Launching DORIS II and ARGUS

Herwig Schopper, Geneva

It is a great pleasure and honor to be back at DESY and talk about one of the most important results obtained in this laboratory. My task will be to sketch the general historical background which will be filled in by more competent speakers.

Early days of DESY and DORIS

When DESY was founded in 1959 by W.Jentschke, the experience concerning high-energy accelerators was very limited in Germany. Nevertheless thanks to the help of American colleagues it became possible to put into operation already in 1964 an electron synchrotron with an energy of 6.3 GeV and experiments started quite fast. After this success DESY became more ambitious and a unique facility was envisaged.

DORIS (**Do**ppel-**Ri**ng-**S**peicher, "double-ring storage") with a circumference of nearly 300 m was proposed in 1966, construction started in 1969 and operation began in 1974. The objective was to study both, collisions between electrons and their antiparticles, the positrons, but also between electrons and electrons. Whereas one ring is sufficient for the first purpose, two rings are needed for the second, since electrons cannot circulate in opposite directions in the same magnetic ring. With two rings also collisions of electrons with protons were considered, a possibility which became a reality only much later with HERA.

A difficult discussion concerned the maximum beam energy which this new facility should provide. Some famous theoreticians argued that it would not make sense to build such a machine with a beam energy of more than about 2 GeV. They had good arguments. The cross section for the collision of pointlike particles is predicted by quantum mechanics to decrease with the square of the collision energy and all form factors for extended particles (known or unknown) have to be smaller than 1. With the number of collisions per second (luminosity) expected for the new facility one could calculate that the number of observed events would be too small to obtain reasonable results.
After consulting many people at DESY and in other laboratories Jentschke took two brave decisions: the initial energy of the beams should be 3 GeV; the magnets keeping the particles on their circular orbits should be good for energies up to 4.3 GeV. The reason for these two different energies was due to the fact that in an electron storage ring the particles lose energy by synchrotron radiation which increases very rapidly with increasing energy. To compensate for this loss powerful radio frequency accelerating cavities have to be used

and the originally foreseen rf power was sufficient to store electrons at 3 GeV. If unexpected discoveries were made, it would be possible to boost the beam energies to 4.3 GeV by just adding rf cavities. Indeed this foresight made it possible that in 1978 DORIS could become a major player in the investigation of the b-quark (Fig.1).

In the two long straight sections of DORIS two experiments were installed, PLUTO and DASP, which were built and operated by international collaborations. Following the surprising discoveries of the J/ψ particle, (a bound state between a c-quark and its antiquark) and the superheavy electron (the τ particle) it became obvious that DORIS was an excellent facility to investigate this rich field of physics. Indeed several important contributions could be made by the DORIS experiments for the "excited charmonium states". The establishment of a new kind of excited state of the J/ψ (p-wave quark-antiquark state) and the discovery of semileptonic decays of the D-particle are only two examples. With these discoveries DORIS made important contributions to establishing the quark model and in particular to proving the existence of heavy quarks.

But DORIS became also a powerful source for synchrotron radiation experiments, although in the early phases they could use DORIS only ‘parasitically’. HASYLAB was established and for EMBL the first outstation was created at DORIS. Among the many achievements I want to mention the first tests of X-ray lithography at DESY, a procedure which was later refined to X-ray depth lithography.

I had become the chairman of the DESY directorate early in 1973 and had the pleasure to live through this (and the following) productive and interesting period in an involved position.

The way to DORIS I

In 1977 discussions started to increase the energy of DORIS (upgrading to DORIS I). This upgrading was initiated by a PLUTO proposal which asked for energies up to 2 x 4.3 = 8.6 GeV, the highest energies planned in the original design. The objective was to measure the total cross section for e+e- annihilation in order to study exited charm states and to investigate the τ lepton. A search for the third quark generation was not mentioned, however.

