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LABORATORI NAZIONALI DI FRASCATI

ANNUAL REPORT 1977

Director of the Laboratories : R. SCRIMAGLIO
Directory Assistant : G. PICOZZA

Editorial Board : A. CATTONI (Technical Division)
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S. TAZZARI (Accelerators Division)
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INTRODUCTION.

The general picture of the activities of the Frascati National Laboratories in 1977 presents a series of initiatives and achievements of considerable scientific interest and upon which depend the development prospects of the Laboratories themselves.

In the following pages the three main divisions of the Laboratories, together with the General Services, report on their activities.

RESEARCH DIVISION.

1.- PARTICLE PHYSICS WITH ELECTRONIC TECHNIQUES.

1.1. - EXPERIMENTS RUNNING AT ADONE.

1.1.1. - MEA GROUP.

LNF Staff: B. Esposito, F. Felicetti, A. Marini, F. Ronga, B. Sechi-Zorn, G. T. Zorn; in collaboration with Roma, Napoli and Padova.

In 1977 the activity of the MEA group was devoted to the study of e^+e^- annihilation processes in the CM energy interval $W = 1450 - 2150$ MeV, using the magnetic facility described in the Frascati report LNF-77/18 (1977).

The following results were obtained:

- a) Measurement of inclusive distributions and of exclusive cross sections for the process $e^+e^- \rightarrow \text{hadrons}$ at $W = 1600$ MeV (see LNF-77/23).
- b) Measurement of the π and K form factors at $W = 1600$ MeV ($|F_\pi|^2 = 0.24 \pm 0.14$, $|F_K|^2 = 0.46 \pm 0.26$) (see LNF-77/14).
- c) Evidence for the existence of a new vector meson of mass $M = 1821 \pm 16$ MeV and width $\Gamma = 31 \pm 15$ MeV (see LNF-77/19).
- d) Preliminary observation of a possible resonant structure in events with more than 2 charged tracks and CM energy $W \simeq 1500$ MeV (see LNF-77/51).
- e) Confirmation of the resonant production of $K^*(892)$ at $W = 2130$ MeV (see LNF-77/51) of which there was a preliminary indication towards the end of 1976. The new results are based on about twice the number of previous events and particle identification is by means of range, TOF and momentum measurements.

In 1978 the group intends to continue taking data in the energy region $W = 1400 - 2000$ MeV, that seems very promising.

1.1.2. - $\gamma\gamma$ GROUP.

LNF Staff: R. Baldini-Celio, G. Battistoni, G. Capon, R. Del Fabbro, E. Iarocci, M. Massai, S. Morigi, G. P. Murtas, M. Spinetti, L. Trasatti; in collaboration with Roma and Bologna.

In 1977 the activity of the group developed along the following lines:

- a) Collection of data for the search of J/ψ type narrow resonances in the energy interval $W = 1.45 - 2.00$ GeV was completed and their analysis is in progress. During this data collection there were interesting signals around $W = 1.5, 1.66$ and 1.82 GeV. These regions were spanned several times.
- b) These data, together with those collected in 1976, are now being analysed in order to determine the various cross sections for multihadron production and the ratio R.
- c) For the same data the study of multihadron production through $\gamma\gamma$ interaction is being undertaken.
- d) The analysis of data on the process $e^+e^- \rightarrow e^+e^- \gamma$, in particular for the search of $e^* \rightarrow e\gamma$ resonant states has been completed.

e) Modification of the apparatus have started. Specifically:

- An internal core of 4 layers of resistive proportional tubes, in limited Geiger regime, with external striped electrodes for focalization along the wires. The electronics for the readout of the system of proportional tubes and hardware recognition of tubes was built by the group from Bologna. The solid angle for the identification of particles will increase from $0.6 \times 4\pi$ to $0.83 \times 4\pi$.
- A system of plastic Cerenkov counters for the identification of K^+ . A prototype of such counters was realised and tested at the LINAC in collaboration with the MEA group. The construction of the counters was started by the Rome group and is in an advanced state.

The results obtaining by the group are:

- a) Evidence for resonant behaviour at $W = 1819 \pm 5$ MeV ($\Gamma = 24 \pm 5$ MeV) in the category of events with 3, 4 charged particles plus at least 1γ (Reported at the Budapest and Hamburg Conferences and at the "E. Majorana" School of Physics).
- b) Evidence of a complex structure with mass of about 1.5 GeV. Preliminary data were presented at the Budapest and Hamburg Conferences. The estimated decay width into e^+e^- is $\Gamma_{e^+e^-} \simeq \simeq 100$ eV. A first search for decay modes, in particular into K mesons, and the identification of the isotopic spin and G parity has been carried out. The analysis of colinear charged 2 body decays is in progress.
- c) Indication of other possible structures, also presented at the Hamburg Conference, has been obtained. In particular the data taken, both before and after the Hamburg Conference, are in substantial agreement with the data of the M3N group at Orsay, in the region between 1.5 and 1.7 GeV. A more detailed study in regard to possible interpretations is in progress.
- d) The study of some decay modes of the J/ψ has been completed and the results published:
 - Search for the radiative decay (see LNF-76/60):

$$J/\psi \rightarrow \eta'(958) + \gamma.$$

- Interpretation of the anomalous charge to neutral ratio found by the group (Phys. Letters 58B, 471), with a demonstration of the necessity of an abundant production (see LNF-77/10):

$$\frac{(J/\psi \rightarrow \eta X)}{(J/\psi \rightarrow \text{all})} \simeq 36\%.$$

- Completion of the study of the process (see LNF-77/33)

$$e^+e^- \rightarrow e^+e^- \gamma,$$

in which a new limit was obtained for the existence of a heavy electron (see Fig. 1).

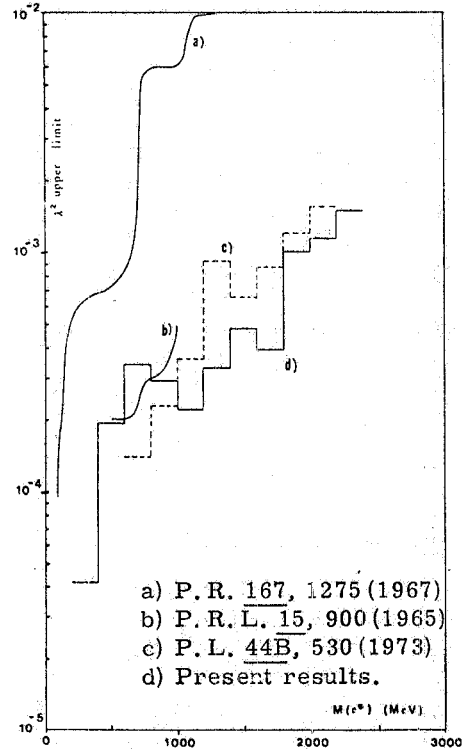


FIG. 1

1.1.3. - $B\bar{B}$ GROUP.

LNF Staff: G. Barbiellini, A. Barletta; in collaboration with Napoli, Pisa and Sanità.

The group continued taking data with its new experimental arrangement using practically all the luminosity from ADONE. The CM mass range between 1750 and 2000 MeV was more thoroughly explored.

A narrow resonance of mass $M = 1812^{+7}_{-13}$ MeV, width $\Gamma = 34^{+21}_{-15}$ MeV (see LNF-77/24) close to and interfering with structures found at DCI was observed.

These results suggested the exploration of the energy region between 1450 and 1600 MeV. Preliminary results on possible narrow resonances with masses $M \simeq 1500$ MeV/ c^2 and $M \simeq 1470$

MeV were presented at the Hamburg Conference (see LNF-77/51).

Data collection at these energies is still in progress in order to confirm with more significant statistics the phenomena observed.

1.2. - THE LONG TERM PERSPECTIVE.

The long term perspective of $e^+ e^-$ physics at LNF is mainly based on the possibility of realizing in the Laboratory an experimental apparatus (MDA) to be installed on a high luminosity storage ring (ALA) intended to search for new resonances, study their relative widths and decay modes etc. In fact, in the second half of 1977 design work has started on an apparatus consisting of scintillating hodoscopes, cylindrical chambers and photon detectors with calorimeters, in a longitudinal magnetic field.

1.3. - EXPERIMENTAL GROUPS WORKING ABROAD.

1.3.1. - DESY 2 GROUP.

LNF Staff: S. Bartalucci, G. Basini, S. Bertolucci, P. Giromini, A. Sermoneta; in collaboration with DESY.

The experiment, whose data collection started in 1974, is a search for new vector mesons of mass between 1.0 and 2.5 GeV in photoproduction of electron-positron pairs in hydrogen. Detection of the new $J^{PC} = 1^{--}$ states is made by either direct measurement of lepton pairs from their decay or by measurement of the interference between the finale leptonic state and the Bethe-Heitler amplitude.

In 1977 the group averaged 4000 hours of data collection. Below is a summary of the main results:

- a) Confirmation of a resonant structure of mass $M = 1097_{-19}^{+16}$ MeV and width $\Gamma = 31_{-20}^{+24}$ MeV. Its photoproduction phase of 40_{-42}^{+36} suggests it is ϕ -like.
- b) Measurement of the photoproduction phases of ρ , ω , and ϕ with statistics an order of magnitude better than heretofore. The new values are 37.70 ± 4.0 , $28.20_{-11.5}^{+13.5}$ and $3.40_{-4.2}^{+5.3}$ respectively.
- c) Measurement of the leptonic decay of $\rho^0(1250)$ which is the first of its kind. For the mass and width of this resonance it was found $M = 1266 \pm 5$ MeV and $\Gamma = 110 \pm 35$ MeV and with an accuracy better than that of previous experiments. The photoproduction phase was measured for the first time and found to be $28^\circ \pm 8^\circ$.
- d) The data taken show good evidence for a new state at a mass of 1380 MeV and for an up to now unknown structure around 1700 MeV.

