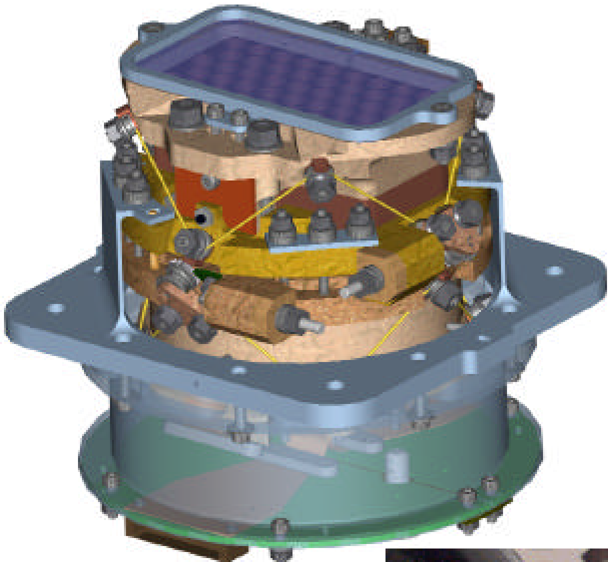
HSO/PLANCK

SPIRE Instrument Detector Arrays CDR



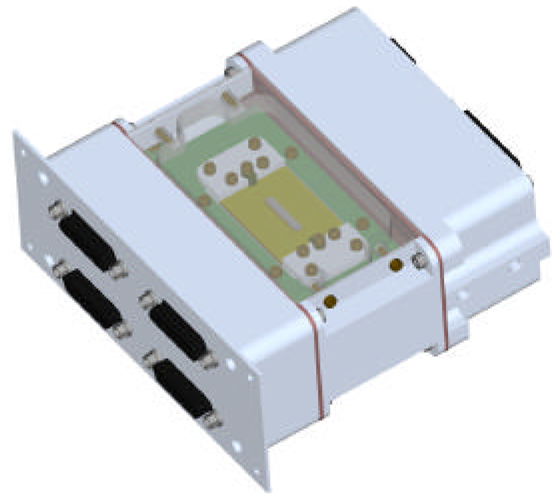
July 30-31, 2001

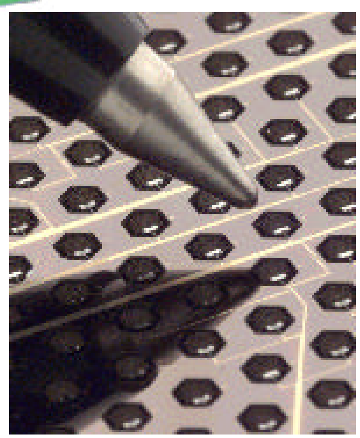
JPL

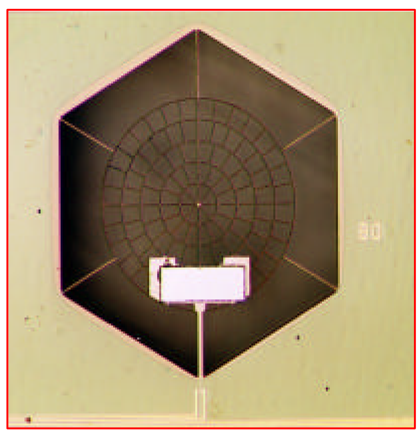
Bldg 233

Room 201A

This Package Complies With ITAR







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1.0
Introduction

Gerald Lilienthal

Charter

- Evaluate the readiness of the SPIRE Detector Subsystem to proceed into CQM fabrication, assembly and test
  - Previous concerns and deficiencies considered and resolved
  - Requirements flowdown from instrument
    - Requirements traceability and compliance matrix
    - Documentation of requirements and interfaces
  - Detailed design is adequate stable and well documented
    - Detailed design responds to requirements
    - Tradeoffs understood
    - Demonstration of technology
    - Configuration control
    - Implementation documentation is adequate (AIDS, Process Sheets, Travellers)
    - Manufacturing process design
    - GSE design and certification of test equipment
    - Integration and test plans
    - Reliability analysis and qualification plans
    - Delivery, handling and shipping plans
  - Product assurance plans are adequate
  - Risks understood and plans exist for managing them

Success Criteria

- Designs and processes meet requirements and are sufficiently defined and documented to proceed with development within the risk policy of the project
- Plans for resolving remaining problems are consistent with available resources and risk policy
- Test approach and test product status is thorough and acceptable with verifying compliance with the requirements
- Technology has been demonstrated by test and correlated to the analyses

Agenda July 30

Start	End	Dur.	Item	Presenter
8:00	8:10	10	1.0 Introduction and Objectives	Gerald Lilienthal
8:10	9:10	60	2.0 Overview	
		|	2.1 Scientific Goals	James Bock
		|	2.2 Instrument Design	James Bock
		|	2.3 Rec/Dels	James Bock
		|	2.4 Requirements	James Bock
		|	2.5 Interfaces	James Bock
9:10	9:20	10	2.6 SPIRE at NASA/Herschel Science Center	Ken Ganga
9:20	9:40	20	3.0 Management Overview	Gerald Lilienthal
9:40	10:00	20	4.0 Interfaces	Dustin Crumb
10:00	10:15	15	**-------Break--------**	
			5.0 BDA	
10:15	11:15	60	5.1 Mechanical Design & Analysis	Dustin Crumb
11:15	11:35	20	5.2 Feedhorn design and test	Jason Glenn
11:35	11:50	15	5.3 BDA thermal model and test results	Terry Cafferty
11:50	12:10	20	5.4 Detector Array Fabrication	Minhee Yun
12:10	1:10	60	**-------Lunch-------**	
1:10	1:30	20	5.5 Detector Development	Hien Nguyen
1:30	1:40	10	5.6 Load Resistor Fabrication	Anthony Turner
1:40	1:50	10	5.7 Kapton Cable Design and Status	Anthony Turner
1:50	2:10	20	5.8 BDA Manufacture and Assembly	Len Husted
			6.0 JFET Modules	
2:10	2:30	20	6.1 JFET Testing Status	James Bock
2:30	2:45	15	6.2 JFET Thermal Model	Terry Cafferty
2:45	3:00	15	6.3 JFET Membrane Fabrication	Anthony Turner
3:00	3:15	15	**-------Break-------**	
3:15	3:25	10	6.4 JFET and RF Module Mechanical Design	Dustin Crumb
3:25	3:40	15	6.5 JFET Module Assembly	Len Husted
3:40	4:05	25	7.0 Harness Definition and Test Procedures	Viktor Hristov
			Board Discussion	

Agenda July 31st

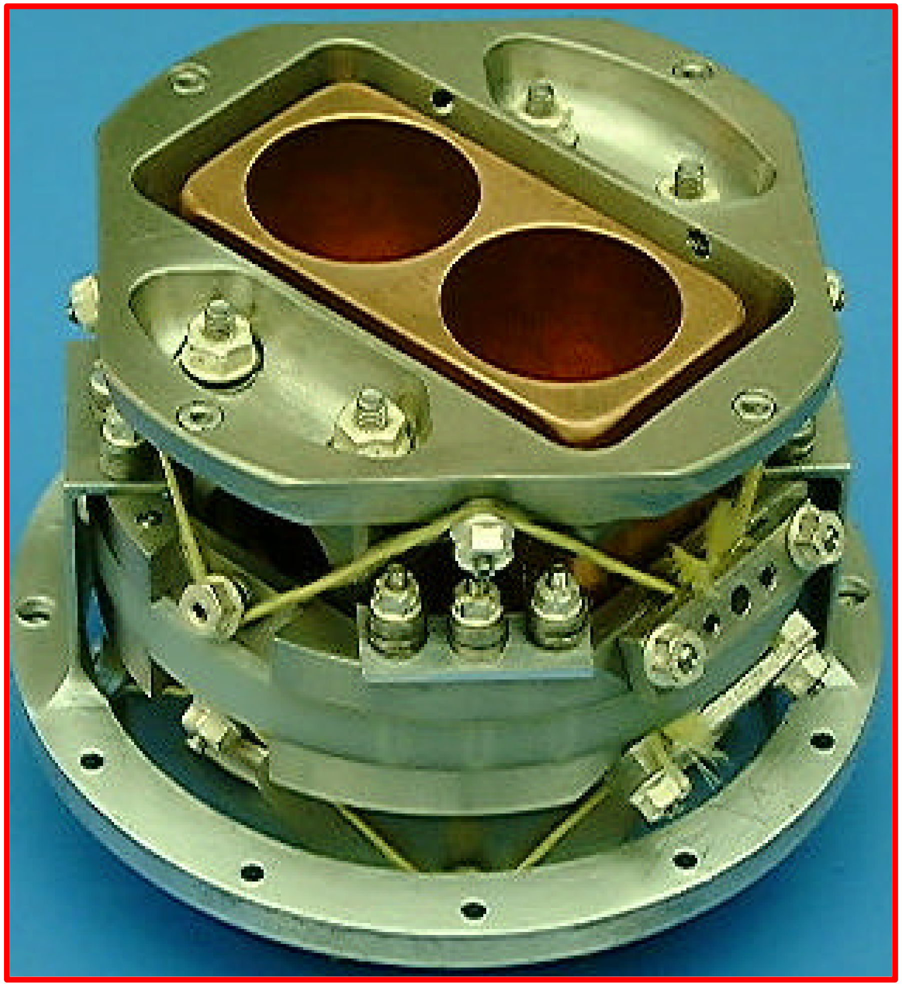
Start	End	Duration	Item	Presenter
8:00	8:20	20	8.0 Warm Electronics	Frederic Pinsard
8:20	8:50	30	9.0 Test program	Kalyani Sukhatme
			9.1 Overview	
			9.2 Verification Matrix	
			9.3 HRCR	
			9.4 Integration and Test Plan	
			9.5 EM Testing and Facilities	
8:50	9:05	15	10.0 Test facilities	Hien Nguyen
9:05	9:45	30	11.0 Mission Assurance	Gordon Barbay
9:45	10:00	15	12.0 Implementation Plan	Jerry
10:00	10:15	15	**-------Break-------**	
10:15	10:30	15	13.0 RFA Summary	James Bock
10:30	10:50	20	14.0 Summary/Objectives	Gerald Liliethal
10:50	11:50	60	**-------Board Report--------**	George Rieke

2.0
Instrument Overview

Jamie Bock

Overview of SPIRE Bolometer Arrays

James J. Bock
Jet Propulsion Laboratory



- **SCIENTIFIC GOALS**
- **INSTRUMENT DESIGN**
- **REC/DELS**
- **REQUIREMENTS**
- **INTERFACES**

The SPIRE Consortium

- Caltech/Jet Propulsion Laboratory, Pasadena, USA
- Cardiff University, Cardiff, Wales, UK
- CEA Service d'Astrophysique, Saclay, France
- Institut d'Astrophysique Spatiale, Orsay, France
- Imperial College, London, UK
- Instituto de Astrofisica de Canarias, Tenerife, Spain
- Istituto di Fisica dello Spazio Interplanetario, Rome, Italy
- Laboratoire d'Astronomie Spatiale, Marseille, France
- Mullard Space Science Laboratory, Surrey, UK
- NASA Goddard Space Flight Center, Maryland, USA
- Observatoire de Paris, Meudon, Paris
- UK Astronomy Technology Centre, Edinburgh, UK
- Rutherford Appleton Laboratory, Oxfordshire, UK
- Stockholm Observatory, Sweden
- Università di Padova, Italy
- University of Saskatchewan, Canada

The U.S. SPIRE Team

INSTRUMENTATION TEAM

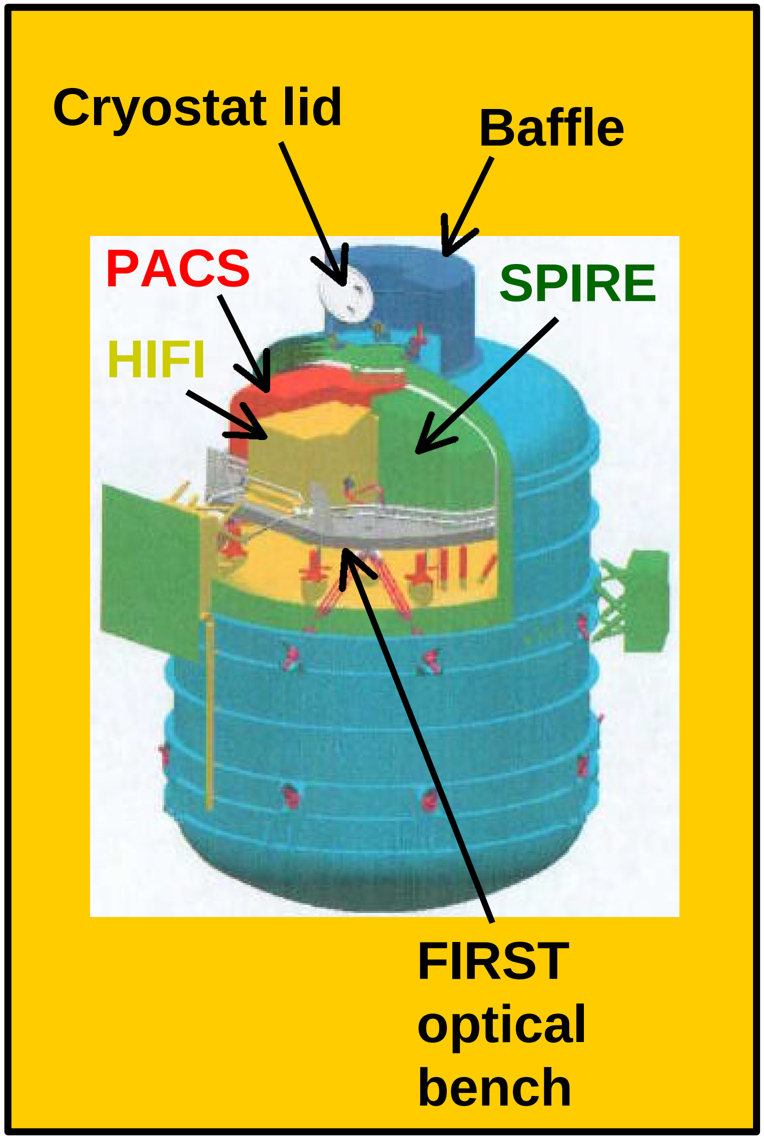
Gordon Barbay	Reliability	JPL
Peter Barrett	Reliablity	JPL
James Bock	SPIRE co-I	JPL
Karsten Browning	Structural Analyst	Swales
Terry Cafferty	Thermal Engineer	TC Tech.
Dustin Crumb	Mechanical Engineer	Swales
Charles Davis	Configuration Control	JPL
Steven Elliott	Cryogenic Technician	JPL
Ed Erginsoy	Parts Program	JPL
Jason Glenn	Feedhorn Design, SPIRE AS	U. Colorado
Viktor Hristov	Electrical Engineer	Caltech
Len Husted	Electronic and Mechanical Assembly	JPL
Eric Jones	Micro-fabrication Engineer	JPL
Michael Knopp	Materials & Processes Engineer	JPL
Andrew Lange	Senior Scientist	Caltech
Timothy Larson	Mission Assurance	JPL
Karan L'Heureux	Safety	JPL
Gerald Lillienthal	Project Element Manager	JPL
Donna Markley	Quality Assurance	JPL
Hien Nguyen	Bolometer Testing, SPIRE AS	JPL
Harvey Moseley	U.S. PI, SPIRE co-I	GSFC
Judi Podosek	Micro-fabrication Engineer	JPL
Brooks Rownd	Feedhorn Testing	U. Colorado
Kalyani Sukhatme	Test Engineer	JPL
Anthony Turner	Micro-fabrication Consultant	Siwave
Minhee Yun	Micro-fabrication Engineer	JPL

SCIENCE ASSOCIATES

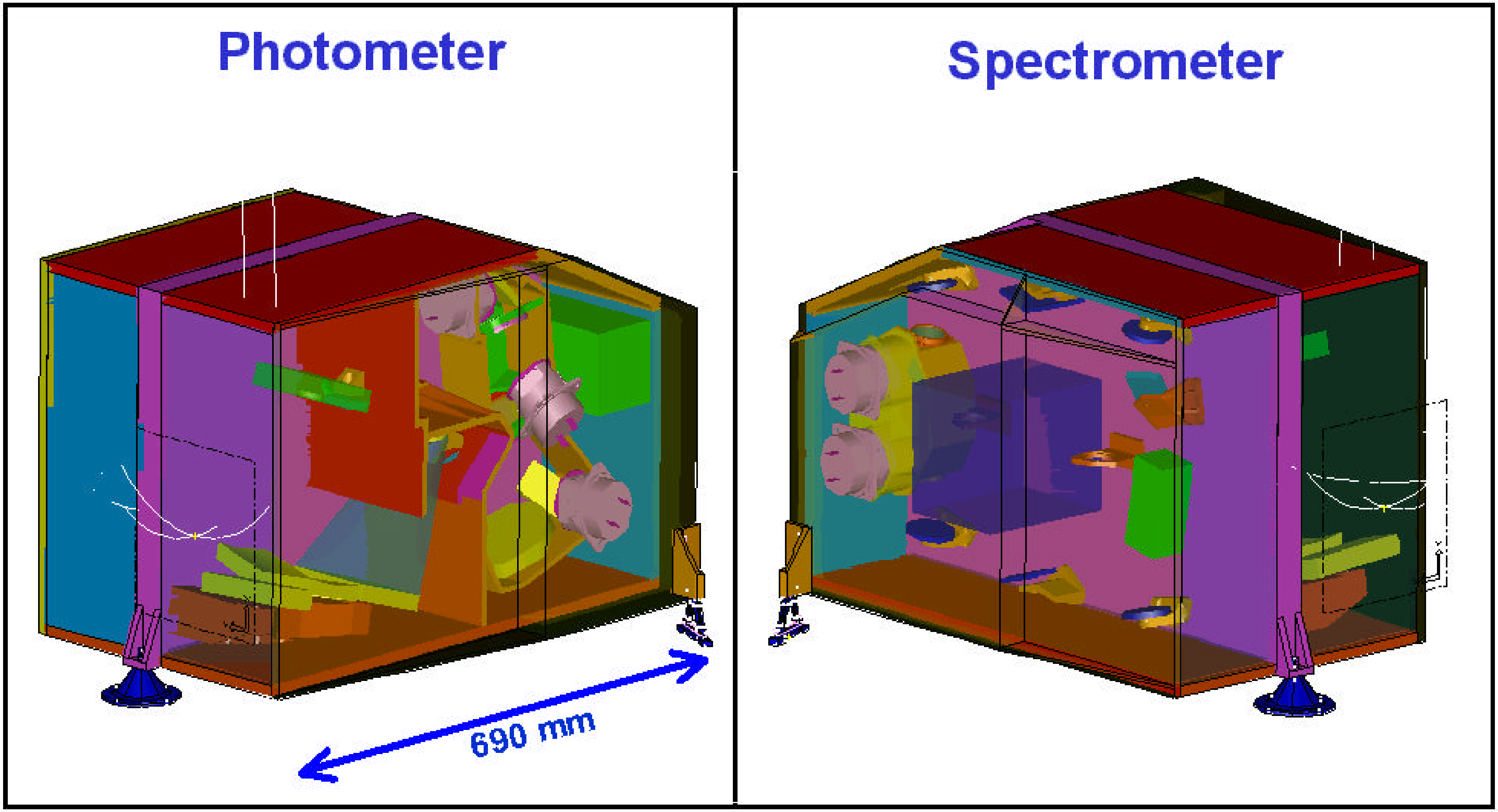
Chas Beichman	Stellar Disks	JPL
Andrew Blain	FIR Galaxy Surveys	Caltech
Sarah Church	Cluster Surveys	Stanford
Ken Ganga	Data Processing	IPAC
Phil Maloney	Interstellar Medium	U. Colorado

SPIRE Instrument Summary

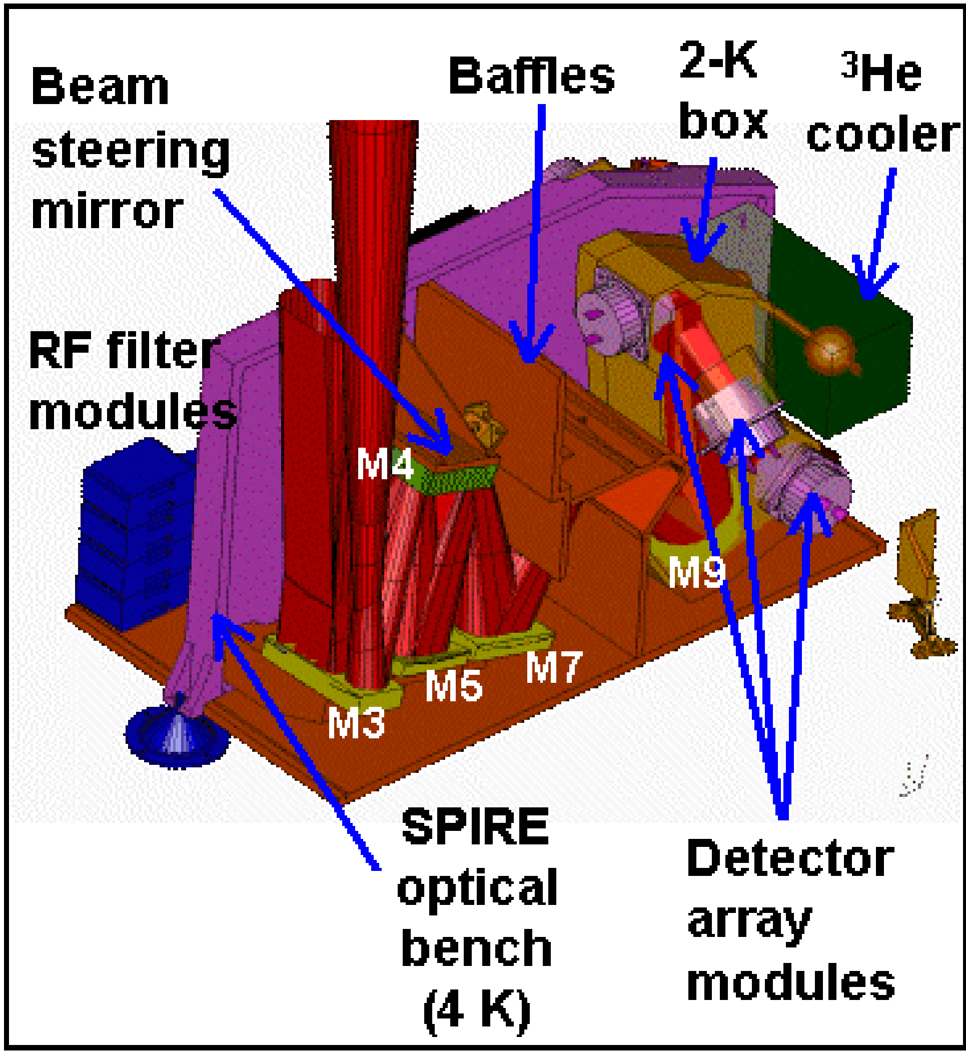
- **3-band imaging photometer**
  - **250, 350, 500 μm (simultaneous)**
  - **λ/Δλ ~ 3**
  - **4 x 8 arcminute field of view**
  - **Diffraction limited beams (17, 24, 35”)**
- **Imaging FTS**
  - **200 - 400 μm (goal 200 - 670 μm)**
  - **> 2 arcminute field of view**
  - **$\Delta\sigma$ = 0.4 cm^{-1} (goal 0.04 cm^{-1}) (λ/Δλ ~ 20 - 100 (1000) at 250 μm)**
- **Design features**
  - **Sensitivity limited by thermal emission from the telescope (80 K; ε = 4%)**
  - **Feedhorn-coupled ‘spider web’ bolometers at 0.3 K**
  - **Minimal use of mechanisms**
  - **Simple observing modes**

