

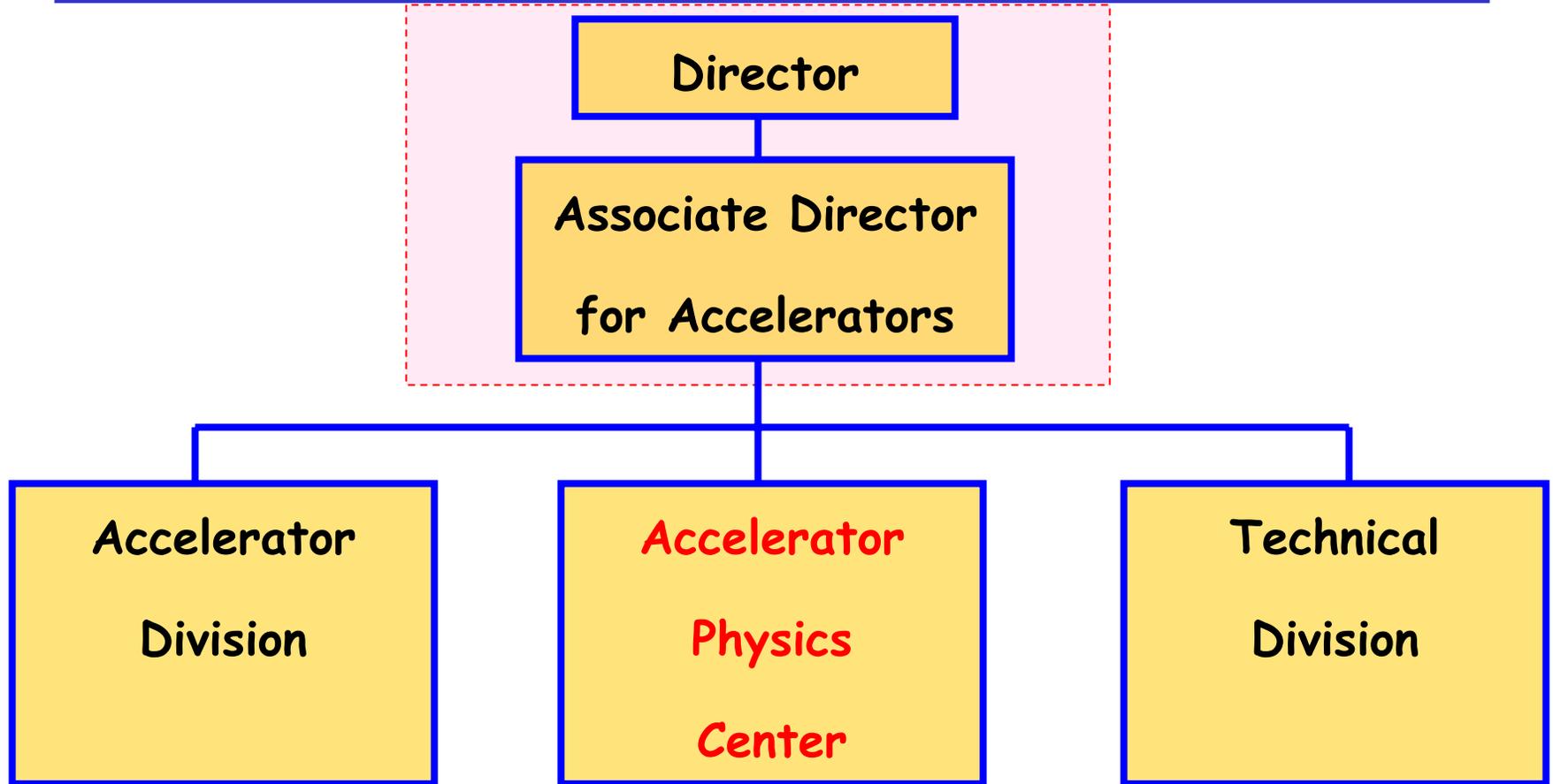


Accelerator Physics Center, Advanced Accelerator R&D and Simulations

Vladimir Shiltsev
FRA Visiting Committee Review
April 20-21, 2007



Fermilab's Accelerator Physics Center





Accelerator Physics Center: Mission

- Coordinate and conduct accelerator R&D aimed at next-generation and beyond accelerator facilities
- Provide accelerator physics support for existing operational programs and the evolution thereof
- Train accelerator scientists and engineers
- Provide leadership and coordination in establishing the necessary facilities for a broad range of accelerator R&D that can be accessed by both Fermilab staff and the world HEP community



Accelerator Physics Center: Goal

- The goal of the Accelerator Physics Center is to provide enhanced emphasis on accelerator R&D activities aimed at Fermilab's future beyond the end of current decade.
 - The APC will provide both a physical location and an org. structure that can accommodate accelerator scientists and engineers, either from Fermilab or outside institutions.
 - The APC will contribute to improvement of performance of the existing accelerator complex, and the development of new technologies and accelerator concepts that could enable new forefront facilities beyond the current decade.
 - In support of this primary goal, the APC will also increase Fermilab involvement in the education of accelerator scientists and engineers.



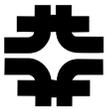
APC: Specific Programs

- Programs to be organized and managed by the APC, in either a primary or supporting role, include:
 - Accelerator physics for Run II, Proton Plan & SuperNuMI (supporting)
 - Simulations, design support & beam experiments for ILC (supporting)
 - Development of instruments for, and coordination of participation in, commissioning, beam studies, operations, upgrades at the LHC (primary)
 - HINS conceptual design and accelerator physics, including design and development of experiments and test facilities (primary)
 - Muon collider R&D, including design and development of experiments and test facilities (primary)
 - Development of generic theoretical and simulation tools for advanced accelerator calculations in areas of energy deposition, beam-beam and space-charge effects, linac emittance evolution, etc. (primary, w/CD)
 - Designing and coordinating programs of advanced accelerator R&D at the NML facility and possibly elsewhere (primary)
 - Accelerator theory and education: Host the USPAS Office, Accelerator PhD program, Peoples Fellows, and other accelerator education initiatives (primary)

