ELSY
The European
Lead Fast Reactor

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**FR09 - International Conference on Fast Reactors
and Related Fuel Cycles**
- *Challenges and Opportunities* - December 7 - 11, 2009
Kyoto, Japan

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European Background on HLM Systems

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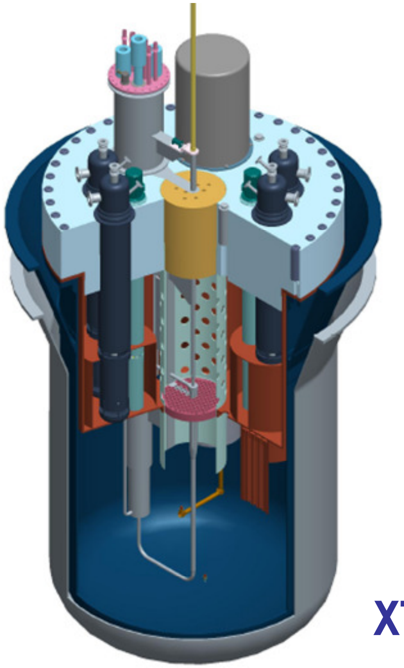


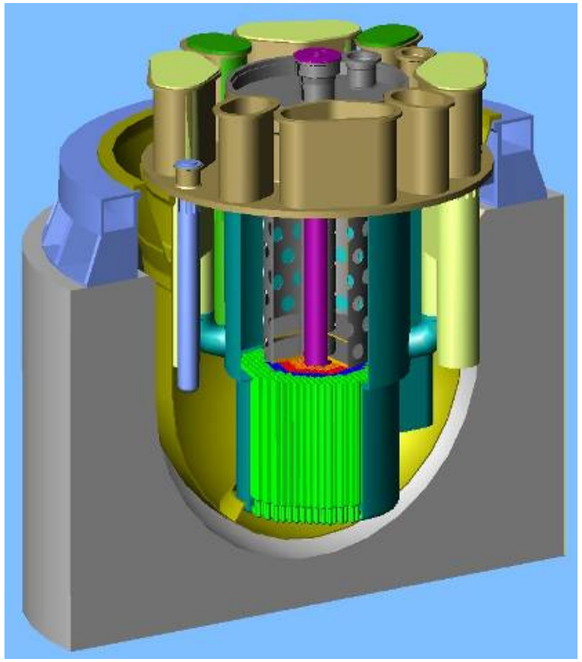
Expertise has been gained in the EU on Heavy Liquid Metal technology (Lead-Bismuth Eutectic – Lead) in the frame of R&D activities on transmutation of Long Lived radioactive waste using Accelerator Driven Systems (ADS)

Projects:

PDS-XADS, IP-EUROTRANS, TECLA

XT-ADS

EFIT



Considering this experience, 17 European Organizations did take the initiative to promote the design of a ***critical fast reactor cooled by pure Lead***

The ***ELSY*** *project (European Lead SYstem) started in 2006, funded by EC in the 6th FP.*

The main design / safety features of ELSY are presented

ELSY Consortium

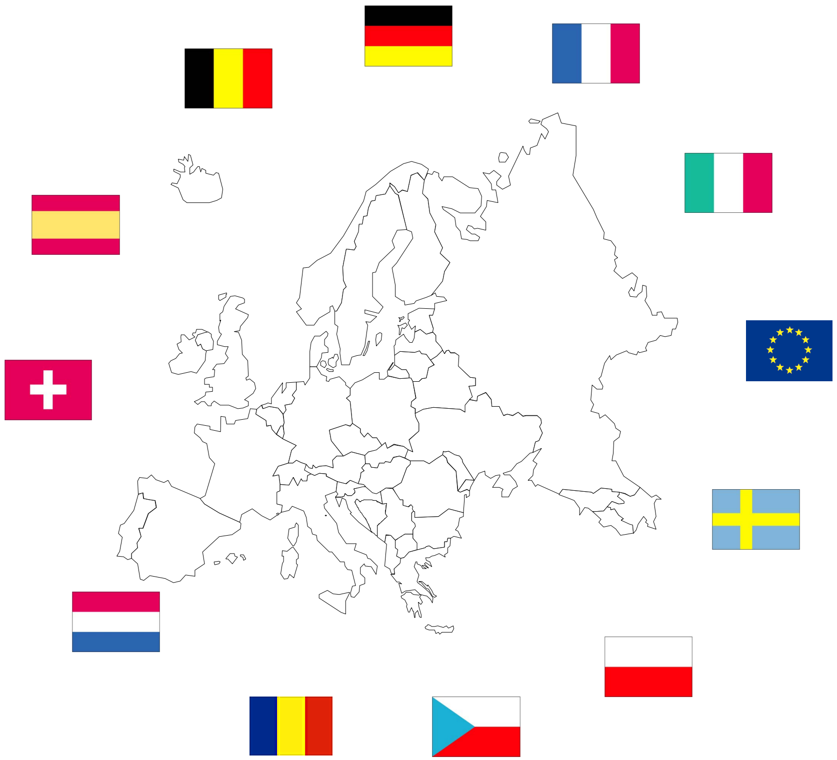
INDUSTRY
Ansaldo Nucleare (Project Coordinator)
Del Fungo Giera Energia
Empresarios Agrupados

UTILITIES
EdF

NATIONAL RESEARCH ORG.
CESI RICERCA, CNRS, ENEA, FZK, INR, NRG, UJV-REZ, PSI, SCK•CEN

EC - JOINT RESEARCH CENTRE
JRC/IE-Petten

UNIVERSITIES
AGH, CIRTEN, KTH



Objectives of ELSY project (EC – 6th FP)
(ELSY – European Lead System)

- ***Demonstration of the technical feasibility of a LFR***

  i.e. possibility to design an economically competitive and safe lead-cooled fast reactor adopting innovative and simple engineering features

