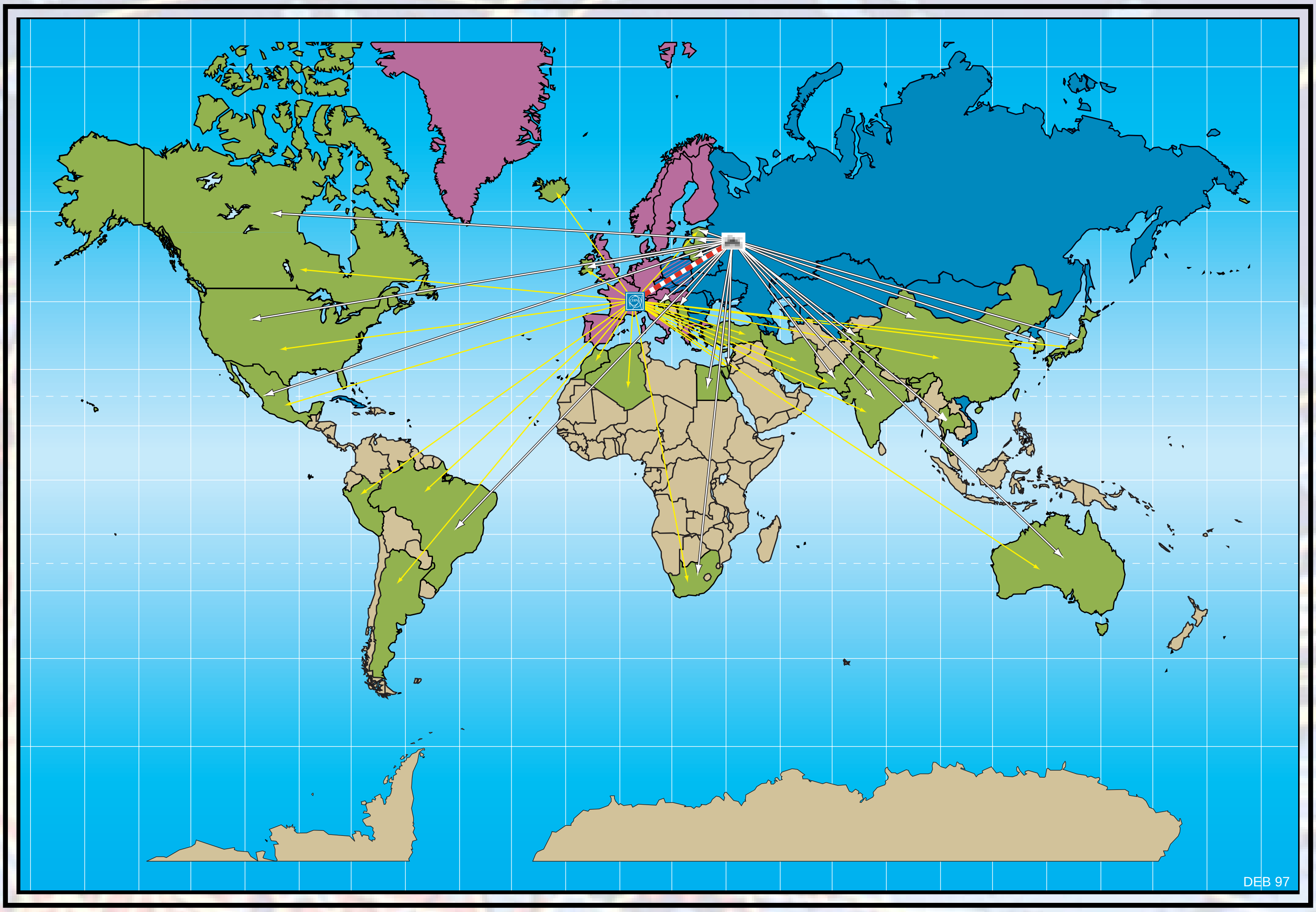
CERN

JOINT INSTITUTE FOR NUCLEAR RESEARCH



Science Bringing Nations Together

April 1999

Introduction

This booklet presents the poster exhibition, *“Science Bringing Nations Together”*, which has been prepared by the European Organisation for Nuclear Research (CERN) in Geneva and the Joint Institute for Nuclear Research (JINR) in Dubna, Russia. The exhibition attempts to show how individuals and groups from all over the world have worked towards common scientific goals independently of political differences, often across almost closed borders, and how this has led to mutual understanding and friendship, not only between scientists, but also between nations.

CERN was founded in 1954 and ,as one of the first international scientific organizations created, it became a model for those which followed. Shortly afterwards, in 1956, JINR was established to unify nuclear research in the Soviet Union and other socialist republics. Scientific co-operation and collaboration in Particle Physics have stimulated understanding among people of many nations; initially within Europe, across the former East-West division, and now on a world-wide scale.

Scientific collaboration was a precious communication channel throughout the period of the Cold War. Particle Physics is a natural pioneer for global scientific collaboration and very often the needs of large-scale basic research required the involvement of politicians at the highest level, lowering barriers and leading to mutual understanding and political collaboration.

Parts of the exhibition have already been shown at the United Nations in Geneva (October 1996), at CERN (December 1996), at the Physics Department of the University of Oslo (August/September 1997) and at UNESCO (October,1998).

Today, CERN is building a new accelerator, the Large Hadron Collider (LHC), in Geneva and physicists from all over the world are preparing sophisticated equipment for a new generation of complex detectors. Large groups of physicists and engineers from JINR and Russia are involved in this long-term preparation.

CERN and JINR are, therefore, at the cutting edge of fundamental science and technology and attract outstanding young people from all over the world. Their experience of working together is helping to build a brighter future for everyone.

CERN & JINR, April 1999

...

"At the very time when the talk is of uniting the peoples of Europe, our attention has turned to the question of developing this new international unit, a laboratory or institution where it would be possible to carry out scientific work above and beyond the framework of the various nations taking part, as it were. Resulting from co-operation between a large number of European states, this body could be endowed with greater resources than those available to the national laboratories and could then embark upon tasks whose magnitude and nature preclude them from being done by the latter on their own. It would serve as a means to co-ordinate research and the ensuing results, to compare the methods used and to adopt and carry out programmes of work with the collaboration of scientists from the various countries concerned."

...

"There is no doubt that the results of such an undertaking would more than compensate the efforts involved. Strengthening the links between the scientists of the various countries, pulling together resources, ensuring co-operation in terms of material and intellectual wherewithal and with the firm aim of facilitating the dissemination of studies, publications and information, the creation of this research centre will symbolize the pooling of some of the intellectual energy of contemporary Europe. This convergence of efforts can be more easily achieved in this area than in others because material and national interests are not so predominant, and it provides an example of what one should gradually strive for in other fields. The universal and very often disinterested nature of scientific research seems to have predestined it for reciprocal and fruitful collaboration."

...

Louis de Broglie

It was in 1949 at the European Cultural Conference in Lausanne, Switzerland, that the distinguished French scientist Louis de Broglie first proposed the idea for a European research laboratory.

Two extracts from de Broglie's visionary address are shown on the opposite page

Louis de Broglie

Pierre Auger and Edoardo Amaldi, benefiting from the encouragements of Isidor Rabi at the UNESCO General Conference of 1950, convinced the European governments to move ahead.

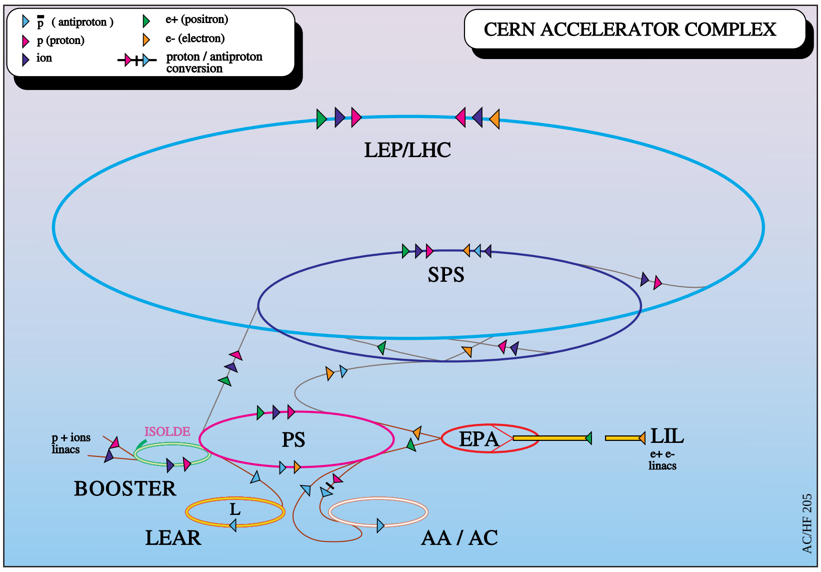
Prepared in the framework of UNESCO and of the Centre Européen de la Culture by Denis de Rougement, the Conseil Européen de la Recherche Nucléaire, CERN, was born in 1952, as a first step towards the Organization which was created in 1954.

Left to Right: CERN pioneers Pierre Auger, Edoardo Amaldi, and Lew Kowarski seen here at the first session of the provisional CERN Council in 1952.

Doing More Together

CERN the European Laboratory for Particle Physics, is the world's largest particle physics research centre. Founded in 1954, the Laboratory was Europe's first scientific joint venture, and has become a shining example of international collaboration.

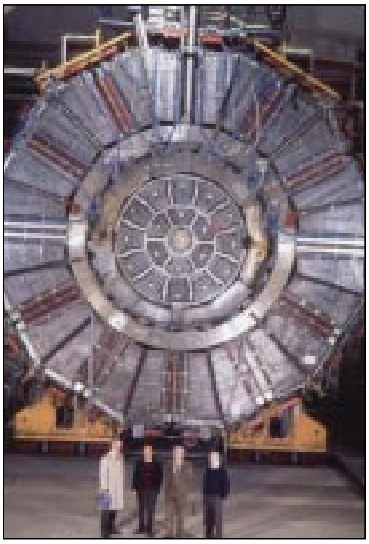
From the original 12 signatories of the CERN convention, membership has grown to the present 19 Member States.



The Laboratory's tools, particle accelerators and detectors, are amongst the world's largest and most complex scientific instruments. Nobel prizes have been awarded to CERN physicists for developments in both.

The accelerator complex has evolved over nearly half a century. When CERN builds a new accelerator, the old ones are not retired. Instead, the new arrival becomes part of the existing system, bringing with it new versatility.

In this way, the Proton Synchrotron, PS, a state-of-the-art research machine in the 1960s, has evolved to become the world's most versatile particle juggler, providing beams for many of CERN's other machines.

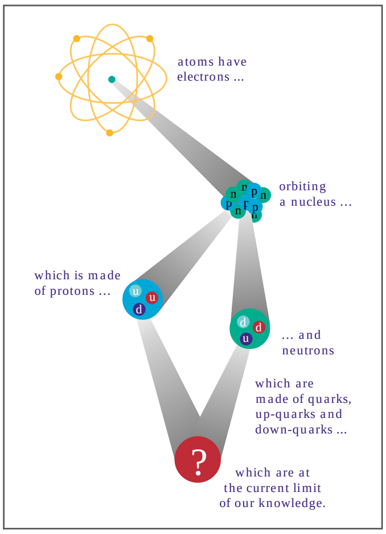


Physicists are dwarfed by the sheer size of this particle detector.

