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Resonant extraction tests at Q_H = 25 2/3 and at Q_H = 25 1/2 on 28th August and on 10th September 1979

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1. Summary

For operation at 450 GeV/c it has been proposed to lower the horizontal and vertical tunes of the SPS by one unit, from tunes around 26.6 to tunes around 25.6. Therefore it seemed necessary to check whether we shall still be able to do all required extractions with the existing extraction quadrupoles, sextupoles and octupoles. First, slow resonant extractions at Q_H = 25 2/3 were set up to both the North and the West. No noticeable difference with respect to the extractions at Q_H = 26 2/3 could be observed. Thereafter fast non- coherent half-integer extraction (spill duration about 1 ms) and two- burst coherent half-integer extraction were tested. Both extractions worked satisfactorily. The horizontal beam profile measured in the gap of the extractor magnet MSE for coherent extraction was, however, somewhat larger than previously observed at Q_H = 26.5, reflecting a larger divergence at the electrostatic septum and revealing the two bursts.

2. Extraction at Q_H = 25 2/3

The slow third-integer extractions were set up on the first and second flat top of a 240/400 GeV cycle adjusted to the new working point and using timings similar to those of cycle 33 which has been proposed for the 450 GeV run in period 5.

During the extractions the radial machine chromaticity was natural and the Landau damping octupoles were set close to their nominal values, that is :

at 240 GeV/c : strength of LODN = + 20 m^{-3} total
strength of LOFN = - 3.3 m^{-3} total

at 400 GeV/c : strength of both types of octupoles nearly zero.

After the excitation of suitably positioned extraction sextupoles (LSE 1060, LSE 1240, LSE 4060, LSE 4240 for North extraction and LSE 2060, LSE 2240, LSE 5060, LSE 5240 for West extraction) the beam was driven into the resonance by the standard quadrupole servo.

Fig. 1 shows the density distribution of the protons extracted to the North as it was observed at the electrostatic septum for a nominal current of 135 A in the extraction sextupoles. The measured maximum jump of 12 to 13 mm is in excellent agreement with the expected theoretical value of 12.7 mm.

Fig. 2 shows the density distribution measured at the electrostatic septum after the current in the LSE's had been increased to 180 A.

The horizontal profile of the extracted beam observed at the extractor magnet MSE also corresponds to the predictions (Fig. 3).

Whereas the low frequency structure of the West spill looked quite satisfactory, the structure of the North spill was somewhat ragged. However, there is no reason to believe that the spill structure, after more careful adjustment, should be less good at Q_H = 25 2/3 than at Q_H = 26 2/3.

3. Fast non-coherent extraction at Q_H = 25 1/2

The angle of the half-integer separatrix at the electrostatic septum critically depends on the lattice position of the extraction quadrupole. It so happens that QE 3140, normally used for extraction at Q_H = 26 1/2, is also in an almost ideal position for extraction at Q_H = 25 1/2 when the resonance is approached from above. This quadrupole is connected to a capacitor discharge supply. During our test the charging voltage was set to 2.8 kV. (Value of the capacity : 600 μF.) Four extraction octupoles (LOE 1300, LOE 2200, LOE 4200 and LOE 6200) were excited with a current of -409 A in order to provide the necessary non-linearity. Three of these octupoles are in optimum positions, whereas LOE 2200 is somewhat too close to a maximum of the two-turn closed trajectory of the unstable fixed points. We indeed observed a distortion of the extracted beam due to this octupole. For normal operation of non-coherent extraction (1 to 3 ms spill) it should therefore not be used. LOE 2200 is, however, needed for coherent extraction as the required total octupole strength can otherwise not be reached.

The details of the procedure used for fast non-coherent half-integer extraction have been previously described (compare for instance SPS Comm. Rep. No. 68).

The spill duration is largely determined by the radial chromaticity of the SPS. Fig. 4 shows the spill obtained at 400 GeV/c with $\xi_H \sim -0.2$.

