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Making Belgian Big Science: A History of the MYRRHA Research Reactor (1994–2010)

ABSTRACT

This article explores the history of the MYRRHA research reactor currently under construction at the Belgian Nuclear Research Centre (SCK CEN). The article demonstrates that the construction of large instruments has obtained an essential role in the moral economy of modern nuclear laboratories. First, an analysis on the internal discussion within the research center reveals how MYRRHA's transformation from a commercially oriented project into a transmutation machine was primarily characterized by the wish to upscale the project. Second, a focus on the European research landscape demonstrates how European collaboration led to further upscaling of the project, having to address technological requirements to fit into the European roadmaps. Third, an emphasis on the interaction between MYRRHA and the Belgian political and public sphere shows how MYRRHA was constructed in a narrative that made the project seem essential to the future of the nuclear research center. Based on archival material and background interviews with key players, this article contributes to our understanding of the development of Big Science in the post–Cold War era in western Europe.

KEY WORDS: MYRRHA, nuclear, EURATOM, Big Science, SCK CEN, science policy

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The following abbreviations are used: ADONIS, Accelerator Driven Operated New Irradiation System; ADOPT, Advanced Options for Partitioning and Transmutation; ADS, Accelerator Driven System; BR2, Belgian Reactor 2; ESFRI, European Strategic Forum for Research Infrastructures; GEN IV, Generation Four; IBA, Ion Beams Applications; MYRRHA, Multipurpose hYbrid Research Reactor for High-tech Applications; OECD/NEA, Organization for Economic Co-operation and Development/Nuclear Energy Agency; SAC, Scientific Advisory Committee; SCK CEN, Studiecentrum voor Kernenergie/Centre d'étude de l'énergie nucléaire; TRADE, TRiga Accelerator Driven Experiment; WAC, Wetenschappelijk Advies Committee

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INTRODUCTION

In November 2019, the Belgian Nuclear Research Centre celebrated a major investment of the Belgian Government in their new research reactor (MYRRHA) by inviting Nobel prize winner Carlo Rubbia to their symposium on MYRRHA. MYRRHA, an acronym for Multipurpose hYbrid Research Reactor for High-tech Applications, is a research infrastructure that primarily aims to demonstrate the technical feasibility to reduce the long-lived toxicity of nuclear waste and is currently under construction at the Belgian Nuclear Research Centre.[1] While the reactor is still under construction, its planning history is the subject of this article. The project was estimated at about 1.6 billion euros in 2018, with a Belgian contribution of about 40%, but originated in 1994 when it was proposed as a small-scale infrastructure estimated at approximately 25 to 50 million euros.[2] The upscaling of the project is also reflected in the shifting deadline, as construction was originally supposed to be completed by 2008 but is now set at 2036. As a large project in a small European country, MYRRHA makes an interesting case study. Due to its strong commitment to international scientific programs, Belgium is integrated in other European projects as well. Annually, Belgium contributes roughly 35 million euro to CERN and 240 million euro to the European Space Agency (ESA).[3] MYRRHA, however, is unique in the sense that Belgium initiated the project on its own, hoping to attract international funding to fully construct the reactor. Throughout its history, the project grew into a substantially larger, more expensive, and technically more complex design than initially envisaged, with significant implications for the Belgian Nuclear Research Centre.

Although upscaling is not a unique phenomenon in the history of Big Science, this article contributes to the body of literature on that topic by focusing on a small European country in the post–Cold War era. While many histories of upscaling have taken the form of success or failure stories, focusing

1. "About MYRRHA." https://myrrha.be/about-myrrha

2. Estimates fluctuated because the design and goals were a constant topic of discussion. In 1997, the ADONIS project was estimated at "less than $50 million"; in 1996, project leader Luc van den Durpel estimated the costs roughly between 1 and 2 billion Belgian Francs. Allen Zeyher, "Belgian Companies Propose New Solution for Isotope Production," *The Journal of Nuclear Medicine* 38, no. 3 (1997); "Radio-isotopen voor geneeskunde via een deeltjesversneller," *De Tijd*, 19 Mar 1996.

3. CERN, "Final Budget of the Organization for the Sixty-Seventh Financial Year, 2021," https://cds.cern.ch/record/2747877/files/English.pdf, p. 12; ESA, "ESA Budget 2022," www.esa.int/ESA_Multimedia/Images/2022/ESA_budget_2022

on the factors that determined the outcome, this article takes a different angle.[4] Here, I will focus on the period in which research priorities, funding strategies, and political support—that is, all that must happen before an instrument can actually be built and used—were established. By examining the development of the MYRRHA project from its early inception in the 1990s until 2010, I follow it through internal discussions, its trajectory through European collaborations, and its political lobbying to obtain the first (small) funding in 2010. Although the post-2010 period was important as well, I have chosen to end the analysis in 2010 for several reasons.[5] That year offers a natural end point because it marks the Belgian government's first financial commitment to the project. That year is also sufficiently distant from the present to establish some temporal distance for historical analysis.

To understand how the Belgian project expanded in costs and complexity, I draw inspiration from David Baneke's notion of normalization as an analytic tool to combine insights from historians' and political scientists' studies of Big Science.[6] The history of Big Science is often associated with the Cold War and the military-industrial-academic complex; the term offers a way to grasp the seemingly endless growth of large-scale scientific projects at that time.[7] Over the past decades, however, it has been pointed out that Big Science has become a persistent feature of science policies, an observation that this article builds upon.[8] By looking at the history of MYRRHA from this point of view, I aim to show that Big Science is not only something unique or spectacular but is to

4. Michael Riordan, Lillian Hoddeson, and Adrienne W. Kolb, *Tunnel Visions: The Rise and Fall of the Superconducting Super Collider* (Chicago: University of Chicago Press, 2015), p. x.

5. By limiting the historical analysis to 2010, several later developments in the fundamental and medical applications (nowadays known as ISOL@MYRRHA) of the reactor will not be included in this article.

6. David Baneke, "Let's Not Talk about Science: The Normalization of Big Science and the Moral Economy of Modern Astronomy," *Science, Technology, & Human Values* 20, no. 10 (2019): 1–31.

7. James H. Capshew and Karen A. Rader, "Big Science: Price to the Present," *Osiris* 7 (1992): 2–25; Peter Galison and Bruce Hevly, *Big Science: The Growth of Large-Scale Research* (Stanford, CA: Stanford University Press, 1992).

8. Aant Elzinga, "Features of the Current Science Policy Regime: Viewed in Historical Perspective," *Science and Public Policy* 39, no. 4 (2012): 416–28; Merle Jacob and Olof Hallonsten, "The Persistence of Big Science and Megascience in Research and Innovation Policy," *Science and Public Policy* 39, no. 4 (2012): 411–15; Olof Hallonsten, *Big Science Transformed: Science, Politics and Organization in Europe and the United States* (Cham: Palgrave Macmillan, 2016); Josephine V. Rekers and Kerstin Sandell, eds., *New Big Science in Focus*, Lund Studies in Arts and Cultural Sciences 8 (Lund: Lund University, 2016); Robert P. Crease and Catherine Westfall, "The New Big Science," *Physics Today* 69, no. 5 (2016): 30–36.

a certain extent business as usual for some scientific communities. While new large instruments may open up new scientific opportunities, they also provide continuity and stability for the community, and are conceived as a necessity. Big Science can in that regard be understood as part of normal science as a variation on Kuhn's concept, in the sense that it does not challenge the stability of a scientific community but rather tries to assure its stability for the future.[9]

Analyzing the planning of new instruments provides insight into what historians have called the moral economy of scientists. The concept of moral economy has been used in various ways by historians of science. While Dominique Pestre emphasized the social interactions among scientists and how they relate to the outside world in a political sense, Lorraine Daston developed a notion of moral economy that I consider more fruitful for this analysis.[10] Moral economies, by Daston's definition, are collective mental states that are at the foundation of scientific activities of a scientific community. They are not about scientists' psychology or personal motivation, nor about the ethos of the scientists. To research the moral economy of a scientific community, one looks into the values that organize the discipline and are at the foundation of its work. In the words of Patrick McCray, the moral economy entails the unwritten expectations and traditions that regulate and structure a community.[11] As David Baneke has pointed out, large instruments play an important role in the moral economy of certain scientific communities: they create careers and long-term prospects for scientists and their institutions and thus represent an important value. This is particularly helpful to understand the moral economy of nuclear physicists. Why are research reactors important to them, and how are new reactors planned? Addressing these questions expands our understanding of how the Belgian community of nuclear physicists functions and what values were at stake in their planning process.

This article also extends the notion of normalization of Big Science to the domain of European science policy. Literature on recent developments in

9. David Baneke, "Let's Not Talk about Science: The Normalization of Big Science and the Moral Economy of Modern Astronomy," *Science, Technology, & Human Values* 20, no. 10 (2019): 3–7.

10. Dominique Pestre, "The Moral and Political Economy of French Scientists in the First Half of the XXth Century," *History and Technology* 13, no. 4 (1997): 241–48; Lorraine Daston, "The Moral Economy of Science," *Osiris* 10 (1995): 2–24.

11. W. Patrick McCray, "Large Telescopes and the Moral Economy of Recent Astronomy," *Social Studies of Science* 30, no. 5 (2000): 685–711.

European science policy shows how it increasingly puts large-scale efforts in research infrastructure at the core, based on more formalized collaborations among countries.[12] This approach contributes to the existing historiography in which the ad-hoc and informal nature of European Big Science collaborations is emphasized.[13] While there continues to be an increasing body of literature on the informal politics of European Big Science, the MYRRHA project is an informative case to understand how a group of nuclear physicists planned their next large research instrument in the context of decreasing support for nuclear research, the budgetary limitations of a small country, and the increasing importance of European science policies.[14] The small size of Belgium meant that the project could not immediately rely on strong government support but had to gain credibility and money through the funding schemes of the European Commission.

The argument is structured in three sections. After a brief introduction to the original plans for a new neutron source, the first section shows that ambitions for upscaling overtook an initially small and commercially oriented project. Upscaling, I argue, became a goal in itself, as the actual research applications were identified only at a later stage. The second section highlights how European policies and roadmaps further shaped the project's ambitions, leading to a complex constellation of collaboration and competition for funding. Finally, in the third section, an analysis of the political lobbying will show how strategic arguments were advanced to obtain domestic support, making it

12. Linda Wedlin and Maria Nedeva, eds., *Towards European Science: Dynamics and Policy of an Evolving European Research Space* (Cheltenham, England: Edward Elgar Publishing, 2016); Henri Delanghe, Ugur Muldur, and Luc Soete, *European Science and Technology Policy: Towards Integration or Fragmentation?* (Cheltenham, England: Edward Elgar Publishing, 2011); Jakob Edler, Stefan Kuhlmann, and Maria Behrens, *Changing Governance of Research and Technology Policy: The European Research Area* (Cheltenham, England: Edward Elgar Publishing, 2003).

13. Olof Hallonsten, "The Politics of European Collaboration in Big Science," in *The Global Politics of Science and Technology, Vol. 2*, ed. Maximilian Mayer, Mariana Carpes, and Ruth Knoblich (Berlin, Heidelberg: Springer Berlin Heidelberg, 2014), 31–46; John Krige, "The Politics of European Scientific Collaboration," in *Science in the Twentieth Century,* ed. John Krige and Dominique Pestre (New York: Routledge, 2003), 897–918; Katharina C. Cramer, *A Political History of Big Science: The Other Europe* (London: Palgrave Macmillan, 2021).

14. An extensively studied case on complex European negotiations regarding Big Science is the European Spallation Source (ESS) in Lund (Sweden). Olof Hallonsten, *The Campaign: How a European Big Science Facility Ended up on the Peripheral Farmlands of Southern Sweden* (Lund, Sweden: Arkiv Academic Press, 2020); Olof Hallonsten, *In Pursuit of a Promise: Perspectives on the Political Process to Establish the European Spallation Source (ESS) in Lund, Sweden* (Lund, Sweden: Arkiv förlag, 2018); Tom O'Dell and Thomas Kaiserfeld, *Legitimizing ESS Big Science as a Collaboration across Boundaries.* (Lund, Sweden: Nordic Academic Press, 2014).

look inevitable to the Belgian public and politicians that the nuclear community needed a major research reactor.

Throughout the article, it will be shown how different purposes of the reactor spoke to different communities. While it was initially seen as a general neutron source, it also had ambitions in the medical field. For international collaborations, however, its potential to contribute to an alternative solution for nuclear waste was the main attraction. This possible solution, known within the community as "partitioning & transmutation" (P&T), will play a key role throughout the article and needs a brief introduction. In the most basic sense, P&T entails a strategic consideration to reduce the radiotoxicity of nuclear waste and alleviate the burden for geological disposal, which is believed to improve the public acceptability of nuclear energy.[15] This strategy implies a significant change of the nuclear fuel cycle with the introduction of advanced reprocessing and fuel fabrication. It also demands the introduction of new technology that performs transmutation. Due to the implications of this approach, this debate in the nuclear sector formed an important strategic consideration throughout the history of MYRRHA.[16]

On a methodological level, readers will notice that this article has benefitted greatly from access to the archives of the Belgian Nuclear Research Centre. The research is funded by the same institute and executed as a PhD project that is embedded at both SCK CEN and KU Leuven. Although this is not a completely unique situation, it does lead to some methodological reflections. First and foremost, the views presented in this article are my own and do not necessarily reflect those of SCK CEN or the interviewees. Second, the archival material was unique and forms the main foundation of this article, but this also comes at a cost. The documents primarily reflect the position and views of the Belgian scientists, while obtaining documents of European partners was not feasible for such a recent case study. Views of European partners are therefore based primarily on material preserved at SCK CEN's archives, or sometimes

15. For a more technical introduction, see T. Kooyman, "Current State of Partitioning and Transmutation Studies for Advanced Nuclear Fuel Cycles," *Annals of Nuclear Energy* 157 (2021): 1–7; M. Salvatores and G. Palmiotti, "Radioactive Waste Partitioning and Transmutation within Advanced Fuel Cycles: Achievements and Challenges," *Progress in Particle and Nuclear Physics* 66, no. 1 (2011): 144–66.

16. For another recent example of the complexity of scientific ambitions and industrial development in the nuclear sector, see the study on the French ASTRID reactor by Stéphanie Tillement and Frédéric Garcias, "ASTRID, Back to the Future: Bridging Scales in the Development of Nuclear Infrastructures," *Nuclear Technology* 207, no. 9 (2021): 1291–1311. https://doi.org/10.1080/00295450.2020.1868892

distilled from international reports. The same goes for political perspectives, which could not be analyzed through archival research. One hopes that future research can build upon the work presented in this article.

I: THE SEARCH FOR NEW NUCLEAR RESEARCH INFRASTRUCTURE AT SCK CEN

Large infrastructure has played an essential role throughout the history of the Belgian Research Centre. Despite its modest size, Belgium had ambitious plans for nuclear research, which led to the establishment of no less than three research reactors at the research centre already by 1962.[17] Belgium was sometimes even considered as the second nuclear nation in continental Europe, after France.[18] The Belgian Reactor 2 (BR2) had a particularly important function in the program. It was initially funded in part through European programs (EURATOM), but since 1968 was mostly used in bilateral agreements on breeder reactors. Although widely praised as a scientifically sophisticated machine, it was also believed to be a reactor that was viable financially for Belgium only when used in international programs. This undermined the position of the BR2 at SCK CEN when these projects were aborted by the end of the 1980s.[19] When the board of SCK CEN decided in 1994 to opt for a refurbishment to extend the lifetime of BR2 until 2010, it was strongly believed that a future replacement was necessary for the long-term survival of the research centre. Therefore, a strategic reflection was organized seeking innovative projects to position SCK CEN again as a leading nuclear research organization by 2010, including the quest for a replacement, in due time (around 2010), of the BR2 by new research infrastructure.[20]

17. For an elaborate introduction in the history of the Belgian Nuclear Research Centre, see Geert Vanpaemel, *Toward a Sustainable Future. The Nuclear Research Centre in Mol 1952–2022* (Belgium: Acco Uitgeverij, 2022). More specifically on the recent history of SCK CEN, see Hein Brookhuis, "Transforming Big Science in Belgium Management Consultants and the Reorganization of the Belgian Nuclear Research Center (SCK CEN) 1980–1990," *Centaurus. Journal of the European Society for the History of Science,* 64 no. 2 (2022).

18. See, for example, Siegfried Balke, "Euratom—Wirtschaftspolitisch gesehen," in *Atomwirtschaft* 3, no. 2 (1958): 44.

19. For SCK CEN, the cancellation of the DeBeNeLux project at Kalkar (Germany) meant the end of several major research programs.

20. Luc van den Durpel, interview by author, 28 Oct 2021.

While these strategic reflections were ongoing, a new project was established, called ADONIS.[21] The ADONIS project started as a collaboration between SCK CEN and the young Belgian company Ion Beams Applications (IBA), which specialized in the construction of cyclotron accelerators for medical purposes.[22] Yves Jongen, the general manager at IBA, was looking for new opportunities to develop medical isotopes in an accelerator-based system. Nuclear scientists at SCK CEN were interested in this project because it could contribute to a demonstration of a then popular new reactor concept. This proposal by Nobel laureate Carlo Rubbia envisioned coupling a reactor with an accelerator (Accelerator Driven System [ADS]). The plan enjoyed significant media attention, and even the Belgian Minister of Energy Melchior Wathelet showed an interest.[23] The basic concept of an ADS entails that the reactor is fed with neutrons externally, rather than sustaining a critical reaction itself. As a so-called subcritical reactor that carried the connotation of an inherently safe system, scientists hoped it would be politically more easily accepted in an era particularly sceptical of new nuclear infrastructure. Rubbia's concept was aimed at the production of energy, but the Belgian collaboration hoped to use his ideas for medical applications. Another reason for SCK CEN to join the project was the possibly positive political reception in Belgium of a project carried out as a collaboration between institutes from the Dutch-speaking north and the francophone south.[24]

Despite the optimism of the research group, the future of the ADONIS project was not bright. By the end of 1995, Yves Jongen had picked up rumors circulating at the British pharmaceutical company in Amersham that the Canadian medical firm NORDION was using its dominant position in nuclear medicine to secure their future income. To remain the dominant

21. ADONIS was initially an acronym for Accelerator Driven Operated Nuclear Isotope System; later, it changed to Accelerator Driven Optimized New Irradiation System.

22. Yves Jongen, interview by author, 6 Oct 2021. See also acknowledgments in Y. Jongen, "A Proton-Driven, Intense, Subcritical, Fission Neutron Source for Radioisotope Production," in *Proceedings of the International Conference on Accelerator-Driven Transmutation Technologies and Applications*, Las Vegas, Nevada, 1994, eds. Anita Rodriquez, Stan Schriber, and Edward Arthur (College Park, MD: American Institute of Physics, 1995), 858.

23. Internal report authored by L. Van Den Durpel, H. Aït Abderrahim, "Réalisation d'une unité de production de 99Mo-99mTc combinant un cyclotron et un assemblage sous-critique. Avant-Projet Technique et Financier," 1994. Private document of IBA; Raad van Bestuur SCK CEN 17 May 1995, doc. nr 4788/RvB. Proposal for collaboration-agreement with Ion Beam Applications (IBA). Private documents IBA.

24. Bureau 34, 26 Apr 1995. SCK CEN Archive 18A, 2, 6.

producer of radio-isotopes, NORDION planned to build two new reactors (MAPLE-X) and tried to force their main clients into exclusive contracts to secure funding for them.[25] Due to the potential risk that this move posed to the commercial prospects of ADONIS, the team agreed on a more aggressive public relations (PR) strategy.[26] The team reported that major figures in the ADS community, such as Carlo Rubbia (CERN) and Charles Bowman (Los Alamos), showed great interest in the project. At the same time, the PR strategy also made the ADONIS project known to the Belgian people through coverage in leading newspapers.[27] The small-scale project thus became publicly known just as its commercial outlook became questionable.

While the commercial outlook soured, the project was steered into different directions. Throughout 1995, the project caught the attention of the board, but much more explicitly as a possible replacement of the BR2. The increasing interest of the directors in ADONIS as a post-BR2 infrastructure went hand in hand with more research-oriented expectations. The ADONIS team was asked in 1996 to conduct an extension study of the concept, exploring applications beyond the production of medical isotopes.[28] To intensify this extension study, an ad-hoc committee consisting of a group of professors from Belgian universities was formed to brainstorm ideas about the further extension of the project during 1997. For the time being, it continued as ADONIS/MYRRHA, in which Myrrha, the mythological mother of Adonis, represented the extension study. The main question SCK CEN asked the professors was, "Should we invest further in building such a facility and what R&D-impact should or could resolve of it?"[29] A larger machine had to be built, but mostly because they wanted a system that would be strategically close to their BR2, while the R&D goals still had to be formulated. A future shift from ADONIS to MYRRHA reflects this ambition to upscale.

While the team in Belgium was determining the research portfolio for their reactor, the same concept experienced a major political breakthrough in

25. This issue was only solved in 1998, when NORDION retracted the strategy of exclusivity contracts. See "Competition: Commission Drops Case against Canadian Molybdenum Producer" *European Report*, 15 July 1998. www.thefreelibrary.com/COMPETITION: COMMISSION DROPS CASE AGAINST CANADIAN MOLYBDENUM . . . -a050159881

26. H. Aït Abderrahim, "Meeting Report SCK CEN & IBA," 10 Nov 1995. Private document IBA.

27. De Standaard, *Belgische doorbraak in nucleaire geneeskunde*, 16 Mar 1996; De Tijd, *Radio-isotopen voor geneeskunde via een deeltjesversneller*, 19 Mar 1996.

28. Minutes of WAC 27, 2 Sep 1996, SCK CEN Archive 4B, 7, 5.

29. "Invitation Letter for Scientific Committee," 7 Jan 1997. SCK CEN Archives, Box 18C, 2, 14.

Europe. Although these systems had been studied before by others, Carlo Rubbia first attracted media attention with his ideas for an accelerator-driven system as an Energy Amplifier in November 1993.[30] In Rubbia's view, the Energy Amplifier was a safe, clean, and sustainable alternative to existing nuclear reactors for producing energy. His ideas were critically received by his peers, including SCK CEN, but widely reported in the media.[31] Rubbia was known as a brilliant but also opportunistic scientist unafraid of presenting preliminary and bold conclusions; he would continue to play a role throughout the Belgian efforts to obtain a new reactor.[32] In 1996, the Belgian team thought that the credibility of their project was at stake because it was "too much linked to the Rubbia-story."[33] The ad-hoc committee was informed by project leader Van den Durpel that the ADS concepts promoted in the USA (by Charlie Bowman) and Europe (by Carlo Rubbia) concerned huge installations focussing on either energy production and/or the transmutation of waste, whereas SCK CEN was "dealing with a much less ambitious, however, very promising R&D-related infrastructure as general neutron source," emphasizing the difference between international and Belgian ambitions.[34] However, in September 1997, they invited Rubbia to a symposium in Mol on their ADONIS/MYRRHA-project.

What had made this seemingly radical switch possible? Rubbia's proposal had undergone an important strategic reorientation. In 1996, the controversial proposal for an Energy Amplifier was redirected to a transmutation project by an advisory group chaired by the British nuclear expert Derek Pooley, a choice that was much more in line with general developments in the ADS community.[35] Transmutation as a strategy to deal with nuclear waste had been

30. F. Carminati et al., "An Energy Amplifier for Cleaner and Inexhaustible Nuclear Energy Production Driven by a Particle Beam Accelerator," CERN Document Server, 1 Nov 1993. https://cds.cern.ch/record/256520

31. Declan Butler, "CERN Head Pushes Claim for 'safe' Reactor," *Nature* 366, no. 6454 (1 Dec 1993): 392; Ann MacLachlan, "Rubbia Accelerator-Generator Gets Skeptical Scientific Reception," *Nucleonics Week* (9 Dec 1993): 4; Pierre D'hondt et al. (1995). *Technological Assessment of the Rubbia-proposals*. https://publications.sckcen.be/portal/files/4486741/BLG_677.PDF

32. John Krige, "Distrust and Discovery: The Case of the Heavy Bosons at CERN," *Isis* 92, no. 3 (2001): 517–40; Gary Taubes, *Nobel Dreams : Power, Deceit, and the Ultimate Experiment* (Chicago: Tempus Books of Microsoft Press, 1988.

33. Raad van Bestuur 199, annex 6, 6 Nov 1996. SCK CEN Archives, Box 18A, 8, 7.

34. "Invitation Letter for Scientific Committee," 7 Jan 1997. SCK CEN Archives, Box. 18C, 2, 14.

35. W. Gudowski, *2nd International Conference on Accelerator Driven Transmutation Technologies and Applications–Conference Wrap-Up* (Sweden: Uppsala University Press 1997); James Varley, "Fast Neutron Incineration as an Alternative to Geologic Disposal: The Rubbia Proposal," *Nuclear Engineering International*, July 1997, 34–36.

considered too complicated and too expensive in the 1970s but regained political and scientific interest in the early 1990s.[36] By redirecting their plans for the Energy Amplifier into a transmutation machine, Rubbia and his team were able to gain major political support in several European countries. His long-time collaborator at CERN, Juan Antonio Rubio, promoted the construction of a European Laboratory for the Energy Amplifier (LAESA) in Spain in March 1997.[37] In Italy, Rubbia set up projects on his Energy Amplifier with Ansaldo, ENEA, and INFN.[38] Although the French nuclear researchers from CEA were initially hesitant, the French parliament showed increasing interest in what was coined the "Rubbiatron" in 1997 and instructed its scientists to look into the topic.[39] Increasingly, Accelerator-Driven Systems were seen as tools that could revitalize nuclear power. They addressed major public concerns regarding nuclear waste, and could attract a new generation of young nuclear researchers.[40] The ADS community tried to not oversell their case, while Rubbia was doing exactly the opposite, as he was mainly selling the proposal with big promises to politicians. Not only did his highly criticized proposal for an Energy Amplifier end up in the proposals for the 5th European framework programs, he even became chairman of the European Technical Working Group on ADS technology for waste transmutation.[41] With his fame as a Nobel laureate, Rubbia acquired what other nuclear scientists were unable to obtain: political leverage for the ADS community.[42]

Increasingly, these international developments influenced the course of the Belgian project, despite existing scepticism toward the economic feasibility of

36. A. Stanculescu, *Accelerator Driven Systems (ADS) and Transmutation of Nuclear Waste: Options and Trends* (International Atomic Energy Agency [IAEA], 2001); NEA/OECD, *Accelerator-Driven Systems and Fast Reactors in Advanced Nuclear Fuel Cycles* (OECD/NEA, 2002), 321–27.

37. Varley, "Fast Neutron Incineration as an Alternative to Geologic Disposal."

38. Internal report authored by Luc van den Durpel (1998) MYRRHA: A Versatile Radiation Source, SCK CEN Archive BR2, 0115, Box D, 6, 3. Page 4.13.

39. "Nucléaire: le Parlement séduit par le 'rubbiatron,'" *Les Echos*, 6 Mar 1997, www.lesechos.fr/1997/03/nucleaire-le-parlement-seduit-par-le-rubbiatron-809754; Eric Glover, "France Urged to Head 'Rubbiatron' Efforts," *Nature* 386, no. 6624 (3 Apr 1997): 426.

40. IAEA, *Accelerator Driven Systems: Energy Generation and Transmutation of Nuclear Waste Status Report* (1997); L. H. Baetsle, T. Wakabayashi, and S. Sakurai, *Status and Assessment Report on Actinide and Fission Product Partitioning and Transmutation* (OECD/NEA, 1999).

41. Åsa Enarsson et al., *Partitioning and Transmutation (P&T) 1997–Status Report* (1997), 48–49.

42. Luc van den Durpel saw Carlo Rubbia as a "useful proponent" to the ADS community, though sufficient prudency had to be applied not to be aligned too much. Interview by author (28 Oct 2021).

transmutation.[43] Throughout 1997, transmutation studies were explored as a possible application of the Belgian system.[44] When the ADONIS/MYRRHA project was presented to the SCK CEN community in September 1997, with Rubbia as a guest speaker, transmutation was even seen as the "main driver" of the project.[45] It was noted later that transmutation studies had at least partly become "the (financial) driving force for this Myrrha-system."[46] With the switch to transmutation, the group at SCK CEN started to believe that the ADONIS/MYRRHA proposal could be a strong project within the forthcoming 5th framework program of the European Commission and thus bring hope for external funding.[47] The European context was interpreted as promising for Belgium. Italy financed its research efforts primarily to support Rubbia's European ambitions but was not yet willing to host a possible prototype themselves. Spain was not considered a serious option, and The Netherlands was not going to substantially invest in a facility. Most importantly, the MYRRHA team observed, the French scientists were heavily divided on the topic. This created the opportunity for Belgium to host a prototype ADS at SCK CEN.[48] The team thought that with the expanded MYRRHA project, SCK CEN could aim for a "post-BR2 major research infrastructure," profit from the "momentum" that existed on the international scene, and become the facility "where European programs [would] be conducted."[49] The switch from ADONIS to MYRRHA as a machine that would conduct transmutation studies was thus mostly a coincidence of local, international, and political developments.[50]

43. Marc Balduyck, "Prof wil atoomafval verbranden. Uitvinding zou toekomst van kernenergie kunnen verzekeren." *Gazet van Antwerpen*, 20 May 1997.

44. Allen Zeyher, "Belgian Companies Propose New Solution for Isotope Production," *The Journal of Nuclear Medicine* 38, no. 3 (March 1997); SCK CEN, Scientific Report 1997, p. 104. https://inis.iaea.org/collection/NCLCollectionStore/_Public/32/053/32053230.pdf?r=1

45. Luc van den Durpel, discussion note for the WAC 37, 26 Nov 1997. SCK CEN Archives, Box 4B, 7, 5.

46. Luc van den Durpel, MYRRHA, a versatile radiation source, 11 Sep 1998. SCK CEN Archives, BR2, 0115, Box D, 6, 3.

47. Luc van den Durpel, discussion note for the WAC 37, 26 Nov 1997. SCK CEN Archives, Box 4B, 7, 5.

48. Luc van den Durpel, discussion note for the WAC 37, 26 Nov 1997. SCK CEN Archives, Box 4B, 7, 5.

49. Luc van den Durpel, MYRRHA, a versatile radiation source, conclusions, 11 Sep 1998. SCK CEN Archive BR2, 0115, Box D, 6, 3.

50. This is also how MYRRHA was introduced in 2001 to an international advisory committee SCK CEN Archive 18A, 2, 8.

A Reactor in Search of a Purpose

Although the focus had now shifted toward a project that would include transmutation studies, the period between 1998 and 2001 was characterized by internal debates about the feasibility of the new reactor. It was not exactly clear what the new MYRRHA machine's main purpose would be, or what the impact of transmutation would be on the machine. In one of his last presentations as project leader, Van den Durpel highlighted that the international context had changed in favor of transmutation in 1997 but that the perspectives of transmutation had to be explored in greater detail.[51] An internal report of 1998 reflects this hesitancy toward a definitive jump toward transmutation. Although the MYRRHA team was asked to look at a potential contribution to transmutation research, they thought that "one should be cautious . . . not to foster unconsidered hopes in P&T which might be viewed later on as a dead end."[52] Therefore, MYRRHA was preferred as a multipurpose machine that would avoid the risk of being completely dependent on the future of transmutation, keeping that topic only onboard as one of many applications. Other important features were medical applications and irradiation experiments for future reactor concepts.

To go ahead with MYRRHA was also a strategic choice. The ad hoc committee of Belgian professors favored MYRRHA over ADONIS in order to construct "the smallest installation possible" for an ADS that could allow transmutation studies.[53] The scientific council, however, struggled with the concept of an ADS as successor for the BR2, as a potential downside of an ADS was its smaller volume for irradiation experiments compared to that of the BR2.[54] The board was mostly interested in an instrument that mimicked the opportunities of their existing reactor:

> For the future, an alternative to BR2 must be sought that offers at least the same advantages in the scientific, technical and social field, but has a smaller impact on the consumption of the budget.[55]

51. Luc van den Durpel, "The MYRRHA Project—Current Status." Document for meeting DAC-VSR, 28 May 1998, Annex 1. SCK CEN Archives, BR2, 0115, D, 6, 3.

52. P&T stands for Partitioning & Transmutation. MYRRHA: concept for a multipurpose neutron source. Report to the 10th meeting on the Scientific Advisory Committee (SAC), 1998, revision 1. https://publications.sckcen.be/portal/files/4486237/BLG_794.PDF

53. Report from the scientific committee on the ADONIS/MYRRHA project, 17 Feb 1998. SCK CEN Archives, Box 4B, 7, 5.

54. Minutes of WAC 40, 25 Feb 1998. SCK CEN Archives, Box 4B, 7, 5; WAC 41, 23 Mar 1998, SCK CEN Archives, Box 4B, 7, 6.

55. Raad van Bestuur 208, *Inleiding tot het strategisch plan*, 25 Mar 1998. SCK CEN Archives, Box 4B, 7, 6.

The discussion about MYRRHA's main applications revealed divergent visions among the different communities involved. In 1998, MYRRHA was in fact a plan in search of a purpose. It was presented as the successor of the BR2 within the framework of SCK CEN's future strategy, but it was noted by advisory committees from the waste department that "some gaps [were] identified in the formulation of what one ultimately wants to do with this instrument."[56] The topic of transmutation had internationally gained interest among reactor physicists but received much less support from scientists working on nuclear waste.[57] A publication in 1998 of the SCK CEN waste department showed similar scepticism. Despite acknowledging that transmutation technology seemed promising, they emphasized that it had never been proven on an industrial scale, would not be applicable to all elements of nuclear waste, still needed a long R&D effort, and could turn out to be very expensive.[58]

Even if transmutation was accepted as a desirable goal, the choice to include it in a machine that should replace BR2 was considered too ambitious by some. Among the main critics at SCK CEN was Léon Baetslé, former chair of the Belgian Nuclear Society. Baetslé was an internationally renowned expert in transmutation and in fact the only Belgian scientist who had attended the international Organization for Economic Co-operation and Development (OECD) meetings on the topic throughout the 1990s.[59] Having just chaired an international report on the status of partitioning and transmutation studies, he was asked by the directors of SCK CEN to share his personal view on MYRRHA.[60] Previously, Baetslé had described ADS technology as an option that theoretically could provide the best results for transmutation, but practically he saw it as "the most challenging option."[61] ADS technology for transmutation, he argued, was "in its infancy" and would require a long-term R&D effort. Most importantly for SCK CEN, Baetslé thought that an ADS

56. Minutes of DAC-ROR, 28 May 1998. SCK CEN Archives, Box 4B, 5, 9.

57. This was still a topic of concern around 2002: OECD, *Actinide and Fission Product Partitioning and Transmutation. Seventh Information Exchange Meeting* (OECD/NEA 2002),. 9, 147.

58. Bernard Neerdael et al., *Beheer van Radioactief Afval* (SCK CEN, 1998), 5–6. https://publications.sckcen.be/portal/files/4483047/BLG_773.PDF

59. The continuous biannual meetings of the OECD on transmutation since 1990 signify the interest this topic gained throughout the 1990s.

60. *Actinide and Fission Product Partitioning and Transmutation Status and Assessment Report* (OECD/NEA, 1999).

61. L. H. Baetslé, *Role and Influence of P&T on Management of Nuclear Waste Streams* (OECD/NEA, 1992), 94.

prototype for transmutation would be made even more complex if seen as a multipurpose machine with several other applications. He therefore claimed that "it would be erroneous to try to upscale the MYRRHA facility in order to use it as a post-BR2 facility."[62] In his view, a versatile and easy-to-adapt small-scale ADS for transmutation studies could be feasible for SCK CEN but not if one expected it to also function as a large facility similar to BR2. Disagreeing with Baetslé, the committee consisting of SCK CEN's director and scientific advisors decided to replace his personal views with the more diplomatic OECD report in the portfolio for the international advisory committee.[63]

International experts were hesitant toward some of the ambitious plans of SCK CEN. They strongly advised to continue with MYRRHA specifically as a multipurpose reactor, and not to restrict it to a prototype ADS or dedicated transmutation machine. They were particularly hesitant of making MYRRHA part of European projects, as this could evoke "excessively complicated solutions" only to address requirements for future machines.[64] Anonymous notes give a brief insight into the meeting. The German nuclear physicist Hans-Henning Hennies warned of the financial impact on the rest of SCK CEN, estimating the construction costs at a minimum of 200 million dollars, rather than the then assumed 75 million.[65] Jean-Pierre Contzen, former head of the European research center (JRC) in Belgium, also recommended to design MYRRHA as a multipurpose machine with research into transmutation only as a secondary priority, and fiercely opposed the suggestion to design it as a demo-machine for European purposes. All in all, the main goal and operational costs of the machine were not yet clear, and construction costs for the machine could turn out to be much more expensive than estimated. Notes of an anonymous author at the meeting concluded that based on these perspectives, "there is a realistic chance that the Centre would get dangerously out of balance."[66]

A change of leadership later in 1998 changed the strategic reorientation of the project. Instead of the recommended multipurpose approach, the scientific council observed that the MYRRHA team was now increasingly working on

62. L. H. Baetsle, *Accelerator Driven Transmutation: Perspectives and Issues in Relation with the MYRRHA Project*. Contribution to WAC 44 meeting, 10 July 1998. SCK CEN Archives, Box 4B, 7, 6.

63. WAC 46 meeting, 22 Sep 1998. SCK CEN Archives, Box 4B, 7, 6.

64. Recommendation SAC, 27–28 Nov 1998. SCK CEN Archives, Box 2C, 1, 1.

65. Memo, SAC 98 regarding MYRRHA, SCK CEN Archives, BR2, 0115, Box D, 4, 9.

66. Memo, SAC 98 regarding MYRRHA, SCK CEN Archives, BR2, 0115, Box D, 4, 9.

a prototype for a "European transmutation machine."[67] The original project leader, Luc van den Durpel, who was seen as the "cavalier seul" of the ADONIS/MYRRHA project, transferred to the OECD/NEA in Paris to study the perspectives of transmutation in the future nuclear fuel-cycle.[68] After Hamid Aït Abderrahim had taken over the project in 1998, MYRRHA was much more explicitly positioned on the debated P&T scene to fit in the European roadmap. The change of leadership thus also reflected a different view on the future direction of the MYRRHA project.

The change of leadership did not put an end to the worries of critics of the project. By 2001, advisors from the waste department still thought that despite its scientifically interesting outlook, transmutation was practically too complex and too expensive, and thus still questioned this direction.[69] The most critical representative of this view was Paul Dejonghe, former deputy-director and expert in geological disposal of waste, who still worked for SCK CEN as an advisor. Dejonghe believed that to improve the disposal of nuclear waste, there were "less ambitious . . . and 'relatively simple' interventions" available, rather than the complex option of transmutation.[70] More specifically related to the development of MYRRHA, he observed that the topic of transmutation had led to divergent views within the institute that created groups of "believers" and "non-believers" of the project.[71] In a report, written with support from the similarly critical Léon Baetslé, Dejonghe's main objection to the proposed design was that the technological requirements for the "pure transmutation option" by far "surpass the needs for more conventional applications" of the machine.[72] MYRRHA, in their view, was made into a more complex machine than strictly necessary for SCK CEN's own needs only in order to join the international efforts in transmutation.

67. WAC 52, 19 Aug 1999. SCK CEN Archives, Box 13A, 5, 1.

68. "De voorzitter, bijgetreden door het voltallige WAC, *drukt waardering en appreciatie uit voor het enorme werk dat door Luc van den Durpel*, praktisch als 'cavalier seul,' werd geleverd in dit Myrrha-Adonis project geheel." In WAC 39, 27 Jan 1998. SCK CEN Archives, Box 4B, 7, 5; NEA/OECD, *Accelerator-Driven Systems (ADS) and Fast Reactors (FR) in Advanced Nuclear Fuel Cycles: A Comparative Study,* 2002.

69. WAC 72 (Extended WAC in preparation of the MYRRHA International Strategic Guidance Committee), 26 Apr 2001; SCK CEN Archives, Box 3B, 4, 10.

70. WAC 72 (Extended WAC in preparation of the MYRRHA International Strategic Guidance Committee), 26 Apr 2001. SCK CEN Archives, Box 3B, 4, 10.

71. WAC 72 (extended WAC in preparation of the MYRRHA International Strategic Guidance Committee), Annex 7; Paul Dejonghe, *The Need for P&T and Its Impact on Waste Management*, 26 Apr 2001. SCK CEN Archives, Box 3B, 4, 10.

72. WAC 72 (Extended WAC in preparation of the MYRRHA-ISGC), Annex 7: Dejonghe, *The Need for P&T and Its Impact.*

Although these critics primarily had backgrounds in chemistry and waste studies, criticism of the project was not limited to the waste department. New professors in the advisory committee for reactor physics had some doubts about the feasibility of the project as well. One of its new members was Dutch nuclear physicist Hugo van Dam, who was concerned that the ADS community was repeating mistakes from the nuclear past by being "over-optimistic," this time about the opportunities of transmutation.[73] This group of advisors endorsed his critical views in their report of 2001, in which they made observations similar to those of Dejonghe and Baetslé:

> Indeed, the present design (i.e., fast neutron spectrum, high fluxes . . . is mainly motivated by the desire to perform basic research on long-lived minor actinides transmutation. Research on nuclear fuel and materials needs also fast (and thermal) fluxes, at a lower level though . . . In contrast, radioisotope production for medical applications requires high *thermal* flux levels, especially if one wants to enter the market of some specific "curative" radioisotopes produced by double neutron capture. . . . All these constraints being taken into account in the design of MYRRHA, the project has become a very impressive one, up to the point where some doubts about its actual feasibility arise.[74]

A highly complex machine would always lead to intense debates, but with large instruments they become of a strategic nature. How could MYRRHA be positioned to be both useful for SCK CEN and feasible enough to obtain funding? Especially in this light, the upscaling of the project into a transmutation machine to fit in the European programs led to important decisions. It was often repeated that the machine had to remain a multipurpose system for SCK CEN, a choice not always compatible with European ambitions:

> The basic dilemma is that, on the one hand, building an irradiation facility to cover all the experimental needs . . . is a very ambitious project that might fail while, on the other hand, building a more dedicated machine might reveal itself a dead-end.[75]

73. Hugo van Dam, "Challenges for Nuclear Power," in *Nuclear Europe Worldscan* 1–2, 2001, pp. 6–7; Hugo Van Dam, Remarks on the MYRRHA project after WAC/DAC meeting, 28 Apr 2000, SCK CEN Archives, BR2 0115, Box C, 2, 2.

74. A synthesis of DAC-VSR's view on MYRRHA, 21 Sep 2001. SCK CEN Archive, Box 3B, 4, 10.

75. A synthesis of DAC-VSR's view on MYRRHA, 21 Sept 2001. SCK CEN Archive, Box 3B, 4, 10

By trying to make use of the momentum regarding ADS and transmutation, the local and international ambitions had to be balanced. An added complexity was that by 2001 the initial hype around these machines was slowly fading away. While an industrial ADS would only be able to burn nuclear waste, so-called fast reactors were believed to be able to both produce electricity and handle their waste efficiently. Advisors had learned from the meeting with international advisors in 2001 that fast reactors were making a comeback on the international scene as part of the future generation of nuclear reactors:

> As outlined by the French and American participants in the . . . meeting last May, the future world market for transmutation dedicated ADS facilities should be small, most minor actinides in Generation IV reactors being burned . . . in the reactor themselves.[76]

Similar worries existed at the ministry of Energy, where director of nuclear applications Theofiel van Rentergem expressed his confusion about the fact that SCK CEN was aiming at a prototype ADS, while other countries were increasingly looking at fast reactors for transmutation options.[77] From a political perspective, however, Van Rentergem admitted that focusing on transmutation of waste could be attractive. Due to the lack of international interest in building several ADS facilities, an extra complexity was that SCK CEN would probably have to aim to become the main European experimental facility. Instead of MYRRHA as a multipurpose facility that could facilitate R&D on transmutation, MYRRHA was now increasingly seen as a prototype for transmutation studies, which would aim to do other experiments as well. The original order of priorities had thus been flipped.

Normalizing Big Science

The search for new infrastructure was perceived as a natural evolution of the Belgian nuclear history rather than a historical abnormality. On the level of the institute, the main driver for the reactor was to have a new research infrastructure, and directors stimulated the researchers to upscale an initially small-scale

76. A synthesis of DAC-VSR's view on MYRRHA, 21 Sept 2001. SCK CEN Archive, Box 3B, 4, 10. By 2002, the OECD/NEA had published a report that favored Fast Reactors over ADS for transmutation, as those instruments held the promise to also produce energy. An important detail is that the scientific secretary of that study was former MYRRHA manager Luc van den Durpel.

77. Theofiel van Rentergem to Paul Govaerts, "MYRRHA. Bedenkingen naar aanleiding van de vergadering van het Internationaal Strategisch Begeleidingscomité—18/19 mei 2001," 31 May 2001. SCK CEN Archives, Box 18B, 2, 1.

initiative. Even after the accelerator-driven system was proposed, scientists were looking for a relevant research program to upscale the system, which became the financially attractive topic of transmutation. Ambitions to equal the opportunities offered by their existing reactor underline how institutional continuity and stability were important values in the planning of a new reactor. Scale itself was thus an important value in the institutional economy of SCK CEN and preceded the choice of scientific applications.

The debate about the relevance of transmutation in the design revealed divergent visions for the future of nuclear energy, but also for how best to secure the future of SCK CEN. The initial project leader Luc van den Durpel had later studied advanced nuclear fuel cycles at the Nuclear Energy Agency (NEA) of the OECD, leading to a report that particularly assessed Fast Reactors and ADS.[78] He was contacted as a consultant in 2002 to brainstorm about future strategies for SCK CEN. Based on the international reports, Van den Durpel wrote that the economics of ADS-based transmutation were unfavorable compared to other options and thus internationally de-selected for the time being. SCK CEN's choice to continue with MYRRHA with a strong focus on transmutation was therefore described by him as a "big bet move." In the view of Van den Durpel, an ADS should be built only as a general neutron source, but not primarily for the technological demonstration of transmutation.[79] Instead of MYRRHA, he suggested focusing on a small and flexible machine that could quickly respond to a rapidly changing R&D environment.

A third observation is the consistent focus on one particular type of reactor. One could ask, if the main goal was to replace BR2, why did it become MYRRHA? While this section has offered clues as to how MYRRHA developed, an important question left to be answered is why other possible designs did not make it. Already in 2001, the international advisory committee argued that the perceived need for new research reactors was in itself not a justification to opt for the complex design of MYRRHA. In their view, "refurbishment of BR2 or a new dedicated material testing reactor should be given serious consideration."[80] Although Director Govaerts believed it would be healthier for the institute to plan several large projects that could compete with each other, this never developed into concrete plans because the search for alternatives "should not disturb the current dynamic of the

78. NEA/OECD, "Accelerator-Driven Systems (ADS) and Fast Reactors (FR) in Advanced Nuclear Fuel Cycles."

79. Luc van den Durpel, *Potential Role for SCK CEN in Scientific and Technological Irradiation Services*, Draft Report for Discussion. 17 Jun 2002. SCK CEN Archives, BR2, 0115, Box C, 2, 1.

80. Annex to report of WAC 67, 03-08-2001. SCK CEN Archives, BR2, D, 6, 7, B.

MYRRHA-project."[81] This privileged position for MYRRHA was addressed by the head of reactor experiments at the BR2 in 2006. At that point, Jean Dekeyser was highly critical of MYRRHA, which he described as a "fictional dreamworld."[82] As a more feasible and affordable alternative, he proposed a possible upgraded BR2 to make it suitable for future research, but felt that such alternatives had never received the necessary support to properly compete with MYRRHA. If the directors of SCK CEN really wished to have an alternative to MYRRHA, he argued, they should provide their researchers with the means to do so.[83]

The directors' choice to go ahead with MYRRHA should be understood against the background of the state of the Belgian Research Centre. After a decade of painful reforms and budget cuts, the MYRRHA project was seen as a source of optimism for the center. KU Leuven professor Yvan Bruynseraede, chair of the scientific council at SCK CEN, believed in 1998 that MYRRHA was "the only project of the scale and level of innovation that was able to enthuse and mobilize the researchers."[84] The transmutation project also provided SCK CEN with international exposure. Another possible reason for SCK CEN's eagerness to join the international scene was that its options for funding were relatively limited given its status as a research center solely dedicated to nuclear science, especially when nuclear fusion received the vast majority of nuclear funding. The opportunity to finally join international efforts again to ensure funding and to even construct a new facility was thus a highly attractive option and played an important role in the historical trajectory of MYRRHA.

II: A EUROPEAN ADVENTURE

Upscaling of MYRRHA was not purely driven by internal considerations but also strongly connected to European developments. Due to the decision to

81. InterDAC/WAC 53, 01-10-1999. SCK CEN Archives, 3, B, 4, 9. WAC 79, 30 Nov 2001. SCK CEN Archives, Box 3B, 4, 10.

82. In particular, the idea that MYRRHA could be established by 2010 was unrealistic, according to Dekeyser: "Vele collega's en ikzelf vinden dat rond MYRRHA een fictieve droomwereld wordt verkondigd, ver van elke wereldse realiteit." ["Many colleagues and myself feel that a fictional dream world is proclaimed regarding MYRRHA, far from any worldly reality." All bracketed translations by the author.] Jean Dekeyser, Commentaren bij het document: "A Step towards the New SCK CEN—Priorities and Future Activities," 13 Apr 2006. SCK CEN Archives, BR2, C, 2, 4.

83. Dekeyser, Commentaren bij het document: "A Step towards the New SCK CEN."

84. Raad van Bestuur 211, 16 Dec 1998. SCK CEN Archives, Box 18A, 2, 7.

upscale MYRRHA and take part in European programs, strategic choices had to be constantly adapted to European developments. Most historians of European Big Science have examined projects founded through ad hoc solutions and contingent negotiations.[85] However, since the 1980s, science became increasingly recognized as a vehicle for economic growth and was funded through framework programs of the European Commission.[86] More formalized forms of scientific collaboration therefore (increasingly) exist alongside ad hoc forms; yet the formalized collaborations made possible by targeted funding have rarely been addressed by historians. The moral economy of nuclear physicists has long been guided by informal and bilateral collaborations, but that way of negotiating is now also partly prescribed by the logic of European programs.

Not only was science in general increasingly incorporated into European policies, specifically for Big Science, but one could even say that it became politically normalized by the European commission.[87] In 2000, European Commissioner Philippe Busquin launched the European Research Area (ERA), which introduced the strategy of Integrated Projects as a way to stimulate "projects of substantial size, designed to help build up the 'critical mass' in objective-driven research with clearly defined scientific and technological ambitions and aims."[88] In 2002, the European Strategic Forum for Research Infrastructures (ESFRI) was launched, and in 2009 the Commission introduced a legal framework (ERIC) for Big Science projects. In the European Commission's discourse, a large collection of small projects was seen as unwanted fragmentation. In order to be able to compete on an international level, the European Commission increasingly promoted large-scale projects, which demanded a high degree of consensus among research communities.[89] The informal space of ad hoc scientific cooperation in Europe has thus over the years been increasingly accompanied by formalized procedures and policies.

85. Hallonsten, "The Politics of European Collaboration in Big Science," 32.

86. Luca Guzzetti, *A Brief History of European Union Research Policy* (Office for Official Publications of the European Communities, 1995), 154–62.

87. Inga Ulnicane, "Ever-Changing Big Science and Research Infrastructures: Evolving European Union Policy," in *Big Science and Research Infrastructures in Europe*, eds. Olof Hallonsten and Katharina C. Cramer (Cheltenham, England: Edward Elgar Publishing, 2020).

88. "The 6th EU Research Framework Programme, MEMO/02/152," European Commission, 27 June 2002. https://ec.europa.eu/commission/presscorner/detail/en/MEMO_02_152

89. Ulnicane, "Ever-Changing Big Science and Research Infrastructures," 85.

This section will analyze how this changing landscape of science policies in Europe and the emphasis on large-scale projects contributed to the development of MYRRHA. In particular, it will focus on strategic interactions among European partners. For transmutation studies, the EURATOM budget increased from the 4th (1994–1998) to the 5th (1998–2002) program by about 20 million euro: from 5.8 to 26 million.[90] Although the ADS community had hoped for more funding, it did make it attractive for SCK CEN to steer their initial MYRRHA proposal in the direction of collaborative transmutation studies.[91] Preparations for MYRRHA were now funded by what was essentially normal science funding, not a dedicated Big Science budget. Because of this strategy, SCK CEN tried to let European partners work for their project, while at the same time the complex European collaborations also shaped the projects ambitions.

Making Europe Work for MYRRHA

Obtaining a strong position in Europe was not easily done for the Belgian group. The European ADS scene was initially dominated by a small coalition of Italy, France, and Spain, led by Carlo Rubbia, Massimo Salvatores, and Juan Antonio Rubio.[92] Together, they hoped to push the strategy for an ADS demonstrator in Europe.[93] With the aim of constructing a 100 MW demo model (coined the As Soon As Possible Demo), primarily Italy pushed for a project significantly bigger than SCK CEN's proposal, which was initially aimed at maximum 30 MW and thus immediately put at risk.[94] SCK CEN's strategy was to present MYRRHA as a small-scale prototype on the European roadmap, but this was not always welcomed by others. Alain Ballagny (CEA), for example, did not believe in the need for MYRRHA. For the French, an

90. Michel Hugon and Ved P. Bhatnagar, "Partitioning and Transmutation in the Euratom Fifth Framework Programme," in *Proceedings of the 6th Information Exchange Meeting* (OECD/NEA, 2000), 11–13.

91. S. Monti, "Overview of the Ongoing Activities in Europe and Recommendations of the Technical Working Group on Accelerator Driven Sub-Critical Systems," in *Review of National Accelerator Driven System Programmes for Partitioning and Transmutation Proceedings of an Advisory Group Meeting Held in Taejon, Republic of Korea, 1–4 November 1999* (IAEA, 2003), 16.

92. Hamid Aït Abderrahim, interview by author, 29 Sep 21.

93. NEA Nuclear Science Committee, ed., *Proceedings of the Workshop on Utilisation and Reliability of High-Power Proton Accelerators: 13–15 October 1998, Mito, Japan* (OECD/NEA, 1999), 131.

94. Raad van Bestuur 214, 23 Jun 1999. SCK CEN Archives, Box 18A, 2, 7.

ADS was but one element in their future transmutation strategy, as they ultimately believed in the option of Fast Reactors.[95] To break the dominance of the three big countries, the Belgian project leader, Hamid Aït Abderrahim, seized the opportunity in the framework programs to set up a formal network called ADOPT.[96] Now that smaller countries (i.e., Sweden, Belgium, and Portugal) also had a say on the strategy, SCK CEN believed that by 2000 they could manage to convince the others of the necessity of MYRRHA as a prototype in the European roadmap.

Collaborating in Europe was sometimes like playing simultaneous chess. Next to the transmutation programs, Belgium, France, and The Netherlands also developed a roadmap for replacement of their old material test reactors in Europe.[97] At SCK CEN, it was believed that CEA primarily saw this collaboration as a vehicle to obtain European financial support for their future Jules Horowitz reactor. To the frustration of SCK CEN, CEA now promoted MYRRHA solely as a transmutation project while questioning the multipurpose approach.[98] Furthermore, SCK CEN thought that the most active groups, primarily Italy, would in the end favor building a large ADS demonstrator.[99] The strongly needed consensus for building MYRRHA was thus far away.

The divergent visions in the community became more problematic when agreements had to be made for the next framework programs. European Commissioner Philippe Busquin had introduced the "Integrated Project" (IP) into European science policy, which demanded a consensus on one big project among the collaborators. MYRRHA's team leader Hamid Aït Abderrahim wanted to continue the existing program as IP-ADOPT with their

95. Notes from Jef Vanwildemeersch,"Onderhoud over de mogelijke samenwerking met CEA," 17 Feb 2000. SCK CEN Archives, Box 3B, 4, 4.

96. Hamid Aït Abderrahim, interview by author, 29 Sep 21.

97. This collaboration was formalized in the FEUNMARR project. See C. Vitanza, D. Iracane, and D. Parrat, "Future Needs for Material Test Reactors in Europe (FEUNMARR Findings)," 2003, http://inis.iaea.org/Search/search.aspx?orig_q=RN:34073903. See also, Cordis, "Future E.U. Needs in Materials Research Reactors." https://cordis.europa.eu/project/id/FIR1-CT-2001-20122/fr

98. "Hierbij is het hinderlijk dat het CEA MYRRHA vooral wil koppelen aan transmutatie en de term 'multipurpose' sterk in vraag stelt." ["Here it is annoying that the CEA wants to link MYRRHA primarily to transmutation and strongly questions the term "'multipurpose.'"] In WAC 79, 30 Nov 2001. SCK CEN Archives, Box 3B, 4, 10. CEA thought for example that adding the medical applications to the transmutation prototype was "too luxurious" for MYRRHA. In "Vergadering op CEA," 27 Sep 2001, SCK CEN Archives, Box 18B, 2, 3.

99. WAC 79, 30 Nov 2001. SCK CEN Archives, Box 3B, 4, 10.

design as the leading project to "avoid the fragmentation of the present P&T and ADS community," creating a "stable research environment" and as such serve as a "trigger for maintaining the national funding in this field at a reasonable level."[100] However, ADOPT was in practice not as coherent as it was often presented, as others observed that the "idiosyncrasy" of the participants had made the project fall apart into subprojects.[101]

This fragmented situation meant that MYRRHA was not the only candidate for the next program. The Italian ENEA, headed by Rubbia, proposed to make their experiment at the research reactor in Casaccia an Integrated Project (as IP-TRADE), with support from CEA's Massimo Salvatores.[102] Due to Salvatores' involvement in the project, the French CEA could not block the Italian project on a European level. In fact, the TRADE project fitted CEA's strategy as they were trying to postpone large investment decisions and wanted to collaborate on ADS systems only if they would be further explored within the European programs. Rumors also suggested that the American Department of Energy (DOE) was interested in contributing to the Italian project, as it was technologically and financially less risky.[103] It was unclear what strategy CEA and Rubbia were exactly following, but the German (FZK, Karlsruhe) participants also seemed more in favor of pushing the Italian project rather than the Belgian. These developments meant a loss of autonomy for SCK CEN and further delay for the MYRRHA project.[104]

The introduction of the so-called Integrated Project thus did not lead to consensus on a European project, as it was used as an opportunity for national centers to make others work for their national projects. It was concluded that European commitment for MYRRHA could not be obtained because this did

100. Aït Abderrahim, Hamid, "European ADS Programme. Present Considered Designs & Perspectives," in *OECD/NEA NSC Workshop R&D Needs for Current and Future Nuclear Systems*, Paris, France, 6–8 Nov 2002 (OECD/NEA, 2002).

101. " . . . de eigenzinnigheid van de deelnemers maakt dat het project uiteen aan het vallen is in deelprojecten." ["The idiosyncrasy of the participants means that the project is disintegrating into subprojects."] Beknopte resultaten van wederzijdse bevraging NRG/SCK CEN, 8 Dec 2003, SCK CEN Archives BR2 C, 7, 2.

102. "TRIGA Accelerator Driven Experiment (TRADE)," 2002, http://inis.iaea.org/Search/search.aspx?orig_q=RN:40010599; Salvatores worked as a scientific advisor at ENEA from 2002 till 2010. "Massimo Salvatores 1941–2020," *Annals of Nuclear Energy* 146 (2020).

103. Beknopte resultaten van wederzijdse bevraging NRG/SCK CEN, 8 Dec 2003, SCK CEN Archives BR2 C, 7, 2.

104. Raad van Bestuur 230, 11 Dec 2002, SCK CEN Archives, Box 18A, 2, 8.

"not always match with the divergent national ambitions."[105] The scientists of SCK CEN were sceptical about the Italian proposal and believed it received visibility only "to satisfy the enormous ego of Carlo Rubbia."[106] The consequence was a fragmented funding scheme for European ADS programs.[107] To change the course of these developments, the MYRRHA team held the opinion that the directors should play a much more active role in lobbying in order to have MYRRHA as the preferred European project.[108]

In order to secure support, new methods of lobbying and negotiating were employed. Toward the end of 2003, the Belgian team still concluded that "no European party at present is willing to work for MYRRHA."[109] Within SCK CEN, frustrations also started to appear, as the scientists and engineers in the team wanted to continue with the design of their machine, while the directors wanted them to focus on research and publications and de-facto put the project temporarily on hold.[110] Meanwhile, the tensions with the Italian competitors culminated when both teams organized competing workshops in October 2003. To break the deadlock, the MYRRHA team wanted to "threaten" their European partners with the option of "going alone" rather than leading an "unreasonable" European program.[111] At their workshop in Mol on October 6, SCK CEN's chair Frank Deconinck gave an opening address in which he indeed suggested that SCK CEN would design the machine itself and join the European program only to the extent that it would be useful for SCK CEN.[112] This can be seen as a compromise between the MYRRHA group and the board because director Govaerts noticed that the decision of the board to put the project on hold had caused unrest at the MYRRHA group.[113] This situation changed abruptly later in the month.

105. Myrrha in het kader van het strategisch plan, doc. N. 5248/RvB 232, 25 Jun 2003, SCK CEN Archives, Box 18B, 2, 12.

106. "MYRRHA strategic positioning in the FP 6 transmutation programme," 19 May 2003. SCK CEN Archives, Box 18B, 2, 10.

107. Bureau 98, 6 Jun 2003, Box 19B, 1, 6.

108. "12th meeting of the MYRRHA International Steering Committee," 12 May 2003. SCK CEN Archives, Box 18B, 2, 10

109. "Minutes of the 13th meeting of the MYRRHA internal Steering Committee (ISC13)," 2 Oct 2003. SCK CEN Archives, Box 18B, 2, 11.

110. "Minutes of the 13th meeting of the MYRRHA internal Steering Committee (ISC13)."

111. "Minutes of the 13th meeting of the MYRRHA internal Steering Committee (ISC13)."

112. *Proceedings of InWor for P&T and ADS'2003, International Workshop on P&T and ADS Development*, Mol (Belgium), 6–8 Oct 2003.

113. Bureau 100, 15 Oct 2003. SCK CEN Archives, Box 18B, 2, 11.

European science collaborations can take highly unpredictable turns. The opportunities for the Belgian team improved when the Italian newspaper *La Repubblica* announced that the Italian parliament had rejected Rubbia's European plans. This did not, however, solve the problems with other collaborators. At SCK CEN they were convinced that MYRRHA was unrealistic without the support of the French CEA. Their strategy, therefore, would not change fundamentally:

> What is left to do in the meantime is to maintain a role in the European programs and to try to steer the other projects within this framework into the direction of MYRRHA.[114]

While SCK CEN's team tried to steer other projects into the direction of MYRRHA, this also worked in reverse. The commitment to turn MYRRHA into an experimental prototype for a European transmutator was seen as a fundamental element to stay important on the international scene, but it also had its downsides. To the ministry, Director Govaerts had to acknowledge that by playing this role in the European roadmap, the projected costs of MYRRHA kept rising:

> This role for MYRRHA has an impact on the design, costs, and timing of the project, but is today unavoidable given the apparent impotence of all possible partners to decide on one big investment decision.[115]

The role for MYRRHA on the European scene would change once more in 2004 during the final preparation for the new framework programs. Although they had not managed to sustain the previous ADOPT program, MYRRHA now became part of the integrated project called IP-EUROTRANS, headed by Joachim Knebel from the Karlsruhe laboratory rather than a representative of the arguing French, Belgian, and Italian participants. The "war" in the ADS community, as project leader Hamid Aït Abderrahim recalled this phase, had split up the initially coherent partitioning and transmutation program of ADOPT. France had taken away the partitioning part when it established a European project around the topic called EUROPART.[116] Furthermore, the original Italian project was now included as a smaller element of the overarching IP-EUROTRANS. Within the new group, SCK CEN was the

114. Bureau 102, 4 Feb 2004. SCK CEN Archives, Box 19B, 1, 6.

115. "Correspondence Van Rentergem—Govaerts," 18 Feb 2004. SCK CEN Archives, Box 18B, 2, 8.

116. Hamid Aït Abderrahim, interview by author, 29 Sep 2021.

only institute left in the European program that expressed an interest in constructing an ADS machine.[117] This meant that their design had to be upgraded from the initially foreseen intermediate step to the actual experimental ADS design.[118]

Nuclear Collaboration in Europe

The development of MYRRHA was largely dependent on its success in European research programs on transmutation. Rather than major funding from the government, the scientists used existing and common funding channels to continue their project. Although the policies to structure European scientific efforts around a limited number of large-scale projects were originally meant to improve their coherence, the case presented here shows that these policies can also accentuate the different views that already exist among the involved communities. The descriptions of European negotiations presented thus far stem primarily from Belgian sources, but other collaborators also testified that, indeed, the initial ADOPT group had "rather unwillingly" evolved into the new EUROTRANS group.[119] Due to the developments on the European scene, the initially small-scale Belgian project had to adapt to overcome the different European ambitions.

While the structure imposed by the EU programs meant a more formalized approach to scientific collaborations, the way scientists dealt with these challenges reveals how much they valued their national projects. Following historian John Krige, European scientific collaboration was at least partly the pursuit of self-interest by other means.[120] Events such as the parallel symposia in October 2003 by the two main rivals show how a formalized approach to scientific collaborations invoked new types of politics among the participants. Similarly remarkable was the strategy to make a relatively neutral partner (Germany) the coordinator of a multinational collaboration. Other strategic uses of the programs were also possible. As shown above, it was perceived that the French CEA used the discussions in the European programs partly to delay investment decisions.

117. Meeting report DAC VSR 12, 30 Mar 2004. SCK CEN Archives, BR2 0115, Box D, 6, 11.

118. Raad van Bestuur 236, 23 Jun 2004. SCK CEN Archives, Box 19B, 1, 6; Meeting report DAC VSR 12, 30 Mar 2004. SCK CEN Archives, BR2 0115, Box D, 6, 11.

119. Per-Eric Ahlstroem et al., *Partitioning and Transmutation. Current Developments–2004. A Report from the Swedish Reference Group on P and T-Research* (2004), 43.

120. Krige, "The Politics of European Scientific Collaboration."

The challenges of MYRRHA were not limited to the European negotiations. Beginning in 2003, the MYRRHA project started to consume money from other projects at SCK CEN.[121] Within the institute it was observed that support for the project in 2005 was roughly 50/50, dividing employees again into those who believed in the innovative system and the sceptics who feared the technological and financial complexities, despite the fact that everyone supported the ambition for a large new nuclear installation.[122] It had become clear that the nuclear industry had rarely shown interest in ADS because they were much more focused on GEN-IV designs.[123]

Although project leader Aït Abderrahim believed that international developments would move in favor of MYRRHA, advisors of SCK CEN felt that transmutation through ADS could be feasible only if the fast reactor programs were delayed or blocked.[124] By 2007, it became more clear that interest in ADS was fading and countries were increasingly turning back to fast

121. SCK CEN Annual report 2003–2004, SCK CEN Library.

122. "Despite the unanimous opinion in favor of a large nuclear installation operated at Mol, there was about as much enthusiasm about MYRRHA as scepticism about the possibility (and interest) for SCK CEN to build this machine." "SCK CEN 2020 and beyond—Synthesis on the Internal Inquiry." Annex 1 to WAC 110. 20 Sep 2005. SCK CEN Archives, Box 3A, 4, 11.

123. Ahlstroem et al., *Partitioning and Transmutation: Current Developments–2004. A Report from the Swedish Reference Group on P and T-Research* (2004), 123.

124. In his meeting report of the French Parliamentary hearing on 20 Jan 2005, Hamid Aït Abderrahim wrote: "Il est clair que les gens commencent à enfin voir ce que nous au SCK CEN avons vu depuis 1998 c.-à-d. que l'ADS deviendra incontournable pour la gestion de façon économique et rationnelle les déchets nucléaires de haute activité et plus particulièrement les MAs" ["It is clear that people are finally beginning to see what we at SCK CEN have been seeing since 1998, that is, that ADS will become a must for the economic and rational management of high level nuclear waste and in particular the Mas."] Rapport de Mission Succinct, 21 Jan 2005. SCK CEN Archive, Box 19A, 1, 10.

From a strategic document of the board: "Eén van de grote problemen is het feit dat de nucleaire wereld niet unaniem voor transmutatie via ADS systemen opteert. Samenvattend kan men stellen dat P&T slechts een toekomst heeft indien de oplossing voor de geologische berging voor heel langlevend afval afgewezen wordt. De kansen voor P&T nemen toe als er een duidelijk nucleaire toekomst aanvaard wordt en/of wanneer de ontwikkeling van nieuwe reactorconcepten met ingebouwde auto-transmutatie vertraagt of vastloopt. Het antwoord hierop zal slechts binnen enkele jaren duidelijker worden." ["One of the major problems is the fact that the nuclear world does not unanimously opt for transmutation through ADS systems. In summary, P&T has a future only if the geological disposal solution for very long-lived waste is rejected. The opportunities for P&T increase if a clearly nuclear future is accepted and/or if the development of new reactor concepts with built-in auto-transmutation slows down or stalls. The answer to this will only become clearer within a few years."] Raad van Bestuur, 23 Mar 2005. "Perspectieven van de prioritaire programma's." SCK CEN Archive, Box 19A, 1, 10.

reactors.[125] Swedish observers concluded that the European funding for ADS systems had never really lived up to the high expectations that the community had in the late 1990s.[126] With an unclear strategic positioning, further European investments in ADS systems were uncertain. Efforts to get domestic support for MYRRHA in Belgium were intensified, hoping it would stimulate European enthusiasm.

III: BELGIAN SUPPORT FOR A EUROPEAN REACTOR

Despite European attempts to smooth over international cooperation in Big Science, it remained an enterprise relying heavily on the financial engagement of the hosting country. Big Science became embedded in European science policy from 2000 onward, mainly under the term Research Infrastructure.[127] As part of his policies to stimulate integrated efforts in large-scale research in 2002, Commissioner Philippe Busquin adopted the idea of a European Strategic Forum for Research Infrastructures (ESFRI), which fitted with the international trend to develop roadmaps. Bolliger and Griffiths have argued that this European list of research priorities is unique "since it is published by a forum without any formal authority or a formal budget, but with the 'hidden' aim of encouraging an alignment of national funding priorities along a list of pan-European [Research Infrastructures]."[128] ESFRI was a diplomatic tool rather than a European funding body.

The diplomatic rather than formal status of the ESFRI did not make it less relevant. Despite the lack of budget or formal authority, SCK CEN's board

125. Per-Eric Ahlström et al., *Partitioning and Transmutation Current Development 2007—A Report from the Swedish Reference Group for P&T Research* (2007) 5–9;74–75; "the world nuclear community is turning increasingly towards fourth-generation reactors, notably fast reactors, as a more attractive tool to transmute long-lived radionuclides." Ann Maclachan, "Swiss Experiment Shows Promise of Accelerator Waste Transmutation," *Nuclear Fuels,* 12 Feb 2007.

126. Ahlström et al., *Partitioning and Transmutation Current Developments 2007—A Report from the Swedish Reference Group for P&T Research* (2007), 75.

127. Katharina C. Cramer, "The Other Europe of Big Science," 42; Inga Ulnicane, "Ever-Changing Big Science and Research Infrastructures: Evolving European Union Policy," in *Big Science and Research Infrastructures in Europe* (Cheltenham, England: Edward Elgar Publishing, 2020), Olof Hallonsten, "Research Infrastructures in Europe: The Hype and the Field," *European Review* 28, no. 4 (2020).

128. Isabel K. Bolliger and Alexandra Griffiths, "The Introduction of ESFRI and the Rise of National Research Infrastructure Roadmaps in Europe," in *Big Science and Research Infrastructures in Europe* (Cheltenham, England: Edward Elgar Publishing, 2020), 122.

recognized that ESFRI could be a useful tool to help forward the MYRRHA dossier.[129] MYRRHA was already briefly mentioned in the 2006 edition of the ESFRI list, but board member Didier Hellin insisted they should try to make it onto the definitive list of 2010 to become recognized as a European priority. Didier Hellin was both vice-president of SCK CEN's board and advisor for the federal cabinet of Science Policy. France had already mentioned MYRRHA in their report, *Les Tres Grandes Infrastructures de Recherche*, and the Belgian Federal Council of Science Policy report, chaired by SCK CEN advisor Bruynseraede, was very positive about MYRRHA. These events were seen as arguments that could work out positively for the project.[130] They knew that other large-scale initiatives such as Horowitz and the ESS had made it to the list as well. It was clear to them that "to obtain European financial support, it is necessary to make it to the ESFRI list."[131]

The first requisite of ESFRI, however, was that the hosting country supported the project, which would normally mean guaranteeing funding for about 40% of the total costs. The third section of this article will therefore be dedicated more specifically to the interaction between the MYRRHA project and the Belgian political and public sphere. Previous sections have shown how the institutional and international context shaped the MYRRHA project and its strategies. This section zooms in on how MYRRHA was presented, perceived, and ultimately accepted within Belgium. This shifts the focus from internal discussion within the community to the strategies employed to convince outsiders of the project.

Becoming a European Infrastructure: The Campaign

The concept behind the MYRRHA project attracted Belgian political interest even before the project existed. Already in 1994, Minister for Energy Melchior Wathelet requested a review of Rubbia's proposals for an Energy Amplifier. To him, these proposals seemed a promising field that could "reassure the future of [nuclear] energy and provide it with a new impulse."[132] Later ministers were

129. Bureau 133, 27 Jan 2009. SCK CEN Archives, Box 19B, 1, 7.

130. See for the French Roadmap: *Les Tres Grandes Infrastructures de Recherche* (2008), www.enseignementsup-recherche.gouv.fr/sites/default/files/imported_files/documents/feuille-de-route-nationale-des-infrastructures-de-recherche——2008–9234.pdf; Bureau 133, 27 Jan 2009. SCK CEN Archives, Box 19B, 1, 7.

131. Bureau 136, 9 Jun 2009. SCK CEN Archives, Box 19B, 1, 6.

132. Letter from Wathelet to SCK CEN, 11 May 1994. SCK CEN Archives, Box 18A, 2, 14.

less enthusiastic, especially when in 1999 the Green party obtained the position of State Secretary of Energy. Not only was State Secretary Deleuze sceptical about the motivations to switch from ADONIS to MYRRHA, he was also especially critical of transmutation studies, which he saw as a strategy to continue Belgium's commitment to nuclear energy. Therefore, he prohibited SCK CEN to use their annual subsidies for the project.[133] A breakthrough for the project occurred when Deleuze was succeeded by Alain Zenner from the liberal party in 2003. Two senior advisors of SCK CEN, André Jaumotte and Léon Bindler, convinced the minister that blocking the MYRRHA project could be disastrous for the future of the nuclear research center. From 2003 onward, SCK CEN was allowed to use their subsidies for the MYRRHA project. [134]

A remarkable feature of the promotion of MYRRHA is the historically inclined narratives constructed to convince politicians that the project fit within a tradition of Big Science in Belgium. In a meeting with the Minister of Science Policy in 2003, MYRRHA was primarily presented to replace the BR2, as they argued that "without a large neutron source, the identity of SCK CEN would fundamentally change."[135] In one of their later plans, it said that "traditionally, SCK CEN dwells among large infrastructures which are necessary to expand our research activities. To obtain a replacing infrastructure for the BR2-reactor . . . is therefore a crucial element in a future-oriented strategy for SCK CEN."[136] In its business plan for MYRRHA, SCK CEN argued that Belgium had a "tradition of participating in large scientific programs: space (ESA), fusion (JET/ITER), high energy (CERN), and sources of photons and neutrons (ESRF/ILL)."[137] The past and the future of the research center would be connected by the missing link: MYRRHA. MYRRHA was not only presented as something new and innovative but also as a continuation of an established tradition.

133. Letter from Olivier Deleuze to Kareld Dieltjens and Jan Michiels (representatives of the government in the board of SCK CEN), 18 Jun 2001. SCK CEN Archives, Box 18B, 1, 13.

134. Letter from Jaumotte and Bindler to Alain Zenner, 22 May 2003. SCK CEN Archives, Box 18B, 2, 10.

135. Studiecentrum voor Kernenergie (SCK CEN), Basisinformatie en lopende problemen. Informatie voor minister Fientje Moerman, 23 Sep 2003. SCK CEN Archives, Box 18B, 2, 11.

136. Raad van Bestuur 246, 27 Sep 2006, "Voorstelling reorganizatieplan SCK CEN, Doc. 5. 378/RvB." SCK CEN Archives, Box 19B, 1, 7.

137. "MYRRHA Business Plan," SCK CEN Archives, Box 19B, 2, 6.

As part of the campaign to obtain support, directors of SCK CEN insisted on the existential importance of MYRRHA for the institute's survival. In 2008, SCK CEN's Financial Director Christian Legrain claimed that it was dangerous "to let one believe that SCK CEN could continue to exist without MYRRHA."[138] To emphasize the importance of MYRRHA to SCK CEN, he repeatedly assumed an extra 5 million euros for MYRRHA in the annual budget for the coming years, to the frustration of government advisors. The financial director argued that it was difficult to leave MYRRHA out because it was inherently connected to the rest of SCK CEN:

> There has been a decade of research going on to prepare MYRRHA. If the government would refuse to approve MYRRHA, the complete strategy should be revisited, and would SCK CEN, without large infrastructure, be doomed to vanish.[139]

The refusal to fund the ambitious MYRRHA project was now presented as an existential threat to SCK CEN. This tied into the politics of the historical narratives, namely, presenting MYRRHA not only as a unique instrument but also as a necessary element to sustain the continuity and stability of the nuclear research center.

In October 2009, the outlook for MYRRHA remained gloomy.[140] In order to secure support, SCK CEN had intensified its PR campaign by hiring a press agency to organize communication with journalists. This led to a substantial increase in media coverage with articles that often reflected the strategic arguments that SCK CEN had previously discussed internally.[141] Arguments focused primarily on economic prospects for the local region, SCK CEN's future, and its international position. The local mayor argued that without MYRRHA it would indeed be "game over" for SCK CEN.[142] Others repeated the argument that by financing MYRRHA, Mol could attract researchers in a similar way CERN did in Geneva.[143] Widely spread was the belief that with MYRRHA the region could attract at least 1,500 extra (indirect) jobs.

138. Bureau 129, 9 Jun 2008. SCK CEN Archives, Box 19B, 1, 7.

139. Bureau 136, 9 Jun 2009. SCK CEN Archives, Box 19B, 1, 6.

140. Pieter Meireleire, "Geen geld voor nieuwe reactor." *Het Laatste Nieuws (Kempen),* 16 Oct 2009.

141. In 2009, eighty-one articles were published in Belgian media on MYRRHA, whereas the number was only twenty in 2008. GoPress Academic: search term "MYRRHA".

142. Het Laatste Nieuws, 16 Oct 2009.

143. Frans Crols, "MYRRHA is een schat." *Knack/Trends*, 12 Mar 2009.

Internally, it was concluded that the PR strategy "had an increasing amount of constructive interviews as effect."[144] SCK CEN thus successfully introduced their arguments into Belgian public discourse, as it made the public and politicians aware of the high stakes for SCK CEN.

The final decision was largely dependent on an expert report from the OECD in November 2009, requested by Minister for Energy Paul Magnette. A direct investment decision was discouraged by the committee, believing the project was technically quite demanding: "SCK CEN's proposed multi-purpose approach, with little overlap between individual needs, does lead to a daunting accumulation of technical requirements."[145] They admitted that MYRRHA was an innovative, exciting, and unique project, but they also pointed out several substantial risks. Most importantly, the project could get very expensive, while funds may turn out to be smaller than expected. Although SCK CEN started the project in the 1990s hoping it would lead to a cheaper alternative to the BR2, the annual operational costs of MYRRHA were now estimated at around 61 million euros, which reflected roughly 60% of SCK CEN's annual budget. MYRRHA thus ended up being more expensive than the BR2 was in the 1990s.[146]

The report could be read in various ways, which is not surprising given the diplomatic nature of the OECD. Although the content seemed rather critical, the experts recommended a risk-reducing approach by first funding a new phase of designing, rather than committing to the construction of the machine. Readings of the report differed among newspapers, politicians, and government officials. The first two groups were relatively positive, while the latter were rather critical.[147] The financial inspector of the government was not convinced of an immediate need to fund the project, partly because no budget was available to do so.[148] One of the main objections was a particularly Belgian

144. Bureau 137, 6 Oct 2009. SCK CEN Archives, Box 19B, 1, 6.

145. OECD/NEA, Independent evaluation of the MYRRHA project. Report by an international team of experts (OECD/NEA, 2010), 15.

146. Costs of BR2 were estimated in 1992 at around 1 billion Belgian Francs, while SCK CEN was working with an annual budget of 2.86 billion Belgian Francs. *Doorlichting van de organizatie van de navorsingseenheid reaktorveiligheidsexperimenten, en van de BR2 Reaktor in het biezonder*. SCK CEN Archives, 3B, 3, 3; SCK CEN Annual Report 1992.

147. "Na gunstig OESO-rapport MYRRHA kan Magnette subsidie niet weigeren," *De Tijd*, 13 Jan 2010; "MYRRHA weer wat dichterbij," *Trends*, 17 Dec 2009.

148. Interfederaal Korps van de Inspectie van Financiën, "Nota aan de Ministerraad ivm MYRRHA project." 4 Feb 2010. Obtained upon request at the Belgian Ministry of Economics and Energy.

phenomenon: for the first five years, SCK CEN would receive 60 million euro, but the nuclear center in the francophone south of Belgium would also receive extra funding. This phenomenon of compensation funding—called waffle-iron politics—was one of the inspector's prime objections. Nonetheless, on March 4, 2010, the Belgian government announced its intention to finance 40% of the project, which led to inclusion on the ESFRI list of 2010. Although no international funds were found, the Belgian government took the initiative to invest around 560 million euros in the phased construction of the reactor in 2018.[149]

CONCLUSIONS

The fifteen-year history of the MYRRHA project, as analyzed in this article, has given new insights into the politics of contemporary Big Science in Europe. To understand the development of the Belgian project, this article explored David Baneke's notion of the normalization of Big Science in both the moral economy of nuclear scientists as well as in the realm of European science policy. To call Big Science "normal" may at first feel counterintuitive but is presented as an interpretative possibility for understanding the trajectory of MYRRHA. The origins of the project go back to 1994, and as of 2022 it has been part of SCK CEN for twenty-eight years. The planning and design activities of the reactor has thus become an integral part of the research center.

One could argue that scientific projects expand to live up to external expectations, and this is to a certain extent the case for MYRRHA. However, I have shown in the article's first section that working on a large project obtained an important position in the moral economy of the Belgian scientists. The ambition to work on a large-scale MYRRHA was at least partly driven by the strategic considerations to mimic their existing reactor (BR2) in scope of opportunities. Next to scientific objectives it was grounded in the desire to maintain a status quo, namely, the survival of the institute. Stability and continuity of the institute were important values in the project, as was the opportunity to attract young researchers into the field. That upscaling the project met with resistance does not necessarily undermine the idea that working on a large-scale project was a normalized feature of a late twentieth-

149. Marc Helsen, "Ministerraad geeft groen licht voor onderzoekssite van 1,6 miljard euro," *Het Nieuwsblad*, 8 Sep 2018.

century nuclear research institute. While criticism of the project was often induced by the fear it could cause instability at the institute, the rationale for planning a new reactor was rarely questioned.

A typical feature of Big Science in a small country is its struggle to obtain funding. It is worth pointing out that the MYRRHA project was not funded by one major investment, but initially financed through regular competitive funding schemes for development and design, something that may be typical for small countries.[150] Phrased differently, MYRRHA drew partly on budgets for normal science rather than privileged funding. These schemes, however, increasingly aimed for large-scale projects and thus also partly normalized such ambitions. In the case of MYRRHA, the focus on largeness in European programs undermined the initial attempt to construct a small-scale prototype. On a more general level, one could question the effectiveness of European ambitions for large-scale projects. European-organized projects such as MYRRHA and the European Spallation Source (ESS, Sweden) have a negotiation history that spans over more than twenty years, and the hosting country still ends up funding about 40% of the budget. Meanwhile, nationally funded projects like the Jules Horowitz reactor and the FRMII reactor (Munich, Germany) started construction work within ten years after their plans were first formulated. Despite European efforts, Big Science remains primarily a case of national investments and interests.[151]

In analyzing the history of MYRRHA, this article has addressed a traditional topic for historians of science, namely, nuclear reactors and their histories. However, by focusing on how the importance of scale shaped internal scientific debates and European collaboration in the Belgian context, this study contributes to a wider discussion of the politics of scale in science and science policy. Large-scale research has become a common feature of scientific communities, be it physical, biological, or even the human sciences.[152]

150. Olof Hallonsten made a similar observation in his work on the Swedish MAX lab: Olof Hallonsten, "Growing Big Science in a Small Country: MAX-Lab and the Swedish Research Policy System," *Historical Studies in the Natural Sciences* 41, no. 2 (2011): 204.

151. Hallonsten, *The Campaign: How a European Big Science Facility Ended up on the Peripheral Farmlands of Southern Sweden*. See note 14.

152. Thomas Franssen, "Research Infrastructure Funding as a Tool for Science Governance in the Humanities: A Country Case Study of the Netherlands," in *Big Science and Research Infrastructures in Europe*, by Katharina Cramer and Olof Hallonsten (Cheltenham, England: Edward Elgar Publishing, 2020), 157–76; Niki Vermeulen, "Big Biology: Supersizing Science During the Emergence of the 21st Century," *NTM* 24, no. 2 (2016): 195–223.

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