

Implementation of the System Thermal-Hydraulic code TRACE into SALOME Platform for Multi-Scale Coupling

Kanglong Zhang, Victor Sanchez-Espinoza, Robert Stieglitz

Institute for Neutron Physics and Reactor Technology (INR)



Presentation Outline

Implementation of the System Thermal-Hydraulic code **TRACE** into **SALOME** Platform for **Multi-Scale Coupling**

- **Motivation of Multi-Scale Coupling**
- **Introduction of TRACE and SALOME**
- **Implementation of TRACE to SALOME**
- **TRACE module in SALOME**
- **Summary**

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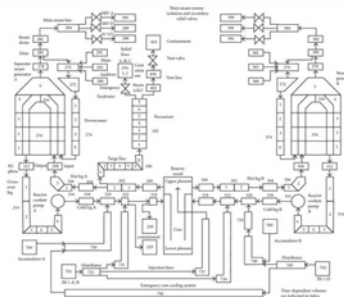
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Motivation of Multi-Scale Coupling

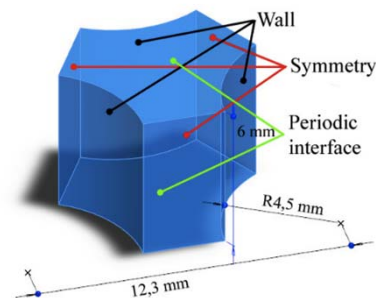
Title: Implementation of the System Thermal-Hydraulic code **TRACE** into **SALOME** Platform for **Multi-Scale Coupling**

➤ What is **Multi-Scale Coupling** and Why?

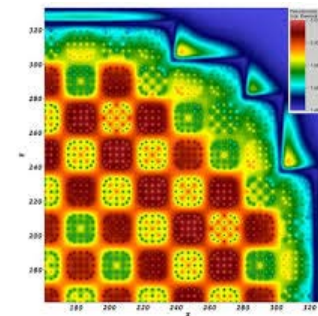
- The thermal-hydraulic simulation codes for nuclear power systems include three typical scales: **macro scale** – system code, **component scale** – sub-channel code, and **micro scale** – CFD.
- Multi-scale coupling is to **combine** the capabilities of those tools together in order to **better describe** the flow and thermal conditions in a nuclear power system.



System code



Sub-channel code



CFD code

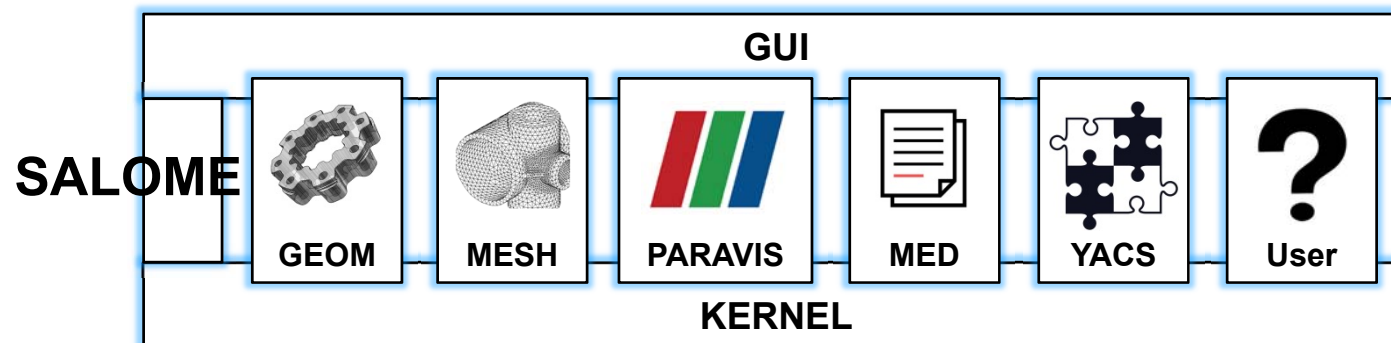
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Introduction of TRACE and SALOME

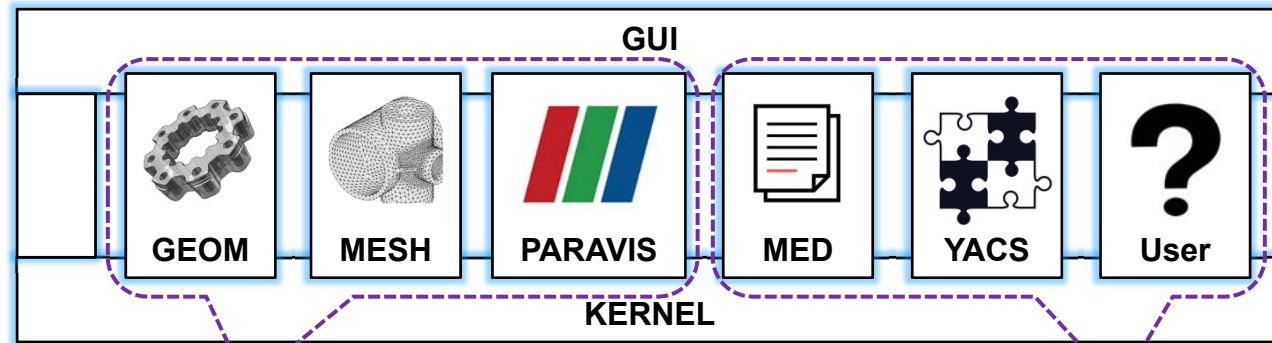
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- What is **TRACE**?
 - TRACE is a U.S. NRC system code.
- What is **SALOME**?
 - SALOME is an open-source software that provides a generic platform for Pre- and Post-Processing for numerical simulation. It is consisted of functional modules e.g. GUI, KERNEL.



