EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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MEMORANDUM

To : Members of the EEC

From : J. Badier, A. Romana, R. Vanderhaghen, I. Videau, H. Videau, J.C.L. Chollet, D. Decamp, J.-M. Gaillard, J. Lefrançois, B. Merkel, J.-P. Repellin, G. Sauvage, J.J. Blaising, Y. Chatelus, R. Morand and A. Navarro-Savoy
(Ecole Polytechnique-Orsay-Strasbourg Collaboration)

Subject : Proposal for experimentation in the hyperon beam

Our main project is the study of hyperon-proton interactions.

1. HYPERON HADRONIC INTERACTIONS

The aim of the proposed experiment is to study elastic scattering and resonance production in hyperon-proton interactions.

From the elastic data one will obtain the slope parameter b fitted in a region between t = 0.065 and t = 0.45 with an accuracy db ±0.025. In the reactions $\Sigma^- p \to Y^{*-} p$ one will study the analogue of the resonances observed in $pp \to N^* p$ [1] ($P_{1/2}$, $D_{3/2}$, $F_{5/2}$). The purpose of the Y^* study will therefore be twofold.

- The observation of the $1/2^+$, $3/2^-$, $5/2^+$ series for the Y^*'s and a study of their decay modes.
- The study of the diffraction dissociation mechanism and its separation from a background due to the Deck effect. This study is helped by the narrower width of the Y^* with respect to the N^* (a factor of 2 to 3) and by the presence of a greater number of decay channels in the Y^* case.

In order to predict the event rate, we have used the $pp \to N^* p$ cross-sections as measured in Ref. 1.

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1) M. Edelstein et al., PRE 14621 (CERN 1972).

1.1 Apparatus

The philosophy of the apparatus is to build a missing-mass detector by measuring the recoil proton energy and angle, and to observe the decay of the forward going Y^* in a streamer chamber set-up very similar to the set-up at present used to measure leptonic decays of hyperons. The apparatus is shown in Figs. 1 and 2.

The projected angles of the incident Σ^- identified by the DISC are measured to ±0.35 mrad by the MWPC on each side of the DISC; the Σ^-'s interact in a H_2 target $\emptyset = 4$ cm L = 40 cm.

The MWPC around the target are used to measure the proton angle to $\Delta\phi \pm 10$ mrad and $\Delta\theta \pm 4$ mrad (multiple scattering contributes an extra uncertainty between 3 and 20 mrad depending on the recoil proton momentum). Redundancy is provided by the fact that both the θ and the ϕ of the proton are measured by three points: θ is measured by wires perpendicular to the beam direction in chambers 1, 2, and 3; ϕ is measured by the incident Σ^- trajectory, and by wires parallel to the beam in chambers 2 and 3. Such a redundancy is needed to cope with the copious stray tracks from muons which traversed the shielding. To reduce the number of amplifiers needed, the θ wires in the 4 chambers 1 and the 4 chambers 2 are connected in series.

The energy of the proton is measured by a mixture of range and pulse-height analyses in a sandwich of eight scintillators. The expected accuracy on p_p is ±10 MeV/c if the pulse height is measured to about ±15%. A fraction of the protons will interact in the scintillator, between 0% and 20% depending on energy, but these events should be recognized by the inconsistency of the dE/dx in the different layers.

The main modifications to the forward part of the present apparatus are: the magnet is brought closer to the DISC in order to increase the acceptance for decays, and the two streamer chambers are fed in serie by the same Blumlein.

1.2 Acceptance resolution and counting rate

The proposed backward detector will accept protons in $\Delta\phi = 0.72 \times 2\pi$, θ between 85° and 65°, and recoil proton momentum p_p between 260 MeV/c and 700 MeV/c (transfer t between 0.065 and 0.45). The mass resolution on the Y^* given by the missing-mass technique comes from three contributions:

- ± 10 MeV caused by a $\Delta p_{\Sigma}/p_{\Sigma} = \pm 2\%$;
- the effect of $\Delta p_{p} = \pm 10$ MeV/c ranges from 0 at the Jacobian peak to ± 23 MeV;
- the contribution from the error on θ varies between 40 and 45 MeV.

The over-all resolution is thus about ± 50 MeV.