- ***Demonstration of the capability to fully comply with Generation IV goals***

ELSY: Simple for Economics

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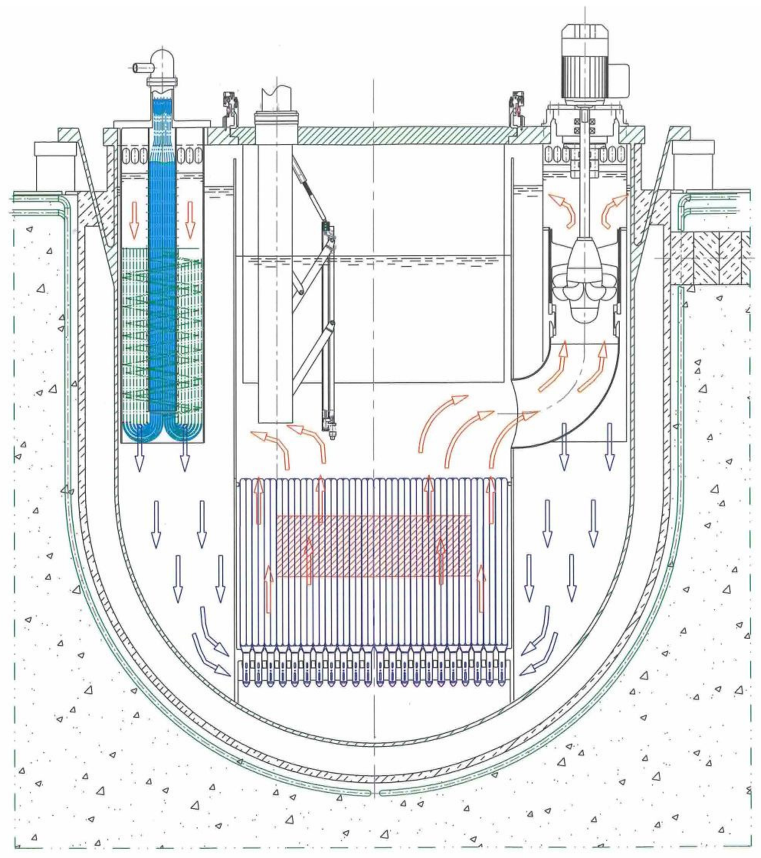
STARTING CONFIGURATION

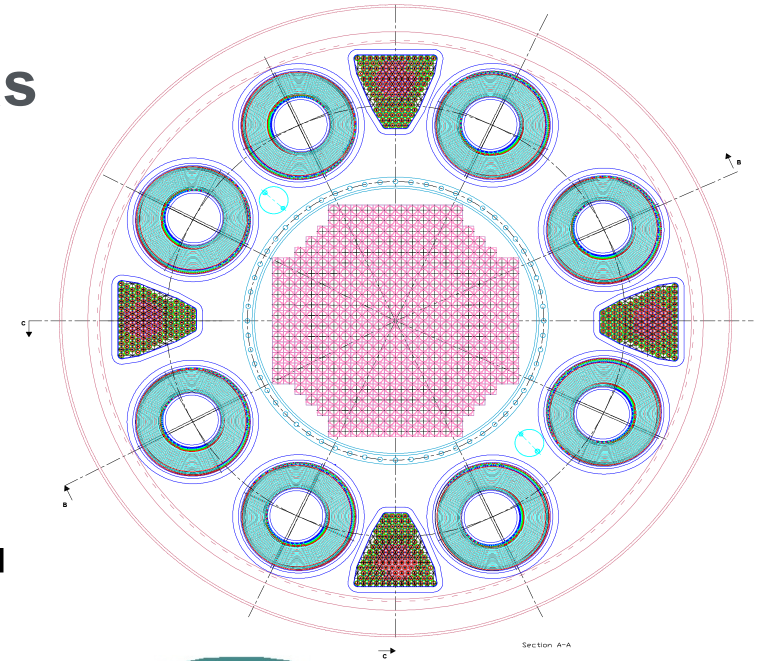
Advantages:
- ***no intermediate system***
- ***simple internals***
- ***removable components***

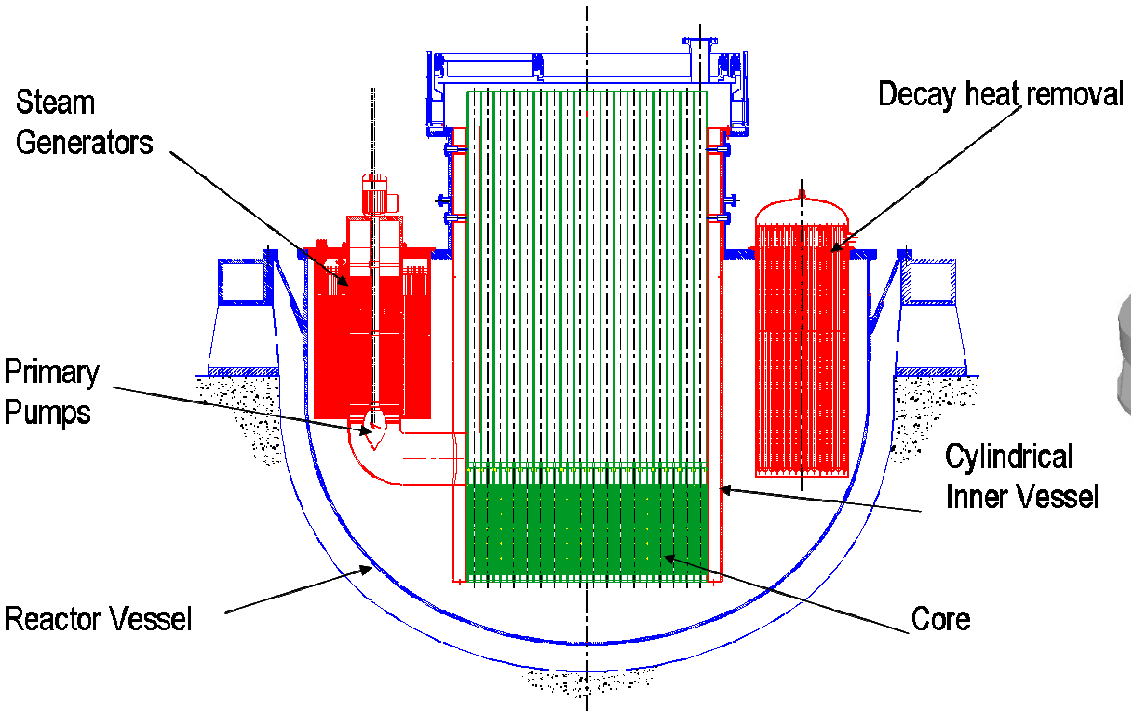
Problems to be solved:
- ***SG design do not favour N.C.***
- ***Lead weight***
- ***Fuel handling inside vessel (below Lead level)***

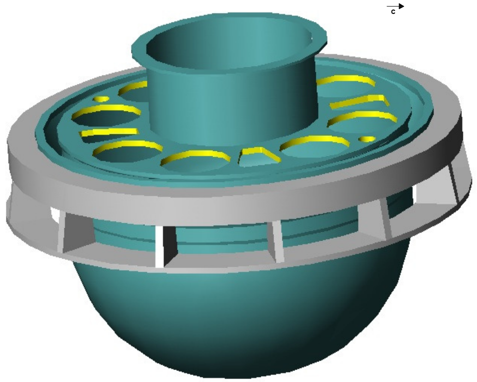


ELSY - 1500 MWth Main Characteristics

- Fuel handling operating in cover gas
- Spiral SG design for Natural Circ.
- Reactor Building seismic isolators
- Lead: ~9000 tons
- Thermal cycle 43%

