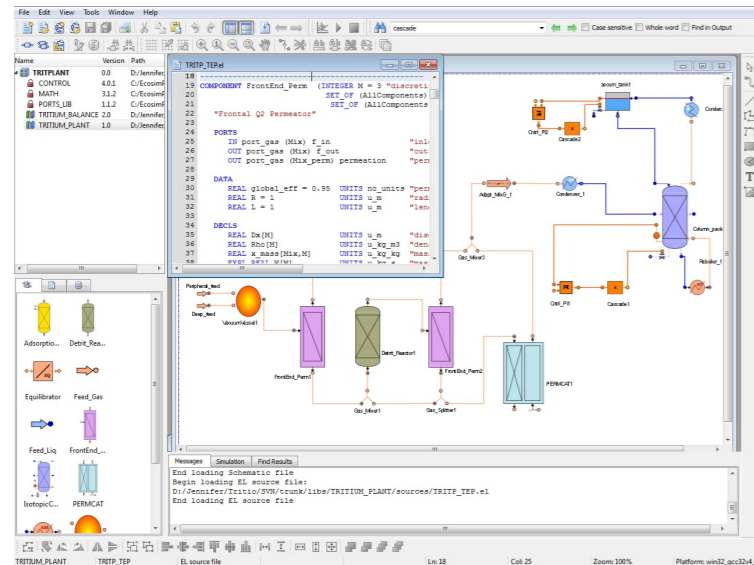


## What is EcosimPro?

EcosimPro is a software tool for modeling and simulating multidisciplinary continuous and discrete systems. It incorporates an object-oriented programming language, a powerful DAE solver and a friendly Graphic User Interface.



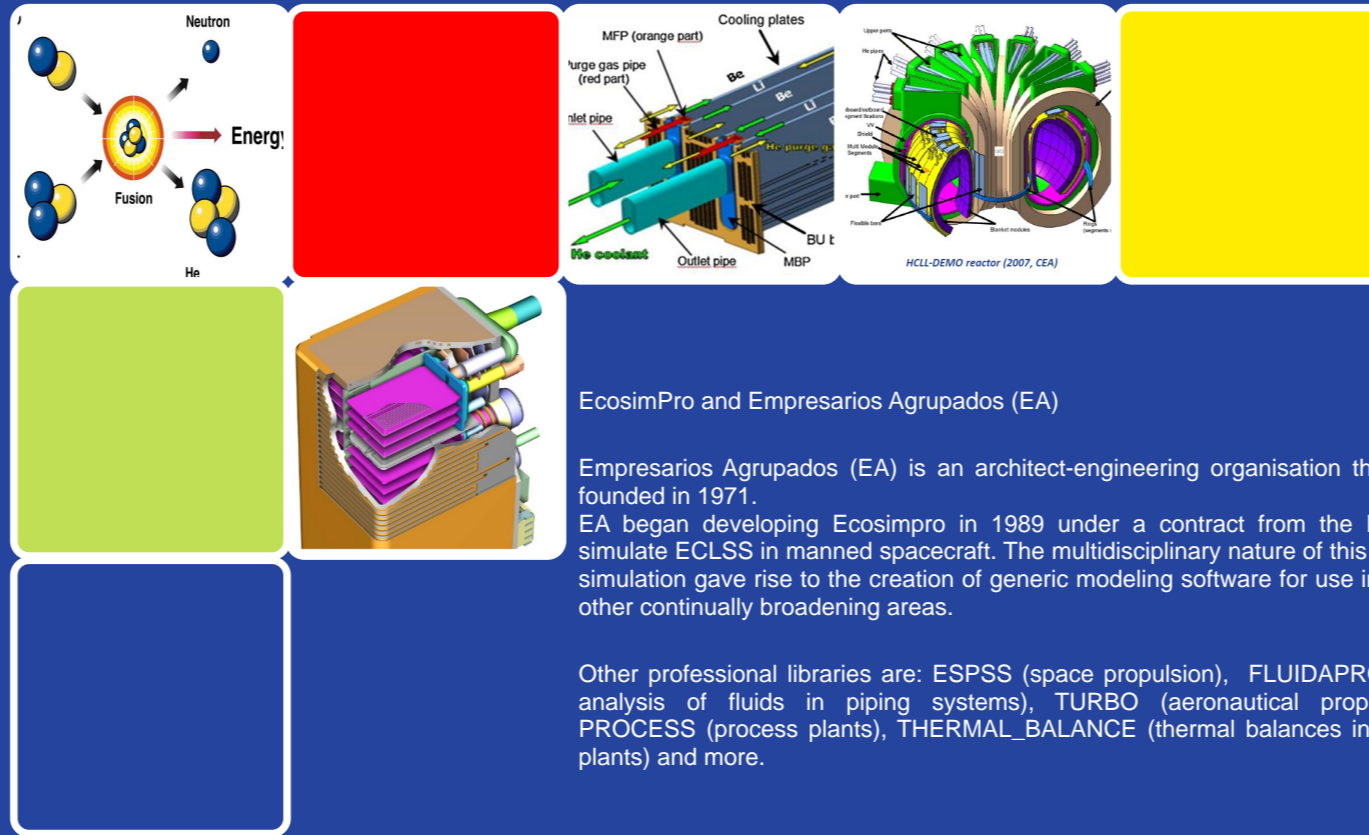
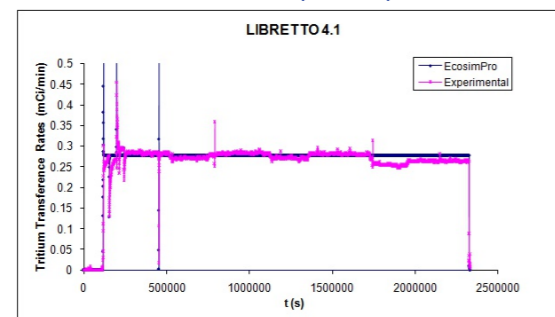
EcosimPro is designed so that components can be reused in many different systems without having to be reprogrammed. It provides a highly intuitive environment that enables the user to easily display simulation schematic diagrams and carry out both transient and steady state studies. One of the main characteristics of EcosimPro is the possibility to modify the existing components due to the fact that the libraries can be delivered with the source code.

