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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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To : W. Paul and P. Preiswerk, Leaders of NP Division,
R. Macleod, Leader of DD Division.

From : R. Blieden, L. Dubal, U. Focacci, W. Kienzle, F. Lefebvres
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Subject : Proposal for a JOINT PROJECT OF THE NP AND DD DIVISIONS OF CERN, with the collaboration of the NUCLEAR PHYSICS LABORATORY OF THE UNIVERSITY OF GENEVA.

COMPLETE VERTEX ANALYSER
("COVERAN")

ABSTRACT

It is proposed to build an elaborate and flexible system consisting of large magnets and detectors with the CDC 6600 computer on-line, as a GENERAL FACILITY rather than a project of a single experimental group. It is believed that the proposed system will make it possible to investigate a wide variety of strong and e.m. interactions by studying their detailed features such as production mechanisms, decay modes and spin-parity determination of mesonic and baryonic resonances, search for new unstable and stable particles, and search for very low cross-section (~ 1 nbarn) phenomena.

It is estimated that the system will be able to handle 10 to 50 events/burst (10^5 to 10^6 events/day). For each event the measured parameters will be written on the magnetic tapes; the tapes will be distributed to research groups at CERN and possibly other European laboratories for analysis.

The formation of a Study Group, for design and cost of the system, is proposed.

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A. DESCRIPTION OF THE SYSTEM AND ITS FUNCTIONING

We propose to build, as a general CERN facility, an almost-4π detector system capable of measuring simultaneously:

i) angles of almost all charged particles emitted from a hydrogen target;

ii) momenta of almost all charged particles emitted from a hydrogen target;

iii) angles and momenta of low-energy ($\leq$ 1.5 GeV/c) neutrons with an efficiency of 20%;

iv) angles of γ's emitted from particle decays, such as, for example, $\pi^0 \rightarrow 2\gamma$, with 75% efficiency (lead converters);

v) masses of forward-emitted (fast) charged particles, for example, identification of K versus π by means of Čerenkov or/and total ionization counters.

The system consists of a liquid hydrogen target placed in a wide-gap (200 cm × 200 cm × 100 cm), strong (15 - 20 kG) magnetic field. The target is viewed from all sides by sets of magnetostriction wire-chambers, placed both inside (about 5 chambers) and outside (about 15 chambers) the magnet; and a system of scintillation counter hodoscopes (about 1,000 elements) distributed also both inside and outside the magnet. Another large magnet of the same size is placed in the forward direction, with Čerenkov counters or/and ionization rise (or similar) detectors. The layout which is now under study is shown in Fig. 1.

For each event, all the measured parameters from which the above-listed physical quantities can be obtained are digitized and stored onto the magnetic tape via a buffer and the CDC 6600 computer. The computer puts each type of event on a separate magnetic tape and the tapes could be distributed to CERN groups and associated European laboratories for analysis.

It is estimated that the system will be able to store 10 to 50 events per PS burst on the magnetic tape (or 3×10^5 to 1.5×10^6 events per day of running). This number depends on the speed (cost) of the data storage system and the recovery time of the wire chambers.

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The detector configuration (i.e., the layout of chambers and counters), and the trigger conditions are decided upon the basis of the demand of experimental groups.

B. TYPES OF REACTIONS

As an idea, we list here the types of reactions, in most general terms, that are believed possible to be investigated by Coveran. (It is quite possible, however, that the detail features of some of the listed processes are not compatible with Coveran.)

In one run, the trigger is designed so as to satisfy as many types of events as possible.

1. Elastic scattering: $\pi + p$, $K + p$, $p + p$, $\bar{p} + p$ medium and large angles. (This can be the by-product when the trigger is set for more complex reactions such as those listed.)

2. Inelastic, boson production:

$\pi + p \rightarrow N + X \rightarrow N^* + X$ N = nucleon, p or n

$\pi + D \rightarrow N + N + X$ where $X = \eta;\ \omega;\ \rho;\ f;\ A, B$, etc.

3. Associated production:

$\pi + p \rightarrow K + Y;\ \rightarrow K^* + Y^*;\ \ K + Y + n\pi;\ \ K^* + Y^* + n\pi.\quad n = 1, 2, \ldots$

4. $p + p \rightarrow N + N^*;\ \rightarrow N^* + N^*;\ \rightarrow N^* + N^* + n\pi$

5. $K + p \rightarrow Y + K;\ \rightarrow Y + K^*;\ \ Y^* + K^*;\ \rightarrow K + K + \Omega$, etc.

