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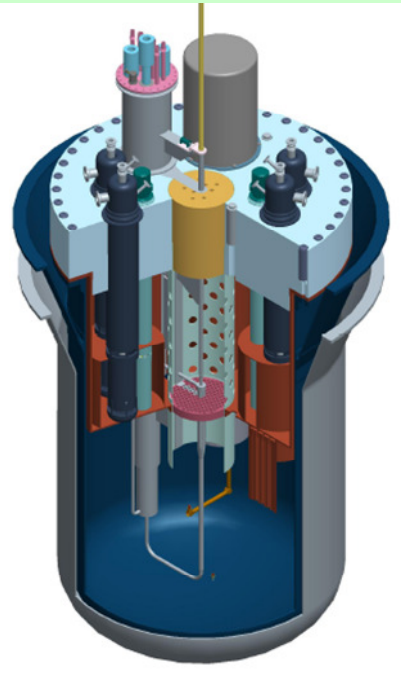
EUROTRANS
- EUROPEAN RESEARCH PROGRAMME FOR THE TRANSMUTATION OF HIGH LEVEL - NUCLEAR WASTE IN AN ACCELARATOR DRIVEN SYSTEM

SIXTH FRAMEWORK PROGRAMME

XT-ADS & EFIT:
Two machines not so different for the same goal



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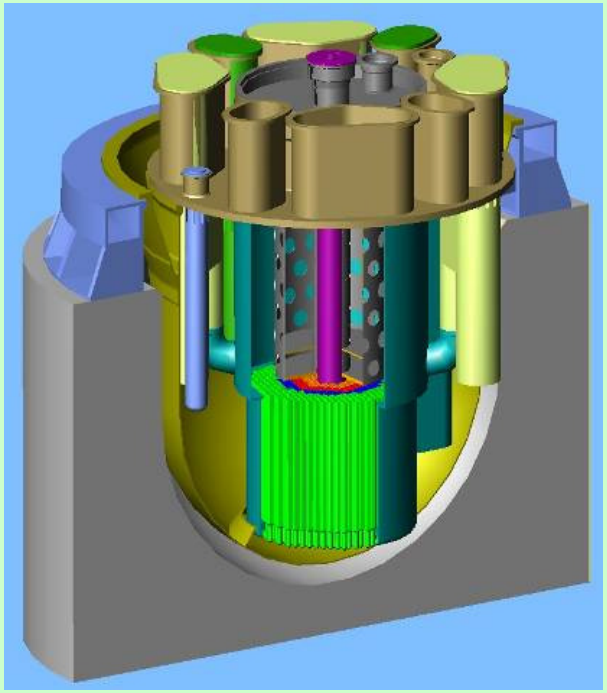

IP-EUROTRANS Main Objectives

Demonstration of the technical feasibility of transmutation using an Accelerator Driven System (ADS)

- Carry out a first advanced design of a 50 to 100 MWth eXperimental facility (realization in a short-term, say about 10 years) demonstrating the technical feasibility of Transmutation in an Accelerator Driven System (**XT-ADS**)
  - XT-ADS has the double role of an **irradiation facility** (high fast flux level in the order of 10^{15} n/cm^2 s) and of an **ADS technology demonstrator**
- Accomplish a generic conceptual design (several 100 MWth) of the European Facility for Industrial Transmutation **EFIT** (realization in the long-term)

Common characteristics to EFIT and XT-ADS (1/2)

- Accelerator
  - ✓ Superconducting ***LINAC*** CW modular Accelerator
  - ✓ Proton Beam injection from the ***top*** of the Vessel
  - ✓ ***Windowless*** Target Type
  - ✓ High ***Reliability*** and ***Availability*** (Spurious Beam Trip < 5/y; continuous operation for < 1 s beam interruptions)
  - ✓ 200μs holes for sub-criticality measurements
- Core
  - ✓ Use of ***fuel pin spacer***, ***wrapper-type*** and ***hexagonal*** fuel assembly
  - ✓ ***Sub-critical by design*** in all operating, accidental and abnormal conditions (no control rods: ineffective for a core sustained by external neutron source)
  - ✓ Possibility to load fuel assemblies with **MA** in selected XT-ADS portions reproducing EFIT irradiation conditions

Common characteristics to EFIT and XT-ADS (2/2)

- Reactor Vessel
  - ✓ Primary system ***integrated*** in the vessel (all components removable from the top for ISI, maintenance and replacement)
  - ✓ Primary coolant circulation is ***forced*** in normal conditions (with mechanical pumps) and is ***natural*** in decay heat removal conditions
  - ✓ Reactor vessel structural material ***316L*** steel
  - ✓ ***Hanged vessel*** and similar vessel support (EFIT has horizontal anti-seismic supports; XT-ADS benefits of Mol soil)
- Heavy Liquid Metal Technology
  - ✓ HLM technology experimental results are in principle ***applicable to LBE and Lead***
- Fuel Handling Outside Reactor Vessel
  - ✓ Rely on ***remote handling***

Different Options between EFIT and XT-ADS

- Accelerator Proton Energy
  - XT-ADS: 600 MeV x 3 mA
  - EFIT: 800 MeV x 20 mA
- Spallation target
  - XT-ADS: LBE confluent flow, off-centred
  - EFIT: Lead perpendicular (horizontal) flow, centred
- Fuel Type and Power Density
  - XT-ADS: MOX; 700 W/cm^3
  - EFIT: U-free: (Pu, AM)O2 + MgO (or Mo) matrix; 450 ÷ 650 W/cm^3
- Primary Coolant and operating temperature
  - XT-ADS: LBE (inlet T: 300°C, outlet T: 400°C)
  - EFIT: Lead (inlet T: 400°C, outlet T: 480°C)
- Fuel Core Loading
  - XT-ADS: from bottom with horizontal fixed handling arm machine
  - EFIT: from top with extendible handling arm machine
- Secondary System
  - XT-ADS: low pressure boiling water
  - EFIT: Superheated water cycle (Electricity production)
- Decay Heat Removal
  - XT-ADS: DHR N°1: portion of secondary system in natural circulation;
DHR N°2: RVACS fully passive
  - EFIT: DHR N°1: Isolation Condenser on secondary system;
DHR N°2: dedicate system in the reactor vessel fully passive

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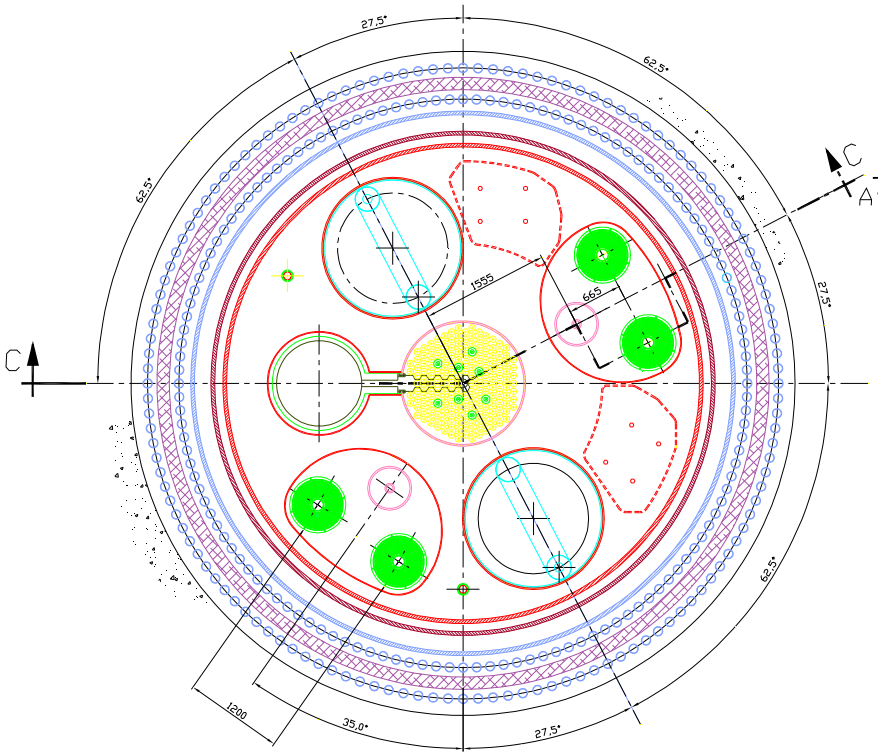
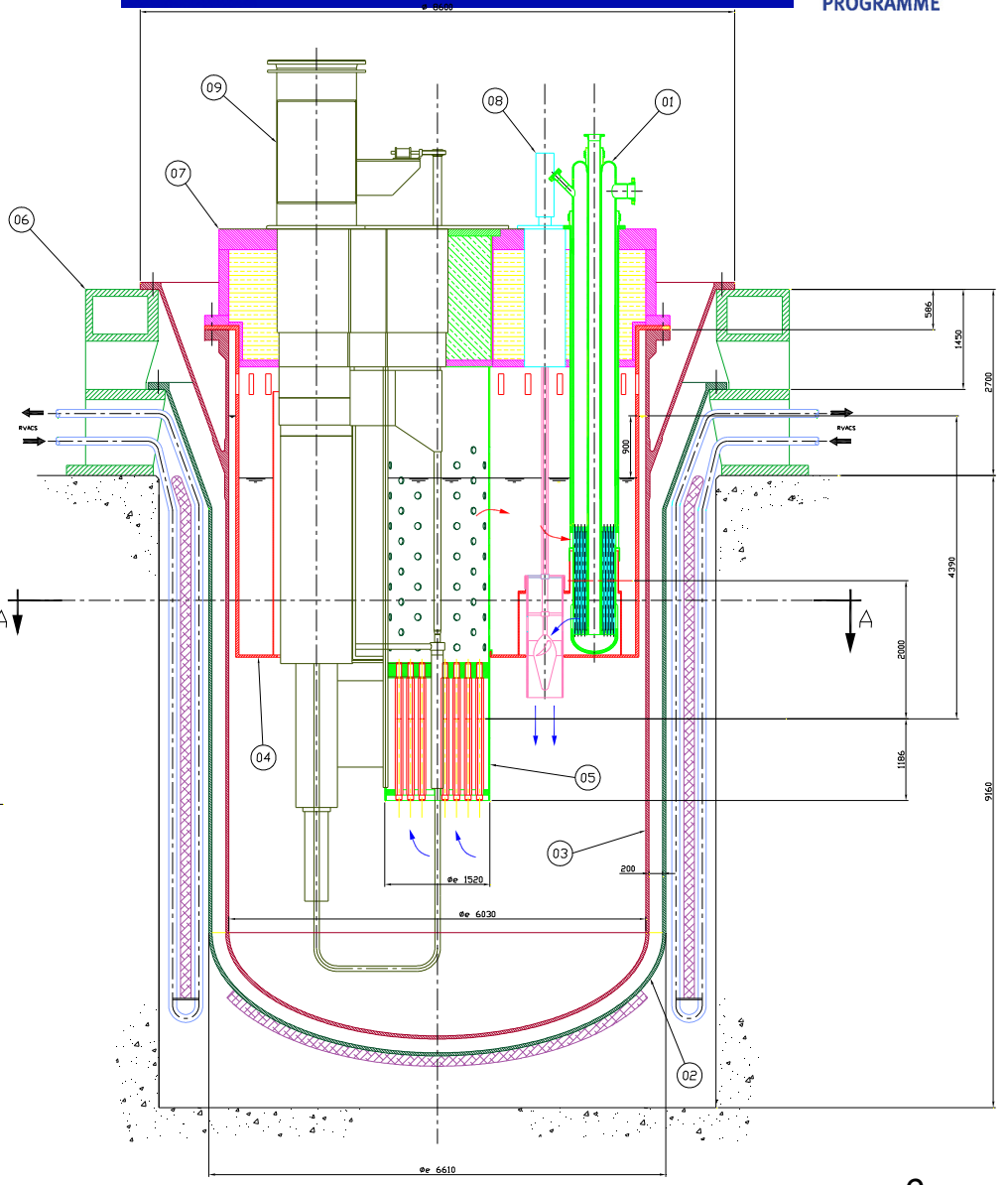
SIXTH FRAMEWORK PROGRAMME