EcosimPro excels in connectivity with others tools (Excel, Matlab-Simulink, C++, optimization routines). Results from other simulations can be accessed in several ways: through C/C++/Fortran functions, tables reading, result file reading.

### TRITIUM\_LIBS Validation

The TRITIUM\_LIBS libraries have been validated by means of the comparison of results of theoretical cases with the Tritium Migration Analysis Program (TMAP), a reference tool for the simulation of tritium transport.

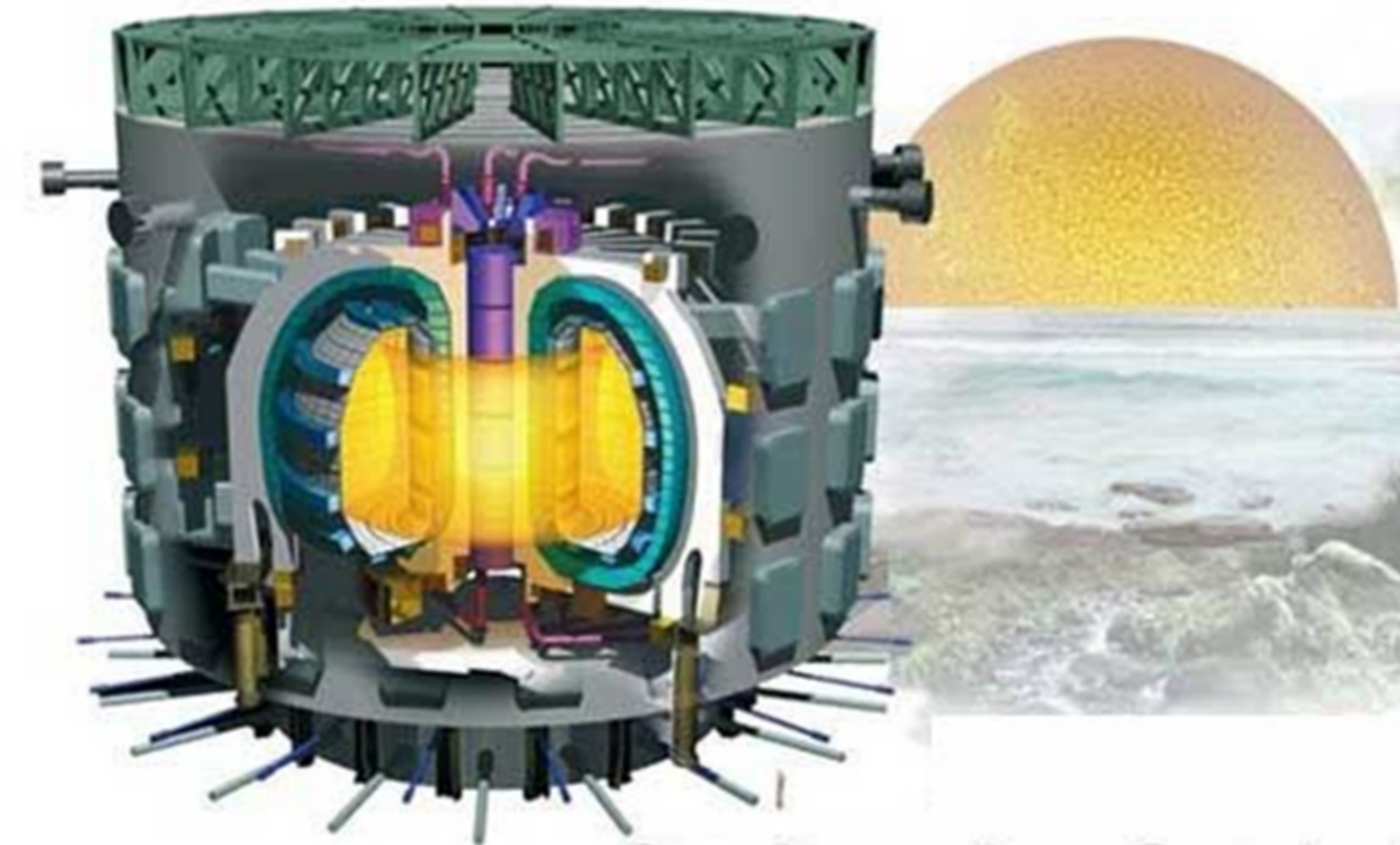
Validations have also been carried out in comparison with experimental results (LIBRETTO 4, Liquid Breeder Experiment with Tritium Transport Option).



### EcosimPro and Empresarios Agrupados (EA)

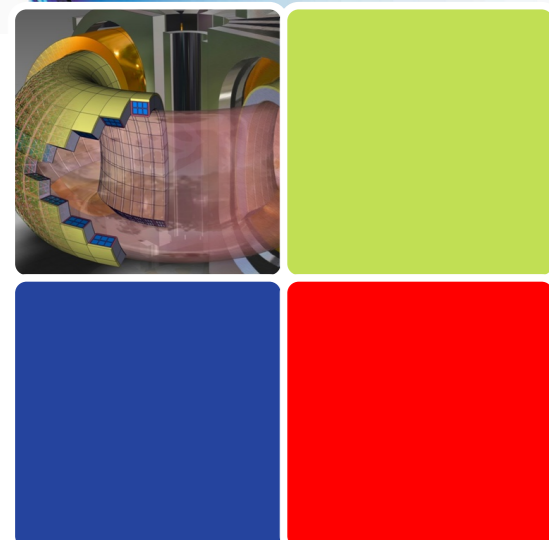
Empresarios Agrupados (EA) is an architect-engineering organisation that was founded in 1971. EA began developing Ecosimpro in 1989 under a contract from the ESA to simulate ECLSS in manned spacecraft. The multidisciplinary nature of this type of simulation gave rise to the creation of generic modeling software for use in many other continually broadening areas.

Other professional libraries are: ESPSS (space propulsion), FLUIDAPRO (flow analysis of fluids in piping systems), TURBO (aeronautical propulsion), PROCESS (process plants), THERMAL\_BALANCE (thermal balances in power plants) and more.



