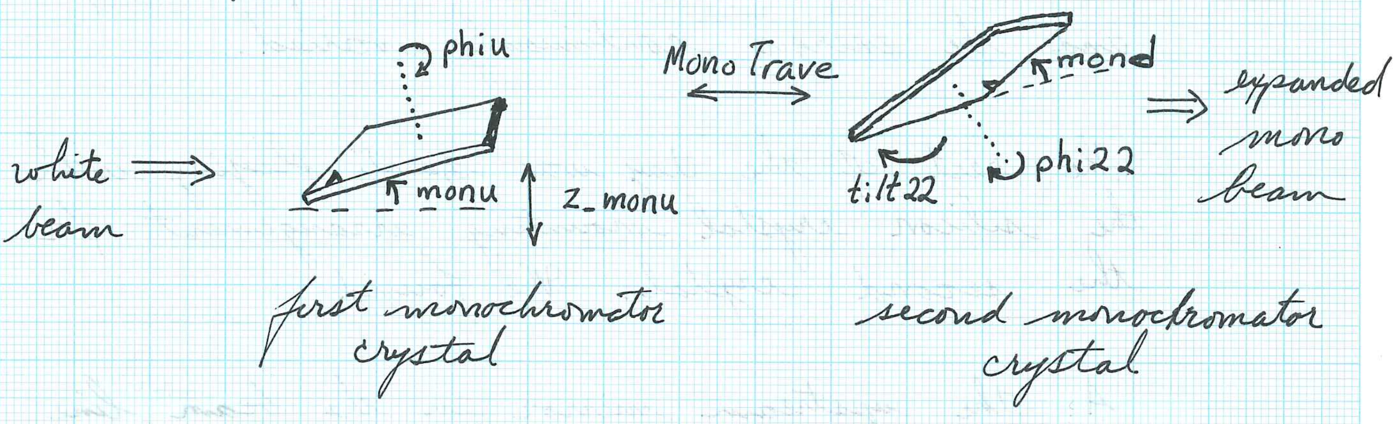
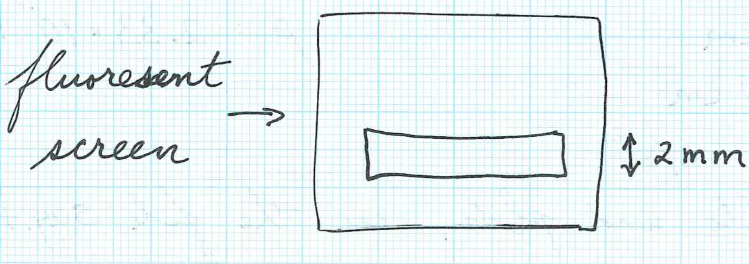
Chess Run May 2009

