CRAY
THE SUPERCOMPUTER COMPANY

HPC Best Practices
Power & Cooling Solutions

March 2011
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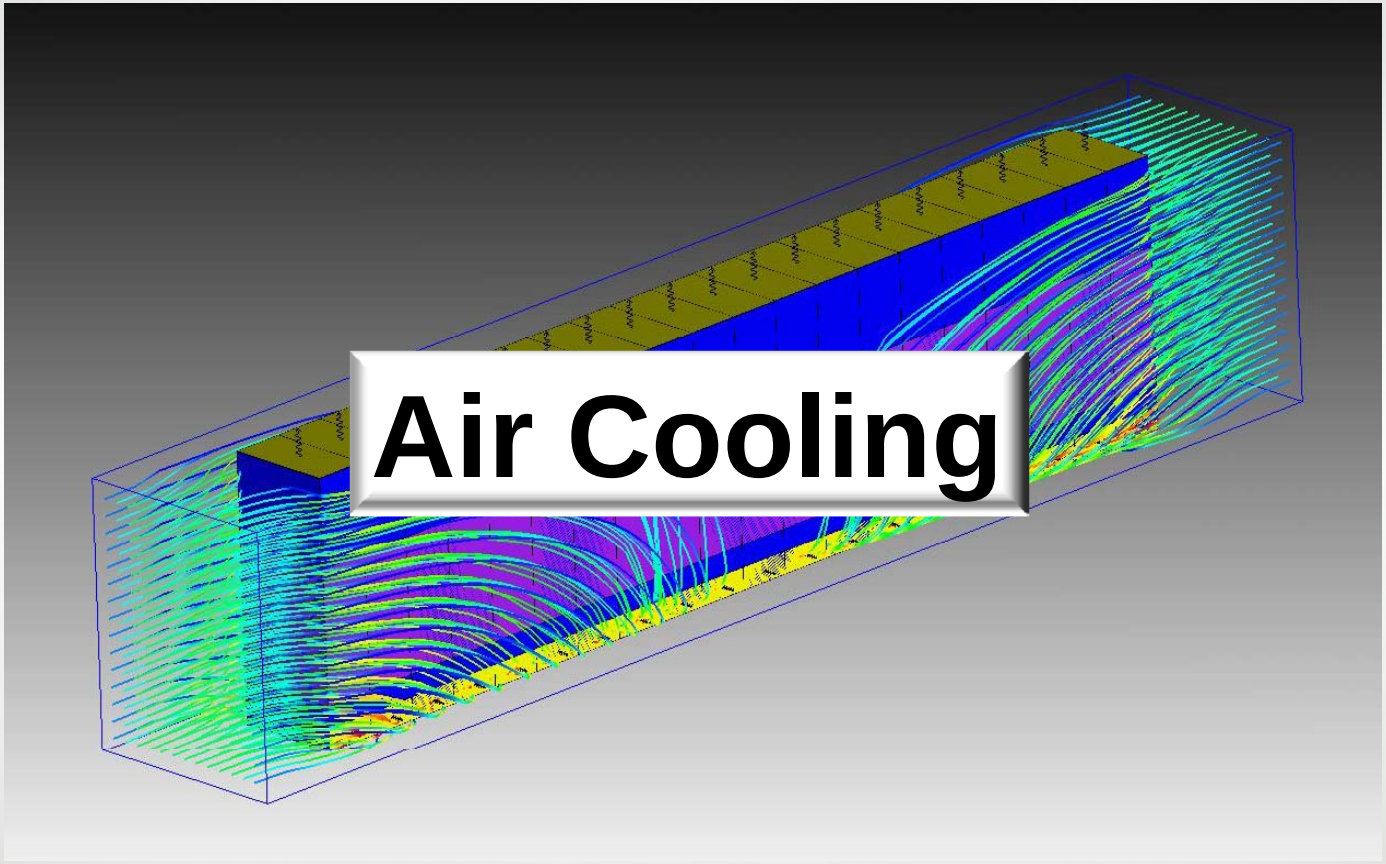
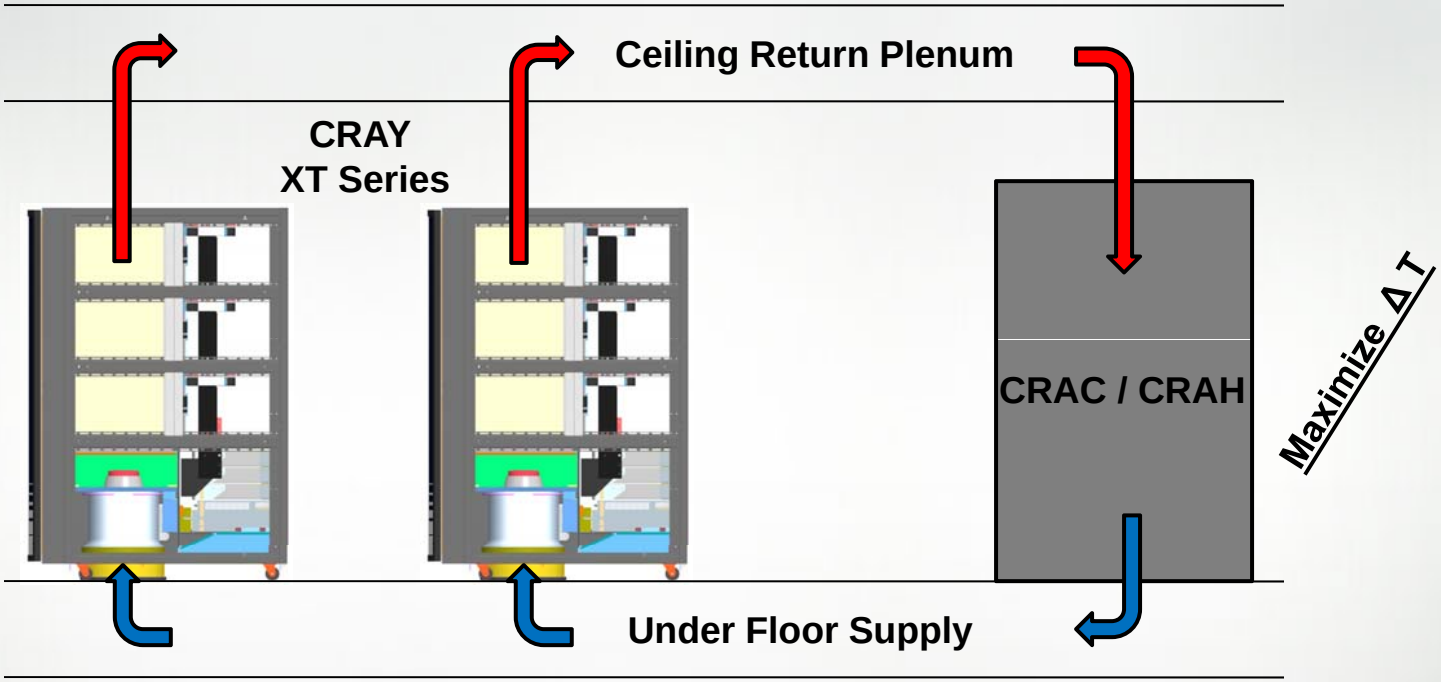
Reduce Energy Demands

