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Laboratori Nazionali di Frascati

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ACTIVITY AT THE NATIONAL LABORATORIES OF FRASCATI

July 1, 1964 - June 30, 1965

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INTRODUCTION

Study and experimentation in fundamental nuclear physics is the principal objective of the Frascati National Laboratories. Particular emphasis is placed upon the field of elementary particles. Until now most of the experimental work has been carried out at the 1100 MeV electron-synchrotron. The continual improvement and the extension of its capability is an important activity of the Laboratories.

The possibilities of experimentation of this machine have increased after the success obtained in extracting the circulating electron beam. Some experiments using the extracted beam have already started.

The construction of a large storage ring for colliding beams of electrons and positrons has been pushed forwards and its completion is foreseen for the fall of 1966. The maximum energy shall be 1500 MeV for each beam. This storage ring will lead to the development of a new and important area of research in elementary particles. The linear electron accelerator, having an energy of 450 MeV, which serves as the injector of the storage ring, will also be used as a source of intense electron and positron beams for the study of nucleon structure and to create an intense medium energy pion beam.

Fundamental research in different fields of physics are encouraged and supported. Research activities include low temperature physics, solid state physics, electronics and instrumentation.

In connection with the synchrotron and the new projects the Laboratories also carry out research in instrumentation and into technical problems.

The scientific and techinical activity of the Frascati National Laboratories are divided in the following groups:

1) High energy nuclear physics group
2) Adone project group (storage ring)
3) LEALE group (linear accelerator)
4) Machine group
5) Cryogenic group
6) Magnetic measurements group
7) Electronics group
8) Technological group
9) Health physics group
10) Computing group

1 - ELECTRON SYNCHROTRON OPERATION

In the period 1/7/64 - 30/6/65 the machine has been used by the experimenters for 5400 hours total time, with a 104h weekly mean. An average efficiency of 91% has been found by the experimenters; it refers to each experimental run, on the basis of beam intensity, stability, spill-out, etc. The machine operation in the above period is plotted in fig.1. During the first

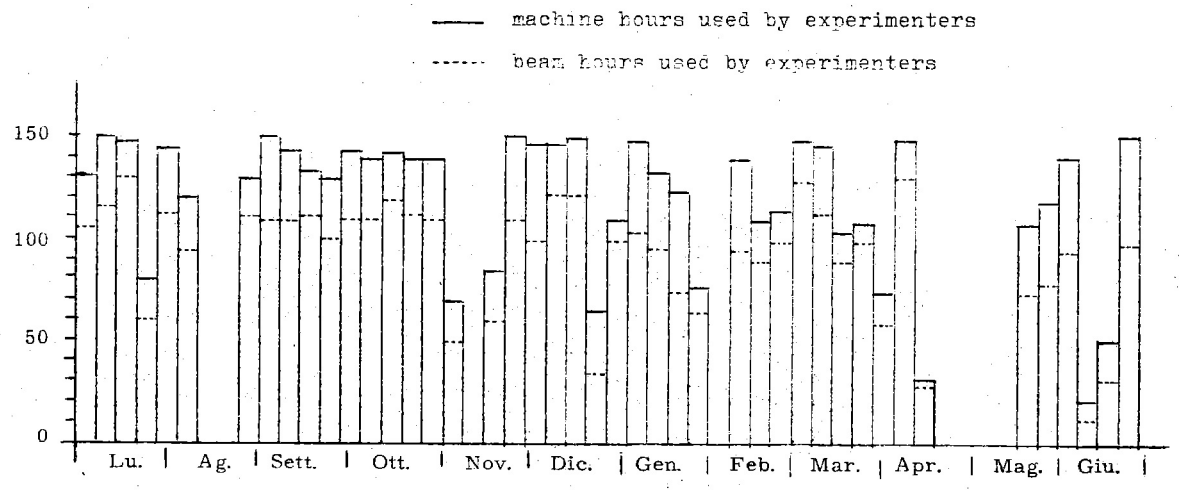


Fig. 1 - Machine functioning from 1.7.1964 to 30.6.1965

six months of this year, the machine stopped four times, owing to unidentified failures. The longest one happened in April, so that the magnetic and mechanical measurements, on the synchrotron magnet, could be executed.

The machine time utilization is reported in table I, while in table II the hours lost for failures are reported, subdivided according to the principal failure sources.

TABLE I

	hours	%
Experiments	5.400	62
Preparation of experiments	500	5,7
Machine-tests and maintenance	300	3,5
Conditioning and starting	300	3,5
Failures	1.000	11,5
Vacation and holidays	800	9,2
Strikes etc.	400	4,6
total	8.700	100

TABLE II

	hours	%
Network	40	4
Magnet	20	2
Vacuum	75	7,5
Injector	102	10,2
Radiofrequency	66	6,6
Beam Searching	665	66,5
Other kinds	32	3,2
total	1000	100

In the above period 14 experiments alterned in the machine work runs. The distribution of the experiments in the synchrotron room, till 30/6/65, in shown in fig. 2.

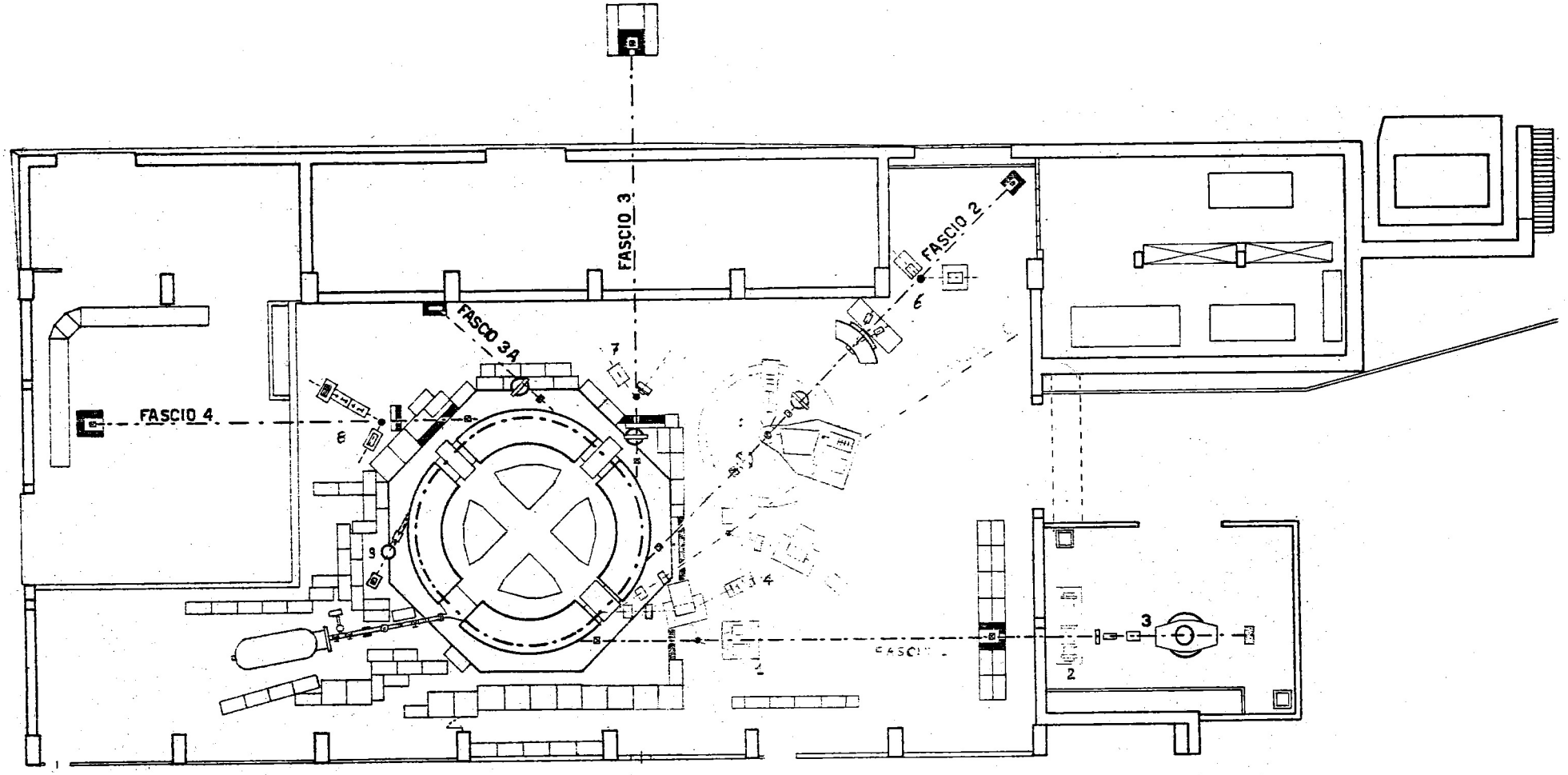


Fig. 2 - Synchrotron building. Experiments layout

The electron beam, extracted from the machine, is available in the experimental room since the first month of this year, besides the 5 usual γ beams. A magnetic channel is beeing studied to transport and utilize the external electron beam in a more convenient area.

Provisionally two quadrupoles and a small deflecting magnet have been settled, allowing the focalization and deflection of the beam, so that some experimental groups could start, preliminary tests in the experimental room.

2 - ACTIVITY OF THE GROUPS

2.1 - HIGH ENERGY GROUPS

The activity of the Frascati Laboratories in the high energy field, has been developed in the period 1.7.1964 - 30.6.1965 by several internal, mixed and external groups. The list of the internal and mixed groups is reported below, together with their activities reference being made to their relations in the single sections.

The external groups are the following:

- Determination of the momentum distributions of protons in nuclei
  INFN, Sottosezione Sanità (U. Amaldi, Cacciani, Campos-Venuti, Cortellessa, Fronterotta Hillman, Matthiae, Reale, Salvadori)

- Researches on H^4
  INFN, Sezioni di Napoli e Pavia (Argan, Piazzoli)

- Photofission cross section at several energies.
  INFN, Sezione di Napoli (Cortini, Muchnik)

- Λ^o Polarization in $\gamma + p = K^+ + \Lambda^o$
  INFN Sezione di Padova (Grilli, Mezzetti, Nigro, Schiavuta)

- Lifetime measurements of flying π
  INFN, Sottosezione Sanità (Ageno, U. Amaldi, Cortellessa, Fronterotta, Matthiae, Reale)

- Determination of the Synchrotron light spectrum
  INFN, Sottosezione Sanità (Missoni, French Group)

- Researches on radiactive isotopes photoproduced at high energy
  Istituto di Chimica Generale, Roma (Di Napoli, Dobici, Salvetti)

- Research of H^5
  INFN, Sezione di Napoli (Argan, Meneghetti, Vitale)

- Cross section for the photoproduction of charged pions in hydrogen
  INFN, Sezione di Roma (Beneventano, Paoluzi, Sebastiani, Severi)

- Photodisintegration and Photoproduction of π in H_e^3, by a diffusion chamber placed in a magnetic field

  INFN, Sezioni di Napoli e Pavia (Argan, Mantovani, Marazzini, Piazzoli, Scanicchio)

The internal and mixed groups are:

1) Photodisintegration of deuterium by polarized γ, about the first resonance.

