SNAP SuperNova Acceleration Probe
at the University of Michigan

Spot-o-matic

A Pin-Hole Projection System: Status

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Work performed by:

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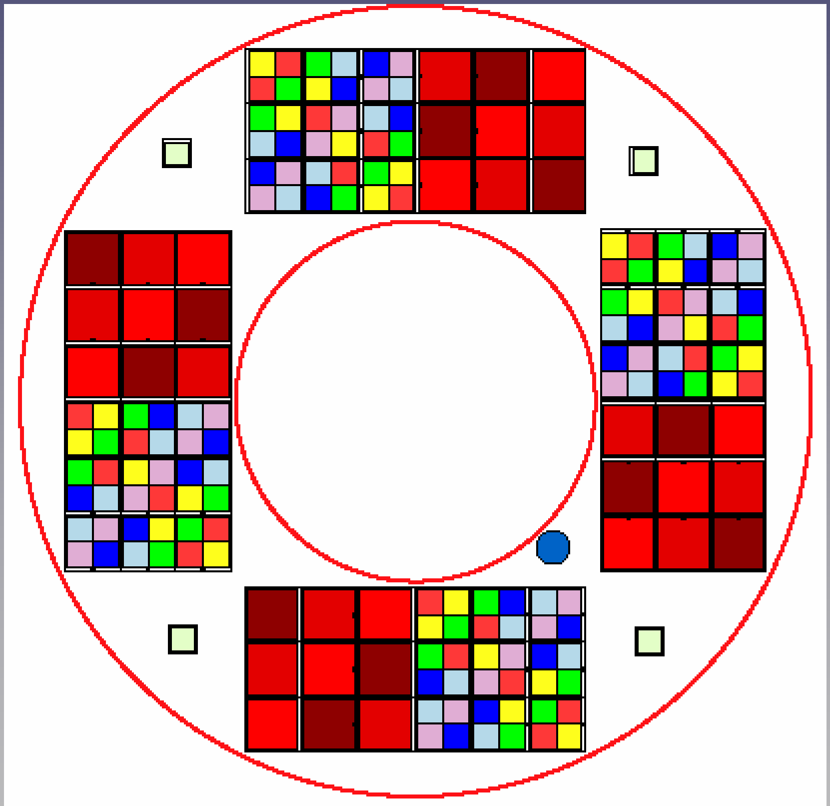
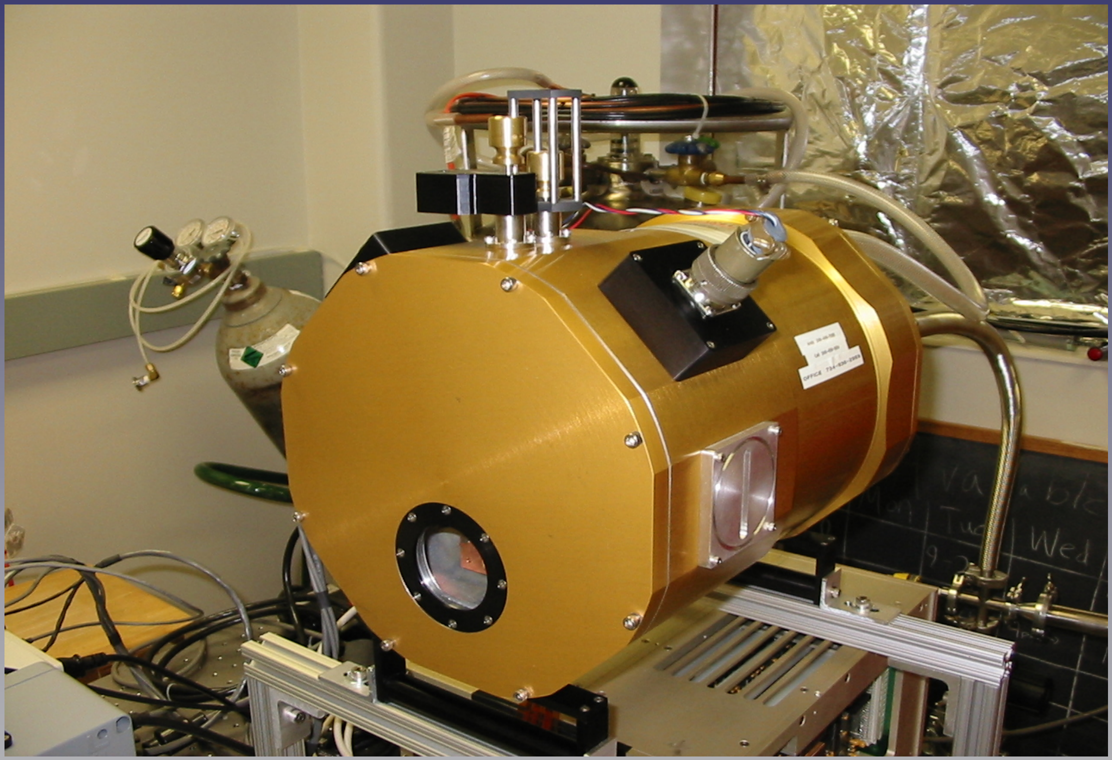
SNAP Detector Design



- We need to test:
  - Intra-pixel response
  - Lateral Charge Diffusion

  – Must shine a sub-pixel sized spot (~3 μm dia) onto the detector, and be able to move it around VERY precisely

Detector Design

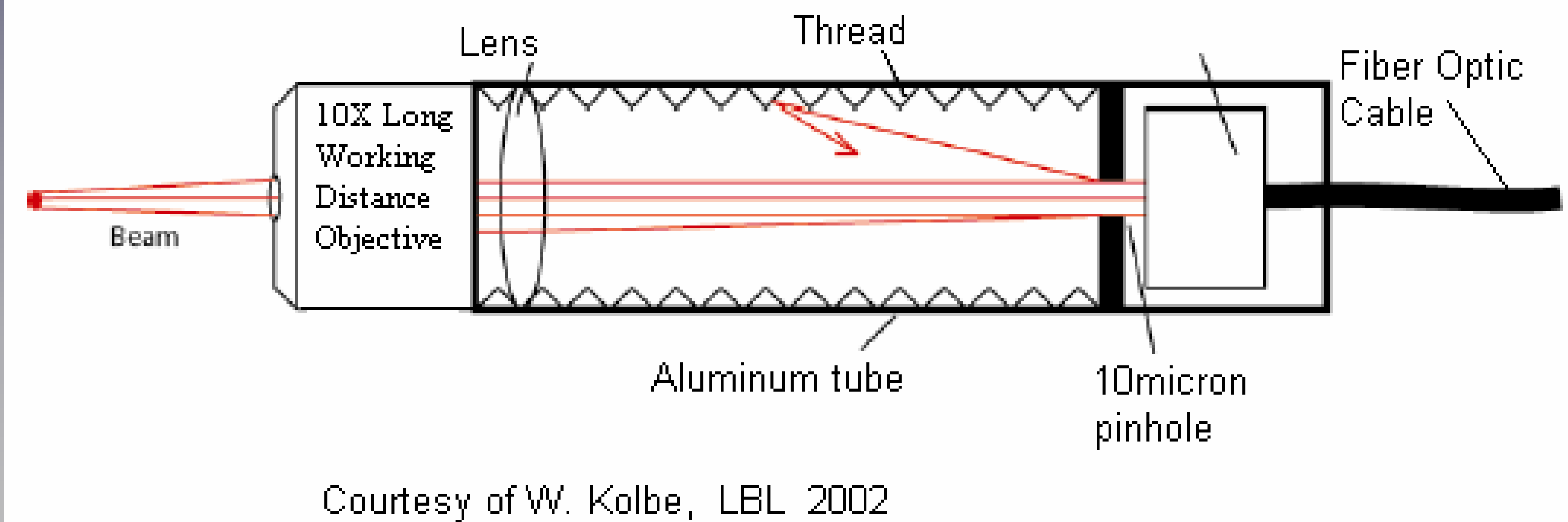


Detector to be tested is mounted inside a dewar to keep it at 140K.

Dewar necessitates a long working distance!

Pinhole Projector

Idea borrowed from an LBL design, adapted for NIR light.



