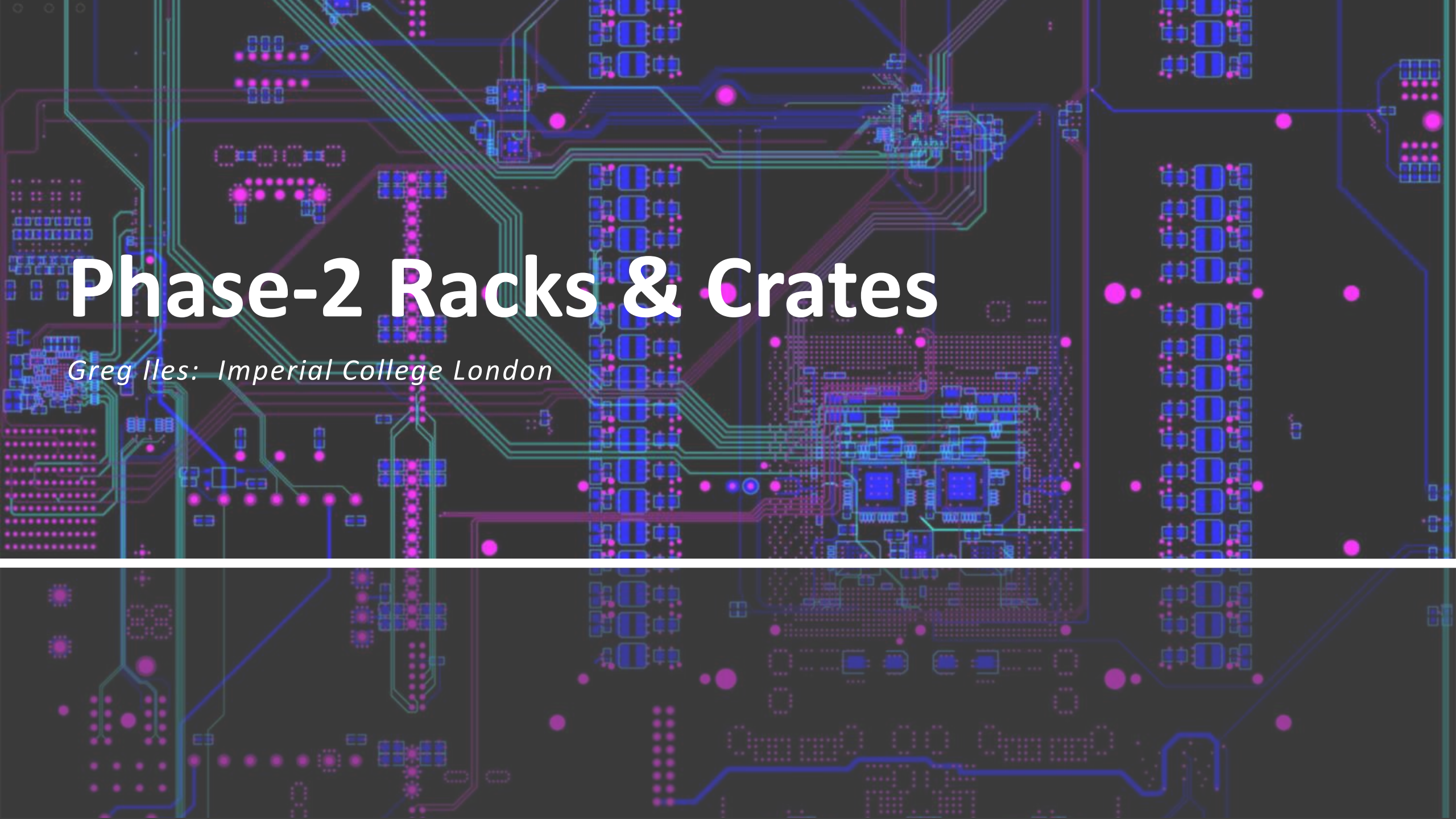


Phase-2 Racks & Crates

Greg Iles: Imperial College London

Introduction

Assume that vertical air cooling is maintained in Pt5

- Front-Back cooling would require thorough study of Pt5 by expert to ensure **room air impedance** not too high.
- May require increase of air temperature to 23 or 24 °C
- Vertical cooling has some benefits (i.e. fire containment & less dust contamination)
  - Although both solvable with front-back cooling
- Beyond the scope of this talk

Introduction

ATCA designed for front-back rack cooling, but vertical within crate

- Places **intrinsic limit on card dimensions**
- Card cannot extend deep into the rack due to limited size of air intake/exit
- Not the case for LHC experiments

- ATCA does have
  - **High speed serial backplane**
  - Power system capable of delivering **400W**, albeit quite complex

- Far from ideal for Phase-2 in other respects
  - Adopted due to **dearth of alternatives**.
  - Noise levels exceeding **85dB**
  - **1-2 kW** used per fan tray
  - **Delicate fibres** optics in strong airflow – risk of damage

Introduction

Much talk about lack of space underground

- Some would argue that it may be self inflicted.
- **Vast amounts of rack space**
  - Changing crate < 100k USD. Digging bigger hole in millions…
- Fundamental limit is 10kW power & cooling per rack (not hard limit as I understand it)