2) Compton effect on protons by polarized γ

3) Polarization of the coherent bremsstrahlung beam of the synchrotron for photons of energy K = 150 MeV.

4) Photoproduction of the 550 MeV pionic resonance (η^o particle)

5) Frascati ω^o

6) Photoproduction of π^+ by polarized γ

7) Forward photoproduction of π^o in hydrogen

8) H_e^3 photodisintegration.

2.1.1 - *Photodisintegration of deuterium by polarized γ, about the first resonance*

G. Barbiellini, C. Bernardini, E. Felicetti, G. P. Murtas (Laboratori Nazionali di Frascati)

The experiment aims at the measurement of the asimmetry function $\Sigma(\theta, K)$ which determines the angular distribution of the planes of the disintegration products with respect to the polarization vector of the incident γ.

The apparatus consist of a range telescope for protons and of a liquid scintillator counter for neutrons: it reveals p - n coincidences at several angles θ in the mass center, and at several energies K of the incident photon (about the first resonance, that is in the energy range 200÷300 MeV).

The polarized γ beam is the one produced on the diamond crystal and the rotation of the polarization is obtained by crystal rotation.

The whole apparatus is ready and we foresee to start the measurement within August.

2.1.2 - *Compton effect on protons by polarized γ*

G. Barbiellini, G. Capon, G. P. Murtas (Laboratori Nazionali di Frascati)

During the period 1/7/64 - 30/6/65 the group has designed and constructed an experimental apparatus which measures che Compton effect on protons by polarized γ: $\gamma + p \rightarrow \gamma' + p$.

The polarized γ beam is produced following the monocrystal technique, developed years ago by Barbiellini, Bologna, Diambrini, Murtas. The experiment aims at the measurement of the branching ratio

$$R\sigma = \frac{d\sigma_{\parallel}}{d\sigma_{\perp}}$$

where $\sigma_{\parallel}$ and $\sigma_{\perp}$ indicate the cross sections for photons polarized, respectively, parallel and perpendicular to the reaction plane.

The experimental layout, shown in fig. 3, consists of a range telescope for protons, endowed with three spark chambers (two for the measurement of the direction and one for the measurement of the energy of the proton), with a Cerenkov integral counter, preceded by an anticoincidence counter, and with a spark chamber, made of Al-Pb-Al sandwich electrodes, to reveal the scattered γ.

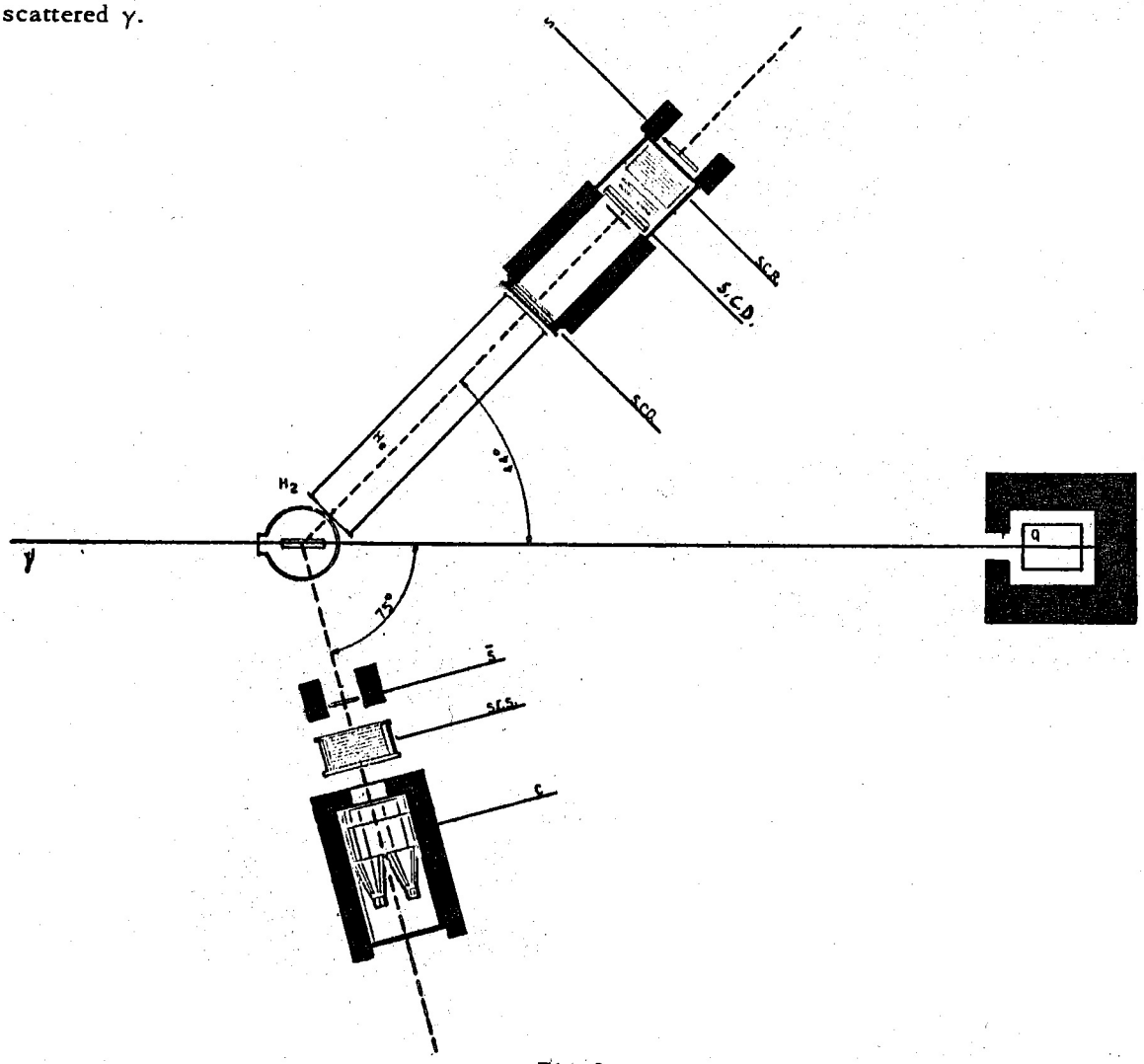


Fig. 3

The latter chamber converts about 75% of the incident photons in electron showers. The process under study may be distinguished from the background due to photoproduced π^o ($\gamma + p \rightarrow p + \pi^o \rightarrow p + 2\gamma$), by the angular correlation between the backscattered proton and the scattered γ.

At present the measurements are made for photon energy in the range 305-340 MeV, and at 90° in the C.M. The photon polarization p, in this range, is about 30%.

Preliminary results have been communicated at the Hamburg Conference (8-12 June 1965). They give a ratio

$$R_c = \frac{c_{\parallel}}{c_{\perp}} = 1.5 \pm 0.5$$

where $c_{\parallel}$ and $c_{\perp}$ are the registered counts for the two polarization states of the photons.

Therefore, being

$$R_\sigma = \frac{|P|\,(R_c + 1) + (R_c - 1)}{|P|\,(R_c + 1) - (R_c - 1)}$$

it is

$$R_\sigma = 3{,}9^{-2{,}6}_{+\ldots}$$

in the energy range

$$305 \leqslant K \leqslant 340 \text{ MeV}$$

The upper limit for R_σ is actually by undefined, due to error propagation, and to the poor statistics at our disposal.

The measurements are going on.

2.1.3 - *Polarization of the coherent bremsstrahlung beam of the synchrotron for photons of energy K = 150 MeV*

G. Barbiellini, T. Letardi, G. P. Murtas, R. Visentin (Laboratori Nazionali di Frascati)
G. Diambrini, F. Grianti (INFN, Sezione di Genova)

In February 1965, the group proposed an experiment to measure the polarization of the coherent bremsstrahlung beam of the synchrotron for photons of energy K = 150 MeV.

Previously [1], the group formed by Barbiellini, Bologna, Diambrini, Murtas, had already measured the polarization, looking at the angular distribution, projected on a vertical plane, of one of the electrons of the pair e^+ e^- (produced in an Al converter 10^{-4} r.l. thick of a pair spectrometer); and then integrating on all the emission angles of the other electron.

The present measurement is executed looking at the angular correlation between the pairs e^+ e^-. In this way a factor 1.4 should be gained on the measurement sensitivity. The experimental apparatus consists of a pair spectrometer, endowed with two large gap spark chambers (each one for each branch of the pair e^+ e^-), which allow to measure the energy of the photons with an accuracy $\simeq$ 0,4%, and the angles, projected on the vertical plane, with an accuracy $\simeq \pm 8^1$.

The measurements are being executed, and the films obtained are under study.

2.1.4 - *Photoproduction of the 550 MeV pionic resonance (η^o particle)*

C. Mencuccini, V. Silvestrini (Laboratori Nazionali di Frascati) and C. Bacci, G. Penso, G. Salvini (INFN, Sezione di Roma)

In the period 1/7/64 - 30/6/65, the group has executed measurements of differential cross section for the photoproduction in hydrogen of the η^o meson, in the energy range 850-1000 MeV of the incident photon, and at angles, in the C.M. system of the η^o, in the range $110^o \div 120^o$.

By the same experimental apparatus, and with the collaboration of M. Spinetti and B. Stella, we have also measured the cross section for the photoproduction of the π^o, in the energy range between the first and the second resonance, at angles of the π^o about 135^o in the C.M. The pre-

(1) G. Barbiellini et al. - Phys. Rev. Lett. 9,396 (1962).

liminary results of this measurements have been reported at the Hamburg Conference (June 1965). We plan to go on and complete, in the next future, the measurements of the cross section for the photoproduction of the η^0 and π^0 mesons, at several angles and energies, the technique being the one employed till now, by which a high energy resolution is available.

2.1.5 – *Frascati* ω^0

R. Del Fabbro (Laboratori Nazionali di Frascati); M. De Pretis, G. Stoppini (INFN, Sezione di Pisa) and G. Marini, L. Tau (INFN, Sezione di Roma)

We have completed the analysis of the data of the experiment

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

executed in Frascati.

The definitive results, submitted for publication to Phys. Rev., are not in agreement either with the prevision based on a purely statistical model, or on the theory of Cutkosky and Zachariasen, which considers the effect due to the nucleonic isobar P_{33}. The authors interpret this anomaly in terms of a π-π interaction in the final state, resonating at about 380 MeV.

