

Bruno Touschek

(1921-1978)

and his extraordinary journey

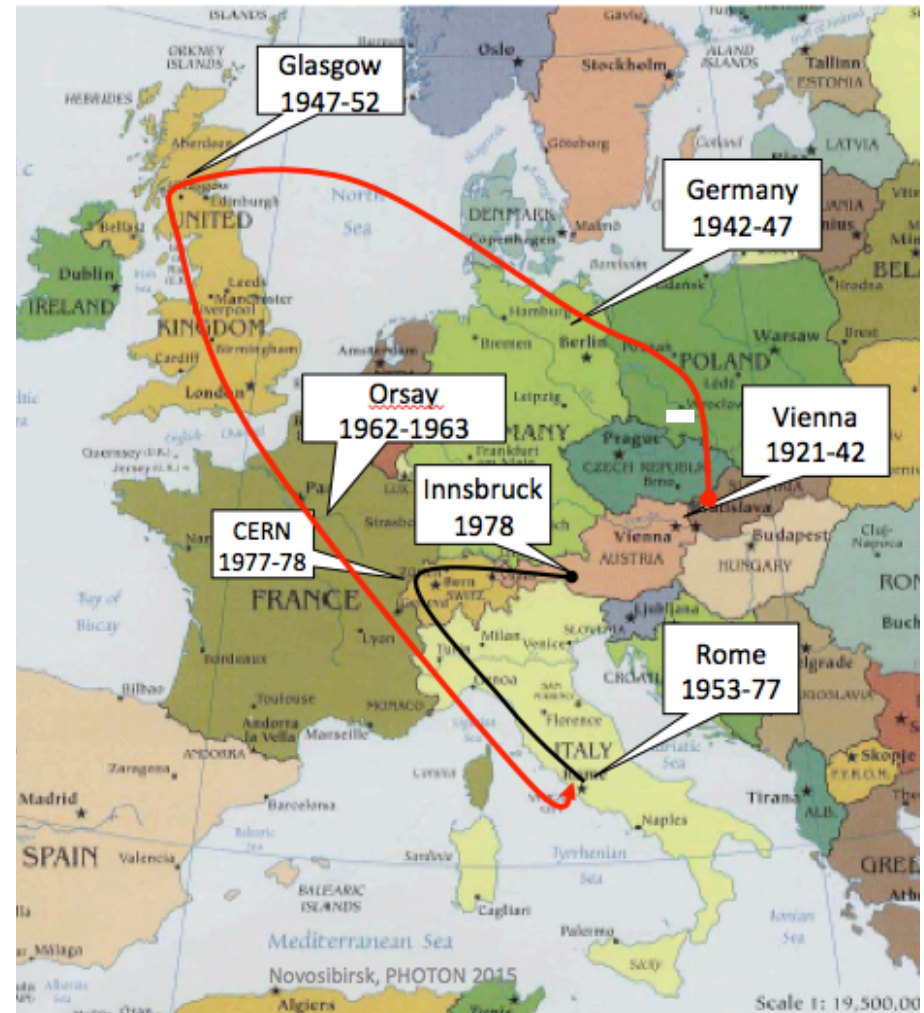
Giulia Pancheri and Luisa Bonolis



Touschek came from Vienna...

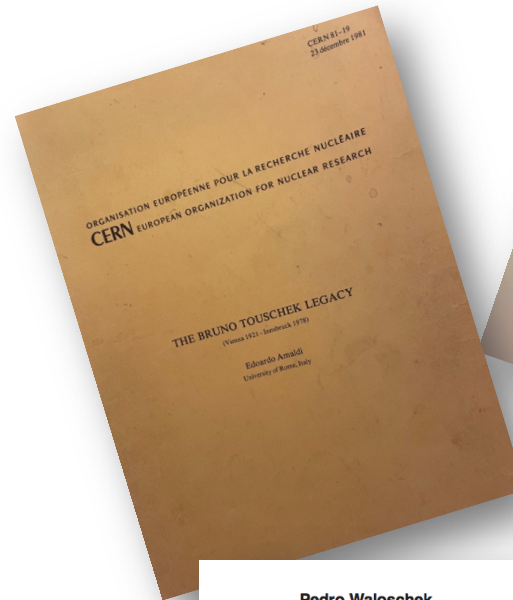
Touschek's life journey mirrors Europe's tragedy and reconstruction

- Through the development of particle physics in Europe in the second half of XXth century: from Vienna, through the war, from the foundation of CERN until the planning of LEP, SpbarpS, LHC
- In Italy and France he catalyzed the energy of the scientists to the construction of an “unthinkable” machine, *AdA where particles which are not found in the world which surround us are kept and stored for a long time* (in Touschek's own words)



