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# A MINISCANNER EQUIPPED WITH SCINTILLATORS

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## Introduction

In p-pbar collision mode the SPS luminosity lifetime is of the order of 20 hours, the p or pbar lifetimes are still higher.~ 100 hours. The emittances then grow very slowly, and a process like multiple Coulomb scattering in the residual gas produces a very small increase in amplitude of a particule from turn to turn. When a collimator is introduced, it will be hit by these high energy particles very near to its edge, where they have a high probability of escaping through the vacuum chamber with about the same energy and a small additional angle. Downstream in the SPS, they will be stopped by an aperture restriction like in the low-beta quadrupoles, producing some background noise in the physics experiments. A collimator can not be seen as a perfect absorber block and its efficiency has to be determined.

In a machine like the LHC with a much higher energy, this effect is still more pronounced. Furthermore with a very low specific heat and a small temperature margin (<0.3 K) in superfluid helium the superconducting coils are highly sensitive to an energy deposit due to beam losses (risk of quenches).

It is important to have a better knowledge of the collimator efficiency. To reduce the background noise in p-pbar mode, collimators called TAL (Target Aperture Limiter ) are installed in LSS1 (TAL1-17, TAL1-19, TAL1-21). The inelastic particles escaping from them are lost downstream in the next bending magnets, while the elastic particles travel into the vacuum chamber and will be lost after one or several turns at any aperture restriction.

To measure these elastic particles the usual miniscanner equipped with a thin wire and detecting secondary emission is not sensitive enough. By replacing the wire by a scintillator and a photomultiplier as detector, it becomes sensitive to single particle traversal. Such a new detector has been installed in LSS2 (BSCS 2-20), far from the inelastic particle effect, but upstream up the first severe proton aperture limitation created by the low-beta quadrupoles in LSS4.

## Mechanics

A BBS miniscanner tank has been modified by replacing the two wires (Horizontal and Vertical) by two plastic scintillators (NA110 type). Figure 1 shows the assembly of one of these scintillators in the vacuum tank, the other being in the perpendicular plane.

To avoid outgassing in the vacuum chamber, each scintillator is located inside a pipe under atmospheric pressure.

Each mechanism moved by a step-motor has two bellows of different diameters to counterbalance the atmospheric pressure and maintain the scintillator in retracted position in case of power failure. The maximum course of each mechanism is 80 mm and both scintillators can reach the tank axis.

The scintillator has a square cross-section ($20*9*9 mm^3$) in order to offer the same length to all particles. The circular light guide (Plexiglas) is glued to the scintillator. It is wrapped into an aluminium-mylar sheet for better transmission and centered by spacers in the stainless steel pipe. To keep the same mechanism as for the BBS, the light output towards the PM must be done at a right angle relative to the mechanism axis. This is done by gluing together the two light guides cut at 45 degrees. To improve the transmission near the angle, a mirror is maintained in contact with the light guides by means of optical grease.

The vacuum tightness is achieved by a TIG welding between the pipe and the support of the bellows of smaller diameter. The scintillator pipe is assembled with the light guide pipe through a vacuum seal between two flanges. A thin stainless steel window of 0.5 mm separates the scintillator from the vacuum.

## Photomultiplier (PM)

With a proton life time of 100 hrs and a proton intensity of $1*10^{11}$ protons/bunch, only 3 protons/bunch are lost in average during each SPS revolution.

The scintillators are set in the "shadow" of the TAL and each of them intercepts only a fraction of the vacuum chamber. By gating the PM by a bunch selector on one particular proton bunch, the PM should detect the crossing of one lost particle per turn.

In a plastic scintillator one photon is produced each time a particle loses ~ 100 eV. With a NA 110 density of $\sim 1 g/cm^3$ and an energy loss of 2 MeV/cm, a particle traversing 9 mm of scintillator produces $\sim 1.8*10^4$ photons. Assuming a 10% efficiency of the light guide transmission, a 20% photocathode efficiency and a 50mA/W cathode sensitivity, the peak intensity emitted by the cathode during 5 ns is $\sim 1.2*10^{-8}$A.

