EUROPEAN COMMISSION
Community research

"Actinide and Fission Product Partitioning and Transmutation 11th Information Exchange Meeting / San Francisco, USA, 1-5 November 2010"

organised by the OECD Nuclear Energy Agency (NEA) and hosted by the Idaho National Laboratory, co-sponsored by the EC and the IAEA (http://www.nea.fr/pt/iempt11/)

Euratom Research and Training Programme for Partitioning and Transmutation

(1) ACSEPT (2008 – 2012) / Actinide reCyling by SEParation & Transmutation
(2) EUROTRANS (2005 – 2010) / TRANSmutation of High Level Nuclear Waste in an ADS

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EURATOM

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1 – Introduction / Sustainable energy development worldwide: challenges of the nuclear energy

- **minimization of the production of long lived radioactive waste**

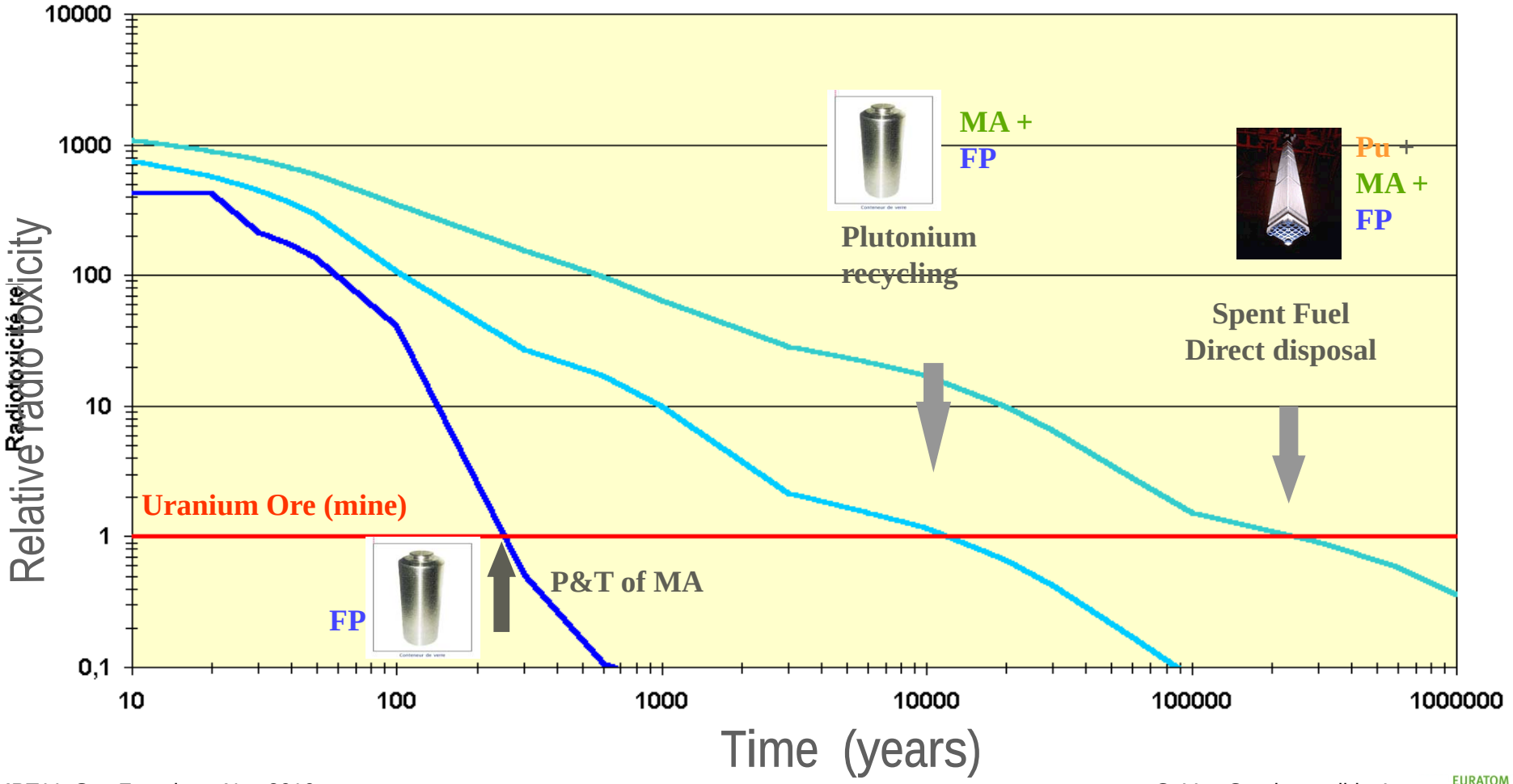
- **optimization of the use of natural resources with an increased resistance to proliferation**

➢ **large efforts under way world-wide concentrating on the disposal of the nuclear waste in deep geological repositories**

➢ **parallel approach = strategy of partitioning and transmutation (P&T) of the high-level nuclear waste**

(P&T, associated to a multi-recycling of all transuranics)

Fast Reactors: reduction of long-term toxicity (courtesy: CEA)



