ISR, the machine that *« changed the landscape of high-energy physics »**

Borings on the future ISR site, Novembre 1963

Construction of the ISR ring (octant no. 3), November 1967

Beam-transfer tunnels, January 1970

The ISR site in September 1970

When high-energy particles from an accelerator slam into a stationary target, most of the valuable projectile energy is taken up by the target recoil, and only a small fraction actually feeds the collision. In the 1950s, physicists realized that if two particle beams could be fired at each other, no recoil energy would be wasted, making for much more efficient use of energy in the collisions.
While other physics laboratories concentrated on building machines to collide beams of electrons, CERN worked with protons. The idea was to use the Proton Synchrotron (PS) to feed two interconnected rings, where two intense proton beams could be built up and then made to collide.
The Intersecting Storage Rings (ISR) were formally approved for construction in 1965, when an agreement was signed to extend the CERN site across the Franc-Swiss border. Construction of ISR started in 1966.
The ISR was used to study proton-proton collisions at the highest energy then available (60GeV). The protons, supplied by the PS, were injected into two identical rings, each measuring 300 metres in diameter, and collided head on at the 8 points where the rings intersected. The installation, which remained in operation until 1984, gave physicists access to a wide range of energies for hadron physics, hitherto restricted to the data from cosmic ray studies.

** Viki Weisskopf, ISR's closing ceremony, 1984.*

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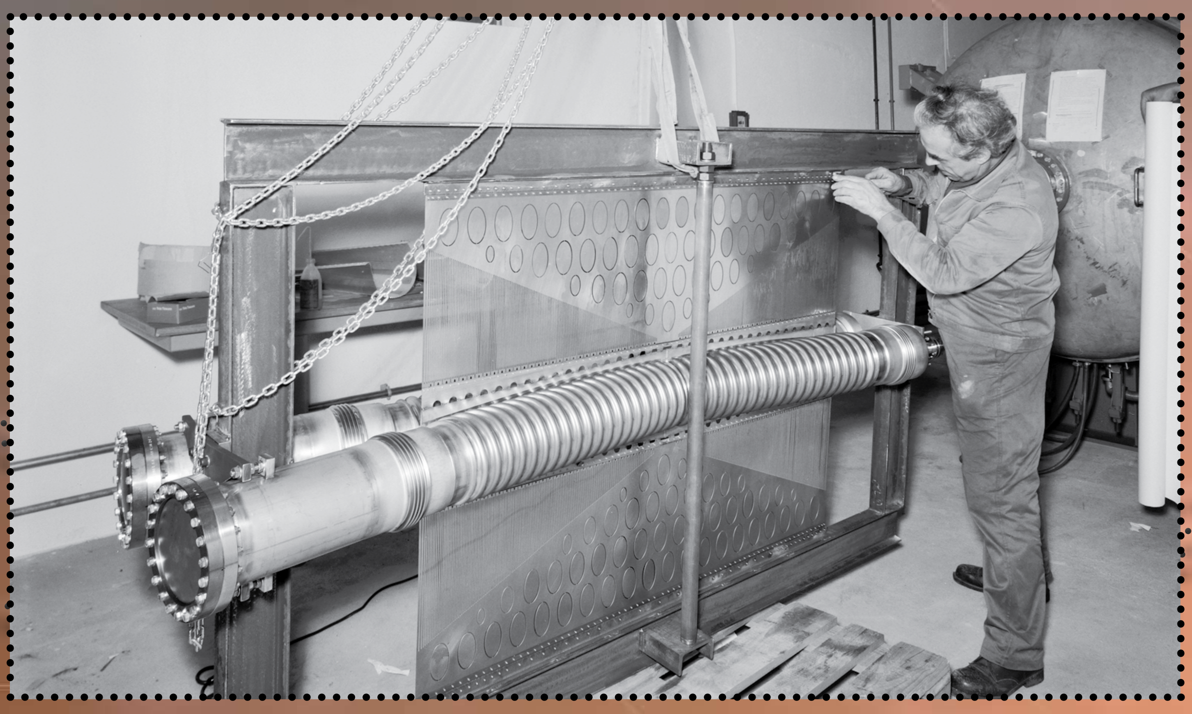
A masterpiece of engineering

Precious skills, techniques and knowledge were acquired building and operating the machine.

Ultra high vacuum

The ISR beamtubes had to be as empty as outer space, a vacuum 100 000 times better than other CERN machines at the time.



"Flat-Fish" Vacuum Chamber, February 1978.

