Synchrotron Light Interferometer Project at Jefferson Lab

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February 21, 2003

- Properties of Light
- Synchrotron Radiation
- Beam Diagnostics with Synchrotron Light
- Synchrotron Light Interferometer at Jefferson Lab with some Experimental Results
- Conclusions

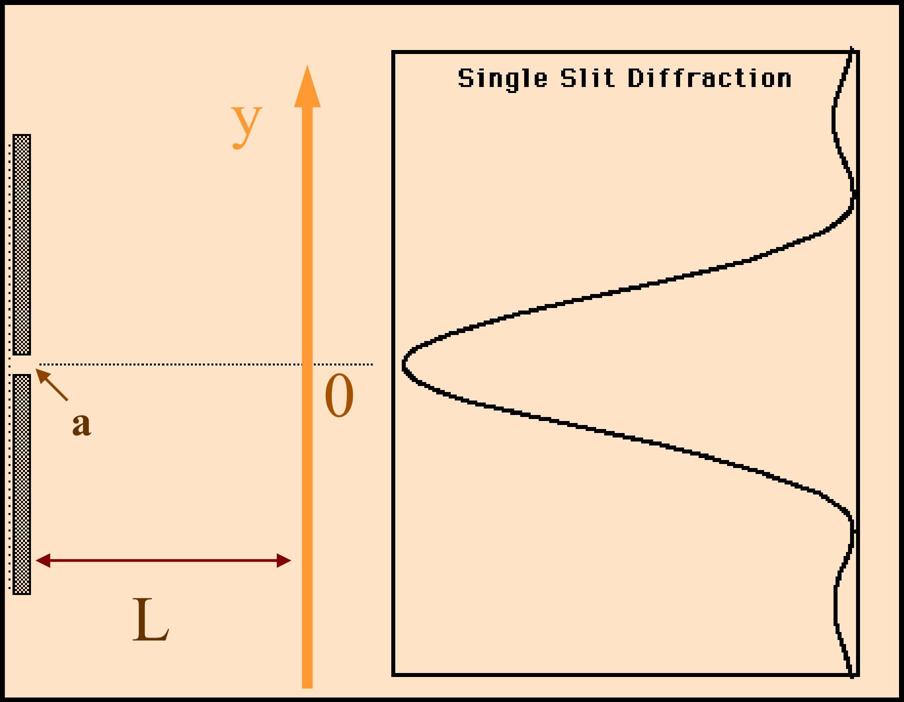
Properties of Light

Diffraction

Diffraction is the spreading of waves around obstacles.

Diffraction describes how light interacts with its physical environment.

S



$$I(y) = I(0)\left[\frac{\sin(\alpha)}{\alpha}\right]^2$$

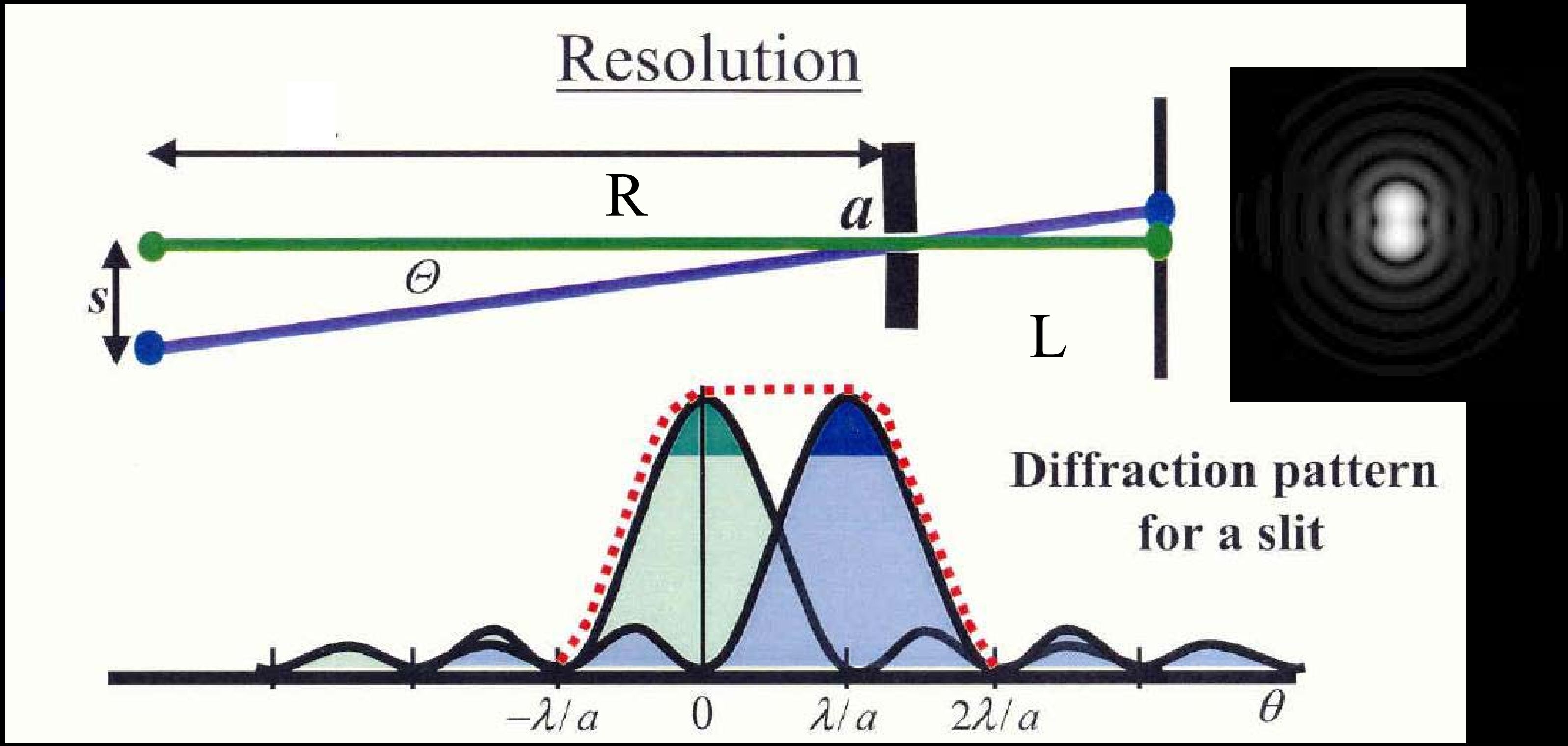
$$\alpha = kay/(2L)$$

$$k = 2\pi/\lambda$$

Resolving power of image-forming systems

Diffraction of light limits the resolution of optical systems. The images of two objects, which are very close to each other, overlap.

How close two points can be brought together before they can no longer be distinguished as separate ?



The Rayleigh criterion states that two similar diffraction patterns can just be resolved if the first zero of one pattern falls on the central peak of the other.

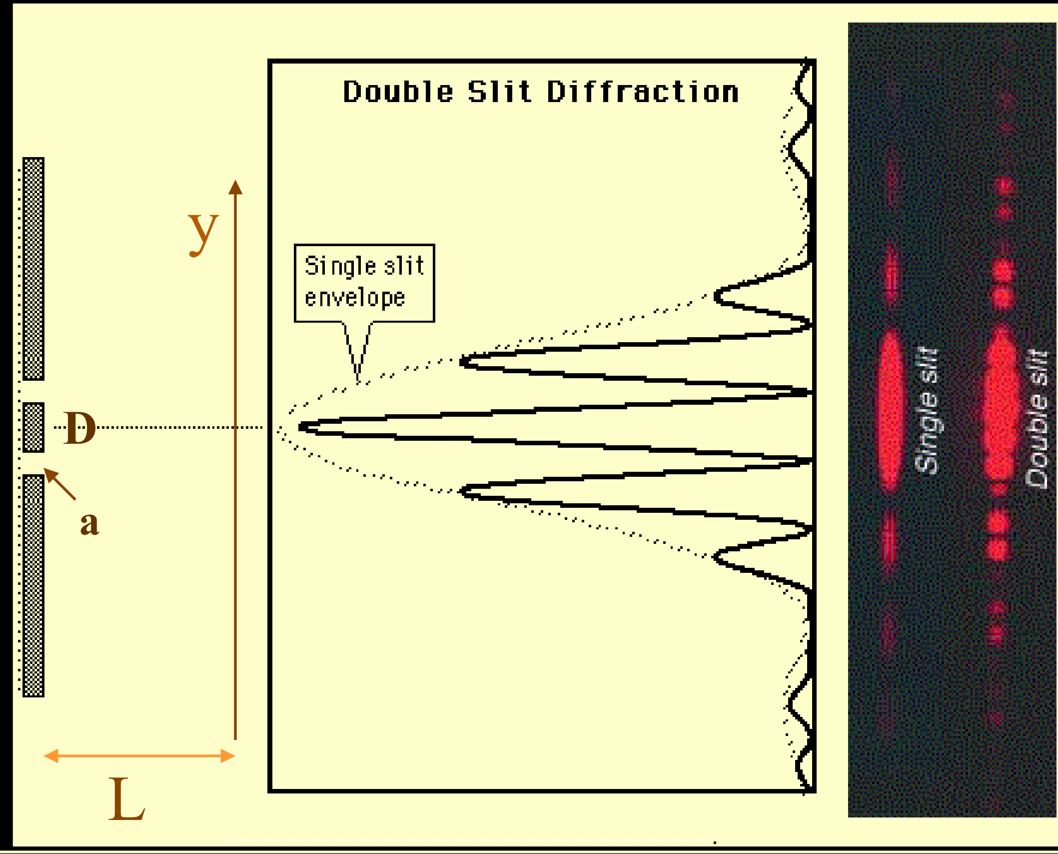
$$\left(\frac{s}{R}\right)_{min} = \theta_{min} = \frac{\lambda}{a}$$

Interference

Interference is the net effect of the combination of two or more wave trains.

Interference results from the superposition of electromagnetic waves. It is the mechanism by which light interacts with light.

S

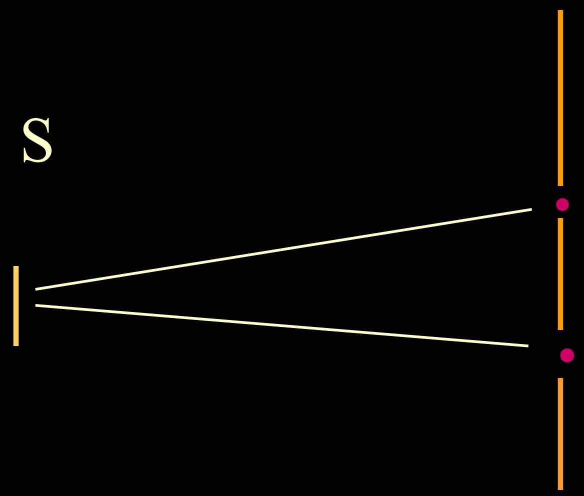


The intensity pattern is given by:

$$I(y) = I_0 \left[\frac{\sin(\alpha)}{\alpha}\right]^2 [\,1 + \cos(kDy/L)\,]$$

$$\alpha = kay/(2L)$$

If the light source is not “point-like”



$$I(y) = I_0 \left[\frac{\sin(\alpha)}{\alpha} \right]^2 [\, 1 + V \cos(kDy/L + \varphi) \,]$$

$$\alpha = kay/(2L)$$

$$V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$ visibility (fringe contrast)

And the visibility and the "phase shift" φ are connected with the degree of coherence Γ: $V = |\,\Gamma\,|$, $\varphi = f\,(\arg \Gamma)$

Theorem of van Cittert – Zernike

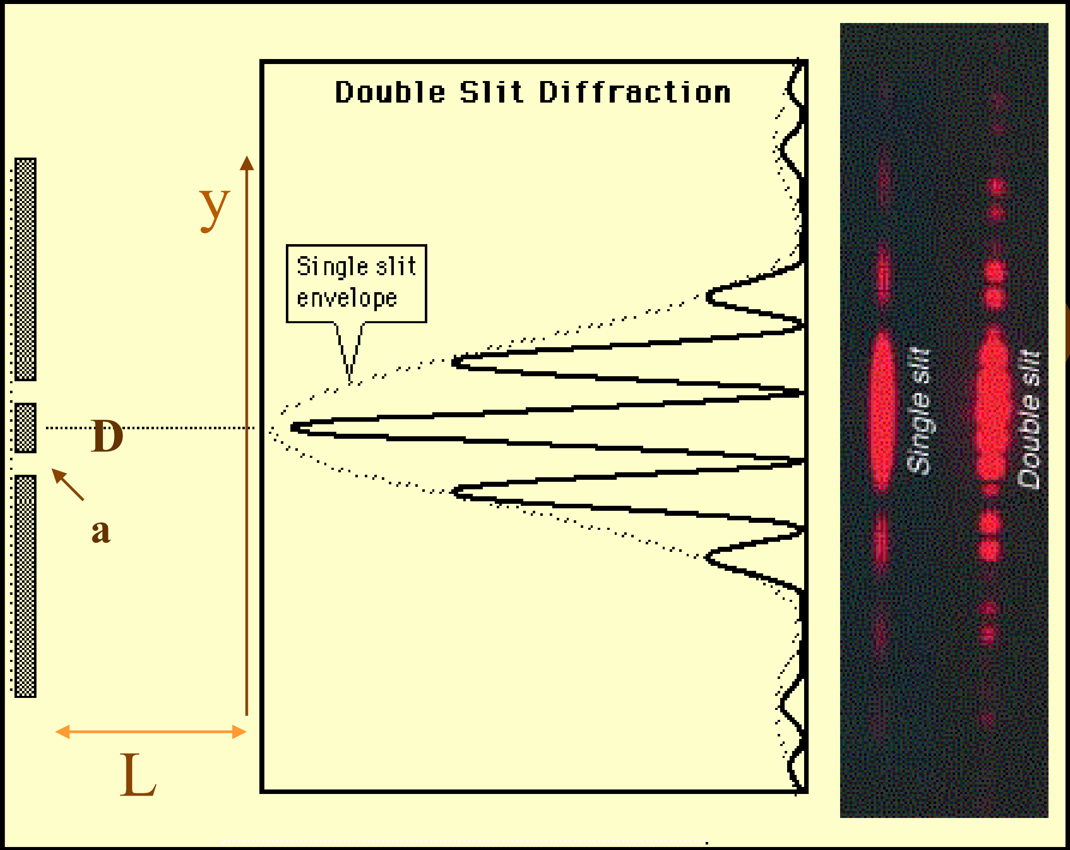
The degree of coherence Γ is given by the Fourier transform of the intensity distribution of the source object.

$$\Gamma(\theta) = \int I(\xi) \exp\{ -i\, 2\pi\, \theta\, \xi\}\, d\,\xi$$

$$\Gamma = \frac{\Gamma(\theta)}{\Gamma(0)} \qquad \theta = \frac{D}{\lambda R}$$

- **the visibility of the interference fringe picture from a point source is equal to 1**
- **a small source object gives a good visibility (fringe contrast)**
- **a large source object gives a poor visibility (fringe contrast)**

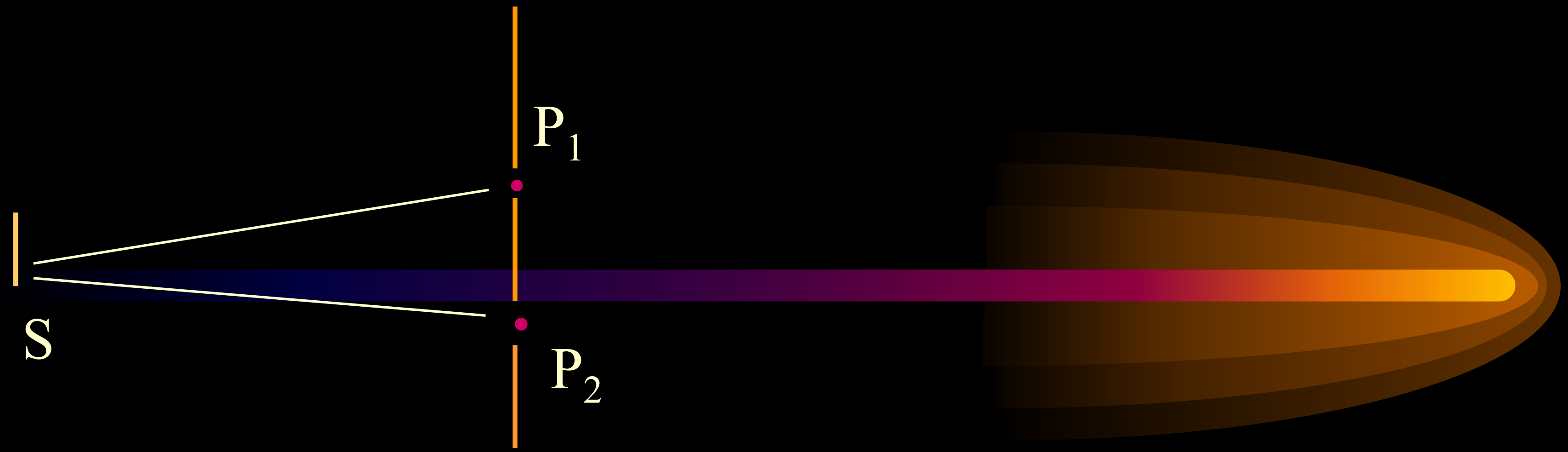
What is about the resolution of such a double slit assembly (interferometer) ?



Following Rayleigh's criterion, $\left(\frac{s}{R}\right)_{min} = \theta_{min} = \frac{\lambda}{2D}$

The resolution can be made very high …

… but only if



P_1 and P_2 remain correlated:

for all typical points S in the source

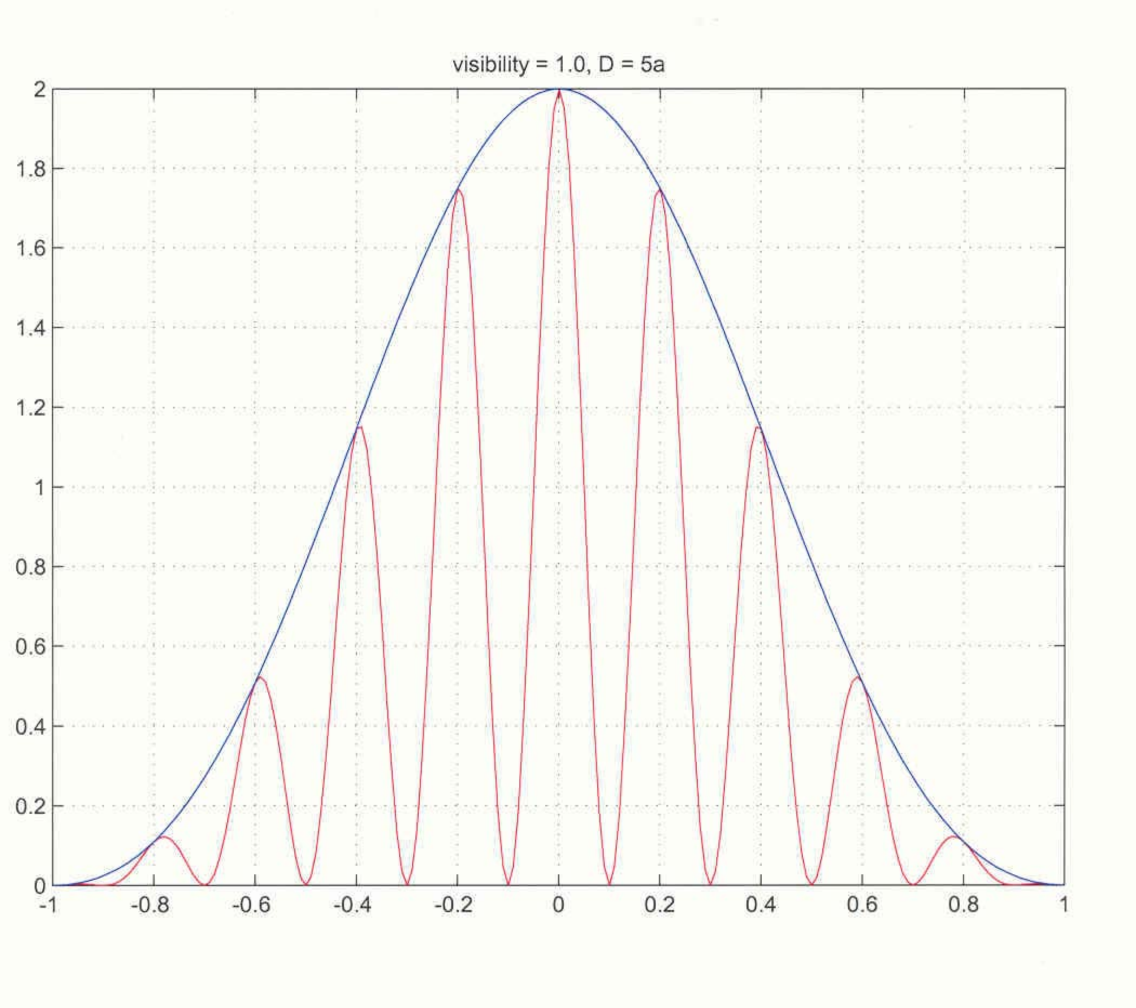
$$| SP_1 - SP_2 | \ll \lambda_0^2/\Delta\lambda$$

$\lambda_0^2/\Delta\lambda$ is the coherence length for the bandwidth $\Delta\lambda$

Behavior of the function:

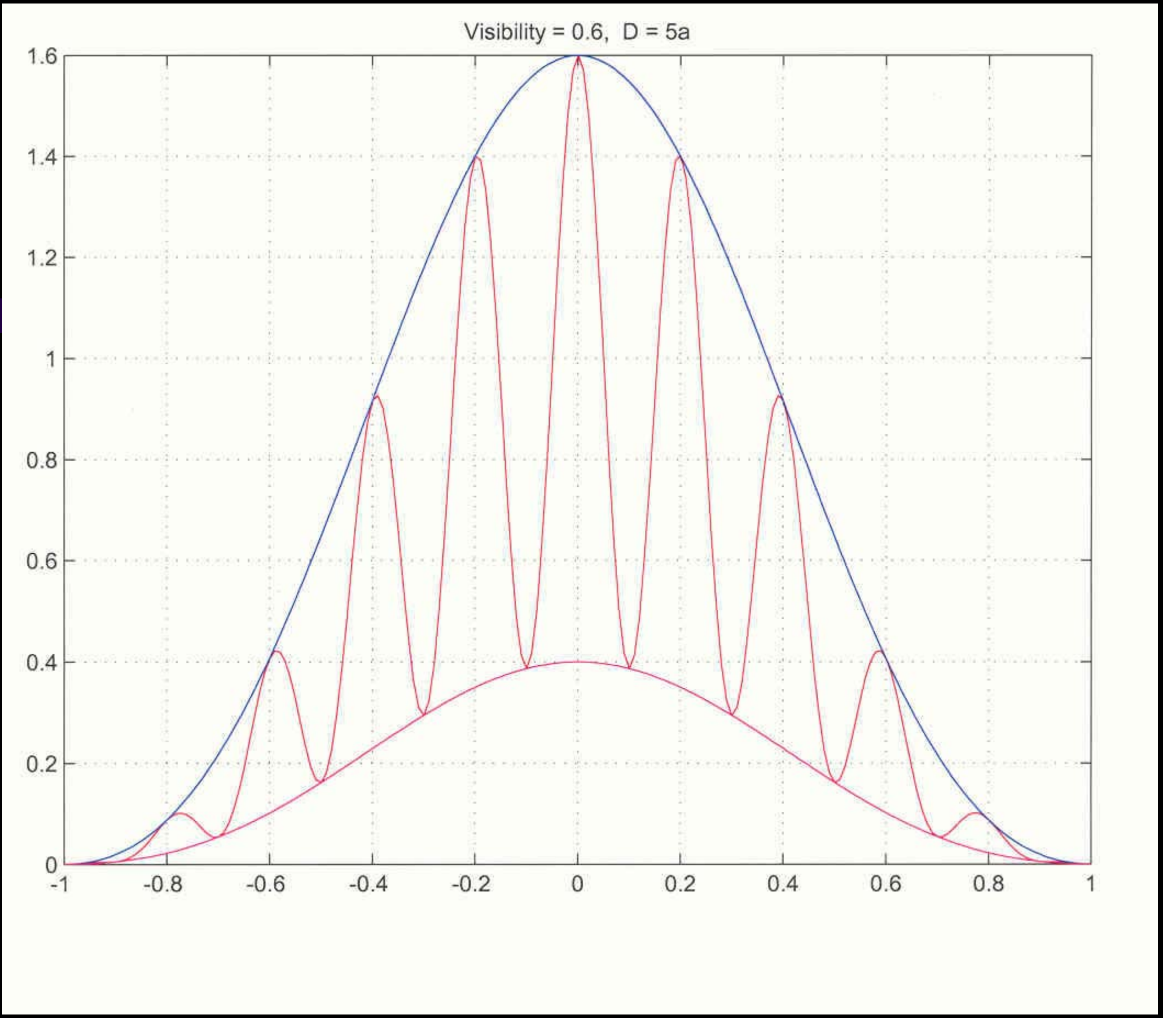
$$I(y) = \left[\frac{\sin(\alpha)}{\alpha} \right]^2 [\, 1 + V \cos(kDy/L + \varphi) \,]$$