We assume the following conditions:

- 17 Σ^-/burst at the entrance of the target corresponding to 30 Σ^-/burst at the DISC. We choose this reduced flux because of background problem in the scintillators.
- Three periods of data taking with 2×10^4 useful bursts/day and 12 useful days/period giving a total number of Σ^-'s at the target entrance: $N_{\Sigma} = 12 \times 10^6$.
- A target length of 40 cm.

Under these conditions the counting rates are given by:

$$N_{events} = 12 \text{ events}/\mu b \times \int_{0.065}^{0.45} Ae^{-bt}\, dt \cdot \varepsilon_F ,$$

where ε_F is the forward detector efficiency and the values of the integral are:

5.5×10^3 μb	for elastic scattering
150 μb	for $P_{1/2}$ production
100 μb	for $D_{3/2}$ production
170 μb	for $F_{5/2}$ production

The trigger will require the detection of a Σ by the DISC, the detection of a particle more than three times minimum ionizing in one of the layers of the sandwich, and some requirement made by a coincidence matrix on the MWPC to define a track as coming from the target and emitted at an angle between 65°-85°. If needed, anticoincidence counters could be used to reduce the number of triggers on multi-body events.

Simultaneously we could trigger on Ξ^- interactions in a less restrictive fashion since the Ξ's represent only about 1% of the Σ^-'s. It should be then possible to obtain about 1000 Ξ^- interactions.

About 300,000 pictures will be taken. From the MWPC and counter information it will be possible to calculate the missing mass off line and thus to reduce greatly the number of streamer chamber pictures to be measured.

The forward apparatus would measure the angles of the particles emitted in a cone of 17° half angle, and the momenta of the particles emitted in a solid angle of ±7.5° in the vertical plane and of ±12° in the horizontal plane.

The channels studied for the Y^* decays are nK^-, $\Lambda^0\pi^-$, $\Sigma^0\pi^-$, $\Lambda^0\pi^-\pi^0$, and $\Sigma^-\pi^+\pi^-$. The average forward acceptance for these decays is about 60% (multiplied by 2/3 when a $\Lambda^0 \to p\pi^-$ decay is required). The over-all Y^* mass resolution (backward detector + forward detector) is typically ±15 MeV/c^2 in the case of a 4C-fit and ±30 MeV/c^2 for a 1C-fit.

2. $\Xi^- \to n\pi^-$ DECAY

The present limit on the branching ratio for this $\Delta S = 2$ decay is 10^{-3}. By setting up two proportional wire chambers 2 m apart behind our magnet, we can select high transverse momentum events. The main contribution to the triggers is due to $\Sigma^- \to n\pi^-$ decays, in which the π^- has a maximum transverse momentum of 193 MeV/c to be compared to 303 MeV/c for $\Xi^- \to n\pi^-$. We expect less than 0.1 trigger per pulse. The neutron is observed in our present spark chamber detector. A kinematical analysis using the neutron direction and the π^- complete information should totally eliminate the background. The efficiency of the apparatus is about 17% and can easily be calibrated by scaling down the magnet current and running with Σ^-'s. This experiment can be run in parallel with the hadronic trigger, and we expect to set a limit of about 2×10^{-5} on the $\Xi^- \to n\pi^-$ branching ratio.

3. PRESENT STATUS

The data taking for the leptonic decays is proceeding as foreseen, and with the machine time available up to the shutdown we expect to collect about 120,000 pictures. The analysis is under way, and with the above-mentioned number of pictures we expect that 3000 to 4000 leptonic decays will constitute our final sample. To collect Σ^- events with the optimum