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Test Platform

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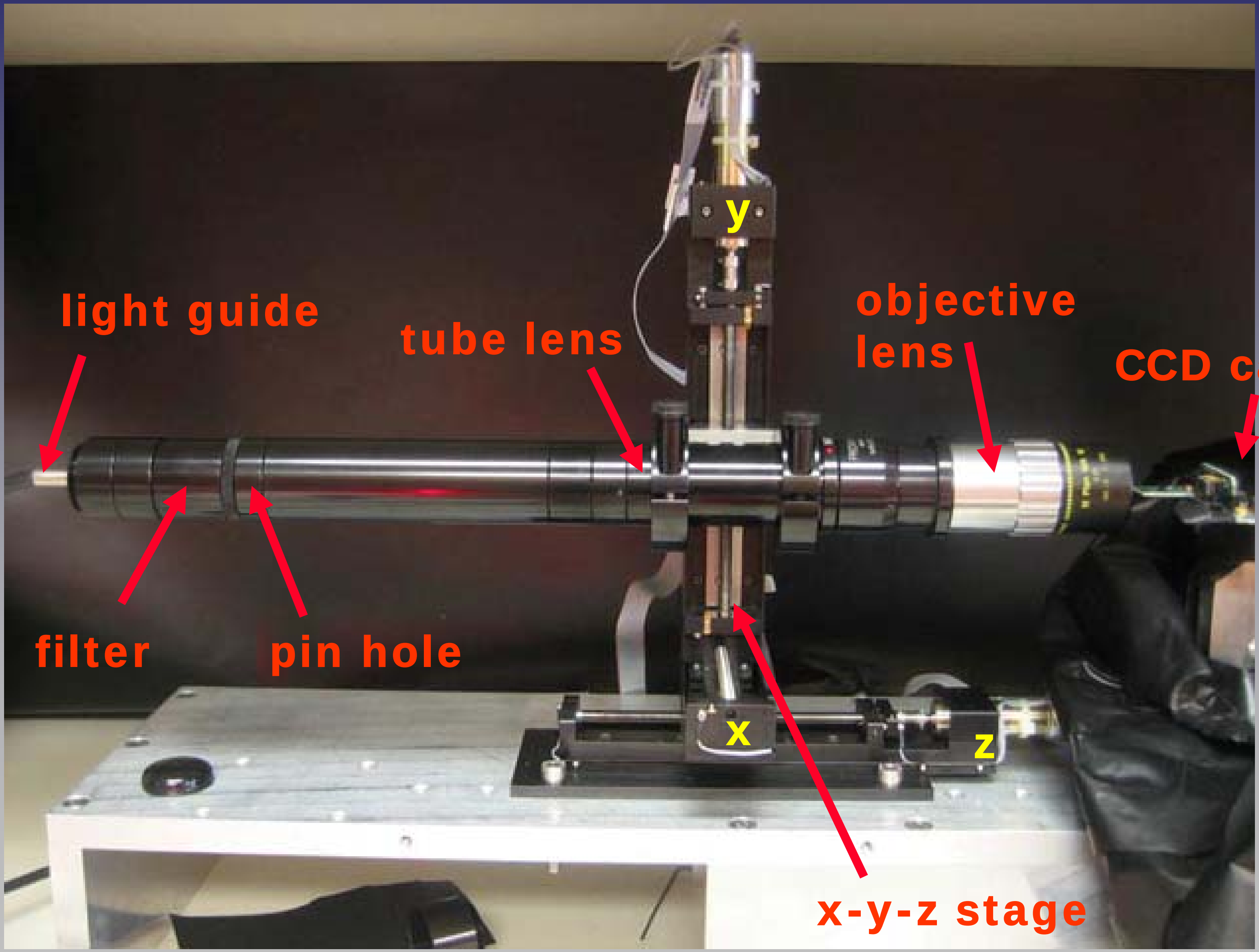

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Properties

- **optical:**
  - — M Plan NIR series (Mitutoyo Long Working distance objective)
  - — magnification (microscope configuration): 10x
  - — range (chromatically corrected): 480-1800 nm
  - — numerical aperture (NA): 0.26
    $\Rightarrow$ minimal spot size [=f(λ)]: 0.96 – 3.6μm (σ)
    2.25 – 8.44μm (FWHM)
  - —**XYZ stage:**
  - — step size: 0.075 μm (±1μm per inch of travel)
- **CCD camera:**
  - — 3COM Homeconnect Webcam
  - — 480x640 pixels (5x5 μm^2 each)
- **light source:**
  - — standard QT halogen lamp with fiber optics: 5% relative stability
  - — Oriel Photomax 60100 with liquid light guide: 0.1% relative stability

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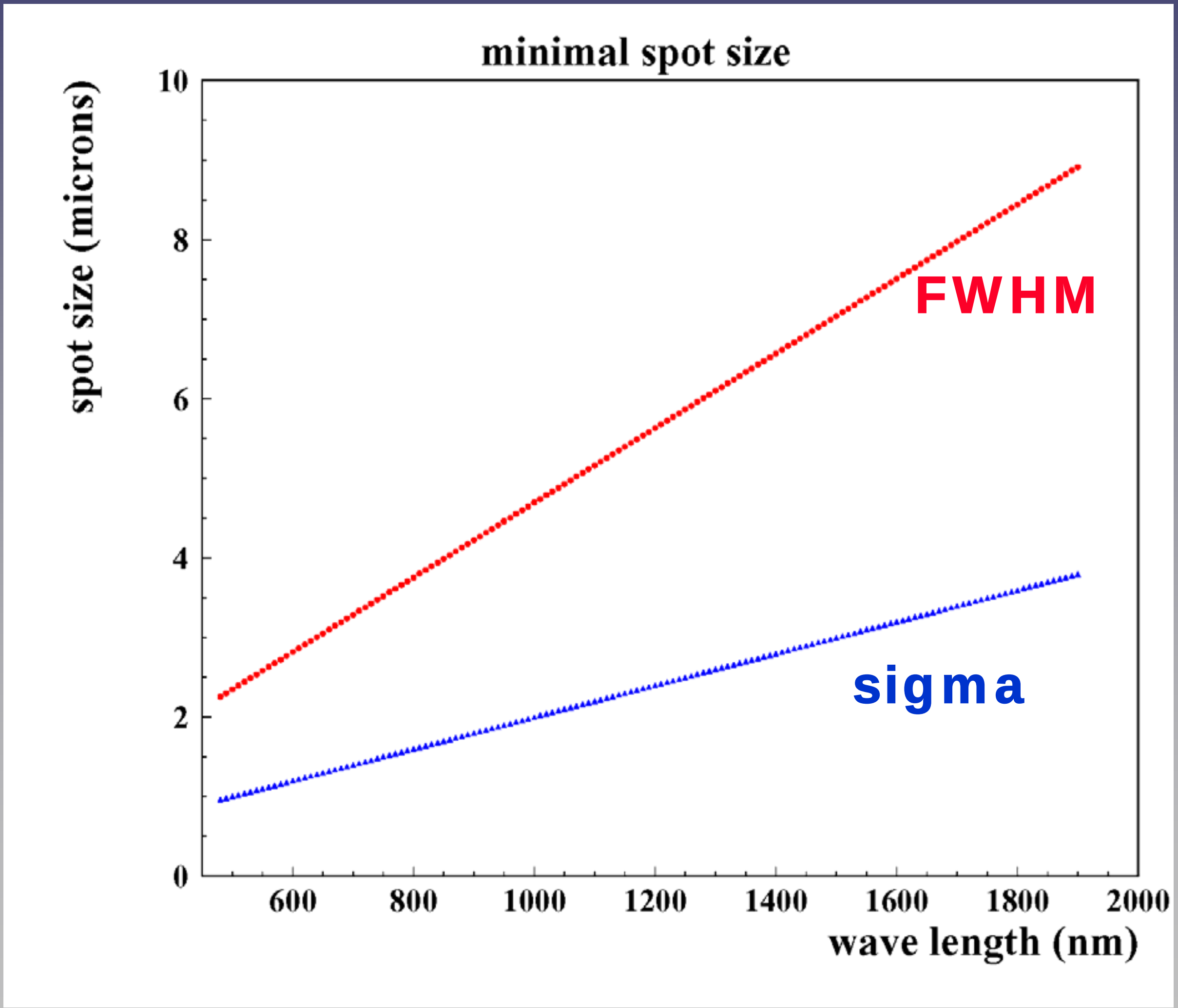
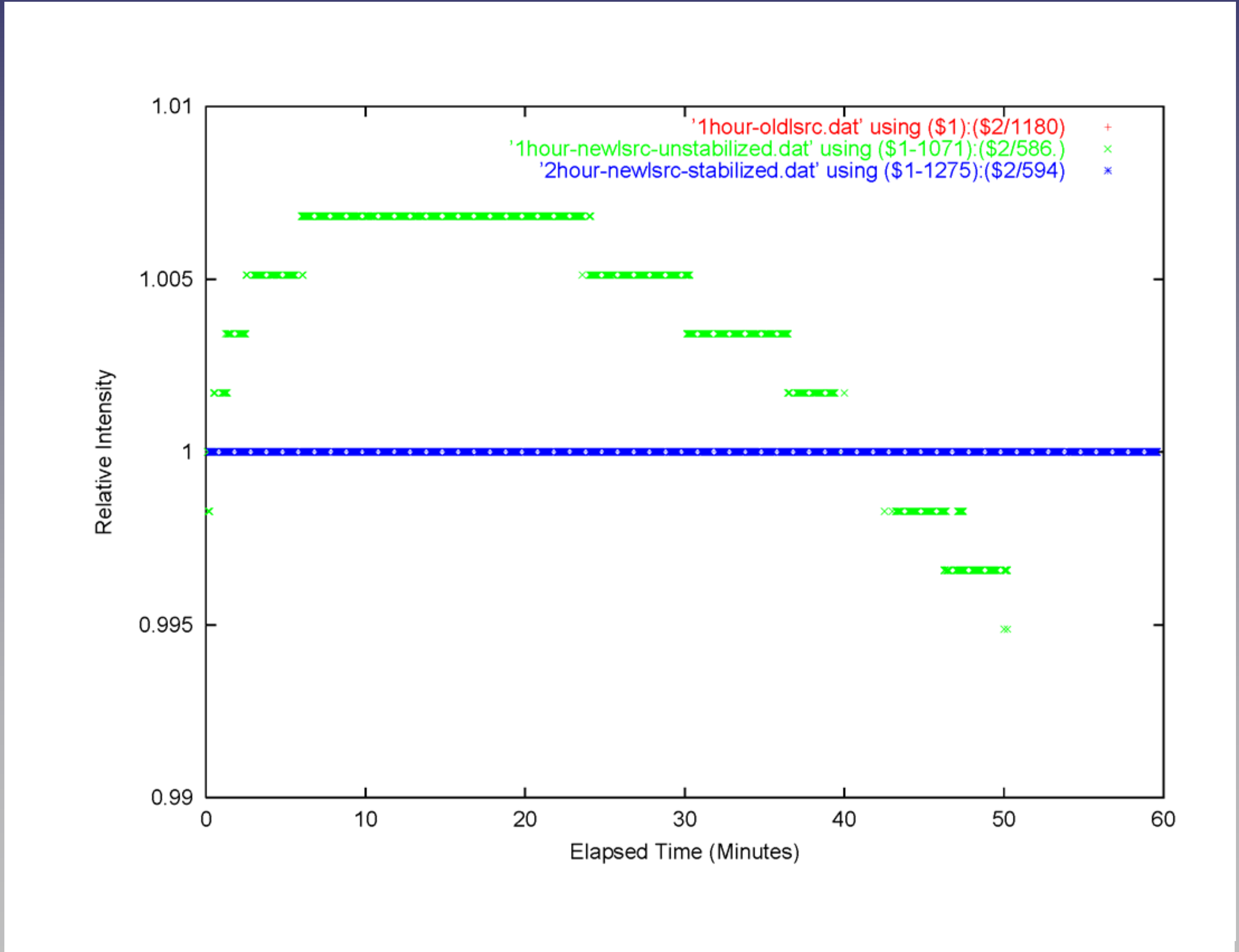
Properties (II)

