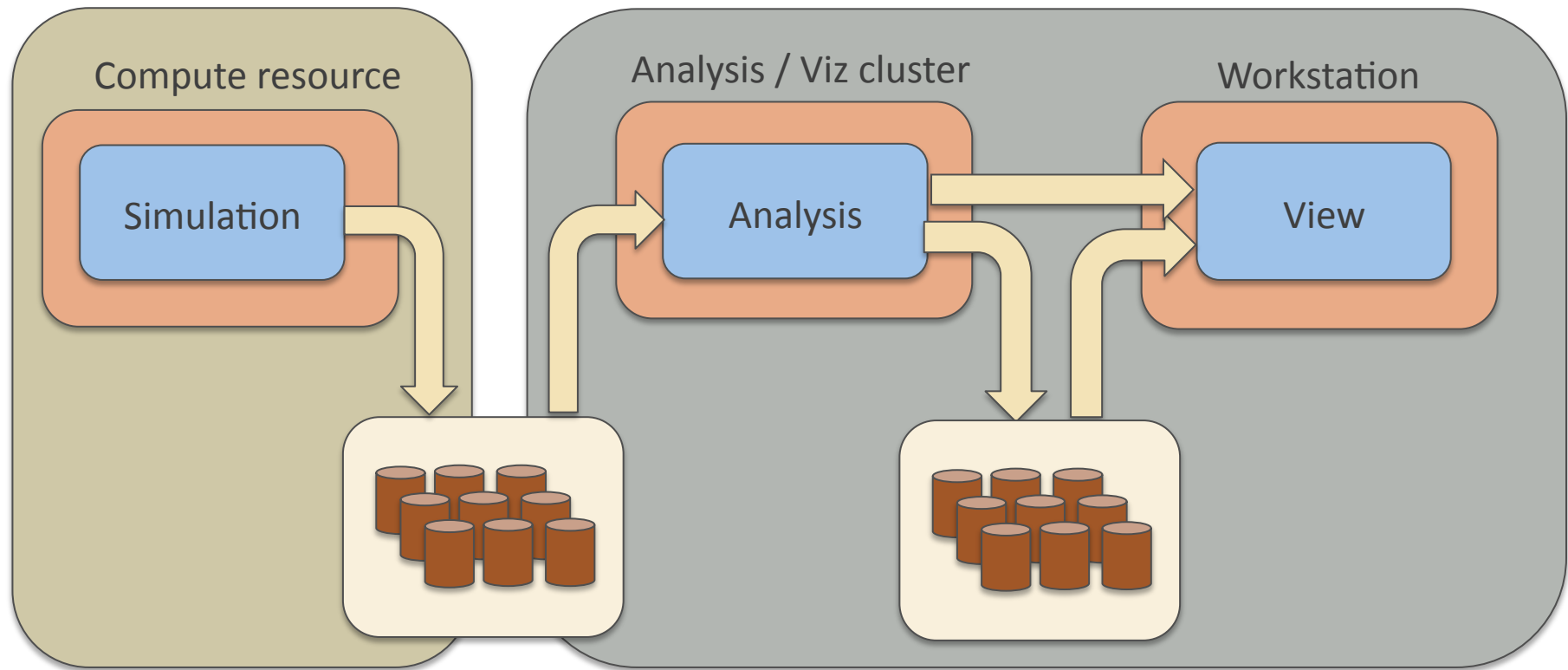


# Data Analysis Approaches at Extreme Scale

Venkatram Vishwanath  
Argonne National Laboratory  
[venkatv@mcs.anl.gov](mailto:venkatv@mcs.anl.gov)