Main public and published sources

- E. Amaldi, **The legacy of Bruno Touschek**, 1981 CERN Yellow Report
L'eredità di Bruno Touschek, Quadernidel Giornale di Fisica, 1982
- G. Battimelli, M. De Maria & G. Paoloni, **Le carte di BrunoTouschek**, 1989
- R. Widerøe, ed. P. Waloschek **The infancy of particle accelerators**, DESY 1994
- P. Marin, Un demi siècle d'accélérateur de partcules (1950-2000), 2009
- L. B. & G. P., Bruno Touschek, father of e^+e^- colliders, EPJH 36 (2011) 1-6
- P. Waloschek, Death rays as Life-Savers during WWII, 2012 (published posthumously)
- A. Sørheim, Rolf Widerøe: obsessed by a dream, 2020

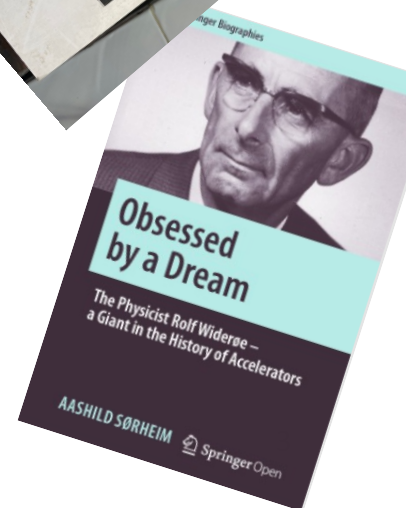


Pedro Waloschek

Death-Rays as Life-Savers in the Third Reich

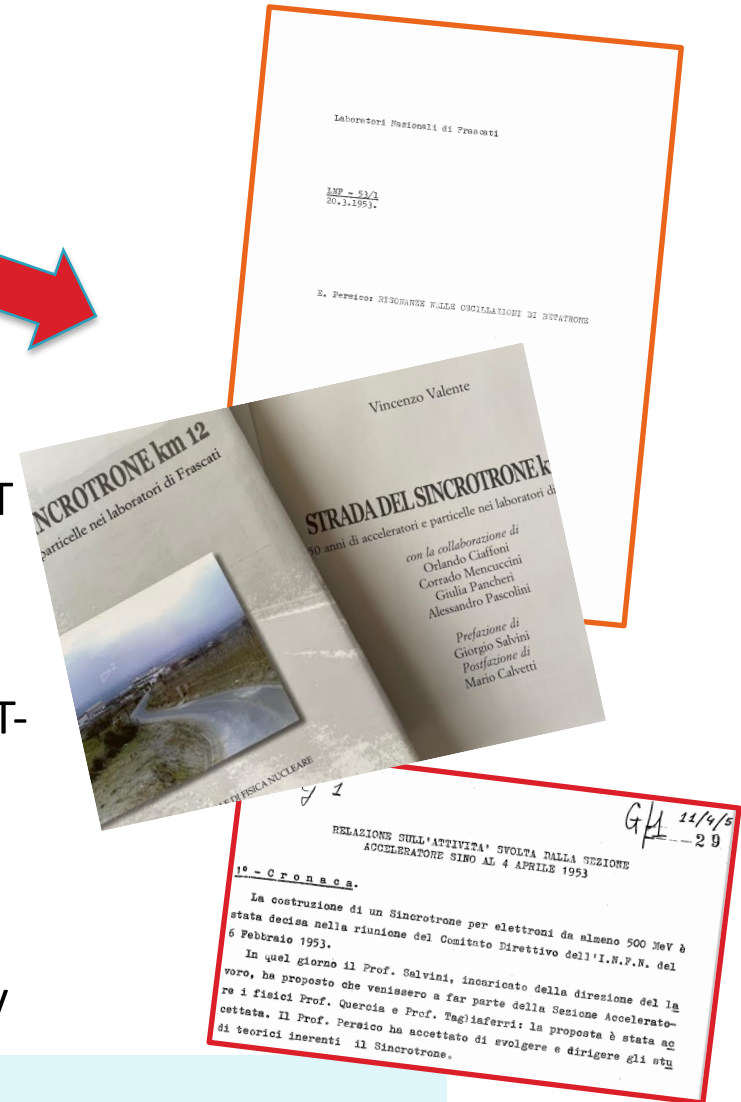
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Public sources : Archives and collections