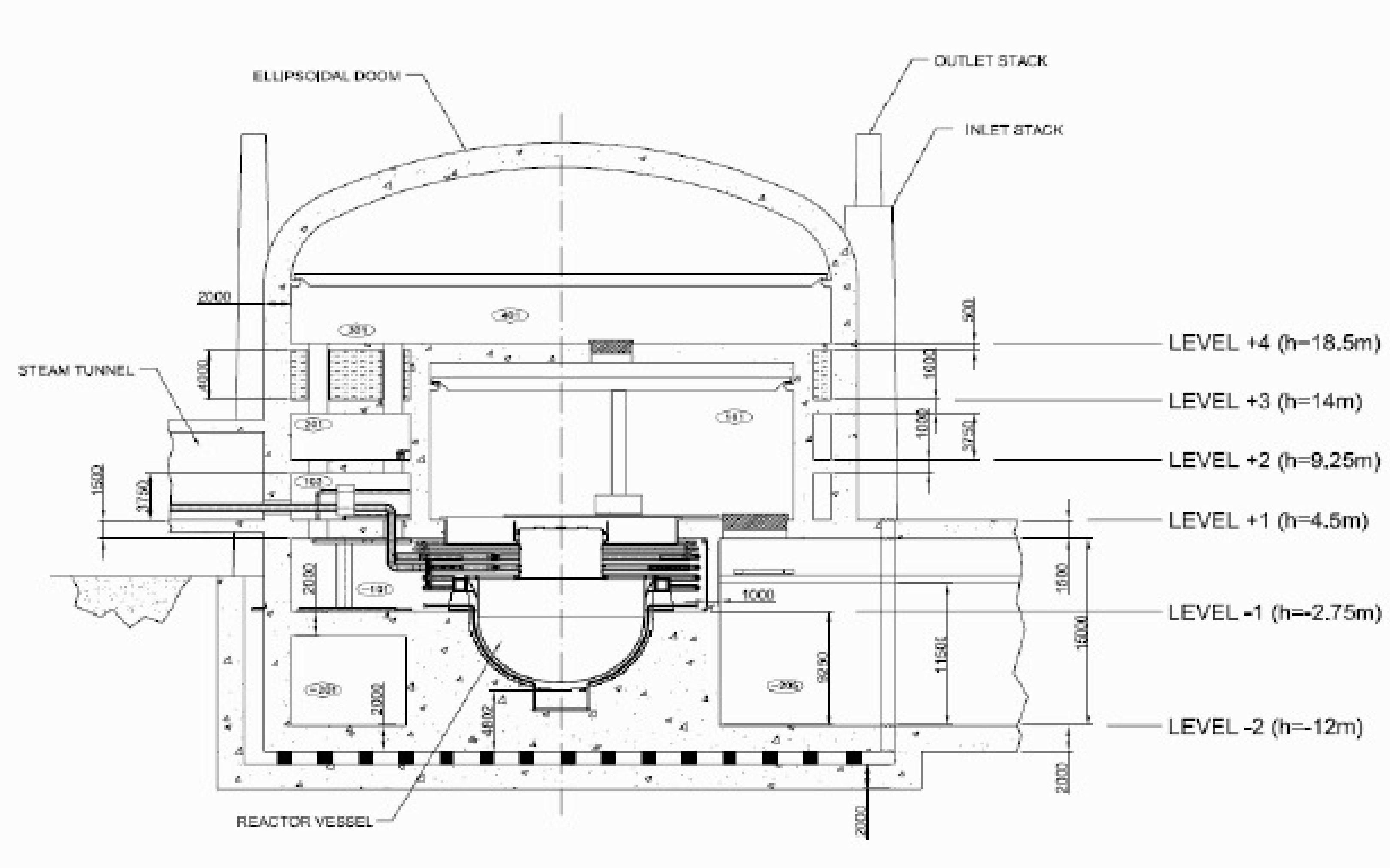




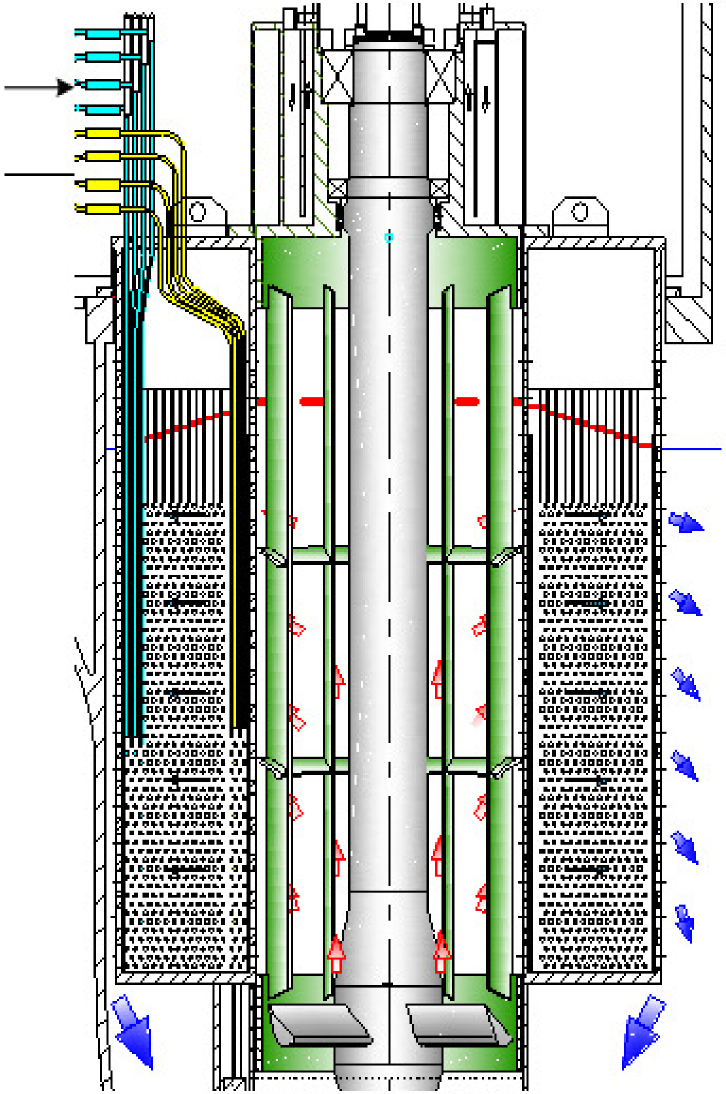


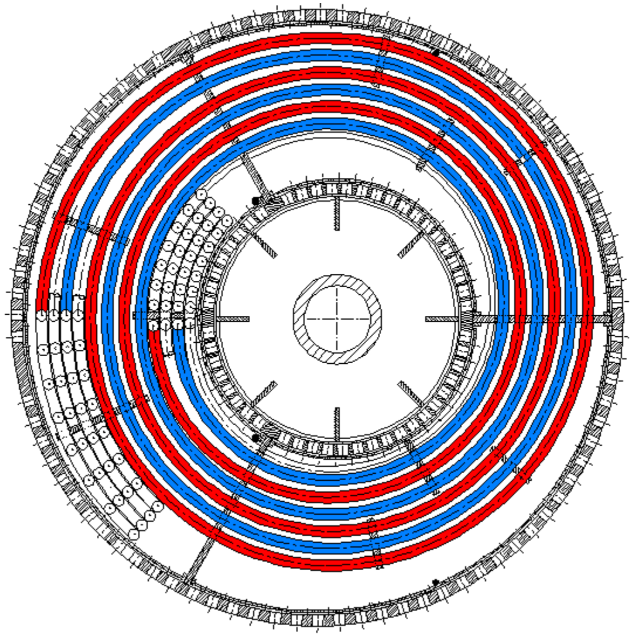
Reactor Vessel and Support assembly

Antiseismic scheme for ELSY Reactor Building



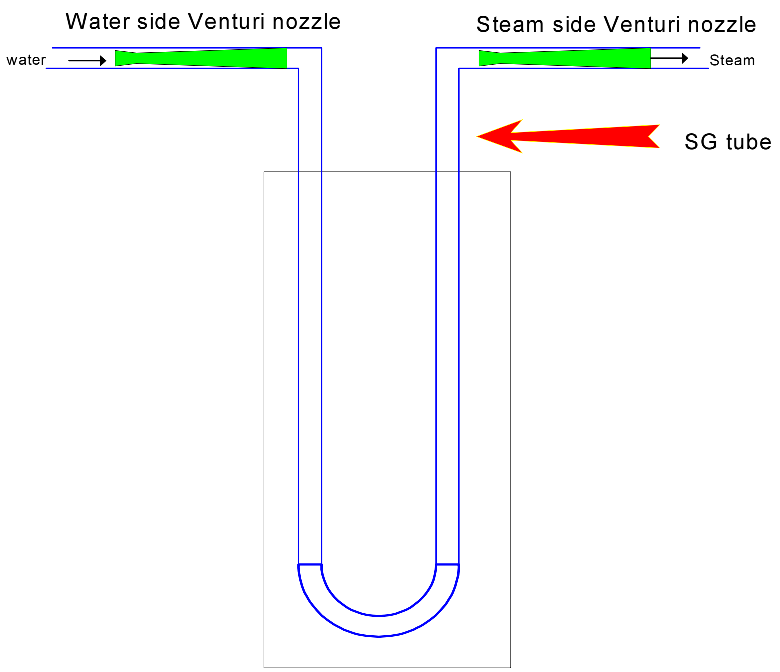
ELSY - Once through Spiral SG

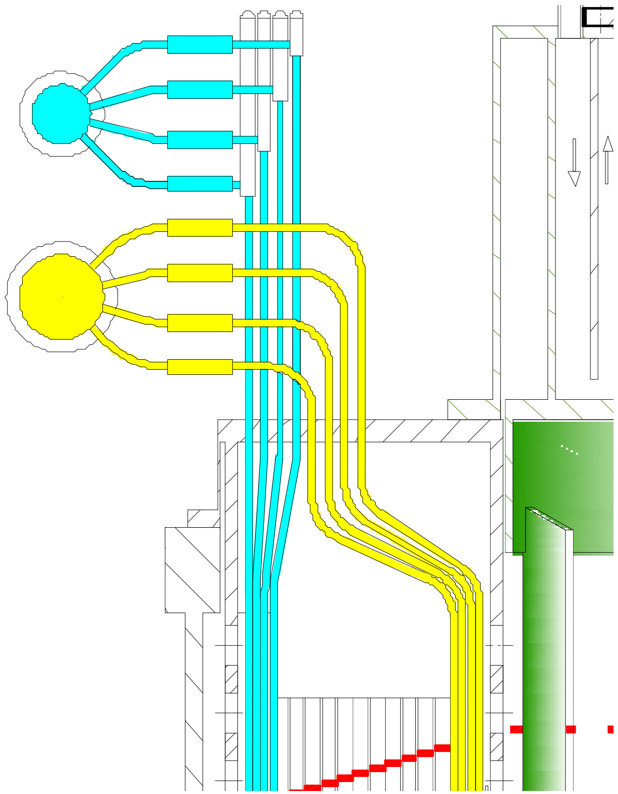




Thermal Duty	MW	187.5
Lead Inlet emperature	°C	480
Lead Outlet temperature	°C	400
Water Inlet Temperature	°C	335
Steam Outlet temperature	°C	470.8
Water Flow	kg/s	114.7
Water Inlet Pressure	Mpa	19.1
Steam Outlet Pressure	Mpa	18

1. Water and steam collectors outside the main vessel.
