# Online data processing with 10 kHz in mind

## Go fast or go home?

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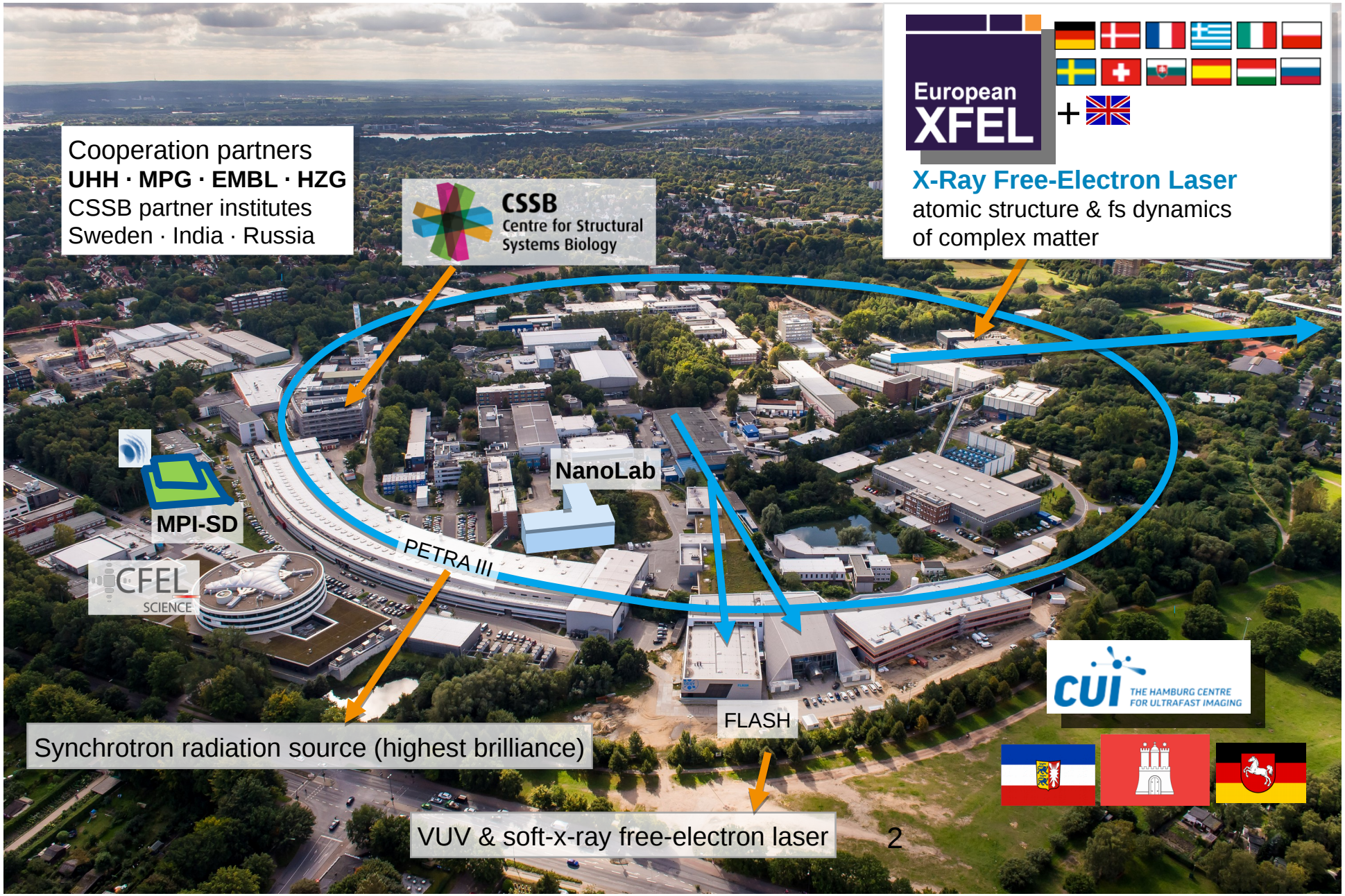
Grenoble, 07-02-2019