# Tritium Transport Libraries

A set of professional libraries, based on EcosimPro, for modelling dynamic transport phenomena of hydrogen



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**EcosimPro**  
Modelling and Simulation Software



**EcosimPro**  
Modelling and Simulation Software

# Tritium Simulation Platform

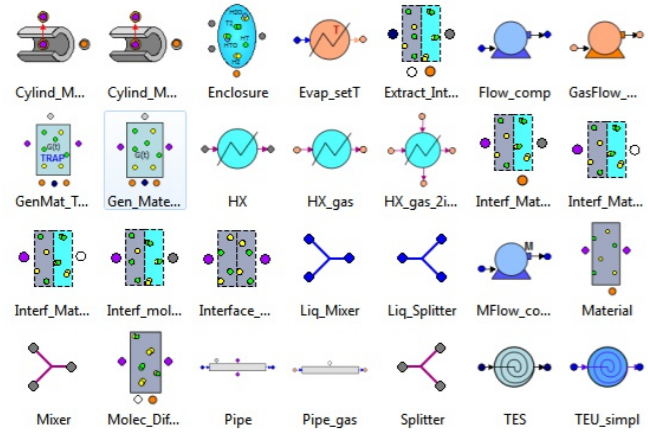
The TRITIUM\_LIBS libraries contain components for the simulation of systems and processes involving hydrogen isotopes for the study of transport phenomena and of physicochemical processes related to the extraction and purification of tritium. The availability of models of such systems is especially important for the ITER project (International Thermonuclear Experimental Reactor), where control of the tritium inventory has to be strict at all times.

## Overview of Tritium\_Libs

The EcosimPro simulation environment has three libraries focussed on the simulation of the processes that take place during the generation and treatment of tritium:

- **TRITIUM\_BALANCE**: includes the basic components that model the hydrogen isotope transfer phenomena.

- Connection between components by means of different ports: diffusion, liquid, gas, etc.
- Definition of the species to be considered and grouping of these species (H, D, T, T2, HT, H2O, etc).
- Calculation of properties: coefficients of diffusion, solubility, disassociation, recombination, etc, based on correlation equations
- 1D diffusion model in materials (LiPb, Eurofer, AISI 316L, etc).
- Interface between materials, or between materials and gas enclosures, controlled by surface phenomena (disassociation and recombination) or by diffusion.
- 1D piping for the circulation of liquid metal (LiPb) and for gases.
- Enclosures in which isotopic reactions are produced.



- **TRITIUM\_TBM**: library focussed on the modelling of the Test Blanket System (TSB) where tritium is generated and recovered in different auxiliary systems:

- Basic equipment used in the TSB (Tritium Extraction Unit), getter beds, etc.
- Basic equipment used in the TSB: TEU.
- Models of the existing systems in the TSB (TBM - Test Blanket Module-, HCS – Helium Cooling System-, LiPb\_loop, etc).

- **TRITIUM\_PLANT**: contains models for simulating the tritiated waste extraction and purification processes.

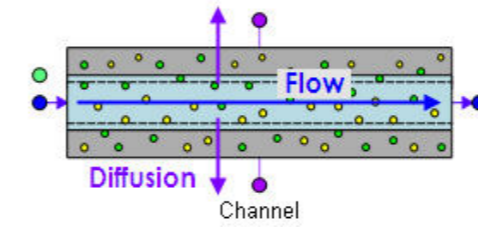
- Vacuum chamber where fusion takes place
- Tritium extraction equipment from a gaseous stream (permeators, distillation columns, etc)
- Storage systems (Storage and Delivery System, SDS)
- Auxiliary systems: equalizers, heat exchangers, etc.

The components of these libraries allow the dynamic calculation of the tritium inventory to be carried out, as well as the quantification of its flow into the environment, and between subsystems.