Built at the leading edge of technology, CERN's accelerators and detectors are some of the finest monuments of 20th century science.

CERN's business is pure science, exploring nature's most fundamental questions.

What is matter?
Where does it come from?
How does it stick together into complicated objects like stars, planets, and human beings?



At CERN, particle beams probe the heart of matter, and the Laboratory's researchers study millions of particle collisions in an effort to find the answers to these questions.

The Laboratory sits astride the Franco-Swiss border west of Geneva at the foot of the Jura mountains. Some 6500 scientists, half of the world's particle physicists, use CERN's facilities. They represent 500 universities and over 80 nationalities.

CERN's job is to provide beams of high energy particles for these physicists to use in their experiments. In this the Laboratory excels, with the largest interlinked particle accelerator complex anywhere in the world.

CERN's largest particle accelerator, the Large Electron-Positron collider, LEP, 27 kilometres in circumference, is buried in a tunnel deep underground. In the photograph it is marked by a large white circle.

The smaller circle, 7 kilometres around is the Super Proton Synchrotron, SPS, scene of the Nobel prize winning discovery of particles called W and Z in the 1980s. The much smaller Proton Synchrotron, PS, is at the extreme left and Geneva airport's 4 kilometre long runway is visible in the foreground.

If you want to know more about CERN, use the Laboratory's invention, the World-Wide Web:

http://www.cern.ch/

CERN's original 12 Member States.

CERN was the first joint venture of countries in post war Europe, and is a model of what can be done when a group of nations joins forces with a common goal.

Its management structure is unique, allowing full intellectual freedom to the Laboratory's users whilst remaining responsive to Member State governments.

CERN's governing body, Council, is composed of two representatives per Member State, usually one from government and the other from the scientific community. Council thus has the means to reconcile the wishes of scientists with the financial will of governments.

The signatures which established the CERN convention in 1953

The sixth session of the CERN council took place in Paris on 29 June-1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by 12 European States

The Organization officially came in to existence one year later in September 1954.

A Role Model for European Research

The CERN experience has proved so successful that the Laboratory has been used as a model for other European research organizations.

First to follow was the European Southern Observatory, ESO, which had its first headquarters at CERN before finding a permanent home in Garching near Munich.

The European Space Agency, ESA, the European Molecular Biology Laboratory, EMBL, the European Synchrotron Radiation Facility, ESRF, and the Joint European Torus, JET, are also founded to a greater or lesser extent on the CERN model.

An Opening towards the East

In the 1960s the Soviet Union took the decision to build the largest particle accelerator the world had seen. Based at Serpukhov, near Moscow, the new machine was complete by 1967.

That same year, an agreement was signed between CERN and the USSR State Committee for Atomic Energy under which CERN would construct special equipment for the accelerator in return for which scientists from CERN Member States would be able to participate in the Serpukhov experimental programme.

On the extreme left Dr. G. Funke, President of the CERN Council watches CERN's Director-General, Professor B. Gregory (centre) and Professor A. Petrosiants sign the agreement.

During the 1970s several joint CERN-Soviet experiments were carried out at Serpukhov, showing how scientific collaboration could surmount political obstacles and blazing a trail for future co-operation.

An Opening towards the World

In 1994, Japan became the first country far from the European region to be admitted as an Observer to the CERN Council. Observer status allows participation in Council meetings, but not in the Laboratory's decision making process.

Japan joins CERN's other observers:

Israel, the Russian Federation, Turkey, the European Commission, and UNESCO.

Japanese Minister for Science and Culture, Kaoru Yosano, and CERN's Director-General, Chris Llewellyn Smith, congratulate each other on having jointly painted in the pupil of one eye of a Daruma doll in a Japanese ceremony to wish a new venture good luck.

The other pupil will be painted in by a future Japanese Minister and Director-General when CERN's next accelerator, the Large Hadron Collider, LHC, comes into operation in 2005.

Collaborating throughout the Cold War

For more than 40 years, Western Europeans have co-operated at CERN in fundamental research essential for the enrichment of human knowledge. But as well as providing an unrivalled focus for science, the Laboratory is also a valued meeting place for researchers from all over the world.

CERN's boundaries have always extended beyond the confines of Western Europe. Physicists from Eastern and Central Europe, and scholars from the Soviet Union have been associated with CERN's success since the 1960s.

Poland, with a strong scientific tradition, became an observer at CERN in 1963. Links with the USSR were sealed with a scientific co-operation agreement signed in 1967, extended in 1975 and 1981. Russian participation in CERN's future programme was reconfirmed with new agreements signed in 1993 and 1997.

The Antonov 22 transporter at Geneva airport in 1970.

This co-operation has transcended political differences, continuing uninterrupted during periods of international tension. Scientists from East and West continued to work together through the invasion of Prague in 1968, the Vietnam war from 1964 - 1975, and the invasion of Afghanistan in 1979.

The ideal of scientific research as an essential and shared part of human endeavour, immune from the vagaries of politics, has always been held high by CERN.

The pictures on this page illustrate this perfectly:

The Antonov 22 transporter caused quite a stir when it arrived at Geneva airport in 1970. A top-secret military aircraft, its first mission beyond the Soviet Union was to collect a state-of-the-art experiment from CERN and take it to Russia where it was to be installed at the worlds' highest energy particle accelerator at the time in Serpukhov.

The Antonov's pilot with the local press.

To escape from the crowds, the Antonov's pilot took a light aircraft for a spin around the Alps whilst waiting for his anything-but-light aircraft to be loaded.

The same pilot was tragically killed the following year while ferrying emergency supplies to earthquake victims in Chile.

The Orlov Committee at CERN 1978 - 1988

Yuri Orlov, seen on the right talking to CERN's Dieter Möhl, founded the Helsinki Watch Group in 1976, was arrested in 1977 and sentenced to seven years in a labour camp.

The Orlov Committee was created by a group of CERN physicists in 1978 with the purpose of supporting scientific colleagues subject to persecution for their actions in defense of human rights. The Committee worked to promote human rights in the scientific communities of several countries including Morocco, Turkey, the Soviet Union and Uruguay.

Yuri Orlov spent one year as a guest professor at CERN in 1991.

Andrei Dimitrievich Sakharov 1921 - 1989

In the citation for his 1975 Nobel Peace Prize, Andrei Dimitrievich Sakharov was described as 'spokesman for the conscience of mankind'.

The talented and versatile scientist and fearless activist was unable to receive the prize in person. Deemed politically unacceptable, from 1980 he was exiled in Gorki, where he tried to keep in touch with scientific developments as best he could.

CERN scientific publications and the CERN Courier, were sent to him by registered mail.

In this clip from a 1985 Soviet TV film, Sakharov was seen picking up a copy of the CERN Courier from his table to demonstrate that the message was getting through.

Yuri Orlov and **Andrei Sakharov** symbolised the struggle for scientific freedom and international collaboration which are the foundations of CERN's existence. Due to their sense of justice, democracy, and their intellectual integrity they both played an important and political role during the "*perestroika*" period and helped to get rid of the old system.

Following the 1967 accord with the USSR and a tripartite agreement between CERN, France's Saclay laboratory, and the Soviet Institute of High Energy Physics, IHEP, at Serpukhov, a unique exchange of people took place.

Mr. André Giraud, Director of the Commissariat à l'Energie Atomique, CEA, in 1970, seen in the classroom of the French School at Serpukhov with the schoolteacher and some of her pupils.

During a period of intense mistrust and international tension from 1967 to 1969, groups of Soviet physicists came with their families to live in Geneva and Paris to gain experience with equipment destined to be used at IHEP, which for four years had the largest energy accelerator in the world (76 GeV).

Between 1968 and 1975, when experiments were installed at IHEP, western physicists travelled the other way. About 100 CERN physicists and engineers spent long periods at Serpukhov, frequently with their families, and around 150 Saclay staff were permanently based there. A French school was even established for their children.

These exchanges challenged the Soviet stereotype of foreigners as dangerous. They gave the Soviet people the chance to see that co-operation and friendship with foreigners was possible. Confidence between physicists from East and West led to permanent links between CERN, Saclay, and IHEP.

A group of CERN & Serpukhov physicists seen, in 1968, in the Serpukhov control room during the first joint experiment.

Following completion of the CERN Super Proton Synchrotron accelerator, SPS, (450 GeV), around 200 Soviet physicists each year were invited to participate in CERN's programmes between 1975 and 1987. Some thirty of them were permanently resident at CERN, and no fewer than 15 CERN experiments had Soviet participation.

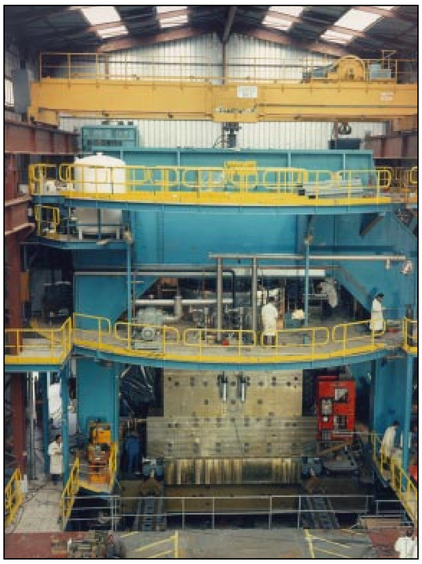
Soviet institutes have also made important contributions to the experiments at CERN's Large Electron-Positron collider, LEP. Today, some 600 Russian physicists are involved with collaborations preparing experiments for CERN's next accelerator, the Large Hadron Collider, LHC.

MIRABELLE

A major installation at the new Serpukhov 76 GeV proton synchrotron was the 7000 litre 'Mirabelle' bubble chamber built by the French Atomic Energy Authority at Saclay, near Paris, where all 3600 tons of it were assembled and tested prior to dismantling for shipment to Serpukhov in 1970.

The particle interactions seen in the Mirabelle bubble chamber explored the highest energies ever seen in a laboratory at the time.

The year 1997 marks the 30th anniversary of the signing of the Franco-Soviet Mirabelle agreement.



The MIRABELLE bubble chamber seen at Saclay prior to shipment to Serpukhov

GAMS

One of the pioneer CERN-Serpukhov experiments was the GAMS photon spectrometer.

The original GAMS-2000 configuration was used at Serpukhov in the 1970s. In the early 1980s, an enlarged version, GAMS-4000, was built at Serpukhov for installation at CERN's new 450 GeV SPS.

A Europe, Japan, Russia, and US collaboration using GAMS at CERN has provided valuable information on several new exotic particles long predicted by theory.

Built at Serpukhov, the GAMS-4000 spectrometer was later installed at CERN

30 years later

In the presence of Professors Maiani and Schopper, Professor Logunov awarded a medal of merit to participants of the collaborations which were active in the 1970's at Serpukov.

1989: the Wall comes down

Between 1947 and 1989 Europe was divided, East-West tensions were strained and the Berlin Wall was built.

From the 60s onwards collaboration with CERN allowed scientists to almost forget which side of the Wall they came from, and simply get on with achieving their shared scientific ambitions.