A vacuum chamber where the proton beams collide in the ISR, June 1973.

Stochastic cooling

« To me, the stochastic cooling story happened in the following way. Simon van der Meer had a fit of pessimism about the planned performance of the ISR. He was afraid that the machine wouldn't work as promised, and he put all his mental energy into finding a way of saving it if this came to pass. Happily, he turned out to be wrong about the ISR, but he nevertheless invented stochastic cooling. When he had worked out the theory, he concluded that it would not help the ISR and he put the idea to one side. Fortunately, he told his colleagues about the idea first. Later on, as the ISR got going, people realised that although stochastic cooling wouldn't help the ISR much, it was a wonderful invention and we'd better take a look at it. So we managed to build in stochastic cooling to the ISR. When we switched it on we saw a reduction in beam height, so we had a clear demonstration that stochastic cooling worked. »

Kjell Johnsen, CERN Courier.

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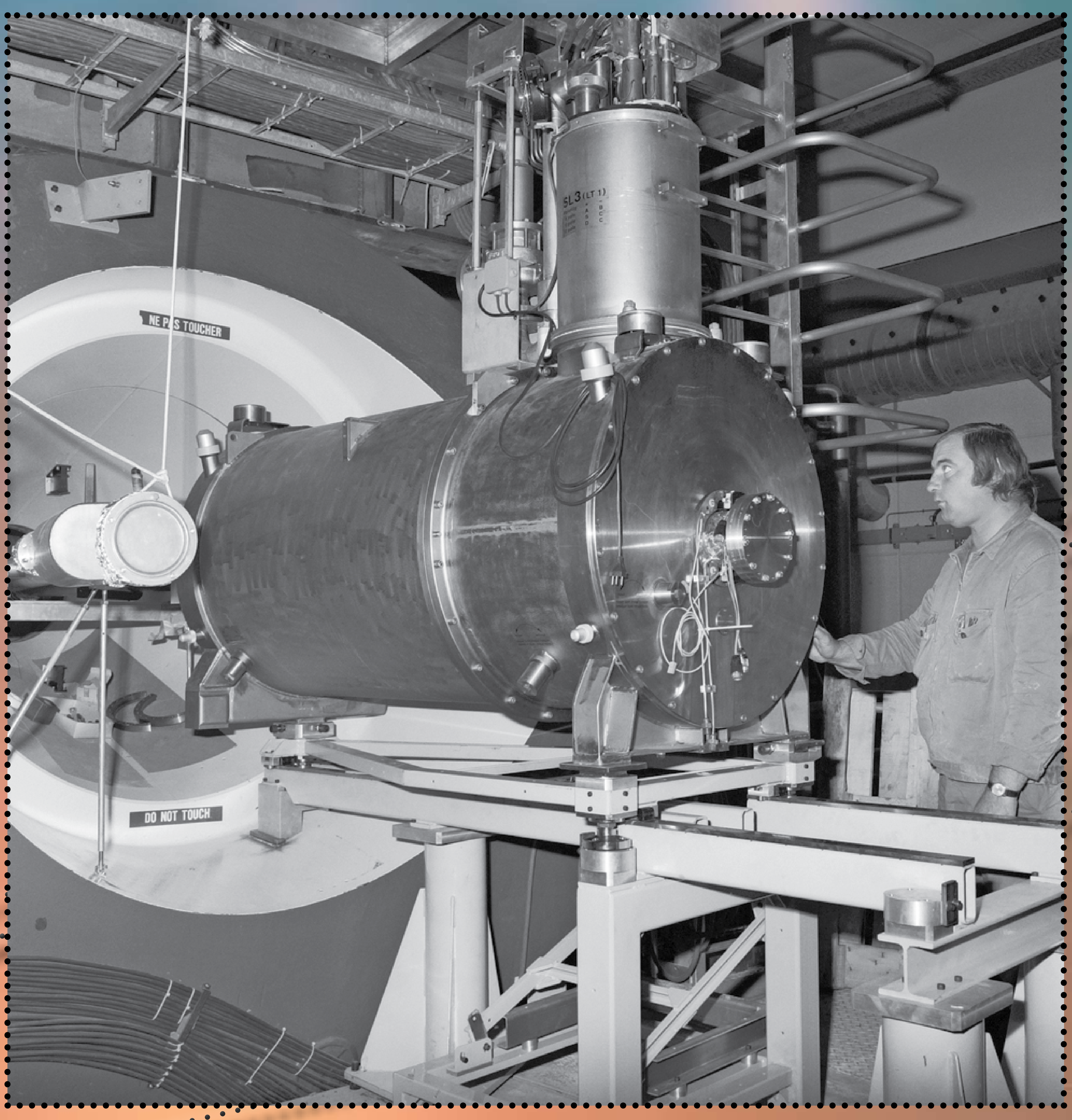
A pioneering particle accelerator

