Distance Education in Beam Physics

Béla Erdélyi, Jens Hoefkens, Kyoko Makino, Martin Berz

Department of Physics and Astronomy and
National Superconducting Cyclotron Laboratory,
Michigan State University, MI 48824, USA

Introduction

Michigan State University (MSU) began using the Internet to deliver instructional programs to an international audience in 1995. Since then MSU became one of the leading "cyber universities" in the United States. Today, students from around the world attend MSU's Virtual University [1], and our Beam Physics M.Sc. and Ph.D. On-line Degree Programs operate within this framework [2,3].

Beam Physics [4] is a rapidly developing sub field of physics that is connected to some of the largest and most expensive scientific experimental devices located at major particle accelerator laboratories. As such, the traditional educational clientele is situated predominantly outside major research universities and scattered among many sites in the U.S. and the rest of the world. Because of these specific circumstances, the field has been recognized as a prime candidate for methods of distance education [5]. As a response to this need, the VUBeam course and degree program has been initiated, and it represents the first distance learning physics program that offers Ph.D. degrees [6,7,8].

The program was launched in 1997, and the degree options were officially implemented by MSU in 1998. Since that time, the program has served approximately 250 course participants from a large number of locations, most of which are listed in Table 1.

Site Name	**Country**	***Participants***
Academia Sinica	Taiwan	1
Argentinean CNEA	Argentina	1
Argonne National Lab.	USA	23
Beijing University	China	3
Brookhaven National Lab.	USA	9
Calcutta University	India	4
Campbell University	USA	2
CEBAF (T. Jefferson National Lab.)	USA	11
Cornell University	USA	1
DESY	Germany	1
Dubna Laboratory	Russia	3

EPN	Ecuador	1
Fermi National Accelerator Lab.	USA	12
IHEP	China	13
Japan	Japan	2
Kansas State University	USA	2
KVI	Netherlands	4
Los Alamos National Lab.	USA	1
Lawrence Berkeley Nat. Lab.	USA	7
Lawrence Livermore Nat. Lab.	USA	2
Mississippi State University	USA	1
Michigan State University	USA	24
Notre Dame University	USA	2
Oak Ridge National Lab.	USA	1
Sandia National Lab.	USA	1
Saratov State University	Russia	1
Alazhar University	Saudi Arabia	1
Stanford Linear Accelerator Center	USA	3
St. Petersburg State University	Russia	7
Stony Brook Laboratory	USA	1
National Central University	Taiwan	1
NASA	USA	1
TRIUMF	Canada	3
Ukrainian College	Ukraine	1
University of Antananarivo	Madagascar	1
University of Chicago	USA	1
Univ. of Illinois, Chicago	USA	1
University of Islamabad	Pakistan	1
University of Texas, Austin	USA	2
Université Laval	Canada	1
University of Helsinki	Finland	1
Unaffiliated		75
Vanderbilt University	USA	1

Table 1. Participating Sites in the VUBeam program

Program overview

Both M.Sc. and Ph.D. programs require regular admission to Michigan State University. The Ph.D. program requires passing a graduate exam in four core subjects in physics at the appropriate level. For the M.Sc. degree, a total of 30 credits has to be accumulated. For the Ph.D. degree, in addition to the completion of a sequence of courses in Beam Physics, the completion and successful defense of a dissertation is required.

In order to provide the flexibility necessary for a successful distance education program, we are offering a variety of alternative methods to earn credits:

- Virtual Interactive Beam Physics Courses
- Courses at the US Particle Accelerator School [9]
- Courses in residence at MSU
- Master's Thesis, up to 12 credits
- Up to 9 transfer credits from other universities

Credits for suitable courses with a minimum grade of 3.0 are accepted from accredited US and foreign universities. While the Web-based courses can be started at any time, the Particle Accelerator School courses are usually offered in two-week blocks twice a year. Thesis work may be started at any time, with the approval of the participant's advisor, which could be any MSU faculty, in residence or remotely, or mutually agreed mentors at National Laboratories or Universities in cooperation with MSU faculty.

