The Targetry Work-package of HiPER

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Introduction

- On Monday **Mike Dunne** gave a presentation, **“HiPER: the European Path to Laser Fusion and Related Plasma Science”**.

- Madrid 25-26 Oct 2007, Madrid: agree the allocation of budgets and deliverables

- April 08: start of HiPER 3-year preparatory phase project.

- HiPER project is planned to take 10 years.

Deliverables

The Target Fabrication activity of HiPER will:

- Produce most (if not all) of the microtargets for the IFE programme
- Produce most (if not all) of the microtargets for the science programmes
- Demonstrate the feasibility of scale up for all production techniques required for a commercial IFE programme

HiPER Conceptual Design Report

Full text can be found at:
www.hiper-laser.org/index.asp

Section 11 of the report “Target Manufacturing Capability and Delivery” summarises the background and delivery strategy for HiPER Targetry.

The following slides present the main points.

Work package objectives

1) Generate design specifications for all HiPER targets (IFE and experimental). Specifically for IFE targets, examine high gain solutions, including the use of new materials.

2) Assess technical feasibility of producing all target types.

3) Identify risks for target production.

4) Assess European capability to fabricate targets for all HiPER programmes, specifically identifying new infrastructure requirements.

5) Propose structure for target fabrication activity that is maximally integrated with all related work packages (such as modelling), especially to ensure rapid response to changes.

HiPER Target Types

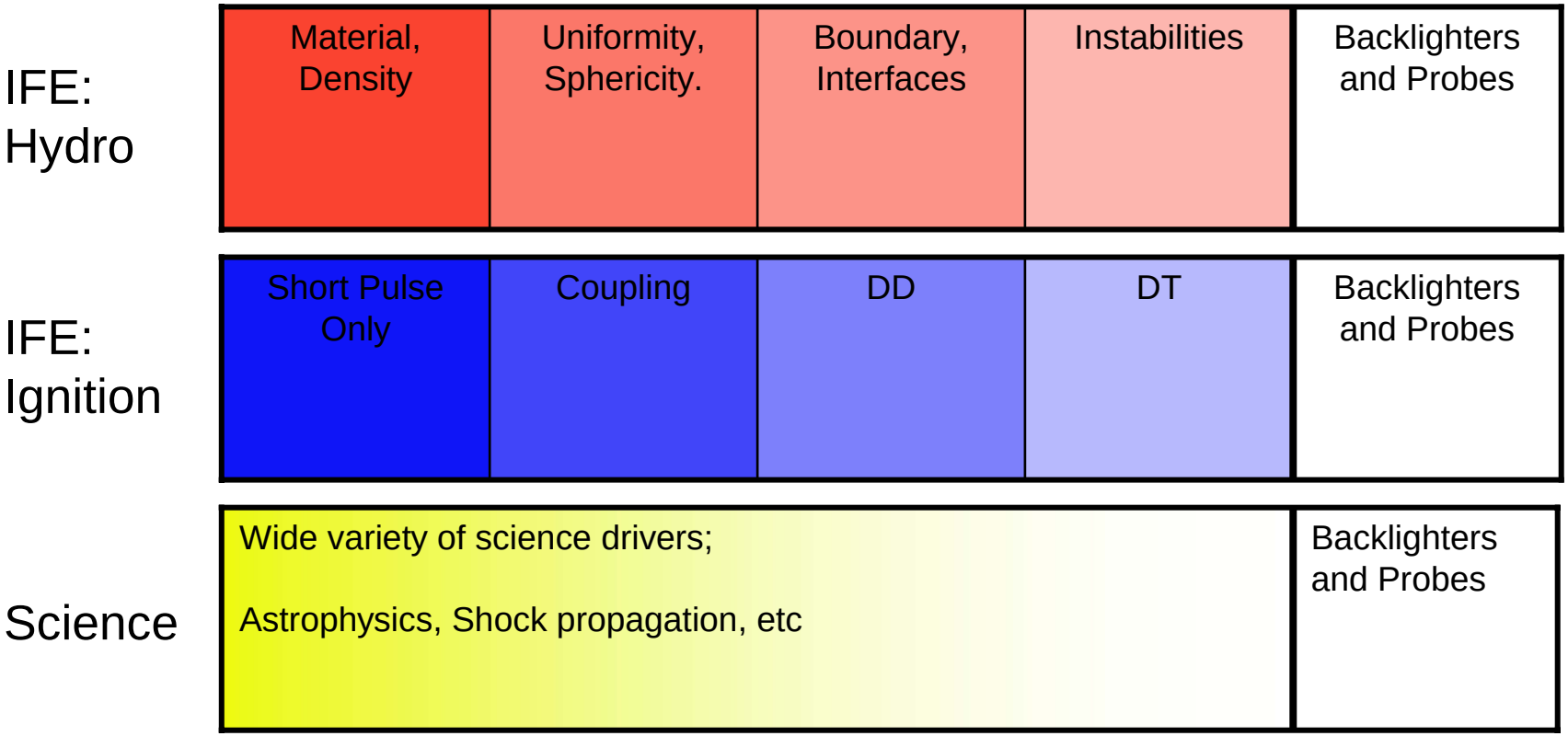
Three generic (overlapping) target types

