Microtarget Requirements, Production and Delivery for HiPER

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Abstract. HiPER - the proposed European laser-driven fusion facility [1] – has received initial funding. An overview of the current status of the Targetry work package (WP11) is given. Baseline microtarget designs and other delivery parameters are discussed. Activities within the Targetry work package are outlined and specific contributions from work package partners are identified, especially those relating to high repetition rate, cryogenics and injection systems.

1. Introduction to HiPER

HiPER will be a European laser-driven fusion demonstration reactor facility (figure 1) in which fast ignition (in its different approaches) can be studied. Although HiPER will enable many novel (non-IFE) experiments to be performed (and an extensive experimental strategy is being developed) the main goal of HiPER will be to study the physics and technology of laser-driven fusion as a basis for commercial IFE reactors.

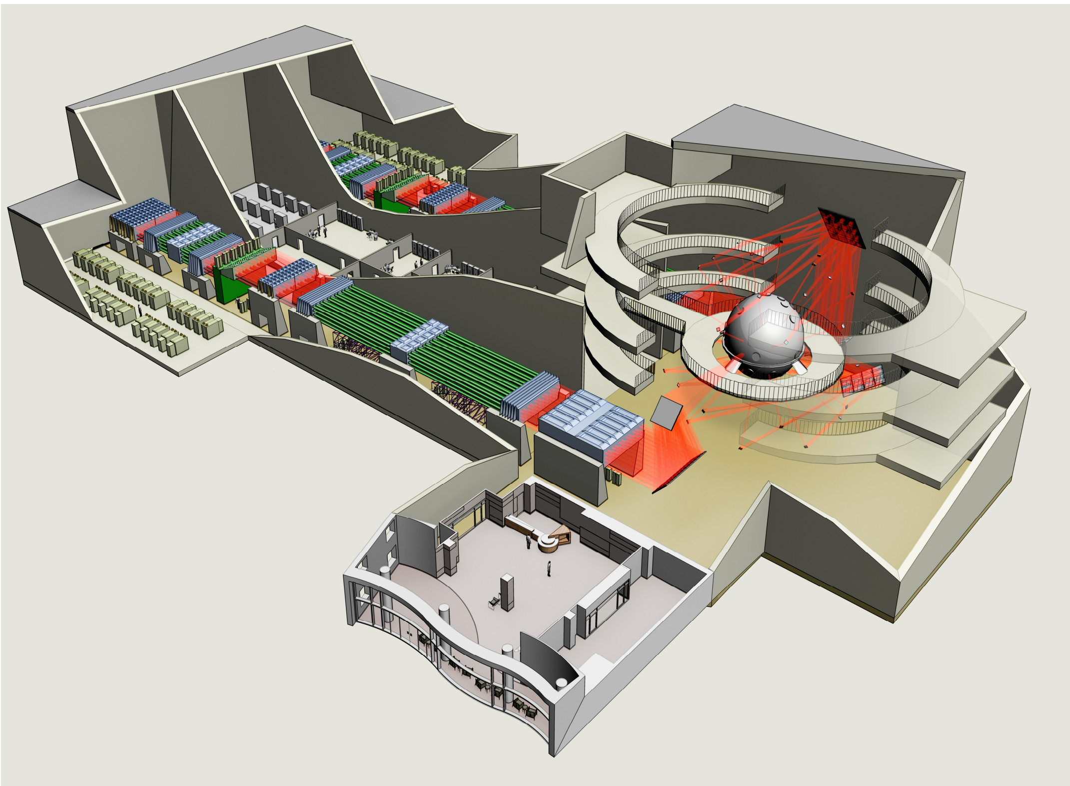

FIG 1. Conceptual design diagram of HiPER.

At the time of writing this paper the preparatory phase has begun and it will end with the submission (in early 2011) of a proposal detailing specifications for the build phase. (See Figure 2 for project timeline.) As well as laser target chamber(s) and facility specifications a range of potential operational regimes will be proposed.