## Modelling of hydrogen isotope transport phenomena

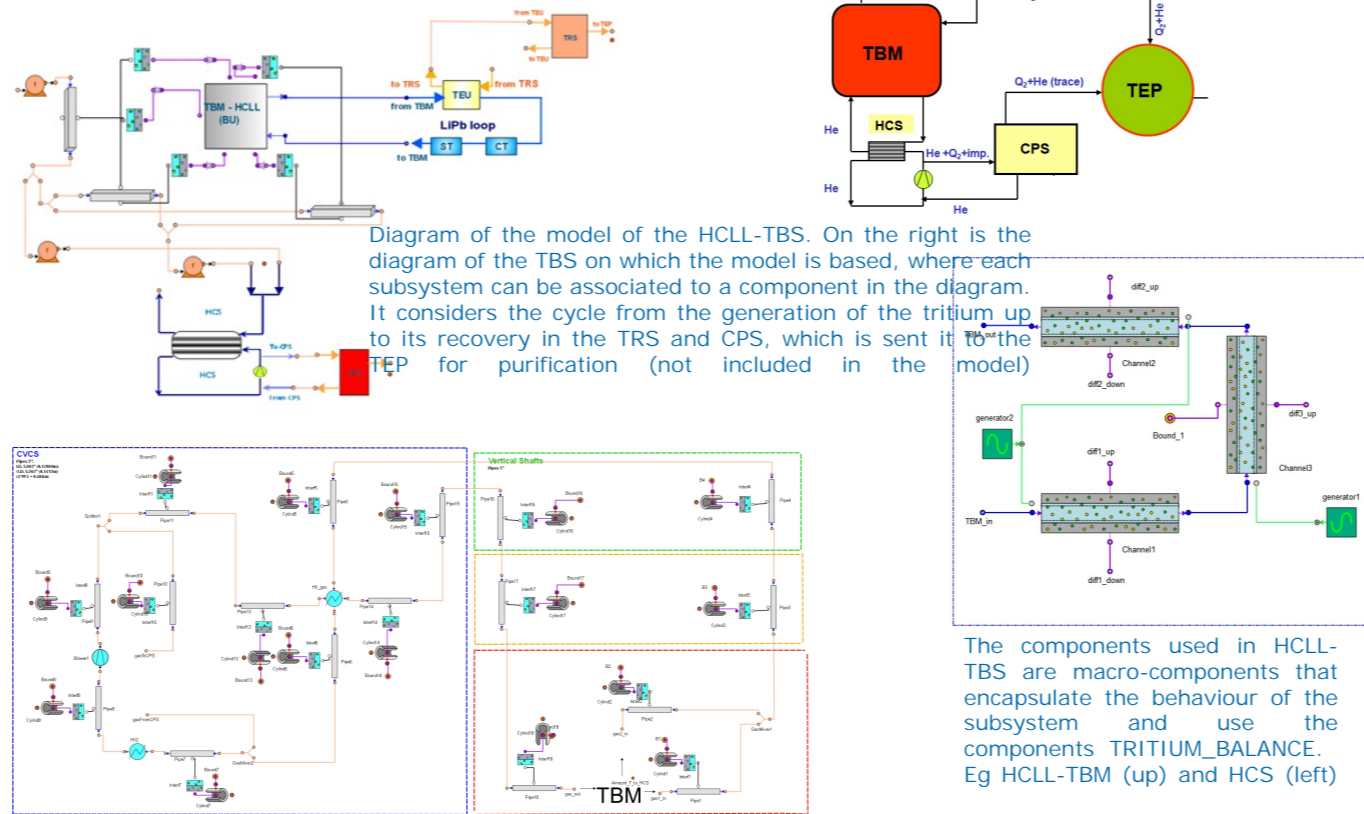
The **TRITIUM\_BALANCE** library contains a number of components that are used to study the atomic diffusion of hydrogen atoms. The following characteristics make this library very flexible, user friendly and mathematically powerful:

- diagrams are built dragging and connecting components
- no limit to the number of components in a model
- user can select the number of nodes for discretization
- pre-defined set of species that can be expanded by the user
- pre-defined materials and the possibility of indicating the Sievert, diffusion, recombination and dissociation coefficients
- temperature profile in the materials selection: constant, linear or thermal balance calculation



