Beppo Occhialini
and the birth of gamma astronomy in Italy

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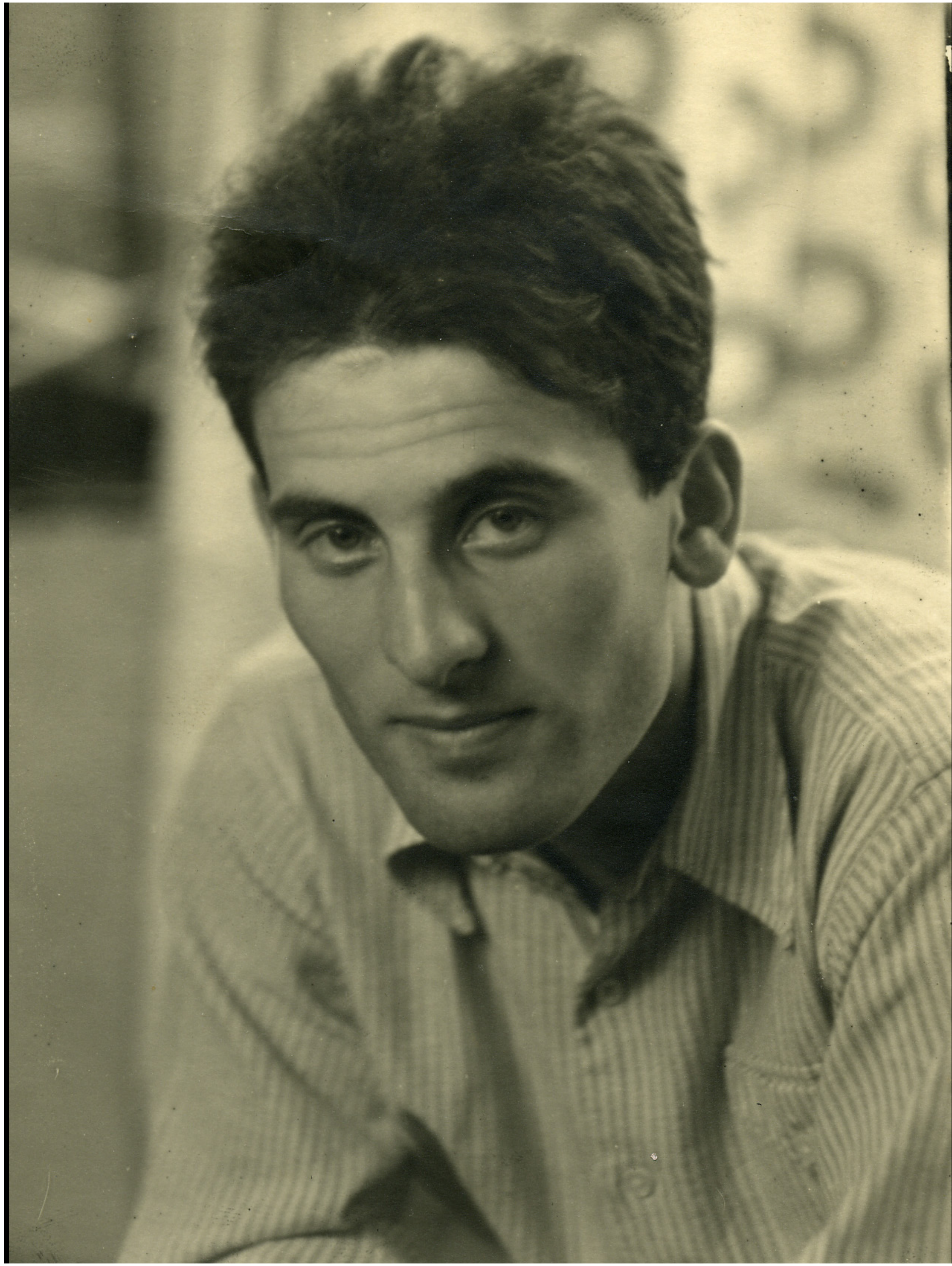


Giuseppe “Beppo” Occhialini
(Fossombrone 1907 – Paris 1993)

Son of Augusto Occhialini

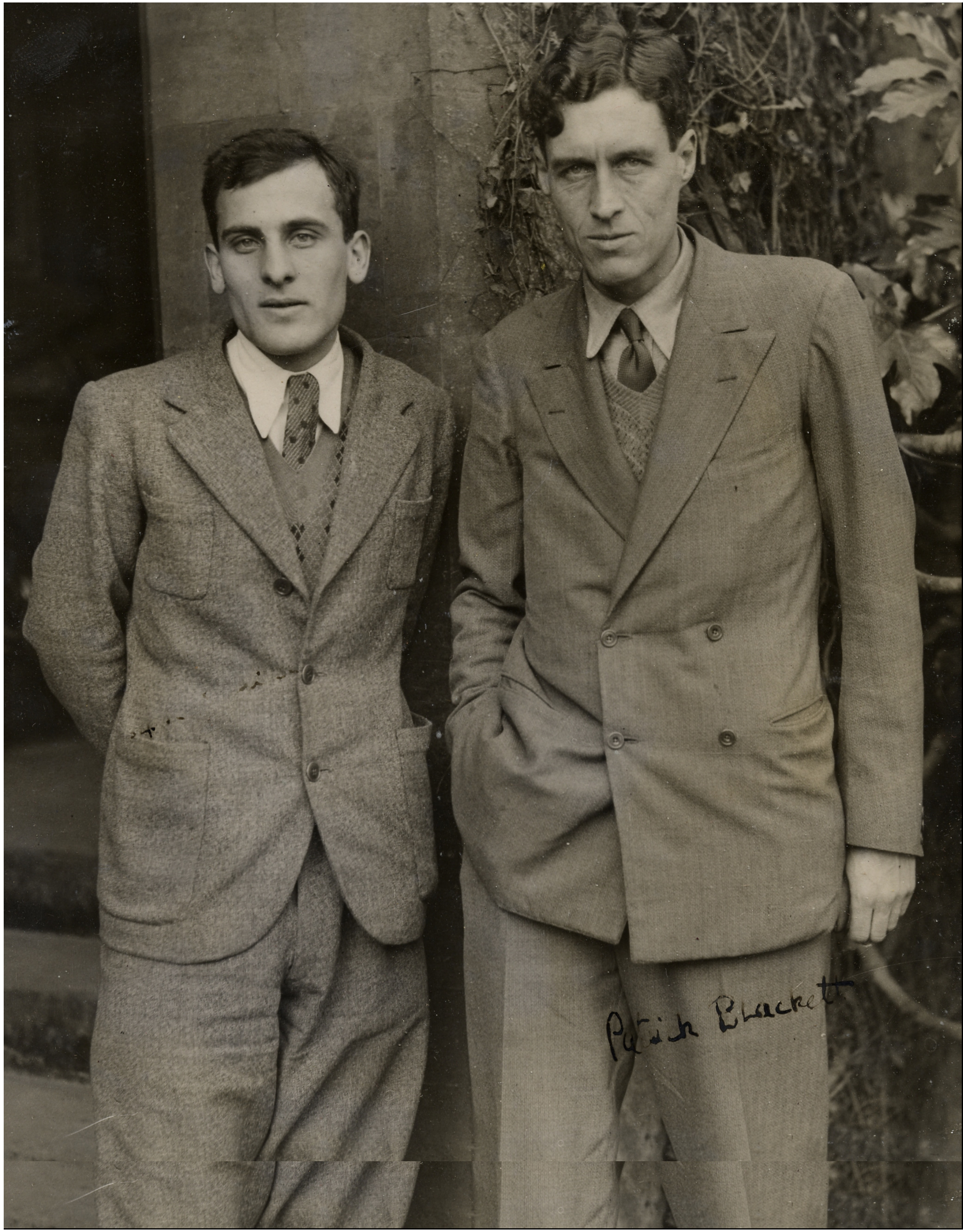
Physics student in Florence (1927-29)

Arcetri cosmic-ray school

Geiger-Müller counters

Bruno Rossi and the coincidence circuit

Rossi’s assistant (1929-32)



The Cambridge years
(1932-34)

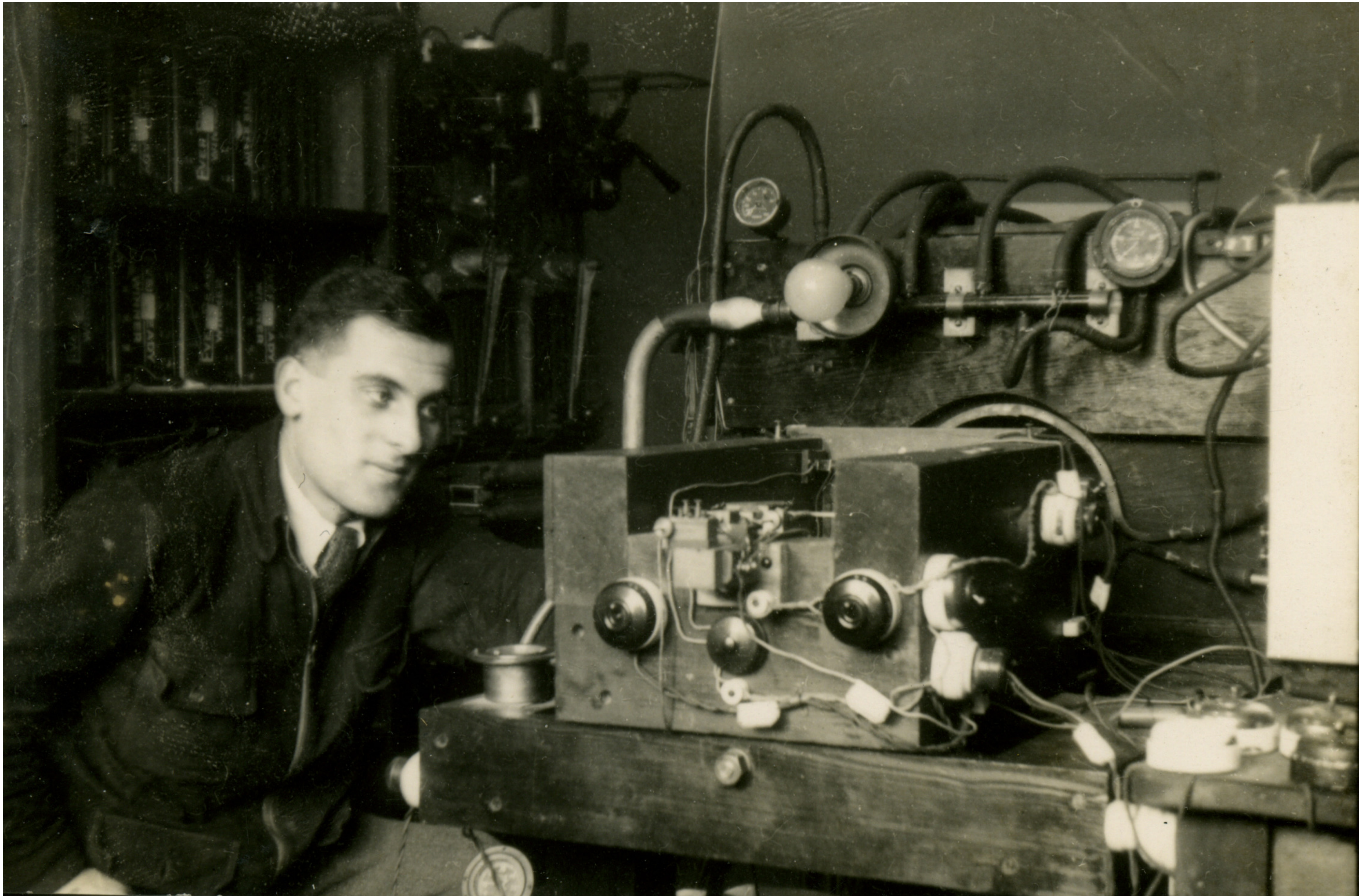
Cavendish Laboratory

Cloud chamber group

Patrick Blackett

“He brought with him the technique of the coincidence counting of cosmic rays developed by Rossi. The marrying of the counter technique with the cloud chamber was an obvious step.” (P. Blackett)

