

Solaris MkII – Engine Annotation

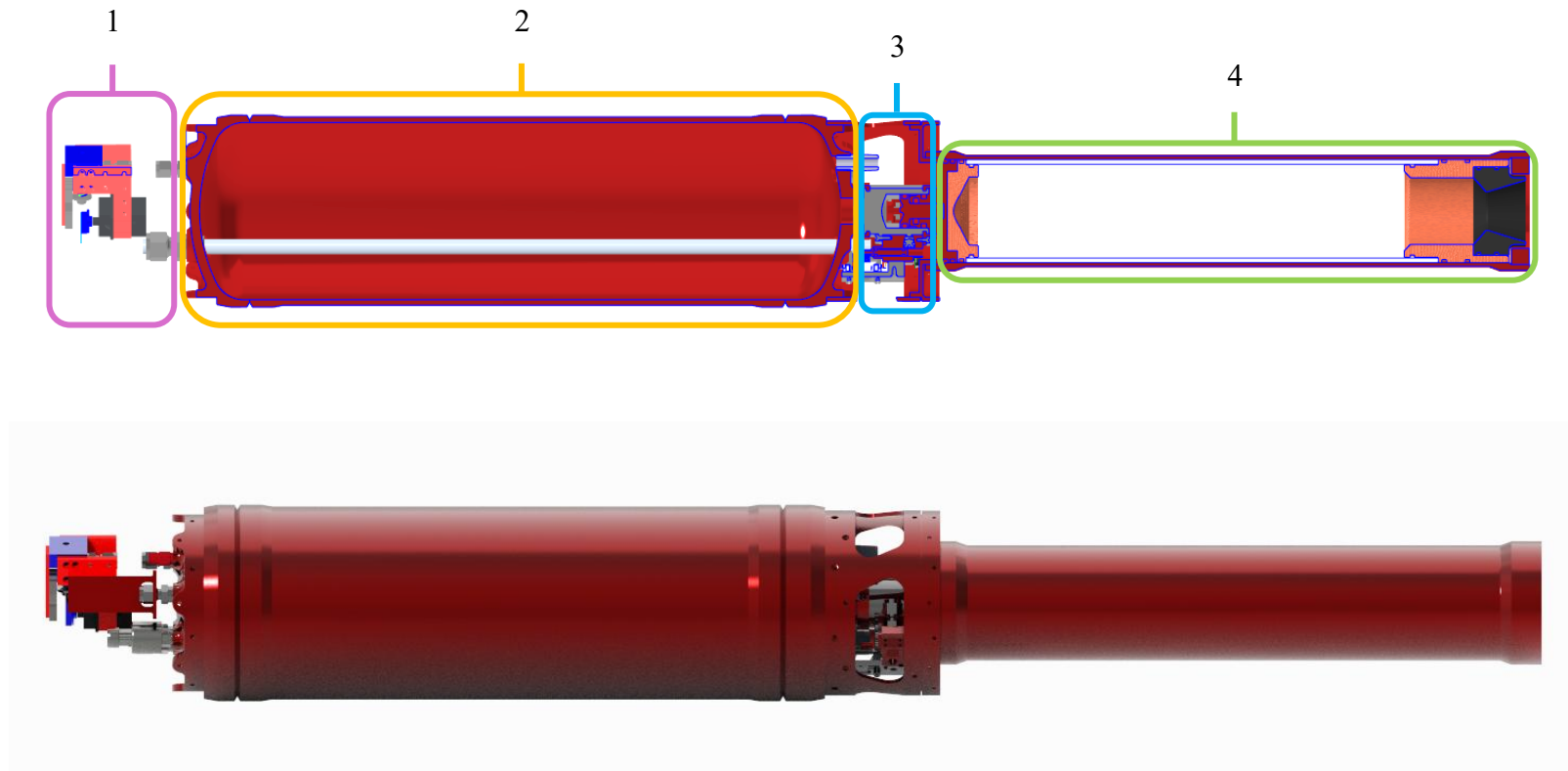


Figure 1: Cross-section and full length view of Solaris MkII

There are 4 main areas across the engine as seen in figure 1:

1. Top bulkhead
2. Tank
3. Valve assembly
4. Combustion chamber

1. At the top of the tank there is several auxiliary systems attached to the tank with $\frac{1}{4}$ inch BSPT fittings or in the case of the SPRV a $\frac{1}{8}$ inch BSPP fitting. Each of these systems are annotated in figure 2.
 - a. Notably, the active vent is located here and attaches directly to the tank where there is a $\frac{1}{16}$ inch brass tube that dips down to a specified height. This exists in case some of our automated systems fail so we can visually see a vent and know our approximate mass in the tank. The active vent uses a cam mechanism with a piston to create a simple valve to close and open vent. The cam is resisted by a spring which allows for a fail open if the servo loses power.
 - b. Our capacitive fill sensor is also located on the top bulkhead which measures capacitance between two concentric aluminium tubes which changes as the nitrous oxide level rises.
 - c. A pressure transducer and SPRV also sit on the top bulkhead.
 - d. Motor Controller top board and the capacitive fill sensor PCB are also secured to the top bulkhead where the top board can communicate to the bottom board with an electrical pass through inside the tank and into system 3.

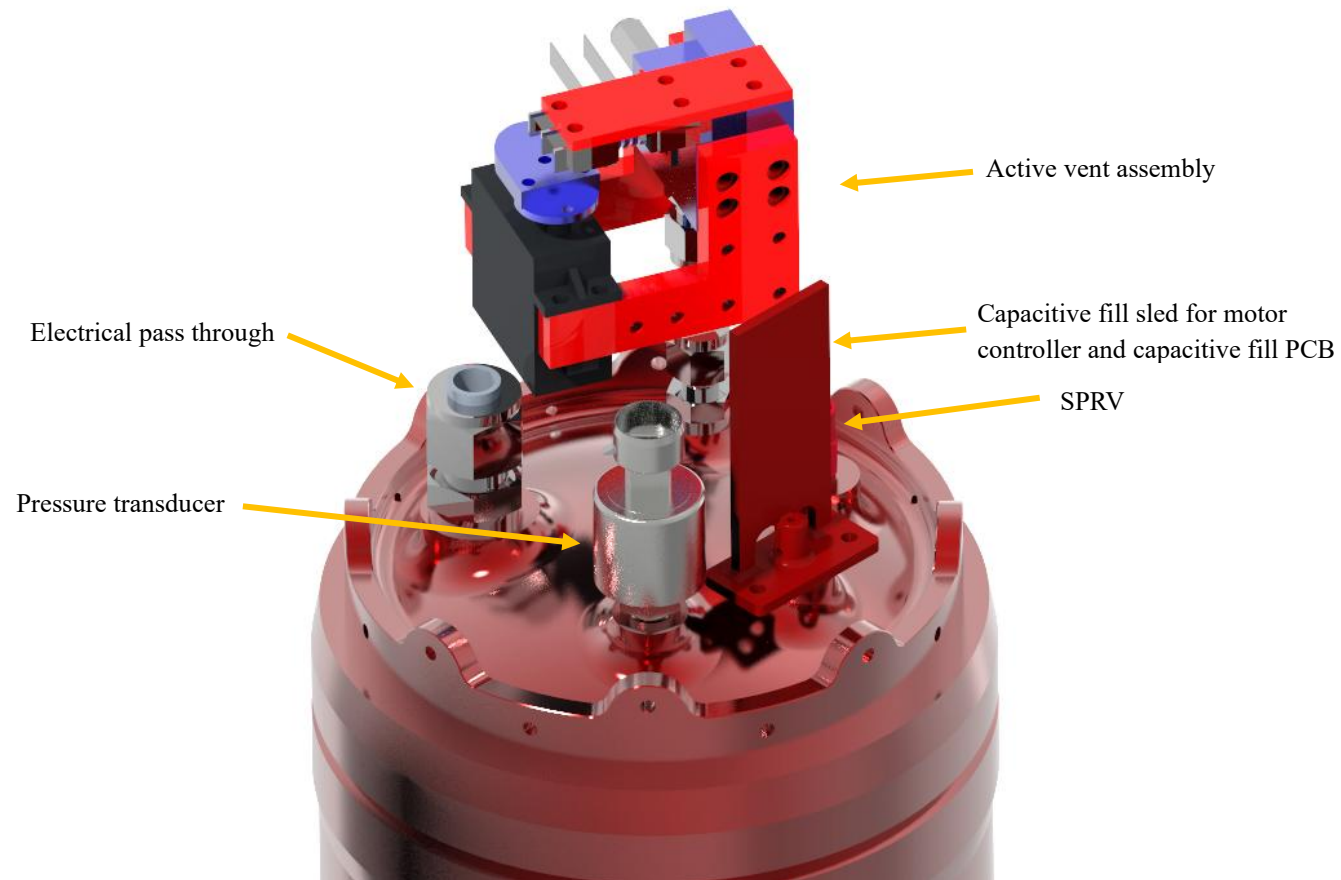


Figure 2: Annotated view of the tank top bulkhead

2. The tank is welded with two in house machined bulkheads welded to a 6 inch aluminium tube. The tank is versatile containing several ports on the top and bottom, mostly consisting of standard BSP ports. The tank also has a higher factor of safety around the welds to account for the heat affected zone.

- a. The bulkheads each have “crowns” of radial bolts (two rows of 8 M4 tapped holes) for attaching to the control coupler and rear tube/structural interface. The bulkheads crowns can be seen in figure 2.

3. The valve assembly consists of the teams SRAD concentric pneumatic valve which is controlled by our pilot valve. The valve uses nitrous oxide tap off from the tank to pressurise the underside of the piston which due to unequal area allows the piston to remain sealed closed (up) and prevent nitrous oxide from being released as per figure 4.2. When it is time to ignite the pilot valve actuates (figure 4.1) and vents the nitrous oxide pressurising the underside of the piston and the piston is then forced down and the nitrous oxide is released to the combustion chamber.
 - a. The structural interfaces shown in figure 3 is how Solaris MkII transfers its thrust through the combustion chamber. The adapter threads onto the combustion chamber and compresses the forward closure to ensure the chamber is sealed internally whilst also preloading itself to allow for the load path to go through the structural interface. The structural interface ring fits onto to the adapter and then they are both bolted to the rear tube and the top of the structural interface ring also bolts to the bottom bulkhead, this configuration takes all thrust loading off the fluid lines which is desirable.

