ISR-RF/JB/DC/HK/CP/PT/ps

20th May 1981

ISR PERFORMANCE REPORT

Running-in and operation of the new $\bar{p}$ Beam Position Monitoring System both in TT6-TT1 and Ring 2

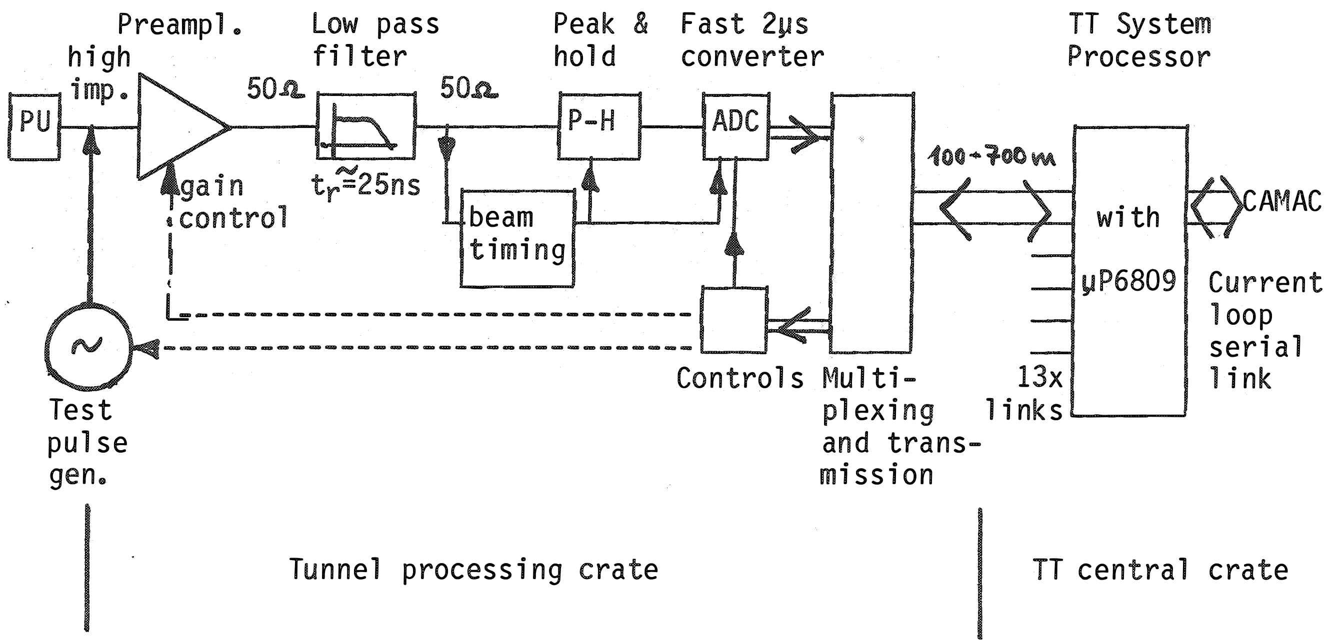
Runs 1178 to 1184, 18.3.82 to 4.4.81

1. System characteristics

1.1 TT6-TT1 BPMS

The transfer line system consists of five monitors or PUs of ISR-type which existed in TT1 (H and V plane), five single-plane TT6-type new monitors (Fig. 1) and three combined TT6 monitors (H and V plane) at the beginning of TT6. Thirteen local processing crates have been installed for each double-plane monitor or between pairs of single-plane monitors (Fig. 2). The digitized signal is transferred via 13 serial links (ACIA MC 6850) to the central TT system (based on µP 6809) localized in Aux. Bdg. 2.

The data acquisition process principle is as follows:



After preamplification both on the PU and in the processing crate, the beam-induced pulse is low-pass filtered, or lengthened, in order to fit the rise time of the following fast peak-and-hold circuit (25 ns rise time). The beam signal is also used to trigger the acquisition timing sequence which starts the ADC conversion and resets the P-H circuit after 2.5 μs. The peak value of the P-H circuit is converted in about 2 μs and is therefore registered in the ADC until the next acquisition. The end of the ADC conversion pulse is used to set a flip-flop which acknowledges the acquisition. This flip-flop is reset at each beam position measurement request. In this way each beam passage is automatically registered without any need for external timing pulse and if measurement has been requested, an acquisition bit acknowledges the following beam passage. The data of the four ADCs of the processing crate are multiplexed and transmitted to the central processor for transfer via V24 serial link to the CAMAC network and ARGUS. The acquisition process is:

ARGUS		TT $\bar{p}$ system
Measurement request	⟶	If acquisition bit of PU 602 or 603 or time out of 60 s
OK	⟵	Answer
Data transmission request PU by PU	⟶	Reading of ADCs and alarm bits
OK and data	⟵	Answer

The reading of the new ADC data can be repeated as many times as desired until the next ADC conversion.

The system process software flow chart is given in Fig. 3.

The system performance can be checked and calibrated with the help of a pulse generator which simulates the beam directly on the PU electrodes. The acquisition process is then exactly the same as for the beam signal. Controls to the system such as gain settings, test-on, reset and DC-offset reading are also transmitted to the hardware via the links.

The system has been designed to operate with antiproton beams corresponding to 10^9 up to 10^{11} particles per pulse. The dynamic range is split into three ranges with -10 dB steps. The system operates down to 5×10^8 p/pulse. The output relative voltage as converted by the 12-bit ADC is:

$$U_{signal} \cong 225\ N \times 10^{-9} \quad [mV_{rel}]$$

(maximum 4096 mV)

The system resolution is about

	N = 5×10^8	10^9	5×10^9	10^{10}	3×10^{10}	10^{11}	$\bar{p}$/p
G = 0	~ ±2	~ ±0.5	~ ±0.07				mm
G = -10 dB			~ ±0.2	~ ±0.1	~ ±0.03		mm
G = -20 dB				~ ±0.35	~ ±0.1	~ ±0.03	mm

Front-end noise contribution + non-linearities

±1 bit uncertainty

The absolute position error is estimated to be ±0.15 mm for TT6-type monitors and ±0.1 mm for ISR-type monitors, to which alignment errors have to be added.

The system electronic resolution is illustrated by the program PURE which represents values histograms for 20 measurements with test generator simulating a centred beam (Fig. 4). This test corresponds to the signal level for 7×10^9 particles.

The overall processing chain gain drift is small. A calibration program compensates for gain unbalance within a pair of channels. It is necessary to do a calibration procedure prior to an injection period.

The processing chains up to the ADC present a DC offset which must be subtracted from the raw data value. This DC offset is temperature-sensitive and less stable than the gain. It is recommended that an offset reading should be proceeded with prior to a new pulse injection. A safety measure is built into the acquisition programs which forces an offset reading if the stored ones are older than 20 min.

1.2 R2 - BPMS

The Ring 2 processing chain is the same as for TT6, but its implementation is different. The antiproton beam signal is picked off the head-amplifiers on the existing ring monitors. In the $\bar{p}$-mode of operation the $\bar{p}$ output signal is selected, amplified and transmitted via the existing video chain. The B output of the end-of-cable amplifier is connected to the octant processing crate (for up to 32 channels, i.e. 8 PU x 4 plates). The A output remains connected to the existing proton-processing chain.

The $\bar{p}$ signal-processing chain is equivalent to that of the TT system but without serial transmission from the tunnel to the Aux. Bdg. The ADC cards are directly connected to the μ-P 6809-bus. The same crate contains the system controls which are active in $\bar{p}$-mode. If the $\bar{p}$ part of the system is not active, the BPMS is automatically available for p operation.

