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Professional Careers of Physicists Trained in High-Energy Physics – A Case Study –

by

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Abstract

The Crystal Ball experiment and its predecessor, the LENA experiment, have been run at the DORIS storage ring at DESY since 1978 and data evaluation lasted until 1991. During those 13 years 50 students had worked on the experiment and left with a PhD or a diploma. The professional career of 46 of them could be followed until 1992/93. Ten of them are still working in high-energy physics (6 with a permanent contract). The other 36 are working in industry, mostly in computing. The industry branches range from medical engineering, communications, chemical industry *etc.* to media and public information.

Contents

1 Introduction

A discussion is going on about the importance and necessity of basic research. By this note we hope to contribute by presenting the results of a case study. The professional careers of 50 physicists who got trained in high-energy physics are followed.

We presently experience a change in national and world economics. It is characterized by increased productivity, saturation of markets in industrialized countries, and, consequently, unemployment followed by budget deficits. Research money becomes rare. In this situation the question about the importance of basic research in our society has been raised.

High-energy physics is a typical example of a field of basic research. Its organization is characterized by international collaborations formed around a few laboratories (worldwide about a dozen). They are big institutions, and therefore they are very visible. The main result of this research has been the discovery of quarks, a new and deeper layer of matter. Also the laws governing their behaviour have been deciphered. The instruments used by experimental high-energy physics are: particle accelerators, particle detectors (combined into large, complex detectors) and computers (online for data taking and experiment control, offline for data analysis and Monte Carlo modelling).

Research in high-energy physics has not yet resulted in applications to everyday life like e.g. electricity (basic research of the 19th century) or microchips (basic research in solid state physics starting in the 20-ies of our century) or magnetic–resonance imaging for medicine (basic research in nuclear physics of the 30-ies and the 40-ies). Nobody dares to predict direct applications of the results of high-energy physics.

None the less this field of basic research has already left its footprints in our society. High-energy physicists especially mention the following results of their work:

1. Basic research is a cultural value, human knowledge is extended and deepened.

2. Often the relations of a field of science to other fields are given as an indication of its importance within our scientific culture. High-energy physics is a child of nuclear physics and was born in 1947, the year of the discovery of the π-meson. Now it reacts back by allowing a deeper understanding of nuclear forces and of the behaviour of nuclear matter under extreme conditions like those at the beginning of the universe. This indicates already the second, presently very important link: to astrophysics and cosmology.

3. Research in high-energy physics is done in international collaborations. This allows people from countries all over the world to meet each other and to work together. It promotes mutual understanding and contributes to a peaceful world. In this context it should be mentioned that scientific collaboration with the USA and within the European community has helped German scientists considerably to come back to the international scene in the postwar years. Also the scientific collaboration between Eastern and Western countries has been a forerunner for the developments since 1989/90.

4. International collaborations in high-energy physics are possible because it is basic research. No immediate use is expected. All discussions can be open without fear of losing

e.g. patent rights.

5. High-energy physics, and basic research in general, are excellent training grounds for young people. They are attracted by the deep questions asked in basic research which are attacked with forefront techniques, both, experimentally and theoretically. Students trained in this field learn also about the values outlined above. It is this aspect, the training of young physicists, which is dealt with in this paper.

Although high-energy physicists stress the importance of the cultural values of the field some applications have already come out. They concern the use of experimental techniques for applied sciences. I want to mention just three examples:

1. Accelerators are extensively used as light sources for synchrotron radiation which in turn is needed for research ranging from atomic over molecular and solid state physics to biophysics and medicine. Actually, most accelerators worldwide serve as synchrotron light sources (about 60 compared to a dozen for high-energy physics). Accelerator physics has also stimulated various technologies, e.g. clystrons and welding, to mention just one near and one far lying development.

2. Physics has always provided measuring techniques for other fields of science, including medicine. And so does experimental high-energy physics. It has been pioneering the use of computers for data-taking which is now standard techniques. Large-area particle detectors may find very useful applications for PET (= positron emission tomography) in medical research.

3. High-energy physcis has also pioneered the simulation of experiments by Monte Carlo techniques. Again, this is now common practice, including medicine.

