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OPERATION OF PROPORTIONAL CHAMBERS WITH MOS-FILAS ELECTRONICS IN THE ISR

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ABSTRACT

Multiwire proportional chambers with the Saclay readout system have been successfully operated at the ISR in a double arm spectrometer. Two new problems related to operation at the ISR were the large distance between chambers and readout and the often excessive radiation levels. To overcome the latter difficulty it sufficed to recess the chamber electronics by 20 to 40 cm from the ISR beam plane.

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CONTENTS

I - The experiment.

Following the discoveries of particles ψ (or J) of 1974, experiment R 702 was proposed aiming to study electron pairs and single electrons at the ISR as well as charm decays of the type : $D \rightarrow \pi K^{0}_{s}$, $D \rightarrow eK\nu$ or $B_{c} \rightarrow e \Lambda \nu$ at high energy proton-proton collisions.

The original apparatus consisted of a double arm spectrometer and was installed at 90^{o} at the ISR. Each arm included a magnet, two sets of chambers for track detection before and after the magnet, Cerenkov counter, lead glass array and three planes of scintilation counters. Drift chambers were chosen for the determination of the horizontal coordinate where there is magnetic bending and maximum precision ($\pm$ 150μ) is required. For the vertical coordinate it was decided to use multiwire proportional chambers (MWPC) in the front while drift chambers with inclined wires at the back giving similar spatial resolutions ($\pm$0.6mm).

To maximize acceptance the magnets were positioned as close to the beams as possible thus limiting severely the space available for the front detector. Space at this intersect had already being limited by the presence of the four low-β quadrupoles used for increasing the luminosity by a factor of about 2.4 since the production cross-section for the reactions sought was expected to be very low.

In the spring of 1976 the experiment was enlarged to include a search for charm through the channel $\mu^{\pm}$ $e^{\mp}$. For this purpose a magnetized iron was added vertically between the two arms on top of the intersection region. Scintilation counters and proportional chambers before and after the iron would provide the track coordinates and consequently the μ-signature.

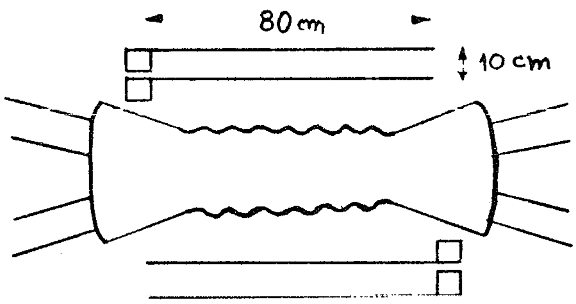
II - The set-up

The experimental set-up including the μ detector is shown in figure 1. The electron arm not shown is identical to the one shown. For the electron arm there are six chambers in front of the magnet -4 drift chambers and 2 MWPC's- and 4 drift chambers at the back. The active area in the front is 25x80 cm^2 drift space 2.5 cm, wire spacing 2mm in MWPC ; active area in the back 100x270 cm^2 drift space 3 cm.

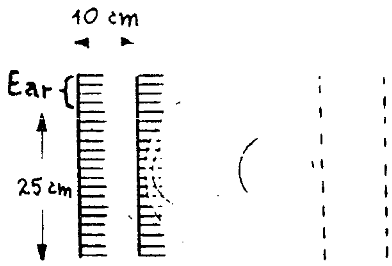
For the μ-arm there are 6MWPC in front of the magnetized iron 46x120 cm^2, 2mm spacing and 6 MWPC in the back 51x180 cm^2 and 4mm spacing.

For all MWPC's the Saclay readout was adopted. In this system integrated circuits of the MOS technology are mounted on cards -LETTI- directly on the chambers and serve as first stage processors. They include amplifier, threshold adjustement, internal delay adjustable up to 1 μs and buffers for storing the wire signals untill they are read by a readout module which comunicates with the on-line computer and is located in the counting room. For operation at the ISR the distance between the readout module and the LETTI-cards has to be large ; in this experiment it was 60m. It was the first time that this readout is used over so long distance and it was necessary to adjust the capacitance of the receiving end at the module. The other effect of the long distance was that the amount of time required for reading an event was now increased by almost a factor of 2, because of the additional length that the communications between readout module and LETTI cards had to traverse.

