Orientation Estimation of Cut Stones Facets

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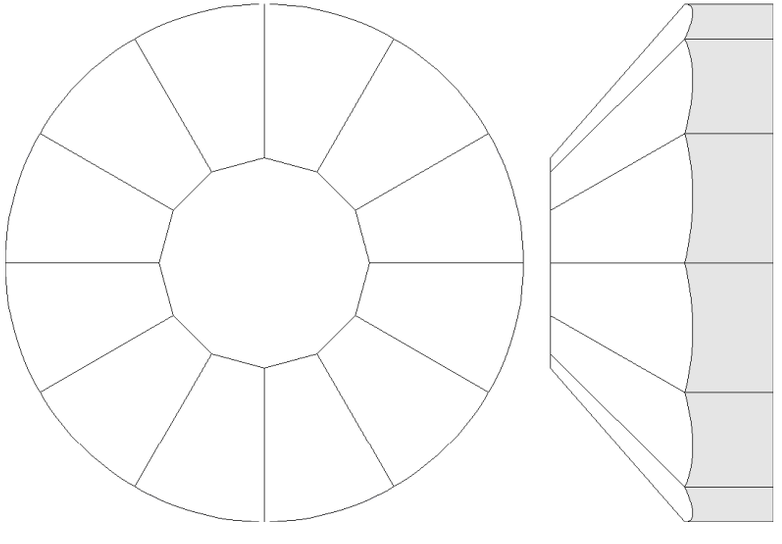
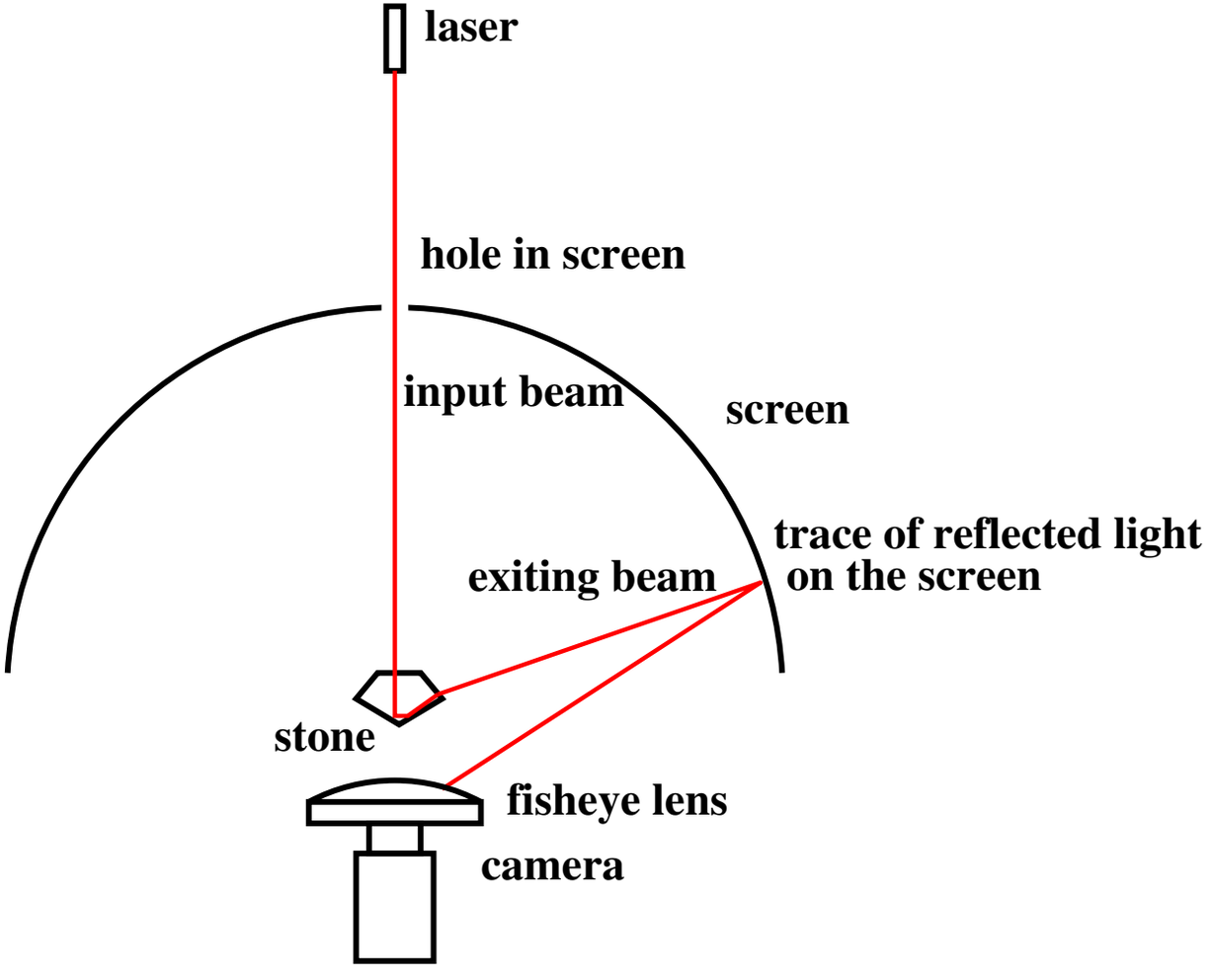
Motivation

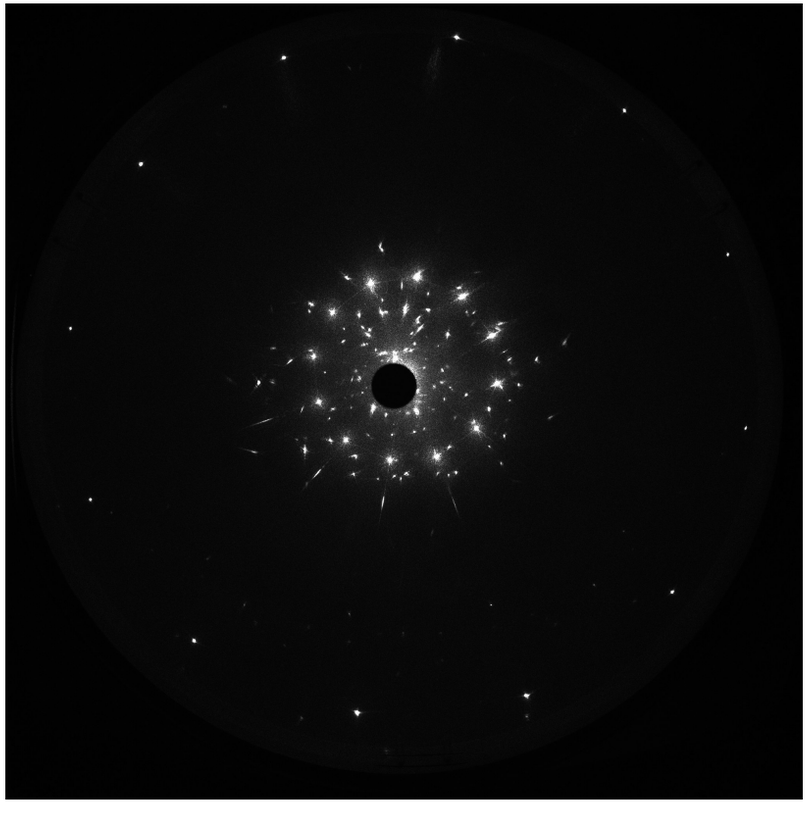
Real cut stone and its defects:

- Surface defects (unpolished, broken,...)
- Material defects (bubbles, inclusions, streaks,...)
- Shape defects
  - Too much/little ground facet — measuring tools exist
  - Deflected facet — measuring angles by direct observation is not accurate enough



Simple Experiment (Reinitz 2001)