XT-ADS Reactor Assembly

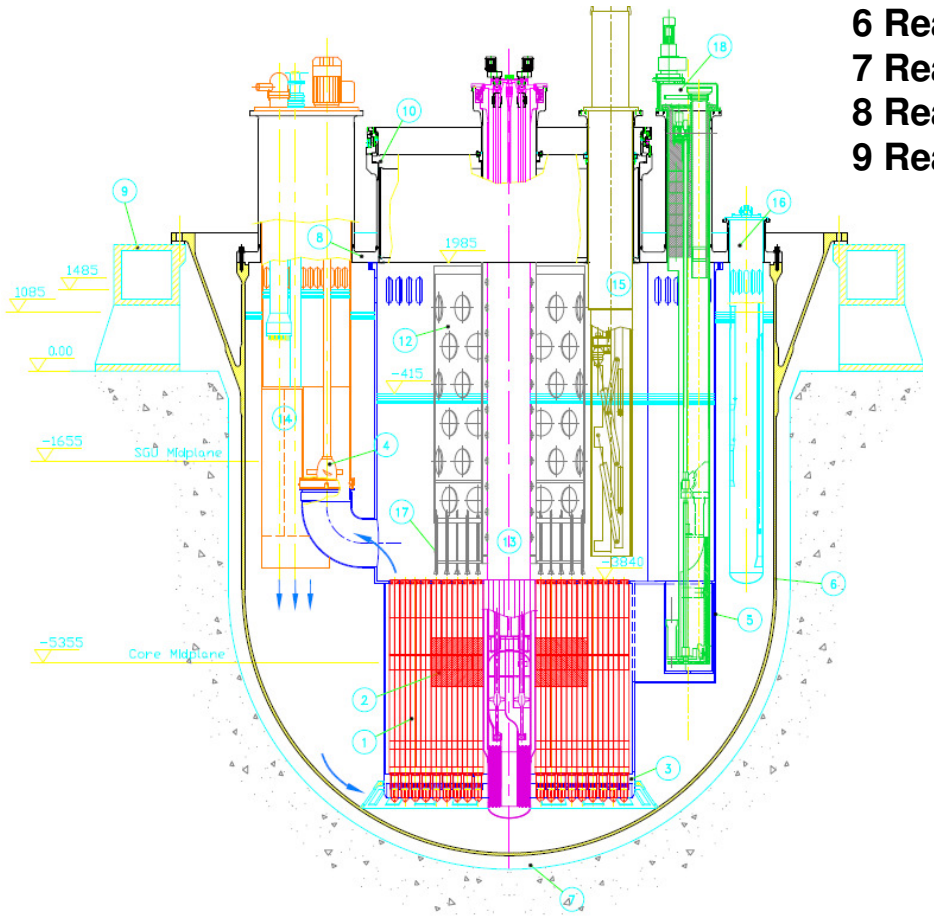
1. PHX (2X2)
2. Safety Vessel
3. Reactor Vessel
4. Inner Vessel
5. Core Barrel
6. Support
7. Reactor Cover
8. Primary Pumps (2X1)
9. Spallation loop

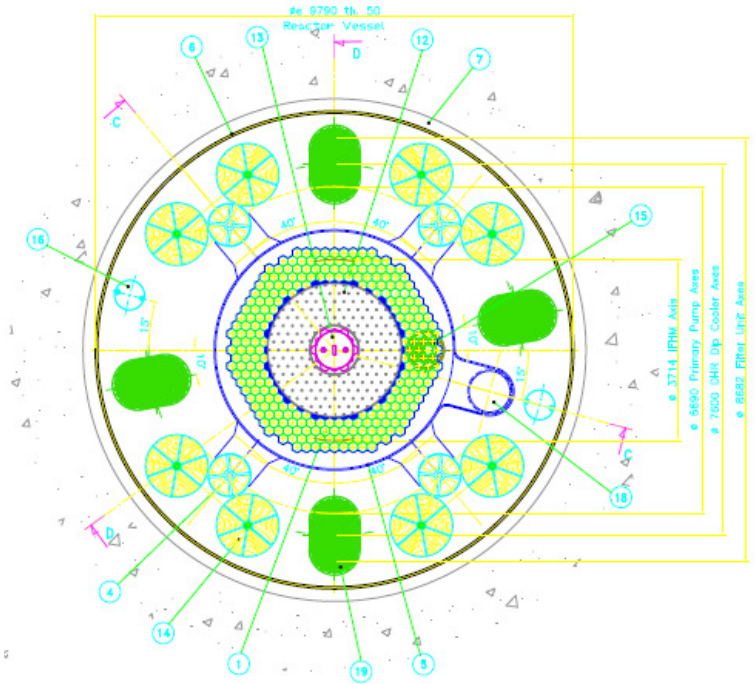




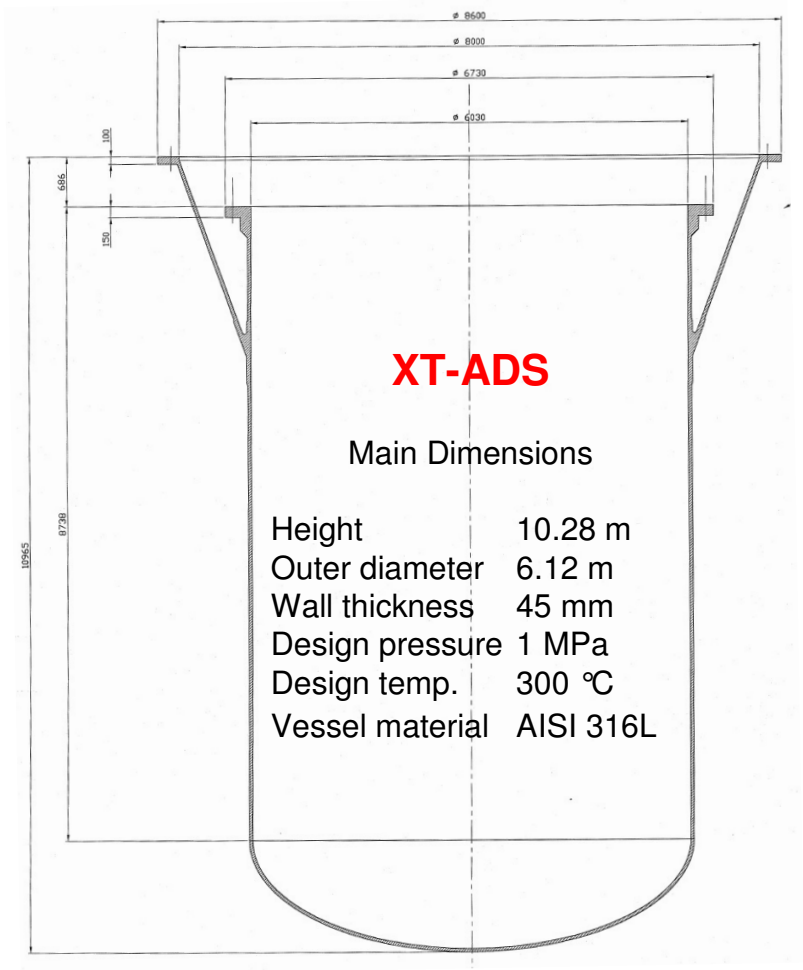
EFIT Reactor Assembly

1 Reactor Core
2 Active Zone
3 Diagrid
4 Primary Pump
5 Cylindrical Inner Vessel
6 Reactor Vessel
7 Reactor Cavity
8 Reactor Roof
9 Reactor Vessel Support
10 Rotating Plug
12 Above Core Structure
13 Target Unit
14 Steam Generator Unit
15 Fuel Handling Machine
16 Filter Unit
17 Core Instrumentation
18 Rotor Lift Machine
19 DHR Dip Cooler





