Power Efficiency and Performance with ORNL's Cray XK7 *Titan*

20 Years of Excellence in Computational Science

OLCF

Oak Ridge Leadership Computing Facility

1992–2012

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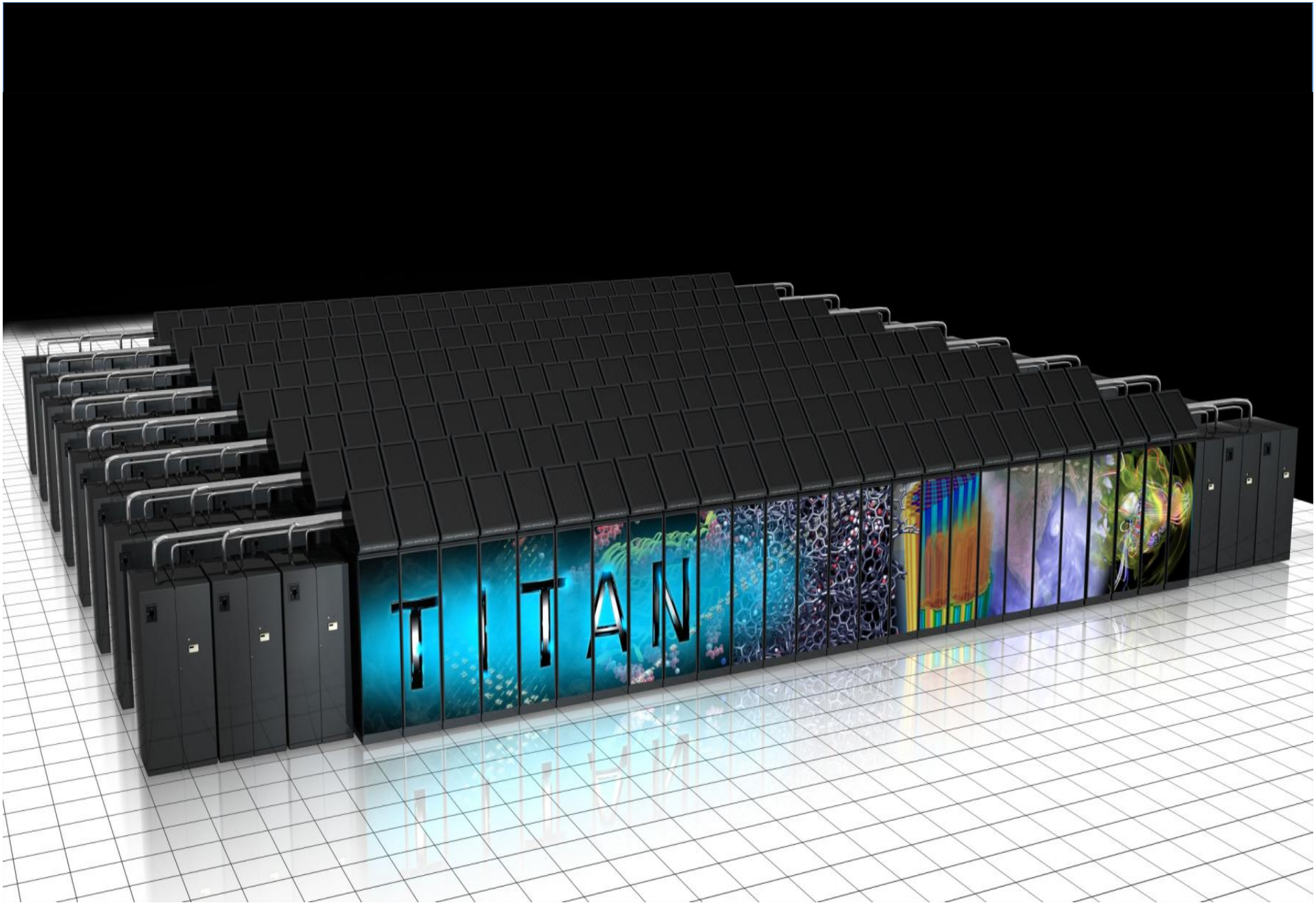
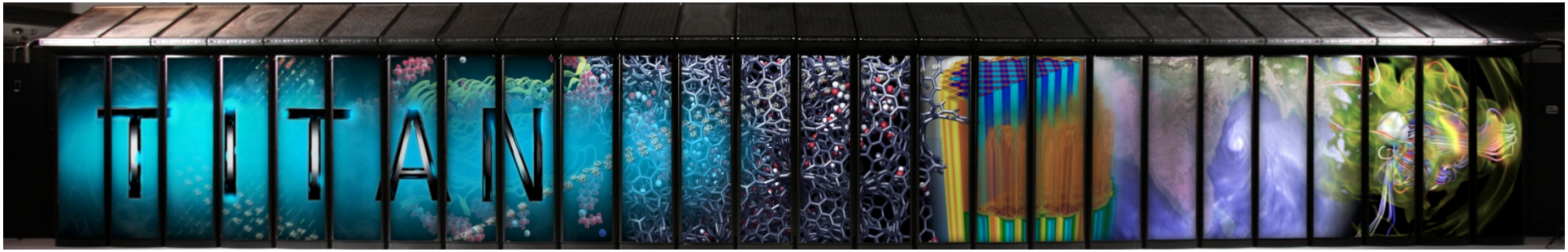
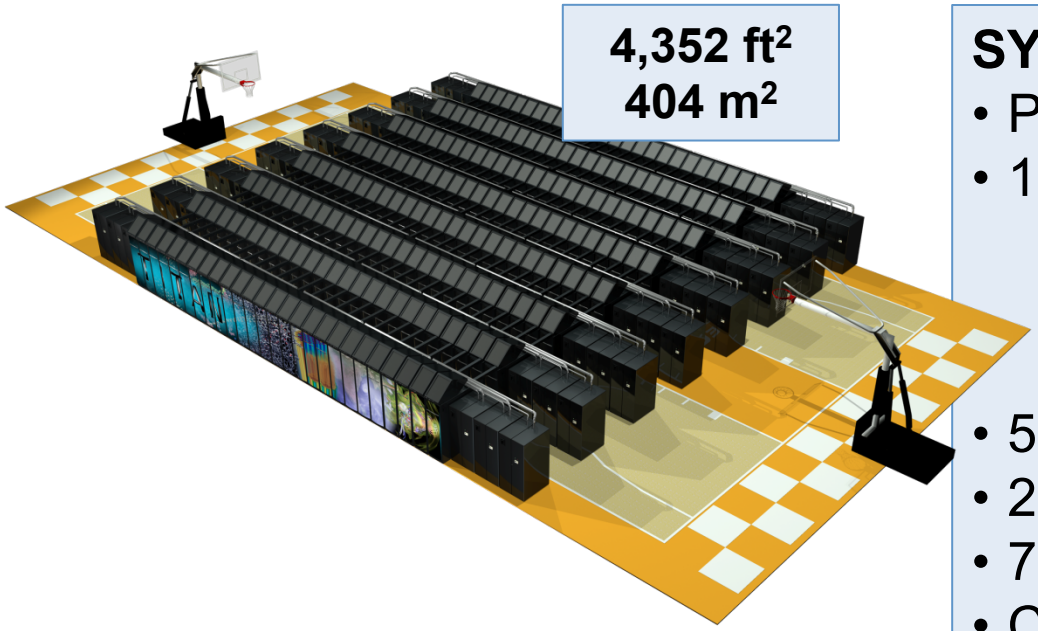