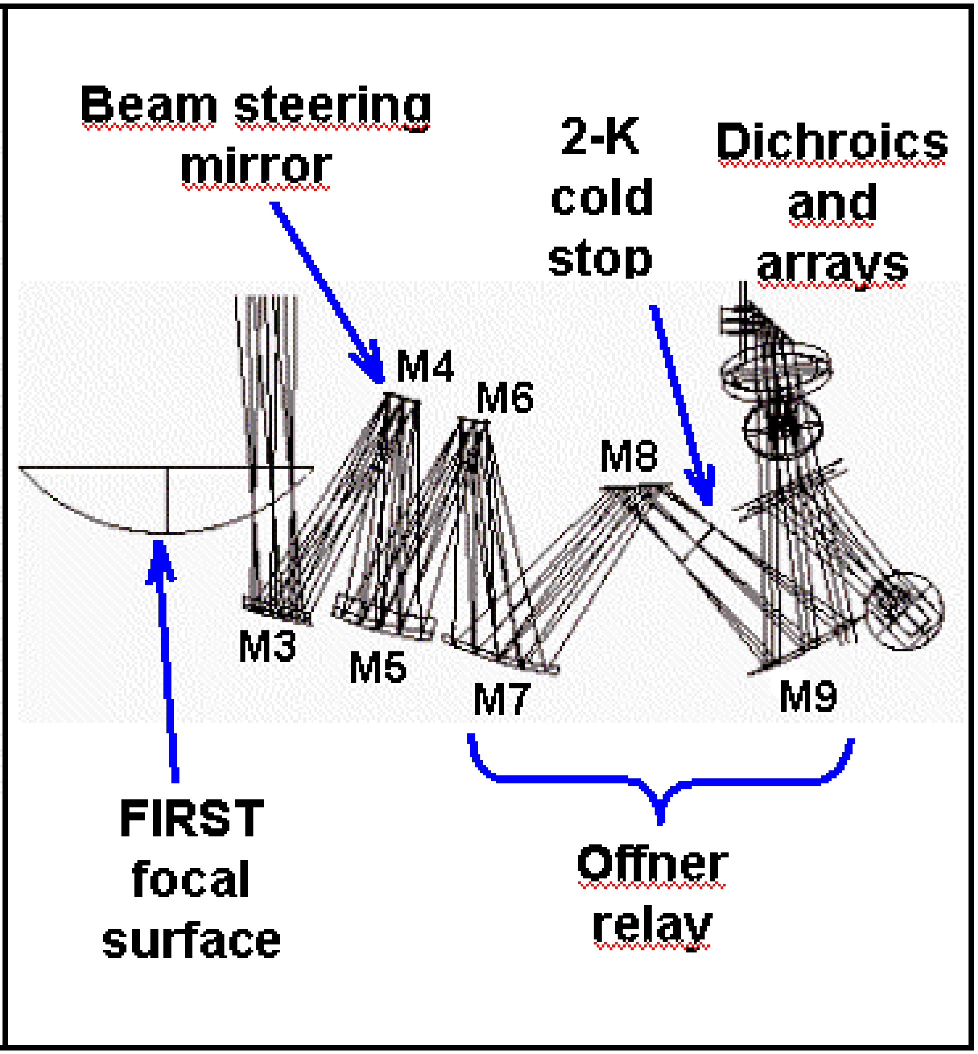


SPIRE FPU

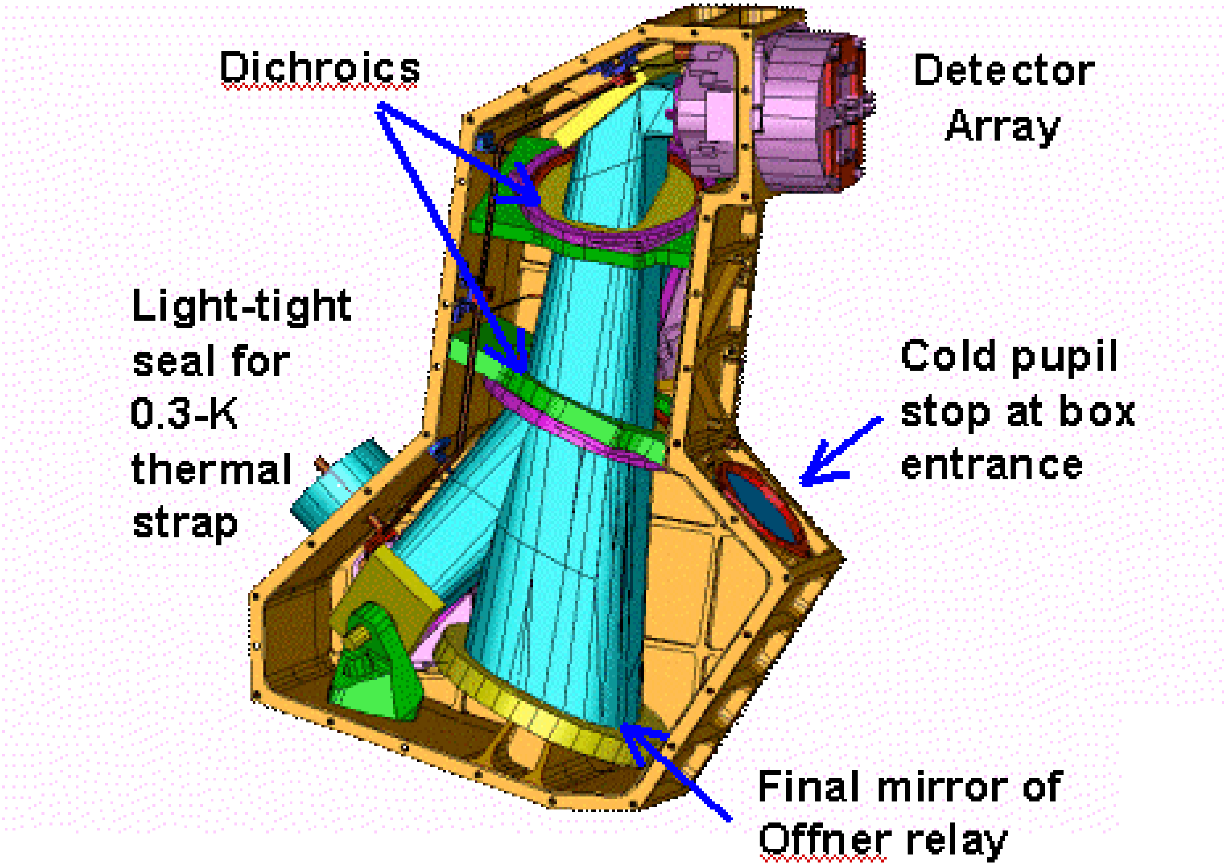


Photometer Layout and Optics

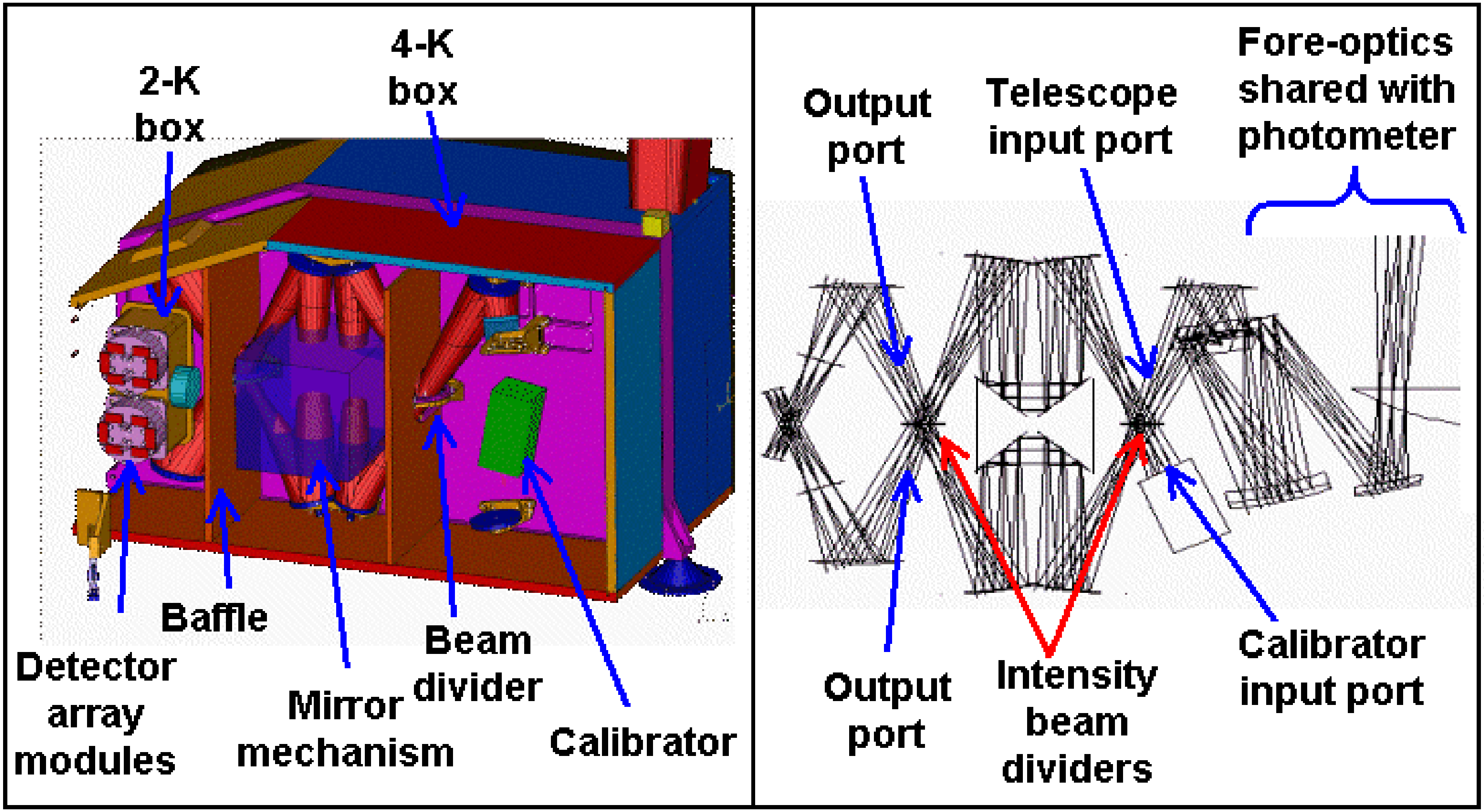




Photometer 2-K Box and 300-mK Straps

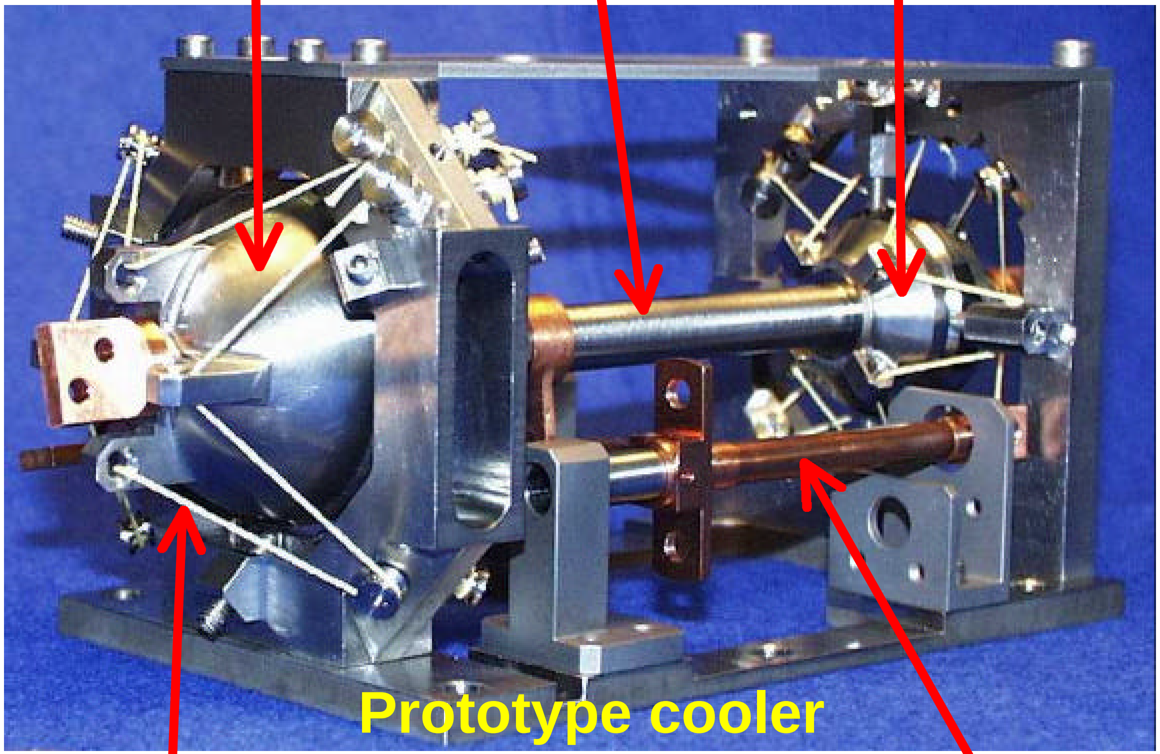


FTS Layout and Optics

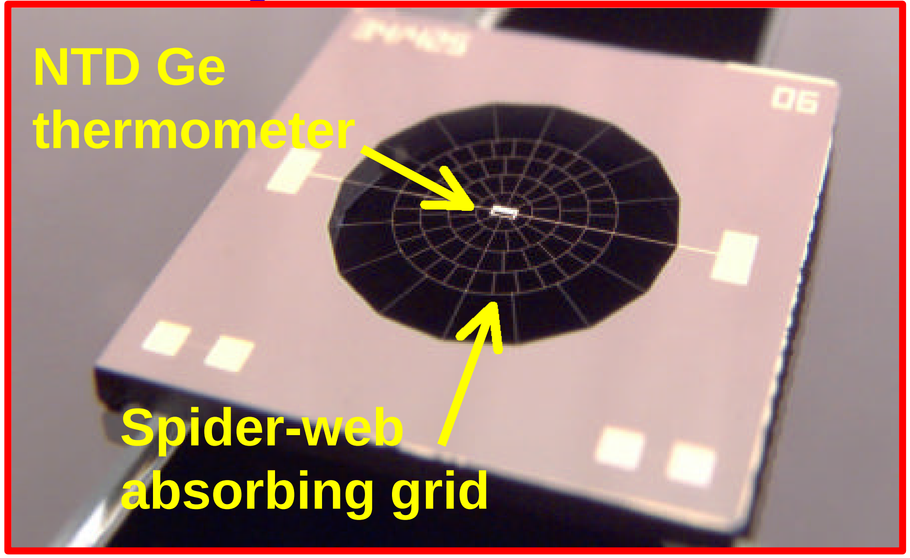


^{3}He Cooler

- **Cold stage temp. < 280 mK**
- **Hold time > 46 hrs**
- **Cycle time < 2 hrs**
- **Average load on ^{4}He tank < 3 mW**
- **Heat lift > 10 μW**
- **Gas-gap heat switches (no moving parts)**

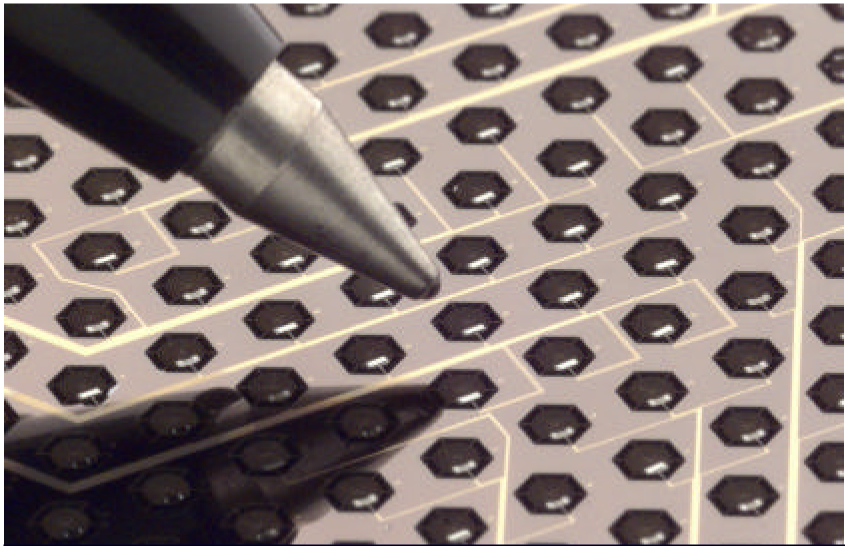


NTD Ge Bolometer Arrays



Spider-web architecture provides
- **low absorber heat capacity**
- **minimal suspended mass**
- **low-cosmic ray cross-section**
- **low thermal conductivity**

  = high sensitivity



Bolometer array wafer

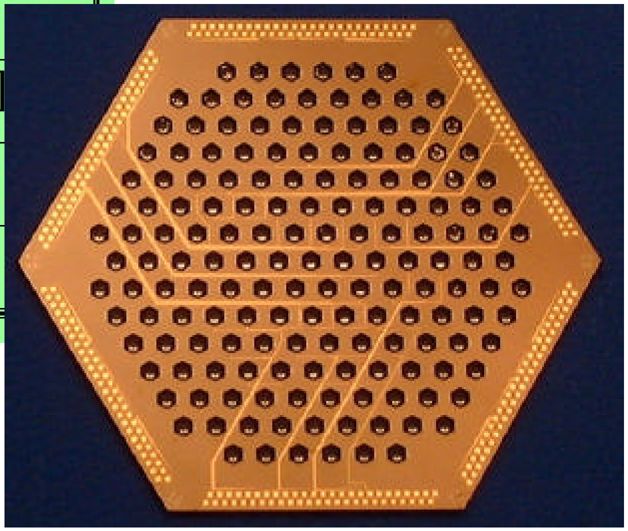
Sensitivities and heat capacities achieved:

NEP = 1.5 x 10^{-17} W/√Hz
C = 1 pJ/K at 300 mK

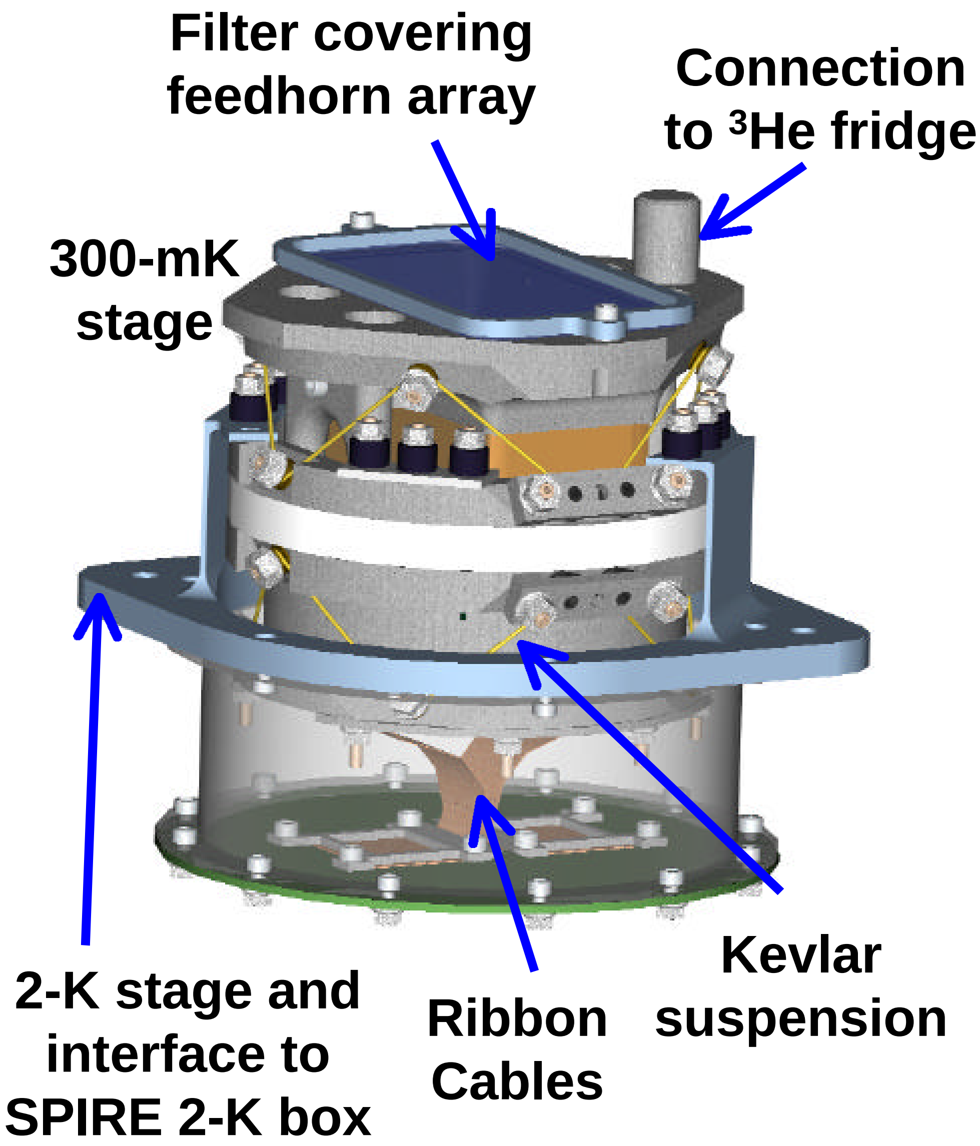
NEP = 1.5 x 10^{-18} W/ √ Hz
C = 0.2 pJ/K at 100mK

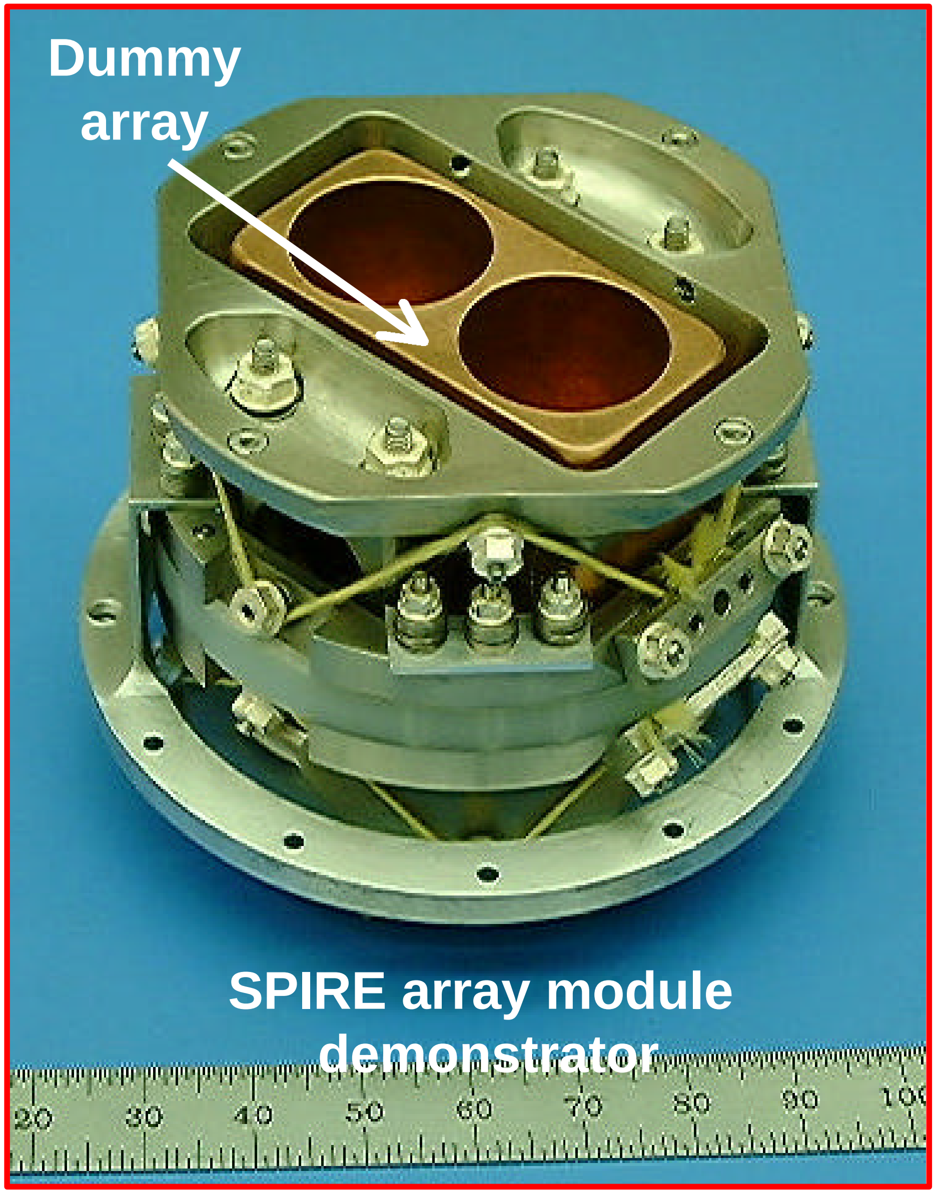
NTD Ge Bolometer Array Development

Quantity	Measured Value	Target	Units
Dark <NEP_{bol}>	2.7×10^{-17}	2.5×10^{-17}	[W/√Hz]
Dark <S_e>	5.88×10^{8} (± 6 %)		[V/W]
Yield	0.9	0.9	
<G_0>	54.8 ± 7.6	60	[pW/K]
<C_0>	0.96 ± 0.24	1.0	[pJ/K]
τ	11.7 ± 0.8	8 / 30	[ms]
η_{bol}	0.46 – 0.64	0.8	
1/f knee	~30	100	[mHz]
NEP_{bol}/NEP_{blip}	1.10 (+0.05, –0.15)	1.15	
DQE	0.38 - 0.53	0.60	



Bolometer Array Module

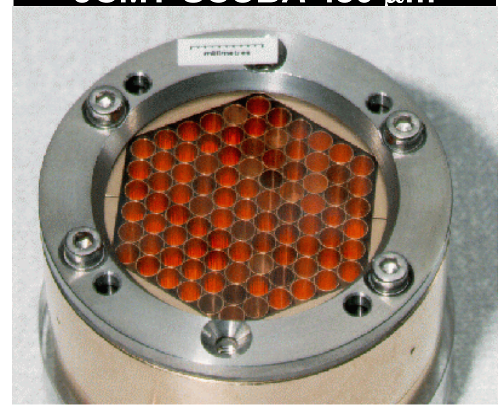




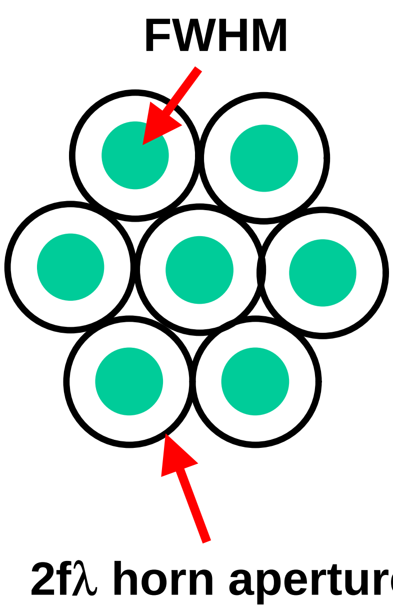
Sky Sampling with Feedhorn Arrays

Full sampling of the image requires scanning or "jiggling" of the telescope pointing

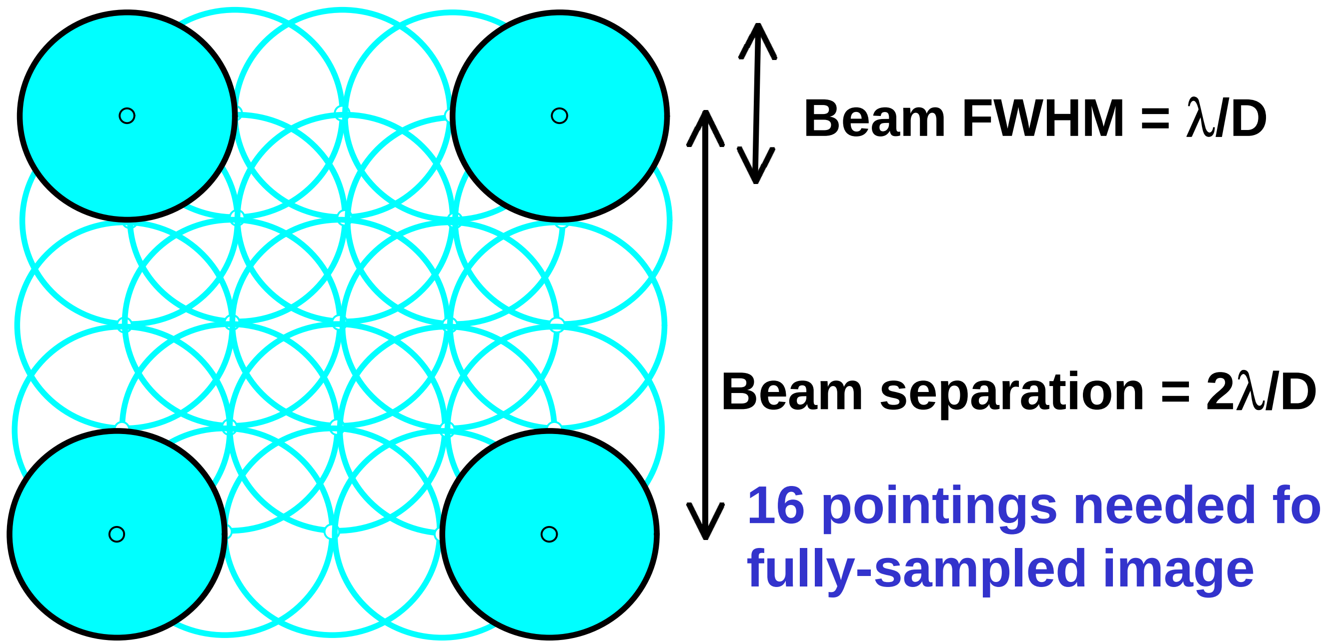
JCMT-SCUBA 450 μm



Feedhorns adjacent in the focal plane



FWHM beams on the sky don't overlap



16 pointings needed for fully-sampled image

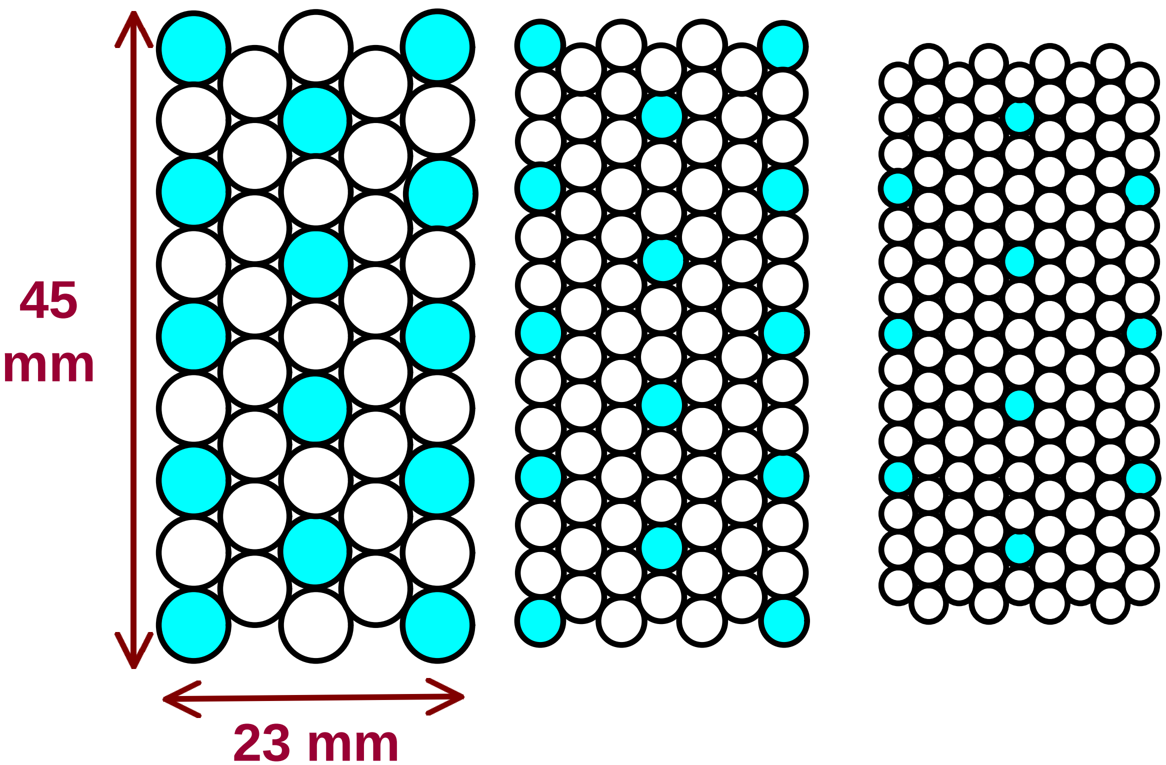
Detector Arrays (2Fλ Feedhorns)

Photometer	Spectrometer

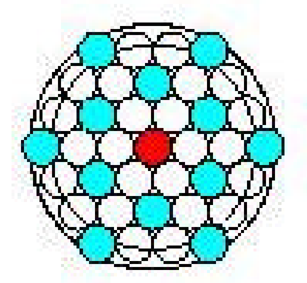
500 μm
43 detectors

350 μm
88 detectors

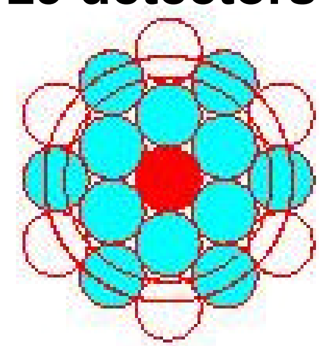
250 μm
139 detectors



200-300 μm
37 detectors



300-670 μm
19 detectors



⇒ **Overlapping beams**

Photometer Observing Modes

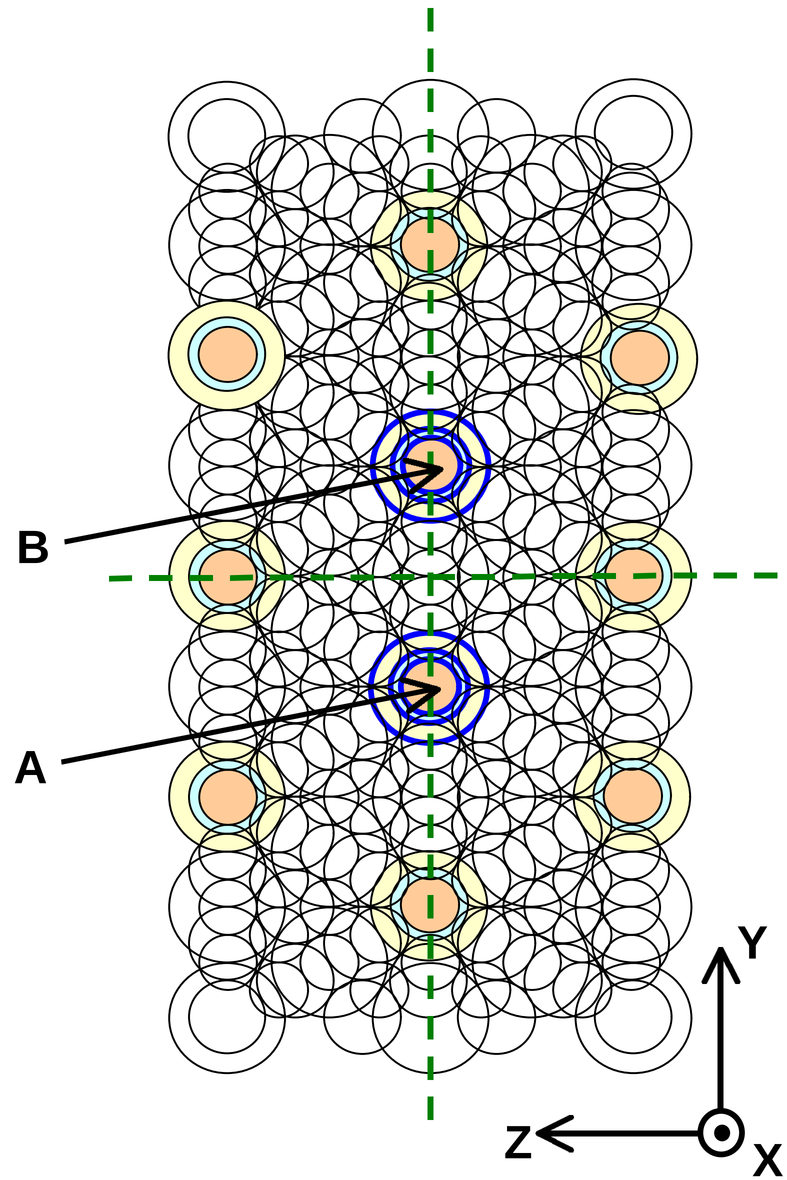
- **Point source photometry:**
  - **Beam steering mirror chops 125" between overlapping sets of detectors**
  - **Seven-point jiggle can be done if desired**

- **Field mapping:**
  - **Beam steering mirror chops up to 4' and performs 64-point "jiggle"**
  - **Available fov = 4' x 4'**

- **Scan mapping:**
  - **Beam steering mirror not operated**
  - **Telescope drift scanning at up to 60"/second**
  - **Scan angle wrt array axis set to give full spatial sampling**

Point Source Photometry

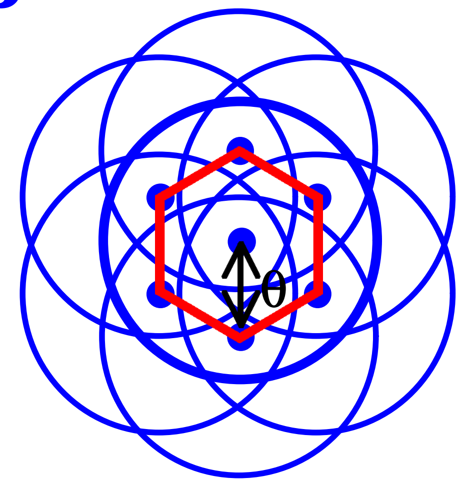
- **Telescope pointing fixed**
- **Chopping in Y-direction between A and B (126”)**
- **Simultaneous observation in the three bands with two sets of co-aligned detectors**
- **Chop without jiggling is OK if the pointing is accurate enough (~ 1.5”)**

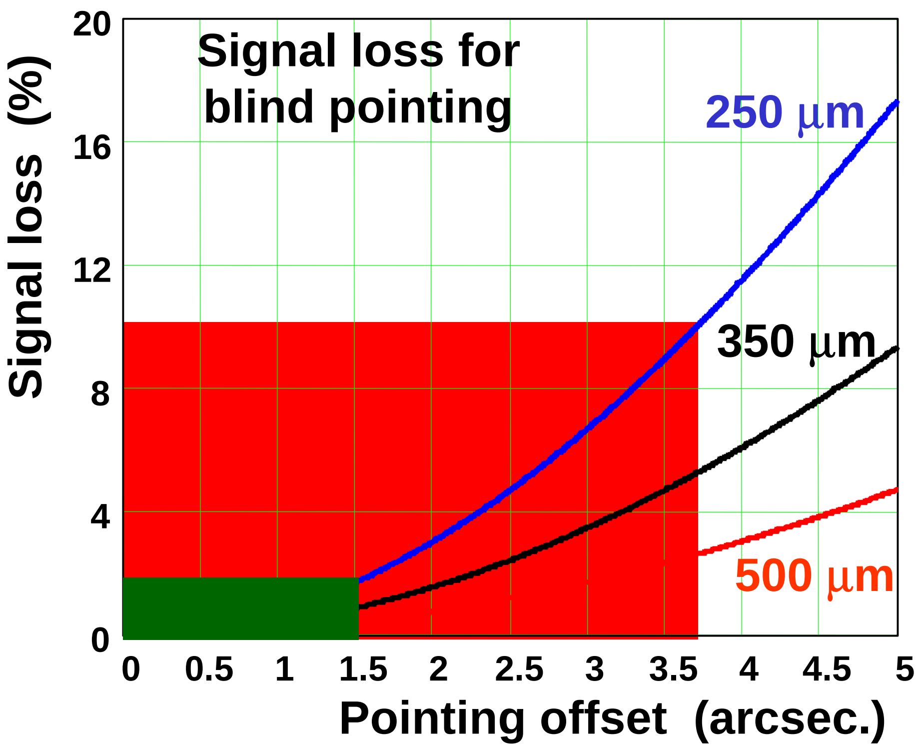


7-point Jiggle Map

- Chopping 126”
- 7-point jiggle pattern
- Angular step θ ~ 4 - 6 arcseconds (> pointing or positional error)
- Total flux and position can be fitted
- Compared to single accurately pointed observation, S/N for same total integration time is only degraded by

