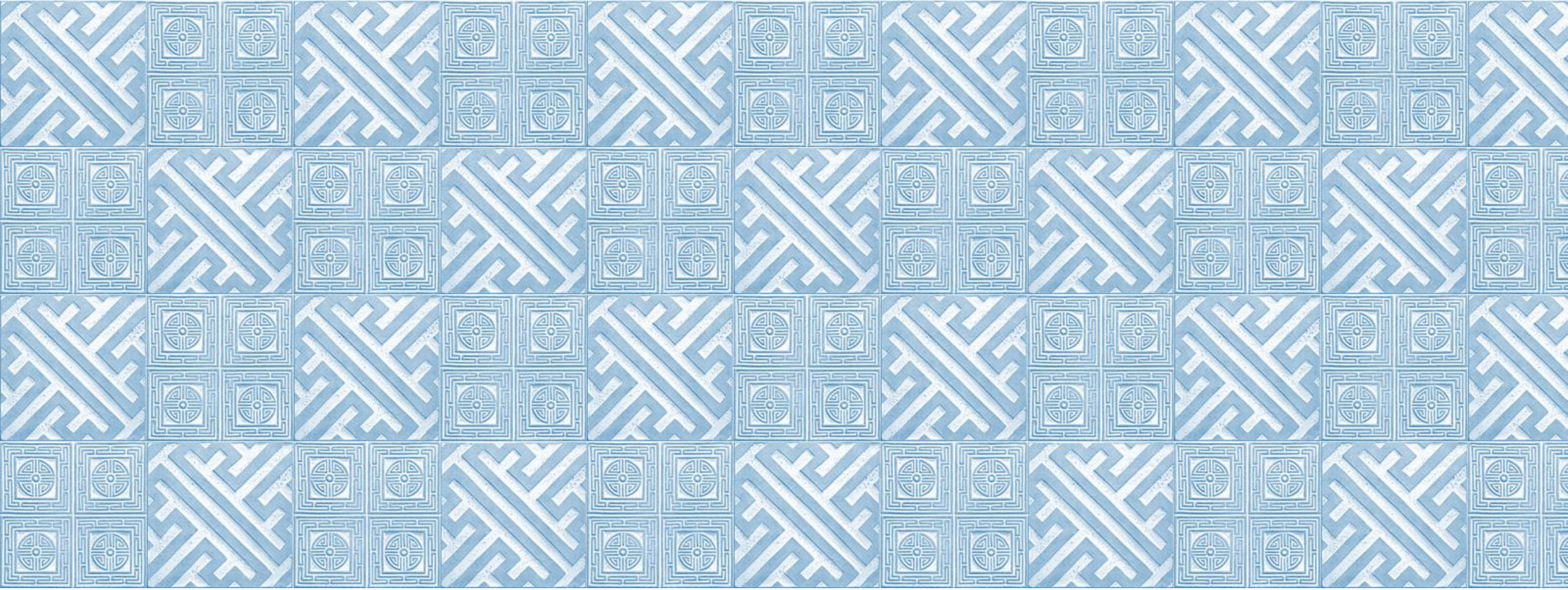


SIMULATION STUDIES OF MULTI CAMERA SETUP

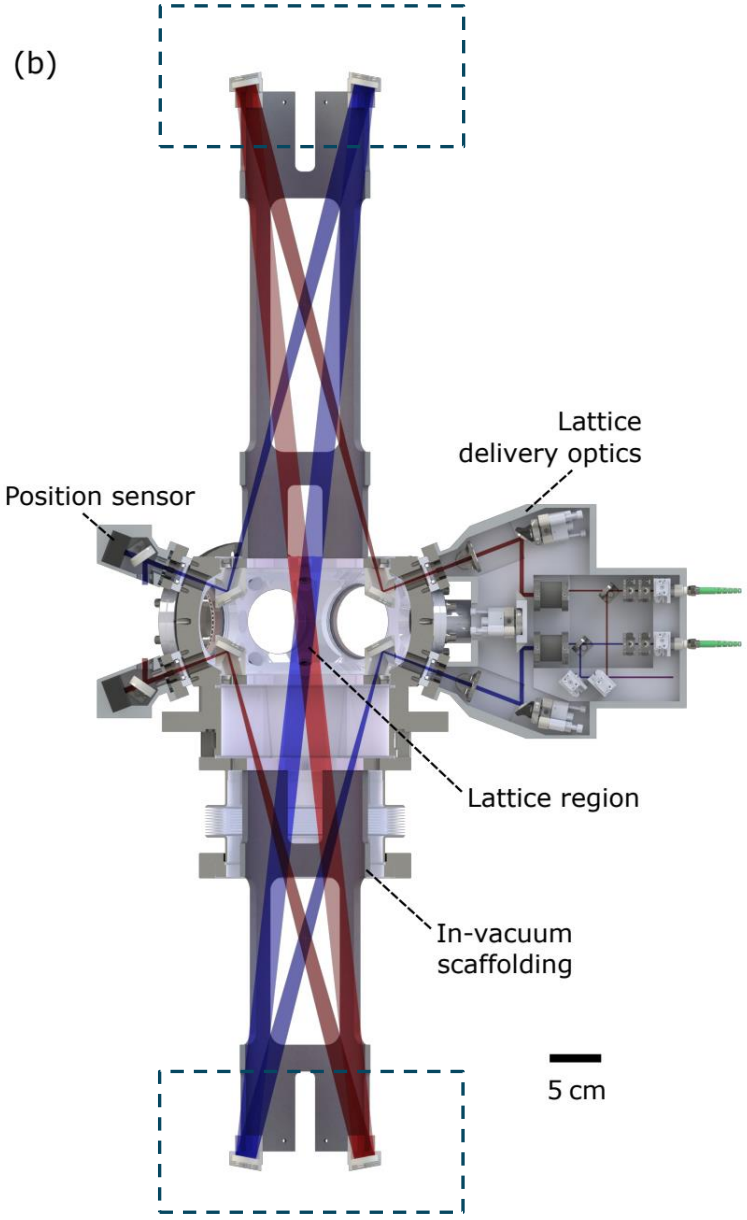
Suyong Choi
Korea U. / SLAC

INTRODUCTION

Opportunities for additional cameras

- Constrain shape of the atom cloud
- Potentially improve measurements

This study is not a complete exploration, but a start.