It is worth mentioning that the fast spill started 105 ms after the end of the slow spill to the North. This delay between the extractions is the minimum needed to switch off the magnets (horizontal bumpers, extraction sextupoles) used for the third-integer extraction to the North, to power the magnets for half-integer extraction to the West and to modify the radial tune and chromaticity of the SPS.

4. Two-burst coherent half-integer extraction

A detailed description of coherent half-integer extraction is given in SPS Improvement Reports Nos. 125, 138 and 151. In the present experiment this extraction was obtained starting from the non-coherent half-integer spill set up as described above. The upstream pair of fast extraction kickers was fired 2.5 ms after the trigger of QE 3140 and with a PFN charging voltage of 50 kV. This resulted in a spill consisting of three 23 μs bursts separated by intervals of the same duration. The first two bursts had equal intensity whereas the third burst was rather small, containing only 2 to 3 % of the extracted protons. By a further optimization of different settings (octupole strength, radial bump at the electrostatic septum, kicker timing and strength, radial chromaticity of the SPS), it may be possible to suppress the small burst. Otherwise it can be dumped in the SPS if required by the users.

Fig. 5 shows the distribution of extracted protons measured in the gap of the electrostatic septum for the "two-burst" extraction at $Q_H = 25\ 1/2$. It is similar to the distribution previously observed for the same extraction at $Q_H = 26\ 1/2$ (Fig. 6 of SPS Improvement Report No. 151).

The horizontal beam profile in the gap of the MSE looked, however, different from the profile measured at $Q_H = 26\ 1/2$ and more clearly revealed the two bursts (compare Fig. 6 of this report with Fig. 7 of SPS Impr. Rep. No. 151). No explanation for this difference has been found so far.