How do we eliminate non-essential loads?

- **More emphasis on power conversion efficiency.**
- **Reducing power transmission losses through higher distribution voltages; both in facility and cabinet.**
- **Reducing dependency on CRACs, CRAHs, chillers.**
- **Reducing power allocated rack cooling fan.**
- **Reducing computer footprint to minimize air handling, lighting, power distribution losses, etc..**
- **Powering down idle equipment for better power utilization.**


Air Cooling

Increase CRAC / CRAH Efficiency



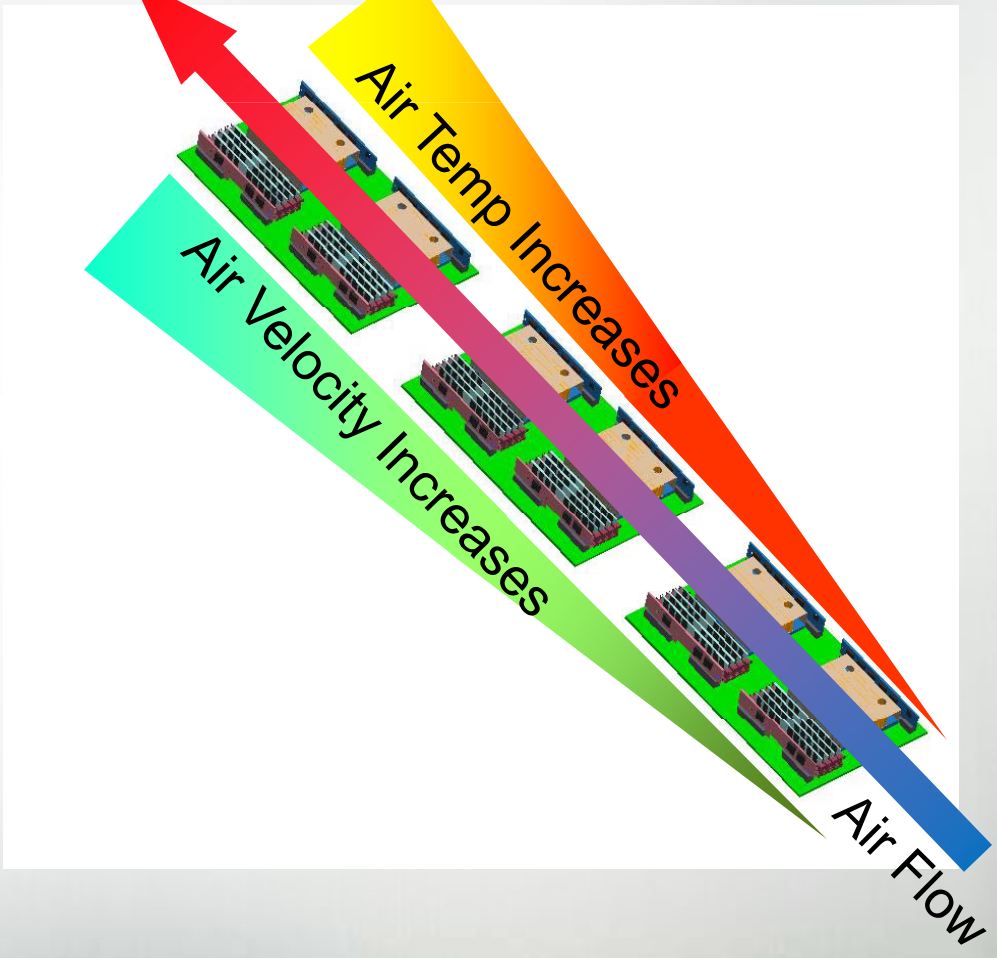
- Eliminate ambient air dilution to CRAC / CRAH.
- Eliminate rack exhaust recirculation or bypass; duct to rack inlet.
- Maximize cooling caloric rise of cooling air through the compute rack.

Cooling with Less Air

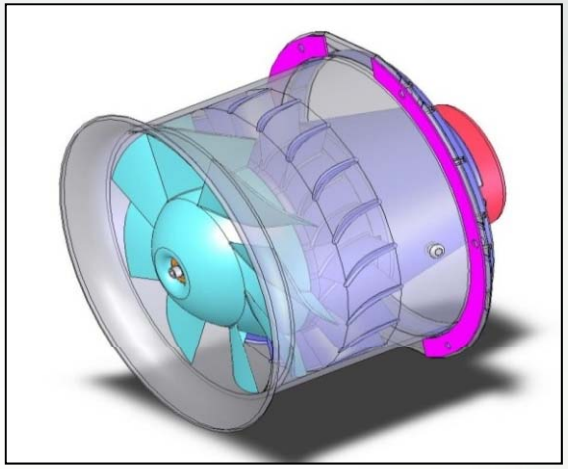
"Progressive Air Cooling" increases local air velocity to offset the increasing temperature of cooling air.