2. Tube break flow limited by critical flow at venturi nozzles
3. Water and steam loops depressurized and isolated
4. Reactor cover gas plenum depressurized by pressure relieving ducts, with rupture discs, connected to the above-Reactor Enclosure.





AXIAL PUMP

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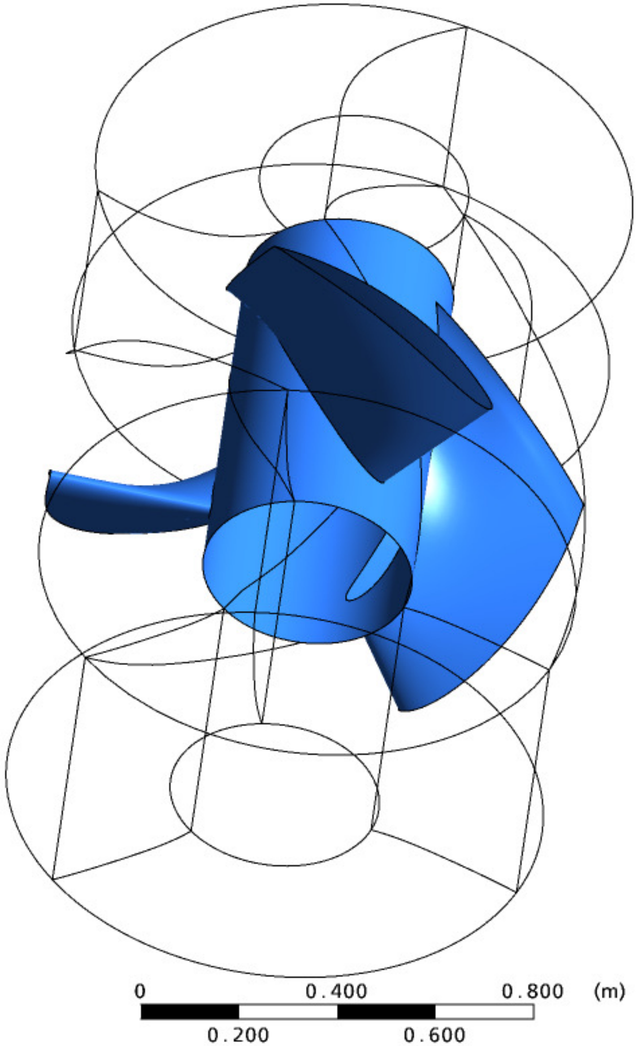


Outside impeller diameter	1.1 m
Hub diameter	0.43 m
Impeller speed	140 rpm
Number of vanes	3
Vane profile	NACA 23012
suction pipe	1.6 m/s
vanes tip	8.7 m/s
Meridian (at impeller entrance and exit)	3.1 m/s

