The USPAS from the perspective of ~~the~~ Instructor

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APS April Meeting, 2008 -- St. Louis
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

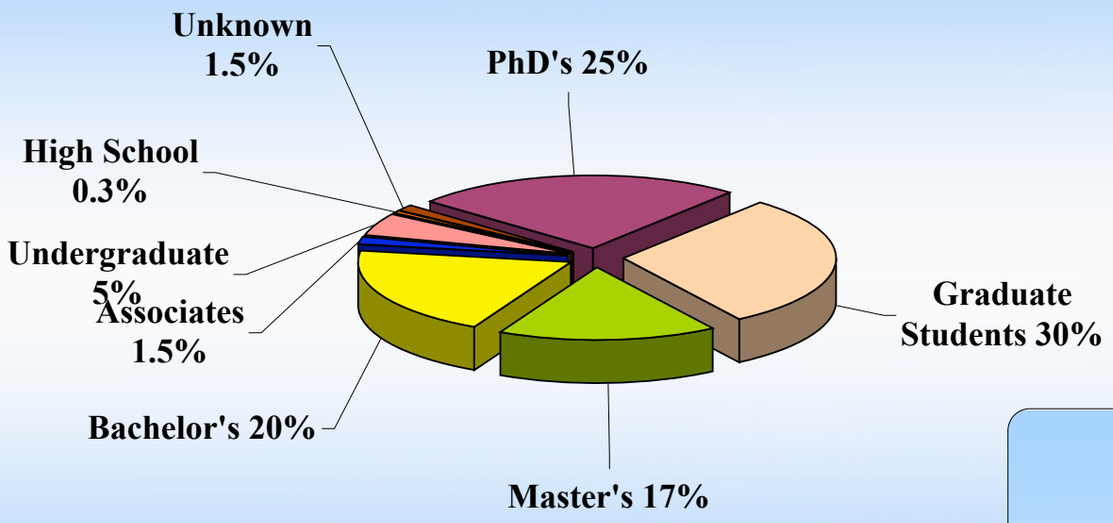
- Taught initial "general intro" course in Accelerator Physics, 1988-1992
- Team-teaching with Donald Edwards (mentor)
- Graduate level credit (as were all courses then)
- Had a textbook in mind; influenced material
- Large classes -- 60-70 students -- with varied background (work exp., educ., etc.)

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

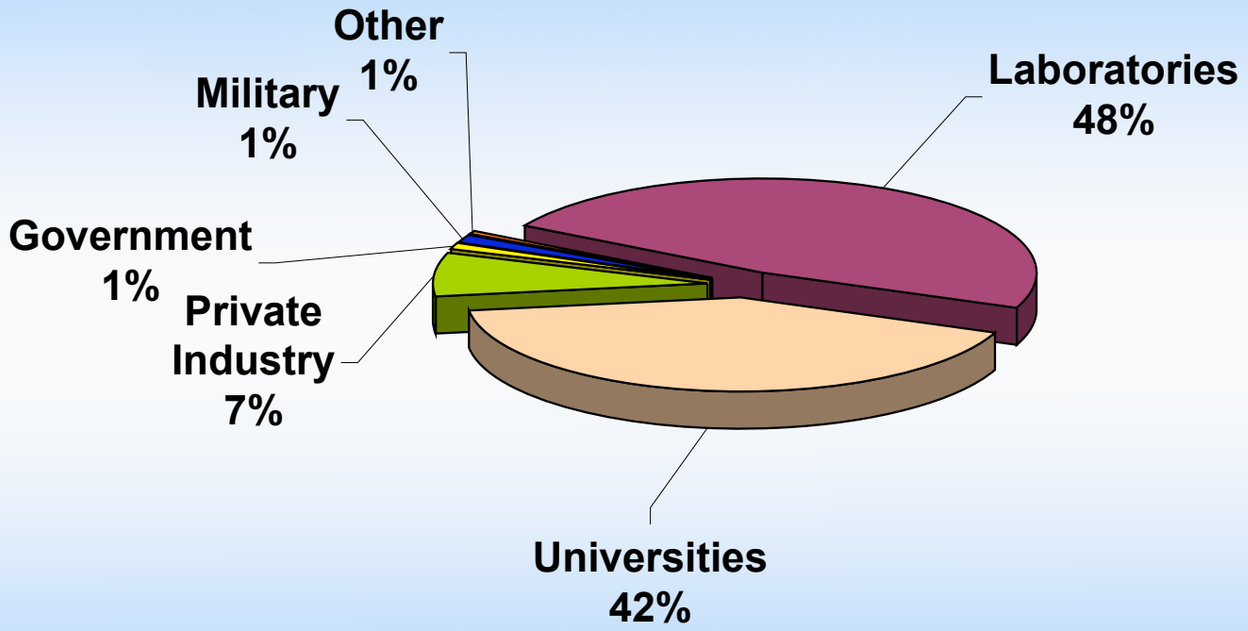
Education Level



- These charts are "overall" for the school

- Individual "intro courses" tend to follow this pattern
- Typically 30, up to 60 students in intro class