Motivation:

- **Reduces air handling to below 75CFM / KW.**
- **Allows all components to run at similar temperatures.**
- **Yields high grade exhaust air (high delta T).**
- **Significantly lowers rack fan power.**
- **I get to keep air cooled blade flexibility.**



Save Power Through Fan Efficiency

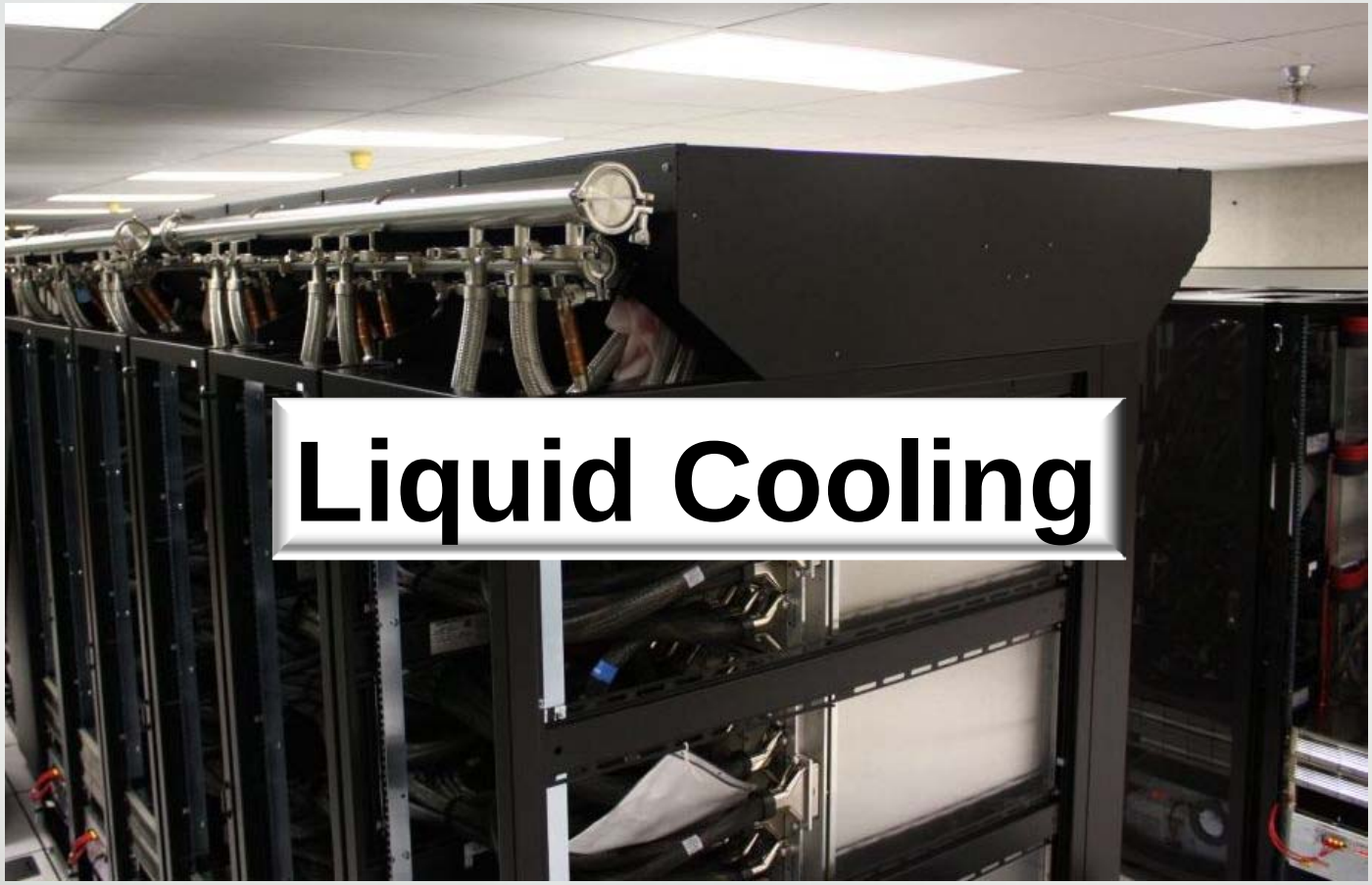


Commodity Cooling Fans

- Efficiency: Less than 30%
- MTBF: ~40,000 hours
- Percent of rack power: 8-30%

Cray Axial Turbo Fan (XT Series)