Working together towards a common goal produced lasting links and friendships which are reinforced today by new experiments. Groups which came together for the first time 30 years ago are still working together in LHC collaborations.

Through collaboration with Eastern Europe, CERN has given the world a real example of peaceful coexistence. The study of fundamental physics demands stable conditions and peaceful relations. It thrives on pooling resources and freely exchanging information. Researchers from the East immersed in this atmosphere have taken their new-found view of the world back to share with neighbours, civil servants, and ministries in their home countries. Their impact on the political change of recent years has been profound.

In a world where East and West are beginning to look at each other as peers, CERN's East-West collaboration has always been a partnership of equals. For those scientists involved, the Wall came down long before 1989.

The Goals of East-West Collaboration in the Post-Cold War Era

- To give scientists from the East the assurance of international recognition for their scientific work and their efforts, often decisive, towards institutional reform in their home countries.

- To consolidate the position of institutes and laboratories by encouraging their personnel to participate in international collaborations as members of their institutes, on equal footing with institutes in the West.

- To facilitate integration by signing accords which stipulate that material and human contributions to experiments be realized in home institutes. On the L3 experiment, at LEP for example, 250 people work in Moscow and St. Petersburg.

- To help the integration of families with particular attention to young students. Some 60 Russian students have completed their studies in local universities over the last 10 years.

- To encourage scientists working in military institutes to refocus their efforts on to applied and innovative R&D.

Towards a renovated Europe for High Energy Physics

1991: Poland becomes a CERN Member State.

1992: Hungary and Czechoslovakia become a CERN Member States.

1993: The Czech Republic and the Slovak Republic both become CERN Member States.

1995: Russia becomes an Observer to the CERN Council.

During this period co-operation started with Albania, Armenia, Belarus, Bulgaria, Estonia, Georgia, Rumania, Russia, Slovenia and Ukraine.

Today 1200 scientists, engineers and technicians of Eastern European countries participate in the activities of CERN.

CERN and Russian delegations met in Dubna in 1995 to agree the terms for Russian participation in the LHC.

The agreement was formally signed in 1997.

The photo shows both delegations. The CERN delegation seated on the left was headed by the Director-General Chris Llewellyn Smith and the Russian delegation by the Science Minister Boris Saltykov.

Left to right, George Collins, Chairman of the Brookhaven Cosmotron Department, Odd Dahl, who was to be in charge of CERN's accelerator project, accelerator pioneer Rolf Wideröe of Swiss company Brown Boveri, and Frank Goward.

First Contacts

In 1952, Europe planned to build its first world-class particle accelerator, larger even than the giant Cosmotron then being built at the US Brookhaven Laboratory, New York. In August that year, a party led by Norwegian Odd Dahl went to Brookhaven to learn about US plans. To prepare for their European visitors, Brookhaven specialists had organized a think-tank which discovered a way of increasing the energy of an accelerator.

The Brookhaven team generously shared this new insight with their European visitors, who gratefully took the idea home with them. The result was the Proton Synchrotron, PS, which began operation in 1959 and is still the cornerstone of CERN's accelerator complex. Thanks to the Brookhaven idea, the PS has an energy nearly three times higher than originally foreseen.

This early visit set the tone for the relationship between European and American physicists. It is a relationship based on mutual respect, coloured by a healthy spirit of competition, and has lasted to this day.

While taking part in an ISR experiment, Sam Ting learns that he has been awarded the 1976 Nobel prize for physics.

Strengthening the Links

In 1956 the **Ford Foundation** made its first grant to CERN. The aim was to finance participation of non-Member State scientists in the Laboratory's programme, and US physicists were the main beneficiaries. Ford Foundation grants are intended to get new projects off the ground, and after supporting 174 people from 24 countries over a 10 year period, the Foundation considered its job done.

Today, CERN devotes a small percentage of its annual staff budget to funding non-Member State visitors.

Although American physicists had been visiting CERN from the beginning, substantial US participation in the Laboratory's research did not come until the 1970s when CERN switched on the world's first proton-proton collider, the **Intersecting Storage Rings**, **ISR**. The chance of doing physics at such an innovative machine proved irresistible to the American particle physics community, and almost half of the experiments at the ISR had US participation.

In the 1980s Sam Ting became spokesman of the first CERN experiment, L3, to be formally supported by the US Department of Energy.

Carlo Rubbia (left) and Simon van der Meer, 1984 Nobel prize winners in physics, accept their colleagues' applause.

European physicists had always been involved in post-war US research, but with the ISR this movement was no longer one way. American physicists participated in CERN experiments whilst CERN Member State physicists were welcomed across the Atlantic in US laboratories.

When CERN SPS experiment **UA1** made the 1984 Nobel prize-winning discovery of W and Z particles, American physicists were there, and when Fermilab near Chicago switched on its **Tevatron** proton-antiproton collider in 1985, European physicists were waiting with their American colleagues to record the first data.

Formalizing the Agreement

With the construction of CERN's Large Electron-Positron collider, LEP, US participation in the Laboratory's experimental programme continued to grow. All four major experiments at LEP today have substantial US participation.

When CERN was established, one of its goals was to stop the 'brain-drain' of talented young European scientists to the US. Today CERN has a concentration of American particle physicists second only to Fermilab, and there are now more American particle physicists working in Europe than European ones in the US.

CERN's Large Hadron Collider, LHC, is due to switch on in 2005. With it the number of American physicists at CERN is set to reach new heights. Already 26 US groups are working in ATLAS and 37 in CMS. Negotiations are nearing completion with US authorities to formalize American participation in the project. *

US and European physicists, laboratories, and industry are working hand-in-hand to realize this bold scientific and cultural move into the new millennium.

East meets West.
Andrei Sakharov (left) and his wife Elena Bonner visiting the ALEPH experiment at CERN. To Bonner's right is American Nobel prize winner Jack Steinberger, spokesman of the experiment, accompanied by CERN's Emilio Picasso (centre) and Nicolas Koulberg.

**On the 8th December 1997, the US formally agreed to contribute $531 million to CERN's LHC project*

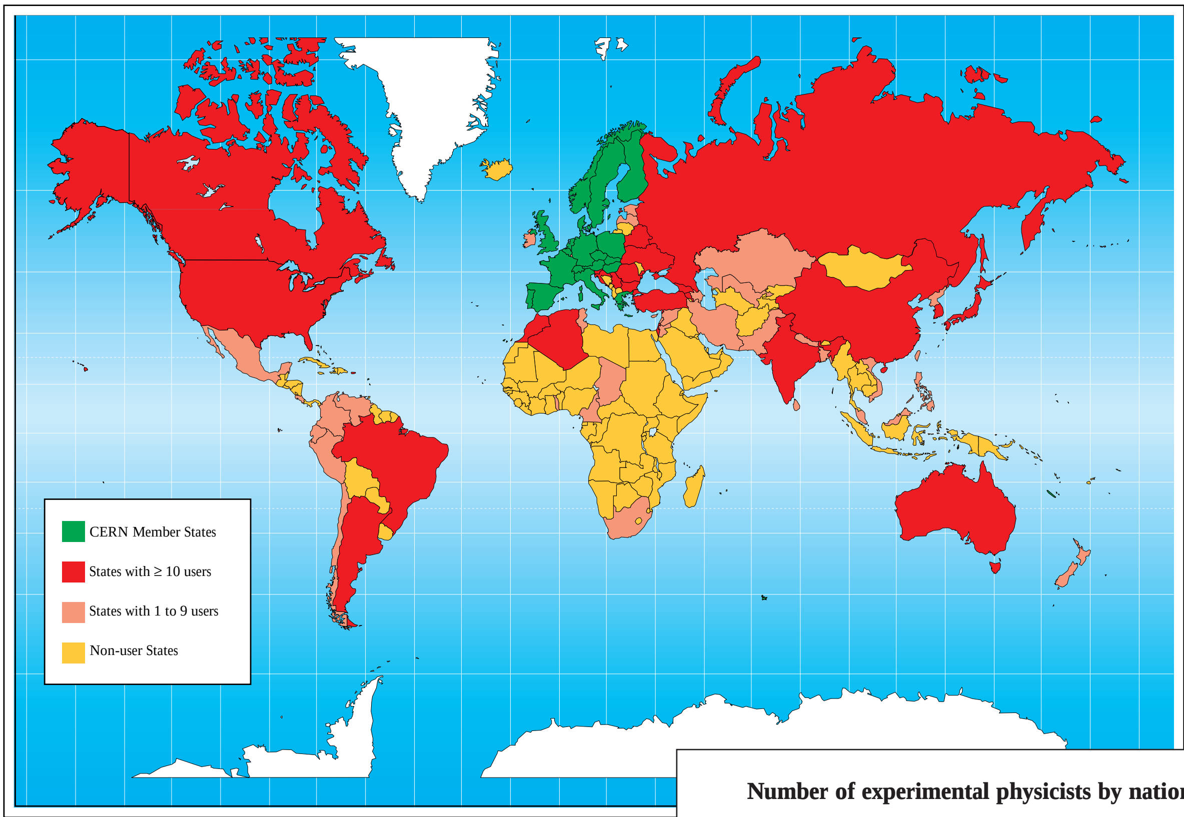
A World Endeavour

CERN is building a new particle accelerator, the Large Hadron Collider, LHC**,** to address some of the most pressing questions in fundamental physics. Due to switch on early next century, the LHC is already bringing together scientists from around the world.

Powerful superconducting magnets will be needed to keep the LHC's particle beams on track. Development of these magnets is well under way in Europe, Japan, and the United States. Several prototypes made in industry have already proved that the high magnetic fields needed for the LHC can be achieved, and full scale production is not far off.

The particle detectors which will study LHC collisions will be bigger and more complex than ever before. The collaborations of physicists building and operating these detectors each involve over 1500 scientists. When CERN was founded in the 1950s, it set the standard for European collaboration in science. As we move into the new century, it is set to become the world's first truly global laboratory.