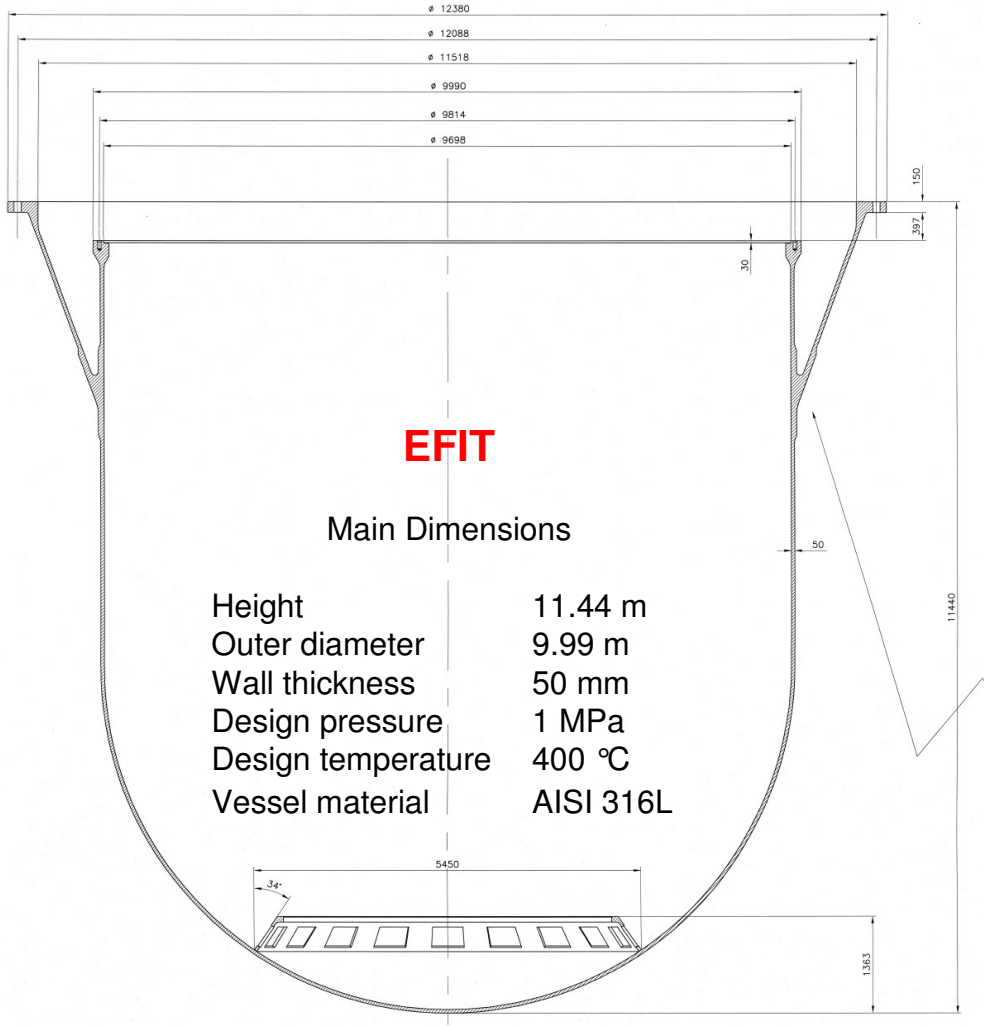
Reactor Vessels



XT-ADS

Main Dimensions

Height	10.28 m
Outer diameter	6.12 m
Wall thickness	45 mm
Design pressure	1 MPa
Design temp.	300 °C
Vessel material	AISI 316L



EFIT

Main Dimensions

Height	11.44 m
Outer diameter	9.99 m
Wall thickness	50 mm
Design pressure	1 MPa
Design temperature	400 °C
Vessel material	AISI 316L

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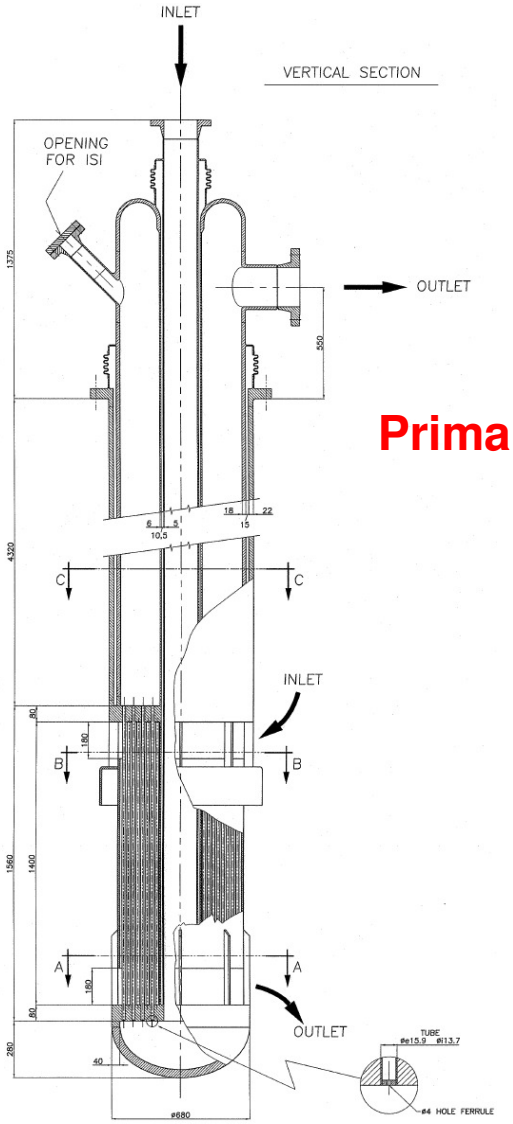
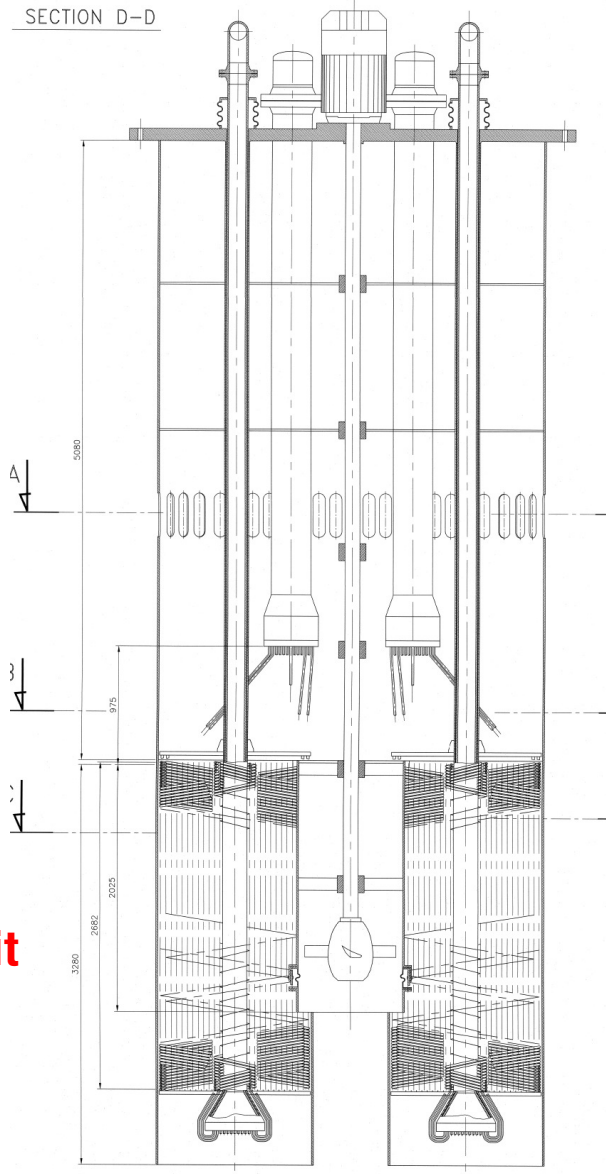
SIXTH FRAMEWORK PROGRAMME