Discovery of the electron-positron pair production from γ-rays in CR showers (1933)



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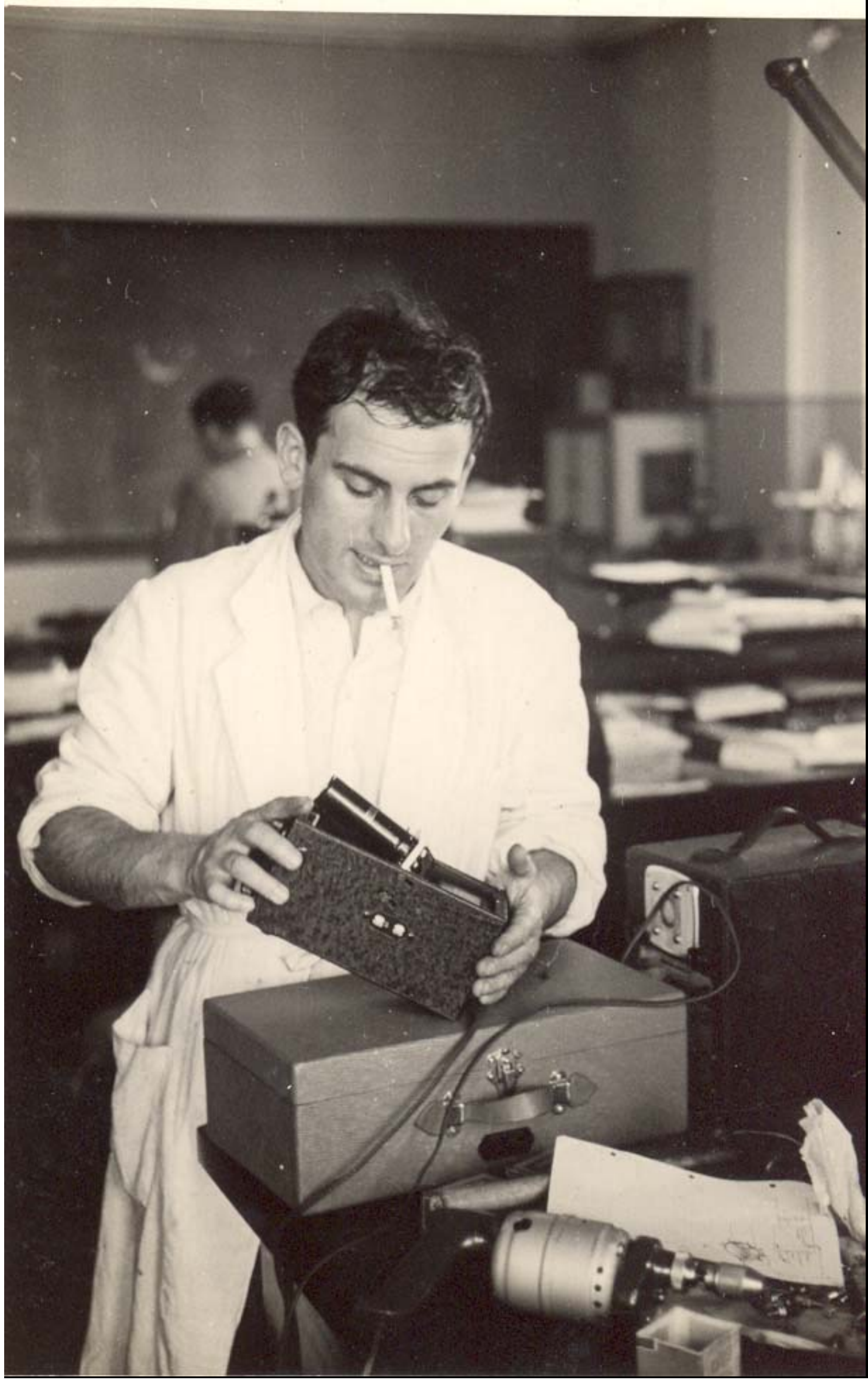


The São Paulo years (1937-44)

Gleb Wataghin

Students: Marcelo Damy de Souza Santos, Cesare Lattes, Ugo Camerini

Latitude effects on CR intensity and spectrum (electrons and γ-rays)

Arthur Compton

Post-war role in the development of Latin American physics (UNESCO mission – Chacaltaya laboratory)

The Bristol years (1945-48)

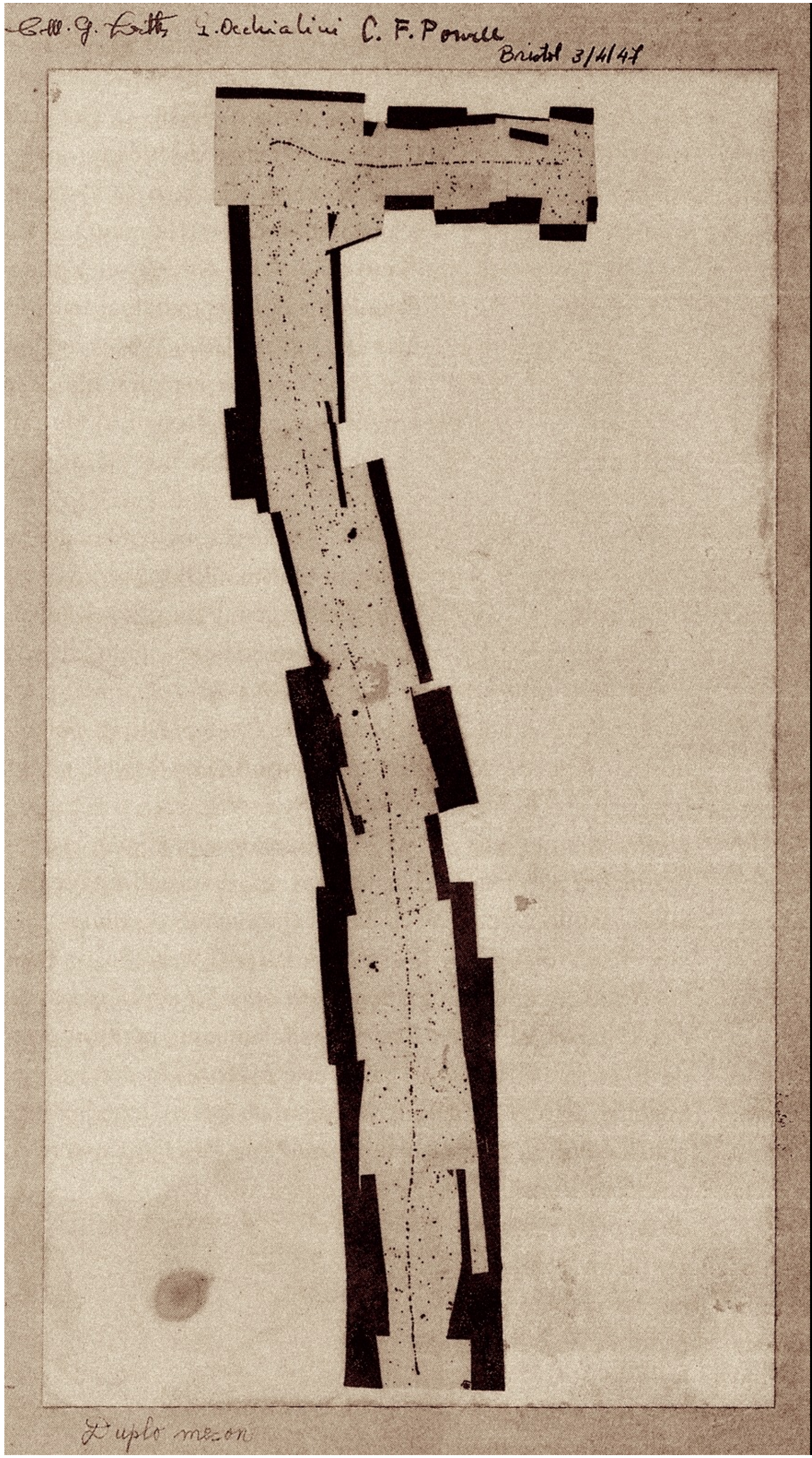
H.H. Wills Laboratories – Bristol University

Cecil Powell

Nuclear emulsions

Discovery of the pion

Constance Dilworth – wife and scientific collaborator


C.M.G. Lattes G. Occhialini C. F. Powell
Bristol 3/4/47
Duplo meson

Two Nobel Prizes: Blackett (1948) and Powell (1950)

Indications de service

Dienstaanwijzingen

D: Télégr. urgent. Dringend telegr

RP: Réponse payée Antw. betaald

PC: Tél. avec accusé de réception. Tél. met kennisgev. van ontvang.

REGIE des TELEGRAPHES et des TELEPHONES

TELEGRAMME
TELEGRAM

REGIE van TELEGRAAF en TELEFOON

Arrivé à : | Toegekomen te

Timbre à date — Datumstempel

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= OCCHIALINI UNIVERSITY
LIBRE BRUSSELS

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\+ MANCHESTER 167/9 29 9/11 1149 =

Heure
Uur

CARO BEPPE WE ARE VERY HAPPY BUT IT WOULD NEVER HAVE HAPPENED
WITHOUT YOU STOP PAT TIL MAY 8 TH 1949 =
= BALCKETT 5 OAK DRIVE MANCHESTER-14 +

TG 7 (FR VL) Imp. HAVAUX, Nivelles

1950 års Charles Vernon Boys Prize "for his work in the application of the photographic method to nuclear physics and cosmic radiation."