Geographical Distribution of CERN Users

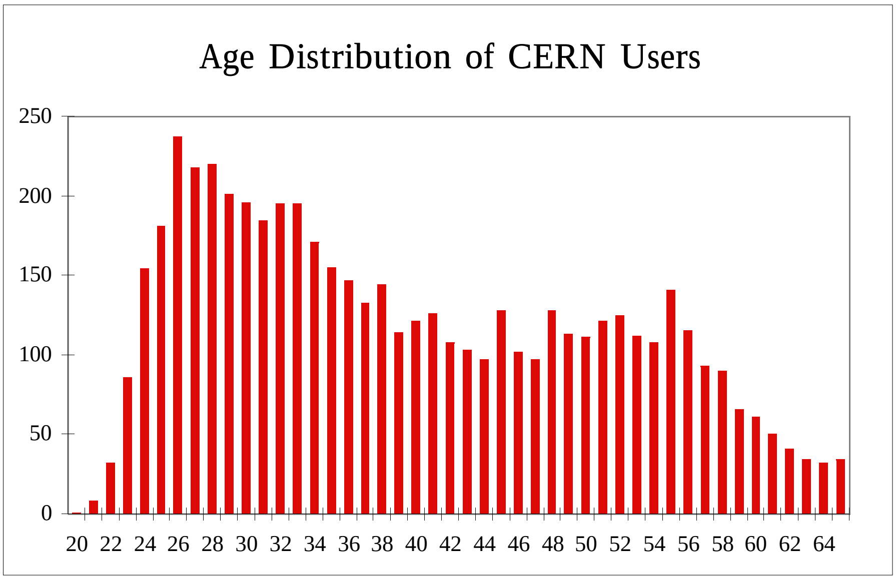


Number of experimental physicists by nationality:

Member States	5084
Russian Federation	647
CIS (exc. Russian Federation)	54
Eastern Europe	72
Canada	98
USA	600
Latin America	41
Japan	104
People's Republic of China	26
India	35
Israel	47
Other countries	87

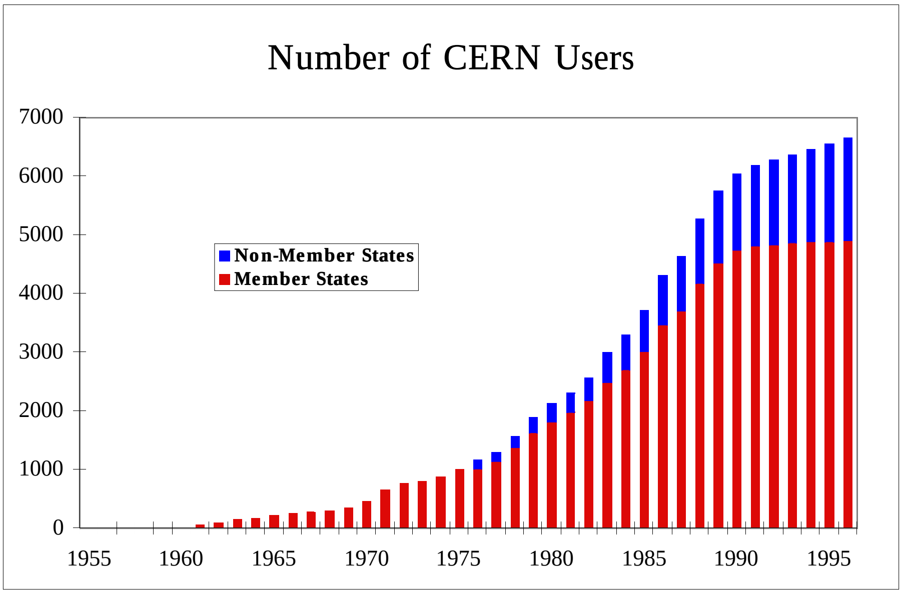
> *"It is so important to be early in life confronted with research of greater depth, greater difficulty, and greater beauty than one will find later during one's career."* - H. Casimir

The age distribution of CERN users is clear evidence that many young people trained at the laboratory look to apply their experience in other walks of life.



The number of scientists using CERN's facilities has risen dramatically to today's figure of around 6500.

Users from non-member states first arrived in significant numbers in the 1970s and today account for nearly one quarter of the laboratory's number.



Venues:

Joint schools indicated by

1962	Switzerland
1963	Switzerland
1964	Yugoslavia
1965	West Germany
1966	Netherlands
1967	Sweden
1968	Spain
1969	Switzerland
1970	Finland
1971	Bulgaria
1972	Italy
1973	Denmark
1974	Great Britain
1975	USSR
1976	Belgium
1977	Greece
1978	Netherlands
1979	Hungary
1980	West Germany
1981	Finland
1982	Great Britain
1983	Czechoslovakia
1984	Norway
1985	Italy
1986	Sweden
1987	Bulgaria
1988	Greece
1989	Netherlands
1990	Spain
1991	Crimea, USSR
1992	West Germany
1993	Poland
1994	Italy
1995	Dubna, Russia
1996	France
1997	Denmark
1998	Scotland

A precious Melting Pot during the Cold War years
Now an annual event

Every year, around 100 young physicists are treated to a fortnight of theoretical particle physics under the guidance of some of the most respected names in the field.

The tradition goes back more than 30 years, to 1962, when CERN held its first school of physics in Switzerland. At first, the school lasted a week and was aimed at students and qualified physicists alike.

1981 - Henko, Finland

In 1964, it was extended to two weeks and held at Herceg-Novi at the invitation of the Yugoslav Federal Nuclear Energy Commission.

In 1965 the school's goals were redefined with the emphasis being on teaching theoretical physics to young experimentalists. This has been the formula ever since.

For the next five years the school circulated around CERN's Member States, but in 1970 there was an important change. The Directors-General of CERN and JINR decided to organize a joint school, and the first CERN-JINR school of physics was held that year in Finland, a country which was not a Member State of either organization.

The 1971 school was hosted by JINR in Bulgaria, beginning a pattern of biannual joint schools, held alternately in Eastern and Western Europe, which continued until 1993.

All expenses were covered by the host organization, JINR or CERN, in order to avoid foreign currency complications and enable young students from the JINR member states to attend schools in Western Europe. In the intermediate years CERN continued to organize its own school.

1996 - Carry-le-Rouet, France

With the changing economic and political order in the East, 1993 heralded a new era. Several the Central and Eastern European countries had become Member States of CERN while remaining members of JINR. The joint school was renamed the **"European School of High-Energy Physics"**. It is organized jointly by CERN and JINR on a yearly basis and circulates among all the countries of Europe including the new Commonwealth of Independent States.

Most of the students are from CERN and JINR member states, but some also come from other countries. Since 1996, students from the developing world have been able to attend with financial support from UNESCO.

Students are mainly between 24 and 30 years old and working towards a doctorate in experimental particle physics.

Accommodation is in double rooms, mixing East and West for two intense weeks of work and leisure. Many lifelong friendships have been founded as a result, frequently leading to scientific collaboration.

Since their inception in 1970, the joint schools have proved their worth as a fruitful and much appreciated contribution to East-West understanding.

1997 - Menstrup, Denmark

NA48: From Russia with Krypton

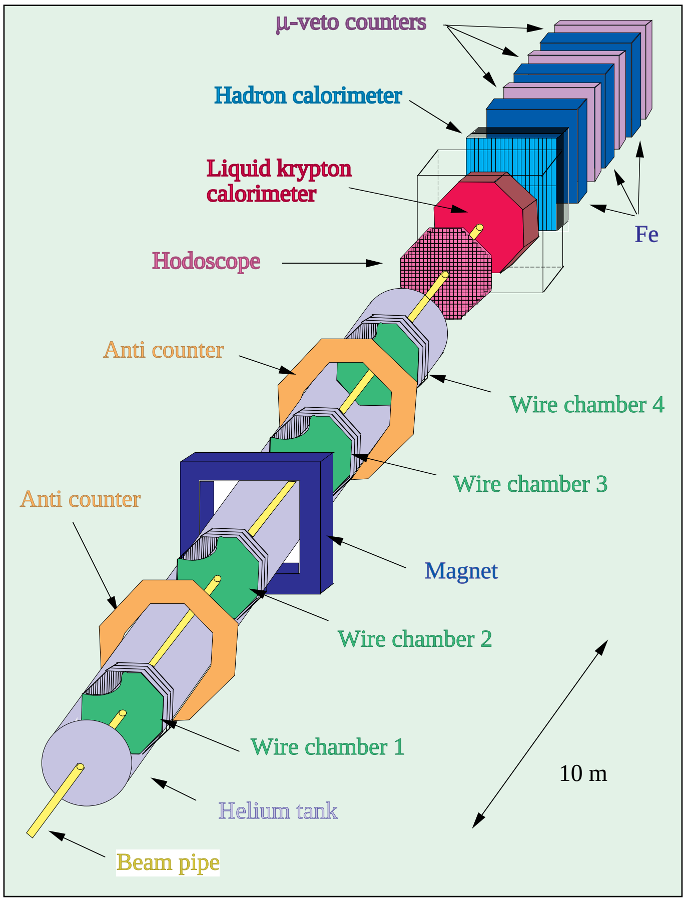
Representatives of Krunichev Enterprises and the NA48 collaboration welcome the arrival of the experiment's new cryostat from Dubna in July 1995.

The apparent absence of antimatter in the Universe is one of nature's best kept secrets. At the Big Bang, matter and antimatter are believed to have been created in equal amounts, but now, when we look around us, or out into space, all we see is matter. So where has all the antimatter gone?

Antimatter behaves as if it were in a mirror world. Charged anti-particles have the opposite charge to their matter counterparts, and behave almost as if left and right were swapped. But the symmetry is not perfect, nature treats matter and antimatter differently. Although the difference is tiny, understanding it could help us understand why there is no more antimatter.

An internal cryostat, built by the Italian National Institute for Nuclear Physics, INFN, is installed inside the Krunichev cryostat.

Under extremely clean conditions, the liquid krypton calorimeter is prepared for installation in the cryostat.



CERN experiment **NA48** studies the matter-antimatter imbalance. NA48 measures the decay of particles called neutral kaons and their antimatter counterparts, antikaons, to study how nature treats matter and antimatter differently.

Both kaons and antikaons decay in several ways, and careful study of their differing decays gives an accurate handle on nature's apparent preference for matter.

NA48: From Russia with Krypton

The **International Science and Technology Center, ISTC**, is an organization which promotes the integration of former Soviet Union scientists and industry, particularly from the top-secret military sector, into the global R&D infrastructure.

Funded by the European Union, Japan, Russia, and the United States, it aims to facilitate the transition from military to civilian research and development in the post cold war era. In addition to the NA48 project, CERN is already involved with eight other projects supported by the ISTC.

A key component of the NA48 detector is a very low temperature cooling vessel, or cryostat, built under an ISTC programme. The cryostat was manufactured by Moscow-based company Krunichev Enterprises, better known for the “Proton” space rocket and the “Mir” space station, in collaboration with ENTEK, a large institute of the Russian Federation’s Atomic Energy Ministry.

Through links with the JINR laboratory, NA48 has forged several initiatives designed to involve Russian physicists and industry. The 22 tons of krypton which form the active medium of the experiment’s energy-measuring calorimeter were manufactured at a specially-built factory in Russia.

Here, the cryostat containing the liquid krypton calorimeter is seen installed in the NA48 detector.

No other supplier could offer the same delivery schedule or price, and the krypton was delivered on-time, fully satisfying the exacting quality criteria specified in the contract. In addition to the cryostat built by Krunichev, some 14 000 electrical feed-though contacts were supplied by the Budker Institute in Novosibirsk, whilst vacuum equipment and stiffening frames have also been supplied by Russian organisations.

