Accelerator Theory, Simulations, and Student Programs

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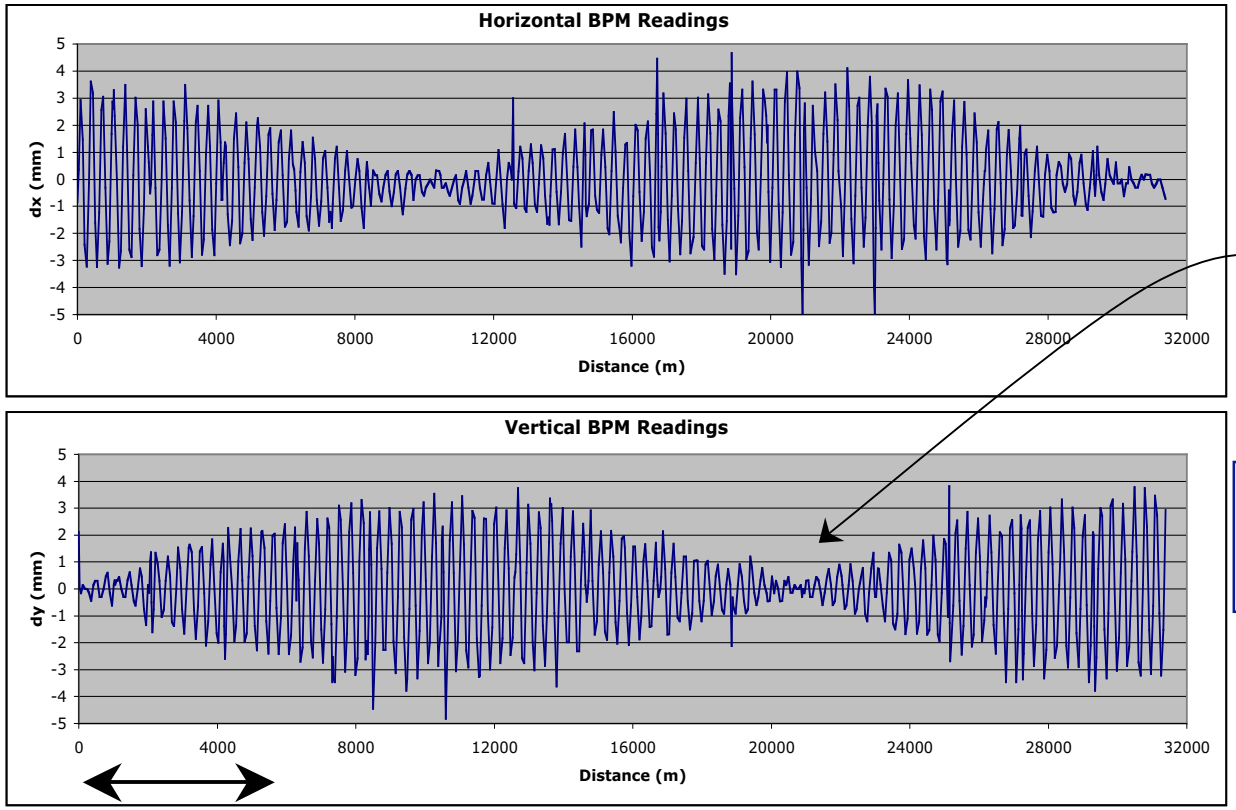
I. Accelerator Theory and Simulation

- Aspects of accelerator theory and complex calculations:
  - computational support of existing accelerator facility
  - compelling need for an eye to the future (*topic of today's talk*)
- Need to support both the current imperative and a vision for the future…

The roles of beam physics:

- understanding problems in present accelerators and their correction:
  - Analysis of coupled Tevatron -- ***most expensive coupled oscillator experiment ever performed!?***



beat period is about
3.3 turns ==> $\Delta\nu \sim 0.3$

Data are consistent with systematic $a_1 \sim 1.4 \times 10^{-4}$/in

G. Annala

The roles of beam physics (cont'd)

