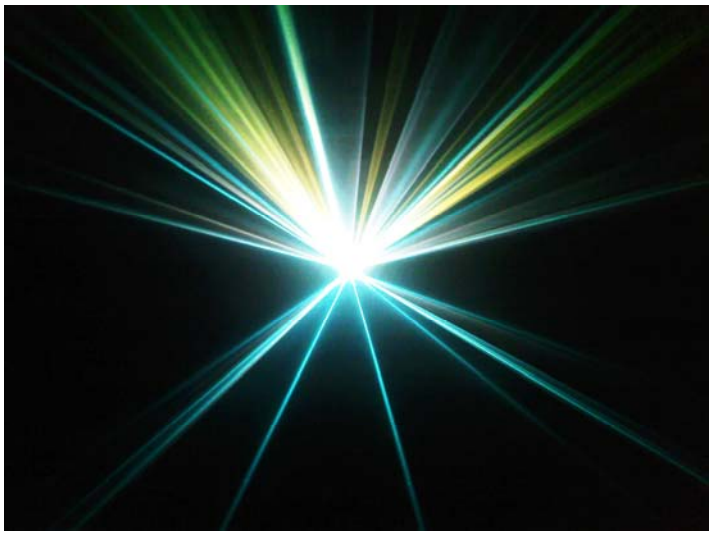
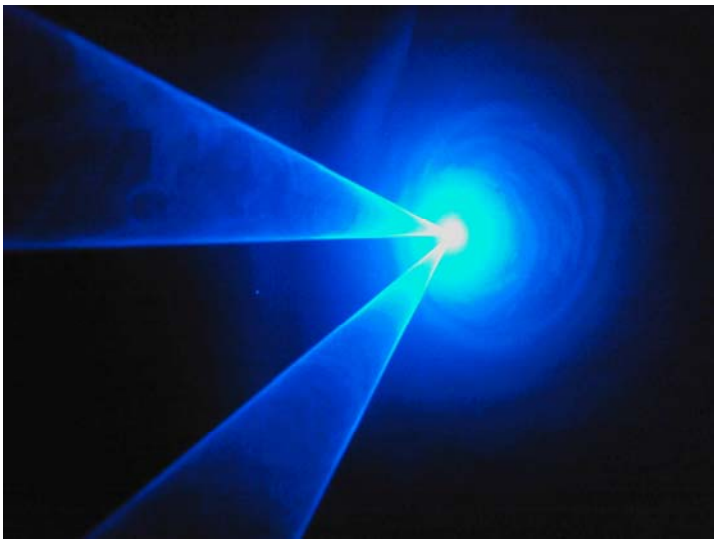
Undergraduate Photons

Presented by Malcolm Hignett, Senior Lecturer in Audio Visual Media and Programme Leader for the BA(Hons)Digital Media Production degree in the Faculty of the Arts, Thames Valley University, London.



'Arctic Dawn' beam show 2009



'Soul Divine' beam show 2009

Abstract

Thames Valley University, London has been running laser display courses for undergraduate students and interested members of the public since 1996. This presentation will evaluate some of the successes and pitfalls of running courses in laser display and show examples of animation and beam shows arising from the final year animation degree students. A SWOT analysis of existing experience within TVU will offer a pointer to the future design, development and updating of courses, both within the higher educational sector and for industry. The follow up to this paper will also seek to revisit and identify within a seminar context with ILDA members, the aesthetic essence of using laser beams and animation for audience entertainment, avoiding 'sameness' in beam shows and maintaining the excitement that we all feel when watching an imaginative, well-designed show.

Keywords

Laser display, Laser shows, laser animation, Pangolin LD2000, laser beam shows, MPE, Laser Health and Safety TVU Laser, storyboarding, narrative, treatment, design and production

Undergraduate Photons

Introduction

Thames Valley University, London[1] gained its Royal Charter in 1992, created from a former Polytechnic and before that an Institute of Higher Education. It is a multi-sector institution with national and international reach, dedicated to providing a personalised education that satisfies the demands of students, employers and stakeholders alike. It has three Faculties, Faculty of Professional Studies, Faculty of Health and Human Science and the Faculty of the Arts (formerly the London College of Music and Media). Within the Faculty of the Arts, there are currently three Schools; the School of Art and Design[2], School of Media and London College of Music. Two laser display courses/modules are offered from within the School of Art and Design; the 'Lasers in Entertainment' short course, offered as an extra curricula short course for all students, members of the public and industry professionals and the 'Laser Display Technology and Performance' year three option module, offered to the BA(Hons) Digital Media Production and BA(Hons) Digital Animation undergraduate students.

