HELMHOLTZ ZENTRUM
DRESDEN ROSSENDORF

Student Project Python CUDA C++ Bindings

S.Ehrig, Dr. Nico Hoffman

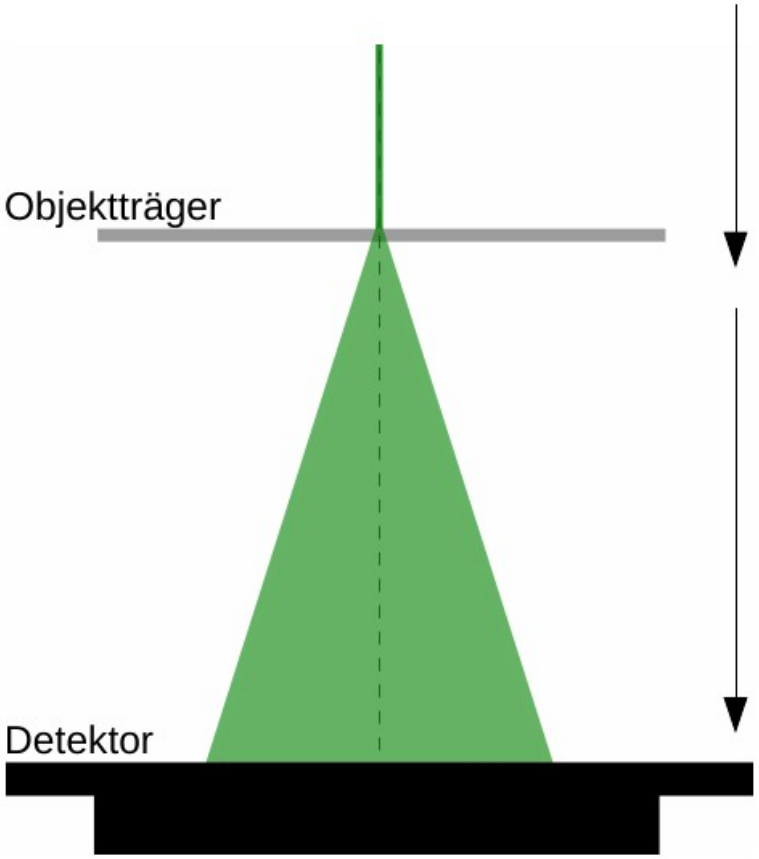
December 15th 2020

Research Group Computer Assisted Radiation Physics · FWKT · Simeon Ehrig · s.ehrig@hzdr.de · www.hzdr.de