Institution Type



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

Later Courses (cont'd)

- 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

```
    rem  *   Sextupole
    rem  *    Program

resize console 100,100,screen width - 100,screen height - 100
cls
backcolor 4000,4000,1000
forecolor 0,60000,0
delay = 200000

amax = 2.0
symax = screen height - 200 : symax = symax/2
sxmax = screen width - 200 : sxmax = sxmax/2

INPUT "tune = "; tune
LINE 0,symax, 2*sxmax,symax
LINE sxmax, 0, sxmax, 2*symax
text  2*sxmax-40, symax+40, "x"
text  sxmax-100, 20, "ax + ßx'"

tpi = 2*3.1415926
a = COS(tpi*tune)
b = SIN(tpi*tune)
c = -b
d=a

do while button = 0
  getmousexy xm, ym
loop
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
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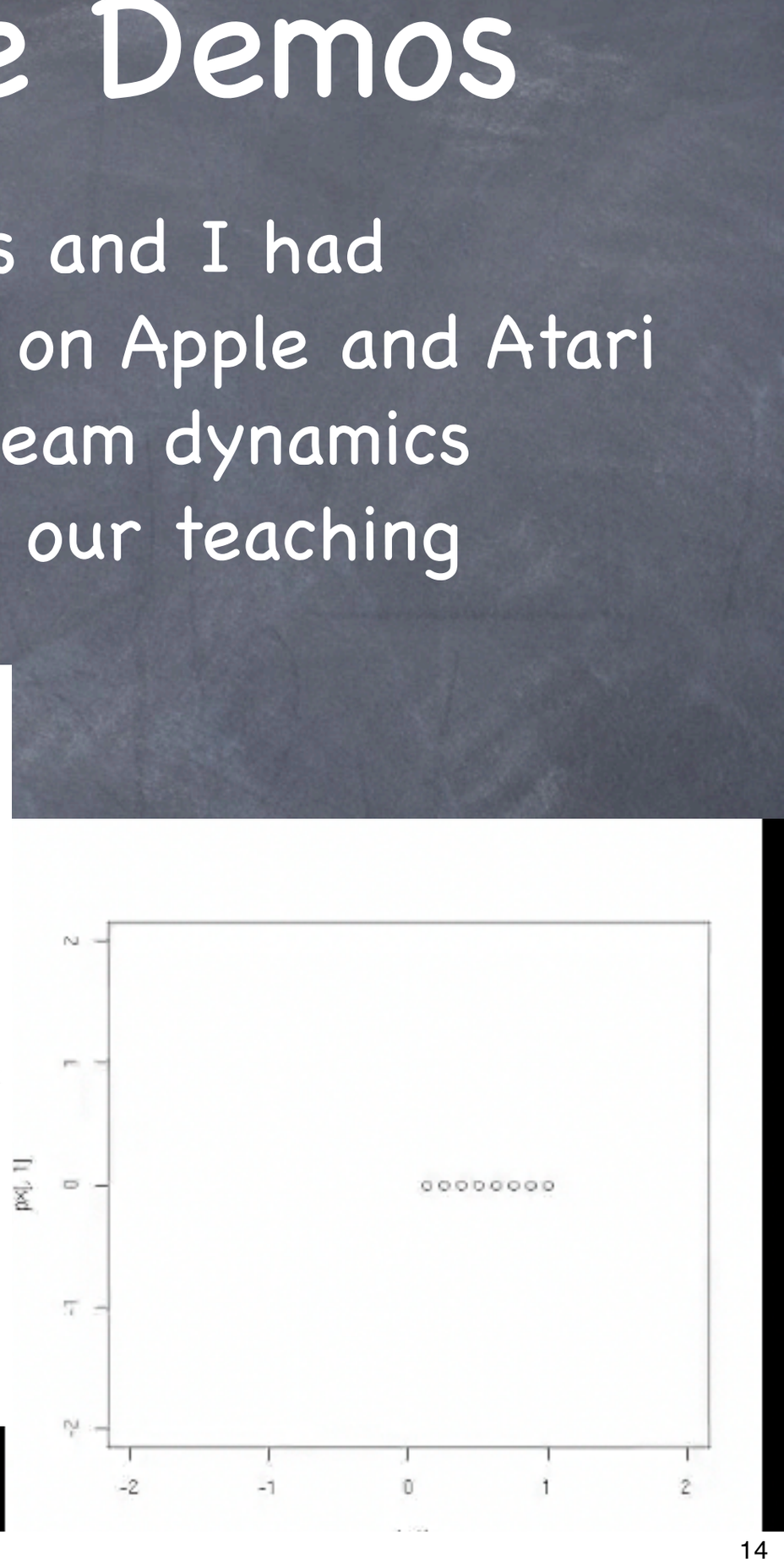
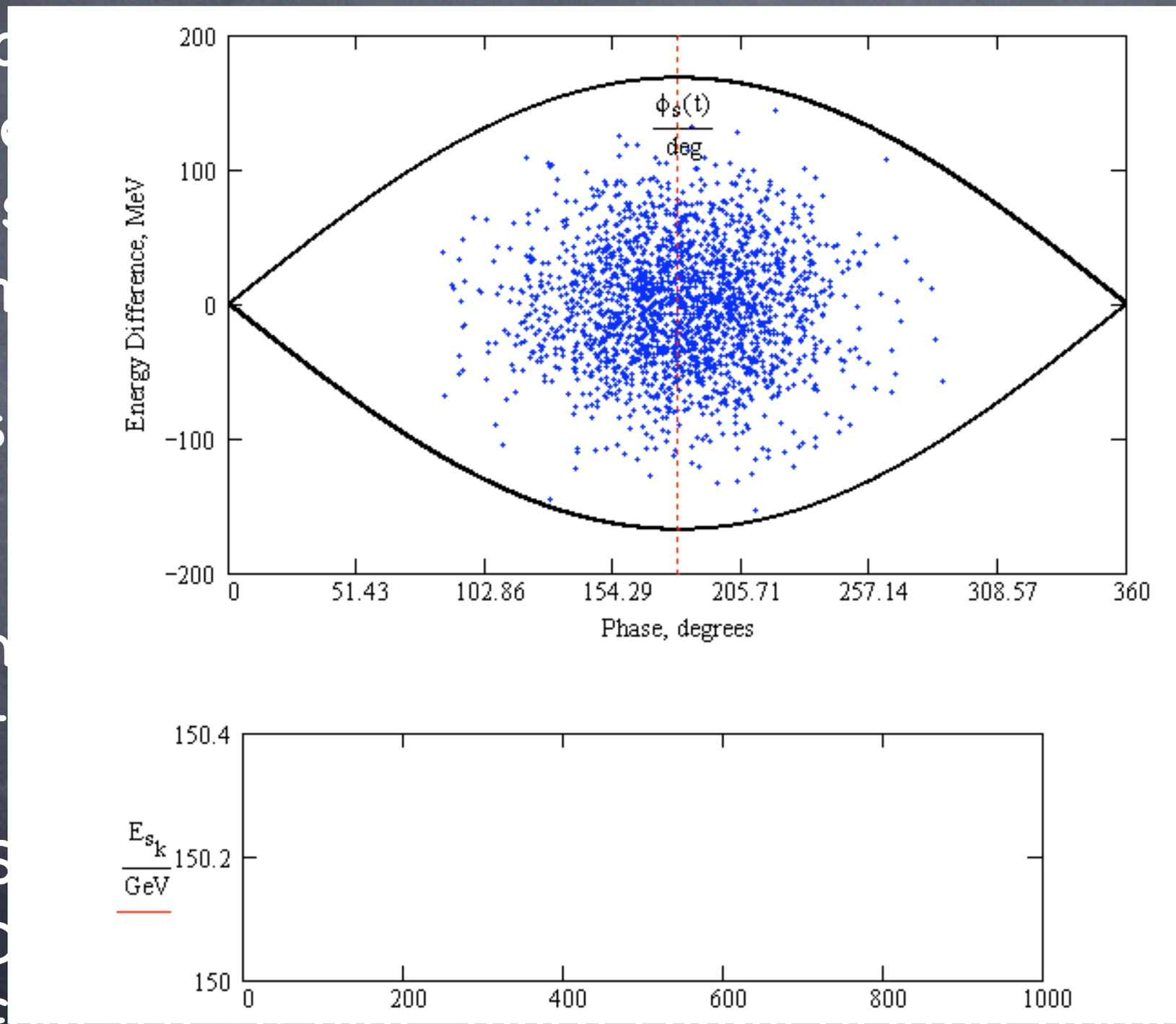


Portable Lecture Demos

- 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
- 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...

Portable Lecture Demos

- Sinc … ad
  deve … and Atari
  pers … mics
  prin … hing
- Firs … western, in
  Fall …).
  - h … ay to show
    t …
  - S … d to add
    D … tors 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

Recent Optics Course

- 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

Recent Optics Course

- 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!

Recent Optics Course

- 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

Complete History of Student Attendance (1987 - 2007)

Total Number of University Programs: 35

Total Number of Individual Students: 2,815

Repeat Attendance	Individual Students	Repeat Attendance %
1 School	1916	68%
2 Schools	514	18%
3 Schools	212	8%
4 Schools	81	3%
5 Schools	41	1%
6 Schools	27	1%
7 Schools	9	>1%
8 Schools	6	>1%
9 Schools	1	>1%
10 Schools	6	>1%
11 Schools	0	0%
12 Schools	0	0%
13 Schools	1	>1%
14 Schools	1	>1%

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