2.1.6 – *Photoproduction of* π^+ *by polarized* γ

P. Gorenstein, M. Grilli, P. Spillantini (Laboratori Nazionali di Frascati) and M. Nigro, E. Schiavuta, F. Soso, V. Valente (INFN, Sezione di Padova)

We have completed a first series of measurements on the angular distribution in the reaction with linearly polarized photons

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

at the enrgy E_γ = 210, 225, 240 MeV and at the angles $\theta_{CM} = 45^\circ, 72^\circ, 88^\circ, 115^\circ, 145^\circ$.

Preliminary results have been comunicated at the SIF Congress (Catania, 1964) and at the Hamburg Conference (1965) and they are going to be published. At present a second series of measurements, in the energy range $R_\gamma = 240 \div 390$ MeV, is going on. The results of these measurements together with those of the preceding ones, will make possible a systematic phenomenological analysis of the process, by resolving it in its various production amplitudes.

Besides we plan to verify experimentally the theoretical models now existing, with a better accuracy than the one available from the experiments of photoproduction with unpolarized γ.

2.1.7 – *Forward photoproduction of* π^0 *in hydrogen*

R. Del Fabbro (Laboratori Nazionali di Frascati); P. Biggs, P. Braccini, M. Del Prete, L. Foà (INFN, Sezione di Pisa) and L. Tau (INFN, Sezione di Roma)

An experiment of single photoproduction of π^0 in hydrogen is in the initial stage.

Measurements will be made of the differential cross-section for the emission of π^0 at small-angles, in the energy range 500 ÷ 1000 MeV of the incident photon. The pions will be detected by using total absorption Cerenkov counters and spark chambers. The experiment is interesting because besides giving accurate measurements in a region of angles and energies

where only few experimental data are available, it allows the possibility to show the eventual existance of a nucleonic isobar in the state P_{11}, of which vague experimental evidence has been found in other laboratories.

2.1.8 - *He^3 photodisintegration*

C. Schaerf, R. Scrimaglio (Laboratori Nazionali di Frascati) and P. E. Argan (INFN, Sezione di Napoli)

The experiment aims at the measurement of the differential cross-section, at 90° in the C.M., for the process

$$\gamma + He^3 \rightarrow p + D$$

for γ energies between 100 and 400 MeV.

The experimental apparatus consists of a liquid He^3 target and of two indipendent channels to detect the proton and deuterium. Each channel consists of five spark-chambers which measure angles and range, and of two scintillation counters in coincidence, which cover an angle of 0,25 sterad.

The present stage of the experiment is:

a) Target: the cryogenic group is completing the tests before setting it in the synchrotron room.

b) Detection apparatus: measurements have been made on spark chambers to define the efficiency both total and for single gaps. The electrical chains for the triggering, and for recording the events are going to be completed and tested with the collaboration of the electronic group.

2.2 - ADONE PROJECT GROUPS

F. Amman, R. Andreani, M. Bassetti, M. Bernardini, A. Cattoni, R. Cerchia, V. Chimenti, G. Corazza, D. Fabiani, E. Ferlenghi, P. Giacalone, M. Greco, L. Mango (till 31.12.1964), A. Massarotti, C. Pellegrini, M. Placidi, M. Puglisi, G. Renzler, S. Tazzari, F. Tazzioli e A. Tenore.

During the year 1964-1965 the design of the various components of the ring has been completed, and most of them are now being constructed.

Referring to the previous, exposed in the Report N. 14, the work has suffered some delays: in the second semester of 1964, because of the non allowance of the requested funds, and in the first semester 1965, owing to syndical agitations.

The activity of the groups in the period 1.7.1964 - 30.6.1965 may be so summarized.

2.2.1 - *Machine theory*

The study of the instabilities of the electron and positron beams in presence of metallic walls of finite conductivity has been developed (with the collaboration of prof. B. Touschek). The study of the properties of ultrarelativistic electron beams at very high density has started; because of the difffculties in the calculations, we do not have too many hopes to obtain useful informations. A program is being developed on the IBM 7040 computer (with the collaboration

of the numerical calculus group) which allows to evaluate the errors of positioning and of gradient, which are tolerable in the magnetic transport channel injector-ring. The study of the effects on the luminosity of the electromagnetic interactions between the crossing beams has started agains, aiming at the evaluation of the contribution from density fluctuations.

Besides we are analyzing the possible monitor reactions; till now, in this field, nothing more than a tentative theoretical work has been made.

2.2.2 - *Linear accelerator*

The tests on the LINAC have been started at the Varian (Palo Alto, California), in September 1964; the tests on the beam started in December 1964 and have been completed in April 1965. Just as foreseen, the four high current sections, the $e^- - e^+$ converter, and one of the eight high energy sections have been settled in the test tunnel.

Results concerning both e^- and e^+ beams, are satisfying; with particular reference to positrons, a peak intensity has been achieved, which corresponds to a conversion coefficient of $7 \cdot 5 \times 10^{-3}$ (primary beam energy 80 MeV), in a total energy band of 10 MeV out of 45 MeV (50% of the current is at 2.5 MeV).

In April the accelerator settlement started at Frascati: till 30.6.1965 all the accelerating sections were positioned (see fig. 4), together with a large part of the supply and control apparata. Tests with the beam should start at the end of August.

2.2.3 - *Magnet and supply*

On the basis of our draft design, the firm furnishing the magnet has developed the detailed construction designs, conforming to its own fabrication standard. Such designs were controlled and accepted by us. The furnishing firm having got ready all the equipment for the production cycle, started, on the last decade of June 1965, the construction of prototypes. Within the end of July 1965 a complete quadrupole and a standard meter of bending magnet should be ready. We will perform the magnetic and mechanical measurements on them.

In the first months of 1965, we completed the design and the technical specifications of the whole equipment accessory to the magnetic structure. It includes, in particular, the bases, for which tenders have been requested.

The design of the mechanical equipment was completed, and its construction has started in our work shop. Some optical instruments, necessary for the above alignment, have been bonght.

We terminated the analysis of the possible solutions for the magnet power supply plant: the preference has gone to static generators realized with controlled silicon rectifiers (thyristors). The plant will comprehend two transformers, with underload voltage control, one feeding the rectifying cells for the bending-magnet circuits, the other those for the two independent circuits of the focalizing and defocalizing quadrupoles. It should be ready at the end of March 1966.

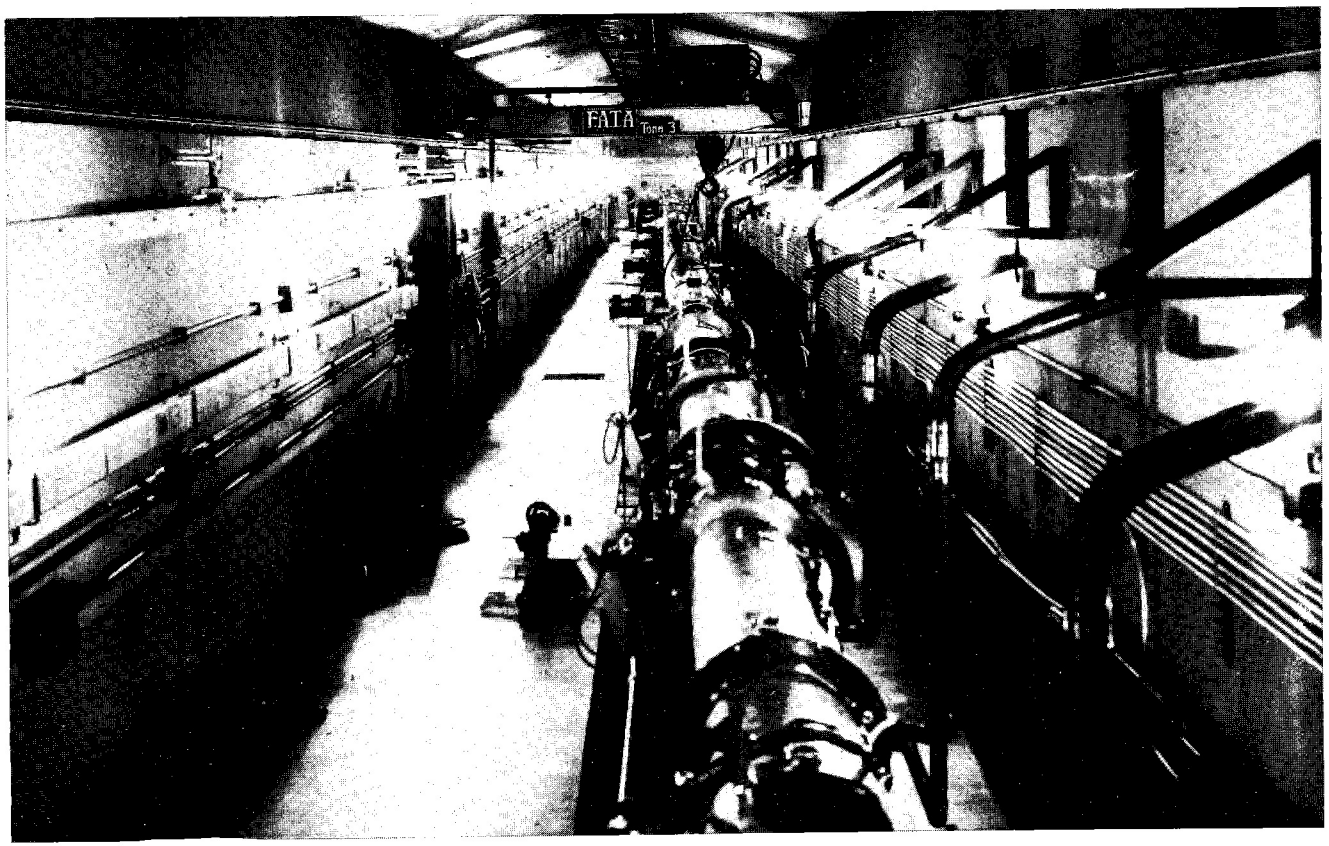


Fig. 4 - Linac tunnel (August, 1965)

2.2.4 - *Magnetic Measurements, Optics and Instrumentation*

The whole apparatus for the magnetic measurements, on the magnet and quadrupole prototypes, has been designed and realized.

The transport channel injector-ring has been completely designed (in a way slightly differing from the previous one) and now is in the executive design stage. We have applied to some national firms for the realization of the stabilized power supplies. Two spectrometers for the energy analysis of the Linac beams have been designed and are now being constructed: one to be placed at the end of the high current section (100 MeV), the other at the end of the Linac (450 MeV).

