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Half-integer extraction at Q_H = 26.5 with a fast pulsed quadrupole Tests on 26th April 1977

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1. Introduction

Half-integer extraction was done at 400 GeV/c keeping the horizontal tune of the machine constant at Q_H = 26.545 and powering QE 6080 by a capacitor discharge after excitation of two extraction octupoles. This method proved to be entirely feasible. Spills of about 2 ms length were achieved. The transverse properties of the extracted beam seemed to be more favourable than those previously reported for fast half-integer extraction at Q_H = 26.5 and obtained with a different extraction method. In fact, a beam without any tails was observed on the first luminescent screen in TT60 and all beam profiles were in good agreement with theoretical predictions.

For the first time it was possible to observe the high frequency structure of a fast resonant spill by means of an air Cerenkow counter recently installed in TT60. The extracted intensity turned out to be strongly modulated at twice the SPS revolution frequency. At present we cannot exclude that this modulation is connected with the applied extraction method.

2. Experimental procedure and experimental conditions

The following methods can be used for fast half-integer extraction from the SPS :

1st method

The strength of the extraction quadrupole is kept constant and the protons are thrown into the resonance by changing the horizontal machine tune at a high rate.

2nd method

The horizontal machine tune is kept constant at a suitable value sufficiently close to the half-integer and the extraction quadrupole is rapidly excited by a capacitor discharge.

Tests and operation of the first method have been previously described (SPS Comm. Rep. No. 57). The present note concerns first tests of the second method.

The experiment was done at 400 GeV/c on Cycle 8. During the tests slow extraction at 200 GeV/c continued for physics in the West Area, leaving about $1.5 * 10^{12}$ ppp for the fast resonant extraction at top energy. The procedure was as follows :

- The octupoles LOE 2340 and LOE 3020 were excited to reach a normalized strength of 90 m^{-2} per LOE before the beginning of the 400 GeV flat top.

- The horizontal tune Q_H was adjusted on the flat top to the desired value of 26.545 in the final setting. Q_V was set to 26.62.

- At 6400 ms after injection the extraction quadrupole QE 6080 was excited by a capacitor discharge. In the final setting the capacitor charging voltage was 2.2 kV. This resulted in a maximum quadrupole current of 200 A, reached after 5 ms.

The separatrices at the electrostatic septum obtained with the described settings are very similar to those shown in Fig. 1 of the

SPS Comm. Rep. No. 57. In particular, the jumps at the septum are limited to about 8 mm due to the somewhat unfavourable position of QE 6080.

3. Results of measurements

At the beginning of the experiment Q_H was set to 27.550 on the 400 GeV flat top which is the value the separatrices had been calculated for. A single capacitor of 250 μF was charged to 2.2 kV. This is supposed to be the highest voltage the capacitor can safely stand.

With the above settings part of the protons were not extracted, but dumped internally as shown in the upper photograph of Fig. 1. This meant that the momentum spread in the beam exceeded $\pm 3.5 * 10^{-4}$ and that, therefore, the settings had to be changed.

For a few pulses the charging voltage was increased to 2.5 kV which resulted in the spill shown in the lower photograph of Fig. 1. Practically all protons were extracted within about 2 ms.

The charging voltage was then set back to 2.2 kV and the horizontal tune was lowered to Q_H = 26.545. These values were maintained during the rest of the experiment and the properties of the extracted beam were carefully measured.

Fig. 2 shows the spill that was obtained with the final settings. The circulating beam current goes down to zero within about 2 ms. The time jitter of the spill did not exceed ± 200 μs.

Figs. 3 to 6 show horizontal profiles of the extracted beam at diffferent positions along the extraction channel. These profiles are in good agreement with theoretical predictions. Fig. 7 shows the loss pattern which seems to be characteristic for resonant extraction at 400 GeV/c (compare SPS Comm. Report No. 57).

The beam spot observed on the first luminescent screen in TT60 (Fig. 8) shows contours better defined than those previously seen for -

the beam extracted with a different method (compare Fig. 8 of SPS Comm. Report No. 57).

As mentioned before it was possible for the first time to observe the high frequency structure of a fast resonant spill. Fig. 9 shows three photographs that were taken early in the experiment when - with the initial settings - only part of the protons were extracted and when the spill had a tail. The signal from the air Cerenkov counter shows throughout the spill the intensity that was extracted per SPS revolution. This is particularly well seen on the lowest photograph where the different revolutions can clearly be distinguished. The examples given in Fig. 9 indicate an important modulation at twice the revolution frequency: the extracted intensity strongly varies from one SPS revolution to the next, but is very similar every second revolution. The modulation changed during the spill and from cycle to cycle.