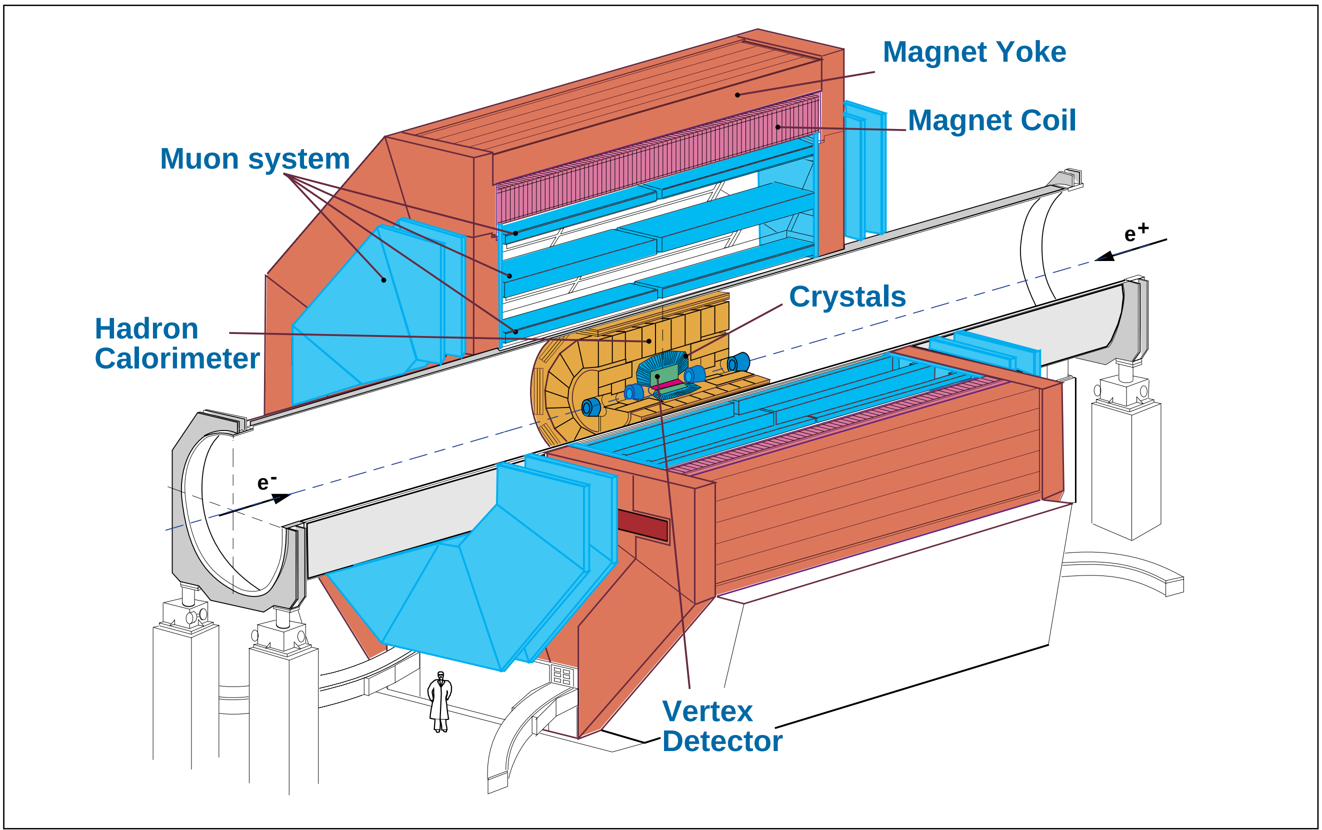
INTAS, the EU-backed International Association for the promotion of co-operation with scientists of the former Soviet Union, has awarded funds to provide fellowships for physicists from Dubna to visit Edinburgh, Saclay, and Siegen.

INTAS will also provide computing and networking infrastructure allowing Russian physicists to participate fully in NA48’s programme. CERN Director-General at the time, Carlo Rubbia, had been influential in getting INTAS initially off the ground.

In the late seventies CERN started planning a new accelerator, the Large Electron-Positron collider, LEP. It was clear from the beginning that the experiments for this new machine would be of unprecedented size and complexity requiring large, international collaborations.

Long before LEP had been approved, people and institutions started coming together to discuss the daunting task of developing the technologies needed to build the experiments. In 1982, formal collaborations were taking shape and in 1983 four were given the green light to proceed. These new experiments were chosen for their complementarity.

The largest, by far, was called **L3**, a collaboration led by Nobel Laureate Sam Ting. To develop and to build the experiment with more than 6000 tons of equipment, L3 brought together institutes from 17 countries spread throughout the World.

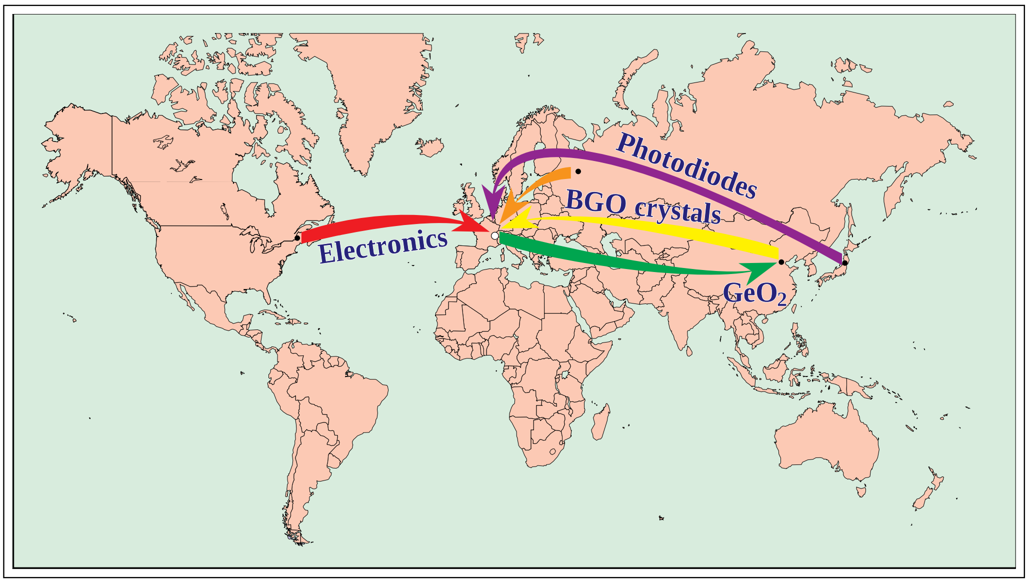


The L3 Detector

L3 aimed to specialize in measuring electrons, positrons, and photons emerging at small angles to LEP's colliding beams with the best possible precision. To achieve this, special crystals made from **Bismuth Germanate, BGO**, were chosen. Such crystals had previously only been made in small quantities, a few cubic centimetres, and never with the purity required by L3.

The experiment would need a massive 12 tons of BGO crystals. Undaunted by this seemingly impossible task, L3 set up a group of about a hundred physicists and engineers from China, France, Germany, Holland, Hungary, Italy, Switzerland, the USA and the USSR to find a solution.

L3: Crystals from China



Cooperation across the world made L3's BGO detector possible

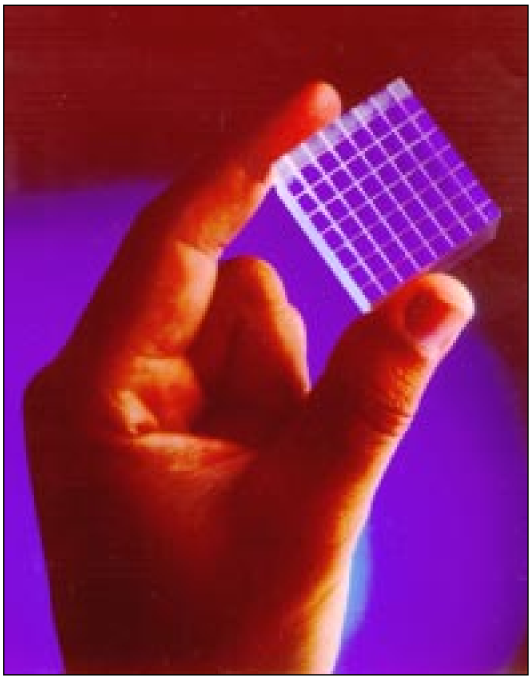
It soon became clear that only the Shanghai Institute of Ceramics (SIC) would be capable of producing such a large number of crystals, some 11 000 in total, with the needed quality, in a time scale of two and a half years, and at an affordable price

National sensibilities were quickly forgotten as Russian industry and authorities agreed to furnish five tons of Germanium Oxide, a highly strategic material, and China supplied the needed amount of highly pure Bismuth Oxide.

French industry developed new machines for crystal cutting and polishing. These were bought by SIC, and engineers from Annecy, France, went to Shanghai to instruct their Chinese colleagues in their use. Meanwhile, specialists from Annecy were developing a machine for automatic quality control of the crystals. This was later given to the Shanghai institute.

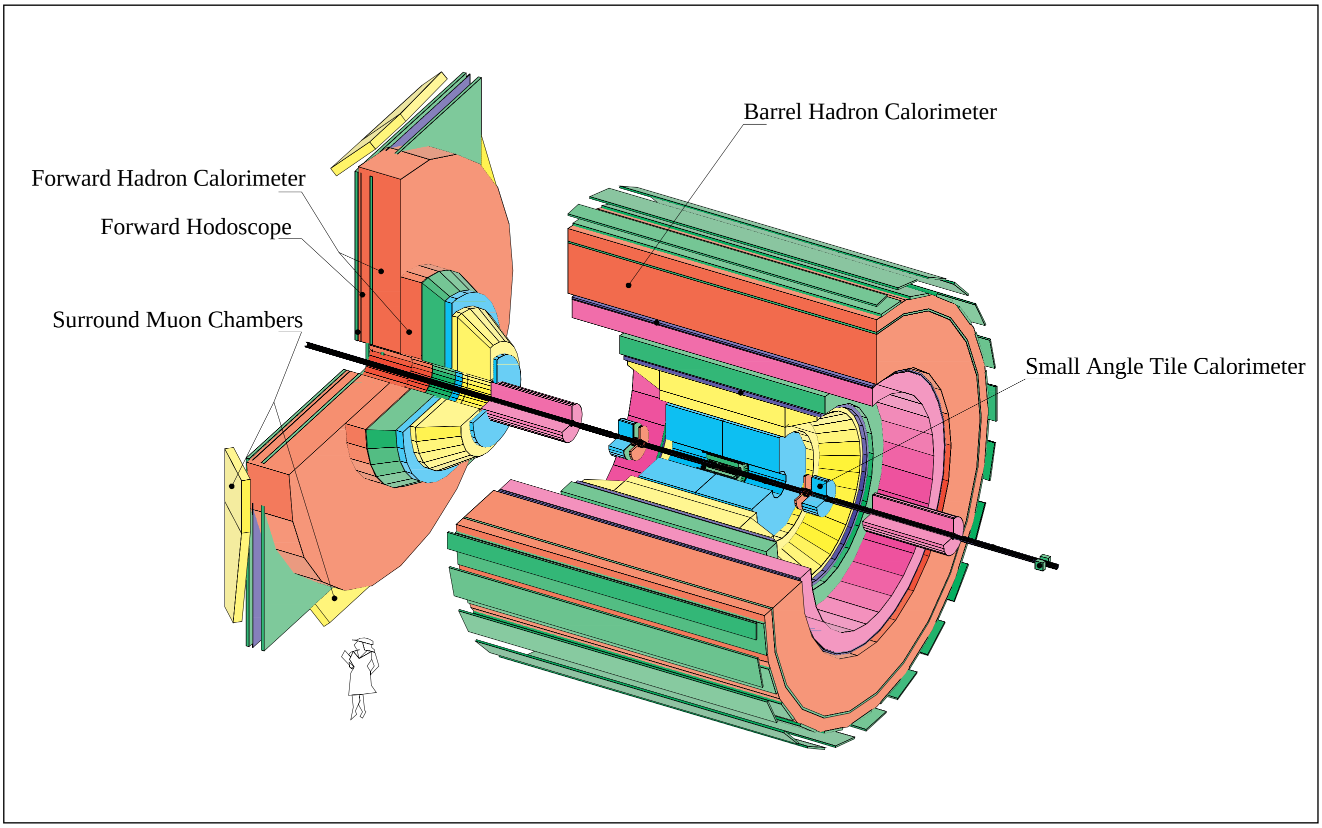
Industrial production of BGO crystals started in 1985, and the finished crystals were delivered to CERN in June 1987. More than 95% passed the most critical quality control tests on arrival at the Laboratory. Final assembly, testing, and mounting was enthusiastically performed by all the teams in L3's BGO group, and the detector was fully operational when LEP started-up in 1989.

