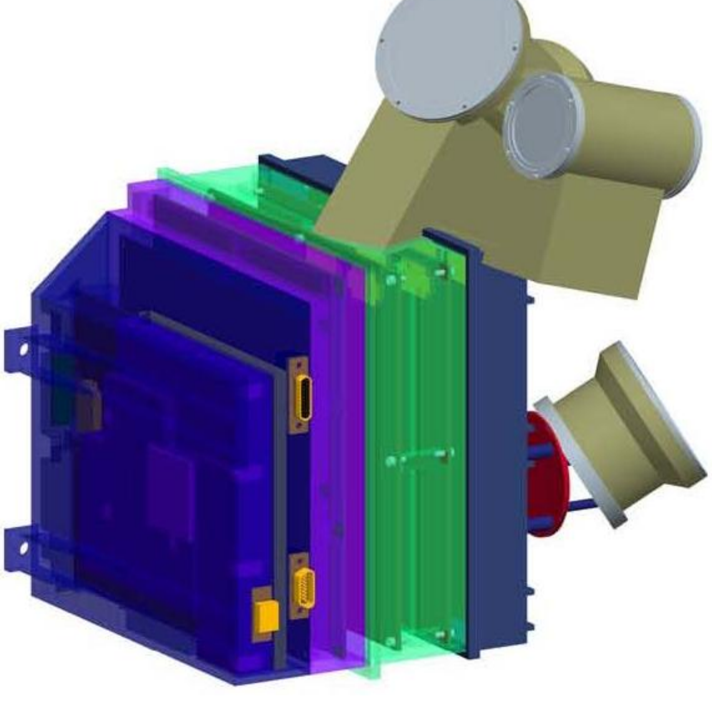
EPI-HI Instrument

Mechanical Peer Review

03 October 2013

Sandy Shuman



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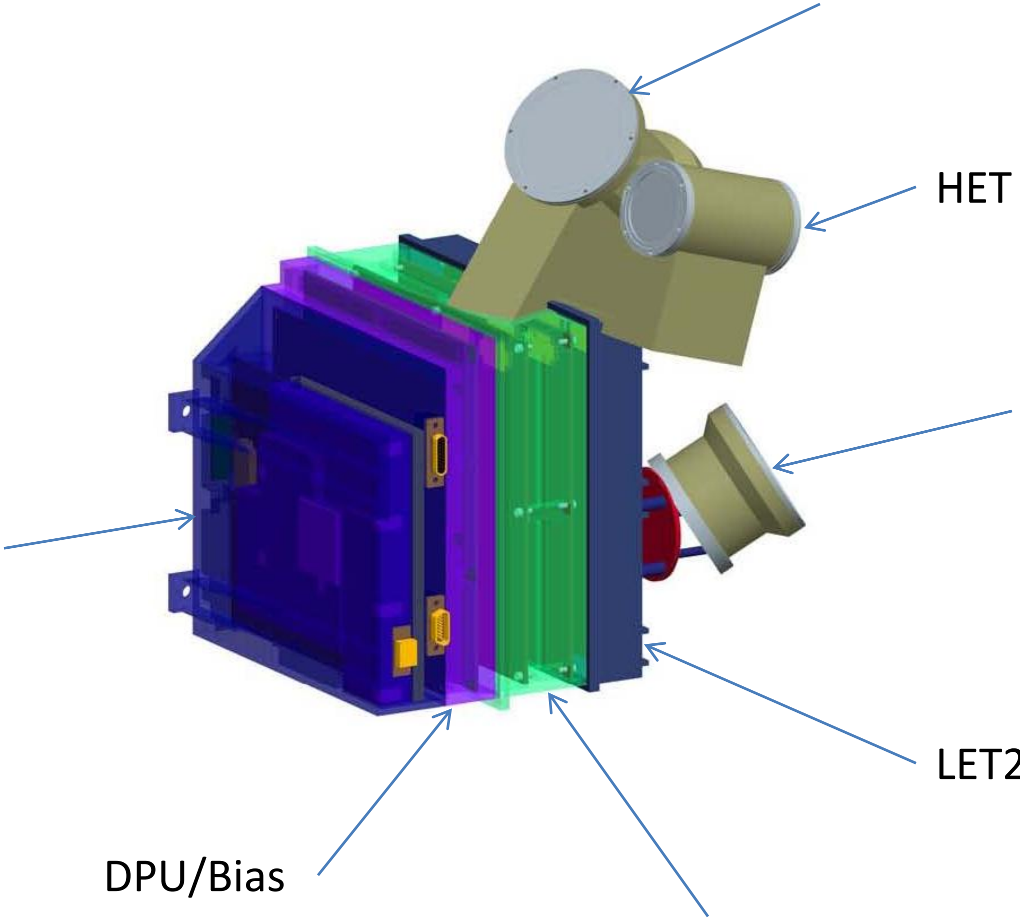
03-Oct-13



LET 1 Telescope

HET Telescope

LET2 Telescope

LVPS

LET2 Electronics

DPU/Bias

LET & HET Electronics

EPI-HI Configuration

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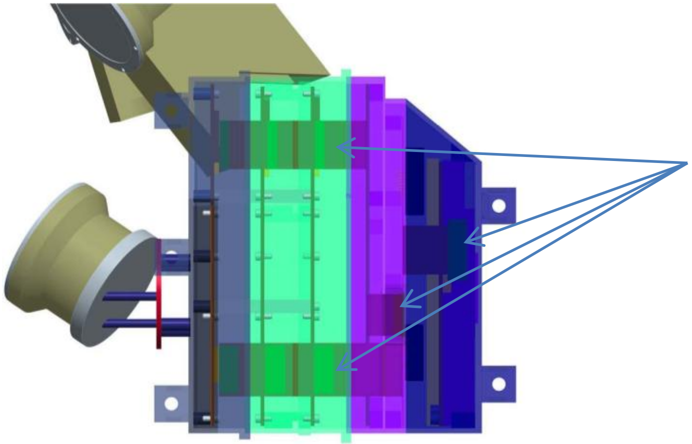
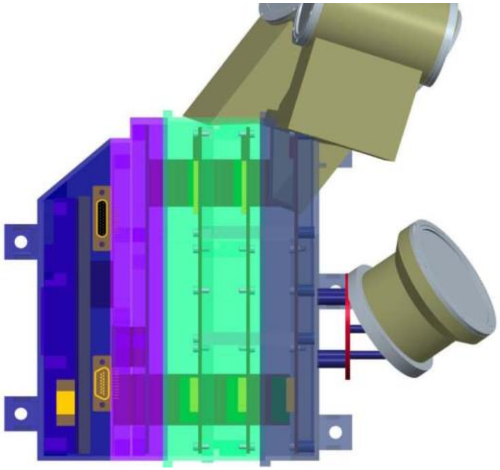


*Access panels in Instrument walls for connector access



*S/C Connections on Instrument wall.
*Instrument isolated from S/C Brkt.
*Instrument has 5 mounting feet.
*Telescopes electrically isolated from Electronics Box.

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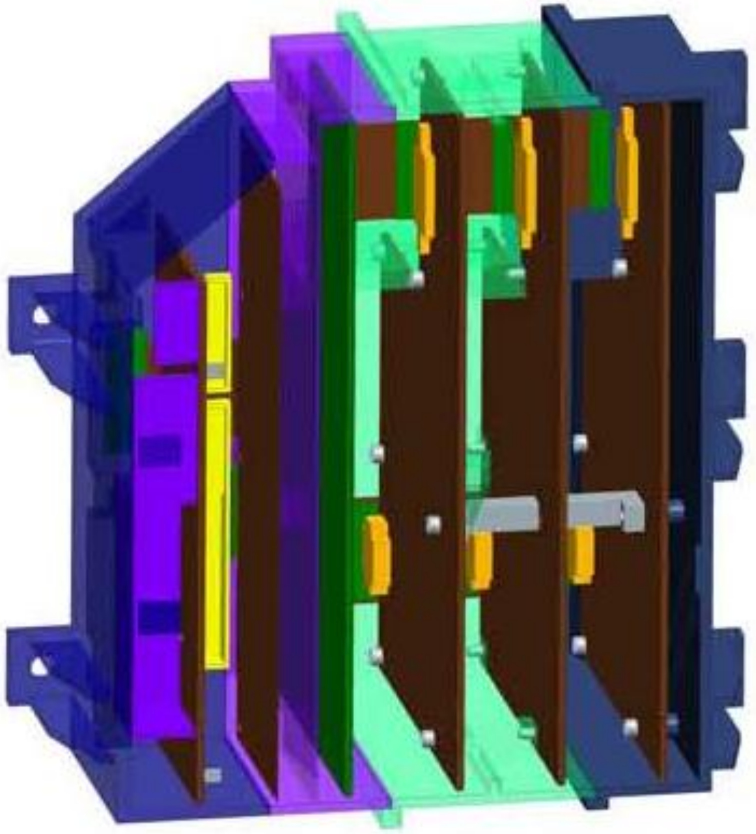

*Frames tied together with standard 300 series stainless steel hardware.

*Frames constructed of 6061 aluminum.

*PCB's constructed of multi-layer fiberglass reinforced polyimide.

*Internal shielding constructed from 6061 aluminum.

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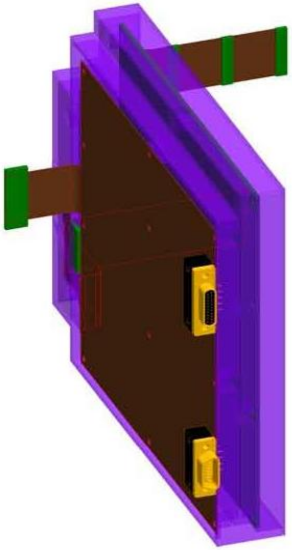
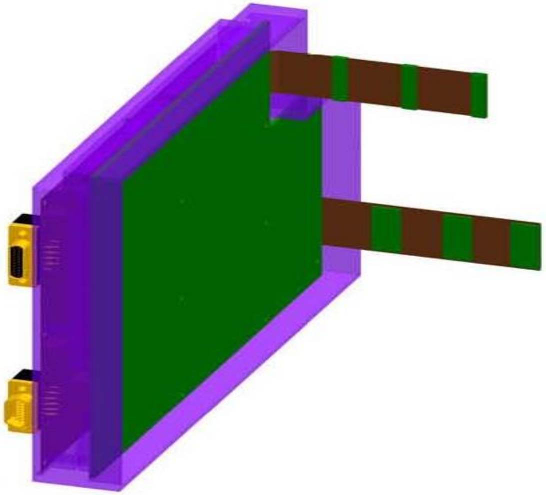


DPU Board (mounted in one side of frame)

- *Flex connection to Telescope Boards
- *Flex connection to LVPS
- *S/C connectors (PCB mount)
- *PCB's mounted to machined in posts in chassis



Bias Supply Board (mounted in one side of frame)

- *Flex connection to 3 Detector Boards
- *Flex connection DPU Board
- *R/F shielding
- * PCB's mounted to machined in posts in chassis

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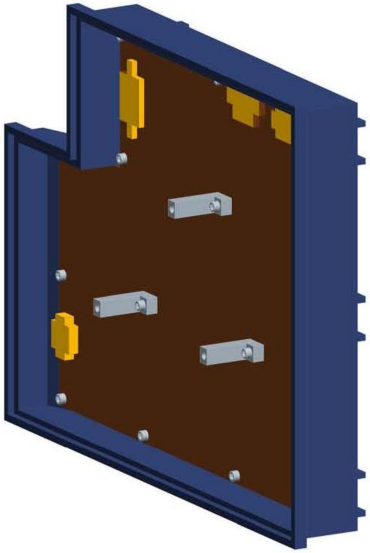


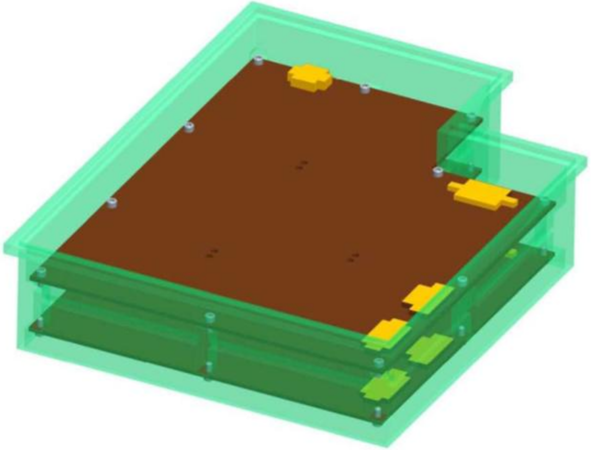
LET2 Telescope Electronics Assembly

*Receives flex connection from Bias Board

*Receives flex connection from DPU Board

*Receives 2 flex connections from Telescope

*Housing provides feet for Instrument to bracket mounting.



HET1 & LET1 Electronics Assembly

Each board receives:

*Flex connection from Bias Board

*Flex connection from DPU Board

*2 Flex connections from Telescope

*PCB's mounted to machined in posts in chassis

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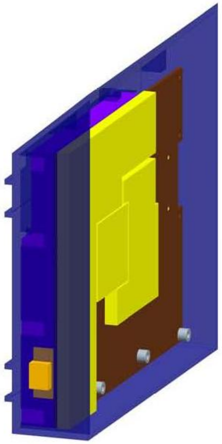

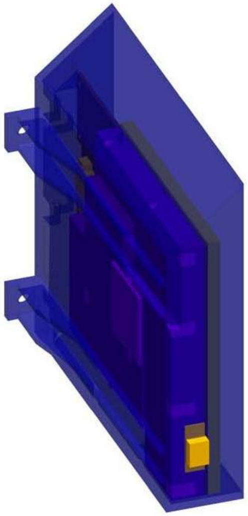

Low Voltage Power Supply

*Receives flex connection from DPU Board

* S/C connectors (PCB mount)

*Individually shielded primary/secondary circuits top and bottom.

*Housing is tapered to avoid HET Telescope FOV

*Housing provides feet for Instrument to bracket mounting.

*PCB's mounted to machined in posts in chassis

*LVPS Board provided by APL

*Chassis and shields designed/provided by instrument team.

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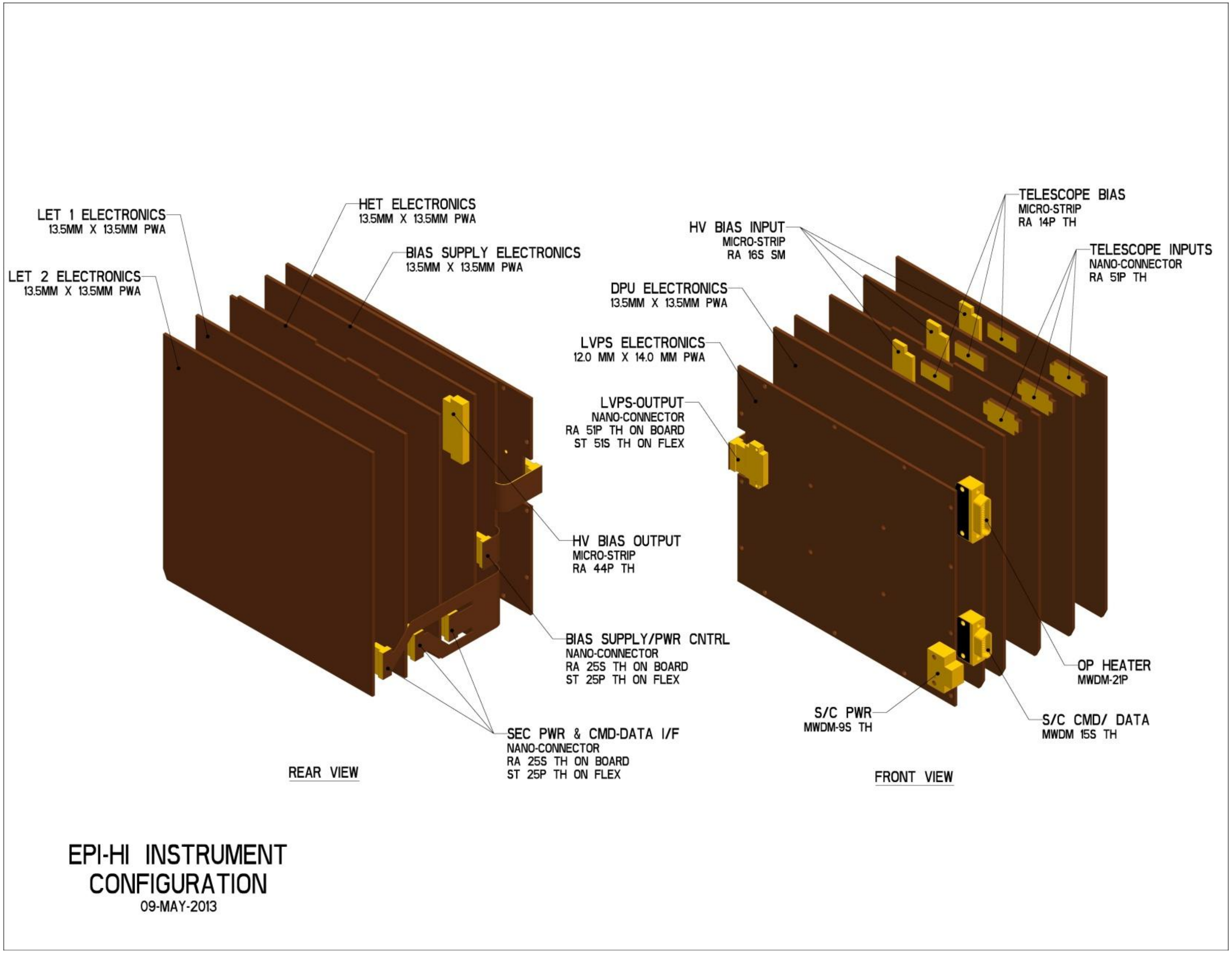

Typical Board stackup (old board size)

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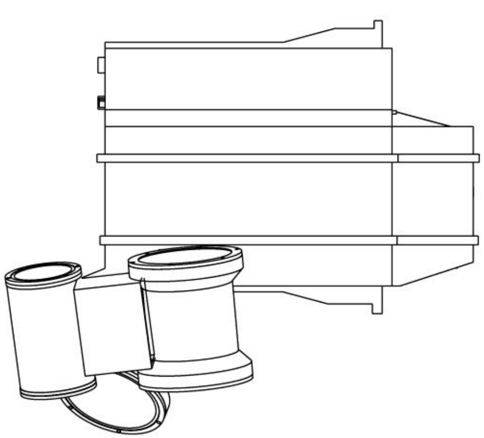
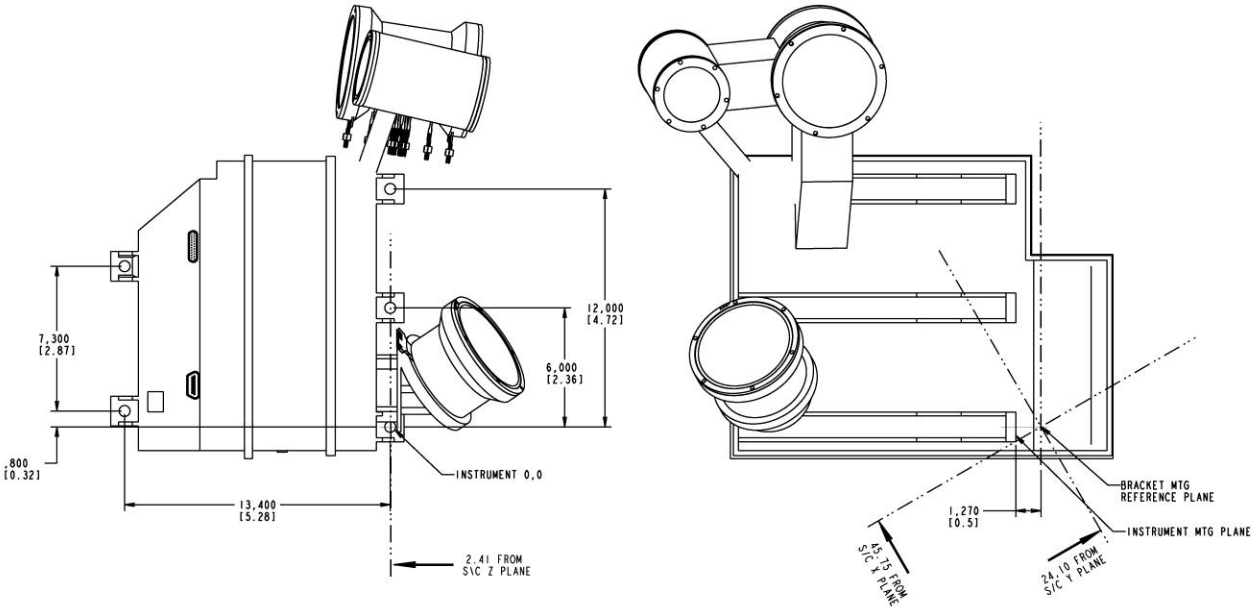
```
MASS =  3.377 e+03 GRAM

CENTER OF GRAVITY W/RESPECT TO S/C CSYS COORDINATE FRAME:
X   Y   Z     5.5555013e+01  2.0430936e+01  1.1242619e+01  CM

INERTIA W/RESPECT TO S/C CSYS COORDINATE FRAME::  (GRAM * CM^2)

INERTIA TENSOR:
Ixx Ixy Ixz  1.9844028e+06 -3.8264025e+06 -2.0818260e+06
Iyx Iyy Iyz -3.8264025e+06  1.1062405e+07 -7.8087049e+05
Izx Izy Izz -2.0818260e+06 -7.8087049e+05  1.2059160e+07

INERTIA AT CENTER OF GRAVITY W/RESPECT TO S/C CSYS COORDINATE FRAME: (GRAM * CM^2)

INERTIA TENSOR:
Ixx Ixy Ixz  1.4353416e+05  1.5792760e+04  3.2435239e+04
Iyx Iyy Iyz  1.5792760e+04  1.8699473e+05 -3.3288509e+03
Izx Izy Izz  3.2435239e+04 -3.3288509e+03  1.9860362e+05

PRINCIPAL MOMENTS OF INERTIA:  (GRAM * CM^2)
I1  I2  I3   1.2455042e+05  1.9042901e+05  2.1415307e+05

ROTATION MATRIX FROM S/C CSYS ORIENTATION TO PRINCIPAL AXES:
       0.88403         0.15828         0.43983
      -0.24481         0.95834         0.14717
      -0.39821        -0.23777         0.88594

ROTATION ANGLES FROM S/C CSYS ORIENTATION TO PRINCIPAL AXES (degrees):
ANGLES ABOUT  X  Y  Z    -9.432          26.093          -10.151

RADII OF GYRATION W/RESPECT TO PRINCIPAL AXES:
R1  R2  R3 6.0658077e+00  7.5003683e+00  7.9538646e+00  CM
```





PRELIMINARY

PLOT DATE: 20-Aug-13

Instrument Properties

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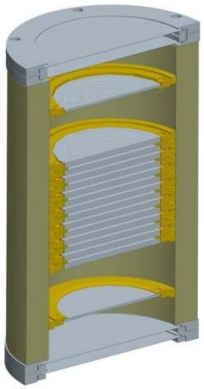
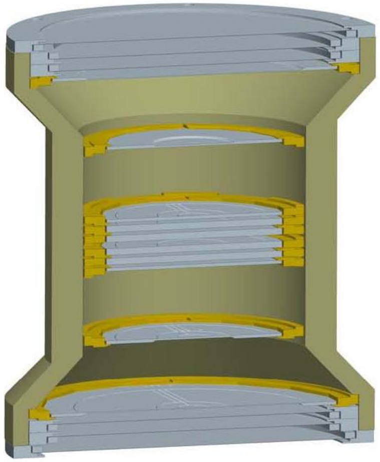


HET Telescope Assembly

- *Double Foil for Micro-Meteorite/Light protection
- *Double Ended Field of View
- *Silicon Wafer Detector Stack
- *Flex-Rigid Detector Mounts



LET Telescope Assembly

- *Triple Foil for Micro-Meteorite/Light protection
- *LET1 Double Ended Field of View
- *LET2 Single Ended Field of View
- *Silicon Wafer Detector Stack
- *Flex-Rigid Detector Mounts

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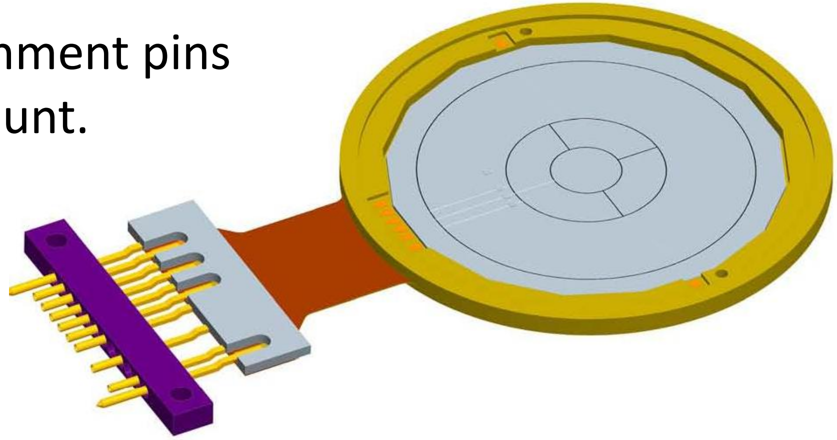
Typical Detector in Flex-rigid PCB Mount

- *Silicon Wafer attached to Polyimide shelf
- *Micro-strip connector output
- * Alignment achieved with alignment pins and concentric shelves on mount.



Current Issues: Failed interconnect strips:

Resolution: *Added stiffener (shown above) to rigidize the area across the transition of pad/trace.

*Redesign of cover layer to cover transition point to reduce gold embrittlement.