# Traditional Science Pipeline



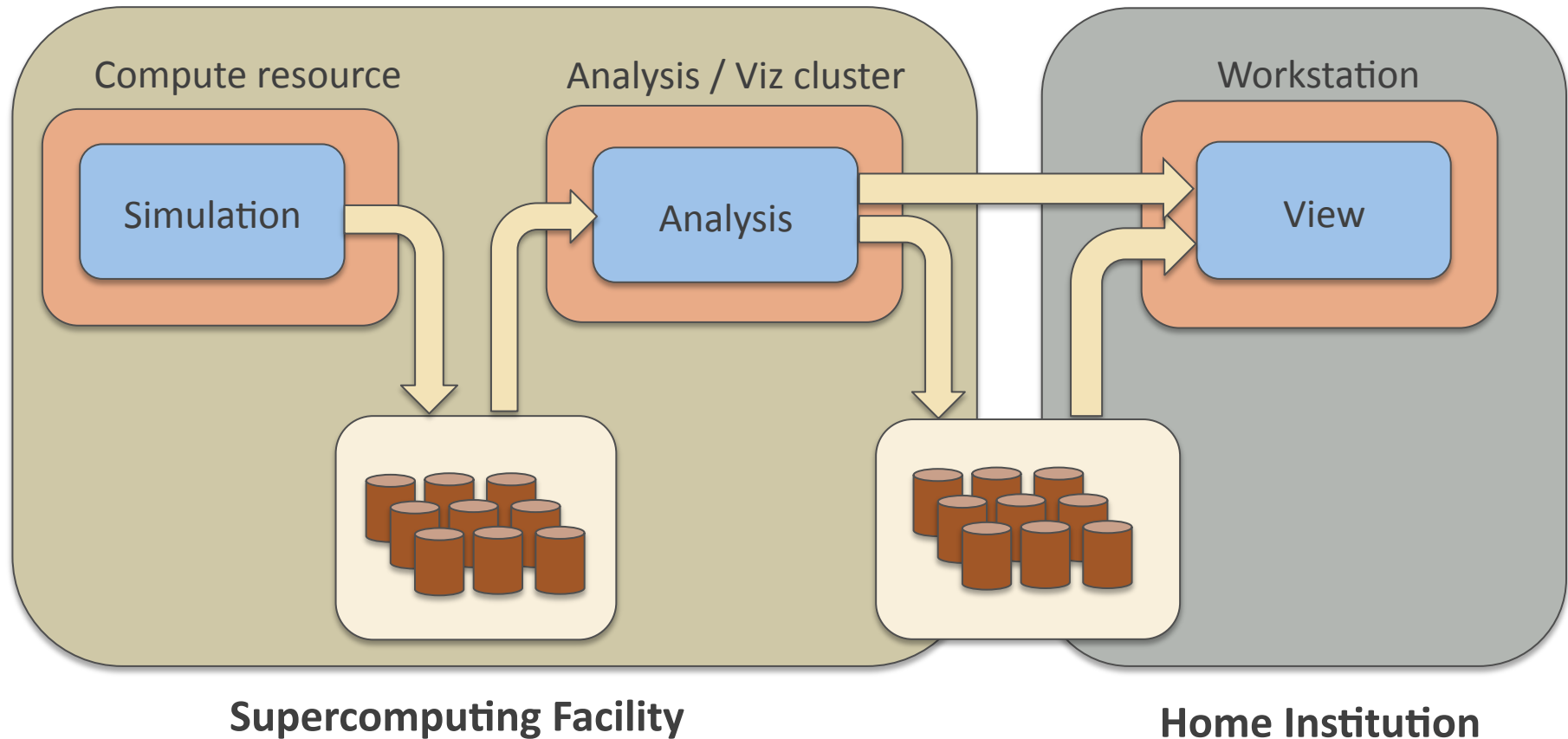
**Supercomputing Facility**

**Home Institution**

- Time to discovery is high as we are moving data to and from storage.
- Due to the data size, moving data is a challenge, and, we need ultra-high-speed networks to enable this.