The Faculty of the Arts has been running courses in laser display since 1996. Following a visit to Futuroscope, Poitiers in France in 1993 and a subsequent meeting with Professor John Tyrer[3] at Loughborough University, Tony Clynick[4], Technical Director at Laser Creations International and Malcolm Hignett[5], Senior Lecturer in Audio Visual Media in the London College of Music and Media at Thames Valley University developed a extra curricula short course in 'Lasers in Entertainment' in 1996. Whilst the University had no technical resources in this field, senior management in the University agreed we should develop a short course in laser display to test out student demand. Chris Matthews and Marlyn Weeks at Laser Creations International (LCI)[6] were very supportive and agreed to run the short course in their laser studio at LCI. Tony and Malcolm devised a 20 hour course which introduced students to laser show design and the health and safety factors required, to be delivered over a 4 week period. In support of this course development, Patrick Murphy, the then President of Pangolin Laser Systems[7] offered a Pangolin Lasershow Designer system at concessionary price to the course leader.

For three years the course was offered each academic year to registered degree students and members of the public and delivered at LCI by Tony Clynick. During this time, a 100mw air cooled argon laser system with General Scanning G-120 scanners was donated to the course. By the year 2000, new accommodation was made available in TVU which enabled the development of dedicated facilities to run this course.

During the period from 2000 to 2004, the short course continued to recruit mainly undergraduate students and was delivered within the TVU teaching campus. Designed on the laser studio facility at LCI, a fibre optic system was installed within the dedicated space in the University to enable further development and expansion of laser fibre head scanners. However, the lack of funding from the University seriously hampered development. By 2004, the 100mw air cooled argon laser was now outputting about 10mw so a search was now necessary to find another, more powerful laser source. Geoff Jones from I-Vision[8] offered 2 Spectra Physics 168 White Light lasers for us to use on long term loan. Whilst one SP168 was giving little power, the other has been giving us approx 1.8Watts of white light and combined with a polychromatic acousto-optic modulator (PCAOM,) a pair of Cambridge Technology scanners (CT6800) controlled by Pangolin's LD2000 Lasershow Designer software, we were able to allow students direct experience of designing and producing beam shows for audience scanning and animation.

[1] Web reference; http://www.tvu.ac.uk/index.jsp
[2] Web reference; http://www.tvu.ac.uk/artdesign/School_of_Art_and_Design.jsp
[3] Web reference; http://wolftest.lboro.ac.uk/staff/tyrer.html
[4] Web reference; http://www.optrosonic.com
[5] Web reference; http://www.research.tvu.ac.uk/staffprofiles/view_profile.aspx?email=malcolm.hignett@ac.uk
[6] Web reference; http://www.lci-uk.com/index.php
[7] Web reference; http://www.pangolin.com/
[8] Web reference; http://www.ivisionuk.com/index.html

In 2005, a full 20 credit module was developed and internally validated entitled 'Laser Display Technology and Performance'. This module was available as a final year option module to Media Technology students. Whilst these students were able to produce average quality work, creativity and animation skills were poor. In 2007, the module was made available to digital animation students and demand was overwhelming, with 29 students wishing to take the option. Additional funds from the Faculty were secured and this allowed us to create 4 Pangolin LD2000 Pro workstations for design and production work. We ran the first course for animation students in 2007 and the second course in 2009.

The Current Laser Projection System

It has taken some years to reach our current configuration of laser facilities. This has been done though generous support from industry, e.g. LCI, I-Vision, LM Productions[9], Pangolin Laser Systems with some support from the University and considerable input from the two staff pioneering this development; Malcolm Hignett and Tony Clynick.

The laser projection system in the TVU main teaching campus comprises the following;

Installed within the secure 'Laser Controlled Area';

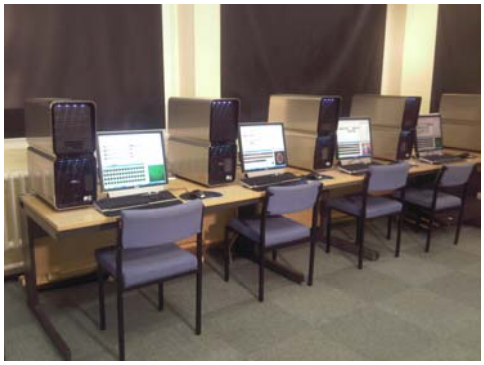
a) 3 Phase 400V power supply, water and pump
b) 1 x Spectra Physics 168 Argon-Krypton White Light laser fitted with an MVM PCAOM within an interlocked enclosure, Spectra Physics 265 Exciter Power Supply Unit, and Majestic 400-208V Transformer.
c) 1 x Spectra Physics Chroma 5 WR-BB, Mixed Gas 4W White Light laser fitted with an AA PCAOM housed within an interlocked enclosure, power supply unit and 400-208V transformer.
d) 1 x Cambridge Technology 6800HP XYscanner fibre head working at 30,000pps