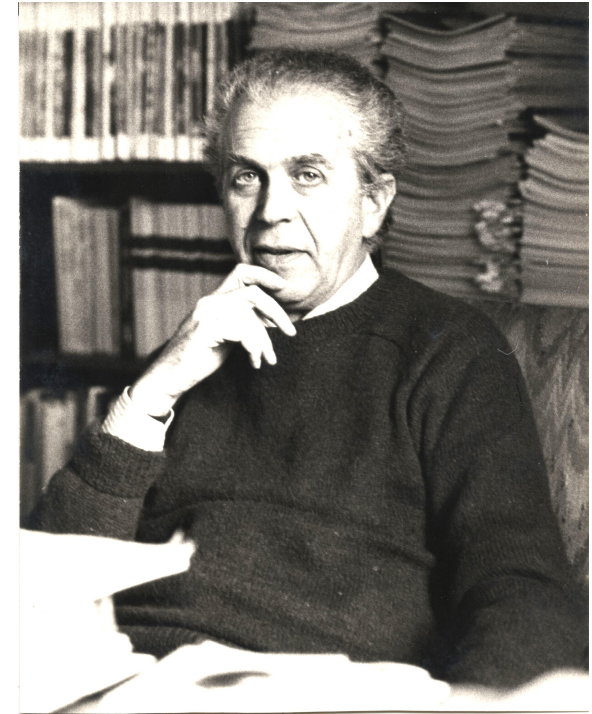
- Amaldi and Touschek Archives Sapienza University of Rome
- INFN Frascati Laboratories (reports and publications since 1953)
- Deutsches Museum Munich (letters BT-Arnold Sommerfeld)
- University of Glasgow Archives Collection (BT-PhD and Nuffield Lecturer)
- Churchill Archives, Cambridge University (lettere BT-Max Born)
- Archives of the Max Planck Society (lettere BT-Werner Heisenberg)
- Accademia dei Lincei (1975 videos of BT lectures)
- Laboratoire de l'Accélérateur Linéaire d'Orsay



...more and some still to be properly explored

Unexpected testimonies came from Videos

- B. Touschek : *After the Lecture by Wideroe*, recorded by F. Touschek, @Accademia dei Lincei, 1975
- *Bruno Touschek and the Art of Physics*, by E. Agapito and L. Bonolis @INFN-2004
- *Touschek with AdA in Orsay*, by E. Agapito, L. Bonolis and G.P. @INFN 2013



After Touschek's death, Carlo Bernardini, (1982) friend and collaborator, became *la voce narrante*

Amaldi's biography is unsurpassed but leaves some questions **unanswered**

- Why was Touschek arrested in 1945?
- How did Touschek's develop into the theoretical physicist who arrived in Rome in January 1953?
- What led to Touschek's proposal for a *experiment worth doing* in February 1960?

The war years

Gottingen and Glasgow

It was not just a brilliant idea

Touschek's letters home give some answers



Personal unpublished letter from Bruno Touschek (BT) to his father and step-mother

- More than **200 lettere** typewritten in German from Bruno to his father were photographed by us in Mrs. Touschek's home, also courtesy of Francis Touschek
- Main historical interest : the period before, during and after WWII through the words of an exceptional young man who participated in a secret project to build a 15 MeV financed by the **Reichsluftfahrtministerium**, with major sponsor Field Marechal General Erhard Milch, Hermann Göring's collaborator.

Touschek's Vienna years and family history



- Jewish from mother's side
- Check-Austrian from father's
- Lost mother as 10 years old (1931)
- Much admired maternal uncle Oskar Weltmann: suicide in 1934
- After the **Anschluss**, Bruno was dismissed from Piaristen Gymnasium 'for racial-political reasons' (December 1938)
- In March 1939, he tried to emigrate to England, unsuccessfully ?



- Bruno enrolled at University of Vienna in September 1939
- Expelled from University of Vienna in May 1940
- Reapplied in 1941, was definitely refused for being a '**mischling**'
- Grandmother Josefine Weltmann deported Theresienstadt in June 1942, died there in March 1943

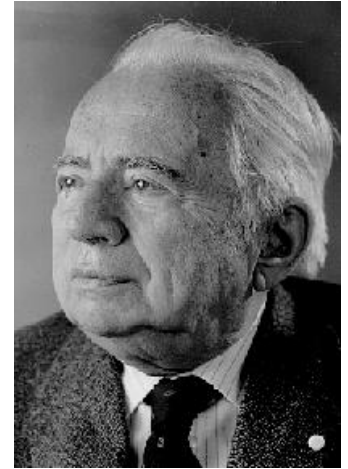
1941-1942 : Austria -> Germany



Arnold Sommerfeld

November 1941: Bruno and **Paul Urban**
-> Arnold Sommerfeld in Munich

December 1941: Correspondence with
Arnold **Sommerfeld**
-> **plan to move” to Germany to
study**



Paul Urban

February 1942 : Touschek leaves Vienna for Munich, -> **further on to Hamburg**

March 1942: Touschek starts earning his living, lectures by **Wilhelm Lenz and Paul Harteck (Uranverein)**

November 1942: -> **Berlin working** for Løwe-Opta, connected to the military

At Löwe Opta, as a referee to the **Archiv für Elektrotechnik** Touschek read Wideroe' article about building a 15 MeV betatron, found some errors, wrote to the author and then joined the project : but is this the whole story?