This proposal was presented to the Forschungskollegium on 30 June 1977 which gave its full support. By chance, on this very same day a public seminar was organized at FNAL in the USA during which the Y(9.46 GeV) resonance was announced. Of course, this became immediately known everywhere and already on 6 July 1977 PLUTO started discussions with machine people concerning a possible upgrade to 5GeV/beam (D.Degele, J.Bürger, L.Criegee, G.Flügge). Such an energy increase seemed feasible provided only one ring of DORIS would be operated and some accelerating cavities of PETRA and power supplies would be used. Also some changes to the DORIS magnetic lattice were envisaged to avoid saturation effects. This scheme was immediately supported by the Forschungskollegium on 15 July 1977. A possible physics program at 10 GeV was discussed at a DESY workshop in October 1977 where J. Bürger and H. Schröder presented the physics program of the PLUTO and DASP II collaborations (since the DASP group had moved to PETRA a new collaboration DASP II had been formed). The physics priorities from the theorists’ point of view were discussed by T. Walsh. Astonishingly enough mainly the physics of the 2nd generation of quarks was considered with the ϒ decay into 3gluons only briefly mentioned. Both experimental groups, on the other hand, discussed in detail the possibility of learning about the properties of the 3. generation of quarks in only a few days of running.

DORIS I was approved by the Directorate on 16.12.1977. This was a difficult decision since the storage ring PETRA was supposed to start in 1978 and it enjoyed highest priority since it was in fierce competition with a similar project PEP at SLAC in California. It had also been foreseen to move PLUTO to PETRA and to dissolve the DASP collaboration. These plans were reconsidered, however, in view of the new situation.

On 20.2.1978, only a few months after this decision, DORIS I started to operate at the higher energy. This achievement was possible thanks to the initiative of Donatus Degele and the experience and dedication of the whole accelerator crew. The rapid energy upgrade of DORIS was unexpected to the outside. I remember a seminar given by A de Rujula at CERN in March 1978 where he discussed ϒ physics and expected the first experimental results from CLEO at Cornell University early in 1979.

DORIS and the b-quark

The scan in the ϒ (1S) region started at DESY on 15.April 1978. Both, the machine and the detectors, had problems in the beginning. A fluctuation observed by ARGUS and less prominently by PLUTO was convincing enough to motivate the DESY director to expend the first bottle of champagne. However, after a few days of running the peak vanished (its trace can still be found in the smaller step size of the scan around 9.38 GeV in the published resonance curve). Yet finally, on 30 April 1978 the resonance signal was established. The results obtained by PLUTO and DASP II proved that the resonance at 9.46 GeV was extremely narrow (Fig.2). In August 1978 DASPII could also find the narrow peak corresponding to the first excited state of the ϒ at 9.9 GeV. These results were presented at the High Energy Physics Conference which took place at Hamburg in August 1978. A few months later DASP II and the LENA collaboration (which had replaced PLUTO) determined the parameters of the ϒ(2S) state. I believe that only the DESY results by resolving the ϒ peaks into narrow resonances and verifying the charge of the b-quark to be 1/3 made the interpretation in terms of a bound state between a third quark and its antiquark credible. In my opinion DESY did not receive an appropriate credit for these measurements.

In 1979 DORIS was not much running since it had been decided to install a small intermediate positron accumulator PIA[1] to improve positron injection for PETRA. This freed DORIS for its own research programme. At the beginning of 1980 DASPII and LENA were continuing to take data for the ϒ resonances but in March 1980 DORIS I stopped temporarily running for high energy physics in order to provide sufficient time for synchrotron radiation for EMBL and the Frauenhofer Society. This for DORIS was the beginning of a serious competition between high energy physics and the synchrotron radiation programme.

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[1] Another girls' name for a facility. A liked this tradition at DESY of using nice easy to remember names. When I arrived many years ago at the airport of Hamburg and asked the taxi driver to take me to DESY he became angry and said he could not know all the addresses of the 'Daisies' at St.Pauli.

ARGUS

"A Russian-German-United States-Swedish Collaboration"[2]. In summer 1977 I encouraged Schmidt-Parzefall whom I knew since our common time at Karlsruhe, to take over DASP (which became DASP II) and to consider the possibility for a new detector for DORIS. This I did since I was afraid of too little physics at DESY besides PETRA and that DORIS would not be used properly. I did it against the advice of many colleagues[3]. Initially the proposal for a new detector was not welcome since most people thought that all efforts should go to PETRA and its experiments. In the end, however, all the committees gave their blessings.

