

THE MULTI-WIRE PROPORTIONAL CHAMBERS AND THEIR CONTROLS

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1. INTRODUCTION

Multi-Wire Proportional Chambers (MWPC) are used as beam profile monitors in the PS and LEAR experimental beam transport lines to help steer the beam along them, and to display its transverse distribution.

In 1983 only 10 MWPCs were installed at LEAR. Today 32 are routinely used for the LEAR experimental area (Appendix 1) and 11 for the PS East Hall (Appendix 2). These detectors must operate in ultra-high vacuum (10^{-12} Torr), for LEAR and therefore must be bakeable at 300 degrees. They can be retractable (LEAR) or fixed (East hall) and they provide information on the beam position and profile in the vertical and horizontal plane [1].

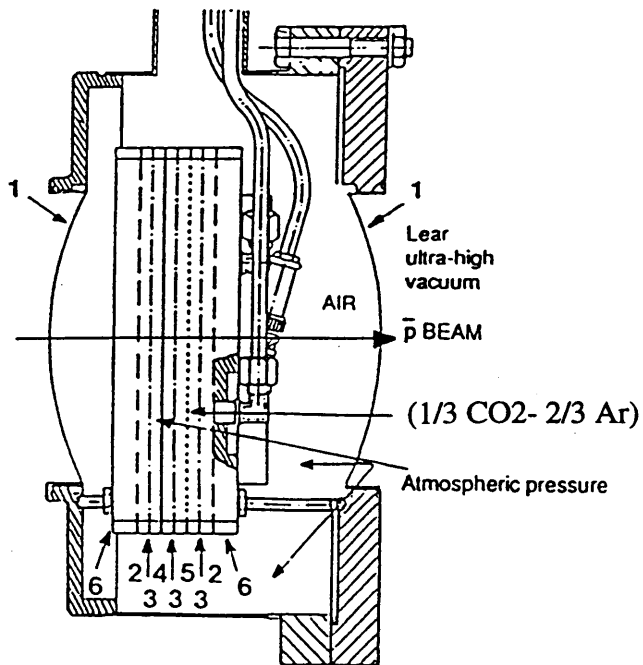
In the frame of the renovation of the control system of LEAR and in order to replace the old "J11" modules which can no longer be maintained, we were asked to develop a new local "intelligent" system that can fully control and acquire data from 48 wire chambers simultaneously either in continuous or one-shot mode (with an external trigger). Up to 4 different chambers can be locally observed at the same time on separate video monitors. All the control and acquisition parameters can be accessed locally, with a dedicated control panel, or remotely via the VAX workstations.

2. PRINCIPLE OF THE MULTI-WIRE PROPORTIONAL CHAMBER. (MWPC)

A charged particle crossing the three planes (Fig. 1), produces a string of electrons and positive ions. Electrons travel along the electric field lines towards the nearest anode wire. The field gradient near the wire is very high and electron multiplication takes place [2, 3]. A measurable pulse in a wire is produced for each charged particle traversing the chamber. In this way, each wire is charged proportionally to the number of particles passing nearby. Due to the geometry of the wires in both planes, we can obtain beam profile and position by integrating the charges on the wires and displaying them in a graphical format.