May 1. Arrived at CHESS. We found that Ken had installed the 331 crystal monochromator in the C-line cave. He had not been able to find a very good alignment that expanded the beam like we had in 2007.




```
1957.FOURC> we

Current Positions  (user, dial)
slit_nort slit_sout  slit_top slit_bott    z_monu      monu      phiu MonoTrave
    slitn     slits     slitt     slitb    monu_z      monu      phiu   montrav
   7.5006  -12.4997   -1.5973   -0.7506   29.0000   20.1412    1.0000   47.3400
   7.5006  -12.4997   -1.5973   -0.7506   35.9749   97.8665  121.0000   61.4250
     mond      mp22    tilt22     sag22      mp21    tilt21     sag21     spare
     mond      mp22    tilt22     sag22      mp21    tilt21     sag21     spare
  20.7320   -9.5000    1.2820    0.0000    0.0000    0.0000    0.0000  -74.7777
  32.1167   -9.5000   -1.2820    0.0000    0.0000    0.0000    0.0000    0.0000
 X-upstrm X_Dwnstre      ztld      ztrd Z_Upstrea Y_Upstrea slit_dnst slit_dnst
      xtu       xtd      ztld      ztrd       ztu       ytu       sdz       sdx
  18.0007    6.0000   -2.5000   -2.5000    6.6600    2.4999   -1.0000    0.0000
  18.0007    6.0000   -2.5000   -2.5000    6.6600    2.4999   11.6493   16.2371
   X_left   Y_right    Y_left    Z_left  Z_rt_dwn   Z_rt_up        na      samz
       xl        yr        yl        zl       zrd       zru        na      samz
  16.1909   -6.0793   -0.2580   89.3648   47.8411   61.6280  -10.9995   -6.7999
  16.1909   -6.0793   -0.2580   89.3648   47.8411   61.6280  -12.6445    5.3800
Two-theta     Theta       Chi       Phi       ath  Z_sample    window     spar2
      tth        th       chi       phi       ath      zsam    window    spare2
  38.0000    0.0000  -90.0000  270.8000    0.0000   30.2500    8.9999  -10.5330
  38.7893  180.0000  270.0000  270.8000   32.0000   30.2500    8.9999  -10.5597
 slitup_x  slitup_z    ncaprx    ncaprz main_wall main_cent      samx   newname
     supx      supz    ncaprx    ncaprz       mwx       mcx      samx   newname
   0.0000    0.0000    0.0400    0.0500    0.0000    0.2500    1.0001    0.0000
  -9.0011    1.4266    2.3850    2.7037    0.0000    0.2500   10.0000    0.0000
   ccmrzu    ccmrzd  ccmrbend    ENABLE  monu_2th   ana_tth ana_xtal2 mon_chcut
   ccmrzu    ccmrzd     ccmrb    ENABLE   xmon2u      atth      ana2    xmoncc
  -1.2000    1.6547   45.0002    5.0000    2.0000  151.9790   12.7567    2.0000
  -2.1088    5.2418   45.0002    5.0000  262.0000   62.4790  279.0599    0.5000
X-dwnstrm       bsz       bsx  Motor 56  Motor 57  Motor 58  Motor 59    mond_z
      xd1       bsz       bsx       m56       m57       m58       m59    mond_z
   2.6508    0.0000    0.0000    4.0400    4.0000    3.5000    2.9744   68.9000
   2.6508    4.1800    2.8500    3.0000    4.0000    3.5000    3.5000   68.9000
```

Using the above settings we were able to get a beam spot, but it was not shaped as expected.



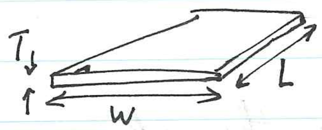
May 2 We proved that this is a 331 reflection using some absorber films and rocking the monochromator through the absorption edge. There are commands that Ken gave to the mono control program that would simultaneously move monu, mond, and monotrave so as the beam spot was preserved and the energy continuously varied.

The rest of the day was spent playing with the silicon crystal mounting arrangement for the second crystal. We found

A. The upstream mirror in the beam line should be straight so as to not introduce any new optical distortions.
B. It matters how the second crystal is fixed to its base. It is upside-down so it can bend under gravity, or under any mounting stresses in its holder.

I wrote a code called "sag.f" and "sag.kumac" that calculate the sag in a piece of silicon under its own weight. I found that the sag is large enough to cause problems (twice the Darwin width) if the crystal is supported along its edges.

$$\text{sag} = \frac{5 g \rho L^4}{32 B T^2}$$

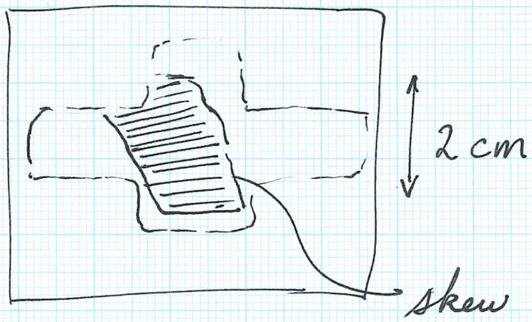


$L = 5.0$ cm
$W = 7.0$ cm
$T = 0.10$ cm
$g = 9.8\ m/s^2$

$B = 130$ GPa
$\rho = 2.33 \times 10^3\ kg/m^3$

For other results and plots, see the file sag.f, .kumac

May 3. Continued working on the second monochromator. We found a second reflection by fixing monu and sweeping mond. This one looks much better than the 331, but cannot be the same because mond is moved ~5° beyond the 331 alignment. After coding up a crystal analysis program, I decided that it was the 311 reflection, which has a significant tilt, but a wider Darwin width, so it made a much larger beam.



skew comes from $\vec{q}$ not in vertical plane.

monod : I wrote this program to search for diffraction settings in the monochromator. By leaving monu at 7.5° and scanning mond, I found the peak observed above to be a 131 reflection at around 12 keV - near the peak intensity of the white beam spectrum.