Introduction of TRACE and SALOME

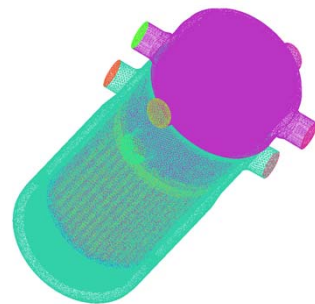
Key point: SALOME can deal with COUPLING problems.



Pre and Post Processing

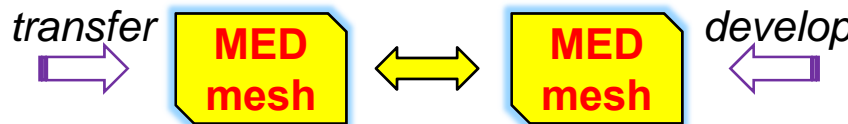
For Coupling and other extended functions

- MED:**
- Provide a **standard** for **meshes** and **fields**.
 - Facilitate the **exchange** between codes and solvers.



*CFD code, Mesh file available
Various mesh format, Fine resolution*

Mapping is impossible between the two "meshes"



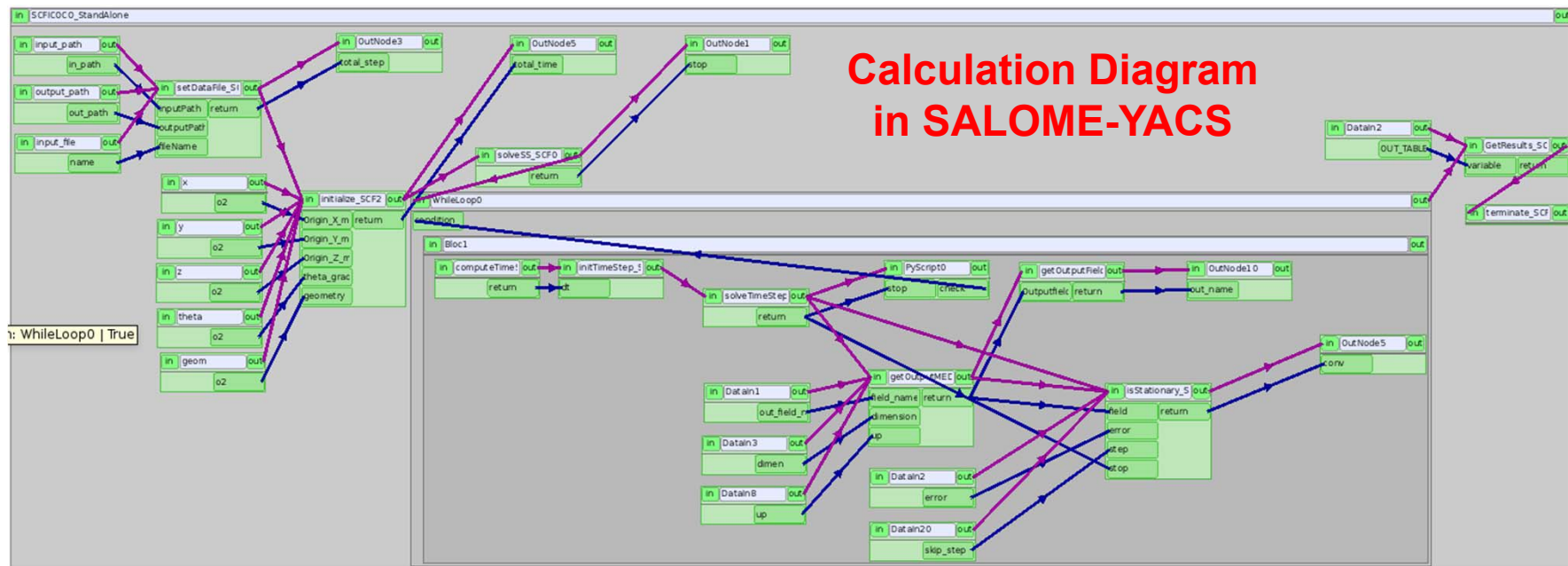
*In **SALOME***



*SYSTEM code, No explicit mesh file,
Coarse resolution*

Introduction of TRACE and SALOME

- YACS:**
- Allows **build**, **edit** and **execute** calculation **schemes**.
 - A calculation scheme defines a **chain** or a coupling of computer codes (SALOME components or calculation components).