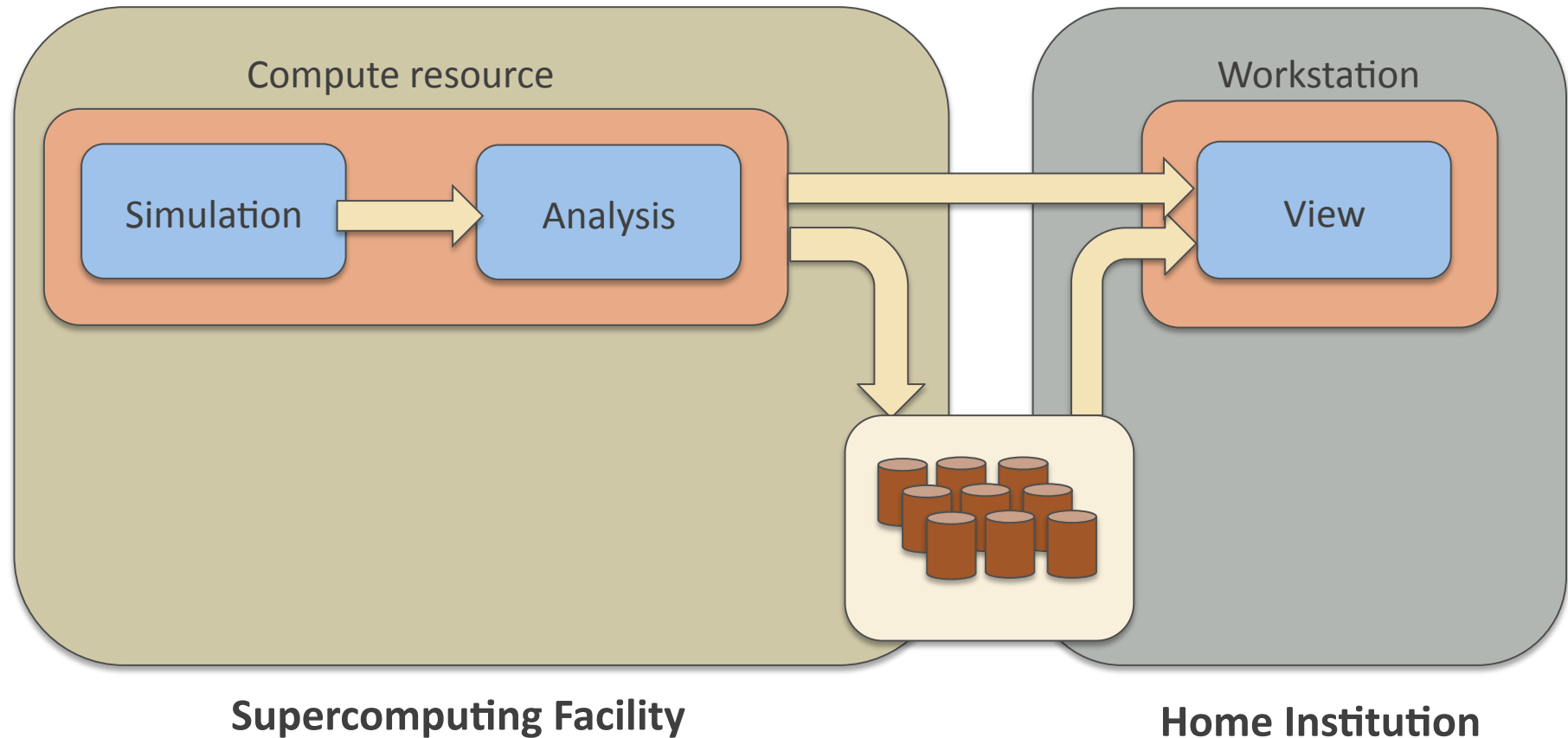
# Post Processing Pipeline in HPC



We are currently unable to cope with the data sizes at extreme scales and this will only get worse in future



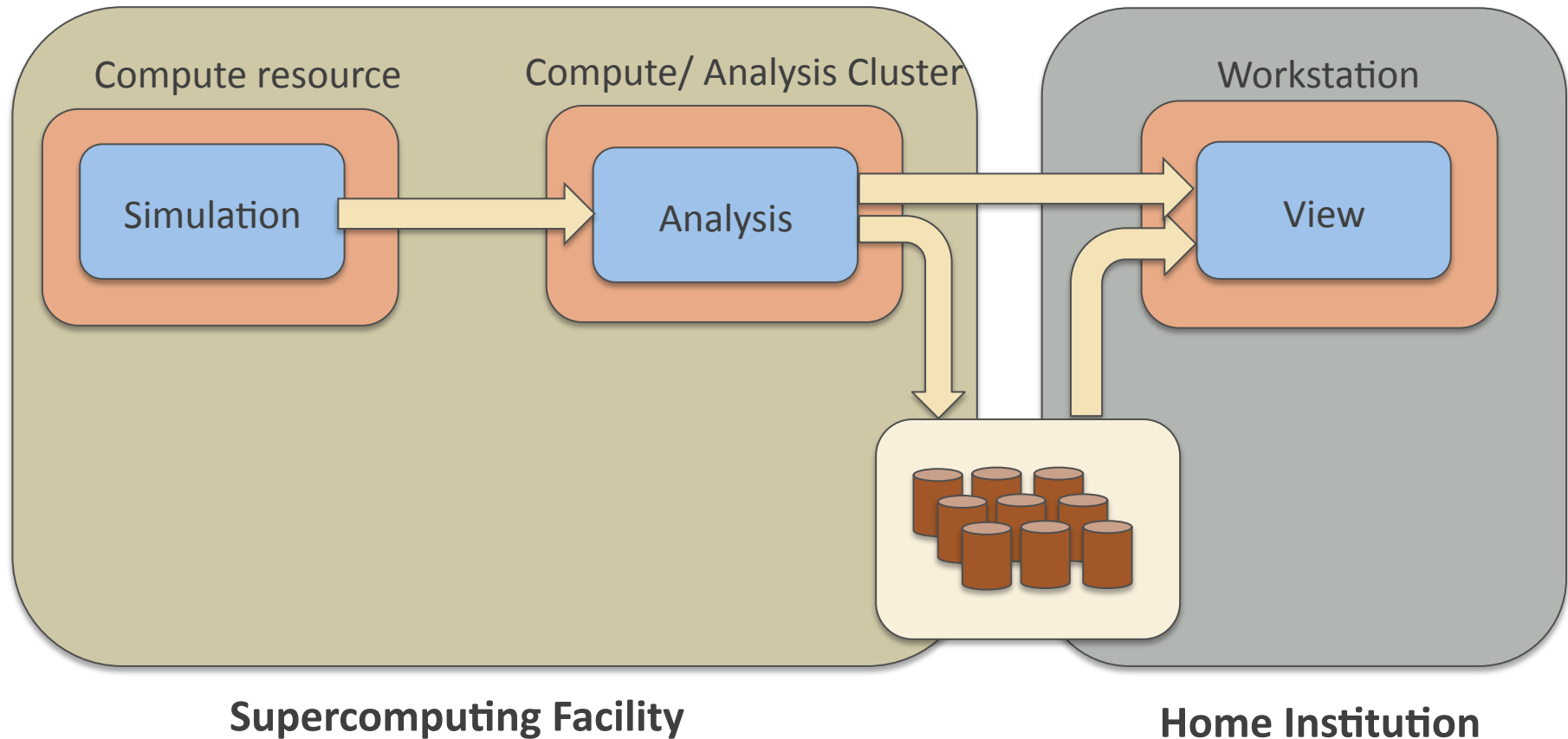
# Simulation Time Analysis on the Compute Resource - *in situ*



Simulation computation and analysis occur on the compute resource



# Simulation time analysis on a direct attached analysis resource - *co-analysis*



- Compute resource and Analysis resource are directly connected over an ultra high-speed network.
- Data is moved to the analysis resource **memory**