Participants not interested in a full degree, or who wish to explore the program before seeking admission, may enroll in individual courses for credit or noncredit, or may earn a certificate. These enrollment options are designed to meet the educational and credential needs of participants throughout the world.

In addition, there are a variety of possibilities for financial assistance. First of all, out-of-state degree candidates will receive scholarship support to reduce their tuition obligation to the level of Michigan residents. Some financial aid is available for students regularly enrolled at accredited US or foreign universities. Furthermore, the Virtual University Beam Physics Tuition Fellowships, as well as teaching- or research assistantships during any period of residency at MSU are awarded on a competitive basis. Participants from the Big Ten Universities and the University of Chicago can formally register for the course through the CIC Traveling Scholars program.

The virtual interactive Beam Physics courses are the "Introduction to Beam Physics (PHY861)" course started in the Spring Semester of 1997, and the more advanced "Nonlinear Dynamics (PHY962A)" and "Particle Accelerators of the World (PHY962B)". Further Beam Physics offerings include the courses at the "US Particle Accelerator School (PHY962C)", and a "Seminar in Beam Physics Research (PHY962D)".

The prerequisites are the following: undergraduate level physics for PHY861, and PHY861 for the PHY962 level courses. PHY962A is the logical continuation of

PHY861 at a more advanced level, while PHY962B is a showcase of major accelerator laboratories of the world, and is currently being expanded to a two-semester version. Lectures are presented through live videoconference sessions originating from the respective sites by leading local experts. PHY962D consist of topics for self-study and seminars drawn from current research in Beam Physics, and it is arranged by mutual interest.

Technical aspects

In this section we discuss some of the technical challenges that were part of establishing the VUBeam online degree program, which in a similar way are likely to be faced by other leading distance education programs as well. In the following subsections we will take a closer look at how we have deployed Internet based technologies to arrange optimal educational settings for all participants. Figure 1 shows the information flow of the course, including local content delivery, live transmission via videoconference and Internet, as well as asynchronous learning experiences.

Content Delivery

Live lectures are broadcast via PictureTel and compatible videoconferencing systems (over ISDN phone) and RealVideo streaming services. The base for PHY962A was videotapes recorded in connection with a course delivered at the US Particle Accelerator School in January 1998. The live PHY962B lectures during Fall 1999 and Spring 2000 have been encoded into Real Video format by our local TV studios WKAR [10], and are available for download.

The lecture notes are posted on the web in Postscript and PDF formats. Occasionally, HTML, DVI and Microsoft Word, or combinations thereof, are also available. The guest lecturers themselves provide most of the lecture notes, as well as homework problems for PHY962B. The textbook for PHY962A is “Modern Map Methods in Particle Beam Physics” by Martin Berz [11], and it is also posted on the web.

Taking into account the large size of the Real Video and lecture notes files, as methods of delivery we also retain the option of mailing CD-ROMs for participants in regions with slow or expensive Internet connections. The CDs contain a mirror image of the course related pages from our web server, including all the lecture notes and video files. Thus, the students that need CD-ROMs are not disadvantaged compared to those with efficient network access.

WebCOSY

The unifying back-end of the VUBeam program is the WebCOSY system for course management [12,13]. It is a Web-based database application that allows the management of virtually all aspects of the program, the courses, and the students. Initially, the system was conceived as an enhancement of the CAPA homework system [14,15] offering a variety of necessary additional features, but it has grown into a sophisticated interactive Web-based tool for homework and course management.