In order to improve the statistics on point d) the group has asked for, in September 1977, 3000 additional hours of data taking. Measurements will continue till the summer of 1978.

1.3.2. - ND GROUP.

LNF Staff: G. Barbiellini, F. Ronga, V. Valente; in collaboration with CERN, Hamburg Amsterdam, Roma and Moscow.

Installation of the experimental apparatus in the SPS neutrino beam started at the beginning of the year. We recall that it is the second apparatus with counters for the study of neutrino interactions and that it consists of a fine grain calorimeter (target: marble; detectors: scintillation counters, drift and proportional wire chambers) followed by a muon spectrometer. By the end of year, 10 out of 13 "iron + coils + marble" modules were installed. These were equipped with 400

scintillation counters (out of a total of 1700) and an equal number of proportional counters, each of 16 wires.

Part of the electronics has been installed and the trigger is already functioning. The on-line acquisition system is in an advanced state of realization and a reduced version of it is already operating.

With the available equipment tests have been made with beam and cosmic ray μ 's. Simultaneously a test calorimeter (scale of linear dimension 1: 3) has functioned on beams of hadrons and electrons at the PS, allowing measurements of energy resolution and angle accuracy of hadronic and electromagnetic showers up to a momentum of 22 GeV/c of incident particles. The possibility of distinguishing between the two kinds of showers on the basis of their evolving characteristics has also been studied with a view to evaluating the feasibility of a ν_{μ} on electrons scattering experiment. The test calorimeter has allowed to test many of the technical solutions used in the experiment (comparative study of the response of various types of scintillators; getting the electronics of the proportional wires ready, etc.).

Data collection on the neutrino beam at SPS is scheduled for March 1978.

1. 3. 3. - FRAM GROUP.

LNF Staff: G. Bologna, F. Celani, F. L. Fabbri, P. Picchi, L. Satta, P. Spillantini, A. Zallo; in collaboration with Pisa and Torino (Laboratorio di Cosmogeofisica of CNR).

In 1977 the construction of the detectors to be installed in the North Area of SPS continued. The main components are: the photon detectors, the system of forward multiwire proportional chambers and the system of cylindrical proportional chambers around the target.

a) Cylindrical chambers.

The innermost vertex detector (Fig. 2) consists of 4 coaxial cylindrical chambers to detect charged particles emitted between 70° and 120° .

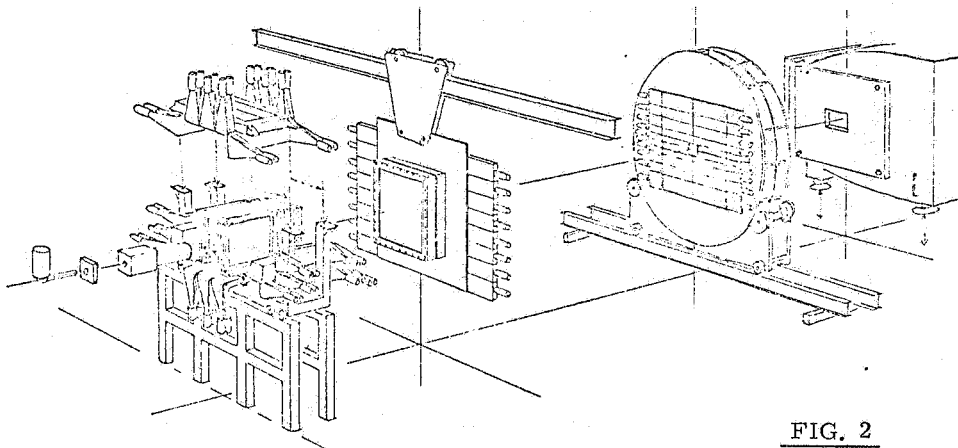


FIG. 2

The proportional wires are parallel to the generators of the cylinders while the cathodes of each chamber consist of helical strips wound at a suitable angle about the axis from right to left. When the multiplicity is not too high each chamber provides an unambiguous measurement of polar angles.

Construction problems arose from the difficulty of ensuring the maximum possible "transparency" of the cathodes, maintaining a tolerance of 0.1 mm on the distance between the cathodes themselves. The support of the cylinders consists of commercially available polymethacrylimid, such as Rohacell 31, whose density is 30 Kg/m³.

Special care was taken in minimizing the thickness of the cathodes formed of copper plated Kepton sheets glued to the Rohacell 31 cylinders. The average total thickness seen by a particle passing through the chamber is 50 mg/cm².

To analyse the signals from the wires the electronic chain described in CERN Report 74-12 (1974) is used. The pulses are fed to 16 channel preamplifiers and then, via twisted pairs, to the processing electronics.

b) Plane proportional chambers.

Tracks between 7° and 45° are measured by 6 planes of proportional wires. The system consists of 2 chambers each of three contiguous planes x, y, u (45°) for a total of 3400 wires.

The essential parameters the MWPC are:

- cathodes: aluminium sheets of 50µm thickness;
- gap width: 8 mm;
- anodes: 5% gold plates tungsten wires, diameter 20 µm and spaced 2 mm;
- mechanical tension of the wires: (50 ± 1) gm;
- gas: 20% isobutane, 0.20% freon, 5% methyal, 69.8% argon;
- effective area: 108 x 108 cm²;
- dimensions: 120 x 120 cm²;
- mechanical precision: 100 µm;
- frame: vetronite and anticoroidal.

The treatment of signals is identical to that described under a). The data presented refer to a prototype tested at CERN on beams of π , μ at the PS (E = 5-10 GeV).

Measurements made at different points of the chamber show good uniformity at the voltage plateaus; the values of the voltage at the knees of the plateau curves are all within an interval of 50 V. Background noise of the chamber is about 2 Hz/ metre of wires. No appreciable variation in efficiency at different points of the chamber on 3 planes was observed; this efficiency is ~98%. The mean multiplicity per wire, strongly dependent on the percentage of freon is 1.4 with 0.17% freon.

c) Power supply system.

The power supply of the vertex detector is remote controlled through serialisation of information (up-down). For the drift proportional chambers the system built in the LNF is able to supply simultaneously up to 256 detectors independently. The definition of the voltage, its control and the reading of the current for each channel are all done automatically by the computer. The stability is about 1‰. The accuracy in establishing the voltage is 2‰.

The system is arranged in such a way that 8 supply channels are contained in the space equivalent to 2 modules of the standard CAMAC. A pair of Lemo RG 174 cables is sufficient to pilot 64 channels allowing thus to save high voltage cables.

The system constitutes a great improvement over the most sophisticated commercial products in regard to the characteristics of the HV power supply, the facilities of the control system and in respect to cost.

In November 1977 the best part of the vertex detector was installed in the North Area of the SPS. The detector consists of:

- A system of 4 cylindrical proportional chambers, with wires parallel to the beam, arranged around the target for detection of charged particles emitted between 30° and 120°.

- A system of 16 drift chambers covering a solid angle of $\simeq 4\pi$ for a total of 576 reading channels (sense + delay).
- Two proportional chambers $120 \times 120 \text{ cm}^2$ formed of 3 contiguous planes for reading each for a total of 3000 reading channels, which detect charged particles with $\theta \leq 35^\circ$.
- A hodoscoped lead-plexipop shower counter for the measurement of the direction and energy of γ 's emitted between 7° and 30° (Front Shower - see Fig. 3) made of 900 sensitive elements ($32 \times 1200 \times 10 \text{ mm}^3$) seen by 270 phototubes.

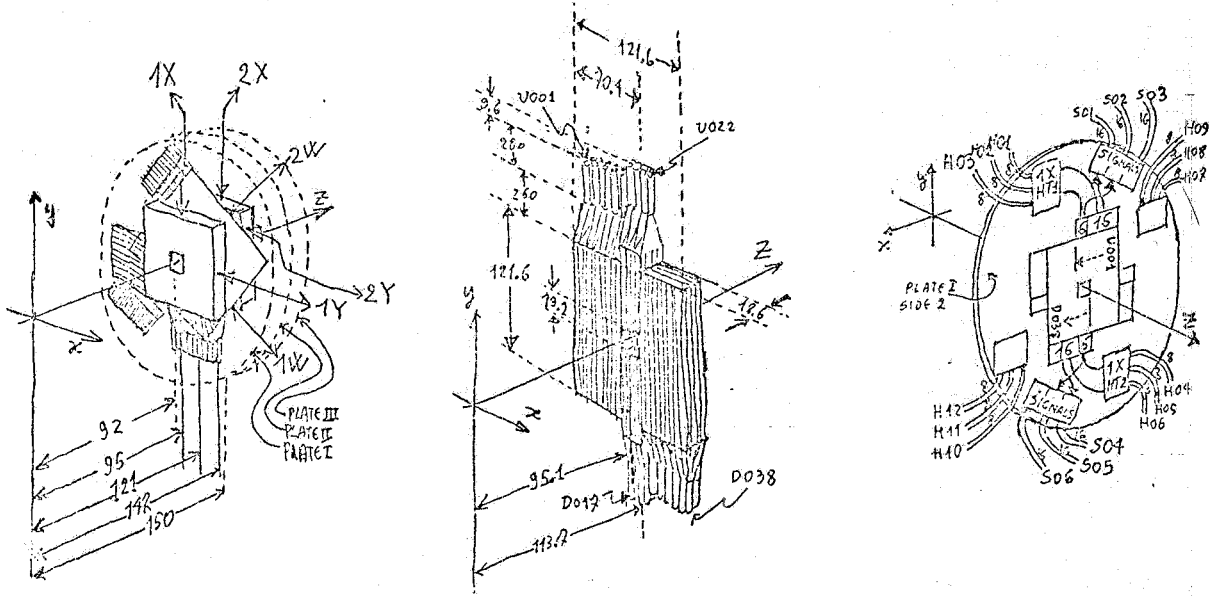


FIG. 3 - "Artistic" view of the FRONT SHOWER.