TOP VIEW OF THE HADRONIC APPARATUS

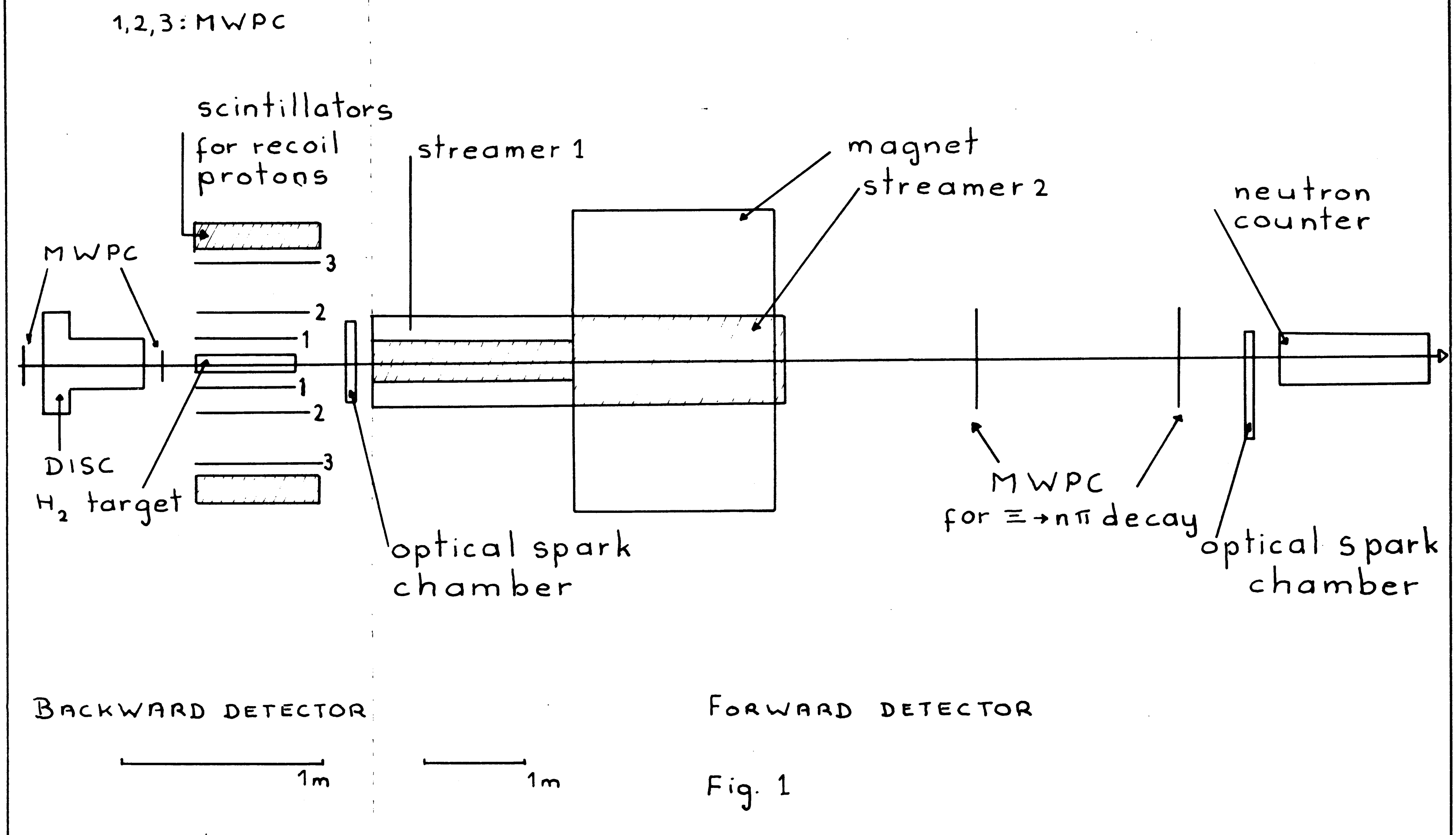

Fig. 1

efficiency, we have been working at 19 GeV/c, where the Σ^- counting rate is almost maximum and the pion flux in the beam is relatively low. This type of running leads to a loss of a factor of 2 in the maximum Ξ^- intensity obtained at 17 GeV/c. The unambiguous topology of the Ξ^- decays makes it possible to work with more particles in the beam.

4. MACHINE TIME REQUIREMENT

The hadronic apparatus cannot be ready for installation before the summer of 1973; we therefore ask approval to use the three periods (nine weeks) of the first half of 1973 to collect more data on Ξ^- leptonic decays (at 17 GeV/c), to investigate the Ω^- production rate and decays, and to set up and begin runs with the $\Xi^- \rightarrow n\pi^-$ detector.

