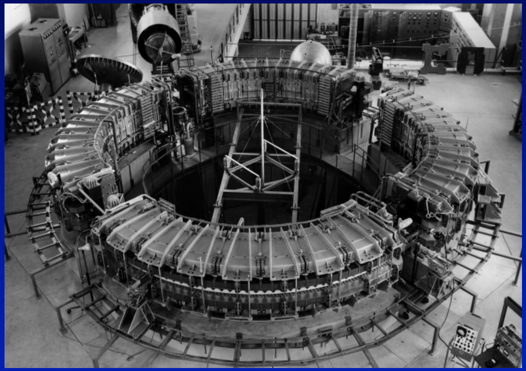


The Synchrotron:
Father of the Frascati Particle Accelerators

Andrea Ghigo

Istituto Nazionale di Fisica Nucleare

PHOTON 2019 Frascati 3 June 2019

The Frascati Synchrotron (1959-1975)

Electro-synchrotron was the first high-energy accelerator made in Italy.
It was approved in 1953 and its construction began in 1957.
After just two years the accelerator was operational.

Background

The desire to continue the studies begun by Enrico Fermi and by the "boys of via Panisperna" was strong but after the war the difficulties of the reconstruction slowed down the project to build high-energy particle accelerators as happened in USA. But the excitement of that school, which enumerated among the best nuclear and particles physicists of the world was not arrestable.

In 1948 a laboratory was set up on the Cervino mountain for the observation of cosmic rays waiting for ''the accelerators that produce them at home", as Gilberto Bernardini said, and at the Testa Grigia at 3500 m height, physicists from all universities worked together establishing strong personal and professional relationship that were fundamental to the growth of the INFN and CNEN

The F(o)unding Fathers

Edoardo Amaldi and Gilberto Bernardini

Enrico Persico

They believed that it would be important to build a high-energy accelerator in Italy

How the construction of the Synchrotron was decided

Amaldi's request to build an accelerator in Italy came up to the Prime Minister, Alcide De Gasperi, through Leone Cattani Minister of Public Works, but public finance had other priorities in that period of reconstruction. The professor Francesco Giordani then contacted the Minister of Industry Pietro Campilli, who demonstrated strong interest in nuclear research initiatives.

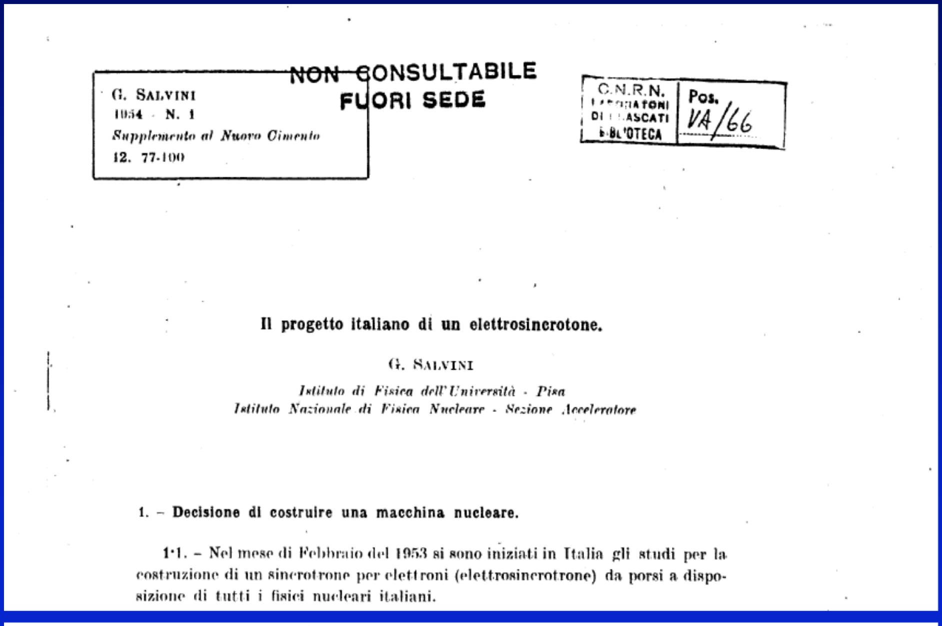

On. Pietro Campilli

Amaldi, Giordani and Campilli agreed to set up the National Committee for Nuclear Research, CNRN, financed by the Ministry of Industry. Minister Campilli, resident in Frascati, convinced his friend Senator Pietro Micara, mayor of Frascati, to give a plot of land with the curious name of ”Macchia dello sterparo” (grove of brushwood…….)

It was decided to build a Synchrotron of energy between 500 and 1000 MeV.

The Boss

The construction of the Synchrotron and the related research center was entrusted to a 31-year-old physicist: Giorgio Salvini. He recruited a team of good and motivated physicists in the Italian universities



G. Salvini
1954 - N. 1
Supplemento al Nuovo Cimento
12. 77-100

NON CONSULTABILE
FUORI SEDE

C.N.R.N. LABORATORI DI FRASCATI BIBLIOTECA Pos. VA/66

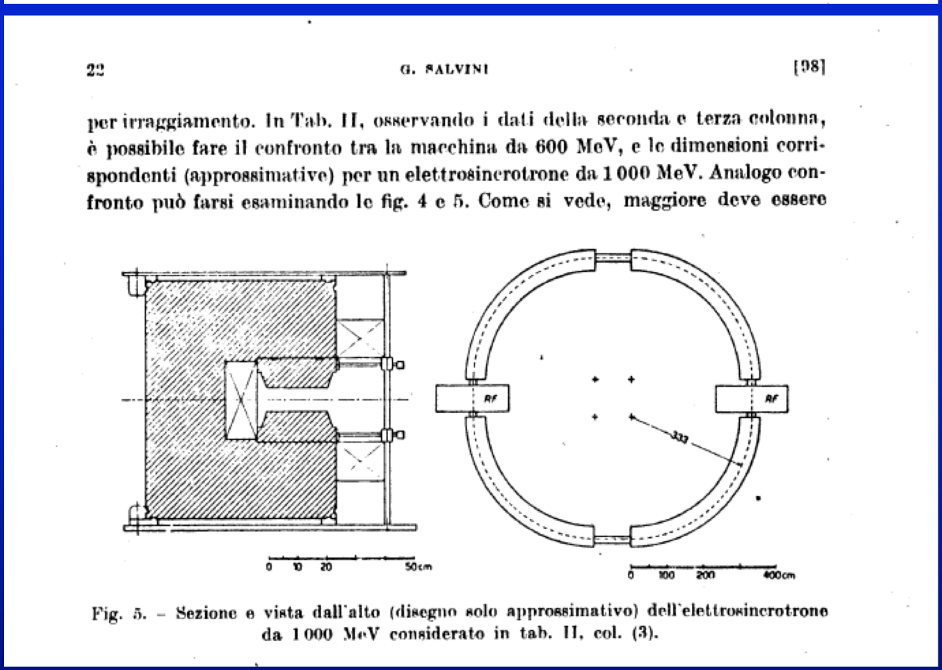
Il progetto italiano di un elettrosincrotone.

G. Salvini

Istituto di Fisica dell'Università - Pisa
Istituto Nazionale di Fisica Nucleare - Sezione Acceleratore

1. – **Decisione di costruire una macchina nucleare.**

1·1. – Nel mese di Febbraio del 1953 si sono iniziati in Italia gli studi per la costruzione di un sincrotrone per elettroni (elettrosincrotrone) da porsi a disposizione di tutti i fisici nucleari italiani.



22 G. SALVINI [98]

per irraggiamento. In Tab. II, osservando i dati della seconda e terza colonna, è possibile fare il confronto tra la macchina da 600 MeV, e le dimensioni corrispondenti (approssimative) per un elettrosincrotrone da 1 000 MeV. Analogo confronto può farsi esaminando le fig. 4 e 5. Come si vede, maggiore deve essere

Fig. 5. – Sezione e vista dall'alto (disegno solo approssimativo) dell'elettrosincrotrone da 1 000 MeV considerato in tab. II, col. (3).

