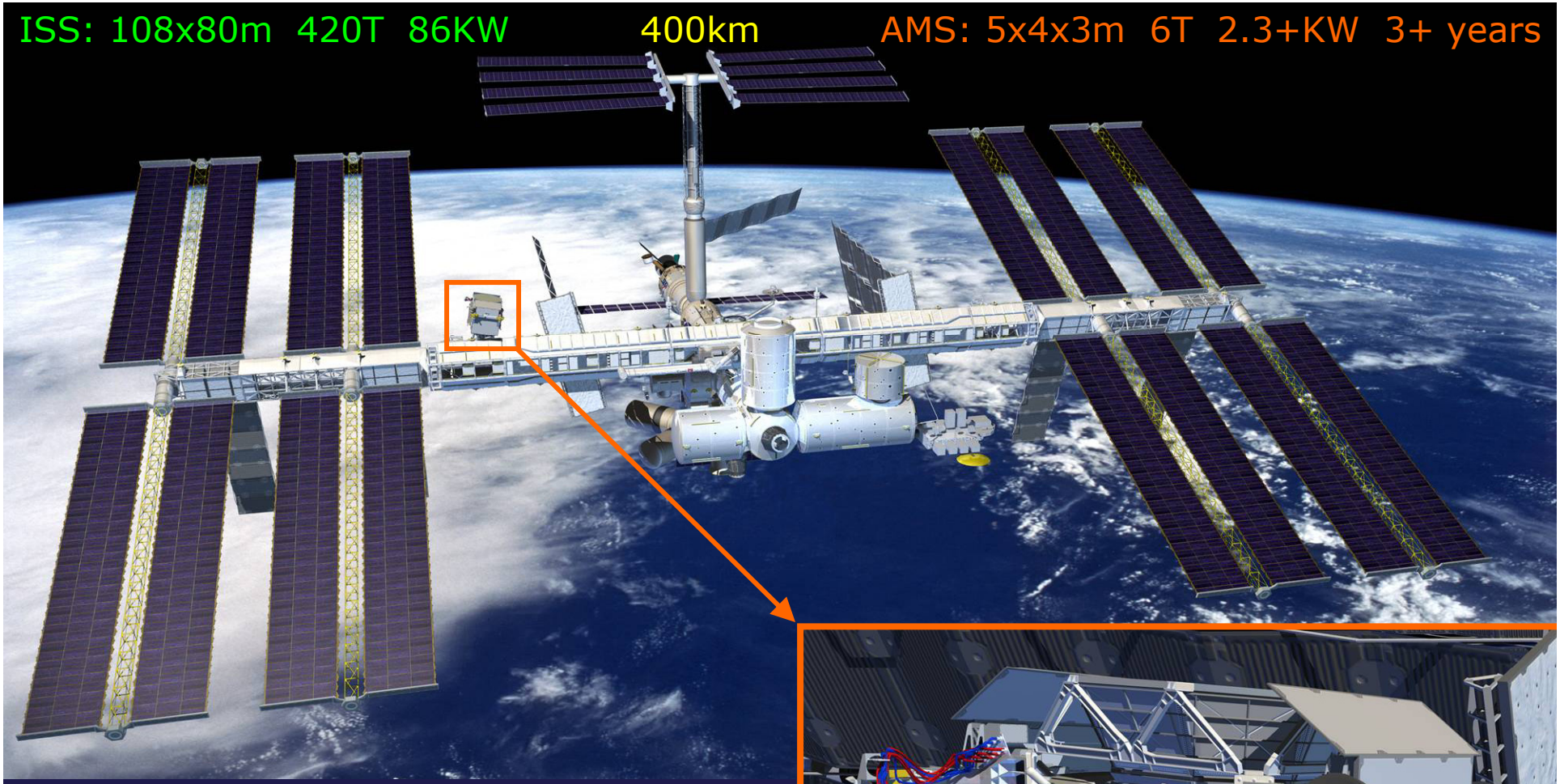
ISS: 108x80m 420T 86KW 400km AMS: 5x4x3m 6T 2.3+KW 3+ years



AMS-02 Avionics

GSR-II (08 Sep 2008)

Mike Capell

Avionics & Operations Lead

Senior Research Scientist

Avionics: Electrical Interfaces on ISS (STS similar)

Power:

109-124VDC
~2.3 KW

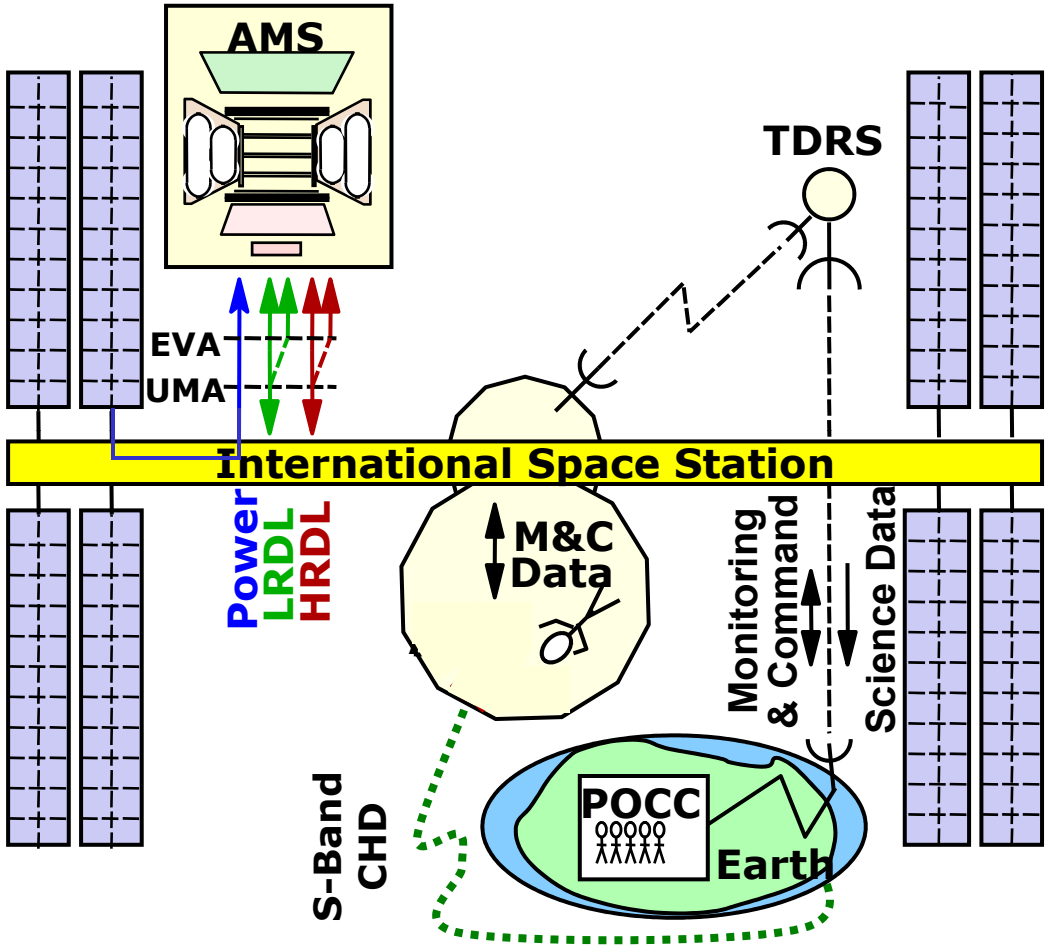
LRDL

for Cmd & Mon
1553B Bus
1 Kbit/s in
10 Kbit/s out
10 B/sec CHD

HRDL

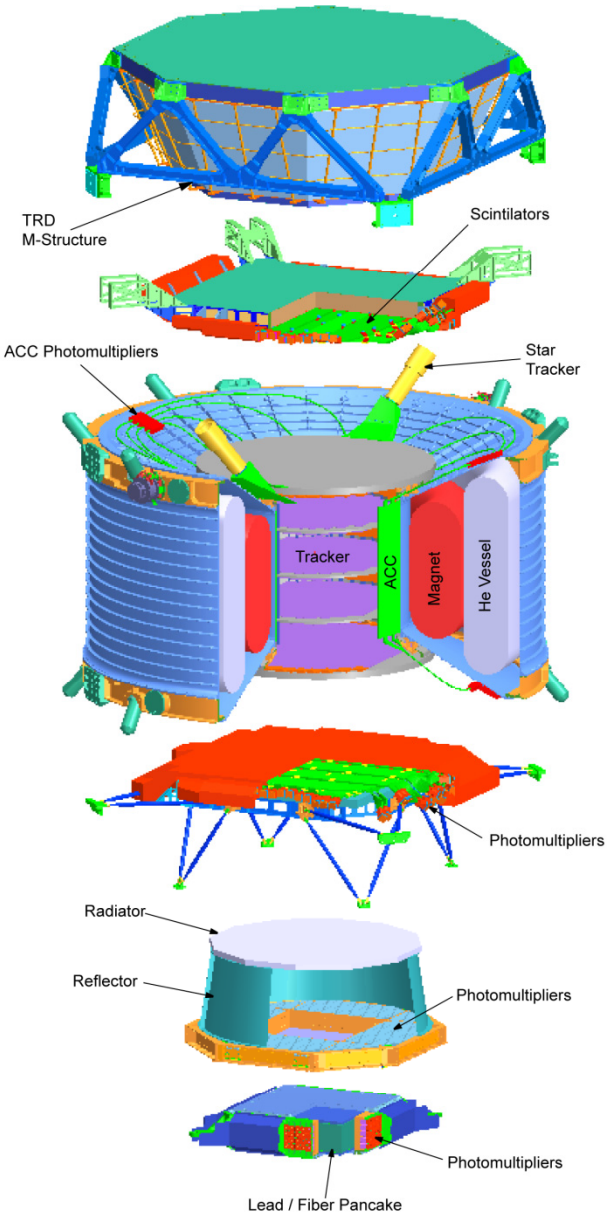
for Event Data
Taxi F/O (STS:RS422)
<2Mbit/s>$_{orbit}$

xRDL: Duty cycle ~70%



Ensure AMS side of interfaces conform to ISS/STS requirements

Subdetector Requirements: Summary



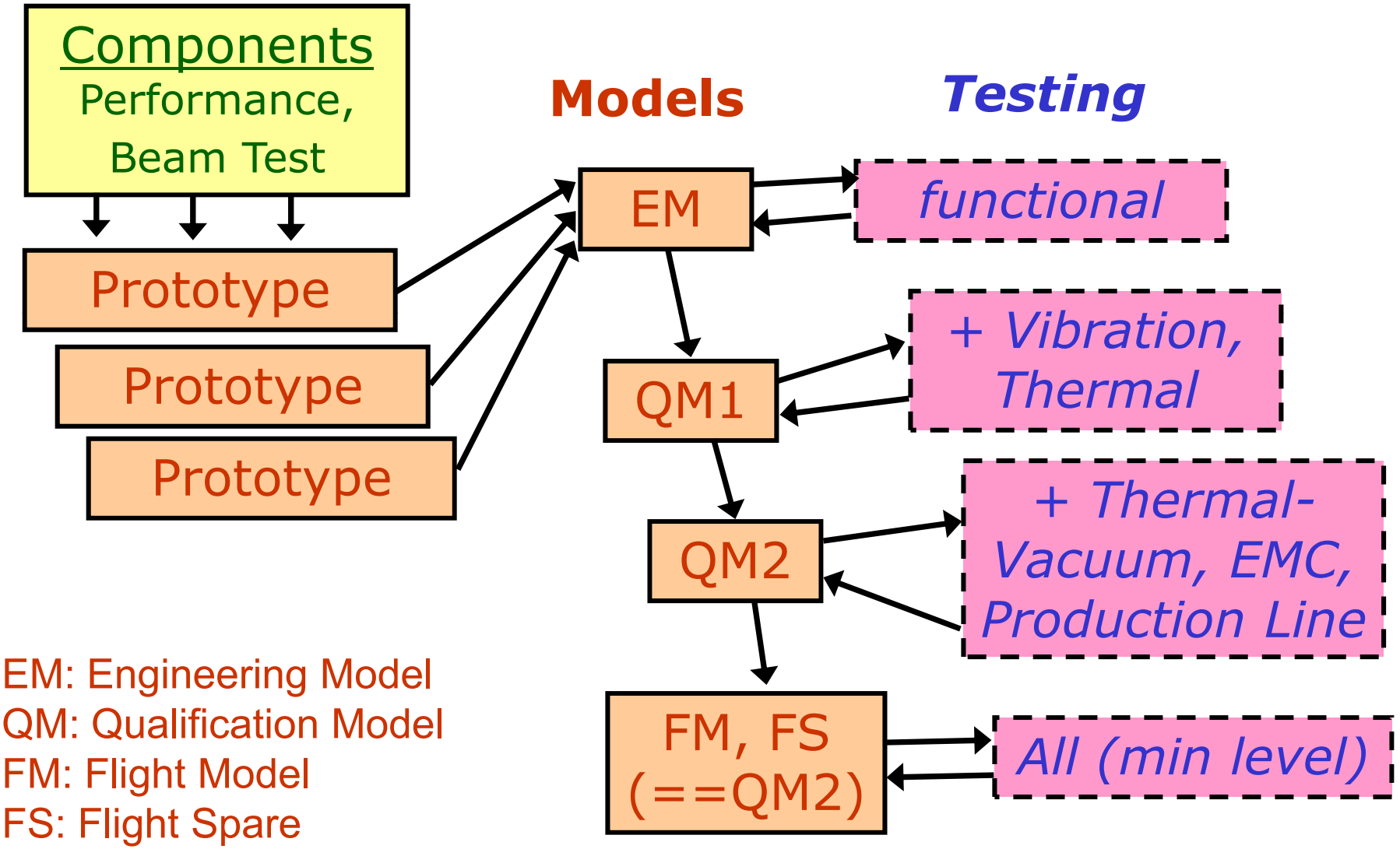
Subdetector	Req'ments	Channels	Raw Kbits
U: TRD	Gas gain	5,248	84
S: ToF+ACC	100 ps	48*4*8	49
T: Tracker	few fC	196,608	3,146
R: RICH	Single γ	680*16*2	348
E: ECAL	1:60,000	324*(4*2+1)	47
Σ Raw Kbits/event			3,674
* Event Rate			≤ 2 Khz
= Total Raw Data Rate			~7 Gbit/sec