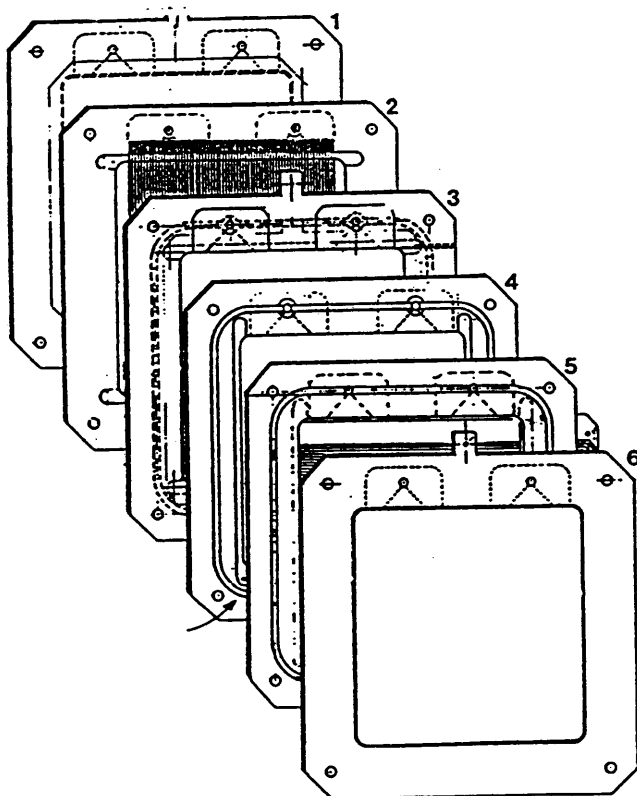
3. CHAMBER DESCRIPTION

The MWPC has a layer of 100 wires of 10 μm CuBe for the horizontal plane and an identical perpendicular one, for the vertical plane. The series of parallel anode wires are in a gaseous environment ($1/3 \text{ CO}_2 - 2/3 \text{ Ar}$) and stretched in the middle of two cathode planes made of thin aluminium foils (Fig. 2).



- 1 ——— 2 Vacuum Windows, stainless steel 38 μm thick.
 - 2 - - - - 2 Protection Kapton MWPC Windows 30 μm thick each.
 - 3 3 Bias (cathodes) Aluminium foils, 15 μm thick each.
 - 4 ——— 100. \varnothing 10 μm BeCu Wires (anodes) for horizontal plane.
 - 5 - - - - 100. \varnothing 10 μm BeCu Wires (anodes) for vertical plane.
 - 6 ——— Metal frame for support.
- Wire spacing 1 mm for both planes

Fig 1 - Cross section of the multi wire proportional chamber



- 1,3,6 High-voltage planes Aluminium 20 μm
- 2 Wires 10 μm horizontal plane
- 5 Wires 10 μm vertical plane
- 4 Guard

Fig. 2 - Exploded view of the MWPC assembly

The voltage applied between the cathodes and the wires can be adjusted in order to tune the MWPC sensitivity to the intensity and energy of the beam to observe, and must not exceed 3.5 kV. Each plane is composed of 100 wires which are combined such as to form 16 groups connected to a 16-channel integrator module. According to the position of the MWPC on the ejected beam and the resolution needed, the central wires are connected to the integrator channels in groups of 1, 2, 4, or 6, while the remaining lateral wires are grouped together on channels 1 and 16. The total interacting mass represents the equivalent of 340 μm of aluminium, including the vacuum windows. To avoid a beam degradation, the MWPC has to be retractable when not in use. Thus the MWPC is fitted in a moving assembly, named pendulum, inside a vacuum box (Fig. 3). The MWPC movement can be controlled either from a local switch panel, or from the main control system.

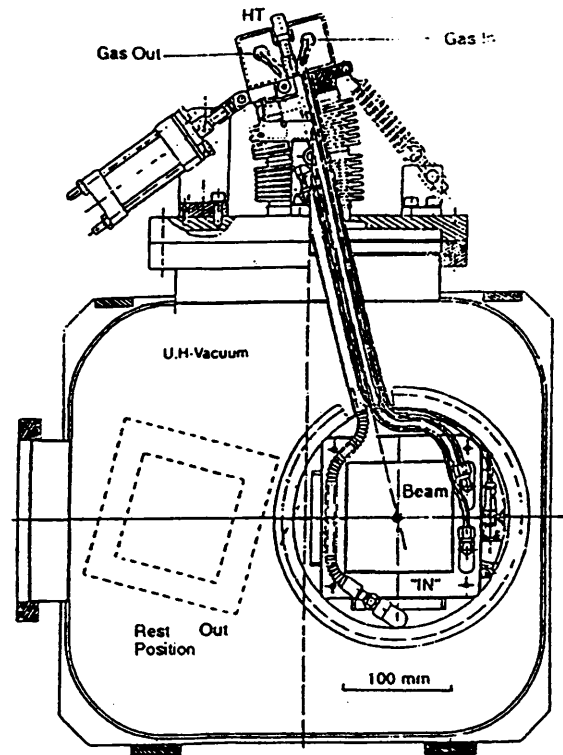


Fig. 3 - MWPC mechanical assembly (pendulum)

The gases (CO_2 and Ar) for the chambers, are supplied through a distribution rack, where the gases are mixed. Each MWPC gas supply is equipped with a flow-meter to adjust the flow between 1 to 2 l/h and a bubbler to control the circuit pressure. The gas status "OK" or "BAD" is generated by a reed-relay on the flow-meter.