Two core options developed:

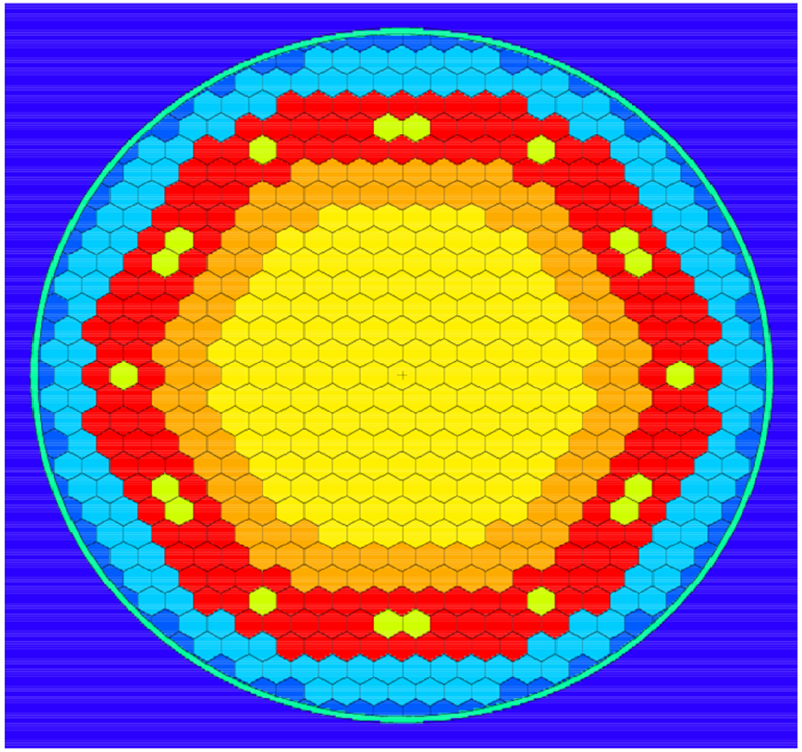
- Open Square design (ENEA)

- Closed hexagonal design (SCK-CEN)

Both options studied and optimized

Reference design based on Open Square option

Closed hexagonal design

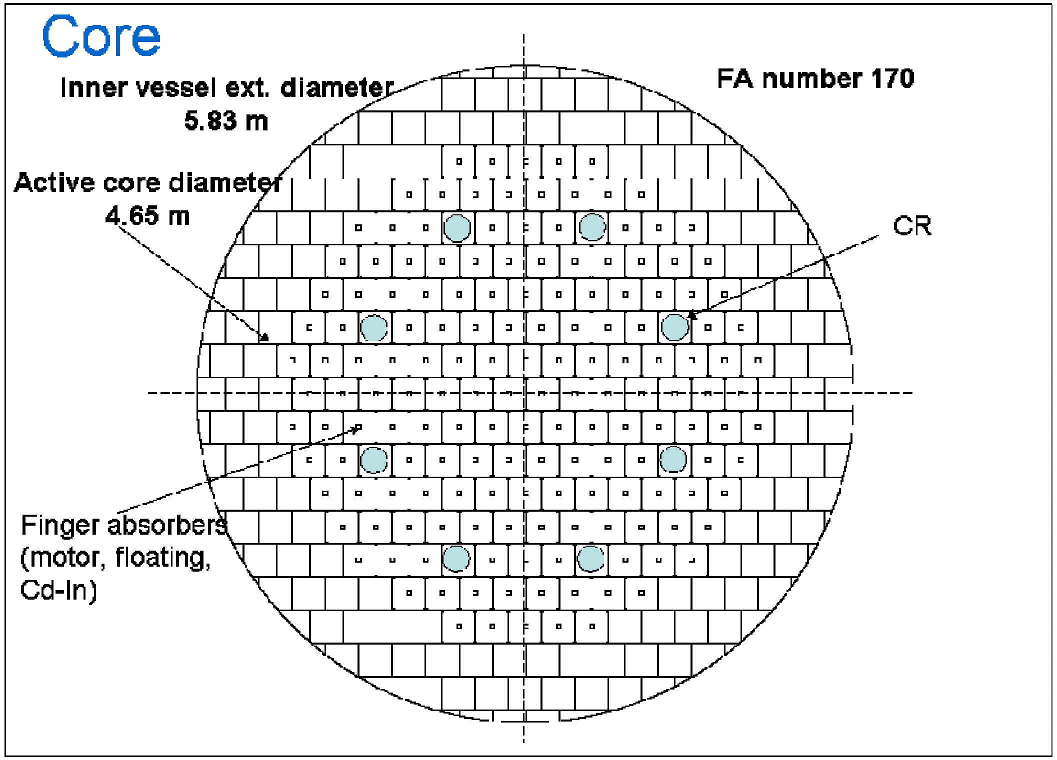


- 433 fuels assemblies
- 163 in inner zone
- 102 in middle zone
- 168 in outer zone
- 18 absorber positions

- Fuel enrichment
- 14.6/15.5/18.5%Pu

- U -7.2% in 5x365 EFPDs
- Pu +1.7% in 5x365 EFPDs
- MA equilibrium 167 Kg

Open Square design



- 162+8 fuels assemblies
- 56 in inner zone
- 62 in middle zone
- 44 in outer zone
- 8 absorber positions