7 Gbit/sec >> 2 Mbit/sec

⇒ Restrict Rate & Size

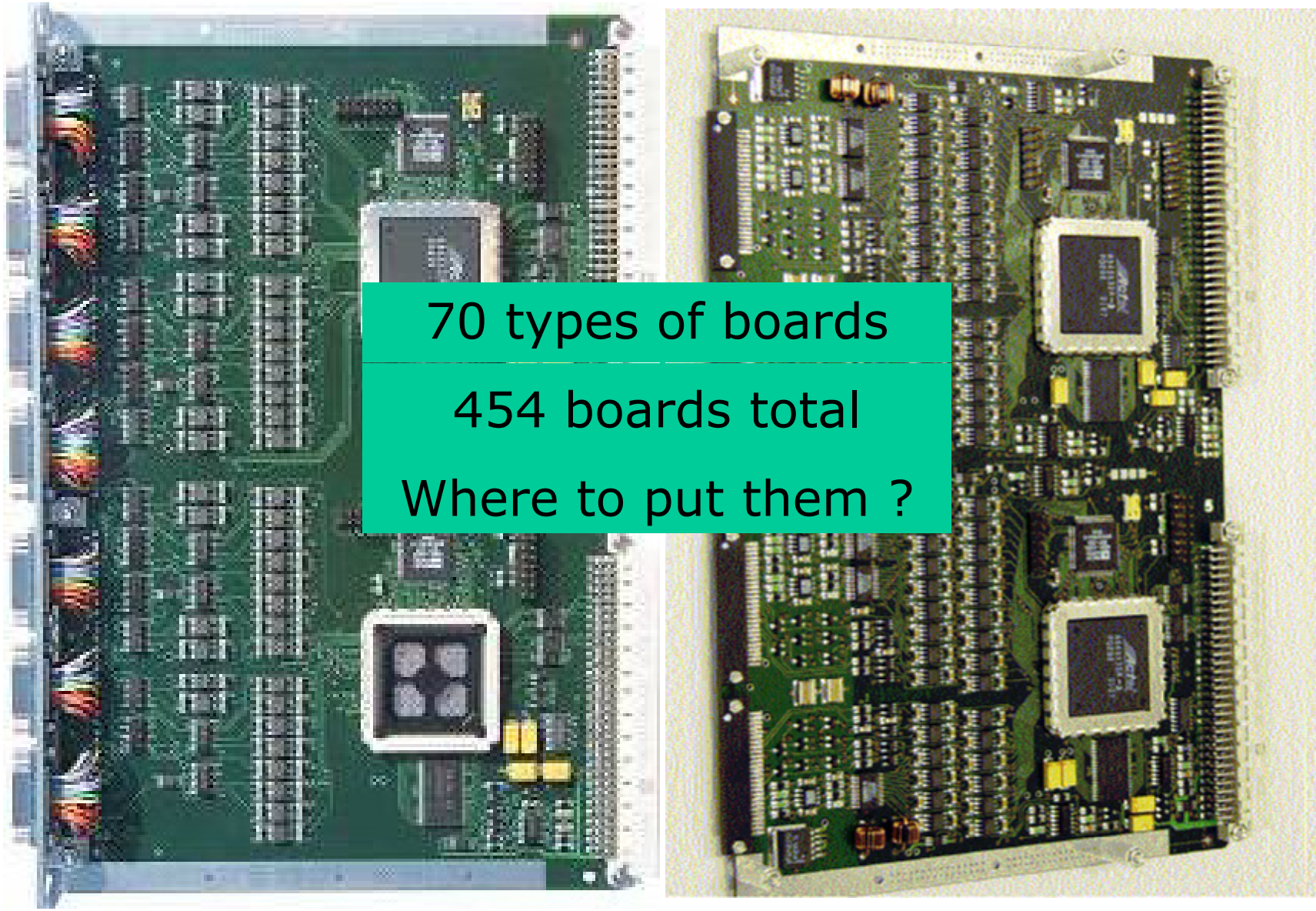
Specify, design, develop, produce:
High Speed, High Capacity,
Low Power, Low Weight, Reliable
Signal & Data Processing
ON ORBIT !

Process to transform electronics from High Energy Physics for use in Low Earth Orbit