Luminosity records and superconducting magnets

From June 1974 onwards, the nominal current of the beams stored in the rings - 20 A per ring - allowed the 10^{31} $cm^{-2}s^{-1}$ luminosity threshold to be exceeded. A further increase in luminosity was achieved when superconducting magnets were introduced in November 1980, the first time they had been used in an accelerator.



Installation of Superconducting High Luminosity Insertion at the ISR. A Superconducting Quadrupole is being installed very close to the Axial Field Magnet spectrometer.

*« **Like all pioneering particle accelerators, the ISR was its own prototype.** The ISR's first – and main – aim was to collide proton beams and it did its brilliantly over its 13-years lifespan, with ever increasing luminosity. Of the other firsts, it was at the ISR that stochastic cooling was proven, with antiproton beams being kept for hundreds of hours […]. Ultra-high vacuum techniques necessary for colliders came of age at the ISR, and it was at the ISR that superconducting magnets were first used with circulating beams. »*

Kjell Johnsen, in Infinitely CERN.

A brilliant start

Two important results came from the ISR, between 1971 and 1973.

Rising cross-sections

An important early discovery at the ISR was that the interaction probability between two colliding protons was steadily increasing with energy. Known as the rising cross section, this result came in 1971.

Large P_T phenomena

Secondly, there seemed to be too many secondary particles with high energy emerging at large angles.

First detectors at the ISR. Some of them were looking at proton scattering at very small angles to the beam direction. September 1971.

First injection tests into ISR Ring I. In the main control room, on the night of 29 October 1970, spectacular success was achieved with the first injection tests into Ring I. The focus of attention, top right, is a monitor which indicated the circulating beam current.

«The early exploitation of the ISR coincided with an important turning point in our understanding of the particles called hadrons, which we now know are composite particles made of quarks. In the late 1960s, hadrons were considered to be relatively large, extended objects. It was an important and quick discovery at the ISR that hard collisions among point-like constituents took place, which were eventually recognised as quarks and gluons. "

« The early detectors were indeed unprepared for the new physics […]. However, it was a timely lesson for the conception of the big and sophisticated detectors to be installed when the SPS was used as a proton-antiproton collider. »
Maurice Jacob, in Infinitely CERN