But the BGO story does not end there. The close collaboration between experts from different nationalities has created bonds of confidence and friendship forming a solid basis for future collaboration. Thanks to L3, BGO crystals are now widely used in detectors for medical diagnosis, in particular in the USA, and Chinese industry has the lion's share of the world's crystal production.



An industrially produced BGO crystal for use in medical imaging

DELPHI was another of the experiments to be approved for LEP in 1983. Its origins can be traced to the early 1980s when a small group of people dreamed of a detector which would push technology to its limits. The Italian Ugo Amaldi was their spokesman, and by the time their dream became reality in 1989, DELPHI consisted of more than 400 physicists from 40 institutes in 18 countries including the Russian Institute of High Energy Physics, IHEP, at Serpukhov, and the International Joint Institute for Nuclear Research, JINR, in Dubna.



The components of the DELPHI detector indicated here have been produced with considerable IHEP and JINR contributions.

Today there are around 550 physicists in DELPHI, and the number of institutes has grown to 56 in 22 countries. Even countries, such as Slovenia, which did not exist when DELPHI was born, have been welcomed into the collaboration, a step on their way to becoming full members of the global community of nations.

The IHEP and JINR contributions to DELPHI were formalized in collaboration agreements signed in 1984. This provided for a total contribution of around 15% of the DELPHI detector. The largest part of this is the 3000 ton steel magnet yoke and the 20,000 particle detectors, called streamer tubes, which it contains. The steel was produced in Russia at the Izhora plant near St. Petersburg, or Leningrad as it was then known.

The streamer tubes, each measuring 4 metres in length, were made in a special workshop at JINR before being shipped to CERN. In 1986, everything was ready, and the magnet yoke was fully assembled and tested at CERN by the following year.

Left to right: Gregoire Kantardjian, Jim Allaby, and Ugo Amaldi welcome a shipment of steel from Russia for DELPHI's magnet yoke.

IHEP and JINR input did not stop with the construction of the detector. Physicists from these institutes have been active in all aspects of DELPHI's research programme, and have taken part in major upgrades to the detector, including the innovative **Small angle Tile Calorimeter**, **STIC**.

The STIC is a precision device conceived by IHEP in collaboration with CERN, Italian, Norwegian, Portuguese, and Swedish institutes. It consists of lead tiles into which several thousand plastic fibres are threaded. When particles pass through the lead, they lose their energy by ionization. This in turn causes the fibres to light up, and the light is converted into an electrical signal.

The detector was built to a tight deadline, and has operated successfully since spring 1994, largely exceeding its design goals. The results obtained have been analysed by young physicists from Italy, Portugal, Russia, and Sweden, forming the basis of seven doctoral theses.

Along with all four LEP experiments, DELPHI has made an invaluable contribution to mankind's knowledge of nature.

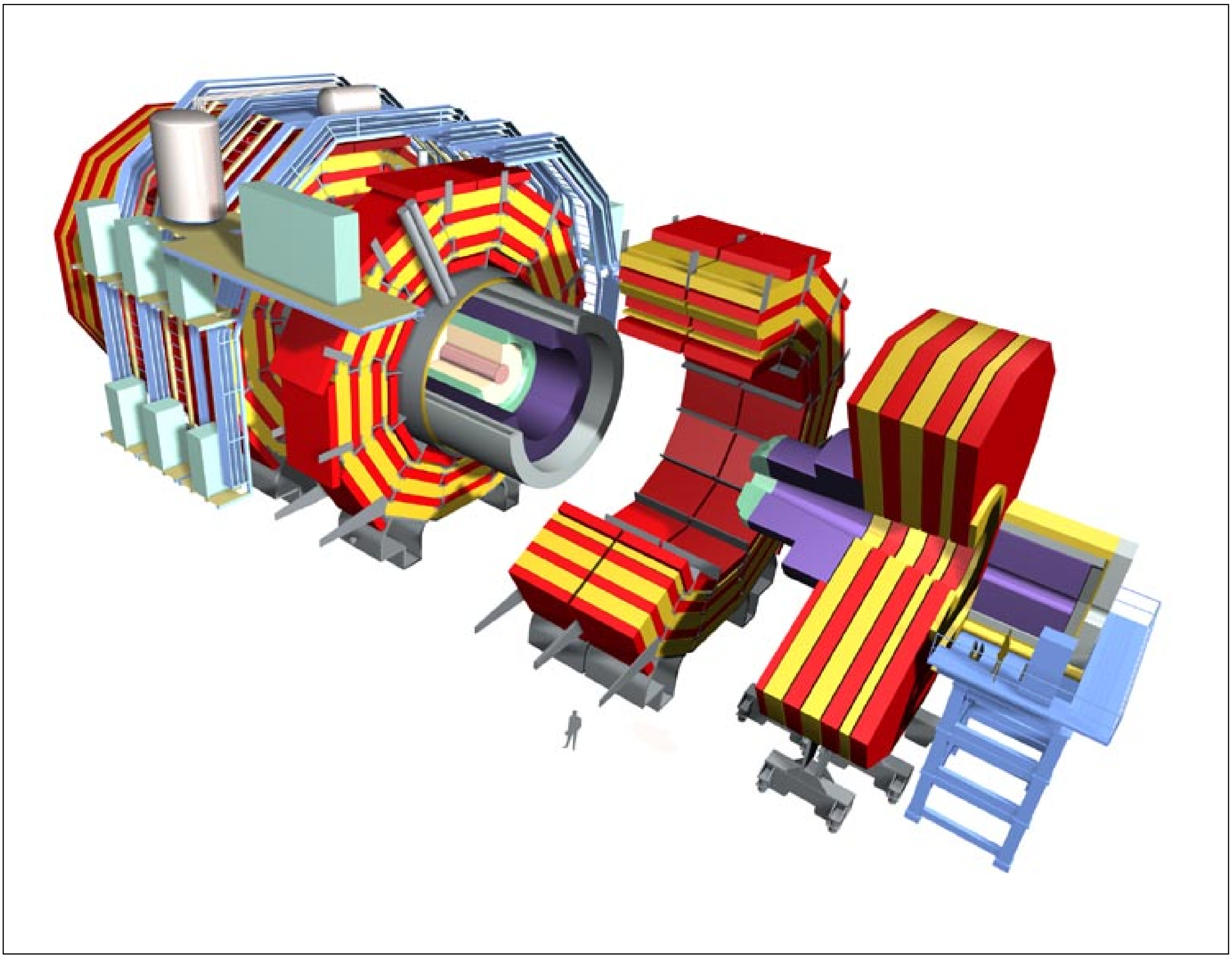
Less tangible but none the less important is the contribution the experiment has made to the training of talented young people. Over 500 students have completed their theses with DELPHI. Many of these students go on to find jobs in industry where the 'free thinking' and 'problem solving' skills developed in fundamental research are greatly appreciated, all the more so since their training took place in an international framework.

The DELPHI detector seen fully installed at CERN

With LEP's work due to end by the turn of the century, CERN's longer term future lies with a new accelerator, the **Large Hadron Collider, LHC**. The LHC project was unanimously approved by the Laboratory's Member States in 1994, and will be built inside the LEP tunnel. The LHC will be the first CERN accelerator to be built in collaboration with non-Member States; Canada, India, Japan, Russia and the United States. When it starts-up in 2005, it will be the most powerful accelerator in the world, addressing many questions of fundamental importance to physics.

Laboratories from all over the world have come together to develop the technologies needed to build the huge detectors needed for the LHC. These will dwarf even those of LEP, but the experience gained at experiments like L3 and DELPHI will be invaluable. The two largest LHC experiments are **ATLAS** and **CMS**.

The Compact Muon Solenoid, CMS, involves some 1560 scientists from 138 institutes in 31 countries.



When complete, the CMS detector will be 21.6 metres long, 14.6 metres high, and weigh 14 500 tons.

Like L3, CMS aims to measure electrons, positrons, and photons with the highest possible precision. After studying several alternative technologies, the collaboration decided that crystals would be best suited to the job.

But although BGO is ideal for LEP, it is not sufficiently robust to work at the LHC, where the number of particles traversing each crystal per second will be much higher.

In 1991 and 1992, Lead Tungstate was recognized as a potential crystal material, and at the Kharkhov Institute in the Ukraine, the first large crystals were grown and studied.

After a period of intense R&D, CMS chose Lead Tungstate for its crystals, and serious investigations of how to produce the large numbers required by the experiment began.

Discussing a finer point during crystal manufacture.

CMS will need 110 000 blocks of crystals. In order to produce these over the five year timescale required, the world's production rate will have to be substantially increased. This will be made possible thanks to expertise gained in China through work on crystals for L3, existing expertise in Russia and the Czech Republic, and financial support from the ISTC for the R&D phase through a joint venture with CERN.

Development work is scheduled to continue in China, the Czech Republic and Russia until 1998 when a pre-production phase will begin. This should see production rates rising to 2000 crystals per month by 1999 when full scale production begins. All the crystals are scheduled to be ready by 2004, one year ahead of LHC start-up.