4. MWPC CONTROL

The local control panel is the master, and has a Local/Remote switch. When a beam profile is needed, the chamber is moved into the beam by the corresponding switch on the panel or from the workstation. Then the status "IN" is given by a micro-switch on the pendulum mechanism. Integration starts automatically if the selected mode is continuous, or with an external trigger if the mode is one-shot. When the required integration time (typically 1 sec for continuous mode) is finished, the integrator voltage is acquired for each wire with a fast ADC (analogue-to-digital converter) and stored in the memory. Finally, the integrators are discharged and a new cycle can start. A software algorithm treats the stored data and shows the beam profile as a video histogram. Optionally the profile can also be shown as a shaded spot which reconstructs the beam cross section. (Fig. 4).

NAME: t10 / 2 mobile

Device: 01 HORIZONTAL
Mode : oneshot Wgap: 08 mm.
Gas : O.K. Sum : 2040
High V: 2700 V. Max (08): 512
Contr. : remote
Intime : 1000 mS.
Posit : Inside

VERTICAL
Wgap : 08 mm.
Sum : 2040
Max (08): 500

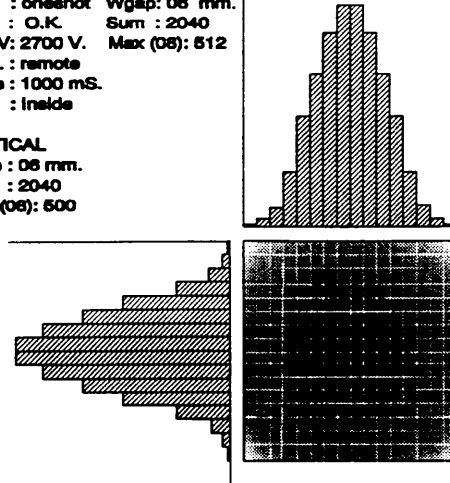


Fig 4 - Simulated histogram and shaded spot representing the beam profile

The wire with the maximum value for each plane is identified and displayed in order to mark the centre of gravity. The sum of the values per plane is also calculated to give a rough idea of the beam intensity. Four displays can be activated simultaneously. The display will appear automatically when a chamber is moved inside the beam. Only the first four activated chambers are displayed locally, but acquisition is done for all the chambers which are inserted along the beam trajectory. The acquired data is made available to the main control system as well as the gas and high-voltage supply status.

For system flexibility, (i.e. application of the same hardware to different machines), the names of the chambers, the gap size, the integration time, the operating modes, and some parameters specific to each chamber, can be modified by the main control system. A default local data base enables the system to work in stand alone mode.

Because of the integration time, the acquired information does not show instantaneous values. Also, the obtained spot may not always represent the real beam distribution, as demonstrated in Fig. 5, where 3 different two-dimensional beam shapes will give the same information in projection.

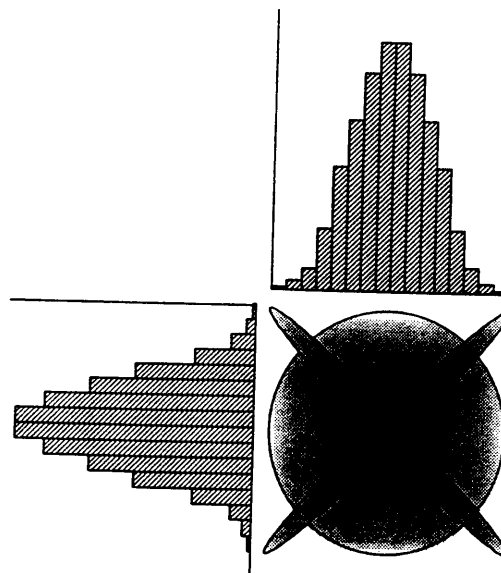


Fig . 5 - An example of 3 different beam shapes which give the same profiles.

4. SYSTEM DESCRIPTION

The system (Appendix 3) is built around a 6809 microprocessor working in a G64 environment. The interface cards are standard types used at CERN. The communication with the central control network is done via an Ethernet link with a standard ISO TP4 protocol. The high-voltage supplies are controlled by a CAEN system which communicates with the G64 CPU via an RS232 port. The in/out movements can be controlled manually from a switch panel, or with a local console, or remotely from the main control network. Four analogue video-composite signals (RS170) are available to display locally the beam profiles. (Fig. 6).

