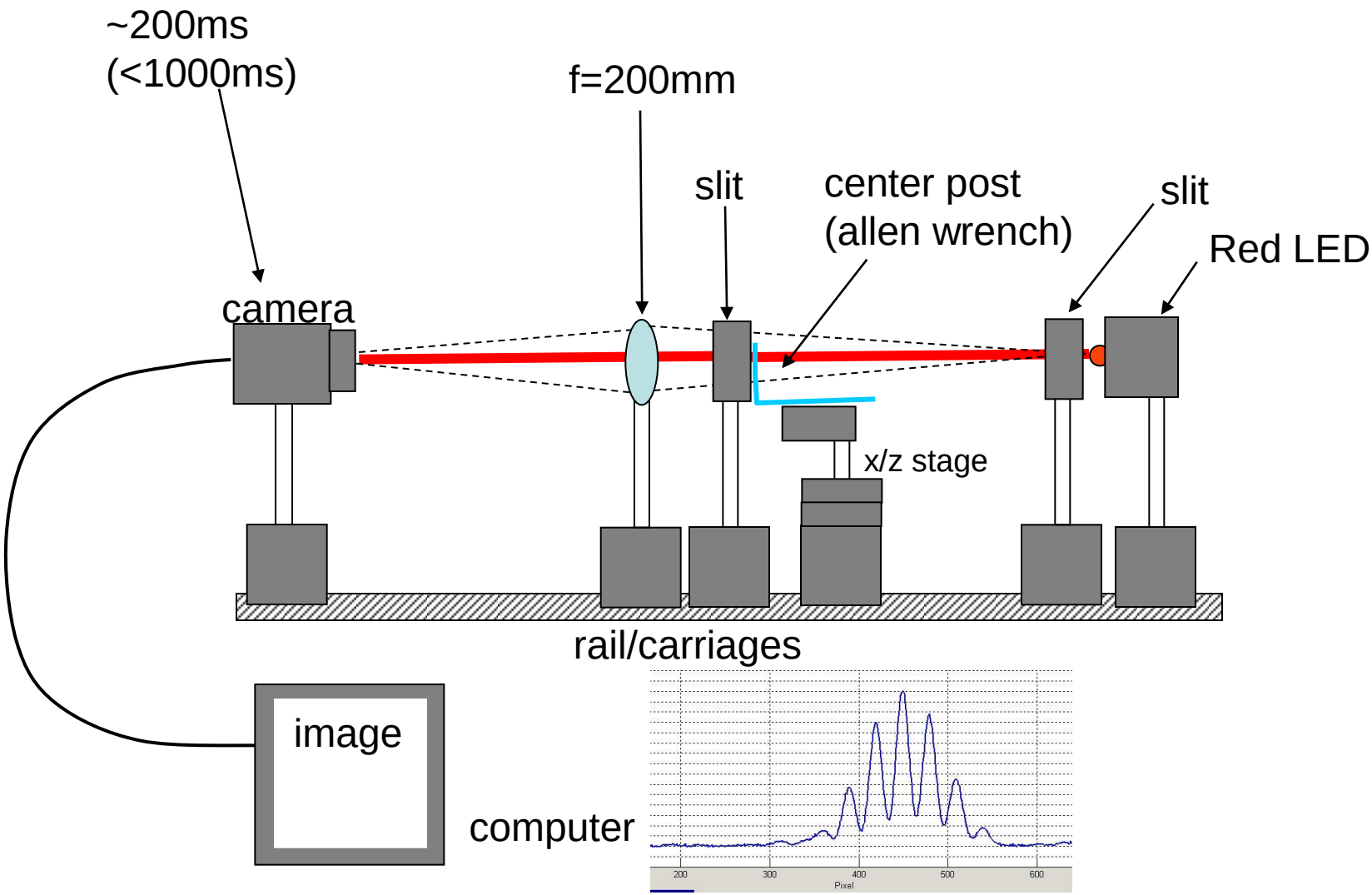
# Interferometer Laboratory and Simulation

US Particle Accelerator School
January 18-22, 2010

- 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 in the Laboratory (cont'd)

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 ~1x10$^{-7}$

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

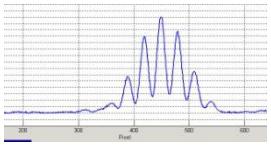
Then D/F must ~10$^{-3}$.
A reasonable configuration is D=1mm, F=1m

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

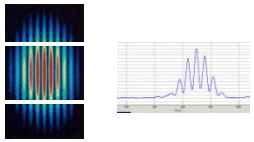
# Interferometer Laboratory (cont'd)