Common objective of all strategies using P&T

⇨ reduce the burden on a long-term waste management, in terms of
- ✓ radiotoxicity
- ✓ volume
- ✓ heat load of high-level nuclear waste

➢ most tangible outcomes of P&T :
- ✓ reduce the monitoring period of final repositories to technological and manageable time scales
- ✓ ease the long-term safety issue of a final repository
- ✓ positive influence on the public acceptance of nuclear fission electricity production

➢ enhance the actual nuclear renaissance in Europe and world-wide

➢ reduce Europe's steadily increasing dependency on energy imports

Possible range of strategies

- from stable or expanding nuclear energy scenarios (with TRUs treated)
  - ✓ either in dedicated transmuters in a separate fuel cycle stratum or
  - ✓ in GEN IV fast reactor systems associated with a closed cycle)

  up to the scenario of a nuclear phase-out
- expanding nuclear energy scenario:
  - ✓ P&T would permit the transition from the currently practiced mono-recycling of Plutonium in Light Water Reactors to actinides (U, Pu, MA) recycling
- phase-out scenario:
  - ✓ the combination of P&T and dedicated burners such as ADS technologies would allow meeting the above objectives of minimizing the radiotoxicity, volume and heat load
- ⇨ Significant common trunk
  - ✓ consensual European roadmap for RTD activities as well as for future pilot-scale facilities
  - ✓ renewed interest for closed fuel cycles in many countries
  - ✓ synergies between P&T as well as with geological disposal or interim storage activities

European Sustainable Nuclear Energy Technology Platform (SNE-TP)

- towards more integration:
  - ✓ European vision on P&T and more globally on future sustainable nuclear systems
  - ✓ European Sustainable Nuclear Industrial Initiative (SNE-TP)
    (ESNII / fast neutron reactors and closed fuel cycle in support of the SET-Plan)

- around 2012 : review national positions
  - ✓ impact of the P&T strategies on geological repository (requirements and capacity)
  - ✓ evaluation of technological options depending on national capacities
    - in fuel reprocessing and fuel fabrication
    - in construction of innovative reactor systems
  - ✓ review of ADS vs. critical fast systems potentialities and their different coolants

⇨ => decisions on demonstration facilities to be built at a time horizon 2015-2020

SNETP
SUSTAINABLE NUCLEAR ENERGY TECHNOLOGY PLATFORM

Implementation of P&T at the European level (RTD)

- Research and development activities : four “building blocks”

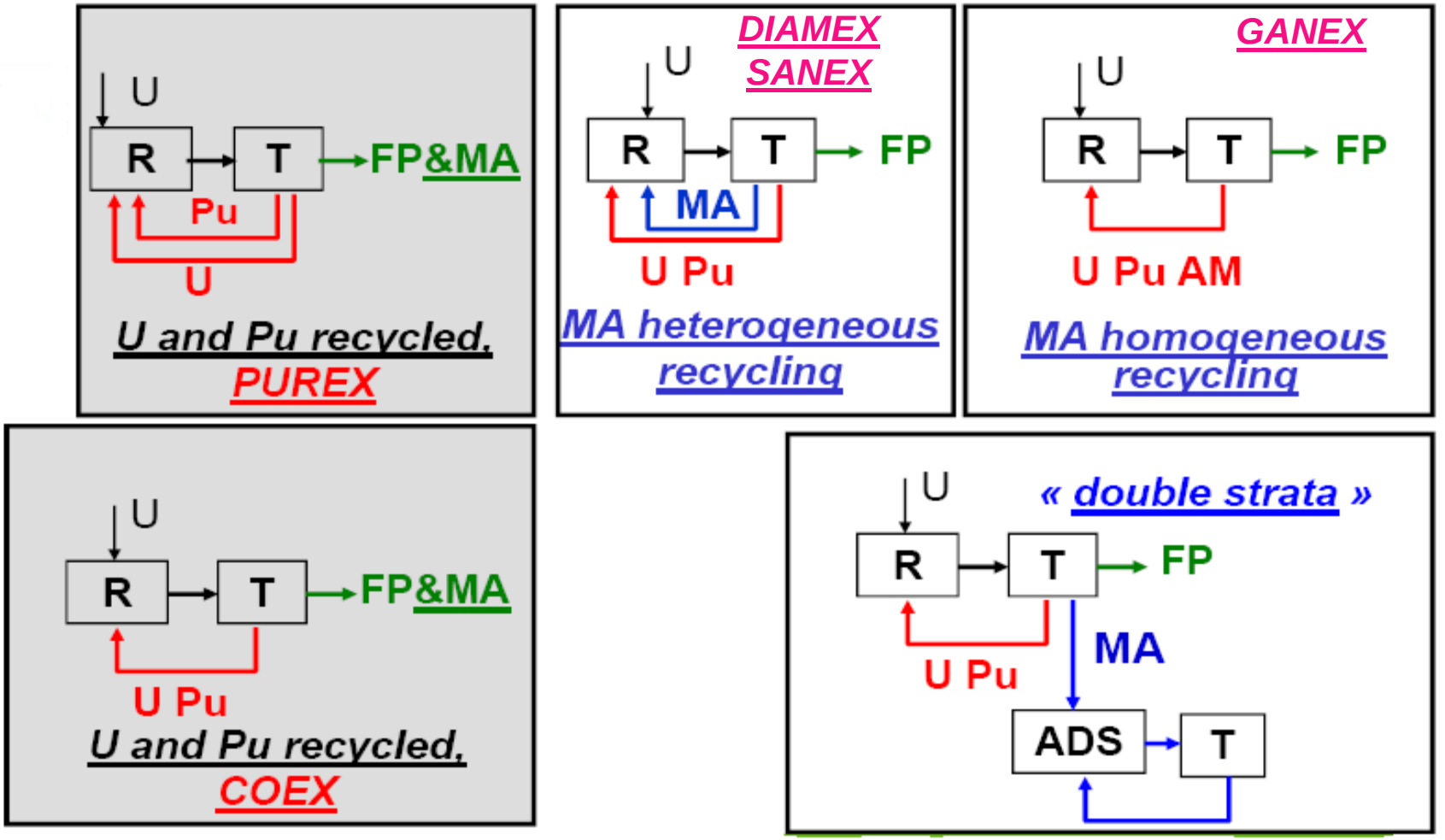
Block 1) Demonstration of the capability to apply advanced reprocessing on sizable amount of spent fuel from commercial power plants (i.e. LWR) in order to separate Pu and MA