More experimental and theoretical work is needed before an explanation can be given for the observed phenomenon which is obviously linked to the symmetry of the half-integer separatrices.

Reported by : K.H. Kissler

Internal dump
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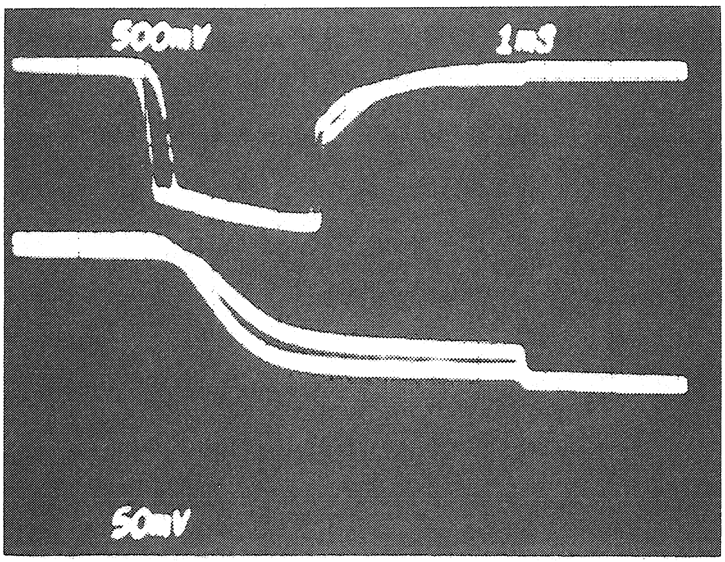
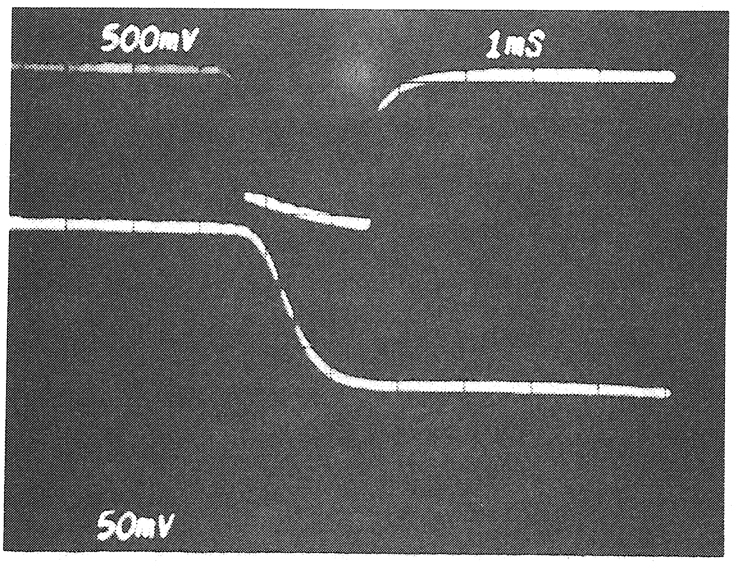


BSI 6103
(saturated)

BCT ring

Q_H = 26.550 ; Charging voltage : 2.2 kV
Scope trigger : 6402 ms



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BCT ring

Q_H = 26.550 ; Charging voltage : 2.5 kV
Scope trigger : 6400 ms

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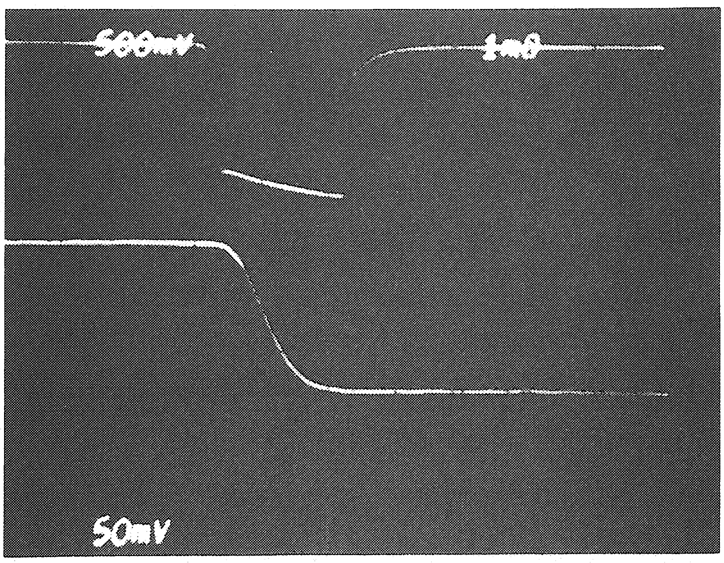
Fig. 1 Half-integer spills obtained with a fast pulsed quadrupole.



