

Building Computing and Data Centres for ExaScale in the EU

Presenter – Peter Hopton
Dissemination Lead, EuroEXA
Founder, Iceotope
<http://thecoolingguy.me>



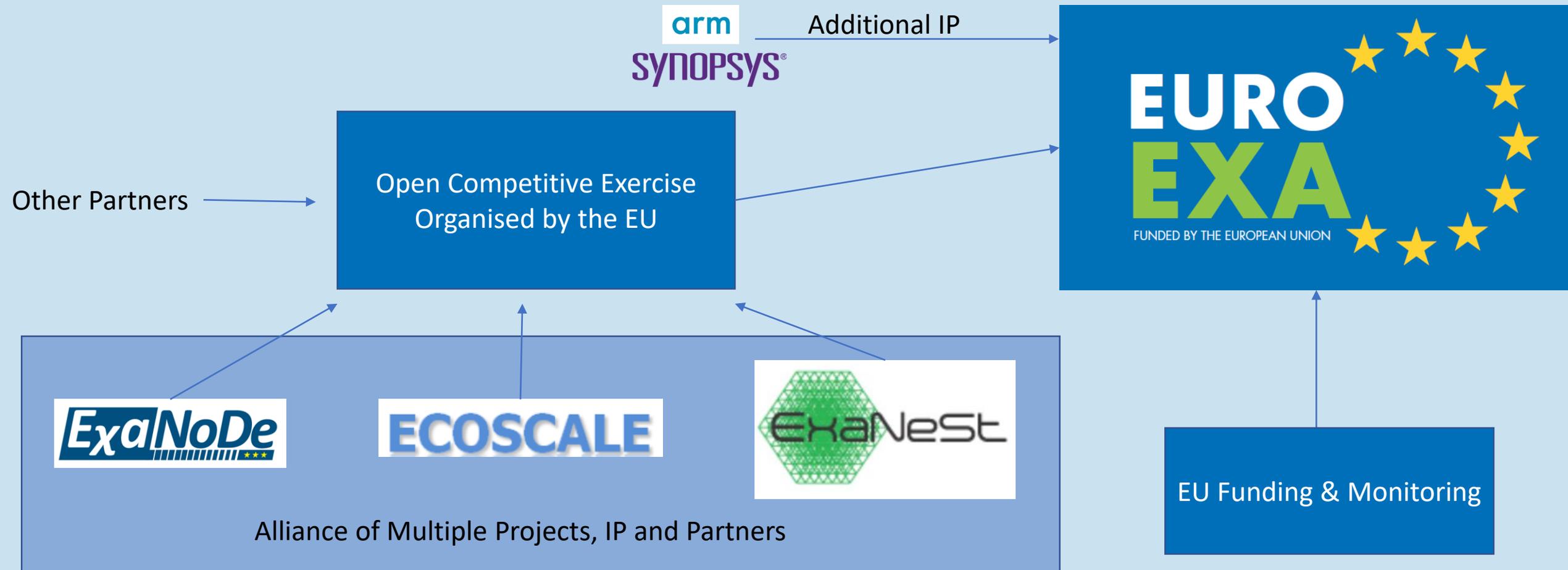
The EU Route to Exa-Scale

- 2015 – First H2020 Exa-Scale Projects (Subject area focus)
- 2017 – First Co-Design Projects
- \cong 2019/20 – First ExaScale Demonstrators
- \cong 2023/24 – First ExaScale Machine Turned On

ExaScale, what do we Expect?

1. 1 Billion Billion (10^{18}) FLOPs or equivalent
2. Approx. €500m per system
3. 20MW-60MW of Power
4. EU expected to procure 2 systems, one from EU only Consortia
5. EU spending substantially in NRE to build an Ecosystem to Deliver
6. Time-scales of 2023 for switch-on
7. 2 €100m “Pre Exa-Scale machines” and (maybe) €40m “Exa-Scale Demonstrators” deployed in the meantime.

What is EuroEXA?





EuroExa: European co-design for exascale applications

The Horizon 2020 EuroExa project proposes a groundbreaking design for mind-blowing results: over four times more performance and four times more energy efficiency than today's High-Performance Computing platforms.

Who Have Been Selected?



Commercial Partners



Academic/Gov. Partners



The University of Manchester



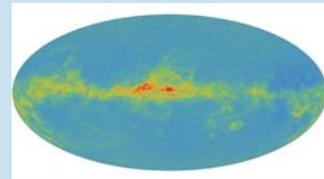
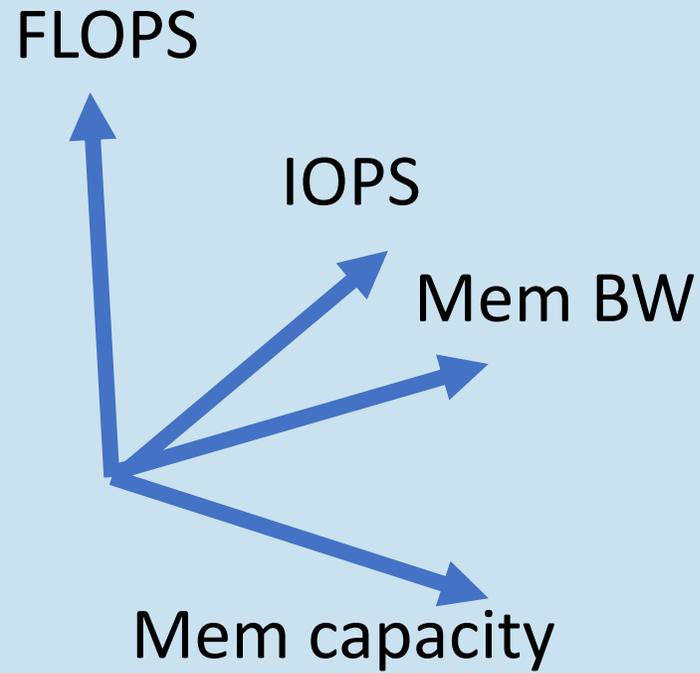
Supporters



