



LUND UNIVERSITY

Continuity and change in the politics of European scientific collaboration

Hallonsten, Olof

Published in:
Journal of Contemporary European Research

2012

[Link to publication](#)

Citation for published version (APA):
Hallonsten, O. (2012). Continuity and change in the politics of European scientific collaboration. *Journal of Contemporary European Research*, 8(3), 300-318.

Total number of authors:
1

General rights

Unless other specific re-use rights are stated the following general rights apply:
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Journal of Contemporary European Research

Volume 8, Issue 3 (2012)

Continuity and Change in the Politics of European Scientific Collaboration

Olof Hallonsten *University of Gothenburg*

This article is based on work that has benefited from the Swedish Savings Bank Foundation Färs och Frosta Research Prize 2009. The author would also like to thank Massimo Altarelli, Karl Witte, and Christian Vettier for valuable contributions.

This article was originally submitted for publication in February 2011 and accepted in May 2011. The delay experienced in publishing is not attributable to the author.

Citation

Hallonsten, O. (2012). 'Continuity and Change in the Politics of European Scientific Collaboration', *Journal of Contemporary European Research*. 8 (3), pp. 300-319.

First published at: www.jcer.net

Abstract

Intergovernmental collaboration in the area of big science has been an important resource for European science since the 1950s. Yet, as a policy area, it has traditionally been left outside of the political integration work of the European Community/Union. Despite this formal detachment, the political realities of the collaborations often draw upon and reflect the (geo)political dynamics of Europe. This article reports on a study of two big projects in the making (the European Spallation Source and the European X-ray Free Electron Laser), and uses two historical cases for comparison (the European Laboratory for Nuclear Research and the European Synchrotron Radiation Facility). It highlights critical issues in establishing and operating collaborations, relates these to the broader context of European political integration, and discusses, on the basis of this, signs of continuity and change in this distinct area of European research policy.

Keywords

European scientific collaboration; big science; international science policy

INTRODUCTION

Europe's experience with multinational collaboration around large-scale scientific infrastructure – popularly called 'big science' – dates back to 1954 and the creation of CERN, the European Laboratory for Nuclear Research. Conceived as a peace project and talent pool for European competitiveness, CERN has been called an important a step in (Western) European integration well on par with the European Coal and Steel Community (ECSC) and the European Atomic Energy Agency (EURATOM) (Krige and Pestre, 1987; Pestre, 1987). In the following half-century, over a dozen¹ similar collaborative projects were established, with similar objectives of competence building and integration, sometimes created to run big science facilities such as reactors, accelerators, or telescopes. These collaborations are complex organisations, deeply embedded in (geo)politics and characterised by the same horse-trading as the jigsaw puzzle of political agreements that make up the European Union. Contrary to the EC/EU project, however, collaboration in scientific infrastructure and similar major undertakings in science (e.g. space programmes, joint laboratories, and other common research activities) have not been subject to coherent policymaking in Europe. Some authors have even claimed that this has actually been a success factor in these collaborative efforts, because it has left them untouched by bureaucracy and institutional inertia (Hoerber, 2009: 410; Gaubert and Lebeau, 2009: 38; Papon, 2004), but notable consequences of the incoherencies have also been a pluralistic system and an opaque and cluttered policy field. Almost every collaborative effort in large-scale science in Europe has been conceived and established on the basis of an *ad hoc* agreement. Starting with the articulation of a scientific need, the process of establishing a scientific facility involves technological design and development work at the cutting edge, as well as a vast and complex assortment of political agreements and negotiations. If successful, this political process leads to the signing of an intergovernmental agreement, sometimes comparable with an international treaty and sometimes establishing a private company with the member countries as shareholders, whereby the collaboration is founded. The variations with regard to the process and the eventual legal agreement are as many as there are collaborations; new shapes and forms have emerged for every new project.

Building on the seminal work of Krige (2003) and Papon (2004), this article updates and adds to the knowledge about European scientific collaboration in the area of large

facilities through the study of two contemporary projects, the European Spallation Source (ESS) and the European X-ray Free Electron Laser (XFEL).² Two historical cases are used for comparison, CERN and the European Synchrotron Radiation Facility (ESRF). By reporting on recent trends visible in the two contemporary cases and relating these to the two historical examples, the article shows that there is both continuity and change in the politics of European scientific collaboration. Although the small sample of cases limits the room for generalised conclusions and, as mentioned, every collaborative effort has been conceived and carried out differently, there are identifiable quandaries that appear to repeat themselves in new cases, but whose significance also clearly varies over time. The article identifies and analyses these and their impact on collaborative projects, and discusses possible implications for the overall understanding of the politics of European scientific collaboration. The article hence seeks to contribute to the literature on European research policy and the history of European scientific collaboration, as well as to highlight peculiarities in a policy area that is of significance for the understanding of European politics despite its formal detachment from the European Community/Union (EC/U).

THE POLITICS OF EUROPEAN SCIENTIFIC COLLABORATION

European scientific collaboration has been described as conceptually unique in science policy, a “new structure and a potent source of funding” for European scientists, made available after World War II (Krige, 2003: 897). A minor qualification is required; as a source of funding it is “potent” but also about *potential* – a lot of uncertainty is always involved, and many projects have historically been proposed but never realised. Despite being formally disentangled from European political integration, as set out in the introduction, collaborations around large-scale scientific infrastructure have been deeply embedded in politics, as will be discussed, and have had noteworthy importance for European integration (see below and Krige, 2006) as well as the long-term evolution of a common European science policy system.

The formal detachment from the European Union and its predecessors is historically rooted. The 1957 Treaties of Rome – establishing the Common Market as well as EURATOM – instructed the member countries to collaborate on very specific areas: coal, steel, agriculture and atomic energy. No collaborative mandate was given in the area of science and technology outside nuclear energy (Grande and Peschke, 1999: 45). The European political integration process that eventually led to the Single European Act and the Treaties of Maastricht and Lisbon was an offspring of the Common Market Treaty, whereas EURATOM after some initial failure evolved into a parent organisation for nuclear energy and thermonuclear fusion energy research activities,³ including research but only in these distinct areas (Papon, 2004: 64-65; Grande and Peschke, 1999: 45). The European Community’s lack of mandate for the promotion of science and technology was to be partly compensated from the early 1970s, when sectorial programmes aimed at closing the ‘technology gap’ were launched (Grande and Peschke, 1999: 45). These were mainly aimed at increasing competitiveness in specific sectors (such as ESPRIT, a flagship programme in information technology), well in line with international trends of science policy, to focus on innovation and applicability of research efforts, and did initially lack the ambition to maintain or develop a broad research base in Europe (Grande and Peschke, 1999: 45; Papon, 2004: 69-70). Nonetheless, in the area of large-scale scientific facilities, the EC had identified a need for coordination and appropriate support for smaller countries without national facilities and launched an *Access to Research Infrastructures* programme of EUR 30M within the Second Framework Programme (FP2, 1987-1991) to support mobility and information across the continent. This has since been successively enlarged, and in line with the mention of research infrastructures as a crucial element in the European Research Area (ERA) policy (European Commission, 2000), the share of Framework Programme funding for infrastructures has been significantly increased to several hundred million Euro. Besides

the Access programme, there is nowadays FP funding for initial planning of infrastructure projects (ESFRI, 2008). In 2002, the European Commission also established the European Strategy Forum on Research Infrastructures (ESFRI), with the mandate to develop a strategy and collect data to inform decisions, which is mainly done through the biannual Roadmap Report for European Research Infrastructures (ESFRI, 2006, 2008, 2010b). Hence while efforts on behalf of the EU have been intensified, they are limited to coordination, information and some seed funding for emerging projects.⁴

Though the historical lack of central coordination in European large-scale collaborative science projects may have been an advantage for the organisations, arguably creating dynamism and efficiency since every specific project has been allowed to meet the demands of its particular scientific community (Hoerber, 2009: 410; Gaubert and Lebeau, 2009: 38; Papon, 2004), it has also made it seemingly impossible to avoid typical pitfalls and repeated exposure to political strains within and between individual European countries. Countries normally partake in collaborations not as an activity separate from national science policy agendas but rather, from the perspective of an individual country, as “the pursuit of one’s interests by other means” (Krige, 2003: 900). Most countries realise that collaboration is necessary to achieve goals beyond the reach of any one of them, but strong traditions of sovereignty create a constant tension between self-interest and the common good, for every participating country, in every collaboration. Quite paradoxically, given the separation of large-scale scientific collaboration from the mainstream European integration process, this tension and its concrete manifestations have often been mirrors of the cycles of the general political situation in Europe, and the scientific and foreign policies of member countries of European scientific collaborations are clearly linked (Krige, 2003). The collaborations are laden with politics, not least when concerning majestic physical pieces of infrastructure that can be made symbols of collaborative spirit. CERN was clearly at least as much a product of politics as of scientific ambition (Krige, 2006); what eventually became the European Southern Observatory (ESO) was delayed eleven years due to British-French political strains in the 1960s (Woltjer, 2009); the establishment of Institute Laue-Langevin (ILL) in Grenoble in 1967 by France and Germany was reportedly the result of a reconciliatory agreement between Charles De Gaulle and Konrad Adenauer (interview: Witte); and the subsequent healthy climate in Franco-German relations in the 1980s was of significance for the creation of the ESRF (Hallonsten, 2009). A recent example is the XFEL facility – the breakthrough in the establishing process for this facility reportedly came with an agreement between Angela Merkel and Vladimir Putin that Russia would contribute substantially, made at a summit meeting in October 2007 that was otherwise described as a “cold encounter” (“Kühle Begegnung”, Kirschstein, 2007). The XFEL agreement was hence highly symbolic: “Paradoxically, just because it is seen as being a ‘non-political’ activity, scientific collaboration can be a particularly useful first and tentative step in a politically delicate context of alliance building” (Krige, 2003: 904).

CERN CRUISING ALONG AND DISRUPTING

The process of choosing a location for a facility is a typical area of controversy in the context of European scientific collaboration. The question of a site for the CERN laboratory had been a “delicate and contentious” issue even before there was a signed agreement between the member states, but the political bargaining over site selection that took place at the first meeting of the Council in 1952 appears to have been guided by the joint ambition of the member states to create a consensual and “unanimous” decision (Krige, 1987b: 239). Scientific prestige as well as the envisioned financial benefits made member countries keen on hosting the facility, but ultimately it appears that the common good of all member states was given primary importance in the negotiations.⁵

The enormous importance and impact of atomic energy for the ending of World War II had made nuclear physics a top priority for governments across the Western world, and it was no coincidence that the European 'peace project' in the shape of a joint scientific laboratory became an institute for accelerator-based nuclear and particle physics research (Krige and Pestre, 1987: 527-528). Created to complement national programmes rather than replace them, CERN did not threaten national science budgets in its first decade of existence, but was largely "cruising along" and leaning on the "universally euphoric state of the European economies at the time" (Pestre, 1990: 785; Pestre and Krige, 1992). This changed dramatically in the 1960s, when the international development in particle physics called for the expansion of CERN to keep up in the competition with the United States and the Soviet Union (see Greenberg, 1999/1967). The proposed upgrade programme was large enough to give rise to plans for a new, separate laboratory under the name 'CERN II'. Initially largely uncontroversial among the member states, the upgrade became a hot issue as soon as the idea of a new site was put on the table. Now member countries openly subjugated collaboration to their own national interest – the generally held view was that the prospective benefits of hosting CERN II were large enough to make the idea of participation without the advantage of hosting a very unfavourable option, especially among the countries contributing the most to CERN financially, i.e. France, Germany, Italy and the United Kingdom. Nearly all members proposed their own sites, and the Federal Republic of Germany (FRG) and the UK both issued ultimatums that they would withdraw completely from the collaboration should the new lab not be located within their borders (Pestre, 1996). An attempt to choose a site on so called 'scientific' grounds, i.e. by the work of an independent and 'objective' expert committee was "warmly praised, and promptly buried" (Krige, 2003: 905). In 1970, the situation was resolved by a decision to build CERN II at the existing CERN site in Geneva, and the cost reductions brought by this solution assisted in convincing the member states (Krige, 1996a; 2003).

The ultimate effect of the go-ahead decision for CERN II was that CERN became the only centre for experimental particle physics in Europe, with the exception of DESY in Hamburg (see below). The very costly construction of the new accelerator (and its sequels throughout the rest of the century) monopolised most national budgets for particle physics (Krige, 1996b). Perhaps policymakers' foresight of this development was what made member states rigidly guard their own interests during the site selection controversy. It is clear, however, that the CERN II project gave the question of *location* a whole new importance in the context of European scientific collaboration.

THE FRANCO-GERMAN ENTENTE AND THE CREATION OF THE ESRF

A general wave of renewed Europeanism marked 1970s Europe, getting its momentum from the highest political levels in France and the FRG – the entente between these countries became the historically important "motor of Europe" that eventually drove the development towards the Maastricht Treaty and European Monetary Union (Judt, 2005; Middlemas, 1995). But the entente played an important role also in scientific collaboration, outside the EU, such as in the establishment of the ESRF.

Synchrotron radiation is extremely intense electromagnetic radiation produced by circular particle accelerators that has been used since the 1960s for experimental work, primarily in the materials and life sciences. A vast expansion of the utilisation of synchrotron radiation in the 1970s gave rise to plans, foremost within the ranks of the newly established European Science Foundation (ESF), to construct a large, dedicated synchrotron radiation laboratory as a European intergovernmental collaboration (Schmied, 1990a). In a 1977 report, an ESF working group argued that neither the qualitative nor quantitative demand for synchrotron radiation in Europe could be met by the national sources in operation and planned at the time and that a European collaborative project could be a solution to this issue (ESF, 1977). ESF had, however, no

financial or political powers, so its work was limited to studying the feasibility of the project and mobilising a scientific community around it.⁶ In May 1979, a 'feasibility study' was published by the ESF, in which the ESRF was outlined (ESF, 1979).

The location of the facility was identified as a problematic issue years before even a conceptual technical design existed or any countries had made binding declarations of support. Denmark, France, Germany, Italy, and the UK proposed sites, and co-location with CERN in Geneva was also briefly on the table (Dickson, 1984a; Schmied, 1990b). France's suggestion, Strasbourg, got passive support from Germany due to its close proximity to the German border, whereby prospects for realisation of the project were immediately improved. The facility design presented by ESF in 1984 envisioned a technically and scientifically world-leading laboratory, which reportedly gave the project some political leverage (Schmied, 1990b). Behind the scene, influential science policymakers in Grenoble managed, assisted by acts of local pork barrel politics involving support from President Mitterand, to switch the French site proposal from Strasbourg to Grenoble (Dickson, 1984b).

On 26 October 1984, France and Germany announced their joint decision to build the ESRF in Grenoble and together provide between 50 and 70 per cent of the construction costs of the facility. Other countries were invited to join (Schmied, 1990b). The same year, the First European Framework Programme for Research and Technological Development (FP1) had been launched, and the year after would see the signing of the Single European Act. The ESRF decision-making process can therefore be interpreted as a mere piece in the jigsaw puzzle of Franco-German partnership and renewed Europeanism in this era. But it did, of course, have its own political circumstances⁷ and it caused surprise and resentment among the prospective collaborating countries, who felt run over by the two big nations (Dickson, 1984b).

The Franco-German proposal was, however, gradually accepted by other countries, and in 1985, a Memorandum of Understanding was signed by France, Germany (FRG), Italy, Spain, and the UK, to go ahead with the Grenoble site. Although technical and scientific updates of the facility took a couple of years, at the time of their finalisation, the legal documents and the negotiations over budget shares had not been concluded (Haensel, 1988). The UK, expected to contribute considerably to the ESRF due to its strong scientific communities in fields utilising synchrotron radiation, had offered to pay only 7 per cent of the construction and operational costs. This caused protests from the other countries and halted the process, but after hard negotiations, the UK contribution was increased to 14 per cent, which was still considered too low and only reluctantly accepted by the other partners (Hallonsten, 2009).

The ESRF Convention was signed in Paris on 16 December 1988, by Belgium, Denmark, Finland, France, the FRG, Italy, Norway, Spain, Sweden Switzerland, and the UK. The Netherlands signed a few months later. In January 1989, construction started, and in September 1994, the facility opened for users.

CONTEMPORARY CASE ONE: THE EUROPEAN XFEL

The aforementioned monopolisation of European experimental particle physics budgets by CERN in the 1970s had one important exception; the research centre DESY (Deutsches Elektronen-Synchrotron, German Electron Synchrotron) in Hamburg, founded in the early 1960s. In the mid-1960s, DESY's research mission had been extended also to include synchrotron radiation. In the 70s and 80s, DESY constructed new accelerators and managed to keep pace with CERN and other competitors in particle physics globally (Lohrmann and Söding, 2009). In 2001, DESY particle physicists presented a technical design report for a next-generation linear accelerator named TESLA (Terra-electronvolt Energy Superconducting Linear Accelerator), with a so-called free electron laser⁸

included as a supplemental facility. The German Federal Ministry for Education and Research showed greater interest in the free electron laser than in the TESLA machine, arguably not only looking at its smaller price tag (in 2001, TESLA had an estimated total cost of at least EUR 3.5 billion, whereas the XFEL facility in a separate estimation made a year later had a price tag of EUR 648 million, Richard *et. al*, 2001; 2002) but also part of a global trend of diminishing support for particle physics in favour of more application-orientated big science (see, e.g., Westfall, 2008; Stevens, 2003; Kevles, 1997). On the Ministry's request, DESY prepared a separate design for an X-ray Free Electron Laser (XFEL) (European XFEL, 2009b; interview: Witte). Prototype work at DESY in the shape of a smaller but fully experimentally operative free electron laser, which opened in 2005, was paralleled by policymaking initiatives to make the XFEL reality as a European collaborative project at DESY – organisationally separate, but with DESY as the German representative and a major shareholder and important contributor (Lohrmann and Söding, 2009; interview: Witte).

In February 2003, the German Federal Ministry for Education and Research announced its plans to go ahead with the XFEL as a European facility located in Hamburg, and to cover approximately half of the construction costs (European XFEL, 2009b; interview: Witte). DESY's strong tradition in synchrotron radiation and accelerator construction, and the aforementioned prototype facility, made Hamburg the obvious choice of location (European XFEL, 2007a). At the end of 2004, a Memorandum of Understanding was signed by France, Germany, Greece, Italy, Spain, Sweden, Switzerland and the UK, to jointly "prepare the ground for a governmental agreement" on the construction and operation of the XFEL. During 2005, China, Denmark, Hungary, Poland and Russia joined, and in 2007, Slovakia (European XFEL, 2009b). The technical documents were updated, and preparatory work for the legal documents was undertaken, but no further agreements were made. In order to get the project started, in 2007, the project group presented a smaller 'start-up configuration' of the facility. In June the same year, despite having only 75 per cent of the construction costs covered, Germany decided to begin construction on the basis of the start-up configuration. Most countries had pledged only very small amounts of money, and it was realised that the project needed another major contributor. Russia's entrance into the collaboration in October 2007 is described by the XFEL project management as a "breakthrough" (interview: Witte) and "turning point" (interview: Altarelli) and meant an effective go-ahead. But it also presented some difficulties. The EUR 250M commitment made Russia a heavyweight at the negotiating table, and when Russian representatives began reassessing issues of intellectual property and access to the facility, it resulted in a change of rules for majorities in Council decisions so that Russia was empowered with a *de facto* veto right on certain issues, such as policy decisions regarding access. Russia entered the collaboration at 23.1 per cent of the shares, and the legal documents were rewritten so that "qualified majority" – necessary for policy decisions about scientists' access to the facility, among other things – was defined as "at least 77per cent of the share capital and the Shareholders of not more than half of the Contracting Parties voting against" (European XFEL, 2009a: 25-26).

On 30 November 2009, the XFEL convention was adopted and signed by Denmark, Germany, Greece, Hungary, Italy, Poland, Russia, Slovakia, Sweden, and Switzerland (European XFEL, 2009b). On 4 February 2010, France signed. Among the other potential collaborating partners, Spain has declared its intention to sign, the UK has withdrawn from the collaboration with reference to increased costs for existing (domestic and international) facilities, and China has left the question of participation hanging (interview: Altarelli). The construction of the XFEL is now underway, based on the start-up configuration, which originally was estimated to cost EUR 849.3M (in 2005 prices) (European XFEL, 2007b). This price tag has since been adjusted due to unfortunate price fluctuations as a result of the global financial crisis, and the start-up configuration will likely cost almost as much as the original estimations for the full facility, which means that participating countries will have to commit additional resources in the future

(interview: Altarelli). It is estimated that the first part of the facility can become operative in 2015 (European XFEL, 2009c).

CONTEMPORARY CASE TWO: THE EUROPEAN SPALLATION SOURCE

An experimental resource for materials science, complementary to synchrotron radiation, is the use of neutrons from reactors or so-called spallation sources. A reactor for this purpose has been in operation since the early 1970s at the ILL in Grenoble (Trischler and Weinberger, 2005). According to abundant claims by the European neutron source user community, the ILL plays a big part in Europe's world-leading role in neutron-based science, a lead that allegedly will be lost unless the next generation neutron source, the ESS, is made reality (Tindemans and Clausen, 2003; ESS, 2002; ESFRI, 2003; 2008).

Plans for the ESS were drafted already in the early 1990s, but didn't get any political leverage until almost a decade later, when made part of recommendations for large-scale scientific projects by the Organization for Economic Cooperation and Development (OECD) together with similar projects in Japan and the USA (ESS, 2002). Work on the Japanese and American facilities promptly began, but even at the time of their completion some seven years later, Europe still had not reached any decisions. At the end of 2008, the issue was taken up by the Competitiveness Council of the Council of the European Union, a cabinet-level EU body for issues of research, industry, and the internal market. By this time, three site contenders had crystallised – Lund in Sweden, Bilbao in Spain, and Debrecen in Hungary – and the political lobbying on behalf of the three was intense. An 'independent' review of the three sites had been undertaken by ESFRI, and though no site was explicitly favoured, the review did in a sense 'approve' all three sites and pointed out their relative strengths and weaknesses, which apparently provided some basis for decision-making (Cesarsky *et al*, 2008; ESFRI, 2009, 2010a). On the initiative of the Czech EU presidency, a meeting was summoned in Prague on 29 May 2009, with representatives of countries that had declared interest in participating in the ESS. The outcome of this meeting was decisive although no formal agreements were made – a majority of the present delegations expressed support for the Lund site, and within the following months, Spain and Hungary conceded and joined the project (ESFRI, 2009).

Despite the message in local media and elsewhere that the ESS was thereby decided upon and that it would be constructed, the decision from Prague in May 2009 and the following written statements of support from the participating countries meant nothing more than an agreement that *if* the ESS is built, it will be built in Lund (interview: Vettier). The EU has not made any decisions on the matter, and the realisation of the ESS in Lund is still a subject of negotiation between interested countries, some of whom have submitted letters of intent to the Swedish government, although with neither any formal pledges of support nor any future financial contributions specified. The current overhaul of the technical design, the scientific case, and the cost estimates is expected to be concluded in early 2013, by which time a final decision is to be made by the collaborating partners, including Sweden. Although this work is by no means finished, very detailed cost estimations and schedules for construction and commissioning are available. A "basic design", not including built-in flexibility such as opportunity for upgrades, is estimated to cost EUR 1,478M (at 2008 prices). On top of this, a number of alternative configurations are currently being developed that will be subject to negotiation between the collaborating countries (interview: Vettier). Construction at the site in Lund is set to begin in 2013, and if the current 'basic design' is eventually implemented, the ESS is expected to be fully operational, with 22 instruments, in 2025.

CRITICAL ISSUES: SITE SELECTIONS, FAIR RETURN, AND IN-KIND CONTRIBUTIONS

The introductory paragraphs identified a constant tension in the politics of European scientific collaboration, that originates in the argument that such collaboration “always involves a loss of, or at least a dilution of, national sovereignty,” a loss that is “accepted but not taken for granted,” and whose “scope is limited, carefully monitored and constantly re-evaluated” (Krige, 2003: 900). In the following sections, the two contemporary and two historical case studies will be used to highlight some specific policy areas where the tension between self-interest and common good shows itself most conspicuously.

Troubles in connection with site selection have been set out above. Decision-making processes are generally surrounded by ample expectations of socio-economic benefits brought to the host country and region by an international research facility, such as the possibility of an emerging high-tech sector around the facility, a well-educated and well-paid workforce moving in, not to mention prestige.⁹ To this should be added the potential benefits for the local scientific community and the risk of being disadvantaged by not hosting – countries may well be forced to reallocate science funding to the new facility abroad at the expense of national programmes (Widmalm, 1993).

As mentioned, the site selection for the original CERN laboratory had elements of bargaining and the safeguarding of national interests, but the allegiance to the common good appeared to be primary at the time (Krige, 1987b). By comparison, the CERN II site selection process was tortuous, including (temporary) withdrawals of Germany and the UK from the collaboration, and it was only resolved by the decision to build the new laboratory at the existing CERN site, which was considered relatively uncontroversial. Regarding the ESRF, for which several countries also made site bids, it seems the bilateral agreement between France and Germany was crucial for resolving the issue, although of course politically viable alternatives may have existed that are not known. The ESS seems perhaps to have had the most difficult site selection process – first drafted back in the early 1990s, the project was outrun by both of its international contenders, and though three clear candidates for hosting had crystallised in 2008, a lot of reluctance or even active resistance seems to have lingered, among European neutron users and in the European scientific communities in general. The project was reportedly “plagued by the unwillingness of European scientists collectively to solve the question of a site” because of “a kind of acceptance that it is never going to happen” (interview: Carlile). The neutron community was allegedly afraid that any government’s commitments to the ESS would simultaneously reduce their national efforts in the area or their contributions to the ILL, or delay or cancel their involvement in the recently initiated ILL upgrade project (interview: Carlile). When a site decision was finally reached, in 2009, it was on the basis of a lengthy process where, after years of negotiation and lobbying, a sufficient number of European countries affiliated themselves with one candidate.

Logically, a predefined site would eliminate much of the difficulty, and the history of the European Southern Observatory (ESO), located in Chile, seems to partly confirm this, although another political disagreement also caused delays.¹⁰ However, later cases show that a predefined site may also become a liability to the host country, because other countries appear to have less interest in participation if the site is already agreed upon. DESY have had trouble attracting the necessary foreign investment for their accelerator projects, being legally all-German projects as well as all being predestined for Hamburg (Lohrmann and Söding, 2009). Hamburg was also the predefined site for the XFEL, and this has reportedly made Germany’s efforts to get other countries to join far more difficult than in previous cases where there was at least a theoretical chance for everyone in the game to win the prize (interview: Witte).

It could be argued that site selection processes have become more dominated by national interest because facilities like the ESRF, the XFEL and the ESS host research activities that in comparison with CERN and ESO (particle physics and astronomy, respectively) are closer to the market and therefore more attractive from the perspective of local and regional commercial spin-offs from the facility. Proving or rejecting such a hypothesis is difficult. Available empirical studies on the matter focus on CERN (Schmied, 1987; Nordberg, 1994), and it appears no clear connection can be established between the activities at ILL and ESRF and the industrial spin-offs in the Grenoble region¹¹ (Papon, 2004). Despite this lack of evidence, it is not unreasonable to conclude that policymakers act partly on the basis of prospects or expectations of industrial applicability and spin-offs from the facilities.

One of the mechanisms that has been put in place to counter the imbalance effects of investment and return that may make hosting of a facility a major economic boost for the local region is so-called *Fair Return* (or *Juste Retour*) on procurement. This policy dates back to the creation of CERN and was institutionalised in the ESRF and codified in its financial rules document,¹² in which it is stated that the collected value of contracts awarded to firms in a member country should, in the long term, reflect that country's relative contribution to the ESRF budget (Krige, 1987a; ESRF, 2001). Although subordinated to the principle to always achieve best value for money, the Fair Return policy does in practice force the ESRF administration always to look for tenders from firms in countries that are "poorly balanced" and give them the contract if they can align with the cheapest offer (ESRF, 2001: 10; Hallonsten, 2009). Fair Return nowadays fall under the category of infringement of the competition policy of the EU's common market of (Leonhard 2010), which has meant that for new collaborations such as the ESS and the XFEL, procurement Fair Return policies are not applied.

One solution that could replace the procurement Fair Return policy is the application of *in-kind contributions* by member states – i.e. the opportunity for member countries to substitute direct financial investment in a facility for the delivery of goods and technology and thus spend their money domestically¹³. The policy does, however, have potential drawbacks; restricting the call for tender to the participating countries might exclude competitive alternatives, and there is also a risk that at the time of delivery, which might be several years after the in-kind agreement was made, the best qualified company may no longer be in the country providing the particular in-kind contribution. Both the ESS and the XFEL projects will rely heavily on in-kind contributions – approximately half of the total investment, according to estimates (ESS, 2011: 22; interview: Altarelli).

CRITICAL ISSUES: SCIENTIFIC FAIR RETURN

Though connected to foreign policy and the foreseen socio-economic benefits, the prime motivation for a country to participate in a European scientific collaboration is likely to be scientific. For member countries, collaborations are often extensions of national science policy, "the pursuit of one's interests by other means," and the balance between investment and return is carefully monitored in this area as well (Krige, 2003: 900).

The scientific facilities under study here are all *user facilities*, i.e. their prime purpose is to serve researchers from academia and other institutions who make shorter visits to the facilities to conduct experiments (except for CERN, where experiments are comparatively long-term). Access is decided on a competitive basis, through an organised peer review process in which scientific quality and technical feasibility of experiment proposals are normally the only (official) assessment criteria. In many of the fields that use neutron, synchrotron radiation, and free-electron laser facilities, experimental time at the leading facilities is simultaneously the most valued commodity and the most crucial resource – not only because it is normally free of charge but because facilities often provide unique

experiment opportunities and thus allow groups to conduct research at the forefront of their field (Hallonsten, 2009). At collaborative facilities, the principle of providing access to researchers solely on the basis of scientific quality and technical feasibility, with no reference to nationality or institutional belonging, is simultaneously lauded and considered somewhat suspect. Officially, by virtue of representing the highest scientific quality it is declared to be in everybody's interest, but participating countries also expect their investment to be matched by availability for their domestic scientific community.

The legal documents regulating the ESRF and the XFEL refer to the possibility of a "lasting and significant imbalance" between a member country's contribution and the use of the facility by this country's scientific community, and that the council of representatives from the participating countries "may decide measures" (ESRF, 1988) or "create the prerequisites" (European XFEL, 2009a) to correct this imbalance. The assertions are not qualified further.

In the late 1990s, the user statistics for the ESRF revealed just such a "lasting and significant imbalance", especially a constant under-use by German and Italian scientists and over-use by the scientific communities of the Nordic countries and the UK. After lengthy discussion of the problem in the ESRF council, a conclusion was reached that a *scientific* Fair Return policy be implemented through the use of a computer programme that would readjust the allocation of experimental time slightly, after the ordinary peer review process, to correct the imbalances. The algorithm used does not affect either the highest nor the lowest rated experiment proposals, and so it could be argued that it is only the groups around the cut-off limit that are meddled with; but the real effect of the policy is a partial subordination of scientific quality to nationality (Hallonsten, 2009: 242-246). Scientific Fair Return also has possible problematic legal implications. The facilities under study here are usually exempt from value-added taxes (VAT), because of their special international status and because experimental time is awarded free of charge. Scientific Fair Return, which means associating the budget contributions of the member countries with their scientific communities' share of the use of the facility, may make experimental time appear as a purchased service for which, according to most national standards, VAT should be paid. Attempts to evade the risk of such an interpretation by tax authorities, while still keeping the possibility for a scientific Fair Return policy open, was an important part of the work in drafting the XFEL legal documents (interview: Altarelli). It is clearly a problematic issue both from the legal and scientific points of view.

Although scientific Fair Return was implemented at the ESRF in the late 1990s and the policy is still in place, there is reportedly a consensus among European countries today – at least those participating in the XFEL collaboration – that scientific Fair Return is a non-preferable option and that, if used at all, it should be limited to a minimum and without question be subordinated to scientific quality guaranteed by peer review (interview: Altarelli). This consensus has one interesting exception – Russia's entering into the XFEL collaboration brought delay to the process because of expectations from the Russian representatives that investment and use should be balanced in detail, to the extent that countries would be allowed to sell the slots of experimental time they would not use (interview: Witte). It is apparently the official standpoint of the Russian shareholder in XFEL, the Russian Corporation of Nanotechnologies, that experimental time should be distributed among the scientific communities of the member countries in accordance with the relative size of their investment. In a press release from 27 November 2009, announcing Russia's signing of the XFEL convention, the Russian Corporation of Nanotechnologies writes: "The main resource of the complex – beam usage time – *will be* shared proportionally to each country's contribution to the project" (Russian Corporation of Nanotechnologies, 2009, emphasis added).

RE-NATIONALISATION?

Papon (2004: 70) suggests that a “re-nationalisation” trend started to show in European scientific collaboration in the 1980s and on, with origins in the growing expenditures of CERN and ESA that made European countries look increasingly to their domestic interest rather than to the wealth of collaborations. Examples include a major all-German accelerator project (at DESY) as well as the emergence in the 1990s of several national synchrotron radiation facilities across Europe (such as Elettra in Trieste, Bessy II in Berlin, Swiss Light Source in Villigen, and MAX II in Lund, Sweden). It is difficult to assess the accuracy of the suggestion, not least since national facilities indeed have been built and operated in European countries since the 1950s, parallel to collaborative projects. Furthermore, a re-emergence of national facilities in the 1990s should be seen in light of the 1970s decrease in the number of national particle physics facilities after the establishment of CERN II, whereby such a re-nationalisation trend would signify a return to the normal. It is, however, possible to suggest another re-nationalisation trend in the cases under study here, conceptualised rather as increased guarding of national interest in the processes of establishing collaborations. The practical implementation of the previously only formally existing scientific Fair Return policy at ESRF in the late 1990s is one indication of this, as is the heavy reliance on in-kind contributions at both the ESS and the XFEL. Another sign – although blame is laid on the economic crisis and associated budget austerity – is Britain’s and Italy’s recent lowering of their contributions to the ESRF, which led to a cutting of the facility’s overall budget by 6 per cent and some reduction of capacity (ESRF, 2010).

In the case of the XFEL, there are further indications of an increase in the guarding of national interest at the expense of the common good. Massimo Altarelli, who is managing director of the European XFEL project and who has been Scientific Director at ESRF and Director of the Italian national synchrotron radiation laboratory, Elettra, has identified what he calls a “perverted mechanism” in the issue of investments, shares, and the expectations of fair return, that makes countries enter the collaboration at the lowest possible level. The background is the following. The minimum level on which a country can enter the XFEL collaboration is one per cent of the construction costs (with one exception, Greece, who have entered at 0.4 per cent but whose future status as a member of the collaboration is not yet fully determined), which equals EUR 11M (in 2005 prices) (interview: Witte). With procurement fair return outlawed in the EU, one possibility of return for investment for member countries is gone. The shares of the participating countries are very unequally distributed, with Germany and Russia having 53.6 and 23.1 per cent, respectively, and none of the other ten countries exceeding four per cent (European XFEL, 2009a: 7). This means that even a doubling or tripling of a smaller country’s share does not increase the *de facto* relative power of that country in the collaboration. The aforementioned apparent consensus among countries that scientific Fair Return should not be implemented, and the generally controversial nature of such a policy, makes it inapplicable or at least not reliable enough to motivate a larger share. In fact, should scientific Fair Return be completely precluded and scientific quality the only standard applied, countries have little or no reason to enter the collaboration at a level higher than absolutely necessary or possible to cover by in-kind contributions, because their scientific communities will have access to the facility anyway, to the extent that they can compete with scientific quality. Here it should be added that although the German scientific community is allegedly extraordinarily strong in areas using synchrotron radiation and free electron lasers, and Russia is presently investing heavily in its public science and technology system, these countries are not likely to manage scientifically to match their shares of 53.6 and 23.1 per cent, which, in effect, means that other countries will become beneficiaries regardless of the size of their investment. In Altarelli’s view, this “perverted mechanism” is worse today compared to when the ESRF was created, and hence the motivation for countries to lower their investment in a facility is now stronger (interview: Altarelli). His testimony would thus indicate re-

nationalisation, although it is restricted to the specific case of the XFEL and hence perhaps not possible to generalise to a 'trend'.

CONCLUDING DISCUSSION

The XFEL and ESS cases show similarities with both CERN and ESRF, but also differences. The constant tension between national interest and common good is a defining factor, and it is arguably a mirror of similar strains in the EC/EU collaborations (e.g. Middlemas, 1995; Bomberg *et al*, 2008; Misa and Schot, 2005). As discussed in the introductory paragraphs, scientific collaboration and the evolution of the practical manifestations of the tension has often reflected the cycles of the general political situation in Europe. CERN was established as a part of the first wave of Europeanism after the war; ESRF was clearly linked to the Franco-German entente of the 1970s and 80s; the breakthrough for XFEL came when Germany and Russia needed a symbol of unity in a time of political disarray. National research councils and science foundations, speaking in the interests of their respective scientific communities, may have important input in early stages of the genesis of an international research facility, not least in formulating initiatives, coordinating scientific and technological planning and design work, and gathering support. Several other aspects surely weigh in when the process moves towards the decision-making stage, such as regional attractiveness and communications. The conclusion here is, however, as the cases clearly show, that *final decisions* (including site selection) are made at the highest political level, on the basis of high-level political considerations.

This influence of high-level politics on the creation and evolution of scientific collaborations also has some impact on the details of how collaborations deal with the issues of site selection, procurement contracts, and scientific access. The Franco-German agreement on the ESRF involved the location of the facility in France (and simultaneously the wind tunnel in Cologne, as already identified). Russia's involvement in the XFEL has been mentioned as crucial for the future of the project but it also brought a re-opening of negotiations over access to the facility, that are still not resolved. For both the XFEL and ESS, it appears that the heavy reliance on in-kind contributions from participants other than the hosting country is compensation for the economic benefits associated with hosting, that these other partners do not gain from.

But the tension also acts out in particular ways in specific policy areas without direct connection with the high-level politics that is involved in the launching of collaborations. Here, continuity could probably be the word of the day. The ESS site selection process was apparently just as problematic as the CERN II issue, although it perhaps to a larger degree took place backstage. The XFEL management is evidently struggling with the legal aspects of scientific use of the facility in a similar way to the ESRF management twenty years ago. The similarities between ESRF and XFEL can perhaps be partly attributed to the relative scientific and technological conformity of these two cases – on the other hand, it could be argued that this similarity should have created customs or practices over time that could help in avoiding pitfalls.

On the level of specific countries, the UK appears to be retaining the complicated attitude towards Europe and European collaboration that, among other things and in combination with a reciprocal hesitance from mainland Europe, made it a late entrant into the EC (Judt, 2005; Gowan, 1997). British participation in CERN and in the ESRF, as well as in ESO and the ILL, was long uncertain and a source of conflict (Herman, 1986; Trischler and Weinberger, 2005; Woltjer, 2009) and so far, the UK has declined to join both the ESS and the XFEL.

Some issues have clearly changed. Considering (cautiously bearing in mind the slightly overstretched comparison) the entire fifty year plus period between the founding of

CERN and the creation of ESS and XFEL, it appears as if there has been a tilt towards national interest in negotiations and general sentiment, at the expense of the common good. The site selection process for CERN reportedly had its challenges but was resolved through consensus built on recognition of what would be the best solution as a whole. In the case of the XFEL, cynical calculations of value for money apparently make smaller countries seek to enter the collaboration at the lowest level possible. The contributions from non-hosting member states to ESS and XFEL is dominated by in-kind contributions. In this comparison, for all its imperfection, CERN almost appears a manifestation of altruism. It is, however, difficult to assess whether the comparable smoothness in the politics around CERN was due to the relatively low cost of the facility (compared to the other cases discussed here, that is), the clear ambition of not letting CERN compete directly with national programmes but rather complement them, the precondition that CERN be detached from military and commercial interests laid down in its founding documents, or whether it is perhaps created at the meta-level by the romantic aura that generally surrounds the accounts of scientific and political achievement in the immediate post-war era.

Apparently evident differences between cases within a relatively small sample are always possible to attribute to individual properties and contexts, and they are thereby disqualified. Only two of the four cases have enough scientific and technical similarities to be comparable, the ESRF and the XFEL, and similarities between these two facilities have already been highlighted. Also if the sample is expanded to include ESO, JET, and the ILL as well, the seven facilities that then would make up the empirical base are all unique with respect to scientific purpose, political circumstances, historical context, and technical challenges. The conclusion would then be, and this is not at all a retreat from the ambitions of the article but rather a sober recognition – that there are few or no *broad, unequivocal trends* in the development of the politics of European scientific collaboration, only different responses to different situations, that need to be analysed for their specificity.

1. A myriad of different organisations, institutes, councils and facilities exist. This article deals exclusively with large-scale scientific facilities that are open for use by scientists and groups from universities and similar research institutions, and that are multilaterally organised and funded. Thus it does not take into account collaborative scientific facilities of 'small science' character, such as the European Molecular Biology Laboratory (EMBL), or organisations put in place to enhance multilateral collaboration between existing institutions, such as the European Space Research Organization (ESRO) or the European Space Agency (ESA) (see Krige, 2002; Gaubert and Lebeau, 2009). Excluded from the analysis are also European multilateral collaborative projects in areas closer to commercial and/or military interest (see Trischler and Weinberger, 2005; Misa and Schot, 2005).

² Interviews were conducted by the author with: Altarelli, Massimo, Managing Director of the European XFEL, Hamburg, April 19, 2010; Carlile, Colin, director of the ESS Scandinavia consortium, Lund, April 7, 2010; Vettier, Christian, scientific director at the ESS Scandinavia consortium, Lund, April 7, 2010; and Witte, Karl, Administrative Director of the European XFEL, Hamburg, April 19, 2010.

³ The Joint Research Centre (JRC) and the Joint European Torus (JET), both of which are still in operation, are funded by and run under the auspices of the EU. In recent years, the EU has played an important role in the process of establishing the International Thermonuclear Experimental Reactor (ITER), a joint EU-US-Japanese facility estimated to cost over 15 billion Euro and being built in Southern France (McCray, 2010).

⁴ This seed funding has been criticised for lack of strategic priority and for spending money in support of projects that are unlikely to succeed, which might cause national governments to stay out of more mature and feasible projects in favour of projects that they have interest in but that are less urgent from a pan-European point of view (interview: Altarelli).

⁵. It appears that in the course of the negotiations, the attraction for each individual member state of hosting the facility became subordinated to the ambition to locate it in acceptable proximity to most

countries, as well as the desire to avoid giving a large country the advantage that would come with hosting CERN. Furthermore, Geneva was favoured also because of Swiss neutrality and the tradition in Geneva of hosting international organisations, which was beneficial given the ambition to establish CERN as such (Krige, 1987b).

⁶. Created in 1974 as an NGO, the European Science Foundation is more of a network organisation for European science councils and academies than a governing body (Herman, 1986), and has, like other collaborative European organisations for science, including the facilities studied in this article, been formally separated from the EC/EU political and economic integration process.

7. The location to Grenoble was a matter of local and national French politics. Furthermore, it is argued that the ESRF was in fact the second prize behind the European Transonic Wind Tunnel (ETW), a test facility for aircraft, that both countries had interest in hosting. The decision that it would be built in Cologne was part of the same agreement that produced the ESRF settlement for Grenoble (Papon, 2004; interview: Karl Witte).

⁸. Free electron lasers are often referred to as the 'next generation' light sources, and experimental work with free electron laser radiation can be described as synchrotron radiation experiments with significant improvement on one or a couple of parameters. Just like synchrotron radiation sources, free electron lasers can be built in varying sizes and to varying costs; the XFEL is a very large facility, consisting of a 3.4 km long subterranean linear accelerator ('linac'), and is in size and cost comparable to the ESRF.

⁹ There is, however, ongoing debate whether the claims of substantial socio-economic benefits from hosting these kinds of large scale scientific facilities (e.g. Valentin *et al*, 2005; Waldegrave, 1993), often put forward by policymakers and lobbyists for specific projects, really can be proven (e.g. Papon, 2004: 71). It is not within the scope of this article to report on this discussion and its substance, as it is comprehensive enough for a separate study, but it is nonetheless important to acknowledge the emphasis with which claims of this sort are made in the decision-making processes for large scientific facilities.

¹⁰. The reported disagreement in site selection concerned a choice between South Africa and Chile and did not involve bids for sites within any member country, which arguably reduced potential disturbance and delays to the process. The background is an early agreement on a site in the southern hemisphere, which was "much less studied" than the northern at the time. The political disagreement that caused delays to the project concerned, in turn, UK hesitance and resistance, a common theme in European collaboration (see below), and whether or not ESO should share its site in Chile with the Association of Universities for Research in Astronomy (AURA) (Blaauw, 1991; Sterken, 2002; Woltjer, 2009).

¹¹ See also note 9; opinions differ widely on whether any (measurable) economic effects on local or regional level can be proven to be caused by large scientific facilities.

¹². Fair Return or Juste Retour is also extensively used in many other European collaborative efforts within the realm of science and technology, for example for the awarding of contracts within ESA (Hoerber, 2009: 406).

¹³. Though nowadays implemented with the aim of including member countries' scientific communities in the construction work for a facility and securing benefits for their local economies, in-kind contributions were once invented as a way to *avoid* direct investment in a facility. At DESY in the 1980s, the next large accelerator project was regarded as too expensive even for West Germany, the world's third largest economy at the time, to carry singlehandedly. Foreign membership in DESY was not considered an option at the time, and thus in-kind contributions from foreign countries were invited and these countries' scientific communities given partial access to the facility. Apart from attracting investment, the model brought in complementary competences to the laboratory (Lohrmann and Söding, 2009).

REFERENCES

- Blaauw, A. (1991). ESO's Early History: The European Southern Observatory from concept to reality. Garching: European Southern Observatory.
- Bomberg, E., Peterson, J. and Stubb, A. (2008). The European Union: How Does it Work? Oxford: Oxford University Press.
- Cesarsky, C., Holtkamp, N., Mason, T. and Tindemans, P. (2010) 'Assessment of the offers to host the European Spallation Source ESS in Lund, Debrecen or Bilbao'. Available at: http://www.vr.se/download/18.5bef722411d4f3021198000177/ESS_SRG.pdf, last accessed 10 December 2012.
- Dickson, D. (1984a). 'Approval Near for European Synchrotron', *Science*, 225 (4660), pp. 391-392.
- Dickson, D. (1984b). 'European Synchrotron Choice Draws Protests', *Science*, 226 (4680), pp. 1294-1295.
- ESF (1979). European Synchrotron Radiation Facility – The Feasibility Study. Strasbourg: European Science Foundation.
- ESF (1977). Synchrotron Radiation – a Perspective view for Europe. Strasbourg: European Science Foundation.
- ESFRI (2010a). 'Annual Report 2009'. Available at http://ec.europa.eu/research/infrastructures/pdf/esfri/home/annual_report_2009_en.pdf, last accessed 10 December 2012.
- ESFRI (2010b). 'Strategy Report on Research Infrastructures: Roadmap 2010'. Available at: http://ec.europa.eu/research/infrastructures/pdf/esfri-strategy_report_and_roadmap.pdf, last accessed 10 December 2012.
- ESFRI (2009) 'Draft Report of the ESFRI Working Group on Site Issues SIG on How to Identify, to Compare and to Choose the Best Sites for Pan-European Research Infrastructures in Proposing the Relevant Criteria and Optimized Procedures'. Available at: http://ec.europa.eu/research/infrastructures/pdf/esfri/publications/esfri_sig_report_en.pdf, last accessed 19 May 2011 10 December 2012.
- ESFRI (2008). 'European Roadmap for Research Infrastructures 2008'. Available at: http://ec.europa.eu/research/infrastructures/pdf/esfri_report_20090123.pdf, last accessed 10 December 2012.
- ESFRI (2006). 'European Roadmap for Research Infrastructures 2006'. Available at: http://ec.europa.eu/research/infrastructures/pdf/esfri-roadmap-report-26092006_en.pdf, last accessed 10 December 2012.
- ESFRI (2003). 'Medium to Long-term Future Scenarios for Neutron-based Science in Europe'. Available at: http://neutron.neutron-eu.net/FILES/esfri_report.pdf, last accessed 10 December 2012.
- ESRF (2010). 'ESRF science looks ahead and new solutions temporarily help funding difficulties of certain member states.' Press release. Available at: <http://www.esrf.eu/news/general-old/general-2010/council/>, last accessed 10 December 2012.
- ESRF (2001). 'Annex 4 to the ESRF Financial Rules: Regulations for the Award of Contracts' Grenoble, European Synchrotron Radiation Facility.
- ESRF (1988). 'Convention concerning the construction and operation of a European Synchrotron Radiation Facility'. Available at: <http://www.esrf.eu/about/organisation/ESRF-convention.pdf>, last accessed 10 December 2012.

ESS (2002). 'The ESS Project, Volume III: Technical Report'. Available at: http://neutron.neutron-eu.net/n_documentation/n_reports/n_ess_reports_and_more/106, last accessed 10 December 2012.

ESS (2011). ESS Activity Report 2010-2011. Available at: https://maiserxx.esss.lu.se/press/documents/ESS_activity_report_2011_lowres.pdf, last accessed 10 December 2012.

European Commission (2000). 'Towards a European research area.' http://ec.europa.eu/research/era/pdf/towards-a-european-research-area_com_2000_en.pdf, last accessed 10 December 2012.

European XFEL (2009a). Convention concerning the Construction and Operation of a European X-Ray Free-Electron Laser Facility. Available at: https://www.xfel.eu/sites/site_xfel-gmbh/content/e63617/e79992/e81065/XFELCONVAoA_E_final_eng.pdf, last accessed 10 December 2012.

European XFEL (2009b). 'Final act of the conference of plenipotentiaries for the establishment of a European X-Ray Free-Electron Laser Facility'. Available at: http://www.xfel.eu/sites/site_xfel-gmbh/content/e63617/e79992/e68656/final_act_english_eng.pdf, last accessed 10 December 2012.

European XFEL (2009c). 'European XFEL DAQ and DM computing Technical Design Report'. Available at: http://www.xfel.eu/sites/site_xfel-gmbh/content/e63617/e79991/e76533/european-xfel-computing-tdr-2009-public_eng.pdf, last accessed 10 December 2012.

European XFEL (2007a). 'The European X-Ray Free-Electron Laser Technical Design Report'. Available at: http://xfel.desy.de/localfsExplorer_read?currentPath=/afs/desy.de/group/xfel/wof/EPT/TDR/XFEL-TDR-final.pdf, last accessed 10 December 2012.

European XFEL (2007b). 'Technical Document 1 attached to the European XFEL Convention'. Available at: http://www.xfel.eu/sites/site_xfel-gmbh/content/e63617/e79992/e68651/convention_technical_document_1_eng.pdf, last accessed 10 December 2012.

Gaubert, A. and Lebeau, A. (2009). 'Reforming European space governance', *Space Policy*, 25, pp. 37-44.

Gowan, P. (1997). 'British Euro-solipsism', in P. Gowan and P. Anderson (eds), *The Question of Europe*. London: Verso, pp. 91-103.

Grande, E. and Peschke, A. (1999). 'Transnational cooperation and policy networks in European science policy-making.' *Research Policy* 28: 43-61.

Greenberg, D. S. (1999/1967). *The Politics of Pure Science*. 2nd ed. Chicago: University of Chicago Press.

Haensel, R. (1988). 'The European Synchrotron Radiation Facility', *Nuclear Instruments and Methods in Physics Research A* 266, pp. 68-73.

Hallonsten, O. (2009). *Small science on big machines: Politics and practices of synchrotron radiation laboratories*. Ph.D. diss., Lund University. Available at: <http://lup.lub.lu.se/luur/download?func=downloadFile&recordId=1419054&fileId=1419183>, last accessed 10 December 2012.

Herman, R. (1986). *The European Scientific Community*. Essex: Longman.

Hoerber, T. C. (2009). 'The European Space Agency and the European Union: The Next Step on the Road to the Stars', *Journal of Contemporary European Research*, 5(3), pp. 405-414.

Judt, T. (2005). *Postwar: A History of Europe since 1945*. London: Pimlico.

Kevles, D. J. (1997). 'Big Science and big politics in the United States: Reflections on the death of the SSC and the life of the Human Genome Project', *Historical studies in the physical and biological sciences*, 27, pp. 269-97.

Kirschstein, G. (2007). 'Kühle Begegnung zwischen Merkel und Putin', *Die Welt*, 16 October 2007.

Krige, J. (2006). *American Hegemony and the Postwar Reconstruction of Science in Europe*. Cambridge, MA: MIT Press.

Krige, J. (2003). 'The Politics of European Scientific Collaboration', in J. Krige and D. Pestre (eds), *Companion to Science in the Twentieth Century*. London: Routledge, pp. 897-918.

Krige, J. (2002). 'The birth of EMBO and the difficult road to EMBL', *Studies in History and Philosophy of Biological and Biomedical Sciences* 33, pp. 547-564.

Krige, J. (1996a). 'CERN from the mid-1960s to the late 1970s', in J. Krige (ed), *History of CERN*. Volume III. Amsterdam: North-Holland, pp. 3-38.

Krige, J. (1996b). 'The Relationship Between CERN and its 'Visitors' in the 1970s', in J. Krige (ed), *History of CERN*. Volume III. Amsterdam: North-Holland, pp. 171-206.

Krige, J. (1987a). 'Survey of developments', in A. Hermann, J. Krige, U. Mersits And D. Pestre (eds), *History of CERN*. Volume I: *Launching the European Organization for Nuclear Research*. Amsterdam: North-Holland, pp. 209-236.

Krige, J. (1987b). 'Case studies of some important decisions', in A. Hermann, J. Krige, U. Mersits and D. Pestre (eds), *History of CERN*. Volume I: *Launching the European Organization for Nuclear Research*. Amsterdam: North-Holland, pp. 237-292.

Krige, J. and Pestre, D. (1987). 'The how and why of the birth of CERN', in A. Hermann, J. Krige, U. Mersits and D. Pestre (eds), *History of CERN*. Volume I: *Launching the European Organization for Nuclear Research*. Amsterdam: North-Holland, pp. 523-544.

Leonard, D. (2010). *Guide to the European Union: The definitive guide to all aspects of the EU*. London: Profile Books.

Lohrmann, E. and Söding, P. (2009). *Von schnellen Teilchen und hellem Licht: 50 Jahre Deutsches Elektronen-Synchrotron DESY*. Weinheim: Wiley.

McCray, W. P. (2010). 'Globalization with hardware: ITER's fusion of technology, policy, and politics.' *History and Technology* 26(4): 283-312.

Middlemas, K. (1995). *Orchestrating Europe: The Informal Politics of the European Union 1973-95*. London: Fontana Press.

Misa, T. J. and Shot, J. (2005). 'Inventing Europe: Technology and the Hidden Integration of Europe', *History and Technology* 21(1), pp. 1-19.

Nordberg, M. (1994). *Contracts Benefits and Competence-based Supplier Strategy: CERN as a Case Study*. Espoo: Helsinki University of Technology.

Papon, P. (2004). 'European Scientific Cooperation and Research Infrastructures: Past Tendencies and Future Prospects', *Minerva* 42, pp. 61-76.

Pestre, D. (1996). 'The Difficult Decision, Taken in the 1960s, to Construct a 3-400 GeV Proton Synchrotron in Europe' in J. Krige (ed), *History of CERN*. Volume III. Amsterdam: North-Holland, pp. 65-96.

Pestre, D. (1990). 'Some characteristic features of CERN in the 1950s and 1960s', in A. Hermann, J. Krige, U. Mersits and D. Pestre (eds), *History of CERN*. Volume II: *Building and running the laboratory, 1954-1965*. Amsterdam: North-Holland, pp. 783-808.

- Pestre, D. (1987). 'The fusion of the initiatives, June-December 1950', in A. Hermann, J. Krige, U. Mersits and D. Pestre (eds), *History of CERN. Volume I: Launching the European Organization for Nuclear Research*. Amsterdam: North-Holland, pp. 97-122.
- Pestre, D. and Krige, J. (1992). 'Some Thoughts on the Early History of CERN', in P. Galison and B. Hevly (eds), *Big Science – The Growth of Large-Scale Research*, Stanford: Stanford University Press, pp. 78-99.
- Richard, F., Schneider, J. R., Trines, D. and Wagner, A. (2002). 'TESLA XFEL: First Stage of the X-Ray Laser Laboratory Technical Design Report Supplement'. Available at: http://tesla.desy.de/new_pages/tdr_update/supplement.pdf, last accessed 10 December 2012.
- Richard, F., Schneider, J. R., Trines, D. and Wagner, A. (2001). 'TESLA Technical Design Report'. Available at: <http://lcdev.kek.jp/TESLA-TDR/>, last accessed 10 December 2012.
- Russian Corporation of Nanotechnologies (2009). 'European XFEL project is set to start.' Press release. Available at: <http://en.rusnano.com/press-centre/news/88183>, last accessed 10 December 2012.
- Schmied, H. (1990a). 'The European synchrotron radiation story', *Synchrotron Radiation News* 3, pp. 18-22.
- Schmied, H. (1990b). 'The European synchrotron radiation story - phase II', *Synchrotron Radiation News* 4, pp. 22-26.
- Schmied, H. (1987). 'About the Quantification of the Economic Impact of Public Investments into Scientific Research', *International Journal of Technology Management* 2, pp. 711-729.
- Sterken, C. (2002). 'ESO and European astronomy: four decades of reciprocity', *Astronomische Nachrichten* 323, pp. 555-558.
- Stevens, H. (2003) 'Fundamental physics and its justifications, 1945-1993', *Historical Studies in the Physical and Biological Sciences*, 34, pp. 151-197.
- Tindemans, P. and Clausen, K. (2003). 'ESS on Hold: Europe Urgently Needs a Strategy', *Neutron News* 14, p. 2.
- Trischler, H. and Weinberger, H. (2005). 'Engineering Europe: big technologies and military systems in the making of 20th century Europe', *History and Technology* 21, pp. 49-83.
- Valentin, F., Larsen, M. T. and Heineke, N. (2005). 'Neutrons and innovations: What benefits will Denmark obtain for its science, technology and competitiveness by co-hosting an advanced large-scale research facility near Lund?' Working Paper 2005-2 from Research Centre on Biotech Business, Copenhagen Business School. Available at: <http://www.skane.se/Public/RU/Bilder/ESS/Neutrons%20and%20Innovations%20Dk%20Summary.pdf>, last accessed 10 December 2012.
- Waldegrave, W. (1993). *Economic Impacts of hosting International Scientific Facilities*. London: Crown.
- Westfall, C. (2008). 'Surviving the Squeeze: National Laboratories in the 1970s and 1980s', *Historical Studies in the Natural Sciences*, 38, pp. 475-478.
- Widmalm, S. (1993). 'Big Science in a Small Country: Sweden and CERN II', S. Lindqvist (ed), *Center on the Periphery: Historical Aspects of 20th-Century Swedish Physics*, Canton, MA: Watson Publishing International, pp. 107-140.
- Woltjer, L. (2009). 'Past and future of ESO', *Experimental Astronomy*, 26, pp. 123-132.