Block 2) Demonstration of the capability to fabricate at semi-industrial level the advanced fuel needed to load a dedicated transmuter

Block 3) Availability of one or more dedicated transmuters

Block 4) Provision of a specific installation for processing of the dedicated fuel unloaded from the transmuter, and fabrication of a new dedicated fuel.

Future fuel cycle options, Reactor and Treatment



source: CEA / IEMPT, Oct 08
http://www.nea.fr/html/pt/iempt10/presentation/SIII01Warin.pdf

ACSEPT and EUROTRANS
FP7 Euratom Fission "Collaborative Projects"

(1) ACSEPT Project (2008 – 2012)

Partitioning Technologies and Actinide Science: towards pilot facilities in Europe

(2) EUROTRANS Project (2005 – 2010)

Transmutation of High Level Nuclear Waste in an ADS: towards a Demonstration Device of Industrial Interest

- join together a great number of Partners coming from European universities, nuclear research bodies and major industrial players in multi-disciplinary consortia
- provide a structured R&D framework (including also non-EU partners) to achieve the sound basis and fundamental improvements for future demonstrations at the pilot level
- in parallel, training and education programmes to share the knowledge among the P&T community and present and future generations of researchers
- cross-cutting activities (e.g. access to large or unique infrastructures of common interest)

2 - ACSEPT Project (2008 – 2012) Partitioning Technologies and Actinide Science: towards pilot facilities in Europe

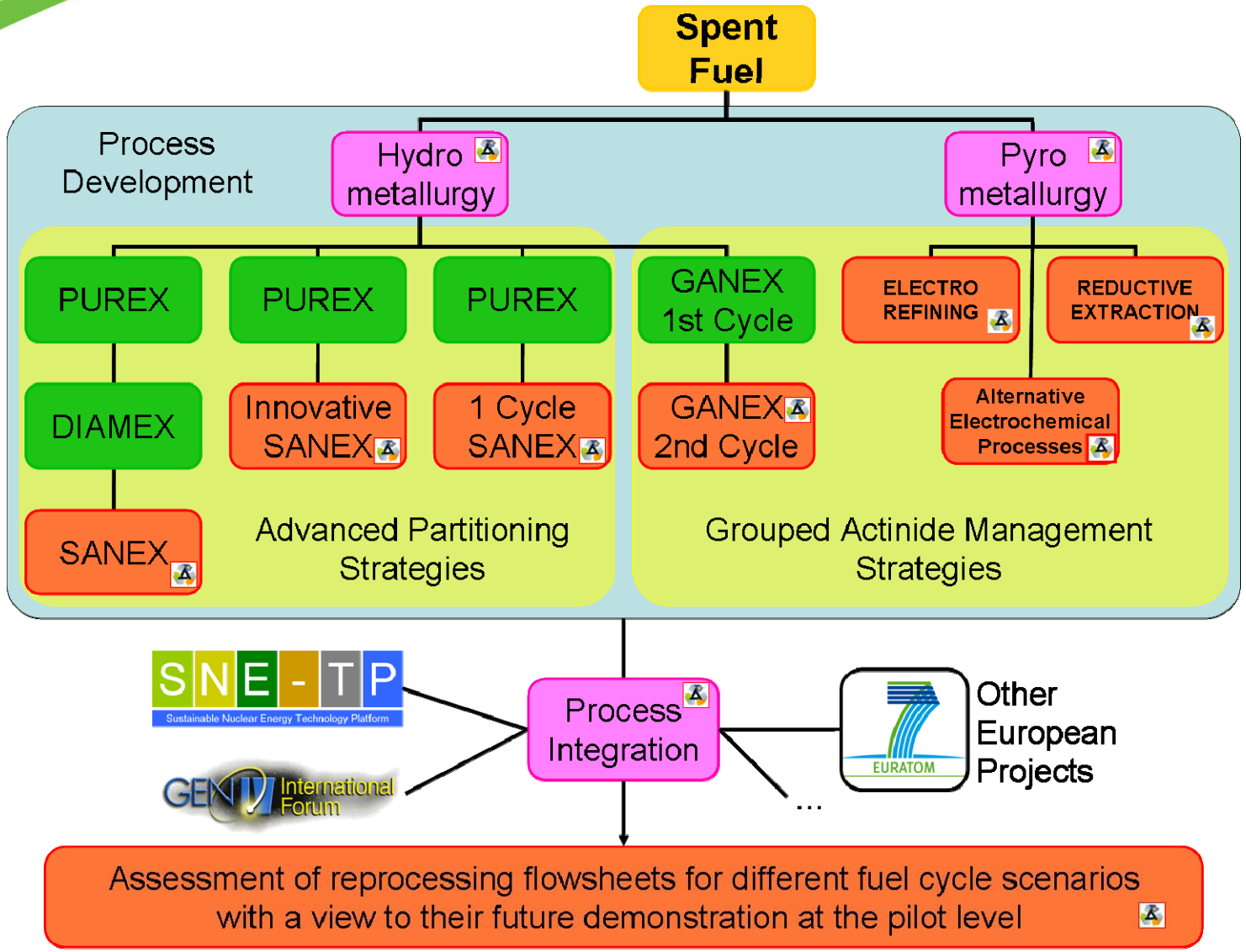
- based on FP6 project EUROPART
  (EUROpean research programme for the PARTitioning of minor actinides and some long-lived fission products from high active wastes issuing the reprocessing of spent nuclear fuels)