$$\alpha = kay/(2L)$$



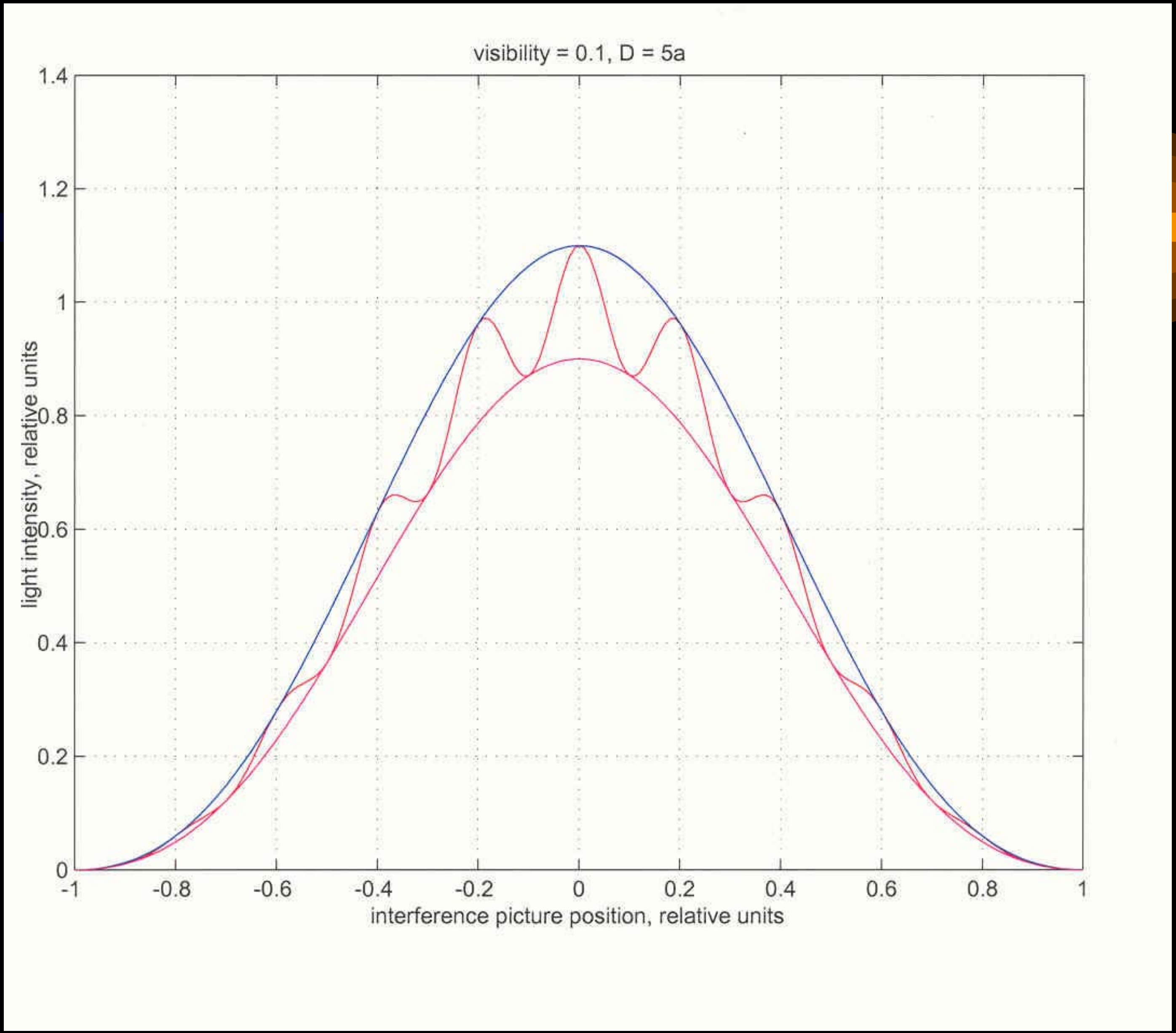
$\alpha = kay/(2L)$

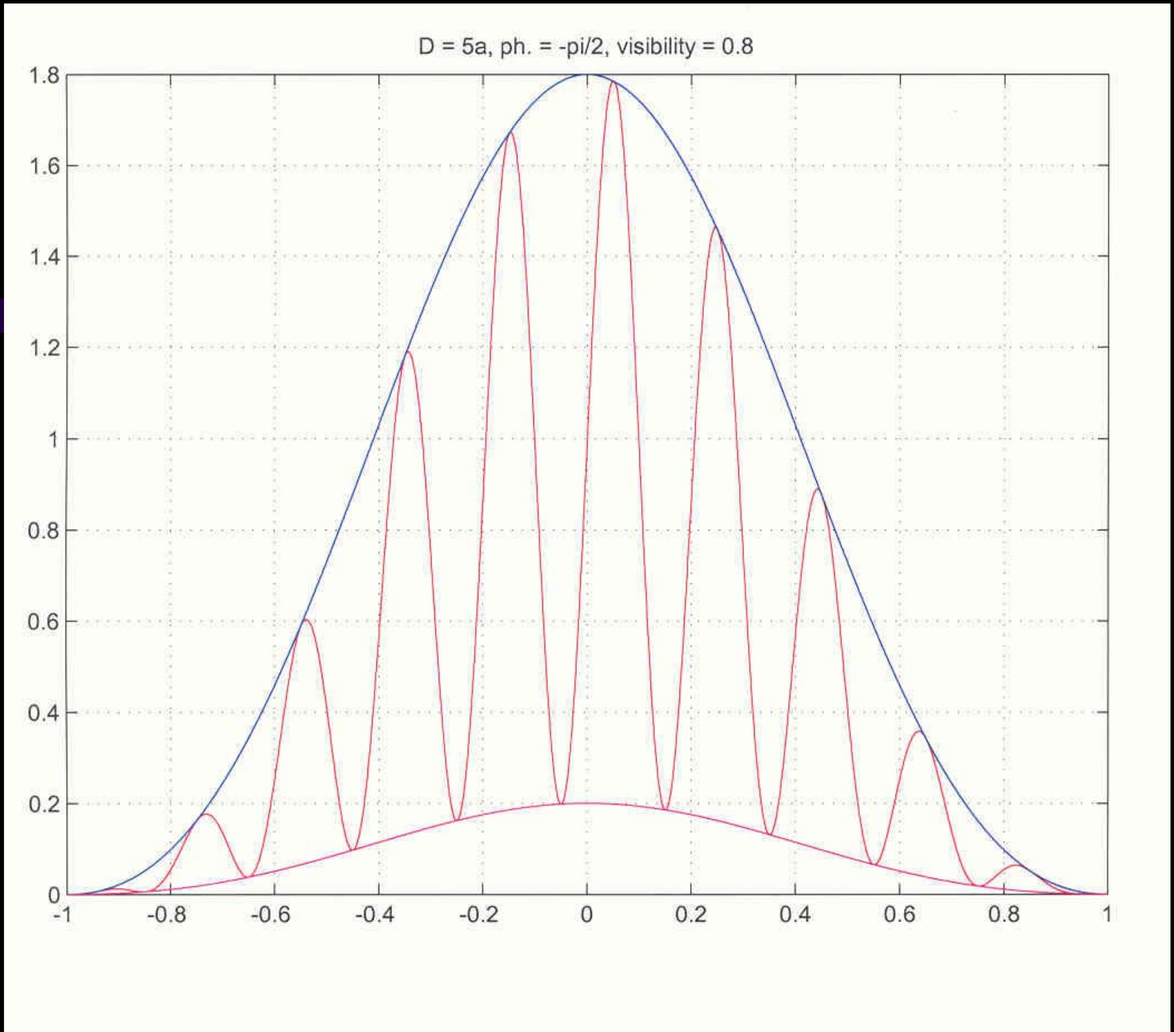
$$I(y) = \left[\frac{\sin(\alpha)}{\alpha} \right]^2 [\, 1 + V \cos(kDy/L + \varphi) \,]$$



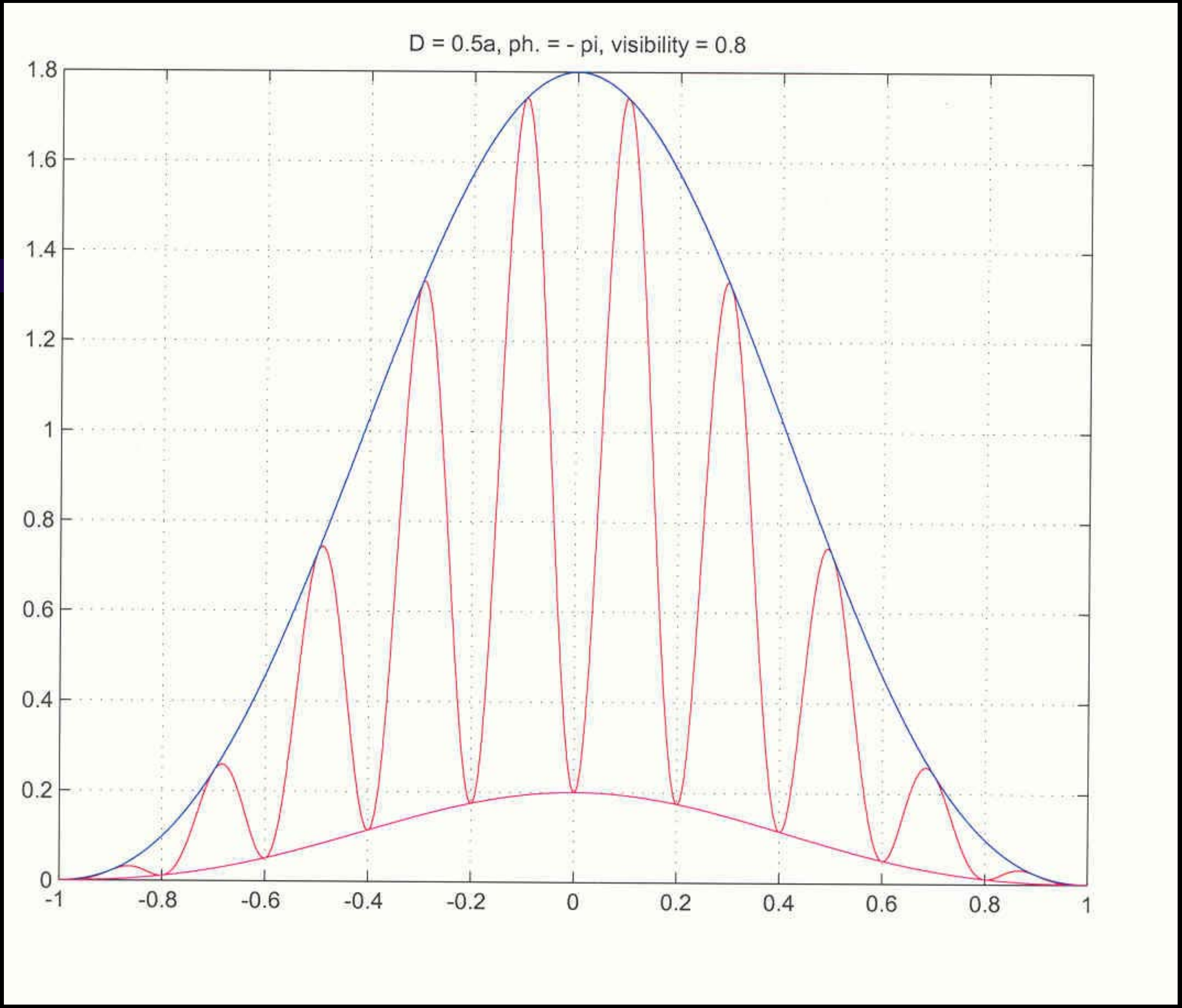
$$I(y) = \left[\frac{\sin(\alpha)}{\alpha} \right]^2 [\, 1 + V \cos(kDy/L + \varphi) \,]$$

$$Env_{1,2}(y) = \left[\frac{\sin(\alpha)}{\alpha} \right]^2 [\, 1 \pm V \,]$$


visibility = 0.1, D = 5a
light intensity, relative units
interference picture position, relative units
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1



$$I(y) = \left[\frac{\sin(\alpha)}{\alpha} \right]^2 [\, 1 + V \cos(kDy/L + \varphi) \,]$$



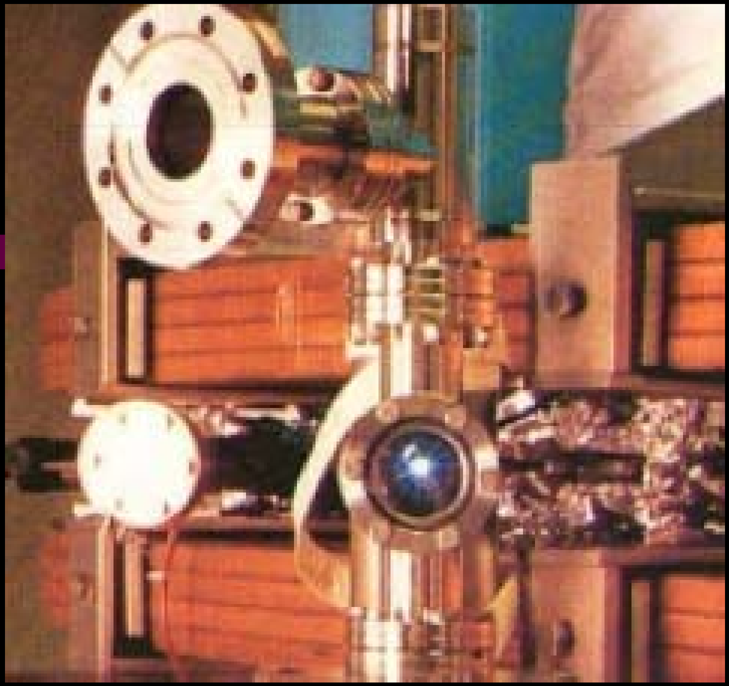
$$I(y) = \left[\frac{\sin(\alpha)}{\alpha} \right]^2 \left[1 + V \cos(kDy/L + \varphi) \right]$$

Synchrotron Radiation

History - 1940th

Theory of radiation from relativistic particles
Pomeranchuk, Ivanenko, Sokolov, Ternov (USSR)
Schwinger (USA)

Synchrotron ideas - 1945
Veksler (USSR), McMillan (USA)

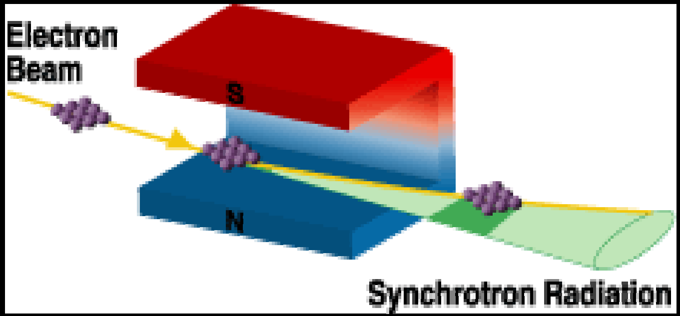


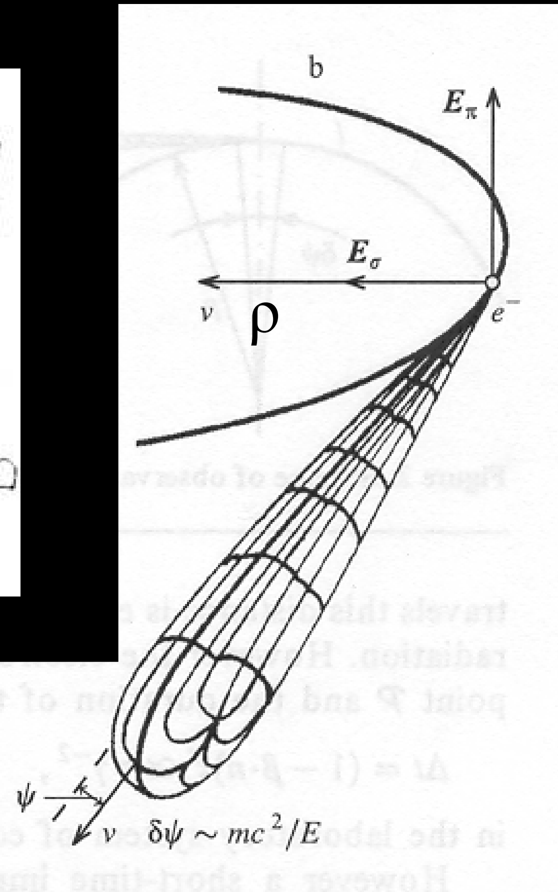
The first visual observation of synchrotron radiation was in 1947 from the General Electric synchrotron in the USA.

Synchrotron radiation (SR) is emitted from relativistic charged particles when their paths are changed.

By the magnetic field, for example.

Everywhere further we will consider only the synchrotron radiation from electrons generated in the bending magnets.





Because of the relativistic effect, the synchrotron radiation is emitted in a narrow cone in the forward direction, at a tangent to the orbit

$\psi \sim 1/\gamma$ (5 GeV electrons -> 10^{-4})

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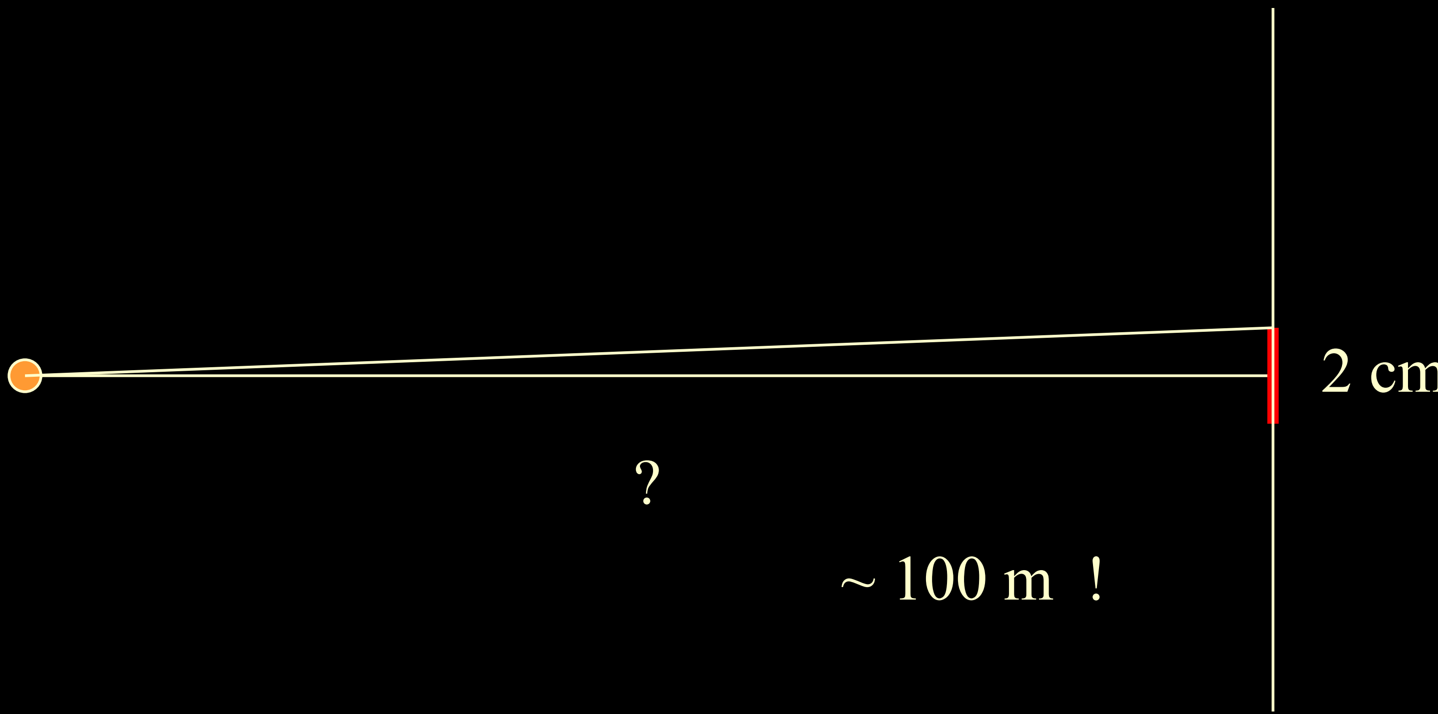
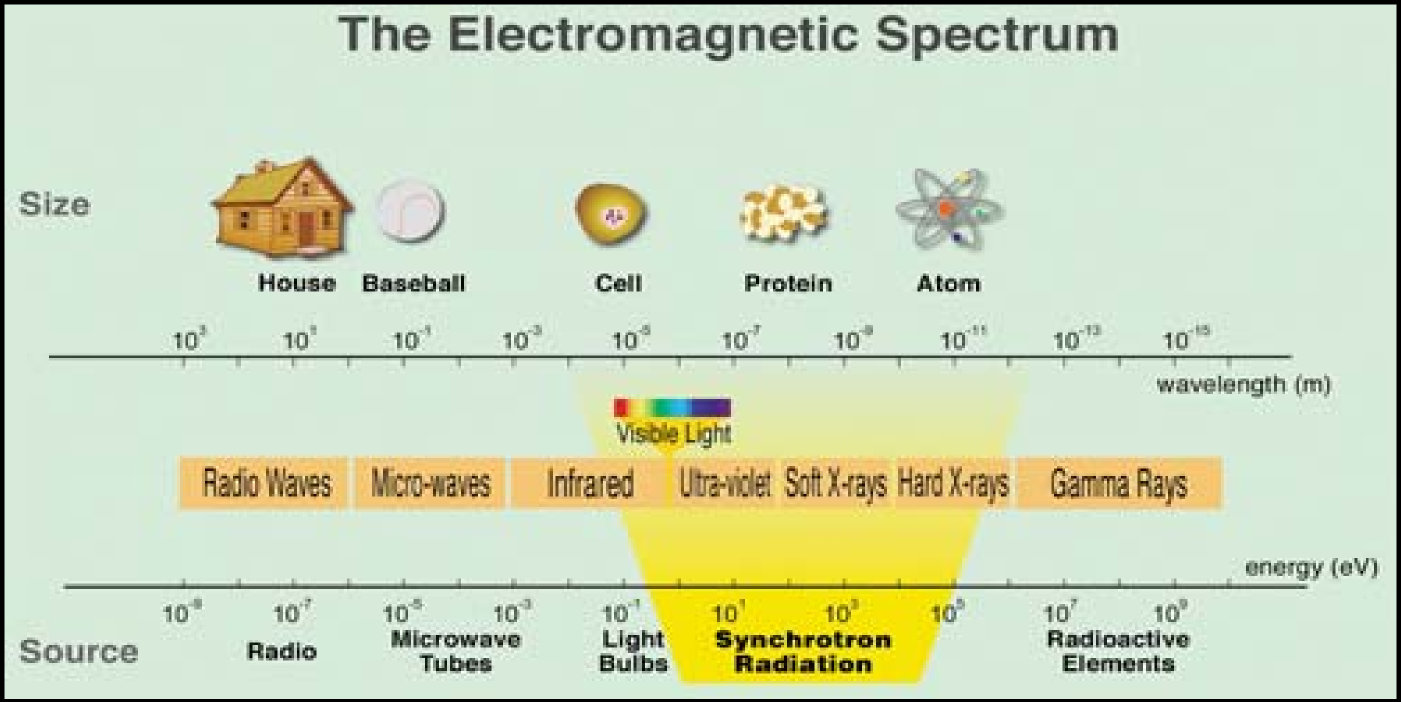
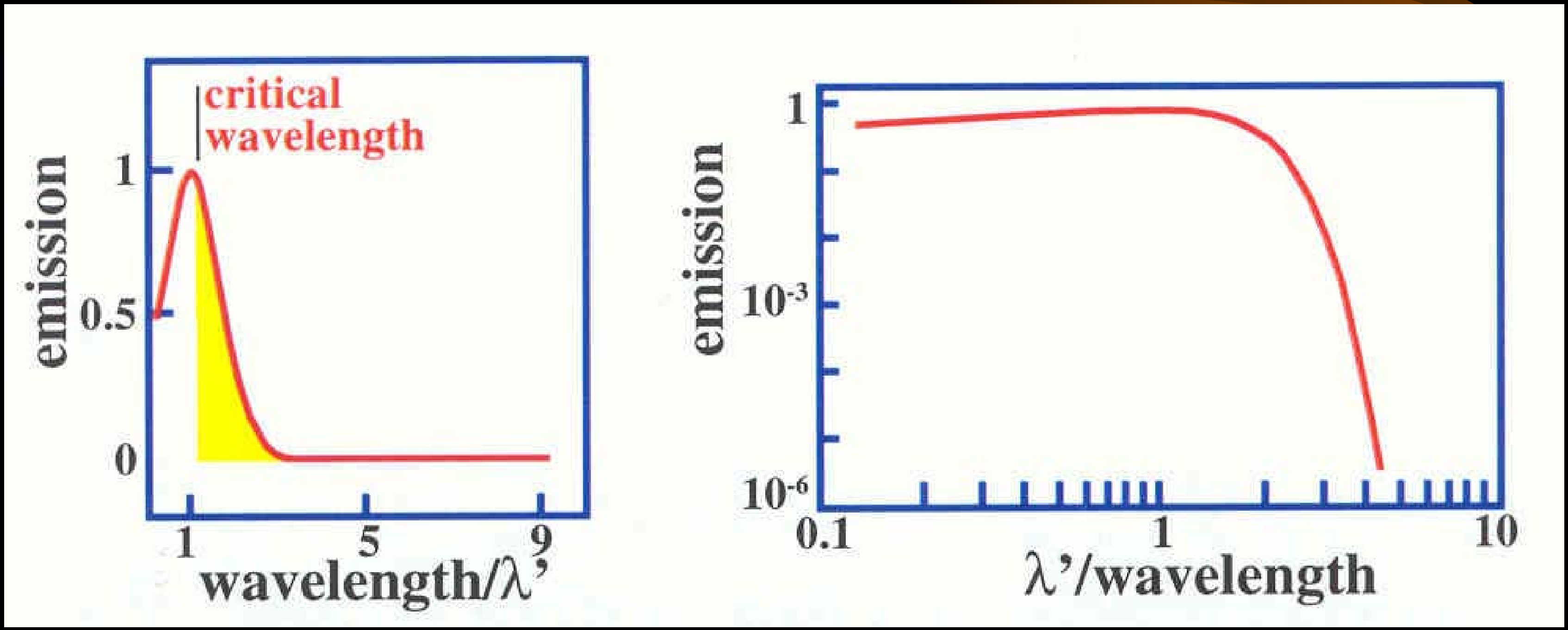


Synchrotron radiation

- extremely intense and highly collimated
- highly polarized (E_σ and E_π)
- has a wide energy spectrum (from infrared to γ-rays)



A typical energy spectrum of synchrotron radiation



The critical wavelength λ' (or λ_c) divides the radiated power into two equal parts: one-half of the power is radiated above this wavelength and one-half below.

The critical wavelength [A. Hofmann]

$$\lambda_c = \frac{4\pi\rho}{3\gamma^3}$$

Example: 5 GeV electrons, $\rho = 40$ m

$$\lambda_c = 0.16 \text{ nm}$$

At low frequencies the properties of synchrotron radiation are independent of the particle energy and depend only on the radius ρ of the curvature.