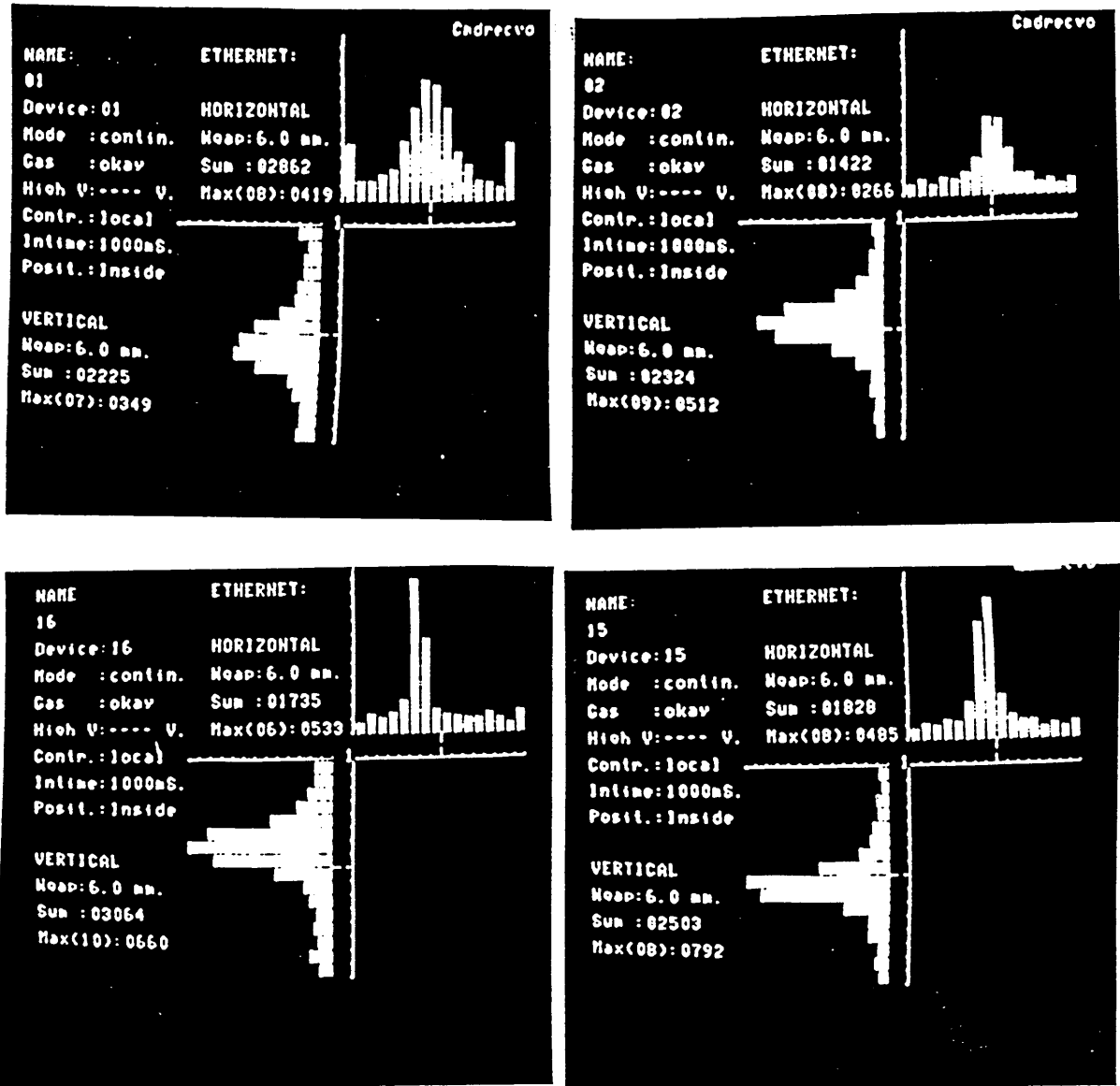


Fig 6-Real MWPC beam profile displays

5. CONCLUSIONS

A new control system has been put successfully into operation in 1992 for the LEAR extracted beam lines, and another one for the extraction lines in the East Hall since March 1993. The general layout is the same for both systems. The only difference is the status "chamber