a) High gain for IFE science,

b) High gain for IFE scale-up to a commercial reactor programme

c) Science programmes.

HiPER Target Types



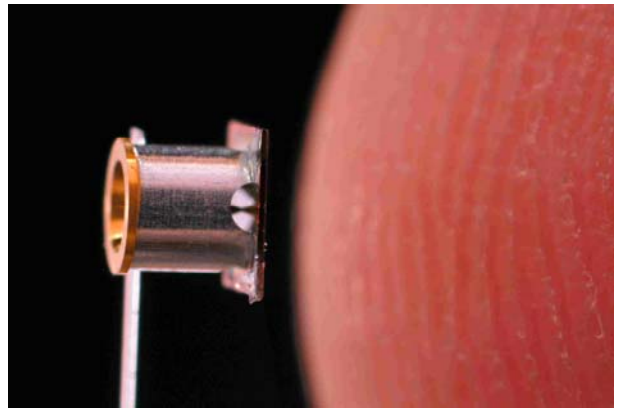
a) High Gain IFE Targets

- Almost certainly have a thin-walled microballoon component with an internal layer of solid deuterium or deuterium/tritium ice (sometimes carried on foam).

- Significant yield improvements anticipated by advances in foam and materials technology

- Many (AFI) targets will have a cone inserted through the side of the microballoon.

- Initial experiments, for example in electron or proton transport, will not require the ice layer, however, cryogenic targets will need to be fielded as the experimental campaigns progress.



b) High Gain IFE Scale-Up Targets

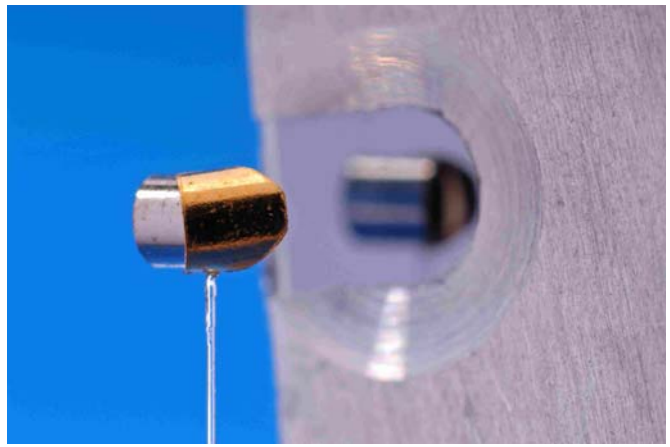
Same general features as type a) but emphasis on:

- Demonstrating high number scale-up capabilities
- Simplifying the physics design
- Relaxing specifications whilst maintaining robust performance.

c) Science Programme Targets

Wide range of types including:

- Multicomponent targets
- Multi-element target clusters
- Targets to establish parameters required for (iteratively) designing target types a) and b).



Target Delivery

Two Main Target Delivery Regimens:

- Single (up to 10 shots per day) using extended LMJ concepts - See **Denis Chatain**, **"Cryogenic System for Inertial Fusion Energy"** (17 Oct)

- High Rep Rate (up to 6Hz continuous delivery for several minutes)

Other Targetry Issues

1) Target Insertion for single shot and high repetition rate operation.

2) Target tracking for high rep rate mode.