EM: Engineering Model
QM: Qualification Model
FM: Flight Model
FS: Flight Spare

Examples: Data Reduction (UDR2, TDR2) Boards



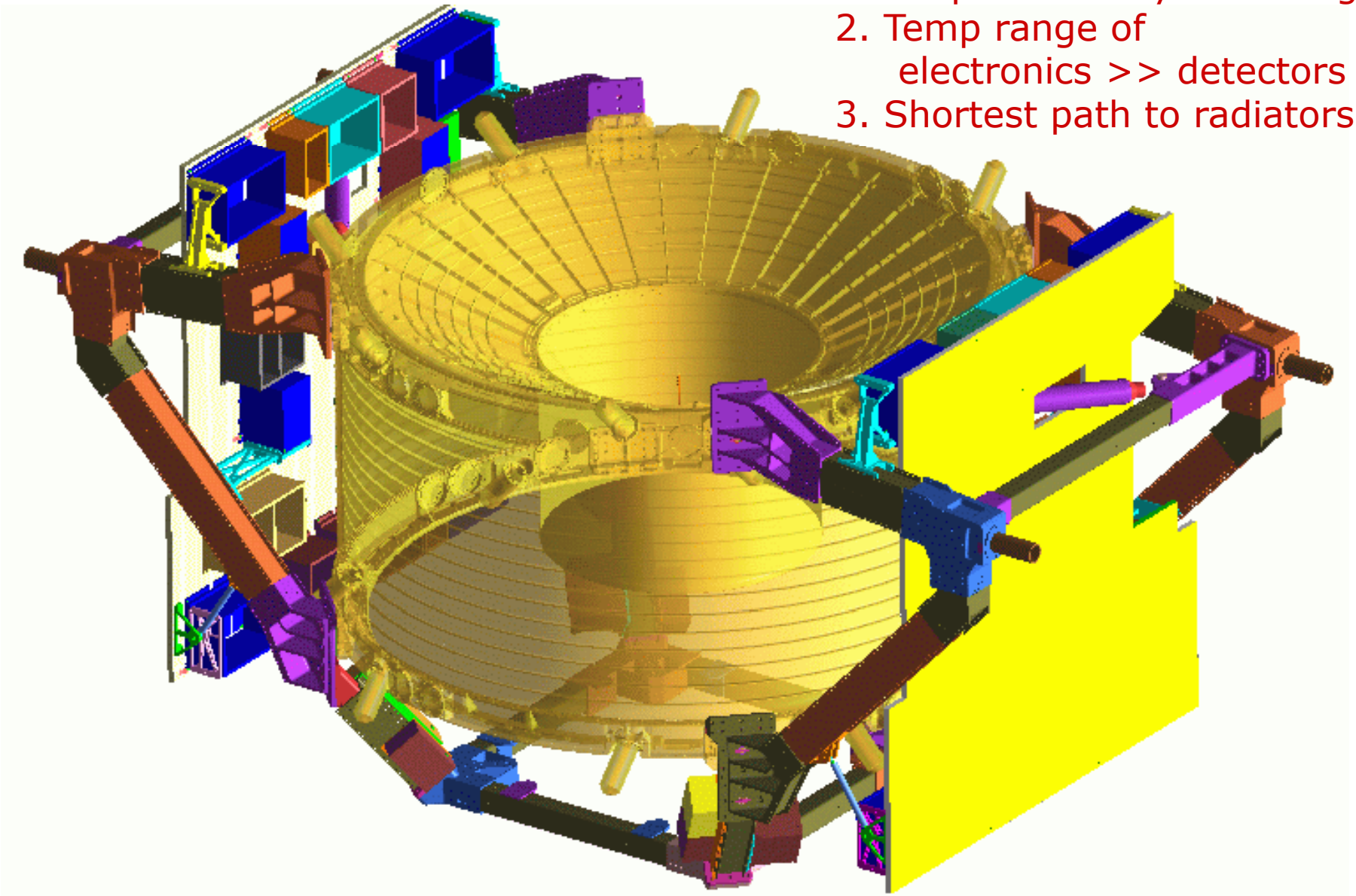
70 types of boards

454 boards total

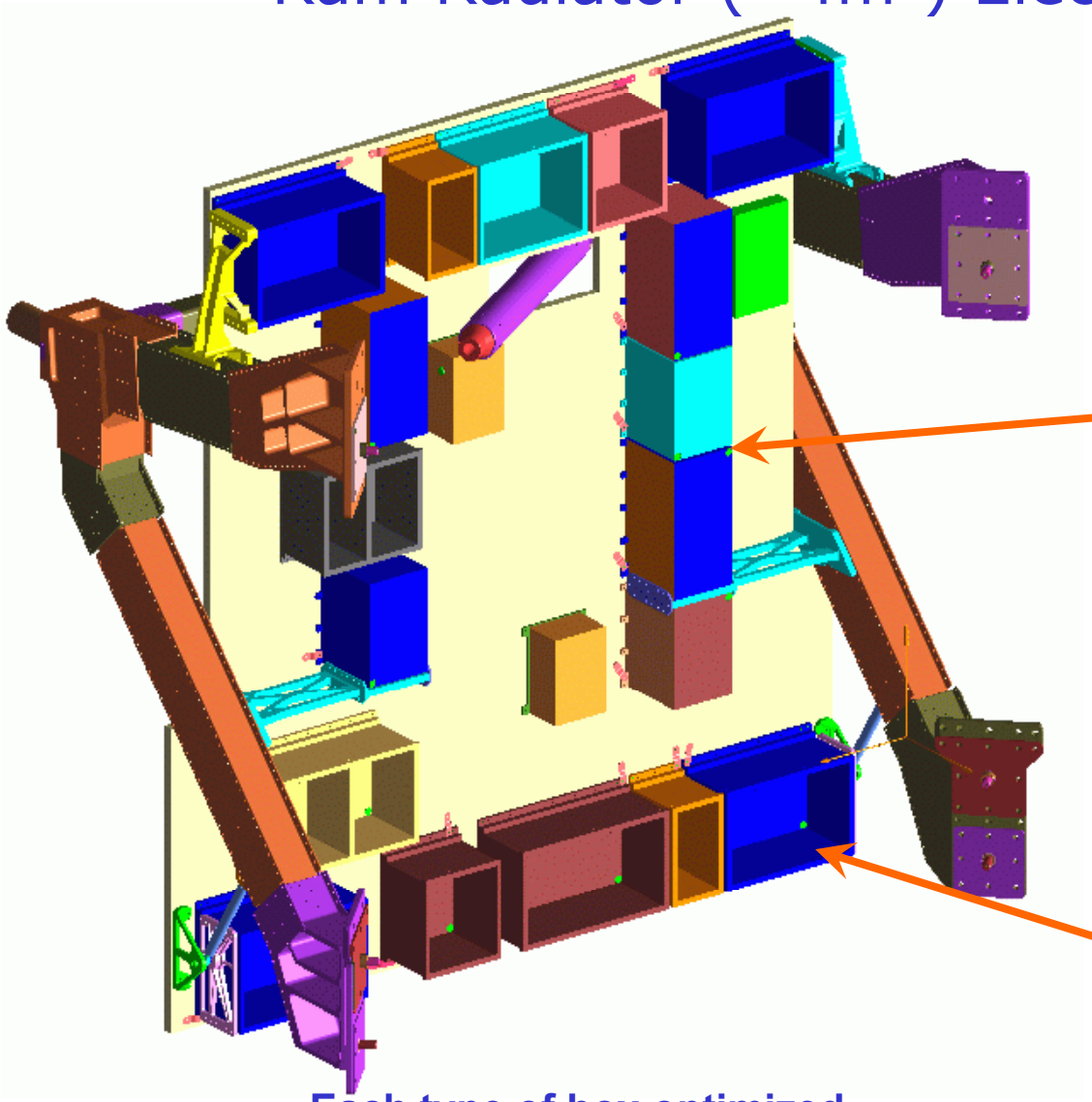
Where to put them ?