We will see later that these applications of high-energy physics needed people trained in this field of science.

2 The sample for this case study

The DORIS electron-positron storage ring at DESY had been upgraded to reach the energies for the $\Upsilon(1S)$ and the $\Upsilon(2S)$ resonances in 1978. In 1978 the DESY Hamburg-Heidelberg MPI-(München) Collaboration (D-HH-HD-MPI) took data on the Υ- resonances using the DESY-Heidelberg detector which had been built and operated for experiments at DORIS in the charm region. The LENA Collaboration upgraded the detector and ran from 1979 to 1980, data evaluation lasted until 1982.

In 1981 discussions had started between DESY and the LENA Collaboration on one side and SLAC and the Crystal Ball Collaboration on the other. It was decided to move the Crystal Ball detector which had been operated very succesfully at the SPEAR storage ring at SLAC/Stanford University to DORIS. This was done in 1982 and test runs could start even in that year. The experiment collected data until the end of 1986. Data evaluation ended in spring 1991.

The work done by the collaborations at DORIS between 1978 and 1991 is listed in [1].

Table 1 shows the number of people associated with the Crystal Ball Collaboration. Its institutions are broken up into three (important) regions of origin because it will turn out that the answer to one important question (How many physicists trained in high-energy physics stay in this field?) strongly depends on the region. Although a more detailed split-up might be interesting it cannot be done because of small numbers. The number of people is further broken up according to their professional experience into PhD and diploma students (those who left the collaboration with this degree). These two categories interest us in this case study.

For completeness we give in Table 1 also the numbers of diploma students who stayed in the collaboration for a PhD (they are included in the number of PhD students and should not be used for the totals) and the numbers for physicists with fixed-term contracts (notation: RA's), i.e. Research Associates, Assistent Professors and Wissenschaftliche Assistenten or Wissenschaftliche Mitarbeiter. In the next category ("professors") are physicists with permanent contracts (Full Professors, Senior Physicists and Staff Physicists). Under "others" are noted people who stayed only for short periods in the experiment. It has to be mentioned that practically nobody remained for the whole period of the experiment (except for the professor category). Also the institutions had differing lenghts of involvement. So the definitions for "RA's" and "others" are somewhat arbitrary. But it has to be stressed that the numbers for students working for a PhD or a diploma are well-defined.

Table 1: **Crystal Ball Personnel**

	German	other European	USA	other	total
institutions	4	3	5	1	13
PhD students	14	6	6	-	26
diploma students who left after diploma	11	3	-	-	14
diploma students who stayed for a PhD	7	1	-	-	8
RA's	5	1	19	-	25
professors	5	10	11	1	27
others	8	5	7	-	20
total	43	25	43	1	112

Explanations: The numbers of PhD and of diploma students (who left left the collaboration with this degree) are given. For completeness the numbers of diploma students who stayed in the collaboration for a PhD, for physicists with fixed–term contracts ("RA's") and for physicists with permanent contracts ("professors") are given. Physicists who stayed only for a short time in the collaboration are grouped under "others". People who changed the institution within the collaboration are mentioned in the category to which they belonged for the longest period.

Table 2 gives the number of people who had been working on the LENA experiment. Included are also the people from the LENA precursor experiment, the D-HH-HD-MPI Collaboration, more precisely from those institutions which had trained students (they also stayed in the LENA Collaboration). The general remarks made above apply also here.

Finally, Tables 3 and 4 give the summaries for these two collaborations in the time period between 1978 and 1991. In Table 3 the numbers are split-up for the regions, in Table 4 for the time span.

Looking at the numbers one difference is seen immediately: Especially German groups work essentially with (PhD and diploma) students and less with research associates as do the

Table 2: **LENA Personnel**

	German	other European	USA & Israel	other	total
institutions	4	2	2	2	10
PhD students	2	1	2	-	5
diploma students who left after diploma	8	1	-	-	9
diploma students who stayed for a PhD	1	-	-	-	1
RA's	5	-	3	1	9
professors	4	3	5	2	14
others	2	2	4	-	8
total	21	7	14	3	45

Explanations: See under Table 1. Some diploma students of the LENA experiment gained a PhD with the Crystal Ball experiment. Included here are the physicists from those institutions of the D–HH–HD–MPI experiment which had trained students.

