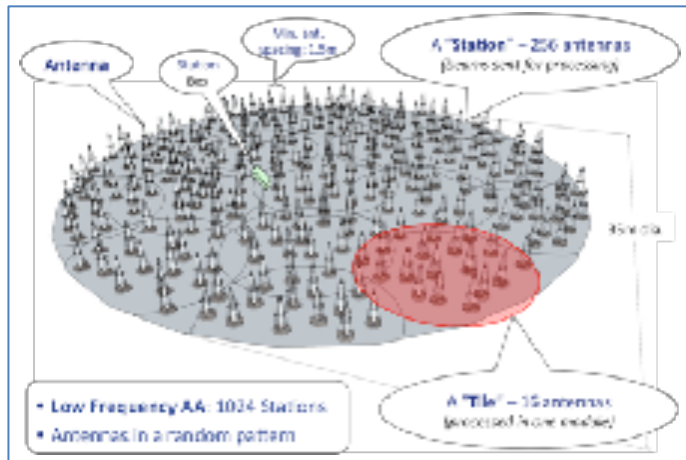
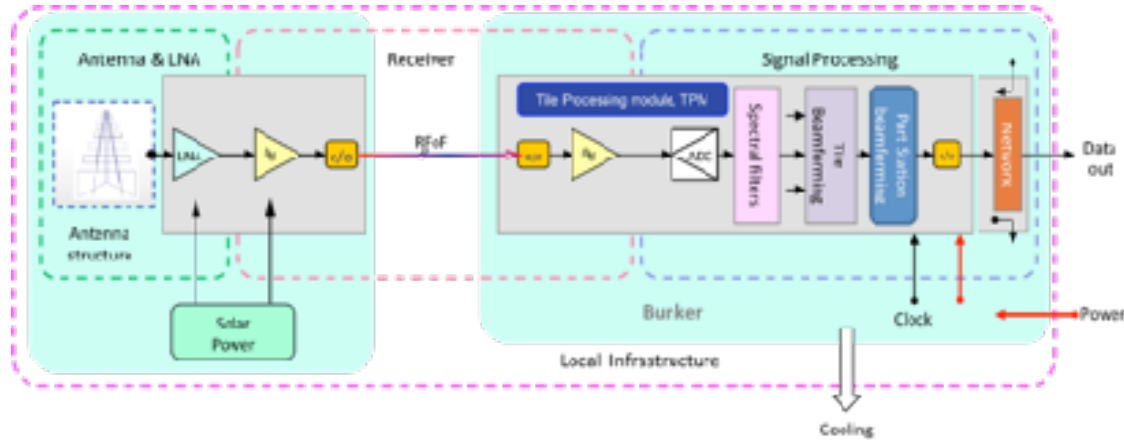


