Sociology of the ARGUS Collaboration

D. Wegener
Institute of Physics, TU Dortmund

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What we call the beginning is often the end and to make an end is to make a beginning. The end is where we start.
ARGUS logbook 21.3.1989*

1. Introduction

Recently a growing number of sociologists and historians of science started to analyze the way physics in Big Science [1] is carried out. Specifically they are interested in the way how collaborations function in general [2]. On the contrary in this paper the ARGUS experiment is taken as an example to discuss the different steps in the development of an efficient collaboration which might provide a benchmark for professionals in the field for their more abstract studies. Moreover, the paper aims to remind people who worked over years in ARGUS of their hard work and stress but also of happy hours of success; fortunately the latter were not too rare.

The late D.R.O. Morrison summarized his experience with and observation of international collaborations in the paper 'The Sociology of International Collaborations' [3]. According to his insights a strong leadership is the necessary condition for a successful experiment, hence he postulated:

- The spokesman is an outstanding physicist and leader who is the dominant personality in the collaboration.

Since he noted a few cases where not enough critical potential was available in a collaboration to avoid publication of wrong results he qualified his requirement:

- It is important to have at least a second major personality in the collaboration.

On the other hand the key for a collaboration to miss its goals according to Morrison was the following organizational structure:

- A collaboration in which there are several major personalities and which is completely democratic does have a problem.

Though ARGUS was not really a democratic organized collaboration and had two successful spokesmen (fig.1) this third criterion formulated by Morrison describes its organization best. Hence the question arises if ARGUS had a problem as foreseen by Morrison.

This can be judged following the old advice 'A fructibus eorum cognoscetis eos' [4]. Refering to the citation statistics ARGUS was very successful. In fig.2 the citations of the DESY experiments are compared; even the first observation of the gluon is less often quoted than the discovery of $B^0\bar{B}^0-$mixing by ARGUS. Moreover, the ARGUS result belongs to the top 20 list of the most influential experimental papers in particle physics. Concentrating to accelerator based experiments ARGUS ranks even at place 11 (table 1). If one trusts more in peer reviews one can quote the judgement of the director of the competing laboratory [5]: 'In particular, the ARGUS collaboration, about 80 physicists from DESY,

*quoting T.S. Eliot

Figure 1: W. Schmidt-Parzefall (left) spokesman 1979 – 1989 and H. Schröder (right) spokesman 1990-2000

Table 1: Accelerator based particle physics experiments – TOP citation list [7]

Experiment	Topic	Publication	cit.
Aubert et al	Observation of J	PRL33(1974)1404	1546
MARKI(SLAC)	Observation of Ψ	PRL 33(1074)1406	1453
CDF(FNAL)	Obs. of Top Quark	PRL74(1995)2626	1408
Cristenson(BNL)	Obs. of CP Violation	PRL13(1964)138	1380
EMC(CERN)	Spin Asymmetry μ DIS	PLB206(1988)364	1354
D0(FNAL)	Obs. of Top Quark	PRL 74(1995)2632	1348
UA1(CERN)	Obs.of W	PLB122(1983)103	1209
EMC(CERN)	Spin Struct. of Proton	NPB328(1989)1	1176
UA1(CERN)	Obs. of Z^0	PLB126(1983)398	1129
HERB(FNAL)	Obs. of Υ	PRL39(1977)252	1109
ARGUS(DESY)	Obs. of $B^0\bar{B}^0-$Mixing	PLB192(1987)245	1097
UA2(CERN)	Evidence for Z^0	PLB129(1983)130	1049

several German universities and others in Canada, Russia and elsewhere has been one of the most productive collaborations in the history of experimental high energy physics'. Similar judgements by G. Altarelli [6] and the chairman of IUPAP, who ranked the observation of the supernova explosion SN1987a, the ARGUS result on $B\bar{B}-$mixing and the observation of high temperature superconductivity as the most important physics results during his chairmanship underline the success of ARGUS. It follows from these judgements that Morrison must have missed essential characteristics of successful collaborations. The question 'did Argus have a problem' should be replaced by 'why was ARGUS so successful'.

2. Conception, Birth and Growth of the ARGUS Collaboration

The details of the conception of the ARGUS experiment and its launching are described in these proceedings by the two main actors [8], [9]. The early stages of running DORIS in the $\Upsilon-$region is discussed in [10] and therefore will not

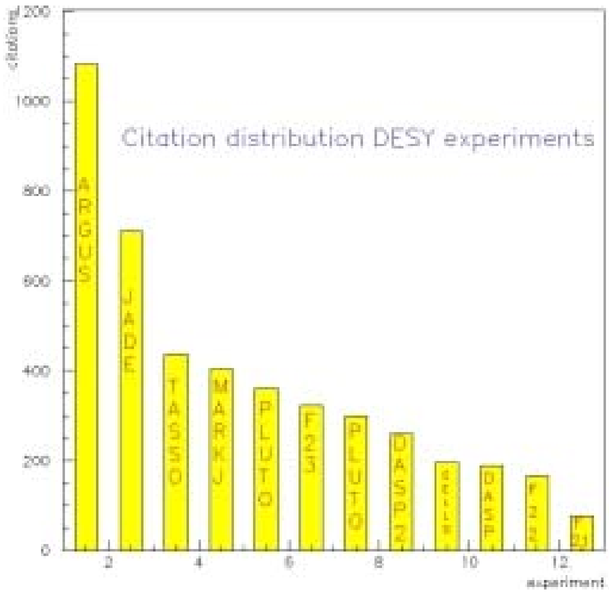


Figure 2: Citation statistics of DESY experiments [14]

be repeated here. Part of the conception phase was a dinner on September 14, 1977 which WSP, myself and our wives had shortly before we left Geneva and started to work at DESY and Dortmund respectively.