- Fuel enrichment
- 14.2/16.2/19.1 % Pu

- U -7.7% in 4x365 EFPDs
- Pu +0.4% in 4x365 EFPDs
- MA equilibrium 410 Kg

ELSY - SAFETY SYSTEMS

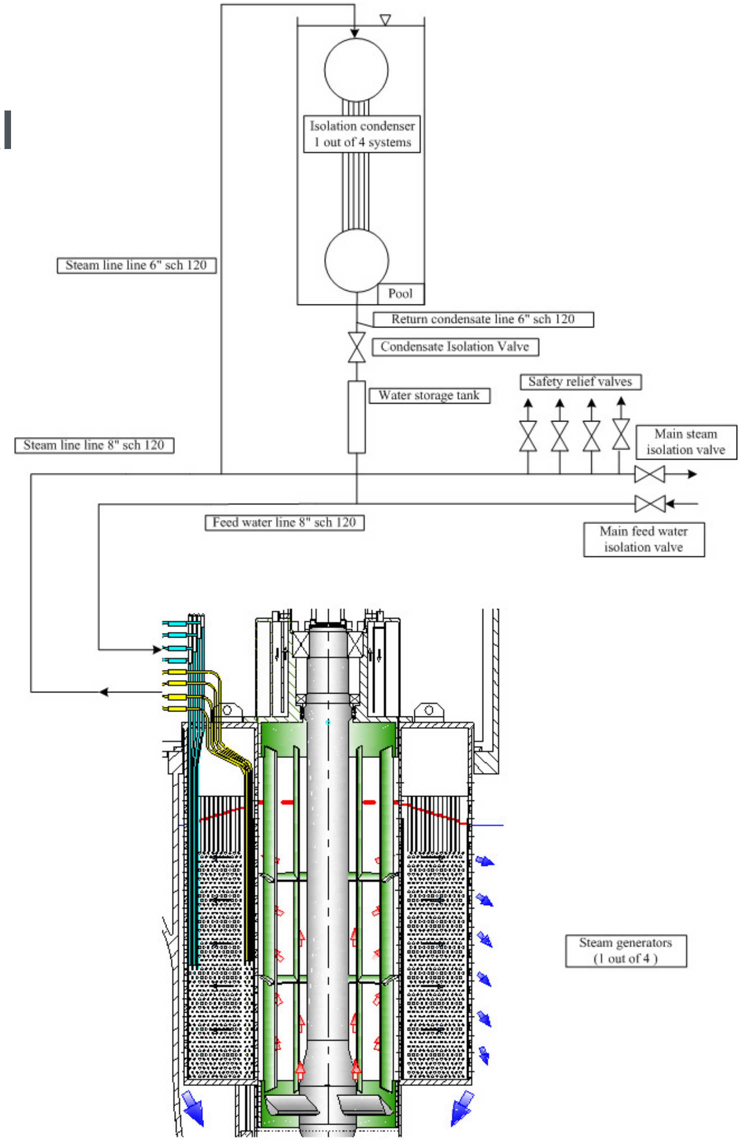
Two independent, diverse, high reliable and redundant Decay Heat Removal systems designed

- DHRs independence based on two different systems with nothing in common: the **W-DHR** and the **IC-DHR**.
- DHRs diversity based on different physical principles.
- DHRs redundancy obtained by means of three out of four loops sufficient to fulfil the DHR safety function.

Each DHR system can fulfil its design function removing the decay thermal power from the core without exceeding primary lead temperatures even if a single failure occurs.

In addition long term cooling is provided by the Reactor Vessel Air Cooling System (RVACS)

Total Heat Removal Capacity 30 MWt.
3 Loops sufficient for Decay Heat removal



TUBE BUNDLE

Number of tubes: 54 tubes for each condenser
Average active tube length: 2000 mm
Tube external diameter: 52.2 mm
Tube thickness: 3.00 mm
Triangular tube arrangement

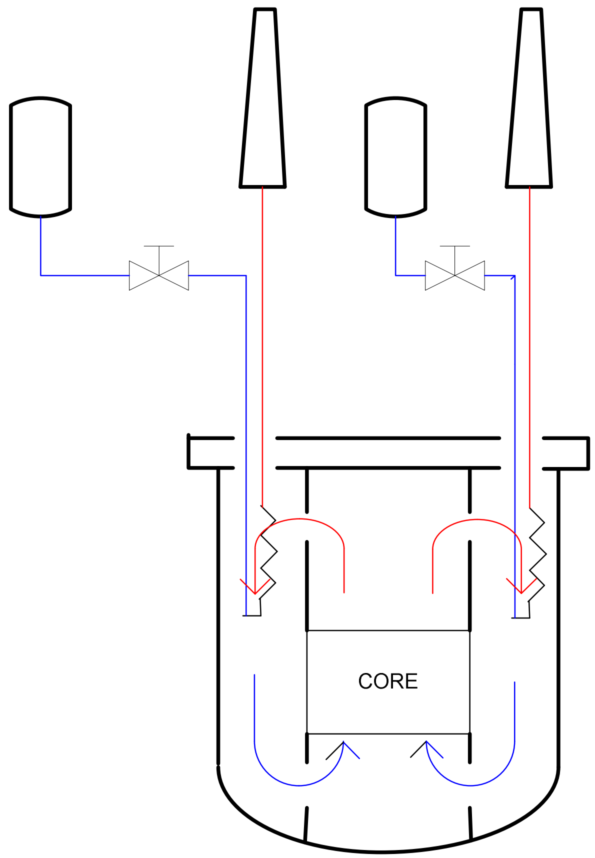
COLLECTORS

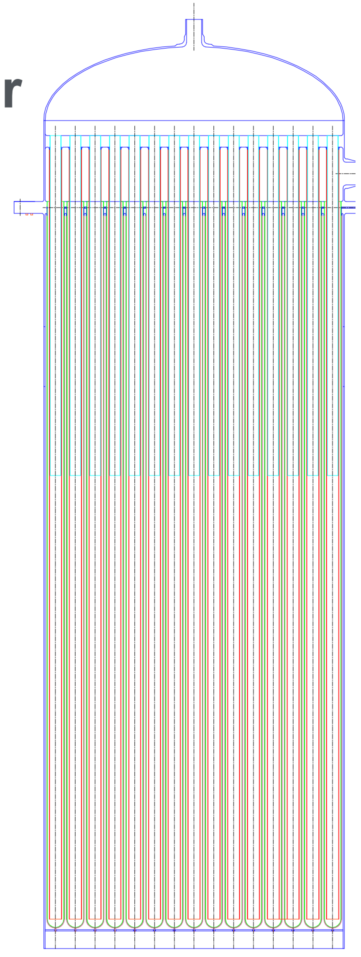
Length: 1500 mm
External diameter: 560 mm
Thickness: 60 mm

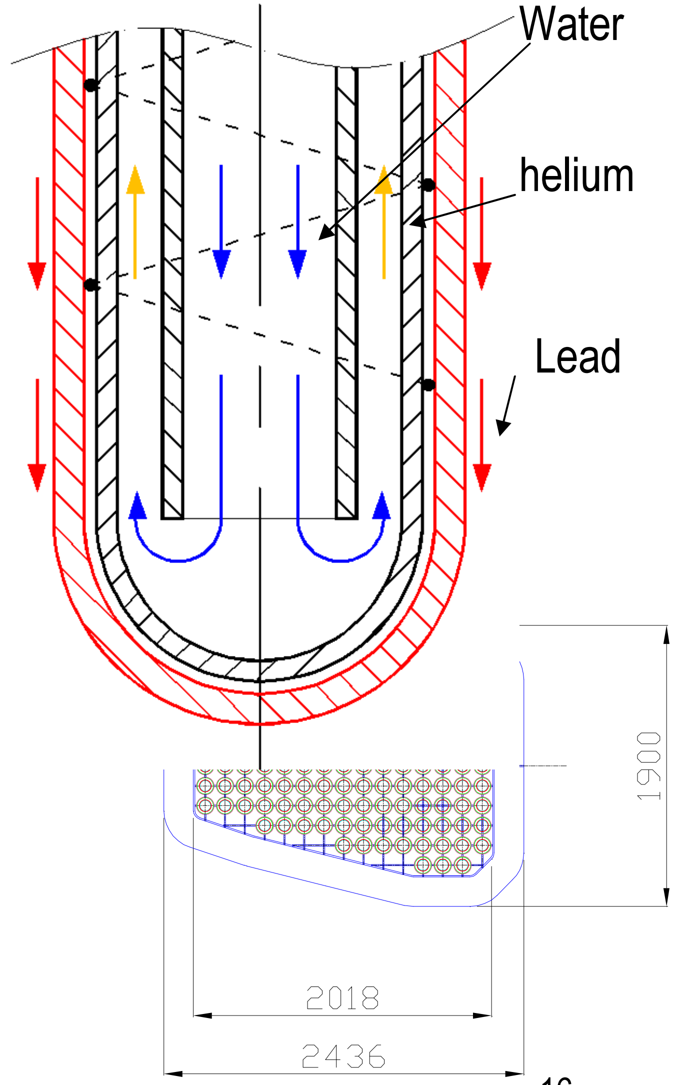
CONDENSER CONNECTION PIPING

Steam inlet : 6” sch 120
Water outlet : 6” sch 120

Double-wall, helium bounded bayonet tubes with continuous monitoring of the double barrier between primary - secondary

