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12/11/91
PBAR Note 517

Measurement of Emittance of beam in the Debuncher during stacking

SUMMARY

The emittance of antiprotons in the debuncher was measured using two methods during normal stacking conditions. With 2.3 seconds of cooling the vertical emittance was found to be 3.6 π mm-mr using scraper D:TJ308, and 2.9 π mm-mr using the profile on SEM806. With 6.9 seconds of cooling time time the measured horizontal emittance was 2.1 π mm-mr using D:RJ306 v.s. 1.9 π mm-mr using SEM806; but with 2.3 seconds of cooling the measured emittance in the debuncher was larger than in the DTOA line, 4.5 π mm-mr v.s. 2.8 π mm-mr. This suggests that some beam is being scraped on a horizontal aperture restriction someplace in the extraction process.

MEASUREMENT TECHNIQUE

The measurements were taken during normal stacking conditions. The cooling systems were gated by setting the switches and timers in Figure 1 to the settings shown. To capture beam in the machine the timing device T:TD8C was turned off. Note that for the longer cooling time, 6.9 seconds, the switches sometimes got confused. In order to obtain a good measurement it was necessary to watch the debuncher schottkey spectrum on SA2 to make sure that the cooling actually was on for the desired 6.9 seconds. To get the timers to work properly try the following: turn off T:TD8C, wait 10 seconds, turn it on then off in time to get one beam pulse.

For each dimension two scrapes were performed. The first using D:ISPECV determined the position of the central orbit. The second, using D:YIELDI, determined the outer edge of the beam. The beam edge was defined as the point where 10% of the beam had been scraped away. D:YIELDI reads out .125 when there is no beam, this offset was taken into account. The emmittance of the beam was

calculated as: 1.19*[delta(x)]**2/beta, where the scale factor converts the measurement of the 90% emmittance to the 95% Fermilab standard.

MEASUREMENT RESULTS

Figures 2 and 3 show the results of the two scrapes using D:RJ306. The distance between the beam center and the 90% point is 8.65 mm; in PBAR units of mm. Using the known beta function at the scraper and correcting for the mis-calibrated scraper scale gives a measured emittance of 4.5 π mm-mr. A similar calculation using the results of Figures 3 and 4 yields a measured vertical emittance of 3.6 π mm-mr.

At the time of this measurement only 1-7/8 SEM's were working in the DTOA channel. Figure 6 shows the distribution on SEM802, which is too narrow to give any useful information. Figure 7 shows the distribution on SEM806, note that two wires in the center of the y distribution are dead. The emittance was calculated using two methods. By counting the total number of wires hit the 100% emittance was calculated to be 3.0 π mm-mr in both dimensions. In the horizontal dimension I also used the calculated σ of the distribution, 3.6 mm, to determine the 95% emittance assuming a gaussian distribution. The 95% horizontal emittance is 2.8 π mm-mr. Please note that the horizontal dispersion at SEM806 is -1.17 meters. The debuncher momentum spectrum after 2.3 seconds of cooling has a full width of .3%. Since the dispersive width should be added in quadrature to the betatron induced with the dispersive effects are negligible.

Two measurements of the vertical emittance agree to my satisfaction. The two horizontal measurements do not agree. One possible explanation for the discrepancy could be if some aperture restriction is cutting off the horizontal tails of the beam. Figures 8 and 9 show measurements of the horizontal emittance taken after 6.9 seconds of cooling. The measured emittances, 2.1 π mm-mr and 1.9 π mm-mr now agree with much better precision than before. This gives me confidence that both methods of measuring

the emittance are indeed correct, and that some beam is being lost on extraction.

CONSOLE LOCATION 15; AP10
Main color TV

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Figure 1

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P60  DEB EMMITTANCE SCRAPE 12/91    SET      D/A    A/D  Eng-U ♦COPIES♦
-<FTP>+ *LX♦ X-A/D   X=D:TJ308   Y=D YIELDI,D:ISPECV,A EMITV ,A IBEAM
COMMAND ---- Eng-U   I=-8         I= .5      , 0       ,-10      , 0
-<22>+   r_81 AUTO   F= 24        F= 2.5     , .5      , 10      , 4
acc10 acc30 acc50 deb10 deb30 deb50 protn  INJ   dtoa   ext    bostr