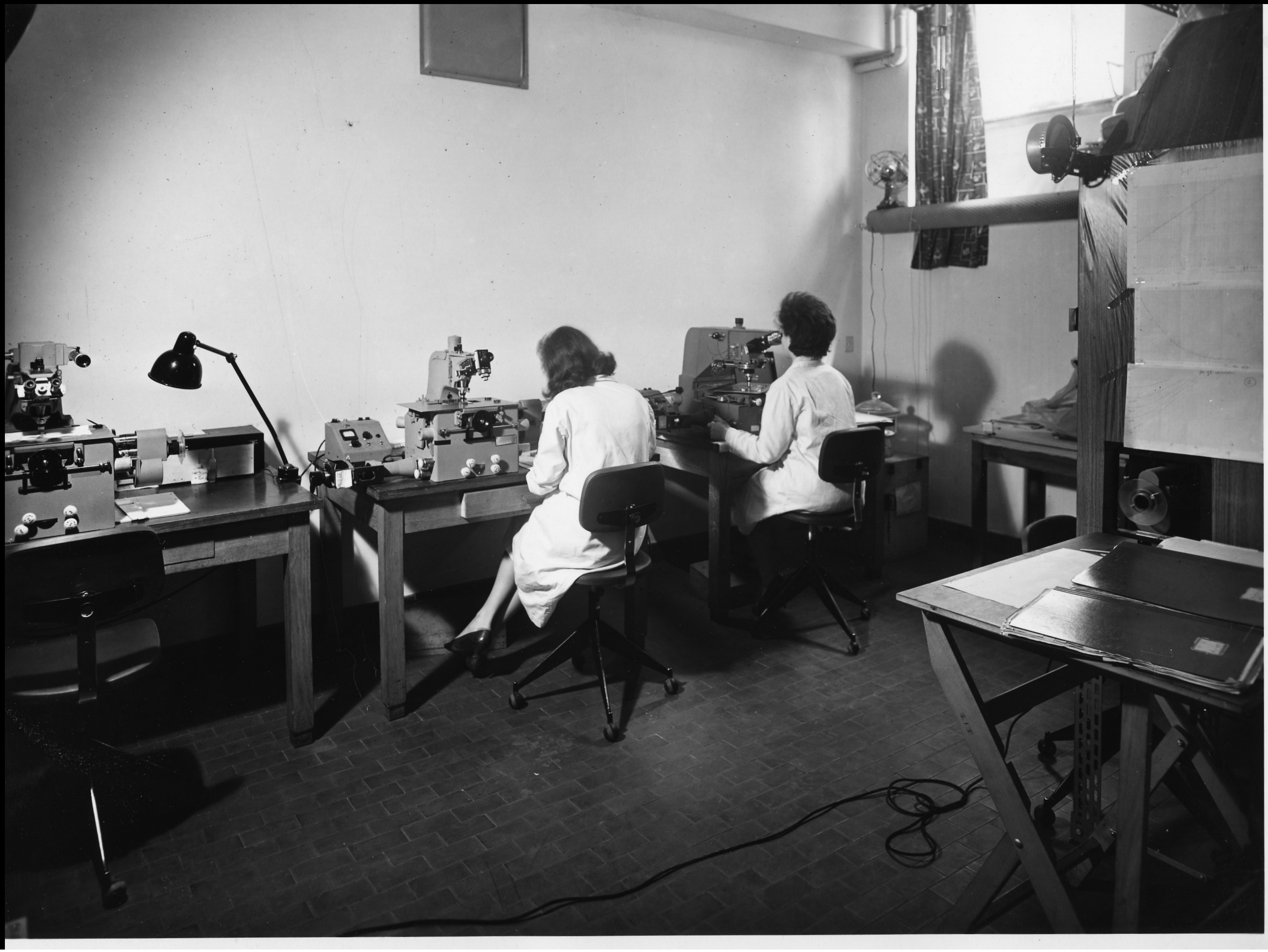
Frånsett dessa under senare år gjorda betydelsefulla insatser kan man dock ej bortse från att professor Occhialini vid början av sin vistelse i professor Powells laboratorium, bildlikt talat, fick sätta sig till ett dukat bord. Det torde ej kunna bestridas, att upptäckten av den tunga mesonen möjliggjordes genom det energiska och målmedvetna forskningsarbete, som professor Powell under ett flertal år nedlagt på att göra den fotografiska metoden användbar för studiet av kärnfysikaliska processer och den kosmiska strålningen. Det kan därför enligt min uppfattning anses fullt motiverat om kommittén i likhet med det stora antalet förslagsställare under innevarande år, föreslår professor Powell ensam till erhållande av 1950 års nobelpris i fysik.

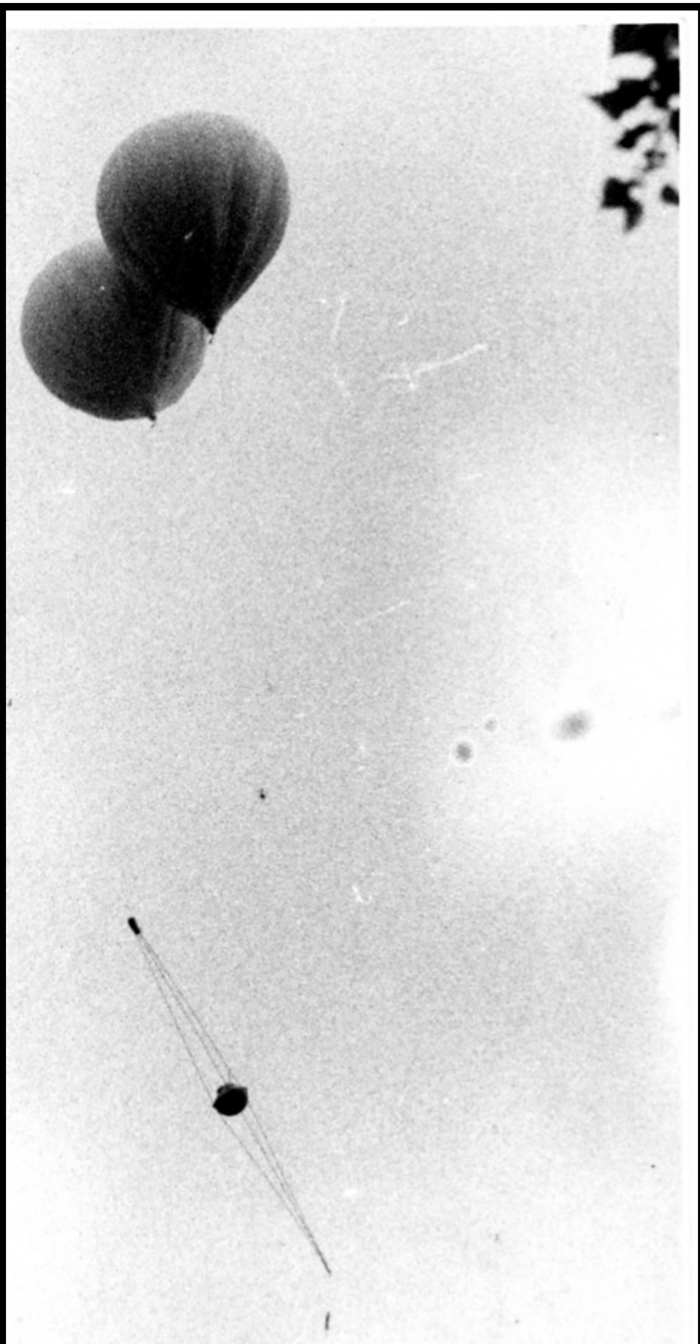
Uppsala i juli 1950.

Axel E. Lindh.

Bruxelles (1948-1959), Genoa (1950-51), Milan (1951-)

Development of nuclear emulsion technique





1950’s: European collaborations for flights of stacks on ballon

On the Masses and Modes of Decay of Heavy Mesons Produced by Cosmic Radiation.

(G-Stack Collaboration)

J. H. Davies, D. Evans, P. E. Francois, M. W. Friedlander, R. Hillier, P. Iredale, D. Keefe, M. G. K. Menon, D. H. Perkins and C. F. Powell

H. H. Wills Physical Laboratory - Bristol (Br)

J. Bøggild, N. Brene, P. H. Fowler, J. Hooper, W. C. G. Ortel and M. Scharff

Institut för Teoretisk Fysik - København (Ko)

L. Crane, R. H. W. Johnston and C. O'Ceallaigh

Institute for Advanced Studies - Dublin (DuAS)

F. Anderson, G. Lawlor and T. E. Nevin

University College - Dublin (DuUC)

G. Alvial, A. Bonetti, M. di Corato, C. Dilworth, R. Levi Setti, A. Milone (+), G. Occhialini (*), L. Scarsi and G. Tomasini (+)

(+) *Istituto di Fisica dell'Università - Genova*
Istituto di Scienze Fisiche dell'Università - Milano (GeMi)
Istituto Nazionale di Fisica Nucleare - Sezione di Milano
(*) *and of Laboratoire de Physique Nucléaire - Université Libre - Bruxelles*

M. Ceccarelli, M. Grilli, M. Merlin, G. Salandin and B. Sechi

Istituto di Fisica dell'Università - Padova
Istituto Nazionale di Fisica Nucleare - Sezione di Padova (Pd)

(ricevuto il 2 Ottobre 1955)

Milan section of INFN (National Institute of Nuclear Physics)

Nuclear emulsions

Cloud chamber (Riccardo Giacconi)

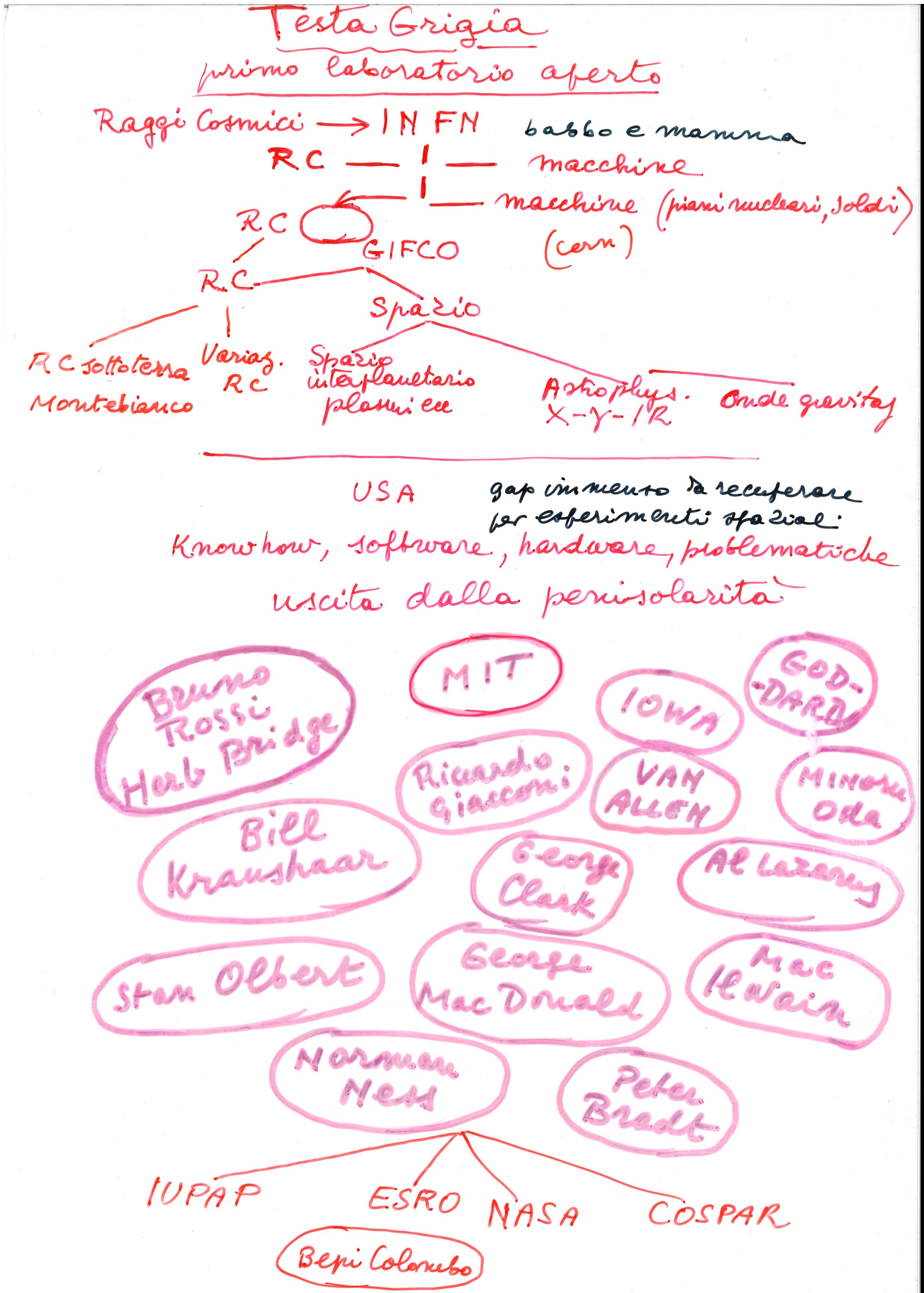
Bubble chamber

Linear accelerator

Relativistic cyclotron

Collaboration with CERN


LO SCIENZIATO SE NE VA



1959-60 Sabbatical year at MIT

1961 Foundation of the Space group

From the INFN («father and mother») to the CNR

Ringraziamenti per il presente a cui mi associo — Ci sono degli enti [le istituzioni] a cui dobbiamo gratitudine - In prima linea L'INFN che ci ha fatto da Babbo, che ci ha aiutato finanziariamente, che ci ha prestato tecnici e che soprattutto ci ha insegnato come lavorare in armonia per il manag. della scienza — Non ci hanno abbandonati la separazione è avvenuta ~~biologicamente~~ come un fenomeno biologico di uno sciame che ha abbandonato l'alveare sotto l'impulso di un'ape regina - C —

[come un antifascista originale porta] ~~l'impronta~~ i segni di questa nascita - è un gruppo [come lo vedo (o è un sogno)] solido, + ricco in fantasia scientifica che fantasia politica, che non ha coltivato capi carismatici, un po' virgiliano, Il contatto con la natura, in osservatori montani, scavi sotto terra, inseguimento di palloni ha prodotto —

INFN … helped us financially, they lent us technicians, most of all they taught us how to work in harmony for the management of science.