Only one month later at a DESY workshop [11] W. Schmidt-Parzefall presented the concept of 'A New Detector at DORIS' which already included the essential features of the final design. The list of physicists who participated in this study is given in fig.3. The arguments in favor of the possible physics program (fig.3) – fortunately not formulated too specifically – and the essential constraints of the detector design (fig.3) turned out to be farsighted. Only the last line of fig.3 demonstrates that no one in 1977 really could forecast the treasures hidden in the gold mine. Especially the theorists at that time underestimated the possibilities of a physics program at DORIS; characteristic is the table of priorities as seen by their representative [12] at the time of the workshop (fig.4).

The ARGUS proposal [13] was submitted October 1978 and presented to the PRC by two young members (fig.5) of the collaboration. Physicists from DESY (8), Dortmund (6), Heidelberg (3), Lund (2), ITEP Moscow (9) and South Carolina (2) signed it. Note that charm decays served as benchmark for the detector layout. The proposal was accepted after a long and cumbersome discussion in June 1979; this date can be identified as the birth of the ARGUS experiment.

2.1 Growth of the ARGUS Collaboration

In order to achieve enough strength and credibility a minimum number of scientists and institutes is necessary. ARGUS passed this threshold when IPP Toronto and Kansas University joined the common effort at the end of 1981.

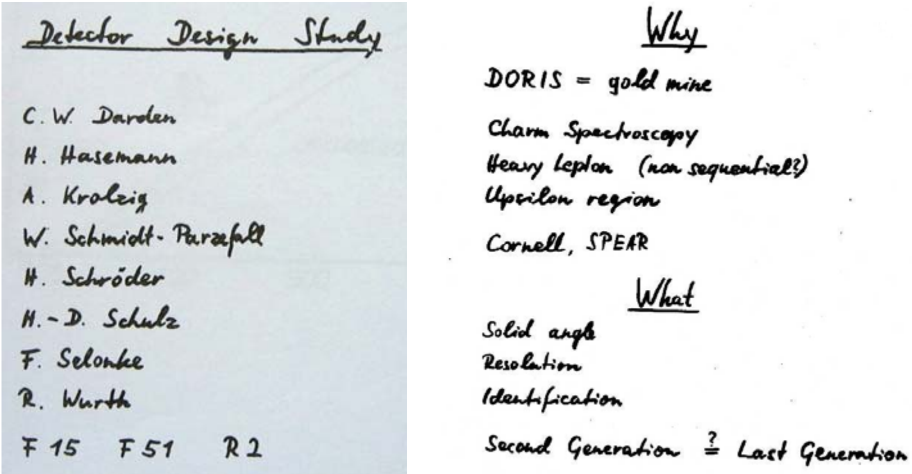


Figure 3: List of physicists who participated in the detector study (left) and arguments in favor of a research program at DORIS (right) [11]

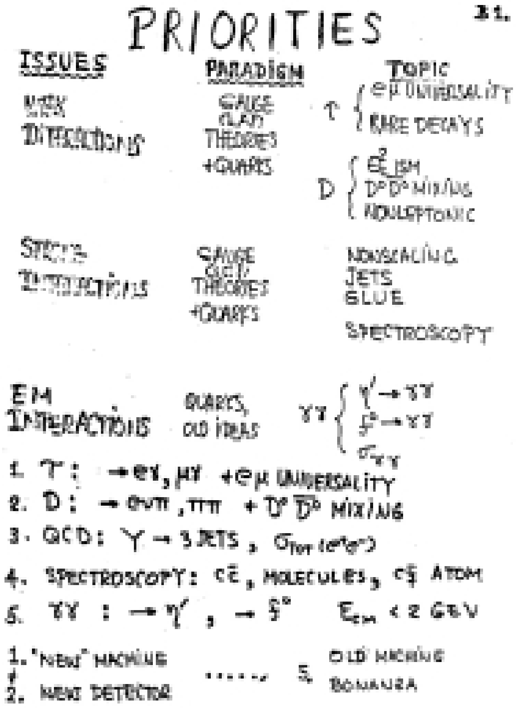


Figure 4: Priority list for the DORIS program as seen by a theoretician in 1977 [12]

Figure 5: W. Hofmann and H. Schröder who presented the ARGUS proposal

At this moment not only the typical number of collaborators for experiments was achieved (Fig.6), but even more important enough experienced groups had joined the experiment who had the expertise and capacity to build the major detector components. Also enough manpower was available to develop the necessary online and analysis software. In retrospect it was especially fortunate that each major component could be developped and built by one of the participating institutes. The necessary technical coordination among other things was minimized by this fact.

Fig.7a shows a typical example of the mass production; as demonstrated by fig.7b during the development phase a few problems were met, but they turned out to be solvable. As shown in fig.8 the final installation was again a common effort of all members. It should be stressed that the detector was build in a very short time; three years after the proposal was accepted the detector was installed in the interaction region. Less than one month was needed to tune the detector and the data collection could start. The necessary diplomatic skills to convince the machine group to reduce the background are described in [9].

A first and essential answer why ARGUS was so successful is based on the facts described above:

- One institute was responsible to develop, build, calibrate and run the major components of the detector;
- during the whole lifetime of the experiment this responsibilty did not change;
- each institute took care that their PhD students achieved hardware experience participating in the running and calibration of the detector;
- each member of the collaboration got the chance to contribute to the general work and most of them made use of it.