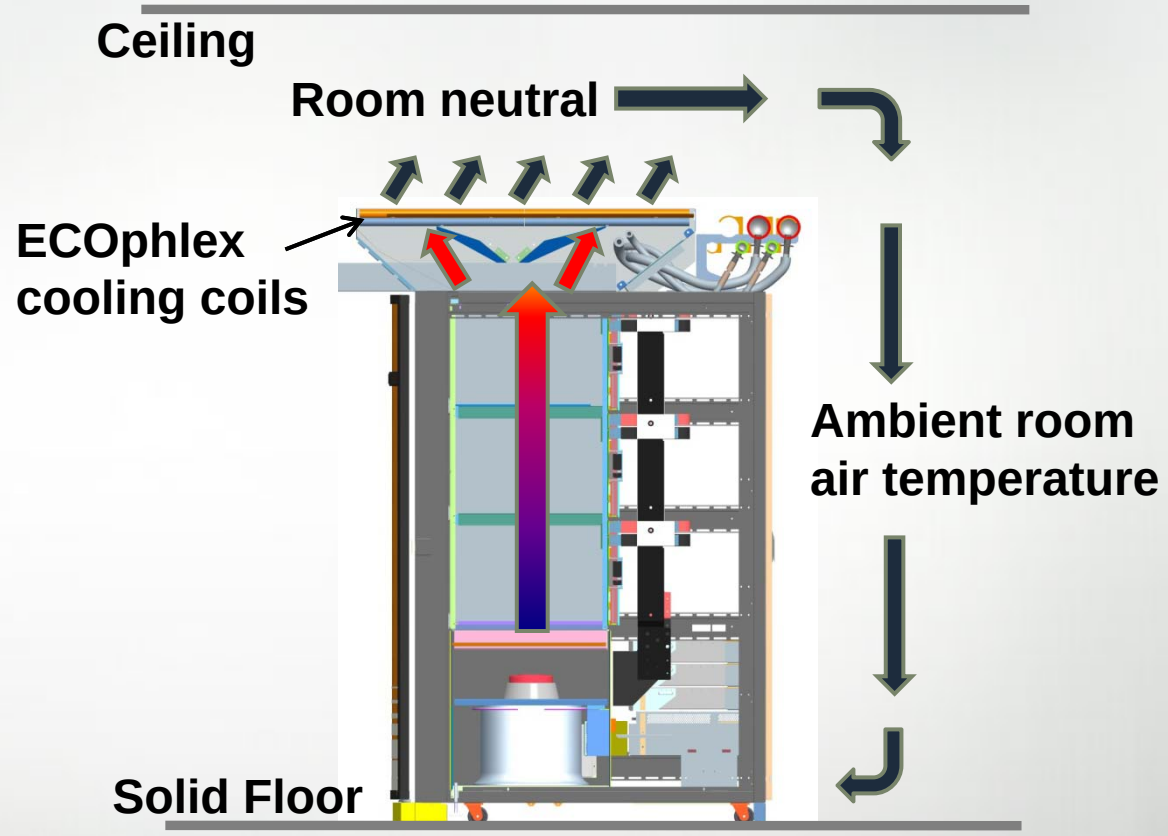
- Efficiency: >70%
- MTBF: >4,200,000 Hrs
- Percent of rack power: 8-10%


