Laboratori Nazionali di Frascati

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Report n. 9: ACTIVITY AT THE NATIONAL LABORATORIES OF FRASCATI. JULY 1, 1960 - DECEMBER 31, 1960.

COMITATO NAZIONALE PER L'ENERGIA NUCLEARE
(National Committee for Nuclear Energy)

LABORATORI NAZIONALI DI FRASCATI
National Laboratories of Frascati

Report n. 9

# ACTIVITY AT THE NATIONAL LABORATORIES OF FRASCATI

July 1 - 1960 - December 31 - 1960

Compiled by the Documentation Office of the National
Laboratories of Frascati of the CNEN
January 1961

## INTRODUCTION

This report N°. 9 will present the activity of the Frascati Laboratories from July to December 1960. This report, like the preceding one, has been divided into three chapters.

The first chapter is a brief synthesis of the electronsynchrotron' working and of the activities pursued to better it. The work concerning the storage ring's construction is also mentioned.

The second chapter briefly describes the activity of the National Laboratories of the Frascati Synchrotron. In reading the various paragraphs, one can plainly see that the laboratories not only solve the various problems connected with the functioning of the electronsynchrotron and with the experiments of high energy physics, but also study specific technological problems which, if not immediately applied, may help nuclear research in Frascati and in other Italian Centers in the future.

In the third chapter the authors give a brief synthesis on research done in conjunction with the electonsynchrotron.

During the last six months research activities, set up in the experimental area of the machine, have arisen from 10 to 14 and other experiments, which will soon be taken up by the laboratories, are being prepared at the various Universities.

We have thought it advisable to list the names of the people who are doing research and the ones responsible for the various technical services belonging to the Laboratories together with the sphere of interest of each, so as to help anybody interested in contacting the right person:

| | |
|---|---|
| Amman Ing. Fernando | Electronsynchrotron Laboratory |
| Bassetti Dr. Mario | Theoretical Group |
| Bernardini Dr. Carlo | Experimentalist, Theoretical Group |
| Bizzarri Dr. Ubaldo | Electronsynchrotron Laboratory |
| Bologna Dr. Gianfranco | Experimentalist, Magnetic Measurements |
| Caribbo Dr. Nicola | Theoretical Group |
| Cerchia Ing. Renato | Building Departement |
| Corazza Dr. Gianfranco | Technological Laboratory, Technical Director |
| Del Fabbro Dr. Raffaele | Electronsynchrotron Laboratory |
| Diambrini Dr. Giordano | Experimentalist, X-ray beam |

| | |
|---|---|
| Evangelisti Ing. Roberto | Experimentalist's magnets laboratory |
| Gatto Prof. Raoul | Theoretical Group |
| Ghigo Dr. Giorgio | Electronsynchrotron laboratory. Machine Director |
| Giannini Dr. Marcello | Electronsynchrotron Laboratory |
| Habel Dr. Roberto | Technological Laboratory |
| Infante Dr. Carlo | Electronic Laboratory |
| Ladu Prof. Mario | Dosimetry |
| Lupoli Mr. Attilio | Electronic Shop |
| Massarotti Dr. Antonio | Radiofrequency Laboratory |
| Modena Dr. Ivo | Criogenic Laboratory |
| Montelatici Dr. Vinicio | Criogenic Laboratory |
| Murtas Dr. Gianpaolo | Experimentalist, beam dosimetry |
| Pandarese Ing. Francesco | Electronic Laboratory |
| Pellegrini Dr. Claudio | Theoretical Group |
| Puglisi Ing. Mario | Radiofrequency Laboratory |
| Quercia Prof. I. Federico | Electronic Laboratory, Director |
| Querzoli Prof. Ruggero | Experimentalist, Electronsynchrotron Laboratory |
| Sacerdoti Ing. Giancarlo | Experimentalist's magnets laboratory, Magnetic Measurements |
| Sanna Dr. Giovanni | Experimentalist's magnets laboratory, Magnetic Measurements |
| Scaramuzzi Dr. Francesco | Criogenic Laboratory |
| Turrin Dr. Angelo | Computing Department, Theoretical Group |

Scholarship winners:

| | |
|---|---|
| Barbiellini Anidei Dr. Guido | Pair Spectrometer |
| Mencuccini Dr. Corrado | Polarization of recoil protons |
| Pesamosca Dr. Giancarlo | Computing Department |
| Putzolu Dr. Gianfranco | Theoretical Group |

On top of the activities of the Laboratories described in the chapters that follow, we would like to mention also the following:

a) Eight students who had prepared their thesis at our Laboratories took their degree at the University of Rome during 1960. The list of names follow.

b) At the present time 19 thesis for degree are being prepared at our Laboratories in Frascati, as listed below. These theses are mainly of students pertaining to the Rome University and the Laboratories of Frascati would be very happy to have students from other Universities as their guests.

c) Following agreements made with EURATOM through the CNEN, students from foreign Universities take a 3 months training period at EURATOM's expense at the Frascati Laboratories.

d) On December 16 and 17, 1960 a small congress for the discussion of present and future activities of the I.N.F.N. groups, both at Frascati and at the CERN, was held at Frascati. Foreign guests from Saclay and CERN also took part.

e) Between July and December 1960, 20 seminars have taken place in the small hall of the Laboratories as listed below.

List of students who have taken their degree in 1960 at the Rome University and who have prepared their theses for the degree at Frascati Laboratories.

Barbiellini Guido (Reporter Dr. G. Diambrini)

Production of electron pairs and bremsstrahlung from high energy primaries in single crystals.

Bitelli Giorgio (Dr. G. Ghigo)

Some detection methods of the electron beam in a 1000 MeV electronsynchrotron.

Letardi Tommaso (Prof. I.F. Quercia)

A scintillation counter.

Mencuccini Corrado (Prof. G. Salvini)

Polarization of recoil protons in $\pi^0$ photoproduction. The Monte Carlo method.

Petilli Maria (Dr. C. Bernardini)

Design of an experiment on the $\gamma$+ nucleus $\to$ nucleus $+ \mu^+ + \mu^-$ reaction.

Sano' Antonio (Prof. I.F. Quercia)

Memory circuits with magnetic cores.

Solimani Corrado (Prof. I.F. Quercia)

An analog computer for the phase equation in the Frascati Electronsynchrotron.

Terenzi Mario (Dr. G. Diambrini)

On the thick-target bhemsstrahlung spectrum of the Frascati Electronsynchrotron.

List of students who are preparing their degree and their thesis at the Frascati Laboratories (provisional titles).

Anselmi Luigi (Relator Dr. Turrin)

Programming numerical calculations of electrodynamic cross-sections.

Antonini Bruno (Dr. G. Diambrini)

Polarization of the $\gamma$ beam with crystals.

Bardotti Graziella (Dr. A. Turrin)

Setting up an "analysing magnet" memory on an IBM 1620.

Bovelli Maria Lavinia (Prof. G. Querzoli)

Proton polarization in $\pi$ meson photoproduction in H and D.

Bramucci Franco (Dr. A. Turrin)

Monte Carlo programming on an IBM 1620 & some simple application.

Breschi Roberta (Prof. M. Ladu)

Photographic dosimetry.

Cacciani Alessandro (Dr. G. Corazza)

A scintillation chamber.

Cagnetti Pietro (Dr. G. Ghigo)

Measurements on an electron-positron beam in a storage ring.

Calvelli Giulio (Dr. G. Ghigo)

Injection methods in a storage ring.

Catoni Francesco (Prof. G. Salvini)

On an integral detector for protons.

Corazza Maria Luisa (Prof. M. Ladu)

Ionization chamber for dosimetry.

Di Giugno Giuseppe (Prof. R. Querzoli)

Cross-section measurements using time-of-flight methods.

Guido Marcella (Prof. R. Cialdea)

Thermodynamic measurements of the energy of the $\gamma$ beam of the Frascati Electonsynchrotron.

Iosi Alessandra (Dr. C. Bernardini)

A new type of detector based on the Cerenkov effect.

Mango Lucilla (Dr. C. Bernardini)

Calculations on a pion-photoproduction experiment.

Mattiti Tito (Dr. A. Turrin)

Numerical solution of first and second order differential equations on an IBM 1620.

Palmieri Luciano (Prof. I.F. Quercia)

Design of equipment for cosmic radiation measurements on rockets.

Pelliccioni Maurizio (Prof. R. Querzoli)

10-chanel Analyzer using magnetic discriminators.

Rapisarda Vittorio (Prof. I.F. Quercia)

Transistor electronics.

List of seminars held at the Frascati Laboratories from 7/1/1960 to 12/31/1960.

Ing. Lisitano (7/14/60)

Diagnostic of micro-wave plasmas (polar method).

Ing. I. Morganti (7/15/60)

General principles on the use and characteristics of new electronic computers.

Dr. Infante (7/21/60)

Activity of the Electronic Laboratory.

Prof. G. Savini (10/13/60)

Spark chambers, their use at high energies.

Prof. I.F. Quercia (10/18/60)

Report on his recent trip to the U.S.

Dr. C. Infante - Prof. R. Querzoli (10/20/60)

Report on their recent trip to the U.S.

Prof. I.F. Quercia (10/26/60)

Continuation of the report on his recent trip to the U.S.

Prof. P. Franzini (10/27/60)

Activity of the bubble chamber group of the Columbia University.

Prof. G. Cortellessa (11/3/60)

Design of an experiment on the photoproduction of the $\omega^{o}$ meson.

Drs. Bassetti, Cabibbo (11/9/60)

Renormalization in perturbation theory (1st seminar).

Dr. Putzolu (11/16/60)
Radiative corrections to $e^{+} - e^{-}$ cross sections.

Dr. Putzolu (11/23/60)
Radiative corrections to $e^{+} - e^{-}$ reactions.

Prof. Amaldi (11/24/60)
Preparation of a $\pi^{+} - \pi^{-}$ beam and lifetime measurements.

Prof. Caianiello (11/28/60)
Thinking machines.

Prof. D.H. WILKINSON (12/1/60)
Three body forces.

Dr. Da Prato (12/5/60)
Peripherical collisions in high energy interactions.

Prof. E. Caianello (12/9/60)
Thinking machines (part II).

Dr. C. Bassetti (12/12/60)
Theoretical problems concerning K mesons' photoproduction.

Prof. J.D. Wire (12/15/60)
Experiments at Cornell on $\pi^{+} - \pi^{-}$ pairs with the Compton effect.

Dr. MONETI (12/22/60)
Description of the helium chamber & work program of the group.

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# CHAPTER I - ELECTRONSYNCHROTRON

## 1. OPERATION

During the second semester of 1960 the machine has worked regularly, except during the month of December in which a lesser intensity was noted. We are now working to bring the machine back to ist optimum characteristics. Figure I.1 shows the operation of the machine during 1960. All told, the machine has been used by experimenters for 5.500 hours (4.350 hours of effective beam); weekly average rose from 102 during the first semester to 106 for the last one.

*Resume of machine hours used during 1960*

| | Hrs | % |
|---|---|---|
| Experiments | 5,500 | 63.5 |
| Preparation of experiments | 1,200 | 14 |
| Machine tests and maintenance | 600 | 7 |
| Conditioning and putting into operation | 400 | 4 |
| Failures | 700 | 8 |
| Off-time for holidays | 300 | 3.5 |
| Totals | 8,700 | 100 |

Two off-periods were necessary during the first days of July and during the end of November, for about 150 total hours to change the doughnut in the western and northern quadrants due to loss of vacum for ageing of gaskets. The graph in fig. I.2 shows the hours that have been lost due to failures according to sources of failure.

Experiments "single crystals" and "annihilation" moved to beam 2 during the month of August. The helium bubble chamber is taking their place. Beam stopper on beam 4 has been moved back to make room for the storage ring (A. d. A.) and electronsynchrotron shielding on beam 2 has been modified to make place for the rome $\tau$ experiment.

All told, as shown in the floor map of fig. I.3, at the end of 1960, 11 experiments are set up in the experimental area: three more are being readied A.d.A., He bubble chamber, Rome $\tau$.

As part of the overall betterment of services, perfection of the new counting room should be underlined (80 racks) and the setting up of 2 cooling towers (1,500 kW.) that allow the closed circuit cooling of the synchrotron magnet and of the experimenter's magnets, thereby saving about 6 lt/sec. of water and 50 KWA. of electric power.

A new 250 kW converting unit is being set up, current-stabilized to 0.1%. The experimenters can therefore use:

2 *250 kW* converting units - *1000 A. ± 0.1%*
1 *600 kW* " " - *3000 A. ± 0.1%*
1 *400 kW* " " - *2000 A. ± 0.1%*

plus other small rotating power units of small capabilities for sweeping magnets, measurements, etc. with each with its cooling system. This has allowed simultaneous operation of various magnets and has reduced the time necessary to switch from one experiment to the next one.

A new hut of about 325 sq. m. with a 15 ton train has nearly been finished: This, together with other smaller buildings, will allow easier preparation of experiments using magnets, bubble chamber etc. A cement block, about 150 sq. m. in area, with a 5 ton train, near the synchrotron building has allowed the ultimate placement of spare shielding blocks to be made.

## 2. LABORATORY ACTIVITY

During this year, research on the machine have shown that saturation effects at 30 mA previously noted are not due to defects in injection optics. Therefore, the hypothesis now under test are that saturation is connected with space-charge effects, with ions produced in residual gases, or to interaction of the beam with the $RF_2$. Equipment, that will allow these tests to be carried out, is now being built. Maximum intensity of the machine is always of the order of $6 \times 10^{11}$ quanta per minute, although this limit has been slightly passed under special circumstances. It should be noted that maintenance problems increase with time and these limit rerearch activity quite strongly. On the other hand, continuous ex-

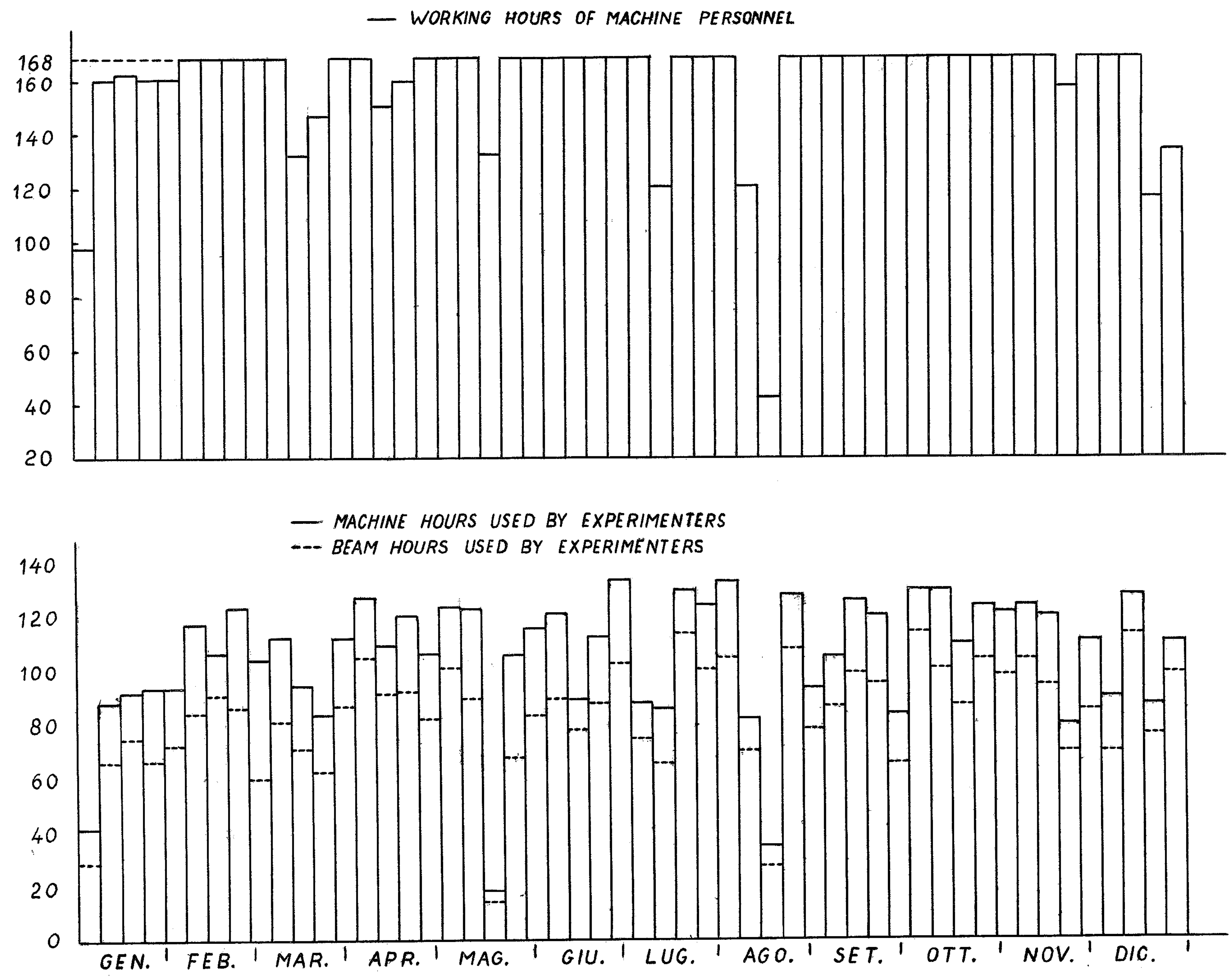


FIG. I.1 - MACHINE FUNCTIONING FROM JANUARY 1, 1960 TO JANUARY 1, 1961.

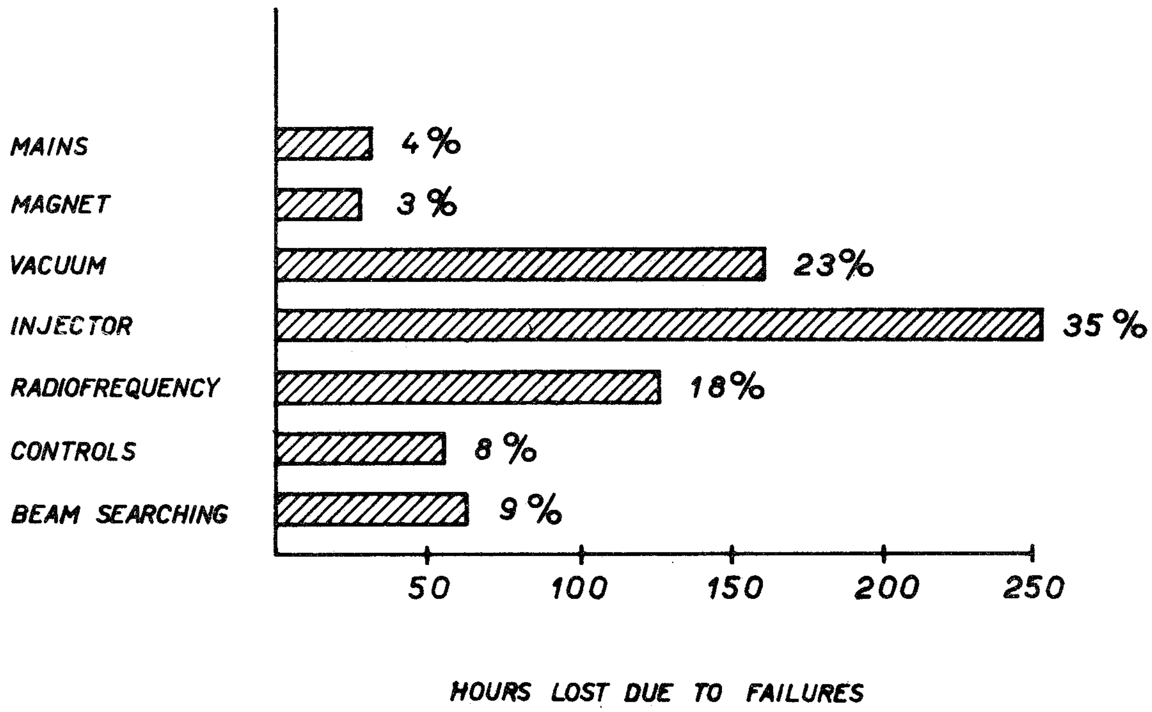


FIG. I.2

MACHINE FUNCTIONING FROM JAN. 4, 1960 TO JAN. 1, 1961 changes of information with other laboratories and the studies now underway on storage rings have increased the number of people interested in problems connected with accelerators so that it is quite probable that a better knowledge on the latter will be achieved.

