Institute of Applied Physics

Friedrich-Schiller-Universität Jena

Metrology and Sensing

Lecture 6-2: Wavefront sensors

2020-12-08

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Content

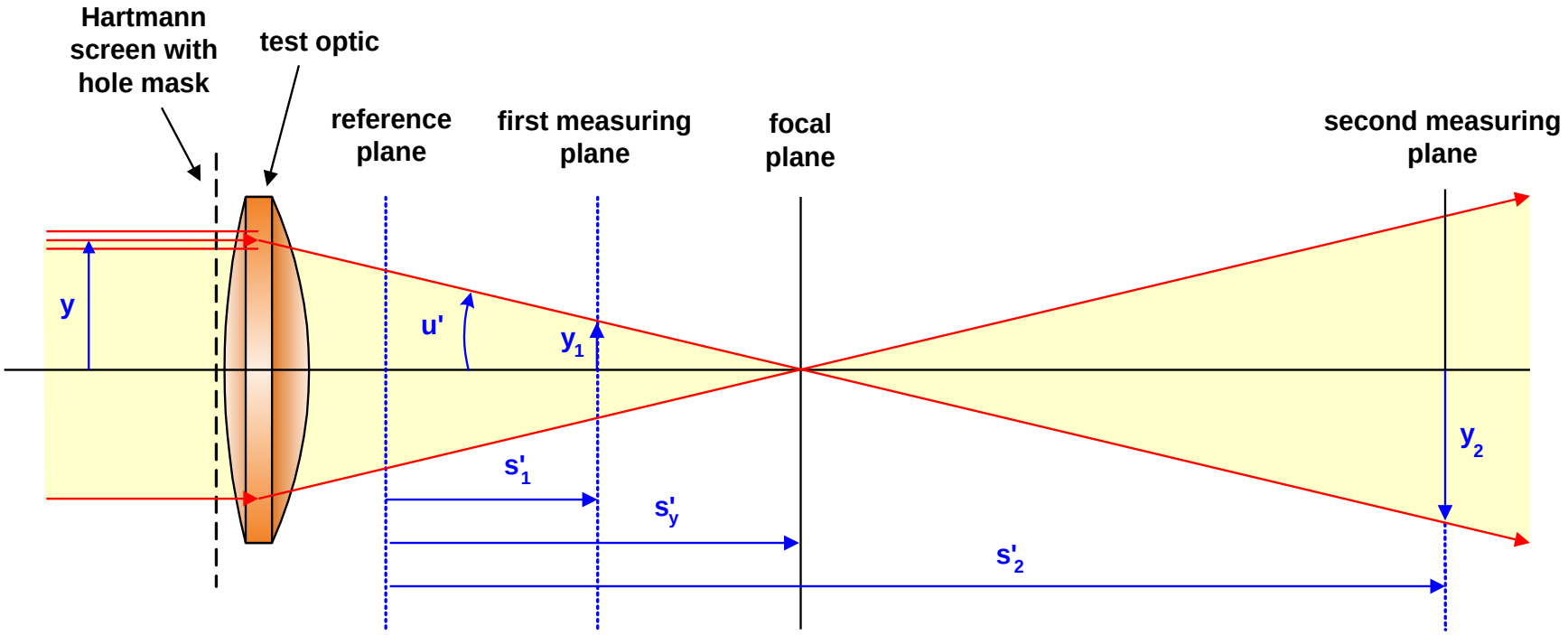
Hartmann-Sensor

- Principle
- Properties

Hartmann Method

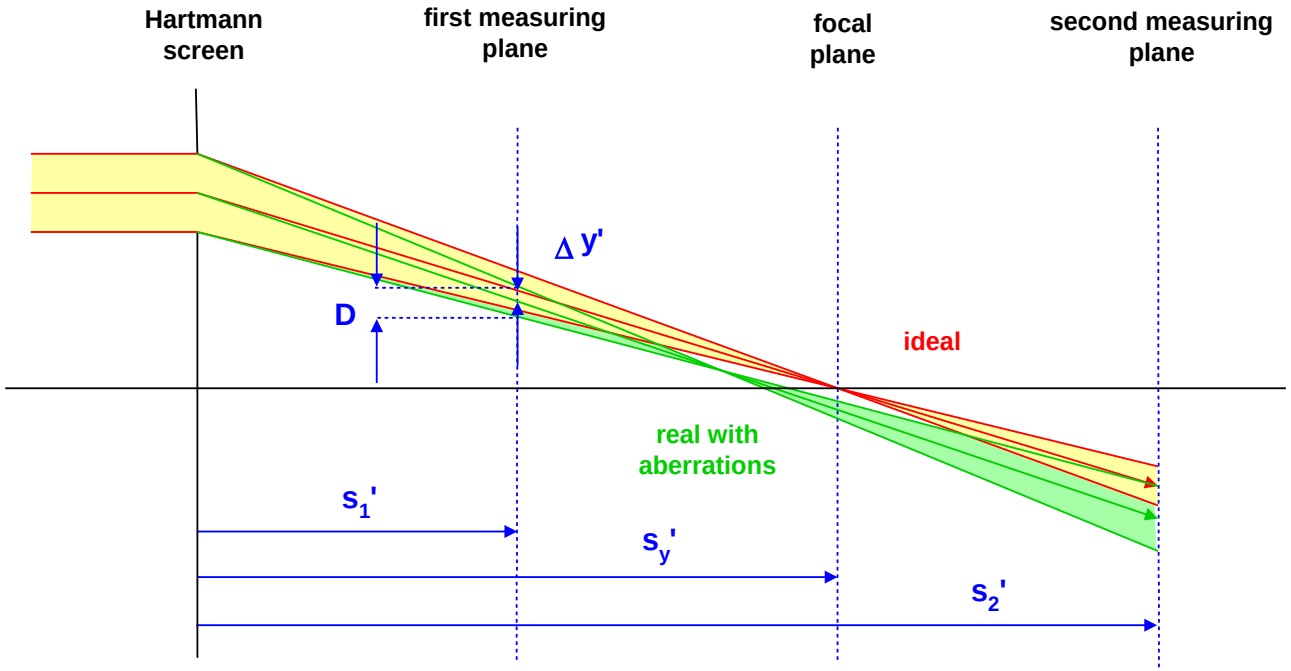
- Similar to Hastmann Shack Method with simple hole mask and two measuring planes
- Measurement of spot center position as geometrical transverse aberrations
- Problems: broadening by diffraction

$$s'_y = s'_1 + (s'_2 - s'_1) \cdot \frac{y_1}{y_1 + y_2}$$



Hartmann Method

- Schematic drawing of transverse aberrations



- Distance of planes limited: overlap of spots
- Coherent coupling of sub-aperture fields, interference induces errors of centroid