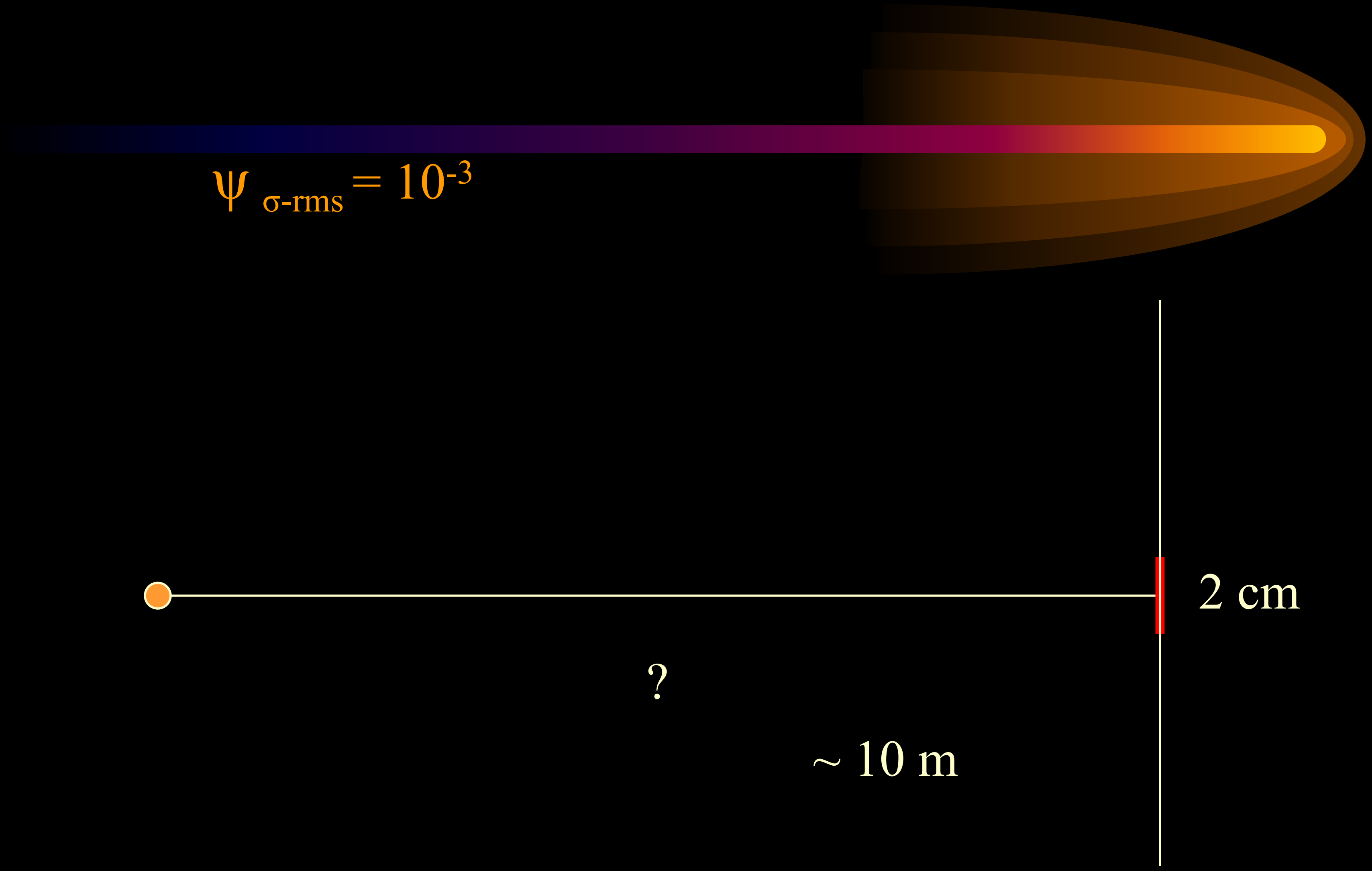
The rms opening angle for $\lambda >> \lambda_c$

$$\psi_{\sigma\text{-rms}} = 0.41 \, (\lambda / \rho)^{1/3}$$

$$\psi_{\pi\text{-rms}} = 0.55 \, (\lambda / \rho)^{1/3}$$

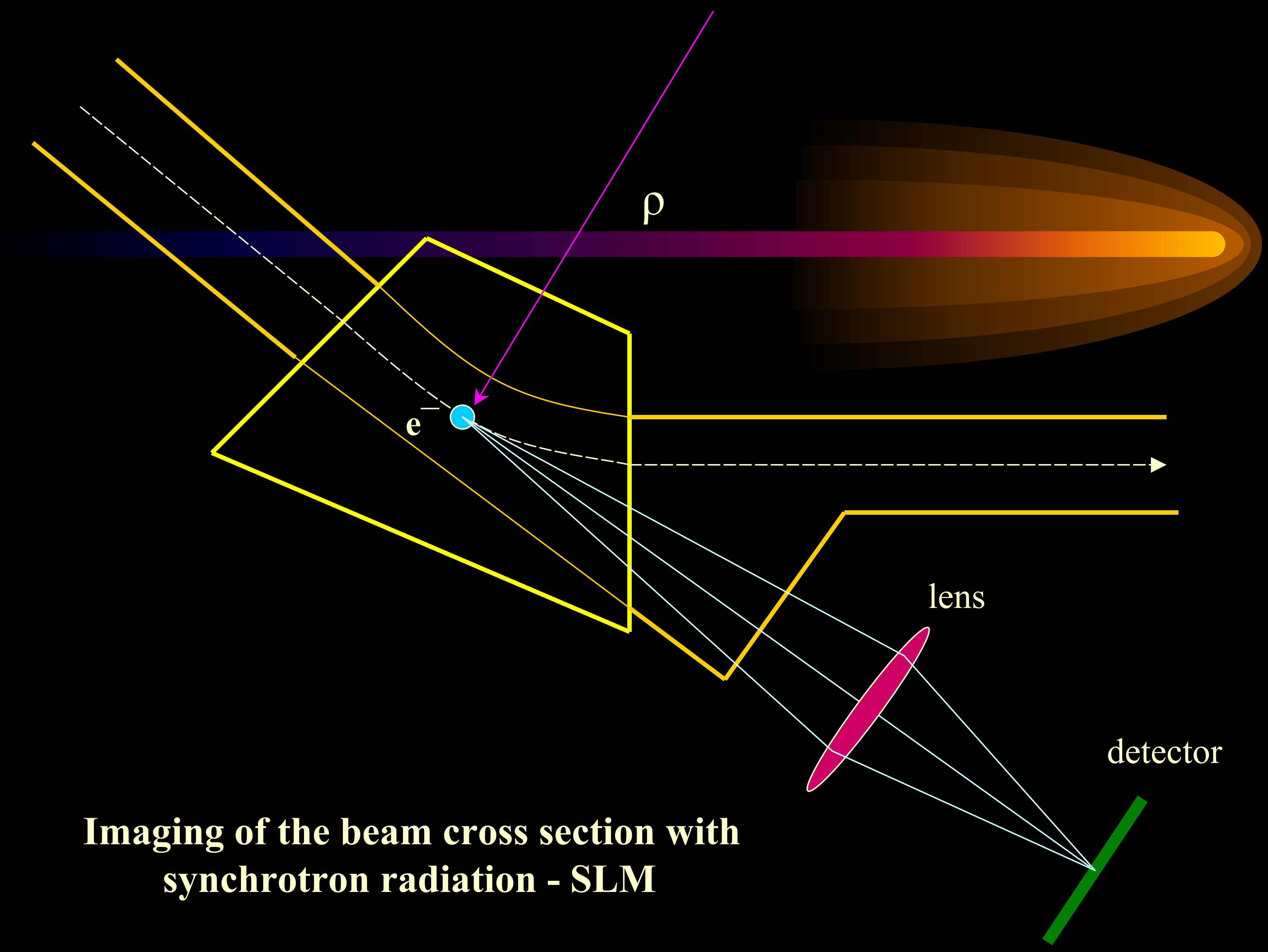
Example: $\lambda = 630$ nm, $\rho = 40$ m

$$\psi_{\sigma\text{-rms}} = 10^{-3}$$



ψ σ-rms = 10-3
2 cm
?
~ 10 m

Synchrotron Radiation Beam Diagnostics



Imaging of the beam cross section with synchrotron radiation - SLM

The natural opening angle of the emitted light sets a limit to the resolution of the SLM

The diffraction limited resolution of synchrotron light imaging systems in the visible part of the spectrum [A.Hofmann]:

$$\sigma_S \approx 0.3\ (\lambda^2\rho)^{1/3}$$

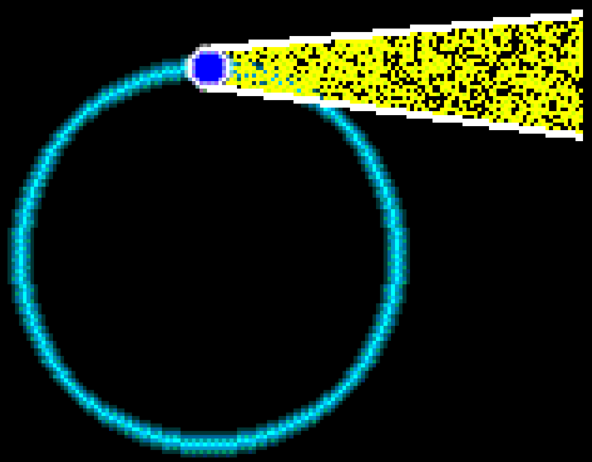
Example: $\lambda = 630$ nm, $\rho = 40$ m

$$\sigma_S \approx 0.1 \text{ mm}$$

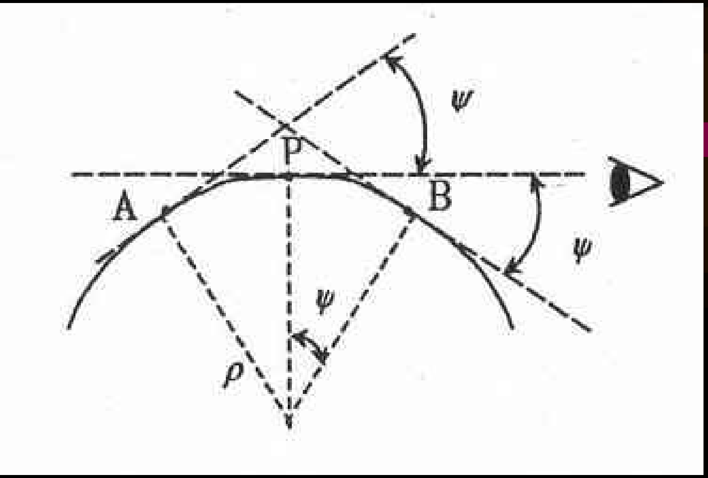
Can we build a synchrotron light interferometer and use its data to measure smaller beam sizes ?

T. Mitsuhashi, Photon Factory, KEK, Japan

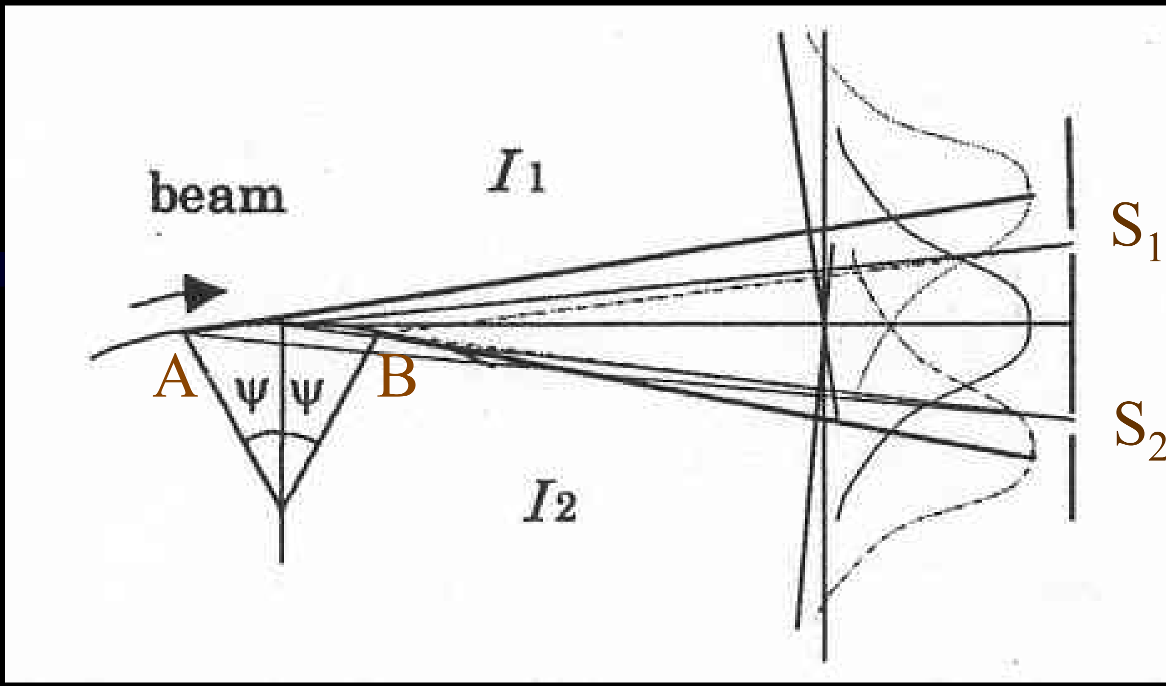
Problems



Synchrotron radiation is like a moving narrow searchlight in horizontal direction.



We observe photons coming from different positions when the electron moves from point A to point B. We must sum these photons.



When an electron is moving from point A to point B, the light is sweeping from slit S_1 to slit S_2.

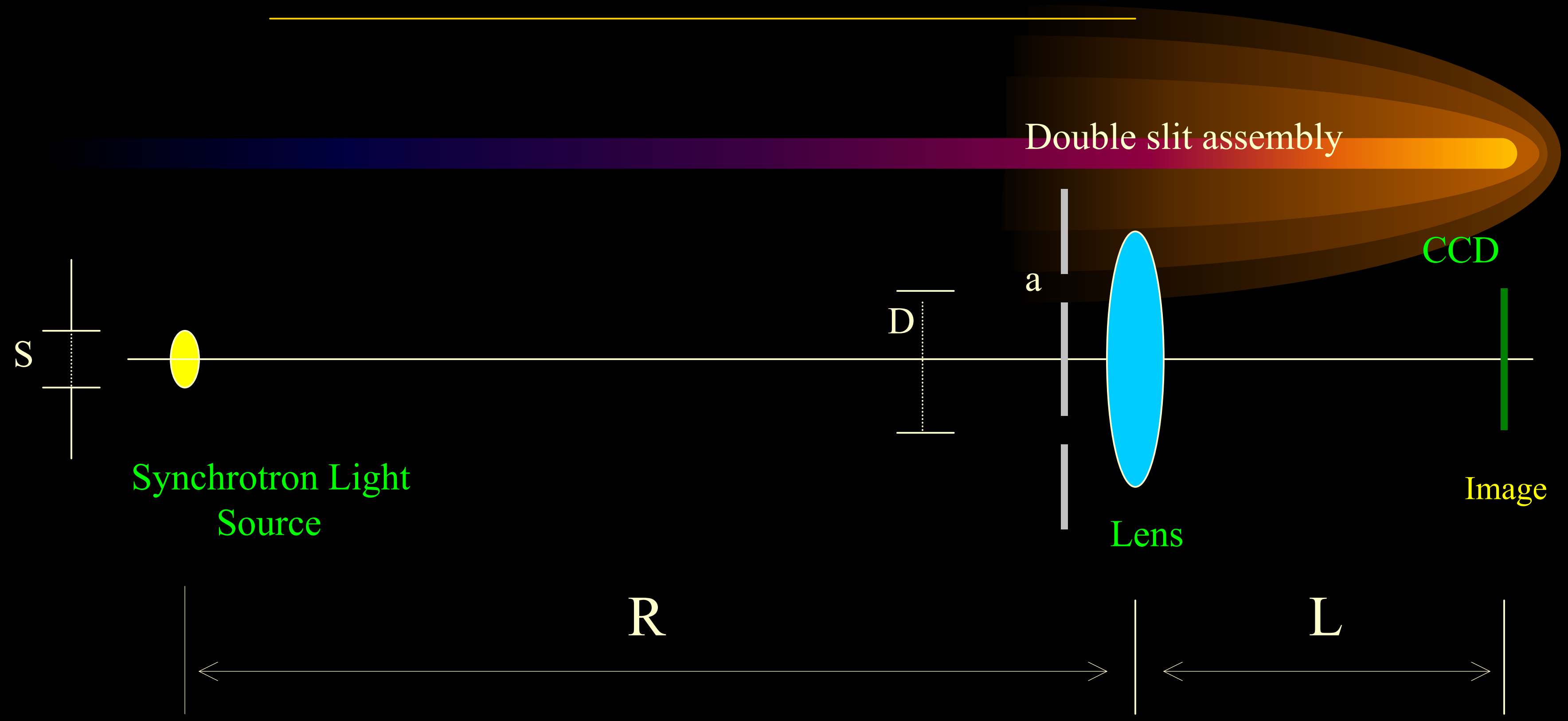
- The intensities of two modes of light illuminating the slits are different.

T. Mitsuhashi has modified the van Cittert-Zernike theorem and developed the method to calculate the beam size on the basis of the interference picture for the synchrotron light emitted by the beam.

"Beam Profile and Size Measurement by the Use of the Synchrotron Light Interferometer"

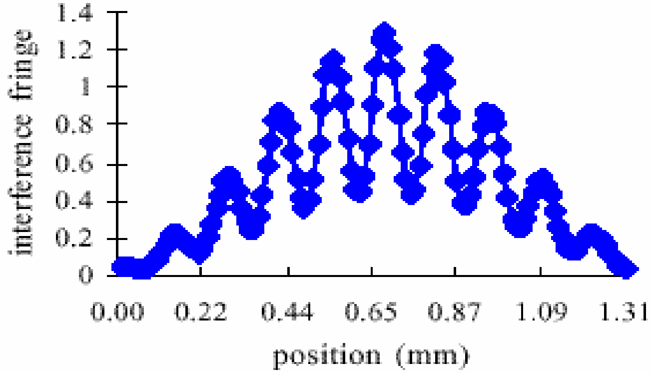
OK. Now we build our interferometer.

Synchrotron Radiation Interferometer

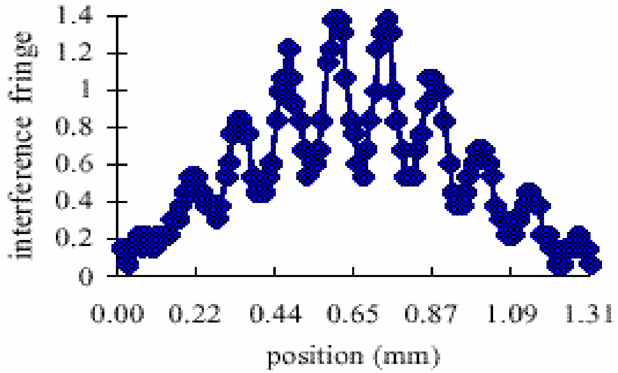


Problems

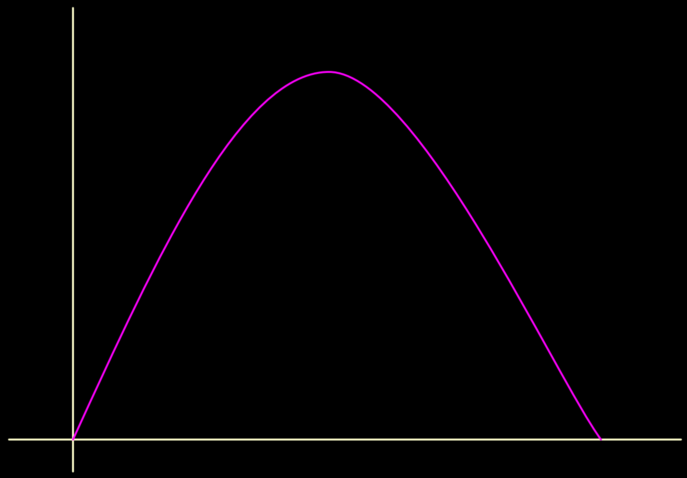
Two polarized components
of the synchrotron light
(p and s) are "in anti-phase".
Their superposition will not give
us the interference fringes at all.
-> We get just a sort of a "SLM".



a) interferogram by s -polarized components.



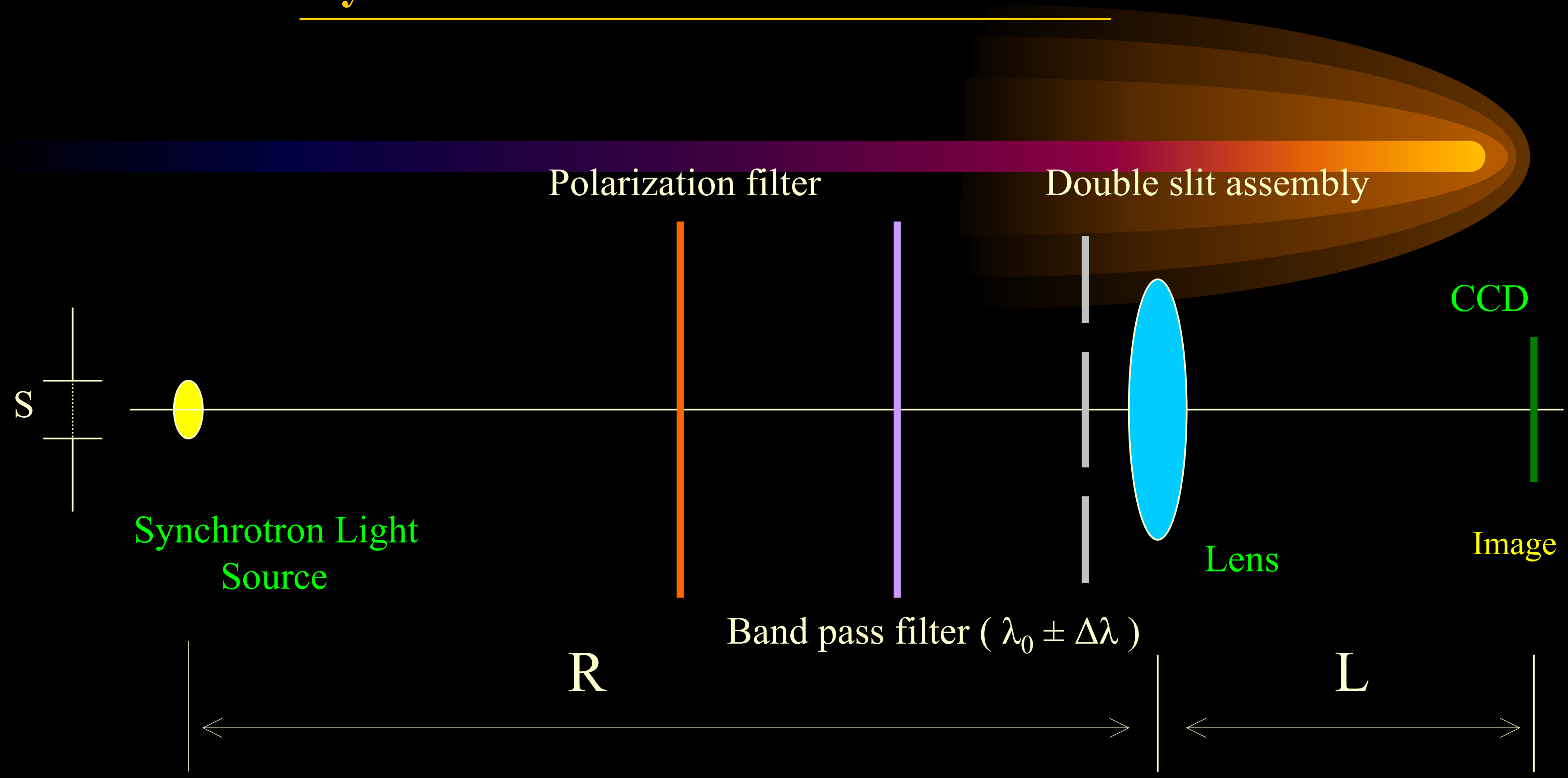
b) interferogram by p-polarized components.

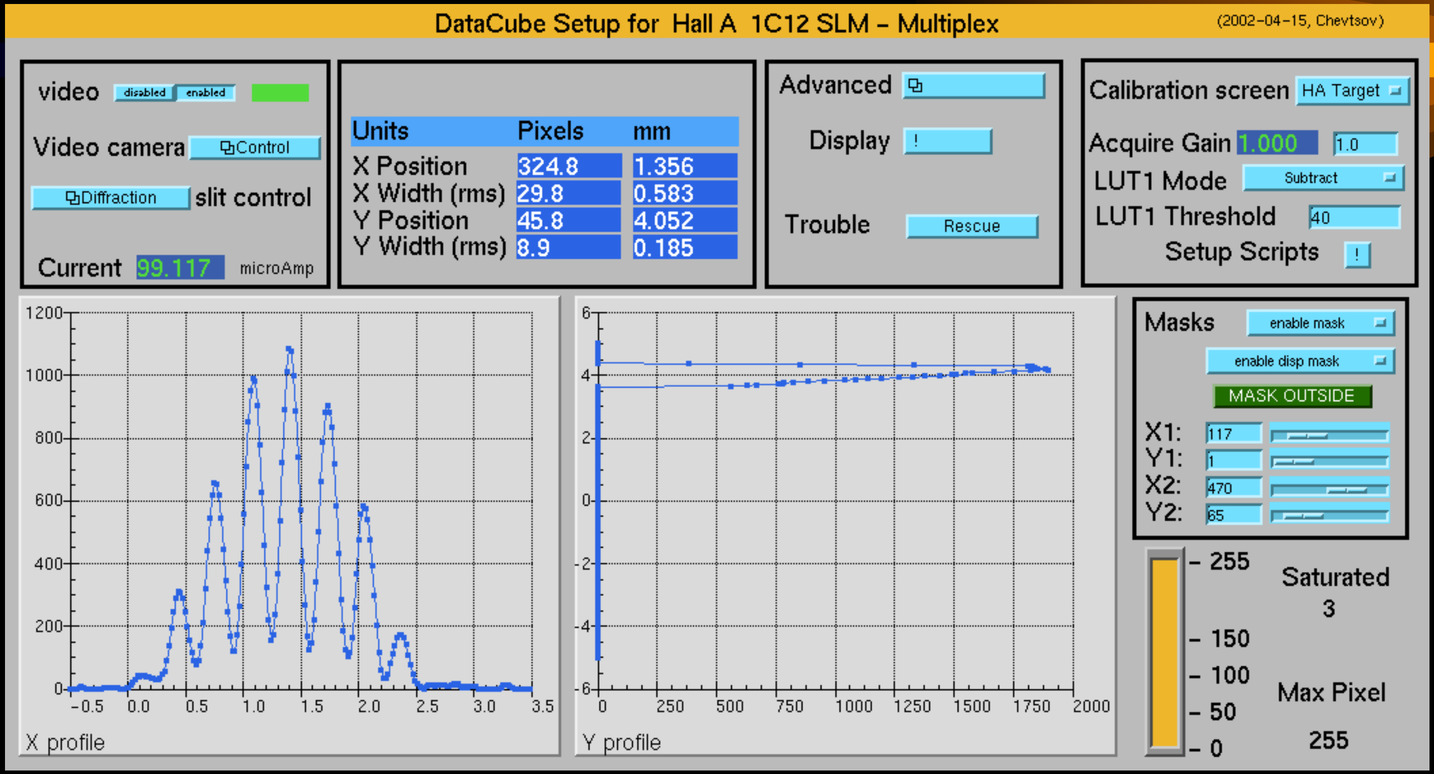


The synchrotron light is not monochromatic.

λ range is the whole visible spectrum !

