Small Animal SPECT:

Competing Technologies

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Overview: Pinhole Camera

Motivation

To adapt existing SPECT equipment for the imaging of small animals

Technologies

- Gamma Camera (Anger, 1957)
- Pinhole (Mo Ti, 500 BC)
- Computed Tomography (Hounsfield, 1971)

Approach

- Replace collimator with a pinhole
- Adapt reconstruction algorithm

Result

- Improved resolution
- Much lower sensitivity
- Small FOV (small rodents)

Overview: Scanning Microscope

Motivation

To find a better way to image small animals

Related Technologies

- Rectilinear scanner for planar gamma imaging (Classen, 1950s)
- Scanning confocal microscope (Minsky 1957)
- Point-focused scanning brain SPECT (Stoddart 1978)
- Computer image deblurring

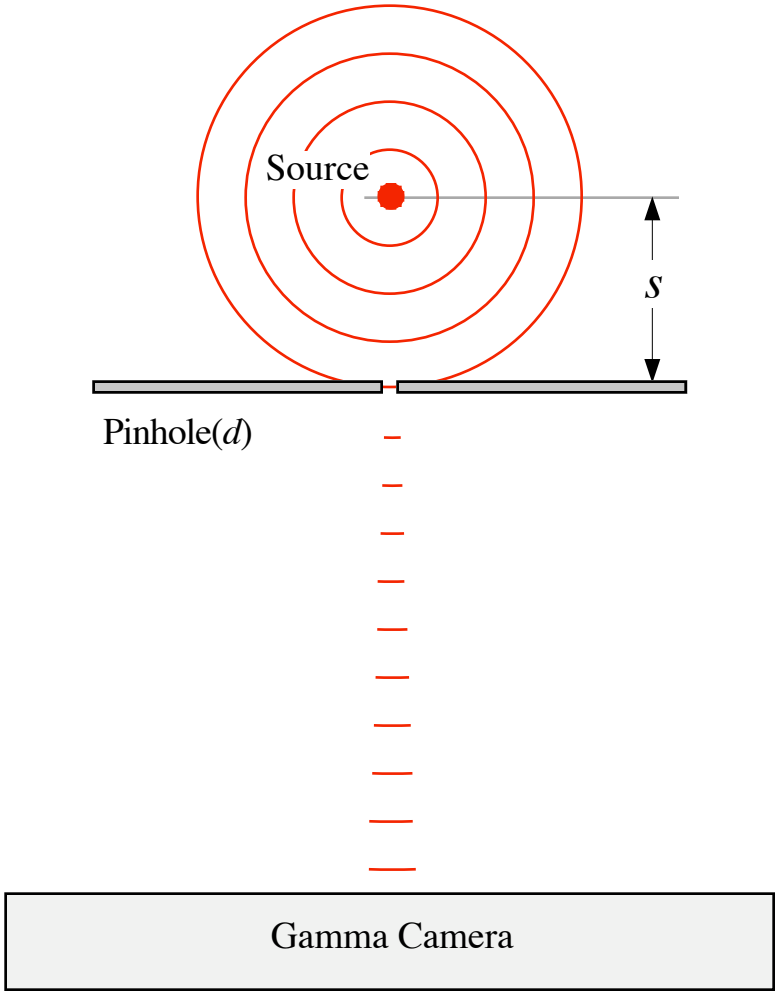
Approach

- Mount point-focused photon counters on x,y,z translation stages
- Apply a 3D deblurring algorithm

Result

- High resolution
- High sensitivity
- Large FOV (rodents to primates)