Foundation of the GIFCO (Italian Group of Cosmic Physics) Occhialini with Edoardo Amaldi, Carlo Castagnoli, Livio Gratton and Giampietro Puppi

1) Milan: IFCTR (Institute for the Research in Cosmic Physics and Relative Technologies

2) Bologna: ITESRE (Institute for the Technologies and Studies of Extraterrestrial Radiation

3) Frascati: IFSI (Institute of Physics of the Interplanetary Space)

4) Turin: CosmoGeofisica

5) Section in Florence

6) Section in Palermo

The transition of GIFCO from INFN to CNR was successful in a first time

«At the beginning, the operation had all the characteristics of a winning move, with a strategic vision and an organic and coherent structure.
[...]
The CNR reacted to the initiative, with the agility of an asthmatic pachyderm, confusing (I quote Occhialini's words) the typical timing of archaeological excavations in Pompeii, with that necessary to react to a rapid countdown for a rocket on the ramp launch; in short, there was a lack of clear vision of the lines of attack, allowing the tendency to navigate in convoy to prevail with the slowest ship imposing the speed.» (L. Scarsi, 1997)

Occhialini's role in the birth of γ-astronomy

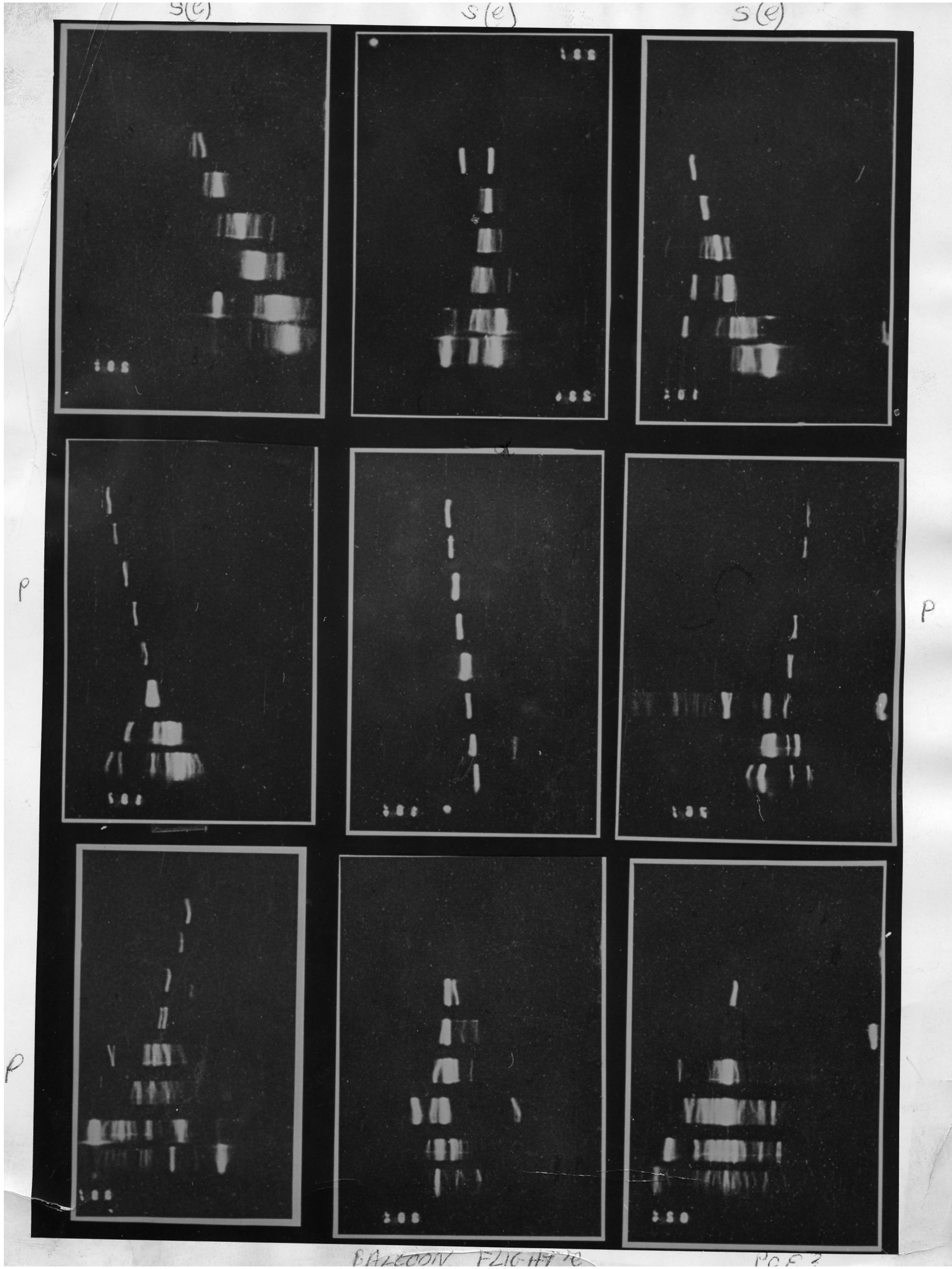
1) Cosmic ray physicists interested in γ-rays since the early days

2) Interaction of cosmic rays and interstellar matter with the production of unstable π^0 which decay into two γ-rays in 10^{-14} s

3) Thus the detection of γ-rays would have shown the presence of high energy protons.

4) Other sources of γ-rays: colliding galaxies made of matter and antimatter

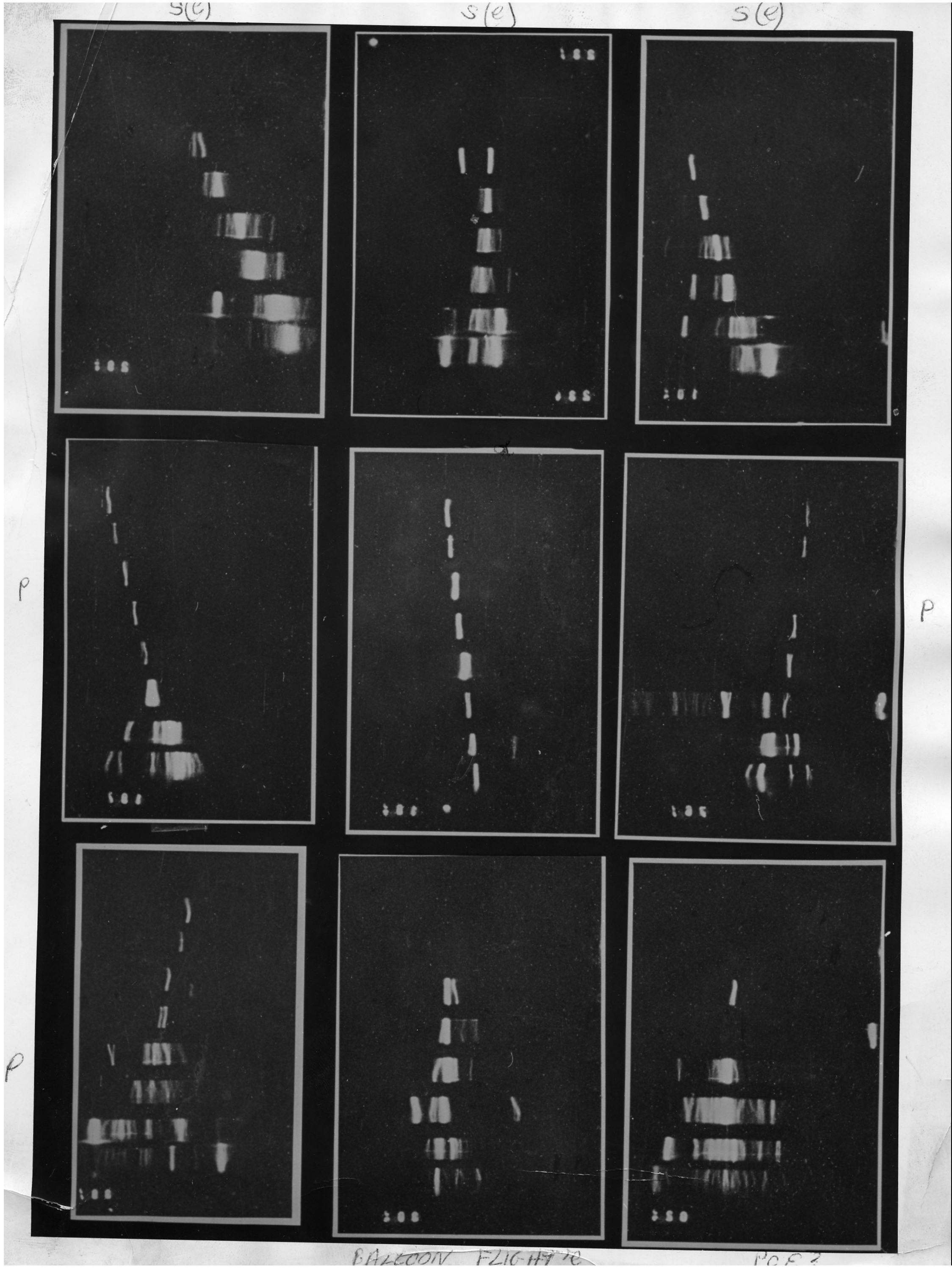
5) Possibile test for the steady state theory.



In the 1960s Occhialini organised flights on balloon of spark chambers.