XT-ADS
Primary Heat Exchanger
Material T91

EFIT
Steam Generator Unit
Material T91



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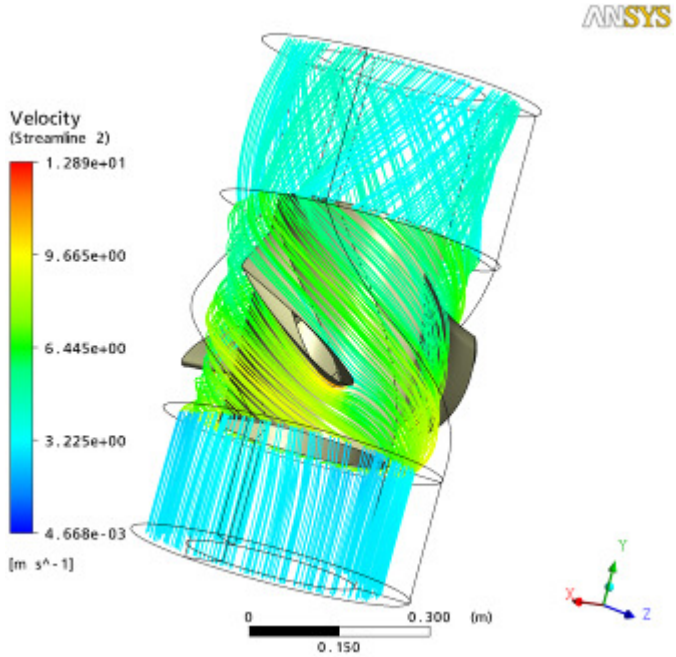
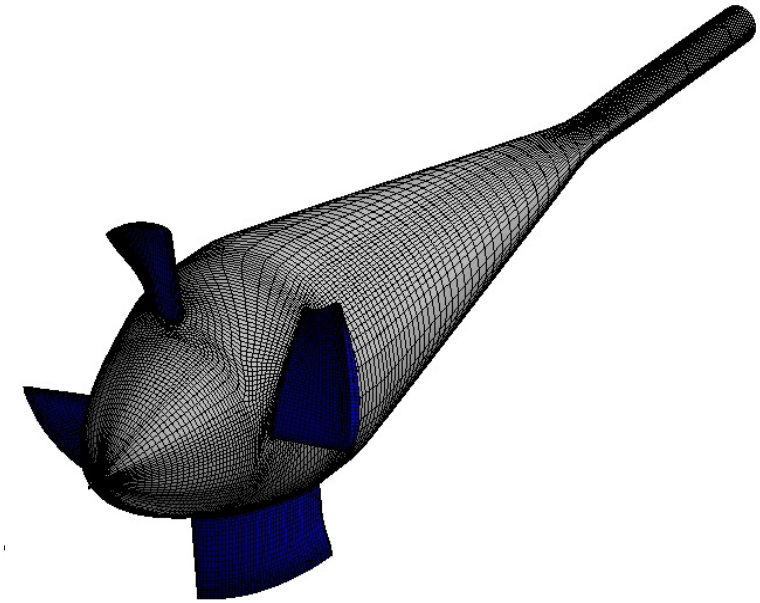
SIXTH FRAMEWORK PROGRAMME

XT-ADS Primary Pumps EFIT

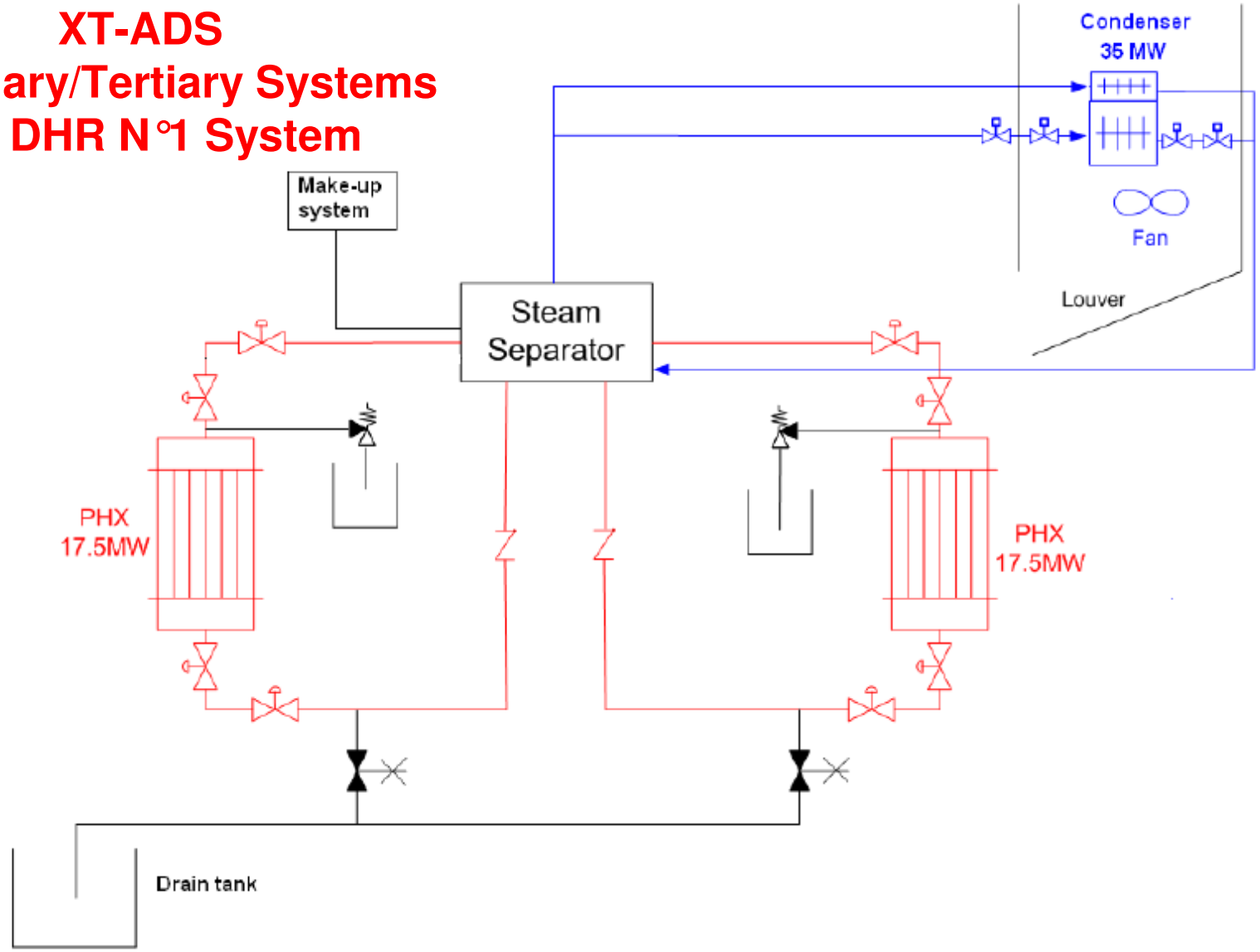
Impeller speed	350 rpm
Outside diameter	0.48 m
Hub ratio	0.604
Number of vanes	3
Vane profile	NACA23012
Velocity in suction pipe	1.9 m/s
Meridian velocity	2.95 m/s
Max velocity relative to the vane	9.1 m/s
Material	MAXTHAL

Impeller Speed	200 rpm
Outside diameter	0.85 m
Hub ratio	0.67
Number of vanes	4
Vane profile	NACA23012
Velocity in suction pipe	1.6 m/s
Meridian velocity	2.75 m/s
Max velocity relative to the vane	9.4 m/s
Material	MASTHAL