3) Characterisation

4) Theoretical and experimental analysis of:

- Target debris
- Shrapnel
- Radiation production

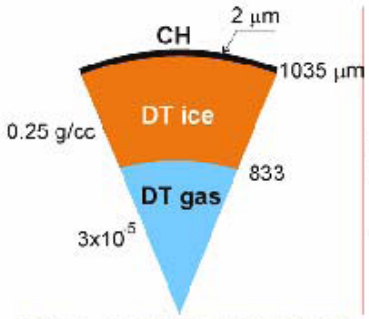
Major Technical Challenges

1	Cryogenic capability
1.1	Cryogenic layering of non-spherical target (solid ice and foam)
1.2	Tritium Handling
1.3	Capsule/cone joint at cryogenic temperatures
1.4	Cryogenic target (transport and) insertion
2	New/novel materials
3	Capsule and cone production
4	Metrology
5	High number scale-up
6	Modelling of materials and processes to inform fabrication
7	Target design/positioning to reduce debris
8	Range of targets for science programmes

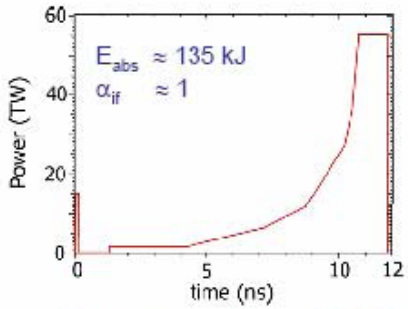
Established (but challenging) technology
Technology requiring significant innovation for HiPER

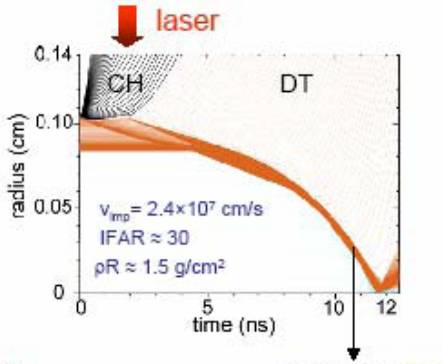
Baseline IFE Target #1

Target implosion and compression



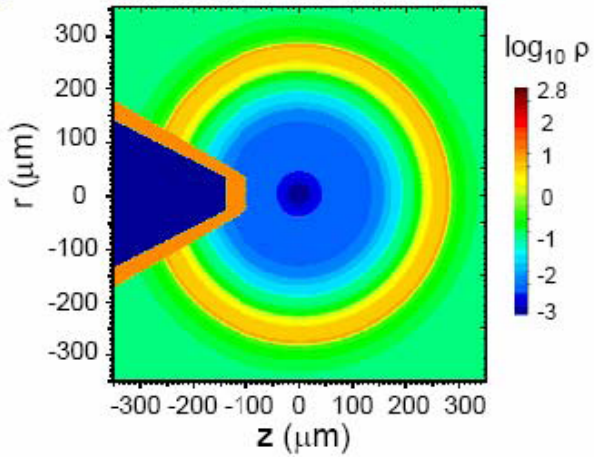
Betti et al., PoP **13**, 100703 (2006)
Atzeni et al., EPS Rome 2006



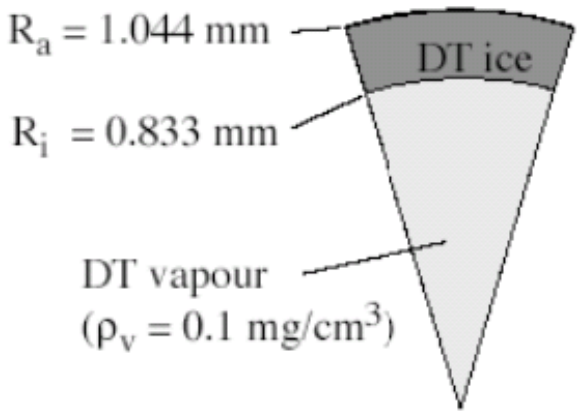


remapping 2D
10% P_1

Cone half-angle = 30°
ρR_{max} = 1.7 g/cm²
ρ_{max} = 660 g/cm³
$m_{\rho>200\ g/cm^3}$ = 0.1 mg (40%)