SKA-LFAA, from iTPM to sub-rack design

Milano, astrosiesta 15 marzo 2018, Sandro Pastore



SKA LFAA iTPM



iTPM- Analog Digital Unit

32 channel AD
14 bit @ 1 GHz

Xilinx 20 nm 400 KLut
Ultrascale FPGA

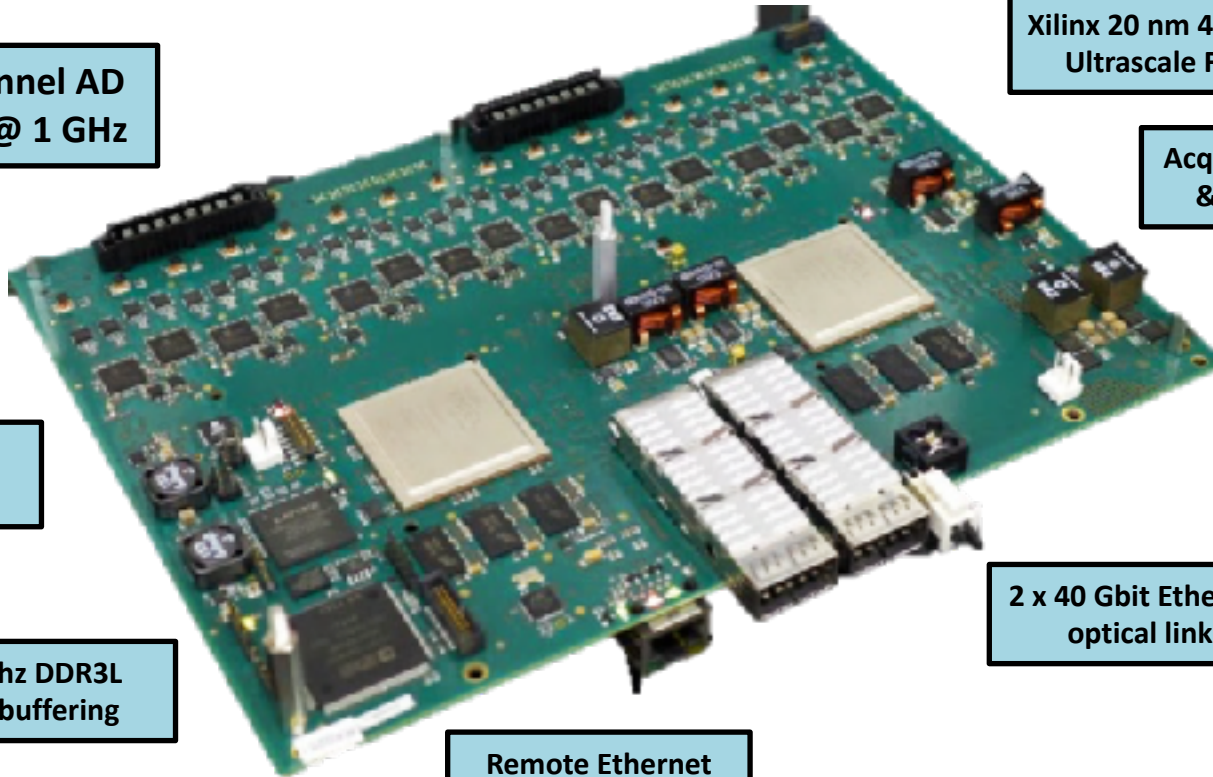
Acquisition, Filtering
& Beamforming

16 x 10 Gbit
AD JESD lines

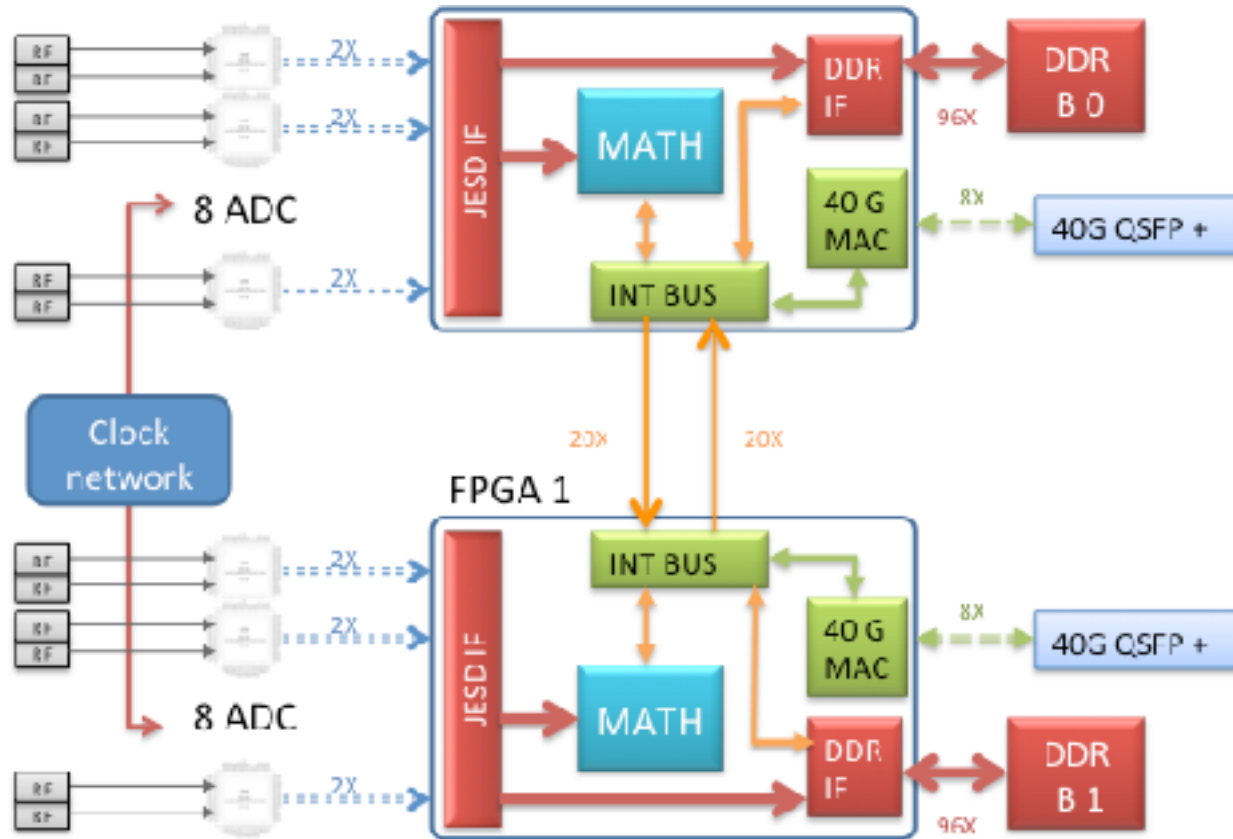
2 x 40 Gbit Ethernet
optical link

1.6 Ghz DDR3L
data buffering

Remote Ethernet
management

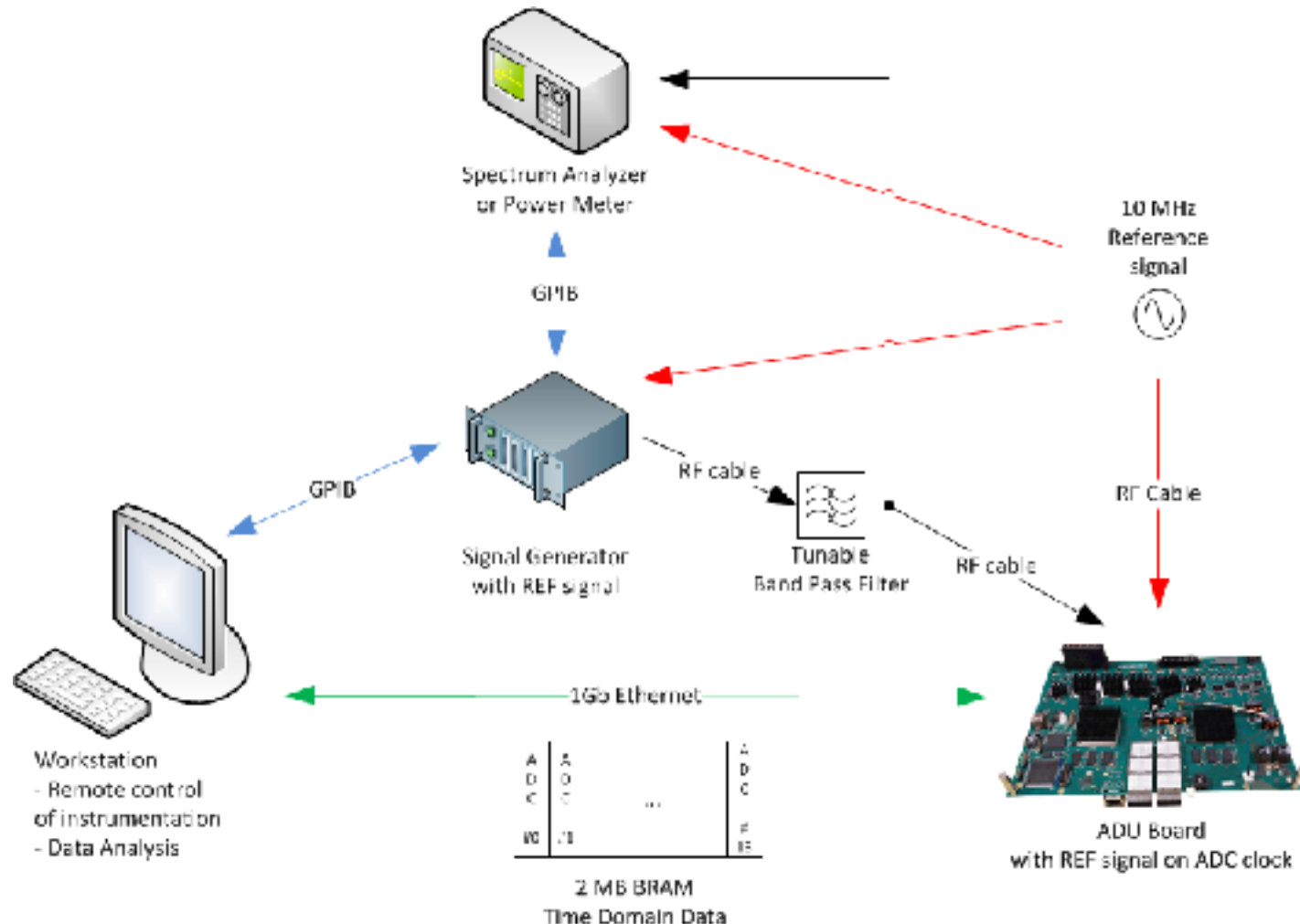


Acquisition and processing architecture



FPGA USAGE:	JESD RX	INT BUS	DDR	40G Eth
	16 GByte/s	5.0 GByte/s	16 GByte/s	22.0 GBit/s

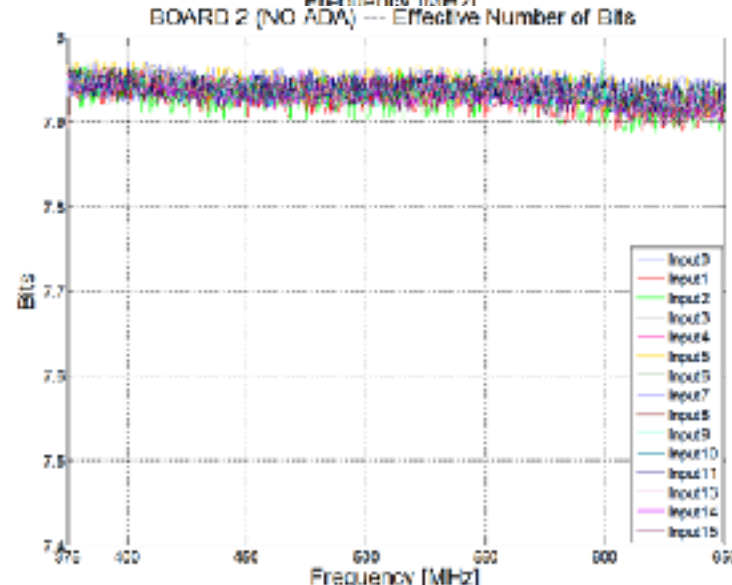
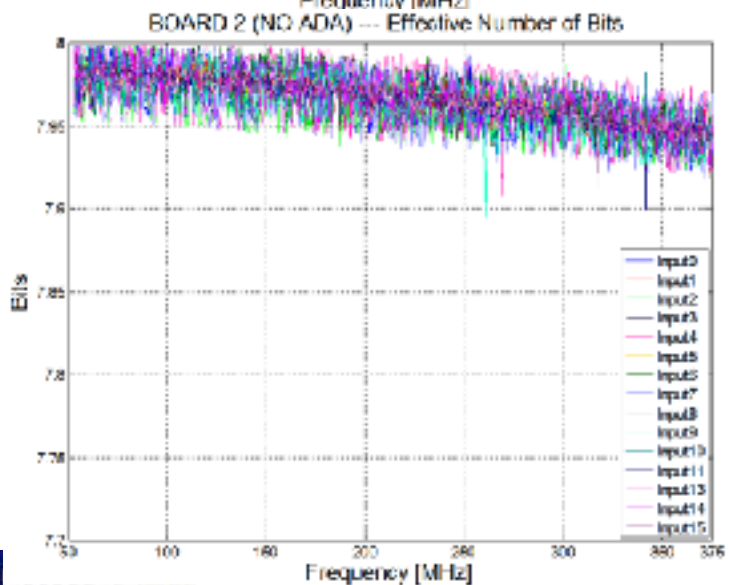
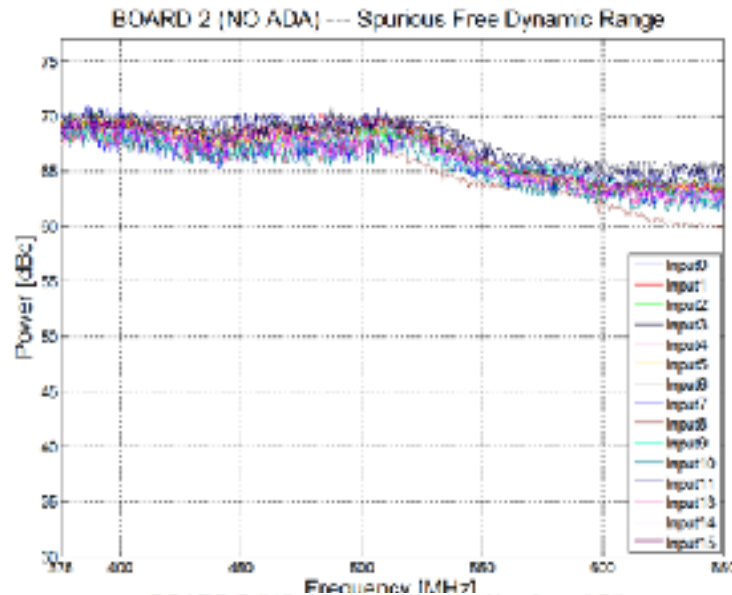
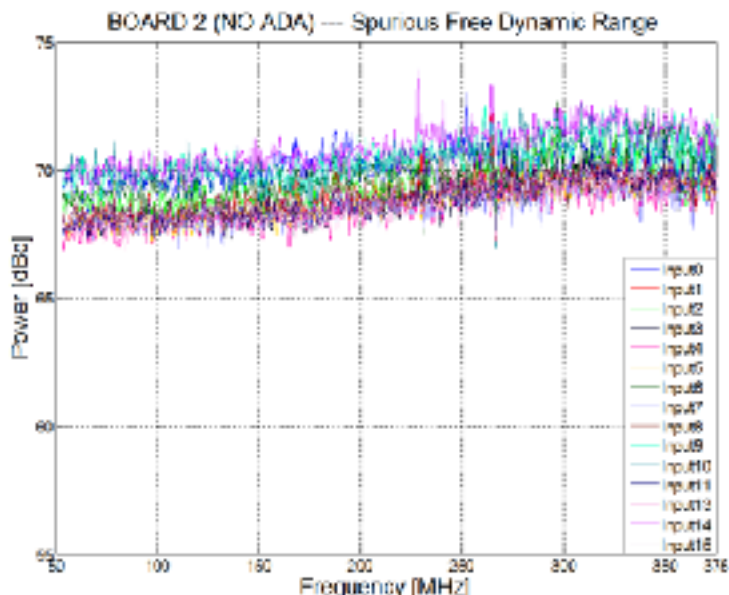
ADU Board Test Setup



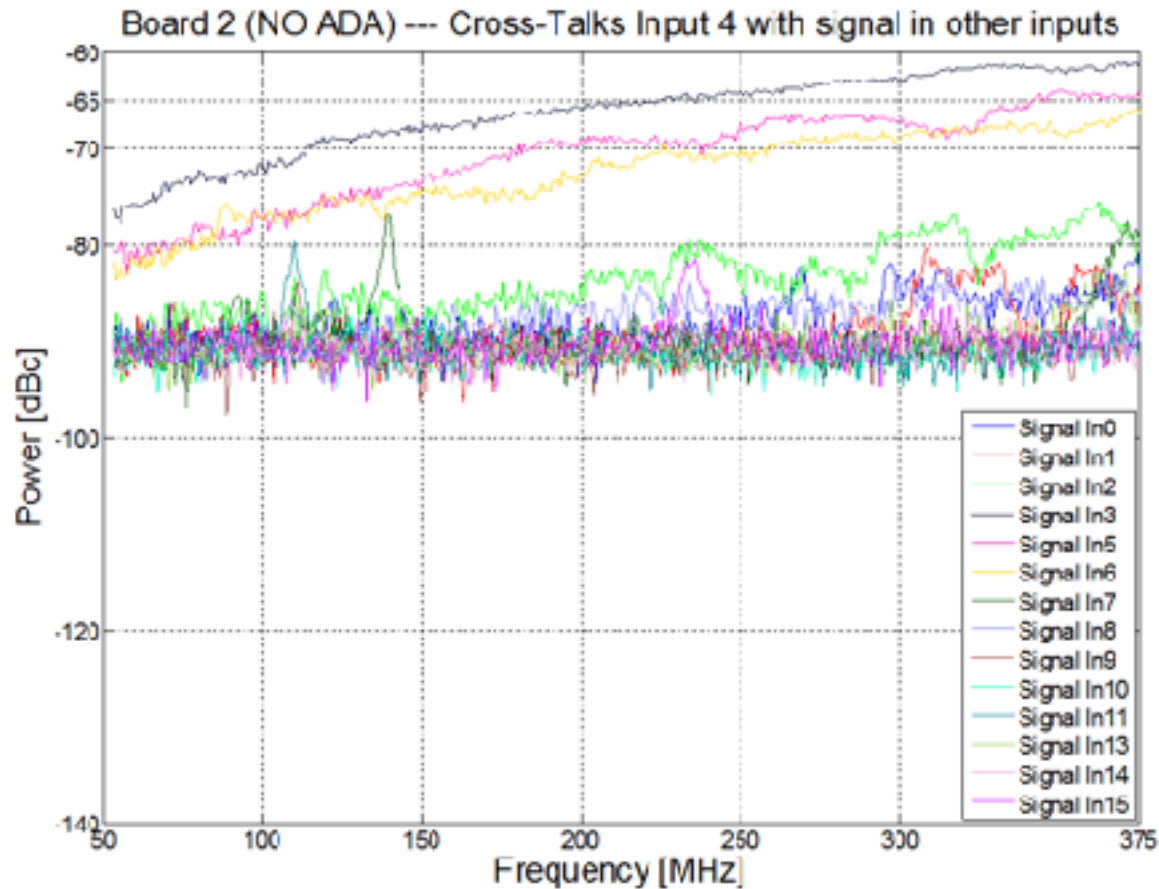
Workstation
- Remote control of instrumentation
- Data Analysis