Schmidt-Parzefall accepted the challenge and contacted colleagues. For the formation of the new collaboration apparently a dinner at Dortmund in September 1977, the 'Wegener Dinner', was essential. Schmidt-Parzefall presented the ARGUS proposal at a meeting on DORIS experiments on 10/11 October 1977 (DESY F15/01,November 1977) which contained already the most important elements of the final design: large solid angle (hermeticity), particle identification, shower counter for detection of low energy photons inside the magnetic coil, muon chambers. The proposal 'ARGUS – a new detector for DESY", was presented to the Forschungskollegium (Proposal Nr. 146) in October 1978. The main actors among the 90 scientists participating in the collaboration were W. Schmidt-Parzefall and H.Schröder from DESY, D.Wegener from Dortmund, K.R.Schubert from Heidelberg, P.Böchmann and L.Jönsson from Lund, M.Danilov from Moscow and R.L.Childers and C.W.Darden from South Carolina.

The Scientific Council gave its approval on 4 December 1978 and it is stated in the Minutes: "Schopper reports further that the Forschungskollegium has positively evaluated the proposal of a new detector ARGUS. The cost will be DM 8 million with the use of several components of DASP". After clarifying all the resources the Directorate approved ARGUS in July 1979 with the target to be operational in 1981.

The final design followed in many details the original idea with only the layout of the drift chamber improved to account for the requirements of optimal pattern recognition. The physics benchmarks in the proposal were charm and τ physics. A detailed evaluation of a possible B- physics program was presented in April 1980. An expanded analysis of the possibilities of studying B physics with ARGUS followed in February 1981 when it became clear that DORIS I could be upgraded to an energy of 11.2 GeV. The ARGUS detector was built and it worked in a stable manner from 1982 to 1992 (Fig.3).

During a DORIS workshop in February 1981 the idea arose to transfer the Crystal Ball detector from SLAC to DESY. The proposal was soon presented and accepted in summer 1981. The Crystal Ball detector was transported to DESY in spring 1982 and started data taking August 1982 while ARGUS rolled in two months later. Both experiments were approved for running for 3 years, but Crystal Ball was given priority for one year. The competition between the two experiments delayed the B -physics program at DORIS for nearly 3 years because the Crystal Ball collaboration preferred to run at the energy of the Υ resonances being optimised for spectroscopic studies.

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[2] One of the spouses knowing the senior members of the group too well interpreted the logo as 'Alle Richtigen Genies Unter Sich'.

[3] The only other case where I took a decision neglecting advice and against the opinion of competent committees was the establishment of the heavy-ion programme at CERN during the construction of LEP.

DORIS II

A new chapter started at DESY on 1 January 1981 when V.Soergel took over the helm of DESY since I left to become Director General of CERN (Fig.4).

Early in 1981 discussions started to increase the energy of Doris further. G.-A.Voss presented to the Scientific Council the possibility to go to about 11 GeV requiring, however, a change of the magnetic lattice of DORIS. Consecutively K.Wille worked out a concrete scheme allowing 2 x 5.6 GeV with reduced considerably the power consumption. The essential differences of DORIS II with respect to DORIS I were the decrease of the magnetic gap width and the increase of the number of coil windings of the magnets thus reducing saturation effects and power consumption. The injection was improved by installing separator plates and a faster kicker magnet. A major increase in the luminosity was achieved by mounting special strong-focussing quadrupoles at a small distance from the interaction points. The cost of the upgrading was estimated at DM 2 million and 6 months of shut down were needed. The shut-down started on 2 November 1981 and after an incredible short time DORIS II started operation in May 1982. With these improvements DORIS II achieved a maximum integrated luminosity of 1.8 pb^{-1}/day and an average luminosity of 0.5 pb^{-1}/day.

In the period 1983-85 DORIS II was running mainly for the Crystal Ball at the Υ(1S) resonance. For second part of 1986 ARGUS was declared to be the main user, but Schmidt-Parzefall had to complain to Scientific Council on 4 March 1986 asking for beam time (100 pb^{-1}) at the Υ(4S) in 1986 and sufficient luminosity in 1987 and indeed the great success came.

On 25 September 1986, H. Schroeder presented at an ARGUS group meeting the first results of an analysis of 50 events with reconstructed B^0-B^0bar. These events allowed the observation of 'B-mixing' which means the transformation of a B meson into its antiparticle, an anti-B meson. It was observed for the first time in the ARGUS detector and implies the discovery of a new fundamental property of the bottom quark. It is characterised by a mixing ratio and its value was found to be rd = 0.20 +/- 0.12. The great news were for the first time communicated 'publicly' in a meeting of the Scientific Council on 16 March 1987 and were reported at the EPS Conference at Uppsala, 25 June 1987. They became the highlights at the International Lepton-Photon Symposium at Hamburg, 27/31 July 1987 and the CERN Courrier[4] reported about this event: "The session on the weak decays of quarks included the now famous result from the ARGUS experiment at DESY on particle mixing in the neutral B meson system".