Reported by : K.H. Kissler

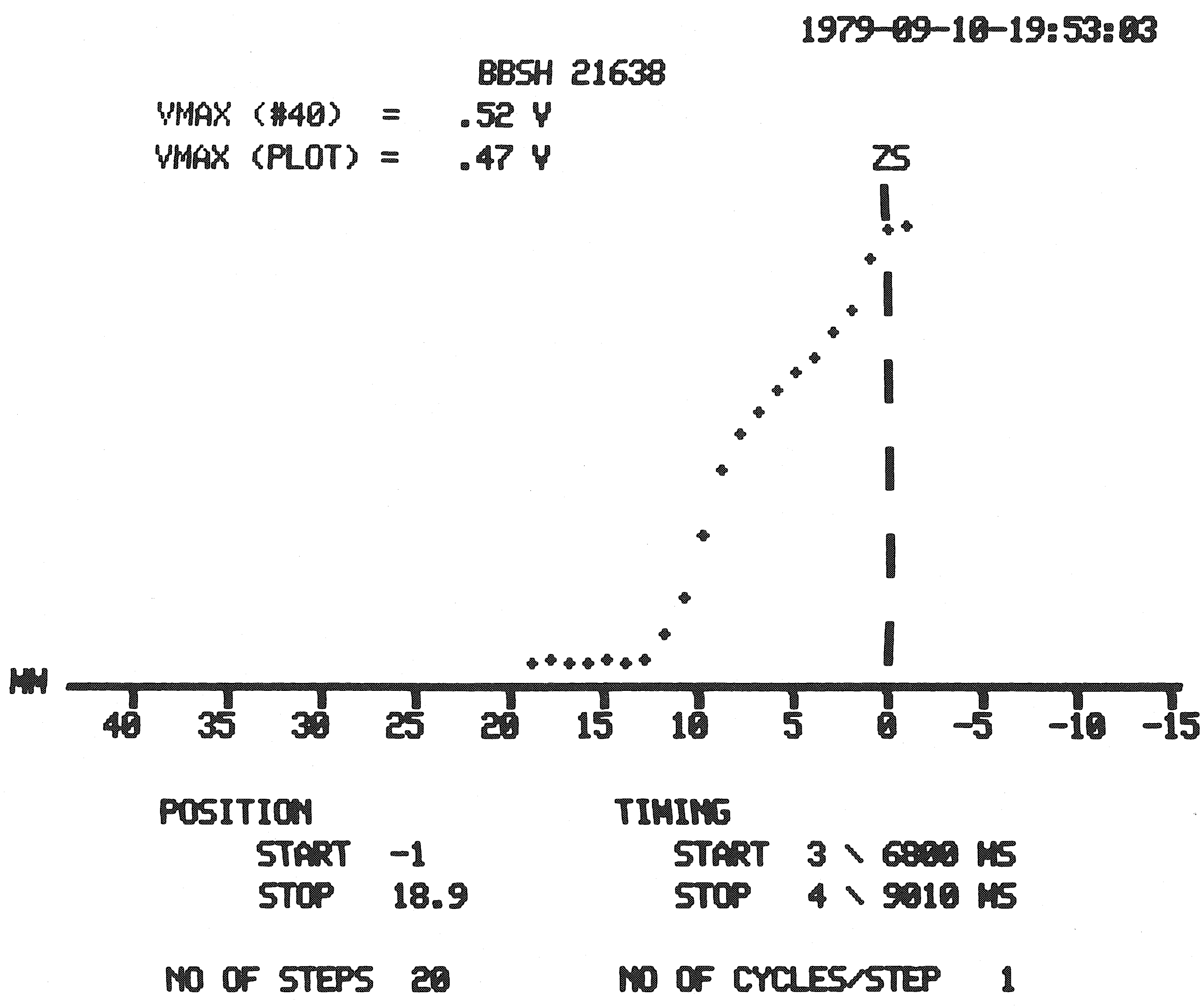

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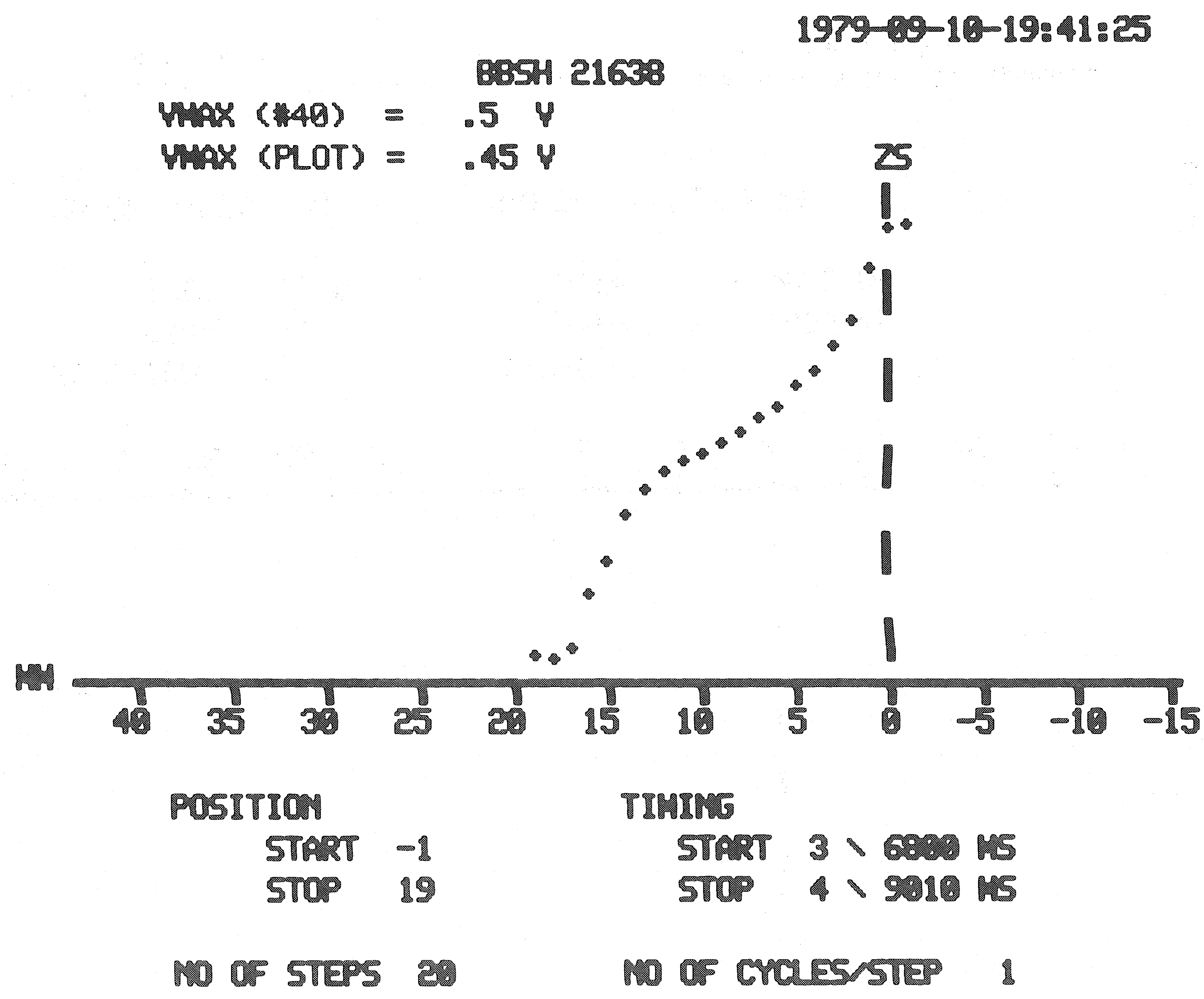
Fig. 1 Density distribution at the electrostatic septum ZS for slow resonant extraction at Q_H = 25 2/3 to the North. LSE current: 135 A.



