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EFFECTIVE SPILL TIMES, RF AND LQE SERVO

I. Comparison of equipments measuring the effective spill time

(P. Actis, L. Burnod, E. d'Amico, G. Ferioli, J. Mann, J. de Vries)

A comparison of equipments was made on 11th April 1978 with the slow extracted beam being sent to the West Hall at 200 GeV/c.

The beam was split onto targets T1, T3, T5. The effective spill time was measured simultaneously by several equipments

$$Te = \frac{\left[\int_0^T I(t)\, dt \right]^2}{\int_0^T I^2(t)\, dt}$$

The characteristics of these equipments are as follows:

(a) Telescope in T1. Gate aperture 32 ns. Provided by a Physics Group.

(b) Telescope in T3. Gate aperture 19 ns. Provided by a Physics Group.

(c) Telescope in LSS6. Gate aperture 19 ns. This is located near the electrostatic septum ZS, looking at the losses produced at 90^o by protons hitting the wires of the septum (30 cm downstream of the ZS input flange).

(d) A sampling device (Biomation) of the analog signal emitted by the BSI located in 610211. A low band filter (400 Hz) was added at the input to avoid saturation of the instrument by higher frequencies.

(e) An analog device located in BC whose input can be the analog signal emitted by either the BSI 6103 or the air Čerenkov detector and transmitted from BA6 to BC. The bandwidth was limited to 10 kHz by a filter.

The corresponding spill times are respectively referred to as, T1, T3, ZS, BOM, ANAL.

The experiments consisted of measuring the spill time at various machine conditions:

- standard settings (RF servo ON, bunch spreader ON) for different extracted beams,
- bunch spreader mistuned,
- low frequency modulations added to the reference of the RF servo with either a strong (15, 64, 100 Hz) or low (20, 200 Hz) modulation,
- injection on 5 CPS turns instead of 10.

The analysis of the measurements leads to the following conclusions.

<u>T1 and T3</u>

When the machine is unperturbed or with low modulation of the extracted beam, T1 and T3 are in good agreement, for example

$$T3 = T1\ (0.8 \pm 0.05)$$

When the percentage of extracted beam or the splitting ratio between T3 and T1 is modified, the calibration factor (0.8) changes and values of 0.6 are reached, nevertheless with a small dispersion ($\pm$ 0.05).

When the machine is strongly perturbed, T1 and T3 decrease, but the dispersion for T3 is greater than for T1.

It is worthwhile noting that T1 corresponds to the central part of the vertically split beam while T3 and T5 obtain the external part. If coupling exists between both planes in the circulating beam during extraction, any important change in the horizontal plane will also affect the external vertical part of the beam in priority.

ZS

The losses on the septum wires are proportional to the effective spill times, but the constant of proportionality varies with the conditions of extraction.

Furthermore, ZS is sensitive to the losses in the extraction region, while T1 or T3 are sensitive to the extracted beam. The number of unwanted events in ZS compared to the number of delayed coincidences is much larger than for T1 or T3. Therefore dispersion between ZS and T3 or ZS and T1 is greater than between T3 and T1, but on the average the behaviour of ZS follows that of T1 (fig. 1).

BOM

As expected, BOM is sensitive to low frequency structures only (≦ 400 HZ). By not seeing the RF structures, BOM is more 'optimistic' than a telescope, and its dispersion from cycle to cycle smaller than that of a telescope (fig. 2).

The maximum dynamic range of the input signal is 40 db (8 bits digitizing).

ANAL

ANAL fed by the Čerenkov signal is in good agreement with BOM if the machine is unperturbed or weakly perturbed. However, in its present configuration the ANAL's dynamic range is limited to 20 db of the input signal therefore necessitating careful adjustment to machine conditions; in the case of the machine being strongly perturbed, the results obtained are very optimistic (due to saturation effects).