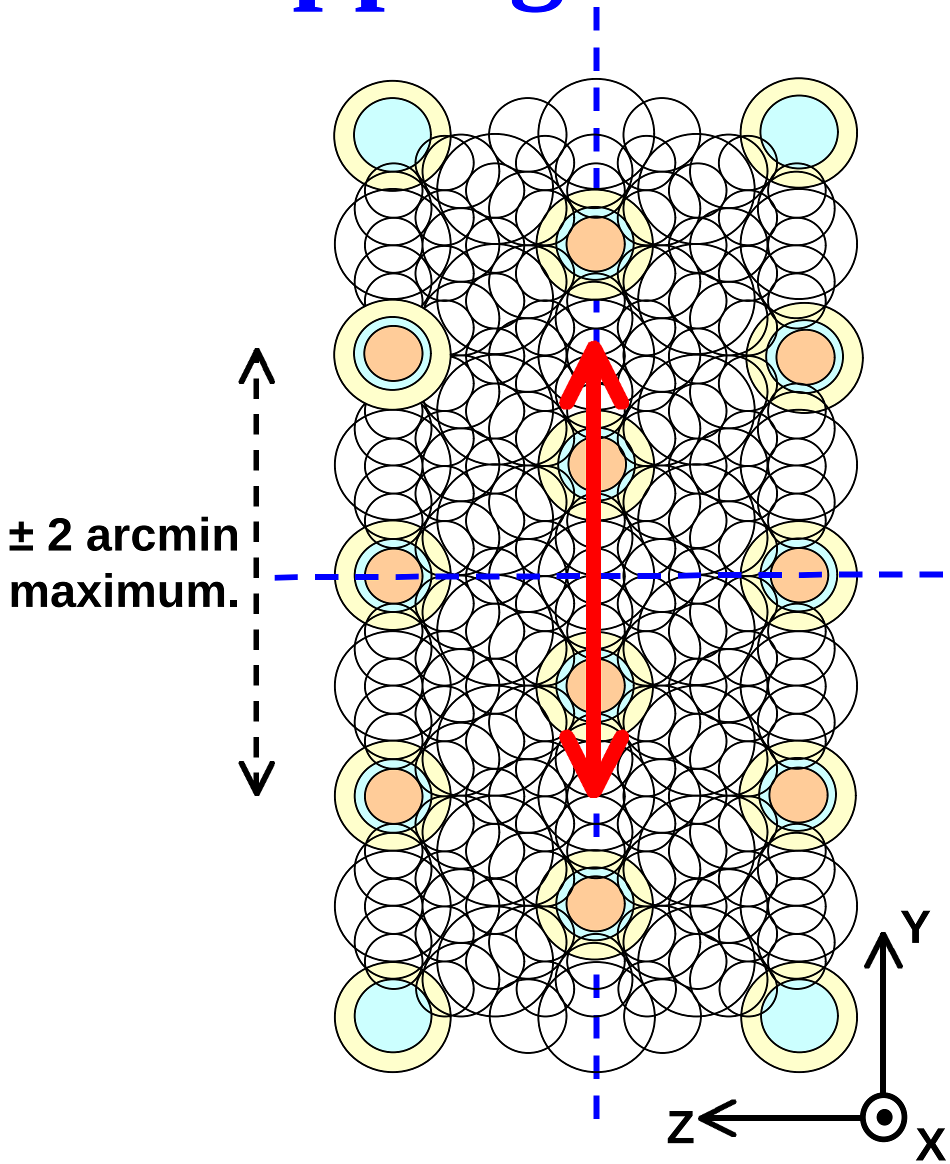
~ 20%	at	250 μm
~ 13%	at	350 μm
~ 6%	at	500 μm





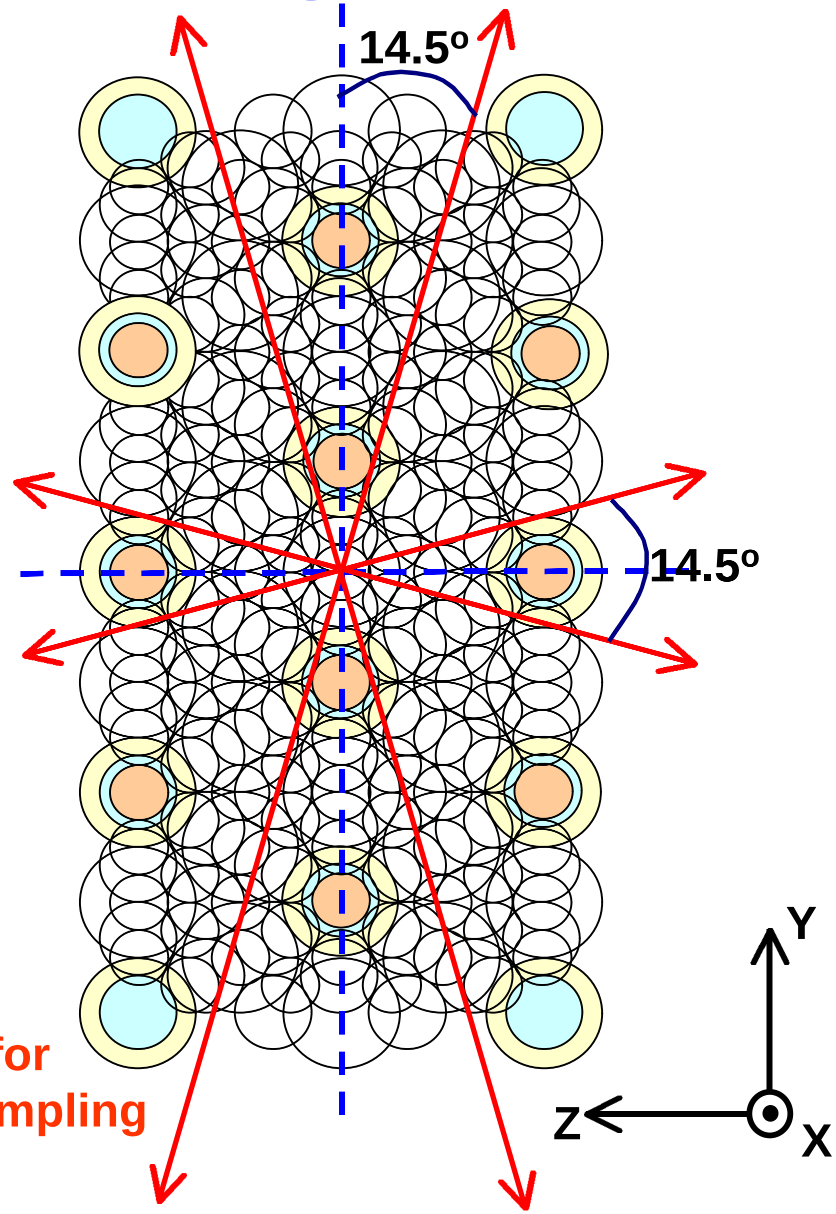
Field Mapping

- **Telescope pointing fixed or in raster mode**
- **Chopping up to 4 arcmin amplitude in Y direction**
- **64-point “jiggle” pattern for full spatial sampling**



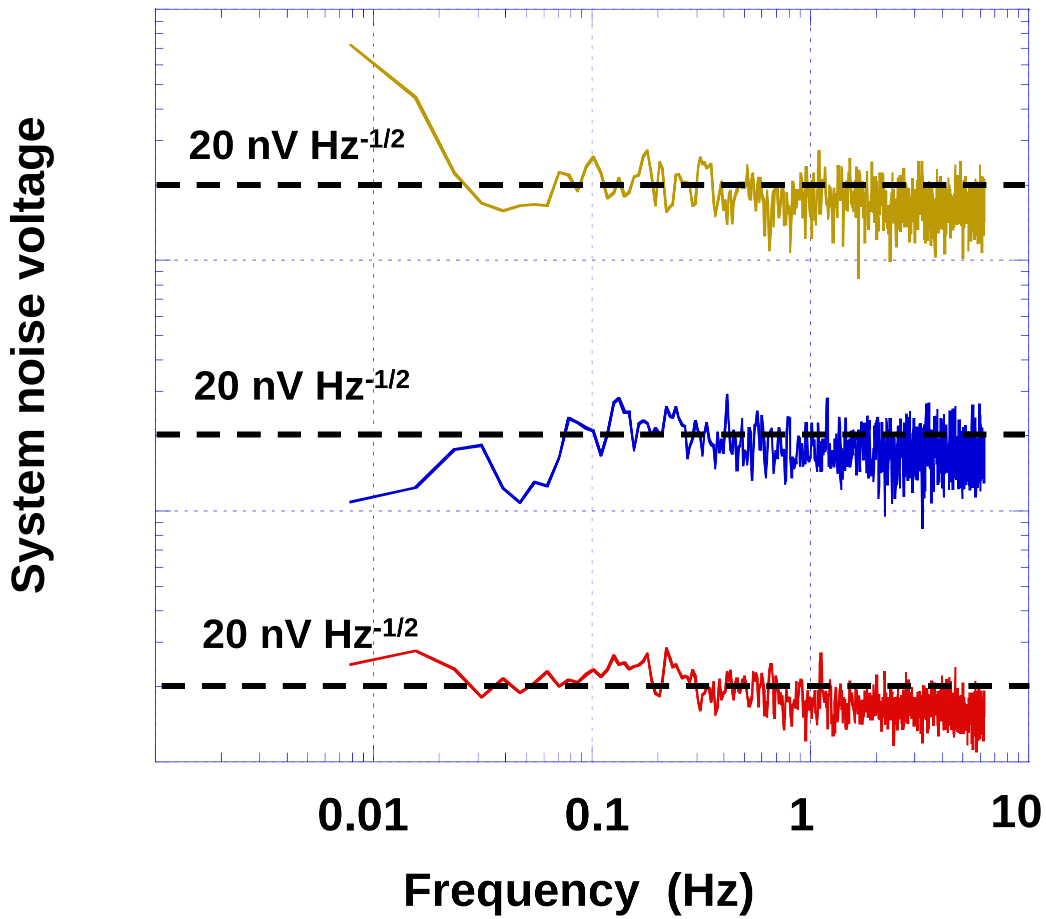
Scan Mapping

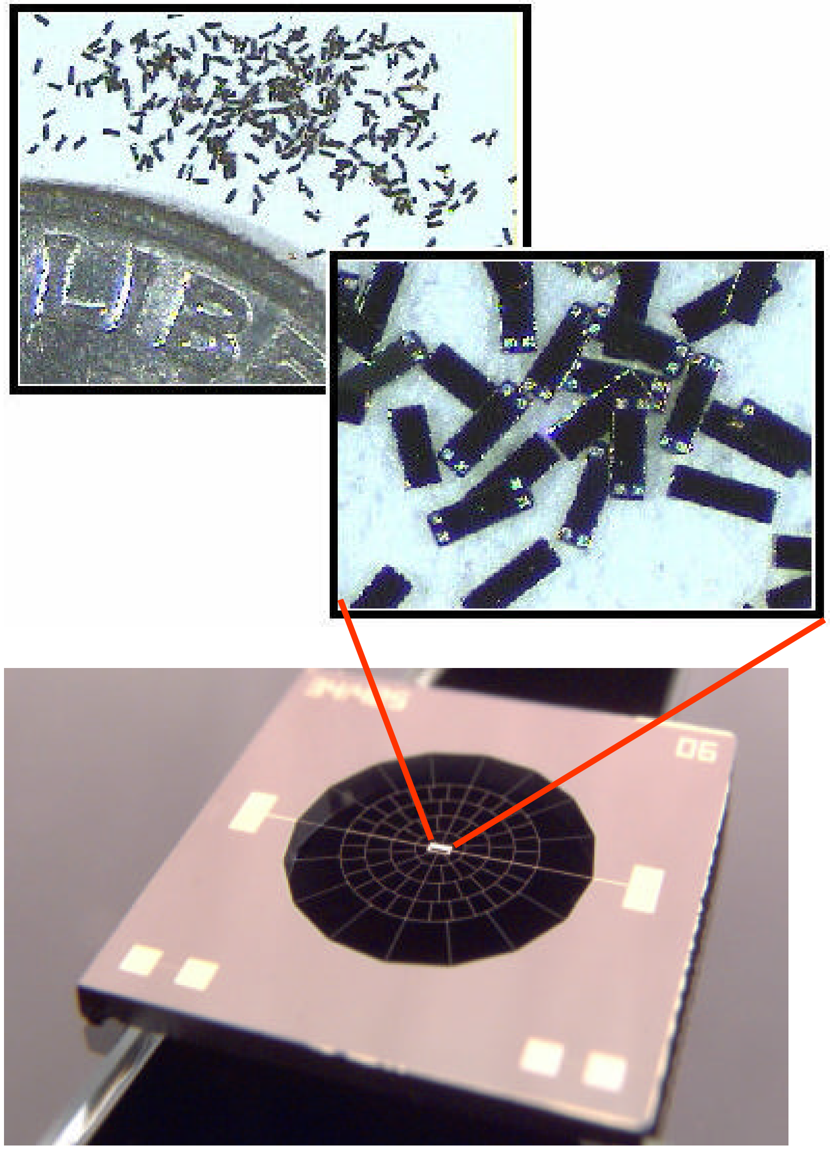
- **Telescope in line scanning mode**
- **Scan rate < 60”/sec.**
- **Map of large area is built up from overlapping parallel scans**
- **Most efficient mode for large-area surveys**



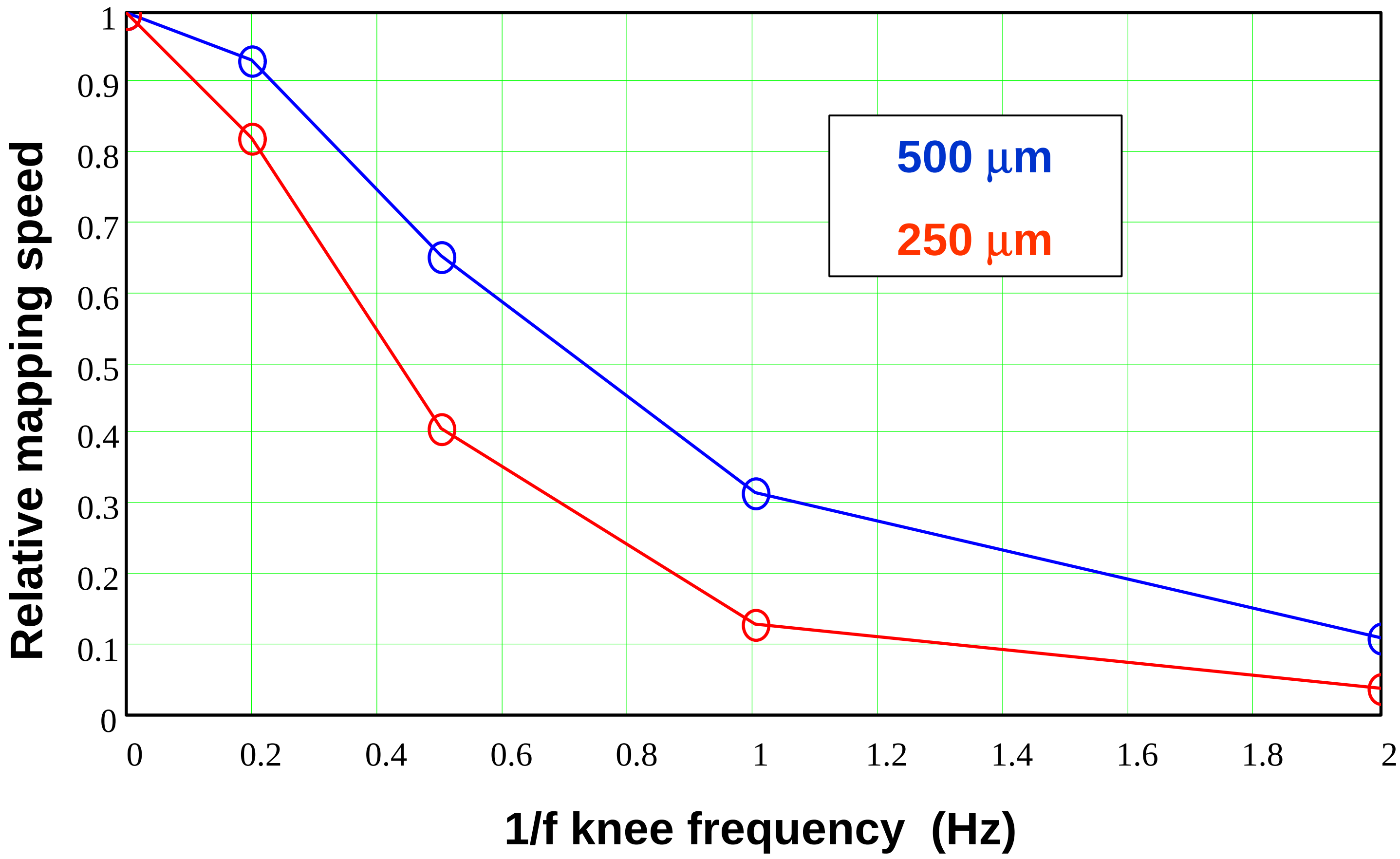
Scan directions for instantaneous full sampling

High 1/f stability with NTD Germanium





Simulations of Scan Mapping



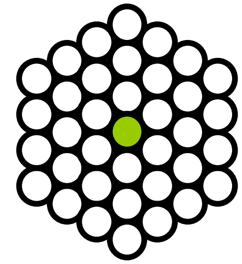
FTS Observing Modes

- Mirror scan rate = 1 mm s^{-1}
- Signal frequency range 6 - 20 Hz
- Maximum scan length = 3.5 cm (14 cm OPD)
- $\Delta\sigma$ = 0.04 - 2 cm^{-1} by adjusting scan length
- Calibrator in second port nulls telescope background

- Point source spectroscopy/spectrophotometry
  - Telescope pointing fixed
  - Background characterized by adjacent pixels

- Imaging spectroscopy
  - Beam steering mirror adjusts pointing between scans to acquire fully-sampled spectral image

200-300 μm
37 detectors



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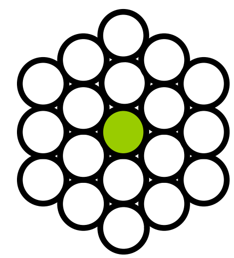


Estimated Instrument Sensitivity

Photometry (all bands)

Flux density (mJy, 5-σ; 1 hr)

Point source	4.0 (req.)	2.0 (goal)
Map (4'x 4')	16 (req.)	8.0 (goal)

FTS: Spectroscopy 200 - 400 μm $\Delta\sigma = 0.04\ cm^{-1}$

Line flux ($W\ m^{-2} \times 10^{-17}$, 5-$\sigma$; 1 hr)

Point source	6.0 (req.)	3.0 (goal)
Map	18 (req.)	9.0 (goal)

FTS: Spectrophotometry 200 - 400 μm $\Delta\sigma = 1\ cm^{-1}$

Flux density (mJy, 5-σ; 1 hr)

Point source	200 (req.)	100 (goal)
Map	600 (req.)	300 (goal)

FTS sensitivity declines by factor of ~ 2 between 400 and 670 μm

SPIRE Large-Area Survey Sensitivity

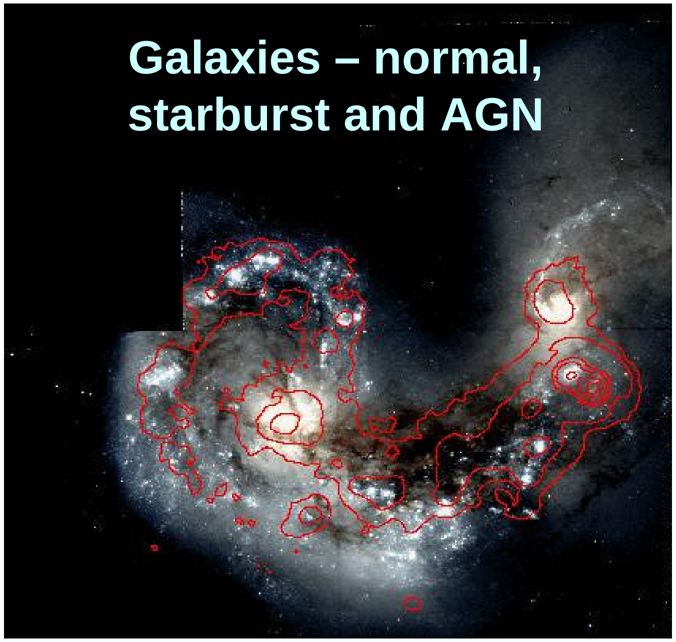
λ (μm)	FWHM (arcsec.)	5σ; 1hr limit (scan-map mode) (mJy)	Confusion limit (1 source per 40 beams) (mJy)	Time to reach confusion limit for one field at 5-σ (min.)	Time to map 1 sq. deg. to confusion limit (days)
250	18	7.3	19	9	1.3
350	25	7.4	20	8	1.2
500	36	7.4	15	14	2.1

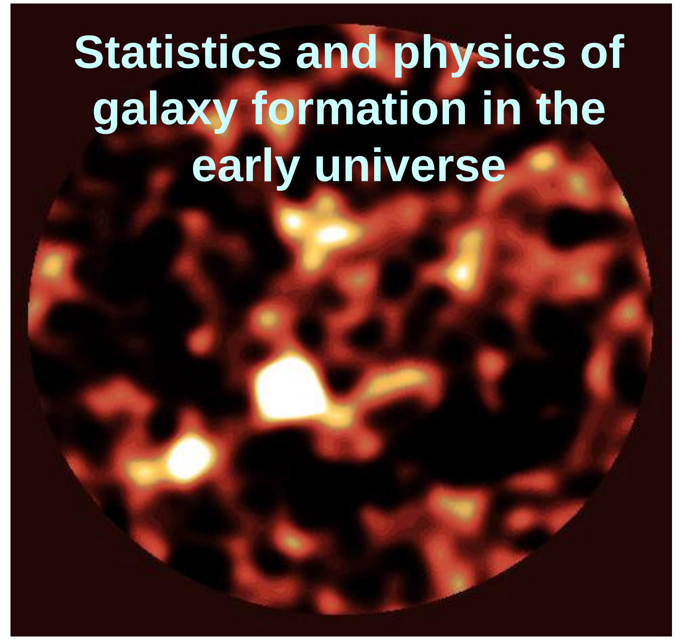
Confusion limits are from the models of M. Rowan-Robinson (*Ap. J., in press*)

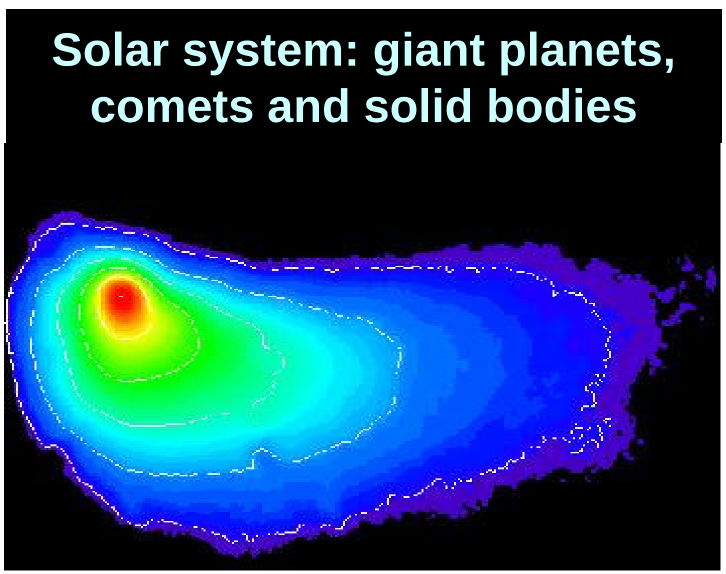
Assumptions

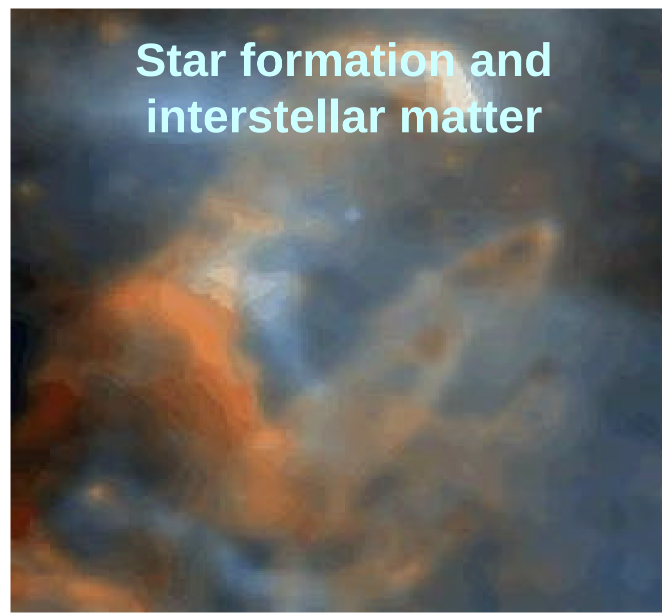
- Scan-map mode
- 90% observing efficiency
- 21 hrs observing/day
- 25% field overlap
- 75% detector yield

SPIRE Scientific Goals









Protostars and YSOs:
Spectral Coverage and Capabilities

- **Unbiased surveys of nearby molecular clouds**
- **Complete census of protostellar condensations within ~ 1 kpc**
- **Temperature and density distributions**
- **Total luminosities**
- **Dust properties**
- **Star formation rate and efficiency**
- **Initial mass function**

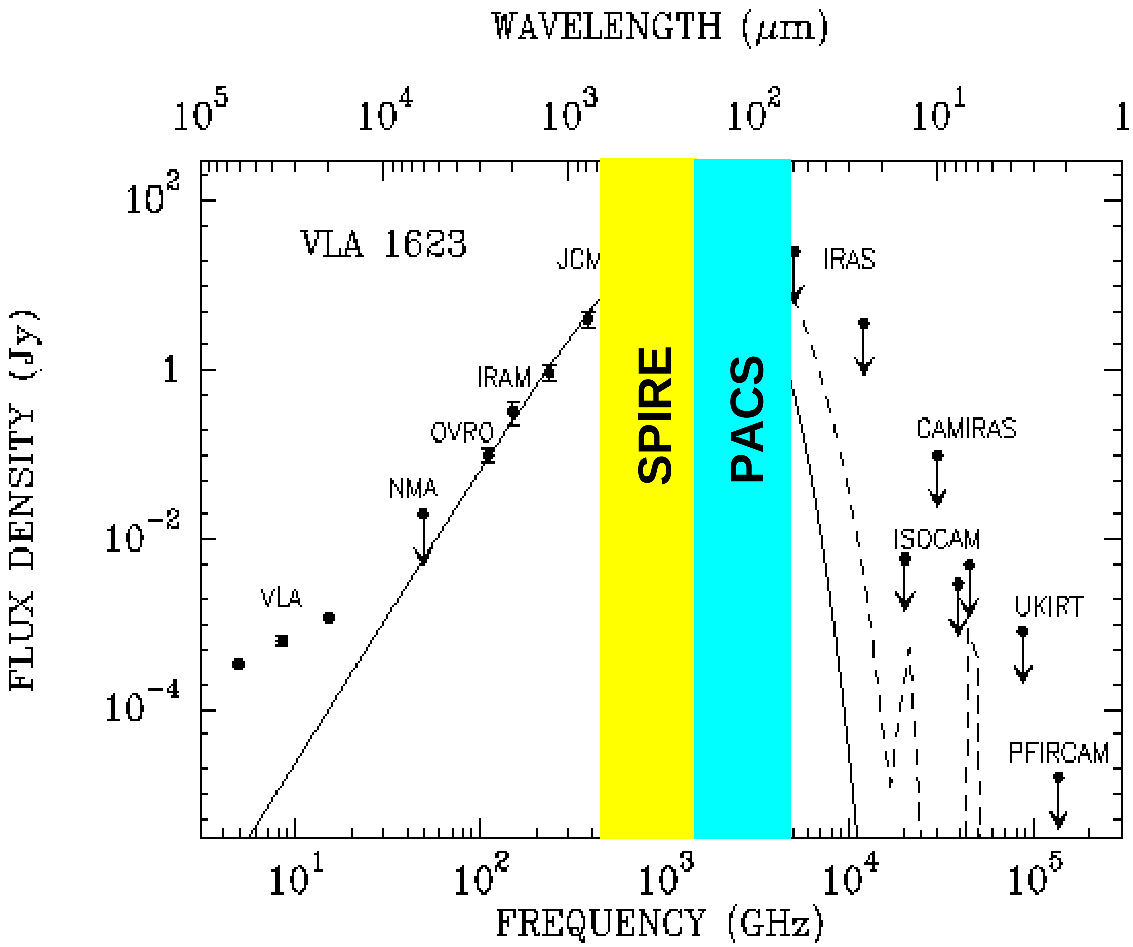
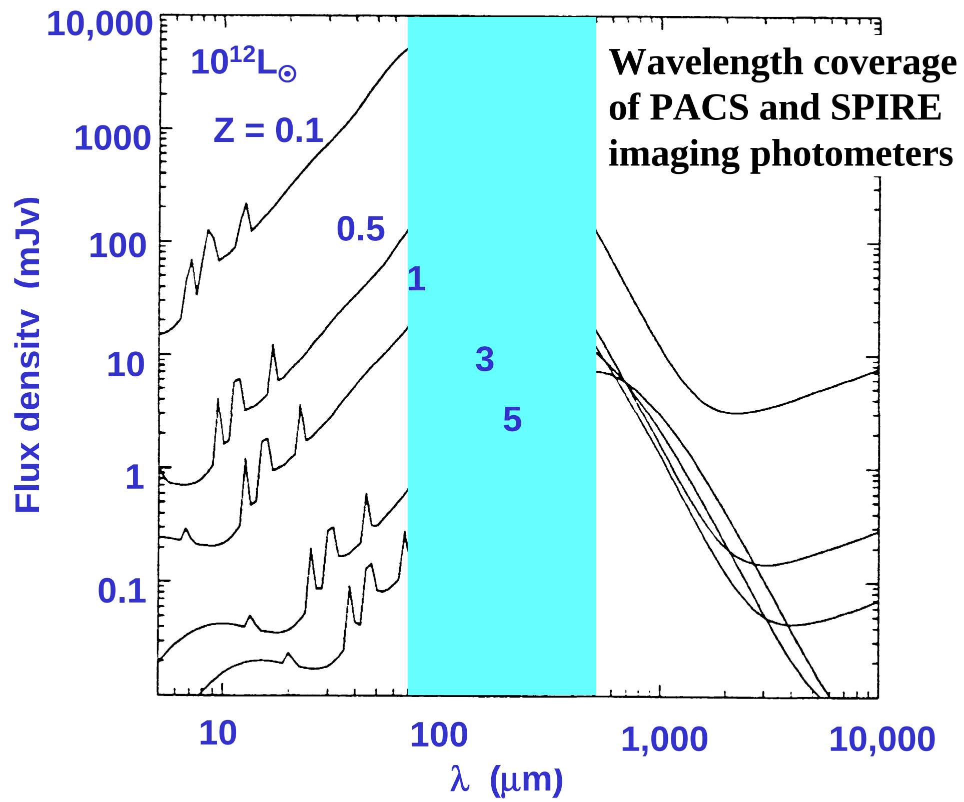


Figure by Philippe André

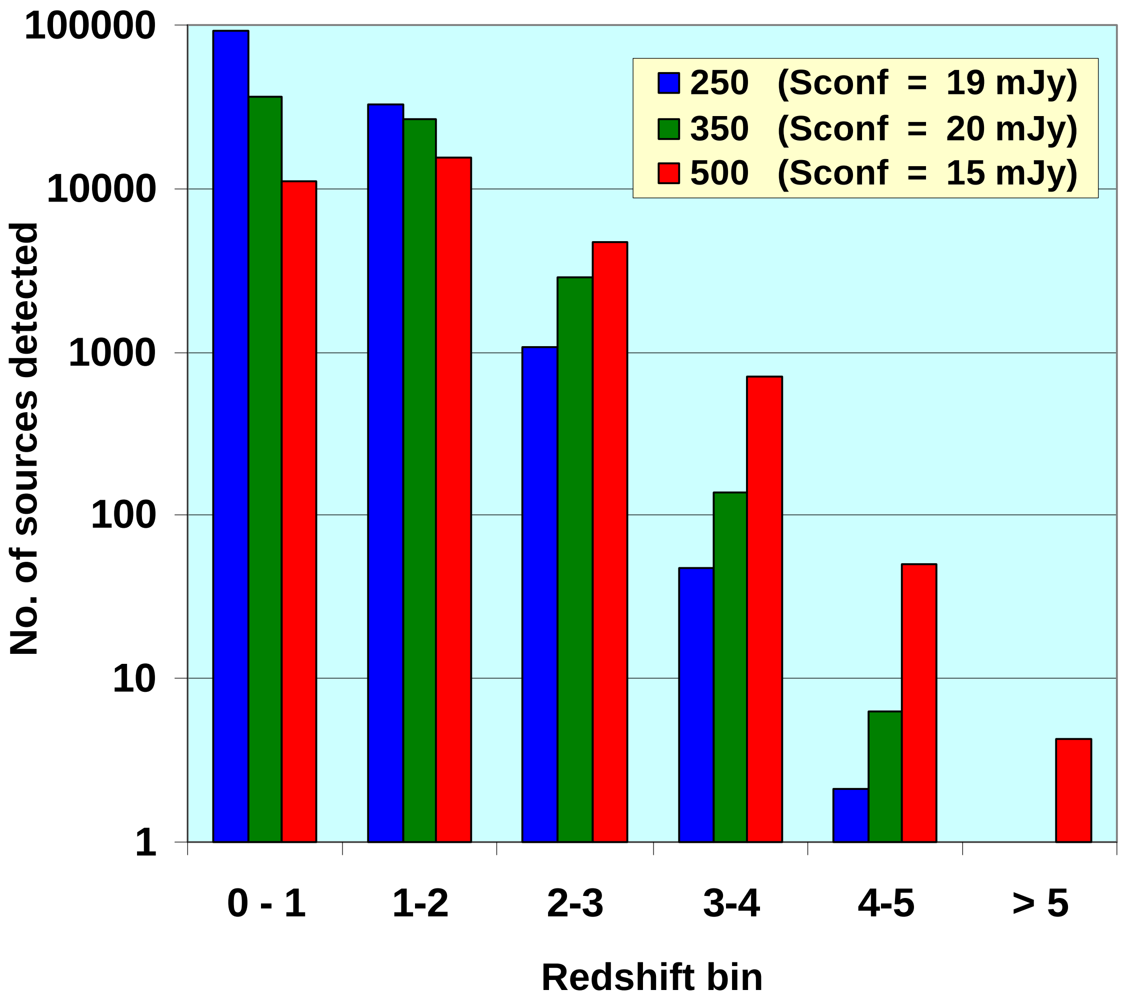
FIR Galaxy Surveys with SPIRE

- Unbiased survey of population of high-z dusty star-forming galaxies missed by current (and future) optical and near-IR surveys
- Large-scale structure in the high-redshift universe
- Star-formation history in galaxies at z out to 5



After Guiderdoni *et al*. MNRAS 295, 877, 1998

Possible SPIRE Survey and Outcome



Source count models of M. Rowan-Robinson

- 100 sq. deg.
- Confusion-limited
- 100 - 200 days
- $\Delta S_{5\sigma} < 15$ mJy

1,300 sources/sq. deg.
660 sources/sq. deg.
320 sources/sq. deg.