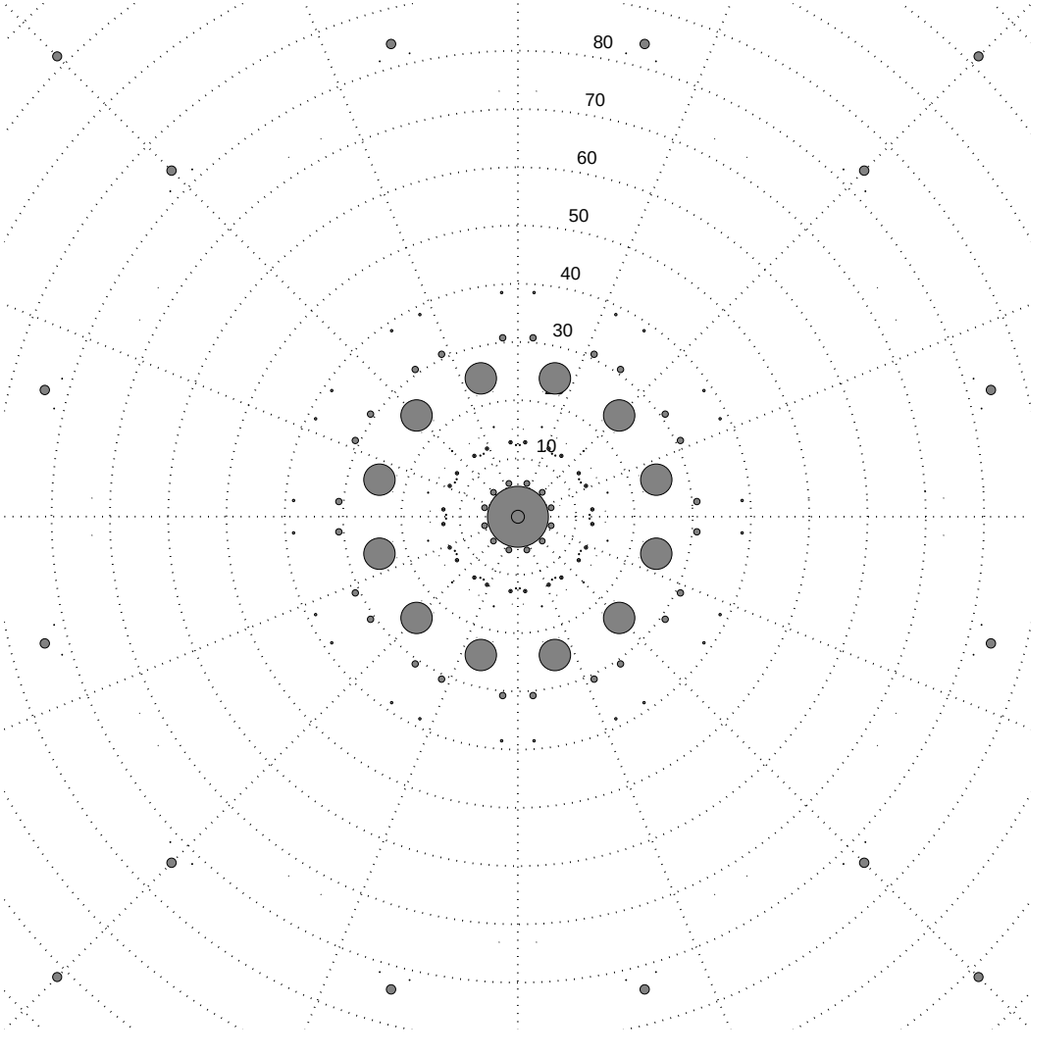


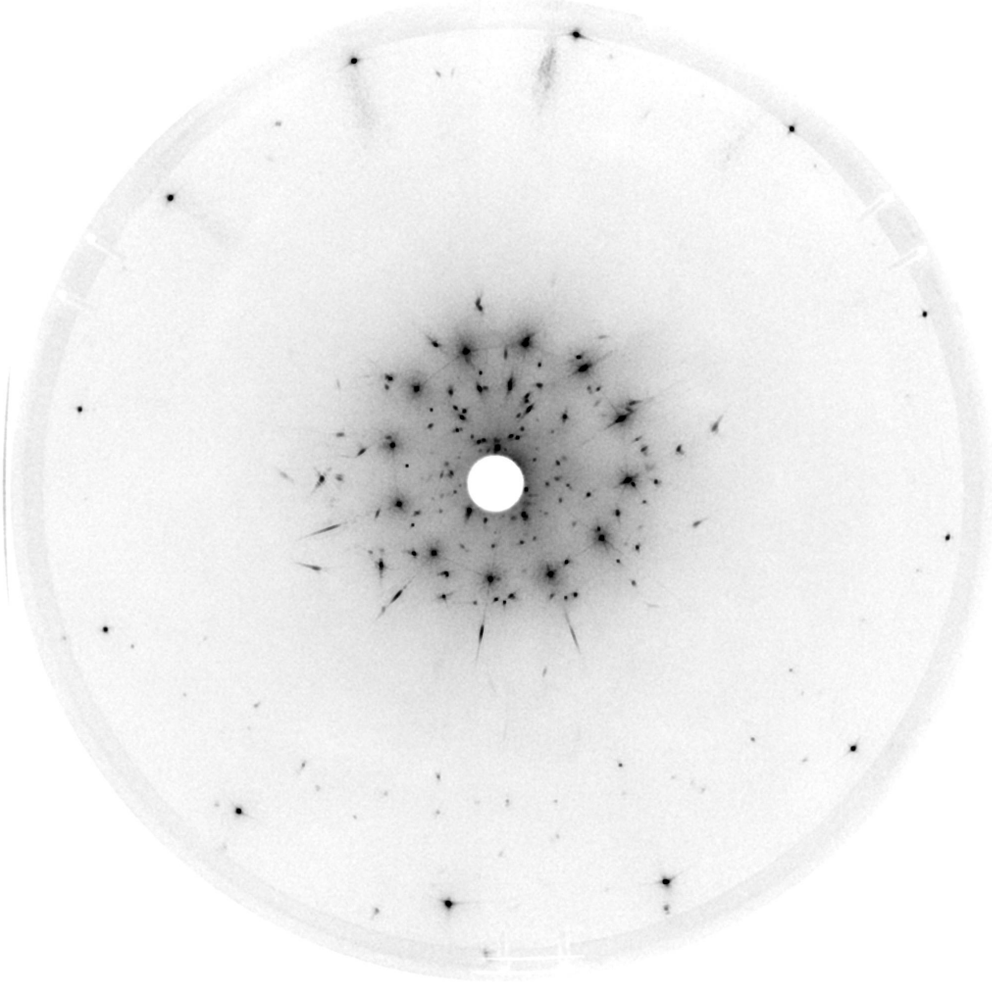
Ladok

- Simulation of the parallel beam propagation through convex polyhedron.
- Simulation involves refraction, reflection, absorption, polarization, smooth, mirroring, absorbing facets, smooth edges between facets.
- Output:
  - Geometry and energetic parameters of output beams
  - Detailed information about the beam pass through the stone
- Forward problem:
  Stone model + an input beam $\rightarrow$ exiting beams

Idea

To compare simulation results with the experimental data





- Inverse problem:
  An input beam + exiting beams $\rightarrow$ stone model

Goal

We want to measure the orientation of facets accurately

Simplification:

- Distance stone – screen $\gg$ size of facets and (slightly) curved facets $\Rightarrow$ position of the facet and beam cross-section is not important

Scenario

- Let us have a real, almost good stone = close to the nominal dimensions
- Let us have an ideal model of the stone
- Let us parametrize the orientation of the facets
- Capture the image of beam traces $\rightarrow$ direction of beams
- Simulate the ideal stone
- Compare the observed directions of beams with simulated
- Make adjustments to the parameters and go to the previous step unless converge

Problems

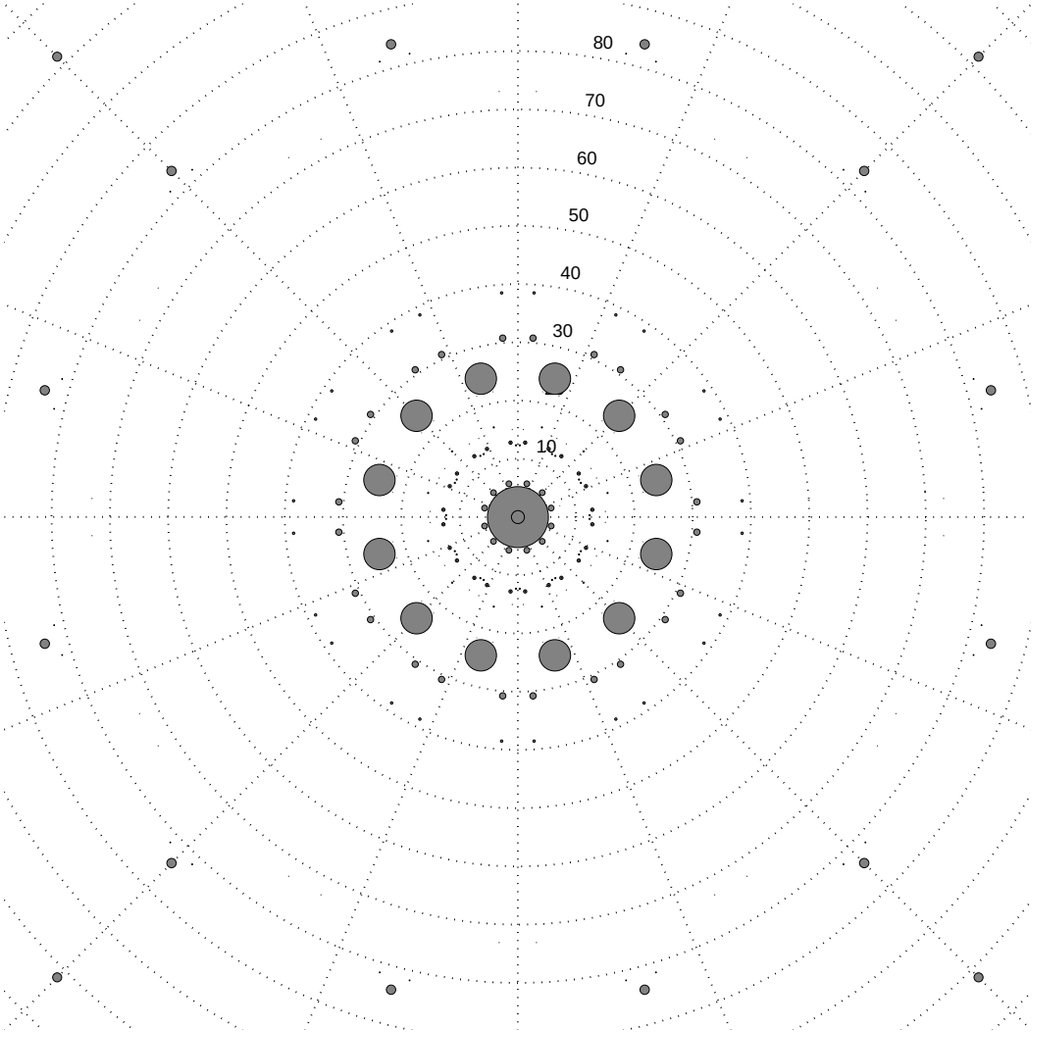
- Correspondences — many small traces

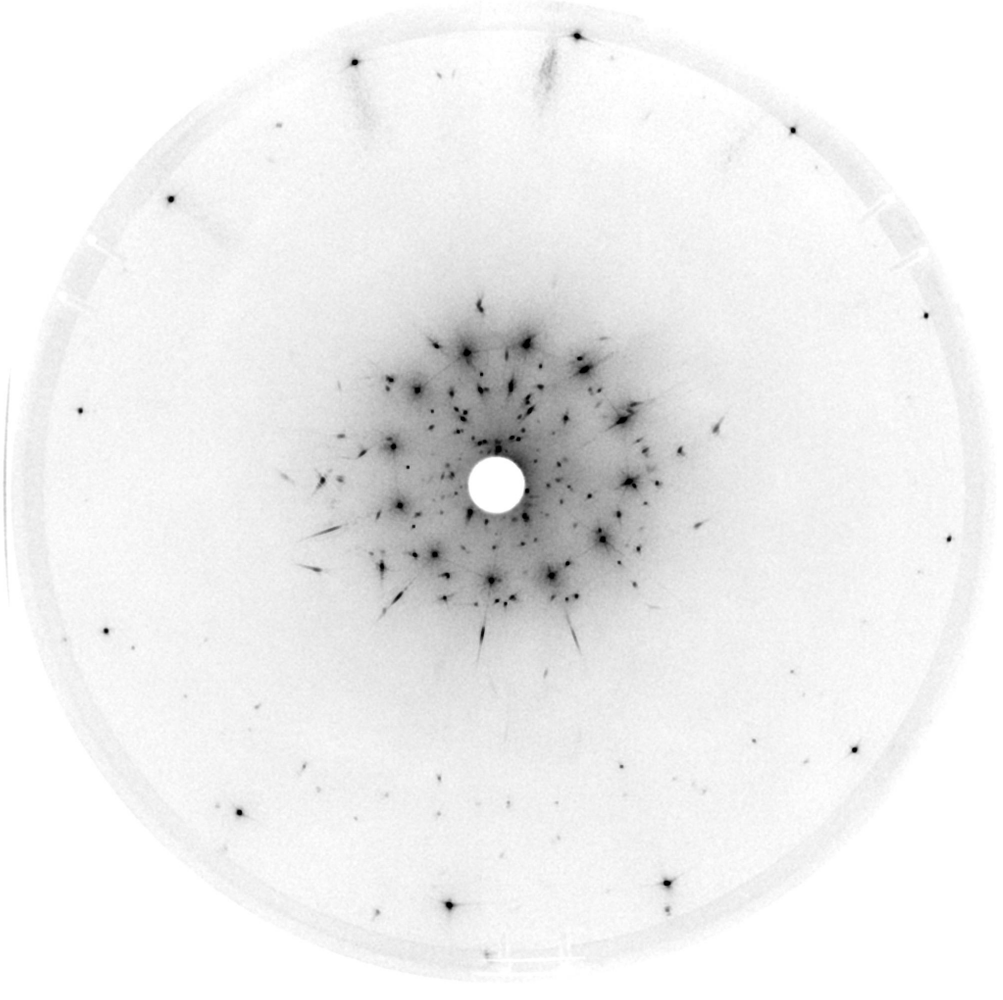
We are able to solve:

- Large stones by scanning — long time of capture
- Simple stones — few traces
- Stones with round edges

