FLUKA

# Unstructured mesh: Hands-on

**UMESH** geometries applied to a fusion device

# Hands-on objectives

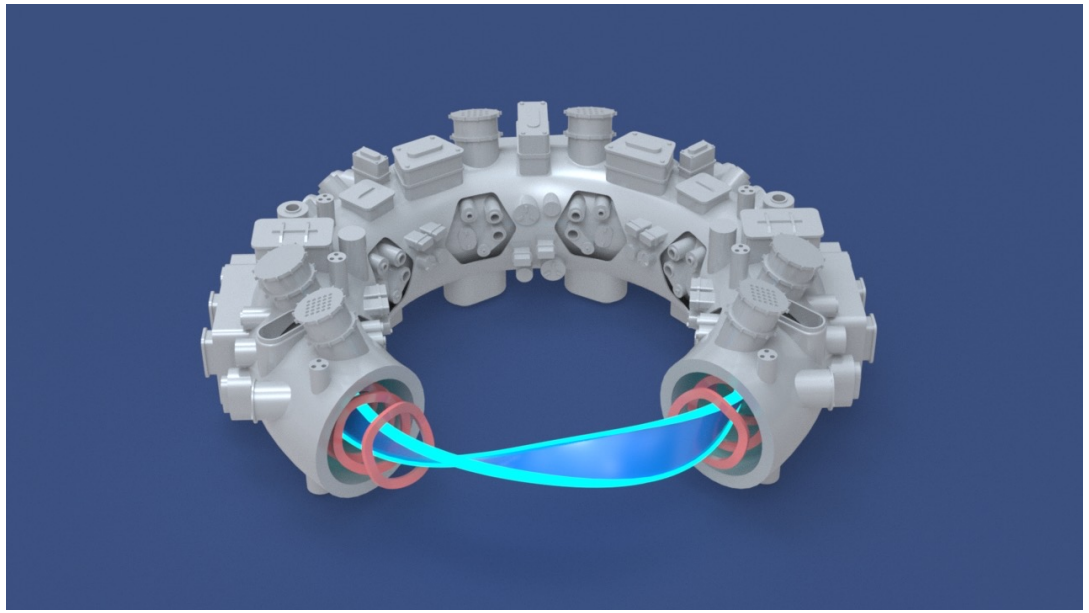
Provided a CAD geometry representing a fusion device, the objectives are:

1. (Optional) Generating mesh with Python script
   - Together with the CAD files, the respective UMs are provided
2. Importing UM in Flair
   - Check **`UMESH`** card entries, the bounding region and assign materials to UM sub-regions
3. Sampling particles uniformly in a UM sub-region
   - Use of provided **`source.f`** routine and visually cross-check the obtained spatial distribution
4. Adding a second mesh as surrounding detectors
   - Apply boolean operations to UM with CSG bodies
5. Scoring for the second mesh