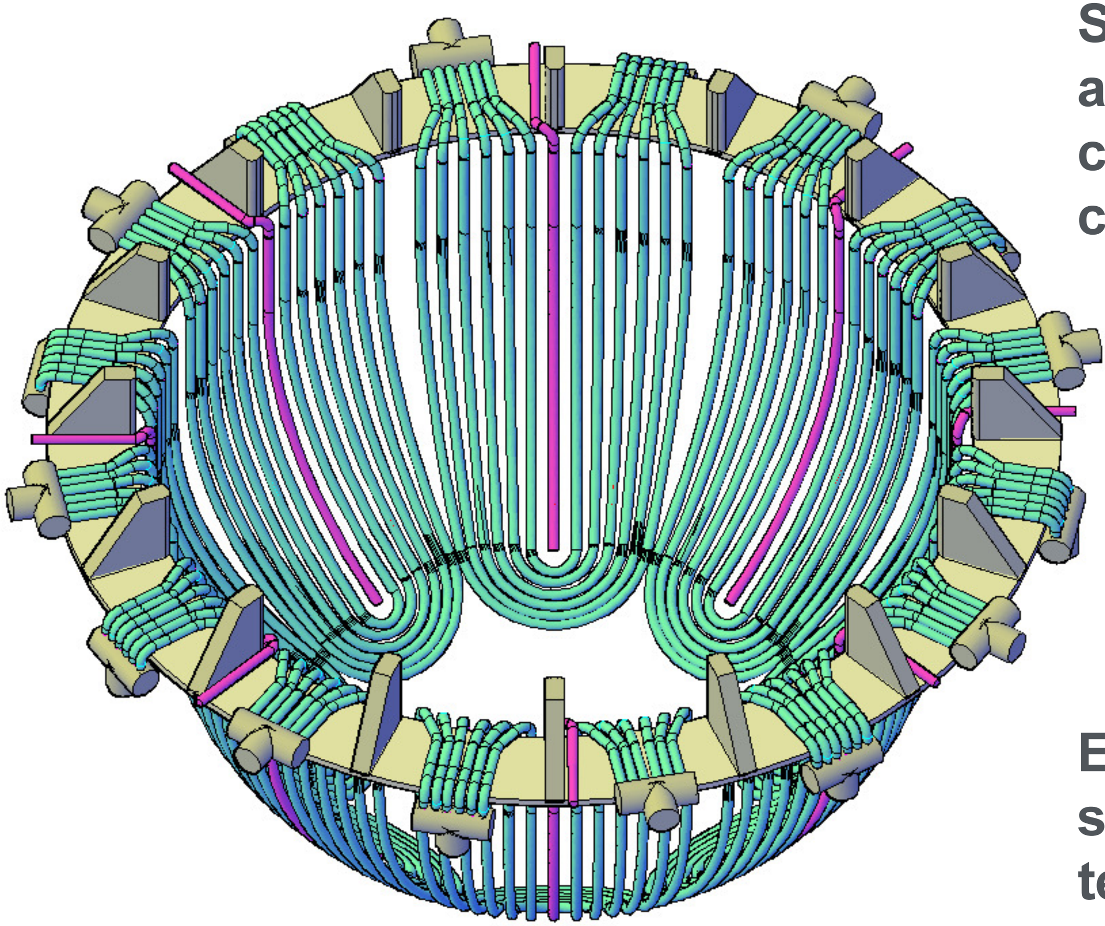






RVACS

RVACS - Long term cooling



Reactor Vessel Air Cooling System connected to an inlet air collector and an outlet chimney to promote natural circulation.

Expected performance of the system:2 MW with a Vessel temperature of 500 °C

MATERIALS

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The design activities performed in the frame of the ELSY project confirmed the attractiveness of a Lead cooled Industrial size fast reactor as well as the system compliance with Generation IV goals

One main issue : MATERIALS

Experience with Pb-Bi shows that it is possible to produce a protective self healing coating on structural steels if the oxygen content of the liquid metal is controlled in a specific range

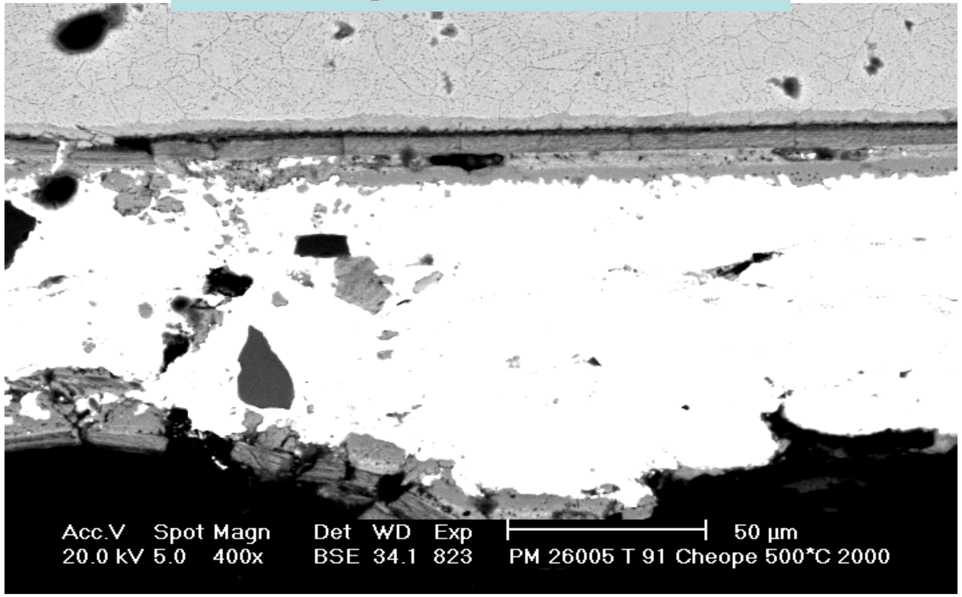
Two main drawbacks:

The active oxygen control system is a delicate device and its applicability to a large commercial reactor requires further R&D

Recent experiments have shown that in pure lead at 500°C, the oxides layer becomes friable