A PM with a gain of $10^6$ is then sufficient and the 10 dynode RTC 1911 PM has been selected
(useful diameter = 14 mm).

## Electronics

The scintillator position is controlled by the Data Module Subroutine STEP, the resolution being 0.05 mm per bit.

The PM voltage is adjusted manually.

The acquisition uses the same electronics as developed for the PMs associated with the fast wirescanner (fig.2).

On request a trigger launches a series of acquisitions of each PM output, made during 3072 consecutive SPS turns of one proton bunch preselected by a bunch selector. The resolution of the ADCs is 5 mV per bit.

A Nodal program allows one to :

- initialise the acquisition and the timing modules
- launch a test program sending a constant voltage to the ADC inputs
- set the scintillator position
- make a series of acquisitions and compare them with a threshold in order to get the percentage of turns where one or more particles have been detected.

**Preliminary Results**

In the laboratory a test has been made with a $CO_{60}$ source (4.1MBq, 1.17 MeV). When the PM voltage is set to 1400V, the maximum signal measured on scope is ~ 400mV on 50 Ohms while the noise remains below 10mV.

In situ when the SPS is in collider mode, the first experiment consisted in moving progressively the scintillator towards the axis of the vacuum chamber, the TAL being set at the beginning of the run to the optimum value according to the background measurement of the two experiments UA2 in LSS4 and UA1 in LSS5.

In the vertical plane the main TAL

(TAL1-19, $\beta_V$ = 46.73 m)

was set to an half-aperture of 4.66 mm around a center position of 3.54 mm. Referred to the scintillator

(BSCS2-20, $\beta_V$ = 24.41 m)

this corresponds to an half-aperture of 3.40 mm.

The vertical beam position in the BSCS2-20 can be deduced from the beam position monitors located in 2-21 and 2 -23 and was -0.7mm

From these measurements the edge of the TAL1-19 as referred to the beam in 2-20 should be at 3.4-0.7=2.7 mm.

The vertical scintillator was progressively moved towards the center of the vacuum chamber up to a position where the background in UA1 and UA2 was just increasing. For each scintillator position relative to the center of the vacuum chamber, Fig.3 gives the percentage of turns where one or more particle are detected (round marks).

The edge of the TAL1-19 as referred to the beam in 2-20 is seen by the scintillator at 2.45 mm, instead of 2.7 mm, which is compatible with the precision of the beam position monitors and the alignment of the BSCS2-20.

The next experiment was to retract the TAL while leaving the scintillator at +2.4mm. The percentage of counts increases from 15.8±3.3 to 57.5±4.8 (Fig 3 square marks). By retracting the scintillator to +2.5mm and +2.7mm, the number of counts was respectively 45±2.8 and 30.5±2.1. This experiment gives a rough value of the collimator efficiency, i.e 1-(15.8/57.5) = 72.5 %.

## Conclusions

From these preliminary results the miniscanner equipped with scintillators appears to be a very sensitive device to measure the background in collider mode and the collimator efficiency. It could be used to reduce the background by finding in both planes the best positions of the set of TALs. It could also allow one to test TAL behaviour and models of emittance growth under different beam configurations.

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Distribution list :