Setup tips –

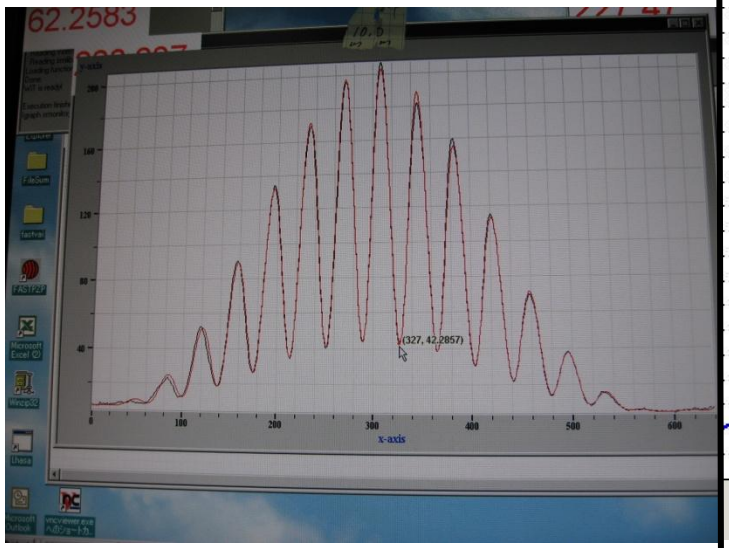
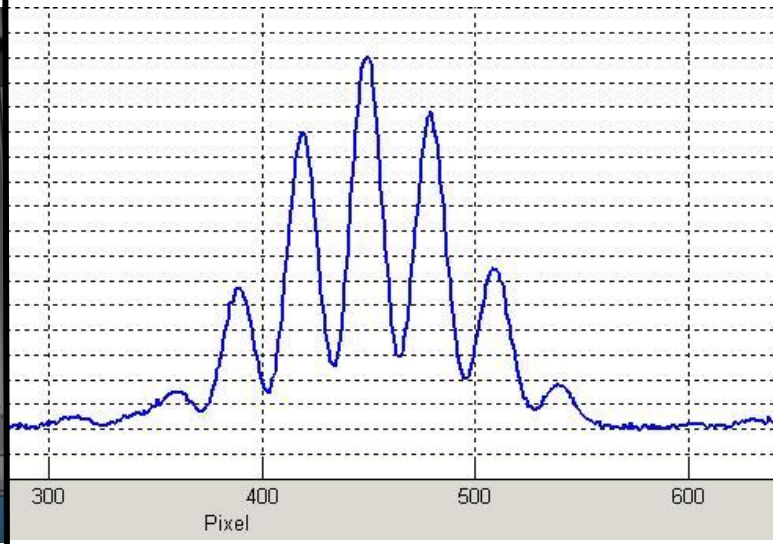
1. use lens on camera to define optical axis
2. adjust lens to focus on LED (not turned on)
3. put in first slit after LED, close to define source
4. put in second slit at lens, on optical axis (with LED on)
5. center allen wrench by translating horizontally
6. adjust for equal image intensity from each 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 vertical region for the lineout 
4. click in lineout/visibility pattern window to view pixels

# Interferometer Laboratory – Raw Data

| Photon Factory | USPAS Laboratory |
| --- | --- |
|  |  |

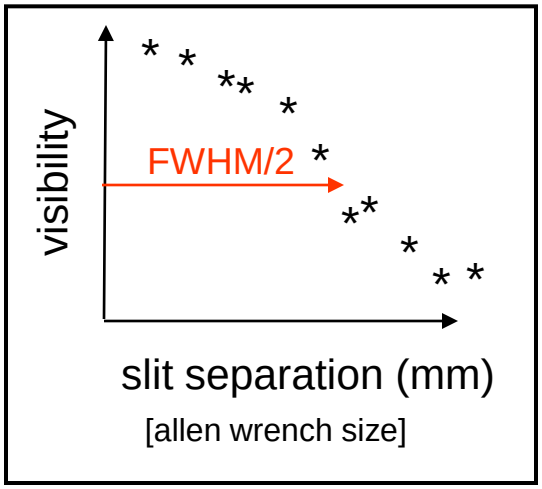


which has wider slit width ‘a’?

which has wider slit separation ‘D’?

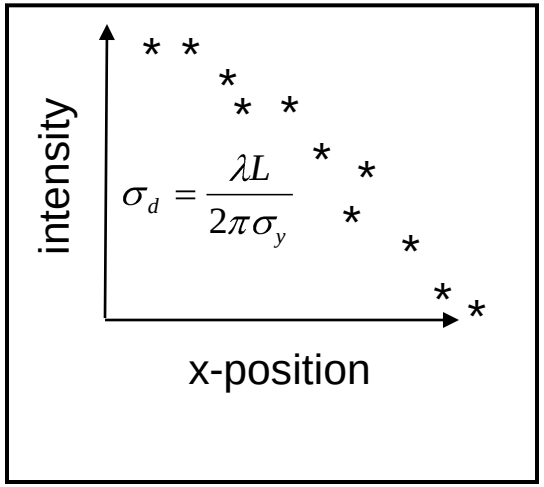
# Interferometer Laboratory - Processed Data