Physics program (1)

- The Frascati Synchrotron aims to accelerate electron beam up to 1GeV energy
- The electron beam had been used to generate a γ beam, up to 1 GeV, by bremsstrahlung on target placed inside the machine.
- The γ beam were had been used to study the interactions between matter and electromagnetic radiation.
- And in particular to study nuclear and electromagnetic forces between elementary particle

Physics program (2)

- Single and multiple photoproduction of charged and neutral pions.
- Photoproduction of strange particle: heavy meson and hyperon

  $\gamma + p \rightarrow \Lambda^0 + K^+$ (threshold 910 MeV)

  $\gamma + p \rightarrow \Sigma^0 + K^0$ (threshold 1040 MeV)

- Electron – photon experience to study nuclear form factors
- Photoproduction of particle pairs ($\mu^+\mu^-$, $\pi^+\pi^-$)

Pisa 1955: Researchers leaving for Rome.

In 1955 the accelerator section of the INFN in Pisa moved to Rome for the construction of the synchrotron. Following the decision to build the synchrotron in Frascati, this team will become the INFN-CNEN National Laboratories of Frascati.

1955: Pisa: Partenza per Frascati

The Synchrotron building during costruction

The inner view of the building with the large synchrotron concrete basement

Cryogenic lab

The first building built in Frascati contained the liquefier bought to make cryogenic plates as a target for the synchrotron beam

1956: The first canteen in Frascati. The photo is taken during the lunch break in a phase of the installation of the liquefier for the cryogenic of the Synchrotron. Recognizable Scaramuzzi, Bellatreccia, Careri and Moneti

A temporary RF laboratory was set up in a tent waiting for the building

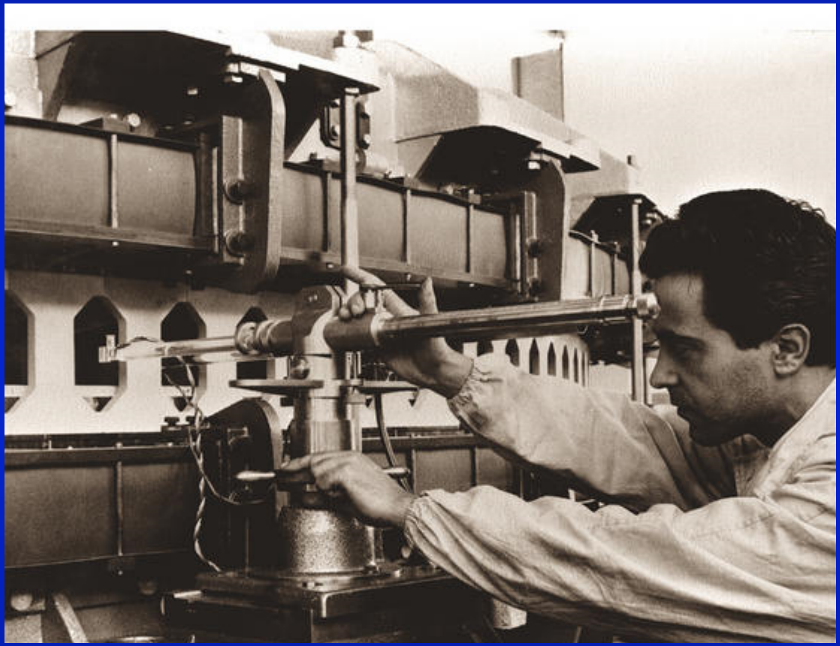
Building ready

The problem of lack of water was solved by digging a well of 160 m "Absurdly deep almost to the antipodes" (Touschek)

Great work of the technicians:

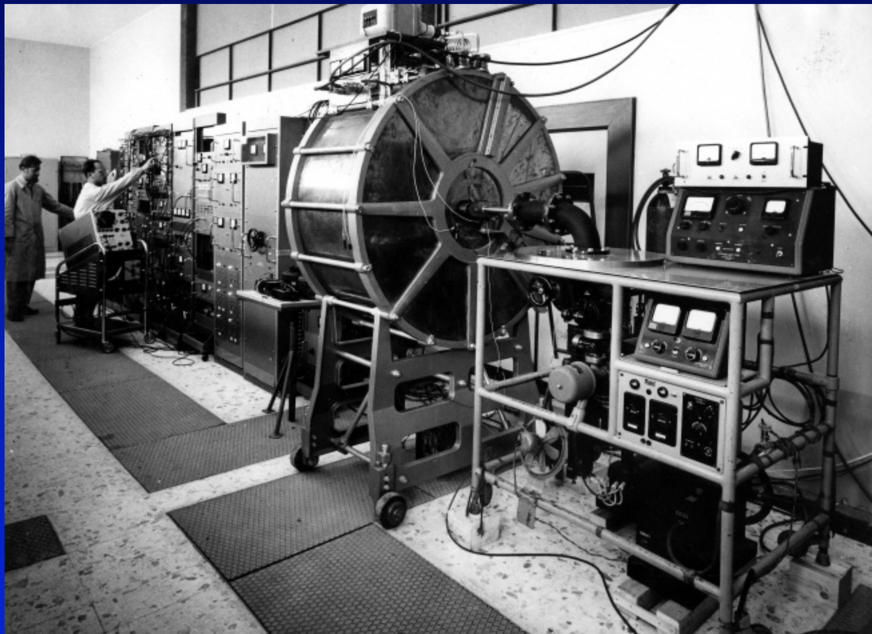
large part of the accelerator components were made in house

Mechanical workshop



Magnetic measurements
In the picture: Di Stefano

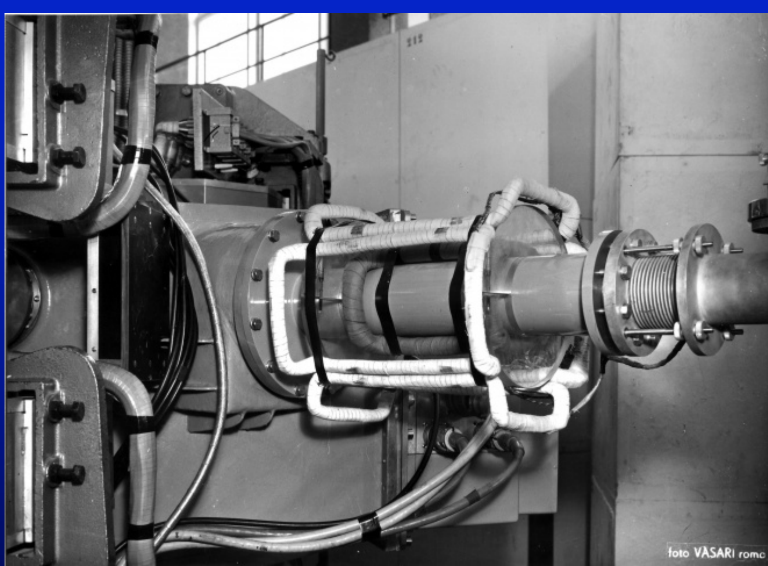
Vacuum chamber quality control
In the picture: Clozza