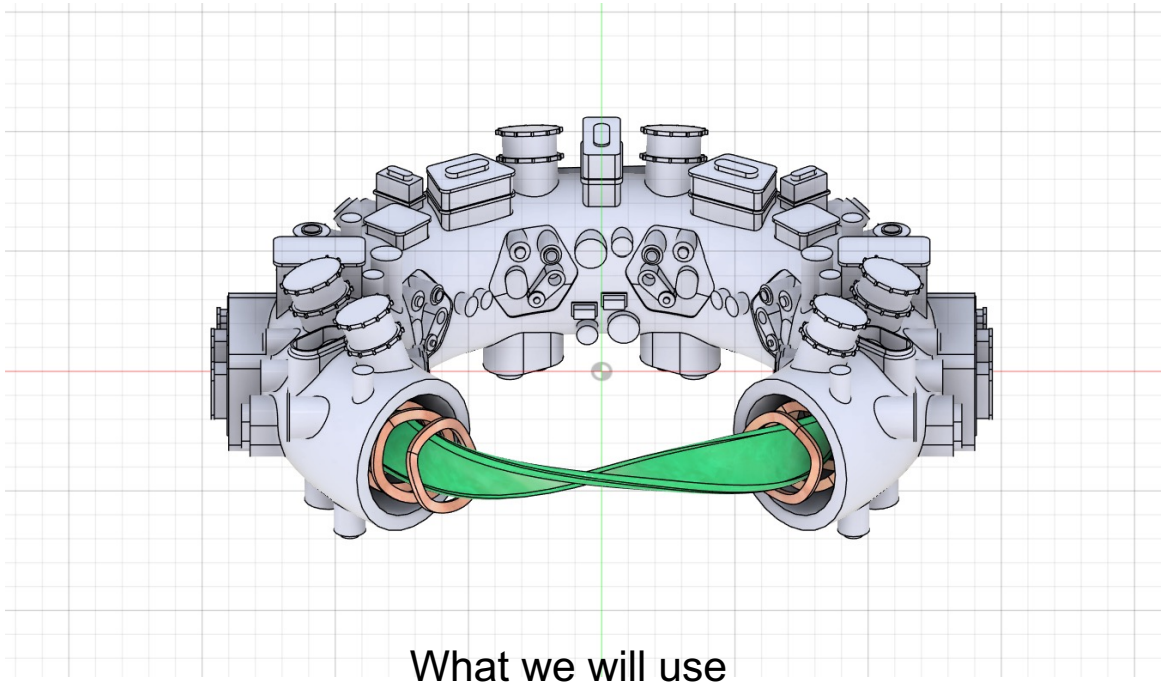
# Initial CAD geometry: Wendelstein 7-X

The **Wendelstein 7-X** (abbreviated W7-X) reactor is an experimental stellarator built in Greifswald, Germany, by the Max Planck Institute for Plasma Physics

The **provided CAD model** is a slightly simplified version of the model from GrabCAD

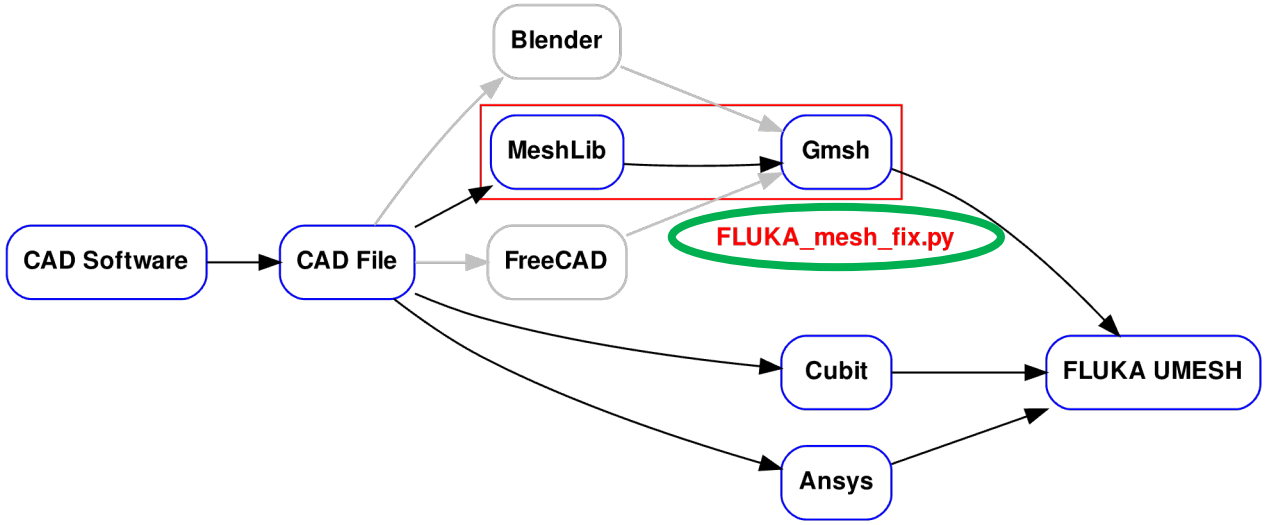


Initial CAD model



What we will use

# 1. (Optional) Generating mesh with Python script




- **Lecture echo**:
  "Highlighted tool complements the 4-5.0 release and contains carefully cherry-picked Gmsh options to handle meshing of complex geometries. The script is available for download at https://fluka.cern/tools/umesh on FLUKA website"

a) Download the `geom_mesh_utils.tar.gz` package

b) Look at the **`--help`** option of the script
   - Check the **`--reg`** option

c) Generate the UM for the provided CAD geometry
   - NB: Script requires the installation of specific python packages (**`meshlib.mrmeshpy`** and **`gmsh API`**)

d) Inspect the generated UM with **`gmsh`**

# 2. Importing UM in Flair

a) Open the provided Flair project, **fusion_device_initial.flair**

b) After the `GEOBEGIN` card, add a new `UMESH` card, give the name **STELLAR**, and select the provided (or generated) UM, **Stellarator_Wendelstein.abaq**