Objectives of ACSEPT project (in line with above "block 1)"):

- develop chemical separation processes compatible with fuel fabrication techniques, in view of their future demonstration at the pilot level

- demonstrate, in the long term, the potential benefits of actinide recycling to minimize the burden on the geological repositories.

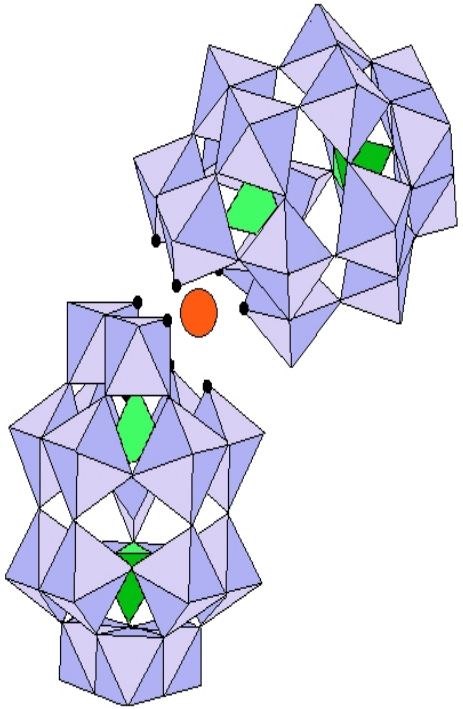
ACSEPT: a structured R&D framework to develop chemical separation processes