Liquid Cooling

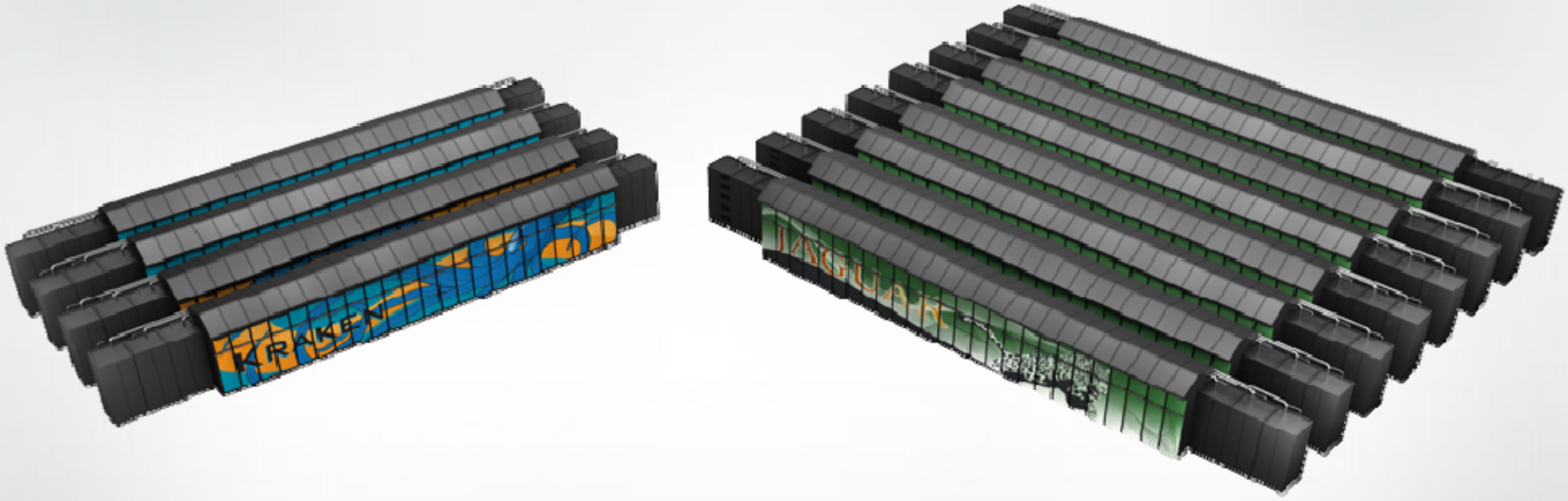
Reduce Facility Air Handling with ECOphlex

Cray ECOphlex™ technology combines progressive air cooling & local phase change heat rejection.

Minimizes parasitic CRAC / CRAH fan power required to move air around facility.



