IT of SPIM Data Storage and Compression

EMBO Course - August 27th

Jeff Oegema, Peter Steinbach, Oscar Gonzalez

Talk Outline

- Introduction and the IT Team
- SPIM Data Flow
- Capture, Compression, and the Data Volume Problem
- Transfer, Network and Storage Infrastructure
- Planning for SPIM

People Involved - IT Staff

Peter Steinbach (steinbac@mpi-cbg.de)
Scientific / HPC Software Development
Data Streaming Library
Compression and HPC Algorithm Development

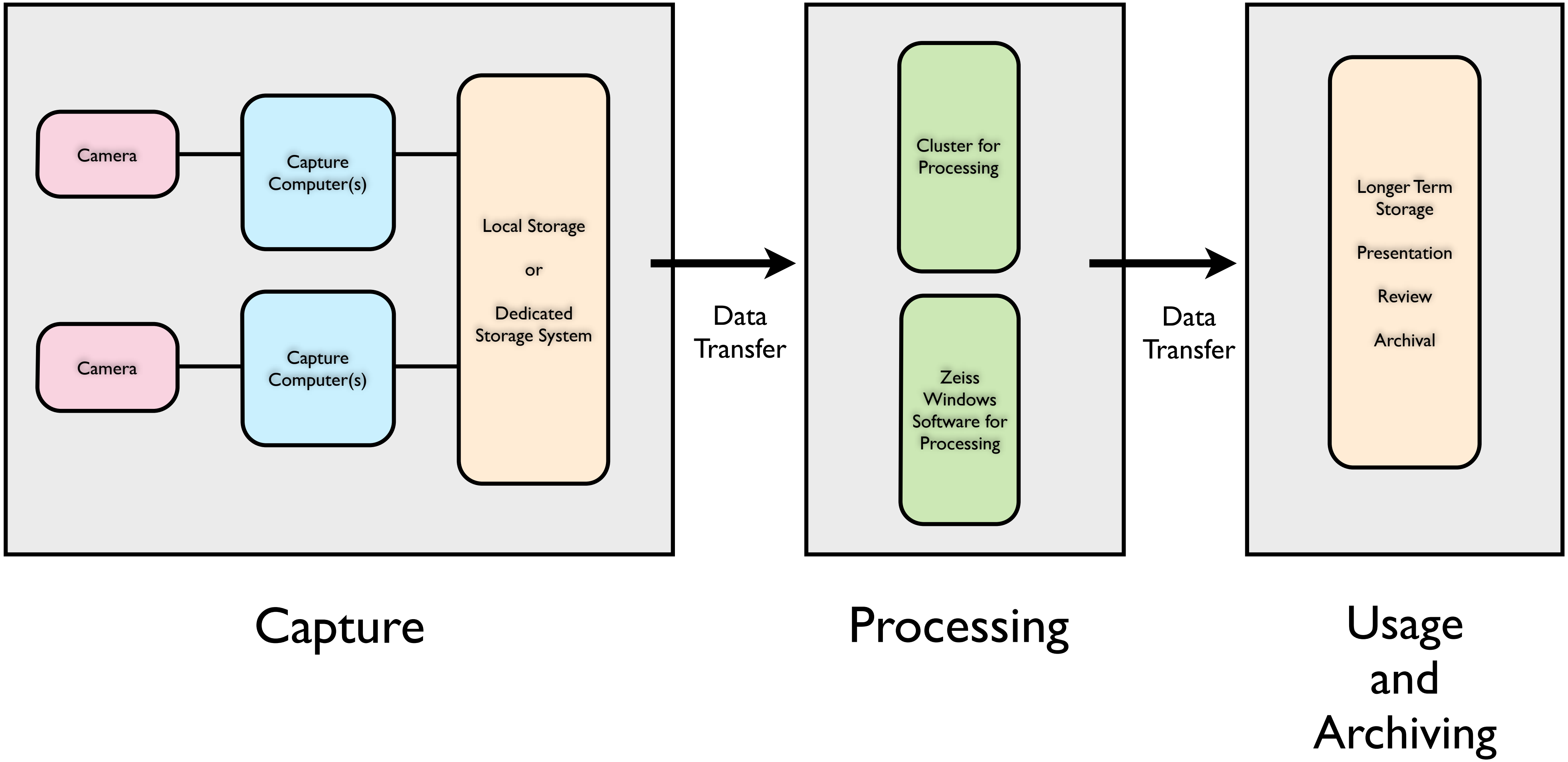
Oscar Gonzalez (ogonzale@mpi-cbg.de)
HPC Administrator
Cluster Interaction and Queuing
High-Performance Storage / Lustre
Network Benchmarking and Performance Tuning

Ian Henry (henry@mpi-cbg.de)
Scientific Computing Leader
Scientific and Project Coordination
Collaboration Management

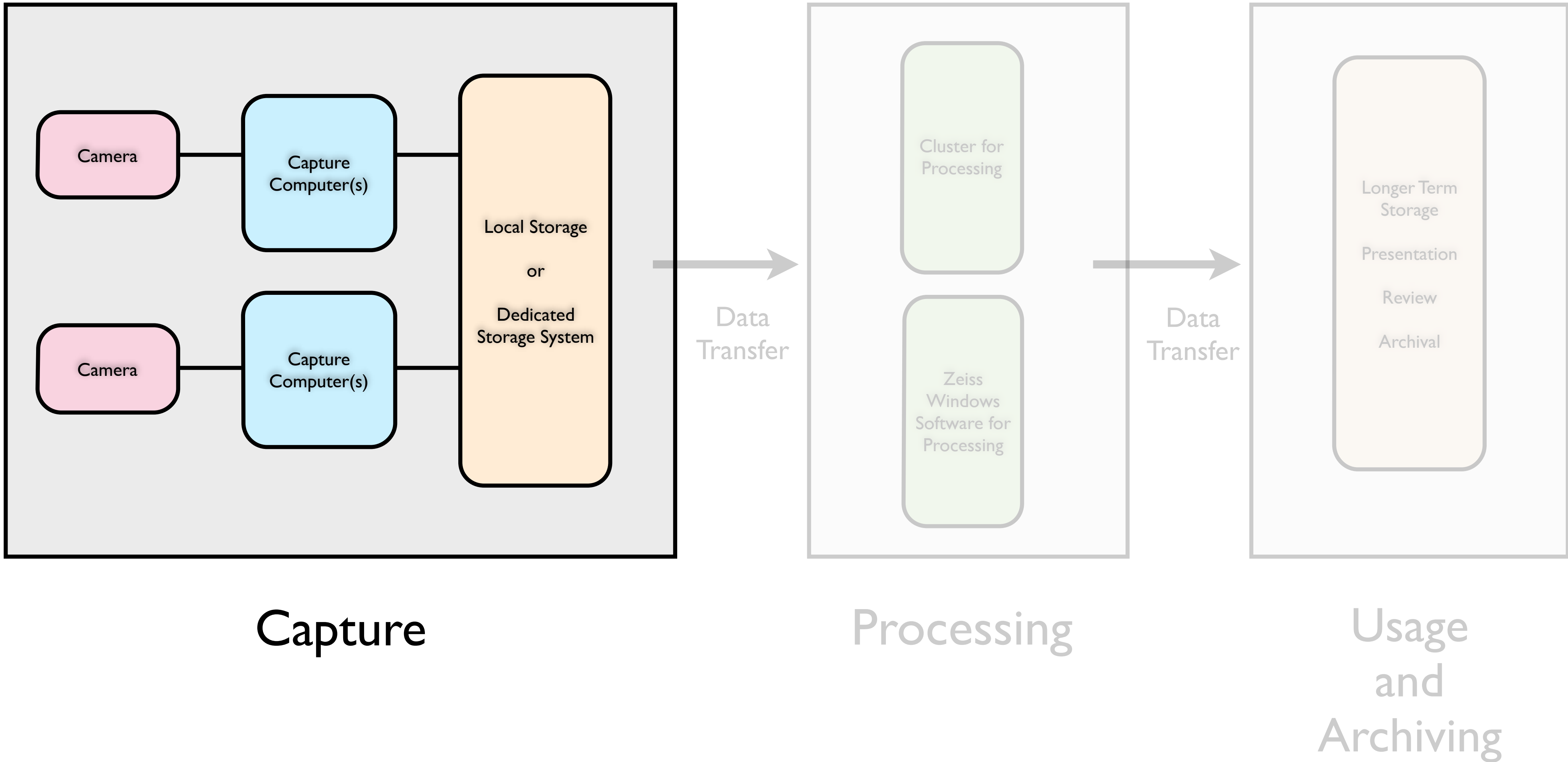
Matt Boes (boes@mpi-cbg.de)
Infrastructure Team Leader
Network Design and Development
Fileserver Design and Development

Jeff Oegema (joegema@mpi-cbg.de)
IT Coordinator
Overall Project Coordination
External Collaboration Management

