Accelerator Physics Center

Vladimir Shiltsev

DOE Annual Program Review

Sep. 24-27, 2007

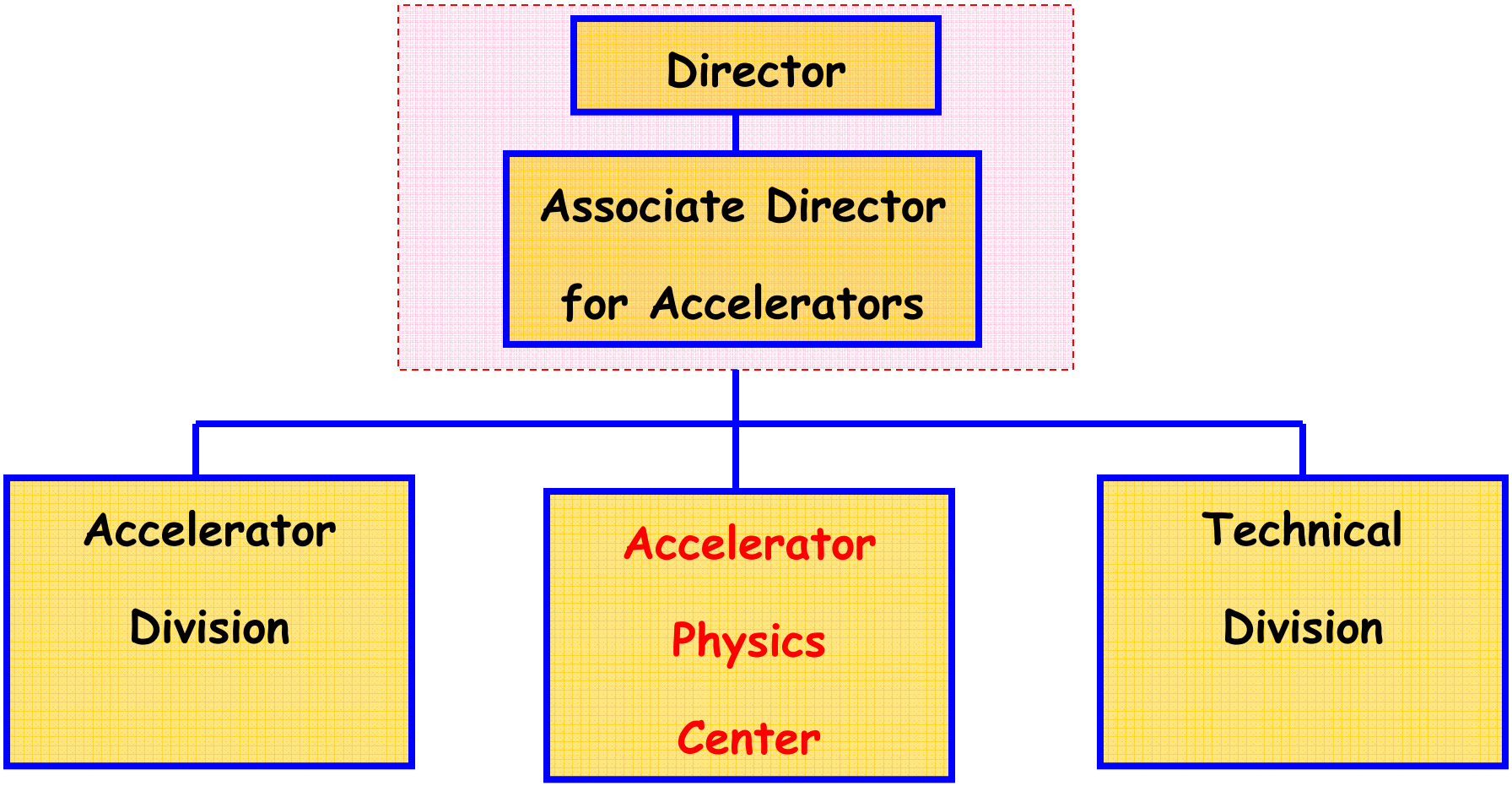
Fermi Research Alliance: Strategic Context

http://fra-hq.org/pdfs/Science_Strategy.pdf

- Fermilab will remain the U.S. center for accelerator-based High Energy Physics, and a pre-eminent center internationally, for the foreseeable future. The major program elements are:
  - Energy Frontier
  - Neutrinos
- ILC is established as the primary goal; in parallel with strong participation in LHC and a world-leading neutrino program whose scope can be adjusted depending upon the fate of the ILC.
- A greater focus on longer term R&D is a key responsibility of the laboratory in the new era.

⇒ Supporting this vision requires a reorientation of the mission of the accelerator organization at Fermilab to provide enhanced support of accelerator R&D aimed at the future beyond Run II.

Fermilab's Accelerator Organization

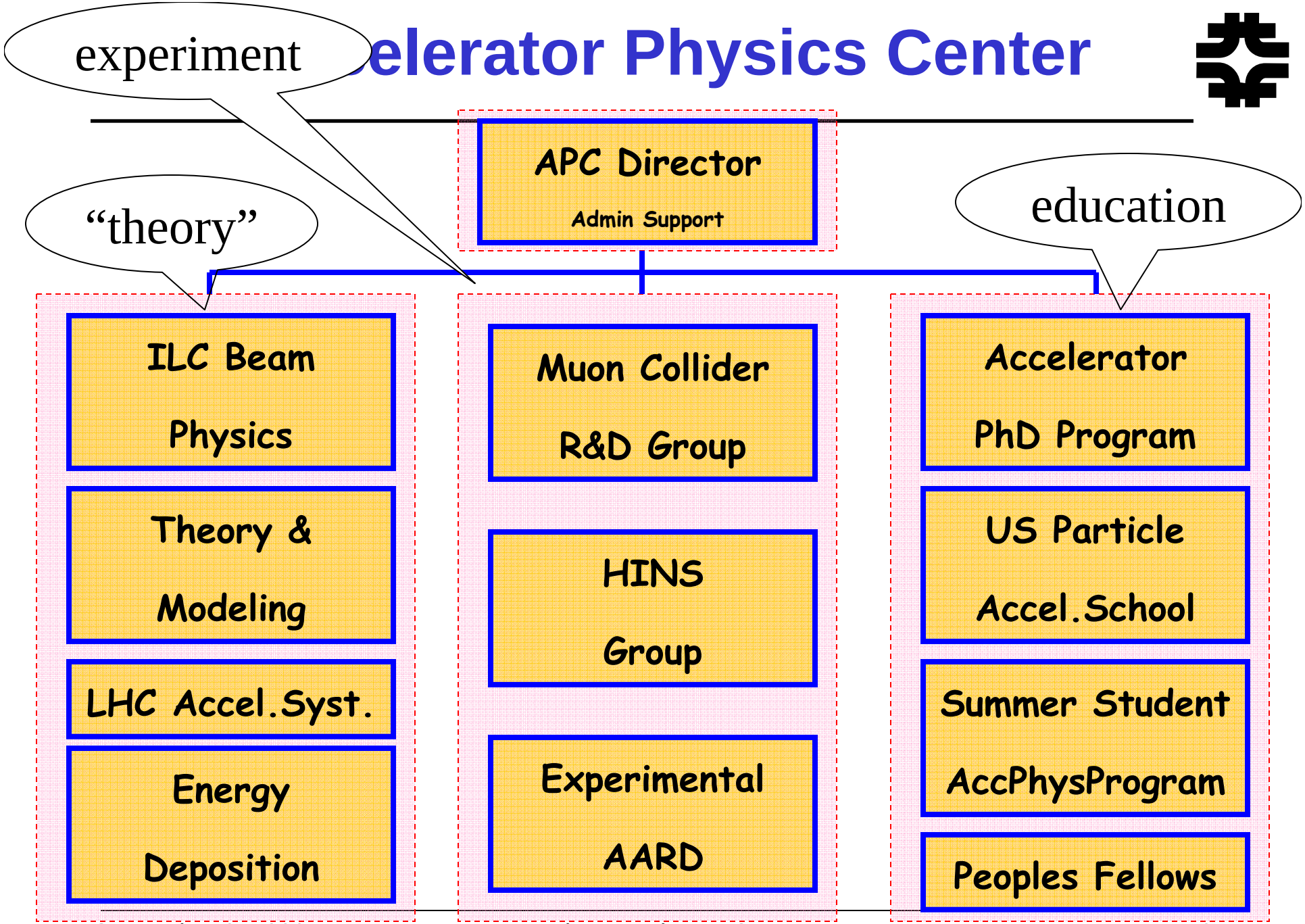


APC celebration 06/01/07

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 and the world HEP community**

elerator Physics Center



APC Org Chart as of 06/01/07

47 staff
8 PhD students
in addition 42 in (…)

ACCELERATOR PHYSICS CENTER
V.Shiltsev, Director
M.Church, Deputy Director
M.Bruce, Admin Associate
(A.Nestander), Budget Mgr.

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

ILC Modeling Group
M.Church (GL)
F.Ostiguy
(A.Valishev)

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

LHC Accelerator Group
T.Sen (GL)
J.Johnstone
H.J.Kim
J.Slaughter
(R.Flora) (E.Gottschalk)
(E.Harms) (E.McCrory)
(D.McGinnis) (R.Pasquinelli)

Theory/Simulation Group
Yu.Alexahin (GL)
V.Balbekov
N.Gelfand
E.Gianfelice-Wendt
V.Kamerdzhiev
G.Kuznetsov(GS)
L.Vorobiev (GS)

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

Exper. AAR&D Group
P.Piot (GL)
(L.Bellantoni) (H.Edwards)
(R.Fliller) (S.Nagaitsev)
(C.Y.Tan) (M.Wendt)

(CPA Group of CD)
(P.Spentzouris, GL)
(J.Amundson) (P.Lebrun)
(L.Michelotti) (E.Stern)
(V.Ivanov, GS) (D.Dechow, V)

Muon Accelerator R&D Department
S.Geer, Head

MCTF Experiment Group
A.Jansson (GL)
K.Yonehara
C.Yoshikawa (GS)
A.Kurup (ICL Fellow)
(C.Ankenbrandt)
(D.Broemmelsiek) (M.Hu)
(F.Garcia) (V.Kashikhin)
(M.Lamm) (E.Prebys)

NFMCC Group
A.Bross (GL)
M.Ellis
A.Moretti
D.Neuffer
X.Yang (ICL Fellow)
(M.Geynisman)
(C.Johnstone)
(A.Klebaner)
(M.Popovic) (A.Tollestrup)

US PAS Office
S.Winchester (GL)
W.Barletta, Director (GS)
I.Novitskaia

Accel.Education Dept.
(V.Lebedev), Head
(V.Yarba), Deputy

Accel.PhD Program
(M.Syphers, Comm.Chair)

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

Peoples Fellowship
(M.Church, Comm.Chair)

Accelerator Summer Students Program
(A.Shemyakin)