DRESDEN concept

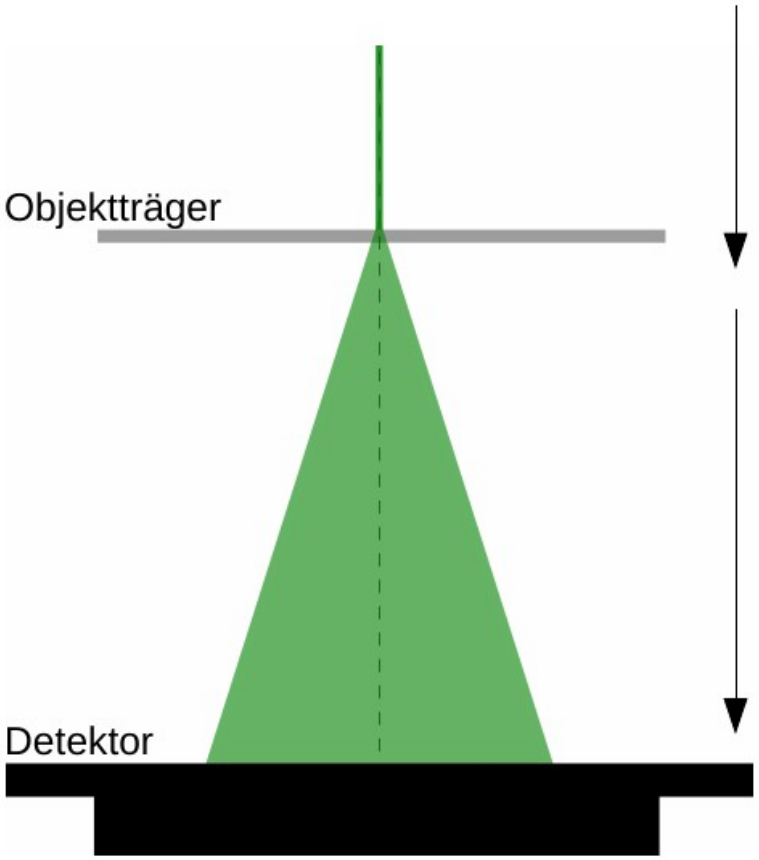
Motivation

Ptychography – lensless microscopy

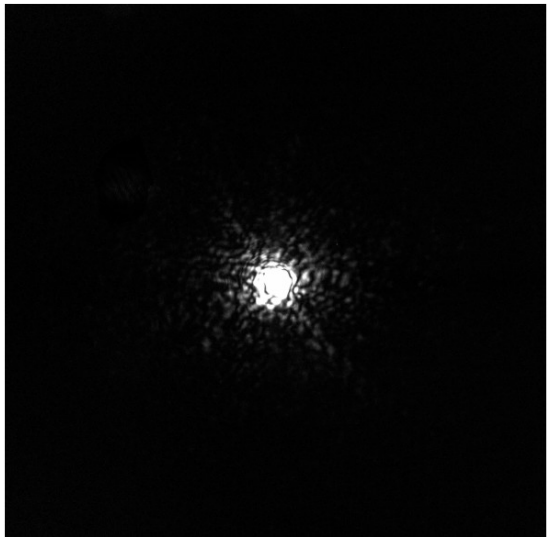


