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Physics and Industry and Industrial Participation in CERN

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" Who can look into the seeds of time and say which grain will grow and which will not?", Macbeth

1 Physics and Industry.

Basic research is curiosity driven. It is not motivated by spin-offs. Yet, it requires large amounts of funding. The present problems of the world are such that, when it comes to very sizable investments, people are more inclined to think according to short-term returns. By the same token they are lead to challenge large spending in so called "pure research". They would prefer that more attention is paid, and more support is allocated, to that research which is likely to yield practical applications and in particular marketable ones. On the other hand, most physicists are convinced that research should proceed on a wide front with much effort put on those problems which appear as the most fundamental, even if no clear spin-offs are in sight. They also think that any clear cut dichotomy between "pure" and "applied" research is misleading. Focusing only on applied research could even lead to expensive blind alleys. Pushing it to the extreme, one may say that it is not in attempting to make better candles that electricity was discovered and its many uses were mastered. Faraday had to face many questions as to the usefulness of his research. Yet humankind should be thankful for what he did. De la Rive, who at about the same time, conducted extensive research on electromagnetism in Geneva used to say "to test the theories of Mr. Ampère one needs much money and many good craftsmen". But, this was good investment.

However one should not be sarcastic and one should not belittle the question of the practical usefulness of physics research. A good relationship and even partnership between Physics and Industry has actually become a must for the survival of basic research at the pace which it needs to maintain to stay alive, with correspondingly high budgets. Addressing this question requires much effort and a better understanding by the research physicists and by the industrialists in the ways of each others. In Europe, we have to face the often-heard remark that the overall situation is much more favourable to Industry in Japan and in the United States. At present, the

European Governments would definitely like to see more overwhelming practical returns for the large funding which they put into basic research.

I am only a theoretical particle physicist, therefore someone a priori very much on the pure research side. Nevertheless, my past chairmanship of the French Physical Society and, later, of the European Physical Society, has on several occasions lead me to devote great attention to the relations between physics research and industry. At EPS much effort has been made in that direction, mainly through the Action Committee for Applied Physics and Physics in Industry. It has, in particular, organized many successful "Europhysics Industrial Workshops". These activities are now further developed within EPS; and ACCAPI has become an Inter Divisional Group. This bears witness to the importance attached to the relations between physics and industry.

The relations between physics and industry come into focus in a particularly striking way in the framework of the large facilities which are more and more needed for basic research and which, in Europe, are increasingly considered within international collaborations.

Whereas these large facilities, with costs given in several hundreds of millions of Ecus, are motivated by pure research goals, their construction implies many important contracts with Industry and the potential industrial returns have even become one element in the decision, in particular in view of the benefits collected by the host region. According to the "farming out" policy, which is more and more followed, many high technology parts are also developed in Industry; and Industry has become keen on the technological transfers which can originate that way.

CERN offers a very interesting example and the LHC, its new project now in the construction stage, should provide a model for still better relations with Industry.

Spain is a Member State of CERN. Spanish particle physics research has beautifully blossomed. This first took place mainly in theoretical physics, something which greatly benefited from Spain's first membership period of CERN. The activities of GIFT, which started then, have been a great success. More recently there has also been a great development on the experimental particle physics side, which expanded from the earlier and more limited high-energy activities within CIEMAT. This development of experimental particle physics is associated with the second membership period of Spain which, we all hope, is here to stay. Yet all the ambitions associated with the "Plan Movilizador" of the mid-eighties have not been met. The relations between Spanish Industry and CERN have to improve. The number of Spanish engineers at CERN is still low as compared to what it should be according to the size of Spain. There are at present 16 of them. They were 12 in 1993. Yet 50 should be a reasonable goal. One can be comforted by the fact that there is a good number of Applied Science fellows from Spain. Yet, there is much to be done. This seminar should be conducive to the launching of new initiatives.