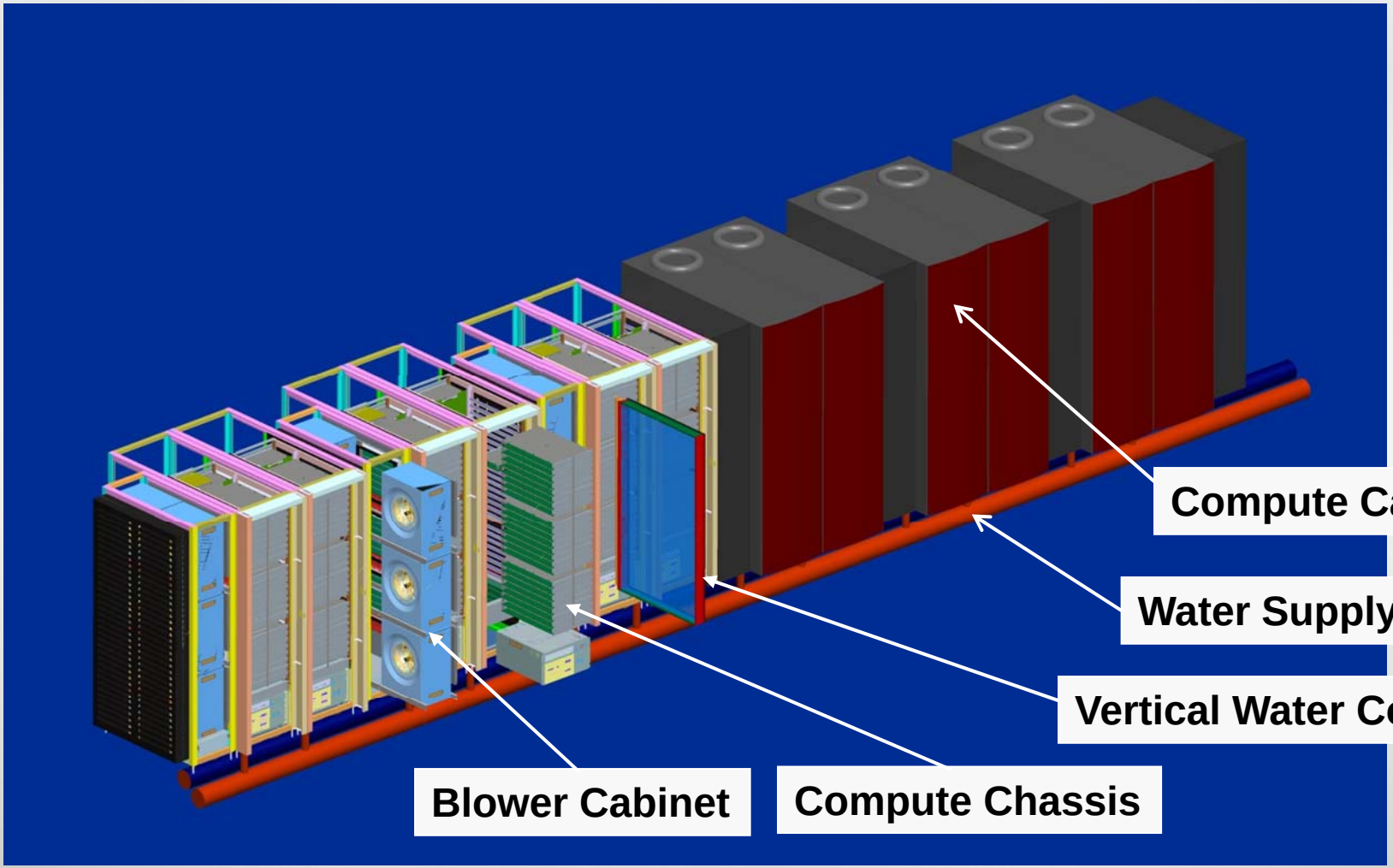
Cray ECOphlex Petaflop Cooling



ORNL's Kraken and Jaguar cooled by ECOphlex

- **Reduced dependency on CRAHs.**
- **Dramatically smaller overall footprint.**
- **Less energy required for cooling.**

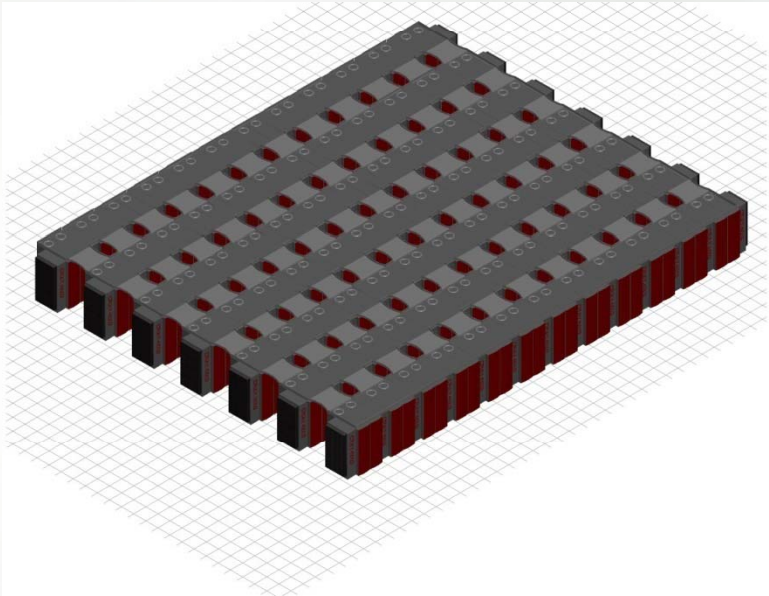
Refrigerant Free Liquid Cooling



Cray Cascade Transverse Cooling System

Transverse Cooling Advantages

- **Allows safe cooling water internal to rack with no condensation risk to components.**
- **Maintains independence from CRAC / CRAH.**
- **Eliminates intermediate heat transfer step in ECOphlex (refrigerant / water) allowing more heat transfer efficiency.**