Assumptions

- Scan-map mode
- 90% observing efficiency
- 21 hrs observing/day
- 25% field overlap
- 75% detector yield

STM Receivables and Deliverables

Structural Thermal Model:

verify the temperature distribution and instrument structure

Item	Del. By	Rec. By
P/LW EM BDA[1]	JPL	RAL
P/MW STM BDA[2]	JPL	RAL
P/SW STM BDA[2]	JPL	RAL
S/LW STM BDA[2]	JPL	RAL
S/SW STM BDA[2]	JPL	RAL
15 JFET STM modules	JPL	RAL
5 (TBC) RF modules for FPU	JPL	RAL
3 (TBC) RF modules for JFETs	JPL	RAL
15 BDA-JFET Harnesses	JPL	RAL
Back Harnesses for JFET rack	JPL	RAL

[1]Kevlar suspended
[2]Structural, thermal, & electrical equivalents

CQM Instrument Philosophy

Cryogenic Qualification Model:

Integration:	Optical Alignment Mechanical & Electrical I/F Commanding and data transfer FPU and JFET bake out
Functional:	Thermal characterization and dissipation
Performance:	***Interaction of subsystems*** Electronics, cabling, 3He cooler, FTS, BSM Optical focus & straylight Microphonics Scientific Performance (sensitivity, spectral response etc.)
Environmental:	Operation of FPU over thermal range EMC susceptibility
Operational:	Observing modes Operational modes

CQM Receivables and Deliverables

Cryogenic Qualification Model:

model of the instrument intended for qualification of cryogenic performance

Item	Del. By	Rec. By
P/LW CQM BDA[6]	JPL	RAL
P/MW CQM BDA[7]	JPL	RAL
P/SW CQM BDA[7]	JPL	RAL
S/LW CQM BDA[6]	JPL	RAL
S/SW CQM BDA[7]	JPL	RAL
S/SW CQM BDA[8]	JPL	RAL
3 JFET CQM modules[9]	JPL	RAL
P/LW far-infrared filter	CARDIFF	JPL
S/LW far-infrared filter	CARDIFF	JPL
S/SW far-infrared filter	CARDIFF	JPL

[6]Fully functional, re-used for FS. Reduced performance acceptable for CQM, not FS.
[7]Kevlar suspended unit without detectors. Returned to JPL for FS delivery.
[8]Fully functional but delivered without testing. Returned to JPL for PFM delivery.
[9]Fully functional, re-used for FS. Reduced performance acceptable for CQM, not FS.

PFM Receivables and Deliverables

Proto Flight Model:

model of the instrument intended for launch and astronomical observations at L2

Item	Del. By	Rec. By
P/LW PFM BDA	JPL	RAL
P/MW PFM BDA	JPL	RAL
P/SW PFM BDA	JPL	RAL
S/LW PFM BDA	JPL	RAL
S/SW PFM BDA	JPL	RAL
8 JFET PFM modules	JPL	RAL
5 (TBC) RF modules for FPU	JPL	RAL
3 (TBC) RF modules for JFETs	JPL	RAL
15 BDA-JFET Harnesses	JPL	RAL
Back Harnesses for JFET rack	JPL	RAL
Temperature Control[11]	JPL	RAL
P/LW BDA far-infrared filter	CARDIFF	JPL
P/MW BDA far-infrared filter	CARDIFF	JPL
P/SW BDA far-infrared filter	CARDIFF	JPL
S/LW BDA far-infrared filter	CARDIFF	JPL
S/SW BDA far-infrared filter	CARDIFF	JPL

[11]Control and monitor thermometers, heaters, fixtures, cable provided pending evaluation of CQM performance

FSM Receivables and Deliverables

Flight Spare Model:
duplicate model of the instrument in event of major failure of PFM instrument

Item	Del. By	Rec. By
P/MW FSM BDA	JPL	RAL
P/SW FSM BDA	JPL	RAL
S/SW FSM BDA	JPL	RAL
Temperature Control[11]	JPL	RAL
P/MW BDA far-infrared filter	CARDIFF	JPL
P/SW BDA far-infrared filter	CARDIFF	JPL
S/SW BDA far-infrared filter	CARDIFF	JPL

[11]Control and monitor thermometers, heaters, fixtures, cable provided pending evaluation of CQM performance

Performance Requirements

The BDA-Sub-System Specification Document (BDA-SSSD) defines:

- Performance criteria are designed to maximize mapping speed
  - "Design values" based on ideal operation
  - "Minimum performance" based on the best current data with margin
  - *No* requirements on performance levels
- The instrument maintains a margin on resource design values. Resource discrepancies are to be resolved at instrument level
- Requirements on other subsystems to meet performance levels
  - operating temperature and stability
  - warm electronics performance
  - mechanical interface requirements
  - RF environment
  - EMI/EMC
- Environmental verification matrix

Detector Performance Criteria

	P/LW		P/MW		P/SW		S/LW		S/SW		
$(NEP_{blip}/NEP_{total})^2$	0.66	0.55	0.73	0.61	0.79	0.66	0.73	0.61	0.79	0.66	
τ	14	32	11	32	9	32	3.4	14	4.9	8	[ms]
η_{opt}	0.85	0.45	0.85	0.45	0.85	0.45	0.85	-	0.85	-	
Yield	0.9	0.75	0.9	0.75	0.9	0.75	0.9	0.75	0.9	0.75	
1/f knee	30	100	30	100	30	100	30	100	30	100	[mHz]
n-n cross-talk	1	5	1	5	1	5	1	5	1	5	[%]
Q	3.0		4.0		5.0		12.5		9.0		[pW]
JFET noise	7	8.5	7	8.5	7	8.5	7	8.5	7	8.5	[nV/√Hz]

Design value

Minimum performance

Subsystem Performance Requirements

Specific requirements are placed on subsystems impacting detector performance

3He fridge	290 mK delivered to BDA interface 10 μK/√Hz temperature stability < 0.1 mK/hr temperature drift
Optics	Performance defined under specified loading
DRCU	7 nV/√Hz total readout noise EMC requirement TBD
Structure	1.7 K delivered at BDA interface Interface plate provides ± 1 mm compensation > 1 kHz resonant frequency for cables Electrically isolated 4 K RF enclosure, 40 dB attenuation EMI requirement TBD

Detailed DRCU Requirements (1)

Requirement ID	Description	Reference	Subsystem Compliance
BDA-DRCU-01	The DRCU signal processing electronics shall have less than 7 nV/rtHz as seen post demodulation, after digitzation. Noise is referred to the input over the frequency range 0.05 to 25 Hz. This performance must be accomplished with a bias input signal to the DRCU of 10 mVrms AC, 5 mV DC, 1 V DC common-mode offset, with an input load of 7 kOhms.	JPL	TBD
BDA-DRCU-02	The input noise impedance shall be greater than 7 kΩ, post-demodulation, referred to the input over the frequency range of 0.1 to 10 Hz.	JPL	Requirement deleted
BDA-DRCU-03	Input capacitance to be less than 100 pF, measured from the DRCU DxMA connector pins without the harness.	JPL	TBD
BDA-DRCU-04	Input impedance to be larger than 1 MΩ from 50 – 300 Hz.	JPL	TBD
BDA-DRCU-05	The DRCU is to provide 5 BDA bias signals, adjustable from 0 to 200 mV_{rms}, and 1 bias signal for temperature readout, adjustable from 0 to 500 mV_{rms}. The temperature readout biases are to be divided from a common oscillator. Each bias shall be adjustable with 8-bit precision. The frequency of each bias shall be adjustable between 50 and 300 Hz, with a precision of 5 Hz.	JPL	TBD
BDA-DRCU-06	The DRCU will provide 15 commandable JFET source voltages with 256 levels. The range of Vss is from 0 V to –5 V.	JPL	TBD
BDA-DRCU-07	Vdd is to be adjustable from 1.5 to 4 V.	JPL	TBD
BDA-DRCU-08	Vdd and Vss lines individually must source 1 mA to 5 mA. Noise on Vss < 1 μV/√Hz, and noise on Vdd < 0.3 μV/√Hz within modulated band (50 – 300 Hz), measured at the DRCU DxMA connector.	JPL	TBD
BDA-DRCU-09	Each of the 15 Vdd and Vss supplies must be commandable ON/OFF for spectrometer and photometer independently, without overshoot. Each Vdd and Vss pair are turned on and off together.	JPL	TBD
BDA-DRCU-10	The DRCU will provide 2 double-wired JFET heater lines with adjustable amplitude and duration. The supplies must be able to provide 5 V and 25 mA (photometer), 3 V and 10 mA (spectrometer). Each heater line is commandable ON/OFF, with a minimum duration of 10 s.	JPL	TBD
BDA-DRCU-11	The common-mode rejection is –60 dB (50 – 300 Hz).	JPL	TBD
BDA-DRCU-12	The DRCU shall provide a dynamic range at the ADC sufficient to maintain the noise performance of the detectors under maximal signal conditions. This is estimated to be 16 ADC telemetry bits (TBC).	JPL	TBD
BDA-DRCU-13	The signal bandwidth of the photometer channels shall be 0.03 Hz to 5 Hz. The 5 Hz cutoff should have a precision of 1 %.	JPL	TBD

Detailed DRCU Requirements (2)

BDA-DRCU-14	The signal bandwidth of the spectrometer channels shall be 0.03 Hz to 25 Hz. The 25 Hz cutoff should have a precision of 1 %.	JPL	TBD
BDA-DRCU-15	The sampling of the photometer channels shall be synchronised with the bias, at a rate selectable between $\nu_{bias}/2$ to $\nu_{bias}/256$.	JPL	TBD
BDA-DRCU-16	The sampling of the spectrometer channels shall be synchronised with the bias, at a rate selectable between $\nu_{bias}/2$ to $\nu_{bias}/256$.	JPL	TBD
BDA-DRCU-17	The DRCU shall provide 2 adjustable power supplies for temperature control using a heater located at the 300 mK stage. This supply must provide at least 300 mV and 50 uA.	JPL	TBD
BDA-DRCU-18	Noise performance BDA-DRCU-01 shall be maintained under bias range 50 – 300 Hz.	JPL	TBD
BDA-DRCU-19	DRCU noise performance (BDA-DRCU-01) to be maintained under a warm electronics thermal drift of 1 K / hour (TBC).	JPL	TBD
BDA-DRCU-20	Thermal requirements on bias stability are implicit in BDA-DRCU-01.	JPL	TBD
BDA-DRCU-21	Thermal requirement on JFET power is dV/V < 500 ppm / K for Vdd and Vss.	JPL	TBD

BDA-DRCU-22	The DRCU shall not saturate at an input voltage as large as 11 (TBC) mV_{rms} at input (photometer), 17 (TBC) mV_{rms} at input (spectrometer). DRCU channels shall remain functional if one input signal goes to Vbias.	JPL	TBD
BDA-DRCU-23	Specification on isolation of power supplies, ripple, noise, EMC TBD. Specifications to flow from keeping the electrical interference and dissipation at the bolometer below fundamental noise as in Table 3-3-3.	JPL	TBD
BDA-DRCU-24	Bias, JFET power, and readout electronics for the spectrometer and photometer arrays are to run from separate dedicated power supplies, with independent, isolated grounds.	JPL	TBD
BDA-DRCU-25	The electrical cross-talk between channels in the DRCU shall be less than 0.05 % (TBC). The electrical cross-talk shall be verified by varying the input signal on one channel and measuring the response in other channels. The input signal level to each channel must be representative.	JPL	TBD
BDA-DRCU-26	Each signal input to the LIA module must be connected to ground by a diode. This provides both protection and allows the JFETs to turn on without the JFET heater.	JPL	TBD

Resource Requirements

	Achieved	Design	Requirement	Margin
BDA mass		560 g	600 g	20 %
JFET mass		235 g	305 g	20 %
RF filter mass		130 g	TBD g	20 %
BDA conduction	< 2.5 μW	2 μW	2 μW	20 %
JFET dissipation	< 11 mW	5.5 mW	5.5 mW	50 %
RF dissipation		0	0	-
Harness Thermal Conduction	-	-	-	-
BDA repeatability	50(x,y)/150 (z) μm		125/625 μm	-

Interfaces

Interface	Hardware Aspect	Agreed Documentation
Mechanical	BDA interface requirements	BDA-SSSD
	BDA	ICD
	JFET modules	ICD
	RF module	ICD
Optical	BDA	ICD
Thermal	BDA conduction	BDA-SSSD
	JFET dissipation	BDA-SSSD
	thermal stability requirement	BDA-SSSD
Environmental	Vibration levels and temperature	Test Plan
	Bake-out temperature	Test Plan
	EMI/EMC	Test Plan
Harnesses	Cryoharness wiring	HDD
	Mechanical requirement	BDA-SSSD
	JFET-BDA harness routing	ICD
Electrical	Warm electronics requirement	BDA-SSSD

Warm Electronics Interface

- There is no <u>formal</u> interface to JPL hardware
  - warm electronics interface to the instrument
- CEA is responsible for performance and delivery

However, the interface requires our interaction in the following ways:

- JPL sets requirements for the warm electronics in the BDA-SSSD
- JPL and CEA jointly agree to the Harness Definition Document and Grounding Network
- JPL and CEA have a memorandum of understanding that
  - EM models are developed and tested jointly at JPL
  - JPL approves the design of the CQM, PFM, and FS models
  - JPL witnesses performance of the CQM, PFM, and FS models
  - Performance is verified with an interface test dewar from JPL

2.5
SPIRE Work at the NASA/Herschel Science Center

Ken Ganga

NHSC Charter

- In its role as the NASA Herschel Science Center (NHSC), at IPAC will:
  - Provide the US community with science and observational support throughout all phases of the Herschel mission.
  - Serve as one of the advocates for the needs of the US-based observers.
  - Work to ensure the necessary resources and tools are available to take advantage of the scientific capabilities of the observatory.

Top Level NHSC Requirements

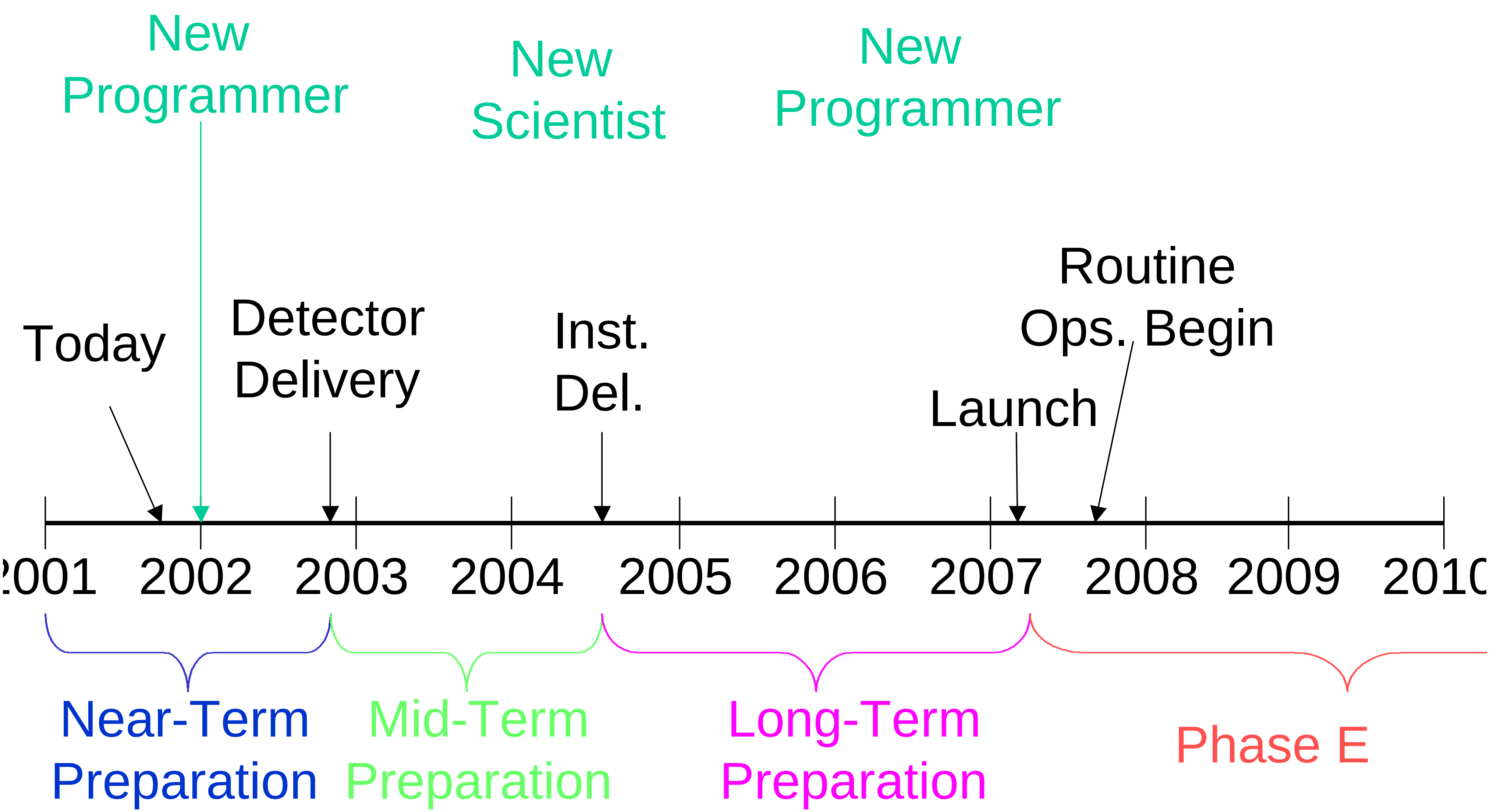
- Educate and engage the US astronomical community regarding the scientific opportunities of the Herschel mission
- Support the U.S. based Science Users with
  – Proposal Preparation
  – Observation Planning
  – Data Analysis
- Using: Expertise, Documentation, Software

Who will IPAC Serve?

- Observers
  - Open Time observers
  - U.S.-Based Guaranteed Time Observers
  - U.S.-Based Key Project Team members
  - International Observers (when possible)

- Any tools or insight we develop will be available to all Herschel users.

Time-Line


New
Programmer
New
Scientist
New
Programmer
Routine
Ops. Begin
Today
Detector
Delivery
Inst.
Del.
Launch
001
2002
2003
2004
2005
2006
2007
2008
2009
201
Near-Term
Preparation
Mid-Term
Preparation
Long-Term
Preparation
Phase E

Near-Term Efforts

- Near-Term Work focussed on detector testing at JPL
  - Will write software to help with detector characterization at JPL
  - Best way to start understanding the instrument
  - A real help to the US SPIRE team (we hope!)
  - Geographically sensible
- Maintain contact with consortium ("Liaison")
  - Bock has nominated Ganga as SPIRE associate
  - Involved in QLA definition
    - Via visits
    - Via e-mail, etc.
  - ISO and Planck connections are of real use here

Midterm Phase

- No real IPAC involvement in “Avionics Model”
  - We'll be busy anyway with detector characterization software
  - Different emphasis in SPIRE as compared to other instruments
- "Extended" European interaction beginning with “Cryogenic Qualification Model” testing.
  - Detector testing software may help form basis of instrument tests at RAL
  - Involvement in instrument-level tests desirable

Mid-Term Involvement

- Extended Involvement in the ICC begins
  - Software Development for Observation Planning
    - Understand science tools that will be available
    - Help define observation strategies that work for US observers
    - Focal Plane visualization
    - Background estimation
    - Interfaces with IRSA, NED, etc.
  - Data Analysis Software
    - The legacy of the detector testing
      - Instrument test help
    - Data extraction
    - Visualization
    - glitch detection
    - Filtering
    - map-making
    - noise estimation
    - source detection
    - etc.

Long-Term Efforts

User Support

– ISO support model used as a loose base
  - "Service Oriented"
  - It's improved by more intimate instrument involvement here and in Europe
  - Developing Remote Support
    – Makes it easier on us as well
  - With modifications to fit in with the HCSS concept

- IRAS / ISO / SIRTF / 2MASS / IRAS / Planck / IRSA / NED tools used where possible
  – All this data is at IPAC, and can be used synergistically
  – BOOMERanG experience will help as well
- Monitor Programs to see what's getting scheduled and what's working
  – Keep users continuously informed
- Detector/Instrument testing work helps form the flight "Quicklook"

Current Status

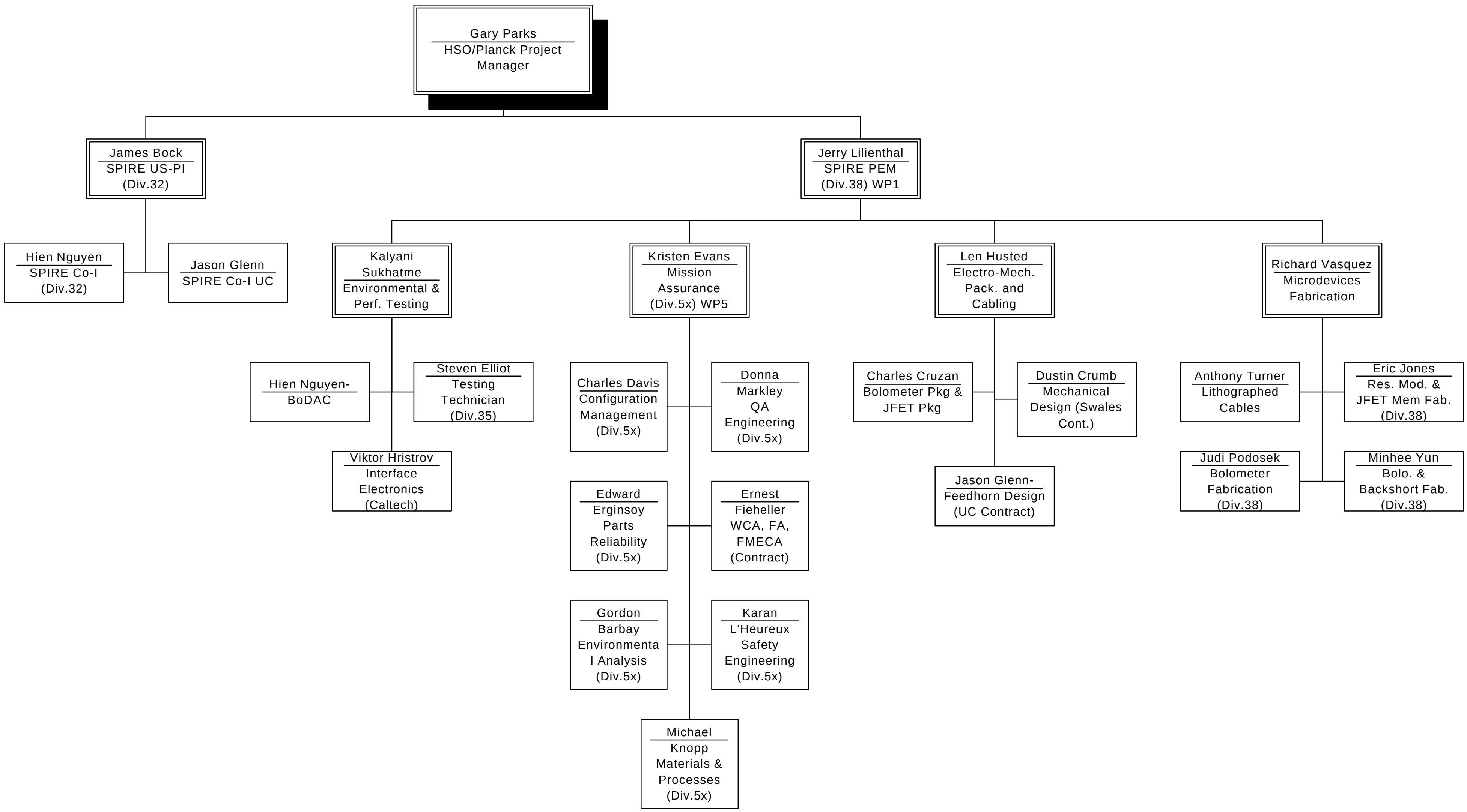
- Getting involved
  - General understanding with US SPIRE team on near-term work
    - Near-term work is best for both IPAC and US SPIRE team
    - Near-term work will aid SPIRE team and US
  - General understanding with SPIRE team on IPAC role in near-term
    - We work with them, but no "deliveries"

- Very good relations with SPIRE team
  - In US
  - world-wide
- SPIRE is one of the leanest Herschel teams
  - Our involvement can make a real difference.
- Personal interest is high
- IPAC SPIRE Liaison is oversubscribed

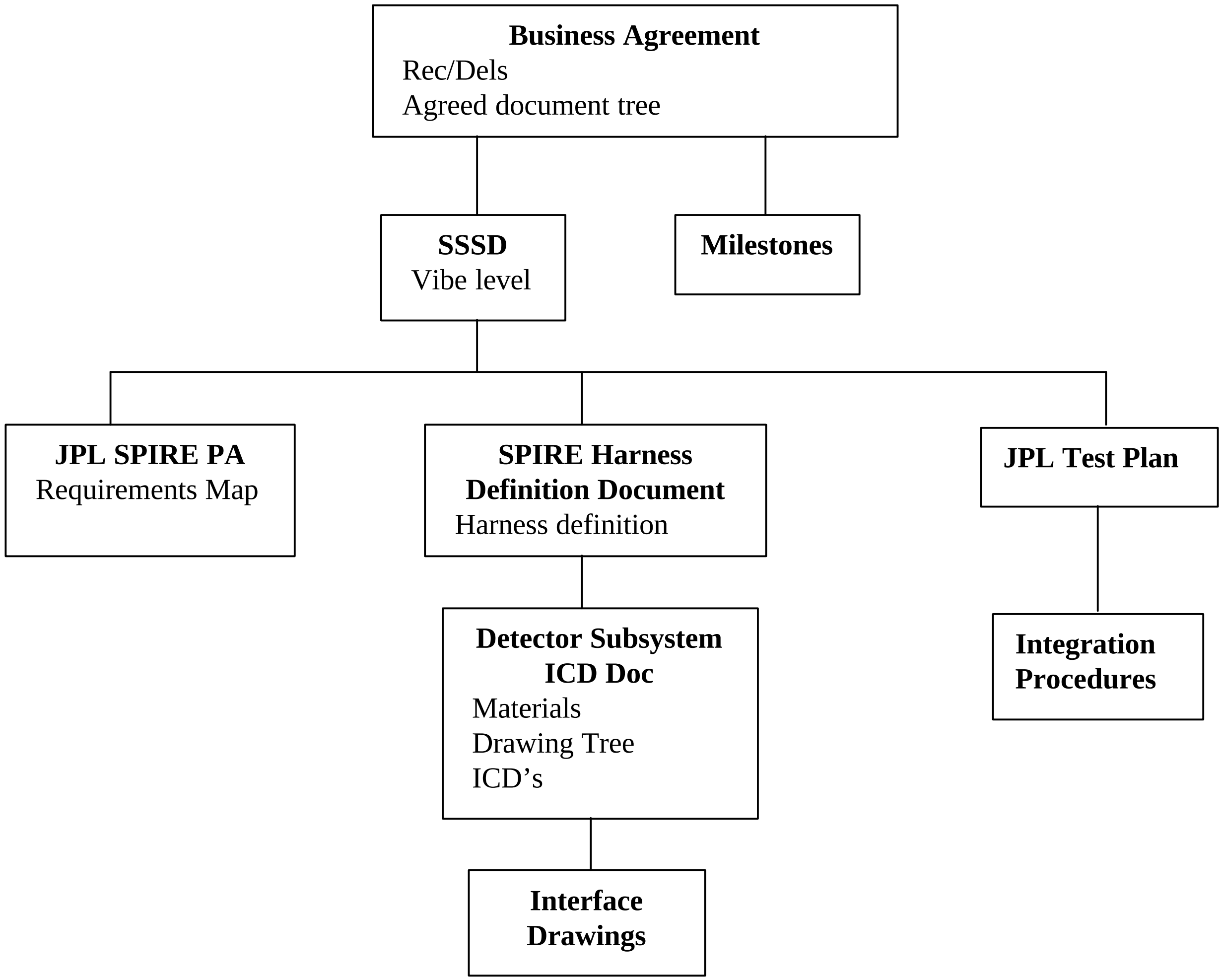
3.0
Programmatic Overview

Gerald Lilienthal

Work Breakdown Structure (WBS)