The R2 system resolution is slightly lower at low intensity than that of the transfer line due to the higher noise level in the video transmission between ring and aux. bdg. The R2 system will operate safely from and above 10^9 $\bar{p}$/pulse.

The main difference between the two BPMS is that in addition to the "first turn" mode of operation, corresponding to the acquisition process in the TT system, the R2 system switches to "average orbit" mode whereby the signal is averaged during 1 ms before acquisition. Therefore, for the same injection, both first turn data and average orbit data are stored and then read by the ARGUS (Fig. 5).

2. ARGUS programs for the $\bar{p}$ BPMS and operational procedures

These programs are described in ref. 1). They can be summarized as follows:

Function	TT	R2 ($\bar{p}$ mode)	Comments
Calibration for the dif. gain settings	CABT,FP(GAIN=Ø) -1Ø -2Ø	CABO,FP(R2,GAIN=Ø) -1Ø -2Ø	For the time being the calibration is done by the specialist
Offset reading	ZEBT	Z parameter in BORA program	To be done before injection
Test with centred simulated beam.	REBT(TØ,GAIN=Ø) -1Ø -2Ø	BORA(R2,TØ,GAIN=Ø) -1Ø -2Ø	For performance check
Display	DIBT		
Beam data acquisition	APSU		For operation, will request injection
Beam position processing and display;			
TT: Print	REBT DIBT,FP(P)		For calculations
Display	DIBT		For visualisation
Print of raw data	REBT,FP(DB)		For signal level control
Ring 2: First t. Print		BORA,FP(R2,NZ,S=1,P)	For calculation
Display		BORA(R2,NZ,S=1)	For visualisation
Average orbit Print		BORA,FP(R2,NZ,P)	For calculation
Display		BORA(R2,NZ)	For visualisation

In ref. 2), point 5, an operational procedure is given for the beam position measurement. It is proposed to slightly change it for responsibility and operational reasons.

At the beginning of a $\bar{p}$ run the RF-BO section takes care of system performance and calibratrion (CABT and CABO). It is only the offset reading which is necessary prior to actual beam data acquisition. The programs sequence will then be:

ZEBT	Offset reading for BT pick-ups
BORA (R2, TØ, Z)	Simulated centred orbit with offset reading (parameter z)
PSBI	Initiates software interlock check. If a fault is found it can be over-ridden by typing IGNOREALL.
APSU	To be entered when PS starts countdown for ejection of antiproton pulse. Initiates pick-ups, which stay active for 45 s.
REBT	Reads B.T. pick-ups
DIBT	Trajectory display
HARD COPY	If desired
BORA, FP (R2, S=1, NZ, P)	Lists first turn pick-up readings
BORA (R2, S=1, NZ)	Orbit display, first turn
HARD COPY	If desired
BORA, FP (R2, NZ, P)	Lists closed orbit pick-up readings
BORA (R2, NZ)	Orbit display, average position
HARD COPY	If desired.

This sequence can be organized as a PROC sequence.

On most data displays an error code is printed next to the PU data the meaning of which is also printed in the list. The most important one for operation is the @ sign indicating acquisition on that monitor. It is a means of recording up to which monitor the beam passed.

3. Experimental results

The first $\bar{p}$ runs (18.3 and 19.3.81) were also debugging and running-in of the new p-BPMS. A few faults were found in the TT6-TT1 system both in the firmware and in the ARGUS programs, i.e.: error in the acquisition process in the vertical plane, wrong sign and diode constant in the programs and some problems with the use of calibration tables. All these faults were quickly discovered and cleared and the TT system was ok for the following $\bar{p}$ runs. The system operated with intensities as low as $5x10^8$ p/pulse.

During the following $\bar{p}$ runs (2.4, 3.4, 4.4 and 6.4.81) the beam reached the ISR where both first turn and average orbits were registered without problem. The ISR system did not present any bugs. Both TT trajectory and ISR orbits were recorded for each p injection and there was no problem with the longer bunch than expected (~50 ns) since the system processing includes a low-pass filter with t_r = 25 ns. Fig. 6 represents a plot of the system raw data amplitude averaged over all monitors relative to the P_{IDC} readings (mean between two monitors) in the transfer line. Operational results are described in ref. 3) in full detail.

Figures 7 and 8 show typical examples of BT trajectories during these runs, with a beam steering between the two figures.

Figures 9 and 10 show typical first turn and average orbits in the ISR.

Figure 11 shows a first turn orbit after horizontal injection correction (to be compared with Fig. 9). The variation between successive measurements or injections is within the predicted value at this low intensity and the systems performances with beam are analysed in ref. 3), p.3.

The debunched beam was then observed with the experimental cavity to extract the longitudinal Schottky signal and the current by the P_{IDC} of the ring. The $\bar{p}$ TT and ISR BPMS is now fully operational and does not interfere with the p BPMS in R2.

A report describing the technical aspects of the p BPMS for TT6-TT1 and R2 is in preparation and will be published soon.

J. Borer, D. Cocq, H. Kropf,
C. Paillard, P. Tranchant
J.Y. Hemery, D. Kemp, R. Keyser

References

1) R. Keyser, J.Y. Hemery, D. Kemp, Software for p operation, ISR Perf. Report, to be published.

2) P.J. Bryant, Data for the running-in of the ISR p transfer lines TT6-TT1, BOM Internal Note, 28.4.81.

3) P.J. Bryant, Optimisation of p transfer, storage and application of Terwilliger scheme (No. 3), ISR Perf. Report, 23.4.81.

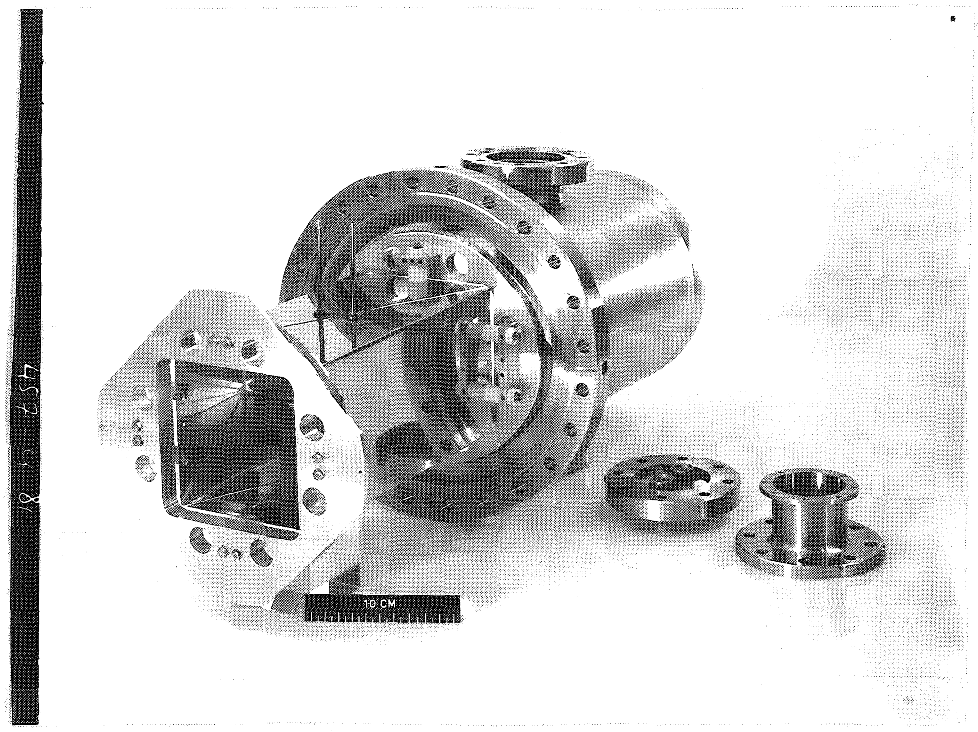


Fig. 1 : TT 6 Electrostatic Monitor (PU), single plane.