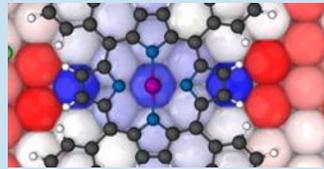
centre nacional d'anàlisi genòmica
centro nacional de análisis genómico



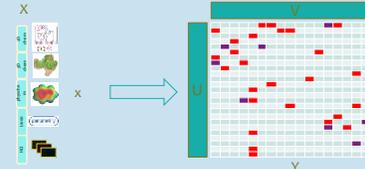
EuroEXA: co-design, demonstration and evaluation using exascale-class apps



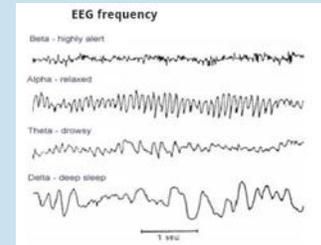
AVU-GSR



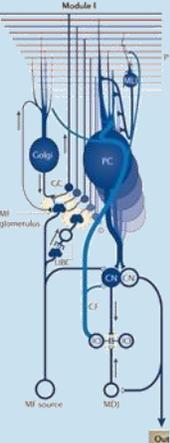
Quantum Espresso



SMURFF



Neuromarketing



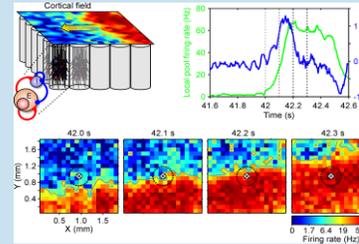
InfOli



NEMO



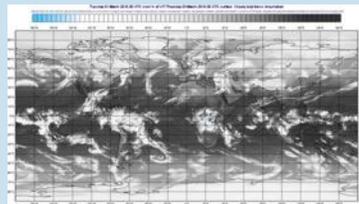
Astronomy image classification



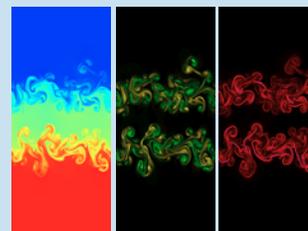
NEST/DPSNN



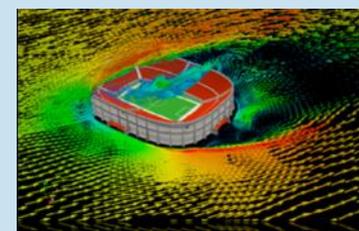
FRTM



IFS



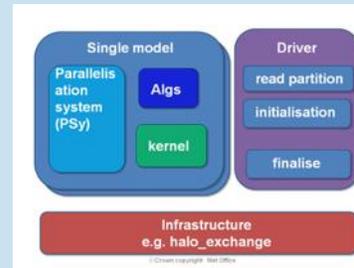
LBM



Alya



GADGET



LFRic

Why these 14 applications?

- 10 strong European application partners
- 14 applications covering three important application domains
 - Climate and weather (LFRic, NEMO, IFS)
 - Physics and energy (LBM, Alya, GADGET, AVU-GSR, FRTM, Astronomy image classification, Quantum E)
 - Life science and bioinformatics (NEST, Neuromarketing, InfOli, SMURFF)
- These domains will require exascale computing in near future
- ALYA, GADGET, NEMO and Quantum ESPRESSO part of PRACE UEABS
- Applications for porting, demonstration, evaluation and co-design

Big Challenges For Exa-Scale

1. Programming models & Applications
2. Resilience and Reliability
3. Supply Chain
4. Scalability
5. Latency/Cooling/Density/Distance
6. **Energy Effectiveness**