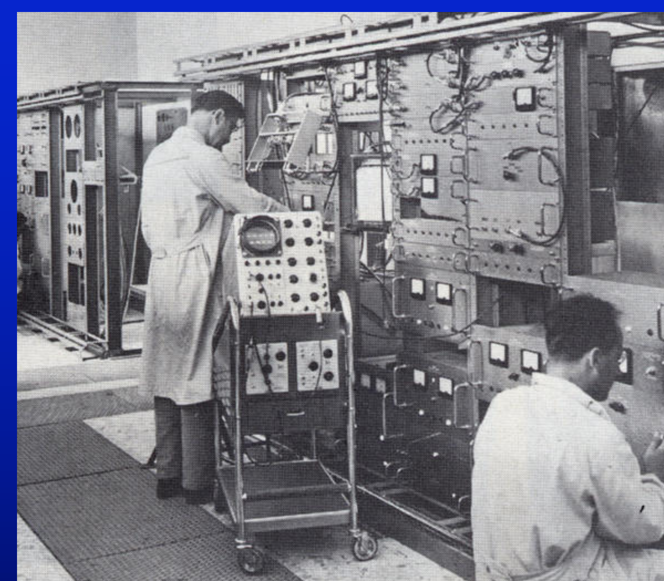
RF cavity with power supply

3 MeV Van de Graaf injector

Injection deflector



Sala controllo
nella foto:Eddy
Grad



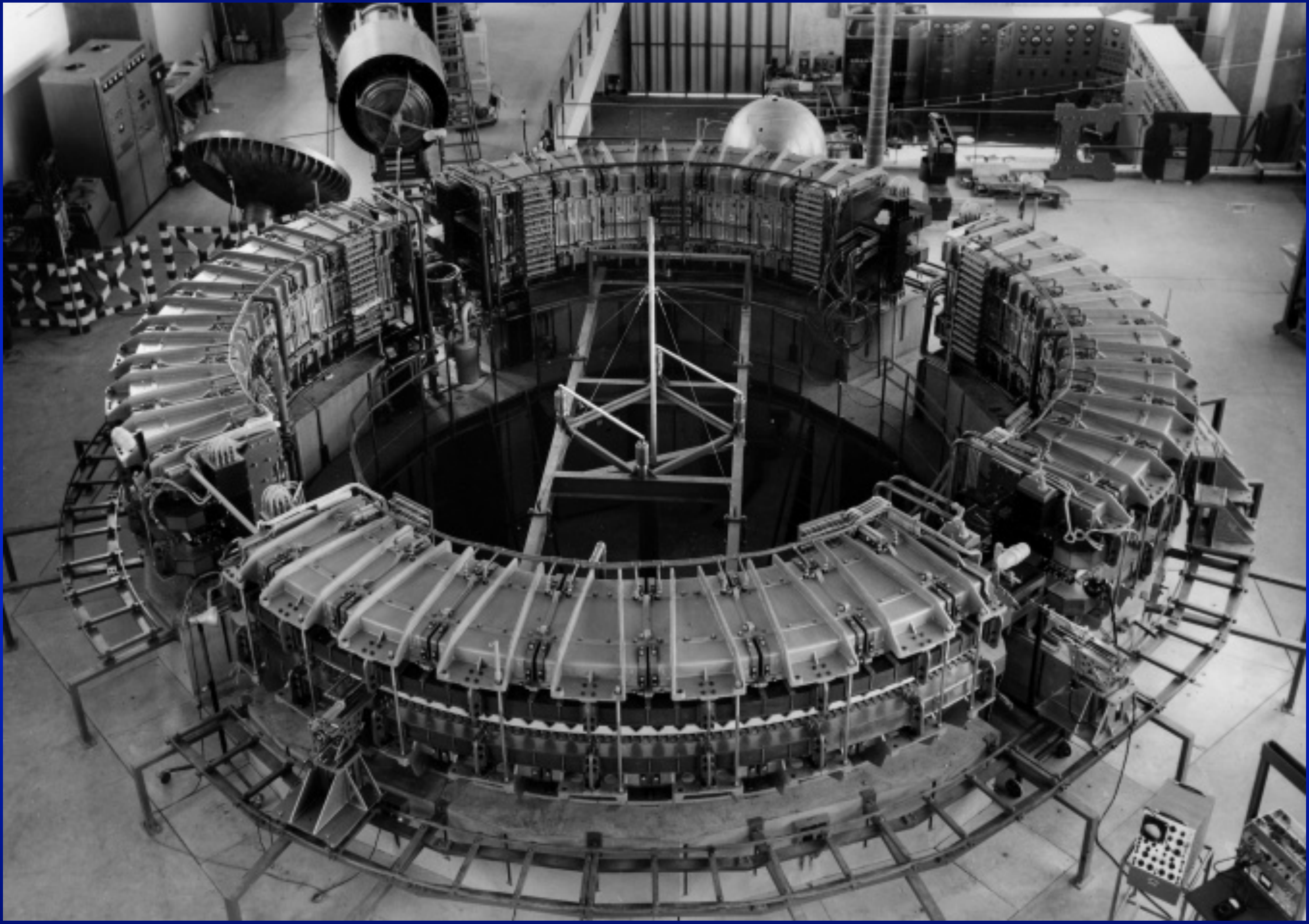
Rotating group for magnet supply

Protection inductor

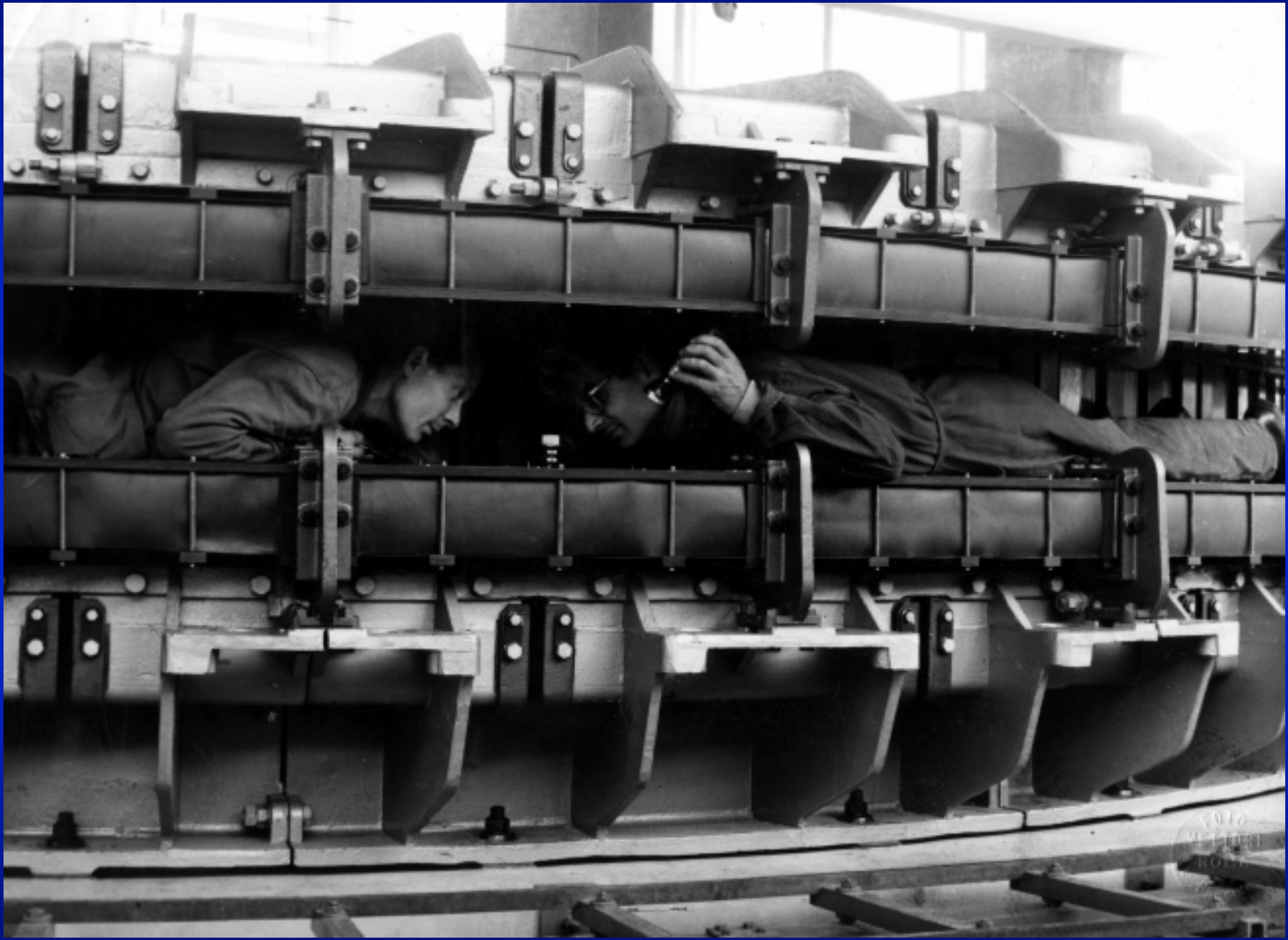
capacitors hall

Synchrotron installation

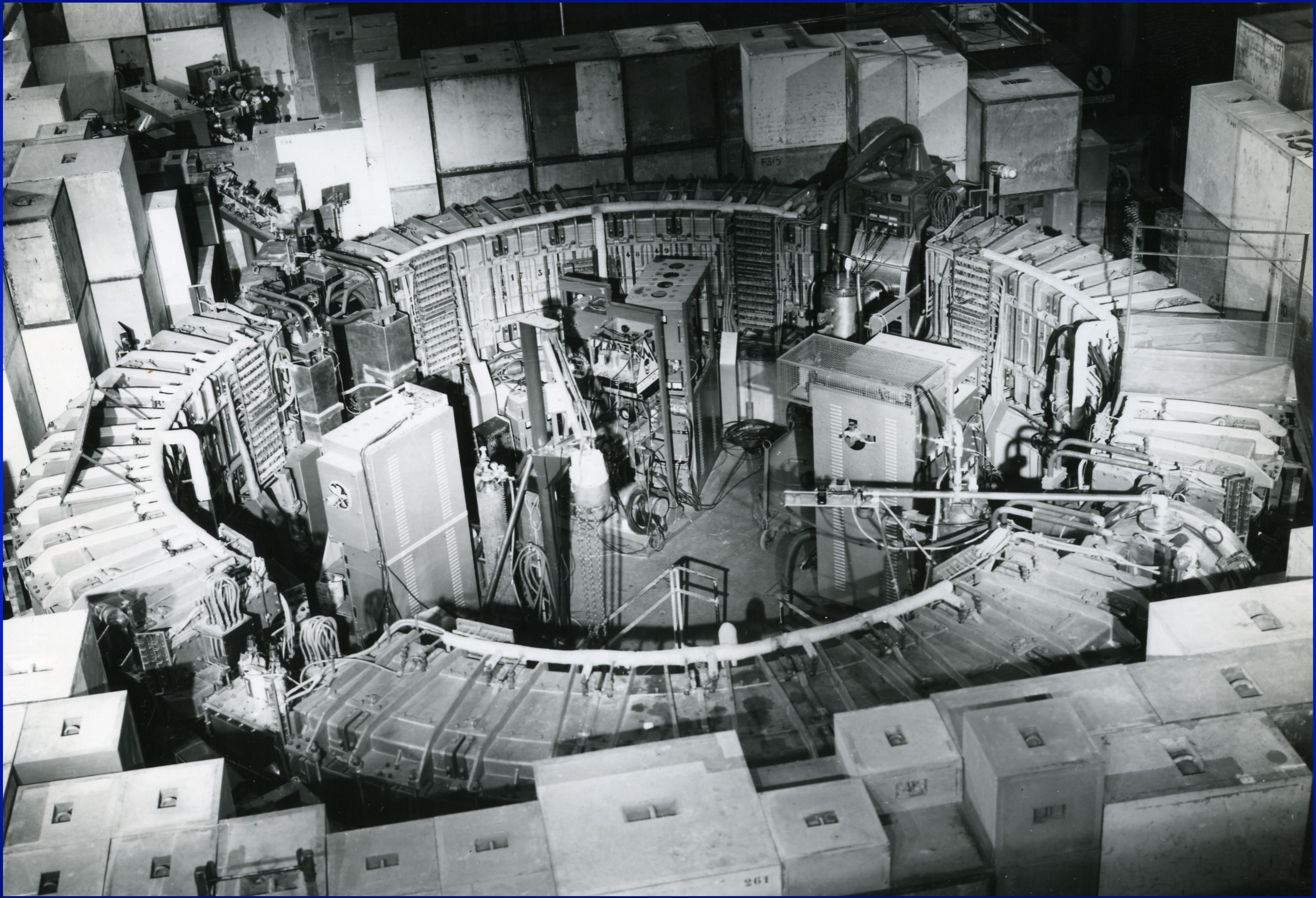
Synchrotron installation



Final magnet inspection : Dr. Murtas inside the gap



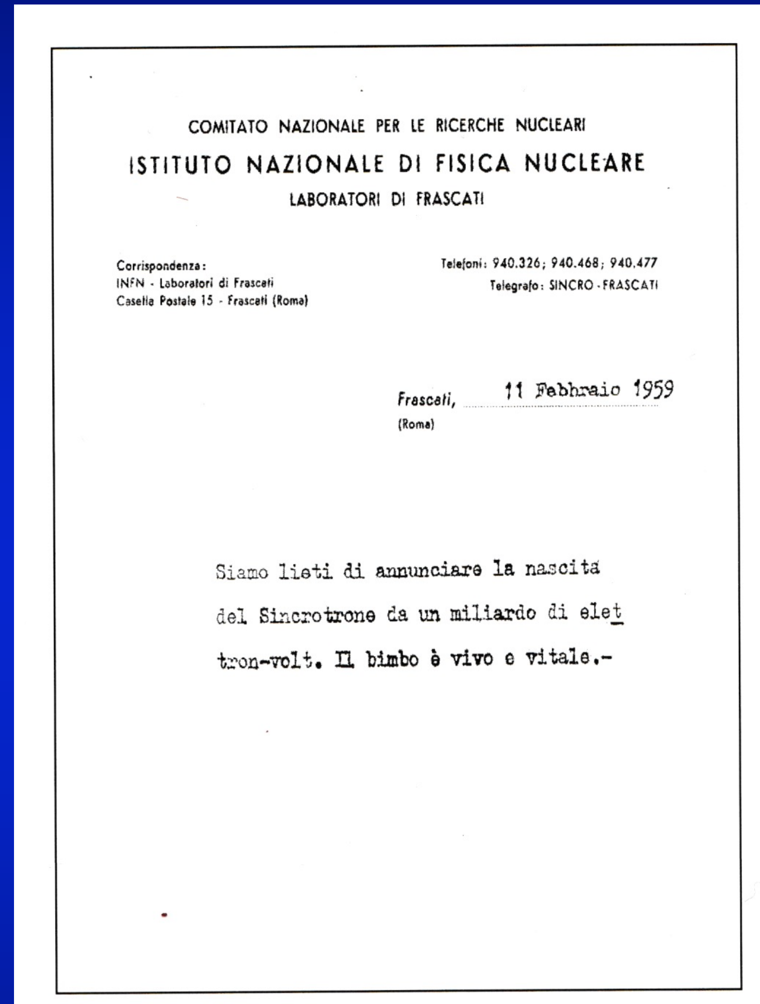
The Sinchrotron ready for the commissioning



Frascati staff : G.Salvini in the center

Ghira,Quercia,Toschi,Bologna,Querzoli,Zanetti,Agostini,DiStefanoGuido,Trevisan, Pistoni,Santangeli,Cavusotti,Brolatti,Murtas,Marra,Pecchi,Scaramuzzi,Bonini, Cerchia,Propersi,Stipchic,Puglisi,Sanna,Martellucci,Eddi,Ivagnes,D'Amato, Sacerdoti,Piredda,Ghigo,Bernardini,Grilli e Cinti.

11 February 1959: the Sychrotron is ready for the experiments



COMITATO NAZIONALE PER LE RICERCHE NUCLEARI
ISTITUTO NAZIONALE DI FISICA NUCLEARE
LABORATORI DI FRASCATI

Corrispondenza:
INFN - Laboratori di Frascati
Casella Postale 15 - Frascati (Roma)

Telefoni: 940.326; 940.468; 940.477
Telegrafo: SINCRO - FRASCATI

Frascati, 11 Febbraio 1959
(Roma)

Siamo lieti di annunciare la nascita del Sincrotrone da un miliardo di elettron-volt. Il bimbo è vivo e vitale.-

The funny official announcement ''we are pleased to announce the birth of the one billion electron-volts synchrotron. The child is alive and viable''

