The USPAS from the perspective of the Instructor

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Joint Session FEd/DPB
Personal Background

- National Laboratories
  - Fermilab, SSC Lab, Brookhaven, Fermilab
- Teaching outside of USPAS:
  - CERN school; Northwestern U.; U. Texas at Austin
- Accelerator Experience
  - Main Ring/Tevatron, AGS, RHIC; + SSC, LHC
- PhD in “HEP” -- thesis in Accel Phys
- recognized early the need for high-quality Accelerator Phys/Technology instruction
Will discuss...

- Lessons learned -- 20 years ago, and today
- Course development
  - making courses (esp. intro courses) accessible to students, and to long-time lab employees
  - Prep consideration, and tools of the trade
- Most recent experience
- Conclusions
Early USPAS Experience

- Taught initial “general intro” course in Accelerator Physics, 1988-1992
- Team-teaching with Donald Edwards (mentor)
- Graduate level credit (as were all courses then)
- Had a textbook in mind; influenced material
- Large classes -- 60-70 students -- with varied background (work exp., educ., etc.)
Early Lessons

While learning to do this, determined...

...USPAS students smart and highly motivated
great, for developing a text book!

...the need for grader(s)!!

...while gets easier the 2nd (3rd, 4th, ...) time, still requires lots of work and energy

Saw build-up during SSC days, which influenced the student population; after a short decline following, the field itself was resilient!
Student Distribution

Education Level

- Unknown 1.5%
- High School 0.3%
- Undergraduate 5%
  - Associates 1.5%
- Bachelor's 20%
- Master's 17%
- PhD's 25%
- Graduate Students 30%

These charts are “overall” for the school

Institution Type

- Laboratories 48%
- Universities 42%
- Other 1%
- Military 1%
- Government 1%
- Private Industry 7%

Individual “intro courses” tend to follow this pattern

Typically 30, up to 60 students in intro class
Development of Later Courses

- Accelerator Design course
  - wanted a “next step”; tried a 1-week course
  - took place Jan 1994, 3 mos. after SSC cancellation; halted further development of this material...

- Undergraduate “Fundamentals” course
  - pancake lunch, May 30, 1994
  - Mel Month was discussing whether we’re hitting the right audience, right material
Fundamentals course (cont’d)

Operators, engineers, programmers, etc, often struggled with graduate level course material

I had given many talks to Operators at Fermilab -- showed Mel my material; right level for new course?

Mel agreed to try, so gave first course 1 year later; offered at essentially every school since then

Most recently, Beam Optics course (more later)
Development of the “Fundamentals” Course

- motivate the basic physics, at the undergrad level
- teach the jargon, but try to relate using well-known physics terms, concepts; Accel Labs have own jargon
- show computer demonstrations, video, etc. during lecture; perform many numerical estimates in class
- homework tends to be more plug & chug rather than lengthy derivations
- but, need to make the problems relevant to their experience
Course Optimization

- Just two weeks for a 3 credit hour course

- Optimization of lectures, homework, labs, discussion/recitation, exams, etc.

  - want homework to be a learning experience as well, not just busy work; should be “doable”

- Often try to put too much into the lectures; need to leave time for recitation, absorption

- Allow for a little “time off”

- Friday PM and weekend, say
Course Preparation

- First, determine major topics to be presented.
- But then, make up HW problems and Labs NEXT.
- THEN, the lectures.
- let the labs/HW guide the course, and make sure students have the material necessary to solve them.
- NEED: review, and Q/A sessions; available help for evening HW study sessions; labs are VERY helpful (real accel HW and/or computer).
- Write the Final Exam while at the school.
Something for Everyone

- Balance the needs of professionals with the needs of credit-earning students
  - rigor of material, examinations -- required by sponsoring universities
  - but, recognize that half of the class members have not been “in school” for years (often decades)
- Credit vs. Non-Credit (typically 50/50 split in an intro class); tough to find the middle road
- Need to be able to adjust the course on-the-fly
Tools of the Trade

Today, “PowerPoint”® has become the tool; but too easy to present too much -- need to slow down

Still prefer blackboard (hence, this background), but expensive to rent in hotel settings...

Use it all -- white boards (>= 2), computer (for special material, simulation demos, charts/graphs, pictures, web look-up, etc.) and real hardware when possible

keep it dynamic, and people may stay awake! (unlike in this talk...)
Portable Lecture Demos

Since the mid-1980’s, Don Edwards and I had developed simple BASIC programs on Apple and Atari personal computers to illustrate beam dynamics principles; incorporated these into our teaching.

```
x=xm
y=ym
plot xm,ym
do

xt = x
y = y - x*x/2.0
x = a*x+b*y
y = c*xt+d*y
y = y - x*x/2.0

if ABS(x)>100 OR ABS(y)>100 THEN
  x = 0
  y = 0
END IF
plot (x/amax)*sxmax+sxmax, -(y/amax)*symax+symax
getmousexy xm, ym
if button = -1 then
  x=(xm-sxmax)*(amax/sxmax)
y=-(ym-symax)*(amax/symax)
plot xm,ym
end if
for t = 1 to delay : next t
loop
stop
end
```
Since the mid-1980's, Don Edwards and I had developed simple BASIC programs on Apple and Atari personal computers to illustrate beam dynamics principles; incorporated these into our teaching.

