

## AN EUROPEAN NEED FOR A NEW SHOCK-TUBE FACILITY

- ▶ Shock-Tubes are the facilities which are able to reproduce the conditions of a spacecraft atmospheric entry with them ost fidelity.
- ▶ They are essential for ensuring the independence of a country or a country block regarding access to Space.
- ▶ Europe had a dedicated Shock-Tube facility developed in the early nineties (TCM2 Facility at Université de Provence, Marseilles) in the scope of the European Space Agency (ESA) HERMES program, abandoned since.
- ▶ The TCM2 facility has been decomissionned in 2006, leading to a stop of the shock-tube reentry activities in Europe.
- ▶ Since then, European independence in the field has been compromised, and European research teams (IPFN and U. Provence) have been conducting research in Moscow, Russia, in the MIPT VUT-1 shock-tube.
- ▶ The European Space Agency, wishing to regain independence in access to space, launched a competitive tender of 1ME, which was won by a consortium led by IPFN.
- ▶ **The development of such a facility, located in Portugal, represents a major achievement for the country, at the time of its 10th birthday of ESA membership, and is a recognition of the excellence of the research conducted by IST and IPFN.**
- ▶ **The ESTHER facility will be the largest laboratory dedicated to Space research in Portugal**
- ▶ The ESTHER shock-tube is to be deployed in the Taguspark campus of IST, operated by IPFN.



Figure: HERMES Spacecraft

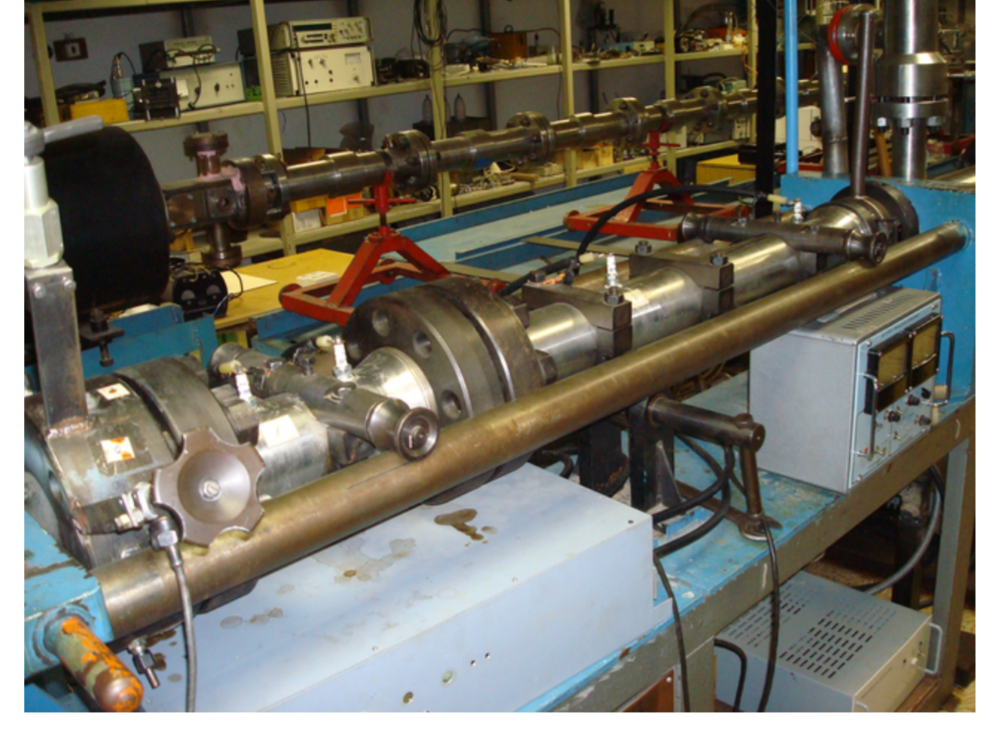


Figure: VUT-1 Shock-Tube located in the Moscow Institute for Physics and Technology

