SPS/ABT/EX/RK 3 June 1982

SPS IMPROVEMENT REPORT No. 195

Will the wires of the electrostatic septa stand future high extracted intensities ?

R. Dubois, R. Ducret, A. Ferrari, W. Kalbreier, R. Keizer, K.H. Kissler,
M. Laffin, R. Mauris

---

1. Introduction

The electrostatic septa of the SPS extraction systems, which were designed in the years 1972 - 1974, work reliably for the extraction of upto 10^{13} protons per extraction channel. Beyond this intensity we have met with increasing difficulties. Excessive sparking or complete destabilization of the septa have forced us on several occasions to limit the extracted intensities. Thus, during period 2A of this year, coherent half-integer extraction for narrow band neutrino physics made the septum in LSS6 trip beyond 10^{13} extracted protons per pulse.

For these reasons, it became urgent to examine the behaviour of the electrostatic septa more closely. A ZST - test station was conceived which permits beam tests under extreme conditions and which can more easily be equipped with special measuring devices than the standard septa.

This station has recently been installed in the pumping module between the second and third ZS unit in LSS2 to do tests in the slowly extracted beams.

The first of a series of measurements was designed to test the extraction capacity of the 0.10 mm diameter W/Re septum wires and is described in the presente note.

2. Description of the test station

The test station is shown schematically in Fig 1 and is depicted in Figs 2 and 3.

A measuring head, called mini-ZS, is mounted on a long arm which is displaced laterally by remote control from the MCR. This mini-ZS has the same cross section and layout as the anodes of the electrostatic septa, but is only 90 mm long.

In the "out"position, the vacuum separation valve may be closed (from BA2) and the measuring head can be changed without breaking the vacuum in the ring.

In the measuring position the septum wires are either aligned with the septa, zero position,or displaced within the range ± 45 mm with a precision of ±0.03 mm.

An intermediate "garage" position can be used for temporary stand-by.

The mini-ZS can be equipped with various measuring devices, such as probes for temperature measurement, equipment for the measurements of the electrical resistance of single wires etc.

A TV camera permits optical inspection of the septum wires from the MCR.

3. Procedure to simulate high extracted intensities

Protons are extracted in LSS2 by bringing them gradually into the third-integral resonance at $Q_H = 26\ 2/3$. Once unstable, the particles rapidly increase their radial betatron amplitudes and are finally thrown into the electrostatic septum.

The density of the unstable protons at the location of the mini-ZS is a well-known function of the radial distance from the circulating beam centre.

This function is shown in Fig. 4. The density is given in % of protons/mm. A density higher than 100% means that the three-turn growth of the radial amplitude of unstable protons is smaller than 1 mm. The electrostatic septum usually cuts into the outward-going stream of resonant particles at a density of about 10%/mm, with a corresponding loss of 1% of the protons on the W/Re wires.

(The total losses during extraction are somewhat higher since the effective thickness of the ZS is bigger than 0.1 mm).

All one has to do in order to simulate high intensity extraction is to move the wires of the mini-ZS out of their zero position (in the shadow of the main septum wires) and to approach the circulating beam. As mentioned before, the nominal proton density at the ZS is 10%/mm. Therefore, pushing the wires of ZST into a density of 110 %/mm for instance, means simulation of an extracted instensity 11 times higher than the actual intensity during the test.

The only problem to be solved during our measurements was to find out the distance between the circulating beam centre and the wires of ZST in zero position. This distance can be determined in two ways

1 - Radial beam profiles can be measured at different locations in the gap of the electrostatic septum. The profiles show the "jump" at the septum, that is the three-turn amplitude growth of a resonant proton just grazing the septum wires. From the amplitude growth one can then deduce the distance from the beam centre at which the ZS cuts into stream of unstable particles.

2 - The relative density distribution is measured by moving the wires of ZST through the unstable protons towards the beam centre and registering the losses indicated by the downstream beam loss detectors. Comparison between theoretical and mesured density distributions then permits to define which point on the theoretical curve corresponds to the zero position of ZST.

4. Test results

A systematic scan of ZST position was made, starting from zero (in the shadow of the main ZS units 1 and 2) and approaching the circulating beam centre as far as possible without provoking emergency dumps by excessive losses. For each position the reading of all loss detectors near the electrostatic septum was registered, the electrical resistance of the first two ZST wires was measured (mainly to ensure that they weren't broken) and the TV picture showing the central part of the wire array was observed.