Agreed-To Documentation Tree

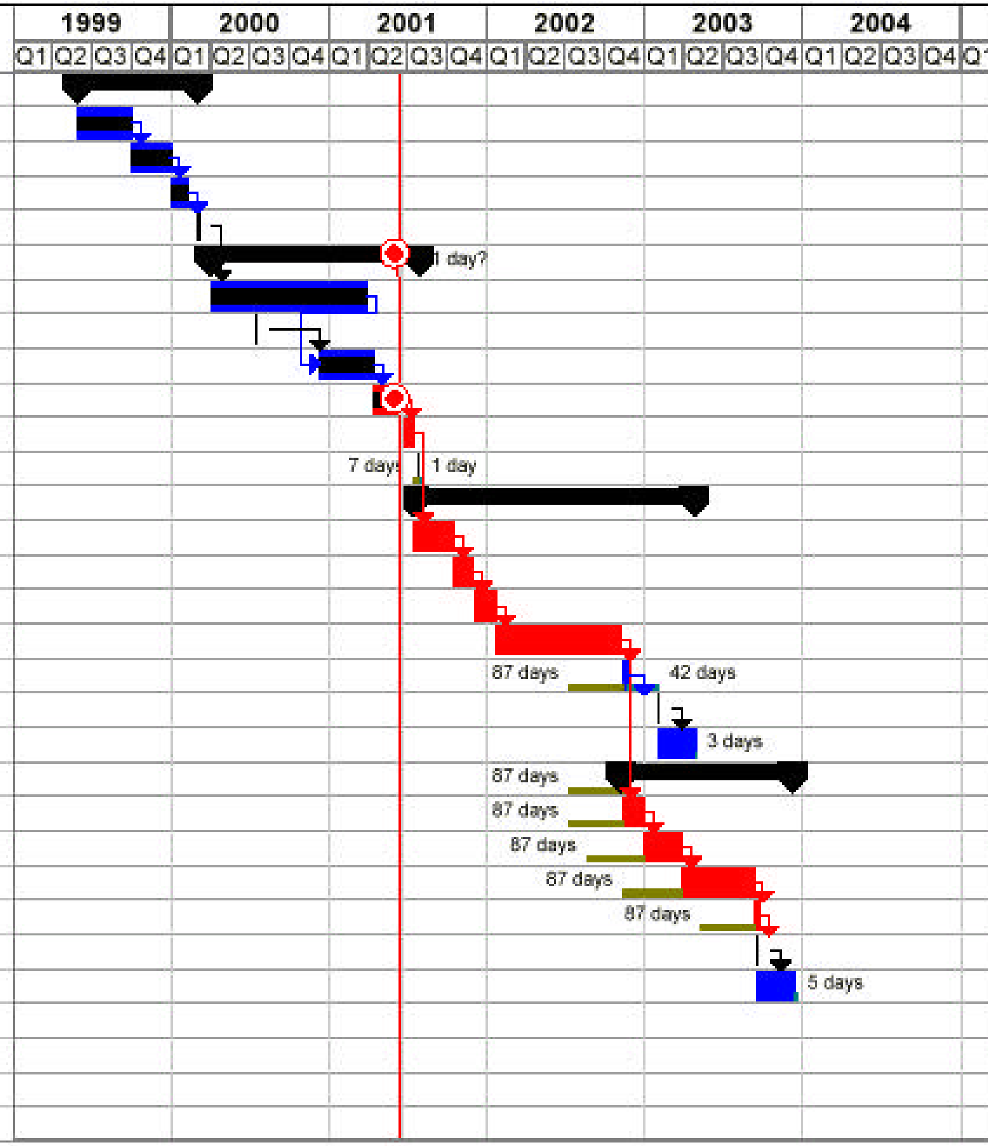


HSO/Planck Project

SPIRE Detector System

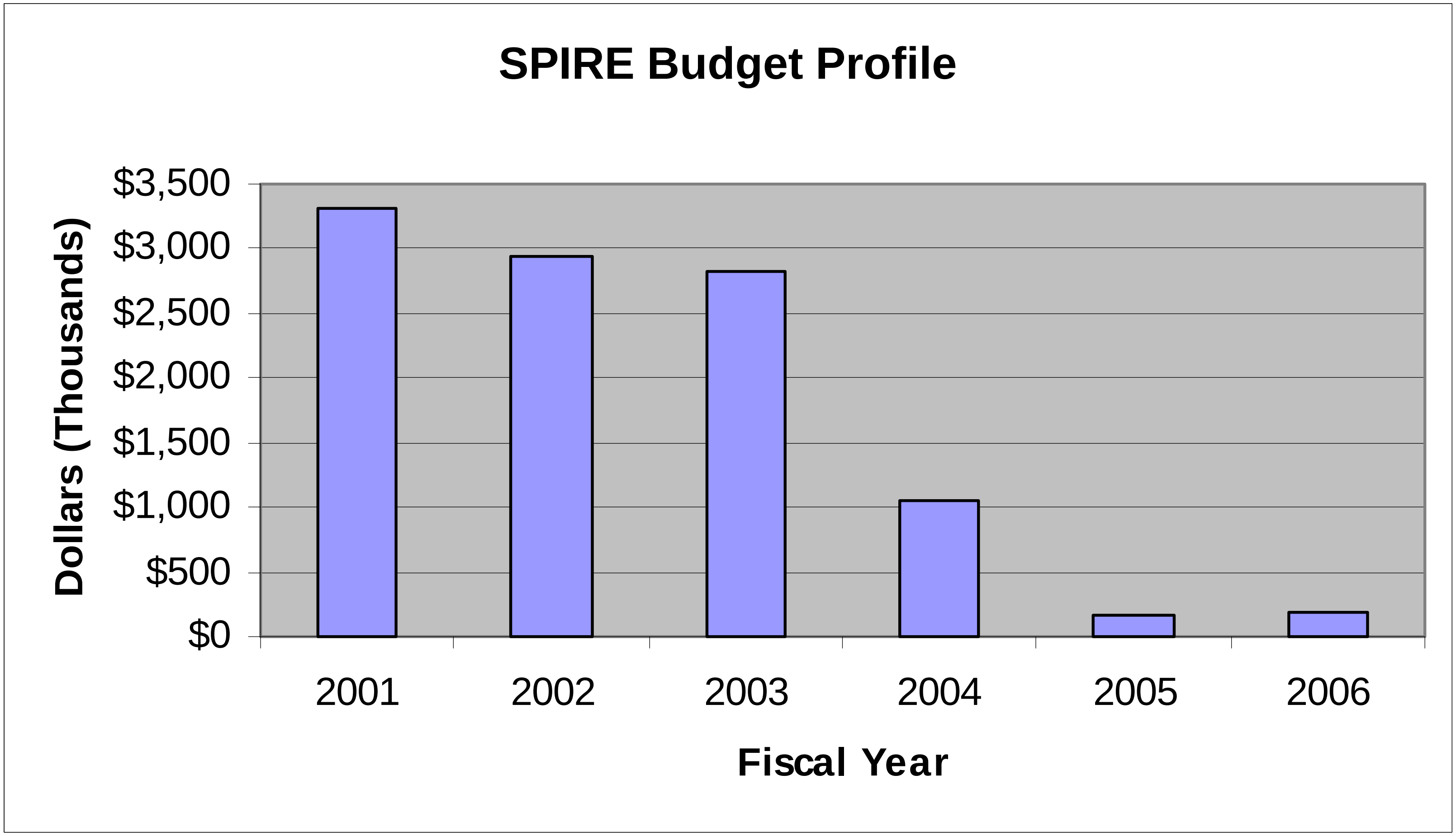
File: SPIRE 6-12-01

ID	Task Name
1	**Prototype Design and Testing Phase**
2	Design
3	Fabrication and Assembly
4	Testing and Data Reduction
5	Downselect Review
6	**Detail Design & EM Development Phase**
7	EM Design
8	PDR
9	EM Fabrication
10	EM Assembly
11	EM Testing & Data Reduction
12	CDR
13	**CQM Phase**
14	CQM/PFM/Spare Fabrication
15	CQM Assembly
16	CQM Environmental Testing & Data Reduction
17	CQM Performance Testing & Data Reduction
18	CQM HRCR & Shipment
19	CQM Required Date (Business Agreement)
20	CQM Integration Support
21	**PFM and Spare Phase**
22	PFM and Spare Assembly
23	PFM and Spare Environmental Testing and D.R.
24	PFM and Spare Performance Testing & D.R.
25	PFM and Spare HRCR and Shipment
26	PFM Required Date (Business Agreement)
27	PFM Integration Support
28	
29	
30	
31	



Page 1 of 23

Budget

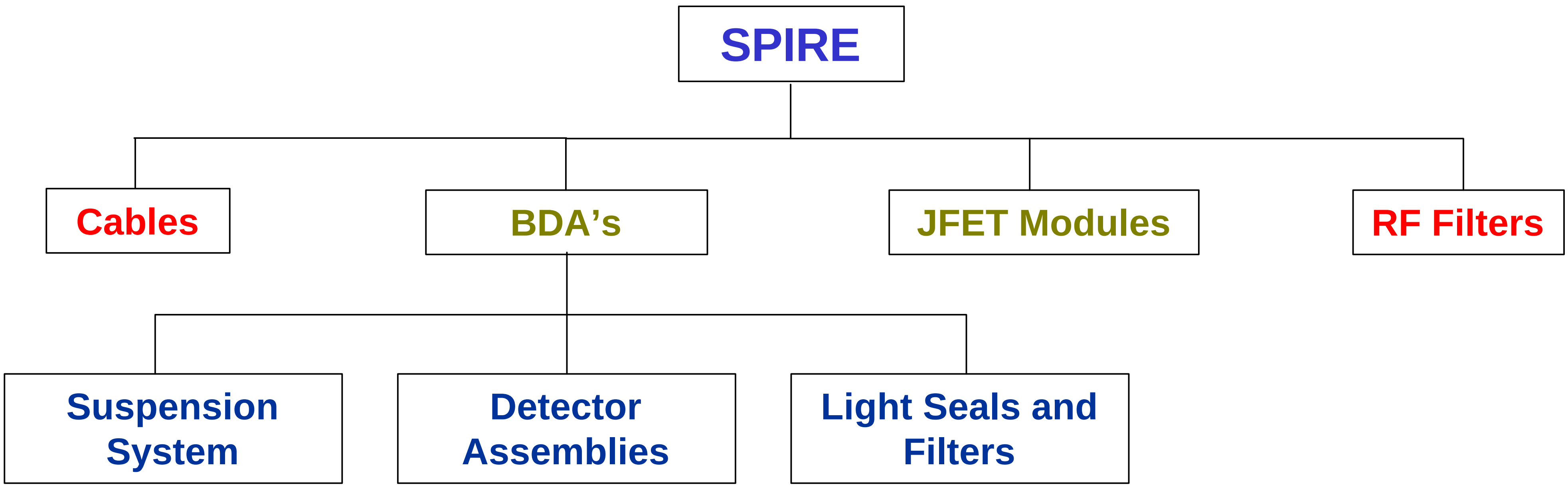


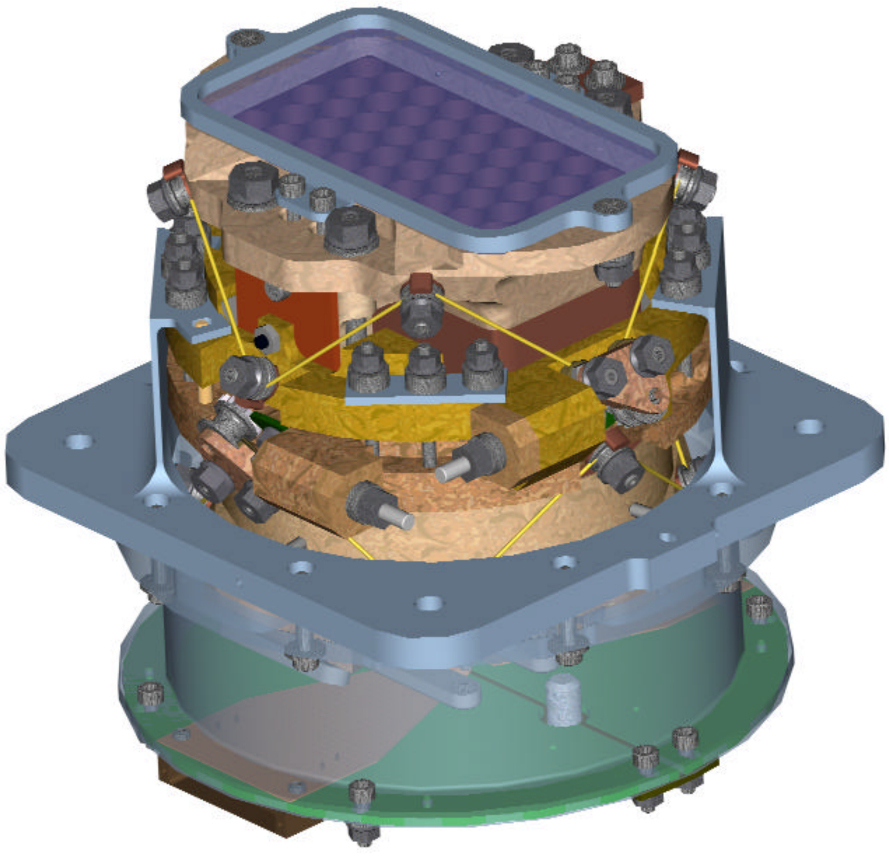
Note: Budget information will be presented in detail at the project CDR in September

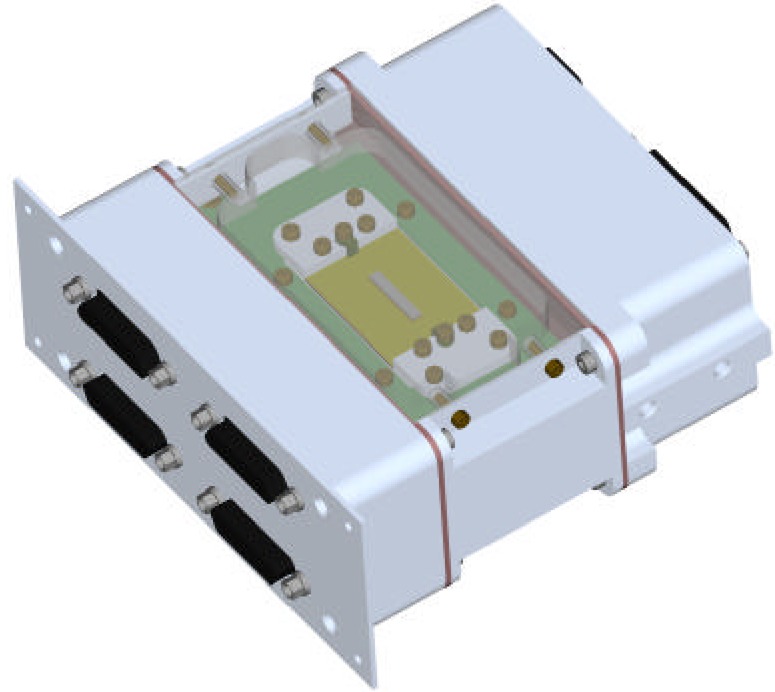
4.0
Interfaces

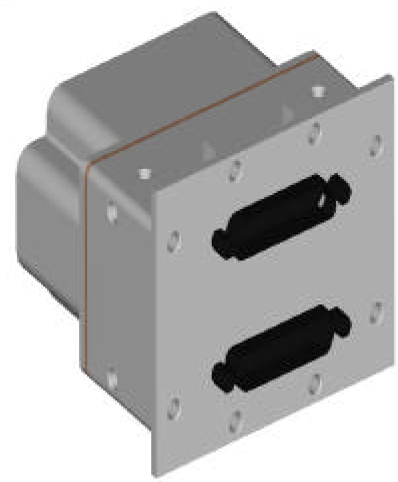
Dustin Crumb

SPIRE Subsystems





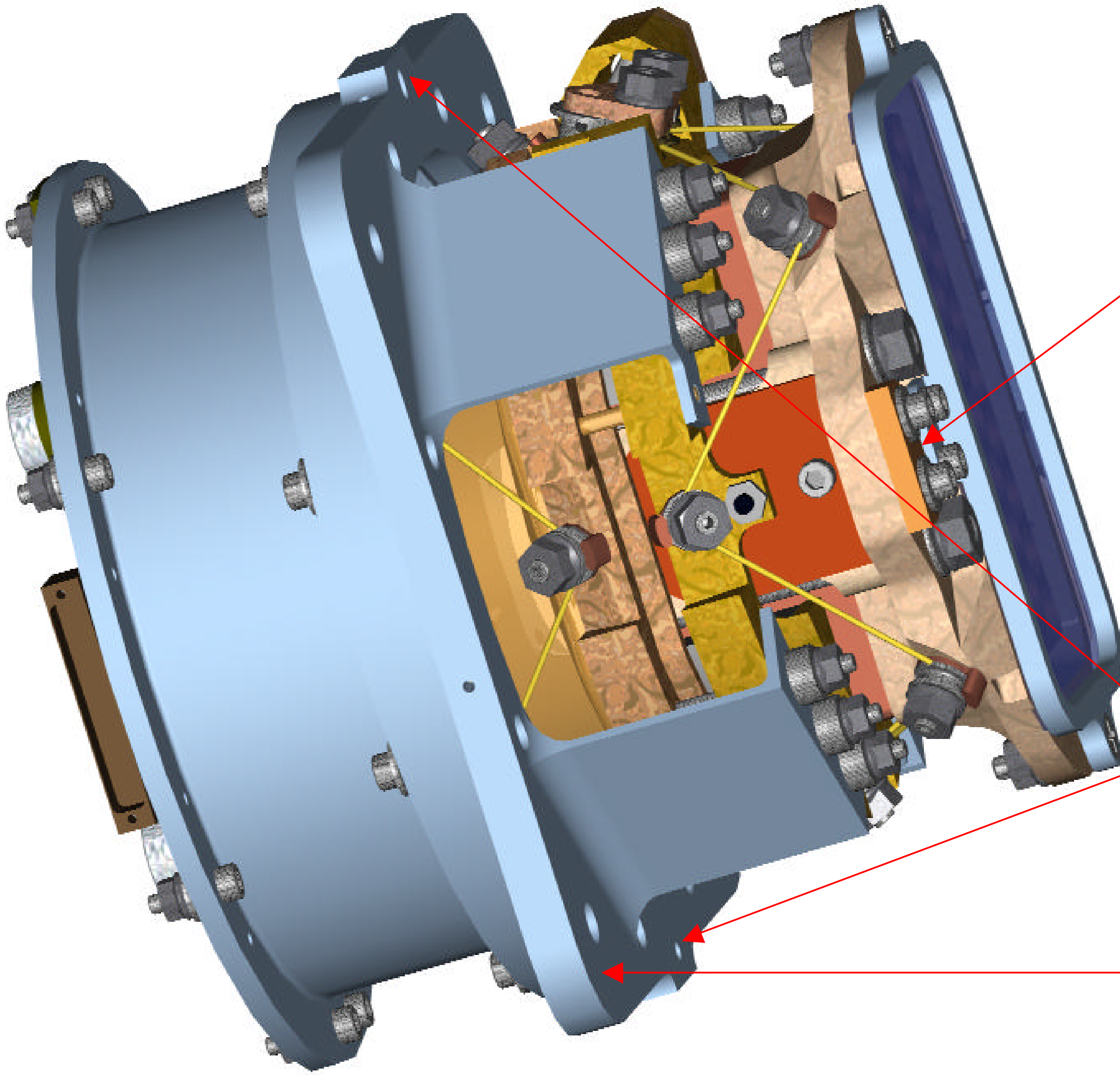




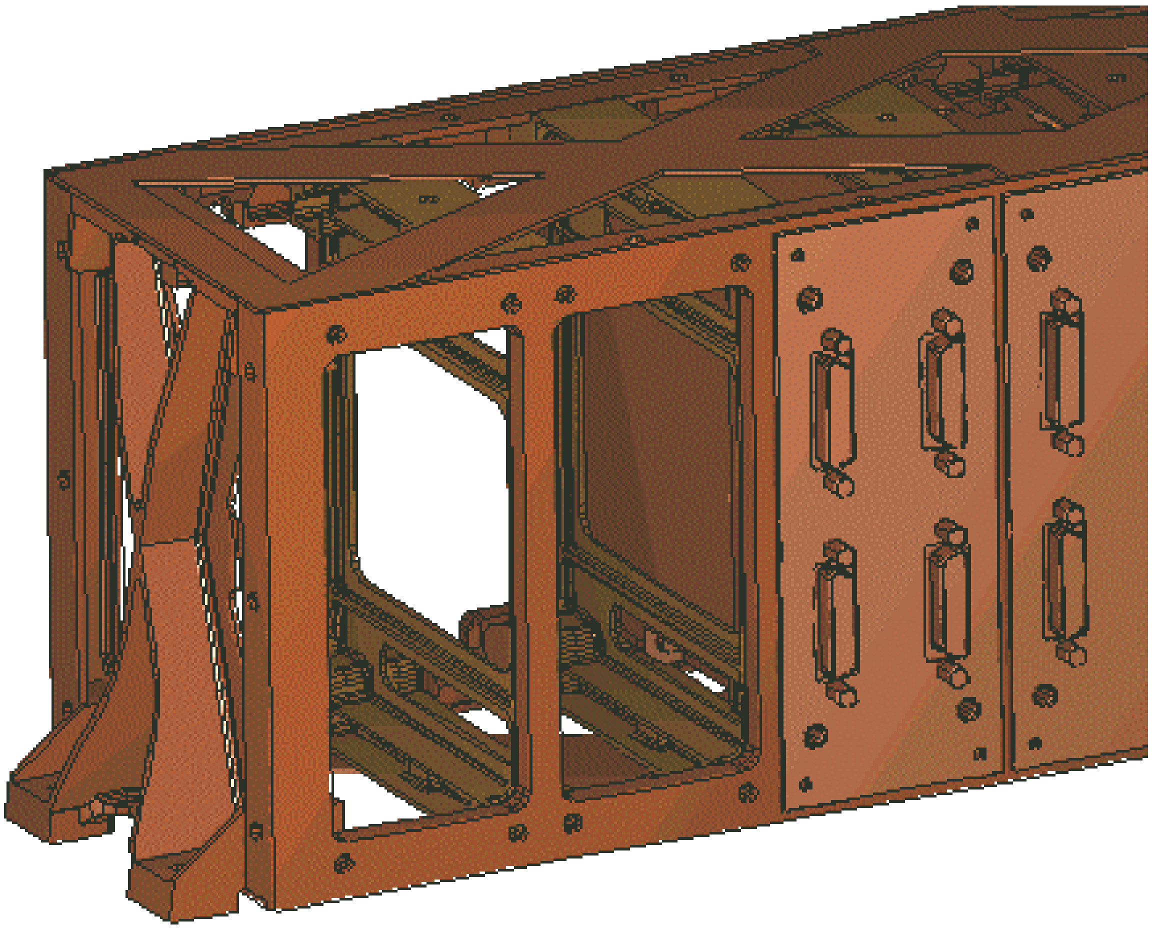
Interfaces
Details

Dustin Crumb

Array Design
Integration into the Instrument



JFET Box Enclosure (RAL)

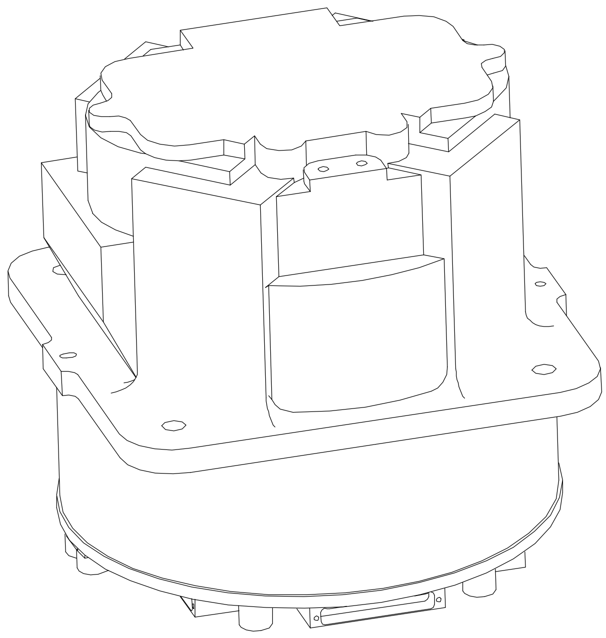


ICD's

• 10209721- BDA	• In Check
• 10209722-JFET Module	• In Check
• 10209723-RF Filter	• In Check
• 10209725-Wiring Schematic	• In Check
• 10209726-Temperature Control	• Conceptual stage
• 10209727-Cold Cabling	• Awaiting input

REVISIONS

LTR	ZONE	DESCRIPTION	CODE	DWN	CHK	STRUCT	MATL	THRM CONT	ENGR	DSGN SUPV	DATA MGT	RELEASE DATE
A		INITIAL RELEASE		SEE TITLE BLOCK								



GENERAL VIEW
REFERENCE ONLY

TABLE I

ARRAY	PART #	MASS	FOCUS	CGX	CGY	CGZ	CONNECTORS
P/LW	10209800-01	672	31.9	7	37.4	0.3	J05, J06
P/MW	10209800-02	615	33.3	10.2	37.5	0.4	J01, J02, J03, J04
P/SW	10209800-03	564	24.1	8.6	37.5	0.4	J01, J02, J03, J04, J05, J06
S/LW	10209800-04	482	35.9	5.8	37.6	0.6	J05
S/SW	10209800-05	466	25.7	37.6	7.8	0.5	J05,J06

6. ALL DIMENSIONS ARE BASED ON AN ASSEMBLY TEMPERATURE OF 20° C.

5 INDICATES CONNECTOR POSITION. CONNECTORS INSTALLED ARE STM 051M6SN.

4 REFER TO TABLE I FOR DIFFERENCES BETWEEN DETECTOR ARRAYS.

3 ASSEMBLY REFERENCE DESIGNATOR, TITLE, PART NUMBER, REVISION LETTER, AND SERIAL NUMBER TO APPEAR AS SHOWN IN THIS AREA.

2. THIS IS THE INTERFACE CONTROL DRAWING FOR THE BOLOMETER DETECTOR ARRAY, JPL PART NUMBER 10209800. JPL DRAWING NUMBER 10209800 SHALL CONTAIN THE FOLLOWING NOTE: THIS ASSEMBLY MEETS THE INTERFACE REQUIREMENTS OF JPL INTERFACE CONTROL DRAWING 10209721.

1. THIS TECHNICAL DATA IS EXPORT CONTROLLED UNDER U.S. LAW AND IS BEING TRANSFERRED BY JPL TO PPARC PURSUANT TO THE NASA / PPARC LETTER OF AGREEMENT WHICH ENTERED INTO FORCE ON DECEMBER 2, 1999. THIS TECHNICAL DATA IS TRANSFERRED TO PPARC FOR USE EXCLUSIVELY ON THE NASA/PPARC SPIRE ON FIRST COOPERATIVE PROJECT, MAY NOT BE USED FOR ANY OTHER PURPOSE, AND SHALL NOT BE RE-TRANSFERRED OR DISCLOSED TO ANY OTHER PARTY WITHOUT THE PRIOR WRITTEN APPROVAL OF NASA.