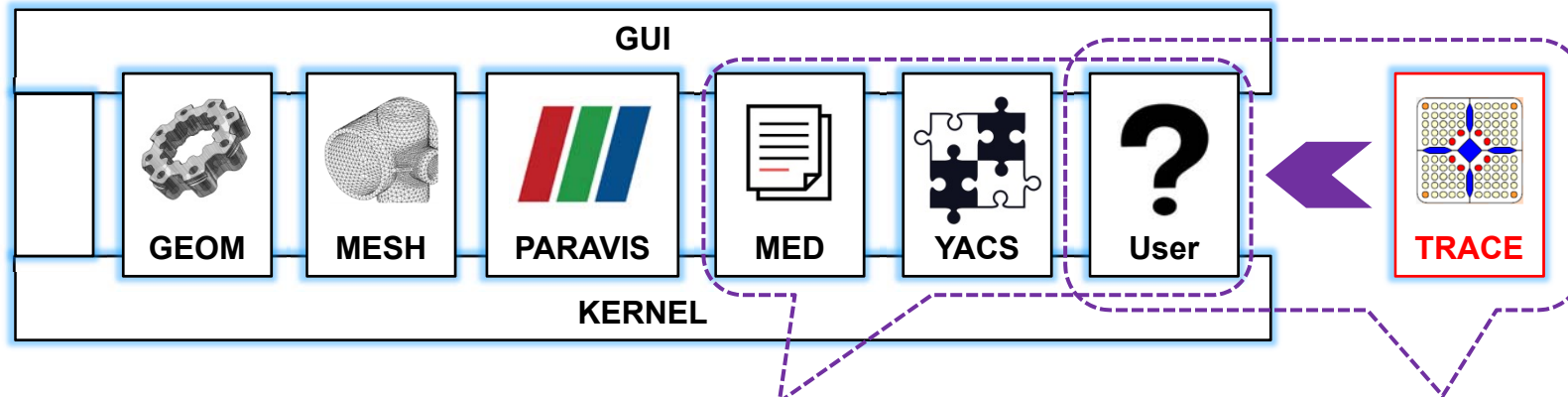
- The code's executable was **split** into various functional **components**.
- Each of the **components** could be **dragged** to the display panel and could be **connected** with each other to form a **calculation scheme**.

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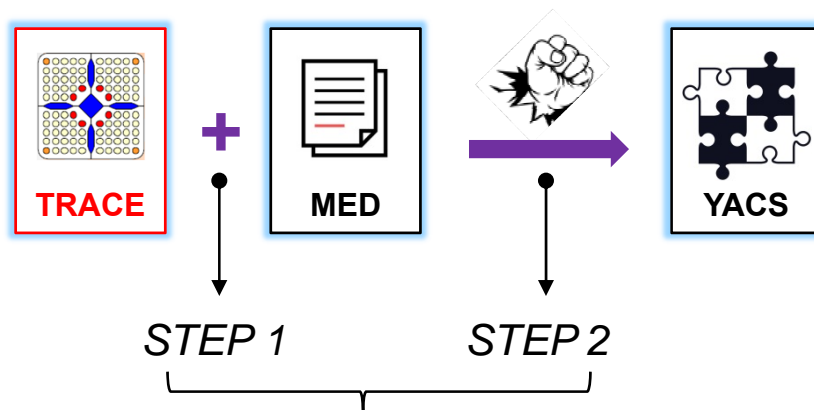
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Implementation of TRACE to SALOME



For Coupling and other extended functions

Implementation to be done



Implementation of TRACE to SALOME

- **STEP 1:** Based on SALOME-MED module, develop an explicit mesh file for TRACE in MED format. Meanwhile, enable TRACE to extract or write physical field data in MED format.
- **STEP 2:** Break TRACE executable into several functional components so that YACS could use this components to organize a calculation scheme.

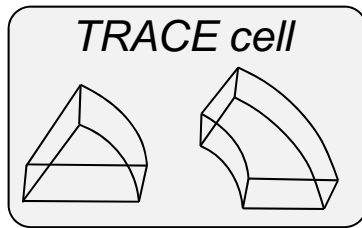
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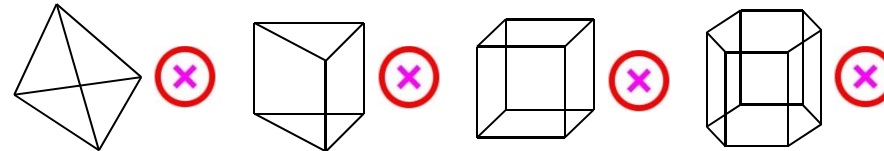
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Develop MED mesh for TRACE

- A typical mesh building process in MED: $\bullet \longrightarrow \text{parallelogram} \longrightarrow \text{cube}$
- Challenge of MED mesh for TRACE: *TRACE cells are in annular or sectorial form.*

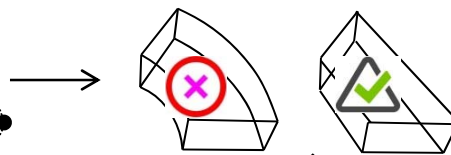
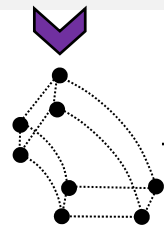


MED support five types of 3D cell – tetrahedron, triangular prism, hexahedron, hexagonal prisms and polyhedron

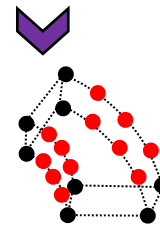


- Only polyhedron cell is possible to describe TRACE cells.

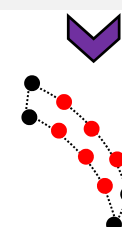
From TRACE input, 8 original points could be derived.