Fig. 5 shows the measured distribution of proton losses together with the theoretical curve. Best agreement between the two distributions is obtained under the assumption that the zero position of ZST was at a distance of 24.5 mm from the beam centre during the experiment. This distance compares well with the value of 24.3 ± 1.0 mm deduced from beam profiles which were measured in the gap of the ZS.

Upto a ZST position of -17.0 mm, corresponding to 7.5 mm distance from the beam centre, the situation was perfecly stable. The proton losses on the wires increased smoothly as expected, a slight increase of the resistance of the first two wires was observed, but none of the wires was broken. The proton density at the ZST position of -17 mm was about 110%/mm as can be seen from Fig. 4. Since the fit of the theoretical curve to the measured loss distribution is very sensitive to the assumption about the zero position of ZST, the distance of the wires from the beam centre is known with a precision of ± 0.5 mm at least.

Accordingly, the above proton density of 110%/mm, is known to the next ± 20%/mm.

The wires of the test station were left at the position of -17 mm for about 30 minutes, during which the proton intensity extracted in LSS2 was stable at $9*10^{12}$ ppp. The density seen by the wires of ZST corresponded to $(11 \pm 2) * 9*10^{12} \approx 1.0 \pm 0.2 *10^{14}$ extracted protons per pulse.

When the ZST was moved towards the beam centre by another 0.5 mm, situation became unstable.

Every few cycles, the losses sharply increased at the very end of the slow spill to the North, provoking an emergency dump. In such an event the wires were observed to glow along the beam trajectory. The first wire of the station was broken. The other wires, however, even survived this extreme heating.

5. Conclusion

No adverse short-term effects on the septum wires could be observed for a (simulated) 400 GeV/c slow resonant extraction of $1*10^{14}$ ppp. We do not expect that the future increase of the proton momentum to 450 GeV/c will considerably change the situation. One should, however, be aware that a possible long term fatigue of the wires cannot be excluded by a test of limited duration. It is also clear that tests must still be done for fast resonant extraction (1 mm spill) and for coherent resonant extraction (two 23μs bursts) before a final conclusion about the "extraction capacity" of the 0.1 mm W/Re wires can be drawn.

Nevertheless, the results of the first test are very encouraging and show that the wires of the SPS electrostatic septa should not be damaged by the slow extraction of proton intensities in reach of the SPS.

Acknowledgments

We would like to thank M.Ainoux, R. Cornali U. Kracht and F. Merle for their help during the installation of the test station.