 !COOLING SWITCH    4=GATED, 12=UNGATED
-D:DVPS01      VERT BETATRON PIN SW          4
 !COOLING SWITCHES 1=GATED, 3=UNGATED
-D:DHPS01      HORZ BETATRON PIN SW          1
-D:DPPS01      DEB MOM PIN SWITCH            1
 !ON TIMES - 81 IS BEAM TIME
-D:DVP11       On Event for D:DVPS01  0              0/81/       SECS ...-
-D:DHP11       On Event for D:DHPS01  0              0/81/       SECS ...-
-D:DPP11       On Event for D:DPPS01  0              0/81/       secs ...-
 !OFF TIMES
-D:DVP21       Off Event for D:DVPS0  2.3            2.3/81/     SECS ...-
-D:DHP21       Off Event for D:DHPS0  2.3            2.3/81/     SECS ...-
-D:DPP21       Off Event for D:DPPS0  2.3            2.3/81/     secs ...-
 !SAMPLE TIMES - NOTE: FIRST TWO ARE IN USEC...
-D:DVTWT1      TWT GET DATA TRIGGER   1000000    *  1000000/81/ USEC ...-
-D:DHTWT1      TWT GET DATA TRIGGER   1000000    *  1000000/81/ USEC ...-
-D:DBTWT1      TWT GET DATA TRIGGER   1             1/81/       SECS ..
-A:SPSA2       TRIGGER FOR SA2        .5            .5/OFF/     SECS ..
 D:YIELDI      SPECT ANAL .1-10000 UAMP                3.335    uAmp
-T:TD8C        Time Delay to make ev  .96  OFF,ON     .96        SECS ...-
-D:RJ306S      DEB SCRAPER R. JAW SLOW      <      >    44.04     mm   .T.
-D:RJ306F      DEB SCRAPER R. JAW FAST      <      >    44.04     mm   .T.
-D:TJ308S      DEB SCRAPER TOP JAW SLOW     <      >    44.79     mm   .T.
-D:TJ308F      DEB SCRAPER TOP JAW FAST     <      >    44.79     mm   .T.
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Fast Time Plot
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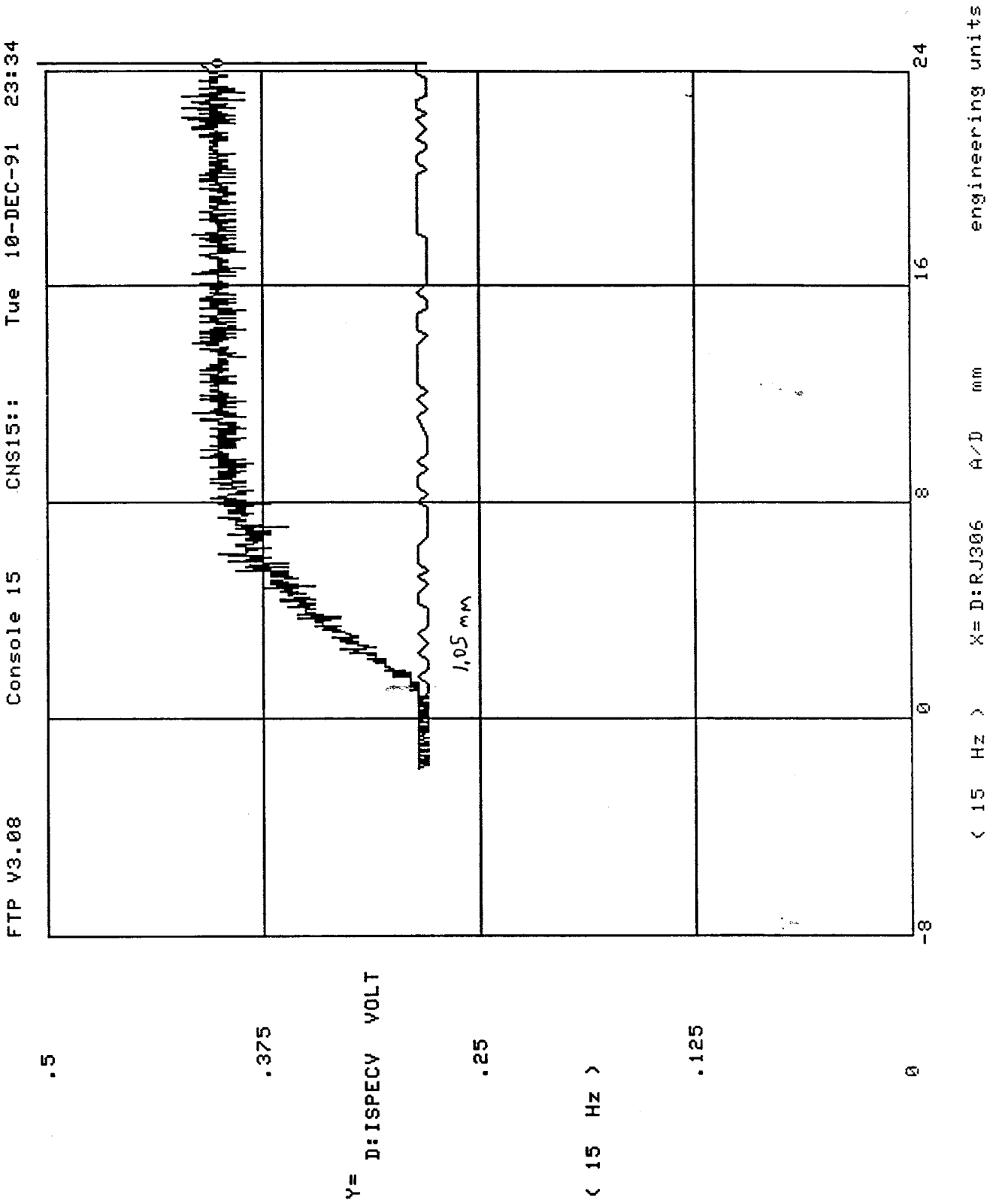
Figure 2