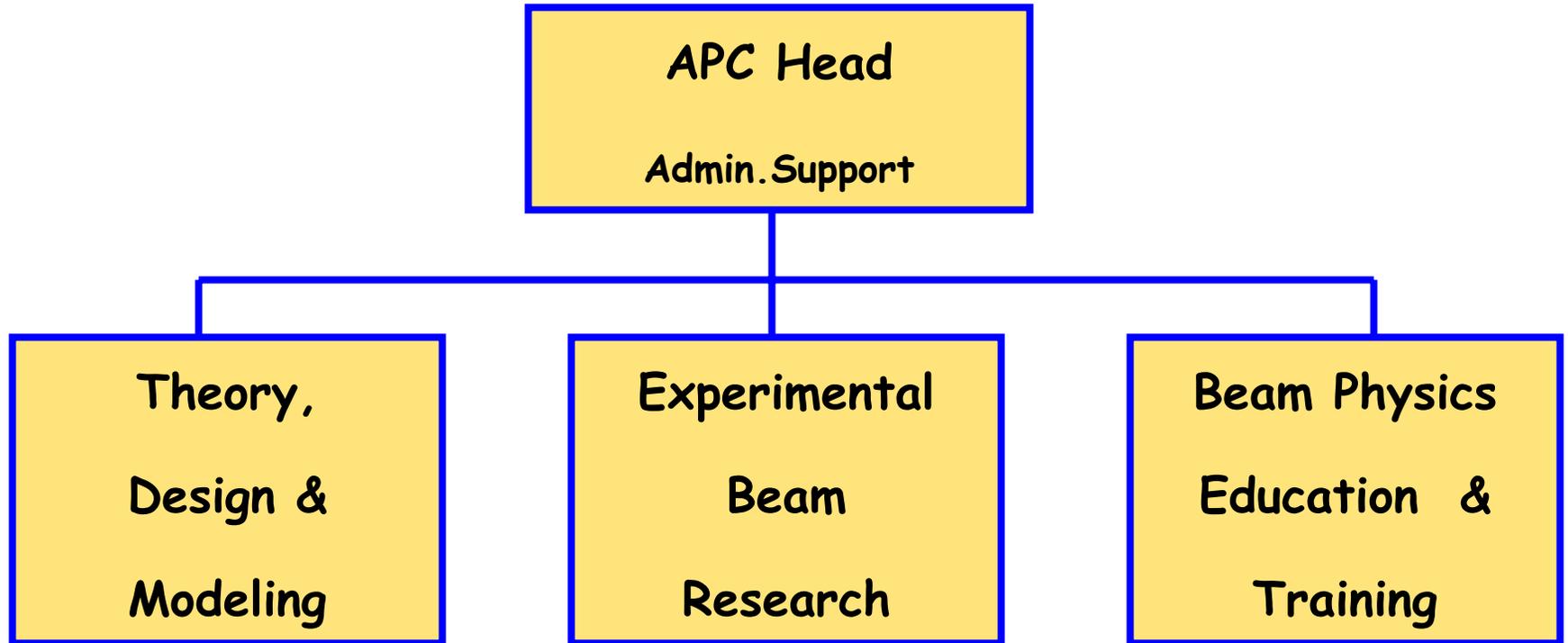


APC: Responsibilities

- Following its creation the APC will assume direct responsibility for management and coordination of advanced accelerator R&D programs as described above.
- The APC is not imagined as having direct operational responsibilities for beam-based test facilities
 - these are expected to be the responsibility of AD.
- Both the AD and TD will provide engineering and technical support for APC, and AD, TD, CD and PPD staff will participate in APC activities.
- The APC will retain responsibility for coordination of inter-institutional collaborations in Adv.Accel. R&D
 - In particular, the APC will work closely with the Argonne Accelerator Institute to coordinate mutual undertakings in accelerator research

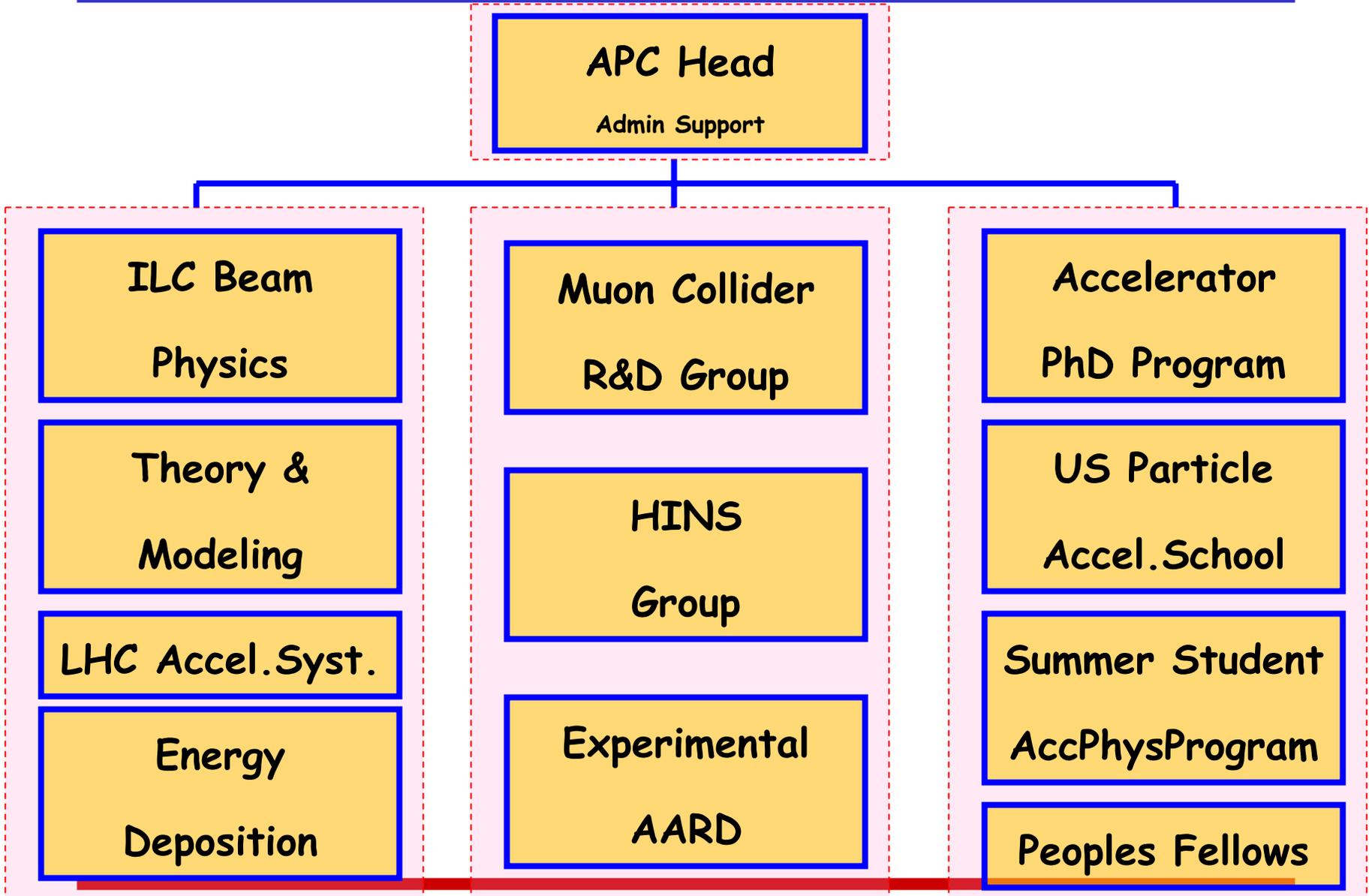


APC: Organization Structure





APC: Components





APC Status: Org Chart, Dates, etc

ACCELERATOR PHYSICS CENTER

V.Shiltsev, APC Head
M.Church, Deputy Center Head
TBD, Admin Associate
(A.Nestander), Budget Mgr.

