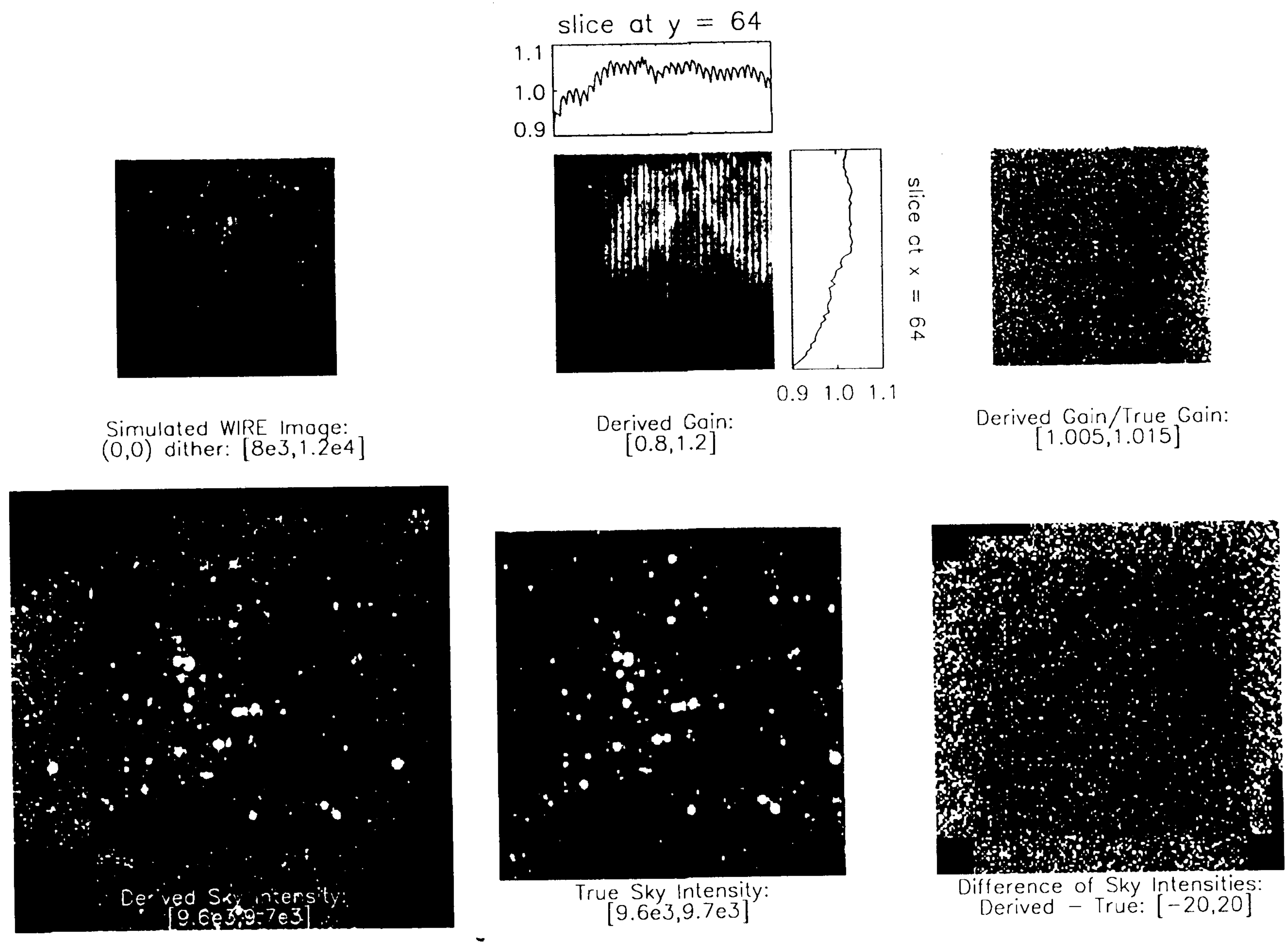
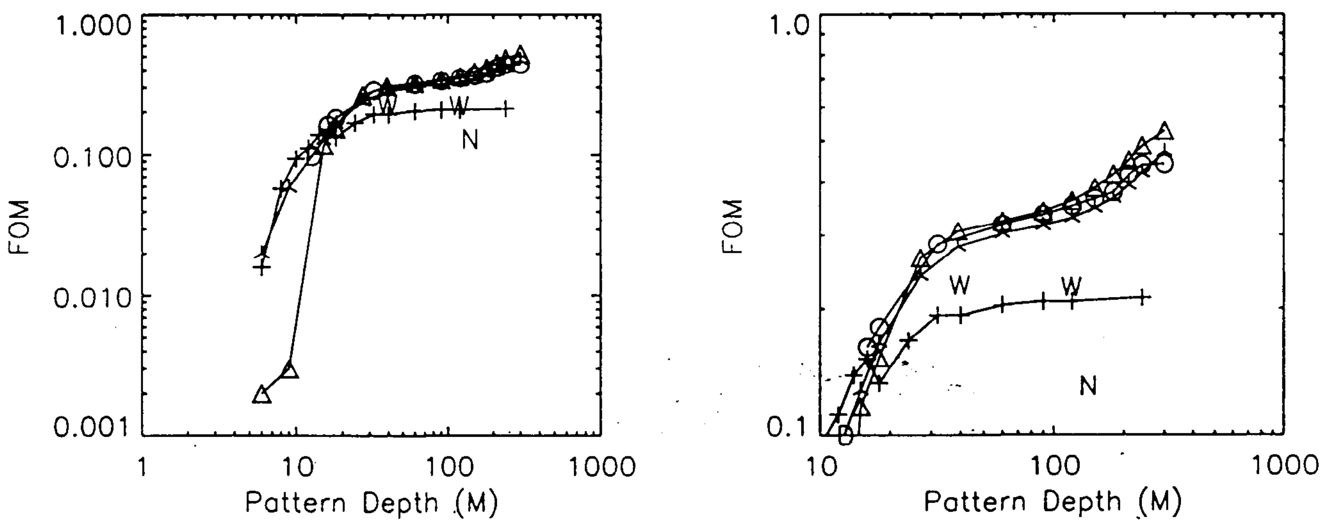