Motivation

Ptychography – lensless microscopy

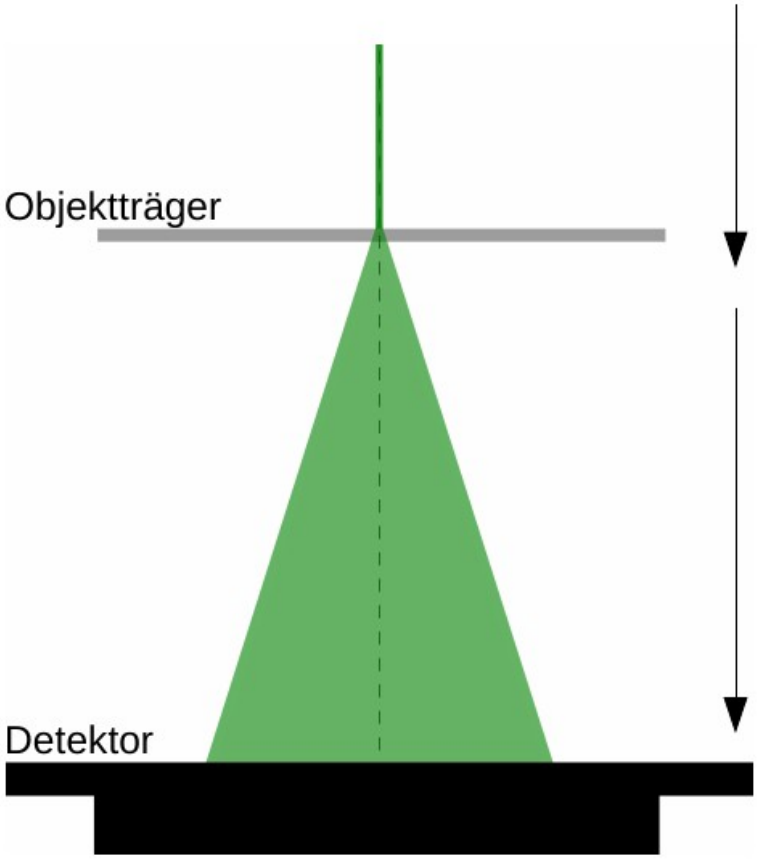


got

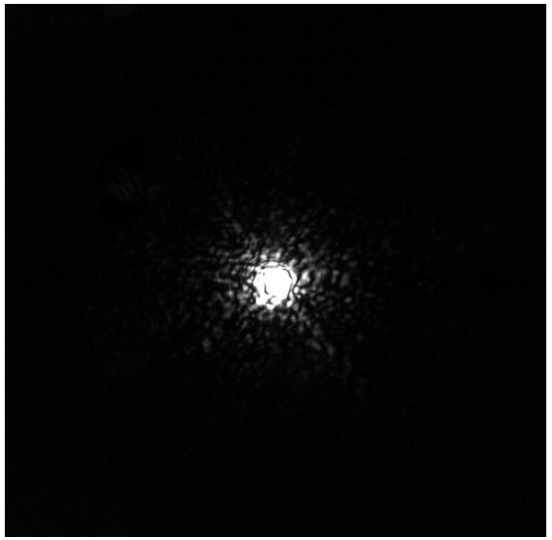


Motivation