II. Comparison of RF and LQE servo at 400 GeV/c

(P. Actis, L. Burnod, E. d'Amico, G. Ferioli, K.H. Kissler, J. Mann, A. Millich, J. de Vries, A. Warman)

The extraction elements were set up for an extraction to the West Hall at 400 GeV/c. It has been shown for the first time that such an extraction is feasible with the RF servo. Up to now this extraction was done with the LQE servo using the two quadrupoles located in 1.143.

The horizontal emittances of the extracted beam were compared for the two types of servo by measuring the horizontal beam profiles at the entrance of the MSE (BBSH 61851). The RF servo showed an emittance four times greater (figures 3, 4, 5).

In both cases the effective spill times were measured by using the ZS telescope, the BSI 6103 signal sampled by the Biomation and the Air Čerenkov signal detected by the analog device. The same remarks as in I. apply for the three spill time devices (ZS, BOM, ANAL) and no significant changes were found between the two types of servo.

However, by seeing the BSI and Čerenkov signals at the scopes and by analysing their spectra we found that in both cases a residual modulation existed with an amplitude for the RF servo lower than that for the LQE. In the case of the RF servo, the residual frequencies were around 85 and 170 HZ while the synchrotron frequency was 88 HZ (fig. 6). For the LQE servo, the residual frequency depends on the correcting networks used in the servo.

Figure 7 shows a residual frequency of 128 HZ when using 25 HZ and 100 HZ correcting networks respectively.