US universities. I.e., German universities are essentially oriented towards education and less towards research.

Table 3: **Crystal Ball and LENA Personnel**

	German	other European	USA & Israel	other	total
institutions	4	4	6	2	16
PhD students	16	7	8	-	31
diploma students who left after diploma	16	3	-	-	19
diploma students who stayed for a PhD	12	1	-	-	13
RA's	6	2	20	-	28
professors	5	12	14	2	33
others	12	8	11	1	32
total	55	32	53	3	143

Explanations: The numbers of PhD and of diploma students who got trained in the Crystal Ball and LENA experiments. Institutions and physicists, respectively, who continued the work in the following experiment are counted only once. Physicists and institutions from the D–HH–HD–MPI collaboration are not counted if the institution did not train students. In comparing the numbers of people from different regions one has to know that many countries, and notably the USA, don't have an equivalent to the diploma as it exists e.g. in Germany.

Table 4: **Summary**

	D-HH-HD-MPI	LENA	Crystal Ball	total
time span	1978–79	1979–82	1982–91	1978–91
institutions	4	10	13	18
PhD students	-	5	26	31
diploma students who left after diploma	3	9	14	19
diploma students who stayed for a PhD	-	1	8	13
RA's	8	9	25	31
professors	7	14	27	38
others	2	8	20	33
total	20	45	112	152

Explanations: Split-up, according to the time span, of the numbers of PhD and of diploma students who got trained in the Crystal Ball and LENA experiments. All physicists in the three successive collaborations are counted. But for the "total" double counting is avoided. So the "total" column is not necessarily equal to the sums of the physicists in the three collaborations.

As a result we can state that those experiments had been the training field for

	31	PhD students	and
	19	diploma students (who left with this degree),	
in total	**50**	**students.**	

The professional career of 46 out of those 50 students can be followed up to the year 1992/93. They stay in contact with some of their peer students and from time to time one of them shows up at DESY to talk to one of the former thesis advisers and he brings news from three or four others. In this way the information is collected in an informal way. Also requests for letters of recommendation provide information.

The degrees were earned by the students in the years between 1980 and 1991. This means that the young physicists now are in very different stages of their professional careers.

3 The professional careers

3.1 How many obtained additional qualification in high-energy physics ?

It is interesting to find out that 18 out of the 31 PhD's worked still for some time in high-energy physics laboratories. By talking to them and by observing one finds that they are looking for additional qualification. For most of them this was in connection with computing. But some who had worked for their thesis on "standard HEP analysis" were explicitely looking for a job in hardware to learn more on e.g. fast electronics. Also mentioned as a reason was proficiency in another language.

As a result one can state that post-doc training in HEP seems to be important for young PhD's who want to work in industry later on.

3.2 How many obtained additional qualification in other fields ?

Out of the 19 students who left the collaboration after the diploma 8 earned a PhD on another experiment or in another field. The split-up is:

2 in HEP because Crystal Ball ended after diploma.
1 in HEP at another experiment/university.
1 with synchrotron radiation.
1 with biophysics.
3 in materials science.

We had 19 diploma students and 20 PhD's from countries which grant a diploma. Out of those 39 finally 28 worked up to a PhD. This is more than average. We can attribute this to the fact that HEP attracts active students.

3.3 How many stayed in high-energy physics ?

Out of the 50 young physicists 10 still stay in high-energy physics. All of those 10 hold a PhD. i.e. 10 out of 31 PhD's remain in the field. But at this moment only 6 of the 10 have an unlimited contract, the other four are still in their RA period. Let's guess that 8 may end up working permanently in high-energy physics.

This picture changes when we study the break-up into different countries. Table 5 shows the details.

Table 5: **Physicists still in high-energy physics**

	Germany	Europe	USA & Israel
all students considered	32	10	8
still in HEP	4	5	1
working now in the region	3	4	3

Explanation: Many of those who stayed in HEP have changed the region in which they work. Lines 1 and 2 refer to the region if origin, line 3 to the region of the present professional activity. Moves have been from Germany and from Europe to the USA, also from Germany to Europe and vice versa.