APC Staff Projections

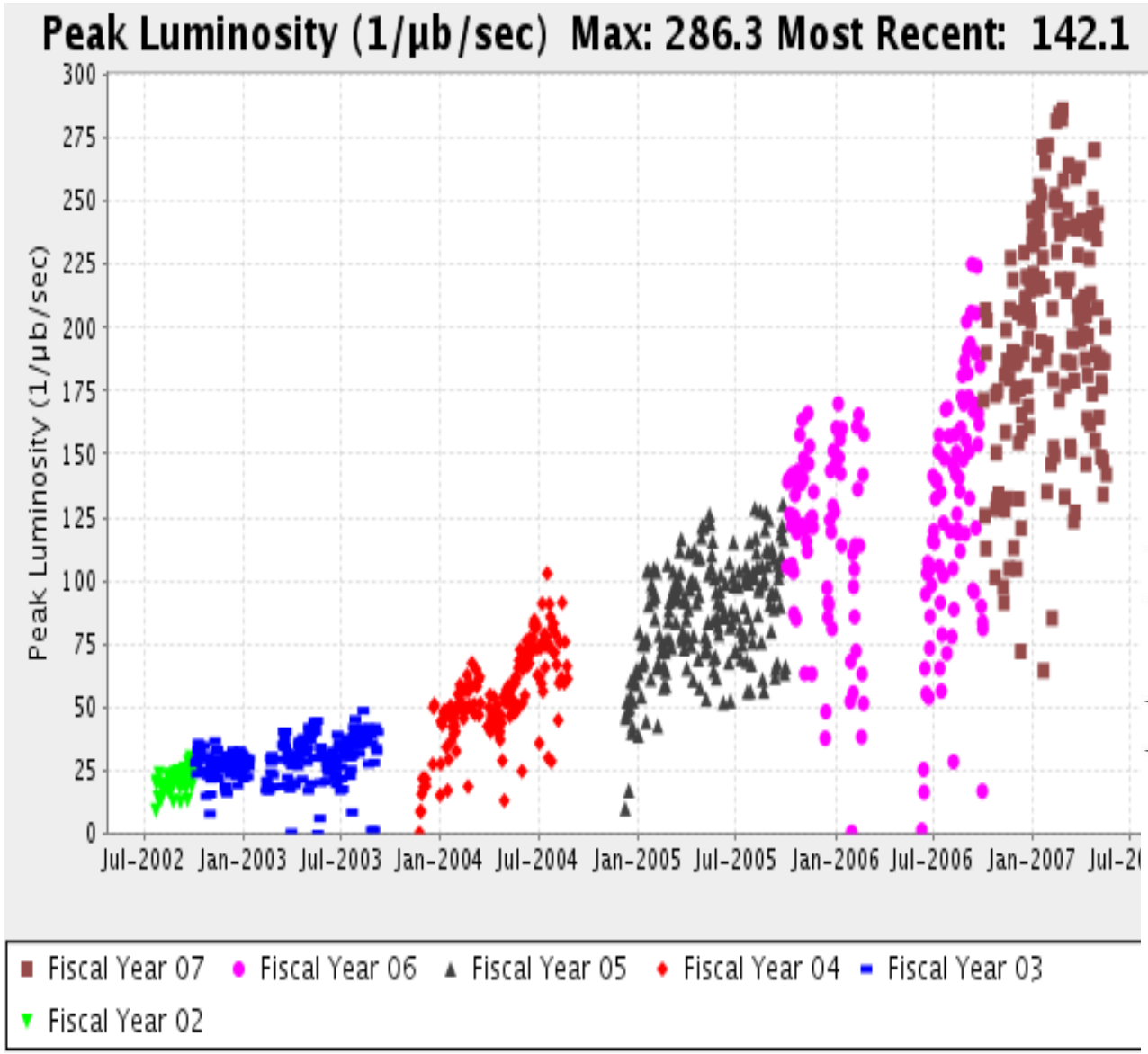
Category	FY2007	FY2008
Scientists	25	30
Post Docs	5	6
Joint Appointments	3	4
Engineers	3	3
Technicians	1	1
Admin. Staff	3	3
Guest Sci. & Eng.	7	7
TOTAL STAFF	47	54
PhD students	8	10

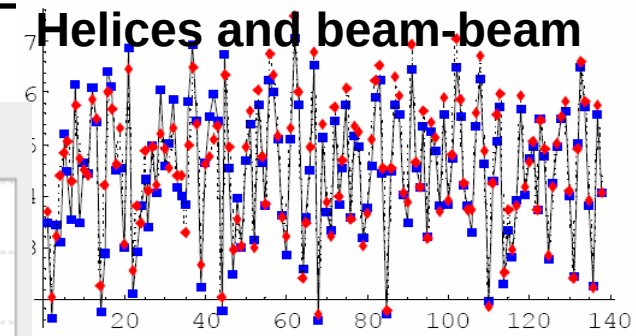
APC : Existing Programs and Next Facilities

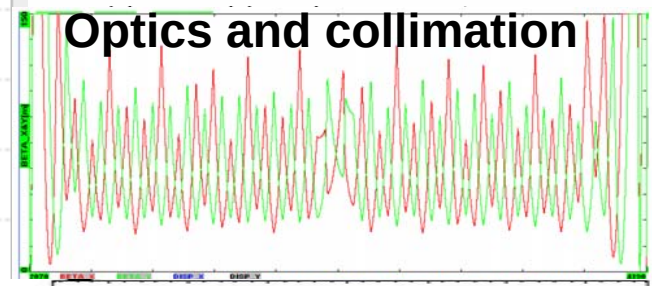
- **Run II** *- see also in P.Spentzouris's talk Wed*
- **LHC** *- details in T.Sen's talk Wed*
- **ILC** *- also in S.Nagaitsev's talk Wed*
- **Proton Intensity Frontier**
  - **NOvA beam phys. issues**
  - **HINS** *High Intensity Neutrino Source* **front end** *- see G.Apollinari's talk Wed*
  - **Project X** *- details in D.McGinnis's talk Wed*

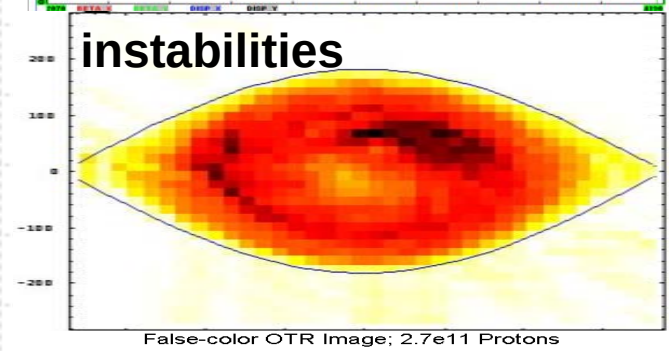
Collider Run II Accelerator Physics

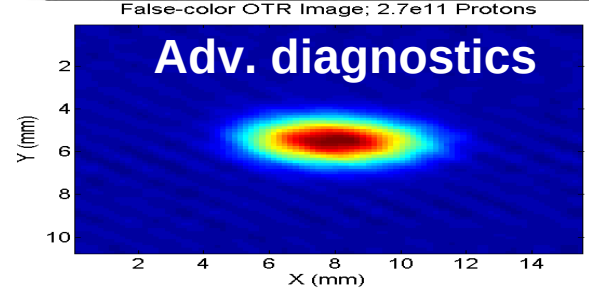
- Core of APC – "Run II veterans"





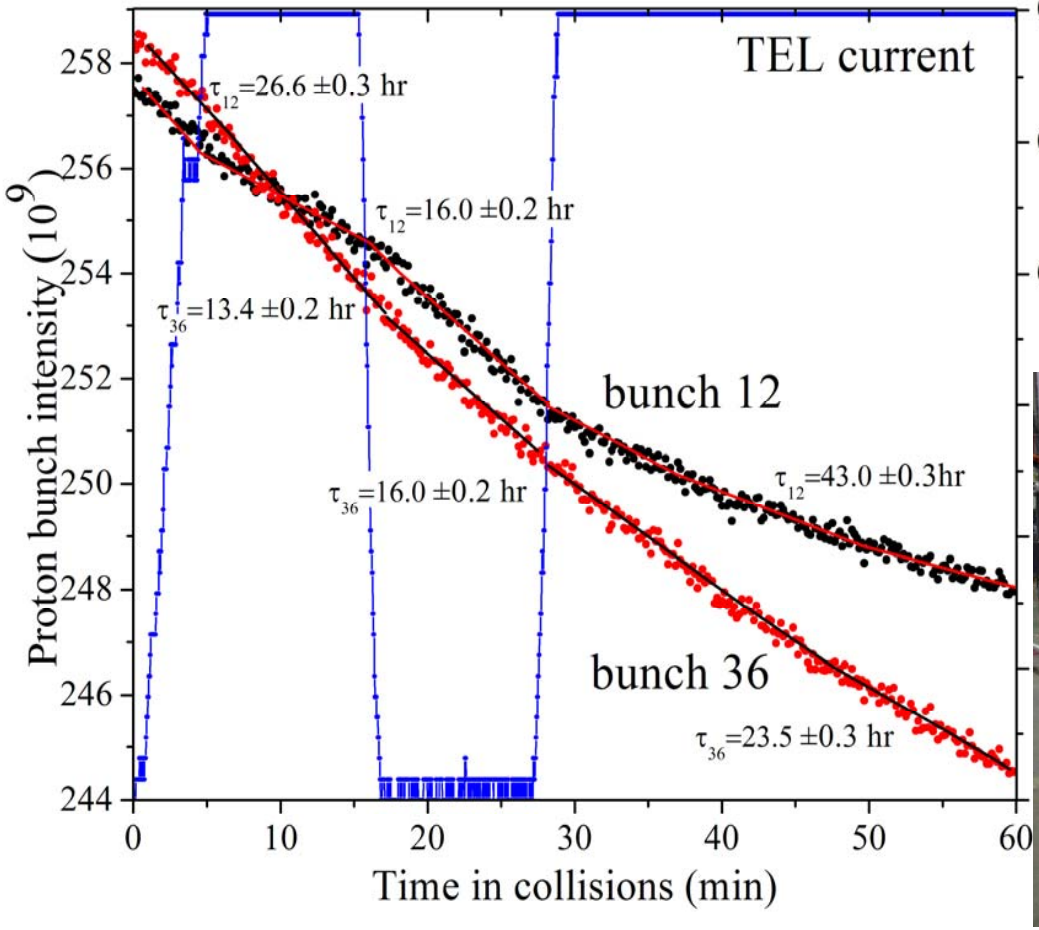


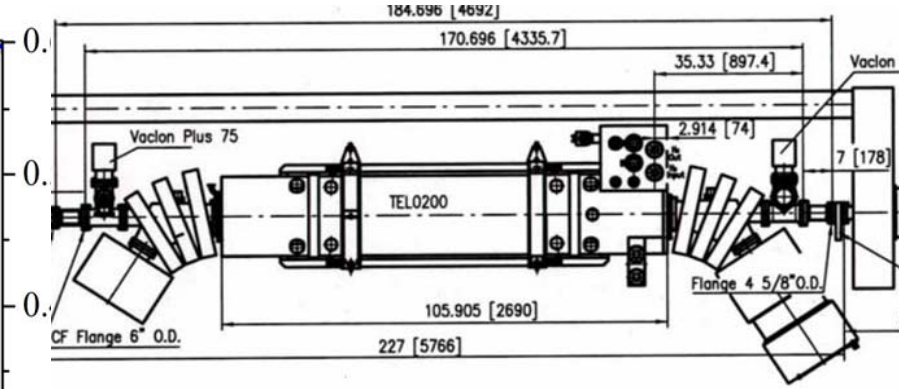


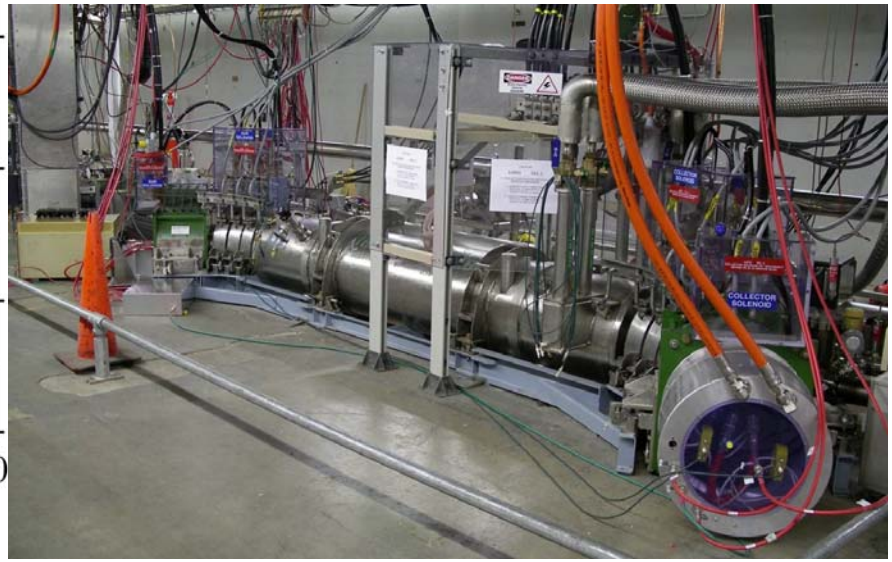


Run II: Tevatron Electron Lenses

First ever active compensation of beam-beam effects with electron lenses



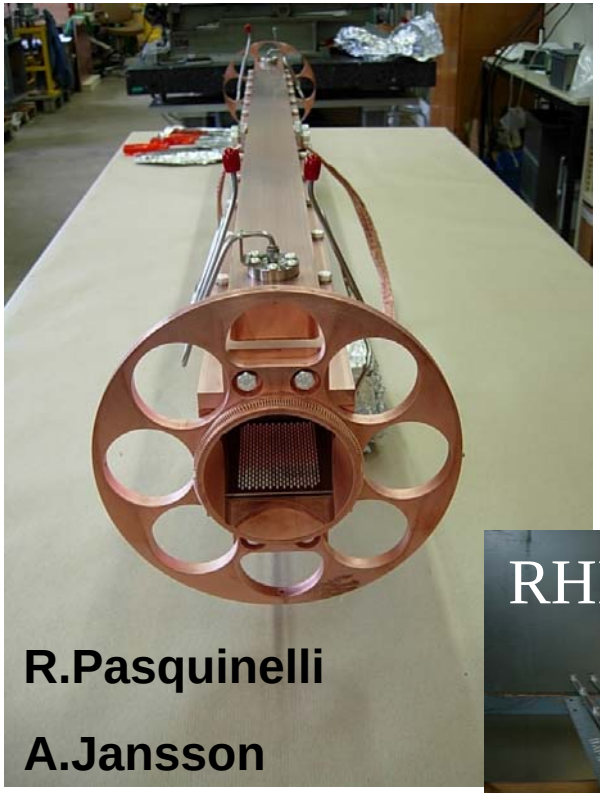




- **APC participates in Booster SC studies, MI and Tevatron optics, MI e-cloud, bent crystal collimator in Tevatron, take MCR shifts**