ADU Board
with REF signal on ADC clock

50-375-650 SFDR & ENOB



Cross-Talk



Measurement Summary

Fs: 800 MSPS --- BW: 50 – 375 MHz

ADC Performance Parameters	ADU Board#1 (with ADA)	ADU Board#2 (without ADA)
Signal to Noise Ratio referenced to Full Scale [dBFS]	≥ 49.19	≥ 49.33
Gain Flatness [dBFS]	≤ ±0.3573	≤ ±0.343
2 nd -order Harmonic Distortion [dBc]	≤ -67.24	≤ -67.74
3 rd -order Harmonic Distortion [dBc]	≤ -66.53	≤ -68.56
Worst Other Spur [dBc]	≤ -67.03	≤ -66.83
Spurious Free Dynamic Range [dBc]	≥ 66.53	≥ 66.83
ENOB [bits]	≥ 7.876	≥ 7.896
Cross-Talk [dBc]	≤ -65.69	≤ -61
IP3 [dB] (F1=184.7 MHz; F2=187.5 MHz)	29.55	32.2
IP2 [dB] (F1=184.7 MHz; F2=187.5 MHz)	66.3	77.5

Fs: 700 MSPS --- BW: 375 – 650 MHz

ADC Performance Parameters	ADU Board#1 (with ADA)	ADU Board#2 (without ADA)
Signal to Noise Ratio referenced to Full Scale [dBFS]	≥ 48.88	≥ 49.32
Gain Flatness [dBFS]	≤ ±0.6252	≤ ±1.356
2 nd -order Harmonic Distortion [dBc]	≤ -65.77	≤ -59.9
3 rd -order Harmonic Distortion [dBc]	≤ -60.78	≤ -65.64
Worst Other Spur [dBc]	≤ -64.16	≤ -63.23
Spurious Free Dynamic Range [dBc]	≥ 60.78	≥ 59.9
ENOB [bits]	≥ 7.788	≥ 7.886
Cross-Talk [dBc]	≤ -70.58	≤ -70.39
IP3 [dB] (F1=500.1 MHz; F2=503.2 MHz)	26	24.4
IP2 [dB] (F1=500.1 MHz; F2=503.2 MHz)	64	58.3



ITPM FROM AAVS1 TO LFAA: SUBRACK DESIGN

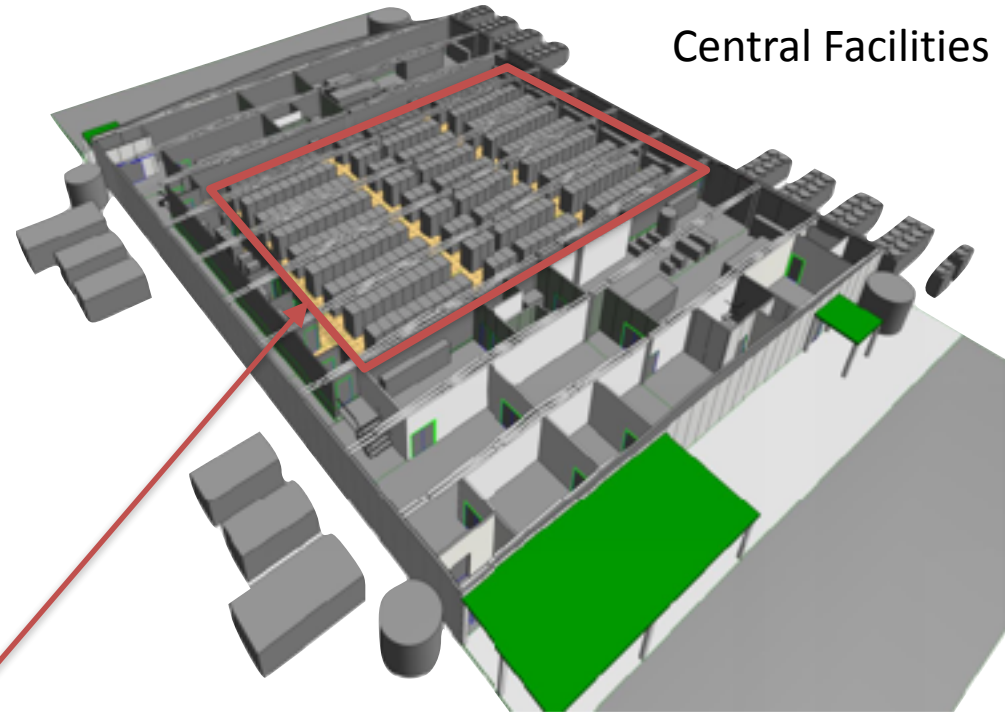
SKA LFAA cabinet

- Australia infrastructure:

- building
- power
- cooling
- synchronization
- networking
- site support

- LFAA (IT & UK mainly)

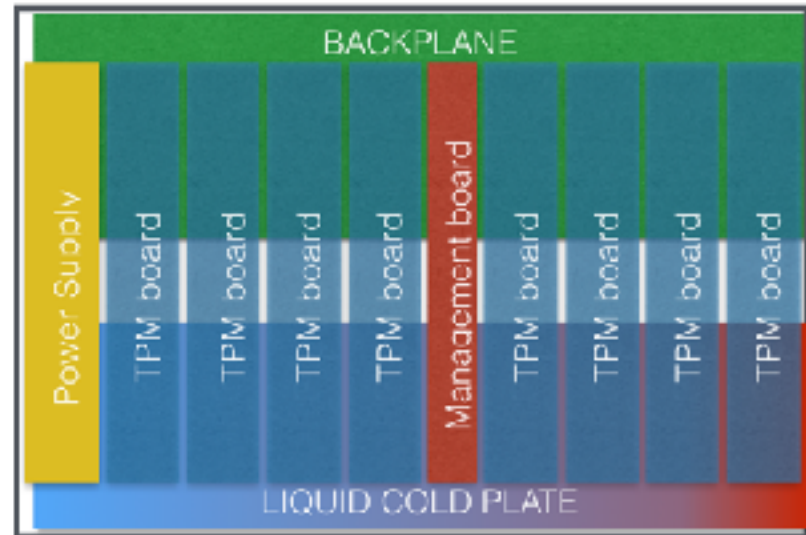
- cabinet
- application



Remote Facilities

iTPM Sub Rack, main mechanics

- 6U Standard chassis
- 8x TPM each, 8 hp
- Power supply unit, 12 hp
- 1 management board, 8 hp
 - Backplane board
- Liquid cold plate to dissipate 70% heat
- FAN air extraction for residual heat



Rack Vertical design, elements

- 42-45U total height
- Side Power Unit distribution (400V DC to 220V single phase)
- 1-2U for 40G EtH switch
- 1U for CABINET Management
- 2U for Heat Exchanger (TBC)