Results on Viva12

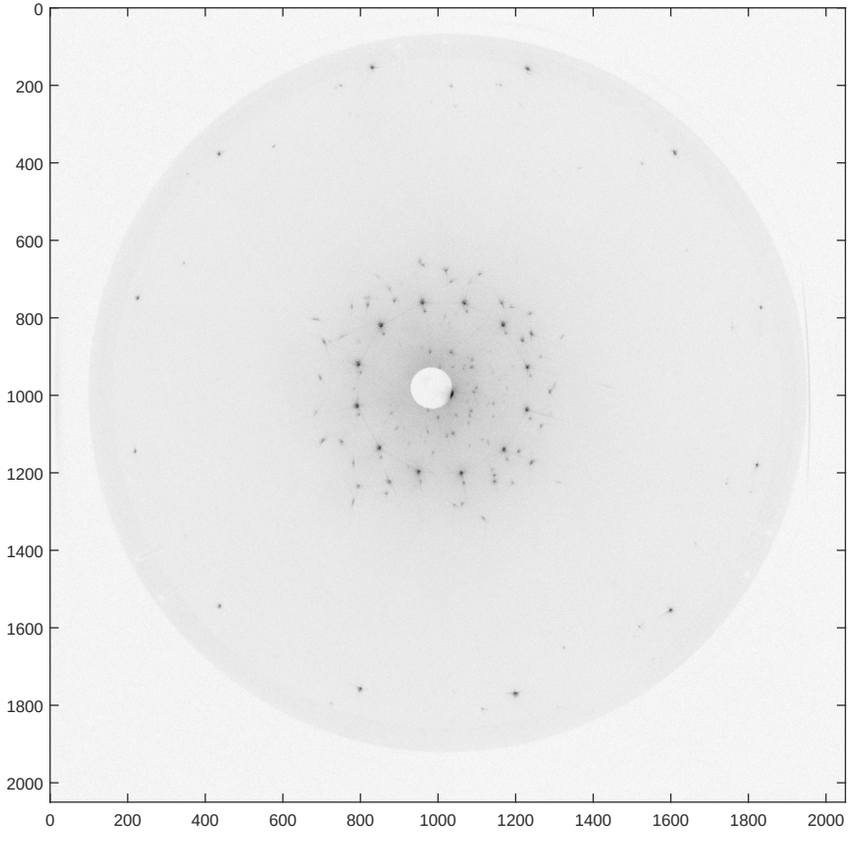
Simulation and experiment: flat-back rose cut, **clear** stone



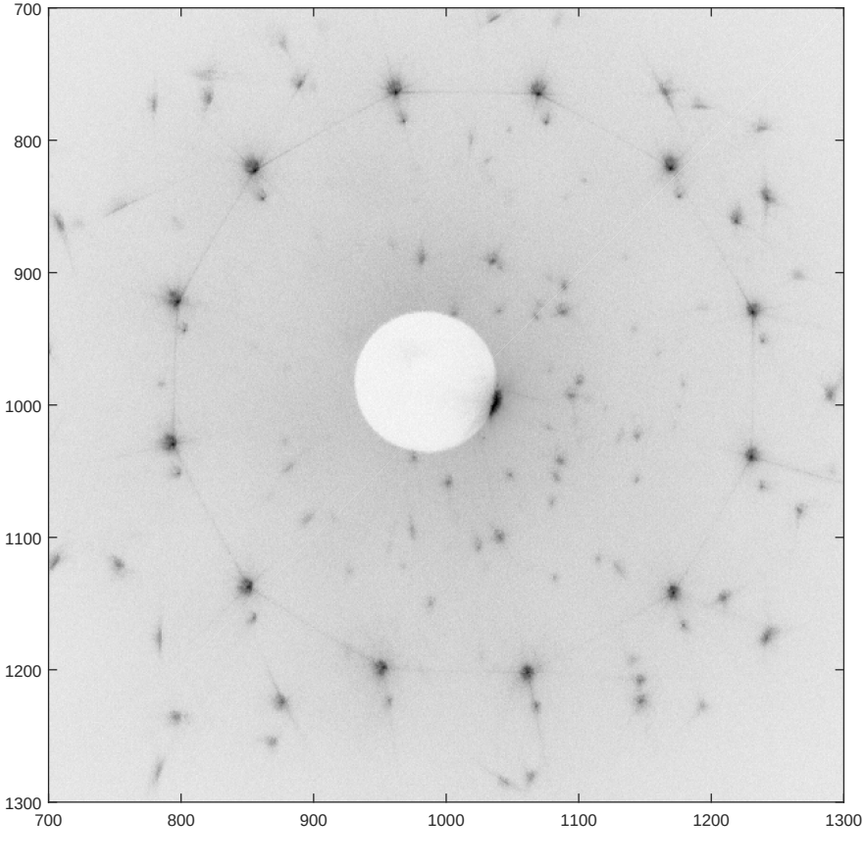


Background Scattered Light

180° degree view,

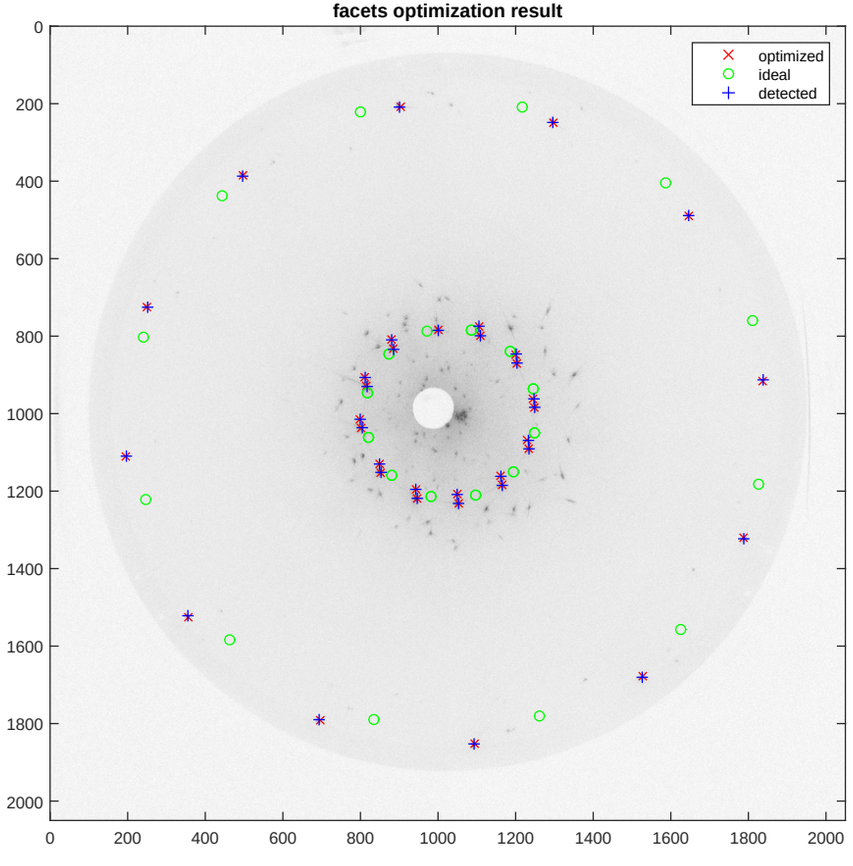


detail



Optimization

180° degree view,



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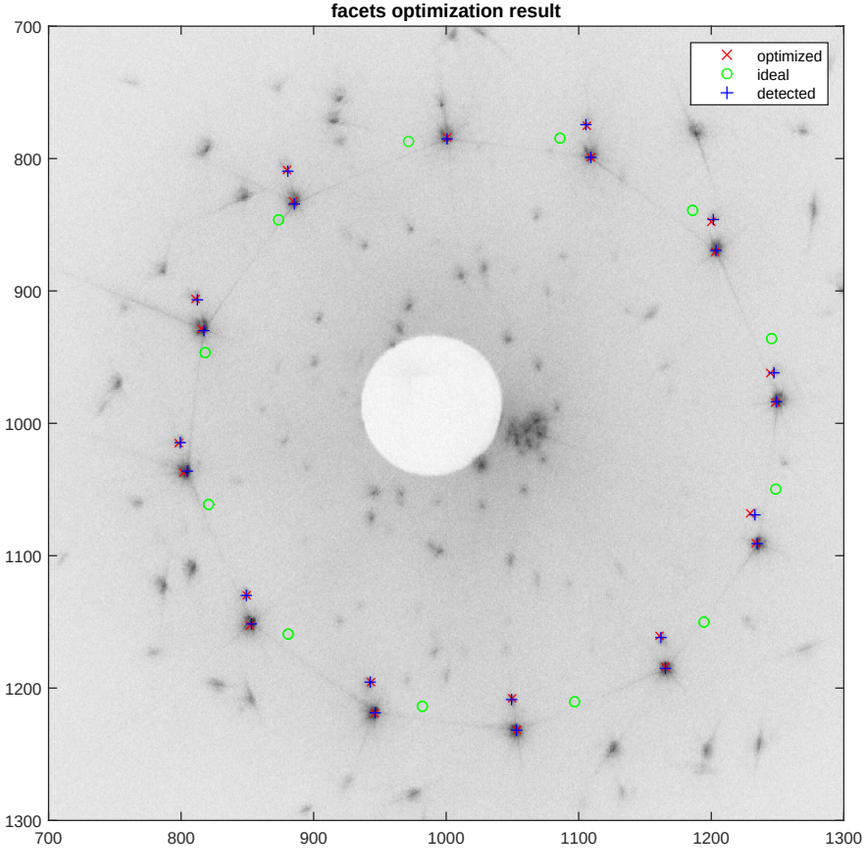
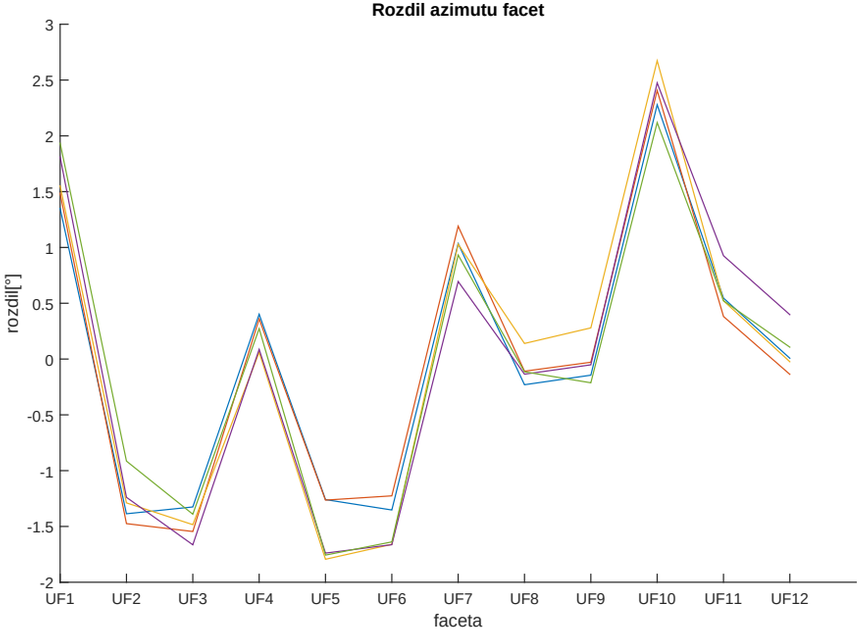