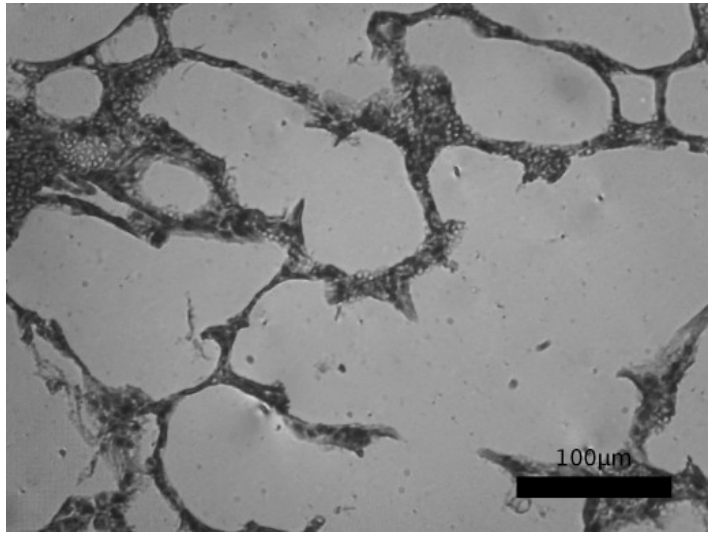
Ptychography – lensless microscopy



got

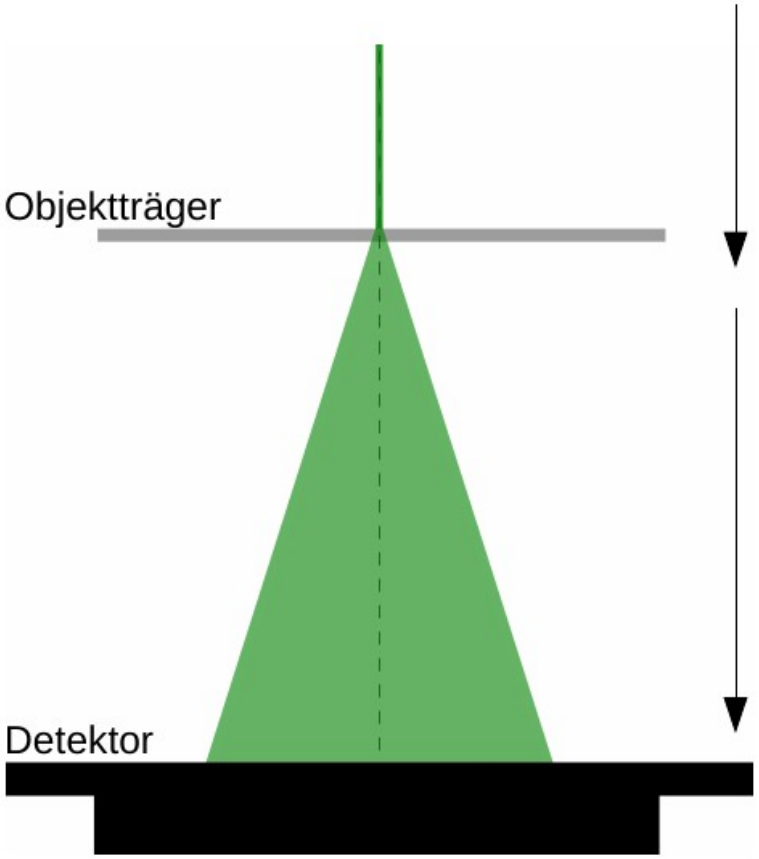


wanted

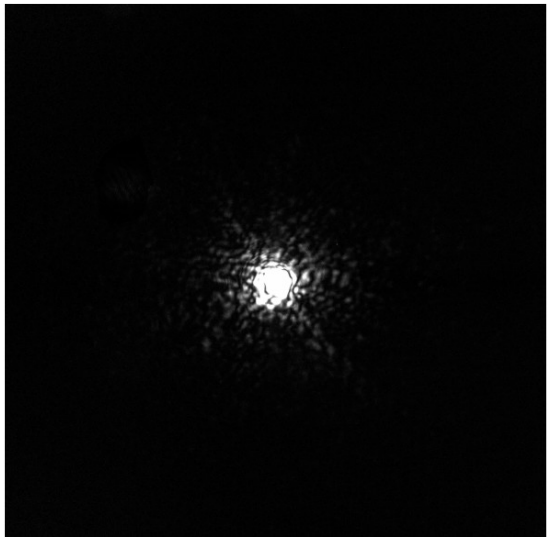