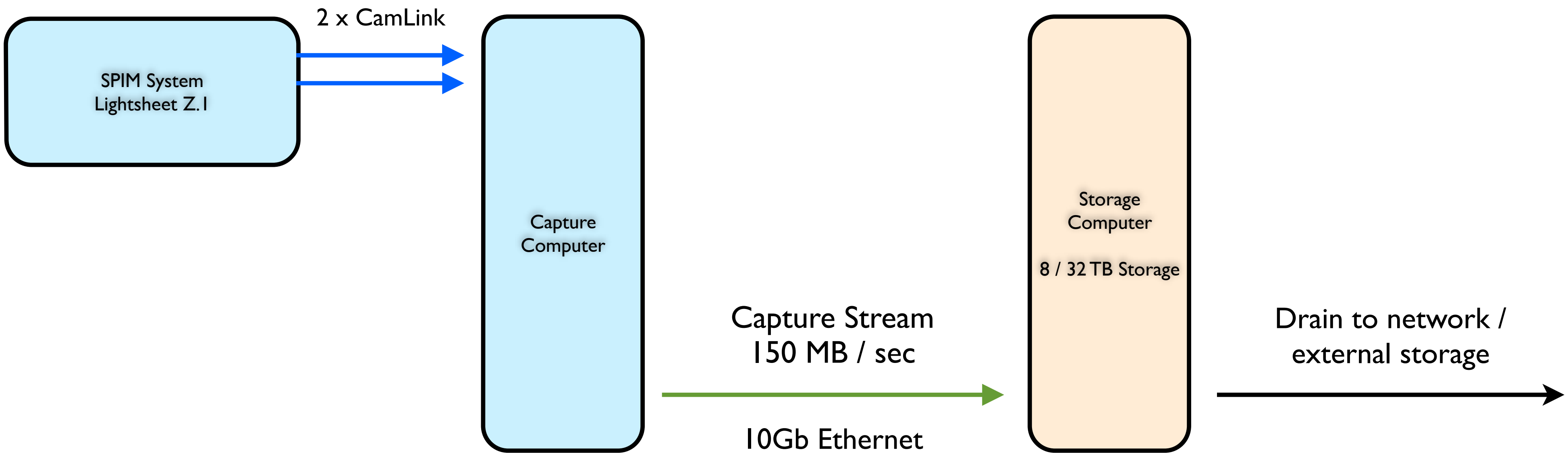
SPIM Dataflow



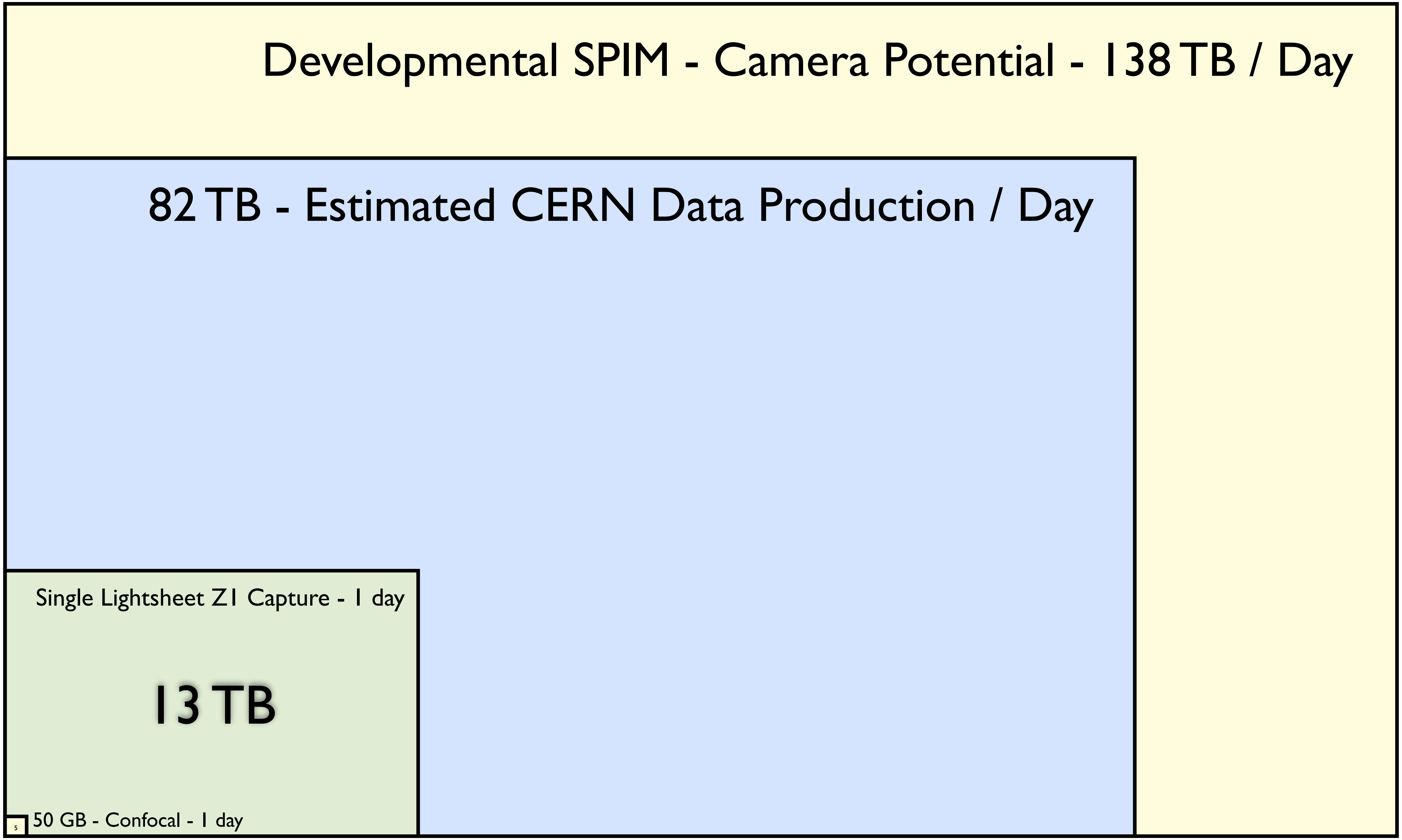
SPIM Dataflow



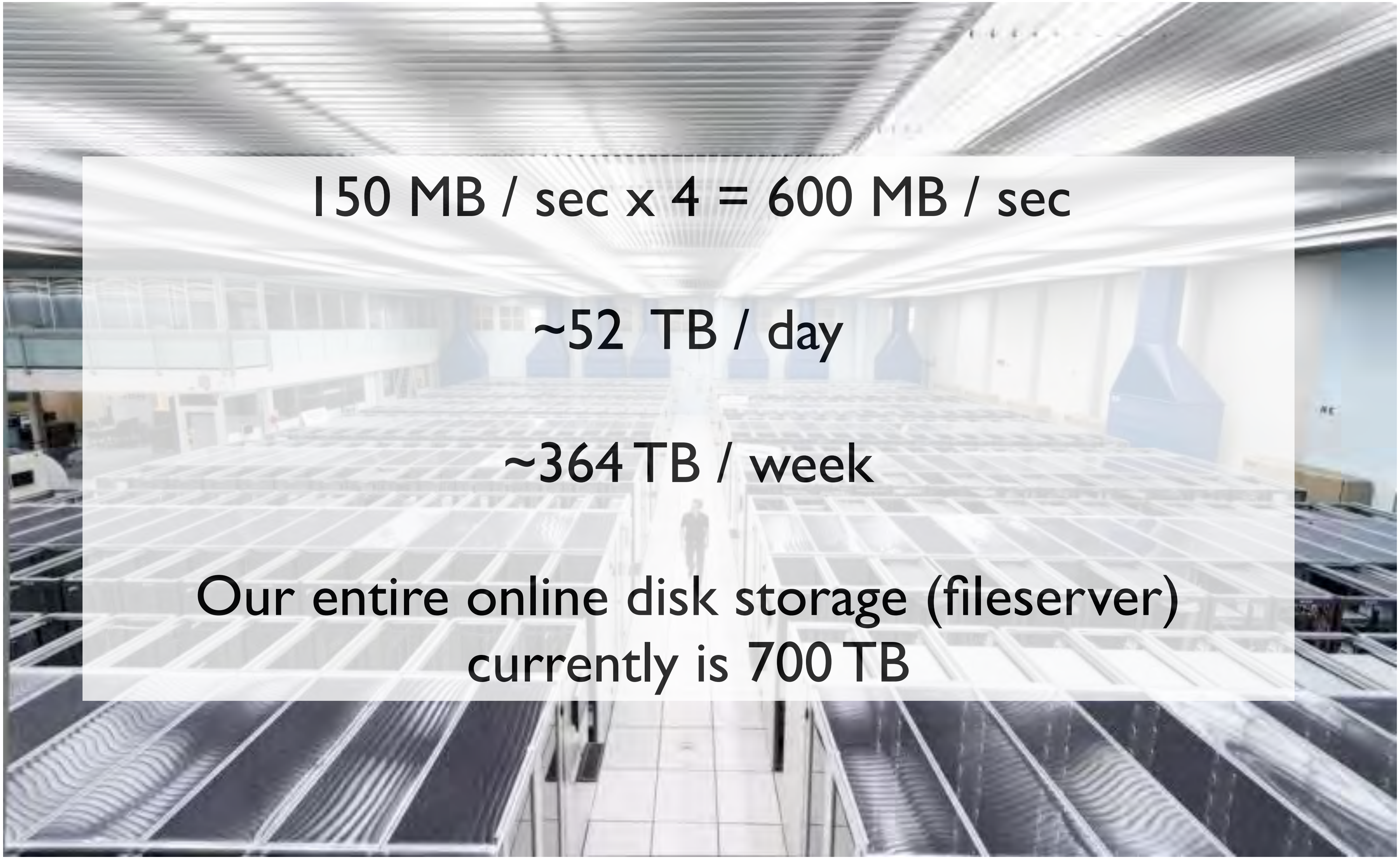
Zeiss Lightsheet Z.1



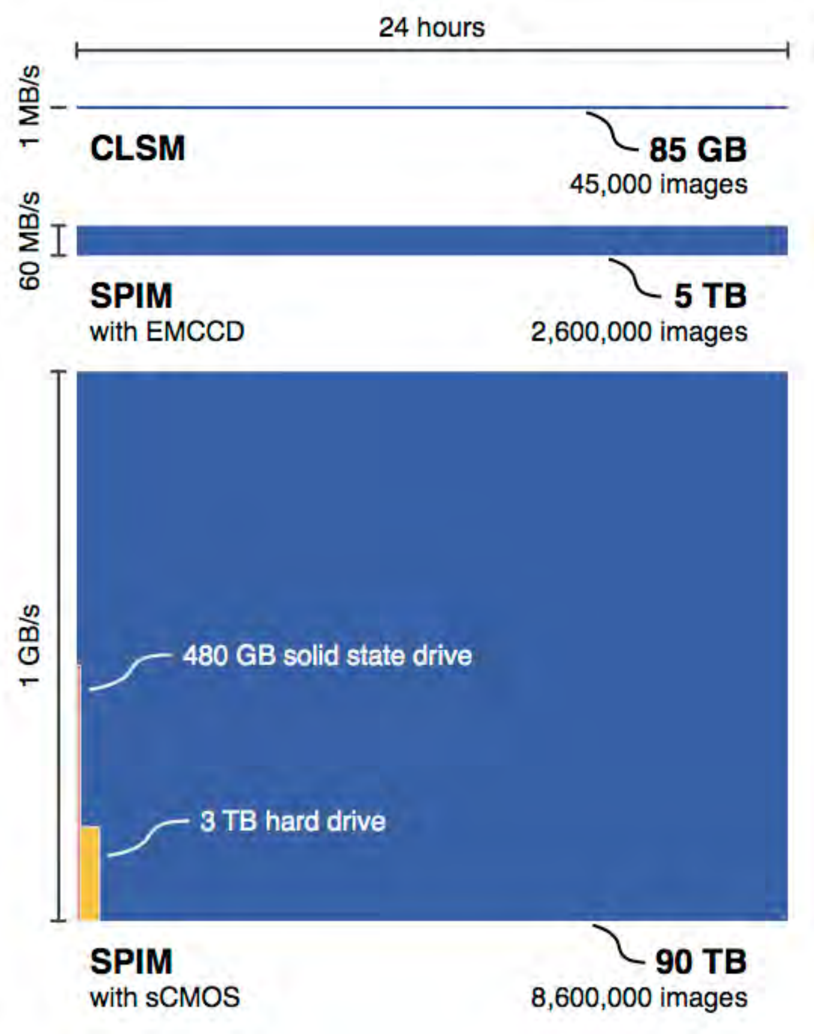
The Potential Deluge



The Potential Deluge - Multiple Lightsheet Z.1



The Potential Deluge - Future Tech



800 MB / sec x 2 cameras = 1.6 GB / sec

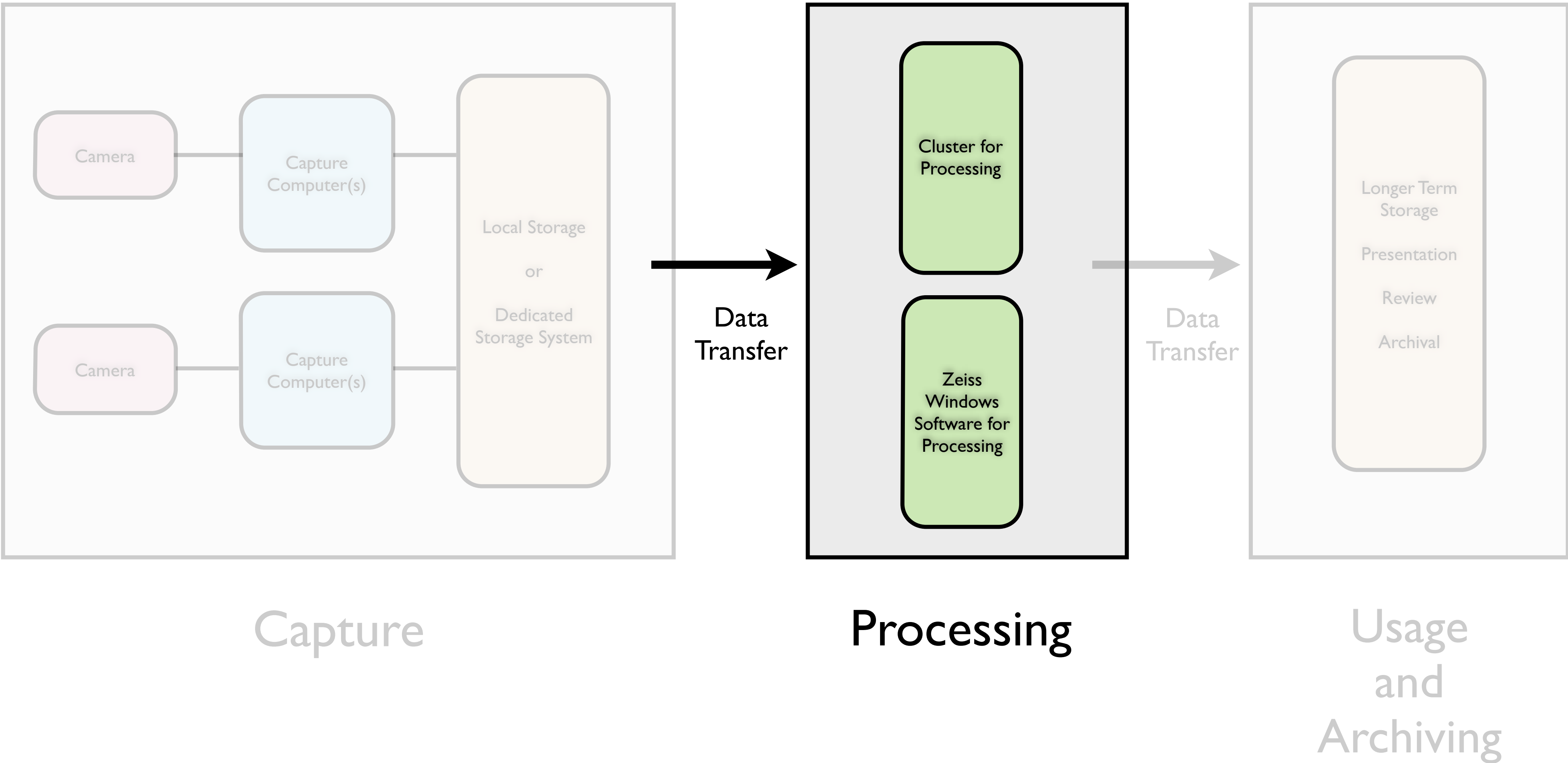
~138 TB / day

Almost a PB per week

CERN produces 30 PB of data annually from LHC experiments*

* http://home.web.cern.ch/about/computing

SPIM Dataflow

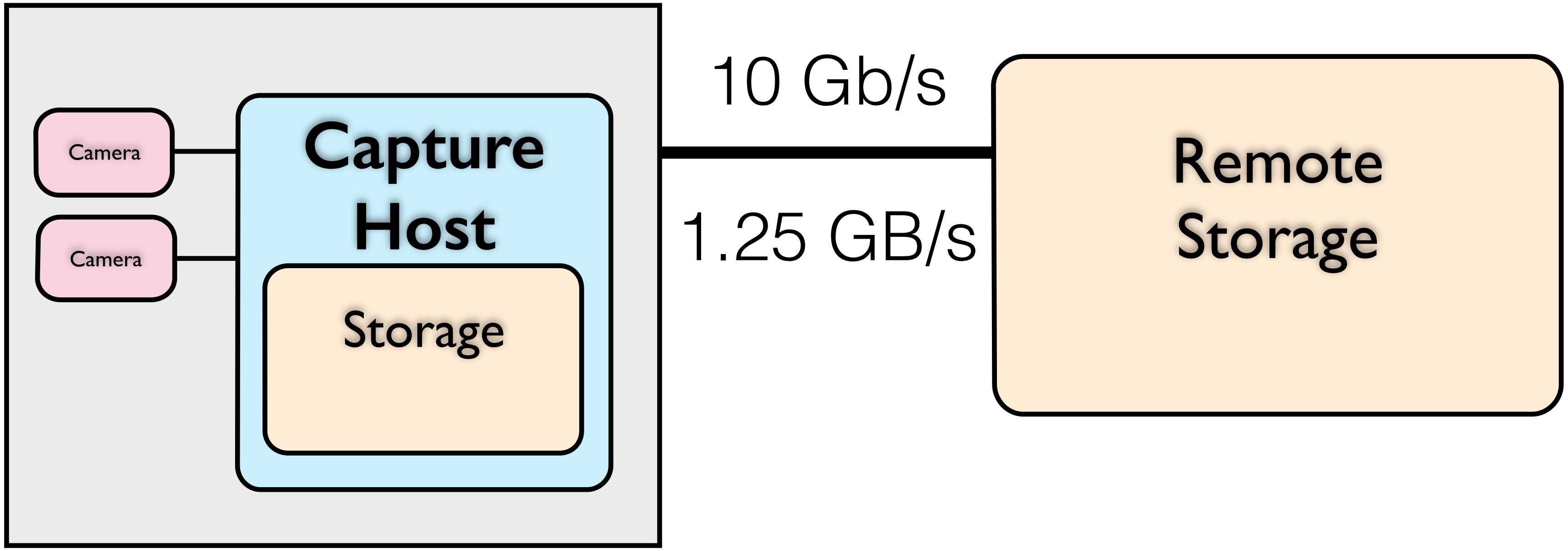


Transfer Volumes and Times

Data Volume / Time	1 Gbit	10 Gbit
150 MB / sec	1.5 sec	.15 sec
9 GB / minute	90 sec	9 sec
540 GB / hour	1.5 hours	9 minutes
~13 TB / day	1.5 days	3.6 hours

This assumes approximately theoretical maximum line speed - which never happens. Typically we see 60%.

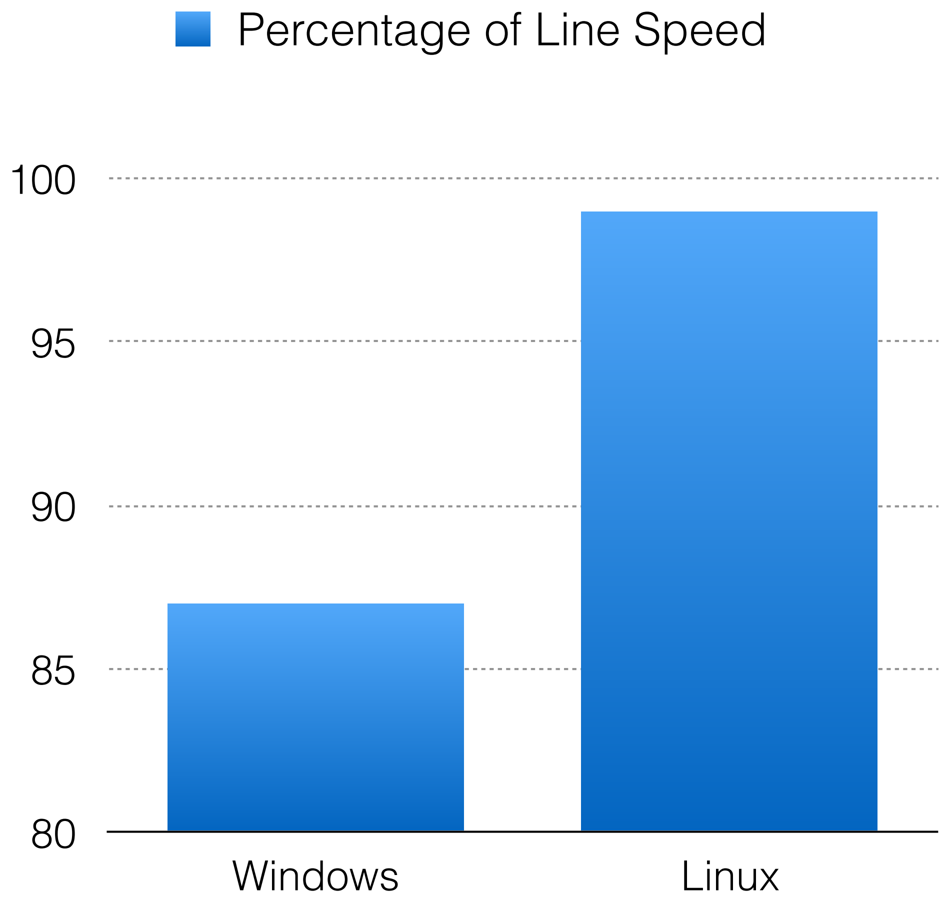
First : Get the Data Off



	pro	con