As regards research carried out on the machine itself a pulsed chopper has been made and an R.F.chopper is being completed. As regards increasing the stability of the machine, the V.d.G. ripple correction circuits are being modified and a new electron source has been built: the latter will allow, among other things, the addition of shielding against low - energy radiation. As for A.d.A., the controls have been built and equipment suited to the detection of few-electron packets is being made. Other equipment to be used in storage rings, such as pulsed deflectors, is being built.

"Plasma guns" techniques have been developed both as sources of pulsed targets and for studying electronics based on highly ionized and dense plasmas as conduction means in vacuum. A fast switch based on this principle has already been made.

## 3. STORAGE RING (A. d. A.)

The storage ring [(1)] will be used to store electrons and positrons *250 MeV* in energy produced by the synchrotron's beam: this will be done alternatively, on two convertors placed diametrically opposite in the machines vacuum chamber.

Storing takes place in the gap of a magnet A.C. supplied at 14,000 gauss with weak focusing poles and an average gradient of 0.6.

A 10.000 volt R.F. cavity tuned to *147 Mc.*, second harmonic of the revolution period of the 2 beams of electrons and positrons, will supply the latter with the energy lost by radiation.

Vacuum inside the doughnut will be made by a titanium pump.

Design pressure in the vacuum chamber will be $10^{-10}$ *mm.Hg*.

Minimum pressure that has now been reached and with which the first tests will be made is $10^{-9}$ *mm.Hg*.

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(1) C. Bernardini, G. Corazza, G. Ghigo, B. Touschek: The Frascati storage ring: N. Cim. 18, 1293, 1960.

Stored beam lifetime, calculated for $10^{-9}$ *mm.Hg.*, should be about 25 hours.

In fig. I.4 an overall view of A.d.A. is seen. As can be seen on a side of the experimental section two pyrex windows have been placed: through the latter, light radiated by the electron and positron beams will be seen. The variation of the light's intensity will give us a quantitative indication of the number of stored electrons and prositrons. From present day calculations we predict that a minimum of 5 electrons per second may be accumulated without special care [(2)]. New injection methods that will allow the storage of a langer number of particles are now being studied.

The machine is in an advanced state of development.

The supporting tower of A.d.A. (see report n. 8, fig. I.4) has already been set up in the power supply area near the synchrotron, on the latter the magnet will be placed as soon as the magnetic measurements now under way have been finished.

The vacuum chamber, including *R.F.*, convertors and vacuum systems, is nearly finished.

All the electronic and electromechanical circuitry for the control of the machine are being tested.

The first storage tests will forseeably be started within Feb. 1961.

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(2) B. Touschek. A study of the mechanism of injection into a storage ring (internal report n. 57).

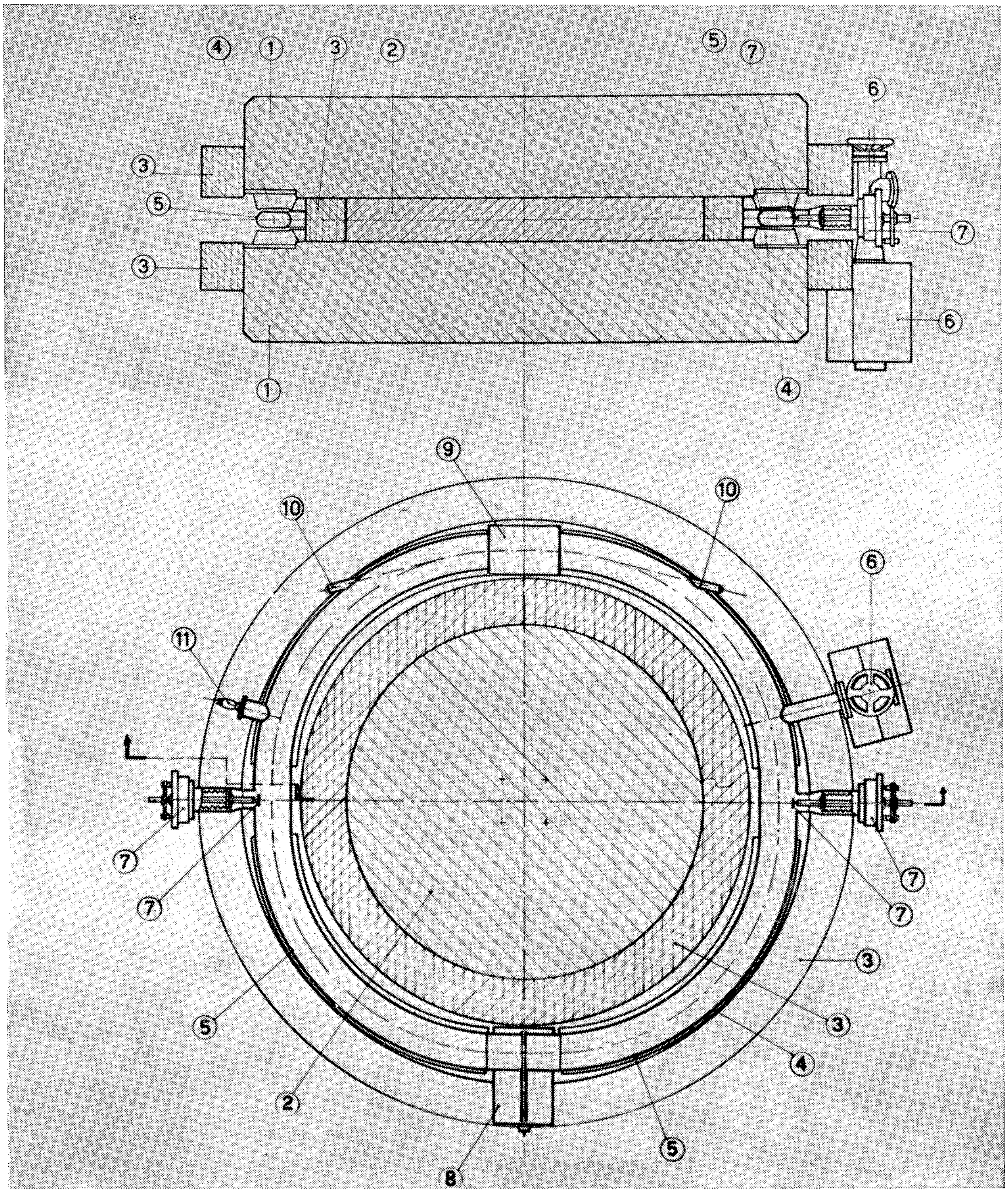


Fig. I. 4

Elevation and plan section of the Frascati Storage Ring (anello di accumulazione = AdA): 1) magnet yoke; 2) magnet core; 3) coils; 4) polepieces; 5) doughnut; 6) titanium pump; 7) injection ports; 8) RF cavity; 9) experimental section; 10 windows for the observation of the synchrotron radiation; 11) vacuum gauge.

## CHAPTER II - ACTIVITY OF THE LABORATORIES

### 1. CRIOGENIC LABORATORY

In the past semester activity at the criogenic laboratory has concentrated on:

a) *Liquefaction of gases*

About *900* litres of hydrogen have been liquefied, these were mostly used as targets at the synchrotron and to a smaller degree in a few diffusion experiments of the Cini - Ricci group of the University of Rome.

Furthermore, about *600* litres of liquid helium have been produced: this has been used in conjunction with the experiments made by the low temperature group of the Padova University, the low temperature group of the Genova University, the neutron defraction and spectrometry group of Ispra, the helium bubble chamber group of the University of Rome and by the low temperature group of Frascati.

Finally, about *25,000* litres of nitrogen and air have been liquefied, these have been used for auxiliary purposes (1).

b) *Assistants to guest groups*

A few experiments that require low temperatures have been made at Frascati by groups belonging to other universities or research centers.

In particular, the Cini-Ricci group of the University of Rome has just completed a series of experiments on the diffusion of *Ne*, *Ht*, and $He^4$ in liquid hydrogen.

Four tests with the helium bubble chamber of the University of Rome have been made: results have been satisfying and the chamber will be soon placed in the synchrotron $\gamma$ beam.

The neutron diffraction and spectrometry group of Ispra is making criogenic tests on a target for neutrons which will be used with the "Ispra I" reactor.

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(1) This is about 40% of the requirements of the laboratories.

Finally, agreements have been made with the solid State group of the Bologna and Perugia Universities for a number of experiments at liquid helium temperatures to be made during the first months of 1961.

c) *Design, building set up and maintenance of cold targets for the synchrotron*

Apart from the normal maintenance work, a new target type "WD" for hydrogen or deuterium (see fig. II.1).

We are now mounting two new cold targets for hydrogen or deuterium with a hydrogen reserve (see fig. II.2).

d) *Research*

A research group interested in low temperature physics (hydrodynamics of liquid helium II) has started activity; two preliminary experiments on ion mobility in rotating helium have been made.

e) *New equipment*

Due to the new requirements for helium and hydrogen, we have decided to buy a new liquefying machine. We have thought it worth while to buy a new machine capable of liquefying great quantities of hydrogen (*50 litres/hr.* of unconverted liquid) made by TBT (Greynoble) and to use the old Collins liquefying plant only for helium. Arrival of the TBT is expected to take place around May 1961; it will be placed in the "criogenic laboratory" building: this will require reasessments of the building and a certain number of auxiliary machines.

We are setting up a research laboratory for low temperature work (up to *0,3°K*) in the building (Southern laboratories I).

We have nearly finished a pipeline designed to recover helium; this will connect the "criogenic laboratory" building with the experimental area of the synchrotron; the pipeline is suspended and has a constant pressure tank at midway.

Erection of a building placed behind the synchrotron building has been completed; we shall place there a machine designed to recover deuterium and the constant pressure tank mentioned above.

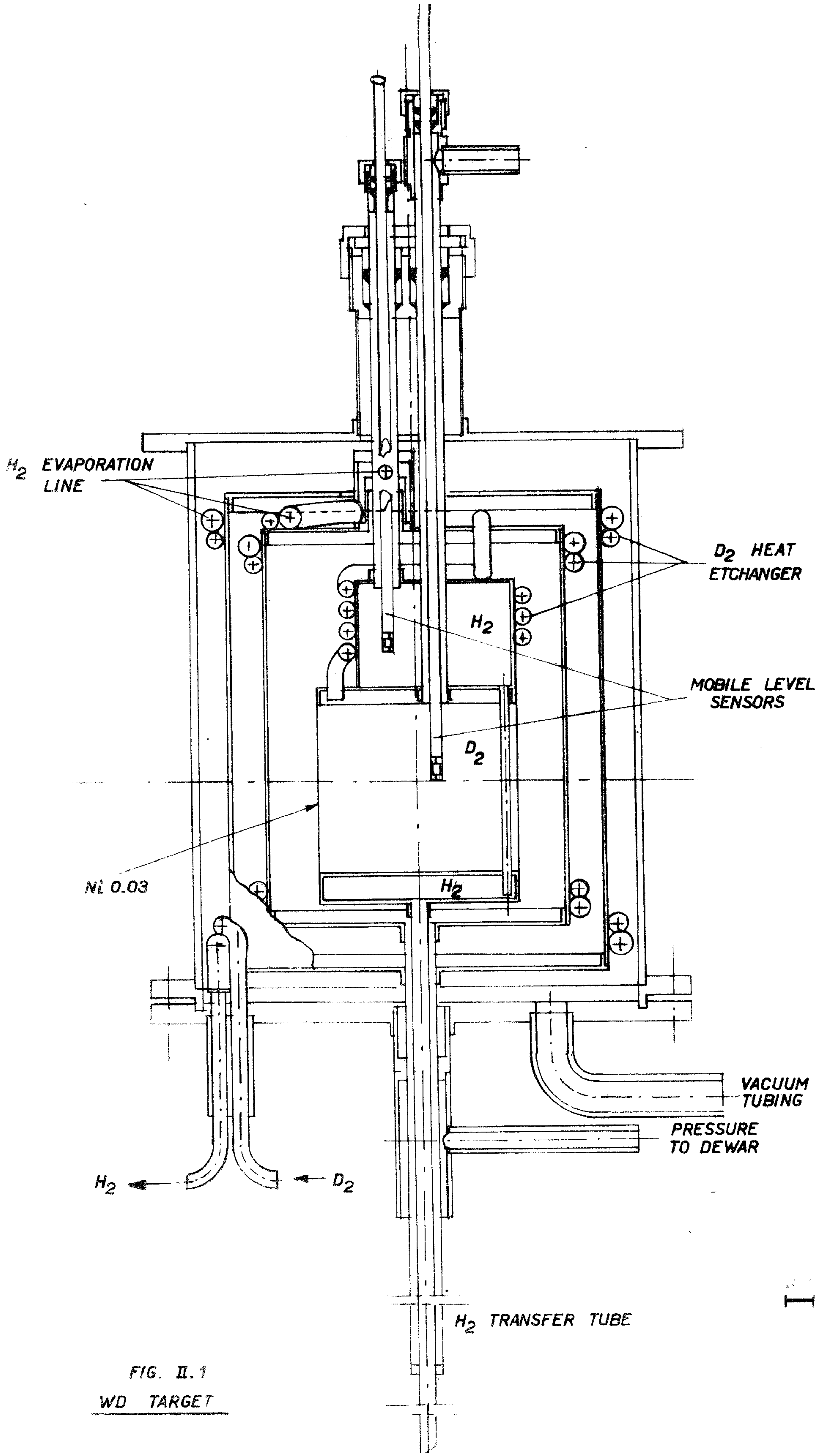


FIG. II.1
WD TARGET

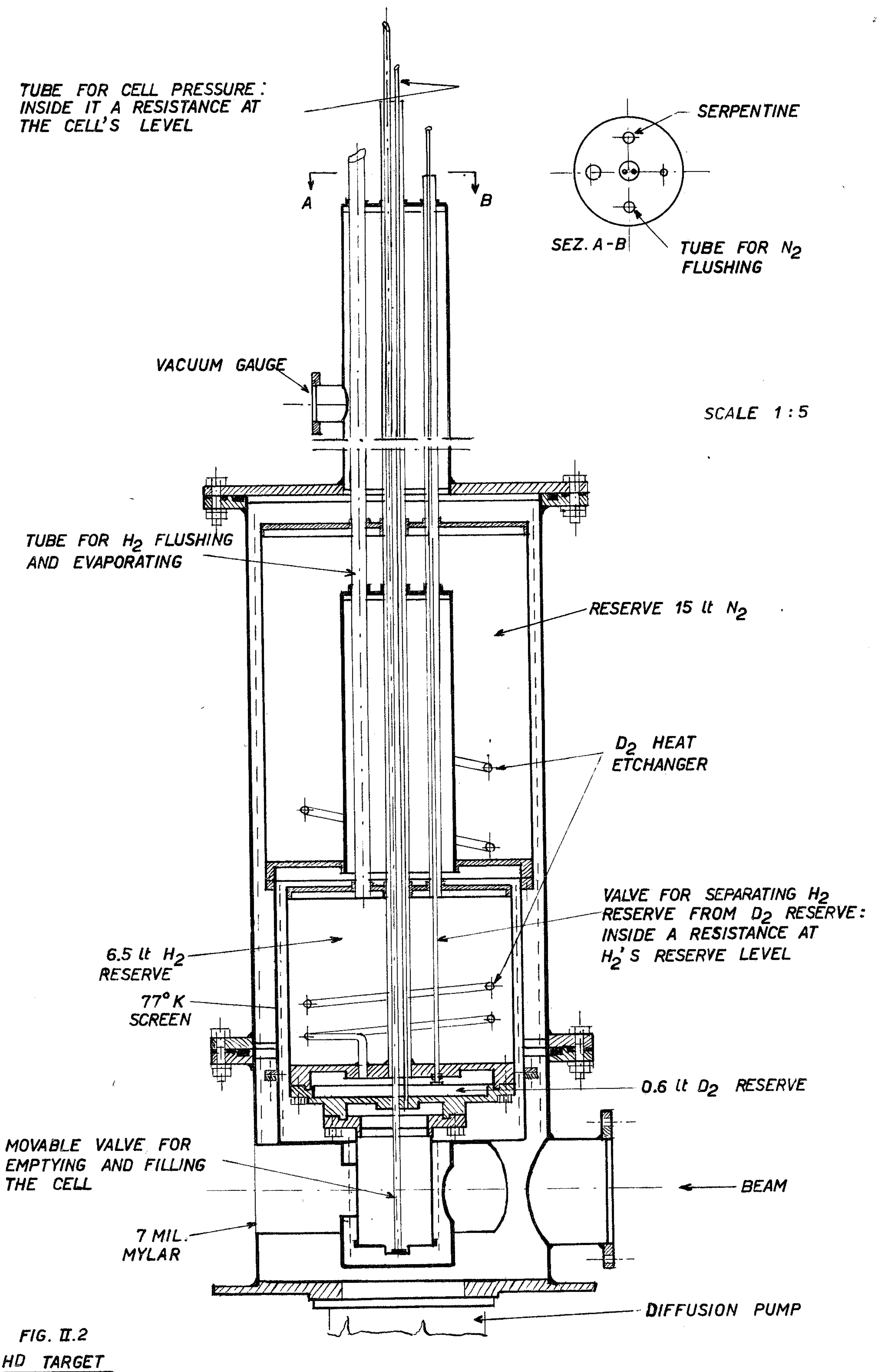


FIG. II.2

HD TARGET

## 2. "RAFELE" (Joint radiofrequency-electronic) LABORATORY

a) *Radiofrequency laboratory.*

Activity of the "Rafele" laboratory in the radiofrequency field from last June up to now has been the natural continuation of activities described in report n.8, with the addition of certain new trends. As regards work designed to improve the performance of the electronsynchrotron in this period, we can underline that the new *150 KW* $RF_2$ cavity is mechanically ready and is undergoing finishing touches. Shortly electrical tests both in air and under vacuum will start. A new limiter-amplifier has been finished and installed between $RF_1$ and $RF_2$. An amplifier has been designed and tested in the laboratory; the amplifier will take the place of the stages now being used in the *X-tal* pilot oscillator of the $RF_2$; this will enable a slight increase in output power and improved modulation characteristics for the whole $RF_2$. Finally we are studying a constant-temperature version of the phase discriminator for the automatic tuning of the $RF_2$. As regards other activities not directly connected with the machine, the radiofrequency system for the storage ring is being completed. In particular, the *147 Mc-2.5 KW* oscillator has been tested both with a resistive load and with a model cavity; the oscillator is now being completed. As regards the cavity we are continuing tests on a semi definitive model, above all we are testing the cooling system; this turns out to be quite critical, due to the small volume of the cavity; we are also studying an automatic tuning system. We have started laboratory tests on the resonance-discharge which was mentioned in the preceding report.

b) *Electronic laboratory*

Work of the electronic laboratory of devoted mainly to studying and building fast circuitry used in nuclear experiments at high energy; circuitry is mainly solid-state. In particular, the laboratory's attention has been focused on the new active element known as the tunnel diode. Due to procurement difficulties, work done up to now has been mainly theoretical: a very simple empirical formula has been found approximating the tunnel diodes characteristics; this will allow the study of the diodes' behaviour as a circuit element. Furthermore, it will allow evaluating the influence of diode and circuit parameters on the circuit's characteristics.