The WebCOSY system consists of a CGI back-end that is written entirely in Perl, and it is divided into the student interface and the administrative front-end. Both parts interact by using the common database back-end of the system. The whole system can be used and administered entirely using the HTML front-end, and it allows personalized problems for students. This includes, but is not limited to, personally randomized numerical and multiple-choice problems that are instantaneously graded by the system. Moreover, the system allows the submission of COSY Infinity input files (COSY is a special purpose code for general nonlinear dynamics as well as specific beam dynamics problems [16,17]). Use of COSY Infinity is a mandatory part of the VUBeam curriculum, and the need for efficient handling of COSY input files was the reason for the development of the WebCOSY system. This execution back-end distinguishes the WebCOSY system from other Web-based interactive homework systems, since it allows the automatic processing of arbitrary user supplied input by appropriate programs, and the redirection of the output to the Web front-end.

To illustrate how the WebCOSY system fits into the general framework of the VUBeam program, consider how a fictitious student “John Doe” progresses through the system from the moment of first registration to eventual graduation with an M.Sc. degree.

1. John hears from the VUBeam program through posters, flyers, e-mail, or word of mouth and decides to enroll for the M.Sc. online degree program: he registers for Physics 861 by filling out an online registration form.

2. The personal data of John Doe are sent by e-mail to the university officials, and the VUBeam professors and TAs.

3. The data of his registration are automatically processed by the WebCOSY system; a record is created for John Doe in the database and it is made available to the people involved.

4. After the data of John have been reviewed, he is given access to the Physics 861 Web pages and homework problems, and an e-mail with the relevant information is sent to him.

5. During the course of the semester, John works on the problems and his grades are recorded in the system.

6. All updates to the administrative records of John Doe (like approval of transferred credits, successful completion of non-VUBeam courses) are made through the WebCOSY interface and are stored in his record.

7. At the end of the semester, the TAs grade the submitted COSY problems of John, and a final grade is determined and stored in his record; an e-mail with information about the grade is automatically sent to him.

8. After successfully completing Physics 861, the process repeats with the other courses of the program (Physics 962A, Physics 962B-I and Physics 962B-II), and John's progress towards his M.Sc. degree is constantly recorded in the WebCOSY system.

9. Once John has successfully completed the courses, he works on the other degree requirements, and information on his progress is stored in his record.

10. After receiving his M.Sc. degree in Beam Physics from Michigan State University, John's account in the WebCOSY system will be closed, but his record stays available for future reference.

This outline illustrates that the WebCOSY system is an integral part of the VUBeam program, and that it facilitates coordination between various individuals that in some cases have never even met in person in the distance education setting: the administrative staff of the VUBeam program and the university, the academic staff of the lecturer, and the student. An important aspect of this collaborative group work approach is that there is no need for instructors or TAs to be located at the Michigan State University campus: it is possible to employ advanced VUBeam participants as TAs for the lower-level courses.

Users and course organizers alike have been highly satisfied using the WebCOSY system. Students praise the system for its easy to use interface and the ability to work on homework assignments at their convenience. Additionally they like the instant feedback and gratification on submitted answers and the well-tested problems of the system.

Discussion Board

Another vital part of the Internet based course setup is the discussion board. In order to facilitate communication between the students and us, this form of open communication turned out to be very useful. We encouraged the students to post questions and/or suggestions to the board instead of sending e-mails directly to the organizers. The benefit of this approach is that is cuts down the volume of e-mails received from the students by avoiding repetition of questions. Students' privacy is maintained, as it is possible to post anonymously to the discussion board. Moreover, we believe that the discussion board spurs private email discussions among students.

Local Contacts

Although we tried to establish the VUBeam program as an Internet based course, it became clear early on that some participants would not feel comfortable without the personal contacts that can only be offered by real people. Therefore it was of prime importance for us to establish close connections to qualified local contact persons that can help the students with questions and can provide personal contact. In some places these instructors even formed small groups with their students that were working together through the course material in local lectures. We think that the general aspect of accessibility of the main instructor and the availability of help close by cannot be stressed enough in the preparation of any distance education course.

