IDPU Overview

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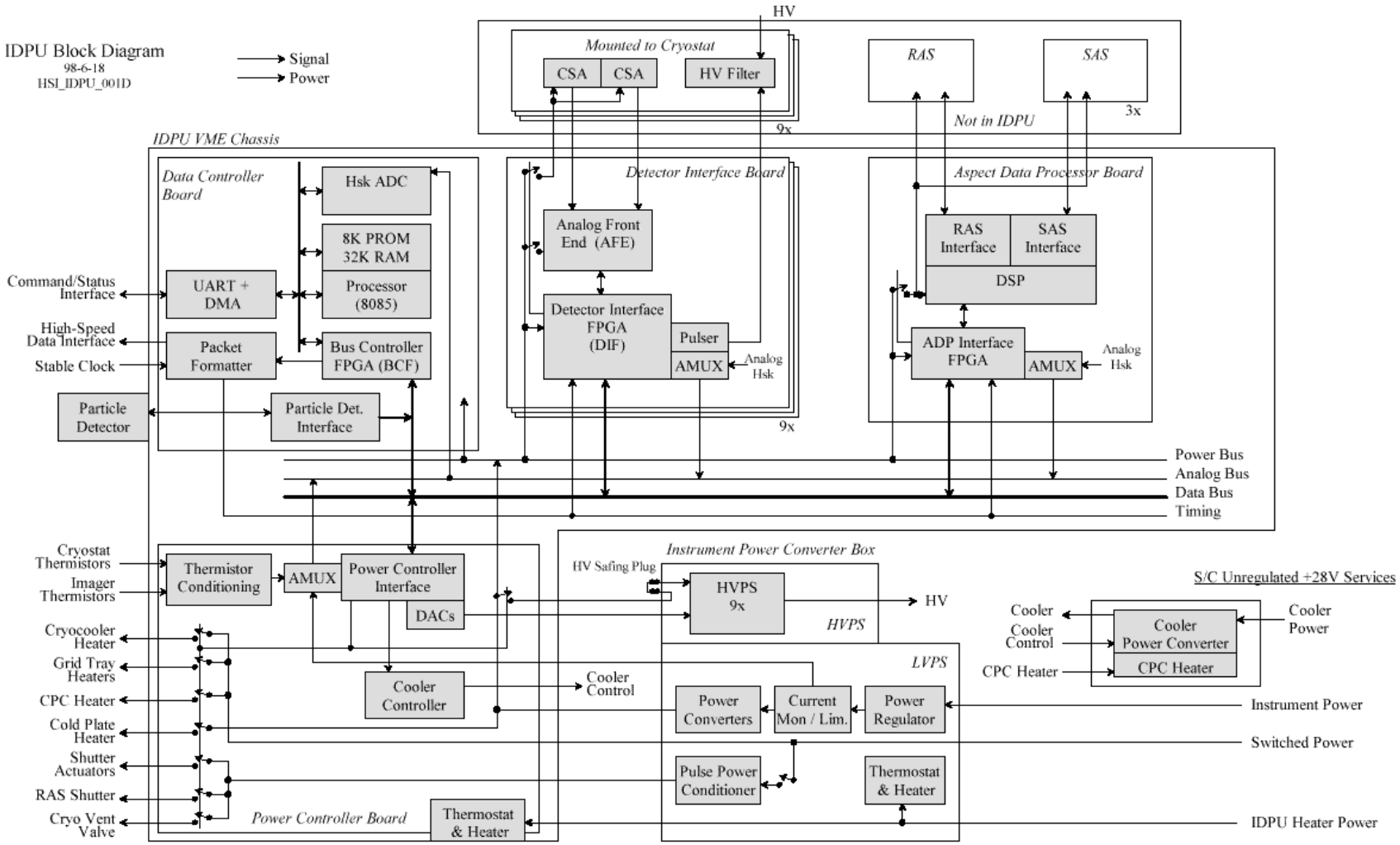
INSTRUMENT DATA PROCESSING UNIT REQUIREMENTS

- **The IDPU serves as the heart of the instrument electronics, and the only instrument electrical interface to the spacecraft.**
- **IDPU Functions:**
  - **Detector Event and Aspect Sensor signal processing & formatting into CCSDS packets**
  - **State Of Health data collection & formatting**
  - **Spacecraft Data Interface**
  - **Automatic Attenuator & Decimation "Event Throttle" control to optimize Solid State Recorder (SSR) memory use and avoid detector electronics saturation**
  - **Instrument Control (Thresholds, etc.)**
  - **Cryocooler Power Converter & Control (including automated cryostat Cool-down & Warm up)**
  - **Actuator Control (spectrometer shutters, RAS shutter, vacuum valve)**
  - **Detector High Voltage Supply / Control (including safing)**
  - **Power regulation & conversion for the instrument, and subsystem power switching**