SIMULATION STUDIES SETUP

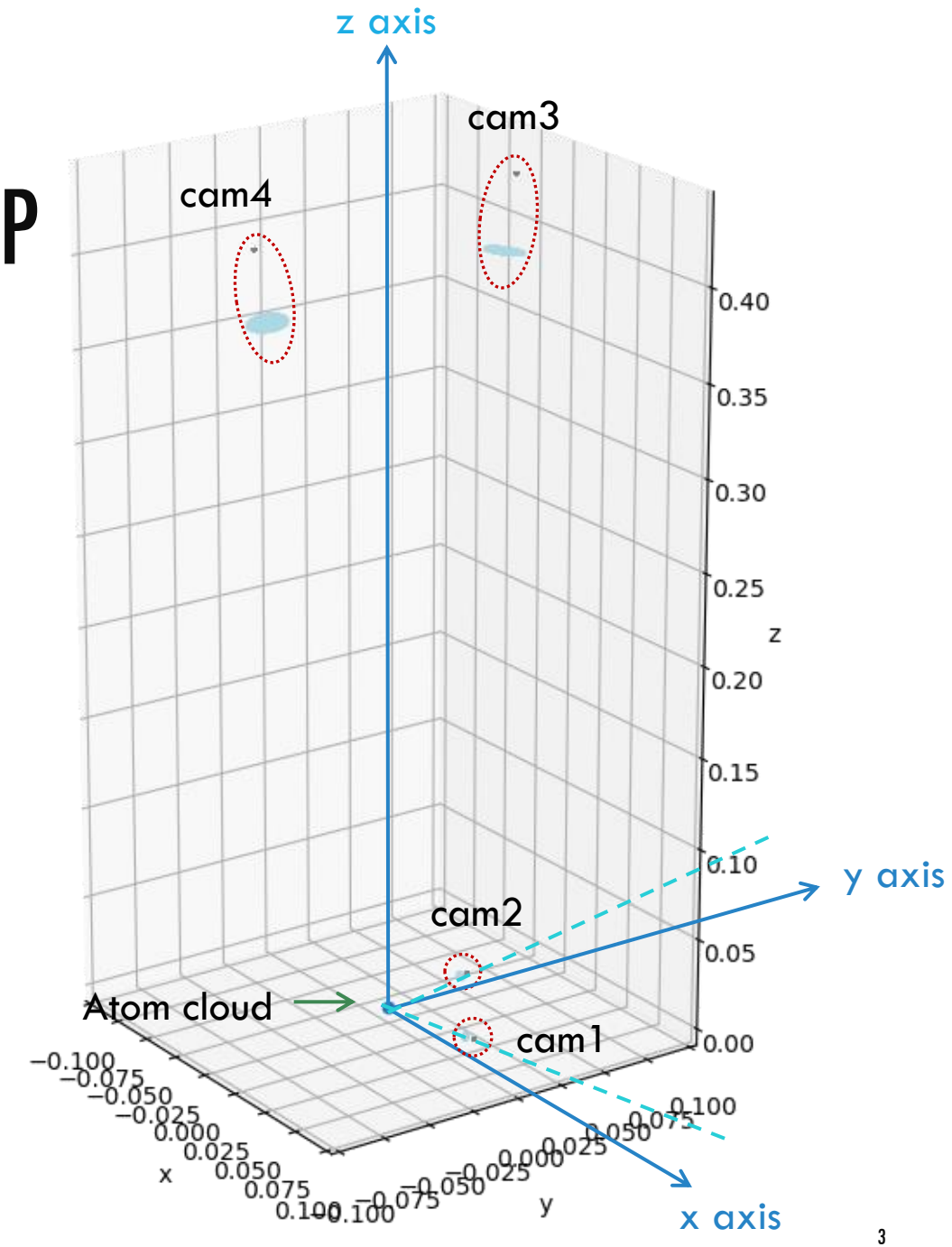
Two cameras at z=0 plane

- 5.2 cm distance, numerical aperture= 1/1.4, mag=0.1

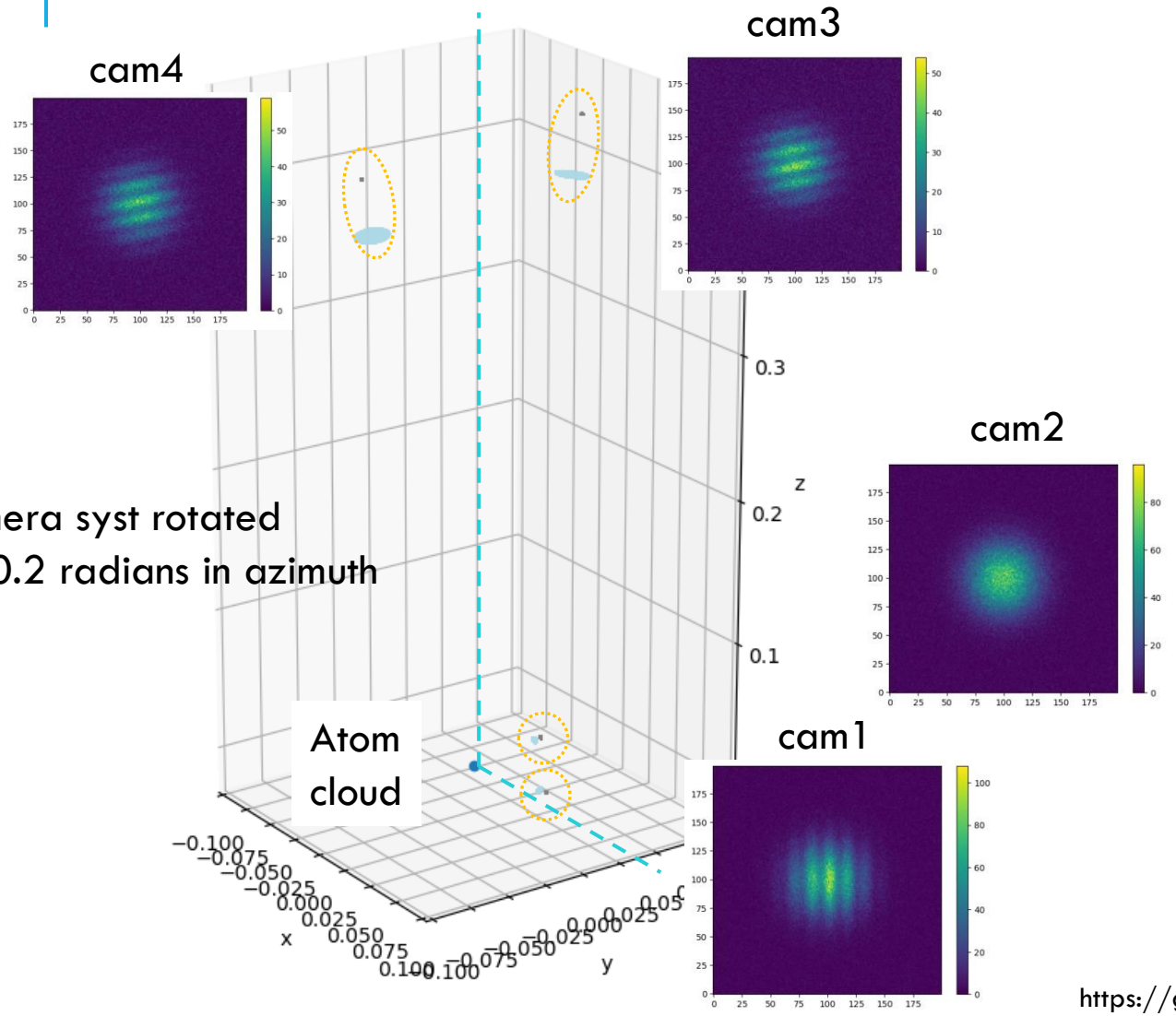
Two more near z views at 40 cm

- NA=1/4, mag=0.1
- Ideal lens diameter 1.8 cm

Gradoptics framework for simulation, backward ray-tracing and minimization



SETUP



camera syst rotated by 0.2 radians in azimuth

4 sensor images simulated

- 2 p.e. mean noise per pixel added
- Poisson sampled
- Phase -1.0 input into the cloud
- Highest contrast when viewed along x or z axis. reduced contrast in cam1 due to rotations.

2 cam vs 4 cam

- Can the parameters determined correctly?

