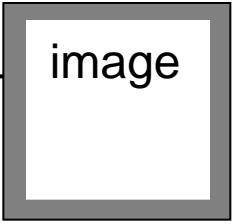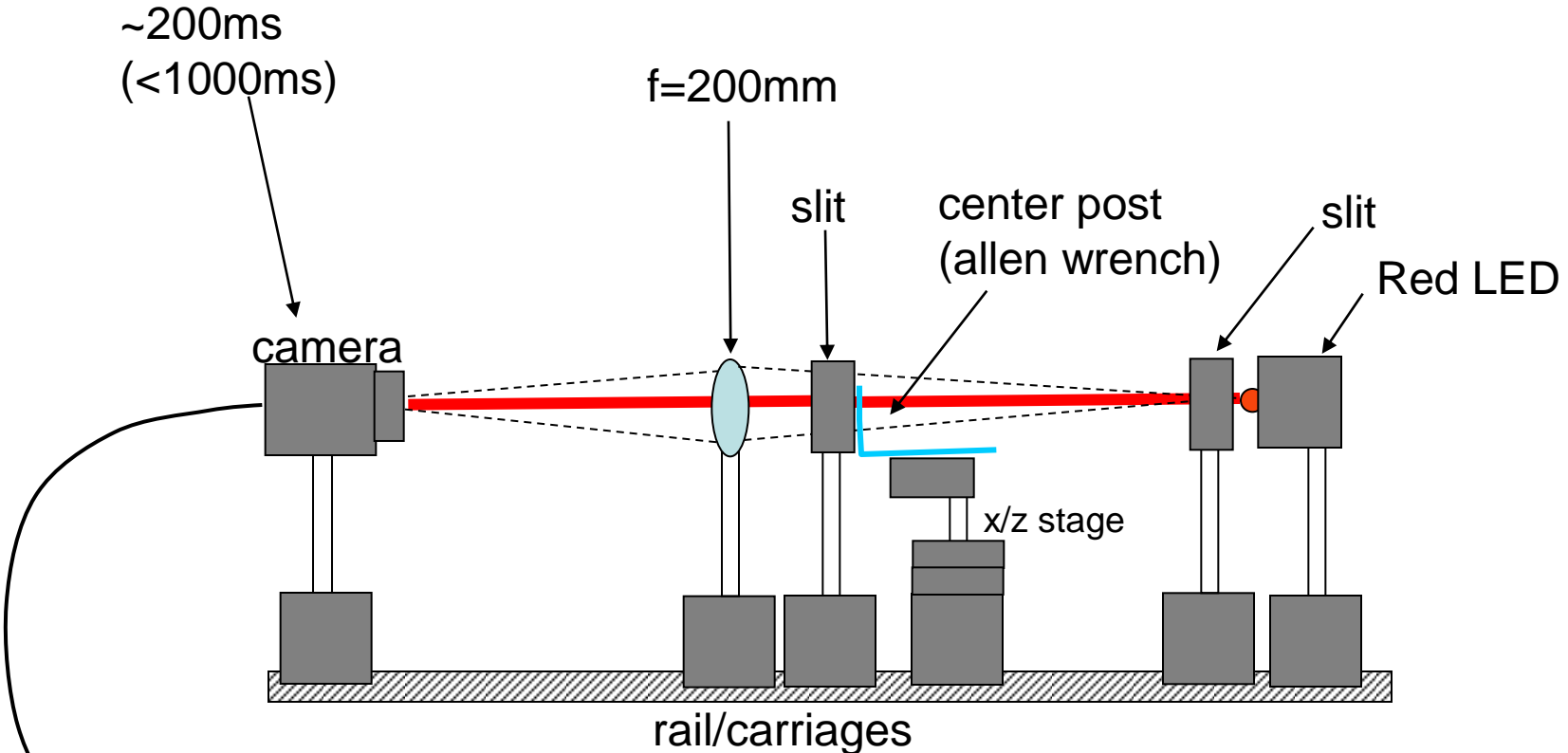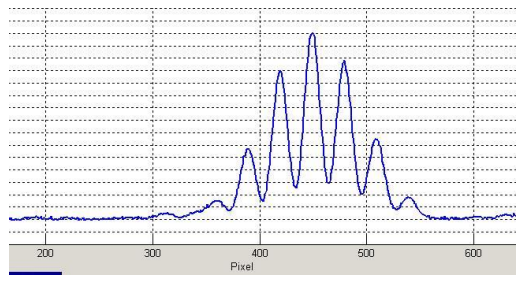# Interferometer Laboratory and Simulation

US Particle Accelerator School
January 14-18, 2008

- Introduction to Interferometer Laboratory

- Introduction to Interferometer Simulator

Interferometer Laboratory

Visibility in the Laboratory

For a monochromatic, Gaussian source

$$v = \exp(-2(\frac{\sigma \pi D}{\lambda F})^2)$$

where   v=visibility
         σ=source size
         D=slit separation
         λ =wavelength
         F=source-to-slit