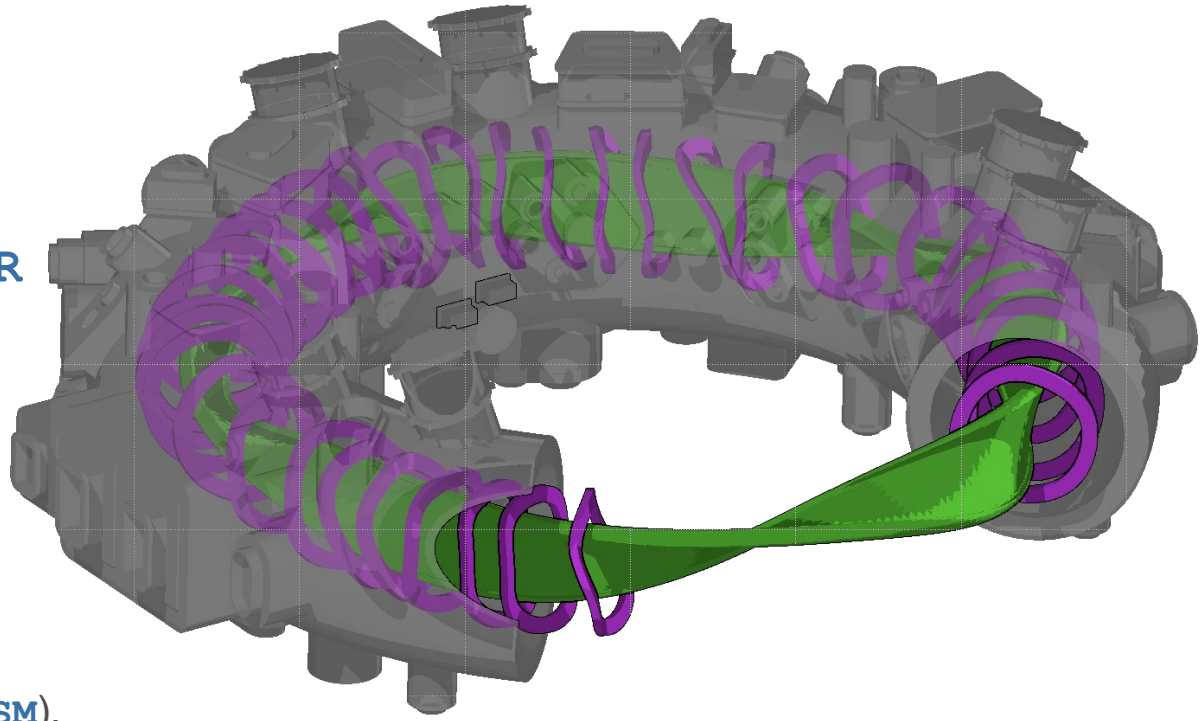
c) Remove from the `VOID` region the `STELLAR` UM

d) Switch to the `Geometry` tab to load the UM
   - Assign some materials to the regions to visualize them

e) (Optional) Create the UM bounding **region** `STELLAR`

f) Check `UMESH` card entries

g) Assign materials to all mesh sub-regions
   - `STELLAR` region in vacuum
   - Vacuum vessel regions (`reg_37`, `reg_38`, and `reg_39`) in stainless steel (`SS317LN`),
   - Plasma flow region (`reg_36`) in low density deuterium (`D2PLASM`),
   - coil regions (all other UM sub-regions) in `NbTi`,