No contingency with current designs

- All based on Samtec FireFly optics. **Cannot switch to COBO optics due to size.**
- FPGA Cooling is possible, but we have already increased heatsink area by x4
  - i.e. 50mm square package uses 100mm square heatsink
  - **Cannot increase area again.**

Optics must be kept **below 50 °C**

- i.e. less than 1% failure over 15 years

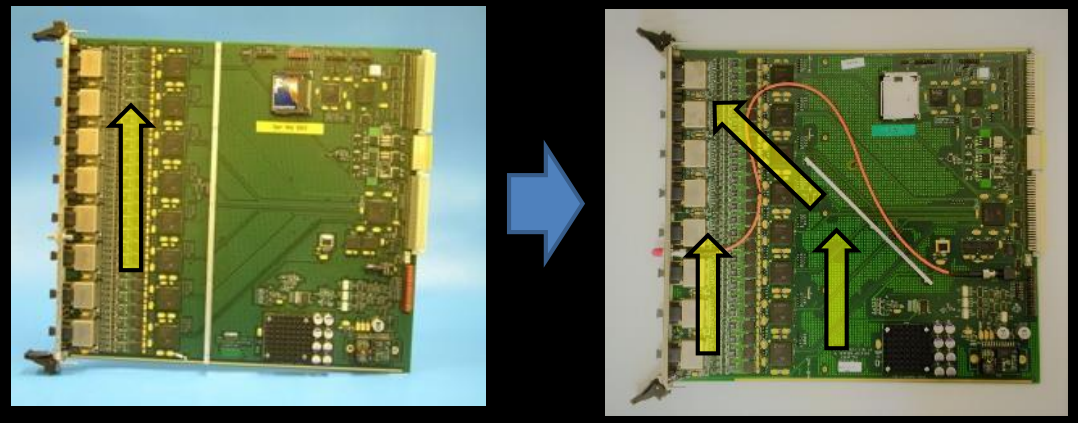
History

Optimistic because cooling needed for PIM & DCDC

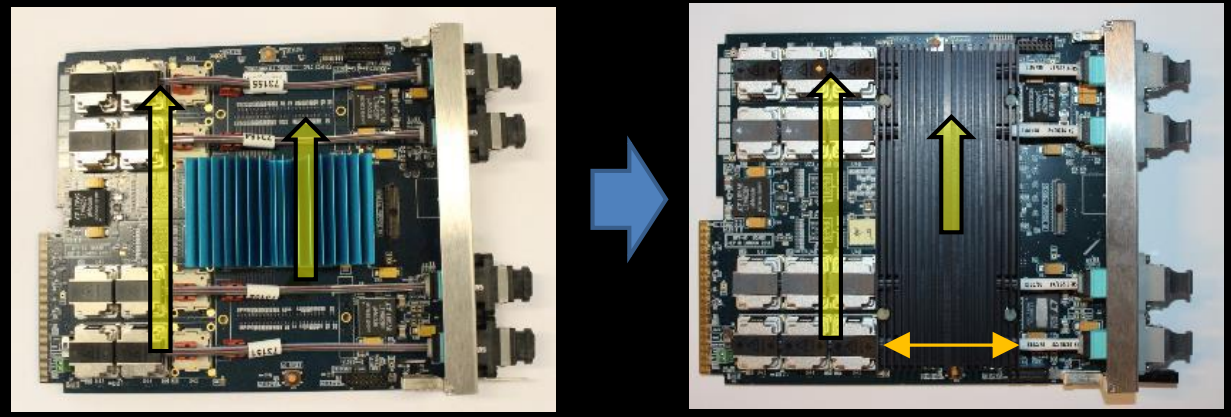
x 10 **x 5**

	Year	FormFactor	Power	Power Denisty	Air Cross-Section	Power Flux
			W	mW mm^{-2}	mm^2	mW mm^{-2}
Tracker FED	2009	VME-9U, 400mm	80	0.5	8000	10
MP7	2012	AMC-DW,FH	70	2.6	5445	13
Phase2-200W	2018	ATCA	200	2.2	8400	24
Phase2-400W	2018	ATCA	400	4.4	8400	48

Lesson from the past…



Cool air for optics. Max 46° C. Average 40° C.