Experimental evidence has been gathered, indicating the possibility of making fast coincidences with resolving times of the order of a few nanoseconds (with pulsers), discriminators and scalers with dead times of the order of 20 nanoseconds or less.

On the problem of multi-channel analysers we are finishing a prototype of a fast (about 3 $\mu sec$) 20 - channel analyser in which decoting is made by successive reflections in a delay line (PHALCO). The first version of the analyser was built using vacuum tubes and in this form we presented it at the Berkeley Congress on nuclear instrumentation held in September 1960. We have started transistorising fast amplitude discriminator circuits.

### 3. ELECTRONIC SHOP

The electronic shop, apart from its normal work related to the design, construction and maintenance of electronic circuitry for the various experimental groups of the Laboratories, and from the research and testing of new components, has studied and completed a plan to better coaxial connectors of the IC 125, IC 197 series; furthermore, in collaboration with the Electronsynchrotron group, the Shop has set up experiments in the new counting area.

Furthermore, the electronic shop, on the basis of studies made during the preceding semester, has completed the setup of the photographic laboratory and of the printed circuit laboratory.

The photographic laboratory, setup mainly for preparing photographic plates for printed circuits, is now able to prepare reductions of electronic or mechanical designs on slides or transparencies.

The printed circuits laboratory, after tests on the new machines and on various plastic sheets (mono-and be-plated) has been brought to an excellent degree of efficiency in building small series of finished printed circuits.

The efficiency of the laboratory can be proved by the assembly of the printed circuits done so far: decimal scalers and transistorised discriminators for the laboratories, binary scalers for the Spatial Research Laboratory of the CNR and low voltage power supplies for the Electronic Laboratory of the Nuclear Studies Center of the Casaccia.

We are preparing other printed circuits for the Spatial Research Laboratory and the Electronic Laboratory mentioned above.

We are keeping up to date and studying new photographic techniques and new materials consulting all the Eastman Kodak bibliography and the data of other firms, both foreign and national, that we have written for.

All this theoretical activity will be condensed shortly in a report on the activity of the printed circuit laboratory; the report will contain the working sequence now in use and an instruction manual for the new processors and tolerances.

## 4. EXPERIMENTALIST'S MAGNET'S LABORATORY

The group has continued development of work already begun (see report n. 8) and new activities have been started.

In particular, studies on pulsed magnets have been continued and calculations and construction possibilities on an explosive pulsed magnet have been developed; the latter has been proposed by Dr. Quercigh of Milan. We have been in contact with German technicians of the Max Plank Inst. (Dr. Bergmann) and of the A.E.G. (Dr. Mayer).

Amongst other research activites we will cite the completion of the optics of the magnetic channel for the Roma $\tau$ experiment, based on the results obtained from the check of the theory with the measurements made. This work may be thought of as finished.

Finally we will cite the research done on a system designed to capture particles by means of rotating magnetic fields (1).

Design activity has focused on the following:

1) A strong focusing analysing magnet has been redesigned completely on the basis of results obtained from measurements made on a model (see report n. 8). This magnet, that will weigh 16 tons, has been completed with the design of the vacuum chamber so as to calibrate it with $\alpha$ particles.
2) Design of 2 quadrupolar lenses for the Trieste University, about

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(1) See internal report n. 58.

*1 ton* in weight each. The support for the above quadrupoles has been designed as well.

3) Design of a support with various degrees of freedom for the *4 ton-20,000 gauss* magnet which was discussed at point c) of the preceding report.
4) Design of a support for the two large quadrupoles of the Bologna University (see report n. 8).
5) Design of other magnets and of smaller equipment: a small scale model of a quadrupole, an electron source for testing the same; in cooperation with the "Rafele" Laboratory a cavity has been designed so as to carry out preliminary tests of the particle container, a rough design of an elicoidal quadrupole has been made and various small magnets have been designed for the Technological Laboratory; the support of a magnet and of the vacuum chamber for the Rome $\tau$ experiment have also been completed.

As regards building activity:

1) Building has been started of coils for a conventional pulsed magnet.
2) The coils of the analyzing magnet of the strong-focussing type have been made: we are now assemblying them on the magnet.
3) The coil of the storage ring has been built and is now being place on iron.
4) We are completing the building of the magnetic channel for neutrons.
5) We are finishing the Bologna quadrupoles that have already been tested from the electric and mechanical standpoint.

As for measurements we have been mainly concerned with the magnetic calibration of the channel for polarized neutrons of the CNEN, with magnetic measurements on a model of the strong-focussing analyzer magnet, of a control center to check maximum temperature measuring the reverse current of germanium diodes, placed on the above analyzing magnet; a peaker magnet meter has also been built.

An other Dicke fluxmeter has also been built.

## 5. TECHNOLOGICAL LABORATORY

During the last months of 1960 two doughnut quadrants have been changed on the electronsynchrotron. This change was made necessary due to loss of vacuum in some gaskets. Loss of vacuum was due to neoprene polimerization after more than a year and a half of exposal to radiation diffused by the electron beam.

Recently on the straight section (experiments) the liguid air vacuum pump has been changed with a new refrigirated one at $-70°C$. If results will be satisfactory then the process will be installed in place of the other vacuum pumps wits great saving and increased reliability of the synchrotron vacuum system.

Durign September a prototype of a d.c. amplifier for ionization chambers has been developed for measuring pressures in the $10^{-2} \div 10^{-12}$ *mm Hg* range. The instrument, built in cooperation with the Electronic Division of the C.N.E.N., has been used for some months at our Laboratories with satisfying results up to now.

Again in cooperation with the electronic division a radiofrequency spectrometer has been built, with the intent of using it as a helium vacuum loss searching unit. The instrument is already working in the laboratory; and we are now making measurements on it and modifying it so as to reduce the noise and so as to raise its sensitivity and resolving power.

A titanium pump (*70 liters* per *second*) has been built and tested: the pump works on the same principle of the Philips vacuum meters and it will be installed on the storage ring's doughnut.

The maximum vacuum reached with this pump has been about $10^{-9}$ *mm. Hg* measured with an Albert-type vacuum meter, after degassing for about *48* hours at *400°C*. We are now finishing A.d.A.'s doughnut, that will be finished within January 1961.

Half of the doughnut has already been installed and on it we have made definitive vacuum tests.

Minimum pressure that we have reached was about $2 \times 10^{-9}$ *mm Hg* after degassing for *48* hours at *400°C*.

We are now getting ready to degas the pump and the half doughnut for more than *48* hours to see if we can reach pressure below $10^{-9}$ *mm Hg*.

Since a few months we have started studying the possibility of using image converters and intensifiers together with high-energy particle detectors.

Since commercially availabe image intensifiers are not designed for our particular needs, we have started studying a special image intensifier as has been done in other Laboratories.

We are now defining the design of a single stage image converter, with magnetic focussing, that will be used in the design of a future multistage intensifier.

This will be used mainly in learning the experimental techniques connected with this type of work (production of fluorescent screens, photoemissive surfaces, etc.).

The rough design of the optics of a single stage tube has been studied in an electrolytic tank on a 5:1 model. We have also begun tests so as to make fluorescent screens.

## 6. COMPUTING DEPARTMENT

a) *Past activity*

Since July 1st we have done the following:

1) The theoretical group has made a program for calculating the differential and total cross sections of the following reactions:

$$\bar{\nu} + p \rightarrow n + e^{+}$$

$$\nu + p \rightarrow p + e^{-}$$

2) A program has been made for completing orbits at injection of A.d.A. with a static non-linear magnetic field.
3) For the beam-calibration group a computation of the bremsstrahlung spectrum from a thick target has been computed; paying special attention to the high side of the spectrum. Results are in good agreement with experimental data.
4) The asymmetry coefficient between electrons and positrons deriving from high energy secondary comptons and produced by photons in a thick target, have been computed.
5) Electron "histories" during the slow capture in the electron-synchrotron have been computed, for various rise times of the *RF I* peak voltage.
6) Counter efficiency for the $\mu$-pairs experiment has been computed following muon scattering in the different counting materials, using Monte Carlo methods.
7) Angular distribution of electron pairs produced by a beam of

polarized photons has been computed.

8) A computation on electron capture in A. d. A. by a radio-frequency electric field, of suitable radial-azimouthal form, has been made.

9) We are finishing computing the angular distribution of bremsstrahlung in a silicon single crystal.

b) *General considerations for the immediate future.*

The computer that the computing department will employ beginning from June 1961, will be an IBM 1620 basic unit. Memory capacity 20,000 random access bits, made of ferrite chores. Transistorised and printed circuitry.

After setting up the 1620 in the department, a very short transient will be experienced: The steady state of the computations to be made will be reached right after the arrival of the machine, since the department will consist already of a sufficient number of people familiar with the machine and of a certain number of programs that have been already tested and used, that are interesting to these Laboratories. Furthermore, within January 15, 1961, a computer of this type will be placed in IBM's Rome branch and the Department will be able to use it since then.

We are already writing programs of use to the laboratory. Three students are working on the following theses:

1) Random number generator on an IBM 1620.
2) Numerical solution of second order differential equations on an IBM 1620.
3) Setting up an "analysing magnet" memory on an IBM 1620.

When the memory unit of the 1620 will prove to be insufficient in the solution of some specific problem, we shall use CNEN's IBM 704, that should start operating in Bologna in January 1961. The latter computer is equipped with 6 magnetic tape units (900,000 words per tape) as a complement to the fast memory unit which has a total capacity of 32,768 words.

With this in mind a fourth thesis has been assigned: numerical computations of electrodynamic cross sections by means of the traces of products of Dirac gamma matrices with up to 10 factors.

## 7. THEORETICAL GROUP

The theoretical group, that has been recently set up, has already completed a certain number of investigations and is now completing others.

The group has been particularly interested in the bremsstrahlung problem and in the production of pairs in crystals; specifically, we have studied the limits of validity of the approximations made by Schiff in computing coherence effects. This investigation was started due to the poor agreement between experimental results in Frascati and the theory proposed by Schiff modfying older results by Überall.

The problem of polarization of $\mu$ mesons produced in pairs by the $\gamma$ ray beam of the electronsynchrotron has been investigated in cooperation with Dr. Erdas of the University of Cagliari: we have discovered noticeable correlation effects in polarization in experimentally reachable ranges at Frascati.

Long range research programs for research in high energy physics have been the subject of an intense study. Amongst other, a set of original theoretical studies has been made in the field of possible experiments with colliding beams of electrons and protons. Computations of radiative corrections to processes originated by electrons and protons have been made. A few new important reactions have also been studied by the group, who has also shown interest to difficulties involving the existence of form factors. A research on form factors of $K$ mesons has been made in cooperation with dr. Salin, of Bordeaux University, with promising results.

In conjunction with week-interaction physics we have studied the possibility of producing eventual vectorial mesons in Frascati. Detailed and laborious computations on high energy processes started by neutrinos have been made and are about to be completed. We have also made some work on the $\Delta T = 1/2$ selection rule as regards $K$-decay, and, in cooperation with Ferrari of Rome, a research on the rare modes on decay of the $K$.

This group in an article on Physical ReviewLetters has made a proposal of special interest of a selection rule that would prohibit muon → electron transitions: this proposal was later reported at Rochester.

The group has also been interested in strong interactions:

in cooperation with CERN physicists we are completing a computation on certain strong processes with three particles in the final state. In cooperation with Prof. Ross of the University of Indiana, now visiting Rome, we are now working on a theory of $K$-nucleon processes based on the effective range approximation.

In connection with recent interest in general relativity, which has been also stimulated by experiments now under way in Frascati, we have been doing some work on this theory. A particular problem under study is the search for a satisfactory expression for the energy-momentum tensor of the total field.

## 8. DOSIMETRIC SERVICE

### a) *Health Physics Service*

The present arrangement of shielding structure around the machine may be thought of as definitive, since radiation level in free access zone, never passes the maximum allowed values established by I.C.R.P.

Control of radiation doses absorbed by personnel is done by means of photographic dosemeters; both $\gamma$ and neutrons are measured. We check a total of 125 persons of which:

50 every 15 days for gamma rays;

60 monthly for gamma rays;

15 simultaneously for gamma and for neutrons.

People who stay longer in the "synchrotron" building are the ones who are checked bi-weekly. Machine personnel is the only one to be checked against neutrons.

Absorbed doses are registered in personal data cards; the latter are kept in a special archive.

Average monthly dose per person checked during 1960 has almost never passed a fourth of the maximum allowable dose. These results have been reached also thanks to the rigorous obedience of safety rules; the latter disciplined access to the dangerous areas.

Measurements of radiation levels around the machine is done with Tracerlab EXCO and Jordan ionization chambers and with a Hurst recoil proton counter, apart from an equivalent tissue ionization chamber.

A bi-weekly check in the control and counting areas and in certain points of the synchrotron area is done using photographic dosemeters for $\gamma$ and neutrons.

The results are plotted on maps and are at the disposal of whoever might need to know the measurements made and the results obtained.

Further checks are made each time experimentalists require them and before allowing personnel to stay in areas where radiation levels might be higher than the maximum allowable doses.

In cooperation with the Biology group, mice have been exposed to the high energy beam to determine the lethal dose.

b) *Dosimetric Laboratory*

According to what was decided during reunions, gathered to set up the dosimetric laboratory in Frascati, the program of fast neutron spectrometry with nuclear emulsions has continued together with the study of ionization chambers.

Two students are working on the above program; one is working on neutron spectrometry around the synchrotron, while the other is studying ionization chamber for measuring high intensities under pulsed conditions.

With nuclear emulsions we have already determined the energy spectrum of neutrons in a point of the synchrotron area, while further measurements are under way.

We have already made measurements on the sensitivy of ionization chambers built in Frascati, (one using graphite, one perspex, one bakelite and two in araldite). We are now undertaking measurements to determine their effectiveness in a mixed field of $\gamma$-rays and neutrons.

Amongst programs for future activity, we are thinking of tritium dosimetry which will be used during some experiments that will be made at the Ionized Gases Laboratory, and of creating a small "hot" laboratory for preparing special radioactive sources.

## 9. TECHNICAL OFFICE

Since October 1960 the Technical Office has been reorganized so as to join activities regarding buildings (including traditional machinery regarding buildings) and electrical installations: each of these divisions is composed of a design, an assembly, and a maintenance section.

We will not describe activity at the technical office during the July-December 1960 semester, referring to the map of fig. II.3, and maintaining the same notation as in the last report for the older buildings.

The first lot of the ionized gases building (n. 13 on the map) has been punctually finished on June 30, 1960 and the group started moving in on July 12; moving was completed within July 20, 1960.

For the same Ionized Gases Laboratory, on July 10, 1960, after the approval of the design carried out in Frascati, constructionn of a western enlargement wing (25) started: since December 1st a study plan has been available, while completion of plans for the vacuum laboratory and for the photographic laboratory will take place within January 15, 1961. During the first semester of the Laboratory's activity, various temporary modifications and installations have been made at the request of the Direction, both in the walls and in the electrical and water plants; all the designs for the office building have been defined, and construction will begin in the next days (26).

To conclude the activity of the Office as regards the Ionized Gases Laboratory, we will add that the following has been built; an electric station for transforming electric current from high to low voltages (N. 27); a liquid gas distribution center, (N. 28) a building for carpentier and painting work (N. 30), a hydrogen and oxygen distribution center (N. 29), and a depot for storing gas containers. (N. 31).

The counting area in the Synchrotron building is completed and working by now, together with ist accessories; similarly for the enlargement of the criogenic laboratory, for the enlargement of the Southern Laboratories N. 1; the construction of two nearby huts can be considered finished excepting the set-up of two cranes that will be done during the next month of January; thae buildings cover an area of 630 sq.m. on a single story, with a free height of 6.50 meters. These huts will serve to house certain experimental group temporarily, as depots for magnets and materials for the electronsynchrotron, for tests on magnets and preparations of experiments. To make these activities possible, we are getting some prefabbricated walls ready, while power to the magnets is generated by existing converter units, and reaches the huts through an underground transitable connection.

The "RAFELE" building is being completed (16): it will house the electronic and Radiofrequency groups, technological laboratory, the direction and secretary offices, and guest groups from the Universities. We foresee completion of the building within November 1961.

The construction of a small building with a single story (N. 32), that the dosimetric service needs to calibrate its sources, has begun.

A steel cabin has been built in the immediate vicinity of the synchrotron building: the cabin is covered in eternit and will be used to house the controls of the water station of the synchrotron and of various magnets: in it the circulation pumps will also be placed (N. 33).

In the square (N. 17) a crane has been installed useful in moving shielding blocks: this crane will also be useful in handling heavy equipment that keeps reaching the Laboratories.

Continued assistance and control of all general installations execution of general services and taking care of the covered areas, maintenance of buildings, retouches and small modifications, conclude the activity of the Technical Office.

## 10. DOCUMENTATION OFFICE

To complete what was written in preceding reports, during the second semester of 1960, the library has had an increase of about 500 volumes and about 700 external reports (microfilms and photocopies included). For the coming year we have renewed past subscriptions and 25 new magazines have been requested. Amongst others two Encyclopedias have been bought: the italian Enciclopedia Treccani and the Encyclopediac Dictionary of Phisics. With these additions the library now stans at:
2.400 books, 5.100 external reports and 110 subscriptions to italian and foreign magazines.

During the month of December the documentation office has contributed in organizing the "Congressino di Frascati" (with secretarial functions).

