Gemini operational statistics 16/17

S. Hawkes *(Central Laser Facility, STFC Rutherford Appleton Laboratory, Harwell Campus, Didcot OX11 0QX, UK)*

During the reporting year, April 16 – April 17, a total of seven complete experiments were delivered in the Astra-Gemini Target Area, and three experiments in TA2. In total, 31 high power laser experimental weeks were delivered the Gemini Target Area and 22 weeks to TA2. The delivered schedule is presented in Figure 2.

The availability of the Gemini laser system (delivery to the Gemini Target Area) was 84% during normal working hours, rising to 145% with time made up from running out of normal working hours. The reliability of the Gemini laser was 90%. An individual breakdown of the availability and reliability for the experiments conducted is presented in Figure 1.

The high levels of total availability were made possible by the continued unique operational model employed on Gemini, which involves running the laser late into the evening. In addition, frequent weekend operational days were made available.

During the year, two system access slots were made available. The first slot was used to separate the Astra and Artemis emergency power off systems, replace the Gemini compressor doors and perform testing of the beam stabilization system in TA3.

The second system access period was used to continue with development of the beam stabilization systems in Gemini and TA3 and to perform initial XPW pulse cleaning system tests in LA1/2. This included the commissioning of an additional Ti:S amplifier to recoup the losses introduced by the XPW system.

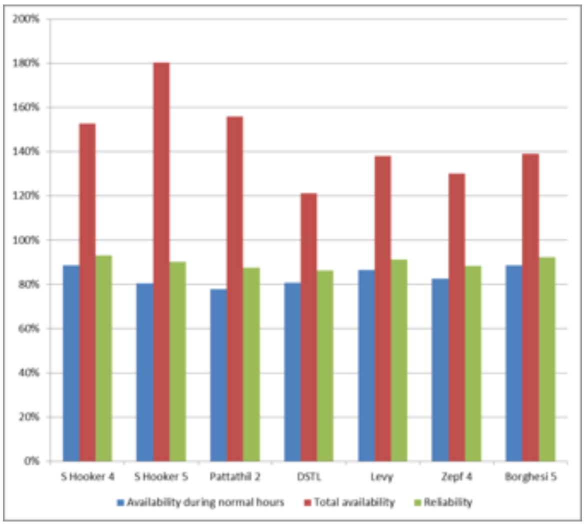


Figure 1. 2016/17 operational statistics

Week beginning	Gemini	TA2
04/04/2016	Extension	
11/04/2016		
18/04/2016	System	
25/04/2016	Access	
02/05/2016		
09/05/2016		
16/05/2016		Commercial Access
23/05/2016	Hooker	
30/05/2016	15210025	
06/06/2016		
13/06/2016		Norreys (pt. 1)
20/06/2016		15210000
27/06/2016	Hooker	
04/07/2016	16110004	
11/07/2016	Maintenance	
18/07/2016	Pattathil 15210023	
25/07/2016	Changeover	
01/08/2016		Norreys (pt. 2)
08/08/2016	Commercial Access	15210000
15/08/2016		
22/08/2016	Quantel	
29/08/2016	Service	
05/09/2016		
12/09/2016	Levvy	
19/09/2016	16110013	
26/09/2016		
03/10/2016		
10/10/2016	Maintenance	
17/10/2016	System optimisation	
24/10/2016	Set up	Norreys (pt. 3)
31/10/2016		15210000
07/11/2016		
14/11/2016	Zepf	
21/11/2016	16110024	Symes (pt. 1)
28/11/2016		16110021
05/12/2016		
12/12/2016		
19/12/2016	Christmas	
26/12/2016		
02/01/2017		
09/01/2017		
16/01/2017	System Access	
23/01/2017		
30/01/2017		
06/02/2017		
13/02/2017		
20/02/2017		Symes (pt. 2)
27/02/2017	Borghesi	16110021
06/03/2017	16110016	
13/03/2017		
20/03/2017		
27/03/2017	Maintenance	

Figure 2. 2016/17 Gemini operational schedule

Contact: S. Hawkes (steve.hawkes@stfc.ac.uk)

Vulcan Operational Statistics

A.K. Kidd and T.B. Winstone *(Central Laser Facility, STFC, Rutherford Appleton Laboratory, Harwell Oxford, Didcot, Oxon OX11 0QX, UK)*

Introduction

Vulcan has completed an active experimental year, with 53 full experimental weeks allocated to target areas TAW and TAP between April 2016 and March 2017.