=>

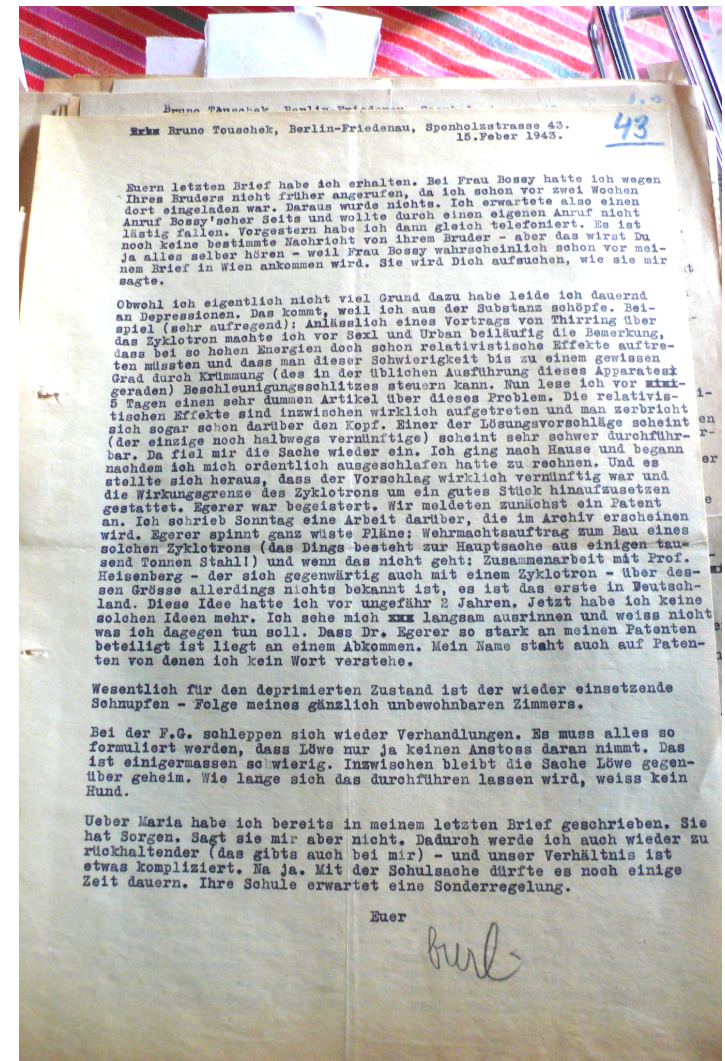
1943-1944

The letters home tell a darker story February 15th, 1943

- Amaldi writes of W's article,

And in Wideröe's book: 'Der Strahlentransformator', Arch. f. Elektrot., **37**, 542-555 (1943), submitted on Sept. 15, 1942.

- But this article was nowhere to be found when we looked for it in 2011 ???
- It was in fact unpublished (proofs exist, courtesy of Waloschek and Sorheim) because the project was classified as war related

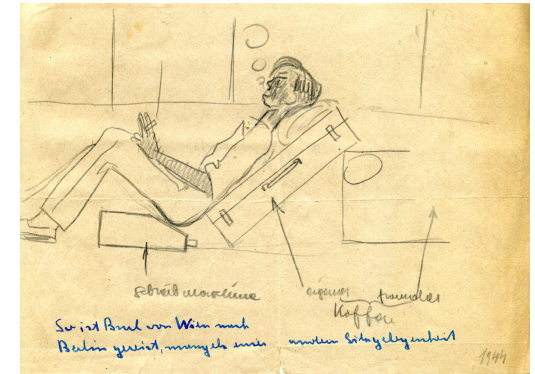


Acquiring a unique knowledge on the electron's ways

- Touschek joined the secret project commissioned to the Norwegian **Rolf Widerøe**, one of the founders of particle accelerator physics
 - ⇒ betatron principle 1922
 - ⇒ first linear accelerator 1928
- BT's contribution to W's success to build the 15 MeV betatron is larger than commonly acknowledged
- as from his later imprisonment and the T-force post war interest



... Our dreams had no limits, Rolf Widerøe in 1994



I am currently working on a very interesting problem that is about the order of a world record, Bruno Touschek, November 1943

Why was Tauschek arrested on March 17 1945?