1 - DOOR-KEEPER'S LODGING
2 - BIOLOGYE LABORATORY
3 - STORE AND CARPENTER'S SHOP
4 - WATER TANK
5 - OFFICES AND LABORATORIES
6 - MECHANICAL SHOP
7 - SYNCHROTRON
8 - INDUCTOR
9 - CRIOGENIC LABORATORY
10 - DEWARS AND GAS TANKS DEPOT
11 - POWER STATION
12 - SOUTHERN LABORATORIES n° 1
13 - IONIZED GASSES LABORATORIES (I.G.)
14 - SOUTHERN LABORATORIES n° 2
15 - MESS-SEJOURN
16 - ELECTRONICS LABORATORIES
17 - CONCRETE BLOCKS DEPOT
18 - REFRIGERATING COLUMNS
19 - DEUTERIUM TANKS AND COMPRESSOR
20 - IRON HUTS
21 - COUNTING AREA ENLARGEMENT
22 - DEPOT
23 - INFLAMMABLE MATERIAL DEPOT
24 - WELL
25 - WESTERN ENLARGEMENT I.G.
26 - OFFICE BUILDING I.G.
27 - ELECTRIC POWER STATION I.G.
28 - LIQUID GAS STATION I.G.
29 - $O_2$ AND $H_2$ STATION I.G.
30 - CARPENTERS AND PAINTERS I.G.
31 - GAS TANKS STORAGE I.G.
32 - DOSIMETRIC SERVICE
33 - SYNCHROTRON AND MAGNETS COOLING SYSTEM

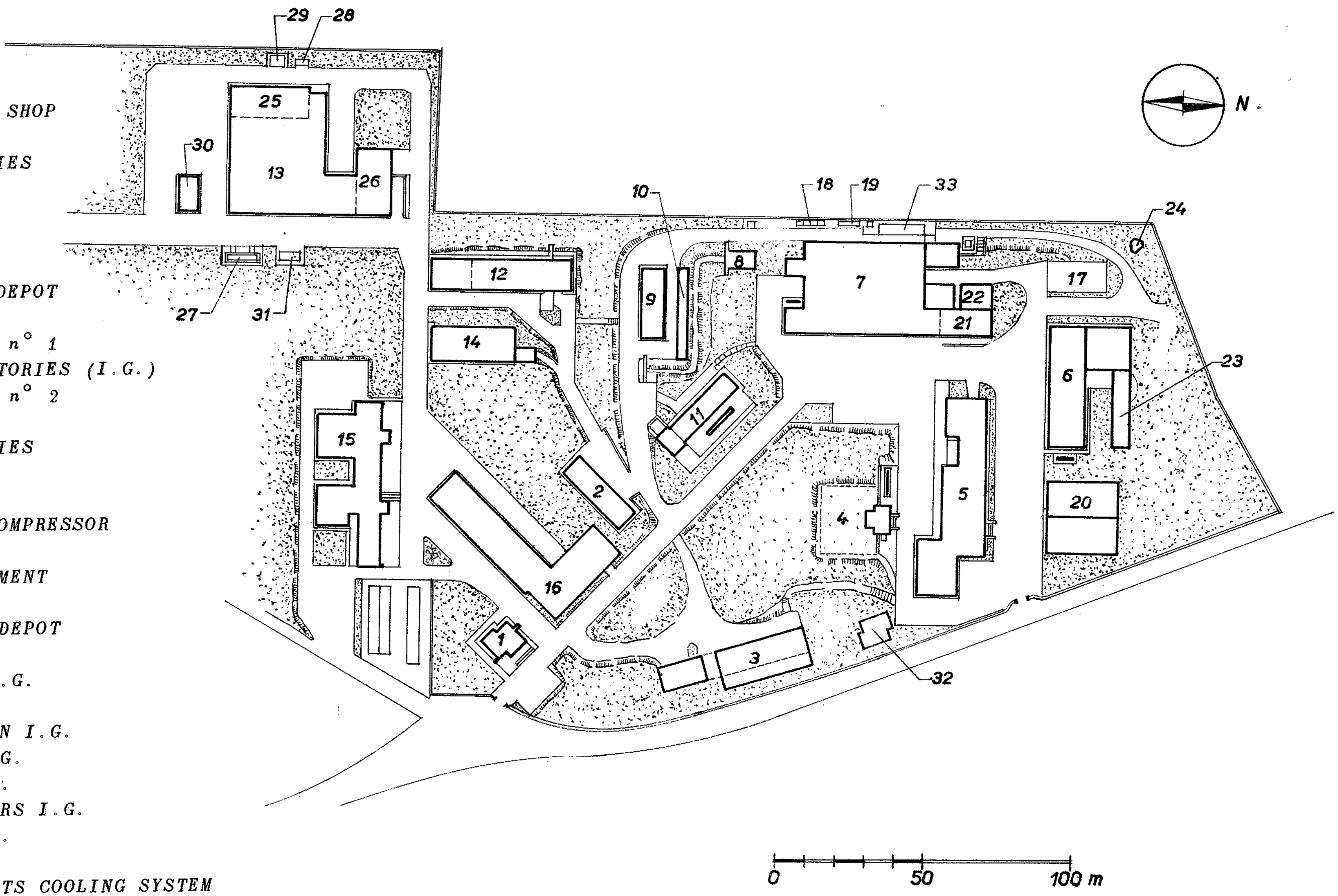


FIG. II.3 - LABORATORIES GENERAL LAYOUT OF

During the month of July, notes of Prof. Millman's course "Electronic circuits using transistors" have been pubblished with a circulation of 200 copies.

The following papers have been published, either as internal repots or on scientific magazines:

1) C. Pellegrini, Stoppini: Remarks on neutral pion photoproduction in the high energy region (Internal report 38).

2) Puglisi, Sacerdoti: Building and experimenting of the "rotatron" as an isotope separator. Experiment proposal (AS 10).

3) Smith: Magnetic field measurements on A.d.A. (I.R. 39).

4) Caribbo, Gatto: Simmetry between muon and electron (I.R. 40).

5) Sacerdoti, Pasotti: Technical news on pulsed magnets for high fields(I.R. 41).

6) Infante, U. Pellegrini: Review and evaluation of fast integral discriminator circuits (I.R. 42).

7) Habel, Quercia: Relation on a visit paid to Philips of Eindhoven on July 11, 1960 (I.R. 42).

8) Caribbo, Ferrari: Some rare decay modes of the $K$ meson (I.R. 44).

9) Barbiellini: Dislocations in the reticule of a silicon crystal exposed to the bremsstrahlung beam of the Frascati Synchrotron (I.R. 45).

10) Querzoli, Salvini, Silverman: The polarization of the recoil proton in the photoproduction of $\pi^{\circ}$ mesons from hydrogen (I.R. 46).

11) Caribbo, Gatto: Consistency of the $K^{+} \to \pi^{+} + \pi^{\circ} + \gamma$ rate with the $\Delta T = 1/2$ rule (I.R. 47).

12) Diambrini, Figuera, Rispoli, Serra: Bremsstrahlung spectrum of the *1,000 MeV* electronsynchrotron at Frascati (I.R. 48).

13) Infante, Quercia, Solimani: A fast 20 - channel pulse height analyser employing line coding (I.R. 49).

14) Querzoli, Salvini, Silverman: The polarization of the proton from the process $\gamma + p \to p + \pi^{\circ}$ in the region of the higher resonances (I.R. 50).

15) Bernardini: Effects of small linear damping terms on non-linear one-dimension motion (I.R. 52).

16) Amman: The *KS - 3 MeV* Van de Graaff injector of the Frascati

electronsynchrotron (I.R. 53).

17) Terenzi: Study of the bremsstrahlung spectrum of a thick target in the electronsynchrotron of Frascati (Thesis - I.R. 54).

18) Bernardini, Corazza, Ghigi, Touschek: The Frascati storage ring (I.R. 55).

19) Montelatici, Scaramuzzi: Report on the trip made to Saclay, Greynoble, and Geneva during the week from September 19 to 25, 1960 (V.S. 43).

20) Infante, Quercia: Report on their trip in the U.S. during September 1960 (V.S. 44).

21) Gildmeister, Giese: Preparation of fluorescent screens for image intensifiesers (translation from German - I.R. 56).

22) Touschek: A study of the mechanism of injection into a storage ring (I.R. 57).

23) Evangelisti, Sacerdoti: A method for capturing particles injected in a week-focusing storage ring (I.R. 58).

24) Massarotti, Turin: A method for preventing resonance discharges in a cavity by means of a steady magnetic field (I.R. 59).

25) Evangelisti, Quercig, Sacerdoti: Report on their trip to Germany in November 1960 (V.S. 45).

26) Sanò: Memory circuits using magnetic chores (Thesis - I.R. 60).

27) Putzolu: Radiative corrections to pion production in electron-positron collision (I.R. 61).

28) Ghigo: Preliminary discussions on A.d.A. (I.R. 62).

29) Massarotti, Sacerdoti: Design elements for a *12 GeV* proton-synchrotron (I.R. 63).

30) Caribbo, Gatto: Simmetry between muon and electron (Phys. Rev. Let.: 5, 114, 1960).

31) C. Pellegrini, Stoppini: Remarks on neutral pion photoproduction in the high energy region (Nuovo Cimento *17* 269, 1960).

32) Infante: Pulse height discriminator employing distributed amplification (Nucl. Instr.: *9*, 102, 1960).

33) Cabibbo, Ferrari: Some rare decay modes of the *K* meson (Nuovo Cimento: *18*, 928, 1960).

34) Cabibbo, Gatto: Consistency of the $K^+ \rightarrow \pi^+ + \pi^0 + \gamma$ rate with the

$\Delta T = 1/2$ rule (Phys. Rev. Let. *5*, 382, 1960).

35) Sacerdoti: Calculation of the equivalent circuit of a resonant cavity excited by a coupling coil (Alta Frequenza, *29*, 401, 1960).

36) Sacerdoti: A new magnetic container for charged particles: the rotatron (L'Elettrotecnica: *47*, 654, 1960).

37) Bernardini, Corazza, Ghigo, Touschek: The Frascati storage ring (Nuovo Cimento *18*, 1293, 1960).

38) Querzoli, Salvini, Silverman: The polarization of the proton from the process $\gamma + p \rightarrow \pi^0 + p$ in the region of the higher resonances (In course of publication on Il Nuovo Cimento).

39) Amman: The *KS-3* Van de Graaff injector of the Frascati Electronsynchrotron (In course of publication on Nuclear Instruments).

40) Diambrini, Figuera, Rispoli, Serrà: Bremsstrahlung spectrum of the *1,000 MeV* electronsynchrotron at Frascati (In course of pubblication on Il Nuovo Cimento).

## CHAPTER III - EXPERIMENTS UNDER WAY WITH THE ELECTRONSYNCHROTRON

*We now give a brief synopsis of the experiments under way at the Frascati Laboratories, written by the authors. Order of presentation, is the same as in the esperimental area, as in fig. 3 of Chap. I.*

### 1. EXPERIMENTS ON THE PHOTOPRODUCTION ON SINGLE MESONS IN HYDROGEN (Sanità)

**G. Cortellessa, A. Reale**
**Physics Laboratories - Istituto Superiore di Sanità, Roma**

With the experimental layout described in the preceding report, we have found experimental results relative to an angle of $57°$ and $90°$ in the center of mass, of the emission of the $\pi^{\circ}$ meson. Experimental data are given in tables 1 and 2, each relative to an angle in the center of mass.

TABLE 1

Measurements of differential cross sections at $57°$ in the C.M.

| $E_{\gamma}$ (MeV) | $\theta^{*}_{\pi^{\circ}}$ | $\left(\frac{d\sigma}{d\Omega}\right)^{*}_{\pi^{\circ}}$ ($\mu b$/ster) |
|---|---|---|
| 630 ± 30 | 56,0° ± 3,0° | 0.97 ± 0,22 |
| 650 ± 30 | 56,5° ± 2,7° | 1,33 ± 0,06 |
| 675 ± 30 | 56,7° ± 2,7° | 2,04 ± 0,12 |
| 700 ± 30 | 56,7° ± 2,7° | 1,72 ± 0,06 |
| 725 ± 30 | 57,2° ± 2,5° | 1,95 ± 0,09 |
| 750 ± 30 | 57,7° ± 2,5° | 1,40 ± 0,11 |
| 820 ± 30 | 56,5° ± 3,5° | 1,41 ± 0,11 |

The first column of these tables gives the average energy and the energy range of the incident photons accepted by the device; the second column gives the average angle in the C.M. and the angular aperture of the emission of the pion (in the C.M.); the last column gives the cross section in the C.M.

TABLE 2

Measurements of differential cross sections at *90°* in the C.M.

| $E_\gamma$ (MeV) | $\theta^*_{\pi^\circ}$ | $\left(\frac{d\sigma}{d\Omega}\right)^*_{\pi^\circ}$ ($\mu b/ster$) |
|---|---|---|
| 595 ± 20 | 90,5° ± 2,8° | 2,70 ± 0,19 |
| 635 ± 20 | 90,6° ± 2,6° | 2,24 ± 0,07 |
| 660 ± 20 | 90,7° ± 2,4° | 3,25 ± 0,20 |
| 675 ± 20 | 90,8° ± 2,3° | 3,60 ± 0,26 |
| 700 ± 20 | 90,7° ± 2,1° | 3,83 ± 0,11 |
| 720 ± 20 | 90,3° ± 2,0° | 3,00 ± 0,25 |
| 760 ± 20 | 90,2° ± 2,0° | 3,07 ± 0,13 |
| 800 ± 20 | 90,0° ± 2,0° | 3,31 ± 0,07 |

One can note, analysing the data on the tables, that both at *57°* and at *90°* in the C.M., the differential cross section shows a very narrow resonance, centered around an energy slightly below *700 MeV*. This experimental result changes the shape of the differential cross-section curve, as deduced by preceding measurements, quite substantially. This variation, that allows one to assign an energy to the second resonance coherent with data presently known on focal production and on scattering of charged $\pi$ mesons, is probably mainly due to bettered geometrical conditions under which the measurements have been made in comparision with experimental conditions chosen by preceding experimenters.

Further measurements are now under way both to extend them with the present device to other angles and to other energies, and to make measurements, with different equipment, also in other ranger of angular distribution that we could not easily reach with the present device.

## 2. PRELIMINARY MEASUREMENTS OF PROTONS COMPON EFFECT (Sanità)

**G. Cortellessa, A. Reale, P. Salvatori**
**Physics Laboratories - Istituto Superiore di Sanità, Roma**

During certain control measurements of the cinematic conditions under which the measurement of differential cross sections for single photoproduction of $\pi^0$ mesons on protons was being carried out, we thought of trying to look for Compton effect on protons. The geometry of the measurement is identical to the one described in the report n. 8 for the measurement of $\pi^0$ meson photoproduction; the only exception is that the position of the Cerenkov counter, that measures $\gamma$-rays in coincidence with a recoil proton, is now such as to detect all the gamma rays coming from an elastic diffusion. In other words, we have fixed the mutual positron of our counters, the slit before the Cerenkov counter and the cinematic conditions so as to maximize the ratio between the events we consider to be good (Compton effect) and the background ($\pi^0$ mesons). Under these conditions we have made some preliminary measurements, that is:

a) an excitation curve, varying synchrotron energy as slowly as possible,

b) a measurement of counting rates ratio when we measure recoil protons and associated $\gamma$ rays, that lie in a plane containing also the beam, and when instead the $\gamma$ ray leaves the plane determined by the synchrotron beam and by the direction of the recoil proton.

These measurements confirm that it is possible to separate Compton effect also under heavy $\pi^0$ meson background, in the high energy region, where no experimental information was to be had to date.

The value of the cross section that one may deduce from the measurements is in agreement with estimates obtained extrapolating data at lower energies.

### 3. SEARCHING FOR THE $\gamma + p \to p + \omega^\circ$ REACTION (Sanità)

K. Berkelman [1], G. Cortelessa, A. Reale
Physics Laboratories - Istituto Superiore di Sanità, Roma

In the past two months a research is going on tending to establish the possibility of evidence for the process $\gamma + p \to p + \omega^\circ$. The meson $\omega^\circ$ of probable mass *310 MeV*, should decay in a pair of charged $\pi$ mesons in a very short time.

The experimental device used in studying this process is very similar to the device we have already described in report n.8 and that we have used to measure differential cross section for $\pi^\circ$ meson photoproduction. The only variation is that we have substituted the counter telescope that measures the $\pi^\circ$ meson decay $\gamma$-rays, with a 2-counter telescope, that will allow the measurements of the charged decay products of the $\omega^\circ$ meson.

The measurement now under way consists in executing an excitation curve of coincidences between recoil protons of the reaction and of the charged mesons due both to normal double production and to the disintegration of the $\omega^\circ$ meson, if it exists.

The presence of the $\omega^\circ$ meson, produced in a 2-body process, would give a step that might be extracted from the background of normal double production, if the cross section of $\omega^\circ$ meson photoproduction is larger than a hundreth of the cross section for the photoproduction of 2-charged $\pi$ mesons.

Measurements made up to now are now being valuated numerically to establish a higher limit, under the present cinematical conditions for the cross section of photoproduction of the $\omega^\circ$ meson. We shall extend these measurements to different cinematical conditions.

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(1) University of Cornell, Ithaca, N.J.: Guest of the Physics Laboratories of the Istituto Superiore di Sanità, with a scholarship of the National Science Foundation.

## 4. AN EXPERIMENT ON BREMSSTRAHLUNG RADIATION PRODUCED BY *1000 MeV* ELECTRONS IN SILICON CRYSTAL (Single crystals)

G. Barbiellini, G. Bologna, G. Diambrini, G.P. Murtas
National Laboratories of Frascati

Measurements related to an experiment described in the preceding report have continued.

As announced, we have bettered the angular precision of the measurements substituting the crystal-rotating device, with a much better one, posessing a sensitivity of about $2\ 10^{-4}$ *rad*.

This has allowed us to detect a fine structure in bremsstrahlung intensity, that is not predicted by Überall's calculations: this is due to the fact that points of the inverse reticule in the first reticular plane must have a discrete distribution, and not a continuous one as stated by Überall. In figure III.1 some experimental results are given that show the fine structure of the bremsstrahlung intensity. The abscissa is the angle $\theta$ between the direction of the $\gamma$-rays and the cristalline axis [111] of the single crystal: the ordinate is the ratio

$$R_{sp} = \frac{N(\theta, K)}{N(\theta, K_0)} \cdot \frac{\sigma_p(K_0)}{\sigma_p(K)}$$

defined in report N. 8.

Bremsstrahlung intensity should show a dependence on the dihedron angle $\Phi$ formed by a reference plane with a plane defined by the above mentioned axis [111] and the direction of the electrons: this dependence should again be due to discontinuous distributions of crystalline points. This takes place also for $\theta = constant$, a fact again not taken into account by Überall.

In fig. III.2 we have shown the results of our measurements as a dependence of the number $N$ of symmetric pairs on $\Phi$ for an angle $\theta = 20\ m\,rad$ and for a photon energy $K = 233\ MeV$; the above mentioned dependence on $\Phi$ is clearly seen.

Also the bremsstrahlung spectrum measured for a certain value of $\Phi$ and of $\theta$ should show a discontinuity for a certain value of photon energy. Measurements made to verify this have shown this effect.