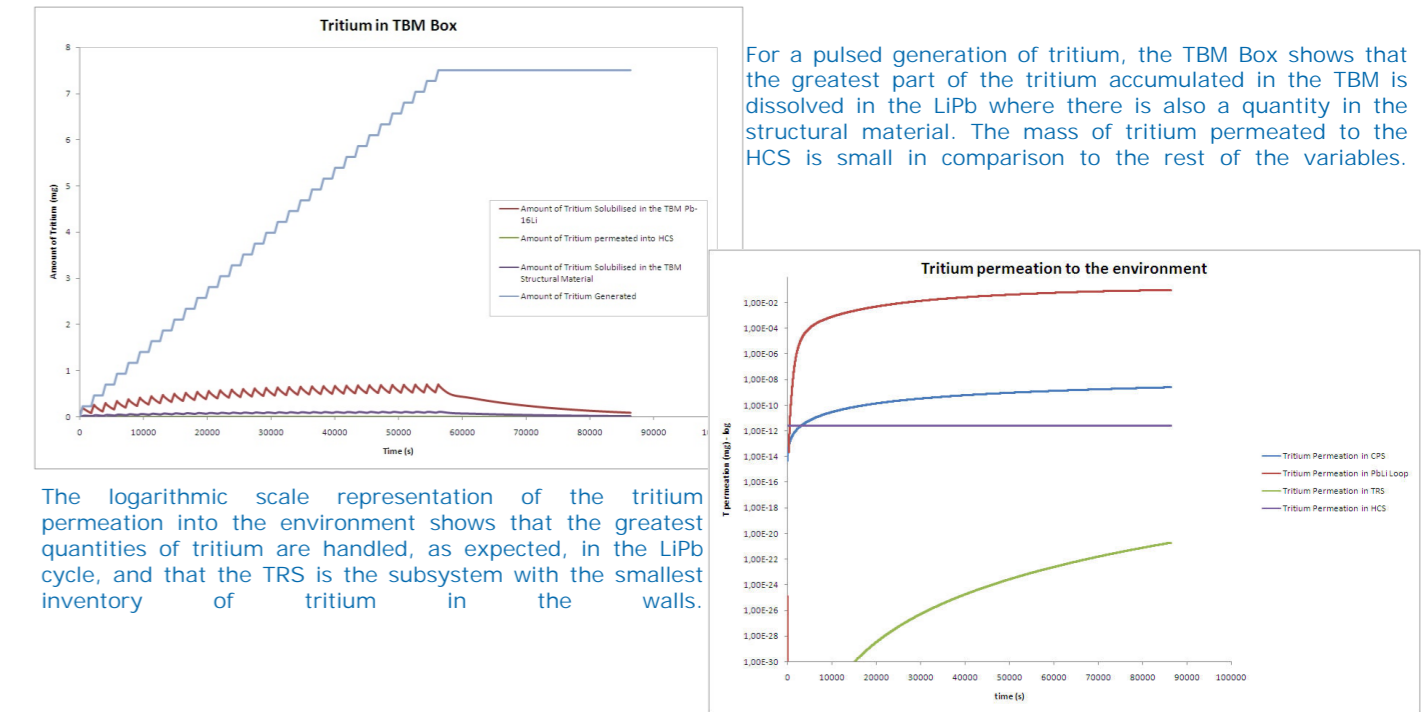
## Modelling of Test Blanket Modules (TBM) & auxiliary systems

The components of the **TRITIUM\_TBM** library have been used to model the tritium breeder unit called **HCLL TBM** (a design proposed by Europe that uses He as coolant). The dynamic simulation of this process allows for following-up of the tritium in the TBS.



The following systems are modelled:

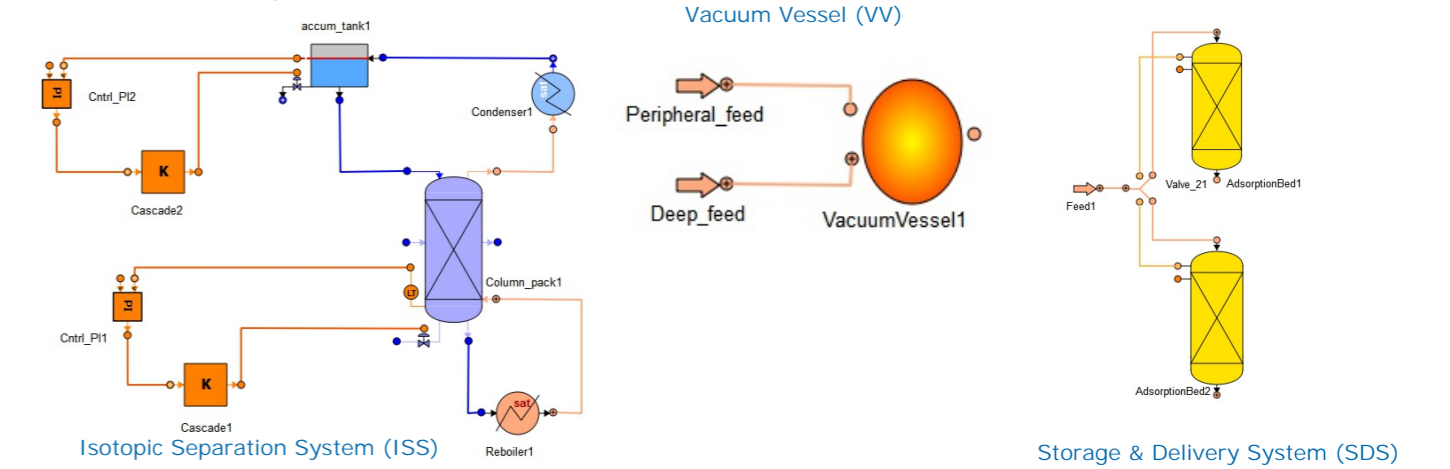
- **TBM**: modelling of U-shaped channels for Pb-16Li circulation where tritium is generated
- **LiPb loop**: System for extraction of tritium from the liquid metal stream
- **TRS**: System for recovering the tritium extracted in the Tritium Extraction Unit (TEU) of the LiPb loop
- **HCS**: coolant cycle in contact with the TBM
- **CPS** (Coolant Purification System): System that extracts tritium dissolved in the coolant (He).



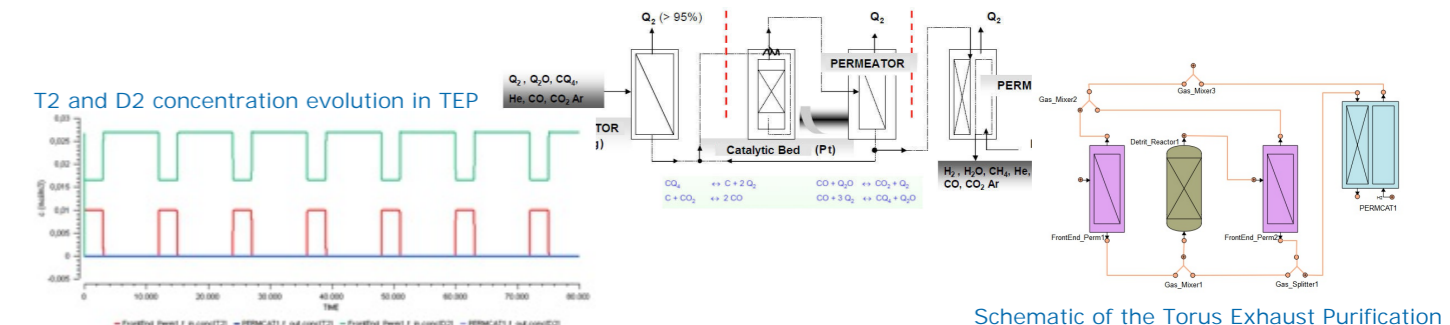
The logarithmic scale representation of the tritium permeation into the environment shows that the greatest quantities of tritium are handled, as expected, in the LiPb cycle, and that the TRS is the subsystem with the smallest inventory of tritium in the walls.

## Modelling of the extraction & purification of tritiated streams

The **TRITIUM\_PLANT** library includes models of different systems of the Tritium Plant used for the extraction and purification of hydrogen isotopes. Due to the complexity and current lack of definition of the processes, the components of this library are modelled in a simulated simplified manner, focussed on the dynamic balance of the tritium.



Torus Exhaust Purification (TEP) System: extraction of tritium from the reactor outlet gases



The graph shows how, in a pulsed feed stream containing T2 and D2, the concentration at the outlet of these species is much lower due to the existing extraction systems by permeation in the TEP.