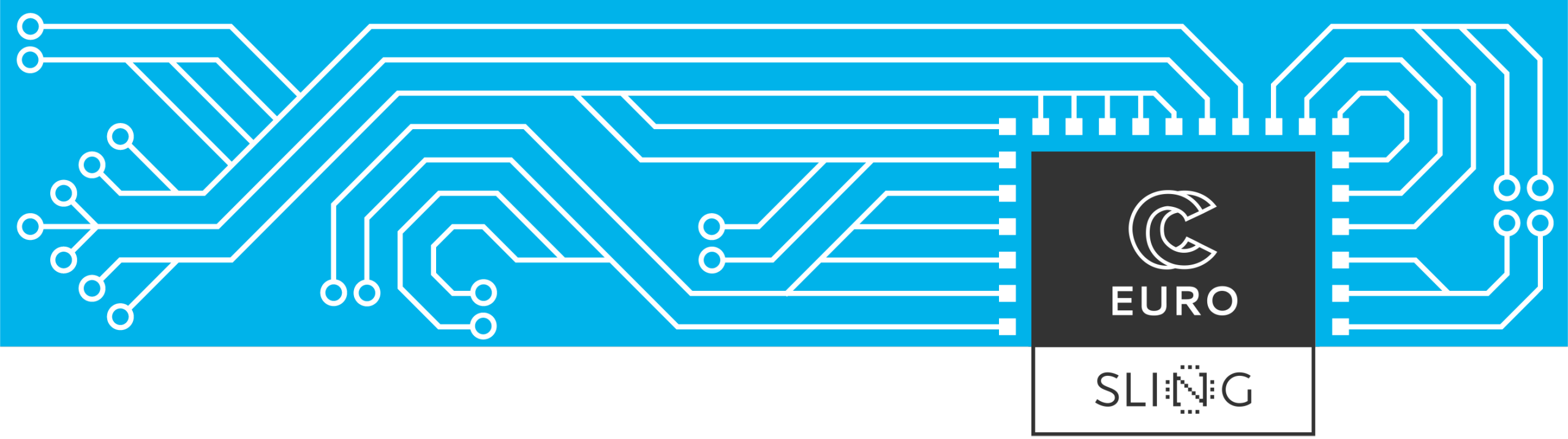

Hands-on Workshop 2 – Scientific Rendering in Nuclear Fusion

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24 September 2024

- Let’s move to Vega and install Raysect/CHERAB:
  - We will create our own python environment. Move to your home folder and create a virtual environment named *raysectpython*:

```
cd
python –m venv raysectpython
```

  - Then we can source the new python:

```
source ~/raysectpython/bin/activate
```

  - Now we can install Raysect and CHERAB:

```
pip install cherab cherab-openadas
```

Example 1:

Let’s first do a simple benchmark of our ray-tracer:

We define a cube with edge length 0.5m and volumetric source of $1W/m^3sr$. Total power radiated by this cube is defined as integration over the volume and the full solid angle (4π steradians):

$$P = L \times V \times 4\pi = 1\ W/m^3sr \times 0.125\ m^3 \times 4\pi\ sr = 0.5\pi\ W \approx 1.5708\ W$$

The total power radiated by the 0.5m edge cube is 0.5π watts or approximately 1.5708 watts.

Let’s check if Raysect provides the same result using MCRT method.

Open the script *raysect_radiative_cube_example1.py* and define:

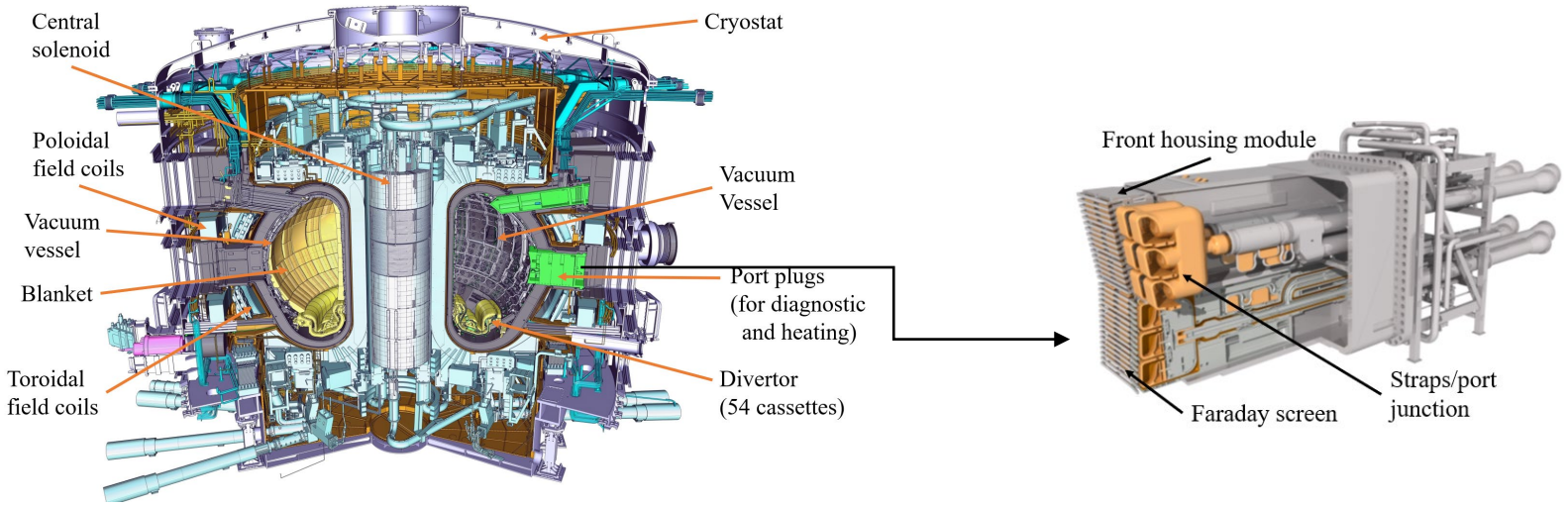
1. First we need to define a scene using *World* class.
2. Then import the box (*"box.vtk"*) that surrounds the cube (in vtk file format)
3. Define the cube and its volume emission to 1W/m^3sr
4. Assign both the box and cube to the world.