6. $\bar{p} + p \rightarrow n\pi;\ \rightarrow mK\bar{K};\ \rightarrow n\pi + mK\bar{K}.\quad m = 1, 2, \ldots$

$\rightarrow Y\bar{Y};\ \ Y^*\bar{Y} + c.c.;\ \ Y^*\bar{Y} + n\pi + mK\bar{K}.$

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C. POSSIBLE EXPERIMENTS

1. Decay modes of resonances, both boson and baryon ones, strong and e.m. decays.
2. Detail properties of resonances by studying various momentum-angle correlations - leading to spin-parity determinations.
3. Detail study of the correlations in the reaction - including polarization of unstable particles - revealing the production mechanisms.
4. Search for new unstable bosons and baryons, by combining missing-mass and the effective mass methods.
5. It is hoped that at later stages, when the art of vertex reconstruction is developed, search for heavier "stable" particles (of the Ω^- type) can be undertaken.
6. Search for very low cross-section phenomena (1 nbarn and perhaps less).
7. Polarization of protons from the reactions and isobar decays.

D. BUBBLE CHAMBER VERSUS COVERAN

Coveran is neither intended, nor could it be an over-all competition to bubble chambers; rather it should be considered as a device complementary to it. The 4π solid angle of the bubble chamber, coupled with the possibility for visual observation, represents two decisive advantages in the investigation of very complex events. The decay vertex reconstruction is always extremely good in bubble chambers.

However, there are certain advantages that can be useful in a sufficiently wide variety of reactions to make the design of Coveran worth consideration. These are listed in Table 1.

It should be pointed out that in the bubble chamber a rare phenomenon can be observed and established on the basis of one picture only. In Coveran this depends very much on the signal-to-background ratio and, although the events could be fitted, one event cannot be relied upon. Rare events have to be investigated statistically in order to be believed.

E. CONCLUSIVE REMARKS

Only the existence of the CDC 6600 computer makes it possible to envisage and materialize the above-described system. CERN should take advantage of its new powerful computer.

It is estimated that the system, including two large magnets, will not cost more than 5 million Sw. Frs.

In the design of Coveran one has to incorporate experience of the counter, bubble chamber and spark chamber physicists, programmers and electronics men. It has, necessarily, to be a joint project of at least two divisions, NP and DD.

F. PROPOSAL

We propose the formation of a full-time Study Group consisting of three members (NP, DD and University of Geneva); and, an eight to ten member Working Party with people from various divisions who will meet periodically with the Study Group.

TABLE 1

Some advantages of Coveran versus bubble chambers that can be used for a study of a wide range of event types. The Alvarez 72-inch bubble chamber, whose parameters are well known, is used for the comparison.

Item	72-inch hydrogen bubble chamber	Coveran
1) Number of incident particles per burst	~ 30	$\sim 10^6$
2) Target length	200 cm $\cong \frac{\text{1 event/1 inc. particle}}{\text{150 mbarn}}$	10 cm $= \frac{\text{1 event/1 inc. particle}}{\text{3.000 mbarn}}$
3a) Cross-section needed to produce 1 interaction per burst ("minimum σ detectable in one burst")	5 mbarn	0.01 mbarn = 10 microbarn
3b) Minimum detectable σ per day of running ($\sim 3\times 10^4$ bursts) Yielding one event	$\sim$ 150 microbarn	0.3 nanobarn and perhaps less (1 nbarn = 10^{-9} b)

I t e m	72-inch hydrogen bubble chamber	Coveran
4a) Number of interactions per burst, for $\sigma = 30$ mbarn (number of all types of events, "desired + undesired")	6	3000
4b) Number of stored events per burst, for $\sigma = 30$ mbarn	6 desired + undesired events stored on film to be scanned; to be measured	Depends of the speed of data storage and recovery time of wire chambers. Estimated: 10 to 50 desired events only (selected by trigger condition); "scanned" and measured; measured parameters stored on magnetic tape instantaneously
4c) Number of stored events per day of running ($\sim 3 \times 10^4$ bursts) with $\sigma = 30$ mbarn	1.8×10^5 desired + undesired events; stored on film; to be scanned; to be measured	3×10^5 to 1.5×10^6 desired events only (selected by trigger); "scanned" and measured; measured parameters stored on mag. tapes, with each tape containing different class of events

Item	72-inch hydrogen bubble chamber	Coveran
5) Detection of recoil neutrons ($p \leq 1.5$ GeV/c)	Efficiency ~ 1%; only angles can be measured	Efficiency ~ 10%; angles and momentum (time-of-flight) can be measured
6) γ detection	With lead plates, 80% efficiency possible	With lead plates, 80% efficiency possible. The lead plates easily removable
7) Mass of the fast particles, e.g. K versus π identification	not done	Can be done with β-sensitive counters in forward cone
8) Momentum resolution for charged particles	± 1% to 5% Depending of the length of the trajectory and the momentum	± 0.1% to 5%
9) Angular resolution for charged particles	$\pm 0.25^{\circ}$ to 1°	$\pm 0.1^{\circ}$ to 0.5°