https://github.com/magis-slac/gradoptics/blob/main/src/gradoptics/distributions/atom_cloud.py

CLOUD MODEL FOR PARAMETER EXTRACTION

Assumed 3D light source in gradoptics for fitting

$$p(\vec{x}|I_0,\vec{o},\mathbb{C},\mathbb{R},\alpha,k,\phi) = I_0 \exp\left[-\frac{1}{2}(\vec{x}-\vec{o})_{\mathbb{R}}^{T}\mathbb{C}^{-1}(\vec{x}-\vec{o})_{\mathbb{R}}\right] \times\left\{1+\alpha\cos\left[k(y-o_y)_{\mathbb{R}}+\phi\right]\right\}$$

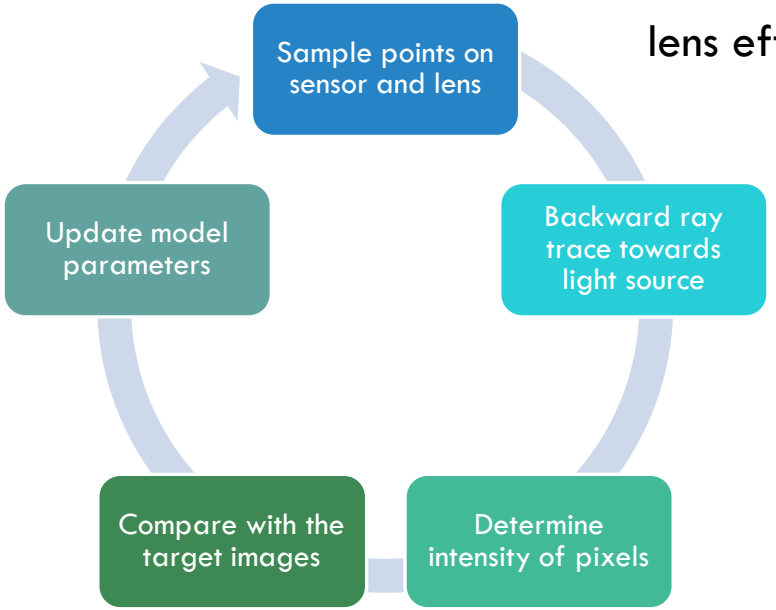
Gaussian

Fringe

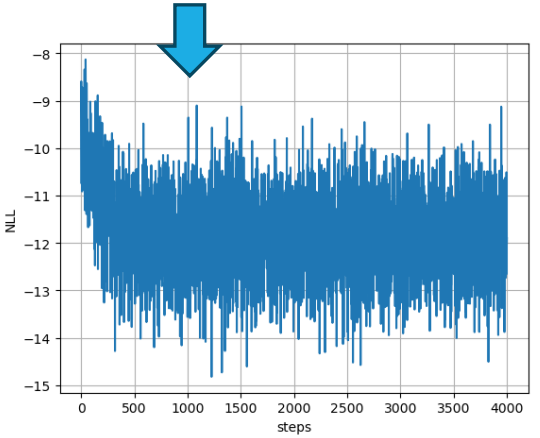
- I_0: intensity
- $\vec{o}$: center of the cloud
- $\mathbb{C}$: covariance (3x3 positive definite symmetric)
- $\mathbb{R}$: rotation (3x3 orthogonal)
- α: contrast $(0 \le \alpha \le 1)$
- k: wave number
- ϕ: phase