Motivation

Ptychography – lensless microscopy

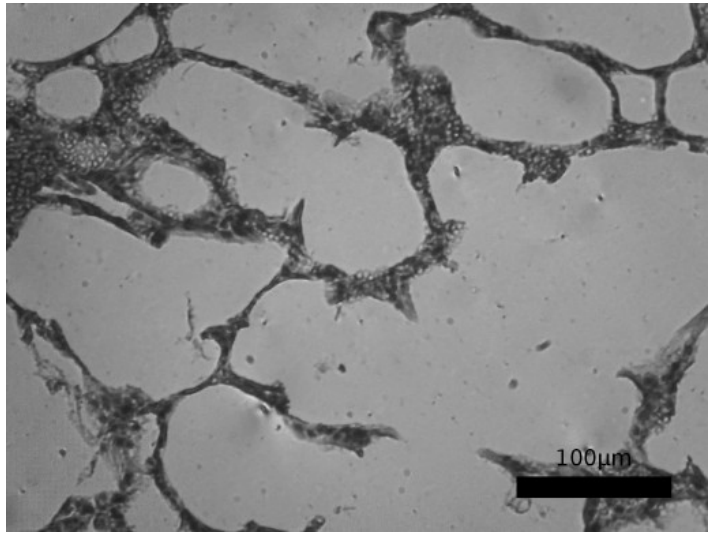


got



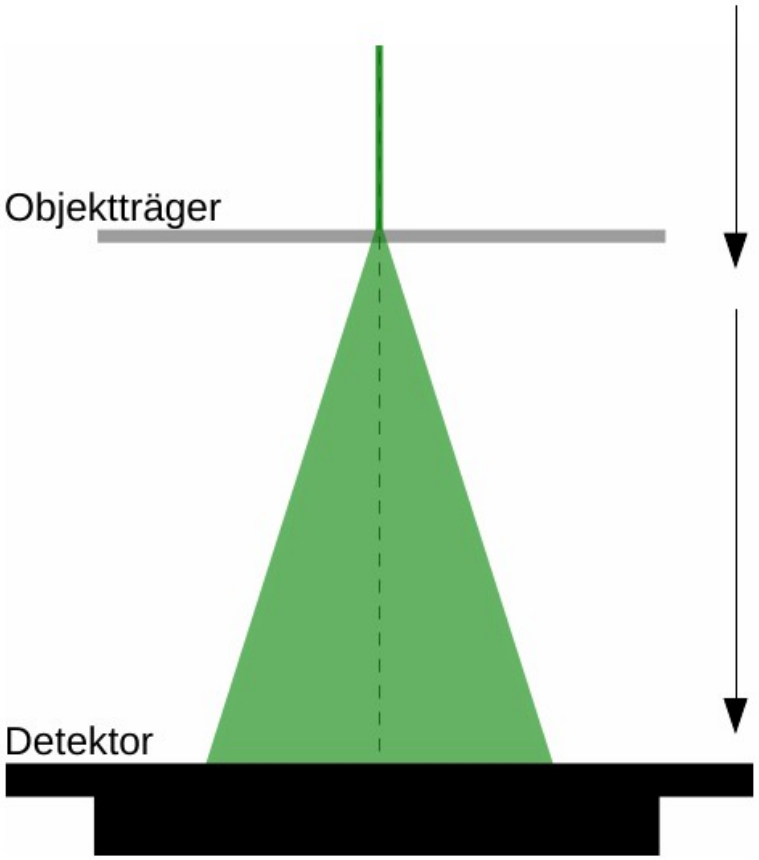
?