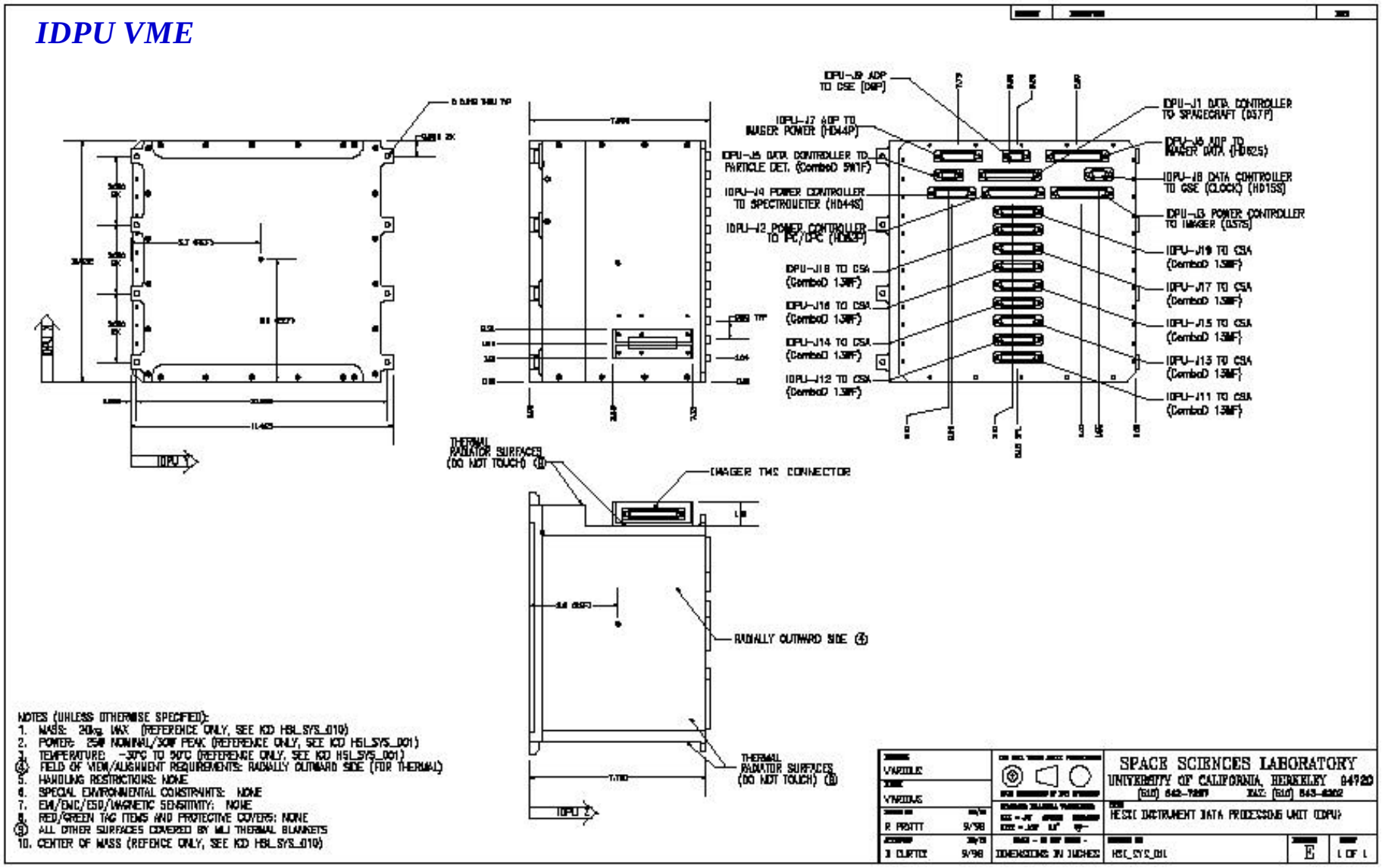
IDPU IMPLEMENTATION

- **IDPU consists of three boxes:**
  - **IDPU-VME (or just IDPU)**
    - **VME Chassis contains:**
      - **Data Control Board (DCB) (IDPU processor)**
      - **Power Control Board (PCB) (power switches & controls)**
      - **Detector Interface Boards (9) (DIB) (GeD Analog Front End)**
      - **Aspect Data Processor Board (ADP) (Imager RAS/SAS Sensor Interface)**
      - **PMT-RAS Interface Electronics**
  - **Instrument Power Converter (IPC)**
    - **IDPU Low Voltage Power Supply (+5D, +/-5, +/-12V)**
    - **Cold Plate Heater Supply (100V)**
    - **Germanium Detector High Voltage Power Supplies (9) (0-5000V)**
    - **Particle Detector Bias Supply (0-400V)**
    - **Actuator Supply(10V)**
    - **Programmable voltages controlled by IDPU-VME**
  - **Cryocooler Power Converter (CPC)**
    - **Power Amplifier - generates 0-100W 58.6Hz supply for Spectrometer cryocooler**
    - **Provided programmable Main and Ballancer waveforms from IDPU VME**

