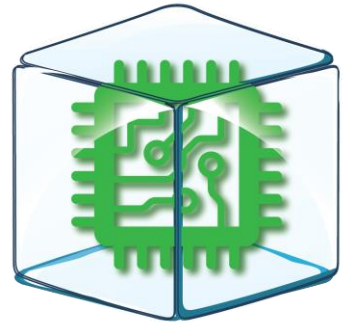
Systems Two-Phase Cooling

Timothy Chainer, IBM Research



Research Division

Elizabeth Hulihan – PM
Pritish Parida – Co-PI, Task 1 Lead
Mark Schultz – Task 2 Lead
Peilin Song – Manager
Todd Takken – Manager
Shurong Tian – Thermal Engineer

Infrastructure Division

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Francis Krug – Mechanical Engineer

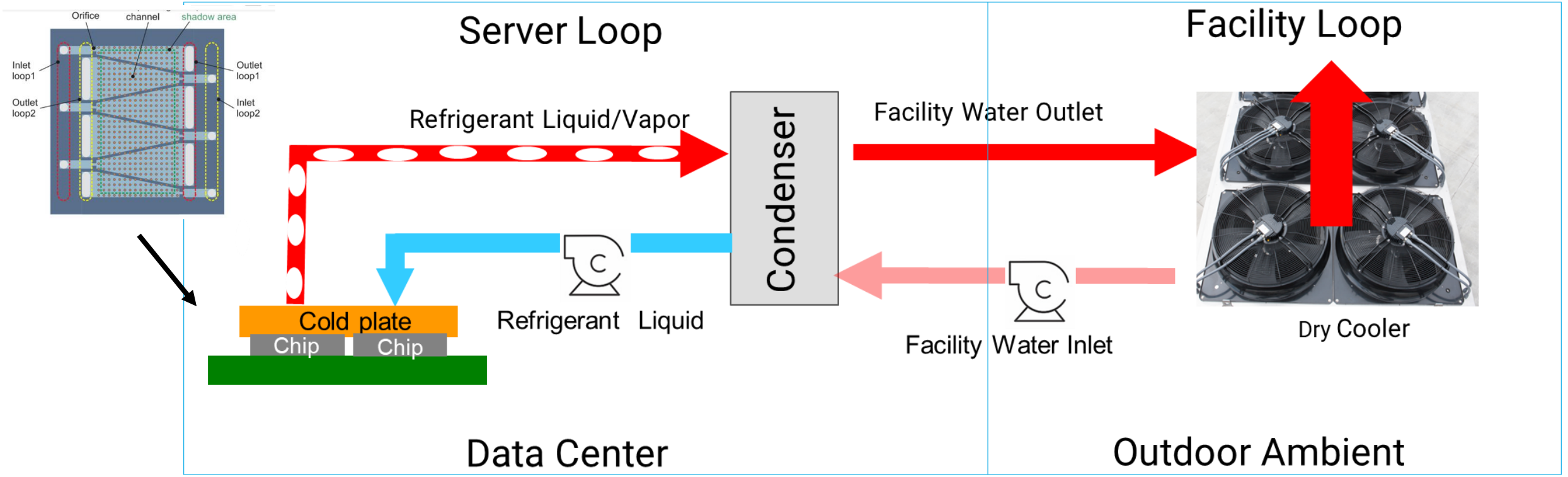
Total Project Cost:	$3.3M
Length	36 mo.

COOLERCHIPS Kickoff Meeting
October 18 & 19, 2023

Project Vision – Dual Loop Two-Phase Cooling System

Develop Two-Phase Dielectric Cooling for Servers

- **Performance** – Low thermal resistance to reduce chip to ambient temperature delta
- **Energy Efficiency** – Heat transfer using coolant above ambient temperature enables COP > 30
- **Water Efficiency** – Eliminate cooling water usage *WUE = 0*



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Systems Two-Phase Cooling Overview

Team member	Location	Role in project, core competencies
IBM Research	Yorktown Heights, NY	Two-Phase Cooling • Experimental Demonstrations – Evaporator designs • Modeling – Full-/Reduced-Physics and System-level models
IBM Infrastructure	Poughkeepsie, NY	High End Server Two-Phase Cooled Product Development • Rack-level System Integration • Multi-server experimental demonstration

