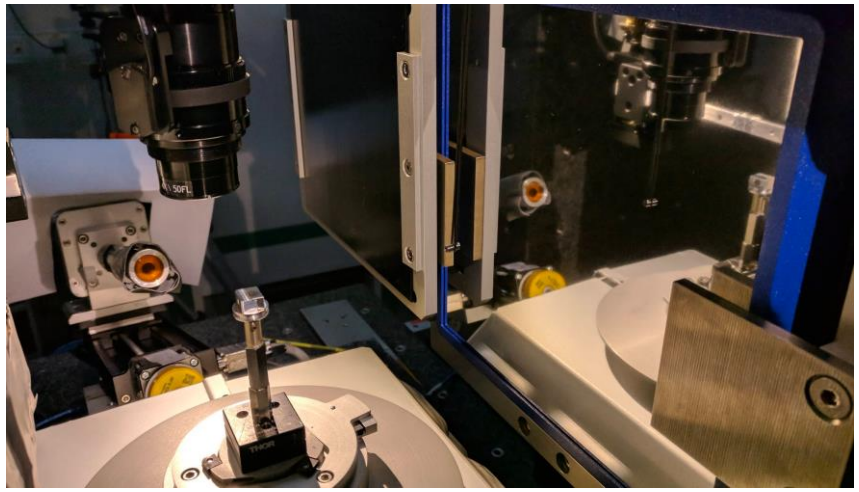

A compression scheme for radio data in high performance computing

K. Masui [a,b,*], M. Amiri [a], L. Connor [c,d,e], M. Deng [a], M. Fandino [a], C. Höfer [a], M. Halpern [a], D. Hanna [f], A.D. Hincks [a], G. Hinshaw [a], J.M. Parra [f], L.B. Newburgh [d], J.R. Shaw [a,c], K. Vanderlinde [e,d]

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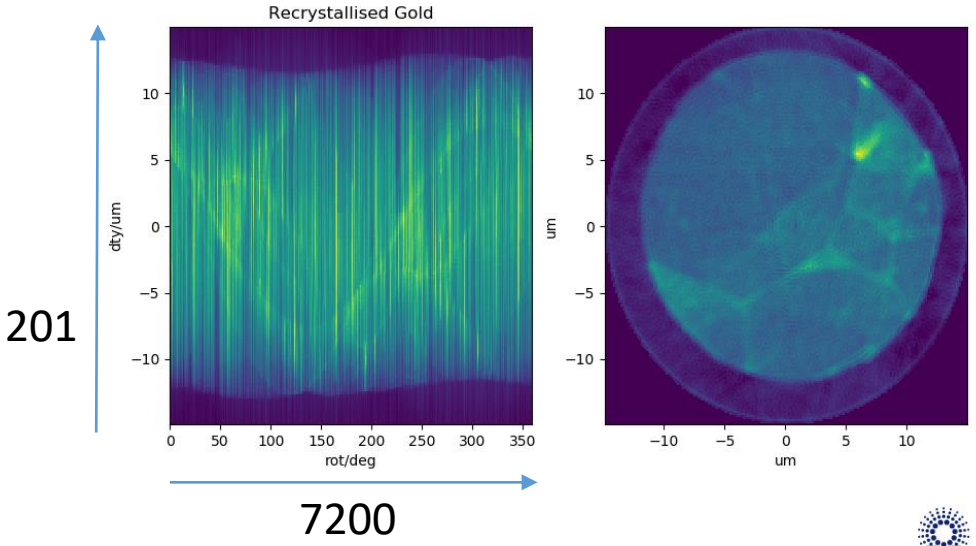
Information #6

To ensure highest stability at full frame rates, DECTRIS strongly advises using *bslz4* compression.