XT-ADS
Secondary/Tertiary Systems and DHR N°1 System



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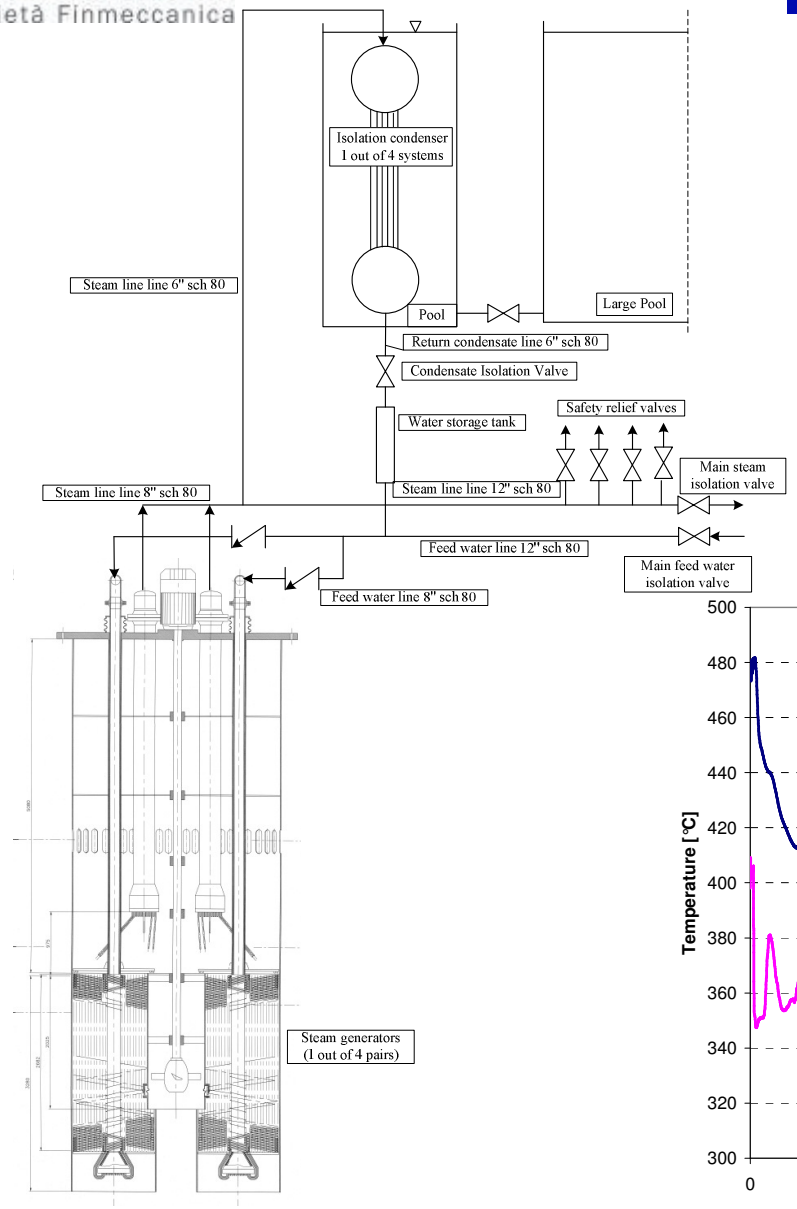
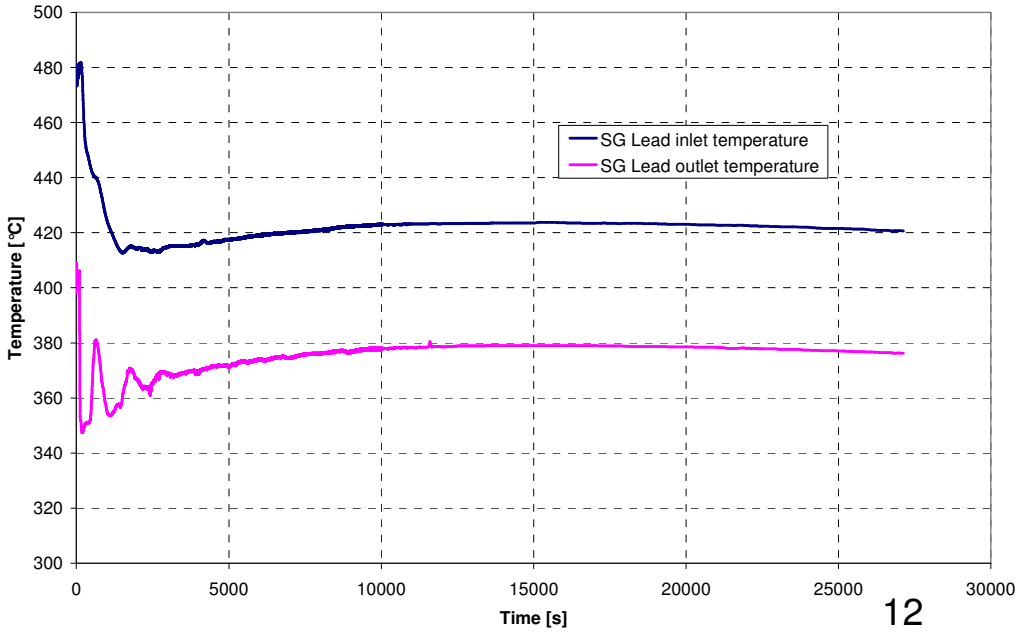
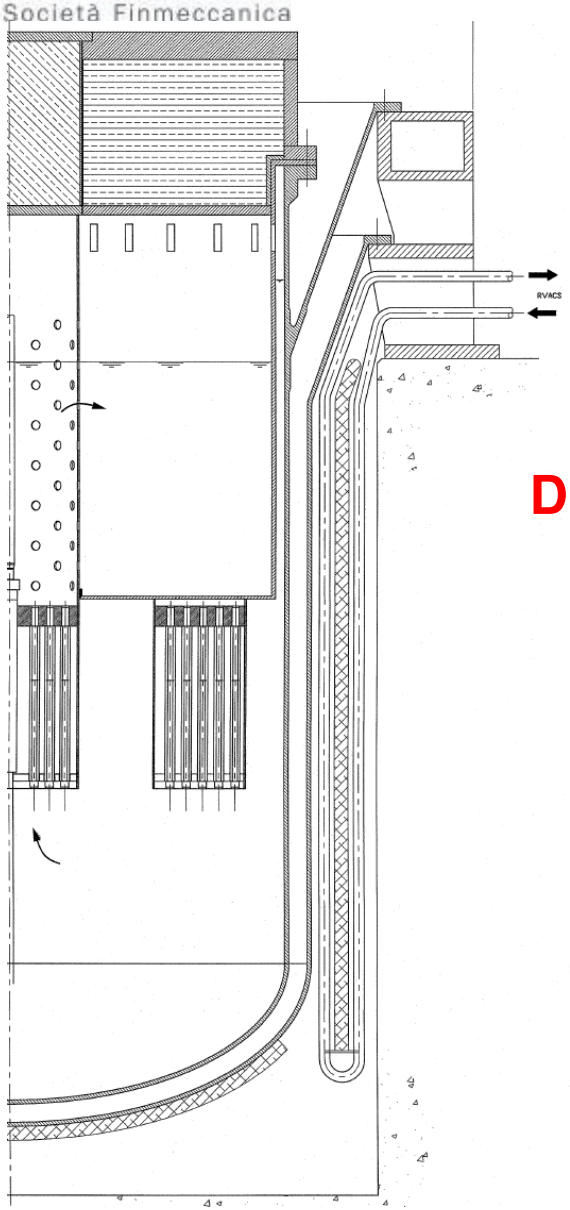
SIXTH FRAMEWORK PROGRAMME