The detecting systems, to be coupled with the spectrometers, are in an advanced construction stage, together with other detectors of total intensity. Besides, a 500 MeV Faraday cup is being constructed, for the absolute measurement of the accelerated current, with errors less than some %.

At present, at the Electronic Laboratory of Casaccia, a complex plant for authomatic data collection, with controls and alarms, to be associated to the ring magnet and to the transport channel is in the executive design stage: it will allow the control of 300 informations of temperature and water flows of the cooling circuits.

2.2.5 - *Vacuum*

We have carried on the studies on the outgassing of the second vacuum chamber prototype which is $1/24^{th}$ of the whole chamber by a moderate warming (of the order of 150° C) we could get a final pressure in the 10^{-11} torr scale.

We have completed the experiment on the gas desorption out of the vacuum chamber walls, due to synchrotron radiation; the final results will be reported at the III International Vacuum Congress (Stoccarda, 1965).

The designes of both the chamber and of the vacuum plant of the machine have been totally defined: the interested firms have been addressed the tender requests for the supply. We have developed a ceramics metal soldering technique, which has given positive results on small pieces. In the next future it will be so developed to allow the laboratory to realize special prototypes of pass-by, which might be necessary for the vacuum chamber.

A detailed study on adsorbing pumps, designed and constructed in our laboratories, has allowed to establish the operation characteristics and the possibilities of use as preliminary pumping system.

2.2.6 - *Deflector*

We have completed the low power tests (magnetic field = 200 gauss) on the modified deflector model. After this the prototypes of the several plant components have been constructed (variable delayers, triggering circuits, trigatron, principal spark-gaps, joints for the coaxial forming line, adapting resistor, deflector protecting resistor). To realize a complete plant, which at present is being assembled.

Within the year it is our purpose to complete the tests on the pilot plant at the operation voltages (100 KV), and to establish consequently all the components of the final plants.

Besides a test circuit is being assembled for the stabilization of the H.V. generators, which supply the pulse forming circuit and the principal trigger circuit. Finally we are designing the servo and protection circuits for the final plants.

2.2.7 - *Radiofrequency*

During this year we have completed the design of the radiofrequency plant: four amplifying chains will be installed, together with four resonating mono-gaps cavities, each operating at 50 KV.

We have studied, constructed, and realized the prototype of the following branch of the plant: pilot, amplifying chain and final amplifier. It has been tested on a resonator which had been constructed for the preliminary tests. We are carrying on the studies to determine the mechanical structure the most apt to test the definitive cavities.

We have started the construction of the definitive plant and developed a new method to measure the high voltages present in the resonant cavity gaps. We have studied the authomatic control system for the phase of the accelerating voltage of the resonators, which is now under test.

2.2.8 - *Building and conventional plants*

At the and of January 1965 the LINAC building was ready, so that the accelerator assembling could start. The works for the electric cabin (60 KV - 10 MW) have gone on: the buildings work is almost terminated, while the plants will be completed within September 1965 (see fig. 5).

The superheated water heating plant which will feed all the buildings of the new area, has been completed together with the distribution pipes.

The Adone Laboratories have been completed and the group occupied them since about 15 June (see fig. 5).

The construction of the ring-building started in February 1965, and will terminate in February 1966 (see fig. 6).

The work of external settlement of the new area has gone on (streets, squares, enclosing, accesses etc.).

We have already referred to the next activity; summarizing, we foresee the finishing of the machine parts, now in construction, within June-July 1966. In the same period the settlement of the magnet and of the beam transport channel should be accomplished. The first tests with electrons in the ring should start in autumn 1965.

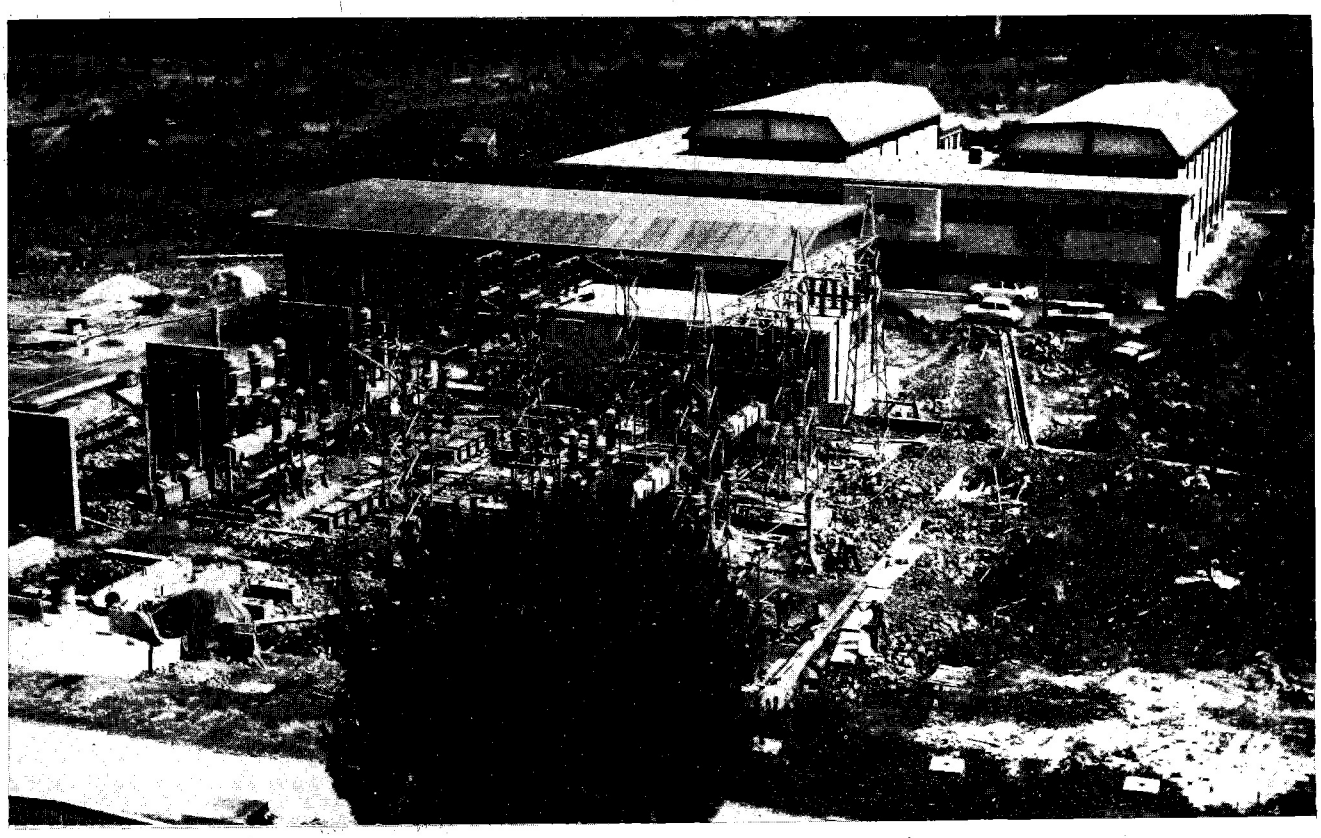


Fig. 5 - Power station and laboratory building (August, 1965)

Fig. 6 - Storage sing site (August, 1965)

2.3 - LEALE GROUP

(C. Castagnoli, C. Schaerf, R. Scrimaglio)

The activity of the LEALE group (Laboratorio Esperienze Acceleratore Lineare Elettroni) has developed in three directions:

a) realization of the executive design of the pion laboratory;

b) beginning of the design of the high energy electron laboratories;

c) preparation of expetimental techniques such as magnetostriction chambers.

As to point *a)* we have developed the design of the optics from the output of the Linear Accelerator, as for as the converter $e \rightarrow \gamma$ and the radiator $\gamma \rightarrow \pi$, together with the optics for the analysis of the pion beam.

All the magnet have been designed, while the coils and iron have been requested. We started the operations to buy the converter groups. A tentative design of the vacuum plant has been developed, and a preliminary arrangement has been established for the several components (collimators, radiators, detecting systems, vacuum and prevacuum etc). We have asked several industrial firms the offers relative components we have started the construction of the prototypes.

The construction design of the buildings have been completed:

1) Pion laboratory

2) Electron shunting room

3) Generator room.

As to point 2) we have established the general characteristics of the transport optics and beam analysis. We have made a tentative study for the experiment room and for the settlement of the accesses and services.

2.4 - MACHINE GROUP

Besides the normal activity concerning the machine operation and the necessary maintenance works, the research activity already started has been carried further on:

2.4.1 - *Microtron*

(U. Bizzarri, A. Vignati).

The realization of this machine slowly developed, the group activity having been mostly devoted to study and realize the beam extraction from the electronsynchrotron.

However we could settle a magnetron which allowed to accelerate the electrons cold-extracted from the cavity walls, up to 4,5 MeV energy, with a final current of about 0,5 mA peak value.

At present we are studying the source and the necessary apparata to realize the thermoionic injection and to increase the machine intensity.

2.4.2 - *Beam extraction*

(U. Bizzarri, M. Conte, I. F. Quercia, A. Turrin).

In november 1964, for the first time, the electron beam was extracted from the electron-synchrotron at the energy of 400 MeV. In February 1965 the beam was extracted up to the maximum 1000 MeV energy. At present the beam is extracted up to 600 ÷ 700 MeV at 20 pulses/sec, while for higher energies, up to 1000 MeV, it can be extracted with a maximum frequency of 10 pulses/sec, owing to the limited power of actual supplies and extracting magnets. Higher power supplies are being constructed together with a magnet, by which it will be possible, within next October, to extract the beam up to 1000 MeV, with a frequency of 20 pulses/sec.

The intensity of the extracted beam, at the exit of the focalization channel, is about 5×10^8 electrons/pulse.

It should increase up to 10^9 electrons/pulse, through the modification of the focalization and extraction magnetic channels. The emittance is horizontally less than 10^{-2} cm/rad and vertically less than 3×10^{-3} cm/rad.

2.5 - CHRYOGENIC GROUP

The research activity followes two main directions; liquid helium physics and the double resonance.

2.5.1 - *Liquid helium physics*

(P. De Magistris, I. Modena, A. Savoia, F. Scaramuzzi).

We have continued the measurements of ionic currents in rotating superfluid He^4. In particular, we have executed the measurement of the positive ion mobility against temperature and rotation speed.

The relative preliminary results have been reported; in September 1964, at the «IX International Conference on low temperature Physics» (Columbus, U.S.A.).

At the same Conference, the results obtained in the measurement of the ionic mobility in liquid He^3, extended up to 0.39°K, have been reported. In this field the measurements are extending toward lower temperatures, and different liquids such as Ne(*).