Another unknown for operation at the ISR was the radiation levels. The 2 MWPC's of each electron arm were positioned at 30 cm and 40 cm from the beam intersect. This proximity to the beams resulted in a geometry where the central LETTI cards of the front chambers were pratically touching the beam pipe while those of the rear ones were a mere 10 cm from it. Both sets of cards were centered around the beam plane.



Top view



View along the beams

The closest MWPC of the μ -arm was 50 cm from the intersect and equal distance from the beam plane. This is the reason that the electronics of those chambers suffered no noticalbe radiation damage.

II - Radiation problems.

Difficult accessibility dictated that all LETTI cards be tested and selected so as to result in well-uniform groups of 16 before installation, in addition all cards were adjusted for optimum operation at 650ns instead of the usual 400ns.

Early tests showed that optimum operation of the chambers could be achieved with a WRITE strobe (Ecriture) as short as 70ns when each chamber was timed individually.

However, the situation deteriorated rapidly within a few days of ISR operation resulting in a large number of LETTI cards being inoperative particularly in the central region of the front chambers. Some cards died completely while others lost sensitivity and become slower. They would need, for example, 40-50mv signal in order to trigger and the FAST OR signals would come out up to 300ns later. "Autopsies" performed on the damaged cards indicated radiation damage. Subsequent studies showed that an integrated dose of 30000rads would render a LETTI card inoperative either by killing it completely or by altering its characteristics beyond recovery. This was in qualitative agreement, if somewhat more pessimistic, with the studies on radiation damage by Billon [1] (some slightly damaged cards were recovered by adjustement of the threshold potentioneter). No ear cards suffered from radiation at any time.

The radiation level in the vicinity of the chamber electronics was measured to be 50rad/hour in a particular ocassion following a low-β machine development study. Indeed, a correlation between low-β operation and high radiation levels was established and consequently the operation of low-β in I7 was minimized. It was not possible to avoid, however, radiation due to injection, bad beam conditions or various other machine development programs.

Subject to space limitations, shielding against radiation proved ineffective.

III - Flat cable prolongations

The observation that LETTI cards at the chamber extremities suffered less damage that those at the beam level motivated efforts towards ways of recessing the cards away from the beam plane. In addition to space considerations, time was at issue as the modifications had to be carried out during an ISR shut down of ten days. The solution arrived at was the following :

Thirty two prolongations of 45cm each were constructed and inserted between the LETTI cards of the front chambers and the mother boards originally carrying the cards. Each LETTI card was thus lowered individually by 45cm while the ear cards and all power connections remained on the mother board. The prolongations were made from Scotchflex multiconductor flat calbe with conducting grid on one side (cable type R 2850). They were equipped with press-on connectors in a quick and efficient way. One end was fitted with small printed circuit boards which plugged in the mother board connectors. A 50-conductor cable was chosen so that additional ground conductors could be inserted between the eight inputs of a card to avoid cross talk. The pattern used between Input, Output and Ground providing adequate isolation between inputs was as follows :

..IGOGIGOGIGOGI...
------------------ grid

All grounds were connected to the grid and the chamber ground at the mother board while at the card input all lines came in parallel with no further ground connections.

IV - Performance

The flat calbe prolongations were installed only on the front two chambers while the rear ones remained as before. In this way evaluation of the modification could be done in terms of direct comparison with the unmodified chambers. A loss in pulse height of a factor of 2 was not surprising considering the capacitive divider seen by an input line and its neighbouring grounds and grid. Such a loss, however, was easy to recover by lowering the threshold (V_{pol}) and/or raising the chamber H.V. In fact, no compensation was necessary once the chambers were operated well into their maximum efficiency plateau. All **four** chambers reached 98% efficiency for tracks of good geometry.

No cross talk was observed.