NOTES: UNLESS OTHERWISE SPECIFIED

INTERFACE CONTROL DRAWING

QTY REQD	ITEM NO	REF DES	CAGE NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	SPECIFICATION	MATERIAL OR NOTE	ZONE

PARTS LIST

MATERIAL

METRIC

THIRD ANGLE PROJECTION

NEXT ASSEMBLY	USED ON
	SPIRE

APPLICATION

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS

LINEAR TOLERANCES:

0–6	± 0.1
OVER 6–30	± 0.2
OVER 30–120	± 0.3
OVER 120–315	± 0.5
OVER 315–1000	± 0.8
OVER 1000	± 1.2

ANGULAR TOLERANCES:
± 0.5°

MACHINE FINISH (MICROMETERS) 3.2

DO NOT SCALE DRAWING
INTERPRET DWG PER ANSI Y14.100M

CONTRACT NO 960939

APPD ____ DATE ____

DWN J. PROEBSTLE 3/30/01

CHK

STRUCT

MATL

THRM CONT

ENGR

DSGN SUPV

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CA 91109

RELEASED THROUGH EDMG

BOLOMETER DETECTOR
ARRAY MECHANICAL ICD
SPIRE

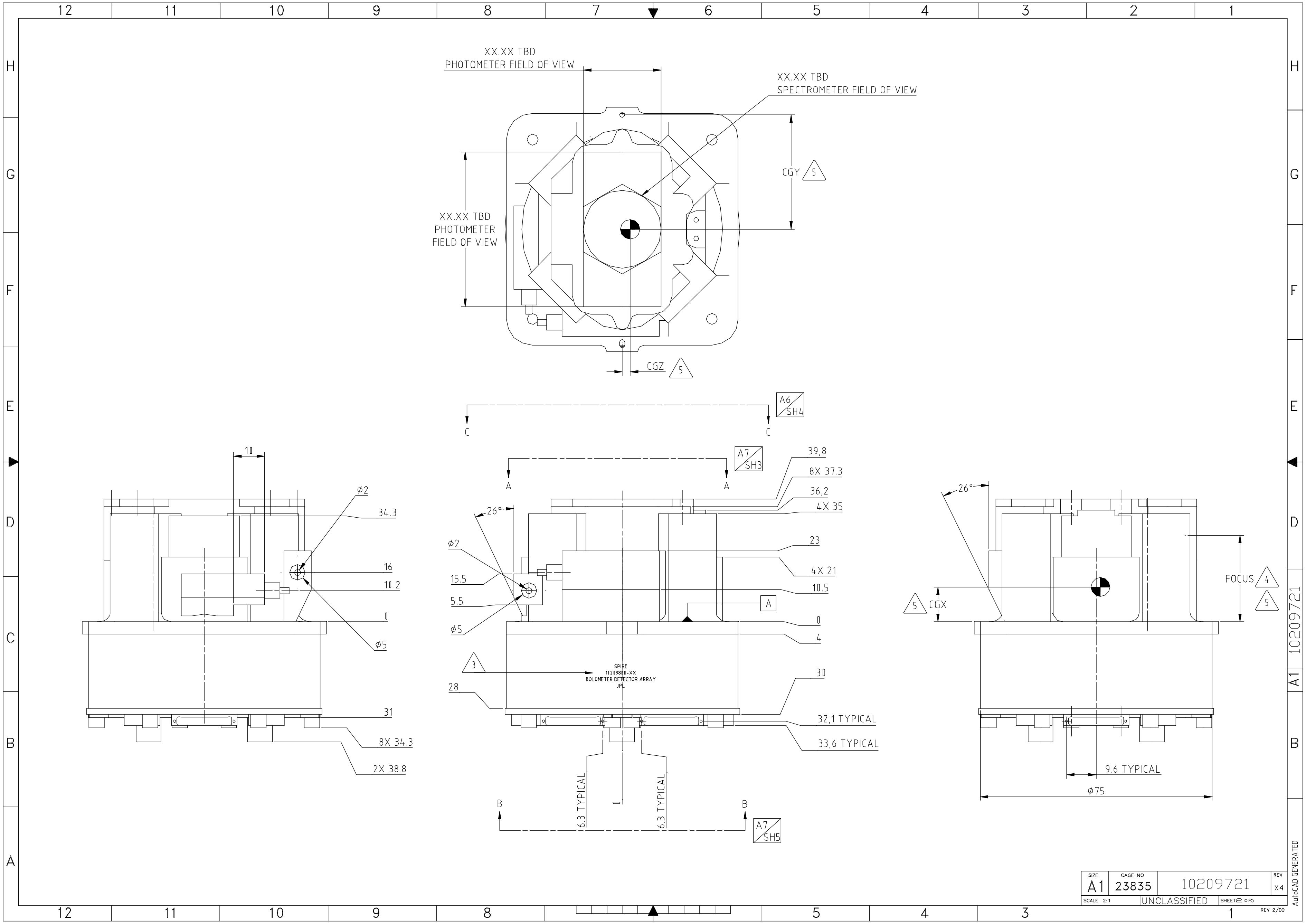
SIZE	CAGE NO		REV
A1	23835	10209721	X4

SCALE NONE UNCLASSIFIED SHEET 1 OF 5

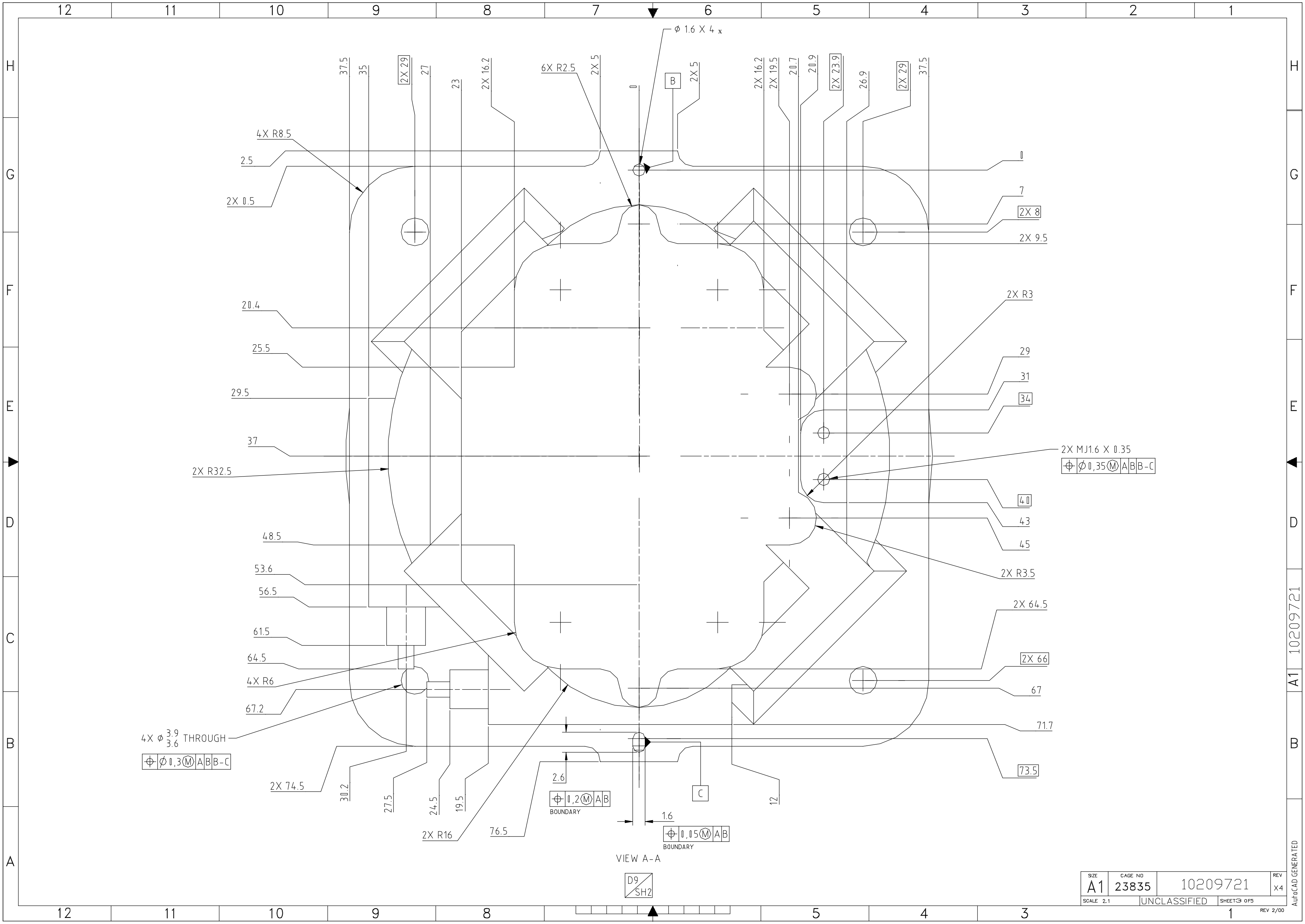
REV 2/00

A1 10209721

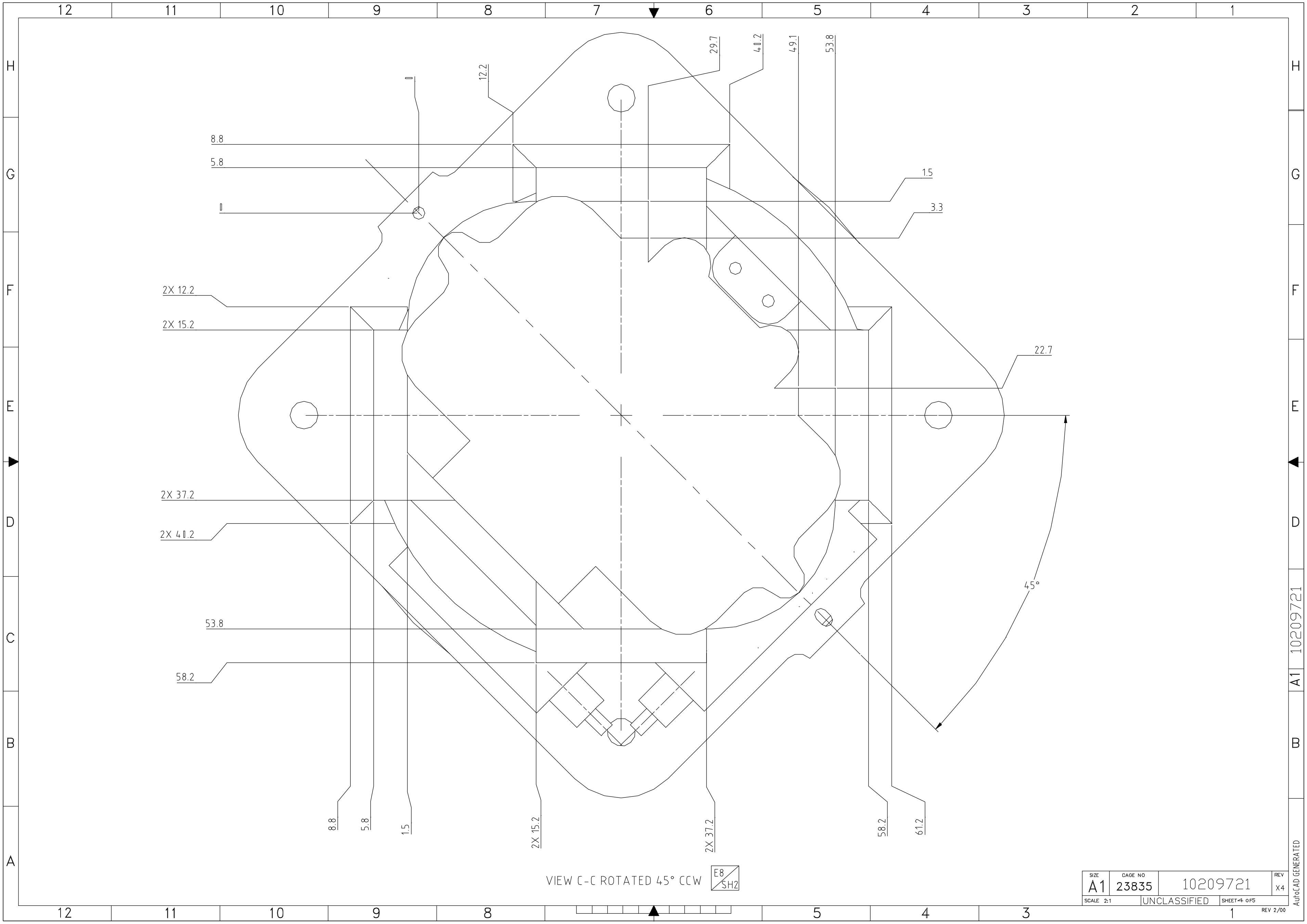
AutoCAD GENERATED



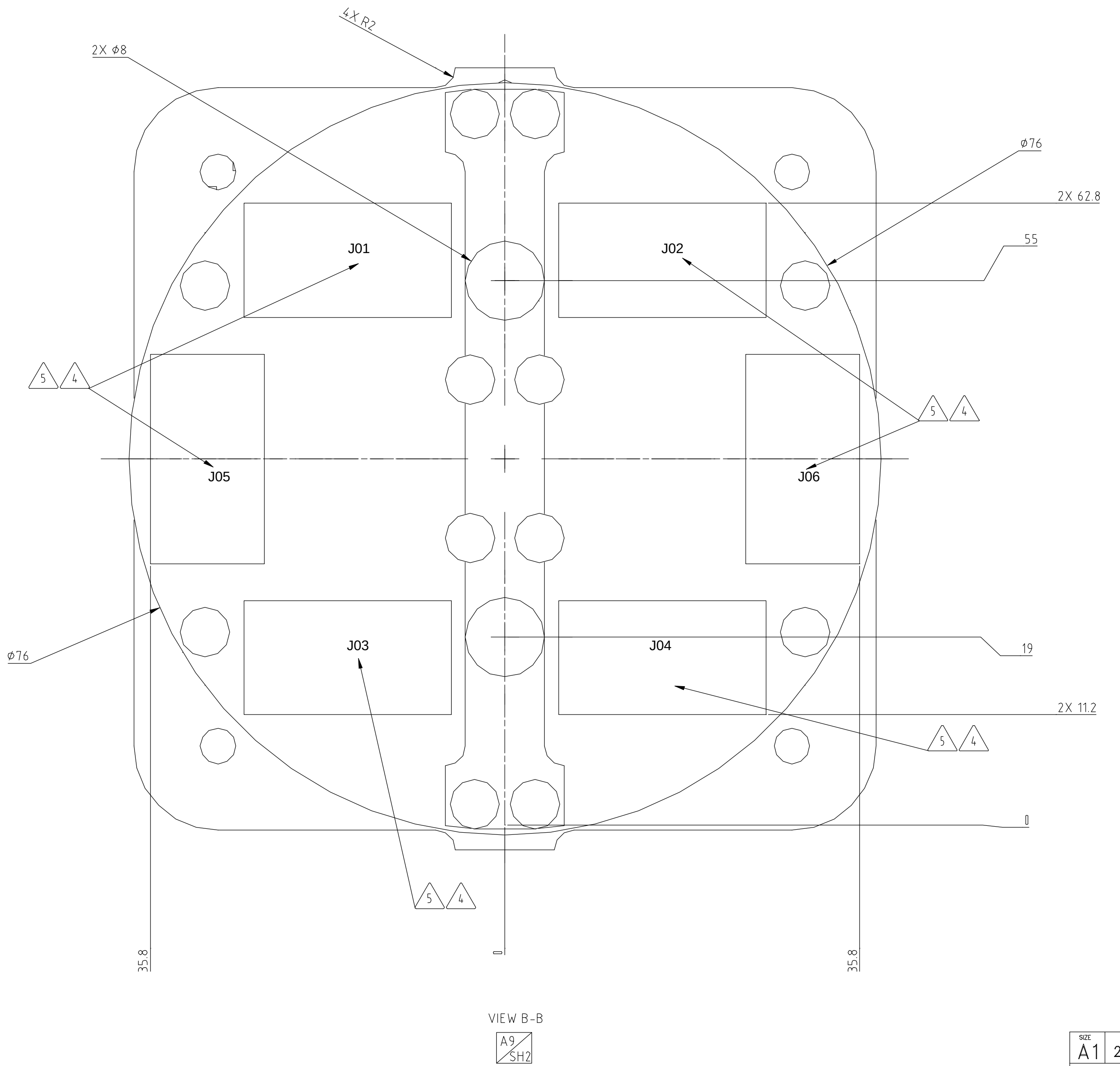
XX.XX TBD
PHOTOMETER FIELD OF VIEW
XX.XX TBD
SPECTROMETER FIELD OF VIEW
CGY
XX.XX TBD
PHOTOMETER
FIELD OF VIEW
CGZ
FOCUS
CGX
9.6 TYPICAL
ϕ75
6.3 TYPICAL
32,1 TYPICAL
33,6 TYPICAL
SPIRE
BOLOMETER DETECTOR ARRAY
JPL
UNCLASSIFIED
10209721
23835
AutoCAD GENERATED



VIEW A-A
4X R8.5
2.5
2X 0.5
20.4
25.5
29.5
37
2X R32.5
48.5
53.6
56.5
61.5
64.5
4X R6
67.2
4X ϕ 3.9 3.6 THROUGH
2X 74.5
30.2
27.5
24.5
19.5
2X R16
76.5
2.6
BOUNDARY
1.6
BOUNDARY
12
6X R2.5
2X 5
ϕ 1.6 X 4
2X 16.2
2X 19.5
20.7
20.9
2X 23.9
26.9
2X 29
37.5
35
27
23
7
2X 8
2X 9.5
2X R3
29
31
34
2X MJ1.6 X 0.35
40
43
45
2X R3.5
2X 64.5
2X 66
67
71.7
73.5
SIZE A1
CAGE NO 23835
10209721
REV X4
SCALE 2:1
UNCLASSIFIED
AutoCAD GENERATED


8.8
5.8
0
2X 12.2
2X 15.2
2X 37.2
2X 40.2
53.8
58.2
12.2
29.7
40.2
49.1
53.8
1.5
3.3
22.7
45°
8.8
5.8
1.5
2X 15.2
2X 37.2
58.2
61.2
VIEW C-C ROTATED 45° CCW
E8
SH2
SIZE A1
CAGE NO 23835
10209721
REV X4
SCALE 2:1
UNCLASSIFIED
SHEET 4 OF5
REV 2/00
AutoCAD GENERATED

ALL CONNECTORS	
PIN #	PIN PURPOSE
1	SIGNAL 1A
2	SIGNAL 2A
3	SIGNAL 3A
4	SIGNAL 4A
5	SIGNAL 5A
6	SIGNAL 6A
7	SIGNAL 7A
8	SIGNAL 8A
9	SIGNAL 9A
10	SIGNAL 10A
11	SIGNAL 11A
12	SIGNAL 12A
13	SIGNAL 13A
14	SIGNAL 14A
15	SIGNAL 15A
16	SIGNAL 16A
17	SIGNAL 17A
18	SIGNAL 18A
19	SIGNAL 19A
20	SIGNAL 20A
21	SIGNAL 21A
22	SIGNAL 22A
23	SIGNAL 23A
24	SIGNAL 24A
25	SIGNAL V+
26	SIGNAL 1B
27	SIGNAL 2B
28	SIGNAL 3B
29	SIGNAL 4B
30	SIGNAL 5B
31	SIGNAL 6B
32	SIGNAL 7B
33	SIGNAL 8B
34	SIGNAL 9B
35	SIGNAL 10B
36	SIGNAL 11B
37	SIGNAL 12B
38	SIGNAL 13B
39	SIGNAL 14B
40	SIGNAL 15B
41	SIGNAL 16B
42	SIGNAL 17B
43	SIGNAL 18B
44	SIGNAL 19B
45	SIGNAL 20B
46	SIGNAL 21B
47	SIGNAL 22B
48	SIGNAL 23B
49	SIGNAL 24B
50	SIGNAL V-
51	SIGNAL BIAS GND



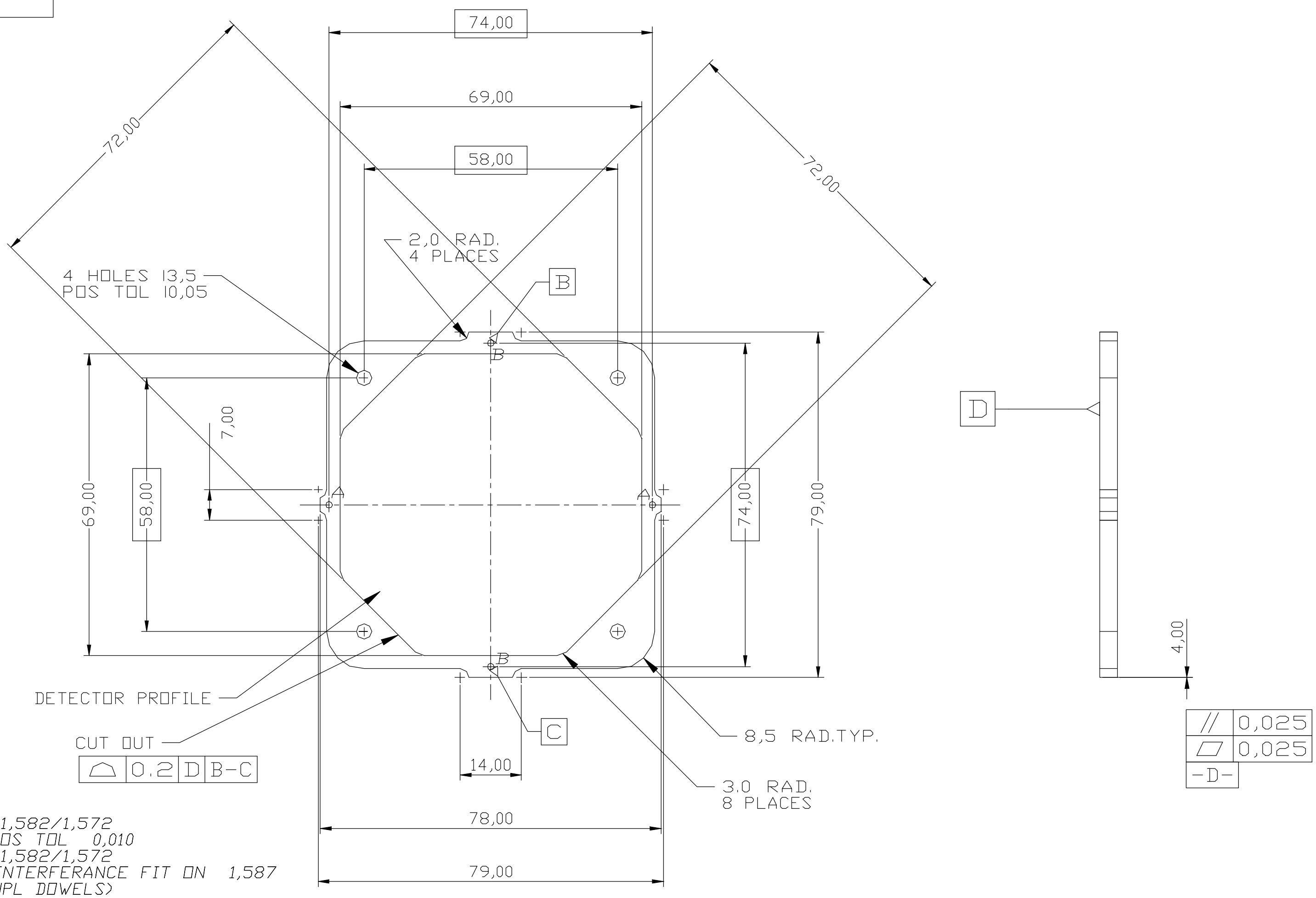
SIZE A1 | CAGE NO 23835 | 10209721 | REV X4
SCALE 2:1 | UNCLASSIFIED | SHEET 5 OF 5

THIRD ANGLE PROJECTION

DO NOT SCALE

DRAWING No. A3 5264 911

USED ON
SPIRE (FIRST)



2 OFF HOLES "A" 1,582/1,572
POS TOL 0,010
2 OFF HOLES "B" 1,582/1,572
(INTERFERANCE FIT ON 1,587
JPL DOWELS)
POS TOØ 0,010

CHECKED			
TRACED			
	2	2/3/01	CUT OUT AND DOWEL HOLES MODIFIED TO JPL DIMS.
DRAWN	ISSUE	DATE	AMENDMENT
AJC	1	19/12/00	ESTD. WT.

PROTECTIVE FINISH: ALOCROM 1200

ACTL. WT.

MATERIAL & SPEC.: ALUM, ALLOY TO:- BS1470 6082T6

DIMENSIONS IN mm

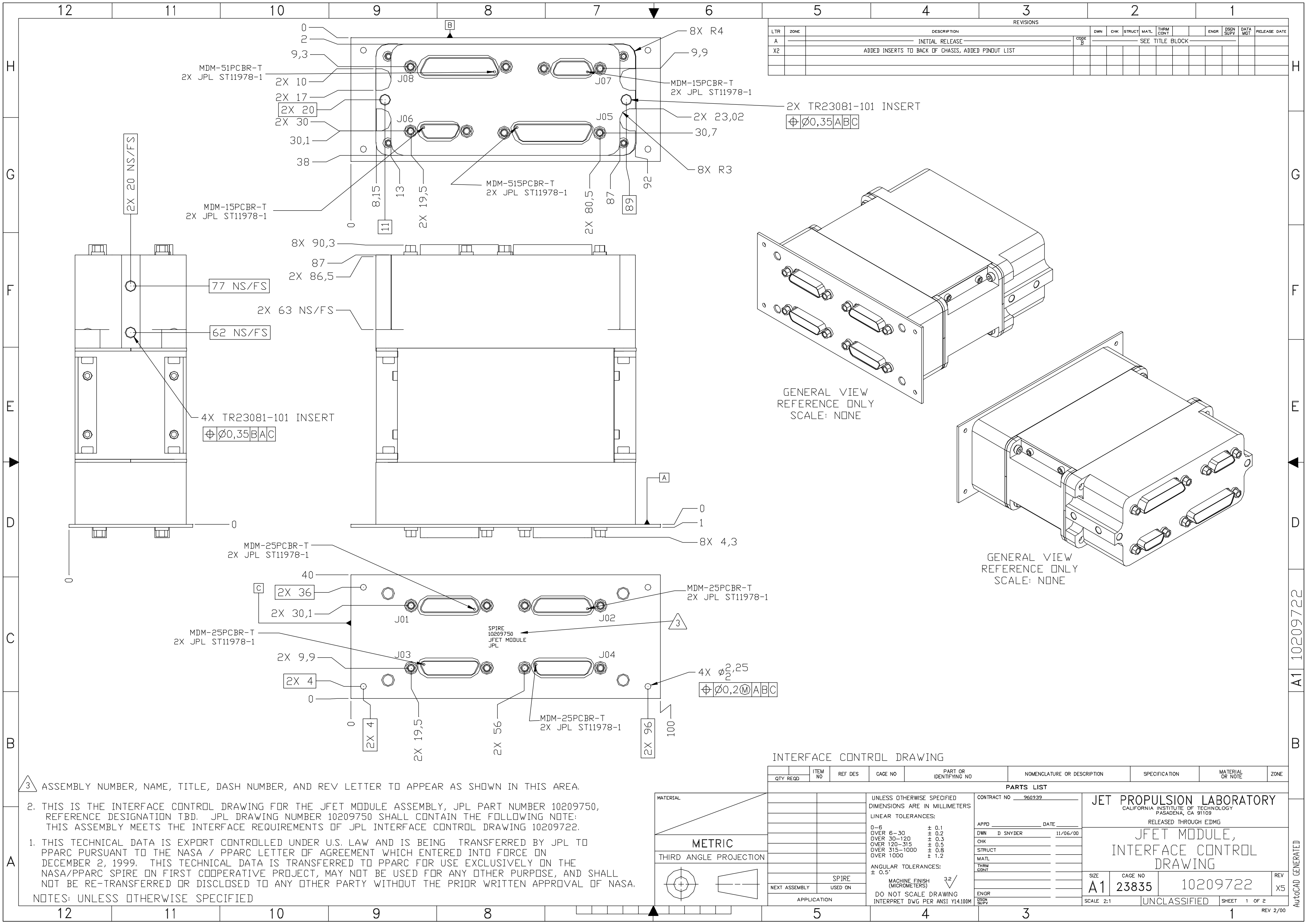
TOLERANCES UNLESS OTHERWISE STATED -
LINEAR +/- 0.10
ANGULAR +/- 0°15'

SCALE

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
DETECTOR INTERFACE ADAPTOR PLATE

DRAWING No. A3 5264 911



REVISIONS
A INITIAL RELEASE SEE TITLE BLOCK
X2 ADDED INSERTS TO BACK OF CHASIS, ADDED PINOUT LIST
MDM-51PCBR-T 2X JPL ST11978-1
MDM-15PCBR-T 2X JPL ST11978-1
MDM-15PCBR-T 2X JPL ST11978-1
MDM-51SPCBR-T 2X JPL ST11978-1
8X R4
8X R3
2X TR23081-101 INSERT
Ø0,35 A B C
J08
J07
J06
J05
77 NS/FS
62 NS/FS
2X 63 NS/FS
2X 20 NS/FS
4X TR23081-101 INSERT
Ø0,35 B A C
GENERAL VIEW
REFERENCE ONLY
SCALE: NONE
GENERAL VIEW
REFERENCE ONLY
SCALE: NONE
MDM-25PCBR-T 2X JPL ST11978-1
MDM-25PCBR-T 2X JPL ST11978-1
MDM-25PCBR-T 2X JPL ST11978-1
MDM-25PCBR-T 2X JPL ST11978-1
J01
J02
J03
J04
SPIRE 10209750 JFET MODULE JPL
4X Ø2,25
Ø0,2 Ⓜ A B C
INTERFACE CONTROL DRAWING
3 ASSEMBLY NUMBER, NAME, TITLE, DASH NUMBER, AND REV LETTER TO APPEAR AS SHOWN IN THIS AREA.
2. THIS IS THE INTERFACE CONTROL DRAWING FOR THE JFET MODULE ASSEMBLY, JPL PART NUMBER 10209750, REFERENCE DESIGNATION TBD. JPL DRAWING NUMBER 10209750 SHALL CONTAIN THE FOLLOWING NOTE: THIS ASSEMBLY MEETS THE INTERFACE REQUIREMENTS OF JPL INTERFACE CONTROL DRAWING 10209722.
1. THIS TECHNICAL DATA IS EXPORT CONTROLLED UNDER U.S. LAW AND IS BEING TRANSFERRED BY JPL TO PPARC PURSUANT TO THE NASA / PPARC LETTER OF AGREEMENT WHICH ENTERED INTO FORCE ON DECEMBER 2, 1999. THIS TECHNICAL DATA IS TRANSFERRED TO PPARC FOR USE EXCLUSIVELY ON THE NASA/PPARC SPIRE ON FIRST COOPERATIVE PROJECT, MAY NOT BE USED FOR ANY OTHER PURPOSE, AND SHALL NOT BE RE-TRANSFERRED OR DISCLOSED TO ANY OTHER PARTY WITHOUT THE PRIOR WRITTEN APPROVAL OF NASA.
NOTES: UNLESS OTHERWISE SPECIFIED
PARTS LIST
METRIC
THIRD ANGLE PROJECTION
SPIRE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS
LINEAR TOLERANCES:
0-6 ± 0.1
OVER 6-30 ± 0.2
OVER 30-120 ± 0.3
OVER 120-315 ± 0.5
OVER 315-1000 ± 0.8
OVER 1000 ± 1.2
ANGULAR TOLERANCES: ± 0.5°
DO NOT SCALE DRAWING
INTERPRET DWG PER ANSI Y14.100M
CONTRACT NO 960939
DWN D SNYDER 11/06/00
JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY PASADENA, CA 91109
RELEASED THROUGH EDMG
JFET MODULE, INTERFACE CONTROL DRAWING
A1 23835 10209722 X5
SCALE 2:1 UNCLASSIFIED SHEET 1 OF 2
A1 10209722
AutoCAD GENERATED

J01 JFET OUTPUT 1, SIGNALS 1-12

PIN #	PIN PURPOSE
1	SIGNAL 13A
2	SIGNAL 14A
3	SIGNAL 15A
4	SIGNAL 16A
5	SIGNAL 17A
6	SIGNAL 18A
7	SIGNAL 19A
8	SIGNAL 20A
9	SIGNAL 21A
10	SIGNAL 22A
11	SIGNAL 23A
12	SIGNAL 24A
13	FPU GND
14	SIGNAL 13B
15	SIGNAL 14B
16	SIGNAL 15B
17	SIGNAL 16B
18	SIGNAL 17B
19	SIGNAL 18B
20	SIGNAL 19B
21	SIGNAL 20B
22	SIGNAL 21B
23	SIGNAL 22B
24	SIGNAL 23B
25	SIGNAL 24B

J02 JFET OUTPUT 1, SIGNALS 13-14

PIN #	PIN PURPOSE
1	SIGNAL 1A
2	SIGNAL 2A
3	SIGNAL 3A
4	SIGNAL 4A
5	SIGNAL 5A
6	SIGNAL 6A
7	SIGNAL 7A
8	SIGNAL 8A
9	SIGNAL 9A
10	SIGNAL 10A
11	SIGNAL 11A
12	SIGNAL 12A
13	FPU GND
14	SIGNAL 1B
15	SIGNAL 2B
16	SIGNAL 3B
17	SIGNAL 4B
18	SIGNAL 5B
19	SIGNAL 6B
20	SIGNAL 7B
21	SIGNAL 8B
22	SIGNAL 9B
23	SIGNAL 10B
24	SIGNAL 11B
25	SIGNAL 12B

J03 JFET OUTPUT 2, SIGNALS 1-12

PIN #	PIN PURPOSE
1	SIGNAL 13A
2	SIGNAL 14A
3	SIGNAL 15A
4	SIGNAL 16A
5	SIGNAL 17A
6	SIGNAL 18A
7	SIGNAL 19A
8	SIGNAL 20A
9	SIGNAL 21A
10	SIGNAL 22A
11	SIGNAL 23A
12	SIGNAL 24A
13	FPU GND
14	SIGNAL 13B
15	SIGNAL 14B
16	SIGNAL 15B
17	SIGNAL 16B
18	SIGNAL 17B
19	SIGNAL 18B
20	SIGNAL 19B
21	SIGNAL 20B
22	SIGNAL 21B
23	SIGNAL 22B
24	SIGNAL 23B
25	SIGNAL 24B

J04 JFET OUTPUT 2, SIGNALS 13-14

PIN #	PIN PURPOSE
1	SIGNAL 1A
2	SIGNAL 2A
3	SIGNAL 3A
4	SIGNAL 4A
5	SIGNAL 5A
6	SIGNAL 6A
7	SIGNAL 7A
8	SIGNAL 8A
9	SIGNAL 9A
10	SIGNAL 10A
11	SIGNAL 11A
12	SIGNAL 12A
13	FPU GND
14	SIGNAL 1B
15	SIGNAL 2B
16	SIGNAL 3B
17	SIGNAL 4B
18	SIGNAL 5B
19	SIGNAL 6B
20	SIGNAL 7B
21	SIGNAL 8B
22	SIGNAL 9B
23	SIGNAL 10B
24	SIGNAL 11B
25	SIGNAL 12B

J05 JFET INPUT 1

PIN #	PIN PURPOSE
1	VOLTAGE +
2	VOLTAGE -
3	SIGNAL 24A
4	SIGNAL 24B
5	SIGNAL 21A
6	SIGNAL 21B
7	SIGNAL 18A
8	SIGNAL 18B
9	SIGNAL 15A
10	SIGNAL 15B
11	SIGNAL 12A
12	SIGNAL 12B
13	SIGNAL 6A
14	SIGNAL 6B
15	SIGNAL 3A
16	SIGNAL 3B
17	SIGNAL 2A
18	SIGNAL 2B
19	BIAS GND
20	SIGNAL 23A
21	SIGNAL 22A
22	SIGNAL 20A
23	SIGNAL 19A
24	SIGNAL 17A
25	SIGNAL 16A
26	SIGNAL 14A
27	SIGNAL 13A
28	SIGNAL 11A
29	SIGNAL 10A
30	SIGNAL 9A
31	SIGNAL 8A
32	SIGNAL 7A
33	SIGNAL 5A
34	SIGNAL 4A
35	SIGNAL 1A
36	SIGNAL 23B
37	SIGNAL 22B
38	SIGNAL 20B
39	SIGNAL 19B
40	SIGNAL 17B
41	SIGNAL 16B
42	SIGNAL 14B
43	SIGNAL 13B
44	SIGNAL 11B
45	SIGNAL 10B
46	SIGNAL 9B
47	SIGNAL 8B
48	SIGNAL 7B
49	SIGNAL 5B
50	SIGNAL 4B
51	SIGNAL 1B