network mounted drives (ex. SMB)	simple	OS dependent
secure network file transfer (scp/sftp/rsync)	secure	encryption may slow transfer
unencrypted file transfer (ex. ftp)	fast	insecure

Operating Systems & Networking

- Extensive Network Streaming Tests
- Win7, Windows Server 2008 R2
- 10 Gbit/s fiber network
- same hardware
- No disk i/o involved



Networks are …

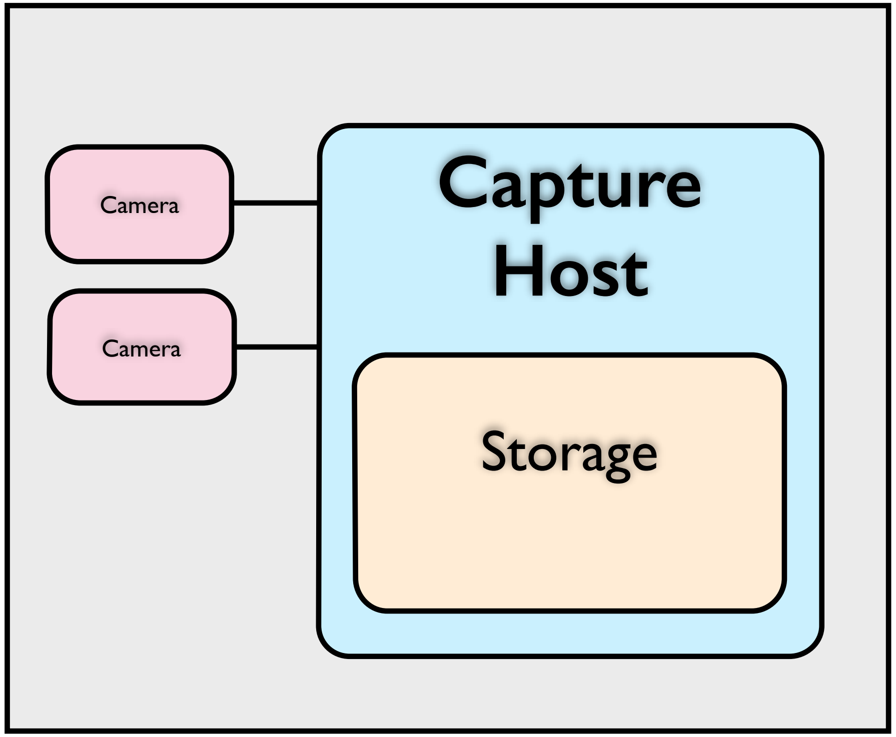
a
shared
resource!

Network File Transfer

- is **necessary** (capture host becomes unusable / full)
- **protocols are important** to keep in mind
- **network is a shared resource**

http://erindriver.travellerspoint.com/148/

Second : Bottlenecks again

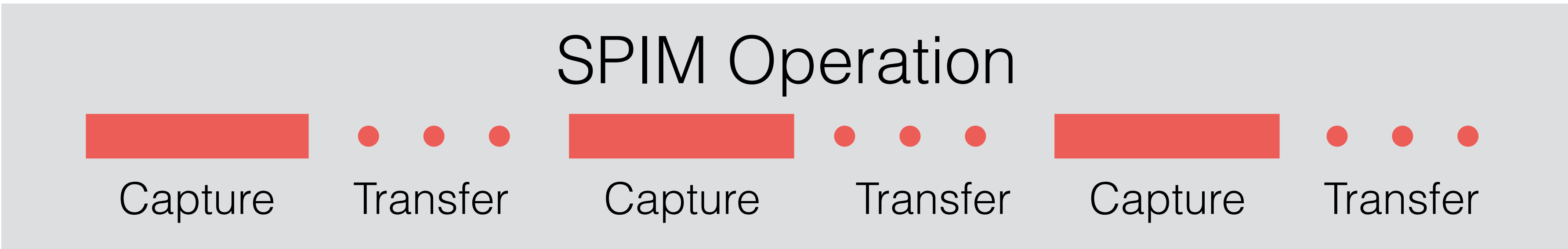


Spinning disk based storage

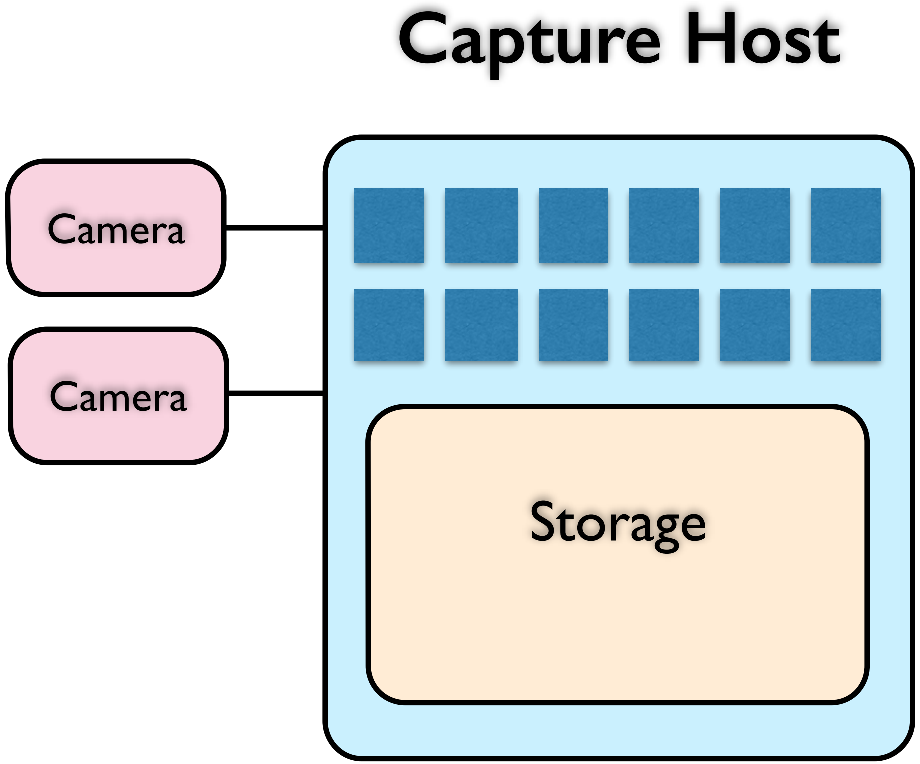
- Large Volume
- Comparatively cheap

SSD based storage

- Fast
- Small Volume
- Expensive



Second : Get it Small



- **cropping**
  (only keep what you need)
- **fusion + deconvolution**
  (n stacks become 1)
- **compression**
- **...**

