Tender for construction of the load-assembly of the MULTI-PINCH/PROTO-SPHERA experiment

The Euratom-ENEA Association undertakes a research action in the field of Spherical Tokamaks, within the framework of a collaboration with the Euratom-UKAEA association. Such a collaboration includes the exchange of personnel and the building of a small experiment (MULTI-PINCH/PROTO-SPHERA), to be installed in Frascati using the vacuum vessel of the START experiment, already trasferred from Culham to Frascati.

The PROTO-SPHERA system, proposed at CR-ENEA Frascati, is a simply connected magnetic configuration, composed by a spherical tokamak (ST, with closed flux surfaces and toroidal plasma current $I_{ST}$) and by a Hydrogen plasma arc, in the form of a screw pinch fed by electrodes (SP, with open flux surfaces and plasma electrode current $I_e$). The screw pinch plasma will be magnetically shaped as a disk near each ring electrode. The low voltage ($\approx 200$ V) electrodes will be the most unconventional items of PROTO-SPHERA. They have been designed as modular, being composed by a large number of elementary tubes ($\approx 600$ hollow gas puffed anode modules) and of wound filaments ($\approx 400$ directly heated cathode modules). In PROTO-SPHERA the screw pinch will replace the central conductor of a spherical tokamak. The SP will carry an electrode plasma current $I_e=60 \text{ kA}$ and will produce an elongated ($b/a\approx 2.2-2.3$) spherical torus of midplane diameter $2R_{sph}\approx 70 \text{ cm}$, aspect ratio $A\approx 1.2-1.3$, driving a toroidal current $I_{ST}=120-240 \text{ kA}$.

The preliminary PROTO-PINCH electrodes testbench has demonstrated the feasibility of the single electrode modules in a simplified axial geometry, however, in order to clarify the breakdown conditions and the stability of the plasma discs near the ring electrodes before the formation of the Spherical Torus, the MULTI-PINCH test-bench has been designed as a reduced setup of the PROTO-SPHERA experiment. MULTI-PINCH will explore the breakdown conditions and the pinch stability needed for the first phase of the PROTO-SPHERA discharge ($I_e\leq 8.5 \text{ kA}$), in presence of the poloidal field (PF) shaping coils alone and therefore in absence of the spherical torus. The MULTI-PINCH cathode will be the final PROTO-SPHERA cathode, but only partially filled with Tungsten emitting filaments (54 Vs. 378). MULTI-PINCH is just an initial load assembly of PROTO-SPHERA: when its aims will have been achieved, the final PROTO-SPHERA experiment will be integrated adding the remaining PF compression coils.

The START spherical tokamak has been transferred to Frascati (May 2004) and disassembled (October 2004). The START cylindrical vacuum vessel (2.0 m in diameter), slightly extended in the vertical direction to 2.5 m, will contain the load-assembly of MULTI-PINCH/PROTO-SPHERA. In the year 2005 the constructive design of the PF shaping coils has been completed with Ansaldo Superconduttori and at the beginning of 2006 the construction has started. The construction is progressing on schedule and therefore the PF shaping coils should be ready for March 2007. The thermomechanical and electrotechnical broad design of MULTI-PINCH has been completed inside CR-ENEA Frascati: therefore the remaining load-assembly (electrodes, internal support structure, internal and external electrodes feeding conductors, vessel support legs and cathode assembly/disassembly equipment) can be built in about 18 months, including 9 months of detailed constructive design by the building firm. The MULTI-PINCH/PROTO-SPHERA experiment can therefore be ready in a short time, such as to fill a possible gap between the FTU experiment and a next ENEA middle-large sized tokamak.
It is therefore necessary to start up the tender procedure for building the remaining parts of the MULTI-PINCH load assembly.

The parts to be built for the load assembly are in more detail:

- The two extensions and leads of the vacuum vessel.
- The internal supports of the coils and electrodes, including all required insulations.
- The anode.
- The cathode, with the exception of the emitting filaments that are directly built by ENEA.
- The two conductor systems (internal to the vacuum vessel) for feeding the two electrodes and the conductors (external to the vessel) that return the current to the coaxial power supply cable.
- The external support legs of the vacuum vessel and the equipment for assembly/disassembly of the cathode from below the machine.

As already mentioned, the PF shaping coils have already been tendered and are being built: the full compatibility of the remaining parts of the load-assembly with such PF coils is the first main critical requirement for the present tender.

The second requirement is that all the internal load-assembly components should be compatible with a vacuum base pressure of \( \sim 10^{-7} \) mbar.

The third requirement is dictated by the 3D complexity of the apparatus and the need of guaranteeing a simple assembly/disassembly of the experiment: the firms interested in this tender should own a CAD CATIA V5R15 licence (the same in use at CR-ENEA Frascati) and should develop all the detailed constructive design with such a tool. This requirement will first allow an optimal transfer of the thermomechanical and electrotechnical broad design of MULTI-PINCH, developed by CR-ENEA Frascati, to the contracting firm; later it will permit an on-line check of the detailed constructive design of the contracting firm by CR-ENEA Frascati.