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SPS IMPROVEMENT REPORT NO. 103

Mr. Volker RODEL E-7

Slow third-integer extraction on the ramp after the 200 GeV flat top. Tests on 22nd and on 25th August 1977

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1. Summary

Slow third-integer extraction on the ramp after the 200 GeV flat top proved to be entirely feasible. During the first tests on cycle 13b spills of up to 500 ms length were readily achieved and longer spills seem possible.

On the ramp of cycle 17 short spills of about 50 ms length were optimized and studied in some detail. A closed loop servo system using LQE 1143 to act on the horizontal machine tune permitted to obtain uniform spills with little low frequency structure. Fractions as low as $1 * 10^{11}$ protons could be extracted with a cycle to cycle stability of about $\pm 3 * 10^{10}$ protons. At present, the maximum amount that can be extracted under servo control within 50 ms is of the order of $8 * 10^{11}$ protons.

2. Experimental conditions and procedure

The extractions were done on the ramp after the 200 GeV flat top of cycle 13b (on 22nd August) and of cycle 17 (on 25th August). The SPS settings on the ramp were the same as for normal runs. Therefore, during extraction, the horizontal chromaticity was equal to + 0.4, the current in the Landau damping octupoles was - 150 A and the RF voltage was 3.5 MV.

Third-integer extraction at $Q_H = 26\ 2/3$ was adjusted as previously described for extraction on the flat top (SPS Comm. Report No. 55) except that all magnetic elements (horizontal and vertical bumpers, MST and MSE and the extraction sextupoles) were excited to track the main magnets. The currents were scaled from the currents normally used on the 200 GeV flat top except for the current of the thin septum magnet MST. The normalized strength of this magnet was increased by a factor of 1.5 in order to compensate for the loss of strength of the electrostatic septum ZS which is always run at a constant field of about 105 kV/cm.

A detailed description of the real time feed-back system that was used to obtain a uniform spill and to control its intensity can be found in the SPS Improvement Report No. 102. The spill signal from the secondary emission monitor BSI 6103 is compared with a reference signal. The difference between the two signals is amplified and acts on LQE 1143, changing the radial tune of the machine.

During the tests on cycle 13b the SPS continued to run as during normal operation at an accelerated intensity of about 7 to 8 $* 10^{12}$ ppp with a spill of about 1.3 sec length on the 200 GeV flat top and a fast resonant extraction at 350 GeV/c.

The tests on cycle 17 were done in parallel with tests on fast extraction. The accelerated intensity was of the order of $4 * 10^{12}$ ppp.

3. Results on cycle 13b

The upper photograph of Fig. 1 shows the first slow resonant spill from the SPS obtained on the ramp.

The lower photograph proves that long spills of 500 ms or more are entirely feasible on the ramp after the 200 GeV flat top. In fact, no observations were made that would indicate any limitations of the spill length.

The spills shown in Fig. 1 were obtained without servo control, simply driving the protons into the resonance by a linear increase of Q_H. Spills under control of the "LQE servo" were also investigated on the ramp of cycle 13b. The results were very similar to those described below for cycle 17.

4. Results on cycle 17

The aim of the tests on cycle 17 was to study in some detail short spills of 50 to 60 ms length produced on the ramp after the 200 GeV flat top. Q_H was adjusted to bring the beam just to the limit of the third-integer stop-band between 3960 and 4020 ms after injection. Protons were then extracted under control of the LQE servo.

The upper photograph of Fig. 2 shows the extraction of $1 * 10^{11}$ protons with the momentum changing during the spill from 212.7 GeV/c to 217.3 GeV/c. Fig. 3 gives an impression of the cycle to cycle stability achieved for such a low extracted intensity.

The lower photograph of Fig. 2 shows the spill when about $8 * 10^{11}$ protons were extracted within slightly more than 50 ms. This intensity is the upper limit that can at present be controlled by the LQE servo for a 50 ms spill.

Figs. 4 and 5 show beam profiles measured in the extraction channel for $8 * 10^{11}$ protons extracted. Two comments can be made :