ILC Beam Phys

(N.Solyak), Head
D.Bogert
Y.Torun (FNAL/IIT)
S.Singatulin(GS)
(J.Volk)

Modeling

M.Church (GL)
F.Ostiguy
K.Ranjan
(A.Valishev)

HINS

R.Webber, Head
J.P.Carneiro
D.Johnson
K.Koch
R.Madrak
E.Peoples
H.Piekarz
J.Steimel
D.Wildman
R.Zwaska
(G.Apollinari)

Muon Accel. R&D

(S.Geer), Head
(M.Lamm)

MCTF Experiment

A.Jansson (GL)
K.Yonehara (GS)
C.Yoshikawa (GS)
A.Kurup (ICL Fellow)
(V.Kashikhin)
(D.Broemmelsiek)
(A.Klebaner)

NFMCC Group

A.Bross (GL)
M.Ellis
A.Moretti
D.Neuffer
X.Yang (ICL Fellow)
(A.Tollestrup)
(M.Geynisman)

US PAS Office

S.Winchester (GL)
(W.Barletta, Director)
I.Novitskaia

Accel.Education

(V.Lebedev), Head

Accel.PhD Program

(M.Syphers, Comm.Chair)
Grad.students (mentor)
R.Miyamoto (A.Jansson)
D.McCarron P.Spentzouris
U.Mavric (B.Chase)
A.Paytyan (H.Edwards)
T.Koeth (H.Edwards)
P.Snopok (C.Johnstone)
A.Poklonsky (D.Neuffer)
P.Yoon (W.Chou)

Peoples Fellowship
(M.Church, Comm.Chair)

Accelerator Summer
Students Program
(A.Shemyakin)

Theory/Simulation

Yu.Alexahin (GL)
V.Balbekov
N.Gelfand
E.Gianfelice-Wendt
V.Kamerdzhev
G.Kuznetsov(GS)
L.Vorobiev (GS)

Energy Deposition

N.Mokhov (GL)
A.Drozhdin
M.Kriss
S.Striganov
N.Nakao (GS)
I.Rakhno (GS)

LARP Accel.Syst

T.Sen (GL)
J.Johnstone
H.J.Kim
J.Slaughter
(E.Harms)

Experim. AAR&D

P.Piot (GL)
(C.Y.Tan)
(S.Nagaitsev)

(CPA Group of CD)

(P.Spentzouris, GL)
(J.Amudson) (P.Lebrun)
(L.Michelotti) (E.Stern)
(V.Ivanov, GS) (D.Dechow, V)

People:

35 directly
assigned

8 guests

8 grad students

4 joint appts.

26 in (...)

Target date:

June 1st, 2007

Budget in work



AARD Possibilities at NML

- NML Linac was described in S.Nagaitsev's talk
- Fermilab wants to establish an AARD program at NML
- Flexible beam injector needed to support various beam parameters (emittance, bunch charge, bunch length):
- Unique beam parameters anticipated:
 - Record high peak current 14kA possible
 - ~20 um bunch length and size
 - Beam energy upto 800 MeV
 - Structure: 3000 bunches or witness bunch 300 um behind
- Number of AARD experiments possible in NML itself:
 - two at low energy (50MeV), one-two at full energy (space!)
- Building extension needed to provide area for 4-7 more
 - not from the ILC funds

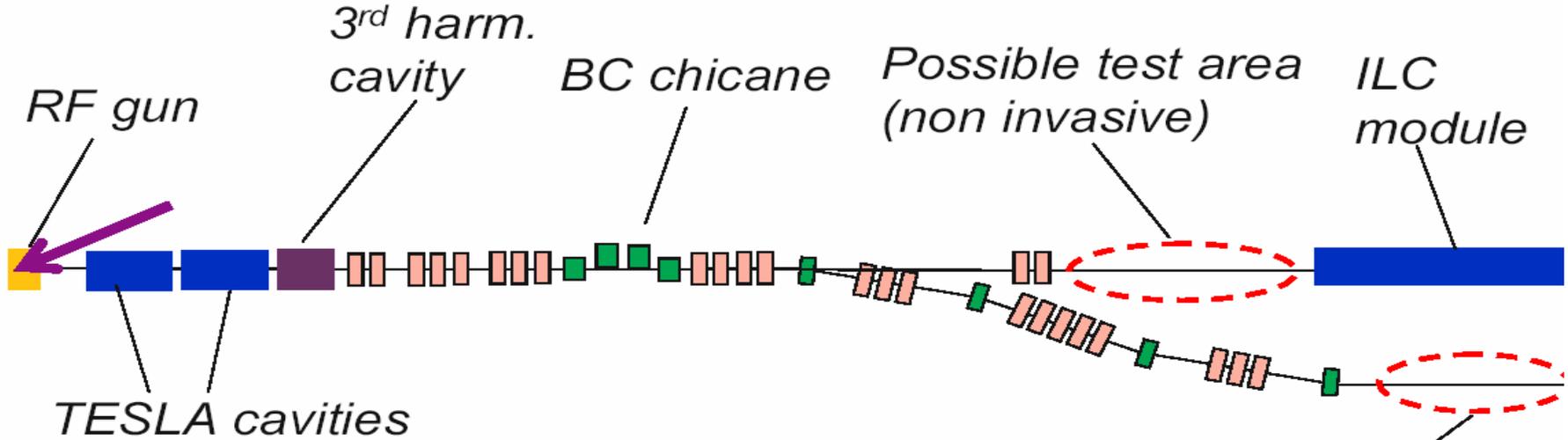


NML AARD Workshop (Nov 28, 2006)

- Sessions chaired by K.J.Kim (ANL), J.Delaven (TJNAF), A.Mikhailichenko (Cornell)
- Proposals:
 - ILC crab-cavity test (low-energy beam 50 MeV)
 - ILC e+ SC undulator test (250-750 MeV)
 - "ILC "keep alive" e+ source test (>500MeV, space!)
 - DR for Optical Stochastic Cooling experiment
 - 4x7 m 250 MeV DR: Cornell, MIT, LBNL, FNAL, Universities
 - importance for HEP: LHC, Muon Collider, RHIC
 - upto 1GeV/m in DLA structure (small beam size)
 - plasma wakefield with witness bunch
 - ultra-bright X-ray source (3000 bunches)
 - new diagnostics (ODR), swept laser accel., etc



Current focus on NML stage I

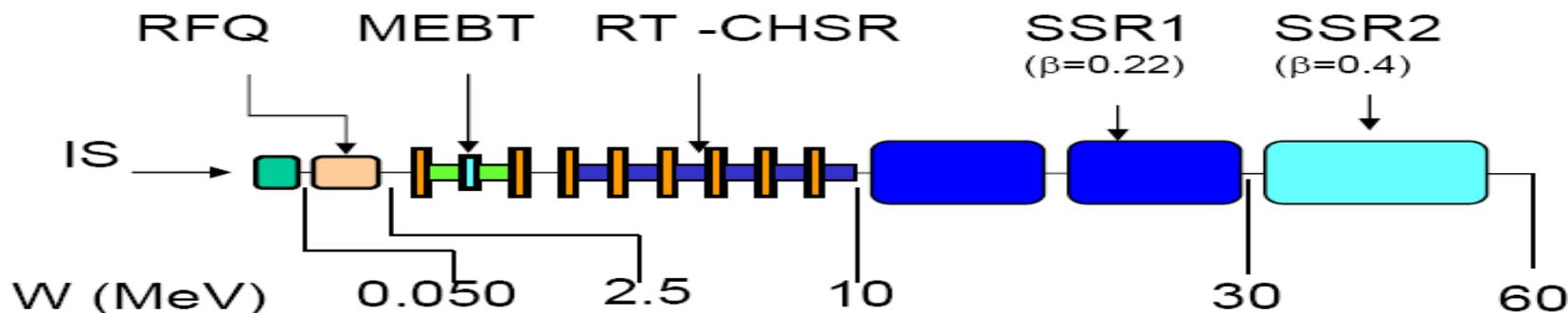


- Rf-gun
- 40-50 MeV injector
- Bunch compressor chicane
- Off-axis beam line (dogleg w tunable R56)

- People and Collaborators:
 - P.Piot (FNAL/NIU) leads the activity
 - Several AD scientists already involved
 - Argonne (AAI) interested to join and participate
 - Lots of interest from Universities