Laser Controlled Area – Spectra Physics 168 and Chroma 5 enclosures and power supply

Installed within the teaching/workshop space;

a) 1 x IBM Intellistation computer with Pangolin LD2000 Lasershow Designer hardware/software, Lasershow Converter FLASH, Lasershow Converter MAX and Lasermet's LaserSafe PC Pro Demo software.
b) 4 x Dell XPS 720 computers with Pangolin LD2000 Pro Lasershow Designer installed with Adobe After Effects, Audition, Illustrator, Photoshop, Soundbooth, Flash CS3 Pro, Autodesk 3D Max 2008, Maya 8.5 and Storyboard Quick 5 software.
c) 2 JEM ZR20 Mk II Fog machines controlled from the laser display computer position.
d) 6 laser mirrors mounted above a 7x2 metre widescreen.
e) 5.1 Surround Sound System comprising 5 JBL Control 5 loudspeakers with JBL Control SB-5 Sub Bass unit and Yamaha DSP-AX1 AV Amplifier.

[9] Web reference; http://www.lm-productions.com/index.php




Pangolin LD2000 Lasershow Designer workstations within studio

Fibre Optic Installation

The studio complex has 5 fibre optic/scanner signal lines installed within aluminium trunking with DB-9 female connectors terminating at black boxes. All fibre optic lines from the black boxes are fed to the 'Laser Controlled Area' where the lasers are positioned. Fibre optic cables are protected and enclosed in flexible tubing from the black box to the scanner position.

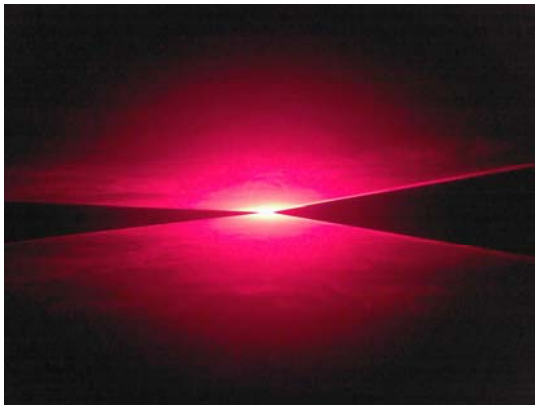
Health and Safety Installation

Since there is a regular throughput of students within the specialised teaching space, two access doors are fitted with Lasermet IS-MAG-05 Sipha Sensors connected to a Lasermet ICS-1 Interlock Control System[10]. This is also linked to the laser shutters within each laser enclosure, emergency cut-out buttons and illuminated 'Danger - Laser Radiation' signs outside each door. If a student opens the door to the 'Laser Controlled Area' or to the studio door, the interlock closes the laser shutter preventing accidental and/or uncontrolled exposure to a laser beam. The system ensures control at all times and can only be reset by the Laser Safety Advisor. As regards Laser Health and Safety compliance documentation, the Laser Safety Advisor has adopted Moseley and Zabierek's Association of University Radiation Protection Officers (AURPO) 'Guidance on the Safe Use of Lasers in Education and Research'[11] as TVU's Code of Practice.

Laser Safety, Maximum Permissible Exposure and Audience Scanning

Embedded within each of the laser courses is a thorough briefing on the Health and Safety issues of using lasers within entertainment applications. Students on both courses must successfully complete a laser safety multiple choice question paper to qualify to progress to practical use of the laser system. In addition, the first assessment on the Year 3 module requires students to discuss the health and safety factors when designing a show within a public space. Students must engage with the relevant guidelines when using lasers. Specific reference will be made to the two IEC Technical Reports IEC/TR 60825-3:2008, '*Safety of Laser Products - Part 3: Guidance for laser displays and shows'*[12] and IEC/TR 60825-14:2004, 'Safety of Laser Products - Part 14: A user's guide'[13]. In addition, students will have access to the HS(G)95 Guidelines on *'The Radiation Safety of Lasers Used for Display Purposes'* [14] which preceded the IEC Reports and Local Council Advisory Sheets on using lasers within public spaces. Within the controlled environment of a studio, students are shown how to measure laser beam power using a FieldMax II Laser Power Meter[15] and make the necessary calculations within Lasermet's LaserSafe PC Pro[16] Demo software. Students are shown how to identify the Maximum Permissible Exposure (MPE) under specific parameters and how the scanned beam can be further attenuated by using the beam attenuation map in Pangolin's LD2000 Showtime software and use of atmospheric fog.