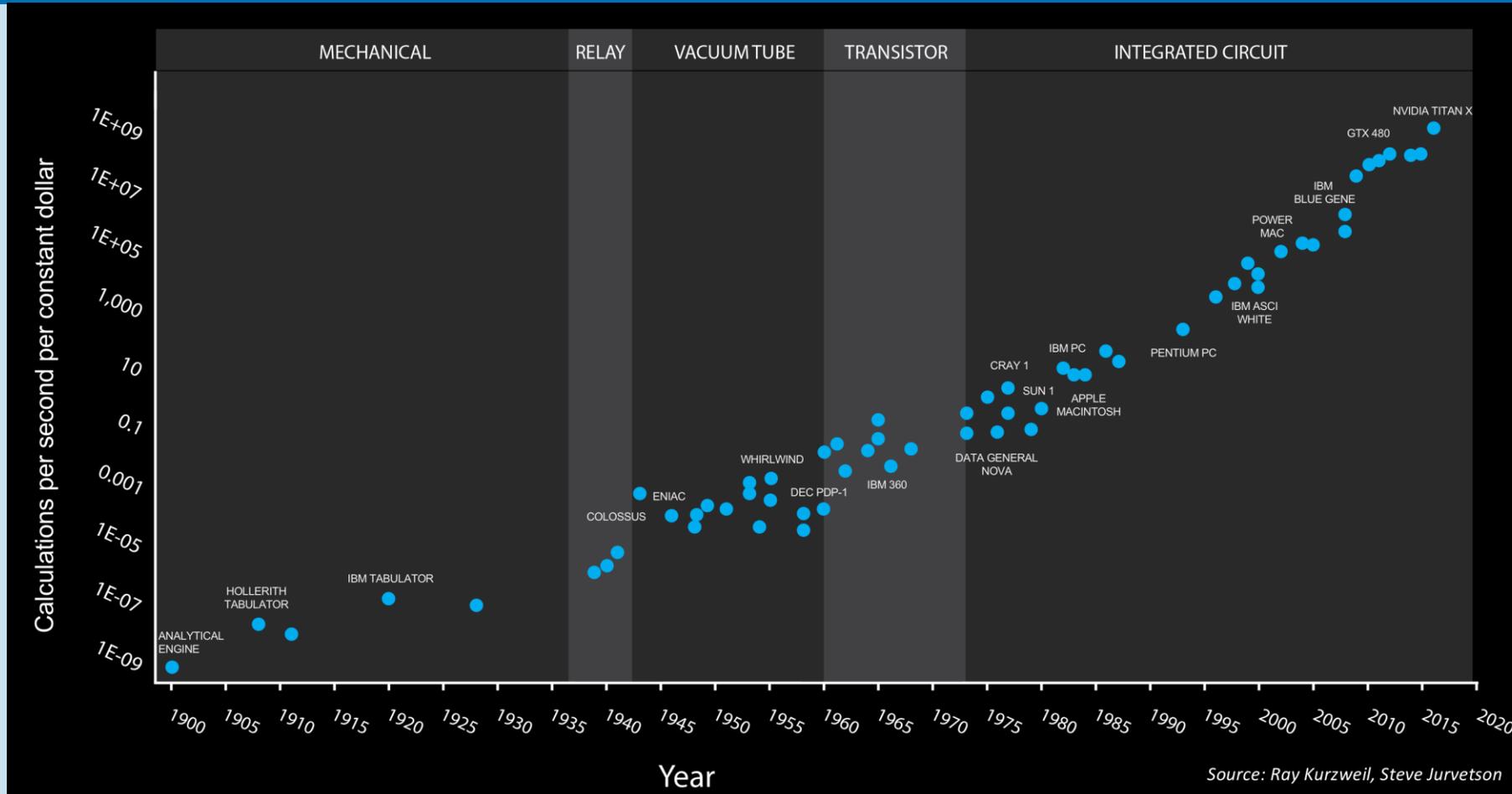
Energy is King

- **Dr Moore's Law –** The observation that the number of transistors in a dense integrated circuit doubles about every two years
- **Dr Koomey's Law –** Describes a long-term trend in the history of computing hardware. The number of computations per joule of energy dissipated has been doubling approximately every 1.57 years.
- **Dr Shannon & Dr Hartley –** Describes bandwidth with respect to signal power and noise of a channel.



Dr Moore

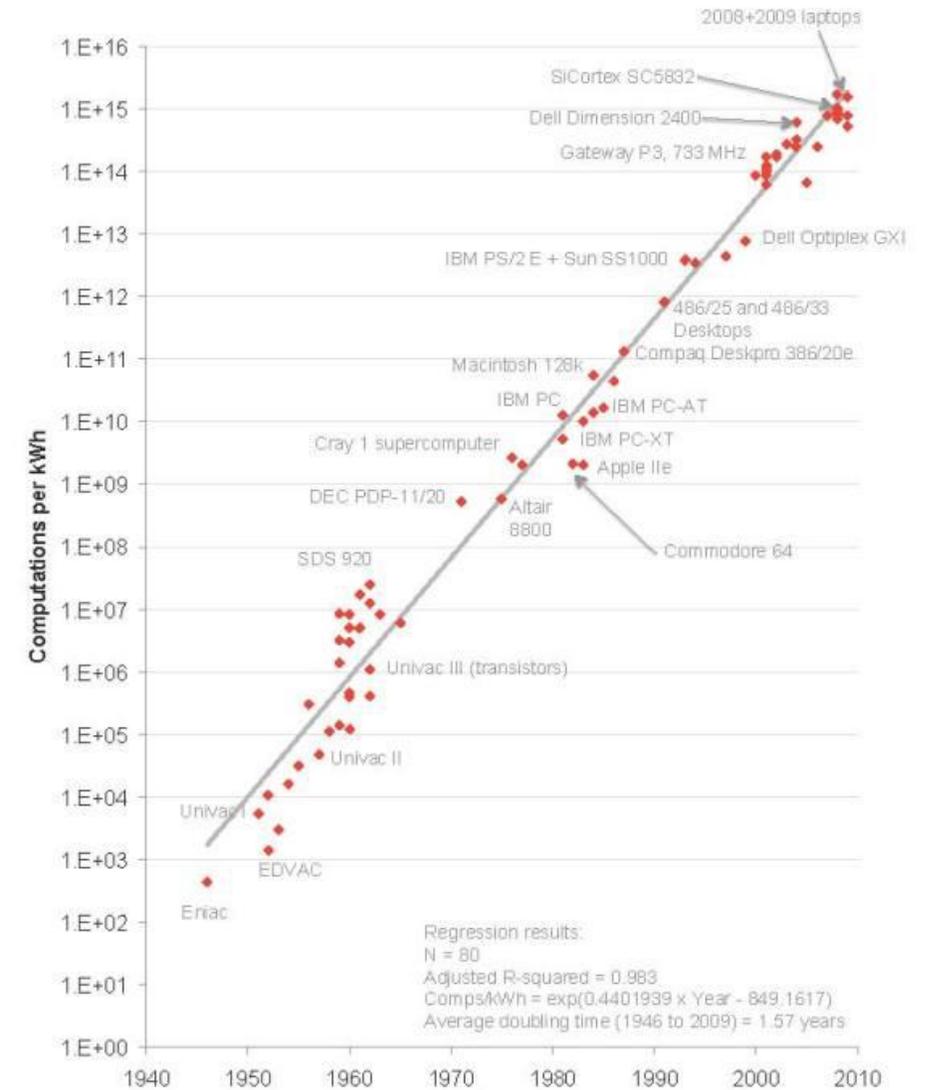
The observation that the number of transistors in a dense integrated circuit doubles about every two years