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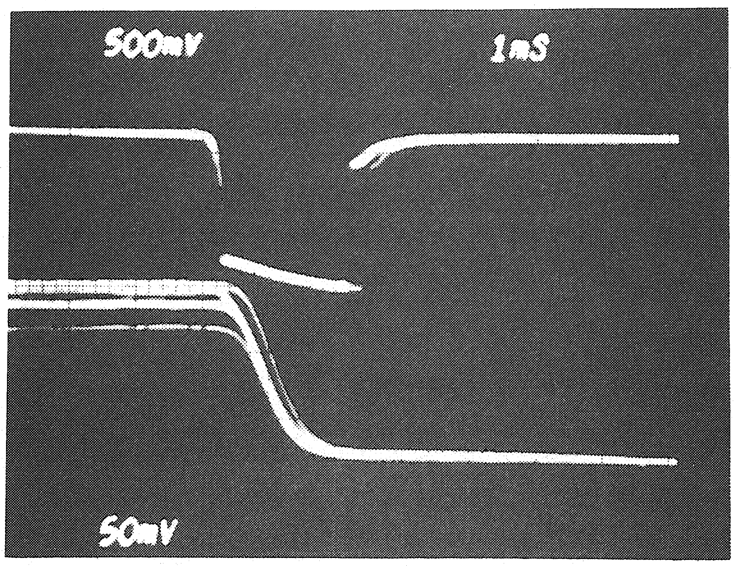
BCT ring



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BCT ring

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Fig. 2 Half-integer spills obtained with a fast pulsed quadrupole. Q_H = 26.545 ; Charging voltage : 2.2 kV
Scope trigger : 6400 ms.