Electronics Mechanics– Crates & Boxes on Radiators

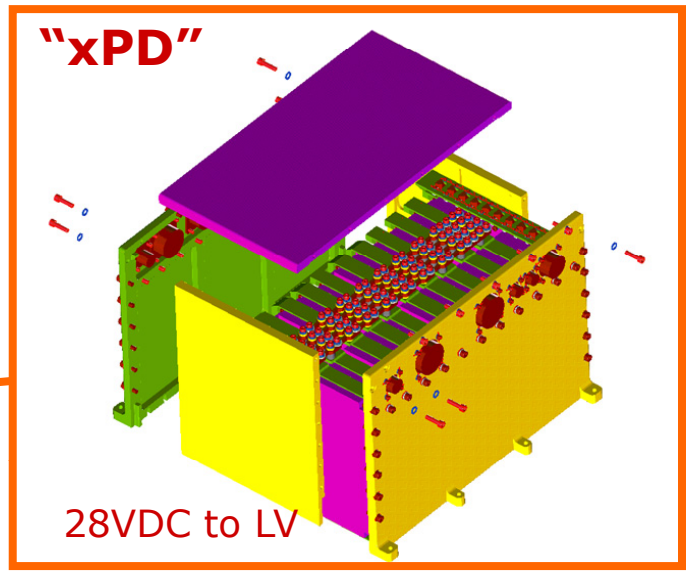
1. Keep heat away from Magnet
2. Temp range of
   electronics >> detectors
3. Shortest path to radiators

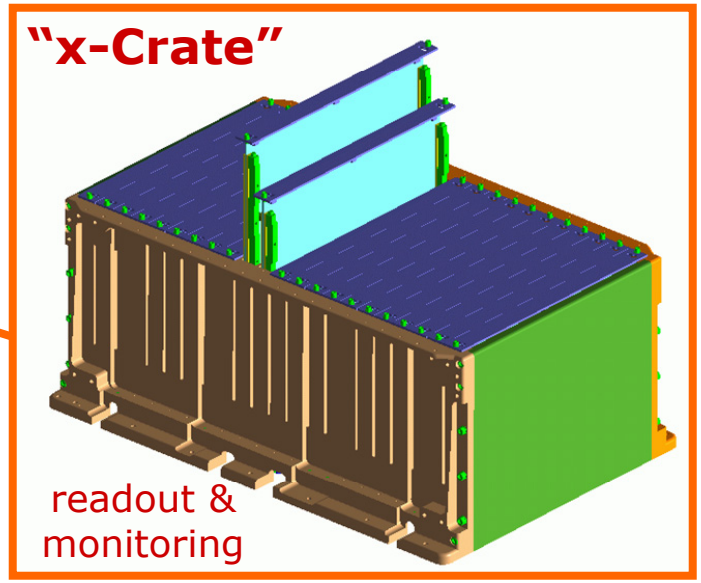


Ram Radiator (~4m^2) Electronics ~ 750W



Each type of box optimized for weight vs. thermal vs. structural performance. Design and test supported by NSPO, Taiwan





x=E,J,S,T,TT,U,UG,...

Electronics on mounting jigs, 4 Aug 2008

Electronics Production & Quality Assurance

- Designed by Academia Sinica, CSIST & MIT

  Adapted for particular subdetectors by Aachen, Geneva, Perugia, Bologna, Madrid, Annecy, Pisa, …

- Most electronics produced at CSIST:

  High Reliability (Mil Spec) infrastructure,

  Qualification: Vibration, Thermal, EMC on site

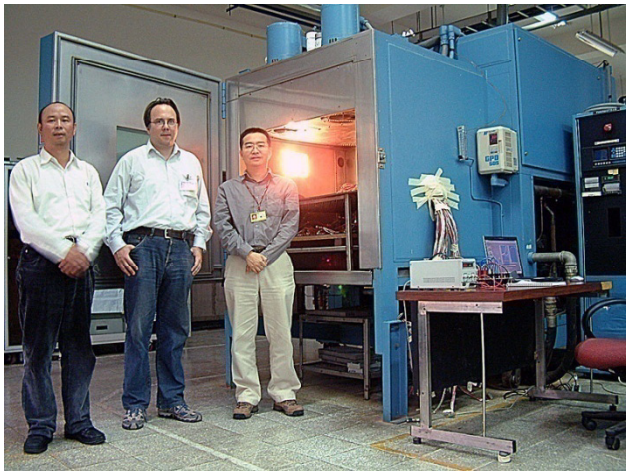
  Team of 25 engineers and 40 technicians

  Quality assured by NASA & AMS team reviews every 3 months.

- Testing & Qualification by board designers

2007 Board Tests at CSIST

Daniel testing TDR2 (June)



Sandor testing DCDC with Wang & Liu (June)