APC coordinates LHC Accelerator Physics @ FNAL

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

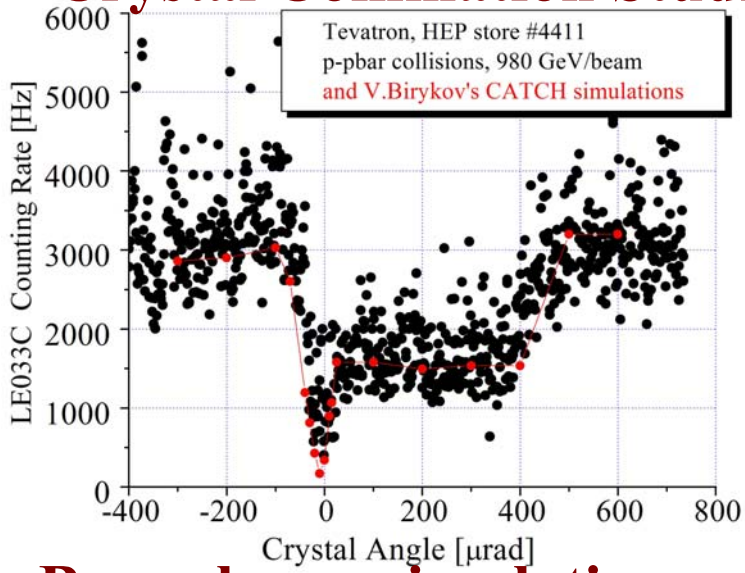


R.Pasquinelli

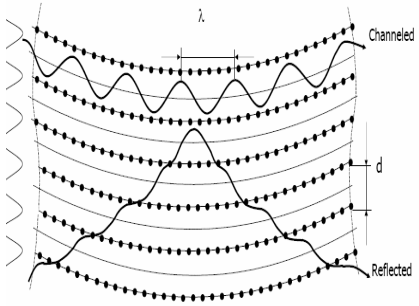
A.Jansson

Installed in LHC tunnel Dec'06

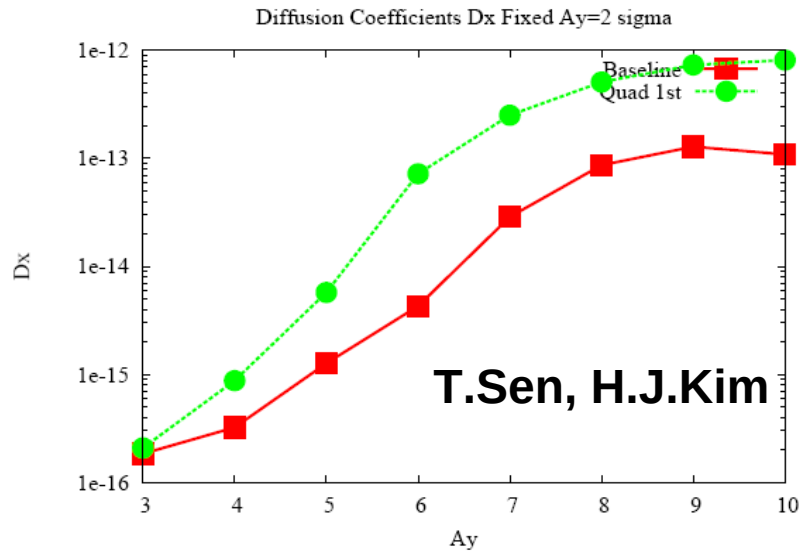
Crystal Collimation Studies in Tevatron



N.Mokhov

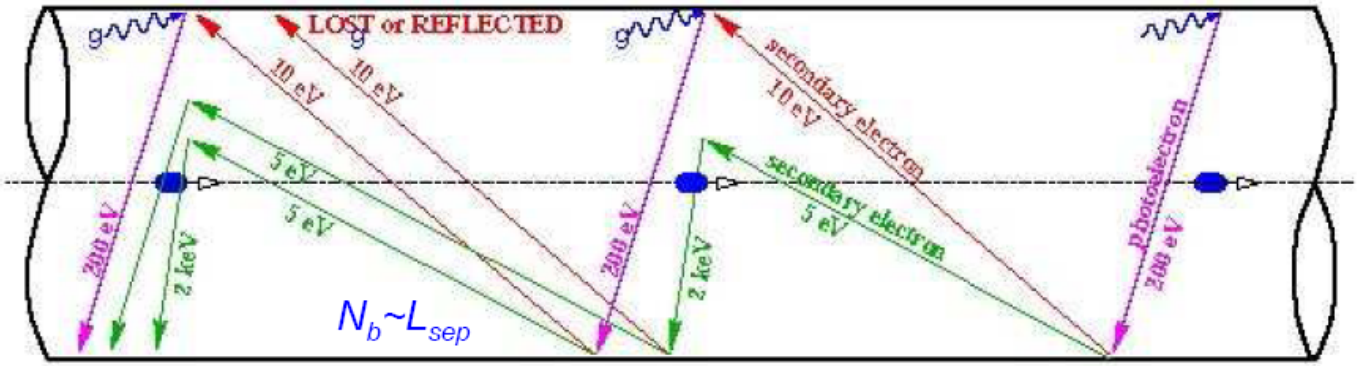


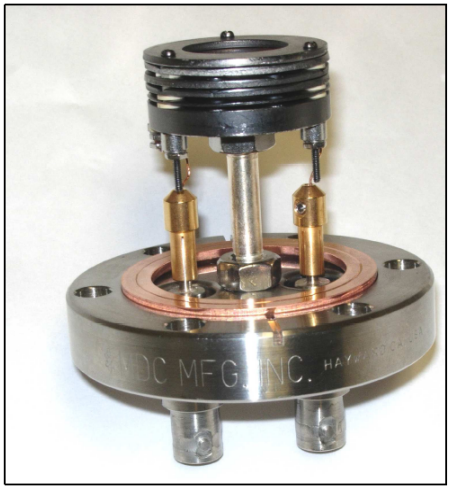
Beam-beam simulations and experiments

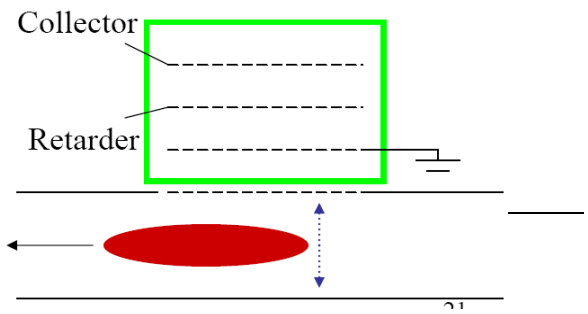


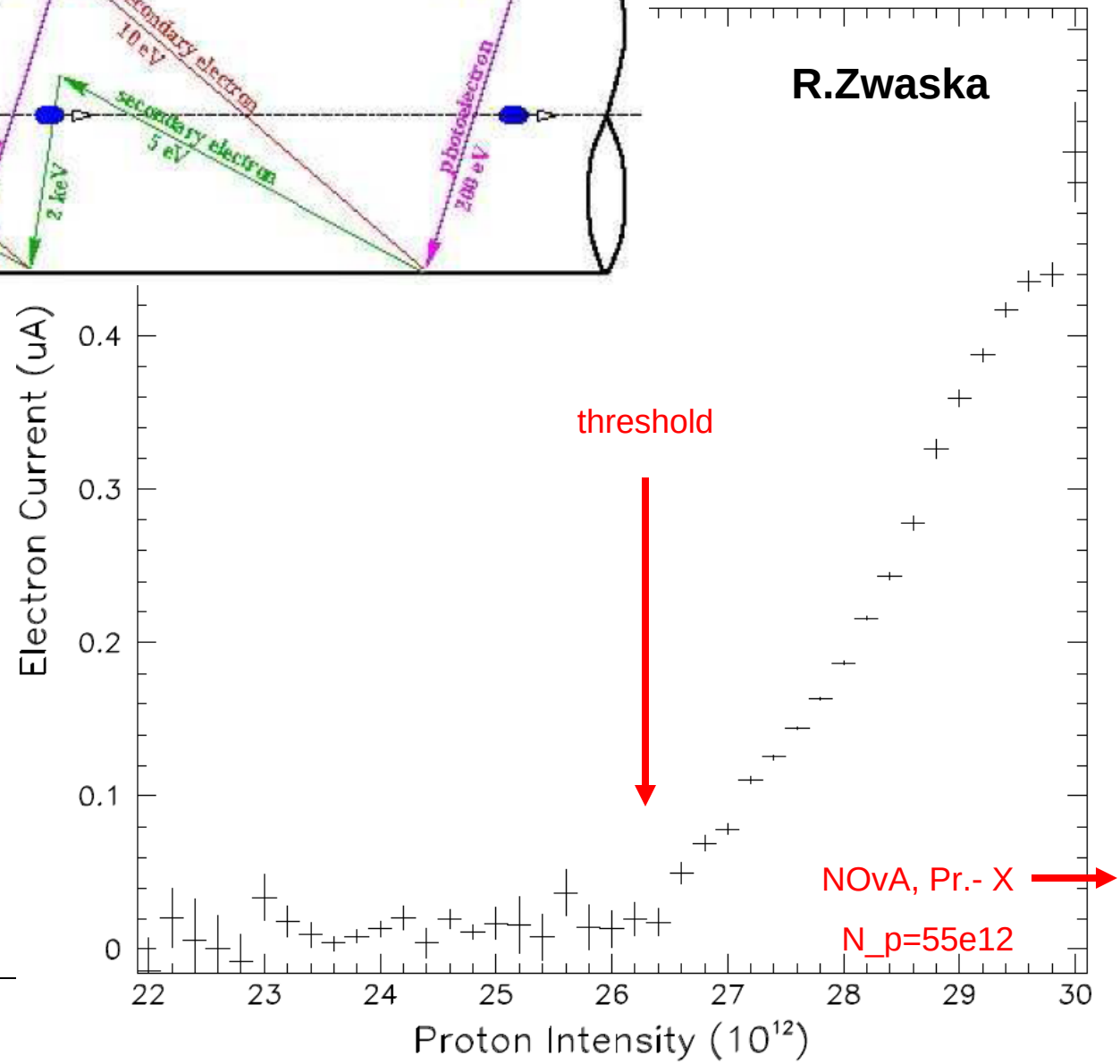
T.Sen, H.J.Kim

Electron Cloud Studies in MI









ILC R&D @ FNAL and APC Role

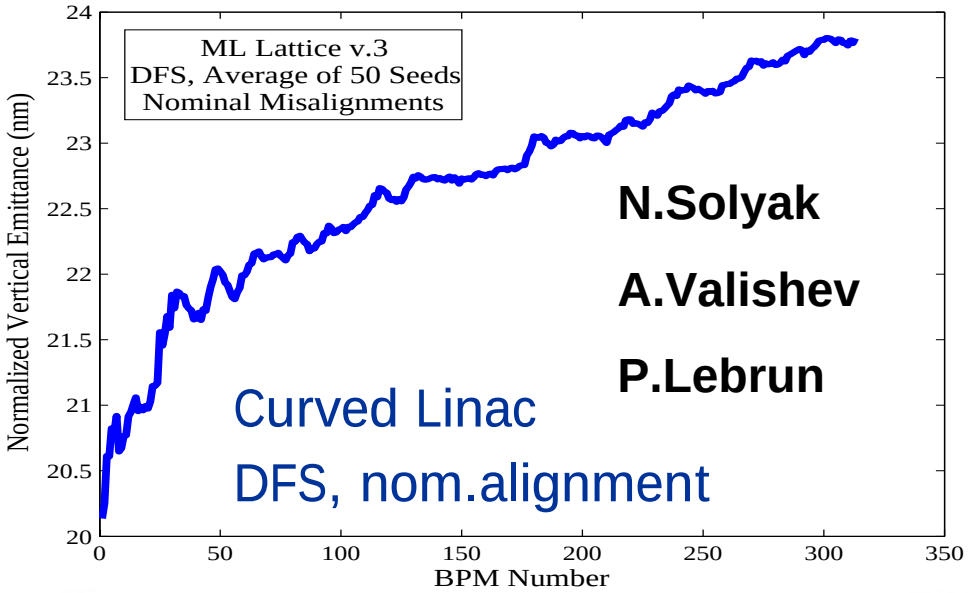
- **ILC SC RF technology**
  - technology development @ TD and AD
  - NML test facility @ AD and TD
- **ILC Engineering Design Report**
  - just started @ TD and APC and AD
- **ILC Beam Physics Studies**
  - simulations @ APC and CD and AD
  - beam studies in NML@ APC and AD
  - beyond NML tests @ APC