Occhialini's role:

1) Organization of tight links between European groups
2) He chose the spark chamber (Jacques Labeyrie) controlled by plastic scintillators as detecting device
3) How to avoid damages during the flight
4) Balloon launching facilities
5) Data transmission



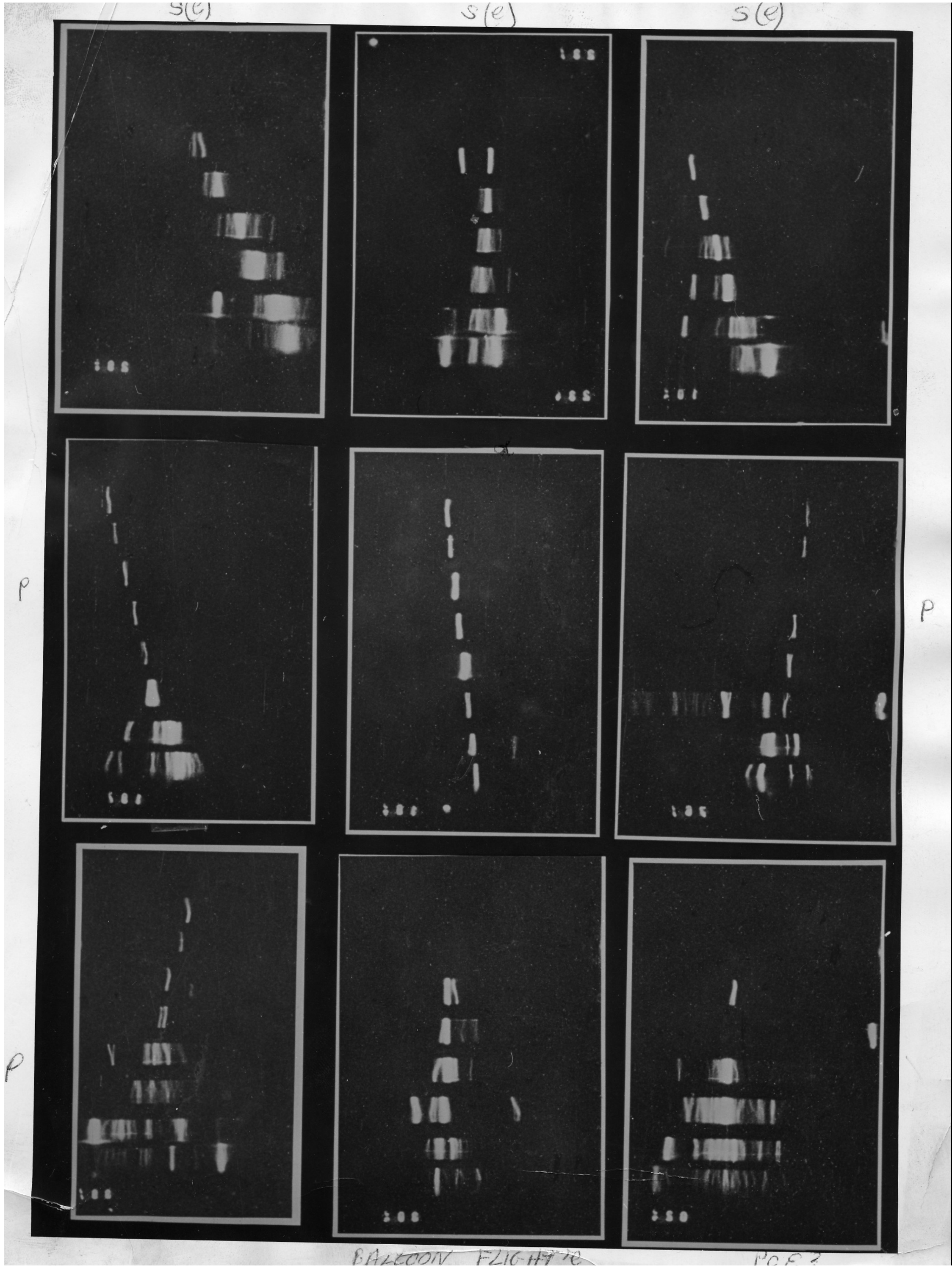
Problems:

1) Unexpected and unforseen stratospheric winds

2) Collaboration with NATO and national armies (cold war time!)

3) Short flight time

Positive attempts of trans-mediterranean and trans-atlantic flights



Balloon-borne experiments were less expensive than experiments on satellite but lasted too short a time to detect γ-ray sources outside the Galaxy plane.

MiMoSa (Milano-Monaco-Saclay) collaboration for a γ-ray experiment on satellite.

Some excerpts from Occhialini's 1965 report:

«The group was formed in late 1960, and represented a return to cosmic ray research from high energy physics on the part of the senior physicists involved.»

Two main activities:

1) Neutrons: flights of counters on balloon from Linate (Milan), New Mexico, Kiruna, Aire-sur-l'Adour) and on rocket

2) Electrons and γ-rays:

a) high energy electrons: flights of spark chamber on balloon from Aire-sur-l'Adour

b) low energy electrons: calibration (CERN, Saclay, Frascati) and construction of Cerenkov and scintillators to fly on balloon

c) γ-rays: S 88

Some excerpts from Occhialini's 1965 report:

γ-rays

«S 88: A directional Cerenkov Counter + S 79 [= HEOS A] element for Measurement

1963-1964: Preliminary design S 88

1964-65: Project S 88: construction of model laboratory tests.
Contract to Galileo.
Design and Project «Caravane»

1965-66: Construction S 88
Construction prototype «Caravane»
Calibrations.
Balloon flights for S 88 and «Caravane»

Some excerpts from Occhialini's 1965 report:

«Group Activity

[...]

1) Balloon-borne Experiments

[...]

1c) The Search for discrete γ-ray sources again in collaboration with Saclay, is in the development stage. Work has begun on the detector which is a large, thin-plate spark chamber with a complex of anticoincidence-coincidence counters for the detection of γ-rays. It is estimated that sources of intensity as low as 5×10^{-6} γ/cm^2 sec can be detected in these balloon flights»

Some excerpts from Occhialini's 1965 report:

«2) Rocket and Satellite experiments

[...]

2c) For the detection of solar γ-rays, a directional Cerenkov is maintained in the Sun-direction. The measurement of energy is obtained with a lead-glass Cerenkov counter. The system is capable of detecting fluxes of as low as 10^{-4} γ-rays/cm^2 sec which may be expected during solar flares. The launch is scheduled for 1969.»

Some excerpts from Occhialini's 1965 report:

«2d) The combined γ-ray and electron experiment has been studied and a project submitted to ESRO. The apparatus consists of large spark chambers with alternative counter control, the detailed information of the events being transmitted via Vidicon.

[...]

Research F[o]unds.
The Physical Astrophysical Committee of the CNR finances the research carried out in balloons and the laboratory development of instrumentation.
A contract with the U.S. Air Force contributes to the financing of the work on neutron albedo.
The National Space Commission finances the construction of rocket and satellite pay loads.»

Some excerpts from Occhialini's 1965 report:

Director: Giuseppe Occhialini

Research staff: John Bland, Giuliano Boella, Giovanni Degli Antoni, Constance Dilworth, Martina Panetti, Emanuele Quercigh, Livio Scarsi, Giorgio Sironi

Technical staff: Giuseppe Aloardi, Renato Ballerini, Edoardo Bardeggia, Pierluigi Dell'Era, Ernesto Franchini, Aldo Igiuni, Piero Inzani, Ennio Ronchi

Post Graduate Students: G. Di Benedetto, H. Hazan, Massimo Isola, S. Moiraghi, Constantinos Paizis, Giuseppe Perola

Scientific Consultant: Giorgio Bendiscioli

They were joined by other students and researchers in the following years:

Giovanni Bignami, Oberto Citterio, Giuseppe Gavazzi, Laura Maraschi, Cesare Perola, Gianfranco Quaranta, Cesare Reina, Emilio Rocca, Aldo Treves, Gabriele Villa

Researchers from abroad:
John Bland, George Clark, Tony Dean, John Kidd, Martin Turner

and many others!

Occhialini and the birth of Space Science in Europe

1961 – COPERS (European Preparatory Committee for Space Research)

1964 – Foundation of the ESRO (European Space Research Organisation)

Member of the Council and of the Scientific and Technical Committee.
Chairman of the COS-Group (Advisory Committee for Cosmic Rays Physics)
Member of the restricted LPAC (Launching Program Advisory Committee)

“Street-car” Principle: each mission was a cluster of experiments proposed by the various scientific groups.

Problems with ESRO:

“The variety of scientific disciplines made it possible to foresee a difficult coexistence among the various scientific groups.”

“The multiplicity of goals logically had to add to the scientific competition between groups that one between states, eager to justify their substantial financial investments with important contracts for their industries.”

“The space Europe of states was not homogeneous in its objectives: small nations tended to limit their space activity to collective ones, large ones wanted to maintain and enhance their national programmes and required the organisation to dedicate itself to spectacular projects beyond the possibilities of a single nation.”

“Europe’s relative inexperience in this field led to underestimating European costs compared to those of the USA and to encouraging projects so ambitious as to exceed the financial possibilities, not only of a single nation, but of the entire organization.”
(Occhialini, Dilworth 1973)


POYNTING SKYLARK
STEERING COMMITTEE
ESRO
CERS
NASA
SAS-B
COS-B
PAYLOAD
GROUP

[redacted]

	1965	1966	1967	1969	1971	1972	1975
Caravane	Proposal	Feasibility study					
COS A			Feasibility study (abandoned)				
COS B			Feasibility study (accepted)		Construct.		Launch
TD 1 (MiMoSa)		Proposal	Accepted	Construct.		Launch	

1965 – Caravane experiment: Proposal of a satellite with only one device to detect γ-rays and electrons.

With Saclay (Jacques Labeyrie) and Munich (Reimar Lüst, Klaus Pinkau)

Milan: see Occhialini’s 1965 report

	1965	1966	1967	1969	1971	1972	1975
Caravane	Proposal	Feasibility study					
COS A			Feasibility study (abandoned)				
COS B			Feasibility study (accepted)		Construct.		Launch
TD 1 (MiMoSa)		Proposal	Accepted	Construct.		Launch	

1966 – Proposal of TD 1 experiment

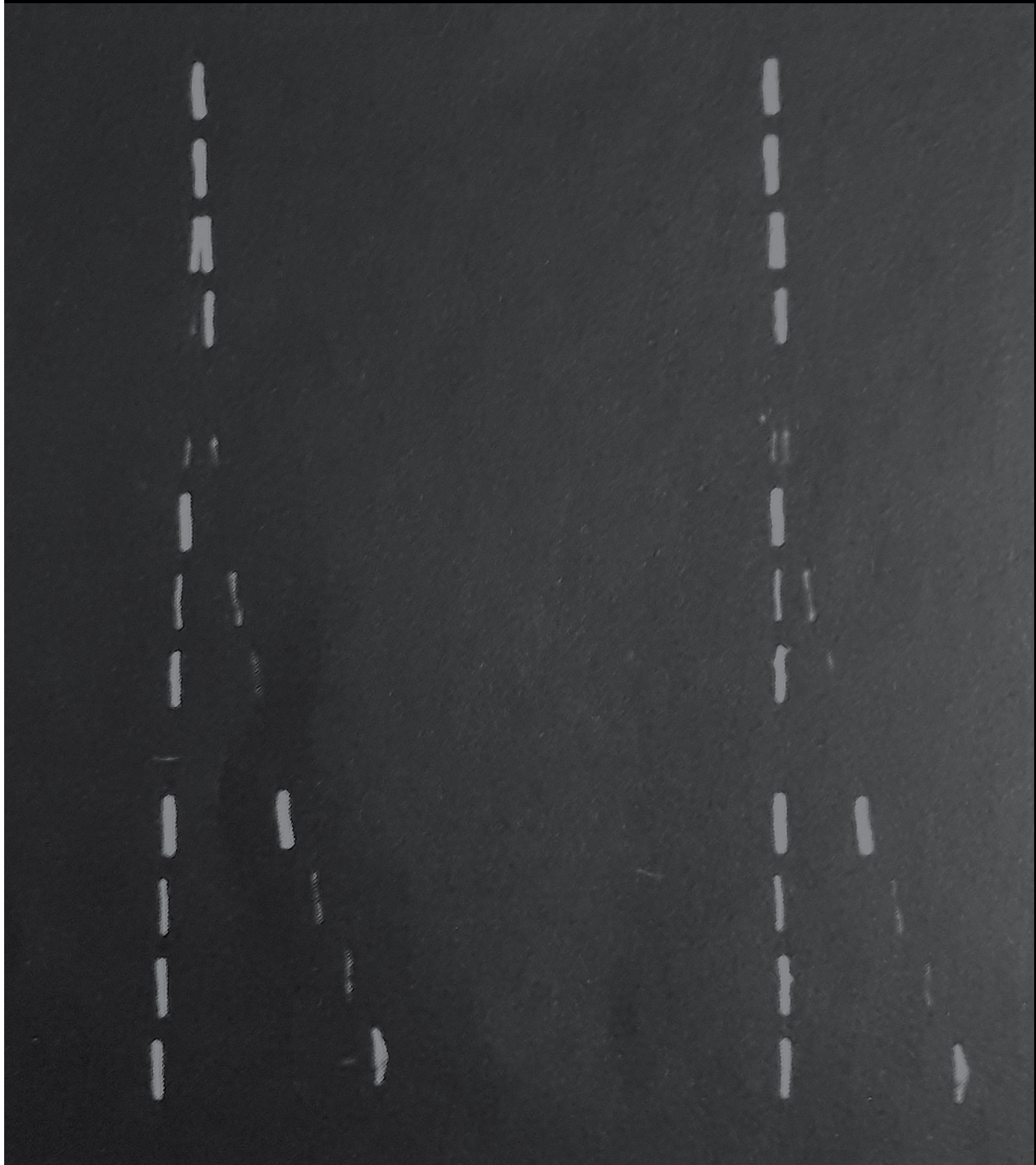
One free slot at disposal: proposal of a small γ-ray telescope (S 133 or MiMoSa)
Feasibility study of the Caravane experiment (merged into other projects)