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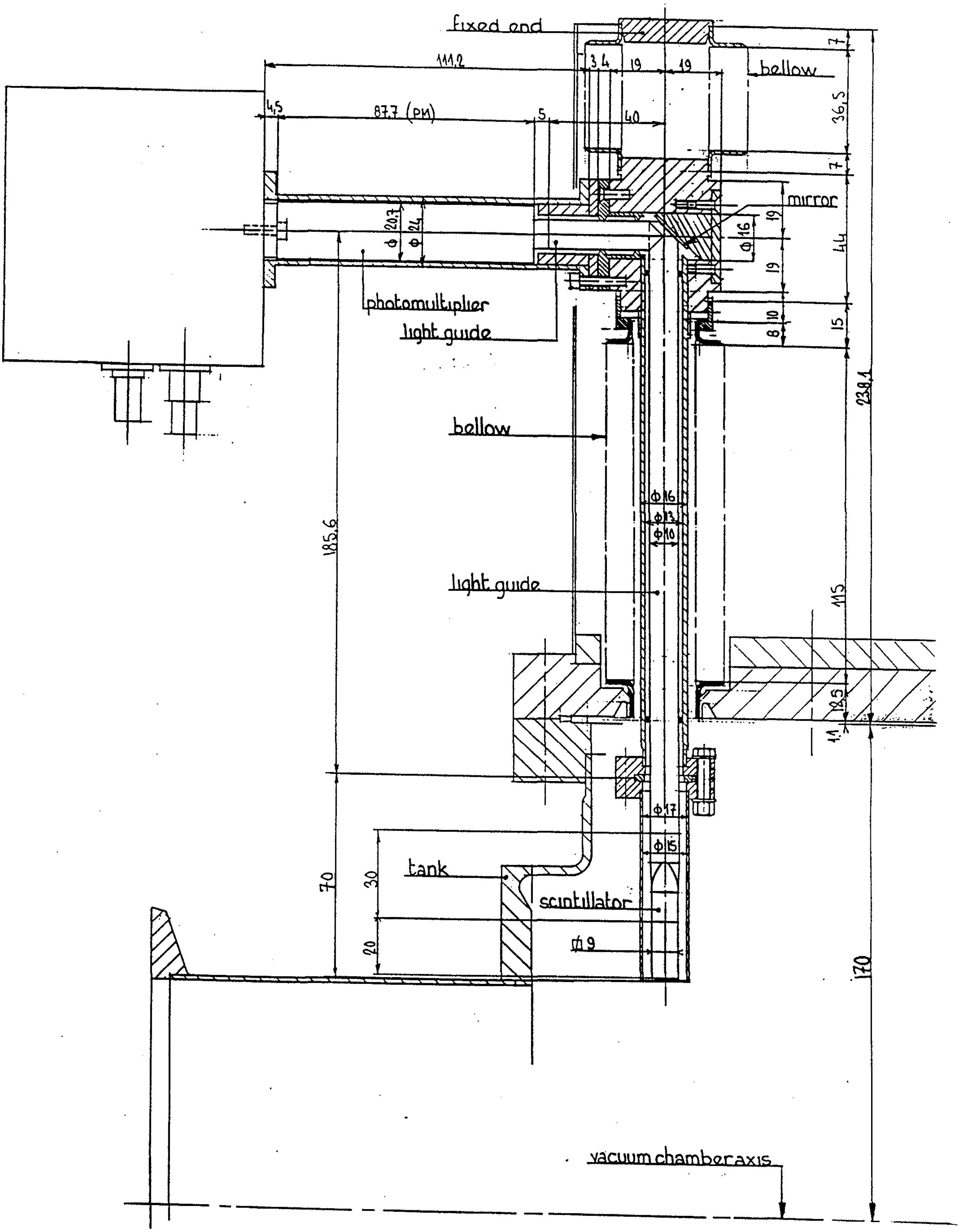
fixed end
bellow
mirror
photomultiplier
light guide
bellow
light guide
tank
scintillator
vacuum chamber axis
111.2
87.7 (PM)
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5
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19
19
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36.5
7
19
44
19
10
8
15
238.1
φ 20.7
φ 24
φ 16
φ 16
φ 13
φ 10
185.6
115
8.5
1.1
φ 17
φ 15
70
30
20
φ 9
170

