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Italy in the European Fusion Programme during the 1980s: A Preliminary Overview

Even a cursory look at the existing literature on the European Fusion Programme (EFP) identifies two main recurrent themes: the creation of the Joint European Torus (JET) as a joint undertaking, and the related leading role of the long-lasting Director of the Fusion Programme in Brussels, Italian physicist Donato Palumbo.[1] The main thrust of these writings consists in tracing the success of JET back to early attempts at setting up a European program in controlled thermonuclear fusion by "networking" several scientific activities in national laboratories and universities, with a view to coalescing them into a coherent ensemble. This approach puts a premium on the hardly surprising political squabbles between member-states over the siting of JET, while it leaves comparably in the shadow the scientific "networking" as such, so that the latter is proposed somewhat as a mere precondition for the big device – the latter being intended both as a defining moment and the end of the story.

When it is investigated, this "pre-history" of JET is in no way juxtaposed – or, even less, opposed – to the joint undertaking; rather, it is often described as the successful outcome of a clever and unswerving work by a theoretical physicist turned science manager and "Eurocrat", i.e. Palumbo.[2] Most accounts prize his scientific authority and diplomatic skills, his vision for the future, and his pertinacity. In the same way, they recognize that the cornerstones of the EFP were a result of his own conceptions: networking via contracts of association and Euratom financial participation, the preferential support scheme in the 1971-1975 program, which pushed European laboratories to converge toward studies in toroidal plasma confinement; the special mobility scheme

1 Danis Willson, *A European Experiment: The Launching of the JET Project* (Bristol: Hilger, 1981); E. N. Shaw, *Europe's Experiment in Fusion: The JET Joint Undertaking* (Amsterdam: North Holland, 1990); Shaw, "Joint European Torus", *History of European Scientific and Technological Cooperation*, eds. John Krige and Luca Guzzetti (Luxembourg: Official Publications of the EC, 1997), 165-78.

2 Donato Palumbo, "Some Considerations on Closed Configurations of Magnetohydrostatic Equilibrium", *Il Nuovo Cimento* B 53 (1968): 507-11.

for scientific personnel; the creation of consultative committees to assure the overall coherence of European efforts and avoid redundancies.[3] In many respects, such accounts reflect Palumbo's own recollections of the Fusion Programme's history, as he made them public on a number of occasions.[4]

Such approach, which is comprehensively adopted even by a recent essay,[5] though it maintains a different focus and deals with a wider timespan, gives rise to two types of shortcomings: first, it has a leaning to look back to the past from the mid-1980s point of view, encompassing the following period in the realm of "consequences"; second, it focuses on Palumbo as a Commission senior official while leaving in the background the contribution of Italy to the Fusion Programme, and the role played by other Italian scientists and engineers in a number of capacities. This is still odder if one considers that in the 1980s Italy developed new sizable projects, which led her effort to be second only to the French and German ones under different headings.[6]

This chapter addresses the "presence" of Italy in the EFP during the 1980s focusing on the support for new Italian initiatives against the background of growing difficulties in raising the necessary funding for fusion in the context of the European Framework Program (FP).

The Background

By the end of the 1970s, with the creation of JET as a joint enterprise, and a growing orientation of the Programme toward fusion as a long-term energy source, the need was felt to adopt new structures for orientation, coordination, and control of activities.

3 Umberto Finzi, "Palumbo Donato", in *Dizionario biografico degli italiani* 80 (2014), www.treccani.it, *ad vocem*; *Commemoration for the Life and Work of Donato Palumbo*, JET, November 21, 2011, Abingdon, United Kingdom; Harry Bruhns, "In Ricordo di Donato Palumbo (1921-2011)", *Il Nuovo Saggiatore*, http://static.sif.it/SIF/resources/public/files/ricordo/palumbo.pdf, last accessed February 18, 2016; Interview with Paolo Maria Fasella, July 31, 1998, Historical Archives of the European Union, European University Institute, San Domenico di Fiesole (Firenze), Italy (hereafter HAEU), INT585, 7.

4 Donato Palumbo, "The European Fusion Programme", in *Industry's Role in the Development of Fusion Power: Papers Delivered at the AIF Conference on Industry's Role in the Development of Fusion Power* (New York: AIF, 1981); Palumbo, "Nature and Prospects of the EURATOM Fusion Programme", *Philosophical Transactions of the Royal Society of London: Series A, Mathematical and Physical Sciences* 322 (1987): 199-211; Palumbo, "Setting JET on Track", presentation for the 25th Anniversary of JET, Culham, May 20, 2004; Palumbo, "The Work of the European Commission in Promoting Fusion Research in Europe", *Plasma Physics and Controlled Fusion* 29 (1987): 1465-73.

5 Patrick McCray, "'Globalization with hardware': ITER's Fusion of Technology, Policy, and Politics", *History and Technology* 26 (2010): 283-312.

6 Expenditures by the fusion associations in 1987, HUAE, ITER 9.

While JET would retain its own organization and each association would continue to be managed by a steering committee including representatives of the Commission, the overall overseeing structure of the Fusion Programme needed reform. After the Council's decision of December 26, 1980, the Consultative Committee on Fusion, the Liaison Group and the Committee of Directors were dissolved and replaced by a single Consultative Committee on the Fusion Programme (CCFP). The structure and guidelines of the CCFP were similar to the JET Council's, while its membership consisted of three representatives of the Commission, two members appointed by JET and for each member-state – as well as for the associate countries, i.e. Sweden and Switzerland – three representatives appointed by each national government. Every national delegation would include both a member coming from a State department and one from the scientific community. In the case of Italy, the three members were selected respectively by the Comitato nazionale per la ricerca e lo sviluppo dell'Energia Nucleare e delle Energie Alternative (ENEA), the Consiglio Nazionale delle Ricerche (CNR) and the Ministry for Scientific Research.[7]

The CCFP had the task of watching over ongoing activities, defining priority actions (subject to preferential support by the Community), and selectivity applying criteria in the definition of new activities. These criteria hinged on the "reactor relevance" of the proposed activity, namely ensuring a focus on tokamaks and a growing attention for the technological aspects of research and development compared to fundamental research in plasma physics. The tokamak (*toroidalnaya kamera magnitnaya katushka*, or "toroidal chamber and magnetic coil") is a magnetic confinement system originally developed in the Soviet Union, which, by the late 1960s, had become the frontrunner in fusion research by achieving a high plasma performance.[8] Central to this process of re-orientation was the definition of conceptual parameters for the Next European Torus (NET), ideally an engineering testing reactor linking JET to a future prototype reactor called DEMO.[9]

In the face of increasing expenses for devices and instrumentation, and to assure maximum continuity, it was agreed that after the first three years a new five-year research program would be implemented, overlapping the last two years of the previous one. This provision gave rise to an almost continuous process of scientific reappraisal and financial negotiation, which allows to sketch some basic features of the EFP during the 1980s. The decade opened with a very substantial budget of 750 millions European Currency Unit (MioECU) for the five-year program 1979-1983, leading to the launch of several mid-

7 "Communication from the Commission to the Council concerning the creation of a "Consultative Committee of the Fusion Programme", COM (79) 771 final, December 19, 1979 and CCFP first meeting, January 8, 1981, HUAE, ITER 1.

8 John Wesson, *Tokamaks* (Oxford: Clarendon, 2004), 15-23.

9 CCFP second meeting, March 9-10, 1981 and CCFP fourth meeting, April 7, 1981, HUAE, ITER 1.

sized experiments in support of or collateral to JET.[10] The entity of the effort was such that by 1982 it drove Palumbo to voice his concern and to propose a period of reflection.[11]

A measure of consolidation occurred already in the years 1982-1986,[12] but cuts were even heavier in the period 1985-1989, with the original proposition (790 MioECU) reduced by 100 MioECU. Though the allocation of funds for the years 1985-1986 allowed for the continuation of activities, a revision of the program became necessary for the post-1986 period. At this time Palumbo expressed his disappointment for the level of support the Commission's proposals had received from national governments once presented to the Council:[13] with fusion bound to be included in the FP – and oil prices heading to full-fledged counter-shock – the Fusion Programme was coming under careful scrutiny.[14]

The budget for the years 1987-1991 was caught up in the battle unleashed by the British determination to curb the projected second FP, which was eventually scaled down from 7.7 billions European Currency Unit (BioECU) to 5.4 BioECU.[15] This was a very delicate moment for the EFP, as the original budget estimate was increased by the preoccupation of strengthening NET and technology-related activities while international cooperation on the ITER project was taking shape. Though a measure of delay was unavoidable, fusion as a FP2 sub-action held out reasonably well, passing from an original request for 1005 MioECU to 985 MioECU, with the latter eventually being cut by 30 MioECU.[16]

The Presence of Italy

Against this background, Italy was able to reinforce its participation in the EFP by applying for preferential support (i.e. 45 per cent of funding from the Community) for two different projects, the Reverse Field Experiment (RFX) and the Frascati Tokamak

10 Note à la Commission, n.d., HAEU, ITER 1.

11 CCFP tenth meeting, June 22-23 1982, HAEU, ITER 2.

12 CCFP third meeting, April 7, 1981 and CCFP seventh meeting, October 15, 1981, HAEU, ITER 1; CCFP ninth meeting, April 2, 1982, HAEU, ITER 2.

13 CCFP twenty-first meeting, October 24, 1985 and Draft communication of the Commission to the Council on the Fusion Programme, n.d., HAEU, ITER 5.

14 "The scientific and technical strategy of the Community", COM (85) 140 final, April 9, 1985, HAEU, ITER 5.

15 Ingo Rollwagen, "Progress in Europe by Integrated Research Policy: Development and Challenges", *EU Monitor*, April 28, 2005: 16, http://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000186906.pdf, last accessed February 18, 2016.

16 CCFP twenty-fifth meeting, February 6-7, 1986 and CCFP twenty-seventh meeting, June 19, 1986, HAEU, ITER 6; CCFP thirtieth meeting, April 29, 1987, HAEU, ITER 7; CCFP thirty-fifth meeting, October 26-27, 1988, HAEU, ITER 8.

Upgrade (FTU), respectively in March and June 1981.[17] Studies of the reverse field pinch family – basically a plasma column carrying current that produces magnetic forces that constrict the column, producing higher plasma densities, and in which the stabilizing toroidal magnetic field reverses on the outside of the torus – had been encouraged at Culham, Los Alamos and Padua by the intrinsically high Ohmic heating power of these devices and by the theoretical work of John Brian Taylor on the relaxation of plasma toward the natural state of lowest energy.[18] In explaining the experimental results obtained in the ZETA device at Culham, Taylor had produced a theory of the self-organization of the magnetic field where the plasma rapidly accesses to minimum-energy states (relaxation), which are the preferred state of the system, by controlling a few global parameters. This opened questions of how and why relaxation occurs.[19] Considering relaxation as a benign process, reverse field pinches were promising from a reactor point of view, since they offered a relatively high ratio of kinetic plasma pressure and magnetic field pressure (by and large an indicator of economic efficiency) and the expected possibility of reaching thermonuclear ignition without additional heating.[20]

In Padua, work on ionized gases started in the late 1950s on the initiative of the Institute of Electric Engineering directed by Giovanni Someda, with the support of the Institute of Physics under Antonio Rostagni.[21] In the 1970s research in toroidal devices and the pinch effect produced promising results in the context of an association between Euratom and the CNR, so that in 1979 the quiescent regime found on ZETA some twenty-five years earlier was reproduced for the first time. This gave rise to a new wave of research projects on the reverse field pinch; among them RFX, originally proposed by Culham as a 1 MA machine and then upgraded to 2 MA by the end of the 1970s, which had been envisaged as a tripartite venture in which Culham, Padua and Los Alamos would participate.[22]

In September 1981, cuts in the British fusion budget and the fact that JET was located at Culham led the United Kingdom Atomic Energy Authority (UKAEA) to

17 CCFP second meeting, March 9-10, 1981 and CCFP fifth meeting, June 26, 1981, HAEU, ITER 1.

18 John Brian Taylor, "Relaxation of Toroidal Plasma and Generation of Reverse Magnetic Fields", *Physical Review Letters* 33 (1974): 1139-41.

19 Sergio Ortolani and Dalton Schnack, *Magnetohydrodynamics of Plasma Relaxation* (Singapore: World Scientific Publishing, 1993), 1-14.

20 Cornelius Marius Braams and Peter E. Stott, *Nuclear Fusion: Half a Century of Magnetic Confinement Fusion Research* (Bristol: Institute of Physics Publishing, 2002), 92-97.

21 For a brief review of early fusion research in Padua see Consorzio RFX, *Fisica e ingegneria della fusione: la ricerca verso una nuova fonte di energia* (Vigorovea: Graficamontaggi, 2007). On Someda and Antonio Rostagni, see Lorenzo Maranesi, *Giovanni Someda e il suo tempo* (Venezia: Ist. veneto di scienze, lettere e arti, 2004); Milla Baldo Ceolin, *Antonio Rostagni* (Padova: Società cooperativa tipografica, 1991).

22 Braams and Stott, *Nuclear Fusion*, 99-101.

inform the Commission that it was not in the position to keep RFX in its program. The American interest too failed to materialize. The Italian delegation to the CCFP, however, was able to express the willingness of the CNR to put in the money and build RFX in Padua. On April 2, 1982 physicist Piero Caldirola assured CNR funding to realize RFX, provided that the project received preferential support from the Commission as originally envisaged.[23]

In the meantime, the CCFP was discussing the proposal for preferential support for FTU put forward by the Laboratorio Gas Ionizzati (LGI) at Frascati. Back in the 1970s, in the wake of general interest by the scientific community for tokamaks, the LGI had established contacts with a group of physicists and engineers working at MIT. Among them, by the late 1960s, Bruno Coppi had developed the idea of producing high-temperature plasma with a compact tokamak with a small major radius, so that Ohmic heating per volume would increase and the temperature would rise. At MIT he had become acquainted with the Francis Bitter National Magnet Laboratory, a centre for the fabrication of exceptionally high field magnets, and its leading magnet designer, Bruce Montgomery. In addition to a small radius, now Coppi imagined a device with a formidable toroidal field called ALCATOR (i.e. high field torus), which by 1974 was achieving resounding success. As a consequence of contacts with MIT, the Frascati laboratory opted for a compact machine of small dimensions having a strong magnetic field, though tempered by the need of having plasma dimensions that were not so small as to disperse the power. This was the Frascati Tokamak, of which FTU was presented as an upgrade.[24]

FTU was criticized at the CCFP meeting of July 15, 1981. François Prévot, head of the CEA Fusion Department, expressed concern on the application of ALCATOR scaling laws (an empirical scaling criterion for calculating energy confinement time according to results in ALCATOR experiments) and, more generally, for a technology which combined high temperatures, high densities and high wall loading. Friedrich Wagner, who was working at Garching on the high-confinement regime for plasma,[25] questioned the NET relevance of FTU and its chance of reaching ignition without additional heating.[26]

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23 Arnold Allen to Donato Palumbo, September 15, 1981, HAEU, ITER 1; CCFP ninth meeting, April 2, 1982, HAEU, ITER 2.

24 Joan Bromberg, *Fusion: Science, Politics, and the Invention of a New Energy Source* (Cambridge: The MIT Press, 1982), 162-64, 230-31; Paola Batistoni, ed., *1960-2010: cinquant'anni di ricerca sulla fusione in Italia* (Roma: ENEA, 2010): 38-41, http://www.fusione.enea.it/EVENTS/eventifiles/50esimo/50anni-fusione.pdf, last accessed February 18, 2016; Kenneth Fawler, *The Fusion Quest* (Baltimore: John Hopkins University Press, 1997), 180.

25 Friedrich Wagner et al. "Regime of Improved Confinement and High Beta in Neutral-Beam-Heated Divertor Discharges of the ASDEX Tokamak", *Physical Review Letters* 49 (1982): 1408-12.

26 CCFP sixth meeting, July, 15, 1981, HAEU, ITER 1.

By the time the CCFP Programme Committee agreed in recommending preferential support for FTU, in January 1982 Palumbo announced that CNEN had sent a new proposal for preferential support in the form of a preliminary draft conceptual design for a high-field, compact tokamak called Ignited Torus (IGNITOR). Indeed, while ALCATOR represented a relatively inexpensive way to study tokamaks in a university environment, at the International School of Fusion Reactor Technology held at Erice, Sicily, in September 1976 Coppi had proposed developing a new line of compact devices as a parallel program to large tokamaks like JET to reach plasma ignition.[27]

The IGNITOR proposal, however, was not really welcomed by the CCFP, which refused to call in American experts to appraise it. After a long discussion, in June 1982 the CCFP requested a position from Etienne Davignon, then vice President of the Commission with responsibility for industrial, energy and research matters, who appointed a special panel chaired by famous British scientist John Adams to assess the scientific and technical interest of IGNITOR for fusion research, as well as the soundness of the project. On the same occasion, both the French and the Germans expressed a negative attitude toward the building of RFX at Padua – with the Germans insisting that RFX had to be seen in connection with IGNITOR.[28] This connection might have disruptive effects both at a European level and in Italy, where the fusion association was being reorganized so that ENEA would take over CNR fusion activities, notably RFX. The Adams Panel reported to Davignon on December 23, 1982, casting both lights and shadows. IGNITOR could be a complementary, low-cost experiment, but the apparatus was considered as potentially dangerous.[29]

Meanwhile, the CCFP agreed on preferential support for RFX by majority vote – not unanimously as would be expected after a positive technical appraisal (and, indeed, as was the case for the other 'alternative line', i.e. the German stellarator Wendelstein 7-AS).[30] European funding for RFX and, most likely, for FTU made the uneasy coexistence with IGNITOR a reason for perturbation in Italy. On the one hand, the two Italian associations with Euratom were being merged under ENEA, the latter being the statutory organization responsible for nuclear energy and other alternative sources, so that RFX (a CNR project) was to fall under the ENEA umbrella. On the other hand, the Ministry for Scientific Research (the parent department of the CNR) insisted on

27 Bruno Coppi, "Compact Experiments for α-Particle Heating", in *Tokamak Reactors for Breakeven: A Critical Study of the Near-Term Fusion Reactor Program*, ed. Heinz Knoepfel (Oxford: Pergamon, 1978), 303-26.

28 CCFP eight meeting, January 7-8, 1982 and CCFP tenth meeting, June 22-23, 1982, HAEU, ITER 2.

29 John Adams to Etienne Davignon, December 23, 1982, HAEU, ITER 3.

30 CCFP eleventh meeting October 20, 1982, HAEU, ITER 2.

the relevance of fusion research (and RFX, in particular) in connection with the Project "Energetics II" (Progetto Finalizzato Energetica II). The latter was a big research and development exercise organized by the CNR in the context of the Piano Nazionale di Ricerca per l'Energia; ENEA would take part on equal footing with its steering committee. On December 22, 1982, the Comitato Interministeriale per la Programmazione Economica (CIPE) approved the start of "Energetics II", but it recommended a comprehensive appraisal of Italian fusion activities in order to define national priorities for action in the field – with special attention to costs and possibilities of European cooperation such as RFX.[31]

Such an appraisal, in fact, was tantamount to holding in abeyance RFX for the time being. Rumors spread that the Italian Government would not support the project anymore. At the CCFP meeting of February 1983, Cees Braams, director of the Institute for Plasma Physics in Nieuwegein (FOM) and "founding father" of Dutch research on nuclear fusion, asked the Italian delegation to comment and Caldirola, hinting at the relationship between RFX and "Energetics II", stated that the position of the CNR had not changed. On the same occasion, FTU received preferential support status and Romano Toschi, the Italian representative from Frascati, definitely stated that IGNITOR did not feature in the fusion association program of ENEA.[32]

These facts seem to point to the possibility that it was IGNITOR, as a latecomer project without any immediate prospect of European funding, which sent shockwaves through the Italian party and put into question the future of RFX. The hypothesis is reinforced by the fact that ENEA was apparently unwilling to put forward a formal proposal regarding IGNITOR, a precondition for any further action by the CCFP. Indeed, this was particularly surprising at a moment when IGNITOR and a tritium handling laboratory figured as favorite items to fill the large gap left at the JRC by the cancellation of Super-SARA – a light-water reactor safety research project abandoned amid chronic delays, escalating costs, and allegations that Italian entities had got too large a share of research contracts.[33]

By June 1983, the Italian authorities confirmed the validity of RFX, but they refrained from giving the green light to the project still pending a decision on funding. At the CCFP meeting of June 15-16, Giorgio Rostagni (Antonio's son and disciple of Giovanni Someda), who had taken over from Caldirola in view of the sensitivity of the RFX situation, tried to reassure his colleagues by pointing out that the delay was due to changes in the Italian government, but the project had passed all stages of verifica-

31 CIPE, delibera n. 107, December 22, 1982; *Progetto finalizzato energetica 2. Studio di fattibilità* (Roma: CNR, 1982).

32 CCFP thirteenth meeting, February 9-10, 1983, HAEU, ITER 3.

33 CCFP fourteenth meeting, April 19, 1983, HAEU, ITER 3.

tion except for the final decision. Undeterred, the CCFP passed a resolution that was actually an ultimatum: if Italy did not make up its mind by the meeting scheduled for October 19-20, 1983, then the CCFP would conclude that RFX did not have the support of the Italian association.[34]

After the general election and the formation of the first Craxi government in August 1983, just a few days before the CCFP deadline the Ministry of Industry and the Ministry for Scientific Research proposed including RFX in the program of ENEA. On October 19, CIPE authorized the necessary funds, but it also recommended that ENEA start a feasibility study of IGNITOR drawing on the existing documentation.[35] The following day, Rostagni was able to take part in the second day of the CCFP meeting after the news had been communicated from Rome directly to commissioner Davignon. On that occasion, the CCFP further noted the merging of the ENEA and CNR contracts and that the financing of RFX would be assured under the single ENEA contract of association.[36]

Subsequently, the troubled life of RFX went relatively smoothly. Even though the collaboration with American and Japanese laboratories, as originally envisaged, did not materialize, the project succeeded in covering a 7.5 MioECU gap through European funds, notwithstanding the constraints to Fusion Programme budgets in the mid 1980s.[37] The RFX construction phase was substantially completed by 1991 and the experimental phase began in 1992.[38] Nowadays the Consorzio RFX is the site where the prototype of one of the plasma heating systems for ITER is being built in cooperation with India and Japan.[39]

FTU started operating in 1989, with a reduced toroidal field compared to the earlier Frascati tokamak (from 10T to 8T), in order to allow openings in the vacuum chamber necessary for the installation of all the radio frequency power coupling structures foreseen. Indeed, unlike IGNITOR (in which Ohmic heating was expected to play a major role), the new high field tokamak at Frascati was developed as a test-bed to study plasma heating and non-inductive current drive[40] efficiency in high density plasmas by equip-

34 CCFP fifteenth meeting, June 15-16, 1983, HAEU, ITER 3.

35 CIPE, delibera n. 93, October 19, 1983.

36 CCFP seventeenth meeting, October 19-20, 1983, HAEU, ITER 3.

37 CCFP twenty-eighth meeting, October 29-30, 1986, HAEU, ITER 6.

38 Giorgio Rostagni, "RFX: An Expected Step in RFP Research", *Fusion Engineering and Design* 25 (1995): 301-13.

39 Sabina Griffith, "Signature Seals Future of Neutral Beam Test Facility", *ITER Newsline*, November 5, 2010.

40 On the interest in maintaining a tokamak current indefinitely by a combination of the electric current self-generated inside the plasma and various mechanisms for non-inductive external current drive, see Braams and Stott, *Nuclear Fusion*, 187.

ping it with three different radio frequency heating systems.[41] Some difficulties occurred in mid-1985 through a combination of budget cuts to the Fusion Programme in general and raising estimates for the installation of a lower hybrid device, i.e. one of the three most successful schemes for radio frequency heating.[42] As Roberto Andreani (director of the ENEA fusion division at Frascati) explained, earlier Italian estimates had been approximate, notably because the potential supplier of gyrotrons had not been able to quote a firm price. Now asked for a revision of the financial ceiling agreed for the heating scheme, the CCFP agreed by majority vote with the provision that ENEA verified the practicability of the heating method via a pre-experiment in the Frascati Tokamak with electromagnetic power at the highest end of the frequency range.[43] One should not make too much of these dynamics, however, as it was in the logic of the CCFP to criticize actions proposed for preferential support in order to assure both the overall coherence of the Fusion Programme and a spend-wise approach to research. Accordingly, in October 1988, the CCFP awarded preferential support both to an ion Bernstein wave experiment,[44] i.e. the use of a hot plasma wave to carry the radio frequency power to heat the tokamak reactor core, and to high density Electron Cyclotron Resonance Heating tests[45] on FTU, provided that ENEA could demonstrate the availability of a gyrotron of advanced design in a time consistent with the proposed timescale pursuant to the technical suggestions received.[46]

As far as IGNITOR was concerned, in 1984 Coppi made a direct approach to Davignon, and on July 12 a special meeting recognized the substantial changes introduced in the original proposal, so that it was agreed that the CCFP would reconsider the project. In October 1984, the Committee questioned Coppi extensively, in particular on the possible position of IGNITOR in the European strategy and whether it was aimed at more than attaining ignited plasma. Coppi admitted that not too much attention had been given to burn stabilization and that, once the physics of the machine had been proven, another core should be built for material testing. At the end, the CCFP, though recognizing the importance of experimental studies of burning plasmas, did not formulate an opinion, nor took any further steps. IGNITOR should be seen in connection with the present US interest in physics machines for the study of burning plasmas, the CCFP concluded, so that it might be played as a possible way of strengthening international collaboration.[47]

41 Batistoni, *1960-2010*, 72-82.
42 Wesson, *Tokamaks*, 261-62, 286-90.
43 CCFP twenty-second meeting, May 23-24, 1985, HAEU, ITER 5.
44 See Braams and Stott, *Nuclear Fusion*, 187.
45 See Wesson, *Tokamaks*, 290-99.
46 CCFP thirty-fifth meeting, October 26-27, 1988, HAEU, ITER 8.
47 CCFP twentieth meeting, October 17-18, 1984, HAEU, ITER 4.

Indeed, Coppi's idea inspired Princeton, with strong backing from the director of the Magnetic Confinement Program in the US Department of Energy, to propose the Compact Ignition Tokamak (CIT) specifically to study the physics of burning plasmas. CIT soon captured the enthusiasm of American fusion scientists, concentrated on advancing toward ignition, even though few if any regarded CIT design as a direct path to a reactor. But CIT's physical dimensions grew dramatically – reflecting the difficulty of building a high-field tokamak with engineering structures that left enough space for a plasma – and the project was abandoned in 1990 among fears that it would not ignite.[48]

On October 15, 1986, the Italian Minister for Scientific Research, Luigi Granelli, directly addressed the vice President of the European Commission, Karl-Heinz Narjes, proposing the inclusion of IGNITOR in the much-discussed program for 1987-1991. After stressing the American interest in this kind of device, Granelli re-launched the idea of siting IGNITOR at Ispra – this time as a joint undertaking. Under this condition, the Italian government would be ready to assume a substantial financial commitment to the project. A couple of weeks later, the Commission – with the support of the Italian delegation – proposed putting the IGNITOR design phase within the activities of the Euratom-ENEA association, thereby granting a support in the order of 2-4 MioECU, which would be included in the financial ceiling of the contract of association for the period 1987-1991. Meanwhile, it would be possible to explore bilaterally with Italy ways and means for the construction of IGNITOR. However, the CCFP's reaction was very cold. Expressing their concern at launching such an initiative before reaching a possible understanding with the United States, some delegations questioned the compatibility of the project with the ongoing construction of RFX and FTU by ENEA. On a more general note, the CCFP pointed out the difficulty of including IGNITOR in the Community strategy, as it was based on big tokamaks with a growing focus on technology and engineering.[49]

The matter, however, remained quiescent for more than two years. The Italian delegation presented the official proposal for priority support only in February 1989. The CCFP reacted once again by voicing the usual misgivings: what would IGNITOR bring to the European Programme? Would it really ignite and what contribution would a transiently ignited device give to the study of burning plasmas? Francis Troyon, director of the Plasma Physics Research Center at the École Polytechnique Fédérale of Lausanne and discoverer of a relationship that expresses the limit in pressure that cannot be

48 Braams and Stott, *Nuclear Fusion*, 228; Fawler, *The Fusion Quest*, 181.

49 Luigi Granelli to Karl-Heinz Narjes, October 15, 1986, and CCFP twenty-eight meeting, October 29-30, 1986, HAEU, ITER 6.

exceeded in a plasma,[50] raised a number of technical points concerning the interconnectedness of physics and technical solutions for such a compact device like IGNITOR. He pointed out the damaging psychological consequences that could arise if, after all, IGNITOR did not ignite. Robert Aymar, then head of the CEA fusion department, requested that IGNITOR's position be considered in direct relation to the US intention of proceeding with CIT – by then on the eve of being cancelled. The CCFT concluded that the proposal should be examined in depth and as diligently as possible,[51] but IGNITOR would never receive Euratom support.

Conclusion

Even from this very restricted investigation, the relevance of Italy to the EFP is considerable, both quantitatively and qualitatively. Italy was able to take advantage of the substantial fusion budget of the early 1980s and successfully defended its major projects, not so much in a logic of "just return", but by conceiving and deeply connecting them to the mainstream of the fusion community. One notable exception is IGNITOR, which has long since remained a subject of heated controversy in the scientific community and, of course, politically.

More research is needed on the political aspects, focusing on the feedback/relationship between scientists and science managers on the one hand and government/EC officials on the other. Far from representing a mere context, this link might be a way to test the consistency of Italy's European policy, maybe discovering a realm in which the country could be ambitious without any risk of marginality.[52] There is a preliminary proviso, however: is this matter really relevant for the understanding of contemporary Italian history? If one cursorily examines references on the country's history in the 1980s, the provisional answer would be negative.[53]

50 François Troyon et al., "MHD-Limits to Plasma Confinement", paper presented to the XI European Conference on Controlled Fusion and Plasma Physisc, Aachan, September 1983, ed. December 1983, http://infoscience.epfl.ch/record/120771/files/lrp_231_83_hq.pdf, last accessed February 18, 2016.

51 CCFP thirty-sixth meeting, February 2-3, 1989, HAEU, ITER 9.

52 See Marinella Neri Gualdesi, "L'Italia e l'Europa negli anni ottanta: tra ambizione e marginalità", in *L'Italia nella costruzione europea. Un bilancio storico (1957-2007)*, ed. Pietro Craveri and Antonio Versori (Milano: FrancoAngeli, 2009), 79-108.

53 See, for example, Silvio Pons, Adriano Roccucci and Federico Romero, *L'Italia contemporanea dagli anni Ottanta a oggi*, 3 vols. (Roma: Carocci, 2014); Marco Gervasoni, *Storia d'Italia degli anni Ottanta: quando eravamo moderni* (Venezia: Marsilio, 2010); Antonio Varsori, *La cenerentola d'Europa? L'Italia e l'integrazione europea dal 1947 a oggi* (Soveria Mannelli: Rubbettino, 2010); Simona Colarizi, ed., *Gli anni Ottanta come storia* (Soveria Mannelli: Rubbettino, 2004); Ennio Di Nolfo, ed., *La politica estera italiana negli anni Ottanta* (Manduria: Lacaita, 2003).

While it is understandable that historical analysis have focused on traditional political and diplomatic dynamics and, as one scholar noted, the attention to the role of scientists in Italian society has been intermittent,[54] this relative lack of attention is somewhat strange. Be it an effect of the traditional Italian difficulty in considering natural sciences as part of "culture"[55] or a manifestation of conflicting views on the possible role of scientific research in Italy,[56] historians should reflect on the relevancy of a subject like fusion research, not simply as an exercise in international or transnational history, but as a significant contribution to the understanding of contemporary Italy and her relations with the rest of the world.

54 Giuliana Gemelli, "Gli scienziati", in *Le élites nella storia dell'Italia unita*, ed. Guido Melis (Napoli: Cuen, 2003), 213-39.

55 Antonio Ruberti, "Riflessioni sul sistema della ricerca dopo il 1945", in *Ricerca e istituzioni scientifiche in Italia,* ed. Raffaella Simili (Roma: Laterza, 1998), 213-30.

56 Giovanni Paoloni, "Lo sviluppo scientifico italiano nell'ultimo sessantennio: due modelli a confronto", *Meridiana* 54 (2005): 39-61.