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Experiences with Interactive Remote Graduate Instruction in Beam Physics

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Abstract

An Internet-based course in Beam Physics being offered by the Department of Physics and Astronomy at Michigan State University is described. This course is part of the MSU Virtual University Degree program in Beam Physics (VUBeam, 1998), and had about 100 registered participants at approximately 25 different sites all over the world at its debut. For the purposes of this course we are using ISDN-based and Internet-based videoconferencing tools, Internet-based transmission of audio and video recordings of the lectures, an interactive Internet-based homework system with on-line grading, and we provide the participants with downloadable lecture notes in a variety of formats.

Beam Physics as a more recent subfield of physics is concerned with the behavior of particle beams in particle accelerators. Because accelerator laboratories are usually not directly connected to university environments, the proper training of beam physicists at these sites often less naturally than in other fields. The availability of video conferencing and other Internet-based tools offers students and employees an option of increasing or refreshing their knowledge of Beam Physics. This approach provides an efficient and inexpensive mechanism to learn in a systematic fashion and offers the opportunity to earn university credit and even degrees without leaving the workplace.

Introduction

Beam Physics incorporates many practical applications and challenging theoretical aspects. It is connected to probing the fundamental properties of nature and the search for new physics through high energy accelerator experiments, which are the largest scientific experiments so far, elucidating the structure of huge biological molecules trough mass spectrometers, visualizing tiny surface details trough electron microscopes, fabricating computer chips trough micro beam lithography, building CRTs for TV sets, separating isotopes, measuring exotic nuclei, and a variety of other techniques.

Site Name	Country	Participants
Argonne National Lab.	USA	21
Beijing University	China	1
Brookhaven National Lab.	USA	8
Calcutta University	India	2
T. Jefferson National Lab.	USA	11
Cornell University	USA	1
DESY	Germany	1
Dubna Laboratory	Russia	2
Fermi National Accel. Lab.	USA	7
Kansas State University	USA	2
KVI	Netherlands	4
Los Alamos National Lab.	USA	1
Lawrence Berkeley Nat. Lab.	USA	6
Lawrence Livermore Nat. Lab.	USA	2
Mississippi State University	USA	1
Michigan State University	USA	11
Sandia National Lab.	USA	1
Stanford Linear Accel. Center	USA	1
St. Petersburg State University	Russia	5
Stony Brook Laboratory	USA	1
TRIUMF	Canada	3
University of Chicago	USA	1
Univ. Of Illinois, Chicago	USA	1
Universite Laval	Canada	1
University of Helsinki	Finland	1

Table 1: Participating Sites

New theoretical methods developed for Beam Physics are at the forefront of physics, both facilitating the understanding of current scientific instruments and providing solutions for future ones, and because of their often fundamental nature stretching out to other scientific domains. Recently established as a Division of the American Physical Society, education within the field of Beam Physics is faced with a rather unique set of boundary conditions. Due to the nature of this field, the highly trained instructors and specialists are often spread over universities and major research laboratories. In the United States, Michigan State is one of only a few universities that provide Beam Physics curricula. A significant amount of instruction is provided by the U.S. Particle Accelerator School via biannual two-week block courses at various locations in the USA as well as some other similar institutions.

Altogether, this situation provides a nearly ideal environment for the utilization of distance education techniques, allowing to provide large scale access to Beam Physics instruction, even internationally. Indeed there are numerous advantages: the convenience of taking such a course without leaving the workplace or school, reduced cost, flexible scheduling, the ability to gather recognized specialists to give guest lectures on their topic of expertise, etc. In the following what has been accomplished in this direction towards a future virtual classroom. Table 1 gives an overview of the participating sites, locations and number of participants per site.

The subsequent sections will provide information about the importance of local contact persons, the technical aspects, the equipment and the Internet based homework assignments we have used. Finally, we discuss the difficulties we have encountered, and summarize our conclusions and directions of future activities.

Technical Details

The method of attending the lectures allows a classification of the participants of our course in 4 major groups, with a subdivision of one of them in two subgroups.

1. PictureTel User
   - Online User
   - Off-line User
2. CU-SeeMe User
3. Real Audio User
4. Videotapes User

Figure 1 gives a schematic overview of the equipment used and the flow of information to the participants for the various groups.