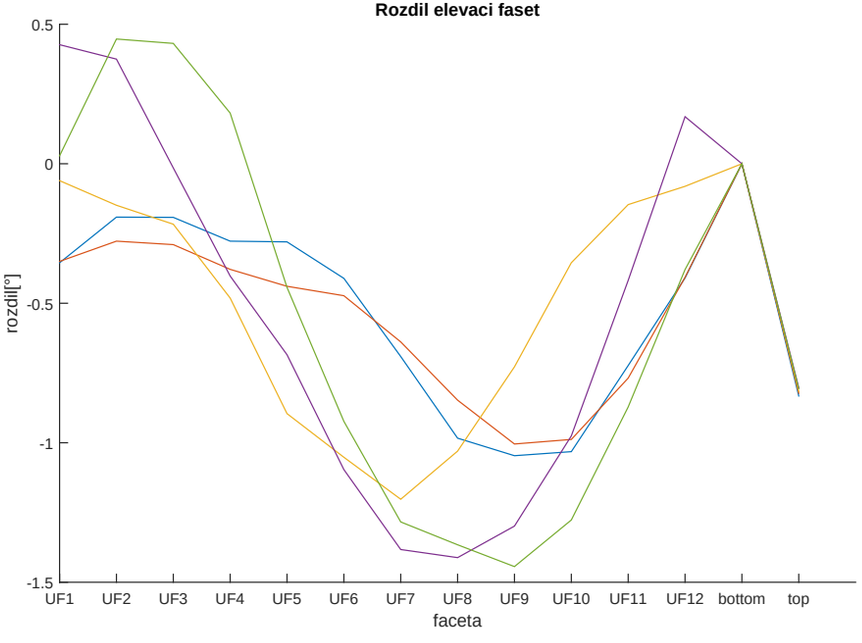
Repeatability Experiment

azimuth,



$\sigma = 0.27°$,

elevation



$\sigma = 0.4°$

Conclusion

- Solving inverse problem is feasible.
- Correspondence is still a problem for highly faceted small stones.
- Still a lot of work to be done.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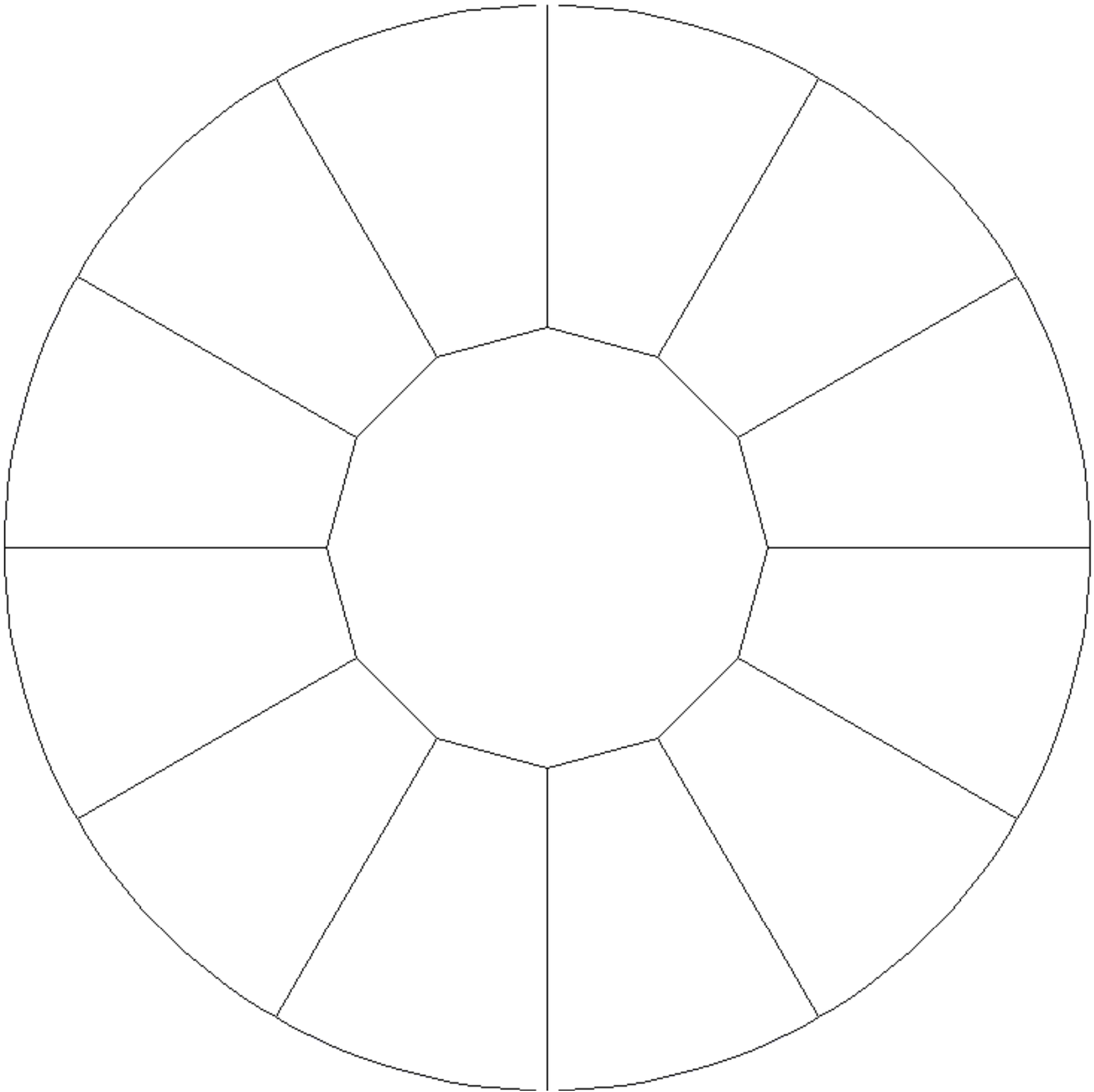
