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History of EISCAT – Part 4: On the German contribution to the early years of EISCAT

Gerhard Haerendel

Max Planck Institute for Extraterrestrial Physics, Garching, Germany

Correspondence to: Gerhard Haerendel (hae@mpe.mpg.de)

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Abstract. The decision of the Max Planck Society (MPG) to get involved in the establishment of an incoherent scatter radar in northern Europe was intimately linked to the future of the Max Planck Institute for Aeronomy (MPAe) in Katlenburg-Lindau. Delegates of the MPG played an important role in defining the rules for participation in EISCAT during the period from 1973 to 1975. The "technical" period from 1976 to 1981 was mainly devoted to the development of the UHF transmitter and the klystrons. The latter encountered great difficulties, causing substantial delays. During the same period the ionospheric heating facility was established by MPAe at Ramfjordmoen, Norway. The period following the inauguration in August 1981 saw a great number of changes in the leading personnel. In this context much attention had to be given to taxation rules. Besides continuing hardware problems with the UHF radar, severe problems arose with design and manufacturing of the VHF klystrons, requiring changes of the contractor. However, by fall of 1983 the UHF radar was able to reach the intended operational level. In 1984 important steps were made for archiving and for proper exploitation of the EISCAT data.

1 The scientific roots

The roots of the participation of Germany in EISCAT were twofold: the work with ionosondes at the Max Planck Institute for Aeronomy (MPAe) at Lindau (now Max Planck Institute for Solar System Research (MPS) at Göttingen) and the work with barium plasma clouds at the Max Planck Institute for extraterrestrial Physics (MPE) at Garching. At MPAe it was in particular Harry Kohl, the expert on ionospheric winds, who discovered the potential of the incoherent scatter radar technique early, while his colleague, Walter Becker, the expert on ionosondes, was initially very skeptical. At MPE it was the derivation of magnetospheric electric fields or plasma drifts from the motion of the barium plasma clouds seeded in the ionosphere which opened our eyes to the potential of other techniques with the same objectives. Since late 1963 we had performed quite a few sounding rocket campaigns, at the Equator, at mid-latitudes, and in the auroral zone and had already created maps of typical ionospheric–magnetospheric plasma motions, when I very logically attended the regional URSI conference at MPAe 24–25 June 1969 and subsequently the URSI General Assembly in Ottawa in August of the same year. It was probably through the presentation of Bengt Hultqvist at the first of these events and attending the session of URSI Commission IV on quasi-DC electric fields at the second event that I strongly widened my knowledge of the incoherent scatter technique. My interest grew further when I read the paper of Farley et al. (1970) on the phenomenon of equatorial spread F observed with the Jicamarca incoherent scatter radar. In 1969 to 1971 I was continuously in contact with my colleagues at Lindau and J. W. (Joe) King at Slough on these matters, although it was clear that our institute would not get actively involved in the upcoming plans of a European radar. I learned more about such ideas at the planning meeting in Stockholm 17–18 September 1970 to which Bengt Hultqvist had invited me and at which consensus was reached with the French delegation on establishing the radar in the auroral zone. Only one month later, I drove by car to Nançay, accompanied by my wife, to a wider meeting organized by François du Castel, where we were both impressed by the group assembled, in particular by the chairman, Tor Hagfors, and the excellent French hospitality. On the German side it was Harry Kohl who subsequently contributed to the joint proposal, called

the "Green Book", which emerged from the accord that had been reached during this period (Du Castel et al., 1971).