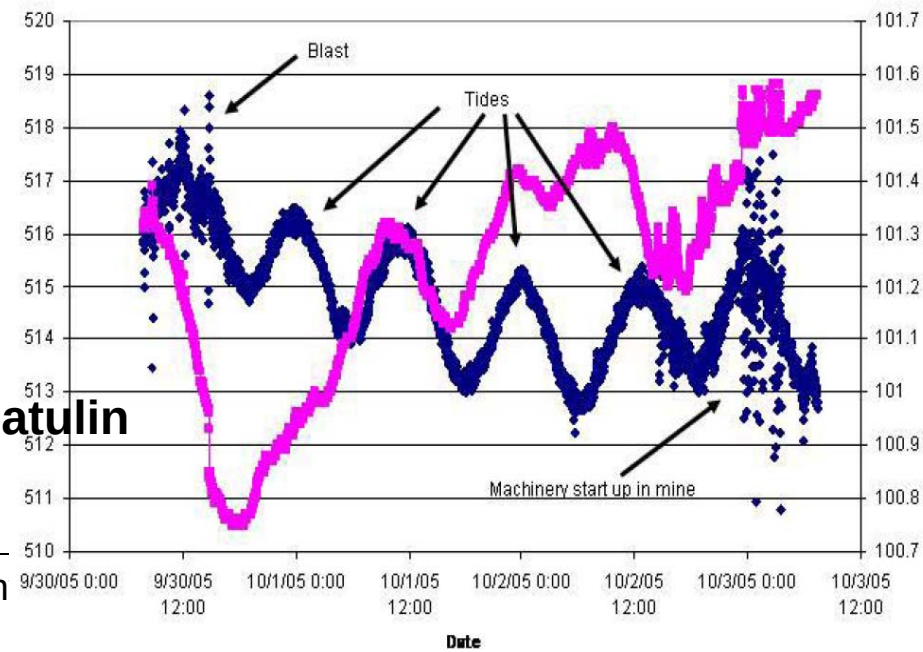
APC is small but important part of the labs' ILC effort

ILC: Dynamics in Main Linac

ILC activities @ APC:

- Error analysis / correction
- Curved linac effects
- CHEF code development
- Code comparison
- Dynamic correction
- Ground motion measurements / analysis

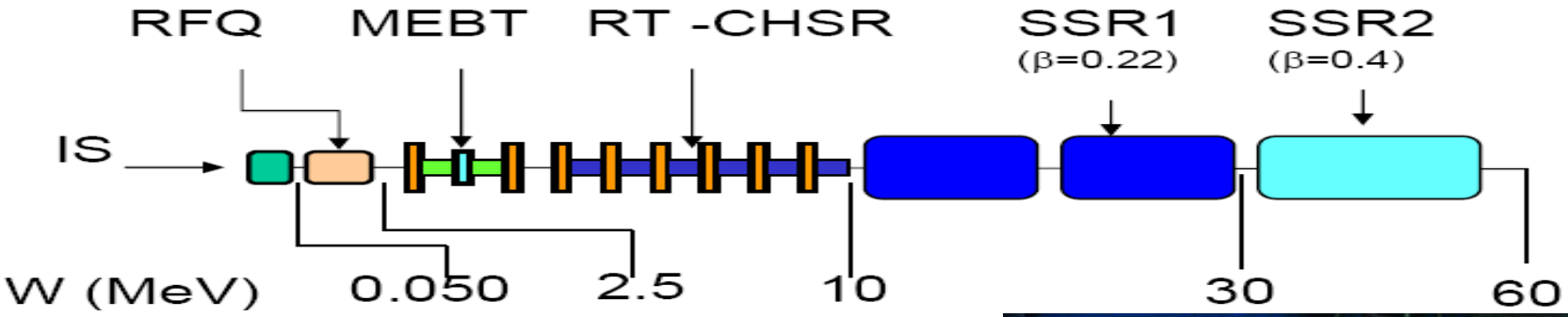




S.Singatulin

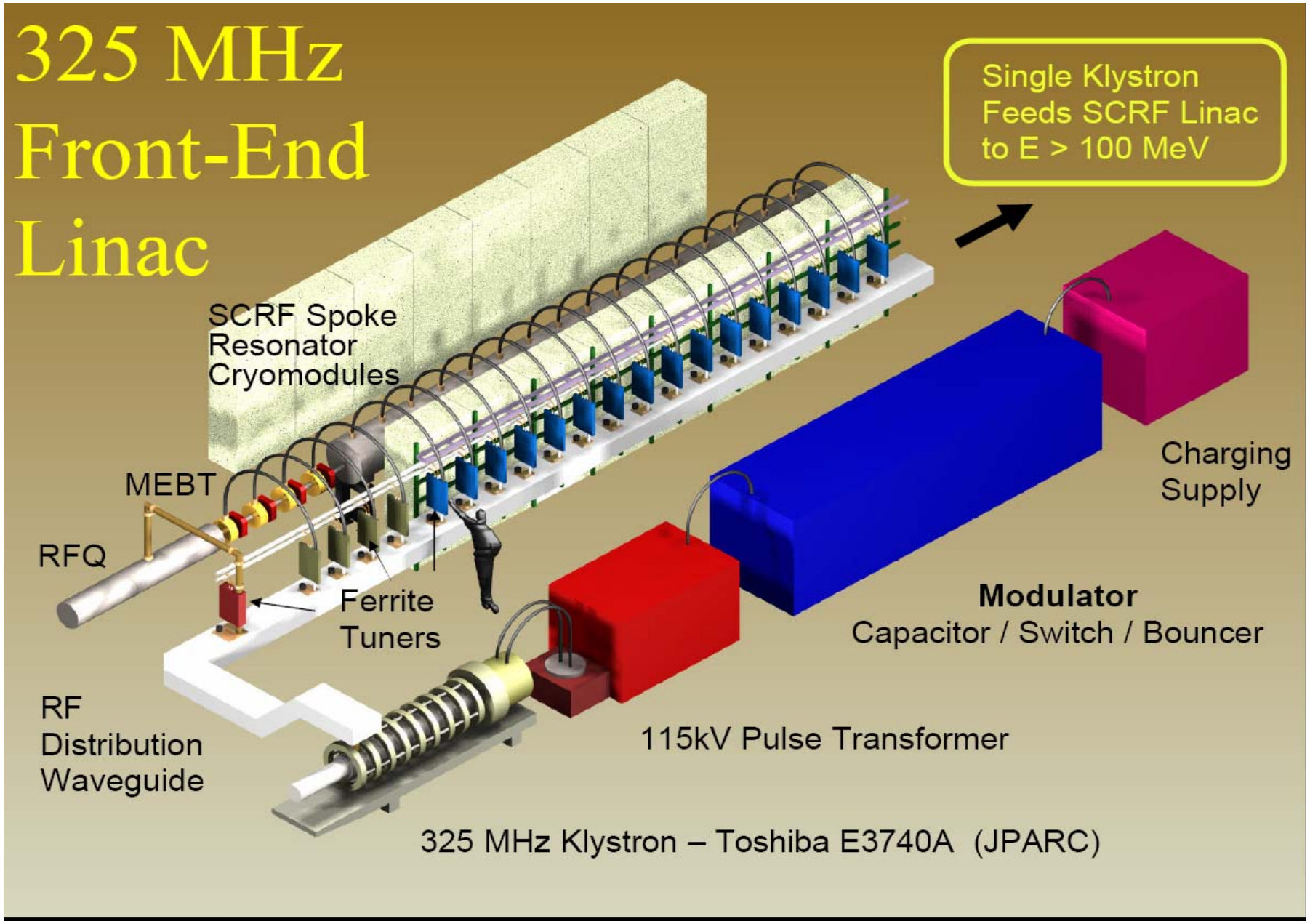
J.Volk

High Intensity Neutrino Source R&D



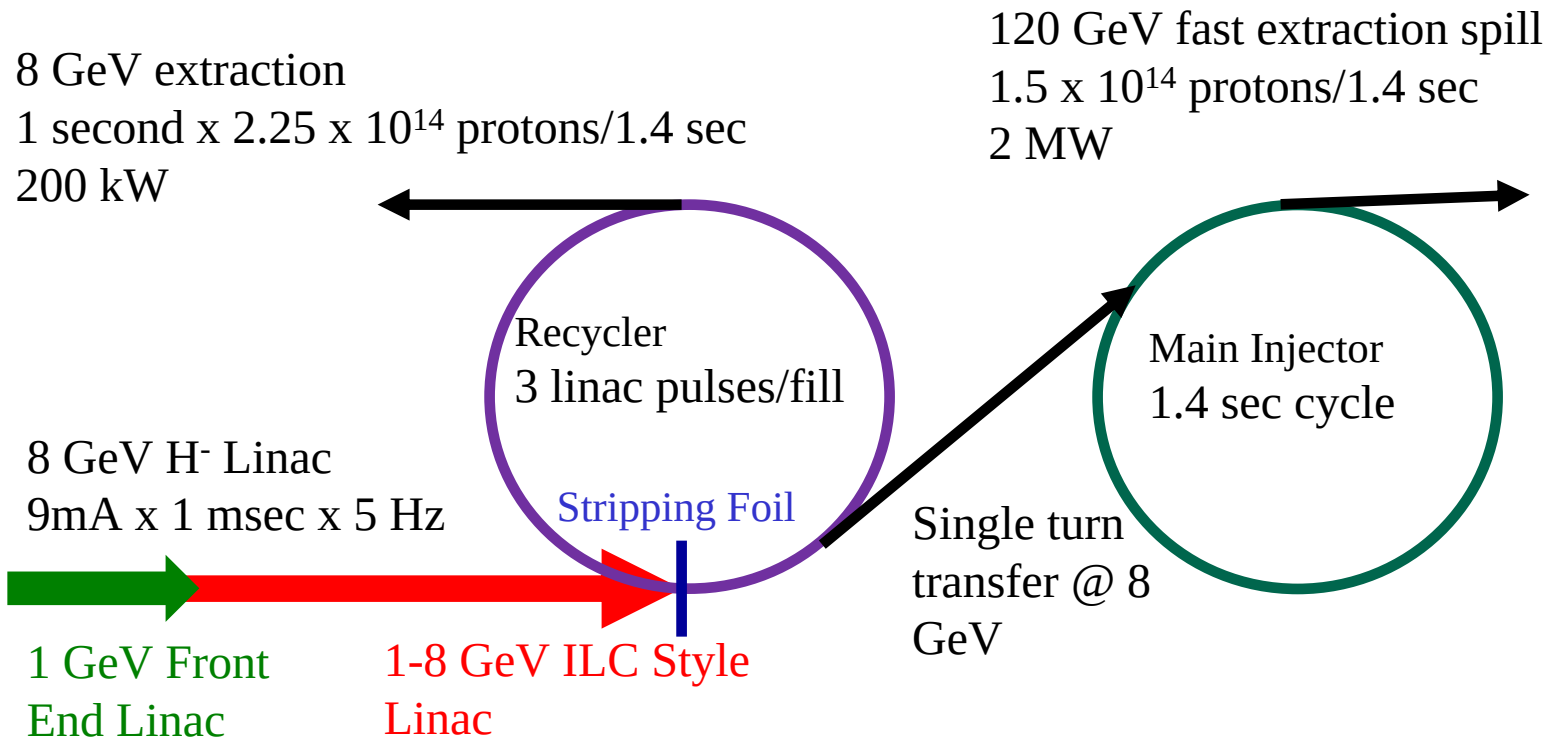
- **One of its kind facility**
  - **Single klystron RF distribution**
  - **Very low energy RT to SC transition**
  - **Solenoidal focusing all along**
- **APC HINS Department :**
  - **Head - R.Webber**
  - **G.Apollinari coordinates TD efforts**
  - **many AD&TD scientists and engineers contribute**
  - **Collaboration with ANL, BNL, LBNL**

