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SEB Extraction Study II - Investigations of the Apparent Beam Intensity Dependence of Extraction Efficiency

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Reported by M. Tanaka and J.W. Glenn

Subject SEB Extraction Study II - Investigations of the Apparent Beam Intensity Dependence of Extraction Efficiency.

Summary

The apparent dependence of extraction efficiency on beam intensity, which was observed during the previous study, was due to a DC offset in the feedback signal from the SEC (CE010) to the SEB spill servo module. Based on SEC calibrations, the best achieved extraction efficiency is estimated to be 95% to 96%.

Introduction

During these studies we concentrated on investigating the cause of the apparent dependence of extraction efficiency (SEC/XCBM) on beam intensity (XCBM), which made it difficult to analyze the data of Ref. #1.

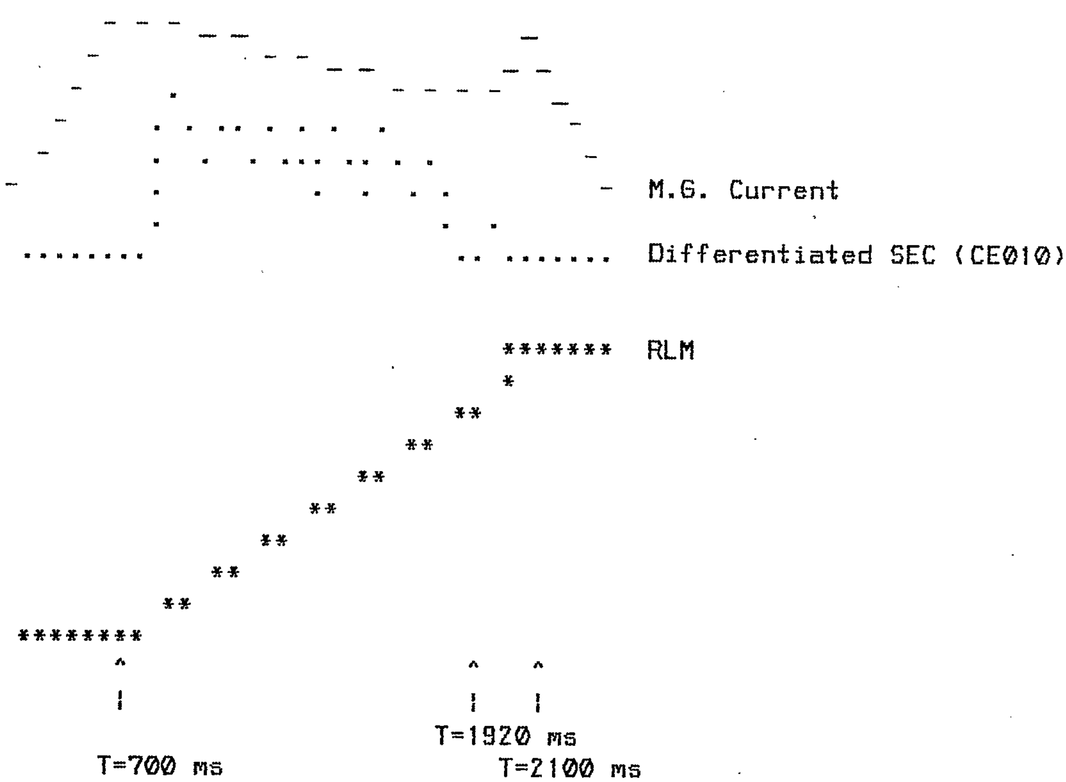
XCBM: Circulating Beam Intensity at T = () ms.

SEC : Integrated Secondary Emission Chamber Readings at CE010 at T = () ms.

RLM : Integrated Total Ring Loss Monitor Readings at T = () ms.

H20L: Integrated H20 Loss Monitor Readings at T = () ms.

Set-Up



SEC(2100)/XCBM(700): directly proportional to extraction efficiency.

RLM(2100)/XCBM(700): directly proportional to extraction inefficiency.

Results and Discussions

A. The following data were taken while XCBM(700) was varied from 10.6 down to 3.2 × 10^{12}ppp;

Fig. A.1.: SEC, RLM & H20L at T = 2100 ms, all divided by XCBM(700) vs. XCBM(700).