# Comparing simulation time in situ and simulation time co-analysis

## In situ

- ✓ uses simulation data structures
- ✓ no additional hardware resource required
- X uses simulation data structures, time and memory
- X time-varying analysis is extremely difficult

## Co-analysis

- ✓ extremely flexible
- ✓ time-varying analytics
- ✓ may not require precious computational resources
- X requires a co-scheduling infrastructure



# How do I analyze my data?

## In situ, Co-Analysis or Post Processing?

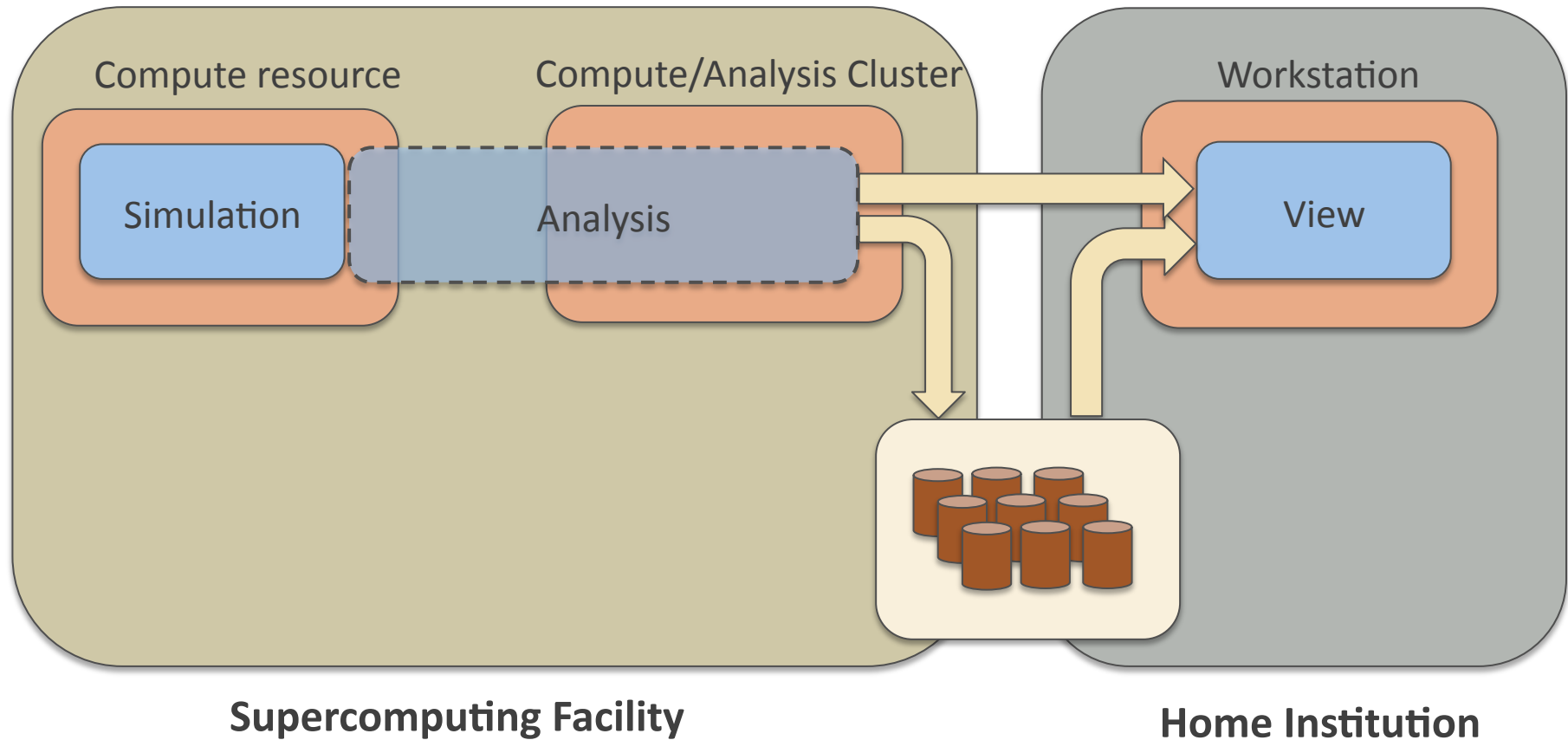
There are multiple answers!!