Synchrotron Radiation Interferometer




DataCube Setup for Hall A 1C12 SLM – Multiplex
(2002-04-15, Chevtsov)
video disabled enabled
Video camera Control
Diffraction slit control
Current 99.117 microAmp
Units Pixels mm
X Position 324.8 1.356
X Width (rms) 29.8 0.583
Y Position 45.8 4.052
Y Width (rms) 8.9 0.185
Advanced
Display
Trouble Rescue
Calibration screen HA Target
Acquire Gain 1.000 1.0
LUT1 Mode Subtract
LUT1 Threshold 40
Setup Scripts
Masks enable mask
enable disp mask
MASK OUTSIDE
X1: 117
Y1: 1
X2: 470
Y2: 65
X profile
Y profile
255 150 100 50 0
Saturated 3
Max Pixel 255

Beam Size Calculation

In case of a gaussian beam shape it is easy:

$$\Gamma(\theta) = \int I(\xi) \exp\{ -i\, 2\pi\, \theta\, \xi\}\, d\,\xi \qquad \Gamma = \frac{\Gamma(\theta)}{\Gamma(0)}$$

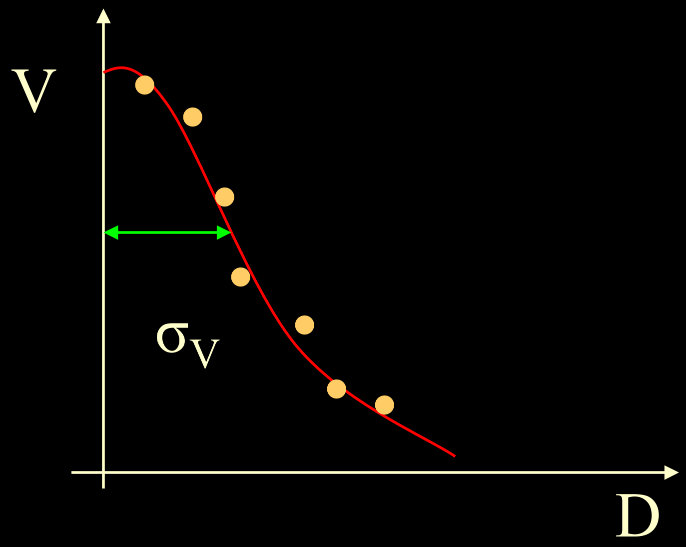
$$I(y) = I_0 \left[\frac{\sin(\alpha)}{\alpha}\right]^2 [\, 1 + V \cos(kDy/L + \varphi)\,] \qquad \alpha = kay/2L$$

$$V = \exp\left(- \frac{2\pi^2 D^2 \sigma^2{}_{beam}}{\lambda^2\ R^2}\right) = V(D)$$

Methods to calculate the beam size

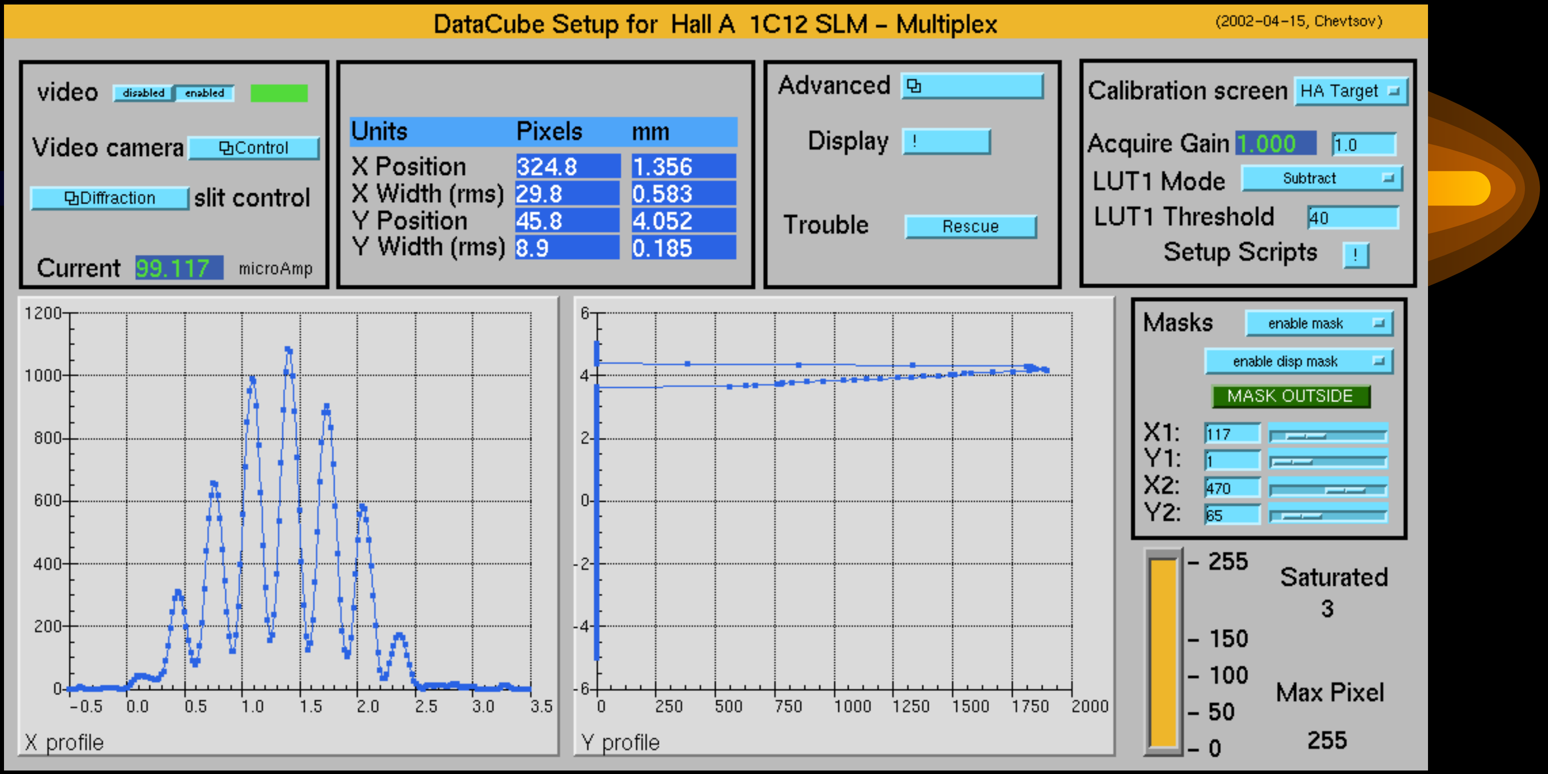
1. We measure (experimentally) the contrast of the interferogram as a function of the slit separation D. Then we define the RMS of the visibility curve σ_V .

$$\sigma_{beam} = \frac{\lambda R}{2 \pi \sigma_V}$$



2. We can also measure the RMS beam size from one data of visibility which is measured at a fixed separation of a double slit assembly

