ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Genova

INFN/AE-95/19
12 Ottobre 1995

L. Rossi:

PERSPECTIVES IN HIGH ENERGY PHYSICS INSTRUMENTATION

Invited talk at the
XXIII Int. Meet. on Fundamental Physics
Comillas, Spain, May 22–26, 1995

SIS–Pubblicazioni
dei Laboratori Nazionali di Frascati

INFN - Istituto Nazionale di Fisica Nucleare
Sezione di Genova

INFN/AE–95/19
12 Ottobre 1995

PERSPECTIVES IN HIGH ENERGY PHYSICS INSTRUMENTATION

L. Rossi*
INFN–Sezione di Genova and Università di Genova, via Dodecaneso 33, I–16146 Genova

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

$$p \cos \lambda = 0.3 z B R \tag{1}$$

* E–mail: rossi@genova.infn.it

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.

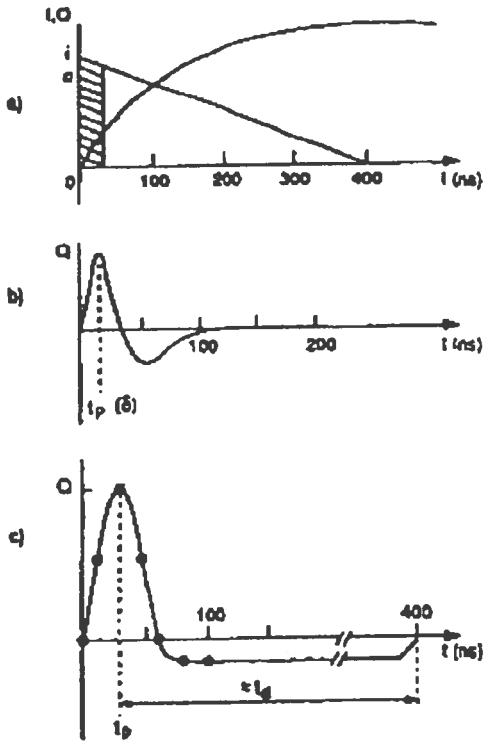

Fig. 21. Signals in a LAr calorimeter: (a) current and induced charge, (b) fast bipolar shaping and (c) the observed signal which is a convolution of (a) and (b) [21]

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/π 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:

$$\sigma\ (\mathrm{E})/\mathrm{E} = 0.096/\sqrt{\mathrm{E}} + 0.004$$

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

$$\sigma(\mathrm{x}) = 5\ \mathrm{mm}/\sqrt{\mathrm{E}}$$

Finally, the uniformity of response, which can be a worry in this geometry, has

been measured below ~1%, as shown in figure 22.

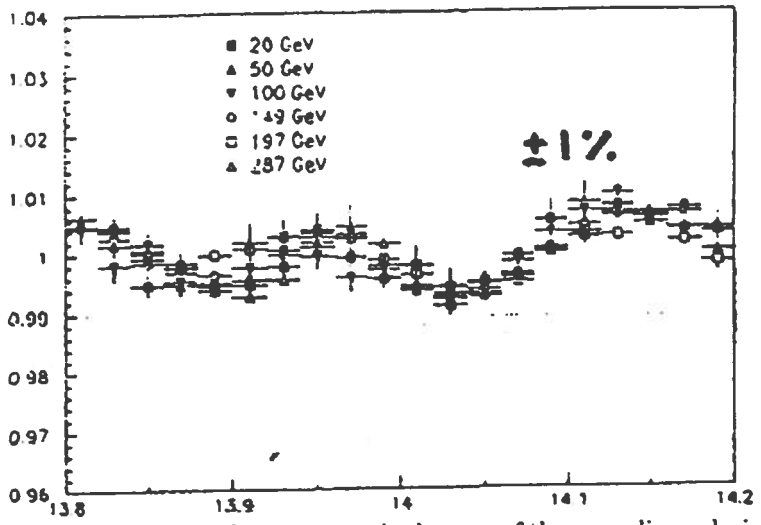

Fig. 22. Uniformity of response to electromagnetic showers of the accordion calorimeter as a function of the impact point of the incoming electron

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 Develpment 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. Aknowledgments

I am grateful to the organizers of this conference for the very kind hospitality in the enchanting atmosphere of Comillas.

6. References

1. *Experimental Techniques in High-Energy Nuclear and Particle Physics* ed. T.Ferbel, World Scientific, Singapore
2. H.A.Bethe, *Annalen der Physik* **5** (1930)325
3. *Principle of operation of multiwire proportional and drift chambers* F.Sauli, Cern Report 77-09 (1977)
4. RD-6 Collaboration, CERN/DRDC/93-46, Nov. 1993
5. Atlas Technical Proposal, CERN/LHCC/94-43, LHCC/P2, Dec. 1994
6. V.L.Ginzburg and I.M.Frank, *IETP* **16** (1946)15
7. G.Charpak et al. *Nucl. Instrum. and Methods* **62** (1968)235
8. G.A. Erskine *Nucl. Instrum. and Methods* **105** (1972)565
9. G.Charpak et al. *Nucl. Instrum. and Methods* **148** (1978)471
10. D.R.Nygren *Phys.Scripta* **23** (1981)584
11. A.Oed et al. *Nucl. Instrum. and Methods* **A263** (1988) 351
12. RD-28 Collaboration, CERN/DRDC/93-34, Sept. 1993
13. CMS Technical Proposal, CERN/LHCC/94-42, LHCC/P1, Dec. 1994
14. S.R.Amendolia et al. *Nucl. Instrum. and Methods* **176** (1980)449
    E.H.M.Heijne et al. *Nucl. Instrum. and Methods* **178** (1980)331
15. M.Adinolfi et al. *Nucl. Instrum. and Methods* **A329** (1993)117
16. E.H.M. Heijne et al. *Nucl. Instrum. and Methods* **A273** (1988) 615
17. H. Spieler *Integrated microsystems as a driving force in modern detector design* Ed. M. Budinich et al., Int. Conf. on the Impact of Digital Microelectronics and Microprocessors on Particle Physics, Trieste 28-30 March 1988 World Scientific, Singapore, 1988 1672
18. F.Antinori et al. *Nucl. Instrum. and Methods* **A360** (1995) 91
19. E.H.M. Heijne *Physica Medica* **9** (1993) 109
20. M.Atac et al. Proc. Calorimeter Workshop, FNAL, Batavia, Ill. (1975)
21. C.W.Fabjan CERN-PPE/94-61
22. C.W.Fabjan et al. *Phys. Lett.* **60B** (1975) 105
23. R.Wigmans *Nucl. Instrum. and Methods* **A265** (1988) 273
24. B.Aubert et al. (RD3 Collaboration) CERN-DRDC/90-31
    B.Aubert et al. *Nucl. Instrum. and Methods* **A324** (1992) 93