Item	72-inch hydrogen bubble chamber	Coveran
10) Optimization of the physics as a function of physics results obtained during the run (incident momentum, selectivity of desired events, etc.)	Not easily done	By analysing completely on-line (kinematic fitting) 10 to 30% of the events "on-line sampling", it is hoped that the phenomena can be "followed", and the effects "hunted" by optimizing the parameters

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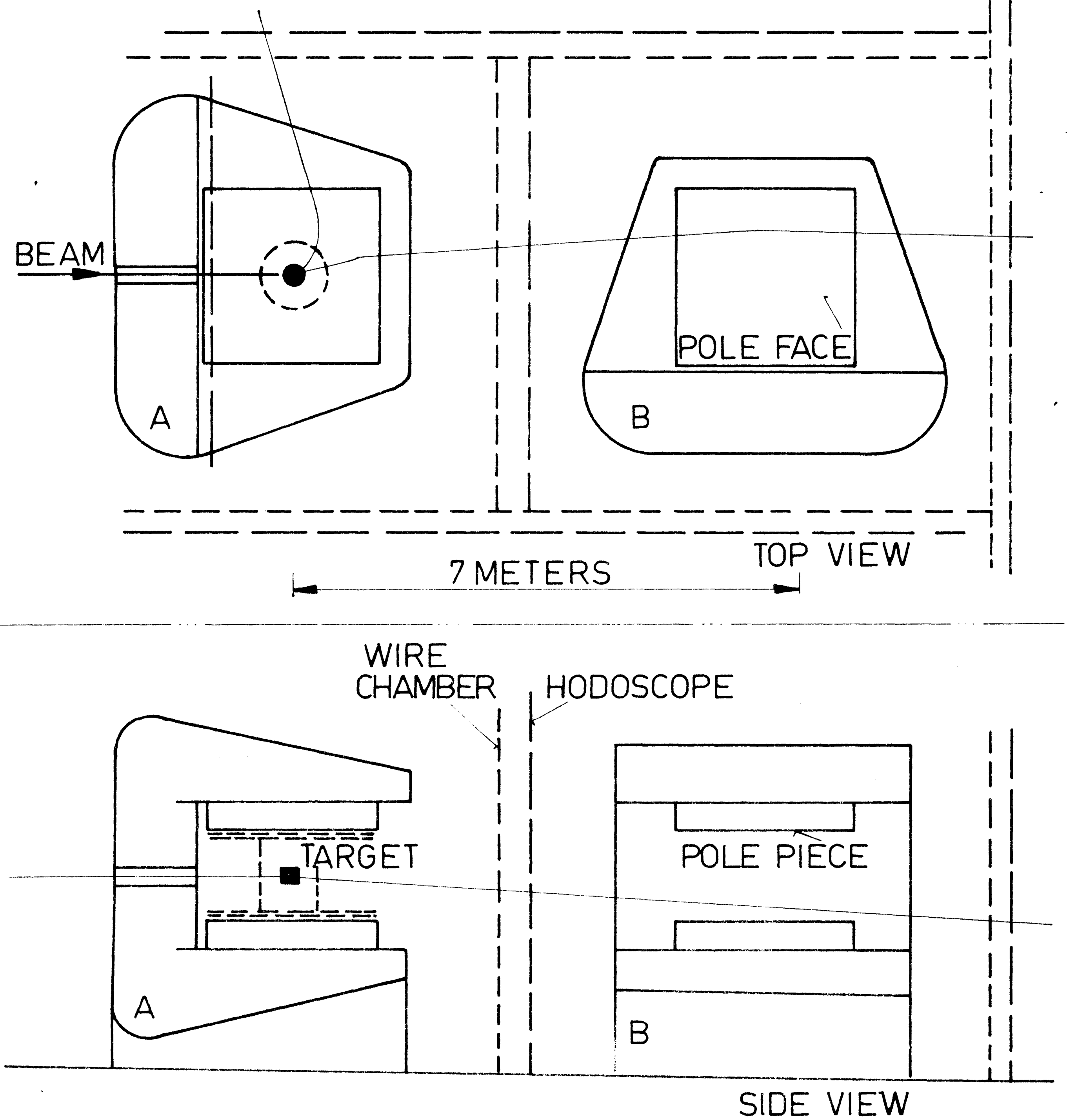

FIG. 1

THE SYSTEM CONTAINS THE TWO MAGNETS A AND B. AND IS IN A HELIUM ATMOSPHERE

——— HODOSCOPES

- - - - - - - WIRE CHAMBER PLANES (THE NUMBER OF PLANES IS A FUNCTION OF THE TYPE OF EVENT INVESTIGATED.)