High Intensity Neutrino Source R&D



- One of its kind facility
 - Single klystron RF distribution
 - Very low energy RT to SC transition
 - Solenoidal focusing all along
- Reviewed by AAC in May'2006
- HINS group exists in Accelerator Physics Dept:
 - R.Webber leads the HINS group in the APD
 - G.Appolinari coordinates efforts in Technical Division
 - many AD&TD scientists and engineers contribute
 - Collaboration with ANL, BNL, LBNL



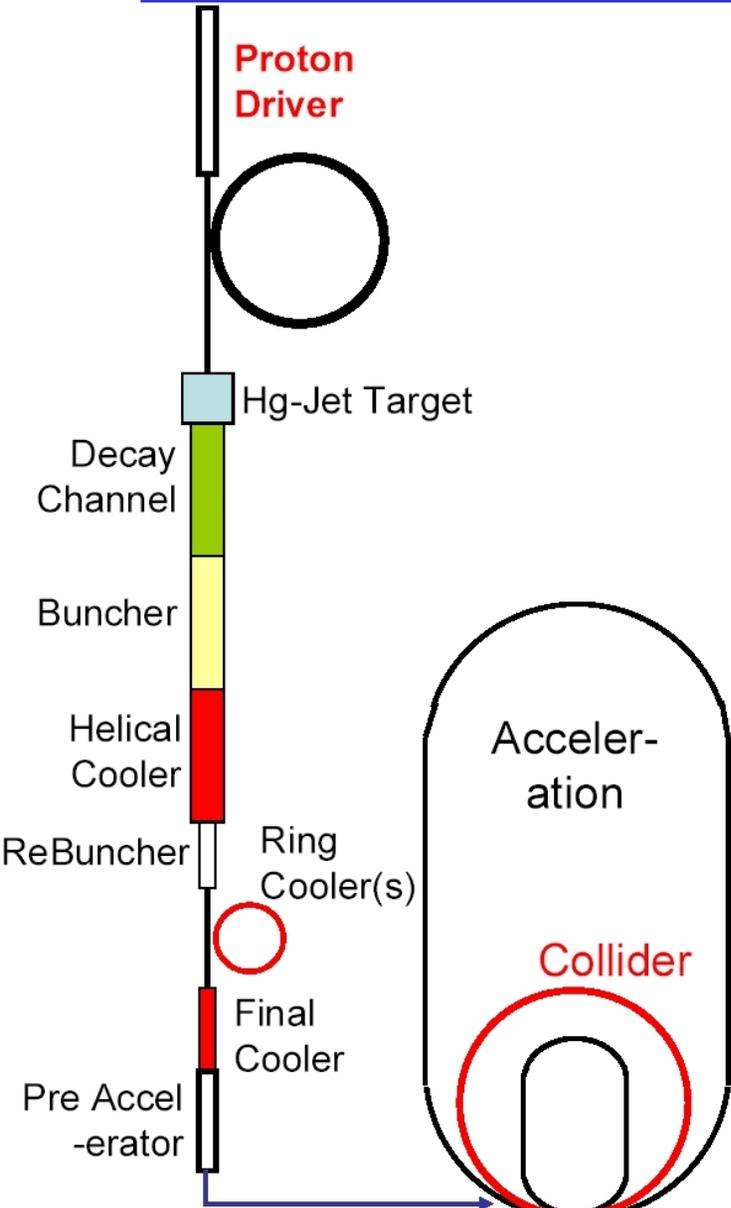


Muon Collider Task Force

- Formed in '06 by FNAL Director, led by S.Geer&V.Shiltsev:
 - "... the Muon Collider represents a possible long term path for extending the energy frontier in lepton collisions beyond 1 TeV..."
 - MCTF formed "...to develop a plan for an advanced R&D program aimed at the technologies required to support the long term prospects of a Muon Collider..."
 - MCTF formed: FNAL(35 people), Muons Inc (5), BNL (6), LBNL(4), JLAB (5), ANL (1)
 - MCTF Proposal includes plan for:
 - Collider design studies and 6D cooling theory and simulations
 - 6D cooling experiment with 230MeV/c muons at Muon Test Area
 - Design and development of Helical Cooling Channel magnets, 50T solenoids, MC dipoles
 - MCTF activities are complimentary to NFMCC
 - Requested funds: 2.8M\$ in FY07, 4.2M\$ in FY08
-



1.5 TeV c.o.m. Muon Collider



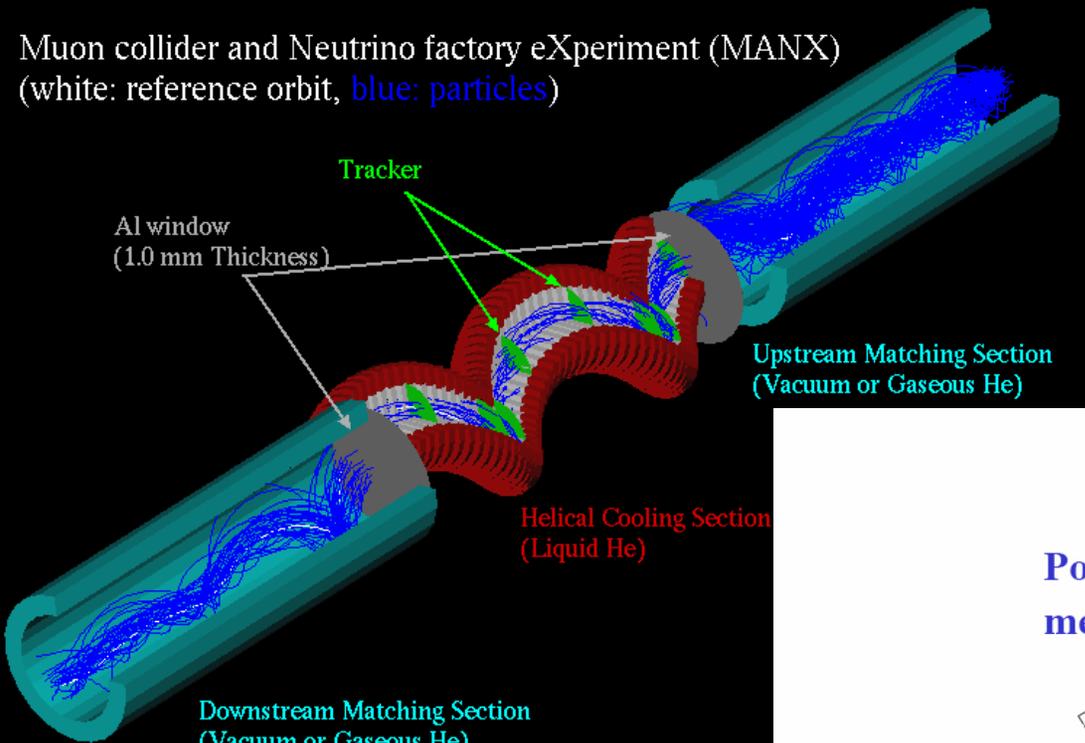
Parameters for low emittance option:

Energy per beam	750 GeV
Average luminosity	$3e34 \text{ cm}^{-2}\text{s}^{-1}$
Repetition rate	65 Hz
Total # of muons	$1e11$
# bunches	10
β^* at IP	0.5 cm
Transverse emittance	2.1 mmmrad
Proton driver power	1.1 MW