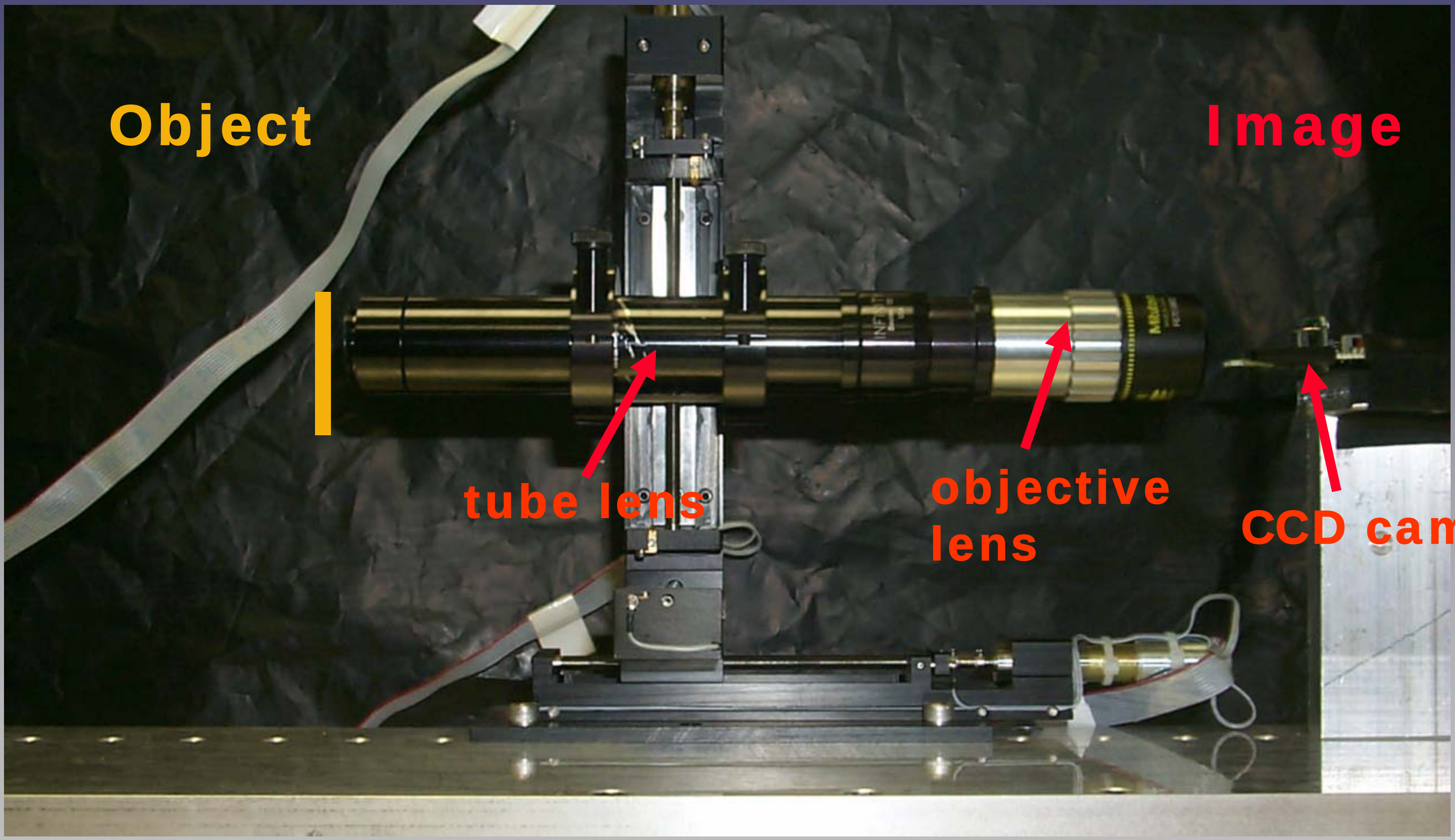


Diffraction limited spot size

Light Stability



Testing General Properties



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Testing General Properties

Object

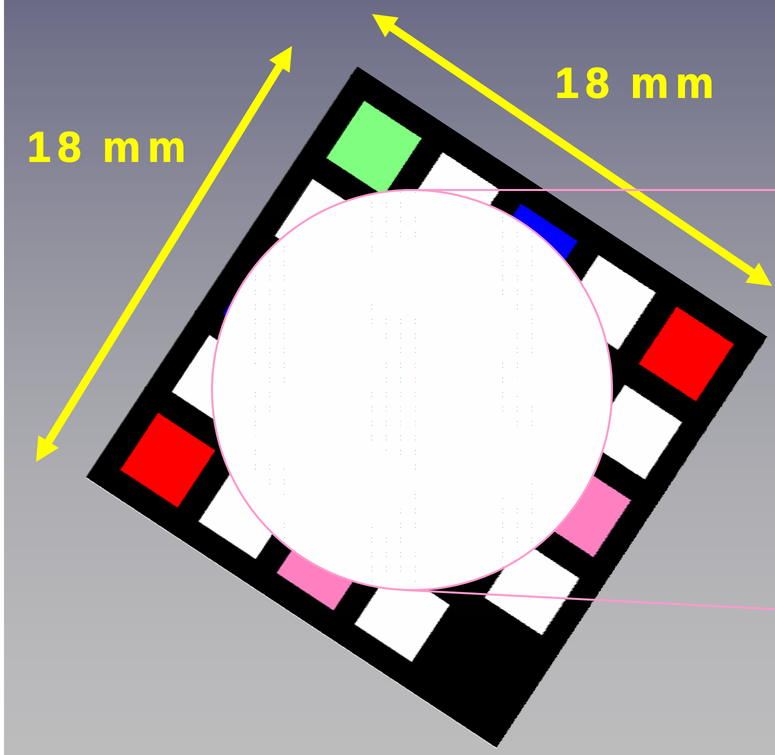
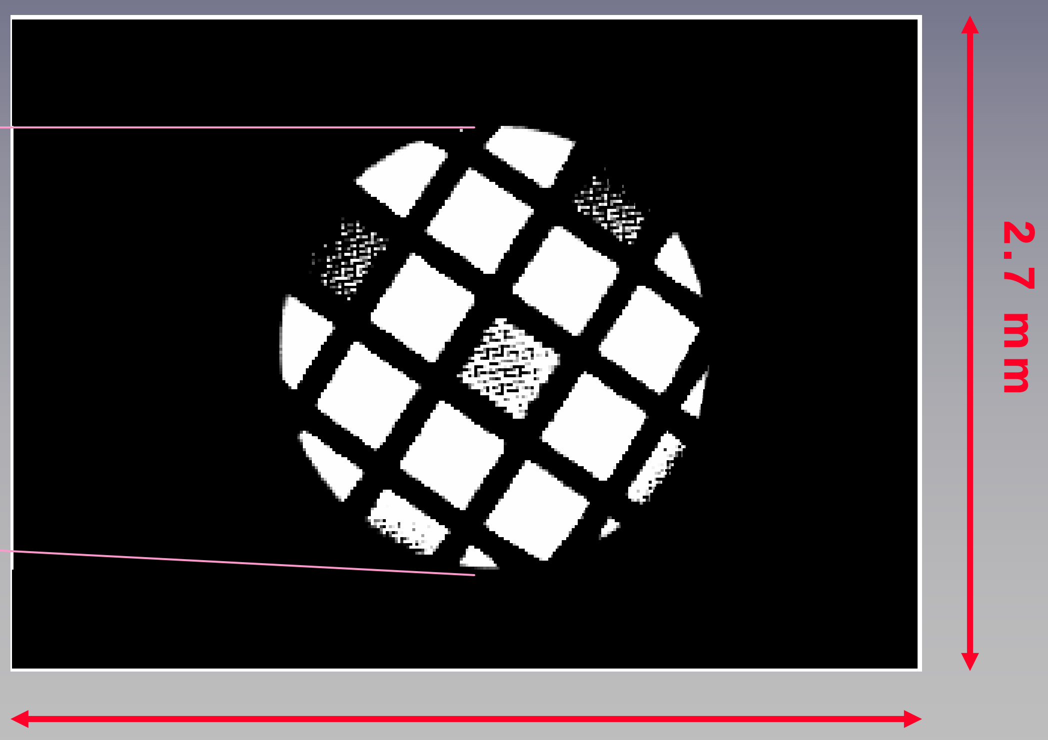
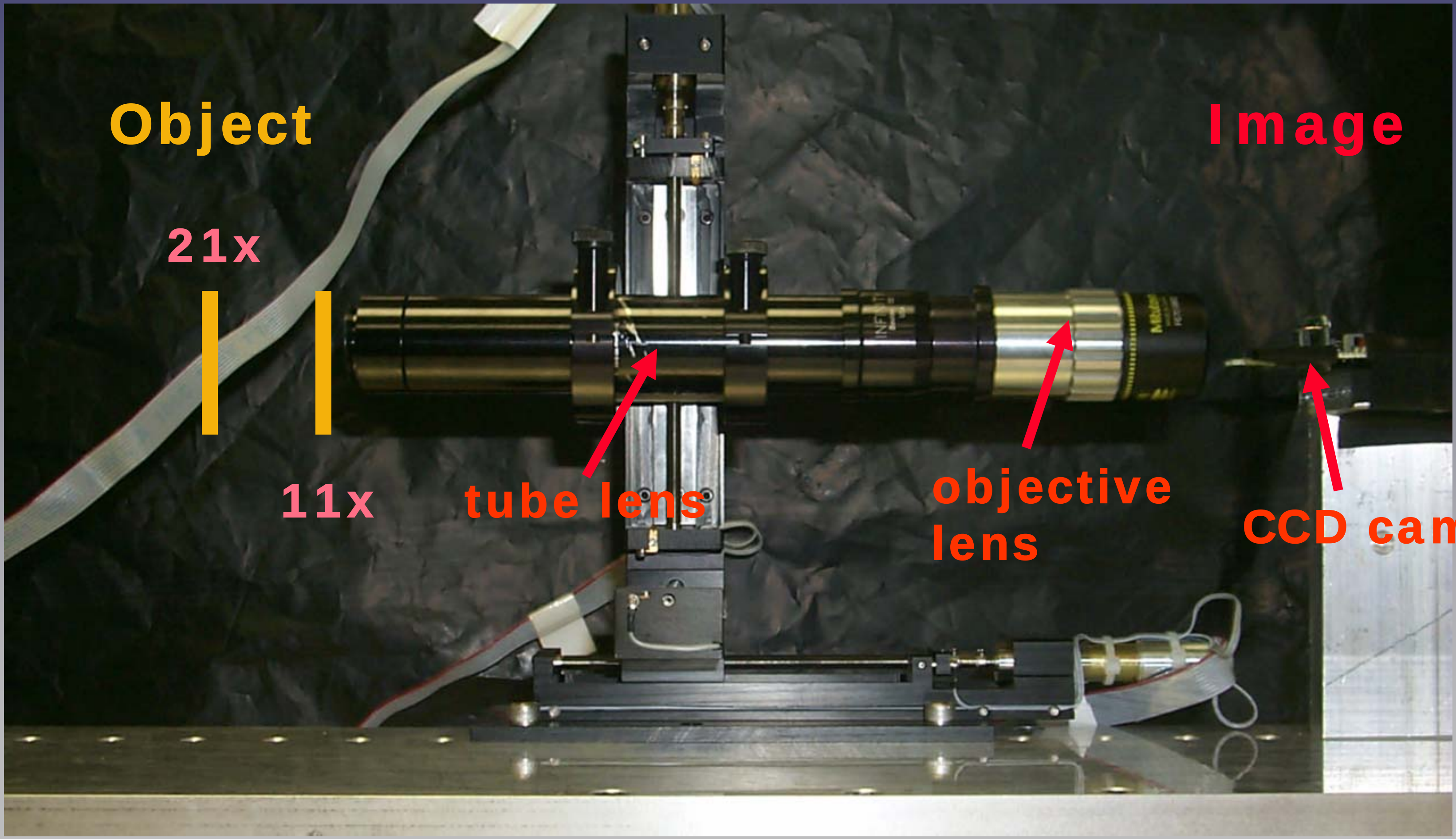