L. Burnod

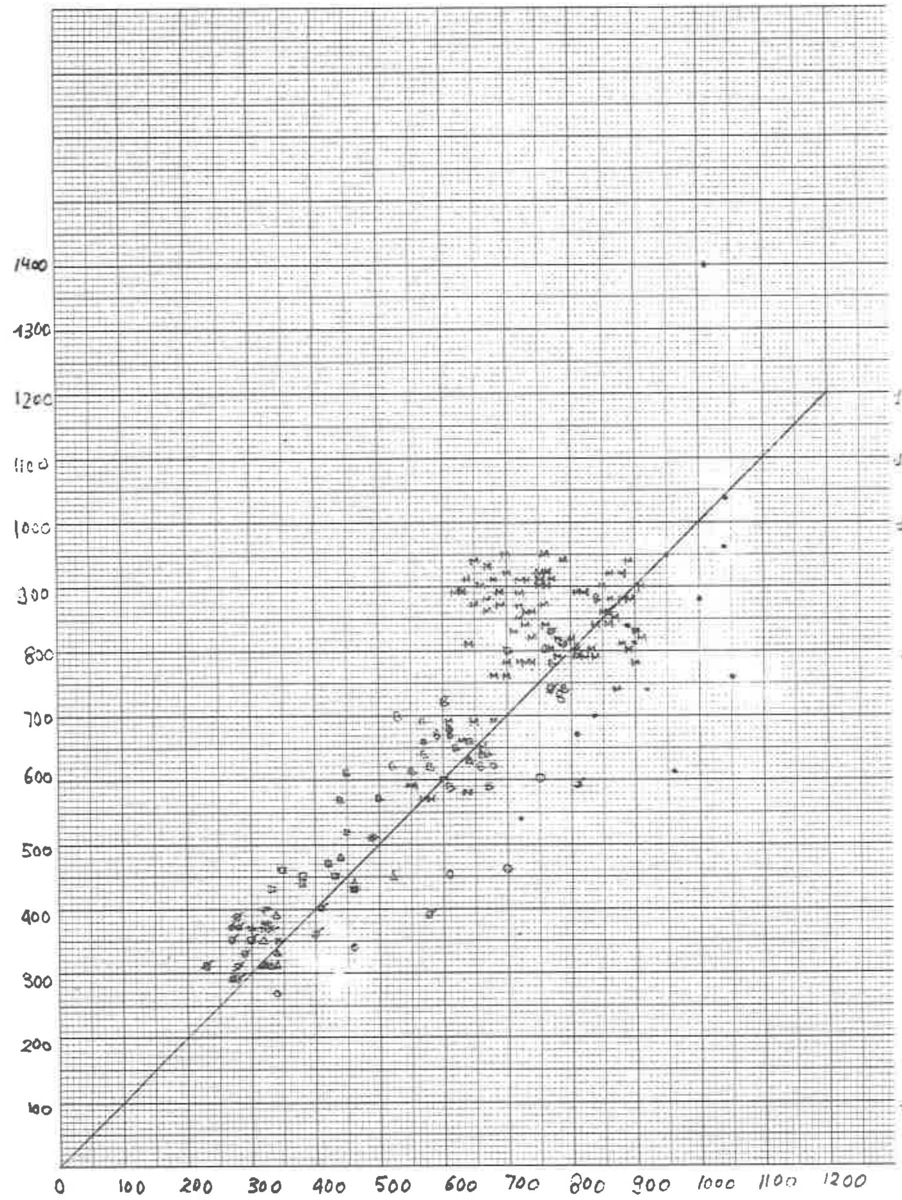

Fig. 1 : Spill time ZS vs T1

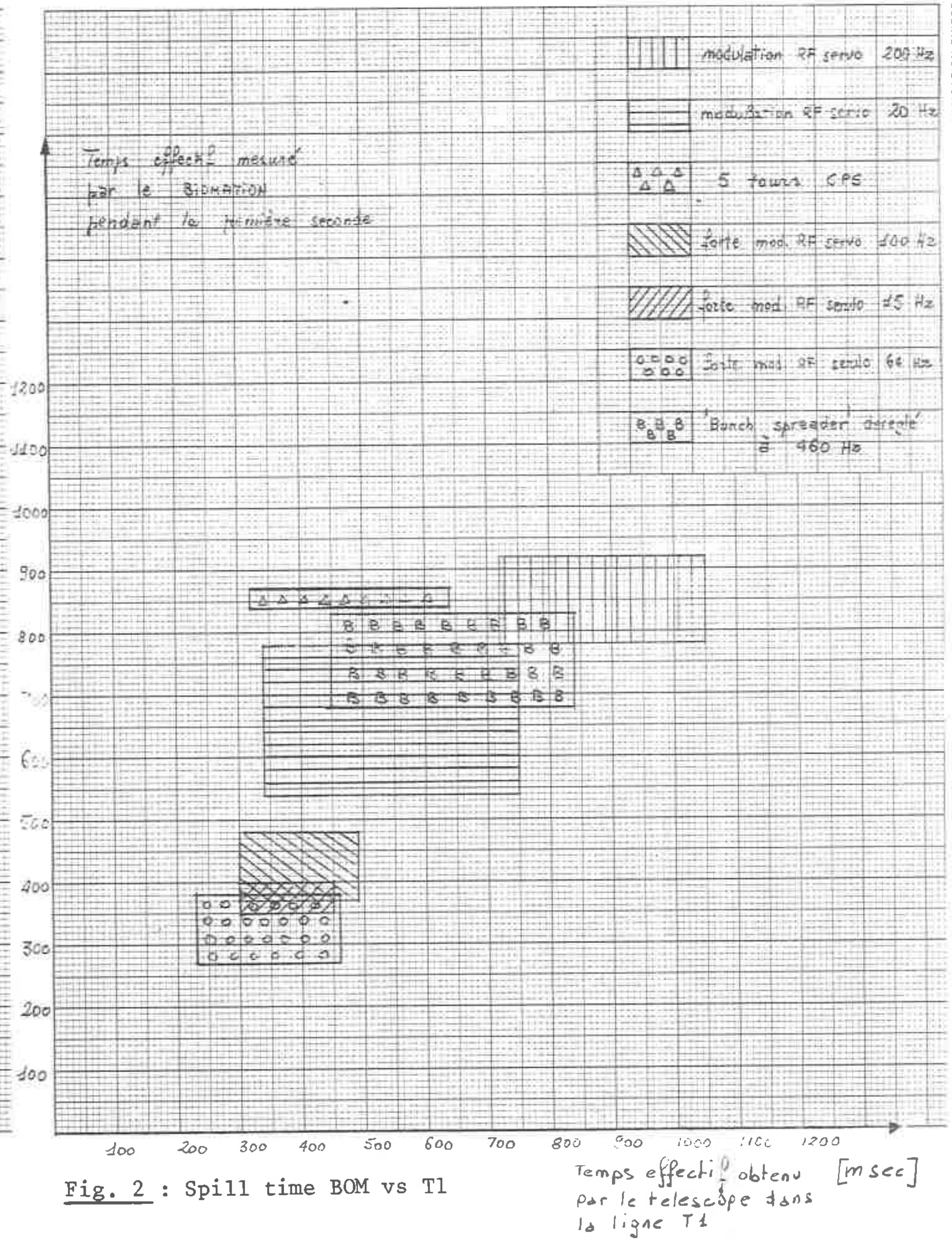

Fig. 2 : Spill time BOM vs T1

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Fig. 3

Beam profile at the MSE
RF OFF without servo

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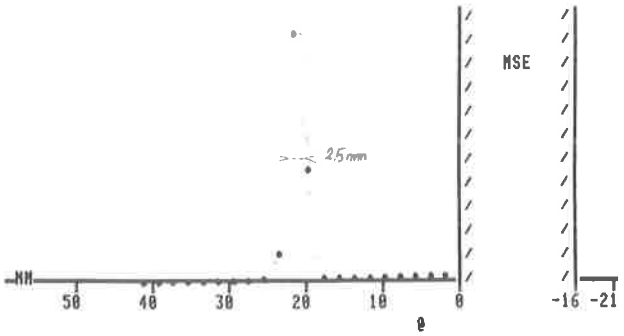
BBSH 61851

VMAX = 8.11 V   MEASUREMENT TERMINATED



POSITION
START 0
STOP 40.0

TIMING
START 3 \ 4200 MS
STOP 4 \ 6890 MS

NO OF STEPS 20   NO OF CYCLES/STEP 1

400 GeV RF OFF extraction sans servo.

Fig. 4

Beam profile at MSE
RF servo ON
LQE servo OFF

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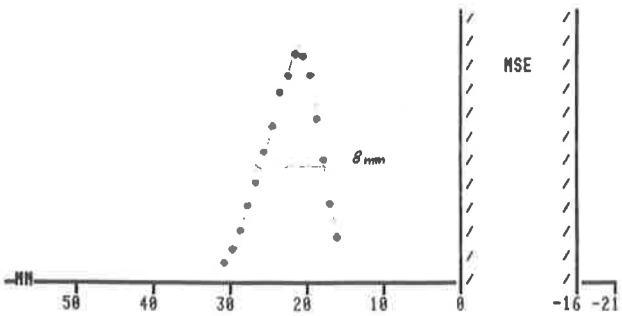
BBSH 61851