Enabling features of our proposed technology

- System component design based on high fidelity full/reduced-physics two-phase flow models
- System integration into a current product platform

Bigger vision / Heat Transfer and System reliability summary

- Pathway to Sustainable Computing: Two-Phase cooling enables energy efficient heat transfer and compute anywhere
- Non-conductive dielectric fluids prevent leaks from generating system damage (reduce risk severity)
- System integration for reliability and redundancy guided by zSystem water cooling data

What is your envisioned goal/success criterion for your project

- Product implementation of two-phase cooling to replace current cooling strategies

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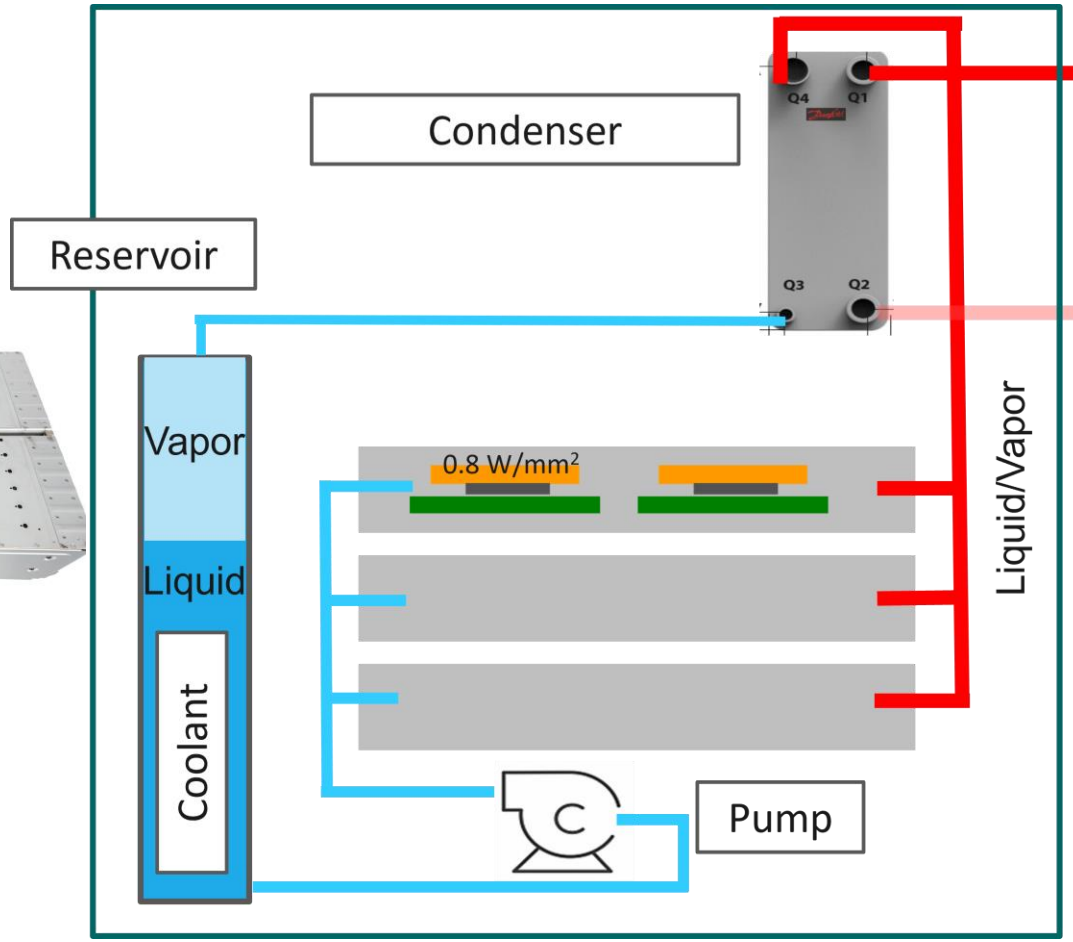
Systems Two-Phase Cooling Concept Detail



