TEKIN BICER  
Assistant Computer Scientist  
Data Science and Learning Division, CELS  
X-Ray Science Division, APS  
Argonne National Laboratory

COLLABORATORS
StarLight & Northwestern University  
Argonne Leadership Computing Facility, ANL  
Advanced Photon Source, ANL  
University of Chicago  
Northern Illinois University

REAL-TIME ANALYSIS OF STREAMING SYNCHROTRON DATA  
SC’19 TECHNOLOGY CHALLENGE DEMO
SYNCHROTRON EXPERIMENTS

- Synchrotron light sources help scientific experiments of many fields
  - Studying internal morphology of materials/samples with very high spatial and temporal resolutions

- Real-time analysis of synchrotron experiments
  - Change data acquisition for dynamic systems
  - Adjust experimental parameters on the fly
  - Detect errors early in experiments
  - Enables smart and efficient experimentation

- High performance network and compute resources are necessary
TOMOGRAPHIC DATA ACQUISITION AND ITERATIVE RECONSTRUCTION

Iterative reconstruction

Input Data

Sinograms

Current update

Forward model

Compare

Inverse model

Rotation stage

I₀(s) = I₀(s) exp [ -p₀(s)]

p₀(s) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} (π \cdot μT(x, y) \cdot A + \text{offset}) \cdot dxy

Projection: p₀(s)

X-ray source

Output data

Stop?

Yes

No

Fig. 2. First, an initial guess of the volume object, which might simply be an empty volume, is used to calculate the

Fig. 3: Reconstructed image of a shale sample with only 30 projections using SIRT.
HIGH-PERFORMANCE TOMOGRAPHIC IMAGE RECONSTRUCTION

*M. Hidayetoglu, T. Bicer et al., Supercomputing 2019
*T. Bicer, D. Gursoy et al., Advanced Structural and Chemical Imaging 2017
Dataset: Dyer et al., Society for Neuroscience (eNeuro) 2017
SYSTEM OVERVIEW
A REAL-TIME TOMOGRAPHIC RECONSTRUCTION WORKFLOW (DATA ACQUISITION)

Continuous vs. Interleaved DAQ

* V. De Andrade et al., Nanoscale 3D imaging at the Advanced Photon Source, SPIE’16
A REAL-TIME TOMOGRAPHIC RECONSTRUCTION WORKFLOW (DISTRIBUTOR)
A REAL-TIME TOMOGRAPHIC RECONSTRUCTION WORKFLOW (TRACE-X)

- * TraceX: A High-Throughput Tomographic Reconstruction Engine for Large-Scale Datasets
- Sliding window with adjustable runtime params.
  - Length (w), iteration (i), func. trigger freq (s).
- Reduction-based processing model
- Highly scalable and efficient
  - Replicated reduction objects
  - 32K cores on Mira, 64K cores on Theta

* T. Bicer et al., Advanced Structural and Chemical Imaging, 2017
* T. Bicer et al., eScience, 2017
A REAL-TIME TOMOGRAPHSIC RECONSTRUCTION WORKFLOW (TOMOGAN: DENOISER)

* Z. Liu, T. Bicer et al., Deep Learning on Supercomputer, SC’19
* Z. Liu, et al., JOSA A (Under review)
A REAL-TIME TOMOGRAPHIC RECONSTRUCTION WORKFLOW (VISUAL OUTPUTS)
* 100GigE network enables simulation of 10 beamlines each with 10GigE detector
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- Many others…

Papers at SC’19