2. The many facets of industrial return.

Industrial returns can be gauged according to orders placed with industry. This is easy to measure but CERN is not very special. There are many other large potential customers. Industrial returns can also be associated with the know-how gained by industry in meeting the stringent specification required by a research laboratory. Industry thus benefits from technical expertise within the organization and this includes what is usually referred to as technological transfer. The latter term also covers innovations made at CERN, often not quite up to the full patent level and which Industry can pick up and develop into marketable products when becoming familiar with them. This type of return is more difficult to measure but here CERN is in a more special position in view of the many high technology domains in which it has achieved excellence. Physics research is a powerful driver for technological innovations.

CERN has been indeed at the origin of several important spin-offs in all aspects of particle accelerator technology with accelerators now finding many uses (industrial, medical, energy source driver) outside of pure and applied research. It had spin-offs in detector technology and one may think in particular of the many applications of Charpak's wire chambers. There are many spin-offs in computing and networking and the World Wide Web stands out as a clear example. Finally, there are technological spin-offs in high vacuum, in superconductivity, in fast electronics, in microwave techniques, in cryogenics. The LHC, with its 27 Km of superconducting magnets cooled by superfluid helium will be a technical masterpiece as well as a unique instrument for the study of the deep structure of matter.

Industrial returns can also be associated with the training of engineers and technicians which, in a wider sense and on a longer-term basis, represents a strong asset for Industry. This is even harder to measure but it is probably the most valuable spin-off. In this CERN is rather special because of its expertise, the sophistication and size of many of its projects and also for its international character. Let us consider the first two points and leave the third one for the next section.

A new large physics project such as the LHC will generate many industrial contracts. There are indeed many pieces of equipment which have to be contracted outside. Large laboratories no longer work as arsenals, building the instruments which they need which are by essence prototypes. The golden rule of "farming out" is "do not do anything which industry can do as well and probably cheaper than you". European industry has also developed to a point where many of the components of a highly sophisticated machine are available from the shelves or can be developed according to requirements. The tenders do not go only for standard equipments but more and more for high-technology products. In the latter case Industry finds even more benefit in learning how to manufacture them than in its profit when fulfilling the contract.

In the past orders were given for pieces of equipment which were eventually assembled at CERN by CERN staff. At present more and more full components are built and installed by Industry.

CERN has no "just return" policy. It was born at a time when industrial return was considered less important than it is today. Tenders are sent around in the different Member States and the Organization awards the contract to the lowest bidder meeting the specification requirements. There is a clear competitive element involved at the level of Europe as a whole. One should not be blind to the fact that this makes things easier for some countries and more difficult for others and in particular some of the relatively new comers. ESA, which is a younger organization has to obey "just return" rules. It is not easy to assess what this means in terms of extra cost but an increase by 15% is a reasonable estimate. This would have dramatic repercussions on the CERN budget which tries very hard to optimize the scientific return . Over one third of it goes to industrial orders. However, whereas we are lucky not to have a full "just return" policy, we should be careful that all Member States receive a reasonable return. Indeed the new purchasing rules go rather far in that direction, differentiating countries with a good return coefficient (>0.8) from countries with a small return coefficient (<0.8), when awarding contracts according to the response to tenders.

For each country one can define an Industrial return coefficient. It is proportional to the ratio between the amount of industrial orders put to that country during one year devided by its CERN contribution. They are globally normalized so as to all take the value one if industrial orders were all proportional to contributions. Since the location and nature of CERN is bound to favour some countries, a return is considered as already satisfactory if it exceeds 0.8.

The Spanish value was 0.5 in 1995. It was 0.42 in 1994 and only 0.15 over the 1991-93 period. One may look at the increase with time as satisfactory. It clearly overcompensates the present reduction in contribution granted to Spain. Yet, there is room for improvement.

One may also define a return coefficient for service contracts. Here the Host States are clearly favoured for many reasons. A reasonable coefficient for a non-host state is therefore considered to be anything above 0.4. The Spanish value was 0.12 in 1995. It was 0.08 in 1994 and 0 over the 1991-93 period. Here again the situation is improving but it is not yet satisfactory.

One should not attach too much value to these return coefficients. Many industries operate at the international level and can act as it suits them best, both at the tender and at the construction levels, through one or some of their national branches. Many contracts also go to consortiums and the individual national returns are harder to evaluate.

It is clear however that, if the Spanish situation has recently improved, much effort is still needed.