6 cm wide, 35W, 60-70° C

Nobody reports optic temperatures…. ☠ ☠ ☠

Horizontal Cross-Section: Air flow

VME front cards

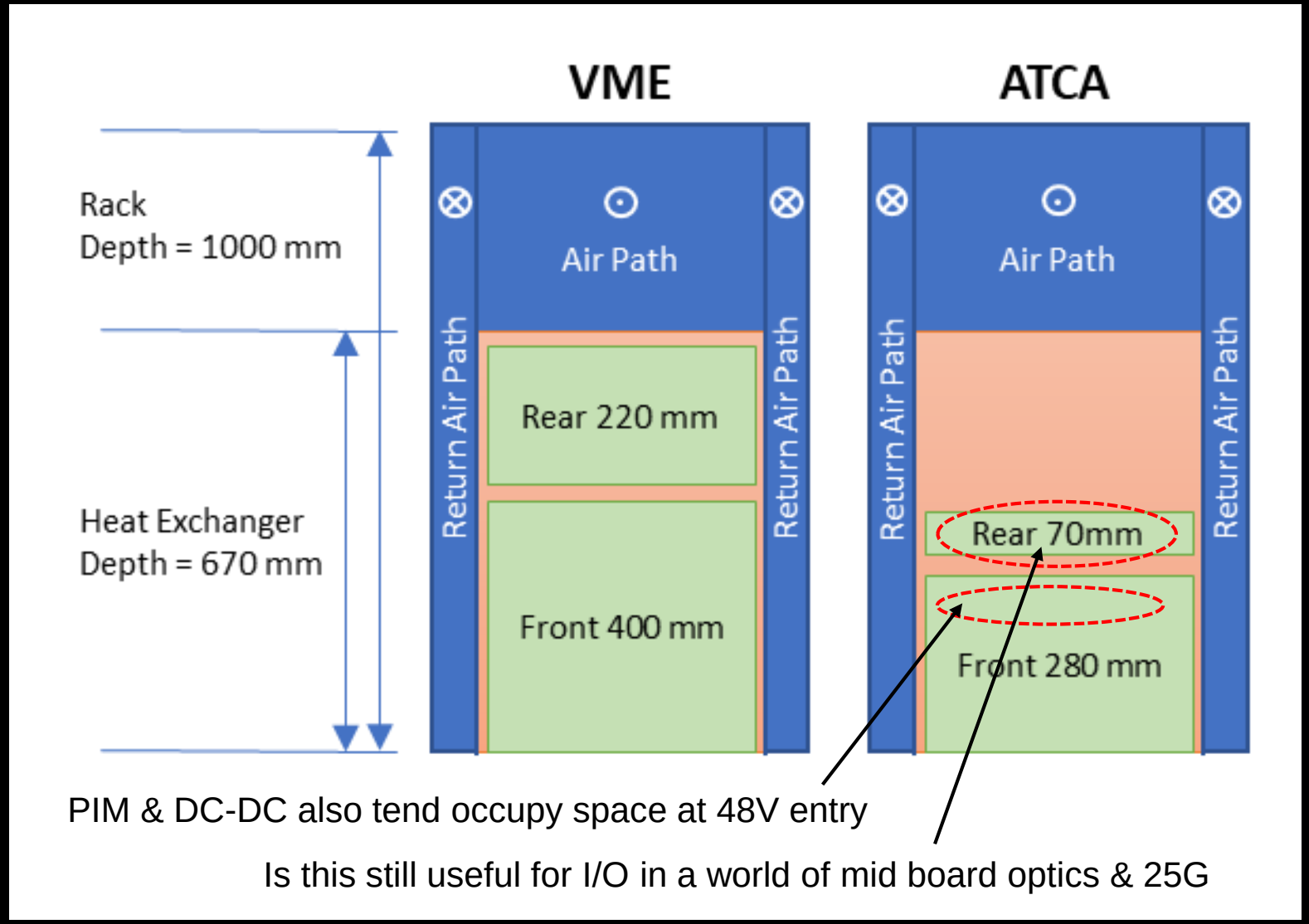
- **43 %** larger than ATCA

VME front & rear cards

- **77 %** larger than ATCA

ATCA Crate occupies just

- **38%** of rack depth



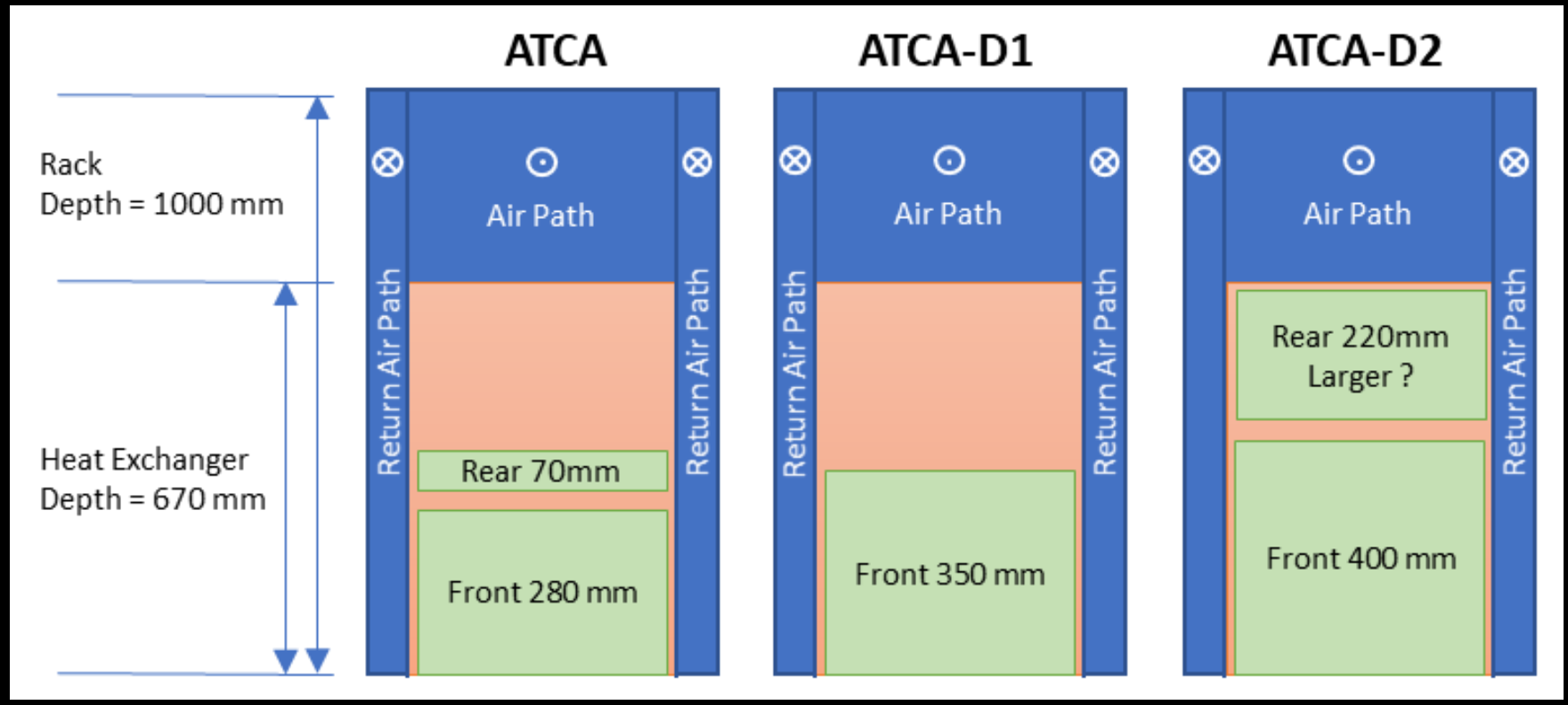
Horizontal Cross-Section: Different depth crates