HINS Front End at MDB



Project X

– as outlined in SG Report, potential to be Fermilab's near future project



APC contributes to:

- H- source
- 8 GeV Linac dynamics
- Collimators
- Civil Construction
- 8GeV injection/extr.
- MI/RR Dynamics

APC Projections

Activity	'07 FTE	2007, k$*			'08 FTE	2008, k$*		
		M&S	SWF	Tot		M&S	SWF	Tot
Run II Beam Ph.	5.1	92	850	940	4.0	86	640	790
LARP Accel.Syst	4.6	50	770	820	5.6	140	870	1,010
ILC Beam Phys.	4.9	5	790	794	6.0	6	1,000	1,006
HINS** and ANU	11.6	45	1,850	1,900	7.3	30	1,220	1,250
Project X	0.6	0	100	100	4.9	0	780	780

* including overheads: 15.5% on M&S and 73% on SWF

** HINS M&S budget in TD: 2.5 M$ in FY07, 3.2M$ in FY08

APC Program: Future Accelerators

- **Muon Accelerator R&D**
  - **muon collider**
  - **neutrino factory**

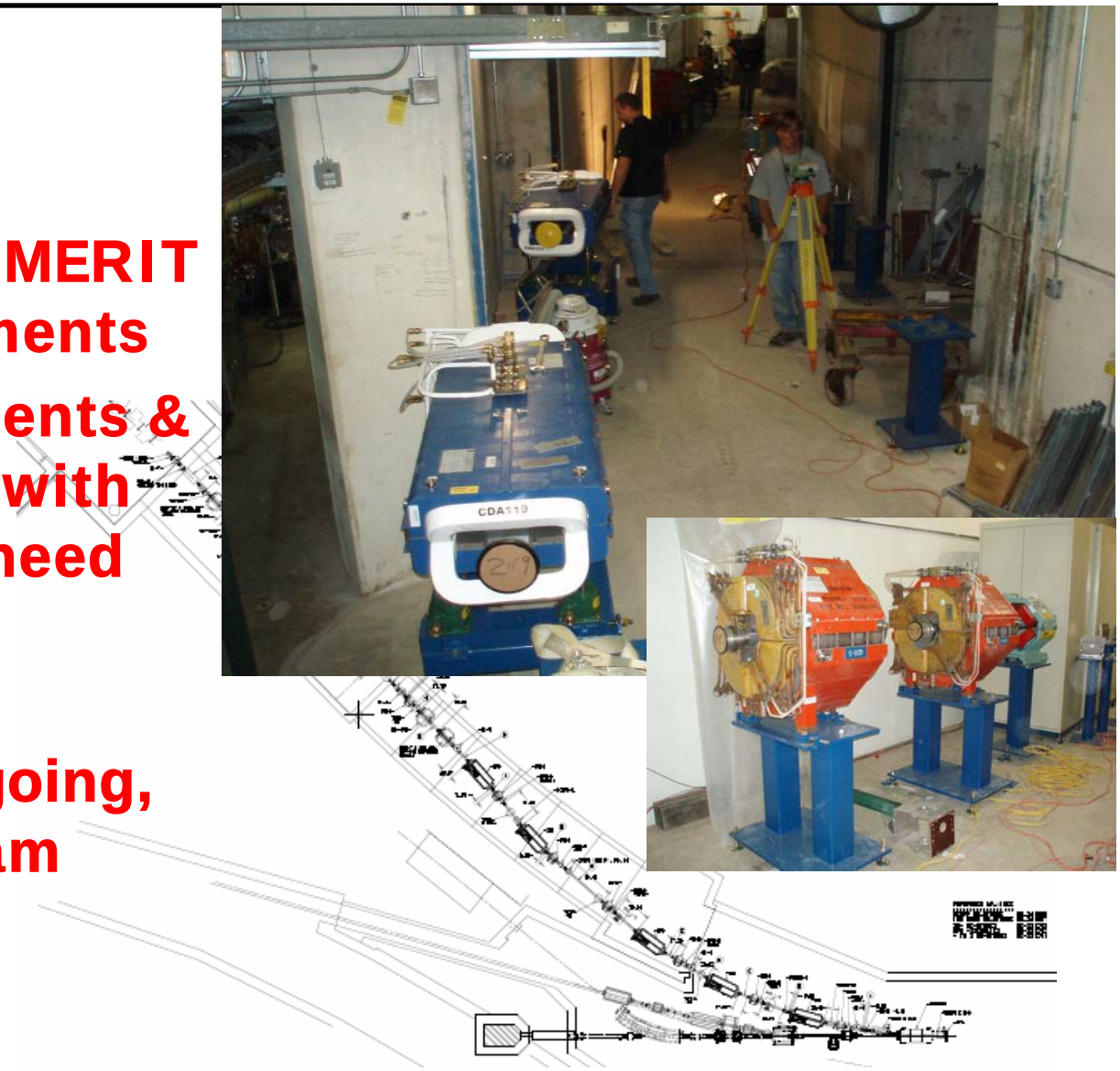
-details in S.Geer and A.Jansson talks Wed, also 4 posters tonight

- **Advanced Accelerator R&D**

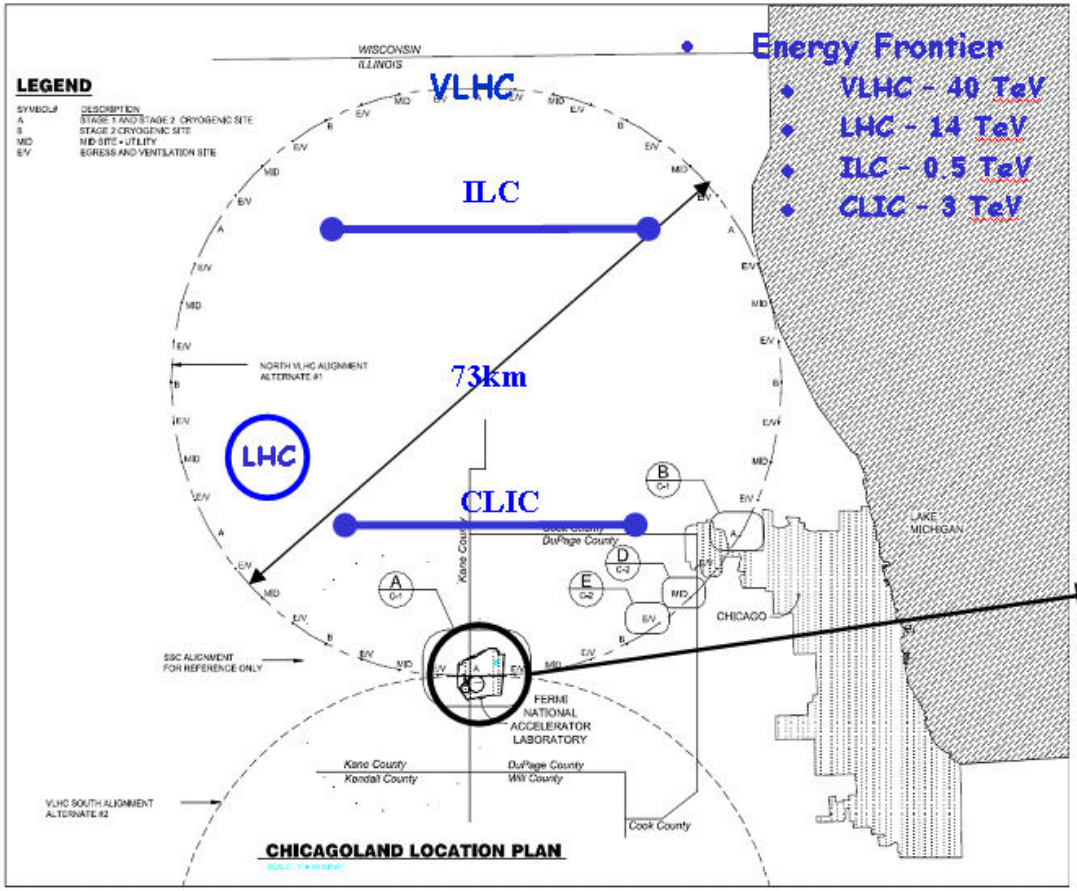
- S.Nagaitsev's talk Wed and P.Piot poster tonight

Neutrino Factory and Muon Collider Collaboration@APC

- **NFMCC:**
  - **MICE (UK) and MERIT (CERN) experiments**
  - **To test components & pressurized RF with intense beam, need beam to MTA.**
  - **MTA beam line installation ongoing, expect first beam early 2008.**



Muon Collider



2 TeV Muon Collider
Fits inside TeV ring

Recommends to boost MC R&D and sets the scale of 20M$/yr and 100 FTEs

- **Steering Group on MC issues:**
  - **6D cooling,front end,rings, detector, etc**

Muon Collider Task Force (MCTF)

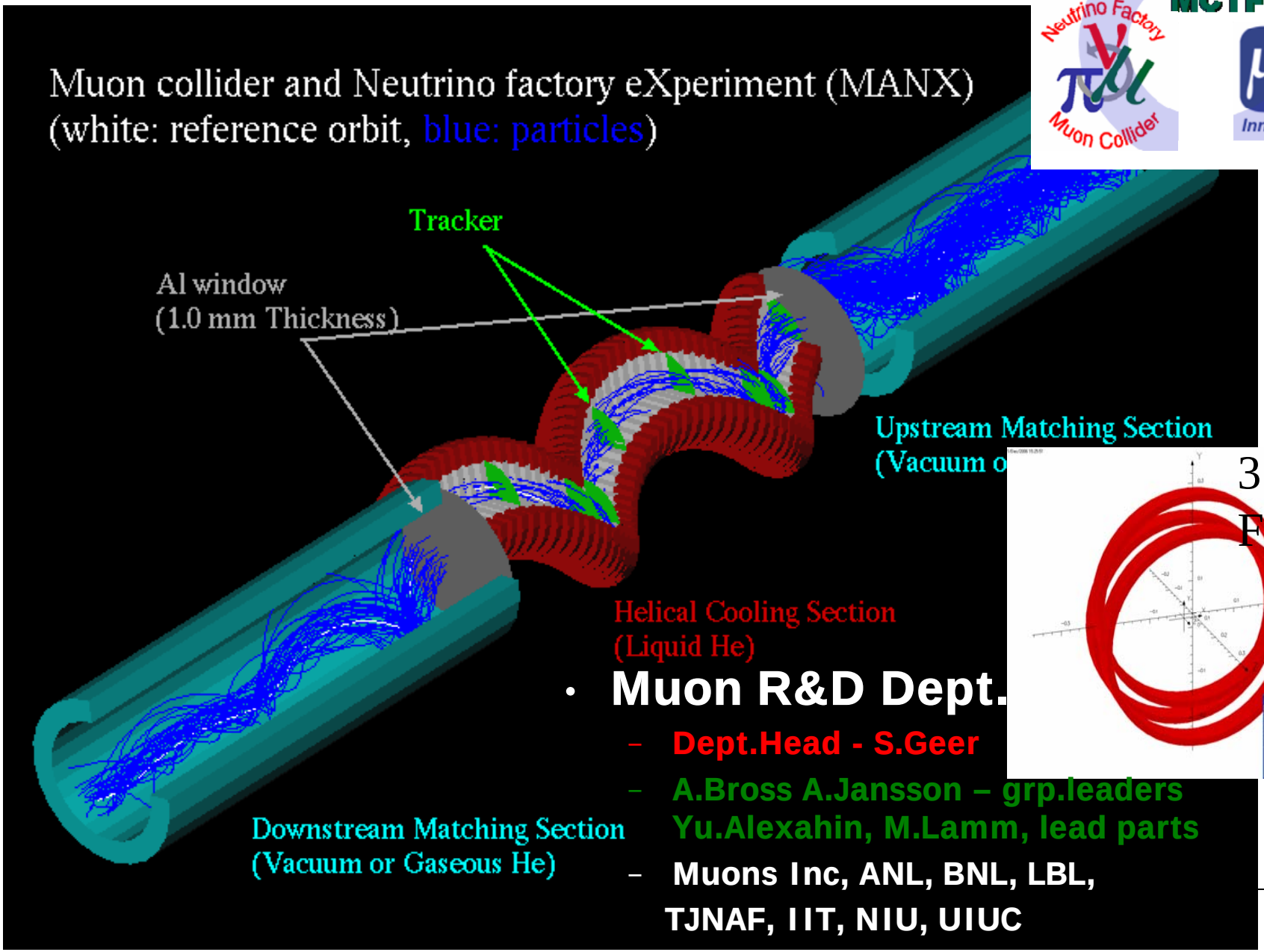
- **Formed in July'06 by FNAL Director:**
  - **"… the Muon Collider represents a possible long term path for extending the energy frontier in lepton collisions beyond 1 TeV…"**
  - **MCTF formed "…to develop a plan for an advanced R&D program aimed at the technologies required to support the long term prospects of a Muon Collider"**
  - **leaders: S.Geer and V.Shiltsev**
  - **Sept'2006: MCTF report delivered outlining a plan for developing the Muon Collider concept based on recent ideas in the realm of ionization cooling, and an associated cooling R&D plan that can be implemented starting in FY2007**
- **People: FNAL(35),BNL(6),JLab (5), Muons Inc. (5), LBNL(4), ANL (1)**

