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PRELIMINARY DESIGN STUDY OF AN EXPERIMENTAL ACCELERATOR-DRIVEN SYSTEM

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FINAL REPORT

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Summary

The project on "Preliminary Design Study of an eXperimental ADS", PDS-XADS, partially funded by the European Commission under the EURATOM 5th Framework Programme, had the objective to assess the safe and efficient operation of Accelerator Driven Systems. It federated 25 institutions (leading nuclear industrial companies, research centres and universities) from 11 European countries under the co-ordination of the nuclear industrial company Framatome-ANP.

The project has evaluated different XADS design candidates in order to select the most appropriate one to be further developed. Three designs, two based on heavy liquid metal (Lead-Bismuth eutectic) cooling and one on gas cooling have been studied according to a common basis and the main needs for future Research & Development have been defined. The three designs fit rather well with the technical objectives fixed at the beginning of the project, consistent with the European Roadmap on ADS development.

The designs are sufficiently consistent and advanced to :

- confirm the overall complexity and extent of the plant compared to a critical system (Accelerator, Interface between spallation target and primary system, accommodation of accelerator beam transfer line above the reactor and within the reactor building, radiation protection/shielding, containment issues),
- confirm the good prospect for the feasibility of the XADS apart from the target itself, which is currently considered the weakest point of the system,
- provide a clear recommendation on the superconducting LINAC accelerator, the only concept capable of satisfying the stringent requirements on reliability,
- compare the three XADS concepts and provide recommendations on the best options to be pursued more in detail in the 6th Framework Programme in particular for the heavy liquid metal technology,
- specify the designers R&D needs through a series of R&D Question Sheets which have been extensively used to establish the 6th Framework Programme technological supporting programmes.

With an efficient management and a strong industrial involvement, this large R&D project involving a total workforce close to 100 person-year, has provided on time substantial technical results well focused on the design of a reactor.

This project has also been a great success in the field of European collaboration. Experience gained in design and related studies for the ADS has helped to maintain and develop for young engineers and physicists, know-how on nuclear engineering and technology expertise all over Europe even in non nuclear countries.

This document is the Final Report of the Project. It contains a summary of the Technical and Management achievements. More technical details can be found within PDS-XADS Public Deliverable 86 “General Synthesis Report of XADS preliminary design studies and needed R&D”.

Contents

List of Appendices

List of acronyms

ADS :	Accelerator Driven System
ADT :	Accelerator Driven Transmuter
ADOPT :	Advanced Options for Partitioning and Transmutation
ASAP :	As Soon As Possible
DBC :	Design Basis Conditions
DEC :	Design Extension Conditions
DHR :	Decay Heat Removal
EC:	European Commission
EFR:	European Fast Reactor
EPR:	European Pressurized (water-cooled) Reactor
ETWG:	European Technical Working group on ADS
GFR :	Gas (cooled) Fast Reactor
HTR :	High Temperature Reactor
IP-EUROTRANS :	Integrated Program - EUROpean research program for the TRANSmutation of high-level nuclear watse in an ADS
ISI & R:	In-Service Inspection and Repair
LBE :	Lead-Bismuth Eutectic
LINAC:	Linear Accelerator
LLFP :	Long Lived Fission Products
LMFBR :	Liquid Metal (cooled) Fast Breeder Reactor
LWR:	Light Water (cooled) Reactor
MA :	Minor Actinide
MEGAPIE :	Megawatt Pilot Experiment (at PSI)
MOX :	Mixed Oxide fuel
MUSE :	Multiplication with an external Source on MASURCA Reactor (at CEA)
MYRRHA :	Multi-purpose hYbrid Research Reactor for High-tech Applications (at Mol)
MWth :	Megawatts, thermal
NPP :	Nuclear Power Plant
PCS :	Power Conversion System
PDS-XADS :	Preliminary Design Study of an Experimental Accelerator Driven System
PMT :	Project Management Team (of the PDS-XADS Project)
P&T :	Partitioning and Transmutation

RCC-MR :	Design and Construction Rules for Mechanical components of FBR Nuclear Islands
RPV:	Reactor Pressure Vessel
RV(A)CS :	Reactor Vault (Air) Cooling System
S/A :	Sub-Assembly
SCS :	Shut-down Cooling system
SPX :	Superphénix LMFBR reactor
TRADE :	TRIGA Accelerator Driven Experiment
TU:	Target Unit
WP :	Work Package
XADS:	eXperimental Accelerator Driven System
XADT:	eXperimental Accelerator Driven Transmuter

1. Background

During the 1990s, a number of European countries considered the use of an Accelerator-Driven System (ADS) as an efficient tool for the transmutation of radioactive wastes. Then, at the national level, some concepts of an ADS were suggested. In 1998, a Technical Working Group (TWG) was mandated by the Research Ministers of France, Italy and Spain, to identify the critical technical issues and to prepare a Roadmap for a demonstration programme.

The Roadmap, Reference 1, which was issued in April 2001 defines the main requirements of an eXperimental ADS (XADS) that was accepted as a common basis by the European countries.

A number of European Research Centres, Universities and Industrial Companies combined their efforts in order to be able to propose a common European XADS. One of the first steps to reach this objective was to evaluate the different XADS candidates previously developed in Europe in order to select the most appropriate concept. This led to the PDS-XADS (Preliminary Design Studies of an XADS) project supported by the European Commission under the 5th Framework Programme.

The PDS-XADS Project is the first major step of a consistent European effort that will allow to design in detail an integral installation for the ADS technology demonstration. The project was linked with the other FP5 projects on Partitionning & Transmutation under the umbrella of the ADOPT network.

The present document is the Final Report of the three years (11/2001 to 10/2004) PDS-XADS project, in the Framework of the European Contract FIKW CT-2001-00179, Reference 2. The main technical and management achievements are reported and an exhaustive list of documents produced within the project is provided.

2. Executive Summary Report

2.1 Project Objectives

The strategy related to the closure of the fuel cycle depends on nuclear policies adopted by each European Union member country. In any case, the transmutation of most of the long-lived radioactive wastes is a promising solution, which could play a substantial role in the safety of the fuel cycle.

Previous studies have shown that a fast neutron spectrum allows maximising the transmutation of Minor Actinides (MA), because of both the better fission efficiency compared to the neutron capturing rate, and the potentially high level of neutron flux. A core dedicated to the fission of the MA should be designed in order to minimise its self-production of actinides. Such a core has a very small delayed neutron fraction and a low Doppler coefficient making its control in a critical core configuration more complex and difficult to achieve; this difficulty can be resolved by using the core in a sub-critical mode; controlled by an external neutron source, namely a spallation source.

The demonstration of the practicability of transmutation on an industrial scale requires cooperation at a European level, for the construction of an Experimental ADS (XADS), at a large enough scale, which will demonstrate the safe coupling of the accelerator, the neutron spallation target and the sub-critical core.

Complementary to the demonstration of the basic phenomena involved in the ADS technologies, the objectives of the design-oriented PDS-XADS programme within the 5th Framework Programme (FP) were :

1. to select the most promising technical concepts,
2. to address the critical points of the whole system,
3. to identify the Research and Development (R&D) in support,
4. to define the safety and licensing issues,
5. to preliminary assess the cost of the installation,
6. to consolidate the road mapping of the XADS development.

2.2 Project Achievements

The project has evaluated different XADS design candidates in order to select the most appropriate one to be further developed. Three designs, two based on heavy liquid metal (Lead-Bismuth eutectic) cooling and one on gas cooling have been studied according to a common basis (General Specifications, Safety Rules).

The 80 MWth LBE-cooled concept, designed by ANSALDO is illustrated in Figure 1.

The 80 MWth Helium-cooled concept, designed by FRAMATOME-ANP is illustrated in Figure 2.

The 50 MWth LBE-cooled small scale concept, also called MYRRHA project, designed by SCK-CEN is illustrated in Figure 3.

The project has been organized into Work Packages (WP) to address conceptual design and feasibility of the main sub-systems.

All the designs have reached a level of definition and justification sufficient to address the six objectives of the project. The cost assessment has been focused on the small scale concept "MYRRHA" construction at Mol. The technical feasibility and synthesis of the activities performed in each of the WP is reported in detail into the WP synthesis.

The main achievements of each WP is summarized in section 2.2.1.

All the WP results have been fed into the WP1/"Global Coherency" to establish overall assessments of the three concepts and comparison. The main findings of this comparison are summarized in section 2.2.2.

2.2.1 Work Packages main technical achievements

The project is organized into WP's addressing reactor key features of the whole system (accelerator, spallation target, sub-critical core, reactor integration, safety).

- ***WP1*** is dedicated to the objectives and specifications of the XADS. It will define the methodologies and criteria for evaluation and comparison of the concepts.

- ***WP2*** concerns the plant performance and safety studies. It is divided into three sub-WP's: WP2.1 will define a common safety approach for all the concepts; WP2.2 concerns the phenomenological studies, and WP2.3 the application to the XADS design concepts.

- ***WP3*** is dedicated to the design studies of the accelerator and the comparison of the accelerator concepts. It will allow to organise the consistency of the accelerator studies and the reactor studies.

- ***WP4*** is related to the core/target design studies. There are three sub-WP's:
  - WP4.1 related to the 80 MWth LBE-cooled core,
  - WP4.2 related to the 80 MWth gas-cooled core,
  - WP4.3 related to the spallation target unit for both LBE and gas cooled concepts.

- ***WP5*** deals with the design studies of the primary circuit and the arrangement of the main components. It is sub-divided in three sub-WP's:
  - WP5.1 related to the 80 MWth LBE-cooled concept,
  - WP5.2 related to the 80 MWth gas-cooled concept,
  - WP5.3 related to the small-scale LBE-cooled concept (called MYRRHA).

The main outcome of each of the WP’s can be summarized as follows :

WP1 : Project global coherency

The global coherency Work Package has provided :

- The general specifications and objectives of the different XADS, derived from Technical Working Group recommendations.

- The justification of the Experimental Programme for ADS Transmutation Application.

- Coherency between the different XADS designs and some links with other 5th FP projects (FUTURE, MUSE, DEMETRA).

- Expertise on some ADS key issues like the definition of the approach on the determination of the level of sub-criticality, the role of the absorber system, preliminary characteristics of the Control and Instrumentation of the ADS core (interface with MUSE) and especially reactivity measurements, uncertainties associated to the core and spallation source, LBE chemistry control and monitoring system, MA loaded advanced fuels characteristics (interface with FUTURE).

- A methodology and set of criteria for the XADS concepts comparison.

- Recommendation on the reference options for both LBE-cooled and Gas-Cooled XADS and ranking of the merits of each reactor style with respect to the criteria established for the concepts comparison.
- A General synthesis of the project including the R&D needs.

WP2 : Plant performance and Safety

Within the WP2, the WP 2.1 has provided the definition of the safety approach to be applied to the three XADS concepts based on the European state of the art for modern reactors (EUR, EFR) and also in accordance with existing IAEA recommendations. The approach considers the XADS innovative and specific features such as (Core loaded with Minor Actinides, Sub-critical core, Power controlled by the accelerator, Coupling of reactor/ spallation target/ accelerator, LBE and helium coolant specific issues). The recommended approach is first deterministic. Regarding the defence in depth principle application, the prevention and mitigation of severe core damage are enhanced in accordance with the recommendations of future reactors in Europe. At this stage of the project, the priority is given to the adequate prevention of severe core damage. Probabilistic objectives are established rather as guidelines for orientating the XADS design than stringent requirements. Situations to be considered in the design of the plant (Design Basis Conditions, Design Extension Conditions, Hazards) and the Residual Risk situations are listed. Main outcomes of the safety approach implementation for both LBE and Gas concepts are provided.

In the WP 2.2 are identified the main safety issues of the XADS and their phenomenology and the methodology of evaluation. This is applied to both LBE and Gas concepts. The tools needed for the evaluation of the plant safety and the supporting R&D needs are also evaluated.

The safety analysis is deterministic and the methodology is to calculate the consequences for certain postulated events. The methodology employed for the safety analysis, in general, consists of a code modelling the thermal-hydraulic process, which has been validated against data obtained for the defined transients. Unfortunately, the lack of data for the XADS systems has not allowed validation of a specific code for LBE-cooled or He-cooled systems.

Thus, the approach in the safety analyses was to employ different computer codes that were available to the partners of this project for the analysis of the DBC and DEC condition transients.

The availability of a number of different codes able to analyse the same transients offered the capability of performing code-to-code comparisons, in the absence of experimental data for validation.

A number of transients were identified for detailed analysis reflecting a very wide range of the potential transient initiators that might be encountered during the operation of the XADS. These transients are categorised into Operational Transients, Protected Transients, and Unprotected Transients.

The main objective of this WP was to produce two Safety Analysis Reports of the XADS with the identification of the design features required to meet the XADS safety objectives and targets established in WP 1 and WP 2.1.

For the large LBE cooled XADS, the demonstration of prevention of severe core damage relies on passive means and large grace time period for corrective actions thanks to the design options in particular the power density, the nature of the coolant and the high natural convection capabilities. The small-scale LBE concept, “MYRRHA” although less forgiving than the large LBE concept (higher power densities and lower natural circulation capabilities) has an acceptable behaviour in transient conditions. The assessment of corrosion issues has to be deepened to provide the required level of prevention. If the demonstration is not convincing enough on this point, a higher confidence in the means used for severe core damage mitigation will be required. The ISI&R potential is to be evaluated more in depth and supported by a R&D program. The severe core damage mitigation preliminary strategy would be based on the maintenance of the floating melted core in the reactor vessel and there will be no need of a high pressure resistant containment.

For the Gas-cooled XADS, the demonstration of the prevention of severe core damage relies on active/passive means and quick corrective actions. The reliability requirements of the Decay Heat Removal Function can be achieved with 3 Shutdown Cooling Systems (2/3 diversification) and a special maintenance scheme. A very reliable accelerator trip system is required for the control of the power, the feasibility of which is to be confirmed. Due to the coolant nature and the reactor internals design, the Gas-cooled XADS shows large ISI&R possibilities. The design options anticipate possible lacks in the demonstration of adequate prevention and for the severe core damage mitigation, a core catcher is implemented below the reactor vessel. The reactor building must withstand an helium discharge of about 300 mbar.

WP 3 : Accelerator

The main technical solutions for an accelerator and its associated beam line with the required beam characteristics: 600 MeV final energy, 6 mA maximum beam current for operation (10 mA for the demonstration of concept), very high reliability (less than a few beam trips per year), and operating in continuous beam mode were first evaluated. A superconducting linear accelerator, composed of independently powered superconducting cavities and a doubly achromatic beam line penetrating the reactor vertically from above has been assessed to be the most suitable concept (figure 4). This generic solution is valid for both the gas-cooled and LBE-cooled XADS, and it also corresponds to the specification of the smaller scale XADS using 350 MeV protons. Comparative studies with the cyclotron clearly showed that the highly modular LINAC was the only concept compatible with the XADS specifications on extreme reliability and potential of extrapolation in energy and in current towards an “industrial” ADS. The reliability of the proposed machine has been extensively analysed and optimized in order to meet the stringent requirements set by the WP1 using derating, redundancy and fault tolerance strategy of the components.

No showstopper has been identified and a preliminary reference design for the XADS driver accelerator, optimised for reliability has been proposed. Associated R&D needs have been identified and are focused on the qualification of the reliability of key components such as the injector section and a cryomodule section.

WP 4.1 & 4.2 : LBE-cooled and Gas-cooled XADS cores

The conceptual design of the XADS core, largely based upon previous fast reactor experience, has been developed within the context of the WP1 specifications.

The initial fuel loading will be MOX type fuel with the similar composition to the standard Superphénix reload fuel. Neutronic, thermal-hydraulical and mechanical assessments have been performed in order to justify core design features and provide reactivity parameters for safety assessment. The core features have not been optimised with respect to transmutation issues.

The sub-criticality level has been justified by safety analysis. The main principle used for this purpose was to exclude criticality during any normal or accidental reactivity insertion. The result of the analysis concludes that the neutron multiplication factor keff must be lower than about 0.97 at nominal power and at the start of the fuel cycle. In both concepts, additional margins at 0.95 keff level, are provided in shutdown condition by insertion of absorber elements.

The low linear rating of the large LBE-cooled XADS core is compatible with very low pressure losses and high natural circulation capabilities.

The Gas cooled XADS exhibits a relatively high linear rating due to the selection of large diameter pins. Thermal-hydraulic studies show that specific flow control gags and clad roughening would be necessary. At this stage of the studies, no showstopper has been identified for the design of the XADS cores. The main difficulties are related to material/corrosion issues for the LBE-cooled cores and core cooling optimisation for the Gas-cooled XADS.

WP 4.3 : Spallation Target for LBE and Gas-cooled large XADS

The Target Unit provides the physical and functional coupling between the proton beam accelerator and the sub-critical core. The designs can accommodate different target options. Basically, the LBE concepts are compatible with both window and windowless solutions. The Gas-cooled XADS relies on the window target solution, but with a helium cooled solid target as a back-up. Different engineering variants have been developed to account for specific requirements.

The selection of T91 steel as the reference material for the target structures was made on the basis of current knowledge resulting from R&D programmes (TECLA and SPIRE) on the corrosion and irradiation behaviour of materials in LBE-cooled systems and very fast neutron spectra. Operating limitations on structural material temperature and LBE velocities are also proposed for the highly irradiated window and for other target structures. Requirements on further R&D studies have been formulated.

For the LBE-cooled XADS, the Windowless Target Unit option appears to present more advantages in terms of lower Reactor Roof activation, longer lifetime and reduced need of material qualification. The feasibility of this option must be demonstrated by significant R&D efforts on the interface between the LBE free surface and the vacuum, LBE purification and radiotoxicity issues. An integral test programme or at least an under beam testing should also be further scheduled on the basis of an established design backed by basic R&D.

The damage rates of the window target are so high that the lifetime cannot be assessed. This option is likely to significantly affect the XADS availability. Further information on the viability of this option will be available at the end of the MEGAPIE integral test. The solid target cooled by helium with a water cooled double wall window seems an appealing option for the Gas-cooled XADS in terms of window integrity and replacement. However, the design is at a very preliminary stage and beam shutdown aspects (timeframe, instrumentation) are to be reviewed.

WP 5.1 : LBE-cooled concept – System integration

The conceptual design of the 80 MWth LBE-cooled XADS primary system has been performed within the context of the WP1 general specification and covers in particular:

- the reactor vessel and internals description including interface with the spallation target and the accelerator beam transfer line,
- the primary coolant circulation,
- the In-Vessel Fuel Handling description,
- the secondary cooling system description,
- the DHR system description,
- the main components definition and functional sizing,
- the primary system preliminary thermalhydraulics and thermo-mechanical assessments,
- the materials selection and description of oxygen control scheme,
- the preliminary ISI&R provisions,
- an assessment of the main R&D needs in support of the design.

The configuration of the primary system is pool-type, similar to the design adopted for most sodium-cooled reactors. In spite of the large mass of LBE in the primary system, main and safety vessel of the LBE-cooled XADS can resist seismic loads, because the reactor building rests on horizontal anti-seismic supports. There are no mechanical pumps but a gas lift system, compatible with low core pressure losses, is provided for circulating the primary coolant.

The fuel transfer operations with the classical rotating plugs are more complicated than in critical reactors because of the interface with the target unit and the last proton beam bending magnet.

With the reduced section of the beam pipe in case of the windowless target unit, code simulations indicate dose rates, at roof level, compatible with operator access for maintenance on roof components.

The main operational parameters such as low coolant temperature, velocity, low core power density, proven fuel and the design options are selected to provide favourable safety characteristics, so that the XADS can be engineered on the basis of a mid-term R&D programme.

Specific safety issues associated to the LBE coolant such as plugging risks, corrosion hazards and ISI and Repair requirements and capabilities are to be evaluated more in depth and supported by R&D programmes.

WP 5.2 : Gas-cooled concept – System integration

The preliminary conceptual design of the 80 MWth Helium-cooled XADS primary system has been performed within the context of the WP1 general specification and covering in particular:

- the selection of main primary system and layout options
- the reactor vessel and internals description including interface with the spallation target,
- the primary coolant circulation and heat rejection system,

- the In-Vessel Fuel Handling description and interface with secondary handling,
- the arrangement of the above roof area including the interface with the accelerator beam transfer line in close collaboration with WP 3,
- the DHR system description,
- the main components definition and functional sizing,
- the primary system scoping thermalhydraulics and thermo-mechanical assessments,
- the materials selection,
- the preliminary ISI&R provisions,
- the assessment of the main R&D needs in support of the design.

The primary system design is extrapolated from modular thermal HTR with a classical Fast reactor core (cladded pins) to limit the specific R&D needs.

The primary system, comprises a reactor vessel housing the core, a separate vessel that houses the Power Conversion System (PCS) and a cross vessel linking the two vessels.

The primary vessel accommodates the target unit, the sub-critical core and associated systems for fuel handling and the Shutdown Cooling System (SCS) for decay heat removal. The PCS vessel provides the coolant circulation, by a motor driven blower, and the heat exchanger rejecting heat to an external cooling water circuit. Key issues identified in the course on the studies are the need for a fast, automatic and reliable protection system (accelerator beam trip), the reliability of the DHR function and the structural integrity of the reactor thimble. An Ex-vessel core catcher for severe accidents mitigation is provided within the pit. The strong advantages in terms of ISI and maintenance are confirmed (all internals potentially removable, fluid transparency,…). The highly irradiated parts (target components and reactor thimble) are conceived as consumable materials subject to preventive replacement.

WP 5.3 : Small scale XADS – System integration

The small-scale XADS is a multipurpose neutron source for R&D applications. The selection of the design options is mainly governed by irradiation machine purposes (flexibility, performances). In particular the reactor integrates an interlinked windowless spallation target (for core performance requirements) which highly influences the design of the reactor internals and Fuel Handling principles and a fully remote handling scheme for the maintenance of the reactor based on the robots developed and operated in the JET fusion facility.

All the activities related to the small-scale XADS (core, spallation loop, primary system/DHR/Fuel Handling designs, ,shielding design, building design, safety analysis, maintenance and ISI&R issues) were grouped within WP 5.3. The preliminary design of the reactor and its main components is provided together with an assessment of the cost of the project and a review of the transmutation capabilities and needed R&D in support of the reactor licensing.

2.2.2 Concepts comparison

2.2.2.1 Introduction

A methodology and a set of criteria for the concepts comparison has been provided by the WP1 within Deliverable 40. The final assessment of the three concepts, given in Deliverable 86 “General Synthesis Report of XADS preliminary design studies and needed R&D”, is summarized in the next sections.

2.2.2.2 Consistency with XADS objectives

The missions, technical specifications and main characteristics assigned to the XADS were defined at the beginning of the Project. They were widely based on the ETWG Roadmap which defined, in 2001, the strategy to be pursued in Europe towards the demonstration of the feasibility of nuclear waste transmutation ; the construction of an XADS being one of the key steps of this demonstration. In this context, the main goal of the PDS-XADS Project was to progress towards the demonstration of the ADS feasibility.

Those missions and objectives assigned to the XADS plants were divided into three main topics :

- The capability to demonstrate the feasibility of an ADS,
- The capacity of the XADS to be converted into a XADT (eXperimental Accelerator Driven Transmuter),
- The reliability and availability of the plant.

The characteristics of the reference XADS main components defined by the WP1 are summarized in Table 1.

The three concepts show a similar overall rating for the consistency with the project objectives.

The weakest points are :

- the feasibility status of the spallation targets (window/windowless/solid) where the gap in R&D and anticipated uncertainties in a proven design are currently judged to be still relatively large,
- the demonstration of the capability to burn Minor Actinides at rates suitable for an Industrial Scale Transmuter which requires important system modifications and an appropriate increase of the power level (in the range of 200 to 400 MWth),

The irradiation capability of the MYRRHA concept (in a few high flux locations) is better than that of the large 80 MWth concepts and would lead to realistic technological feasibility demonstration of ADS as well as of MA transmutation at a reasonable scale (~1 kg of MA burned/18 kg of Am-Ufree fuel loaded).

2.2.2.3 Safety evaluation

The goal of the safety analysis of any design is to show that radiological release hazards from the plant under all service conditions are limited, below intolerable values regarding the environment, the health of public living near the plant site, and the health of the operational staff.

A common safety approach, based on the feedback from European Utility Requirements (defined for modern PWR) and the European Fast Reactor project (EFR) has been applied to the three concepts. The safety strategy is the same as applied to EFR : the objective being to provide a very high level of prevention of severe core damage.

A set of safety related criteria and a rating system has been proposed within Deliverable 40 to make an overall safety evaluation of the three concepts.

Applying this methodology, all 3 concepts are judged to provide a very similar level of safety.

On the safety issue of control and reactivity, all 3 systems are considered very similar.

On the safety issue of decay heat removal, all 3 systems are basically considered comparably effective.

On the safety issue confinement of radioactive products, the LBE-cooled systems are considered to be somewhat more effective in the retention of these products on account of the LBE providing an effective material matrix which binds a significant fraction of non-volatile and semi-volatile fission products. The He-cooled concept does not offer an equivalent material matrix which can function as a retention buffer to radio-nuclides.

On the issue of radiation protection of personnel, all 3 systems are judged to provide a similar level of safety. All 3 concepts rely on accelerator tubes directing the proton beam to the core. These beam tubes require shielding. Personnel are thus basically exposed to a similar source of potential radiation. Nevertheless, the fully remote maintenance of the MYRRHA concept is a more favourable feature.

On the issue of transient response of the 3 systems, the LBE-cooled systems are judged to provide a somewhat higher level of safety because of the large thermal inertia associated with the large mass of LBE-coolant in their primary systems.

On the issue of general design base, the He-technology is considered to rely on a larger, more readily available experimental data base obtained during the operation of gas-cooled reactor systems in various European countries during the last 40 years (i.e., Dragon project in Great Britain, HTR experience in Germany) and current HTR and GFR projects..

On the issue of meeting reliability targets, a similar line of reasoning applies in that the European reactor experience using gas-technology is significantly larger than in the use of LBE-technology.

On the issue of inspectability and maintenance of safety systems, the He-cooled system is judged clearly superior to the LBE-cooled systems since the He-coolant allows in-vessel and safety component inspection under transparent conditions and at colder temperatures. Moreover, the ISI needs on internal structures are more important for the LBE-cooled systems due to potential corrosion damages).

As regards system qualifications, all systems were considered to be rather similar. The He-technology is again judged more readily available than the LBE-technology, and the MYRRHA design incorporates more innovative features compared to the 80 MW LBE design.

As regards severe accident management, the LBE systems were considered to have a slight advantage because of the large in-vessel retention capability of these systems ascribable to the large LBE-mass in the primary system, and their relative insensitivity to transients.

The above summary illustrates that the LBE-cooled concepts clearly exhibit an advantage as regards the level of operational safety due the large inherent safety characteristics associated with the LBE-coolant. In contrast, difficult maintenance (larger ISI needs with respect to the risk of corrosion, and difficulty to practically inspect the internal structures) and lack of available technological database provide the counterbalance on operational safety.

In contrast, the He-cooled XADS exhibits very clear advantages as regards operational maintenance and a readily available technological database. These positive aspects are however balanced by the operational safety features that rely on the assured availability and performance of the accelerator beam trip and on active DHR systems in depressurized conditions. By proper optimization of both the core and the design of the plant, these features can be however largely compensated.

2.2.2.4 Structural integrity issues

For the three concepts the most critical issue is the structural integrity of the target components facing very high irradiation damages. This is particularly true for the concepts using a beam window for which a sound value of the lifetime cannot be assessed on the basis of existing data. With this respect, the LBE cooled XADS rely on a windowless target for which “reasonable” lifetimes should be attainable. For the Gas-Cooled XADS the Solid target option with a cold window should be developed to improve lifetime and window replacement aspects.

On a generic standpoint for the LBE systems, the key issue is the compatibility of the LBE coolant with the reactor structures materials. It must be adequately demonstrated that corrosion can be excluded by relying on engineering measures such as oxidation protection layers. The design of the large 80 MWth LBE system has been justified by rather detailed structural mechanics assessments including seismic evaluations. It appeared that the very heavy pool reactor behaviour seems adequate if the building is rested on horizontal anti-seismic supports. The MYRRHA reactor which includes more innovative options for the reactor internals and vessel needs to be justified by more detailed thermo-mechanical assessments.

For the Gas-cooled XADS primary system, the main issue is the structural integrity of the reactor thimble facing significant irradiation damages. The lifetime of this thimble and the material selection requires further considerations and needs to be backed by representative testing before assessing the lifetime of this component. It seems however that a higher operating temperature should be a prudent choice at least for the reference T91 ferritic material.

2.2.2.5 Economic trends

The stage of development of the three concepts being very different, a detailed cost comparison would be meaningless. For instance the stage of development of the Gas Cooled XADS is not sufficient to derive sound cost estimates of both reactor primary system and components and reactor building. The components are still in a very early development stage and the reactor vessel and internals are significantly oversized in terms of dimensions and weight balance. Only a comparison of dimensions and physical quantities of the three reactor concepts has been performed which shows that the extent of the Reactor Buildings are quite similar and rather large compared to critical facilities due to the extra height of the building to accommodate Accelerator Beam Transfer line and Target handling operations. For what concerns the liquid metal systems, the primary system of the LBE reactors compares quite well with an extrapolated sodium cooled reactor which can indicate an order of magnitude of the cost.

The cost exercise was then focused on the accelerator part and on the MYRRHA construction at Mol.

The cost of the Reference XADS LINAC (600 MeV, 6mA), based on an extrapolation of the ESS (European Spallation Source) Project, amounts to 303 M€ at 2003 economic conditions. It was then extrapolated to the MYRRHA characteristics (350 MeV, 5 mA), single injector, site specifics radiation protection to reach a “minimum construction cost” of 185 M€.

For the 50 MWth MYRRHA construction, an estimated total of 440 M€ is obtained and taking into account the possible contingencies on the different items, a global "high total" of around 560 M€ is also estimated.

The reactor part cost is therefore in the range of 255 M€ to 355 M€, rather consistent with the estimate derived from sodium cooled reactors.

This estimate does not include the cost of the Engineering During Construction which typically amounts to 20% of the construction cost of such a prototypical machine.

The R&D cost, commissioning & operational costs, dismantling costs at the end of life (which however may be estimated to range between 15 and 20% of the construction costs) are not included either.

2.2.2.6 Option validation status

R&D needs have been specified for the different components and concepts of XADS in the course of the PDS-XADS project and in particular through 37 Question Sheets addressed to the ADOPT network.

The R&D needs are classified into five main domains :

- Reactor physics,
- Fuel development,
- Thermal-hydraulics,
- Main component development,
- Materials.

Using the set of criteria defined within D40, the comparison of the R&D needs of the three concepts can be summarized as follows:

On the Reactor Physics, the R&D needs are mostly generic and common to the three concepts and each concept still requires extensive uncertainty assessments on Sub-criticality levels and Transition to Transmutation Core strategy.

The situation is the same for fuel development. As far as cladding is concerned, it is considered that the development needs for both concepts are similar (Corrosion protection/ aluminization for LBE concepts and rough cladding for gas).

Concerning thermalhydraulics, significant R&D needs can be expected for the LBE systems including test on fuel pin bundles and behaviour of the large LBE plena involving low flow areas but this is not a critical issue for this concept which shows high design margins. For the gas, past experiments are already available but additional confirmations are highly recommended because maximum clad temperature is here a key issue. Therefore more emphasis is to be put on R&D on the gas.

On the materials issue, the LBE concepts are facing a lower ranking due to corrosion related issues. Significant R&D efforts (testing in non-isothermal pool configurations, potential need for aluminization on cladding, oxygen control process and monitoring, control/ISI of metal oxide film for corrosion inhibition) are necessary to fully qualify the materials to exclude corrosion damage.

On components and system qualification, the accelerator is a common issue for all concepts and the R&D needs are well established and covered by existing programmes. Windowless targets are requiring larger R&D programmes and an integral test which is not scheduled today but the R&D effort and prospect for successful outcome is judged at the same low level from today (no proof of phenomena) for both window/windowless options. The solid target could drastically reduce the R&D needs but the level of knowledge of this option for the XADS is not sufficient to improve the rating. Components of the primary system and in particular, visualisation/inspection sensors and associated carriers and also maintenance aspects (handling/washing /decontamination) require large developments for both LBE concepts. The MYRRHA reactor and its more innovative design of the primary systems will call for a larger technological development programme. Concerning other components and systems, there are further R&D needs for the Gas components in terms of qualification of their reliability.

The comparison shows a slightly smaller extent of R&D needs for the Gas-cooled XADS compared to the LBE concepts. The difference is however not very significant. More important is the fact that most of the R&D needs are common with other helium cooled reactors (Gas Cooled Fast Reactors for core and DHR issues and High Temperature Reactors for the technology. This is likely to significantly reduce the specific development costs (technology, CFD and system codes, use of the same Helium loops, large synergy on core/cladding issues,…).

2.2.3 Project technical conclusions and outlook for FP6

The XADS main objective is to proceed with a global demonstration of the safe operation of an ADS, coupling an accelerator, a spallation target and a sub-critical core, at a large enough scale to be the precursor of an industrial transmuter.

The PDS-XADS project has developed three XADS concepts, two based on LBE-cooling and one on Helium-cooling, in sufficient detail that allows definition of the critical issues as regards design, safety and associated technological and basic R&D needs.

The three designs fit rather well with the technical objectives fixed at the beginning of the project in consistency with the European Roadmap on ADS development.

The designs are sufficiently consistent and advanced to :

- confirm the overall complexity and extent of the plant compared to a critical system (Accelerator, Interface between spallation target and primary system, accommodation of accelerator beam transfer line above the reactor and within the reactor building, radiation protection/shielding, containment issues),

- confirm the good prospect for the feasibility of the XADS apart from the target itself, which is currently considered the weakest point of the system, and

- compare the three concepts and provide recommendations on the best options to be pursued in the 6^{th} Framework Programme.

For what concerns the accelerator, the superconducting LINAC has been clearly assessed as the most suitable concept for the three reactors in particular with respect to the stringent requirements on reliability. Associated R&D needs have been identified and will be focused on critical components (injector, cryomodule) long term testing.

The comparison between the three XADS is rather balanced with no clear advantage of any of them. Each system exhibits advantages in one area which are somehow counterbalanced by other less favourable design features.

This is particularly clear when comparing the 80 MWth LBE-XADS and the 50MWth MYRRHA both using LBE coolant. Both designs appear attractive and fit with the overall objectives of the PDS-XADS project with an emphasis on passive features for the 80 MWth LBE-XADS and some attractive features on the irradiation capabilities for the 50 MWth MYRRHA. This clearly demonstrates the necessity to identify the pro and cons of each system but also to enlarge the objectives associated to the plant to transmutation capability and economical aspects.

The design of the Gas-cooled XADS, which did not benefit from an available large base of prior system analyses (compared to the 80 MW LBE-XADS), still has the potential for further optimization. The main issues associated with an Helium cooled XADS needing further improvement have been clearly identified and are being currently addressed. The concept design based on conventional steel cladding, compatible with the ASAP objective of the XADS, imposes stringent constraints on the maximum power rating which is today close to the limit of about 50 MW/m^3. Besides, the demonstration of prevention of severe core damage strongly relies on the reliable proton beam trip and on an active DHR system in depressurized conditions. Such a conclusion could be revised significantly if more innovative fuel or plant designs such as the ones envisaged for GFR are used (Silicon Carbide ceramic cladding material).

The LBE-cooled systems do not have such constraints, and clearly exhibit an advantage as regards the level of operational safety due to the large inherent safety characteristics associated with the LBE-coolant. In contrast, important demonstration, mainly in the field of technology, is needed to establish the prevention of corrosion damage and the requirements and feasibility of inspection of reactor internal structures.

Integration of the liquid LBE spallation target is more straightforward in the LBE systems than in the Gas system and offers a wider range of possibilities (compatibility with window and windowless targets). The lifetime of the window target are expected to limit the availability of the plant. Emphasis is thus to be placed in the development of the windowless target which requires significant R&D efforts on the interface between vacuum and LBE free surface. The two designs of windowless target for 80 MWth and 50 MWth (MYRRHA) are significantly different and would require an in-depth evaluation and comparison.

It is recognised that an Experimental ADS facility is required to acquire knowledge and praticable experience in coupling an accelerator to a sub-critical core, on one hand, and on the other hand to accumulate some experience in the irradiation behaviour of advanced U-free fuel. For that purpose, LBE-coolant seems the preferable option because of its lower operating temperatures. The existing MYRRHA design includes features which make it attractive for a multi-purpose R&D facility (high flux level, high power density, small diameter target, multi-batch core, remote handling) while the 80 MWth LBE-XADS exhibits very positive features as regards its safety behaviour, its expected reliability and its overall economic performance.

Preliminary studies on the transmutation capabilities have demonstrated that only plant sizes in the order of several hundreds of MWth can reach satisfactory transmutation rates, the optimum being 45kg/TWhth of actinides coming from a PWR park. The technical demonstration of the feasibility of this remains an extrapolation of the plants being studied up to now.

It should be pointed out that in case of difficulty in the demonstration of the LBE technology (R&D support on corrosion, inspection, maintenance), the currently existing (and validated) technology of the sodium cooled Fast Reactors provides a “natural Fall-back option”. It would allow concentration of the R&D efforts on ADS specific issues such as coupling of the accelerator and target. It would also provide some guarantee on the feasibility of the construction in the short term of a Demonstration Facility.

As a final statement, the PDS-XADS project has been the first project to start a rather detailed ADS design, making full use of European expertise of different research organizations, industries and universities.

The three designs are sufficiently advanced to confirm the practicable prospects for the successful feasibility of such ADS plants. The engineering drawings (blue prints) of the three XADS concepts are of sufficient detail to provide reasonable assurance and confirmation of this feasibility. It appears that each ADS concept has advantages and weaknesses, weaknesses that should be overcome by additional studies. Pending questions associated to technology gaps have been identified and appropriate R&D programmes should be activated to overcome them.

In the next future, one of the purposes of the EUROTRANS integrated project will be to demonstrate that an ADS, designed to transmute nuclear waste, is feasible at reasonable cost, the assessment being set up on a best-estimate approach. These studies will concentrate on the Lead-cooled system preferred in the long run to LBE (reduction in the generation of Polonium, high cost of Bismuth, higher efficiency of the plant). A gas-cooled ADS with a higher temperature cladding material will also be considered as an alternative as this type of design might offer advantages for larger size plants.

A second objective will be to go further in the design studies of the intermediate step Experimental ADS (XT-ADS), with a MOX-fuelled core cooled by LBE, to demonstrate the main features of an Industrial Transmuter.

These design activities will be complemented and supported by activities on accelerator sub-critical core coupling experiments, on U-free dedicated fuels, on LBE technology and materials and on nuclear data uncertainty evaluation and improvement within the EUROTRANS Integrated Project.

This work is intended to provide an overall assessment of the feasibility and cost for an ADS based transmutation so that a decision can be taken to launch a detailed design and construction of the intermediate step Experimental ADS.

3. Detailed Final Report

The detailed assessment of each of the three concepts and their comparison has been made within the Global Coherency Work Package (WP1) following documents:

- Deliverable 61 “Technical option Report “ for the two LBE systems and Deliverable 62 for the Gas cooled XADS are giving a detailed and consistent synthesis of the main technical options (Accelerator, Spallation Target, Core, Reactor system) for each of the three concepts.
- Deliverable 77 “Recommendation Report for the Reference Options of XADS” is providing an assessment of the main options of the XADS together with recommendations, and their rationale, for the choice of the reference concept for the follow-on programme.

- The assessment and comparison of the three concepts is completed by “D86 Final Synthesis Report”.

The main findings of these synthesis are reported in the Executive Summary section.

Public Deliverable 86 “General Synthesis Report of XADS preliminary design studies and needed R&D” provides a detailed Final Scientific and Technical Report of the project.

4. Management Final Report

4.1 Introduction

The PDS-XADS project rallied the main European organisations involved in Partitioning and Transmutation studies (Table 4.1.1), both industrial companies and European research institutes and also Universities. The duration of the project was three years (from 01/11/2001 to 31/10/2004) and its workforce more than 1000 persons-months.

Organization	***Country***
Framatome ANP SAS (Coordinator)	*F*
Ansaldo	*I*
Tractebel S.A (Suez-Engineering)	*B*
Empresarios Agrupados	*E*
NNC Ltd	*UK*
Framatome ANP GmbH	*D*
BNFL	*UK*
CEA	*F*
CIEMAT	*E*
CNRS IN2P3	*F*
Univ. of Frankfurt	*D*
EC-JRC-Petten	
ENEA	*I*
FzK	*D*
INFN	*I*
Univ. of Mining and Metallurgy	*PL*
Paul Scherrer Institute	*CH*
Nuclear Research & consultancy Group	*NL*
Kungl Tekniska Högskolan	*S*
SCK•CEN	*B*
Univ. Politecnica de Madrid	*E*
CRS4	*I*
Instituto Tecnologico e Nuclear	*PT*
Not Used	
Ion Beam Application	*B*
FzJ	*D*

Table 4.1.1: PDS-XADS List of Partners

Considering the very large number of partners from very different origins, and the nature of the activities design-oriented studies, it was deemed necessary to establish from the beginning of the project clear and strict instruction rules on Project organization, communication, work programmes, technical quality and quality control. This was achieved through the Project Instruction Book containing procedural regulation for a common uniform approach to the completion of the Project.

The project was organized in five main Work Packages addressing the key issues of the XADS reactors. The Work Packages 2 (Safety), 4 (Core and Target) and 5 (System integration) are sub-divided into three Sub-work packages to cover each main domain or reactor concept.

A Project Management Team (PMT), is made up of the Coordinator and the eleven leaders of the Work Packages as illustrated on the chart, Table 4.2.1:

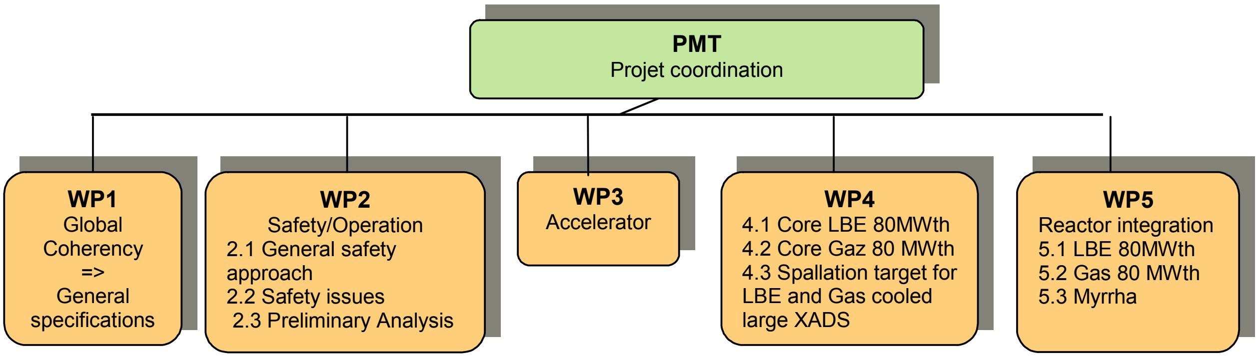


Table 4.2.1: Project organization chart

The PMT, chaired by the Coordinator, is responsible for the day to day management of the Contract and in particular the technical coordination between the Work Packages and the communication between the partners and also external to the Project.

Three main stages were included in the PDS-XADS work programme:
• Stage 1: Definition and technical specification of the XADS, mainly in charge of WP 1 during the first six months,
• Stage 2: Preliminary conceptual design studies of the three concepts, design activities within the technical Work Packages for two years,
• Stage 3: Evaluation, comparison of the alternatives, synthesis and recommendations during the six last months, again led by the WP 1.

4.2 Management and Coordination

4.2.1 Amendments

The first Amendment to the contract, due to withdrawal of participant N°24: Laboratorio del Amplificador de Energia S.A "LAESA", was signed by the European Commission on December the 2nd, 2002. LAESA was an assistant contractor of Universitad Politecnica de Madrid (UPM) and their activities concern only two work packages : WP 3 Accelerator and WP 4.3 Target Unit Design. After agreement with the other partners and the Commission, and in order to keep the consistency of the project, all the LAESA activities and associated budgets were transferred to participant N°23:Instituto Tecnologica e Nuclear "ITN" and N°21 : "UPM" who have similar competences on these subjects. ITN is also an assistant contractor of UPM.

The second Amendment to the contract was only due to the change in the legal status of Tractebel S.A., Contractor N° 3, further to its merger with the Société Générale de Belgique S.A. on 31 october 2003 to Suez-Tractebel. It has been signed by all the partners and sent to the Commission for signature in march 2005.

4.2.2 Coordination aspects

It was necessary to change the coordinator during the last year of the project due to a change of responsibilities within Framatome ANP SAS of the former coordinator. The replacement coordinator was already deeply involved in the project as leader of the WP 5.2 and a smooth transition was achieved.

The implementation of a Consortium Agreement between the partners was found too difficult to achieve and not mandatory for the good progress of the project.

4.2.3 Work Programme adjustments

The scope of work within the Work Packages has not been significantly modified except two minor rearrangements which did not impact the project objectives:

- SCK-CEN scope of work within the WP 4.3 : Spallation Target of the windowless concept
- FANP-SAS scope of work within the Work Package 2.3. on Transient Analysis of the "80 MWth He-cooled experimental XADS".

Within the Work Packages, detailed Work Programmes have been issued during the first six months of the project to clearly establish the contribution expected from each contributing partner and the links or interfaces with other Work Packages. These documents have been further updated in case of need.

4.2.4 Meetings

Two Work Package meetings per year is a reasonable frequency for the WP leaders to control the general work progress for such a design oriented R&D project. WP technical meetings, grouped within a one month timescale, were followed by a PMT meeting during which progress of the work was reported and interfaces between the WPs were reviewed. PMT has been the place for some project decisions like the role of the absorber system and the approach for the determination of the maximum operating sub-criticality level.

For the day to day work, additional working meetings have been organized on dedicated subjects like WP1/WP3 coordination meetings on Accelerator specifications and beam characteristics, Solid target development within WP5.2 and involving WP3, Gas-cooled XADS operation and transients, WP2.3 Transient calculations.

4.2.5 A few lessons from the Project Coordination

The main coordination lesson from the PDS-XADS project is that a very large consortium with 25 partners coming from 11 countries and with very different cultures (Industries, Research Centres, Academic Institutes, Universities) can be managed provided that :

- The project rules are well defined,
- These rules are well understood and followed by the partners,
- The partners and working scientists/engineers have a high technical motivation,
- The Industry is strongly involved in the design.

For the PDS-XADS project, all these requisite conditions were fully met and this is the main explanation of the success of this project.

Activities of the WP1 “Global coherency” were somewhat difficult and involving some risk of redundancy with other WPs especially for what concerns the synthesis documents. However, this WP is essential for such a project because of:

- The necessity to reach as far as possible common views,
- The specification of the machine is to be left to future potential owners/users, namely, the R&D organizations and should not be left to the designers whose role is just to orientate the technical choices,
- There were three projects in parallel and an important need for consistency.

The activities on the small-scale XADS, MYRRHA grouped within WP 5.3, were too disconnected from the other WPs especially at the beginning of the project. This is one of the reason why we have very different engineering options between MYRRHA and the 80 MW^{th} LBE.

In the future, a mix of the design teams would provide more consistent results an a better agreement of the technical options.

The links between PDS-XADS project and other P&T clusters can be further improved. This will be the added value but also the challenge of the FP6 EUROTRANS Integrated Project.

The number of partners in a given WP should be limited to about 10 and very small contributions should be avoided.

With respect to the documentation, strict guidelines should be provided on the structure and length of the Deliverables and long documents should be completed by a few pages executive summaries.

The official release of documents by E-mail was not fully appropriate to this large project. In the future, a dedicated web-site mastered by the coordinator is to be used.

In general, the lessons gained in the course of the coordination of the PDS-XADS project are well taken into account in the EUROTRANS Integrated Project, except may be the involvement of Industry which is less than for PDS-XADS. The big challenge and improvement of the integrated project will be the management of the links between the domains.

4.3 Link with other FP5 projects

The PDS-XADS Project was linked with the other FP5 activities on Partitioning & Transmutation studies under the umbrella of the ADOPT network (Figure 4.3).

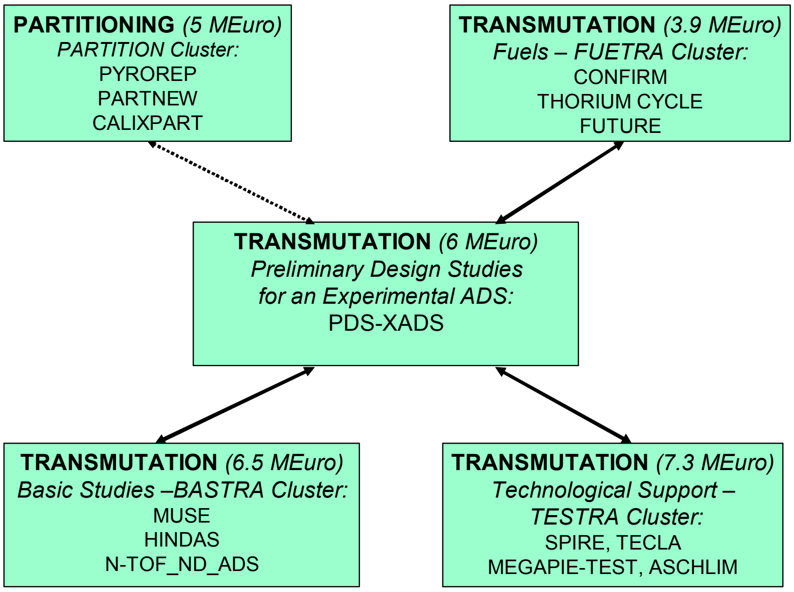


Figure 4.3: FP5 projects on P&T under the umbrella of the ADOPT network

The main links in the course of the project were related to :

- WP1 activities and FUTURE and MUSE projects,
- The selection of the spallation unit structural materials in accordance with the feedback from SPIRE and TECLA projects,
- Link between WP 4.3 and MEGAPIE project for the design of the Target Unit,

In addition, the Project design team has identified critical technological areas and development needs and addressed 37 Question Sheets to the organizations involved in the ADOPT network. The Question Sheets were extensively used for the definition of the supporting R&D activities to be launched in the 6th Framework Programme.

4.4 Exhaustive list of project documents

The core of the PDS-XADS technical documentation is the 86 Project Deliverables.

In the course of the studies, it appeared necessary to issue a rather large number of additional technical document (drawings, reports,…). Most of these documents, in support of the Deliverables are providing a level of detail which was judged excessive to be fully integrated in the Deliverables.

The whole project documentation, structured by the type of documents, is given in the next paragraphs.

4.4.1 List of Coordination documents

The list of documents issued by the Coordinator is given in Appendix 1. The minutes of the PMT meetings, also issued by the Coordinator are listed together with WP minutes within Appendix 6.

4.4.2 List of Deliverables

The list of the 86 project Deliverables, responsible partner, dissemination level, planned date of issue and actual date of issue is given in Appendix 2.

Planned activities were completed and no modification has been applied to the list of Deliverables.

A fairly large number of Deliverables have been issued with a significant delay. The delays mainly resulted from the “start from scratch” nature of the design activities on the Gas-cooled system including especially the optimization of core cooling and from the evolution to a 50 MWth reactor power unit for the small LBE XADS which also resulted in core cooling optimisation studies.

However, these delays did not jeopardise the objectives of assessment of the three concepts, at the end of the project.

4.4.3 List of additional documents

The list of 52 additional technical documents, classified by WP and identified as DOC Project documents is given in Appendix 3.

The list of drawings, classified by WP and identified as DRW Project documents is given in Appendix 4.

The list of Work Programmes is provided in Appendix 5.

The list of Minutes of the meetings, classified by WP and identified as MIN Project documents is given in Appendix 6.

The list of the Question Sheets, classified by WP and identified as RDQ Project documents is given in Appendix 7.

4.4.4 List of publications

Studies performed in the framework of PDS-XADS project have been regularly presented in International Conferences and published in the proceedings or in Scientific Journals. The scientific and technical publication activities culminated during the ADOPT International Workshop on P&T and ADS development organized by SCK-CEN in Mol, October 6-8 2003. The PDS-XADS activities where presented through a large number of papers during oral session (5) and poster sessions (41). In addition, PDS-XADS representatives were deeply involved in the final panel discussion.

In total, the PDS-XADS has been presented, during the project through 138 papers or posters and about 40% of the publications were devoted to the WP 5.3, Small-scale ADS/MYRRHA project. The list of publications, classified by WP is given in Appendix 8.

5. General Conclusions

The project on "Preliminary Design Study of an eXperimental ADS", PDS-XADS, partially funded by the European Commission under the EURATOM 5th Framework Programme, had the objective to assess the safe and efficient operation of Accelerator Driven Systems. It federated 25 institutions (leading nuclear industrial companies, research centres and universities) from 11 European countries under the co-ordination of the nuclear industrial company Framatome-ANP.

The project has evaluated different XADS design candidates in order to select the most appropriate one to be further developed. Three designs, two based on heavy liquid metal (Lead-Bismuth eutectic) cooling and one on gas cooling have been studied according to a common basis and the main needs for future Research & Development have been defined. The three designs fit rather well with the technical objectives fixed at the beginning of the project, consistent with the European Roadmap on ADS development.

The designs are sufficiently consistent and advanced to :

- confirm the overall complexity and extent of the plant compared to a critical system (Accelerator, Interface between spallation target and primary system, accommodation of accelerator beam transfer line above the reactor and within the reactor building, radiation protection/shielding, containment issues),

- confirm the good prospect for the feasibility of the XADS apart from the target itself, which is currently considered the weakest point of the system,

- provide a clear recommendation on the superconducting LINAC accelerator, the only concept capable of satisfying the stringent requirements on reliability,

- compare the three concepts and provide recommendations on the best options to be pursued more in detail in the 6th Framework Programme in particular for the heavy liquid metal technology,

- specify the designers R&D needs through a series of R&D Question Sheets which have been extensively used to establish the 6th Framework Programme technological supporting programmes.

With an efficient management and a strong industrial involvement, this large R&D project involving a total workforce close to 100 person-year has provided on time substantial technical results well focused on the design of a reactor.

This project has also been a great success in the field of European collaboration. Experience gained in design and related studies for the ADS has helped to maintain and develop for young engineers and physicists, know-how on nuclear engineering and technology expertise all over Europe even in non nuclear countries like Poland and Portugal.

List of references

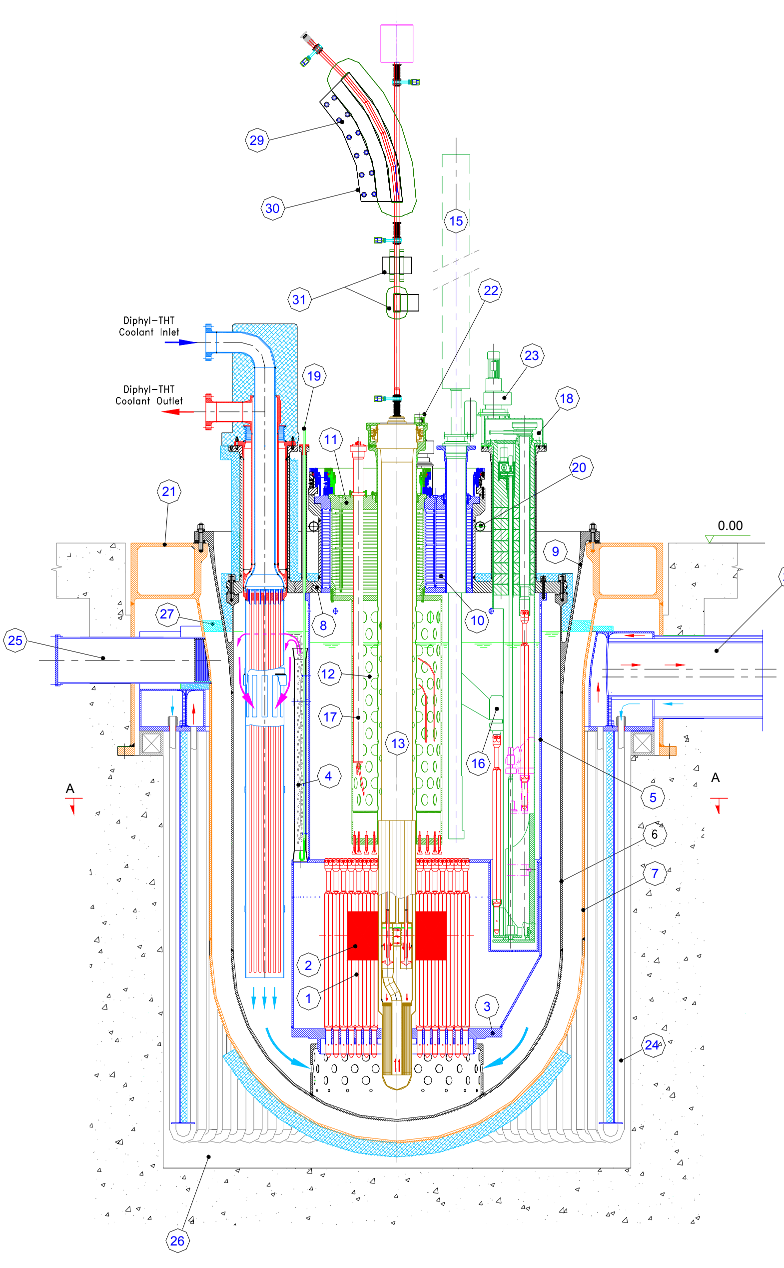
(1) A European Roadmap for developing ADS for Nuclear Waste Incineration, the European technical Working Group on ADS – ENEA April 2001

(2) Preliminary Design Study of an Experimental Accelerator Driven System
Rev. 3 – 29th June 2001

Table 1 : Reference XADS main requirements

Accelerator requirements	
Max. Beam Intensity	6 mA
Proton Energy	600 MeV
Beam entry	To be defined
Beam trip number	Less than 5 per year for the accelerator design Less than 50 per year for the reactor design
Beam type	CW, best solution Pulsed, back-up solution
Beam power stability	± 2 %;
Beam energy stability	± 1 %;
Beam intensity stability	± 2 %;
Beam footprint dimensions	± 10 %.
Target requirements	
Target Life time	Not higher than one fuel cycle
Target Material	LBE
Target Power	2 to 5 MW
Proton current intensity	Lower than 50 µA/cm² for the window concept
Subcritical core requirements	
Operational Sub-Criticality	To be determined according to coolant technology, design choice and required margins (transient and safety analysis)
Power	60 to 100 MW_{Th}
Min. core volume	500 litres
Vol. Power	80 à 200 W/cm^3
Fuel technology	MOX
Pu	Less than 35 %
Max Flux	10^{15} n $cm^{-2}s^{-1}$
Load factor	0,5

Figure 1 : 80 MWth LBE-cooled system (designed by ANSALDO)



1. REACTOR CORE (#294 assemblies)
2. FUEL ZONE (#120 fuel assemblies)
3. DIAGRID
4. RISER CHANNEL (# 24)
5. CYLINDRICAL INNER VESSEL
6. REACTOR VESSEL (Dex.=6000 mm; th.=40mm)
7. SAFETY VESSEL (Dex.=6780 mm; th.=40 mm)
8. REACTOR ROOF
9. REACTOR VESSEL SUPPORT
10. ROTATING PLUG
11. ABOVE CORE STRUCTURE (ACS): upper part
12. ABOVE CORE STRUCTURE (ACS): lower part
13. TARGET UNIT-WINDOWLESS OPTION
14. INTERMEDIATE HEAT EXCHANGER (#4 units)
15. TRANSFER MACHINE
16. TRANSFER MACHINE GRIPPER
17. FAILED FUEL DETECTION UNIT (#2 units)
18. ROTOR LIFT MACHINE
19. GAS INJECTION PIPES
20. GAS INJECTION PIPES COLLECTOR
21. ANNULAR STRUCTURE
22. ABOVE CORE STRUCTURE DRIVE
23. ROTATING PLUG DRIVE
24. R.V.A.C.S. HEAT EXCHANGER
25. RADIAL PENETRATION FOR I.S.I.
26. REACTOR CAVITY
27. THERMAL SHIELDING
28. R.V.A.C.S. INLET/OUTLET DUCTS
29. PROTON BEAM PIPE
30. TARGET UNIT: OUTER SUPPORT
31. TARGET UNIT: INNER SUPPORT
32. PURIFICATION UNIT (#2 units)

Figure 2 : 80 MWth Gas-cooled system (designed by Framatome ANP)

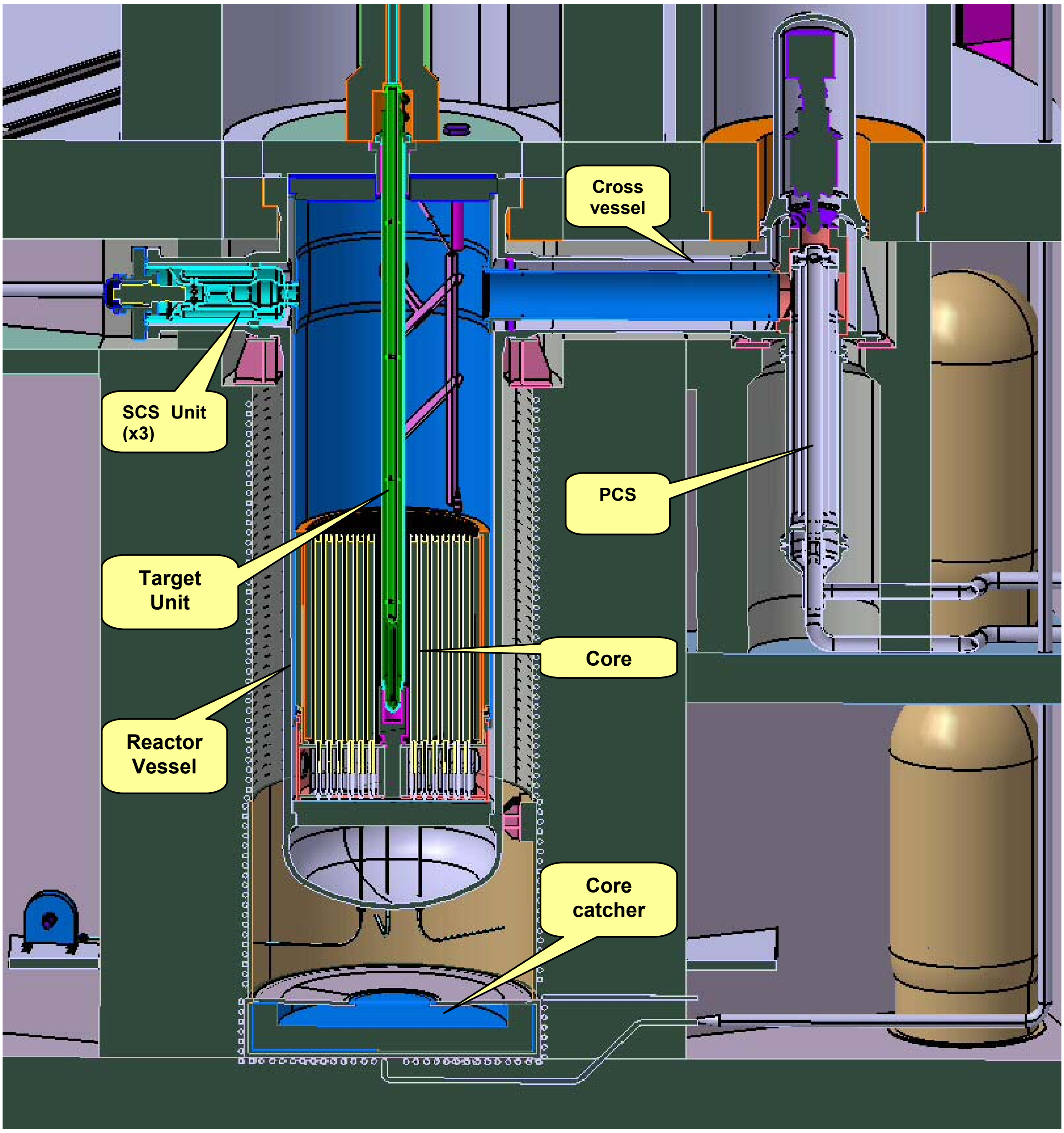


Figure 3 : 50 MWth LBE-cooled system (MYRRHA designed by SCK-CEN)

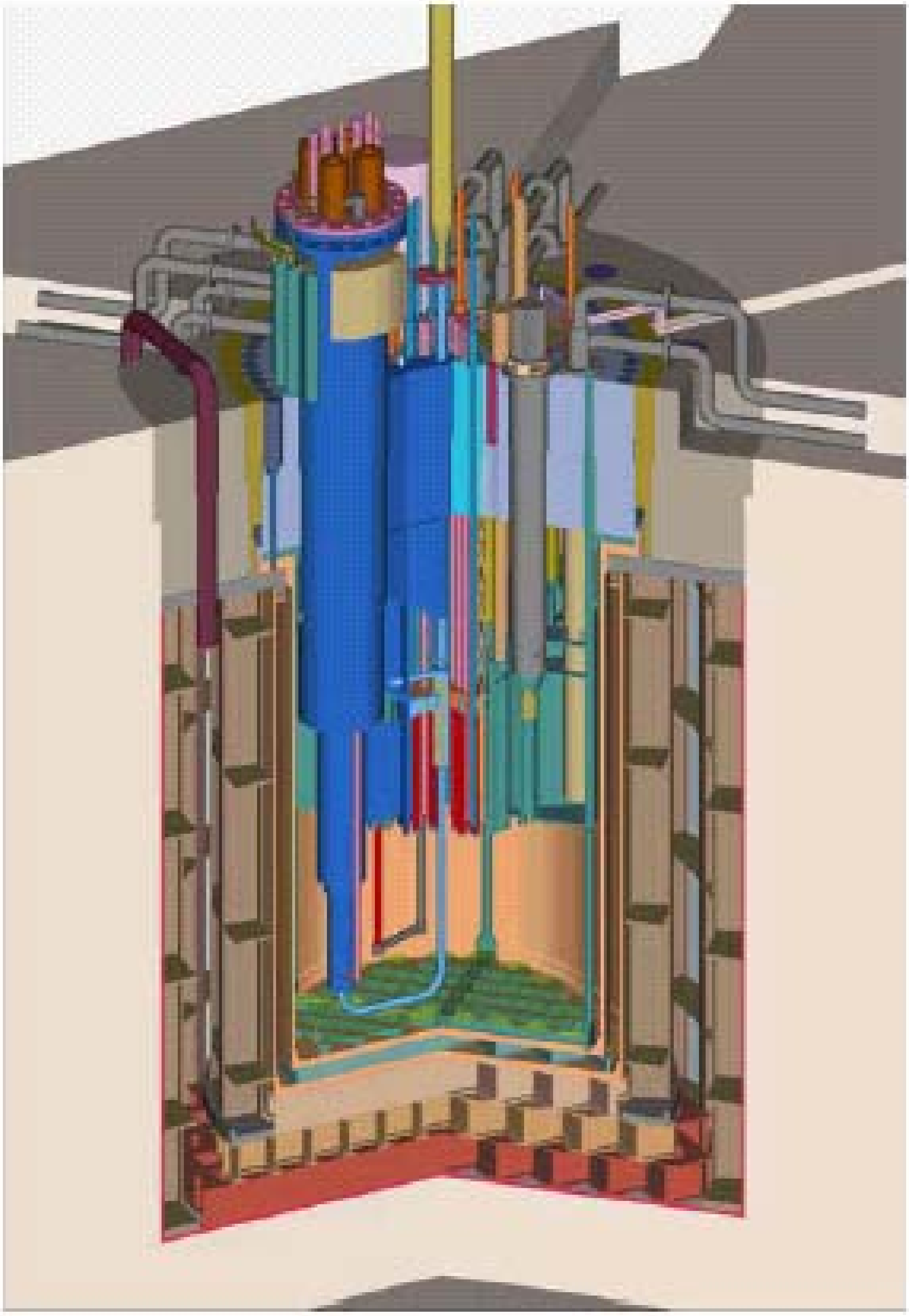
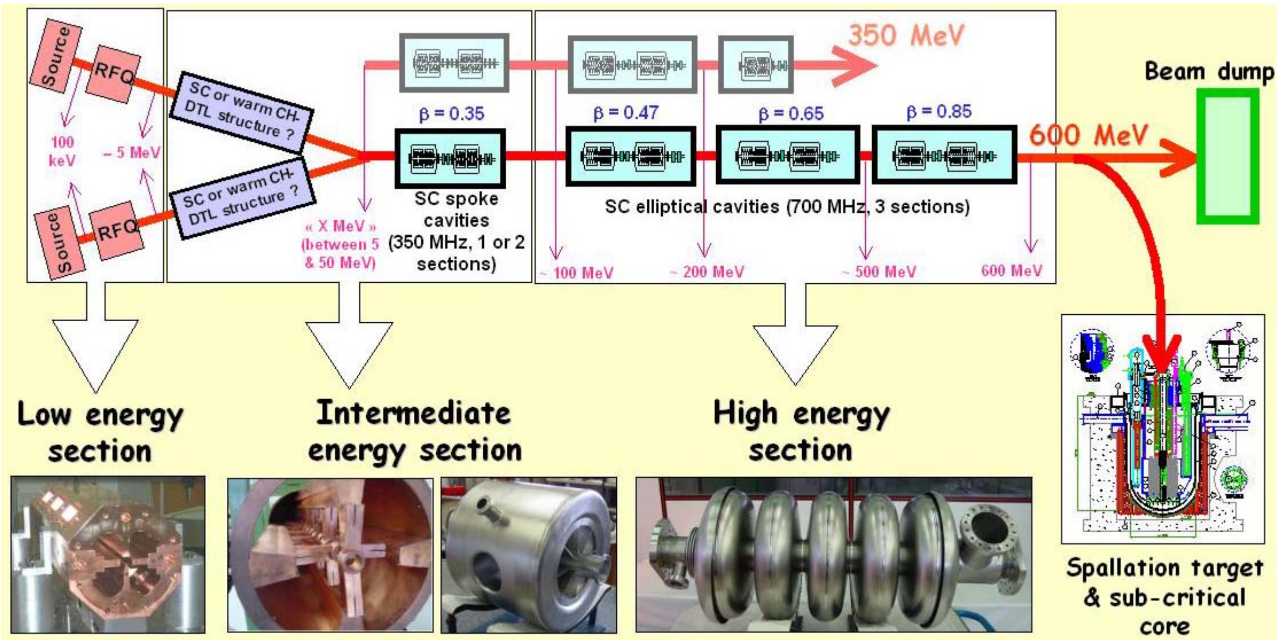
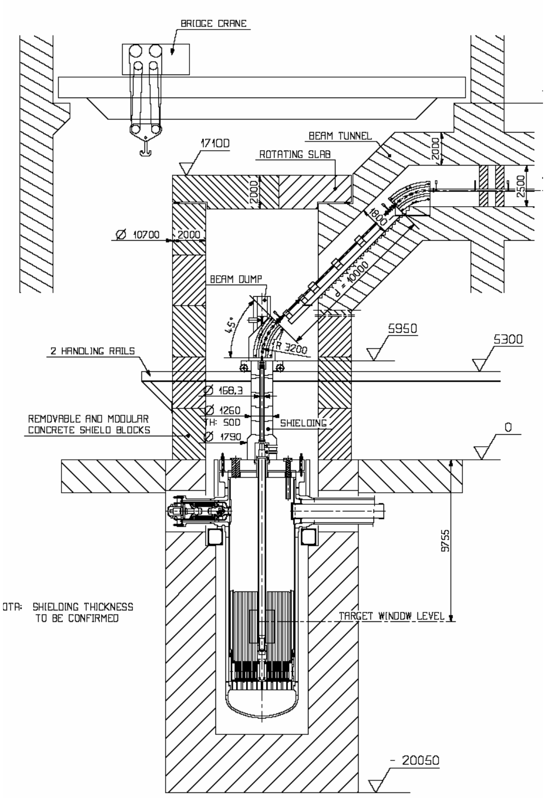


Figure 4 : Scheme of the Reference XADS Accelerator and Interface between Beam Transport Line and the Reactor





Appendix 1

List of coordination documents

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
Coordinator	118	18/01/2002	DOC	2	16/04/2003	Carluec	FANP SAS	Technical Corresp.	yes	Project instruction book
Coordinator	121	28/01/2002	DOC			Carluec	FANP SAS		no	Consortium Agreement **(draft issued on 01/2002)** **Document cancelled**
Coordinator	127	25/03/2002	DOC			Bigallet	FANP SAS	Technical Corresp.	yes	Work-packages budgets
Coordinator	143	26/06/2002	DOC			Carluec	FANP SAS	Tech. Corresp. WP Leaders	yes	Rules for using the web site
Coordinator	157	22/10/2002	DOC			Carluec	FANP SAS	E.C. + all	yes	Six monthly management report
Coordinator	205	17/12/2002	DOC	1	28/02/2003	Carluec	FANP SAS	E.C. + all	yes	First annual scientific/technical report
Coordinator	245	13/06/2003	DOC			Carluec	FANP SAS	E.C. + all	yes	Second six monthly management report
Coordinator	258	11/07/2003	DOC	1	20/11/2003	Carluec	FANP SAS	E.C. + all	yes	Mid term report
Coordinator	285	26/01/2004	DOC	1	25/02/2004	Carluec	FANP SAS	E.C. + all	yes	Annual Scientific/Technical report
Coordinator	345	24/05/2004	DOC			Giraud	FANP SAS	E.C. + all	yes	Fourth Six Monthly Management Report
Coordinator	364	02/11/2004	DOC			Giraud	FANP SAS	E.C. + all	yes	Fifth Six Monthly Management Report
Coordinator	376	24/03/2005	DOC			Giraud	FANP SAS	E.C. Mr Hugon	yes	TIP

Appendix 2

List of Deliverables

DEL	TITLE	WP	RESPONSIBLE	Dissemination Level	Delivery Date Contract	Distributed date
1	Technical specification, mission of XADS, recommendations for the main characteristics	1	CEA	PU	01/2002	Rev. 0 03/05/2002 Rev. 1 22/07/2002
2	Specification for core and fuel element design for the LBE-cooled XADS	4.1	ANSALDO	RE	01/2002	18/03/2002
3	Specification for core and fuel element design for the Gas-cooled XADS	4.2	NNC	RE	01/2002	26/07/2002
4	Technical assessment of different proton beam penetration directions for the Target Unit	4.3	FRA GmbH	RE	01/2002	28/02/2002
5	XADS requirements, constraints and key data	1	ANSALDO	PU	05/2002	23/01/2003
6	The integrated safety approach - goals - principles, rules for assessment, safety design and criteria	2.1	FRA SAS	RE	11/2002	07/07/2003
7	Primary system description and functional note of the LBE-cooled XADS	5.1	ANSALDO	RE	05/2002	20/06/2002
8	Primary system description and functional requirements for Gas-cooled XADS	5.2	NNC	RE	05/2002	01/08/2002
9	Requirements for the XADS accelerator and technical answers	3	CEA	RE	08/2002	24/10/2002
10	Core configuration technical specification of LBE-cooled XADS	4.1	ANSALDO	RE	08/2002	Rev. 0 06/02/2003 Rev. 1 28/11/2003
11	Core configuration technical specification of Gas-cooled XADS	4.2	NNC	RE	08/2002	Rev. 0 24/06/2003 Rev. 1 28/10/2004
12	Sub-critical core design of the small-scale XADS: sizing, drawings, fuel handling	5.3	SCK CEN	RE	08/2002	Rev. 0 22/10/2003 Rev. 1 21/09/2004
13	Core cooling design of the small-scale XADS: pump, heat exchanger, sizing and drawings, nominal operation	5.3	SCK CEN	RE	08/2002	Received from SCK 11/03 Issued 04/2004
14	Data for safety analysis of the gas-cooled XADS reactor	5.2	FRA SAS	RE	05/2003	07/11/2003
15	Main components technical specifications and outline drawings of the LBE-cooled XADS	5.1	ANSALDO E.A., TEE	RE	09/2002	Rev. 0 31/10/2002 Rev. 1 31/03/2003 Rev. 2 08/11/2004
16	Main components technical specifications and outline drawings of the Gas-cooled XADS	5.2	FRA SAS, NNC, E.A.	RE	05/2003	14/03/2003

DEL	TITLE	WP	RESPONSIBLE	Dissemination Level	Delivery Date Contract	Distributed date
17	XADS technical objectives and justification of the experimental programme for ADS transmutation application	1	CEA	PU	11/2002	20/01/2003
18	ISI&R requirements and constraints	2.1	FRA SAS	PU	11/2002	27/05/2004
19	DBC scenarios for LBE-cooled XADS	2.1	ANSALDO	RE	11/2002	Rev. 0 01/02/2003 Rev. 1 18/02/2004
20	DBC scenarios for Gas-cooled XADS	2.1	NNC	RE	11/2002	08/05/2003
21	System classification	2.3	E.A.	RE	11/2002	14/02/2003
22	Safety system design requirements	2.3	E.A.	RE	11/2002	Received from EA 03/2003 Issued 07/2003
23	Neutronic source characterisation of the LBE-cooled XADS	4.1	NRG	RE	11/2002	Rev. 0 14/05/2003 Rev. 1 22/10/2003
24	ISI&R requirements and feasibility studies of the LBE-cooled XADS	5.1	ANSALDO	RE	11/2002	03/03/2003
25	ISI&R requirements and feasibility studies of the Gas-cooled XADS	5.2	FRA SAS	RE	11/2002	02/10/2003
26	Spallation loop design of the small-scale XADS: sizing, drawings, nominal operation	5.3	SCK CEN	RE	11/2002	20/04/2004
27	Reactor vessel and shielding design of the small-scale XADS: sizing, drawings	5.3	SCK CEN	RE	11/2002	26/03/2004
28	Data, safety models and computer codes	2.2	KTH	RE	02/2003	10/02/2003
29	Evaluation of candidate material properties under irradiation (p, n) and corrosive conditions to relevant target unit structures (LBE and gas cooled concepts	4.3	ENEA + FZK	RE	02/2003	02/06/2004
30	Containment requirements	2.3	E.A.	RE	03/2003	03/06/2004
31	Functional and mechanical target integration (window and windowless options) with primary cooling system	4.3	FRA GmbH	RE	03/2003	27/04/2004
32	Identification and probabilities of DEC scenarios for LBE-cooled XADS	2.1	KTH	RE	05/2003	02/12/2004
33	Identification and probabilities of DEC scenarios for gas-cooled XADS	2.1	NNC	RE	05/2003	23/09/2004
34	Accident control mechanisms / safety limits	2.2	ENEA	RE	05/2003	12/11/2003

DEL	TITLE	WP	RESPONSIBLE	Dissemination Level	Delivery Date Contract	Distributed date
35	Assessment of the possibility to adopt special assemblies with MA and LLFP in the LBE-cooled XADS core	**4.1**	CIEMAT	RE	05/2003	19/07/2004
36	Assessment of the possibility to adopt special assemblies with MA and LLFP in the gas-cooled XADS core	**4.2**	KTH	RE	05/2003	09/06/2004
37	Data for safety analysis of the LBE-cooled XADS	**5.1**	E.A.	RE	05/2003	09/12/2002
38	Building and containment design of the small-scale XADS: sizing, drawings	**5.3**	SCK CEN	RE	05/2003	11/03/2004
39	Neutronic source characterisation of the gas-cooled XADS	**4.2**	NRG	RE	05/2003	19/07/2004
40	Methodologies and criteria for concept comparison	**1**	CEA	PU	11/2003	21/12/2004
41	Main specific safety phenomena for the LBE-cooled XADS	**2.2**	ENEA	RE	11/2003	26/07/2004
42	Main specific safety phenomena for the Gas-cooled XADS	**2.2**	CEA	RE	11/2003	31/03/2005
43	Normal operation of the LBE-cooled XADS	**2.3**	ANSALDO	RE	11/2003	11/02/2004
44	Normal operation of the Gas-cooled XADS	**2.3**	FRA SAS	RE	11/2003	22/10/2004
45	Transient accident analysis of the LBE-cooled XADS	**2.3**	KTH	RE	11/2003	07/09/2004
46	Transient accident analysis of the gas-cooled XADS	**2.3**	KTH	RE	11/2003	08/10/2004
47	Accelerator: feedback systems, safety grade shutdown and power control	**3**	CEA	RE	11/2003	08/04/2004
48	Accelerator: radiation safety and maintenance	**3**	CNRS	RE	11/2003	09/02/2004
49	Core reference cycle analysis for the LBE-cooled XADS	**4.1**	ENEA	RE	11/2003	Rev. 0 21/01/2004 Rev. 1 25/02/2005
50	Core reference cycle analysis for the Gas-cooled XADS	**4.2**	NNC	RE	11/2003	02/06/2004
51	Evalutation of radiation damage and circuit activation of the gas-cooled XADS	**4.2**	FZK	RE	11/2003	02/06/04
52	Primary system chemistry control technical specification for the LBE-cooled XADS	**5.1**	ANSALDO	RE	11/2003	23/02/2004

DEL	TITLE	WP	RESPONSIBLE	Dissemination Level	Delivery Date Contract	Distributed date
53	Reactor pit layout of he Gas-cooled XADS	**5.2**	E.A., FRA SAS, CEA	RE	11/2003	09/06/2004
54	Small-scale XADS: system operation, inspection, maintenance	**5.3**	SCK CEN	RE	11/2003	31/03/2005
55	Fuel element material selection and preliminary mechanical design for the Gas-cooled XADS	**4.2**	BNFL	RE	11/2003	26/05/2004
56	Core thermohydraulics of the LBE-cooled XADS	**4.1**	FZK	RE	11/2003	07/09/2004
57	Potential for reliability improvement and cost optimisation of the Linac and cyclotron accelerators	**3**	INFN	RE	02/2003	23/07/2003
58	Evaluation of radiation damage and circuit activation of the LBE-cooled XADS	**4.1**	ENEA	RE	11/2003	Rev. 0 10/02/2004 Rev. 1 25/02/2005
59	Core thermohydraulics of the Gas-cooled XADS	**4.2**	CEA	RE	11/2003	02/11/2004
60	Target unit: evalutation of spallation products and purification system Sub-DEL 60.1 to 60.3	**4.3**	FZK, ENEA, UMM, CEA	RE	11/2003	26/07/2004
61	Technical option report on LBE-cooled XADS	**1**	ENEA	PU	05/2004	Rev. 0 20/12/2004 Rev. 1 11/02/2005
62	Technical option report on Gas-cooled XADS	**1**	CEA	PU	05/2004	14/01/2005
63	Definition of the XADS class reference accelerator concept and needed R&D	**3**	CNRS	PU	05/2004	Rev. 0 21/09/2004 Rev. 1 26/11/2004
64	Core design summary report on LBE-cooled XADS	**4.1**	ANSALDO	PU	05/2004	23/09/2004
65	Core design summary report on gas-cooled XADS	**4.2**	NNC	PU	05/2004	02/07/2004
66	Safety systems and analysis of the small-scale XADS: sizing, drawings, analysis report	**5.3**	SCK CEN	RE	05/2004	21/09/2004
67	Fuel element material selection and preliminary mechanical design for the LBE-cooled XADS	**4.1**	ANSALDO	RE	05/2004	27/05/2004
68	Main components thermomechanical sizing and assembly drawings for the LBE-cooled XADS	**5.1**	ANSALDO E.A.	RE	05/2004	05/05/2004
69	Main components thermomechanical sizing and assembly drawings for the Gas-cooled XADS	**5.2**	FRA SAS	RE	05/2004	06/12/2004

DEL	TITLE	WP	RESPONSIBLE	Dissemination Level	Delivery Date Contract	Distributed date
70	Target unit: Technical evalutation and preliminary design Sub-DEL 70.1 to 70.12	**4.3**	Ansaldo, Fra Sas, E.A., TEE, Fra GmbH	RE	05/2004	Rev. 0 30/06/2004 Rev. 1 20/10/2004
71	Definition of R&D needs for safety rules	**2.2**	KTH	PU	07/2004	13/12/2004
72	Core flexibility/convertibility: proposal for design options of LBE cooled XADS	**4.1**	ANSALDO	RE	07/2004	22/12/2004
73	Core flexibility/convertibility: proposal for design options of Gas cooled XADS	**4.2**	CEA	RE	07/2004	21/12/2004
74	Target unit summary report	**4.3**	FRA GmbH	PU	07/2004	04/11/2004
75	Primary system summary report for LBE-cooled XADS	**5.1**	ANSALDO	PU	07/2004	07/09/2004
76	Primary system summary report for Gas-cooled XADS	**5.2**	FRA SAS	PU	08/2004	12/01/2005
77	XADS - Recommendations report for the reference options of XADS	**1**	CEA	PU	11/2004	31/01/2005
78	Overall safety acceptance criteria and comparison with safety goals for both LBE and Gas-cooled systems	**2.1**	FRA SAS	RE	11/2004	10/03/2005
79	Summary of the safety analysis	**2.3**	E.A.	PU	11/2004	31/01/2005
80	Extrapolation from XADS accelerator to the accelerator of an industrial transmuter	**3**	INFN	RE	11/2004	03/11/2004
81	Definition of the relevant supporting R&D of the target unit	**4.3**	FRA GmbH	PU	11/2004	18/11/2004
82	Definition of the relevant supporting R&D of the primary system of LBE-cooled XADS	**5.1**	ANSALDO	PU	11/2004	19/11/2004
83	Definition of the relevant supporting R&D of the primary system of Gas-cooled XADS	**5.2**	FRA SAS	PU	11/2004	24/01/2005
84	Cost evalutation and further scaling of the small-scale XADS	**5.3**	SCK CEN	RE	11/2004	14/03/2005
85	Suggested performance assessment and needed R&D for licensing of the small-scale XADS	**5.3**	SCK CEN	RE	11/2004	31/03/2005
86	General synthesis report of XADS preliminary design studies and needed R&D	**1**	FRA SAS	PU	11/2004	31/03/2005

Appendix 3

List of additional documents

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
1	172	04/12/2002	DOC			Rimpault	CEA	WP Leaders	yes	Negative pulse techniques for online reactivity monitoring of accelerator driven systems
1	244	06/06/2003	DOC			Richard	CEA	WP Leaders	yes	LBE chemistry control and monitoring - Needs for the design
1	261	29/07/2003	DOC			Richard	CEA	WP Leaders	yes	Malfunctions of the accelerator of the XADS
1	274	28/10/2003	DOC			Mansani	ANSALDO	WP Leaders	yes	Summary of the estimated reactivity effects in the LBE-cooled XADS concept and combination to determine the operational subcriticality
1	369	13/12/2004	DOC			De Bruyn	SCK.CEN	WP Leaders	yes	Contribution to DEL 61
2.1	227	05/03/2003	DOC			Bianchi	ENEA	WP Leaders	yes	Contribution to DEL 19
2.1	231	03/04/2003	DOC			Bianchi	ENEA	WP Leaders	yes	Contribution to DEL 32
2.1	347	02/06/2004	DOC			Pirson	TRACTEBEL	WP Leaders	yes	Contribution to DEL 19
2.2	108	12/12/2001	DOC			Petrazzini	ANSALDO	WP Leaders	yes	Technical Report - Pb-Bi thermodynamic tables
2.2	211	07/09/2004	DOC			Monti	ANSALDO	WP Leaders	yes	Oil thermophysical and thermodynamic properties
2.3	273	28/10/2003	DOC			Mansani	ANSALDO	WP Leaders	yes	Radioisotopes sources term for the 80 MWth LBE-cooled XADS concept
2.3	337	03/05/2004	DOC			Jardi	EA	WP Leaders	no	Contribution to DEL 30
2.3	350	21/06/2004	DOC			Coddington	PSI	WP Leaders	yes	PDS-XADS safety PSI transient analysis report
2.3	351	25/06/2004	DOC			Giraud	FANP SAS	WP Leaders	yes	PDS-XADS Gas Cooled reactor 3D Thermalhydraulic analysis
2.3	354	01/07/2004	DOC			Meloni	ENEA	WP Leaders	yes	Protected and unprotected transients for LBE XADS -D45 contribution
2.3	355	26/07/2004	DOC			S.Jouve	FANP SAS	WP Leaders	yes	Reliability analysis of the Shutdown Cooling System of the Gas-Cooled XADS
2.3	357	21/09/2004	DOC			Maschek	FZK	WP Leaders	yes	SIMMER III DEC transient calculations of LBE cooled XADS (in support of D45)

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
2.3	358	23/09/2004	DOC			Monti	ANSALDO	WP Leaders	yes	LBE cooled cncept: plant response to non-LOCA design basis accidents
2.3	359	23/09/2004	DOC			Monti	ANSALDO	WP Leaders	yes	LBE-cooled concept: ATWS analysis
2.3	360	23/09/2004	DOC			Monti	ANSALDO	WP Leaders	yes	LBE-cooled concept: highlights on plant response to some particular abnormal and accident events
2.3	361	06/10/2004	DOC			Coddington	PSI	WP Leaders	yes	Transient Analysis of the 80 MWth Helium cooled experimental accelerator-driven system using the TRAC/AAA code
2.3	362	06/10/2004	DOC			Meloni	ENEA	WP Leaders	yes	ENEA's activity in the safety analysis of the gas cooled XADS
2.3	366	19/11/2004	DOC			Sehgal	KTH	WP Leaders	**no**	Contribution to DEL 45
3	130	17/04/2002	DOC			Tkatchenko	CNRS	WP Leaders	yes	Preliminary design of a vertical beam injection into the reactor (gas-cooled primary system)
3	213	03/02/2003	DOC			Biarrotte	CNRS	WP Leaders	yes	Basis for the reliability analysis of the PDS-XADS linac
3	263	27/08/2003	DOC			Biarrotte	CNRS	WP Leaders	**no**	Recommendations concerning the XADS proton/beam time structure
4.1	126	11/03/2002	DOC			Bestwick	NNC	WP Leaders	yes	NNC contribution covering material choice and definition of physical, thermal and mechanical properties (part D67)
4.1	169	03/12/2002	DOC			Mansani	ANSALDO	WP Leaders	yes	Appendix A - Deliverable 10
4.1	170	03/12/2002	DOC			Burn	ENEA	WP Leaders	yes	Appendix B - Deliverable 10
4.1	171	03/12/2002	DOC			Mansani	ANALDO	WP Leaders	yes	Appendix C - Deliverable 10
4.1	228	12/03/2003	DOC			Meulekamp	NRG	WP Leaders	**no**	Relation between the intrinsic core criticality and multiplication of the source in ADS applications
4.1	229	12/03/2003	DOC			Meulekamp	NRG	WP Leaders	**no**	The neutron source in ADS applications
4.1	248	04/07/2003	DOC			Mansani	ANSALDO	WP Leaders	yes	Appendix D deliverable 10
4.1	272	28/10/2003	DOC			Mansani	ANSALDO	WP Leaders	yes	LBE cooled XADS fuel assembly pressure drops experimental measurement

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
4.1	338	03/05/2004	DOC			Vettraino	ENEA	WP Leaders	yes	Appendix D deliverable 67: Fuel rod thermal and mechanical analysis
4.1	339	03/05/2004	DOC			Bianchi	ENEA	WP Leaders	yes	Appendix B deliverable 67 : Fuel element and pin flow-induced vibrations analysis
4.1	353	30/06/2004	DOC			Peluso	ENEA	WP Leaders	yes	Special Element Transmutation in the Fuel Cycle of the XADS (Annex 2 of D35)
4.1, 4.2	131	25/04/2002	DOC			Carluec	FANP SAS	WP 4.1 - WP 4.2	yes	Memo - Composition of the second core of SPX1
4.2	153	27/09/2002	DOC			Leon	E.A.	WP Leaders	yes	Contribution to deliverable 3
4.2	259	15/07/2003	DOC			Pelloni	PSI	WP Leaders	yes	Code Eranossource
4.2	346	27/05/2004	DOC			Rimpault	CEA	WP Leaders	yes	Justification for the initial choice of k=0.97 for the operating sub-criticality level
4.3	348	11/06/2004	DOC			Nam-il Tak	FZK	WP Leaders	yes	Thermal Hydraulic analysis of Window Target Unit for LBE cooled XADS Contribution FZK to DEL 70.7
4.3	349	11/06/2004	DOC			Martinez-Val	UPM	WP Leaders	yes	Study on the radiation damage in the target window of the PDS-XADS gas cooled reactor core UPM contribution to DEL 60.1
4.3	144	03/07/2002	DOC			Rathjen	FANP SAS	WP Leaders	yes	Window target - Proton current profile of the beam footprint
4.3	328	05/04/2004	DOC			Zucchini Turoni	ENEA	WP Leaders	yes	thermal mechanical calulations for the window target LBE option
4.3	329	14/04/2004	DOC			Martinez-Val	UPM	WP Leaders	yes	Study of the energy deposition in the target window of the PDS-XADS gas cooled reactor core
4.3	335	26/04/2004	DOC			Broeders	FZK	WP Leaders	yes	Physics investigations for the spallation target of the LBE-cooled XADS design
4.3	377	30/03/2005	DOC			Schuurmans	SCK.CEN	WP Leaders	yes	Assessment of the vacuum system of the windowless PDS-XADS spallation target
5.2	234	30/04/2003	DOC			Cinotti	ANSALDO	WP Leaders	yes	In-vessel fuel handling system feasibility studies
5.2	279	09/12/2003	DOC			François	FANP SAS	WP Leaders	no	Preliminary conceptal design of CRDM - Support to NC1
5.2	325	31/03/2004	DOC			Richard	CEA	WP Leaders	yes	Definition and description of an absorber system for the gas-cooled XADS - Contribution to the conception of the reactivity monitoring system

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
5.3	**377**	22/03/2005	DOC			Schuurmans	SCK.CEN	WP Leaders	yes	Assessment of the vacuum system of the windowless PDS-XADS spallation target

Appendix 4

List of drawings

PDS-XADS Final Report
Appendix 4
List of Drawings (DRW)

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
4.1	116	09/01/2002	DRW	1	26/05/2004	Saccardi	ANSALDO	WP leaders	yes	Drawing - Fuel assembly - Core and fuel element specification
4.1	174	09/12/2002	DRW			Mansani	ANSALDO	WP Leaders	yes	Mechanical drawing - Dummy assembly outline
4.1	175	09/12/2002	DRW			Mansani	ANSALDO	WP Leaders	yes	Mechanical drawing - Absorber element outline
4.2	140	11/06/2002	DRW			Every	BNFL	WP Leaders	no	Drawing XADS 002 GR/02 - CANCELLED
4.2	141	11/06/2002	DRW			Every	BNFL	WP Leaders	no	Drawing XADS 003 G5/02 - CANCELLED
4.2	249	08/07/2003	DRW			Every	BNFL	WP Leaders	yes	XADS004 Fuel pin
4.2	250	08/07/2003	DRW			Every	BNFL	WP Leaders	yes	XADS005 - Upper axial neutron shield rod fuel sub assembly
4.2	251	08/07/2003	DRW			Every	BNFL	WP Leaders	no	XADS006 - Spike assembly bolted option - CANCELLED
4.2	252	08/07/2003	DRW			Every	BNFL	WP Leaders	no	XADS007 - Spike assembly welded option - CANCELLED
4.2	253	08/07/2003	DRW			Every	BNFL	WP Leaders	yes	XADS008 - General arrangement
4.2	254	08/07/2003	DRW			Every	BNFL	WP Leaders	yes	XADS009 - Outer shell assembly
4.2	255	08/07/2003	DRW			Every	BNFL	WP Leaders	yes	XADS010 - Lifting head
4.2	256	08/07/2003	DRW			Every	BNFL	WP Leaders	yes	XADS011 - Bottom support grid
4.2	264	27/08/2003	DRW			Every	BNFL	WP Leaders	yes	Drawing XADS 012
4.2	265	29/08/2003	DRW			Every	BNFL	WP Leaders	yes	Drawing XADS 013
4.3	112	18/12/2001	DRW			Cinotti	ANSALDO	WP Leaders	yes	Mechanical drawing - Hot window target cooled by organic diathermic fluid
4.3	115	08/01/2002	DRW			Cinotti	ANSALDO	WP Leaders	yes	Drawing - Configuration of the windowless target unit
5.2	165	29/11/2002	DRW			Giraud	FANP SAS	WP Leaders	yes	Drawing Reactor vessel
5.2	166	29/11/2002	DRW			Giraud	FANP SAS	WP Leaders	yes	Drawing Preliminary arrangement of the pit - Fuel handling
5.2	167	29/11/2002	DRW			Giraud	FANP SAS	WP Leaders	yes	Drawing Preliminary arrangement of the pit - Target handling

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
5.2	168	29/11/2002	DRW			Giraud	FANP SAS	WP Leaders	yes	Drawing Reactor pit arrangement - Status 10/02
5.2	235	30/04/2003	DRW			Cinotti	ANSALDO	WP Leaders	yes	Mechanical drawing - In-vessel fuel handling system general layout
5.2	236	30/04/2003	DRW			Cinotti	ANSALDO	WP Leaders	yes	Mechanical Drawing - In-vessel fuel handling system fuel manipulator assembly
5.2	237	30/04/2003	DRW			Cinotti	ANSALDO	WP Leaders	yes	Mechanical drawing - In-vessel fuel handling system fuel manipulator details
5.2	238	30/04/2003	DRW			Cinotti	ANSALDO	WP Leaders	yes	Mechanical drawing - In-vessel fuel handling system fuel manipulator operating sequences
5.2	342	18/05/2004	DRW			Giraud	FANP SAS	WP Leaders	yes	Reactor Vessel 04/04 Assembly drawing
5.2	343	18/05/2004	DRW			Giraud	FANP SAS	WP Leaders	yes	Reactor Building 04/04 - Primary circuit installation
5.2	344	18/05/2004	DRW			Giraud	FANP SAS	WP Leaders	yes	Reactor Building 04/04 - Primary circuit installation - Complementary sections
5.2	365	19/11/2004	DRW			François	FANP SAS	WP Leaders	no	Gas cooled system reactor vessel

Appendix 5

List of work programmes

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
1	**208**	08/01/2003	DOC			Rimpault	CEA	Leaders	yes	Work programme WP 1
2.1	**119**	18/01/2002	DOC	1	03/06/2002	Rochwerger	FANP SAS	WP Leaders	yes	Work programme WP 2.1
2.2	**156**	17/10/2002	DOC			Koszela	KTH	Leaders	**no**	Work programme WP 2.2
2.3	**124**	05/03/2002	DOC			Dominguez	E.A.	WP Leaders	yes	Work programme WP 2.3
3	**215**	12/02/2003	DOC			Biarrotte	CNRS	Leaders	yes	Work programme WP 3
4.1	**125**	04/05/1900	DOC			Mansani	ANSALDO	WP Leaders	yes	Work programme WP 4.1
4.2	**147**	26/07/2002	DOC			Sunderland	NNC	WP Leaders	yes	Work programme WP 4.2
4.3	**129**	15/04/2002	DOC			Rathjen	FANP SAS	WP Leaders	yes	Work programme WP 4.3
5.1	**128**	04/04/2002	DOC	2	16/05/2003	Cinotti	ANSALDO	WP Leaders	yes	Work programme WP 5.1
5.2	**137**	29/05/2002	DOC	1	24/07/2003	Giraud	FANP SAS	WP Leaders	yes	Work programme WP 5.2

Appendix 6

List of Minutes of meetings

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
1	109	12/12/2001	MIN			Bernardin	CEA	EC + WP leaders	yes	WP1 - Minutes of kick-off meeting
1	139	07/06/2002	MIN			Richard	CEA	EC + WP Leaders	yes	Minutes of meeting WP 1 - Cadarache 19/04
1	161	06/11/2002	MIN			Richard	CEA	EC + WP Leaders	yes	Minutes progress meeting 04/10
1	216	19/02/2003	MIN			Richard	CEA	WP Leaders	yes	Minutes of meeting WP 1 Lyon
1	243	06/06/2003	MIN			Richard	CEA	EC + WP Leaders	yes	Minutes of technical meeting Orsay
1	262	29/07/2003	MIN			Richard	CEA	WP Leaders	yes	Meeting CEA / ENEA 10-11/07/2003
1	278	28/11/2003	MIN			Richard	CEA	EC + WP Leaders	yes	Minutes of 5th technical meeting
1	336	30/04/2004	MIN			Richard	CEA	EC + WP Leaders	yes	Minutes of 6th technical meeting
1	352	29/06/2004	MIN			Richard	CEA	WP Leaders	yes	Minutes of the WP1/WP3 - Cadarache 4/06/2004
2	138	03/06/2002	MIN			Fernandez	E.A.	EC + WP Leaders	yes	Minutes of meetings WP 2 - 17-18/04
2	164	28/11/2002	MIN			Fernandez	E.A.	EC + WP Leaders	yes	Minutes of technical meeting n° 3
2.1	101	16/11/2001	MIN			Rochwerger	FANP SAS	EC + WP leaders	yes	WP2.1 - Kick Off meeting Minutes
2.2	114	21/12/2001	MIN			Sehgal	KTH	EC + WP leaders	yes	WP2.2 - Minutes of kick-off meeting
2.3	103	23/11/2001	MIN			Jardi	E.A.	EC + WP leaders	yes	WP 2.3 - minutes of kick-off meeting
2.3	330	20/04/2004	MIN			Jardi	E.A.	EC + WP Leaders	yes	Minutes of 6th technical meeting
3	113	21/12/2001	MIN			Biarrotte	CNRS	EC + WP leaders	yes	Minutes of the kick-off meeting
3	142	13/06/2002	MIN			Biarrotte	CNRS	EC + WP leaders	yes	Minutes of Genoa meeting 23/04
3	152	27/09/2002	MIN			Biarrotte	CNRS	EC + WP leaders	yes	Minutes of progress meeting Frankfurt
3	212	03/02/2003	MIN			Biarrotte	CNRS	WP Leaders	yes	Minutes of WP 3 meeting
3	240	22/05/2003	MIN			Biarrotte	CNRS	EC + WP Leaders	yes	Minutes of technical meeting WP 3 Orsay

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
3	270	24/10/2003	MIN			Biarrotte	CNRS	EC + WP Leaders	yes	Minutes of 5th technical meeting
3	323	09/03/2004	MIN			Biarrotte	CNRS	EC + WP Leaders	yes	Minutes of 6th technical meeting 08-09/01/2004 Milan
3	367	29/11/2004	MIN			Biarrotte	CNRS	WP Leaders	yes	Minutes of meeting Lisboa May 2004
3	368	29/11/2004	MIN			Biarrotte	CNRS	WP Leaders	yes	Minutes of meeting Capri October 2004
4.1	105	26/11/2001	MIN			Mansani	ANSALDO	EC + WP leaders	yes	WP 4.1 - Minutes of kick-off meeting
4.1	132	22/05/2002	MIN			Mansani	ANSALDO	EC + WP Leaders	yes	Minutes of meeting WP 4.1 - Cadarache 16/04
4.1	158	29/10/2002	MIN			Mansani	ANSALDO	EC + WP Leaders	yes	Minutes of progress meeting 30/09
4.1	239	30/04/2003	MIN			Mansani	ANSALDO	EC+ WP Leaders	yes	Minutes of technical meeting (09/04/03)
4.1	271	28/10/2003	MIN			Mansani	ANSALDO	EC + WP Leaders	yes	Minutes of 5th technical meeting
4.1	333	20/04/2004	MIN			Mansani	ANSALDO	EC + WP Leaders	yes	Minutes of 6th technical meeting
4.2	104	23/11/2001	MIN			Peers	NNC	EC + WP Leaders	yes	WP 4.2 - Minutes of kick-off meeting
4.2	135	23/05/2002	MIN			Sunderland	NNC	EC + WP Leaders	yes	Minutes of meeting WP 4.2 - Cadarache 15/04
4.2	160	04/11/2002	MIN			Murgatroyd	NNC	EC + WP Leaders	yes	Minutes of technical meeting Paris 01/10
4.2	246	24/06/2003	MIN			Sunderland	NNC	EC + WP leaders	yes	Minutes of meeting Stockholm
4.2	267	15/10/2003	MIN			Sunderland	NNC	EC + WP Leaders	yes	Minutes of technical meeting Villigen
4.2	324	25/03/2004	MIN			Sunderland	NNC	EC + WP Leaders	yes	Minutes of 6th technical meeting - 23/03/04 - FZK
4.3	107	12/12/2001	MIN			Rathjen	FANP GmbH	EC + WP leaders	yes	WP 4.3 - Minutes of kick-off meeting
4.3	134	23/05/2002	MIN			Rathjen	FANP GmbH	EC + WP Leaders	yes	Minutes of meeting WP 4.3 - Genoa 22/04
4.3	155	15/10/2002	MIN			Rathjen	FANP GmbH	EC + WP Leaders	yes	Minutes of progress meeting 02/10
4.3	242	05/06/2003	MIN			Coors	FANP GmbH	EC + WP Leaders	yes	Minutes of technical meeting Stockholm
4.3	277	24/11/2003	MIN			Cinotti/Coors	ANS/FANP GmbH	EC + WP Leaders	yes	Minutes of 5th technical meeting
4.3	334	26/04/2004	MIN			Coors	FANP GmbH	EC + WP Leaders	yes	Minutes of 6th technical meeting

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
5.1	106	12/12/2001	MIN			Cinotti	ANSALDO	EC + WP leaders	yes	WP 5.1 - Minutes of kick-off meeting
5.1	133	22/05/2002	MIN			Cinotti	ANSALDO	EC + WP Leaders	yes	Minutes of meeting WP 5.1 - Genoa 23/04
5.1	154	07/10/2002	MIN			Cinotti	ANSALDO	EC + WP Leaders	yes	Minutes of 3 rd progress meeting
5.1	233	29/04/2003	MIN			Cinotti	ANSALDO	EC + WP leaders	yes	Minutes of 4th technical meeting
5.1	275	30/10/2003	MIN			Cinotti	ANSALDO	EC + WP Leaders	yes	Minutes of 5th technical meeting
5.1	340	06/05/2004	MIN			Cinotti	ANSALDO	EC + WP Leaders	yes	Minutes of 6th technical meeting
5.2	111	17/12/2001	MIN			Giraud	FANP SAS	EC + WP leaders	yes	WP 5.2 - Minutes of the kick-off meeting
5.2	136	29/05/2002	MIN			Giraud	FANP SAS	EC + WP Leaders	yes	Minutes of meeting WP 5.2 Genoa 22/04
5.2	163	15/11/2002	MIN			Giraud	FANP SAS	EC + WP Leaders	yes	Minutes of Technical Meeting N°3
5.2	260	16/07/2003	MIN			Giraud	FANP SAS	EC + WP leaders	yes	Minutes of TM N°4
5.2	266	22/09/2003	MIN			Giraud	FANP SAS	EC + WP Leaders	yes	Minutes of technical meeting
5.2	331	20/04/2004	MIN			Giraud	FANP SAS	EC + WP Leaders	yes	Minutes of 6th technical meeting
5.3	230	01/04/2003	MIN			De Bruyn	SCK CEN	EC + WP Leaders	yes	Minutes of progress meeting 25/03
5.3	269	22/10/2003	MIN			De Bruyn	SCK CEN	EC + WP Leaders	yes	Minutes of 5th technical meeting
5.3	327	05/04/2004	MIN			De Bruyn	SCK CEN	EC + WP Leaders	yes	Minutes of 6th technical meeting
Coordinator	102	15/11/2001	MIN			Carluec	FANP SAS	EC + WP leaders	yes	Coordination - Minutes of the kick-off meeting
Coordinator	123	07/02/2002	MIN			Carluec	FANP SAS	Technical Corresp	yes	Minutes PMT meeting Bruxelles 28/01
Coordinator	149	03/09/2002	MIN			Carluec	FANP SAS	EC + WP Leaders	yes	Minutes of 2nd PMT meeting 24/05
Coordinator	209	09/01/2003	MIN			Carluec	FANP SAS	EC + WP Leaders	yes	Minutes of 3rd PMT meeting
Coordinator	241	22/05/2003	MIN			Carluec	FANP SAS	EC + WP Leaders	yes	Minutes of the 4th PMT meeting (20/05/03)
Coordinator	276	07/11/2003	MIN			Carluec	FANP SAS	EC + WP Leaders	yes	Minutes of 5th PMT meeting
Coordinator	332	20/04/2004	MIN			Giraud	FANP SAS	EC + WP Leaders	yes	Minutes of PMT meeting

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
Coordinator	370	23/12/2004	MIN			Giraud	FANP SAS	EC + WP leaders	yes	Minutes of the 7th PMT meeting.
Coordinator	371	23/12/2004	MIN			Giraud	FANP SAS	EC	yes	Minutes of the PDS-XADS Final Meeting

Appendix 7

List of Question Sheets

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
1	162	15/11/2002	RDQ			Rimpault	CEA	ADOPT	yes	Need for LBE purification (window and windowless concept
1	177	13/12/2002	RDQ			Rimpault	CEA	ADOPT	yes	Control and instrumentation of an ADS
1	178	13/12/2002	RDQ			Rimpault	CEA	ADOPT	yes	Minor actinide loaded advanced fuels
1	179	13/12/2002	RDQ			Rimpault	CEA	ADOPT	yes	Uncertainties associated to the ADS core characteristics and the spallation source
2.2	180	1312/2002	RDQ			Sehgal	KTH	ADOPT	yes	Polonium release rates from lead-bismuth and deposition mechanisms on metal structures and along piping
2.2	210	13/01/2003	RDQ			Sehgal	KTH	ADOPT	yes	Safety aspects of advanced minor actinide fuels for ADTs with emphasis on severe accident behaviour and phenomena
2.2	224	28/02/2003	RDQ			Sehgal	KTH	ADOPT	yes	Severe accident progression in a lead-bismuth subcritical reactor for transmutation applications
2.2	225	28/02/2003	RDQ			Sehgal	KTH	ADOPT	yes	Stabilization of the severe accident for the gas cooled subcritical XADS
2.3	192	13/12/2002	RDQ			Dominguez	E.A.	ADOPT	yes	Safety and plant performance of the gas-cooled XADS concept
2.3	196	17/12/2002	RDQ			Dominguez	E.A.	ADOPT	yes	System allocation
3	182	13/12/2002	RDQ			Mueller	CNRS	ADOPT	yes	R&D required for the PDS-XADS accelerator
3 - 4.3	181	13/12/2002	RDQ			Mueller	CNRS	ADOPT	yes	Characterisation and assessment of means for removal of the spallation vapours
4.1	184	13/12/2002	RDQ			Mansani	ANSALDO	ADOPT	yes	Fuel assembly pressure drop evaluation
4.1	185	13/12/2002	RDQ			Mansani	ANSALDO	ADOPT	yes	Materials for the fuel assemblies
4.1	186	13/12/2002	RDQ			Mansani	ANSALDO	ADOPT	yes	Fuel rod fluid induced vibrations

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
4.1	195	13/12/2002	RDQ			Mansani	ANSALDO	ADOPT	yes	Heat transfer coefficients in LBE environment
4.2	187	13/12/2002	RDQ	1	13/08/2004	Sunderland	NNC	ADOPT	yes	Effects of creep strain on fuel pin cladding
4.2	188	13/12/2002	RDQ	1	13/08/2004	Sunderland	NNC	ADOPT	yes	Effect of clad roughness on thermal hydraulics
4.2	204	17/12/2002	RDQ	1	13/08/2004	Sunderland	NNC	ADOPT	yes	Choice of a suitable fuel pin clad material
4.3	189	13/12/2002	RDQ			Rathjen	FANP GmbH	ADOPT	yes	Experimental verification of the LBE windowless target
4.3	190	13/12/2002	RDQ			Rathjen	FANP GmbH	ADOPT	yes	Experimental verification of target LBE natural circulation
4.3	356	09/09/2004	RDQ			Coors	FANP GmbH	ADOPT	yes	Feedback from MEGAPIE test
5.1	199	17/12/2002	RDQ			Cinotti	ANSALDO	ADOPT	yes	LBE purification from oxides particles
5.1	197	17/12/2002	RDQ			Cinotti	ANSALDO	ADOPT	yes	Modelling of molten Pb alloy sloshing
5.1	198	17/12/2002	RDQ			Cinotti	ANSALDO	ADOPT	yes	Stainless steel 316L-SPH in contact- with Pb-Bi
5.1	200	17/12/2002	RDQ			Cinotti	ANSALDO	ADOPT	yes	Control of the oxygen activity in the melt
5.1	201	17/12/2002	RDQ			Cinotti	ANSALDO	ADOPT	yes	LBE enhanced circulation by means of gas injection
5.1	202	17/12/2002	RDQ			Cinotti	ANSALDO	ADOPT	yes	Technologies for ISI in LBE
5.1	203	17/12/2002	RDQ			Cinotti	ANSALDO	ADOPT	yes	Materials for mechanical equipment operating in LBE
5.2	191	13/12/2002	RDQ			Giraud	FANP SAS	ADOPT	yes	Tribology and He purification requirements for the gas cooled XADS system
5.2	193	13/12/2002	RDQ			Giraud	FANP SAS	ADOPT	yes	Material qualification and design code for the gas cooled XADS system
5.2	194	13/12/2002	RDQ			Giraud	FANP SAS	ADOPT	yes	Qualification of engireering options for the gas cooled XADS system
5.3	219	25/02/2003	RDQ			Ait Abderahim	SCK CEN	ADOPT	yes	Establishement of database for CR9 martensitic steel specific to the design needs
5.3	220	25/02/2003	RDQ			Ait Abderahim	SCK CEN	ADOPT	yes	MOX fuel development and qualification for XADS driver

WP	Nr	DATE 1st issue	NAT.	REV.	DATE	RESPONSIBLE	COMPANY	ADDRESSEES	ISSUED	TITLE
5.3	221	25/02/2003	RDQ			Ait Abderahim	SCK CEN	ADOPT	yes	Development of robotic elements for remote manipulation under liquid LBE
5.3	222	25/02/2003	RDQ			Ait Abderahim	SCK CEN	ADOPT	yes	Visualisation and instrumentation under LBE
5.3	223	25/02/2003	RDQ			Ait Abderahim	SCK CEN	ADOPT	yes	Experimental verification of the LBE windowless target

Appendix 8

List of publications

WP	Conference	Place	Date	Title of papers	Writers
1 + all	**Spanish Nuclear Society Magazine**		November 2003	El proyecto europeo PDS XADS: estudios preliminares de diseño de un sistema accionado por acelerator (ADS). Article adapted from the one presented at ICAPP03	Empresarios Agrupados Framatome ANP SAS
1	**NEA HPPA**	Santa Fe USA	12-16 May 2002	The European Program	SCK.CEN, CNRS, Framatome ANP
1	**ICAPP 03**	Cordoba Spain	4-7 May 2003	PDS-XADS – Engineering activities	Empresarios Agrupados, Framatome ANP SAS
1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	The European Project PDS-XADS, Preliminary design studies of an experimental accelerator driven system	Oral Session Framatome ANP
1	**EURADWASTE 2004**	Luxembourg	March 29 April 1st	The European project PDS-XADS: Preliminary Design Studies of an eXperimental Accelerator Driven System	Framatome ANP SAS
1	**ICRS-10 / RPS 2004**	Madeira Island Portugal	9-14 May 2004	ADS key issues for transmutation purposes	CEA
1, 2.3	**PHYSOR 2004**	Chicago USA	25-29 April 2004	Source and reactivity perturbations in accelerator driven systems with conventional MOX and advanced fertile free fuels	FZK Serco Assurance (sponsored by BNFL)
1, 3	**22nd International Nuclear Physics Conference**	Göteborg Sweden	27 June – 2 July 2004	Nuclear waste incineration and accelerator aspects from the European PDS-XADS study	CNRS
1, 5.2	**GLOBAL 2003**	New Orleans USA	16-20 November 2003	HE cooled XADS instrumentation and control	CEA ; NNC ; Framatome ANP
2.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Preliminary design study of an experimental accelerator driven system. Safety approach	Poster session Framatome ANP, ENEA, Empresarios Agrupados, Ansaldo, NNC, Tractebel Engineering, CEA, FZK, KTH

WP	Conference	Place	Date	Title of papers	Writers
2.1	**EURADWASTE 2004**	Luxembourg	March 29 April 1st	Preliminary Design Studies of an eXperimental Accelerator Driven System - Safety Approach (Poster)	Framatome ANP SAS
2.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Assessment of the safety of the PDS-XADS designs	Poster session KTH, Framatome ANP, Empresarios Agrupados, Ansaldo, NNC, ENEA, CEA, FZK, PSI, JRC Petten
2.3	**7th Information exchange meeting**	Jeju Korea	14-16 October 2002	Loss of flow in LBE cooled XADS	Ansaldo
2.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Transient analysis of the gas-cooled PDS-XADS design	Poster session PSI, JRC Petten, Framatome ANP
2.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Transient analysis of the LBE-cooled PDS-XADS design	Poster session FZK, Ansaldo, ENEA, PSI, JRC Petten, KTH
2.3	**GLOBAL 2003**	New Orleans USA	16-20 November 2003	Analyses of unprotected transients in the lead/bismuth-cooled accelerator driven system PDS-XADS	FZK
2.3	**EURADWASTE 2004**	Luxembourg	March 29 April 1st	Results of Transient Analyses of the LBE-cooled and He-cooled (Poster).	FZK
2.3	**NEA workshop on HPPA**	Daejon Korea	16-19 May 2004	Safety analysis of the E.U. PDS-XADS designs	PSI, FZK, KTH, FANP SAS, ANSALDO, ENEA, JRC Petten,
2.3	**NEA workshop on HPPA**	Daejon Korea	16-19 May 2004	Comparative transient analyses of accelerator driven systems with mixed oxide and advanced fertile free fuels	FZK
2.3	**Jahrestagung Kerntechnik 2004**	Dusseldorf Germany	24-27 May 2004	Analysis of unprotected blockage accident in the accelerator driven system PDS-XADS	FZK
2.3	**NUTHOS-6**	Nara Japan	4-8 October 2004	Multiphase flows and fuel relocations in disrupted core of accelerator driven system PDS-XADS	FZK
2.3, 4.1, 4.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Swiss activities related to the analysis of experimental accelerator driven systems	Poster session PSI
3	**8th European Particule Accelerator Conference**	Paris France	3-7 June 2002	Design and fabrication of beta=0.35 spoke-type cavity	CNRS, CERCA

WP	Conference	Place	Date	Title of papers	Writers
3	**8th European Particule Accelerator Conference**	Paris France	3-7 June 2002	R&D on spoke-type cryomodule	CNRS
3	**8th European Particule Accelerator Conference**	Paris France	3-7 June 2002	High intensity proton SC linac using spoke cavities	CNRS
3	**8th European Particule Accelerator Conference**	Paris France	3-7 June 2002	700 MHz superconducting proton cavities development and first tests in the horizontal cryostat "CryHoLab"	CNRS, CEA
3	**XXI International Linac Conference**	Gyeongyu Korea	August 2002	Beam dynamics layout of H-type drift tube linacs for intense light ion beams	J.W. Goethe Universitaet Frankfurt
3	**20th Particule Accelerator Conference**	Portland USA	12-16 May 2003	Experimental results on 700 MHz multicell superconducting cavity for proton linac	CEA, CNRS
3	**5th Symposium on nuclear Physics**	Tours France	25-28 August 2003	Nuclear waste incineration by ADS and main aspects of the accelerator studied within the European PSD-XADS	CNRS
3	**11th workshop on RF superconductivity**	Travemünde/Lübeck Germany	8-12 September 2003	Development of SRF spoke cavities for low and intermediate energy ion linac	CNRS
3	**11th workshop on RF superconductivity**	Travemünde/Lübeck Germany	8-12 September 2003	Superconducting RF activities at the IPN Orsay	CNRS
3	**11th workshop on RF superconductivity**	Travemünde/Lübeck Germany	8-12 September 2003	CryHoLab, a horizontal test facility: new results and development	CNRS, CEA
3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	The PDS-XADS reference accelerator	Oral session CNRS-IN2P3
3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Status and perspectives of the R&D programs for the XADS linear accelerator	Poster session CNRS IN2P3
3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Design of a XADS linear accelerator	Poster session CEA
3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Reliability studies of the PDS-XADS accelerator	Poster session INFN
3	**EURADWASTE 2004**	Luxembourg	March 29 April 1st	The PDS-XADS Reference accelerator (poster)	CRNS
3	**ICRS-10 / RPS 2004**	Madeira Island Portugal	9-14 May 2004	The PDS-XADS reference accelerator and its radiation protection issues	CNRS
3	**NEA workshop on HPPA**	Daejon Korea	16-19 May 2004	The PDS-XADS reference accelerator	IBA

WP	Conference	Place	Date	Title of papers	Writers
3	**NEA workshop on HPPA**	Daejon Korea	16-19 May 2004	Reliability considerations for the PDS-XADS accelerator design	INFN
3	**NEA workshop on HPPA**	Daejon Korea	16-19 May 2004	Beam dynamics studies for the fault tolerance assessment of the PDS-XADS linac design	CNRS, INFN, CEA
3	**NEA workshop on HPPA**	Daejon Korea	16-19 May 2004	Spoke cavities; an asset for high reliability of superconducting accelerators. Studies and test results of a b=0.35 2-gap prototype and its power coupler at IPN Orsay	CNRS
3	**9th European Particle Accelerator Conference**	Luzern Switzerland	5-9 July 2004	Recent developments on superconducting b035 and b015 spoke cavities at IPN for low and medium energy sections of proton linear accelerators	CNRS
3	**9th European Particle Accelerator Conference**	Luzern Switzerland	5-9 July 2004	Beam dynamics studies for the fault tolerance assessment of the PDS-XADS linac design	CNRS, INFN, CEA
3	**22nd International Linear Accelerator Conference**	Lübeck Germany	16-20 August 2004	High power CW superconducting linacs for EURISOL and XADS	CNRS
3	**22nd International Linear Accelerator Conference**	Lübeck Germany	16-20 August 2004	Performance improvement of the multicell cavity prototype for proton linac projects	CEA, CNRS
3	**33rd ICFA Advanced Beam Dynamics Workshop on "Hign Density and High Brightness Hadron Beams"**	Bernsheim Germany	18-22 October 2004	Beam dynamics studies for the fault tolerance assessment of the PDS-XADS linac design	CNRS, INFN, CEA
4.1	**ENC2002 Scientific seminar**	Lille France	7-9 october 2002	LBE cooled XADS nuclear design uncertainty	Ansaldo
4.1	**7th Information exchange meeting**	Jeju Korea	14-16 October 2002	XADS proposed subcriticality level	Ansaldo
4.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Preliminary nuclear design calculations for the PDS-XADS LBE-cooled core	Poster session ENEA, Ansaldo
4.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Optimization calculations by MCNP of neutronic parameters of ADS EAP-80 core	Poster session SCK.CEN, ENEA
4.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Uncertainty evaluation of the nuclear design of PDS-XADS	Poster session NRG, Ansaldo, ENEA, UMM, PSI, CIEMAT

WP	Conference	Place	Date	Title of papers	Writers
4.1, 4.2	**ENC2002 Scientific seminar**	Lille France	7-9 october 2002	LBE and gas cooled XADS core configurations	Ansaldo
4.1, 4.2	**AccApp03**	San Diego USA	1-5 June 2003	On the use of existing high enriched MOX fuel in an experimental ADS	FZK, UMM, KTH
4.1, 4.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	ADS neutronics	Poster session NRG
4.1, 4.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	On the use existing high enriched MOX fuel in an experimental ADS	Poster session FZK, UMM/KTH, KTH
4.1, 4.2	**PHYSOR 2004**	Chicago USA	25-29 April 2004	PDS-XADS LBE and gas-cooled concepts: neutronic parameters comparison	PSI
4.2	**AccApp03**	San Diego USA	1-5 June 2003	Reference core design for a european gas cooled experimental accelerator driven system	KTH, UMM, NNC, FZK
4.2	**AccApp03**	San Diego USA	1-5 June 2003	Moderating reflectors with burnable absorbers for reactivity swing reduction in small ADS	UMM, KTH
4.2	**AccApp03**	San Diego USA	1-5 June 2003	Study on transmutation assembly performance in the gas-cooled XADS	KTH, UMM
4.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Preliminary design study of a helium-cooled experimental accelerator driven system	Poster session NNC, FZK, PSI, KTH, BNFL, NRG
4.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Core instrumentation and reactivity control of the experimental ADS	Poster session CEA, NNC, Framatome ANP, Ansaldo, CNPS IN2P3
4.2	**CAPRA / CADRA**		5-7 April 2004	The gas-cooled XADS reference cycle analysis, neutronics and thermal hydraulics	NNC
4.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	On the modeling of the XADS window material behaviour in aggressive irradiation and corrosion environment	Poster session FZK
4.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	The TRASCO-ADS project windowless interface: theoretical and experimental evaluation	Poster session INFN, ENEA, SAES-Getters, Ansaldo
4.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Window target unit for the XADS gas cooled primary system	Poster session Framatome ANP, UPM, ITN

WP	Conference	Place	Date	Title of papers	Writers
4.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Window target unit for the XADS lead-bismuth cooled primary system	Poster session FZK, Framatome ANP
4.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Design of a windowless target unit for the XADS lead-bismuth cooled system	Poster session Ansaldo, CRS4, ENEA, Tractebel Engineering, Framatome ANP
4.3	**EURADWASTE 2004**	Luxembourg	29 March-April 1st 2004	Target Units for XADS Primary Systems ((poster)	Framatome ANP GmbH
4.3	**NEA workshop on HPPA**	Daejon Korea	16-19 May 2004	CFD analysis on the active part of window target unit for LBE cooled XADS	FZK
4.3	**Jahrestagung Kerntechnik 2004**	Dusseldorf Germany	24-27 May 2004	Numerical simulation on lower part of window target for experimental ADS	FZK
4.3	**Nuclear Energy for New Europe 2004**	Portoroz Slovenia	6-9 September 2004	Lead bismuth eutectic cooled experimental accelerator driven system: windowless target unit thermal-hydraulic analysis	ENEA, SIET SpA, CRS4
5.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Status of the studies performed by the European Industry on the LBE cooled XADS	Oral session Ansaldo, Framatome ANP SAS, Framatome ANP GmbH, CEA, KTH, Empresarios Agrupados
5.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	XADS cooled by Pb-Bi system description	Poster session Ansaldo, ENEA, Empresarios Agrupados, Tractebel Engineering
5.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	XADS cooled by Pb-Bi mechanical verification of critical components	Poster session Ansaldo, Empresarios Agrupados
5.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Interfaces with proton beam of XADS cooled by Pb-Bi	Poster session ENEA, Tractebel Engineering, Ansaldo
5.1	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Verification and validation of the instrumentation for hydraulics test of the CIRCE test facility	Poster session ENEA, Ansaldo
5.1, 5.2	**ICRS-10 / RPS 2004**	Madeira Island Portugal	9-14 May 2004	Principal concepts of the XADS designs in the 5th FP	ANSALDO, FANP SAS, SCK CEN

WP	Conference	Place	Date	Title of papers	Writers
5.1, 5.2, 5.3	**EURADWASTE 2004**	Luxemburg	March 29 April 1st	The XADS designs in the 5th FP (poster)	Ansaldo, Framatome ANP, SCK.CEN
5.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Preliminary design study of an experimental accelerator driven system, overall description of the gas-cooled system	Oral session Framatome ANP
5.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Preliminary design study of an experimental accelerator driven system. Description of the gas-cooled primary system	Poster session Framatome ANP, NNC, Empresarios Agrupados, Ansaldo, CEA
5.2	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Preliminary design study of an experimental accelerator driven system Description of the Power Conversion System PCS	Poster session NNC
5.3	**Nuclear Instruments and Methods in Physics Research, Section A, 463 (2001) pp. 487-494**		2001	"MYRRHA: a multipurpose accelerator driven system for reserach and development",	SCK CEN, IBA
5.3	**Fourth International Meeting on Accelerator Driven Transmutation Technology and Applications, AccApp'01 & ADTTA'01**	Reno USA	11-15 November 2001	"MYRRHA, a multipurpose ADS for R&D. Pre-design phase completion"	SCK CEN, IBA
5.3	**Fourth International Meeting on Accelerator Driven Transmutation Technology and Applications, AccApp'01 & ADTTA'01**	Reno USA	11-15 November 2001	Design concept of the thermal flux island in MYRRHA for LLFP transmutation. Present status	SCK CEN
5.3	**Accelerator Driven Transmutation Technology and Applications (ADTTA´01)**	Reno USA	11-15 November 2001	Researches on corrosion mitigation in MYRRHA multipurpose ADS for R&D	SCK CEN
5.3	**Fourth International Meeting on Accelerator Driven Transmutation Technology and Applications, AccApp'01 & ADTTA'01**	Reno USA	11-15 November 2001	MYRRHA: Design and verification experiments for the windowless spallation target of the ADS prototype MYRRHA	SCK CEN

WP	Conference	Place	Date	Title of papers	Writers
5.3	**ERCOFTAC**	KUL-Leuven	7 December 2001	CFD simulations of a liquid metal free surface flow for the design of the windowless spallation target of the MYRRHA Accelerator Driven System", presented at, ,	SCK CEN
5.3	**Accelerator Reliability Workshop (ARW'2002),**	Grenoble France	4-6 February 2002	A Cyclotron based European Multipurpose ADS for R&D (MYRRHA) - Pre-Design Phase Completion" , in proceedings of cd-rom, Grenoble, France,	SCK CEN
5.3	**ANS 12th biennial RSPD topical meeting**	Santa Fe USA	14-18 April 2002	Shielding of the fast core of the MYRRHA Accelerator driven system	SCK CEN
5.3	**ANS 12th biennial RSPD topical meeting**	Santa Fe USA	14-18 April 2002	Influence of the Proton Beam Line on the Shielding Aspects of the MYRRHA ADS	SCK CEN
5.3	**3rd International Workshop on Utilisation and Reliability of High Power Proton Accelerators**	Santa Fe USA	12-16 May 2002	The European ADS Program	SCK CEN, CNRS Framatome ANP SAS
5.3	**3rd International Workshop on Utilisation and Reliability of High Power Proton Accelerators**	Santa Fe USA	12-16 May 2002	Design and Verification Experiments for the Windowless Spallation Target of the ADS Prototype MYRRHA	SCK CEN
5.3	**Symposium on Nuclear Reactor Surveillance and Diagnostics SMORN-VIII**	Göteborg Sweden	27-31 May 2002	Reactivity monitoring in ADS. Application to the MYRRHA ADS project.	SCK CEN
5.3	**European Working Group "Hot Laboratories and Remote Handling**	Mol Belgium	25-27 September 2002	Fuel Activities Related to ADS development at the SCK·CEN: (application to MYRRHA)	SCK CEN
5.3	**11th International Conference on Emerging Nuclear Energy Systems (ICENES 2002),**	Albuquerque USA	September 29- October 4, 2002	MYRRHA: A Multipurpose Accelerator Driven System for Research & Development	SCK CEN
5.3	**11th International Conference on Emerging Nuclear Energy Systems (ICENES 2002),**	Albuquerque USA	September 29- October 4, 2002	VICE –Vacuum Interface Compatibility Experiment: R&D support for a windowless liquid metal spallation target in MYRRHA	SCK CEN

WP	Conference	Place	Date	Title of papers	Writers
5.3	**The 2002 Frederic Joliot & Otto Hahn Summer School in Reactor Physics**	Marseille France	22 August 2002	MYRRHA, A Multipurpose Accelerator Driven System for Research & Development", , Marseille, France	SCK CEN
5.3	**The 2002 Frederic Joliot & Otto Hahn Summer School in Reactor Physics**	Marseille France	22 August 2002	The European ADS Program.	SCK CEN
5.3	**European Nuclear Conference 2002**	Lille France	7-9 October 2002	MYRRHA, A Multipurpose Accelerator Driven System for Research & Development	SCK CEN, IBA
5.3	**7th Information Exchange meeting, OECD/NEA**	Jeju Korea	14-16 October 2002	MYRRHA, A Multipurpose Accelerator Driven System for R&D. Pre-design study completion	SCK CEN
5.3	**7th Information Exchange meeting, OECD/NEA**	Jeju Korea	14-16 October 2002	Vice: R&D Support for a Windowless Liquid Metal Spallation Target in MYRRHA	SCK CEN
5.3	**7th Information Exchange meeting, OECD/NEA**	Jeju Korea	14-16 October 2002	Applicability of the RELAP code Pb-Bi to ADS MYRRHA safety studies	SCK CEN
5.3	**CAARI 2002: Seventeenth International Conference on the Application of Accelerators in Research and Industry**	Denton USA	12-16 November 2002	MYRRHA, a Multipurpose Accelerator Driven System for Research and Development. Pre-design phase completion", , Denton, Texas, USA,	SCK CEN
5.3	**Application of Accelerators in Research and Industry: 17th International Conference**		2003	Pred-design of MYRRHA, A Multipurpose Accelerator Driven System for Research and Development	SCK CEN, IBA
5.3	**Visit of Loyola de Palacio & Philippe Busquin to SCK•CEN**	Mol Belgium	4 February 2003	MYRRHA, A Multipurpose European ADS for R&D	SCK CEN
5.3	**7th International Topical meeting RRFM 2003 (Research Reactor Fuel Management),**	Aix-en-Provence France	9-12 March 2003	Fuel performance evaluation for ADS MYRRHA	SCK CEN
5.3	**Commission National d'évaluation pour la gestion des déchêts nucléaire**	Paris France	2 April 2003	MYRRHA, A Multipurpose Accelerator Driven System for R&D. Pre-design study completion	SCK CEN
5.3	**TSM, IAEA**	Vienna Austria	2-4 April 2003	European ADS programme. Present considered designs & perspectives	SCK CEN

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5.3	**WP2 TREND/SANDAT meeting**	Geel Belgium	22-23 April 2003	IP-ADOPT – Nuclear Data Needs for ADS	SCK CEN
5.3	**NANUF03 (New Applications of Nuclear Fission)**	Bucharest Romania	8-12 September 2003	MYRRHA, A Multipurpose European ADS for R&D",)	SCK CEN
5.3	**Journées Scientifiques Francophones - Codes de Calcul en Radioprotection, Radiophysique et Dosimétrie**	Sochaux France	2-3 October 2003	Evaluation des doses autour du système hybride MYRRHA	SCK CEN
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	MYRRHA, small-scale LBE XADS ; state of the project at mid-2003	Oral session SCK.CEN, Tractebel, CIEMAT
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Small-scale LBE-cooled ADS: MYRRHA – Engineering design description	Poster session SCK.CEN
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Simulation of the primary system of MYRRHA with the RELAP code	Poster session SCK.CEN
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	The MYRRHA remote handling scheme for maintenance and decommissioning	Poster session SCK.CEN, Oxford Technologies
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Heat exchangers design for the MYRRHA sub-critical system	Poster session SCK.CEN
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Building design for the MYRRHA subcritical system	Poster session SCK.CEN, Belgatom
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Neutronic calculations for the updated pre-design proposal of the MYRRHA ADS	Poster session SCK.CEN, CIEMAT
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Thermal spectrum applications in the MYRRHA ADS design of thermal flux island	Poster session SCK.CEN
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	MYRRHA spallation loop design	Poster session SCK.CEN
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	VICE: R&D support for a windowless liquid metal spallation target in MYRRHA	Poster session SCK.CEN
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	The MYRRHA windowless target – R&D on thermohydraulics	Poster session SCK.CEN, NRG
5.3	**International Workshop on P&T and ADS development**	Mol Belgium	6-8 October 2003	Evaluation of the fuel design performance of the experimental ADS MYRRHA	Poster session SCK.CEN

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5.3	**Visit of the French parliamentary OPECST (Office Parlementaire des Choix Scientifiques et Technologiques)**	Mol Belgium	9 October 2003	MYRRHA: A Multipurpose European ADS for R&D State-of-the-art at mid.2003", delegation, SCK•CEN Mol, Belgium	SCK CEN
5.3	**IIIrd International Workshop on Materials for Hybrid Reactors and Related Technologies**	Rome Italy	15-17 October 2003	The XADS Designs in the 5th FP", , Rome, Italy	SCK CEN, Ansaldo, Framatome ANP SAS
5.3	**IAEA Technical Meeting on 'Theorectical and Experimental Studies of the Heavy Liquid Metal Thermal Hydraulics'**	Karlsruhe Germany	27-31 October 2003	CFD Analysis of the Heavy Liquid Metal Flow Field in the MYRRHA Pool", , FZK Karlsruhe	SCK CEN
5.3	**IAEA Technical Meeting on 'Theorectical and Experimental Studies of the Heavy Liquid Metal Thermal Hydraulics'**	Karlsruhe Germany	27-31 October 2003	Free Surface Fluid Dynamics Code Adaptation by Experimental Evidence for the MYRRHA Spallation Target	SCK CEN
5.3	**Global'2003 ANS/ENS International Winter Meeting**	New Orleans USA	16-21 November 2003	MYRRHA, A Multipurpose European ADS for R&D – State of the Project at mid.2003	SCK CEN
5.3	**Global'2003 ANS/ENS International Winter Meeting**	New Orleans USA	16-21 November 2003	MA and LLFP Transmutation in the MYRRHA ADS	SCK CEN
5.3	**Global'2003 ANS/ENS International Winter Meeting**	New Orleans USA	16-21 November 2003	Performance Evaluation of Driver and Experimental Fuel Rods for Experimental ADS MYRRHA	SCK CEN
5.3	**2nd Meeting on Materials modeling and Simulation for Nuclear Fuels (MMNSF2-2003)**	New Orleans USA	21 November 2003	Modelling Behaviour of Prototypic (Am, Pu)O2 targets with ZrO2 and ThO2 matrices in a Small Experimental ADS MYRRHA	SCK CEN
5.3	**HLMC-2003 (Heavy Liquid Metal Coolants in Nuclear Technologies),**	Obninsk Russia	11-12 December 2003	MYRRHA A Multipurpose European ADS for R&D State-of-the-art at mid. 2003", ,	SCK CEN
5.3	**HLMC-2003 (Heavy Liquid Metal Coolants in Nuclear Technologies)**	Obninsk Russia	11-12 December 2003	VICE – Vacuum Interface Compatibility Experiment in support of the MYRRHA windowless design	SCK CEN

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5.3	**Journal Tunnels et Ouvrages en Souterrain, N°182**		Mars - avril 2004	Construction techniques for a large underground structure in aquifer sands – The MYRRHA project case, Mol, Belgium	SCK CEN, Suez-Tractebel
5.3	**ICRS-10 / RPS 2004**	Madeira Island Portugal	9-14 May 2004	MYRRHA, a PB-BI experimental ADS. Specific approach to radiation protection aspects in the project	SCK CEN Oxfort Technologies Ltd
5.3	**HPPA-4, 4th International Workshop on the Utilisation and Reliability of High Power Proton Accelerators**	Daejeon Korea	15-20 May 2004	The European Project PDS-XADS "Preliminary Design Studies Of An Experimental Accelerator-Driven System"	SCK CEN Framatome ANP SAS
5.3	**HPPA-4, 4th International Workshop on the Utilisation and Reliability of High Power Proton Accelerators**	Daejeon Korea	15-20 May 2004	KEFF and KS burn up swing compensation in MYRRHA"	SCK CEN
5.3	**International Conference on Nuclear Data for Science and Technology (ND2004)**	Santa Fe USA	01 October, 2004	MYRRHA: A Multipurpose ADS for R&D, Need for New Nuclear Data?	SCK CEN, Suez-Tractebel, CIEMAT