TITAN

ORNL's Cray XK7 Titan

A Hybrid System with 1:1 AMD Opteron CPU and NVIDIA Kepler GPU



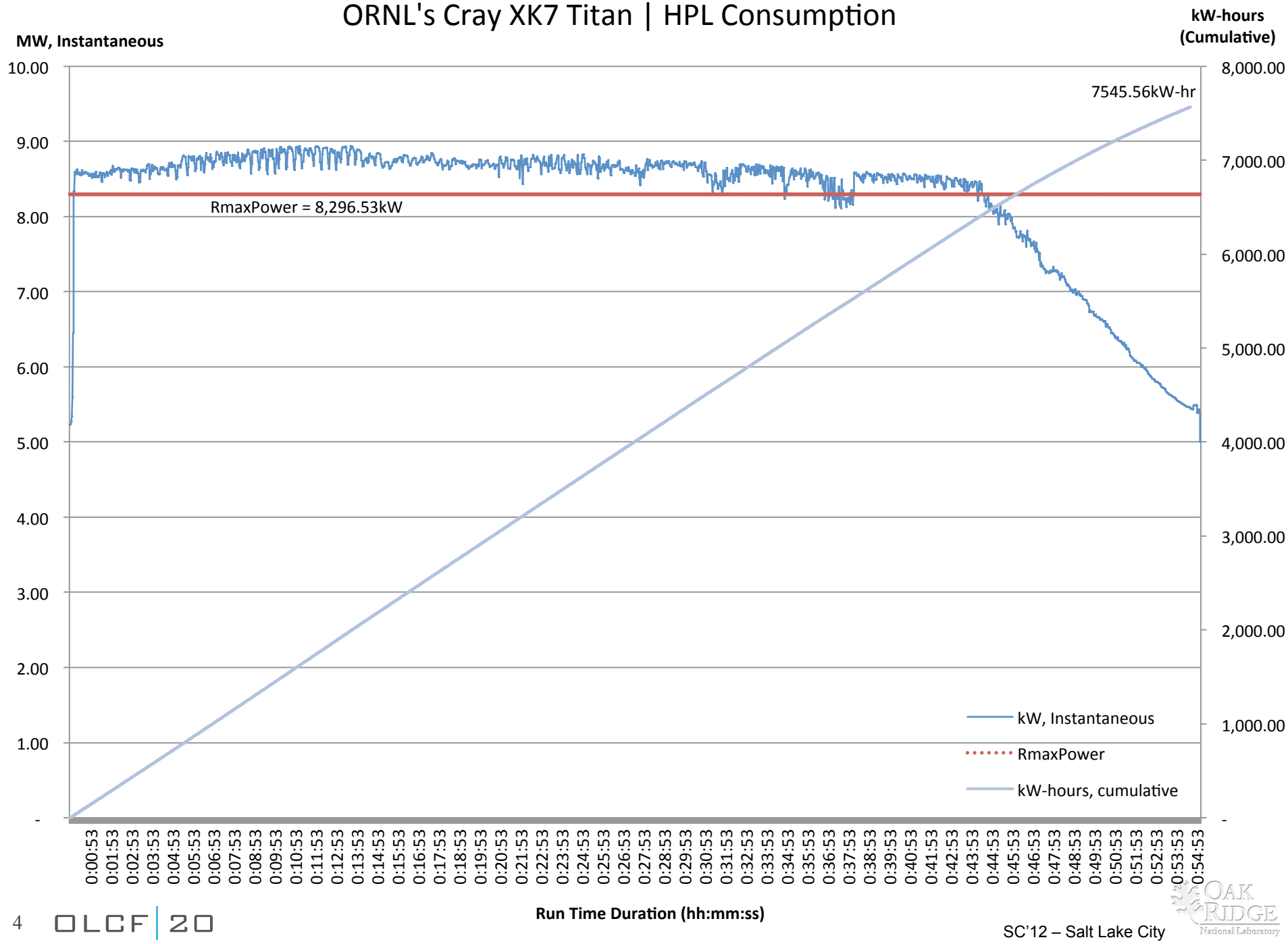


4,352 ft^2
404 m^2

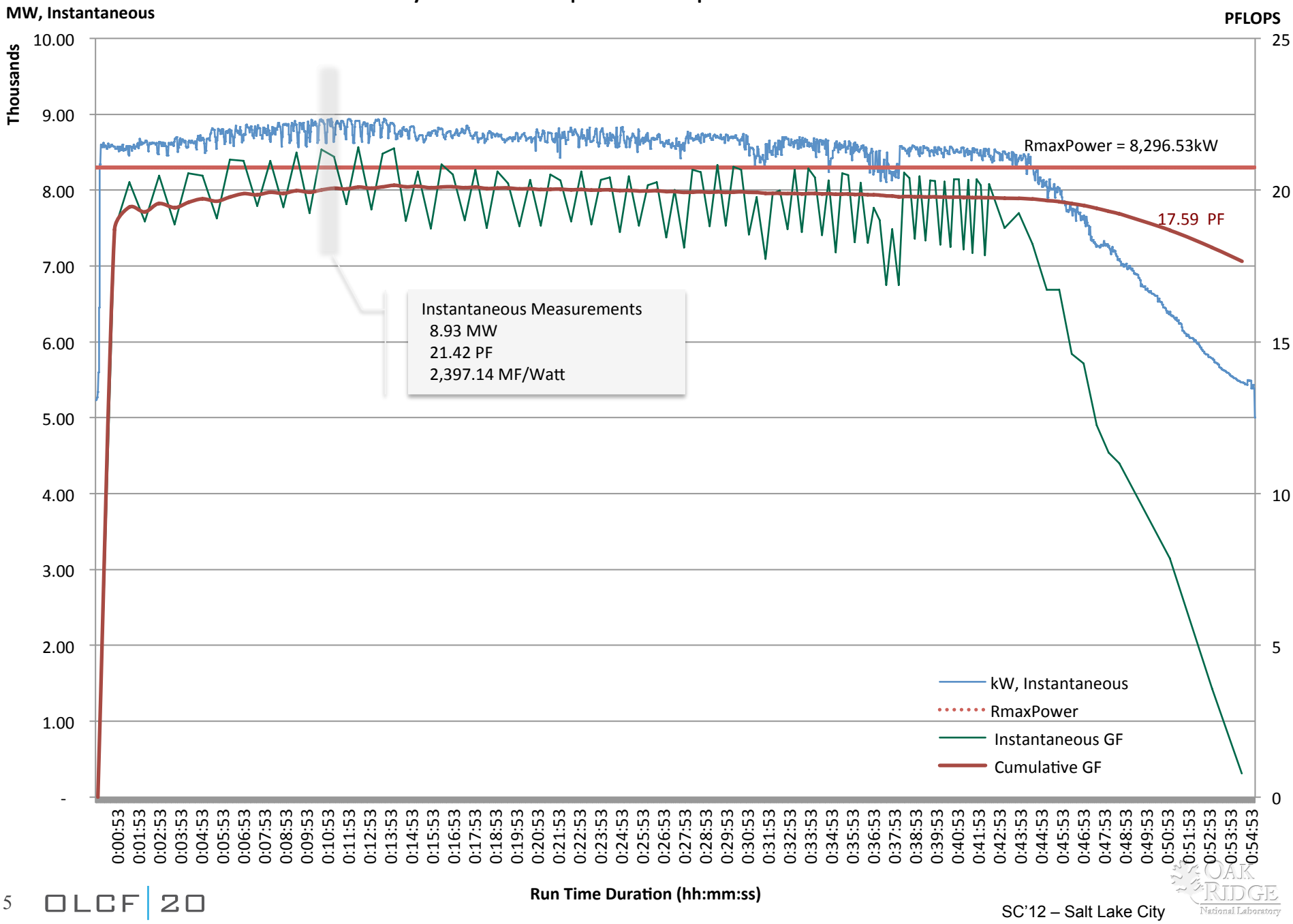
SYSTEM SPECIFICATIONS:

- Peak performance of 20+ PF
- 18,688 Compute Nodes each with:
  - 16-Core AMD Opteron CPU
  - NVIDIA Tesla "K20x" GPU
  - 32 + 6 GB memory
- 512 Service and I/O nodes
- 200 Cabinets
- 710 TB total system memory
- Cray Gemini 3D Torus Interconnect
- 8.9 MW peak energy measurement