Hartmann Method: Pinhole Array Geometry

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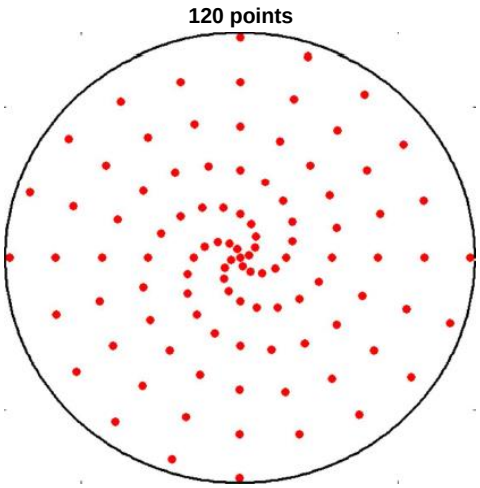
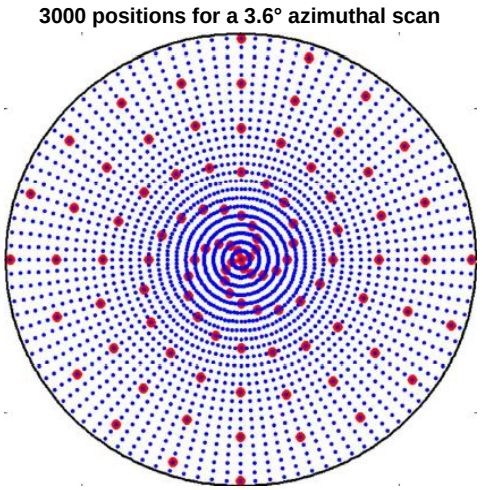
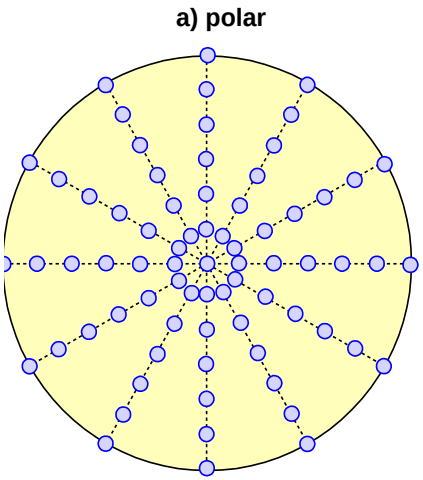
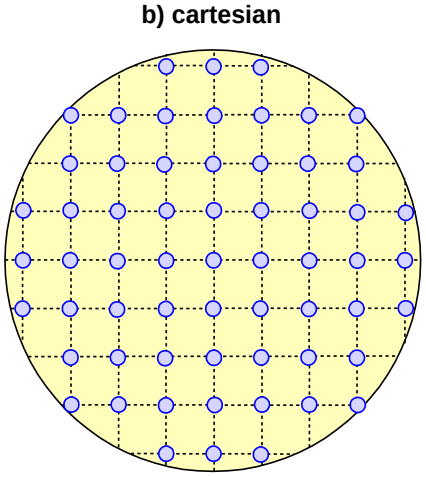
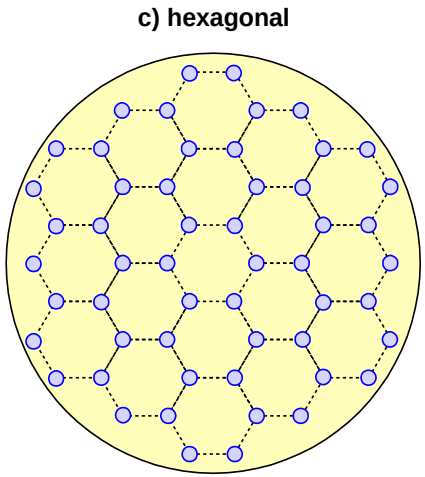
- Possible geometry of the pinholes:
  - number of pinholes,
  - size of holes
  - distance / geometry
- Parameters determine the accuracy