We are now elaborating all the measurements we have made and

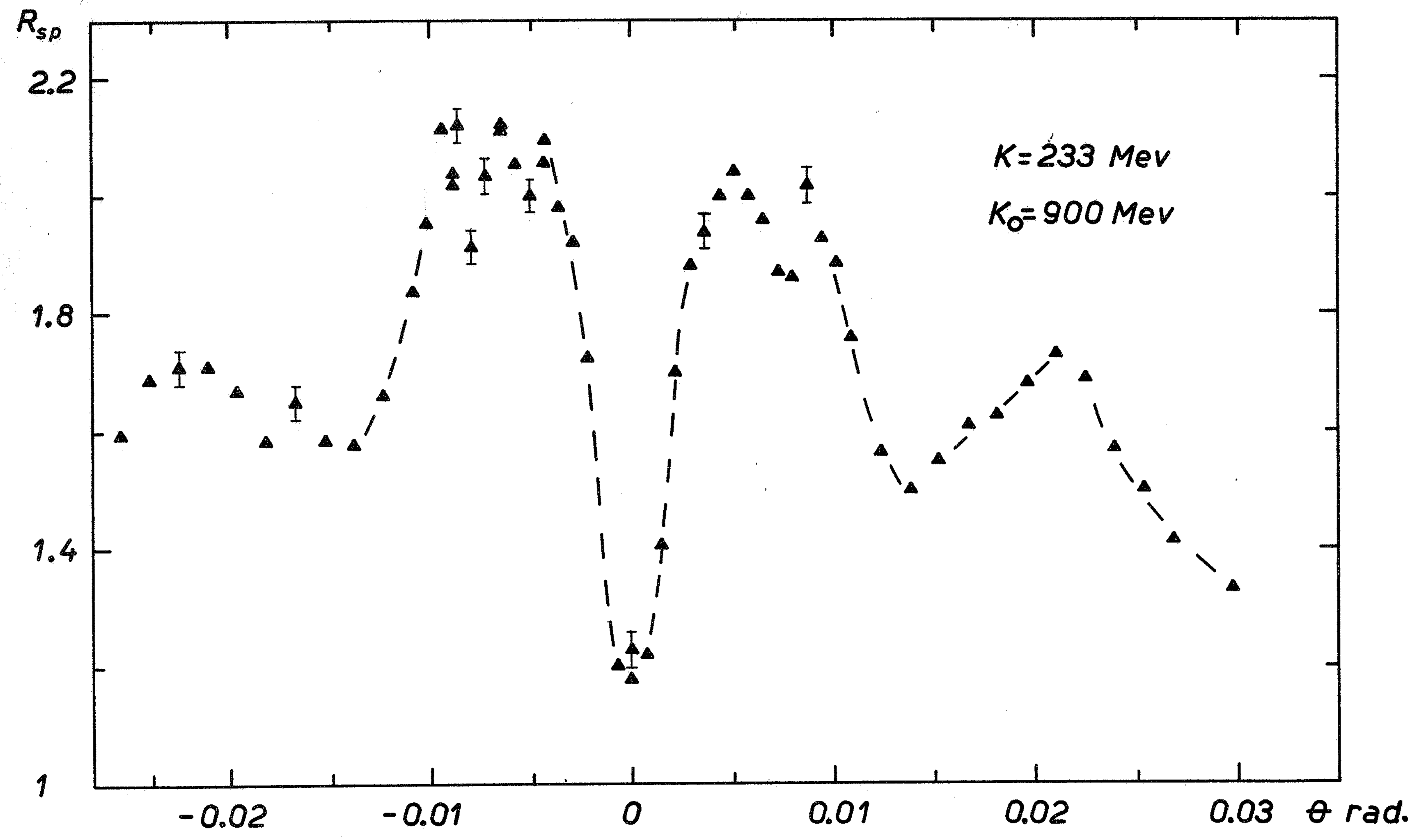
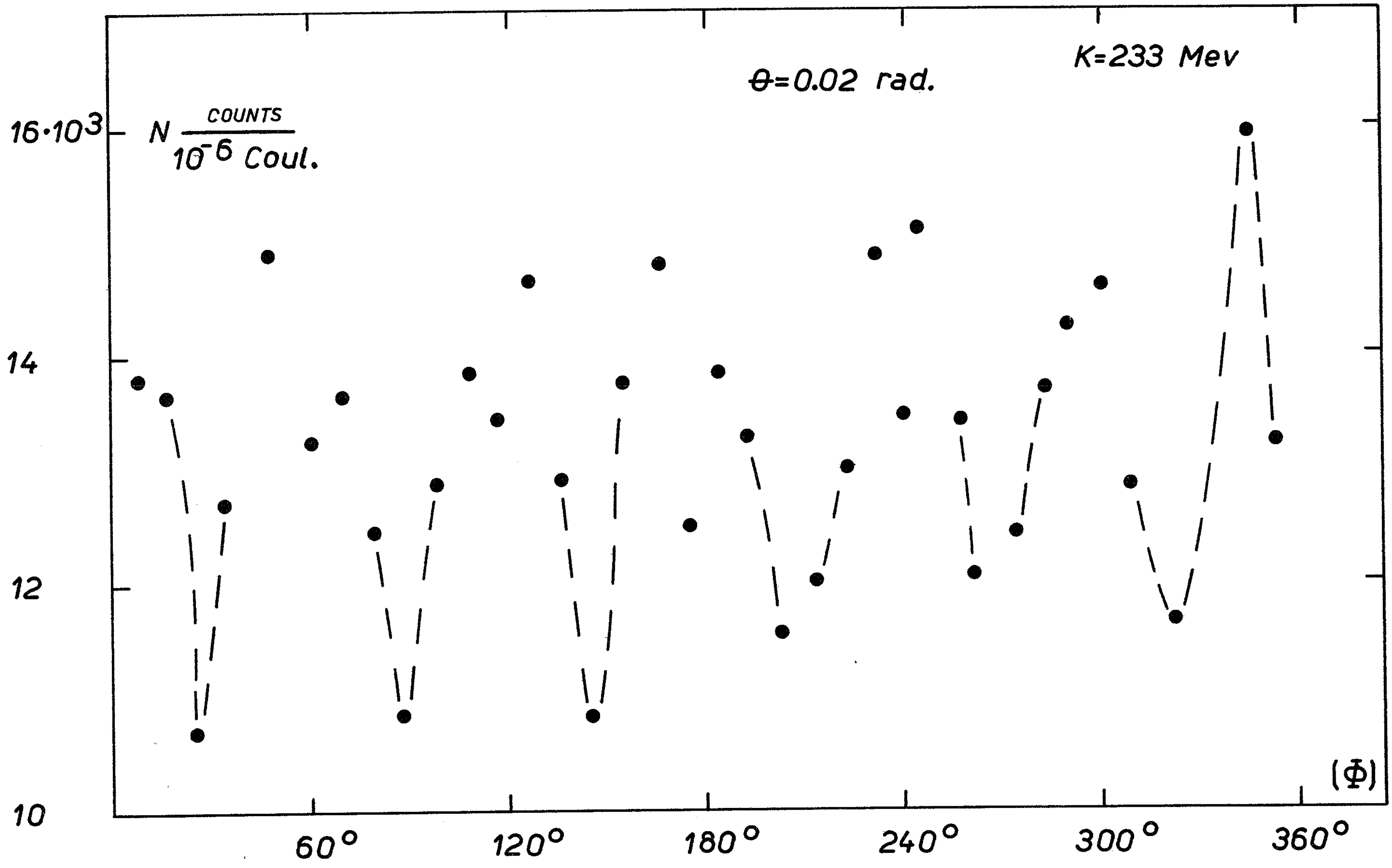



FIG. III.1



K=233 Mev
θ=0.02 rad.
N COUNTS / 10^-6 Coul.
16·10^3
14
12
10
60°
120°
180°
240°
300°
360°
(Φ)


FIG. III.2

we shall publish them shortly. We are thinking of trying to measure electrodynamically the polarization of the $\gamma$ beam produced by the single crystal in the future with the same experimental set up.

## 5. PHOTOPRODUCTION OF SINGLE AND MULTIPLE PIONS IN HYDROGEN, DEUTERIUM AND HEAVY NUCLEI (Genova)

**P.E. Argan, G. Bendiscioli, G. Ciocchetti [1], A. Gigli, A. Piazzoli, E. Picasso, G. Piragino [1]**
**Institute of Physics of the University of Genova**

The device used in detecting photoproduction events, is a diffusion chamber of *60 cm* in diameter, whose sensitive strate is immersed in a magnetic field, that can reach up to about *10.000 gauss* (see fig. III.3). Photoproduction eventstake place directly in chamber's gas, after the $\gamma$-beam has passed through a *LiH* hardener to eliminate low-wnergy rays ($< 50$ *MeV*).

Measurement of cross-sections is made determining the energy of the event-producing photon, by means of the star's cinematics, the total flux of the $\gamma$-rays, counting the number of electron pairs produced in the chamber's gas, and the spectrum in the chamber, by cinematically studying a certain number of electron pairs.

a) *Multiple pion photoproduction in hydrogen*

We have taken about 15.000 pictures corresponding to about 20 events of multiple photoproduction with a maximum beam intensity of *1000 MeV* (fig. III.4). In cooperation between Frascati and Genova, a pulsed target is being built; this will allow the diffusion chamber to work simultaneously with other experiments with the elecronsynchrotron; this has to be done so as to reduce machine time, which would be to long to reach the necessary statistics to finish the experiment (about 150.000 pictures will have to be taken to complete the experiment).On the basis of data already accumulated in hydrogen, we have already determined the spectrum of the rays in the chamber for a maximum energy of *1000 MeV* (fig. III.5); this spectrum is in good agreement with spectra reported by other Authors.

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(1) Institute of Physics of the University of Torino.

b) *Single and multiple photoproduction in deuterium.*

For these measurements one must use deuterium, impoverished in tritium content, so as not to increase average ionic load in the chamber eccessively.

We have already reached an agreement with Cornell University so as to obtain some deuterium, impoverished in tritium content, that Cocconi and coll. have already used in similar conditions. We are therefore waiting for this deuterium to reach Italy.

c) *Single and multiple photoproduction in heavy nuclei and photo-disintegration of the same at high energy.*

We have taken
2000 pictures in Nitrogen (maximum $\gamma$-ray energy, *1000 MeV*)
2000 pictures in Argon (maximum $\gamma$-ray energy, *1000 MeV*)
2000 pictures in Oxygen (maximum $\gamma$-ray energy, *500 MeV*).

Each group of 2000 pictures yields about 150 events between photodisintegration and photoproduction of pions. Photoproduction events are about 20% of the total.

By examining the above pictures we think we can deduce the $\gamma$ ray energy at least 70-80% of the time, through measurements of momentum, range, photometric density and from star cinematics.

At the time of the writing, we have completed scanning pictures taken in Nitrogen, Argon and are scanning pictures taken in Oxygen (fig. III.6).

In the future we shall predictably increase our present statistics for Nitrogen, Argon and Oxygen at *1000 MeV* and at lower energies, and then pass to other gases such as Helium, Methane, Neon and Xenon.

## 6. PHOTOPRODUCTION OF SINGLE $\pi^+$ MESON IN HYDROGEN AROUND $0°$ (Rome $\pi^+$)

**M. Beneventano, G. Finocchiaro, R. Finzi, L. Mezzetti, L. Paoluzzi, C. Schaerf**
**Institute of Phisics of the University of Roma**

In order to make measurements of the differential cross section of the

$$\gamma + p \rightarrow n + \pi^+$$

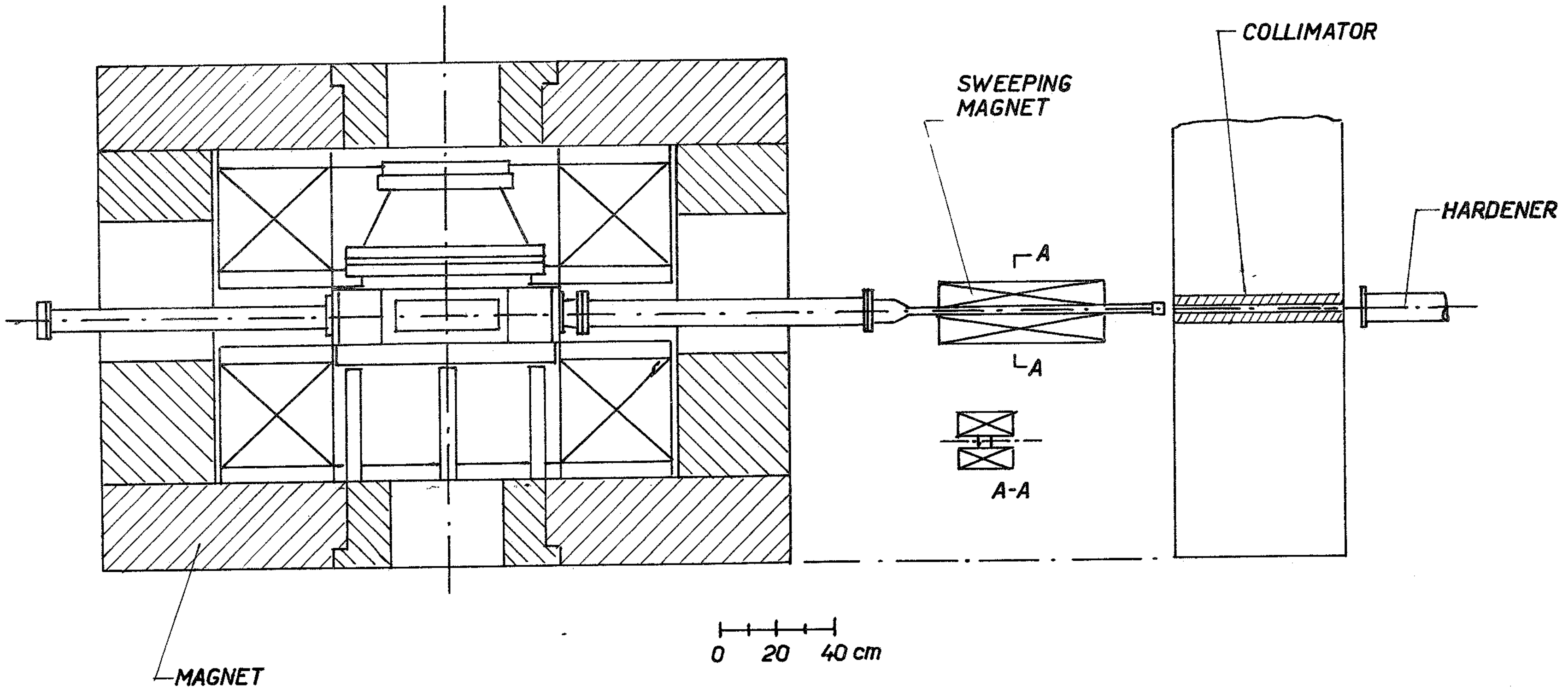



FIG. III.3

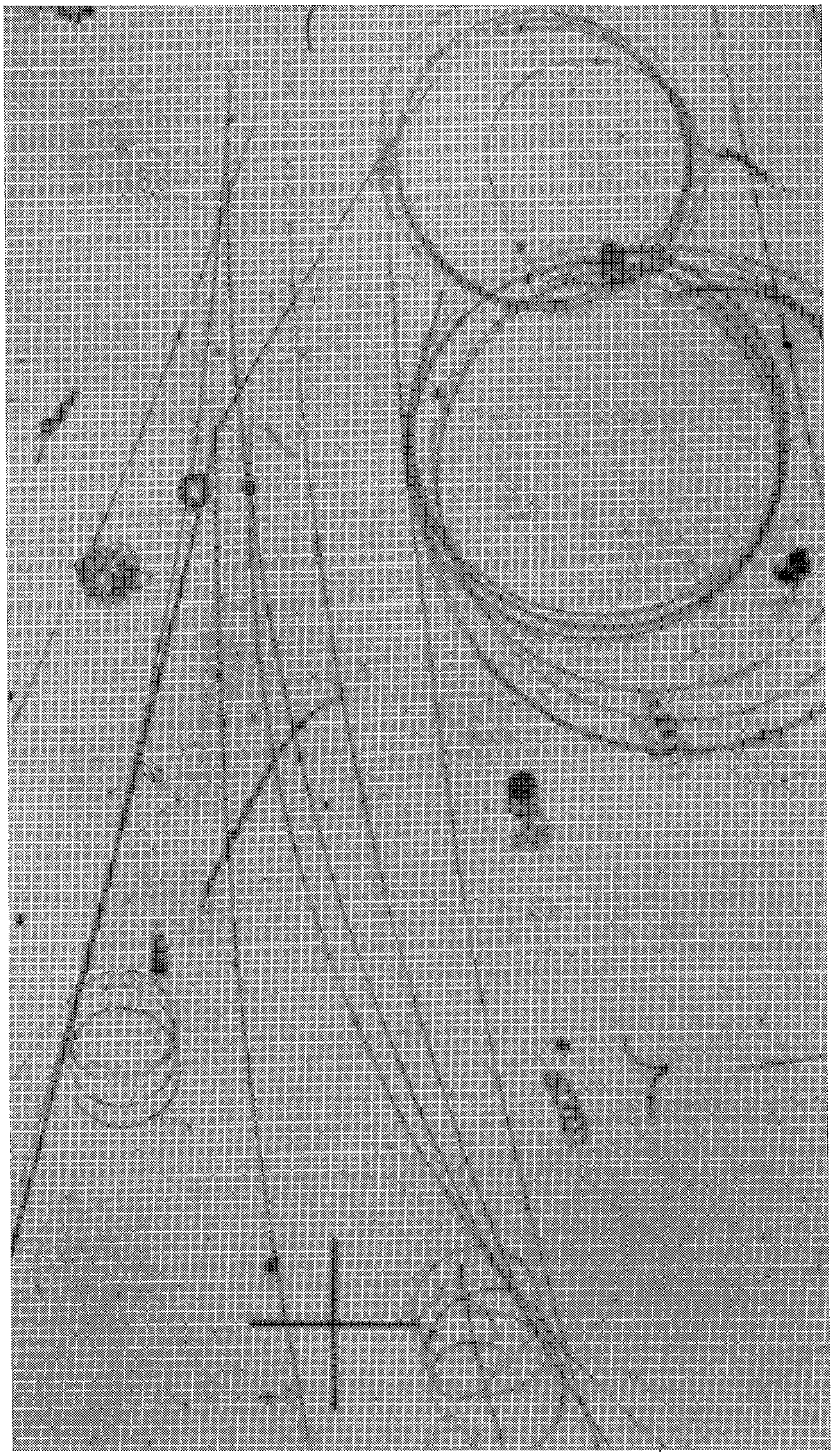


Fig. III. 4

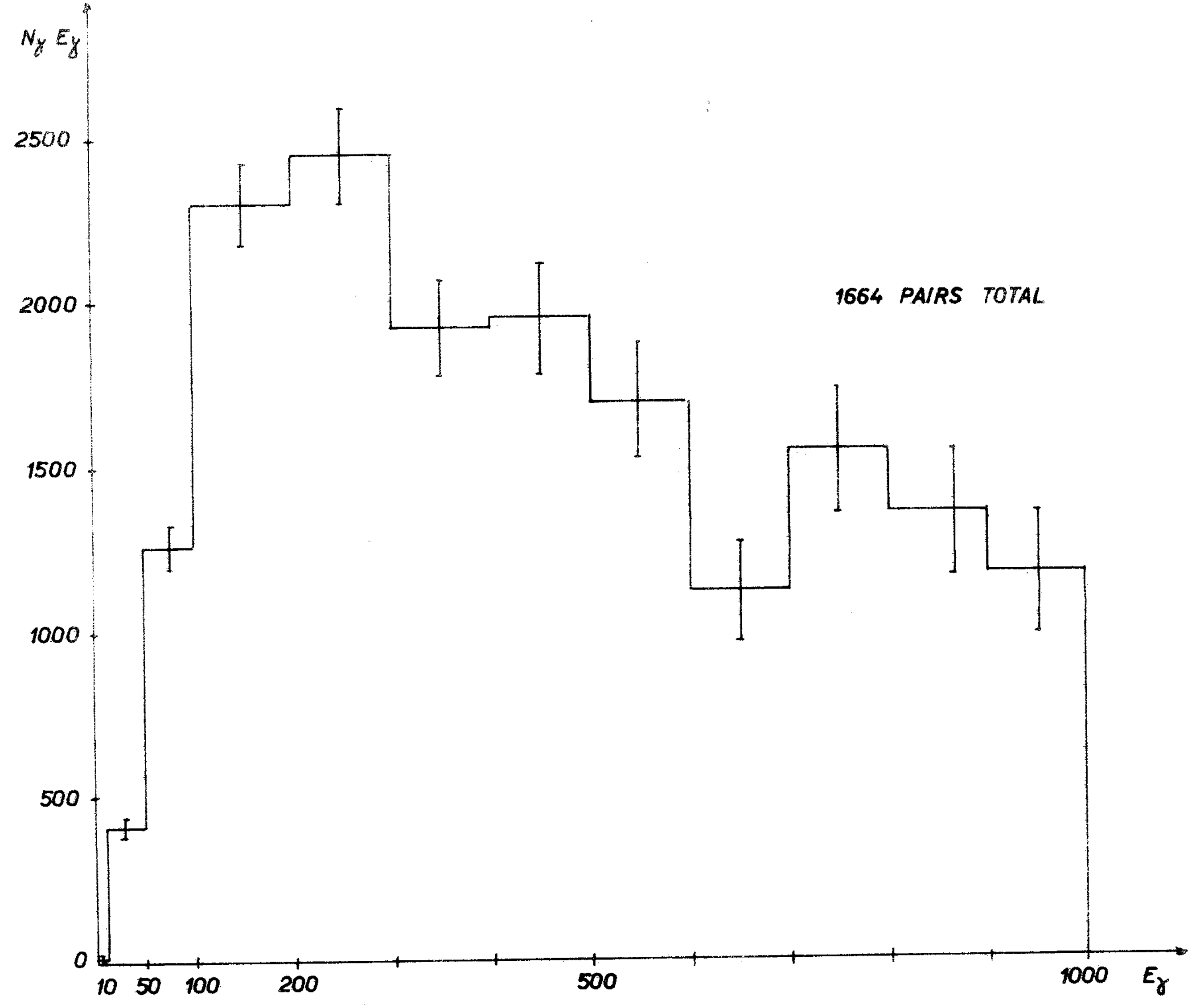

$N_\gamma E_\gamma$
2500
2000
1500
1000
500
0
1664 PAIRS TOTAL
10
50
100
200
500
1000
$E_\gamma$