Between these latter meetings I had written a letter to Walter Dieminger, director of MPAe, pointing out the enormous potential of this new technique for the scientific goals of his institute. To my surprise the initial reaction was lukewarm. Dieminger in a later conversation told me that their backscatter observations were equally powerful in determining ionospheric plasma drifts as the much more demanding incoherent scatter technique. In June 1971 I attended the working meeting at Titisee in the Black Forest organized by Harry Kohl, where the "Green Book" was presented. This was a compilation of reports presented at a meeting in Helsinki in May 1971. It was probably in fall of that year that Walter Dieminger and his wife, passing through Garching on their return from vacation, visited me to let me know that he had changed his opinion and saw a future for MPAe in what had meanwhile been named EISCAT by Bengt Hultqvist. My diary tells me that on 15 November 1971 there was a discussion at the headquarters of Max Planck Society (MPG). It must have been on that occasion that I informed Friedrich Schneider, the General Secretary of the MPG, about the plans for EISCAT and the great potential that facility had for the future of the institute at Lindau. On 6 June 1972 Walter Dieminger and Georg Pfotzer came to MPE for further discussions. As documentation of the emerging role of MPAe, I include Fig. 1 from Harry Kohl's article in the 25-year-anniversary book of MPAe printed in 1972 showing the EISCAT configuration already with Tromsø as the transmitter site (Kohl, 1972). Among the still small number of German scientists paying attention to the conception phase of EISCAT, it was Harry Kohl who maintained the strongest ties.

In the early 1970s I had taken a strong theoretical interest in the phenomenon of equatorial spread F. To this end MPE had conducted a rocket campaign in Thumba, southern India, in March 1972, with the aim of artificially triggering the related instabilities. Ben Balsley and his mobile VHF radar had participated. This led also to long-lasting relations with Ron Woodman, Don Farley, and César LaHoz, to visits of the Jicamarca incoherent scatter radar, and increased my personal interest in making use of this technique. It was possibly during the second half of that year, when I was absent from Germany, that it was decided within the Max Planck Society to take an active interest in the development of EISCAT. This became apparent when, on 25 October 1973 in London, Friedrich Schneider assumed the role of chairman of the new steering committee for the development of the EISCAT radar. At this meeting the EISCAT project was in an uneasy situation. Every potential member was waiting for the other to make a commitment. It was Schneider who broke this deadlock, stating that he was authorized by the MPG to promise a substantial contribution at once and more in the following years, provided that France and the Scandinavian countries would contribute to the project as well. From then on, MPAe assumed an active role in the development of EISCAT, in particular after the appointment of Ian Axford as director of MPAe in July 1974. MPE remained an interested observer and potential user. Building payloads for sounding rockets and satellites and performing several observing campaigns per year in remote areas did not allow us to truly cooperate.

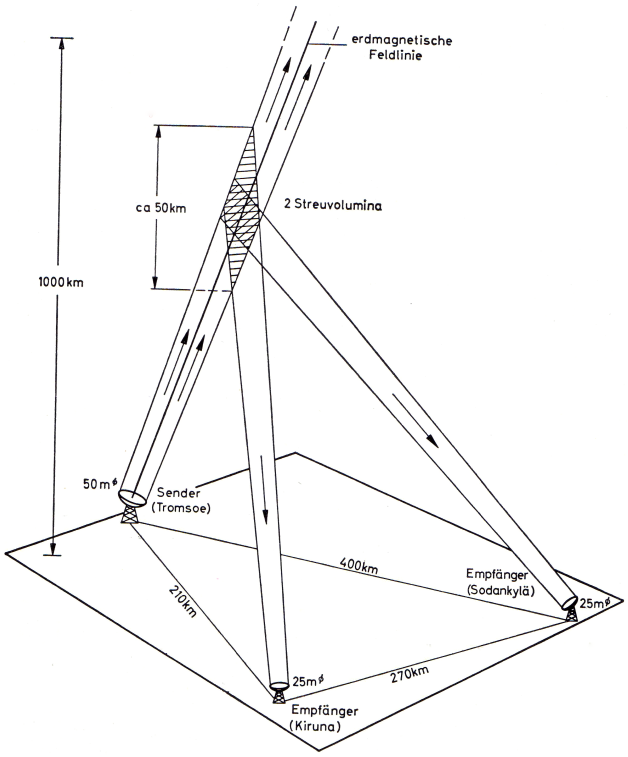

Figure 1. EISCAT configuration after H. Kohl (1972). It should be noted that in this figure a fixed dish of 50 m diameter was suggested for the transmitter site. This concept was substantially changed at a later time due to Ian Axford's intervention in favor of a fully steerable dish.