J06 JFET SERVICE 1

PIN #	PIN PURPOSE
1	Vss
2	V+
3	H+
4	V-
5	V-
6	H+
7	V+
8	Vss
9	BIAS GND
10	Vdd
11	H-
12	
13	H-
14	Vdd
15	BIAS GND

J07 JFET SERVICE 2

PIN #	PIN PURPOSE
1	Vss
2	V+
3	H+
4	V-
5	V-
6	H+
7	V+
8	Vss
9	BIAS GND
10	Vdd
11	H-
12	
13	H-
14	Vdd
15	BIAS GND

J08 JFET INPUT 2

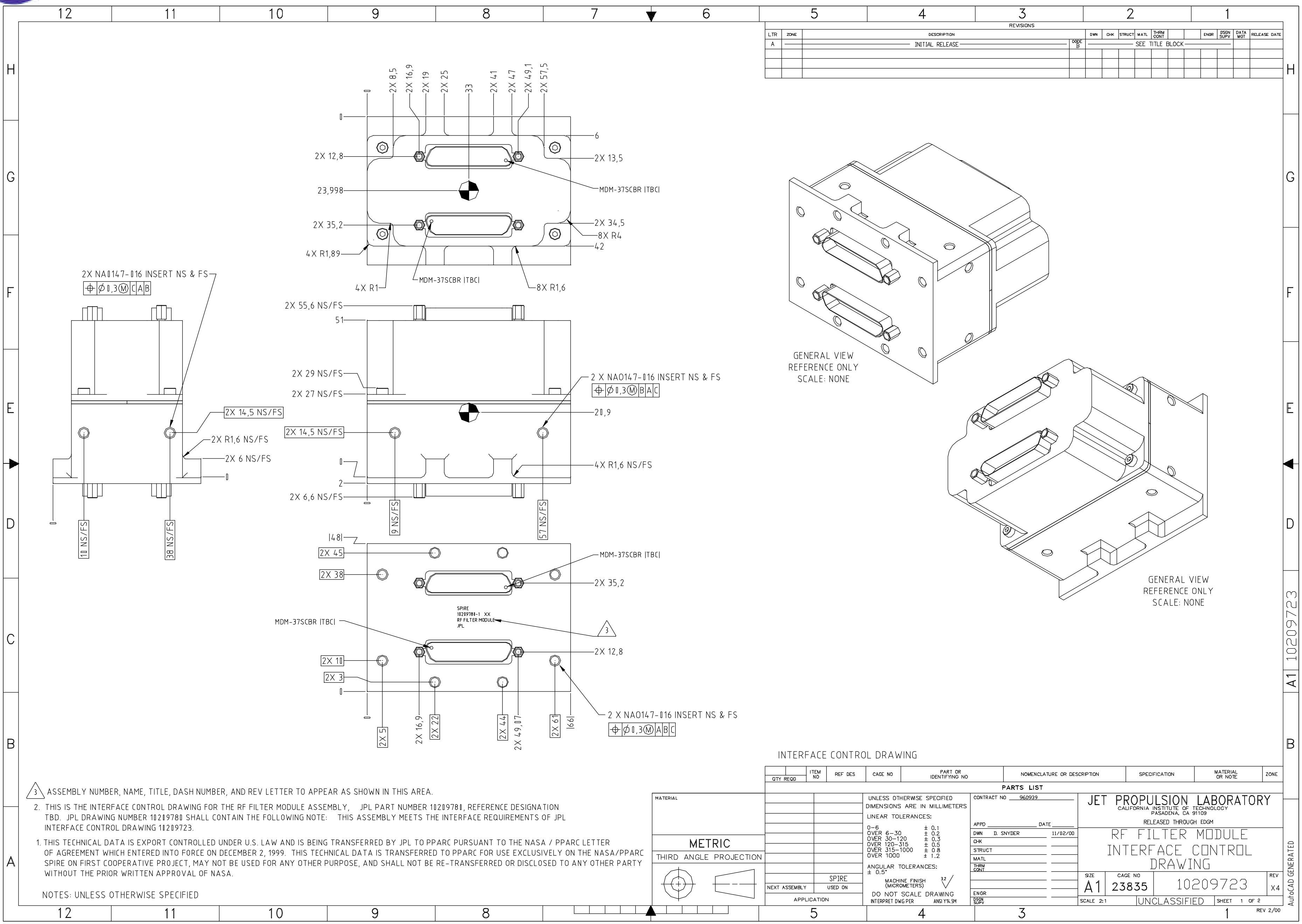
PIN #	PIN PURPOSE
1	VOLTAGE +
2	VOLTAGE -
3	SIGNAL 24A
4	SIGNAL 24B
5	SIGNAL 21A
6	SIGNAL 21B
7	SIGNAL 18A
8	SIGNAL 18B
9	SIGNAL 15A
10	SIGNAL 15B
11	SIGNAL 12A
12	SIGNAL 12B
13	SIGNAL 6A
14	SIGNAL 6B
15	SIGNAL 3A
16	SIGNAL 3B
17	SIGNAL 2A
18	SIGNAL 2B
19	BIAS GND
20	SIGNAL 23A
21	SIGNAL 22A
22	SIGNAL 20A
23	SIGNAL 19A
24	SIGNAL 17A
25	SIGNAL 16A
26	SIGNAL 14A
27	SIGNAL 13A
28	SIGNAL 11A
29	SIGNAL 10A
30	SIGNAL 9A
31	SIGNAL 8A
32	SIGNAL 7A
33	SIGNAL 5A
34	SIGNAL 4A
35	SIGNAL 1A
36	SIGNAL 23B
37	SIGNAL 22B
38	SIGNAL 20B
39	SIGNAL 19B
40	SIGNAL 17B
41	SIGNAL 16B
42	SIGNAL 14B
43	SIGNAL 13B
44	SIGNAL 11B
45	SIGNAL 10B
46	SIGNAL 9B
47	SIGNAL 8B
48	SIGNAL 7B
49	SIGNAL 5B
50	SIGNAL 4B
51	SIGNAL 1B

SIZE	CAGE NO		REV
A1	23835	10209722	X5
SCALE NONE		UNCLASSIFIED	SHEET 2 OF 2

A1 10209722

AutoCAD GENERATED

REV 2/00



REVISIONS
LTR | ZONE | DESCRIPTION | DWN | CHK | STRUCT | MATL | THRM CONT | ENGR | DSGN SUPV | DATA MGT | RELEASE DATE
A | INITIAL RELEASE | SEE TITLE BLOCK
2X 8,5
2X 16,9
2X 19
2X 25
33
2X 41
2X 47
2X 49,1
2X 57,5
6
2X 12,8
2X 13,5
23,998
MDM-37SCBR (TBC)
2X 35,2
2X 34,5
8X R4
42
4X R1,89
4X R1
MDM-37SCBR (TBC)
8X R1,6
2X NA0147-016 INSERT NS & FS
2X 55,6 NS/FS
51
2X 29 NS/FS
2X 27 NS/FS
2 X NA0147-016 INSERT NS & FS
20,9
2X 14,5 NS/FS
2X 14,5 NS/FS
2X R1,6 NS/FS
2X 6 NS/FS
4X R1,6 NS/FS
2
2X 6,6 NS/FS
10 NS/FS
38 NS/FS
9 NS/FS
57 NS/FS
(48)
2X 45
2X 38
MDM-37SCBR (TBC)
2X 35,2
MDM-37SCBR (TBC)
SPIRE
10209780-1 XX
RF FILTER MODULE
JPL
2X 12,8
2X 10
2X 3
2 X NA0147-016 INSERT NS & FS
2X 5
2X 16,9
2X 22
2X 44
2X 49,07
2X 61
(66)
GENERAL VIEW
REFERENCE ONLY
SCALE: NONE
GENERAL VIEW
REFERENCE ONLY
SCALE: NONE
INTERFACE CONTROL DRAWING
3 ASSEMBLY NUMBER, NAME, TITLE, DASH NUMBER, AND REV LETTER TO APPEAR AS SHOWN IN THIS AREA.
2. THIS IS THE INTERFACE CONTROL DRAWING FOR THE RF FILTER MODULE ASSEMBLY, JPL PART NUMBER 10209780, REFERENCE DESIGNATION TBD. JPL DRAWING NUMBER 10209780 SHALL CONTAIN THE FOLLOWING NOTE: THIS ASSEMBLY MEETS THE INTERFACE REQUIREMENTS OF JPL INTERFACE CONTROL DRAWING 10209723.
1. THIS TECHNICAL DATA IS EXPORT CONTROLLED UNDER U.S. LAW AND IS BEING TRANSFERRED BY JPL TO PPARC PURSUANT TO THE NASA / PPARC LETTER OF AGREEMENT WHICH ENTERED INTO FORCE ON DECEMBER 2, 1999. THIS TECHNICAL DATA IS TRANSFERRED TO PPARC FOR USE EXCLUSIVELY ON THE NASA/PPARC SPIRE ON FIRST COOPERATIVE PROJECT, MAY NOT BE USED FOR ANY OTHER PURPOSE, AND SHALL NOT BE RE-TRANSFERRED OR DISCLOSED TO ANY OTHER PARTY WITHOUT THE PRIOR WRITTEN APPROVAL OF NASA.
NOTES: UNLESS OTHERWISE SPECIFIED
QTY REQD | ITEM NO | REF DES | CAGE NO | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | SPECIFICATION | MATERIAL OR NOTE | ZONE
PARTS LIST
MATERIAL
METRIC
THIRD ANGLE PROJECTION
SPIRE
NEXT ASSEMBLY | USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
LINEAR TOLERANCES:
0-6 ± 0.1
OVER 6-30 ± 0.2
OVER 30-120 ± 0.3
OVER 120-315 ± 0.5
OVER 315-1000 ± 0.8
OVER 1000 ± 1.2
ANGULAR TOLERANCES:
± 0.5°
MACHINE FINISH (MICROMETERS) 3.2
DO NOT SCALE DRAWING
INTERPRET DWG PER ANSI Y14.5M
CONTRACT NO 960939
APPD DATE
DWN D. SNYDER 11/02/00
CHK
STRUCT
MATL
THRM CONT
ENGR
DSGN SUPV
JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CA 91109
RELEASED THROUGH EDGM
RF FILTER MODULE
INTERFACE CONTROL
DRAWING
SIZE A1
CAGE NO 23835
10209723
REV X4
SCALE 2:1
UNCLASSIFIED
SHEET 1 OF 2
REV 2/00
A1 10209723
AutoCAD GENERATED

J01 RF OUTPUT 1

PIN #	PIN PURPOSE
1	OUTPUT 1
2	OUTPUT 2
3	OUTPUT 3
4	OUTPUT 4
5	OUTPUT 5
6	OUTPUT 6
7	OUTPUT 7
8	OUTPUT 8
9	OUTPUT 9
10	OUTPUT 10
11	OUTPUT 11
12	OUTPUT 12
13	OUTPUT 13
14	OUTPUT 14
15	OUTPUT 15
16	OUTPUT 16
17	OUTPUT 17
18	OUTPUT 18
19	OUTPUT 19
20	OUTPUT 20
21	OUTPUT 21
22	OUTPUT 22
23	OUTPUT 23
24	OUTPUT 24
25	OUTPUT 25
26	OUTPUT 26
27	OUTPUT 27
28	OUTPUT 28
29	OUTPUT 29
30	OUTPUT 30
31	OUTPUT 31
32	OUTPUT 32
33	OUTPUT 33
34	OUTPUT 34
35	OUTPUT 35
36	OUTPUT 36
37	OUTPUT 37

J02 RF OUTPUT 2

PIN #	PIN PURPOSE
1	OUTPUT 38
2	OUTPUT 39
3	OUTPUT 40
4	OUTPUT 41
5	OUTPUT 42
6	OUTPUT 43
7	OUTPUT 44
8	OUTPUT 45
9	OUTPUT 46
10	OUTPUT 47
11	OUTPUT 48
12	OUTPUT 49
13	OUTPUT 50
14	OUTPUT 51
15	OUTPUT 52
16	OUTPUT 53
17	OUTPUT 54
18	OUTPUT 55
19	OUTPUT 56
20	OUTPUT 57
21	OUTPUT 58
22	OUTPUT 59
23	OUTPUT 60
24	OUTPUT 61
25	OUTPUT 62
26	OUTPUT 63
27	OUTPUT 64
28	OUTPUT 65
29	OUTPUT 66
30	OUTPUT 67
31	OUTPUT 68
32	OUTPUT 69
33	OUTPUT 70
34	OUTPUT 71
35	OUTPUT 72
36	OUTPUT 73
37	OUTPUT 74

J05 RF INPUT 1

PIN #	PIN PURPOSE
1	INPUT 1
2	INPUT 2
3	INPUT 3
4	INPUT 4
5	INPUT 5
6	INPUT 6
7	INPUT 7
8	INPUT 8
9	INPUT 9
10	INPUT 10
11	INPUT 11
12	INPUT 12
13	INPUT 13
14	INPUT 14
15	INPUT 15
16	INPUT 16
17	INPUT 17
18	INPUT 18
19	INPUT 19
20	INPUT 20
21	INPUT 21
22	INPUT 22
23	INPUT 23
24	INPUT 24
25	INPUT 25
26	INPUT 26
27	INPUT 27
28	INPUT 28
29	INPUT 29
30	INPUT 30
31	INPUT 31
32	INPUT 32
33	INPUT 33
34	INPUT 34
35	INPUT 35
36	INPUT 36
37	INPUT 37

J05 RF INPUT 2

PIN #	PIN PURPOSE
1	INPUT 38
2	INPUT 39
3	INPUT 40
4	INPUT 41
5	INPUT 42
6	INPUT 43
7	INPUT 44
8	INPUT 45
9	INPUT 46
10	INPUT 47
11	INPUT 48
12	INPUT 49
13	INPUT 50
14	INPUT 51
15	INPUT 52
16	INPUT 53
17	INPUT 54
18	INPUT 55
19	INPUT 56
20	INPUT 57
21	INPUT 58
22	INPUT 59
23	INPUT 60
24	INPUT 61
25	INPUT 62
26	INPUT 63
27	INPUT 64
28	INPUT 65
29	INPUT 66
30	INPUT 67
31	INPUT 68
32	INPUT 69
33	INPUT 70
34	INPUT 71
35	INPUT 72
36	INPUT 73
37	INPUT 74

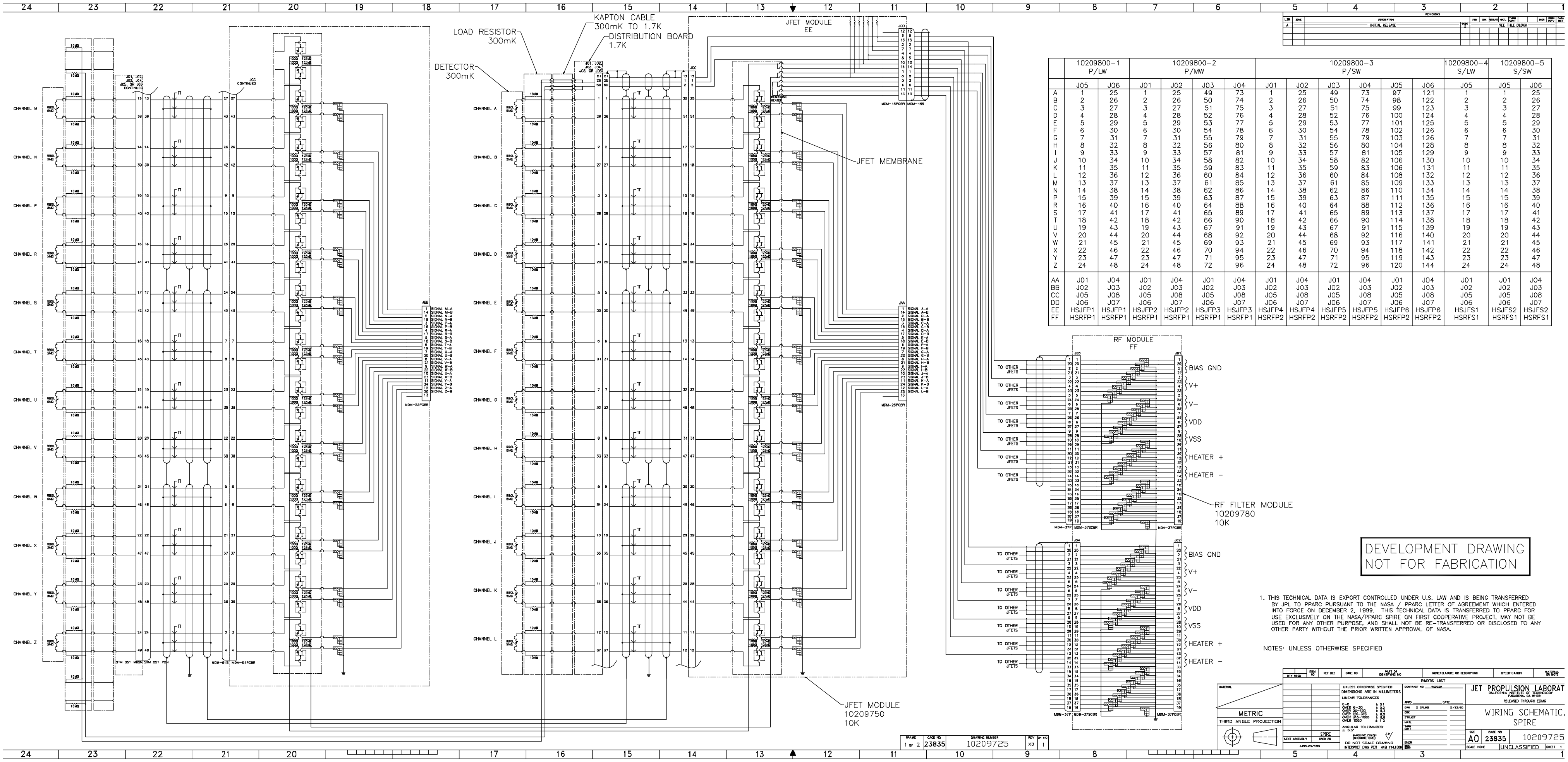
A1 10209723

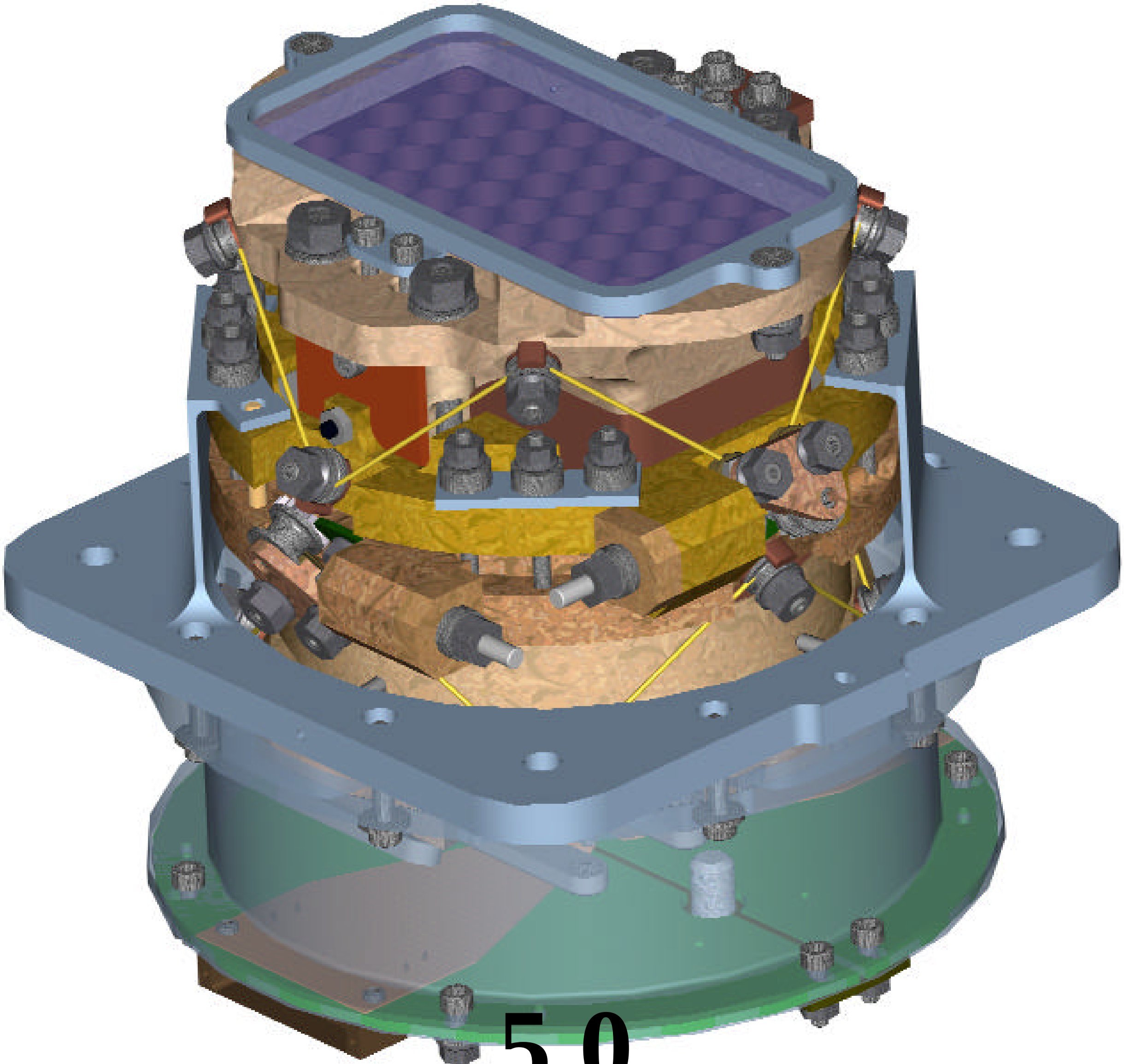
SIZE	CAGE NO		REV
A1	23835	10209723	X4
SCALE NONE	UNCLASSIFIED	SHEET 2 OF 2	

REV 2/00

AutoCAD GENERATED

Wiring Schematic





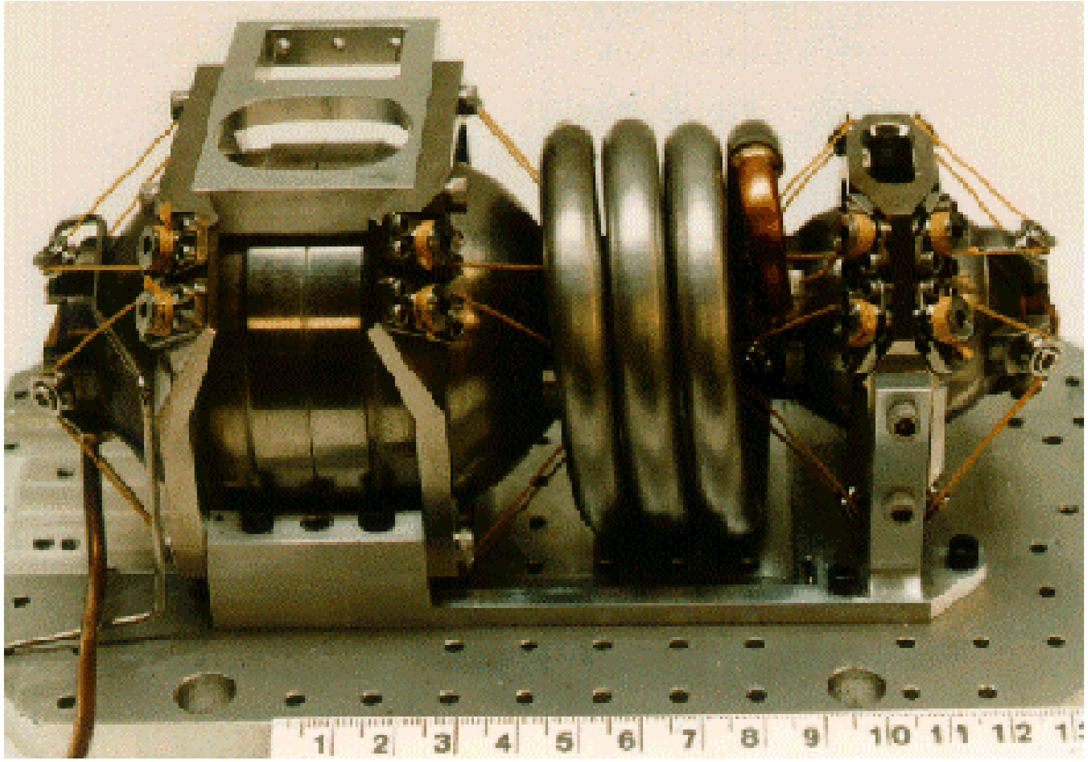
5.0

Bolometer Detector Assembly (BDA)

Requirements

Specification ID	Description	Requirement Reference	Compliant
BDA-TEC-01	The BDA shall accommodate a defined mechanical interface to the 2 K structure.	IRD-DETS-R08 IRD-DETP-R14 IRD-STRP-R01	Yes
BDA-TEC-02	The BDA shall provide an attachment point and/or a thermal interconnect to a 300 mK thermal strap.	IRD-STRP-R01	Yes
BDA-TEC-03	The BDA mass will have a design value of 600 g (TBC) average over 5 detector arrays, including output connectors.	IRD-SUBS-03	Yes
BDA-TEC-04	The first resonant frequency of the BDA will be > 200 Hz (TBC), with a goal of > 250 Hz.	IRD-DETP-R15 IRD-DETS-R16	Yes
BDA-TEC-05	The mechanical envelope of the BDA will be described by the ICD.	IRD-DETP-R12 IRD-DETS-R13	Yes
BDA-TEC-06	The total power dissipated onto the 300 mK cooler will be < 15 μW (minimum performance); < 8 μW (design value). Assumes the focal plane mount is held at 1.7 K.	IRD-DETP-R13	Minimum Value not compliant. Design Value is compliant.

Array Design Mechanical Structure Heritage: Kevlar Supports



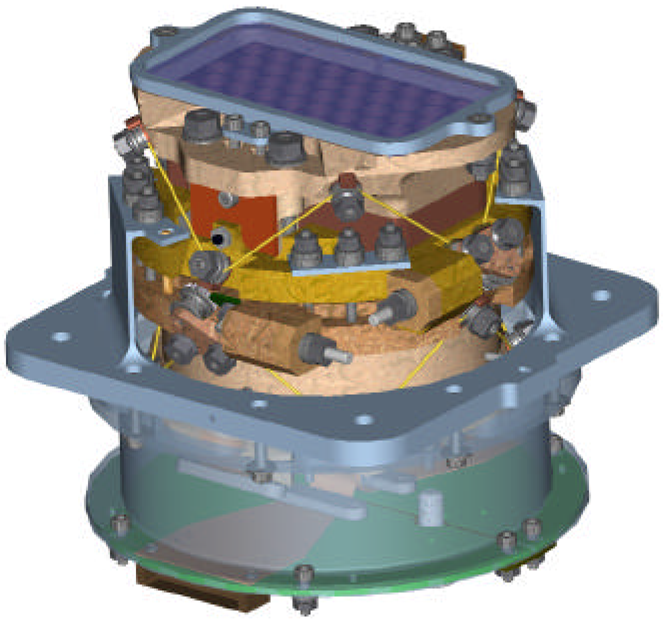
^{3}He Refrigerator for the Infrared Telescope in Space

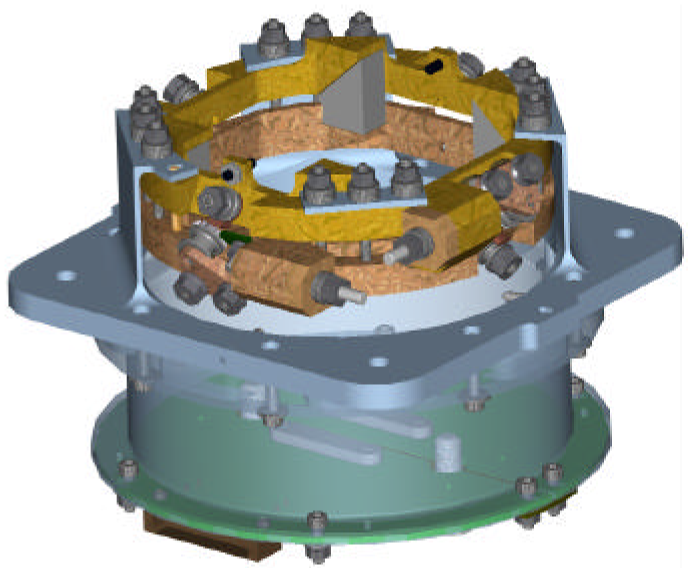
- suspended mass =350 g
- lowest resonant frequency = 280 Hz
- single-strand/pully/kapston design
- tensioned maintained by thermal contraction
- < 1μW kevlar heat leak to 300mK
- successfully flown on IRTS