Dr Koomey—

Describes a long-term trend in the history of computing hardware. The number of computations per joule of energy dissipated has been doubling approximately every 1.57 years.



Dr Shannon & Dr Hartley—

1928/1948 Bell Labs

Describes bandwidth with respect to signal power and noise of a channel.

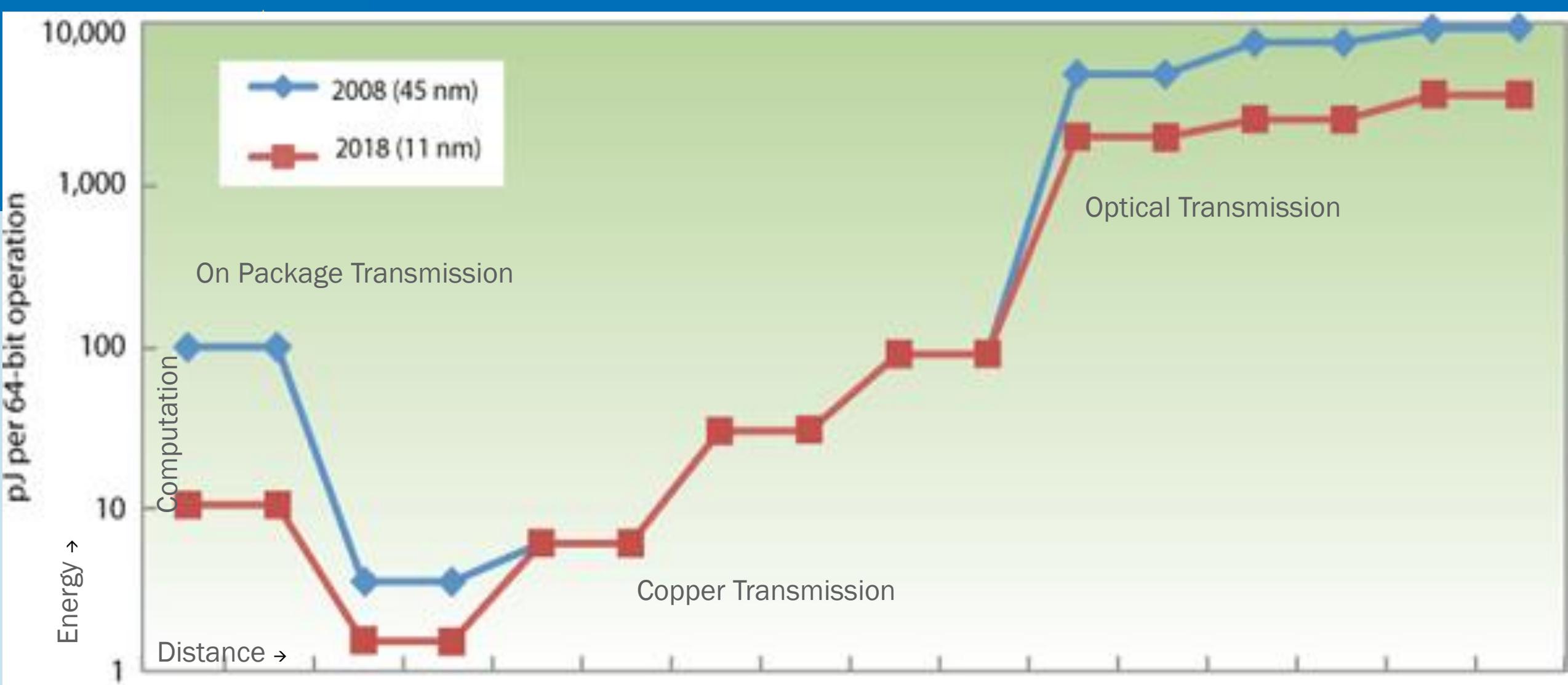
$$C = B \log_2 (1 + S/N)$$

bandwidth of the channel

Channel capacity in bits/s

signal-to-noise ratio

OR, it can be re-presented as the **minimum amount of energy** required to transmit a bit of data over a channel with an environment of noise.



Redefining High Density....

- Not 10kW per Cabinet,
- But 60MW in a <40m Diameter
- Leading to 200kW in a conventional Cabinet footprint
- Requires a rethink...