A solution needs to consider, among others:

- Simulation characteristics
- Analysis characteristics
- System characteristics
- Be flexible enough to meet the needs of the scientist



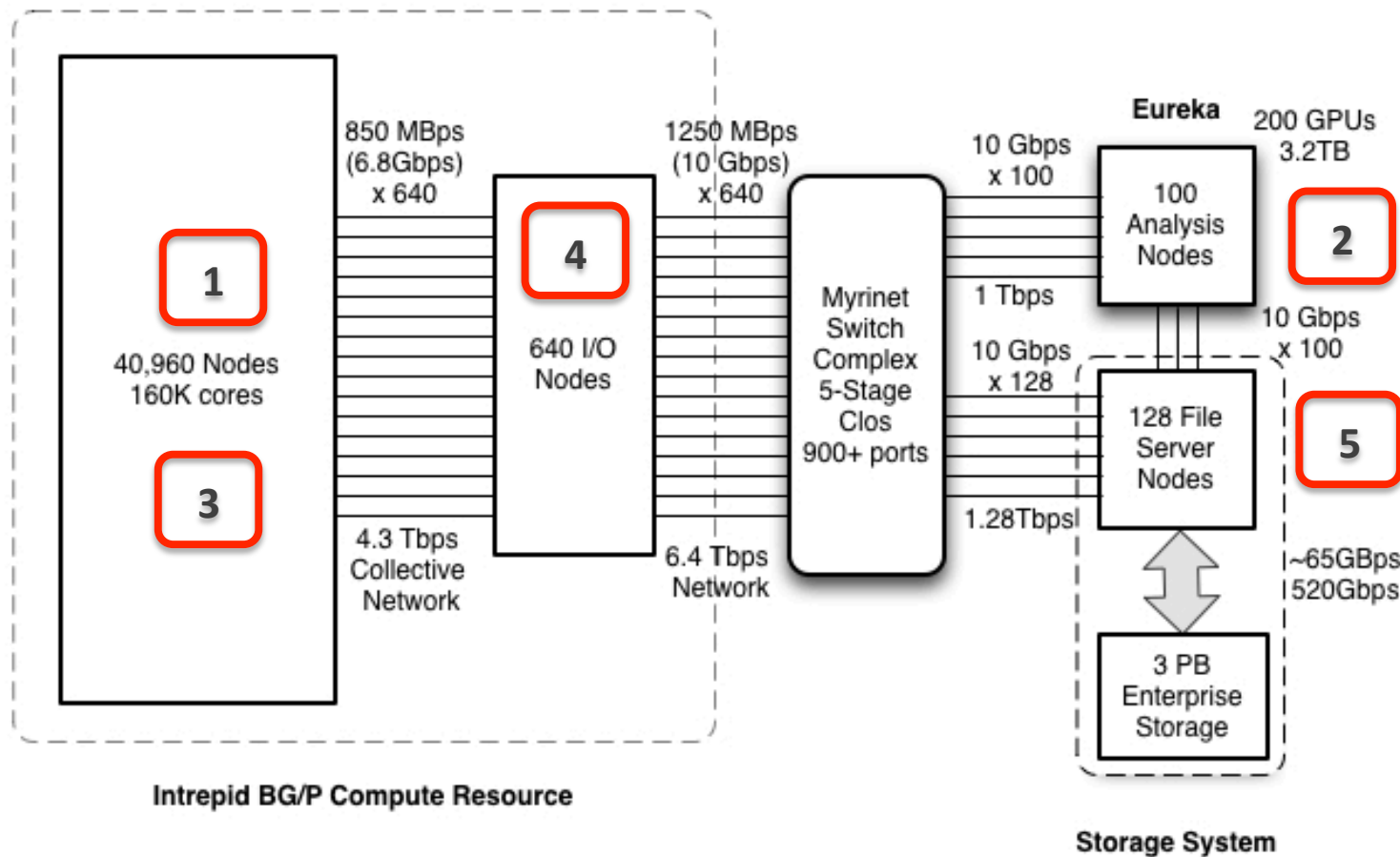
# Our Approach



A flexible, hybrid approach taking into account application, analytics and system characteristics