Table 1 shows the operational schedule for the year, and reports the shot rate statistics for each experiment.

PERIOD	TAW	TAP
2016		
18 Apr – 22 May		**R Smith** A first investigation of ultra-high intensity laser interactions with levitated micro-targets (29, 0, 100.0%) (80.3%, 117.0%)
13 Jun – 17 Jul	**S White** Disentangling the contributions to plastic relaxation at a shock front: nucleation versus viscosity (116, 12, 89.7%) (81.7%, 111.3%)	
01 Aug – 04 Sep	**F Keenan** Novel Vulcan experiments to produce high photoionization parameter plasma: recreating a Seyfert galaxy in the laboratory (124, 13, 89.5%) (92.3%, 111.4%)	**N Woolsey** Resubmission of extreme x-ray radiation fields created during an ultra-intense laser-solid interaction (53, 3, 94.3%) (85.6%, 102.9%)
19 Sep – 24 Oct	**S Kar** Intense thermal and epithermal neutron source using high power lasers (87, 12, 86.2%) (83.5%, 108.3%)	**P McKenna** Ultra-intense laser-driven ion acceleration with near-diffraction limited focal spots (99, 6, 93.9%) (79.0%, 122.3%)
07 Nov - 11 Dec	**R Gray** Temporally resolved optical probing of picosecond laser propagation and filamentation in underdense and near-critical density plasmas (120, 10, 91.7%) (93.0%, 108.8%)	
2017		
16/23 Jan - 26 Feb	**D Riley** XUV probing of warm dense matter (150, 20, 86.7%) (84.7%, 122.4%)	**M Roth** Laser-driven acceleration by microstructured silicon targets (116, 15, 87.1%) (86.1%, 110.9%)
13 Mar - 30 Apr		**D Margarone** Proton acceleration from thin cryogenic ribbons (54, 2, 96.3%) (91.8%, 108.4%)

Table 1. Experimental schedule for the period April 2016 – March 2017

(Total shots fired, failed shots, reliability)
(Availability normal, additional hours)

Numbers in parentheses indicate the total number of full energy laser shots delivered to target, followed by the number of these that failed and the percentage of successful shots. The second set of numbers are the availability of the laser to target areas during normal operating hours and including outside hours operations.

The total number of full disc amplifier shots that have been fired to target this year is 948. Table 2 shows that this figure is less than in the three previous years. 93 shots failed to meet user requirements. The overall shot success rate to target for the year is 90%, compared to 89%, 88%, 88% and 91% in the previous four years. Figure 1 shows the reliability of the Vulcan laser to all target areas over the past five years.

	No of shots	Failed shots	Reliability
12 - 13	860	93	89%
13 - 14	1015	121	88%
14 - 15	1087	133	88%
15 - 16	1143	108	91%
16 - 17	948	93	90%

Table 2. Shot totals and proportion of failed shots for the past five years

The shot reliability to TAW is 89%, down a percent from the previous year. The shot reliability to TAP is 93% - up from 91% in 2015-16.

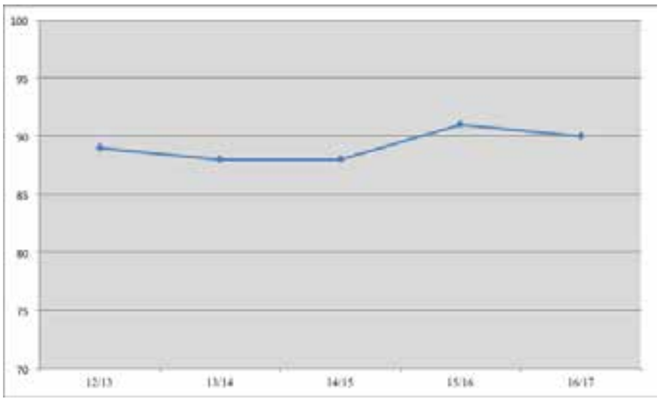


Figure 1. All areas shot reliability for each year 2012-13 to 2016-17

Analysis of the failure modes reveals that, as in recent years, the two overriding causes of failed shots are alignment and front end related issues. These two causes are manifested in low or high energy output of the roda amplifier chain. Approximately three-quarters of failed shots are due to this cause. Commissioning of further high repetition rate diagnostics in the front end and throughout the laser area should allow us to identify and resolve specific sources of instability.