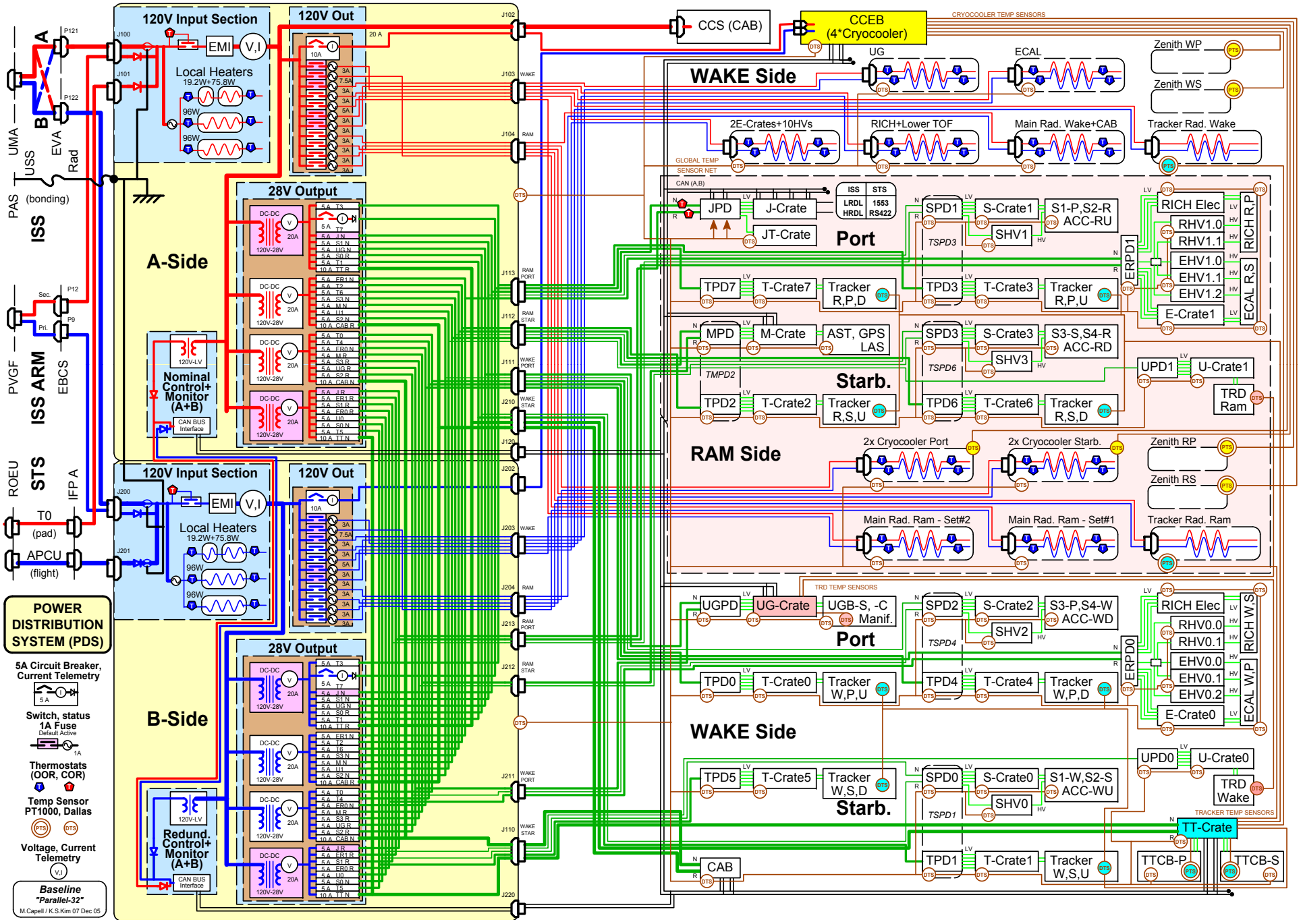
Sylvie & Nadia testing EIB (July)

Lucio testing TBS & TPSFE (July)

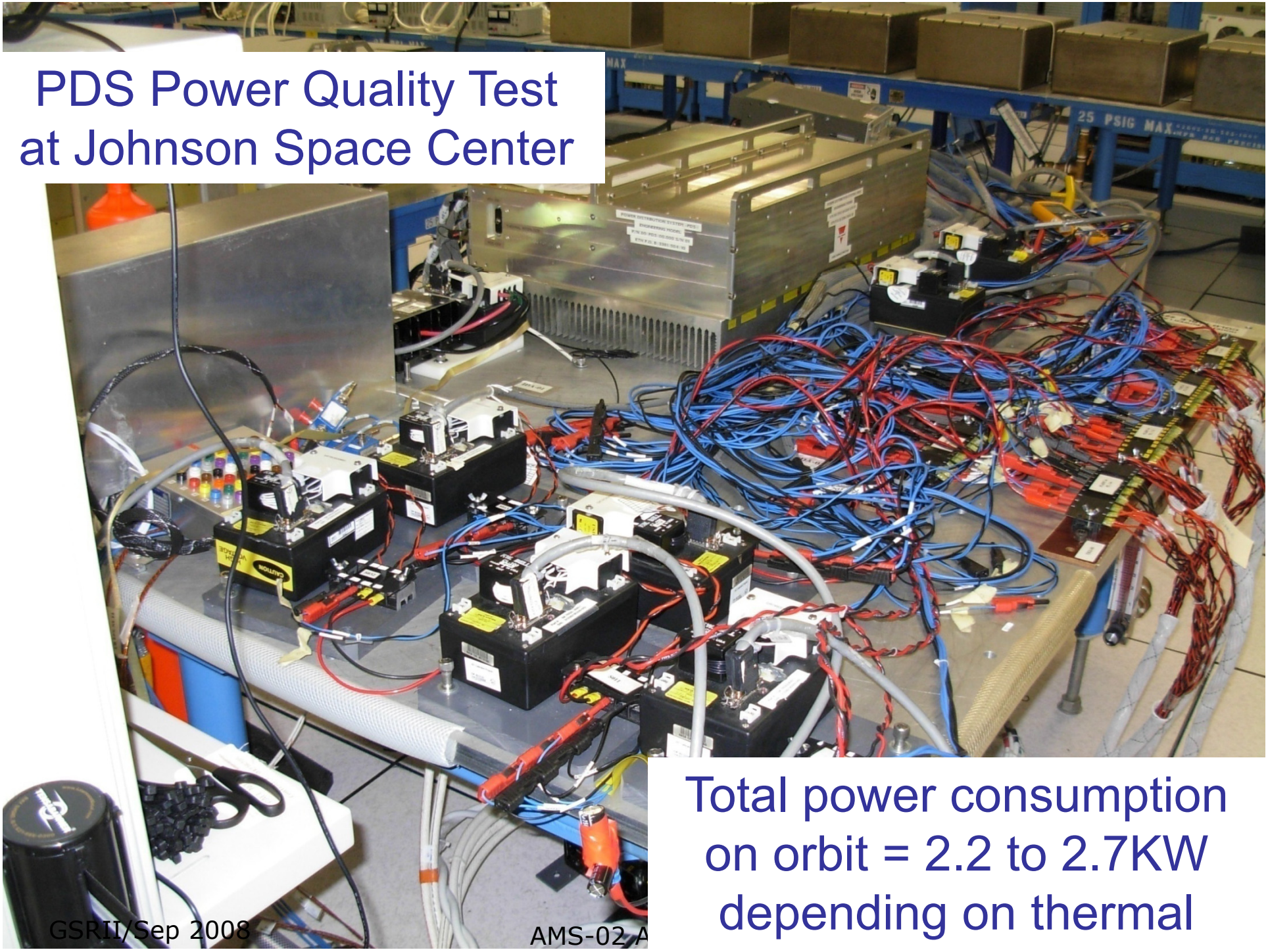
Jesus & Antonio test DC-DC (July)

Alpha Magnetic Spectrometer
AMS-02
Europe • Asia
North America
Functional Integration Test / January 2005

AMS-02: Power System (PDS) for ISS+SSRMS+STS



PDS Power Quality Test at Johnson Space Center



Total power consumption on orbit = 2.2 to 2.7KW depending on thermal

High Voltage, etc.