We would install the apparatus around August 1973. The runs on hadronic interactions could start in the last period of 1973, with tests of the apparatus, giving the possibility of modifying the set-up and finishing the installation during the shutdown. We foresee a total time (setting up and data taking) of five periods for the hadronic experiment, and we request approval for this amount of running time.

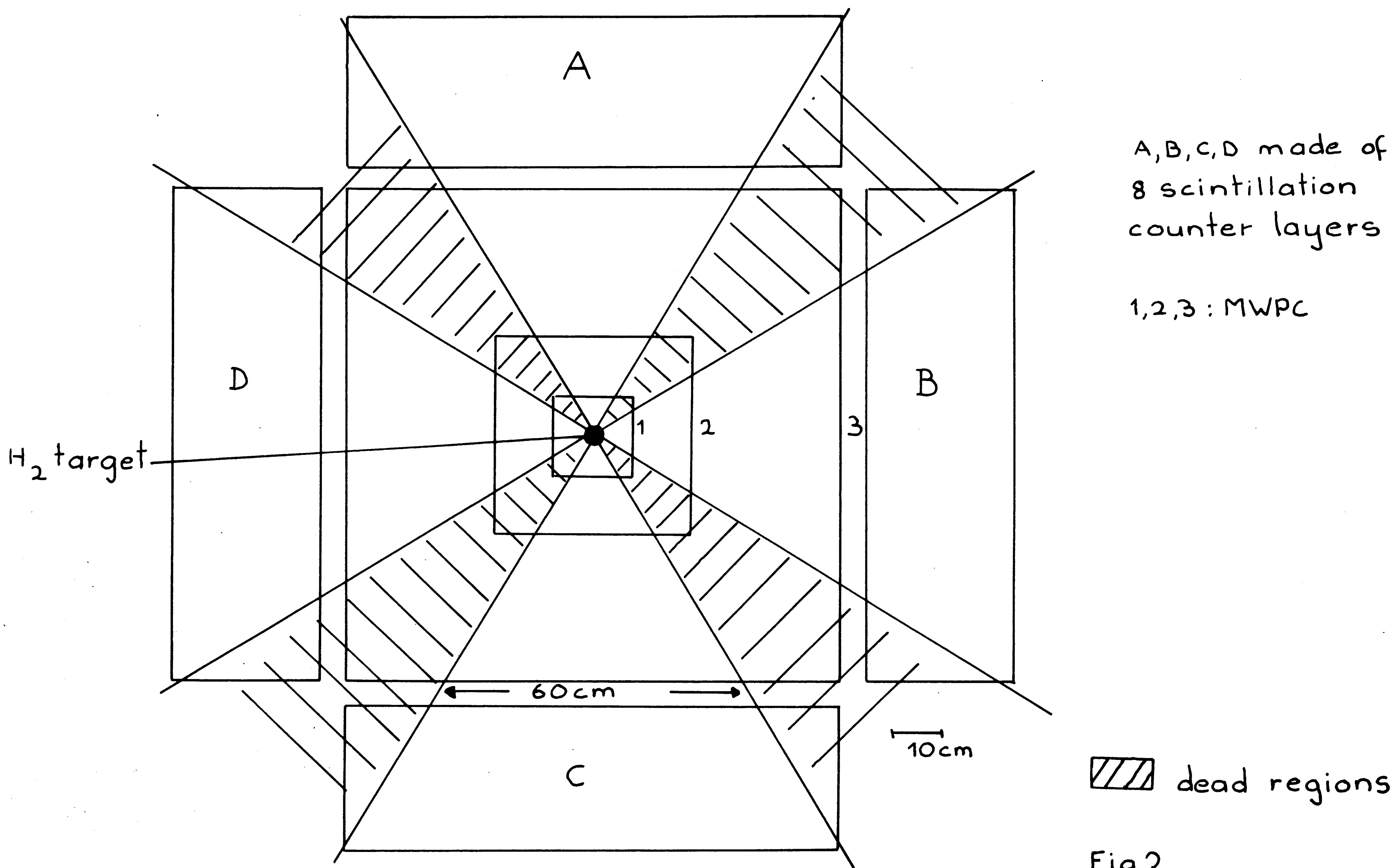

Fig.2

CROSS SECTION OF THE BACKWARD DETECTOR