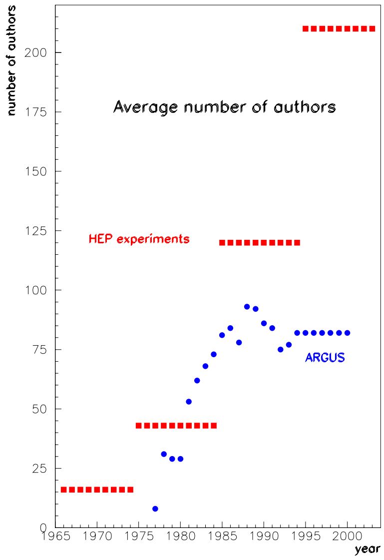


Figure 6: Number of authors signing ARGUS papers compared to average collaboration size [14] as a function of time

3. The Collaboration in its Maturity

The data taking of the ARGUS experiment started on October 6, 1982 and ended on October 8, 1992 (fig.9); during these 10 years less than 30% of the time DORIS II was available for high energy physics (fig.10). In principle 2/3 of the running time was scheduled for high energy physics and 1/3 for synchrotron radiation. But in 1987 DORIS II was switched off for most of the time because of HERA preparations, the short running time available was then scheduled for synchrotron radiation. In 1990 DORIS II was upgraded for synchrotron radiation (Bypass), only a short test run for ARGUS was foreseen. Also in 1991 and 1992 nearly no luminosity for ARGUS was delivered. Only in the years 1985, 1986, 1988 and 1989 the ARGUS collaboration could collect luminosity for its physics program.

The first paper was submitted end of October 1983 [15]. It was followed by the only paper where ARGUS and Crystal Ball [16] combined their data to achieve a precision measurement in this case of the $\Upsilon(2S)-$mass. The last publication [17] appeared in 2000, eight years after the end of data collection. In total 151 journal papers were published by the ARGUS collaboration. It is worth noting that after 1989 six results were only submitted as preprints because the statistics available was too small to arrive at conclusive results.

3.1 Organization

Actually the organization of collaborations due to the complexity of the experiment and the large number of physicists and institutes participating is extremely elaborate with many boards and committees. Already the sheer number of co-

a)

b)

Figure 7: Shower counter modules prepared for calibration run (a) and model of support structure (b) of the shower counters

a)

b)

Figure 8: Installation of detetector components: insertion of shower counters (a) and cabling of drift chamber (b)

ordinators and deputies in one of the LHC experiments exceeds the number of ARGUS members. Hence much simpler ways to organize the work of the ARGUS collaboration were necessary and possible: Decisions were taken by the spokesman who used his telephone and the daily meeting of the senior coffee club to make sure that essential arguments were considered. The decisions were clear and problem orientated and could immediately be realized (fig.11a). The spokesman and other members of the ARGUS collaboration were not forced to attend unnumerable meetings but had time for real work as demonstrated by fig.11b. Outsiders sometimes received the impression of chaotic conditions to prevail in the ARGUS collaboration but the principle of selforganization proved to be very effective. This is exemplified in a symbolic way by fig.12; while fig.12a symbolizes the chaotic phase, fig.12b recorded a few minutes later, proves the effectiveness of ARGUS selforganization.

The daily work was discussed once a week in the group meeting on Thursday morning where the running status and new results from data analysis were presented. Here for the first time the observation of $B^0\bar{B}^0-$mixing (fig.22) was discussed and I remember the talk of M. Danilov where he showed why ARGUS was a factor of 7 better than CLEO at that time. Of course, information was also exchanged by telephone and quite early e–mail was used. The first e–mail I found in my folders dates from 1988. Of special importance were collaboration

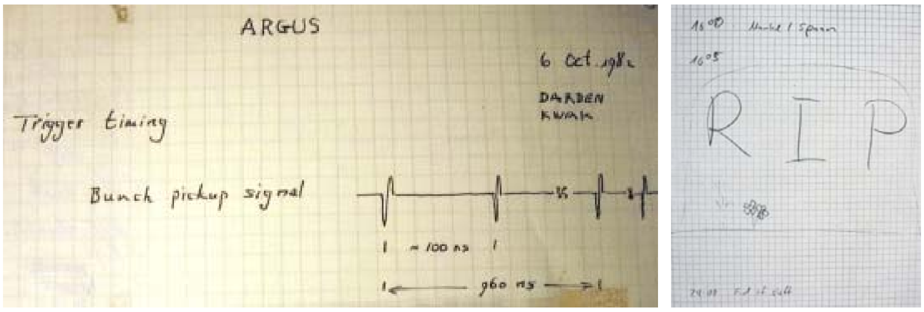


Figure 9: First entrance 6.10.1982 (left) and last one 8.10.1992 (right) in the ARGUS logbook

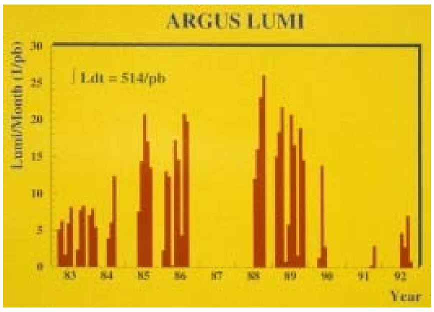
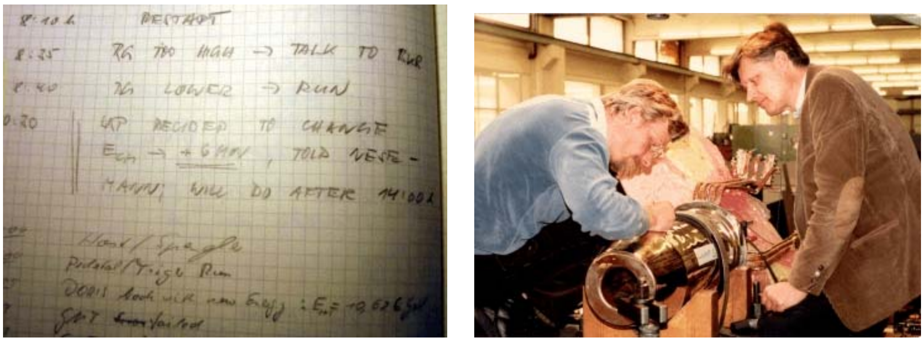


Figure 10: Integrated luminosity collected by ARGUS as function of time

meetings which took place twice a year. Each year one of these meetings was held at one of the outside institutions (Dortmund, Heidelberg, Moskau, Ljubljana, Montreal) before the summer conferences and the second in December usually in Stade. Parallel sessions which nowadays dominate the agenda of collaboration meetings were avoided; thus every member was able to follow the full program. No one was tempted to skip a session in order to do computer work since WWW was in its infancy.