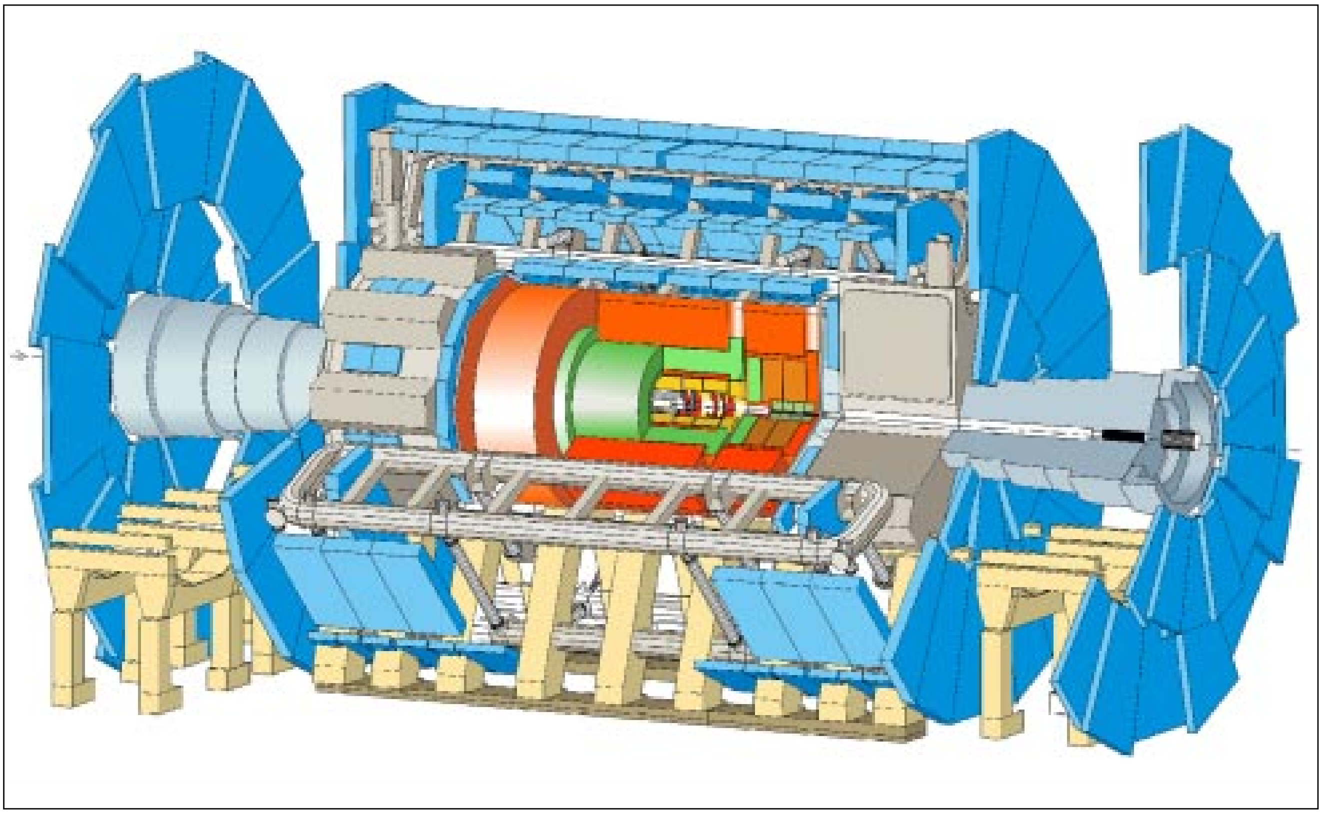
As with BGO before it, industry around the world is keeping a close eye on Lead Tungstate development. These crystals could be used in medical imaging, where in conjunction with other technologies developed for physics, they could offer sensitivity 10 times better than today's imaging devices.

Members of the CMS crystal team with a sample of the finished product

ATLAS, whose name is abridged from 'A Toroidal LHC Apparatus' is a large multi-purpose experiment for the LHC.

It seems paradoxical that studies of the smallest components of matter require some of the largest machines ever built. The manufacturing techniques involved are correspondingly substantial. The ATLAS detector, for example, requires some 80 tons of plastic material which glows when charged particles pass through it. Such plastics are called scintillators, and will be used in ATLAS in the shape of tiles to form a part of the detector called the hadronic calorimeter. This will measure the energy of particles emerging from collisions between protons in the LHC.

There are over 1600 scientists in the ATLAS collaboration representing 148 institutes in 32 countries.



The ATLAS detector will stand 22 metres high. It will be 25 metres long, and weigh 7000 tons.

The Russian Institute of High Energy Physics at Serpukhov, IHEP, is a major ATLAS partner, bringing with it a long tradition of expertise in scintillator technology. IHEP has adapted plastics industry processes to the production of scintillators for particle physics. The result is a calorimeter design which has proved extremely popular, and which has been chosen for the ATLAS hadronic calorimeter.

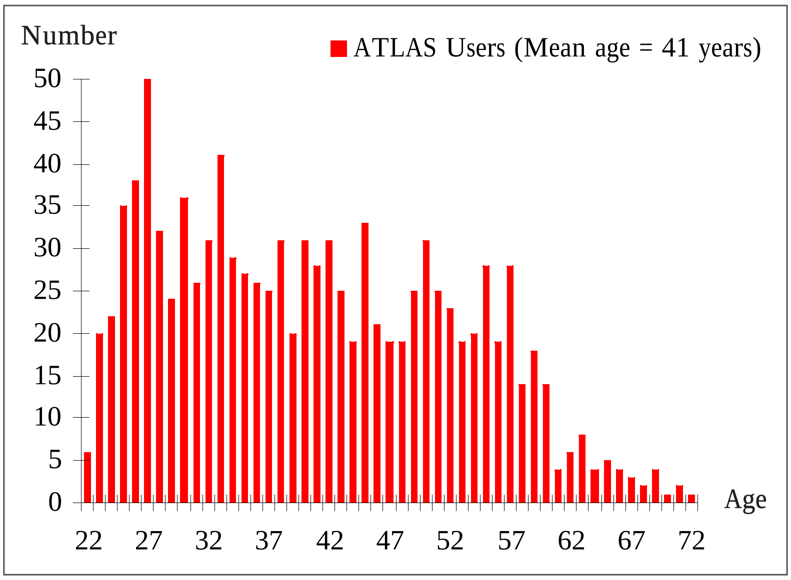
Portugal has a strong plastics industry, but Portuguese companies are inexperienced in working with the stringent demands for optical quality made by particle physics.

Through the ATLAS collaboration, Portuguese industry and Russian scintillator know-how are being brought together. Under an ISTC agreement, Portuguese and Russian concerns will collaborate to produce the half a million scintillating tiles required by ATLAS, bringing benefits to both partners and ensuring that the physicists' exacting demands are met.

The face of a young scientist is clearly visible through a stack of 10 centimetre-thick plastic scintillator tiles produced in Portugal for use in the ATLAS detector.

The motivation of working in a large global collaboration is something which should not be underestimated. Taking part in the mixing of cultures to reach a common goal is a challenge eagerly taken up by young people, and nowhere more so than in ATLAS. Many of the scientists working on the experiment are doctoral students or recent Ph.D. graduates.

The ATLAS project has great scientific, technical, and educational value. Many technological challenges have to be solved, from highly integrated electronics to large-scale engineering, from the most powerful computer processors to creative software methods.

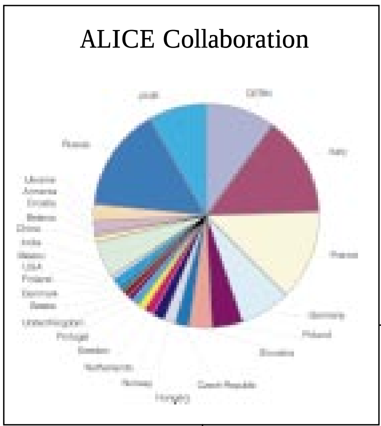


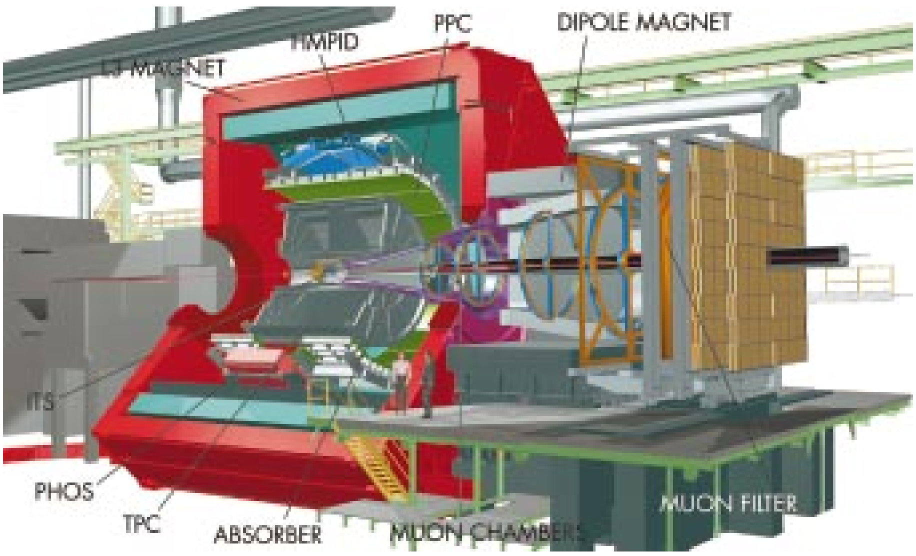
But perhaps most importantly of all, young people on ATLAS are learning to work together and share the excitement of scientific and technical progress with colleagues from all over the world. An invaluable education, wherever their future careers may take them.

The LHC will be a unique facility to recreate the conditions of the early Universe, just after the Big Bang, by colliding lead nuclei head-on at energies never before reached in the laboratory.

ALICE, whose name is derived from 'A Large Ion Collider Experiment', will be a great opportunity to study in detail the behaviour of the super-dense matter that formed the early Universe. The results of this study are of interest not only to particle physics but also to astrophysics and cosmology.

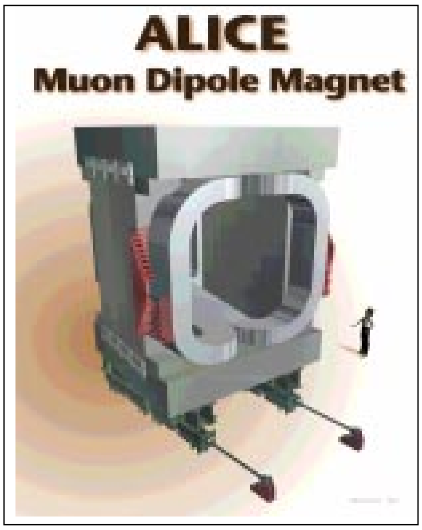
Making good use of previous investments, the central part of ALICE will be embedded in the large magnet now serving the L3 experiment at CERN's current flagship accelerator, LEP. ALICE also profits from the long-established Sino-Russian collaboration in crystal manufacture. For L3, this joint effort resulted in the energy-measuring device built with Bismuth Germanate (BGO) crystals. For ALICE, the sharing of expertise continues with the development of Lead Tungstate crystals for the Photon Spectrometer.





Conceptual view of the ALICE apparatus. Many components, like the Photon Spectrometer and the Dipole Magnet, will be built with substantial involvement of groups from Russia and JINR. The ALICE Collaboration currently consists of more than 800 physicists and engineers from 73 institutes in 27 countries.