IDPU BLOCK DIAGRAM



IDPU VME


IDPU-J9 ADP TO GSE (D9P)
IDPU-J7 ADP TO IMAGER POWER (HD44P)
IDPU-J5 DATA CONTROLLER TO PARTICLE DET. (ComboD 9W1F)
IDPU-J4 POWER CONTROLLER TO SPECTROMETER (HD44S)
IDPU-J2 POWER CONTROLLER TO PC/DPC (HD62P)
IDPU-J1 DATA CONTROLLER TO SPACECRAFT (D37P)
IDPU-J6 ADP TO IMAGER DATA (HD62S)
IDPU-J8 DATA CONTROLLER TO GSE (CLOCK) (HD15S)
IDPU-J3 POWER CONTROLLER TO IMAGER (D37S)
IDPU-J10 TO CSA (ComboD 13W3F)
IDPU-J17 TO CSA (ComboD 13W3F)
IDPU-J15 TO CSA (ComboD 13W3F)
IDPU-J13 TO CSA (ComboD 13W3F)
IDPU-J11 TO CSA (ComboD 13W3F)
IDPU-J18 TO CSA (ComboD 13W3F)
IDPU-J16 TO CSA (ComboD 13W3F)
IDPU-J14 TO CSA (ComboD 13W3F)
IDPU-J12 TO CSA (ComboD 13W3F)
THERMAL RADIATOR SURFACES (DO NOT TOUCH) (5)
IMAGER THIS CONNECTOR
RADIALLY OUTWARD SIDE (4)
THERMAL RADIATOR SURFACES (DO NOT TOUCH) (5)
IDPU 1
IDPU 2
NOTES (UNLESS OTHERWISE SPECIFIED):
1. MASS: 20kg MAX (REFERENCE ONLY, SEE ICD HSI_SYS_010)
2. POWER: 25W NOMINAL/30W PEAK (REFERENCE ONLY, SEE ICD HSI_SYS_001)
3. TEMPERATURE: -30°C TO 50°C (REFERENCE ONLY, SEE ICD HSI_SYS_001)
4. FIELD OF VIEW/ALIGNMENT REQUIREMENTS: RADIALLY OUTWARD SIDE (FOR THERMAL)
5. HANDLING RESTRICTIONS: NONE
6. SPECIAL ENVIRONMENTAL CONSTRAINTS: NONE
7. EMI/EMC/ESD/MAGNETIC SENSITIVITY: NONE
8. RED/GREEN TAG ITEMS AND PROTECTIVE COVERS: NONE
9. ALL OTHER SURFACES COVERED BY MLI THERMAL BLANKETS
10. CENTER OF MASS (REFENCE ONLY, SEE ICD HSI_SYS_010)
VARIOUS
R PRATT 9/98
J CURTIS 9/98
DIMENSIONS IN INCHES
SPACE SCIENCES LABORATORY
UNIVERSITY OF CALIFORNIA, BERKELEY 94720
HESSI INSTRUMENT DATA PROCESSING UNIT (IDPU)
HSI_SYS_001
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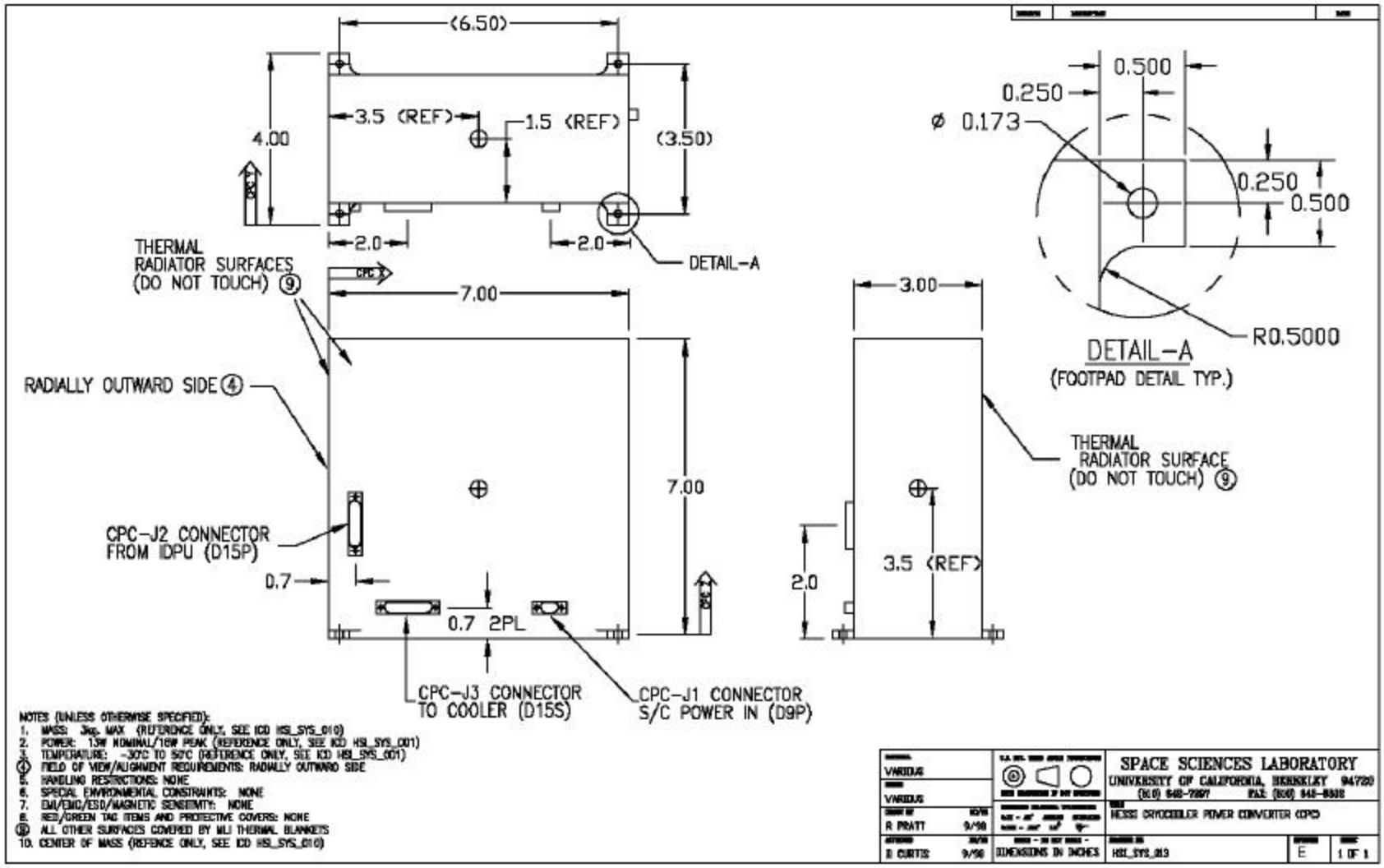
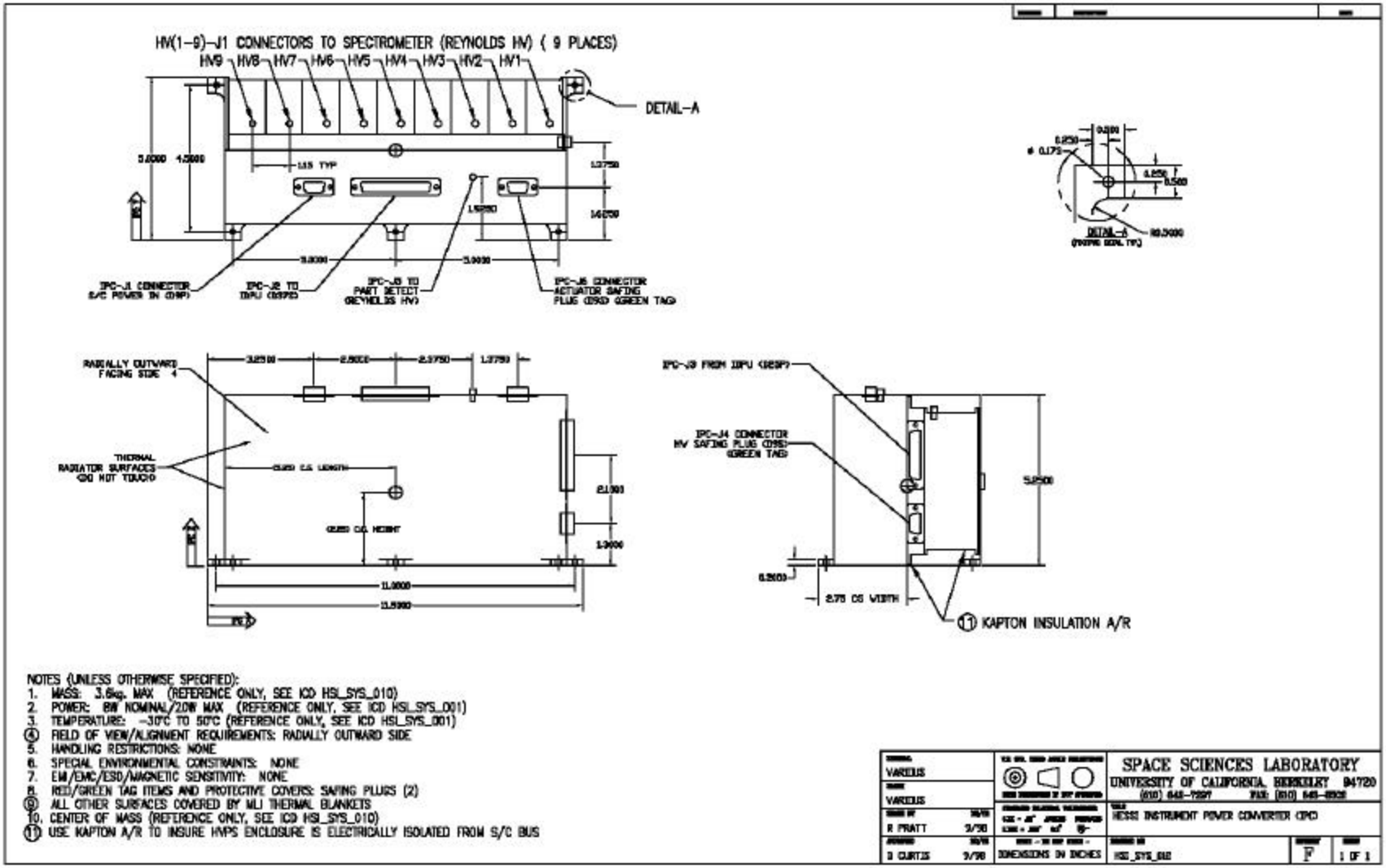
1 OF 1