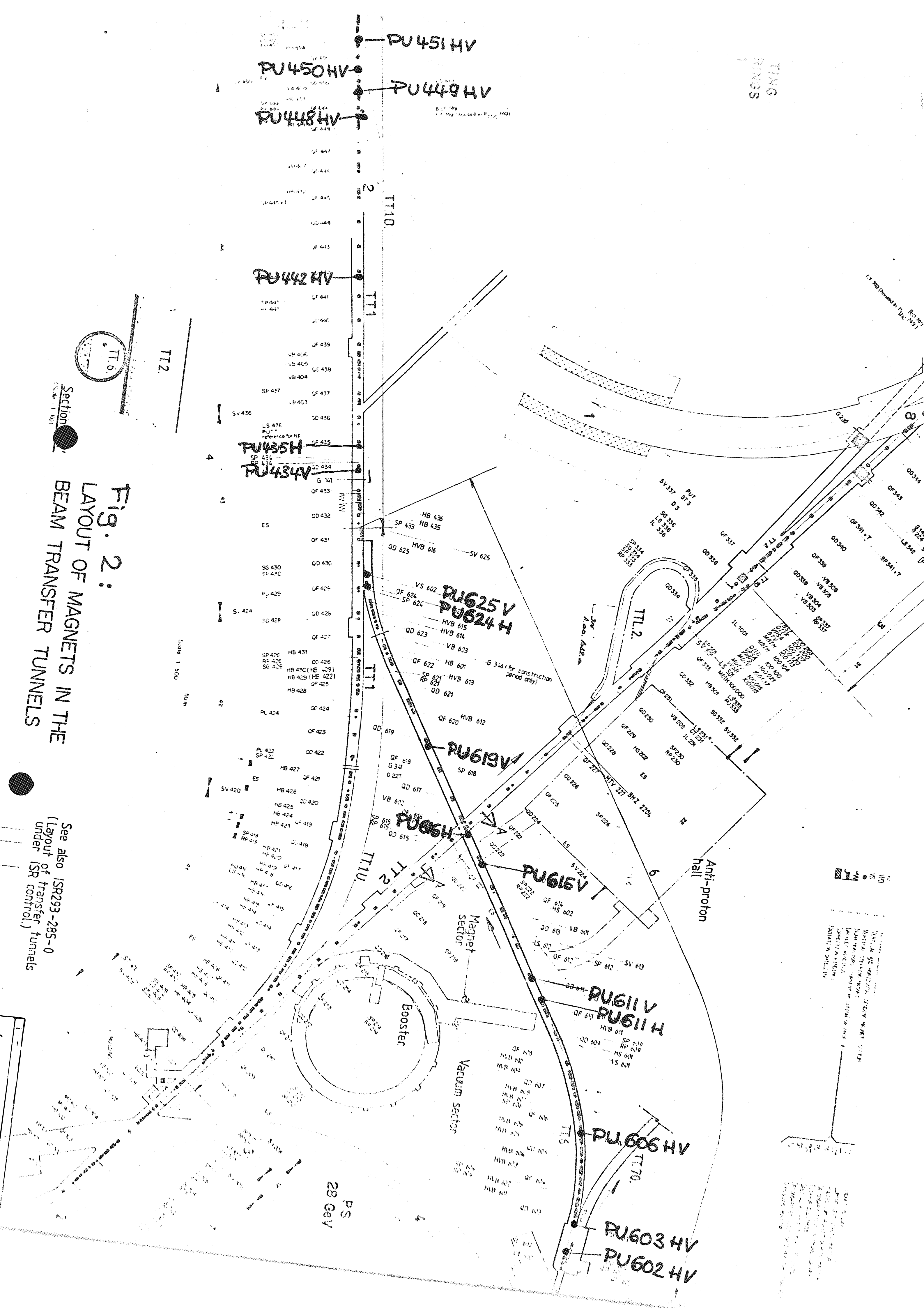


Fig. 2: LAYOUT OF MAGNETS IN THE BEAM TRANSFER TUNNELS

SOUS-ROUTINE ACQUISITION AVEC FAISCEAU (COMMANDE B)