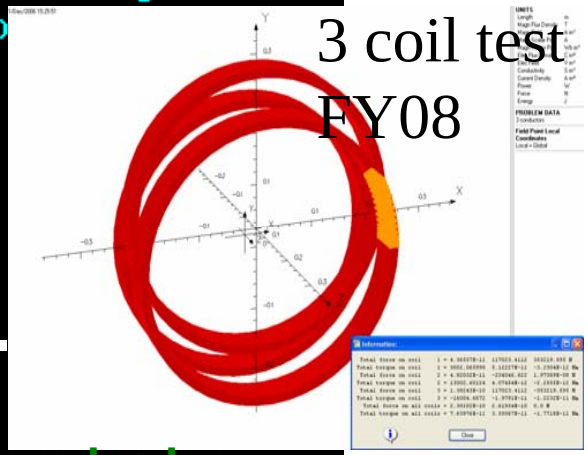
Muon Collider R&D in APC

The plan focuses on revisiting the overall Muon Collider design, and on developing and testing the cooling channel components that are needed (beyond those needed for a Neutrino Factory):

1. Muon Collider Design and Simulations
   - conceptual design, main components
   - establish the required cooling parameters
2. Component Development.
   - helical magnets (together with Muons Inc.)
   - pressurized RF cavities (together with Muons Inc.)
   - HTS high-field solenoids
3. Beam tests and Experiments.
   - high Intensity proton beam tests
   - muon beam tests, 6D cooling experiment

6D Muon Cooling Experiment

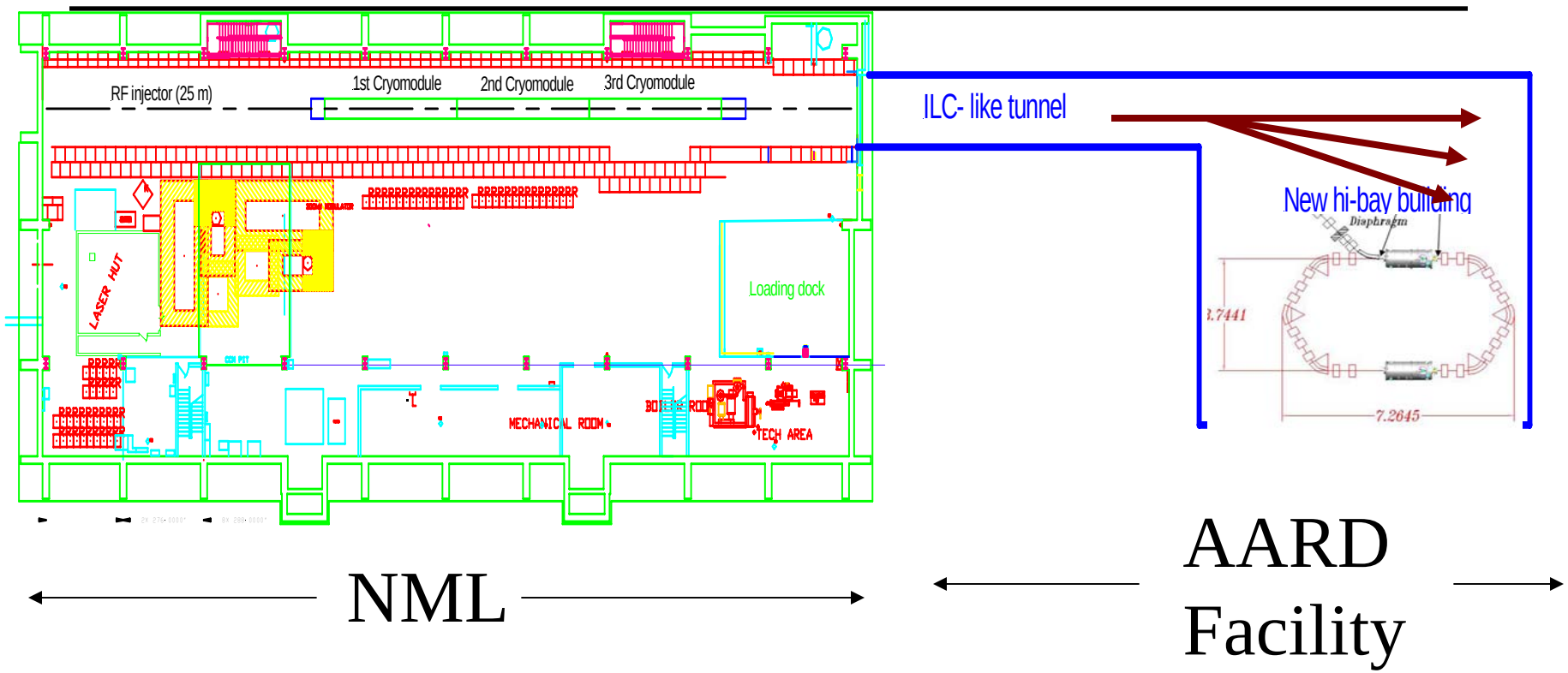




3 coil test
FY08

- **Muon R&D Dept.**
  - **Dept.Head - S.Geer**
  - **A.Bross A.Jansson – grp.leaders**
    Yu.Alexahin, M.Lamm, lead parts
  - **Muons Inc, ANL, BNL, LBL, TJNAF, IIT, NIU, UIUC**

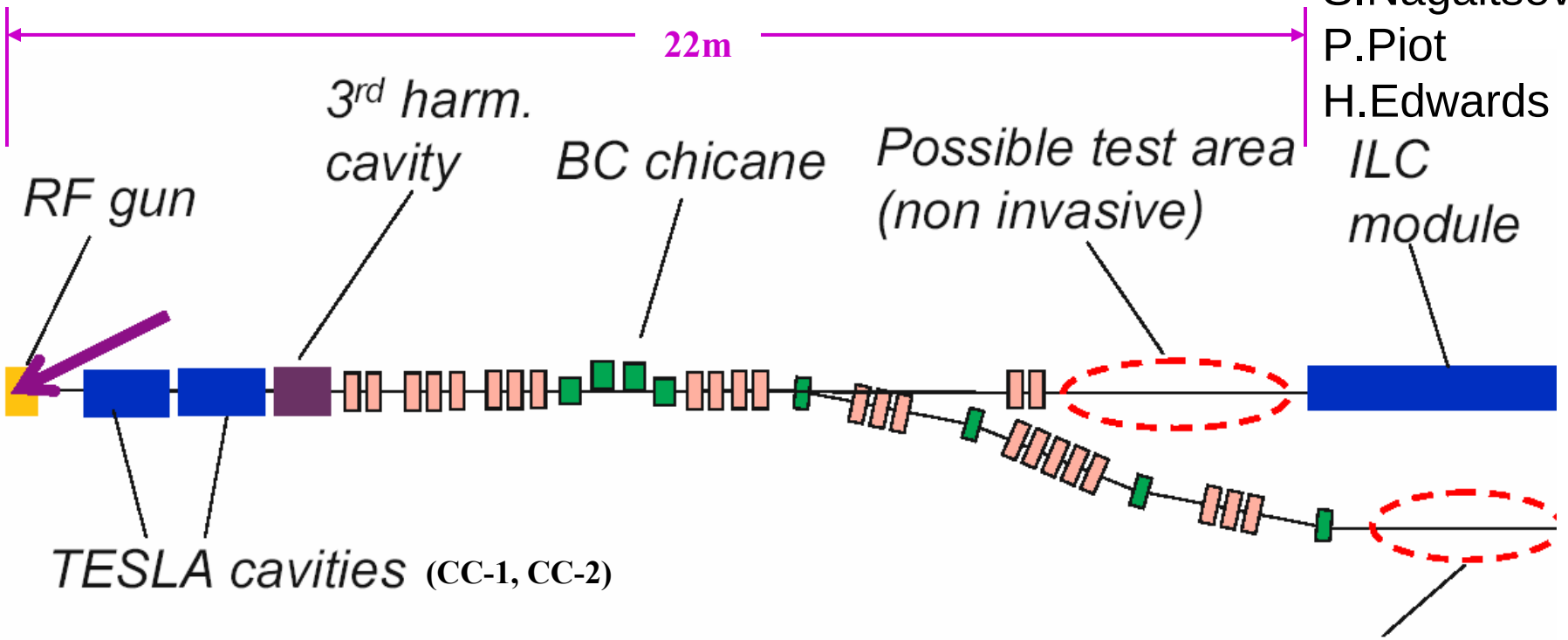
New Muon Lab Building Extension for AARD Facility



- **Construct a new building ~50m away from NML. Connect by a tunnel when schedule allows. ILC-like tunnel, space for 3 more cryomodules**
- **Set a program of Advanced Accelerator R&D experiments in the Users' Facility**

NML Injector Layout

S.Nagaitsev
P.Piot
H.Edwards



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

APC Projections

Activity	'07 FTE	2007, k$* M&S	SWF	Tot	'08 FTE	2008, k$* M&S	SWF	Tot
Muon Coll./NF**	10.0	830	1,600	2,430	12.1	1,610	2,020	3,630
Adv. Accel. R&D	0.6	10	90	100	0.6	10	90	100

* including overheads: 15.5% on M&S and 73% on SWF

** Muon Coll./NF FTEs and SWF also in TD, AD, PPD

FY07 2007 M&S is total in AD, APC, TD, PPD

Accelerator Education Programs

- US Part.Accel.School
- Accel. PhD Program
- Summer Students Pr.

