Simulation of the multi-view imaging system with differentiable ray tracing

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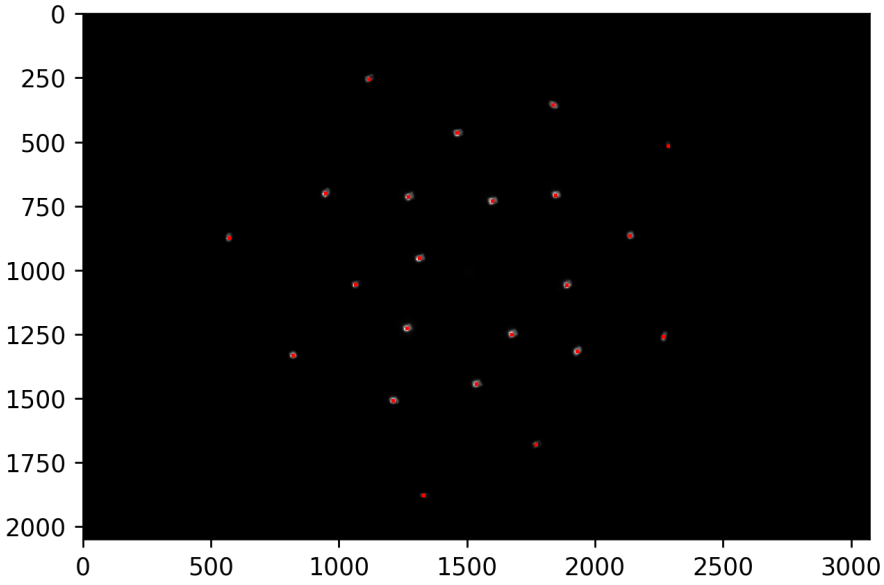
U.S. DEPARTMENT OF ENERGY
Office of Science

SLAC NATIONAL ACCELERATOR LABORATORY

Gradient-based calibration

- The simulator has been calibrated with gradient-based optimization
  - Only fitting for the normals
- Target positions extracted with k-means clustering

- **How good is the calibration?**



Synthetic calibrations

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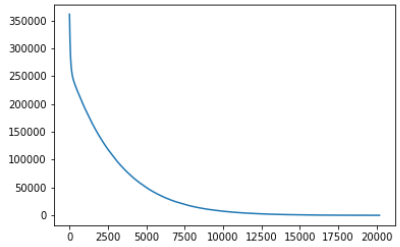
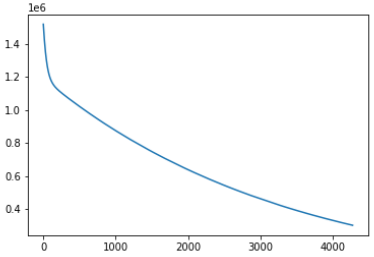
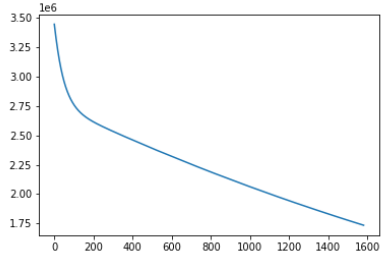
- Calibration from simulated images
  - → known ground truth
- Perfect calibration when only the normals are altered
  - Single measurement
- The problem is more difficult when both the normals & cloud's position are alterded
  - Using multiple measurements
    - Fixed normals
    - Different cloud's position for each measurement (±1mm in all directions)

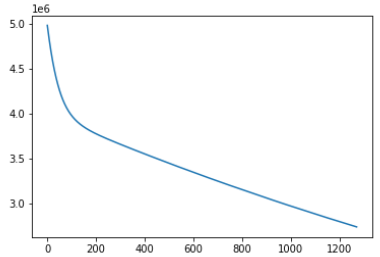
Synthetic calibrations

Training Loss (L2 norm)
Observed / known

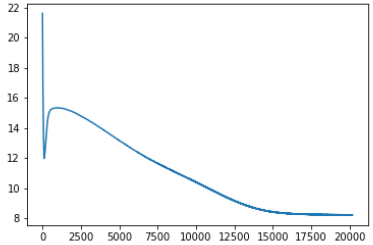




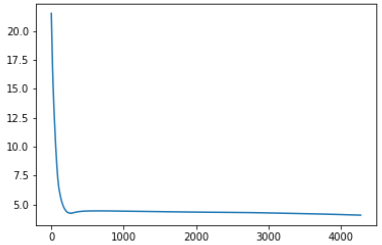




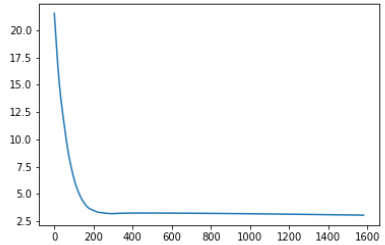
Absolute angular error (23 mirrors)
Unknown