One sees that the percentage of those who stay in HEP strongly depends on the country of origin. It is practice in some European countries that those who work on a PhD can continue to work in HEP.

From the German students about 10% stay. Considering that the time for a diploma work is one year, for a PhD thesis three years, that about half of the students work for a PhD thesis in HEP, one gets an average time of $2\frac{1}{2}$ to 3 years which is needed to train a student in HEP. The span of professional life is about 30 years (on average from the age of 30 to 60 years). With 10% of the people staying in the field after 3 years of training (on average) for a professional life of 30 years, the field of HEP continues in Germany with constant personnel.

Table 5 also shows that the USA is a country of immigration for physicists (but note the very small numbers in this case study).

3.4 In which industry branches do they work ?

In this case study we have a sample of 36 people trained in high-energy physics and now working in industry. The industry branches are very widespread. The list contains:

chemical and pharmaceutical industry,
communications,
computing and networks,
traffic systems,
medical industry,
physics instrumentation,
electronic components,
fusion research,
nuclear physics,
patent engineer,
insurance company,
public relations and media,
sales.

It should be mentioned that some companies have explicitely looked for somebody trained in high-energy physics to work for them.

3.5 What are their job assignments ?

While the industry branches vary widely the job assignments are practically all on computing and its applications. Many of them got extensive additional training by their companies. This includes in several cases work in foreign countries. For those who are already several years in their company (up to ten years in this case study) one can observe changes of job assignments towards more responsibility. Changes of companies are rare. If it happens people stay in their specialization.

4 Comments

A few comments on the feeling of our former students when they look back to their time in high-energy physics research should be made. They result from discussions with them, without aiming at a systematic inquiry.

They appreciate our working style and how cooperation and division of tasks in a collaboration is handled. Only knowledge and achievements count. Contrary to this they observe in industry a stronger hierarchial system.

The major complaint against university style research is that one does not learn efficient working. As a typical example it is stated that nearly all the secretarial work has to be done by physicists, starting with all typing from letters to scientific texts, contacts with administration and travel preparation. Also all work for the frequent changes of offices and laboratories has to be done by the physicists. The resulting unability to work with supporting staff is given as one of the reasons why people who stayed too long in university research have difficulties to adapt in industry which pays much attention to efficient work of the personnel.

There is one point where high-energy physics has to be extremely careful. We have seen that practically all our students have ended up in computing and its applications. If it would turn out some day that high-energy physics is no longer at the forefront in computing this might be detrimental for young physicists trained in high-energy physics.

What do the students know about the prospects to find a job? All students have always sent out several dozens of applications. During the time span when the students of this case study had been looking for a job in industry (1980–1991) all of them got several offers and they could choose. By now it is generally known that industry is extremely reluctant to hire people older than 35 years. This seriously limits the time during which somebody can still stay in university research after a PhD. If a person decides to continue, he/she wants to gain additional qualifications, be it in computing (e.g. systems) or in hardware. As we have seen the possibility to work as a research associate plays an important role.

What do the students know about the working style in industry? Though quite a few of them had jobbed in industry they are generally not aware of the duties of a physicist in industry. The most common statement is "it is not so much different from university".

I would like to end with a few personal remarks on my observations. Firstly one has to state that the physics students who come to the point to work for a diploma or a PhD thesis are in a large majority well trained and highly motivated. One finds real creativity. Since several years I sincerely hope that industry recognizes which intellectual potential is available to them now.

It should be mentioned that those physics students who had a professional training before getting the high-school degree and starting university (the "second way of education" in Germany) form a group by themselves. Besides the fact that their motivation can be seen easily it is their efficient working style which characterizes them.

I want to finish with a self-criticism of my work over the last 30 years. As it should be in front research we had used several times new ideas and methods. We did not follow these topics, but went on to the next high-energy physics problem. Later on we learned that people from other fields have developed the same ideas to new tools in physics. Maybe not all, but some of us should have devoted more time to look for applications of high-energy physics.

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References

[1] J.K. Bienlein, Int. Report DESY-F31-91-02
The Crystal Ball Detector at DORIS–II – Review of Achievements –