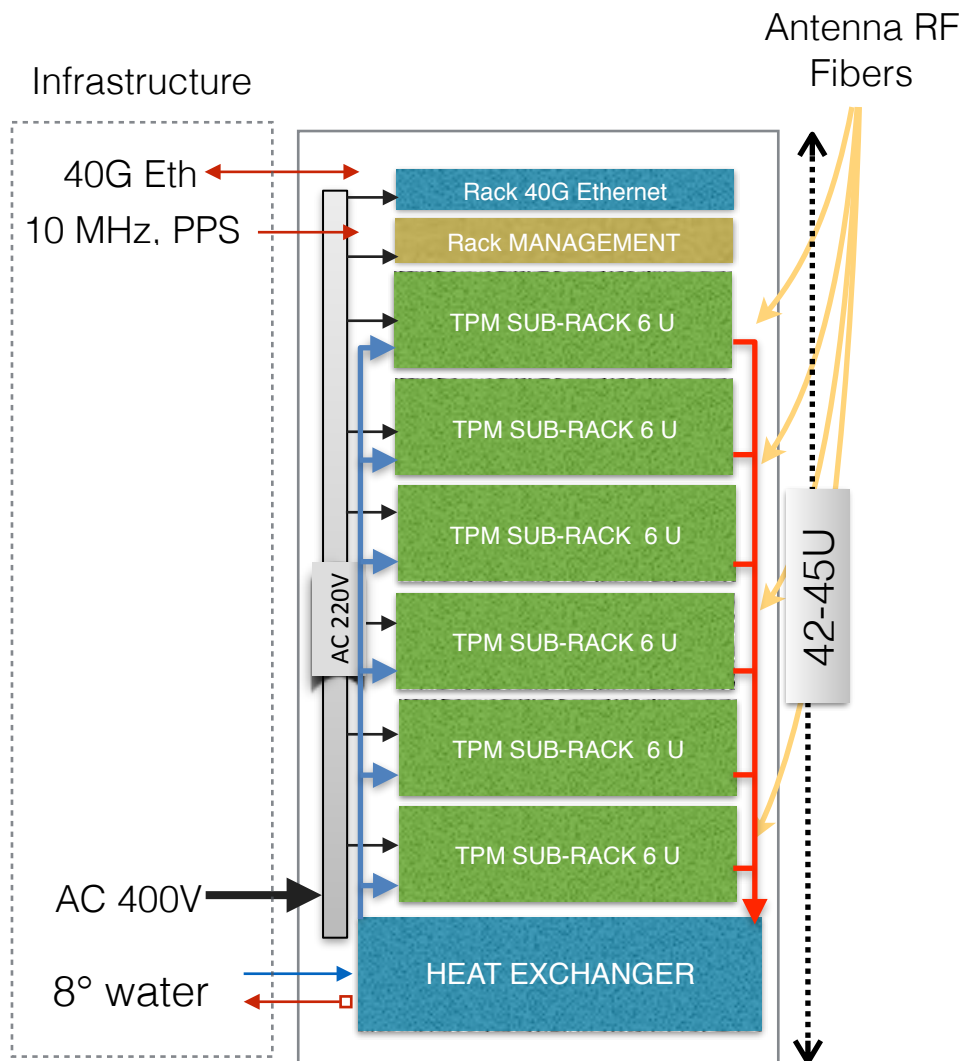


37-41U free for TPMs

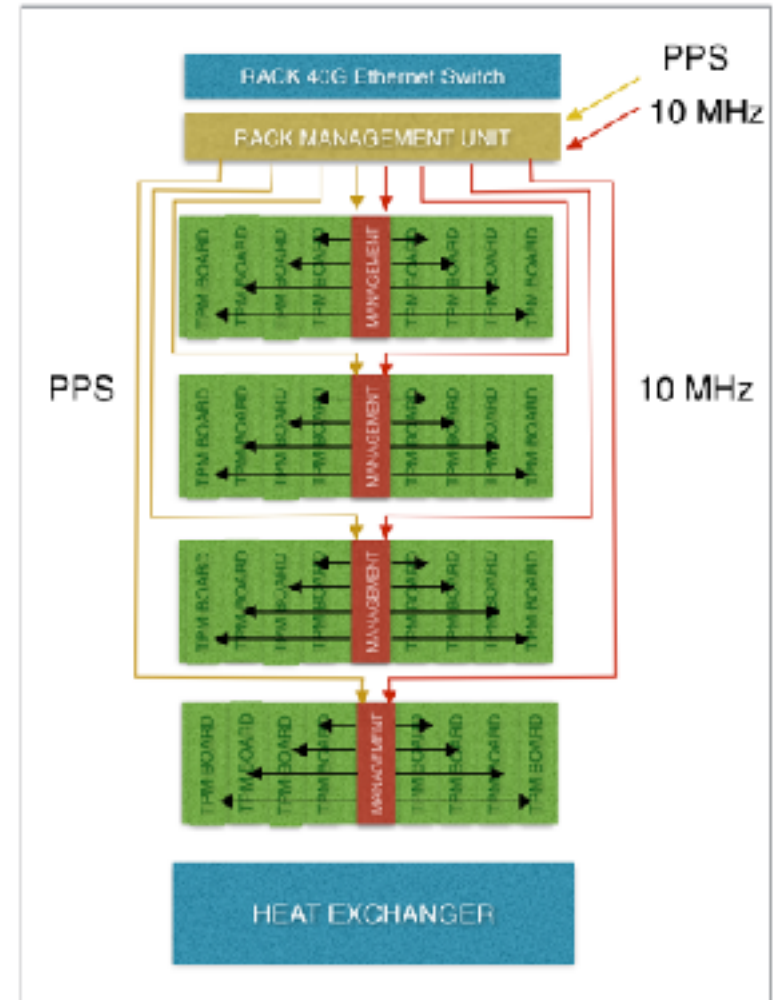
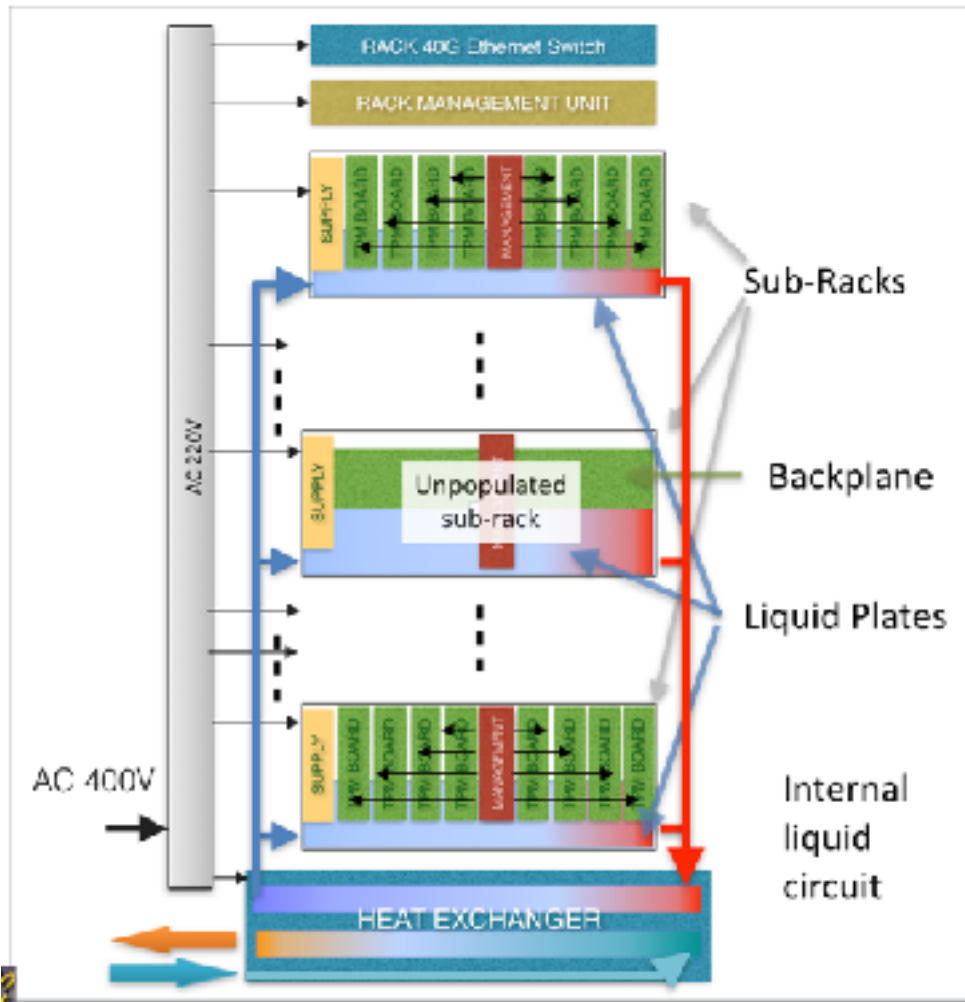
- 6U for 8TPM Sub-Rack



4-6 Sub-Rack for CABINET

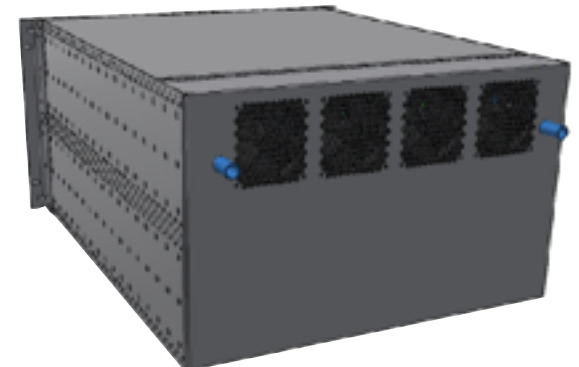
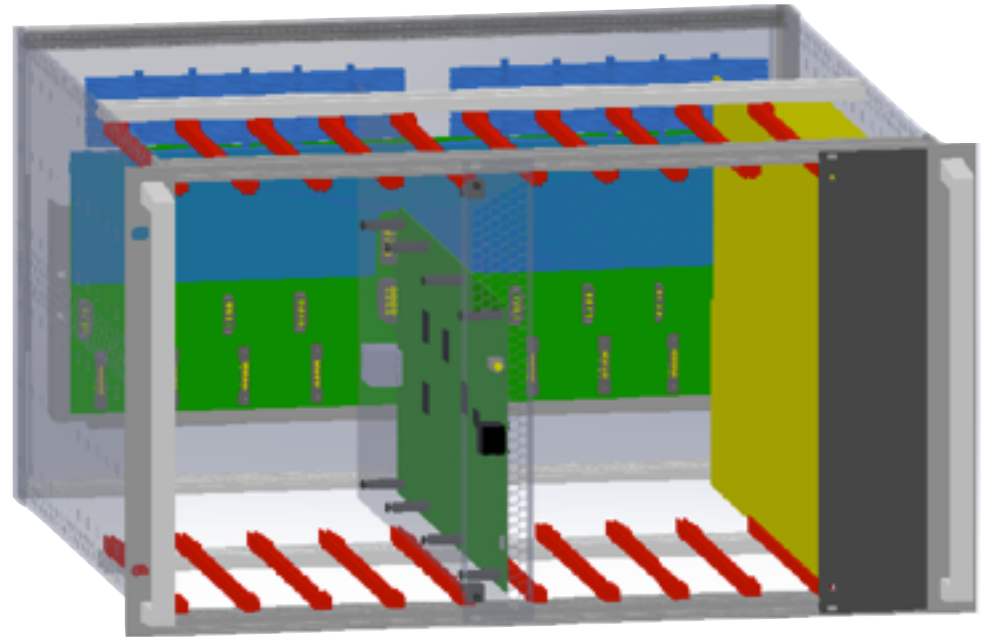