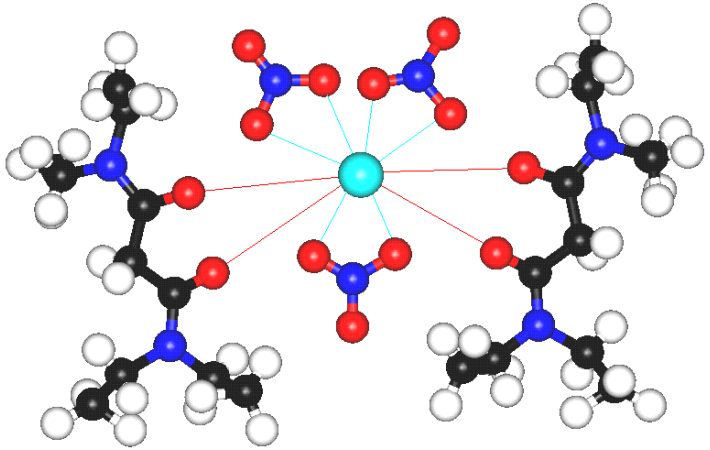


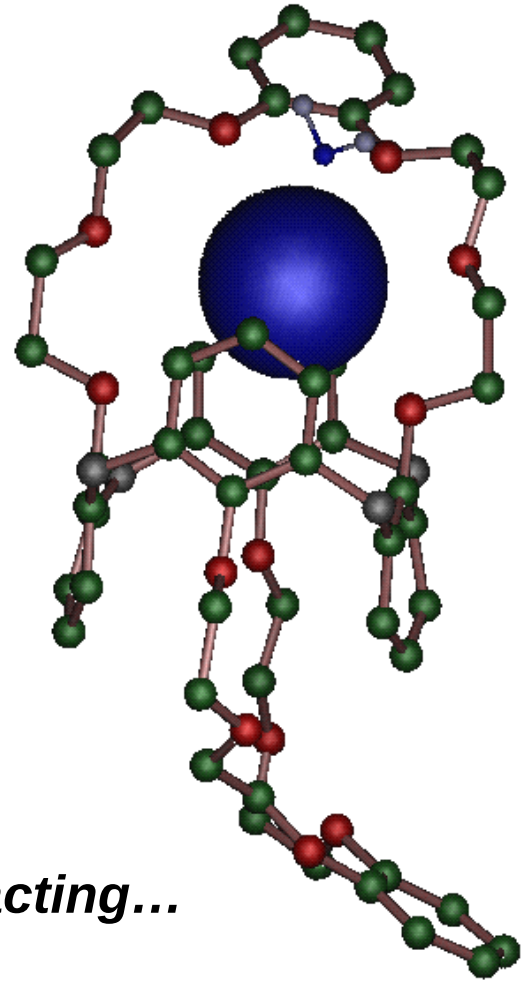
Three technical domains of ACSEPT

- technically mature aqueous separation processes
  - ✓ optimize and select the most promising ones dedicated either to actinide partitioning or to group actinide separation
  - ✓ exploratory research focused on the design of new molecules
- high temperature pyrochemical separation processes
  - ✓ enhance the two reference cores of process selected within FP6-EUROPART
  - ✓ key scientific points compulsory for building a whole separation process
- future demonstration at a pilot level
  - ✓ carry out engineering and systems studies on hydro and pyrochemical processes
  - ✓ design the minor-actinide containing pins (prior to their fabrication in the FP7 project FAIRFUELS)

New separation needs, new molecules







Selective, radiation-resistant, reversible, fast-acting… challenges for research!

3 - EUROTRANS Project (2005 – 2010) Transmutation of High Level Nuclear Waste in an ADS: towards a Demo Device of Industrial Interest

- **based on the three FP5 Clusters FUETRA, BASTRA and TESTRA together with the PDS-XADS Project**

  + FP6 Project PATEROS (P&T European Roadmap for Sustainable Nuclear Energy, 2006 - 2008)

  + Thematic Network ADOPT (Advanced Options for Partitioning and Transmutation, 2006 - 2008)

For example, FUETRA = three FP-6 projects FUTURE, CONFIRM, and THORIUM CYCLE

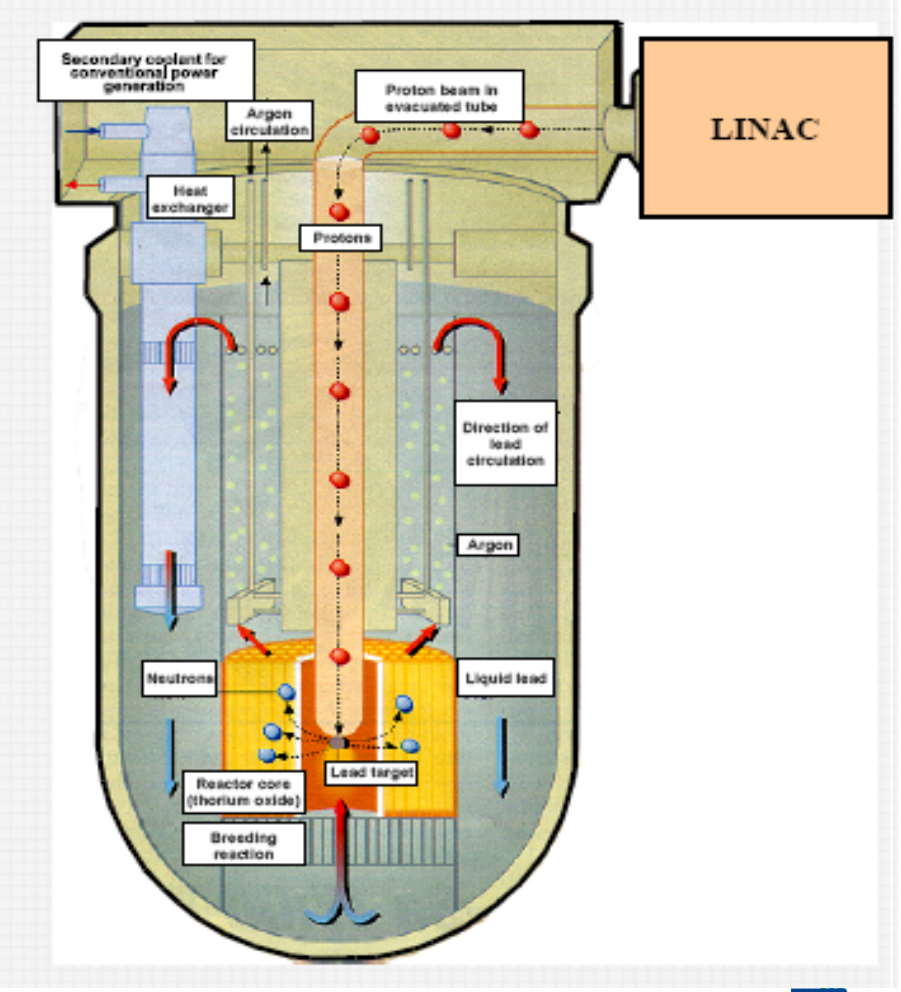
- **FUTURE = development of TRU oxide homogeneous fuel for transmutation (Pu-Am oxide, Th-Pu-Am oxide, and Pu-Am-Zr oxide)**
- **CONFIRM = development of inert (uranium-free) nitride fuel (U-Pu, Pu-Zr, and Am-Zr nitrides) including irradiation experiments for characterization and modelling**
- **THORIUM CYCLE = feasibility of the thorium cycle for light water reactors (PWRs) and for ADS (irradiation experiments using U-oxide, Th-oxide, U-Pu oxide, and Th-Pu oxide targets)**