CONSOLE LOCATION 15; AP10
Fast Time Plot

10-DEC-1991 23:31
0

Note offset
Zero - no
Beam = .125

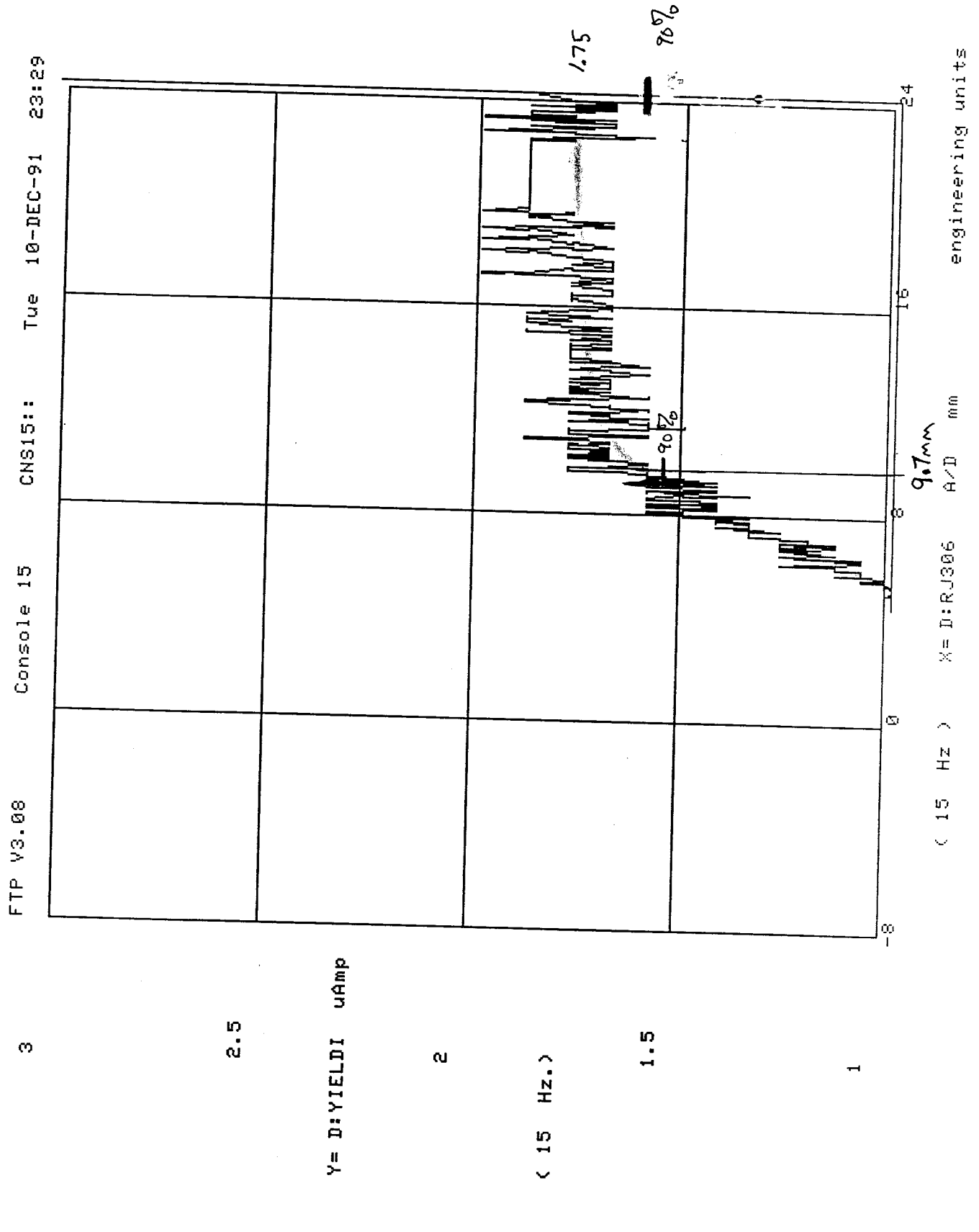


Figure 3

$\Delta X = 8.65$ mm

$\xi_X = \frac{5.7 \text{ mm-mr}}{(.2213)^2} = 3.8 \text{ mm-mr}$