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY

# DESY

## DESY?


Cooperation partners
UHH · MPG · EMBL · HZG
CSSB partner institutes
Sweden · India · Russia
CSSB
Centre for Structural Systems Biology
European XFEL
+
X-Ray Free-Electron Laser
atomic structure & fs dynamics
of complex matter
NanoLab
MPI-SD
CFEL
SCIENCE
PETRA III
FLASH
CUI
THE HAMBURG CENTRE FOR ULTRAFAST IMAGING
Synchrotron radiation source (highest brilliance)
VUV & soft-x-ray free-electron laser
2

# The Past, Now, and the Future

## The past was easy peasy

### The Past

- Step Scanning
- Slow acquisition
- Small data volume
- Data retrieval after acquisition, before movement
- Data analysis on file basis (ASCII files)
- Mostly single threaded applications

### Now

- Continuous scanning
- Fast acquisition (1 kHz)
- Multi modal acquisition
- Large data volumes (TBs/day)
- No data retrieval by the control software during a scan.
- Detectors controllers are responsible for writing the data.
- Mainly file based data output.
- HDF5 files.
- File based analysis.
- ZMQ based data pipelines.

### The Future

- Bigger
- Faster
- Better??

# Some Numbers

## OOPS, Problem

### Acquisition and Data Rates

- 2D Detectors (max. 3 simultaneously used so far)
  - Eiger 4M, 750 Hz (40 Gb/s)
  - Eiger 500k, 9 kHz (40 Gb/s)
  - Lambda 750k, 2 kHz (20 Gb/s)
  - Zylar, PCO Edge, 100 Hz (10 Gb/s)
- 1D Detectors (max. 2 simultaneously used)
  - Xspress3, 1 kHz (1 Gb/s)
- 0D Detectors (max. 10 simultaneously used)
  - PiLCs, 10 kHz (100 Mb/s)
  - Interferometers, 10 MHz (480 Mb/s)