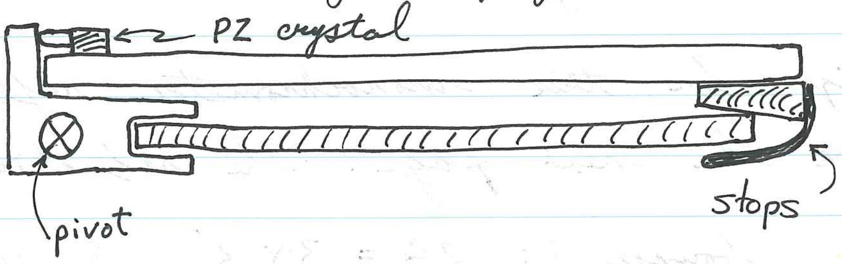
The settings for this monochromator reflection are shown on the next page. The reflections are as follows:

bounce 1: $2\theta = 38.3°$, $\phi = 26.2°$ from vertical

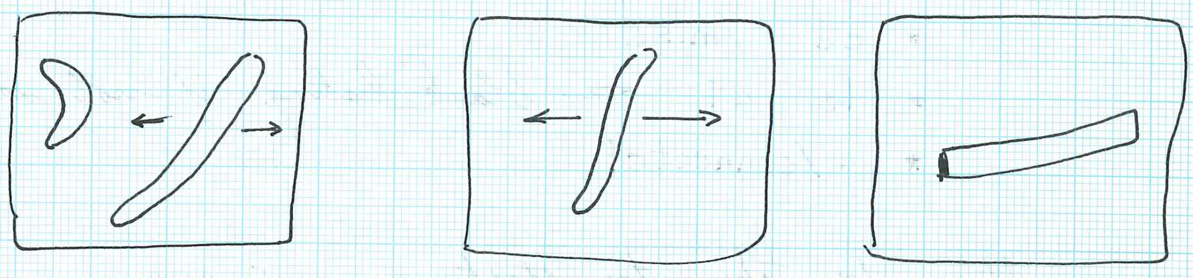
bounce 2: $\theta_f = 0.4°$, $\phi_f = 23°$ from vertical

```
specuser@c1:~ - Shell - Konsole
Session  Edit  View  Bookmarks  Settings  Help

slitn = -10.501, which way (-)?
2557.FOURC> we

Current Positions  (user, dial)
slit_nort slit_sout  slit_top slit_bott    z_monu      monu      phiu MonoTrave
    slitn     slits     slitt     slitb    monu_z      monu      phiu   montrav
 -10.5013  -21.0001   -4.0002   -4.0002   29.4602   19.3729   -6.0000   48.6469
 -10.5013  -21.0001   -4.0002   -4.0002   36.4351   97.4403  118.9170   60.6370
     mond      mp22    tilt22    sag22       mp21    tilt21     sag21     spare
     mond      mp22    tilt22    sag22       mp21    tilt21     sag21     spare
  23.4390   -6.0500   -0.7501    0.0000    0.0000    0.0000    0.0000  -74.7777
  36.1548   -6.0500    2.7501    0.0000    0.0000    0.0000    0.0000    0.0000
 X-upstrm X_Dwnstre      ztld      ztrd Z_Upstrea Y_Upstrea slit_dnst slit_dnst
      xtu       xtd      ztld      ztrd       ztu       ytu       sdz       sdx
  18.0007    6.0000   -2.5000   -2.5000    6.6600    2.4999   -1.0000    0.0000
  18.0007    6.0000   -2.5000   -2.5000    6.6600    2.4999   11.6493   16.2371
   X_left   Y_right    Y_left    Z_left  Z_rt_dwn   Z_rt_up        na      samz
       xl        yr        yl        zl       zrd       zru        na      samz
   9.6909   -6.0793   -0.2580   81.3648   39.8411   53.6280  -10.9995   -6.7999
   9.6909   -6.0793   -0.2580   81.3648   39.8411   53.6280  -12.6445    5.3800
Two-theta     Theta       Chi       Phi       ath  Z_sample    window     spar2
      tth        th       chi       phi       ath      zsam    window    spare2
   0.0000    0.0000  -90.0000  270.8000    0.0000   30.2500    8.9999  -10.5330
   0.7893  180.0000  270.0000  270.8000   32.0000   30.2500    8.9999  -10.5597
 slitup_x  slitup_z    ncaprx    ncaprz main_wall main_cent      samx   newname
     supx      supz    ncaprx    ncaprz       mwx       mcx      samx   newname
   0.0000    0.0000    0.0400    0.0500    0.0000    0.2500    1.0001    0.0000
  -9.0011    1.4266    2.3850    2.7037    0.0000    0.2500   10.0000    0.0000
   ccmrzu    ccmrzd  ccmrbend    ENABLE monu_2th   ana_tth  ana_xtal2 mon_chcut
   ccmrzu    ccmrzd     ccmrb    ENABLE   xmon2u      atth      ana2    xmoncc
  -1.1500    1.7047    0.0000    5.0000    2.0000  151.9790   12.7567    2.0000
  -2.0588    5.2918    0.0000    5.0000  262.0000   62.4790  279.0599    0.5000
X-dwnstrm       bsz       bsx  Motor 56  Motor 57  Motor 58  Motor 59    mond_z
      xd1       bsz       bsx       m56       m57       m58       m59    mond_z
   2.6508    0.0000    0.0000    4.0400    4.0000    3.5000    2.9744   68.9000
   2.6508    4.1800    2.8500    3.0000    4.0000    3.5000    3.5000   68.9000

2558.FOURC> 
```