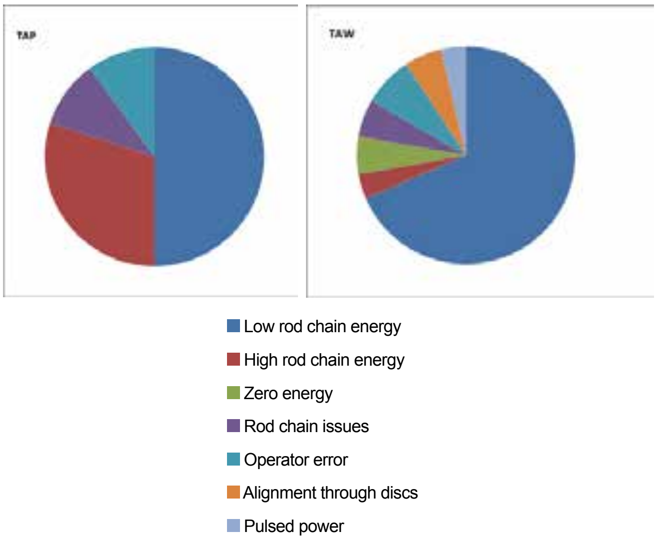


Figure 2. Individual contributions to failed shots for each target area TAP and TAW

There is a requirement which was originally instigated for the EPSRC FAA that the laser system be available, during the five week periods of experimental data collection, from 09:00 to 17:00 hours, Monday to Thursday, and from 09:00 to 16:00 hours on Fridays (a total of 195 hours over the five week experimental period). The laser has not always met the startup target of 9:00 am but it has been common practice to operate the laser well beyond the standard contracted finish time on several days during the week. In addition, the introduction of early start times on some experiments continues to lead to improvements in availability.

On average, Vulcan has been available for each experiment to target areas for 85.8% of the time during contracted hours, compared with 83.2% for the previous year. Although this figure is slightly up, the overall availability remains at the same level as 2015-16 which is 112.4% to all target areas. The time that the laser is unavailable to users is primarily the time taken for beam alignment at the start of the day.

Contact: A. Kidd (andy.kidd@stfc.ac.uk)

Artemis operational statistics

R. T. Chapman *(Artemis, Central Laser Facility, STFC Rutherford Appleton Laboratory, Harwell Campus, Didcot, OX11 0QX, UK)*

The Artemis team delivered a total of eleven user experiments from April 2016 to March 2017, as well as two weeks of development projects in partnership with facility users. In total, we delivered 26 weeks of user access and twelve weeks of dedicated experiment setup. Table 1 shows the schedule for the year.

Week Beginning	Experiment
04/04/2016	Setup for Miwa
11/04/2016	
18/04/2016	Laser down due to excavations outside the lab
25/04/2016	Miwa 16120009
02/05/2016	
09/05/2016	Set-up for Chapman
16/05/2016	Chapman 16120011
23/05/2016	
30/05/2016	Imaging beamline engineering
06/06/2016	
13/06/2016	Set-up for Brocklesby
20/06/2016	Brocklesby 16120012
27/06/2016	
04/07/2016	Air conditioning installation
11/07/2016	Giannetti 16120004
18/07/2016	
25/07/2016	Crepaldi 16120002
01/08/2016	
08/08/2016	Spin TOF installation
15/08/2016	Few-cycle idler development
22/08/2016	Laser service - RedDragon
29/08/2016	Few-cycle idler development
05/09/2016	Topas service Mon 5 - Wed 7; Set-up for Cacho
12/09/2016	Set-up for Cacho
19/09/2016	Cacho 15120042
26/09/2016	
03/10/2016	Setup for Bertoni
10/10/2016	Bertoni 16120023
17/10/2016	
24/10/2016	
31/10/2016	AMO installation
07/11/2016	Setup for Chapman
14/11/2016	Chapman 16120011
21/11/2016	
28/11/2016	Setup for Fielding
05/12/2016	Fielding 16120021
12/12/2016	
19/12/2016	Maintenance
26/12/2016	
02/01/2017	Laser service - RedDragon
09/01/2017	Set-up for Miwa
16/01/2017	Miwa 16120009
23/01/2017	Miwa 16120018
30/01/2017	Setup for Scholl
06/02/2017	Scholl 16220013
13/02/2017	
20/02/2017	Spin TOF installation
27/02/2017	Set-up for Minns
06/03/2017	Minns 16120015
13/03/2017	
20/03/2017	Set-up for Carley
27/03/2017	Minns 16120015