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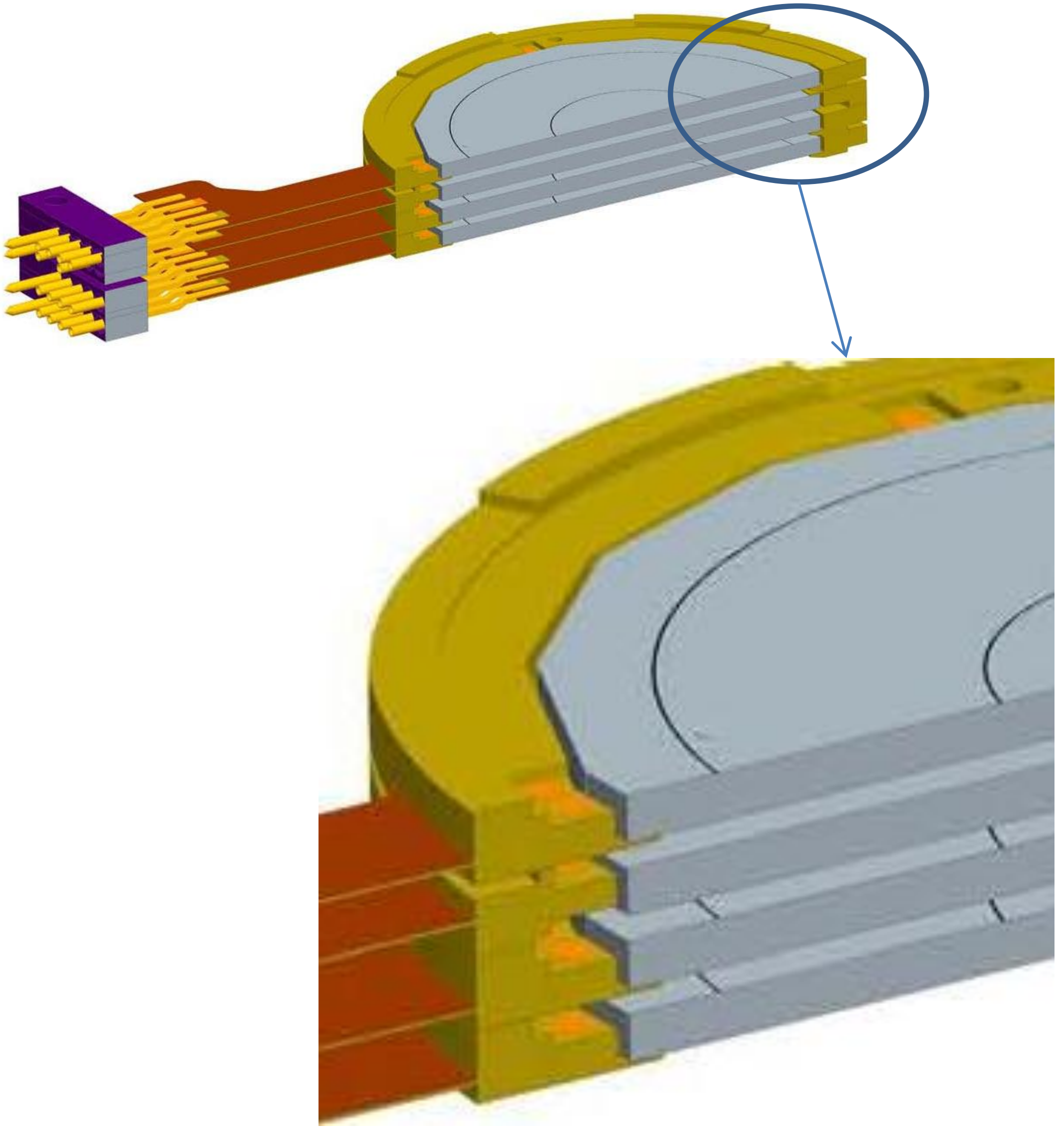

*Mount design allows stacking of detectors face to face, face to back and back to back while maintaining same spacing .

*Detector spacing= 0.5MM

*Detector Voltage ~200V

*Mounts provide adequate spacing for wirebond wire clearance

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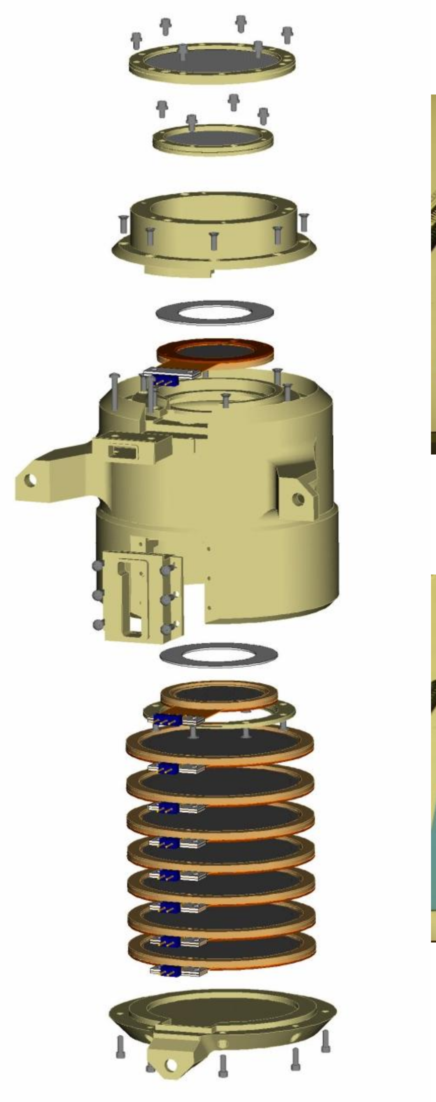
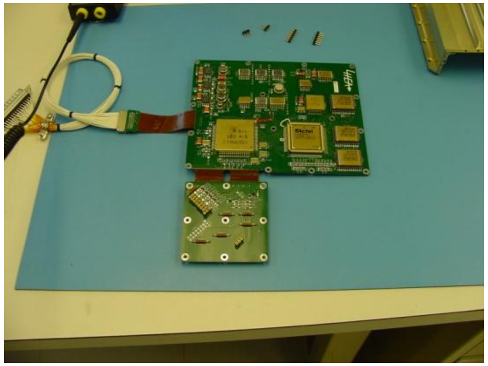
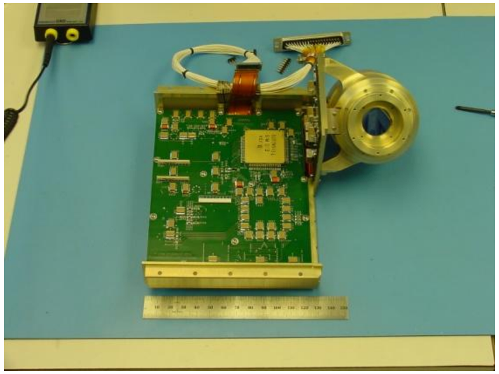






Telescope/Bracket Mounting and Interconnect:

- *Heritage design
- *Uses alignment pins to stack detectors in telescope body
- *Mounting bracket designed into telescope body.
- *Output signal cable will be completely enclosed in assembly providing proper shielding.

Pictures shown are of STEREO\HET Telescope

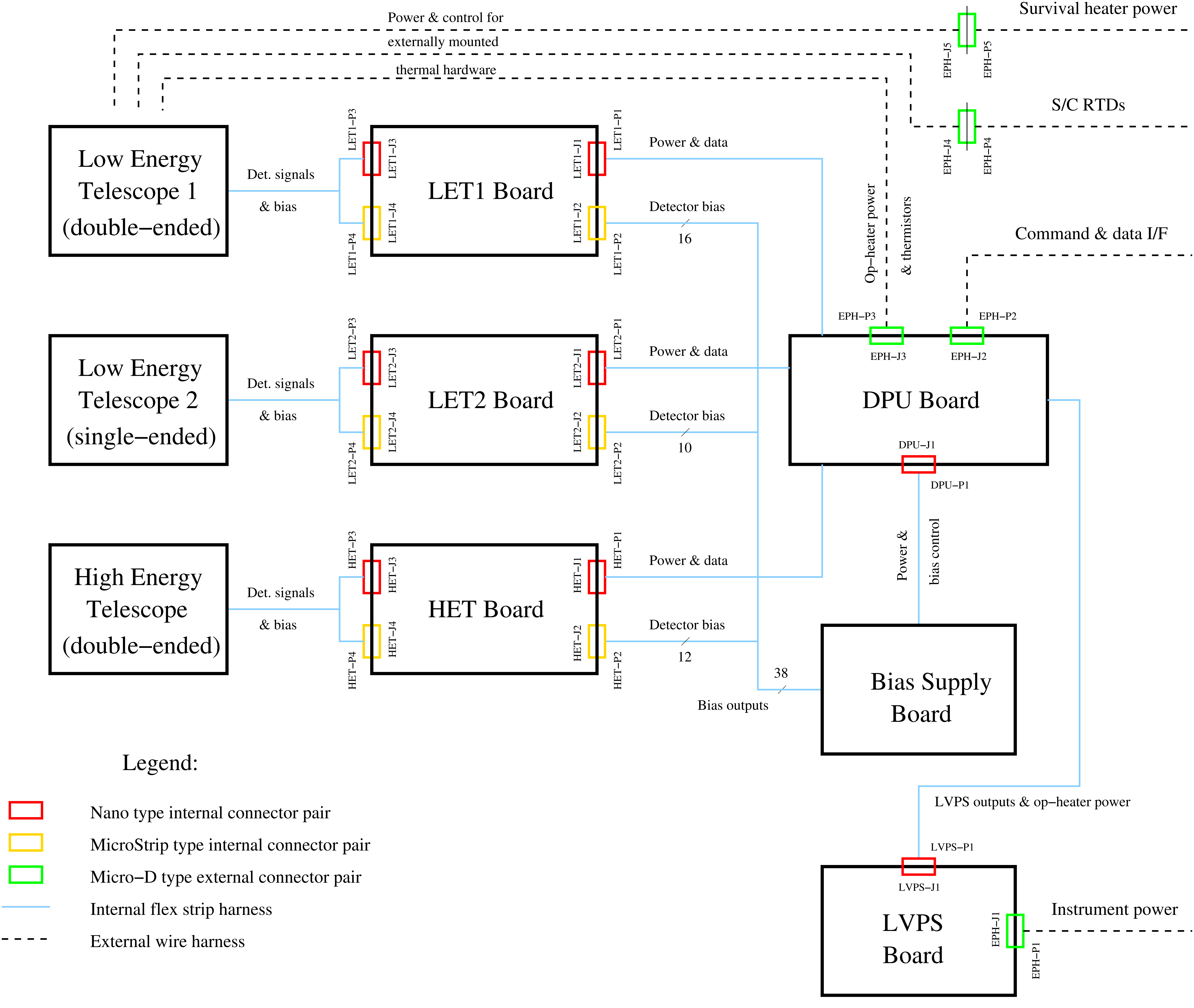
EPI-Hi resources: Mass [g]

	4/27/11	6/1/12	2/12/13	4/5/13	8/14/13	
Component	**Baseline**	**Past**	**Past**	**Intermed.**	**Present**	Uncertainty
LET1 det. & housing	225	225	225	225	225	20%
LET1 electronics	257	238	221	240	258	20%
------------------------	------	------	------	------	------	
LET1 subtotal:	**482**	**463**	**446**	**465**	**483**	20%
LET2 det. & housing	145	145	145	145	145	20%
LET2 electronics	235	209	190	214	233	20%
------------------------	------	------	------	------	------	
LET2 subtotal:	**380**	**354**	**335**	**359**	**378**	20%
HET det. & housing	120	120	120	120	120	20%
HET electronics	235	238	221	231	250	20%
------------------------	------	------	------	------	------	
HET subtotal:	**355**	**358**	**341**	**351**	**370**	20%
Elec. box & hardware	1091	1000	1050	1100	1335	20%
DPU board	279	247	198	197	197	20%
Bias Supply	228	228	228	286	354	20%
LVPS	292	292	260	260	260	20%
------------------------	------	------	------	------	------	
Central elec. subtotal:	**1890**	**1767**	**1736**	**1843**	**2146**	20%
------------------------	------	------	------	------	------	
EPI-Hi subtotal:	**3107**	**2942**	**2859**	**3019**	**3377**	20%
EPI-Hi bracket	0	0	0	0	0	
Thermal hardware	0	0	50	50	50	20%
Thermal blankets	34	34	100	100	100	20%
------------------------	**------**	**------**	**------**	**------**	**------**	
EPI-Hi total:	**3141**	**2976**	**3009**	**3169**	**3527**	20%

Resource history: Mass [g]	**4/27/11**	**6/1/12**	**2/12/13**	**4/5/13**	**8/14/13**	
Component	**Baseline**	**Past**	**Past**	**Intermed.**	**Present**	Uncertainty
LET1 det. & housing	225	225	225	225	225	20%
Proposal MEL - Rounded up						
2/23/10 MEW memo	225	225	225	225	225	C
LET1 electronics	257	238	221	240	258	20%
6/18/13 BK update - the requested increase in LET1 board area has been approved by the Project						
5/1/13 BK update - requested 20% increase in LET1 board area for risk reduction (adding 9cm x 4cm extension; 0.51 g/cm2)					18	C
4/5/13 BK update - board area 85% populated; comp, staking, conf coat; 0.95 g/cm2				147	147	C
4/5/13 BK update - LET1 blank board 13.5cm x 13.5cm; 0.51 g/cm2				93	93	C
2/13/13 BK update - board area 80% populated; comp, staking, conf coat; 0.95 g/cm2						C
2/12/13 BK update - LET1 blank board 15cm x 13.5cm; 0.51 g/cm2						C
2/7/13 BK update - board area 90% populated; comp, staking, conf coat; 0.95 g/cm2			139			C
2/7/13 BK update - LET1 blank board 12cm x 13.5cm; 0.51 g/cm2			83			C
5/28/12 BK update w/ HKchip; board area 70% populated; comp, staking, conf coat; 0.95 g/cm		135				C
LET1 has 3 PHASIC hybrids as before						C
5/28/12 BK update - LET1 blank board 15cm x 15cm w/ corner cutout 9cm & 5cm; 0.51 g/cm2		103				C
4/14/11 MEW memo	257					C
2/23/10 MEW memo						C
------------------------	------	------	------	------	------	
LET1 subtotal:	**482**	**463**	**446**	**465**	**483**	20%
LET2 det. & housing	145	145	145	145	145	20%
Proposal MEL - Rounded up						
2/23/10 MEW memo	145	145	145	145	145	C
LET2 electronics	235	209	190	214	233	20%
6/18/13 BK update - the requested increase in LET2 board area has been approved by the Project						
5/1/13 BK update - requested 20% increase in LET2 board area for risk reduction (adding 9cm x 4cm extension; 0.51 g/cm2)					18	C
4/5/13 BK update - board area 70% populated; comp, staking, conf coat; 0.95 g/cm2				121	121	C
4/5/13 BK update - LET2 blank board 13.5cm x 13.5cm; 0.51 g/cm2				93	93	C
2/13/13 BK update - board area 60% populated; comp, staking, conf coat; 0.95 g/cm2						C
2/12/13 BK update - LET2 blank board 15cm x 13.5cm; 0.51 g/cm2						C
2/7/13 BK update - board area 70% populated; comp, staking, conf coat; 0.95 g/cm2			108			C
2/7/13 BK update - LET2 blank board 12cm x 13.5cm; 0.51 g/cm2			83			C
5/28/12 BK update w/ HKchip; board area 55% populated; comp, staking, conf coat; 0.95 g/cm		106				C
LET2 has 2 PHASIC hybrids as before						C
5/28/12 BK update - LET2 blank board 15cm x 15cm w/ corner cutout 9cm & 5cm; 0.51 g/cm2		103				C
4/14/11 MEW memo	235					C
2/23/10 MEW memo						C
------------------------	------	------	------	------	------	
LET2 subtotal:	**380**	**354**	**335**	**359**	**378**	20%

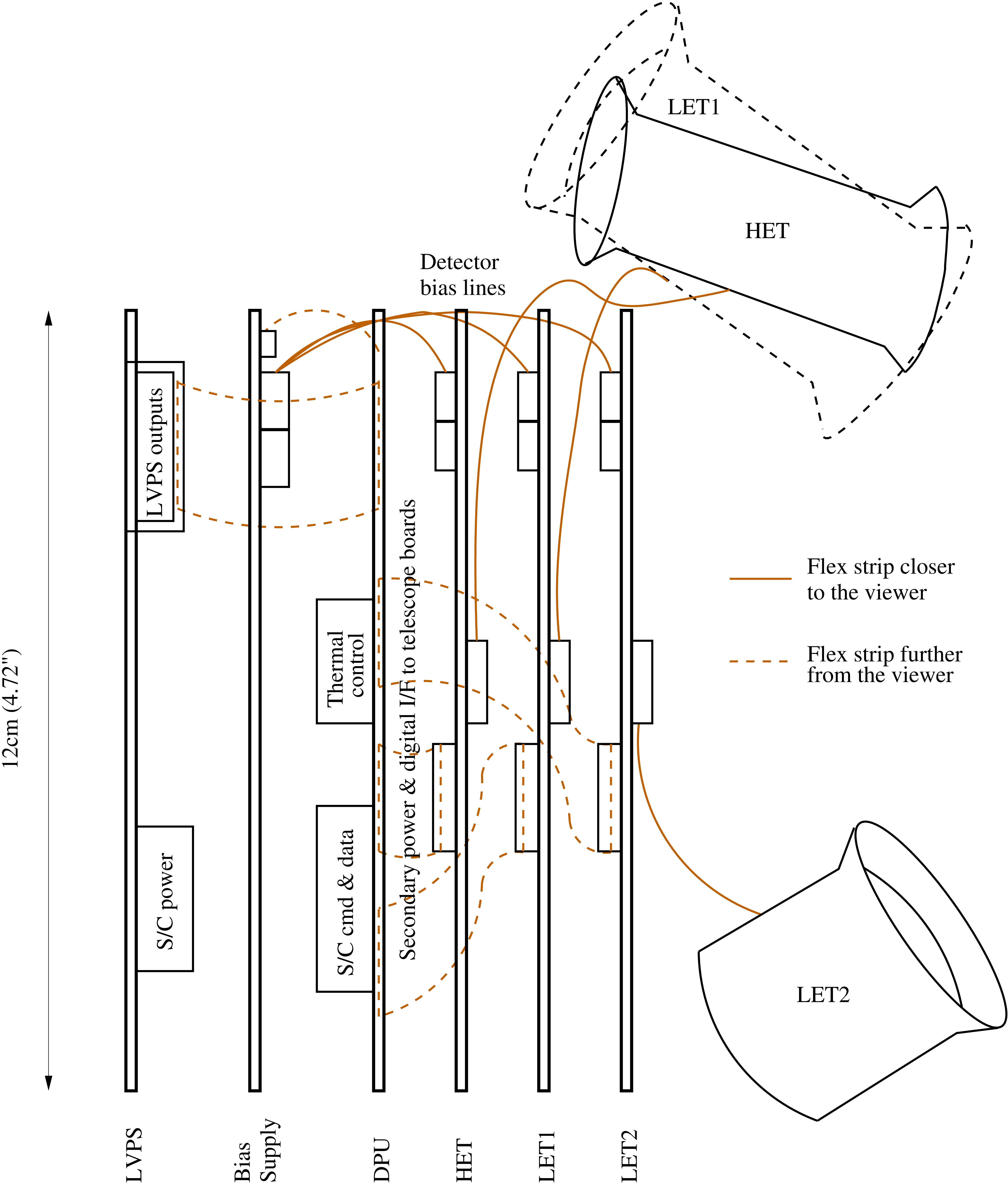
HET det. & housing	120	120	120	120	120	20%
2/23/10 MEW memo	120	120	120	120	120	C
HET electronics	235	238	221	231	250	20%
6/18/13 BK update - the requested increase in HET board area has been approved by the Project						
5/1/13 BK update - requested 20% increase in HET board area for risk reduction (adding 9cm x 4cm extension; 0.51 g/cm2)					18	C
4/5/13 BK update - board area 80% populated; comp, staking, conf coat; 0.95 g/cm2				139	139	C
4/5/13 BK update - HET blank board 13.5cm x 13.5cm; 0.51 g/cm2				93	93	C
2/13/13 BK update - board area 80% populated; comp, staking, conf coat; 0.95 g/cm2						C
2/12/13 BK update - HET blank board 15cm x 13.5cm; 0.51 g/cm2						C
2/7/13 BK update - board area 90% populated; comp, staking, conf coat; 0.95 g/cm2			139			C
2/7/13 BK update - HET blank board 12cm x 13.5cm; 0.51 g/cm2			83			C
5/28/12 BK update w/ HKchip; board area 70% populated; comp, staking, conf coat; 0.95 g/cm		135				C
5/28/12 HET now has 3 PHASIC hybrids						C
5/28/12 BK update - HET blank board 15cm x 15cm w/ corner cutout 9cm & 5cm; 0.51 g/cm2		103				C
4/14/11 MEW memo (HET has 2 PHASIC hybrids)	235					C
2/23/10 MEW memo (HET has 2 PHASICs)						C
-----------------------	------	------	------	------	------	
HET subtotal:	**355**	**358**	**341**	**351**	**370**	20%
Elec. box & hardware	1091	1000	1050	1100	1335	20%
6/18/13 BK update - the requested increases in E-box size and telescope bracket mass have been approved by the Project						
5/1/13 BK update - requested 100% increase in telescope bracket mass for risk reduction					80	C
5/1/13 BK update - requested 20% increase in board area for risk reduction (adding 9cm x 4cm extension) requires more hardware/spacers					30	C
5/1/13 BK update - requested 20% increase in board area for risk reduction (adding 9cm x 4cm extension) requires bigger box					125	C
4/5/13 BK update - Elec box 14cm x 14cm x 15cm				800	800	C
2/11/13 Sandy update - Hardware, spacers, connections			220	220	220	C
2/11/13 Sandy update - Telescope brackets			80	80	80	C
2/11/13 Sandy update - Elec box 13cm x 14cm x 15cm			750			C
6/1/11 Radiation shielding not needed since PHASIC will be rad-hard		0				C
4/14/11 MEW memo - Hardware	177	177				C
4/14/11 MEW memo - Radiation shielding	91					C
4/14/11 MEW memo - Telescope brackets	58	58				C
4/14/11 MEW memo - Elec box 16cm x 16cm x 10.4cm	765	765				C
Proposal & DPU/LVPS increments - Hardware						C
Proposal & DPU/LVPS increments - Elec box						C
2/23/10 MEW memo - Hardware						C
2/23/10 MEW memo - Elec box						C
2/23/10 MEW memo - Extra Board Area						C
DPU board	279	247	198	197	197	20%
7/8/13 Sandy update - DPU board height reduced by 0.8cm to accommodate chamfer on the E-box; new board dims 13.5cm x 12.7cm						
4/5/13 BK update - board area 60% populated; comp, staking, conf coat; 0.95 g/cm2				104	104	C
4/5/13 BK update - DPU blank board 13.5cm x 13.5cm; 0.51 g/cm2				93	93	C
2/7/13 BK update - board area 75% populated; comp, staking, conf coat; 0.95 g/cm2			115			C
2/7/13 BK update - DPU blank board 12cm x 13.5cm; 0.51 g/cm2			83			C
5/28/12 BK update w/ HKchip; board area 65% populated; comp, staking, conf coat; 0.95 g/cm		119				C
Component area now 4.9" x 3.5" w/ HKchip, which makes 25% reduction						C
DPU board has MDM connector and MCM SRAM		30				C

DPU board has flexi-strip cutouts of approximately 10cm2						C
5/28/12 BK update - DPU blank board 15cm x 15cm w/ corner cutout 9cm & 5cm; 0.51 g/cm2		98				C
4/14/11 MEW memo (component area 4.9" x 4.7" per JAB layout)	279					C
Proposal DPU increment						C
2/23/10 MEW memo						
Bias Supply	228	228	228	286	354	20%
6/18/13 BK update - the requested increase in Bias Supply board area has been approved by the Project						
5/1/13 BK update - requested 20% increase in Bias Supply board area for risk reduction (adding 9cm x 4cm extension; 0.51 g/cm2)					18	C
5/1/13 BK update - if 20% increase approved, DPU and Bias Supply boards will be swapped in the stack; the latter will need an extra RF shield; both shields will be 20% large					130	C
5/1/13 Dean Aalami update for RF shield 0.030" thick					54	C
4/5/13 Dean Aalami update for board heavily populated; comp, staking, conf coat				127	127	C
4/5/13 Dean Aalami update for blank board area 13.5cm x 13.5cm (2.78 g/sq.in)				79	79	C
4/5/13 Dean Aalami update for RF shield 0.050" thick				80		C
2/12/13 BK update - Bias Supply blank board 15cm x 13.5cm; 0.51 g/cm2						C
4/14/11 MEW memo - Shield	82	82	82			C
4/14/11 MEW memo - Board	146	146	146			C
Proposal MEL - Board & Shield						C
2/23/10 MEW memo - Shield						C
2/23/10 MEW memo - Board						C
LVPS	292	292	260	260	260	20%
7/29/13 Sandy update - LVPS board height reduced by to accommodate chamfer on the E-box; new board dims 14cm x 10.8cm						
2/7/13 Reid Gurnee update - based on similar design and board size for another project			160	160	160	C
2/7/13 BK update - estimate for top RF shield			100	100	100	C
Proposal LVPS increment	292	292				
2/23/10 MEW memo						
------------------------	------	------	------	------	------	
Central elec. subtotal:	**1890**	**1767**	**1736**	**1843**	**2146**	20%
------------------------	------	------	------	------	------	
EPI-Hi subtotal:	**3107**	**2942**	**2859**	**3019**	**3377**	20%
EPI-Hi bracket	0	0	0	0	0	
4/14/11 MEW memo	0	0	0	0	0	
2/23/10 MEW memo						
Thermal hardware	0	0	50	50	50	20%
2/12/13 BK update - estimate for heaters, thermistors, thermal harness			50	50	50	C
Thermal blankets	34	34	100	100	100	20%
2/7/13 BK update - estimate for all blankets			100	100	100	C
4/14/11 MEW memo	34	34	34	34	34	C
2/23/10 MEW memo						
------------------------	------	------	------	------	------	
EPI-Hi total:	**3141**	**2976**	**3009**	**3169**	**3527**	20%



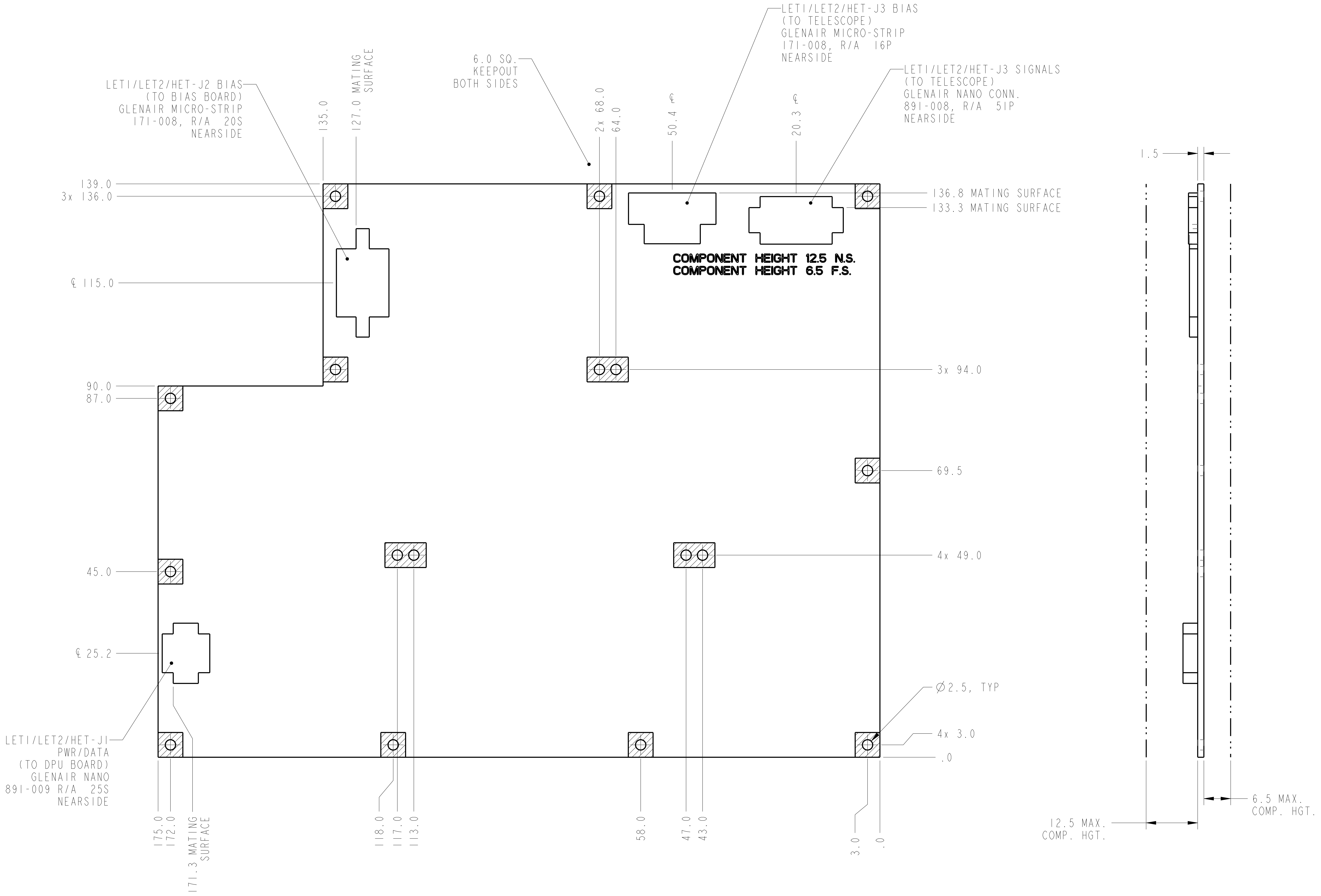
EPI−Hi Harness Diagram

BK 5/12/13



EPI−Hi Boards, Telescopes, Connectors & Interconnections
(side view, opposite from ISIS bracket)

REVISION				
REV	ZONE	DESCRIPTION	DATE	APPROVAL
-	-	-	-	-



PRELIMINARY

PLOT DATE: 27-Jul-13

ITAR RESTRICTED DATA

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ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
-		X	-	PWB, POLYIMIDE FLEX, MULTI-LAYER	POLYIMIDE	-

LIST OF MATERIAL

THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION
A

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.

HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]

METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
&surf_finish ✓
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5°
FINISH IN μIN

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.07 X.X ±0.15 X ±0.2 ∠ ±0.5°
XX ±0.3 XXX ±0.8 XXXX ±1.5
✓ FINISH IN μM

SOFTWARE: Pro/ENGINEER WF5.0
FILE LOCATION: SSHUMAN\SOLARPROBE
DRAWING FILE: 2190773 REV -
MODEL FILE: ELECTRONICS-BOARD-LETI REV -

NEXT ASSY	USED ON
2190784	HET ELEC BD
2190774 2190779	LETI ELEC BD LET2 ELEC BD

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD ☒
WALLOPS ISLAND, VA ☐

NAME	INIT.	DATE
DESIGNED S. SHUMAN		
DRAWN S. SHUMAN		
CHECKED B. KECMAN		
APPROVED - ELEC ENGINEER B. KECMAN		
APPROVED - ELEC ENGINEER R. COOK		
APPROVED - SYS ENGINEER B. KECMAN		
APPROVED - PDL T. vonrOSENVINGE		

DRAWING INTERPRETED PER 500-PG-8700.2.5

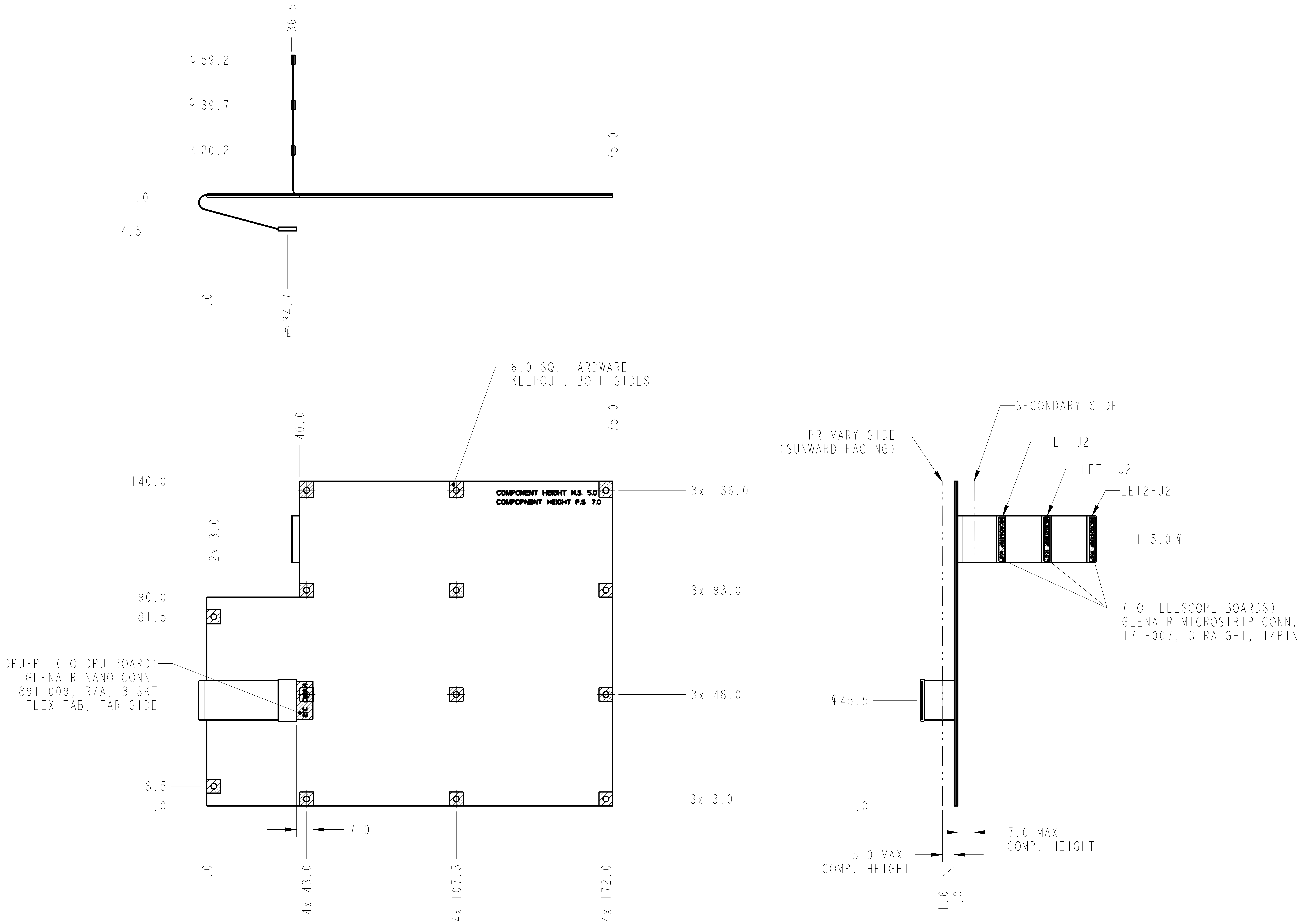
TITLE
OUTLINE DRAWING, TELESCOPE ELECTRONICS BOARD

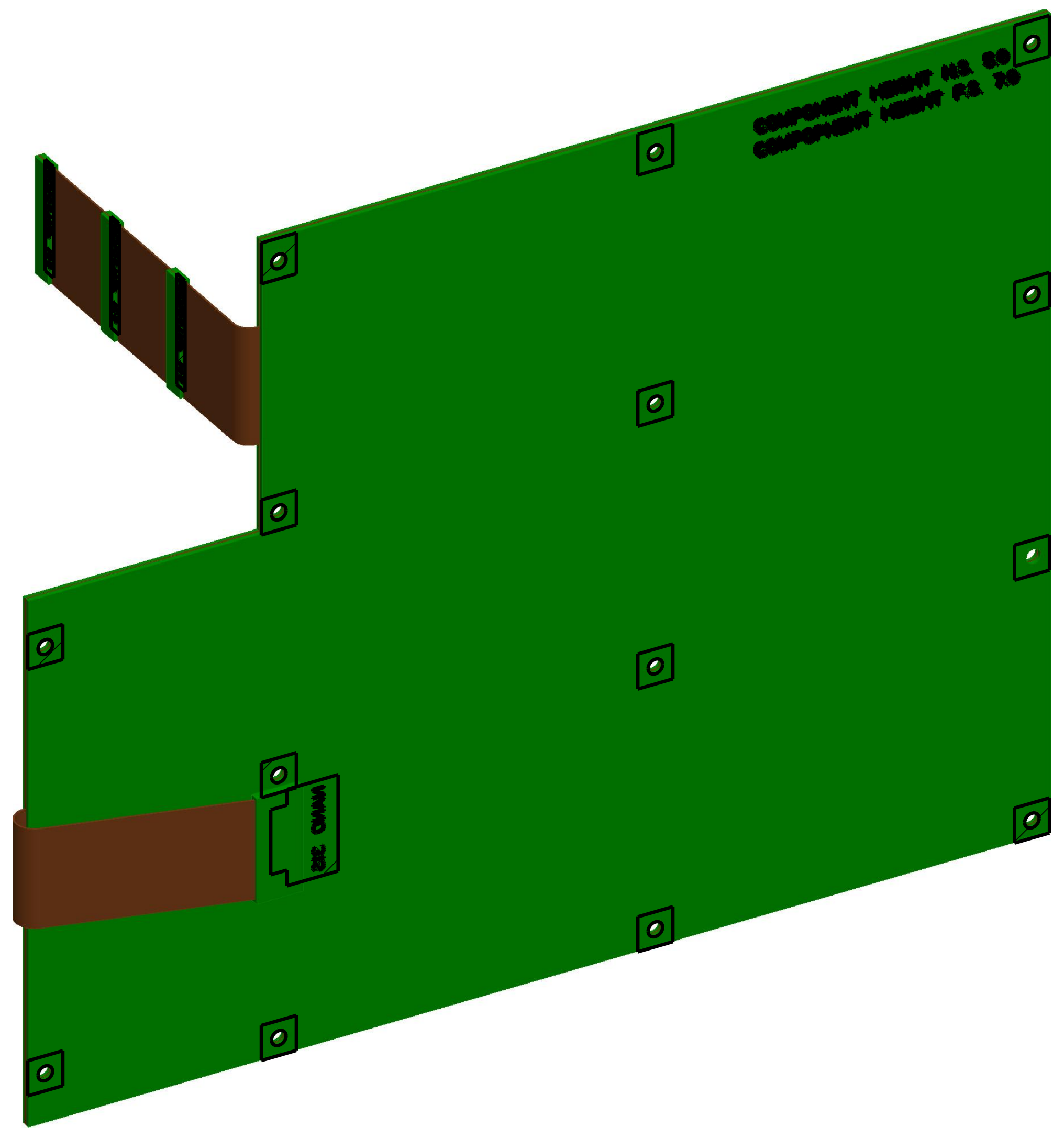
SIZE D CAGE CODE 36FC1 DWG NO. 2190773 REV -
SCALE: 1.000 SHEET: 1 OF 1

GSFC 660.3/M (01/10)

2190773
REVISION -

REVISION				
REV	ZONE	DESCRIPTION	DATE	APPROVAL
-	-	-	-	-





PRELIMINARY

PLOT DATE: 08-Jul-13

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ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
-		X	-	PWB, POLYIMIDE FLEX, MULTI-LAYER	POLYIMIDE	-

LIST OF MATERIAL

THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION
A

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.

HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]

METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
&surf_finish ✓ FINISH IN μIN
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5°

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.07 X.X ±0.15 X ±0.2 ∠ ±0.5°
XX ±0.3 XXX ±0.8 XXXX ±1.5
- ✓ FINISH IN μM

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD ☒
WALLOPS ISLAND, VA ☐

NAME	INIT.	DATE
DESIGNED S. SHUMAN		
DRAWN S. SHUMAN		
CHECKED B. KECMAN		
APPROVED - -		
APPROVED - ELEC ENGINEER R. COOK		
APPROVED - SYS-ENGINEER B. KECMAN		
APPROVED - PDL T. vonROSENVINGE		

DRAWING INTERPRETED PER 500-PG-8700.2.5

TITLE
OUTLINE DRAWING, BIAS ELECTRONICS, BOARD

SIZE D
CAGE CODE 36FC1
DWG NO. 2190793
REV -
SCALE: 1.000
SHEET: 1 OF 1

SOFTWARE: Pro/ENGINEER WF5.0
FILE LOCATION: \SSHUMAN\SOLAR-PROBE
DRAWING FILE: 2190793 REV -.IL9.0
MODEL FILE:ELECTRONICS-BOARD-BIAS REV -.IL9.0

2190794	BIAS BOARD
NEXT ASSY	USED ON

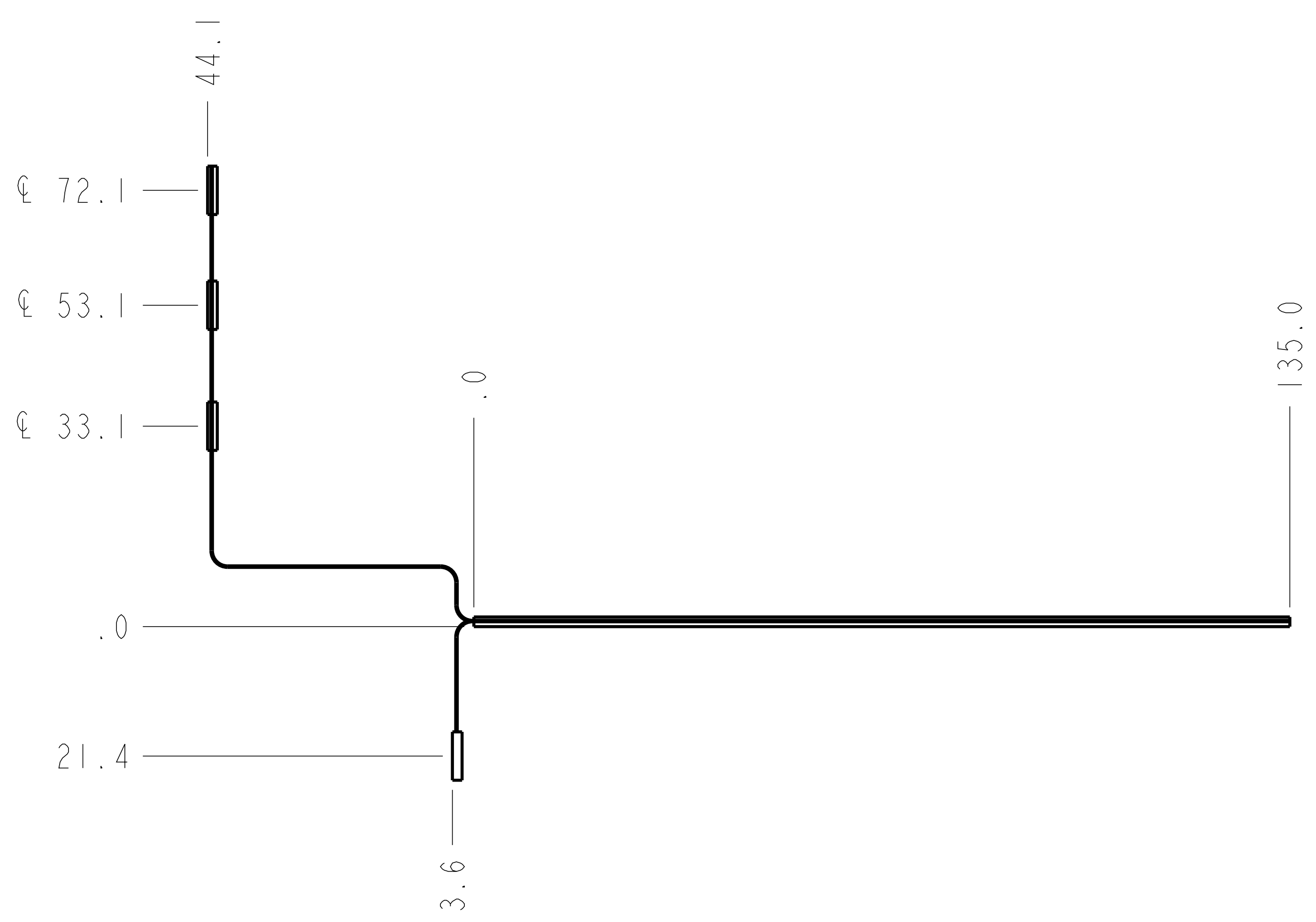
GSFC 660.3/M (01/10)

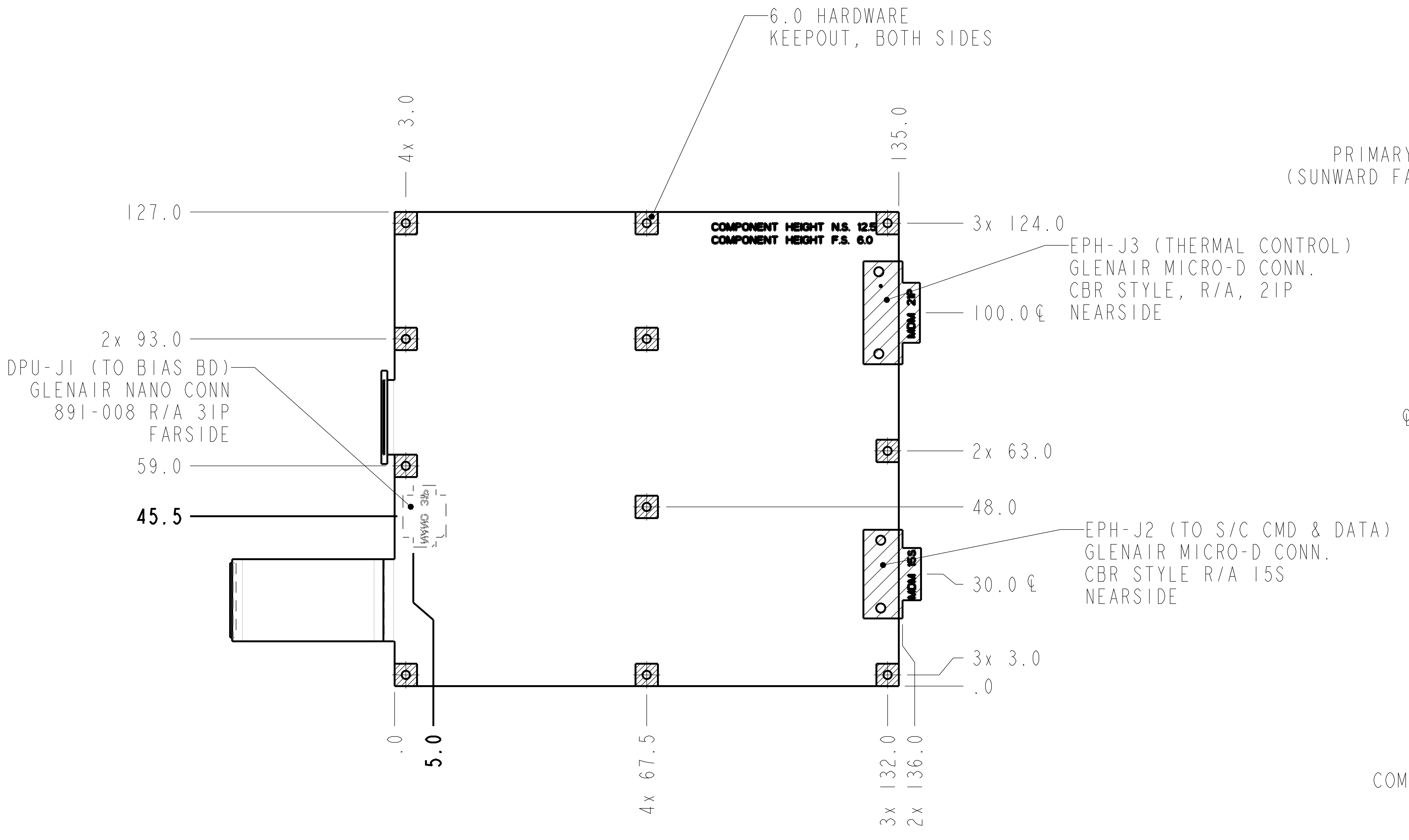
FOLD LINE

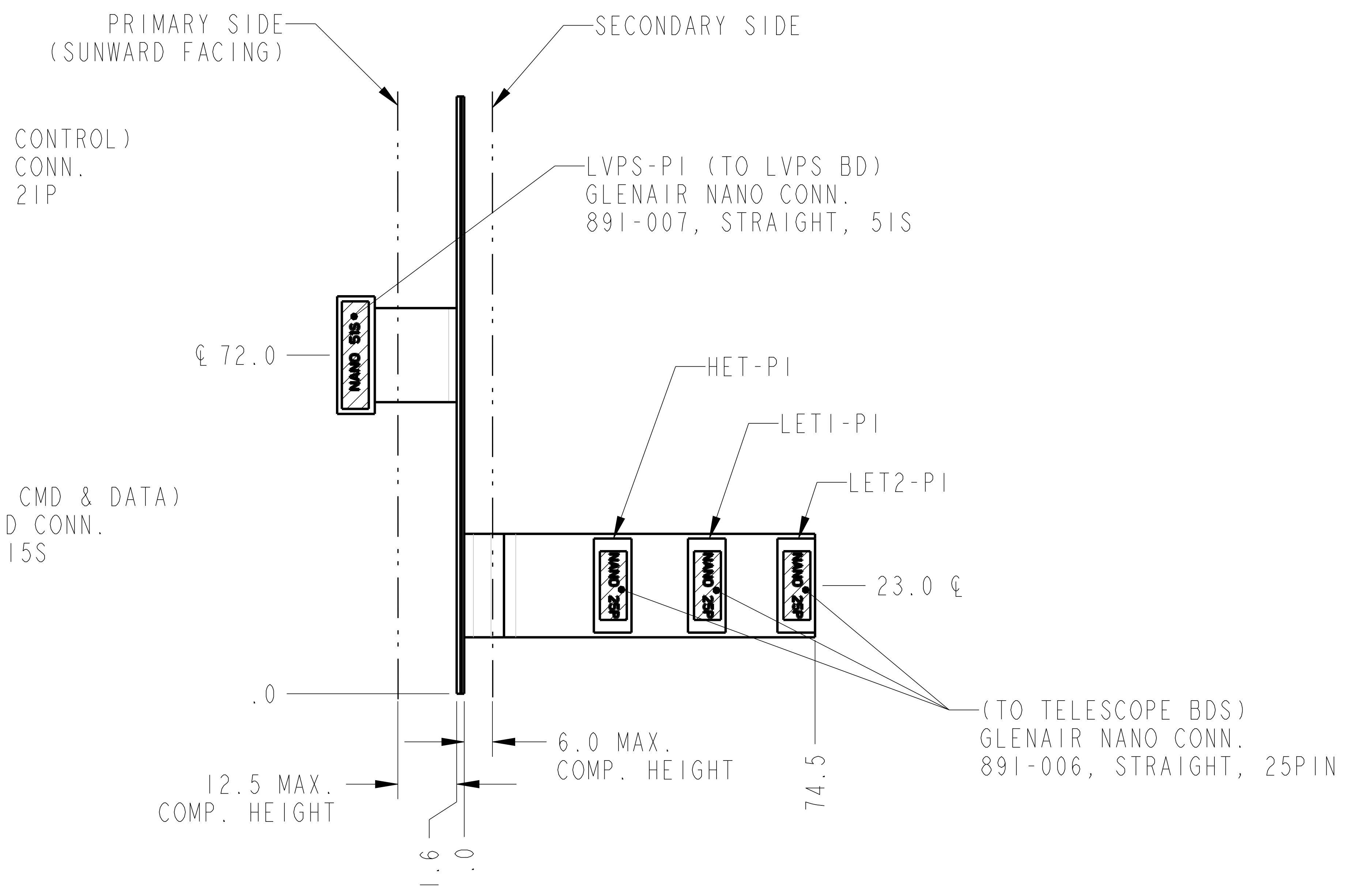
DWG NO. 2190793

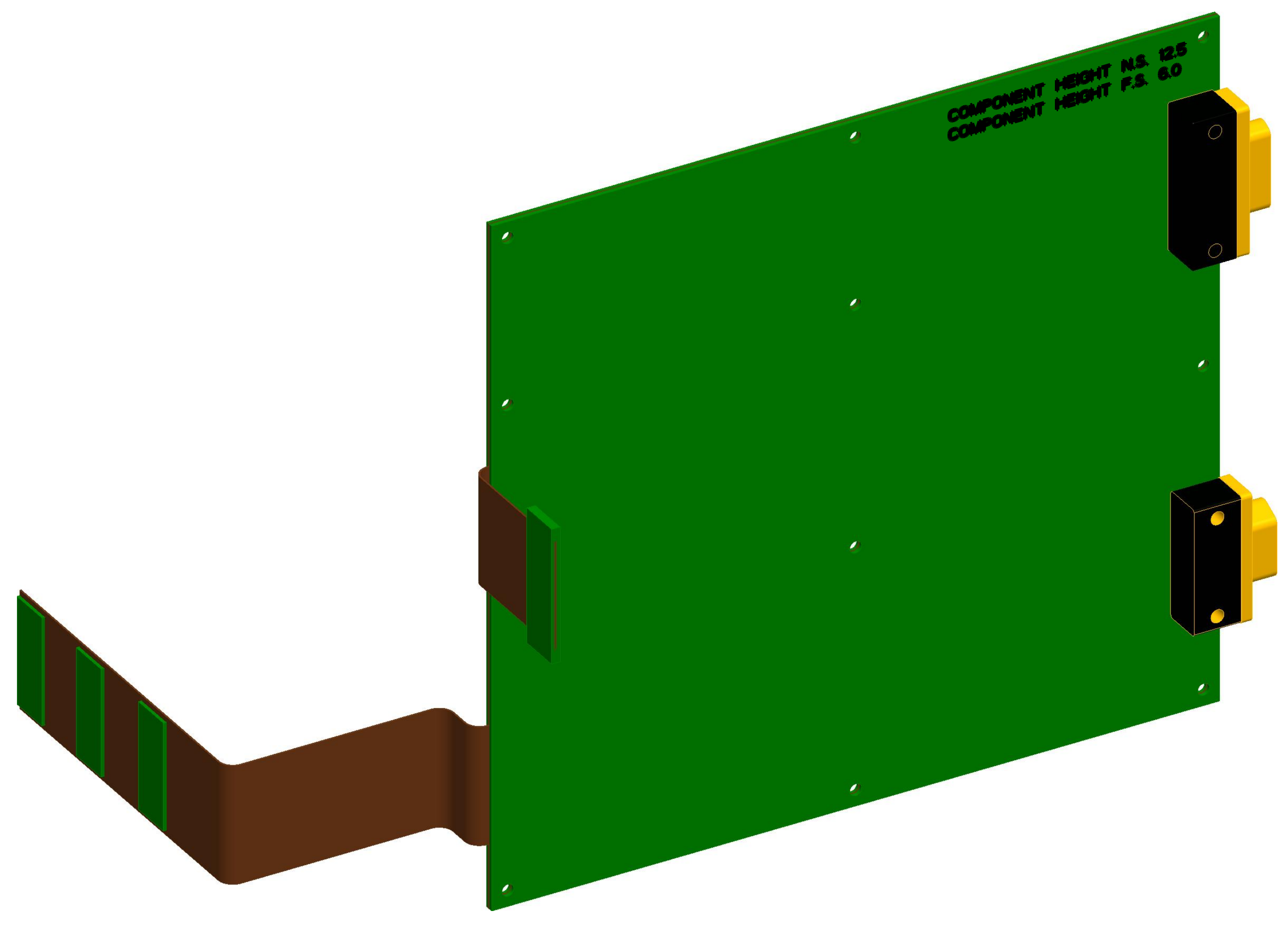
REVISION -

REV	ZONE	DESCRIPTION	DATE	APPROVAL
-	-	-	-	-









PRELIMINARY

PLOT DATE: 06-Jul-13

ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
-		X	-	PWB, POLYIMIDE FLEX, MULTI-LAYER	POLYIMIDE	-

LIST OF MATERIAL

THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION
A

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.

HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]

METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
&surf_finish
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5°
FINISH IN mIN

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.07 X.X ±0.15 X ±0.2 ∠ ±0.5°
XX ±0.3 XXX ±0.8 XXXX ±1.5
FINISH IN mM

SOFTWARE: Pro/ENGINEER WF5.0
FILE LOCATION: SSHUMAN\SOLARPROBE
DRAWING FILE: 2190788 REV -
MODEL FILE: ELECTRONICS-BOARD-DPU REV -

NEXT ASSY	USED ON
2190789	DPU BOARD

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD ☒
WALLOPS ISLAND, VA ☐

	NAME	INIT.	DATE
DESIGNED	S. SHUMAN		
DRAWN	S. SHUMAN		
CHECKED	P. GOODWIN		
APPROVED - ELEC ENGINEER	J. BURNHAM		
APPROVED - ELEC ENGINEER	R. COOK		
APPROVED - SYS ENGINEER	B. KECMAN		
APPROVED - PDL	T. vonrOSENVINGE		

DRAWING INTERPRETED PER 500-PG-8700.2.5

TITLE
OUTLINE DRAWING, DPU ELECTRONICS BOARD

SIZE	CAGE CODE	DWG NO.	REV
D	36FC1	2190788	-

SCALE: 1.000
SHEET: 1 OF 1

GSFC 660.3/M (01/10)

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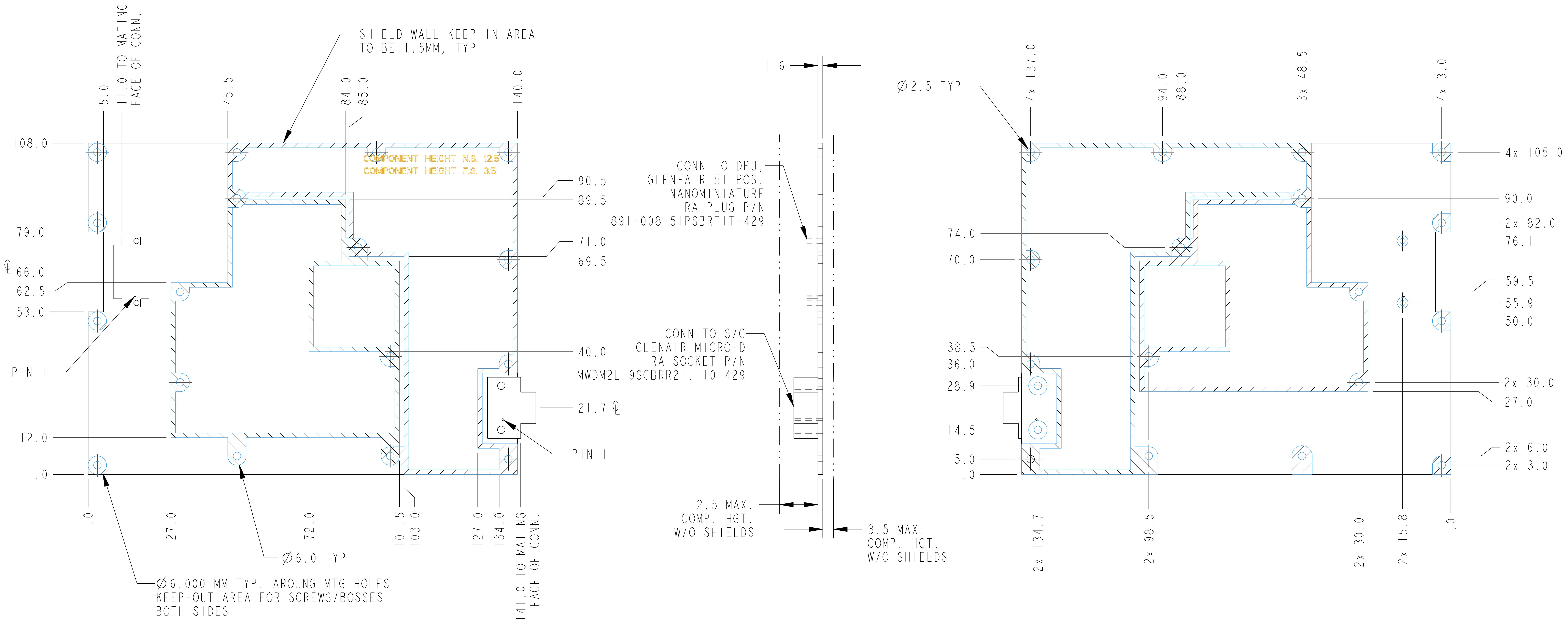
FOLD LINE

REVISION				
REV	ZONE	DESCRIPTION	DATE	APPROVAL
-	-	-	-	-

NOTES-
UNLESS OTHERWISE SPECIFIED:

1. MATERIAL: SEE B.O.M..

2. THIS DRAWING CONTAINS INFORMATION FOR THE DESIGN OF PWB. ALL ARTWORK AND PWB RELATED DRAWINGS SHOULD REFERENCE THIS DRAWING.



FRONT VIEW
(SUNWARD FACING)
(PRIMARY COMP. SIDE)

PRELIMINARY
PLOT DATE: 24-Sep-13

FOLD LINE

2190766

-

-		X	2190766	MULTILAYER PCB	POLYIMIDE	-
ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
	LIST OF MATERIAL					

ITAR RESTRICTED DATA

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THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION
A

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.

HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]

METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:

.XX	.XXX	X/X	∠
±.01	±.005	±1/16	±.5°

- FINISH IN µIN

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:

X.XX	X.X	X	∠
±0.08	±0.15	±0.2	±0.5°

XX	XXX	XXXX
±0.3	±0.8	±1.5

- FINISH IN µM

SOFTWARE: Pro/ENGINEER WF5.0
FILE LOCATION: \SOLAR-PROBE
DRAWING FILE: 2190766 REV -
MODEL FILE: 2190766 REV -

-	SPP\EPI-HI\LVPS
NEXT ASSY	USED ON

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD ☒
WALLOPS ISLAND, VA ☐

NAME	INIT.	DATE
DESIGNED S. SHUMAN		
DRAWN S. SHUMAN		
CHECKED -		
APPROVED -		
APPROVED - ELEC-ENGINEER R. COOK		
APPROVED - SYS-ENGINEER B. KECMAN		
APPROVED - PDL T. vonROSENVINGE		

DRAWING INTERPRETED PER 500-PG-8700.2.5

TITLE
OUTLINE DRAWING, LVPS BOARD, EPI-HI INSTRUMENT

SIZE	CAGE CODE	DWG NO.	REV
C	36FC1	2190766	-

SCALE: 1.000 SHEET: 1 OF 1

GSFC 660.3/M (01/10)

Specification for Thick/Thin Silicon Detectors for the EPI-HI Instrument for Solar Probe Plus

Version 1.01, 29 March 2012

1. **Applicability.**
   - This specification applies to thin, silicon solid-state detectors for use in the EPI-Hi LET telescopes to be developed for NASA's Solar Probe Plus (SPP) mission.
2. **Detector Designations.**
   - Two different detector types are specified. They are designated L0 and L1.
3. **Technology.**
   - Detectors shall be fabricated by ion implantation of crystalline silicon. The silicon shall have a ⟨100⟩ crystal orientation. Detectors are to be fabricated using thick/thin technology based on silicon-on-insulator (SOI) wafers. The active thickness of the detectors shall be controlled by the thickness of the SOI device layer, with the SOI's buried oxide layer being used as an etch stop in achieving this thickness.
4. **Operation.**
   - Detectors will be operated fully depleted in a transmission-type configuration. Signals will be taken from the junction (p^+) surface, which will be operated at ground potential; the ohmic (n^+) surface will be operated at a positive bias.
5. **Active Element Geometry.**
   - The overall active area of each detector shall be a circle of diameter 11.2 mm (providing a 100 mm^2 total active area). On the junction surface this area shall be subdivided into 5 equal-area segments, a central bull's eye of diameter 5.0 mm surrounded by 4 quadrants of a ring, as illustrated in the accompanying figures. The gaps between adjacent active detector segments shall be kept sufficiently narrow to assure efficient collection of signal charge produced by particles passing through the gap region. The manufacturer shall advise the EPI-Hi team of the proposed gap width.
6. **Thin Membrane Shape and Area.**
   - The thin Si membrane on which the detectors are fabricated shall extend outside the area occupied by the active elements of the detector and any surrounding floating guard rings (see below). For L1, the excess radius shall be sufficient to allow easy alignment of the patterning used for thinning the SOI with the patterning used for producing the detector elements. For L0, the thin membrane shall have a diameter of 36 mm, significantly larger than the active diameter of the detector.
7. **Chip Size and Shape.**
   - The overall shape of the detector chips shall be 16-sided regular polygons. The size of the L1 chip shall be 25 mm measured from flat to flat. The size of the L0 chip shall be 60 mm measured from flat to flat.
8. **Orientation.**
   - The detector chips shall be fabricated with a fixed, specified orientation relative to the primary and secondary flats on the device layer of the SOI wafer.

9. **Guard Rings.**
   - The manufacturer shall provide recommendations concerning the advisability of including a set of narrow, floating guard rings surrounding the detector active area.
10. **Contacts.**
    - Each of the 5 active segments shall be connected by a narrow trace to a wire bonding pad located on the thick portion of the wafer. The trace connected to central bull's eye segment of the detector shall be routed between between two of the surrounding four segments.
    - On the L0 detectors these traces will need to be relatively long due to the larger diameter of the thin membrane relative to that of the active area. The manufacturer shall provide advice on the desirability of isolating these traces from the silicon.
11. **Active Thickness.**
    - In their active regions the L0 detectors shall have an overall thickness of $10{\pm}0.5\,\mu$m and the L1 detectors shall have an overall thickness of $25{\pm}0.5\,\mu$m. These thicknesses shall correspond to the device layer thickness specified for the SOI wafers.
12. **Thickness Uniformity.**
    - Good thickness uniformity is a high priority. The uniformity goal is <1% thickness nonuniformity over the $100\,\mathrm{mm}^2$ active areas. The SOI wafers shall be specified to have a device layer thickness that varies by no more than $0.5\,\mu$m microns over the entire wafer and the SOI wafer order shall specify that the manufacturer attempt to achieve uniformity better than $0.2\,\mu$m on a best-effort basis. Etching and other processing of the wafers shall be carried out in such a way as to not significantly degrade the thickness uniformity from that of the SOI device layer.
13. **Handle Wafer Thickness**
    - The handle wafer used in fabricating the SOI shall have a nominal thickness of $500\,\mu$m.
14. **Segment Isolation.**
    - The DC resistance between each active electrode and all other active electrodes on the junction surface of the detector shall be greater than $10\,\mathrm{M}\Omega$, with a goal of greater than $100\,\mathrm{M}\Omega$.
15. **Dead Layers.**
    - The junction and the ohmic surfaces of the detector shall each have dead layers of thickness $<0.2\,\mu$m due to ion implantation and metallization.
16. **Metallization.**
    - The detector surfaces shall be metallized with aluminum having a thickness <1000 Å over the active area of the device. Thicker aluminization outside the active area is acceptable.
17. **Surface Condition.**
    - The detectors shall have specular reflecting (mirror) surfaces of good quality.
18. **Detector Mounting.**
    - Transmission-style detector mounts will be designed and procured by NASA's Goddard Space Flight Center and supplied to the detector manufacturer. The detector

manufacturer shall review and approve the detector mount specification and design prior to fabrication of the mounts. It is anticipated that detector mounts will be fabricated as multilayer circuit boards using G10/FR4 and flexible Kapton leads with appropriate connectors for mating to external circuitry. Detector chips shall be installed in the detector mounts using Shin-Etsu KJR-9022E resin. The resin shall be mixed and cured according to manufacturer's instructions. An alternative mixing and curing procedure is acceptable, if approved by NASA.

19. **Mounting Tolerances.**
    - The detector chips shall be installed in the mounts in such a way as to maintain the following tolerances: parallelism between chip and mounting ledge, $<1°$; translational accuracy in the plane of the detector <0.2 mm; rotational accuracy about an axis perpendicular to the plane of the detector, $<0.5°$.
20. **Electrical Connections.**
    - Electrical connections between detector contacts and nearby pads on the detector mount shall be made using a minimum of 4 separate wire bonds per connection. Wire bonding shall be done using soft aluminum wire with a nominal diameter of $50\,\mu$m. Wire bond lengths shall be kept as short as practical with a goal of <3 mm. The minimum bond strength shall correspond to the pull of a 10 gram weight. A non-destructive pull test shall be performed by the manufacturer on 2 of the detector bonds connected to each detector contact to demonstrate compliance with this specification.
21. **Depletion Voltage.**
    - The maximum depletion voltage, V_d, for the two detector types shall be as follows: for L0, 2 V; for L1, 4 V.
22. **Breakdown Voltage.**
    - The minimum acceptable breakdown voltages for the two detector types shall be: for L0, 10 V; for L1, 15 V. The breakdown voltage shall be determined from measurements of the detector's leakage current (I) versus bias (V) with all detector segments connected in parallel. The breakdown voltage shall be taken to be the value of V for which I has value equal to twice its value at V_d.
23. **Leakage Current.**
    - The maximum allowable leakage current shall be: for L0, 1 nA, for L1, 2 nA. For determining whether these specifications have been met, leakage currents shall be measured with all detector segments connected in parallel and with the detector biased at least 1 V above the full depletion voltage. These measurements shall be made at room temperature in a vacuum $<5\times10^{-6}$ torr after the detector has been allowed to stabilize for at least 1 hour. The leakage current specification shall be met within 30 seconds of bias being applied. The leakage currents shall not exceed the values listed above by more than a factor of 2 for a period of at least 1 year after delivery.
24. **Alpha Particle Resolution.**
    - The range of alpha particles from typical sources (e.g., ^{241}Am or ^{244}Cm) is longer than the thickness of the L0 and L1 detectors. To obtain a measurement of the detector

resolution, the alpha particles shall be collimated in a narrow beam and allowed to penetrate a thin, uniform energy-degrader foil (e.g., aluminum) prior to impinging on the detector. The foil thickness shall be such that alpha particles penetrate between 50% and 90% of the nominal detector thickness. The resulting pulse height from the detector shall be measured with all detector segments connected in parallel using a charge sensitive amplifier, a shaping amplifier having peaking time (zero to peak) in the range 1 to 4 μs, and a pulse height analyzer. The alpha particle resolution shall not exceed 50 keV FWHM, after correcting for the energy spread of the source and additional broadening introduced by the degrader foil.

25. **Temperature Ranges.**
    - The detectors shall have an operating temperature range of −40°C to +40°C and a non-operating temperature range of −60°C to +60°C. The detectors shall meet the performance specifications after being returned to 20°C following exposure to the storage temperature extremes for at least 1 hour.
26. **Radiation Hardness.**
    - The detectors shall remain suitable for use after being subjected to proton radiation doses of up to 100 krad.
27. **Vacuum Stability.**
    - The detectors shall be tested for at least 72 hours at room temperature in a vacuum of 5×10^{-6} torr or better with the detectors continually biased to at least 1 V above the depletion voltage. The leakage current and, if possible, the electronic noise, shall be monitored throughout this test and the measurements reported as part of the documentation package to be delivered with the detector.
28. **Thermal Cycling.**
    - The detectors shall be cycled at least 10 times between temperatures of −40°C and +40°C at a rate of approximately 2°C/minute. This test shall be performed with no bias applied in a vacuum of 5×10^{-6} torr or better or in a dry nitrogen atmosphere.
29. **Random Vibration Testing.**
    - The detectors shall be subjected to a single-axis random vibration test with the acceleration axis normal to the detector surface. The test shall be performed using a vibration spectrum and overall amplitude appropriate for the Solar Probe Plus launch (details to be provided). After the vibration test the detectors shall be thoroughly inspected for cracks, detached wire bonds, or other damage.
30. **Acoustic Testing.**
    - Acoustic testing of all of the L0 and L1 detectors are planned after receipt from the manufacturer using an acoustic spectrum and an overall amplitude suitable for the Solar Probe Plus launch. For the acoustic test the detectors will be mounted in a fixture that will approximate the acoustic response of the EPI-Hi instrument. This fixture will be designed and fabricated by the EPI-Hi team. The detectors will be thoroughly inspected after the test for cracks, detached wire bonds, or other damage.

If so desired, the detector manufacturer may propose an option for performing the acoustic testing prior to detector delivery.

31. **Detector Identification.**
    - Each detector shall have a unique, 2-digit identification number written on the mount with an indelible ink compatible with use near solid-state detectors. This serial number shall be used to label all data to be included in the documentation package to be delivered with the detector.
32. **Documentation Package.**
    - Each delivered detector shall be accompanied by a documentation package containing information about the detector fabrication and testing. As a minimum, this package shall contain the following: 1) detector identification number, 2) original delivery date (month and year), 3) ID number of the SOI wafer from which the detector was fabricated, 4) copy of the specifications and data sheet for the SOI wafer obtained from the SOI manufacturer, 5) copy of the batch traveler documenting the detector fabrication and testing steps, 6) plot of detector capacitance versus bias, 7) plot of detector leakage current versus bias measured at room temperature and atmospheric pressure, 8) depletion voltage, 9) breakdown voltage, 10) alpha particle and test pulser pulse-height spectra measured with the alpha particles incident on the junction side and on the ohmic side of the detector using the procedures described above, 11) alpha particle resolution calculated from the measurements, 12) environmental test results. The measurement results shall be reported in a standard format to be agreed upon by the detector manufacturer and the EPI-Hi team.

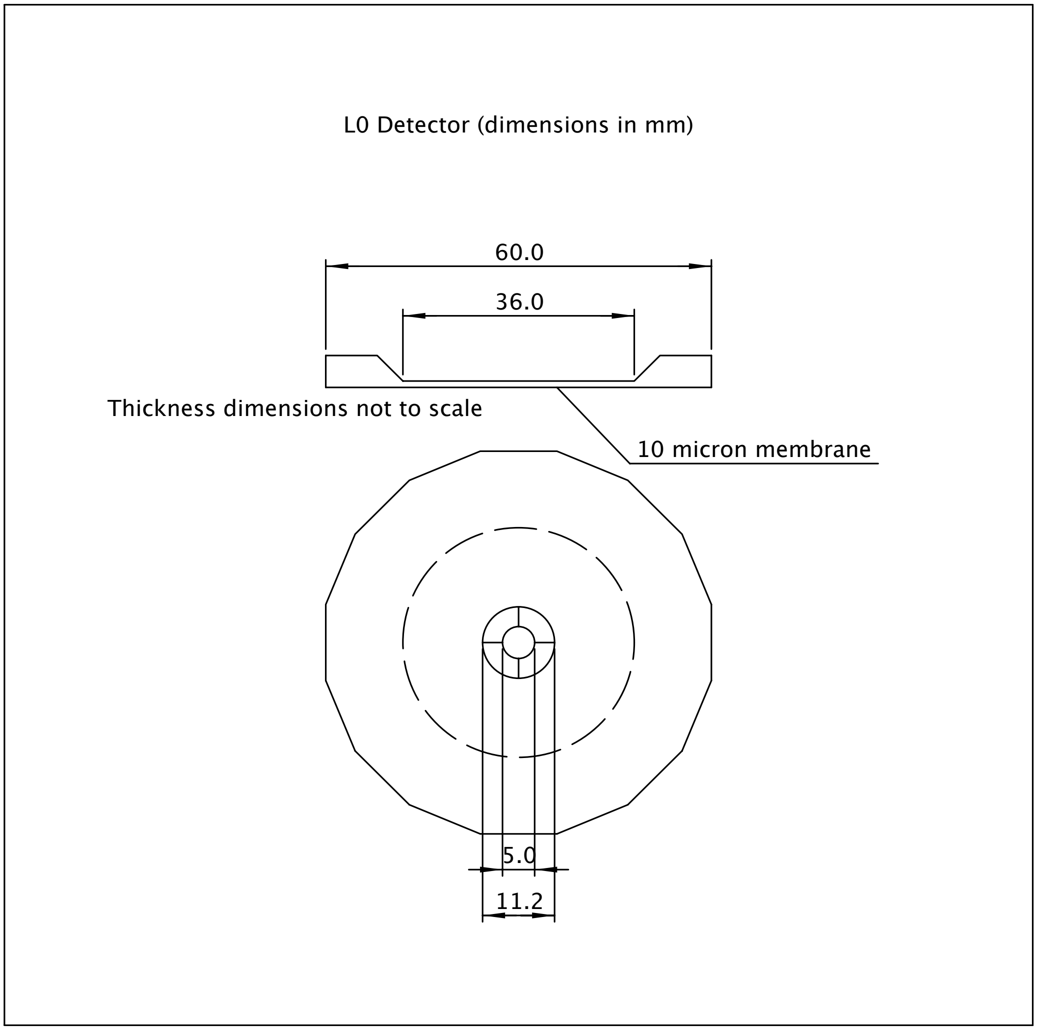

L0 Detector (dimensions in mm)
60.0
36.0
Thickness dimensions not to scale
10 micron membrane
5.0
11.2

Figure 1.

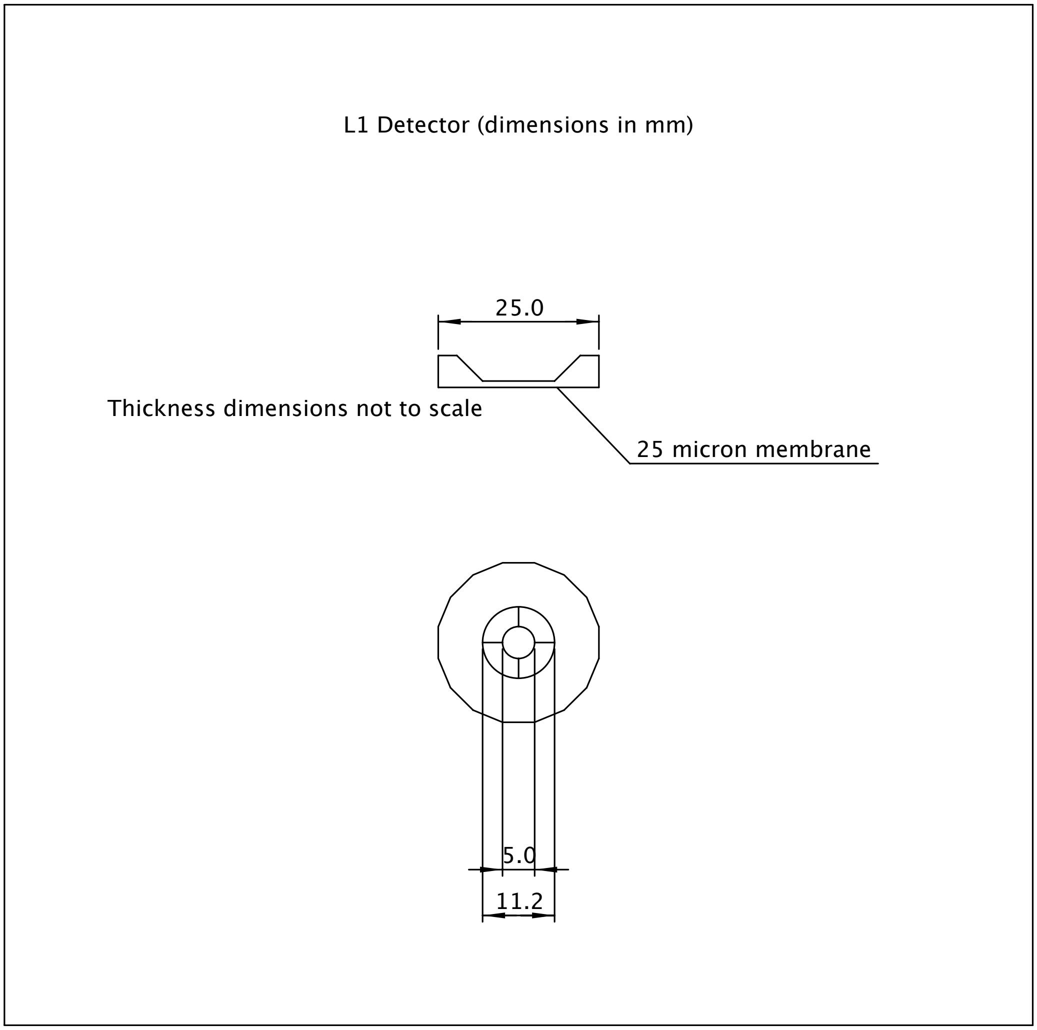

L1 Detector (dimensions in mm)
25.0
Thickness dimensions not to scale
25 micron membrane
5.0
11.2

Figure 2.

Specification for Thick Silicon Detectors for the EPI-HI Instrument for Solar Probe Plus

Version 1.03, 25 April 2012

1. **Applicability.**
   - This specification applies to conventional silicon solid-state detectors for use in the EPI-Hi Low-Energy Telescope (LET) and High-Energy Telescope (HET) sensors to be developed for NASA's Solar Probe Plus mission. A separate specification describes the requirements for "thick/thin" silicon detectors for use in LET.
2. **Designations.**
   - Two different LET detector types are specified. They are designated L2 and L3. In addition, three different HET detector types are specified, with designations H1, H2, and H3. Requirements for each of these detector types are discussed in the following paragraphs and summarized in Table 1. The accompanying figures illustrate the detector geometries.
3. **Technology.**
   - Detectors shall be fabricated by ion implantation of crystalline silicon. The silicon shall have a ⟨100⟩ crystal orientation. Detectors are to be fabricated using conventional lapped and polished silicon wafers
4. **Operation.**
   - Detectors will be operated fully depleted in a transmission-type configuration. Signals will be taken from the junction (p^+) surface, which will be operated near ground potential; the ohmic (n^+) surface will be operated at a positive bias.
5. **Active Shape and Area.**
   - The active areas of the detectors shall be segmented into various numbers of signal elements, as follows.
     - The L2 design shall contain 6 elements, consisting of a central bull's eye of diameter 5.0 mm surrounded by 4 quadrants of a ring with outside diameter of 11.3 mm. These 5 elements shall be surrounded by an additional ring having outside diameter of 24.0 mm. The L2 design is illustrated in Figure 1.
     - The L3 design shall contain 2 elements, consisting of a central circular area of diameter 11.3 mm surrounded by a ring having an outer diameter of 24.0 mm. The L3 design is illustrated in Figure 2.
     - The H1 and H2 designs shall each contain 7 elements. A central bull's eye of diameter 5.0 mm shall be surrounded by 4 quadrants of a ring with outside diameter of 11.3 mm. These 5 elements shall be surrounded by two narrow rings having outside diameters of 14.3 mm and 17.3 mm, respectively. Thus each of these rings shall have a radial width of 1.5 mm. The H1 and H2 designs are illustrated in Figure 3.
     - The H3 design shall contain 3 elements. A circular central area of diameter 11.3 mm shall be surrounded by two narrow rings having outside diameters of

14.3 mm and 17.3 mm, respectively. Thus each of these rings shall have a radial width of 1.5 mm. The H3 design is illustrated in Figure 4.