Image on CCD Camera

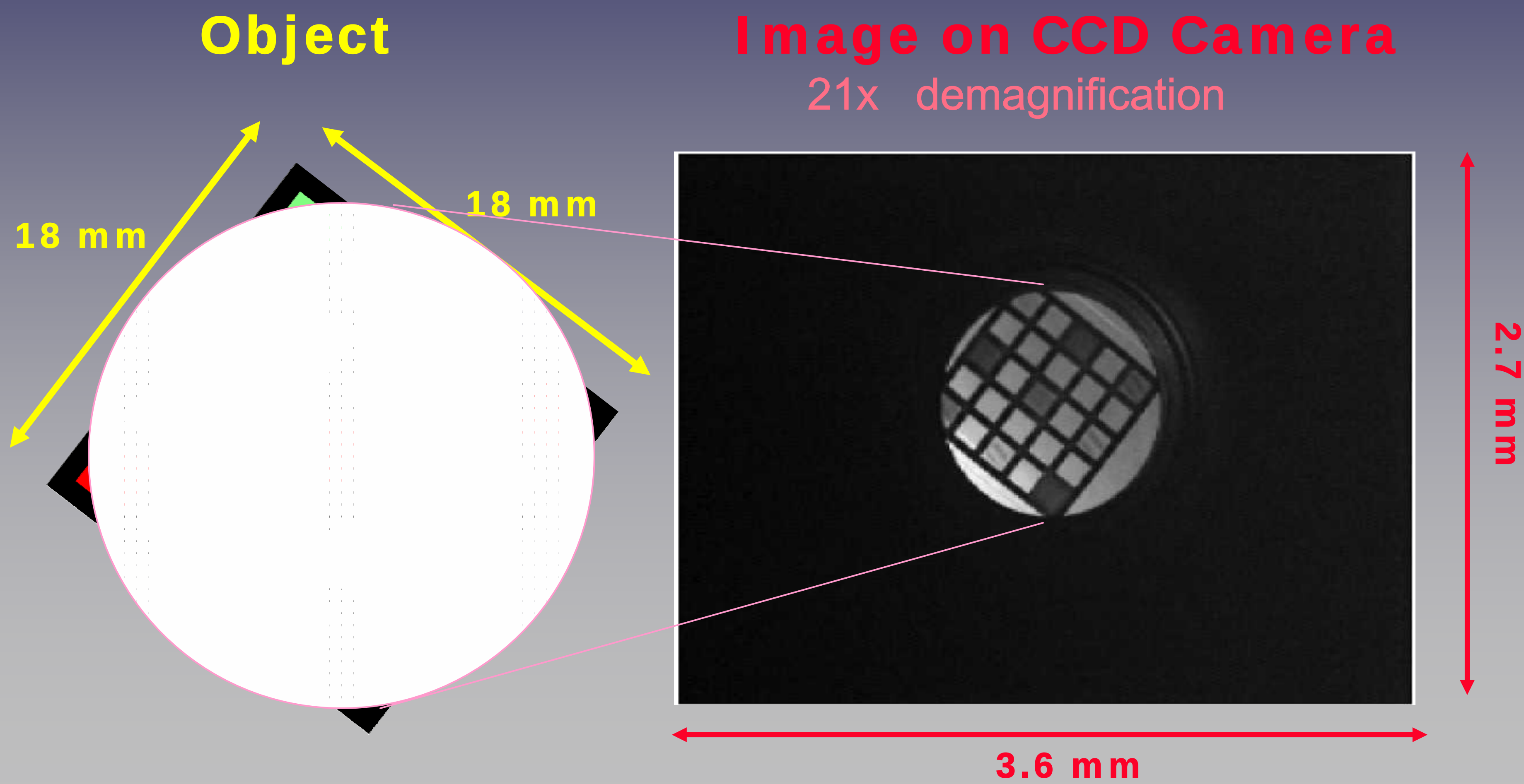
11x demagnification



Testing General Properties

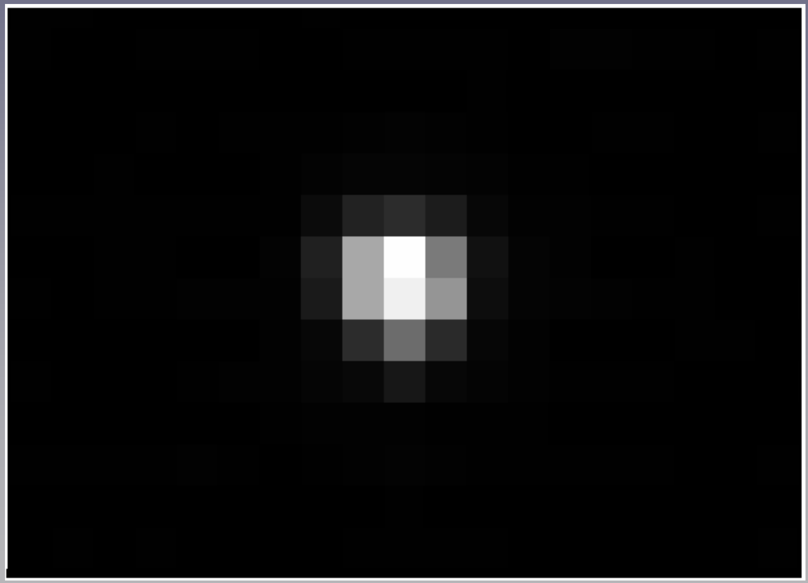


Testing General Properties



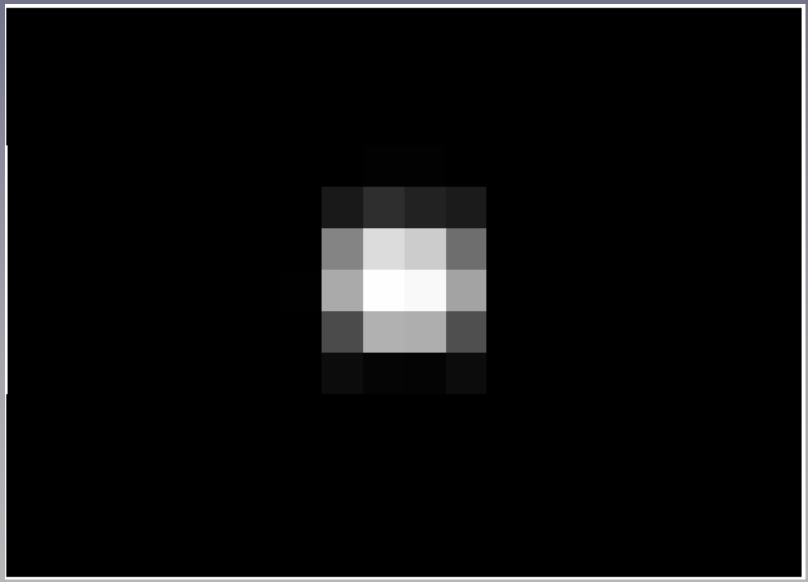
Imaging pinholes

100 μm pinhole



800 nm filter

10 μm pinhole

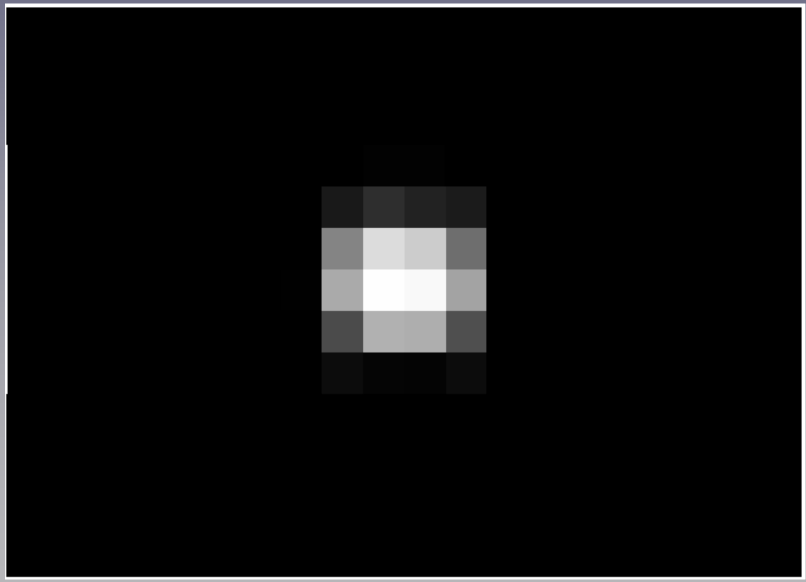