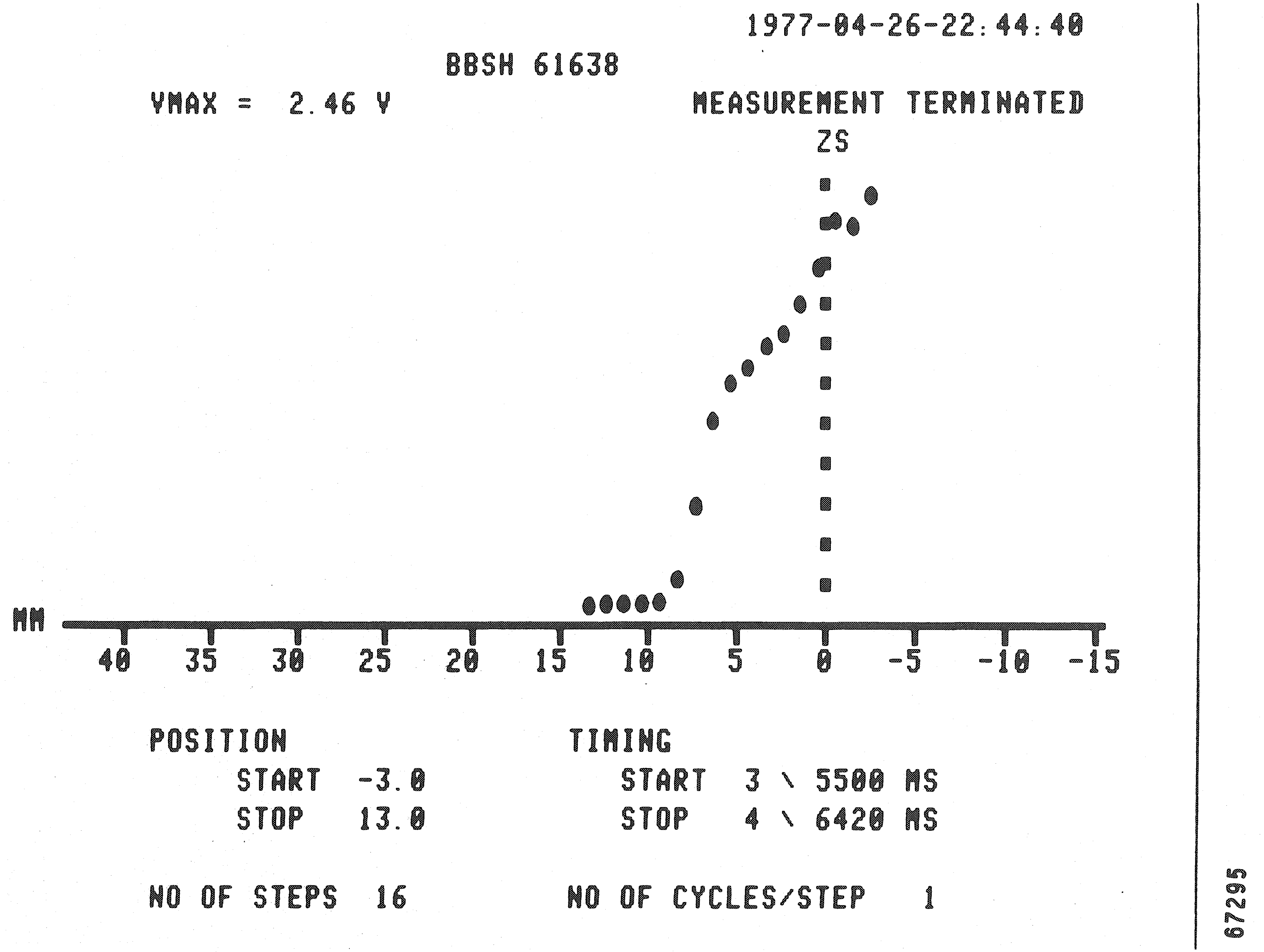

Fig. 3 Density distribution at the electrostatic septum ZS.

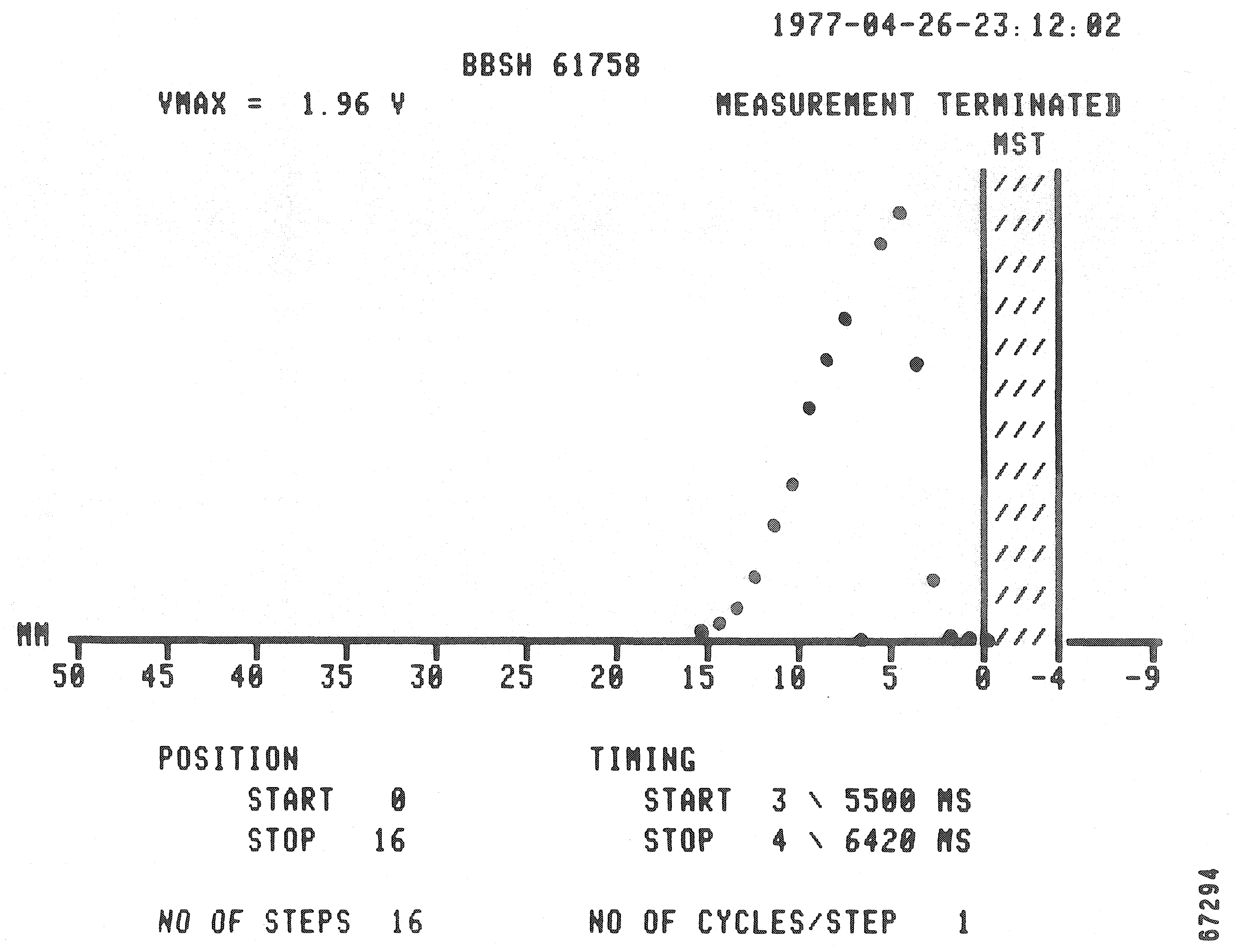

Fig. 4 Horizontal profile of the extracted beam at the entrance of the thin septum magnet MST.