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<u>Fig. 2</u> Density distribution at the electrostatic septum ZS for slow resonant extraction at Q_H = 25 2/3 to the North. LSE current: 180 A.

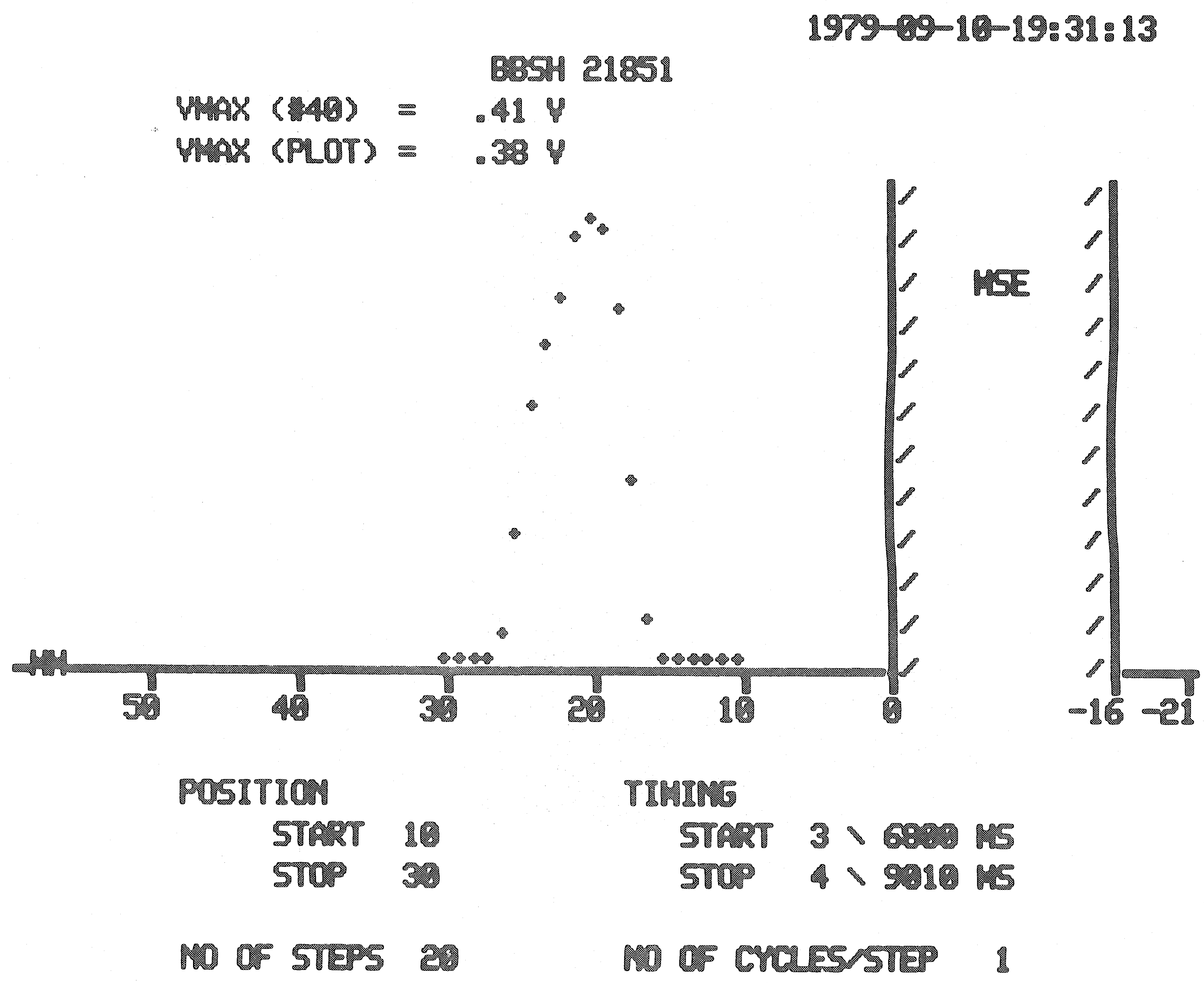

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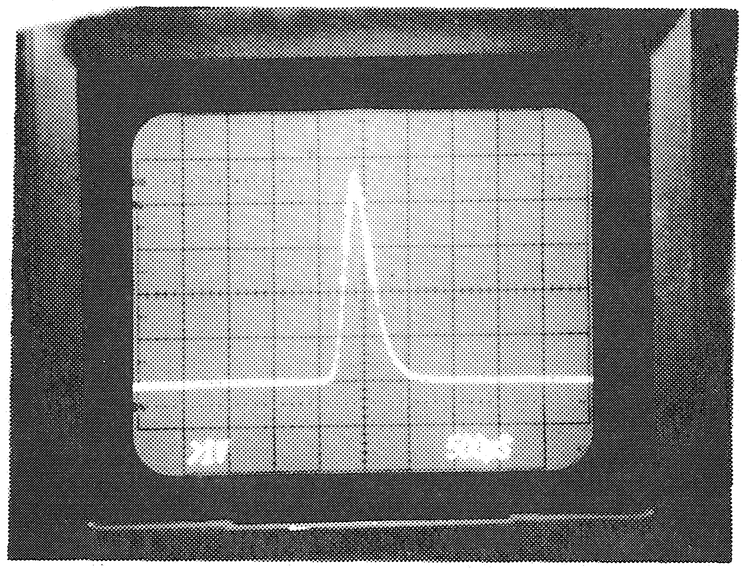
Fig. 3 Horizontal profile of the extracted beam in the gap of the extractor magnet MSE for slow resonant extraction at $Q_H = 25\ 2/3$.



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<u>Fig. 4</u> Fast non-coherent half-integer spill at 400 GeV/c.

Q_H = 25.55 $\xi_H \sim -0.2$

QE 3140: capacitor charging voltage = 2.8 kV.