2 Defining the EISCAT rules

During the period from 25 October 1973 to 25 April 1975 the structure of EISCAT assumed shape and the first hardware concept; the UHF radar became defined. This was the time of the steering committee which was strongly dominated by a French–German dialogue, Jacqueline Mirabel and Pierre Creyssel of the Centre National de la Recherche Scientifique (CNRS) on the one hand and Friedrich Schneider, and Günter Preiss on the other, Friedrich Schneider acting as chairman. The first half of 1974 was filled with exchanges of draft agreements between Paris and Munich. Between January and April I participated in several small meetings in Munich, Paris, and London, with Jean Delhaye, Harry Atkinson, Friedrich Schneider and Günter Preiss. By June there was agreement on the division of the operational funding. It was fixed to be 25 % each from France, Germany, and UK, provided the latter was able to join EISCAT by June 1975, and

the residual 25 % were to be shared by the three Nordic countries. The MPG and CNRS were to share the responsibility for providing the UHF transmitter and antennas. The door was held open for the Science Research Council (SRC) of UK to join with a contribution equivalent to those of CNRS and MPG. The numbers of representatives of the council and scientific advisory committee were fixed, and the duration of the association was set to be 13 years from the date of signing the agreement. The steering committee meeting in Hamburg on 27 July was pretty much devoted to editing of that document. Most important was the establishment of a project group, to be headed by Tor Hagfors, for the technical planning of the radar facility. Its first meeting took place at Trondheim on 23 September. From the German side, Ian Axford and K. H. Geisweid from MPAe participated.

All of the above was reviewed and amended during the steering committee meeting in Paris on 26 September 1974. Points of discussion were the legal status of EISCAT with preference for a legal entity of its own, confirmation of Kiruna as site of the EISCAT Headquarters, restriction to a UHF system for the time being, and whether CNRS and MPG should maintain a common financial pool for the hardware funding. The procedures for tender were debated but not finalized, in particular whether orders should go to the member states. Bengt Hultqvist presented a report on the distribution of investment and running costs between Suomen Akatemia (SA), Finland, Norges Almenvitenskaplig Forskningsråd (NAVF), Norway, and Statens Naturvetenskapliga Forskningsråd (NFR), Sweden. G. Preiss, A. Schwerer, and B. Hultqvist were to form a working group for formulating the bylaws.

I was unable to attend the next steering committee meeting on 14 January 1975, because I was engaged in a sounding rocket campaign in Greenland. At the said meeting CNRS, MPG, and NAVF initialed the text of the agreement, Finland and Sweden to follow within weeks. The project group was advised to press forward with planning the UHF radar. It was agreed to set up a contracts review committee (CRC).

The meeting of the steering committee on 25 April 1975 in Paris was also the last one, as it had become quite clear that EISCAT was on its way and a new level of commitment could be reached. Friedrich Schneider decided that he could resign and leave the future to the other MPG representatives. Striving for consent with all partners, he had a great share in the relatively fast progress of defining this complex international endeavor. An important issue was that G. Preiss convinced the participants that the envisaged legal status according to Swedish law would not restrain the autonomy of EISCAT. At the same meeting it was agreed to set up a provisional council and members were named. The representatives of MPG were to be W. I. Axford, G. Haerendel, and G. Preiss. At this point the very active roles of H. Kohl and K. H. Geisweid of MPAe as members of the project group and of G. Preiss for the CRC should be mentioned.

The provisional council met on 17 July in London with F. Schneider as an observer. However, he was able to conclude his work for EISCAT with signing the agreement on behalf of MPG, as did P. Creyssel for CNRS and A. Sandbo for NAVF, the other two associates to follow soon. Harry Atkinson reported on the decision of the SRC to join EISCAT on the basis of providing the VHF transmitter, with the consent of the British government still pending. Necessary amendments of the agreement were discussed in a small group on the following day. It was agreed to issue henceforward all documents only in English language but to consider the texts of the agreement in both French and English as equally binding.

The last meeting of the provisional council took place at Garching on 6 November 1975 with the UK members still in the role of observers. The chairman, Pierre Creyssel, expressed his great concern about the missing authorizations for the delegates from Sweden, Finland, and UK to sign the agreement. In addition, there were unsolved issues about the bylaws, and European industry had been unable to deliver satisfactory proposals for the transmitter. The response of the said delegations was that they assured the provisional council that the necessary authorization would be available before the end of the year. This was necessary because otherwise the EISCAT project was threatened to be reconsidered in France. Two important decisions were made: (1) the scientific association EISCAT could be constituted if the documents were signed by those organizations which would contribute at least 90 % of the overall investments (mostly for the benefit of Finland). (2) A working group was to meet under the chairmanship of G. Preiss and with a Swedish lawyer to elaborate on the open issues of the agreement and bylaws and to examine the question of contracts between the association and the Nordic countries on the installations and infrastructure to be provided by them.

Also NFR (Sweden) and SA (Finland) signed the EISCAT Agreement before the end of 1975. The agreement contained among other things the establishment of the Scientific Advisory Council (SAC), with members from all participating countries, and the appointment of two assistant directors. The first assistant directors were Svante Westerlund from Sweden and Kristen Folkestad from Norway. Furthermore, it was decided (1) that MPG, CNRS, and SRC would pay their financial shares in EISCAT into a common pool, (2) that the UHF and VHF transmitters would be combined, and (3) that tenders would be issued internationally for the construction of the combined transmitter and the antennas for UHF and VHF. The contract for the transmitters was signed in 1975 with the American company Aydin Corp., which was going to use klystrons developed by another American company called Varian. The contract to build the three UHF antennas was signed with the Canadian company Toronto Iron Works in 1977, and the VHF antenna was contracted to the German company Messerschmitt-Bölkow-Blohm (MBB) in 1978.

After the SRC had formally joined EISCAT by signing the agreement before the end of the year, Harry Atkinson proposed at the first EISCAT Council meeting on 20 January 1976 in Kiruna to abandon the CRC and integrate its functions in an administrative and finance committee (AFC) which, in addition, would take the responsibility for drafting the annual capital and operating budgets and the staff complement. G. Preiss chaired this committee for many years. The meeting has been described extensively by Hultqvist (2011).

The summary of activities given in this section exhibits the strong role played by the Max Planck Society represented by Friedrich Schneider and Günter Preiss and the CNRS represented by Pierre Creyssel and Jacqueline Mirabel for the legal and financial foundation of the scientific association EISCAT.

3 A few remarks on the period 1976–1981

Hultqvist (2011) properly named these five years of development of the UHF system the "technical" period. It stretched longer than expected because of the unforeseen problems with the development of the klystrons by Varian. All the same, we were sufficiently confident in the progress that the German associate held an EISCAT winter school in Oberstdorf in January 1979 under beautiful snow conditions, in order to train interested scientists in making use of the new system. There were many young participants, and practically all leading experts in the incoherent scatter technique were involved as lecturers (e.g., Tor Hagfors, John Evans, Ron Woodman, and Don Farley).

In November 1979, the council had decided to set up a small expert committee on klystrons chaired by the director with the task to visit Varian and inspect and analyze design and manufacturing of the electron beam tubes. At their visit in December 1979, the problems still existing were analyzed and also the performance problems encountered after installation in the transmitter at Aydin. After that, progress was rather rapid and delivery to Aydin was expected to happen in March 1980. All the same, the chairman, Sir Granville Beynon, felt that the envisaged date for the inauguration on 27 August 1980 could not be maintained and had to be delayed until 1981.

At its November 1979 meeting, the council had decided to offer the position of assistant director of science to P. J. S. (Phil) Williams from the University College of Wales, Aberystwyth. In order to cope with the Swedish tax laws, he was seconded from SRC in England and was given assurance that EISCAT would refund him for any Swedish tax he might have to pay in addition to the UK taxes already deducted. Such special arrangements in response to the extreme Swedish taxes were also made on later occasions.

Another important asset to EISCAT was the Heating facility installed by MPAe at Ramfjordmoen between 1977 and 1980. The facility consisted of 12 HF radio transmitters generating CW power in the frequency range from 2.5 to 8 MHz with up to 125 kW per transmitter. It turned out to be extremely successful in performing a wide range of plasma experiments including ionospheric modifications, creation of short-scale field-parallel irregularities, trigger of parametric plasma instabilities, airglow, and polar electrojet modifications (Stubbe et al., 1982). The facility was inaugurated in September 1980. The choice of location was made with the obvious intention that EISCAT could serve as a diagnostic tool for changes of the temperature as well as for enhancements of electron and ion-acoustic wave activity. In addition to Heating there was a dedicated diagnostic HF radio-wave propagation experiment installed. Furthermore, the STARE (Scandinavian Twin Auroral Radar Experiment) backscatter radar (Nielsen and Schmidt, 2014) and a host of other diagnostic geophysical instruments not too far from Tromsø made the location most suitable.

On the negative side, one soon discovered substantial interference between the Heating and EISCAT operations. At the request of the EISCAT Council in November 1983 the involved parties agreed on a coordination between Heating and EISCAT operations at an early stage. In 1992, the Heating facility was integrated in EISCAT.

On 17 April 1980 a meeting was held alongside the Fifth ESA Symposium on European Rocket and Balloon Programmes and Related Research at Bournemouth, UK, with the goal to exploit EISCAT for coordinated measurements with the GEOS 2 satellite at geostationary orbit. This spacecraft was to be reactivated during the first half of 1981. A wide group of interested scientists, chaired by Henry Rishbeth, participated in discussing the various aspects of ionospheric, auroral, and magnetospheric physics on which such coordinated measurements could shed light. It also served in whetting the appetite of many researchers to soon get their hands on EISCAT data. I believe that not much came out of this initiative because of the initial problems of the radar, but the Bournemouth meeting had another aspect for me. I had the opportunity to present for the first time my theory of auroral arcs. During the subsequent years of EISCAT operation, my group at MPE exploited EISCAT to verify some of the observational implications of that theoretical concept.

4 First years of operation and the VHF radar

Hultqvist (2011) has nicely described the inauguration ceremony on 26 August 1981. I attended the event at Tromsø. There is one little observation worth reporting. EISCAT had chartered a plane to deliver the participants to Kiruna and Tromsø. We gathered at Arlanda airport. When admitted to board the plane, I wondered why there was no security inspection, which was already common at that time. When seated in the cabin, there was a long wait until the plane finally took off. Then came the announcement: "Your Majesty,

ladies and gentlemen, . . . ". I was deeply impressed by this manifestation of trust in the ethics of a group of people dedicated to creating a European research facility.

After the inauguration there was a great change among the key personnel of EISCAT. Tor Hagfors had decided to leave in mid-1982 and the contract with the associate director of science, Phil Williams, expired after two years in April 1982. I followed Sir Granville Beynon as chairman of the council from 1982 until the end of 1984. The new director was found in Murray Baron from the Stanford Research Institute (SRI) in Menlo Park. Since secondment from SRI was not an option, another solution needed to be found. After long negotiations with Swedish authorities, Bengt Hulqvist succeeded in creating a visiting professorship for Murray Baron for two years less one day at the Kiruna Geophysical Institute (KGI), free from Swedish taxes but liable to taxes in the USA. On 23 April 1982 I signed the agreement with KGI that Dr. Baron was entirely at the disposal of EISCAT. I had the pleasure to negotiate with Murray the detailed terms and conditions. An easier solution was found for Jürgen Röttger from MPAe, who was appointed as the associate director of science for a period of two years from May 1982 and seconded from his institute, which was reimbursed by EISCAT.

One important meeting of the council was held at Sodankylä in May 1983, just at the last moment before the invasion of mosquitos. I remember the impressive hospitality. We were greeted by the Lady Mayor and treated to one of the best salmon dinners in the evening. The dominant subject of concern to the council during that period was the considerable hardware and software problems with the UHF system. It had persisted all of 1982 and most of 1983. Among other things, the UHF klystron beam geometry had to be redesigned. After having retired from EISCAT, Tor Hagfors wrote me a letter in November 1982 suggesting to hire an experienced RF high-power engineer to help solve the transmitter problems at the site. Hard financial negotiations were held with Aydin. Only at the end of this troublesome period could the director announce that from October to December 1983 EISCAT had achieved and often exceeded the intended operational level. This continued into the following spring. On the positive side, 16 papers based on the first UHF data and presented at a workshop at Aussois in September 1983 were published by the *Journal for Atmospheric and Terrestrial Physics* (*JATP*) in 1984. This workshop was the first in a very successful and still continuing series of EISCAT workshops. The second took place in Aberystwyth, Wales, in 1985, and the third in Bad Lauterberg, Germany, in 1987.

The center of concern, however, was the development of the VHF system. Severe problems appeared when testing the transmitter with a klystron installed. In addition, mechanical defects were found in one of the tubes. Thus already in October 1983 I had to ask the council members for their consent to allow the director to choose Valvo, a German company, as supplier of two new klystrons, whereas Varian only offered to refurbish the damaged tubes. Although this required additional funds, a contract was concluded between MPG and Valvo on the supply of two new VHF tubes and their installation at the transmitter site at Ramfjordmoen, the first one expected for summer or fall of that year.

Towards the end of my chairmanship two important steps were made with regard of the operation of EISCAT: (1) a contract was concluded with the Centre National des Études Spatiales (CNES), Toulouse, for developing an archiving system of raw and processed data and their distribution among the six associates, and (2) guidelines were developed for the management of scientific programs, observing time and use of data.

It was very fortunate that we could extend the contract of the director for one year above the original expiration date until the end of August 1985, because rather unexpectedly the assistant technical director at Tromsø, Dr. Kristen Folkestad, had sent notice to leave EISCAT by the end of March 1984. This was a particularly severe loss, since he had overseen the whole build-up of the transmitter and its first operation at Tromsø. The secondment of Jürgen Röttger from MPAe also came to an end in April but could be extended until the end of September. His presence was of great value to EISCAT, as together with Murray Baron he helped greatly to overcome the many initial difficulties and to intensify the usage of the facility. Eventually, he returned to EISCAT, after a year as visiting scientist at the Arecibo radar, and was to become the next director. Two new faces in the leadership of EISCAT were Tauno Turunen, who joined EISCAT Headquarters as assistant director in July 1984, and César La Hoz, who started work at Tromsø, also as assistant director, in early 1985.

Negotiating contracts and finding ways to cope with the Swedish taxation laws was one of my main duties as chairman of the council besides worrying about the completion of the VHF transmitter. For all that time I enjoyed the great support from the MPG, in particular through the role of Günter Preiss as council member and as chairman of the AFC for many years, and the legal help by Heide Jantke. The perhaps greatest German contribution to EISCAT during the operational years was the secondment of Jürgen Röttger as director for a large number of years. The Max-Planck-Gesellschaft remained as the German associate to EISCAT until 2006, when it was succeeded by the Deutsche Forschungsgemeinschaft.

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References

Du Castel, F., Holt, O., Hultqvist, B., Kohl, H., and Tiuri, M.: A European Incoherent Scatter Facility in the Auroral Zone (EISCAT), Auroral Observatory, Tromsø, June 1971.

Farley, D. T., Balsley, B. B., Woodman, R. F., and McClure, J. P.: Equatorial Spread-F: Implications of VHF radar observations, J. Geophys. Res., 75, 7199–7216, 1970.

Hultqvist, B.: History of EISCAT – Part 1: On the early history of EISCAT with special reference to the Swedish part of it, Hist. Geo Space Sci., 2, 115–121, doi:10.5194/hgss-2-115-2011, 2011.

Kohl, H.: Eine geplante "incoherent-scatter" Anlage in Skandinavien, edited by: Dieminger, W., Institut für Ionosphärenphysik im Max-Planck-Institut für Aeronomie, Lindau/Harz, 171–173, 1972.

Nielsen, E. and Schmidt, W.: The STARE/SABRE story, Hist. Geo Space Sci., 5, 63–72, doi:10.5194/hgss-5-63-2014, 2014.

Stubbe, P., Kopka, H., Lauche, H., Rietfeld, M. T., Brekke, A., Holt, O., Jones, T. B., Robinson, T., Hedberg, A., Thide, B., Crochet, M., and Lotz, H. J.: Ionosphetric modification experiments in northern Scandinavia, J. Atmos. Terr. Phys., 44, 1025–1041, 1982.