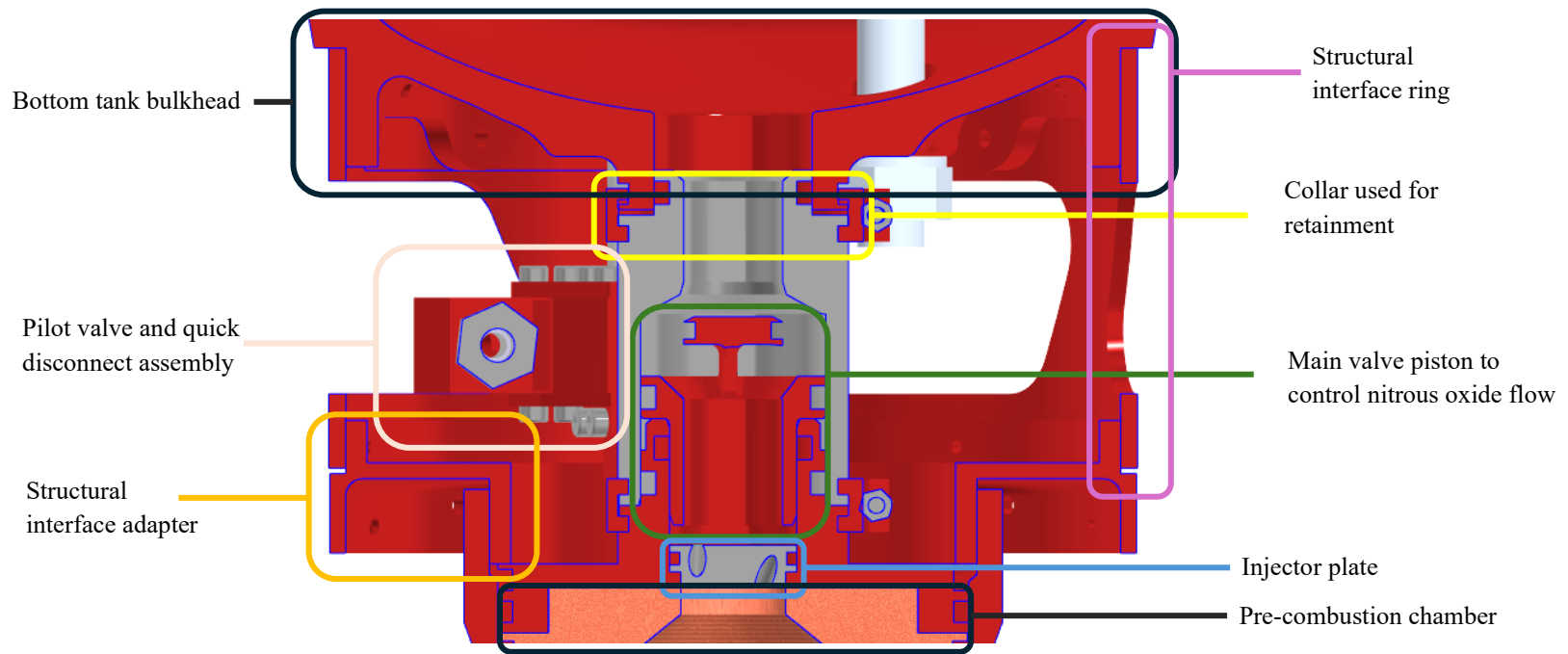


Figure 3: Annotated cross-section view of valve assembly

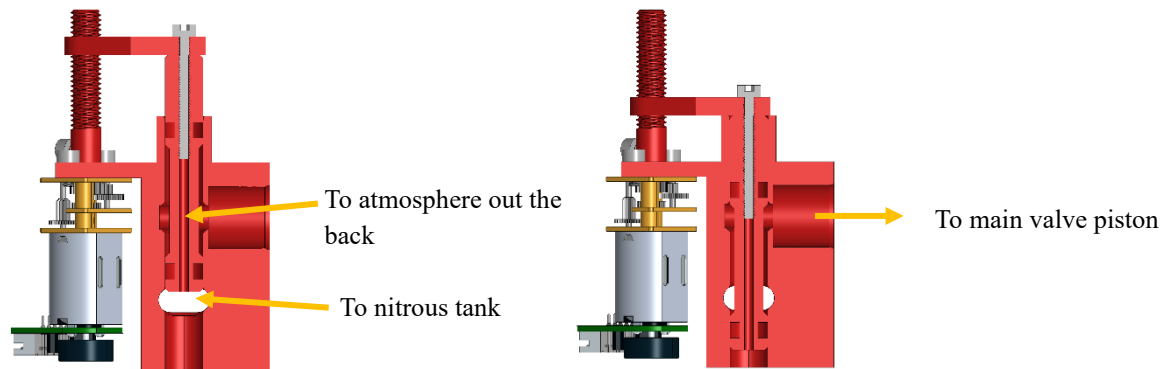


Figure 4.1: Pilot valve in "vent" state

Figure 4.2: Pilot valve in "fill" state

- a. The quick disconnect functions by having an external SRAD piece that inserts into the quick disconnect box (figure 5), the nitrous flows through the internals and to the onboard tank as well as to the main valve. It is attached to this assembly with fishing line that is burnt through by e-matches when desired. When the e-matches are burnt through the quick disconnect is pushed out of the quick disconnect box by pressure and the black piston (figure 5) is pushed by pressure and a spring to seal the exit port when the quick disconnect exits the body.