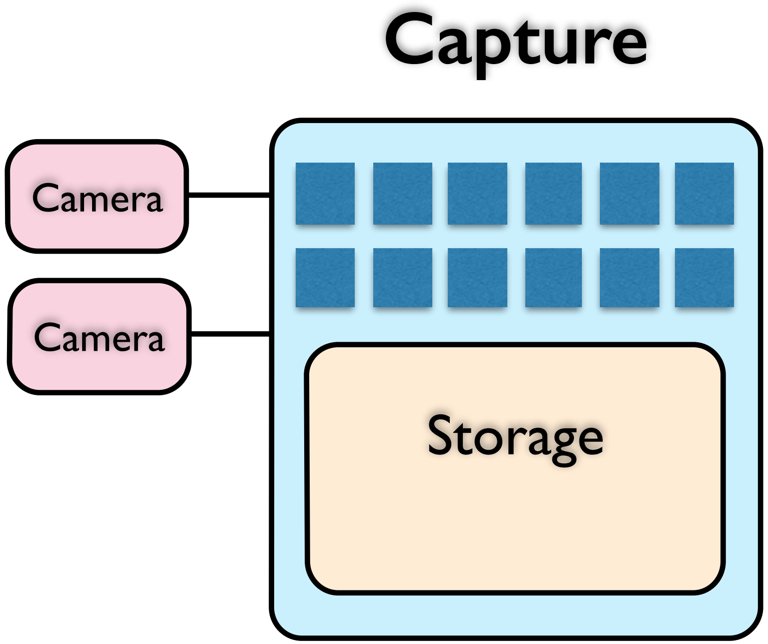
Reduce data volume **before** any network or disk!

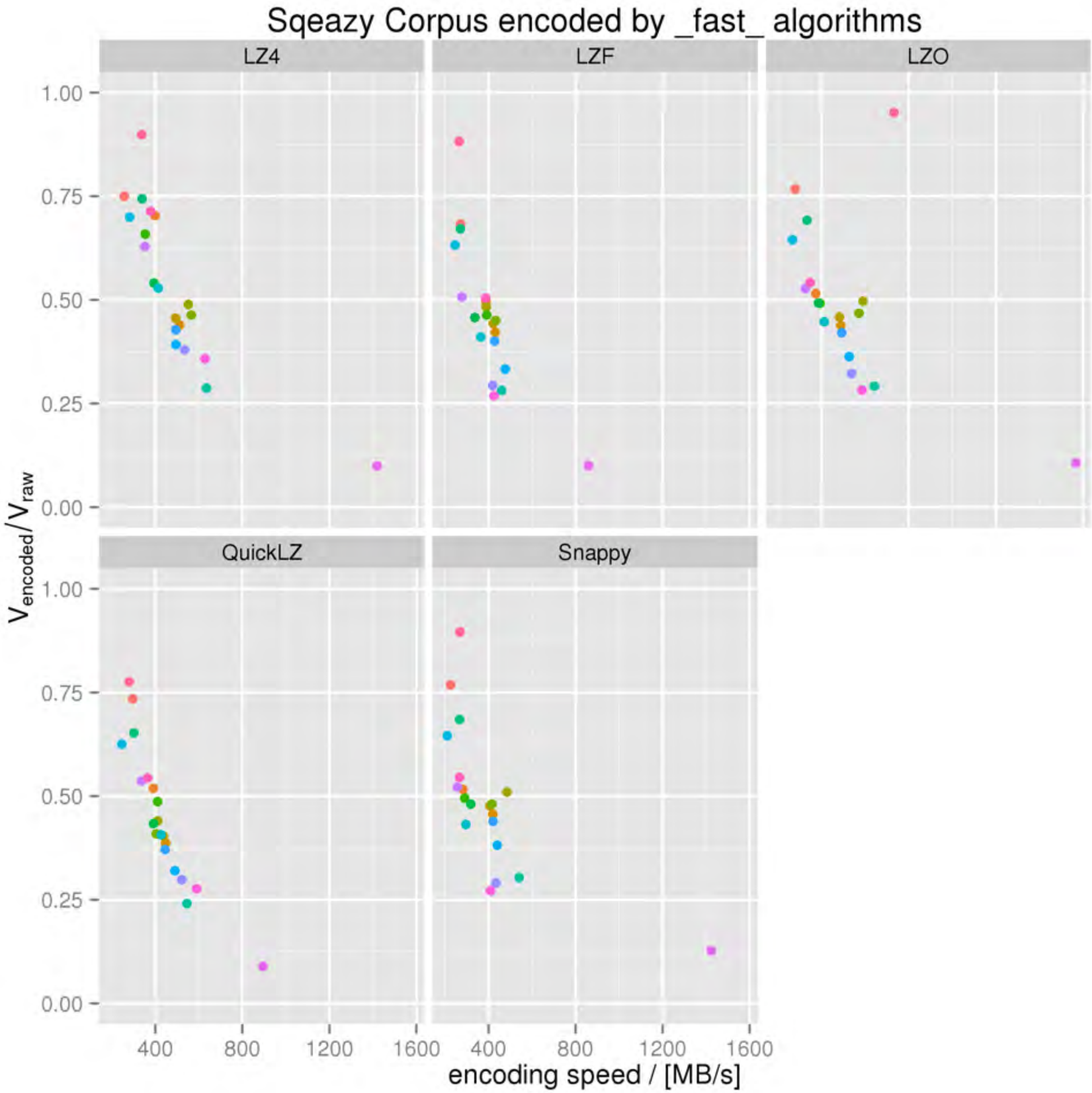
Compression : Demonstration

Please zip a SPIM dataset of your choice!

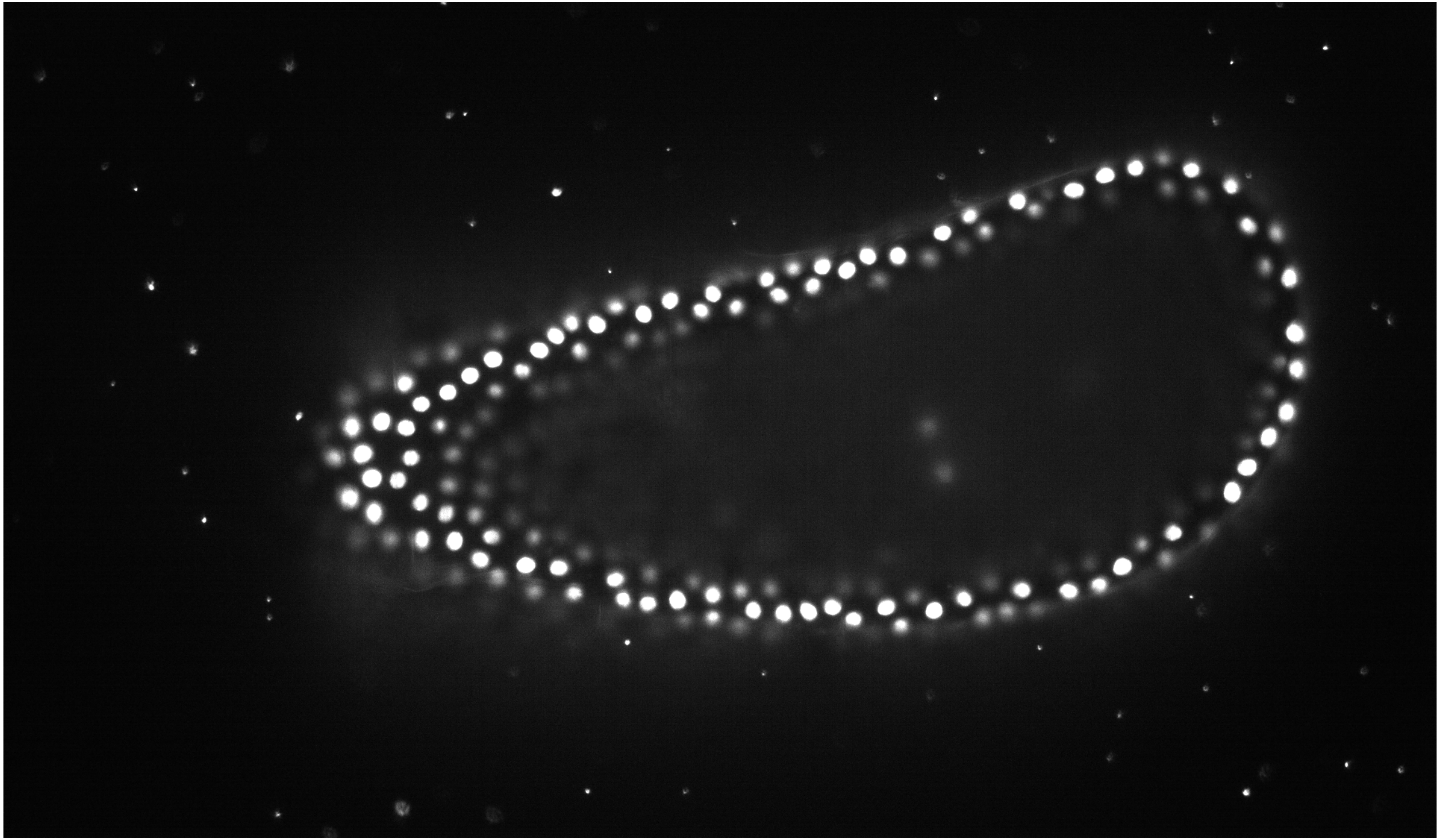
How long did it take?
How small is the compressed data?