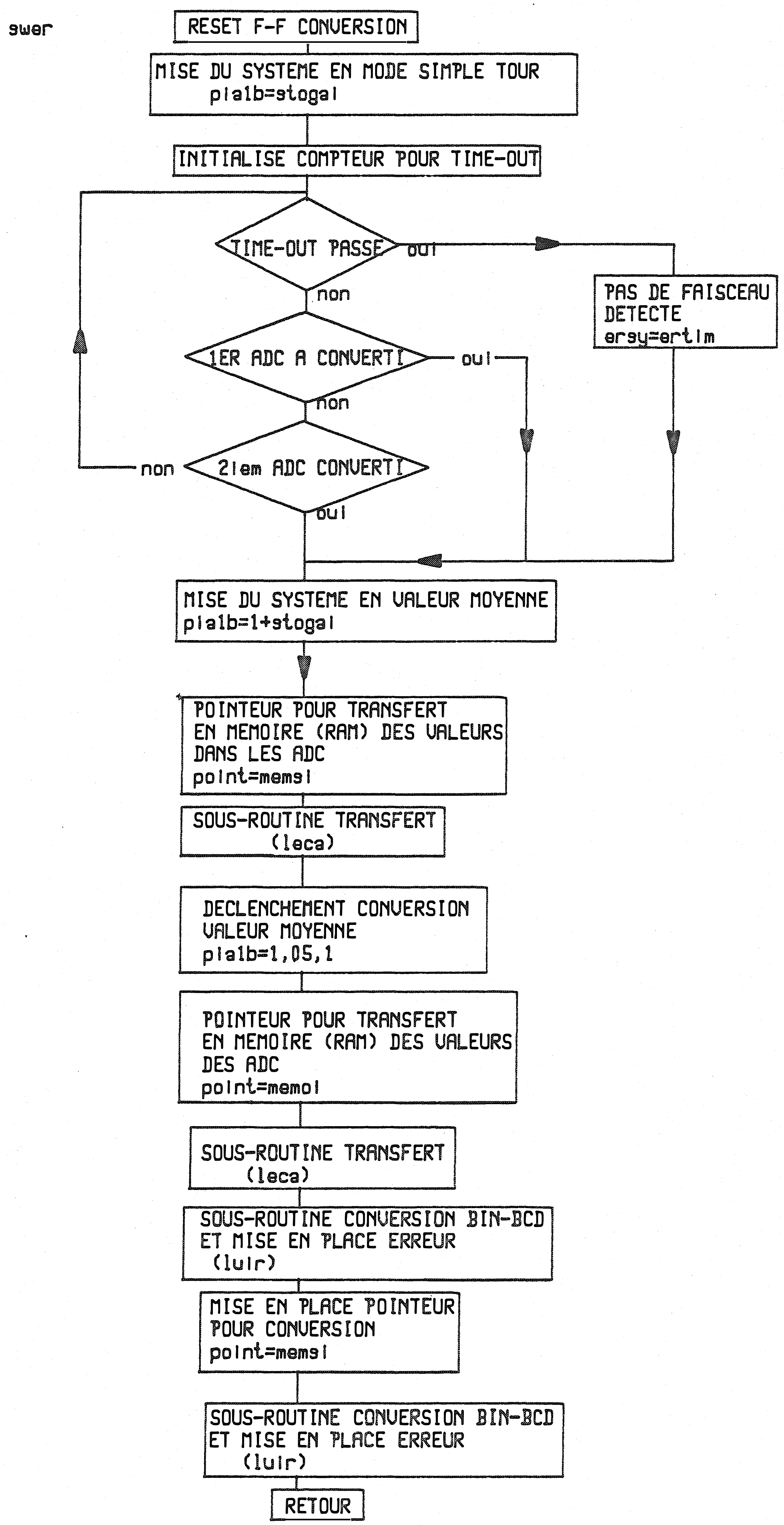


Fig. 3

```
81-05-11   08H45M42S        STATION  616     GAIN:    0
      AVERAGE              MAX              MIN          PEAK TO PEAK         RMS
     X        Y        X        Y        X        Y        X        Y        X        Y
   -0.01    0.00     0.09     0.13    -0.11    -0.03     0.20     0.16    0.059    0.034
```

X VALUES HISTOGRAM - (1/100 MM)

```
 50 I
 45 I
 40 I
 35 I
 30 I
 25 I
 20 I
 15 I
 10 I*
  5 I*******
  0 I*******
 -5 I**
-10 I***
-15 I
-20 I
-25 I
-30 I
-35 I
-40 I
-45 I
-50 I
-55 I
-60 I
-65 I
-70 I
```

Y VALUES HISTOGRAM - (1/100 MM)

```
 60 I
 55 I
 50 I
 45 I
 40 I
 35 I
 30 I
 25 I
 20 I
 15 I*
 10 I
  5 I***
  0 I****************
 -5 I
-10 I
-15 I
-20 I
-25 I
-30 I
-35 I
-40 I
-45 I
-50 I
-55 I
-60 I
```

Fig. 4 : Progr. PURE

20 measurements in test mode

Gain = 0 dB

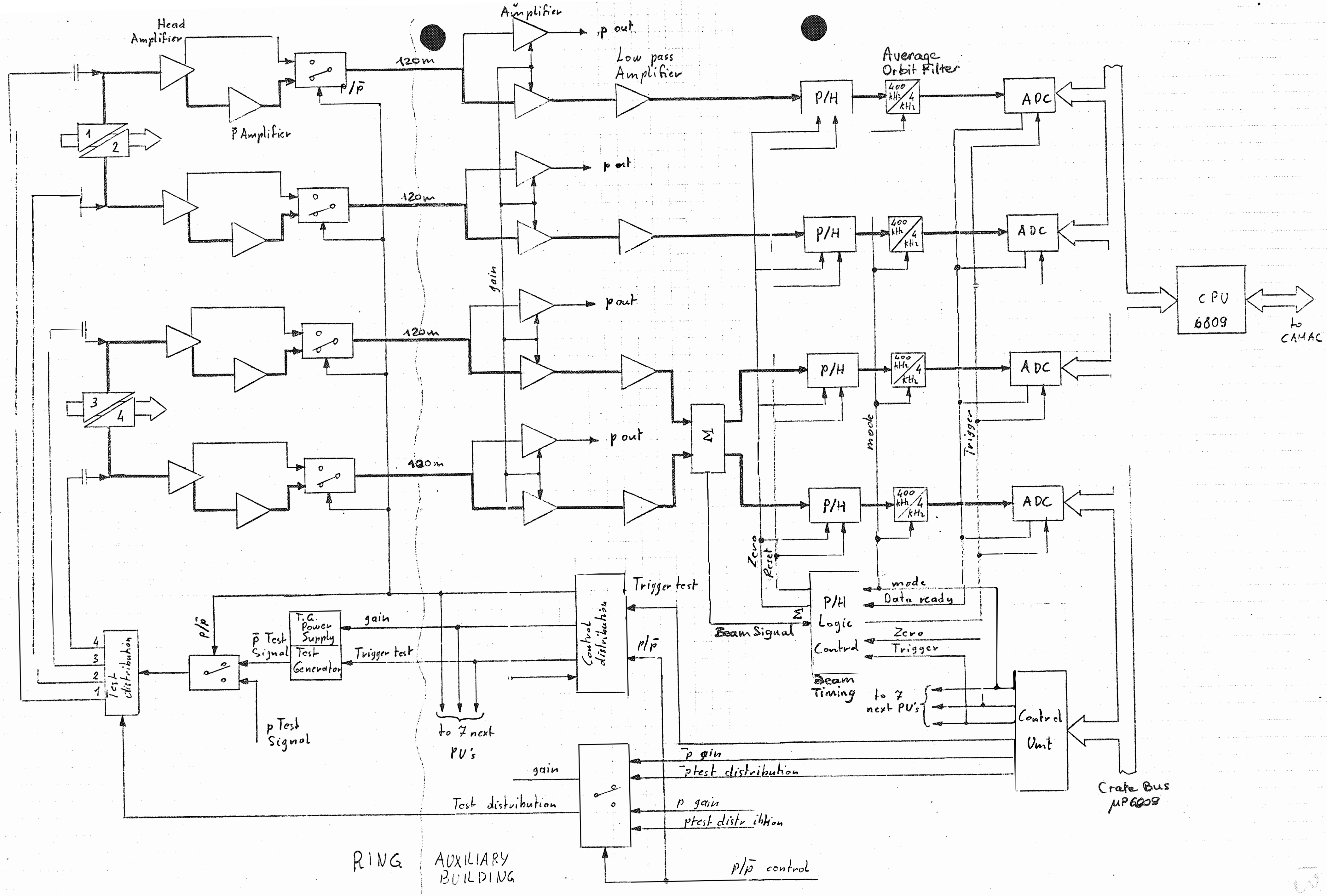


Fig.5: ISR $\bar{P}$ Pick-Up - Block Diagram (R2)