No doubt, the discovery of the B-mixing belongs to the most important discoveries made at DESY and hence it is fully justified to celebrate its 20 anniversary!

It should be mentioned that another important result reported at the Hamburg conference was the observation of the B-decay 'without charm', i.e. no particles containing a charm quark were observed in the final sate of the decay.

ARGUS was one of the most successful detectors at DESY. Hence the leading physicists received a number of distinctions. W.Schmidt-Parzefall, spokesman of ARGUS for many years, received in 1995 the Gentner-Kastler Prize, a common prize of the German and

[4] CERN Courrier, 27, September, pg.4, 1987

French Physical Society. M. Danilov was honoured by the Max-Planck Research Prize in 1996 and the Karpinskij -Prize of the Töpfer Foundation in 1998. Finally H.Schröder and Y.Zaitsev were distinguished in 1997 by the Panofsky Prize of the American Physical Society.

A short Top excursion

I may be allowed to insert a short diversion concerning the top quark. My top story started when in 1977 a 'sure' theoretical prediction was made for the mass of the top $m_{top} \approx 44$ GeV/c^2. Consequently a strong request was made that PETRA operating at beam energies around 19 GeV should be pushed to higher energies. The accelerating RF power was increased at quite some cost and 22 GeV/beam could be reached! The result: no top was found!! The lesson is that experiments do more than just confirm theories!

Nine years later the experimental situation was still unsatisfactory, the top had still not been observed and theorists were unable to make any predictions for its mass. In 1986 the UA1 experiment at CERN claimed[5] to have observed a signal for the top with a mass of about 40 GeV/c^2. Great enthusiasm! and I had the honour to baptise a newly born tiger in the zoo of Leipzig with the name Top (Fig.5).

What is the relation with ARGUS? For a top mass as observed by UA1 a small B-mixing parameter of about rd = 0.01 was expected which was in disagreement with the final ARGUS result of rd = 0.171 +/- 0.048. From the large mixing parameter measured by ARGUS one could infer that the top mass had to be large, $m_{top} > 50$ GeV/c^2. It is now history that the top mass was indirectly determined at LEP and that the top was finally produced by the TEVATRON at FNAL with a mass of about 171 GeV/c^2, much higher than ever expected. However, the ARGUS result was the first experimental indication for such a high top mass.

The last days of ARGUS

The year 1989 was another good year for ARGUS with 190 days of running with a total luminosity of 201 pb^{-1} and only 66 days for synchrotron radiation. During the first quarter of 1990 a new vertex detector and central drift chamber were installed in ARGUS and it was running until June, but with low total luminosity 17 pb^{-1}. In July a long shut-down started for the installation of a by-pass at DORIS to produce higher intensities for synchrotron radiation users. Also a silicon detector was installed for Argus. 1991 was the last good year for Argus with a luminosity of 300 pb^{-1} which allowed the production of many interesting data.

But 1992 became a fatal year for ARGUS. The bypass turned out to be very useful for synchrotron radiation but a catastrophe for high-energy physics. The previously reached high luminosities could never be achieved again. Only a total luminosity of 17 pb^{-1} could be obtained in 1992 and in October ARGUS stopped data taking after a mishap (damage of the silicon vertex detector by the beam) had occurred. V.Soergel asked the Extended

[5] G. Arnison et al. (UA1), Phys. Lett. B147 (1987) 493

Scientific Council on 26 November 1992 for advice on the future DORIS programme. It was decided that the high-energy physics programme should be abandoned if the previously achieved luminosities could not be reproduced until spring 1993. This attempt failed and B.Wiik who had followed V.Soergel as chairman of the Directorate, had to inform the Extended Scientific Council on 17 June 1993 that in agreement with the ARGUS group the Directorate had decided to stop DORIS II for particle physics. The achievements of ARGUS were acknowledged in a colloquium on 22 November 1993 by D.Cassels and B.Stech.

This is the short story of ARGUS and how it contributed to the reputation of DESY. Looking back this seems to have been the Golden past when decisions could be taken and implemented at short notice. More details will be reported by other authors at this meeting.