Compression : Fast

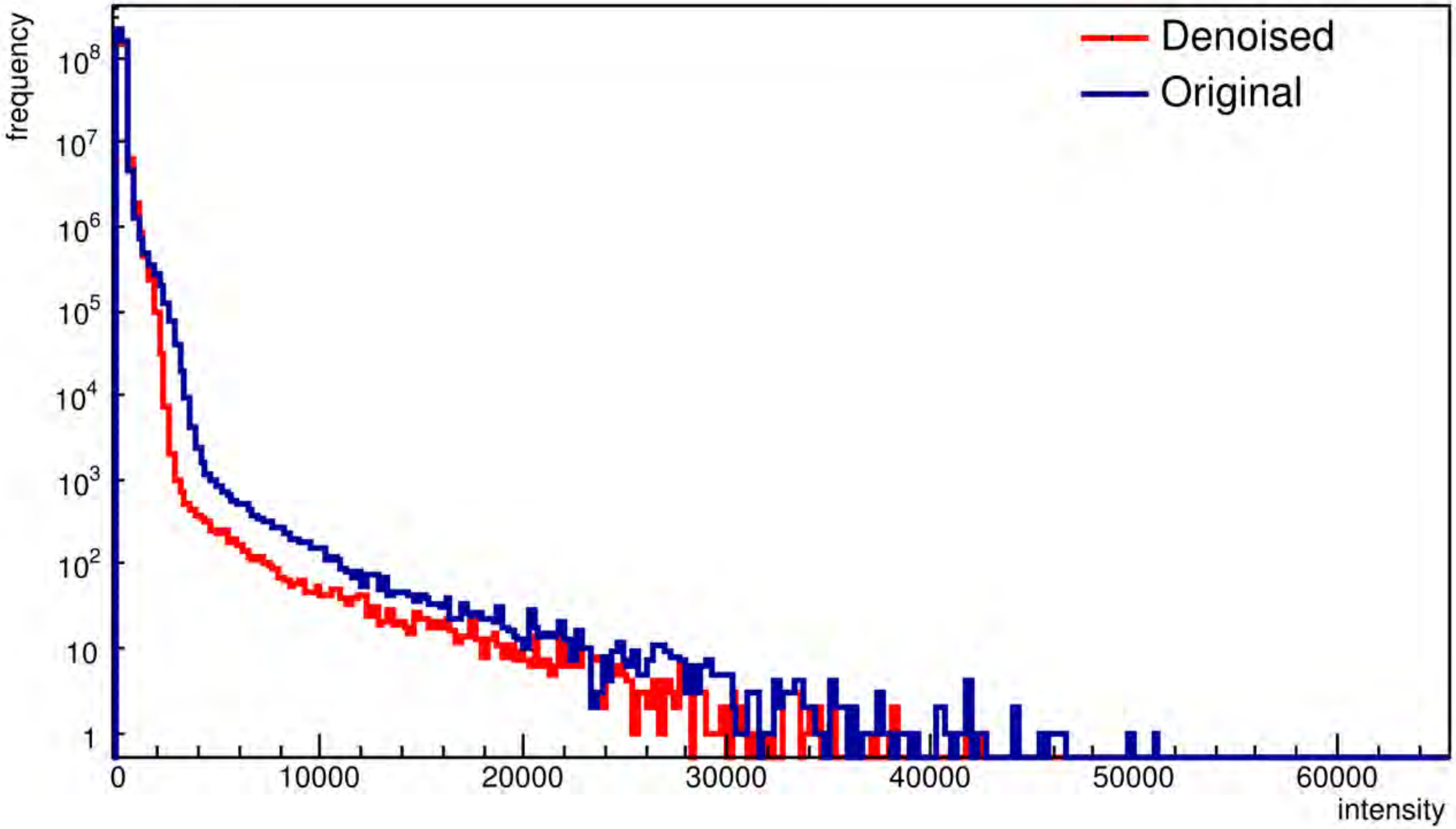




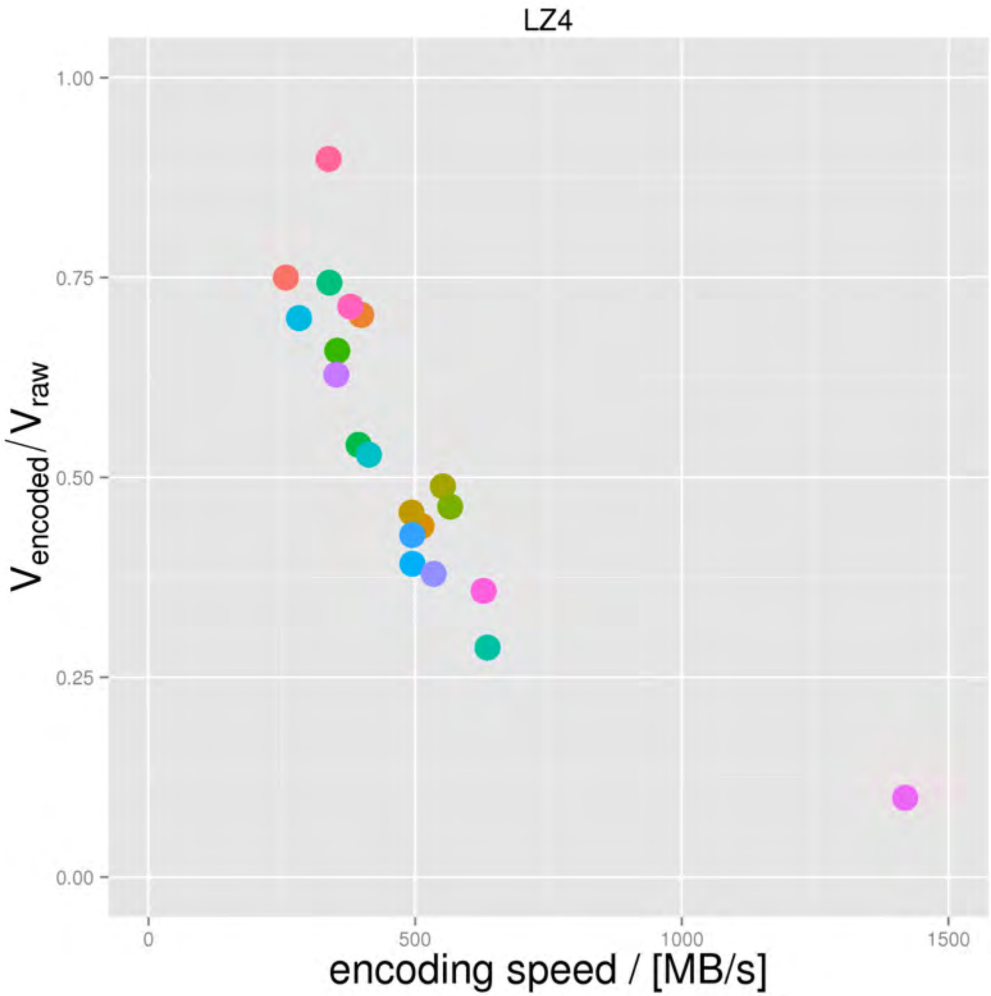
Compression : Noise?