1 - B. Billon, Radiation Exposure tests. Société pour l'étude et la fabrication de circuits intégrés spéciaux. Grenoble.

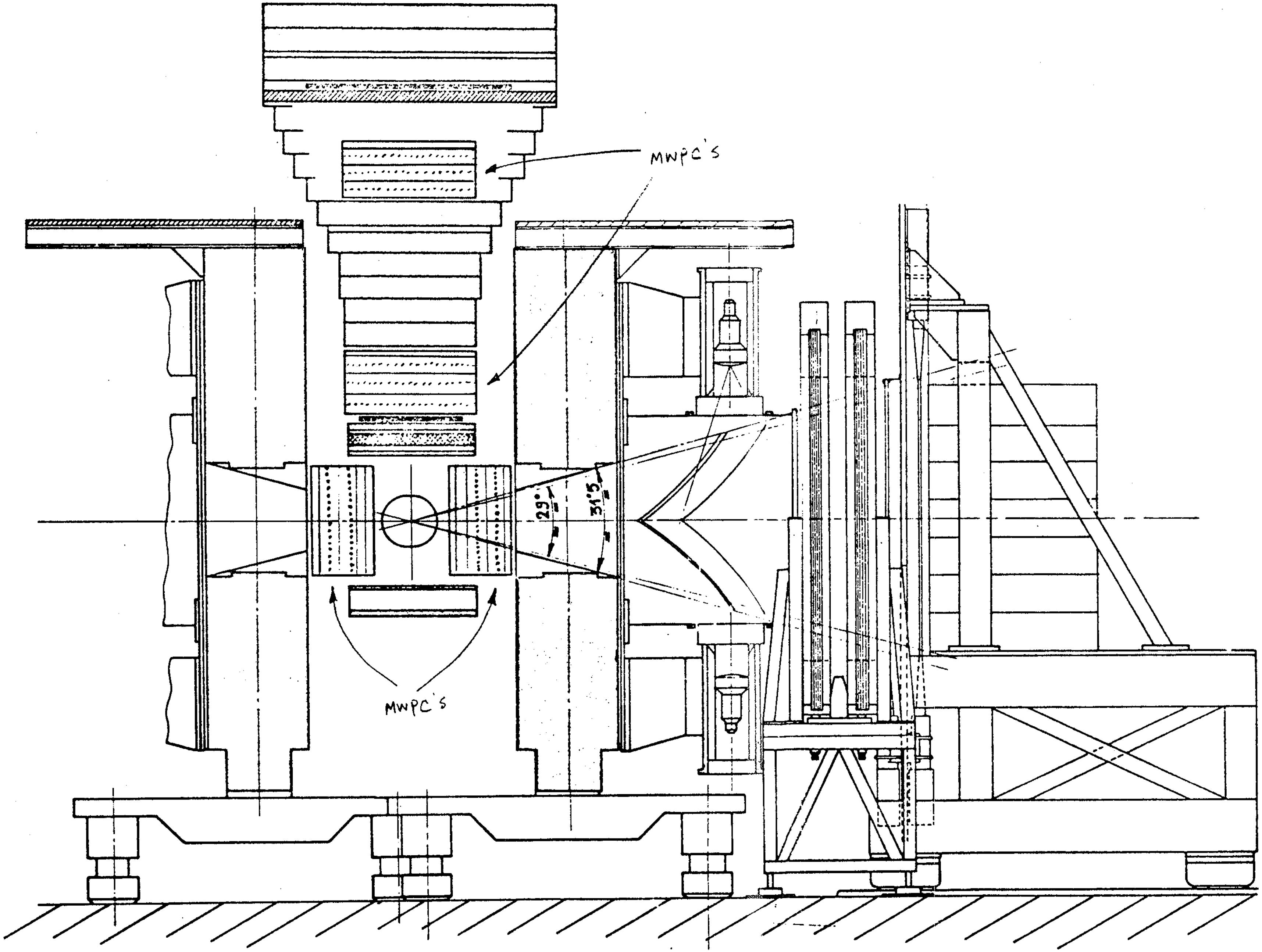


Figure 1. The experimental set up