DESY will remain an outstanding laboratory for particle physics, even with HERA having stopped to operate and PETRA being converted into a dedicated synchrotron radiation facility. Of course, emphasis will change but accelerator and detector development will remain a major part of the DESY programme. Participation in experiments at other laboratories will be another important objective in which case DESY should also have the task to support groups from other German universities or laboratories. Non-accelerator experiments will remain an essential activity of DESY – Zeuthen. Together with new facilities such as the free electron X-ray laser, DESY has, as I am certain, a bright future for which I transmit my best wishes.

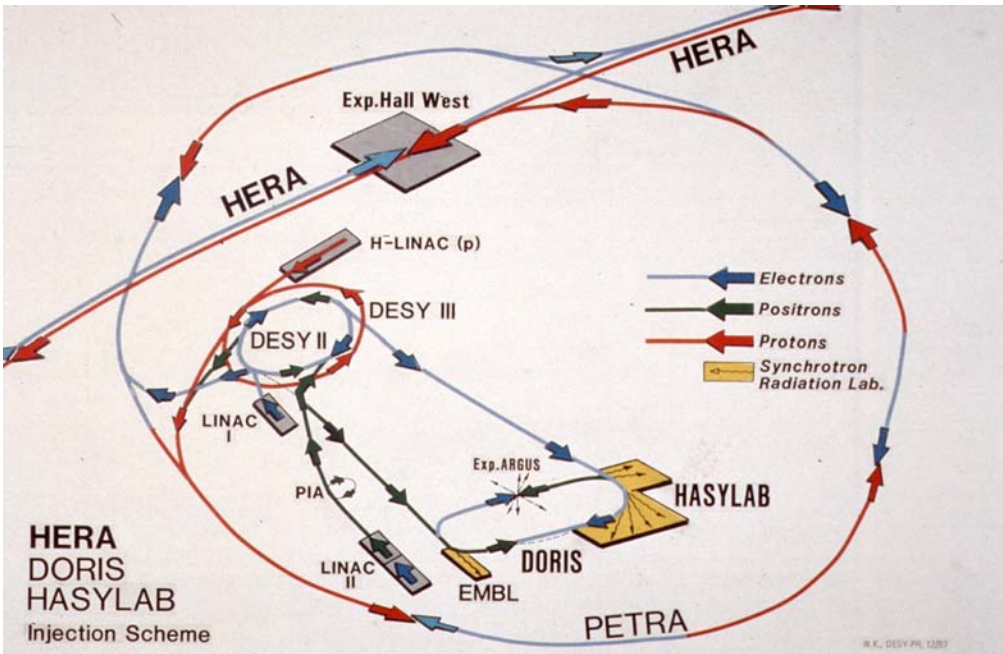
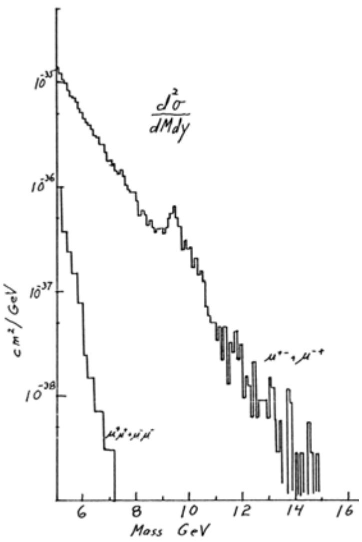


Fig.1. The plan of DESY

FNAL
First evidence of Upsilon



DASP
Upsilon resonances resolved

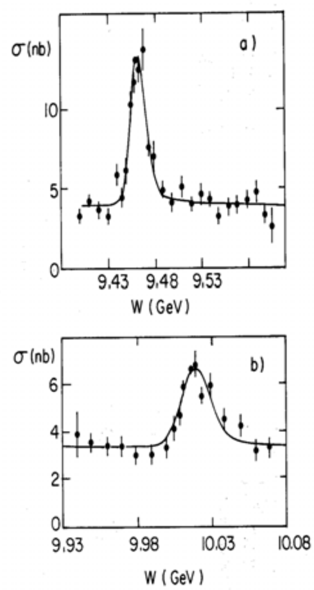


Fig.2. The discovery of the Upsilon

Fig.3. The ARGUS crew

Fig.4. Jentschke, Schopper and Soergel in 1980

Fig.5. Schopper baptises a new born tiger at the name TOP in the zoo of Leipzig with the director of the zoo watching