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Fast Time Plot

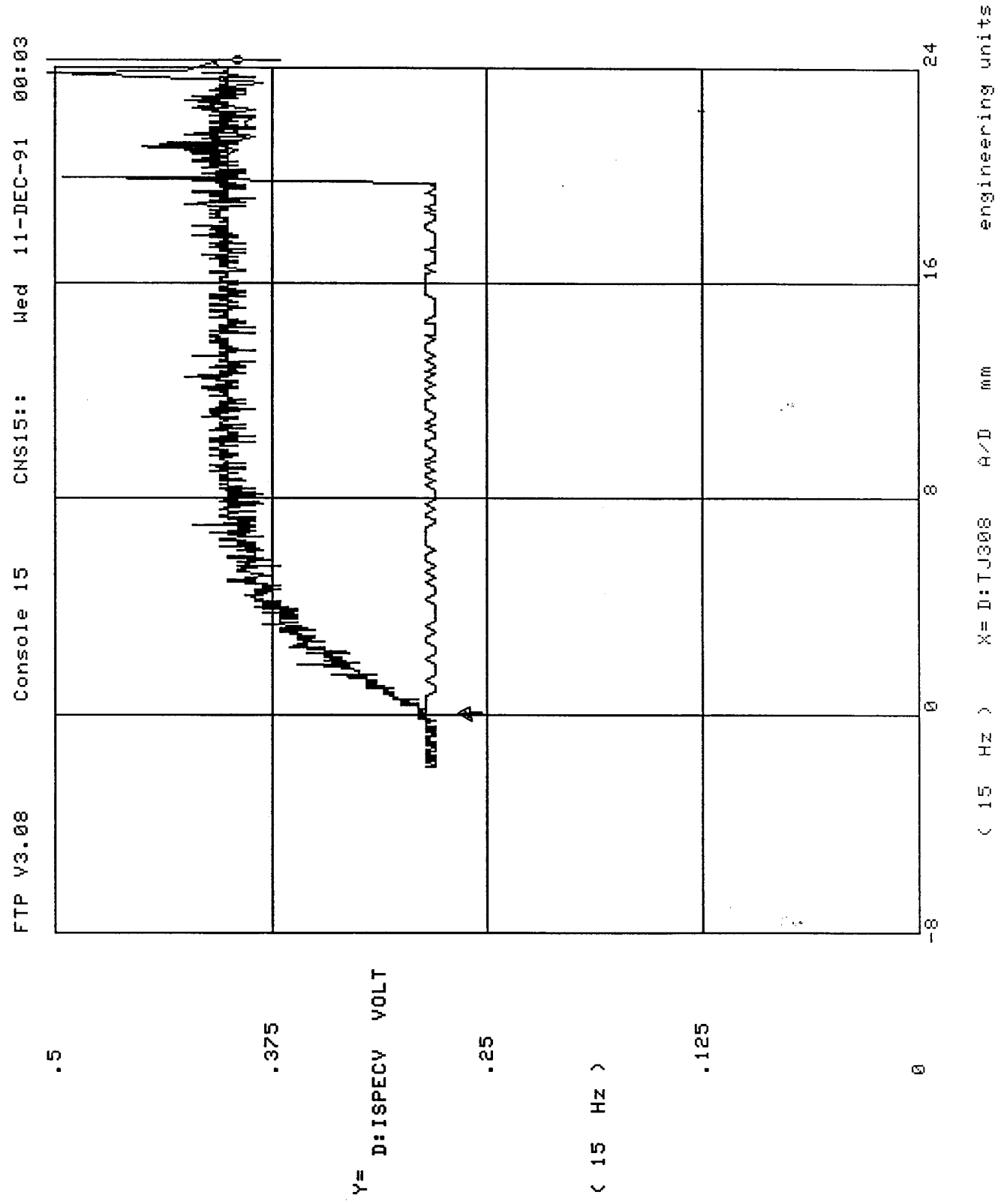
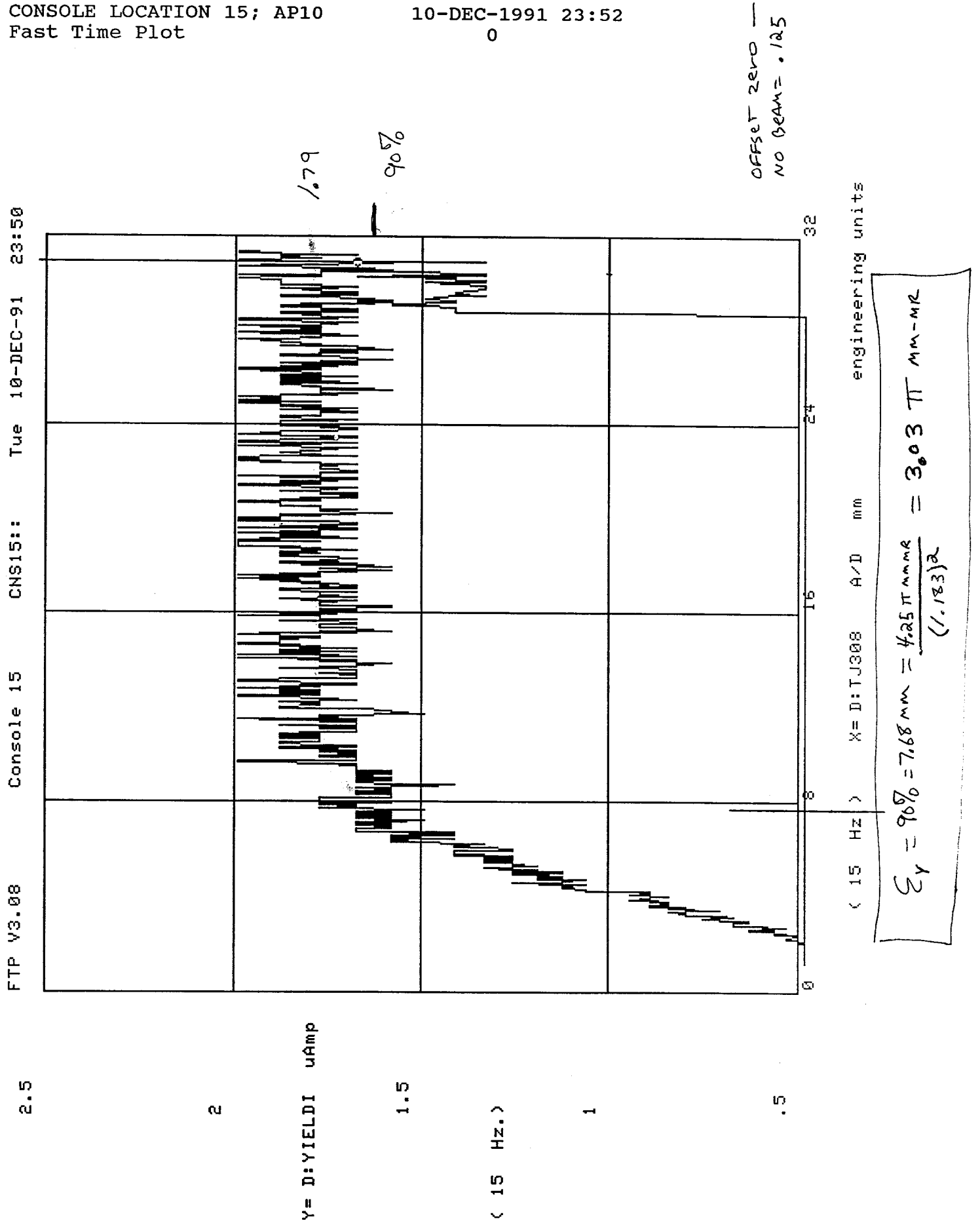


Figure 4

Figure 3



$$\varepsilon_Y = 90\% = 7.68\,mm = \frac{4.25\,\pi\,mm\text{-}mr}{(1.183)^2} = 3.03\,\pi\,mm\text{-}mr$$