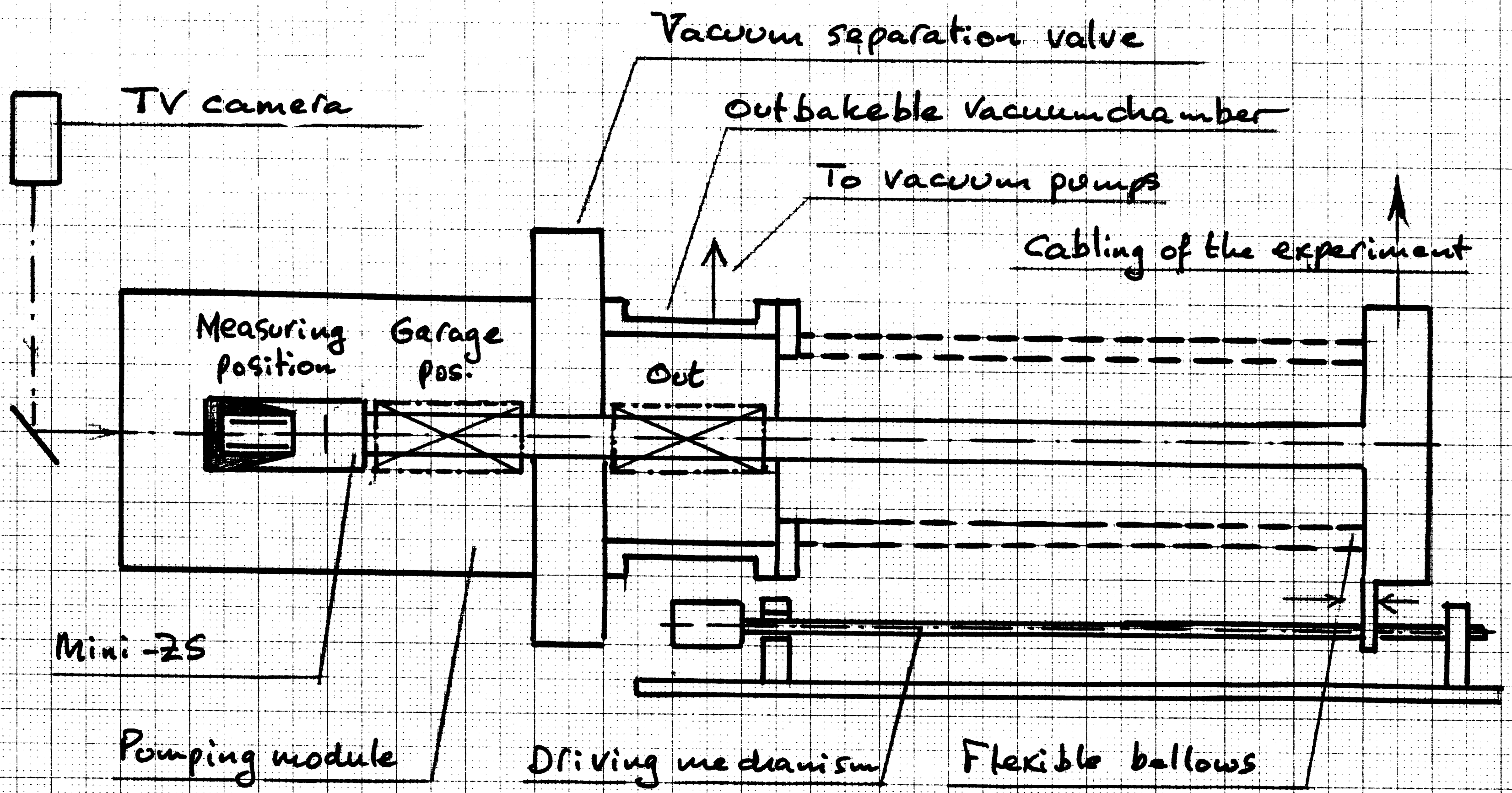

FIG 1 SCHEMATIC LAY-OUT OF THE ZST-STATION

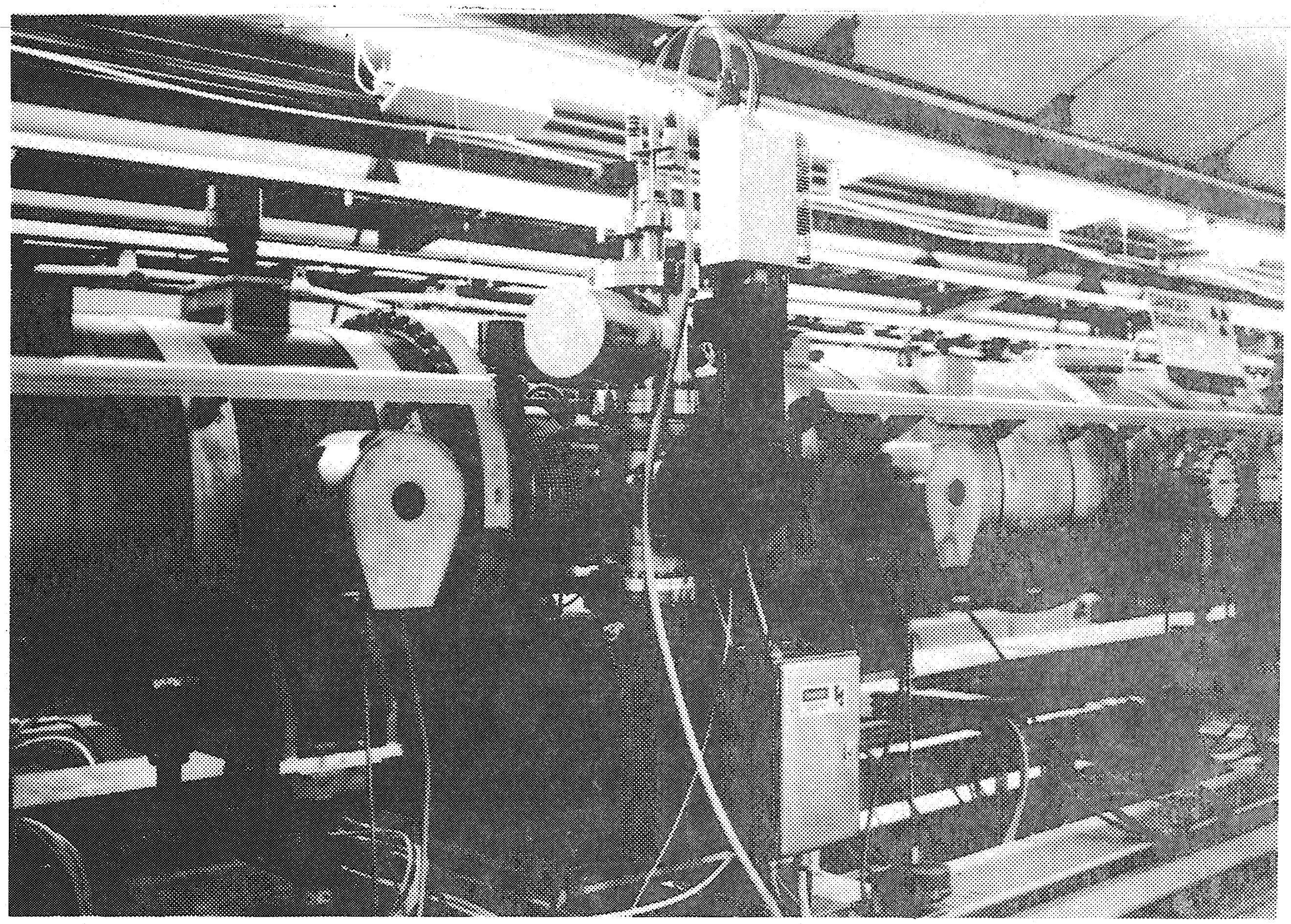