VMAX = 2.41 V   MEASUREMENT TERMINATED



POSITION
START 15.0
STOP 30

TIMING
START 2 \ 6400 MS
STOP 3 \ 7000 MS

NO OF STEPS 15   NO OF CYCLES/STEP 1

RF servo ON   ΔBCT ≈ 1.2 x 10^{12} ppp

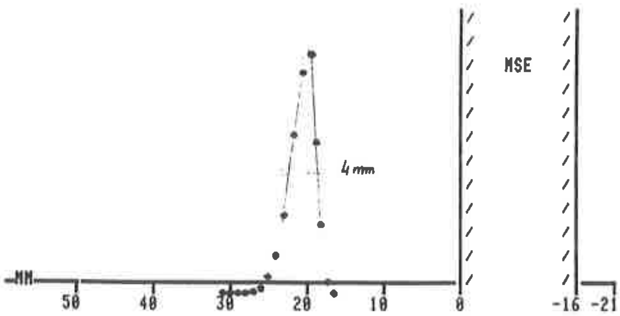
Fig. 5

Beam profile at MSE
LQE servo ON
RF voltage OFF

1978-04-18-05:20:09

BBSH 61051

VMAX = 5.40 V   MEASUREMENT TERMINATED



POSITION
START 15.0
STOP 30

TIMING
START 2 \ 6400 MS
STOP 3 \ 7000 MS

NO OF STEPS 15   NO OF CYCLES/STEP 1

LQE servo ON   ΔBCT ≈ 2.4 10^{12} ppp

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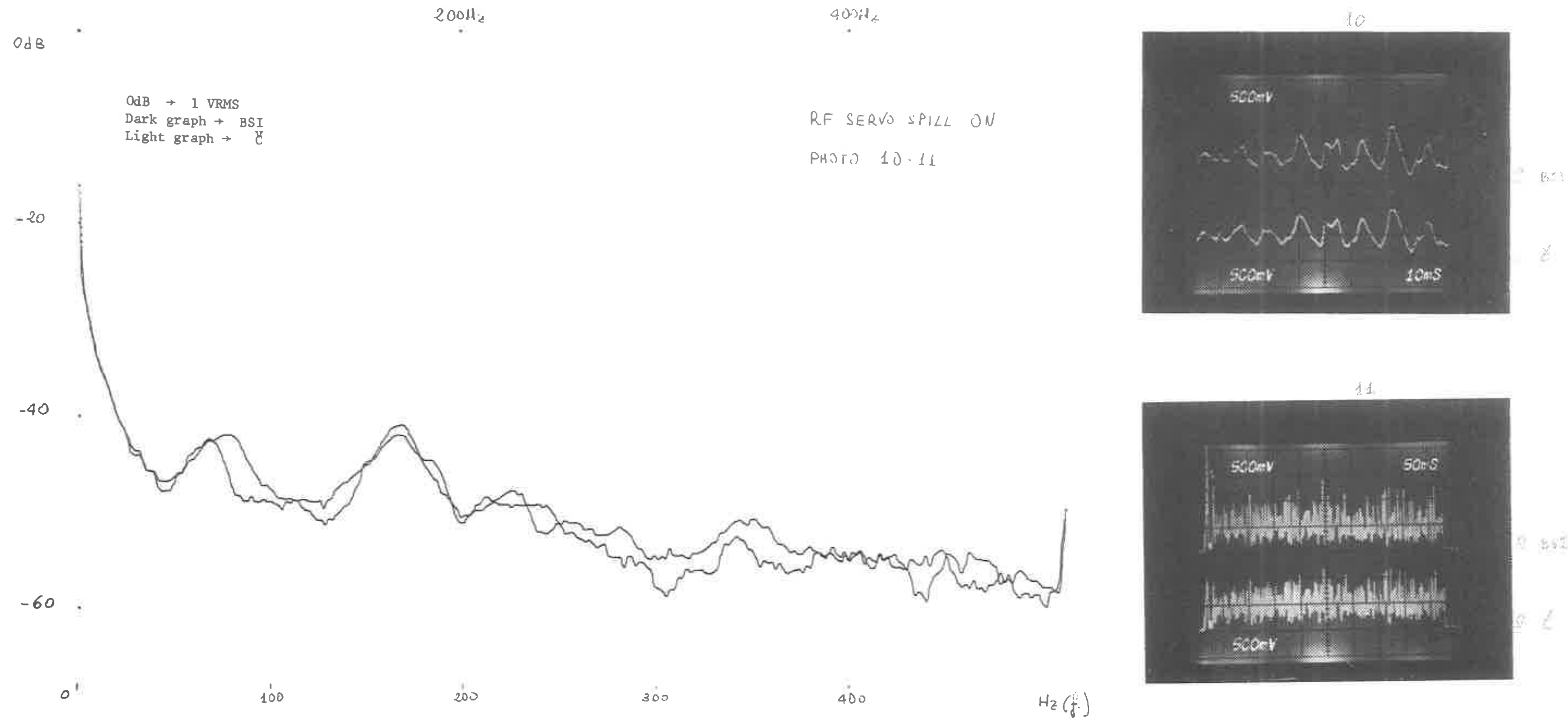

