



AdA, Frascati 1961

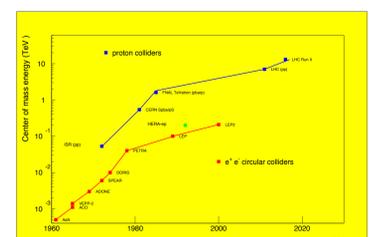
ADONE, Frascati 1969

## Bruno Touschek (1921 – 1978) and the road to modern day particle accelerators

L. Bonolis, D. Del Re, S. Giagu, M. Mancini and G. Pancheri – HoP Dublin, June 2022



CERN L HC tunnel 2008



The road to particle colliders

### Early years in Vienna (1921 - 1942)

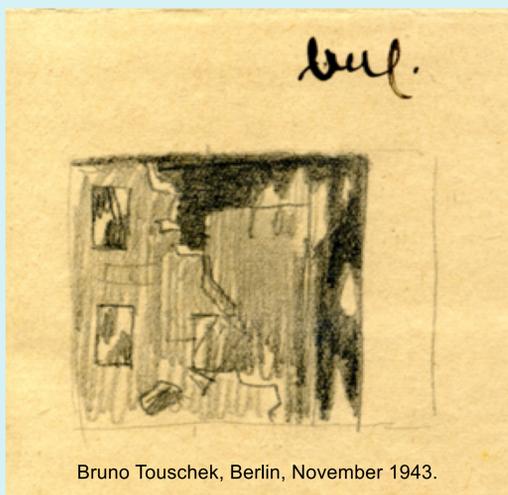
Bruno Touschek was born in Vienna. He was of Jewish from the maternal side. After the March 1938 annexation of Austria to Germany, he unsuccessfully attempted to emigrate to England to study chemistry in Manchester, and finally enrolled in physics at the University of Vienna. Expelled in 1941 because of his mixed origins, he decided to continue his studies moving to Germany, under the protection of Arnold Sommerfeld and in February 1942, left Austria for Munich.

### Germany (1944 – 1945)

During the last two years of WWII, Bruno Touschek worked on the secret betatron project. He was moving between Hamburg, and Berlin, where he attended University classes by Max von Laue and Werner Heisenberg, while continuing to work at Löwe-Opta, and experiencing the heavy fire-bombing of both Hamburg and Berlin.

While on the betatron project, Bruno, as a half Jew, was under constant threat to be deported to forced labor by the Todt Organization. In March 1945, as the English and American forces were approaching Hamburg, Bruno and Widerøe transferred the working betatron to Wrist. On his return to Hamburg, Bruno was arrested by the Gestapo.

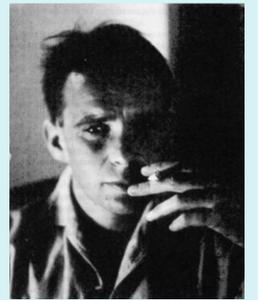
He was brought to the infamous Fuhlsbüttel prison, from where a forced march of 200 prisoners took him toward the Kiel concentration camp. Shot by a guard and left for dead, he was freed on April 30th, coming under the protection of the T-force, the Allied Corp in charge of assessing Germany's scientific assets and preparing its post-war reconstruction.



Bruno Touschek, Berlin, November 1943.

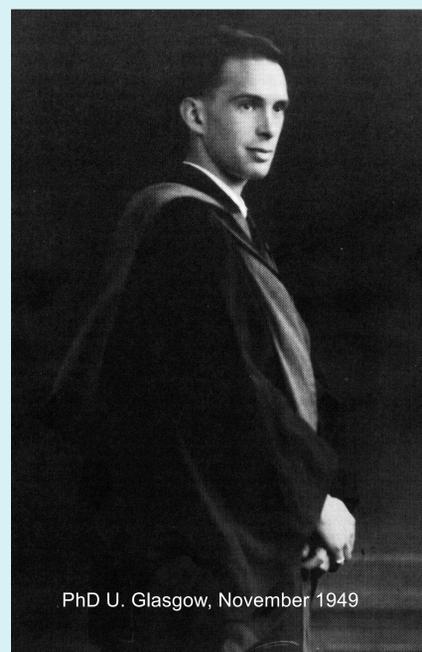
### Germany (1942 - 1943)