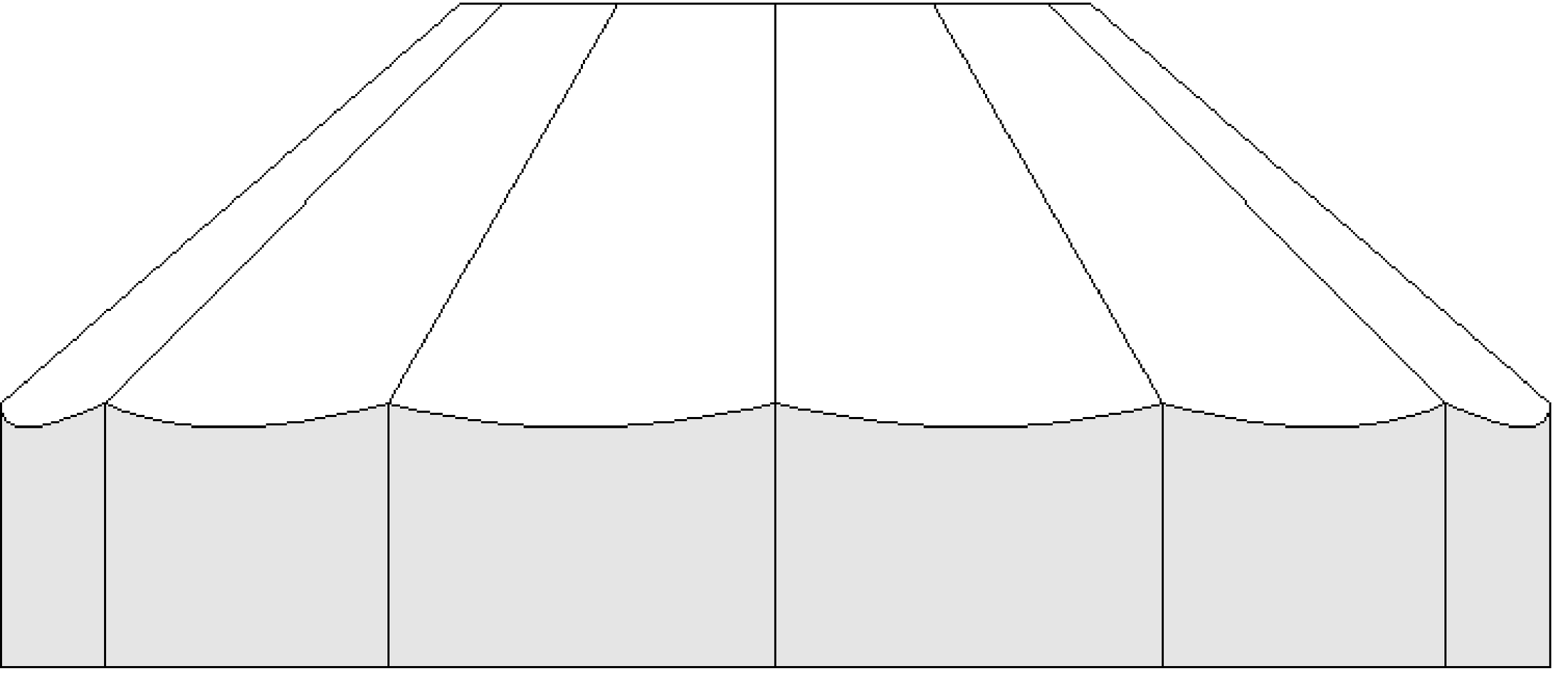
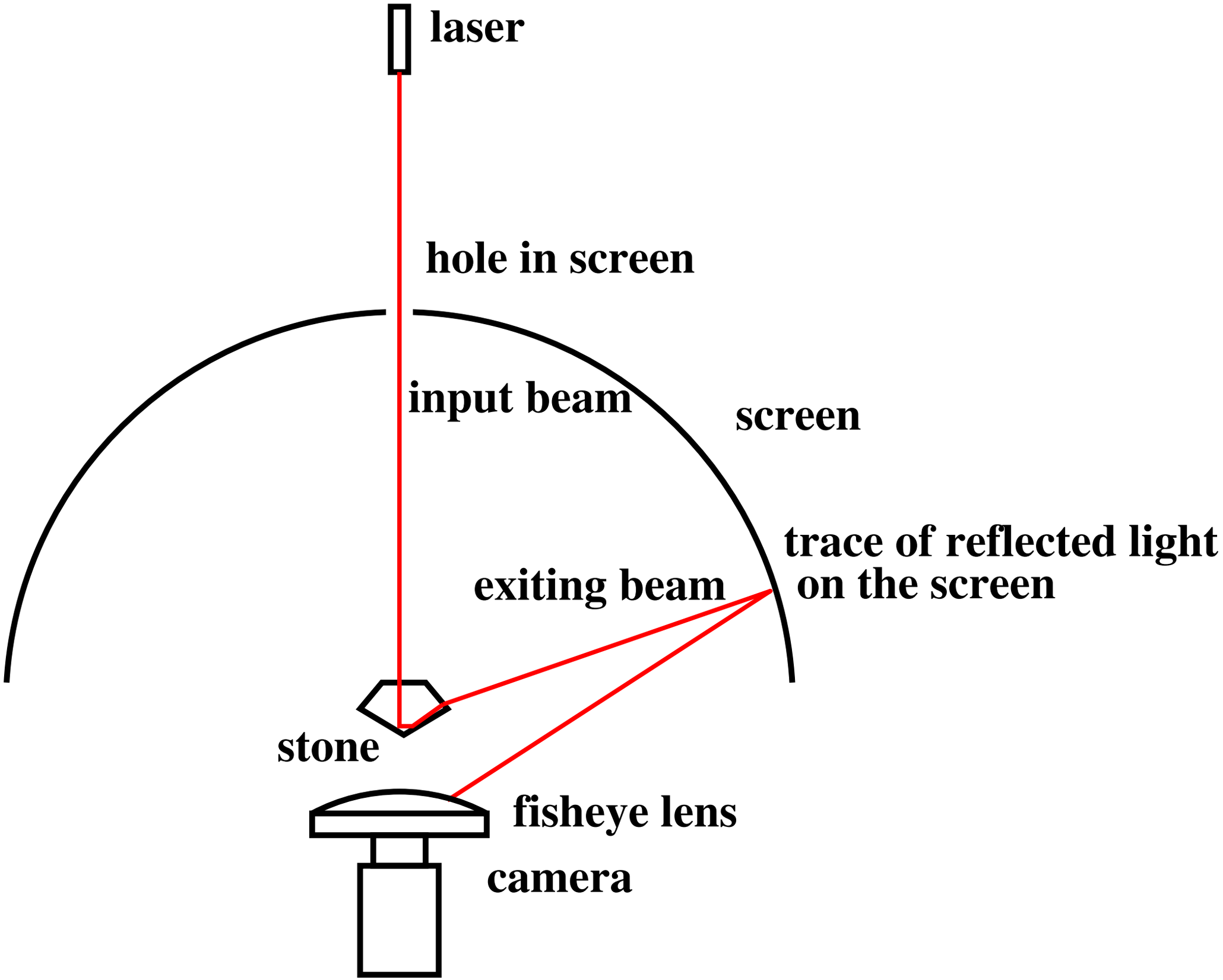
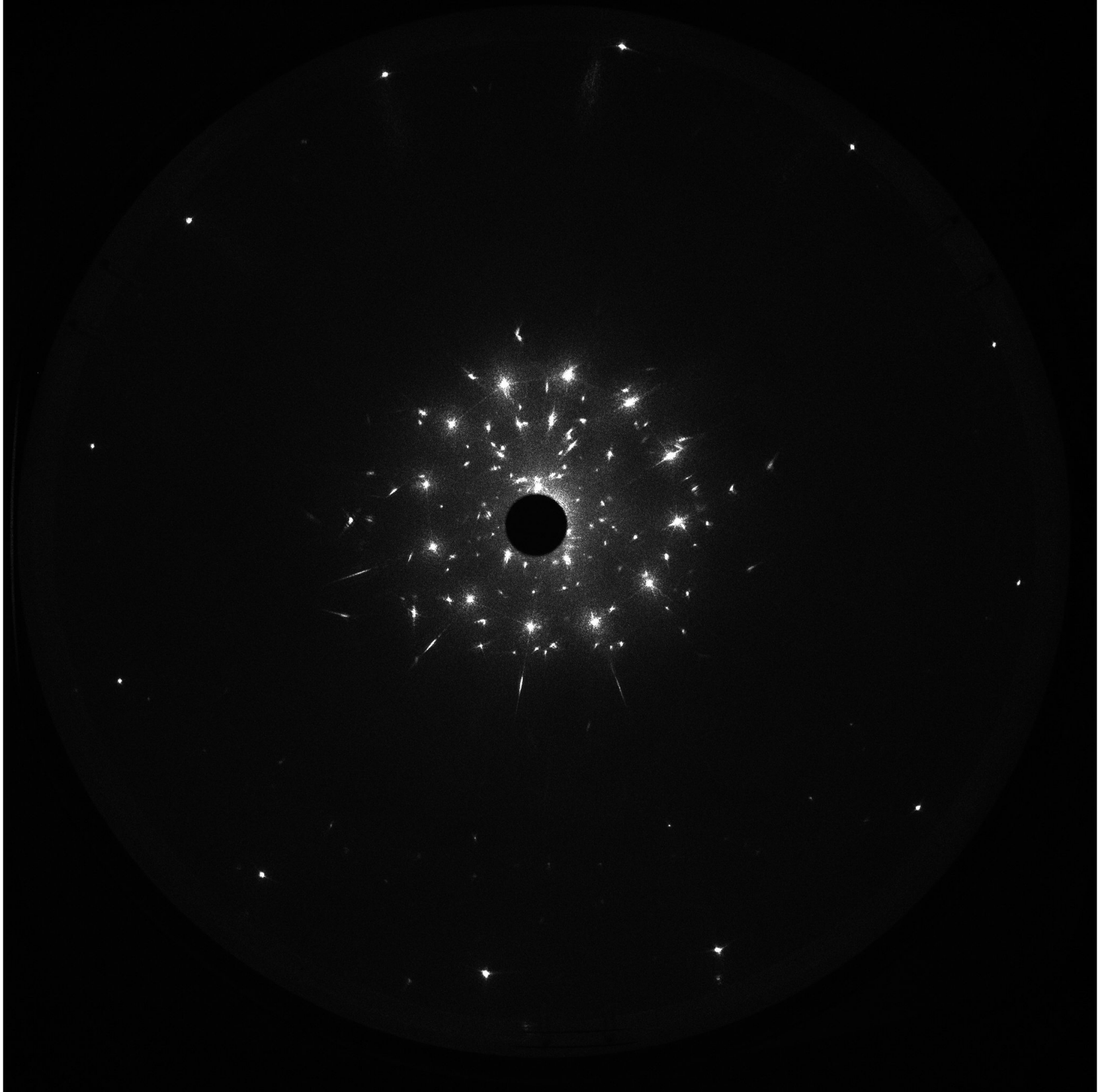
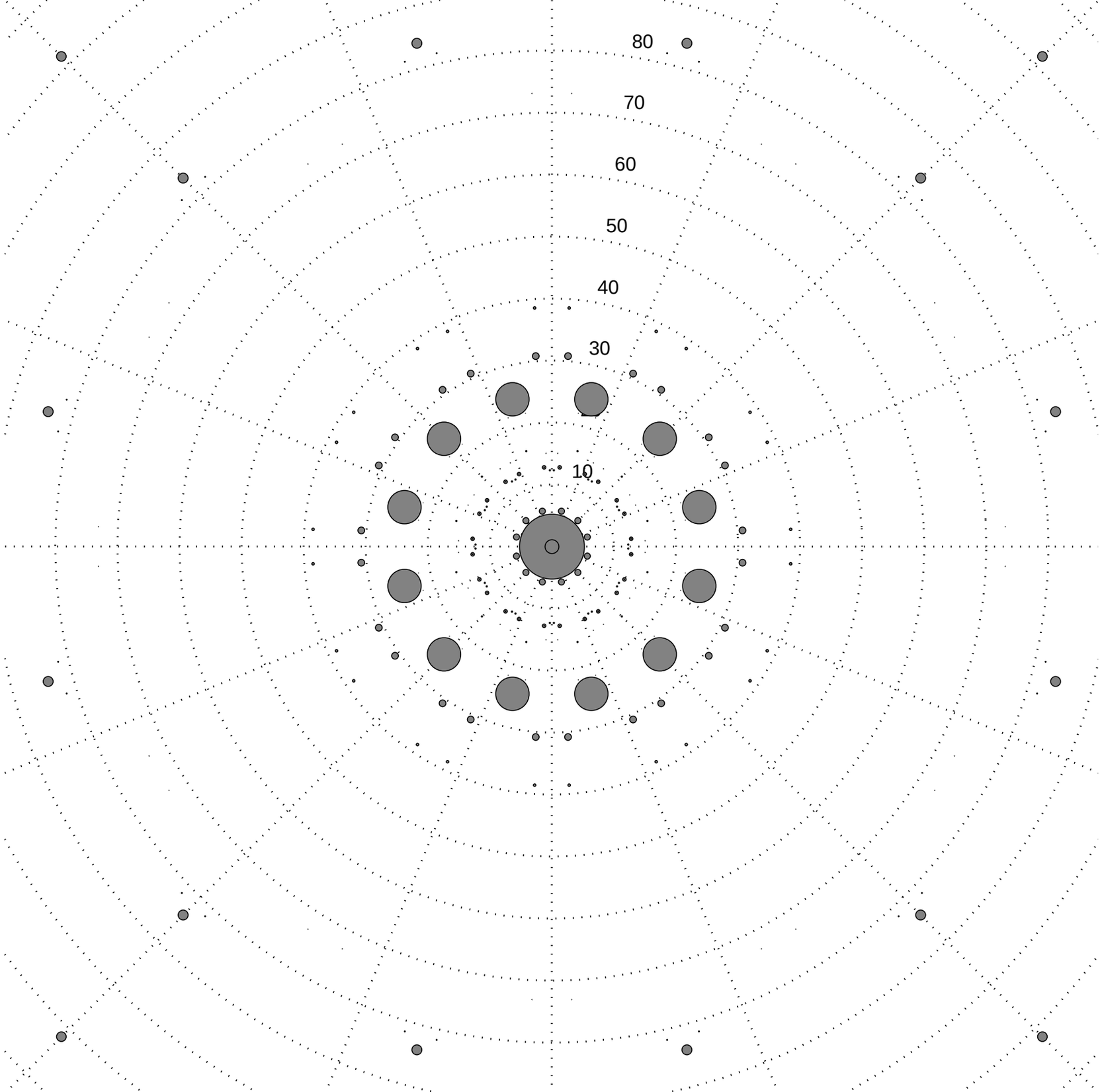





laser
hole in screen
input beam
screen
trace of reflected light
on the screen
exiting beam
stone
fisheye lens
camera