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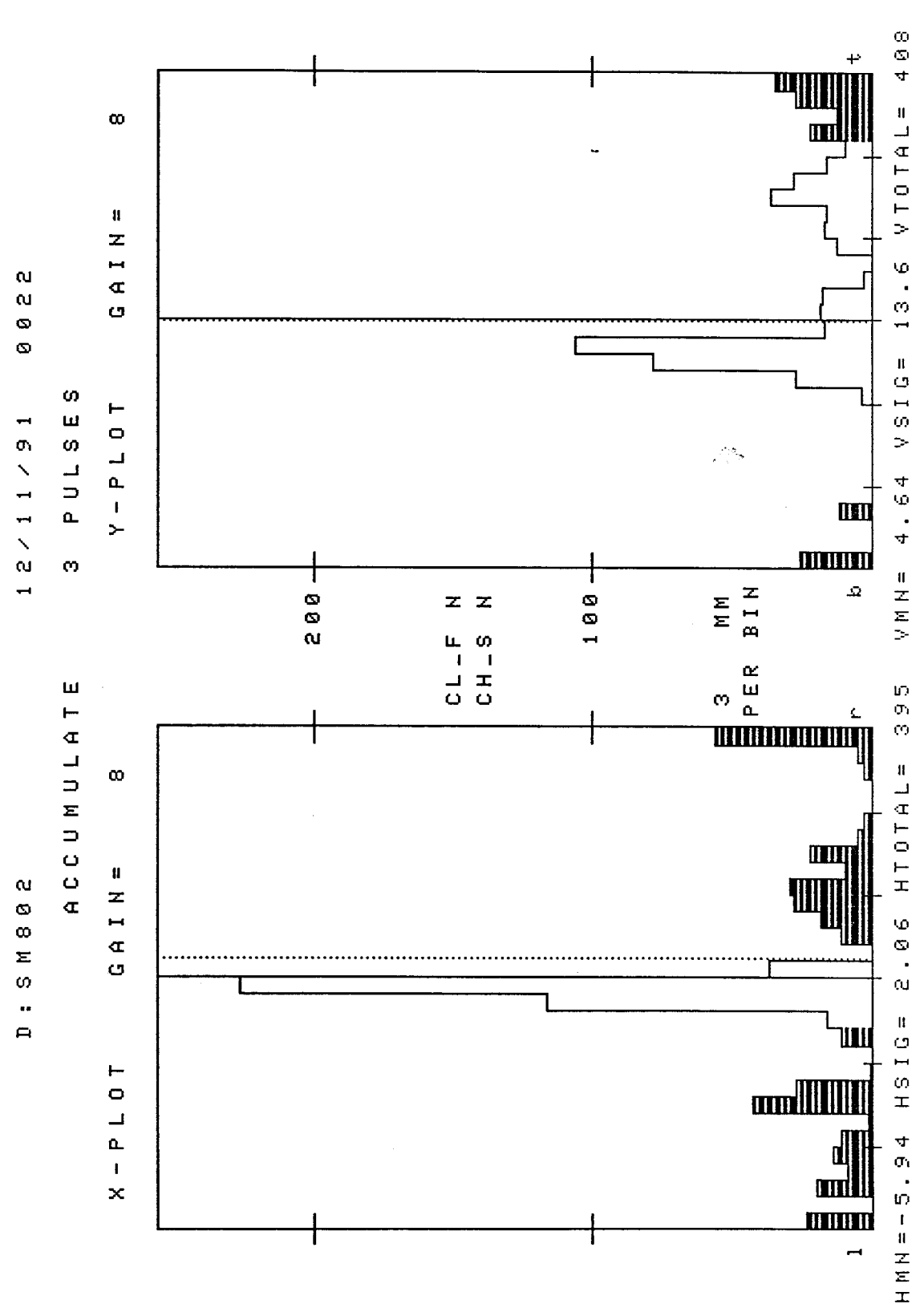
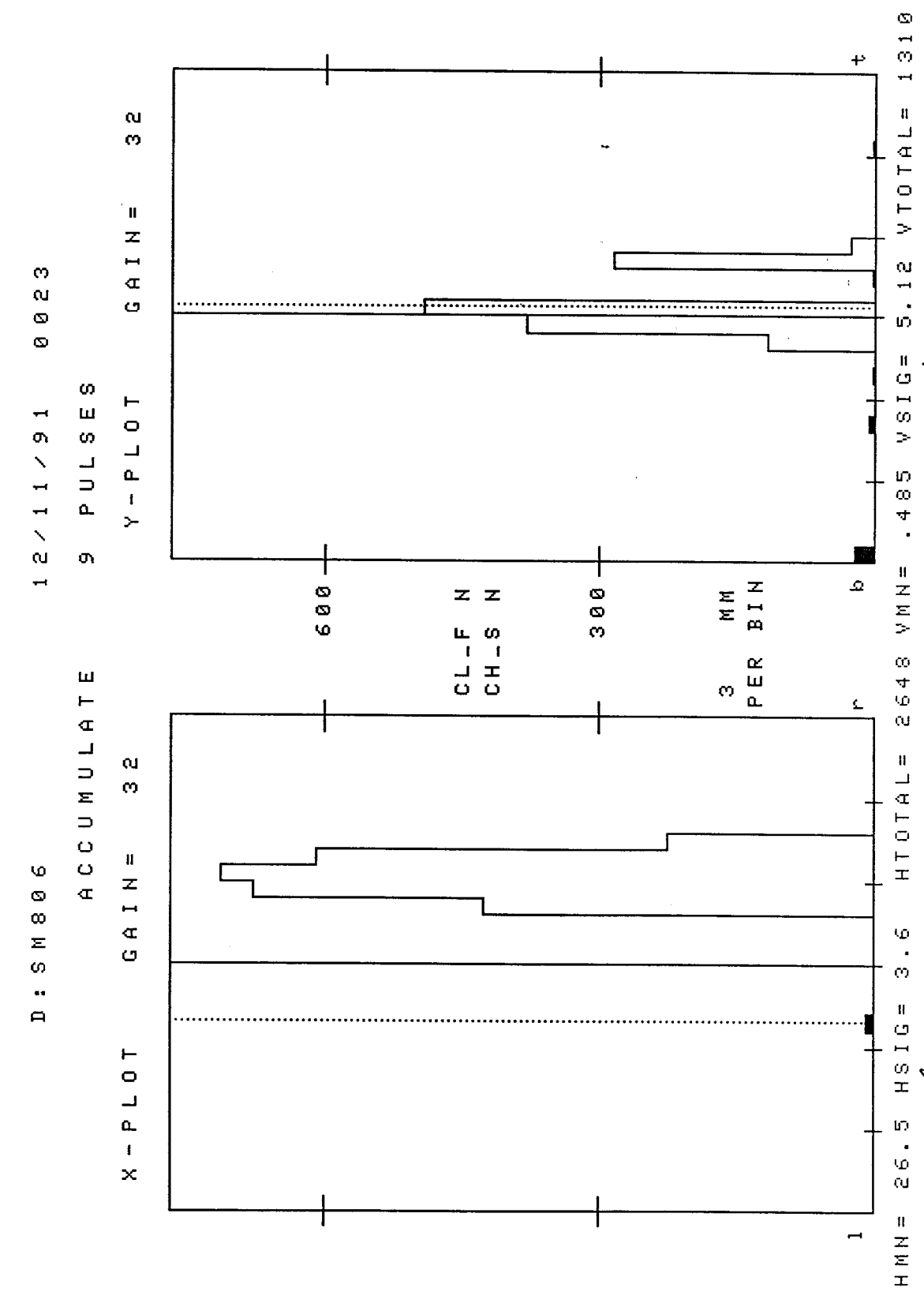
C614 Storage Scope Emulation