Is **rear transition** card useful?

- Probably used for I/O extension in the past
- Less relevant with 25G mid-board optics
- Could provide additional processing
- Cable woe in rear?

Is **deeper card front** card useful?

- Cooling
- Real Estate



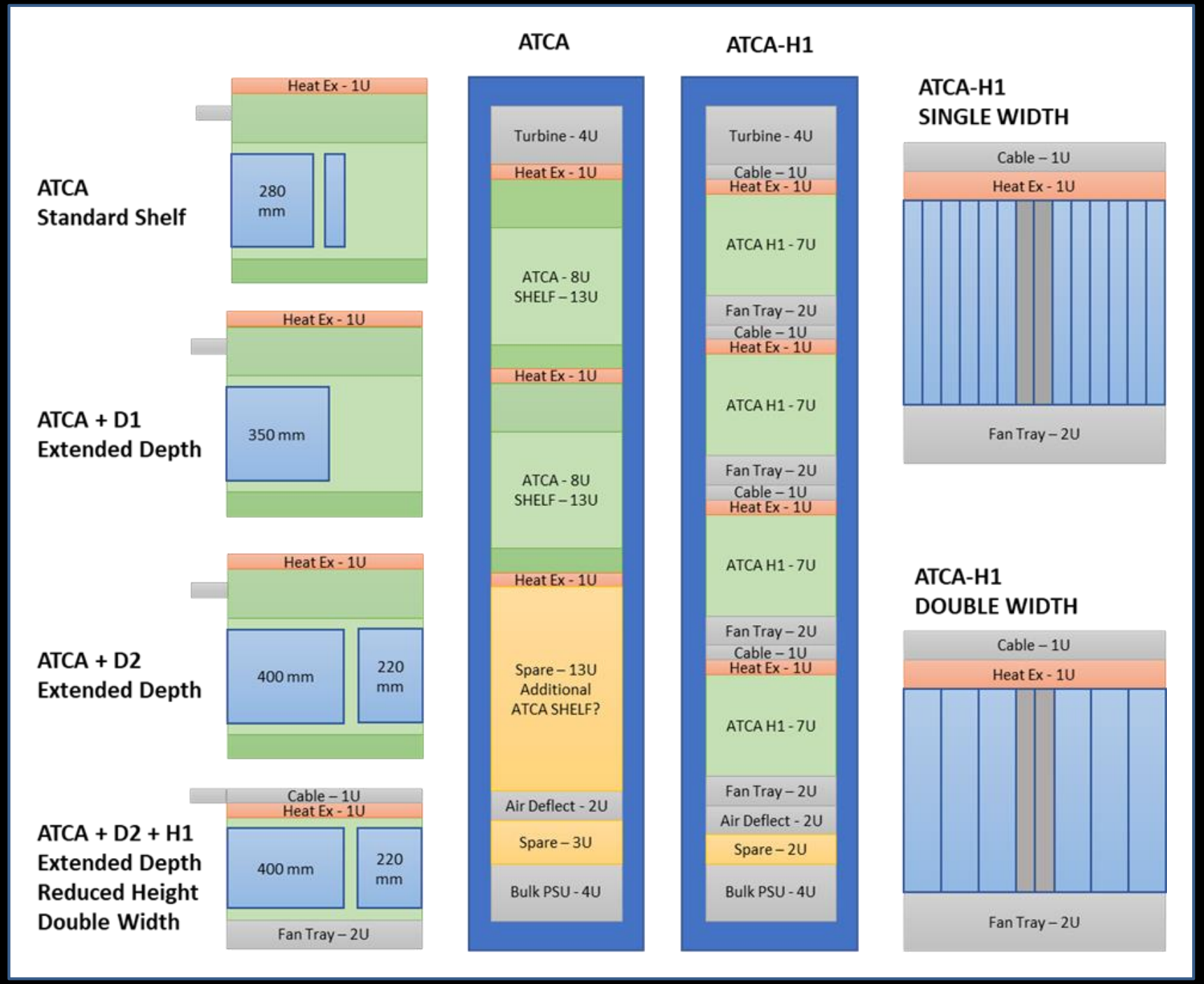
Racks

Present ATCA rack design uses just **7%** of the rack (front cards) or **9%** (front & rear cards)

Adopting rack ATCA-H1 with ATCA-D2 extended depth cards increases rack volume to **18%** (front cards) and **27%** for front & rear cards.