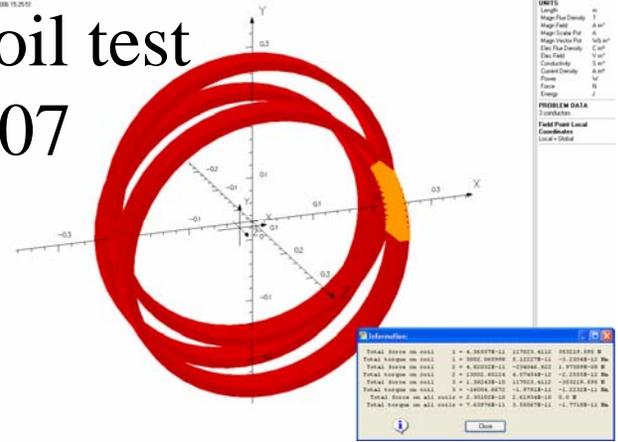


Muon Cooling is the Key → 6D Cooling Experiment @ MTA

Muon collider and Neutrino factory eXperiment (MANX)
(white: reference orbit, blue: particles)

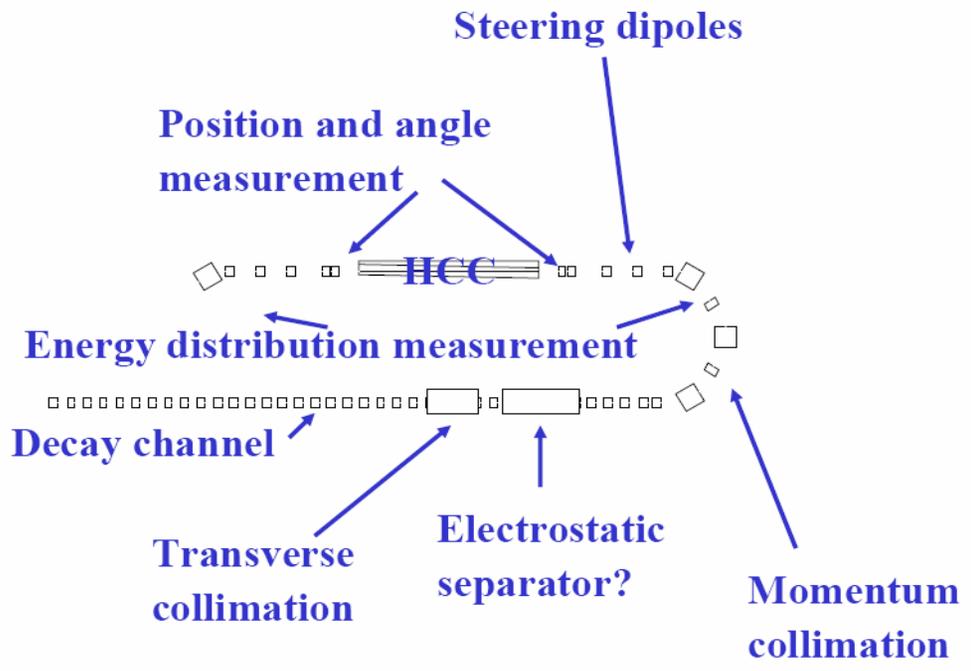


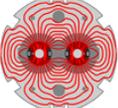
3 coil test FY07



■ Muon R&D Dept. in APC:

- Dept.Head - S.Geer
- A.Bross A.Jansson - grp.leaders
Yu.Alexahin, M.Lamm, lead parts
- Muons Inc, BNL, LBNL, TJNAF,
IIT, NIU, UIUC, UC





APC to coordinate LHC Accelerator Physics @ FNAL

LARP

LHC 4.8 GHz Schottky Monitors (Q, Q', dP/P, ε)

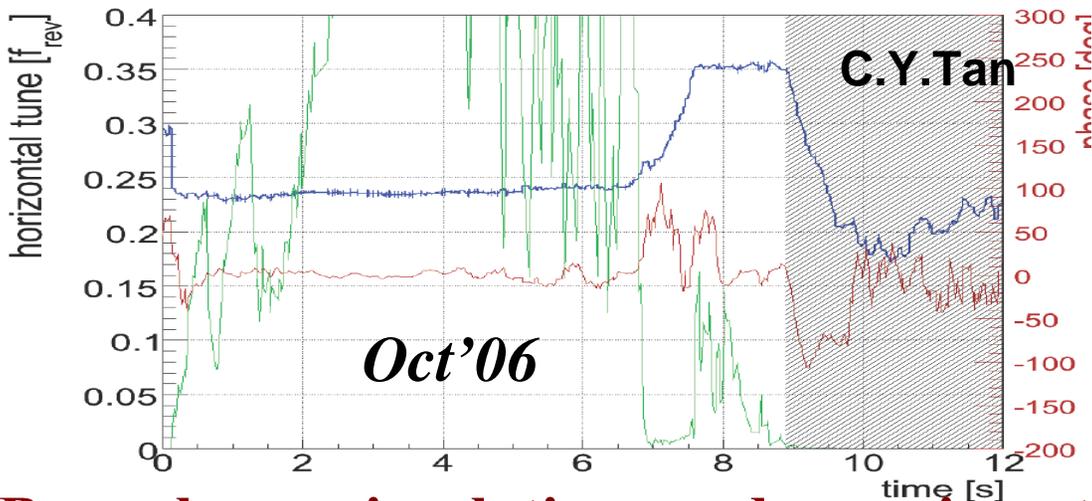


R.Pasquinelli

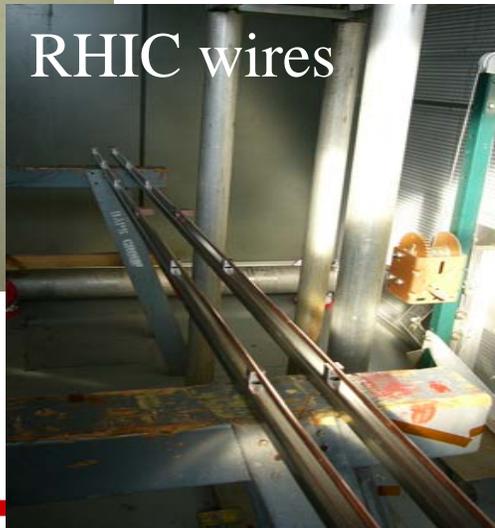
A.Jansson

Installed in LHC tunnel Dec'06

SPS: 3D Tune & Coupling tracking

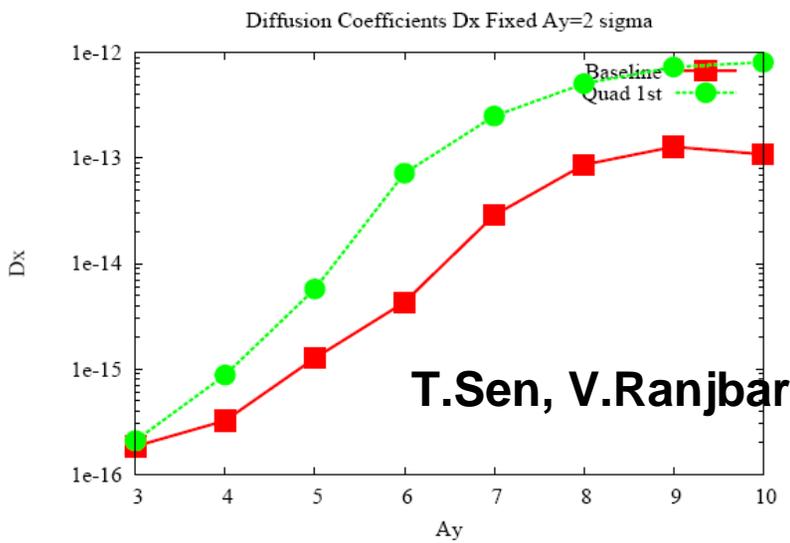


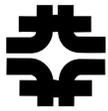
Beam-beam simulations and experiments



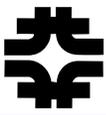
RHIC wires

2007 FRA Visiting Committee





- **Mission:**
 - the group coordinates all LHC-related activities supported by FNAL and LARP Accelerator Systems tasks. It takes lead in advanced accelerator simulations, development of novel instrumentation and participation in commissioning and beam studies @LHC.
- **People and collaborators:**
 - T.Sen leads APD/LARP Group
 - ~15 LARP collaborators in the rest of AD
 - LHC@FNAL Remote Access Room (E.Gottschauk, CD)
 - LAFS=LHC Accelerator Fermilab Software (CD/AD, D.McGinnis, S.Gysin, J.Patrick, E.McCrory)
 - FNAL TD ("Magnets" Part of LARP)
 - Other LARP Laboratories (BNL, LBNL, SLAC)