Extra points



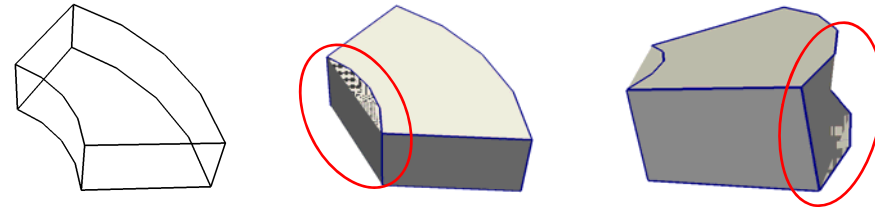
Points are not sharing the same surface



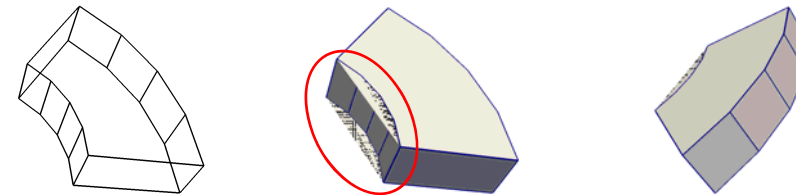
An annular cell was expected. but a hexahedron was got.
Four points are not enough to form a spatial 3D cylindrical surface.

Develop MED mesh for TRACE

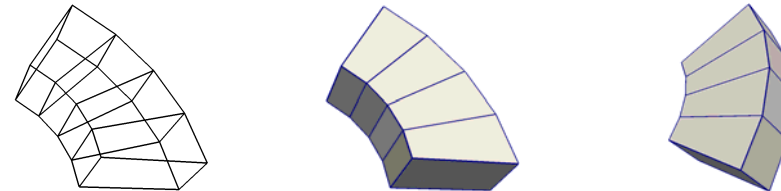
- 1) If use 6 surfaces including 2 spatial 3D cylindrical surfaces to build the annular volume, a misshapen cell will come out.



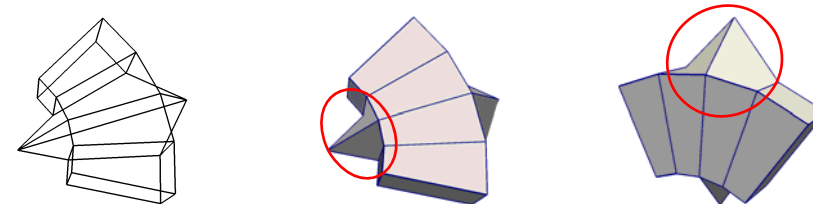
- 2) With the same points, several quadrangles could wrap the spatial cylindrical surface. Now the cell could be correctly built but still with display problems.



- 3) With the same points, several quadrangles warp the top and bottom surfaces. The perfect cell for TRACE is obtained.

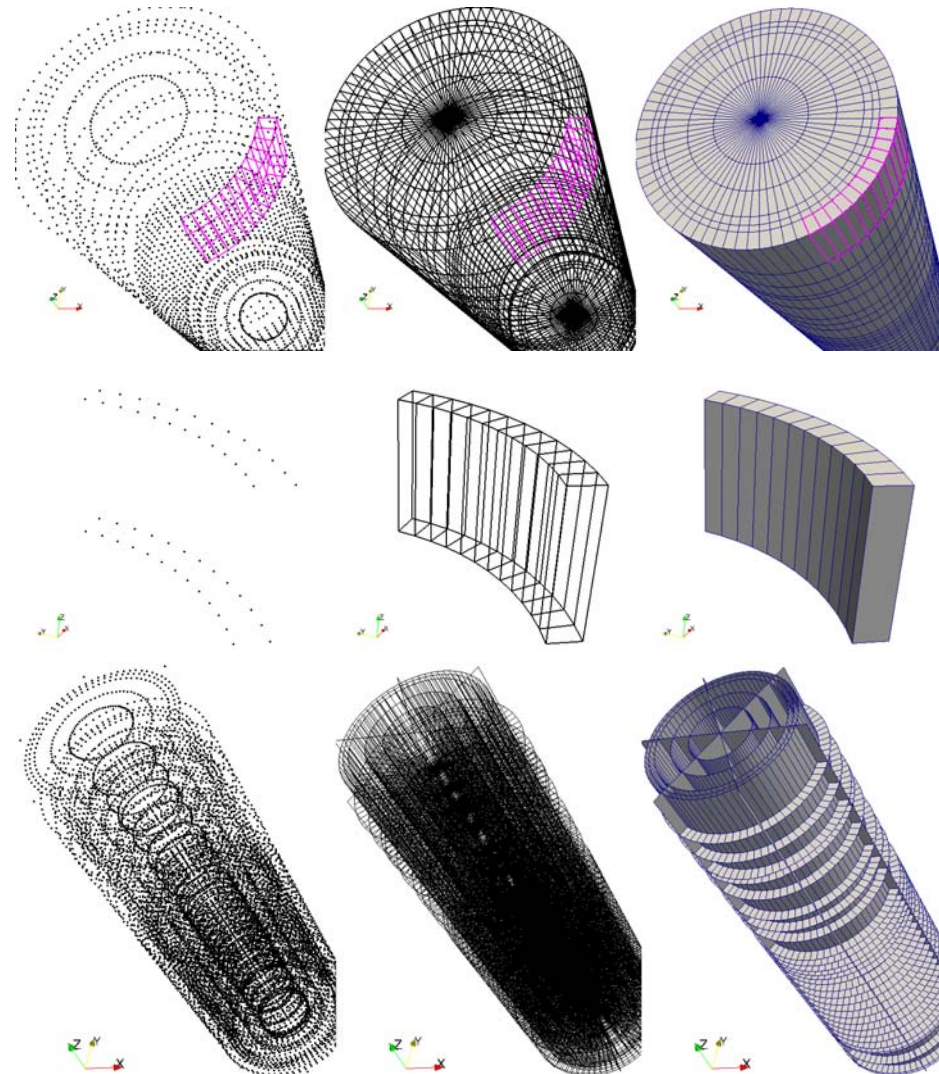


- 4) All of the problems we have encountered come from the logic which SALOME applied to estimate the coplanarity of the points set.