2.5.2 - *Double resonance*

(V. Montelatici, G. Baldacchini, P. Bounin)

The studies on the double resonance (+) phenomenon have gone on. A microwave bridge at the frequency of 24 Gcps was tested and employed to detect the resonance test samples. We have grown crystals of La and Mn double nitrate doped with impurities (see fig. 7).

(*) I. Modena, Relation at the SIF Congress (Catania, 1964).

(+) V. Montelatici «Trattazione termodinamica della temperatura di spin e di reticolo», Relation at the SIF Congress (Catania, 1964).

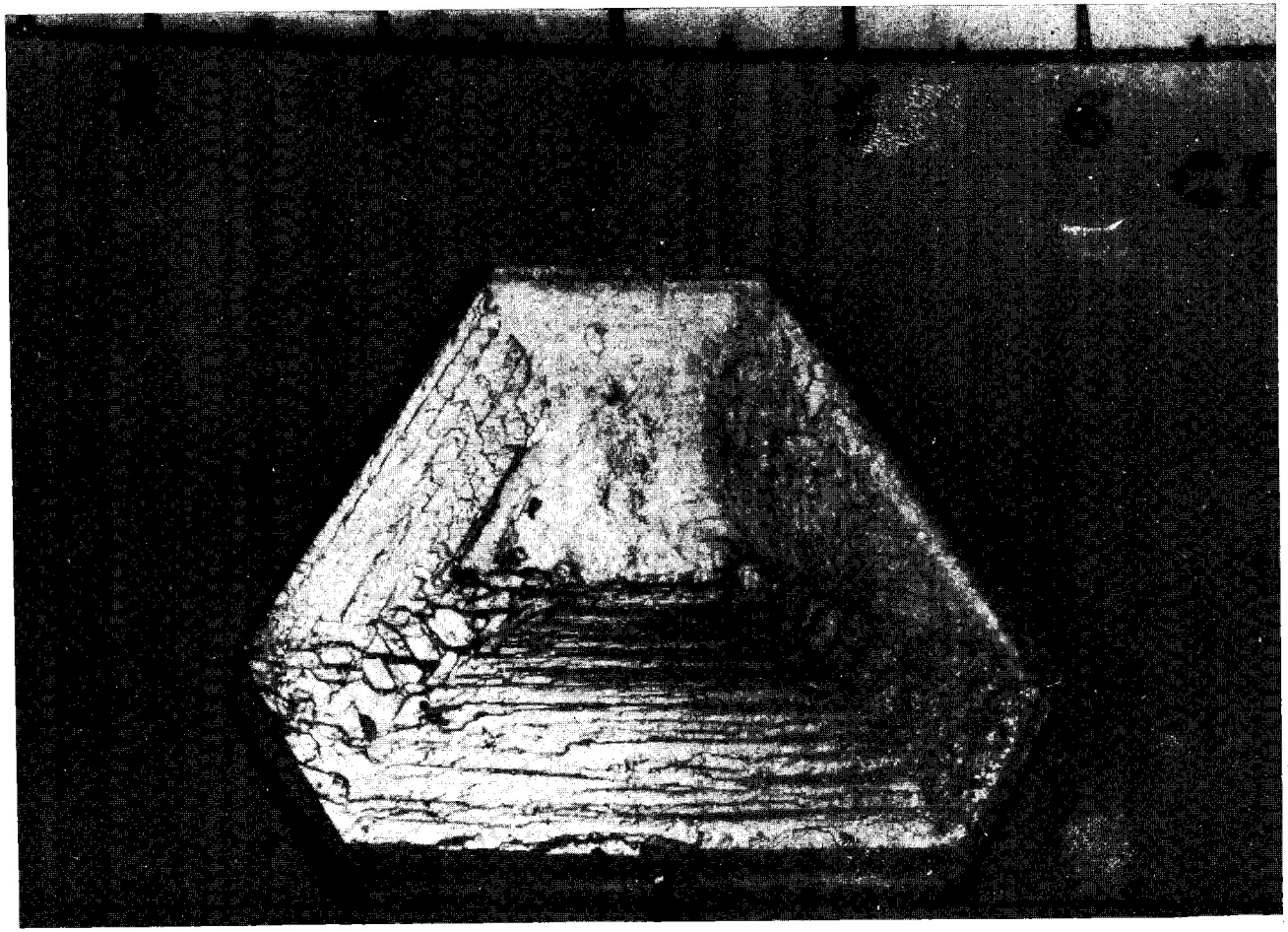


Fig. 7

The apparatus works at low temperatures (1°K ÷ 4°K). We have executed a preliminary experimental study on resonant cavities and, in particular, on their coupling, which we made variable, to the feeding line. In this way we could execute a measurement of the superficial impedance of the cavities, employing a dynamic method based on confronting the reflected power from the cavity with the incident one.

In fig. 8 we report the theoretical curve of the Q factor versus the temperature, together with the experimental points (with their errors) of a cilindrical cavity, oscillating in the lowest transverse electrical mode(+); the internal surface of the cavity was coated with electrically deposited Sn, the nominal purity of which was 99%, and resonated at 22,99 Gcps.

Finally, we made a theoretical study of the possibility of executing an experiment of electron-polarized proton scattering(*).

The service and technological research activities are the following:

a) *Cold targets for the electronsynchrotron*

We have developed and succesfully tested a target consisting of a liquid He^3 cell with liquid N_2, N_2, He^4 refrigeration. We obtained the following values for the chryostat autonomy: liquid N_2 about 1 week; liquid He^4 at 4.2.°K $\simeq$ 4 days; liquid $H_2 \simeq$ 1 week; liquid He^4 at 2.5°K > 1 day.

Together with the normal service activity, concerning the operation and maintenance of the operating targets and the realization of new cells requested by experimenters, we have begun to study cold targets of fast construction.

b) *Assistance on low temperature problems.*

We started a collaboration with the laboratory of conversions of the CNEN, to realize a source of gaseous He with a purity better than 50 parts per million. We have designed and realized a device to purify He^3 of T_2 up to one part in 10^{14}, which is now under test. Such He^3 should be emploied in the diffusion chamber of the Genova group.

c) *Production and supply of liquified gases.*

The numbers for this year follow below:

Liquid Helium	3110	lt
Liquid Hydrogen	1034	lt
Liquid Nitrogen and Air	40000	lt
Bought liquid Nitrogen	92000	lt

(+) G. Baldacchini, V. Montelatici, «Misure di impedenza superficiale a 23 Gcps, a basse temperature (to be published).

(*) P. Bonnin, «Proposta di esperienza con una targhetta di protoni polarizzati per verificare la velocità dell'approssimazione di Born nella diffusione elastica elettrone-protone (To be published).

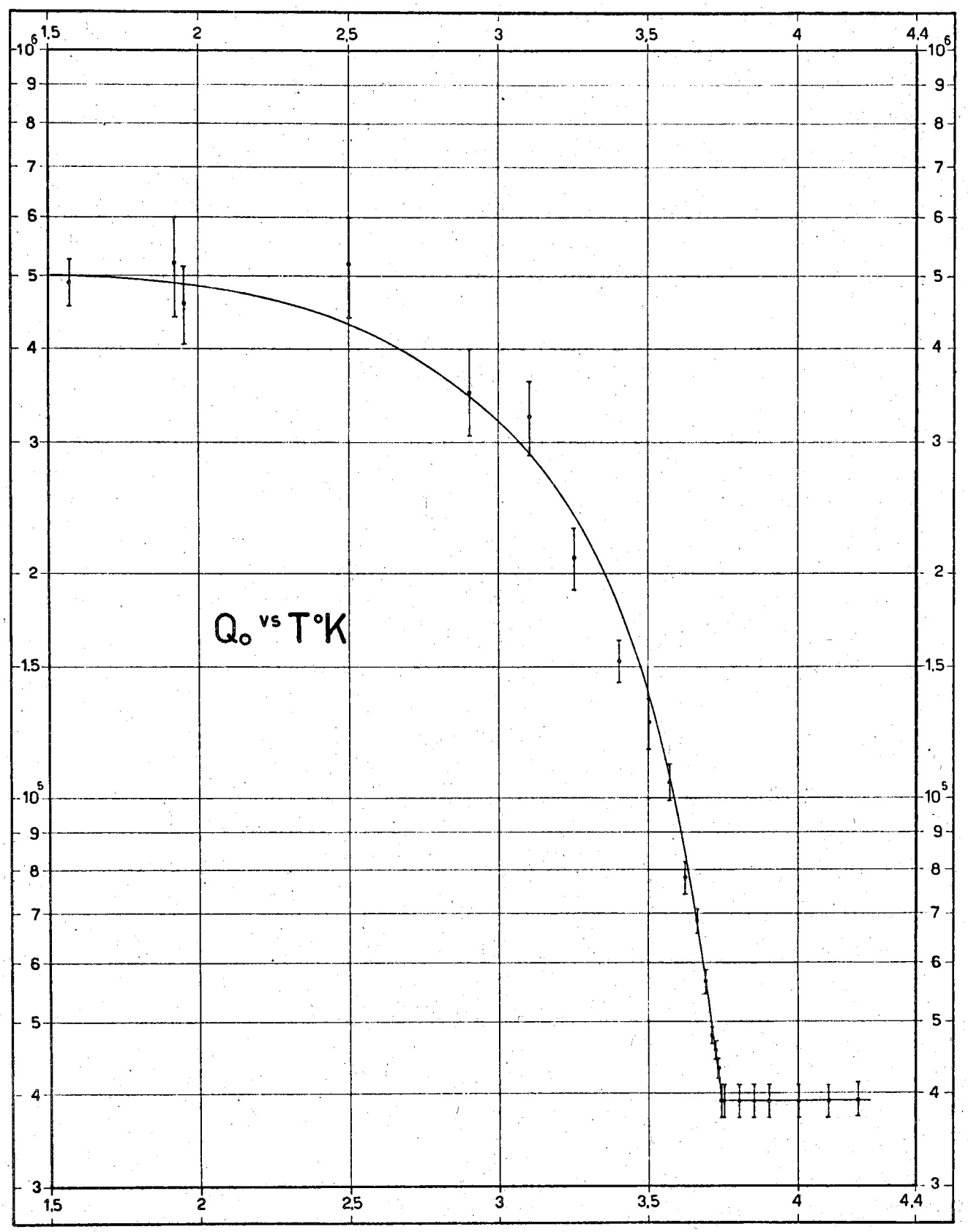


Fig. 8

2.6 - MAGNET EXPERIMENTAL GROUP

The activity of the Magnet experimental group develops in the following directions:

1) Physical research activity
2) Applied research activity
3) Service activity.

2.6.1 - *Physical research activity*

(G. Sacerdoti, G. Sanna, A. Susanna).