- The manufacturer shall advise the EPI-Hi team of the proposed width of the gaps between adjacent detector segments in these designs.
- It should be noted that the H1 and H2 detectors have identical sizes and configurations of active elements, but have different thicknesses.

6. **Chip Shape and Area.**
   - The completed chips shall be 16-sided regular polygons. The manufacturer shall review these chip dimensions and advise the EPI-Hi team on the minimum outside dimensions of the chip required for achieving optimum detector performance. For purposes of this draft specification, the following flat-to-flat dimensions of the chips have been assumed: L2, 28 mm; L3, 28 mm; H1 and H2, 21.3 mm; H3, 21.3 mm. These overall chip dimensions are indicated in Figures 1 through 4.
7. **Orientation.**
   - The detector chips shall be fabricated with a fixed, specified orientation relative to the primary and secondary flats on the silicon wafers.
8. **Floating Guard Rings.**
   - The detectors shall all include sets of floating multi-guard structures around the periphery of the active area of the detector. The manufacturer shall design this multi-guard structure to optimize detector characteristics and shall advise the EPI-Hi team on the width required to implement it.
9. **Contacts.**
   - The active elements of each detector shall be connected by narrow traces to wire bonding pads located near the periphery of the chip. In some cases this will require that the trace pass through a narrow gap between or through surrounding element(s). The widths of such gaps should be kept to the minimum required for good detector performance. The manufacturer shall recommend suitable widths for the trace and the gap to the EPI-Hi team.
10. **Active Thickness.**
    - The detector thicknesses shall be as follows: L2, 500±5 μm; L3, 1000±5 μm; H1, 500±5 μm; H2, 1000±5 μm; H3, 1000±5 μm.
11. **Thickness Uniformity.**
    - The total thickness variation over the active area of each detector shall be less than ±2.5 μm for the 500 μm detectors and less than ±5 μm for the 1000 μm detectors.
12. **Segment Isolation.**
    - The DC resistance between each active electrode and all other active electrodes on the junction surface of the detector shall be greater than 10 MΩ, with a goal of greater than 100 MΩ.
13. **Dead Layers.**
    - The junction and the ohmic surfaces of the detector shall each have dead layers of thickness <1 μm due to surface implants and metallization.

14. **Metallization.**
    - The detector surfaces shall be metallized with aluminum having 2000±500 Å thickness.
15. **Surface Condition.**
    - Detectors shall have specular reflecting (mirror) surfaces of good quality.
16. **Detector Mounting.**
    - Transmission-style detector mounts will be designed and procured by NASA's Goddard Space Flight Center and supplied to the detector manufacturer. The detector manufacturer shall review and approve the detector mount specification and design prior to fabrication. It is anticipated that detector mounts will be fabricated as multilayer circuit boards using G10/FR4 and flexible Kapton leads with appropriate connectors for mating to external circuitry. Detector chips shall be installed in the detector mounts using Shin-Etsu KJR-9022E resin mixed and cured according to manufacturer instructions. An alternative mixing and curing procedure is acceptable, if approved by NASA.
    - An important requirement for the HET and LET sensors is to have close spacings between successive detectors in the telescope stacks. The maximum allowable gap between successive detectors in a stack (bottom surface of one detector to top surface of the next detector) is 0.5 mm. For the H3 devices, multiple detector chips will be electrically connected together to effectively produce thicker detectors. Two mounting schemes are being considered for these devices: one in which each chip is in a separate mount, the other in which an individual mount holds two chips. NASA/GSFC will produce concept drawings for both approaches for review by the detector manufacturer. A choice between the two approaches will be made by the EPI-Hi team taking into account advice from the manufacturer.
17. **Mounting Tolerances.**
    - The detector chips shall be installed in the mounts in such a way as to maintain the following tolerances: parallelism between chip and mounting ledge, <1°; translational accuracy in the plane of the detector <0.1 mm; rotational accuracy relative to the symmetry axis perpendicular to the plane of the detector <0.5°.
18. **Electrical Connections.**
    - Electrical connections between detector contacts and nearby pads on the detector mount shall be made using a minimum of 4 separate wire bonds per connection. Wire bonding shall be done using soft aluminum wire with a nominal diameter of 50 μm. Wire bond lengths shall be kept as short as practical with a goal of <3 mm. The minimum bond strength shall correspond to the pull of a 10 gram weight. A non-destructive pull test shall be performed by the manufacturer on 2 of the detector bonds connected to each detector contact to demonstrate compliance with this specification.
    - The wirebonding shall be done in such a way as to minimize the maximum height of the wire bond above the detector surface. This requirement is imposed in order to minimize the chance of electrical breakdown between the wirebond and the surface of the adjacent detector when the detector telescope is operated in a dry nitrogen

environment. The manufacturer shall propose a suitable wirebonding approach for approval by the EPI-Hi team.

19. **Full-Depletion Voltage.**
    - The maximum full-depletion voltage, V_d, for the 500 μm detectors (L2 and H1) shall be 40 V and for the 1000 μm detectors (L3, H2, H3) shall be 160 V.
20. **Breakdown Voltage.**
    - The minimum acceptable breakdown voltages for the 500 μm detectors (L2 and H1) shall be 120 V and for the 1000 μm detectors (L3, H2, H3) shall be 250 V. The breakdown voltage shall be determined from measurements of the detector's leakage current (I_L) versus bias (V) with all detector segments connected in parallel. The breakdown voltage shall be taken to be the value of V for which I_L has a value equal to twice its value at V_d.
21. **Leakage Current.**
    - The maximum allowable leakage currents at 20°C shall be as follows: for L2, 150 nA; for L3, 300 nA; for H1, 75 nA; for H2, 150 nA; for H3, 150 nA per chip. For determining whether these specifications have been met, leakage currents shall be measured with all detector segments connected in parallel and with the detector biased at least 20 V above the full-depletion voltage. These measurements shall be made at room temperature in a vacuum $<5\times10^{-6}$ torr after the detector has been allowed to stabilize for at least 1 hour. The leakage current specification shall be met within 30 sec of bias being applied. The leakage currents shall not exceed the values listed above by more than a factor of 2 for a period of at least 1 year after delivery.
22. **Alpha Particle Resolution.**
    - Measurements of detector resolution shall be made in a vacuum using an alpha particle source (e.g., ^{241}Am or ^{244}Cm). The source shall be positioned at least 10 cm from the detector and shall illuminate the entire active area of the detector. The resulting pulse height distribution from the detector shall be measured with all detector segments connected in parallel using a charge sensitive amplifier, a shaping amplifier having peaking time (zero to peak) in the range 1 to 4 μs, and a pulse height analyzer. Measurements made with the alpha particles incident on each of the detector surfaces shall be reported.
23. **Temperature Range.**
    - The detectors shall have a operating temperature range of −40°C to +40°C and a non-operating temperature range of −60°C to +60°C. They shall meet the performance specifications after being returned to 20°C after exposure to each of the non-operating temperature extremes for at least 1 hour.
24. **Radiation Hardness.**
    - The detectors shall be designed to remain suitable for use after being subjected to proton radiation doses of up to 100 krad.
25. **Vacuum Stability.**
    - The detectors shall be tested for at least 72 hours at room temperature in a vacuum of 5×10^{-6} torr or better with the detectors continually biased to at least 20 V above

the full-depletion voltage. The leakage current and, if possible, the electronic noise, shall be monitored throughout this test and the measurements shall be reported as part of the documentation package to be delivered with each detector.

26. **Thermal Cycling.**
    - The detectors shall be cycled at least 10 times between temperatures of −60°C and +60°C at a rate of approximately 2°C per minute. This test shall be performed with no bias applied in a vacuum of $5{\times}10^{-6}$ torr or better or in a dry nitrogen atmosphere. Visual inspections and electrical tests shall be carried out to establish that the performance of the detectors has not been degraded due to the thermal cycling.
27. **Random Vibration Testing.**
    - The detectors shall be subjected to a single-axis random vibration test with the acceleration axis normal to the detector surface. A specification for the spectrum and overall amplitude of the vibration will be provided by the EPI-Hi team. The detectors shall be thoroughly inspected after the test for cracks, detached wire bonds, or other damage. Any observed damage shall be reported to the EPI-Hi team. The damaged detectors shall, at the discretion of the EPI-Hi team, be delivered for further inspection.
28. **Detector Identification.**
    - Each detector shall have a unique, 2-digit identification number written on the mount with an indelible ink compatible with use near solid-state detectors. This serial number shall be used to label all data to be included in the documentation package to be delivered with the detector.
29. **Documentation Package.**
    - Each delivered detector shall be accompanied by a documentation package containing information about the detector fabrication and testing. At a minimum this package shall contain the following: 1) detector identification number, 2) original delivery date (month and year), 3) wafer ID number and copy of the wafer manufacture's data sheet for the silicon wafer from which the detector was fabricated, 4) plot of detector capacitance versus bias, 5) plot of detector leakage current versus bias measured at room temperature and atmospheric pressure, 6) depletion voltage, 7) breakdown voltage, 8) alpha particle and test pulser pulse-height spectra measured with the alpha particles incident on the junction side and on the ohmic side of the detector and alpha-particle resolution derived from these data, 9) environmental test results, 10) copy of the manufacture's batch traveller documenting the fabrication and testing steps that the detector has gone through. The measurement results shall be reported in a standard format to be agreed upon by the detector manufacturer and the EPI-Hi team.

Table 1.

Solar Probe Plus EPI-Hi Instrument Silicon Detector Key Requirements Summary

Design ID:	L2	L3	H1	H2	H3
Thickness:	500±5 μm	1000±5 μm	500±5 μm	1000±5 μm	1000±5 μm
Chip Shape:	16-sided polygon	16-sided polygon	16-sided polygon	16-sided polygon	16-sided polygon
Chip Size (flat-to-flat):	28 mm	28 mm	21.3 mm	21.3 mm	21.3 mm
Active Segments:	6	2	7	7	3
Segment Geometry:	Figure 1	Figure 2	Figure 3	Figure 3	Figure 4
Thickness:	500±5 μm	1000±5 μm	500±5 μm	1000±5 μm	1000±5 μm
Thickness Variation:	±2.5 μm	±5 μm	±2.5 μm	±5 μm	±5 μm
Full-Depletion Voltage:	40 V	160 V	40 V	160 V	160 V
reakdown Voltage:	120 V	250 V	120 V	250 V	250 V
Leakage Current (20°C):	150 nA	300 nA	75 nA	150 nA	150 nA per chip

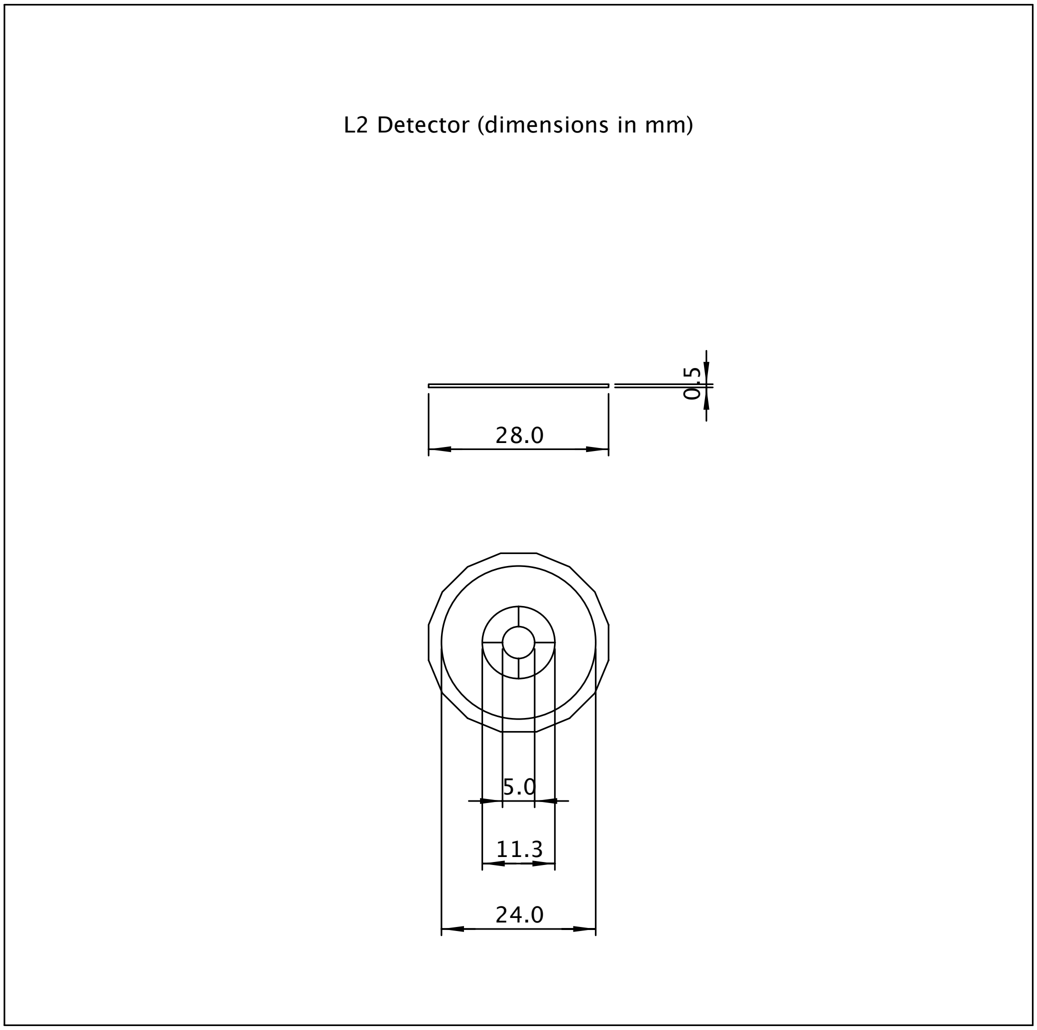


Figure 1.

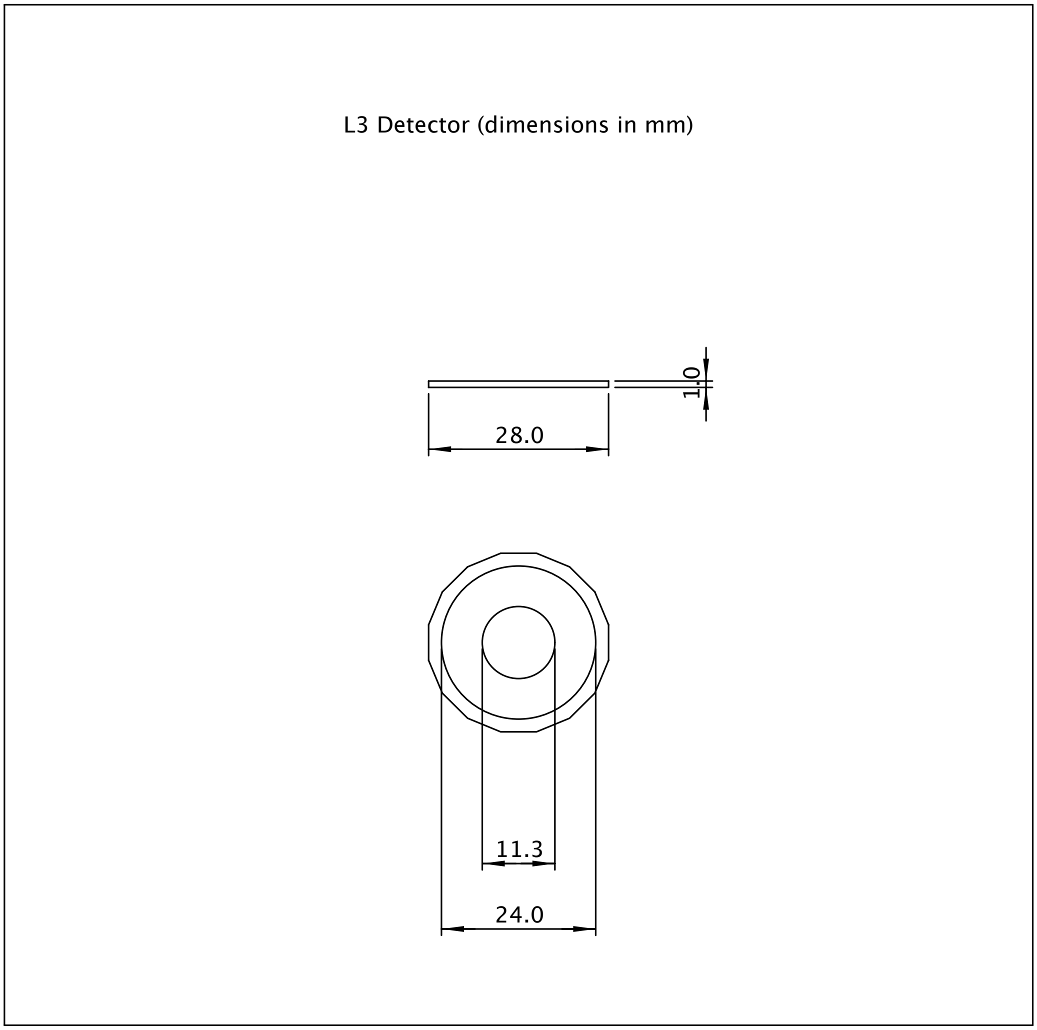


Figure 2.

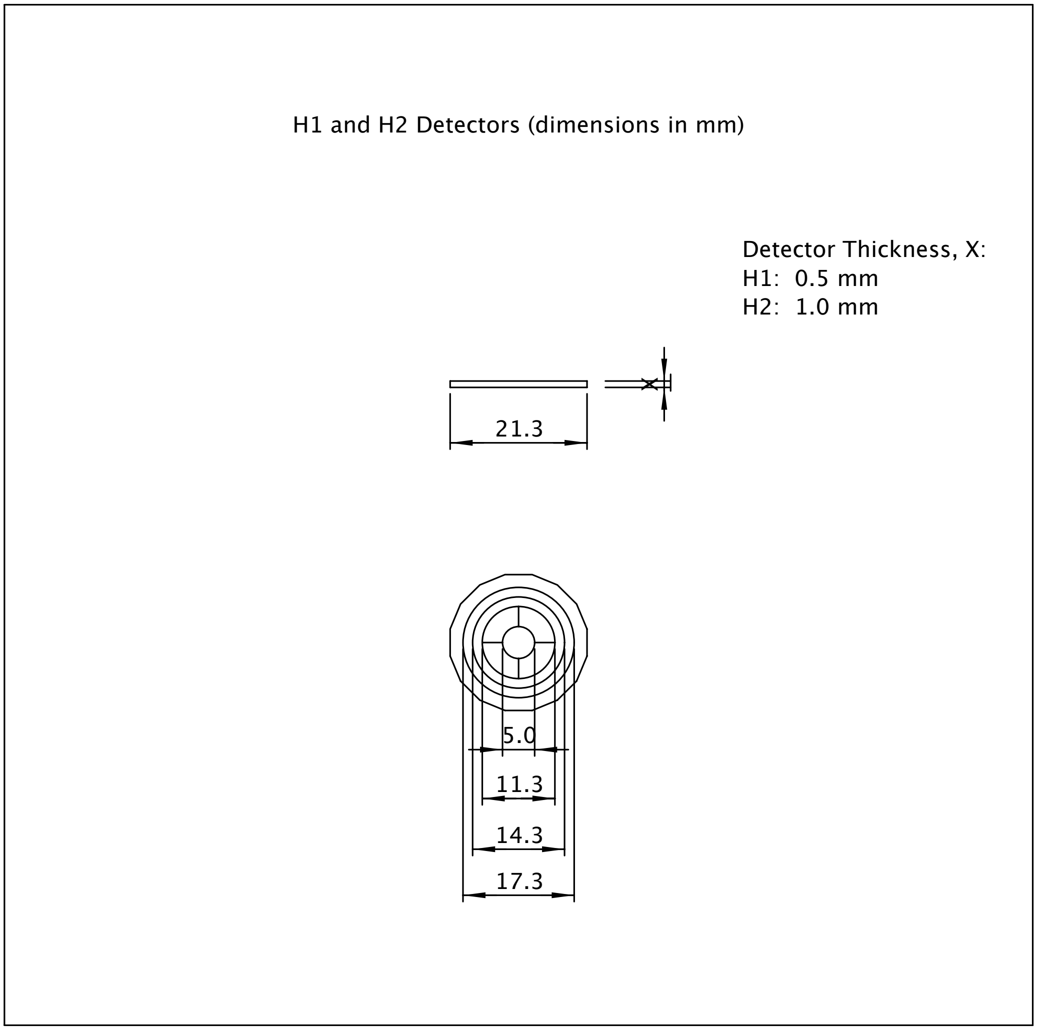

H1 and H2 Detectors (dimensions in mm)
Detector Thickness, X:
H1: 0.5 mm
H2: 1.0 mm
X
21.3
5.0
11.3
14.3
17.3

Figure 3.

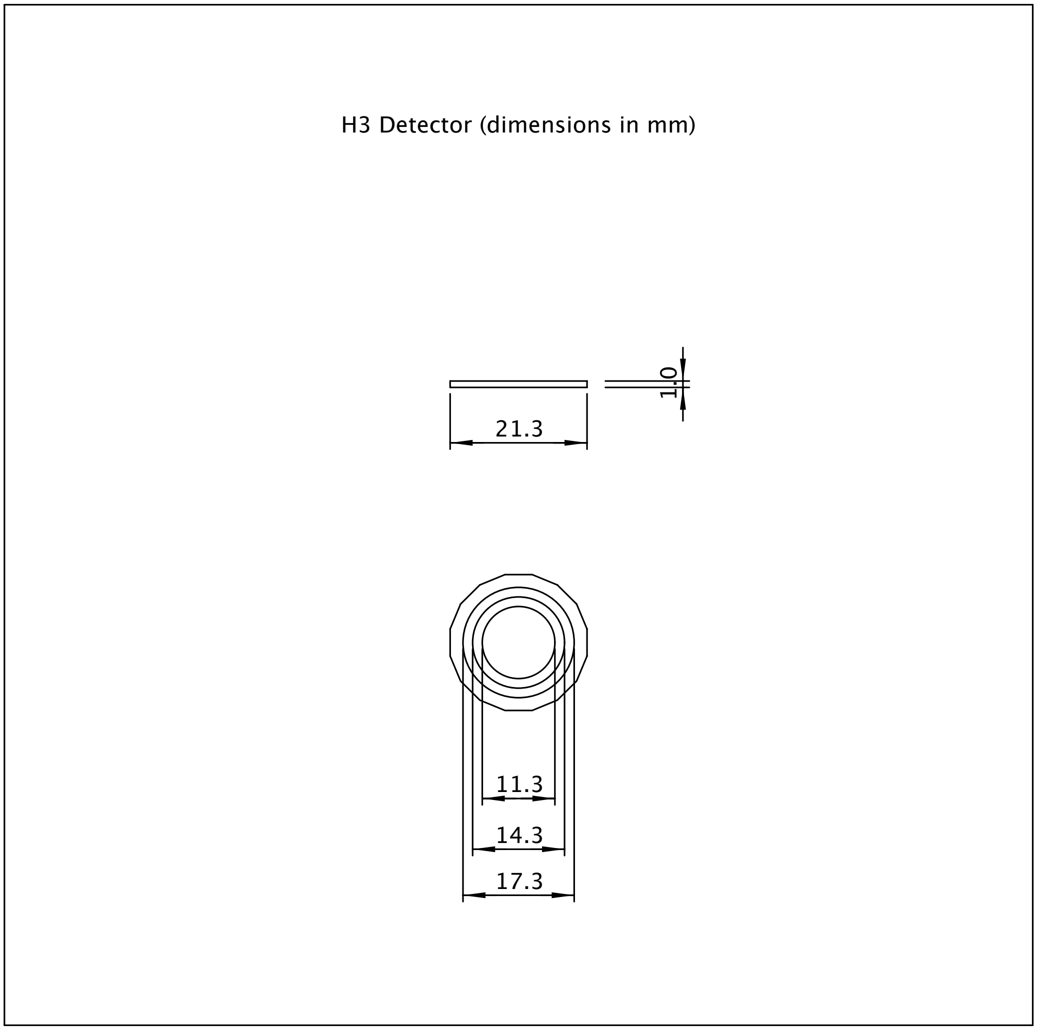
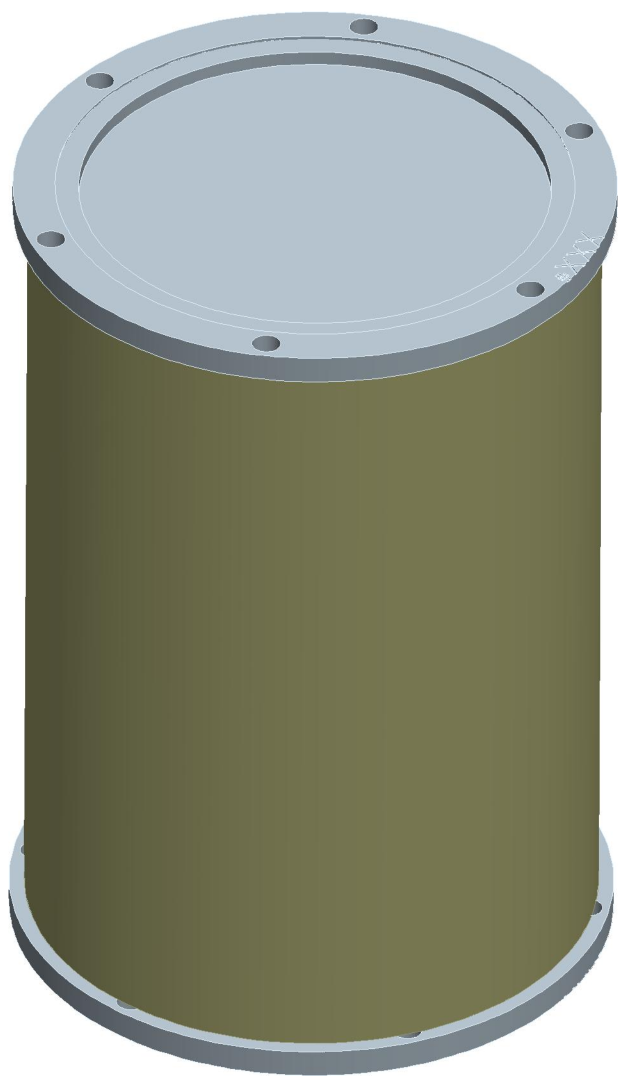
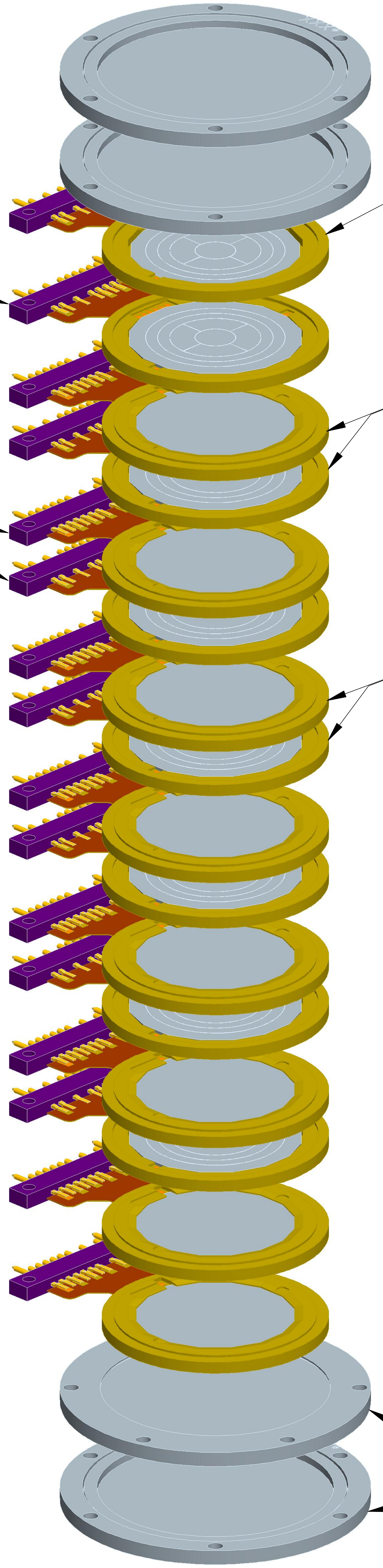


Figure 4.