Rack Power & clock distributions

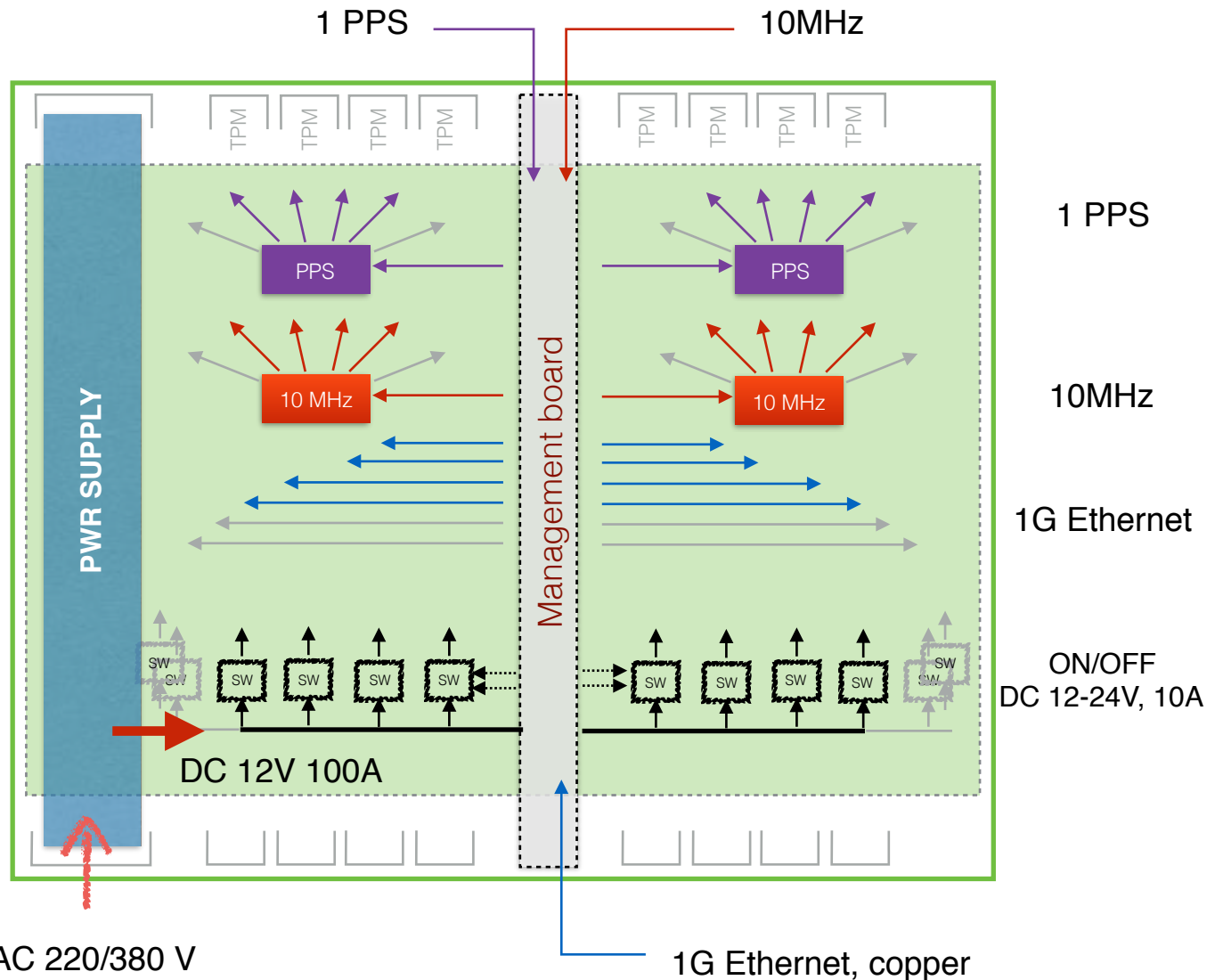


iTPM Sub-Rack mechanical design

- 6U Standard chassis, 84 hp
- Backplane board
 - Liquid cold plate
 - FAN air extraction
- 8 hp, TPM integration
- 8 hp, Management board
- 12 hp, Power supply

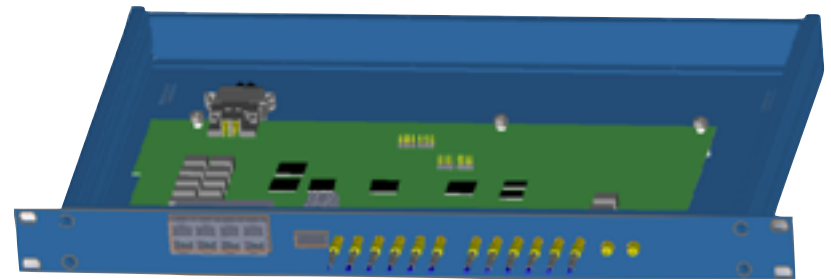
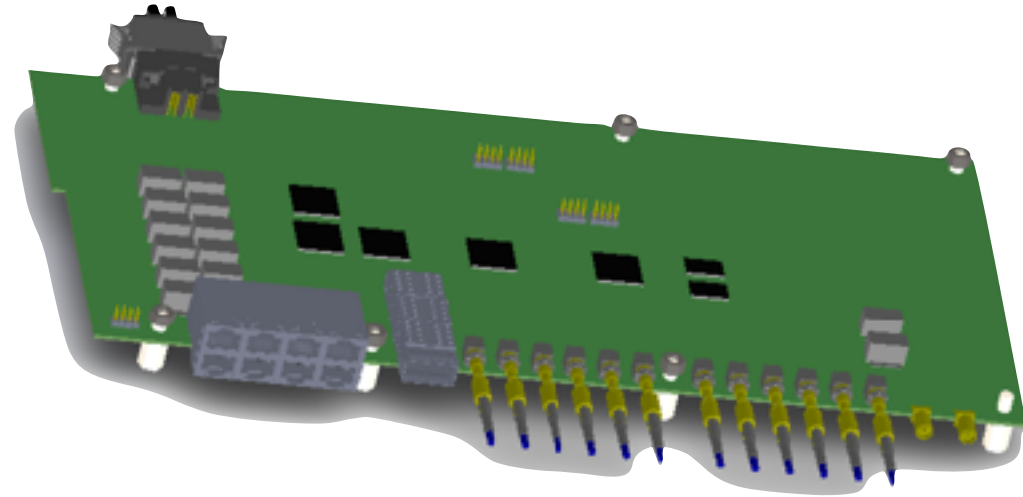


Sub-rack BACK PLANE

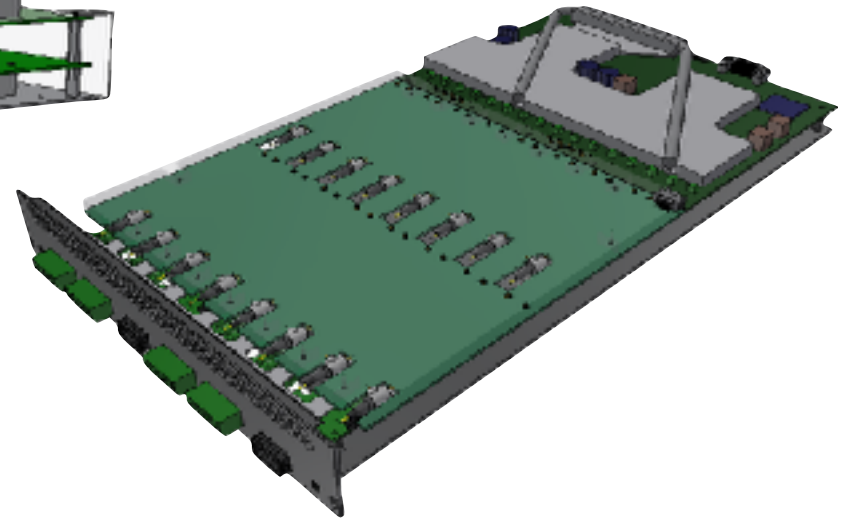
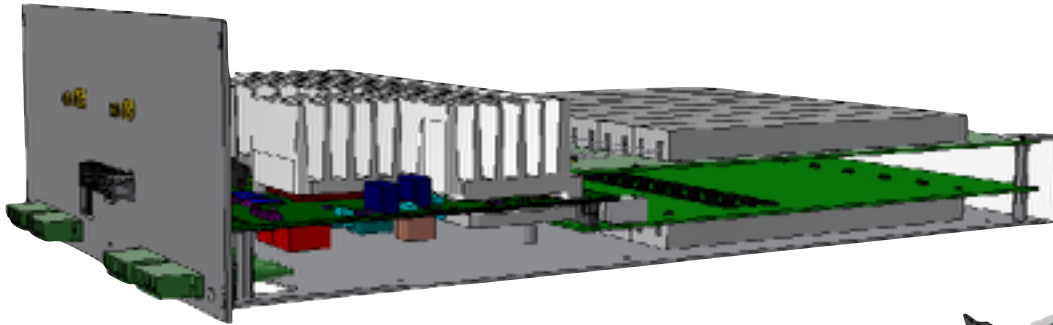


Rack management board

- 1U Standard chassis
- 40G Ethernet Interface for management link
- Linux CPU, high level communication interface for Rack-level command
- 10 MHz & PPS rack-level distribution
- 8 Port Ethernet Gigabit switch
- 220V direct supply