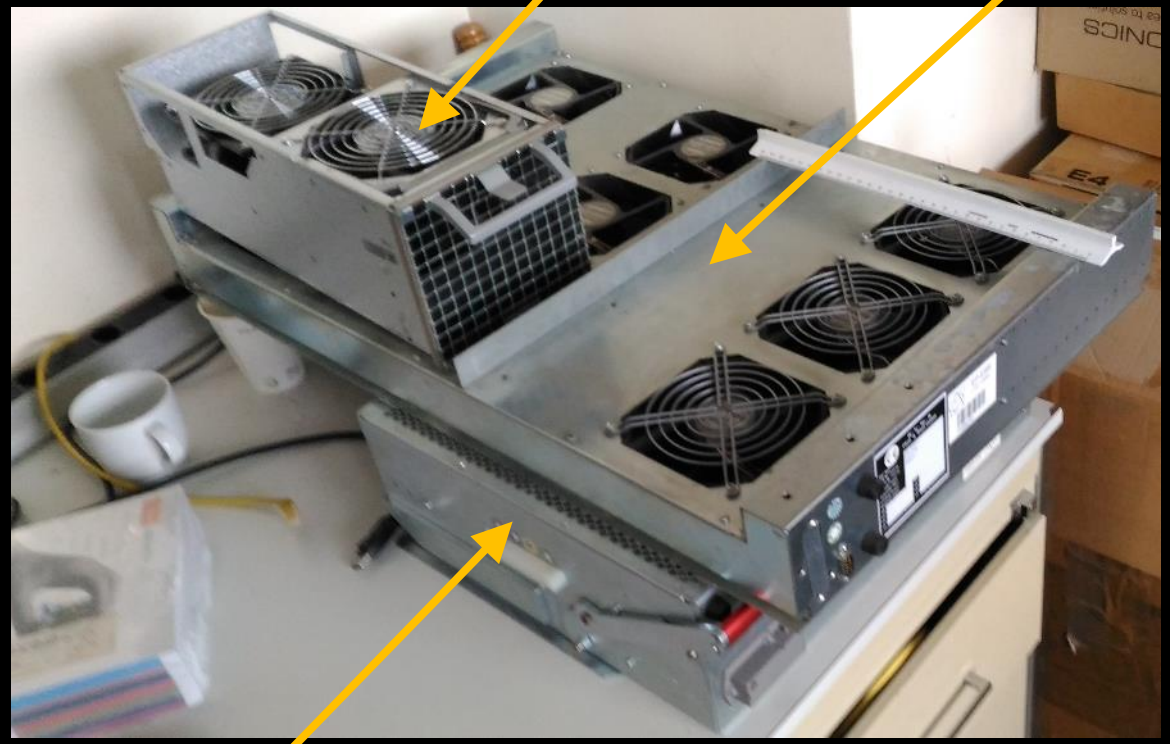
Increase in in volume

- **x2.6** for front cards
- **x3.0** for front & rear cards



ATCA & VME fan trays

A few pictures to give you a sense of scale



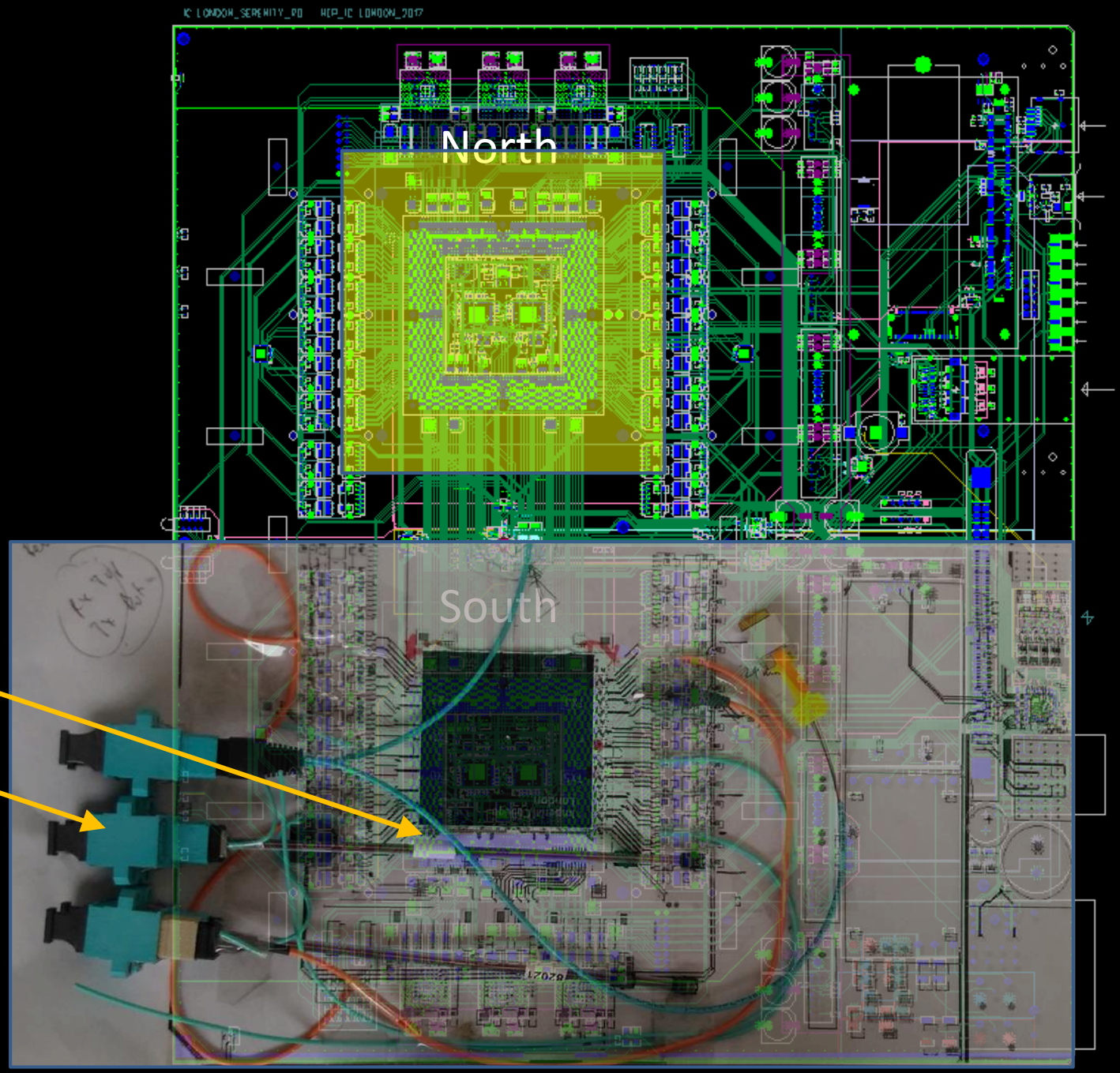
Sense of scale

Size of heatsink to get reasonable cooling
100mm x 100mm
Used for cooling studies in appendix

Do not want fibre vibrating in airflow for a decade