D. Coeq 13.5.81

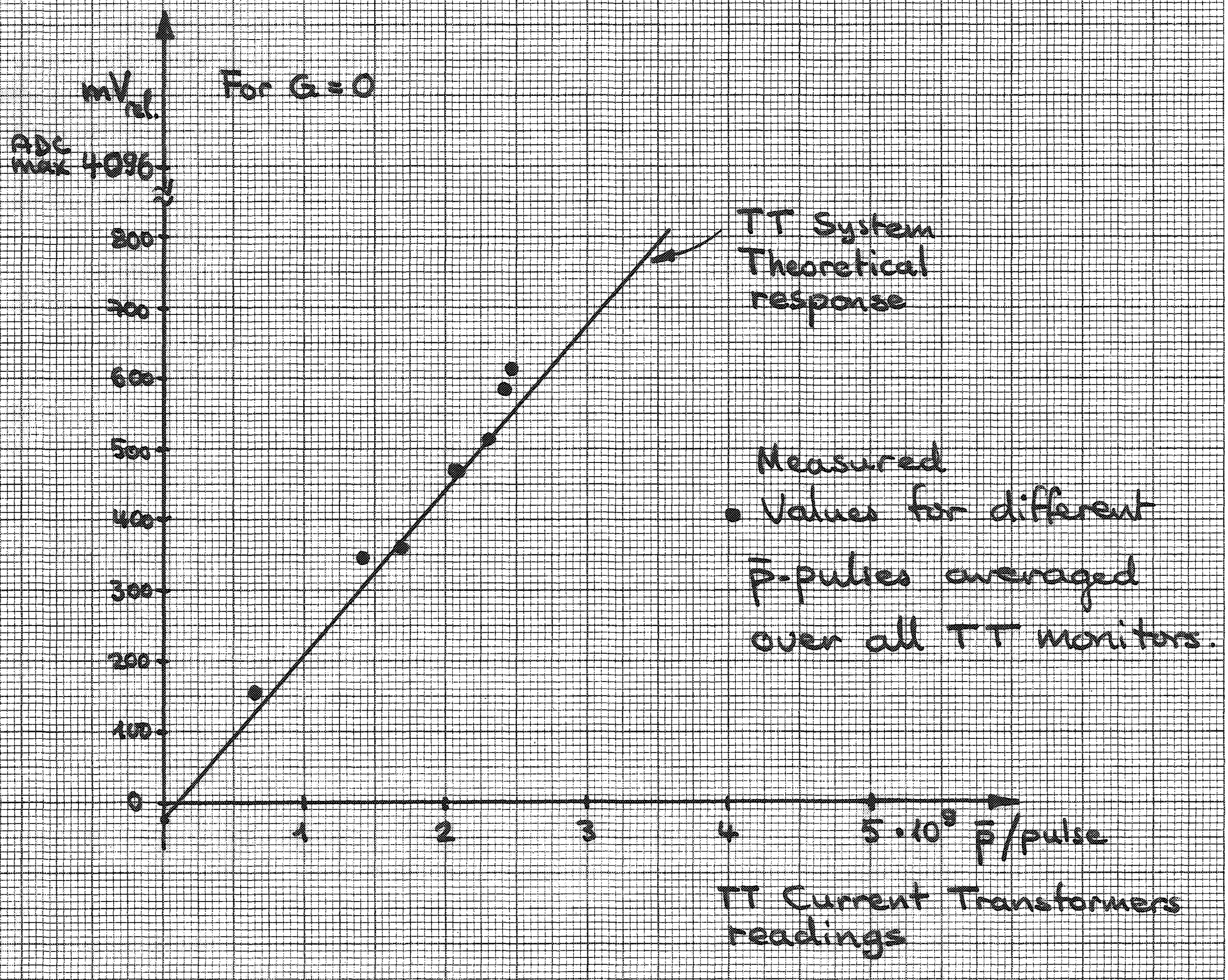
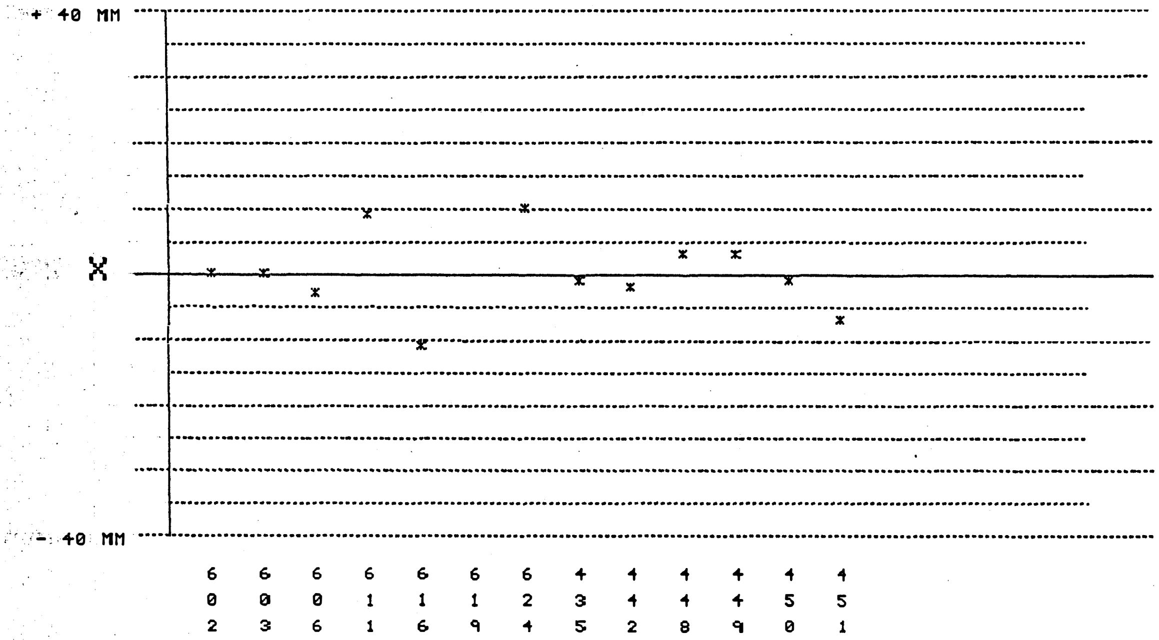
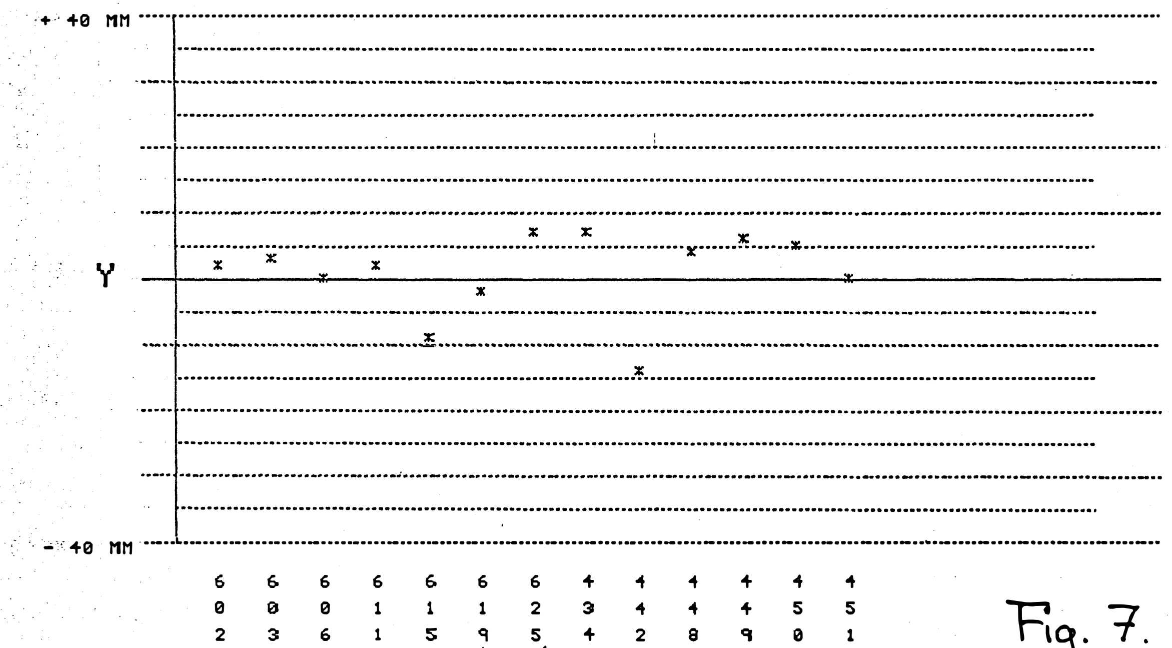


Fig. 6 : Sum Signal as converted by the ADC relative to $\bar{p}$-intensity. (Raw data per plate for a centred beam).