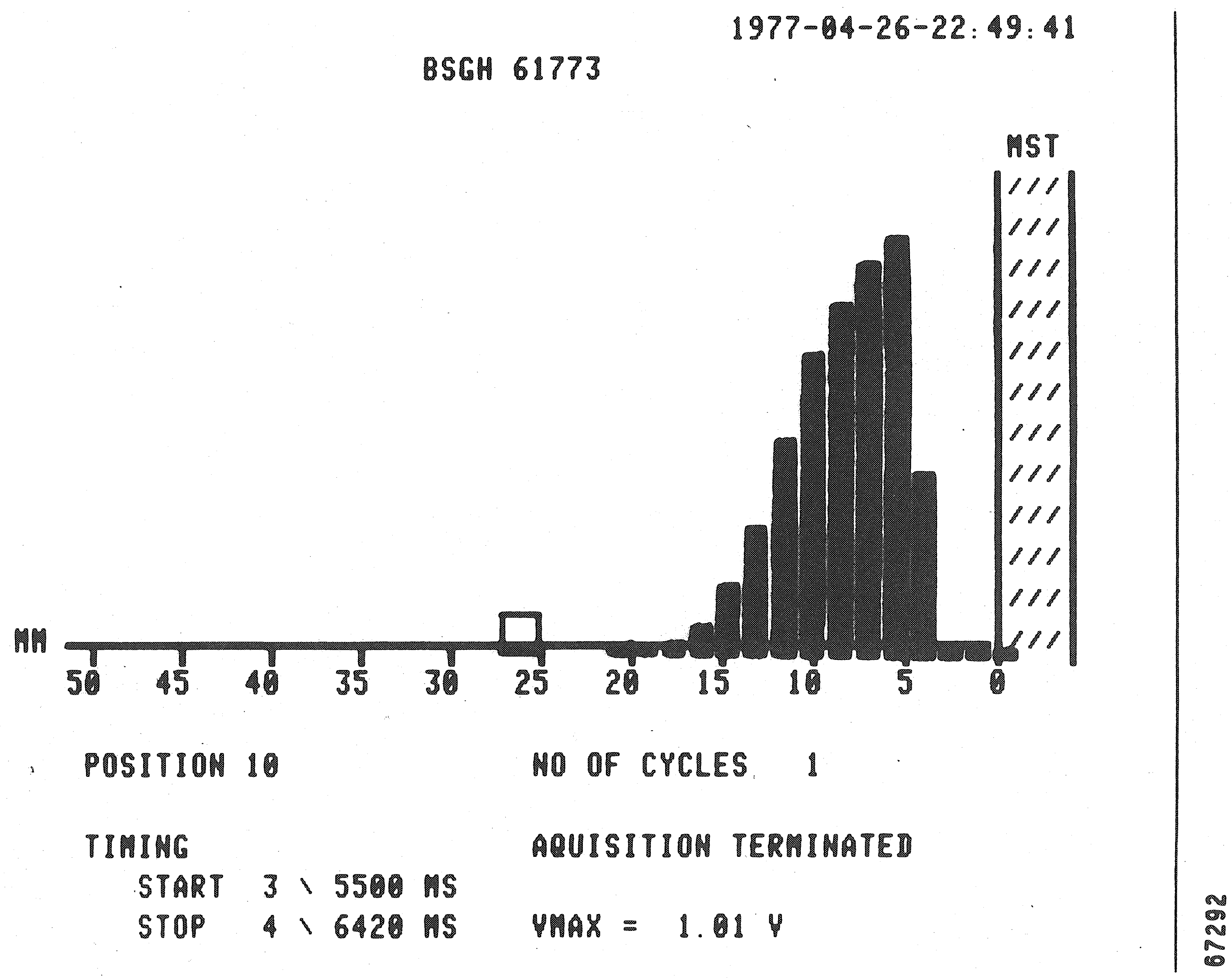

Fig. 5 Horizontal profile of the extracted beam in front of the second MST tank.