- A lead-plexipop shower counter consisting of 16 elements for the detection of γ rays emitted between 30° and 45° (Middle Shower - see Fig. 4).
- A system of 28 plexipop counters (Surrounding Shower) around the target for the detection of γ rays emitted at large angle ($\theta_{\text{lab}} \leq 120^\circ$).

The part that has been installed include the Front Shower the Middle Shower and the MWPC.

By April 1978 the installation of the vertex detector will be completed.

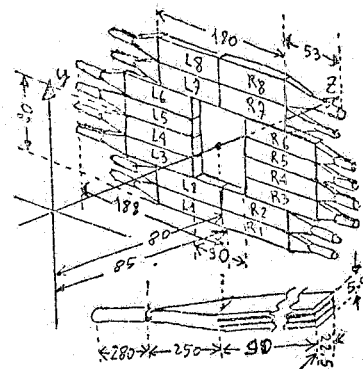


FIG. 4 - "Artistic" view of the MIDDLE SHOWER.

1.3.4. - FRASCATI-ISR 2 GROUP.

LNF Staff: G. Bellettini, P. Spillantini, F. Zetti; in collaboration with Napoli and Pisa.

The 16 drift chambers (effective area $86 \times 32 \text{ cm}^2$) constituting telescope III of experiment R209 (known as ISR 2) have been installed on the ISR with all their flux and feed on system, and the performance under measurement conditions has been checked.

Fig. 5 shows the voltage plateau of the nearest to the beam sensitive wire (12 cm, at 5 meters from the point of interaction) of some chambers.

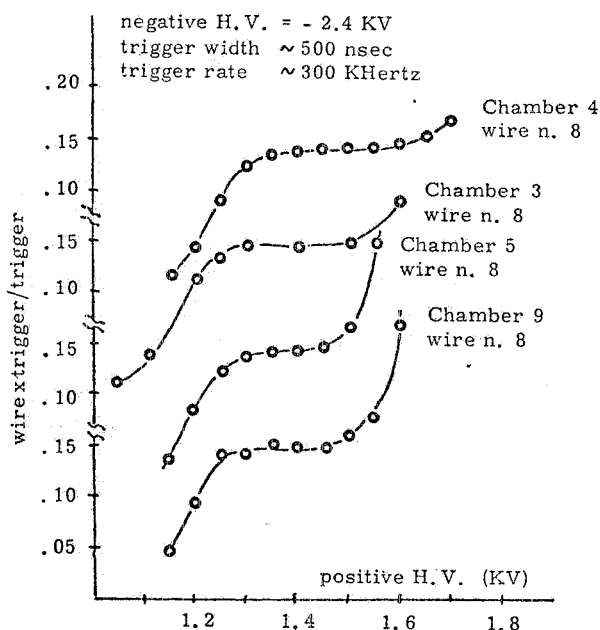


FIG. 5

The plateaus are satisfactory in view both of the high frequency of beam-beam events (300 KHz) in coincidence with the chamber and of the length of pulses formed (500 nsec), to be collected over a drift cell ($\pm 2 \text{ cm}$). If the beam-beam pulse is reduced to 45 nsec one obtains the plateaus in Fig. 6.

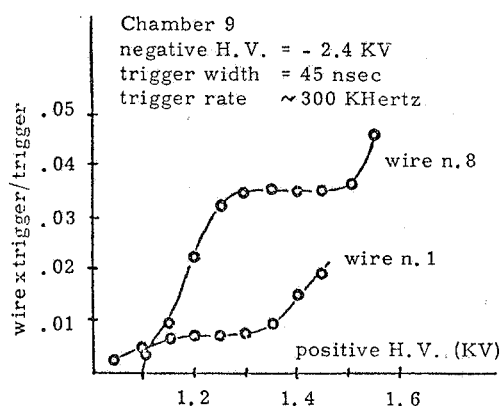


FIG. 6

The chambers will be in condition to provide useful data for the experiment as soon as the readout electronics will be available.

1.3.5. - FRASCATI-SACLAY GROUP.

LNF Staff: F. L. Fabbri, P. Picozza, L. Satta; in collaboration with Torino (Laboratorio di Cosmogeofisica del CNR), Saclay and Caen.

The group completed taking data at the Saclay protosynchrotron Saturne during the first months of 1977. The rest of the year was dedicated to analysing the data. The main results are:
a) $\alpha\alpha$ elastic scattering at 4.30 and 5.05 GeV/c.

The preliminary data in the region of the first and second minimum ($0.05-0.7 \text{ GeV}^2/c^2$) for incident momentum of 4.3 and 5.05 GeV/c are shown in Fig. 7. This reaction is an interesting test of models constructed in the framework of Glauber's theory.

Because of the absence of spin effects it is easy to compute the ratio of real to imaginary part of the NN amplitude. From Fig. 7 the characteristic diffractive trend is evident in the data

with the minima corresponding to double and triple scattering. There is no energy dependence except in the region of the first minimum. The data have been compared with two models. The continuous line is the prediction of the model of Czyz and Maximom (Ann. Phys. 52, 59 (1969)) and is based on a Gaussian single particle density. In the model of Małecki and Satta (see LNF-77/36) indicated by the dashed line, the effect of pair correlation in the nuclear wave function is included. The choice of nuclear parameters is the same in both models. For high momentum transfers and in the region of the second minimum and beyond, the predictions of these models differ from each other and from the data.

b) Elastic proton-helium scattering at 1.05 GeV.

1.05 GeV protons, from the protosynchrotron Saturne, incident on ^4He liquid target were used to study elastic proton- ^4He scattering at 180° in the centre of mass, where the value and the structure of the cross section are strongly dependent on energy (see J. Berger et al., Phys. Letters 63B, 111 (1976)). At this energy the ^4He recoil is sufficiently strong to allow an analysis with the spectrometer used previously in the ^4He -p configuration. The elastic peaks obtained show little contribution from "empty target" confirming in this way the applicability of this technique to high energies.

The preliminary differential cross section as a function of the cosine of the CM scattering angle is shown in Fig. 8. The value of the cross section is an order of magnitude smaller than obtained in our previous measurement at an equivalent proton energy of 850 MeV.

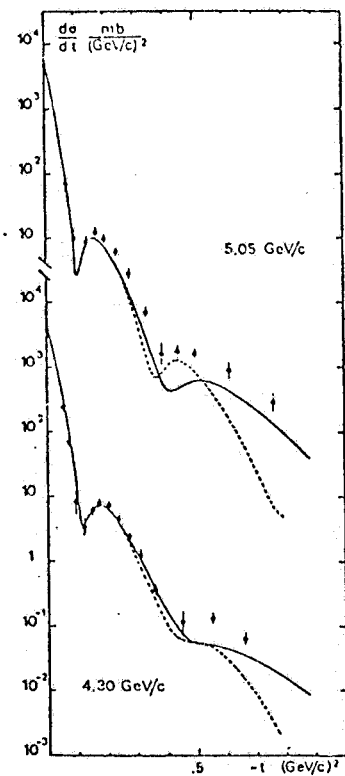


FIG. 7

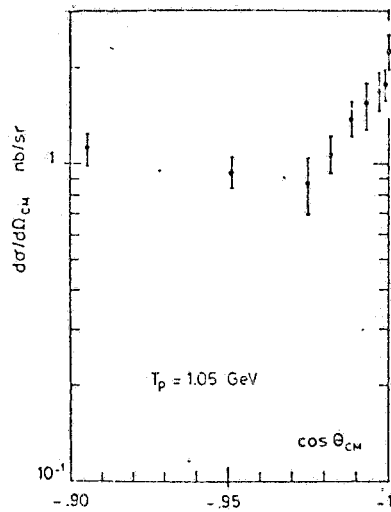


FIG. 8

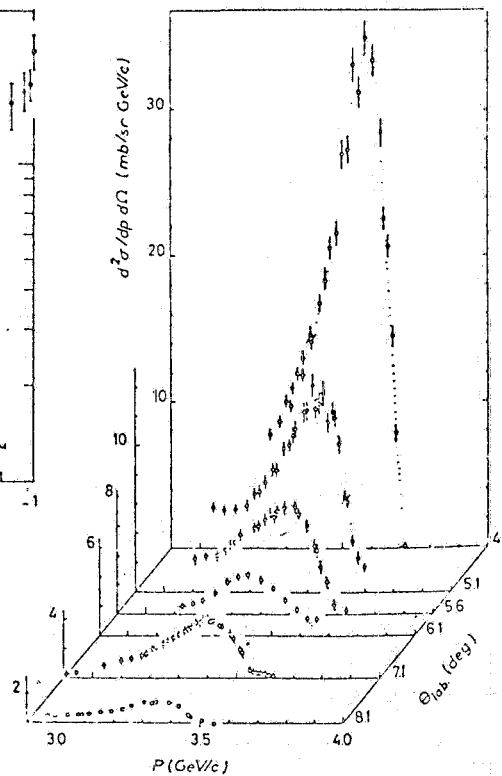
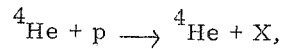


FIG. 9

c) Inelastic αp scattering.