May 4 Today we studied ways to broaden the beam coming from the monochromator. The evidence suggests that the reflection at the settings shown on p. 138 is from the 331 planes but suffers from strain in the second monochromator crystal. To test this, we remounted the second crystal with an artificial strain controlled by a piezo-electric crystal.



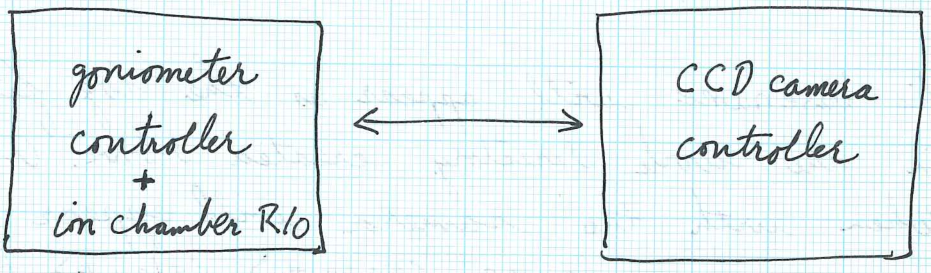
Using the PZ control and gravity we are able to produce variable strain across the crystal, with what is probably a single complicated strain pattern. This had a big effect on the beam shape from the 331 reflection



zero strain — low strain — high strain

This introduced the concept of "the worm" which we seem to be stuck with for the rest of this run.

May 5. <u>Data Acquisition</u>



c1.chess.cornell.edu

fli-detector.dynamic.chess.cornell.edu

* log on as specuser
* pw: CThrooMe
* spec
* ... any spec command
* ccd_on
* ...
* ccd_off
* ccd_on
* ascan ...

* log in as ~~root~~ specuser
* pw: CThrooMe
* cd /home/specuser/camserver
* ./camserver

(listening on port 41234)

"camera configured"
"shutter enable"

"closing socket, exiting process"

If the camserver computer gets rebooted for some reason, the following command must be executed on the fli-detector machine as user specuser.

* cd /misc
* ls c1 ← blank listing if not mounted
* ./connectc1

Steps to take to start a new run.