First showed in university course at Northwestern, in Fall of 1989. Again at CERN school, in 1990.

had demo’s for \( 5^+ \) years; but no good way to show them to a large audience until 1989.

Still use many of these today (note: had to add Do Loops to slow down the action by factors of few \( 10^6 \)...); plus, more sophisticated demos...
Since the mid-1980's, Don Edwards and I had developed simple BASIC programs on Apple and Atari personal computers to illustrate beam dynamics principles. First showed in a university course at Northwestern, in Fall 1989. Again at CERN school, in 1990.

Portable Lecture Demos

- Still use many of these today (note: had to add Do Loops to slow down the action by factors of few 10...), plus, more sophisticated demos...
Introduce Computer Session

First “Fundamentals” course was given in Spring 1995

Had expressed to Mel Month how important the computer demos were in the grad course; can we make computers available to students to use?

Learned week before the school that Computer Room on U. Washington campus available for two afternoons

Quickly transformed a few of the BASIC demos into Mathcad spreadsheets; generated “worksheets” to go with them on the plane to Seattle...
Student Reaction

- The computer exercises were very well received by the students.
- Clear that hands-on experience was very fulfilling.
- Developed more files and worksheets to use in future versions of the course.
- A USPAS Computer Lab was established in 2001 to be available at every future venue.
- Added “hardware” explorations into the Fundamentals course in 2003 (Wiedemann).
The Problem with Answers

After first 2-3 years, copied answers to HW began to appear at the schools; as might expect, large selection of HW has since been developed as result.

- Some problems are “too good” and are used every time; but, need to change numbers, etc.

- Started out using set of HW, expect ALL to be done.

- Then, tried “do 4 out of 7” (give people at diff. levels a chance to shine) -- way too much work for graders (not me, by this time!)

- Now, assign HW as go along from a large set
Recent Optics Course

MJS -- wanted to teach basic beam optics, grad level
need for more/better "opticians" in the field

WAB -- wanted a second "intro" alternate to the Fundamentals course

we agreed that optics IS fundamental to most areas of accelerator physics; so, developed u.g. course

took "optics" material from Fundamentals and expanded it

taught beam optics design principals more than would in the Fundamentals course
Recent Optics Course

Original goal: Wanted students to be able to design an accelerator or beam line; however, worried that “intro” students couldn’t learn enough at required level (esp. tools to use) to do this by the second week.

28 in class: 3 PhD, 4 MS, 5 gs, 11 BS, 4 ug, 1 HS(!)

Daily computer session, however, was a great success; found that the basic concepts were being learned (as determined through homework and lab worksheets); the ability to adjust the syllabus helped greatly to encourage the students.
By the end of first week, recognized that students were diverse in education, but all highly motivated

Students were gaining proficiency in one particular “optics” software package. So, tried an experiment...

Re-formatted the syllabus over weekend, generated a new assignment for last 3 days: choose from...

- light source, proton synchrotron, e⁻ beam line
- gave “requirements” to be met; allowed students freedom to work (and play) in groups; but required individual reports at the end
Students worked hard on their designs for three days (and also kept up with other daily homework) (OK, that was slightly adjusted, too ...)

Their final design just “had to work” (i.e., stable lattice, realistic magnet parameters); but, students worked hard to develop good, optimized designs

“Design Reports” were turned in, with parameter lists, graphs of lattice functions, schematic layout, etc.

Great fun for them, and for me!
Rejuvenated my interest in teaching at the school...

typically, by the end of one of these highly-intensive two week sessions:

“never doing this again”  (just too tired!)

but, time constant of ~1 year

here, time constant was reduced by about an order of magnitude

Already have ideas for next time...
Repeat Business

-One measure of “success” is the amount of Repeat Business

-32% or more of students that attend the school, return

-Intro courses prep students for the more advanced, specialized topics

-Something for everyone

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**Complete History of Student Attendance (1987 - 2007)**

- **Total Number of University Programs:** 35
- **Total Number of Individual Students:** 2,815

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Concluding Remarks

After 20 years, still feel the need and desire to teach at the USPAS every 2-3 years

USPAS extremely important part of accelerator field
  gives new students an intro to the field; allows expert students chance to grow further
  time away from one’s lab provides a chance to learn things in depth that may not have time for otherwise (applies to teacher as well as student!)

Also important for those who teach
  best way to learn -- teach it to someone else
  if done well, can attract good students, workers to you, your lab, our field
More Concluding Remarks

- Students at the USPAS have always been highly motivated
- makes teaching courses very pleasurable
- USPAS staff and leadership consistently top notch
- program usually well thought out and timely
- staff always helpful and accommodating
- often great venues, too

- Not many programs in which to teach accelerator physics and technology in this country; USPAS has allowed the field to generate and maintain a stronger “academic” presence