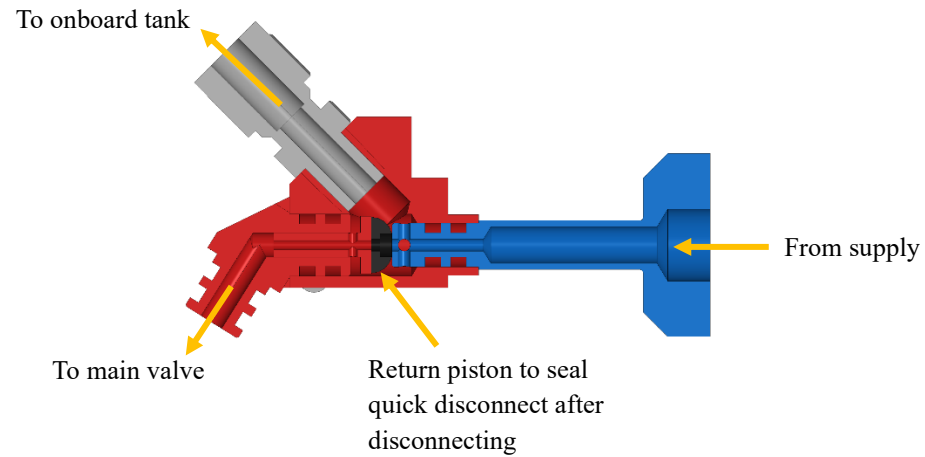


Figure 5: Annotated top-down cross-section of the quick disconnect assembly

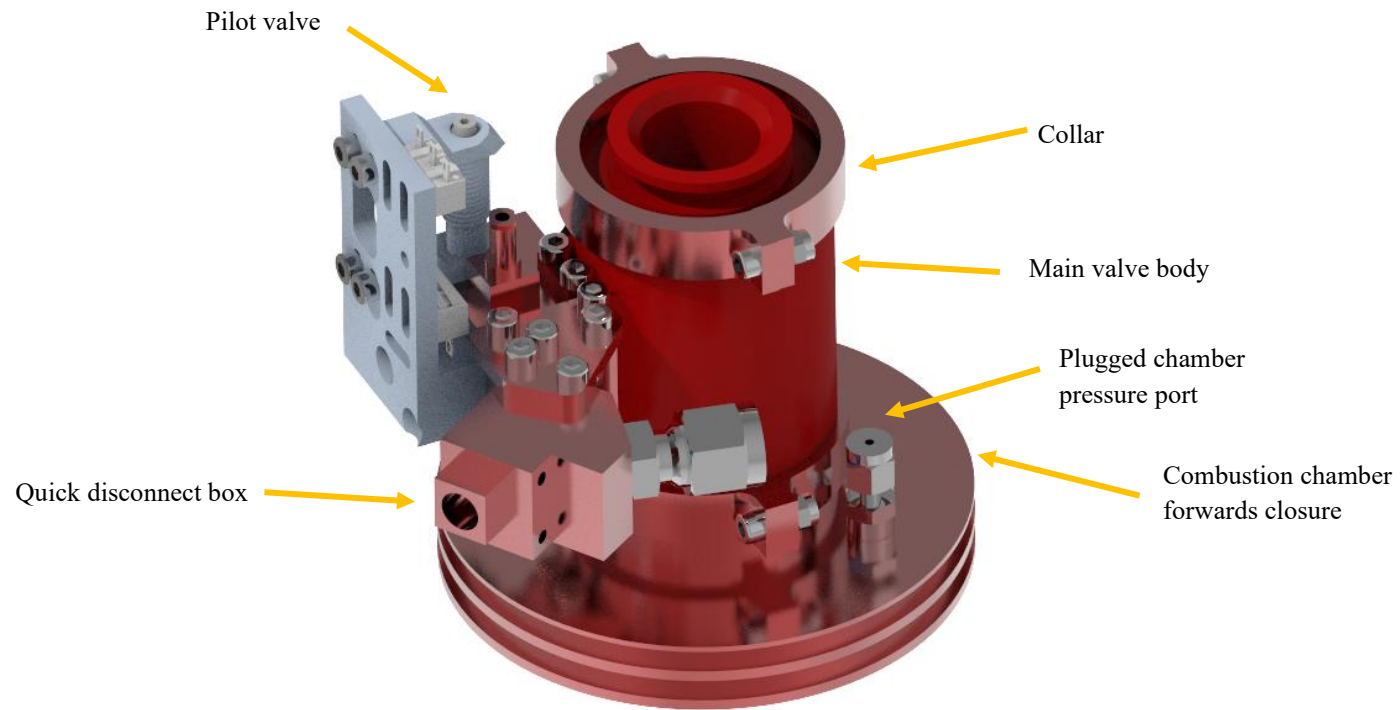


Figure 6: Annotated view of the valve assembly

4. The combustion chamber is made from turned aluminium tube and contains everything from our pre-combustion chamber to our nozzle. The length was determined based on desired O/F ratio and clearance for various other internals and the diameter was chosen for a standard 4 inch air frame for first iterations and was maintained as it provided the right amount of fuel grain for the impulse we require for IREC 2025.

- a. For retainment this combustion chamber features threaded closures. The aft section is retained by a ring shown in figure 7, the forward section is retained by our structural interface adapter which features the same thread and adapts from 4 inch to 6 inch to be integrated with the tank.