Table 1. Artemis schedule for 2016-17

Experiments

Five of the eleven experiments conducted used the angle resolved photoemission chamber for studying condensed matter samples. Two further experiments were carried out using the spin time of flight chamber in conjunction with condensed matter samples. Two experiments used a new time of flight detector on the AMO chamber looking at small molecules in the gas phase. One experiment used the coherent imaging chamber and one experiment used the flat field spectrometer for high harmonic spectrometer. The Artemis team dedicates approximately one week of set-up to each experiment, before users arrive. Similar experiments are grouped together, to minimize set-up time.

Facility performance and reliability

Figure 1 shows the availability and reliability calculations for the 2016-17 year. We run the laser continuously from Mondays through to Fridays during experiments, and regularly carry on data-taking over weekends. In this calculation, the availability for unsupported data-taking overnight and at weekends is weighted equally with supported hours.

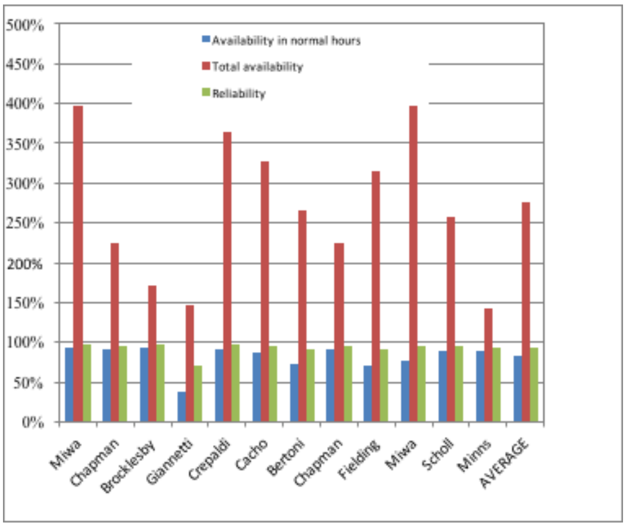


Figure 1. Availability and reliability for user experiments in 2016-17

Contact: R.T. Chapman (richard.chapman@stfc.ac.uk)

Octopus and Ultra Operational Statistics

B. C. Bateman, D.T. Clarke *(Central Laser Facility, STFC, Rutherford Appleton Laboratory, Harwell Oxford, Didcot, Oxon OX11 0QX, UK)*

OCTOPUS facility

In the reporting period (April 2016 to March 2017), 56 unique User groups submitted a total of 71 proposals bidding for time at the Octopus facility. 33 experiments comprising of 87 weeks access time was awarded and delivered to the UK User community including 1 week to European Users throughout the year. A full breakdown of number of weeks applied for versus number of weeks scheduled is shown in Figure 1 indicating an oversubscription ratio of 2.36:1. Figure 3 shows that Biology and Bio-materials formed the majority of applications.

There were a total of 21 formal reviewed publications recorded throughout the year.

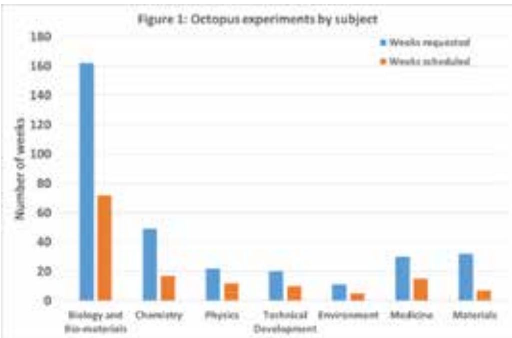
ULTRA facility

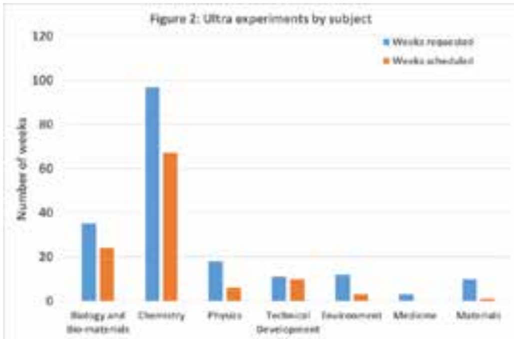
In the reporting period (April 2016 to March 2017), 30 unique User groups submitted a total of 41 proposals bidding for time at the Ultra facility. 28 experiments comprising of 73 weeks access time was awarded and delivered to the UK User community including 1 week to European Users throughout the year. A full breakdown of number of weeks applied for versus number of weeks scheduled is shown in Figure 2 indicating an oversubscription ratio of 1.50:1. Figure 4 shows that Chemistry formed the majority of applications.