FIG. III.5

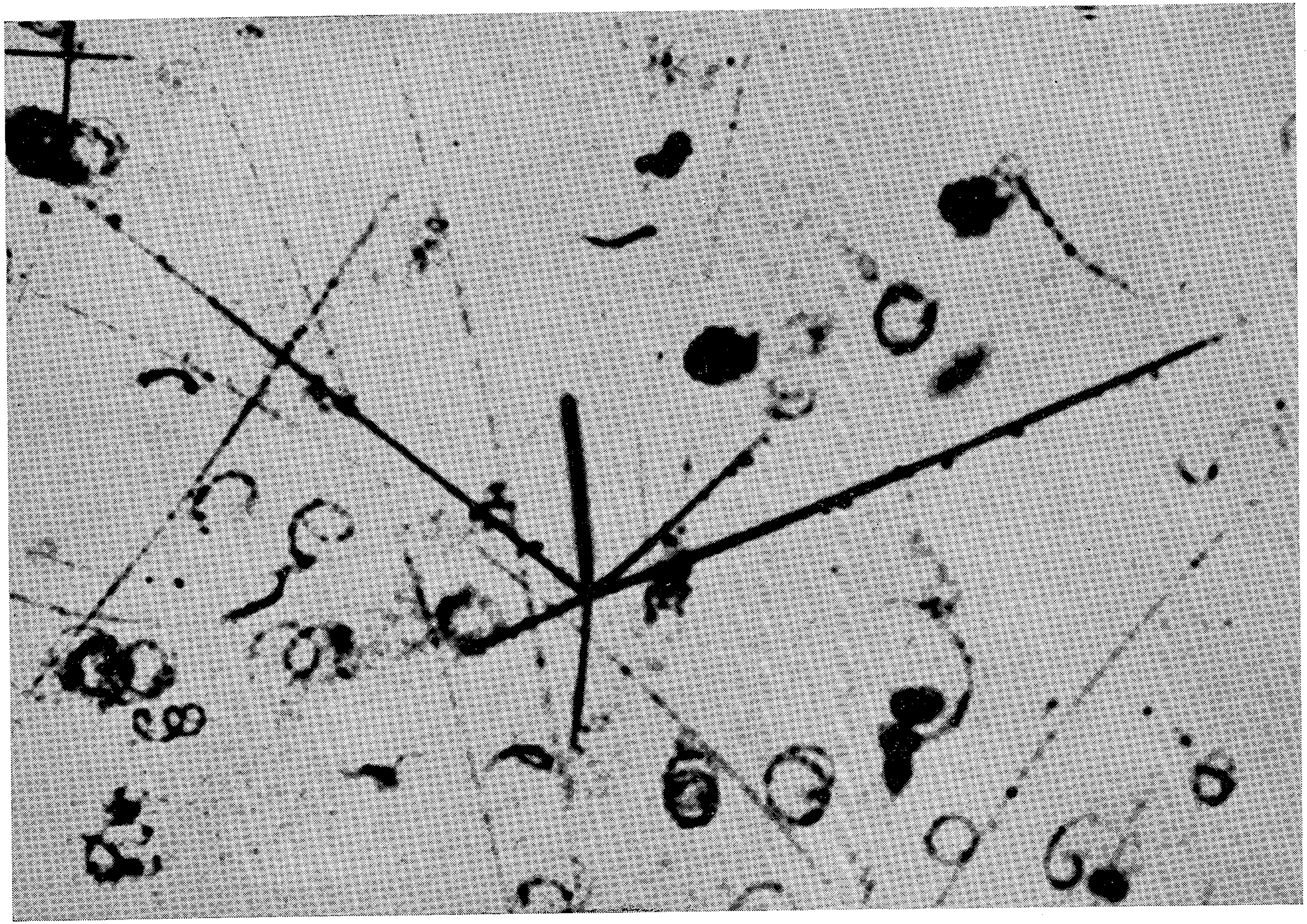


Fig. III. 6

reaction, at angles $\theta_\pi < 10°$ *CM*, we have modified the experimental arrangements described in report n. 8 as described below.

Positive particles produced in the target are analysed by a magnetic spectrometer and focused on counter $S_2$ [1] that is in the inside of gas-Cerenkov counter $G$ (see fig. III.7).

Angular resolution is given by counter $S_{11}$ while momentum resolution and vertical aperture are determined by counter $S_2$; proton background is eliminated by water-Cerenkov counter, $Ca$.

Discrimination against electrons is made by means of a $CO_2$ Cerenkov counter $G$ with an electron detecting efficiency of $0.99998$ and a detecting system consisting of a lead sheet 3 radiation lengths thick and counter $S_5$. $S_5$'s pulses are analysed with a 200-channel analyser that is triggered by anti-coincidence $S_{11}S_{12}S_2S_4$ $Ca\ \bar{G}$. Pulse height renders distinction between pions and shower-generating electrons possible.

Spectrometer characteristics are as follows:

$\frac{\Delta p}{p_0} = \pm\ 0.0265 \pm 0.005$ for a point source (determined with floating wire methods).

$\Delta\theta = \pm\ 1.45°$ (determined by the half width of the electron peak at $2°$)

$\Delta\Omega \cong 0.23\ 10^{-3}\ str$ (computed).

With this equipment we have made measurements at photon energy between $600$ and $700\ MeV$. Angular distribution between $10°$ and $4°$ *CM* is given in fig. III.8.

The cross section has been computed from measured counting rate after subtraction of target and electron contribution (as deduced from the diagram of detected electrons); it has also been corrected for chance coincidences; however, we want to state that these results are preliminary and that further measurements, together with a better data evaluation, may change them substantially. Further measurements are under way.

## 7. AN EXPERIMENT ON $\mu$ PAIR-PHOTOPRODUCTION ($\mu$ PAIRS)

**A. Alberigi Quaranta [2], C. Bernardini, G. Marini [3], A. Odian [4], M. De Pretis Cagnodo [5], G. Stoppini [3], L. Tau [3] - National Laboratories of Frascati**

Purpose of the experiment is the measurement of the cross

(1) All counters designed by a letter $S$ are scintillation counters.
(2) Physics' Institute of the University of Bologna.
(3) " " " " " " Roma.
(4) " " " " " " Trieste.
(5) University of Illinois, Urbana.

section of the

$$\gamma + nucleus \rightarrow nucleus + \mu^+ + \mu^-$$

process at various energies.

For this, we have thought of bettering the experiment made by Panofsky and Masek detecting muons by means of a coincidence between the two branches of each pair, and discriminating against pions on at least one branch.

The characteristics of the first experimental device proved insufficient because $\mu$ pair counting rate, that was already low enough, was of the same order of magnitude as accidental counting rate.

Therefore, together with the decision of changing the experimental setup (changing the magnet with a larger aperture one) we have also decided to analyse the pion background using only the magnetic channel of the first setup (see fig. III.9).

With this we have measured charged photoproduction pions from nuclei of *C, Al, Sn, Pb*, at an angle of *30°* with the primary direction and at pion momentums of *300*, *500* and *700 MeV/c*. Furthermore, we have measured the above mentioned flux from hydrogen by means of polythene-carbonium difference.

Result of these measurements can be written as

$$\frac{yield\ from\ nucleus\ A}{yield\ from\ hydrogen} = K\ A^{2/3}$$

where the coefficient $K$ is between *1* and *2* depending on energy (with an error of about 20%), if one normalized yield for target nuclei. The exponent *2/3* is present in all measurements with an error that generally $< 5\%$.

The experimental arrangement is the one that has been already described (see report n. 8).

We foresee beginning within the next semester new measurements on muon pairs with the new setup.

## 8. MEASUREMENTS ON THE POLARIZATION OF THE RECOIL PROTON IN THE $\gamma + p \rightarrow \pi^\circ + p$ REACTION (Frascati $\pi^\circ$)

C. Mencuccini, R. Querzoli, G. Salvini
National Laboratories of Frascati

Measurements on the polarization of the recoil proton have

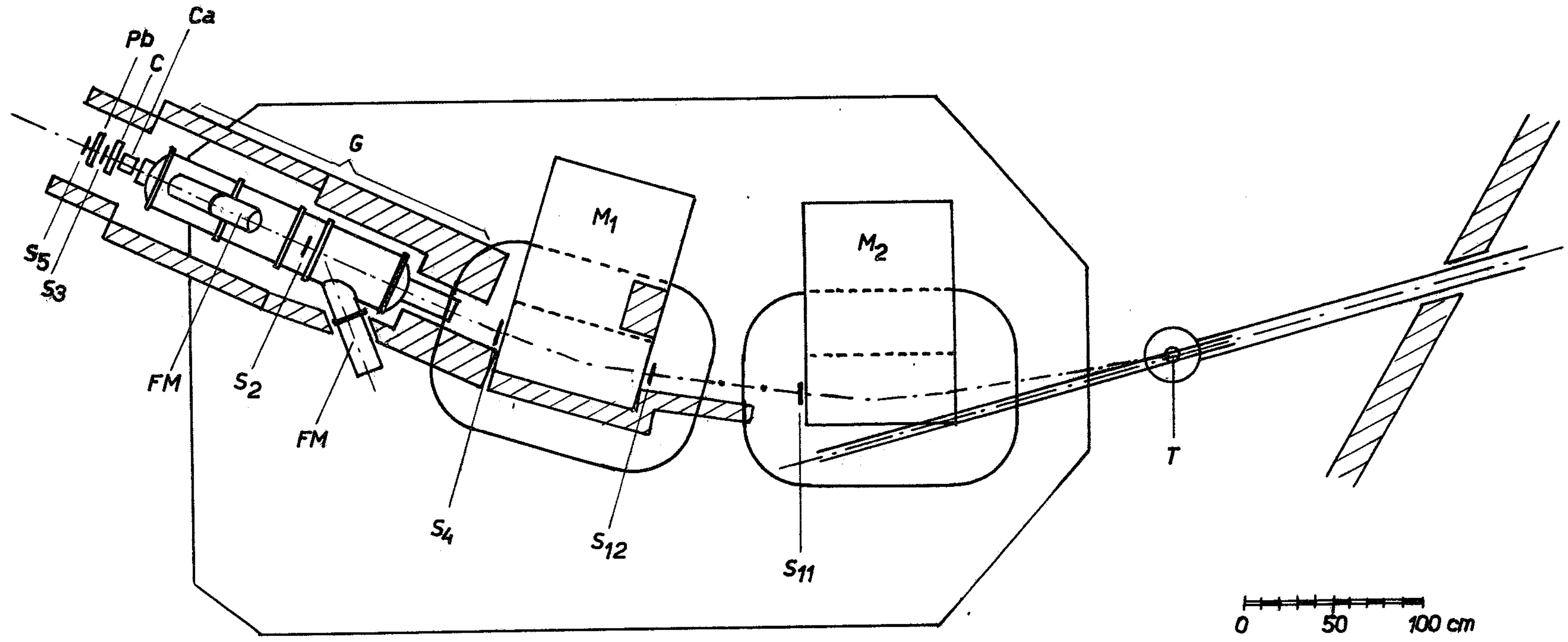
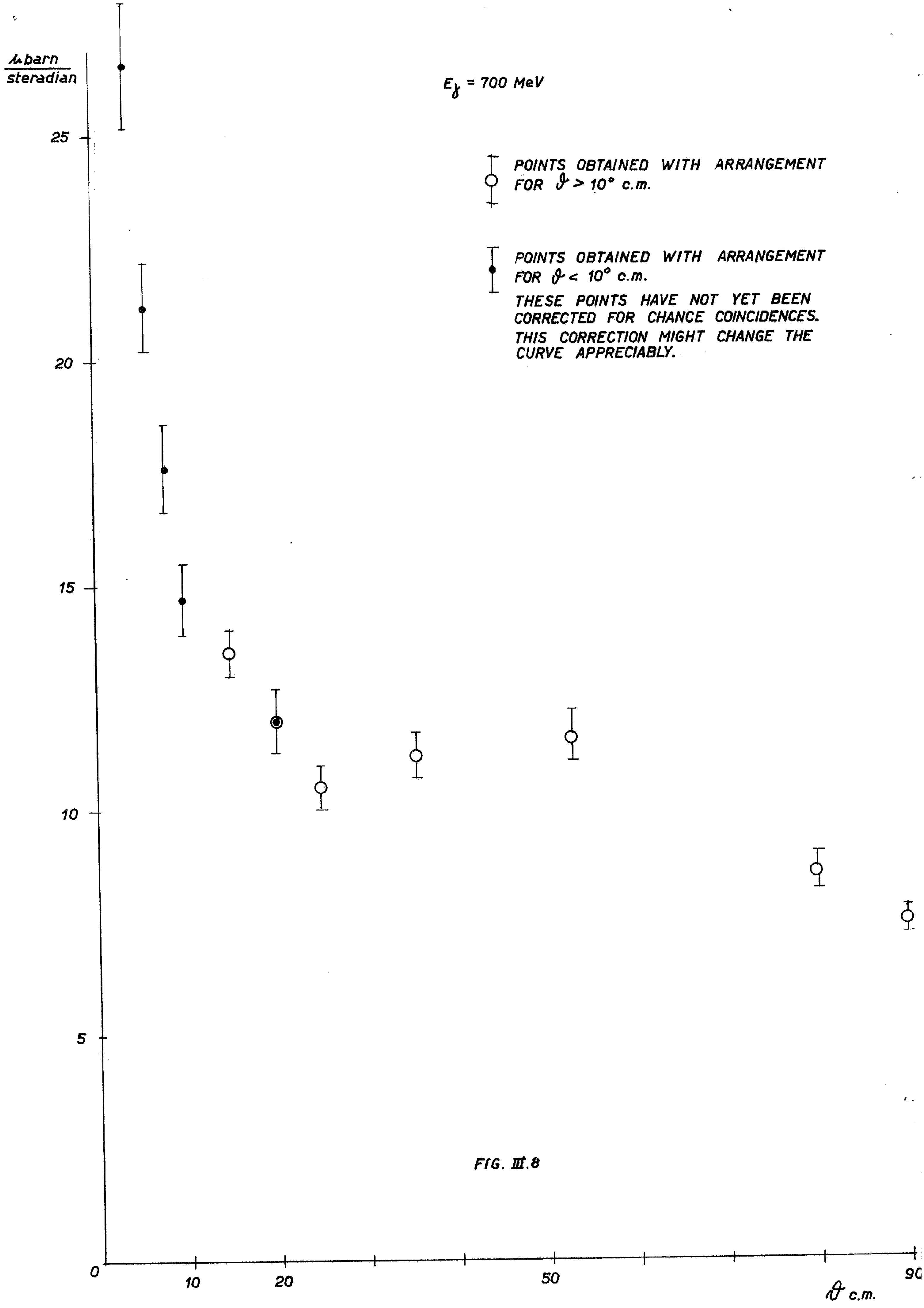



FIG. III.7



μbarn / steradian
25
20
15
10
5
0
$E_\gamma$ = 700 MeV
POINTS OBTAINED WITH ARRANGEMENT FOR ϑ > 10° c.m.
POINTS OBTAINED WITH ARRANGEMENT FOR ϑ < 10° c.m.
THESE POINTS HAVE NOT YET BEEN CORRECTED FOR CHANCE COINCIDENCES. THIS CORRECTION MIGHT CHANGE THE CURVE APPRECIABLY.
10
20
50
90
ϑ c.m.


FIG. III.8

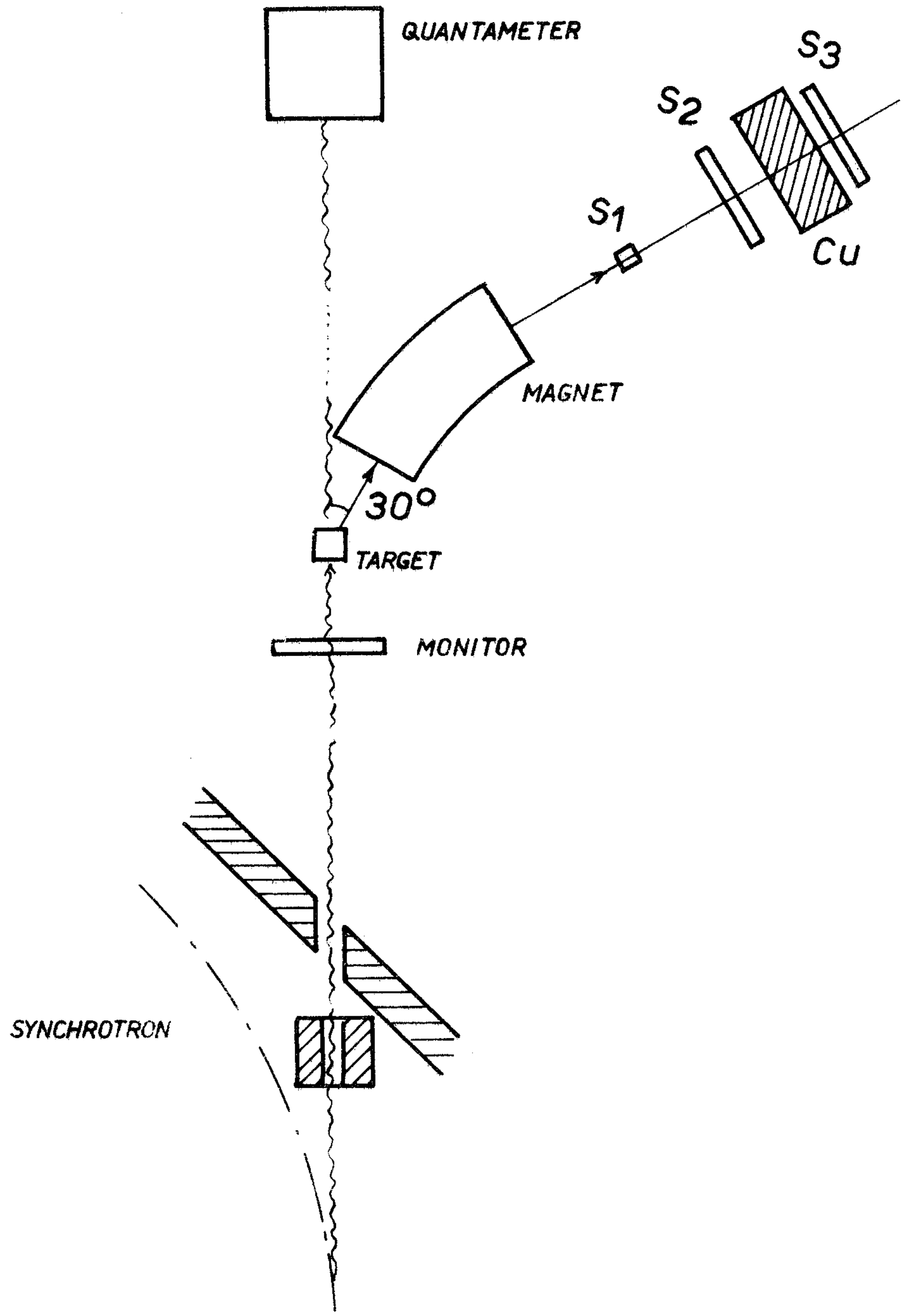

QUANTAMETER
S3
S2
S1
Cu
MAGNET
30°
TARGET
MONITOR
SYNCHROTRON

FIG. III.9

already been described in the report n. 8, page 36, and have been presented at the Rochester Conference (report of Rochester Conference 1960).