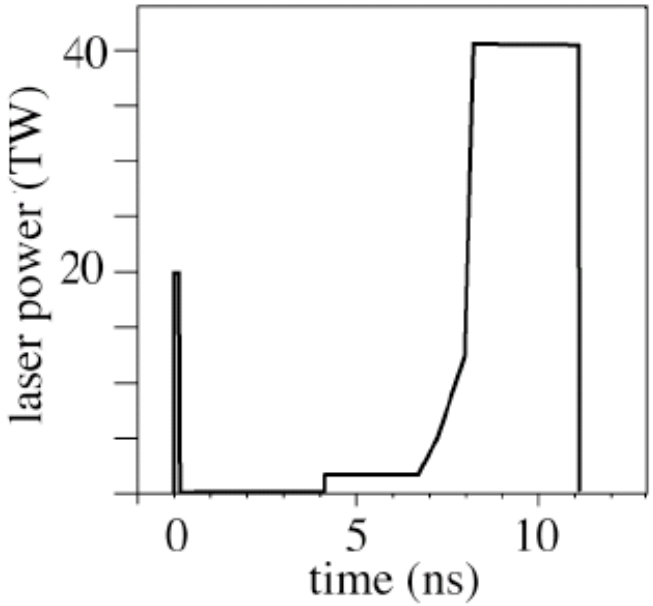
Baseline IFE Target #2



compression laser pulse

- wavelength = 0.35 μm
- focussing optics f/18
- energy = 132 kJ

- absorbed energy = 90 kJ



Existing Target Fabrication capabilities relevant to HiPER

1) Academic European laboratories and universities

There are number of centres of expertise in microtarget fabrication distributed throughout Europe. They are not currently coordinated.

2) CEA France (LMJ programme)

- CEA/Grenoble: conceptual design and prototype production of LMJ cryogenics.
- Valduc laboratory: comprehensive capability for fusion target manufacture.

3) US infrastructure: GA and LLNL

- General Atomics: commercial company producing wide range of microtargets.
- LLNL: established programme in the development of IFE materials.

Weaknesses and Strengths

Although European researchers have significant strength in the physics research related to fast ignition, the co-ordinated capability in Europe for the *production* of complex targets is scarce and/or limited to defence laboratories.

Many technologies developed at LMJ and NIF could be directly extended to HiPER and future IFE power production programmes.

Collaboration between experienced groups should significantly decrease the risks for HiPER as well as reduce the length of many R&D programmes.

Lead tasks: Academic European Institutions

Lead, specify and co-ordinate HiPER target fabrication activities.

Analysis of European infrastructure requirements to enable all necessary aspects of HiPER IFE target fabrication.

Analysis of fabrication capabilities which will be required for HiPER science programmes targets.

Examine new materials, especially for improving yield of IFE targets.

Study foam layering of shells.

Detail tritium handling procedures.

Computational modelling of cone-shell target layering including target and thermal (shroud) environment.

Lead tasks: CEA Laboratories

Design system to field single shot HiPER cryogenic targets based on modifying existing technology using both fill tube and permeation.

Cryogenic infrastructure: design of cryostats, DT fill apparatus, target positioner, thermal shroud and shroud remover; mK control of target fill and layering.

Specify permeation facility and technologies for transport of cryogenic targets.

Produce cost estimates for HiPER single shot cryogenic capability.

For more details see the presentation **“Cryogenic System for Inertial Fusion Energy”** by **Denis Chatain** today.

Lead tasks: GA and LLNL

Propose plausible methods for mass production of cone-shell targets including mass-production of; capsules and foam shells, capsule hole cutting, assembly and layering. Perform laboratory-scale demonstration of key techniques.

Analyse high repetition rate injection and tracking techniques including target placement accuracy.

Cost analysis for continuous high repetition rate (cryogenic) IFE target production and insertion including; optimised solution(s) and infrastructure (such as a target manufacturing plant).

Examine new materials, especially for improving yield of IFE targets.

Details were given in the previous presentation **“Mass Production of Targets for Inertial Fusion Energy”** by **Robert Cook**.

Organisational Structure

A key task for the preparatory phase is to establish a credible route to securing an effective microtarget fabrication capability able to deliver to the timescales of the project.

In addition to the technical issues already discussed this will require the development of:

- Management structure for co-ordination between groups
- Ensuring that enough suitably skilled staff are available

Novel Opportunities

- Opportunity (especially in primary stages of project) to think in an innovative way about technical and operational issues

- Operate in a highly proactive (rather than reactive) way, for example, integrate very closely with physics/target design group to introduce new materials, fabrication techniques and designs

- Establish generalised techniques where possible (rather than programme specific) to enable target modifications

Conclusions

The preparatory phase of HiPER has been funded and work is due to commence April 2008.

Targetry for HiPER poses significant technical and organisational challenges.

Large-scale collaboration will be required.

Thank you for your attention

The Round Table Discussion “European Project HiPER and International Cooperation” is scheduled for 11:00am – 1:30pm on Thursday 18 October in Column Hall, Third floor of General LPI building.

Chris Spindloe

MWTA, 17 Oct 2007, LPI