### Analysis Frequency

Worst case scenario per thread

- 2D Detectors
  - 1 Hz
- 1D Detectors
  - 10 Hz
- 0D Detectors
  - No issue

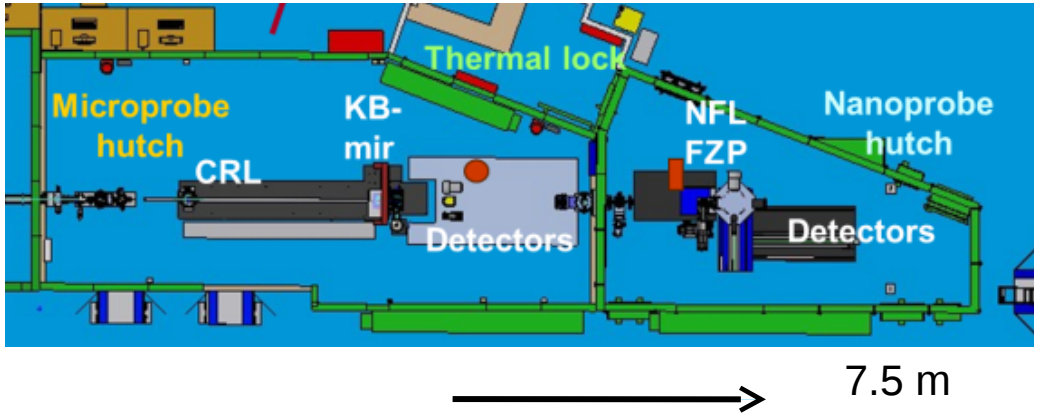
### Offered Techniques

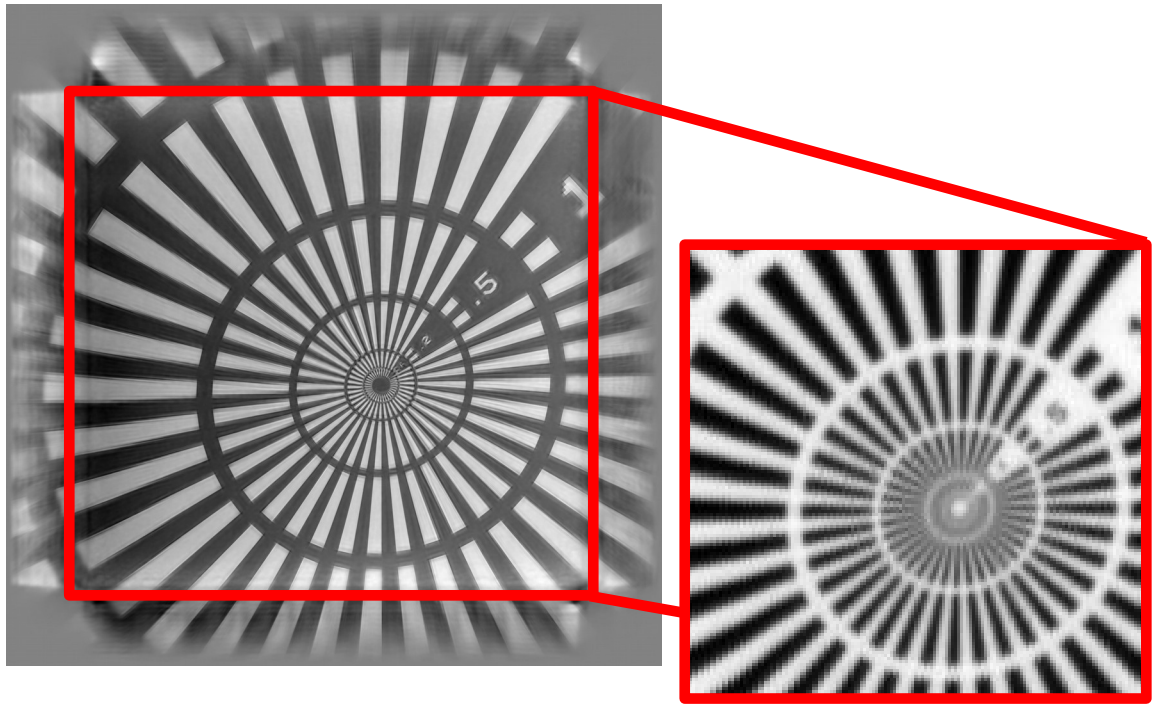
- XRF
- XANES
- XRD
- Ptychography
- Tomography
- Holography
- Full field tomography (supporting technique)

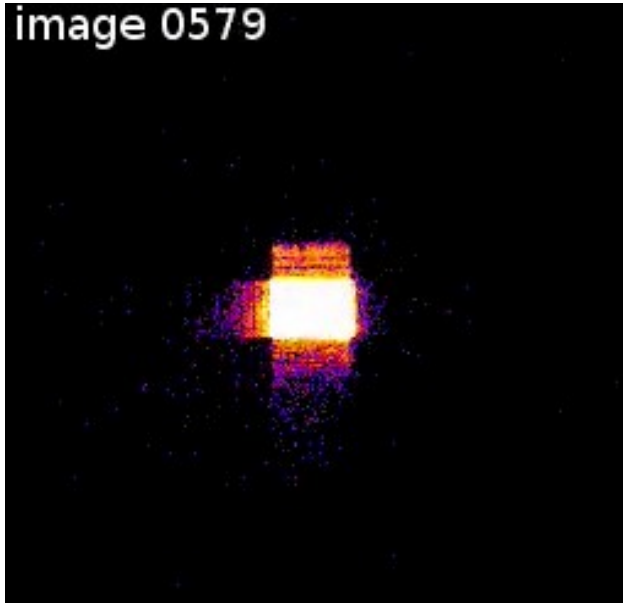
# XRF-Ptychographic Tomography

## FCC Particle

- Simultaneous Maia + Eiger 4M on-the-fly scan
- Coherently illuminated KB, 250x350 nm focus
- Eiger at 7.5 m propagation distance
- Acquisition up to 500 Hz