Parameters determined using gradoptics by minimizing Negative log-likelihood

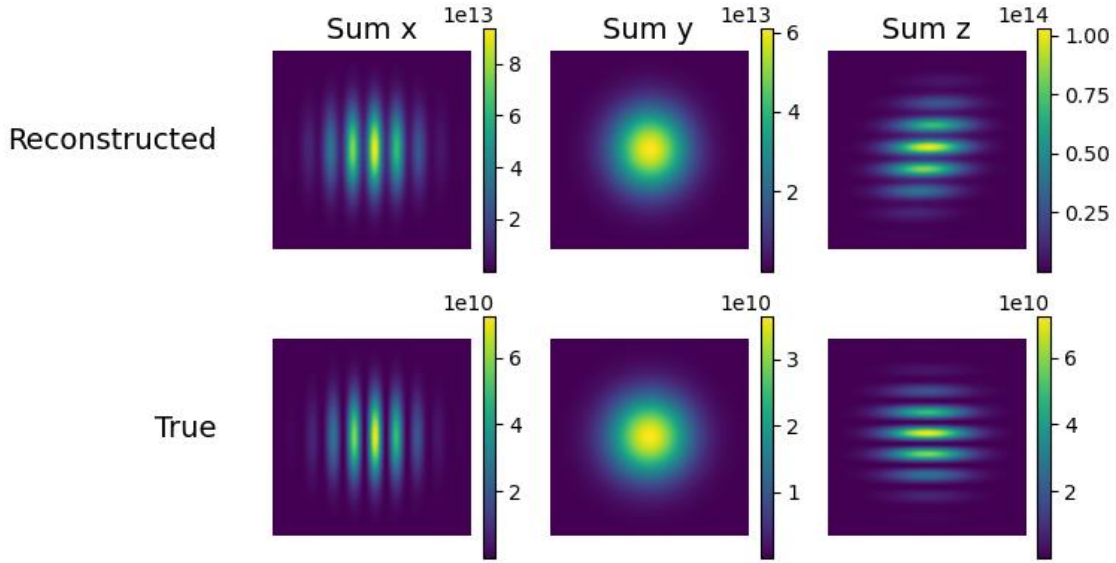
Includes lens effects



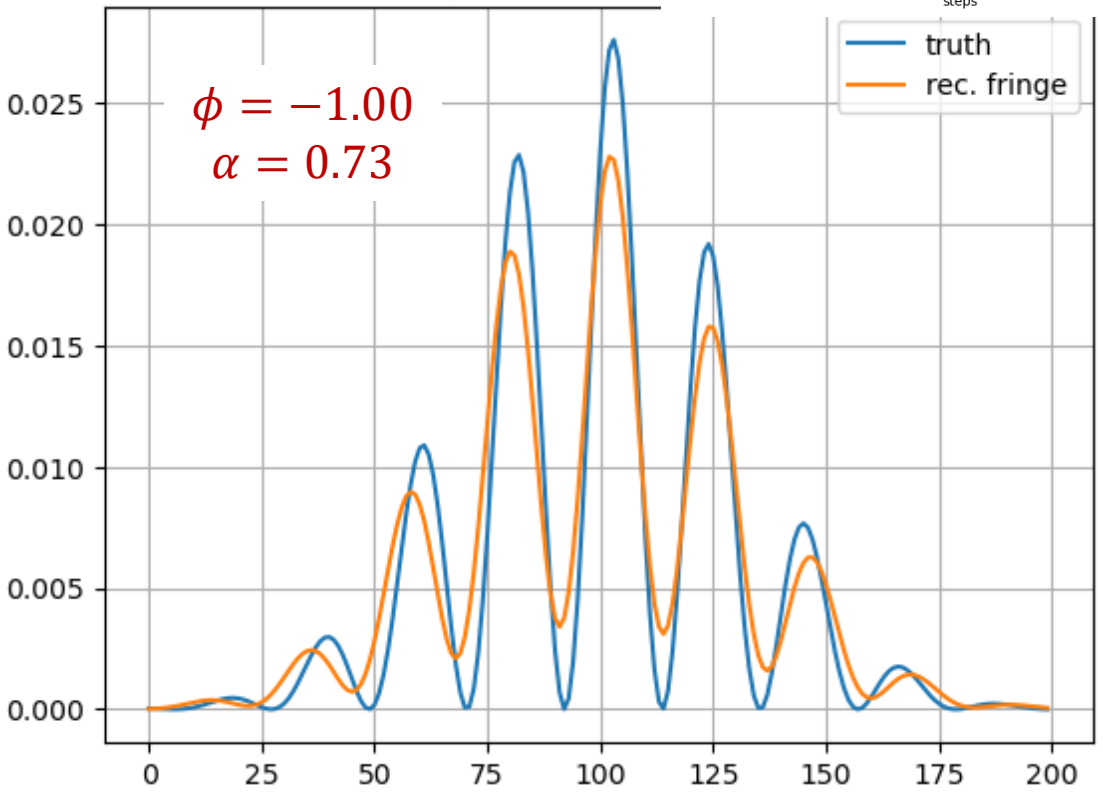
2 CAMS – ROTATION AND GENERAL COVARIANCE