PictureTel

The major lab sites in the US are equipped with ISDN-based teleconferencing tools like PictureTel (PictureTel, 1997). These sites use this equipment to participate in the lectures. Based on ISDN, the Integrated Digital Data Service, it offers higher bandwidths than ordinary phone lines and wide availability. While these solutions by themselves offer only point-to-point connections, Lawrence Livermore National Laboratory in California offers a service that allows more than two sites to connect to one video conference (VCS, 1997). We are using this service (bridge) to serve the PictureTel based participants. This service is provided to institutions supported by the US Department of Energy for free; it is also available commercially at a rather affordable rate of about $40/hour. But the equipment for the system lies in a price range from about $20,000 to $100,000, which naturally restricts the users of this system to participants located at the major lab sites in the US and Europe. While this system in principle has no restrictions on the locations (in fact we successfully transmitted lectures from Hamburg, Germany), all but the German site are located in the US.

Since the participants in this system actually see the other participants on a regular TV screen and the video signal is highly compressed, special arrangements have to be made in order to transmit a readable picture of the lecture notes. A designated document camera is used and the text has to be in a slightly bigger font than usual.

Due to the time shift in the US and our lecture schedule commencing at 9:45AM EST, the lecture took place rather early in the morning at the West Coast. The participants at these places recorded the lecture with a normal VCR and watched the lecture later off-line (PictureTel Off-line User Group). The members of the PictureTel Online Group attended the lectures live and online.

CU-SeeMe

The second group of our participants were the CU-SeeMe users. CU-SeeMe is a videoconferencing technology developed at Cornell University that uses regular TCP/IP to transmit highly compressed video and audio data over the Internet (CU-SeeMe, 1997). The major advantage of this technology is that the necessary soft- and hardware is free or rather inexpensive. All the participants of this group need a personal computer, a network connection (fast modem connections are sufficient) and a sound card. Altogether these equipment needs can almost be considered standard for modern personal computers.

In addition, the participants need the CU-SeeMe client software. There are two choices to obtain the software: it can either be purchased from a commercial vendor, or one can use one of the many freeware clients. Although the commercial product has some enhancements over the free versions, we do not use it in order to maintain compatibility with the participants that do use the free versions. Even the commercial product is rather affordable. On the server side a Windows-based PC with a frame grabber card is needed, currently at a cost of approximately $250. It is not necessary to use commercial software in order to transmit the signals. In order to operate the CU-SeeMe part of the video conference, the participants log in to the *deflector*, which - as its name suggests - mirrors the incoming videoconference signal to the participants.

Real Audio, Video Tapes

In order to provide participants who cannot attend the lecture live with as much information as possible, an audio recording of the lectures is made available on the Internet. These audio files are encoded from the video tapes which we recorded during the lecture. The file format is the Internet standard Real Audio from Progressive Networks (Progressive Networks, 1997). The participants can download these files a few hours after the lecture and listen to them while they follow the lecture notes that are available on the web. Other participants are provided with copies of these video tapes by mail.

Both of these methods of participation are suitable for students that take the course on a standalone basis, cannot afford the PictureTel equipment, have very slow Internet connections to US sites, cannot take the lecture due to time shift problems or who just missed the class for whatever reason. Due to recent developments by Progressive Networks towards a high-compression video standard for off-line viewing, we hope that in the near future it will be possible to provide the off-line participants not only with audio data but also video recordings of the lecture. However, for users with low bandwidth connections, the resulting files may become too large, considering that the audio files alone require about eight megabytes per lecture.