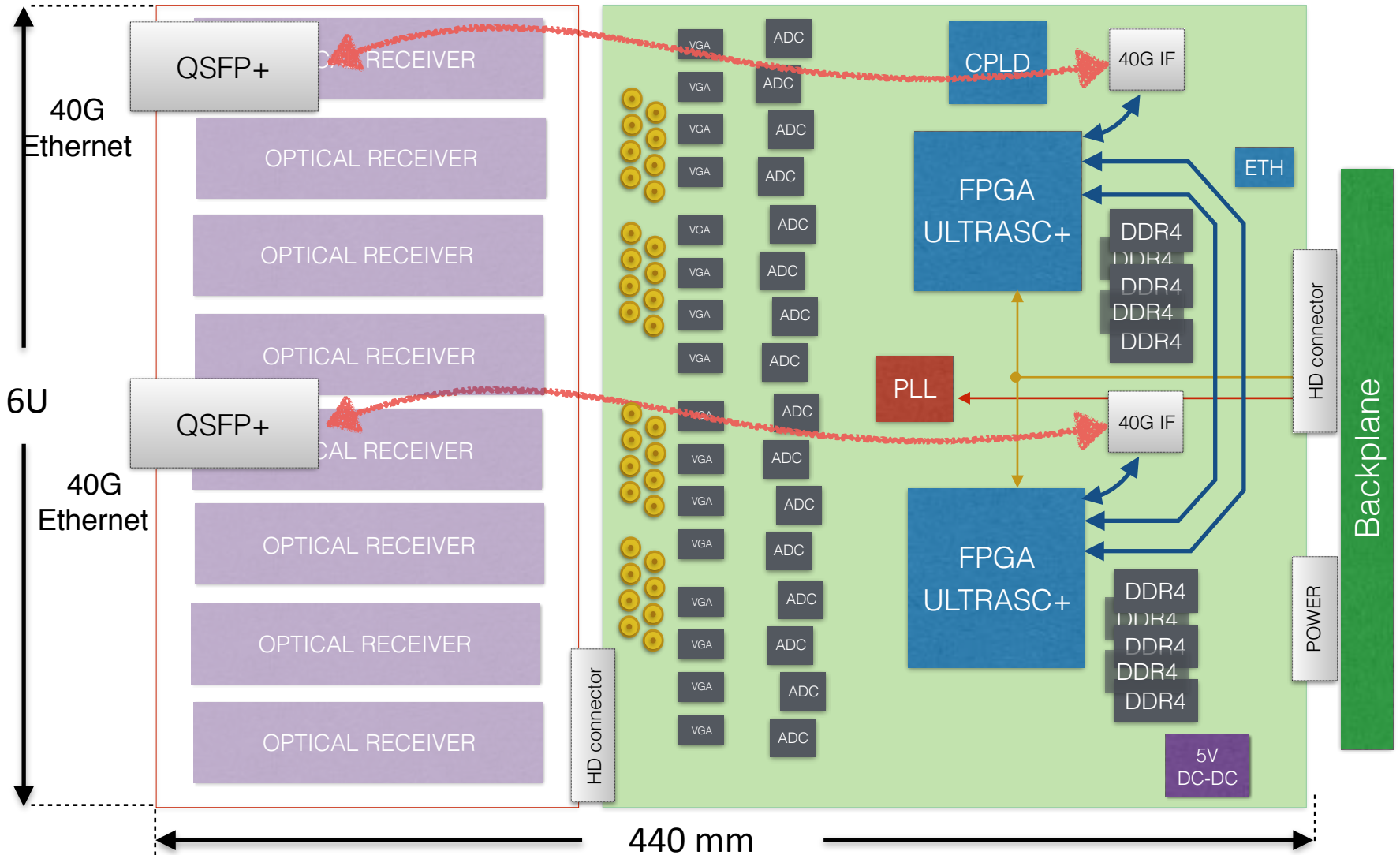
TPM 1.5 form factor: planar design



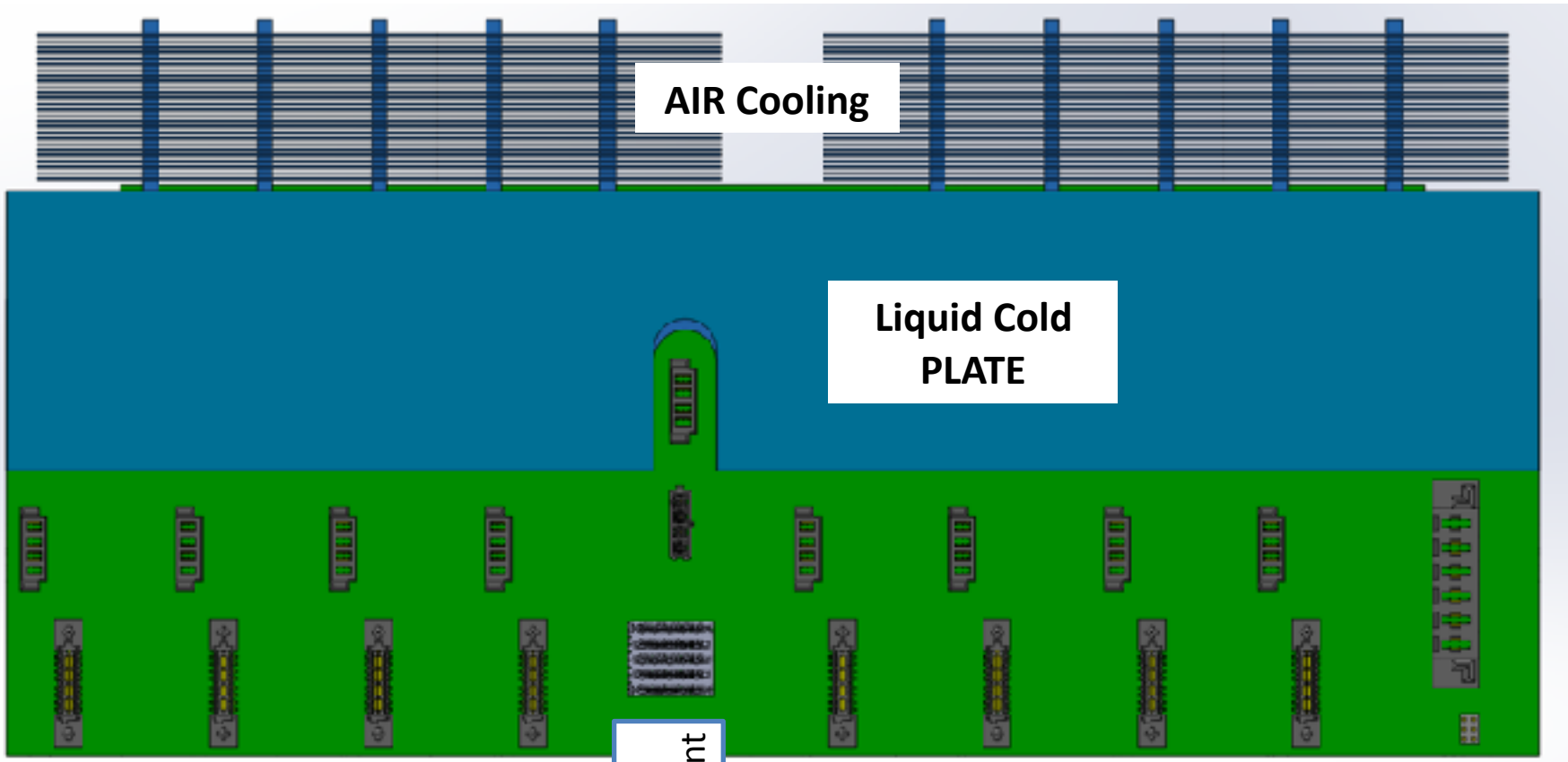
AAVS1 iTPM, air cooled, 21 HP
LFAA iTPM, hybrid cooled, 8 HP