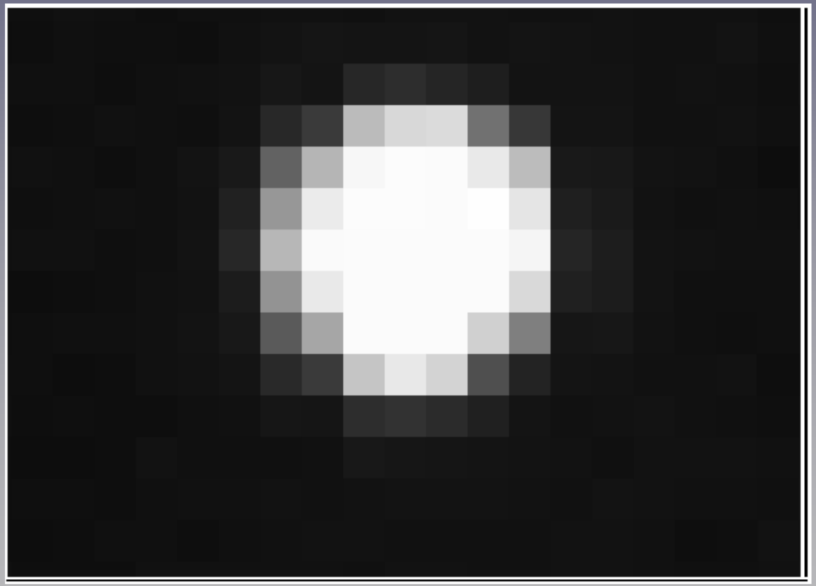
no filter

Imaging pinholes

10 μm pinhole

+135 μm off focus

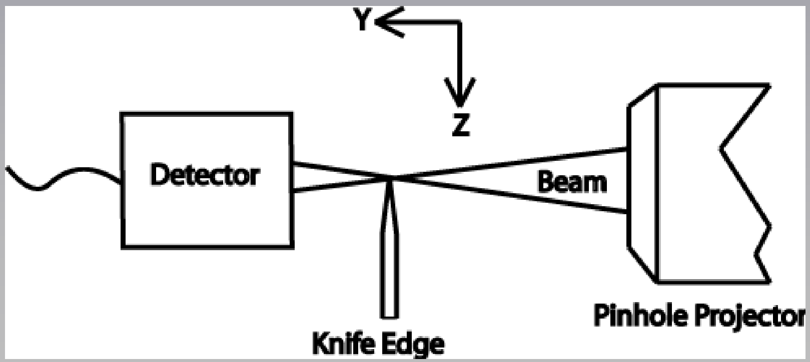


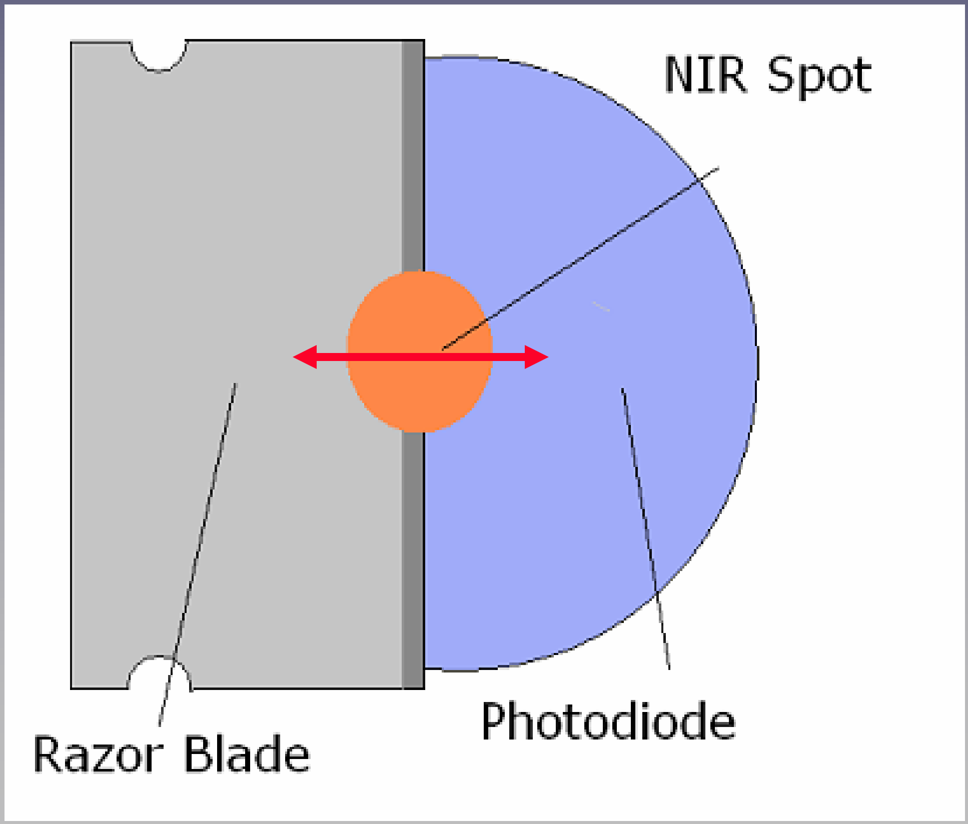


How do you actually measure how big the spot really is?

• Use the knife-edge test to find the integral of intensity vs. position.