Garrevoet et al., in preparation

Meirer et al., in preparation

# The ZMQ Approach

## P06 Hard X-ray Micro/Nano Probe

### Needs

- Fast
- On the fly scalability
- Flexible
- Support multiple languages

### What does it offer

- Fast
- On the fly scalability
- Flexible
- Support multiple languages
- Forgiving towards heterogeneous systems
  - Clock speed
  - Networking interfaces
  - Shared resource

### Multiprocessing using ZMQ

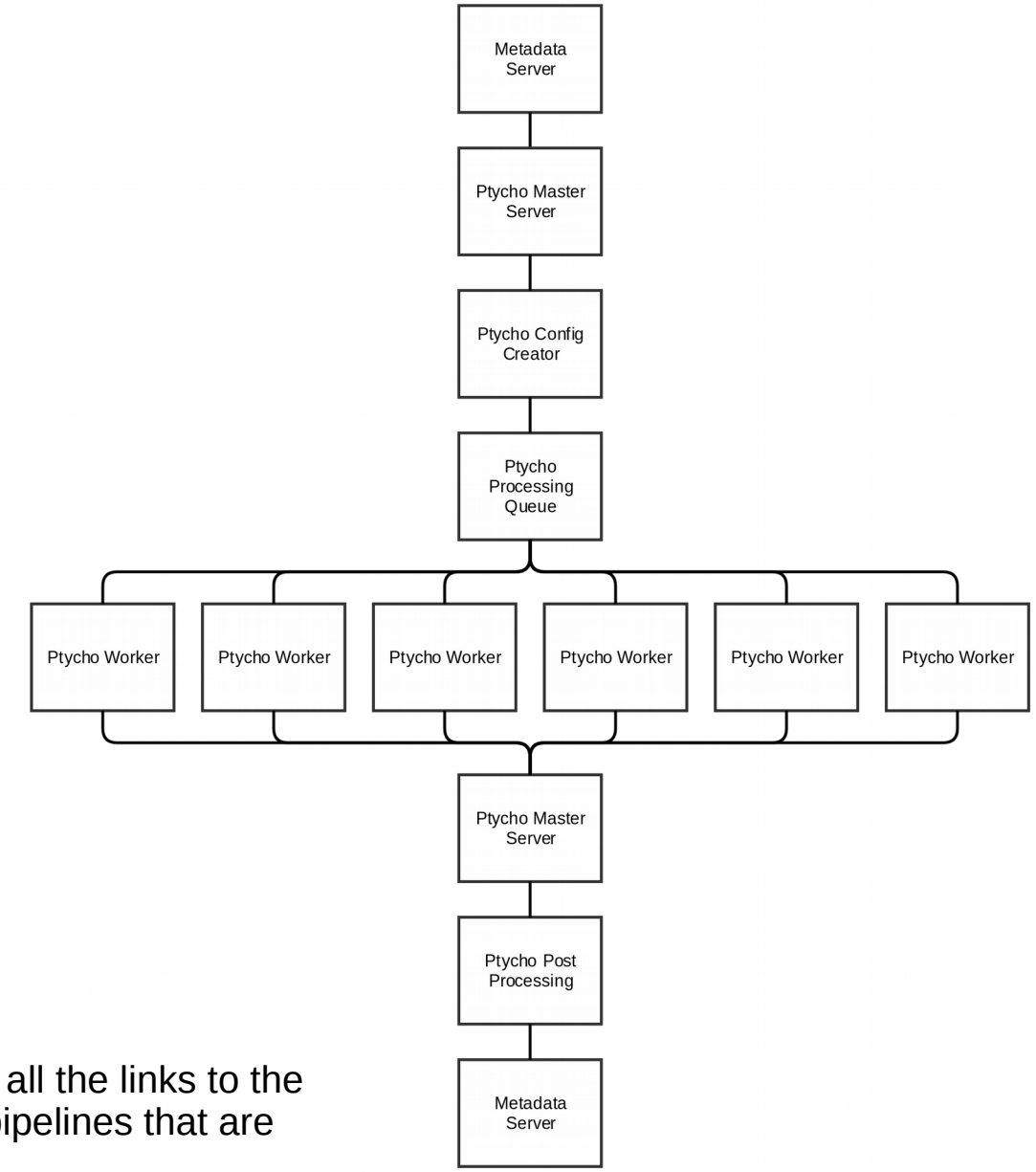
- People can keep on writing single threaded applications
  - ZMQ does the distribution to thread level
- MP applications limited to 1 node
  - ZMQ does the distribution to node level