Objectives of EUROTRANS project (in line with above "block 2)")

- design and feasibility assessment of an industrial ADS prototype dedicated to transmutation with the following major activities:
  - ✓ first design of an eXperimental facility demonstrating the technical feasibility of Transmutation in an Accelerator Driven System (XT-ADS)
    + conceptual design of the European Facility for Industrial Transmutation EFIT
    => European Transmutation Demonstration (ETD) / step-wise approach
  - ✓ coupling of an accelerator, an external neutron source and a sub-critical blanket: experimental input (such as experimental techniques, dynamics, feedback effects, shielding, safety and licensing issues) at sufficient power (20-100 kW)
  - ✓ associated technologies: reliable linear accelerator components, fuels, structural materials at high temperature and high radiation exposure conditions, thermal-hydraulics, heavy liquid metal technologies, measurement techniques, nuclear data
  - ✓ Demonstration of overall technical feasibility and economic assessment of the whole system, in order to start a decision process towards a EU demonstration facility.

Transmutation with Accelerator Driven Systems

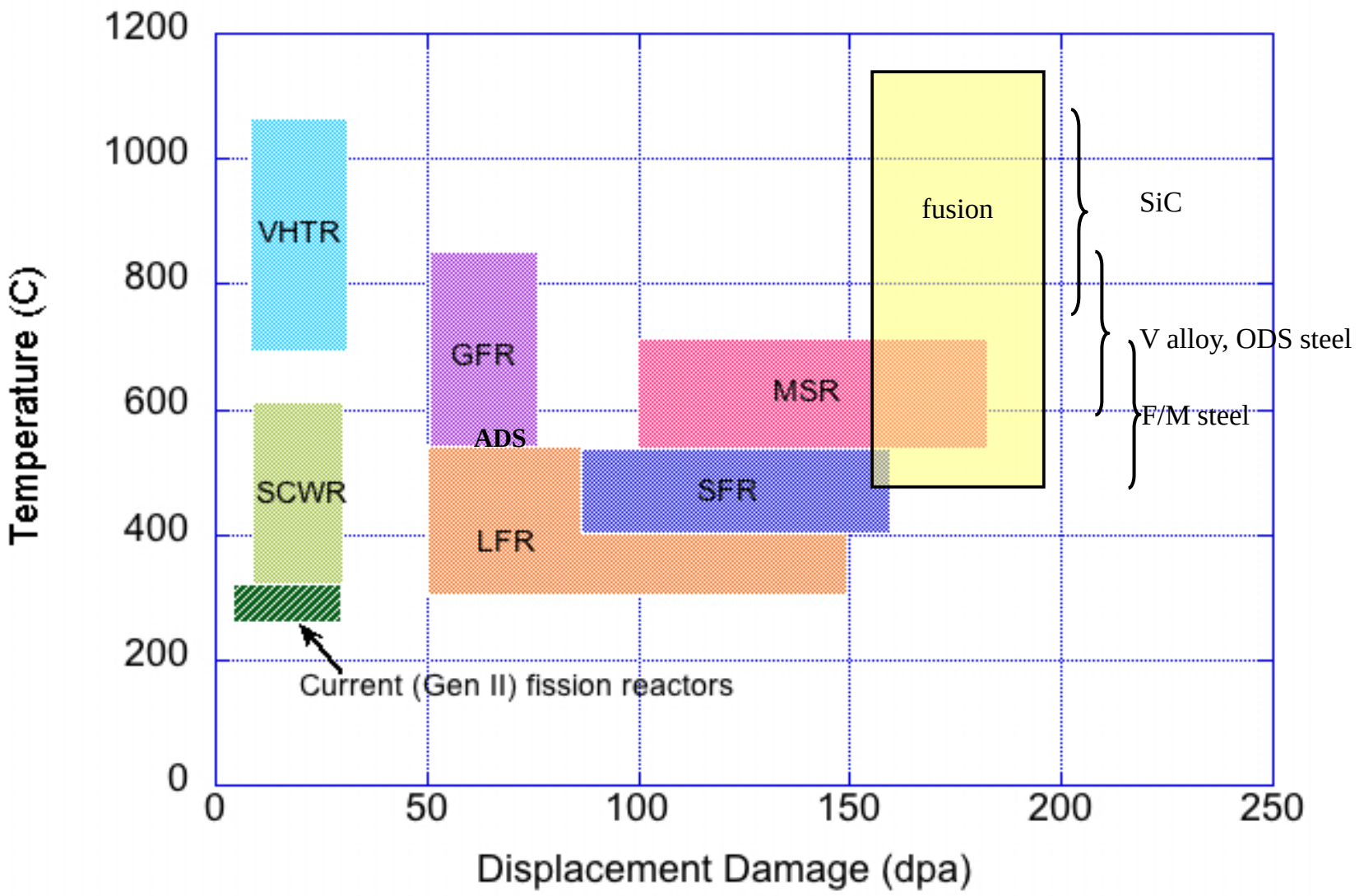
- Transmutation/incineration of Minor Actinides (MAs) in subcritical ADT (accelerator driven transmuter)
- Supposed advantages of ADTs compared to 'critical' transmuters with respect to fuels:
  - High MA masses
  - High incineration rate (MAs)
  - Flexibility in fuel composition
  - Safety (subcriticality)
- Support of 5th FP and 6th FP of European Commission