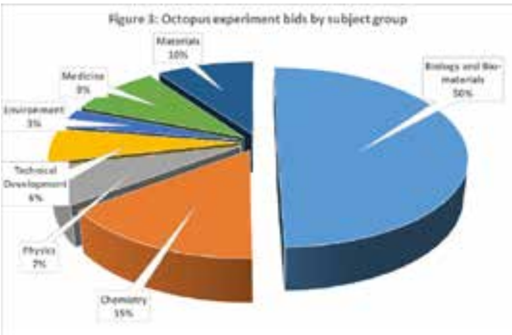
There were a total of 24 formal reviewed publications recorded throughout the year.

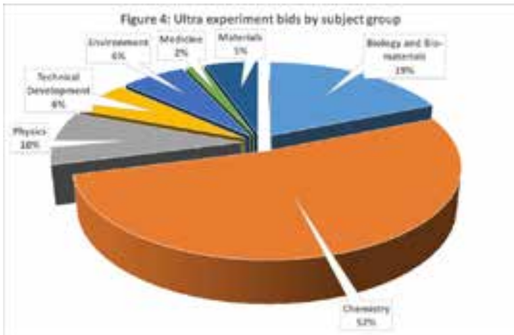
User satisfaction

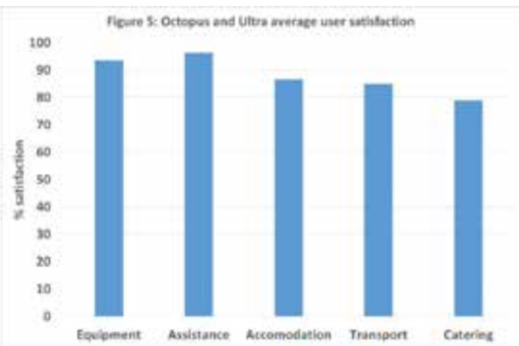
The average User satisfaction marks obtained from the scheduled Octopus and Ultra Users are shown in Figure 5, with an average satisfaction of 88.1% across the categories. There was a total of 337 hours downtime reported over the combined 160 weeks of access.











Contact: D.Clarke (dave.clarke@stfc.ac.uk)

Target Fabrication Operational Statistics

D. Haddock, C. Spindloe & M. K. Tolley *(Target Fabrication Group, Central Laser Facility, STFC Rutherford Appleton Laboratory, Harwell Campus, Didcot OX11 0QX, UK)*

RAL Experiments

This paper details Target Fabrication support given to experimental groups in the Vulcan target areas TAW and TAP, as well as the Gemini Target Area, between April 2016 and April 2017. Target Fabrication supported nine solid target Vulcan experiments and one solid target Gemini Experiment, totalling 50 weeks of Vulcan access (plus training weeks) and 6 weeks of Gemini access. Other Gemini experiments were also supported for filters and other diagnostic elements, which are non-trivial but not reported on in these statistics. The number of weeks supported is almost the same as last year (57), and lower than the 64 in 2014-15.

The Target Fabrication group also supported academic access experiments at AWE and internal experiments, such as the April 2017 HAMS campaign.

This report does not include support for other areas of the CLF, including Artemis and the LSF.

1) Target Numbers

For the reporting year, the total number of targets produced for each experiment is shown in Table 1. High specification targets are defined as targets that have taken significant staff research and development time, or have taken more than ten times as long to produce as a typical target.

The total number of targets supplied to target areas at RAL by the group this reporting year is 1546 compared to 2371 last reporting year, 1937 in 2014-2015, and 2507 in 2013-2014. Experiments in this period were not concentrated on foil type targets (which typically require high quantities) explaining the decrease. The number of high specification targets increased to 98 from 87 last reporting year, and 87 in 2014-2015. The number comprises 6% of the total targets delivered and is important because of its effect on staff workload.