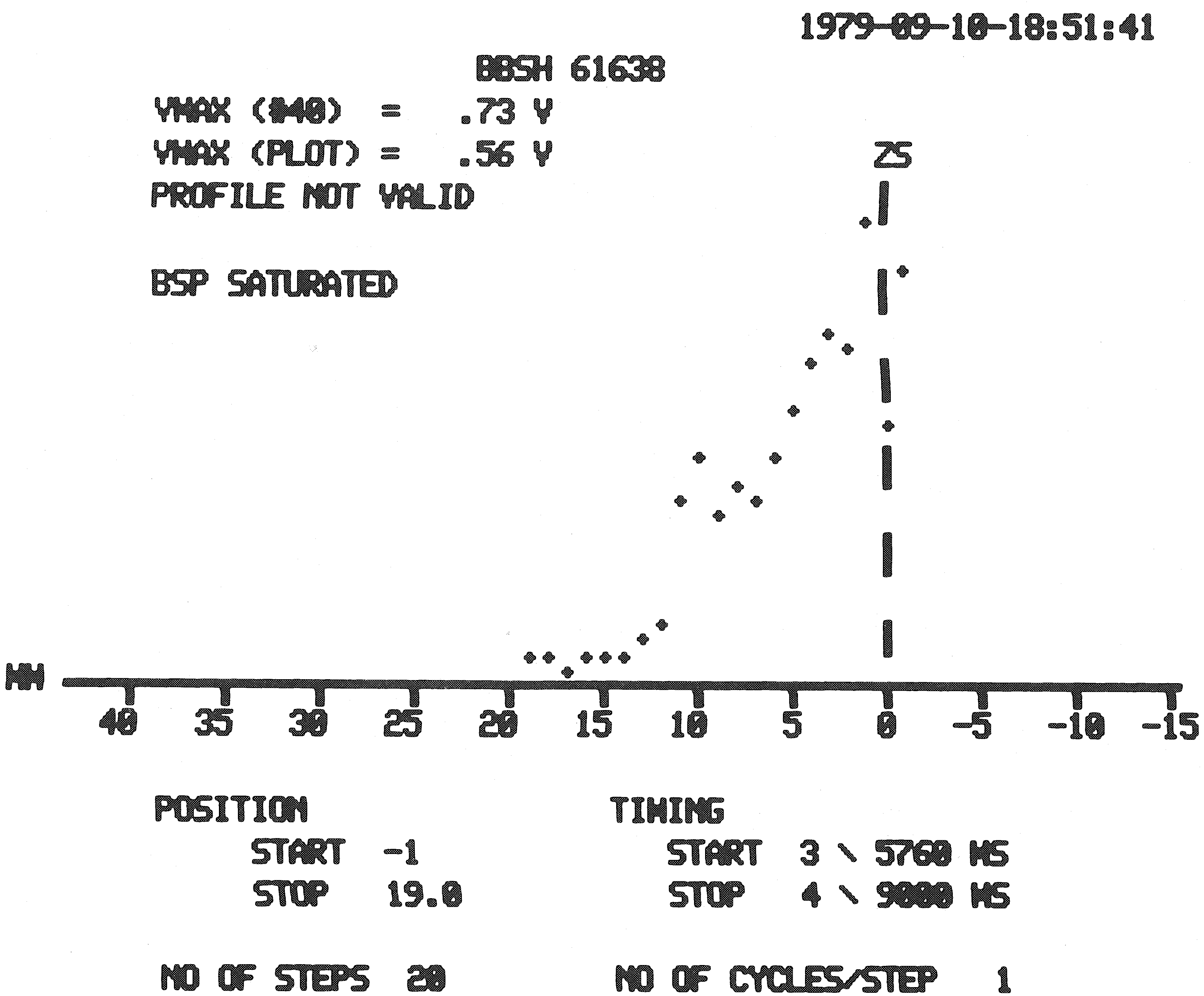

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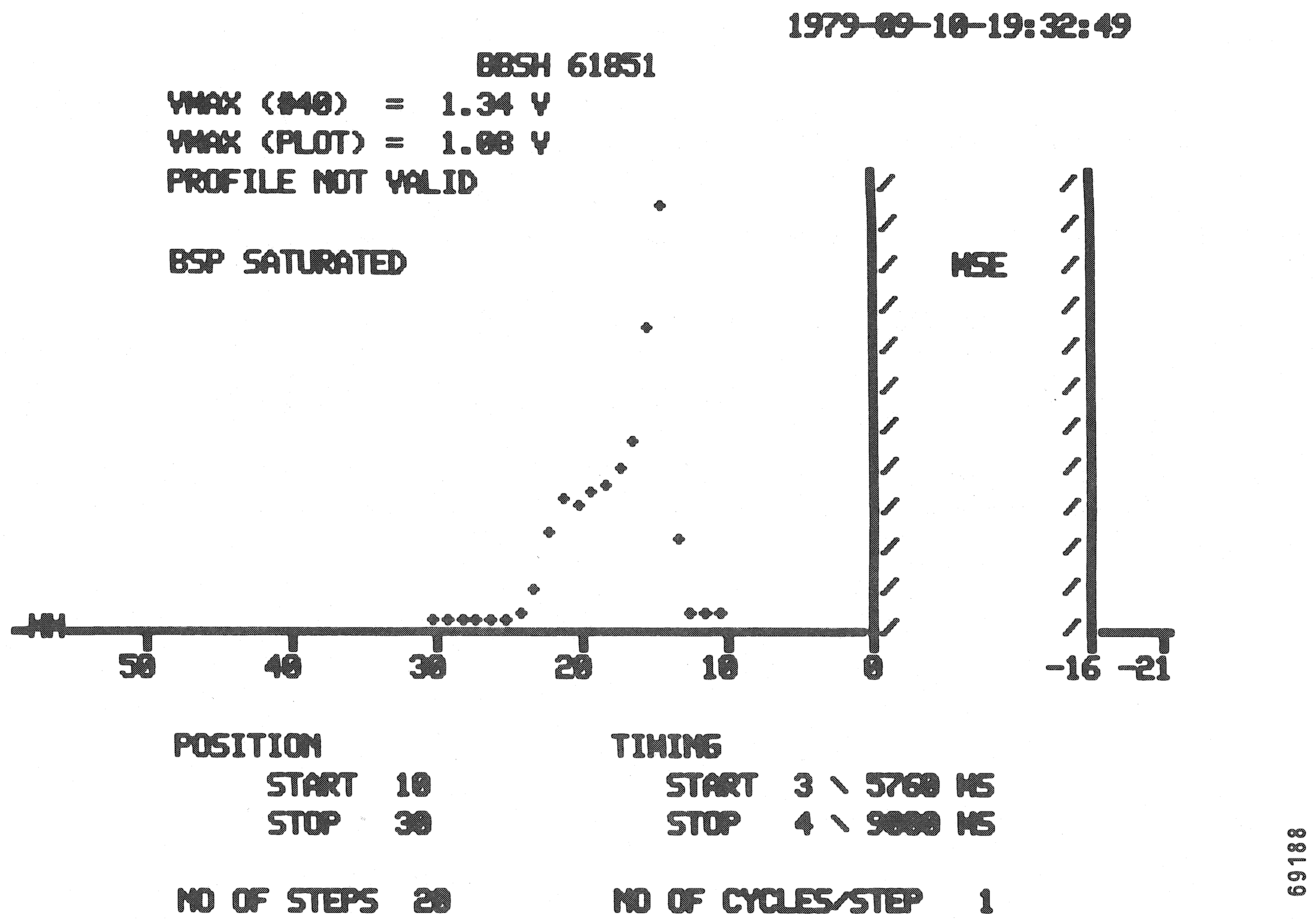
Fig. 5 Density distribution at the electrostatic septum ZS for two-burst coherent half-integer extraction at $Q_H = 25\ 1/2$.



<u>Fig. 6</u> Horizontal profile of the extracted beam in the gap of the extractor magnet MSE for two-burst coherent half-integer extraction at $Q_H = 25\ 1/2$.