On The Horizon

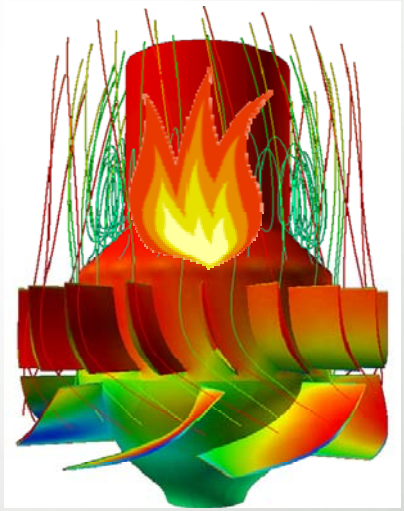
Power & Cooling Development Plans

- Take cooling to new highs; free air cooling year round almost anywhere.
- True PUE ratings approaching 1.0.
- Extreme rack power conversion efficiencies over 90%.
- Ultra dense packaging.

Extreme Air Cooling Development

Target: Virtually eliminate power allocated to facility HPC cooling.

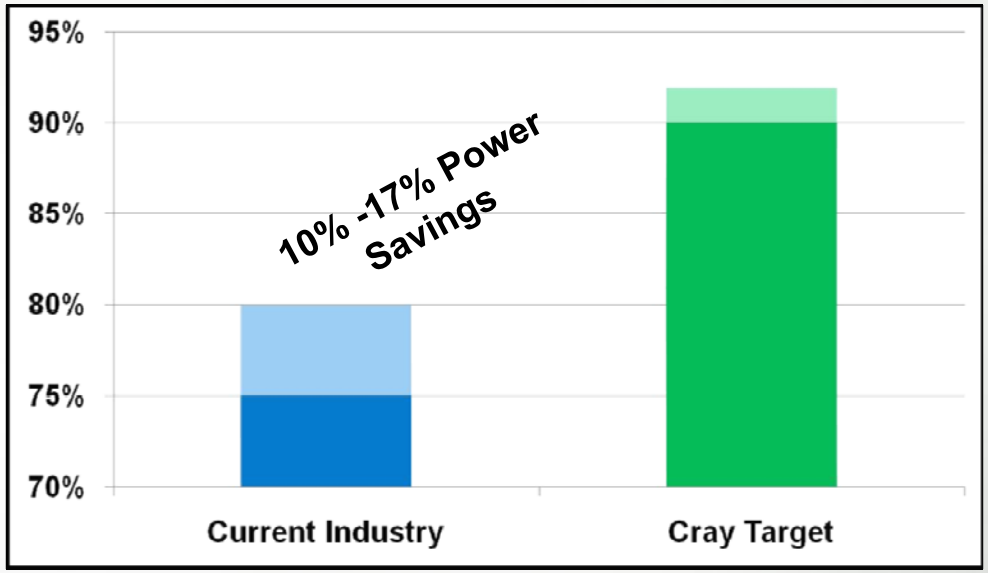
- **Provide free air cooling with Cray's next generation progressive air cooling technology.**
- **Allocate less than 2% of rack power to the cooling fan.**
- **Achieve less than 50 CFM / KW cooling air requirement.**
- **Eliminate under floor plenum requirement.**
- **Reduce facility air movers with higher rack fan capacity.**



Extreme Power Efficiency Development

Target: Increase cabinet power conversion efficiency beyond 90%.

- **Reduced voltage conversion steps in rack power topology.**
- **Utilize super efficient power factor correction front end.**
- **Move to 400 VDC / sub 12VDC bus conversion for highest point of load efficiency.**
- **Implement GaN FETs in voltage conversion circuits.**



Total Cabinet Power Conversion Efficiency
(from wall breaker to POL)

Thank You!