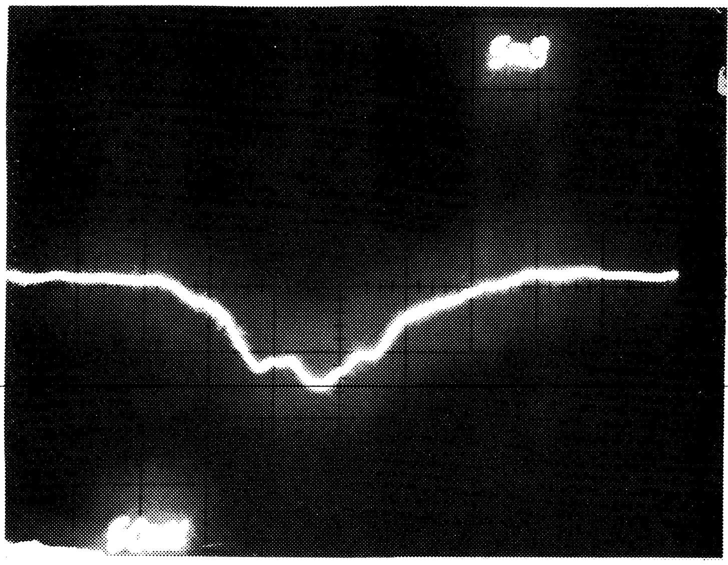
- The jumps at the electrostatic septum are somewhat larger than those observed on the 200 GeV flat top for the same normalized strength of the extraction sextupoles. Computer calculations prove that this is due to the contribution of the chromaticity sextupoles to the driving force of the resonance at $Q_H = 26\ 2/3$. (The chromaticity sextupoles are not excited on the flat top.)

- Due to the reduced amount of horizontal chromaticity the influence of the RF on the extracted beam emittance was considerably reduced.

The horizontal profile measured at the MSE is in fact rather narrow in spite of an RF voltage of 3.5 MV. (On the 200 GeV flat top the RF voltage is normally reduced to some 700 KV to keep the horizontal emittance of the extracted beam reasonably small.)

Finally it should be mentioned that an attempt to control the slow spill on the ramp with the RF servo failed for reasons that are not yet understood.

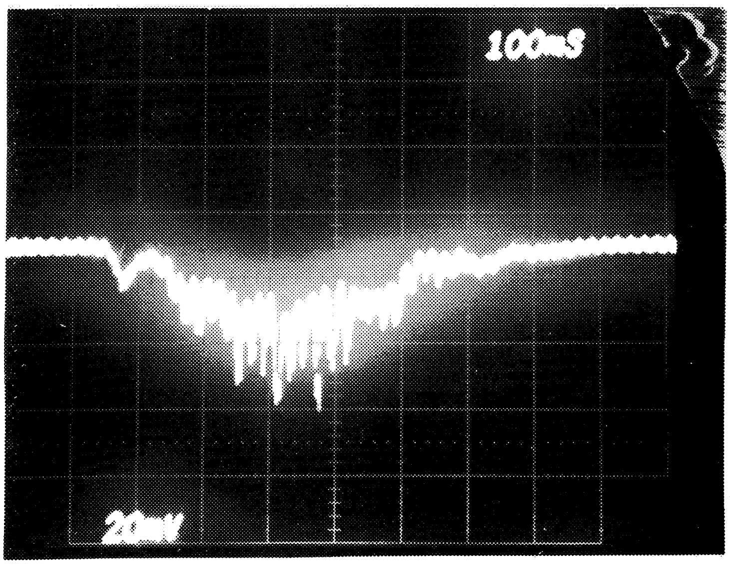
Reported by : K.H. Kissler



BSI 6103

Scope trigger: 4055

First third-integer spill on the ramp after the 200 GeV flat top of cycle 13b.



BSI 6103

Scope trigger: 3800

Slow third-integer spill on the ramp after the 200 GeV flat top of cycle 13b without servo control.

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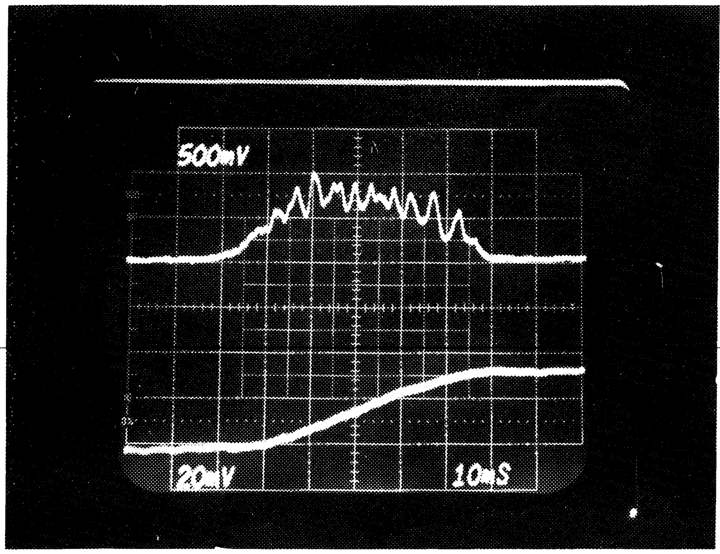
Fig. 1