MTPs are big, even with short boot

Size of FPGA
50mm x 50mm



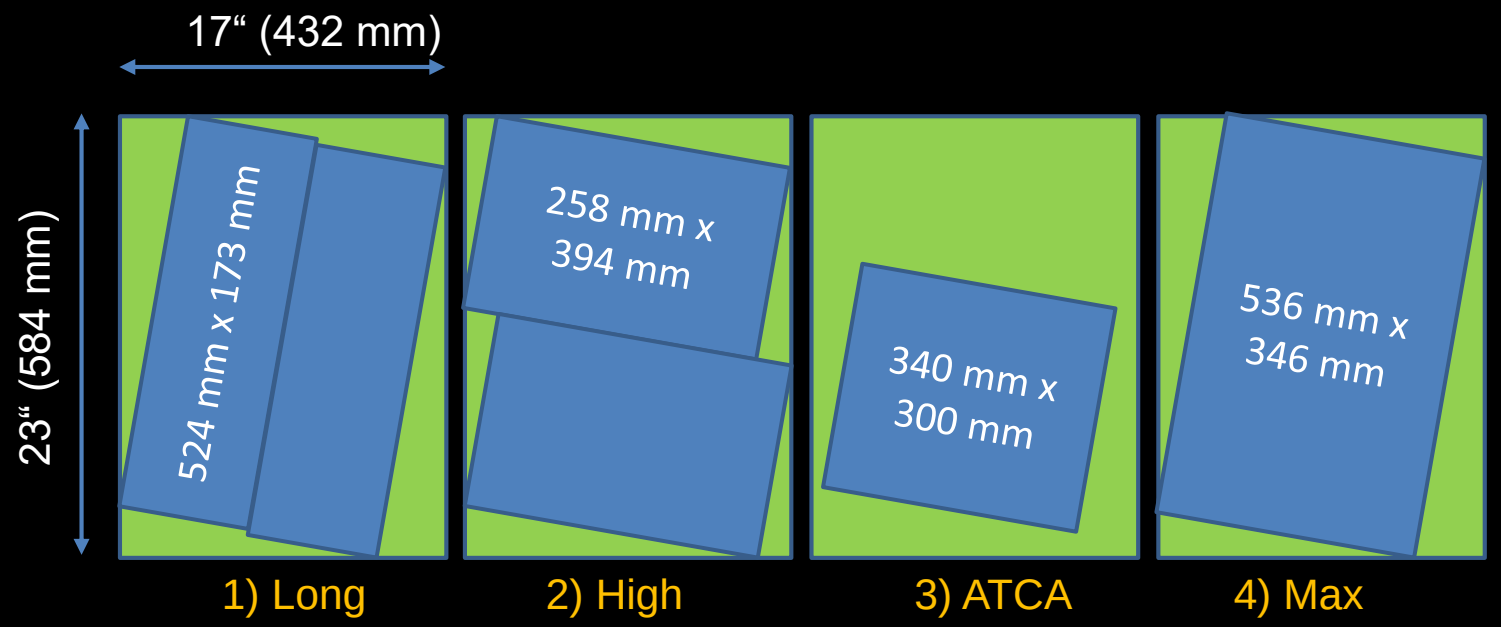
Efficient use of Panel

Standard 24” x 18” panel

- A bit optimistic: assumed 0.5” perimeter wastage, but actually 0.8”
- Usable area 570 x 420mm
- Other sizes available
- Minimal handling tabs on designs drawn
- Require 2.5mm between PCBs

How does assembly risk scale with PCB size?