Sensitivity: Pinhole Camera



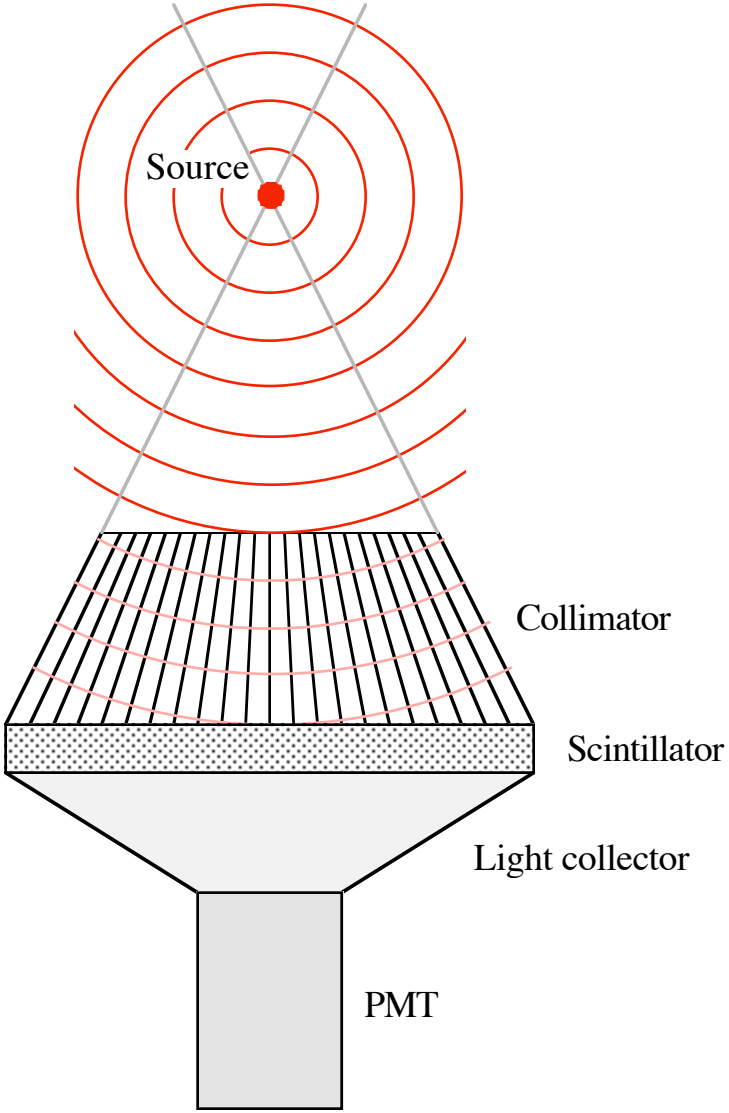
Sensitivity

$$\frac{\text{counts}}{\text{emissions}} = \frac{\pi(d/2)^2}{4\pi s^2}$$

d = pinhole diameter

s = pinhole to source distance

Sensitivity: Scanning Microscope



Sensitivity