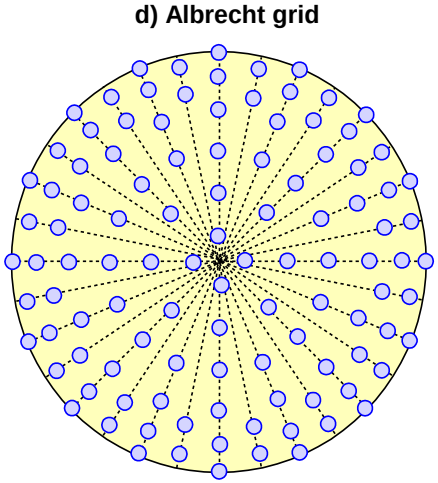








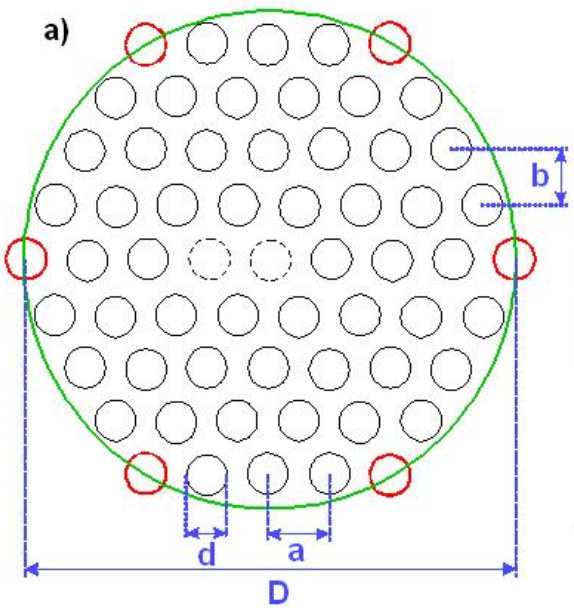


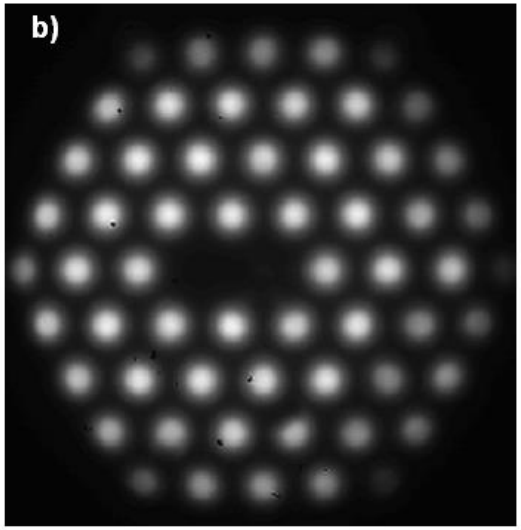


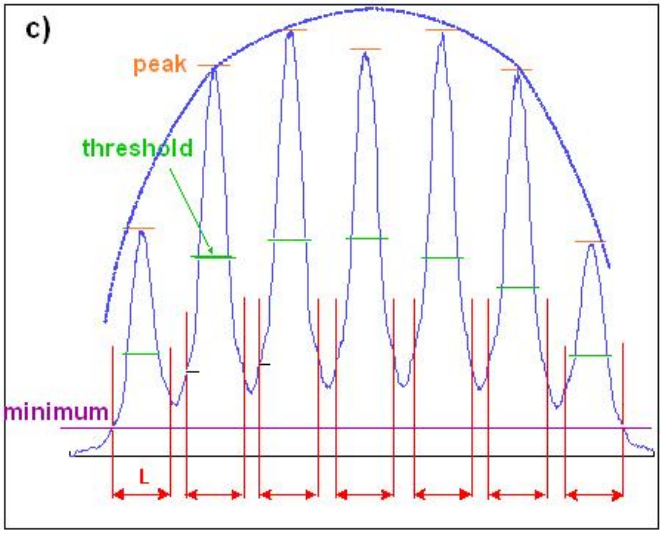
Hartmann Method Properties

- z-positions critical for large spots diameters
- No dependence on spectral range and polarization
- Coherence is critical, interference for overlapping pinhole images
- Apodization not critical
- Averaging gives stable data evaluation