Atom density projections



Y projection



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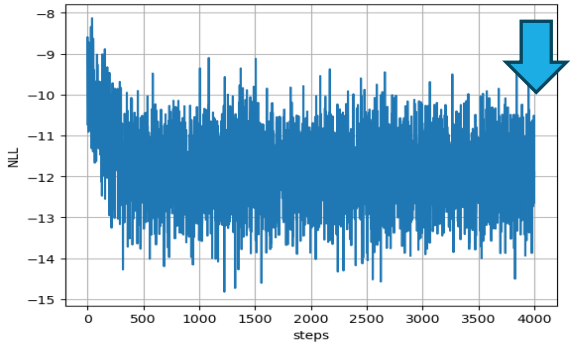
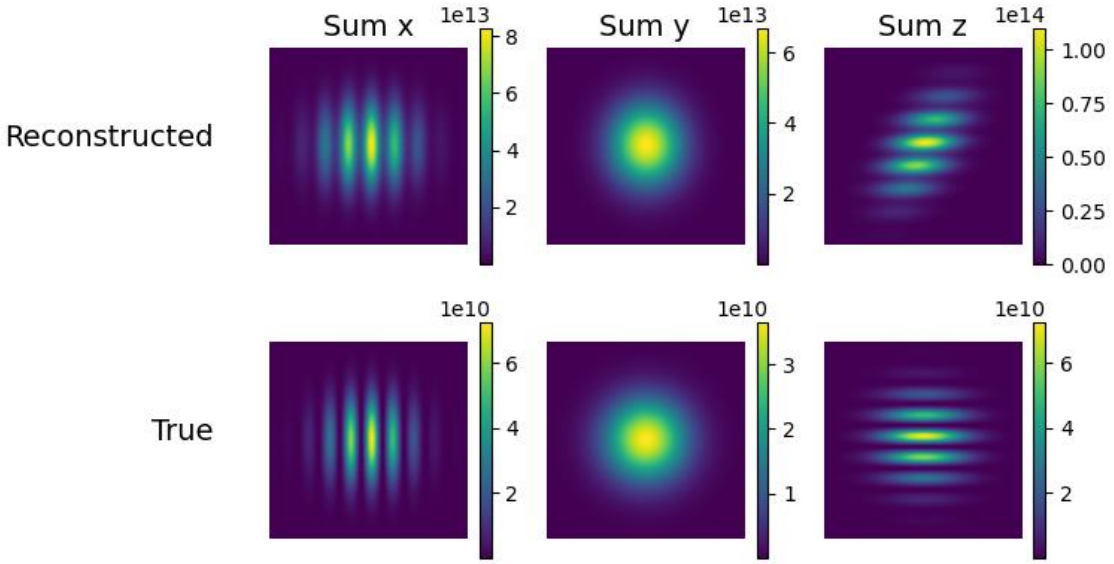
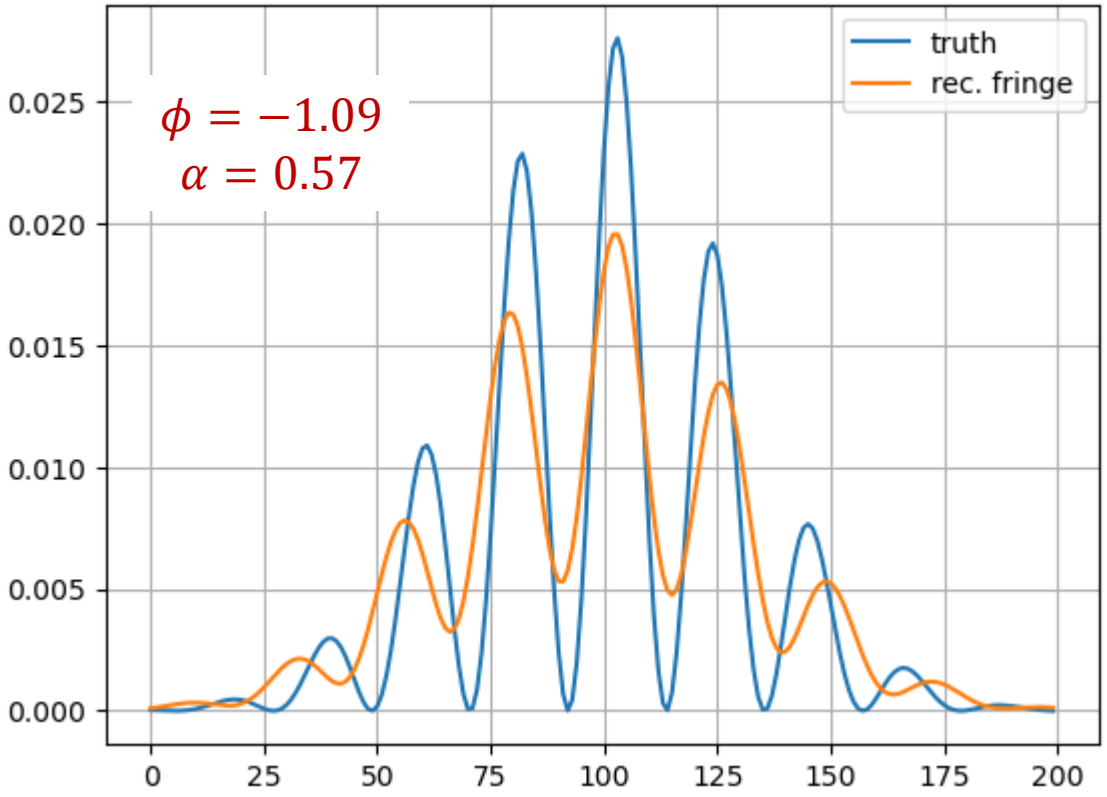


