ESTHER: A laser-ignited, combustion-driven, two-stage shock-tube for the simulation of hyperbolic planetary entries

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A new shock-tube facility is being developed by an international consortium led by IST-IPFN, under funding from the European Space Agency. This facility encompasses several key innovations which allows reaching almost unparalleled performance (being capable of shock-speeds above 12km/s) alongside with improved repeatability and cleanliness specifications, made possible by the development of a laser-driven "clean" H2/He/O2 combustion driver, a technology that has been implemented for the first time in a shock-tube facility. A scale test model has been developed to validate this concept, and has allowed reaching successful deflagrations of mixtures up to 100bar filling pressures, for a final combustion pressure in excess of 600bar. Careful tailoring of the gas mixture has allowed avoiding the outset of detonations, providing a very reliable and repeatable proof-of-concept setup for the ESTHER driver section.

1. Outline

An 1064nm Nd:Yag laser has been deployed on the ESTHER test bombe, with the testing of several dilution ratios from He (from 50% to about 80%) and with lean and rich mixtures. The obtained pressure signals (see Fig. 1) have shown that an He dilution around 70% with a lean (O2 rich mixture) allow avoiding the outset of detonation, leading to smooth and repeatable pressure rise signals. The validation of this concept will allow deploying it on the final combustion chamber of the ESTHER facility (see Fig. 2).

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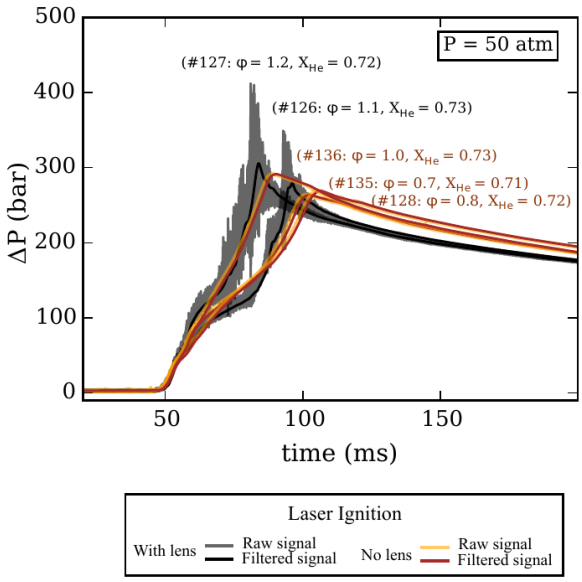

Fig.1: sample pressure signals from laser-ignited shots

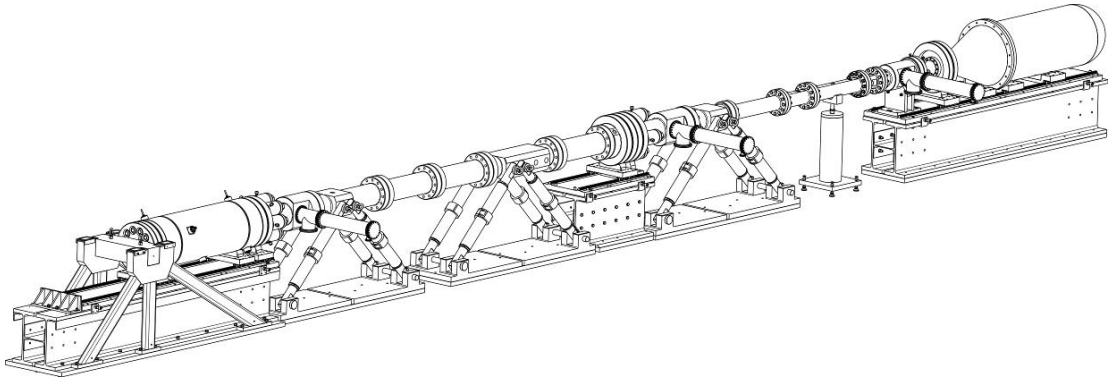

Fig.2: outline view of the ESTHER shock-tube