Notoriety: famous guests arrive

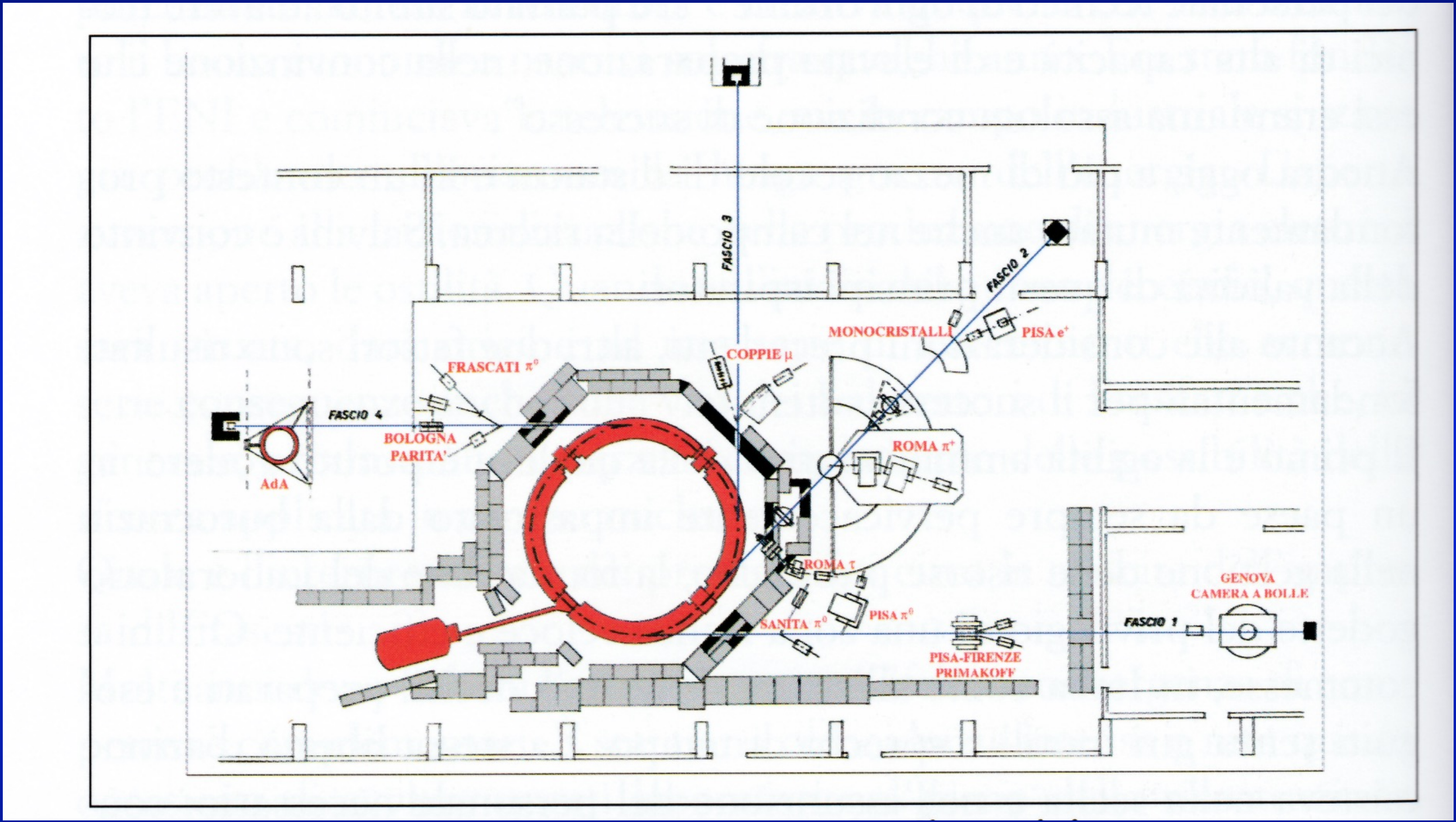
Italian president: Gronchi
3 April 1959

1959: President of EURATOM

Prince Philip of Edinburgh
3 May 1961

16/11/1959 The most famous visit:
Ranieri di Monaco and Grace Kelly

Synchrotron and experimental beam lines layout



The four sychrotron beam lines with the arrangement of the experimental apparatus at the beginning of 1961

Experimental hall

Experiments counting room

IL NUOVO CIMENTO Vol. XVII, N. 2 16 Luglio 1960

Forward Angle Photoproduction of Single Positive Pions on Hydrogen.

M. Beneventano, G. Finocchiaro, R. Finzi
L. Mezzetti, L. Paoluzzi and C. Schaerf
Istituto di Fisica dell'Università - Roma
Istituto Nazionale di Fisica Nucleare - Sezione di Roma

(ricevuto il 25 Luglio 1960)

IL NUOVO CIMENTO Vol. XVIII, N. 6 16 Dicembre 1960

Preliminary Results of a Measurement of the Differential Cross Section for Single π^0 Meson Photoproduction in Hydrogen.

G. Cortellessa and A. Reale
Istituto Superiore di Sanità - Roma

(ricevuto il 6 Giugno 1960)

Volume 6, Number 5 PHYSICAL REVIEW LETTERS March 1, 1961

SEARCH FOR THE ω^0 IN PHOTOPRODUCTION

K. Berkelman,* G. Cortellessa, and A. Reale
Laboratori di Fisica, Istituto Superiore di Sanità, Roma, Italy
(Received February 8, 1961)

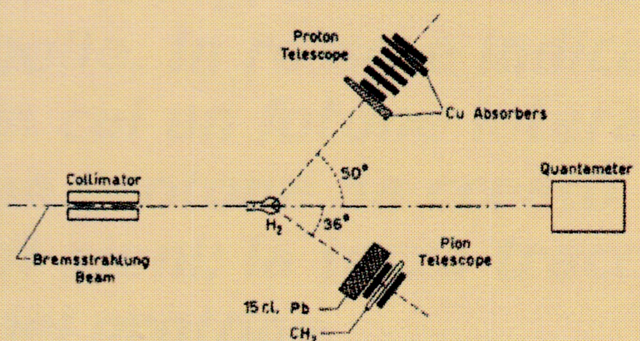


FIG. 1. The experimental setup (not drawn to scale).

hydrogen target HD1

VOLUME 8, NUMBER 11 PHYSICAL REVIEW LETTERS JUNE 1, 1962

EXPERIMENTAL EVIDENCE FOR A QUASI-MONOCHROMATIC BREMSSTRAHLUNG INTENSITY FROM THE FRASCATI 1-GeV ELECTRONSYNCHROTRON

G. Barbiellini, G. Bologna, G. Diambrini, and G. P. Murtas
Laboratori Nazionali di Frascati del Comitato Nazionale per l'Energia Nucleare, Frascati, Roma, Italia
(Received April 24, 1962)

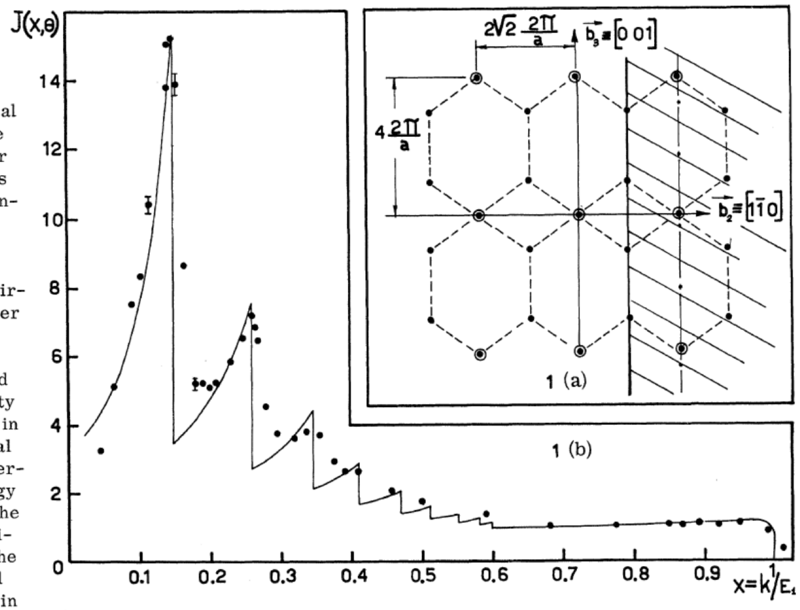
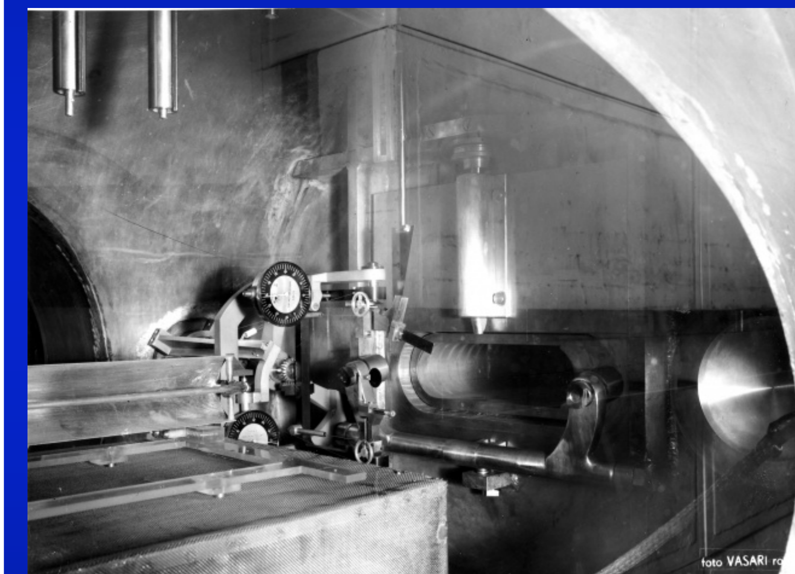