Solve for source size

$$\sigma = \frac{\lambda F}{\pi D} \sqrt{\frac{1}{2} \ln(\frac{1}{v})}$$

Choose λ=630nm, isolate experimental parameters on the left

$$\frac{\sigma D}{F} = \frac{\lambda}{\pi} \sqrt{\frac{1}{2} \ln(\frac{1}{v})}$$

visibility formula:
$$\frac{\sigma D}{F} = \frac{\lambda}{\pi}\sqrt{\frac{1}{2}\ln(\frac{1}{v})}$$

For visibility 0.5-0.8 the square-root term is 0.3-0.6

When v=0.5 the factor on the right is ~1×10^{-7}

Assume a source size of 100micron (10^{-4})

Then D/F must ~10^{-3}.
A reasonable configuration is D=1mm, F=1m

Longer wavelengths allows slightly larger slit separation or smaller source-to-slit distance F

Setup tips –

   1. use lens on camera to define optical axis

   2. adjust lens to focus on LED (not turned on)

   3. put in first slit after LED, close to define source

   4. put in second slit at lens, on optical axis (with LED on)

   5. center allen wrench by translating horizontally

   6. adjust for equal image intensity from each of Young's slits

   7. don't forget to subtract baseline
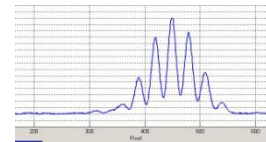
Interferometer Laboratory - Software

1. the program name is 'intf_gui' (interferometer GUI)

2. includes camera shutter time and gain control
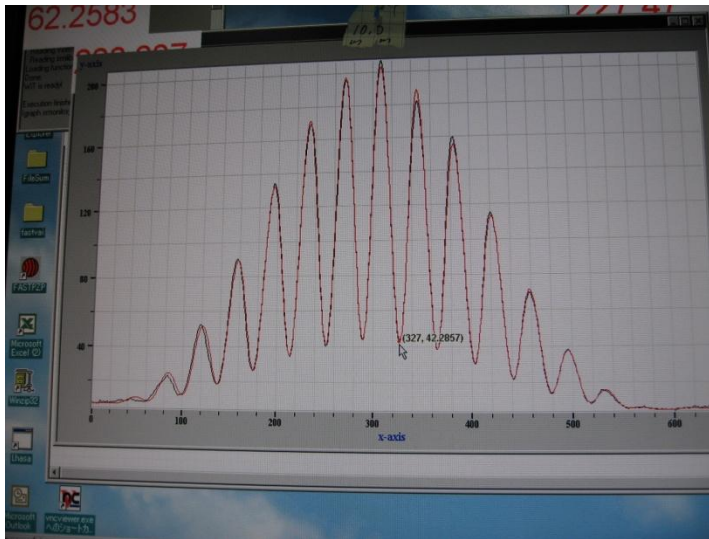
3. select a <u>vertical</u> region for the lineout
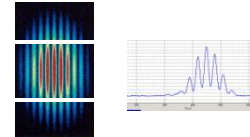
4. click in lineout/visibility pattern window to view pixels

Interferometer Laboratory – Raw Data

Photon Factory

USPAS Laboratory
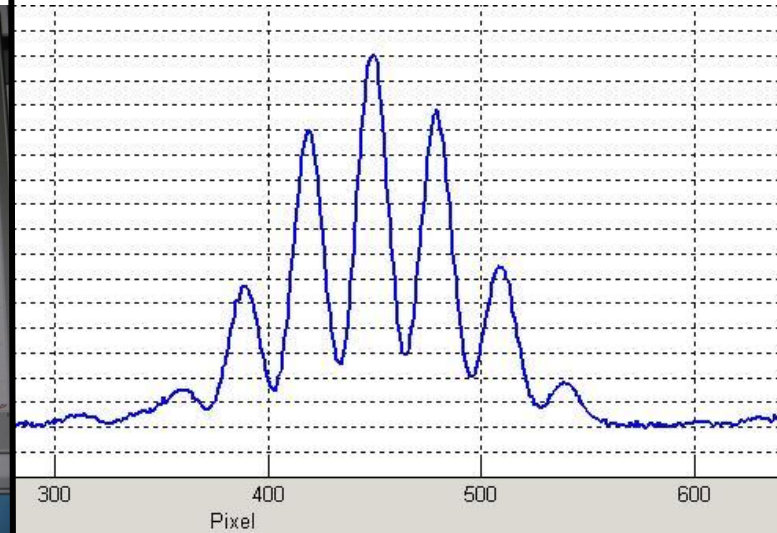
which has wider slit width 'a'?

which has wider slit separation 'D'?