- b. The pre and post combustion chambers are both manufactured from phenolic billet. The pre-combustion chamber serves as protection for the forward closure and any otherwise exposed aluminium while the post-combustion chamber is present to improve performance and create a sleeve for the graphite nozzle.
- c. The fuel grain used is a cylindrical fuel grain made from 3D printed ABS with a gyroidal infill with paraffin wax poured in. This provides strength to the paraffin wax while sacrificing little performance as the ABS is a fuel grain in and of itself. The liner is crafted from fire retardant PVC tube for its low cost and strong compatibility with our setup geometrically.
- d. The graphite nozzle provides excellent thermal and abrasion resistance and from our tests have shown little wear of many test fires. They are housed in a phenolic sleeve to prevent heat transfer into the aluminium wall.

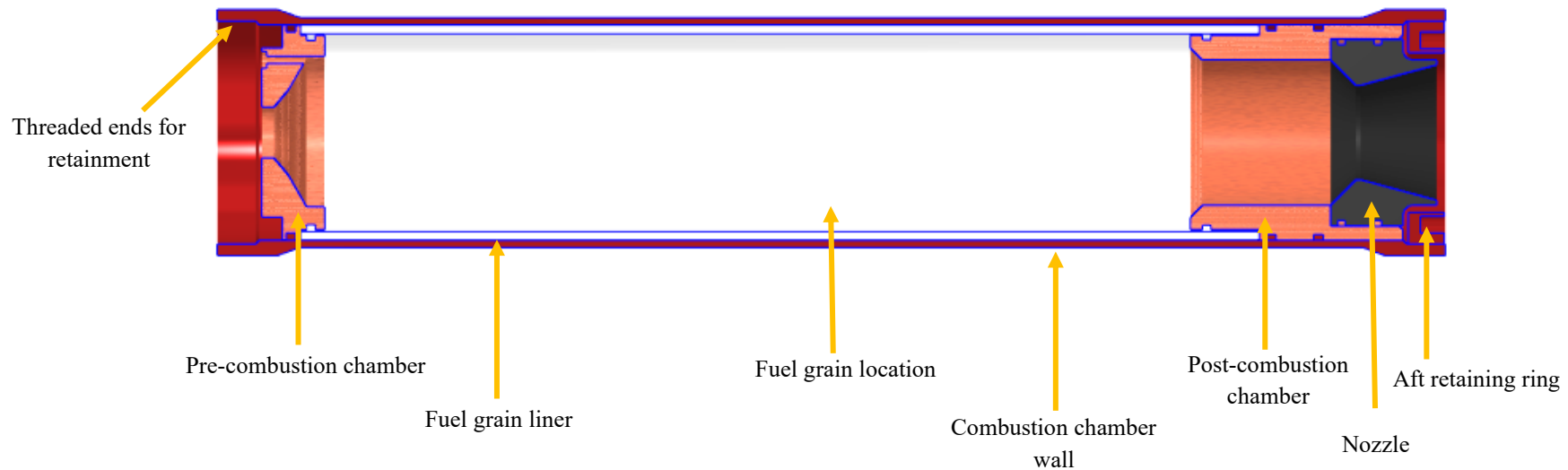


Figure 7: Annotated cross-section view of the combustion chamber