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SEB Extraction Study I - Calibrations of the Ring Loss Monitor (RLM) and the Secondary Emission Chamber (SEC) by Changing the Electrostatic Septum Position and Skew (H2OUS/DS)

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Subject SEB Extraction Study I - Calibrations of the Ring Loss Monitor (RLM) and the Secondary Emission Chamber (SEC) by Changing the Electrostatic Septum Position and Skew (H20US/DS)

I. Introduction

As the AGS beam intensity has been steadily increasing, a further improvement in SEB extraction efficiency is seriously under consideration in order to keep the activation of sensitive machine components during extraction as low as possible. In 1979 an electrostatic wire septum was installed at H20, resulting in an increase of the SEB extraction efficiency from 85% to 97%.

Since it is difficult to measure the absolute extraction efficiency, which is close to 100%, with high accuracy, the beam loss, i.e., the extraction inefficiency, is measured instead.[1] The purpose of this study is to measure the extraction inefficiency with the present H20 septum calibrating the RLM against the SEC.

II. SEC Sensitivity on the Beam Position

The beam spot (0.6 cm ϕ) on the CE011 flag was moved horizontally from the edge to edge (2.5 cm) by changing the F10 ejector current (F10FN) to check the so-called radiation induced aging effect. During the movement, the SEC response normalized to the circulating beam intensity (CBM), SEC/CBM, stayed constant at 8.14 ± 0.06, showing no aging effect within an accuracy of $\pm$ 0.8% level (Figure 1).

III. RLM/CBM vs SEC/CBM

To study the RLM response against the SEC reading, the beam loss during extraction was varied by changing H20US and/or H20DS. Results are summarized in the following figures:

A.(1) CBM = 4.2×10^{12} ppp
Figure 2a: SEC, RLM.../CBM vs H20US with H20DS = 2043 (mils)*
Figure 2b: RLM/CBM vs SEC/CBM

*There was a minimum hardware limit of H20US = 1725.

(2) CBM = 2.4×10^{12} ppp
Figure 3a and 3b: the same except CBM*

*When learning that H20LS (H20 loss monitor) was not functioning properly, CBM was reduced to protect the H20 septum from possible radiation damages.

- As H20US moves back and forth, SEC/CBM exhibits the so-called backlash effects as much as 10 counts (mils).

- Somehow the curves of RLM/CBM vs SEC/CBM display a substantial amount of hystersis, which cannot be explained simply by the backlash effects.

- SEC/CBM dropped by 15% when CBM changed from 4.2 to 2.4×10^{12} ppp while RLM, F105L.../CBM did not show any strong CBM dependence.

  It is not expected that there is any strong beam intensity dependence since SEC, RLM... are normalized to CBM.

- During this data taking, the CBM reading varied to to 18% pulse by pulse, indicating that the machine was not stabilized enough. In the figures, 5 to 10 pulse-average values are plotted to eliminate pulse-to-pulse variations.

B. The following data was taken when the beam intensity was rather stable with CBM = $(2.6 + 0.1) \times 10^{12}$ ppp.

Fig. 4a: SEC,RLM.../CBM vs H20DS with H20US = 1773
Fig. 4b: RLM/CBM vs SEC/CBM
Fig. 5a: SEC,RLM.../CBM vs H20DS with H20DS = 1725
Fig. 5b: RLM/CBM vs SEC/CBM

Since the amount of hysteresis had been reduced significantly with the more stable beam, Fig. 4b and 5b are combined. Ignoring the hysteresis, a linear fit to the data gives RLM/CBM = 13 - 1.9 x SEC/CBM, which yields a SEC calibration of 6.8 counts/10^{10} protons and a RLM calibration for beam loss to be 13 counts/10^{10} protons. At the optimum position of H20US = 1725 and H20DS = 2043, the extraction (in)efficiency is estimated to be approximately 96(4)%.

IV. Spiral Pitch at H20

Fig. 6a shows SEC,RLM and H20LS/CBM as a function of H20DS with H20US adjusted to minimize the H20LS at each point as shown in Fig. 6. From the figure, the spiral pitch or beam width can be measured to be 0.56 cm (0.22") as the distance between the dip in RLM around H20DS = 2040 and the fall-off in H20LS near H20DS = 2260.

Fig. 6a: SEC, RLM, H20LS vs H20DS with the optimum H20US position which minimizes H20LS at each H20DS setting.
Fig. 6b: H20US vs H20DS

V. Conclusions

We attempted to calibrate the SEC and RLM, which have been used to measure the SEB extraction efficiency, by moving the H20 septum position and skew. The data indicate that at the optimum H20 position the extraction efficiency is in the vicinity of 96% and the spiral pitch at H20 is 0.56 cm, consistent with the previous measurements.[2]

However, it is unclear at this point to what extent the measured calibration factors are accurate and reliable because the data exhibit a strong beam intensity dependence, a large amount of hysteresis, pulse-to-pulse variations, and day-to-day variations without any change of the SEB parameters.

We later learned that the CBM timing trigger was set at 100 ms to T0, i.e., before the transition. For extraction efficiency measurements the XCBM (post transition CBM) with a timing trigger just before the extraction (780 ms) is a proper parameter. the use of XCBM has reduced pulse-to-pulse variations of SEC/XCBM as shown in Fig. 7a and Fig. 7b. CBM (100) ≃ 1.1 x XCBM (780).

For the next SEB extraction study, we plan to investigate the SEC and RLM responses on the beam intensity (XCBM), rather than playing with other SEB parameters like the F5 septum position and skew.