$$\frac{\text{counts}}{\text{emission}} = \frac{\text{collimator solid angle}}{4\pi}$$

Sensitivity: Comparison

Pinhole Camera

Sensitivity depends on

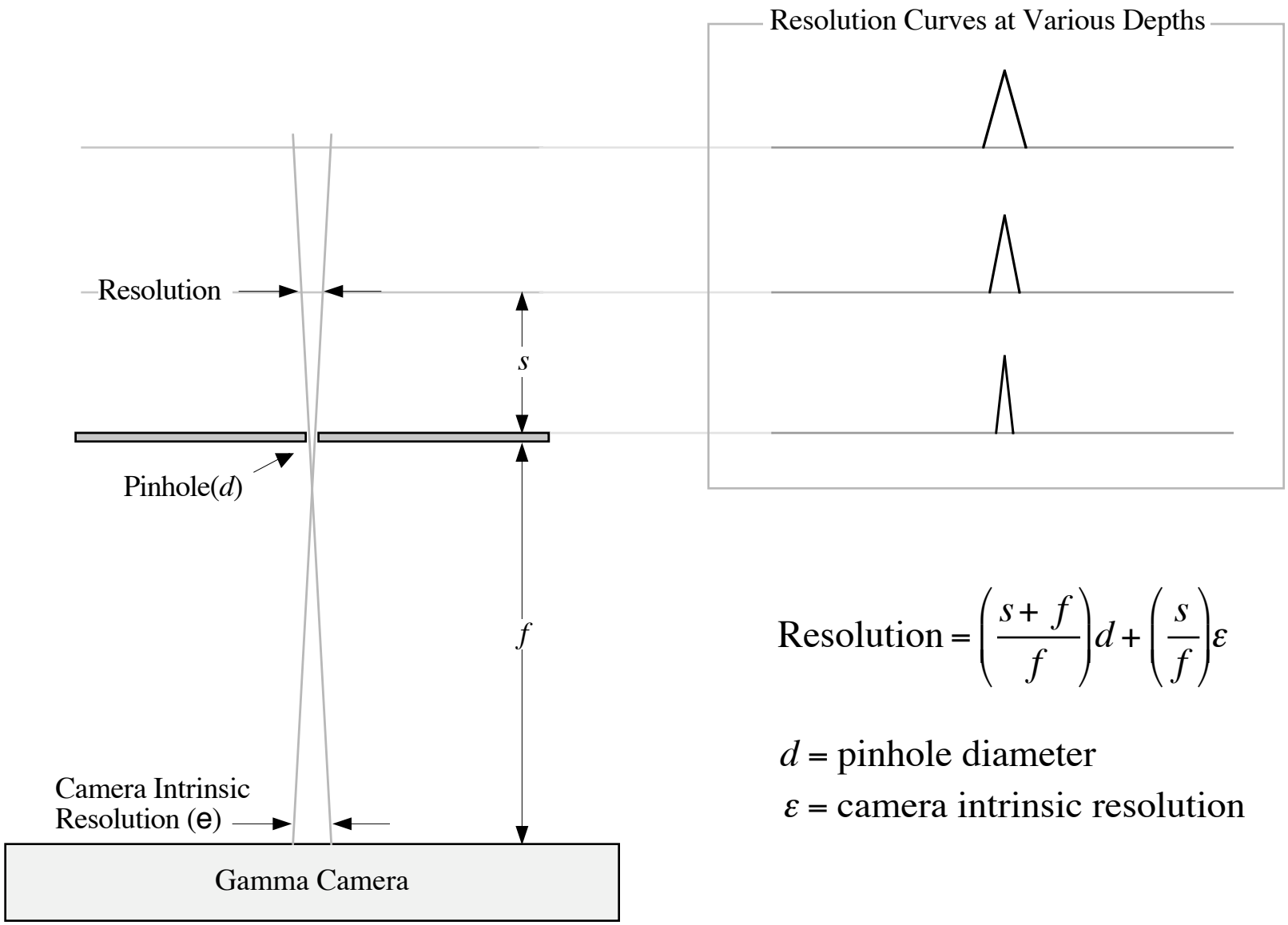
- Size of pinhole (d)
- Distance from pinhole to source (s)