Hartmann Method





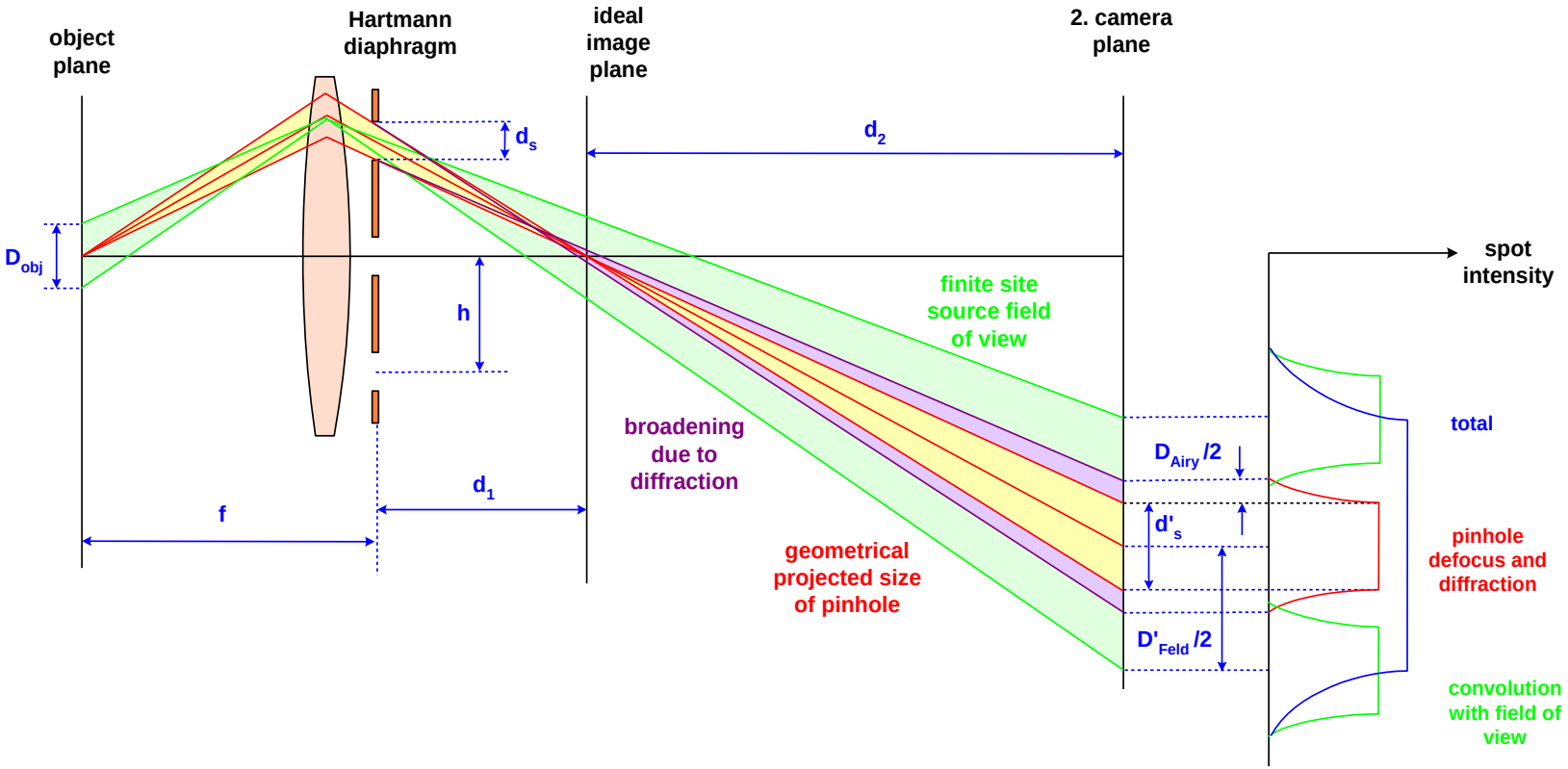


- Real pinhole pattern with signal
- Problems with cross talk and threshold

Hartmann Method

Separated spots in case of diffraction

$$d_s'^{(gesamt)} = \frac{d_2}{d_1} \cdot d_s + (d_1 + d_2) \cdot \frac{D_{obj}}{f} + (d_1 + d_2) \cdot \frac{2.44 \cdot \lambda}{d_s}$$



Hartmann Method in Case of Apodization

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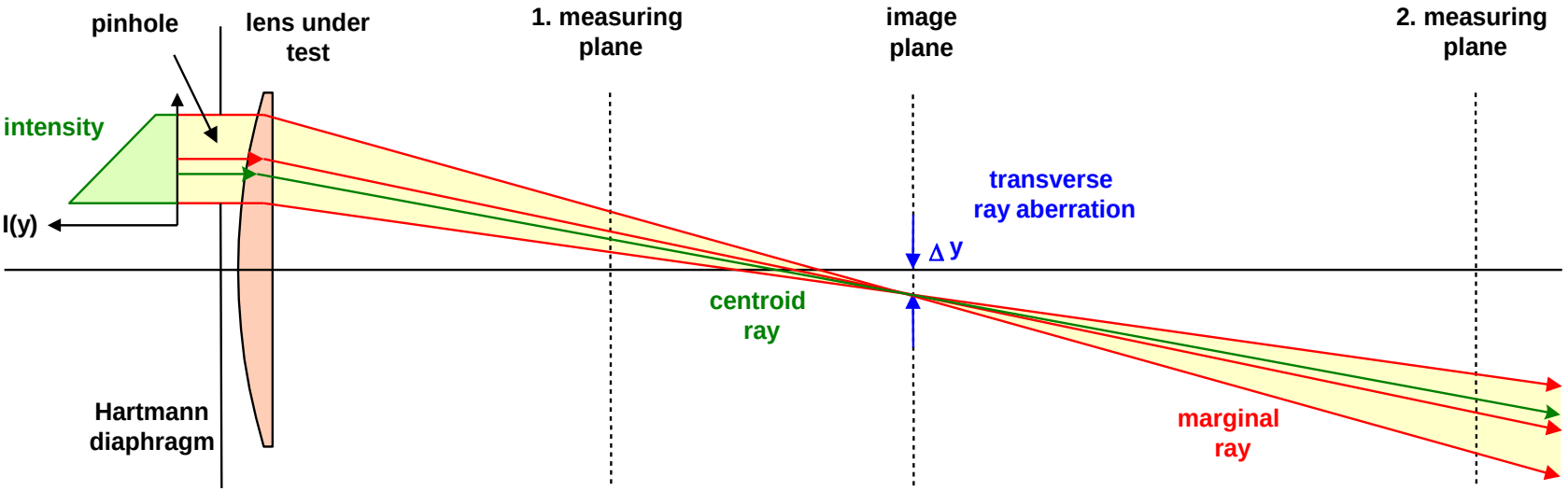
- Apodized beam: centroid rays pass through the perfect image point
- A cetroid error is eliminated