visibility plot

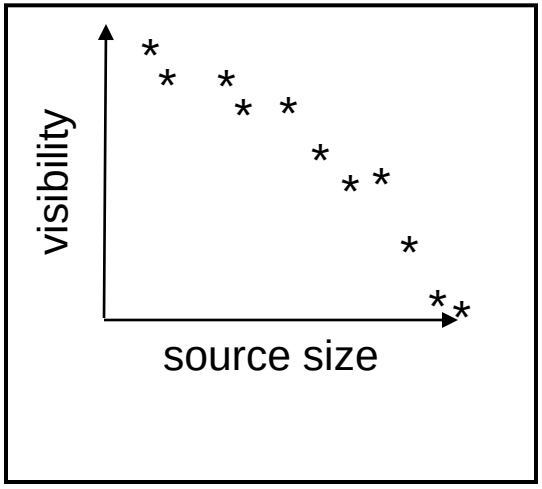



Fourier Transform

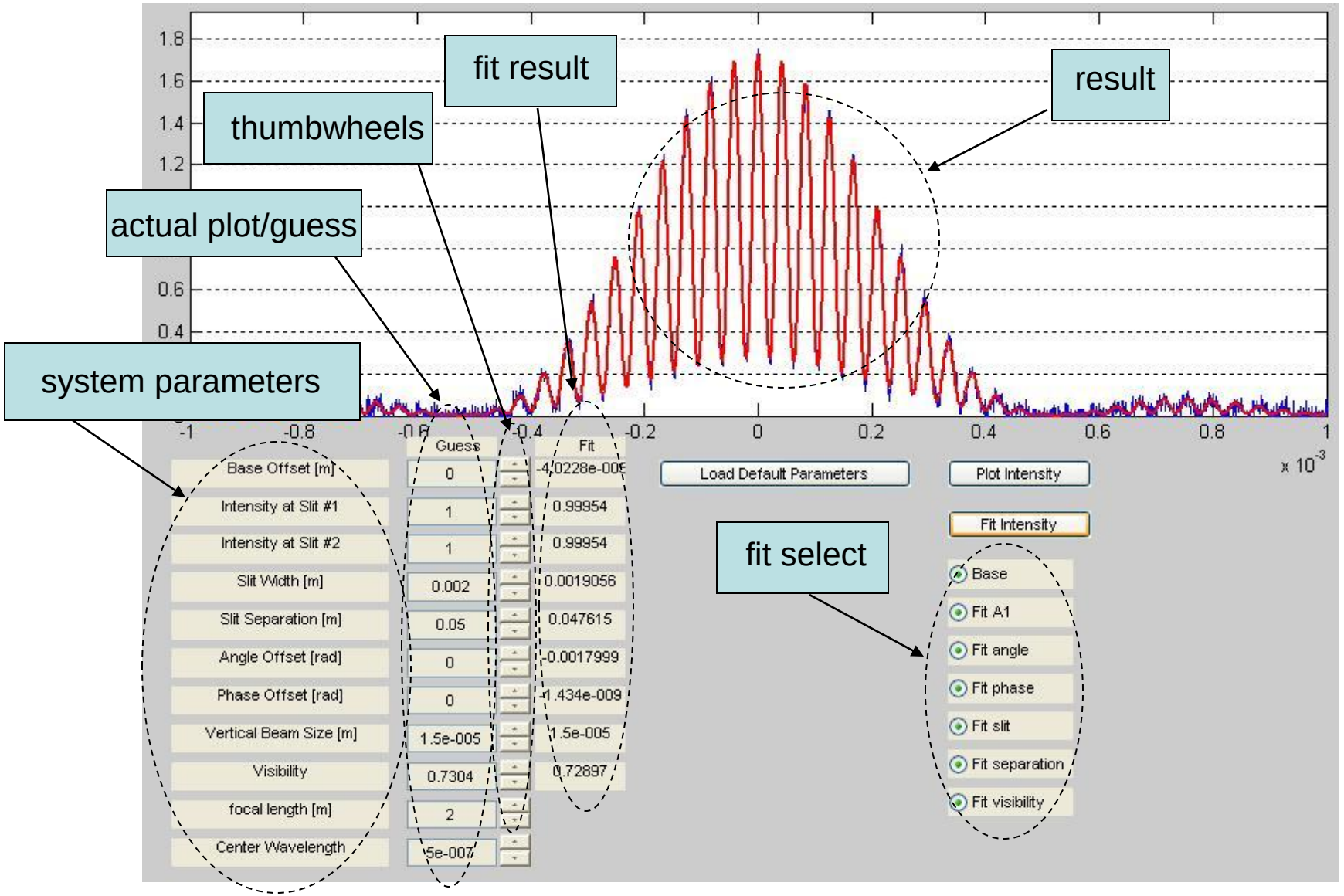
source reconstruction




visibility vs. source size



# Interferometer Simulation



# Interferometer Simulator (cont'd)

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

$$I(y) = I_0\left[\underbrace{\sin c\left(\frac{2\pi a}{\lambda R}y\right)}_{\text{Single-Slit}}\right]^2 \cdot \left[\underbrace{1 + |\gamma|\cos\left(\frac{2\pi d}{\lambda R}y + \Phi\right)}_{\text{Two-Slit}}\right]$$

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/Marquardt 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