	1965	1966	1967	1969	1971	1972	1975
Caravane	Proposal	Feasibility study	Abandoned				
COS A			Feasibility study	Abandoned			
COS B			Feasibility study	Accepted	Construct.		Launch
TD 1 (MiMoSa)		Proposal	Accepted	Construct.		Launch	

1967 – Crisis of TD and reorganisation of ESRO

Proposal of a satellite with a γ-ray telescope and an X-ray telescope (COS A)

Proposal of a satellite with only the γ-ray telescope (COS B)

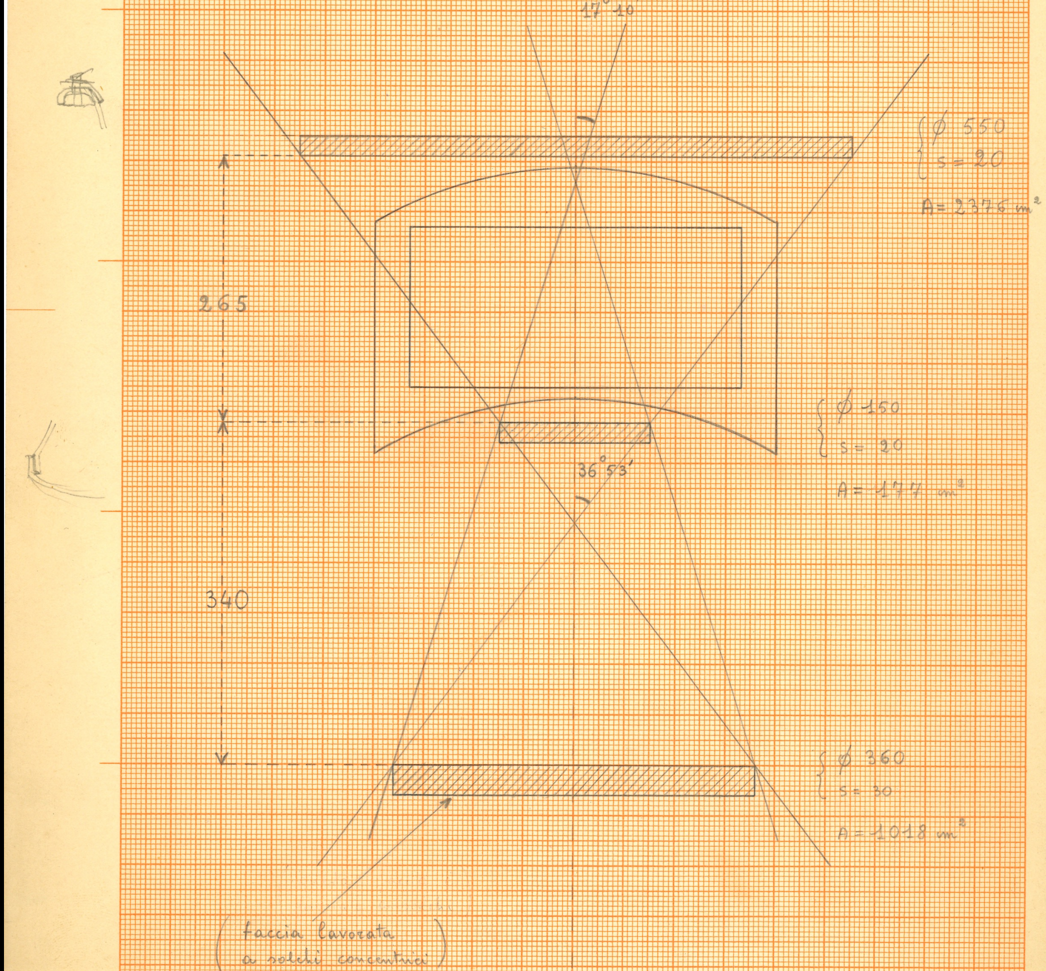


TD 1 and COS B use a spark chamber to detect the electron-positron pair from a γ-ray

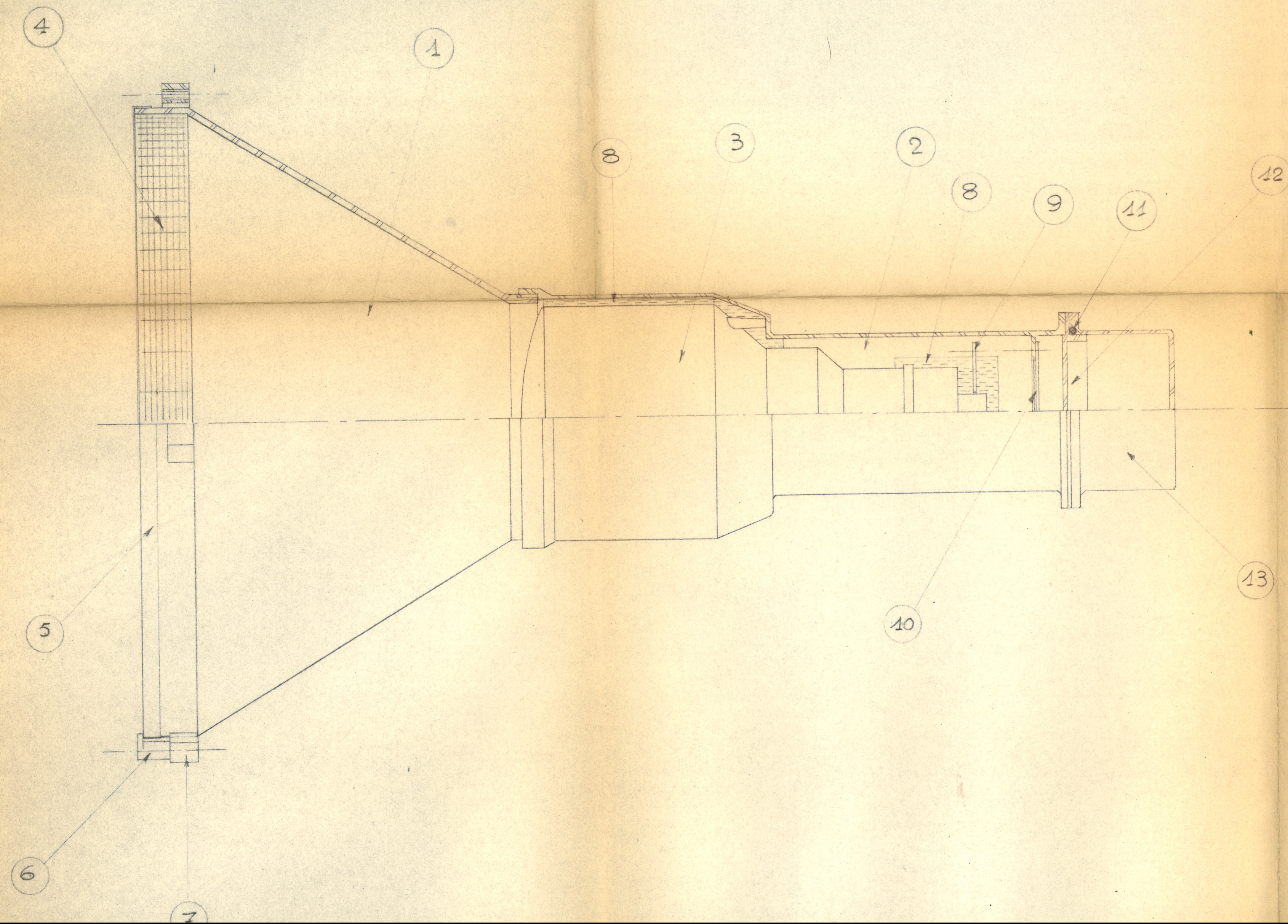
TD 1: 100 cm^2 area, exploring 15° during one orbit; map of the whole sky in 6 months

COS B: 500 cm^2 area, with a telescope of counters in coincidence and anti-coincidence, and a calorimeter to measure the γ-rays energy spectrum.