# The ZMQ Approach

## P06 Hard X-ray Micro/Nano Probe

**1 to N | N to 1**

- Central message broker
- Distribute and conquer
- Sink
- Viewer



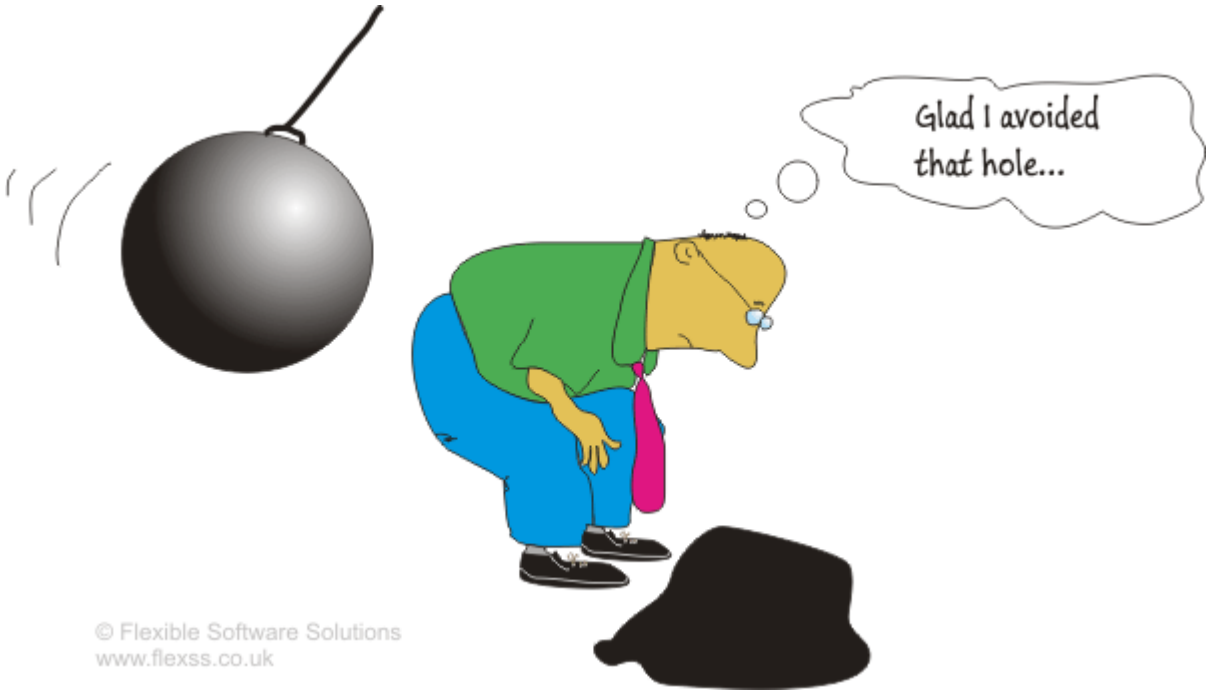

Not shown are all the links to the other parallel pipelines that are needed.

# The ZMQ Approach

## P06 Hard X-ray Micro/Nano Probe

### Pitfalls

- Network I/O
  - Drop messages when not fast enough
  - Use files to fill the gaps after the fact
- Complex network topology
- Keep the overview
- Easy to maintain
- ??



# PyFAI

## P06 Hard X-ray Micro/Nano Probe

### Plans

- Incorporate into the data pipelines
- Switch from using XRDUA and Fit2D
- Supporting users
- When/where possible contribute