- Warpage, etc



Do we still need 10 degree rotation with new weaves?
- Weave is probably better, but eye diagrams just 30ps @ 30Gb/s

Conclusions

Many have queried the risk of making a crate change

- I would argue that there is also a risk of doing nothing.

Past Changes

- The VME specifications were before my time, but I'm told **VME-9U-400mm** originates from the needs of experiments
  - Should we have an **ATCA-400mm?**
  - Modifying ATCA is not uncommon.
  - Pentair/Schroff have already done so for another customer.
- MicroTCA would have had insufficient cooling without the adoption of **full height** cards.

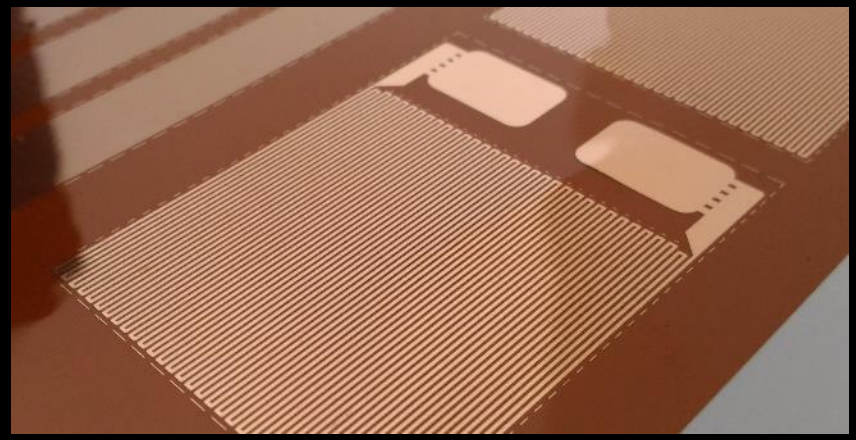
Difficult to strike a balance between what is essential, desired and complexity, risk, cost.

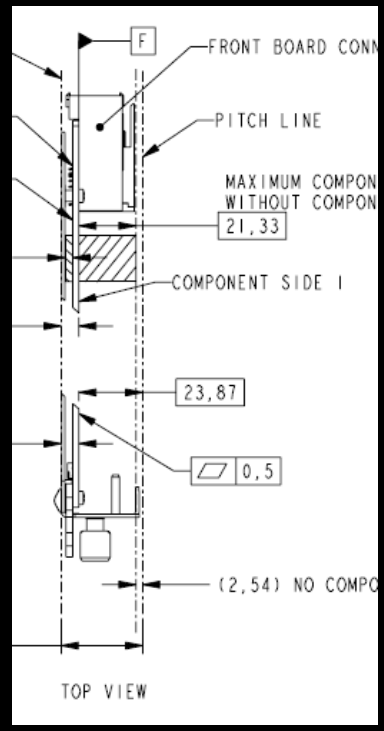
- I have attached a document to the agenda that explores the issues in more depth.
- ATCA was conceived almost 20 years ago for a different application.
  - How relevant to our applications?

Last thoughts & plans

Does anybody else merge large number of optics with ATCA?

- Are we creating perverse hybrid?





Thermal **simulation** & **validation**

- Validate with dedicated test stand
- Kapton heaters will simulate FPGA / optic power