The external α beam of the protosynchrotron Saturne has been used to study the reaction



where ${}^4\text{He}$ is detected by means of a magnetic spectrometer.

The use of an incident beam of alpha particles instead of a fixed target of ${}^4\text{He}$ allows an easy detection of the whole helium nucleus, since it has a momentum that becomes more and more equal to the incident one as the momentum transfer diminishes.

Measurements were made for incident momentum of 4.00 GeV/c and 5.08 GeV/c at different angles. Evidence was found for a narrow peak in the πN system of mass $M = 1130$ MeV, width $\Gamma = 80$ MeV and isospin $I = 1/2$.

The main characteristic of the data appears to be the strong dependence of the cross section on the momentum transfer t . The momentum distribution of ${}^4\text{He}$ is shown in Fig. 9.

2.- PARTICLE PHYSICS WITH VISUAL TECHNIQUES.

LNF Staff: P. Allen, G. Piredda, G. Susinno and L. Votano.

2.1. - 3PI EXPERIMENT.

In 1977 the Frascati-Padua-Rome-Trieste collaboration completed the analysis of experiment 3PI. A study of the Dalitz plot of the $\pi^+ \pi^- \pi^0$ state obtained from the annihilation of 3 GeV/c antiproton on a neutron is about to be published. The experiment was carried out to observe if the regular trend of maxima and minima found at low energy by the Berkeley-Padova-Pisa-Torino collaboration, would repeat itself at high energy.

This feature, evident at 1.2 - 1.6 GeV/c does not appear at 3 GeV/c; there is still a dip at $m^2(\pi^+ \pi_1^-) = m^2(\pi^+ \pi_2^-) \simeq 1 \text{ GeV}^2$; less pronounced structures are also present.

2.2. - ANTIP 2 EXPERIMENT.

This experiment, in collaboration with CERN-Padova-Roma-Trieste, is for the study of the resonant state of long lifetime ($\Gamma \simeq 9$ MeV) at $M = 1936$ MeV. The experiment uses the 2 m CERN bubble chamber. Particular care was devoted in this measurement to the characteristics of the beam. The beam has a $\Delta p/p = 0.005$ and an average of $3\bar{p}$ per photogram. The measurement of the antiproton track in the chamber up to the point of interaction allows the reconstruction of the energy with a resolution of 2 MeV, necessary for the study of such narrow resonances.

227 films in hydrogen and 153 in deuterium for a total of 1200000 photograms have been taken. The film is analysed on the PEPR's of Padova and Frascati. The study of the resonance in the $\bar{p}p$ and $\bar{p}n$ channels will allow to establish its isotopic spin.

2.3. - PEPR (Frascati-Roma collaboration).

This instrument allows automatic analysis of bubble chamber photograms to be carried out. Its realization has been the major technical engagement of the group in the last four years.

At present PEPR is being used for the analysis of the ANTIP 2 films. The procedure followed does not require premanual measurements and reduces the intervention of the operator to emergencies and to vertex measurements.

Once the photogram has been positioned PEPR searches and measures the fiducial points, then starts to locate the incident \bar{p} 's and establishes their identity in the background of π , μ on the basis of ionisation. Each \bar{p} is then followed and measured up to the interaction vertex.

2. 4. - EHS (European Hybrid Spectrometer).

A letter of intent has been prepared for the study of diffractive processes at SPS energies with the "European Hybrid Spectrometer" in collaboration with CERN-Heidelberg-Madrid-Roma-Pavia-Wien.

This complex apparatus will start to function in 1980 in the North Area of the CERN SPS. The apparatus consists essentially of a rapid cycle bubble chamber for recognition of event vertices, and a spectrometer for the measurement of momentum, recognition of masses and detection of neutrals in the forward cone. The PEPR as an interactive automatic instrument, able to connect information from the electronic parts of the apparatus to that contained on film, is one of the best instruments for the analysis of the events that will come out of EHS.

3.- NUCLEAR PHYSICS.

3. 1. - EXPERIMENTS WITH THE LINEAR ACCELERATOR (Laboratorio LEALE).

3. 1. 1. - PION BEAM (Measurement of the cross section of elastic and inelastic scattering of π^+ on nuclei at 180°).

LNF Staff: C. Guaraldo, A. Maggiora, R. Scrimaglio; in collaboration with Torino.

The purpose of the experiment is to measure the cross section for elastic and inelastic scattering of π^+ on nuclei at large angles ($> 150^\circ$) using a helium streamer chamber in a magnetic field. There are no measurements at angles greater than 150° and, in particular, for energies below about 100 MeV theoretical predictions at 180° differ up to an order of magnitude. During 1977 the analysis of elastic scattering measurements between 25 and 35 MeV on ^{12}C was completed. The results, to be published in Physics Letters, show an angular distribution with a steep rise at 180° . In particular the value at 150° is in agreement with the recent results of Triumph, presented at the Zurich Conference.

The experimental apparatus has been improved by substituting the 220 KV high voltage generator of the streamer chamber with a 500 KV one in order to get longer and brighter tracks, better suited for automatic analysis of photograms with the CNAF in Bologna. With the new apparatus measurements of π^+ scattering on ^{12}C at a nominal energy of 50 MeV and for a total of 14.432.475 π^+ have been carried out. The analysis of the data will be completed by January 1978.

In this way the energy interval 25-95 MeV in π^+ - ^{12}C scattering has been completely covered. Large angle scattering of π^\pm on ^9Be has been studied in order to investigate the effects of the scattering of π^\pm on ^9Be has been studied in order to investigate the effects of the scattering of π^\pm on inner shell neutrons. A dose of 6.829.170 π^+ and 8.817.960 π^- has been collected.

The analysis of the data will be completed by the Spring of 1978.

3.1.2. - MONOCHROMATIC GAMMA BEAM.

LNF Staff: G. P. Capitani, E. De Sanctis, P. Di Giacomo, S. Gentile, C. Guaraldo, E. Polli, R. Scrimaglio; in collaboration with Genova.

This program uses a beam of quasi-monochromatic photons (obtained from the annihilation of positrons accelerated in our LINAC of energy variable between 80 and 300 MeV to perform experiments on the photodisintegration of light nuclei at energies above the giant resonance and on the photoproduction of pions at threshold.

The activities concerned have been:

a) Improvement of the positron beam transport and of beam facilities in general.

In the positron transport line two magnets with plane poles (dimensions $40 \times 20 \text{ cm}^2$, gap $10 \times 15 \text{ cm}$) have been inserted to permit variation of the incident angle of positrons on the annihilation target of liquid hydrogen. This device allows to vary the angle of the photons relative to the line of flight of positrons between 0° and 1.5° , without changing the alignment of the collimators, system of detectors and monitor.

A pair spectrometer for on-line measurement of the spectrum of the photon beam is now available. It was made using a C-shaped magnet with parallel poles (dimensions $40 \times 90 \text{ cm}^2$, gap 15 cm) recovered from the electrosynchrotron laboratory. The photons enter the magnetic field through an aperture at the knee of the magnet; the electron-positron pairs created in the converter are deviated through $\sim 110^\circ$ by the magnetic field and are detected by two wire proportional chambers (effective area $26 \times 13 \text{ cm}^2$) and by scintillation counters. The computed characteristics of the spectrometer are the following: momentum acceptance $\sim 14\%$, dispersion $\sim 0.8 \text{ MeV/cm}$, resolution $\sim 0.2\%$.

The wire chambers have not yet been installed.

b) Photodisintegration measurements on deuterium.

Photodisintegration of deuterium (measurement of angular distribution of emitted protons and of the total cross section) in the energy interval 80-300 MeV allows to obtain information on mesonic effects in nucleon-nucleon interactions. The detection apparatus consists of 4 telescopes of E, dE/dx scintillation counters for protons of energy up to 120 MeV and of a range telescope of 10 plastic scintillators and one Cerenkov for protons of energy $\gtrsim 85 \text{ MeV}$. These telescopes are mounted on rotating supports on a platform, hence it is possible to carry out measurements at different angles (from 15° to 145°). The first measurements to get the apparatus and the beam ready have been made.

In 1978 the group will:

- instal the pair spectrometer vacuum chamber and start measurements with a hodoscope of 4 scintillation counters per branch (total resolution 1.5 MeV);
- finish laboratory tests on the wire proportional chamber readout by PDP 15;
- complete data taking on photodisintegration of deuterium.

3.2. - LADON GROUP.

LNF Staff: G. Giordano, L. Federici, G. Matone, P. Picozza, D. Prospero; in collaboration with Roma and Sanità.

In 1977 the activity of the group has been the following:

a) Preparation of the remotely controlled apparatus to be installed on ADONE. The two vacuum channels to be connected to the doughnut and all other vacuum hardware have been completed

and tested. The system controlling laser and collimator movements, the vacuum control system, the laser remote control and laser modulation control system have been completed.

- b) Preparation of the apparatus for the first set of experiments to be performed with the γ beam. While the existent detectors have already been tested, a prototype of wire chambers has been constructed and is presently in the testing phase. The modification of an existing magnet to make it into of a pair spectrometer is being worked on.
- c) Commissioning of the laser system. After having completed the tests on laser SP 166, the modulation system of the new laser SP 171 has been put into operation. At the moment a laser pulse ~ 15 nsec long, with repetition period ~ 177 nsec (Adone RF) and peak power ~ 40 50 W has been obtained.