FIG. 1. (a) Structure of the diamond reciprocal lattice plane through the origin and perpendicular to the axis (110); $a/2\pi$ is the edge of the fundamental cube in units of the Compton wavelength of the electron. For the points enclosed in the circles $|F|^2=8$; for the other points $|F|^2=4$ (F is the Laue-Bragg structure factor). (b) Normalized bremsstrahlung intensity of $E_1=1$ GeV electrons in a diamond single crystal at room temperature versus the fractional energy $x=k/E_1$ of the photon; the momentum $\vec{p}_1$ of the primary electron makes the angle θ with the crystal axis $\vec{b}_1\equiv(110)$ and lies in the plane of the axes $\vec{b}_1$ and $\vec{b}_2\equiv(1\bar{1}0)$. The solid curve represents the calculated quantity (2) and the dots represent the measured quantity (1), for $\theta=\theta_1=4.6\pm0.1$ mrad. The statistical error is indicated for some points.



Device with diamonds for single crystal generation

Cerenkov counter

IL NUOVO CIMENTO Vol. LIV A, N. 4 21 Aprile 1968

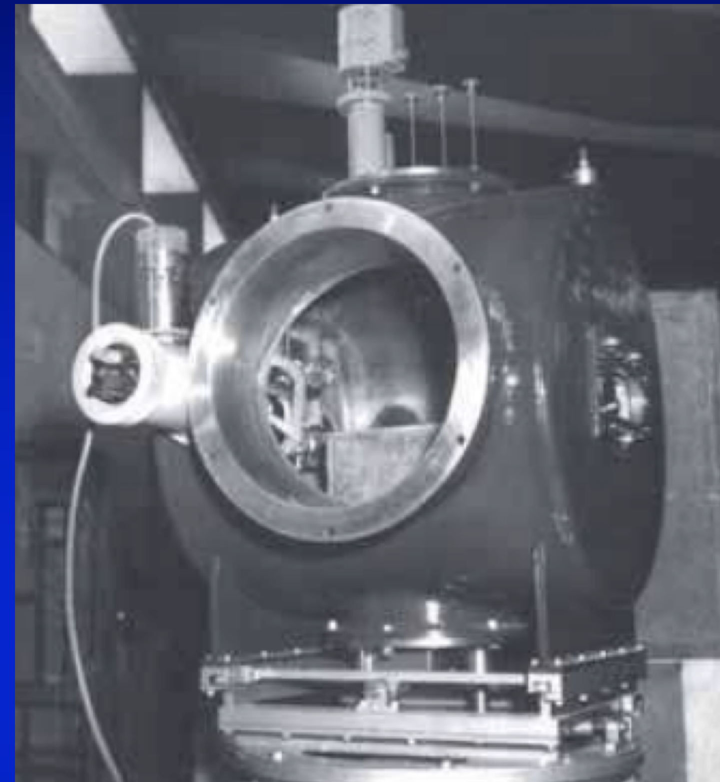
Positive-Pion Photoproduction by Linearly Polarized γ Rays.
I. - Experimental Method and Results.

M. Grilli, P. Spillantini and F. Soso
Laboratori Nazionali di Frascati del CNEN - Roma

M. Nigro, E. Schiavuta and V. Valente
Istituto di Fisica dell'Università - Padova
Istituto Nazionale di Fisica Nucleare - Sezione di Padova

(ricevuto il 10 Ottobre 1967)

Summary. — The apparatus and the experimental method used for the measurements of the single-π^+ photoproduction by linearly polarized γ rays are described. The present results on the asymmetry ratio $A(\theta)$ are summaized. The range covered by our results is $\theta = (30 \div 145)°$ (c.m.) and $E_\gamma = (200 \div 450)$ MeV.



Goniometer for crystal polarizer

Spectrometer with counters

frame of the bubble chamber: in red the point at which the photon, interacting with a proton, has created a pair of pions; the third trace is that of the proton

Bubble chamber during lab test

PHOTOPRODUCTION AND NEUTRAL DECAY MODES OF THE η PARTICLE

C. Bacci, G. Penso, G. Salvini, and A. Wattenberg*
Istituto di Fisica dell'Università di Roma, Roma, Italy
and Istituto Nazionale di Fisica Nucleare, Sezione di Roma, Roma, Italy

and

C. Mencuccini, R. Querzoli, and V. Silvestrini
Laboratori Nazionali del Comitato Nazionale per l'Energia Nucleare, Frascati, Roma, Italy

(Received 11 June 1963)

Photoproduction of the η particle has been observed at 978 and 939 MeV using the 1100-MeV Frascati electron synchrotron. We have evaluated the branching ratio of the $\gamma+\gamma$ decay mode relative to other neutral modes, and the differential production cross section $d\sigma/d\Omega$ for the process

$$\gamma+p\rightarrow\eta+p. \quad (1)$$

The quantity directly measured was $(d\sigma/d\Omega)\times(\Gamma_{\gamma\gamma}/\Gamma_{total})$. The results are given in Table I.

The experimental arrangement[1] is shown in Fig. 1. The γ-ray beam from the electron syn-

Table I. Results of the present experiment (reaction $\gamma+p\rightarrow\eta+p$). E_0 is the energy of the electrons in the synchrotron; $k\pm\Delta k$ is the lab energy and energy interval of the photons hitting the proton; $T_p\pm\Delta T_p$ is the energy and energy interval for the proton; θ^* is the c.m. angle of the η; $[(d\sigma/d\Omega)(\Gamma_{\gamma\gamma}/\Gamma_{total})]_{c.m.}$ is the differential cross section for photoproduction of η's decaying in the $\gamma+\gamma$ mode; $d\sigma/d\Omega$ is the c.m. differential cross section for η photoproduction (3.2 times the preceding values; we obtain from the branching ratio measurements and other results that $\Gamma_{\gamma\gamma}/\Gamma_{total}=1/3.2$). $R=(\gamma+\gamma)/[(3\pi^0)+(\pi^0+\gamma+\gamma)]$ is the branching ratio. The numbers in parentheses are less certain; see text. The errors include an estimate for our uncertainties in solid angle, efficiency, and background.[a]

E_0 (MeV)	$k\pm\Delta k$ (MeV)	$T_p\pm\Delta T_p$ (MeV)	θ^*	$(d\sigma/d\Omega)(\Gamma_{\gamma\gamma}/\Gamma_{total})$ (10^{-32} cm^2/sr)	$(d\sigma/d\Omega)$ (10^{-32} cm^2/sr)	R	Method	Dosis (10^{14} equiv. quanta)
1000	978±22	278±18	106°±5°	7.6±1.6	~24	0.78±0.34	γ method	2.05
1000	978±22	278±18	106°±5°	6.2±1.3	~20	0.83±0.31	step	3.5
1000	939±14	248±11	103°±5°	(11.5±2.6)	~(36)	(0.53±0.22)	γ method	1.53
950	937±13	248±11	103°±5°	(10 ±2.1)	~(32)	(0.88±0.58)	γ method	1.95

[a]See reference 1.