Five technical domains of EUROTRANS

- design and feasibility assessment of an industrial ADS prototype dedicated to transmutation with the following major activities:
  - ✓ Domain DM1: DESIGN (Development of a detailed design of XT-ADS and a conceptual design of EFIT with heavy liquid metal cooling)
  - ✓ Domain DM2: ECATS (Experimental activities on the Coupling of an Accelerator, a spallation Target and a Sub-critical blanket)
  - ✓ Domain DM3: AFTRA (Advanced Fuels for TRAnsmutation Systems)
  - ✓ Domain DM4: DEMETRA (DEvelopment and assessment of structural materials and heavy liquid MEtal technologies for TRAnsmutation systems)
  - ✓ Domain DM5: NUDATRA (NUclear DAta for TRAnsmutation)

Cross-Cutting Materials R&D

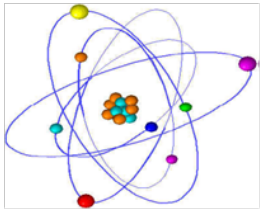


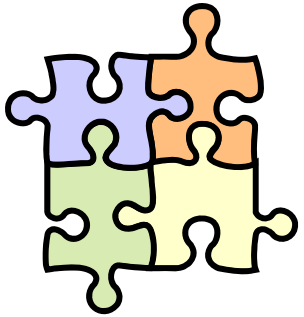
Source: S. Zinkle, SMINS 2007, Karlsruhe

4 - Conclusion: towards pilot-scale facilities for P&T (innovative fuels and systems for increased sustainability)

- **next step beyond ACSEPT and EUROTRANS:**
  ultimate goal = industrial transmutation machine and re-processing facility (building "blocks 3) and 4)" mentioned above)

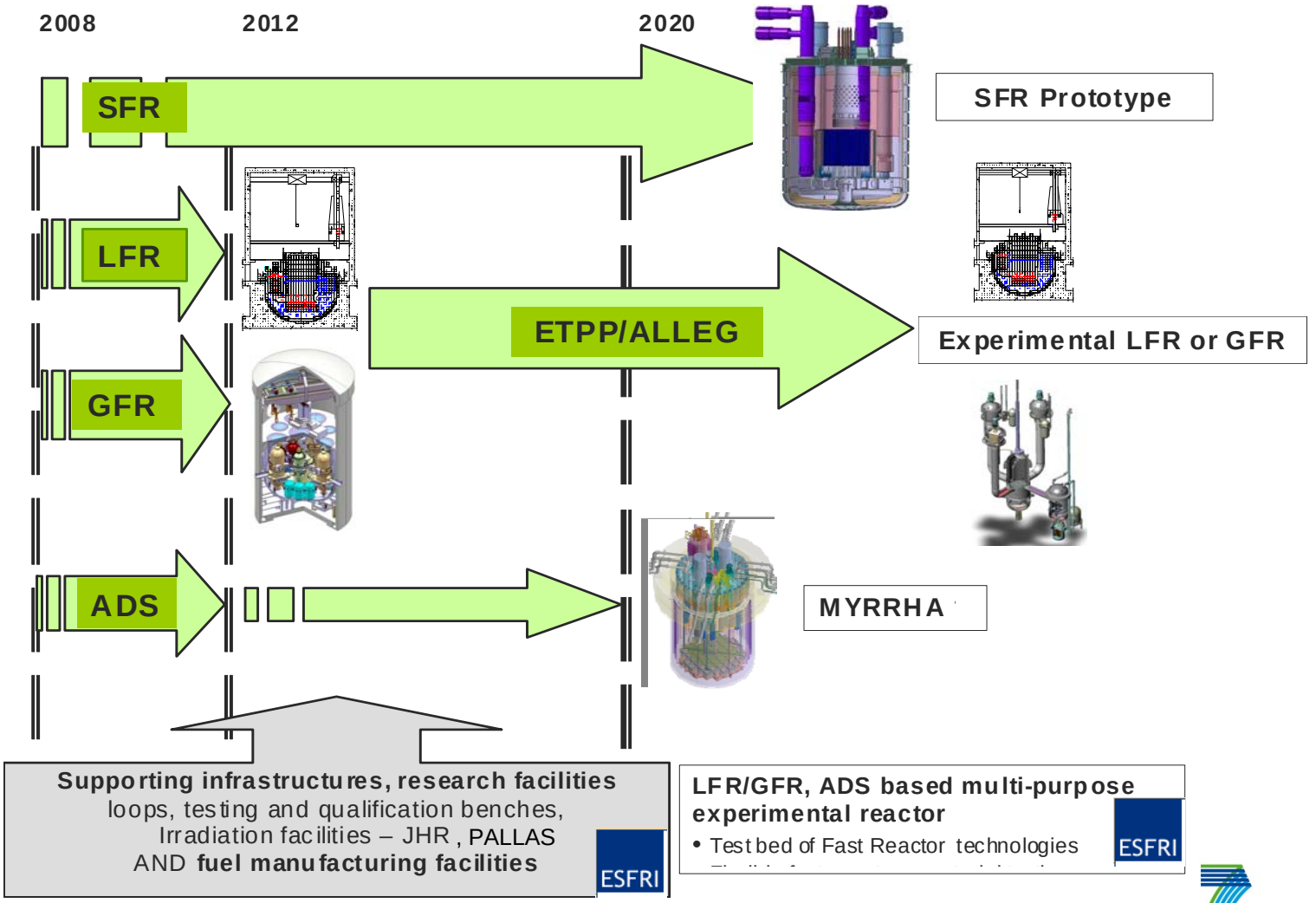
- **FP7 Project Central Design Team (CDT) for a Fast-spectrum Transmutation Experimental Facility, co-ordinated by SCK-CEN**