The Physical research activity has developed on the following arguments:

a) *Superconductivity studies.*

We have completed the measurements of the superconductive currents, decaying in soft superconducting rings which have been exposed to radiation, and we published the results (65/3). We have considered the possibility of studying the kinetics of the transitions between normal superconductive currents, by a microwave technique by the introduction of persistent currents on the walls of a superconducting wave guide (see fig. 9), produced applying circularly

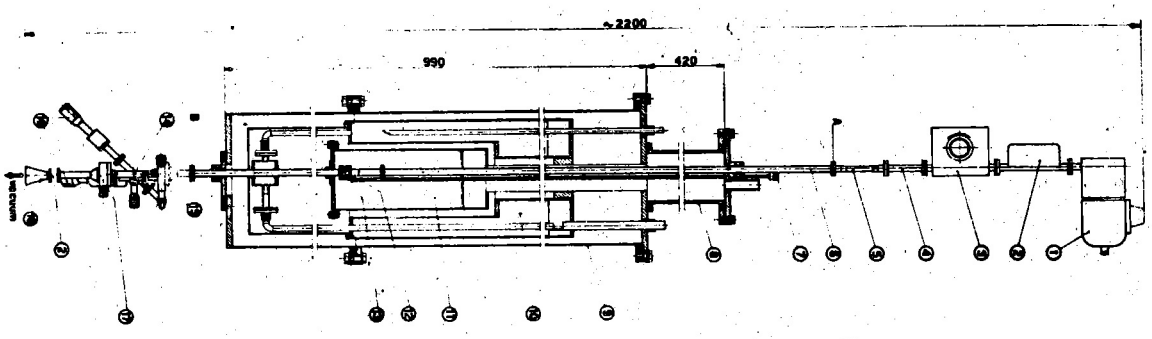


Fig. 9

polarized waves (65/15). After useful discussions with Prof. M.H. Çoen, we have started the construction of the experimental apparatus, with the collaboration of the Selenia firm which is interested in the experiment.

b) *Tunnel effect.*

We have developed a technique to measure the tunnel effect between superconductors: with the actual apparatus we can detect the influence of the superconductive currents on the energy gap, within films.

c) *De Haas - Van Alfen effect.*

At present a group from Catania University contributes to this experiment, which has started at the magnet group.

A technique of field modulation, with synchrotrons detection, has been developed. Till now we have worked on bysmuth crystals at low fields (600-700 gauss) and in the temperature range from 1.1 to 4.2° K (see fig. 10).

MONOCRISTALLO Bi

$T = 4.2\ ^{o}K$

$t_f - t_i = 89$ sec

$\left\langle \frac{dhs}{dt} \right\rangle = 46$ G/sec

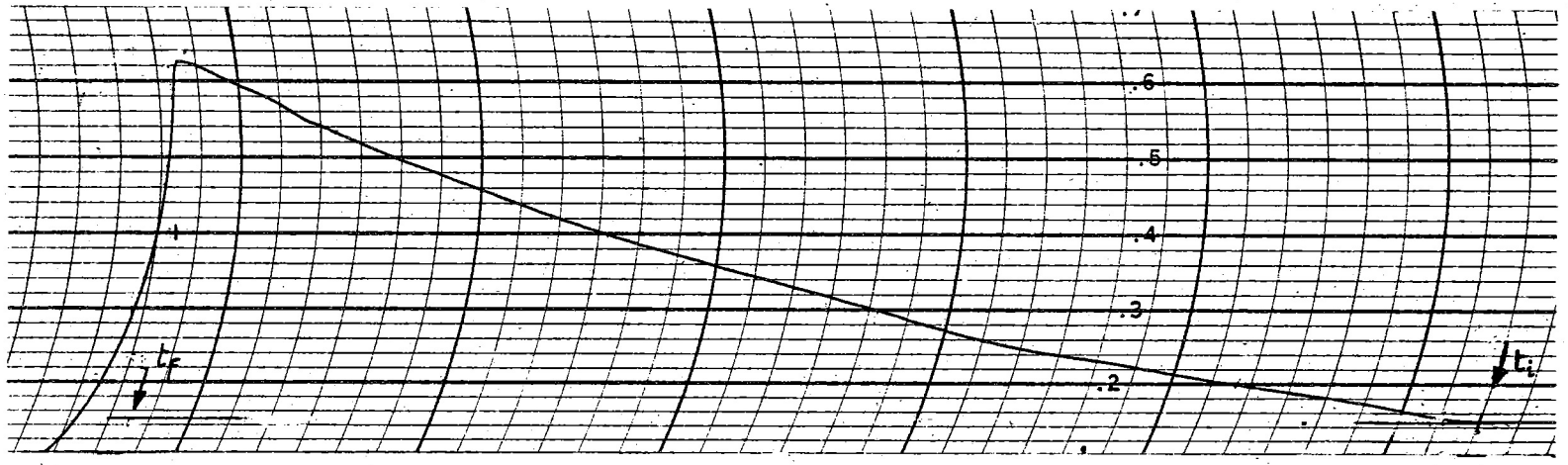
$h_0 = 45$ G

$hs_{min} = 1535$ G

$\tau = RC = 0.03$ sec

$\nu = 50$ Kc/s

$hs_{max} = 5590$ G



TEMPO (1 div. piccola ≙ 2.66 sec)

CAMPO PRINCIPALE (hs)
(1 div. piccola ≙ 168 G)

TEMPO (1 div. piccola ≙ 2.46 sec)

SEGNALE USCITA
RIVELATORE SINCRONO
(1 div. piccola ≙ 0.2 mV ≙
≙ 2.6 μV ingresso)

Fig. 10

A device has been constructed to change the crystal orientation in the magnetic field in the dewar, the aim being to study the anisotropy of the effect. We are starting tests to detect possible oscillations, of the De Haas-Van Alfen kind, of the counting speed of γ pairs from positron annihilation in monocrystal placed in a magnetic field. The ideas of this experiment and experimental apparatus design, have been developed with the collaboration of the Catania University.

d) *Measurement of the lattice relaxation time by Faraday effect (see fig. 11).*

This experiment has started with the collaboration of the Maser-Laser enterprise of the CNR and of the INFN section of Pisa, under the responsability of Prof. Toraldo di Francia,

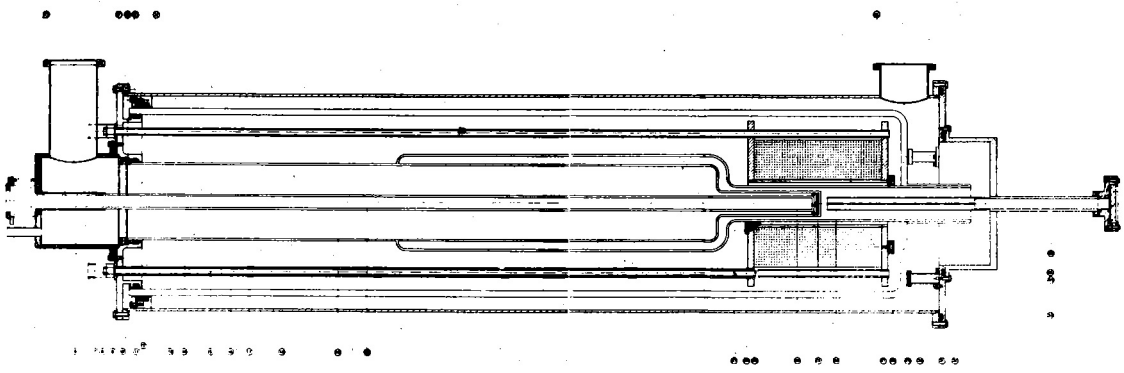


Fig. 11

whom the magnetic group gives an essentially technical assistance. We have made measurements of the Verdet constant of Neodimium glass in stationary fields, and have arranged an apparatus to start test in pulsed fields.

2.6.2 - *Applied research activity*

(G. Pasotti, N. Sacchetti, G. Sacerdoti, G. Sanna, A. Susanna).

a) *Metallization banc*

The metallization banc constructed in the preceding year has been ulteriorly improved and now we can make toroidal rings alterning layers, of variable thickness, of two different metals, according to a prefixed program.

b) *High field pulsed magnets.*

We have constructed solenoids, to be used in experiments on the Faraday effect, which can work at low temperature and be fed by the condenser banc now working. We plan to study a pulsed magnet, with coils made of a high mechanical resistance alloy, and insulated by alluminium oxide, by which we expect to get fields of about 1 MGauss.

c) *Superconducting magnets.*

Small superconducting magnets have also been constructed, to be used in experiments and in tests on materials.

d) *Coils of anodized Al.*

We have started tests for the construction of the coils of the Leale group magnets, with the collaboration of the Experimental Institute of Light Metals, to realize the insulation by anodization. This insulation process seems to work better in presence of radiation.

2.6.3 - *Service activity (the whole group).*

The group has been very much engaged in designing: the magnets (see fig. 12) and the supply systems; the settlement of the experimental room of the linear accelerator; the plan of the magnetic measurements; the flussometer, coodinatometer, and the thread-odoscope, necessary to calibrate the above magnets. Besides, we are designing a high field cryogenic magnet, which will be employed by the MPD group of the Ionized Gases Laboratory. Finally, we are constructing quadrupoles for the electron beam extraction from the electronsynchrotron.

2.7 - ELECTRONIC GROUP

(B. Bertolucci, M. Coli, C. Dardini, F. Pandarese, R. Rizzi, R. Visentin).

2.7.1 - *Fast counting chain*

We have completed the 100 Mc/Sec counting chain, which now is being tested at the electrosynchrotron. To make it work in the operative conditions, we had to overcome problems of compatibility, overload at the input, and protection against overvoltages produced by the presence of spark chambers.

The chain consists of the following modules (for their characteristic see the references):

a) fast coincidence (SFER Elech: Nucl. 63-73119)
b) fast discriminators (64/37, Nuovo Cimento SIF. 1964).
c) 200 Mc decade (65/19)
d) 35 Mc decade (Internal report, Electronic Group)
e) linear gate NIM 34 (1965)
f) linear gate with fast and polarized output
g) 5 outputs fan out circuit with input limiters.
h) linear amplifier (65/14)

2.7.2 - *Flight time measurements*

(C. Dardini, A. Villalba, R. Visentin).

We have realized a circuit which measures times of flight in the range $0 \div 100$ ns, exhibiting a high stability and a resolution F.W.H.M. of 130 psec (with photomultiplier).

2.7.3 - *Analysis of spark chamber photos*

(B. Bertolucci, M. Avaltroni, F. Pandarese).

We have designed an analyzer of spark chamber photos (64/51). A reading apparatus for large gap spark chamber photos has been built.