Fig. 6 : Spectrum analysis and oscillograms of the extracted beam with RF servo (BSI & CERENKOV)

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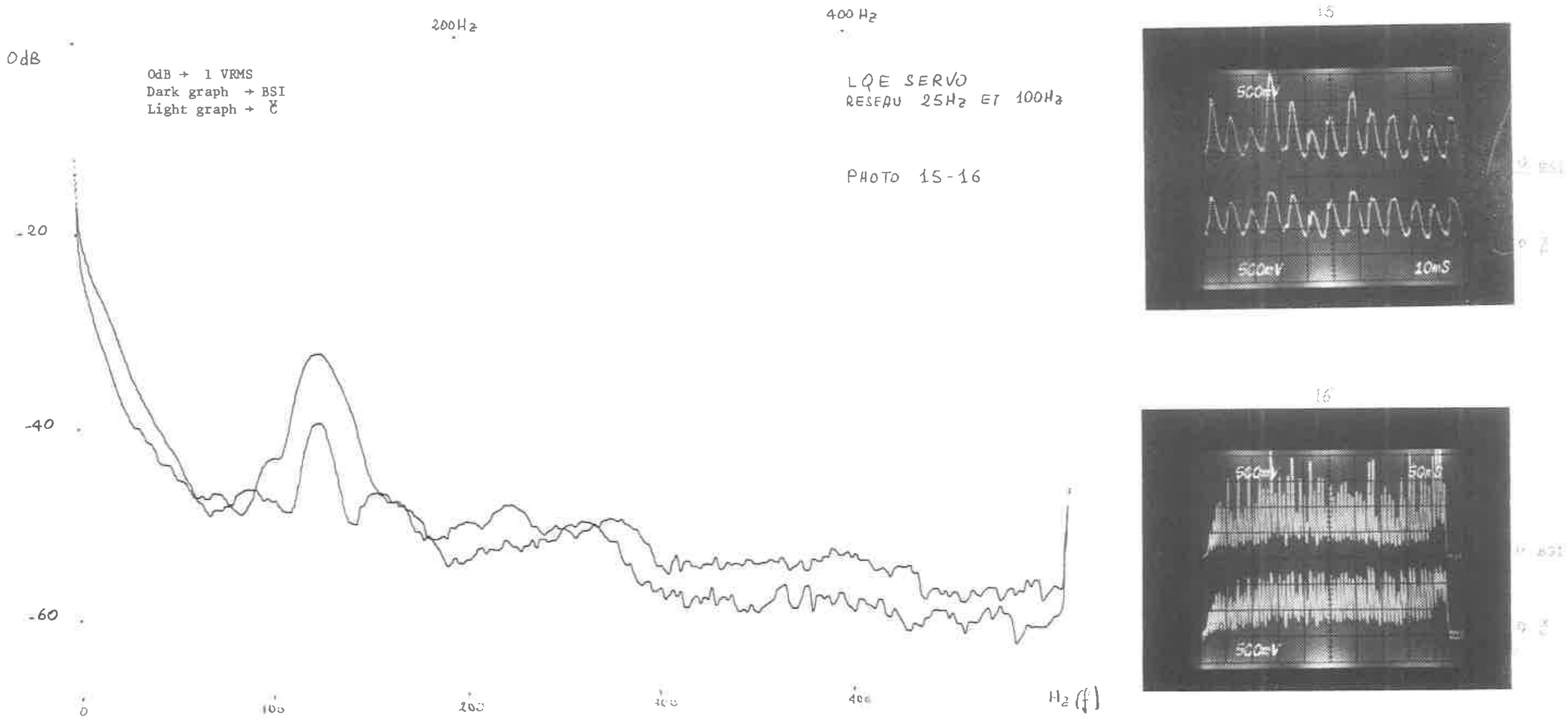

Fig. 7 : Spectrum analysis and oscillograms of the extracted beam with LQE servo (BSI & CERENKOV)

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