- future studies in beam physics:
  - should not be limited to a specific goal or facility
  - rather, cross-fertilization of ideas is absolutely necessary
    - e.g.: emittance manipulations demonstrated at FNAL to produce a flat beam, though motivated by possible application to a linear collider, have found interest in the synchrotron radiation (light source) field

Organization of efforts

- In recent years, the Beam Physics Department has been charged with both of these roles, and more…
  - Tevatron optics modeling, shielding calculations, beam-beam calculations, Booster calculations, C0 IR, NuMI beamline, …
    - plus, code development and maintenance (optics, tracking, energy deposition, C++ libraries, …); unix cluster maintenance
  - LHC, Proton Driver studies (I,II); VLHC study; linear collider efforts, muon collider efforts, neutrino factory study, …
- Public concerns have been expressed about a perceived lack of support for Run II; as a consequence, the Department has been disbanded and its personnel redirected to emphasize the primary mission of the laboratory
  - Desirable though this may be, it creates a void

Question:

- How does one support the future possibilities within this new framework?

- Present model: generation of Task Forces, through negotiations with other organizations when necessary (muCool, for example), using staff from throughout Beams Division and elsewhere

  - Allows for more resources from throughout Beams Division (for example) to participate in “future” activities

  - Will resources really be made available when required?

II. Fermilab Accelerator PhD Program and other Educational Efforts

- Accelerator PhD program initiated by Leon Lederman in 1985 because of lack of people coming into Beam Physics
  - Situation is same today, 20 years later; is exacerbated by diminishing support for new facilities
- Level of support for accelerator PhD students within the Program recently doubled

Joint University-Fermilab Doctoral Program in Accelerator Physics

- Student completes all university course requirements and prelims
- A professor at the university acts as advisor
- Fermilab staff member acts as mentor
- PhD awarded by the university

- Fermilab Accelerator PhD Committee approves application, and thesis topic.
- The Committee periodically reviews progress, approves continuation of the student in the program.
- Fermilab reimburses the university for the student's salary,and also provides an additional housing allowance.

Accel. PhD Program Graduates

Linda Imbasciati	(TU-Vienna) 2003	quench process in VLHC magnets
Vadim Kashikhin	(SRIEA, Russia) 2002	sc magnets
Vincent Wu	(Cincinnati) 2001	rf cavities/muCool
Jean-Paul Carneiro	(U. of Paris) 2000	photoinjector
O. Krivosheev	(TPU, Russia) 1998	energy deposition
K. Langen	(Wisconsin) 1997	
E. Colby	(UCLA) 1997	
L. Spentzouris	(Northwestern) 1996	
D. Olivieri	(Massachusetts) 1996	
P. Chou	(Northwestern) 1995	
D. Siergiej	(New Mexico) 1995	
X. Lu	(Colorado) 1994	
W. Graves	(Wisconsin) 1994	
K. Harkay	(Purdue) 1993	
P. Zhou	(Northwestern) 1993	
T. Satogata	(Northwestern) 1993	
J. Palkovic	(Wisconsin) 1991	
X. Wang	(IIT) 1991	
P. Zhang	(Houston) 1991	
S. Stahl	(Northwestern) 1991	
L. Sagalofsky	(Illinois) 1989	
L. Merminga	(Michigan) 1989	
M. Syphers	(Illinois - Chicago) 1987	

Present Students in Program:

- Kip Bishofberger (Vladimir Shiltsev) (UCLA, J. Rosenzweig) Tevatron tune-shift compensation.
- Sergei Seletskiy (Segei Nagaitsev) (Rochester, Adrian Melissinos). Recycler electron cooling.
- Ludovic Nicolas (Nikolai Mokhov) (Glasgow, P. Bussey) Small angle effects in the Tevatron.
- Mohammad Alsharoa (Al Moretti) (IIT, M. Gosz) High gradient rf cavities for muon collider and neutrino factory
- Phil Yoon (Tanaji Sen/Mike Syphers) (Rochester, Arie Bodek) Beam stability studies in the Tevatron
- Xiaobiao Huang (Eric Prebys) (Indiana, SY Lee) Booster studies for higher intensity
- Pavel Snopok (David Neuffer/Carol Johnstone) (Michigan State, Martin Berz) Capture of a large phase space beam
- Alexey Poklonsky (Carol Johnstone/Valeri Lebedev) (Michigan State, Martin Berz) Optimization and control of Tevatron parameters
- Bernardo Bordini (Emanuela Barzi) (Pisa) Nb3Sn cable.