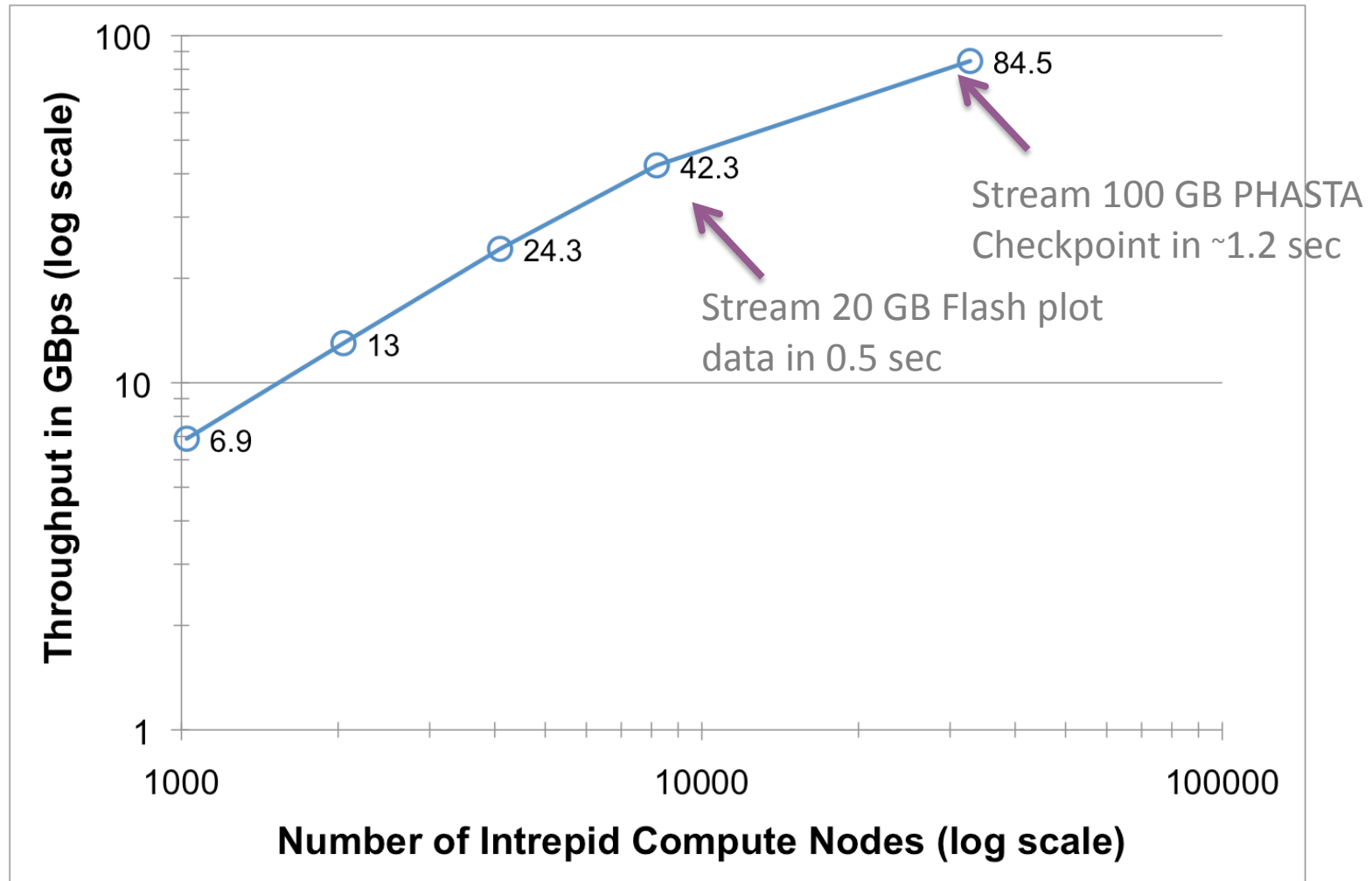
# Simulation-time Analysis Opportunities on ALCF Intrepid



The analysis abstractions are applicable to other leadership class infrastructures including systems at ORNL, NICS, TACC and NCSA



# Data Streaming from Intrepid



V. Vishwanath et al., "Accelerating I/O Forwarding in IBM Blue Gene/P Systems", To appear at SC 2010, New Orleans, November 2010



# Datasets: Application view vs Storage view

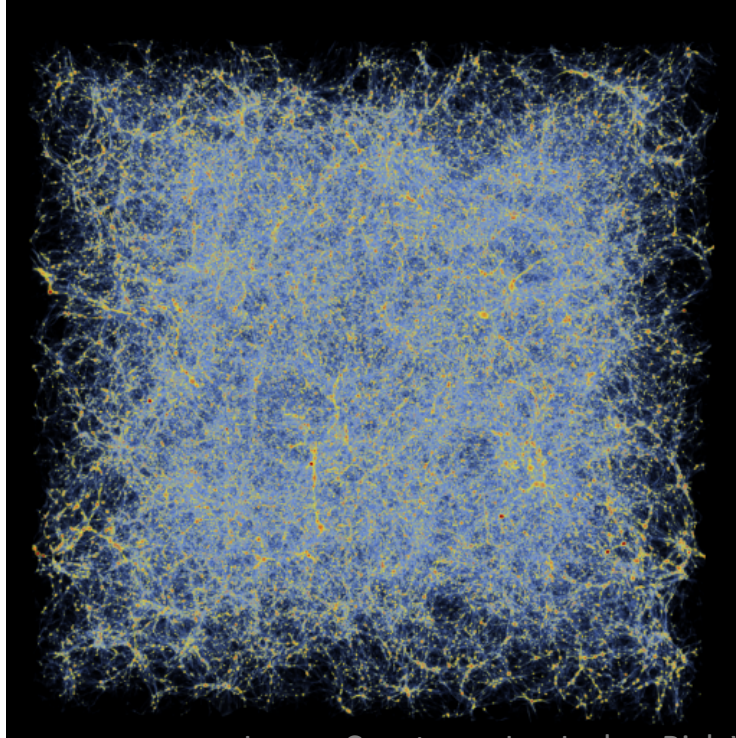
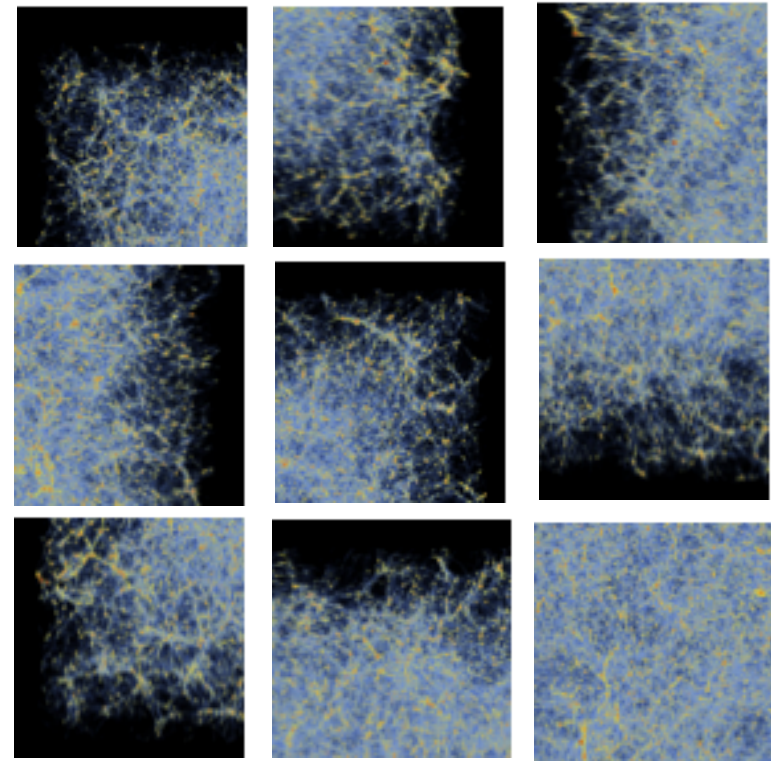