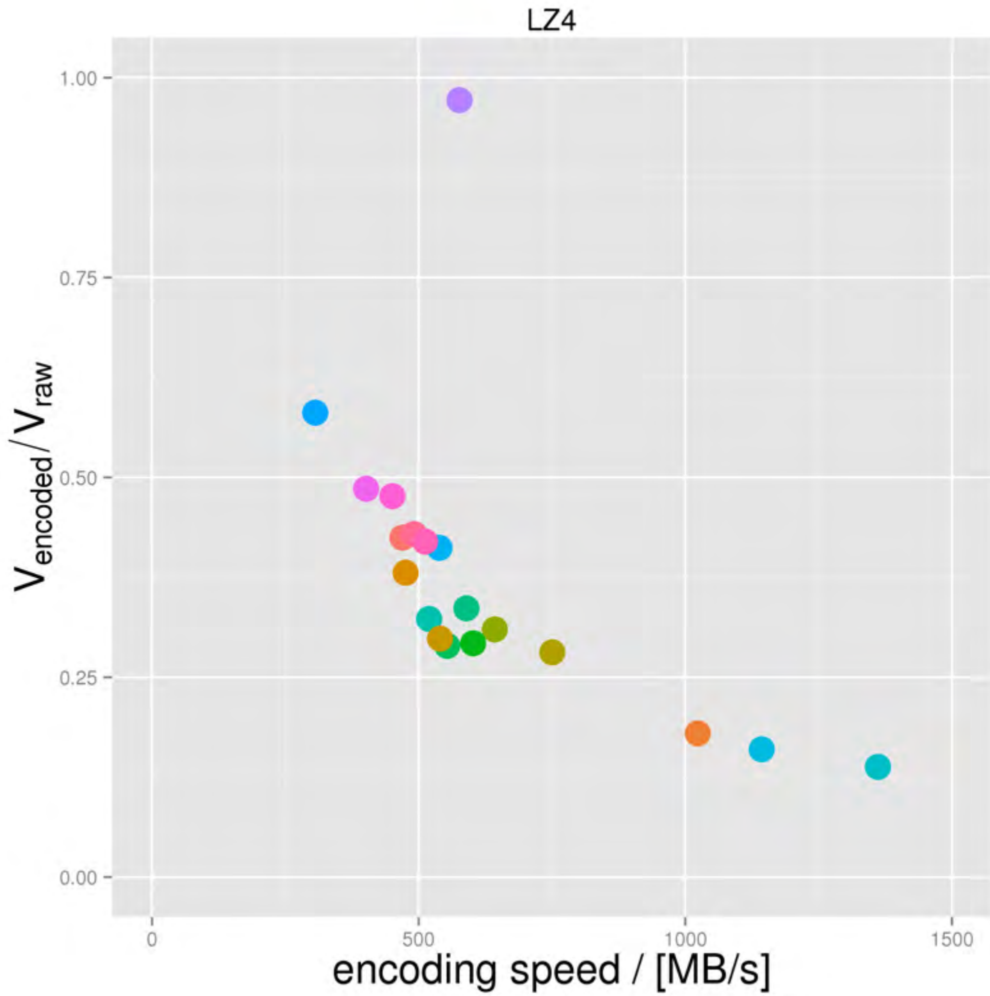
Compression : Denoised



Compression : Denoised

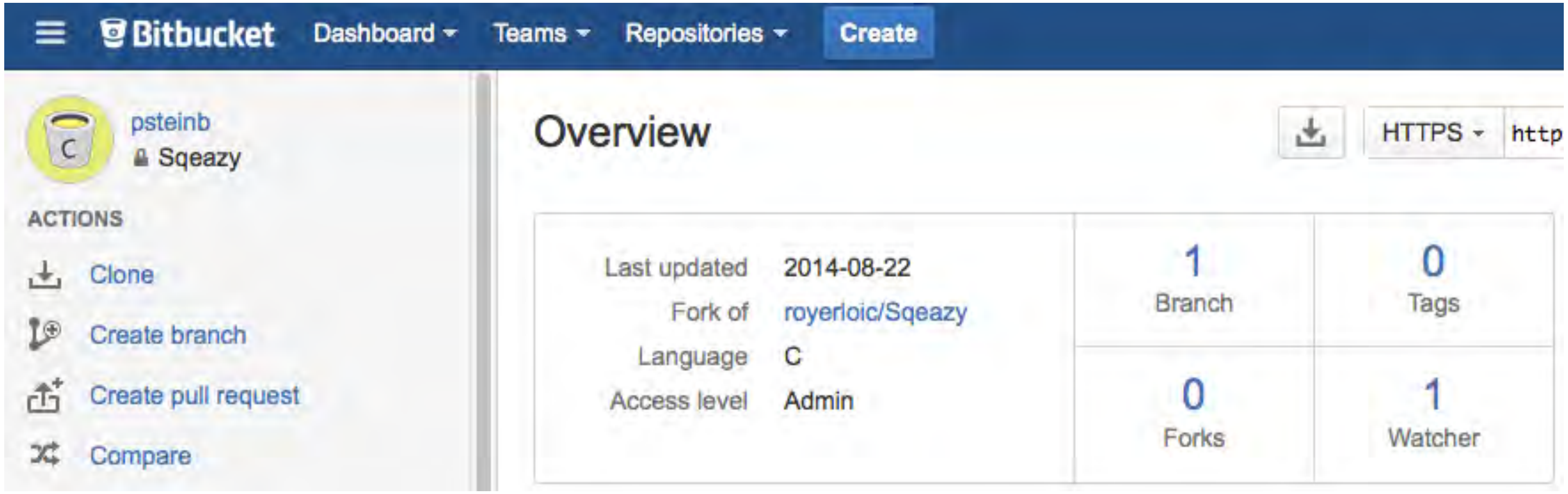


Original



Denoised

Compression : Sqeazy



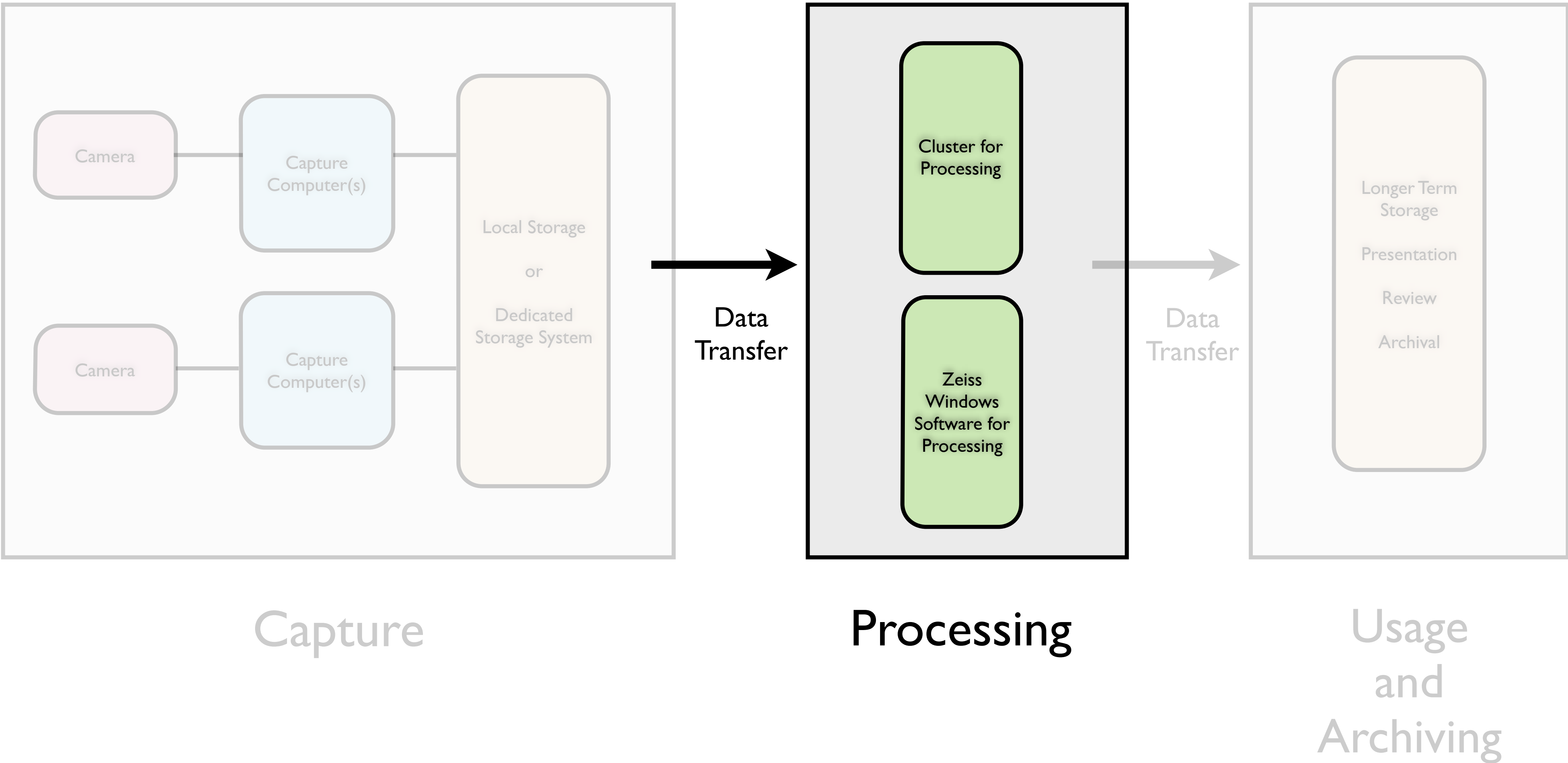
- pipeline standard compression algorithms fast
- soon to be open-sourced
- currently:
  3x lossless compression
  10x lossy compression

initiated by:

Loic Royer

Martin Weigert

SPIM Dataflow

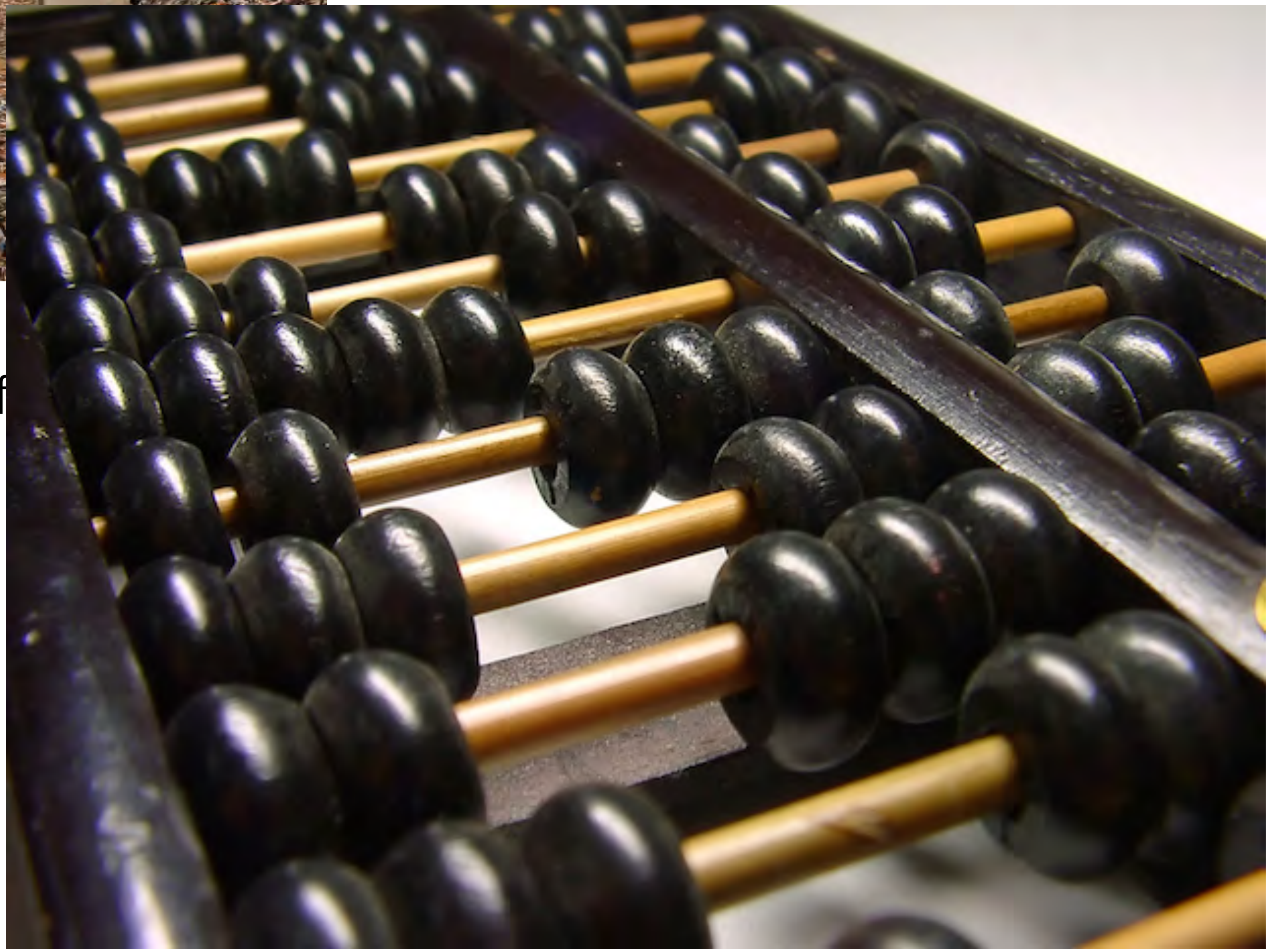


HPC for SPIM

Lots of image data

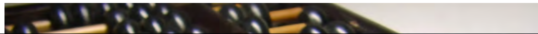
HPC for SPIM

Lots of



CPU intensive

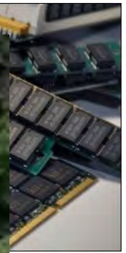
HPC for SPIM



Lot

High memory footprint

HPC for SPIM

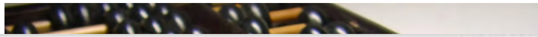


Lot

tprint

High I/O

HPC for SPIM



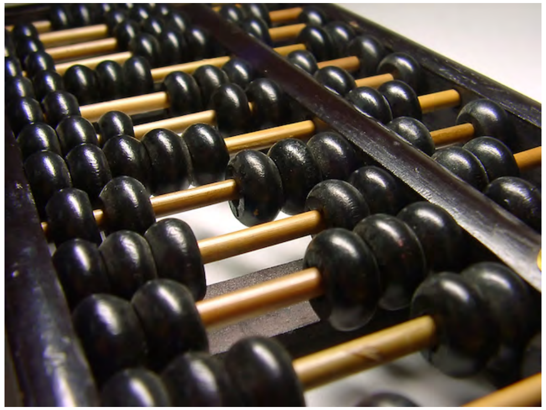
Lots of ... footprint

H

GPUs are promising

HPC for SPIM

Lots of image data

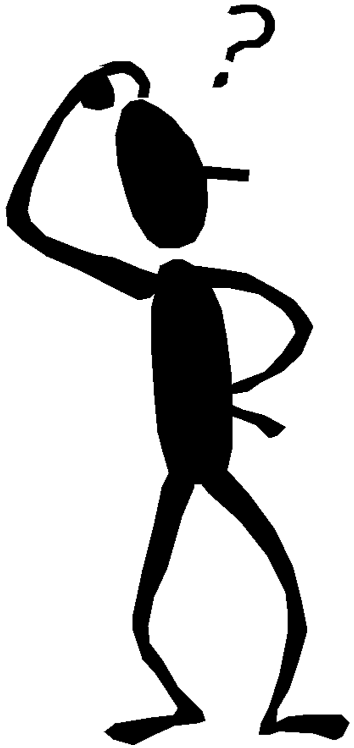


CPU intensive

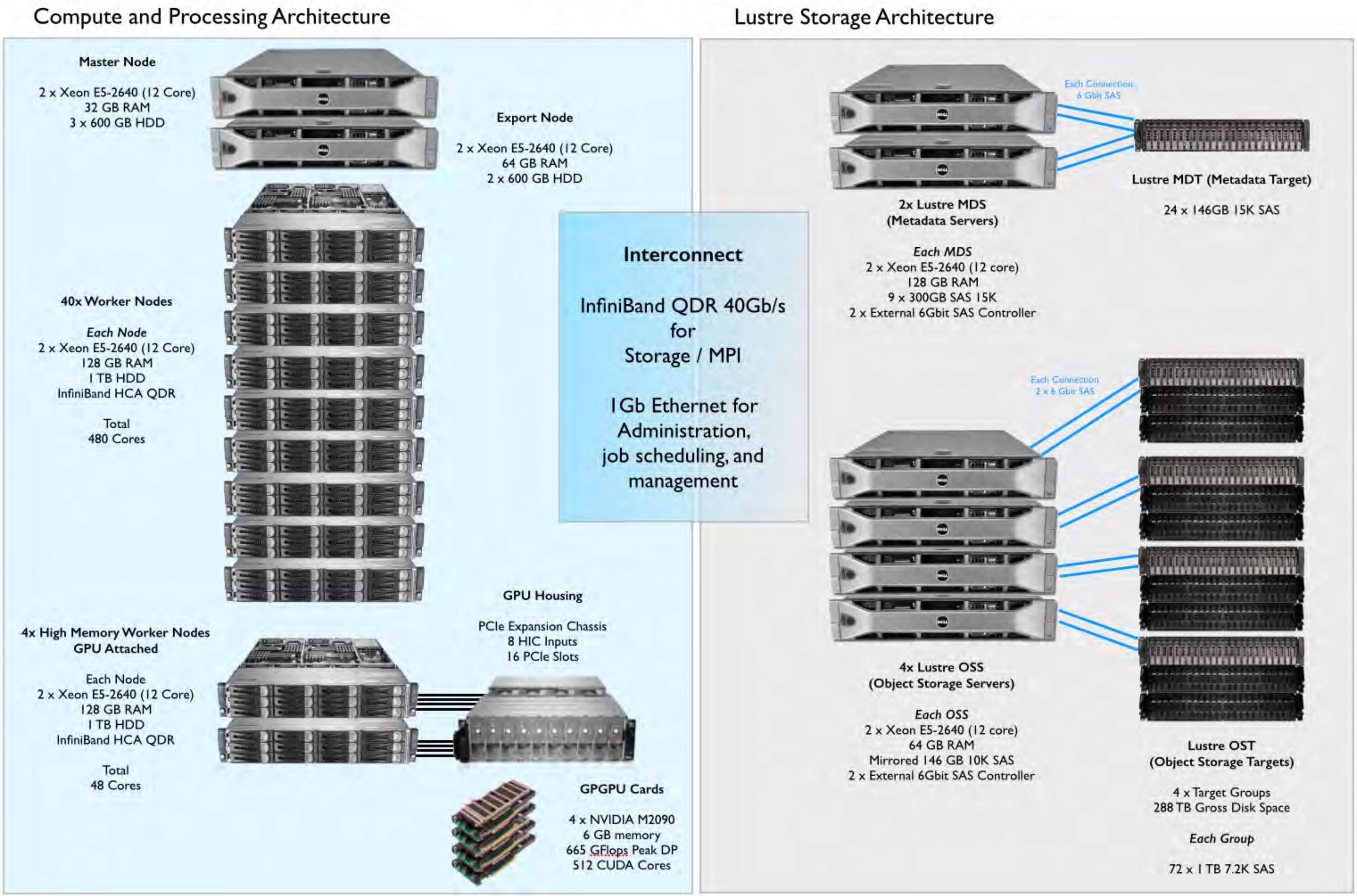
High memory footprint

High I/O

GPUs are promising



Cluster Architecture



Cluster Architecture

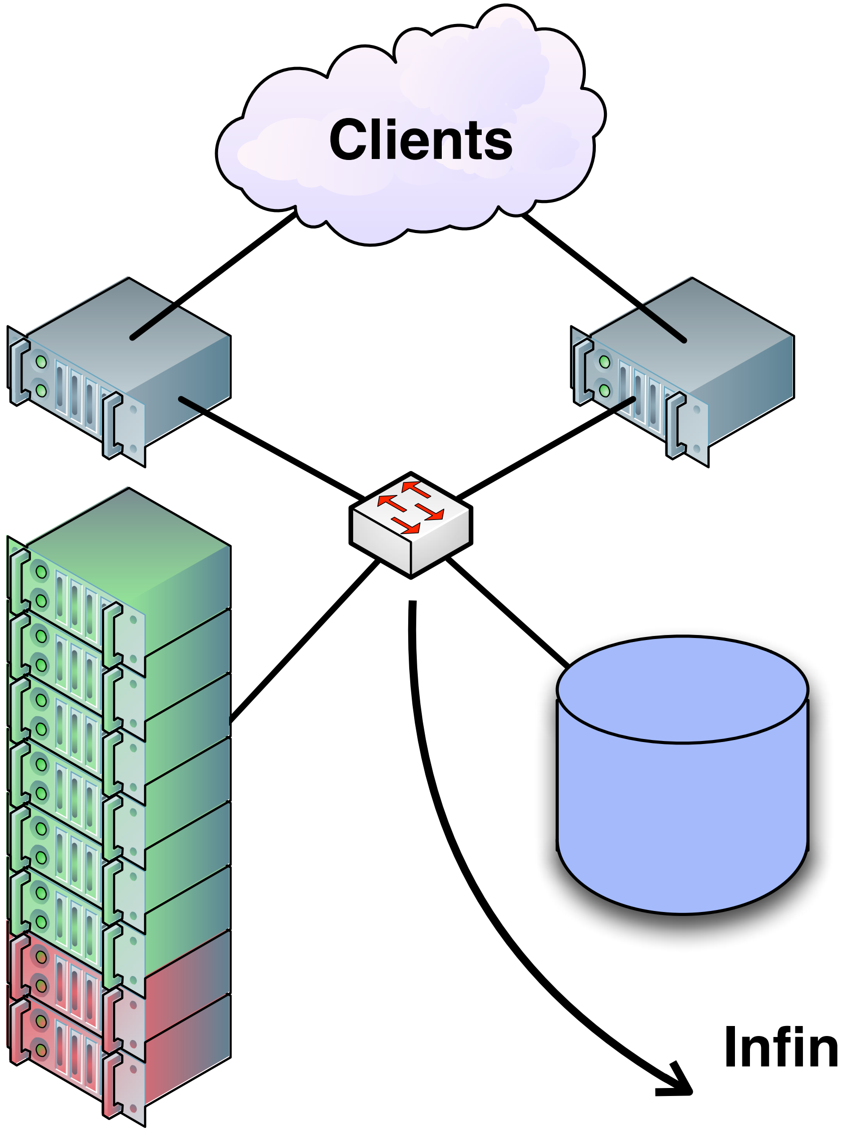
Head node

Job management
Cluster monitoring

Worker nodes

40x:
* 12 cores
* 128 GB RAM
* 1 TB HDD

4x:
* 12 cores
* 128 GB RAM
* 1 TB HDD
* GPU



Export node

10 GbE

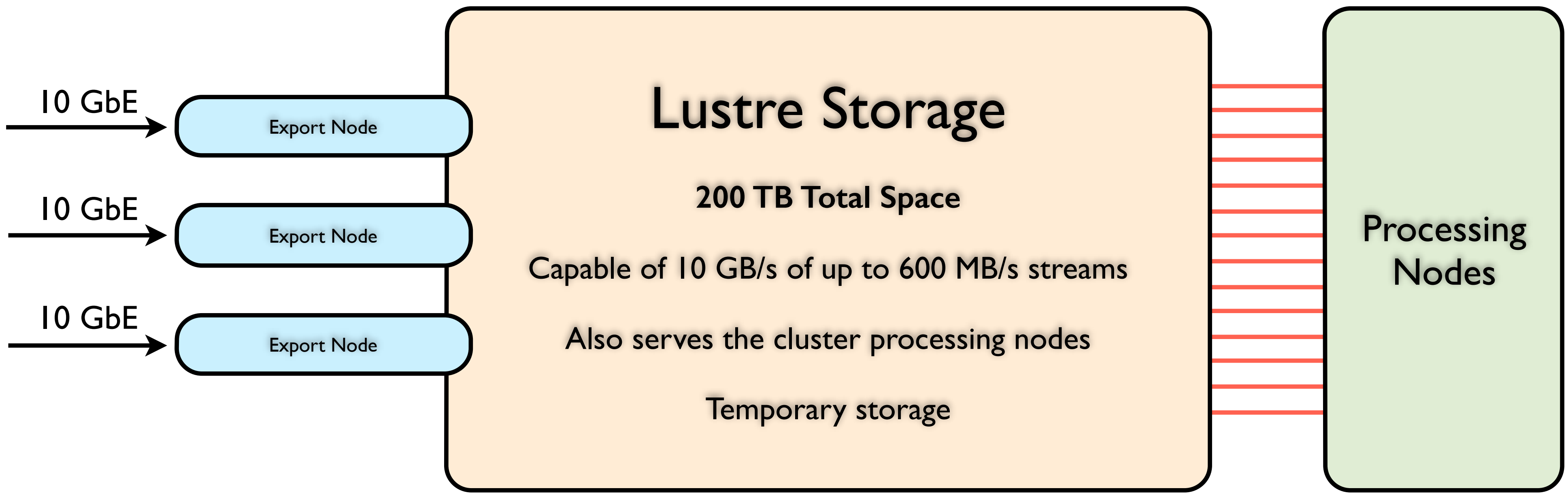
Disk server

200 TB net space (RAID 6)
10 GB/s

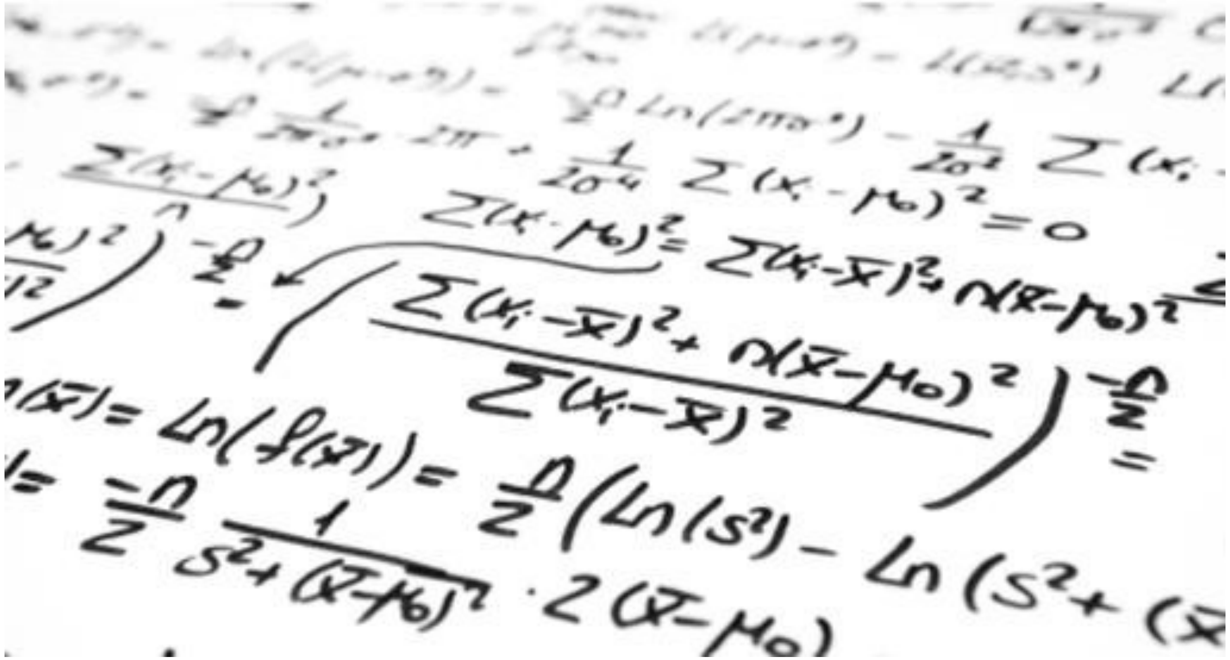
InfiniBand

non-blocking
400-600 MB/s (up to saturation)

MPI-CBG Cluster Storage



Resource Usage



- The cluster was made available on Feb 2013
- Total number of jobs done: 6,852,661
- Average throughput: 462 jobs/h
- CPU time consumed: 151y 46d 10h 59m 12s
- Average CPU time: 11m 35s

Lessons Learned

- Cluster design is very important - think before you buy
- I/O is critical to move data in and out of the cluster
- I/O is VERY critical to access data from the cluster
- Storage requirements are huge, both inside and outside the cluster
- GPU resources might be useful but you need enough to make it practical

Workstations

If/when a cluster is not an option, check what your WS can do.

Example Data PC

- 12 cores
- 128 GB
- 4x 2TB (RAID 5)

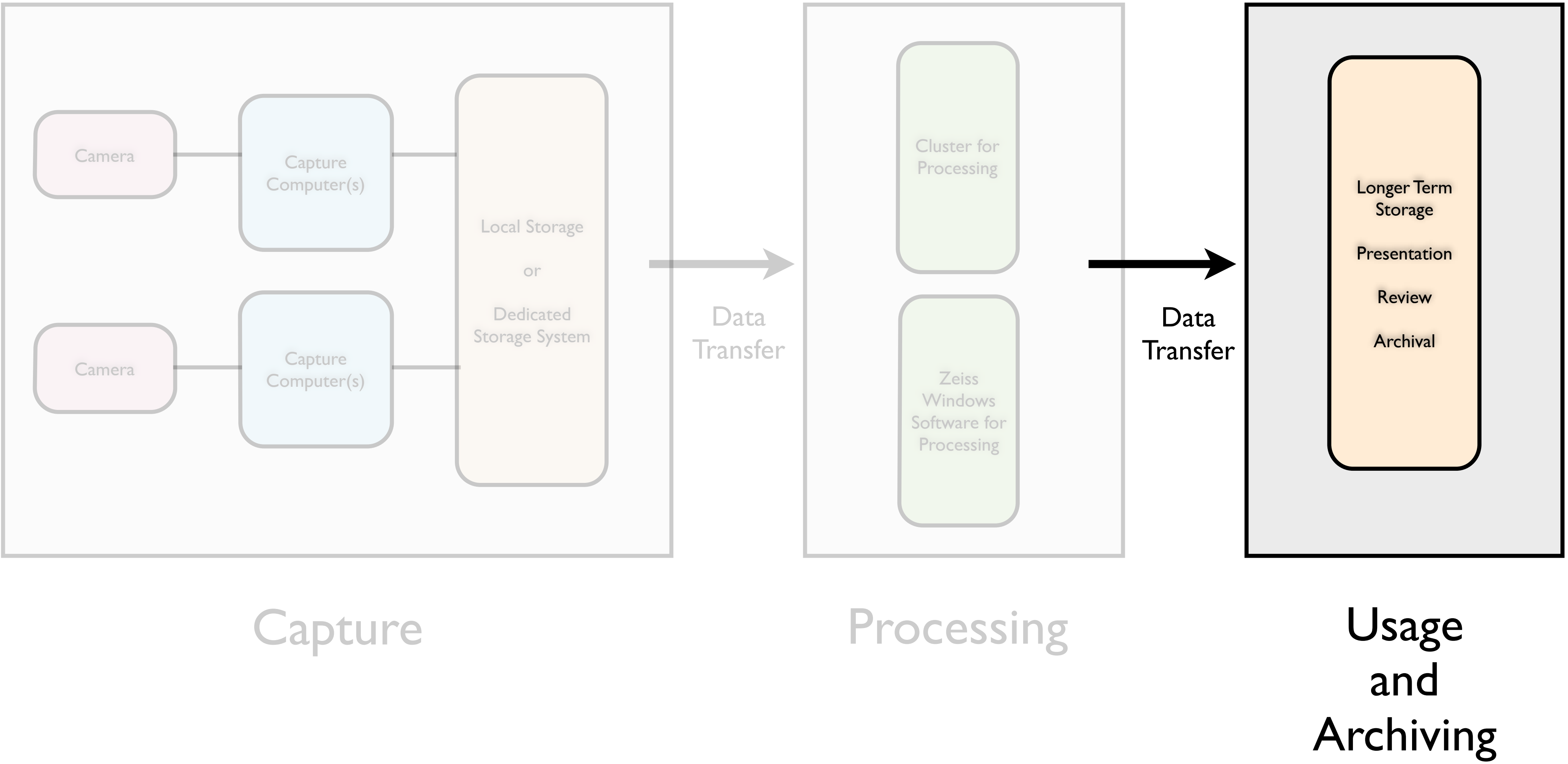
Pros:

- Rather cheap
- Fine for small datasets
- Convenient for data visualisation

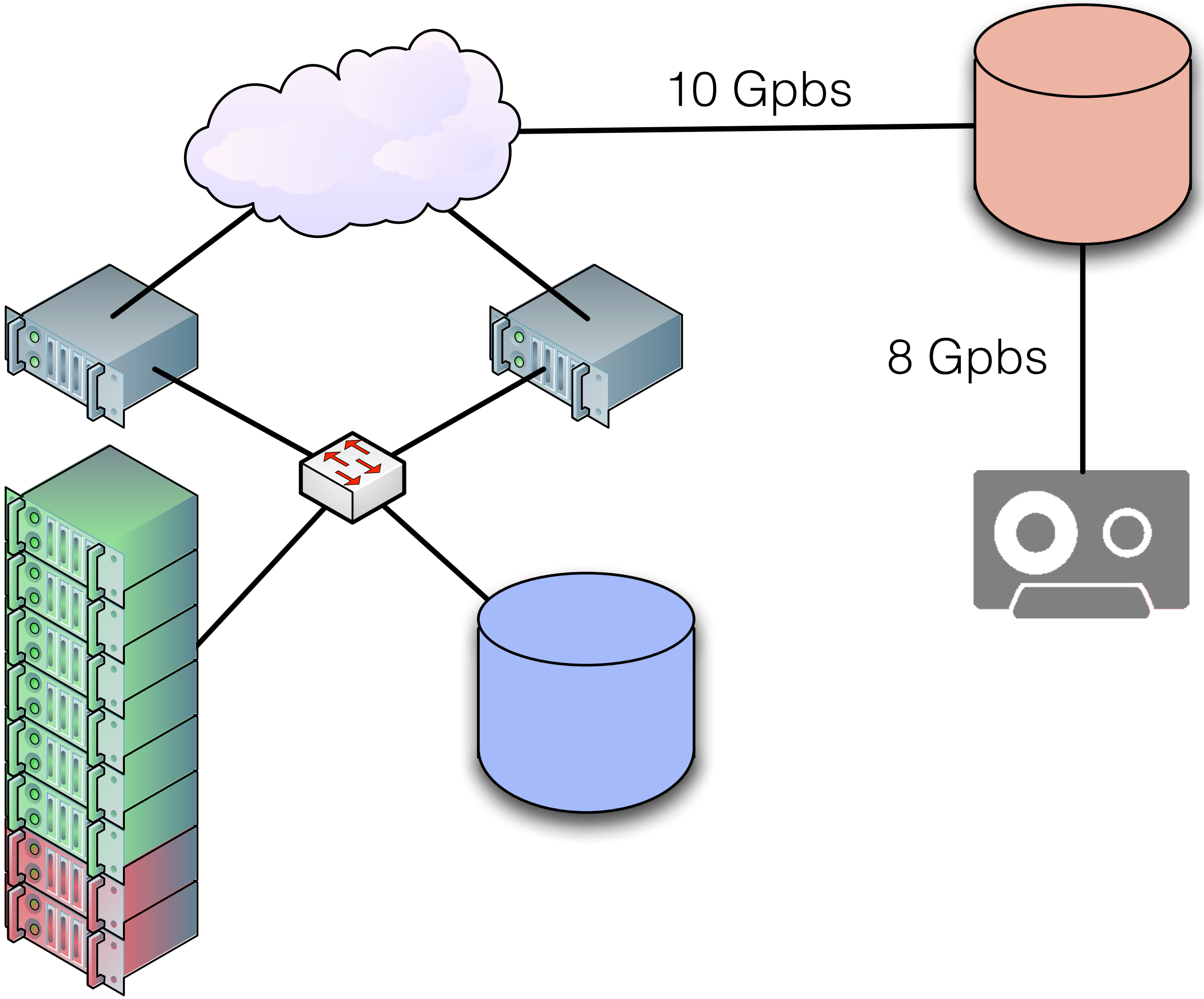
Cons:

- Limited computing resources
- Limited storage capacity and bandwidth

SPIM Dataflow



Current Infrastructure



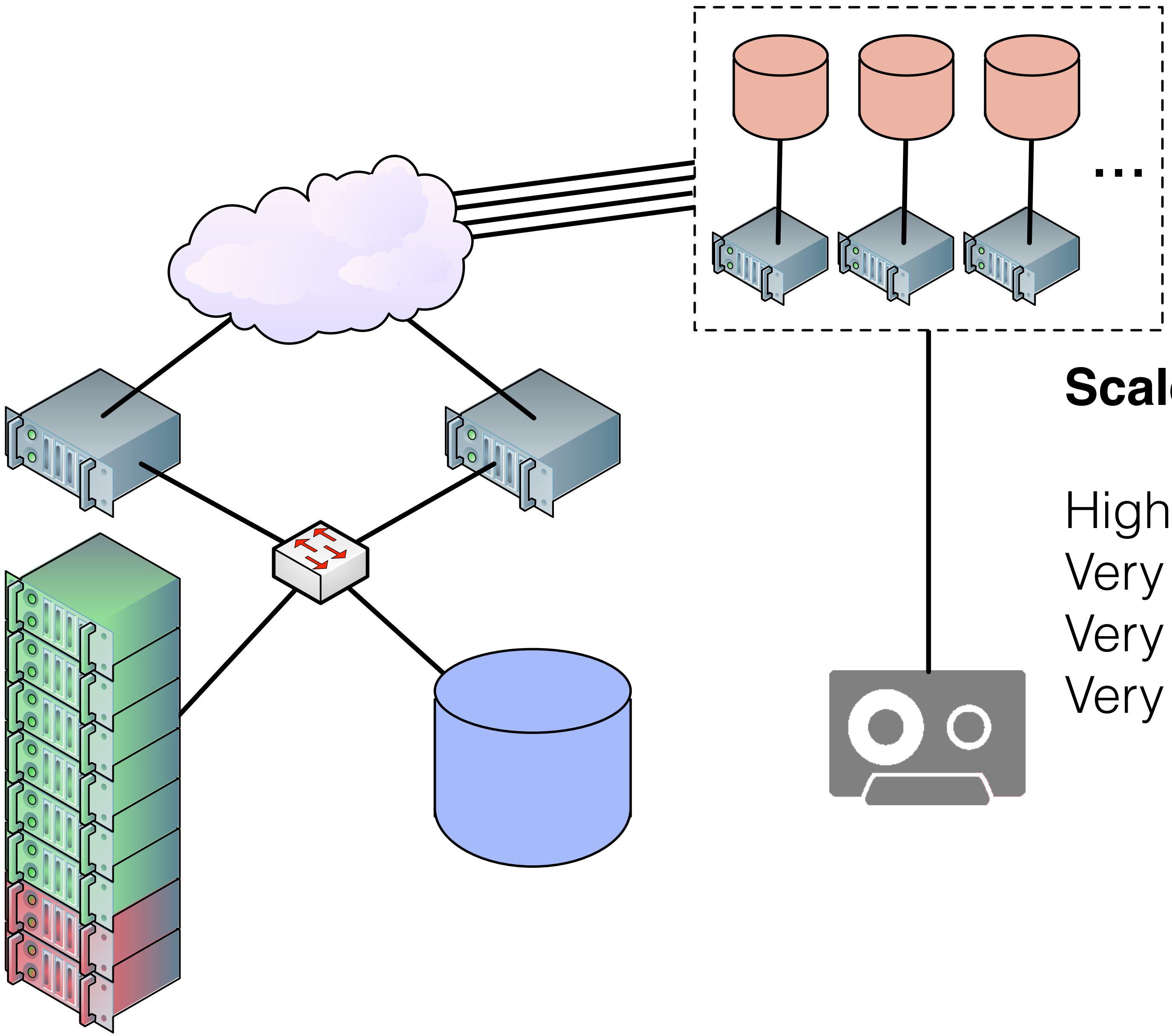
Fileserver

Visible network-wide
High capacity (900 TB)
Robust (no SPOF)
Backed up daily

Tape library

Second copies
Long term storage

Future Plans



Scale-out NAS

Highly scalable
Very high capacity (10 PB)
Very high bandwidth
Very robust (no SPOF)

Taking it Home - External Drives
4TB transfer

Protocol

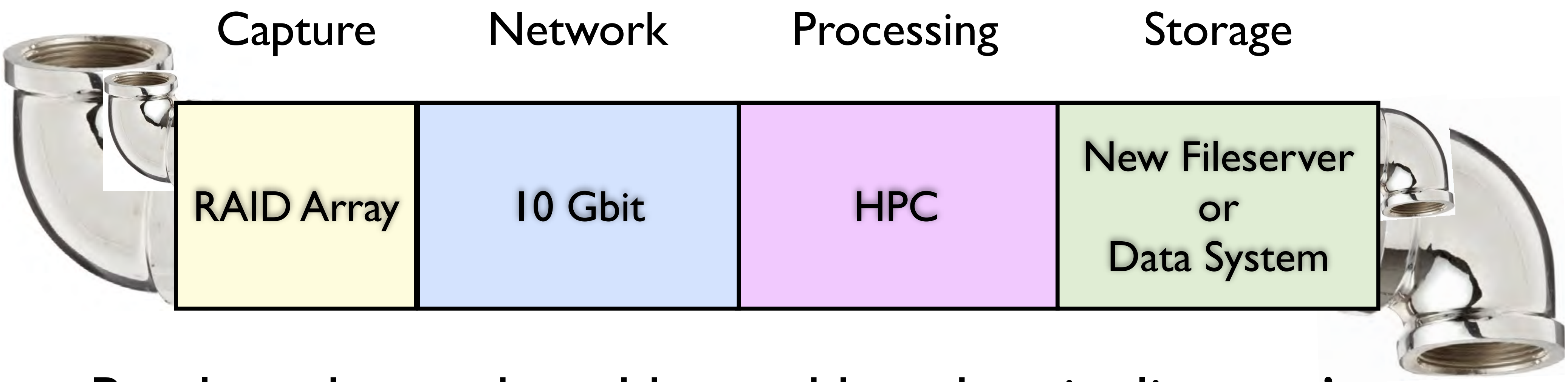
USB 3.0 (600 MB / sec)	1.85 hours
USB 2.0 (60 MB / sec)	18.5 hours

Drive Speed

WD Black (130.4 MB / sec)	8.52 hours
Hitachi Deskstar (102.95 / MB sec)	**10.79 hours**
Samsung SSD - 1 TB (550 MB /sec)	2.02 hours

The limitation is the <u>slower</u> of the two!

Bottlenecks at Each Stage



Bottlenecks can be addressed but the pipeline can't be made infinitely wide

Experiment Design and Data Management become extremely important!

Compression can help but the issue remains

IT Planning for SPIM
(or "things to think about before I capture")

What is the practical output of your SPIM setup?

How long are you planning on capturing at a time?

What processing do you need to do on your data?
How fast do you need to complete the processing?

What is the data you will consider primary data for publication?

How will you present your data to the world or turn it into movies or results more easily shared?

Discussion and Questions