[10] Web reference; http://www.lasermet.com/interlock-systems.htm
[11] Web reference; http://www.aurpo.org/docs/AURPO_GN7_Lasers_0107.pdf
[12] Web reference;http://webstore.iec.ch/Webstore/webstore.nsf/0/7E2546094E09B01FC125740A0010B551
[13] Web reference; http://webstore.iec.ch/Webstore/webstore.nsf/0/01E0CE874038908FC125727F00581074
[14] Web reference; http://www.hse.gov.uk/pubns/INDG224.htm
[15] Web reference; http://www.coherent.com/Lasers/index.cfm?fuseaction=show.page&ID=1023
[16] Web reference; http://www.lasermet.com/laser-safety-software.htm



'Sex Drive' beam show 2009

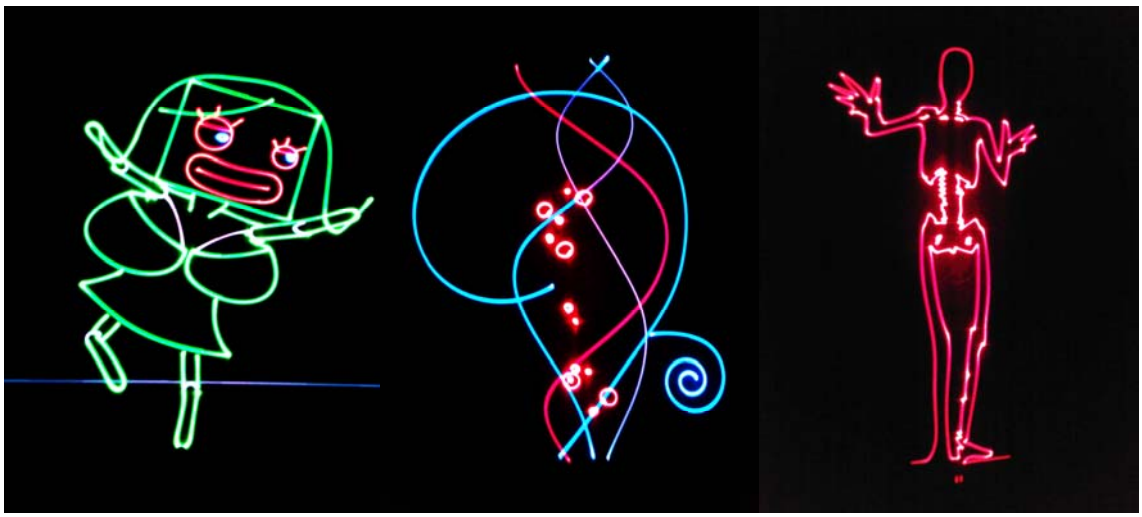
'Soul Divine' beam show 2009

Translating Laser Health and Safety Guidelines into Practice

Whilst all students are fully aware of the Health and Safety implications of using audience scanning techniques, translating this into responsible design practice and demonstrating this within assignment work is sometimes problematic. Such an example may be seen in Jake's work (not actual name). Whilst Jake chose the 'Laser Display Technology and Performance' module as one of his options in the final year of his degree, he thought this might be 'easy'. Since the first few lecture sessions covers the science, technology and health and safety issues pertinent to this medium he started to realise this was not an easy option. His attendance became erratic though he did manage to achieve a pass mark of 46% on his Health and Safety paper for assignment 1. For assignment 2, he designed a simple beam show using Flash and converted into Pangolin Showtime but clearly gave little thought to the design process to ensure his beams were animating and safe. Following assessment, this student has now been referred for a resit achieving only 29% for this assignment. He will need to redesign his show to ensure he is compliant with the laser safety display guidelines and submit for remarking. If he does not demonstrate compliance he will fail the module and could possibly fail his Honours degree.