$$\sigma_{beam} = \frac{\lambda R}{\pi D}\sqrt{0.5 \ln(1/V)}$$



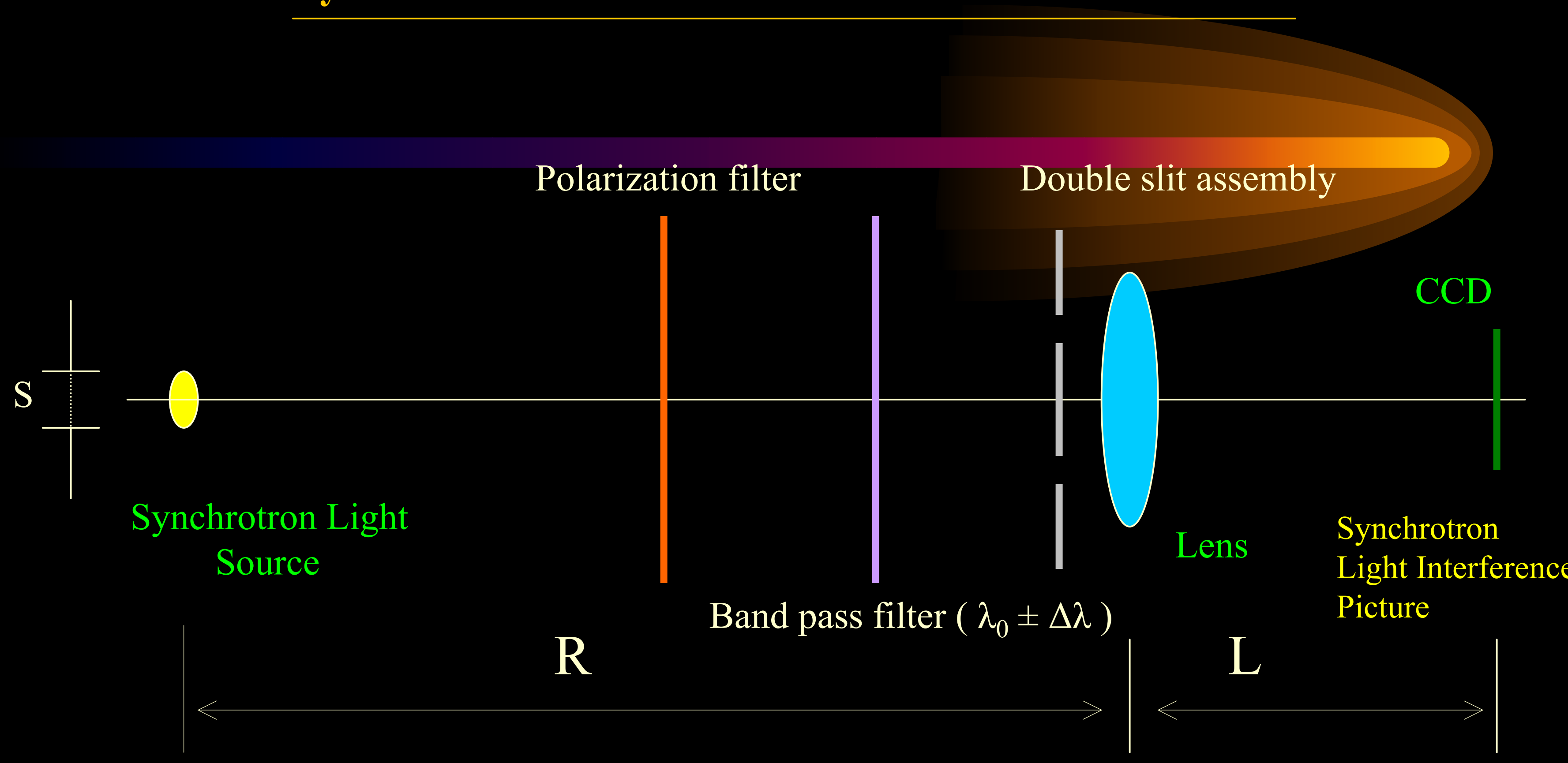
$V = 0.8$

$\sigma_S = 0.12$ mm

Synchrotron Light Interferometer at Jefferson Lab

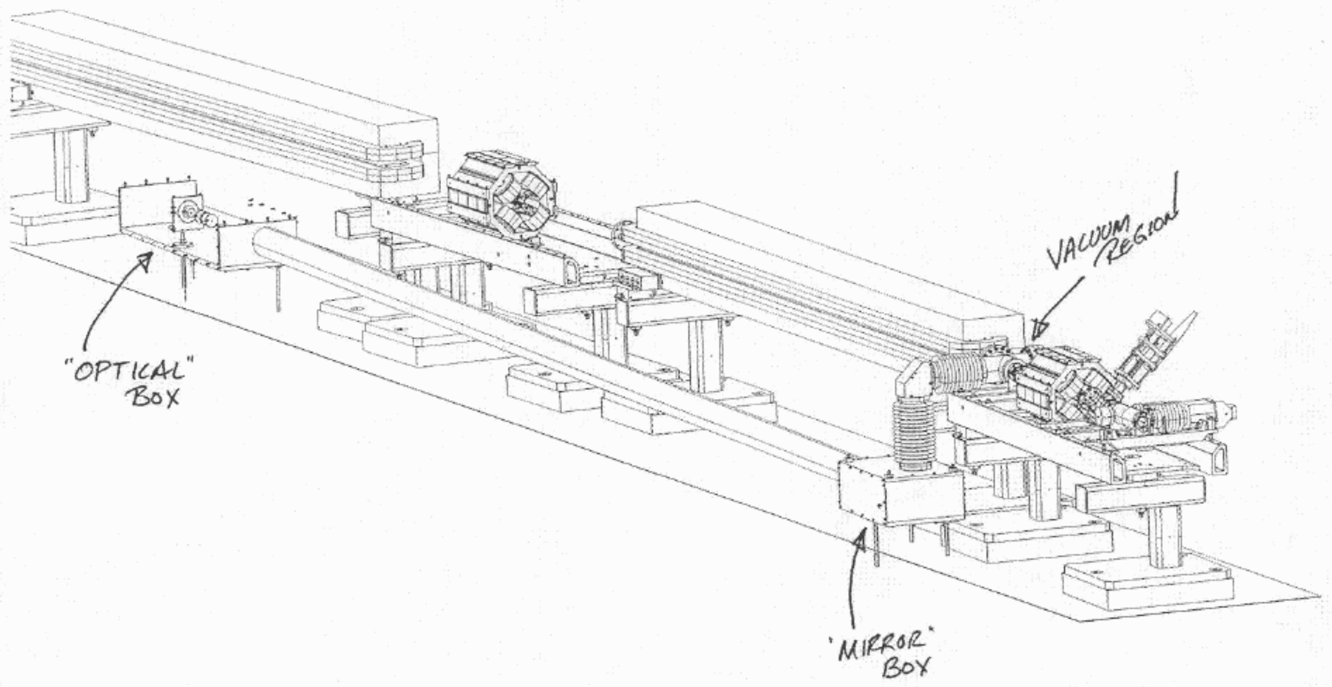
Main Components

Synchrotron Radiation Interferometer at Jefferson Lab

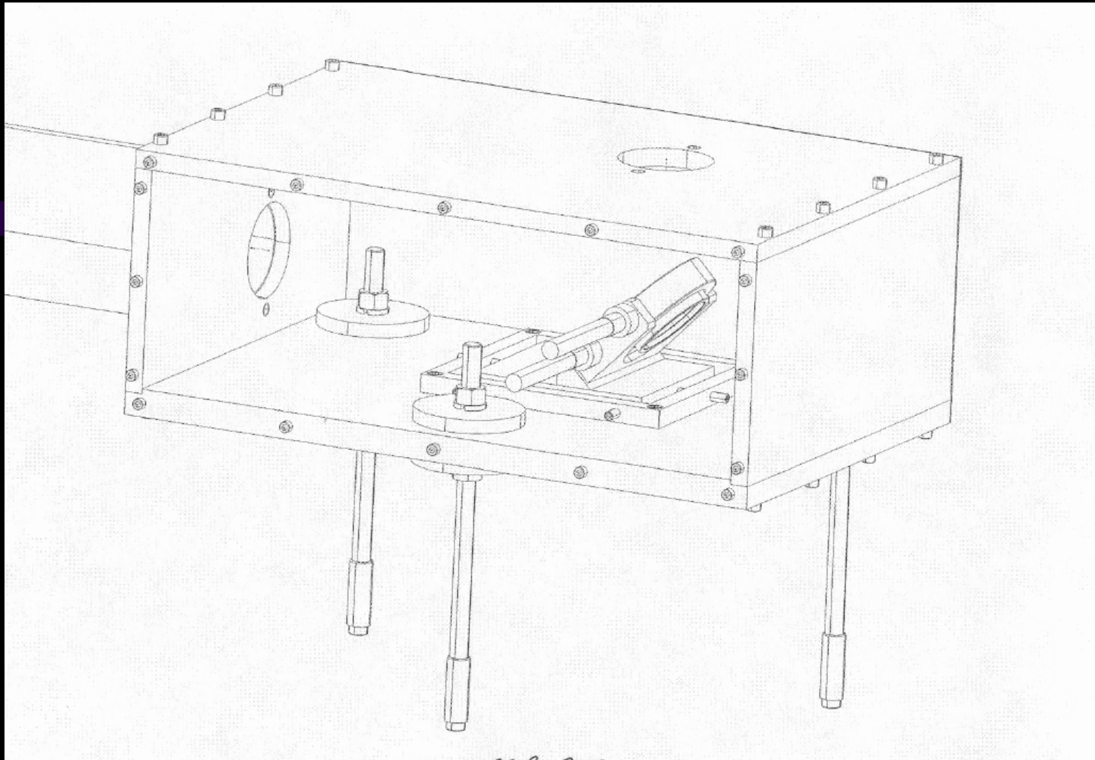


$R = 9.18$ m $L = 1.12$ m $\lambda_0 = 630$ nm $\rho = 40$ m

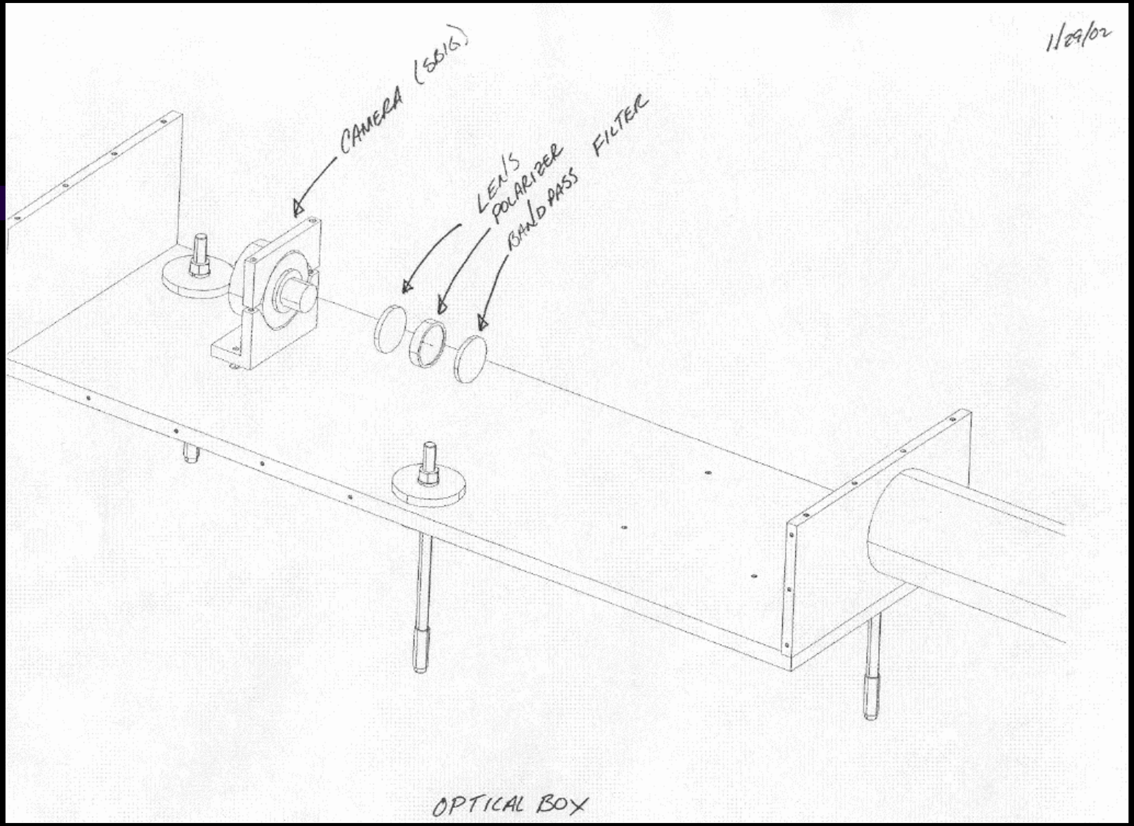

1C12



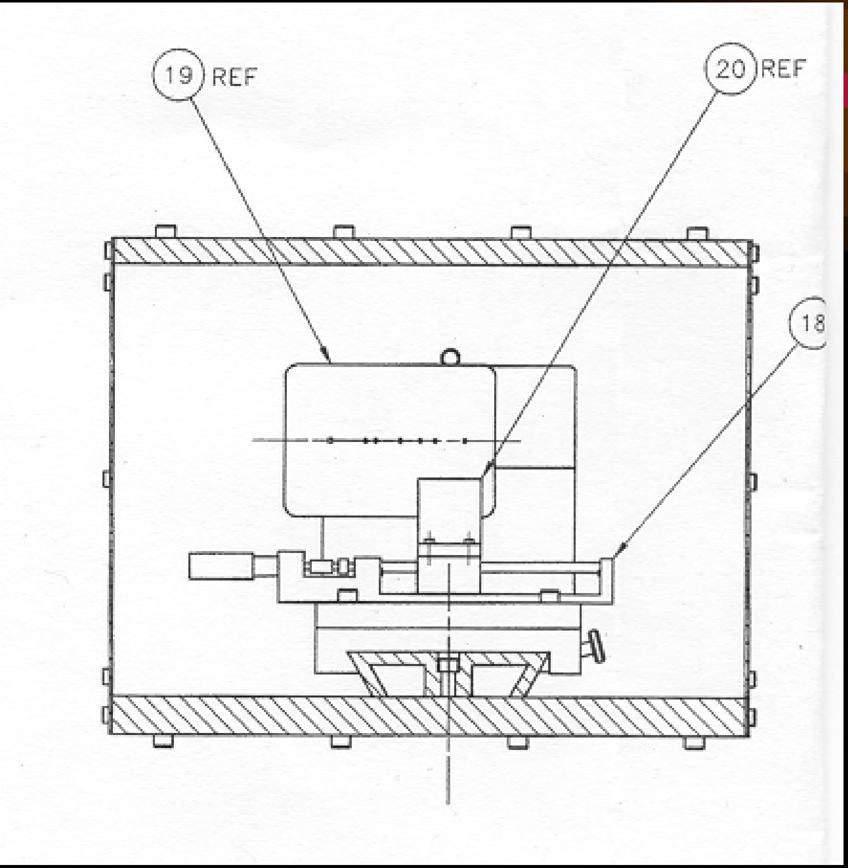
HIGH RESOLUTION SLM
@1C12



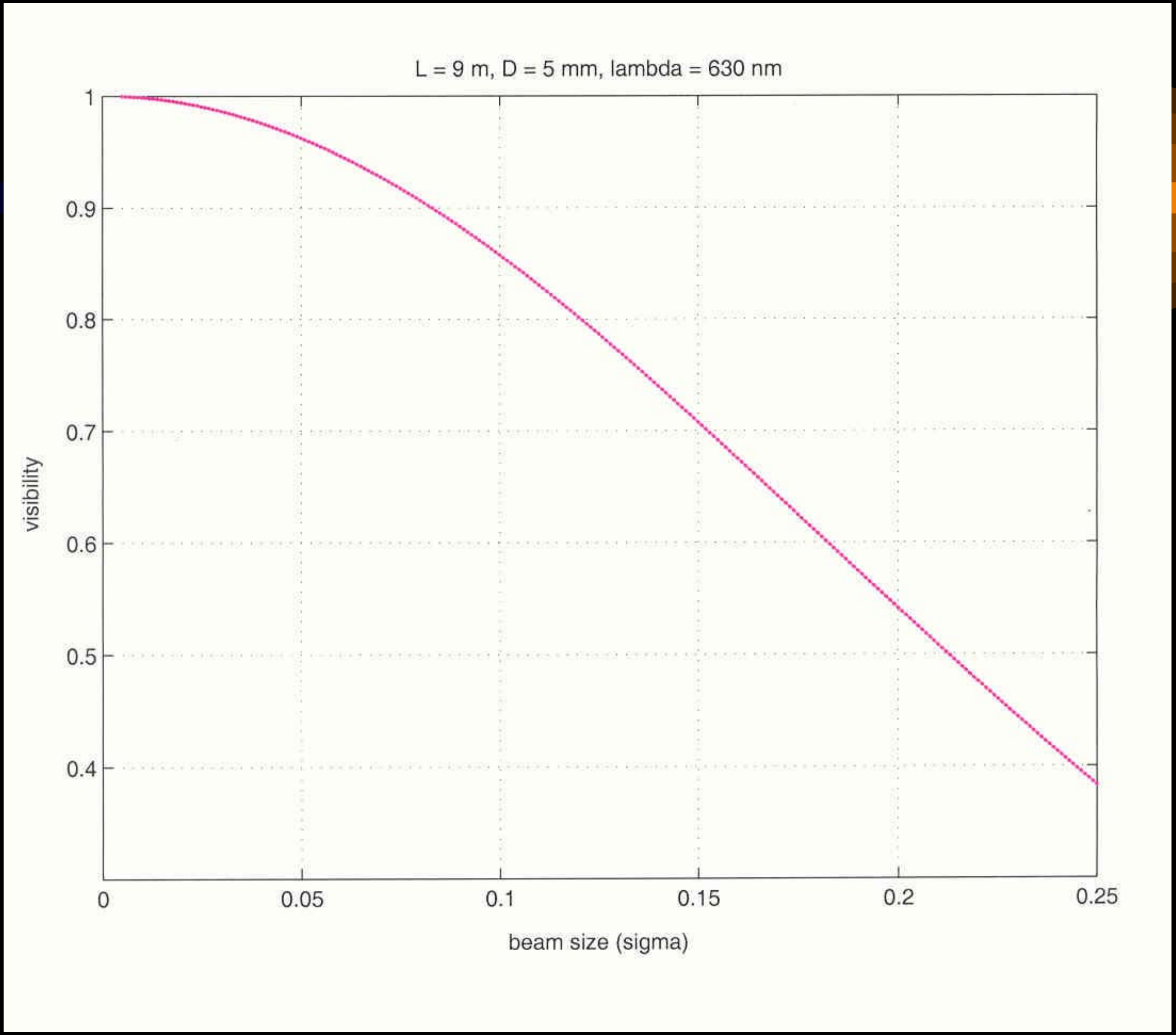
MIRROR BOX

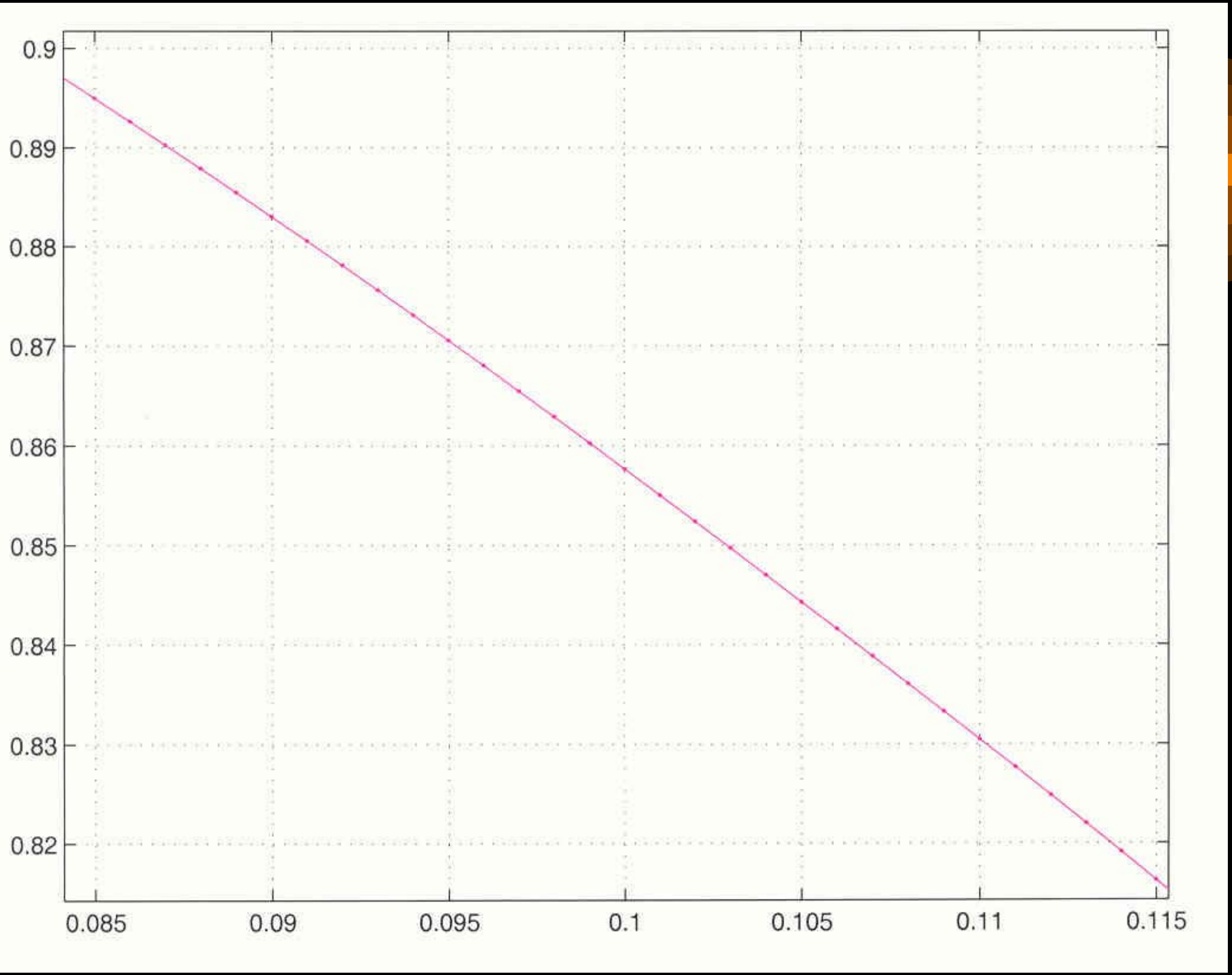


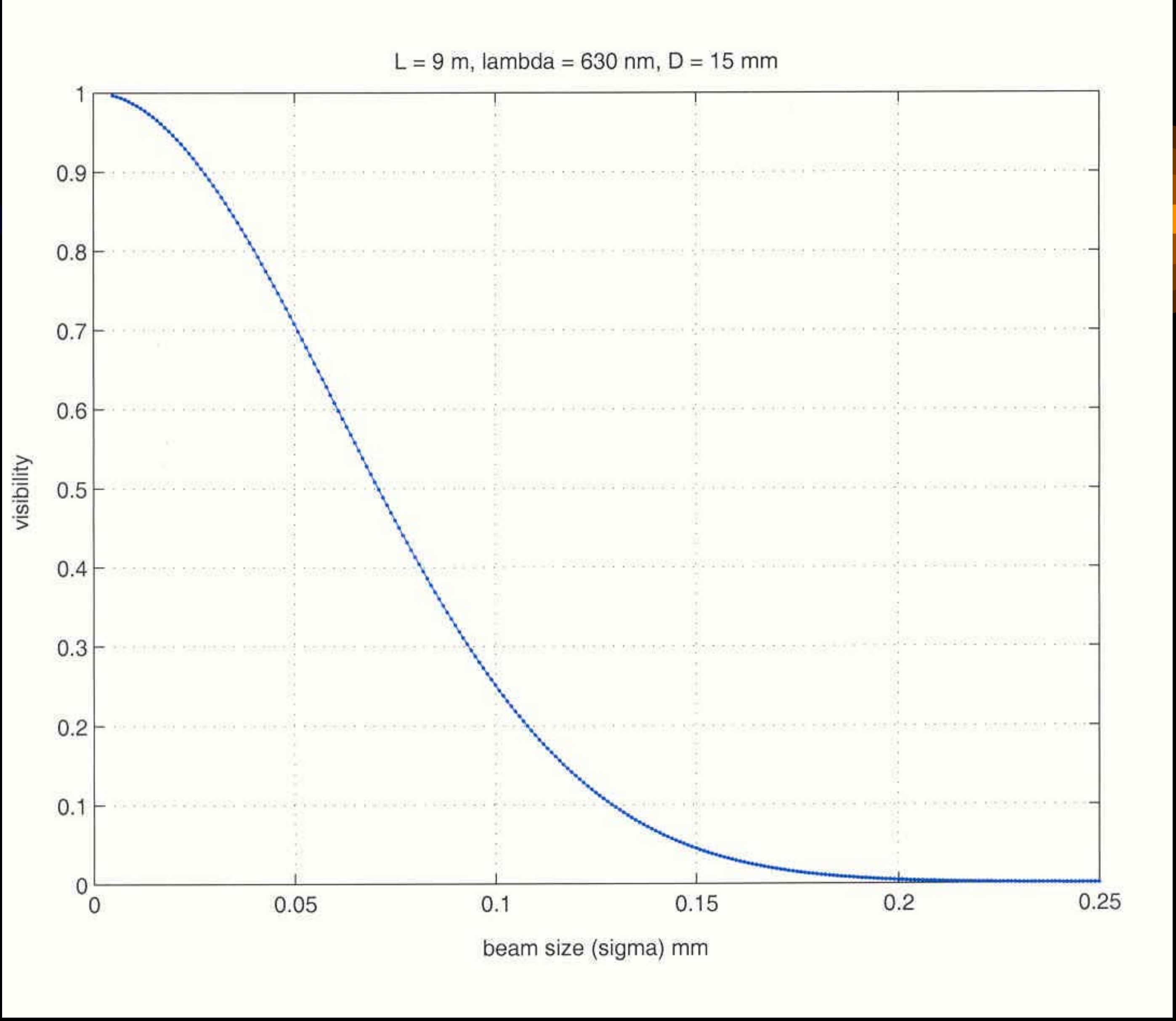
1/29/02
CAMERA (SBIG)
LENS
POLARIZER
BAND PASS FILTER
OPTICAL BOX


19 REF
20 REF
18

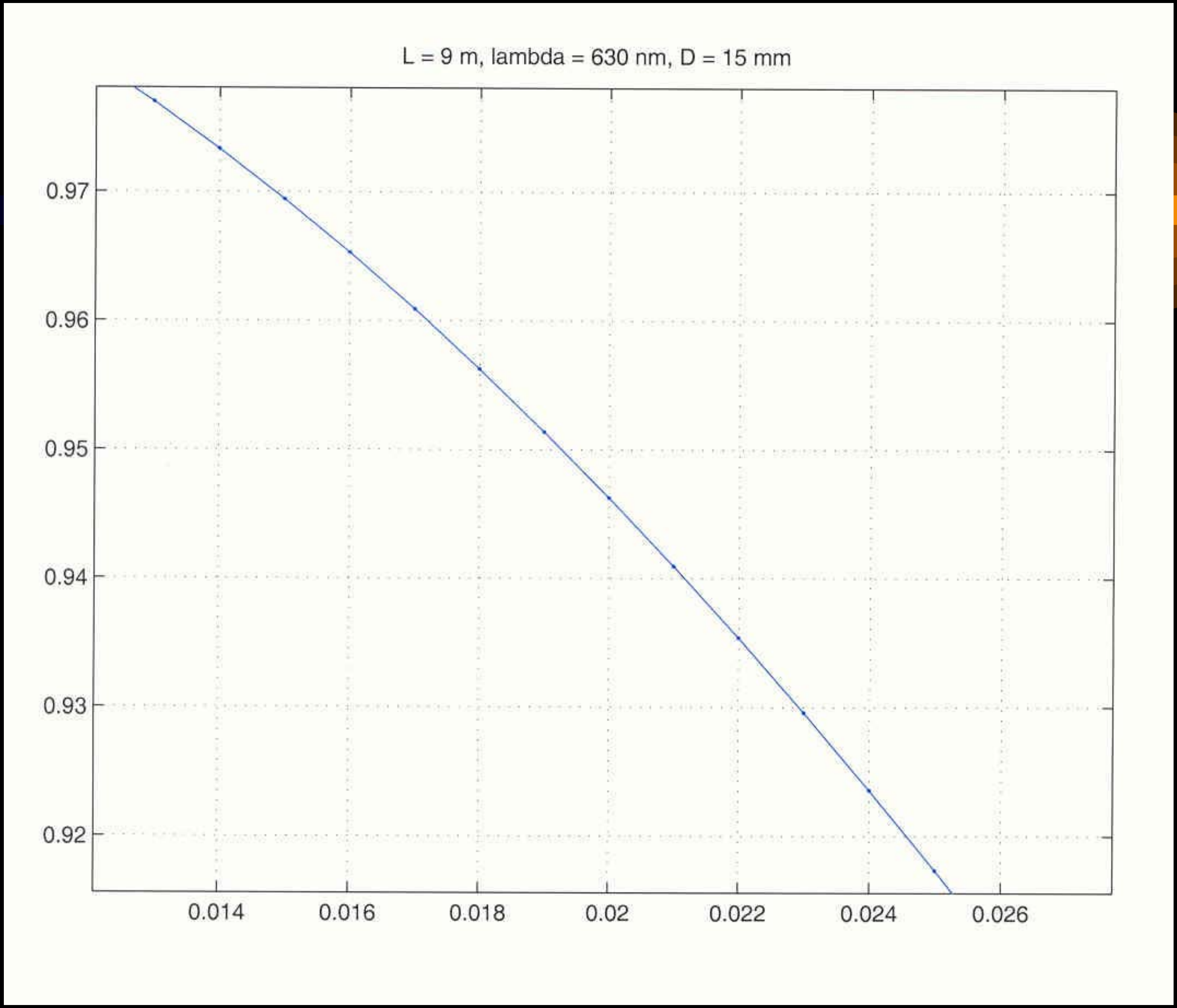
Resolution of our synchrotron light interferometer


L = 9 m, D = 5 mm, lambda = 630 nm
visibility
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.05
0.1
0.15
0.2
0.25
beam size (sigma)


0.9
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.085
0.09
0.095
0.1
0.105
0.11
0.115

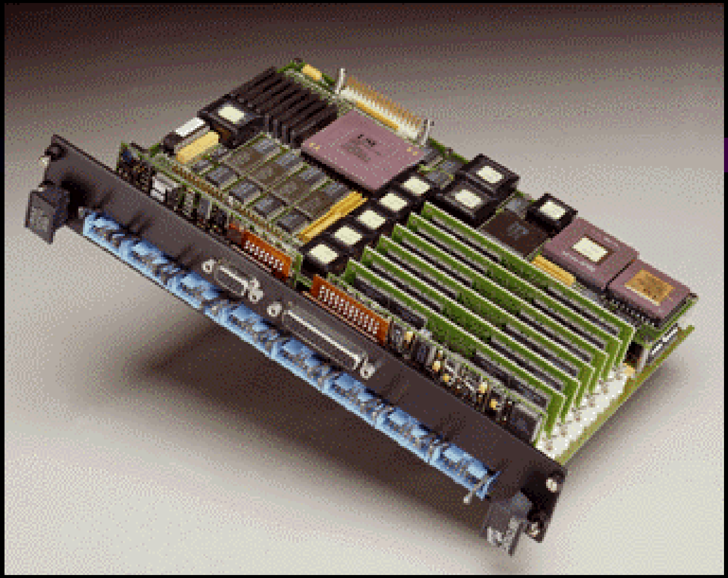


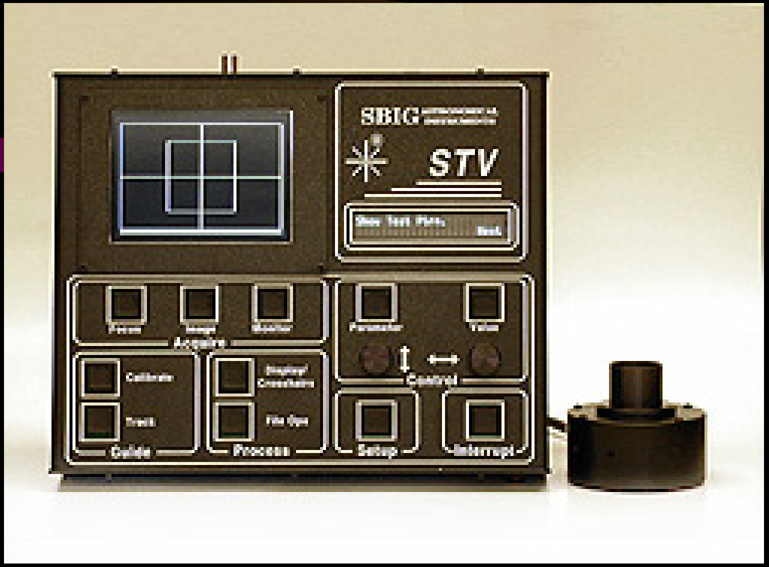
L = 9 m, lambda = 630 nm, D = 15 mm
visibility
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.05
0.1
0.15
0.2
0.25
beam size (sigma) mm

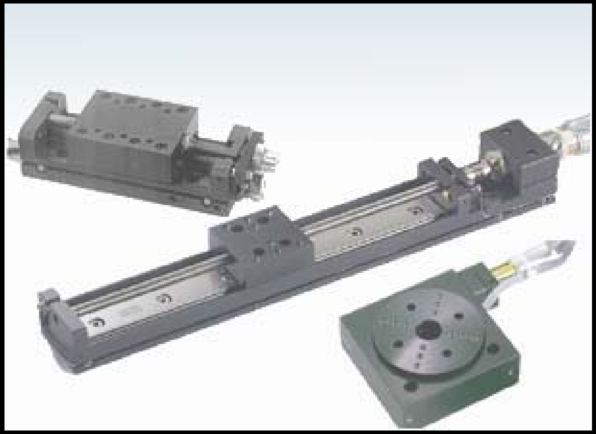

L = 9 m, lambda = 630 nm, D = 15 mm
0.97
0.96
0.95
0.94
0.93
0.92
0.014
0.016
0.018
0.02
0.022
0.024
0.026

Our Synchrotron Light Interferometer

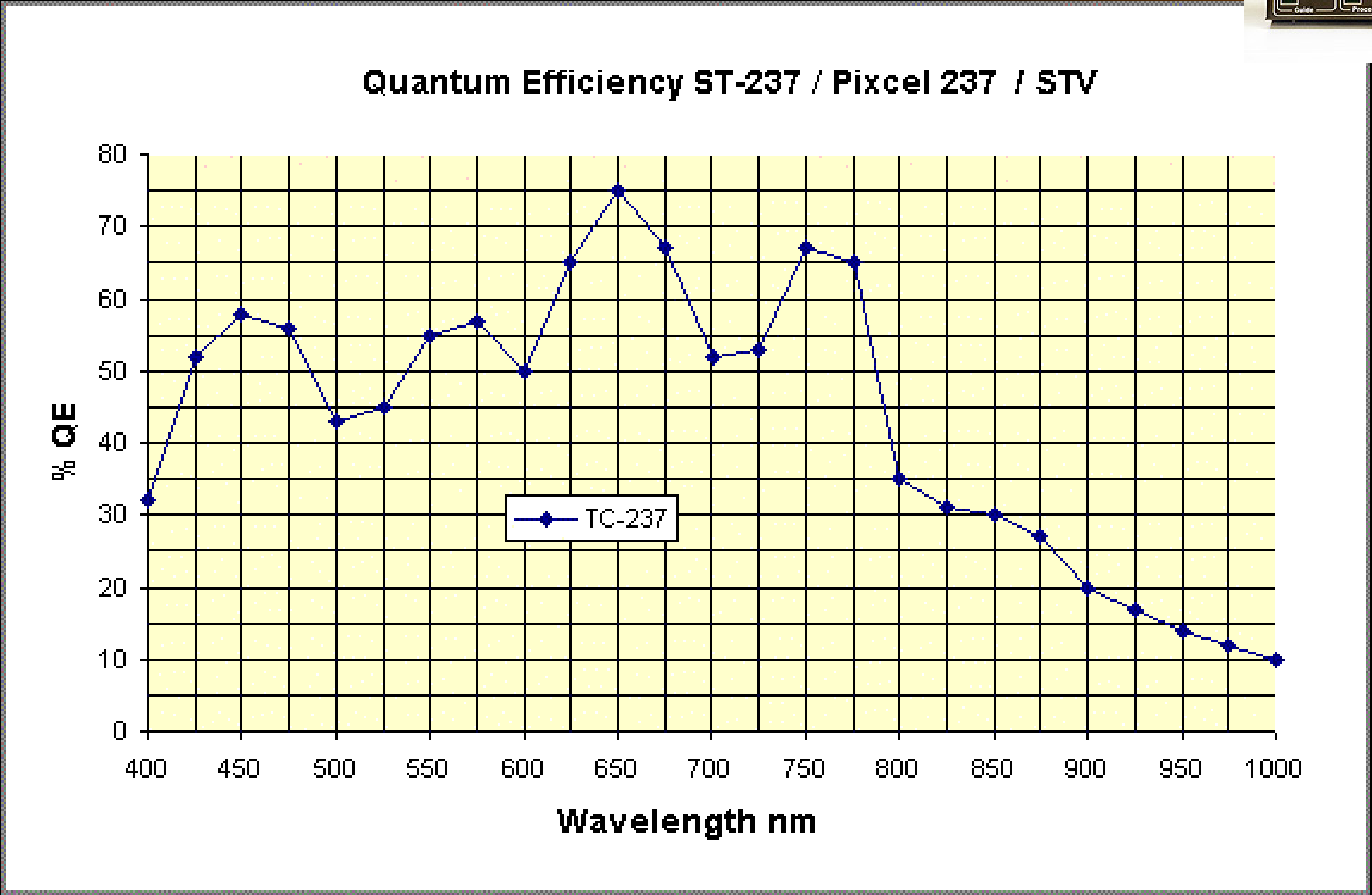
Main Control Components



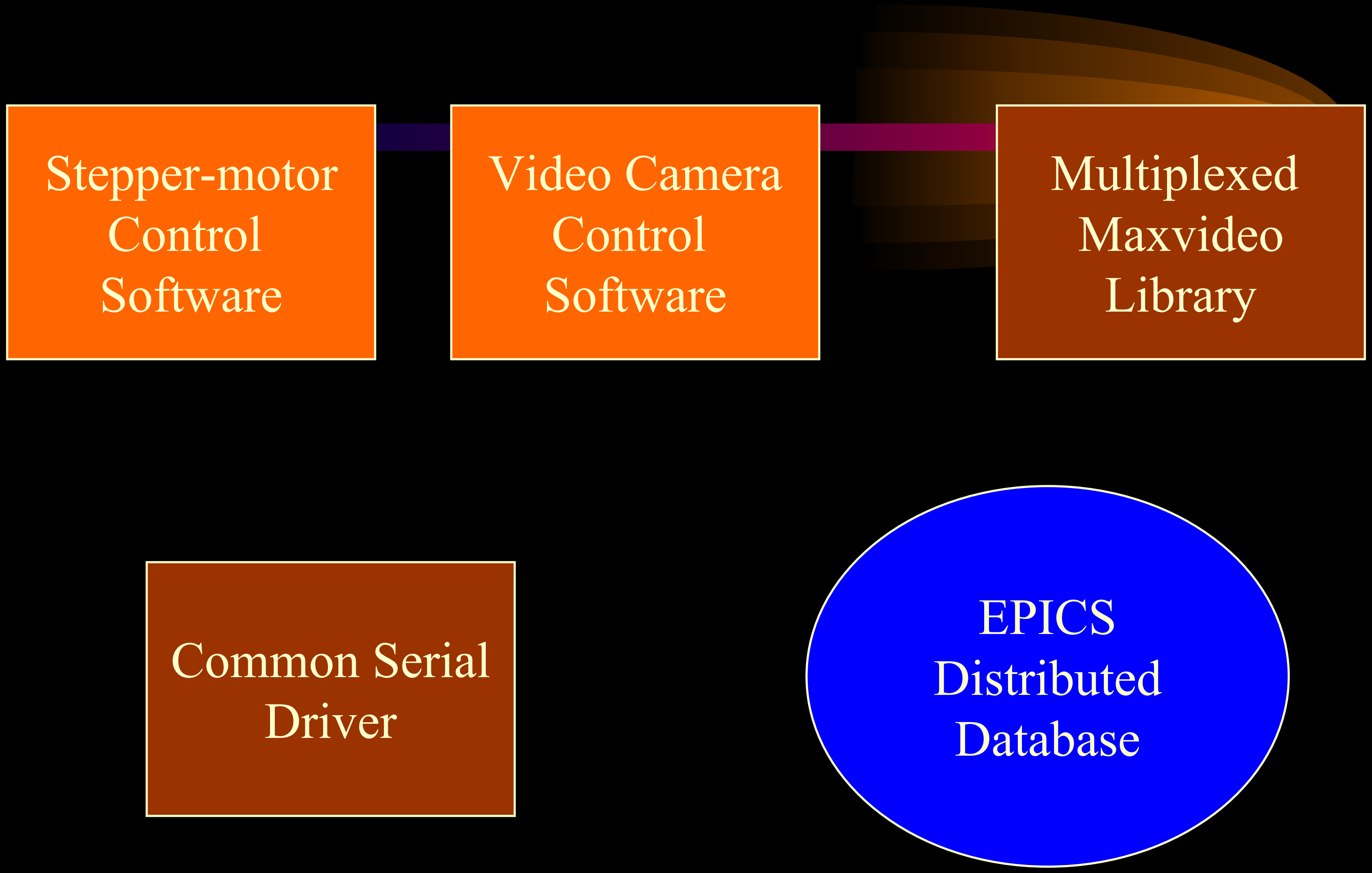

SBIG
STV
Acquire
Calibrate
Track
Guide
File Ops
Process
Control
Setup
Interrupt

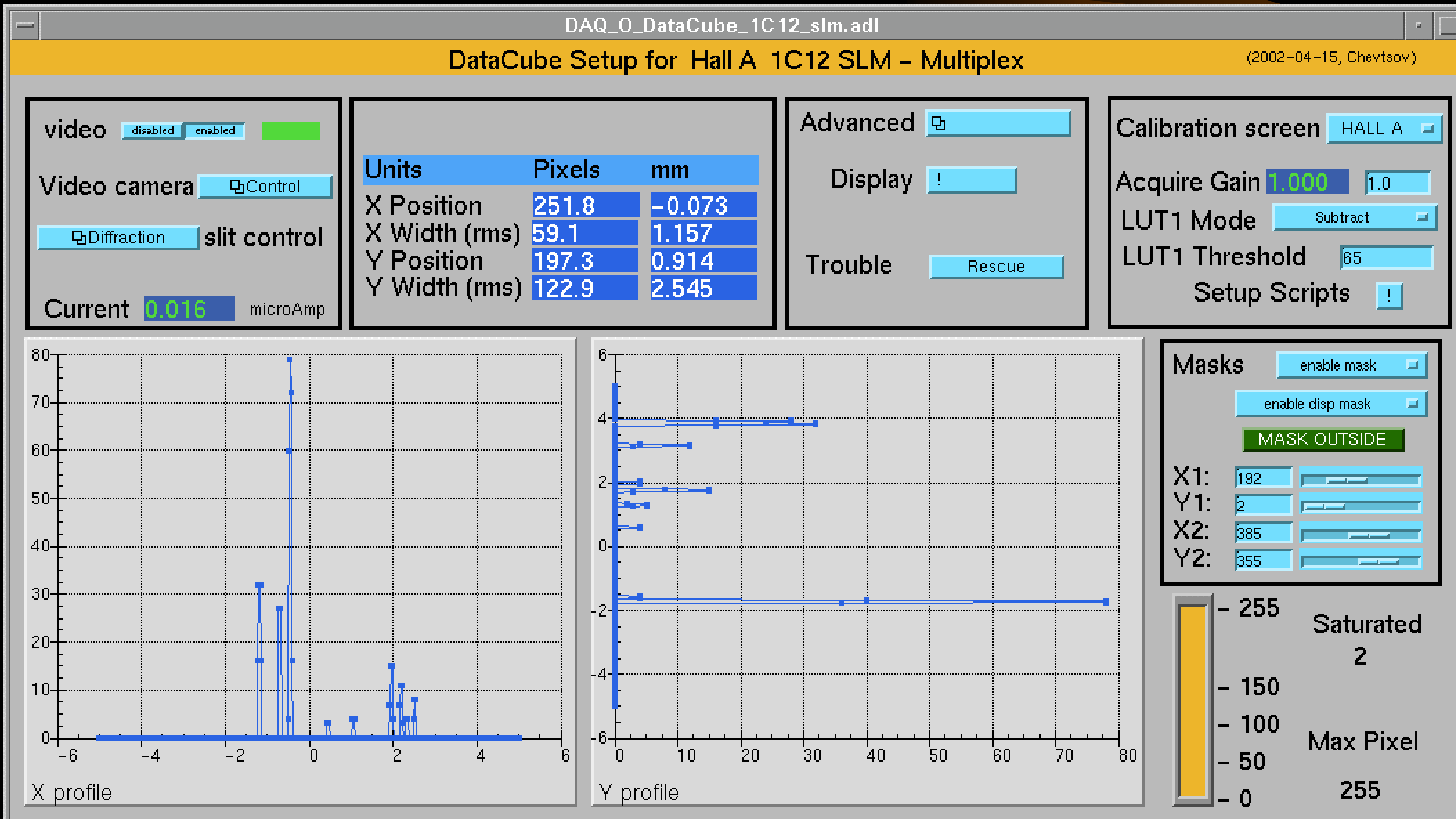


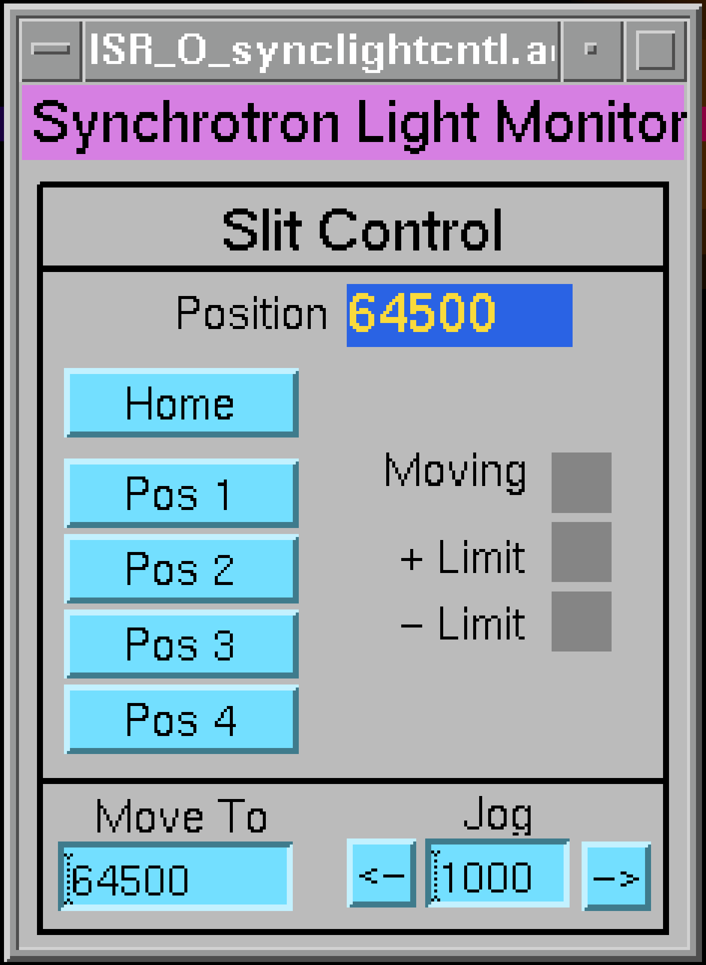

SBIG
STV

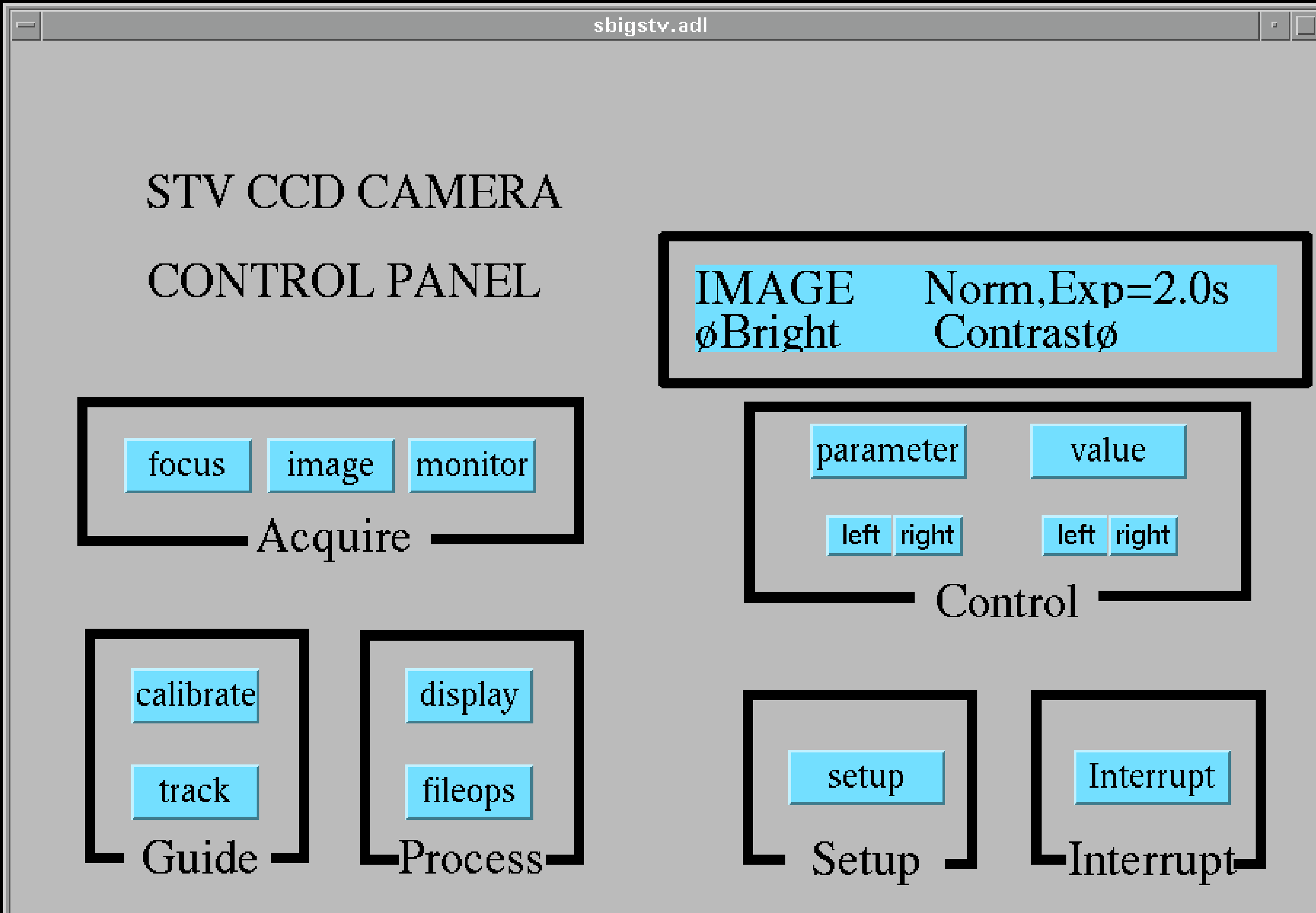

Quantum Efficiency ST-237 / Pixcel 237 / STV
% QE
80
70
60
50
40
30
20
10
0
400
450
500
550
600
650
700
750
800
850
900
950
1000
Wavelength nm
TC-237