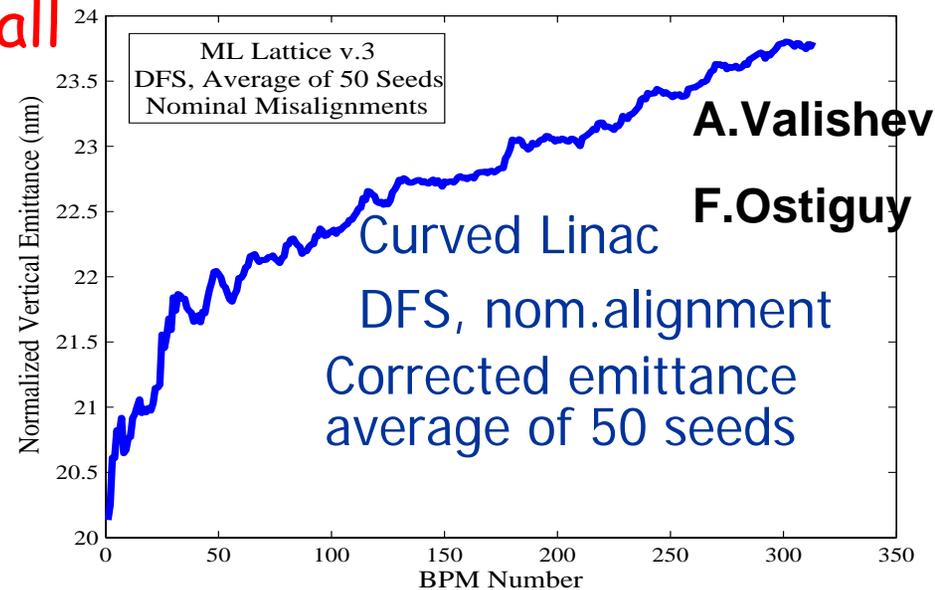
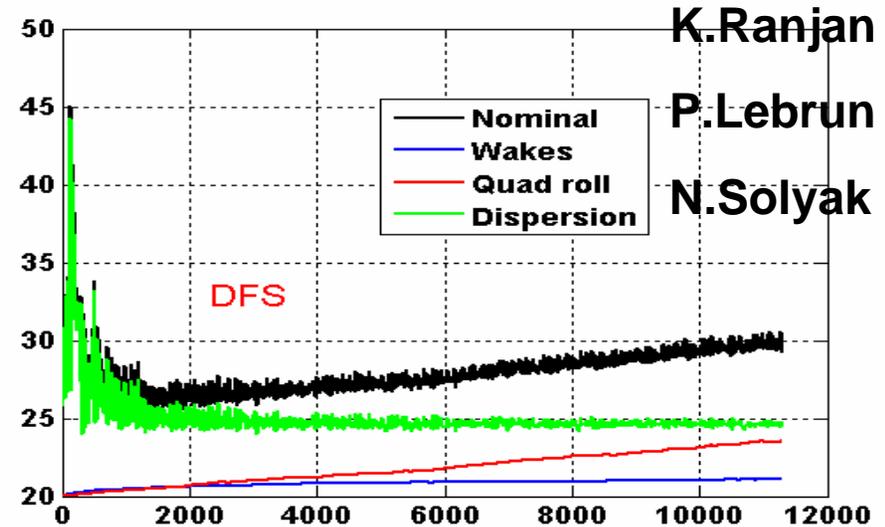


ILC Main Linac Simulations

- Fermilab activities include:
 - Error analysis and correction
 - Curved linac effects
 - CHEF code development
 - Code comparison
 - Dynamic correct
 - Ground motion data analysis

- Currently, the effort spread all over the Lab :

- Accelerator Division
- Technical Division:
- Computing Division





■ Mission:

- The group provides beam physics support to Fermilab ILC program. It carries out beam dynamics simulations for the ILC, supports the NML facility experiments and Illinois ground motion measurement program for the ILC. The group coordinates related activities in Fermilab's AD, TD and CD.
- ILC EDR coordination

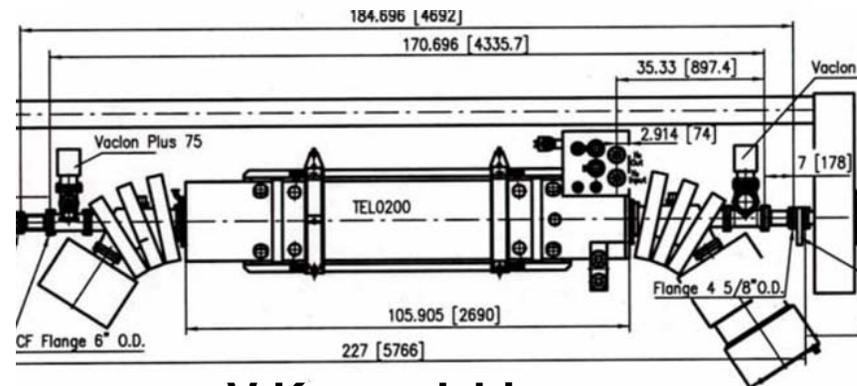
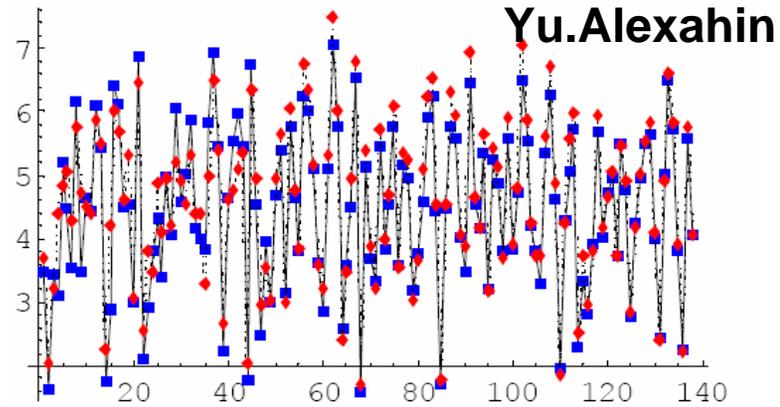
■ People and collaborators:

- N.Solyak (GDE Main Linac Ldr.) - Dept. Head
- Other dedicated scientists in APD and TD
- Closer ties with CD Group (moving to WH13)
- AD+TD ground motion/vibration team