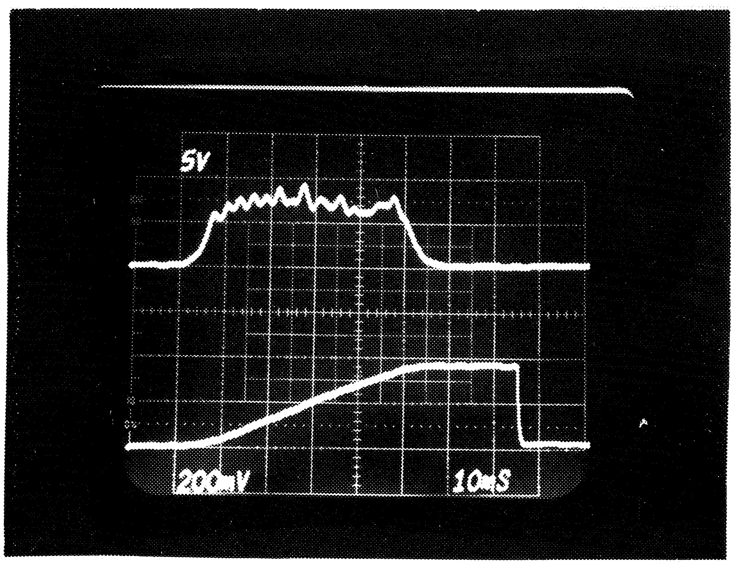


Spill signal
(BSI 6103)

Integrated spill

Scope trigger: 3950

Slow third-integer extraction of 1 * 10^{11} protons on the ramp of CY17. The proton momentum changes during the spill from 212.7 GeV/c to 217.3 GeV/c.



Spill signal
(BSI 6103)

Integrated spill

Scope trigger: 3970

Slow third-integer extraction of ∿ 8 * 10^{11} protons on the ramp of CY17. The proton momentum changes during the spill from 213.9 GeV/c to 218.1 GeV/c.

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Fig. 2

	I1(T=3950)	I2(T=4030)
1	294	290
2	283	276
3	276	269
4	316	309
5	284	274
6	336	326
7	290	278
8	310	300
9	393	381
10	335	325
11	306	293
12	303	295
13	292	286
14	336	328
15	274	267
16	315	308
17	1	1
18	309	297
19	328	318
20	305	296
21	301	294
22	288	279

<u>Fig. 3</u> Cycle to cycle stability of a low intensity extracted during 60 ms on the ramp of CY17. I1 and I2 are the circulating beam intensities (in 10^{10} protons) before and after the spill.

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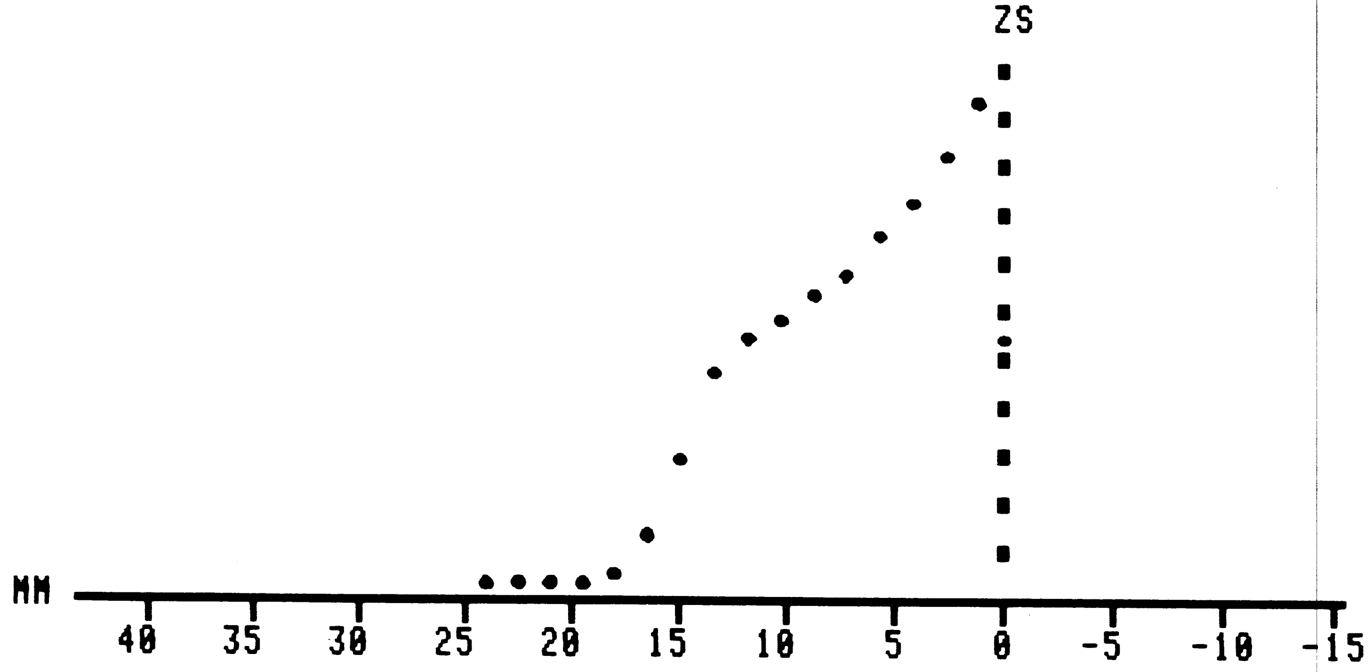
BBSH 61638