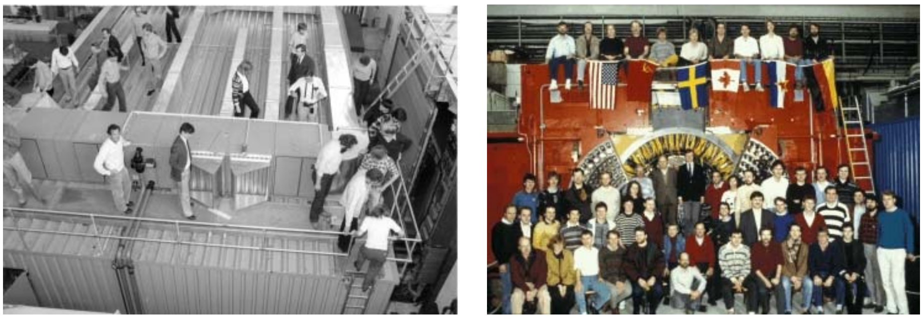
None of the ARGUS physicists belonged to the DESY establishment; this fact turned out to be a major disadvantage, especially when priorities in the lab were defined. ARGUS' output for sure suffered from this fact.

One might get the impression that the young postdocs and PhD students were decoupled from the decisions taken in the experiment. This was not true on the contrary they were able to influence the priorities in the experiment to a large extend. This is best demonstrated [18] by te so called "Zwergenaufstand" (fig.13,14). At the end of the first long running period of the ARGUS experiment a series of possible improvements of the hardware as well as of the software were identified. Since no immediate reaction of the ARGUS management followed, a group of engaged young postdocs and PhD students took the initiative after a discussion with the spokesman and seized his suggestion to elaborate their ideas for an improvement program. They not only collected in a brainstorming session 'many unordered ideas regardless of the smallest chances of realization'. In a paper [19] they summarized in detail their 'ideas in a structured manner'.



a) b)

Figure 11: Note in the logbook 6.4.1989 (a) and preparation of the mini–quadrupoles (b)



a) b)

Figure 12: Demonstration of effective selforganization

They even made a step further: a priority list and an estimate of the necessary manpower were compiled. Fig.14 gives an impression of their work. Moreover, they found those people in the collaboration who were willing to take over the work to be done. This initiative turned out be be extremely successful and is an example of the power of selforganization. The results of these efforts were an essential ingredient of the ARGUS success.

3.2 Data taking

As discussed in the beginning of this chapter luminosity was delivered only part of the time. Even worse in the first years priority was given to the Crystal Ball experiment, only in the year 1985 ARGUS physics program got priority. In retrospect this decision of the DESY directorate needs some explanation. In 1983 priority for the Crystal Ball experiment was a natural decision and even for the year 1984 a rational argument exists:

- Crystal Ball had a running detector;
- it was an established and successful collaboration with a respectable record of discoveries;

Zwergenaufstand
Teil I

Anwesend waren :
Uwe B., Gernod H., Dietmar K., Herbert K.,
Ulf M., Klaus S. und Siegfrid W.
Nicht anwesend war:
Andreas D.

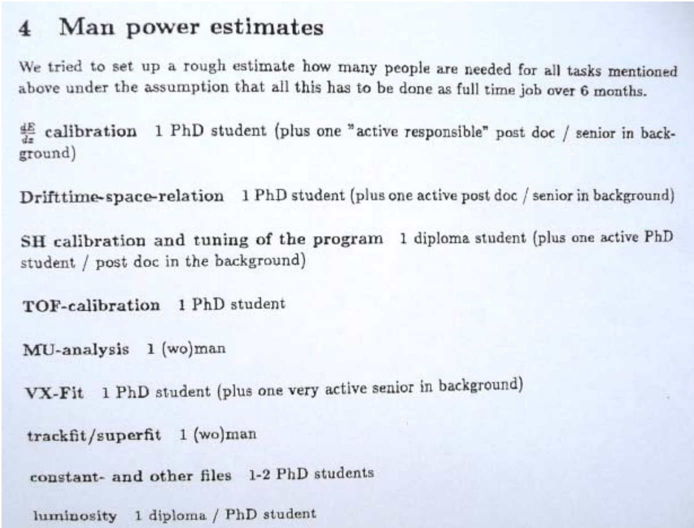
2.11.86, 20:00
in der "Blauen Blume"

Figure 13: Postdocs and PhD students of the 'Zwergenaufstand' [18]

- the ARGUS senior members were youngsters at that time and not every one at DESY was convinced that we could compete successfully with the CLEO experiment;
- Crystal Ball observed [20] an unexpected signal in the decay channel $\Upsilon(1S) \to \gamma\zeta$. Hopes were running high for a short time at DESY that a light Higgs boson had been observed.

The signal observed in the 1983 data could not be reproduced by Crystal Ball [21] in the data collected in 1984. In agreement with this result ARGUS derived from its data a limit of the branching ratio [22] which was a factor 3 below the value originally claimed by Crystal Ball [20]. A 'model which might explain the disappearances' [23] seems to have been a strong enough argument for the directorate to schedule in 1986 50% of the running time available for high energy physics to collect data ± 12 MeV below and above the $\Upsilon(1S)$. This model seems to be described in ref.[24]; its explanative power had been analyzed with a negative result [25] already in spring 1985 by a senior member of the Crystal Ball collaboration. When discussing the DORIS II program for 1986, the PRC did not formulate an explicit recommendation for the 1986 running period, the minutes simply state 'the directorate will take a wise decision' [26]. No signal was observed either [23]; unfortunately these data could only be used for studies of $\gamma\gamma-$physics and not for the really interesting physics questions. As the final resumé of the Crystal Ball collaboration after three years of hard work one finds in [23] the statement 'the observation of ζ has to be interpreted as a statistical fluctuation'.