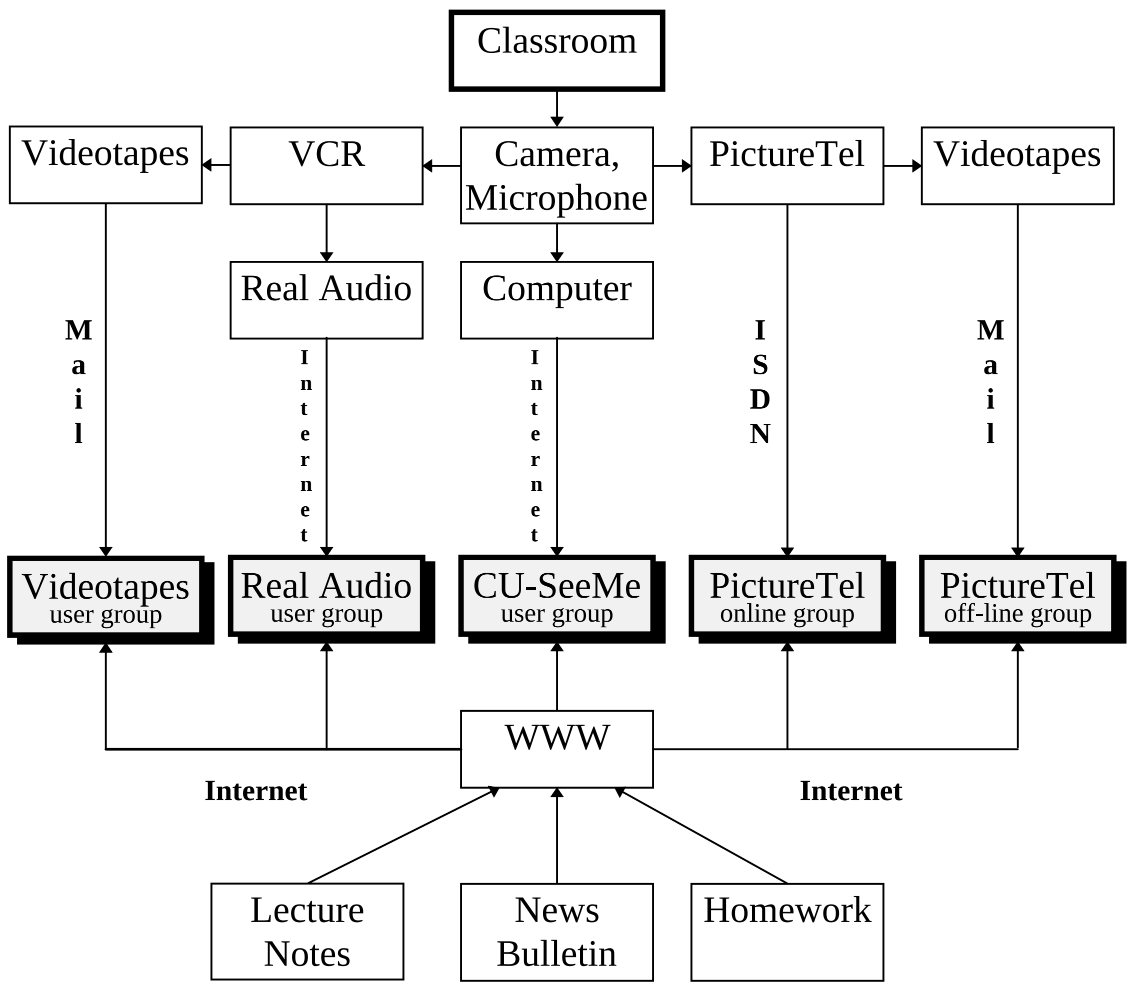

Figure 1: Information flow of the course

Local Contact Persons

It became clear early on that some participants would not feel comfortable with an Internet-based course that lacks the personal contact with the main instructor. Therefore it was of prime importance 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. To provide further assistance for the participants, we established local office hours. During a fixed time slot we were offering the students the possibility to reach the lecturers by phone, fax, electronic mail and CU-SeeMe to ask questions regarding the lectures and the homework problems. We think that the general aspect of accessibility of the main instructor and the availability of help closeby cannot be stressed enough in the preparation of any distance education course.

Homework

For homework assignments, we are using CAPA (CAPA, 1997; E. Kashy, 1994; E. Kashy, 1995), which is a software tool to implement a Computer-Assisted Personalized Approach for homework assignments, quizzes, and examinations, and more recently the WebCOSY system (WebCOSY, 1998). CAPA was developed in such a way that it provides each student with a personalized assignment or examination with both quantitative and conceptual qualitative questions. An instructor can create problem sets which include pictures, graphics, tables, etc., with variables that can be randomized and modified for each student. Once a problem has been defined in CAPA it is immediately available to all other instructors as well. In this way the system comes with a growing database of tested problems which simplifies the creation of problem sets. Students input the solutions via a standard web browser, are given instant feedback and relevant hints, and may correct errors without penalty prior to the assignment due date. The system records the students' participation and performance in assignments, quizzes and examinations; and records are available online to both the instructor and the individual student.