Fig. A.2.: SEC(2100) & RLM(2100)/XCBM(700) vs. XCBM(1920)/XCBM(700).

Fig. A.3.: RLM(2100)/XCBM(700) vs. SEC(2100)/XCBM(700).

The apparent extraction efficiency (SEC/XCBM) dropped as much as ~ 50% as XCBM reduced from 10.6 to 3.4 × 10^{12}ppp while the inefficiency (RLM/XCBM) increased a factor of 10, as shown in Fig. A.1. It implies that the beam intensity dependence of extraction (in)efficiency is real.

Fig. A.2. shows that extraction in(efficiency) is (inversely) proportional to a fraction of beam (XCBM(1920)/XCBM(700)) which has not been successfully extracted at the end of the spill process but which has been left in the machine, then spirals into the inside of the machine aperture and is lost at the time of T-invert. The RLRM output also revealed an increase of radiation level in the region E20 to G2. The jitters at the spill tail were observed.

A linear fit to the data points in Fig. A.3. yields,

$$RLM/XCBM = 7.69 - 0.89 \times SEC/XCBM$$

which gives a RLM calibration for beam loss of 769 counts/10^{12}ppp, a SEC calibration of 864 counts/10^{12}ppp, and extraction (in)efficiency of 95.4 (4.4) %.

B. For each beam intensity setting (XCBM), the main magnet field slope (SESLD) during the flatop was manually adjusted so that the spill length remained approximately constant. This adjustment was necessary, due to an imbalance in the SEB spill servo system. As the spill servo reference output is proportional to XCBM, the adjustment should not be necessary (Ref. #2).

Fig. B.1.: SEC, RLM & H20L/XCBM(700) vs. XCBM(700).

With the adjustment, these variables normalized to XCBM become clearly independent of XCBM.

It was later found that there was a DC offset in the CE10 beam spill signal from the SEC to the servo amplifier module, and subsequently it has been corrected.

C. After back to the initial condition at XCBM = 10 × 10^{12}ppp, the following preliminary calibration data were taken to check the loss monitor response for various sources of beam loss.

Fig. C.1.: RLM & H20L/XCBM vs. SEC/XCBM, varying H20DS
Fig. C.2.: RLM & F05L/XCBM vs. SEC/XCBM, varying F05US
Fig. C.3.: RLM & F10L/XCBM vs. SEC/XCBM, varying F10US

It is quite evident that data points for each loss monitor do not lie on a universal straight line since each monitor response naturally depends on the details of where and how the beam is lost (e.g., the H20L was insensitive to beam loss due to the leftover beam, as seen in Fig. A.1., because most of the beam was lost in the region of E20 to G2).

There are some data points which are far out of the line, having both low (high) inefficiency and low (high) efficiency. If well localized beam loss occurred at a specific region, some or all loss monitors could not respond properly. If this happened at a region near the SEC, then SEC reading might go up, i.e., a false increase of extraction efficiency.

Neglecting the outlying data points and concentrating on a working area which represents more normal running conditions (i.e., extraction efficiency > 90% and extraction inefficiency < 10%), all data give a consistent estimated extraction efficiency of 94 to 96%. On the other hand, an estimated inefficiency varies from ~ 1.5% to ~ 5%, though we need more data points.

Miscellaneous

A. To find a better extraction efficiency, we have tried to tune the machine varying by small amounts the following SEB extraction parameters: H20DS, F5DS, F10DS, DSXPS, FPBLW, HPBL, F10FN, F20VB, SHORZ, QHORZ, QSKEW, etc. However, we have obtained no significant improvement in extraction (in)efficiency. The best obtainable efficiency remained to be 95 to 96%.

B. We have observed that the pulse-to-pulse variations of SEC/XCBM and RLM/XCBM depend on the momentum spread, dp/p at the flattop.

C. We know that there is always a small fraction of beam left inside the machine (Woody calls it the non-resonant component. Estimated to be ~ 1.5% of the XCBM based on the analog signal of CBM).

D. We have frequently observed a small bump after the spill tail in the analog signals from the SEC just before the time of T-invert. The size of the bump can be varied by changing the field slope (SESLD). This bump is sometimes a real spill and sometimes is not.

Conclusions

The apparent beam intensity dependence of extraction efficiency was due to the offset in the CE010 beam spill input to the SEB spill servo system.