wanted

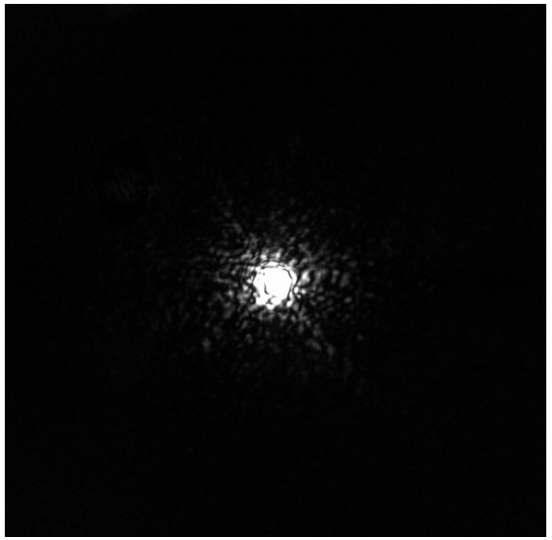


Motivation

Ptychography – lensless microscopy

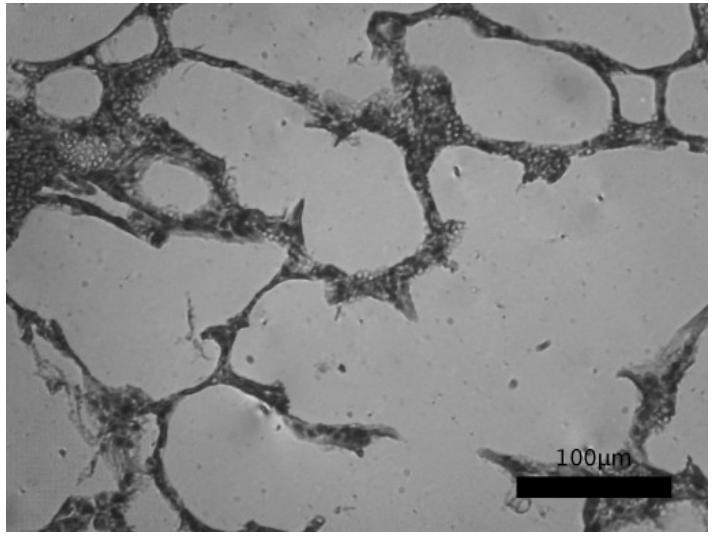


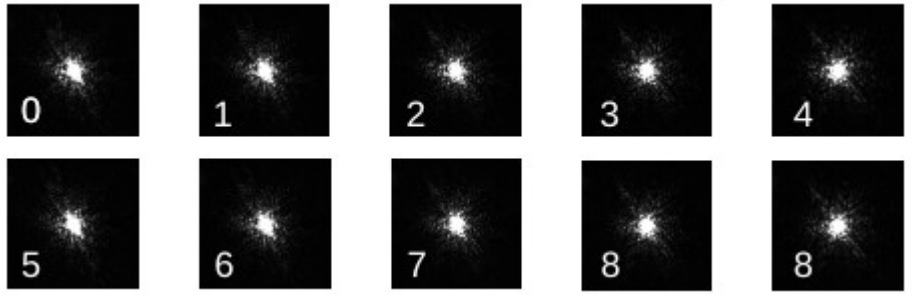
got



?

wanted



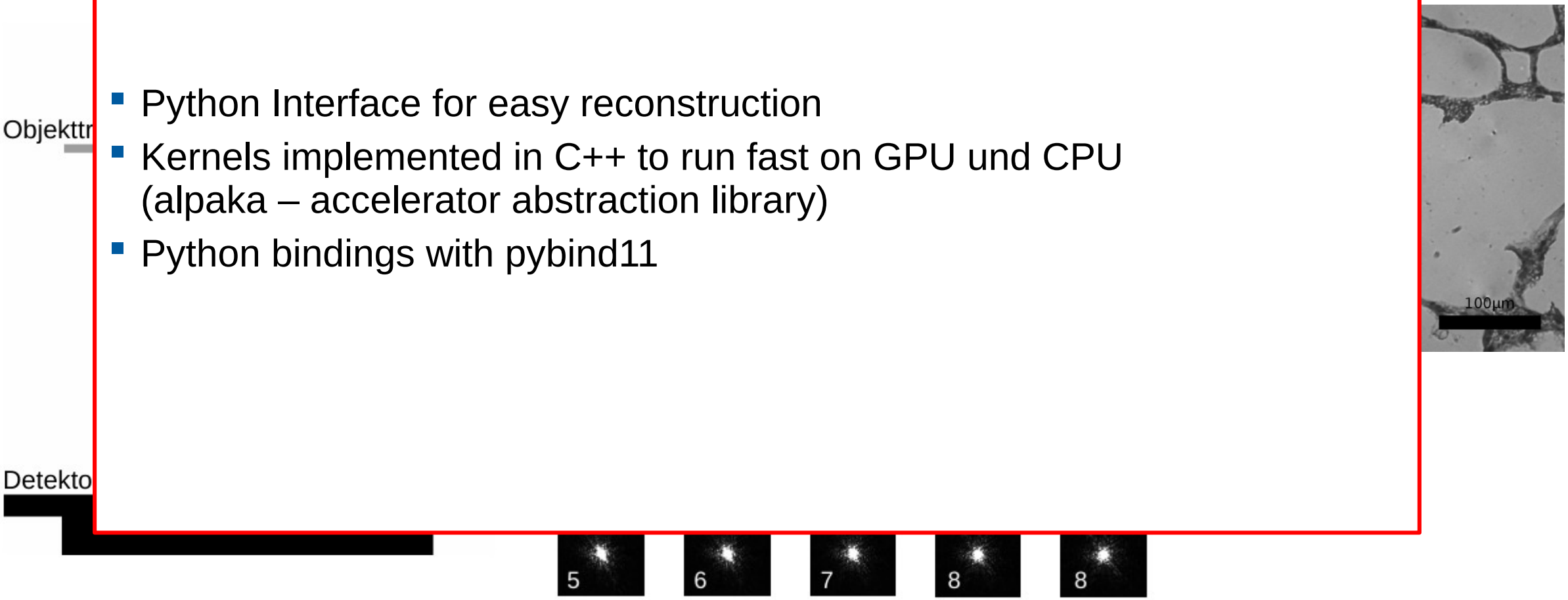


Motivation

Ptychography – lensless microscopy

Developing library for Ptychography

- Python Interface for easy reconstruction
- Kernels implemented in C++ to run fast on GPU und CPU (alpaka – accelerator abstraction library)
- Python bindings with pybind11