- Camera is already defined. Run the case. Total power on the surface of the box will be printed to the console. Compare it to analytical solution.

Example 2:

Radiation on ICRH antenna Faraday screen.

Ion cyclotron resonance heating (ICRH) is the third additional heating scheme to be deployed on ITER. Its two antenna arrays, installed on the outboard midplane in equatorial port plug, will deliver 20 MW of RF power in the 40-55 MHz frequency range. A generator, transmission lines and an antenna are necessary for ion cyclotron heating. A generator produces a high-power radio frequency waves that are carried along a transmission line to an antenna located in the vacuum vessel. The plasma-facing component of the ICRH antenna assembly is the Faraday screen, comprising beryllium (Be) tile armoured, actively cooled bars located only $\sim 1\ cm$ radially behind the innermost point of the shaped Be first wall panels (FWPs).



The plasma-facing component of the ICRH antenna assembly is the Faraday screen, comprising beryllium (Be) tile armoured

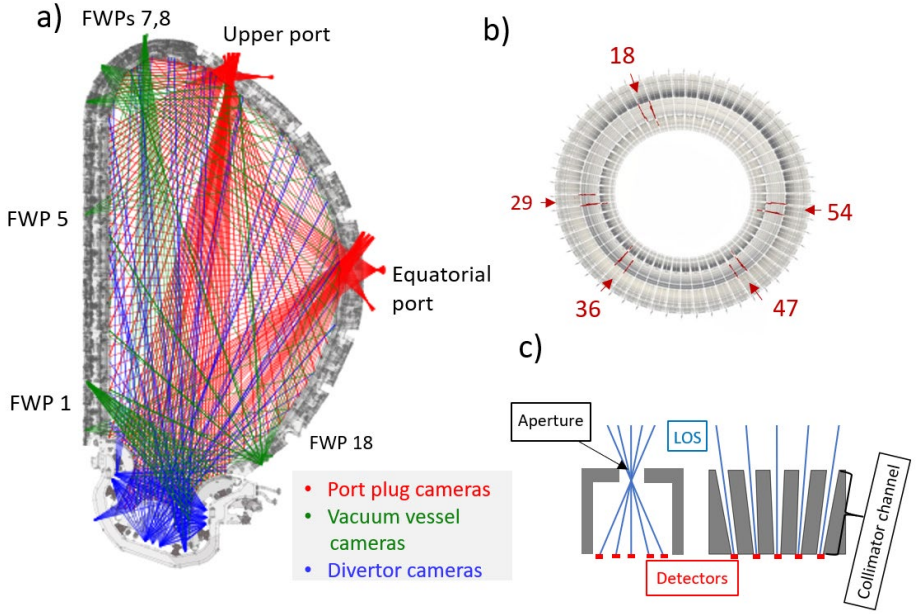
Example 2:

Radiation on ICRH antenna Faraday screen.

1. Open the script *raysect_faraday_screen_example2.py.* Inside, 2D radiation profile (in R-Z) of plasma in ITER tokamak is imported (*plasma_radiation_profile.csv*). Another python script (*"create_plasma_vtk.py"*) will convert the .csv file into .vtk file which can be visualized in Paraview.
2. Reduce the number of ray samples in the MeshCamera class to 5. Submit the job to compute node using SLURM.
3. Change the material of panels from AbsorbingSurface to another surface, that reflects rays. Does the result in Faraday screen change?