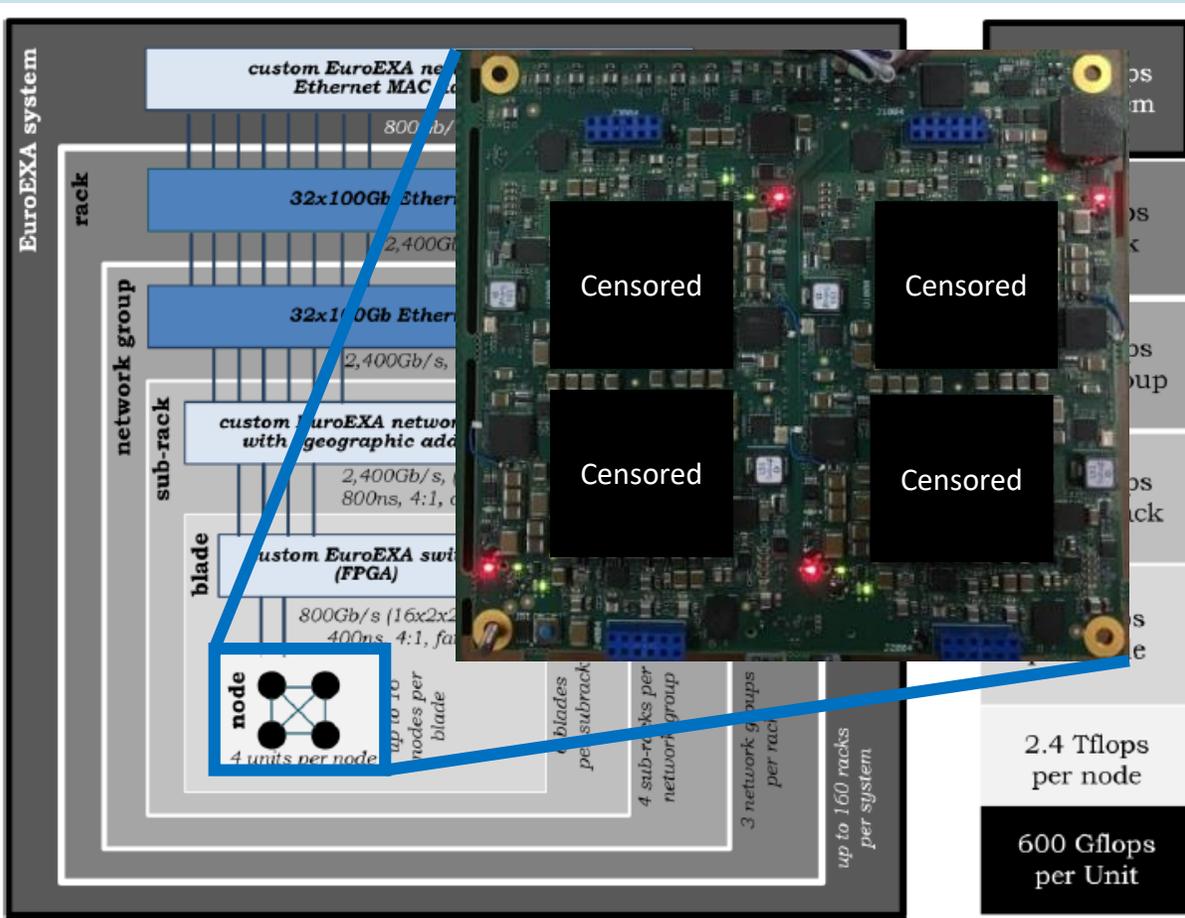
Co-Design; The Next 3 Years

- 3 Testbeds will be deployed to test the co-design of selected technologies
 - **Testbed 1** will be installed in early 2018, providing 50 nodes of new technology for software development.
 - **Testbed 2** will be installed in early 2019, providing 500 nodes and new infrastructure technologies to test scaling
 - **Testbed 3** will be installed in 2020, to test new node and processor technologies that will ultimately deliver Exa-Scale

Architectural Features

- UniMem
- PGAS (Partitioned Global Address Space)
- Reprogrammable Accelerators with Partial Reconfiguration
- Flexible, High Speed, Low Latency Network (INFN/UoM)

System architecture and technology: Testbed 1 compute node



Initial technology from FORTH (QFDB)

- 12 cm x 13 cm
- 4 ARM Processors and 4 FPGA Accelerators
- M.2 SSD
- 4 x SODIMMs + Onboard RAM
- Daughterboard style
- 160 Gb/s of I/O