VI. References

1. J.W. Glenn and H. Weisberg, AGS Div. Tech. Note No. 133 (1977).
2. H. Weisberg and J.W. Glenn, Nucl. Inst. & Methods 169, 319 (1980).

mvh
TANAKA/STUDY

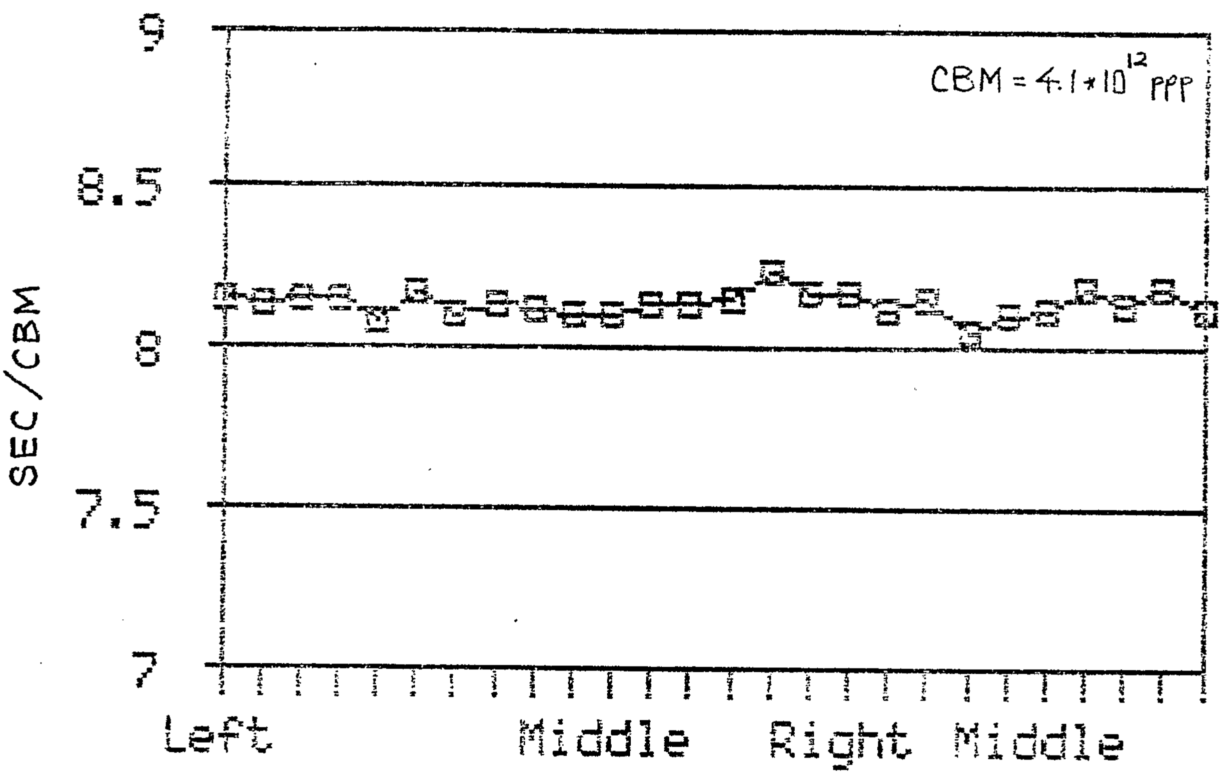


Fig. 1 The Beam Spot Position

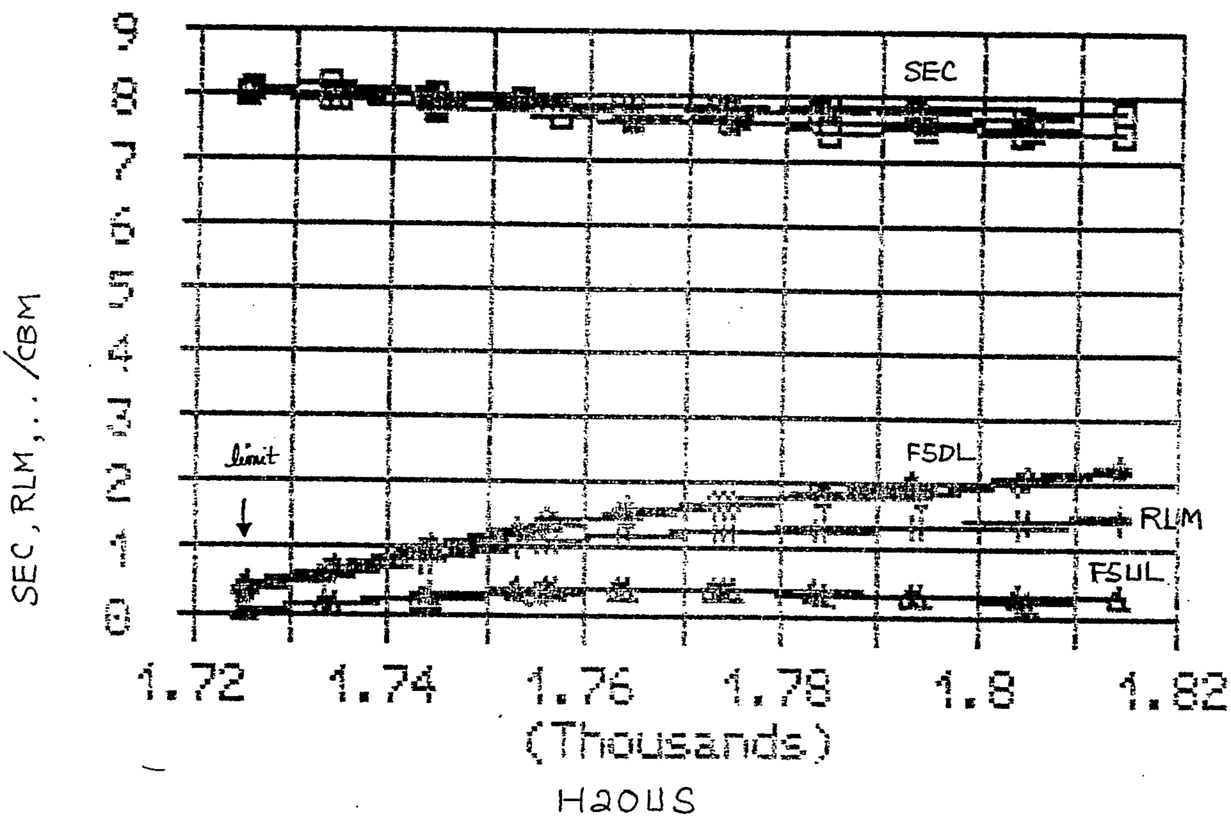


Fig. 2.a

$CBM = 4.2 \times 10^{12}$ ppp