3.3 - A MICROSCOPIC DESCRIPTION OF HEAVY ION FEW NUCLEON TRANSFER REACTIONS AT INTERMEDIATE ENERGIES.

LNF Staff: P. Di Giacomo, A. Reale; in collaboration with Cracovia, Roma and Torino.

Heavy ion few nucleon transfer reactions are treated within the framework of the Glauber model. Approximated transition amplitudes are deduced both in the prior and in the post representation, making use of a judicious eikonal axis choice, and of the zeroth longitudinal range approximation; a nucleus-nucleus profile function is given. The essential steps in the actual calculation are:

- a) inert core approximation;
- b) inclusion of Coulomb phase shifts for extended gaussian shape nuclei;
- c) independent particle model description of the core nuclei;
- d) energy dependence accounting for, relating the nucleon-nucleon scattering amplitude of the total cross-section via the optical theorem;
- e) assumption of uncorrelated nucleon transfer.

3.4. - THE LONG TERM PERSPECTIVE.

The Frascati linear accelerator at the moment produces a beam of 400 MeV electrons, which can generate secondary beams of photons, pions and muons. The principal limitation is the time structure of the beams, which implies an extremely low duty factor.

A new ring (ALFA Project) has therefore been studied to improve the duty factor by many orders of magnitude. In addition by increasing the maximum energy of the linear accelerator to 500 MeV one would obtain highly competitive machine, with possibilities of performing nuclear physics experiments in which many particles are simultaneously detected.

3.5. - EXPERIMENTS ABROAD.

3.5.1. - SFR (Saclay-Frascati-Roma) COLLABORATION.

LNF Staff: G. P. Capitani, E. De Sanctis; in collaboration with Saclay, Sanità, Heidelberg (in measurement d), Basle, Clermont-Ferrand and Louisiana (in meas. b).

a) Reaction D(e, e'p)n.

The purpose of the experiment is to study the momentum space wave function of deuterium detecting in coincidence the scattered electron and the emitted proton for quasi elastic scattering. In the impulse approximation and neglecting final state interactions the cross section is proportional to the product of the elastic electron-proton cross section and the square of the momentum distribution of the proton inside deuterium.

The experiment was performed at the Saclay linear accelerator with 500 MeV electrons in condition of coplanar kinematics and keeping the relative energy of the n-p system in CM constants (= 100 MeV). The apparatus consists of two high resolution magnetic spectrometers (respectively 4×10^{-4} simple focalisation, deviation angle 153° , and 1.5×10^{-4} double focalisation and deviation angle $169^\circ 42'$) and two detection devices consisting of proportional wire chambers, Cerenkov and scintillation counters.

Fig. 10 shows the preliminary results on the momentum distribution. The values shown in this plot have not been corrected for radiative effects (which should not influence the form of the distribution) and have arbitrarily normalized to the distribution of Turreil and Spring (Nuclear Physics A201, 193 (1973)) from neutron-proton interaction. This latter is shown in the figure as the dashed curve for the 3S_1 state and as a continuous curve for the $^3S_1 + ^3D_1$ state. The results of the preliminary analysis were presented at the Zurich and Tokyo Conferences.

b) Measurement of the cross section for quasi elastic electron scattering on ^{12}C .

The purpose of the experiment is to measure the cross section for the reaction $^{12}\text{C}(e, e')$ in the excitation region of the nucleus which includes the quasi elastic peak and the beginning of the $\Delta(1236)$ resonance. The incident energy varied from 160 to 520 MeV and scattering angle between 60° and 130° with a resolution of 0.5 MeV and high statistics (0.6%).

The preliminary results were presented at the Washington Conference. They show a possible existence of a wide shoulder from the high energy part of the quasi elastic peak. No evidence was seen on the other hand of any anomalous narrow structures in the quasi elastic peak (contrary to J. Berthot and D. B. Isabelle, in Lett. Nuovo Cimento 5, 155 (1972)).

c) Reaction (e, e'n) on some nuclei.

At present very little is known about the neutron wave function in nuclei. A comparison of the results of (e, e'n) experiments with (e, e'p) ones performed under the same kinematical conditions should provide direct information, since they are practically independent of distortion of the neutron and proton wave functions in nuclei. In such an experiment it is necessary to measure the momentum vector of the neutron, in other words, measure its energy, the emission angle and then identify its mass.

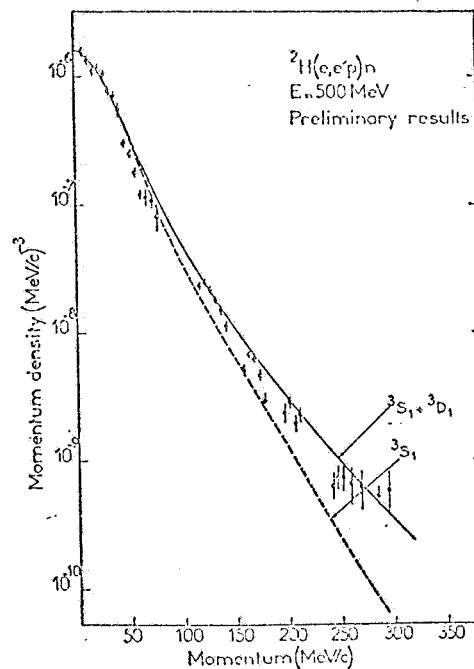


FIG. 10

In our case this is done with a liquid scintillator (a cylinder of diameter 12.7 cm and thickness 12.7 cm) by measuring time of flight of the detected particle (basis of time of flight ~ 8 m) and using the technique of determining the form of the impulse (D. W. Glashow et al., Nuclear Instr. & Meth. 114, 535 (1974)) to distinguish photons.

The neutron counter and the anticoincidence counter for rejecting charged particles have been constructed. The project for the screening of the detector system and the installation of the neutron source for laboratory tests have been initiated.

d) Reaction (e, e'p) on ^{16}O and ^9Be .

The purpose of the experiment is to determine the "spectral function" $S(E, \bar{p})$ for protons (see Dieperink and De Forest, Ann. Rev. Nucl. Sci. 25, 1 (1975)) which represents the combined probability to extract a proton of momentum \bar{p} with separation energy E (energy imbalance) from the target nucleus.

What we summarise here is the first measurements of the reaction (e, e'p) on ^{16}O (the only measurements on the extraction of a nucleon from ^{16}O performed in the past were the (p, 2p) experiments performed at Harvard and at Chicago (Tyren et al., Nuclear Phys. 321 (1966)).

The experiment was performed with the 500 MeV electron beam of the Saclay linac in the missing mass region (0-120 MeV) and of recoil momentum (0-350) MeV/c keeping the outgoing proton momentum constant (= 100 MeV) in order to simplify the corrections due to distortions. The apparatus is the same as that described above. The targets are BeO and Be; data on oxygen are obtained by subtraction.

Figs. 11 and 12 show the spectra of missing energy in particular kinematical conditions. In the ^{16}O the two peaks at 11,5 MeV and 18 MeV take the maximum part of the intensity of the states $^1\text{P}_{1/2}$ and $^1\text{P}_{3/2}$; the ^1S state appears clearly around 45 MeV of the missing energy with significant intensity up to 80 MeV.

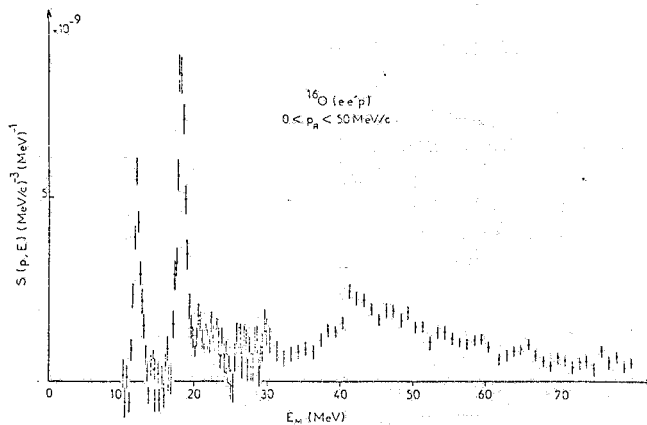


FIG. 11

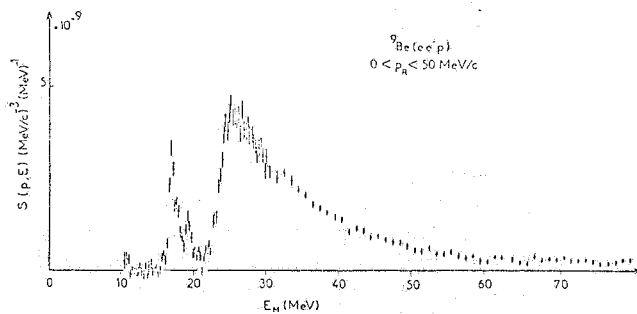


FIG. 12

In ${}^9\text{Be}$ the contribution of the 1S state appears as an asymmetric peak in the 25 MeV region. The preliminary data were presented at the Zurich and Tokyo Conferences.