Scanning Microscope

Sensitivity depends on

- Geometry of the focused collimator
- Time-on-target

Resolution: Pinhole Camera

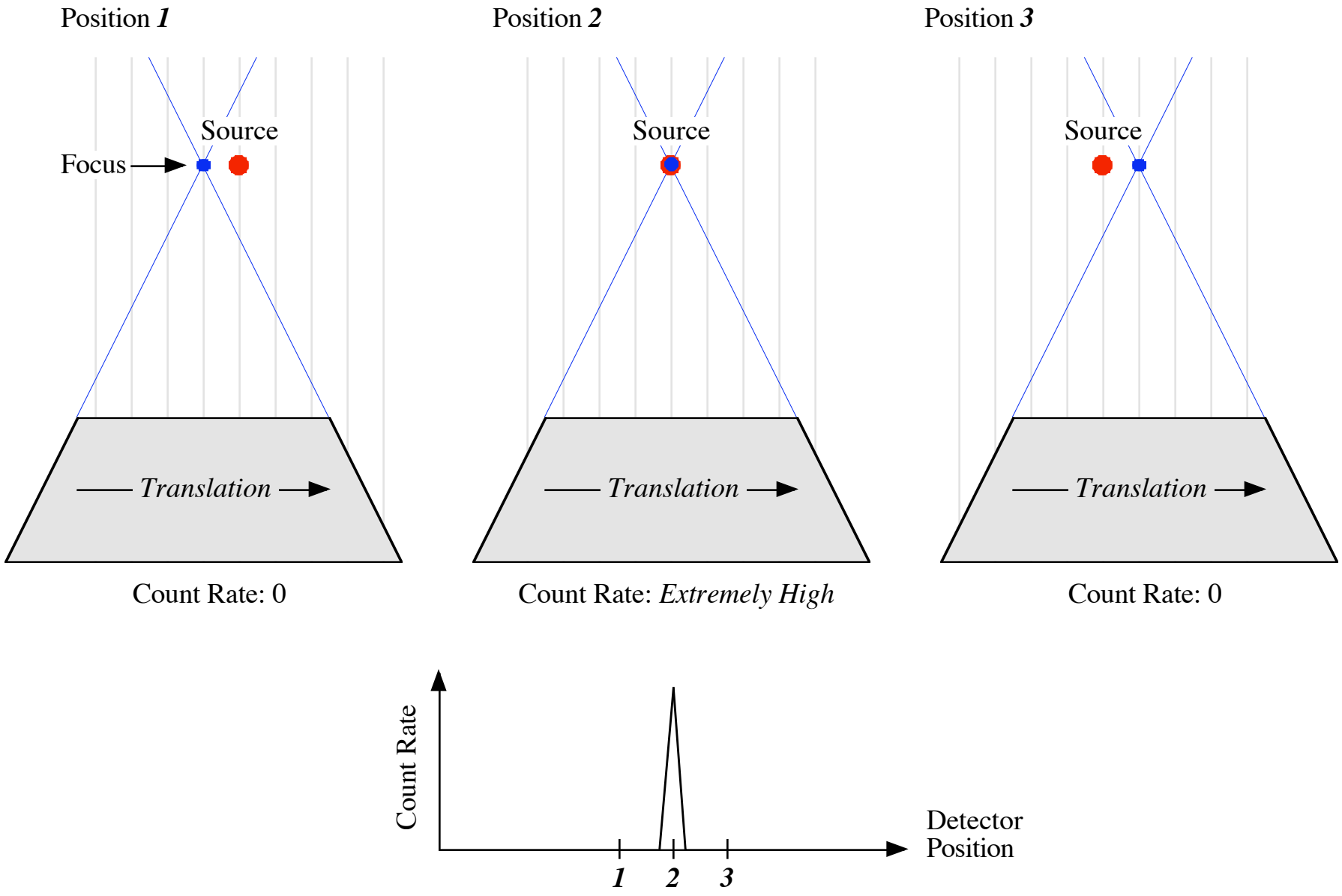


$$\text{Resolution} = \left(\frac{s+f}{f}\right)d + \left(\frac{s}{f}\right)\varepsilon$$

d = pinhole diameter

ε = camera intrinsic resolution

Resolution: Scanning Microscope



Resolution: Comparison

Pinhole Camera

Resolution depends on

- Size of pinhole (d)
- Distance from pinhole to source (s)
- Distance from pinhole to camera (f)
- Camera intrinsic resolution (ε)