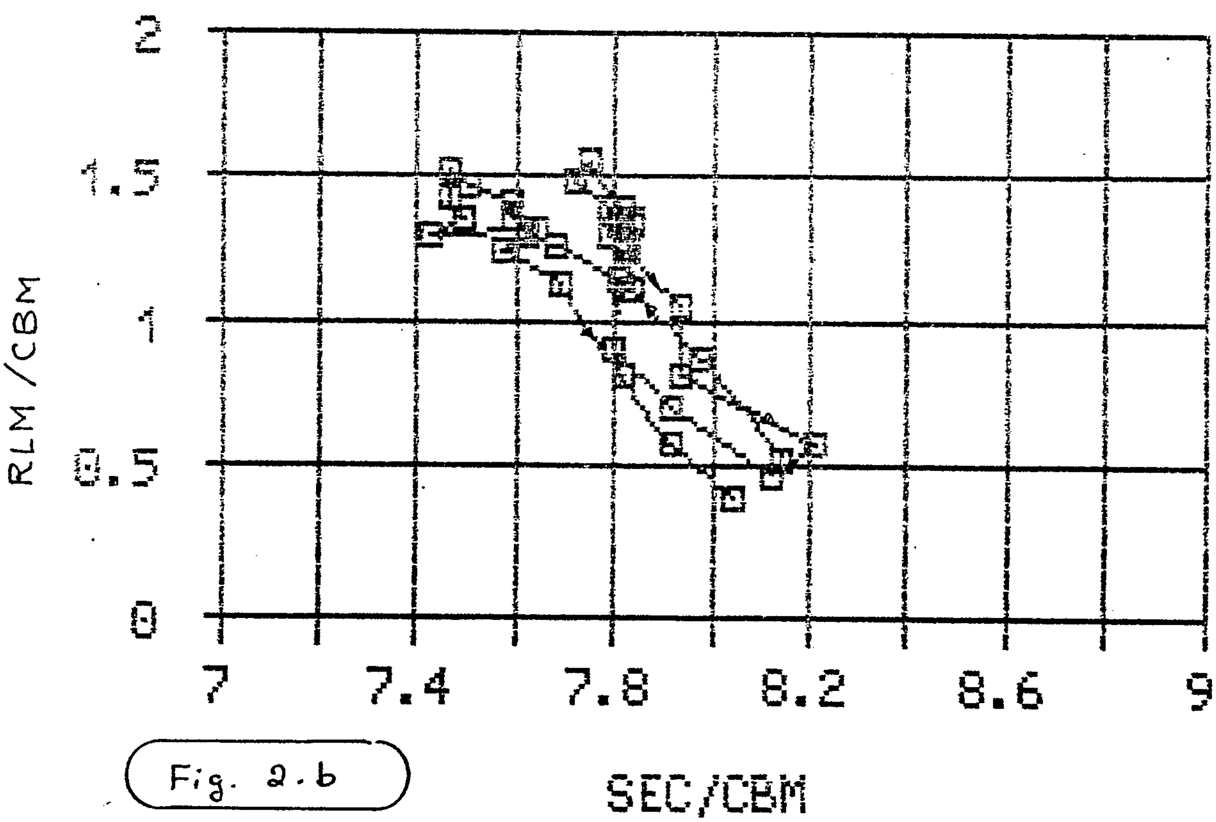


Fig. 2.b

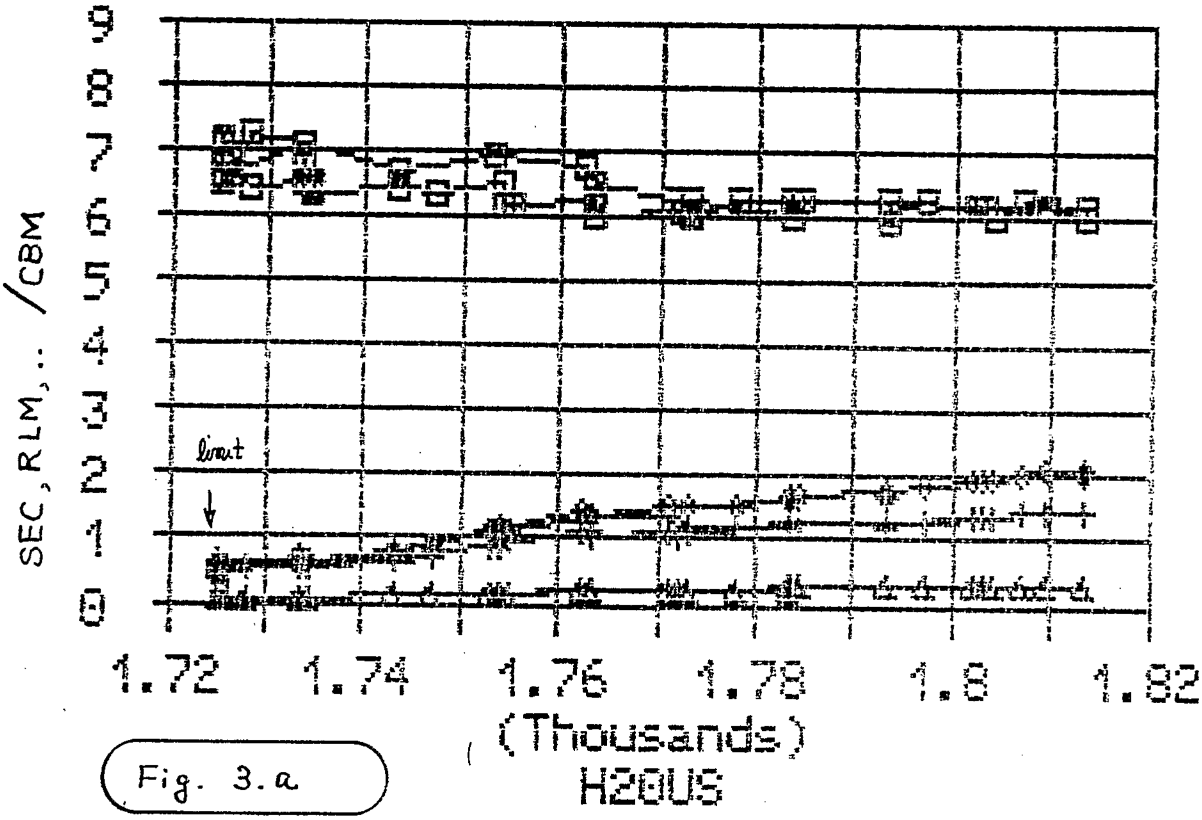


Fig. 3.a

CBM = 2.4 × 10^12 ppp

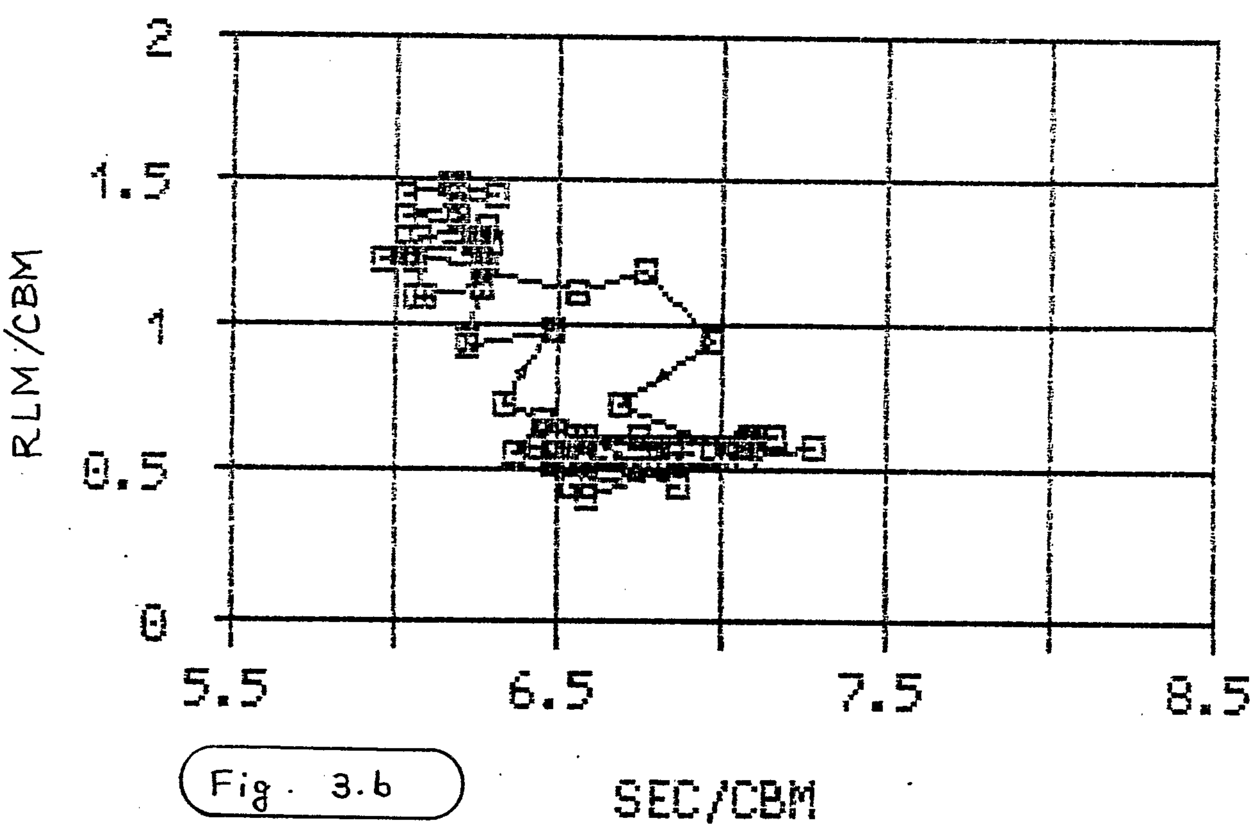