All HV sources are insulated and buried within the payload.

When charging or discharging the magnet there is a large current (~400A) but at a low voltage (<10V).

The 2 UPSes on the P/L are potential high current sources, but well insulated, protected.

High Voltage & Current Sources from FSR II

High Voltages (and Currents) in AMS-02.				M.Capell	30-Jun-05						
Item	Subsystem	Source	Load	Voltage	Current	Cable	Qty	AWG	1	2	3
1	Cryocooler	CCEB	Cryocooler 1	120Vpwm	<5A	M22759/44-22-*	3 pairs	22	CCEB/J101	CC cable-1	Cryocooler-1
2	Cryocooler	CCEB	Cryocooler 2	120Vpwm	<5A	M22759/44-22-*	3 pairs	22	CCEB/J102	CC cable-2	Cryocooler-2
3	Cryocooler	CCEB	Cryocooler 3	120Vpwm	<5A	M22759/44-22-*	3 pairs	22	CCEB/J103	CC cable-3	Cryocooler-3
4	Cryocooler	CCEB	Cryocooler 4	120Vpwm	<5A	M22759/44-22-*	3 pairs	22	CCEB/J104	CC cable-4	Cryocooler-4
5	Cryomagnet	CCS in CAB	Charge Patch Panel	<10VDC	<460A	M22759/41-02-5D	3 pairs	00	CAB/TL[1-6]	Primary Charge Cable	
	Cryomagnet	Charge Patch Pane	Cryomagnet	<10VDC	<460A	OFHC rope	16 pairs	10sq mm	Charge Patch Panel	2nd Charge Cable	VC Port USR 100.313°
6	Cryomagnet	Cryomagnet	CDD	<10VDC	<460A	M22759/41-02-5D	1 pair	00	CAB/TL7	Discharge Cable 1	CDD
7	Cryomagnet	UPS-0	CSP in CAB	<32VDC	<90A	M22759/44-12-*	3 pairs	12	UPS-0/J1	UPS Cable-0.1	CAB/J24
9	Cryomagnet	UPS-1	CSP in CAB	<32VDC	<90A	M22759/44-12-*	3 pairs	12	UPS-1/J1	UPS Cable-1.1	CAB/J25
8	Cryomagnet	CSP in CAB	Quench Heaters	<32VDC	<90A	M22759/44-12-*	3 pairs	12	CAB/J22	Cryomagnet Harness	VC Port USR 17.813°
10	Cryomagnet	CSP in CAB	Quench Heaters	<32VDC	<90A	M22759/44-12-*	3 pairs	12	CAB/J23	Cryomagnet Harness	VC Port USR 17.813°
	Cryomagnet	Cryomagnet	Quench Detectors 1-9	<1KV	<1A	Reynolds 178-8066	9 pairs	24	Coils	VC Internal	VC Port LSR 197.813°
	Cryomagnet	Cryomagnet	Quench Detect 10-18	<1KV	<1A	Reynolds 178-8066	9 pairs	24	Coils	VC Internal	VC Port LSR 197.813°
11	ECAL	EHV0-0	55 ECAL PMTs	<1000VDC	<250uA	Reynolds 167-2896	55	Coax-36	EHV0-0	ECAL HV Cables	ECAL PMTs on Wake & Port
12	ECAL	EHV0-1	55 ECAL PMTs	<1000VDC	<250uA	Reynolds 167-2896	55	Coax-36	EHV0-1	ECAL HV Cables	ECAL PMTs on Wake & Star
13	ECAL	EHV0-2	55 ECAL PMTs	<1000VDC	<250uA	Reynolds 167-2896	55	Coax-36	EHV0-2	ECAL HV Cables	ECAL PMTs on Wake & Star
14	ECAL	EHV1-0	55 ECAL PMTs	<1000VDC	<250uA	Reynolds 167-2896	55	Coax-36	EHV1-0	ECAL HV Cables	ECAL PMTs on Ram & Star
15	ECAL	EHV1-1	55 ECAL PMTs	<1000VDC	<250uA	Reynolds 167-2896	55	Coax-36	EHV1-1	ECAL HV Cables	ECAL PMTs on Ram & Port
16	ECAL	EHV1-2	55 ECAL PMTs	<1000VDC	<250uA	Reynolds 167-2896	55	Coax-36	EHV1-2	ECAL HV Cables	ECAL PMTs on Ram & Port
17	Interface	ISS	AMS	120VDC	<25A	M22759/12-8-*	2 triplets	8	UMA/PAS	Interface Cable-1A,-1B	EVA Panel
18	Interface	ISS/PVGF	AMS	120VDC	<15A	M22759/12-12-*	2 triplets	12	PVGF	Interface Cable-2A,-2B	EBCS
18	Interface	ISS/T0	AMS	120VDC	<25A	M22759/12-12-*	3 pairs	12	ROEU	Interface Cable-3A	IFP-A
19	Interface	STS/APCU	AMS	120VDC	<25A	M22759/12-8-*	1 triplet	8	ROEU	Interface Cable-3B	IFP-A
20	Power	PDS	CCS in CAB	120VDC	<20A	M22759/44-12-*	2 pairs	12	PDS/J102	PDS Cable 102/1	CAB/J01
21	Power	PDS	CCEB	120VDC	<7.5A	M22759/44-12-*	4 pairs	12	PDS/J102,J202	PDS Cable 202/2,102/2	CCEB/J099,J100
22	RICH	RHV0-0	40 RICH PMTs	<1000VDC	<80uA	Reynolds 167-2896	40	Coax-36	RHV0-0	RICH HV Cables	RICH HV Busses
23	RICH	RHV0-1	40 RICH PMTs	<1000VDC	<80uA	Reynolds 167-2896	40	Coax-36	RHV0-1	RICH HV Cables	RICH HV Busses
24	RICH	RHV1-0	40 RICH PMTs	<1000VDC	<80uA	Reynolds 167-2896	40	Coax-36	RHV1-0	RICH HV Cables	RICH HV Busses
25	RICH	RHV1-1	40 RICH PMTs	<1000VDC	<80uA	Reynolds 167-2896	40	Coax-36	RHV1-1	RICH HV Cables	RICH HV Busses
26	S:TOF+ACC	SHV0	34 TOF+4 ACC PMTs	<2500VDC	<50uA	Reynolds 167-2896	24	Coax-36	SHV0	S HV Cables	34 TOF PMTs on layer S1 & S
27	S:TOF+ACC	SHV1	34 TOF+4 ACC PMTs	<2500VDC	<50uA	Reynolds 167-2896	24	Coax-36	SHV1	S HV Cables	34 TOF PMTs on layer S1 & S
28	S:TOF+ACC	SHV2	38 TOF+4 ACC PMTs	<2500VDC	<50uA	Reynolds 167-2896	24	Coax-36	SHV2	S HV Cables	38 TOF PMTs on layer S3 & S
29	S:TOF+ACC	SHV3	38 TOF+4 ACC PMTs	<2500VDC	<50uA	Reynolds 167-2896	24	Coax-36	SHV3	S HV Cables	38 TOF PMTs on layer S3 & S
30	Thermal	PDS	ECAL Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/1,203/1	LUSS-HPP
31	Thermal	PDS	Ram Heaters	120VDC	<7.5A	M22759/44-20-*	6 pairs	20	PDS/J104,J204	PDS Cable 104/2,204/2	Ram Radiator Heater Bracket
32	Thermal	PDS	TRD Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/3,203/3	TRD HPP
33											
34	Thermal	PDS	Tracker Wake Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/4,203/4	Tracker Wake HPP
35	Thermal	PDS	Wake Heaters	120VDC	<5A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/5,203/5	Wake Radiator Heater Bracket
36							2 pairs	20			CAB Radiator Bracket
37	Thermal	PDS	LUSS Boxes	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/6,203/6	LUSS-HPP
38											
39											
40											