Academic Approaches to Laser Show Design Practice

The teaching and learning strategy adopted ensures that health and safety compliance is embedded within the design and production process. The approach taken is to replicate the client/producer/designer model formalised to satisfy the academic requirements of assessment and demonstrate the thinking, creative and production processes.



'Malvis' Animation 2009 *' Coca Cola' Animation 2009* *'Play My Game' Animation 2009*

When embarking on a laser display project, students are expected to pre-visualise their ideas on paper first. This should be coupled with familiarising themselves with the laser display software within workshops and their own independent study time. The following documents are required to demonstrate their thinking and management of process;

The Production Brief

To begin the process, students must prepare a 'Production Brief' which identifies on one sheet of paper, a working title, a possible client, context, target audience, aims and objectives of designing the show, short synopsis, outline of the likely graphic/beam content, format (aspect ratio), length and audio source.

Treatment

The treatment should describe what the audience sees, hears and feels whilst experiencing the completed piece of work. As with other time-based media, radio, film and television, a well written treatment will recreate the work within the reader's mind. Whilst this applies equally to producing a graphics/animation laser piece, pre-visualisation and articulation of a laser beam show in written form becomes more difficult.

Storyboard

Again, as with other time-based media, a student should be able to pre-visualise the visual and aural form in the correct aspect ratio and describe the shape and structure of the proposed work. Once again, the designing of a graphics/animation work within storyboard format is more of a straight forward process but simulating beam animation in a meaningful way on paper becomes more difficult.

Technical Specification

Students should be able to visualise their laser show within a specific venue, plan the technical configuration and explain beams paths, both above and below MPE within their chosen space. For a student who has never even experienced a laser display within a venue, this may seem quite a daunting task.

Health and Safety Analysis

Building upon the technical specification produced above, students should be able to make reference to relevant health and safety guidelines, calculate their own MPE values within their chosen space and provide ground, elevation and section plans as appropriate showing beam paths above and below the MPE. Until recently, this has only been an aspiration since it requires some sophistication in mathematics to make the relevant calculations. However, with specialised laser safety software now available to make the calculations for you, students are now able to experiment with the 'what if's', to design a configuration that is controlled and safe for audiences.

Risk Assessment Documents

All students must apply standard methods of risk assessing their proposed laser display. The more able and motivated students will prepare their own risk assessments closely applied to their chosen venue. Others will draw upon the standard documents provided for them on the online learning resource facility. In one recent example, a student independently contacted a laser company who provided them with their own risk assessment document. This was then modified and cited by the student.

Design and Production Schedule

Students must demonstrate they are capable of planning a production and are in control of the creative, technical and procedural processes. This will be articulated by a schedule of activities from the start of the process through to completion.

Crew List

Collaborative working is seen as an essential skill in preparing a student for working life. Prior to embarking on the development of a laser display project, students are encouraged to work within teams of two. If the skills are available to produce an original audio track, this might become a team of three. Occasionally teams disintegrate due to lack of communication, work pressures or poor motivation and students may then have to work independently. To mitigate against this, student teams must develop their own 'Working Contract' which defines how they will apportion working tasks and if required, how the marks will be re-weighted to reflect individual contributions.

Final Laser Display and Supporting Files

As a laser display project develops, students are allocated folders on the laser display computer in which they can store their work. At the end of the process, they move the appropriate files to the 'Final Show' folder for assessment. In addition, all students must submit their original files on CD/DVD. If students have used Flash, 3D Studio Max, Illustrator, Poser or Maya, it is expected that the original files are included on the CD/DVD.

Sources and Bibliography

Finally, all students must declare their sources. If students have drawn upon library material or taken frames from other shows, this must be declared. Similarly, if they have used a published audio track, full details must be given. If the audio track is original, permission/release forms must be signed by the originator. Throughout, it is expected a student should use the Harvard method of referencing where appropriate.

Evaluation of Assessment Process

The current strategy of setting a health and safety assessment prior to allowing students access to the laser system has its advantages and disadvantages. On the plus side, students become fully aware of the need for compliance with the appropriate health and safety guidelines early on in the design process. Through the formal lectures, seminars and workshops, students gain grounding in the factors that may constitute dangerous use of this medium to audiences and operators and can apply and extend their research in the first assessment, the Laser Health and Safety Essay. Only when students achieve a pass at this stage can they progress to designing a laser display, either beams or animation.