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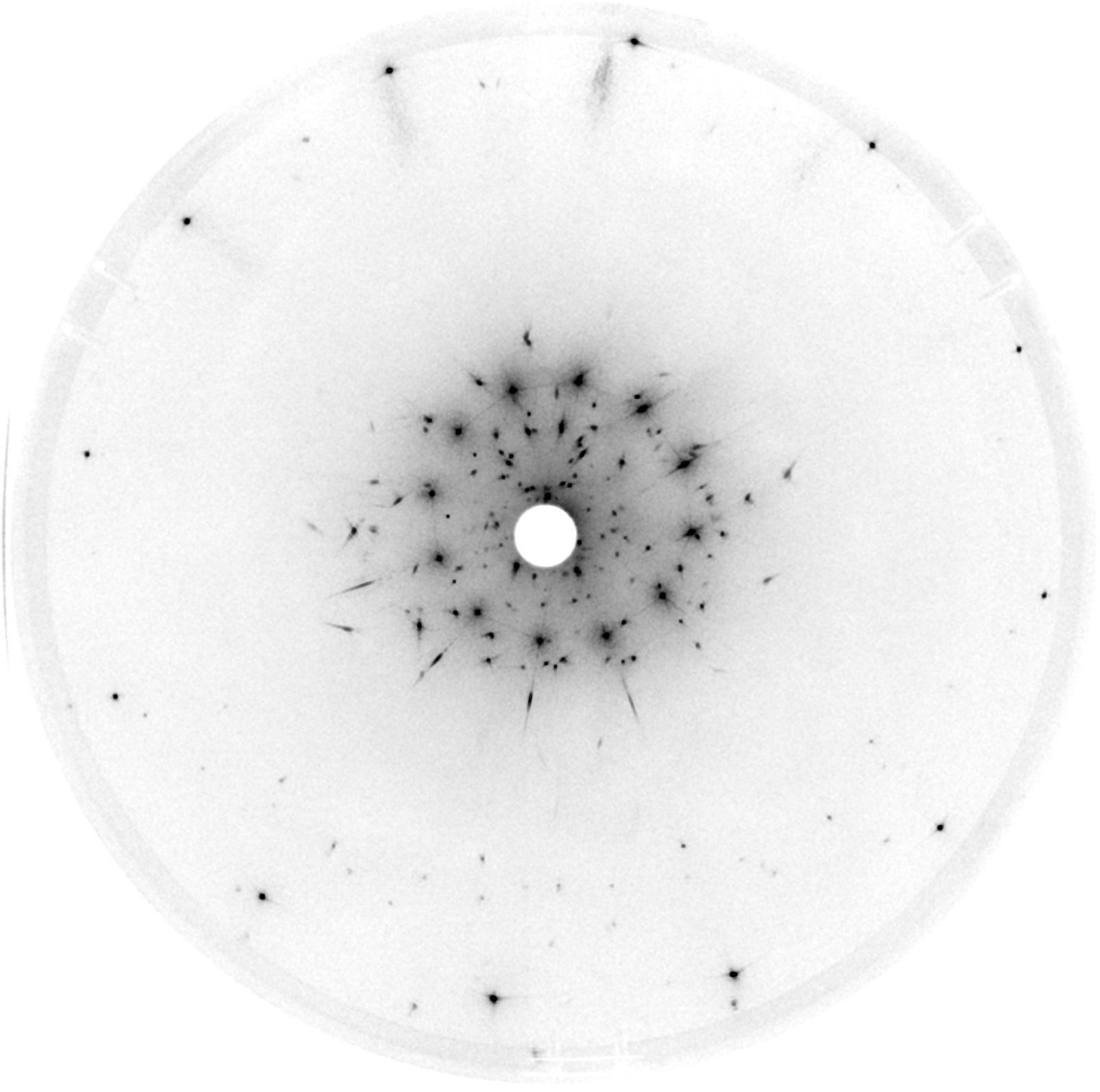

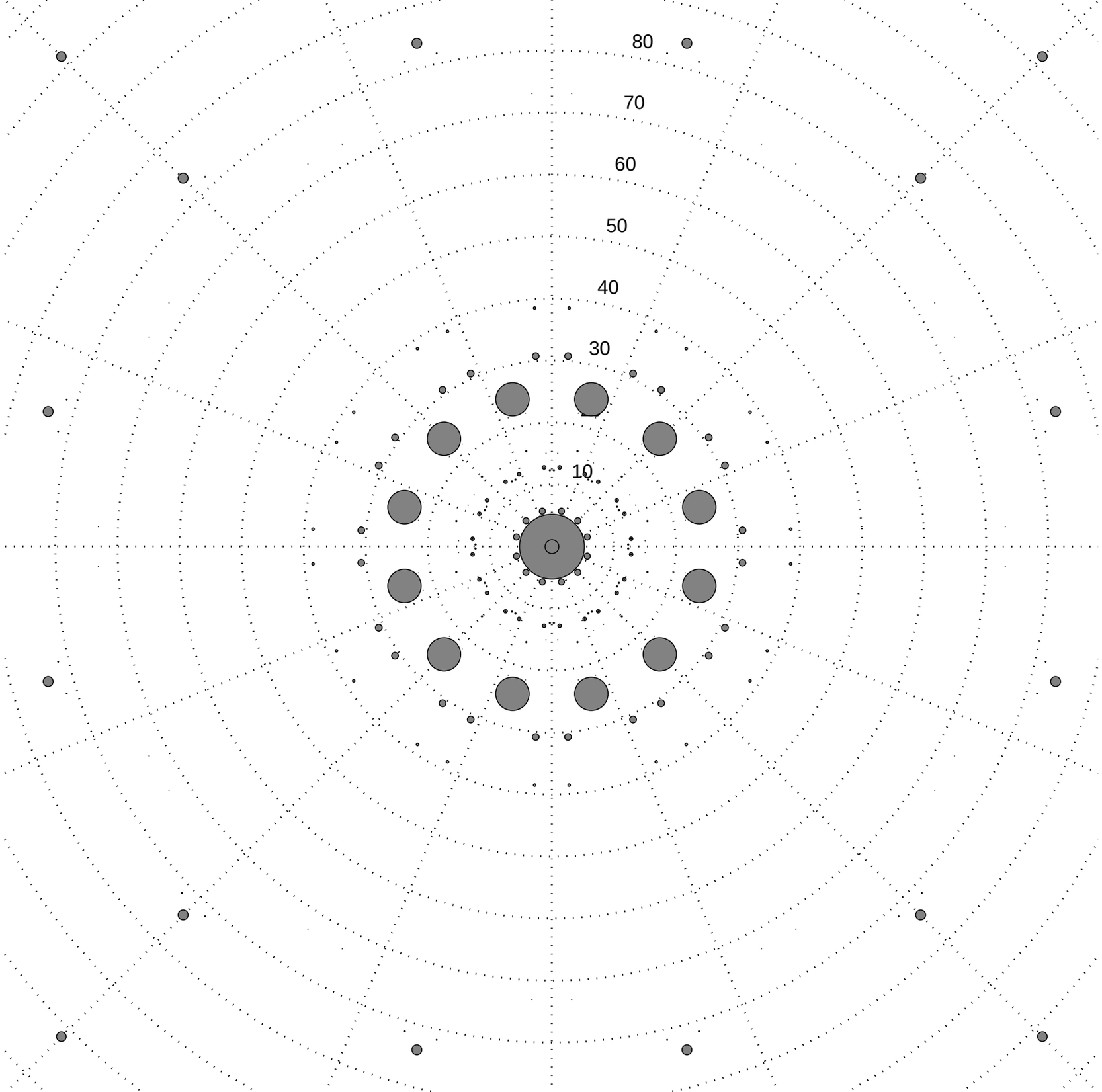
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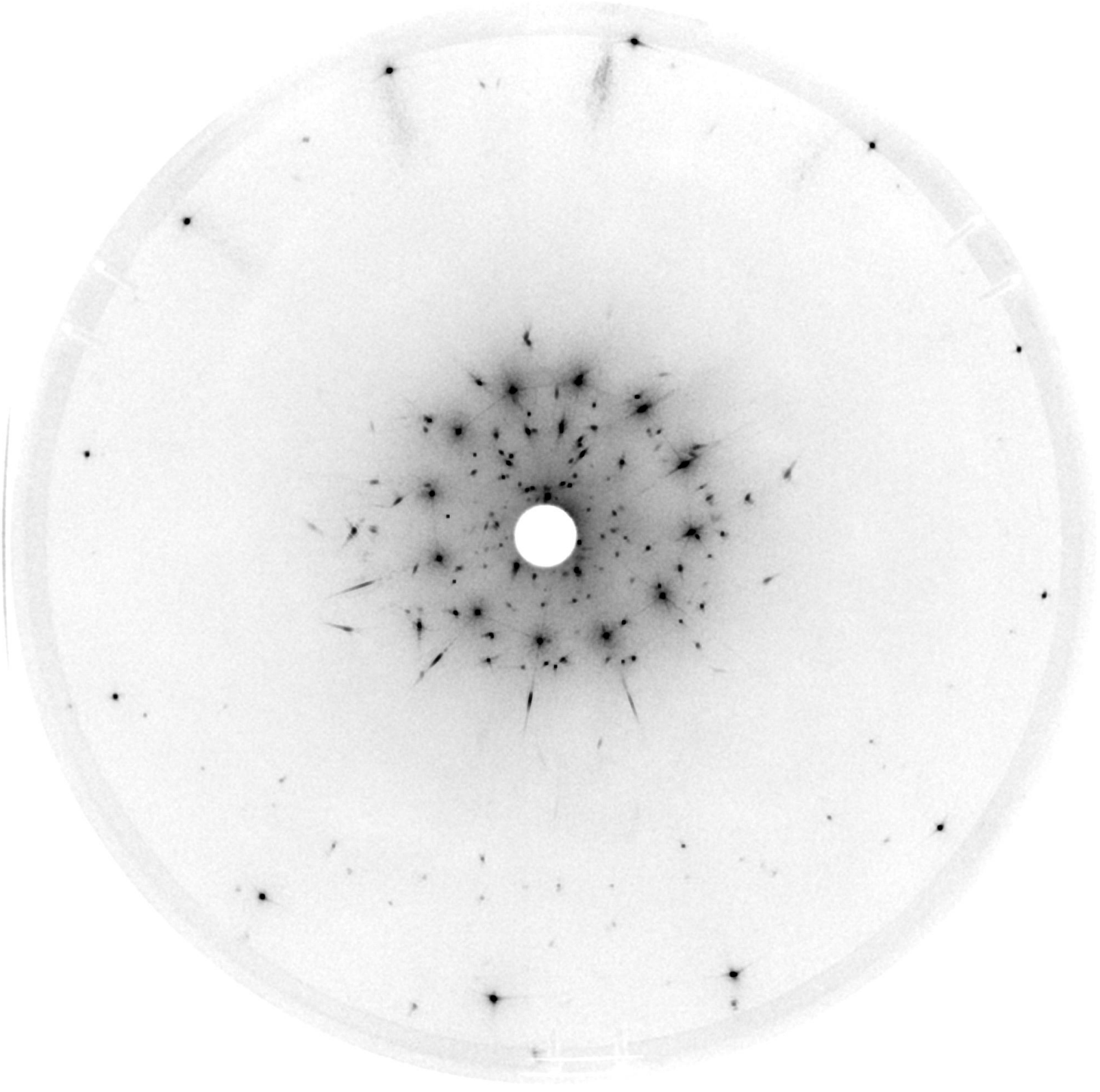