1 day XRDCT : [30] [201] [7200] [2162] [2068]

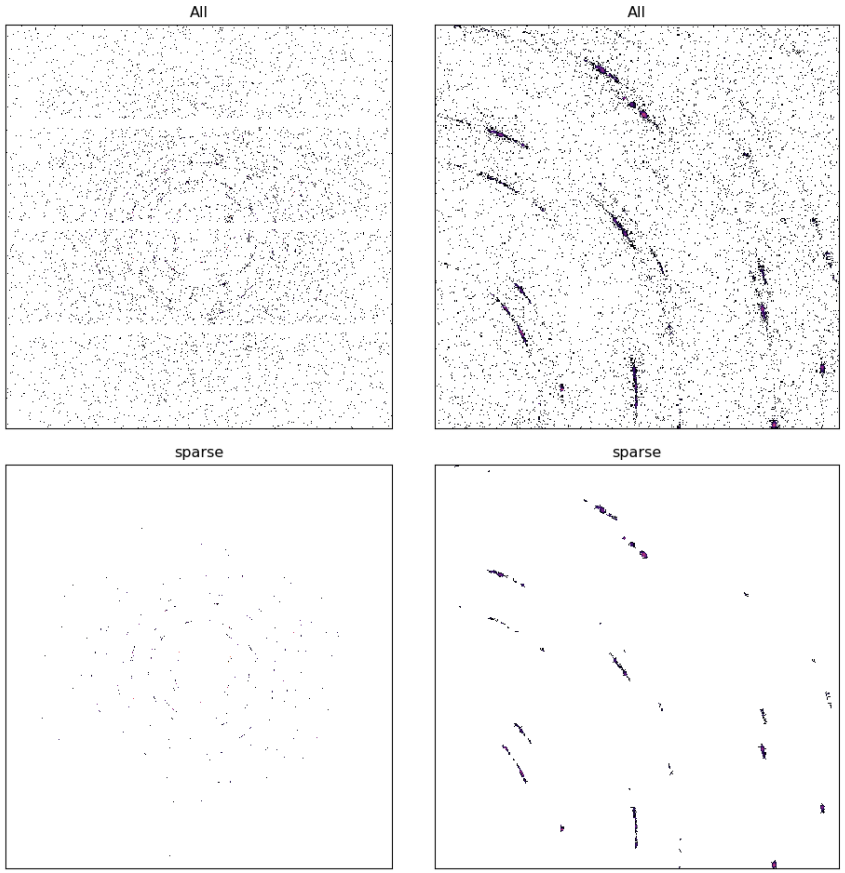
500 fps

Data rate
(raw uncompressed)
… 4 GB/s
… 14 TB / hour
… 345 TB / day



Diffraction data : Average bits per pixel is very low

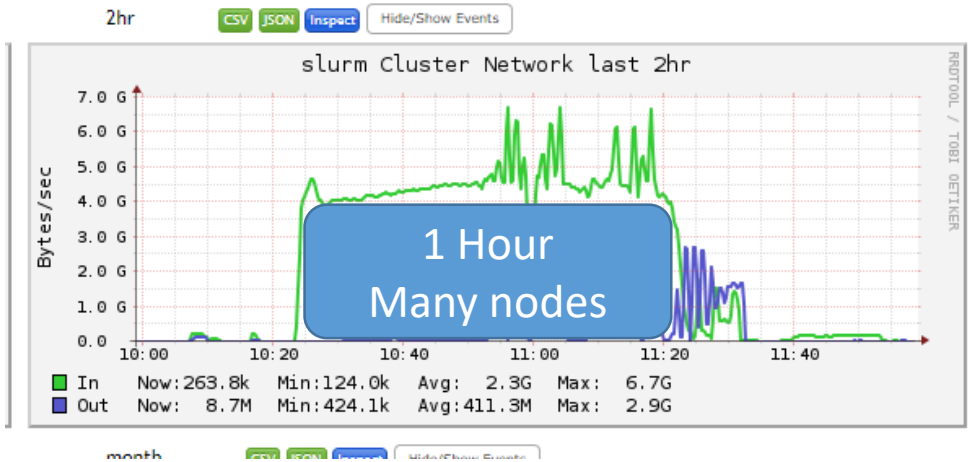
Peak ~ 10,000 ph/px
Background <0.1 ph/px



Recent example:

Dectris bslz4 in hdf5 containers
10 - 45X compression

~500 TB raw -> 13 TB disk -> 62 GB sparse



CPU data reduction from BSLZ4

- “Typically” 1 GB/s/core for LZ4 decompression*
- 1 core is 4X slower than the detector
- Stream benchmark gives >10 GB/s single core (50 GB/s all cores)
- GPFS supplies hdf5 data at 2 GB/s
  - Network storage can offer 20 – 80 GB/s uncompressed
  - Needs 20-80 cores

- GPU’s are useful for image processing anyway (background estimate, etc)

(* ignoring: LZ4 from Intel IPP, threading per frame, reductions inside the decompressor)

GPU decompression : nvcomp offers LZ4

- BSLZ4 HDF5 plugin uses an internal block size of 8 kB

- ESRF Lima uses 1 frame hdf5 chunk-size (2162x2068 pixels)
  - u16 : 8.5 MB = **1094**.5859375 blocks
  - u32 : 17.1 MB = **2189**.171875 blocks

- Scan through chunks on CPU to locate internal blocks
  - 58 µs / frame h5py for IO
  - 76 µs / frame with scanning (overlap with IO?)
  - … ROI decompression

https://github.com/NVIDIA/nvcomp

Tesla V100-SXM2-32GB, 1000 frames, 16 bit

```
==1769648== Profiling application: python3 -O test_itercuda.py /tmp_14_days/eiger_0000.h5 /entry_0000/ESRF-ID11/eiger/data
==1769648== Profiling result:
            Type  Time(%)      Time     Calls       Avg       Min       Max  Name
 GPU activities:   41.37%  74.668ms      1000  74.668us  67.931us  117.72us  h5lz4dc
                   35.20%  63.543ms      1000  63.543us  62.844us  64.507us  shuf_8192_16
                   13.57%  24.486ms      1000  24.485us  23.772us  25.628us  reduce_kernel_stage1
                    6.93%  12.505ms      2000  6.2520us  1.2470us  12.704us  [CUDA memcpy HtoD]
                    1.34%  2.4179ms      1000  2.4170us  2.1400us  5.4040us  simple_shuffle_end
                    0.91%  1.6496ms      1000  1.6490us  1.4360us  2.0440us  reduce_kernel_stage2
                    0.69%  1.2366ms      1000  1.2360us  1.2150us  1.3120us  [CUDA memcpy DtoH]

      API calls:   44.70%  254.97ms         1  254.97ms  254.97ms  254.97ms  cuCtxCreate
                   15.60%  88.971ms      3003  29.627us  9.1110us  291.51us  cuMemFree
                   10.42%  59.418ms         1  59.418ms  59.418ms  59.418ms  cuCtxDetach
                    9.88%  56.362ms      5000  11.272us  9.2210us  43.504us  cuLaunchKernel
                    7.55%  43.067ms      2000  21.533us  13.839us  154.85us  cuMemcpyHtoD
                    5.68%  32.404ms      3003  10.790us  5.3960us  4.9651ms  cuMemAlloc
                    4.88%  27.857ms      1000  27.856us  25.767us  45.389us  cuMemcpyDtoH
                    0.72%  4.1128ms      5000     822ns     617ns  5.7850us  cuFuncSetBlockShape
                    0.26%  1.4547ms         7  207.81us  172.81us  297.96us  cuModuleLoadDataEx
                    0.25%  1.4231ms      3011     472ns     336ns  6.2590us  cuCtxGetDevice
                    0.04%  233.70us         7  33.386us  17.159us  106.24us  cuModuleUnload
                    0.00%  17.737us        22     806ns     295ns  2.6830us  cuDeviceComputeCapability
                    0.00%  16.996us        31     548ns     283ns  1.8260us  cuDeviceGetAttribute
                    0.00%  10.711us        10  1.0710us     554ns  1.5800us  cuModuleGetFunction
                    0.00%  8.9610us         2  4.4800us  3.8030us  5.1580us  cuDeviceGetPCIBusId
                    0.00%  2.2600us         1  2.2600us  2.2600us  2.2600us  cuCtxPopCurrent
                    0.00%  2.1060us         3     702ns     569ns     836ns  cuDeviceGet
                    0.00%  2.0090us         3     669ns     394ns     953ns  cuDeviceGetCount
                    0.00%  1.2480us         1  1.2480us  1.2480us  1.2480us  cuCtxPushCurrent
```