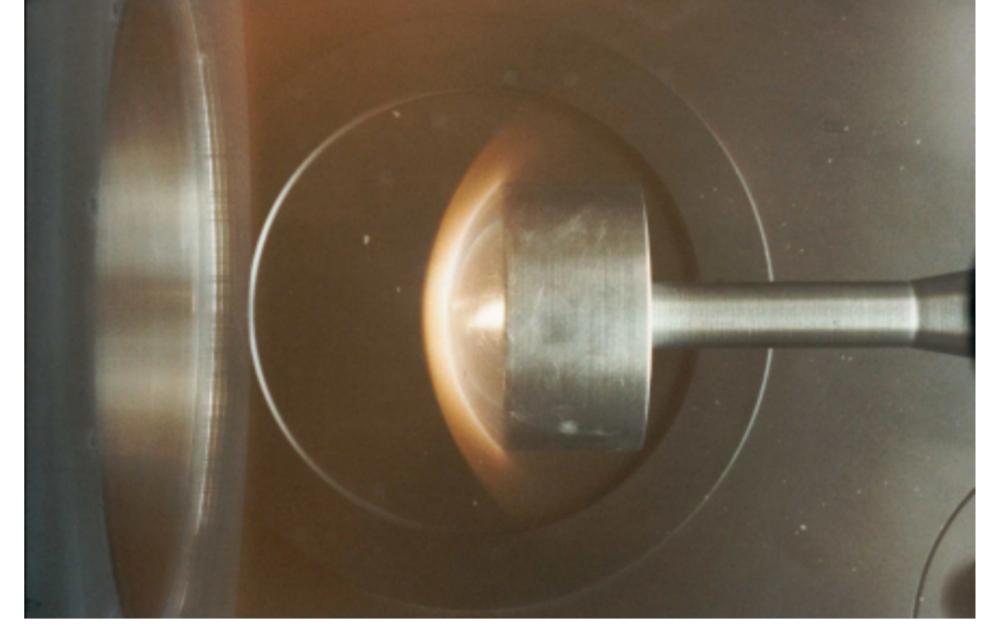


Figure: Experiment in the TCM2 Shock-Tube ©Université de Provence

## PARTICIPANTS OF THE PROJECT

- ▶ **Instituto de Plasmas e Fusão Nuclear, Lisboa, Portugal:** Prime contractor of the activity. Tasked with the development of the new laboratory where the facility is to be installed, and tasked with the development of the associated team and diagnostics. Coordinator of the activity.
- ▶ **Université de Provence, Marseille, France:** Previously operated the TCM2 shock-tube facility, and are providing the engineering plan for the new facility. Charge with the procurement of the shock-tube parts with the manufacturers.
- ▶ **Fluid Gravity Eng., Ermsworth, UK:** Leading British company in the domain of Aerothermodynamics. Tasked with the prevision of the performance of the new facility, payment to manufacturers, and development of software for the hydrodynamic simulation of shocked flows.
- ▶ **Instituto de soldadura e Qualidade, Oeiras, Portugal:** In charge of the security and quality management plan of the future laboratory. Tasked with the integration of the facility in its new location.
- ▶ **Ingénierie Systèmes Avancés, Bordeaux, France:** Survey of research and operational procedures in different international Shock-tube Laboratories.
- ▶ **Moscow Institute for Physics and Technology, Moscow, Russia.** Tasked with a concurrent shock-tube validation campaign, where shocks simulated in the MIPT VUT-a facility are to be compared against equivalent shocks produced in the ESTHER facility.
- ▶ **Shock Waves Laboratory, Aachen, Germany.** Consultants to the project. Development of Pressure gauges for the new facility
- ▶ **University of Manchester, Manchester, UK.** Consultants to the project.
- ▶ **Université Paris VI and Université Blaise Pascal, Paris and Clermont-Férrand, France.** Consultants to the project regarding spectroscopic techniques.



## A NEW GENERATION SHOCK-TUBE FACILITY FOR ATMOSPHERIC ENTRY STUDIES

- ▶ The ESTHER shock-tube will be capable of reproducing shockwaves for velocities raging from 3 to 11km/s, for pressures from 1 to 1000Pa.
- ▶ Outline concept: Rupture of a diaphragm separating a high-pressure and a low pressure gas reservoir leads to the discharge of the high pressure driver gas towards the low pressure gas, leading to the formation of a shockwave, whose speed depends on the pressure differential.
- ▶ High-pressure gas produced by the deflagration of a  $H_2-O_2-He$  stoichiometric mixture in a combustion chamber.
- ▶ Low-pressure gas can be either air,  $CO_2-N_2$ ,  $N_2-CH_4$ , or  $H_2-He$ , simulating the atmospheric composition of different planets (respectively Earth, Mars/Venus, Titan, or Jupiter/Saturn).
- ▶ The shock-tube allows for future extensions: Addition of an expansion tube would potentially lead to higher shock speeds ( $\approx 14km/s$ ). This capability would answer to future request for the support of ESA missions regarding high-speed hyperbolic entries (moon and Mars return, gas giants entries, etc...).