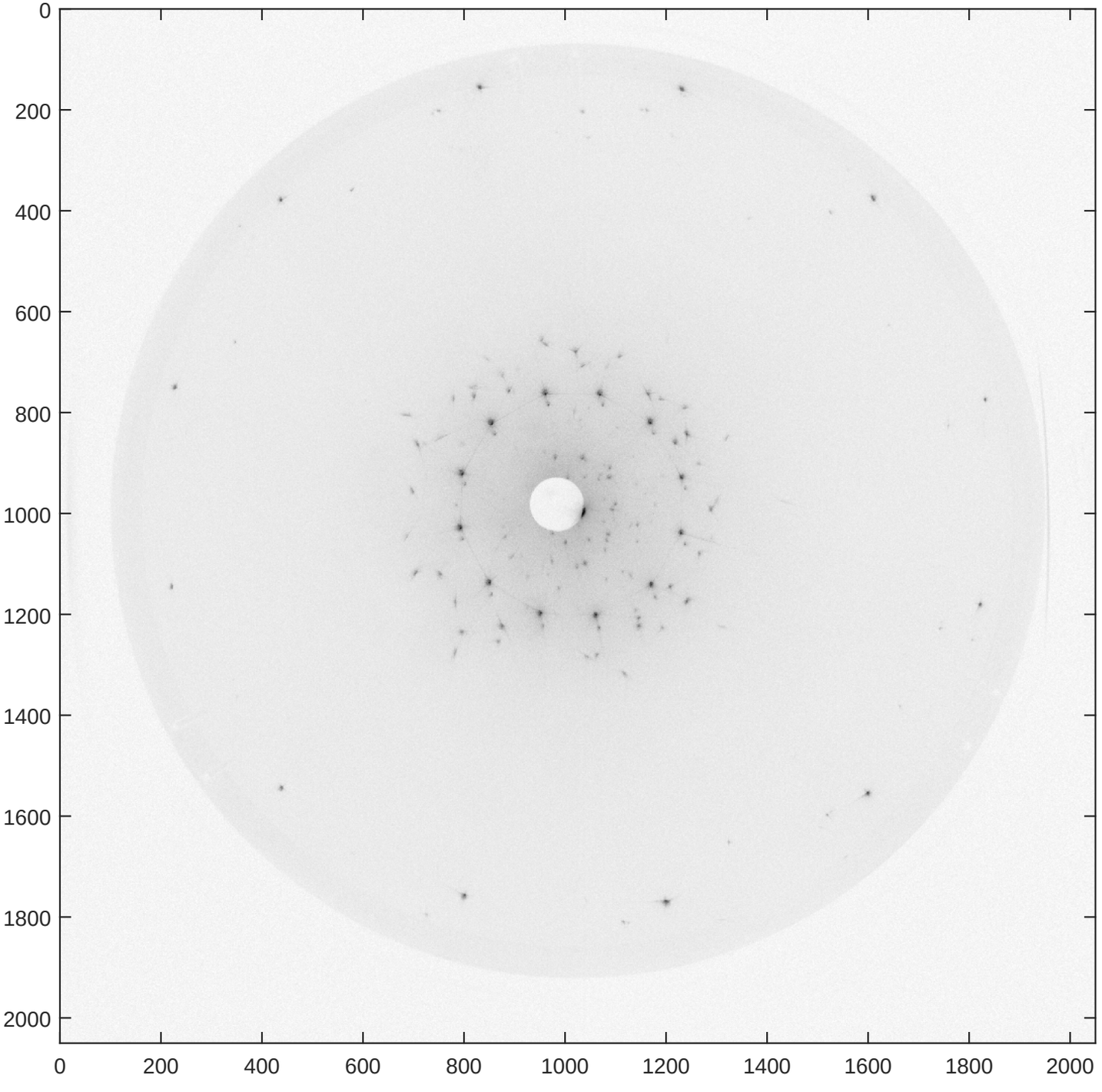
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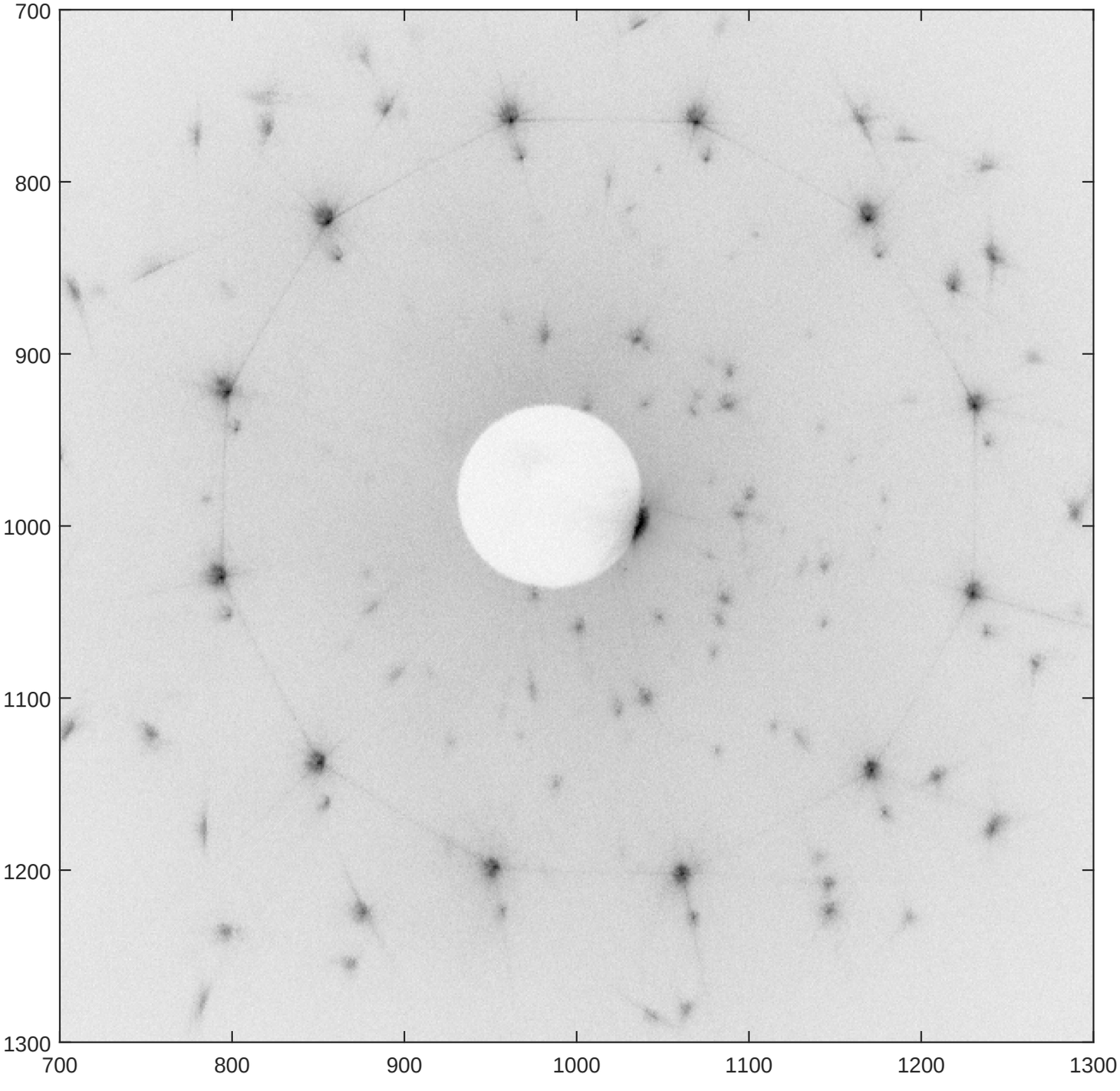
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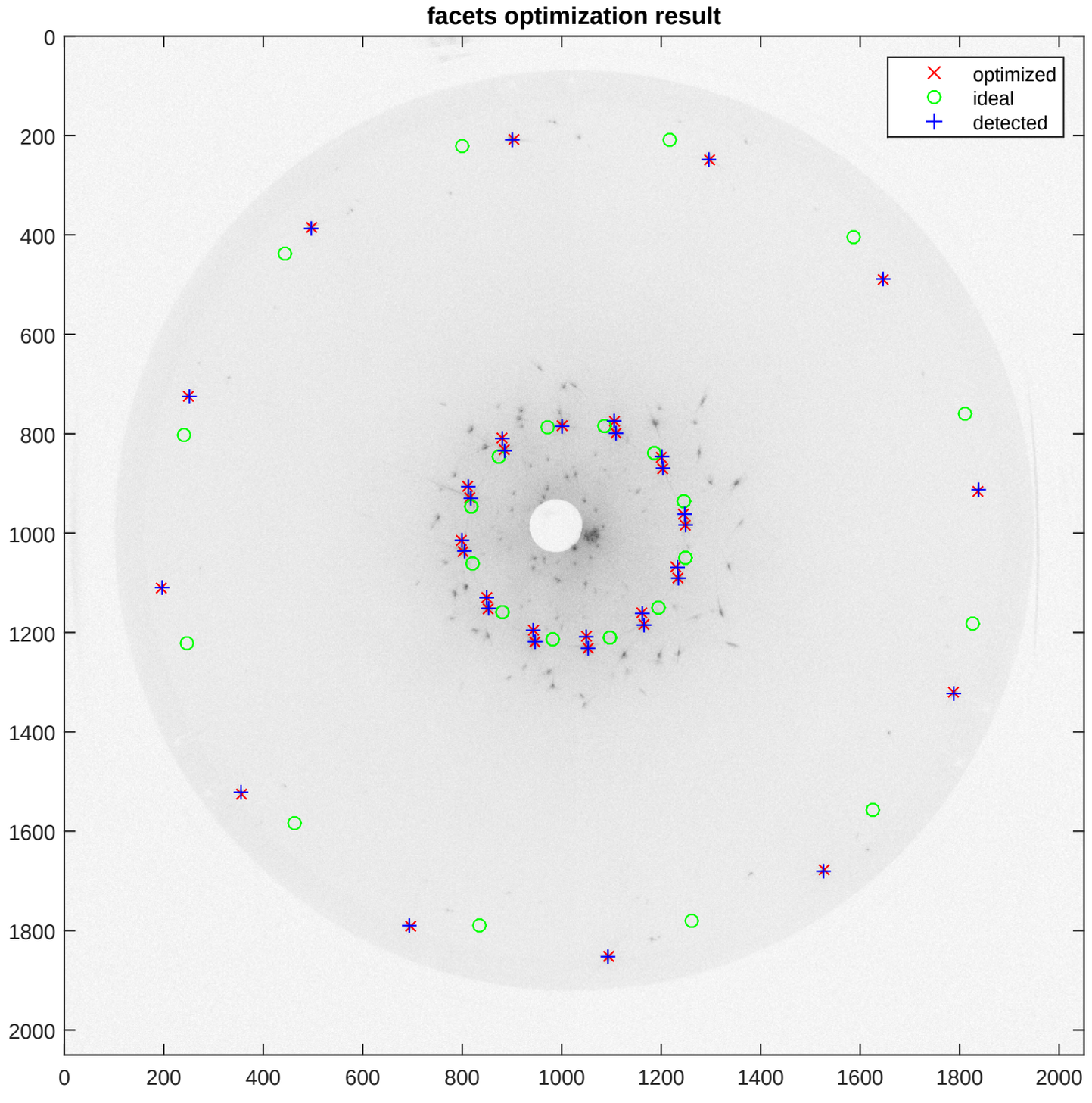
facets optimization result
optimized
ideal
detected
0
200
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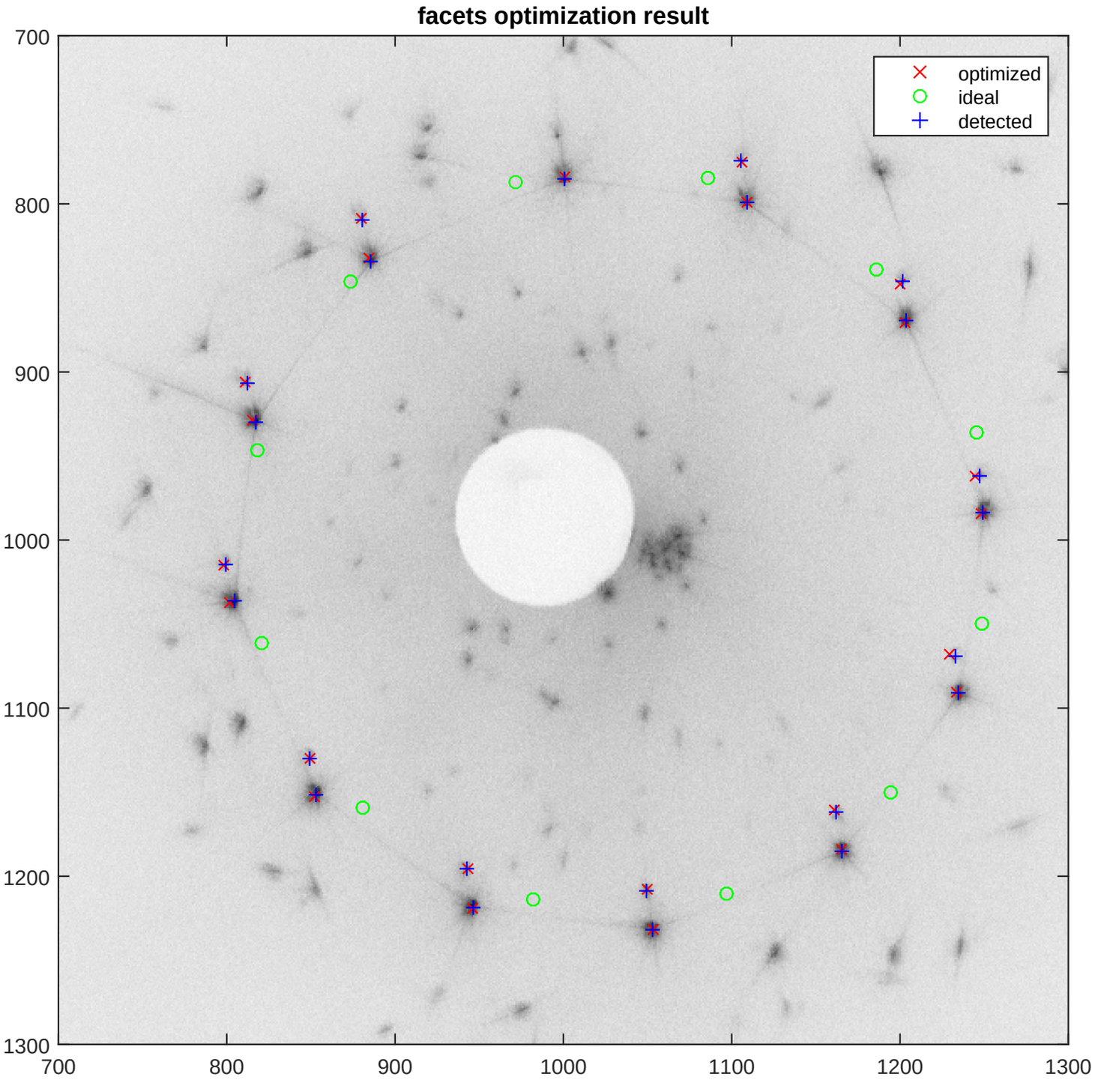
facets optimization result
optimized
ideal
detected