CRYCOOLER POWER CONVERTER (CPC)



INSTRUMENT POWER CONVERTER (IPC)



NOTES (UNLESS OTHERWISE SPECIFIED):
1. MASS: 3.6kg, MAX (REFERENCE ONLY, SEE ICD HSI_SYS_010)
2. POWER: 8W NOMINAL/20W MAX (REFERENCE ONLY, SEE ICD HSI_SYS_001)
3. TEMPERATURE: -30°C TO 50°C (REFERENCE ONLY, SEE ICD HSI_SYS_001)
4. FIELD OF VIEW/ALIGNMENT REQUIREMENTS: RADIALLY OUTWARD SIDE
5. HANDLING RESTRICTIONS: NONE
6. SPECIAL ENVIRONMENTAL CONSTRAINTS: NONE
7. EMI/EMC/ESD/MAGNETIC SENSITIVITY: NONE
8. RED/GREEN TAG ITEMS AND PROTECTIVE COVERS: SAFING PLUGS (2)
9. ALL OTHER SURFACES COVERED BY MLI THERMAL BLANKETS
10. CENTER OF MASS (REFERENCE ONLY, SEE ICD HSI_SYS_010)
11. USE KAPTON A/R TO INSURE HVPS ENCLOSURE IS ELECTRICALLY ISOLATED FROM S/C BUS

VARIOUS		SPACE SCIENCES LABORATORY UNIVERSITY OF CALIFORNIA, BERKELEY 94720 (510) 643-7297 FAX: (510) 643-8928	
VARIOUS			
R PRATT 3/98		HESSI INSTRUMENT POWER CONVERTER (IPC)	
D CURTIS 9/98	DIMENSIONS IN INCHES	HSI_SYS_010	F 1 OF 1