How to improve industrial returns?

When Spain re-joined CERN, industrial relations started in a very good way. This was the time of LEP construction and Spain could obtain some interesting contracts. However they corresponded to rather conventional activities which came out during a large tunnel construction period. This however did not continue during the LEP exploitation phase and the question of the industrial benefit which Spain was receiving from CERN became serious. Yet some technical co-operation agreements were implemented in particular on quadrupole development, on cryogeny, on power supplies and on vacuum techniques. With the assistance of CDTI, a number of Spanish companies have manufactured prototypes for CERN and sent engineers and technicians to CERN for training periods. These efforts should eventually bear fruit with the construction of the LHC. An already noticeable achievement was, for instance, the contract obtained by INGOVI (in association with SICN)) for the RF couplers of LEP-2.

However, nothing comes simply by itself. If one considers those non-Host States which achieved a very good industrial return, such as Norway a few years ago and Finland more recently, one can link the success achieved to the existence of very good industrial liaison (a single person or a small office). This has also been the case for the recent improvement of the Spanish situation which owes a lot to the fruitful efforts of Santiago Romo.The role of the liaison is to be on the watch for CERN's present and forthcoming needs and to advise CERN on where best to target tenders for particular purchases. It must however also to be in close touch with national Industry to provide good tendering advice and also to convince industry to respond to the tenders which it receives. In some cases Industry may feel that it is not worth the effort in view of the cash value of the contract or in view of the overwhelming competition which it may be afraid to meet. The liaison office should in some cases be able to convince Industry that the matter is worthwhile, not only for the chance of getting a contract but also for the reference value which it may draw from being a purveyor of CERN, in particular on high technology matters. There are also the gains to be collected from developing a product benefiting from expert advice from CERN. This is a clear form of technological transfer. The main benefit from a CERN contract may not be the amount paid by CERN but rather the know-how gained at meeting the specifications within a competitive price. The tasks of a good liaison office are not easy; and technical and commercial expertise are needed. Nevertheless some countries have achieved that very well and we very much encourage all others to follow suit. We have all reasons to think that Spain will do very well.

There can be highlights like the setting up of an Industrial exhibition at CERN so that the potential engineers-buyers there become more familiar with the products and expertise offered. This is done. Yet there is nothing like the continuous work of industrial liaison offices. CERN does its best to help them with their work. Yet in our case, initiative has to come from Spain.

One may remark that contacts are much easier when there are many engineers on the staff. For many reasons they have a better knowledge of

what Industry can offer in their home country. Here we have to face another current Spanish problem, namely the relatively small number of engineers on the staff. CERN should pay more attention to this problem than it has in the past but recruitment follows applications and some effort is also needed in Spain to trigger and encourage such applications. It is difficult because we are dealing with small numbers when considering yearly recruitments. At present CERN is going through an important decline in its complement which is linked with a stronger "farming out" attitude. Recruitment is low and one cannot expects immediate results. One cannot trigger too much expectation for a very limited job market. Yet one should work on a longer-range basis. The "first employment" scheme now under discussion should favour the recruitment of young engineers as they leave engineering school. One should advertise this in Spain in the hope of encouraging people to apply.

A promising recruitment pool is also offered by the fellowship programme and its possible extension. CERN has an Applied Science fellowship programme according to which 40 new young applied scientists are recruited every year for a 2-year stay at CERN. There are therefore 80 of them at any given time. The Spanish average value over 1994-95 was 8.5. Spain has therefore more than its share. These fellows are a natural source of recruitment for staff engineers but, for most of them, who leave CERN after 2 years, their stay has provided a very valuable training in some advanced technology. As opposed to scientific fellows who chose the research group which they join while at CERN, applied science fellows are selected according to valuable and open training assignments to which they are allocated. The CERN programme is funding limited. There could be easily twice as many interesting training slots as those presently occupied by the recruited fellows. CERN would therefore welcome Applied Science fellows who would be supported by external sources. CDTI and CERN are in the process of finalizing an agreement according to which 10 more young Spanish engineers or applied physicists could be at CERN for a 2-year period. This would extend to CERN a scheme which has been working already very satisfactorily with ESA and would certainly help in recruiting Spanish engineers. It would also provide Spanish Industry with young engineers having benefited from a very valuable training in high technology. Indeed it is with such training opportunities that one finds probably one of the most valuable long-term industrial spin-off of CERN membership.