EFIT
DHR N°1 System

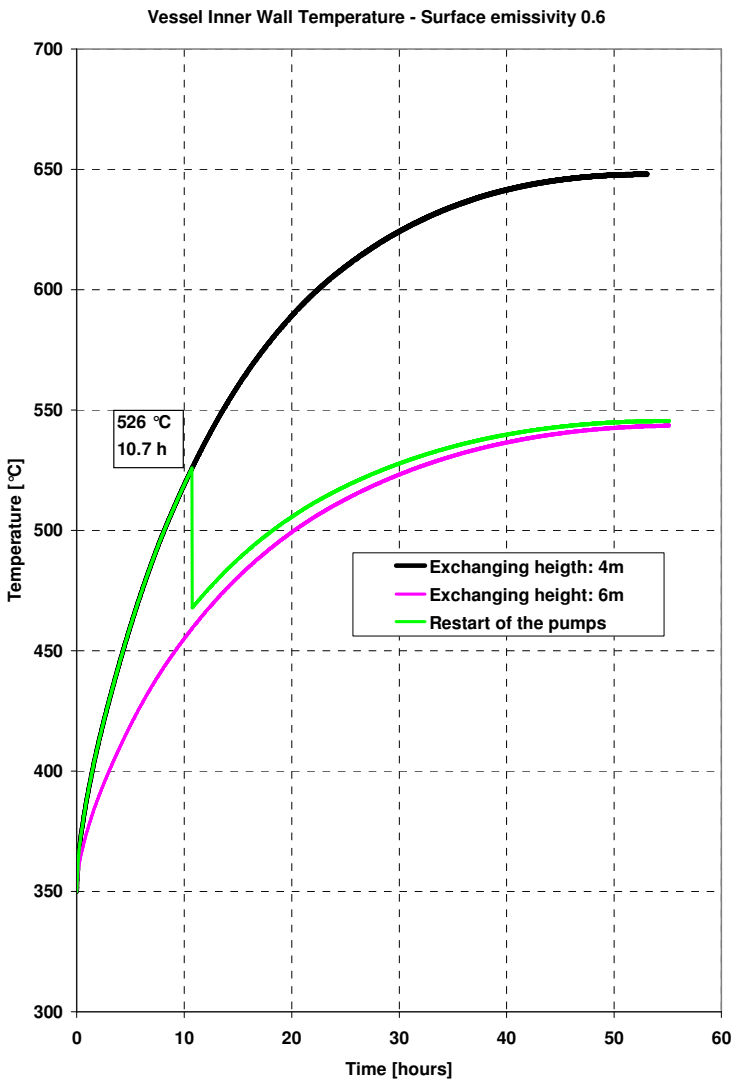




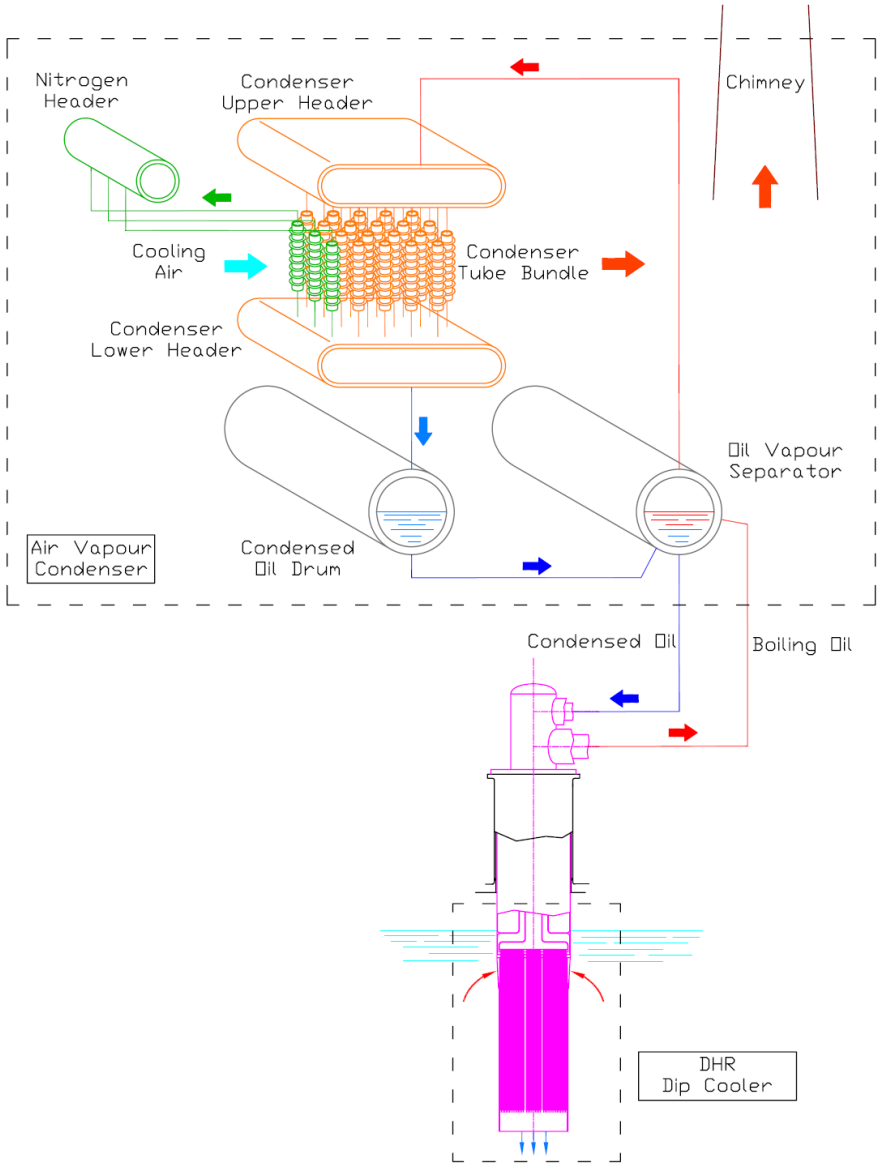


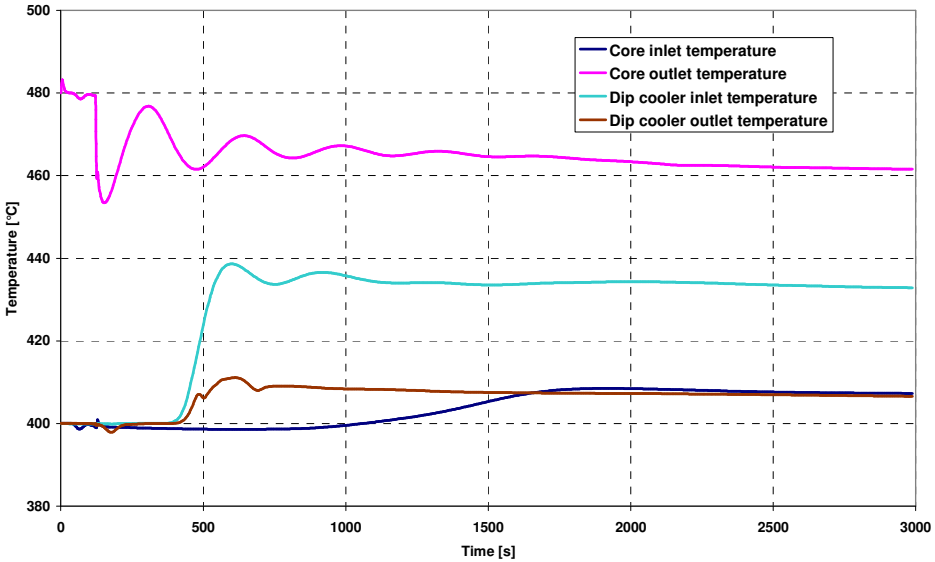
XT-ADS

DHR N°2 RVACS

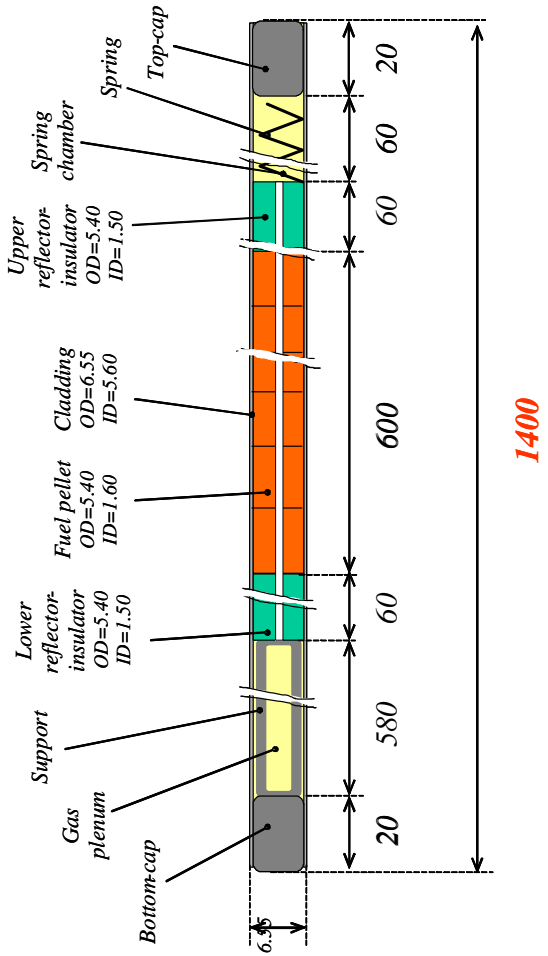


EFIT
DHR N°2 System

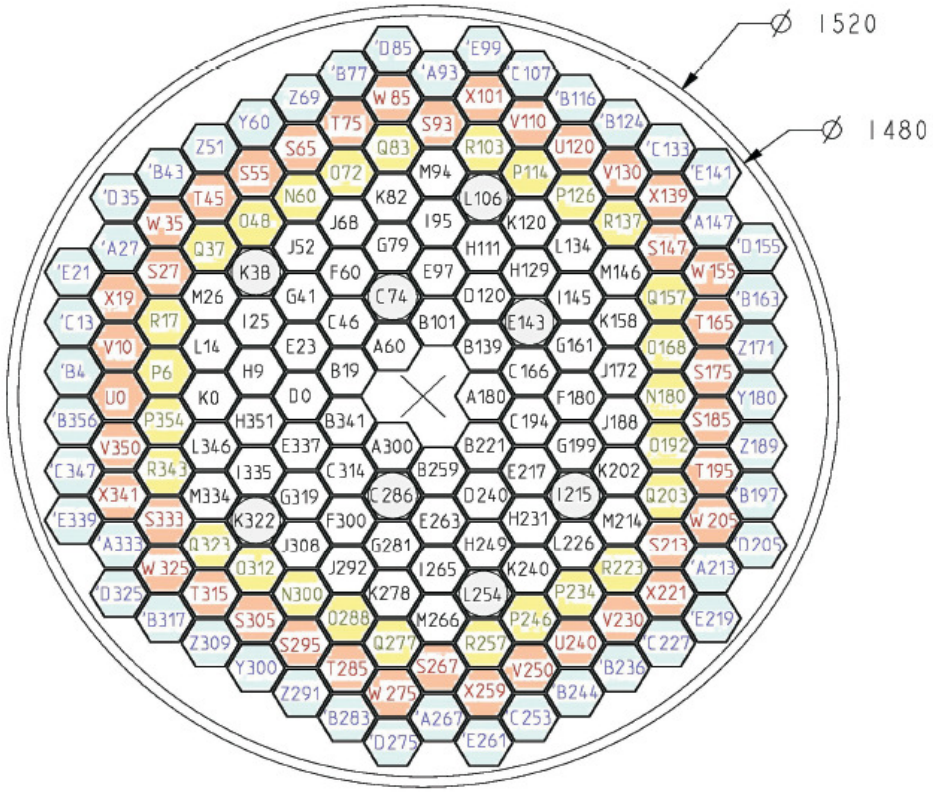




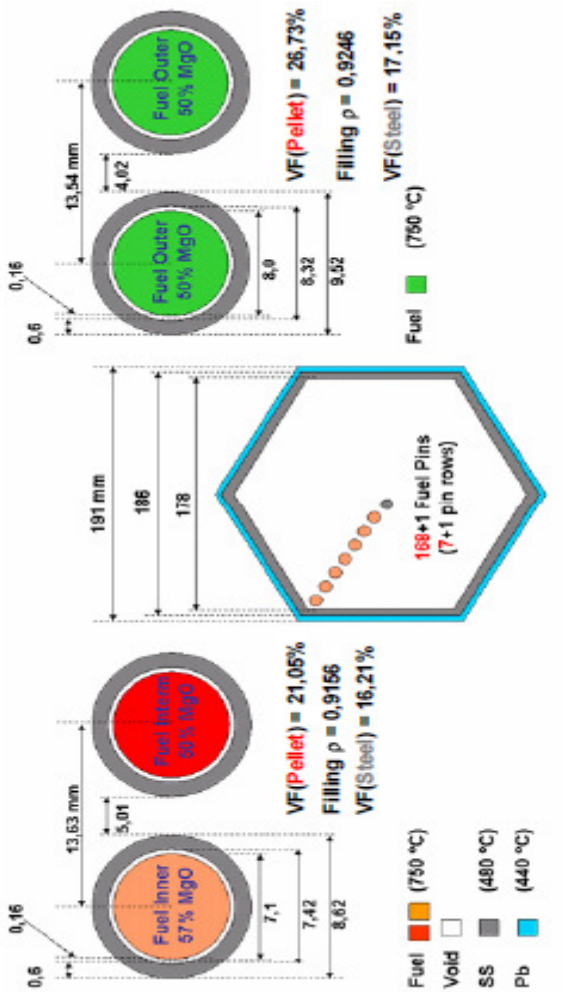
XT-ADS Fuel Pin & Core Section



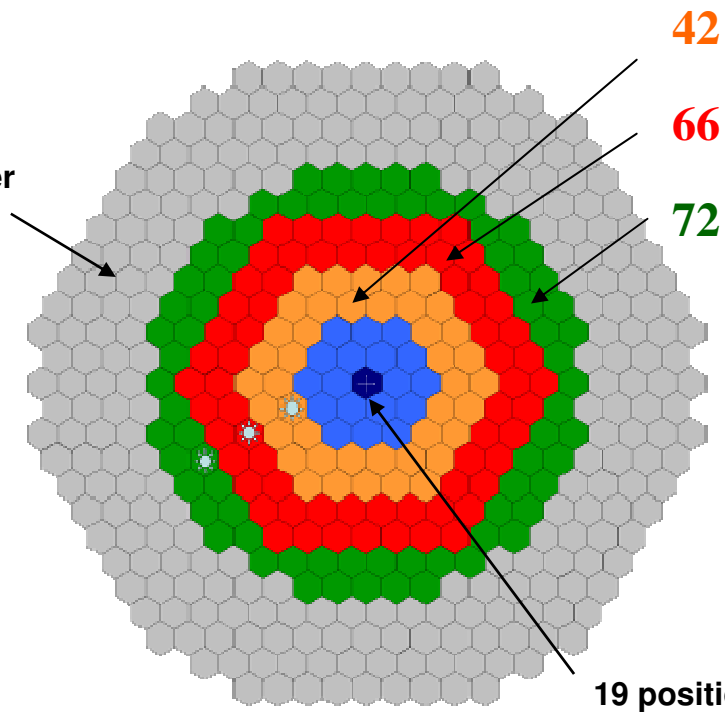
72 Fuel Assemblies
99 Dummy/Shielding Assemblies