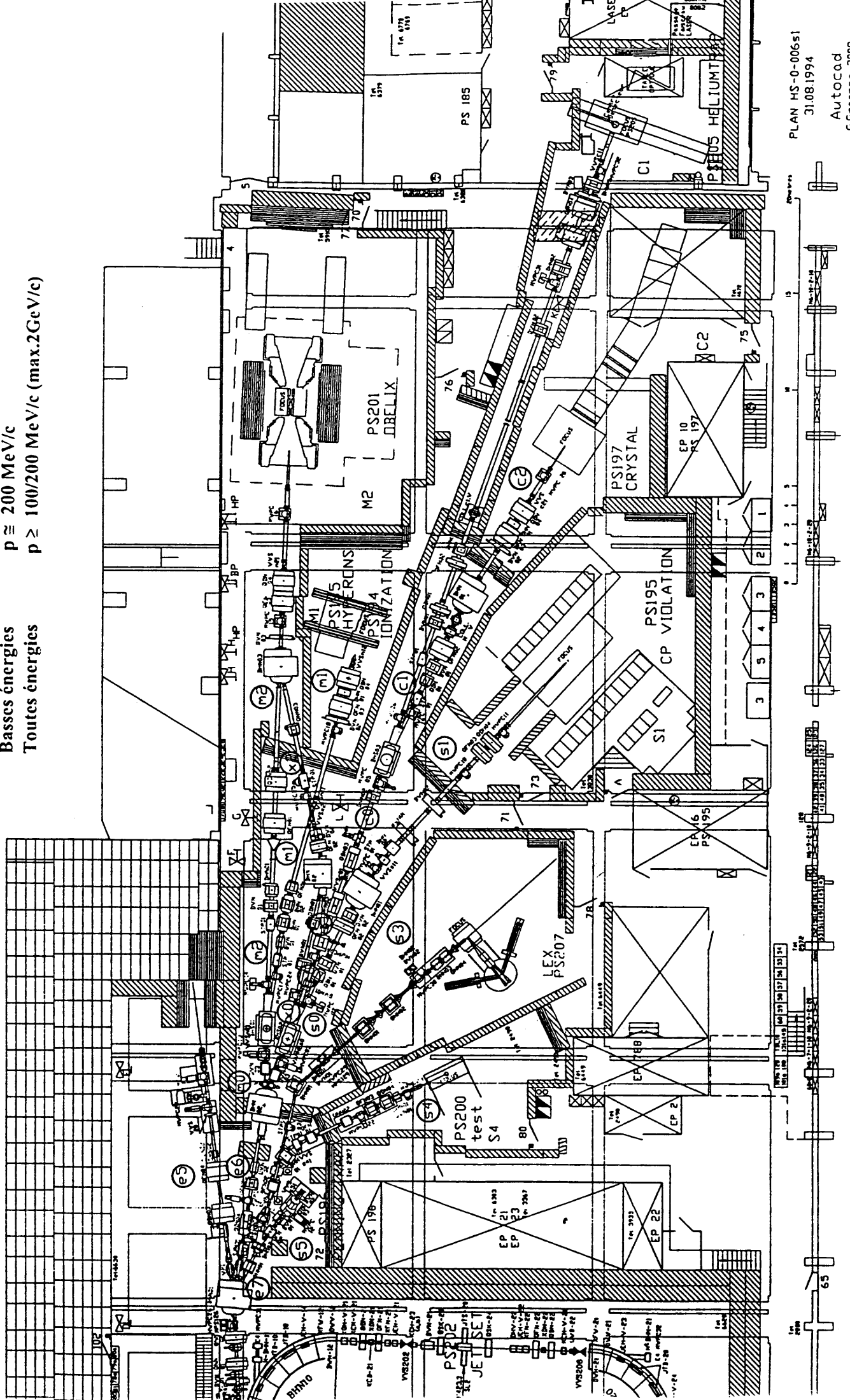
IN/OUT" which is simulated by the control panel in the East hall system. Here the MWPC need not be retracted because the interacting mass has almost no degradable effect on the beam, due to the high energy in use in this area. The same system has been implemented for acquisition of MultiPM and scintillating fibre devices. [4]