On the negative side, such emphasis on health and safety and the managerial aspects of designing a laser display may demotivate some students, particularly the weaker ones. It may also constrain creativity and originality, since students want immediate 'hands on' experience. With a class size of up to 20 students, a limited number of workstations and one laser scanner with no supporting technician, this is not possible. The strategy so adopted is one of balancing the opportunities for creativity with the academic requirements of control of process, management and health and safety, set against the constraints on available resources.

The Hardware and Software Platform

As outlined above, students have access to a range of animation software as well as four bookable Pangolin LD2000 Lasershow Designer workstations. Students are encouraged to apply their existing skills in using 3D Studio Max, Maya and Flash and convert their frames using the Lasershow Converter FLASH software. However, in recent courses students are not making the effort to learn the tools available in Lasershow Designer and Showtime. In their 'Critical Evaluations', students comment that they prefer to use the software they already know and convert frames into Lasershow Designer. They find adjusting to the differences in user interfaces between the animation software and laser software time consuming, preferring to apply their existing skills in animation software and convert to laser frames.

The following comments are taken from student Critical Evaluations following the production of their laser display.

> 'We both know Flash well and we both knew the basics of Lasershow Designer, however we decided that Lasershow Designer would take a while to grasp. Also we did not have access to Lasershow Designer that we did with Flash. So we knew that Flash would be more than adequate to create the show.....Bearing in mind that the whole show would be projected through a laser scanner and the outcome would differ from what we had initially been working on in Flash, we had to work and create animations which had good potential as beam show segments'
> Field and Cordice (2007)

> 'The music was the starting point for the whole beam show; this was a large part of our inspiration for the whole visual piece. We followed the rhythm of the track and animated the scenes to the beat patterns, tempo and baselines. We programmed pieces of animation to move to the kick drum only, some parts of the snare only and some parts of the baseline. We made sure that a lot of the beam show was in sync with the music and that they worked well together'
> Field and Cordice (2007)

> 'The good thing about the Pangolin package is that you are able to create frames in other applications i.e. Flash, Maya and the Pangolin software package comes equipped with a Flash converter..... A range of animation software was used. I started off with Maya creating the base model of the animated girl ..... I also used other applications... Adobe Flash CS4/CS3 Poser Pro. Poser was very new to me... it enabled you to create your own model from scratch and then add a pre-rigged skeleton to the body enabling you to animate the character. It is a very time saving program and is recommended if you wish to make a quick animation'
> Quailey (2009)

> 'Despite all the setbacks to our laser beam show, I think that I would still use Pangolin Laser Designer if I had to design another show. I think this as I watched other laser beam shows that were created using Flash entirely, although they looked very well and smooth, I thought they were messy when watching from the audience point of view.'
> Townsend and Connoughton (2007)

From the above comments, it is shown that students will find a variety of software applications to create their laser frames for animation or beams and specialist laser software needs to allow for importing, conversion and point reduction. Without the ability to import frames via the SWF file format using Pangolin's Flash Converter, students would not be able to draw on their existing animation software skills.

A SWOT Analysis

Strengths

- An academic environment to develop the medium without the pressures of commerce.
- Support from industry in the designing and building of technical facilities
- A stable studio environment to build and develop the medium.
- Set within a Faculty of the Arts, a creative, mixed and multimedia environment
- Engagement with industry and experienced laser display sector professionals in the development of facilities and the assessment process.
- Students may work with music specialists to produce original audio
- Access to Digital Animation specialist undergraduates who already have knowledge and experience in animation techniques and a variety of animation software,
- Support from the University's Health and Safety Manager.
- These courses appear to be the only courses available in the UK in the creative applications of laser display.
- A number of students taking the 'Lasers in Entertainment' short course have gone on to incorporate their experience within the industry sector.

Weaknesses

- The 'Lasers in Entertainment' short course only offers 20 hours of taught time, limiting what can be achieved by students. As a 'half module' students must invest a further 80 hours of independent study time but without technical support.
- The 'Lasers Display Technology and Performance' year 3 degree module offers 42 hours of taught time. As a full module it is expected a student will spend a further 158 hours of independent study time but without technical support.
- Since photonics is not an available discipline within the University, there's a lack of in-house engineering and technical expertise to build and develop facilities.
- Limits have to be imposed on student registrations due to the constraints on hardware and software provision and laser safety precautions.
- Access to the facilities is limited due to the use of the studio for other module teaching.
- Constraints on funding from the University mean it takes a long time to develop and upgrade facilities e.g. the urgent need for scan fail circuit, additional fibre heads etc.
- Final year degree students do not have a foundation in designing animation for the laser XY scanner.
- Currently there is no systematic approach to audio/music analysis which promotes a 'sameness' viewed in beam shows.