TPM 1.5 layout



Backplane, Front View



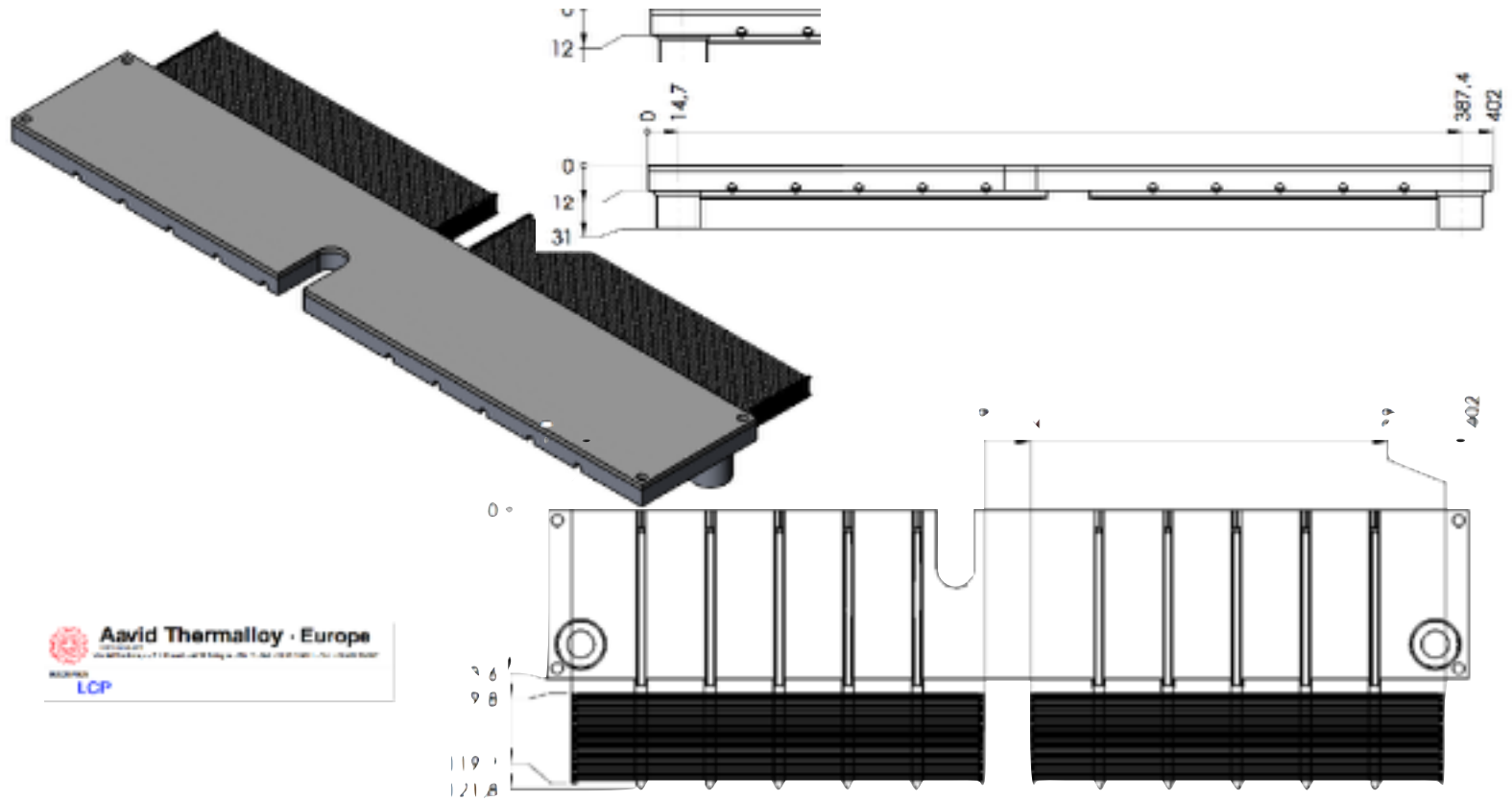
4 x 8HP TPM


8 HP
Management

4 x 8HP TPM

SubRack
SUPPLY
12 HP

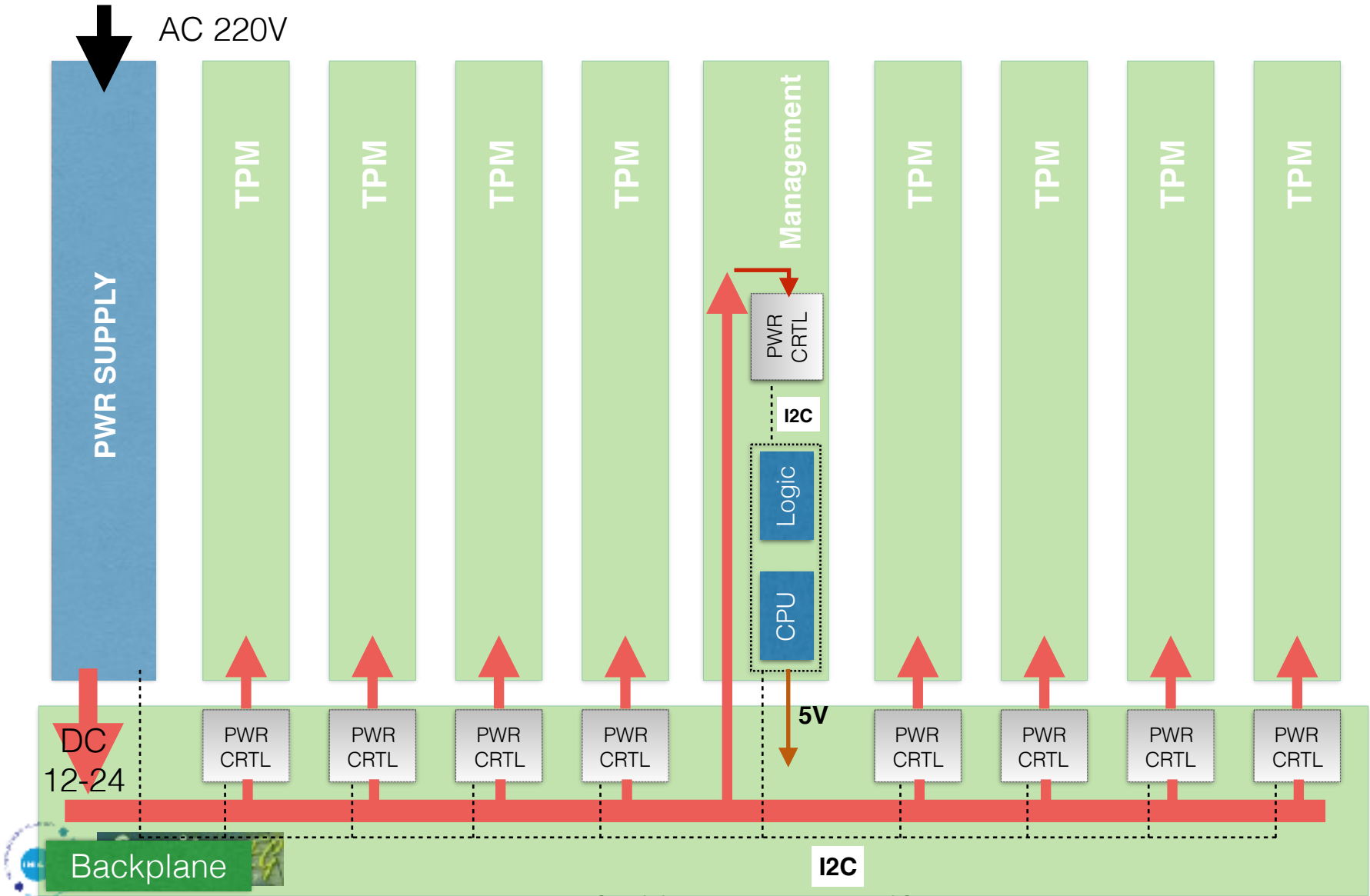
Backplane Liquid Plate



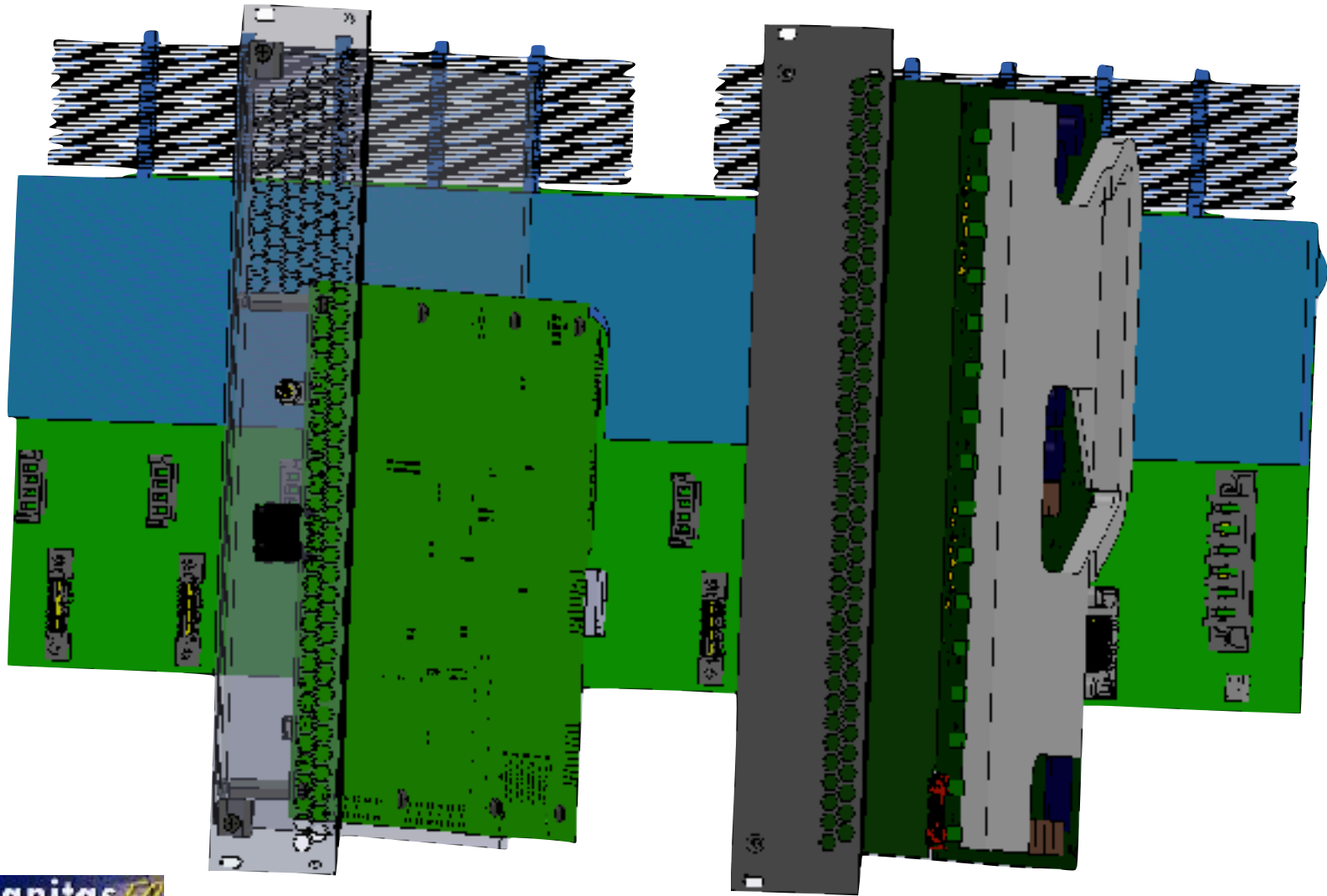

Aavid Thermalloy - Europe
 LCP

DEVELOPMENT

Power distribution



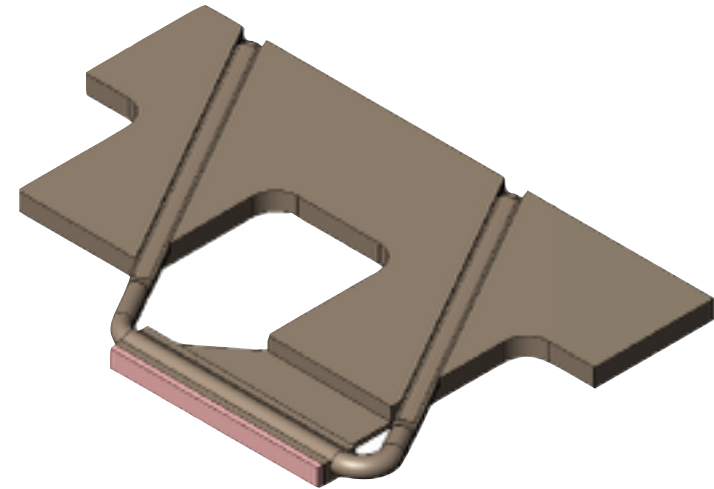
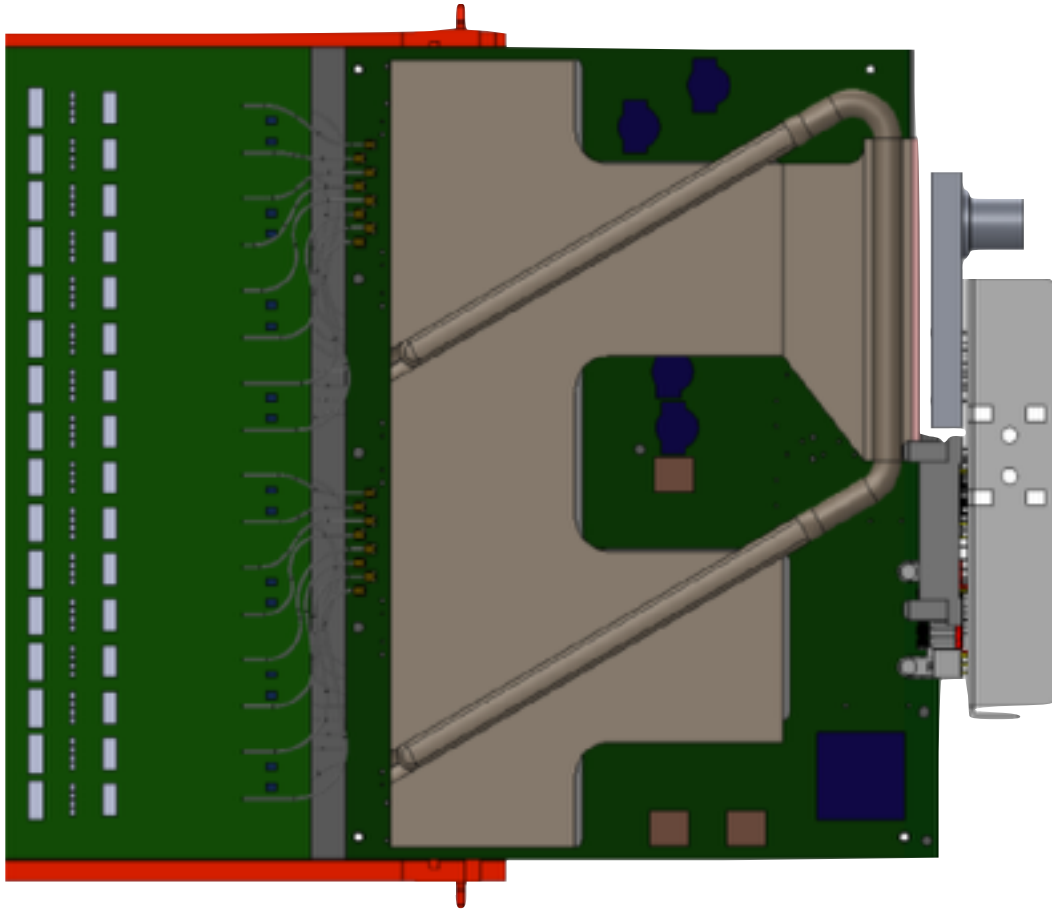
Main Boards Integration