Based on the SEC calibrations, the best achieved extraction efficiency is estimated to be 95 to 96%.

To measure the inefficiency from the loss monitors we need more calibration data of the RLM, F5, F10, and H20 loss monitors.

We certainly have to understand the phenomena described in Miscellaneous.

It becomes clear that the extraction efficiency depends not only on the so-called SEB extraction parameters, e.g. H20US/DS, but also on the fine adjustment of the spill servo system as well as the beam quality before the extraction. Reliability of stable extraction and the quality of extracted beams also have to be considered, in addition to extraction efficiency.

References

1. M. Tanaka, AGS Studies Report #219.
2. J.W. Glenn and H. Weisberg, AGS Div. Tech. Note #133.

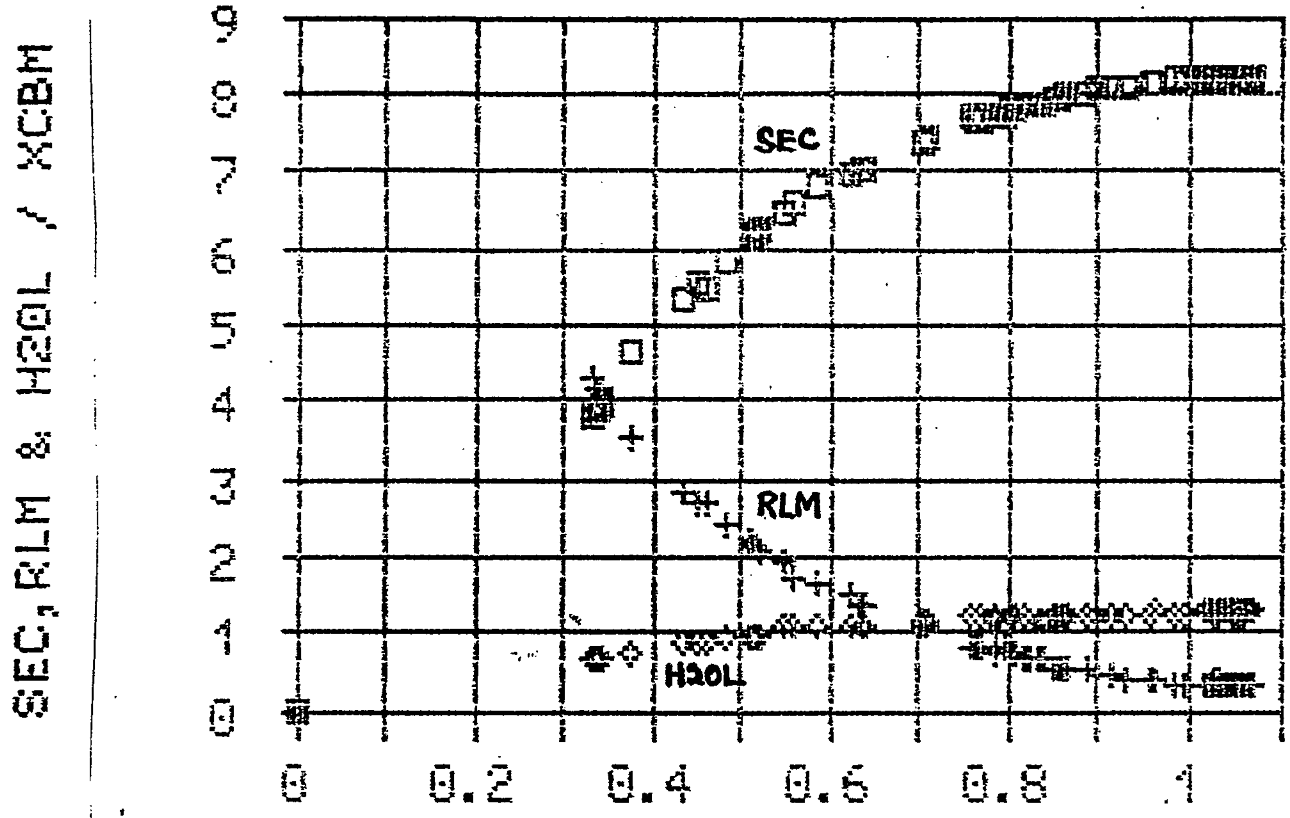


Fig. A.1 XCBM

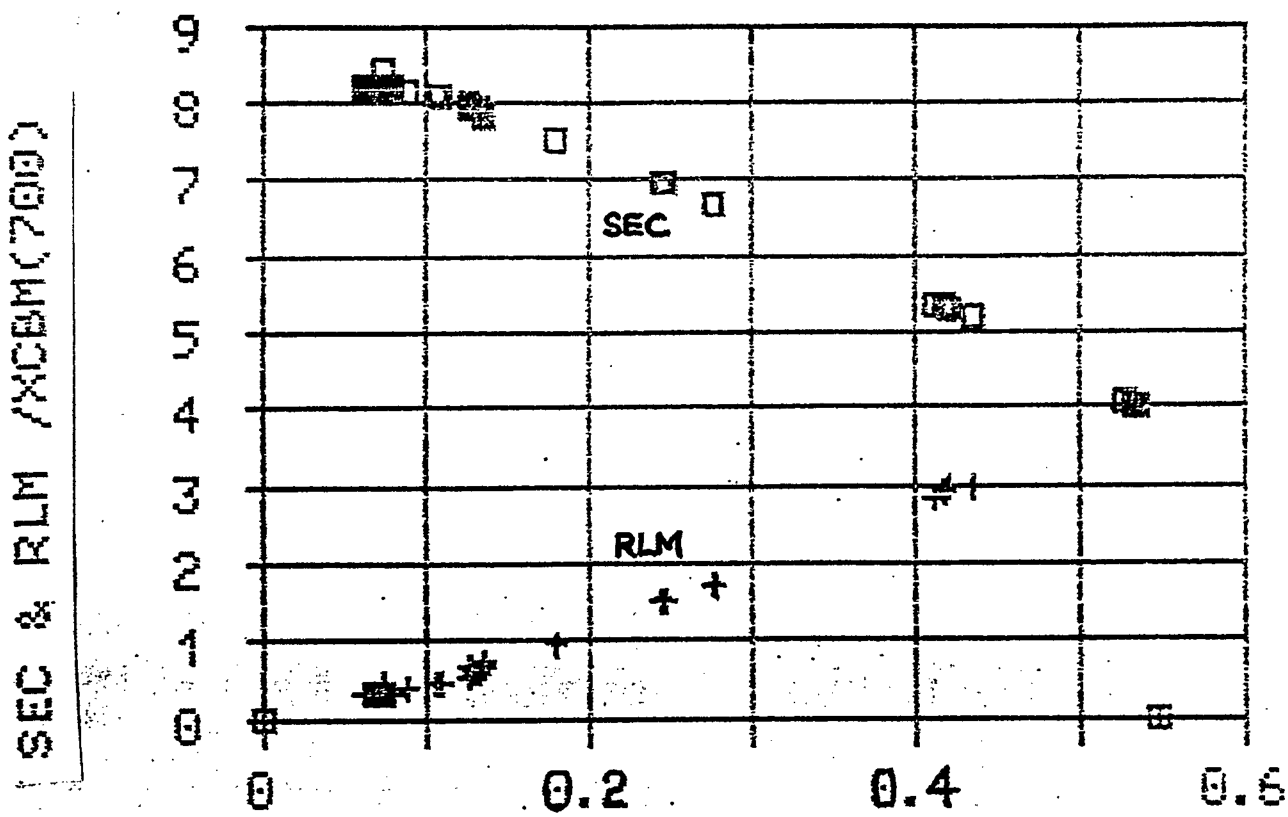
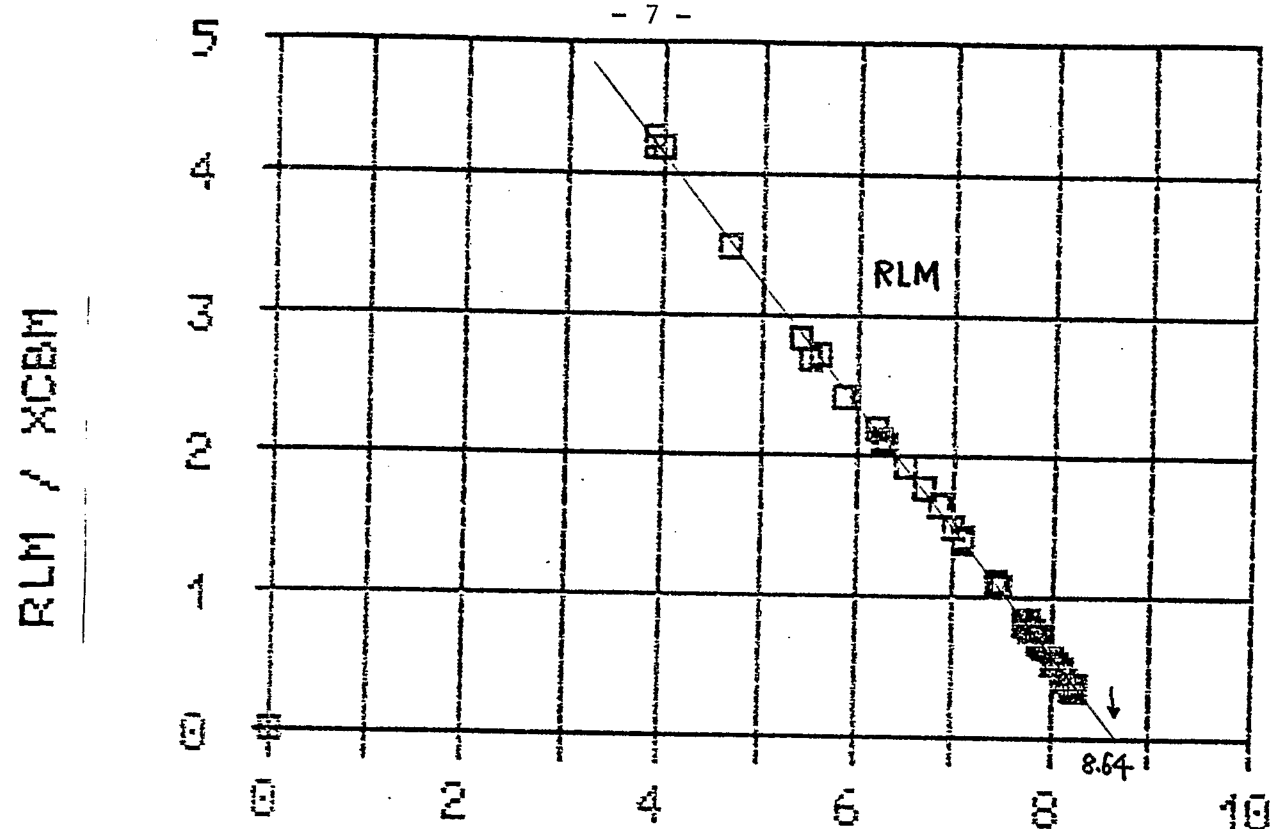