U.S. Particle Accelerator School

- Joint support by 11 Nat'l Labs & Univ.
- 20 years of offering credit courses in Beam Physics/Accelerator Technology
- 2 wk courses in Winter and Summer
- FNAL hosts the US PAS office (dir+2)

Accelerator PhD Program

- **Format:**
  - Students come from Universities
  - Professors(=Thesis advisors) and Fermilab mentors
  - FNAL provides facilities and financially supports stipends
  - thesis → PhD from University

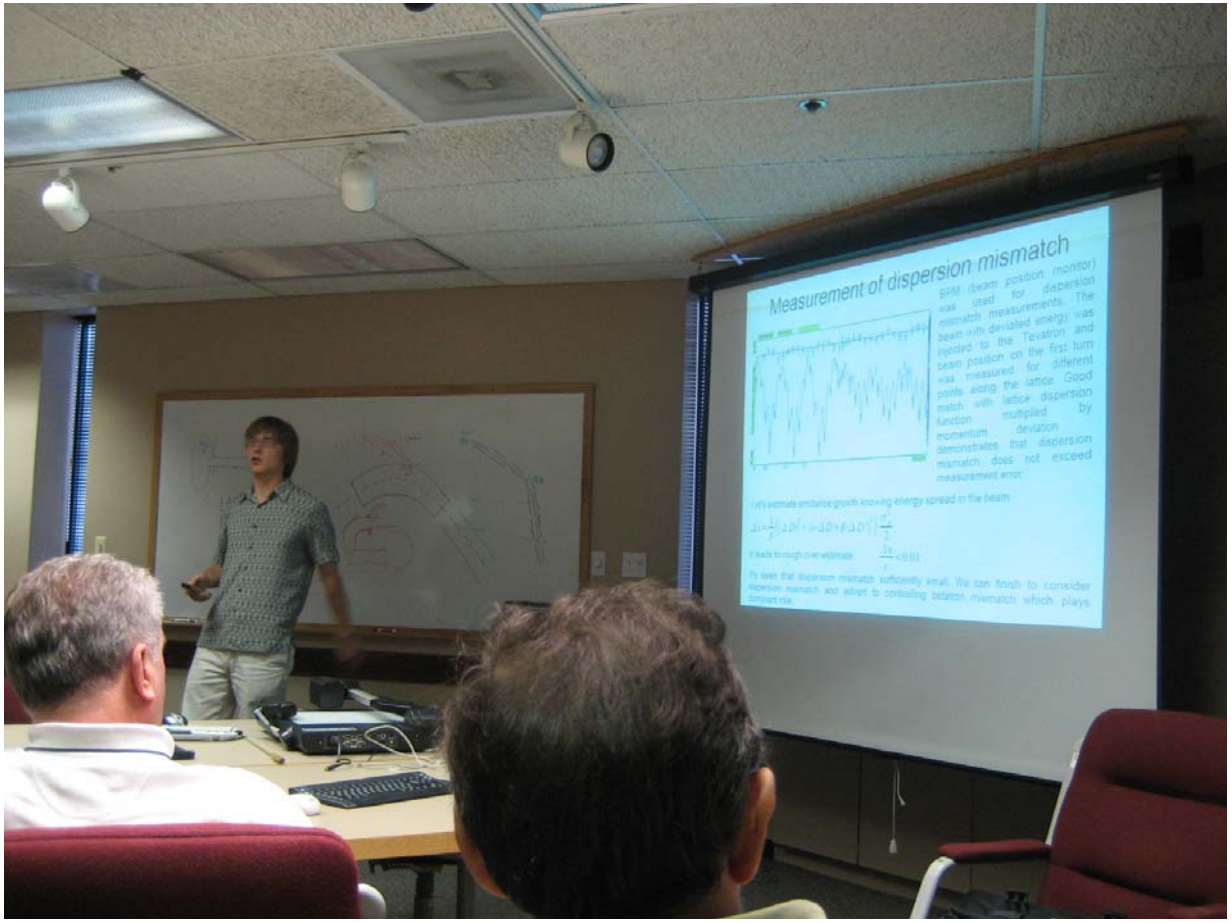
-18 stay in the field, incl. 3 @ FNAL

- **32 graduates since 1989; 9 currently in the program:**

1. Phil Yoon W.Chou (Rochester, A.Bodek) Space charge issues in Proton Driver
2. Alexey Poklonsky D.Neuffer (Mich.State, M.Berz) Optimization and control of Tevatron parameters
3. Tim Koeth H.Edwards (Rutgers, S.Schnetzer) SC cavity as a diagnostic for a high-brightness electron beam
4. Arthur Paytyan H.Edwards (Yerevan, E.Laziev) Control system for SC RF
5. Ryoichi Miyamoto A.Jansson (UT Austin, S.Kopp) AC Dipole Instrimentation
6. Dan McCarron P.Spentzouris (IIT, L.Spentzouris) Booster injection beam dynamics
7. Uros Mavric B.Chase (University of Ljubljana,) ILC low level RF.
8. Wai-Ming Tam G.Romanov (Indiana, S.Y.Lee) Front End of 8 GeV linac
9. Justin Keung S.Nagaitsev (U.Penn, N.Lockyer) Characterization of NML injector

Tim Koeth (Rutgers) in MDB

Summer Student Programs in Accelerator Physics



A summer student reports his results at the meeting of the accelerator-related section of the IPM (Internship for Physics Major) program. In summer of 2006, Matvey Berdnikov, student of the Novosibirsk State University (Russia) majoring in Accelerator physics, analyzed dispersion mismatch at the injection to the Tevatron under guidance of A.Jansson.

- Internship for Physics Major (all, incl. Accel)
- Russian Summer Students Program (~10/summer)
- New! Lee Teng Internship (~10, USPAS+ANL+FNAL)

APC Projections

Activity	'07 FTE	2007, k$* M&S	SWF	Tot	'08 FTE	2008, k$* M&S	SWF	Tot
US PAS	1.9	71	400	470	3.0	74	470	544
Accel.PhD Prog.	0.2	370	40	410	0.3	405	60	465
Summer St.Prog.	0.2	92**	80	172	0.3	154	60	214
Peoples Flwship	0.1	6	20	26	0.1	7	21	28

* including overheads: 15.5% on M&S and 73% on SWF

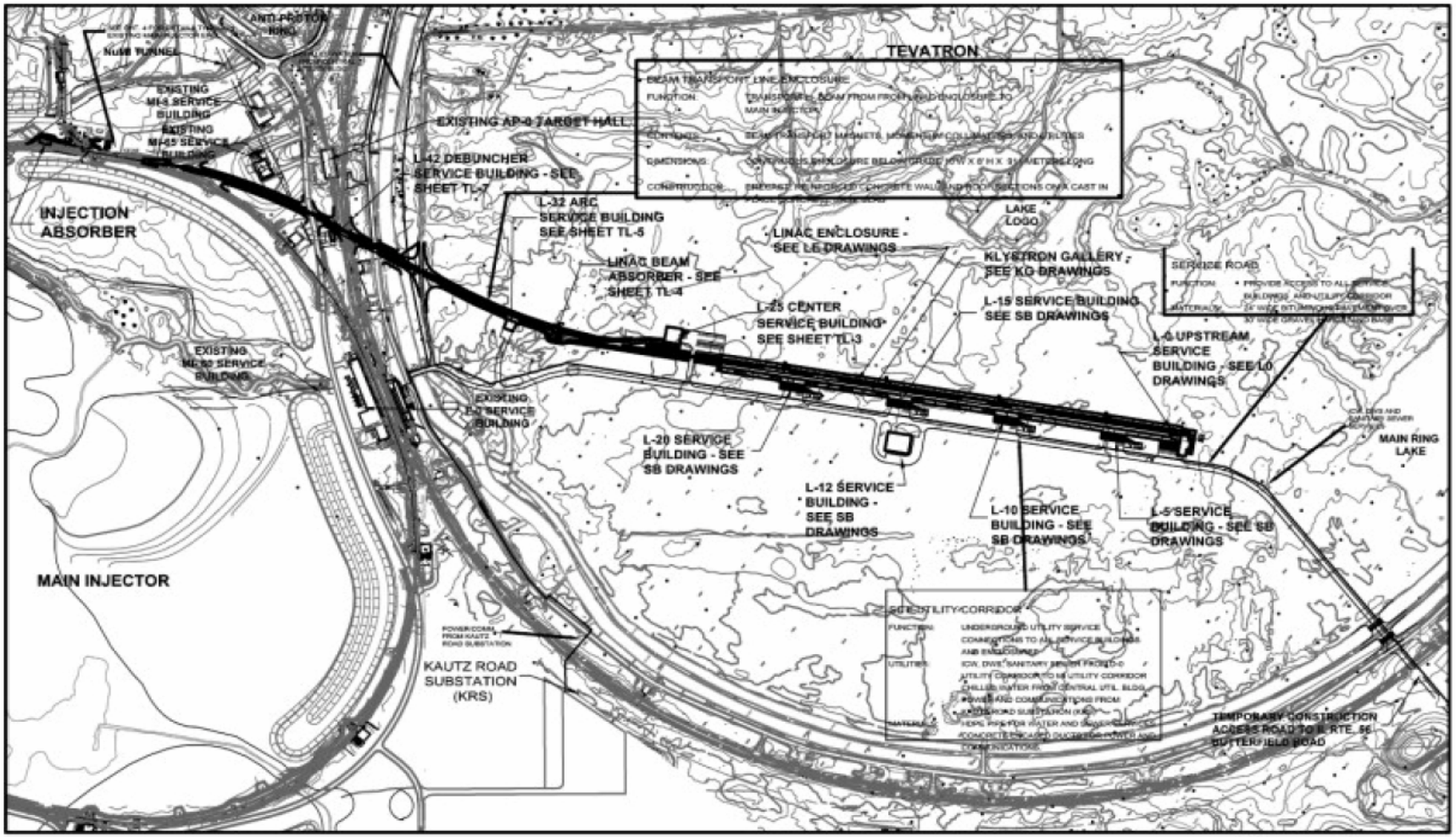
** in FY07, Summer Students M&S spread over TD, AD, APC

Summary

- **Fermilab is enhancing its accelerator research program; Accelerator Physics Center created June 1st, 2007**
- **People from AD, TD, CD and PPD migrate to / collaborate with the Accelerator Physic Center to do:**
  - **Advanced accelerator research at experimental beam facilities**
  - **Beam theory and modeling**
  - **Raise next generations of accelerator scientists**
- **The APC coordinates inter-institutional collaborations in Adv.Accelerator R&D:**
  - **with other National Labs, Universities, international**
- **Current focus on:**
  - **support Run II and ILC, near future (NOvA, Project X)**
  - **expansion of Muon Collider and NF R&D Program**
  - **build and commission HINS experiment**
  - **expand accel.education program and plan AARD Facility**

- **Back up slides**

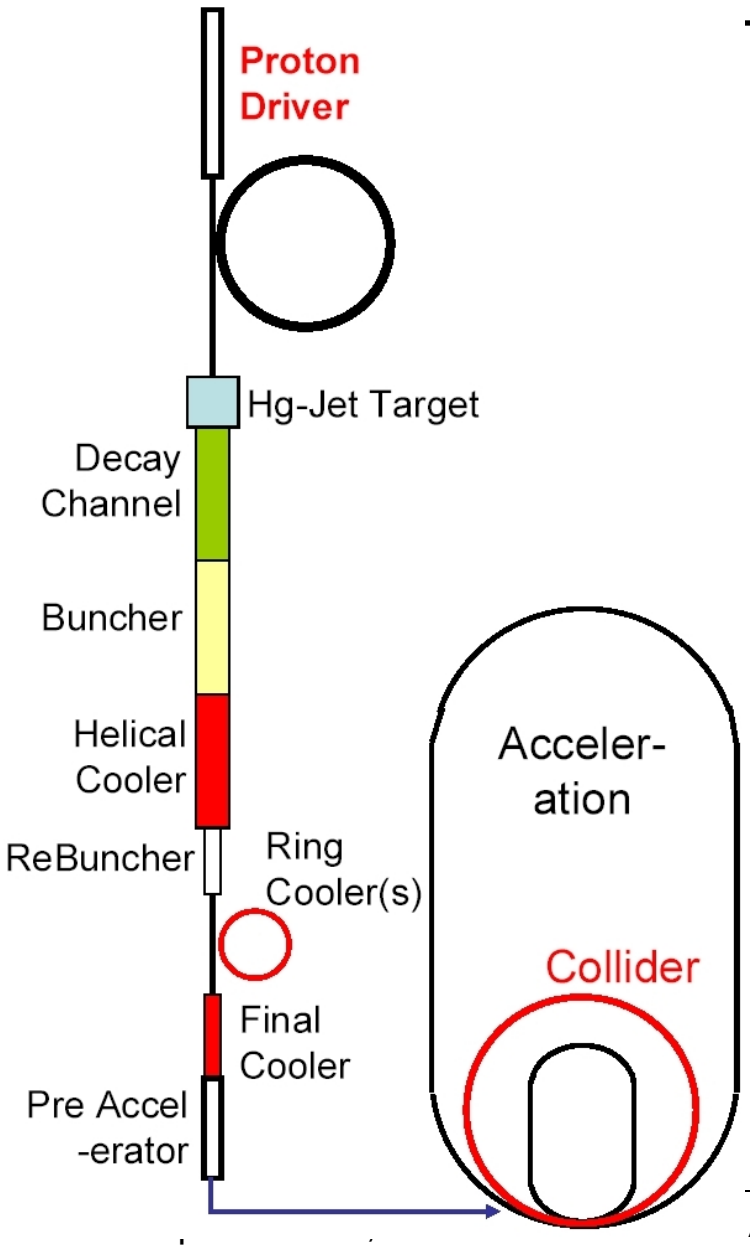
APC: Project X Issues



- H- source
- 8 GeV Linac dynamics
- Collimators
- Civil Construction
- 8GeV injection/extr.
- MI/RR Dynamics