Stellarator UM geometry

# 3. Sampling particles uniformly in a UM sub-region

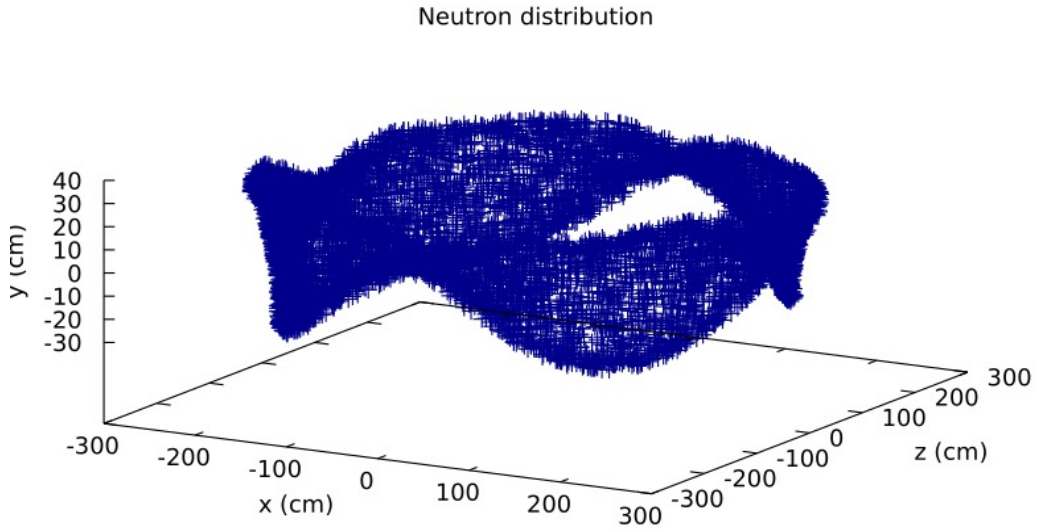
a) Add a `SOURCE` card

b) Check the provided `source_newgen_umesh.f` routine and compile it

c) Check the meaning of `SOURCE` **`WHATS`** required by the source routine

d) Define a mono-species beam of neutrons from **D-T reaction** (**14.028 MeV**), with an energy sigma of **0.1 MeV**, **uniformly distributed in the plasma flow sub-region (`reg_36`)**

e) Visually check the particle distribution as printed by the routine with the **pre-defined plot in Flair**



# 4. Adding a second mesh as surrounding detectors

a) Add a second **UMESH** card, give the name **DETSHELL** and select the provided **Wendelstein_detectors.abaq**

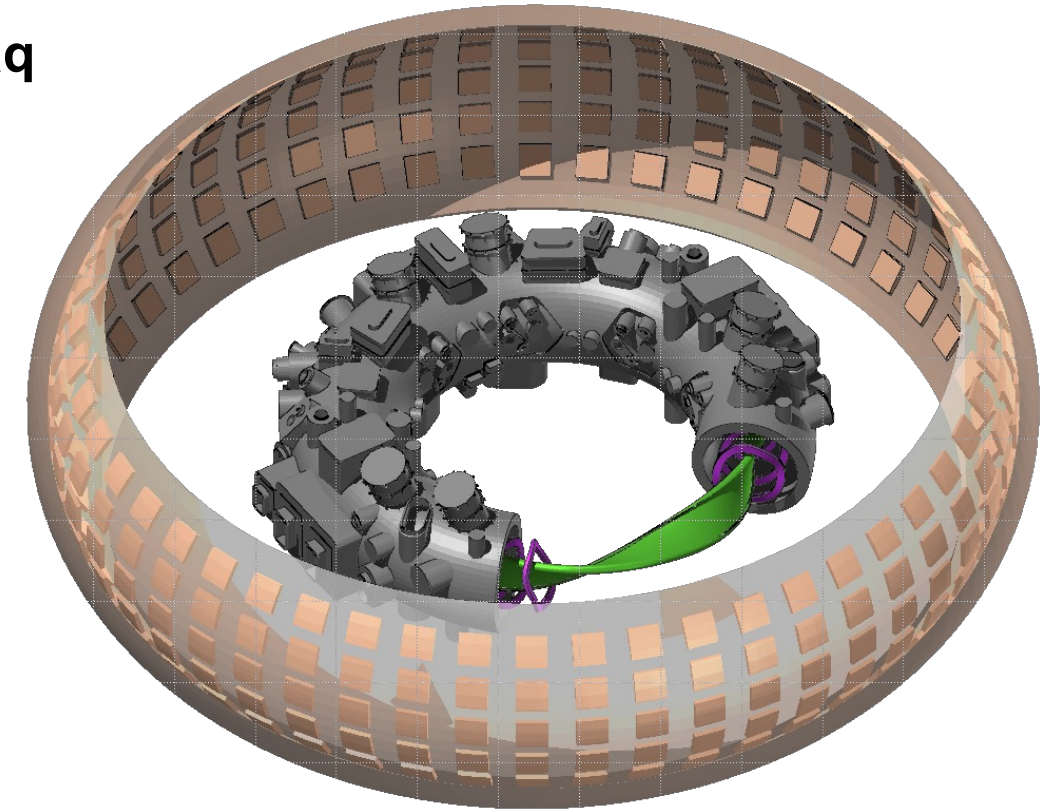
b) Remove from the **VOID** region the **DETSHELL** UM