LZ4 : 120 GB/s

~180 µs/frame
11X detector

The European Synchrotron | ESRF

GeForce GTX TITAN X, 1000 frames, 16 bit

```
==49242== Profiling application: python -O test_itercuda.py /data/id11/nanoscope/blc12454/id11/WAu5um/WAu5um_DT3/scan0001/eiger_
==49242== Profiling result:
Time(%)      Time     Calls       Avg       Min       Max  Name
 38.21%  189.53ms      1000  189.53us  188.00us  193.03us  shuf_8192_16
 36.68%  181.92ms      1000  181.92us  169.60us  234.21us  h5lz4dc
 13.19%  65.440ms      1000  65.440us  63.393us  68.129us  reduce_kernel_stage1
  9.09%  45.078ms      2000  22.539us  1.1840us  52.289us  [CUDA memcpy HtoD]
  1.30%  6.4596ms      1000  6.4590us  6.3360us  7.0720us  simple_shuffle_end
  0.79%  3.9153ms      1000  3.9150us  3.6160us  7.1040us  reduce_kernel_stage2
  0.54%  2.6655ms      1000  2.6650us  1.9200us  9.6960us  [CUDA memcpy DtoH]
  0.20%  989.96us      1000     989ns     608ns  8.1290us  [CUDA memcpy DtoD]

==49242== API calls:
Time(%)      Time     Calls       Avg       Min       Max  Name
 60.28%  1.48397s      3004  494.00us  10.084us  4.1736ms  cuMemFree
 17.38%  427.98ms      3004  142.47us  9.3940us  2.3956ms  cuMemAlloc
  9.92%  244.25ms         1  244.25ms  244.25ms  244.25ms  cuCtxCreate
  4.32%  106.42ms      2000  53.207us  10.887us  3.0975ms  cuMemcpyHtoD
  2.81%  69.269ms      5000  13.853us  8.7170us  168.53us  cuLaunchKernel
  2.39%  58.827ms         1  58.827ms  58.827ms  58.827ms  cuCtxDetach
  1.32%  32.521ms      1000  32.521us  18.418us  162.30us  cuMemcpyDtoH
  0.94%  23.032ms      1000  23.031us  17.821us  92.496us  cuMemcpyDtoD
  0.30%  7.3015ms         7  1.0431ms  538.27us  1.6180ms  cuModuleLoadDataEx
  0.17%  4.2039ms      5000     840ns     456ns  11.638us  cuFuncSetBlockShape
  0.15%  3.6542ms      5012     729ns     351ns  357.79us  cuCtxGetDevice
  0.01%  342.64us         7  48.949us  23.517us  140.86us  cuModuleUnload
  0.00%  17.916us        10  1.7910us     498ns  3.4070us  cuModuleGetFunction
  0.00%  15.065us        22     684ns     311ns  1.9420us  cuDeviceComputeCapability
  0.00%  11.063us        25     442ns     337ns  1.1050us  cuDeviceGetAttribute
  0.00%  4.3840us         2  2.1920us  1.9100us  2.4740us  cuDeviceGetCount
```

LZ4 : 50 GB/s

~470 µs/frame
4X detector

The European Synchrotron | ESRF

Status

- ✓ Parse bslz4 chunks to blocks
- ✓ Calls to nvcomp LZ4 CUDA decompressor from python
- ✓ Naïve bitshuffle CUDA kernels

Pull requests welcome:
https://github.com/jonwright/bslz4decoders

- ❑ Streams to overlap IO
- ❑ GPU image processing

Thanks!

- Bjoern Enders, Nick Wright (LBNL)
- @carsonswope (github)
- Jerome Kieffer (ESRF)