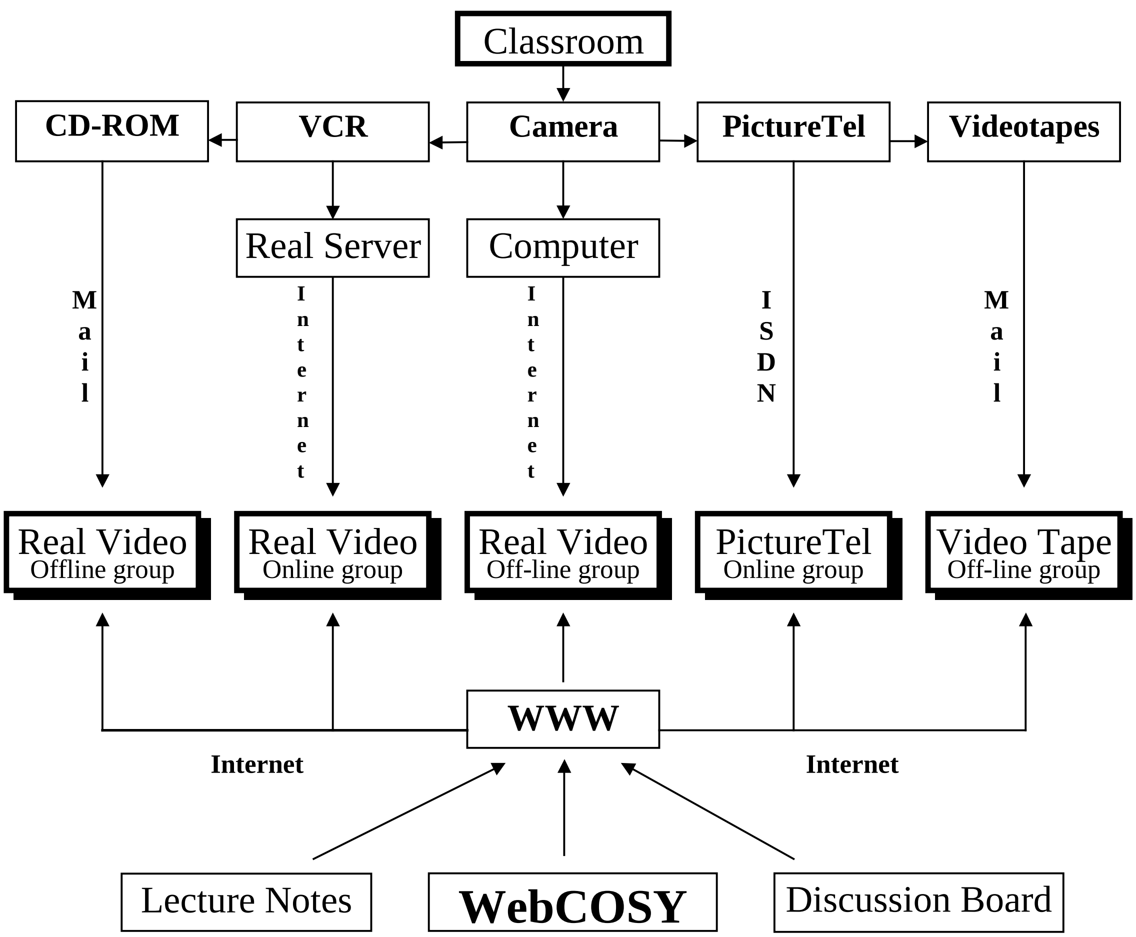

Figure 1. Information flow of VUBeam courses

For the degree participants, the local contacts also serve as advisors during the completion of M.Sc. and Ph.D. dissertations.

Summary

Currently there are 11 M.Sc. and 12 Ph.D. students enrolled, and several additional applications are currently pending. Although coursework can be started at any time, the deadlines for all homework submission usually coincide with the end of semesters to be able to report grades on time. We are accepting applications up to the starting date of semesters for the respective semester. For the Fall 2000 semester we had more than 20 applications.