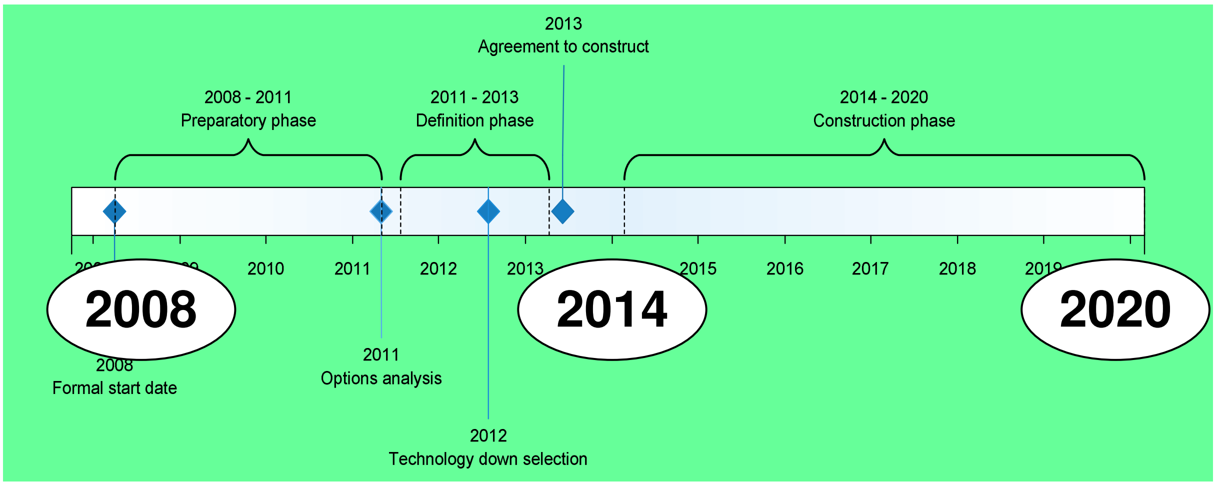

FIG 2. Project timeline for HiPER.

2. HiPER Targetry

The HiPER program will require a wide range of high energy density solid targets for which both manufacturing and delivery to the interaction chamber present a range of technical challenges. High gain IFE targets will be of central interest. Such targets will almost certainly have a thin-walled microballoon component with an internal layer of solid deuterium or deuterium/tritium ice. For some targets the layer may be carried on foam (particularly to increase target efficiency). Also many of the targets will have a cone inserted through the side of the microballoon (see section 2.1). It is likely that most experiments for electron or proton transport will not require the ice layer, however, cryogenic targets will probably need to be increasingly fielded as the experimental campaigns progress. The range of target types encompass varying levels of risk and it is very important for IFE technology to gain experience in a suitable range of production and injection techniques to enable the manufacture of high quality, fully characterised targets.

A key issue in HiPER will be to assess the targetry requirements for IFE high gain high repetition rate scale-up. Such targets will have the same general features as single shot targets but the emphasis will be on demonstrating high number scale-up capabilities. Mass-production, injection and tracking will be studied as they are the key points for presenting laser-driven fusion as a realistic option for commercial energy production. Tritium handling procedures will also be required.

HiPER will also need the capability to fabricate targets for a wide range of science programs. Such targets will encompass a wide range of morphologies and materials including multi-component targets and multi-element target clusters. Targets will also provide experimental data on the interdependence of a range of parameters used by IFE target designers to specify viable high yield targets.

Additionally, the target fabrication activity will be enhanced by fundamental research in new advanced materials utilising both modelling and materials experiments.

An important issue, critical for some aspects of chamber design, is an understanding of the effects caused in the chamber by target ignition (for example from debris, shrapnel, and radiation). Again results from such studies will iteratively inform both target and chamber design.

Characterisation applicable to both R&D and production is an integral part of the project and areas which may require innovation will be examined.

2.1. Baseline Target Designs

There are currently two main types of high gain target being considered, namely a) cone + shell [2,3] (see figure 3) and b) shock ignition (see figure 4). Although current designs are given in figures 3 and 4 it is anticipated that throughout the lifetime of the project iteration with other workpackages, especially Modelling (WP9) and Experimental (WP10) will refine and extend target specifications.