Develop MED mesh for TRACE

- 1) A VVER vessel model for TRACE. 30 axial levels, 6 radial rings and 6 angular sectors. Each cell is bounded by several surfaces.
- 2) Users can define the resolution of the circles in the model. In other words, users can decide how many points to be added to the model.
- 3) Edge mesh of the TRACE model could also be built. The motivation is that physical fields as Velocity and Pressure drop are all defined in the boundary of two cells.



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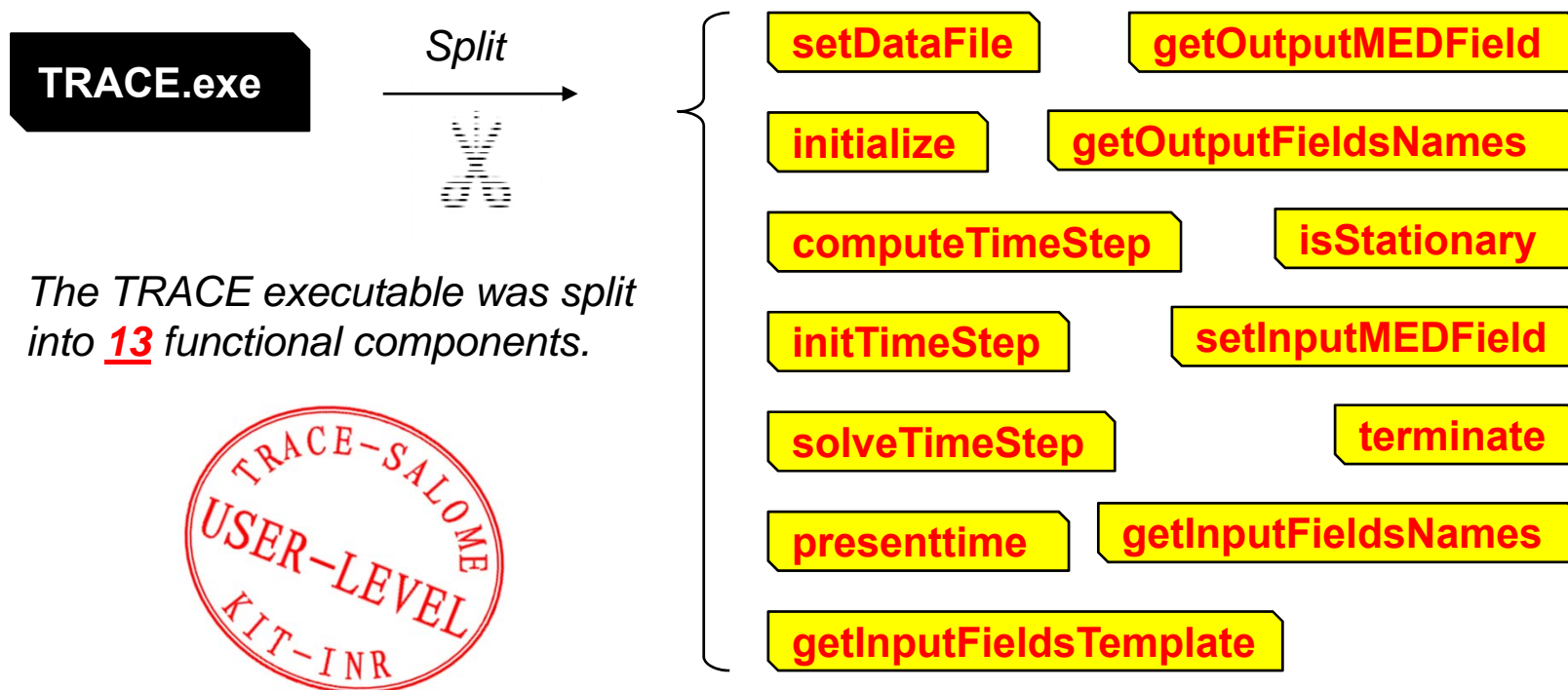
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Develop TRACE YACS component