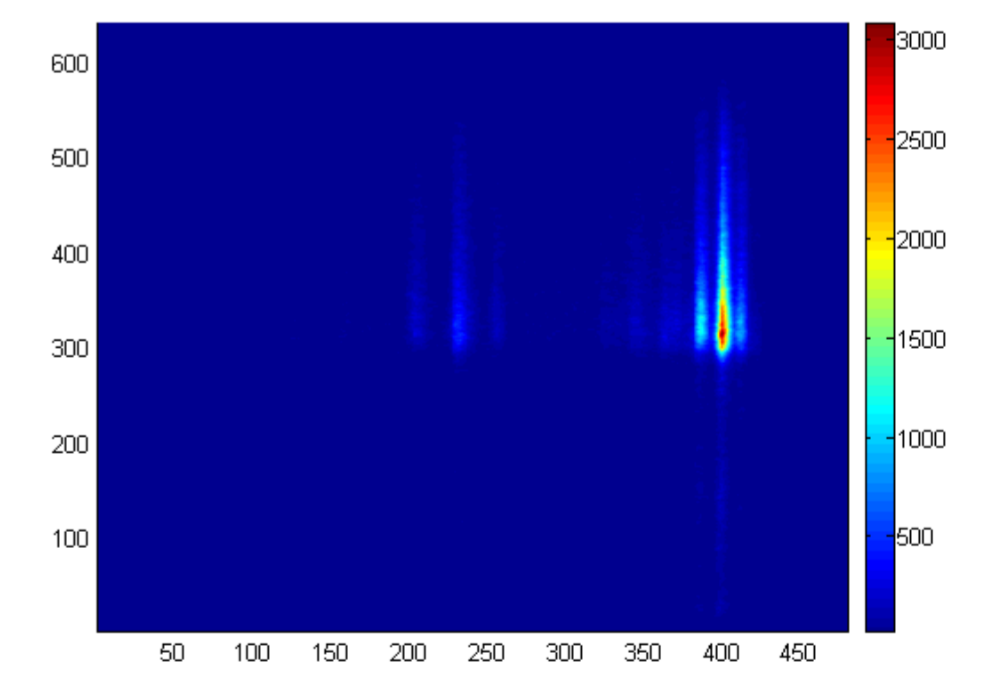


Figure: Streak image of the CN Violet system radiation (VUT-1 shock-tube)

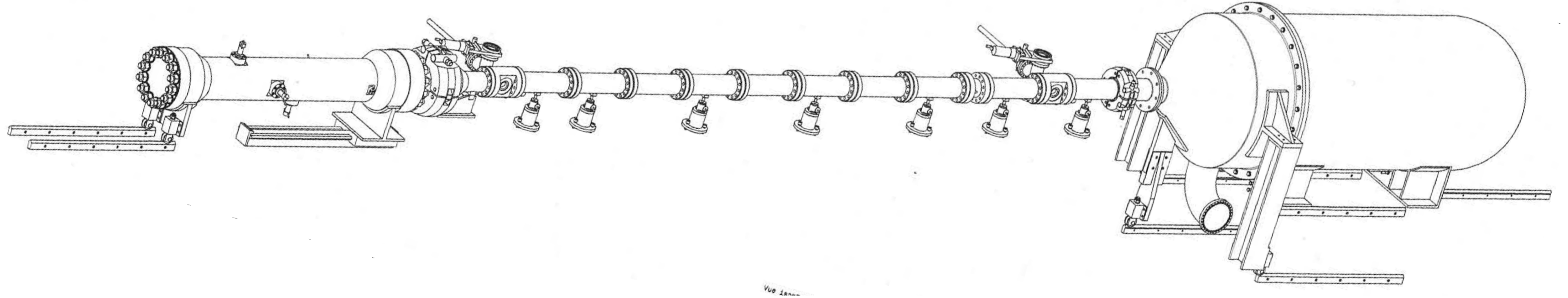


Figure: Project for the Proposed New Generation Kinetic Shock Tube for Atmospheric Entries Research