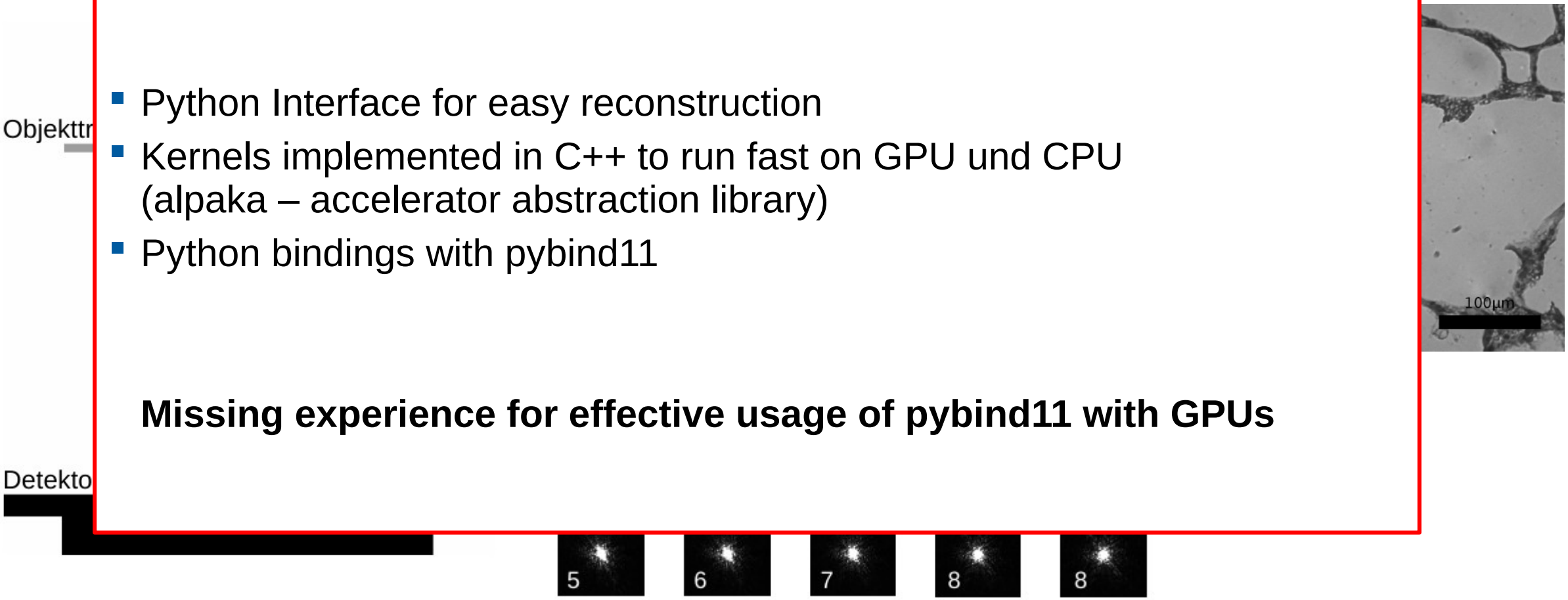
Motivation

Ptychography – lensless microscopy

Developing library for Ptychography

- Python Interface for easy reconstruction
- Kernels implemented in C++ to run fast on GPU und CPU (alpaka – accelerator abstraction library)
- Python bindings with pybind11