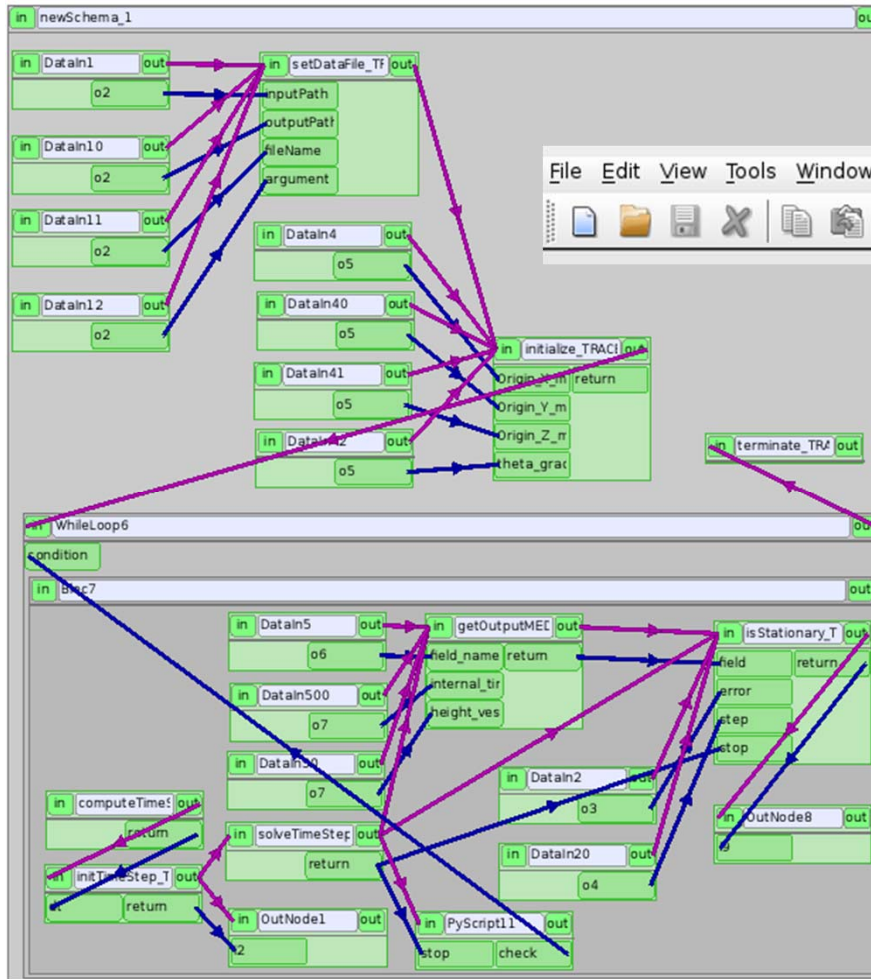


- *TRACE has been enhanced with MED mesh ability.*
- *The remaining is to make TRACE available in SALOME-YACS.*

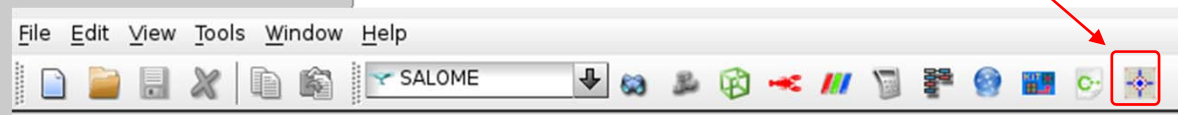


Develop TRACE YACS component

Standalone TRACE in YACS display panel



TRACE icon in SALOME toolbar

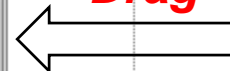


TRACE components in YACS catalog

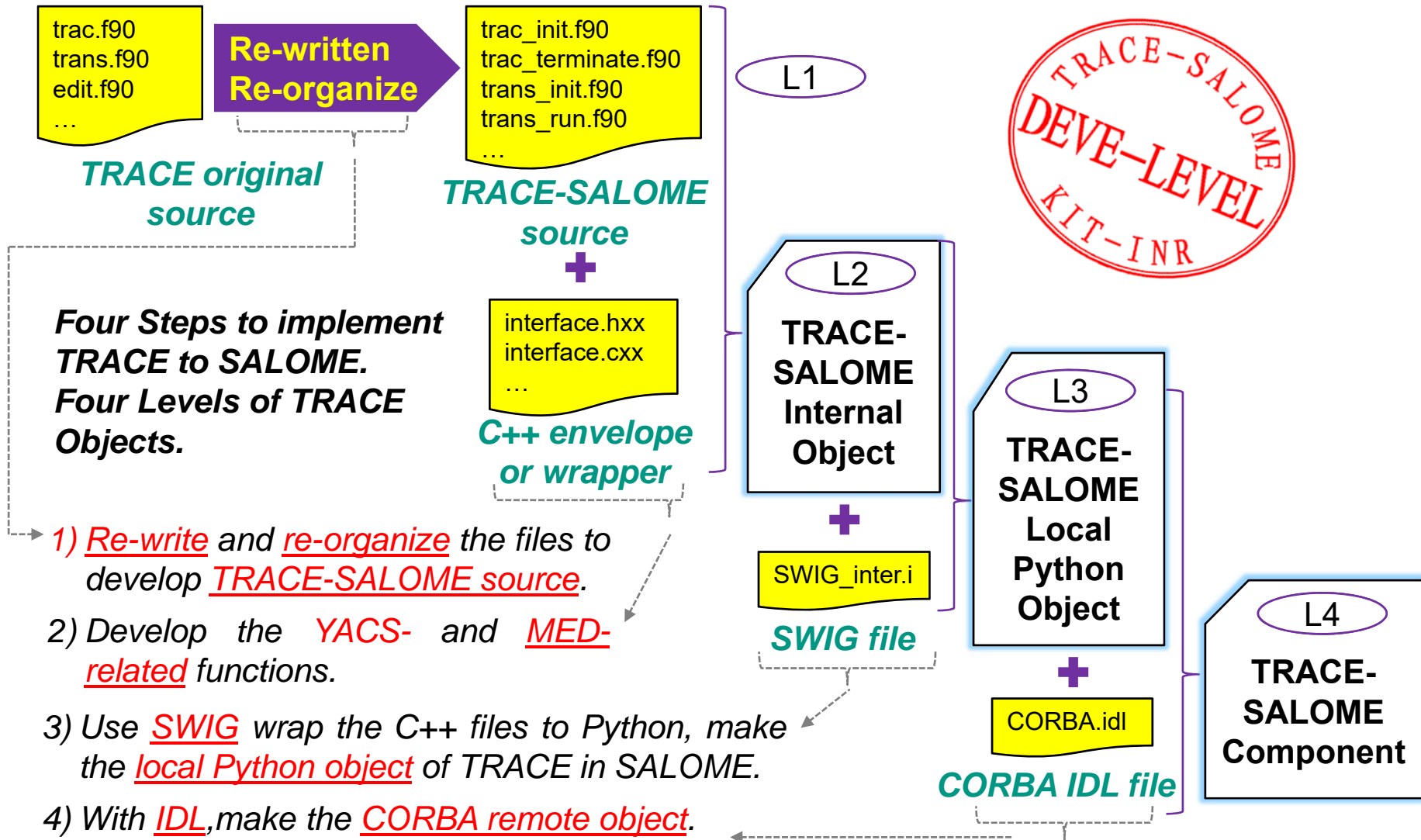
- ⊕ Built In
- ⊖ Current Session
- ⊕ Types
- ⊖ Components
- ⊕ GEOM
- ⊕ GEOM_Superv
- ⊕ HOMARD
- ⊕ PVSERVER
- ⊕ SCFICOCO
- ⊕ SMESH
- ⊕ SUBCHANFLOW
- ⊖ TRACECOCO
- ⋮ computeTimeStep_TRACE
- ⋮ getInputFieldsNames_TRACE
- ⋮ getOutputFieldsNames_TRACE
- ⋮ getOutputMEDField_TRACE
- ⋮ initTimeStep_TRACE
- ⋮ initialize_TRACE
- ⋮ isStationary_TRACE
- ⋮ presenttime_TRACE
- ⋮ setDataFile_TRACE
- ⋮ setInputMEDField_TRACE
- ⋮ solveTimeStep_TRACE
- ⋮ terminate_TRACE
- ⊕ YACSSchemaCatalog.xml