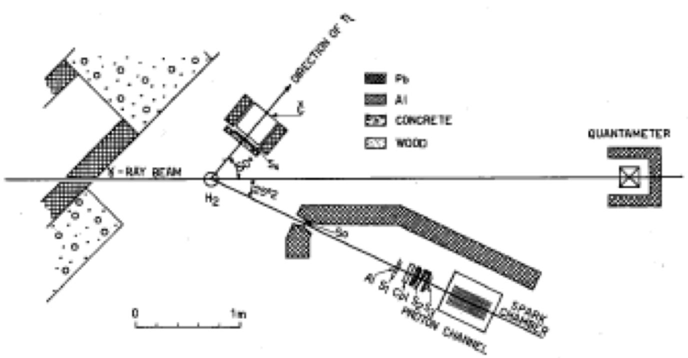
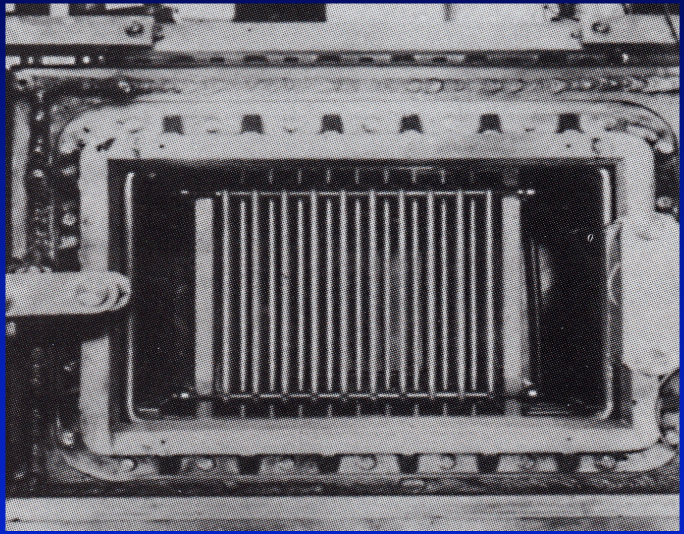
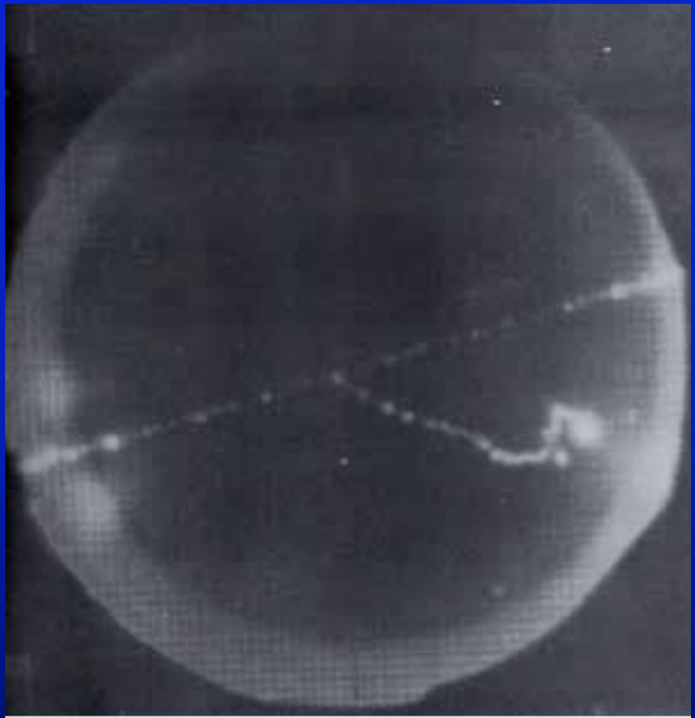


FIG. 1. Experimental arrangement.[1] The wedge-shaped shim in the proton channel corrects for the angular dependence of the proton energy.

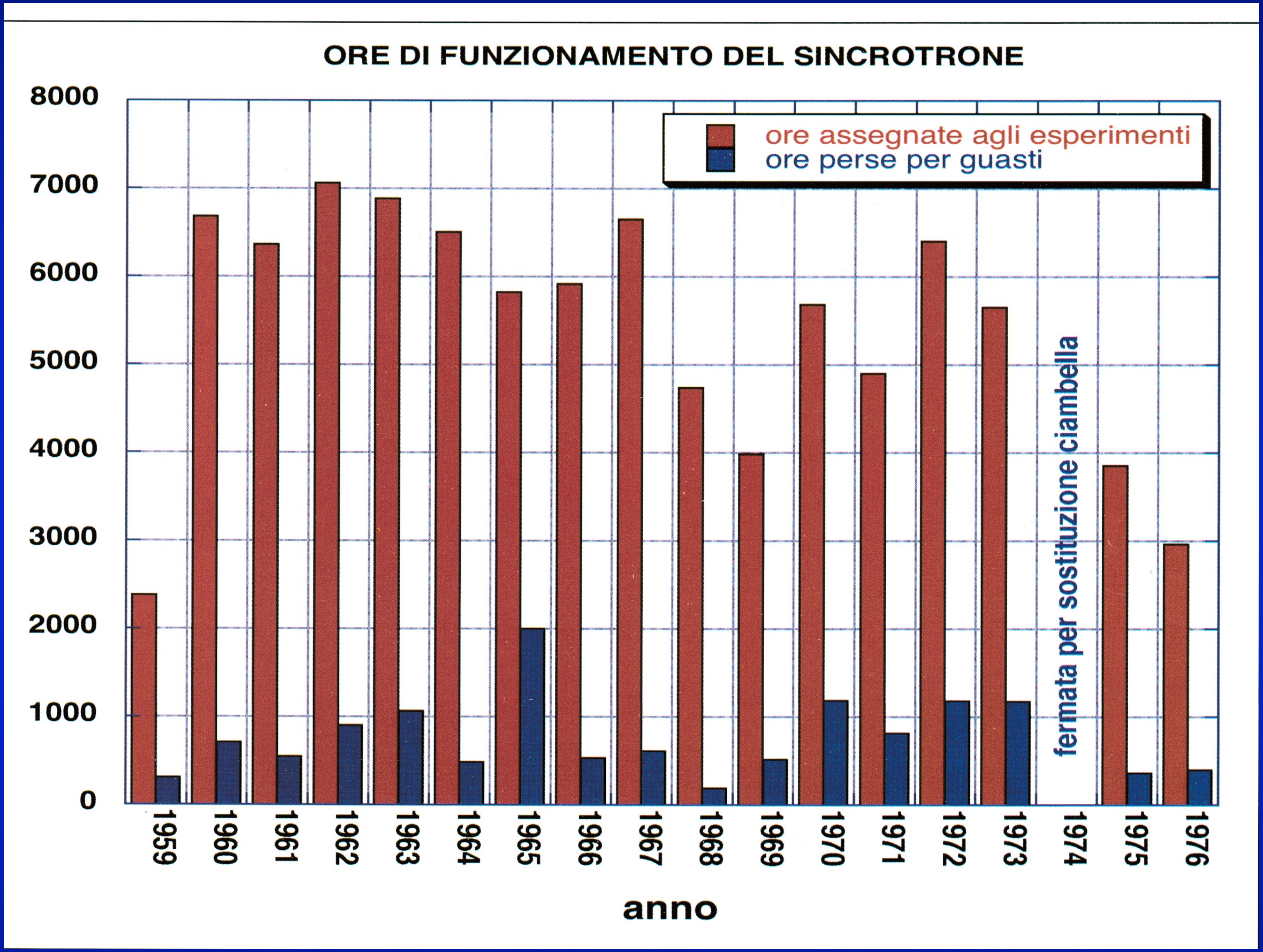


First Spark chamber, 1959



Traces in the Spark chamber

Great availability and reliability



Synchrotron duty cycle: in red the working hours for experiments per year, in blue the hours lost due to faults