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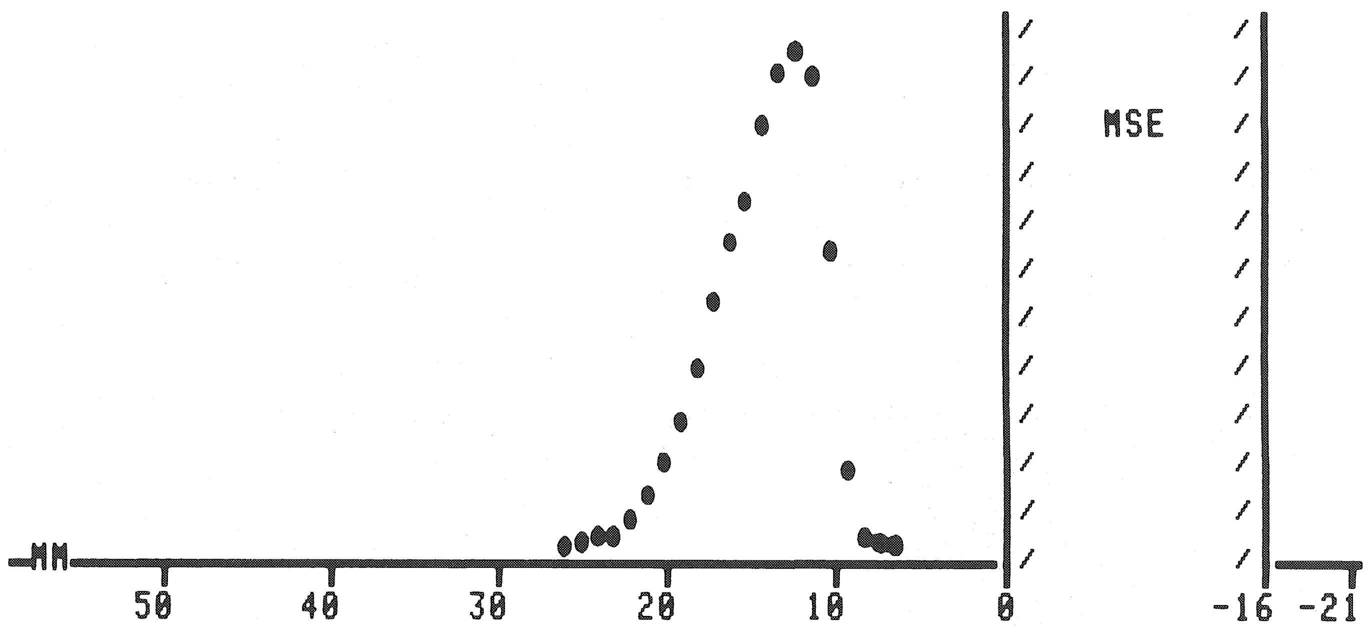
VMAX = 2.42 V   MEASUREMENT TERMINATED



POSITION
START 5
STOP 25

TIMING
START 3 \ 5500 MS
STOP 4 \ 6420 MS

NO OF STEPS 20

NO OF CYCLES/STEP 1

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Fig. 6 Horizontal profile of the extracted beam at the extractor magnet MSE.