Fig. 3.b

at H2OUS=1773

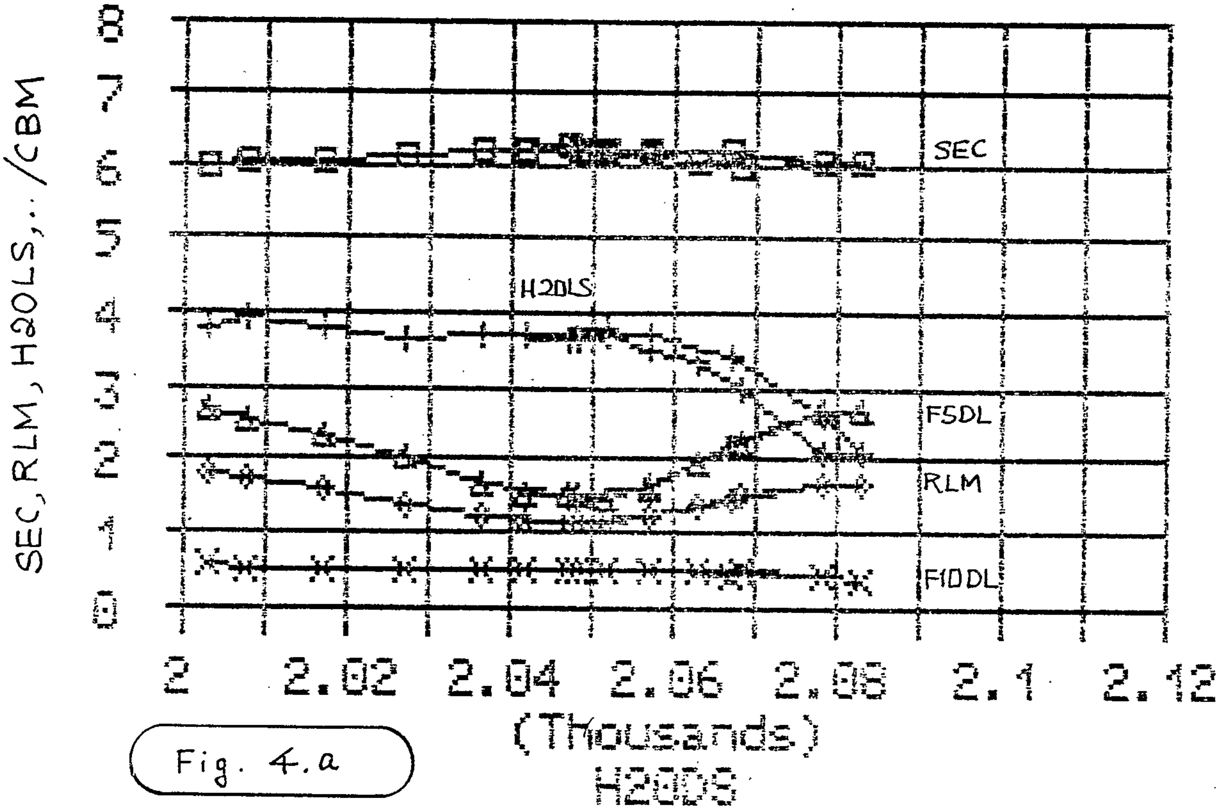


Fig. 4.a

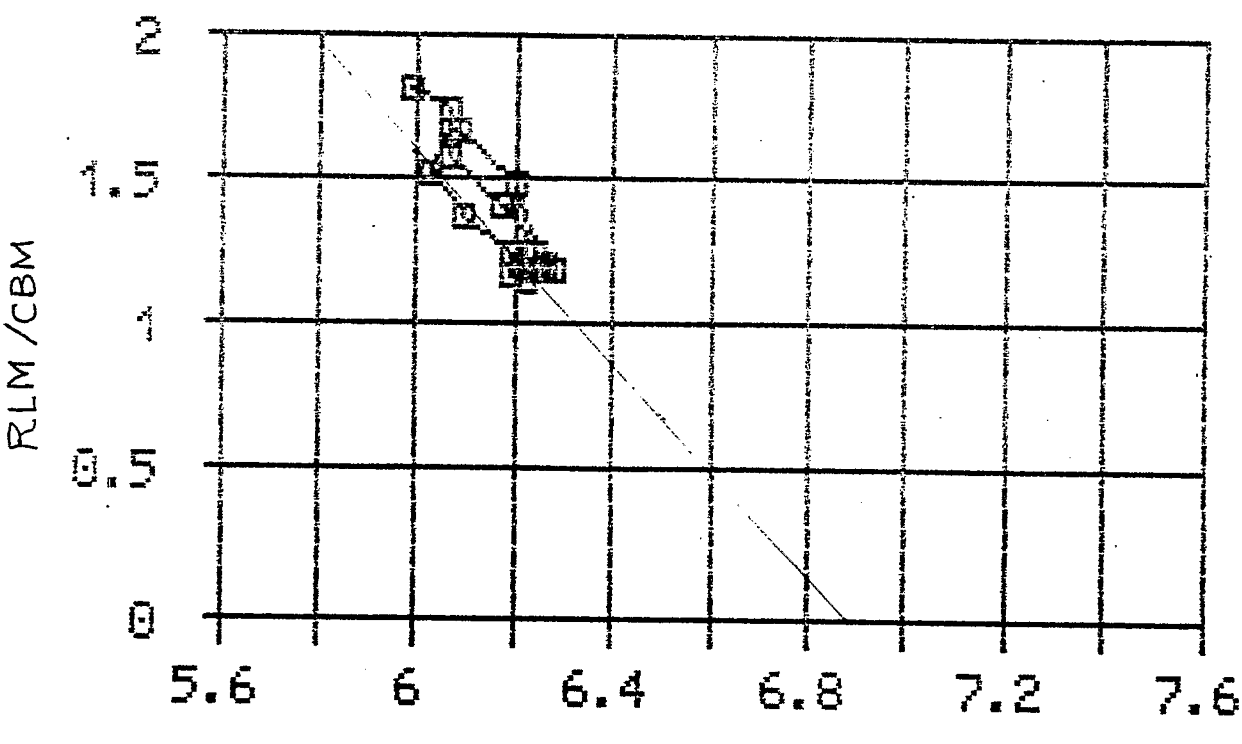


Fig. 4.b

at H2OUS=1725