First Pulse

BEAM TRANSFER OBSERVATION PULSE NO: 52959 RUN= 1184 81-04-02 19H23M22S





GAIN: 0 DB C= 1

PU	X	Y
602/ 602	0.56	1.66
603/ 603	0.55	2.54
606/ 606	-1.90	0.33
611/ 611	10.45	1.93
616/ 615	-9.94	-8.81
619/ 619	.....	-2.30
624/ 625	10.86	7.47
435/ 434	0.07	6.56
442/ 442	-1.17	-14.29
448/ 448	3.97	3.81
449/ 449	3.50	5.88
450/ 450	0.18	5.03
451/ 451	-6.00	0.28

X	X'	Z	Z
0.69	0.05	0.64	0.16

HOR. DELTA P / P

PU606	PU611
0.037	2.160

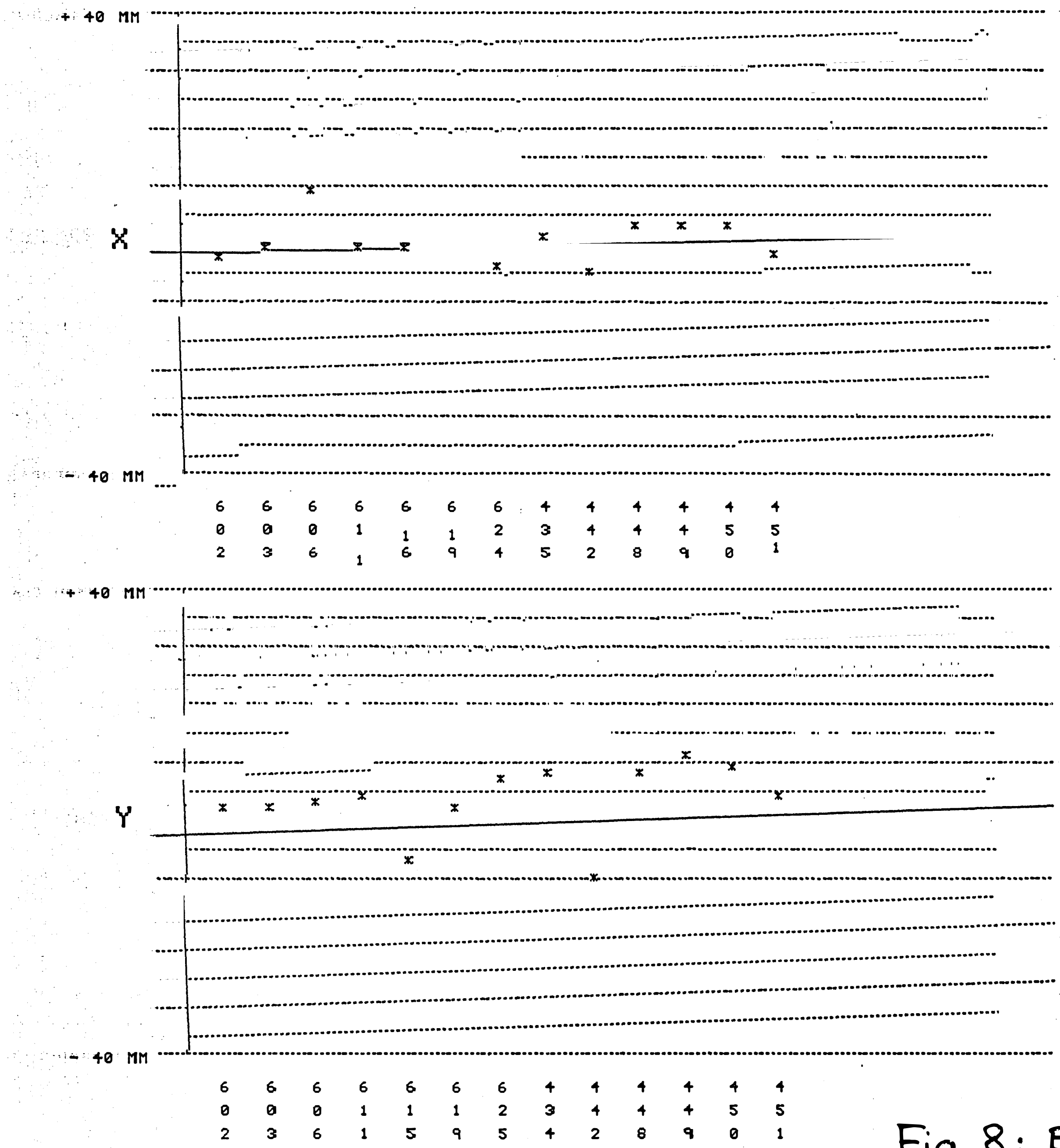
CT 602: LAM NOT SET

CT 449: LAM NOT SET

Fig. 7. BT Display

Second Pulse

BEAM TRANSFER OBSERVATION PULSE NO: 39690 RUN= 1184 81-04-03 21H35M38S



GAIN: 0 DB C= 1

PU	X	Y
602/ 602	-0.29	1.80
603/ 603	0.45	2.17
606/ 606	9.57	2.79
611/ 611	0.19	4.20
616/ 615	-0.23	-7.35
619/ 619	.....	1.76
624/ 625	-2.92	7.27
435/ 434	2.01	7.56
442/ 442	-3.66	-9.65
448/ 448	4.31	8.41
449/ 449	3.74	11.22
450/ 450	3.53	9.06
451/ 451	-1.31	3.64