FIG2 ZST-STATION, VIEW FROM THE INSIDE OF THE SPS

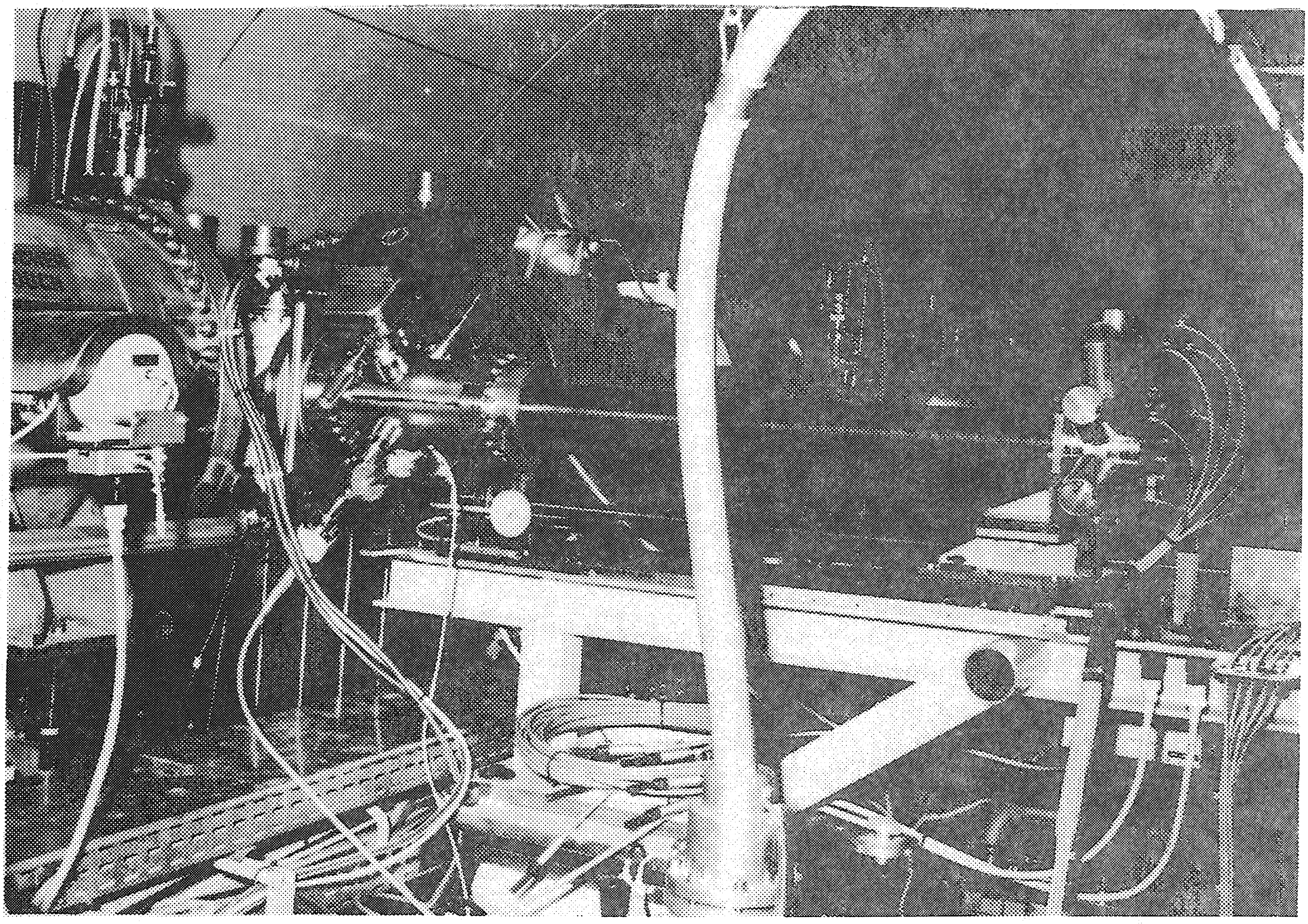

FIG3 ZST-STATION, VIEW FROM THE OUTSIDE OF THE SPS