• Then take derivative to find the beam profile.





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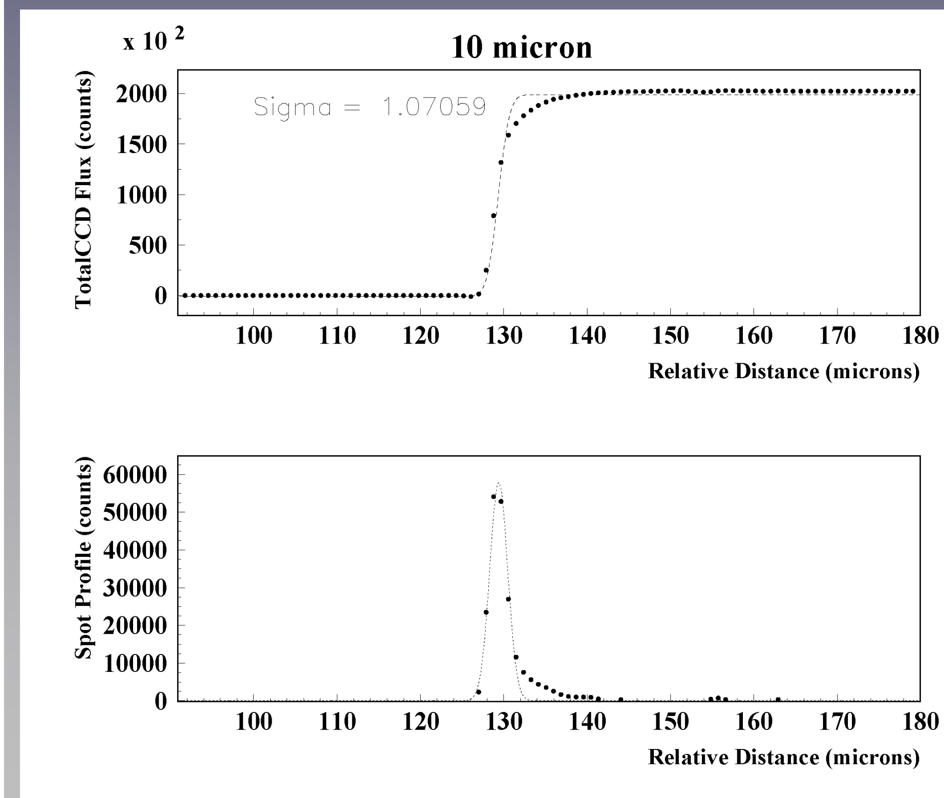
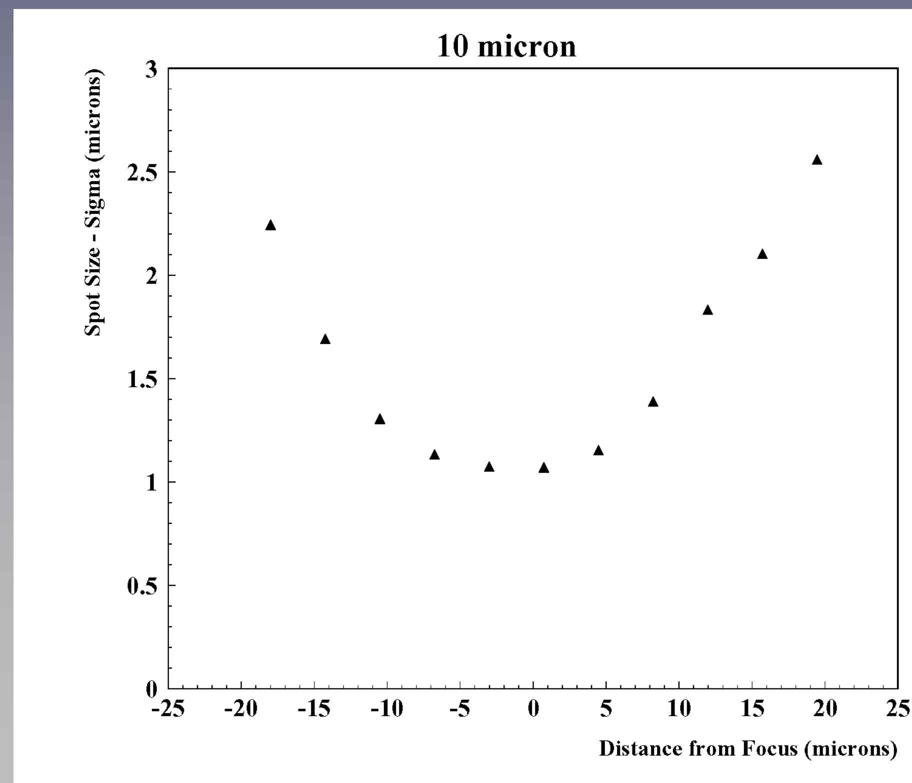
Results

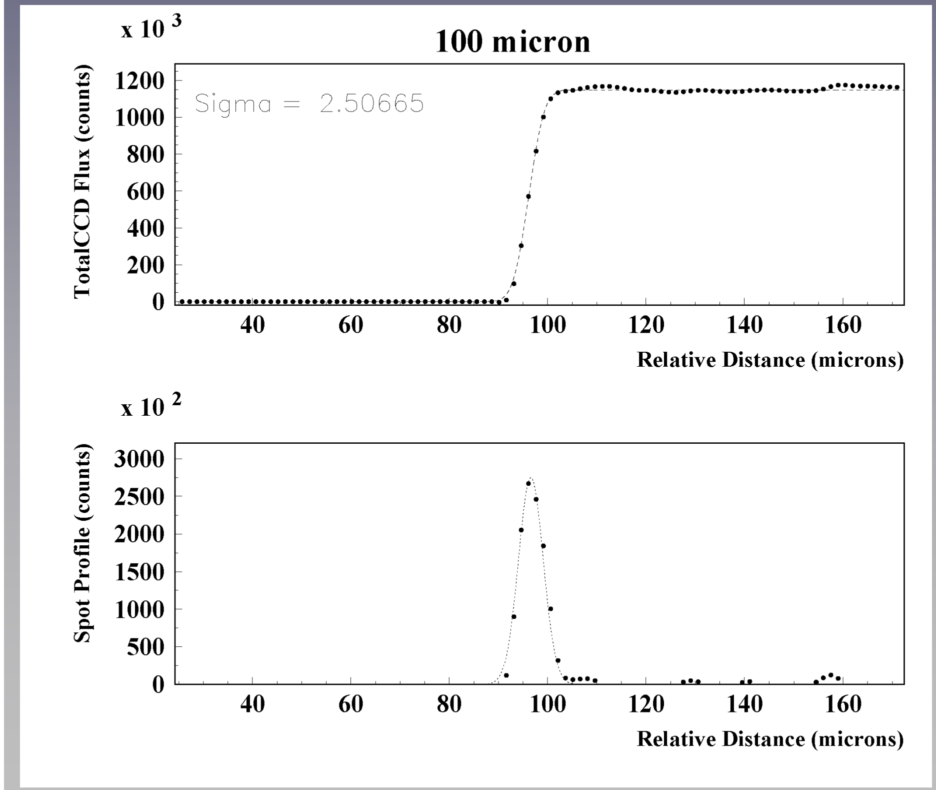
10 μm pinhole $\Rightarrow$ 2.5 μm (FWHM) spot on CCD