Technology – (Codesign)DB



Original plan: QFDB

Four Xilinx Zynq UltraScale+ ZU9P



New proposal: CRDB

Xilinx Zynq UltraScale+ ZU9P for interconnect

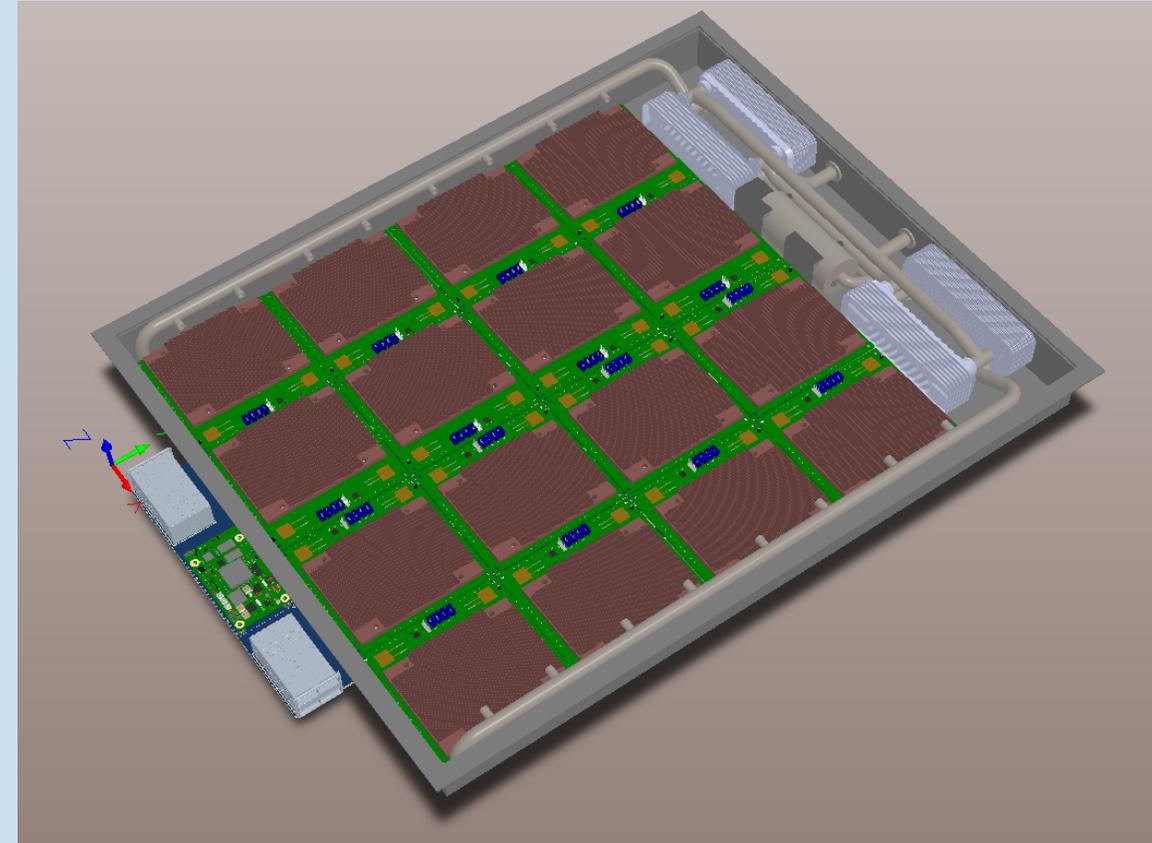
Xilinx Zynq UltraScale+ VU9P for acceleration

Advantages of CRDB

- More FPGA resources to help compute heavy applications
- Higher I/O bandwidth and memory bandwidth
- HPC applications already demonstrated on VU9P
 - Maxeler: BQCD, NEMO, QE, SpecFEM3D
- Compatibility with Maxeler and Amazon AWS EC2 F1
- Lower proportion of compute FPGA used for interconnect
- Removes heterogeneity among compute FPGAs

Technology from Iceotope:

- 16 COM Express Extended Nodes
- 1oU Chassis
- High Speed Switch
- 3.2kW per oU
- Total Liquid Cooling technology
- 48v DC distribution
- Hot water out, chiller-less operation



Liquid Cooling 2MW Boxes

- To Truly Scale:
 - We Needed Zero Airflow = immersion
 - But immersion tanks are usually space inefficient
 - The project used Iceotope technology “immersion without submersion”