1. create a new directory under the specuser account on c1.chess.cornell.edu, eg.
   $ mkdir jones-5-2009
   $ cd jones-5-2009
2. start spec (or fourc) and cd into it.
   $spec> cd jones-5-2009
3. make a new run file inside spec
   $spec> newfile <basename>

This basename will appear as the log file name in the work directory created above. Any images taken with the camera will appear as

basename_<scan #>_<step #>.tif

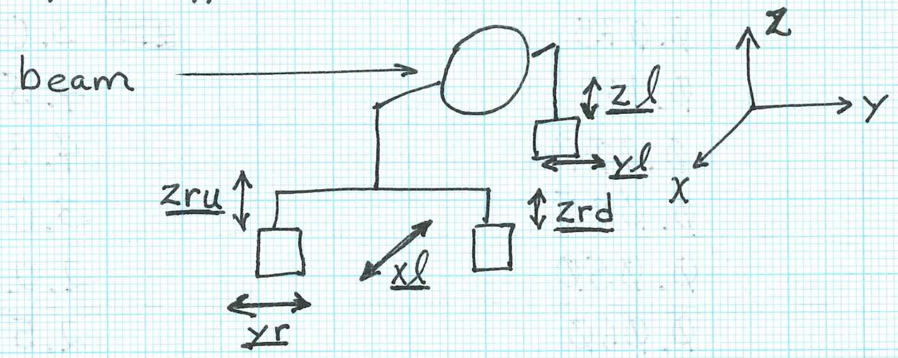
How to select a region of interest in the camera field

On the camserver machine, at the camserver prompt, use the command:

* flicommand imgarray <xlow><ylow><xhigh><yhigh>

Reducing 1040 × 1024 → 400 × 400 reduces total acquisition time for a 1-second exposure from 31s to 17s.

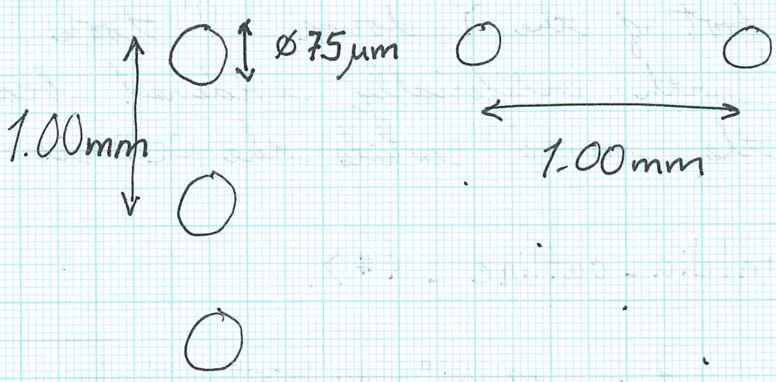
Layout of ~~d~~diffractometer displacement motors.



(Motor names in spec/fourc program are underlined)

Focusing the CCD camera

We obtained a mask with a round hole pattern



Pixels between hole centers: (in pixel units)

212, 166   254, 165

210, 124   253, 121

↕ 43 pixels = 1 mm

↔ 43 pixels = 1mm

> pixels are 23 µm x 23 µm

250, 36 → 254, 164 = 4 holes

= 42.7 pixels / mm <u>this checks out</u>

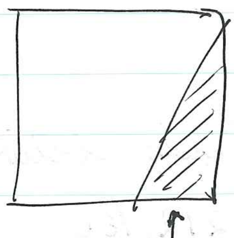
The micrometer on the side of the camera should be adjusted to optimize the focus.

Date	run	micrometer setting (in)	RMS size (pixels)
May 6	7	0.075	~~2.5~~ 3.0
	8	0.100	4.5
	9	0.000	4.3
	10	0.025	3.0
	11	0.050	2.2
	12	0.060	2.5
	13	0.040	2.5
	14	0.050	

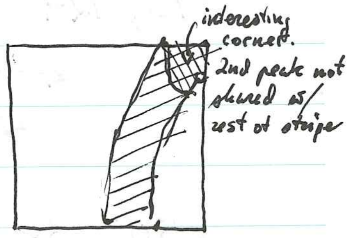
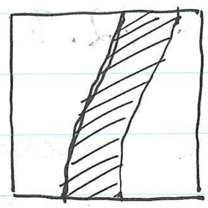
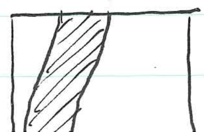
These files are saved as bnldia_spots_<run>.tif
These images are taken near X = -90. The diamond is oriented with the 3-tone surface upstream and the foot of the Y down. I took some topographs with artificially widened beam by sweeping the mono while the CCD is open.

bnldia_outline_<#>.