How can the observation of the ζ by Crystal Ball be explained? A convincing explanation may be the guidelines for searches formulated by J. W. Goethe, a critical observer of our field [27]. However, in addition the group dynamical explanation by Morrison [3] in his essay has to be considered for research performed by large collaborations: '... there are a number of published results which seem exciting and caused great activity, but are finally found to be wrong. It is not easy to say precisely how this occurs, may be by constantly repeating it to one another a surprisingly result becomes acceptable. The problem is when it becomes an article of faith for members of the collaboration to believe the result'.


4 Man power estimates

We tried to set up a rough estimate how many people are needed for all tasks mentioned above under the assumption that all this has to be done as full time job over 6 months.

$\frac{dE}{dx}$ calibration 1 PhD student (plus one "active responsible" post doc / senior in background)

Drifttime-space-relation 1 PhD student (plus one active post doc / senior in background)

SH calibration and tuning of the program 1 diploma student (plus one active PhD student / post doc in the background)

TOF-calibration 1 PhD student

MU-analysis 1 (wo)man

VX-Fit 1 PhD student (plus one very active senior in background)

trackfit/superfit 1 (wo)man

constant- and other files 1-2 PhD students

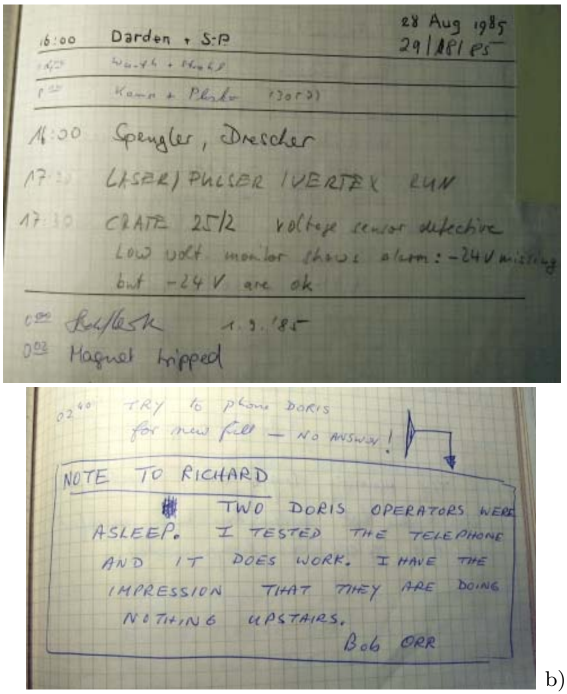
luminosity 1 diploma / PhD student

Figure 14: List of tasks to improve the ARGUS detector as presented by the dwarfs in their memo [19]

There were of course for ARGUS as in every other high energy physics experiment some problems due to external influences. The machine had to be switched off in the late afternoon because of energy costs. Moreover, DORIS II was sometimes not running smoothly and for long periods no data could be taken due to machine problems (fig.15a). Also the cooperation of the operators was not optimal as demonstrated by records in ARGUS logbook (fig.15b).

ARGUS itself produced also problems causing serious losses during data taking. The computing system was unstable quite often producing desperation to the people on shift; the note in the logbook (fig.16) expresses the frustration of a shifty. Sometimes detector components were running unstable; fortunately seniors knew the basic tricks to solve the problems (fig.17). Some of the youngsters soon developped a stoic attitude (fig.18a); moreover, as observed also in other collaborations the experiment not always benefitted from the presence of active experts (fig.18b).

ARGUS was confronted with one real hardware problem already at an early stage of the experiment. Not totally unexpected [28] a serious aging of the driftchamber due to deposits on the wires was observed in February 1984. Experts all over the world were contacted (fig.19a), unfortunately no unambiguous advice was given. Finally the spokesman, after discussing the problem with his friends at CERN, decided that water admixture should solve the problem (fig.19b) as it indeed did. After the successful operation, we could send a telegram to the spokesman who had gone for skiing, reporting the success of the procedure. The simple organizational structure of ARGUS (see ch.3.1) was in this case a real advantage to arrive at a quick decision.



a)
b)

Figure 15: Notes in ARGUS logbook demonstrating external problems (a) 28.8.1985 and (b) 24.6.1984

Despite of these problems a successful data taking was possible and on some days unexpected high luminosities were collected (fig.20) followed by a spontaneous party of the shift crew. As explanation for this successful luminosity run the acknowledgement in the logbook might serve: ‘The result would not have been possible without the help of a nice bottle of Manatirka Slivovic (ARGUS logbook VII p.103). It is not clear from the notes if the bottle was provided to the DORIS operators (following the example of WSP and Micha Danilov in 1982 [9]) or to the ARGUS shift team.

Enough data for a successful physics program including the first observation of $B^0 - \bar{B}^0-$mixing and the establishment of the $b \to u$ transition was available to mention only the highlights in B–physics program. One might wonder, if a schedule of DORIS II considering the ARGUS wishes with higher priority would have allowed to observe in addition Penguin transition $b \to \gamma$ for the first time. The later CLEO result [29] for the branching ratio excludes this in retrospect; a factor of 4 to 5 higher luminosity would have been needed.