HET TELESCOPE CONFIGURATION

03-MAY-2013





H1 DETECTOR
(0.5MM THK)
INNER ACTIVE ∅5.0MM
SEGMENTED ACTIVE ∅11.3MM
ACTIVE RING ∅14.3MM
ACTIVE RING ∅17.3MM
INACTIVE OUTER RING ∅21.3MM

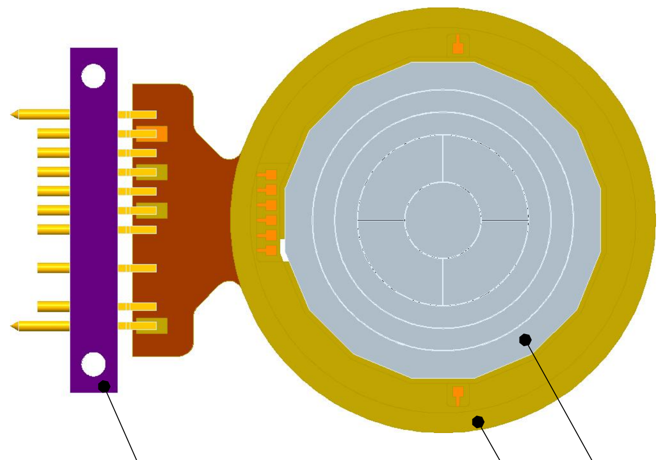
H2 DETECTOR
(1.0MM THK)
INNER ACTIVE ∅5.0MM
SEGMENTED ACTIVE ∅11.3MM
ACTIVE RING ∅14.3MM
ACTIVE GUARD RING ∅17.3MM
INACTIVE OUTER RING ∅21.3MM

H3 DETECTOR
(1.0MM THK X 2)
INNER ACTIVE ∅11.3MM
ACTIVE GUARD RING ∅14.3MM
ACTIVE GUARD RING ∅17.3MM
INACTIVE OUTER RING ∅21.3MM

H4 DETECTOR
(1.0MM THK X 2)
INNER ACTIVE ∅11.3MM
ACTIVE GUARD RING ∅14.3MM
ACTIVE GUARD RING ∅17.3MM
INACTIVE OUTER RING ∅21.3MM

H5 DETECTOR
(1.0MM THK X 2)
INNER ACTIVE ∅11.3MM
ACTIVE GUARD RING ∅14.3MM
ACTIVE GUARD RING ∅17.3MM
INACTIVE OUTER RING ∅21.3MM

PROTECTIVE FOILS
0.5 MIL KAPTON FOIL
(BOTH ENDS)



SILICON DETECTOR

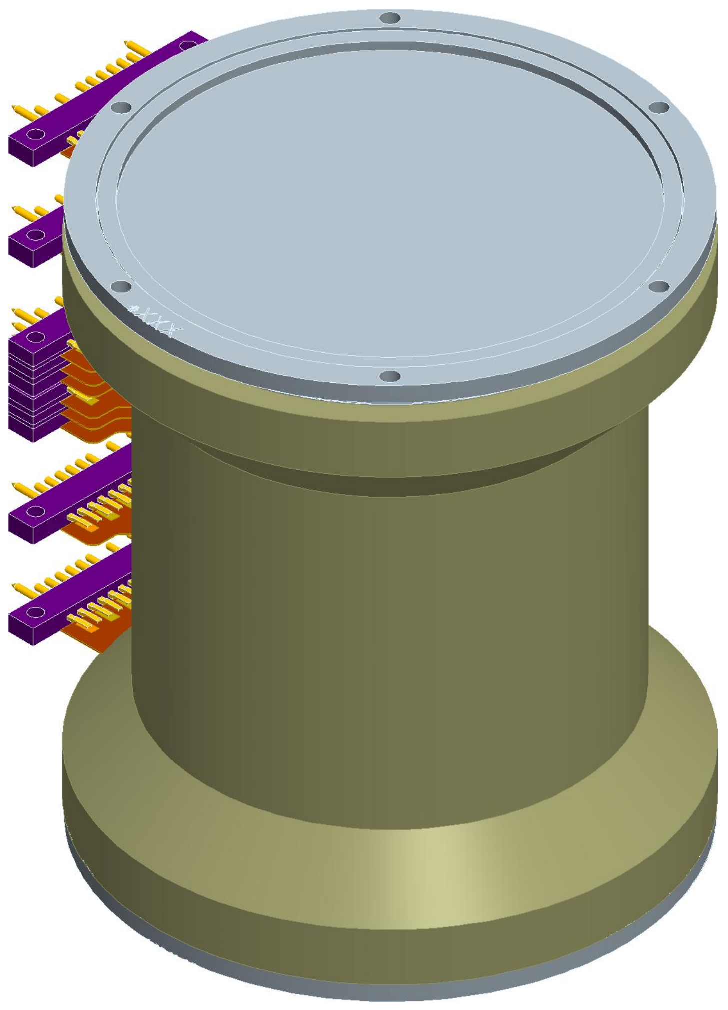
RIGID/FLEX MOUNT

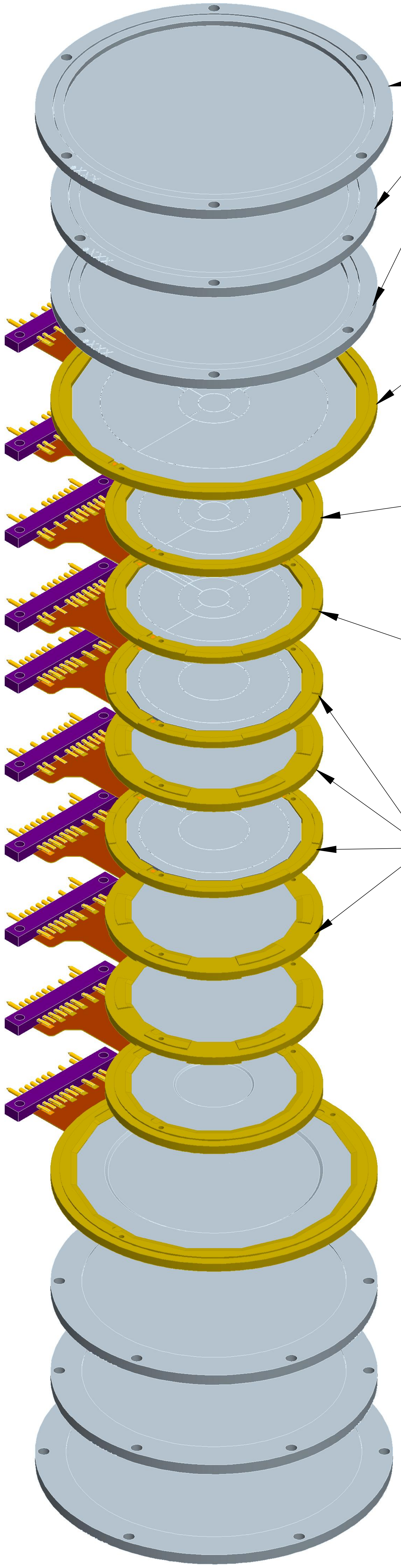
GLENAIR MICRO STRIP
CONNECTOR

LET TELESCOPE CONFIGURATION
02-MAY-2013

LET 2	LET 1
L0	L0A
L1	L1A
L2	L2A
L3	L3A
L4	L4A
L5	L4B
L6	L3B
	L2B
	L1B
	L0B

DETECTORS BELOW LINE ARE FLIPPED OVER W/ SEGMENTATION FACING REVERSE DIRECTION





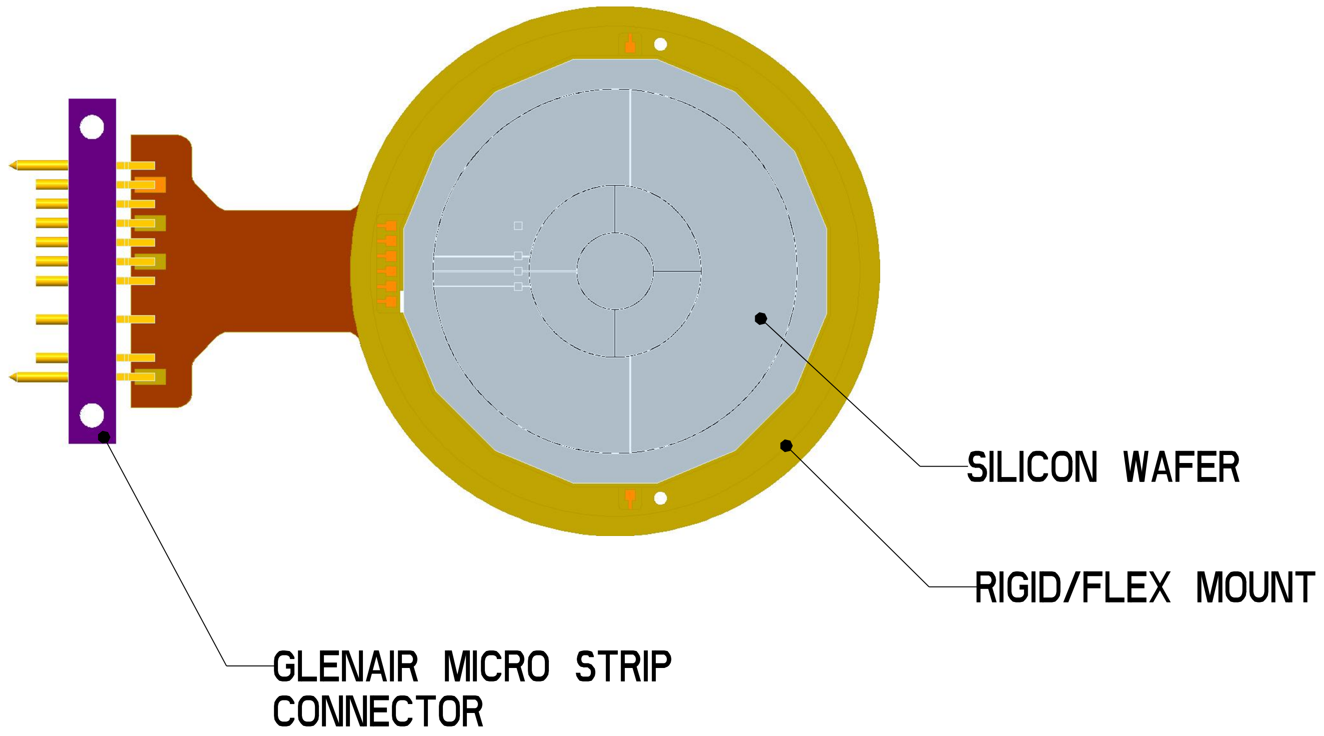
PROTECTIVE FOILS
1.0 MICRON POLYIMIDE OVER
95% OPEN POLYIMIDE MESH
(BOTH ENDS)

L0 DETECTOR
INNER ACTIVE ∅5.0MM X 0.01 THK
SEGMENTED ACTIVE ∅11.3MM X 0.01 THK
OUTER ACTIVE ∅34.0MM X 0.01 THK
HANDLE INACTIVE ∅45.5MM X 0.30 THK

L1 DETECTOR
INNER ACTIVE ∅5.0MM X 0.025MM THK
SEGMENTED ACTIVE ∅11.3MM X 0.025MM THK
HANDLE INACTIVE ∅28.0MM X 0.5MM THK

L2 DETECTOR
INNER ACTIVE ∅5.0MM X 0.50MM THK
SEGMENTED ACTIVE OUTER ∅11.3MM X 0.50MM THK
OUTER ACTIVE ∅24.0MM X 0.50MM THK
WAFER INACTIVE OUTER ∅28.00 X 0.50MM THK

L3, L4, L5 & L6 DETECTOR
INNER ACTIVE ∅11.3MM X 1.0MM THK
OUTER ACTIVE ∅24.0MM X 1.0MM THK
WAFER INACTIVE OUTER ∅28.0MM X 1.0MM THK



REVISION				
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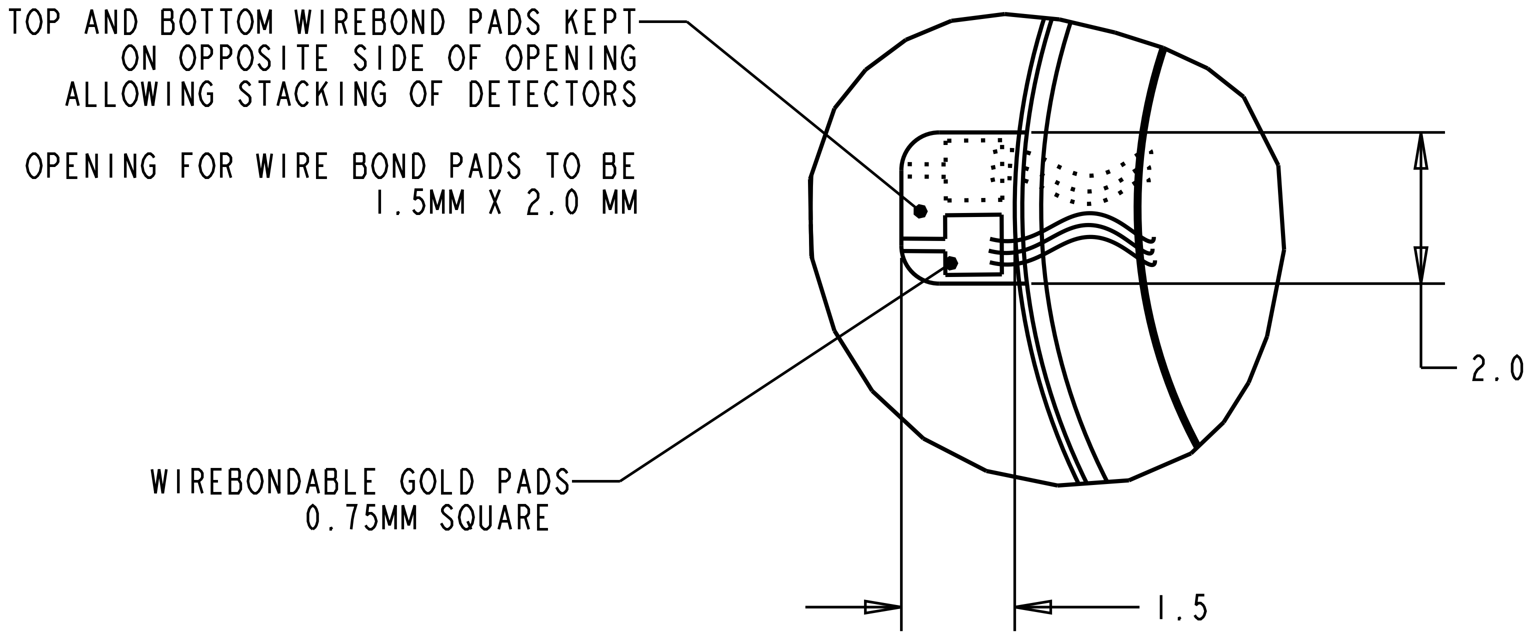

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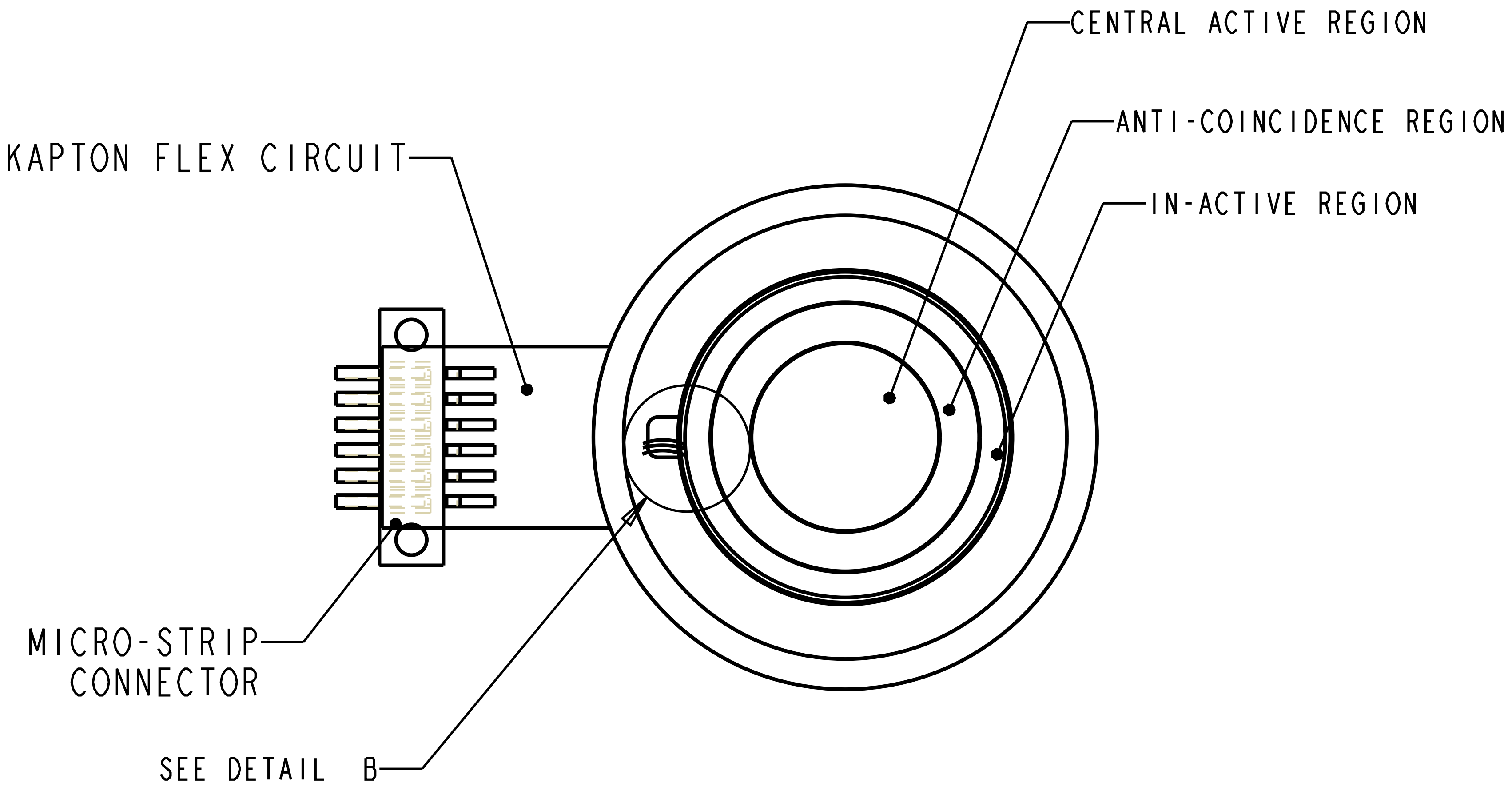

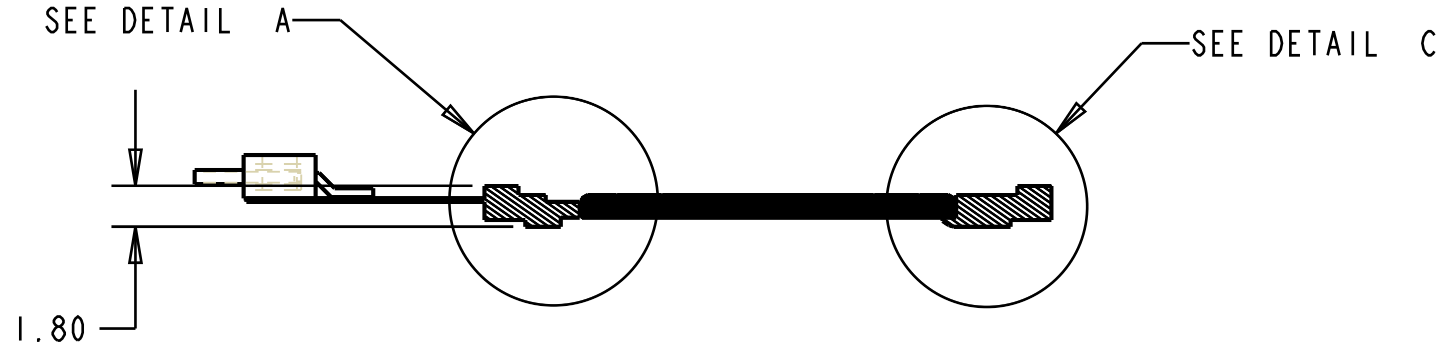

SECTION A-A
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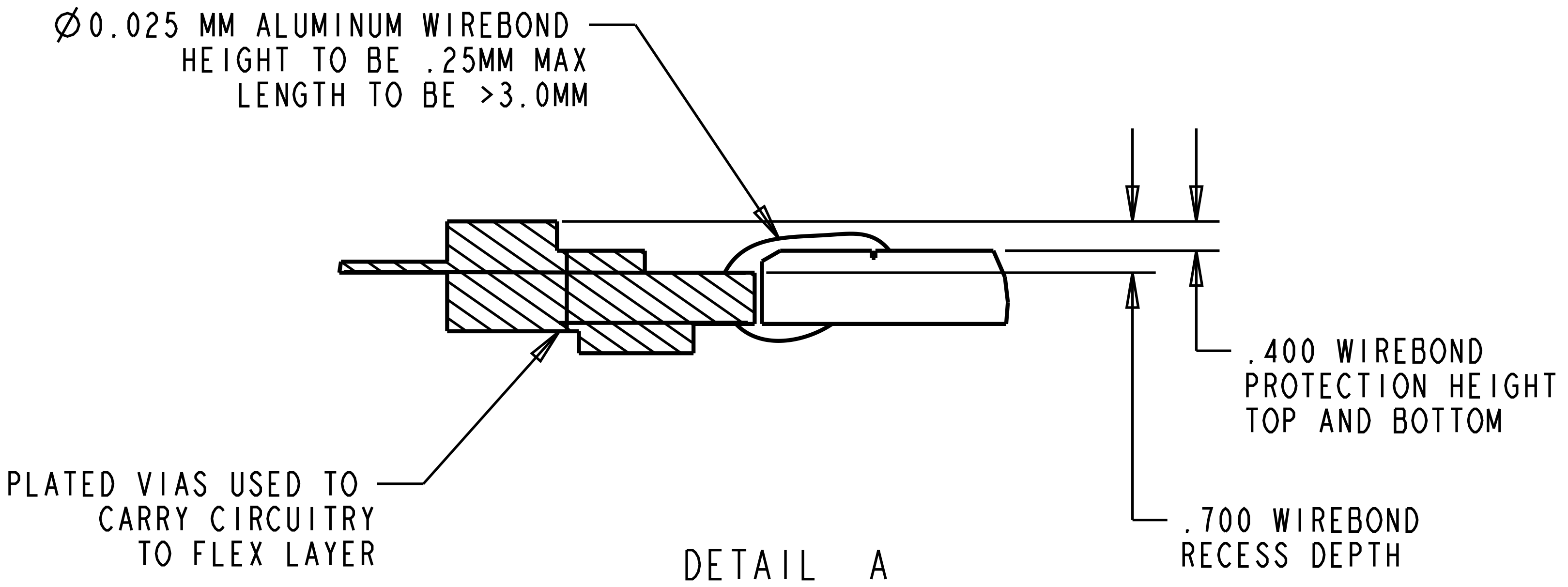

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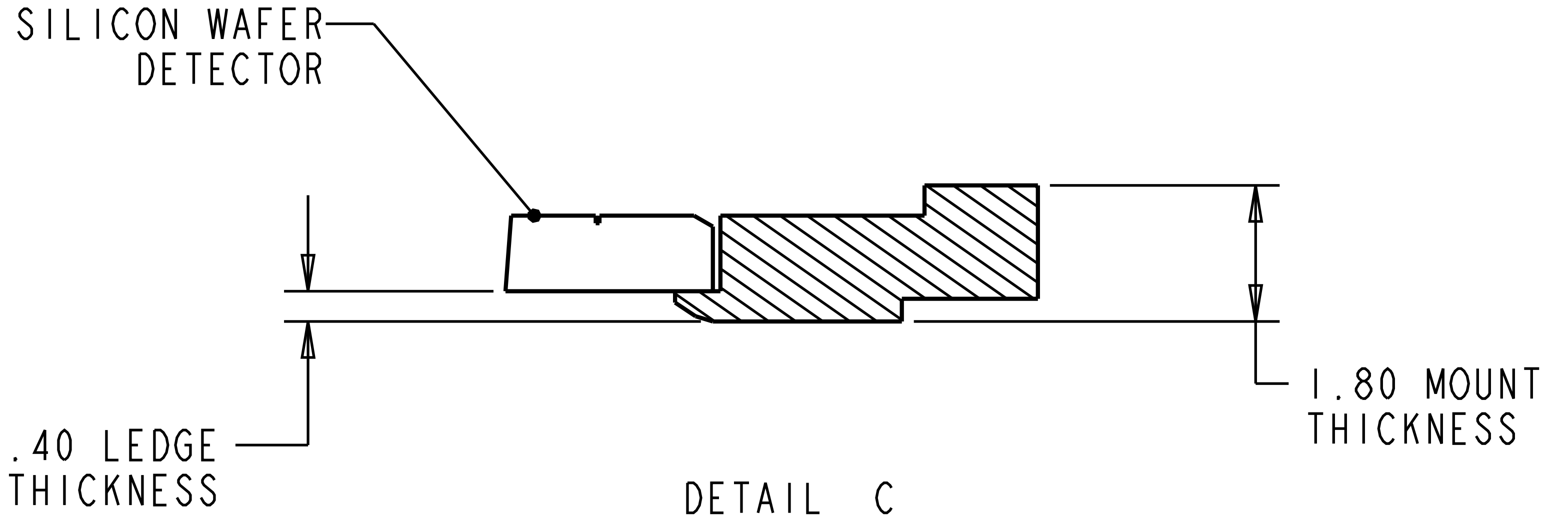


DETAIL C
SCALE 10.000

ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
	LIST OF MATERIAL					

THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.

HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]

METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5° &surf_finish ✓ FINISH IN μIN

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.07 X.X ±0.15 X ±0.2 ∠ ±0.5° &surf_finish ✓ FINISH IN μM
XX ±0.3 XXX ±0.8 XXXX ±1.5

SOFTWARE: Pro/ENGINEER
FILE LOCATION:
DRAWING FILE:DETECTOR-MOUNT-SINGLE REV .
MODEL FILE:DETECTOR-MOUNT-STACK REV .

NEXT ASSY | USED ON

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD ☐
WALLOPS ISLAND, VA ☐

NAME	INIT.	DATE
DESIGNED		
DRAWN		
CHECKED		
APPROVED -		
APPROVED -		
APPROVED -		
APPROVED - PDL		

DRAWING INTERPRETED PER 500-PG-8700.2.5

TITLE
DETECTOR MOUNT,
SINGLE DETECTOR,
SOLAR PROBE PLUS

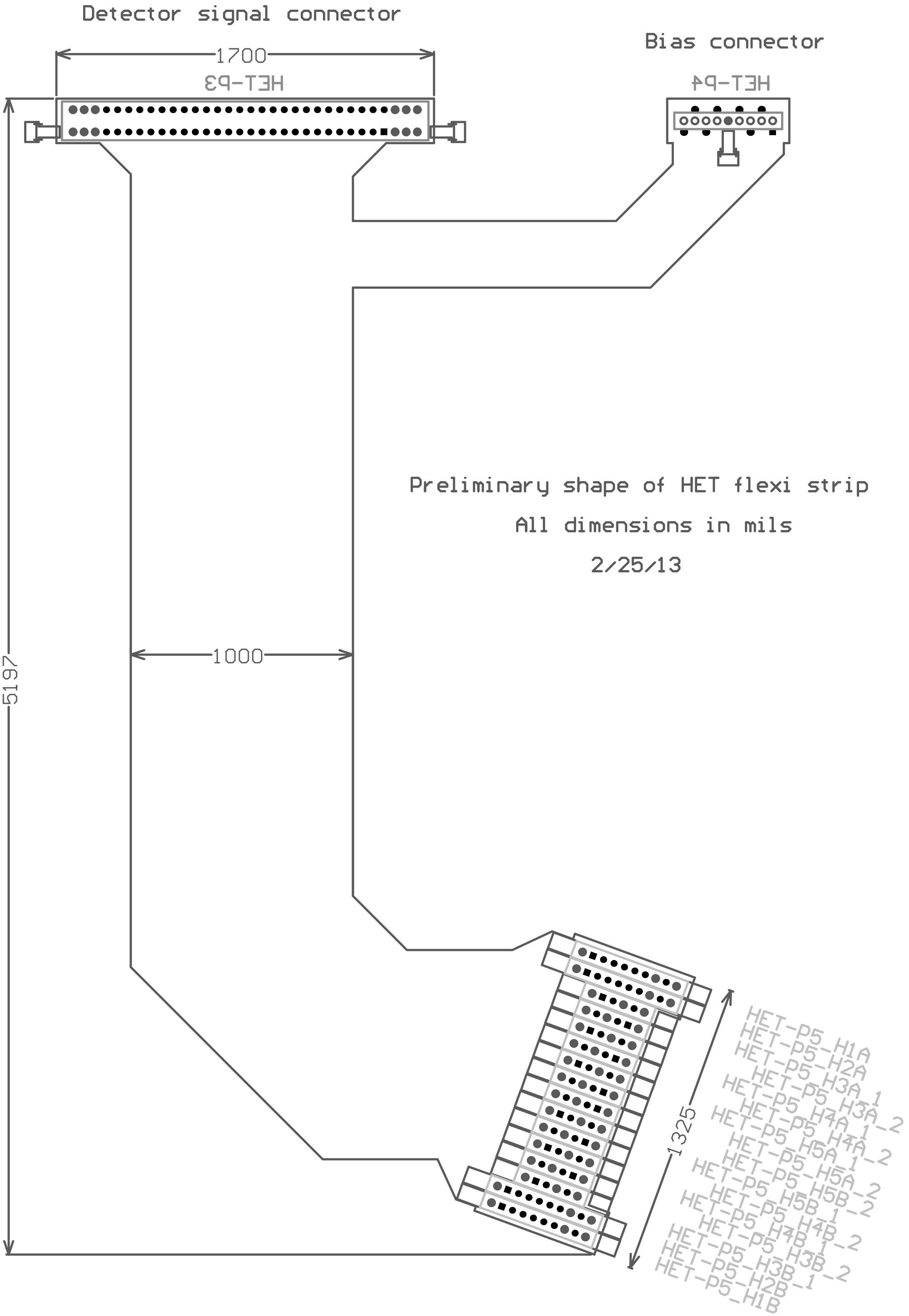
SIZE C | CAGE CODE 36FC1 | DWG NO. DETECTOR-MOUNT | REV
SCALE: 4.000 | SHEET: 1 OF 2

GSFC 660.3/M (01/10)

DWG NO. DETECTOR-MOUNT-SINGLE
REVISION

FOLD LINE

FOLD LINE



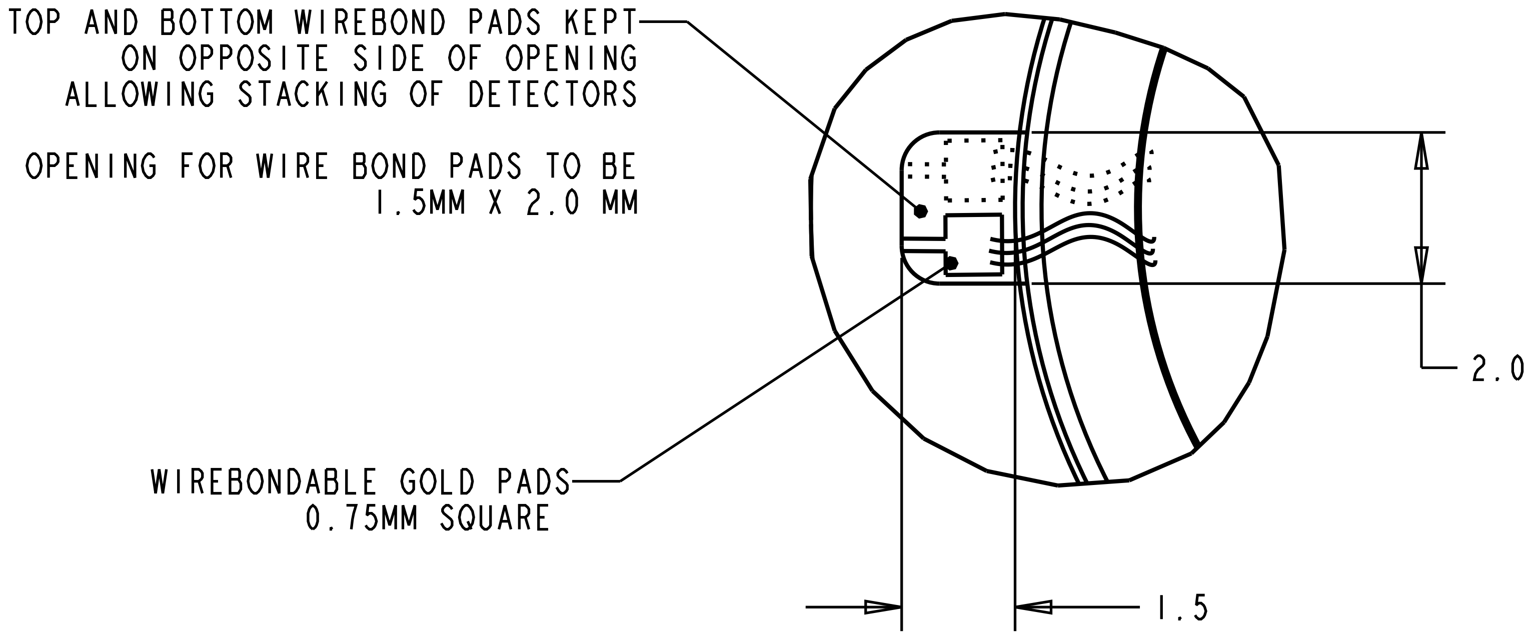
Preliminary shape of HET flexi strip

All dimensions in mils

2/25/13

Indented labels signify flipped connectors & detectors

REVISION				
REV	ZONE	DESCRIPTION	DATE	APPROVAL
-	-	-	-	-



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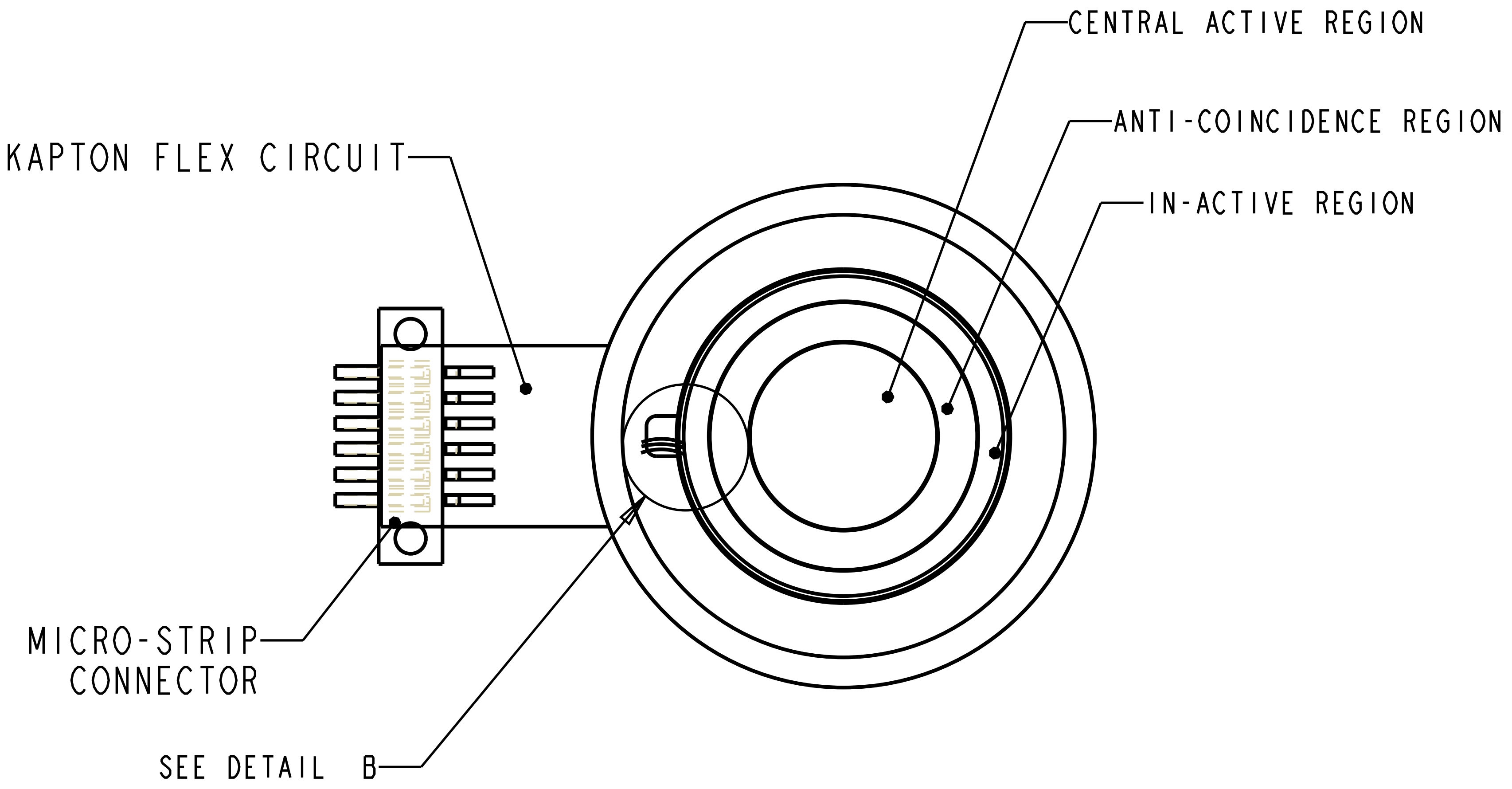

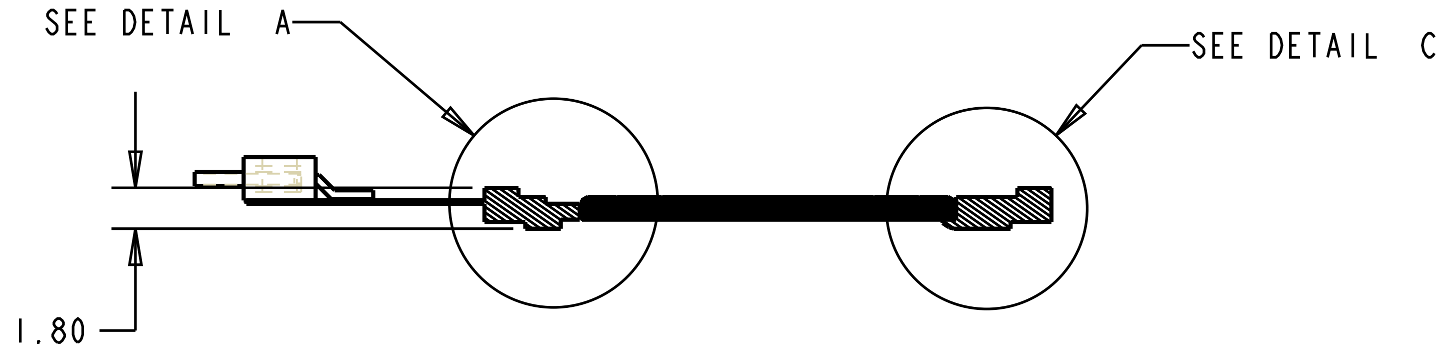

SECTION A-A
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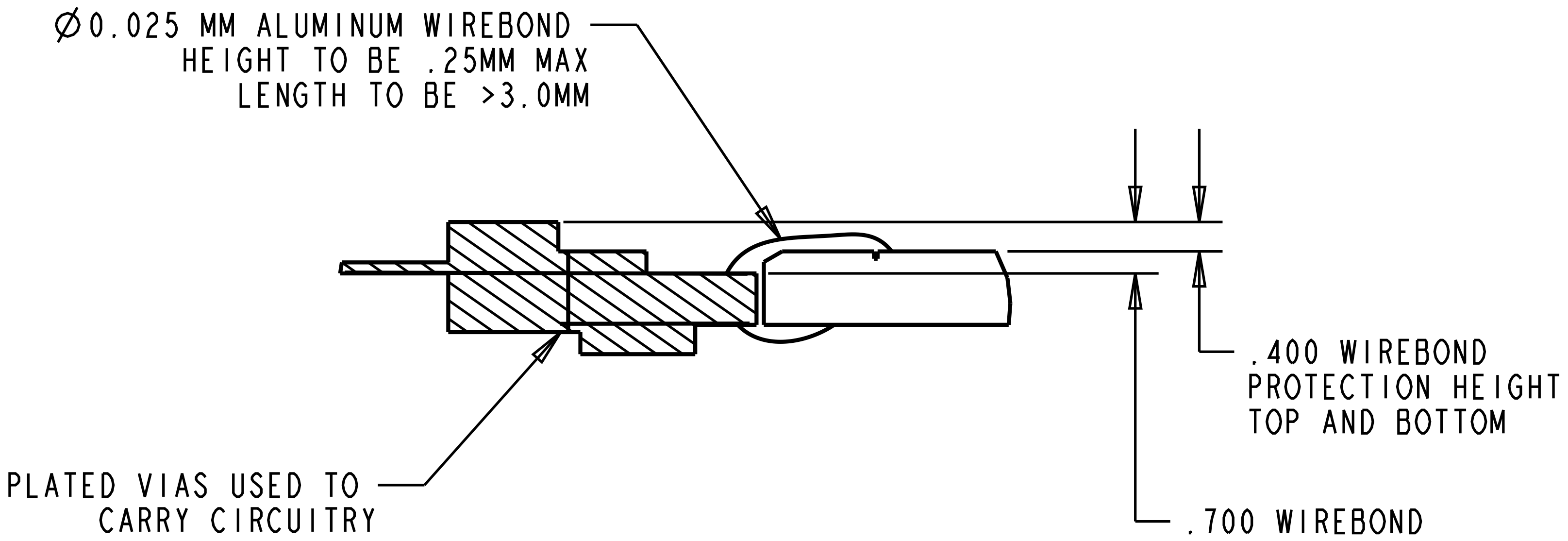

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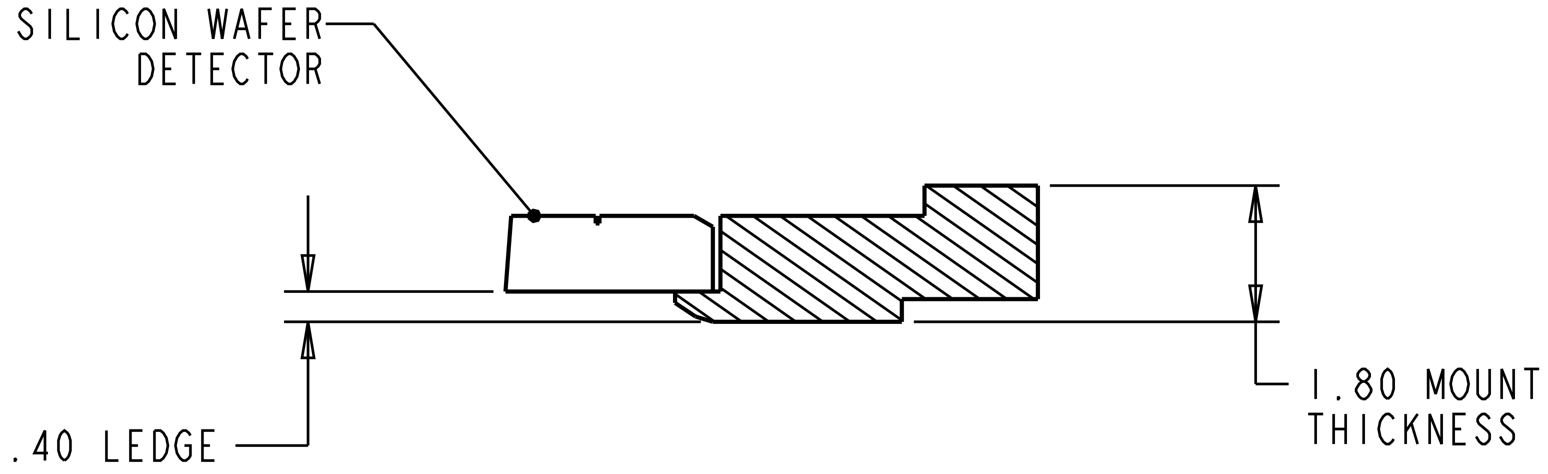


DETAIL C
SCALE 10.000

ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
	LIST OF MATERIAL					

THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.

HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]

METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
&surf_finish ✓
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5°
FINISH IN µIN

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.07 X.X ±0.15 X ±0.2 ∠ ±0.5° &surf_finish ✓
XX ±0.3 XXX ±0.8 XXXX ±1.5
FINISH IN µM

SOFTWARE: Pro/ENGINEER
FILE LOCATION:
DRAWING FILE:DETECTOR-MOUNT-SINGLE REV .
MODEL FILE:DETECTOR-MOUNT-STACK REV .

NEXT ASSY | USED ON

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD
WALLOPS ISLAND, VA

NAME	INIT.	DATE
DESIGNED		
DRAWN		
CHECKED		
APPROVED -		
APPROVED -		
APPROVED -		
APPROVED - PDL		

DRAWING INTERPRETED PER 500-PG-8700.2.5

TITLE
DETECTOR MOUNT, SINGLE DETECTOR, SOLAR PROBE PLUS

SIZE C
CAGE CODE 36FC1
DWG NO. DETECTOR-MOUNT-
REV
SCALE: 4.000
SHEET: 1 OF 2

DWG NO. DETECTOR-MOUNT-SINGLE
REVISION

FOLD LINE

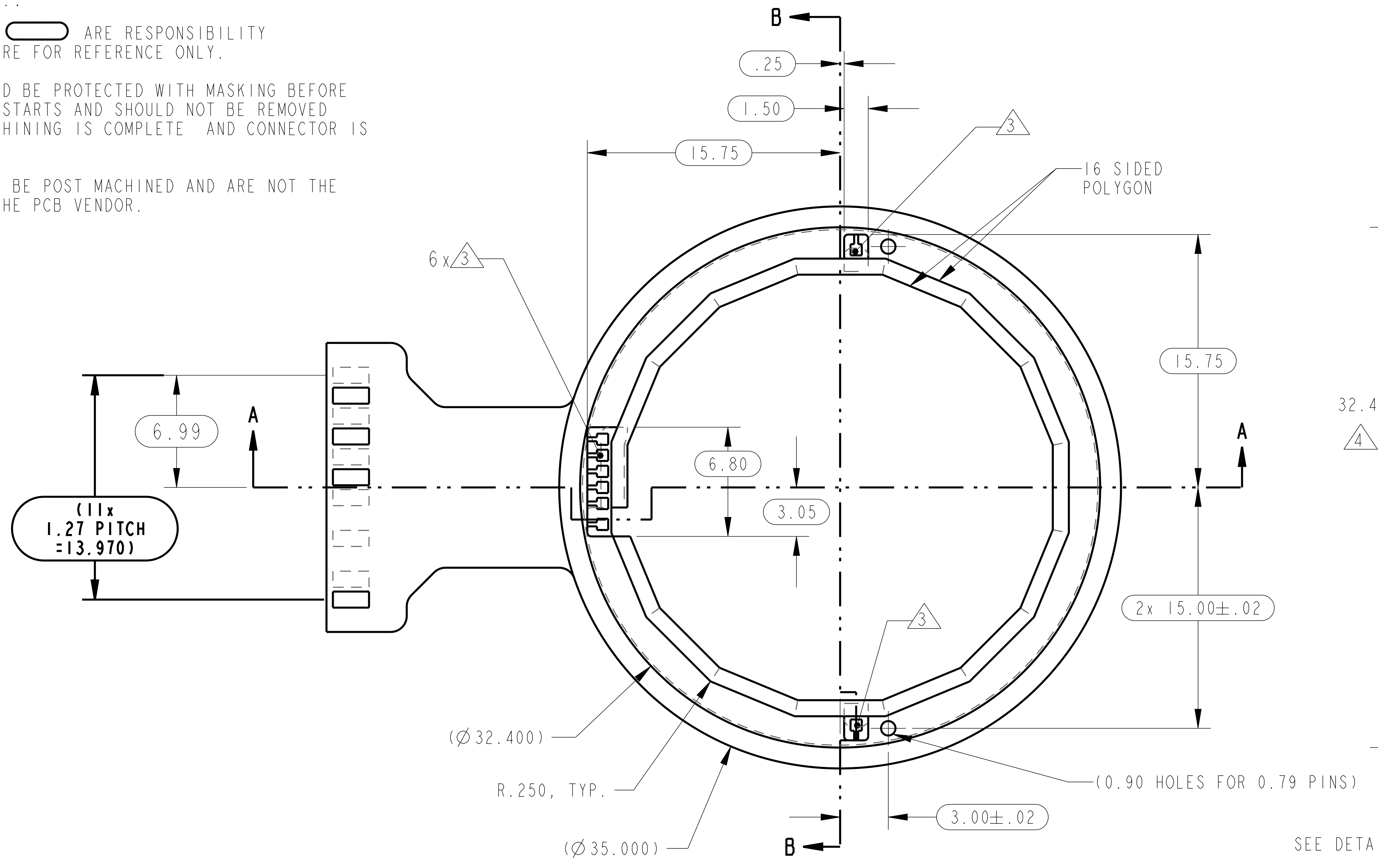
GSFC 660.3/M (01/10)

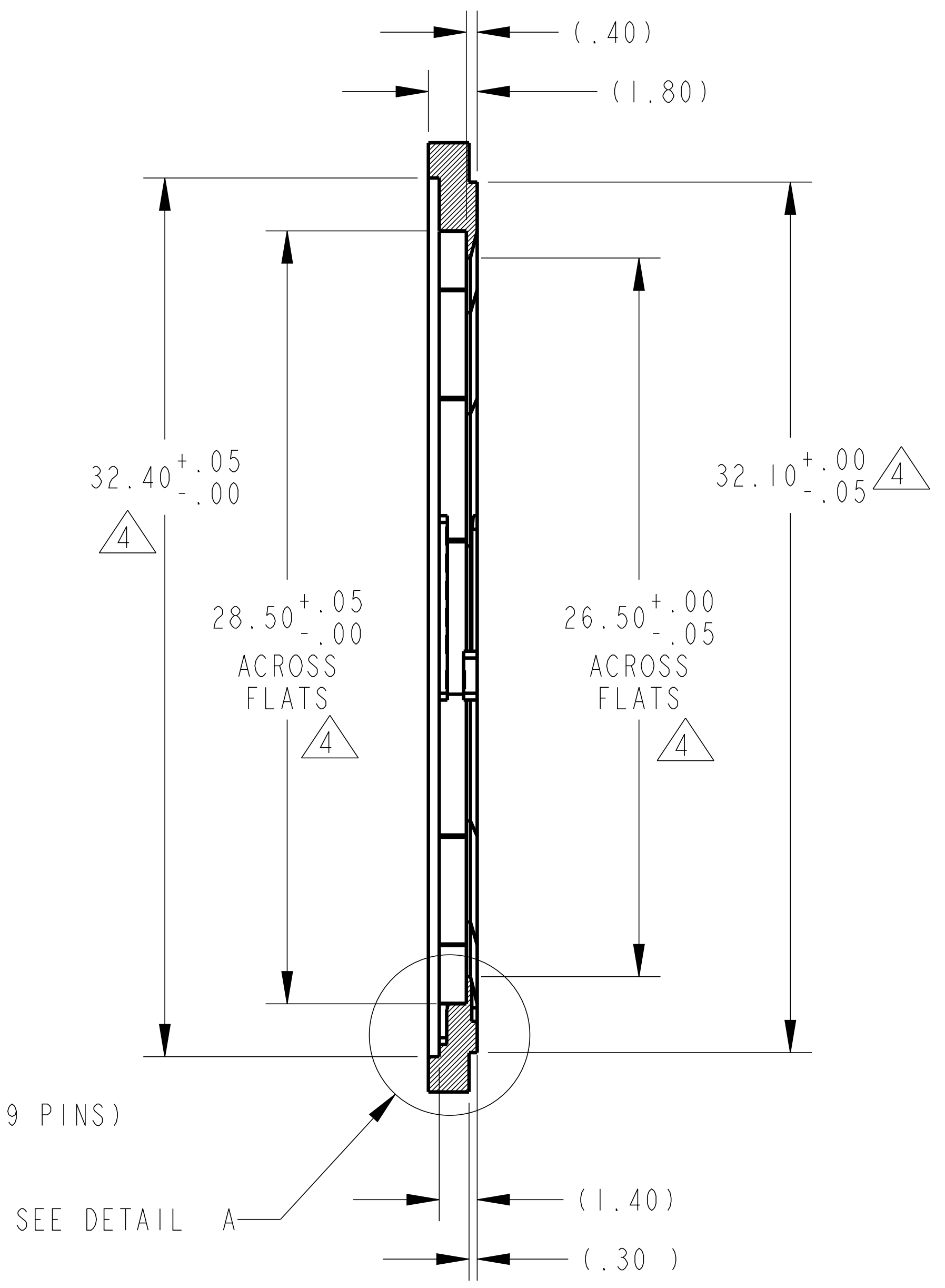
REVISION				
REV	ZONE	DESCRIPTION	DATE	APPROVAL
-	-	-	-	-