Of particular note was the January 2017 period in which the TAW experiment required a significant number of targets to be delivered, with the total number of targets being the most ever delivered to a Vulcan experiment run. This experiment ran alongside an experiment in TAP that required significant characterisation support. The resource was able to be balanced due to the Target Fabrication Quality Management System (QMS), enabling streamlined and efficient processes.

The QMS enables the tracking of the targets delivered and also is used to record whether they were modified from the initial design during the run. The modification number is a useful metric, as it indicates the extra resources needed to support an experiment. For the reporting year, the number of modifications is shown in Table 1, recording targets that were delivered but not initially defined on the approved target list. The table includes modifications to designs or completely new requests during the campaign. It is important to note that the capability to change designs can often ensure experimental success and, consequently, understanding the required resource is important.

Experiment	Targets Produced	High Specification Targets	Modified Targets	
0616 TAW	198		152	77%
0816 TAW	158	38	80	51%
0816 TAP	68	30	47	69%
0916 TAW	63		1	2%
0916 TAP	150		116	77%
1116 TAW	97			
0117 TAP	153	20	83	54%
0117 TAW	403		82	20%
0217 GTA	150	10	26	
0317 TAP	106		26	24%
TOTAL	**1546**	**98 (6%)**	**587**	**38%**

Table 1: Target production summary for 2016-2017. High specification targets include 3D micro-structures, low density targets and mass limited targets. Modified targets are targets that were not in the pre-approved target list and are either modifications to approved designs or additional requests.

2) Experimental Response

It is seen as a significant strength of Target Fabrication to be rapidly responsive to experimental results and conditions by working collaboratively with user groups. The Target Fabrication group responds to experimental changes during a campaign, and often implements a number of modifications or redesigns to the original requests. The number of modifications and variations on each experiment is variable, dependent on the type of experiment and also on experimental conditions such as diagnostic and laser performance. For this reporting period, a total of 587 targets were modified or redesigned from the target list agreed in the planning stage which comprises 38% of the total targets delivered. In the last reporting year the percentage was 27.5% and the year prior to that the percentage modified was 25%. (It was 22% in 2013-2014.) This year there were five experiments that required significant modifications to their target requests (>50% modified targets), a rise from three in the previous year. This explains the increase in modified target numbers and can be attributed to increasing experimental complexity.

3) Target Categories

Targets can be separated into seven main categories, as shown in Figure 1 and Table 2.

Ultra-thin foil targets are specified as having a thickness <500nm and require a coating capability and a skilled fabricator to process; thick foils make up the rest of single component foils. Multilayer foils are stacks or layers of foils that require thin film coating capability to deposit multiple layers onto an existing foil; there are often different composition layers with different thicknesses. Alignment targets are specified as wires or pinholes that are used for set-up purposes. 3D micro-structures are complex 3D geometries that require skilled assembly or micro-machining to produce them. Foam targets are low density polymer structure manufactured through chemistry based techniques.

Target Category	2016-2017	2015-2016	2014-2015
Ultra-thin Foil	449	197	530
Thick Foils	743	1349	708
Multi-layered Foils	237	605	500
Alignment	78	110	85
3D Micro-structures	38	99	82
Foams	0	0	5
Mass-limited	0	11	0
TOTAL	**1546**	**2371**	**1937**

Table 2: Target category summary for the last 3 reporting years. 3D micro-structures are targets that require micromachining or skilled micro-assembly. Mass-limited targets are targets designed to have minimal support structures

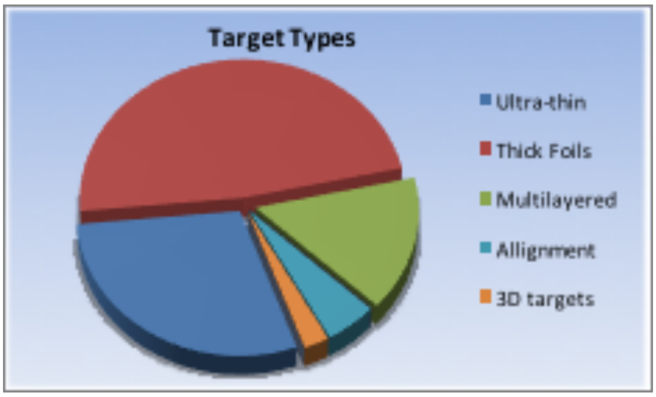


Figure 1: Targets delivered by type

It should be noted that Figure 1 is not a reflection of staff effort, because assembly time for a single thick foil target is relatively short, whereas for a batch of 3D targets, trials, manufacture and characterisation activities can amount to weeks of effort.