It is expected in 1978 to :

- complete the analysis of the data of $D(e, e'p)n$;
- complete the analysis of the data $(e, e'p)$ on ${}^{16}\text{O}$ and ${}^9\text{Be}$;
- complete the analysis of the data on ${}^{12}\text{C}(e, e')$;
- start measurements on the reaction ${}^3\text{He}(e, e'p)$;
- complete the construction of the neutron counter together with screening and start the first feasibility tests of the reaction $(e, e'n)$.

3.5.2. - STUDY OF THE SCATTERING OF π^+ ON D, ${}^3\text{He}$, ${}^4\text{He}$ WITH A STREAMER CHAMBER IN A MAGNETIC FIELD (Project Godesc).

LNF Staff: C. Guaraldo, A. Maggiora, R. Scrimaglio; in collaboration with Torino and Dubna.

Discussion of the Godesc project continued in Dubna. This is a vast program of experiments with the JINR 400 MeV pion beam on light nuclei such as D, ${}^3\text{He}$, ${}^4\text{He}$. The experimental apparatus is a self-shunted streamer chamber in a magnetic field.

Measurements of elastic and inelastic total and differential cross sections are planned. Among the inelastic processes it is proposed in the first place to study double charge exchange as a test of existing models (cascade model, pair correlation model, isobaric model). In planning for the experiments special attention was paid to the system of triggers, that is, the scintillation counters and the proportional chambers to be placed around the streamer chamber. In collaboration with Turin, the construction of the proportional chambers and the design of the associated electronics have commenced.

Side by side with this, and always under the collaboration with Dubna, the analysis of the data of inelastic π^+ scattering on ${}^4\text{He}$ at 110 and 160 MeV from the pion beam of Laboratorio Leale has been completed. Particular attention was paid to the processes of knockout of nucleons induced by pions in the reaction $(\pi, \pi N)$ with special regard to the ratio of the cross sections of these process σ^-/σ^+ relative to the pure channel $T = 3/2$ and the mixed ones $T = 3/2$ and $T = 1/2$. As is well known in the simple PWIA this ratio should be 3, in the knockout of a neutron, while all experimental results on ${}^{12}\text{C}$ and our present one on ${}^4\text{He}$ give a value near one.

A simple theoretical model has been developed which incorporates in the PWBA an exchange mechanism and thus adds to the term with a one nucleon final state also that of three nucleons. The agreement with the dependence of the differential cross section on angle is only qualitative, above all at large angles; however the predicted ratio of the total cross sections is close to that of the experiment. The work is to be published in Nuovo Cimento.

4.- THEORETICAL PHYSICS.

LNF Staff: G. De Franceschi, E. Etim, S. Ferrara, M. Greco, A. F. Grillo, C. Natoli, F. Palumbo and G. Parisi.

4.1. - NUCLEAR PHYSICS.

The study of the behaviour at the origin of the partial waves of the hyperspherical expansion of many-body wave functions was completed in 1977. Knowledge of this behaviour is necessary in order to impose the boundary conditions in the calculation of nuclear wave functions and in the determination of the asymptotic behaviour of form factors.

The properties of isotopic spin and parity of nuclear matter with density fluctuation and pion condensation were also studied.

The existence, in nuclei with non axial deformation, of a new type of collective nuclear excitation which has as the corresponding degree of freedom the angle the axis of the protons and that of the neutrons was proposed. The quantum numbers of such an excited state were determined with an estimate of the energy.

4. 2. - PARTICLE PHYSICS.

In analysing the S-D coupling in charmonium it was shown that by reason of it the S and D waves have in general an anomalous behaviour which renders the decay widths into e^+e^- divergent. The conditions which spin dependent potentials must satisfy in order for these decay widths to be finite were determined. Finally relativistic sum rules were established for the tensor coupling.

The study of two virtual photon meson (axial or tensor) vertices, important in the radiative transitions of the mesons $f_2(3.55)$ and $\chi_1(3.51)$ was completed.

Study of charmonium levels continued as well as that of transitions involving η_c and η_c' . Side by side with the finding of new levels in Adone the decay properties of the various radial and orbital excitations of ρ , ω , ϕ were studied.

The effect of the Pauli principle on the asymptotic behaviour of the form factor of a composite relativistic system was studied. It was shown that, contrary to the non-relativistic case, there is only a strong reduction in the coefficient of the leading power in the expansion but not a change in the power itself.

The study of unified theories of elementary particles with the inclusion of gravity was continued. These theories are based on a new gauge principle (local supersymmetry) and the corresponding gauge field is a spin 3/2 fermion (gravitino).

Recently the non polynomial character of supersymmetric gravitational theories with internal $O(N)$ ($N \geq 4$) symmetry. It was also shown, using results of graded Liealgebras, how the non-abelian symmetry associated with vector mesons unified with the graviton originate from a cosmological term.

4. 3. - QUANTUM GRAVITY.

The behaviour of quantum fields in the presence of strong gravitational fields was examined in relation to global conservation of baryon number and the process of black-hole evaporation proposed by Hawking.

The method of coherent states used in QED for the treatment of infrared divergences was adapted to QCD where it allowed to prove the finiteness of the cross section for states of definite colour.

5.- TECHNICAL RESEARCH AND GENERAL PHYSICS.

5. 1. - RESEARCH ON THE DYNAMICS OF TWO LEVEL SYSTEMS.

Contribution by: A. Turrin.

The damped optical Bloch equations have been used to derive (see LNF-76/52) the form of the "corresponding" two-level atomic dynamics. It turns out that the simple exponential decay which is implied by the phase relaxation terms introduces non-linear terms in the quantum-mechanical version of these equations.

The effect of depolarizing resonances for protons circulating on an exponentially growing flat-top field in a synchrotron has been calculated (see LNF-77/6). Resonant depolarisation can

be evaluated with good accuracy by making use of the Froissart-Stora formula in the case where the resonance is passed through, or, if not, by making use of the adiabatic following approximation formula.

The response of a two-level atom to an optical pulse which has a sech envelope and a tanh frequency sweep has been calculated (see LNF-77/28). The model is shown to give respectable agreement in the adiabatic and near-adiabatic limits, with the well known Landau-Zener formula. This suggests that the transition probability does not depend upon the details of any other form one may devise for the pulse envelope.

The formal similarity of the coupled mode equations used in two-mode coupled theory and the Schrödinger equation of a perturbed two-level atom has been recognized (see LNF-77/49). The use of the Bloch equations in a formal description of the exchange of power between the two modes has been proposed.

5.2. - PULS GROUP.

LNF Staff: A. La Monaca, S. Mobilio and A. Savoia; in collaboration with CNR, Roma.

The activity of the PULS group (Programma Utilizzazione Luce di Sincrotrone) is financed through a CNR-INFN agreement on the use of synchrotron radiation emitted in ADONE for interdisciplinary research in general physics, biology, chemistry, technology, optics, and materials properties.

In 1977 the structure of PULS was the following: Channelling group, Optics group, Spectroscopy group, EXAFS group and the Photoemission group.

The main effort in 1977, as will be reported in the following, was on the realisation of the light channels to the optics laboratory, and on preparing experiments to be started towards the end of 1978 in EXAFS (Extended X-ray Absorption Fine Structure), Photoemission, Optical Spectroscopy and the Development of Detectors for X-rays.

In 1977 the part of the channelling leading up to the external wall of ADONE has been practically completed, and that leading from there to inside of the PULS laboratory was started. Work continued on the important changes to be made in two Hilger-Watts and McPherson monochromators in order to adapt them to the requirements of ADONE's vacuum. Work also continued on the double crystal monochromator for the EXAFS line and the best part of the apparatus for photoemission experiments was ordered. The building of a drift chamber for hard X-rays commenced. Finally a number of experiments on optical spectroscopy, photoemission and superfluidity were completed.

5.3. - SEM GROUP.

LNF Staff: M. Spinetti; in collaboration with Sanità, Roma, Padova and Pisa.

In 1976 the group started investigating new data acquisition systems to be used in large high energy physics experiments and in all those cases where the speed of minicomputers is not sufficient.

System SEM (Sistema di Elaborazione Multiprocessor), of which the first prototype is being built in our laboratory, exploits the power of parallel computing, by a modular system consisting of an arbitrary number of communicating NOVA 3 processors with common memories and with I/O external channels, through standardized interconnection designed specially for the purpose. The construction of the hardware part is about to be finished while the basic software will be tested and put into operation in 1978.

The importance of this research also comes from its close relationship with future advanced data acquisition systems being studied in the USA and in Europe (NIM and ESONE).

Details on this project can be found in report LNF-77/20.

ACCELERATORS DIVISION.

1. - OPERATION.

The accelerators in operation in the Laboratory are ADONE, a 1.5 GeV $e^+ e^-$ storage ring, and a 450 MeV LINAC, injector to Adone also providing e^+ and e^- beams for nuclear physics experiments (LEALE).

Their operation in 1977 is summarized by the graph in Fig. 13 showing the actual number of hours of beam-on time delivered to experiments. Beam-on time is defined as the sum of the times when either one or two beams are circulating in the storage ring, for experiments, plus the time during which the LINAC beam is delivered to LEALE primary and parasite users. One-beam time in ADONE accounts for a few percent of the overall beam-on time, and LINAC-beam time for about 20% of it. The total beam-on time amounts to 3995 hours corresponding to an overall efficiency in the vicinity of 80% of the scheduled time, including injection, beam set-up and unscheduled machine down time. Fig. 14 shows the energy distribution of the $\sim 500 \text{ nb}^{-1}$ of total integrated luminosity.

In August and September there has been a long shutdown for maintenance and new installations.