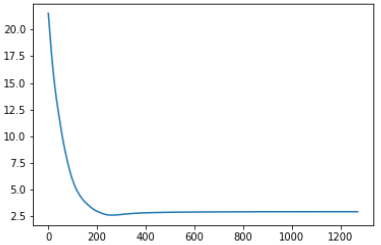
10 measurements



50 measurements



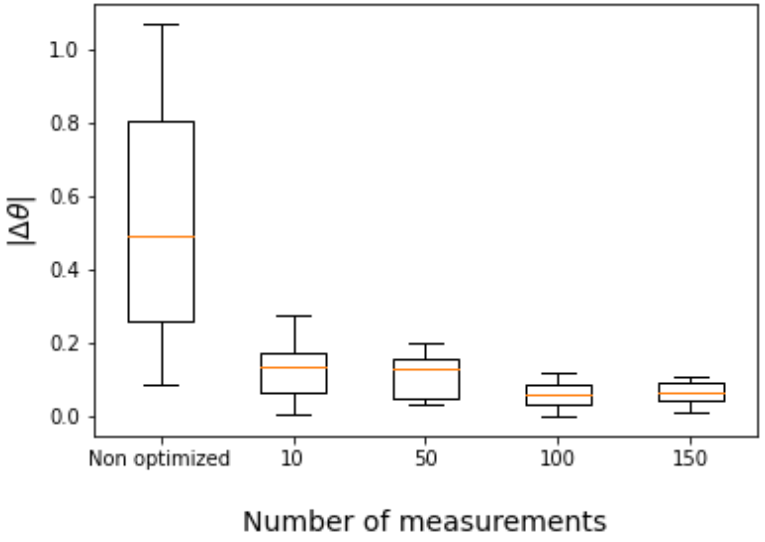
100 measurements

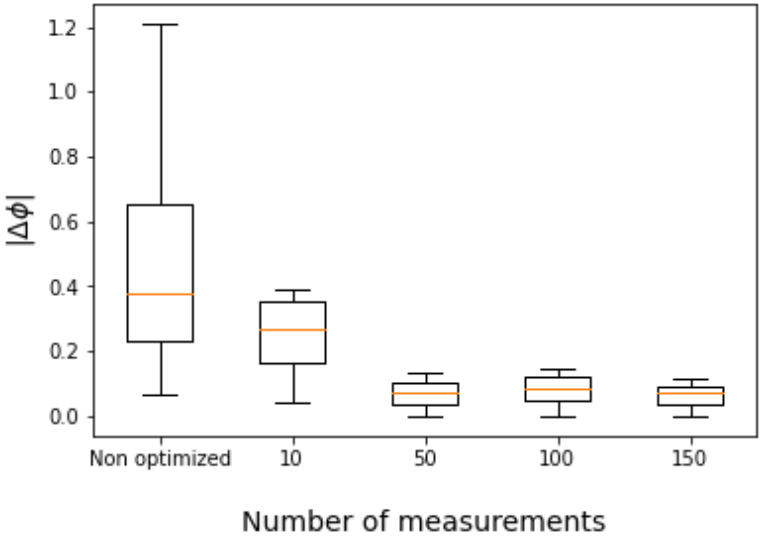


150 measurements

Synthetic calibrations

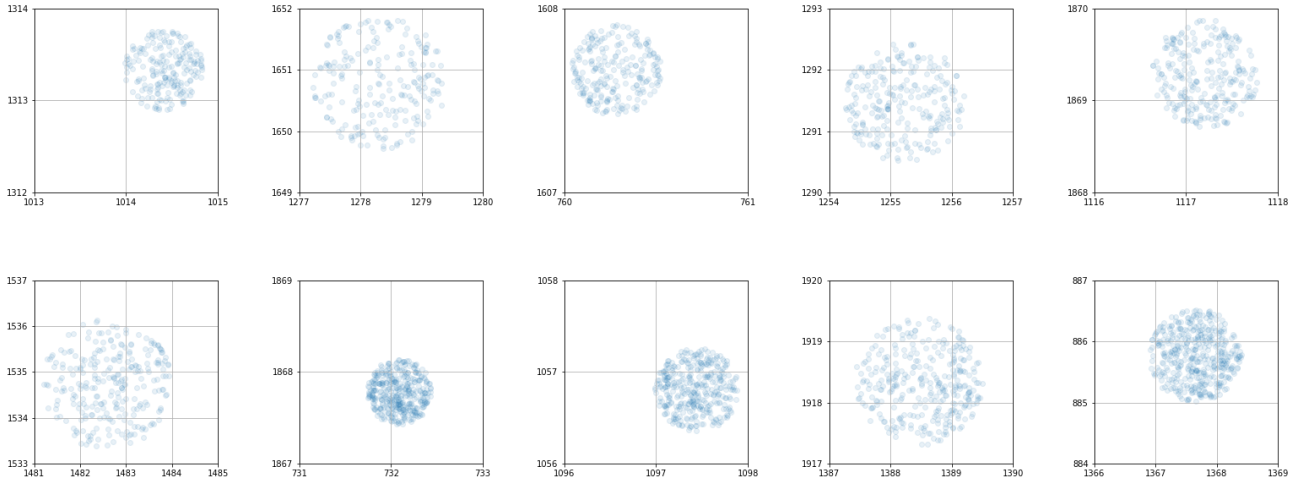
	$mean\ (|\Delta\theta|)$ — in degree	$mean\ (|\Delta\phi|)$ — in degree
10 measurements	0.13	0.25
50 measurements	0.11	0.07
100 measurements	0.06	0.08
150 measurements	0.07	0.07





Defocus

- Target positions extracted with k-means clustering
  - Convenient
  - Does not use defocus information



Geometric blur

- Normal angles (altered by ~1°)
- Cloud's position ($\pm$1mm in all directions)

Next steps

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- Reconstruction
  - Initiate reconstruction with the current calibration

- Calibration
  - More measurements?
  - Constrained optimization?
  - Using defocus information?
    - Requires to model PSF + geometric blur
    - Requires an ~ ideal point source
      - Or a known object (which is itself not calibrated…)
  - Add extra nuisance parameters (lens' position & dome's position)
    - Orientations?