6. REFERENCES:

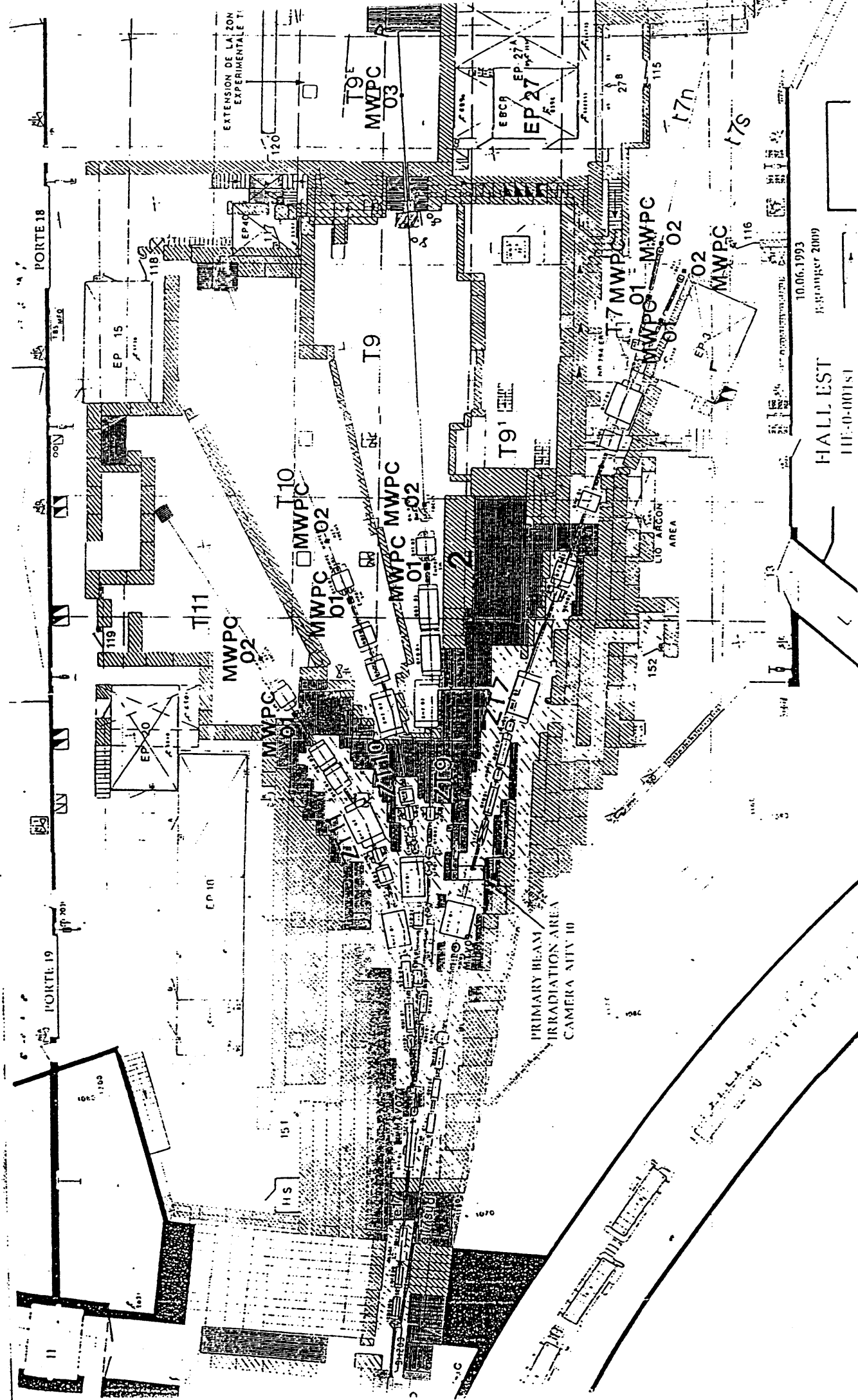
- [1] V.Agoritsas, *Beam instrumentation*, CERN-PE-ED-92, 1992.
- [2] C.W. Fabjan H.G. Fischer, *Reports on Progress in Physics*, 43, 1003, The Institute of Physics, 1980.
- [3] H. Koziol, *Beam Diagnostics for Accelerators*, Procs. of C.A.S. 92, and CERN/PS 92-56 (BD), 1992.
- [4] C. Fernandez-Figueroa and G. Molinari, *Détecteur à fibres scintillantes pour l'analyse des faisceaux dans la ligne de mesure de LEAR*, PS/AR/Note 90-16, 1990.