- Reconstruction of the transverse aberrations delivers the wave aberration

$$W(x,y) = -\frac{1}{R}\int_0^x \Delta x' dx$$

Hartmann Sensor

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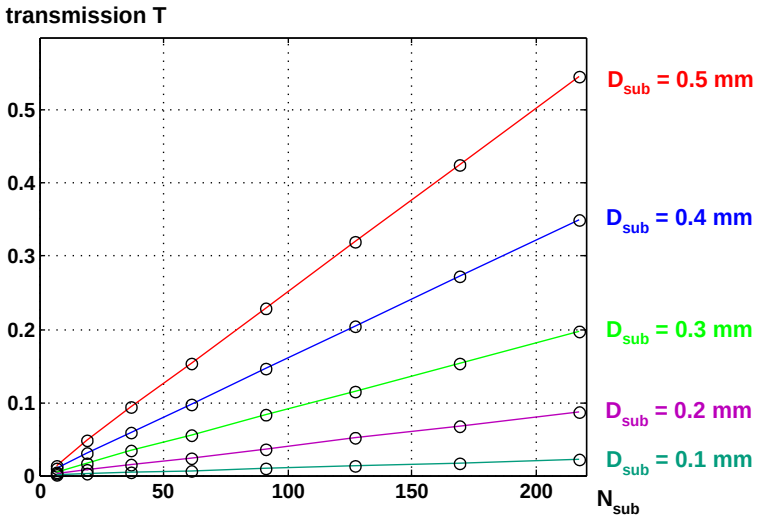
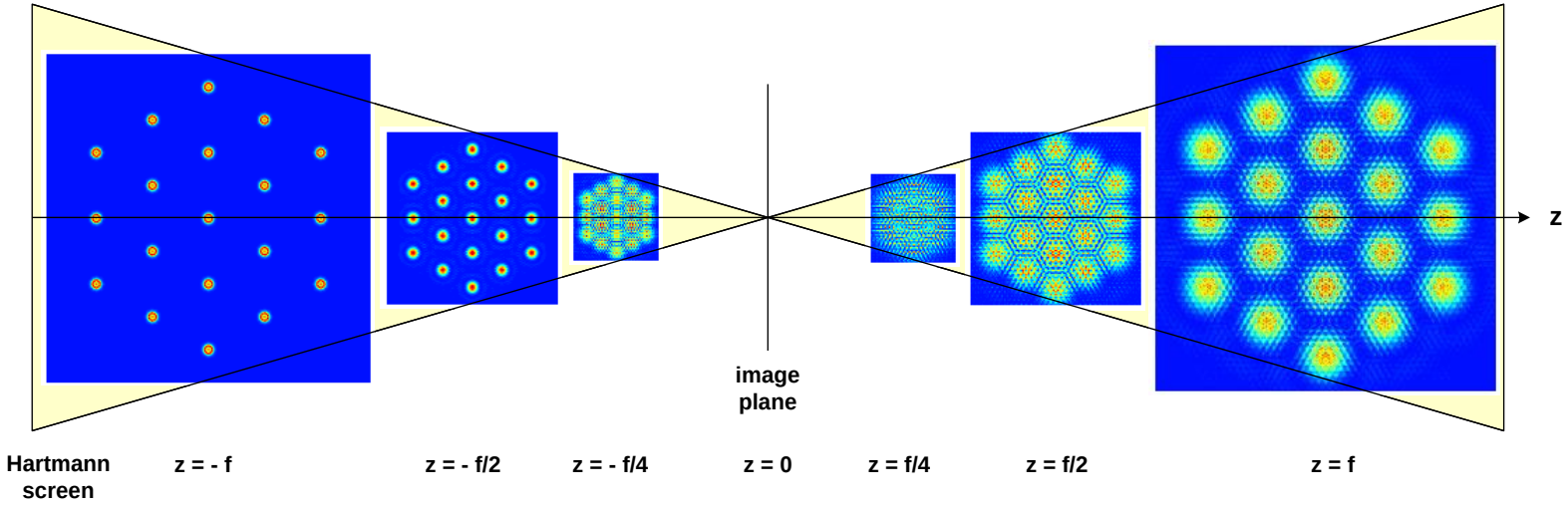
- Small power transmission



- Problem: diffraction spreading of light pencils



Hartmann Sensor

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- Problem: diffraction spreading of light pencils