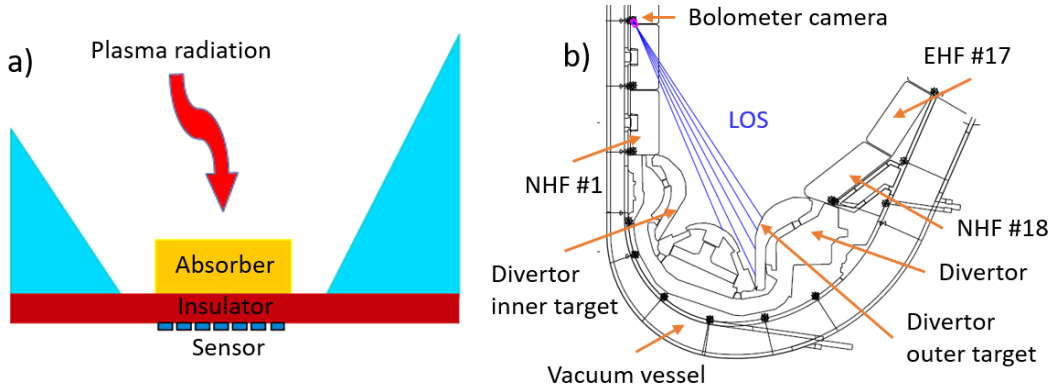
Example 3:

Calculate signal on bolometer.



(a) LOS for the entire ITER bolometer system projected onto the poloidal plane. (b) Toroidal location of bolometer cassettes. (c) Schematic of the two types of ITER bolometer camera design: pinhole (left) and collimator (right)

A bolometer is an instrument used for measuring the energy of incident electromagnetic radiation. It measures the radiant heat from the plasma over a broad spectral range (from X-ray to infrared light) and the power flux due to charge-exchange neutrals (CXN) through the temperature rise due to energy deposition on an absorptive element.



(a) Principle of resistive bolometer. Plasma radiation heats up the absorber. The temperature change causes a change of resistance in a metallic sensor (b) Lines of sight (LOS) of a bolometer camera consisting of 5 sensors, pointing into outer side of divertor

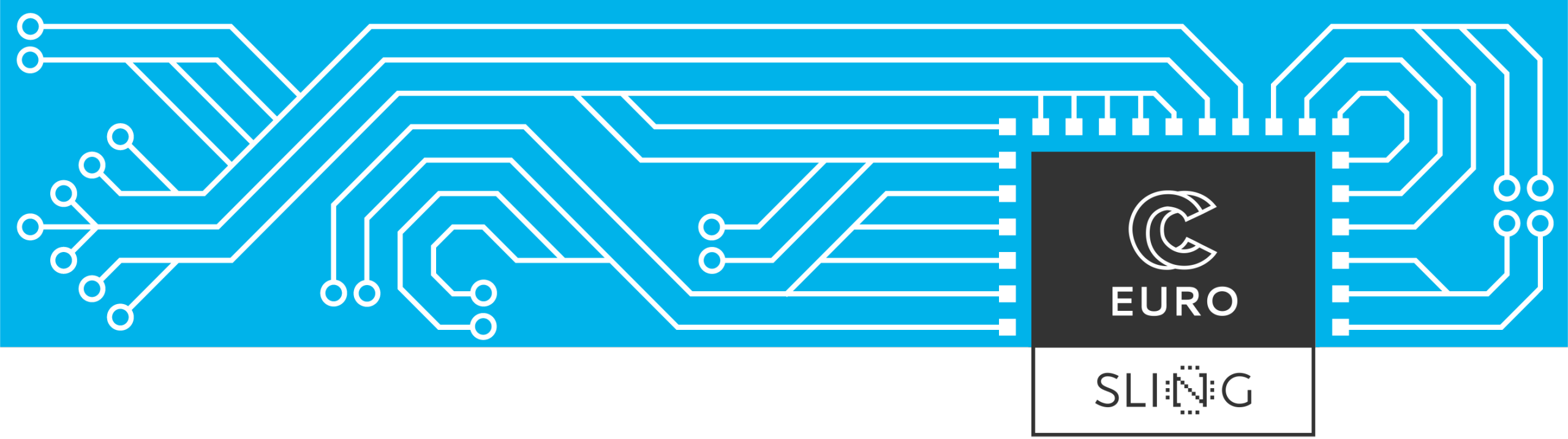
Example 3:

- Open file *raysect_bolometer_signal_calculate_example3.py*. In this script, bolometer camera and a simple plasma is defined.
- Run the script to calculate power arriving at each camera. The script will plot the simple plasma and then calculate power arriving at each foil.
- Try to modify the plot_emission_contour function so that it will also plot the bolometer's lines of sight.
- Take the emission profile from previous example. Define a custom bolometer and calculate signals.

Example 4

Produce realistic image of ITER tokamak.

- Create a new scene and load ITER first wall panels (*first_wall_panels.vtk*). Define its material to beryllium. Define a custom light source and camera. Help yourself with example "*cornell_box.py*" from Raysect documentation.
- Run the case and try to reproduce a realistic image of first wall in ITER tokamak.



EuroHPC Joint Undertaking

REPUBLIC OF SLOVENIA
MINISTRY OF HIGHER EDUCATION, SCIENCE AND INNOVATION

This project has received funding from the European High-Performance Computing Joint Undertaking (JU) under grant agreement No 101101903. The JU receives support from the Digital Europe Programme and Germany, Bulgaria, Austria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Italy, Lithuania, Latvia, Poland, Portugal, Romania, Slovenia, Spain, Sweden, France, Netherlands, Belgium, Luxembourg, Slovakia, Norway, Türkiye, Republic of North Macedonia, Iceland, Montenegro, Serbia.