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

<table>
<thead>
<tr>
<th>Year</th>
<th>FormFactor</th>
<th>Power</th>
<th>Power Density</th>
<th>Air Cross-Section</th>
<th>Power Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>W</td>
<td>mW mm⁻²</td>
<td>mm²</td>
<td>mW mm⁻²</td>
</tr>
<tr>
<td>Tracker FED</td>
<td>2009</td>
<td>VME-9U, 400mm</td>
<td>80</td>
<td>0.5</td>
<td>8000</td>
</tr>
<tr>
<td>MP7</td>
<td>2012</td>
<td>AMC-DW,FH</td>
<td>70</td>
<td>2.6</td>
<td>5445</td>
</tr>
<tr>
<td>Phase2-200W</td>
<td>2018</td>
<td>ATCA</td>
<td>200</td>
<td>2.2</td>
<td>8400</td>
</tr>
<tr>
<td>Phase2-400W</td>
<td>2018</td>
<td>ATCA</td>
<td>400</td>
<td>4.4</td>
<td>8400</td>
</tr>
</tbody>
</table>

Optimistic because cooling needed for PIM & DCDC

\[ x \times 10 \]

\[ x \times 5 \]

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

PIM & DC-DC also tend occupy space at 48V entry

Is this still useful for I/O in a world of mid board optics & 25G
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 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

- ATCA – 1/3 of top fans
- VME fan tray
- VME PSU
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
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

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

Set to high LUT usage, high DSP usage

Two estimates of air speed with 96 dBA in USC55

480 Mhz clock - Dual 68W

240 Mhz clock - Dual 45W

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