Opportunities

- Students are able to work within a blended media environment; working with WATCHOUT video projection and 5.1 surround sound.
- Further develop use of MIDI and DMX control, e.g. use of keyboard to play beams.
- Extend availability of laser display courses for music technology students
- Develop these courses for the leisure industry, aimed specifically at the UK club sector.
- Develop a module at MA level and offer to MA students e.g. MA New Media Art and Design.
- With continued support from the laser industry display sector, extend the studio configuration to a multi scanner system, e.g. rear fibre head for graphics animation plus two/three fibre heads above wide screen.
- Become a focus for research into the creative applications in laser display

Threats

- Lack of funding within the University sector as a whole
- Laser display is seen as an esoteric discipline and not mainstream.
- Inability to offer students sufficient time on the laser workstations for them to develop expertise in the specialised programs e.g. Pangolin LD2000 Lasershow Designer and LivePro,
- For final year degree students, the learning curve to develop expertise in specialised programs for laser design and control is demanding.
- Due to the above point, students prefer to design their laser frames in other software, e.g. Flash, Illustrator, Maya etc. and convert them using Pangolin's Lasershow Converter FLASH
- Pressure on studio accommodation may prevent students from having adequate independent study time on the specialist facilities.

Conclusion

Setting up and establishing appropriate resources to run laser display courses within a creative university environment for group sizes of up to 20 students is fraught with problems and unless the institution is willing to make the large initial investment, developing adequate resources inevitably will be a slow process. Universities with separate Photonics and Arts Faculties are well suited to develop courses in laser display since this would potentially bring together the essential skills and resources required to work creatively in this entertainment sector.

Without the help and support from industry and close industry colleagues, the courses we have developed at TVU would not exist. Whilst the current configuration of laser display facilities is limited to just one fibre head, it is hoped to expand this to at least two fibre heads in the future. In addition, further work on making the systems portable, will make this medium more visible to the student population e.g. laser displays in the Student Union Hall.

Creatively, students find designing for the laser exciting though initially frustrating when they realise they must confine their ideas to work in line animation. Despite the majority of students coming from the animation degree many students prefer to design beam shows, designing in 3D space, something they cannot achieve in their other animation modules. When assessing many of the beam shows, students are not analysing the music tracks sufficiently to prevent 'sameness' from one show to the next. In part, this might be due to the choice of music, e.g. dance club music, but more particularly, animation students don't necessarily have the language or analytical tools to 'notate' their chosen music track against a storyboard format. To an extent, this can be done using the WAV representation of the audio file, but this is imprecise. Perhaps another reason for this 'sameness' appearance is that most beam shows are now being designed in Flash and converted into Pangolin LD2000 Lasershow Designer and Showtime. Students are designing their shows in 2D rather than thinking of the 3D spatial impact on the audience.

On the whole students are responding well to addressing the Health and Safety aspects of working with lasers but further work needs to be done to embed this understanding. This can only be done by making the laser system within TVU portable and available to use within student events within the University and making students responsible for calculating the MPE in a given venue.

Finally, it is gratifying to know that when students do engage with this specialist art medium, they are resourceful enough to find ways of using their existing design, animation and software skills to create the end product and output using the specialist laser software. At TVU, we are now at a stage where we can extend the use of this medium for student projects and at postgraduate level, develop our experience in using LivePro via keyboard control and linking laser graphics/animation and beam show projection with Dataton's WATCHOUT edge blended wide screen video projection facility.

Presented by Malcolm Hignett M.Art(RCA), PGCE, Cert Film Stud, FHEA.
Programme Leader BA(Hons) Digital Media Production
School of Art and Design,
Faculty of the Arts,
Thames Valley University
St. Mary's Road,
Ealing,
London
W5 5RF
Email: malcolm.hignett@tvu.ac.uk
Tel: +44 (0)20 8231 2537

Acknowledgements
The author would like to thank Tony Clynick for his constant help and support in developing the laser display facilities at TVU; Chris Matthews and Marlyn Weeks at LCI Productions for providing their own facilities to enable us to deliver the short course from the start and supporting us with items of technology needed to build a laser system at TVU; Geoff Jones at I-Vision (UK) for providing 2 Spectra Physics 168 White Light lasers on long term loan; Stephen Harvey at LM Productions LLP for providing an AA PCAOM, Patrick Murphy and Bill Benner for supporting us with Pangolin LD2000 Pro Lasershow Designer hardware/software at educational price and Dr John O'Hagan, Group Leader of the Radiation Protection Division, Health Protection Agency (UK), for providing supportive comments on revisions to this paper.