X	X'	Z	Z
-0.70	0.01	0.96	0.09

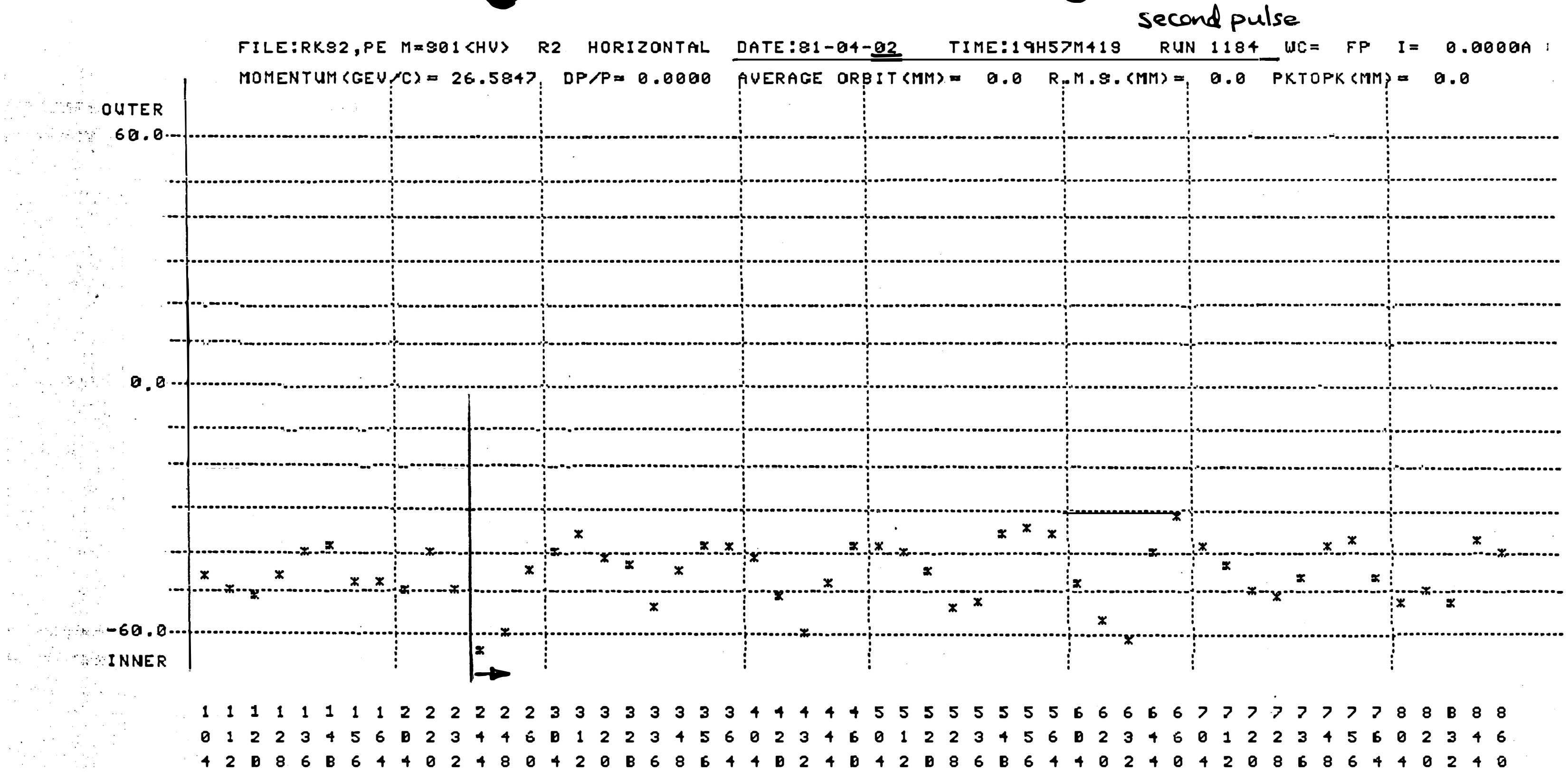
HOR. DELTA P / P

PU606	PU611
-1.575	-0.212

CT 602: 217 10** 7

CT 449: 191 10** 7

Fig. 8: BT Display after H corrections.