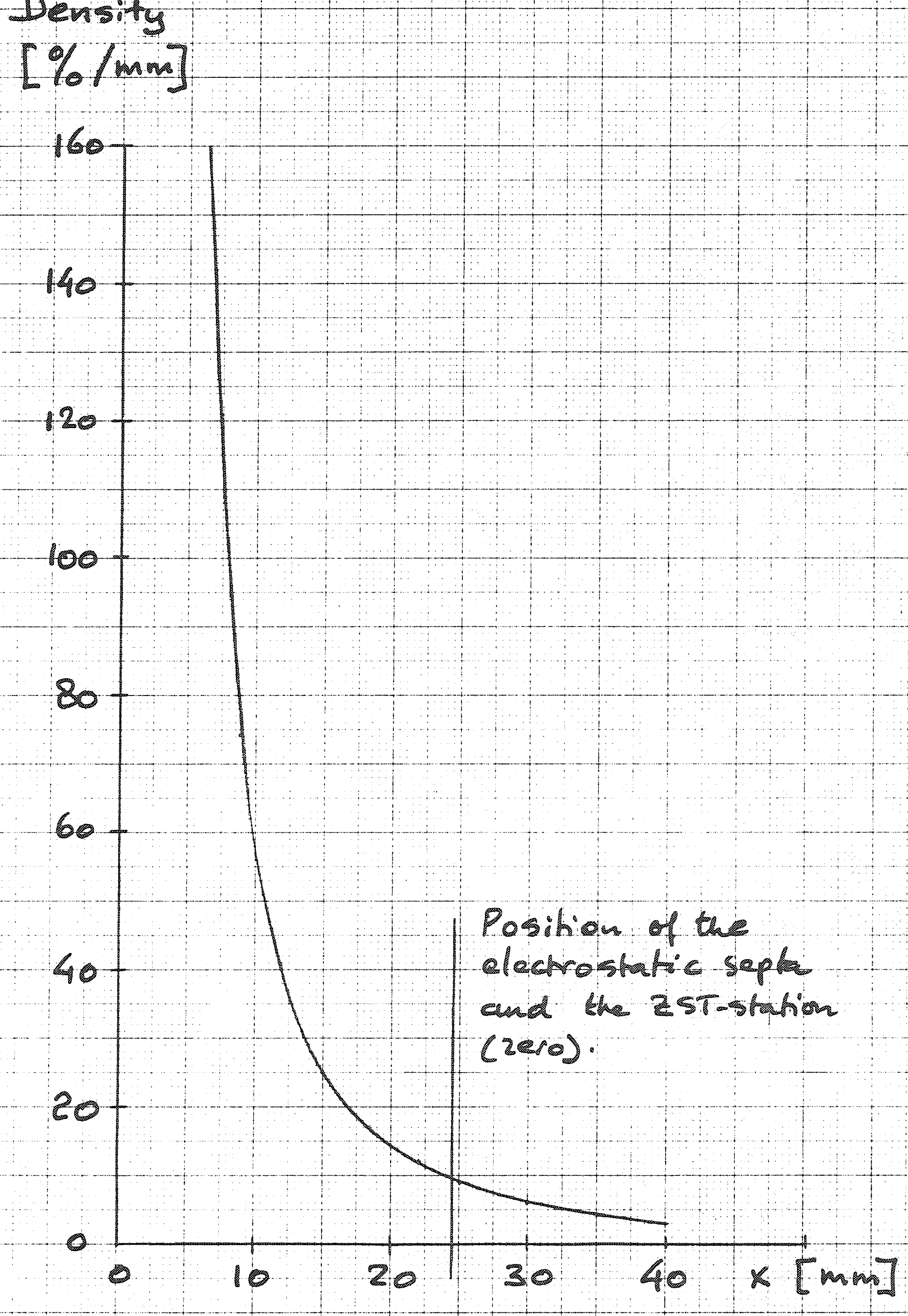

FIG 4 THE PROTON DENSITY DISTRIBUTION AS FUNCTION OF THE DISTANCE FROM THE BEAMCENTRE