Turning it up to 11

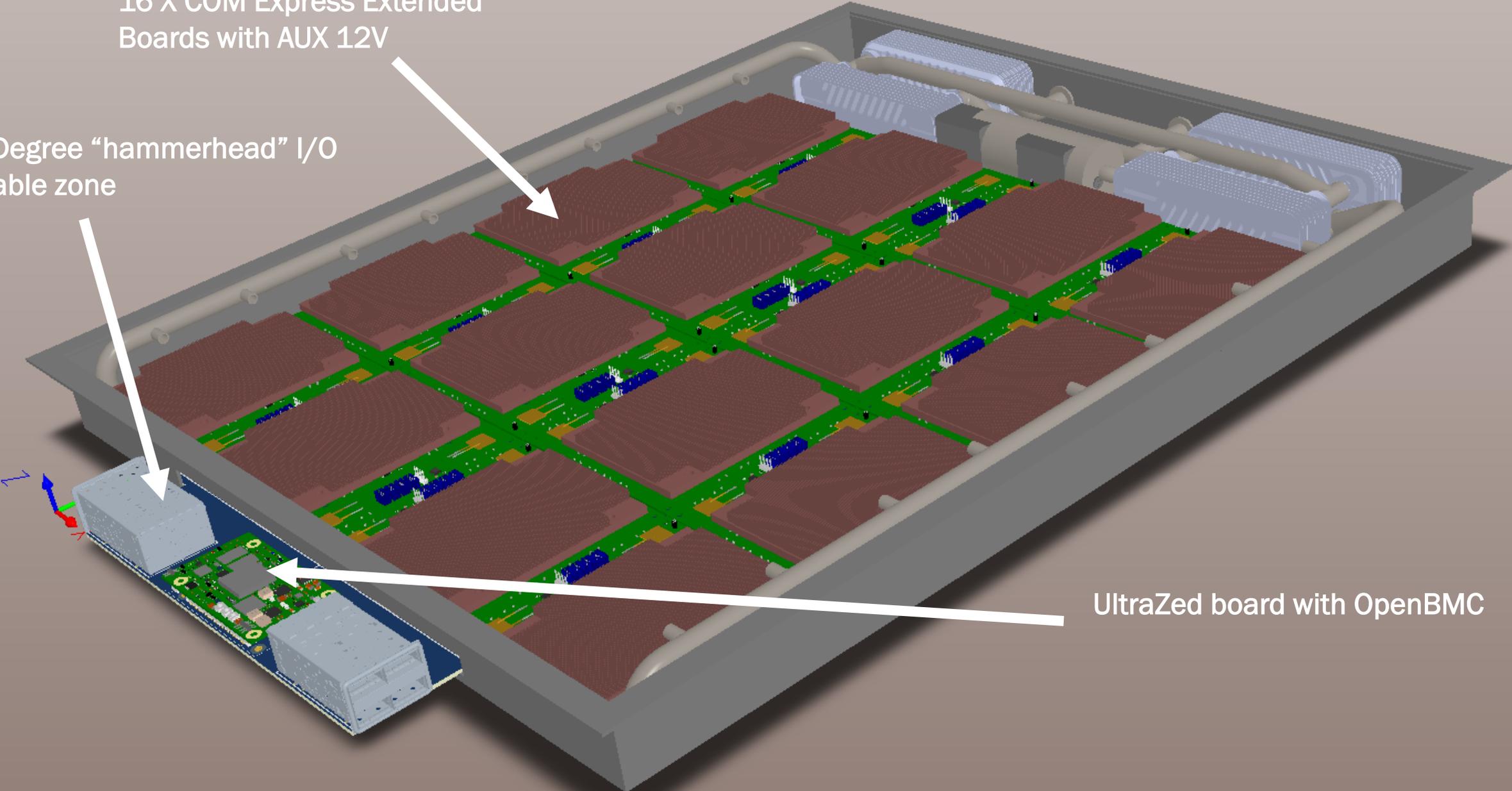
- >100kW a cabinet needs liquid cooling solutions
- OCP OpenRack is perfect for liquid cooling as it reduces wasted space and maximises density
- Reducing the depth, enables dense facilities
- Distributed DC power enables consolidation of PSUs – also saving space



<https://www.youtube.com/watch?v=4xgx4k83zcc>

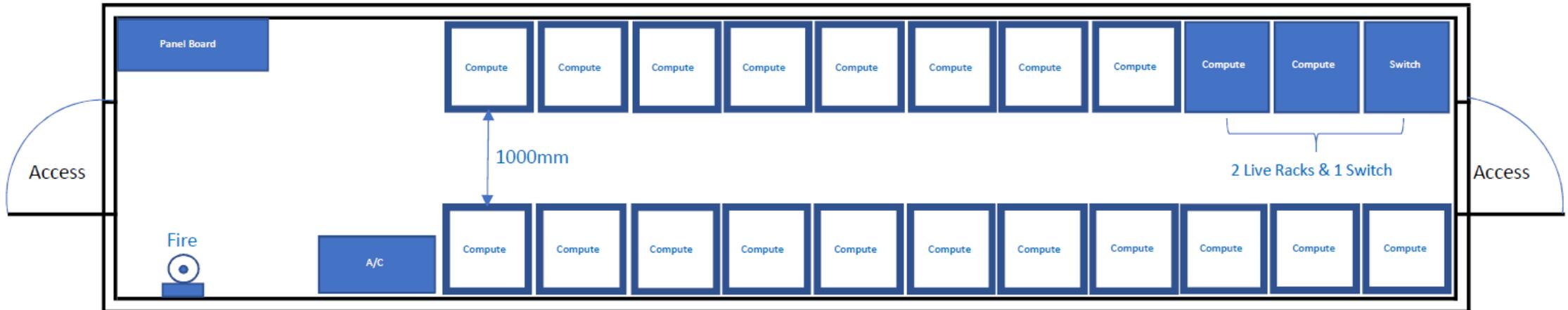
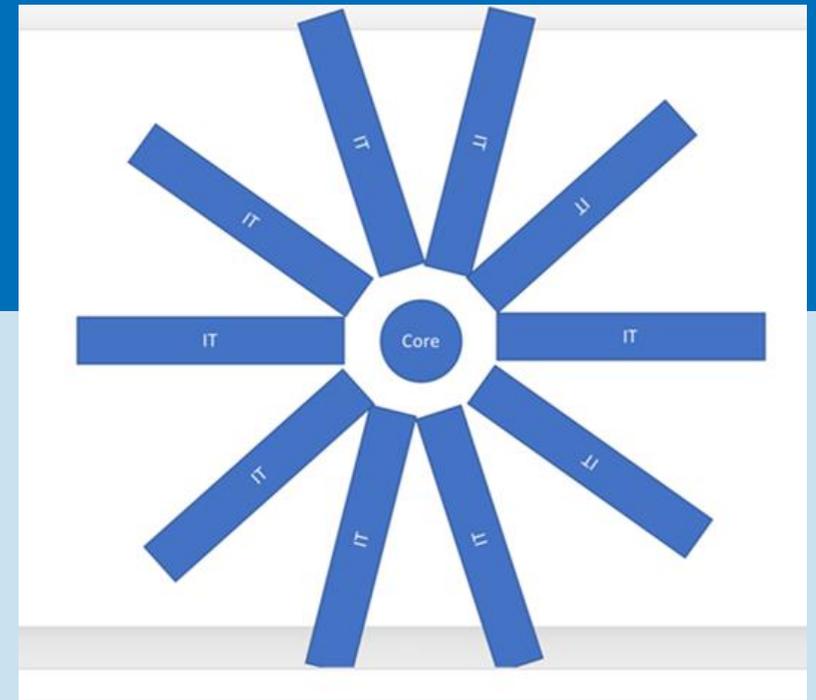
16 X COM Express Extended Boards with AUX 12V