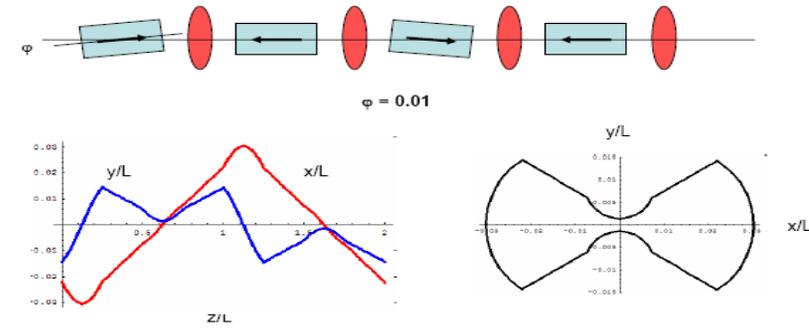


APD Theory Group: Current Scope of Work

- Recent contributions to the Run II luminosity progress:
 - Helix optimization with new separators (10% more p's @150 GeV and 10% L-lifetime)
 - Decoupling application for MCR
 - TEL1&2 for abort gap and BBC
- Other projects:
 - MI and Booster optics on ramp
 - Tevatron new WP
 - Tevatron tune drift at 150 GeV
 - 6D ionization cooling theory
 - Muon Collider design
 - Advanced acceleration concepts
 - Space charge theory
 - Beam-beam theory and simulations



V.Kamerdzhev





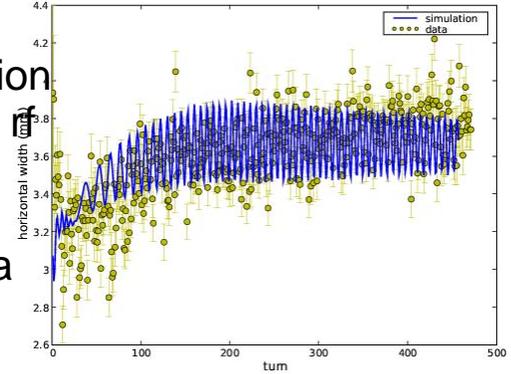
CD/Accelerator Modeling department mission:

- to develop computational accelerator physics tools
- to perform simulations for for future accelerators

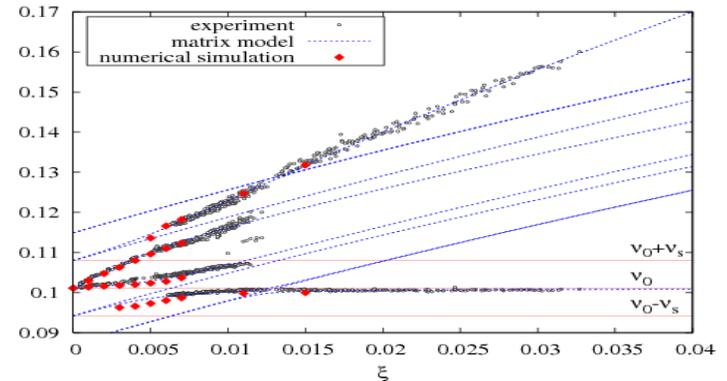
AMD/Computational Physics for Accelerators group has expertise in simulations of:

- Space-charge
- Beam-beam
- Electron cloud
- Linac emittance growth

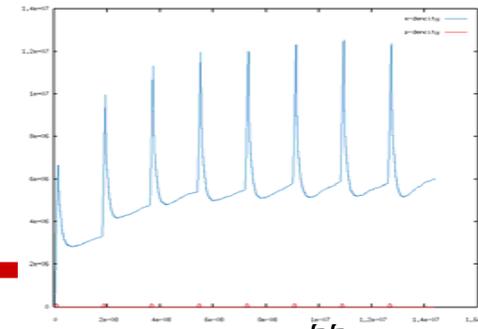
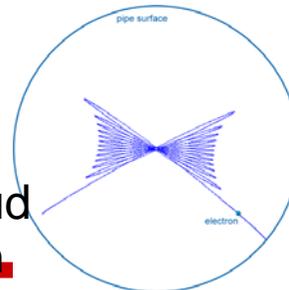
3D Booster simulation including injection, ramping, etc.
Comparison with experimental data