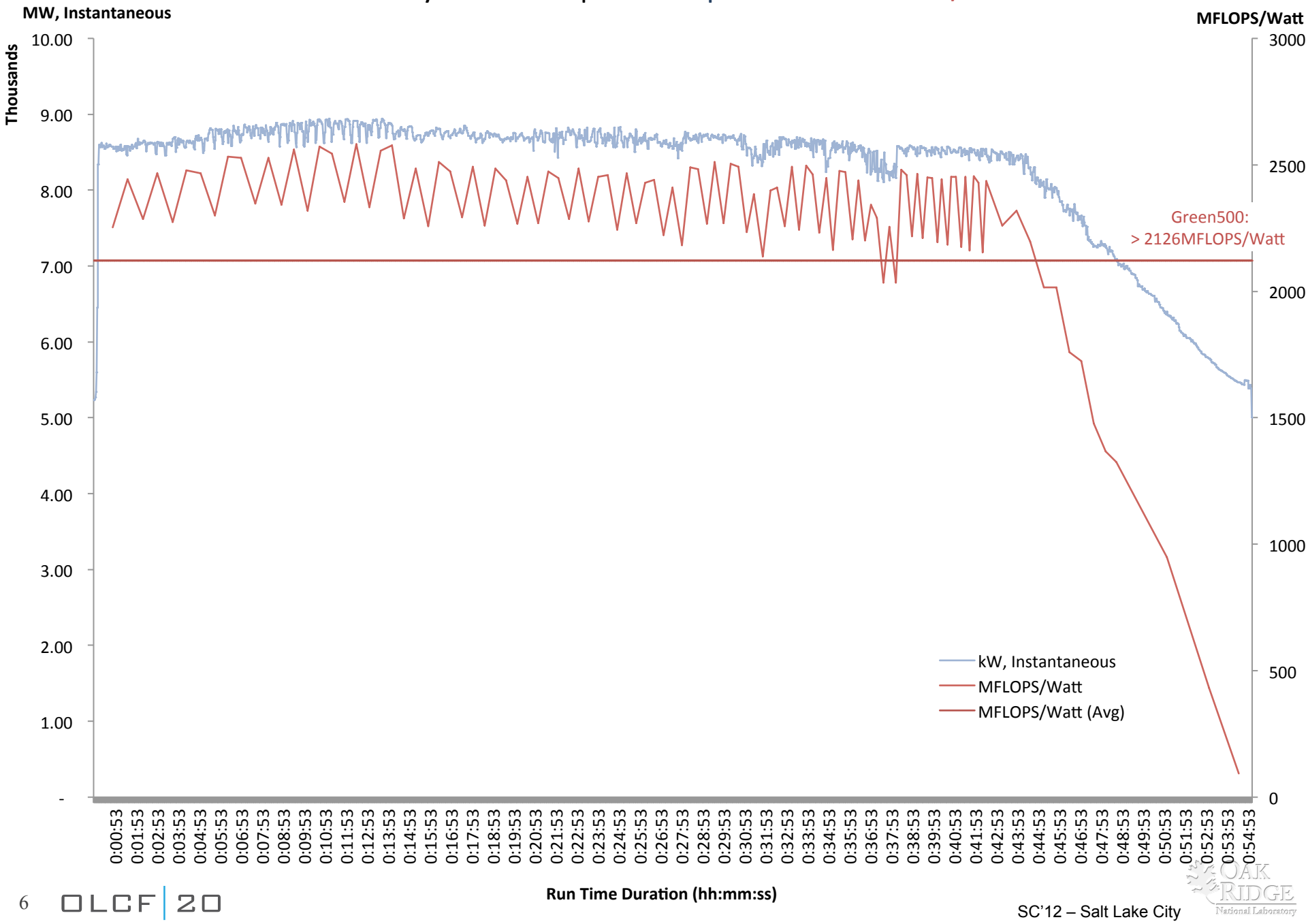
ORNL's Cray XK7 Titan | HPL Consumption



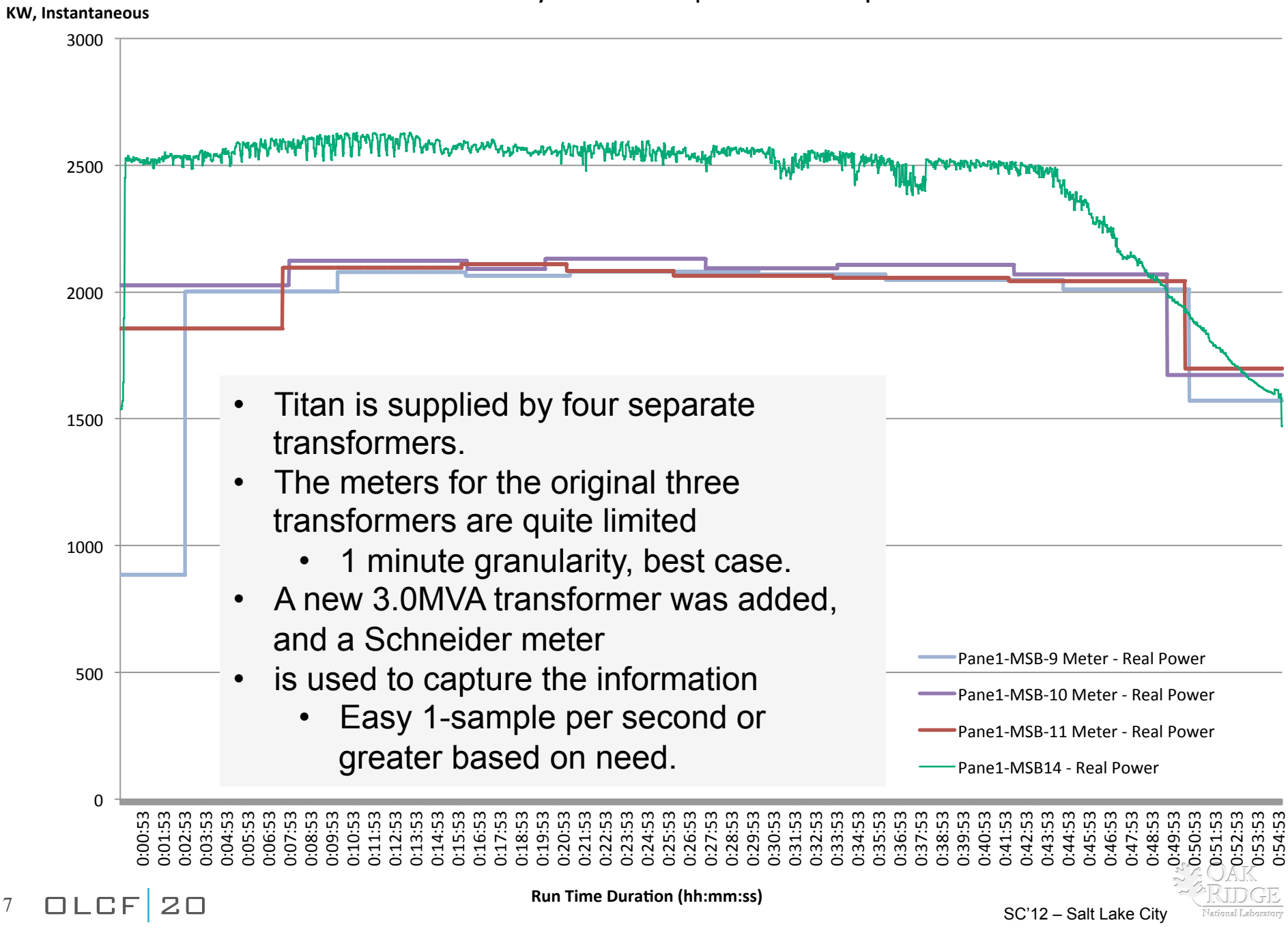
ORNL's Cray XK7 Titan | Consumption v. HPL Performance