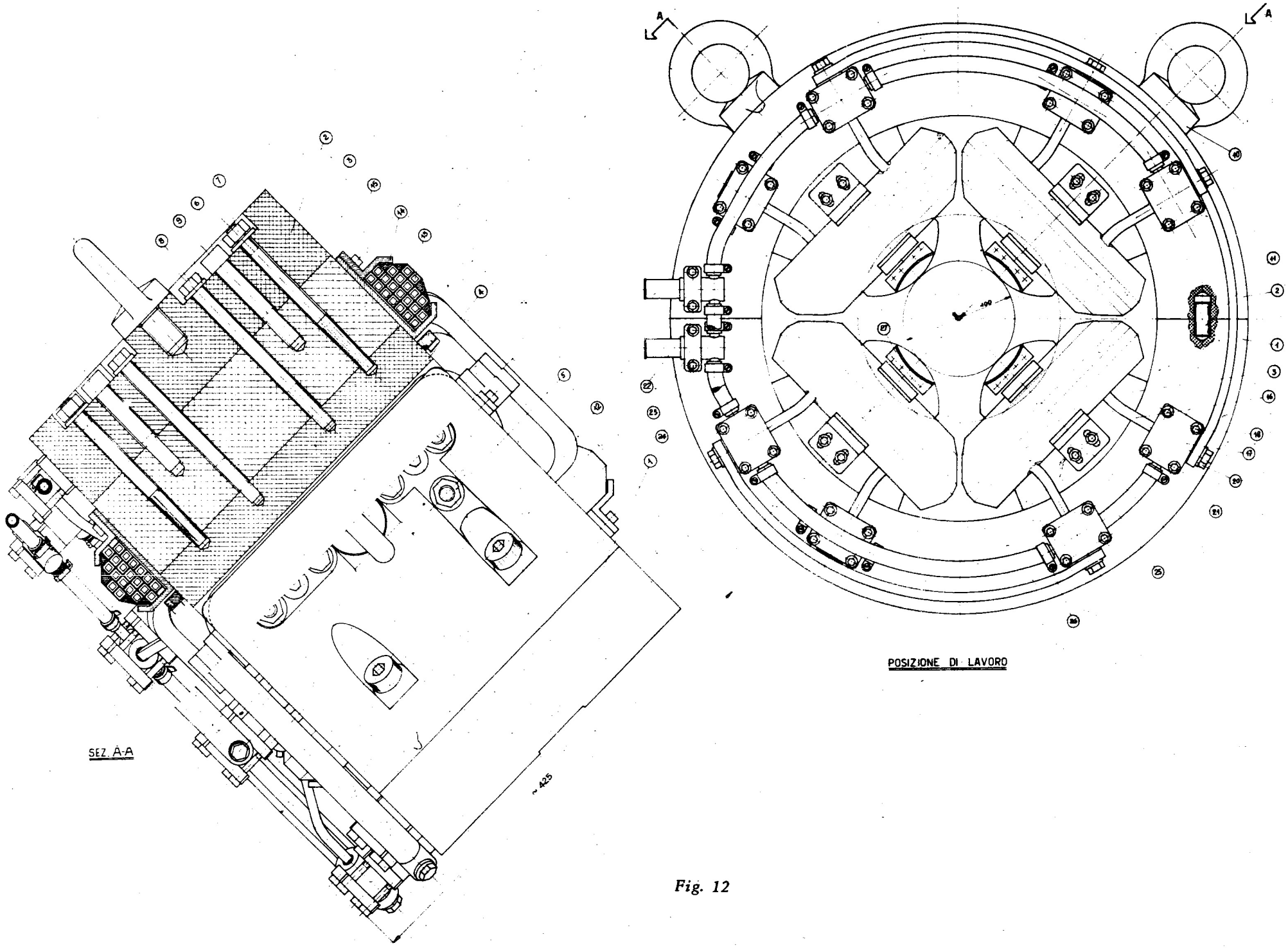


Fig. 12

It employes a multichannel as memorizing unit and data output. By such a reader we have studied the influences on the spatial resolution produced by such factors as contrast and film type.

2.7.4 - *System for automatic acquisition and presentation of data (S.A.D.).*

(B. Bertolucci, S. Lupini, A. Villalba, C. Dardini, R. Visentin).

We are completing a system for the acquisition and presentation of experimental data. It consists of the following parts:

a) Input unit: It consists of a memory with ten input channels, each being capable to count up to 10^4. Each channel may be connected in series with one or more of the others, so as to increase the counting capacity for that channel.

b) Central unit. The informations from all the input channels go in it through a triggered electronic selector.

c) Output unit. It consists of a conversion system from the binary (1242) to the decimal system, which allows to trigger the visual presentation on NIXIE, the numerical one on H.P. press, and the analogical one on the scope. The machine may be triggered in the following three ways:

a) totally manual
b) totally automatic
c) semiautomatic.

2.7.5 - *Special circuits*

(C. Dardini)

a) We have realized an amplitude to time converter which analyses pulses from 0.5 to 6 Volt.

b) For the Machine Group (beam extraction) we have studied the operation of controlled diodes, to get current pulses up to 3000 A, and 5 msec duration, to feed the magnets for the beam extraction.

c) We have designed a 600 A current pulser, employing power transistors, which now is being constructed.

d) Three higher stability delay circuits (from 12 to 35 msec) have been realized to trigger the current pulsers.

2.7.6 - *Stabilized current feeders*

(M. Avaltroni, M. Coli).

On request by Adone Group, two prototypes of current feeders have been constructed They have a current stability of 10^{-4}, and can supply respectively:

0-30 A with voltage up to 35 Volt (1 KW);
0-200 A with voltage up to 50 Volt (10 KW).

The above feeders are self protected against overwarming. The stabilization is complete

for a variation of the A.C. supply within ± 20%, and for a 100% load variation. Outside these ranges of variation the control is performed by a servo system.

At the end, the electronic group services have developed along the following principal activities:

a) electronic assembleing

b) maintenance, instrument repair

c) printed circuits.

The fast circuits of three counting chains to be used in experiments (60 circuits) have been assembled on modular units according to the ESONE Standard.

Logical circuits for experiments, fiducial mark trigger, film advancing systems, containers with feeder for the ESONE standard, spark gap triggers have been assembled. Besides, the service section has worked for the realization of the prototypes of both the S.A.D. and the current feeders.

In the printed circuit Laboratories, together with plates for the electronics of the experiments (about 10 m^2 by galvanic treatment) they have made other works, such as photoinversion or reticle incisions for spectrometers and spark chambers.

The instrument maintenance service performed about 450 repares, with the collaboration, in some cases, of external firms.

2.8 - TECHNOLOGICAL GROUP

(L. Bartolini, R. Habel, T. Letardi).

2.8.1 - *Monogap spark chambers*

(R. Habel, T. Letardi, R. Visentin)

In this period we have worked to improve the electrical characteristics of a H.V. pulser of the Marx kind, which feeds the spark chambers. We have realized an 8 stage pressurized, pulser, exhibiting the following characteristics:

Output capacity:	70 pf
Pulse amplitude:	50 ÷ 160 kV (variation being achieved by chaing of the pressure)
Rise time:	< 3 ns
Jitter:	< 3 ns
Dimensions of the cylindrical container	diameter 20 cm height 20 cm

We have performed a series of measurements on formation times of the sparks, at several values of E/p. Besides we have measured the shift of the spark from the primary track when the latter is inclined with respect to the electric field E.

2.8.2 – *Image converters*

(R. Habel, T. Letardi)

Another stage image intensifier has been realized (see fig. 13). Its characteristics are:

Semitransparent photocathodes	C_sS_b-O
Spectral response	S11
Fluorescent screen	2ns AG
Fluorescence	bleu
Focalization	magnetical
Gain	5×10^3
Maximum operating voltage	50 KV
Resolution power (on the screen)	10 line couples/mm

On the basis of the experience made with the three stage tube, we started the construction of a four stage image intensifier, designed to yield a quantum gain greater than 10^5, by which the single photoelectron emitted from the first photocathode should be visible.

The mechanical part of the tube is ready, while phosphors are being prepared. In this semester we have completed the construction of an electronographic image converter (see fig. 14).

In this kind of image converter, the electrons emitted from the photocathode undergo a suitable acceleration and pass through a mica window about 4μ thick. The image forms on a nuclear emulsion placed in contact with it. Such an instrument has better characteristics of detection and noise to signal ratio than those exhibited by a normal multistage tube (with cascade multiplication or transparent dynodes). The photocathode efficiency has been measured, resulting of about 30 μA/lumen. A rough evaluation of the background has been made; it may be neglected at 35 KV supply voltage up to exposition times of the order of 15 m. We have also started the measurement of the resolving power.

2.8.3 – *Photoconduction in CdS monocrystals.*

(L. Bartolini).

Recently we have grown up CdS photoconducting monocrystals by the reaction in the vapor phase between cadmium and sulfur, following a modified Frerichs's method. The main morphologic and Crystallografic characteristics have been determined by microscope analysis of samples under polarized light. Some problems, regarding the realization of non rectifying electrical contacts have been resolved.

We have experimented doping by Cu and the production of Cd vacancies in pure crystals; measurements of spectral sensibility have been made. The monocrystals containing Cd vacancies show a photosensitivity peak at 5150 Å (edge transitions), and a remarkable quenching effect has been measured in the range 6500 ÷ 9000 Å, and we have measured its influence on the gaps energy determinations made by photoconduction experiments by polarized light. On the other end we have seen that the Cu doping produces a photosensitivity peak in the red region of the spectrum (sensitization), so totally eliminating the queching effect up to 9000 Å.