We are extending them, with substantially the same counter arrangement, at higher energies and at angles different from 90° in the C.M.

We have revised the electronics so as to better resolving power and are now making measurements at *800* and *900 MeV* of the incident photon.

## 9. PREPARATION OF SPARK CHAMBER TECHNIQUES FOR MEASURING PROTON POLARIZATION IN THE PHOTOPRODUCTION OF SINGLE NEUTRAL PIONS AND IN MULTIPLE PHOTOPRODUCTION (Frascati $\pi^\circ$)

**M. Deutsch** [(1)], **C. Mencuccini, R. Querzoli, G. Salvini, G. V. Silvestrini** [(2)]
**National Laboratories of Frascati**

Parallel to the measurements of the polarization of recoil protons in the $\gamma + p \rightarrow \pi^\circ + p$ reaction with counters, we have started studying possible applications in this and in eventually other measurements, of the new spark chamber technique.

A possible experimental arrangement is shown in fig. III.10; the structure of a chamber suited to this purpose is shown schematically in fig. III.11.

From a measurement of this type one can await a wealth of information on the cross sections for neutral pion photoproduction. Furthermore, we are thinking of using spark chamber techniques in the near future so as to investigate double pion photoproduction in hydrogen, in relation to the problem of $\pi - \pi$ interaction that recent theoretical and experimental investigations (Crowe and Coll.) have shown to be of special interest.

The main problem is the measurement of the effective resolving power of the spark chamber and its "resistance" to highly intense $\gamma$-beams. We have therefore, built a prototype, so as to check the effective possibility of using the spark chamber; the prototype uses alluminum plates in an Argon and Neon atmosphere, as done by

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(1) Massachusetts Institute of Technology, Cambridge.
(2) Institute of Physics of the University of Pisa.

Cronin and Corke.

The chamber we have built consists of 19 aluminum plates and has a useful volume of $16 \times 16 \times 28$ *cu.cm.* It is furnished with a camera (stereoscopic $90^\circ$ vision and has been tested first with cosmic rays, then directly on the beam in these last days.

Results may be taken as fairly satisfying:

a) the chamber has a high gap-efficiency also with minimum-ionizing particles (cosmic rays);

b) we have been able to see traces of pions and protons triggered by counters and produced against hydrogen from the $\gamma$ beam, without large backgrounds.

We are now investigating these preliminary results.

We have simultaneously started studying the chamber's behavious as a function of its various parameters (type of gas and its pressure, amplitude of the high voltage pulse, delay between passage of the particle to be detected and the voltage pulse at the plates, intensity of the clearing beam, characteristical time constance of the circuit, contamination of the gas, angle between the particle's direction and the perpendicular to the plates). This study is made on a small chamber using cosmic rays.

We are simultaneously thinking of equipment to analyse the photographs automatically or semi-automatically.

## 10. AN EXPERIMENT ON PARITY CONSERVATION (Bologna)

**E. Fuschini, A. Forino, C. Maroni, P. Veronesi**
**Istitute of Physics of the University of Bologna**

Work done up to now was maynly the alignment of counting apparatus which is made up of three counter telescopes *A B C* placed with their axes perpendicular to the direction of the beam as shown in fig. III.12. *A* and *B* consist of three scintillation counters in coincidence, while *C* consists of three counters (7, 8 and 9) in coincidence, all in anticoincidence with counter 10. The events we are looking for are coincidences *AC* and *BC* due to the $\gamma + p \rightarrow p + \pi^+ + \pi^-$ reaction.

We have encountered large difficulties in reducing counter duty ratio, since these are placed a few centimeters from the beam "core". We have tried many different ways, experimenting different

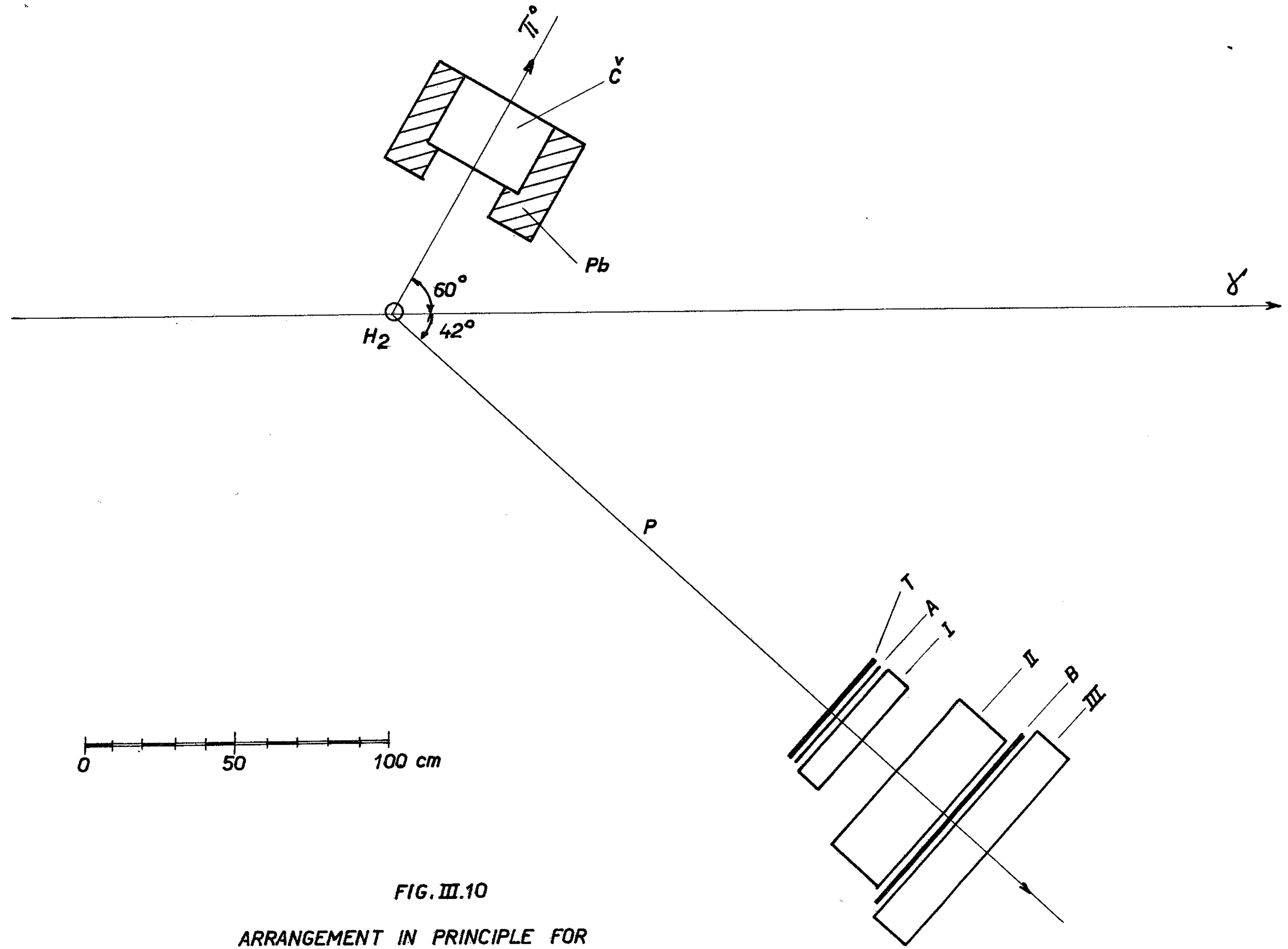
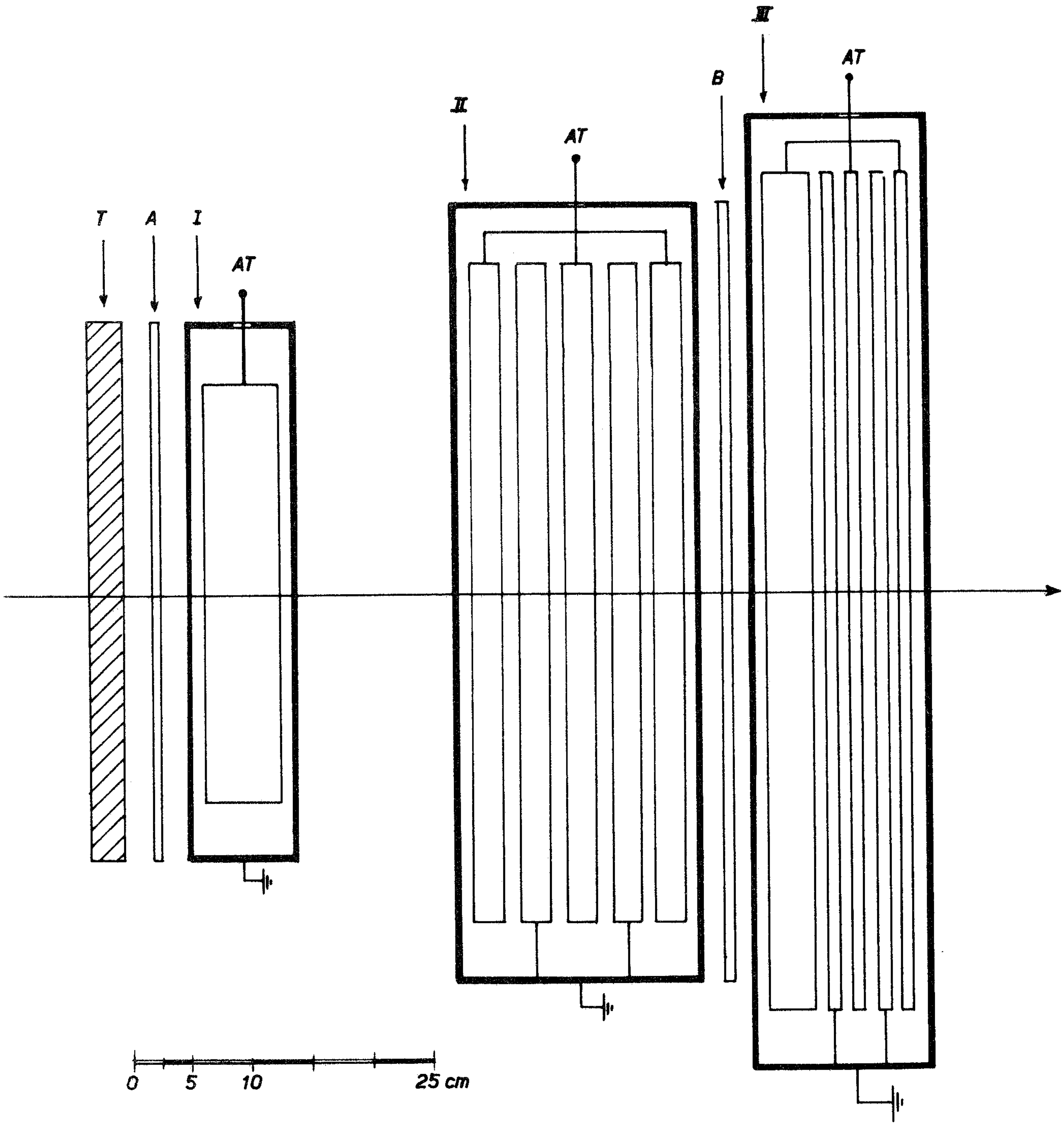



FIG. III.10

ARRANGEMENT IN PRINCIPLE FOR
MEASURING POLARIZATION USING
A SPARK CHAMBER




A - COUNTERS
I - II - III - BOX
B - COUNTERS
T - ASSORBERS

FIG. III.11

MEASUREMENT ARRANGEMENT OF SPARK CHAMBER

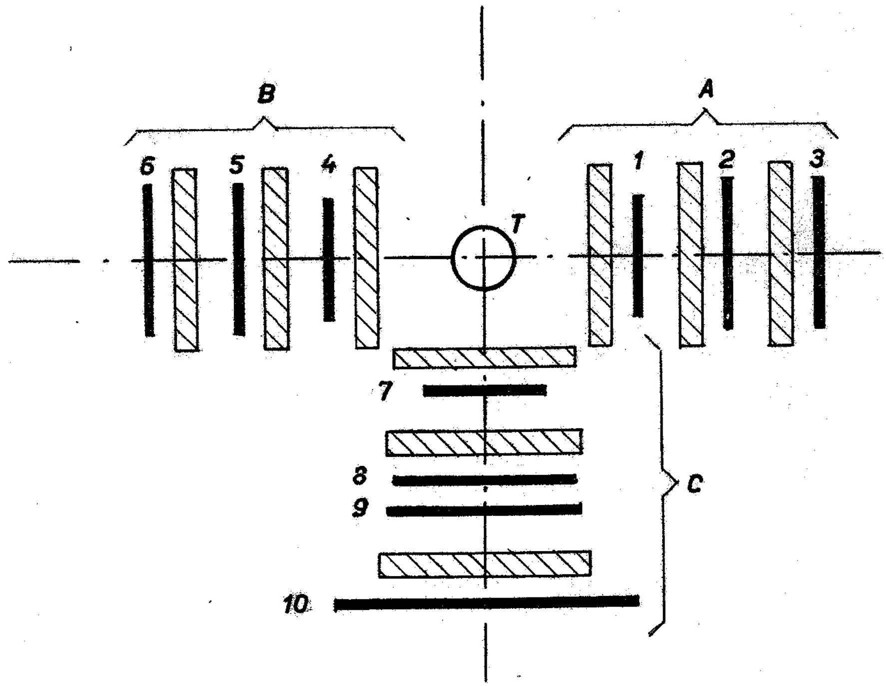



FIG. III.12

shielding arrangements and comparing counter behaviour in the various situations.

Definite and sistematic tests have been made only since the group has been assigned a definite place in the counting area.

The target we have used during our tests was made of various strips of polythene placed so as to simulate both in dimensions and in density our effective liquid hydrogen targets.

The results of this preliminary work may be synthesized as follows:

1) At a distance of about 5 meters from the electronsynchrotron target, and using a second collimation of about 50 centimeters of lead with a hole about *4 cm.* in diameter, we have obtained a beam about *3 cm.* in diameter, with an intensity of about $10^9$ equivalent quanta per minute.

2) Scintillation counters measuring $4 \times 6 \times 1$ *cu.cm.*, $9 \times 12 \times 1$ *cu.cm.* and $15 \times 20 \times 1$ *cu.cm.* placed at a distance of *10 cm.*, *20 cm.* and *36 cm.* respectively from the beam "core", show tolerable duty ratios. The ones with the highest counting rate produce pulses of less than *20* nanoseconds in duration, with an average interval between pulses of about *200* nanoseconds; with a protection of *2 cm.* of *Cu*, average interval in time between successive pulses is of the order of *1* microsecond.

3) Coincidences *AC* and *BC*, with the beam hitting the above mentioned polythene target have a counting rate of about 10 coincidences per sweep, (since one sweep lasts *30* seconds on the average, we count 20 events per minute). These events should be attributed, for the greatest part to double photoproduction; that is to say to coincidences between mesons of *100 MeV/c* minimum momentum within a momentum range about *160 MeV/c* wide for channel *C*, and to mesons of *300 MeV/c* minimum momentum, within the whole momentum range cinematically allowable, for channels *A* and *B*. Definition of momentum ranges and edges was obtained using suitable absorbers.

4) An asimmetry ratio $\frac{AC - BC}{AC + BC}$ between counting rates due to "space inverted" configurations has shown simmetry to exist between the two configurations, within experimental errors of a few percent.

## 11. PHOTOPRODUCTION OF $K^+$ NEAR THRESHOLD $\gamma + p \rightarrow \Lambda^\circ + K^+$ PROCESS (Rome $K$)

C. Bemporad [1], M. Grilli [2], L. Mezzetti, L.S. Osborne, S. Tazzari
Institute of Physics of the University of Rome

With the experimental arrangement described in report n. 8 (see fig. III.13 and III.14) we have made some preliminary measurements on $K^+$ meson photoproduction from the $\gamma + p \rightarrow \Lambda^\circ + K^+$ reaction for $E_\gamma = 960 \pm 20$ *MeV* and $\theta_K = 90° \pm 10°$ (C.M.).

The event "$K$" is identified on the basis of energy loss due to ionization in scintillation counters (plastics) of the $F = C_8 \div C_{10}$ block (stoppers), that the charged particle crosses before stopping in one of them; and of the delay between the pulses from the stoppers and the pulse from counter $C_3$ (charged decay secondary). Energy loss due to ionization is deduced measuring signal amplitude from the respective counter: amplitudes and delays are measured by looking at 'scope traces of the signals, after having suitably mixed them.

Interesting events are preselected through a pilot coincidence $P = C_1 C_2 C_3 \check{C} \bar{C}_4$, that requires the presence of a charged secondary ($\pi^+$) within the solid angle subtended by counter $C_1$, and a *neutral* secondary (at least one of the two decay $\gamma$'s of the $\pi^\circ$).

We have made measurements for a total of 5,770 doses (one dose $= 4.9\ 10^{10}$ equivalent quanta) with $E_{max} = 1{,}050$ *MeV*; and 1502 doses with $E_{max} = 900$ *MeV* (the latter measurements are under threshold). Corresponding delay distributions $t = C_3 - F$ are given in fig. III.15.

Events that may be identified as $K$ mesons should obviously be looked for amongst the "delayed" ones.

The total number of observed delayed events is of about 280. We are now analysing results. In particular, we are elaborating amplitude selection criteria, to take into account saturation effects of block $F$ scintillators, not well known up to now.

On a sample of events, selected with the above mentioned amplitude criteria and having delays $\geqslant 4$ nanoseconds, the resultant lifetime ($13 \pm 1.4$ nanoseconds) agrees with known $K^+$ lifetime. The same sample has a distribution of number of events formed in the

(1) Institute of Physics of the University of Pisa.
(2) " " " " " " " Padova.