γ 800



Scala 1:5



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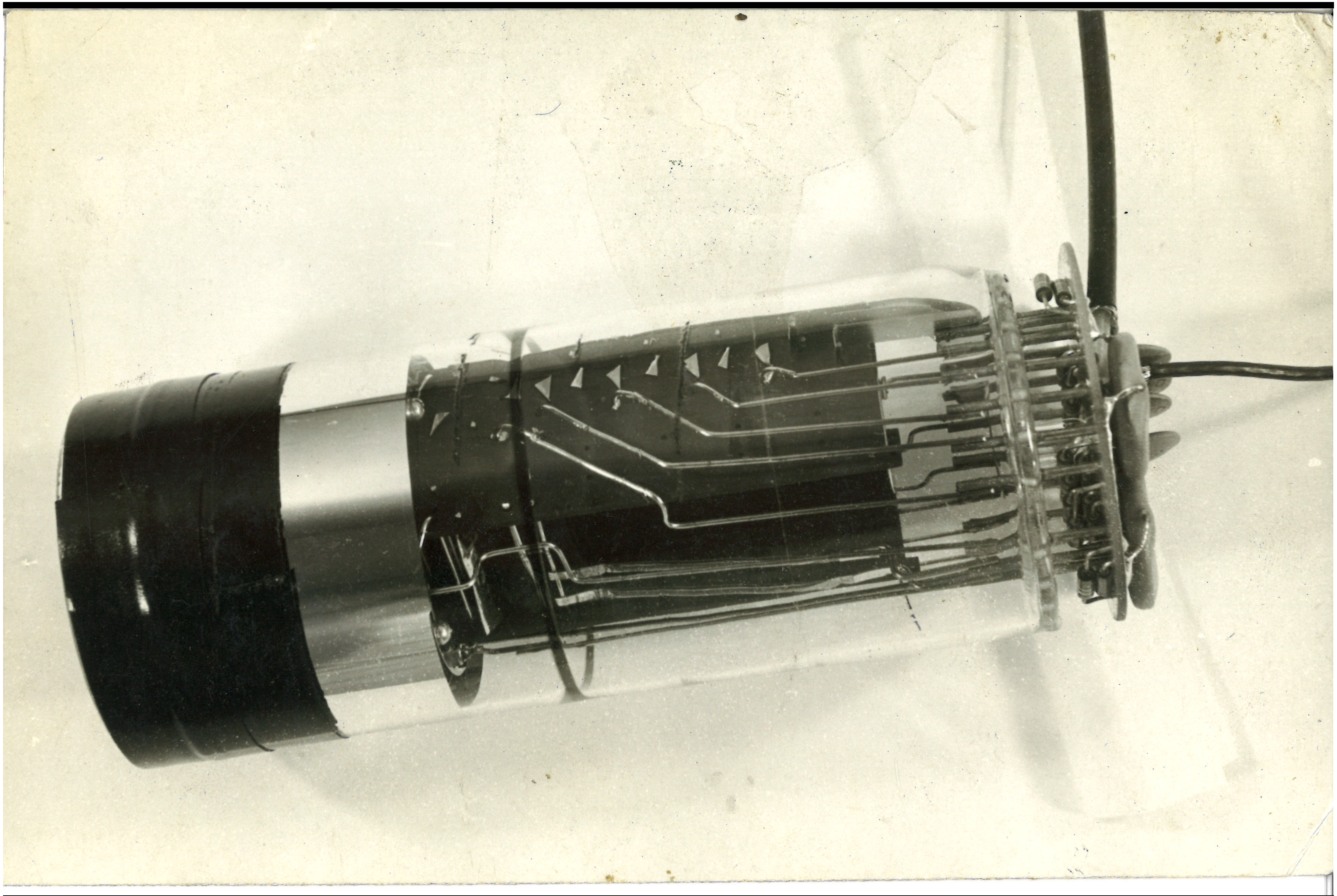
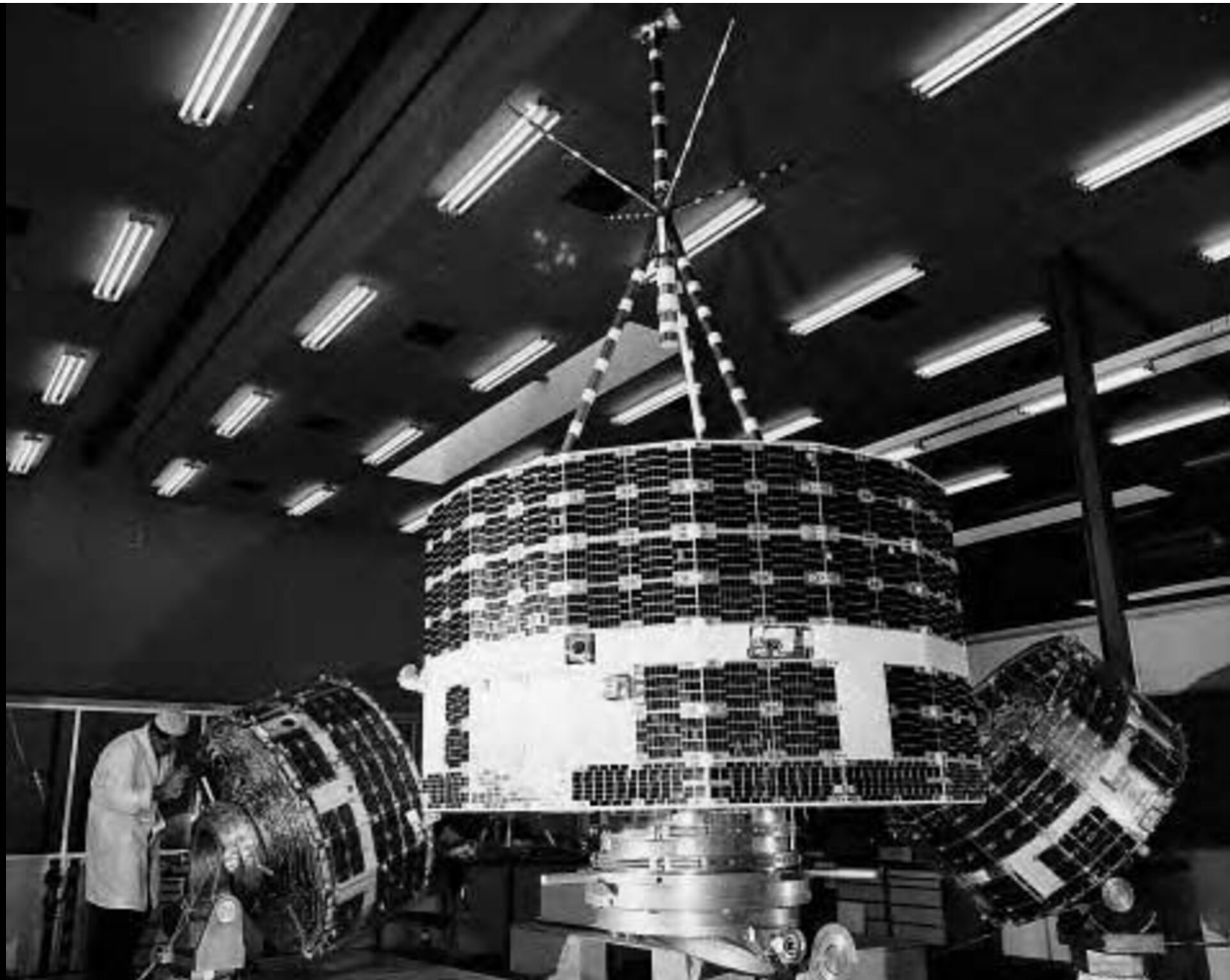
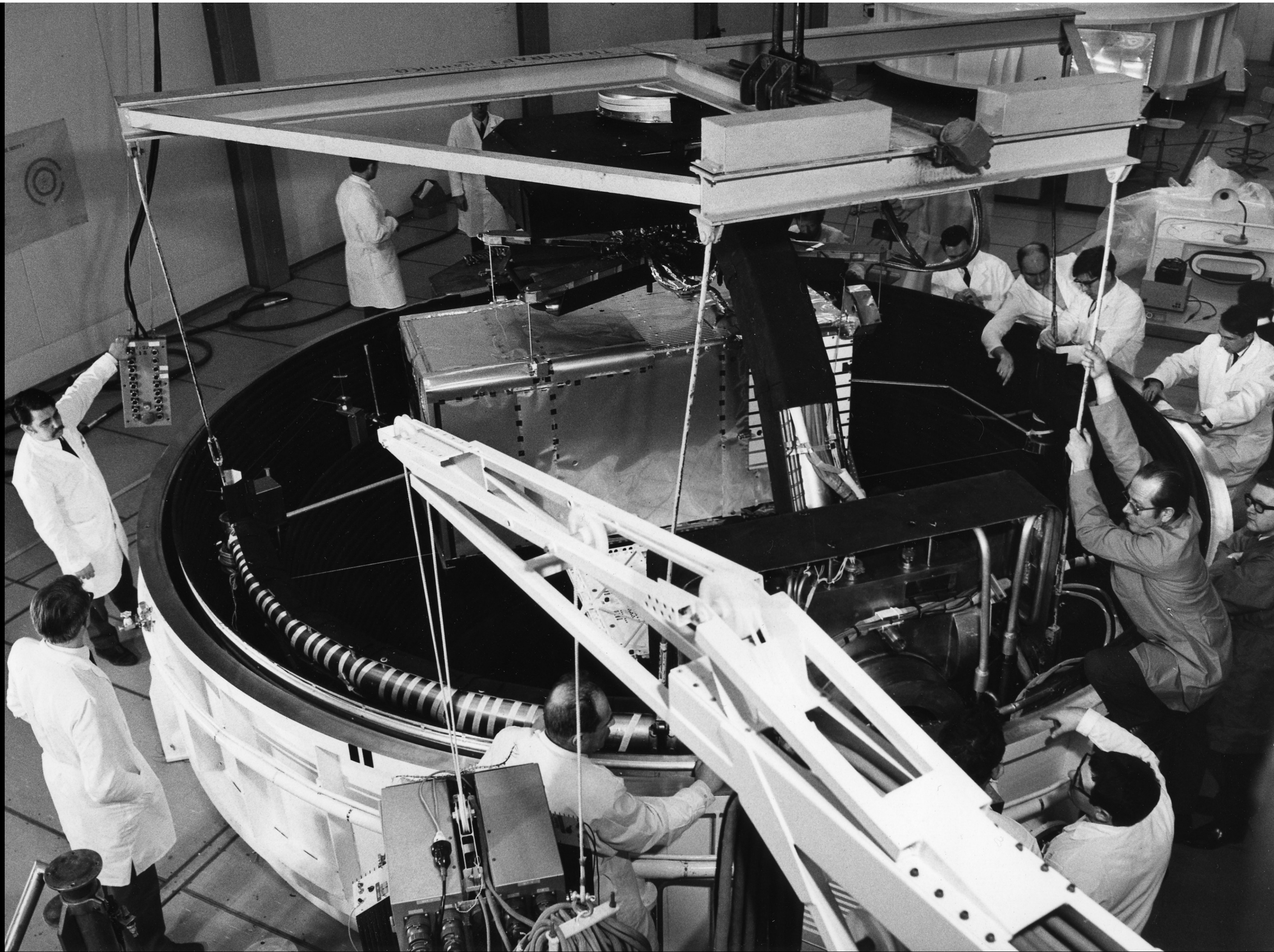




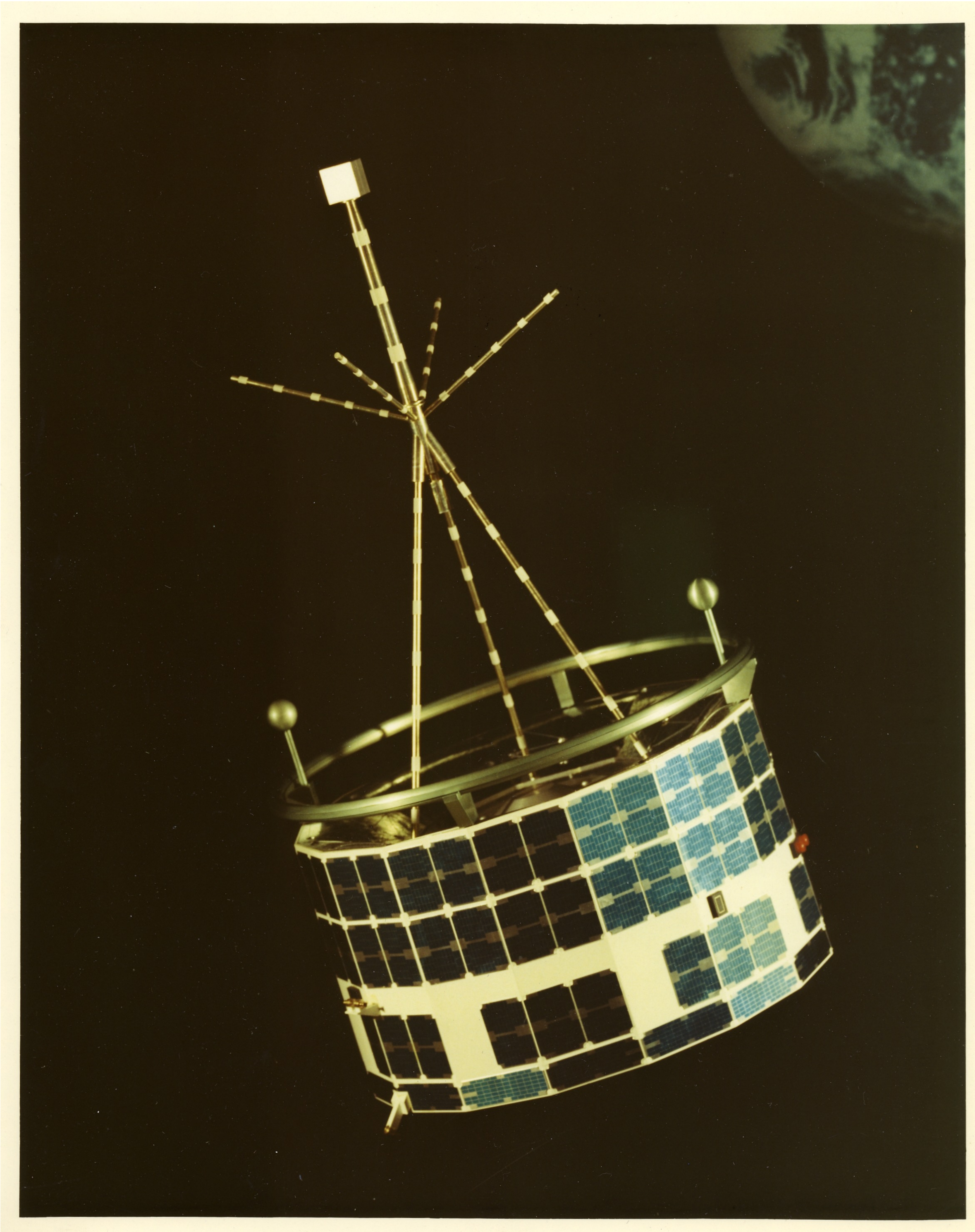
1968 – Launch of HEOS A1
Milan: S 79 = primary CR electrons (with Saclay)
Observation of high energy electrons emitted during solar flare events, and the echo reflected from a distant border some days later.



1972 – Launch of TD 1

Milan: S 88 = Solar γ-rays (50-500 MeV)

S 133 = Celestial γ-rays (70-300 MeV) (with Saclay and Garching: MiMoSa experiment)



1972 – Launch of HEOS A2

Milan: High-energy electrons (with Saclay)

1975 – Launch of COS-B

Caravane Collaboration (with Garching, Leiden, Palermo, Saclay and ESLAB in Nordwijk)

First detailed γ-map of the Galaxy

First catalogue of discrete sources in the range of a few 100 MeV

Excerpts from Occhialini’s 1974 final report (he left the IFCTR direction in July 1975):

«S. 133 experiment on board ESRO TD.1 satellite
It is a telescope, based on the use of a spark chamber, put into orbit in March 1972 with the aim of studying celestial gamma radiation with energy greater than 30 MeV, created in collaboration with the Cosmic Physics Laboratory of Milan and groups of space physics at the Max Planck Institute in Garching/München and at the C.E.A. in Saclay.

During 1974, the work of sequencing, cleaning and analysis of all the data transmitted by the satellite in 1972 began.

The telescope's research unit, which is very similar to the orbiting unit, was also subjected to calibration using gamma ray beams of known characteristics.»

Excerpts from Occhialini's 1974 report:

«ESRO COS.B Satellite
It is a satellite entirely dedicated to the study of celestial gamma radiation with energy above 30 MeV created by a collaboration between laboratories in Milan, Munich, Leiden, Saclay and the ESTEC SSD in Nordwijk.

During 1974 the Laboratory participated in the preparation, development and qualification of the satellite's flight units, whose launch was scheduled for the summer of 1975. All the instrumentation was tested and calibrated with gamma ray and proton beams at the Hamburg (DESY) and CERN (PS) accelerators.

Work also continued on the drafting and development of programmes for the automatic analysis, classification and extraction of information from the images of the spark chamber which is part of the telescope mounted on board the satellite.»

Excerpts from Occhialini’s 1974 report:

« «Nuova Gamma 10» Telescope
Following the destruction of a previous version of the instrument in 1973 due to a flight accident, in 1974 the design and construction of a new version began, in collaboration with the University of Southampton, of an improved telescope for the study and search for celestial sources of gamma rays with energy between 0.5 and 20 MeV.
The instrument, based on the use of a highly efficient semi-active collimator system, will be used for observations starting in 1976.

«Gamma 50 MeV» Experiment»
The analysis of data on the galactic gamma background obtained in previous years, in collaboration with the Saclay Laboratory, with a spark chamber has been completed.»

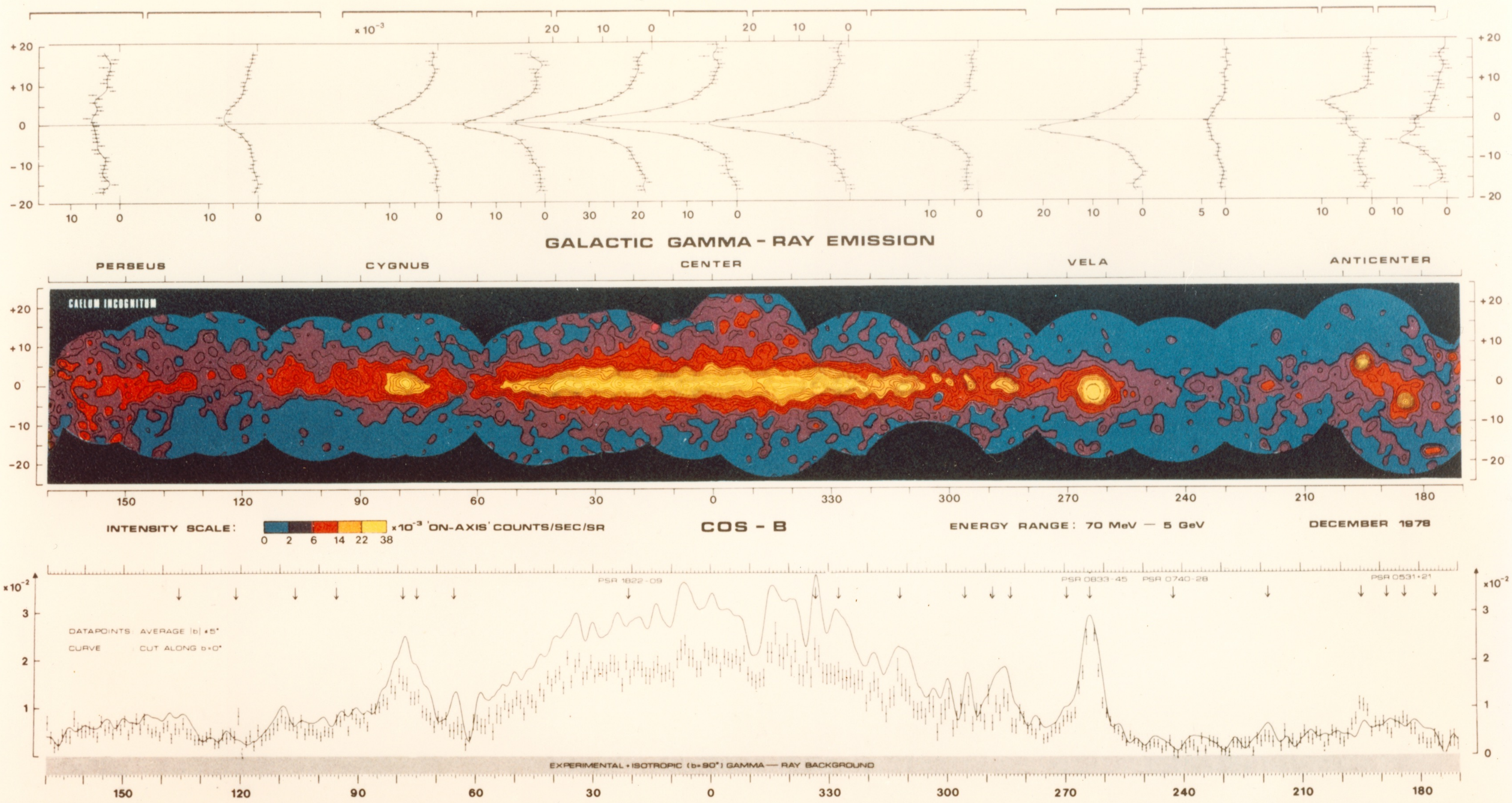
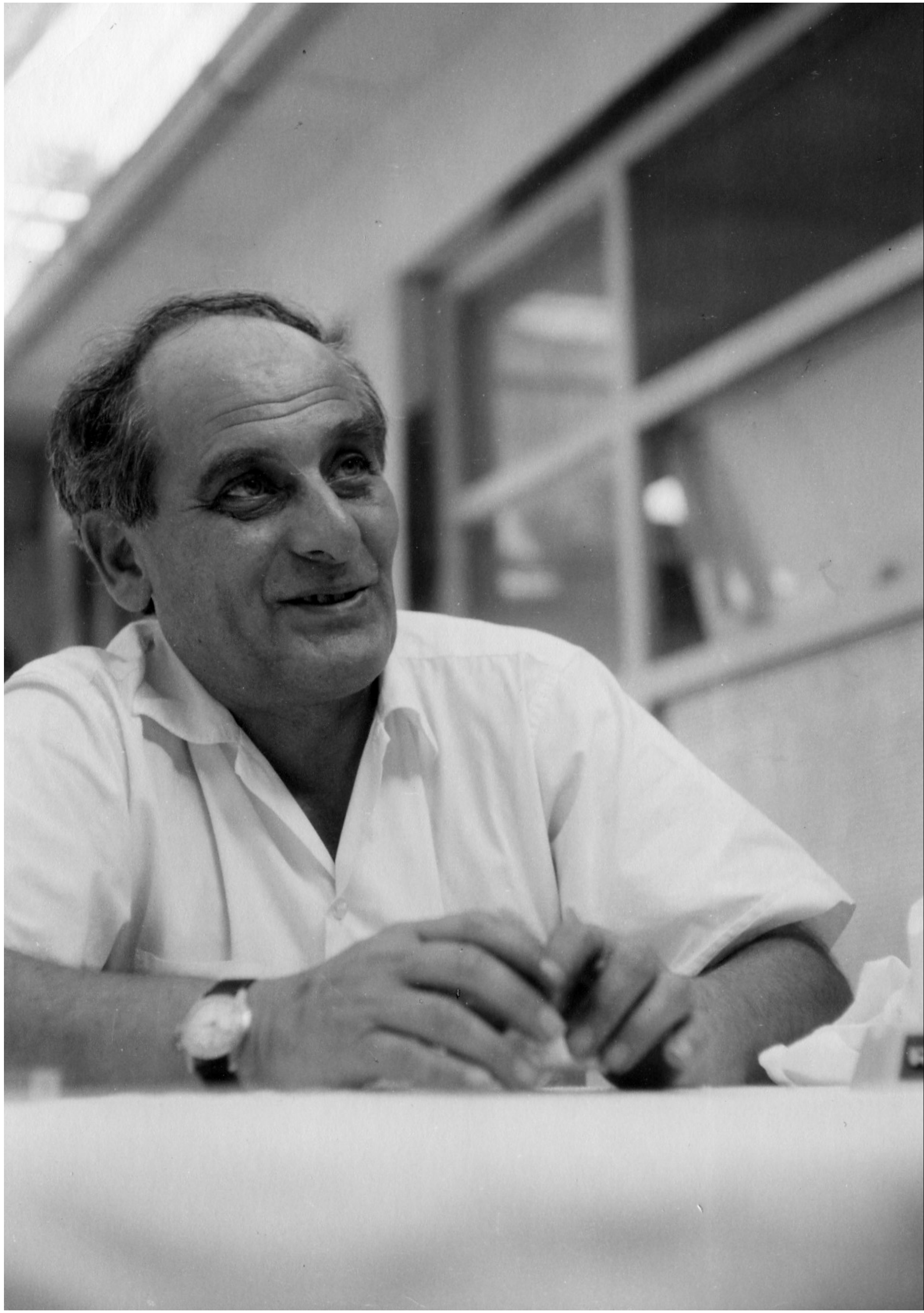


Abb. 63: Isointensitätskontourenkarte der Gammaemission der Milchstraße. Profile entlang galaktischer Länge bzw. Breite.

"At the celebration of the seventh anniversary of the active life of COS-B in 1982, Beppo deputed other people to act for him: he felt it at that time as a distant creature and of a relative interest" (L. Scarsi)

“He did not like to speak to the public, but he talked with pleasure. He was a storyteller, and he hold his listeners spellbound when he talked about his discoveries in physics, his speleological explorations, the scientists and artists he met, the beauty of Tuscany and Umbria landscape, his adventures during his travels.”(G. Tagliaferri)



«He liked artists, literature, and poetry; he could, to quote his quote, “see the world in a grain of salt and eternity in an hour”.» (V. Telegdi)