FIG 1

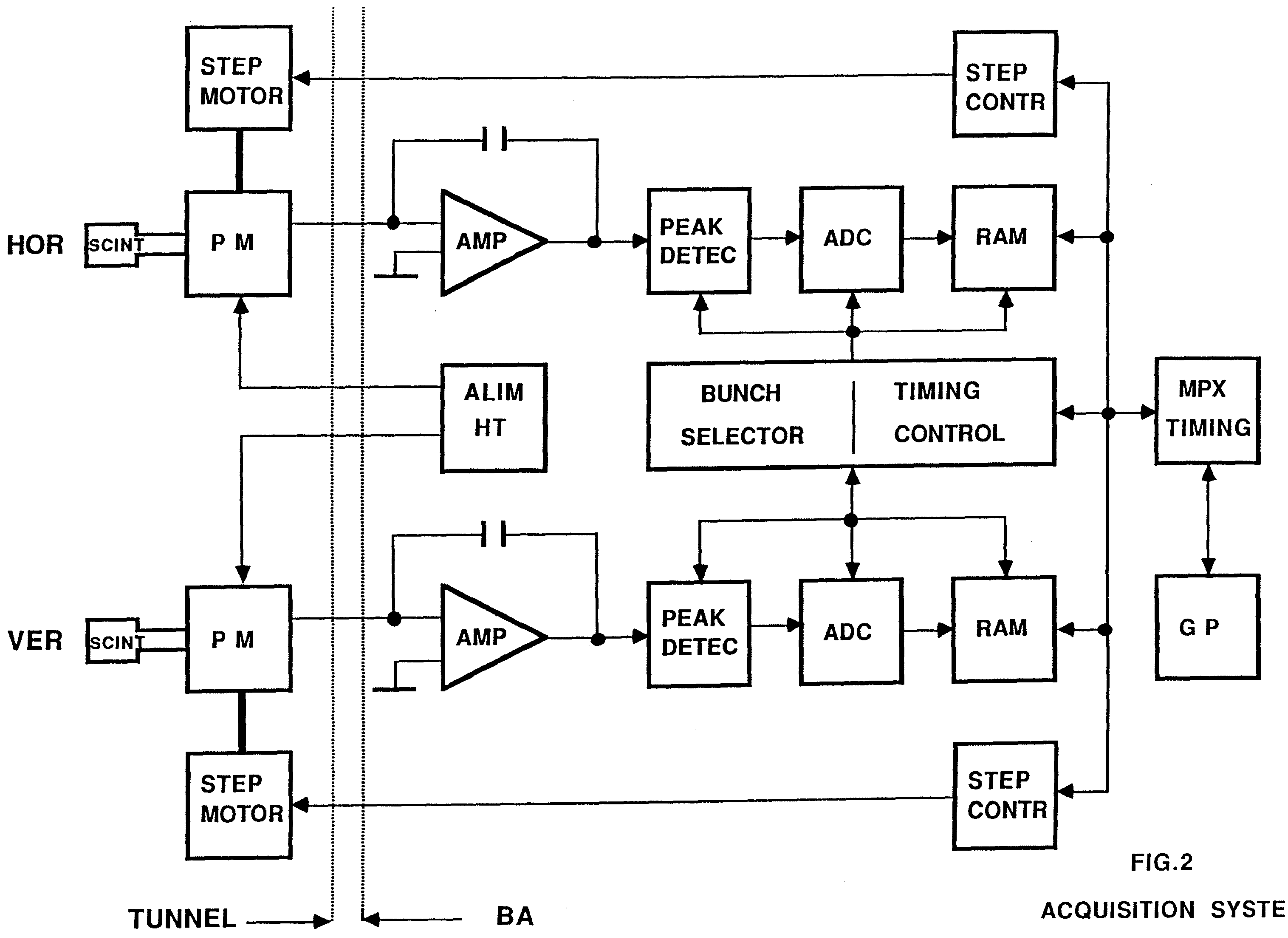
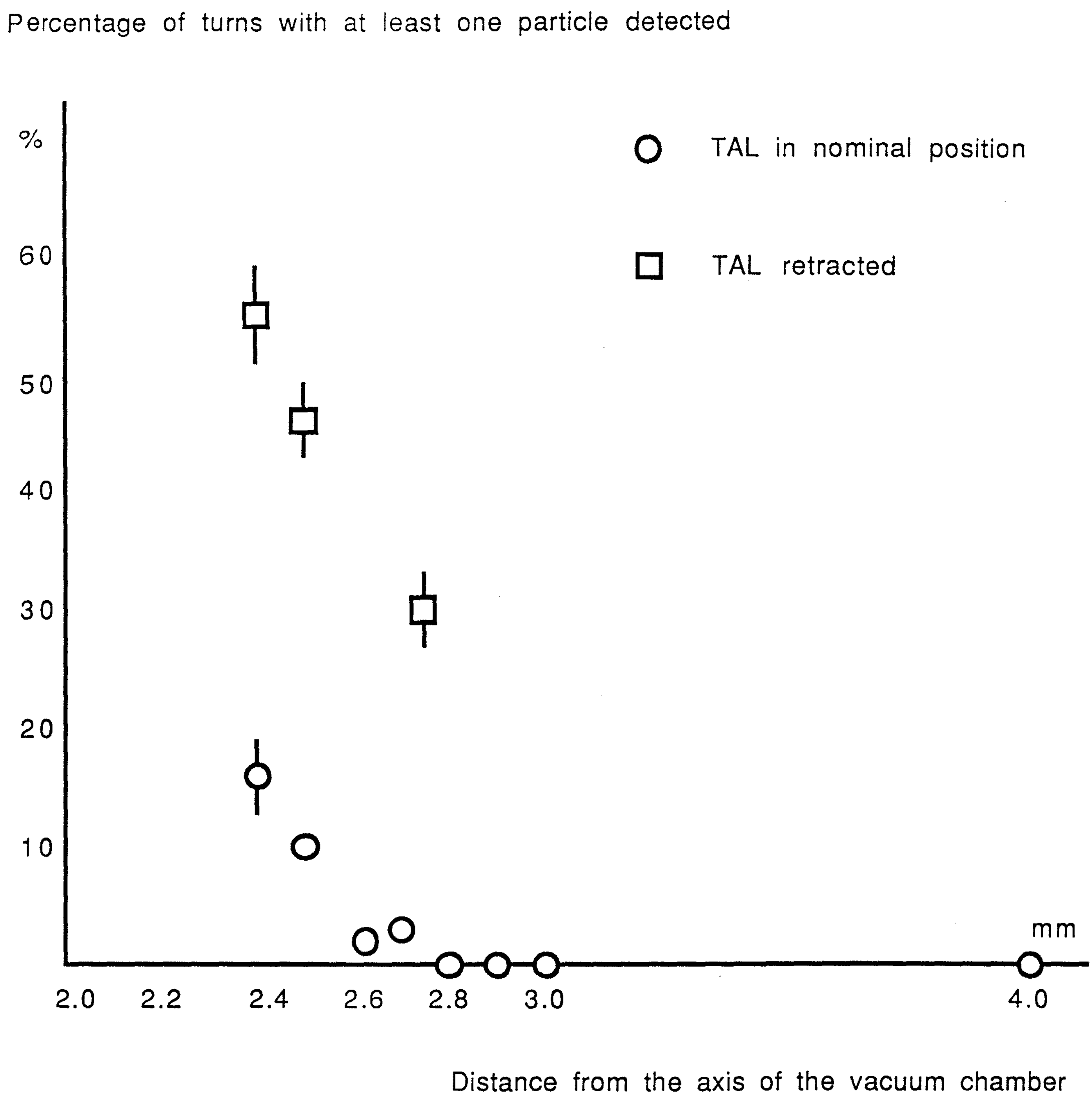



FIG.2

ACQUISITION SYSTEM



Percentage of turns with at least one particle detected
%
60
50
40
30
20
10
TAL in nominal position
TAL retracted
mm
2.0
2.2
2.4
2.6
2.8
3.0
4.0
Distance from the axis of the vacuum chamber


Fig. 3