Figure 6



CONSOLE LOCATION 14; AP10 11-DEC-1991 00:23
C614 Storage Scope Emulation

Figure 7



$B_y = 4252$
100% of Beam within 2.5TT

$B_x = 22.14$
100% of Beam within 2.5TT
96% of " " 2.35TT

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Fast Time Plot

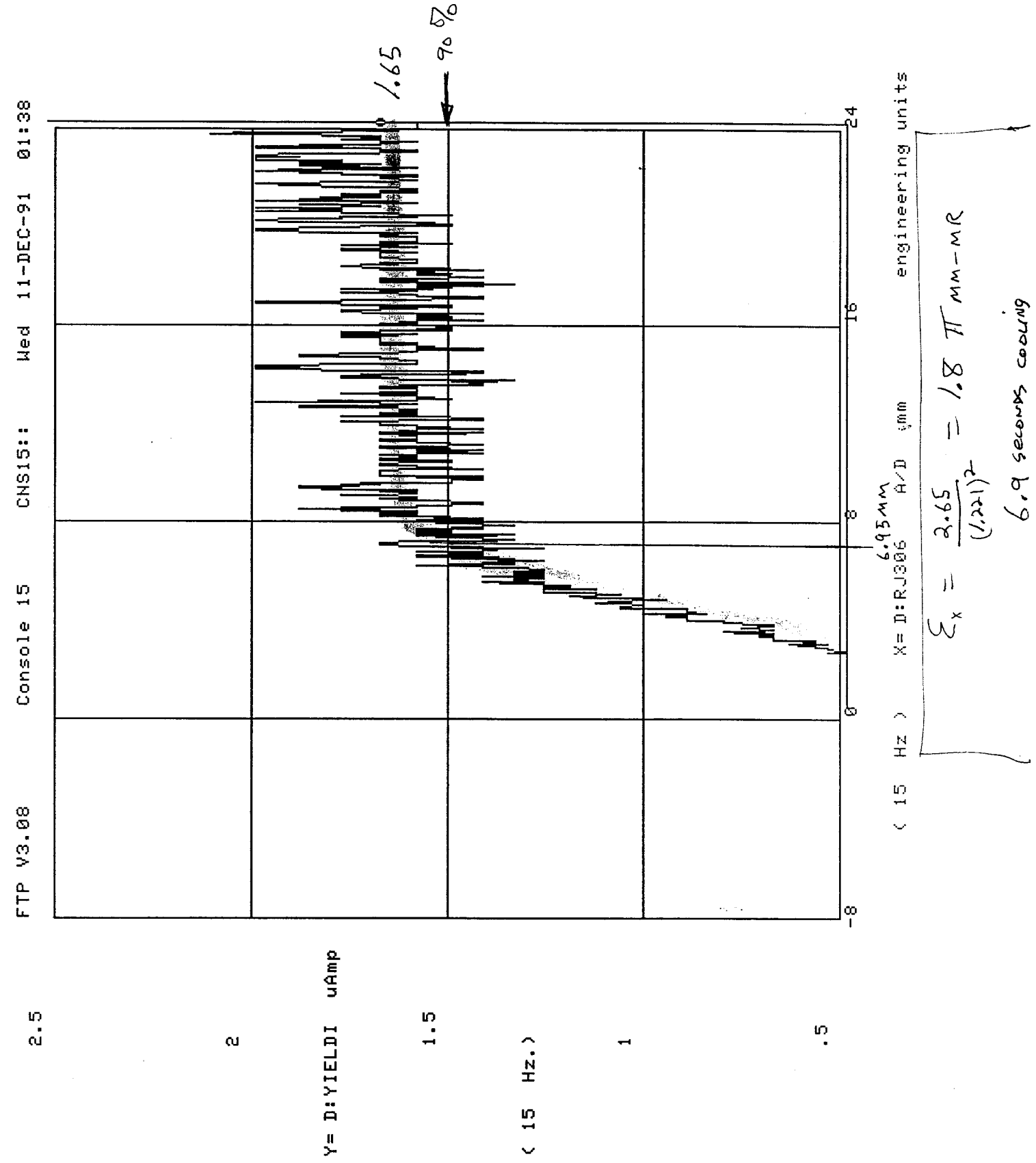

Figure 8

$$\varepsilon_x = \frac{2.65}{(1.221)^2} = 1.8\ \pi\ mm\text{-}mR$$

6.9 seconds cooling

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C614 Storage Scope Emulation