After first visiting Arnold Sommerfeld in Munich, he went to Hamburg, and then to Berlin, where Bruno was hired by the electronic firm Löwe Opta and came across an article submitted by the Norwegian scientist, Rolf Widerøe, inventor of the betatron. This article led to a secret project for the construction of a 15 MeV betatron, financed by the Aviation Ministry of the Reich, and directed by Rolf Widerøe. The project was approved in summer 1943, and Touschek joined the project in November. Working with Widerøe, Touschek first heard about the idea of storing particle beams and make them clash against each other.



Bruno Touschek, 1955,

### Formation years: from Göttingen to Glasgow



PhD U. Glasgow, November 1949

In 1946, Bruno was taken to Göttingen, where German science was being reconstructed for pacific purposes under Werner Heisenberg's leadership. After obtaining the Diploma in physics on the theory of the betatron, Bruno was Werner Heisenberg's assistant for 6 months. In March 1947, his war time expertise with Widerøe's betatron was sought by the University of Glasgow, where a 350 MeV electron synchrotron was to be built. From 1947 to 1949, he collaborated with all the major synchrotron groups in the UK. Awarded the PhD in 1949, he remained in Glasgow as research fellow. He was befriended by Max Born in Edinburgh and Bruno Ferretti from University of Rome, where he moved in December 1952.

## ITALY (1953-77) AND FRANCE (1962-64)

### Rome: Theoretical Physics and good times



Bruno Touschek and Edoardo Amaldi, 1952 CERN General Secretary, mid-1960s.



Accademia dei Lincei – Bruno Touschek (left), P. Dirac (at center), around 1975.

Strongly supported by Edoardo Amaldi, who attracted him to Rome as INFN researcher, Bruno worked on neutrino physics, and Time Reversal, becoming friends with Wolfgang Pauli who inspired Bruno's faith in the CPT theorem (and thus prepared him to support AdA's feasibility).

### From Frascati National Laboratories to Orsay and back

In April 1959, an electron synchrotron, whose construction had been directed by Giorgio Salvini, started operating in Frascati National Laboratories. Following this success, between February and March 1960 Touschek proposed to the Rome and Frascati scientists to build the first ever storage ring for electron-positron collisions, AdA, Anello di Accumulazione. The proposal was accepted and, in February 1961, a team led by Touschek, with Carlo Bernardini, Giorgio Ghigo, Gianfranco Corazza, Ruggero Querzoli and Giuseppe Di Giugno, was able to see the first electrons circulating in AdA.

To improve performance, AdA was brought to LAL in Orsay, France, where the *Touschek Effect* was discovered and proof of the feasibility of electron-positron storage rings was obtained, in collaboration with Jacques Haïssinki and Pierre Marin.



LINAC, Orsay



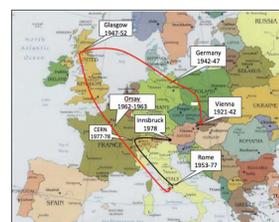
P. Marin, 1966

### ADONE

Inspired by AdA's pioneering adventure, and knowledge brought by its successful operation, electron-positron colliders were designed and built in all major world laboratories. Among them, ACO in France, and ADONE, in Italy, which Touschek had proposed in November 1960, fully confident in the feasibility of electron positron storage rings as a major discovery tool for particle physics. In 1969, ADONE, with 3 GeV c.m. energy, was first in discovering multiple hadron production and, in 1974, confirmed the American discovery of a bound state of a new type of quark, the charm.

### CERN (1977-78)

Touschek spent the last months of his life as visiting scientist at CERN, where early plans for LEP, a giant electron-positron collider were discussed. He became very ill while he was participating in the planning of the CERN antiproton-proton collider, where the W-and Z-bosons were discovered in 1983. In March, a CERN car took him to Austria, where he passed away on 25th May 1978.



Touschek's life journey