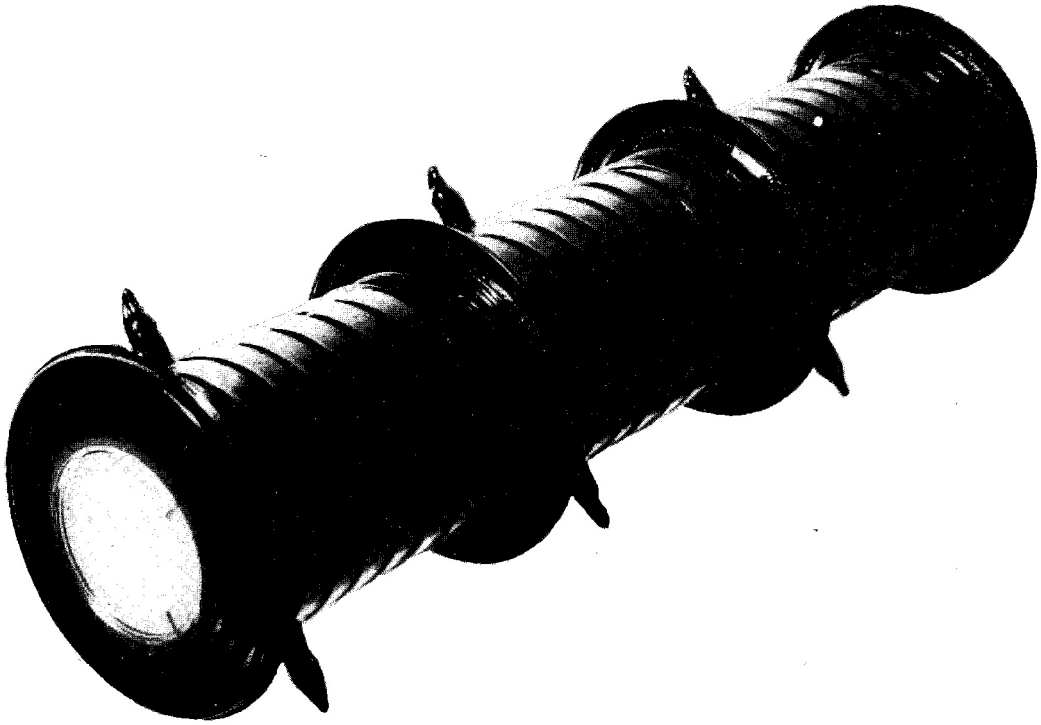


Fig. 13

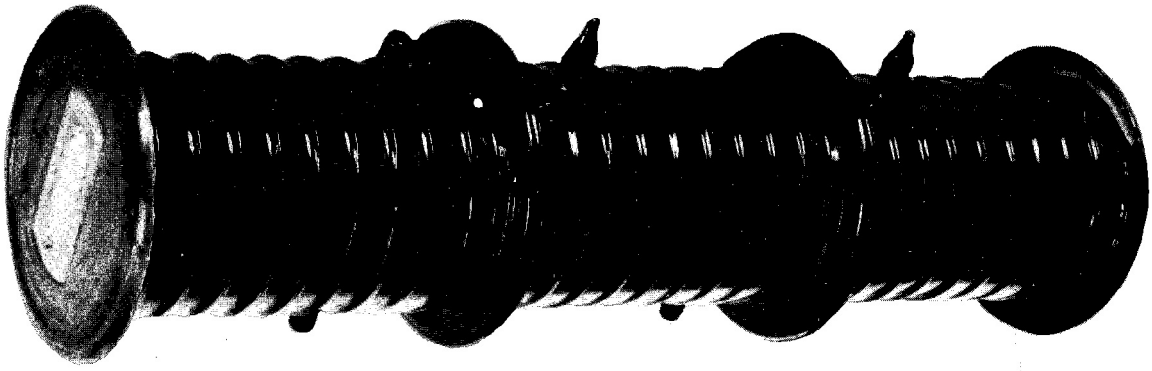


Fig. 14

We have now under study the possibility of correlating in a simple way sensitization with quenching effect.

2.9 – DOSIMETRY GROUP.

(M. Ladu, M. Pelliccioni, M. Roccella).

In this period the Dosimetry group, together with the research activity already started, has been particularly interested in the problems of safety and dosimetry of the 400 MeV LINAC. This, jonitly with the normal service activity, which develops in the electronsynchrotron area. This activity, as it was already written in the preceding reports, consists in periodically controlling and recording the doses absorbed by the synchrotron staff, in periodically detecting the radiation levels near the electronsynchrotron, in performing all those measurements, which are time by time asked for by experimenters, in preparing and distributing radioactive sources, and in maintaing the efficiency and calibration of all the monitoring instruments, etc.

In this period the service activity developed for the LINAC and the LEALE Group, has been concerned with:

- the study, in collaboration with Electronic Laboratory of the Casaccia, of the fixed monitoring system around the Linear Accelerator;
- the study of the production in and the ejection out the machine tunnel of the toxic and radioactive gases;
- the study of the efficiency of the screens working around the accelerator;
- the preliminary study of the beam quenching well;
- the calculation of radiation levels present in particular zones around the LINAC, and of the activation of some materials;
- the realization of a proportional counter, made of a material equivalent to human tissue, to measure and eventually evaluate the biological damage by high energy neutrons.

2.10 – NUMERICAL CALCULUS GROUP

(R.M. Buonanni, M.A. Locci, M. Spano-Mencuccini, G. Trenta, A. Turrin, G. Verri).

This year the group has worked for the internal groups of the LNF, I.N.F.N., Ionized Gases Lab. (Euratom-CNEN), Astrophysical Study Center (C.N.R.).

We may mention; the calculation of the loading effect of electrons an the Adone resonating cavities, under several operation conditions (R.M. Buonanni); the calculation of the response of multistage RC Filters (R.M. Buonanni).

We have performed for the LEALE Group, calculations both for the LINAC screenings(*) and on the photoproduction of pions on nuclei, in the impulse approximation (R.M. Buonanni).

We have assisted, the η^0 group both in the statistical analysis of experimental data (M.A. Locci), and in calculations of detection efficiencies (M.A. Locci, M. Spano-Mencuccini, G. Trenta).

(*) M. Locci, P. Picchi, G. Verri: Study of a nucleonic cascade in Al for energy of primaries between 400 and 30 MeV (to be published).

The Cryogenic Group has been assisted in the calculation of the thermomolecular pressure (G. Verri).

Calculations on the pulsation of a Cefeide in the stellar atmosfere has been performed for the Astrophysical Study Center (CNR), (G. Trenta).

Within July 1965, the 1620 IBM memorizing power will be increased to 40.000 memory positions.

Being so doubled the number of memory positions, programs needing a large computer memory will be developed more easily. Besides, we shall be able to give instructions by Fortran II, that is by a language nearer to Fortran IV, which is the one employed in high performance computers.

Of course the above enlargement will not satisfy the needs of the laboratories the 1620 constituting only a mean to test programs: it will still be necessary to use, with increasing frequency, external computers capable of better performance.

3 - LIST OF PUBLICATIONS

64/32 - J. E. Allen and A. Turrin: *The collection of positive ions by a probe immersed in a plasma,* Proc. Phys. Soc. *83,* 177 (1964).

64/33 - C. Bernardini, G. Corazza, G. Di Giugno, J. Haissinski, P. Marin, R. Querzoli and B. Touschek: *Measurements of the rate of interaction between stored electrons and positrons,* NI - 249.

64/34 - M. Placidi: *Le misure magnetiche sui modelli dei magneti e dei quadrupoli di Adone,* NI - 250.

64/35 - N. Sacchetti, G. Sacerdoti, G. Sanna, F. Smriglio, A. Susanna: *Experimental study of the decay of persistent currents in a soft superconducting rings under* α *- particle irradiation,* NI - 251.

64/36 - E. Celeghini e R. Gatto: *Possible determination of the* η^0 *lifetime with electron-positron colliding beams,* Nuovo Cimento *33,* 657 (1964).

64/37 - C. Dardini e G. Mazza: *Un discriminatore rapido,* NI - 252.

64/38 - R. Scrimaglio e G. Verri: *Calcolo della relazione range-energia per mesoni* μ *fino a* 10^8 *MeV,* NI - 253.

64/39 - M. Fascetti e A. Massarotti: *Un circuito di trigger per spark-gap,* NI - 254.

64/40 - B. Bertolucci e M. Coli: *Convertitore digitale analogico flessibile per il controllo di esperienze «on line»,* NI - 255.

64/41 - C. Schaerf and R. Scrimaglio: *High resolution energy loss magnetic analyser for scattering experiments,* NI - 256.

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64/43 - G. Pasotti, N. Sacchetti, G. Sacerdoti and G. Sanna: *Some experimental results of superconducting solenoides,* Nucl. Instr. and Meth. *27,* 275 (1964).

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64/46 - R. Habel, T. Letardi and R. Visentin: *Construction and operation of a single gap spark chamber,* NI - 258.

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64/49 - I. Modena, A. Savoia and F. Scaramuzzi: *Change of the mobility of positive ions in rotating helium II,* NI - 260.

64/50 - C. Guaraldo, G. Sacerdoti e A. Susanna: *Proposta di un nuovo sistema per indurre correnti persistenti in un anello superconduttore,* NI - 261.

64/51 - B. Bertolucci e F. Pandarese: *Studio di un sistema di scanning di fotogrammi da C a S con accoppiamento CRT - grande calcolatore,* NI - 262.

64/52 - G. Sacerdoti, S. Cappannini e G. Pasotti: *Un cannone elettronico per l'evaporazione di materiali ad alto punto di fusione,* L'Elettrotecnica *51,* 683 (1964).

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64/54 - M. Bernardini: *Livelli medi di radiazione intorno all'acceleratore lineare e all'anello di accumulazione,* NI - 263.

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64/56 - E. Mazzucato e F. Pandarese: *Particolari effetti non lineari in alcuni dielettrici (Reman-Laser),* Rendiconti della LXV riunione annuale dell'Ass. Elettrotecnica ed Elettronica Italiana. Palermo (1964). Fasc. III, n. 93.

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64/61 - E. Borchi and R. Gatto: *Charge symmetry of the axial current and radiative muon absorption by a nucleus,* Nuovo Cimento *33,* 1472 (1964).

64/62 - C. Schaerf and R. Scrimaglio: *High resolution energy loss magnetic analyser for scattering experiments,* Nucl. Instr. and Meth *30,* 359 (1964).

64/63 - V. Silvestrini: *Photoproduction and neutral decay modes of the η particles,* Strong Electromagnetic and Weak Interactions (Benjamin, New York 1964) pag. 217.

64/64 - M. Bassetti: *Considerazioni sul cromatismo di un canale magnetico rettilineo,* NI - 268.

64/65 - *The Frascati storage rings.*

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64/69 - *Attività dei Laboratori Nazionali di Frascati dal 1.7.63 al 30.6.64,* Notiziario n. 14.

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64/71 - C. Bernardini, G. Corazza, G. Di Giugno, G. Ghigo and R. Querzoli: *Lifetime and beam size in electron storage rings,* Proc. of the Intern. Conf. on High Energy Accelerators, Dubna 1963 (Atomirdat, Moscow, 1964) p. 332.

64/72 - I. F. Quercia: *Progressi nella strumentazione per la ricerca fisica,* Nuovo Cimento, suppl. *2,* 602 (1964).

65/1 - G. Altarelli, F. Buccella and R. Gatto: *Su_6 and non leptonic hyperon decay,* Phys. Letters *14,* 70 (1965).

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65/3 - N. Sacchetti, G. Sacerdoti, G. Sanna, F. Smriglio and A. Susanna: *Experimental study of the decay of persistent currents in a soft superconducting rings under α-particle irradiation,* Phys. Rev. *137,* A796 (1965).

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