Image Courtesy: Joe Insley, Rick Wagner

**Application View**  
**(4096)<sup>3</sup> pressure**



**Storage View**  
**4096 files 64MB each**

There is a growing disparity between an application's data models and how the data is mapped onto storage



# Enhancing productivity by capturing the workflows of scientists

Welcome, John. [Change password](#) / [Log out](#) 11th January 2010 09:48 -0600

**Filter by Date**  
Before:   
After:   
☐ Show Hidden

**Filter by Tag**  
FlameBubble  
RTFlame  
WD\_def  
mass study  
multiple bubbles  
☐ All ☒ Any

**Filter by Site**  
ellipse.uchicago.edu  
franklin.nersc.gov  
intrepid.alcf.anl.gov

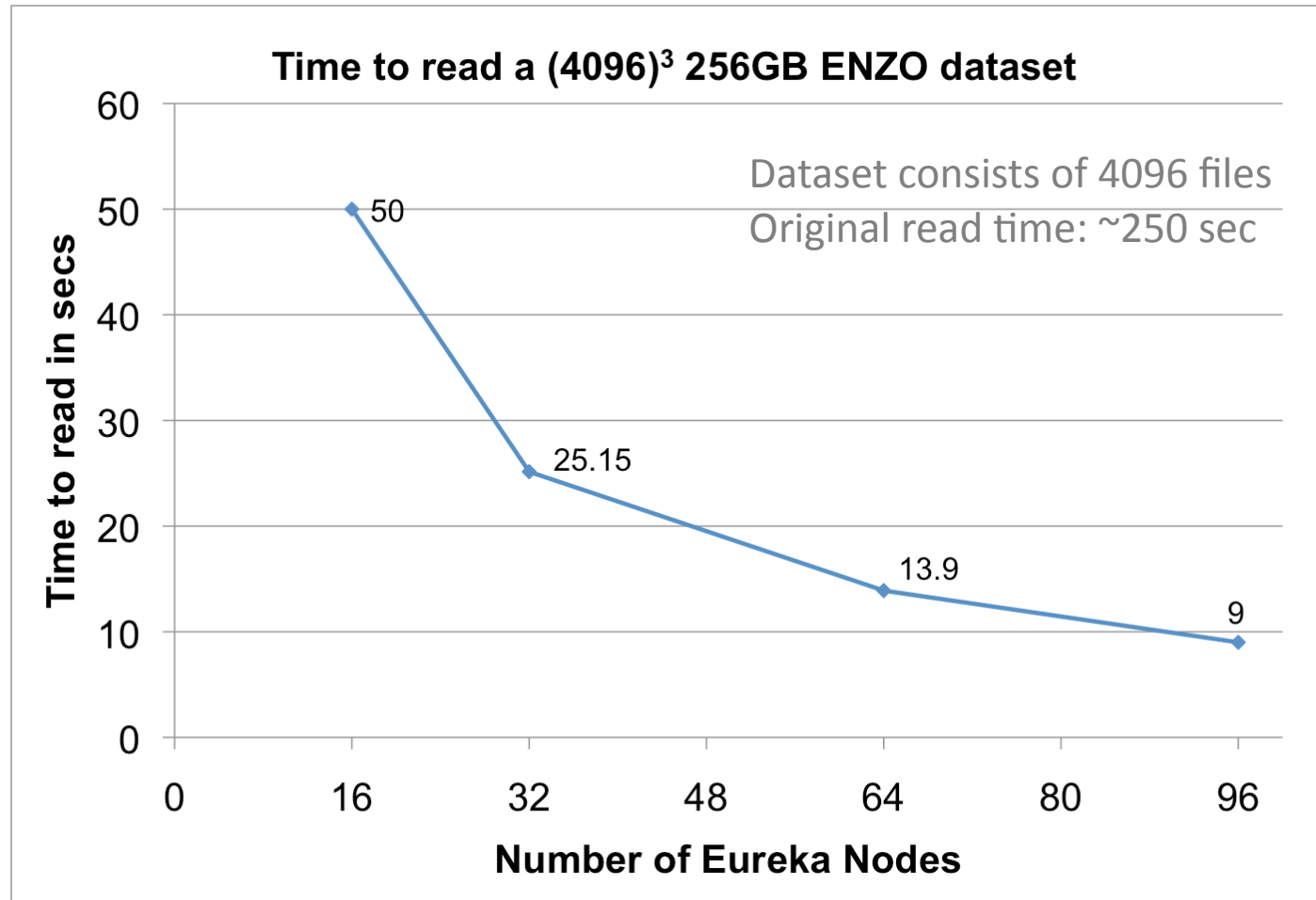
**Filter by Owner**  
Cal Jordan  
Carlo Graziani  
Chad Glendenin  
Chris Daley  
Dean Townsley  
Eva Wuyts