VMAX = .88 V

MEASUREMENT TERMINATED



POSITION
START 0
STOP 24.0

TIMING
START 2 \ 3900 MS
STOP 3 \ 4100 MS

NO OF STEPS 16

NO OF CYCLES/STEP 1

Fig. 4 Density distribution at the electrostatic septum ZS for a 50 ms spill on the ramp of CY17.

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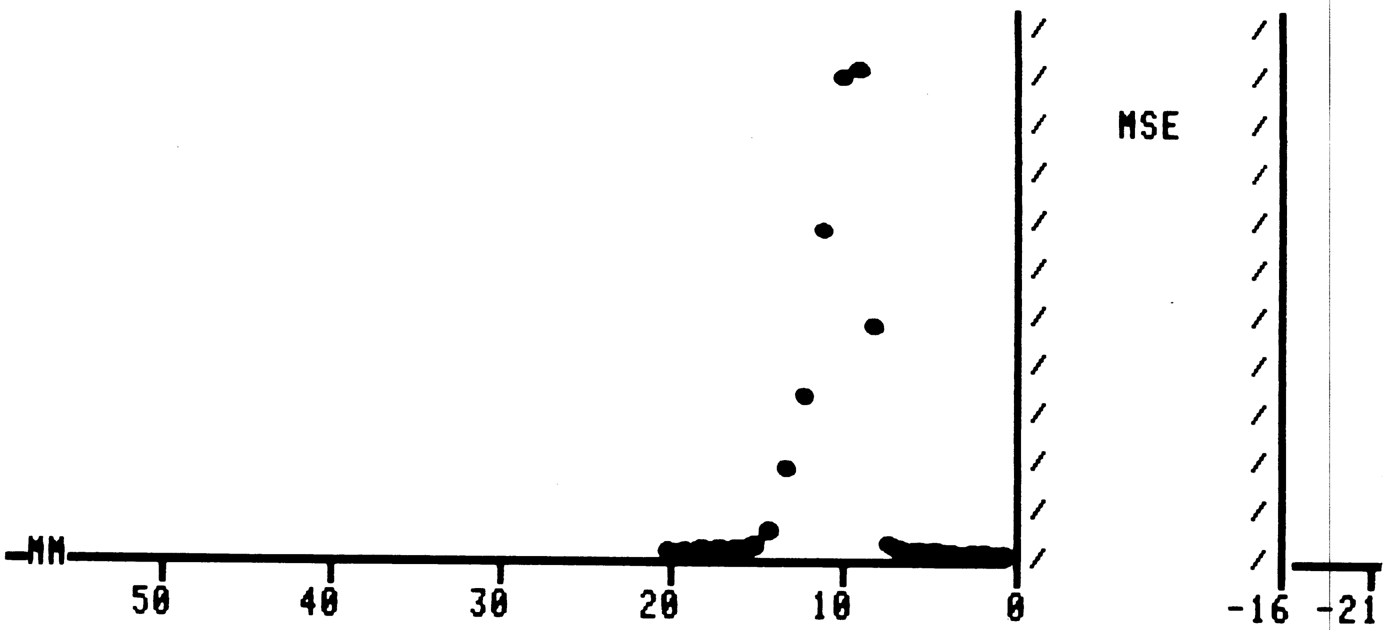
BBSH 61851

VMAX = 3.79 V

MEASUREMENT TERMINATED



POSITION
START 0
STOP 20

TIMING
START 2 \ 3900 MS
STOP 3 \ 4100 MS

NO OF STEPS 20

NO OF CYCLES/STEP 1

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Fig. 5 Horizontal profile of the extracted beam at the extractor magnet for a 50 ms spill on the ramp of CY17.