3.3 Physics

DORIS II turned out to be a gold mine as emphasized by W. Schmidt-Parzefall at the first presentation (fig.3b) of the physics program [11]. It covered such different topics as:

- B–physics

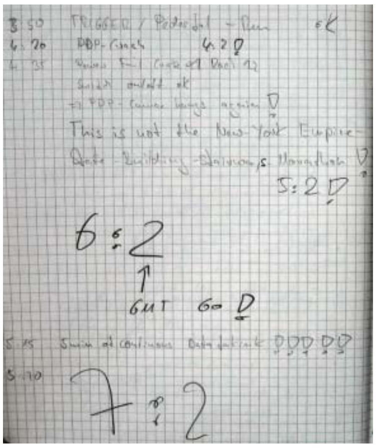


Figure 16: Frustration of a shift team due to computer crashes, ARGUS logbook 3.5.1990

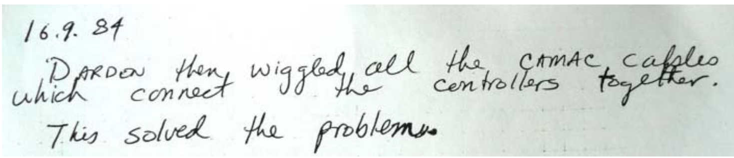


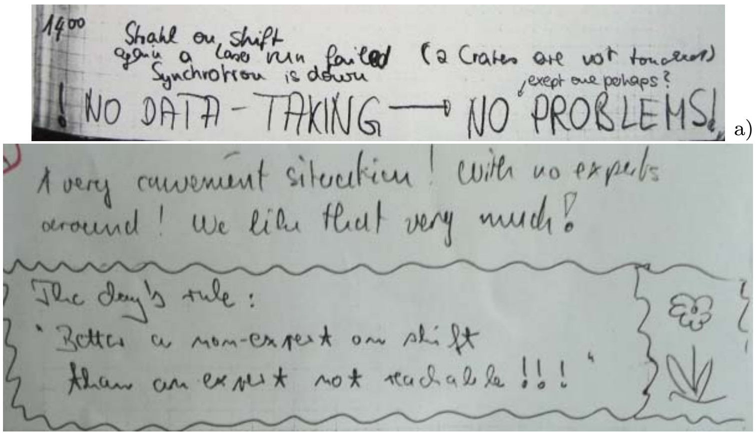
Figure 17: Note from the ARGUS logbook 16.9.1984

- Charm–physics
- $\tau-$physics
- Spectroscopy of $b\bar{b}$ bound states
- Quark and gluon fragmentation
- $\gamma\gamma-$physics
- Searches for new physics

In all these fields papers were published starting with 'First observation of ...'. More than 50% of the publications were based on PhD thesis (fig.21).

There existed a plethora of physics problems which could be attacked. This fact made life easy since every one could find problems whose solution promised reward. Comparing the number of PhD thesis with the number of publications and the time distribution of diploma and PhD thesis a characteristic time shift is observed which also shows up in other experiments. It can easily be explained by the fact that publications were often based on results of PhD while diploma thesis very often covering technical developments.

Why was ARGUS so successful to exploit the rich physics accessible? We had an excellent detector and optimally designed software, but of course most



14^00 Stahl on shift
again a laser run failed (2 Crates are not touched)
Synchrotron is down
! NO DATA-TAKING → NO PROBLEMS! (except one perhaps?)

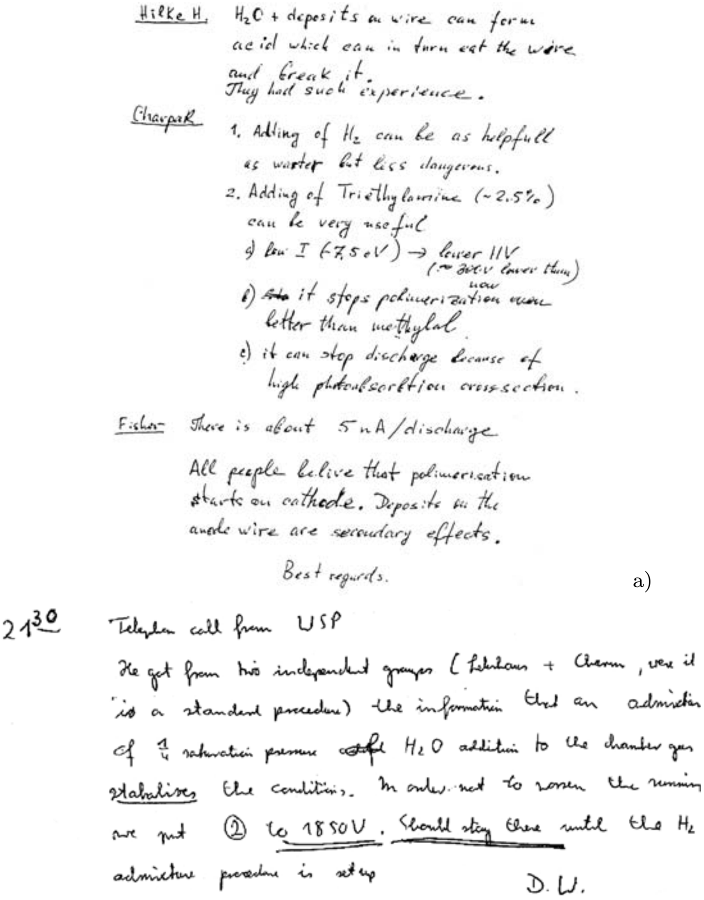
a)

A very convenient situation! with no experts around! We like that very much!

The day's rule:
"Better a non-expert on shift than an expert not reachable!!!"

b)

Figure 18: Notes in the ARGUS logbook (a) 22.5.1985 and (b) 17.4.1989



Hilke H. H_2O + deposits on wire can form acid which can in turn eat the wire and break it.
They had such experience.