Fig.A.2 XCBM(1920)/XCBM(700)



RLM/XCBM = 7.69 - 0.89 * SEC/XCBM

Fig.A.3 SEC/XCBM

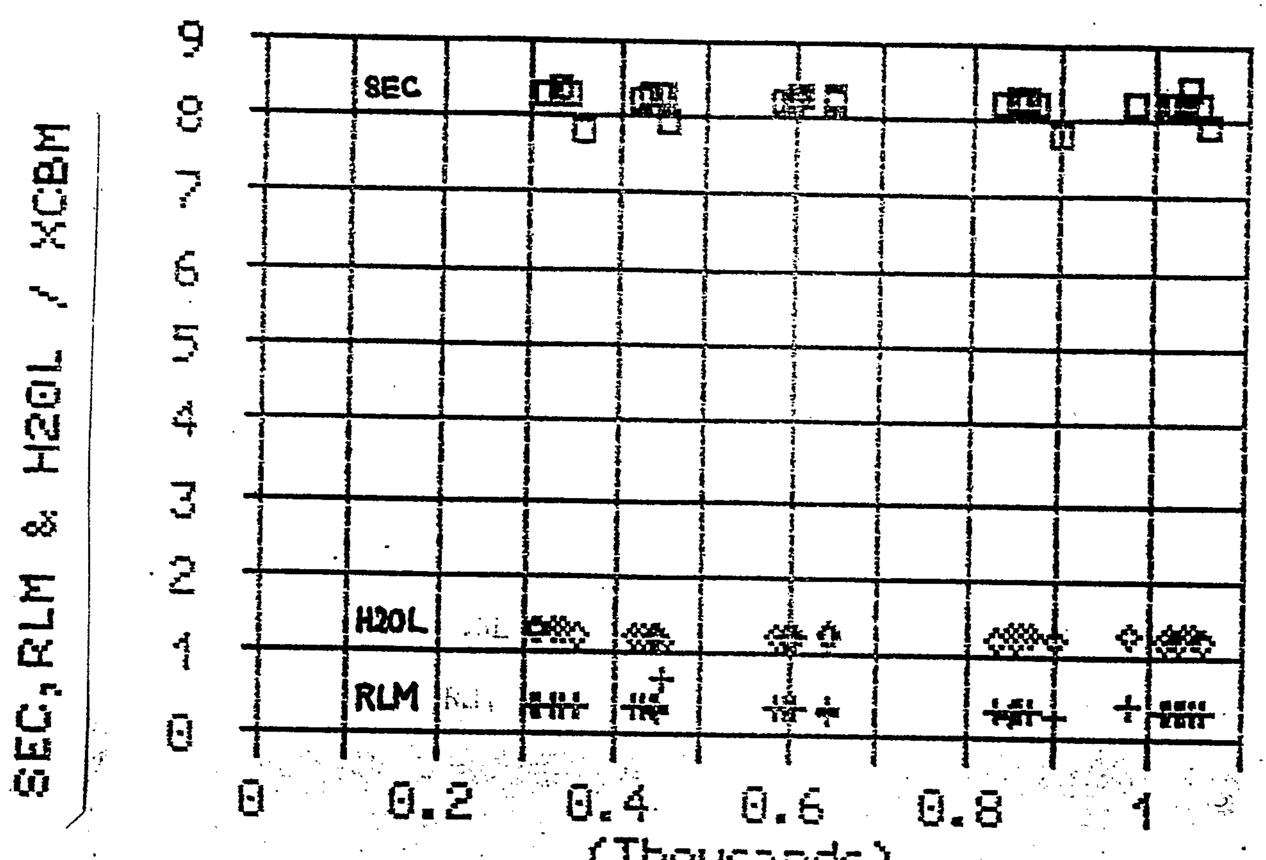