Atom density projections



Y projection

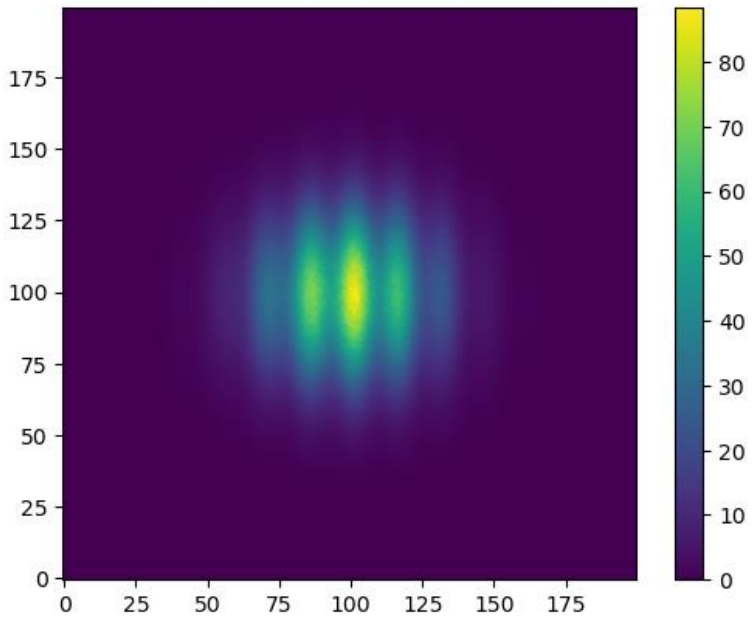


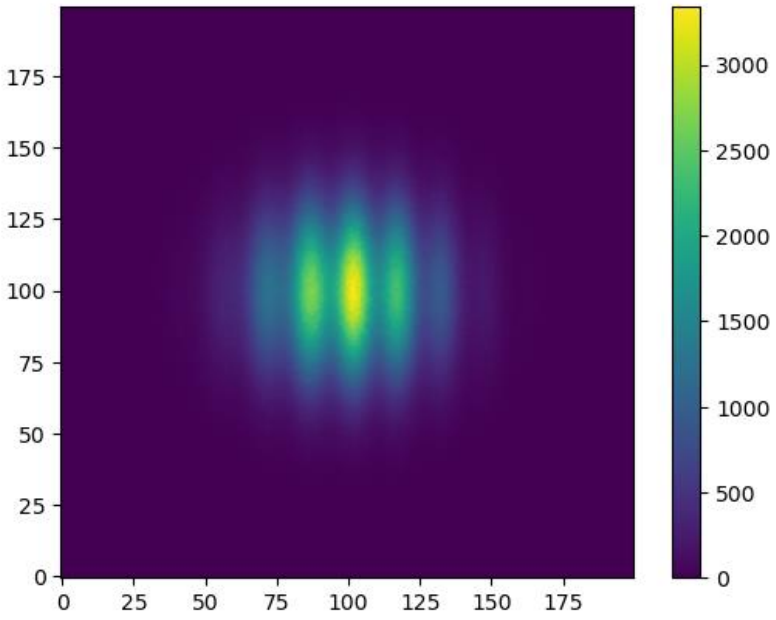
Ambiguity in shape due to using only two images