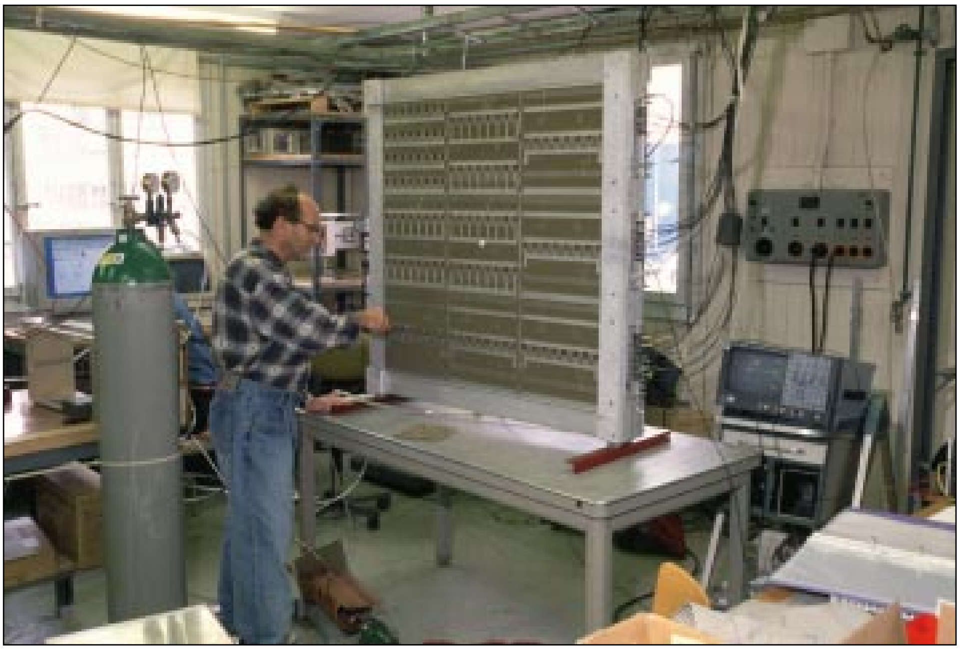
Understanding the results of energetic collisions between lead nuclei is a task requiring many simultaneous observations. One of the expected signals for the transition from ordinary nuclear matter to the state of free (deconfined) quarks and gluons is a reduction in the number of certain particles (J/Ψ and upsilons) produced in the collision. These particles decay into particles called muons whose detection will allow ALICE's physicists to monitor their production rate.



ALICE's 0.7 Tesla dipole magnet, 8 metres high and weighting some 800 tons, was jointly designed by JINR and CERN groups.

The Muon Spectrometer is the ALICE subsystem dedicated to measuring muons. The complexity of its design and construction has led to a close collaboration between several institutes from different countries. For instance, the Dipole Magnet, a key element of the Muon Spectrometer, is a joint effort of the JINR and CERN groups within the ALICE Collaboration. The coils of this magnet will be built from straight aluminium bars providing a magnetic field over gap-size – distance between the magnet's poles – larger than in any magnet constructed so far.

The tracks of muons emerging from the LHC collisions will be measured by a series of thin gas-filled chambers. Passing muons will knock electrons out of atoms in the gas. These electrons will be accelerated by an electric field, knocking out more electrons as they go. The resulting ionization will cause the induction of an electric signal in the readout sensors (pads) along the muon path, allowing to accurately reconstruct the particle tracks.



This large area prototype of an ALICE Muon Spectrometer pad chamber was built by a group from St. Petersburg.

The technology required to build the tracking chambers of ALICE's Muon Spectrometer, gas-filled chambers with pad read-out, is well known, but the large total detector surface (over 100 m^2) and the corresponding number of electronic channels (almost one million) demand close collaboration between institutes from France, India, Italy and Russia.

Continuing Collaboration

The Spokesman for the LHCb experiment, Tatsuya Nakada, describes a model of his forthcoming experiment to the new Russian Science Minister, Mikhail Kirpichnikov, during his first visit to CERN. Felix Grishaev of Russian Mission in Geneva accompanied him.

The Minister confirmed his country's commitments to CERN's LHC programme.

In addition to their major contributions to LHC experiments, the Russians are providing many components for the LHC accelerator itself.

Welcoming new friends. At a special meeting of CERN Council in March 1999 a Bulgarian delegation was welcomed for the first time.

Mr Stefan Piperov (left), Mr Petko Baev, Conseillor Bulgarian Mission (center), and Mr Petko Draganov, Ambassador, listened as CERN's new Director General Luciano Maiani announced that two years of patient negotiations had led to a satisfactory conclusion for both CERN and Bulgaria.

Following the expected ratification of the agreement on Bulgarian accession to CERN, Bulgaria will become the laboratory's first new Member State since 1992.

When LEP started up in 1989, L3 was the first big CERN experiment to have substantial Chinese participation. Today, as four collaborations prepare experiments for LHC, two of them involve large Chinese groups coming from both academic and industrial sectors.

President Jiang Zemin of China (second from right) came to CERN in April 1999 to see the fruits of his compatriots' labours at CERN. He was accompanied by Swiss President Ruth Dreifuss (on his right) and CERN Director General Luciano Maiani (on his left) during a visit to the L3 experiment guided by L3 Spokesman Sam Ting (left).

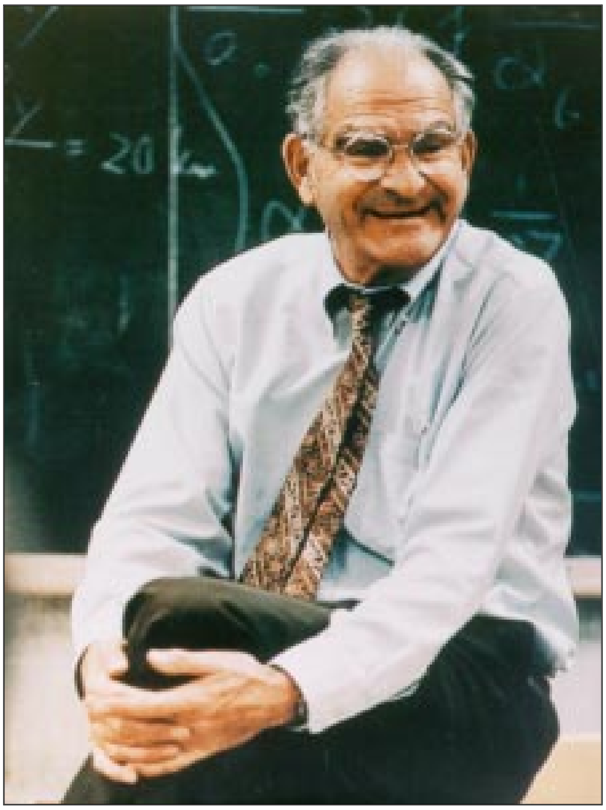
Sir Ben Lockspeiser, First President of the CERN Council, October 1954

"Scientific research lives and flourishes in an atmosphere of freedom - freedom to doubt, freedom to enquire and freedom to discover. These are the conditions under which this new laboratory has been established"

An extract from the March 1988 issue of 'Scientific American' in which, in the course of a book review, Professor V. F. Weisskopf made the following remarks:

...
"In a variety of ways, the style and the level of scientific and technical work are determined in pure research. This is one of the important social functions of pure science; it establishes the climate in which all scientific and technological activities flourish; it pumps the lifeblood of ideas and inventiveness into laboratories and factories."
...

"Basic research, therefore, is an essential part of higher education in science and engineering."



Professor V. F. Weisskopf, Director-General of CERN from 1961-1965

John Peoples, Director of the Fermi National Accelerator Laboratory in the United States summed it up nicely in his 1994 birthday letter to CERN:

John Peoples, Director of FNAL

> *"For 40 years, CERN has given the world a living demonstration of the power of international co-operation for the advancement of human knowledge. May CERN's next 40 years bring not only new understanding of our Universe, but new levels of understanding among nations."*

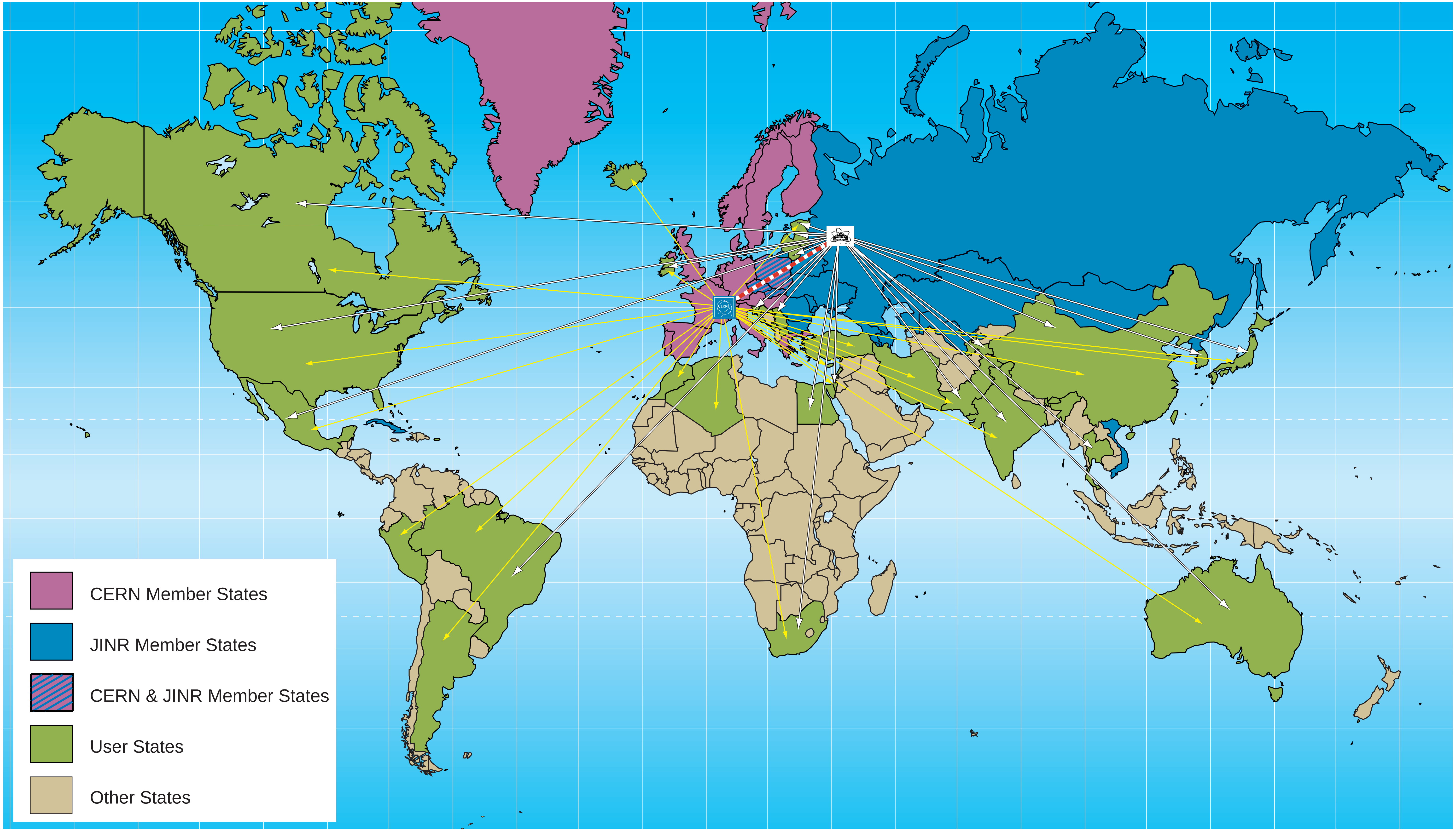
With their shared enthusiasm to push back the frontiers of knowledge, physicists can bridge political and ideological barriers.

A historic meeting on high energy, condensed matter and environmental physics in Dahab, Sinai, in 1995 brought together Egyptian, Israeli, Jordanian and Palestinian researchers.

Israel has had a co-operation agreement with CERN since 1990.

Sergio Fubini of Turin and CERN flanked by Egyptian Minister for Scientific Research Venice K Gouda (left) and President of the Israeli Academy of Science and Humanities Jacob Ziv.

Connecting the World



Science Bringing Nations Together