Fig.B.1 XCBM

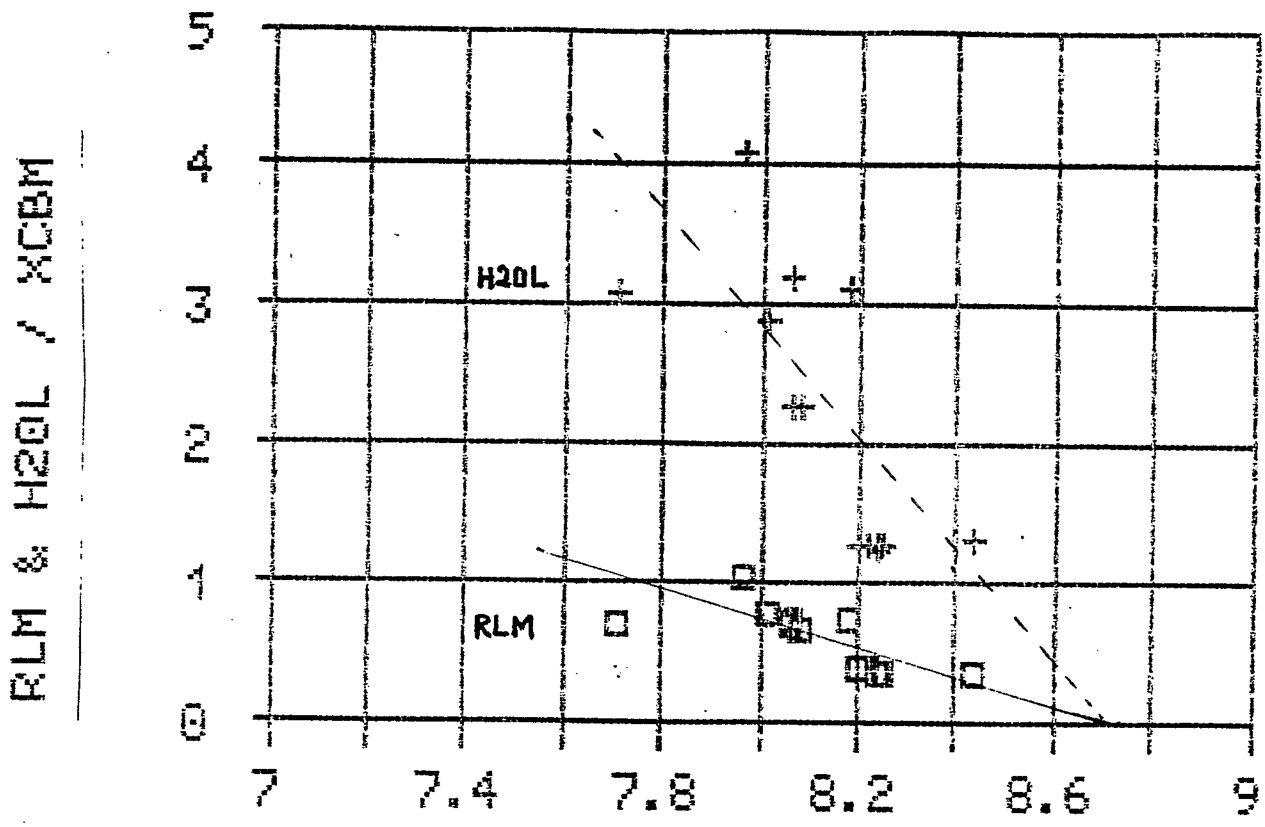


Fig.C.1 SEC/XCBM