Backplane, iTPM Assembly



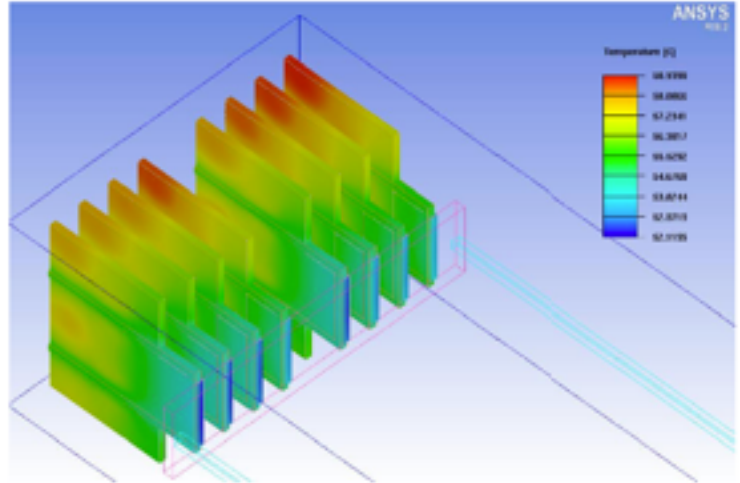
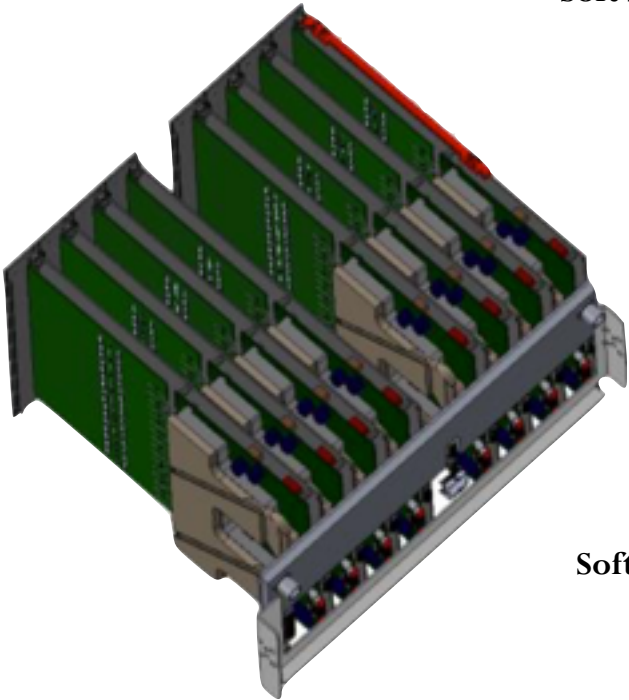
iTPM Single Heat-pipe Bridge



Heat Pipe results, Inlet water, 25°C

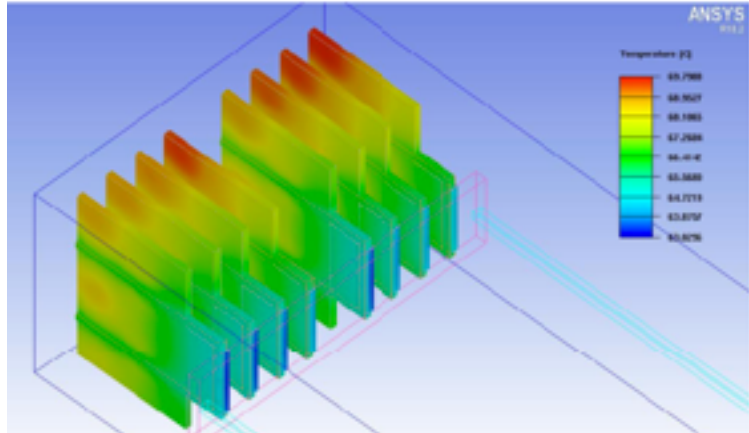
Soft Silicone with 1 mm THICKNESS

$T_{MAX} = 58.9\text{ }^{\circ}\text{C}$



Soft Silicone with 1.5 mm THICKNESS

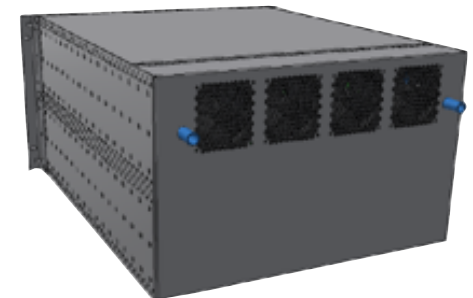
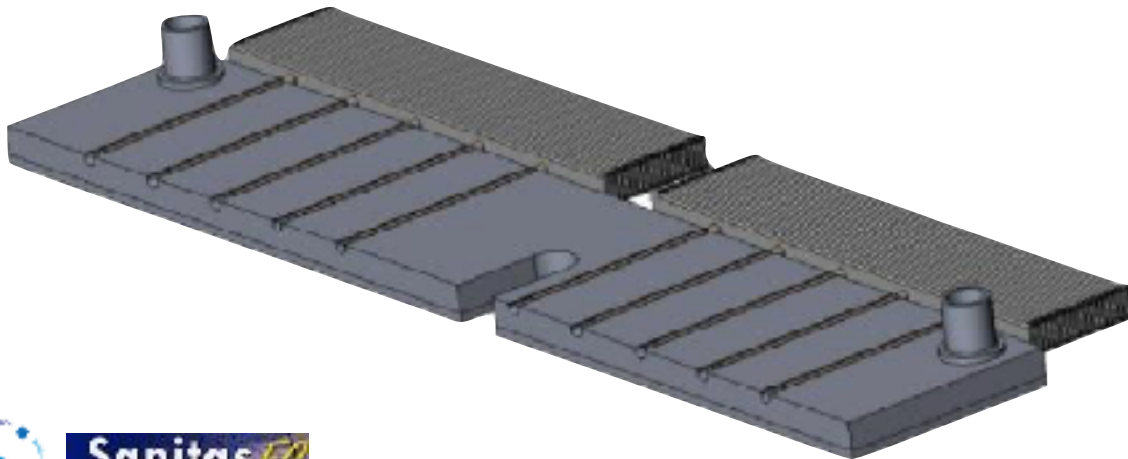
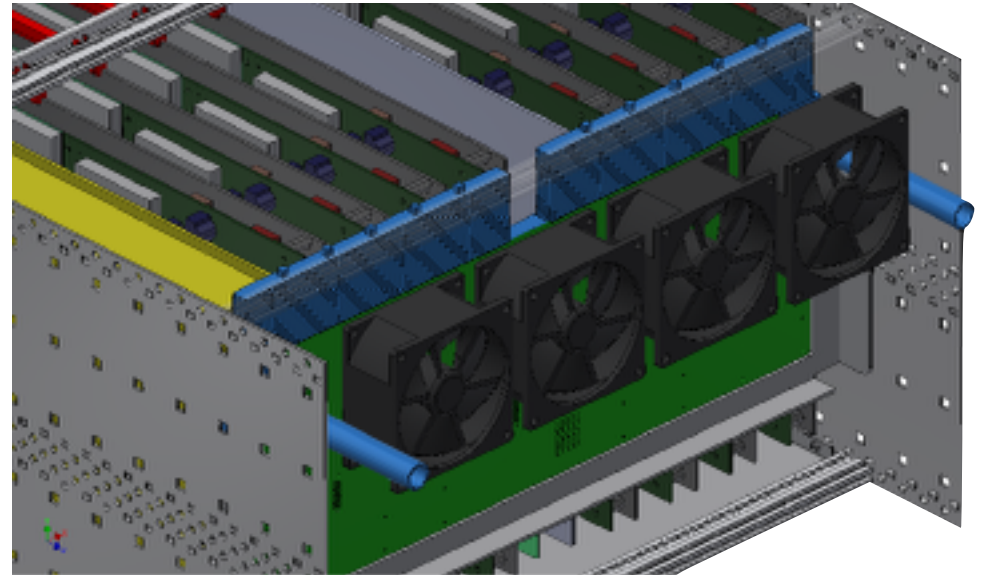
$T_{MAX} = 69.8\text{ }^{\circ}\text{C}$



Cover iTPM main Power-related components

Air Cooling System

SPECIFICATION		LIMIT	UNIT
LIQUID COLD PLATE	FLOW RATE	10	[l/min]
	PRESSURE DROP	0.33	[bar]
	MAXIMUM OPERATIVE PRESSURE	6	[bar]
	CONNECTORS THREAD HOLE	1/4 GAS	
FAN	DIMENSIONS	120x120	[mm]
	NUMBER	4 UNITS	
	VOL. TAPE	10	[V]



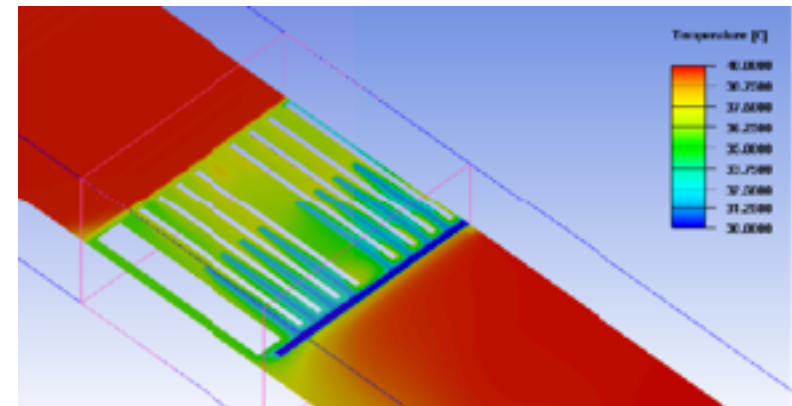
Simulation results

Component temperatures:

SILICONE THICKNESS	T_{MAX} UNDER COMPONENT
[mm]	[°C]
1	53.9
1.5	68.9

Extracted air temperatures:

Assuming an inlet ambient temperature of 40 °C, the air flowing in between the fins will be cooled down of $\approx 8^{\circ}\text{C}$ by the liquid flowing inside the Cold Plate.



END OF PRESENTATION