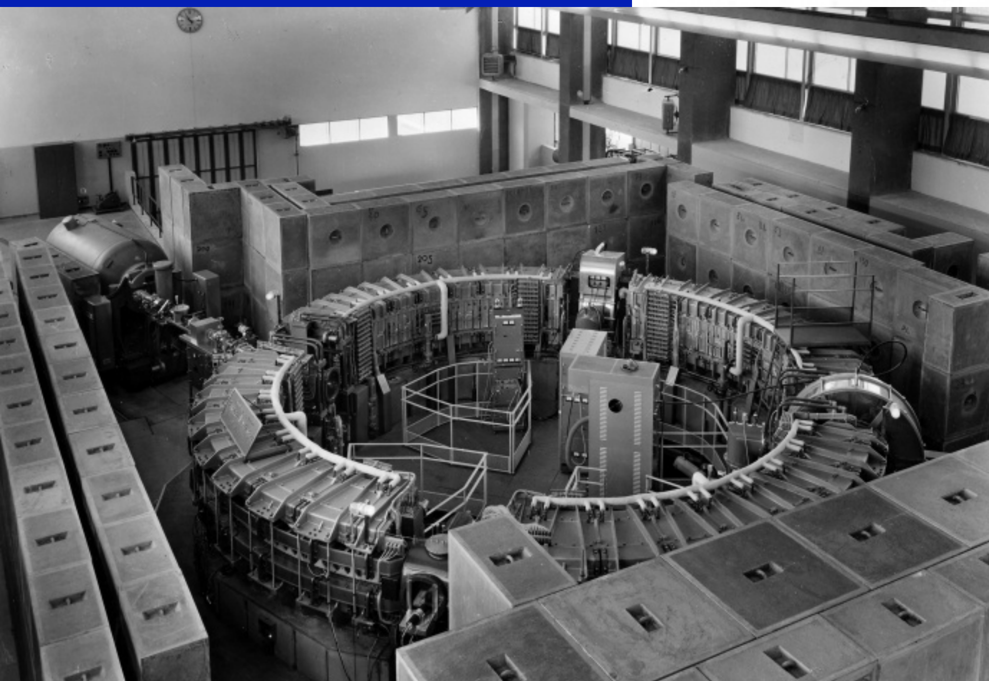
Beam extraction

U. Bizzarri, *et al.*
1° Aprile 1966
Il Nuovo Cimento
Serie X, Vol. 42, pag. 639-648

The External Electron Beam of the Frascati Electron Synchrotron (*).

U. Bizzarri, M. Conte (**), I. F. Quercia and A. Turrin
Laboratori Nazionali del CNEN - Frascati (Roma)

(ricevuto il 10 Novembre 1965)



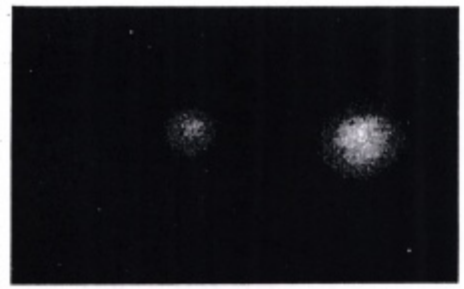
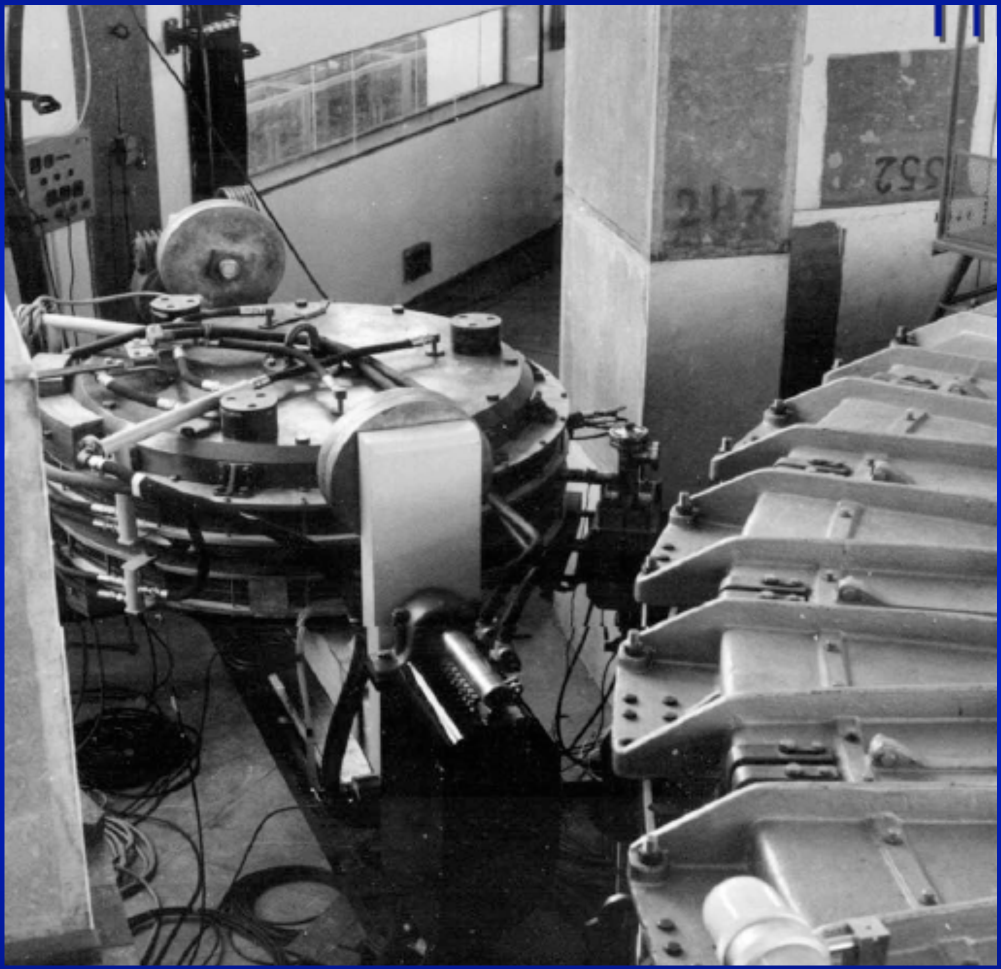


Fig. 5. – Film exposure at about 3 m from the two targets, while the perturbation is applied. The left spot represents the γ-ray beam (extracted electrons) coming from the 5 mm target. The right one represents the γ-ray beam from the 1 mm target. In this case the extraction efficiency is about 20%.

The study of the physics of the nucleos requires the extraction from the synchrotron to send the electron beam on target. The difficult problems had been solved with a RF resonant excitation

The beam extracted was also used to inject in the first electron-positron collider of the world, called ADA (Anello Di Accumulazione) invented by Bruno Touschek



To switch from electron to positron injection the magnet had been rotated around its axis: a technique called "the rotisserie"

The Frascati Storage Ring.

C. Bernardini, G. F. Corazza, G. Ghigo
Laboratori Nazionali del CNEN - Frascati

B. Touschek
Istituto di Fisica dell'Università - Roma
Istituto Nazionale di Fisica Nucleare - Sezione di Roma

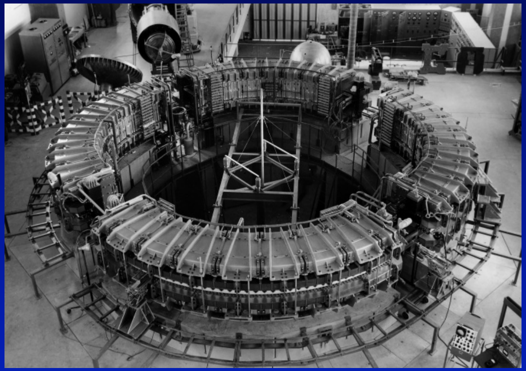
(ricevuto il 7 Novembre 1960)

Nobody could tell which were positrons and which electrons

Bruno Touschek

But this is another story……..

Istituto Nazionale di Fisica Nucleare



Thanks for the attention

bibliographic and photo sources: E.Amaldi, G.Battimelli, C.Bernardini, P.Campana,M.Ricci-Ghigo, G.Salvini, V.Valente and … many friends