Charpak
1. Adding of H_2 can be as helpfull as water but less dangerous.
2. Adding of Triethylamine (~2.5%) can be very useful
a) low I (7.5 eV) → lower HV (~300V lower than)
b) it stops polimerization now better than methylal
c) it can stop discharge because of high photoabsorbtion crossection.

Fischer There is about 5 nA/discharge

All people belive that polimerization starts on cathode. Deposits on the anode wire are secondary effects.

Best regards.

a)

21^30 Telephon call from USP
He got from two independent groups (Lebedev + Cern, where it is a standard procedure) the information that an admixture of 1/4 saturation pressure of H_2O addition to the chamber gas stabilises the conditions. In order not to worsen the running we put (2) to 1850V. Should stay there until the H_2 admixture procedure is set up
D. W.

b)

Figure 19: (a) Proposed actions to cure aging effects and (b) method applied successfully, logbook 8.3.1984

Figure 20: Record of very successful data taking day 5.8.1989

important was the quality of the physicists using them. A colleague from US once pointed out to me the importance of the nearly ideal mixture of experienced competent senior physicists from DESY and the excellent PhD students and postdocs of the participating universities. Their close cooperation turned out to be extremely effective and allowed to exploit the goldmine and successfully compete for many years with our colleagues from CLEO.

Twice the publication of wrong results was avoided in the last moment. The delivery of the DESY preprint concerning D_s-meson observation was delayed by 8 month: the DESY preprint number is DESY 84–043 (May 1984), while the paper [30] was finally submitted January 7, 1985. In ref.[31] the reason for the delay is discussed. The first version of the preprint was collected in the last moment by K. Schubert and eco–friendly disposed [31].

A first preliminary limit on $B0\bar{B}^0-$mixing was presented at Berkeley conference, it amounted to $r_d = \frac{N(B^0B^0)+N(\bar{B}^0\bar{B}^0)}{N(B^0B^0)} \leq 0.11$. Returning from this conference H. Schröder started in August 1986 an analysis using an increased data sample of the exclusive decay $\bar{B}^0 \rightarrow D^{*+}l^-\bar{\nu_l}$. For this purpose he developped a new selection method exploiting the excellent particle identification capabilities, the hermiticity and the large efficiency of the ARGUS detector. Along with 23 candidates for unmixed events he observed 2 B^0e^+, 2 $\bar{B}^0e^-$, and 1 $\bar{B}^0\mu^-$ and 1 fully reconstructed B^0B^0-event.The results were presented at the weekly ARGUS group meeting September 25, 1986 (fig.22). The delivery of the paper, prepared immediately after the Berkeley conference, was stopped in the last moment; the final results were published in June 1987 [32]

In one case the quality assurance methods of ARGUS did not prove successful [33]. A peak showed up in the $p\bar{p}\pi^+$ channel which is an allowed decay channel of the B^+-meson. Unfortunately, also the signal of one negative hadron in the shower counters was compatible with a $\bar{p}$ [34]. This decay channel meanwhile has been observed [35] with a branching ratio a factor of 100 smaller than the value

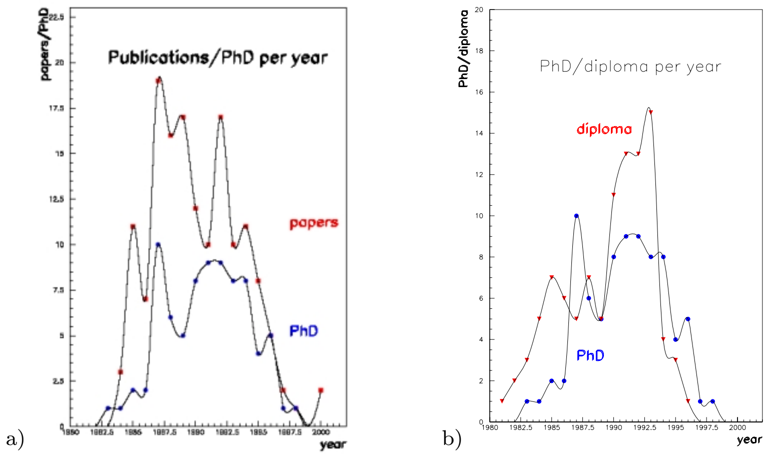


Figure 21: (a) Number of PhD thesis and publications per year, (b) comparison of ARGUS PhD and diploma thesis per year as function of time

derived from the ARGUS 'signal' which has to be interpreted as a fluctuation. This analysis suffered from the fact that no realistic model of $\Upsilon(4S)-$decays existed at that time and the cuts applied to select the 'signal' were tuned on the data. The bias introduced by this procedure was not realistically estimated at this time and thus the significance of the two fluctuations overestimated. Also the group dynamics [3] mentioned in ch.3.2 seems to have been important. In a later publication [36] the withdrawal of this result was indicated in an indirect way. The procedure proposed by L. Meitner to O. Hahn [37] when they were forced to withdraw their previous results on $n-$capture in U after the observation of nuclear fission would have been more elegant; ARGUS had the chance for such an approach when they observed for the first time $b \to u$ transitions in inclusive semileptonic B–decays [38]; this opportunity was not used.

In consequence of this mishap a formal referee system was introduced where a critical expert of the collaboration, not involved in details of the analysis, was asked to check the different steps leading to the result. This procedure established a very effective control mechanism.

3.4 Social life

Good personal relations between the members of a collaboration are of high importance and in the ARGUS collaboration they were indeed usually very good. The many important discoveries from the beginning of the experiment on made the work rewarding and hence satisfying. The friendly competition with CLEO [39] enforced the feeling of solidarity and the work towards a common goal. People made friends and supported each other if necessary. Disagreements on technical and scientific matters were expressed clearly but usually in a polite way. Scanning the notes in the logbook one finds only one (fig.23) where the opposing opinions clashed; fortunately a senior was around to rise the discussion to the usual level.