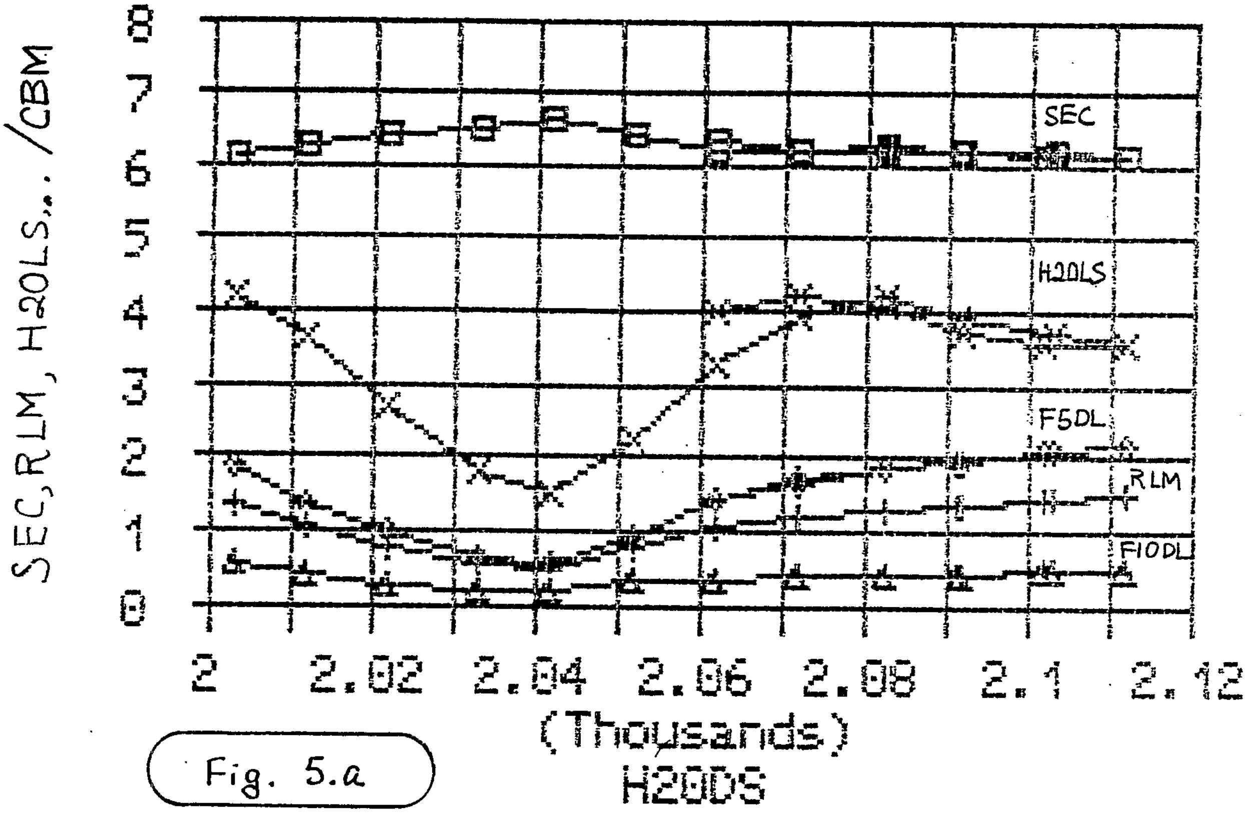


Fig. 5.a

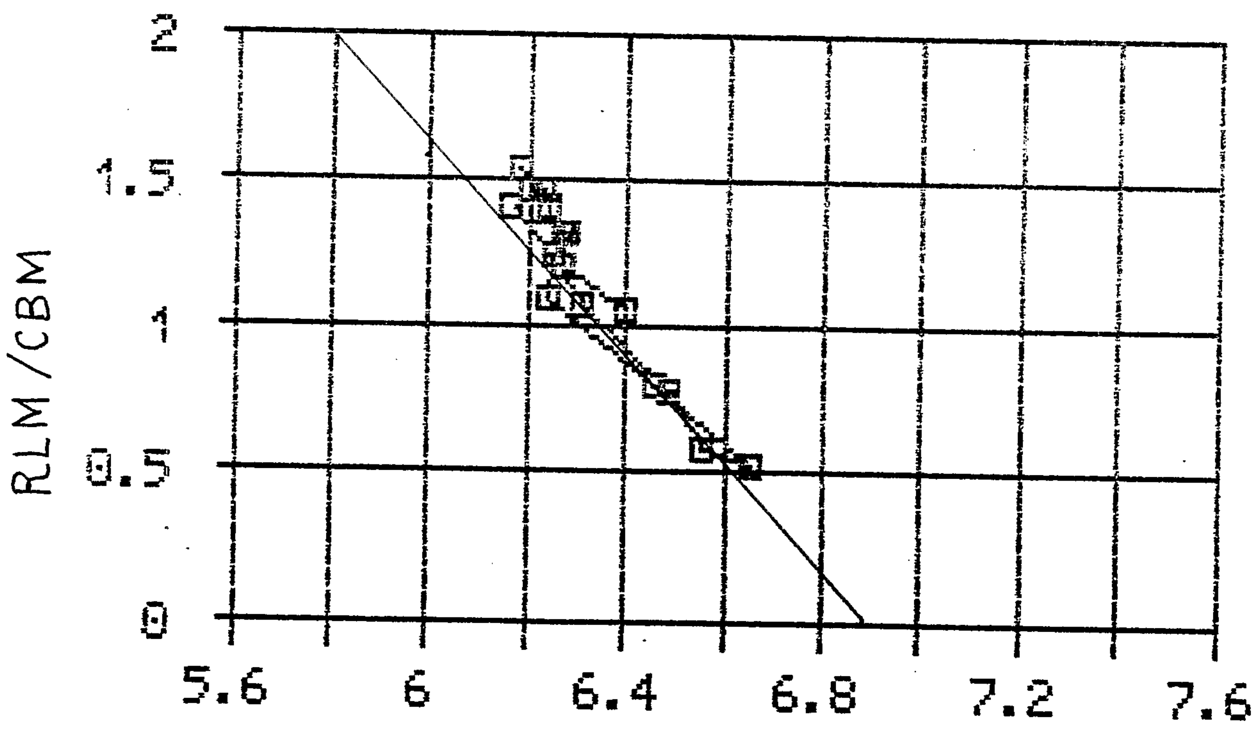


Fig. 5.b

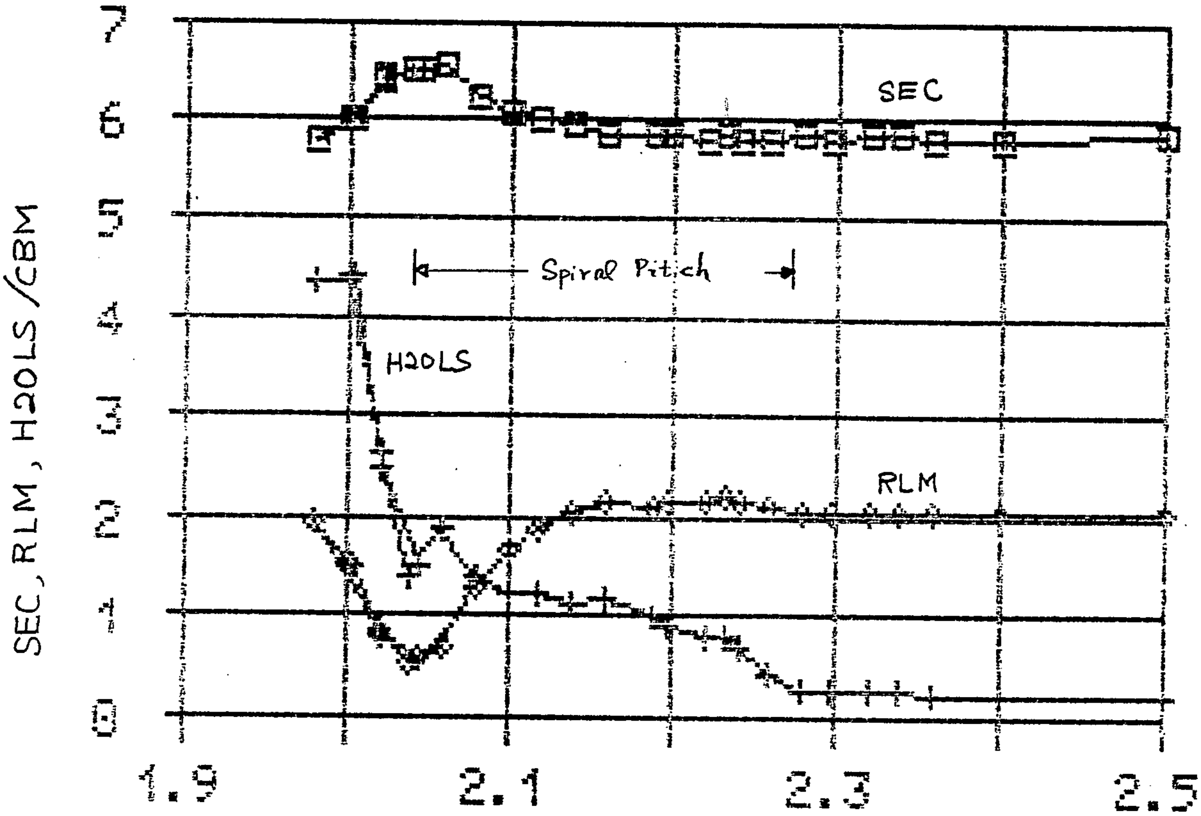


Fig. 6.a