The dark years 1943-45

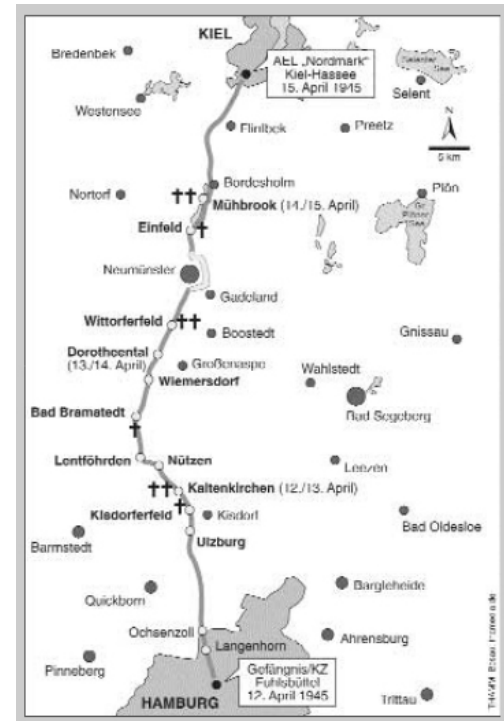
From the letters: O.T. ?

The Todt Organization calls

- And then it acts....on March 17th 1945 Tauschek is arrested

Three letters 1944 & 1945 mention
a call to Bruno
*October 1944 to report to the O.T.
camp in Eichkamp3 with my
luggage as an unskilled worker.*

= > Tauschek's work was sufficiently
important that his petition not to
follow up on the call to forced labor
was accepted 3 times



Without Tauschek Widerøe's 15 MeV
betatron would not have worked

But as soon as the betatron was 'safely'
taken out of Hamburg, Bruno was arrested!

Post war reconstruction in the UK and the Glasgow synchrotron, life in UK

- Cyclotrons -> betatrons -> synchrotrons : particle accelerators became the tool for nuclear physics research
 - 1946 UK Government Committee to build new accelerators in : Birmingham, Cambridge, Liverpool, Oxford, and Glasgow
 - Allied T-force was interested in Bruno, one of very few experts in accelerator physics in Europe (Wideroe had come back to Norway)
- ➔ BT should go to Glasgow where Philip Dee was planning to construct a 300 MeV synchrotron

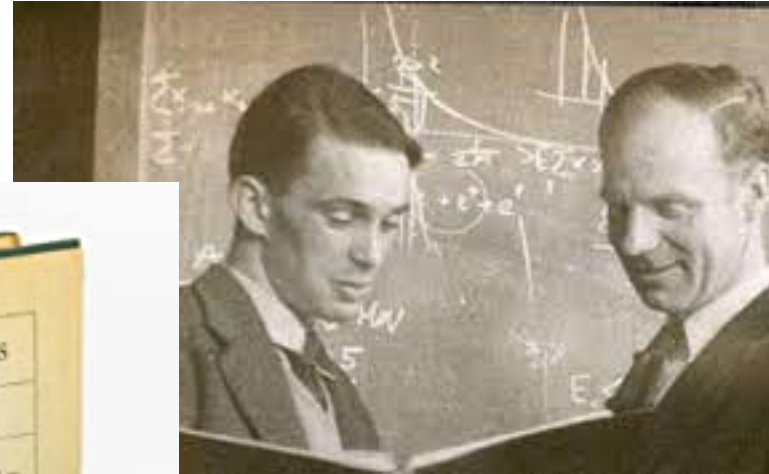
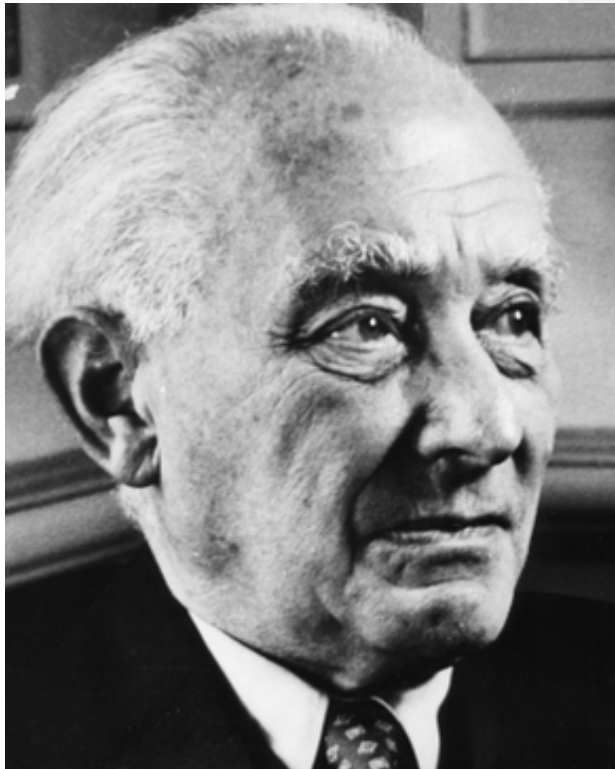