End

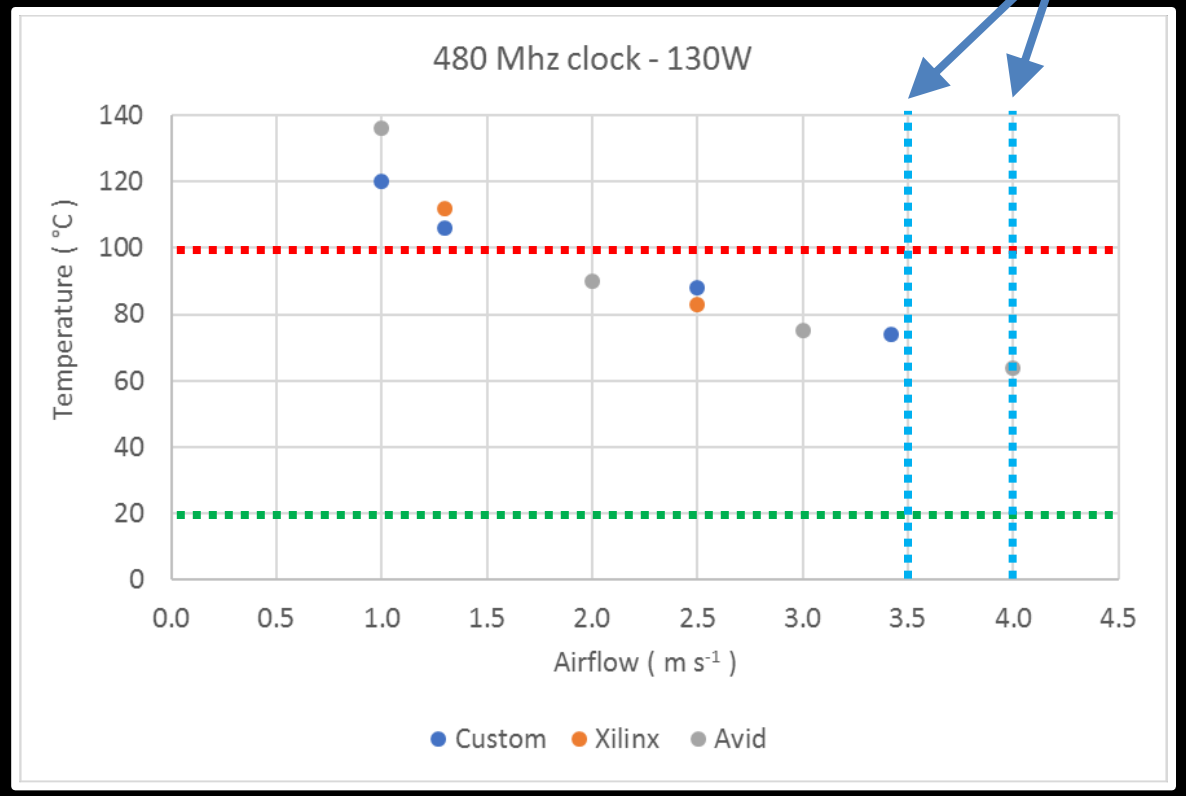
Single Mid-range Ultrascale+

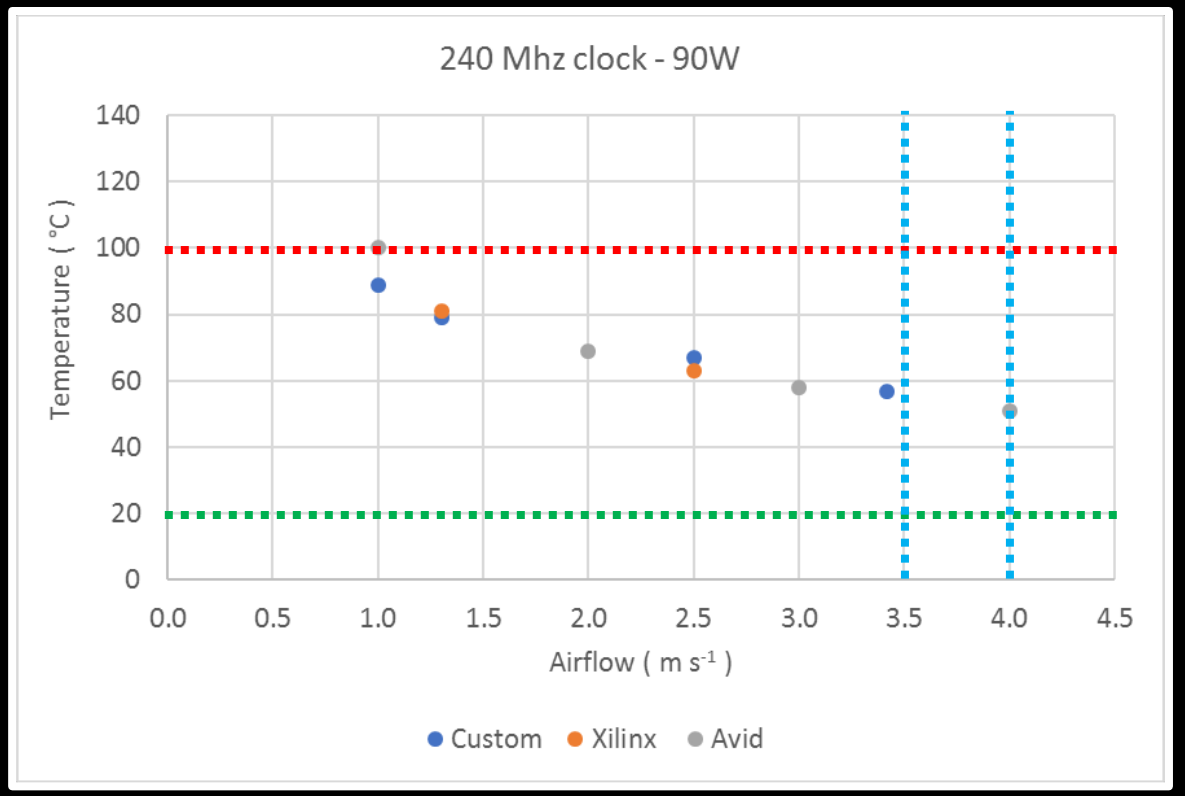
This is best case – Real world performance may be different

VU9P, C2104
LUTs & FFs @ 80%
DSPs @ 30%
Clock @ 480 MHz
72 Low Power 10G transceivers
28 DFE 25G transceivers
4 transceivers unused
BRAM & URAM @ 80%
No I/O or external memory

Set to high LUT usage, low DSP usage

Two estimates of air speed with 96 dBA in USC55





Dual High-End Kintex Ultrascale

This is best case – Real world performance may be different

KU115, D1517
LUTs & FFs @ 80%
DSPs @ 80%
Clock @ 480 MHz
64 Low Power 16G transceivers
BRAM & URAM @ 80%
No I/O or external memory

Set to high LUT usage, high DSP usage

Two estimates of air speed with 96 dBA in USC55