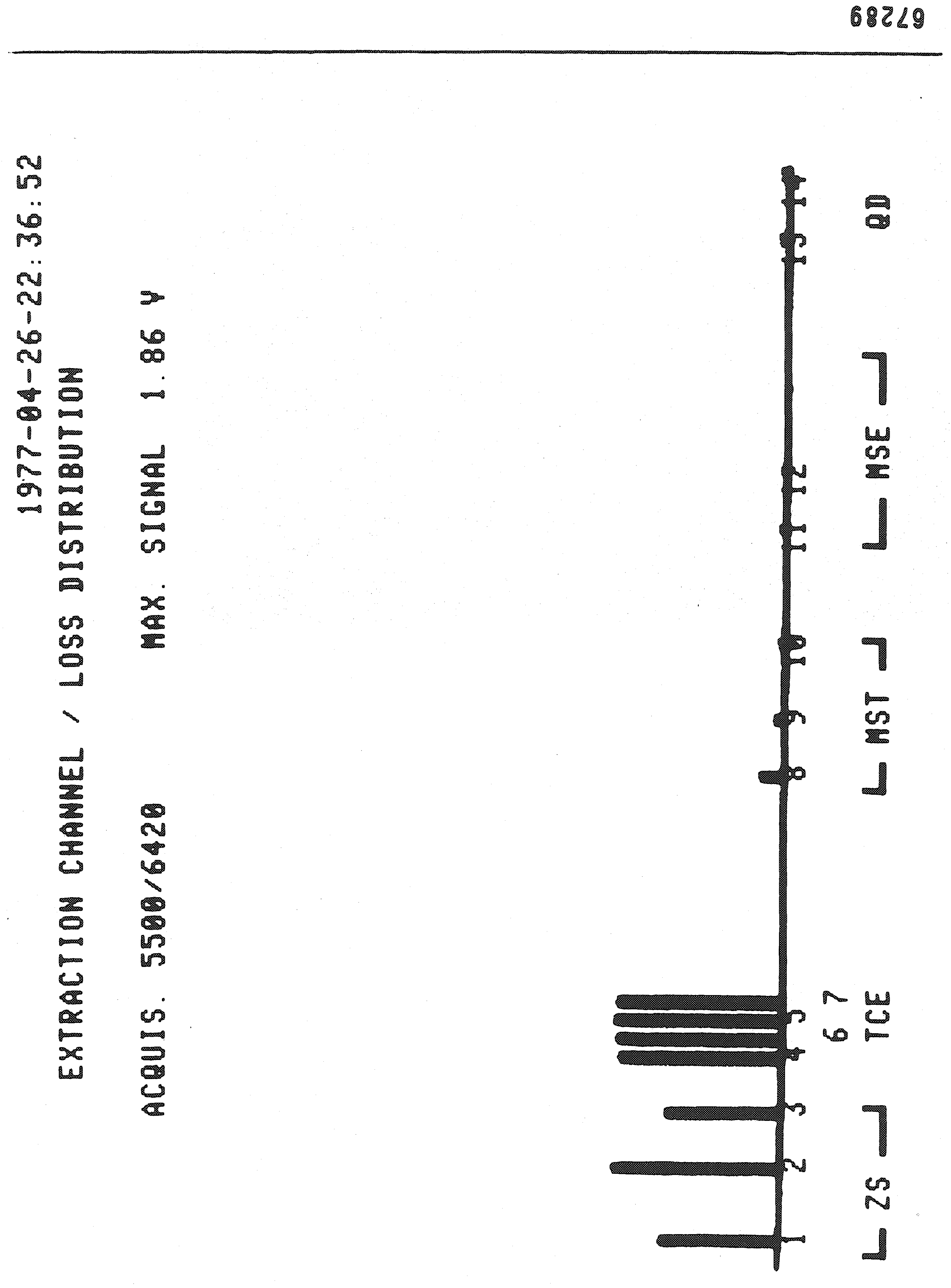

Fig. 7 Loss distribution along the extraction channel for the half-integer spill at 400 GeV/c obtained with a fast pulsed quadrupole.