with minimum H2OLS

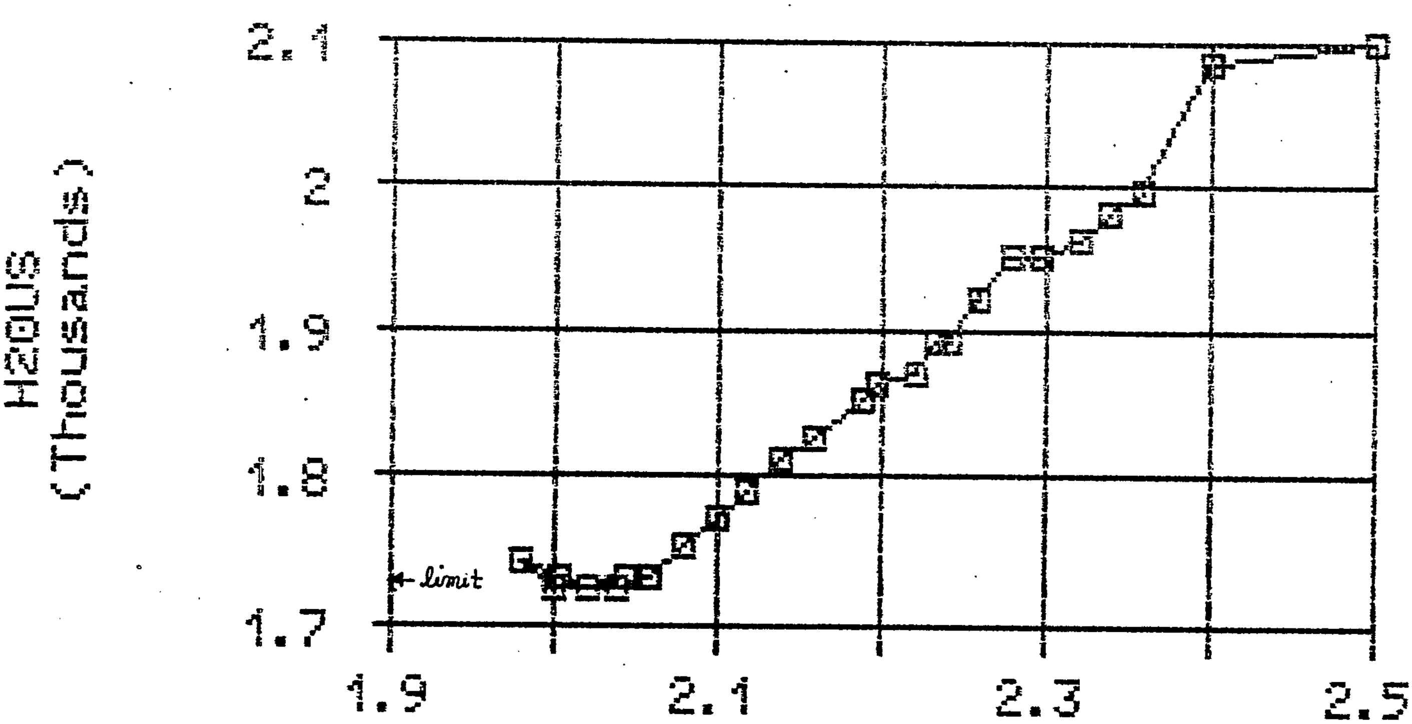
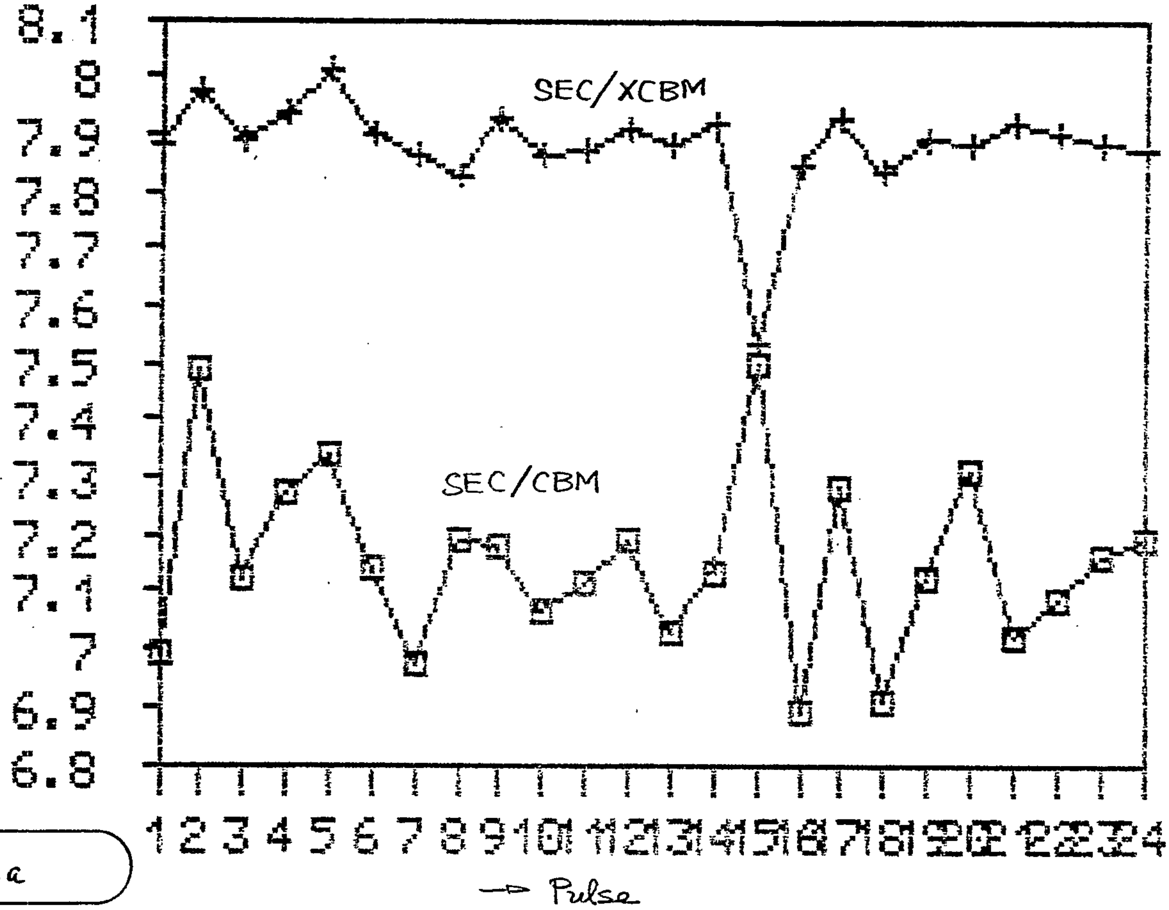
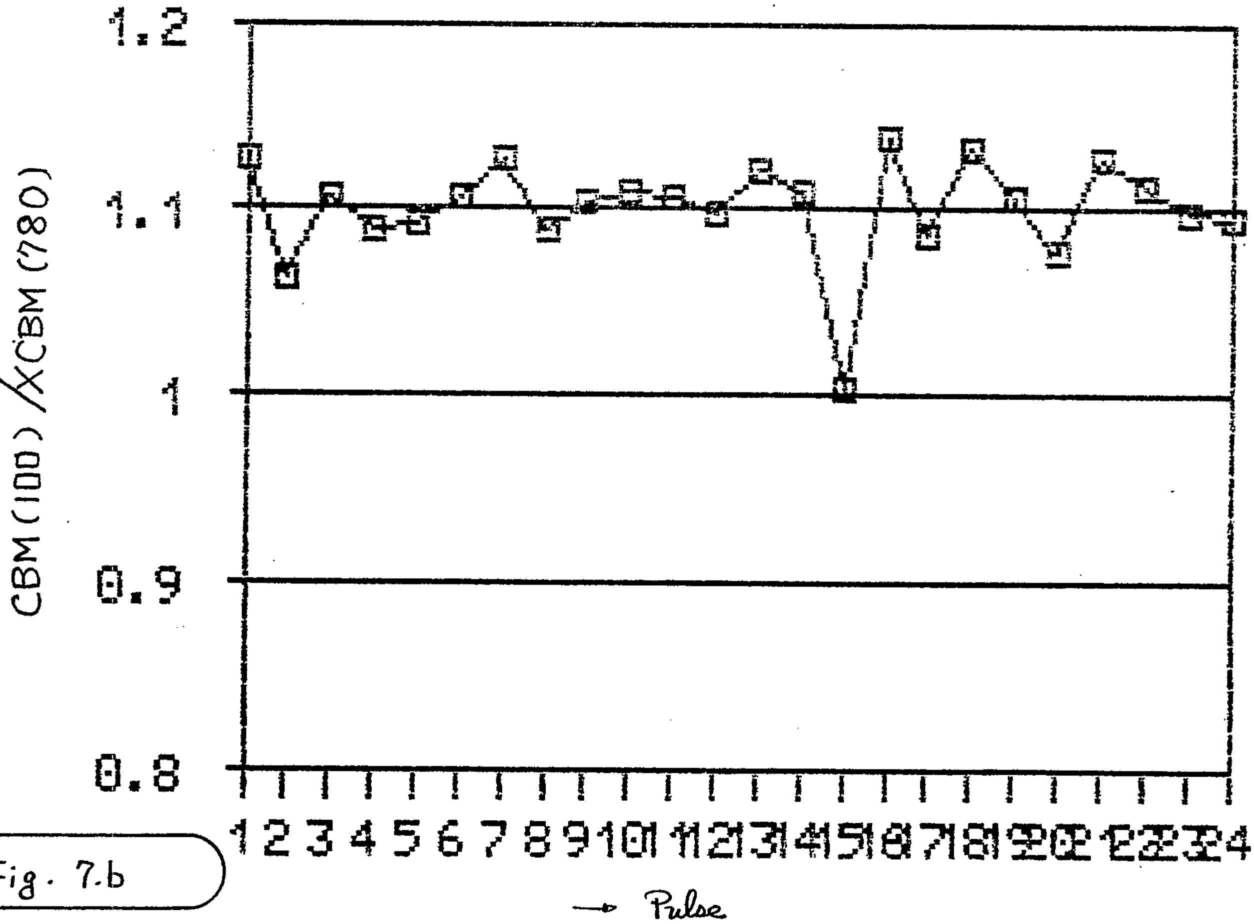


Fig. 6.b



SEC/XCBM
SEC/CBM
8.1
8
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7
6.9
6.8
→ Pulse

Fig. 7.a



CBM (100) / XCBM (780)
1.2
1.1
1
0.9
0.8
→ Pulse

Fig. 7.b