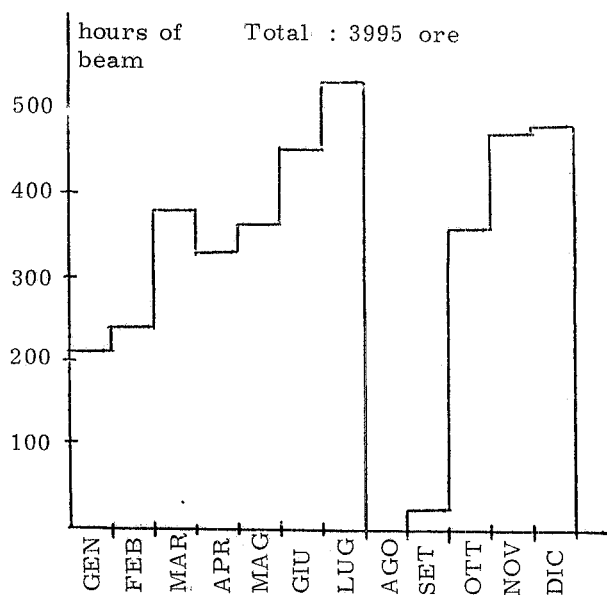


FIG. 13

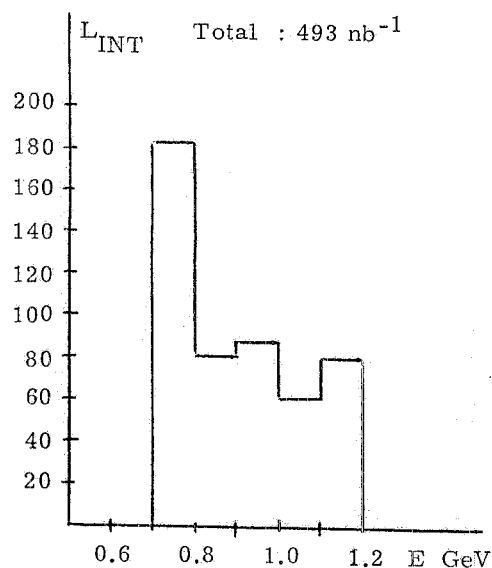


FIG. 14

In 1977 the improving staff situation has made it possible to increase the number of hours devoted to routine maintenance of the accelerators. This allowed the actual beam-on time to be steadily increased to ~ 500 hours a month, close to the maximum obtainable. About 900 hours were spent on routine maintenance and short repair operations.

Major maintenance operations, carried out during the August-September shutdown, were the following (~ 3500 man-hours):

- dismantling, repair and remounting of Linac section n. 8;
- complete overhaul of the injection optics, solenoid, main ADONE and MEA power supplies;

- replacement of 2 klystrons;
- commissioning of a spare modulator for component testing and preconditioning;
- overhaul and improvement of the LINAC cooling system and extension of the compressed air network;
- installation of a new closed circuit TV system;
- rebuilding of the low power stages of both storage ring RF transmitters.

It should be noted that the expansion of experimental activities in the Laboratory produced a steep rise in the requests for assistance to experimental groups.

2. - RESEARCH ACTIVITIES.

In the course of 1977 the Division has produced a design study on a high luminosity, 1.2 GeV $e^+ e^-$ ring (M. Bassetti et al. : "ALA - 1.2 GeV high luminosity electron-positron storage ring, design study" - LNF-78/15), a preliminary study for a 500 MeV LINAC pulse stretcher ring ("Proposta ALFA - Relazione del gruppo di studio" - LNF-77/46) and has initiated the construction of a 1.8 T, 6-pole wiggler magnet for Adone (M. Bassetti, A. Cattoni, M. Preger and S. Tazzari: "A transverse wiggler magnet for Adone", Proceedings of the X Int. Conf. on H. E. A., Serpukhov 1977 - pag. 391), expected to produce a soft X-ray beam with a critical energy of ~ 3 KeV.

Time has also been devoted to following and collaborating with European (LEP and ESRF) initiatives in the storage ring field.

3. - NEAR FUTURE PLANS.

Work has started in 1977 in preparation for the new installations scheduled to be brought into operation in 1978, namely PULS, LADON and Wiggler Magnet. The PULS and LADON facilities are described elsewhere in this report.

From the machine point of view the new installations require substantial modifications of the storage ring vacuum and control systems.

Improvements of the LINAC control system and conversion of the ring RF system to 51.4 MHz are also being worked on.

TECHNICAL DIVISION.

For the technical division 1977 was a year of internal organization. At the beginning of the year there were 15 members of staff of which only 7 were fully qualified. Under these conditions, the work done during the first six months of the year was essentially through external firms. The central workshop and store were completed and the detector workshop was essentially fully occupied by the preparation of the FRAM experiment.

The detectors group built 4 proportional wire coaxial cylindrical chambers with self-centered supports. The precision requirements within $1/10$ mm imposed severe technological problems (see Figs. 15 and 16). The same group is now working on the construction of 16 drift chambers for the same experiment (a prototype is shown in Fig. 17).

In the second half of 1977 the detector of which Fig. 18 shows the mechanical structure was installed and aligned on the axis of the beam in the North Area of the CERN SPS. It consists of 900 sensitive elements with 180 finger shaped light pipes and 88 45° elements with light pipe for a total of 268 phototubes. The definition of the structure was done in collaboration by the Detector

and the Design groups. It has been successfully tested at CERN.

Also for FRAM the anticoincidence and shower counters have been installed at CERN. They comprise 16 counters with light pipe and require a perfectly alignable mechanical structure with a deformation well under a millimeter. They were built in the central workshop and in the detector workshop.

The Detector group is also responsible for the Photography laboratory in which a medium-sized installation for the production of printed circuits has been installed in the course of 1977. 143 masters have already been produced and the first prototype circuit with metallized holes were made. The laboratory will go into full production in 1978.

It was only towards the second half of the year that the number of people in the Mechanics and Vacuum group reached 11. The main activities have been the following:

- mechanical work for the groups PULS, LADON and the Machine Division;
- construction of metallic carpentry for FRAM;
- continuation of the work on the new aluminium RF cavity and start of vacuum tests;
- beginning of the construction of targets for the LINAC positron converter;
- servicing and testing of vacuum for the PULS and LADON channels.

A new pulsed magnet for the injection optics and its elliptical vacuum chamber with corrugated thin wall were also completed (see Figs. 19-20).

The main design jobs completed by the Design group in 1977 are the following:

- design of a wiggler magnet to be installed in ADONE including the alignment system on ADONE, the supports and the coordinatometer for magnetic measurements;
- various designs for FRAM: plane chambers, "tappabuchi", drift chambers. Mechanical dimensional tests were carried out as well as deformation checks of the pieces constructed. Participation in the assembly and alignment of the experiment at CERN;
- design of a vacuum chamber for the pair spectrometer of the LEALE gamma beam;
- design of the cooling system for LADON;
- study and design of a new workshop;
- study of the container for the MDA liquid argon calorimeter.

The Division Electrical group is new in the laboratory. The group deals with all engineering problems relating to power supply to the accelerators and the experiments. In 1977 it completed the installation, testing and putting into operation of two power supplies for LEALE (100 KW and 300 KW), and took care of the maintenance and repair of the low and medium voltage distribution network throughout the Laboratory.

Contributions to research on new accelerators and experimental facilities are the following:

- study of the magnetic structure for ALA;
- preliminary design of the power supplies for ALA;
- preliminary design of the vacuum system for ALA;
- electrical design for the wiggler magnet;
- contributions to the ALFA project.