He lived in the house which had been built for Lord Kelvin, 11 The University Glasgow

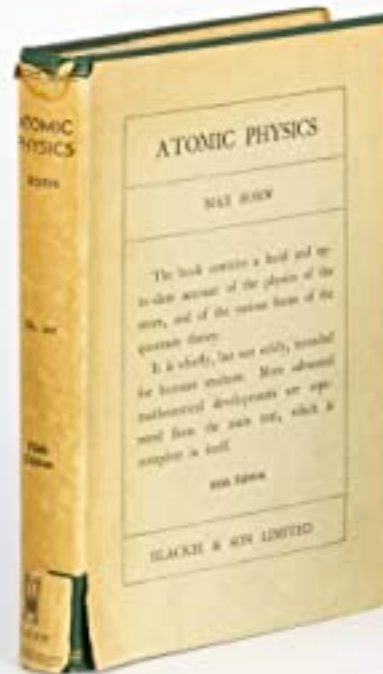
The years of healing: Glasgow 1947-1952

***"In January,** I worked with M Born in Edinburgh and wrote a chapter and an appendix for him. That was quite entertaining."*

Bruno Touschek, letter to father Glasgow, February 13th, **1950**.



With Samuel Curran



1951 : Paper with Walter Thirring on covariant formulation of Bloch & Nordsieck's theorem about infrared catastrophe in QED

1950-52 : Two years Touschek & Max Born correspondence, **Churchill Archives** in Cambridge-> copy in Rome Archives

How did Touschek's develop into the
theoretical
physicist who arrived in Rome in
January 1953?

Touschek unique formation in physics

- Theoretical physics

Hans Thirring

Vienna School 1940-41



- Reaching out to his peers in theoretical physics

- Arnold Sommerfeld – Munich 1941-42 ->
- Werner Heisenberg – Berlin and Göttingen -> 1944-47->
- Max Born – Edinburgh 1947-52
- Wolfgang Pauli – Rome 1953-1958



Arnold Sommerfeld



Werner Heisenberg



Max Born and Wolfgang Pauli-1925

Physics in Rome in the 1950'

- Arriving in Rome, Touschek found
- Edoardo Amaldi, Gilberto Bernardini, Bruno Ferretti, Giorgio Salvini
- CERN creation and foreign visitors
- a new generation of students and young professors
- a grand project, an electron synchrotron
- to be built on the Tusculum hills
- And started his friendship with Wolfgang Pauli

Via del sincrotrone km 12



In Rome Touschek's formation as a theoretical physicist came together with his hands-on experience as accelerator builder

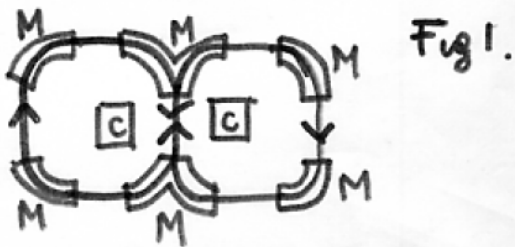
In mid 1950's : towards the first matter-antimatter collider

Theorists worked symmetries

- CPT Theorem 1950-57
- Parity Non Conservation and Discovery of antiprotons – New York 1956
- BT on neutrino, and chiral symmetry – 1957-58

Ideas about colliders were vented at conferences (Geneva 1956)

G. O'Neill



Bruno Touschek, T. D. Lee and Wolfgang Pauli in September 1957.

Touschek's humorous drawing about T. D. Lee and Parity violation.

What led to Touschek's proposal for
an
experiment worth doing on
February 17th, 1960?

In Rome and Frascati questions were
asked

Life changes: 1958 -1959

SOCIETÀ ITALIANA DI FISICA
SCUOLA INTERNAZIONALE DI FISICA “E. FERMI”
IX CORSO - VARENNA SUL LAGO DI COMO - VILLA MONASTERO - 18 - 30 Agosto 1958



Bruno Touschek, director of the course “Fisica dei Pioni”, indicated by the circle in the first row.