IDPU-SPACECRAFT POWER INTERFACE

- **Four Services provided by the Spacecraft:**
  - **Instrument Power (SC_IDPUON.proc, SC_IDPUOFF.proc)**
    - **Powers IDPU processor, ADP (Imager), DIB**
    - **Must be powered on before Cryocooler or Switched Power services**
  - **Cryocooler Power (SC_CPCON.proc, SC_CPCOFF.proc)**
    - **Powers Spectrometer Cryocooler via Cryo Power Converter (CPC)**
  - **Switched Services Power (SC_IDPU_SWPWRON.proc, SC_IDPU_SWPWROFF.proc)**
    - **Powers Grid Tray and RAS heaters (software controlled)**
    - **Powers Actuators (Spectrometer attenuator actuators, RAS shutter, Vacuum Valve Actuator)**
  - **IDPU Heater Power (SC_HTRON.proc, SC_HTROFF.proc)**
    - **Powers thermostatically controlled survival heaters in IDPU, IPC, CPC, and Cryocooler set at -30C**
- **24V-36V**
- **Spacecraft provides Current Monitors and Current Limiters (circuit breakers with ground-commanded reset and override)**
  - **Tendency for current limiter trip on power-on of IDPU services**

IDPU-SPACECRAFT DATA INTERFACE

- **High Speed Telemetry Interface directly to Solid State Recorder (40Mbps capability)**
- **Low Speed Bi-Directional Interface (Standard UART, 38.4Kbps, RS422 levels)**
  - **Commands, Spacecraft Status, Spacecraft Time in**
  - **State-of-Health Telemetry, Diagnostic Telemetry, Aspect Solution out (backup for spacecraft FSS)**
  - **Fixed format blocks exchanged once a second**
- **Stable Spacecraft Clock provided for timing**
  - **1Hz, 2^{20} Hz, plus Time over Low Speed Interface once a second**
- **Instrument Reset signal provided**
- **IDPU, IPC, CPC, RAS, Spectrometer Spacecraft-monitored AD590 temperature sensors**
  - **Other subsystem temperatures monitored by IDPU**
  - **Only spacecraft-monitored temperature sensor data is valid when IDPU is off.**

IDPU-SPECTROMETER INTERFACE

- **Charge Sensitive Amplifier (CSA) to Analog Front End (AFE) Interface x9**
  - **Front and Rear segment signals**
  - **Secondary Power (+/- 12.5V)**
- **IDPU to HV Filter x9**
  - **High Voltage from IPC (5000V) x9**
  - **In-flight Test Pulser from AFE, plus separate ground test input**
- **Cryocooler Power from Cryocooler Power Converter**
  - **60Hz @ 100W into low impedance load, programmable amplitude**
  - **60Hz Anti-vibration counter weight drive, programmable amplitude and phase**
- **Cryostat Thermal Control**
  - **Five Temperature Monitors (Cold Tip, Cold Plate, Barrier)**
  - **Cold Plate Heater (Three 100V Zener Diodes)**
- **Radiator / Cryocooler Thermistor & Heater (keep Cryocooler above minimum operating temperature)**
- **Vacuum Valve Actuator & position read-back circuit**
- **Shutter Attenuator Actuator & position read-back circuit**
- **Diagnostic Accelerometer**
- **Harnesses:**
  - **CSA & HV routed in a single bundle, double shielded**
  - **Cryocooler harness separately routed**