P.Spenzouris



Beam-beam code validation comparing with VEPP-II data



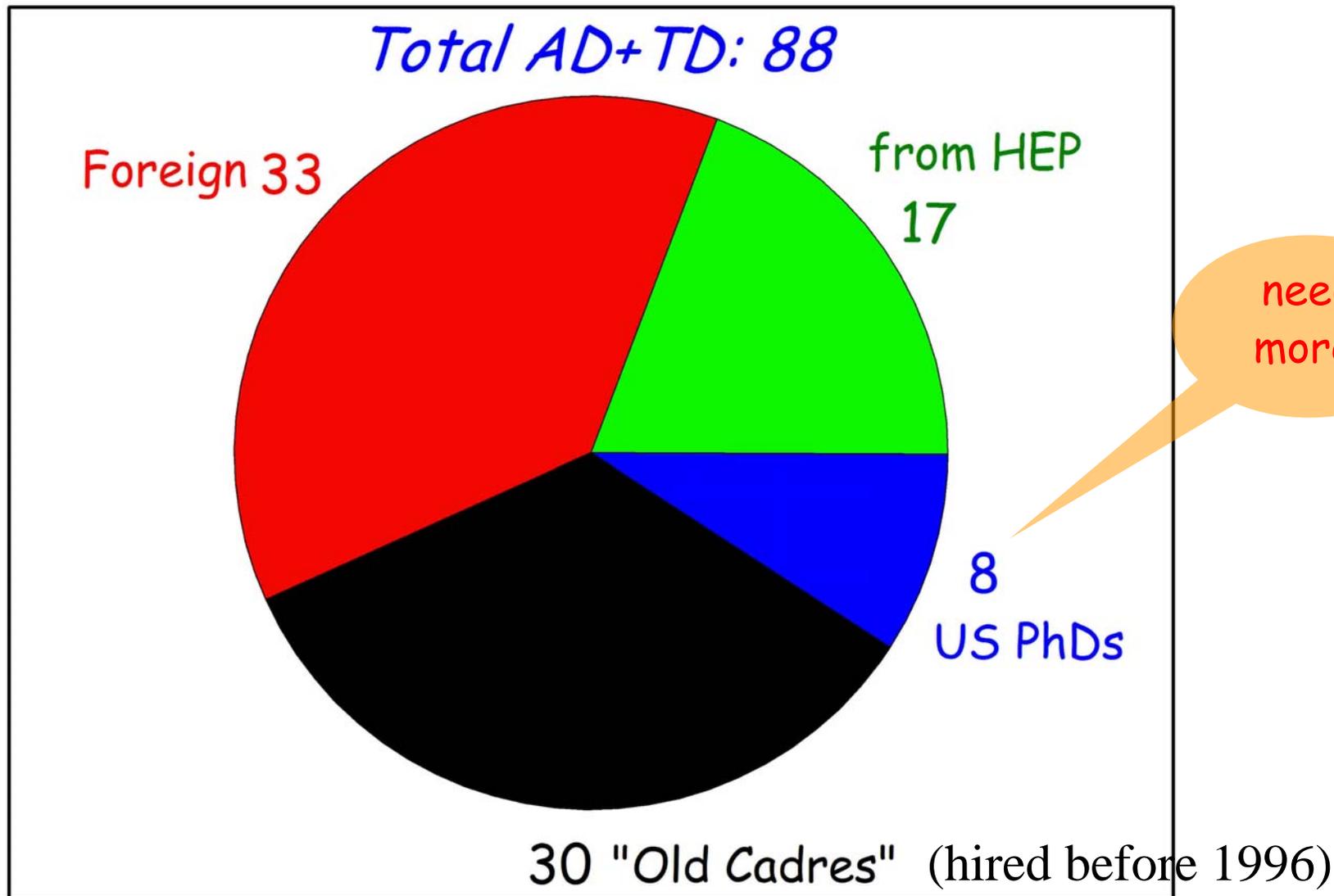


APC: Theory & Modeling Group

- At present, accelerator theory & modeling expertise at FNAL is spread over APD, AD, CD
- **Mission:** The APC Theory group takes a lead at Fermilab in carrying out theoretical beam dynamics calculations and development of accelerator physics models:
 - provides accelerator physics support to various accelerator projects, including Run II, Proton Plan-2, SNuMI
 - performs simulations and participates in beam studies: beam-beam and b-b-compensation, beam optics, beam instabilities, etc.
 - supports beam physics research for the LHC, ILC, Muon Collider
 - assists in education and training accelerator scientists.
- **People and collaborators:**
 - Yu.Alexahin - group leader
 - Few other accelerator physicists from Accelerator Division
 - More at the end of Run II
 - Computing Division AMD/CPA Group (is now moving to WH13)



Workforce of FNAL Accelerator Scientists

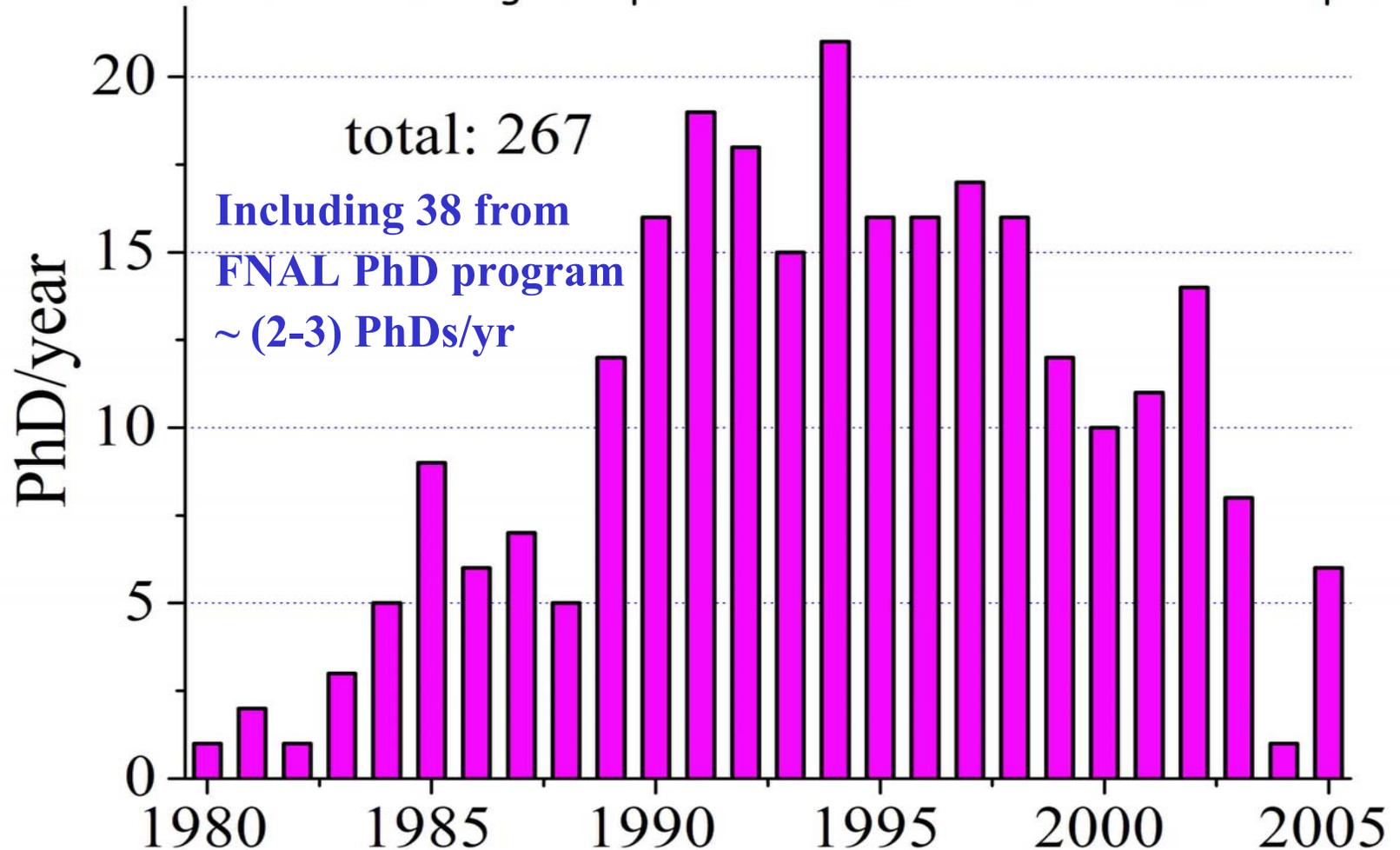




Accelerator Physics PhD Production in the US

DOE Advanced Technology R&D Yearbook

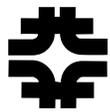
www.science.doe.gov/hep/AdvTechR&D2005/TechR&D2005.pdf





New Accelerator Education Initiative

- The situation with Accelerator PhD production, and particularly, those entering HEP, is worrisome:
 - future does not look sustainable
 - An informal task force formed to explore new possibilities:
 - Y.K.Kim, V.Yarba, S.Nagaitsev, et.al
 - Under consideration now - Fermilab Accelerator Education Consortium (naturally, be part of the APC):
 - goal is to double # of accelerator PhD students doing research at FNAL (and staying at FNAL afterward)
 - close involvement of local Universities:
 - UChicago, NWU, NIU, IIT, UIUC - delegate faculty
 - Universities match Fermilab funds/efforts
 - be in position to select the best students, better advertising
 - attract not only graduates, but also undergraduates
 - extended summer student programs
 - need more possibilities/facilities for accelerator R&D
 - new roles for US PAS, PhD Program, AP summer program, etc.
-



- The goals of APE Department:
 - consolidate existing accelerator education programs @ FNAL
 - attract graduate and undergraduate students
 - train and develop them into the accelerator scientists and technologists who will carry our field forward in the future and enhance Fermilab's capabilities in accelerator science and related technologies.
 - Four existing programs:
 - Accelerator PhD program
 - US Particle Accelerator School
 - Accelerator Physics Summer Student program
 - People Fellowship program
 - Joint appointments/ programs:
 - IIT, NIU / with NIU at AO, and in RF ME
 - **New initiative: Accelerator Education Consortium**
-



Summary

- Fermilab is enhancing its accelerator research program; Fermi Research Alliance initiates Accelerator Physics Center
- Planning for the APC is well underway: mission, goal, responsibilities and main organizational principles are set, startup organization chart finalized, budget logistics is being set
- People from AD, TD, CD and PPD will migrate to / collaborate with the Accelerator Physics Center to do:
 - Advanced accelerator research at experimental beam facilities
 - Beam theory and modeling
 - Raise next generations of accelerator scientists
- The APC will retain responsibility for coordination of inter-institutional collaborations in Adv. Accelerator R&D:
 - with other National Labs, Universities, international