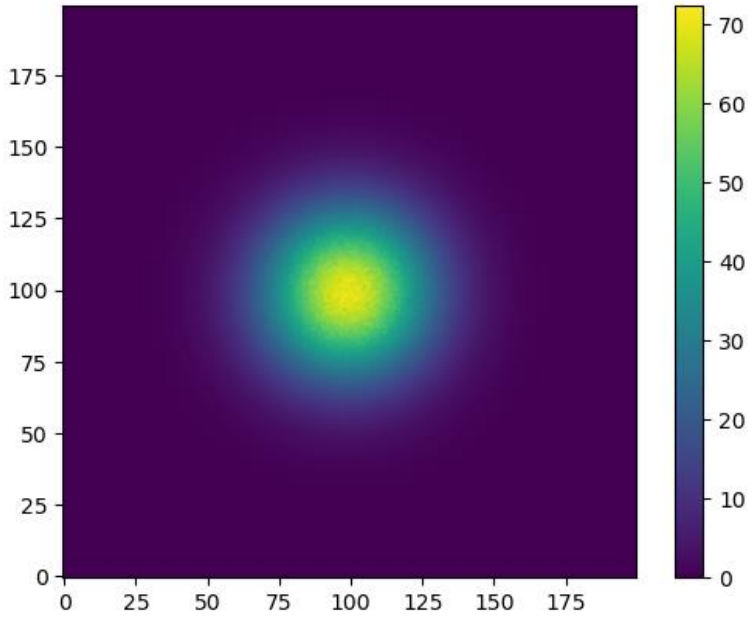
After reconstruction

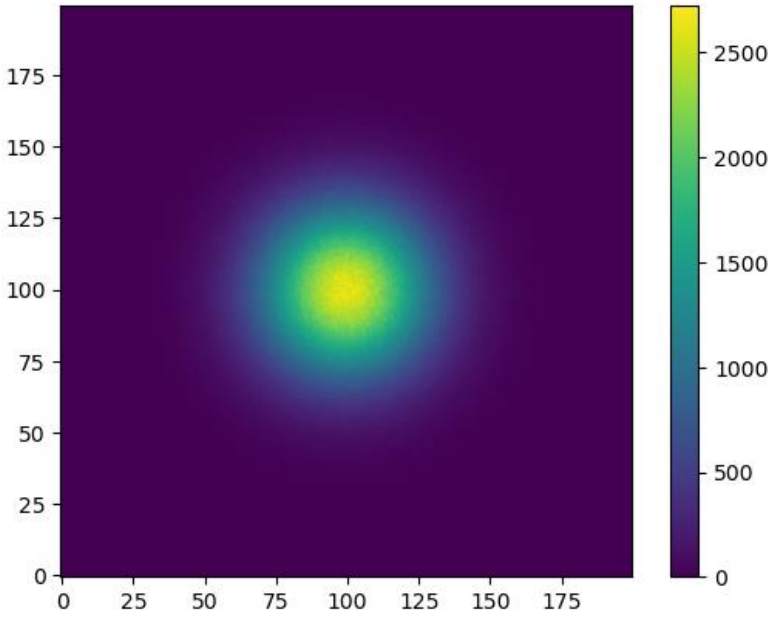
Input intensity

Intensity in Sensor planes

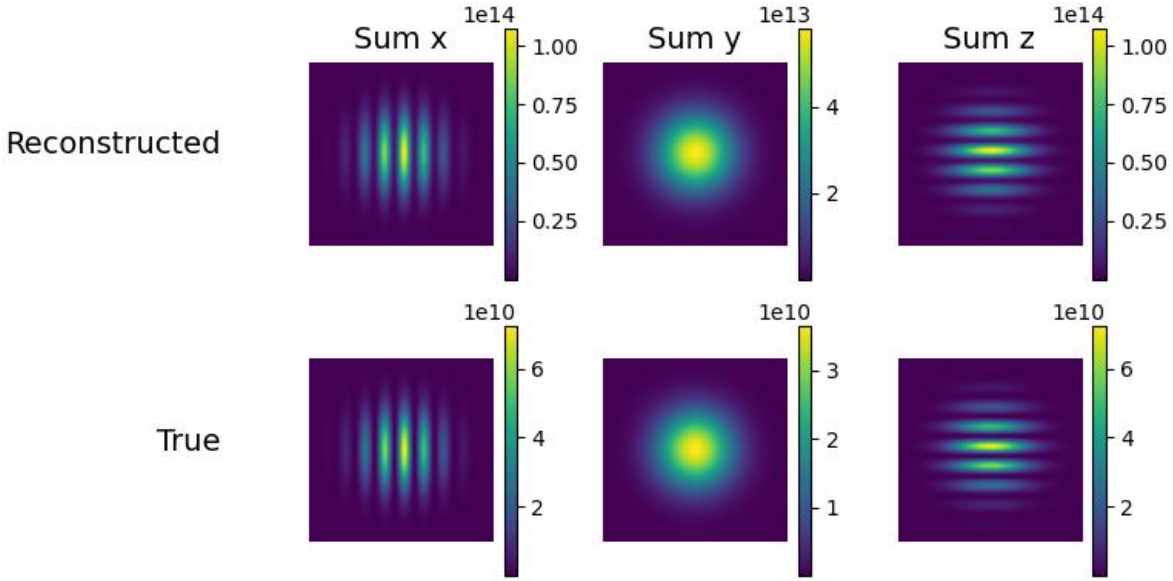


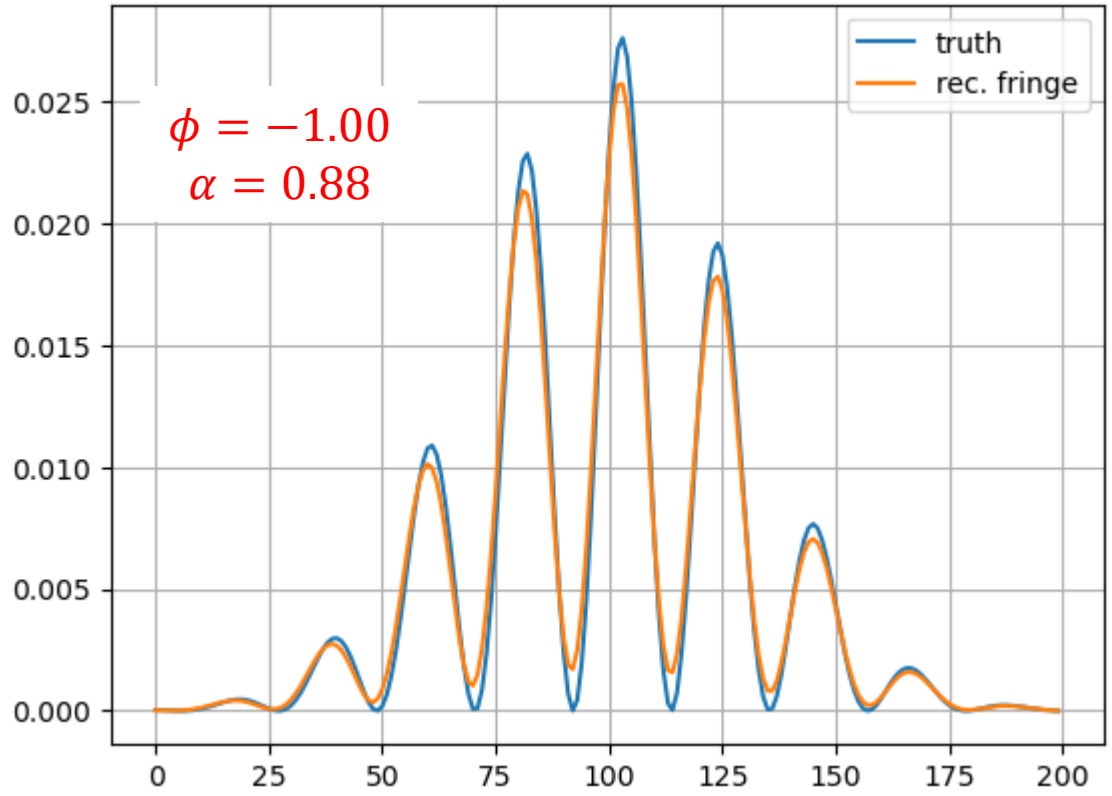






4 CAMS – ROTATION AND GENERAL COVARIANCE



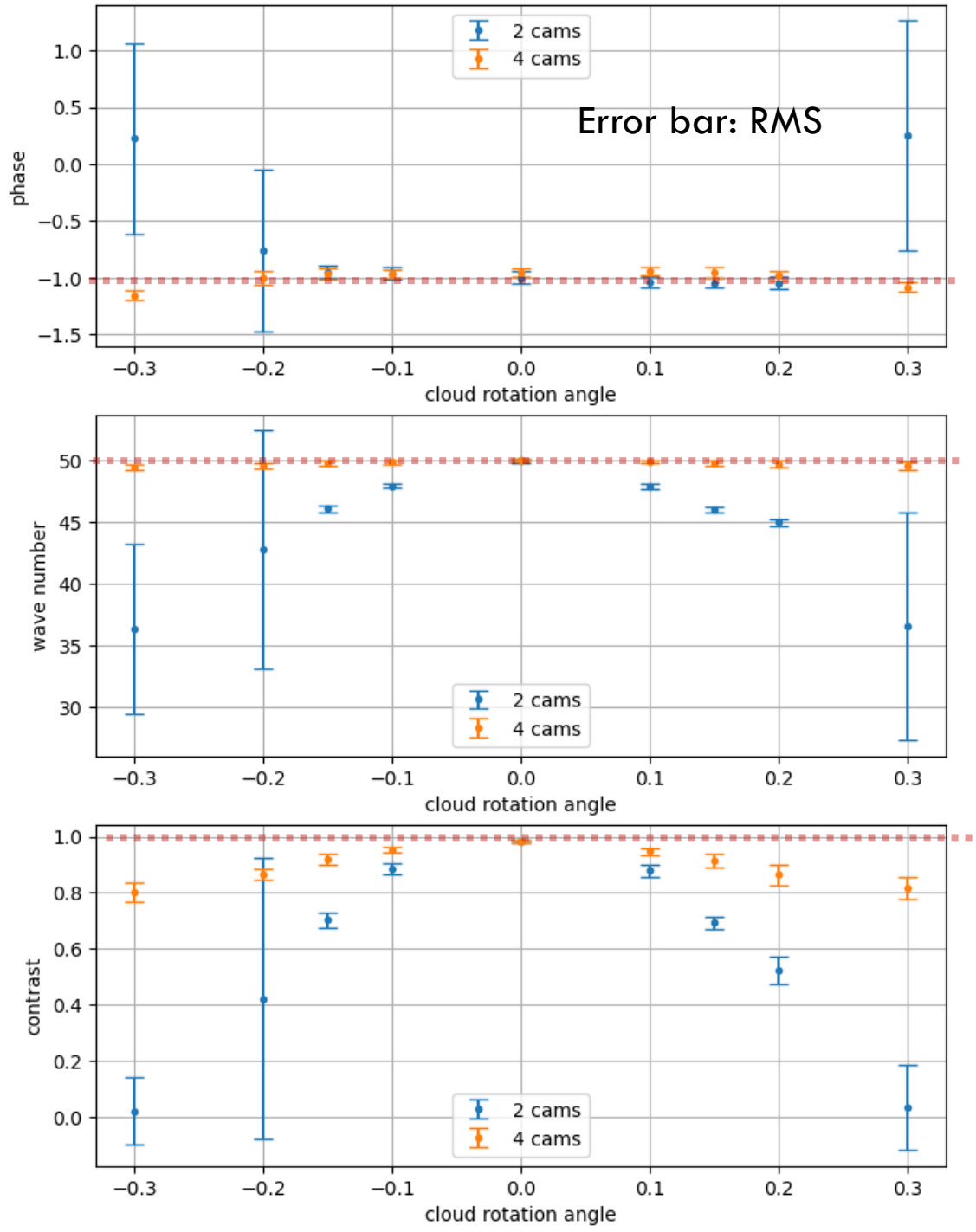


Correct shape obtained

IMPACT OF ADDITIONAL VIEWS

For large angles, 2 cam setup fails to fit sometimes, hence, large error bars

Better determination of parameters possible with more views