APPENDIX 1 - LEAR EXPERIMENTAL AREA

Très basses énergies $p \approx 105 \text{ MeV/c}$
 Basses énergies $p \approx 200 \text{ MeV/c}$
 Toutes énergies $p \geq 100/200 \text{ MeV/c (max. 2 GeV/c)}$



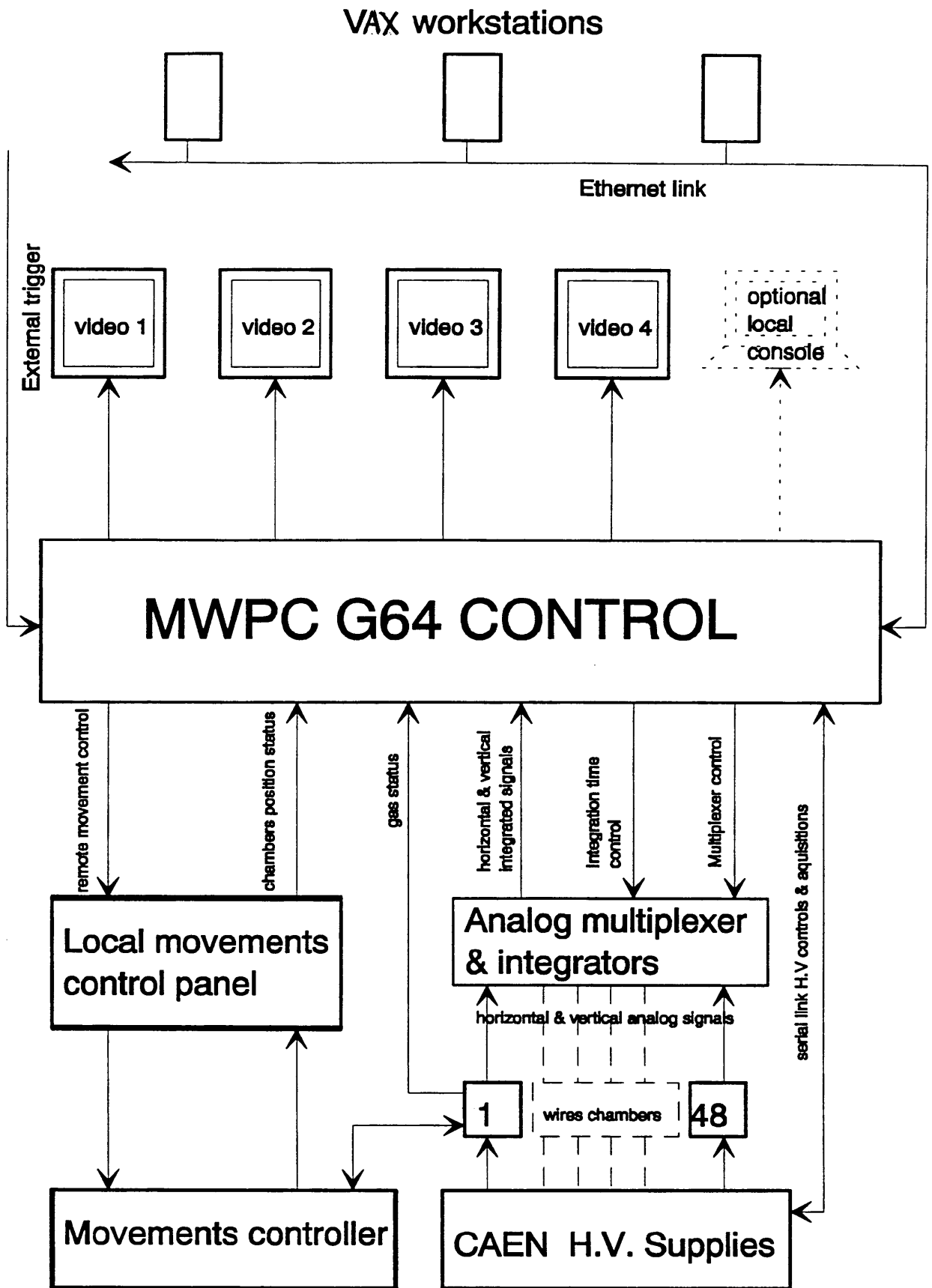
PLAN HS-0-006s1
 31.08.1994
 Autocad
 G. Renner 2009



10.06.1993
 H. Bamber 2009
 IHE-0-00181

HALL EST

APPEN: 2 - The East Hall MWPC layout. The contr. are at EP 27



APPENDIX 3 - General system layout