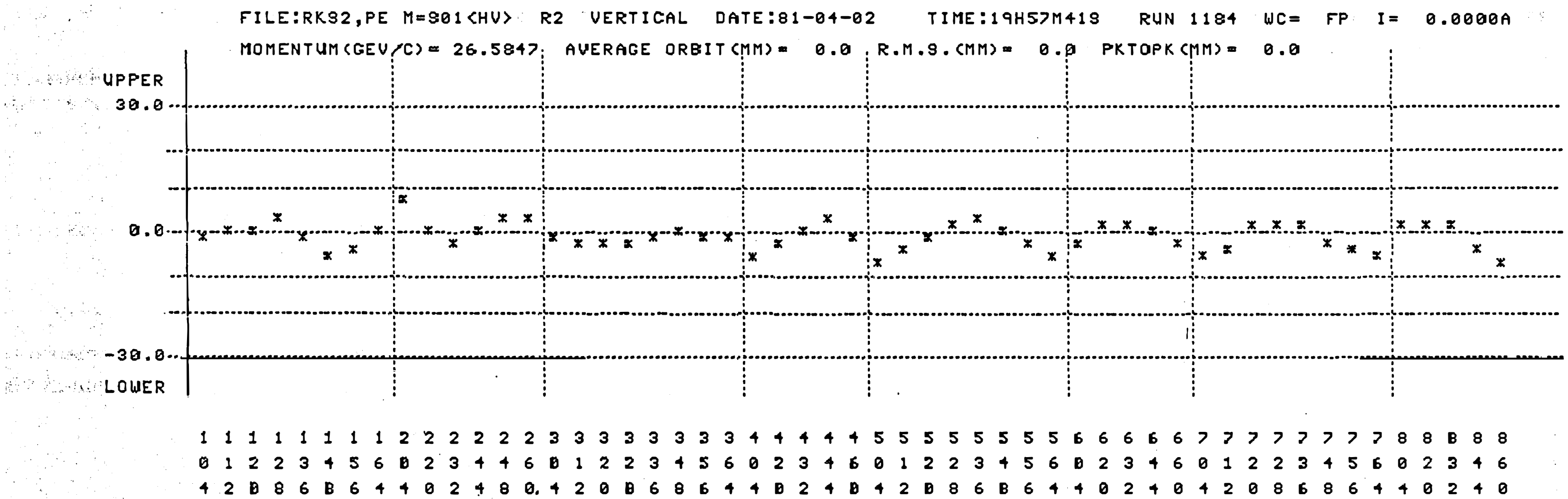


Fig. 9: R2 First Turn Orbit Display

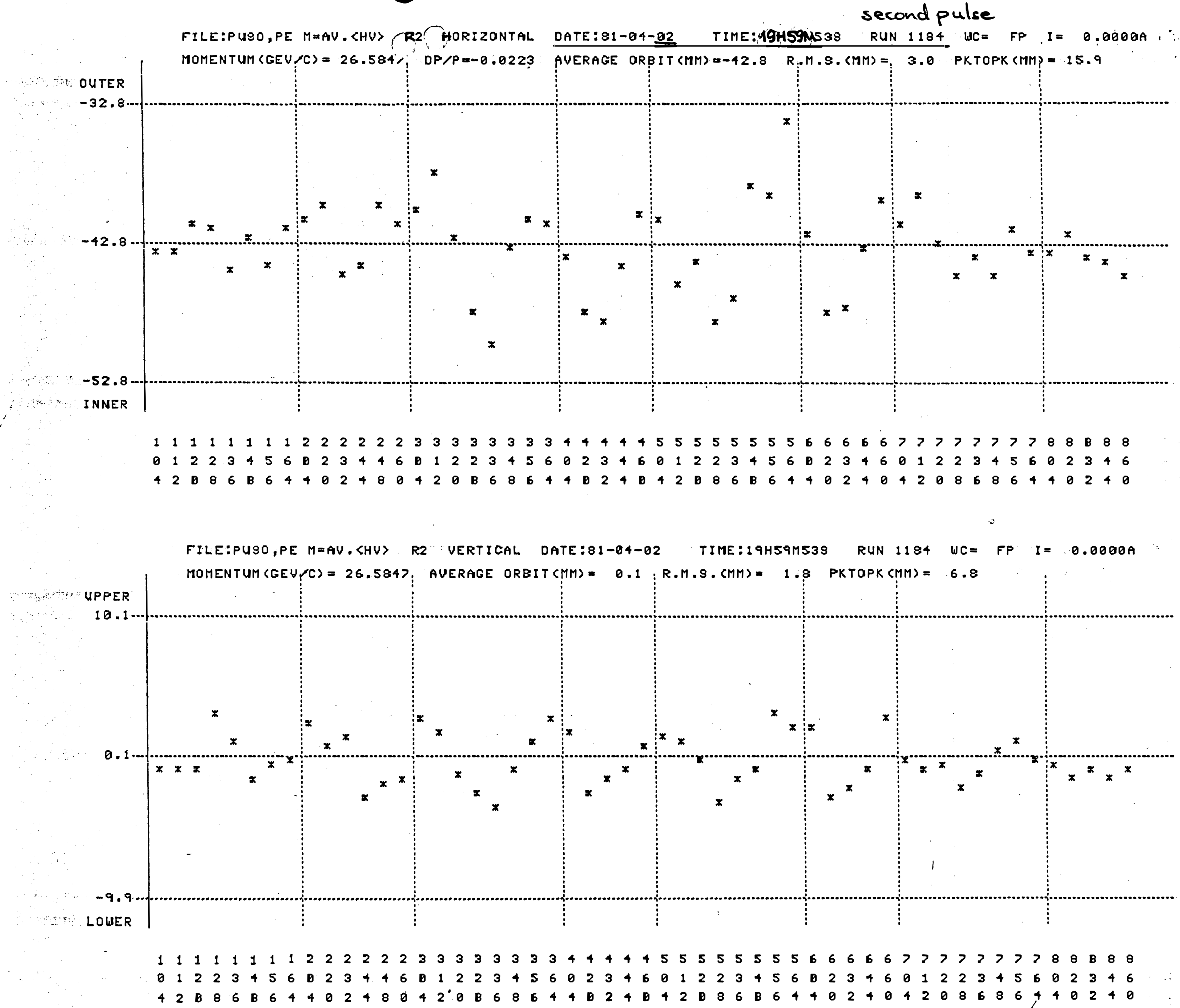
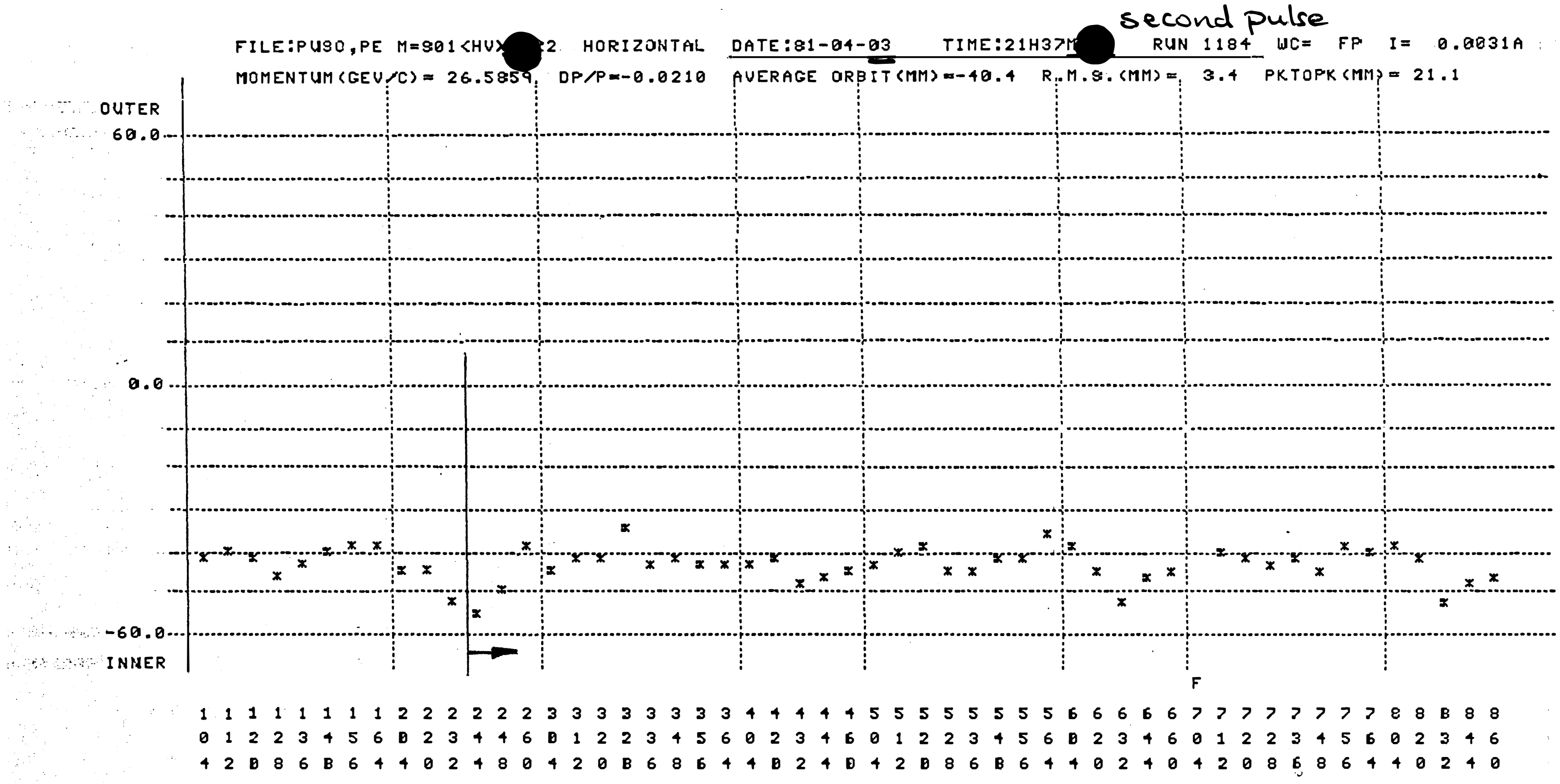


Fig. 10 : R2 Average Orbit Display



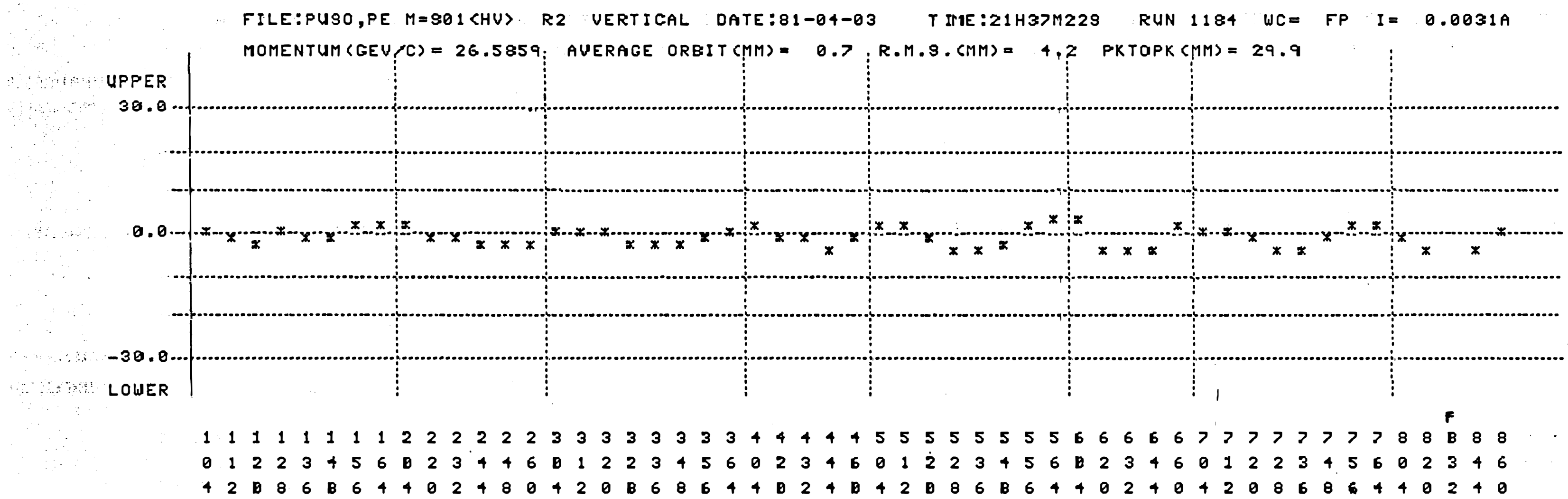


Fig. 11: First Turn Orbit after H Distortion and Injection Correction