Interferometer Laboratory – Processed Data

visibility plot

FWHM/2

visibility

slit separation (mm)

[allen wrench size]

Fourier Transform

source reconstruction

intensity

$$\sigma_d = \frac{\lambda L}{2\pi\sigma_y}$$

x-position

visibility vs. source size

visibility

source size

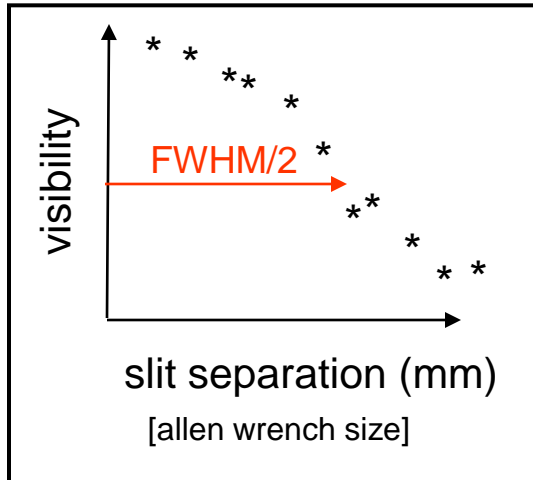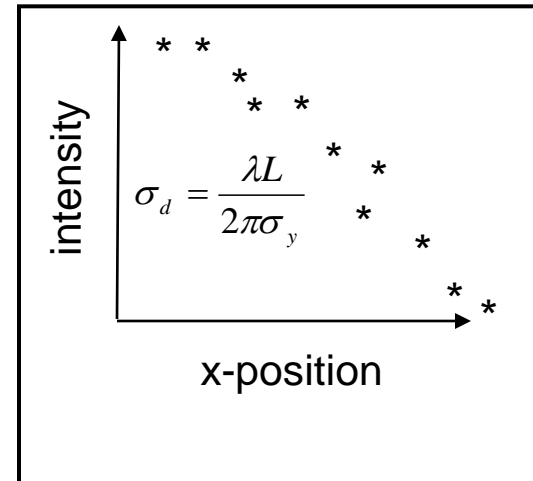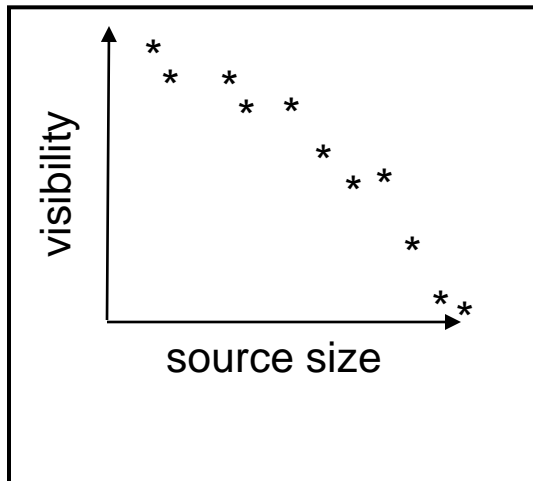# Interferometer Simulation

result

fit result

thumbwheels

actual plot/guess

system parameters

fit select

	Guess		Fit
Base Offset [m]	0		-4.0228e-009
Intensity at Slit #1	1		0.99954
Intensity at Slit #2	1		0.99954
Slit Width [m]	0.002		0.0019056
Slit Separation [m]	0.05		0.047615
Angle Offset [rad]	0		-0.0017999
Phase Offset [rad]	0		-1.434e-009
Vertical Beam Size [m]	1.5e-005		1.5e-005
Visibility	0.7304		0.72897
focal length [m]	2		
Center Wavelength	5e-007		

Load Default Parameters

Plot Intensity

Fit Intensity

- Base
- Fit A1
- Fit angle
- Fit phase
- Fit slit
- Fit separation
- Fit visibility

Interferometer Simulator (cont'd)

$$I(\theta) = E_{01}^2 + E_{02}^2 + E_{01}E_{02}|\gamma|\cos(\gamma + \theta)$$

$$I(y) = I_0 \left[\sin c \left(\frac{2\pi a}{\lambda R} y \right) \right] \cdot \left[1 + |\gamma|\cos \left(\frac{2\pi d}{\lambda R} y + \Phi \right) \right]$$

Single-Slit

Two-Slit

beam intensity
(equal both slits)

visibility factor (mutual coherence)

$$Visibility = \frac{I_{Max} - I_{Min}}{I_{Max} - I_{Min}} = |\gamma|$$

Interferometer Simulator (cont'd)

General comments

Program name is 'michelson_gui'

Default parameters for SPEAR3
 source is small and 17m from slits – high frequency cosine
 wavelength filter is 550nm

 No bandpass filter term

 Intensity at slit #1 = Intensity at slit #2

 Can not 'edit' visibility, just initial guess (change beam size)

Levenberg/Marquedt fitting algorithm

Summary

-Interferometer Laboratory

    tune for maximum visibility
    plot visibility vs. slit separation
    reconstruct source size
    plot visibility vs. source size

-Interferometer Simulator
    parameter dependence (wavelength, slit size, etc
    plot visibility vs. slit separation