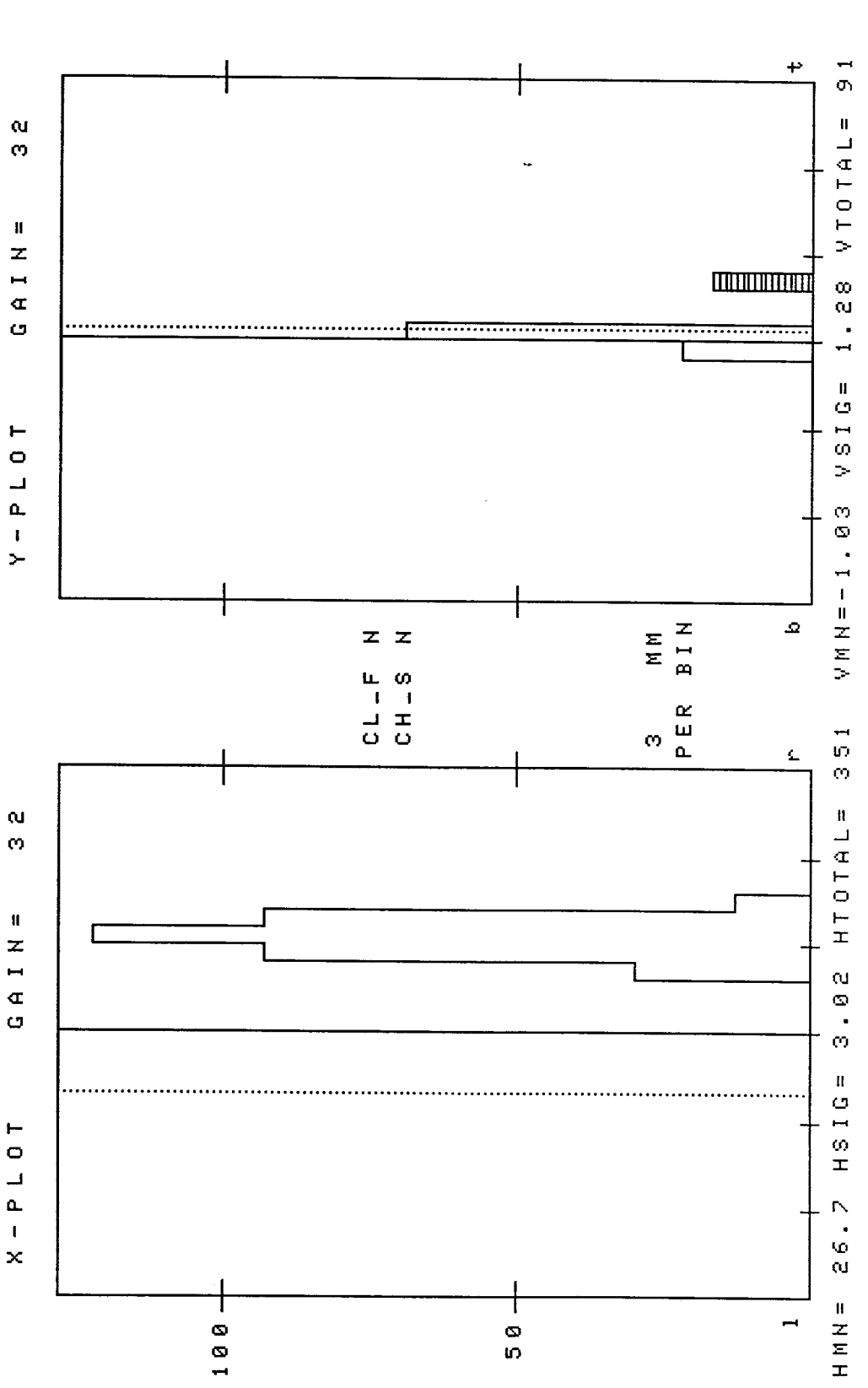

Figure 9
6.9 seconds cooling

$\sigma_x = 1.62$ mm-mr
96%

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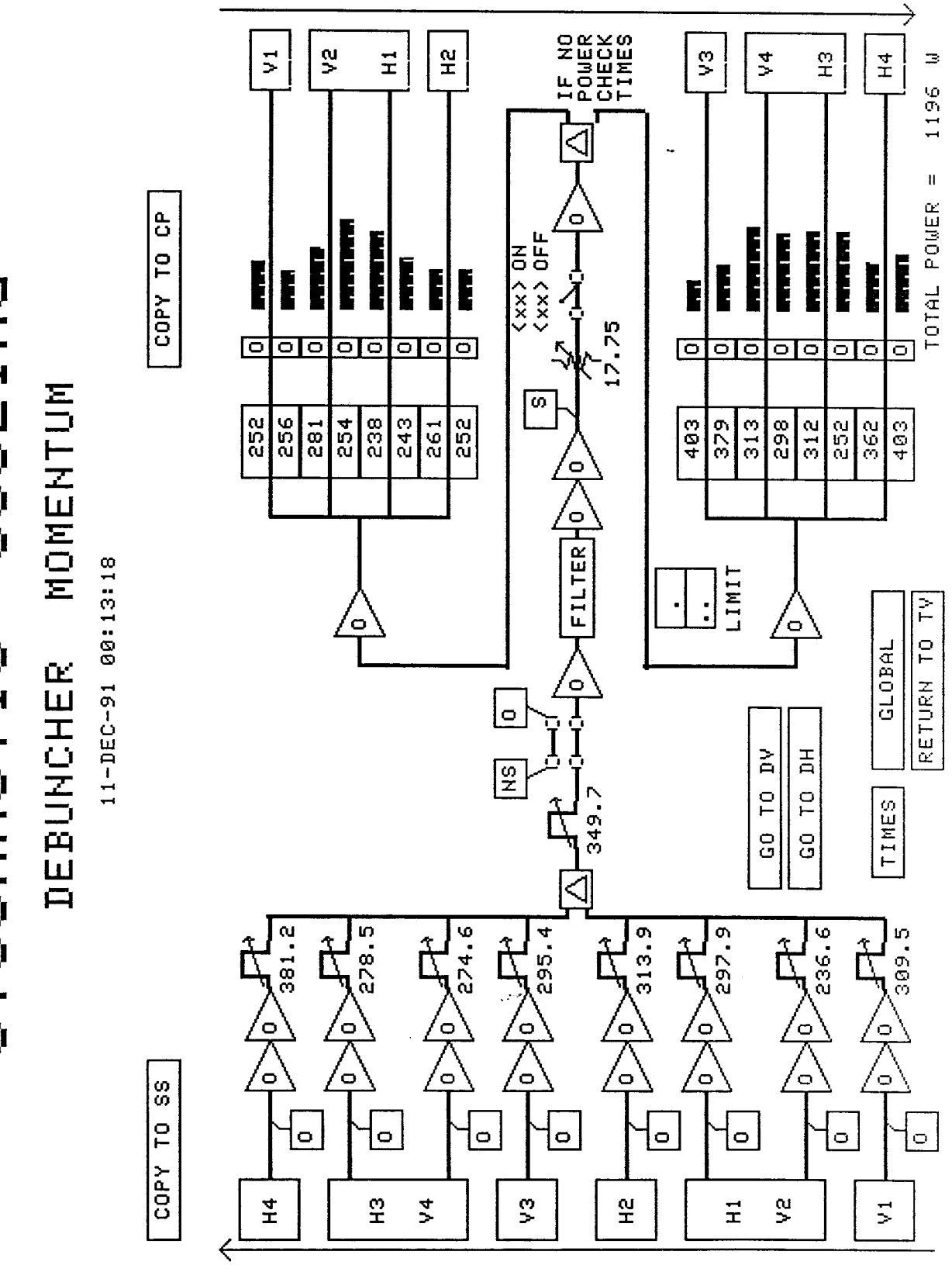