ORNL's Cray XK7 Titan | Consumption and MFLOPS/Watt



ORNL's Cray XK7 Titan | Meter Comparison



- Titan is supplied by four separate transformers.
- The meters for the original three transformers are quite limited
  - 1 minute granularity, best case.
- A new 3.0MVA transformer was added, and a Schneider meter
- is used to capture the information
  - Easy 1-sample per second or greater based on need.

Energy Efficient HPC Working Group

EE HPC WG

- Driving energy conservation measures and energy efficient design in high performance computing.

- Demonstrate leadership in energy efficiency as in computing performance.

- Forum for sharing of information (peer-to-peer exchange) and collective action.

http://eehpcwg.lbl.gov

Energy Efficient HPC System Workload Power Measurement Methodology

	Level 1	Level 2	Level 3
Aspect 1a: granularity of power measurements	1 instantaneous power sampling per second	1 instantaneous power sampling per second ✓	continuously integrated total energy
Aspect 1b: timespan of power measurements	at least one power averaged measurement covering at least 20% of the run	a time series of equally spaced power averaged measurements ✓	a time series of equally spaced integrated total energy values
Aspect 1c: reported analyzed measurements	core phase average power	core phase average power, whole application average power, idle power	core phase average power, whole application average power, idle power ✓
Aspect 2: machine fraction	the greater of 1/64 of the machine or 1 kW	the greater of ⅛ of the machine or 10 kW	whole machine ✓
Aspect 3: subsystems included	all participating subsystems, either measured or estimated	all participating subsystems, either measured or estimated	all participating subsystems must be measured ✓
Aspect 4: power measurement point	upstream of power conversion OR power conversion loss modeled with manufacturer data	upstream of power conversion OR power conversion loss modeled with off-line measurements of single power supply	upstream of power conversion OR power conversion measured simultaneously during the same run ✓

- ORNL agreed to be an early adopter/ participant
- The Nov'12 Titan measurement is as close to Level 3 as we can achieve with existing equipment.
- New meters support the Level 3 1a/1b requirements

Energy Efficient HPC Working Group

Membership: The Energy Efficient High Performance Computing Working Group is open to all interested parties. Please contact us if you would like to join.

EE HPC WG Website
http://eehpcwg.lbl.gov

Email
energyefficientHPCWG@gmail.com

Energy Efficient HPC Linked-in Group
http://www.linkedin.com/groups?gid=2494186&trk=myg_ugrp_ovr

Other Technical Sessions

Birds of Feather: "Setting Trends for Energy Efficiency"

Wednesday, 12:15-1:15PM 250 AB

EE HPC WG **Guide** to **SC12** Technical Program Sessions on **Energy Efficiency**

http://insidehpc.com/energy-efficiency-focus-in-the-sc12-technical-program/

http://eehpcwg.lbl.gov/events-and-links