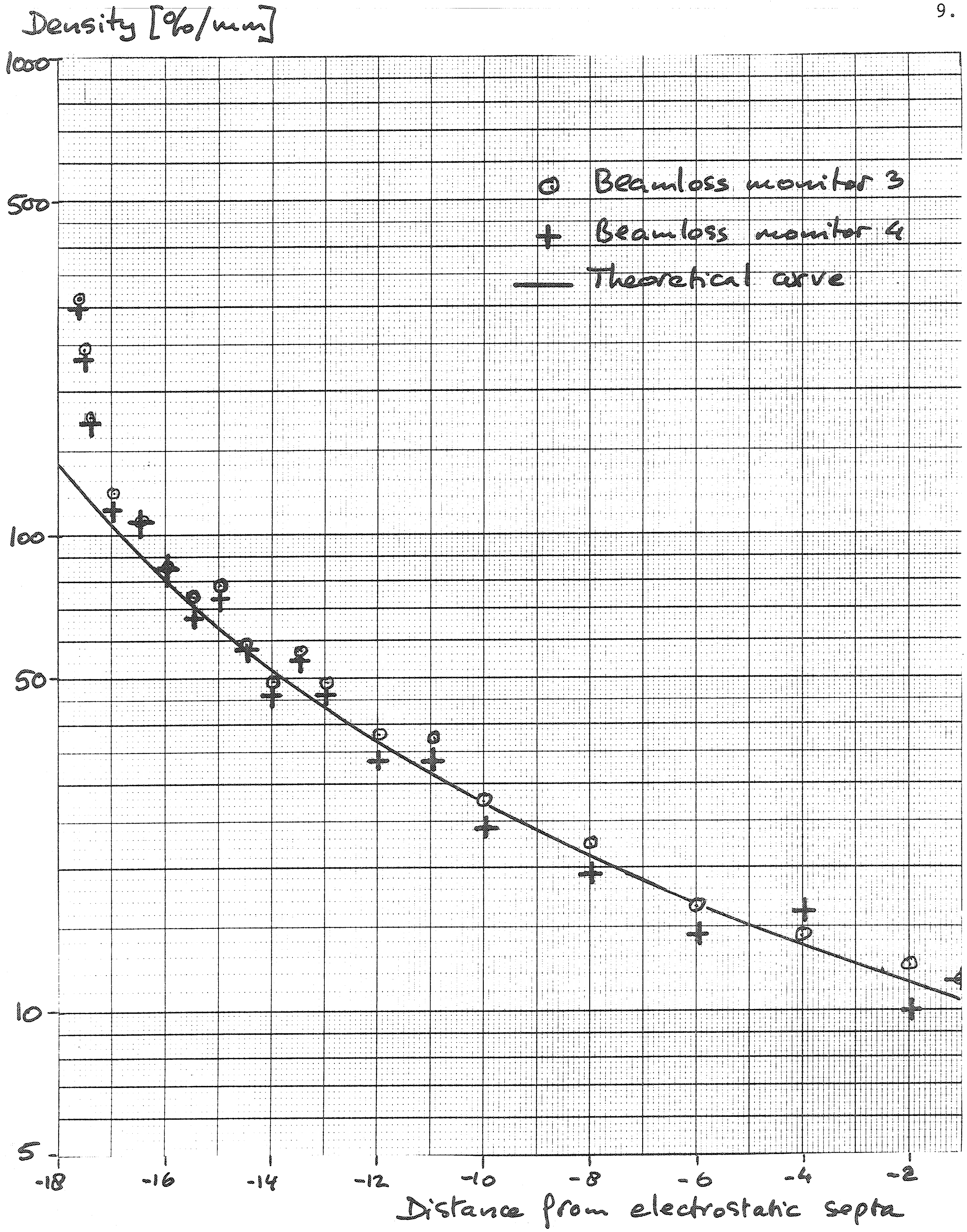

FIG5 COMPARISON OF MEASURED AND THEORETICAL BEAM DENSITY DISTRIBUTIONS