1958-1960 and AdA's proposal

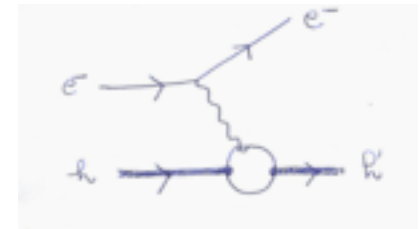
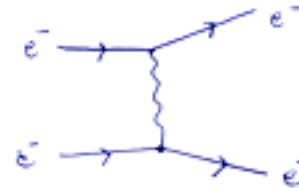
December 1958 : with Pauli's death Touschek loses his compass in theoretical physics

Spring 1959: aunt AdA passes away and the synchrotron starts working

July 1959: Varenna School reminiscing
with Waloschek about Widerøe

and **Kiev HEP** conference

- in Kiev W. Panofsky presents ee Princeton-Stanford project
- Hofstadter presents nucleon form factor experiments

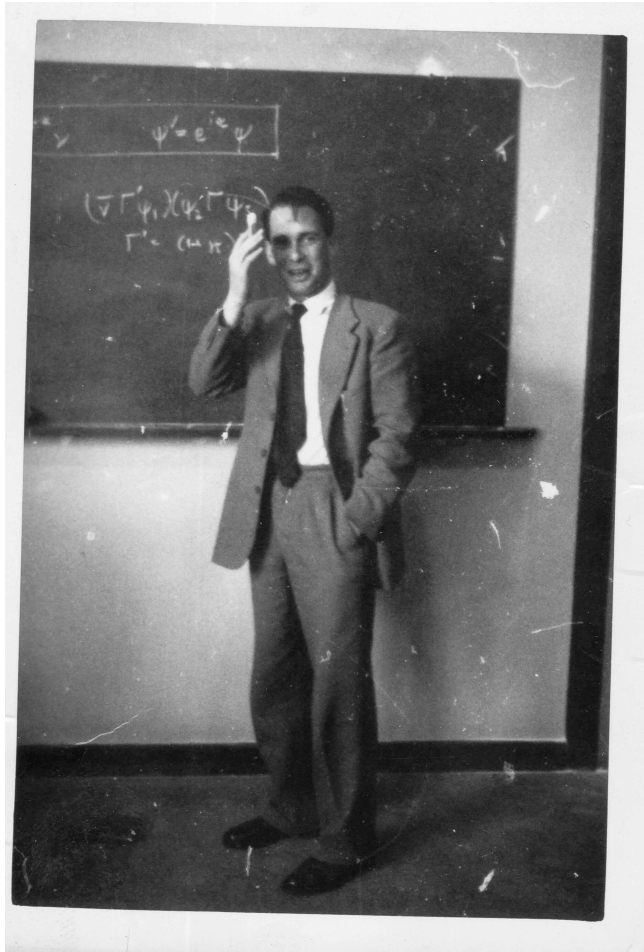


October 26th 1959: Rome and Frascati
Panofsky's seminars => Touschek poses
a question : why not electrons and
positrons in a single ring? [Cabibbo]

Cabibbo & Gatto, Brown and Calogero,
Phys. Rev. Lett. March 1960, submitted
February

17 Febbraio 1960 Bruno proposes
to Frascati to make an “*esperiment really worth making*” : study of
electrons and positrons head-on-collisions in the synchrotron
⇒ Proposal for a new (small) ring prepared in ~ 2 weeks
⇒ approved March 7th 1969

And Bruno started calculating



18.2.60.

State of affairs. Discussed plan with
 G. proposed use of γ -beam also
 for electrons.
 Typical possibility:

$\gamma = \gamma$ -beam, T = target, M_1 = separating
 magnet, St. = Storage magnet, C = acc.
 circuit.

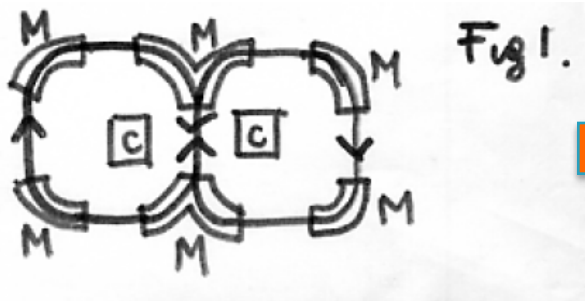
Basic formulae

$$q = N^2 (v\tau)^2 \frac{\sigma}{q} \cdot \frac{c}{\pi R}$$

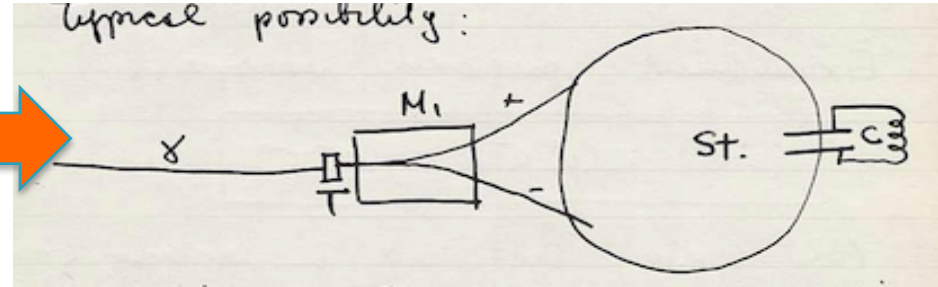
N = number of particles accepted per pulse
 v = repetition rate of the Synch ($v = 20$)