CAPA was developed through a collaborative effort of the Physics-Astronomy, Computer Science and Chemistry Departments at Michigan State University, and the current version 4.6 became available in February 1998. However, since the homework requirements of graduate education are going beyond the features CAPA offers, soon after the course was offered for the first time, the WebCOSY system was developed, a program that has the functionality of CAPA but at the same time enhances it in ways necessary for graduate instruction in Beam Physics. Currently, the basic types of problems include numerical, multiple choice, matching, and true-false types, all of which are also present in CAPA . The functionality of external programs processing student's input was added. This allows for programming language source code submissions, automated compilation and execution of the submitted programs. The output is then made available to the instructors for grading. Furthermore, in principle it is possible to have analytical derivations checked with computer algebra systems like Mathematica or Maple.

Publishing of Scientific Texts on the WWW

During the preparation of the course the currently available mechanisms to publish scientific text on the WWW were evaluated. One major aspect was the need to have a tool that allows the transformation of texts that are written in LaTeX, the main text editing software supporting complicated mathematical expressions, to HTML documents. Since most scientific texts containing extensive mathematics are written in LaTeX format, it seemed natural to us that there should be a way to publish these documents on the web. Two major aspects have been important for us. First of all the transformation should be as easy and as compatible with any computer platform as possible, and secondly the result should be esthetically pleasing.

While there is a tool that transforms LaTeX input files to HTML documents (LaTeX to HTML) the results are unfortunately often far from pleasing, since every single equation is transformed into a separate GIF file. The resulting documents loose nearly all the nice formatting typical of LaTeX, and due to the literally hundreds of GIF files the loading times of the resulting HTML documents are unacceptable. Besides this tool there are other solutions for LaTeX publishing on the web (TeX Explorer from IBM - a Netscape plug-in for Windows (IBM Alpha Works, 1997), Scientific Notebook - a proprietary browser from TCI Soft (TCI Software, 1997)). But all of them have the shortcoming that the software solutions are restricted to certain browsers and/or platforms. Since we had to maintain wide compatibility, these solutions ruled themselves out.

A portable way of displaying the documents would be given by Java applications that can process mathematical equations by directly displaying the output of the LaTeX typesetting system. The IDVI (IDVI, 1996) tool offers exactly this functionality and the utilization of these tools is an ongoing effort in our preparation of future online courses. But lacking the ability to print the documents, this program may not be the ultimate solution to the problem of publishing scientific documents on the web.

Finally the WWW Consortium has recently published a standard for the publication of mathematical texts on the WWW (MathML, 1998). While it may take several years for capable browsers to become widespread, this is certainly an interesting development that will is expected to eventually provide the necessary tools in the near future. Until then it seems that the publishing in PostScript format, with its shortcoming of non-interactivity, will remain the standard for distributing scientific texts containing mathematics in the near future. Another promising approach towards this problem seems to be the future development of the Portable Document Format (PDF) by Adobe (Adobe, 1996), which offers a certain level of interactivity.

Conclusion and Future Developments

Overall we rate the Internet- and video conferencing-based courses in Beam Theory we have been given since the spring term of 1997 at Michigan State University as a full success. Not only was it possible to reach a wide audience, but the resulting interactive distance education environment was found to be sufficiently robust to be used throughout MSU's remote Master's and Ph.D. program in Beam Physics (VUBeam, 1998). Certainly this method of remote graduate instruction has its place in modern education and will become even more important in the next years, while improvement of the used technologies and methods will be an ongoing effort.

Since all the material is available in a web browser readable format, it is a natural extension to produce a CD-ROM out of the course material. This would allow students to take the course as it fits their needs and independent of the curriculum at Michigan State University. Given the interactive homework approach via CAPA and WebCOSY, it is even possible to award credit to each individual who has at his own pace completed a full set of problems. This CD-ROM could be viewed with any web browser and could even contain the necessary additional programs (like the Real Audio player and the free GhostView PostScript viewer).

Finally, the methods are in the process of being applied to all new Internet-based courses in Physics that will be available in the near future. We hope that all these activities will greatly facilitate education and student contact within the newly approved degree program in Beam Physics.

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