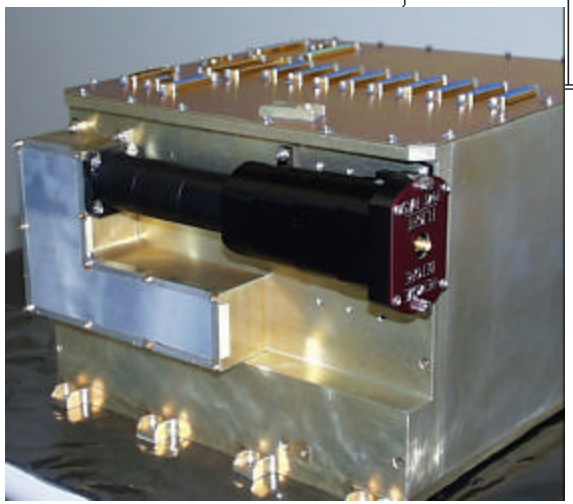
IDPU-IMAGER INTERFACE

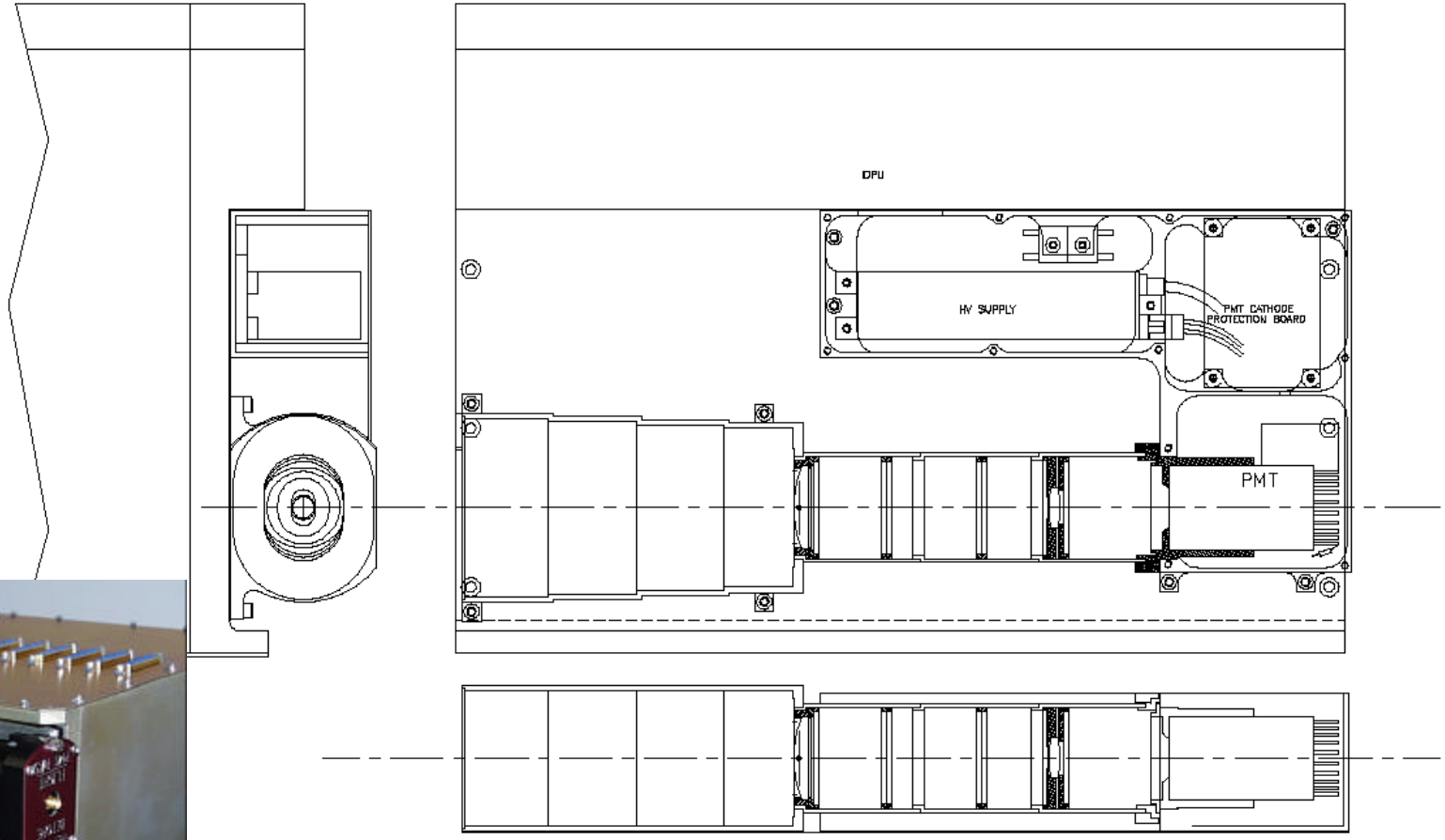
- **Sun Aspect Sensor (SAS) Interface to Aspect Data Processor (ADP) x3**
  - **Signals (Logic levels)**
  - **Secondary Power**
- **Roll Angle Sensor (RAS) Interface to ADP**
  - **Signals (Logic Levels)**
  - **Secondary Power**
  - **RAS Shutter Actuator (Redundant, from Power Controller)**
- **ADP Interface to IDPU**
  - **ADP is a card in the IDPU VME Chassis**
  - **IDPU Backplane Interface defined**
- **Imager Grid Tray Thermal Control (Maintain grid trays within 3°C), Interface to Power Controller**
  - **Four Thermistors on each grid tray**
  - **Redundant Heaters on each grid tray**

RAS-PMT

- **This system added late to reduce perceived risk in the RAS development effort.**
- **It is fully redundant with the RAS, which has since overcome its development problems. It is being flown as a backup.**
- **It is mounted to the IDPU VME Chassis, and contolled by a PWB piggy-backed onto the IDPU mother board**
- **It consists of optics that focus light onto 5° x 0.2 ° slit parallel to the spin vector, followed by a photomultiplier tube (PMT)**
- **A collimator reduces scattered earthlight reaching the PMT from outside the FOV**
- **Electronics identifies the brightest object seen in any millisecond accumulation inteval each 1/4 second. The time of this maximum plus the count rates in the peak and two surrounding time intervals are included in telemetry.**
- **Electronics detects excessive illumination (photocathode current) and shuts down the first few dynode stages to protect the PMT (meets manufacturers specifications)**
- **Programmable High Voltage Power Supply (0-1500V) controlled by IDPU (/IPMT_HVDAC), powered off regulated, limited HV28V secondary supply (same supply used to run GeD HVPS)**
- **Accumulation mode controls readout enable, HV enable, accumulation rate (/IPMT_MODE)**
- **Data is transmitted as a diagnostic packet about once a minute (ApID 154)**

RAS-PMT





PARTICLE DETECTOR

- **The Particle detector counts electron and proton background rates**
  - **These rates contribute to the GeD background**
- **Based on a small Solid State Detector (SSD)**
- **Requires a bias supply set to about 200V**
- **Should be cold (<0C desired)**
  - **Will power down bias supply if > 30C**
- **Two counters counters sampled 8 times a second (PD_A, PD_B)**
- **PB_B counter event threshold programmable (/IPD_THRESH), PD_A threshold fixed**
  - **Nominally PD_A counts ions, PD_B counts electrons**
- **Counters read out in Monitor rates science packet**
- **Counters also read out in SOH telemetry once a second**

SAFE MODE & RESET

- **SAFE mode signal provided automatically by spacecraft to instruct IDPU to go to low power mode in case a power emergency is detected.**
  - **Detector and Aspect Electronics shut down**
  - **Cooler off**
  - **Cryocooler needs to be powered back on ASAP by flight ops to avoid detector warm-up**
    - **15+ hours to risk of detector contamination by non-structured warm-up**
    - **most of which could be between pass supports worst case**
  - **High Voltage is left powered on in Safe mode to limit detector radiation damage**
  - **SAFE mode disables most subsystems: Must run IDPU_INIT.proc (embedded in SC_IDPUON.proc) to go to NORMAL mode to enable use of most subsystems**
- **IDPU RESET can be entered for a number of reasons:**
  - **IDPU power-on (SC_IDPUON.proc)**
  - **Command (/IDPURESET)**
  - **IDPU software crash (watchdog reset)**
- **IDPU RESET is identical to SAFE mode except that high voltages are off**
  - **Critical radiation damage from passing through South Atlantic Anomaly with HV off.**
  - **Flight Ops needs to be prepared to get HV back on ASAP.**