90 Degree "hammerhead" I/O in cable zone



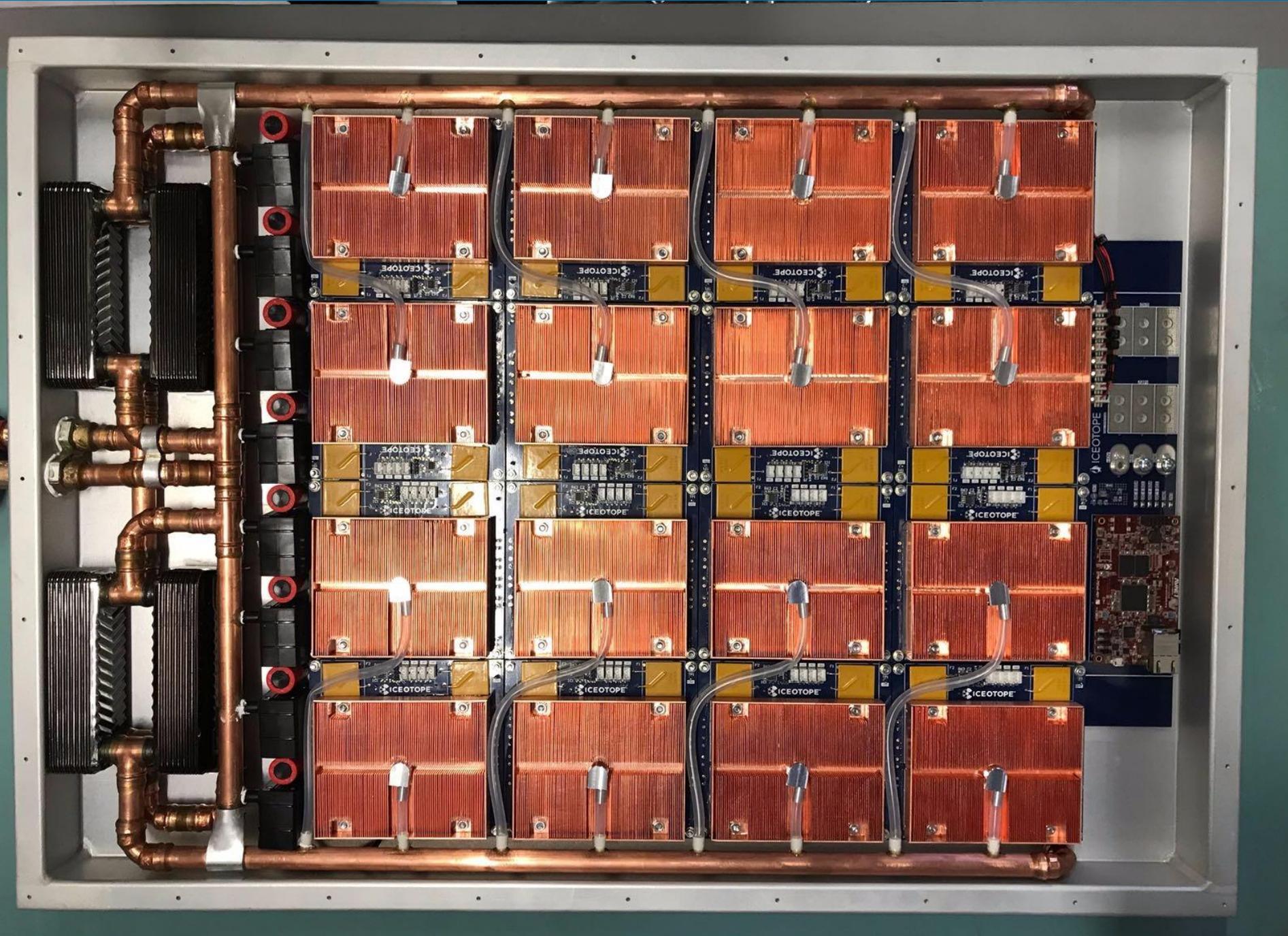
UltraZed board with OpenBMC

60MW in 35m Diameter
10 40ft High-Cube ISOs per layer
3 Layers
2MW per ISO
Approx. 110kW per Rack
Prototype will feature 1 container, initially with 3 live Racks



Liquid Cooling Objectives

- 45C Inlet “Chiller-less” ASHRAE W4/W5
- Ultra-Low Risk Server Coolant System
 - PFPE Coolants, small quantity, non conductive, low dielectric constant.
 - Low Pressure Drop Heat Exchange
- Ultra-Low Risk Facility Coolant System
 - Sub Atmospheric Leak Prevention System



- TED – Test Rig
- Thermal-proxy
Extra-high
Density
- 4kW in 10U test
capacity
- 16 Little
Modules



- Immersion without Submersion
- Achieved:
47C inlet
55C outlet
@3.2kW/OU





Rack-Centre, Lagos Nigeria

Many Thanks
Please Connect at
thecoolingguy.me

Presenter – Peter Hopton
Dissemination Lead, EuroEXA
Founder, Iceotope
<http://thecoolingguy.me>