c) Switch to the Geometry tab to load the UM
   - Assign **SILICON** to all sub-regions
   - See the overlapping between the two UMs…

d) Create the UM bounding region **DETSHELL**

e) Create an RCC around the **STELLAR** UM

f) Redefine **VOID** and **DETSHELL** regions to fix the overlapping UMs



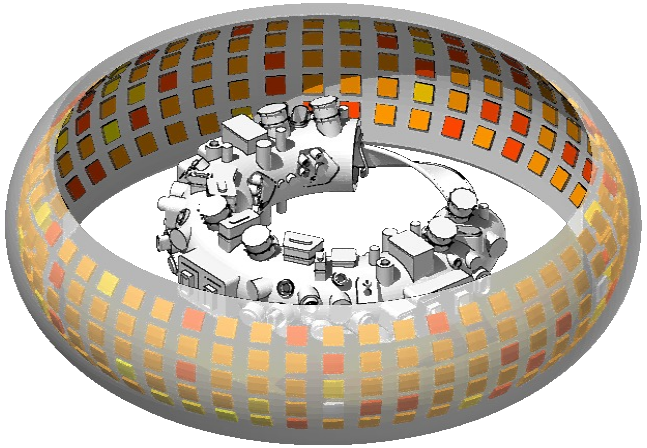
3D View: Both meshes together

# 5. Scoring for the second mesh

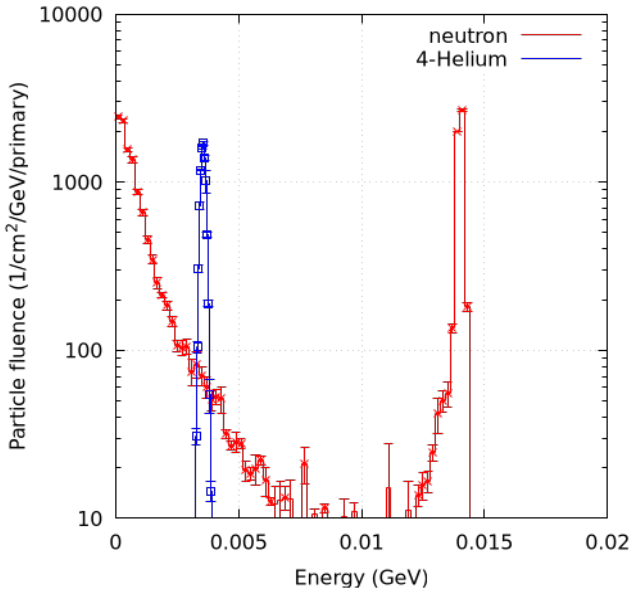
a) Change the `SOURCE` card to emit **uniformly from the plasma flow region**, together with the neutrons, also the `4-HELIUM` (**3.561 MeV**) resulting from the **D-T reaction**

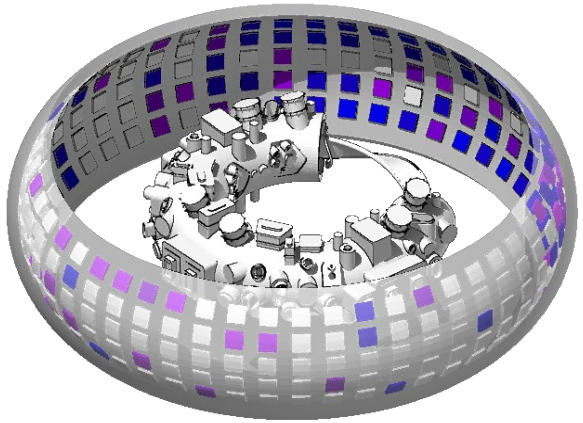
b) Add two `USRBIN` with scoring **by region** and select all sub-regions of `DETSHELL` UM
   - Score `4-HELIUM` for the first and **neutrons** inside the second card

c) Add two `USRBDX` for **`neutrons`** and **`4-HELIUM`** and score the spectra in the `STELLAR` UM at transition from the vacuum around the plasma to the stainless-steel vessel (`reg_37`)

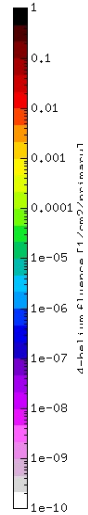



3D View: Neutrons



3D View: He-4




FLUKA