Control Software Structure

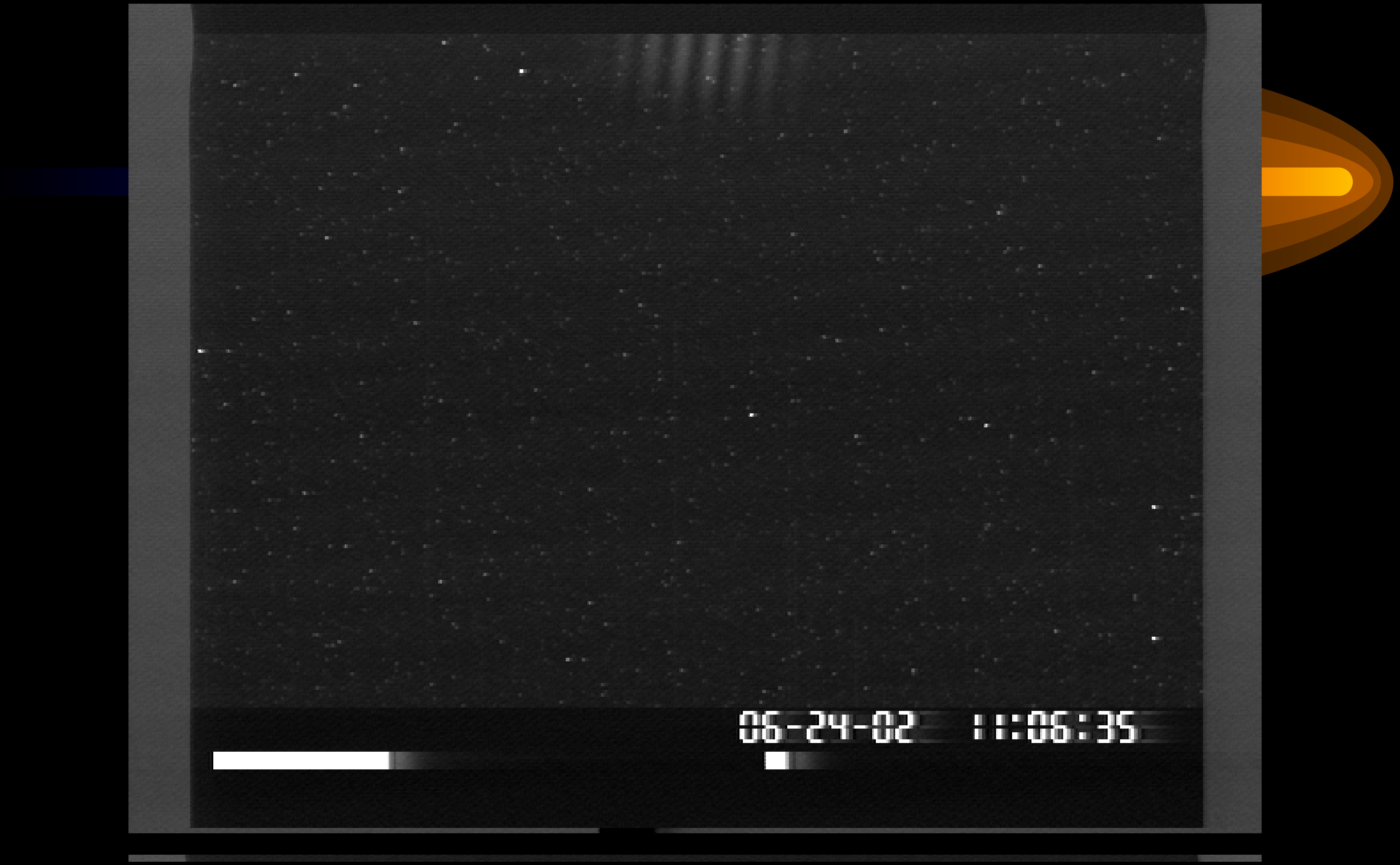



DAQ_O_DataCube_1C12_slm.adl
DataCube Setup for Hall A 1C12 SLM – Multiplex
(2002-04-15, Chevtsov)
video
disabled
enabled
Video camera
Control
Diffraction
slit control
Current 0.016 microAmp
Units Pixels mm
X Position 251.8 -0.073
X Width (rms) 59.1 1.157
Y Position 197.3 0.914
Y Width (rms) 122.9 2.545
Advanced
Display
Trouble
Rescue
Calibration screen
HALL A
Acquire Gain 1.000 1.0
LUT1 Mode Subtract
LUT1 Threshold 65
Setup Scripts
Masks
enable mask
enable disp mask
MASK OUTSIDE
X1: 192
Y1: 2
X2: 385
Y2: 355
255
150
100
50
0
Saturated
2
Max Pixel
255
X profile
Y profile

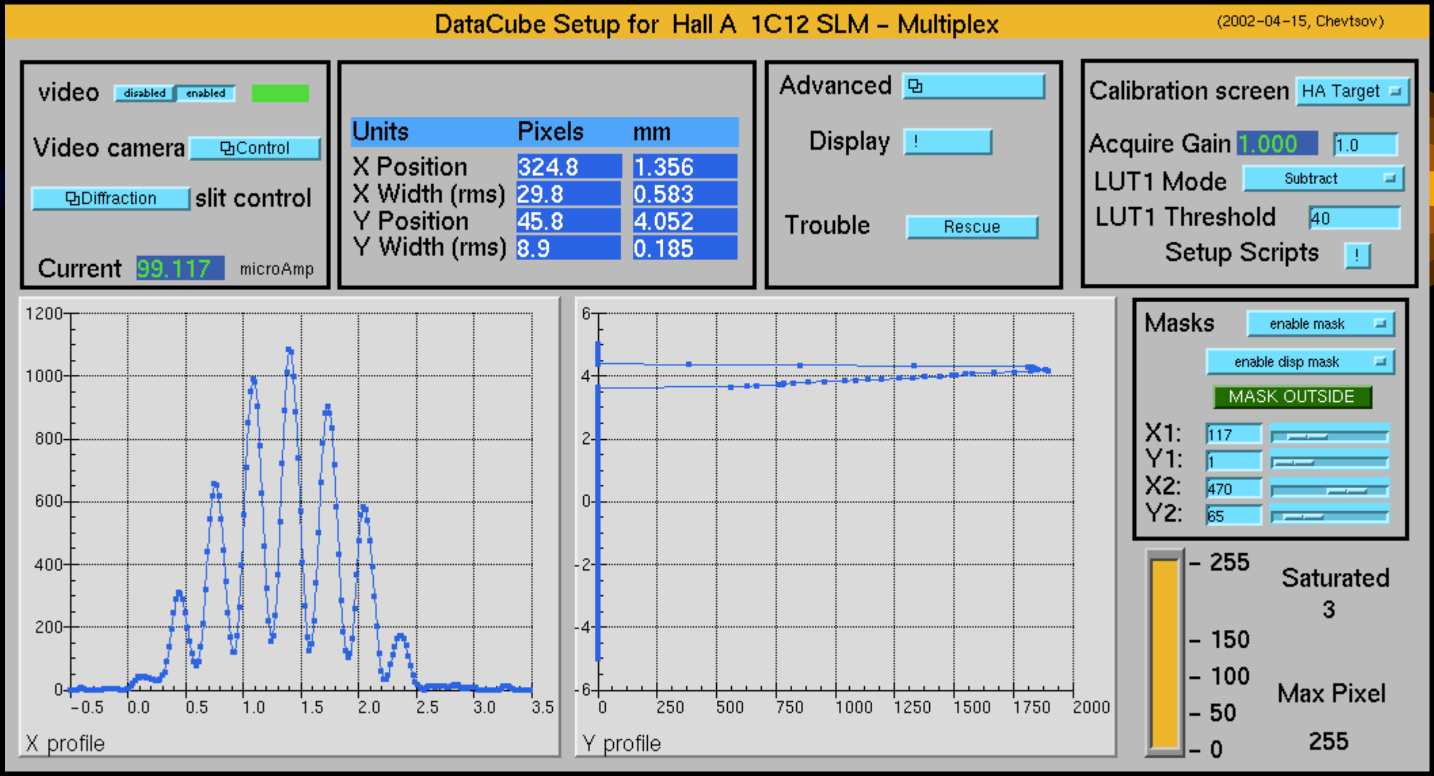

ISR_O_synclightcntl.a
Synchrotron Light Monitor
Slit Control
Position
64500
Home
Pos 1
Pos 2
Pos 3
Pos 4
Moving
+ Limit
– Limit
Move To
64500
Jog
<–
1000
–>


sbigstv.adl
STV CCD CAMERA
CONTROL PANEL
IMAGE Norm,Exp=2.0s
øBright Contrastø
focus
image
monitor
Acquire
parameter
value
left
right
left
right
Control
calibrate
track
Guide
display
fileops
Process
setup
Setup
Interrupt
Interrupt

Very First Experimental Results

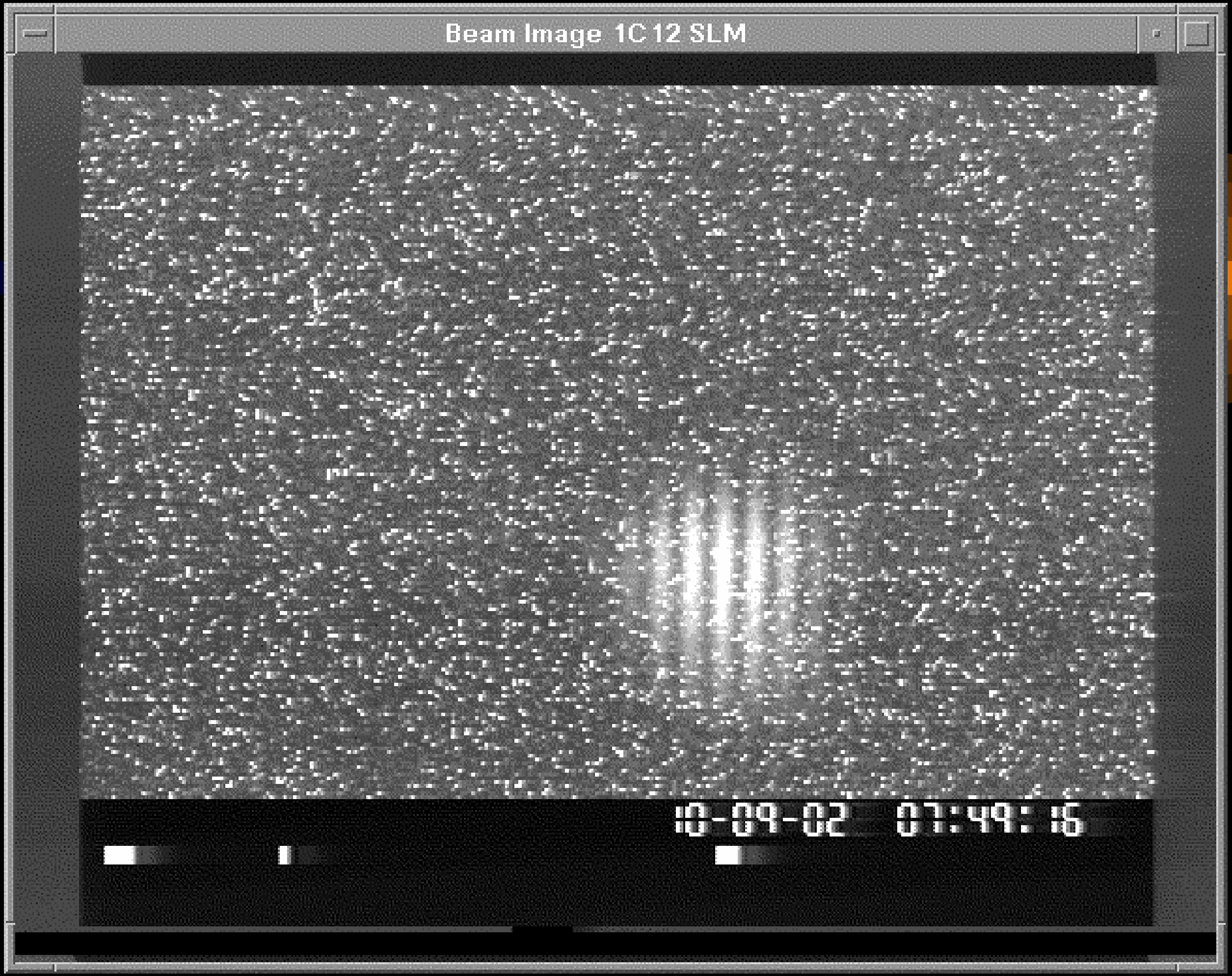


(exposure time = 2 sec)

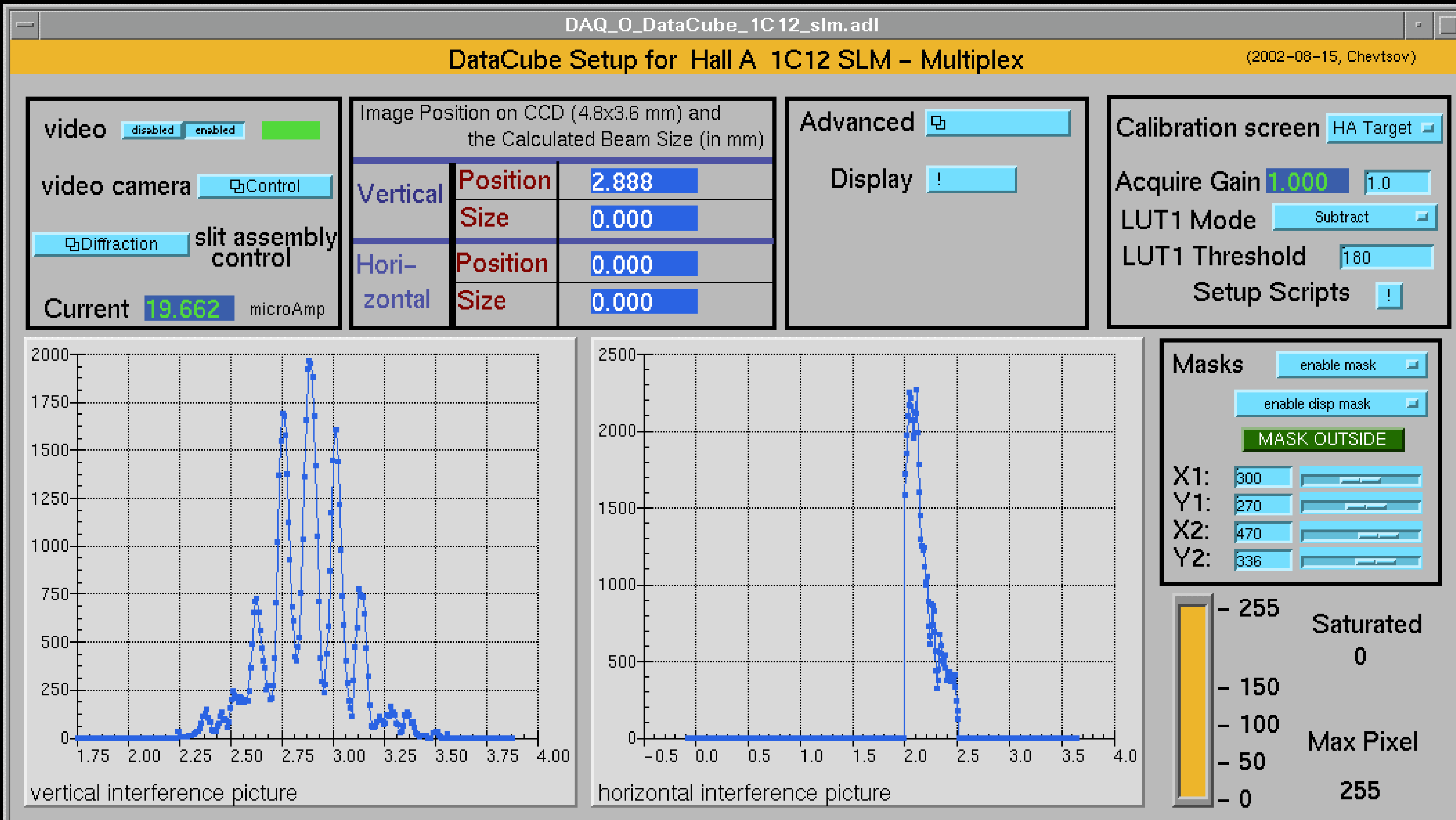


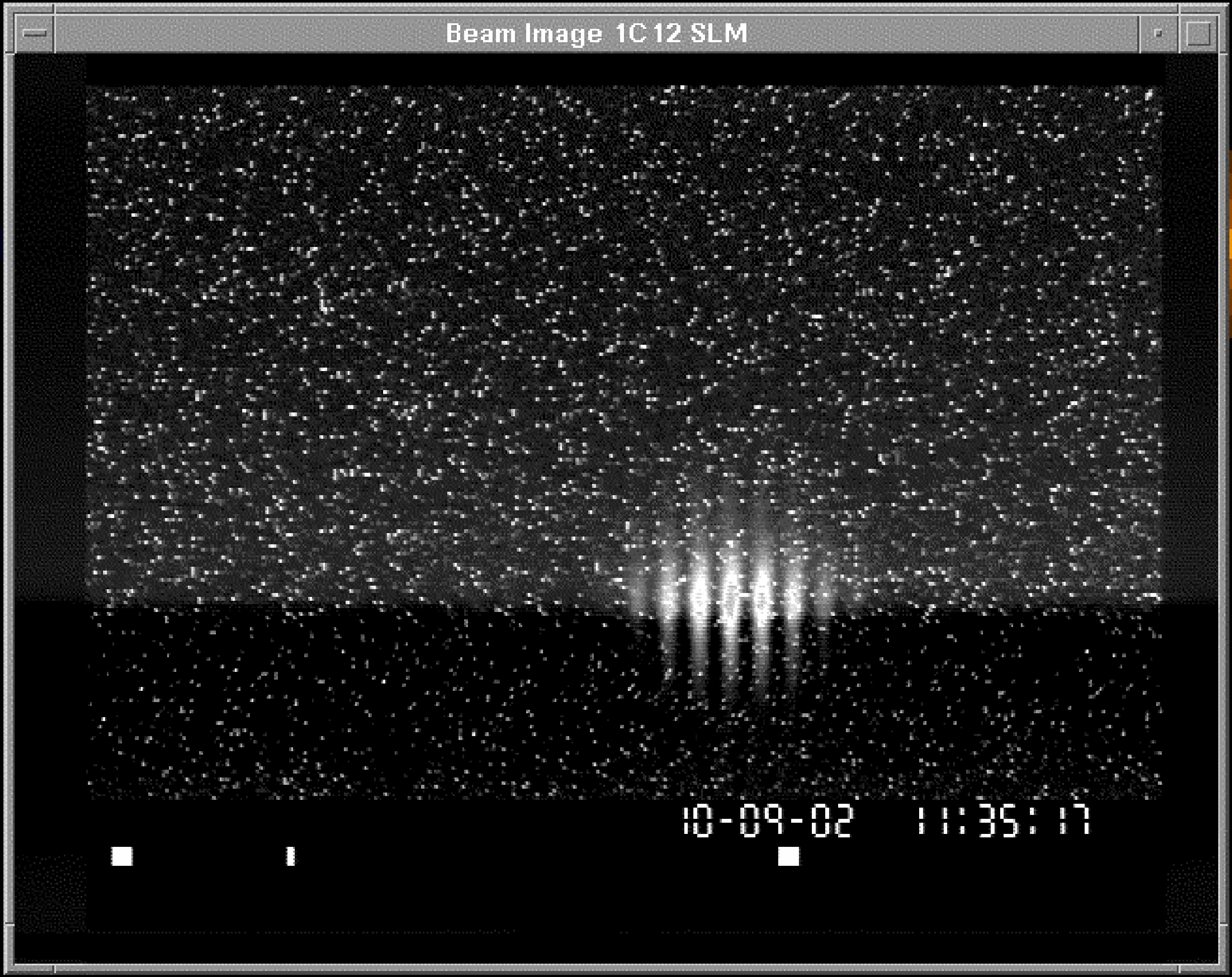
$V = 0.8 \qquad \sigma_S = 0.12\ \mathrm{mm}$

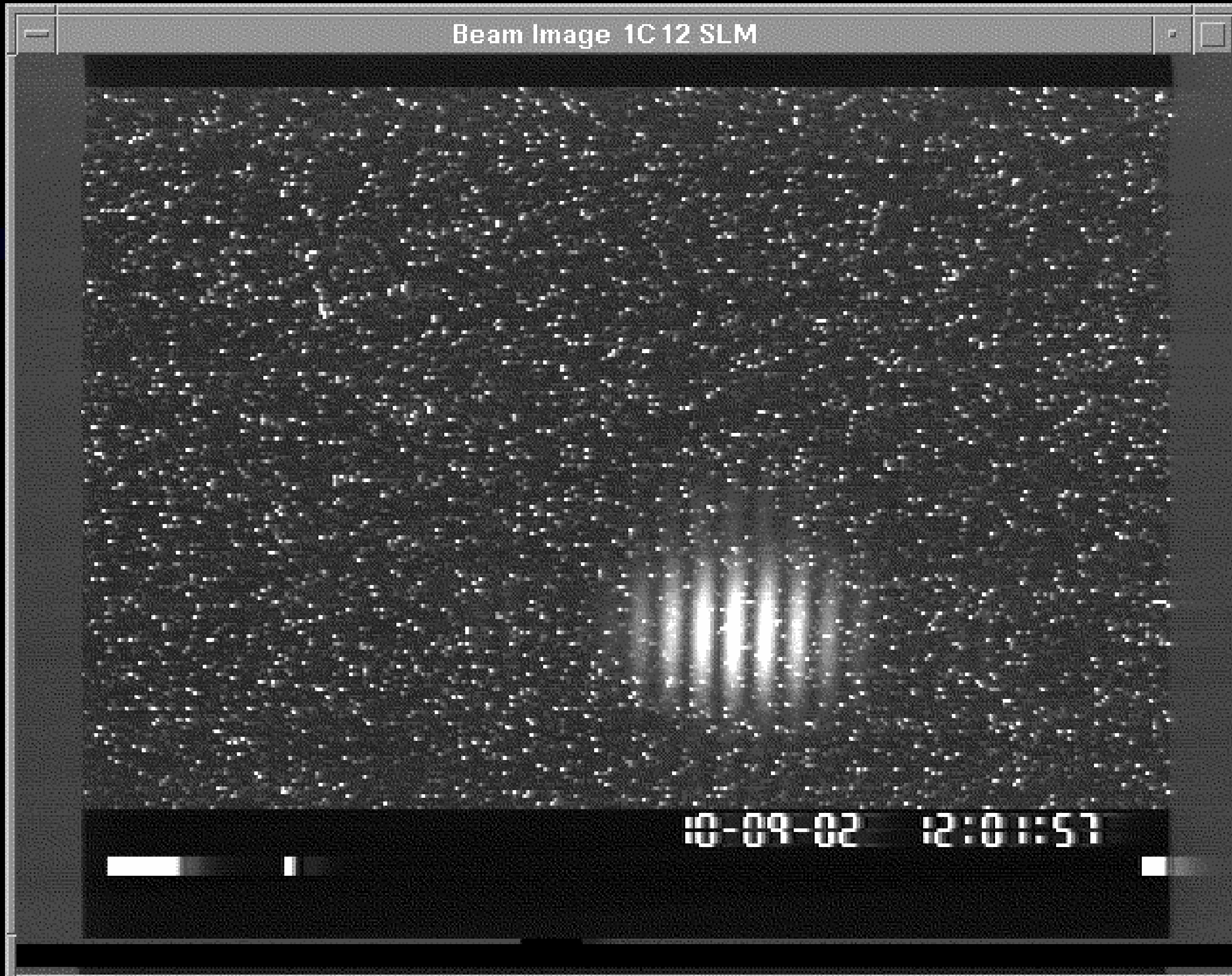
SLI Data After 2002 Summer Shutdown



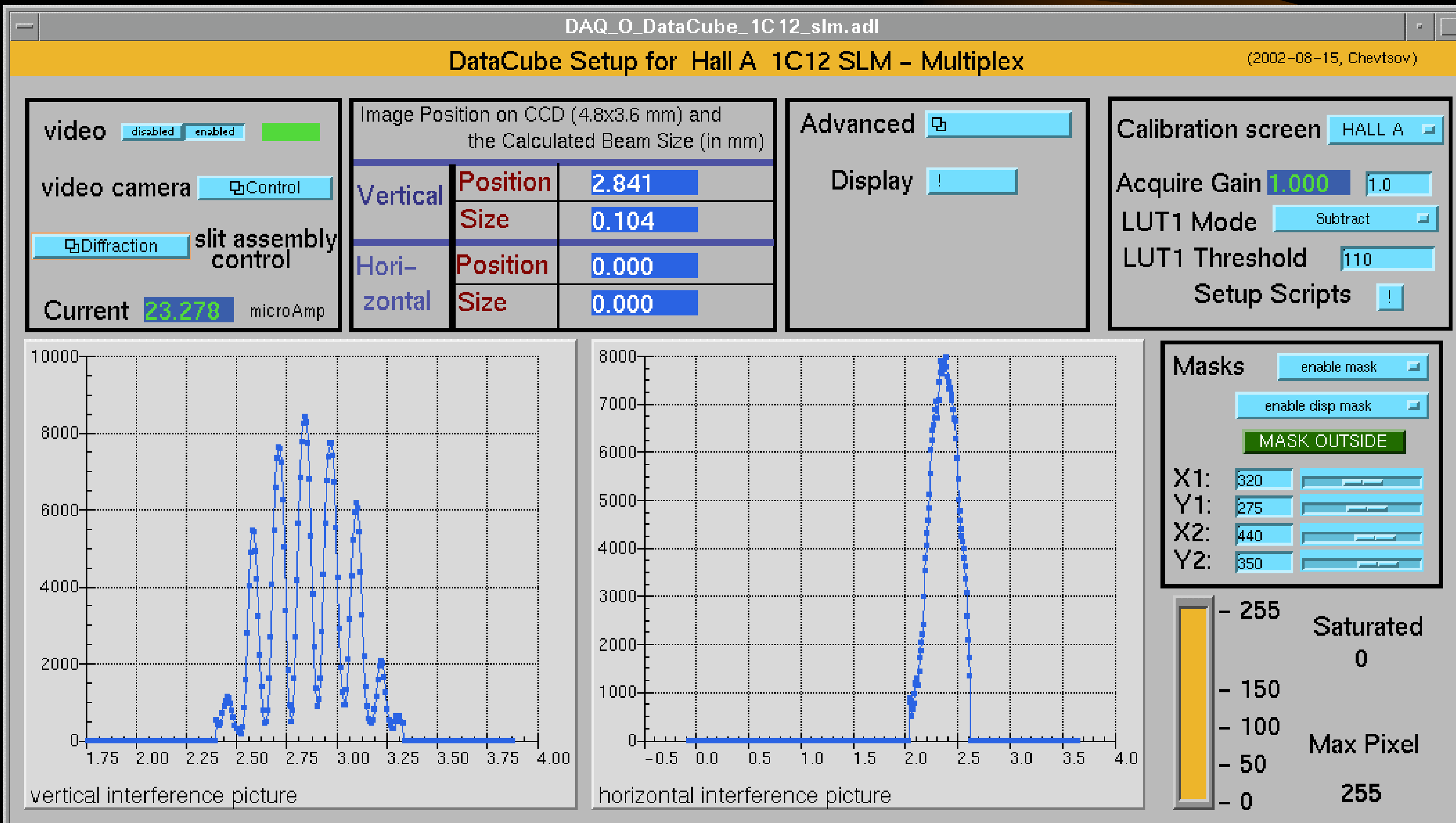
(exposure time = 50 sec)


DAQ_O_DataCube_1C12_slm.adl
DataCube Setup for Hall A 1C12 SLM – Multiplex
(2002-08-15, Chevtsov)
video
disabled
enabled
video camera
Control
Diffraction
slit assembly control
Current
19.662
microAmp
Image Position on CCD (4.8x3.6 mm) and the Calculated Beam Size (in mm)
Vertical
Position
2.888
Size
0.000
Hori-zontal
Position
0.000
Size
0.000
Advanced
Display
Calibration screen
HA Target
Acquire Gain
1.000
1.0
LUT1 Mode
Subtract
LUT1 Threshold
180
Setup Scripts
vertical interference picture
horizontal interference picture
Masks
enable mask
enable disp mask
MASK OUTSIDE
X1:
300
Y1:
270
X2:
470
Y2:
336
Saturated
0
Max Pixel
255


Beam Image 1C12 SLM
10-09-02 11:35:17



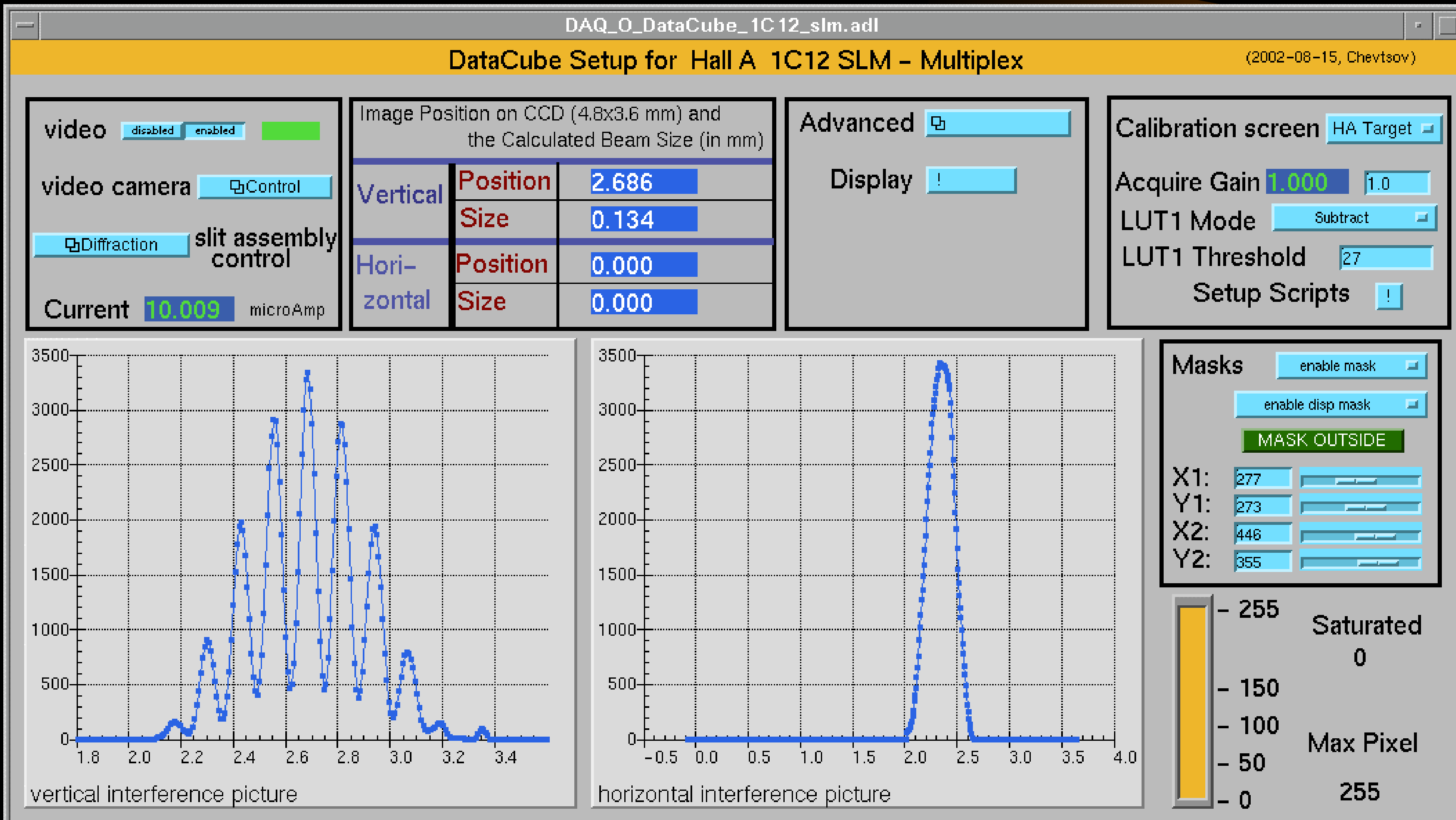
(exposure time = 10 sec)

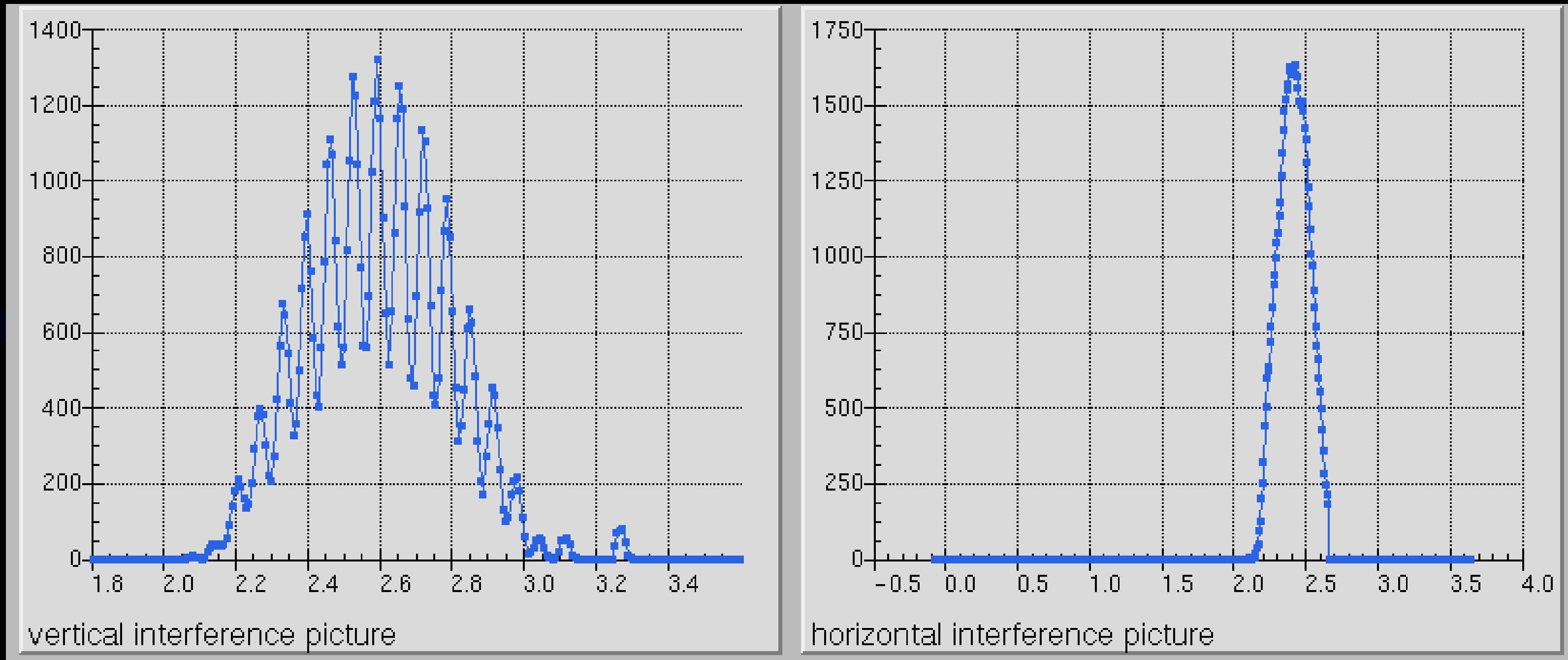

DAQ_O_DataCube_1C12_slm.adl
DataCube Setup for Hall A 1C12 SLM - Multiplex
(2002-08-15, Chevtsov)
video
disabled
enabled
video camera
Control
Diffraction
slit assembly control
Current
23.278
microAmp
Image Position on CCD (4.8x3.6 mm) and the Calculated Beam Size (in mm)
Vertical
Position
2.841
Size
0.104
Hori-zontal
Position
0.000
Size
0.000
Advanced
Display
Calibration screen
HALL A
Acquire Gain
1.000
1.0
LUT1 Mode
Subtract
LUT1 Threshold
110
Setup Scripts
Masks
enable mask
enable disp mask
MASK OUTSIDE
X1: 320
Y1: 275
X2: 440
Y2: 350
vertical interference picture
horizontal interference picture
255
150
100
50
0
Saturated
0
Max Pixel
255

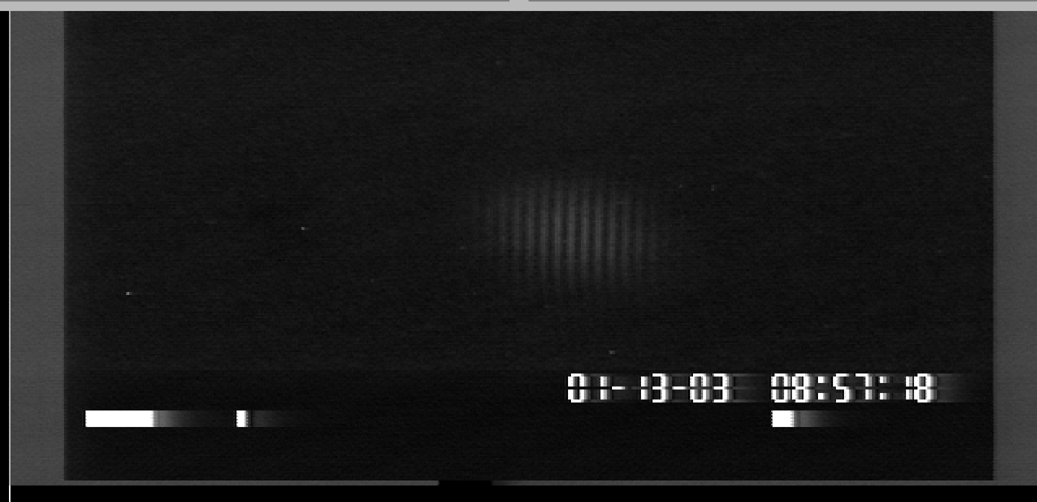
```
From - Thu Oct 10 10:44:23 2002
Received: (from majordom@localhost)
        by mailer.jlab.org (8.11.6/8.11.6) id g9ADBv915120;
        Thu, 10 Oct 2002 09:11:57 -0400 (EDT)
Received: from jlab.org (localhost [127.0.0.1])
        by mailer.jlab.org (8.11.6/8.11.6) with ESMTP id g9ADBsx15113;
        Thu, 10 Oct 2002 09:11:55 -0400 (EDT)
Message-ID: <3DA57C9A.7C97CC1A@jlab.org>
Date: Thu, 10 Oct 2002 09:11:54 -0400
From: Jay Benesch <benesch@jlab.org>
X-Mailer: Mozilla 4.78 [en] (X11; U; HP-UX B.10.20 9000/785)
X-Accept-Language: en
MIME-Version: 1.0
To: machine-ops@jlab.org
Subject: 8am mtg 10/10/02
Content-Type: text/plain; charset=us-ascii
Content-Transfer-Encoding: 7bit
Sender: owner-machine-ops@jlab.org
Precedence: bulk
Reply-To: Jay Benesch <benesch@jlab.org>
-------------------
Day SHIFT SUMMARY
Shift began with beam delivery to both halls. At 10:00 we terminated
beam delivery to the halls to do a spot move, repair Fast Feedback, and
send CW G0 beam to the BSY dump. All of these things were achieved :)
Spot move increased A current to ~24uA.
FFB restored by returning missing trim cards.
Steered ~12uA CW G0 beam to BSY dump. G0 beam delivery continued in
parallel with delivery to halls A and B.
```

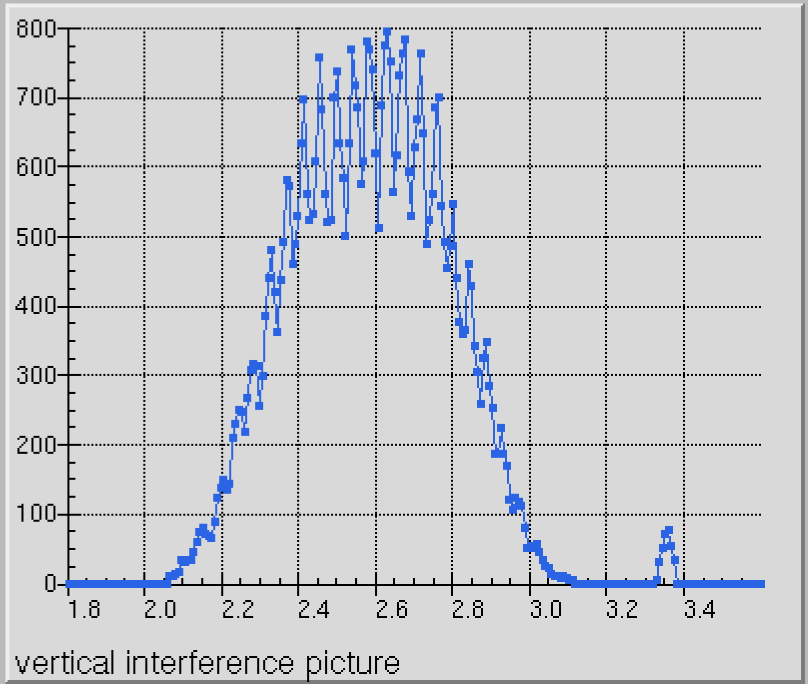
Recent Data

(exposure time = 15 sec)

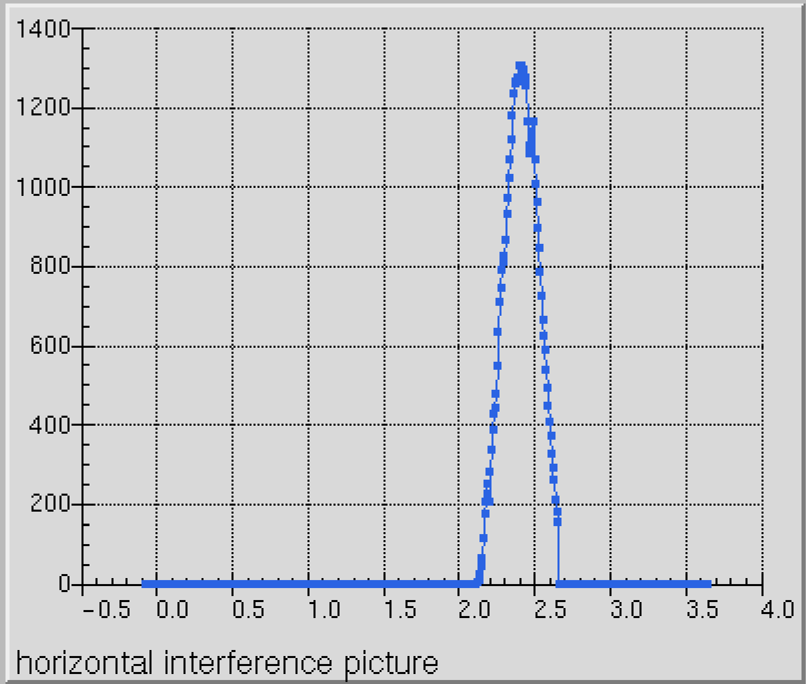

DAQ_O_DataCube_1C12_slm.adl
DataCube Setup for Hall A 1C12 SLM – Multiplex
(2002-08-15, Chevtsov)
video
disabled
enabled
video camera
Control
Diffraction
slit assembly control
Current
10.009
microAmp
Image Position on CCD (4.8x3.6 mm) and the Calculated Beam Size (in mm)
Vertical
Position
2.686
Size
0.134
Hori-zontal
Position
0.000
Size
0.000
Advanced
Display
Calibration screen
HA Target
Acquire Gain
1.000
1.0
LUT1 Mode
Subtract
LUT1 Threshold
27
Setup Scripts
Masks
enable mask
enable disp mask
MASK OUTSIDE
X1:
277
Y1:
273
X2:
446
Y2:
355
255
150
100
50
0
Saturated
0
Max Pixel
255
vertical interference picture
horizontal interference picture


1400
1200
1000
800
600
400
200
0
1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4
vertical interference picture
1750
1500
1250
1000
750
500
250
0
-0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
horizontal interference picture

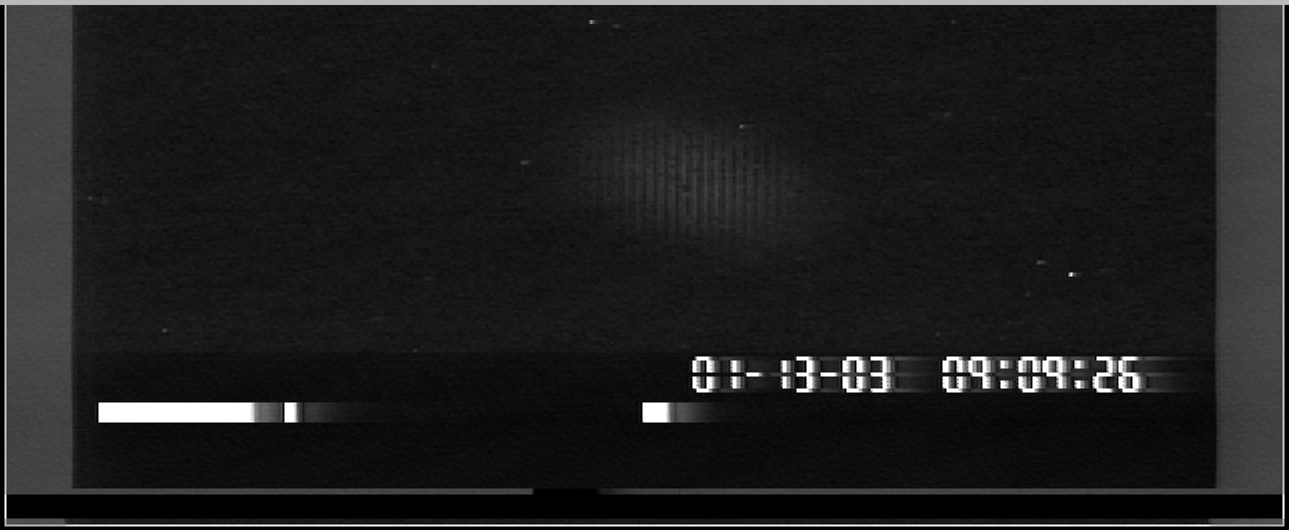




800
700
600
500
400
300
200
100
0
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
vertical interference picture

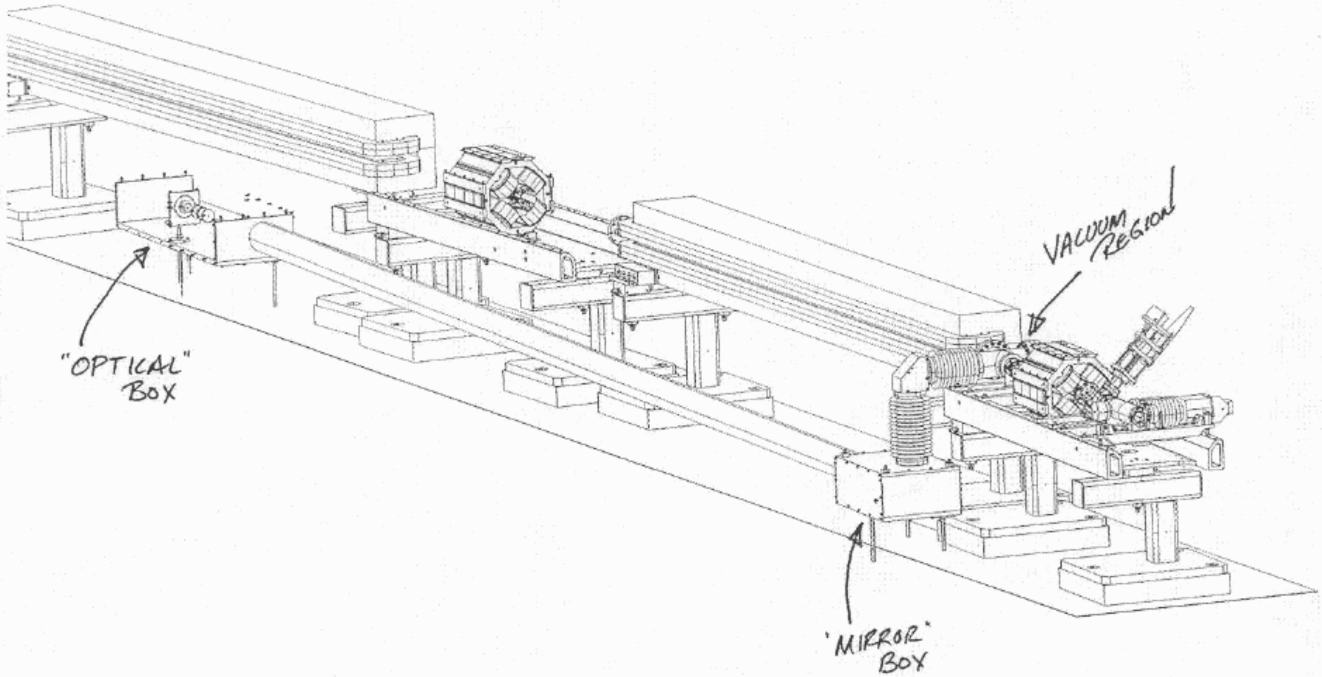


1400
1200
1000
800
600
400
200
0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
horizontal interference picture