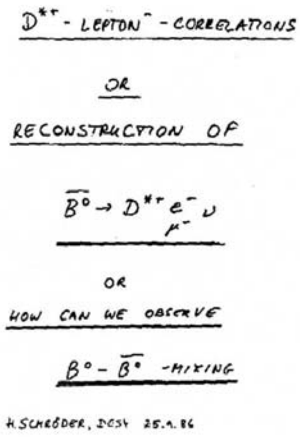


Figure 22: Front transparency of H. Schröder's talk announcing first observation of $B^0\bar{B}^0-$mixing

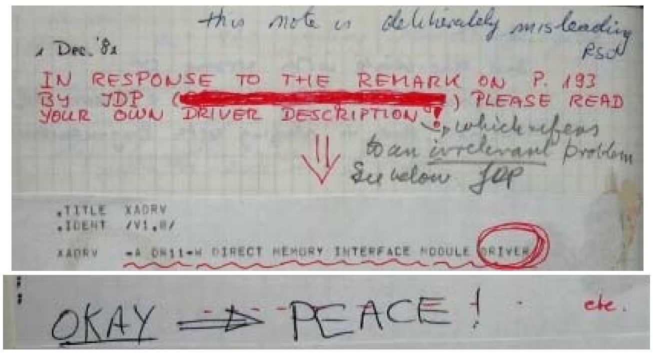


Figure 23: Notes from ARGUS logbook (1.12.1982) expressing controversial opinions

The collaboration meetings usually included social events which are documented in figs.24–26. The first meeting dedicated to the preparation of the proposal was held in 1978 at Geneva enforced by political reasons. In 1981 the group had grown (fig.24), but it was still small enough that all group members could be invited to the home of a senior. This changed later on; the highlight for sure was the collaboration meeting 1987 in Bled. Figs.25 prove the good spirit characteristic for the ARGUS collaboration. Usually a half–day excursion was planned during the outside collaboration meetings (fig.26a,b). Also these activities helped to improve solidarity within the collaboration. On long term these undertakings payed off. At DESY the social contacts were more on a personal level, only a few times on special events like finishing calibration runs or starting data taking Booze–ups took place. In these cases the training of our spokesman during student days as a 'Blauer Sänger' made him an ideal barkeeper (fig.27).

Figure 24: Documents of collaboration meetings 1978 at CERN and 1981 at Dortmund

Figure 25: Collaboration dinner at Bled 1987

Figure 26: Collaboration meeting in Moscow and Bled

Figure 27: The spokesman in full action

3.5 Careers

Besides the publication and citation statistics the future careers of the collaboration members reflects the success of an experiment. 81 PhD and 101 Diploma/Master students prepared their thesis in the ARGUS collaboration. As shown in fig.28 most of the German graduates work nowadays in industry, some of them in leading positions. About 50% of the ARGUS students from outside Germany are still active in high energy physics.

Figure 28: Position in science and industry of german (left) and non–german ARGUS members (right)

Many of the seniors and postdocs of the ARGUS collaboration are nowadays in leading research positions (table 2). Three of the former postdocs are now spokesmen of one of the present day large international collaborations; as far as I can see no other collaboration has been as successful. The list of former PhD students which now have an influential position at universities and research centers is also long (table 2).

Finally the list of honors and prizes awarded to ARGUS members is impressive:

- 1989 B. Spaan Benno-Orenstein–Preis
- 1991 D.B. MacFarlane Herzberg Medal and
  1995 Rutherford Medal

Table 2: ARGUS members who achieved leading positions in research institutions

Seniors	Postdocs	PhD
M. Danilov	A. Golutvin	S. Ball
H. Kolanoski	W. Hofmann	D.J. Britton
W. Schmidt-Parzefall	P. Krizan	D.M. Gingrich
K.R. Schubert	D.B. MacFarlane	G. Herrera
	H. Schröder	S. Khan
		J.A. McKenna
		J. Parsons
		M. Paulini
		T. Ruf
		S. Schael
		B. Spaan
		J.D. Swain
		G. Tsipolitis
		S. Westerhoff

- 1995 W. Schmidt-Parzefall Gentner–Kastler Preis
- 1996 M. Danilov Max–Planck–Forschungspreis
- 1997 H. Schröder W.K.H. Panofsky Prize of APS
- 1997 Y.M. Zaitsev W.K.H. Panofsky Prize of APS
- 2001 G. Herrera Premio de Investigación 2001 de AMC
- 2004 C. Darden Russell Research Award
- 2007 D. Wegener Bundesverdienstkreuz 1. Klasse

Summary

The success of the ARGUS collaboration had different sources. First of all the physics in the $\Upsilon(4S)$ region turned out to be extremely multivarious and many fundamental problems could be attacked and solved. This was not expected when the ARGUS collaboration started. A powerful detector was necessary to exploit the goldmine and indeed the ARGUS detector fulfilled all conditions: charged and neutral particles were detected in nearly the full phase space, its hermiticity could be exploited in the analysis by innovative ideas. It had excellent particle identification possibilities. The fact that one institute was responsible for a component and this did not change during the lifetime of the experiment was essential for the optimal exploitation of the detector. All components achieved their design values and some even surpassed them. The design of the detector was optimized for pattern recognition and special effective analysis software was developped. ARGUS had excellent PhD students whose contribution was essential to develop and exploit original ideas in the analysis. Of course a little bit of luck was also necessary and the friendly competition with CLEO should not be underestimated [39].

Last but not least ARGUS was so successful because of the enthusiasm of its members and since the spirit in the collaboration was unique. It is best characterized by the introductory remarks of the report written by the “dwarfs” (fig.13,14): ‘Please note that some of the “dwarfs” very probably will not have the opportunity to profit by the future of ARGUS. So account for their participation in our meetings as an expression of responsibility’.

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