L. Rossi:

PERSPECTIVES IN HIGH ENERGY PHYSICS INSTRUMENTATION

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PERSPECTIVES IN HIGH ENERGY PHYSICS INSTRUMENTATION

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Abstract
The discovery potential of the next generation of particle accelerators, and in particular of the Large Hadron Collider (LHC), can only be fully exploited by very sophisticated particle detectors. The basics of detectors for momentum and energy measurement is here presented together with a recollection of recent developments which are relevant for use at high luminosity accelerators.

1. Introduction

The field of elementary particle detectors is wide and it evolves rapidly. Try to fit a complete description in one hour talk may turn out to be frustrating both for the speaker and for the audience. I have therefore decided to limit the presentation to few detectors which I consider representative of two classes: the momentum measurement devices and the energy measurement devices. These devices allow to determine the particles four-vector and then study the kinematics of the reactions under scrutiny. The interested reader may find a good and exhaustive description of the most widely used particle detectors in a book edited by Tom Ferbel 1. In my talk I’ll give special attention to those characteristics (space accuracy, dynamic range, granularity, pattern recognition capability, time resolution, etc.) which are crucial to better cope with the large momenta, the high multiplicity and the high interaction rate expected at the LHC.

The description of the detectors will be pedagogical, starting from the principle of operation to the most recent R&D results. Whenever convenient the historical evolution of a particle detector concept will be underlined.

2. Momentum measuring devices

Particle momenta are deduced from the formula

\[ p \cos \lambda = 0.3zBR \]  

(1)

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b) the read-out of the ionization is obtained through pick-up kapton electrodes located at the centre of each LAr gap and connected to the preamplifier at the back of each accordion tower. This set up minimizes the capacitance of the transmission line to the preamplifiers and optimizes the speed of the detector. Only one part of the ionization signal is used if high rate operation is necessary. Fast shaping of part of the triangular current pulse (see figure 21) allows to measure the total charge deposit by simple extrapolation.

Fig. 21. Signals in a LAr calorimeter: (a) current and induced charge, (b) fast bipolar shaping and (c) the observed signal which is a convolution of (a) and (b) \(^{21}\)

Drawback of the accordion geometry is the difficulty to implement longitudinal segmentation, which is necessary to measure the profile of the shower deposit along the calorimeter. This information is important to optimize the \(e/\pi\) separation. Large scale prototypes of the accordion calorimeter have been built and all the basic measurements have been carried out. The energy resolution has been found to be:

\[
\frac{\sigma(E)}{E} = 0.096/\sqrt{E} + 0.004
\]

the space resolution, which is important for \(\pi^0\) reconstruction and for matching the information provided by the calorimeter with the information of the tracking detectors, has been measured to be:

\[
\sigma(x) = 5\ \text{mm}/\sqrt{E}
\]

Finally, the uniformity of response, which can be a worry in this geometry, has
been measured below $\sim 1\%$, as shown in figure 22.

![Graph showing uniformity of response to electromagnetic showers of the accordion calorimeter as a function of the impact point of the incoming electron.]

**Fig. 22. Uniformity of response to electromagnetic showers of the accordion calorimeter as a function of the impact point of the incoming electron.**

4. Conclusions

Many recent developments in particle detectors have been driven by the very demanding needs of LHC. A lively R&D program has been set up at Cern from 1990 to 1994 under the control of the Detector Research and Development Committee to find ways of better exploiting the potentialities of a high luminosity collider like the LHC. Most of the novel results presented in this review originate from this program.

5. Acknowledgments

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