slice at y = 64
1.1
1.0
0.9
slice at x = 64
0.9 1.0 1.1
Simulated WIRE Image:
(0,0) dither: [8e3,1.2e4]
Derived Gain:
[0.8,1.2]
Derived Gain/True Gain:
[1.005,1.015]
Derived Sky Intensity:
[9.6e3,9.7e3]
True Sky Intensity:
[9.6e3,9.7e3]
Difference of Sky Intensities:
Derived − True: [−20,20]

FIGURE OF MERIT for dither patterns

$$\text{FOM} = \mathcal{V}_{p0p0} / \Sigma\, |V_{ip0}|$$

V_{ij} = covariance matrix for the detector
$\mathcal{V}_{ij}$ = idealized covariance matrix where $\mathcal{V}_{ij} = 0$ for $i \neq j$
p_0 = selected reference pixel (row or column)

$$0 \leq \text{FOM} \leq 1$$



+ = geometric progression

λ = VLA

O = random (gaussian)

Δ = Reuleaux triangle

W = WIRE moderate and deep surveys

D = DASI

N = NICMOS HDF-S

Fig. 4

Gain Errors for Simulated WIRE Data

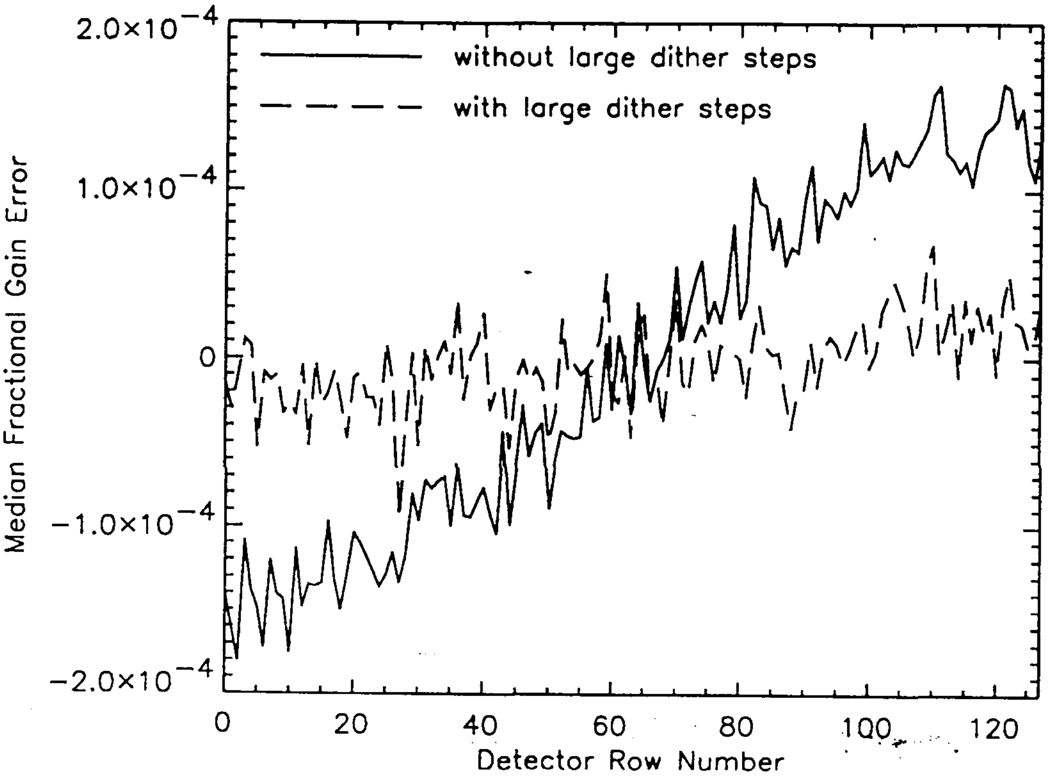
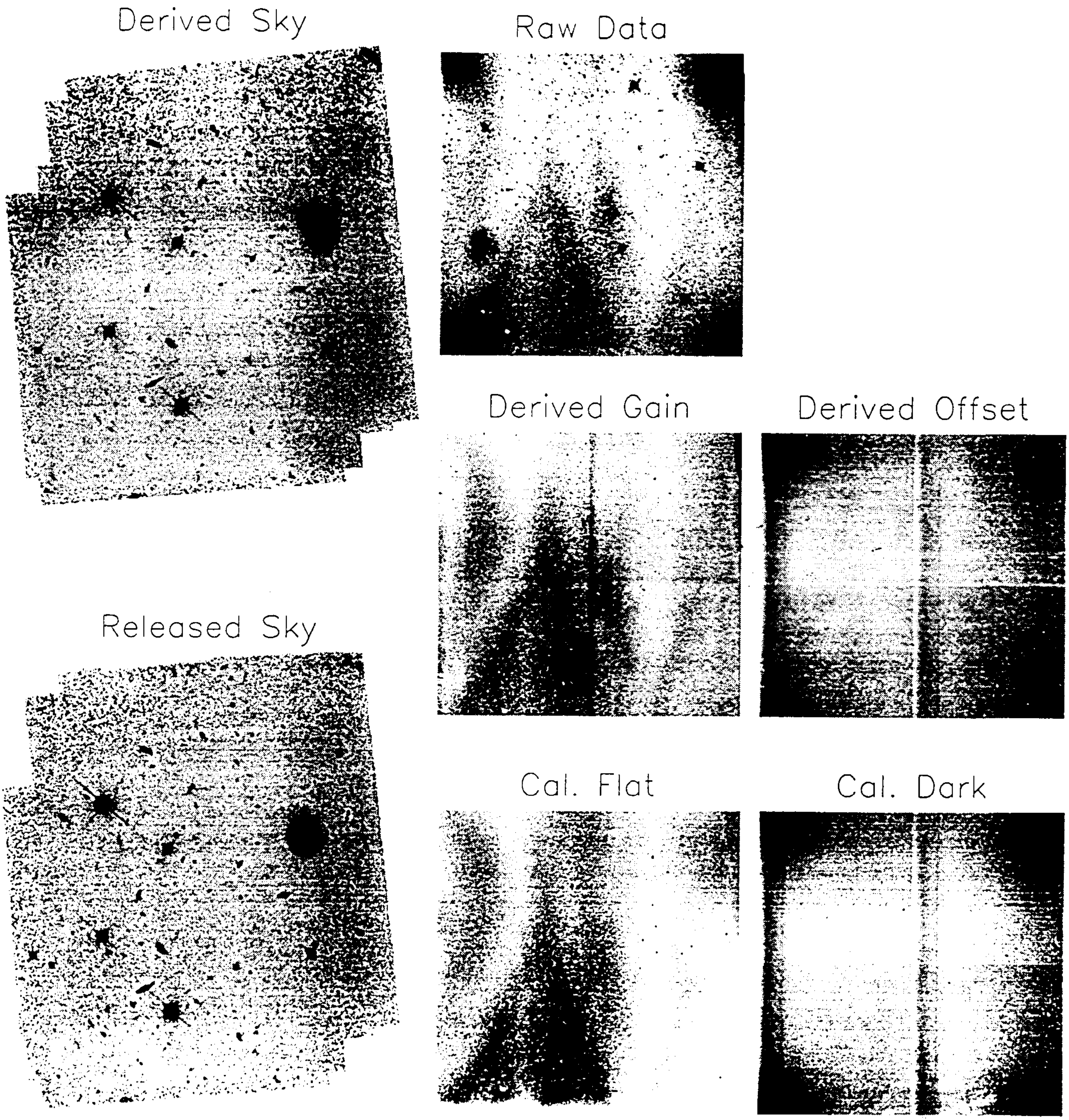


Fig. 7

NICMOS HDF-S (F110W band)



Matt Griffin
Viewgraph Summarising Simulations Discussion

SIMULATIONS FOR DETECTOR SELECTION

FILLED ARRAY vs FEEDHORN ARRAY

- BEAM PROFILE : • NO DIFFERENCE
- SKY SAMPLING : • NO DIFFERENCE IN PRINCIPLE
  • FILLED ARRAYS BETTER IF POINTING NOISE SIGNIFICANT
- MAPPING SPEED : • FILLED ARRAYS FASTER PROVIDED ...
- PRIORITIES:
  - SCANNING SPEED CONSTRAINTS AND INFLUENCE OF 1/f NOISE] * (ACTION)
  - DETAILS OF ARRAY READOUT AND INTERLEAVING OF SAMPLES] *
  - ANY SIGNIFICANT DIFFERENCES IN OVERHEADS
  - KNOW AS ACURATELY AS POSSIBLE THE MAPPING SPEED DIFFERENCES BETWEEN THE 3 OPTIONS
  - INFLUENCE OF TELEMETRY [LIMITS FILLED ARRAYS]