3. Training at CERN

At present, unemployment is one of the greatest evils in Europe. Yet, as a growing proportion of applied scientific research is being performed in Industry and as some of the science-based industries expand at a high rate, they often suffer from shortage of qualified research staff. The real weakness at the moment is the lack of skills and not the lack of jobs. Europe has lost many of its standard industrial jobs either to automation or to the developing world, as is natural in an competitive economy which operates more and more on the world scale. It can maintain its style of life only by providing

goods and services which others can still not deliver. It has the potential to create many new jobs in promising domains but it has difficulties in filling them. Knowledge-based competitiveness has become the crucial success factor for Industry and services. We are past the third industrial revolution with its emergence of the information society. The most precious resources for industrial developments are no longer abundant raw materials and cheap energy. It is the intellectual capital which every region has or can generate. The conditions for cross-border mobility of highly trained people in Europe are clearly unfavourable compared to the United State or Japan. Yet companies seek expertise regardless of national borders.

What modern Industry needs most is people competent in high technologies, computer fluent and used to working in an international environment. It is a great spin-off which it can expect from CERN.

Beside the obviuos training of engineers, there is also the "training through research" of young scientists eventually turning to Industry for a career.

Take a young researcher at CERN. He or she has to work at the frontier of knowledge, at the frontier of technology, within the very strict scheduling constraints associated with the use of a large facility and within the framework of an international team. This can only be an excellent training for Industry even if the research themes may seem very remote from potential applications. Some high-energy physicists become computer wizards. It is no accident that the World Wide Web was invented at CERN.As H. Casimir said "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 within one's career."

If one looks at the age distribution of the CERN users one finds a very strong peak at 28 followed by a shoulder of old timers extending to people of my age. The youth of many of our users bears witness to the fact that CERN has remained a young organization despite its being over 40 years old. But what will all these young people do? There are not enough academic jobs to take even half of them! Very often they work on the development of detectors which will be operative only long after they have left academic life proper. If one still find so many young researchers to come and work hard at CERN it is because they feel that they thus get a very valuable training while participating in an exciting endeavour. Many of them will seek a job in Industry to do very well something usually very different from what they have been doing at CERN. Nevertheless in that new job, the advanced training which they have gone through will be an invaluable asset. Industry should capitalize on that. This is the key to success since the efficiency of acquisition and application of new knowledge determines the competitiveness of Industry in the modern world. In the past,physicists going to Industry usually joined a reasearch laboratory operated by a large company. This is no longer the case for many. They go to Industry to do something different.

Coming back to the training of young engineers at CERN, one should say that training opportunities exist in all domains previously itemized when presenting technological spin-offs. Accelerators and detectors rely on state of the art-technologies whether considering hardware (microwave, vacuum, cryogenics....) or software (simulation, microprocessors, networking....). and the corresponding training takes place within international teams which operate under often stringent time constraints.

The fellowship programme and its possible extensions (with national or EU funding) has already been presented.Long visits (3 to 6 months or even more) can be organized for engineers already working in Industry, while on leave. They can also be organized for students as part of their syllabus in engineering school. In the former case the CERN Associate programme provides the proper framework. Engineers or research scientists from Industry coming under that programme are then supported either fully or partly by CERN, or by their home firm or by a National Agency, depending on the nature of the work or training. In the latter case the Technical Student Committee deals with applications. Support is provided by national sources. At present, and in both cases, CERN funding is limited but the welcome possibilities of CERN are far from being saturated, even though they would be if everyone was emulating Finland. CERN can still encourage applications. In particular some firms should know that they can thus obtain at very little cost good training possibilities in domains where they may need technical expertise and an international perspective.

Training is certainly an important aspect of industrial participation in CERN. The returns may not be of a short-term and readily accountable nature. In the long run they may well be among the most precious ones.

I would like to thank F.Castro for inviting me to give this talk. It is a pleasure to thank O.Barbalat for valuable comments.