We are considering as dropout the fact that no homework has been solved by the time the deadlines passed. According to this definition the average dropout rate is highest for PHY861 (approximately 15%), it decreases for PHY962B (less than 10%), and there is virtually no dropout for PHY962A, which is probably the most difficult course of the curriculum at the present time. The statistics reflects the situation for all the students enrolled. If we consider only the degree students, there is no dropout whatsoever. We intend to look more deeply into the dropout question in the future. For example, it is conceivable that part of it is due to cultural differences between the US’ and other countries’ style of handling homework for graduate students. However, compared to some other distance education programs our rates seem more favorable, which is probably connected to the fact that this is a highly specialized program, and most of our students are inherently self-motivated.

The grades obtained by the on-line students are similar to the grades of students who took the traditional versions of the same courses, but perhaps a tad lower. Also, we asked for feedback on the clarity of formulation and level of difficulty of the problems. The reaction was limited, which we take as a good sign. Nevertheless, it helped us to fine-tune some of the homework problems. The amount of work involved on our side increases drastically around deadlines, and more so than in a regular classroom setting because of an apparently stronger focus and attention to the homework problems as the deadline approaches. That is why for PHY861 we group the homework problems into three sections, each section with its own deadline. Other than that, a significant amount of time is invested sometimes in a few “high maintenance” students (similar to the famous 80/20 rule – 20% of the students require 80% of the attention).

In conclusion, we reached a stage of development where most of the processes involved flow smoothly. With the growth of the program and eventual graduation of the graduate students currently helping in the program as teaching assistants and departure of postdocs, there is a need to find ways for smooth transitions. Altogether, we believe that we managed to create a successful program that will stand the trial of time, and from which hopefully many students will benefit.

References

[1] MSU Virtual University Homepage, http://www.vu.msu.edu/

[2] B. Erdélyi, J. Hoefkens, L. Diening, K. Makino, M. Berz, *The Michigan State University M.Sc. and Ph.D. On-line Degree Programs in Beam Physics*, Quarterly Review of Distance Education, **1**, 4 (2000)

[3] VUBeam Homepage, http://vubeam.nscl.msu.edu/

[4] American Physical Society, Division of Physics of Beams, http://www.aps.org/units/dpb/

[5] M. Berz, B. Erdélyi and J. Hoefkens, *Experiences with Interactive Remote Graduate Instruction in Beam Physics,* Journal of Interactive Learning Research, **10** (1999) pp. 49-58

[6] SLOAN-C Catalog of On-Line Educational Programs, http://www.sloan-c.org/catalog/

[7] Peterson's Guide to Distance Education, http://www.petersons.com/

[8] The Chronicle of Higher Education, November 1999, http://www.chronicle.com/

[9] US Particle Accelerator School, http://www.indiana.edu/~uspas/

[10] WKAR Michigan State University Broadcasting Services, http://www.wkar.org/

[11] M. Berz, *Modern Map Methods in Particle Beam Physics*, vol. **108**, Advances in Imaging and Electron Physics, Academic Press (1999), ISBN 0-12-014750-5

[12] J. Hoefkens, L. Diening, M. Berz, B. Erdélyi, *The WebCOSY System for Course Management in Distance Education*, Journal of Computers in Mathematics and Science Teaching, in print (2000)

[13] WebCOSY Test Page, http://webcosy.nscl.msu.edu/; use Login "demo" and Password "webcosy"

[14] E. Kashy, D.J. Morrissey, Y. Tsai and S.L. Wolfe, *CAPA - A Versatile Tool for Science Education*, MSUCL-971, September 1995

[15] E. Kashy, Y. Tsai, N. Davis, S. Wolfe*, Using Networked Tools to Promote Student Success in Large Classes*, Journal of Engineering Education (1998) pp 385 - 390.

[16] M. Berz, *COSY INFINITY Version 8 Reference Manual*, National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824, MSUCL-1088 Revised (1999); see also http://cosy.nscl.msu.edu/

[17] K. Makino and M. Berz, *COSY INFINITY Version 8*, Nuclear Instruments and Methods A **427**, 1-2 (1999) pp. 338-343