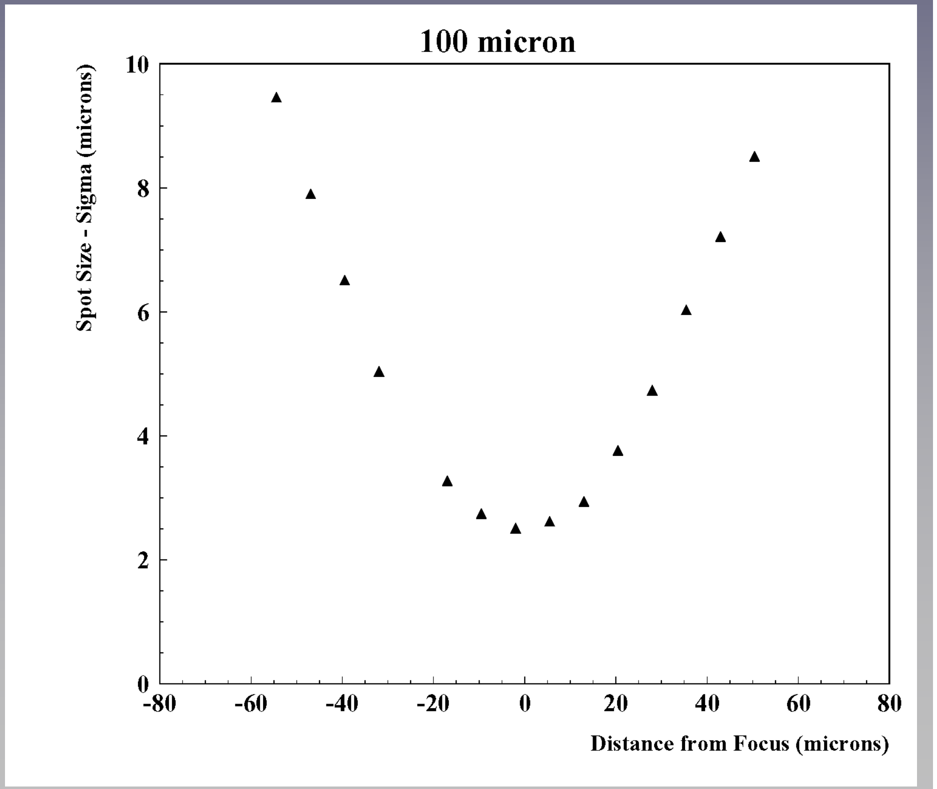




Results

100 μm pinhole $\Rightarrow$ 5.9 μm (FWHM) spot on CCD





Results

Summary

Pinhole Size	Smallest spot on CCD	Expected spot size (no diffraction)	Expected spot size (incl. diffraction)
100 μm	5.9 μm	4.8 μm	5.4 μm
10 μm	2.5 μm	0.48 μm	2.5 μm

Demagnification: 21x

Resolving Power = $0.61\lambda / N.A. \approx 1.2\ \mu\mathrm{m}$.

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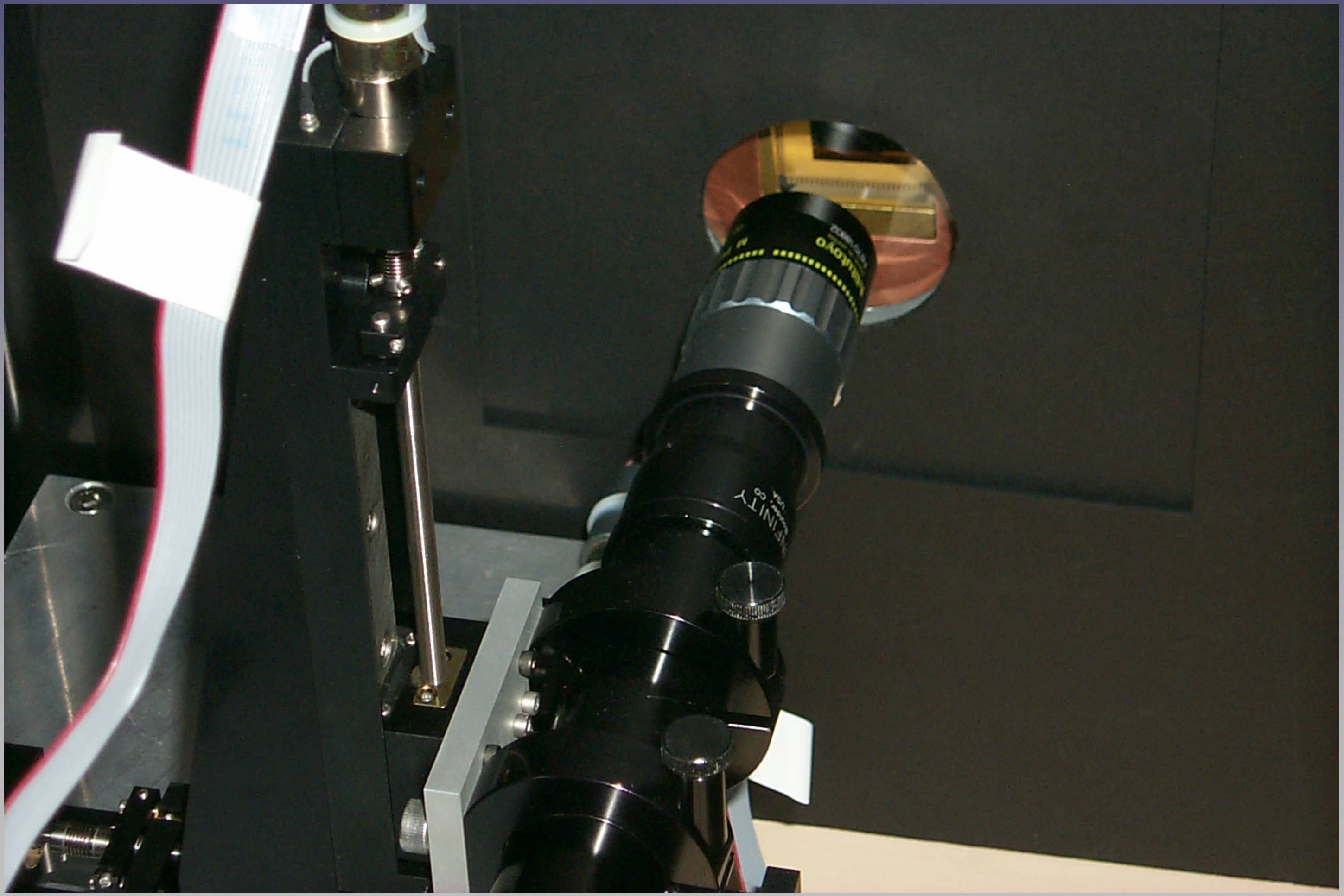
Putting a Spot on the InGaAs Detector