AdA : the perfect synthesis

1. New frontiers in accelerators physics

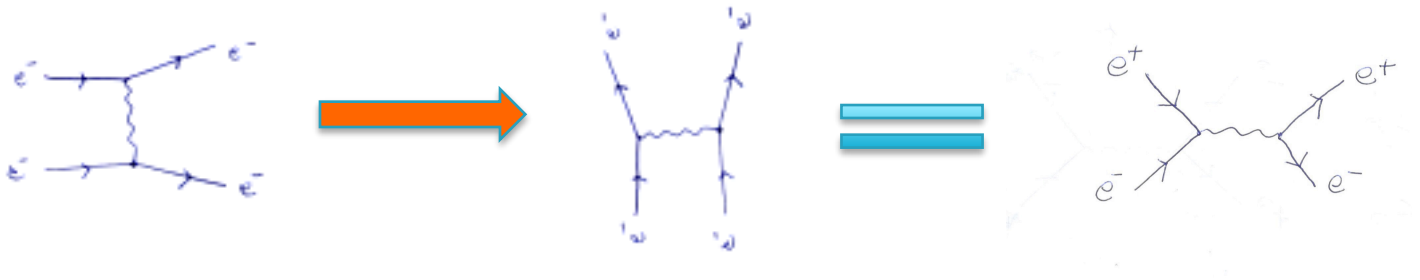


O'Neill 1956



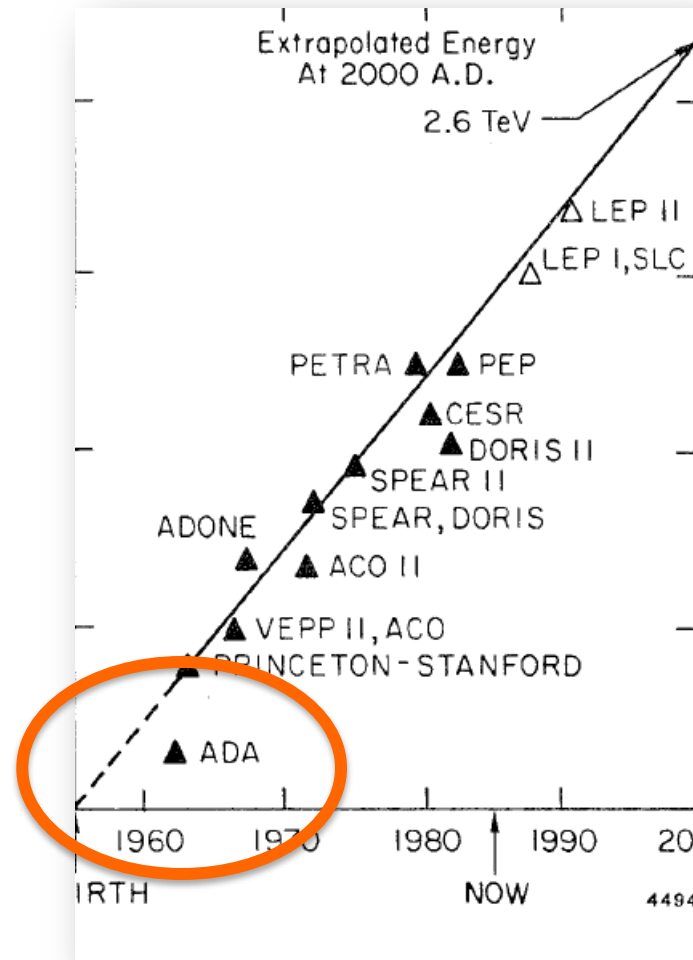
Touscek 1960

2. new ideas and discoveries in theoretical and experimental particle physics
QED, symmetries, CPT theorem, anti-particles discovered and laboratory produced



3. New powerful accelerators : **synchrotrons** (Frascati) and linear accelerators (SLAC, Orsay)

The road to particle colliders goes on and on



ADONE started in 1969, by which time new generation colliders took over and in 1974 the American competition won the race, discovering a new particle, the J/Psi, and a new quark, called *charm*, whose existence had been predicted in 1970 by S. Glashow, J. Iliopoulos and L. Maiani.

Extras