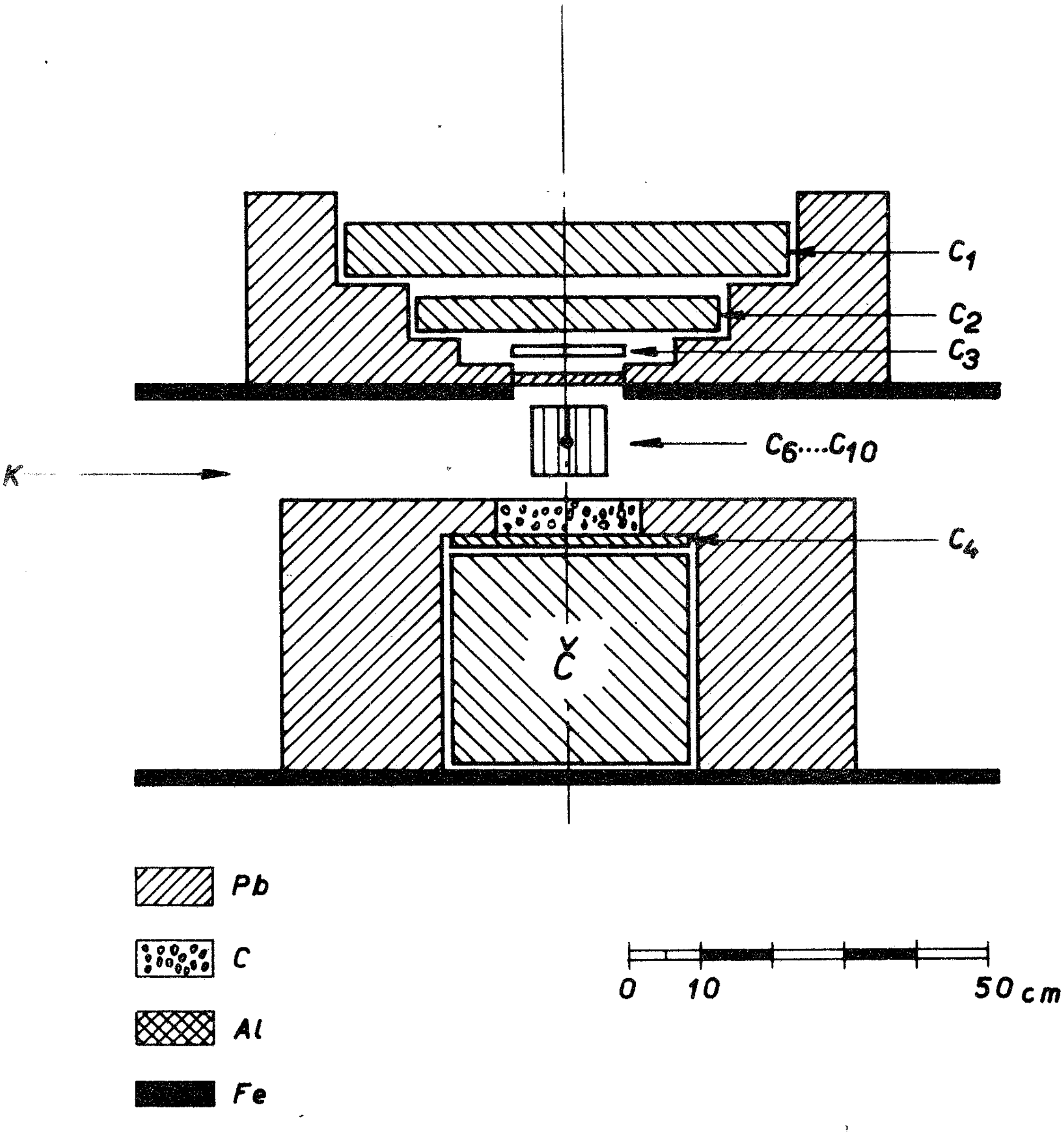



FIG. III.13

PROGRAM OF $\gamma + p \longrightarrow \Lambda^{\circ} + K^{+}$ COUNTER

| | | |
|---|---|---|
| $C_1, C_2$ | toluene counters | } $\pi^+$ detection channel $(K \to \pi^+ + \pi^0)$ |
| $C_3$ | plastic counter | |
| $C_6 \ldots C_{10}$ | plastic counters | ($K^+$ stoppers) |
| $\check{C}$ | Cerenkov | } $\pi^0$ detection channel |
| $\bar{C}_4$ | plastic counter | |

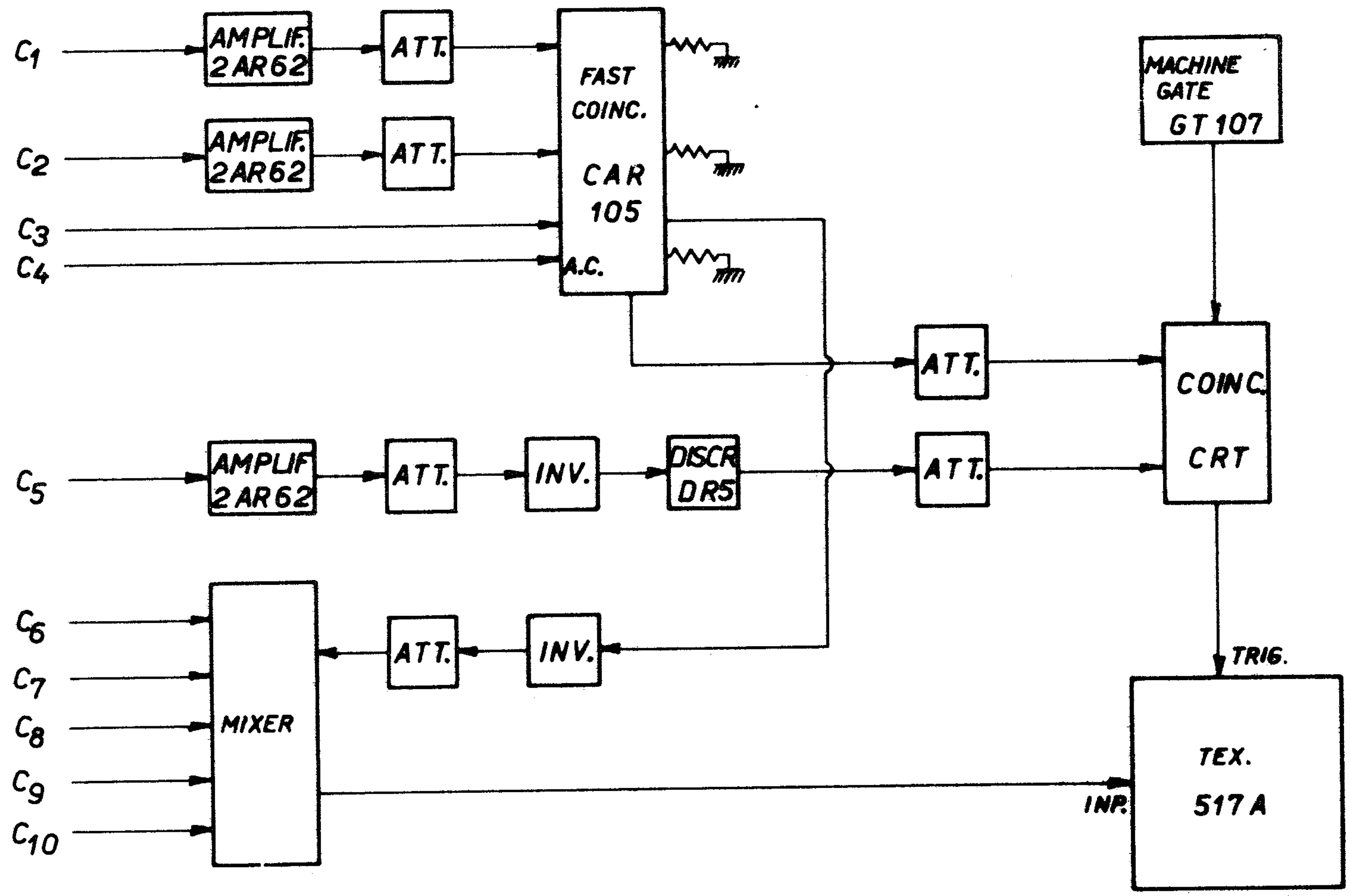
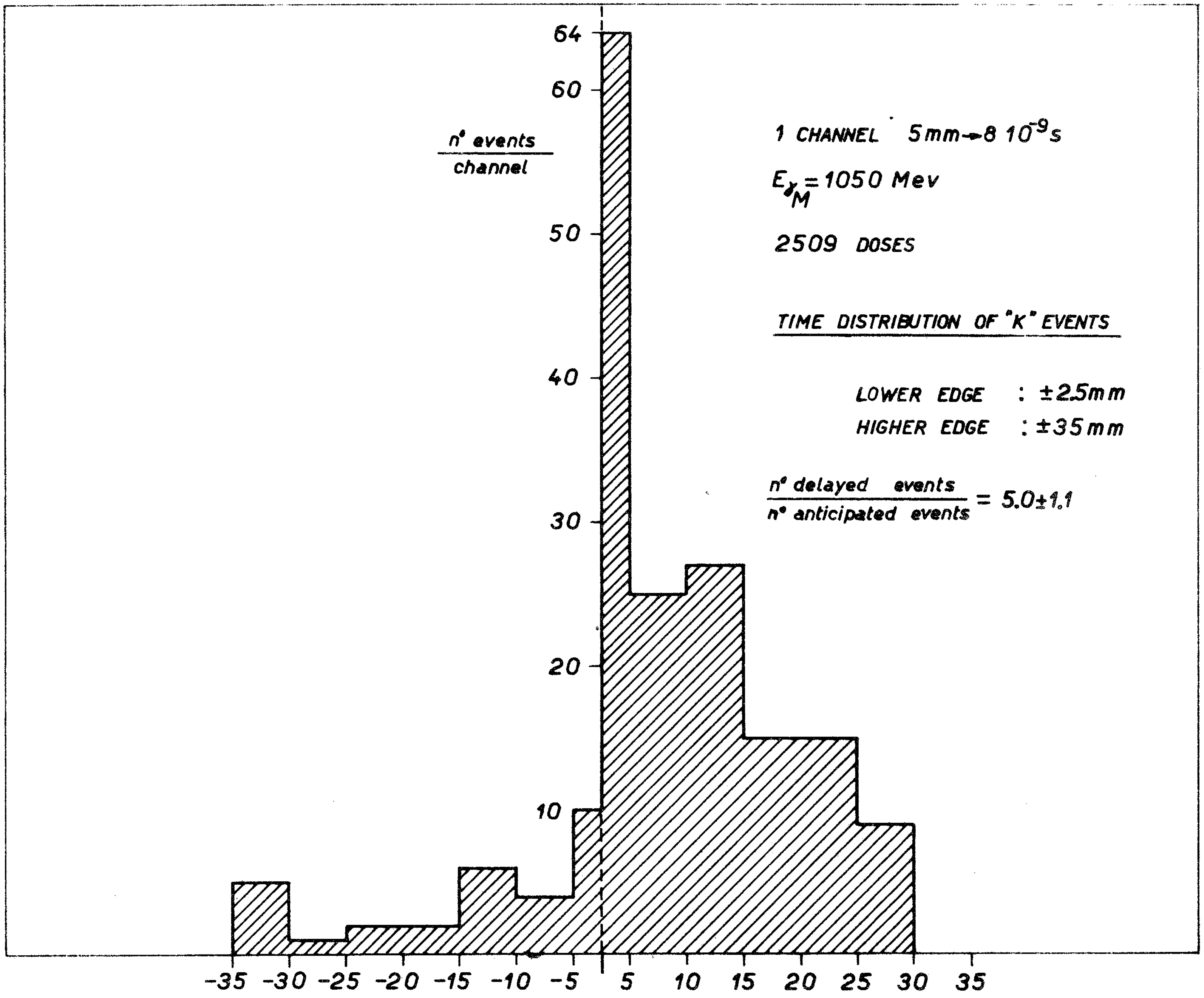
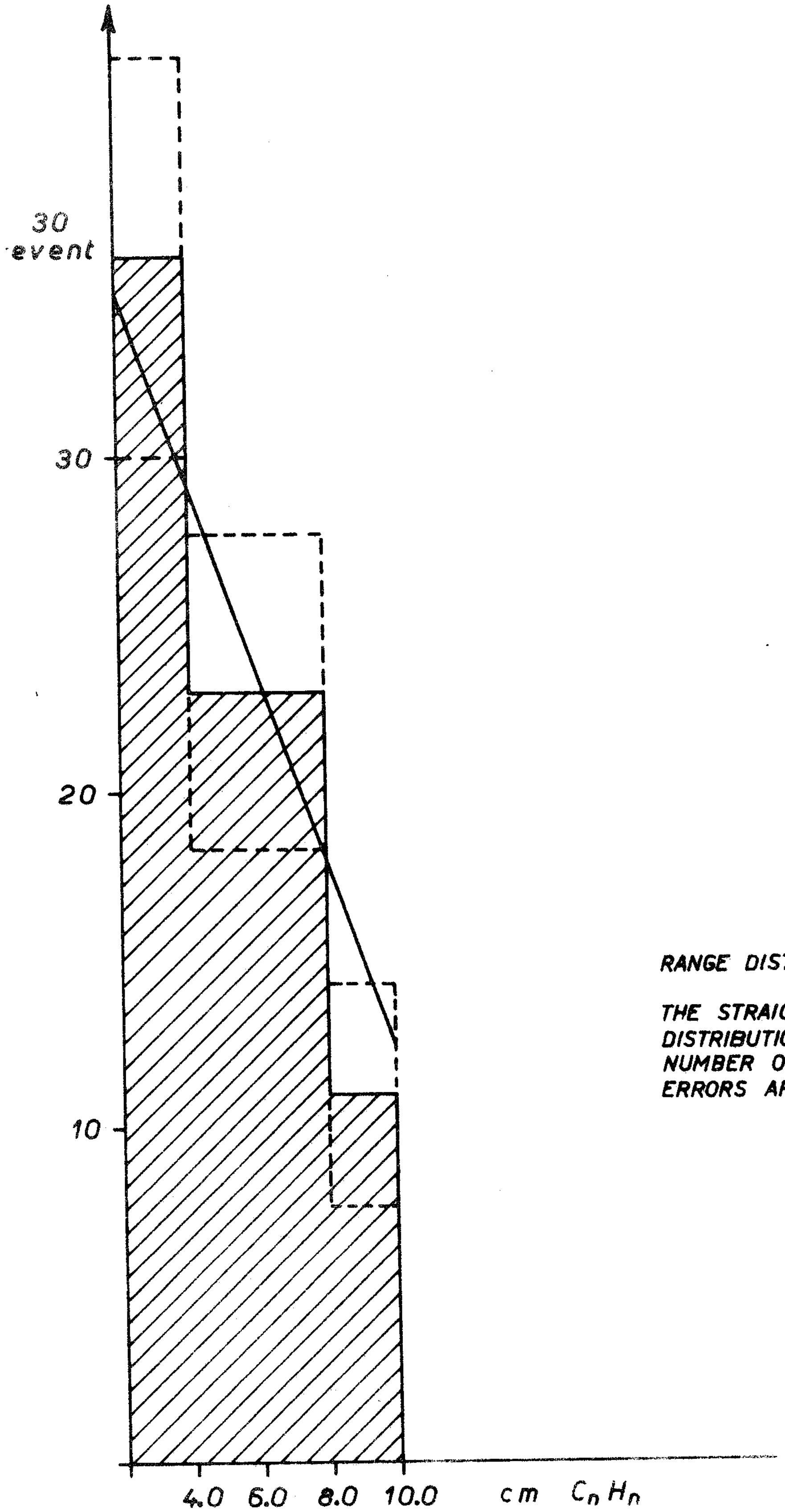

C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
AMPLIF. 2AR62
AMPLIF. 2AR62
AMPLIF 2AR62
ATT.
ATT.
ATT.
ATT.
ATT.
ATT.
FAST COINC. CAR 105
A.C.
INV.
INV.
DISCR DR5
MIXER
MACHINE GATE GT 107
COINC. CRT
TRIG.
INP.
TEX. 517 A

FIG. III. 14



64
60
50
40
30
20
10
n° events / channel
1 CHANNEL 5mm → 8 10^-9 s
E_γM = 1050 Mev
2509 DOSES
TIME DISTRIBUTION OF "K" EVENTS
LOWER EDGE : ±2.5mm
HIGHER EDGE : ±35mm
n° delayed events / n° anticipated events = 5.0±1.1
-35 -30 -25 -20 -15 -10 -5 5 10 15 20 25 30 35


FIG. III.15




RANGE DISTRIBUTION OF 95 $K^+$ EVENTS

THE STRAIGHT LINE IS THE THEORETICAL DISTRIBUTION NORMALIZED TO TOTAL NUMBER OF EVENTS.
ERRORS ARE STATISTICAL.

FIG. III.16

various counters of block $F$ that agrees with the distribution predicted for the $K$ mesons on the basis of the cynematics of our reaction (fig. III. 16). Measurements of which we have shown the results have been made at $\theta = 25°$ (L.S.).

For measurements at angles smaller than about $10°$, we have conclude that we need a magnetic channel, the construction of which we have requested.

## 12. AN EXPERIMENT ON THE $e^+ + e^- = 2\gamma$ ANNIHILATION (Annihilation)

**P.L. Braccini, G. Poiani [1], G. Torelli, R. Torelli Tosi, I.X. Ion**
**Institute of Physics of the University of Pisa**

This experiment intends to measure the total cross section of the annihilation process at energies of the order of $1000\ MeV$, to deduce an experimental evaulation of the contribution of radiative corrections and an indication on validity limits of electrodynamics at short distances [2].

This experiment is meant to be the first of a group of experiments designed to measure annihilation cross section at increasingly higher energies (CERN - Hamburg); due to the different dependance from energy of radiative corrections and of electrodynamic break-down effects,it is reasonable to predict the possibility of separating with certainty the two effects with three measurements at different energies.This would allow a fairly accurate check of the modern theoretical interpretation.

The experimental setup chosen for the experiment consists in a magnetic line that shapes the collimated beam of positrons or electrons and that momentum-selects them, and in a scintillation counter telescope that de-fines the beam in an annihilation target, followed by an anticoincidence counter, a sweeping magnet that eliminates charged particles from the $\gamma$ beam produced by annihilation, and finally by a total - absorbtion Cerenkov counter that allows measurements of the energy of the $\gamma$-rays to be made.

The counter telescope that precedes the target measures the

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(1) Institute of Physics of the University of Trieste.
(2) G. Andreassi, P. Budini, I. Rejna: Possible test of the validity of electrodynamics at short distances (Nuovo Cimento: *12*, 488, 159).

number of incident positrons; the annihilation event is recognized by the simultaneous occurrence of two facts: the absence of a charged particle in the counter immediately following the target and the arrival of a high energy $\gamma$ in the Cerenkov counter. Such a selection criterion needs a fairly fast electronics, if one wants to work with an incident particle intensity that is not too low; Furthermore, it specially requires a Cerenkov counter whose response spectrum at high energy $\gamma$ rays does not show noticeable tails towards the low energies.

Waiting for completion of the magnetic line, that will not be ready before March 1961, the electronics devices, as has been said in report n. 8, have been mounted behind the pair spectrometer and is nearly ready, although it uses a lead perchlorate Cerenkov counter, unsuited to measurements of this type. We have ordered some time ago lead-treated glass to build a Cerenkov counter with sufficient resolving power.

## 13. HELIUM BUBBLE CHAMBER

**E. Di Capua, U. Dore, G. Giallanella, P. Guidoni, J. Laakso [(1)], G. Moneti**
**Institute of Physics of the University of Roma**

A liquid helium bubble chamber, built by a group of the University of Rome, is a guest since May 1959 of the criogenic laboratory.

The chamber has been completed and successfully tested in the period between July and November, and is now being prepared for an exposition at the electronsynchrotron. With it we want to analyse the polarization of the proton from the $\gamma + p \rightarrow p + \pi^{\circ}$ process for $\gamma$ ray energies just above the first resonance.

The useful volume of the chamber is *4.2* litres, the repetition frequency is *1* expansion/second; consumption of liquid helium is of about *2.5 lt/hr*, of which *1.6 lt/hr* for radiant heat input and *0.9 lt/hr* for heat dissipated during the expansion cycle.

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(1) University of Turku, Finland.

## 14. PHOTOPRODUCTION OF *K* MESONS IN HYDROGEN WITH NUCLEAR EMULSION TECHNIQUES

**G. Baroni, A. Manfredini, M. Mucnik, I. Quassiati, M. Severi**
**Institute of Physics of the University of Roma**

We have made various expositions using $G_5$ and $K_5$ emulsions placed at about $38°$ respect to the direction of the beam, to determine the best conditions for background made by low energy $\gamma$ rays.

We have concluded that the best conditions were for expositions lasting about half an hour (60 pulses) at the smallest possible distance from the target (22 *cm.*). The emulsion chosen ($G_5$ and $K_5$) should allow the recognition of each *K* meson from the decay track (minimum ionizing) and to assign to each *K* the direction and the point of ist entry into the emulsion.

Scannings made on emulsions exposed under these conditions have allowed us to conclude:

- the background is already sufficiently high so as to prohibit us from recognizing the decay tracks in about 30% of the cases;
- to recognize the *K* meson with certainty, we must make ionization measurements on the tracks to separate the masses.

We have calculated the loss of information one encounters by not using minimum sensitive tracks and identifying the *K* meson from the length of its visible track.

We have seen that under these conditions the experiment is still possible and we are therefore exposing $K_2$ emulsions.

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