Single experiments generally require similar targets types usually with varying thickness, composition or geometry; for example, a thin foil experiment typically requests a thickness scan of a particular material. In such experiments, each thickness or composition change requires a separate coating run.

For experiments using 3D targets, each geometry change usually requires a new assembly set up. Within the total of 1546 targets there were 277 unique target variations, which averages 6 targets per variation. Last reporting year the average number of targets per variation was 7 (324 total) and the two years previous to this the average was 6. The flexibility provided by the group is a key capability of the CLF and enables the user community to fully utilize the limited time that is available during each experiment on both the Vulcan and Gemini laser systems.

4) Adapting to Demand

The Target Fabrication group endeavours to be adaptable to the changing demands of the experimentalists as experiments develop. Each experiment that is carried out often has widely varying target demands and as a result the group is constantly developing its capabilities.

For this and the previous two reporting years, foils have dominated the target types, comprising just over 75% of the targets delivered.

Ultra-thin and multilayer targets are reliant on coating plant capability and numbers are largely in line with the two previous years.

5) Waste Reduction

Unexpected delays or changes during an experiment often result in a number of targets that have been fabricated but that are not used by the end of experimental campaign. Un-shot targets in this reporting period totalled 154, accounting for 10% of the total targets made. Statistics for the return of un-shot targets in previous years are as follows: 2014-2015 12%; 2013-2014 16%; 2012-2013 19%; 2011-2012 43%; and 2010-2011 10%.

Any un-issued or returned targets are carefully sorted and high specification targets are stored under closely controlled conditions for potential use on future experiments. Where possible all spare target components and mounts are also stored for future use. The variety of mounts and components held in stock by the Target Fabrication group contributes to their ability to adapt target designs quickly in response to experimental changes.

There has been a noticeable reduction in waste since the complete implementation of the ISO9001 Quality Management System (QMS), which has allowed the Target Fabrication group to plan experimental delivery of targets in a more structured way. The improved planning processes enable long-term delivery projects to be managed effectively. It should be noted that this has not led to less flexibility, as the percentage of modified and re-designed targets is in line with the figures for before the implementation (2009-2010, 2010-2011).

Approximately 3% of targets were returned as non-conforming under the QMS in this reporting period. It should be noted that reporting will be improved because such targets are often recorded as "returned un-shot".

Orion Academic Access

The Target Fabrication Group has supplied targets to the AWE Orion academic access campaign for Strathclyde led consortium experiment on proton focusing. The collaboration included target supply from TUD and GA with design, assembly and target manufacture conducted by the CLF. A total of 41 complex targets were provided over two weeks of experiments. The targets were complex and required the implementation of a range of existing and new technologies including complex assembly integrated with real-time, high specification characterisation.

External Contracts

Scitech Precision Ltd (a spinout company from CLF Target Fabrication) has supplied micro-targets, specialist coatings and consultancy to a number of external contracts. In the year 2016-2017, a total of 150 contracts were completed including coatings, characterisation, full target design and assembly, and laser machining. Of the contracts, 32% were for laser machining which is an increase from the previous year, partly attributable to an increase in onsite support contracts. Scitech contracts were delivered to external facilities internationally including France, Germany, Italy, India and the US. In this reporting year Scitech Precision has supplied phase plates to LULI, LCLS and other large facilities.

Summary

Target Fabrication has supported ten experiments in the CLF and eleven other international facilities in the last year, as well as providing an increasing amount of characterisation services and acting as a knowledge base for Target Fabrication activities throughout Europe. This year has seen a total number of 56 weeks supported and a decrease in the total number of targets delivered to 1546. The decrease is mainly accounted for by a lower number of high repetition rate target experiments supported on Gemini. Generally, the type of targets has largely followed the same pattern over the past three years, with a large proportion being ultra-thin foils. The complexity of experiments was substantial with more high-specification targets than the previous two years. Also five experiments required more than half of the initial target requests to be modified.

Contact: D. Haddock (david.haddock@stfc.ac.uk)

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