High Voltage & Current Sources from FSR II

High Voltages (and Currents) in AMS-02.				M.Capell	30-Jun-05						
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**Cable**	**Qty**	**AWG**	**1**	**2**	**3**
34	Thermal	PDS	Tracker Wake Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/4,203/4	Tracker Wake HPP
35	Thermal	PDS	Wake Heaters	120VDC	<5A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/5,203/5	Wake Radiator Heater Bracket
36							2 pairs	20			CAB Radiator Bracket
37	Thermal	PDS	LUSS Boxes	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/6,203/6	LUSS-HPP
38											
39											
40											
41	Thermal	PDS	RICH Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J103,J203	PDS Cable 103/7,203/7	LUSS-HPP
42	Thermal	PDS	LTOF Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J104,J204	PDS Cable 104/8,204/8	LTOF Heater bracket
43	Thermal	PDS	CC1&2 Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J104,J204	PDS Cable 104/9,204/9	CC-HPP
44											
45	Thermal	PDS	Tracker Ram Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J104,J204	PDS Cable 104/10,204/10	Tracker Ram HPP
46	Thermal	PDS	CC3&4 Heaters	120VDC	<3A	M22759/44-20-*	2 pairs	20	PDS/J104,J204	PDS Cable 104/11,204/11	CC-HPP
47											
48	Tracker	TPD0	2 TBS in T0-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T0-Crate
49	Tracker	TPD1 in TSPD1	2 TBS in T1-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T1-Crate
50	Tracker	TPD2 in TMPD2	2 TBS in T2-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T2-Crate
51	Tracker	TPD3 in TSPD3	2 TBS in T3-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T3-Crate
52	Tracker	TPD4 in TSPD4	2 TBS in T4-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T4-Crate
53	Tracker	TPD5	2 TBS in T5-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T5-Crate
54	Tracker	TPD6 in TSPD6	2 TBS in T6-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T6-Crate
55	Tracker	TPD7	2 TBS in T7-Crate	<120VDC	<10mA	M22759/44-22-*	4 quads	22	TPD0/J19,J110	TPD LV Cabling	TBP in T7-Crate
56	Tracker	2 TBS in T0-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T0-Crate	TBP in T0-Crate	12 TDR2 in T0-Crate
57	Tracker	2 TBS in T1-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T1-Crate	TBP in T1-Crate	12 TDR2 in T1-Crate
58	Tracker	2 TBS in T2-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T2-Crate	TBP in T2-Crate	12 TDR2 in T2-Crate
59	Tracker	2 TBS in T3-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T3-Crate	TBP in T3-Crate	12 TDR2 in T3-Crate
60	Tracker	2 TBS in T4-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T4-Crate	TBP in T4-Crate	12 TDR2 in T4-Crate
61	Tracker	2 TBS in T5-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T5-Crate	TBP in T5-Crate	12 TDR2 in T5-Crate
62	Tracker	2 TBS in T6-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T6-Crate	TBP in T6-Crate	12 TDR2 in T6-Crate
63	Tracker	2 TBS in T7-Crate	24 Tracker Ladders	<80VDC	<10mA	2K10602_FK1-A02*	24	26	2 TBS in T7-Crate	TBP in T7-Crate	12 TDR2 in T7-Crate
64	TRD	UPD0	6 UHVG in U0-Crate	<120VDC	<35mA	M22759/44-22-*	12 triplets	22	UPD0/J28,J29,J210	UPD LV Cabling	UBP in U0-Crate
65	TRD	UPD1	6 UHVG in U1-Crate	<120VDC	<35mA	M22759/44-22-*	12 triplets	22	UPD1/J28,J29,J210	UPD LV Cabling	UBP in U1-Crate
66	TRD	6 UHVG in U0-Crate	2624 TRD Straw Tubes	<1800VDC	<100uA	Reynolds 167-2896	42	Coax-36	6 UHVG in U0-Crate	TRD HV Cabling	42 UHVD on Octagon Wake
67	TRD	6 UHVG in U1-Crate	2624 TRD Straw Tubes	<1800VDC	<100uA	Reynolds 167-2896	42	Coax-36	6 UHVG in U1-Crate	TRD HV Cabling	42 UHVD on Octagon Ram
68	TRD-Gas	UPD0	UHVG in U0-Crate	<120VDC	<35mA	M22759/44-22-*	2 triplets	22	UGPD/J64	UGPD LV Cabling	UGBP in UG-Crate
69	TRD-Gas	UHVG in UG-Crate	4 Rad Monit Tubes	<1800VDC	<100uA	Reynolds 167-2896	42	Coax-36	UHVG in UG-Crate	UG HV Cabling	4 Rad Monit Tubes in TRD Gas Box

Grounding

All electrical grounding is brought to the USS using 5x1 ground straps and alodined mating surfaces.

During flight the bond paths are out through the CAS guide vanes (ISS) or trunnions (STS).

AMS as delivered configuration will have just passed full STS & ISS EM compatibility testing (including CE, CS, RE, RS).