OTHER IDPU MODES

- **SAFE Mode**
  - **Described Above**
  - **Default mode on IDPU Reset**
- **NORMAL Mode**
  - **Entered via "IDPU_INIT.proc" or "/IDPU_NORMAL"**
  - **Allows most subsystems to be enabled (but does not enable them)**
- **ENGINEERING Mode**
  - **Entered via "/IDPU_ENGIN"**
  - **Allows additional services to be enabled:**
    - **Cold Plate Heaters**
    - **RAS Shutter Actuator**
    - **Vacuum Valve Actuator**
    - **Attenuator Uncage Actuator**
    - **Attenuator Unstick Actuators**

IDPU POWER SWITCHING FUNCTIONS

- **Each DIB includes a current limiter/switch for the analog electronics supplies (IDIB_ON.proc)**
  - **Commandable overcurrent trip override**
- **ADP includes power switches (IMGR_ON.proc)**
  - **DSP (ADP processor)**
  - **RAS**
  - **SAS (3)**
- **HV28, source supply for GeD and PMT High Voltage, is current limited and switched (IHV_ON.proc)**
  - **Commandable overcurrent trip override**
- **Analog Housekeeping ADC has an overcurrent trip**
  - **Commandable overcurrent trip override**
  - **Automatic re-enable attempt in software**
  - **No IDPU analogs are valid if tripped**
- **Actuator Supply (10V)**
  - **Powered on in actuator command scripts as needed**
- **Grid Tray, RAS and Cold Plate Heater switches**
  - **Software controlled closed-loop to achieve/maintain desired temperature**

"ONE TIME" ACTUATOR CONTROL

- **Powered via switches in the IDPU, for a programmable interval**
  - **RAS shutter <1s, rest about 10-15s to actuate**
- **IDPU Must be in ENGINEERING Mode**
- **RAS Shutter (redundant)**
  - **Protects RAS from direct sunlight exposure in LEO off-nominal spacecraft attitudes**
  - **Opened as soon as attitude stabilized on the Sun**
  - **No verification except RAS measurements**
  - **Manual reclose only**
- **Spectrometer Vacuum Valve (redundant)**
  - **Opens Cryostat (to space)**
  - **Only used in contingency operation, prior to GeD Anneal**
  - **Actuator is capable of opening cryostat on the ground (very bad). Normally Vacuum Valve connector is disconnected during I&T at Spectrometer (a simulator GSE may be connected)**
- **Spectrometer Attenuator Uncage**
  - **Releases launch lock-down of Attenuator mechanism**
  - **Activated after minimum science achieved (about L+2 months)**
  - **Manual re-cage only**
- **Spectrometer Attenuator Unstick (one per attenuator, 2)**
  - **Forces Attenuator into default position in case mechanism sticks**
  - **Manual reset only - attenuator will no longer move. Verify only by in/out status**

ATTENUATOR ACTUATORS

- **Spectrometer has two attenuators used to control the GeD count rate to avoid saturation in the electronics**
- **Attenuators are under software control once uncaged and enabled**
  - **Used to manage GeD count rate to avoid saturation/dead time in DIB electronics**
- **Manual positioning commands for ground test or contingency operation**
- **Quick motions - typically 1-2s**
- **Verification of position: in/out/in-motion**
- **Automatic shutoff on reaching desired location, with software timeout**
- **Cannot move an attenuator until actuator cools**
  - **Indicated by Tense/Relaxed SOH**
  - **Enforced in software**
- **Software limits on number of moves per orbit**
  - **preserve limited life (about 100,000 motions)**

HIGH VOLTAGE CONTROL

- **9 GeD HV, PMT HV, and Particle Detector Bias voltages controlled by ground command**
  - **8-bit DAC control**
- **Rate of change of voltage is limited by IDPU software on commanded increase**
  - **1 step/second for PD and PMT HV**
  - **programmable for GeD HV, default = 1 step/4 seconds, max = 1 step/second**
- **Immediate DAC response on decrease in setting, but supply will decrease slowly**
- **HV will not respond to DAC setting command unless:**
  - **HV28V is on (PMT and GeD)**
  - **Spectrometer is cold (GeD)**
  - **HV Supply is enabled (separate enable for GeD, PMT, and PD)**
- **PMT and PD supplies are turned off in SAFE mode; GeD stays on (protects GeD detectors from radiation damage)**
- **HV28 supply has an overcurrent trip / switch, default is off on reset.**
  - **Overcurrent trip can be disabled**
- **No SOH analog monitor on PMT or PD voltage settings (only current setting)**
  - **GeD HV have analog monitors**

CRYOCOOLER CONTROL

- **IDPU has a programmable waveform generator that makes the required waveforms to run the cryocooler**
  - **CPC provides the drive amplification for this signal to 100W**
- **Two synchronous waveforms are required: Main and Balancer**
  - **Main sets the cooling power, Balancer compensates for vibration caused by the Main part of the cryocooler**
- **Waveforms ate 58.6Hz sine waves**
- **Amplitude of the two waveforms is programmable (/ICRYOMAIN and /ICRYOBAL)**
- **Phase of balancer waveform with respect to main waveform is programmable (/ICRYOPHASE)**
- **Cryocooler power level corresponding to a given ICRYOMAIN setting is a function of cryocooler and cold tip temperatures**
  - **SOH data must be monitored to keep desired power level on cryocooler**
  - **An ITOS CFGMON calculates the power level from available SOH values**
- **Cryocooler power levels must be limited by the flight ops team as a function of the cold tip temperature (Spectrometer team to advise)**
- **Balancer amplitude and phase must be selected to minimize vibration as measured by an accelerometer measurement in the SOH telemetry**
  - **Nominal settings as a function of Main setting value have been calibrated, but will need tuning at the spacecraft level and on-orbit by the Spectrometer team**