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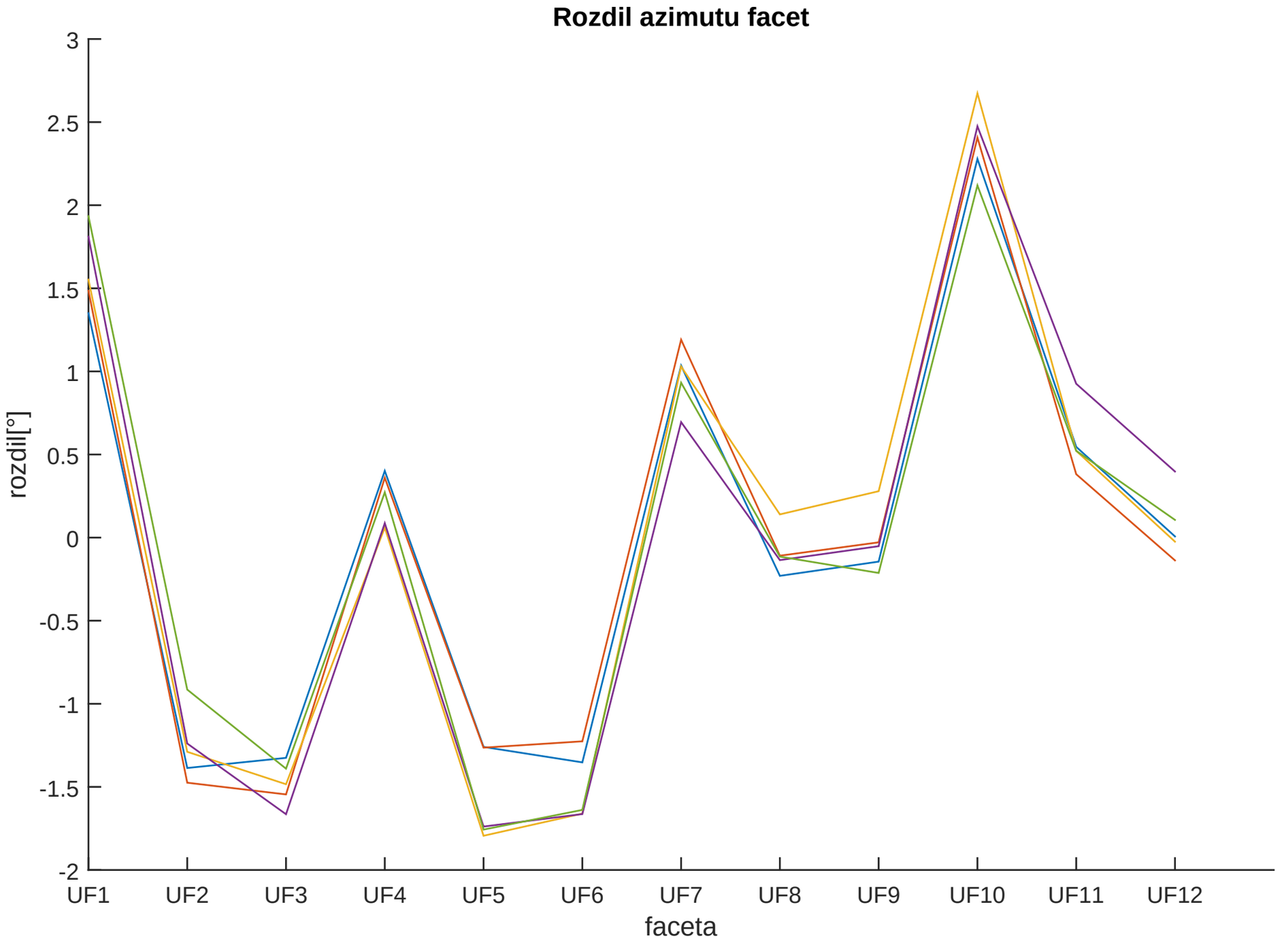
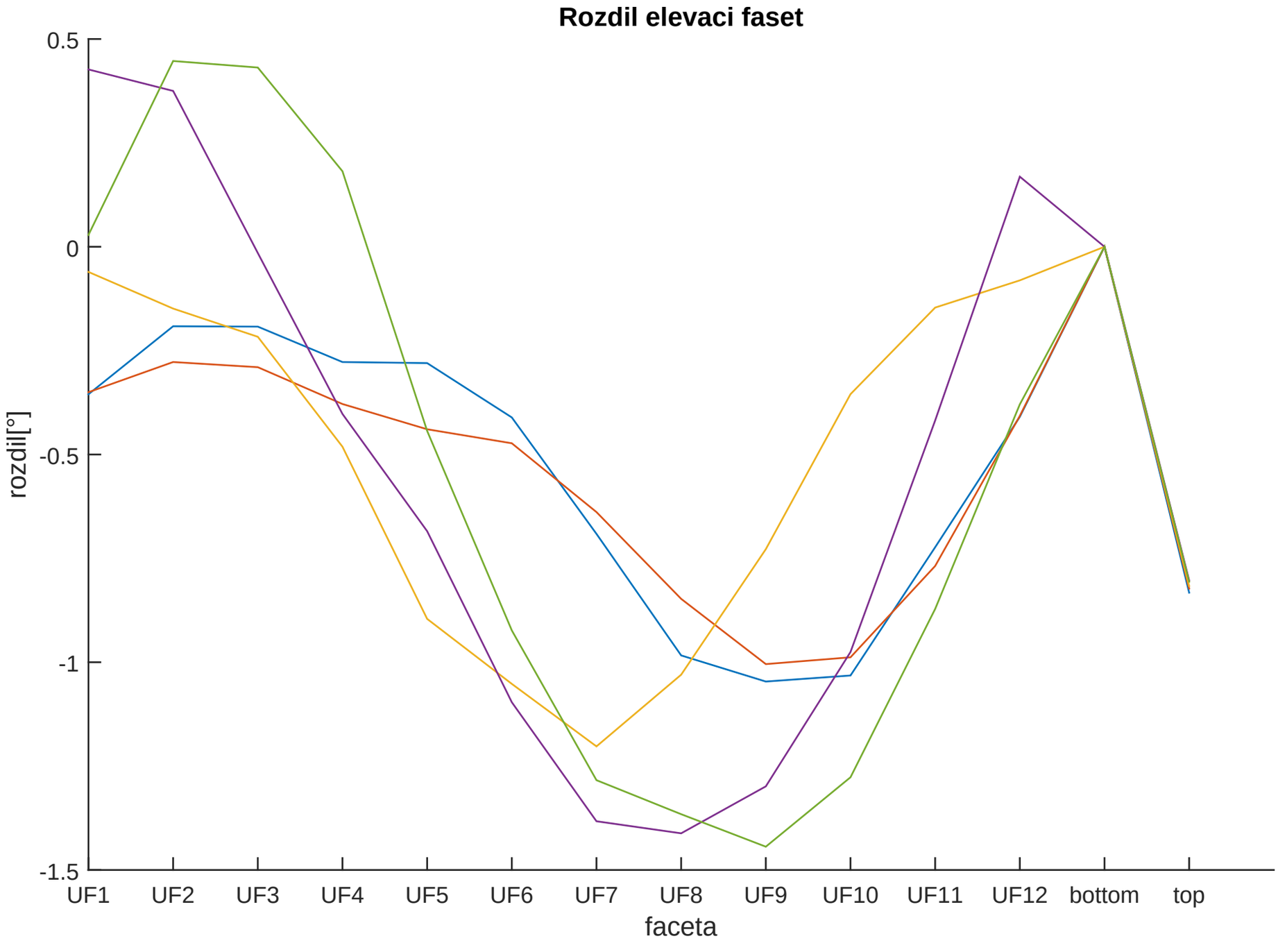

Rozdil azimutu facet
rozdil[°]
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
UF1
UF2
UF3
UF4
UF5
UF6
UF7
UF8
UF9
UF10
UF11
UF12
faceta


Rozdil elevaci faset
0.5
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-1.5
rozdil[°]
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UF2
UF3
UF4
UF5
UF6
UF7
UF8
UF9
UF10
UF11
UF12
bottom
top
faceta