Name	Date	Tags	Description	Dim	Owner	Graph
8km_3_3000_1 [14]	2009-06-03	WD_def	/intrepid-fs0/users/gjordan/pe...	16x16x16	Cal Jordan	
Multiple Bubbles [51]	2009-03-31		Multiple bubbles experiments.		Cal Jordan	
8km_63_128o78_m1365_1 [76]	2009-06-20	multiple bubbles,WD_def	/intrepid-fs0/users/gjordan/pe...	16x16x16	Cal Jordan	
8km_63_128o68_m1365_1 [75]	2009-06-20	multiple bubbles,WD_def	/intrepid-fs0/users/gjordan/pe...	16x16x16	Cal Jordan	
8km_63_128o48_m1365_1 [70]	2009-03-15	multiple bubbles,WD_def	/intrepid-fs0/users/gjordan/pe...	16x16x16	Cal Jordan	
8km_63_128o58_m1365_1 [73]	2009-04-01	multiple bubbles,WD_def	/intrepid-fs0/users/gjordan/pe...	16x16x16	Cal Jordan	
8km_multi_63_128o188_m1365_1 [72]	2009-03-18	multiple bubbles,WD_def	1.365 solar mass, 63 bubbles, ...	16x16x16	Lynn Reid	
rundir_0001 [385]	2009-03-18	multiple bubbles,WD_def	All on /intrepid-fs0/	16x16x16	Lynn Reid	
rundir_0002 [387]	2009-03-19	multiple bubbles,WD_def	1.14 to 1.737 secs 8km_multi...	16x16x16	Lynn Reid	
rundir_0003 [389]	2009-03-19	multiple bubbles,WD_def	1.7 to 2.52 secs 8km_multi_6...	16x16x16	Lynn Reid	
rundir_0004 [390]	2009-03-20	multiple bubbles,WD_def	/intrepid-fs0/users/lynnreid/p...	16x16x16	Lynn Reid	
rundir_0005 [393]	2009-03-21	multiple bubbles,WD_def	3.565 to 4.07 secs 8km_multi_...	16x16x16	Lynn Reid	
rundir_0006 [395]	2009-03-22	multiple bubbles,WD_def	4.07 to 4.39 secs 8km_multi_...	16x16x16	Lynn Reid	
rundir_0007 [396]	2009-03-22	multiple bubbles,WD_def	4.39 to 4.52 secs 8km_multi_63...	16x16x16	Lynn Reid	
rundir_0009 [398]	2009-03-26	multiple bubbles,WD_def	4.53 to 5.00 secs 8km_multi_...	16x16x16	Lynn Reid	
rundir_0010 [400]	2009-03-28	multiple bubbles,WD_def	5.00 to 5.65 secs 8km_multi_...	16x16x16	Lynn Reid	
rundir_0011 [402]	2009-04-01	multiple bubbles,WD_def	5.65 to ?? secs 8km_multi_63...	16x16x16	Lynn Reid	
rundir_0012 [405]	2009-04-02	multiple bubbles,WD_def	6.26 to 7.193 secs 8km_multi_...	16x16x16	Lynn Reid	
rundir_0013 [410]	2009-04-03	multiple bubbles,WD_def	/intrepid-fs0/users/lynnreid/p...	16x16x16	Lynn Reid	
8km_63_128o88_m1365_1 [69]	2009-03-13	multiple bubbles,WD_def	new simulation 63 128o88 0.0s ...	16x16x16	Cal Jordan	
rundir_0001 [365]	2009-03-13	multiple bubbles,WD_def	new simulation 63 128o88 0.0s ...	16x16x16	Cal Jordan	
rundir_0002 [366]	2009-03-14	multiple bubbles,WD_def	restart rundir_0002	16x16x16	Cal Jordan	
rundir_0003 [369]	2009-03-15	multiple bubbles,WD_def	/intrepid-fs0/users/gjordan/pe...	16x16x16	Cal Jordan	

Image Courtesy: Randy Hudson, Flash Center



# Accelerating ENZO Analysis by Leveraging Data Semantics



Data semantics will be of extreme importance at exascale



# Parting Thoughts

- Simulation time data analysis at extreme scales is critical in order to reduce the amount of data written.
- There are multiple solutions for simulation time analysis. A solution needs to take into account resource, application and analysis characteristics.
- Leveraging data models will be key in order to deal with future data sizes



# Acknowledgements

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