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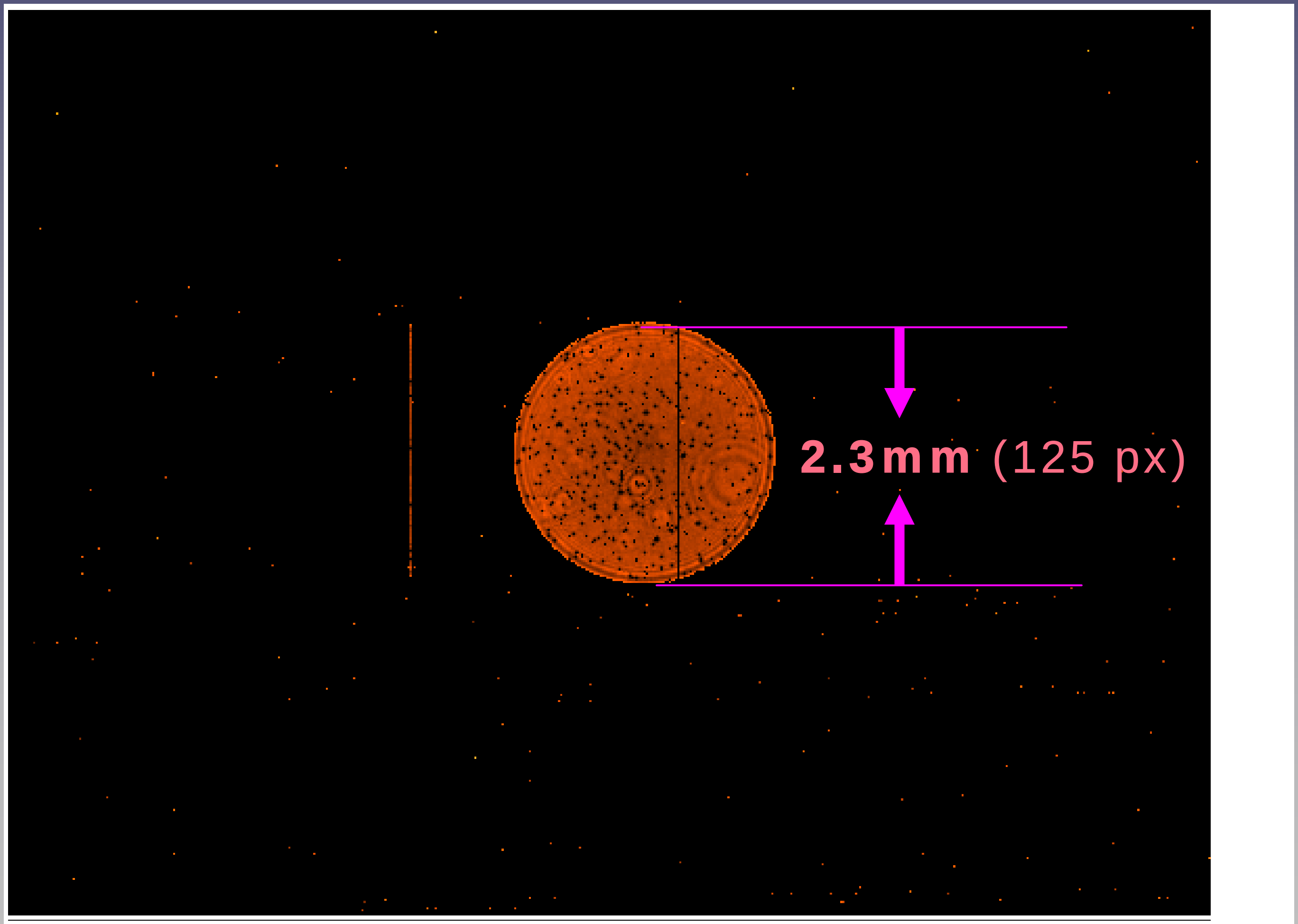
Putting a Spot on the InGaAs Detector (II)



filter:

1400 ± 50 nm

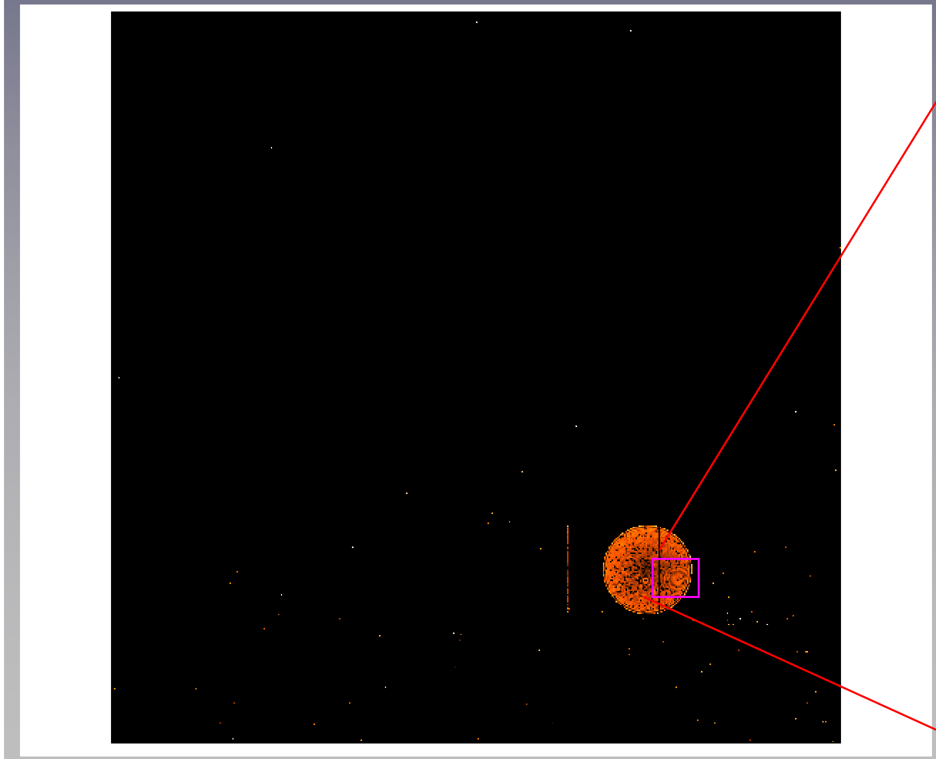
4.2mm from focus

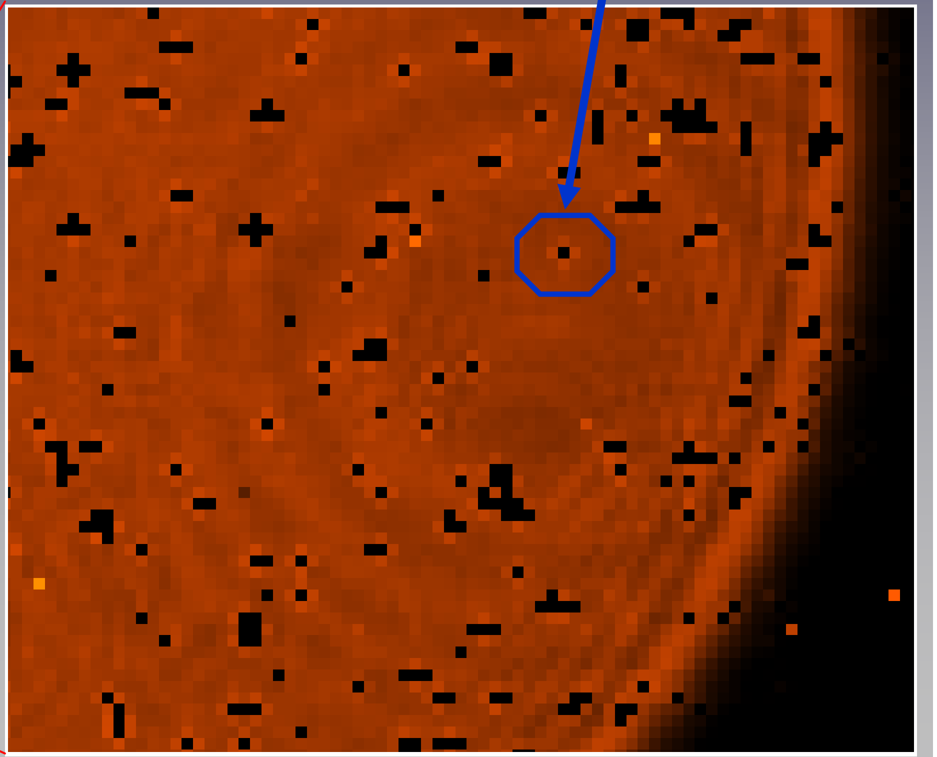
standoffs ready to install

Putting a Spot on the InGaAs Detector (III)

Full view (1k x 1k)

Zoomed in ⇒ daisy-ing





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Capabilities

- minimal spot sizes: 0.96 – 3.6 μm (σ) for λ=480-1800 nm
  - — mapping out pixel response function
  - — requires deconvolution of PSF of spot-o-matic as determined by knife edge tests (known) and pixel response function (unknown)
  - — study lateral charge diffusion
- any spot size above diffraction limit available by
  - — defocussing minimal spot
  - — using larger pin holes
- can simulate airy disks for SNAP focal plane
  - — evaluation of dithering schemes
- daisy-ing effect:
  - — peculiar situation
  - — another handle on charge diffusion using spot-o-matic ?

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Summary

- Pin Projection system tested using CCD
  - fully automated
  - NIR operation
- first image on a InGaAs device
- minor modifaction on dewar needed
  - project spots within 1 week on InGaAs detector
- ready to measure
  - intra-pixel response of HgCdTl and InGaAs detectors
  - lateral charge diffusion
- embark on program to partially characterize pixel response function
  - 2μm rastering: 81 exposures per pixel (2 min ea)
    $\Rightarrow$ 16 yrs per device !!
  - full characterization NOT feasible