The Russian Connection . . .

Early summer 2001, Victor Yarba proposed seeking Russian graduate students to participate in FNAL Accelerator PhD program.

By August 2001, Mike Witherell agreed to donate funds for 5 more positions, with ICAR playing leading role in the search. Efforts coordinated by Linda Spentzouris.

Universities participating:
Chicago, IIT, NIU, Northwestern, Illinois, MSU, UCLA, Cornell

Spring 2002, team assembled and sent to Russia --
Kwang-Je Kim, Jaime Rosensweig, Hasan Padamsee, Victor Yarba

February 2003:
Pavel Snopok and Alexey Poklonsky from St. Petersburg accepted into program, as students from MSU

September 2003, second team sent: Yarba, Court Bohn, Mike Syphers
on-going negotiations with institutes visited…

US Particle Accelerator School

Fermilab Instructors (Summer 1988 - Summer 2003):

Instructor	Total Credit Hours	Course Titles
Carey, David	3	Introduction to Accelerator Optics (ug)
Cossairt, J. Donald	9	Topics in Radiation Damage
		Radiation Physics at Accelerators
		Radiation Physics, Regulation, and Management
Edwards, Donald	12	Introduction to Accelerator Physics
Glass, Henry	1.5	Magnetic Measurements
Holmes, Stephen	12	Experimental Methods in Accelerator Physics
		An Introduction to Particle Accelerators
Jackson, Gerald	13.5	Experimental Methods in Accelerator Physics
		Accelerator Instr. & Beam Measurement Lab
		Accelerator Vacuum Laboratory
Carol Johnstone	3	Accelerator Fundamentals (ug)
McGinnis, David	6	Introduction to RF Systems
		Microwave Measurement and Beam Physics Lab
Michelotti, Leo	6	Introduction to Modern Dynamics
Ng, K.Y.	6	Physics of Collective beam Instabilities
Ostiguy, Francois	9	Computer Lab for Accel Phys and Tech courses
Pasquinelli, Ralph	4.5	Microwave Measurement and Beam Physics Lab
Read, A. Lincoln	1.5	Topics in Radiation Damage
Spentzouris, Linda	9	Accelerator Fundamentals (ug)
		Plasma Physics in Beams
Syphers, Michael	25.5	Introduction to Accelerator Physics
		Design of High Energy Accelerators
		Accelerator Fundamentals (ug)
Webber, Robert	1.5	Introduction to RF Systems

16 instructors, ***123 credit hours,*** ***~16 topics***

List does not include semester courses taught at non-USPAS universities.

Other Education Initiatives

- Undergraduates --
  - Summer programs
  - IMSA -- no official involvement; should be explored...
- High school teachers
  - FNAL Summer program
    - Brings in high school teachers for the summer to enhance exposure to modern physics and accelerator facilities
- American Renaissance in Science Education (ARISE)
  - also started by Lederman
  - Physics --> Chemistry --> Biology
  - Some school systems in the country have embraced this sequence

Students are our future:

- suppose(!) Linear Collider is on the 10-year horizon . . .

--> PhD students of that time are today's Junior/Senior High School students!

(My) Recommendations

- Following recent reorganization of Beam Physics personnel, an assessment of the continuation of activities beyond Run II must be undertaken

- Fermilab needs to encourage participation in educational activities by accelerator staff members

Concluding Remarks

- It has proven difficult to get enough good people to take time for students
  - There is a low level of interest in basic accelerator physics, basic acceleratoor R&D at the laboratory
- Also difficult to get good people to teach at USPAS
  - Once rewarded for these efforts, incentives have deteriorated; lab needs to encourage and recognize teachers
- The field of beam physics has worked hard to become a recognized discipline
  - APS: *Division of Physics of Beams* formed in 1985
  - **The leading accelerator lab in the US needs to recognize its responsibility.**