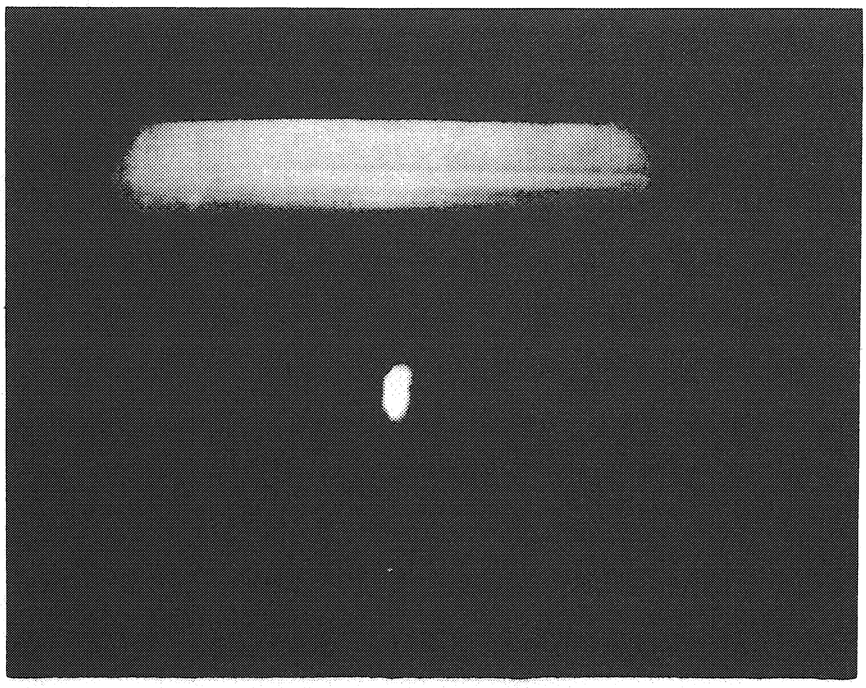

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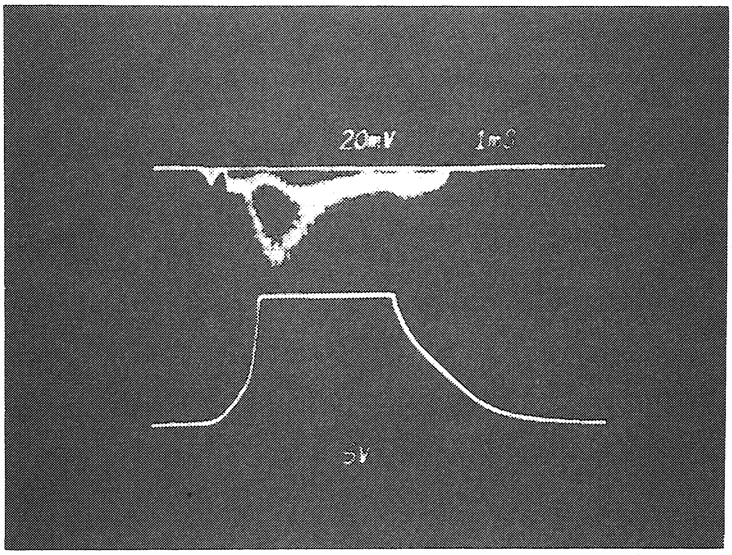
Fig. 8 Fast resonant extracted beam on the first luminescent screen in TT60.



Cerenkov counter

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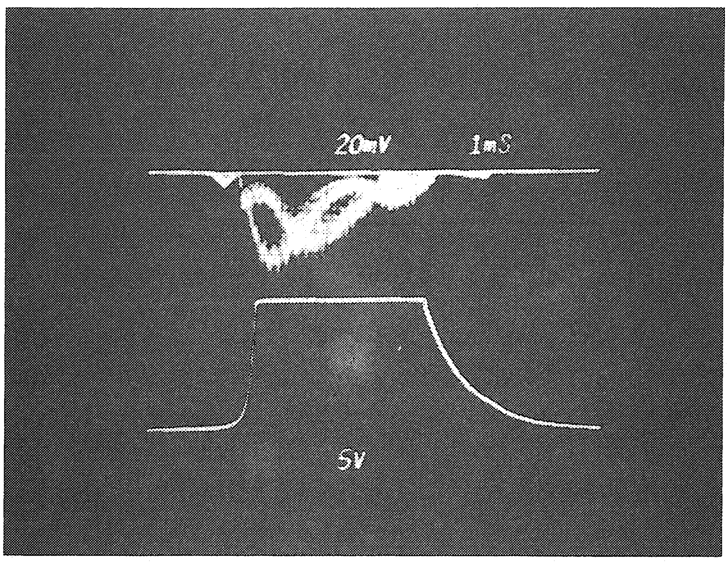

Cerenkov counter

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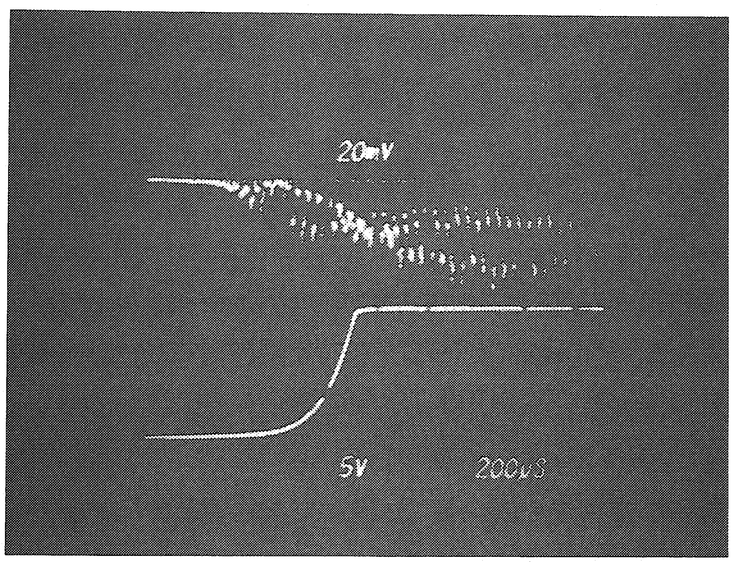
(saturated)



Cerenkov counter

BSI 6103
(saturated)

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Fig. 9 High frequency structure of the fast half-integer spill.