Drag



Develop TRACE YACS component



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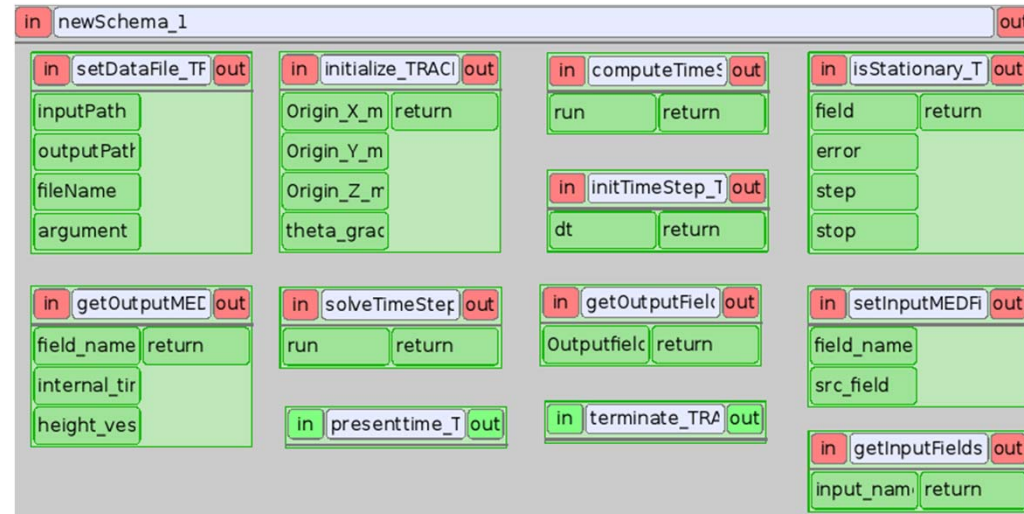
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TRACE Module in SALOME

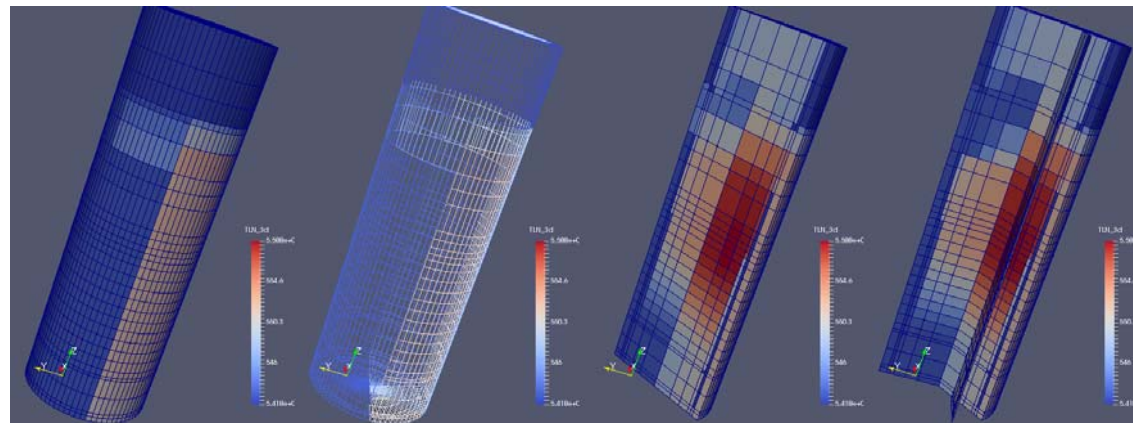
- TRACE now is able to implement a very **flexible**, **highly-automated** and **high-precision** coupling approach with another code thanks to MED in SALOME.
- TRACE could achieve **flexible** coupling strategy with another code thanks to the splitted functional components.