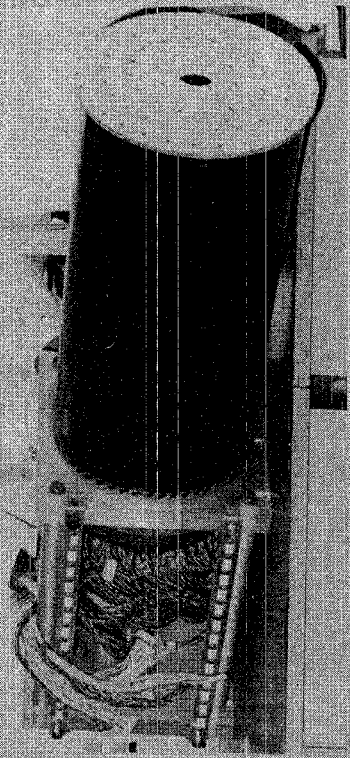


FIG. 14



FIG. 17

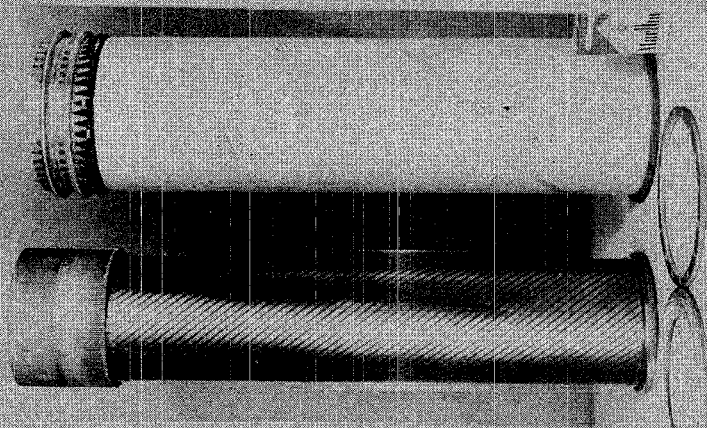


FIG. 15

FIG 18

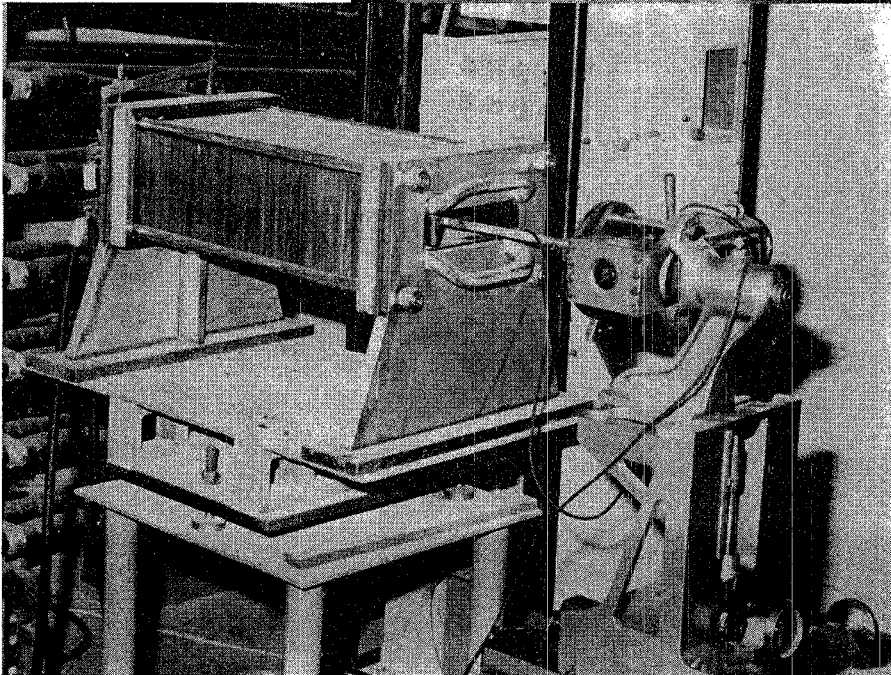
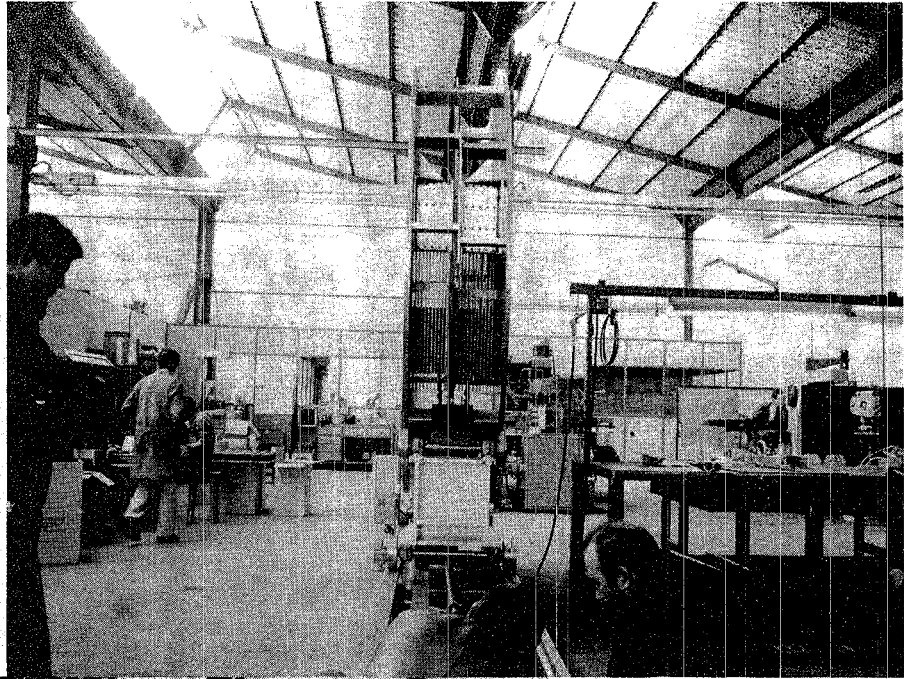


FIG 19

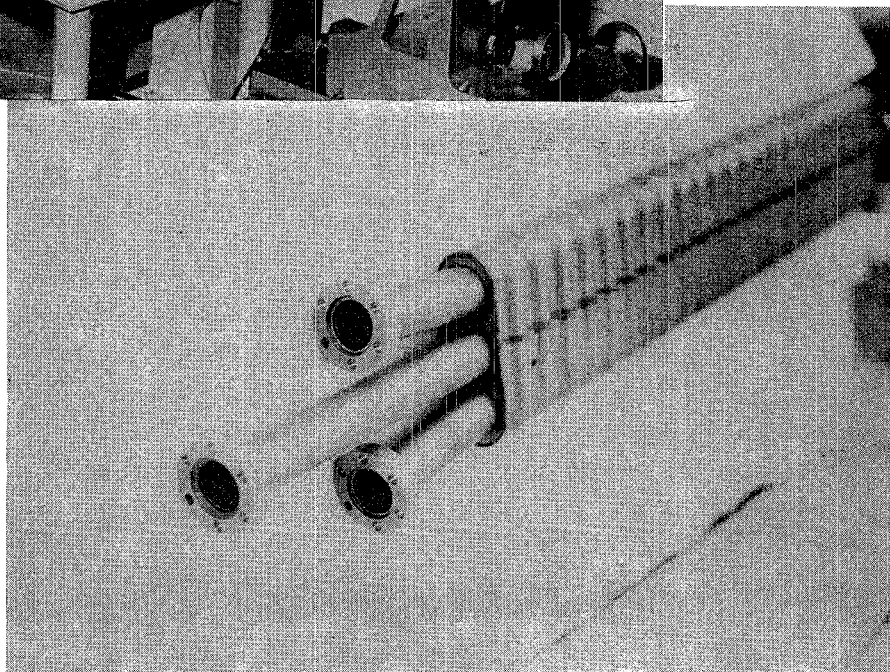


FIG 20

SERVICES.

COMPUTING FACILITIES.

In October the INFN asked for the establishment of a connection for the transmission of data between the National Laboratories (LNF) and the computing system CINECA. For this purpose an annual contract was signed with the DATA S.p.A. of Rome for renting and maintenance of a Remote Job Entry terminal consisting of:

- Central Unit with console;
- 450 cards/minute card reader;
- 300 lines/minute printer.

The terminal will be installed in the high energy physics building. For the connection a telephone of 4800 bits/sec will be used, through which the Physics Department of the University of Rome is already connected.

It is hoped to have the active connection on the part of the Laboratories by the end of January 1978. Supposing that the engagement of the line is the same as for the CNEN IBM 370/168 (30.000 lines of printing and 5.000 cards a day) then this would occupy about 15% of the total capacity of the line in an 8 hours working day.

The Computing service has been given the PDP 11/34 minicomputer, bought for the DIANA project, and will install it in the terminal room. Training courses for interested users of PDP 11 are being organized and an internal network to connect the minocomputers in the Laboratories is being worked on.

DOCUMENTATION SERVICE.

In 1977 the Documentation service published 60 reports, of which more than a half were sent to specialised journals or were part of reports presented at Conferences, as follows from the list of publications. In addition about 30 reports were published for the other sections of the INFN, as well as the "Proceedings of the First Course of the International School of Physics of Exotic Atoms (Erice, April 1977)".

During the year the following Meetings were organised in the Laboratories:

- "Vacuum: Experimental Techniques (13-23, April);
- "Theoretical and Experimental Physics" (26 April - 6 May);
- Round Table on "Synchrotron Radiation applied to Crystallography" (14 June);
- "PULS - Programma per l'Utilizzazione della Luce di Sincrotrone" (20-24 June);
- "Cryogenics: Experimental Techniques" (7-17 December).

LIST OF PUBLICATIONS (LNF).

- 77/1(P) S. Bartalucci, S. Bertolucci, C. Bradaschia, M. Fiori, D. Fong, T. Mc Corrison, P. Giromini, S. Guiducci, C. Rippich, M. Rohde, A. Sermoneta and L. Trasatti: A search for new vector mesons in the mass range between 0.9 and 2.2 GeV/c²; Nuovo Cimento 39A, 374 (1977).
- 77/2(P) K. Zalewski: Sum rules for vector meson-nucleon scattering from the generalized vector meson dominance model; Lett. Nuovo Cimento 21, 468 (1978).
- 77/3(P) F. Palumbo: Behaviour at the origin of the partial waves in the hyperspherical expansion of many-particle wave functions; Phys. Letters 69B, 275 (1977).
- 77/4(R) V. Chiarella: Camere drift. Principi di funzionamento e problemi connessi.
- 77/5(R) C. Coluzza, M. Meuti, C. Quaresima and R. Rosei: Thermotransmission measurements on self-supporting metal films.
- 77/6(P) A. Turrin: Resonant depolarization in a flat-topped proton synchrotron; Proc. X. Intern. Conf. on High Energy Accelerators, Protvino (1977), vol. II, pag. 81.
- 77/7(P) J. Berger, G. Bizard, A. Boudard, J. Dufflo, F. L. Fabbri, J. Goldzahl, C. Le Brun, J. Oostens, P. Picozza, F. Plouin, L. Satta, M. Van den Bossche, L. Vu Hai and Y. Terrien: Angular distribution measurement of the reaction $ap \rightarrow {}^3\text{He} d$ at 3.98 GeV/c; Lett. Nuovo Cimento 19, 287 (1977).
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