8 IPS (L106; C74; E143; K38; I 215; C286; K322; L254)
2 Radio-isotopes production (O72; O288)
2 LLFP irradiations (R137; R223)



EFIT Core Section
Inner, Intermediate, Outer Fuel Pin&FA



252 position for Dummy Assemblies and Absorber Elements



42 FA

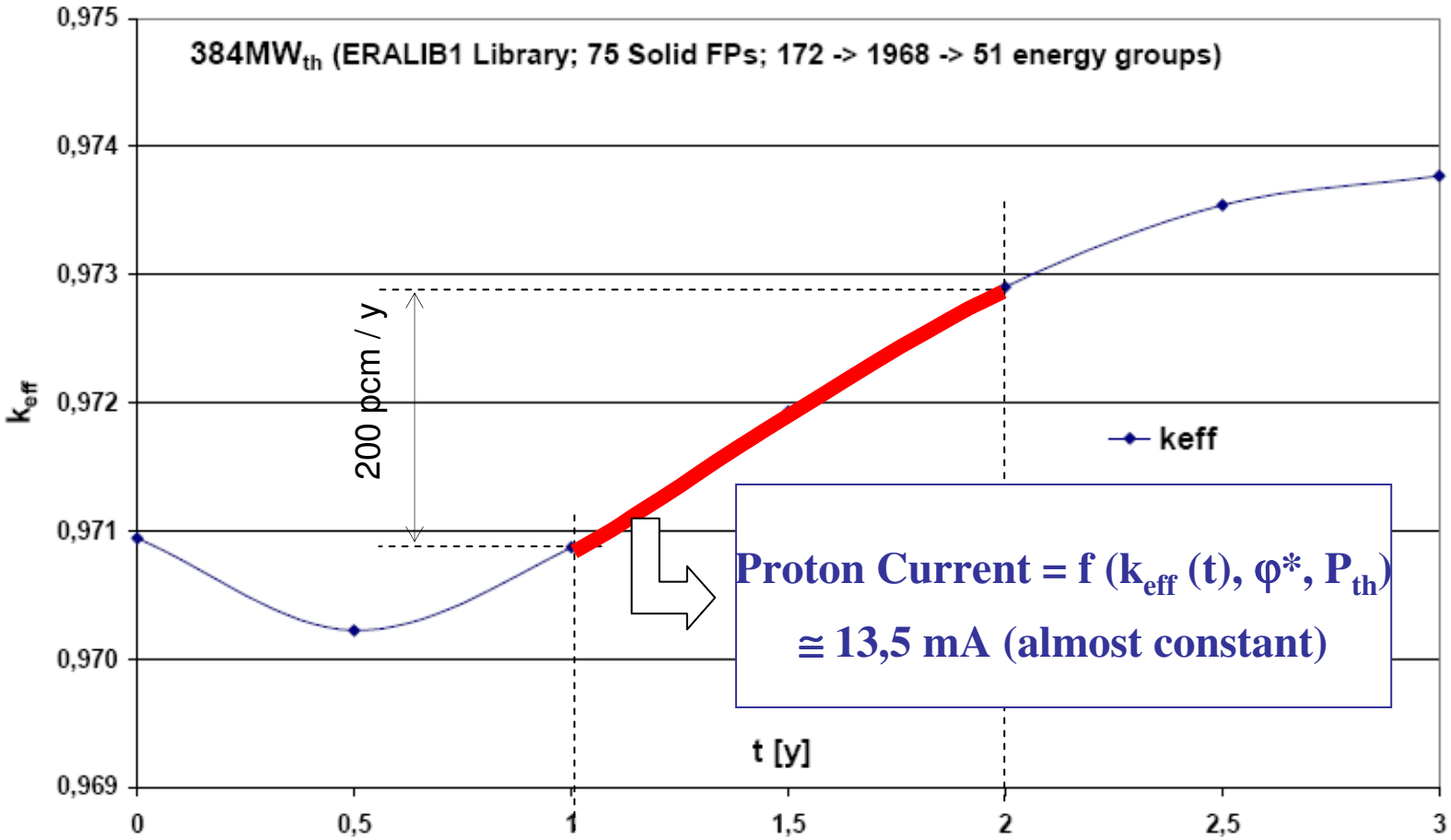
66 FA

72 FA

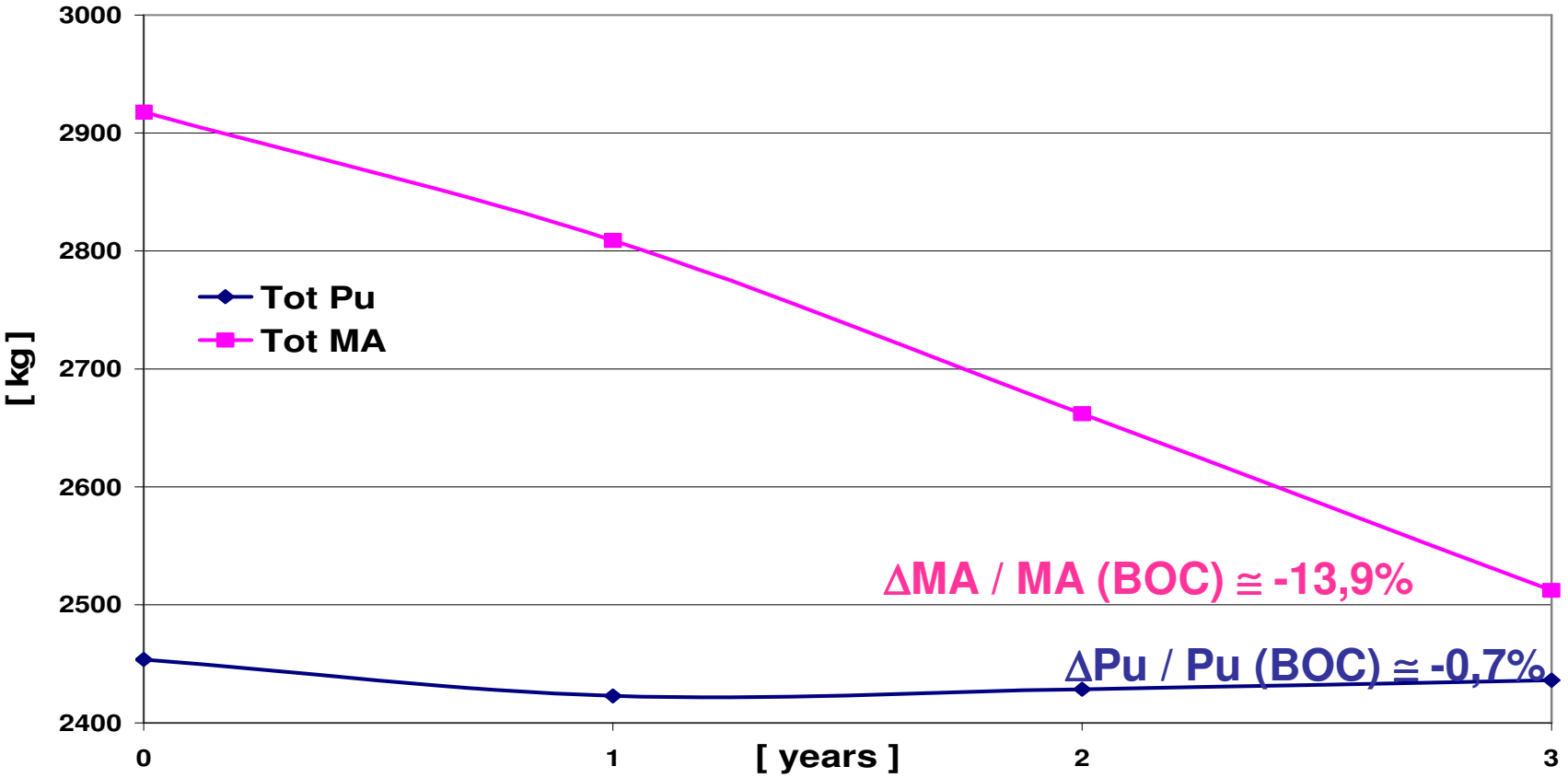
19 position for Target

Target | Fuel_1_Inner | Fuel_2_Intermediate | Fuel_3_Outer | Box Dummy | Hot FA per zone