TRACE functional components in SALOME-YACS



- **21** data sets (2D or 3D) could be extracted and written to MED mesh for post-processing and visualization.
- **5** data sets (2D or 3D) could be interpolated and derived from other codes and written to TRACE memory on-the-fly.

Coolant Temperature in VVER TRACE model



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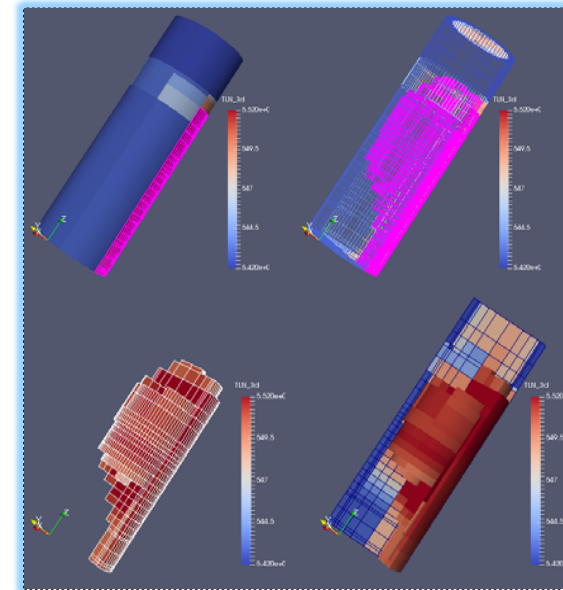
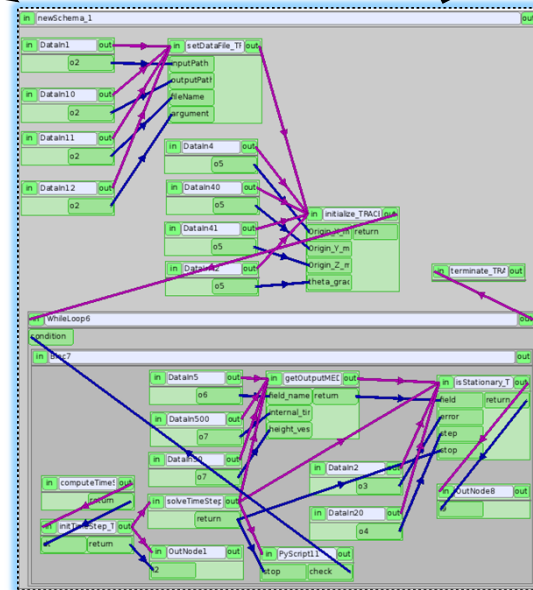
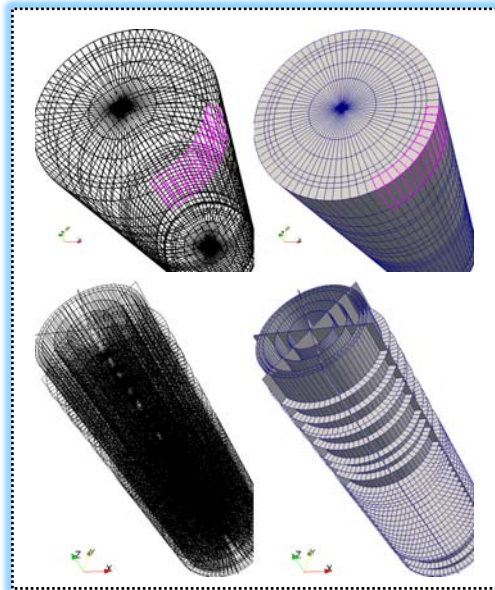
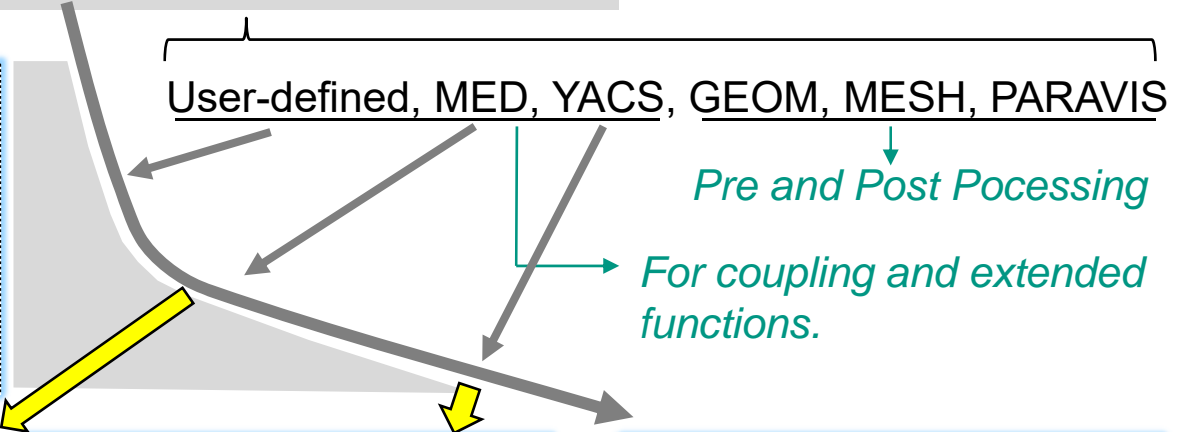
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- 1) **TRACE-SALOME** source.
- 2) Develop the **C++** interface files.
- 3) Develop the **SWIG** file and build **TRACE** local python object.
- 4) Develop **CORBA IDL** file and build **TRACE** remote object which is also the final **SALOME** module.



Thank you for your attention.

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