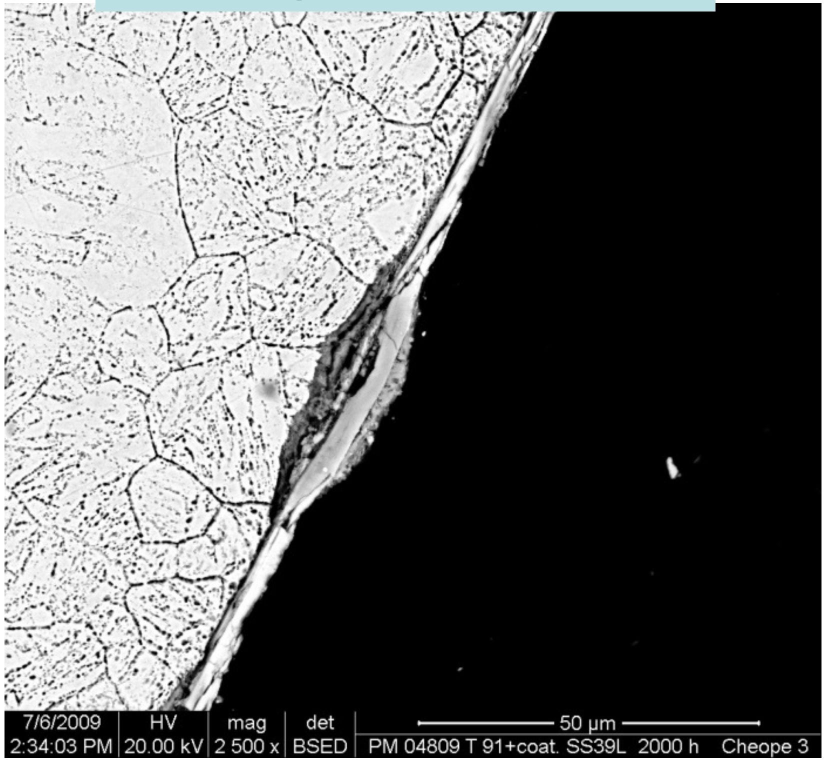
MATERIALS

Flowing Lead at 500 °C



oxide on T91 steel after 10000 hours

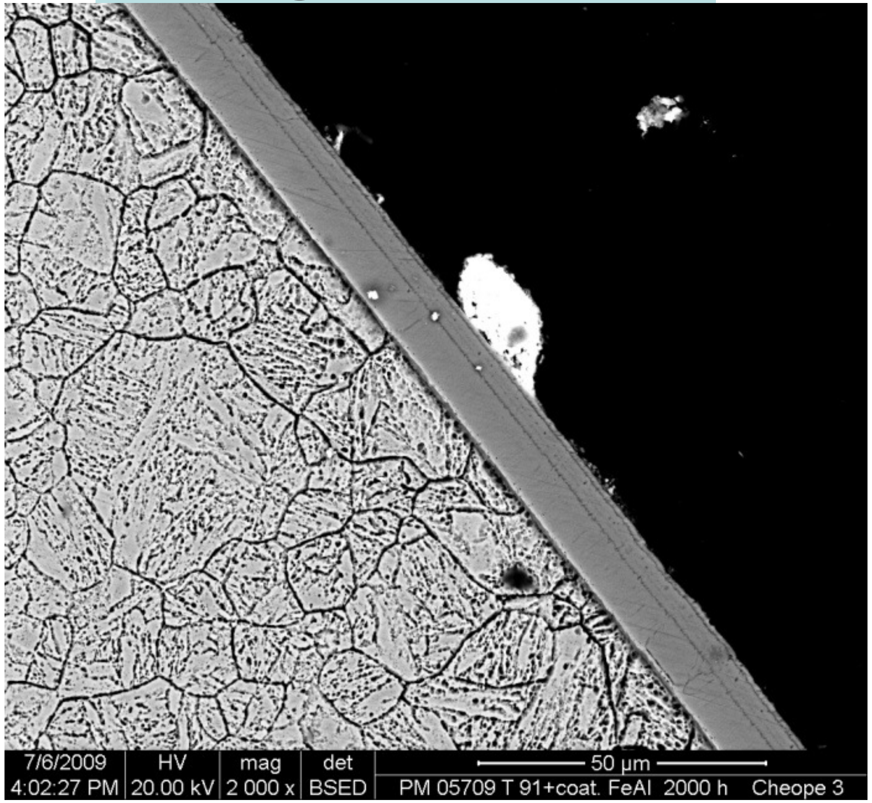
Flowing Lead at 500 °C



SS39L® coating after 2000 hours

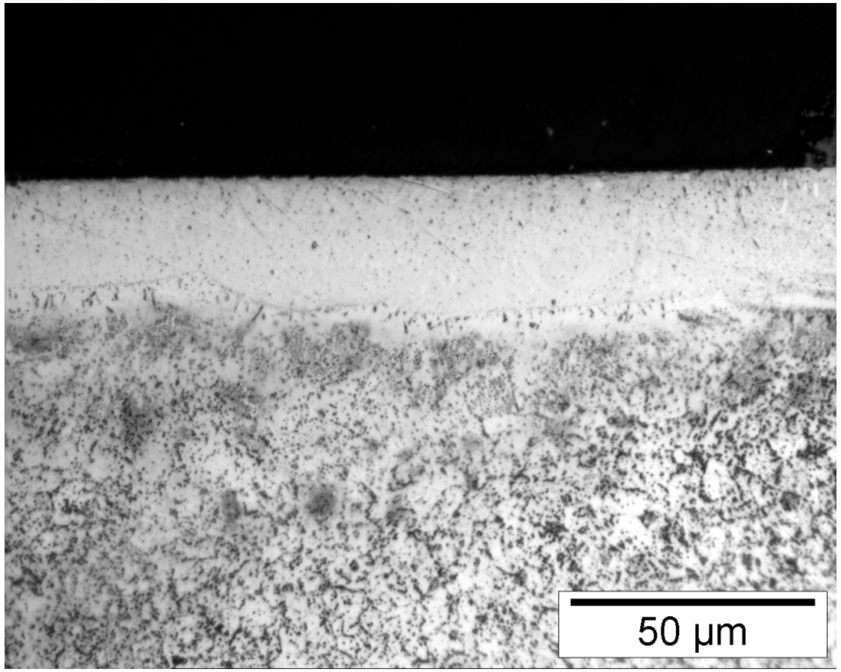
MATERIALS

Flowing Lead at 500 °C



Fe-Al coating after 2000 hours
Developed by TRENTO University

GESA coating - under investigation
Developed by FzK (Karlsruhe)



CONCLUSION ?

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END of ELSY project scheduled for February 2010

On the basis of the achievements of ELSY a new three years project will start in March 2010 (again funded in the frame of EU – 7th FP) with the aim to put another stone on the road of LFR development

LEADER

Lead-cooled European Advanced DEmonstration Reactor

THANKS

FOR YOUR ATTENTION