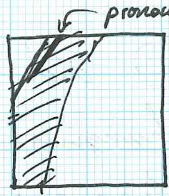
Now for scan 1 : 19.45° - 19.55°
(100 steps)



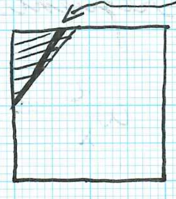
exposed

~~~6/6/pm~~ Scan 2 : — " — " — " —



~ 6 pm Scan 3 : — " — " — " —



~ 6:30pm Scan 4 : — " — " — " —


~~~

~ 6:55pm scan 5: —' —' —' —



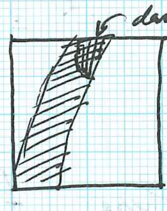
~ 7:25pm scan 6: — ' — " — -



false start with high-res run – dummy scan 7

High-resolution scan :8 θ: [19.490, 19.512], 100 steps

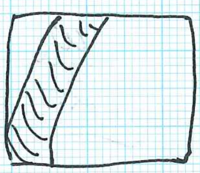
Repeat of above with settle time of 10s.



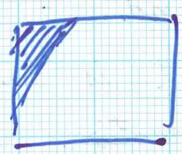
Now rotate the diamond in X to −183°. We found the peak again somewhere around θ = 18.85° and dancing around badly. Scan goes over 18.79° − 18.86°.

X = −48.5°

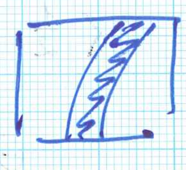
21:55 scan 12, 100 steps



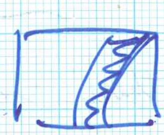
~23:00 scan 14, 100 steps



23:54 scan 15, 100 steps

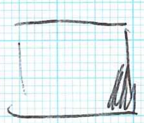


00:43 scan 16, 100 steps



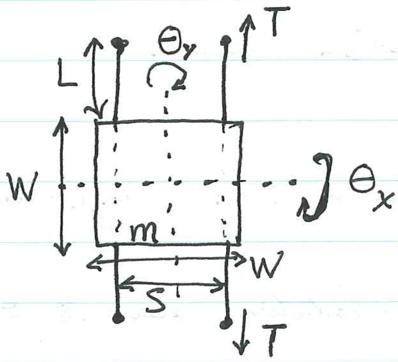
01:19 scan 17, 100 steps

scan 18, 100 steps



May 7 I did a normal modes analysis of the diamond hanging on these wires, and found the major frequencies.

$$\omega_x^2 = \left(\frac{W^2 T f}{I L} \right)$$



$$\omega_Y^2 = \left(\frac{S^2 T f}{I L} \right)$$

where $f = kL \cot(kL) \to 1$ for heavy mass m.
and $k = \frac{\omega}{v}$, $v = \sqrt{\frac{T}{\lambda}}$, λ = mass/length for the wire
and ω is the natural oscillation frequencies that are present in the driving force.
Numerically, I find for this setup.

$$\frac{\omega_x}{2\pi} = 200\ Hz \quad , \quad \frac{\omega_Y}{2\pi} = 180\ Hz$$

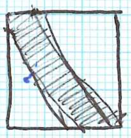
and $f = 0.98$ so the approximation $f \simeq 1$ is OK.
It is interesting to ask what the range of thermal motion is as a function of resonant frequency ω_0

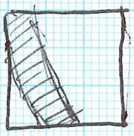
$$\langle \tfrac{1}{2} I \omega^2 \Theta^2 \rangle = \tfrac{1}{2} k T = \frac{(1.38 \cdot 10^{-23} /K)(293\ K)}{2}\ J$$

$$\Theta_{rms} = 1 \times 10^{-8} \text{ radians}$$ ≈ too small to care about here!

So there must be local vibration sources that are driving this motion. In general, increasing the frequency should result in lower amplitude and less sensitivity to local noise sources.