Missing experience for effective usage of pybind11 with GPUs



Tasks

- Implement the algorithm in CUDA C++ and add Python bindings

Tasks

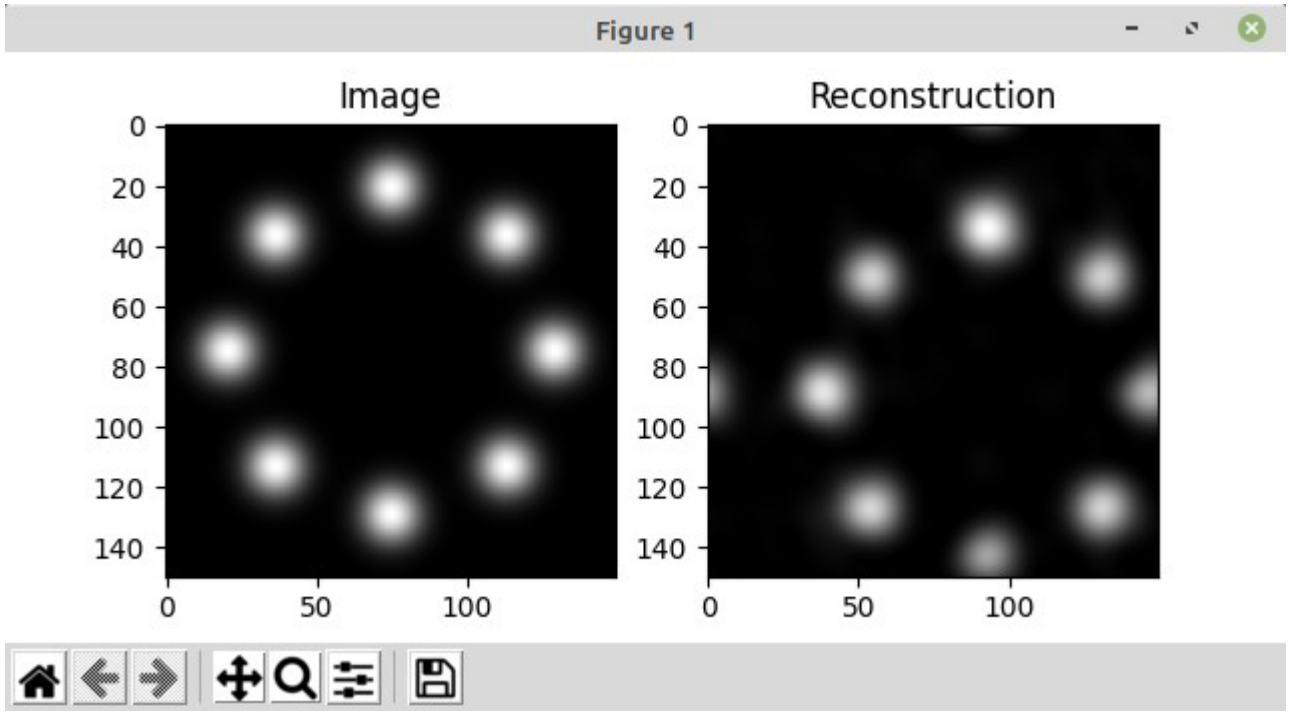
- Implement the algorithm in CUDA C++ and add Python bindings
- Develop Python bindings with pybind11 in different fashions
  - a single Python function call for the main loop
  - m Python function calls for each iteration
  - m*n Python function calls for each kernel

Tasks

- Implement the algorithm in CUDA C++ and add Python bindings
- Develop Python bindings with pybind11 in different fashions
  - a single Python function call for the main loop
  - m Python function calls for each iteration
  - m*n Python function calls for each kernel
- analyze performance overhead of the Python bindings
- Analyze GPU memory behavior (ownership and copies)
- Optimize code

Algorithm

- Gerchberg–Saxton algorithm
- Reconstruction of greyscale images only from measurements of the magnitudes.
- Python implementation exists: https://github.com/tuelwer/phase-retrieval



Algorithm

```
def Gerchberg–Saxton(Magnitude, Initial_Phase, numIters = 1000):
    "
    Magnitude: experimentally acquired diffraction image
    Initial_Phase: first guess of phase

    returns:
        A: real-domain reconstruction
    "

    A := Magnitude × exp(i × Initial_Phase)
    while i in range(numIters):
        B := IFT(A)
        B[B<0] = 0

        C := FT(B)
        A := Magnitude × exp(i × Phase(C))

    return A
```

Repository

- Project Repository (privat):
  https://github.com/ComputationalRadiationPhysics/student_project_python_bindings/