# Flexible X-Ray Image Processing on GPUs

Matthias Vogelgesang, Suren Chilingaryan and Andreas Kopmann

Karlsruhe Institute of Technology

## X-Ray Tomography at Synchrotrons

X-ray tomography is a non-destructive technique to analyze and visualize the inner structure of organisms and materials in three and four dimensions.

High pixel resolutions, bit depths and frame rates of state-of-the-art cameras increase the size of a single data set to several gigabytes. In order to process sequences of recon-structed volumes during acquisition, GPU processing is in-evitable.

## Image Processing Toolkit

Our software toolkit is used for pre-processing, image re-construction and post-processing in online and offline environments. Most algorithms can be expressed as a composition of smaller sub-operations such as convolutions, filters and complex arithmetics. Thus, we map each of the processing stages to a computation graph representing the full algorithm. Each node in the graph is connected using a queue that is used to push processed data to its successor and scheduled according to its workload.

Some of its key features are:

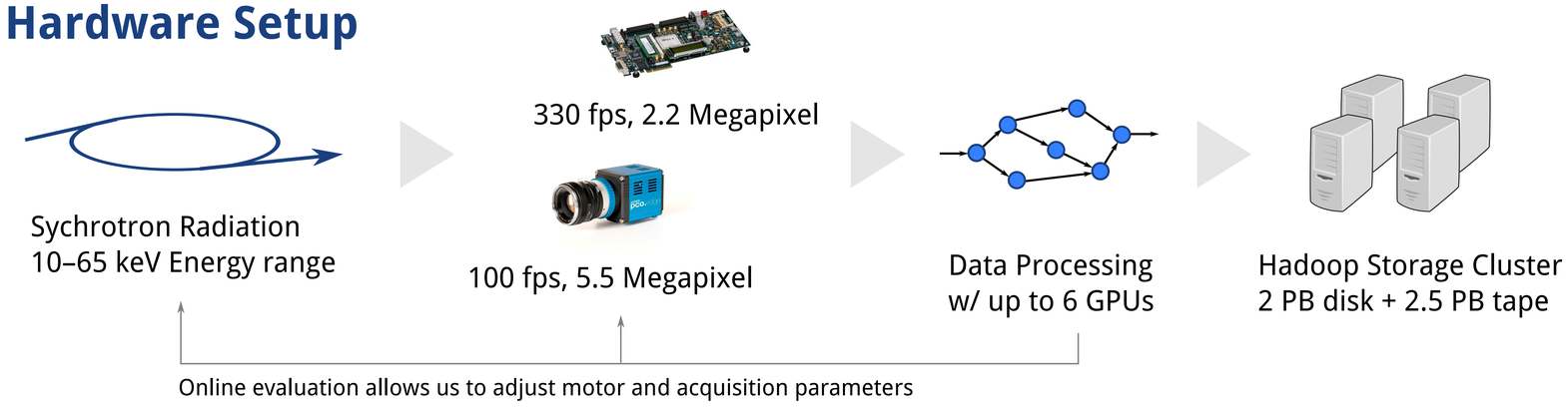
- Core written in C
- Uses hardware-dependent OpenCL kernels
- Python and JS bindings
- Implicit buffer management
- Multi-threading and implicit synchronisation using asychronous queues
- Automatic node-to-GPU mapping using heuristics

```
from gi.repository import Ufo

g = Ufo.Graph()
for f in ['reader', 'writer', \
    'fft', 'ifft', 'ramp']:
    globals()[f] = g.get_filter(f)

bp = g.get_filter('backproject')
fft.set_properties(dimensions=1)
reader.connect_to(fft)
fft.connect_to(ramp)
ramp.connect_to(ifft)
ifft.connect_to(bp)
bp.connect_to(writer)

g.run()
```

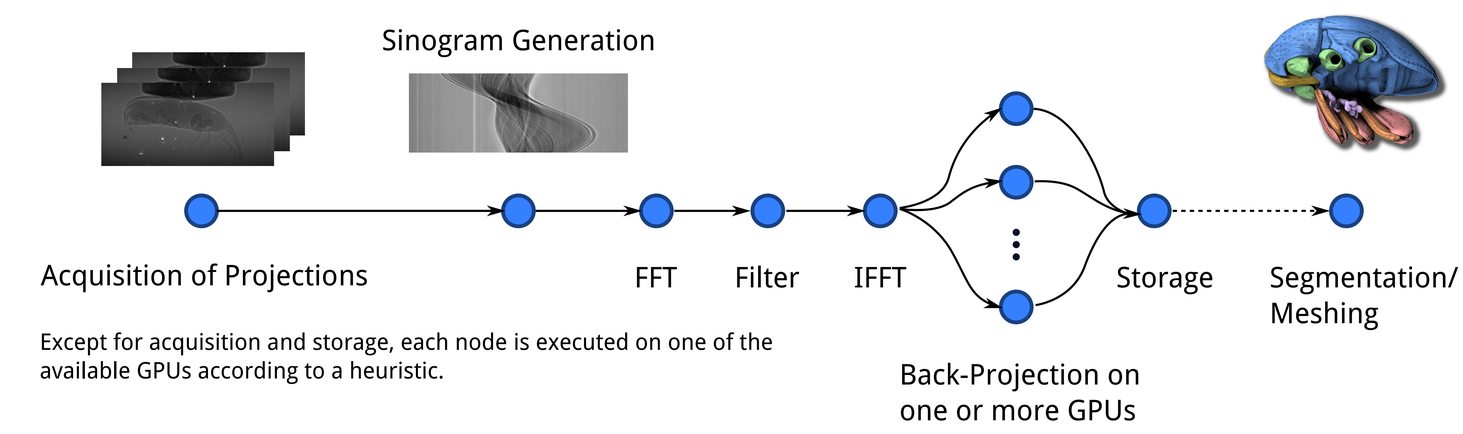
## Reference

Chilingaryan, Mirone, Hammersley, Ferrero, Helfen, Kopmann, dos Santos Rolo and Vagovic. “A GPU-Based Architecture for Real-Time Data Assessment at Synchrotron Experiments” IEEE Transactions on Nuclear Science, vol. 58, pp. 1447–1455, Aug. 2011.

## Hardware Setup



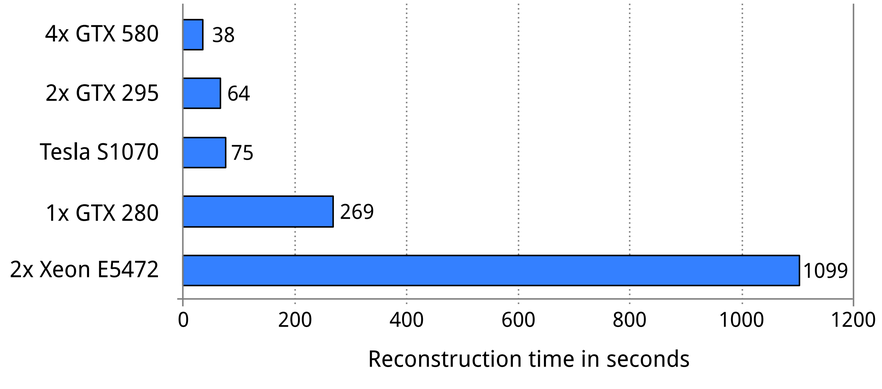

## Example: Reconstruction Graph




Except for acquisition and storage, each node is executed on one of the available GPUs according to a heuristic.

## Results

Time for reconstructing an 11 GB 3D Volume from 2000 Projections (~ 24 GB)




Scalability of Back-Projection on Tesla S1070