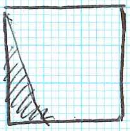
03:44 scan 22, th 27.74 – 28.09°, 100 steps 

04:27 scan 23 → 

scan 24 stopped at image 87 due to RF problems → 

8:20 am: Igor's shift

CESR stable by the time of my arrival
scan 24 completed automatically.

scan 25: (same θ range) 

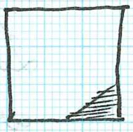
9:30 am
Rotating 90° to −138.5° to do the other 004 plane

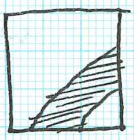
Looking for beam/diamond orientation: scan 26: θ [27.84°, 28.00], 20 steps 3sec exp.

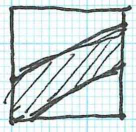
Playing with θ-knob to get the outline of the diamond, it was found that the region of interest must be moved down to (600,455)(1000,655). This should not pose a problem of beam coverage – the "worm" extends far below this region.

Another crude scan to determine sensible limits in θ: scan 27: [27.6–27.75], 16 steps

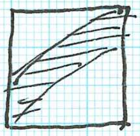
Settled on θ range: [27.65, 27.74], 90 steps should suffice for this short range.

10:09 am scan 28 

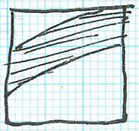
~10:35 am scan 29 

11:13 am scan 30 

Looks like the rocking curve is shifted or broader starting at this point (toward higher θ). Switching to θ ∈ [27.65, 27.75], 100 steps

11:53 am scan 31 Note: air conditioning shut off for this run. Compare to previous curves. 

Supplementary scan 32 was necessary because the tail at higher θ is cut off. 30 steps to 27.78°

~12:50 scan 33: New limits: θ: [27.7, 27.8], 100 steps. 

13:20 scan 34, new limits: [27.73, 27.83], 100 steps 

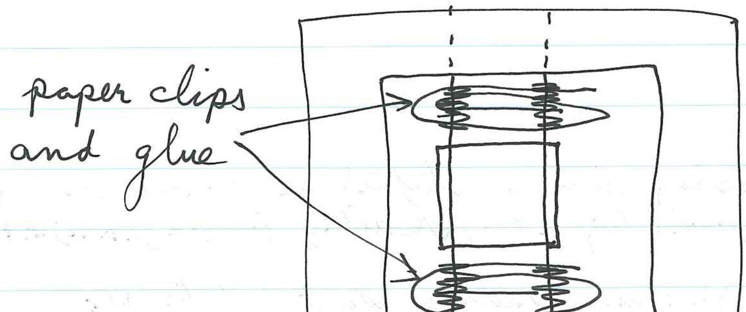
* Changed to new run: <u>bnl-5-2009a</u>

Oriented the diamond back in 220 position at $\chi = -93.5°$. Added paper clips to load the wire oscillations and shift down the frequencies.

scan 1 : rough scan : $\theta = 19.5° - 19.9°$; 20 steps
this rocking curve looks narrower!

2 : fine scan : $\theta = 19.68° - 19.74°$, 100 steps
(aborted, must start earlier)
3 : $\theta = 19.67° - 19.74°$, 100 steps
(aborted, must start earlier)
4 : $\theta = 19.65° - 19.74°$, 100 steps
(failed due to shutter, retry)
5 : $\theta = 19.65° - 19.74°$, 100 steps
(stopped to put "tent" over target)
6 : $\theta = 19.65° - 19.74°$, 100 steps

Looks even wider than before, I think there are still significant oscillations in the diamond with the paper clip weights.



The paper clips do not touch the frames, only the wires. See photos for more detail.

Now we removed the diamond from the wires and stuck it on a post in a lump of wax.

scan # 8 $\theta = 21.492° - 21.522°$

-scan stopped after 50 frames - narrow peak!

scan # 9 $\theta = 21.492° - 21.522°$

shifted beam, run scan again

-aborted because peak region moves with worm!

scan # 10 $\theta = 21.482° - 21.512°$

-aborted, still need to bracket peaks.

scan # 11 $\theta = 21.472° - 21.502°$

- cut short at 40 steps, peaks finished

scan # 12 $\theta = 21.522° - 21.552°$

- aborted, beam spot seems too close to last.

scan # 13 $\theta = 21.522° - 21.552°$

#14-20 - aborted, searching for the peaks again

scan # 21 $\theta = 21.4617° - 21.4917°$

scan ended after 15 steps to take down beam.

Orientation check of the diamond in wax: