IP EUROTRANS
Integrated Project on European Transmutation

European Research Programme for the Transmutation of High Level Nuclear Waste in an Accelerator Driven System (ADS)

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45 partners from 14 European countries
Objectives of IP EUROTRANS

- to develop a detailed design of a short-term experimental demonstration of the technical feasibility of Transmutation in an Accelerator Driven sub-critical System (XT-ADS) with a power below 100 MW(th), together with a more Generic ETD with a power of up to several 100s MW(th) to be the industrial transmuter,
- to experimentally demonstrate the stable operation and dynamic behaviour of an ADS at power, the reactivity measurement, and the sub-criticality monitoring techniques through the TRADE experiment,
- to develop and demonstrate the necessary associated technologies, especially fuels, structural materials at medium to high temperature and high radiation exposure conditions, thermal-hydraulics, heavy liquid metal technologies, and nuclear data,
- to prove its overall technical feasibility,
- to perform an economic assessment of transmutation through the ADS route.
Design Concepts of XADS

80MWth Pb-Bi cooled XADS

80MWth Gas-cooled XADS

50MWth Pb-Bi cooled MYRRHA

Ansaldo

Framatome ANP

SCK·CEN
### Development Scheme: FP5 to FP6

<table>
<thead>
<tr>
<th>FP</th>
<th>Design Concepts</th>
<th>Objectives</th>
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<tr>
<td>1999</td>
<td>FP5</td>
<td><strong>XADS (Pb-Bi)</strong>&lt;br&gt;80 MW(th)&lt;br&gt;110 W/cm&lt;br&gt;single batch loading</td>
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<tr>
<td>2004</td>
<td><strong>XADS (Gas)</strong>&lt;br&gt;80 MW(th)&lt;br&gt;250 W/cm&lt;br&gt;single batch loading</td>
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<td>2005</td>
<td>MYRRHA (Pb-Bi)&lt;br&gt;50 MW(th)&lt;br&gt;500 W/cm&lt;br&gt;multi batch loading</td>
<td><strong>XT-ADS</strong>&lt;br&gt;Short-term demonstration of transmutation on a sizable scale and of the ADS behaviour</td>
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<td>2025</td>
<td><strong>ETD / XT-ADS</strong>&lt;br&gt;&lt;br&gt;Generic ETD&lt;br&gt;Several 100 MW(th)&lt;br&gt;250 - 300 W/cm&lt;br&gt;multi batch loading</td>
<td><strong>Generic ETD</strong>&lt;br&gt;Long-term transmutation on an industrial scale</td>
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**FP Objectives**

**Generic ETD**
- Several 100 MW(th)
- 250 - 300 W/cm
- multi batch loading

**European Transmutation Demonstration**
- advanced design

**ETD / XT-ADS**
- < 100 MW(th)
- 250 - 300 W/cm
- multi batch loading

**MYRRHA (Pb-Bi)**
- 50 MW(th)
- 500 W/cm
- multi batch loading

**XADS (Gas)**
- 80 MW(th)
- 250 W/cm
- single batch loading

**XADS (Pb-Bi)**
- 80 MW(th)
- 110 W/cm
- single batch loading
IP EUROTRANS: Integrated Project on European Transmutation

**IP EUROTRANS: Organisation Diagramme**

- **IP Co-ordinator**
- **EC**
- **DM0 Management**
  - Project Office
- **DM1 DESIGN**
  - ETD Design
- **DM2 TRADE-PLUS**
  - TRADE Experiment
- **DM3 AFTRA**
  - Fuels
- **DM4 DEMETRA**
  - HLM Technologies
- **DM5 NUDATRA**
  - Nuclear Data
IP EUROTRANS: Integrated Project on European Transmutation

**Partners of IP EUROTRANS**

- IP EUROTRANS is integrating critical masses of resources and activities of 45 participants from 14 countries, including education and training (E&T) efforts, within the industry (10 participants), the national research centres (18) and 17 universities in Europe.
- **Duration:** 4 years
- **Overall budget:** 23M€ EC contribution

![Graph showing EC Contribution in k€ by sector]

**EC Contribution in k€**

- Industry: 5000,0
- Research Centres: 12000,0
- Universities: 18000,0
- JRC-EC: 4000,0
ENEN Associations represents universities in IP EUROTRANS

**Statutes:** Article 3.1

« Provide high-level scientific education in the nuclear field - as full time teaching and providing the bases for doctorate studies - based on internationally recognized research in nuclear engineering and/or nuclear sciences carried out jointly by the teaching staff, the students, doctoral and post-doctoral researchers in the same geographic location or in association with a nuclear research centre”

IP EUROTRANS: Domains and Work Packages

- **Domain DM1: DESIGN**
  - Development of a reference DESIGN for the European Transmutation Demonstrator (ETD) with heavy liquid metal cooling
  - WP1.1 Reference Design Specifications
  - WP1.2 Development and Assessment of Generic ETD and XT-ADS Designs
  - WP1.3 High Power Proton Accelerator (HPPA) Development
  - WP1.4 Spallation Target Proof of Feasibility
  - WP1.5 Safety Assessment
  - WP1.6 Cost Estimates and Planning Issues for the Reference Design for the Generic ETD and XT-ADS
DM1 DESIGN: Objectives

- Development of a reference design for a Generic European Transmutation Demonstrator (Generic ETD) with a power of up to several 100s MW(th), as basis for a cost estimate for an ADS based transmutation. The coolant for the reference design of the core and the spallation target is the liquid lead (Pb), and gas (He) cooling is considered as a back-up solution for the core.

- An interconnected and consistent objective is to undergo a more detailed design activity leading to a short-term eXperimental demonstration of the technical feasibility of Transmutation in an ADS (XT-ADS); realisation being foreseen within the next 10 years.

- The XT-ADS is intended to be as much as possible the testing bench of the main components and of the operation scheme of the Generic ETD. The use of Lead-Bismuth Eutectic (LBE) as core coolant and spallation target material in the XT-ADS will allow lower working temperatures for this experimental facility and thus put less request for innovative structural materials.
**Domain DM2: TRADE-PLUS**

Development, design, construction and operation of the TRADE (TRiga Accelerator Driven Experiment) facility

- WP2.1 Design of the Facility
- WP2.2 Design of the Beam Transport Line and the Test Station
- WP2.3 Target System Design and Tests
- WP2.4 Safety and Licensing
- WP2.5 In-pile Instrumentation and Experiments
- WP2.6 Experiments Interpretation and Transposition to Future ADS
DM2 TRADE-PLUS: Objectives

OBJECTIVES:
Demonstration of the coupling between proton accelerator, spallation target and sub-critical blanket in the experimental facility TRADE at sizeable power (several 100 kW) in presence of thermal reactor feedback effects.

OUTCOMES:
The expected outcomes of this Domain represent important input to the design, construction and operation of the XT-ADS and the Generic ETD, i.e.
- proof of stable operability,
- procedures for start-up and shut-down,
- reactivity and sub-criticality monitoring,
- dynamic behaviour,
- response to accelerator beam trips,
- definition of licensing issues of an ADS
Preliminary Experiments in TRIGA RC1

IA: Characterisation of reference TRADE configuration:
- core thermo-hydraulic features
- core dynamics code validation
- fission rate traverses
- sub-criticality measurements
- neutron flux distribution

IB: Measurements with external n sources (Cf-252, DD, DT):
- neutron energies
- fundamental reactor physics measurements:
  - MSA for MSM factors assessment;
  - determination of kinetic parameters by dynamic techniques.
Before the coupling with the accelerator, an experimental campaign is being carried out in TRIGA RC-1 over 2003-2005 inserting into the central thimble of the core different known standard fixed n sources (Cf-252, DD, DT), and performing static and dynamic measurements for different sub-criticality levels.

Such set of experiments will provide a link with the MUSE experiments and characterise the sub-critical core from a safety point of view.
- H⁻ cyclotron-accelerator of about 140 MeV and a max of about 300 µA
- Beam transport line to bring beam in TRIGA reactor operated as sub-critical system
- Solid target inserted in the core of TRIGA for producing an adequate neutron source by the spallation reaction
- Additional shielding due to the injection of a particle beam to conservatively ensure an adequate radiation protection of the above new components.
TRADE Facility

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IP EUROTRANS: Domains and Work Packages

- **Domain DM3: AFTRA**
  Advanced Fuels for TRAansmutation Systems
  - WP3.1 TRU-fuel Pre-design and Performance Assessment (Normal Operation)
  - WP3.2 TRU-fuel Safety Assessment
  - WP3.3 Irradiation Tests and Fuel Qualification
  - WP3.4 Out-of-pile Property Measurements
DM3 AFTRA: Objectives

- Design, development and qualification in representative conditions of a U-free fuel concept for the Generic ETD, compatible with the reference design studied in DM1 DESIGN. Ranking of different fuel concepts according to their main out-of-pile properties, their in-pile behaviour and their predicted behaviour in normal and transient operating conditions, and their safety performance in accidental conditions. Recommendations about fuel design and fuel performance of the most promising fuel candidate(s) are given.

- Fuel selection:
  - Reference fuel (selected from FP5/FUTURE):
    Oxide composite: (Pu, MA, Zr)O2; (Pu, MA)O2+MgO or Mo
  - Backup solution (selected from FP5/CONFIRM)
    Nitride inert matrix fuel: (Pu, MA, Zr)N
IP EUROTRANS: Domains and Work Packages

- **Domain DM4: DEMETRA**
  - Development and assessment of structural materials and heavy liquid metal technologies for TRansmutation systems
    - WP4.1 Specification and Fabricability of the Reference Materials and its Operation Conditions
    - WP4.2 Reference Materials Characterisation in HLM and technology development (WP responsible: D. Gomez-Briceno, CIEMAT)
    - WP4.3 Reference Materials Irradiation Studies
    - WP4.4 Advanced Thermal-hydraulics and Measurement Techniques
    - WP4.5 Large-scale Integral Tests
    - WP4.6 MEGAPIE Related Studies: PTA
DM4 DEMETRA: Objectives

- Improvement and assessment of the Heavy Liquid Metal (HLM) technologies and thermal-hydraulics for application in ADS, and in particular to Generic ETD and XT-ADS, where the HLM is both the spallation material and the primary coolant;

- Characterisation of the reference structural materials in representative conditions (with and without irradiation environment) in order to provide the database needed for design purposes (e.g. fuel cladding, in-vessel components, primary vessel, instrumentation, spallation target with or without beam window).
IP EUROTRANS: Domains and Work Packages

- **Domain DM5: NUDATRA**
  - NUclear DAta for TRAnsmutation
    - WP5.1 Sensitivity Analysis and Validation of Nuclear Data and Simulation Tools
    - WP5.2 Low and Intermediate Energy Nuclear Data Measurements
    - WP5.3 Nuclear Data Libraries Evaluation and Low-intermediate Energy Models
    - WP5.4 High Energy Experiments and Modelling
DM5 NUDATRA: Objectives

- Improvement and assessment of the simulation tools and associated uncertainties for the ADS transmuter core, the shielding design and its associated fuel cycle.

The activity is focussed on the improvement of evaluated nuclear data libraries and reaction models for isotopes contained in transmutation fuels, coolants, spallation targets, internal structures, and reactor and accelerator shielding. Increased accuracy as well as extended energy range are required for the design and optimisation of ADS transmuters, and in particular Generic ETD and XT-ADS.
DM5 NUDATRA: Work

Measurements of $^{206,207,208}\text{Pb}(n,n')$ and $^{209}\text{Bi}(n,n')$ measurements at GELINA
Neutron capture cross sections of minor actinides at nTOF at CERN
$^{244}\text{Cm}(n,f)$ cross section measurements deduced from $^{243}\text{Am}(3\text{He},pf)$ at Orsay

Upgrade and test of nuclear model code TALYS for reactions on minor actinides
Evaluation of experimental data for minor actinides, especially Americium isotopes
will be assembled and theoretically analyzed.
Reevaluation of Pb and Bi libraries including covariance information

Measurement of the production of long-lived intermediate mass fragments as
$^7\text{Be}$, $^{10}\text{Be}$ from selected targets (Bi, W, Ni) from 100 to 1000 MeV as well as
the helium production
Improvement on the intranuclear cascade model INCL4 and evaporation-fission
model ABLA. Specifically the extension to low energies and composite charged
particles.
Quality assessment and impact of the new models in ADS simulations
Conclusions

- As a joint European effort, the Integrated Project IP EUROTRANS of the Euratom 6th Framework Programme is devoted to the study and development of transmutation of high-level waste from nuclear power plants, with emphasis on transmutation in an Accelerator Driven System (ADS).
- The project will be performed by 45 partners. Among these 17 university groups which are presented by ENEN.
- IP EUROTRANS should start in March 2005.
- IP EUROTRANS is open to international collaborations.
- The requested support is 23 M€

The presentation has been performed on behalf of the participants of IP EUROTRANS.
IP EUROTRANS

- **Objectives:** IP EUROTRANS is focused on the European Transmutation Demonstration (ETD), i.e. the demonstration of the feasibility of an ADS-type dedicated transmuter.

- **Partners:** IP EUROTRANS integrates critical masses of resources and activities of 45 participants from 14 countries, including education and training (E&T) efforts, within the industry (10 participants), the national research centres (18) and 17 universities in Europe.

- **Duration:** 4 years

- **Envisaged start:** March 2005

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