09:09:26

Very Last Data



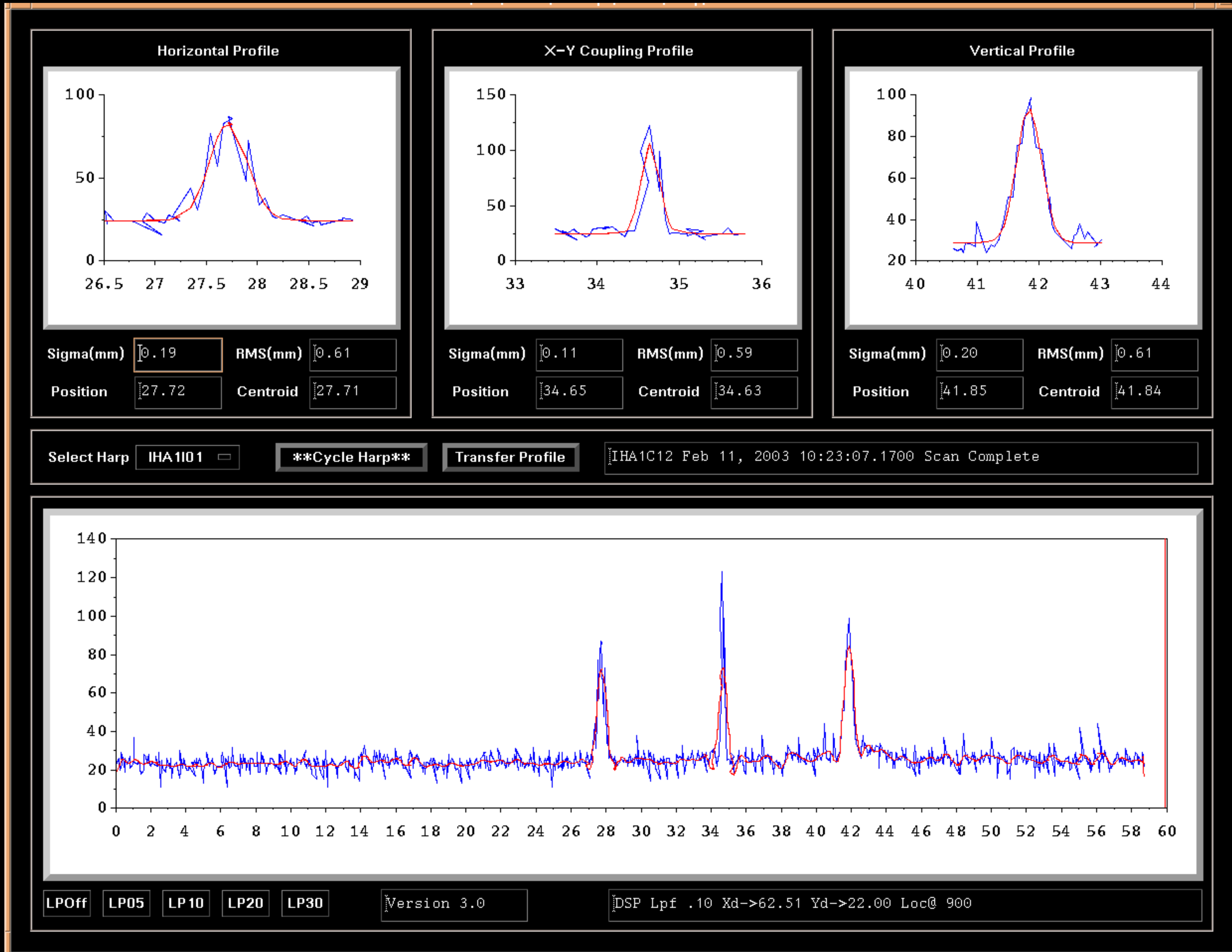
HIGH RESOLUTION SLM
@ICI2

MAG_O_1C_quads.adl

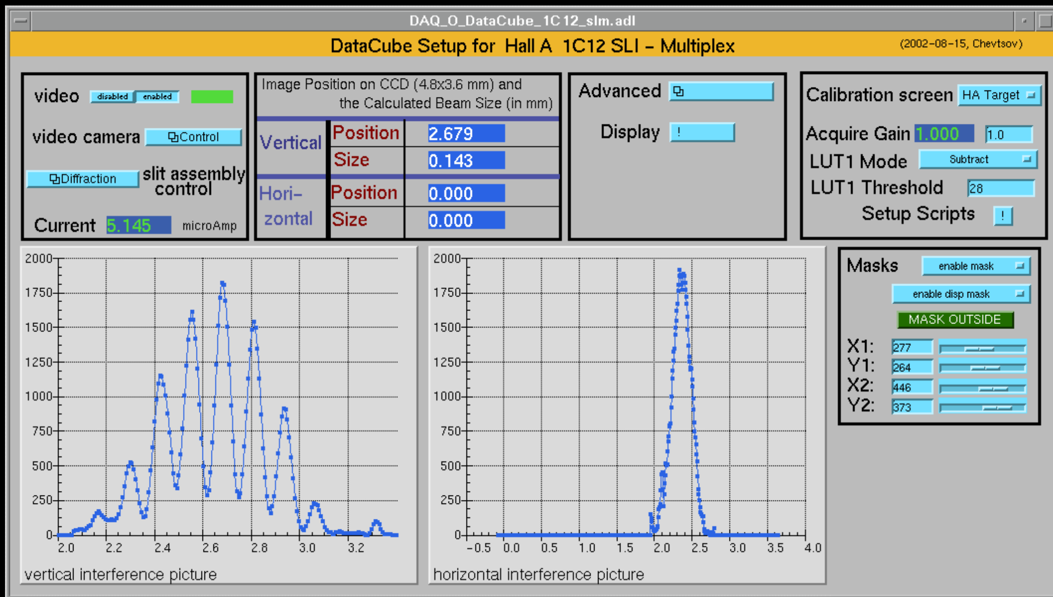
Quadrupoles for the 1C Region

MIS	ASSUMED	OFFLOOP	RAMPING	MAGNET NAME	HYSTERESIS LOOP SWITCH	INTEGRATED FIELD SET POINT (DIPOLE UNITS IN GAUSS-CM, QUADRUPOLE UNITS IN GAUSS, SEXTUPOLE UNITS IN GAUSS/CM)	CURRENT SETPOINT (amps)	CURRENT READBACK (amps)	EXPERT SCREENS
				MQA1C01	On Off	32991.699	3.065	3.063	
				MQA1C02	On Off	-53771.199	-5.495	-5.494	
				MQA1C03	On Off	33732.102	3.139	3.137	
				MQA1C04	On Off	40372.398	3.800	3.798	
				MQA1C05	On Off	-21106.400	-2.249	-2.248	
				MQA1C06	On Off	2735.050	0.091	0.089	
				MQA1C07	On Off	-18061.000	-1.950	-1.949	
				MQA1C08	On Off	25156.598	2.291	2.286	
				MQA1C09	On Off	0.000	-0.177	-0.178	
				MQA1C10	On Off	0.000	-0.177	-0.178	
				MQA1C11	On Off	-20419.801	-2.182	-2.181	
				MQA1C12	On Off	40953.801	3.858	3.854	
				MQA1C13	On Off	-17858.699	-1.930	-1.929	
				MQA1C14	On Off	0.000	-0.177	-0.177	
				MQA1C15	On Off	0.000	-0.177	-0.178	
				MQA1C16	On Off	22431.900	2.022	2.018	
				MQA1C17	On Off	-13819.199	-1.533	-1.533	
				MQA1C18	On Off	13987.000	1.192	1.190	
				MQA1C19	On Off	-50556.801	-5.172	-5.172	
				MQA1C20	On Off	41559.500	3.918	3.918	
				MQA1H01	On Off	-6500.000	-0.815	-0.815	
				MQA1H04	On Off	4081.280	0.222	0.215	
				MQA1H04A	On Off	0.000	-0.177	-0.178	

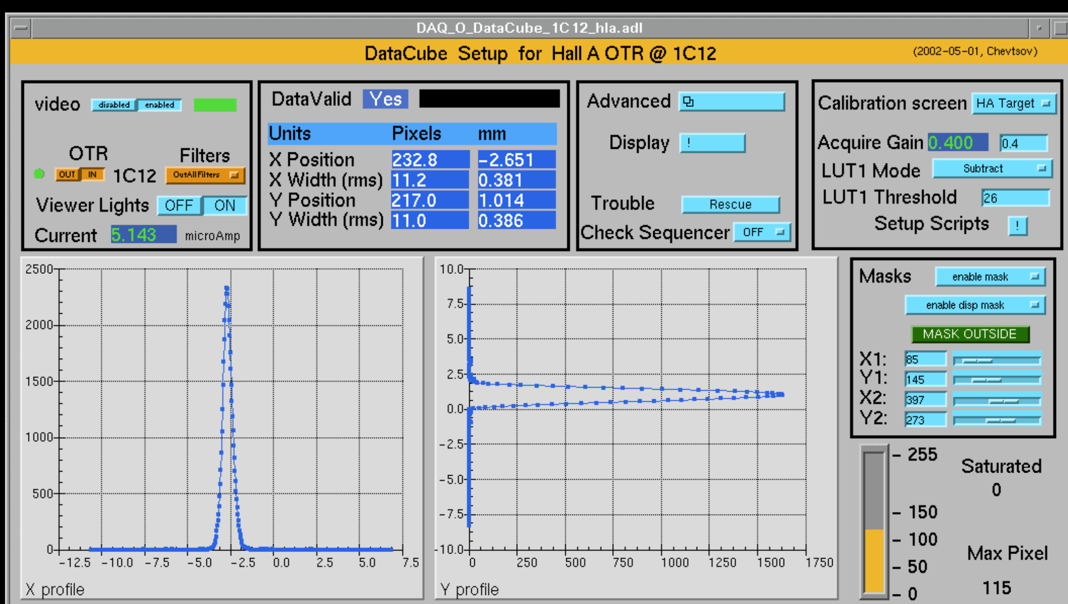
This screen is generated from the routine ../screen_codes/magnets/magpanel.c V3.64 (Green, 2002-09-16)

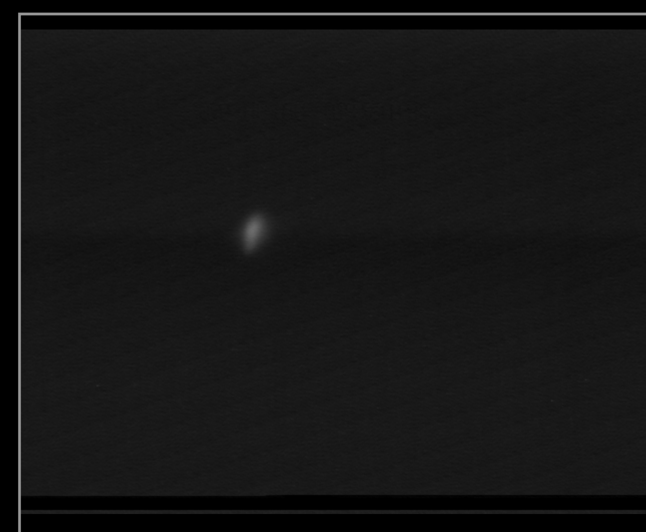


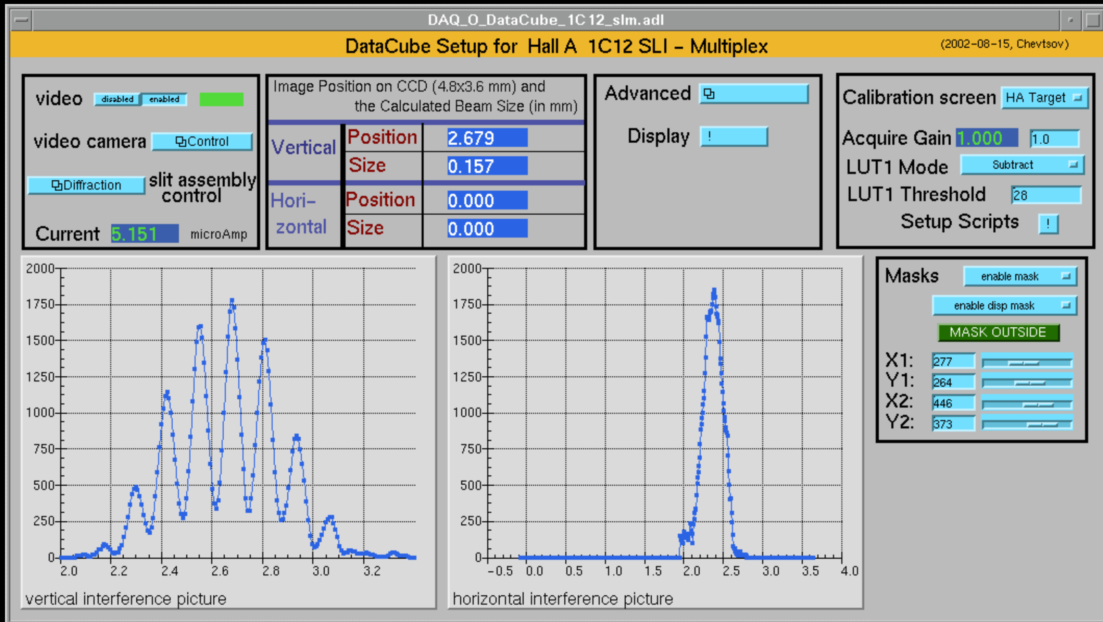
Horizontal Profile
X-Y Coupling Profile
Vertical Profile
Sigma(mm) 0.19
RMS(mm) 0.61
Position 27.72
Centroid 27.71
Sigma(mm) 0.11
RMS(mm) 0.59
Position 34.65
Centroid 34.63
Sigma(mm) 0.20
RMS(mm) 0.61
Position 41.85
Centroid 41.84
Select Harp
IHA1I01
Cycle Harp
Transfer Profile
IHA1C12 Feb 11, 2003 10:23:07.1700 Scan Complete
LPOff
LP05
LP10
LP20
LP30
Version 3.0
DSP Lpf .10 Xd->62.51 Yd->22.00 Loc@ 900

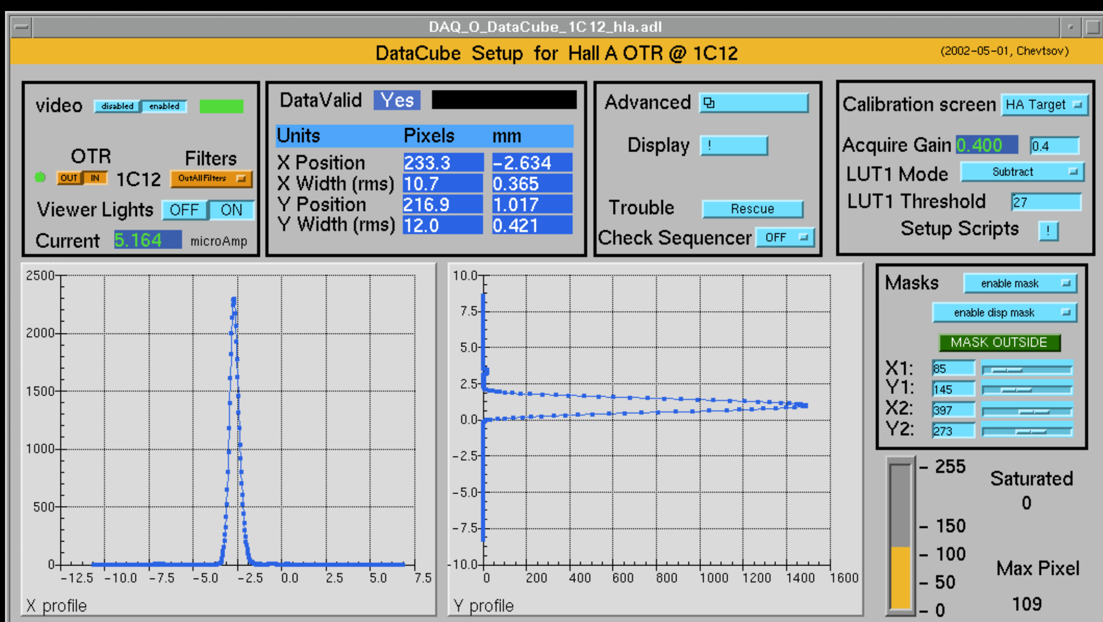

DAQ_O_DataCube_1C12_slm.adl
DataCube Setup for Hall A 1C12 SLI – Multiplex
(2002-08-15, Chevtsov)
video disabled enabled
video camera Control
Diffraction
slit assembly control
Current 5.145 microAmp
Image Position on CCD (4.8x3.6 mm) and the Calculated Beam Size (in mm)
Vertical Position 2.679
Size 0.143
Hori–zontal Position 0.000
Size 0.000
Advanced
Display
Calibration screen HA Target
Acquire Gain 1.000 1.0
LUT1 Mode Subtract
LUT1 Threshold 28
Setup Scripts
Masks enable mask
enable disp mask
MASK OUTSIDE
X1: 277
Y1: 264
X2: 446
Y2: 373
vertical interference picture
horizontal interference picture

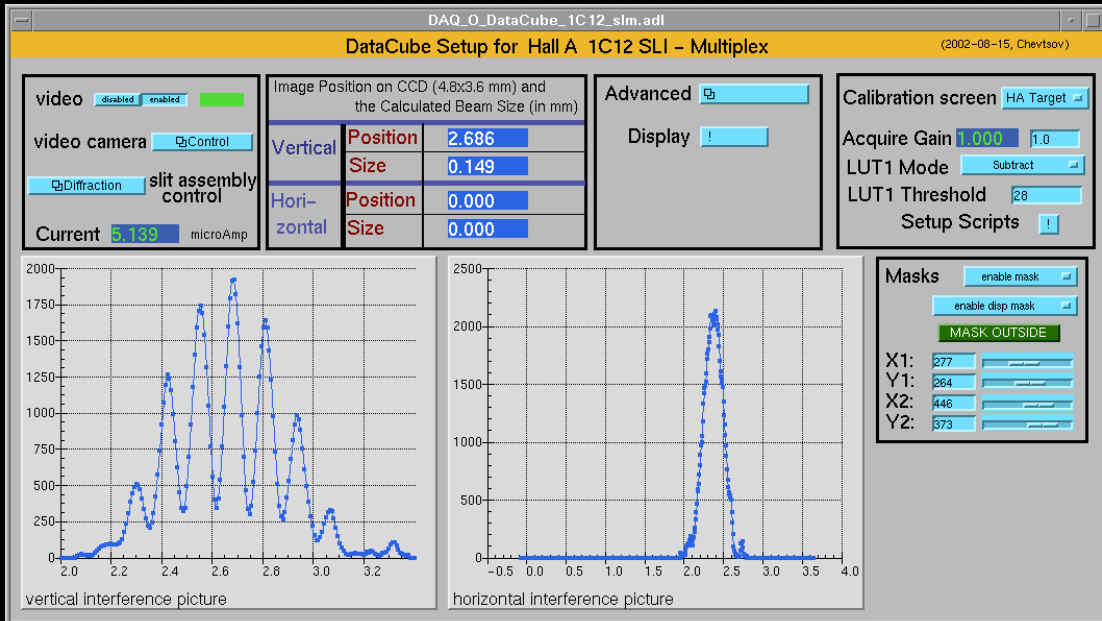

02-11-03 09:59:01

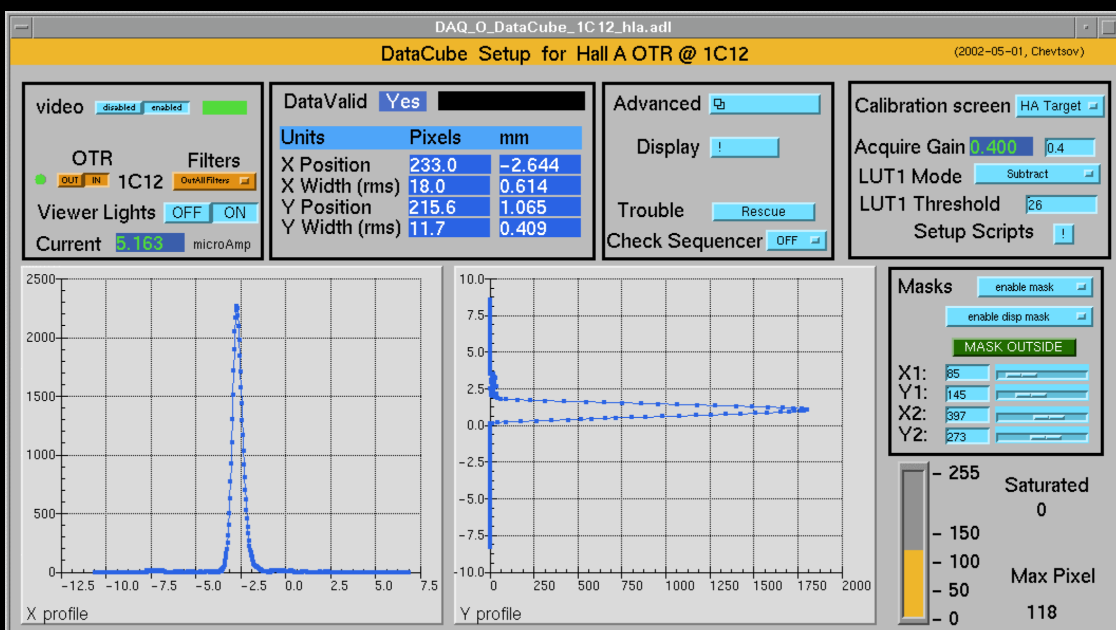

DAQ_O_DataCube_1C12_hla.adl
DataCube Setup for Hall A OTR @ 1C12
(2002-05-01, Chevtsov)
video disabled enabled
OTR Filters
OUT IN 1C12 OutAllFilters
Viewer Lights OFF ON
Current 5.143 microAmp
DataValid Yes
Units Pixels mm
X Position 232.8 -2.651
X Width (rms) 11.2 0.381
Y Position 217.0 1.014
Y Width (rms) 11.0 0.386
Advanced
Display
Trouble Rescue
Check Sequencer OFF
Calibration screen HA Target
Acquire Gain 0.400 0.4
LUT1 Mode Subtract
LUT1 Threshold 26
Setup Scripts
Masks enable mask
enable disp mask
MASK OUTSIDE
X1: 85
Y1: 145
X2: 397
Y2: 273
255
150
100
50
0
Saturated 0
Max Pixel 115
X profile
Y profile




DAQ_O_DataCube_1C12_slm.adl
DataCube Setup for Hall A 1C12 SLI – Multiplex
(2002-08-15, Chevtsov)
video
video camera
Control
Diffraction
slit assembly control
Current 5.151 microAmp
Image Position on CCD (4.8x3.6 mm) and the Calculated Beam Size (in mm)
Vertical Position 2.679
Size 0.157
Hori-zontal Position 0.000
Size 0.000
Advanced
Display
Calibration screen HA Target
Acquire Gain 1.000 1.0
LUT1 Mode Subtract
LUT1 Threshold 28
Setup Scripts
Masks
enable mask
enable disp mask
MASK OUTSIDE
X1: 277
Y1: 264
X2: 446
Y2: 373
vertical interference picture
horizontal interference picture

02-11-03 10:06:46

DAQ_O_DataCube_1C12_hla.adl
DataCube Setup for Hall A OTR @ 1C12
(2002-05-01, Chevtsov)
video
OTR 1C12 Filters
OUT IN
OutAllFilters
Viewer Lights OFF ON
Current 5.164 microAmp
DataValid Yes
Units Pixels mm
X Position 233.3 -2.634
X Width (rms) 10.7 0.365
Y Position 216.9 1.017
Y Width (rms) 12.0 0.421
Advanced
Display
Trouble Rescue
Check Sequencer OFF
Calibration screen HA Target
Acquire Gain 0.400 0.4
LUT1 Mode Subtract
LUT1 Threshold 27
Setup Scripts
Masks
enable mask
enable disp mask
MASK OUTSIDE
X1: 85
Y1: 145
X2: 397
Y2: 273
255
150
100
50
0
Saturated 0
Max Pixel 109
X profile
Y profile



DAQ_O_DataCube_1C12_slm.adl
DataCube Setup for Hall A 1C12 SLI – Multiplex
(2002-08-15, Chevtsov)
video disabled enabled
video camera Control
Diffraction
slit assembly control
Current 5.139 microAmp
Image Position on CCD (4.8x3.6 mm) and the Calculated Beam Size (in mm)
Vertical Position 2.686
Size 0.149
Hori-zontal Position 0.000
Size 0.000
Advanced
Display
Calibration screen HA Target
Acquire Gain 1.000 1.0
LUT1 Mode Subtract
LUT1 Threshold 28
Setup Scripts
Masks enable mask
enable disp mask
MASK OUTSIDE
X1: 277
Y1: 264
X2: 446
Y2: 373
vertical interference picture
horizontal interference picture

02-11-03 10:11:22

DAQ_O_DataCube_1C12_hla.adl
DataCube Setup for Hall A OTR @ 1C12
(2002-05-01, Chevtsov)
video disabled enabled
OTR 1C12
Filters OutAllFilters
OUT IN
Viewer Lights OFF ON
Current 5.163 microAmp
DataValid Yes
Units Pixels mm
X Position 233.0 -2.644
X Width (rms) 18.0 0.614
Y Position 215.6 1.065
Y Width (rms) 11.7 0.409
Advanced
Display
Trouble Rescue
Check Sequencer OFF
Calibration screen HA Target
Acquire Gain 0.400 0.4
LUT1 Mode Subtract
LUT1 Threshold 26
Setup Scripts
Masks enable mask
enable disp mask
MASK OUTSIDE
X1: 85
Y1: 145
X2: 397
Y2: 273
Saturated 0
Max Pixel 118
X profile
Y profile


Summary

- Jefferson Lab has a modern beam diagnostic device based on non-invasive technology

- Jefferson Lab has a great experience in design and installation of such a device

- The resolution of this device can be made less than 10 μm

- The device’s operational current range:
  a few microamps –> milliamps

SLI team:

P. Chevtsov, J.-C. Denard, R. Hicks, K. Capek, D. Hardy, D. Wetherholt, Z. Kursun

Special thanks to:

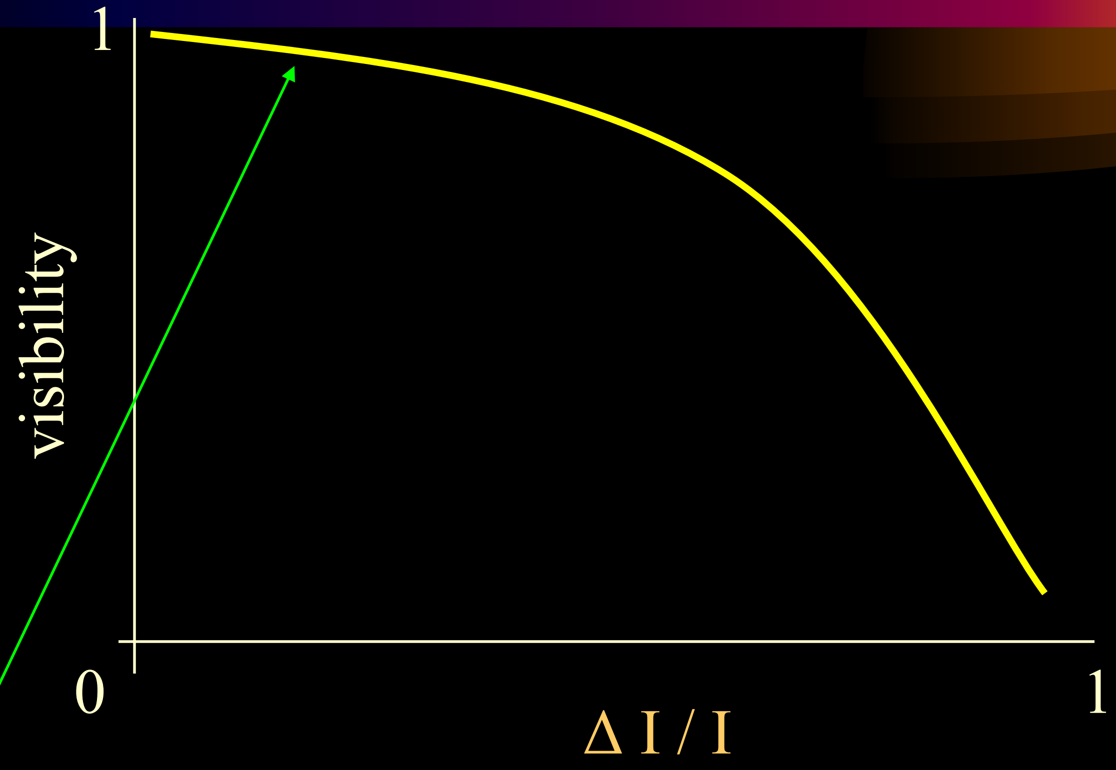
M. Tiefenback, G. Krafft, H. Areti, L. Merminga, J. Benesch, A. Bogacz, A. Freyberger, Y. Derbenev, A. Hutton, K. White.

Many thanks to:

S. Suhring, M. Spata, O. Garza, all accelerator operators and technicians.

E N D

Visibility as a function of the intensity imbalance (simulation)



(~0.7 % for 20%)