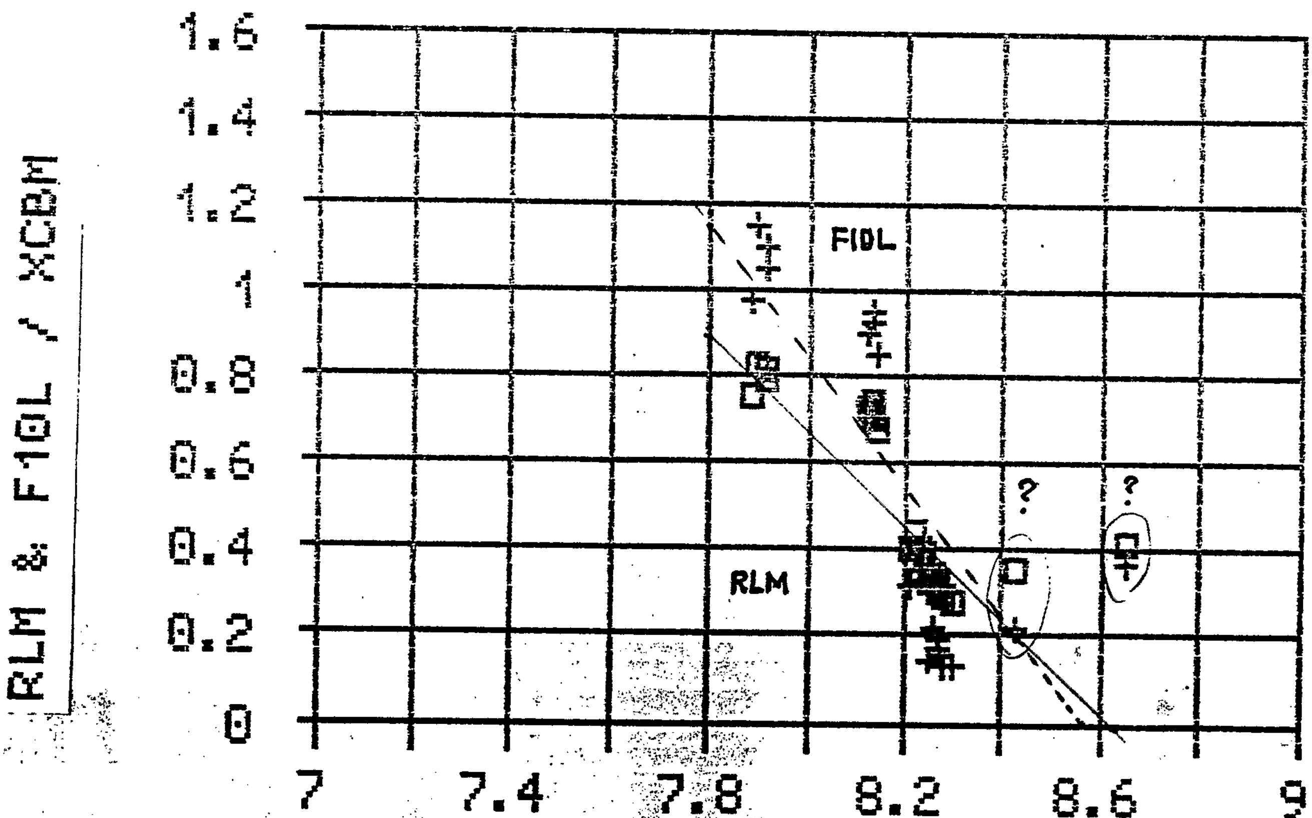


Fig. C.3 SEC/XCBM

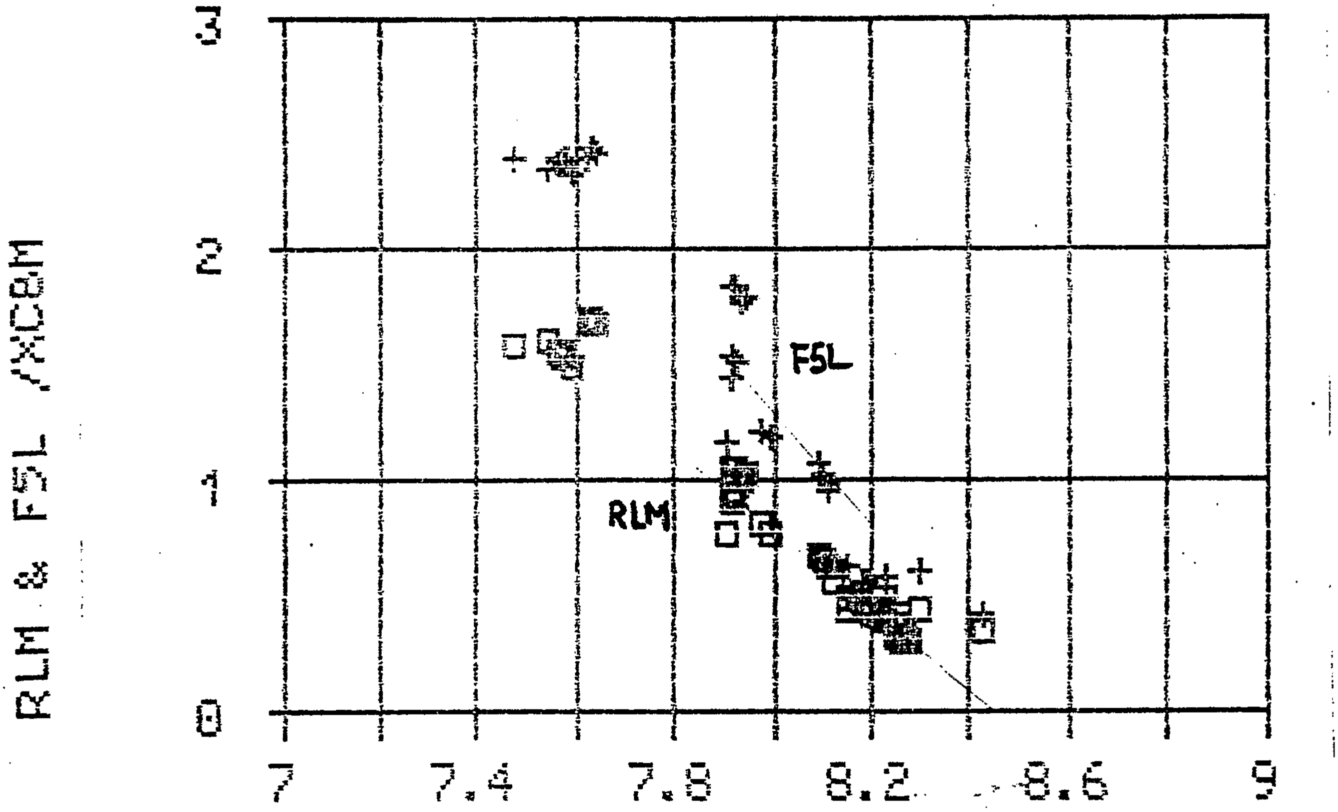


Fig. C.2 SEC/XCBM