References
Dunstan, Jane (2008)
Course Leader BA(Hons) Digital Animation
Faculty of the Arts, Thames Valley University,
http://www.tvu.ac.uk/artdesign/subjects/Digital_animation.jsp

Hignett, Malcolm (2008)
Course Leader BSc(Hons) Media Technology
Course Leader BA(Hons) Digital Media Production
Faculty of the Arts, Thames Valley University,
http://www.tvu.ac.uk/artdesign/subjects/Digital_media_production.jsp

Hignett, Malcolm (2008)
'Lasers in Entertainment' Module Study Guide November 2008
'Laser Display Technology and Performance' Module Study Guide October 2008
Faculty of the Arts, Thames Valley University,
http://www.tvu.ac.uk/blackboard/index.html

Moseley and Zabierek, Trevor and Gus (2006 Edition)
Guidance on the Safe Use of Lasers in Education and Research
Association of University Radiation Protection Officers (AURPO)
Guidance Note No 7
http://www.aurpo.org/docs/AURPO_GN7_Lasers_0107.pdf

Safety of Laser Products - Part 3: Guidance for laser displays and shows
IEC Technical Reports IEC/TR 60825-3:2008,
http://webstore.iec.ch/Webstore/webstore.nsf/0/7E2546094E09B01FC125740A0010B551

Safety of Laser Products - Part 14: A user's guide
IEC Technical Reports IEC/TR 60825-14:2004,
http://webstore.iec.ch/Webstore/webstore.nsf/0/01E0CE874038908FC125727F00581074

The Radiation Safety of Display Laser Installations HS(G)95
Health and Safety Executive Books 1996
ISBN 0 7176 0691
http://www.hse.gov.uk/pubns/INDG224.htm

Student Critical Evaluations
Field and Cordice, (2007)
'Detroit' Beam show
Critical Evaluation, Thames Valley University

Quailey, (2009)
'Play My Game' animation display
Critical Evaluation, Thames Valley University

Townsend and Connoughton, (2007)
'Dsico' Beam show
Critical Evaluation, Thames Valley University

Foot Note References:

Benner, Bill
Pangolin Laser Systems Inc., 9501 Satellite Boulevard, Suite 109, Orlando, FL 32837 USA Phone +1-407-299-2088
Fax +1-407-299-6066
http://www.pangolin.com/ (accessed 1 June 2009)

Clynick, Tony
Former Technical Director at Laser Creations International and Arcstream AV London
Optrosonic Ltd., Audio Visual and Laser Consultant, London UK
Mobile: +44 (0)7974431347
www.optrosonic.com (site under construction)

Harvey, Stephen
LM Productions LLP, Unit 6H Southbourne Business Park, Courtlands Road, Eastbourne, East Sussex BN22 8UY United Kingdom
Phone: +44 (0)1323 432170
Fax: +44 (0)1323 432171
http://www.lm-productions.com/index.php (accessed 1 June 2009)

Jones, Geoff
I-Vision (UK), Lakeside House, Lakeside, Cwmbran, Gwent, Wales, NP44 3XS UK
Phone: +44 (0)1633 482500
http://www.ivisionuk.com/index.html (accessed 1 June 2009)

Matthews and Weeks, Chris and Marlyn
LCI Productions, 55 Merthyr Terrace, Barnes, London, SW13 8DL UK
Phone: +44 (0)20 8741 5747
Facsimile: +44 (0)20 8748 9879
http://www.lci-uk.com/index.php (accessed 1 June 2009)

Murphy, Patrick
ILDA Executive Director, 7062 Edgeworth Drive, Orlando Florida 32819, USA
Phone: +1-407-797-7654,
Fax: +1-503-344-3770
http://www.laserist.org/index.htm (accessed 1 June 2009)

Tozer, Paul
Lasermet Limited, Lasermet House, 137 Hankinson Road, Bournemouth, Dorset BH9 1HR, UK
Tel: 44 (0)1202 770 740
Fax: 44 (0)1202 770 730
http://www.lasermet.com/ (accessed 1 June 2009)
http://www.lasermet.com/laser-safety-software.htm (accessed 1 June)

Tyrer, John
Professor of Optical Instrumentation, Loughborough University
http://wolftest.lboro.ac.uk/staff/tyrer.html (accessed 1 June 2009)