All in the same boat

SNETP roadmap for Gen IV Fast Systems



Bibliographic and web references

(1) SNE-TP - The Sustainable Nuclear Energy Technology Platform (SNETP) promotes research, development and demonstration of the nuclear fission technologies necessary to achieve the Strategic Energy Technology (SET) Plan goals in the EU - (http://www.snetp.eu/)

(2) ACSEPT – Partitioning Technologies and Actinide Science: towards pilot facilities in Europe (FISA-2009 lecture)
by S. Bourg and N. Ouvrier (CEA), C. Hill1, C. Caravaca and A. Espartero (CIEMAT), C. Rhodes, R. Taylor and M. Harrison (NNL-UK), C. Ekberg (CHALMERS), A. Geist (FZK-INE), G. Modolo (FZJ), L. Cassayre (CNRS), R. Malmbeck (JRC-ITU), G. de Angelis (ENEA), S. Bouvet (ALCAN) (http://www.acsept.org/)

(3) EUROTRANS - EU Research Programme for the Transmutation of High Level Nuclear Waste in an ADS: Towards a Demonstration Device of Industrial Interest (FISA-2009 lecture)
by Joachim U. Knebel and Concetta Fazio (KIT/FZK), Hamid Aït Abderrahim and Didier De Bruyn (SCK•CEN), Marylise Caron-Carles (AREVA NP SAS) , Fabienne Delage and Gilbert Granget (CEA), Michel Giot (UCL), Enrique Gonzalez (CIEMAT), Luigi Mansani (ANSALDO), Stefano Monti (ENEA), Alex C. Mueller (CNRS) – (http://www.fzk.de/eurotrans)

(4) FISA-2009 Conference - Seventh European Commission conference on Euratom research and training in reactor systems (22-24 June 2009, Prague, Czech Republic (http://cordis.europa.eu/fp7/euratom-fission/fisa2009_en.html)

Available links
(Euratom FP6 and FP7 publications)

- EU Energy research: http://ec.europa.eu/research/energy/index_en.htm
- Euratom Seventh Framework Programme: http://cordis.europa.eu/fp7/euratom/home_en.html
- Information on FP7 and access to programmes and calls: http://cordis.europa.eu/fp7/home_en.html
- Euratom Seventh Framework Programme funded projects http://cordis.europa.eu/fp7/euratom-fission/library_en.html

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  - http://cordis.europa.eu/fp7/euratom-fission/library_en.html
  - Euratom FP6 Research Projects and Training Activities, Volume I-II and III (PDF)
  - Volume I ftp://ftp.cordis.europa.eu/pub/fp6-euratom/docs/nuclear_fission_eur21228_en.pdf
  - Volume II ftp://ftp.cordis.europa.eu/pub/fp6-euratom/docs/nuclear_fission_eur21229_en.pdf
  - Volume III ftp://ftp.cordis.europa.eu/pub/fp7/docs/euratom-fission_eur22385_en.pdf
  - Euratom FP7 Research Projects and Training Activities, Volume I (PDF)
  - Volume I ftp://ftp.cordis.europa.eu/pub/fp7/docs/fin-266-euratom-web-jun09v02_en.pdf
  - Volume II http://ec.europa.eu/research/energy/pdf/euratom-fp7-vol-2.pdf

- Research*eu magazine http://ec.europa.eu/research/research-eu/index_en.html
- Strategic Energy Technolog Plan SET-Plan http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm
- FISA 2009 http://cordis.europa.eu/fp7/euratom-fission/fisa2009_en.html

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FISA2009

Prague,
Czech Republic
22 > 24 June 2009

Seventh European Commission conference on
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