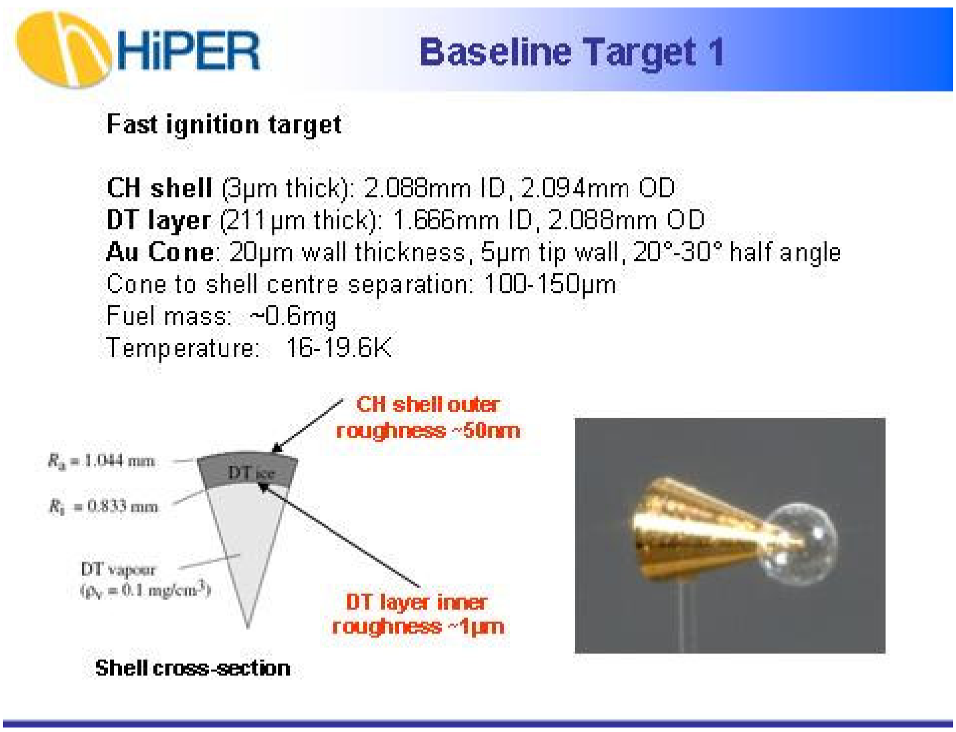

FIG. 3. Baseline cone + shell target for HiPER.

HiPER **Baseline Target 2**

Shock ignition target

CH shell (3µm thick): 2.040mm OD
Foam + DT layer (70µm thick)
DT layer (120µm thick)

CH shell outer roughness ~50nm

DT layer inner roughness ~1µm

Mat	R_{int}(µm)	Δr(µm)	R_{ext}(µm)	ρ_0
DT	0	830	830	1.e-4
DT	830	120	950	0.253
$CH(DT)_6$	950	70	1020	0.364
CH	1020	3	1023	1.05

FIG. 4. Baseline shell targets for HiPER.

2.2. Activities within the Targetry work package of HiPER

Extensive discussions between partners in the Targetry work package in the period preceding preparatory phase commencement identified key technical challenges. In essence the main challenges are: cost-effective target production for high rep rate; target injection, tracking and engagement; cryogenic targetry; and tritiated targets. A summary version of the subtasks in the form of a table of deliverables is shown in figure 5.

HiPER **WP11 (Targetry) Deliverables**

11.1	Structure and procedures for Targetry activities within HiPER
11.2	Input realistic targetry constraints to the HiPER point design model (WP9) and specify target production techniques
11.3	Cost effective High rep-rate target production techniques – requirements analysis and proposed solutions (including initial prototyping)
11.4	Requirements analysis for target injection and tracking techniques and proposed solutions
11.5	Roadmap for development of cryogenic DT capability and infrastructure, based on detailed analysis of solutions for single-shot, and outline solutions for high rep-rate
11.6	Advanced New Materials assessment for increased energy efficiency
11.7	Tritium Handling issues and proposed solutions

FIG. 5. Targetry work package deliverables for HiPER.

2.3. Targetry work package partners

There are currently six main partners within WP11, specifically:

- **STFC**: Central Laser Facility, Rutherford Appleton Laboratory, UK
- **CEA**: Commissariat a L'Energie Atomique, Grenoble, France
- **LPI:** Lebedev Physical Institute, Russian Academy of Sciences, Russia
- **GA**: General Atomics Inc, San Diego, CA, US
- **UPM**: Universidad Politecnica de Madrid, Spain
- **TUD**: Technische Universität Darmstadt, Germany

2.4. Targetry work package strategy

To reduce risk and minimize delivery time tasks have been assigned to partners in areas where they already have proven capability, specifically:

- **STFC**: mass production
- **CEA**: cryogenic single shot
- **LPI:** cryogenic shell mass production
- **GA**: injection, tracking and engagement
- **UPM**: advanced target materials
- **TUD**: medium rep rate cryogenic targetry

3. Conclusion

HiPER target production and delivery offers significant challenges and opportunities for innovation. The scope is made more complex by the dynamic nature of the HiPER project arising from simultaneous interdependent activity in many areas, such as experiments and modelling. Furthermore there has to be a balance between risk reduction (for example by considering alternative technologies) and on-time delivery solutions.

Appendix 1: References

[1] http://www.hiper-laser.org/index.asp

[2] R. Kodama et al, Nature **412** (2001) 798

[3] R. Kodama et al, Nature **418** (2002) 933