Facility Water

Supply Coolant	< 55 C
Rack Power Density	22-55 kW/42U
PUE	< 1.03
WUE	0
COP	> 30 [12]

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Task Outline and Technical Objectives

Objectives

- *Demonstrate robust two-phase cooling of a commercial computer system with multiple servers while varying power levels*
- *Develop and advance two-phase component and system models to inform designs and system configuration*

Task 1 - Two-Phase Cooling Design Simulation

Task 2 - Two Phase Coldplate Development

Task 3 - Two Phase Cooling Loop Component Assessment

Task 4 - Demonstrate Two Phase Cooling for High End Servers

Task 5 - Technology to Market

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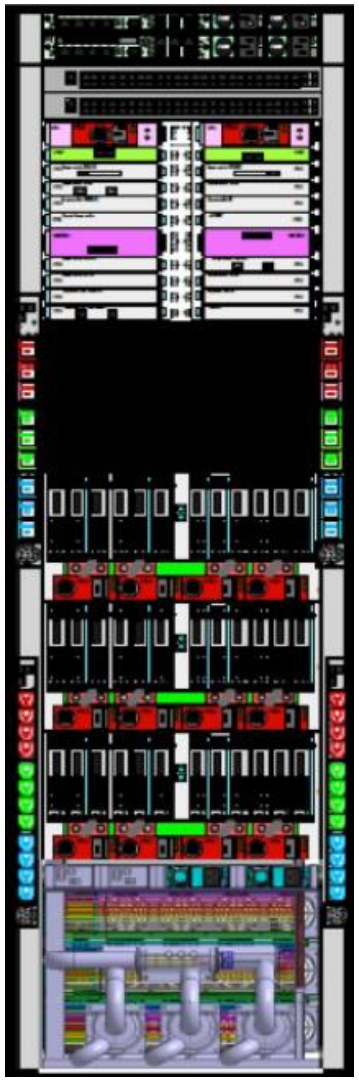
Demonstrate Two Phase Cooling in IBM zSeries

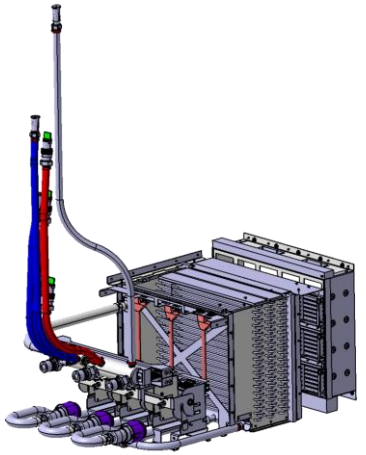
Front view z16

Rear schematic view



Task 4 will design, integrate and demonstrate a two-phase cooled system, with components designed and selected from Task 2 and 3, on an IBM zSeries mainframe composed of 3 processor drawers with 12 dual-chip modules

Hoses with quick disconnects



Design a two-phase cooling system which minimizes rack volume to target existing radiator unit footprint

Radiator Cooling Assembly (RCA)

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Technology-to-Market Approach

- The objective of this program is to demonstrate a system level two-phase cooling technology on a commercial high-end server to accelerate toward commercial adoption.

- The commercial transition of the proposed technology needs to be driven by:
  - A demonstration of the technology with proven performance, reliability, availability, and serviceability expected of the enterprise
  - End-user acceptance through a positive ROI in new and existing data centers.
  - The near-term market opportunity includes systems that currently deploy direct liquid cooling (e.g., high-end systems, supercomputers, and AI systems).

- Results of this program will be shared with the data center community, component suppliers, and modeling software companies to encourage commercial adoption of two-phase liquid cooling

Needs and Potential Partnerships

- *Please list any additional current needs for your project: resources, expertise, etc.*
  - *Development of advanced compact condensers beyond state of the art*
    - *High heat transfer coefficient (UA)*
    - *Low pressure drop*
    - *Compact form factor*

Acknowledgement

- *The information, data, or work presented herein was funded in part by the Advanced Research Projects Agency-Energy (ARPA-E), U.S. Department of Energy, under Award Number DE-AR0001577. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.*

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Q & A

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