EFIT k_{eff} Behavior



EFIT MA and Pu Balances



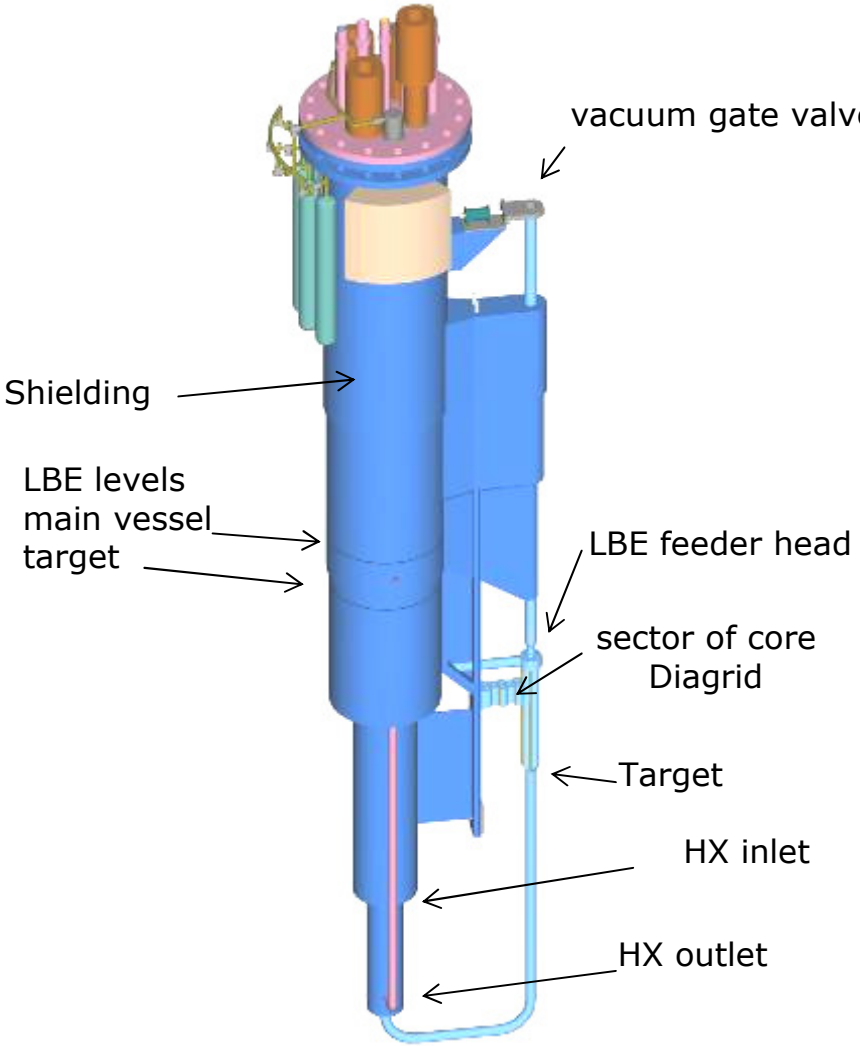
3 years

- $\overline{BU}$ = 78,28 MWd / kg (HM)
- Total E = 10,0915 TWh_{th}

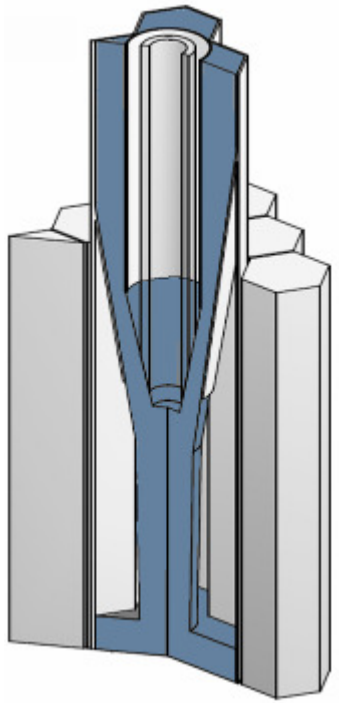
BU →

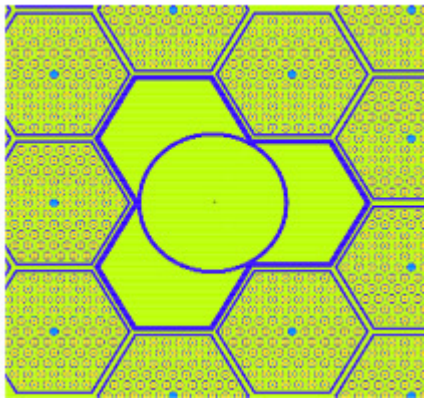
- -40,17 kg (MA) / TWh
- -1,74 kg (Pu) / TWh

XT-ADS Spallation loop

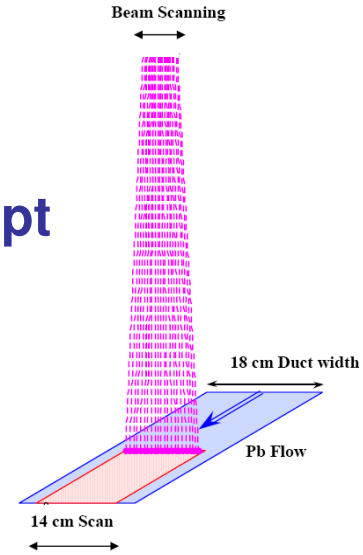


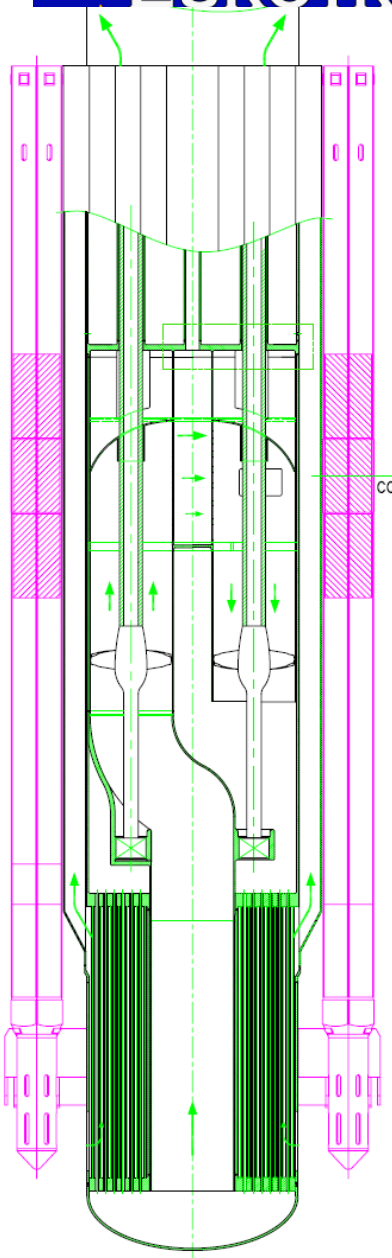
Spallation Target





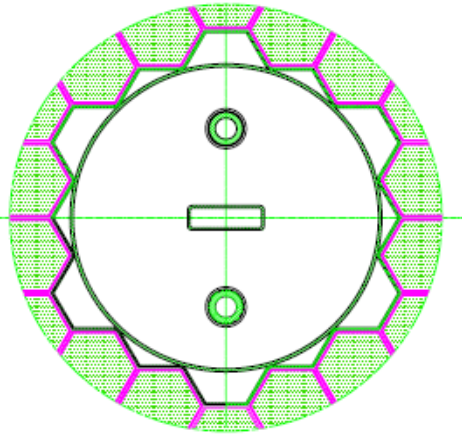
EFIT Target Unit: Windowless Concept

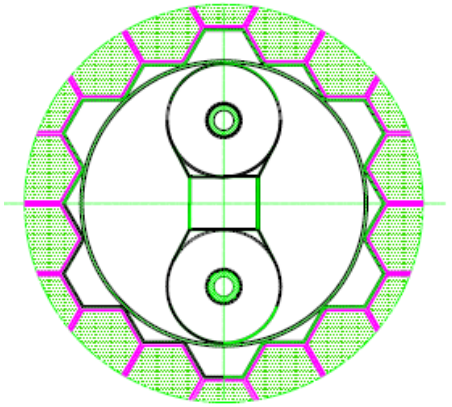




FA positions occupied 19

Outside diameter 78.2 cm





Main data

Proton Beam Energy, MeV	800
Max proton beam current, mA	20
Proton beam energy deposited, MW	11.2
Primary Pb Coolant inlet Temp. (°C)	400
Primary Pb Coolant outlet Temp. (°C)	450
Primary Pb d Coolant Flow-rate (kg/s)	1500
Target Pb Coolant Cold Temp. (°C)	419
Target Pb Coolant Hot Temp. (°C)	515
Target Pb Coolant Flow-rate (kg/s)	800

Conclusions

- EFIT and XT-ADS are two machine conceived for the same goal in a different time frame
- The first major step in the development of the ADS is the construction and full operation of an XT-ADS Facility (within 2020)
- XT-ADS will serve as a test-bed for:
  - ✓ Component qualification for EFIT and LFR
  - ✓ Demonstration of efficient transmutation in ADS based on MA bearing inert fuels
  - ✓ Study of material and fuel behavior in support of fast spectrum technologies (LFR, SFR,GFR)
- A prototype for industrial transmutation EFIT can be designed in detail, constructed and put into operation by 2035÷2040