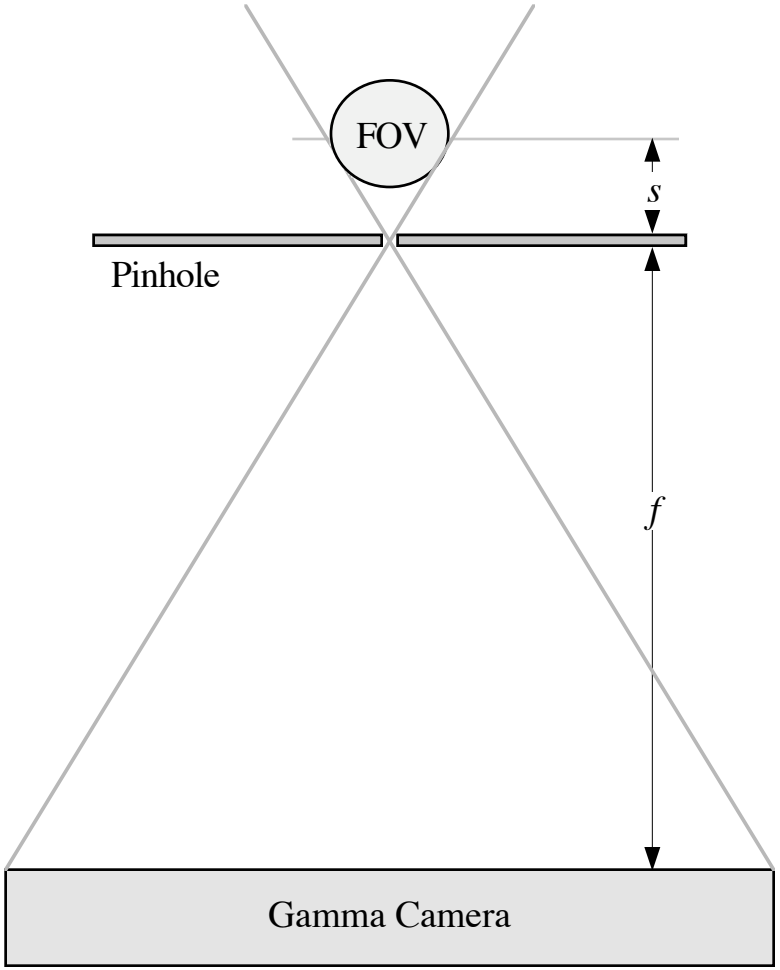
Scanning Microscope

Resolution depends on

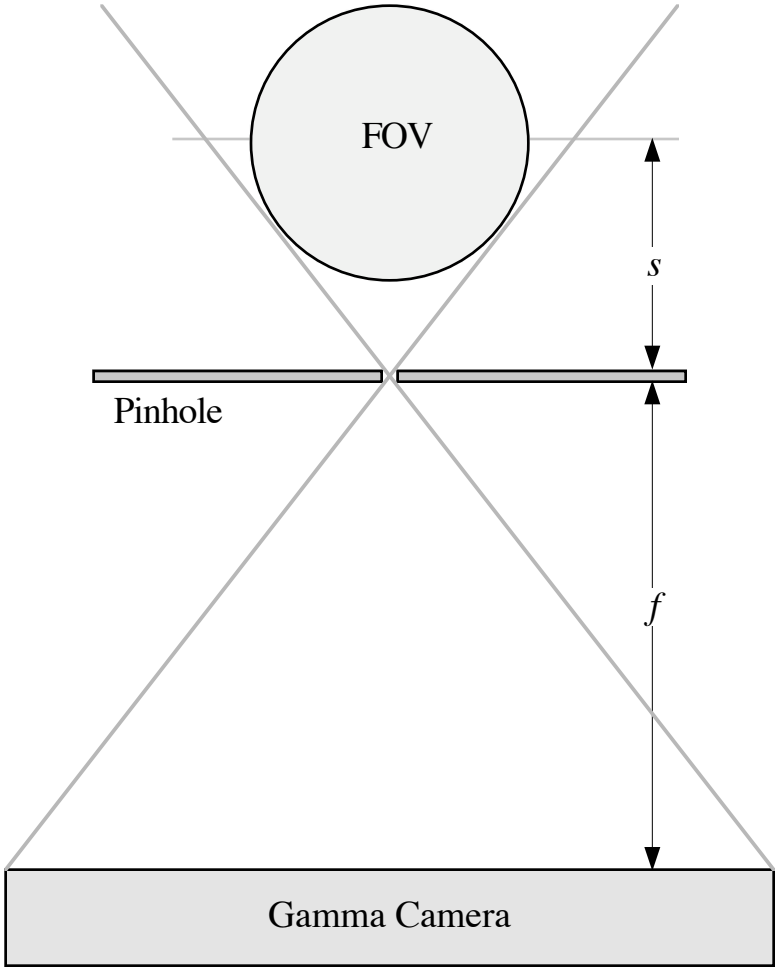
- Designed “sharpness” of the focused collimator

FOV: Pinhole Camera

Small Source Configuration

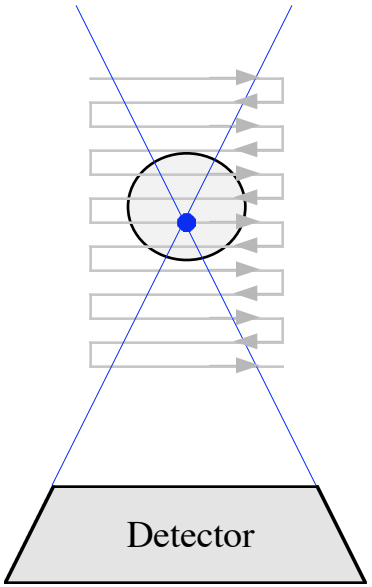


Large Source Configuration

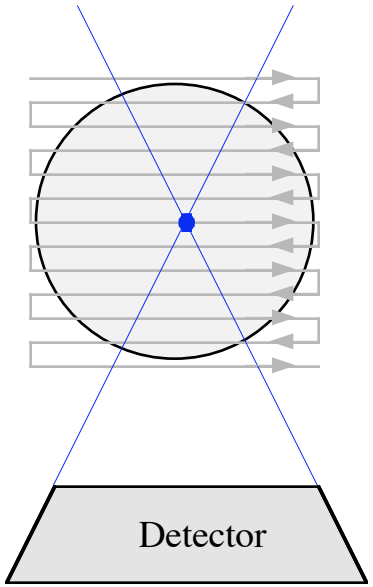


FOV: Scanning Microscope

Small Source



Large Source



Accommodations

- Variable scan range and/or time-on-target
- No configuration change

FOV: Comparison

Pinhole Camera: Resolution and/or sensitivity rapidly degrade with FOV

Scanning Microscope: Resolution and sensitivity independent of FOV