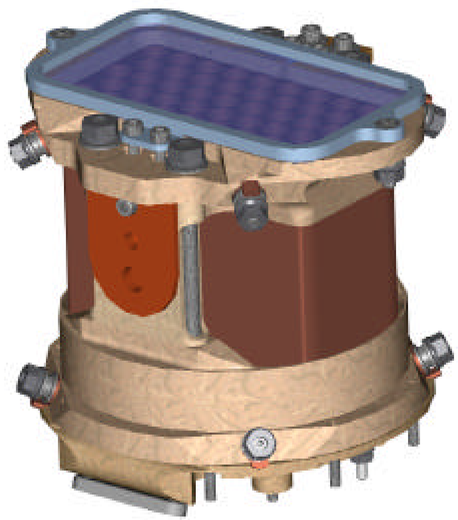
Array Design
Mechanical Structure

75 x 75 mm

80 mm





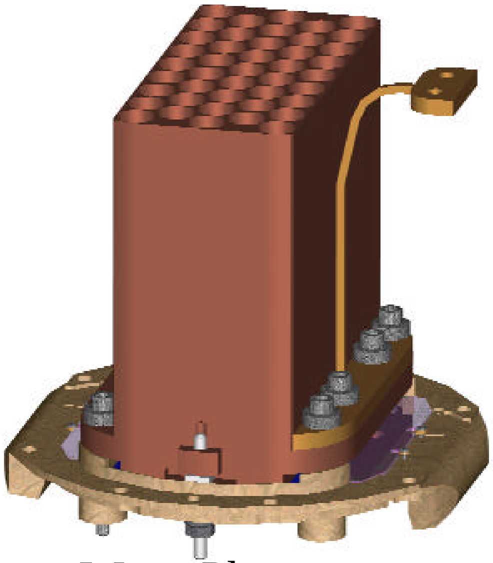


Focal Plane

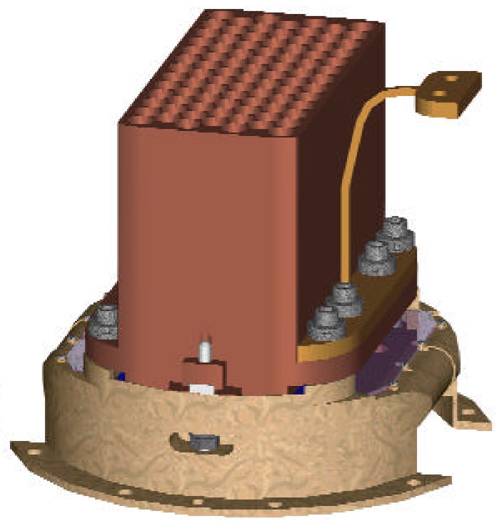
2K Structure

.3K Structure

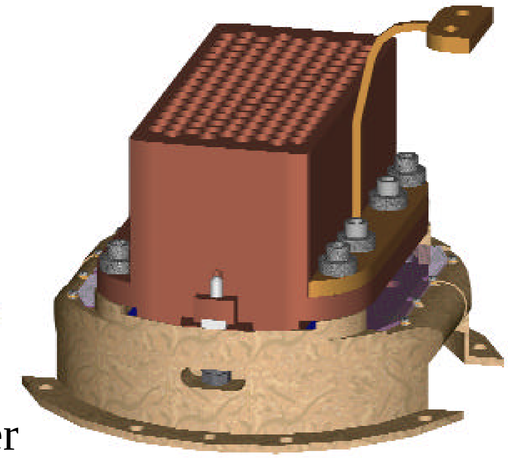
Detector Design/Detector Assembly



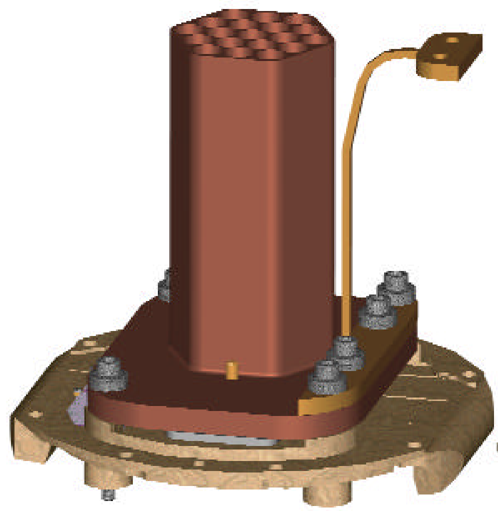
Long Wave Photometer



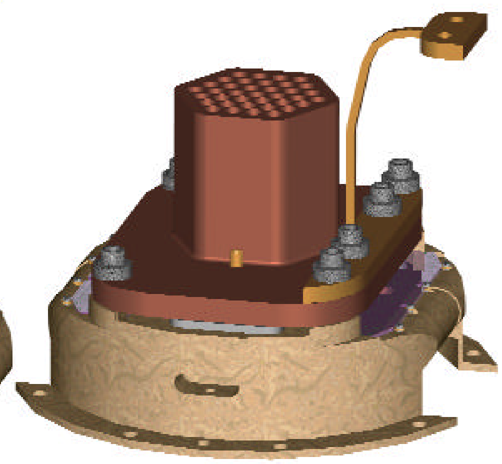
Medium Wave Photometer



Short Wave Photometer



Long Wave Spectrometer



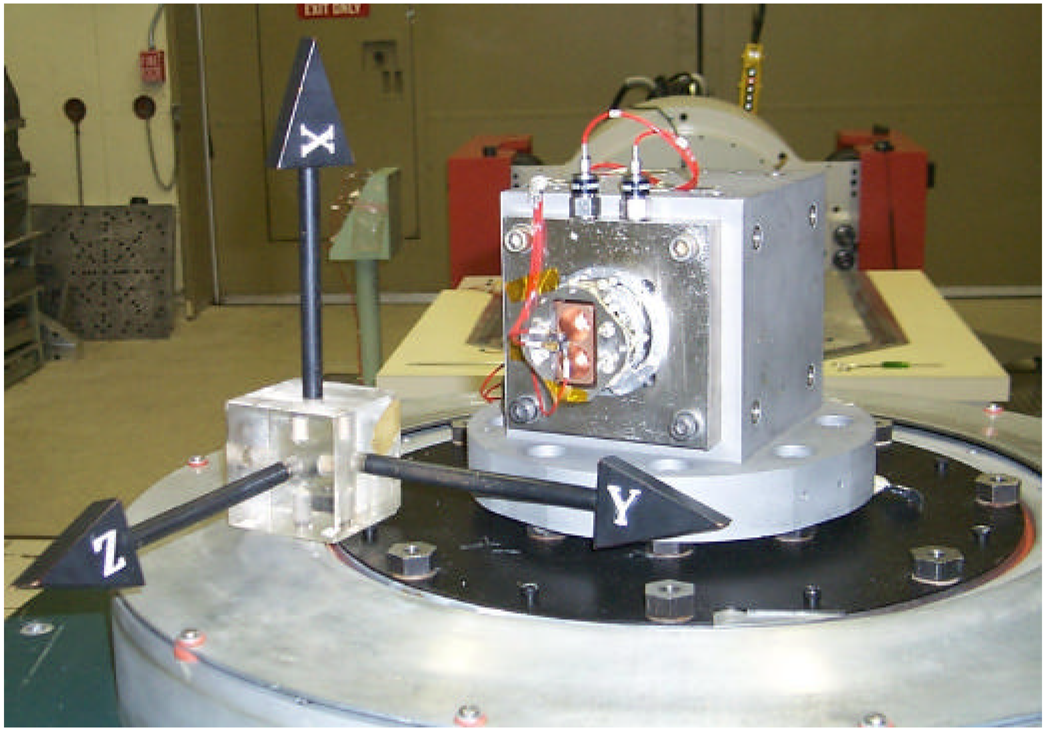
Short Wave Spectrometer

Array Design: Fabrication of Mechanical Prototype
Prototype finished January 2000

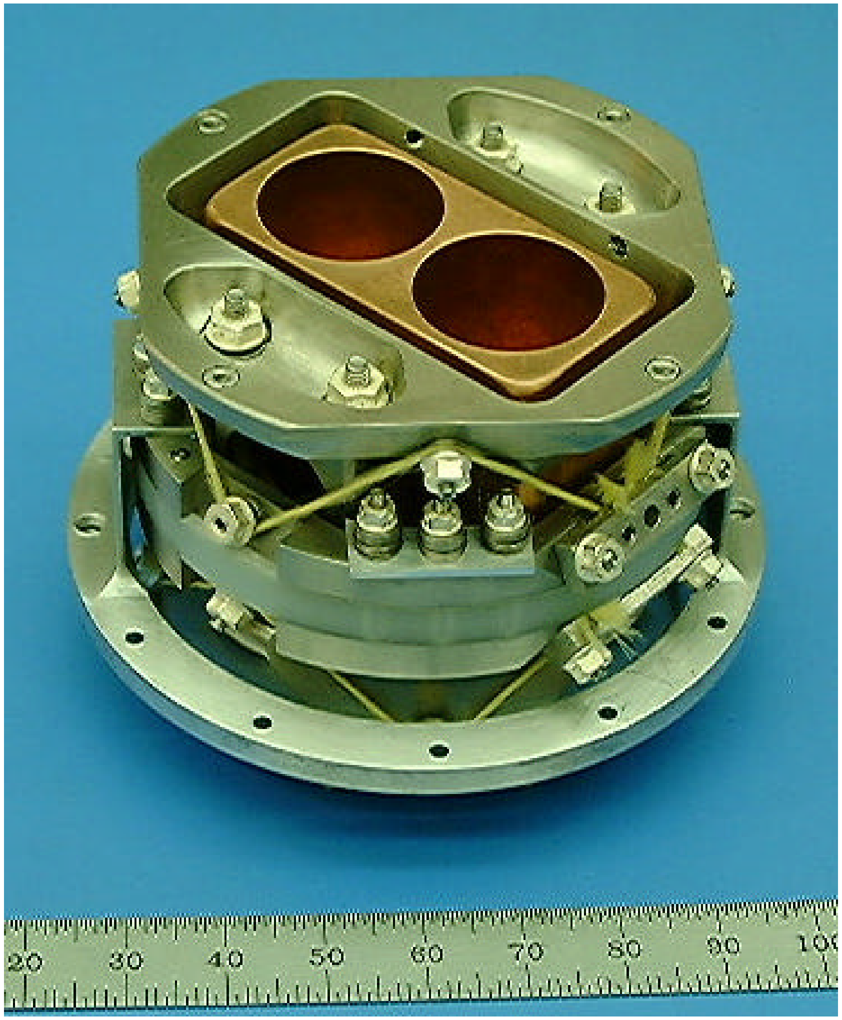
1st Natural Frequency is
208.6 Hz Experimental

Vibration test level:

5 - 30 Hz: 2.1 mm displacement amplitude
30 - 400 Hz: 7.5 G acceleration amplitude
400 - 2000 Hz: 15 G acceleration amplitude



SPIRE FPU under vibration test



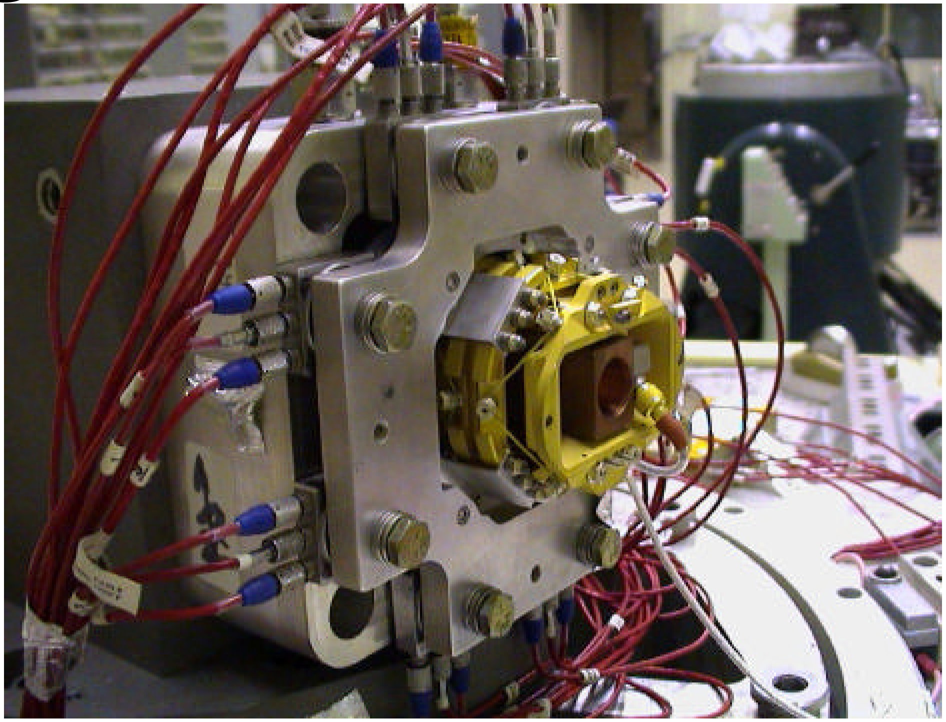
SPIRE Focal Plane Unit

Engineering Models

Three units Built

- Thermal Characterization Model
- Vibration Model
- Spare Unit

Engineering Models



Vibration Model

- •Metrology
- •Warm Shake
- •Metrology
- •Thermal Cycled to LN_2
- •Metrology
- •Warm Shake with force Transducers
- •Metrology
- •Cold Shake
- •Metrology

Need table of metrology results after each test

Mass Summary (grams)

	Previous Mass	Current Mass	Change
P/LW Detector	639	672	4.8%
P/MW Detector	574	615	6.6%
P/SW Detector	520	564	7.8%
S/LW Detector	494	482	2.6%
S/SW Detector	445	466	4.6%
	Current Average	560	4.2%
	Allocated	600	
	Margin	6.7%	

Mass may still come down depending on how feedhorns are manufactured.

Structural Analysis - BDA

Materials				
Material - Temper	Alum 7075 - T7351	Invar 36	Kevlar 29	Vespel
Reference	MIL-HDBK-5H Table 3.7.4.0(b3)	Carpenter Technology Corp.	MatWeb	Dupont, Vespel Design Hdbk
Form	Plate	Cold Drawn Bar	3000 Denier	SP1 - M
Basis	A			
Ftu, ksi		90	400	12.5
L	68			
LT	69			
Fty, ksi		70		
L	57			
LT	57			
Fcy, ksi				
L	56			
LT	59			
Fsu, ksi	38	& 54		
Fbru, ksi				
(e/D = 1.5)	103	# 90		
(e/D = 2.0)	132			
Fbry, ksi				
(e/D = 1.5)	81	# 70		
(e/D = 2.0)	97			
E, 10^3 ksi	10.3	2.05	9.0	0.45
G, 10^3 ksi	3.9			
μ	0.33	0.3		0.41
ρ, lb/in^3	0.101	0.291	0.051	0.052
α*, in/in/°F	9.14E-06	1.25E-06	-1.11E-06	1.69E-05

* NASA Tech Brief, "Thermal Expansion Properties of Aerospace Materials", Brief 69-10055, March 1969

& Taken as 60% of Ftu

Fbru and Fbry are taken as Ftu and Fty respectively. This is conservative since bearing values are typically 1.5 times higher.

Structural Analysis - BDA

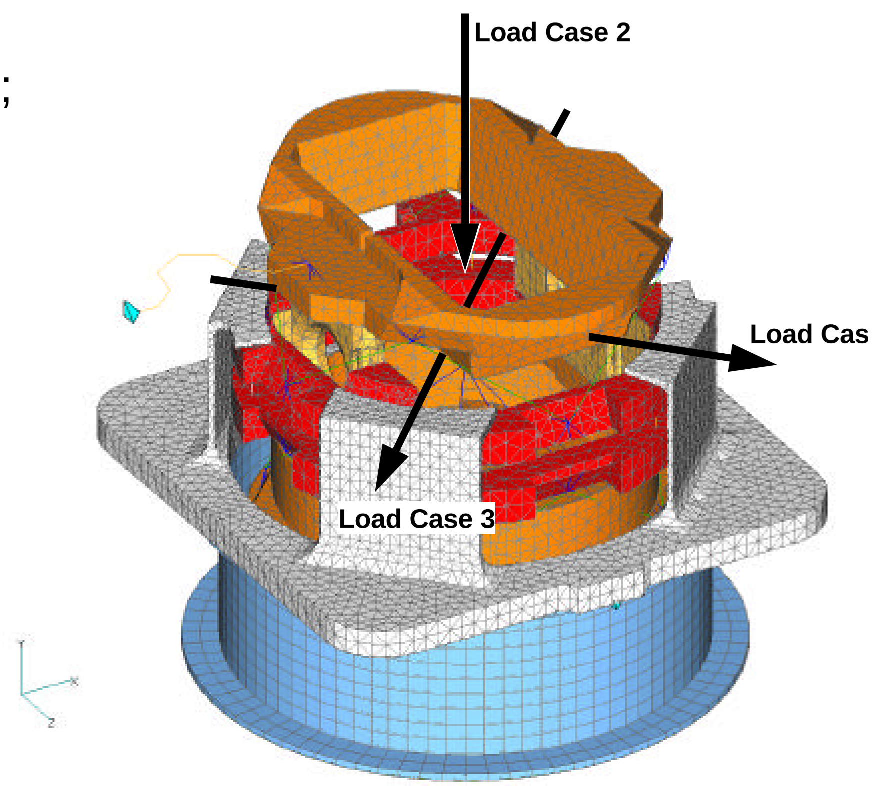
- Analysis Requirements Used to Verify Structural Integrity
  - Qualification Random Vibration Levels (IID - A)

Location	Axis	Freq Range	Density	RMS Value
Herschel Optical Bench	ALL	20 - 80 Hz 80 - 300 Hz 300 - 2000 Hz	+3 db/Oct .077 G^2/Hz -6 db/Hz	6.67 G

  - Factors of Safety (ERD D-19155)
    - FS_{yld} = 1.25
    - FS_{ult} = 1.4
    - Unconventional Material FS_{ult} = 2.0 (e.g. Kevlar cable)
  - Limit Loads (ERD D-19155)
    - 20 G Any Direction

Structural Analysis - BDA

- Load Cases (applied in three directions deemed most critical for stress)
  - Each load case consists of:
    - 82 G Quasi Static Equivalent Load
      - 1.5% damping (JPL Std.)
      - 3σ Value
      - Value above Limit Load requirement; wanted to assess capability
    - 50 lb. Kevlar cable preload
    - Thermal transition from 70ºF to -460ºF



- Constraints
  - Fixed at BDA-to-FPU Fastener Locations (4 Locations)
  - Appropriate DOFs constrained for guiding pins (2 pins)

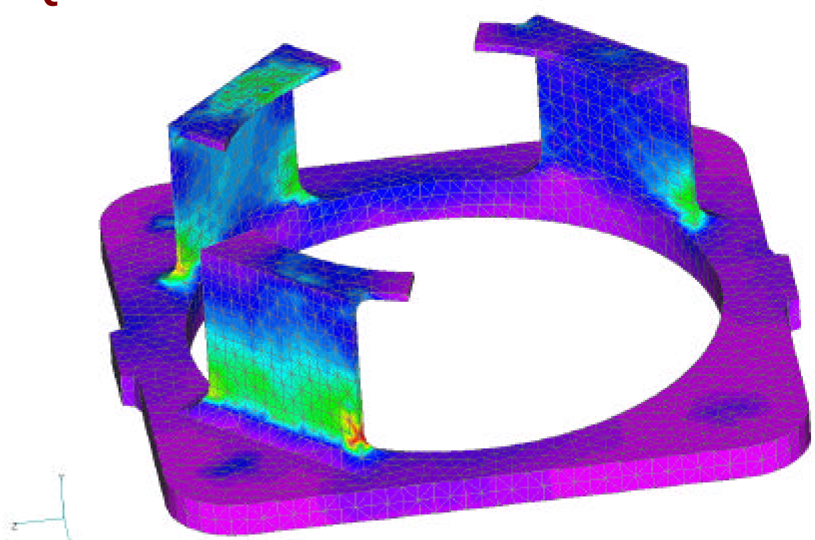
Structural Analysis - BDA

Margin of Safety Summary for Structural Elements at Qualification Levels

Part	Load Case	Stress	F.S. (Yield)	F.S. (Ult.)	F_{yld}	F_{ult}	Failure Mode	MS (Yield)	MS (Ult.)
Flexure Ring	82G(.707, 0., .707),P,T	27,871 psi	1.25	1.4	57,000 psi	68,000 psi	Von Mises	0.64	0.74
Top Ring	82G(.707, 0., .707),P,T	25,082 psi	1.25	1.4	70,000 psi	90,000 psi	Von Mises	1.23	1.56
Invar Rings	82G(-.707, 0., .707),P,T	21,878 psi	1.25	1.4	70,000 psi	90,000 psi	Von Mises	1.56	1.94
Light Can	82G(.707, 0., .707),P,T	3,990 psi	1.25	1.4	36,000 psi	42,000 psi	Von Mises	6.22	6.52
Spacers	82G(-.707, 0., .707),P,T	10,155 psi	1.25	1.4	70,000 psi	90,000 psi	Von Mises	4.51	5.33
Cover Plate (P/LW & S/LW)	82G(-.707, 0., .707),P,T	11,986 psi	1.25	1.4	70,000 psi	90,000 psi	Von Mises	3.67	4.36
Bottom Ring	82G (0., -1., 0.),P,T	38,396 psi	1.25	1.4	70,000 psi	90,000 psi	Von Mises	**0.46**	0.67
Kevlar Cable	82G(-.707, 0., .707),P,T	199,199 psi	N/A	2.0	N/A	400,000 psi	Tension	N/A	**0.00**

N/A = Not Applicable

Margin of Safety Summary for Fasteners at Qualification Levels



Location	Load Case	FSult	Failure Mode	M.S. (ult)
Circuit Board to Light Can	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	2.24
Light Can to Flexure Ring	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	1.83
Flexures to Invar Ring	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	1.55
Bottom Ring to Cover Plate	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	1.92
Spacer to Top Ring & Bottom Ring	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	**1.41**
Spacer to Top Ring (Horiz)	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	2.41
BDA to Detector	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	1.54
Spacer to Bottom Ring Pins	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	3.77
Flexure to Invar Ring Pins	82G RSS, P, T	1.4	Bolt Tension-Shear Interaction	3.68
Pulley Fastener (Bot Ring - 2.0 mm dia)	82G (0, -1., 0.), P, T	1.4	Bolt Tension-Shear Interaction	1.64

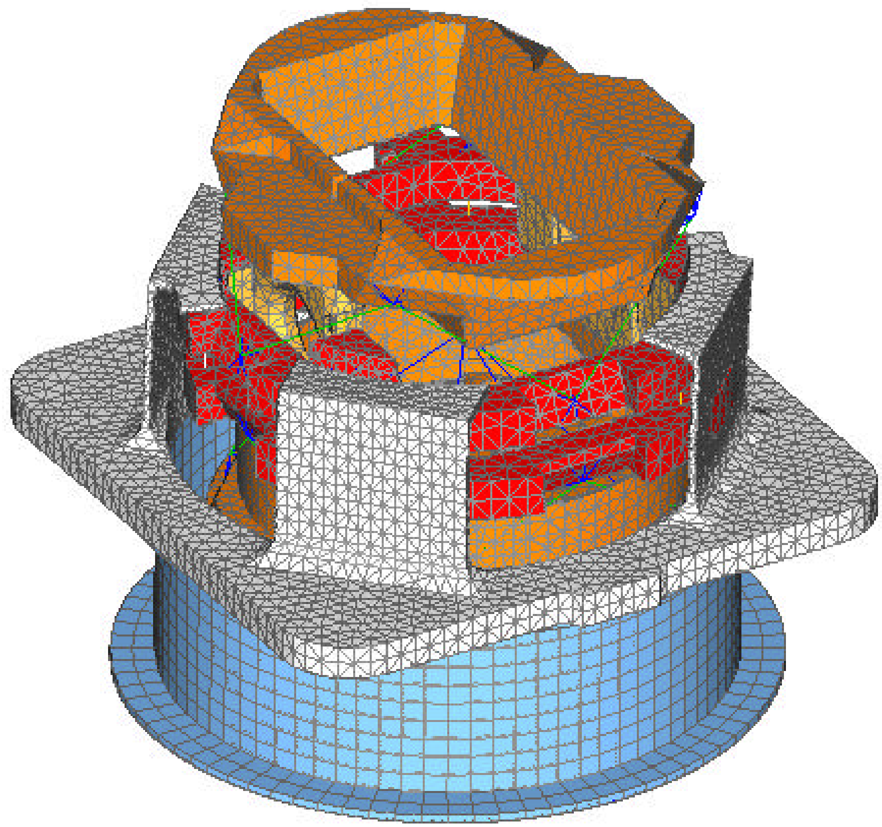
RSS = Root-Sum-Square

Structural Analysis - BDA

- Computer Model Validation - Comparison to Test Data
  - Modal Frequencies
    - Tests were conducted with S/LW variant of detector

Mode #	Computer Model (S/LW)	Warm Test	Cold Test
	(Hz)	(Hz)	(Hz)
1	265	253	TBD
2	328	386	TBD
3	399	486	TBD

Table of damping values



Mode 1: 265 Hz

Structural Analysis - BDA

- Where Are We Now?
  - Input Spectrum at BDA interface as proposed by MSSL
    - Quasi Static Equivalent (3σ Value) = 278 G

Location	Axis	Freq Range	Density	RMS Value
Herschel Optical Bench	ALL	20 - 100 Hz 100 - 600 Hz 600 - 2000 Hz	+6 db/Oct .8 G^2/Hz -6 db/Hz	27.9 G

VS.

  - Survivable Spectrum for Current Design (Machined Parts Only)
    - Quasi Static Equivalent (3σ Value) = 102 G

Location	Axis	Freq Range	Density	RMS Value
Herschel Optical Bench	ALL	20 - 100 Hz 100 - 600 Hz 600 - 2000 Hz	+6 db/Oct .17 G^2/Hz -6 db/Hz	12.74 G

Kevlar Testing

• Pulley diameter is not strongly tied to breaking strength for yarn.

• Clamping kevlar reduces ultimate strength by approximately 10%.

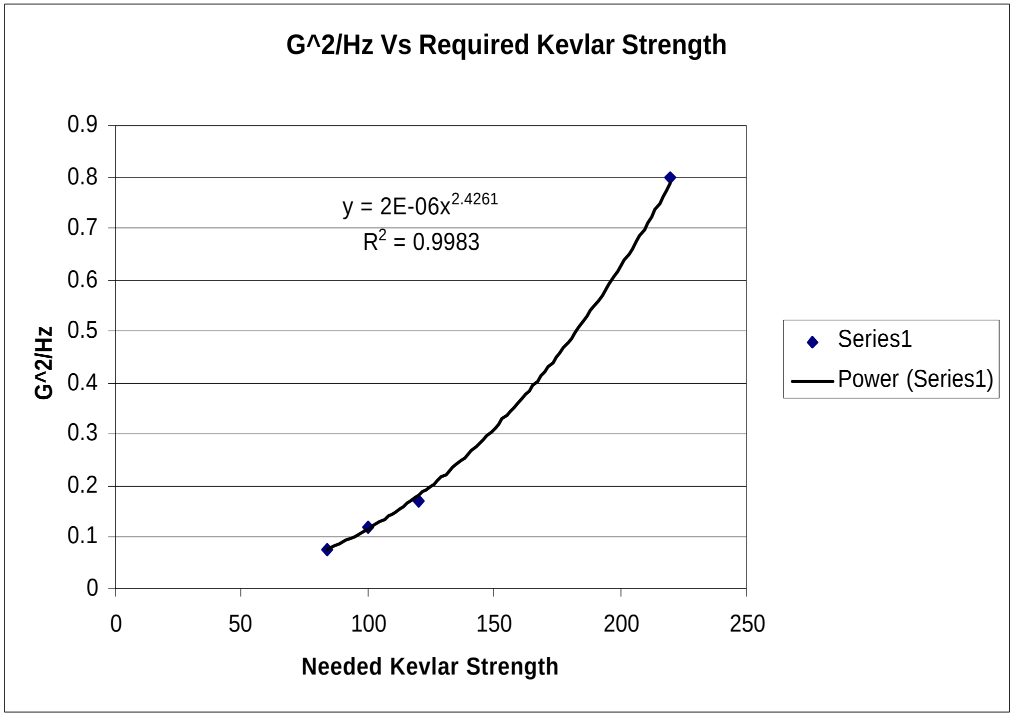
• Original EM capstan design provided under 30% of rated strength for yarn

• New larger capstan design now baseline for CQM provides better then 95% of rated strength for braided

Kevlar Preload

G^2/Hz	Dynamic +/-	Recommended Preload	Max Dynamic Load	Needed Strength
0.077	16	26	42	84
0.170	25	35	60	120
0.800	50	60	110	220
~0.12*	20	30	50	100

- 100lbs is Max load demonstrated so far
- Value estimated from curve fit of a power series
- Assumes 1.5% damping



Time Dependent Properties of Kevlar

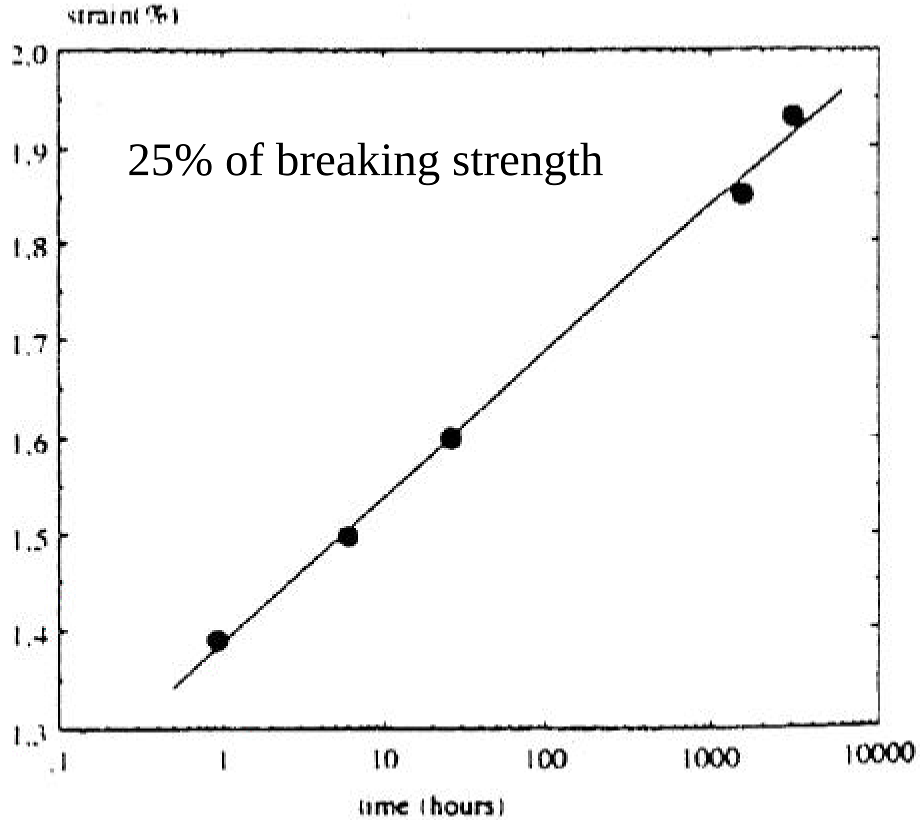
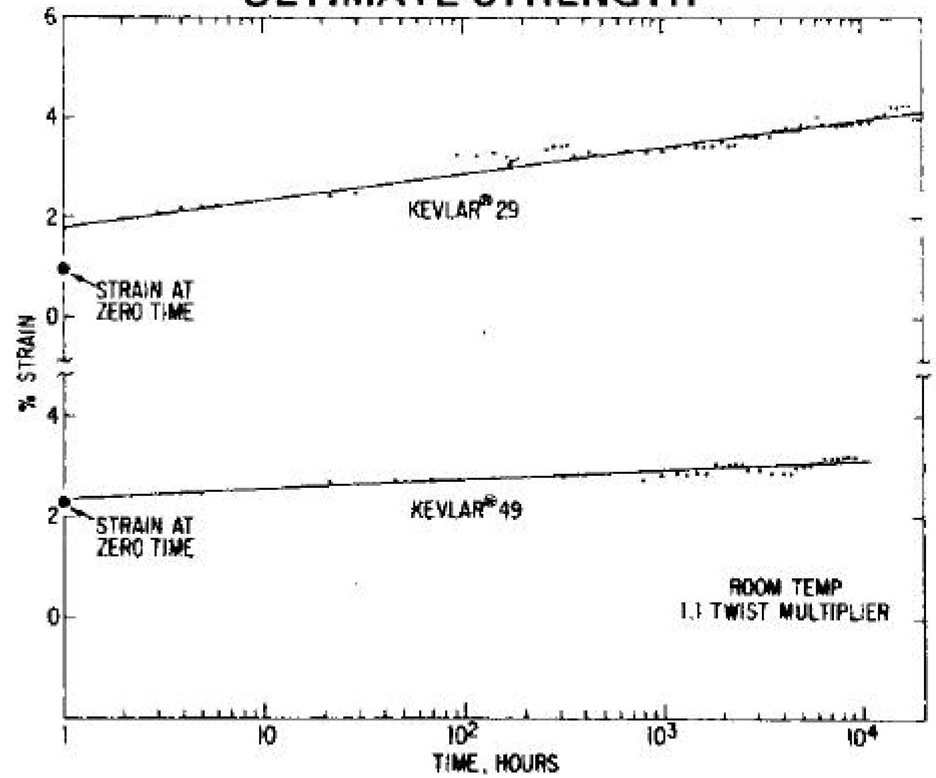


Figure 4 Measured creep of Kevlar 29 braided cords

Graph from **L. Duband, L. Hui and A. Lange.** Thermal Isolation of large loads at low temperature using Kevlar rope *Cryogenics* (1993) 33 643-647

FIGURE 5
CREEP OF YARNS OF KEVLAR® 29 AND KEVLAR® 49 ARAMID AT 50% OF ULTIMATE STRENGTH



Graph from Characteristics and Uses of Kevlar 29 Aramid, company memo, Dupont, Wilmington, Deleware, USA.

Kevlar Issues

Yarn - Highest Strength, difficult to work with, hard to do it same way every time

Braided - Easiest to work with, fraction of strength of Yarn

Twisted - Need more information on

List of Materials in BDA

- AL 6061-T6
- AL 7075
- A 286 CRES
- INVAR 36
- 303 CRES
- Kapton
- Vespel
- Kevlar 29
- 2216 Epoxy
- HDPE

- Silicon Nitride
- Gold
- Miller Stevens 903 Epoxy
- CDA 172
- Copper 99.999%
- Constantin
- Indium
- NTD Germanium
- Buried Oxide Silicon Wafers
- Nickel
- Titanium
- Ablestik 84-3 Epoxy (TBC)