SUMMARY

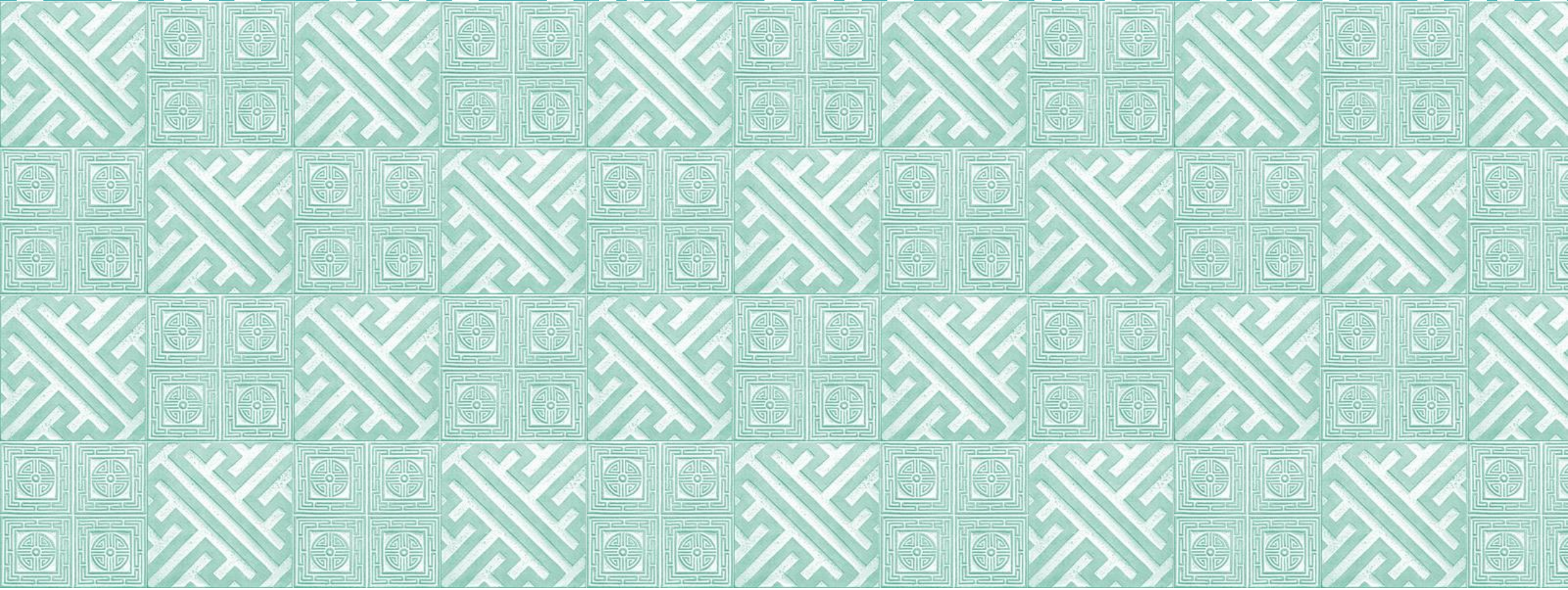
Benefits of cameras with different views

- Sample case study
- Constrains the shape and improves parameter determination (for scientific nodes).

Opportunities for additional views

- Other potential applications / physics opportunities (laser wavefront aberrations)
- Can we accommodate more cameras? Space constraints?

Edmund optics: #59-873
Length: 53.7mm
Diameter: 35.8mm



2 CAMS – NO ROTATION & PERFECT SPHERICAL SHAPE