HOUSEKEEPING (SOH)

- **IDPU samples all housekeeping at least once a second and includes it in SOH telemetry (VC0/VC1)**
- **Some housekeeping values are only valid if certain power systems are on (as indicated in the HSI_CTM database)**
- **All analog values are sampled by a common ADC**
  - **housekeeping is invalid if ADC goes into overcurrent trip**
  - **IDPU software will attempt to re-power ADC in the event that it trips, and make an error message**
- **A selected analog housekeeping value can be read out at a much higher rate via a diagnostic telemetry mode**
  - **One possible use is to measure vibration waveform by sampling accelerometer**
- **Standard accelerometer measurement is a max-min value computed by the IDPU from a limited number of samples**
  - **This is used to tune the cryocooler balancer waveform settings**

SCIENCE TELEMETRY

- **Science Telemetry (VC2/VC3) is collected by the IDPU software at high bit rates (up to 40Mbps)**
  - **IDPU software configures the telemetry channel but does not touch the data**
- **All science telemetry is routed via the Solid State Recorder (SSR)**
  - **SOH and diagnostic telemetry is routed to the SEM, bypassing the SSR**
- **Science Telemetry packet types include:**
  - **Event data from GeD (one 32-bit word per detected photon)**
  - **Monitor rates from the GeD and PD (periodic samples of rate counters)**
  - **Fast Rates from the GeD (enabled by the software when rates are high)**
  - **ADP (RAS/SAS) data**
    - **These are generated by the ADP processor**
    - **RAS produces "star event" packets consisting of pixels around a bright event on the RAS CCD**
    - **SAS produces "limb" packets consisting of the location and adjacent pixels to an identified solar limb in the SAS CCD**
    - **There are also a number of diagnostic image mode packet types (from the linear CCD detectors)**
    - **Mix of ADP packet types selected via the ADP "Parameter File" settings**
- **Each packet type can be enabled/disabled by ground command**

SCIENCE TELEMETRY AUTOMATION

- **IDPU software has some control of the GeD telemetry:**
  - **Excessive event rates can be controlled via the Spectrometer Attenuator settings**
  - **If the SSR starts to fill up (which it is designed to do), the software will start limiting the kinds of events it collects by "decimation" (taking only some of the abundant low energy photons)**
    - **Software rules control when and how decimation is done**
  - **If the SSR is almost full, event and fast rate telemetry are disabled to avoid over-writing old data**
    - **This can have unexpected results if the SSR pointers are not watched during testing**
    - **The SSR read pointer are automatically moved when data is telemetered in normal operation, so the system should take care of itself**
    - **The read pointer can be moved backwards in the event of a bad pass, but should not be moved back past the write pointer**
  - **Fast Rates packets will be enabled automatically by the IDPU software if a selected event rate is exceeded**
    - **This data provides a limited extension of the count rate dynamic range if the system is unable to limit the count rate adequately using the attenuators**

DETECTOR INTERFACE BOARDS (DIBs)

- **The IDPU contains 9 DIBs, one per GeD**
- **Each DIB contains the analog processing electronics, or analog front end (AFE) for each segment of its detector, plus ADC conversion of the measured energy pulse**
- **Digital logic captures the energy measurement plus timing and other data, and forms a 32-bit event word for each measured photon**
- **This data is passed to the Data Control Board (DCB) for inclusion in the Event packets**
- **The DIB digital electronics also contains the Monitor Rates counters and Fast Rates counters which are read periodically by the DCB for inclusion in those packets**
- **The DIB includes a programmable test pulser that can be used in ground tests or in-flight to test and calibrate the DIB and Spectrometer electronics**
- **The DIB has a number of programmable thresholds and settings that control its operation. Most of these settings are set by ground command via a table write (/IDPULOADTBL)**
  - **DIB Decimation settings are controlled by the IDPU software**
- **All DIB (and other IDPU register) settings are updated periodically by the IDPU to avoid possible problems caused by Single Event Upsets of those registers**

ASPECT DATA PROCESSOR (ADP)

- **The ADP is a card in the IDPU provided by PSI (the Swiss) to control and read out their Roll Angle Sensor (RAS) and Sun Angle Sensors (SAS)**
- **The RAS and SAS are CCD-based detectors with suitable optics for viewing starts (RAS) and the Sun (SAS).**
  - **There are 3 SAS detectors. They tell you where on the Sun the Imager is pointed by detecting the edge or "limbs" of the sun in their FOV**
  - **RAS tells you the roll angle of the spacecraft by detecting stars as they go in and out of the RAS FOV.**
- **The card includes a DSP to control, process, and format the data, digital logic to collect the data and interface with the IDPU, and power switches to control and limit power to the RAS and SAS sensors and the DSP**
- **The RAS and SAS sensors have proven to be difficult sensors to get to work as desired**
- **There are a large number of parameters that control the ADP operation. These parameters are encoded into "Parameter Files" (PF). At this time only PSI knows how to build a good parameter file.**
- **These are also "hot spot" tables that may need to up uploaded to the ADP if a CCD has problems**

ADP SOFTWARE

- **The ADP flight software is provided by PSI**
- **ADP flight software may also need uploading post-launch**
  - **There are 4 slots for flight programs available in the ADP**
  - **An ADP program is selected to run by a series of /ADPRESET commands**
  - **If all 4 ADP programs are somehow contaminated, ADP is lost.**
- **ADP hardware has some timing problems which occur only at temperature extremes. These can be solved by changes in the software (wait states). A change in software may be required if it is found that the ADP operates at a temperature extreme.**