NOTES-
UNLESS OTHERWISE SPECIFIED:

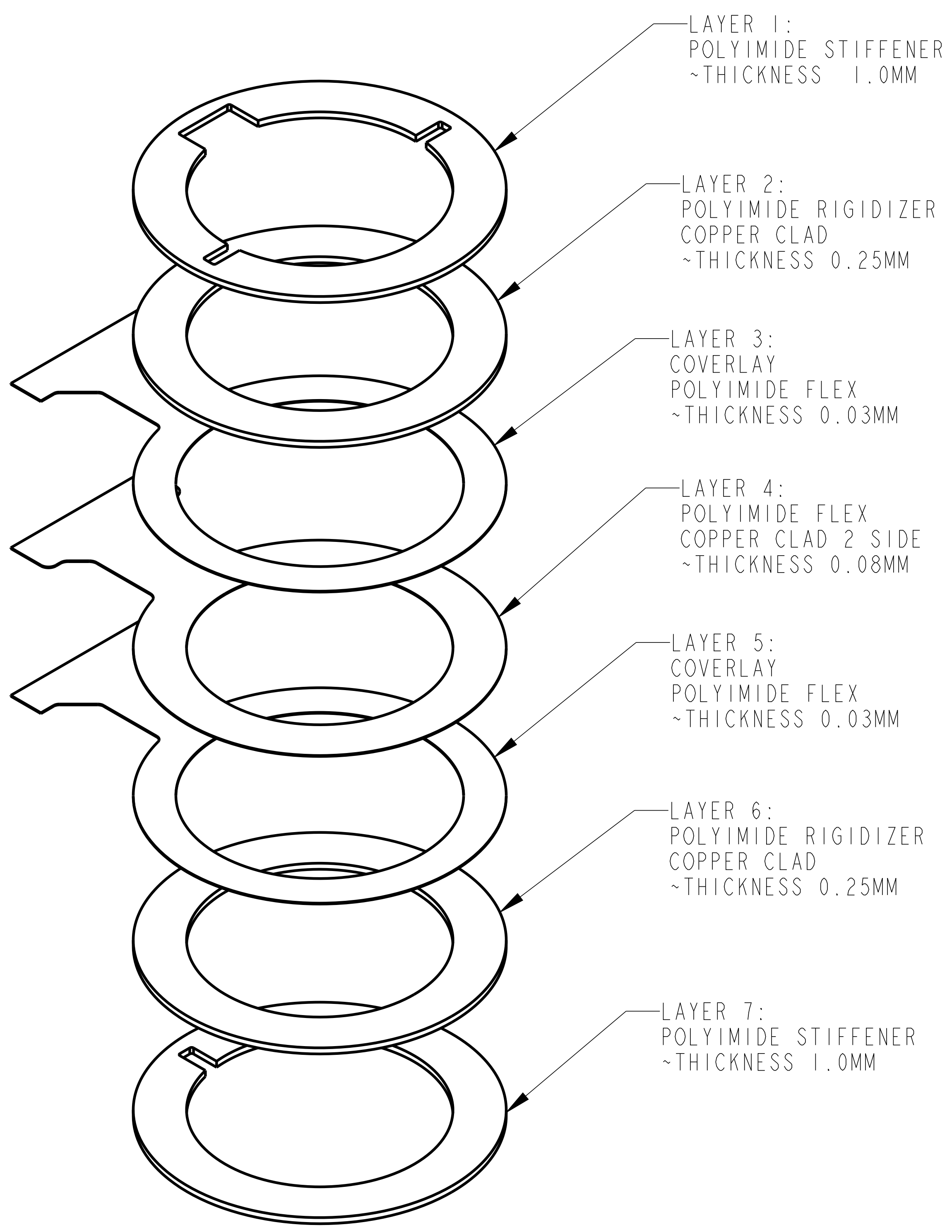
1. MATERIAL: SEE B.O.M..
2. DIMENSIONS SHOWN AS ⬭ ARE RESPONSIBILITY OF PCB VENDOR AND ARE FOR REFERENCE ONLY.
3. ALL GOLD PADS SHOULD BE PROTECTED WITH MASKING BEFORE ANY POST-MACHINING STARTS AND SHOULD NOT BE REMOVED UNTIL AFTER ALL MACHINING IS COMPLETE AND CONNECTOR IS INSTALLED.

△4 THESE FEATURES WILL BE POST MACHINED AND ARE NOT THE RESPONSIBILITY OF THE PCB VENDOR.

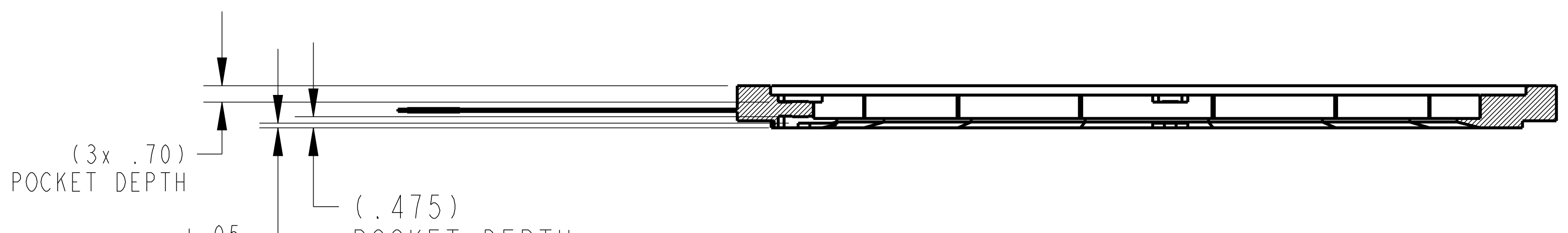




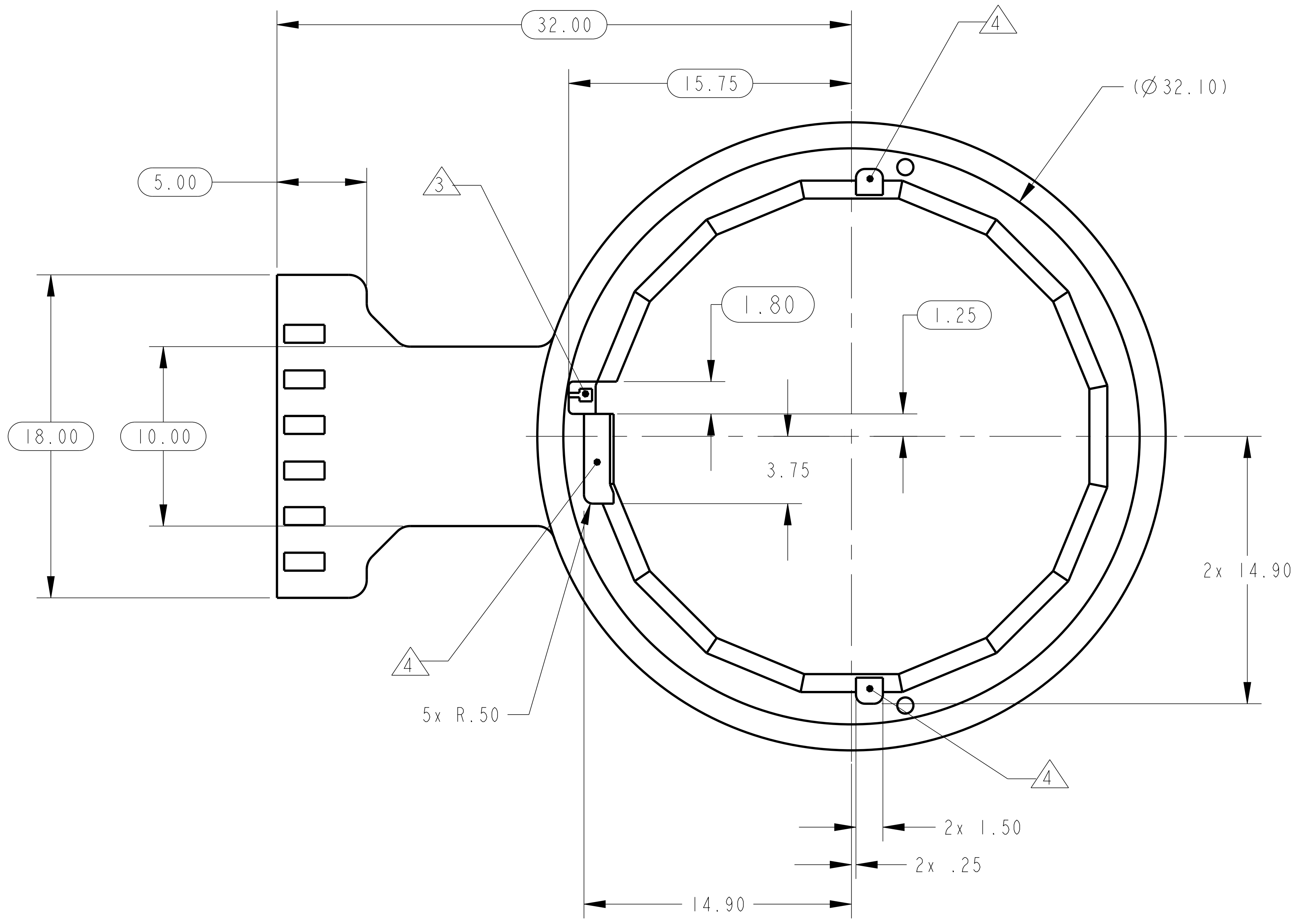
SECTION B-B

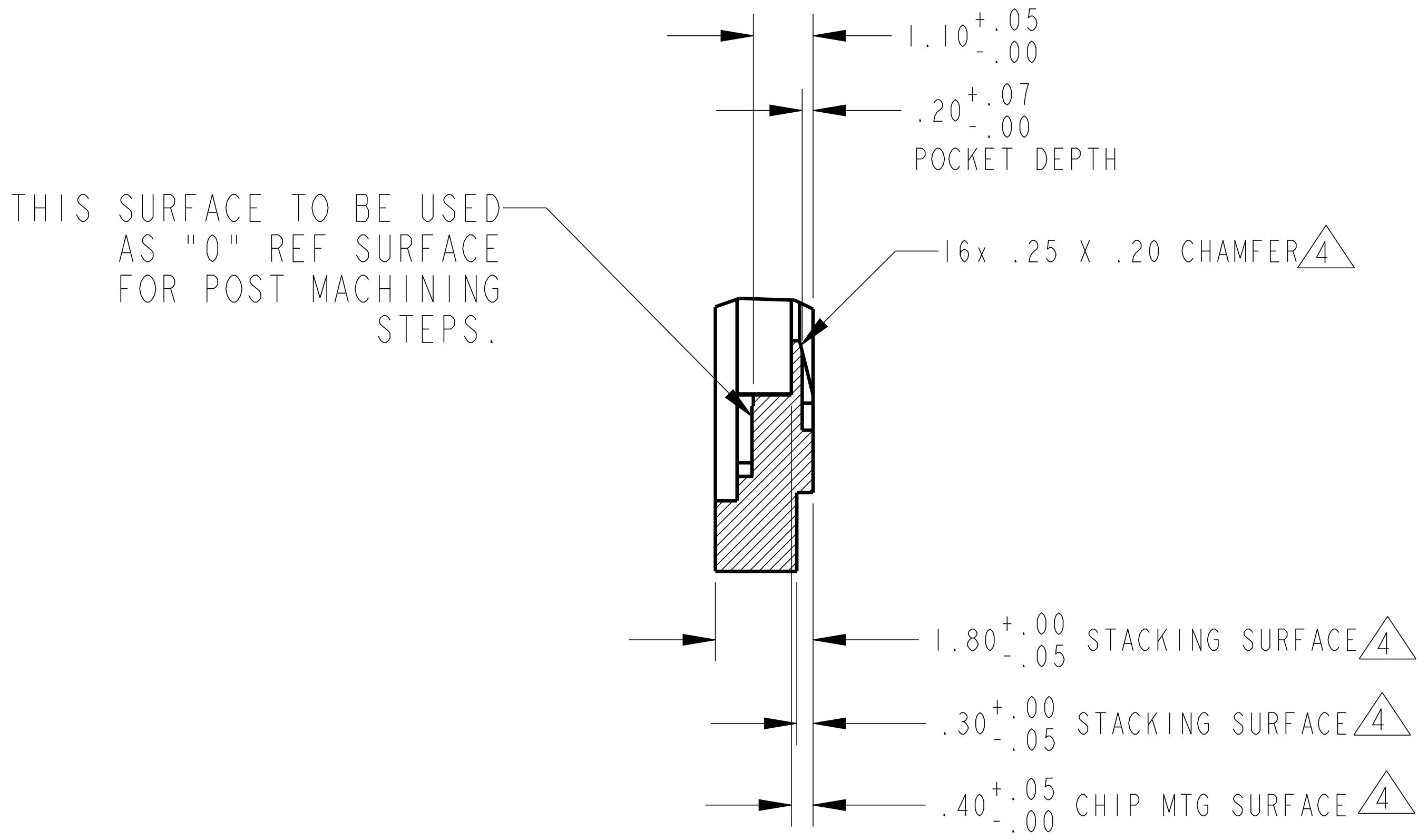


PCB LAY UP



SECTION A-A





DETAIL A
SCALE 8.000

PLOT DATE: 04-Jun-13

ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
		-	2190833	RIGI-FLEX PCB, MULTI-LAYER	POLYIMIDE	-

LIST OF MATERIAL

THIRD ANGLE PROJECTION
HARDWARE CLASSIFICATION
A

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.
HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]
METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5°
&surf_finish ✓ FINISH IN µIN

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.07 X.X ±0.15 X ±0.2 ∠ ±0.5°
XX ±0.3 XXX ±0.8 XXXX ±1.5
&surf_finish ✓ FINISH IN µM

SOFTWARE: Pro/ENGINEER WF5.0
FILE LOCATION: \SOLAR-PROBE
DRAWING FILE: 2190833 REV -.-
MODEL FILE: DETECTOR-MOUNT-SINGLE-LI REV -.-

NEXT ASSY	USED ON
2190834	SPP\EPI-HI
2190832	SPP\EPI-HI

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD ☒
WALLOPS ISLAND, VA ☐

DRAWING INTERPRETED PER 500-PG-8700.2.5

NAME	INIT.	DATE
DESIGNED S. SHUMAN		
DRAWN S. SHUMAN		
CHECKED P. GOODWIN		
APPROVED PROJECT M. WEIDENBECK		
APPROVED ELEC. ENGINEER R. COOK		
APPROVED SYS ENGINEER B. KECMAN		
APPROVED - PDL T. vonROSENVINGE		

TITLE
DETECTOR MOUNT, LET STACK DETECTORS,
SOLAR PROBE PLUS\ EPI-HI

SIZE D
CAGE CODE 36FC1
DWG NO. 2190833
REV -
SCALE: 4.000
SHEET: 1 OF 1

GSFC 660.3/M (01/10)

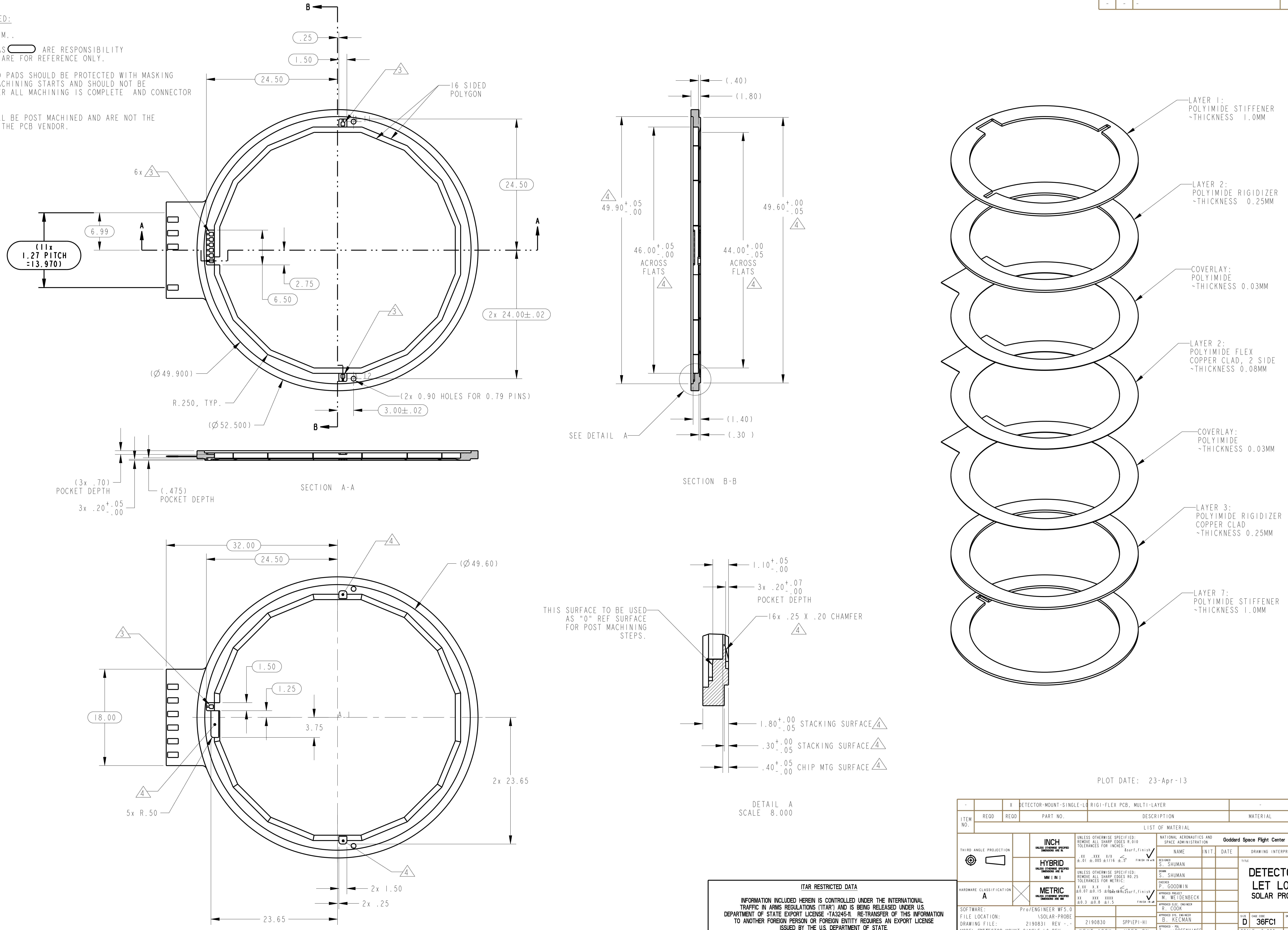
REVISION				
REV	ZONE	DESCRIPTION	DATE	APPROVAL
-	-	-	-	-

NOTES-
UNLESS OTHERWISE SPECIFIED:

1. MATERIAL: SEE B.O.M..
2. DIMENSIONS SHOWN AS ⬭ ARE RESPONSIBILITY OF PCB VENDOR AND ARE FOR REFERENCE ONLY.

△3 ALL GOLD WIRE BOND PADS SHOULD BE PROTECTED WITH MASKING BEFORE ANY POST-MACHINING STARTS AND SHOULD NOT BE REMOVED UNTIL AFTER ALL MACHINING IS COMPLETE AND CONNECTOR IS INSTALLED.

△4 THESE FEATURES WILL BE POST MACHINED AND ARE NOT THE RESPONSIBILITY OF THE PCB VENDOR.



PLOT DATE: 23-Apr-13

-		X	DETECTOR-MOUNT-SINGLE-LO	RIGI-FLEX PCB, MULTI-LAYER	-	-
ITEM NO.	REQD	REQD	PART NO.	DESCRIPTION	MATERIAL	MAT'L SPEC OR CAGE CODE
	LIST OF MATERIAL					

ITAR RESTRICTED DATA

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THIRD ANGLE PROJECTION

HARDWARE CLASSIFICATION
A

INCH
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN.

HYBRID
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN
MM [IN]

METRIC
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE MM

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R.010
TOLERANCES FOR INCHES:
&surf_finish
.XX ±.01 .XXX ±.005 X/X ±1/16 ∠ ±.5°
FINISH IN µIN

UNLESS OTHERWISE SPECIFIED:
REMOVE ALL SHARP EDGES R0.25
TOLERANCES FOR METRIC:
X.XX ±0.07 X.X ±0.15 X ±0.2 ∠ ±0.5° &surf_finish
XX ±0.3 XXX ±0.8 XXXX ±1.5
FINISH IN µM

SOFTWARE: Pro/ENGINEER WF5.0
FILE LOCATION: \SOLAR-PROBE
DRAWING FILE: 2190831 REV -.-
MODEL FILE: DETECTOR-MOUNT-SINGLE-LO REV -.-

2190830	SPP\EPI-HI
NEXT ASSY	USED ON

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
GREENBELT, MD ☒
WALLOPS ISLAND, VA ☐

NAME	INIT.	DATE
DESIGNED S. SHUMAN		
DRAWN S. SHUMAN		
CHECKED P. GOODWIN		
APPROVED PROJECT M. WEIDENBECK		
APPROVED ELEC. ENGINEER R. COOK		
APPROVED SYS. ENGINEER B. KECMAN		
APPROVED - PDL T. vonROSENVINGE		

DRAWING INTERPRETED PER 500-PG-8700.2.5

TITLE
DETECTOR MOUNT, LET LO DETECTOR, SOLAR PROBE PLUS\ EPI-HI

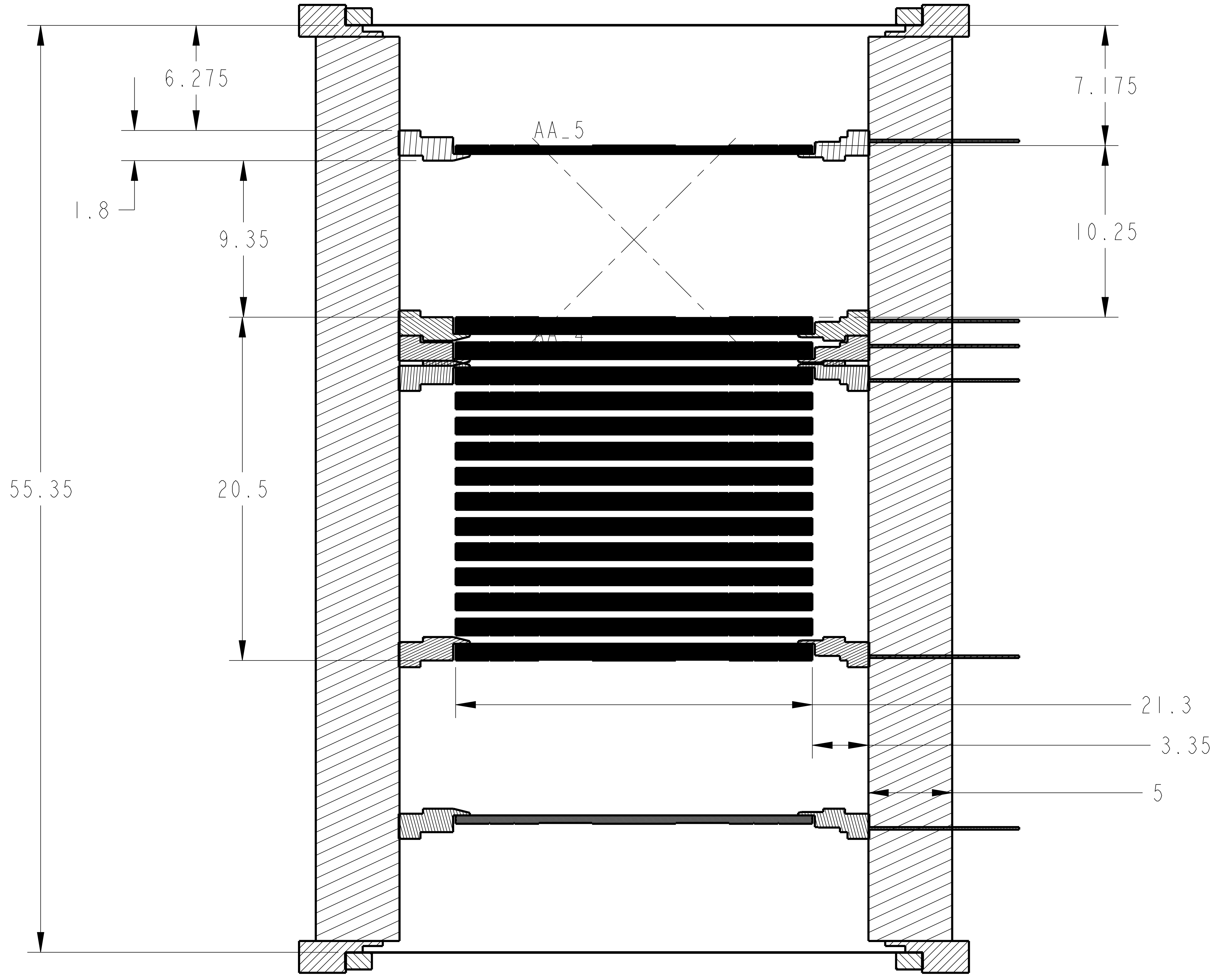
SIZE D
CAGE CODE 36FC1
DWG NO. 2190831
REV -
SCALE: 3.000
SHEET: 1 OF 1

GSFC 660.3/M (01/10)

FOLD LINE

DWG NO. 2190831

REVISION -



SECTION A-A