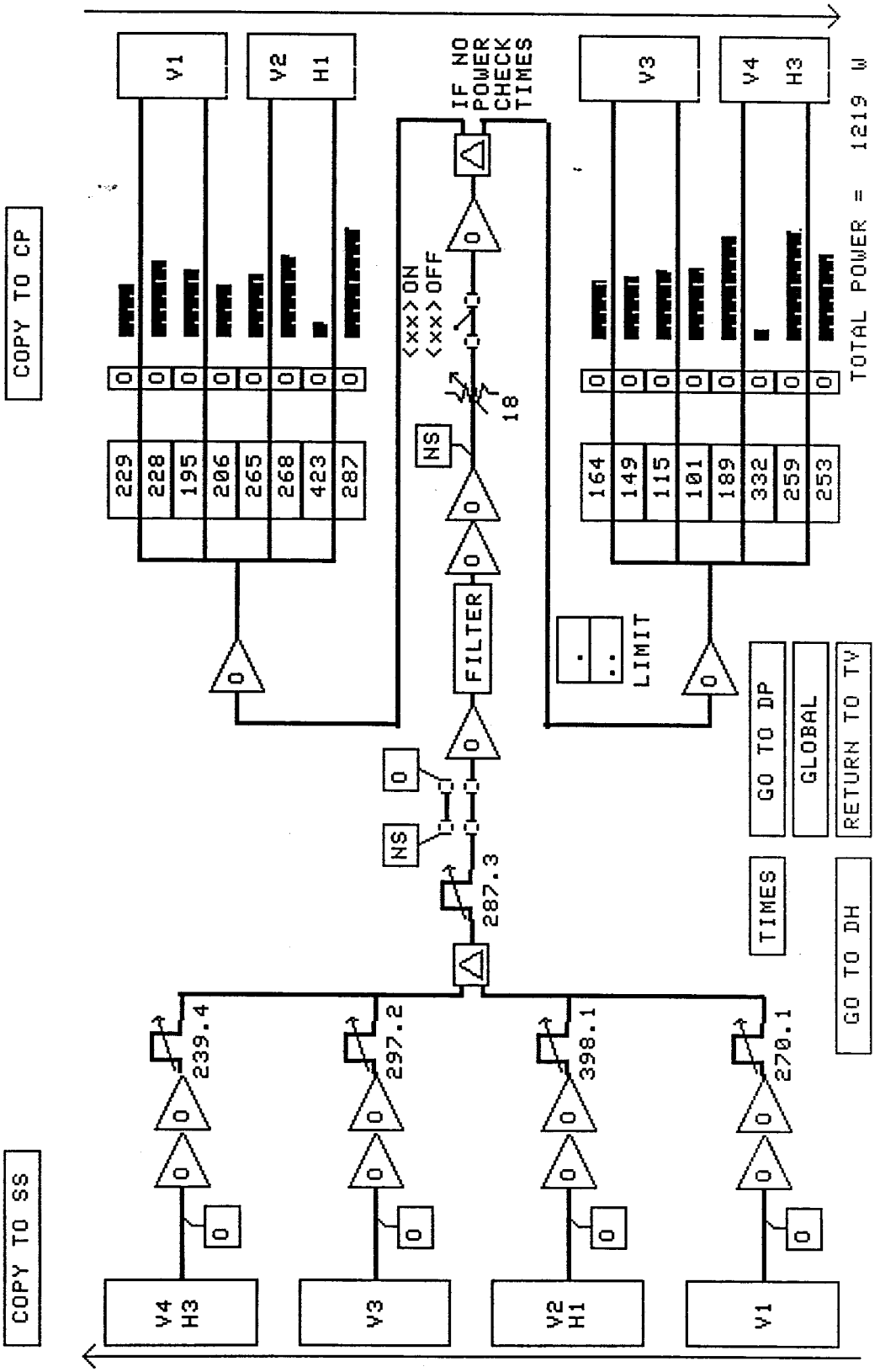
P25 GRAPHICS DISPLAY



CONSOLE LOCATION 43; 11-DEC-1991 00:14
P25 GRAPHICS DISPLAY



CONSOLE LOCATION 43; 11-DEC-1991 00:14
P25 GRAPHICS DISPLAY