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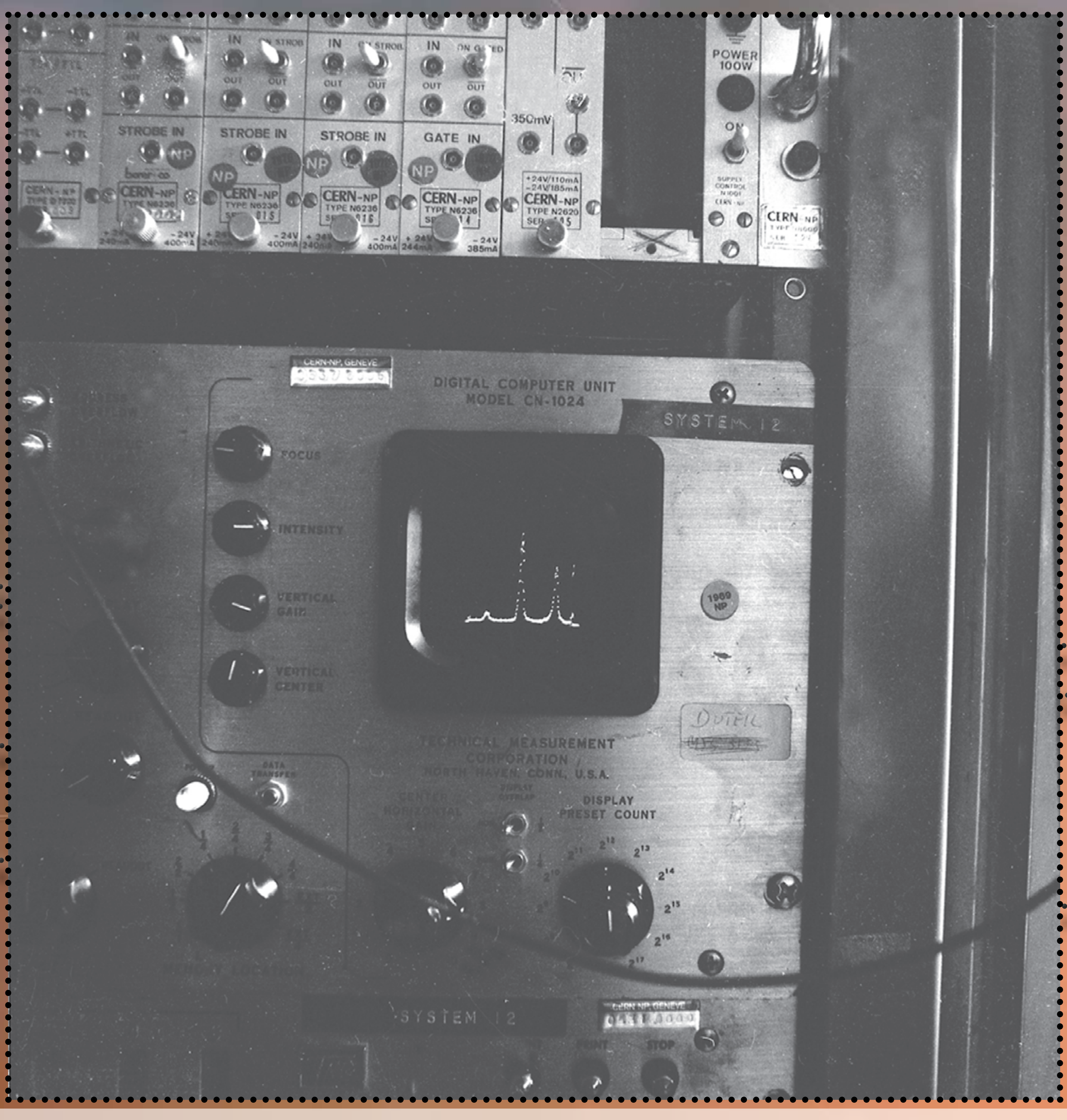
The world's first
proton–proton
and proton-antiproton collisions

On 27 January 1971 the ISR produced the world's first proton–proton collisions The ISR later produced the world's first proton-antiproton collisions on 4 April 1981, paving the way for proton-antiproton collisions in the Super Proton Synchrotron (SPS), and the Nobel prize for Simon van der Meer and Carlo Rubbia.



The first interactions between the two beams in the ISR. The time differences between pulses from detectors on the two sides of the intersection region are shown. The central peak is due to beam-beam collisions, those at either side to beam-gas or beam wall collisions. January 1971

On 27 January 1971, Kjell Johnsen, who led the construction team which built the ISR, announced that the first ever interactions from colliding protons had been recorded. On the left are Franco Bonaudi, who was responsible for the civil engineering and Dirk Neet, who later took charge of the ISR.

The inauguration ceremony for the ISR was held on 16 October 1971. Kjell Johnsen is seen in the picture handing a symbolic key to the ISR to Edoardo Amaldi. From left to right on the podium: Viki Weisskopf, former Director-General; M Antonioz; Willibald Jentschke as Director-General of CERN, and on the other side Werner Heisenberg.

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The first in a long line

« The ISR were the world's first hadron collider. This was the machine on which the young generation of machine physicists who designed, built and operated the antiproton source and the proton-antiproton collider gained their experience and their expertise. It worked superbly, exceeding its design goals in both energy and luminosity. […] It is also the machine with which a generation of physicists learned how to design experiments at hadron colliders. »
Pierre Darriulat, CERN Courier

« I very much enjoyed my long and close association with research at the ISR. I was of course only a (talkative) observer rather than a proper user, but I value the friendships developed with experimental and theorical colleagues, and also with the machine physicists who made the machine run so well. It was altogether a great adventure, provided by the first hadron collider in a series of great machines – now to continue with the Large Hadron Collider. »
Maurice Jacob, Infinitely CERN

« To close, I would like to echo the sentiments of Viki Weisskopf, who pointed out at the [ISR] closing ceremony that children frequently outshine their parents. As the first hadron collider, the ISR can count among its offsprings illustrious machine such as the SPS proton-antiproton collider at CERN, the Tevatron at Fermilab, RHIC at Brookhaven, and perhaps even HERA at DESY. And today, we are looking forward to the next generation with the LHC at CERN. The ISR therefore has pride of place in the history of particle physics as founder of an illustrious dynasty ».
Kjell Johnsen, Infinitely CERN