NML Test Facility: Upgrade for Adv. Accel. R&D

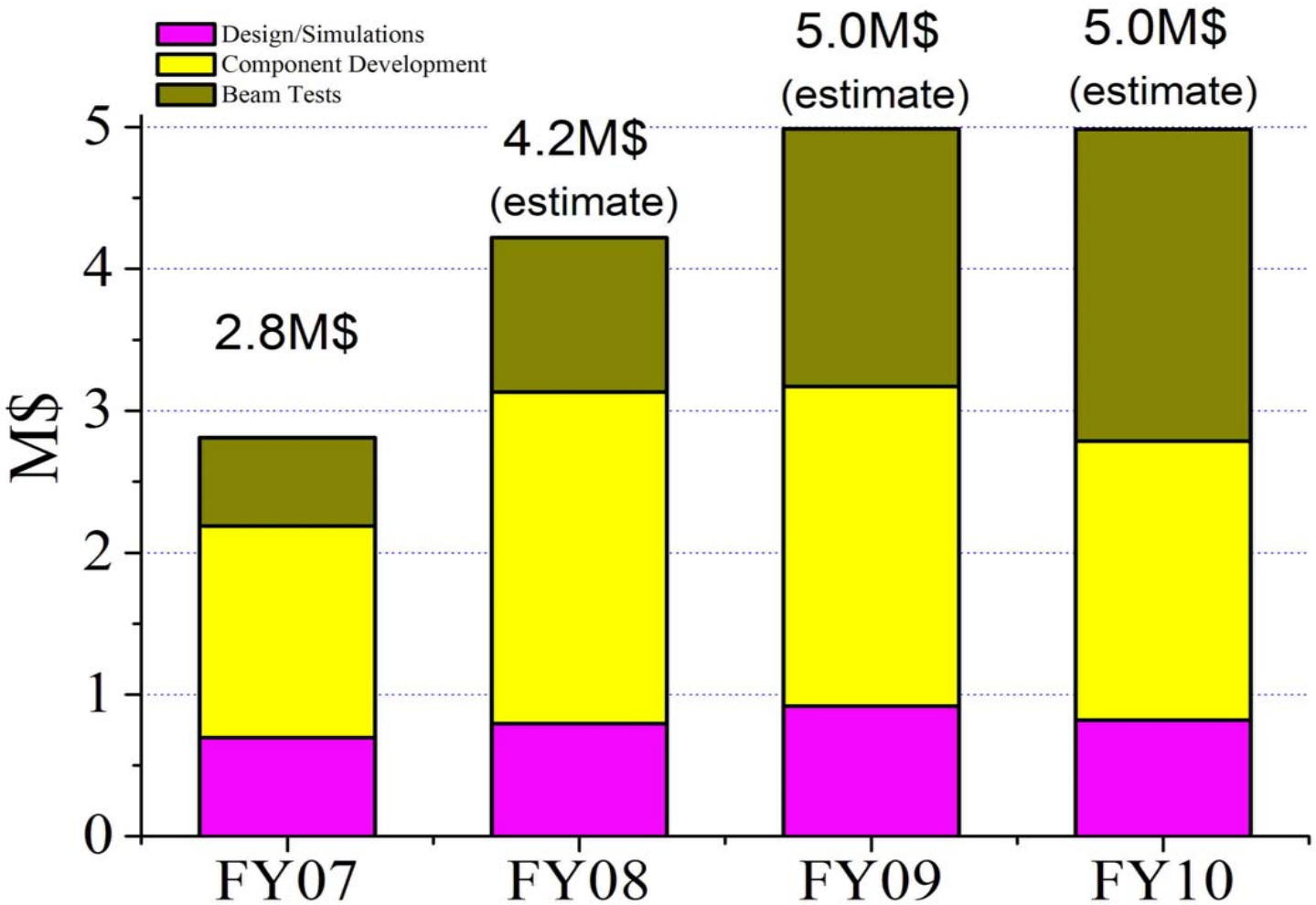
1.5 TeV c.o.m. Muon Collider



Possible parameters for low emittance MC:

Energy per beam	750 GeV
Average luminosity	3e34 $cm^{-2}s^{-1}$
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

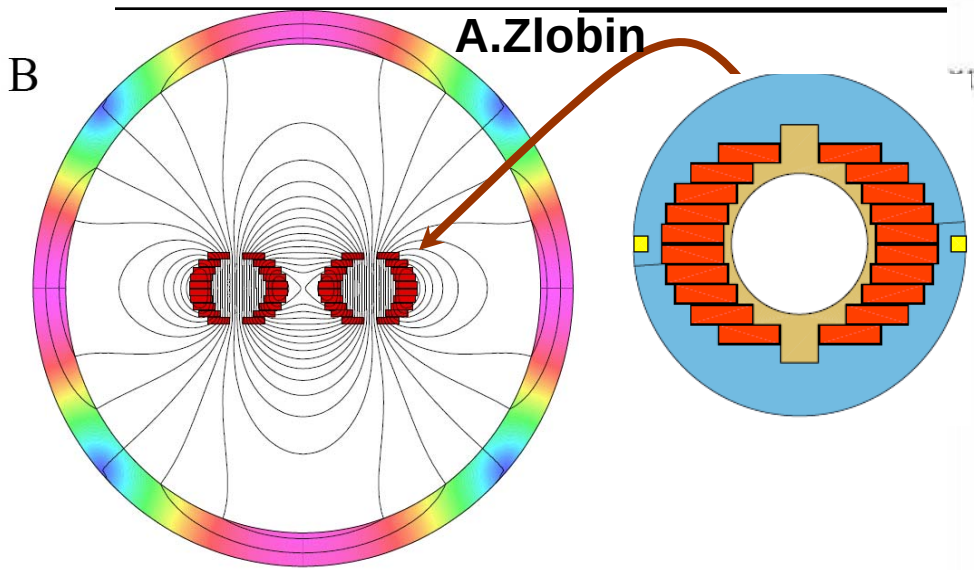
MCTF Report (https://mctf.fnal.gov)



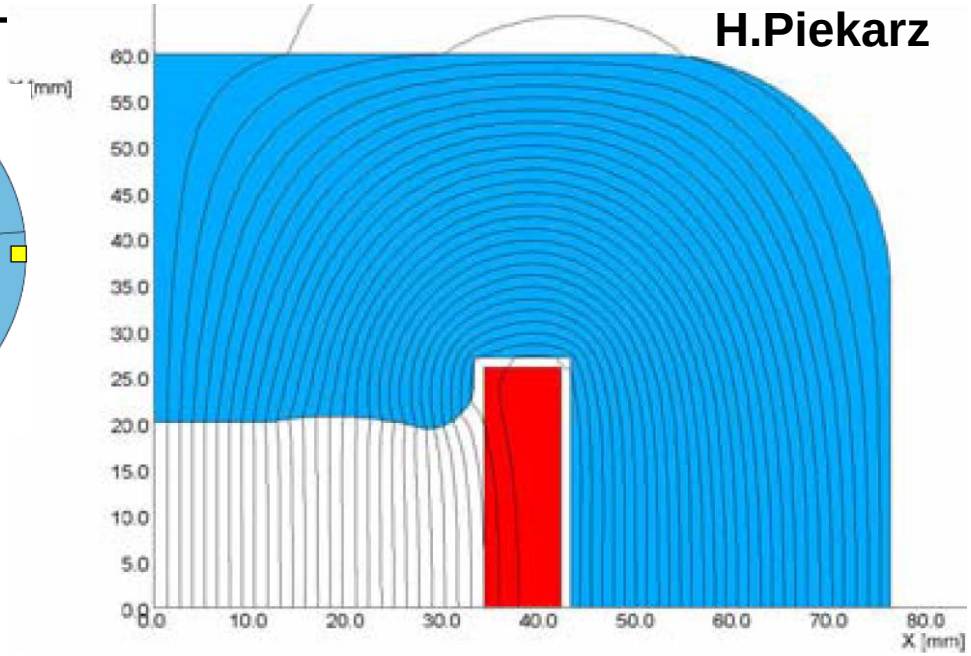
- **FY07: 750k$ total (MTA p-line and NFMCC experiment)**
- **FY08 guidance: 1.4M$ M&S – slow ramp up**

VLHC=(3-14) x LHC → Magnets

A.Zlobin



H.Piekarz



- **New Magnet Concepts:**
  - **100kA in each Nb_3Sn conductor**
  - **4-5 blocks → 4-5 T**
  - **10-12 blocks → 12 T**
  - **Thin warm iron shell**
  - **(good field quality)**

- 35kA in HTS conductor
- 1.7-2 T superferric
- low eddy current losses
- 2 T/s ramping
(good field quality)

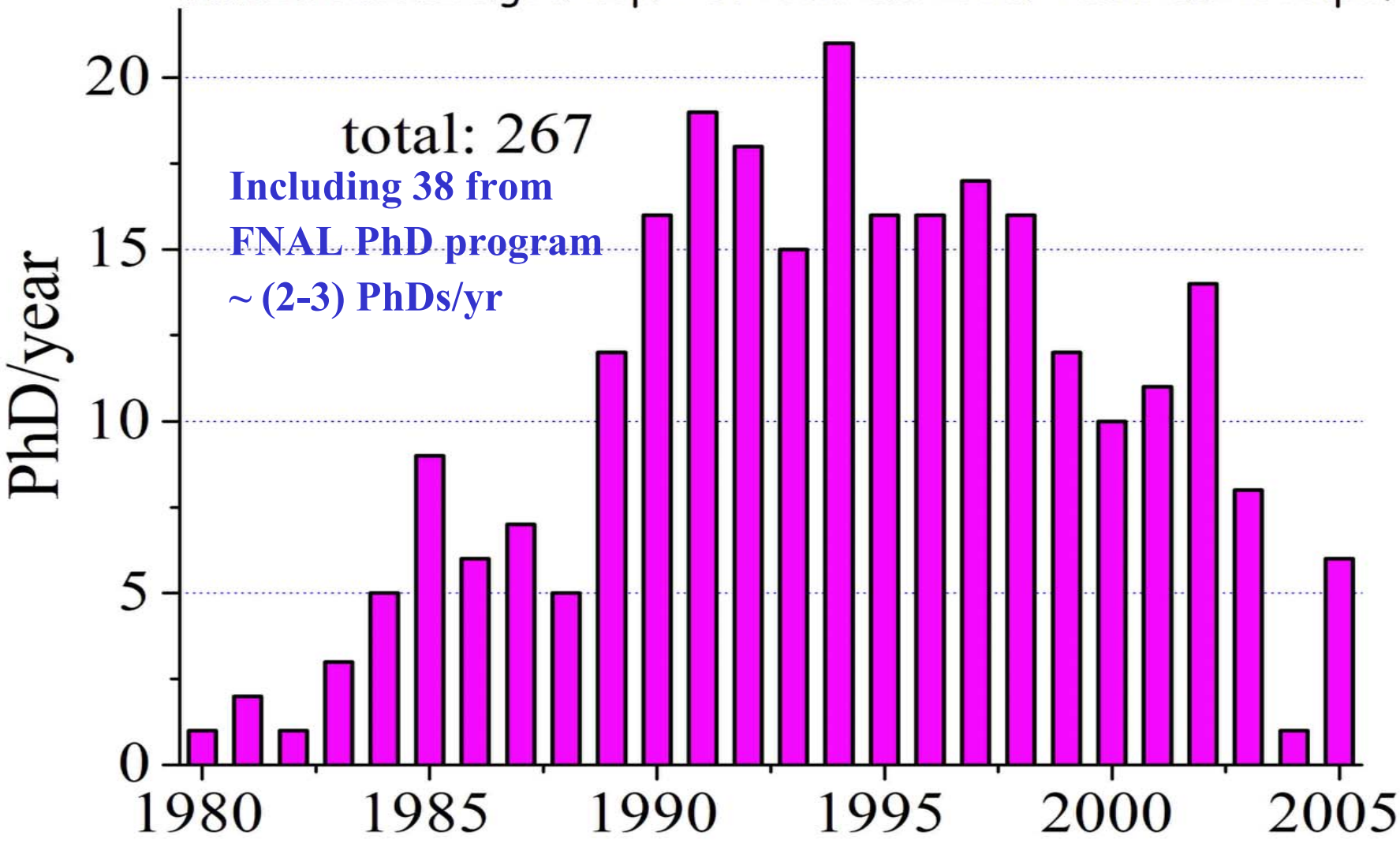
- **VLHC ring size is ~3 times smaller – APC to consider**

*** as VLHC injector or 480 GeV synchr. in Tev**

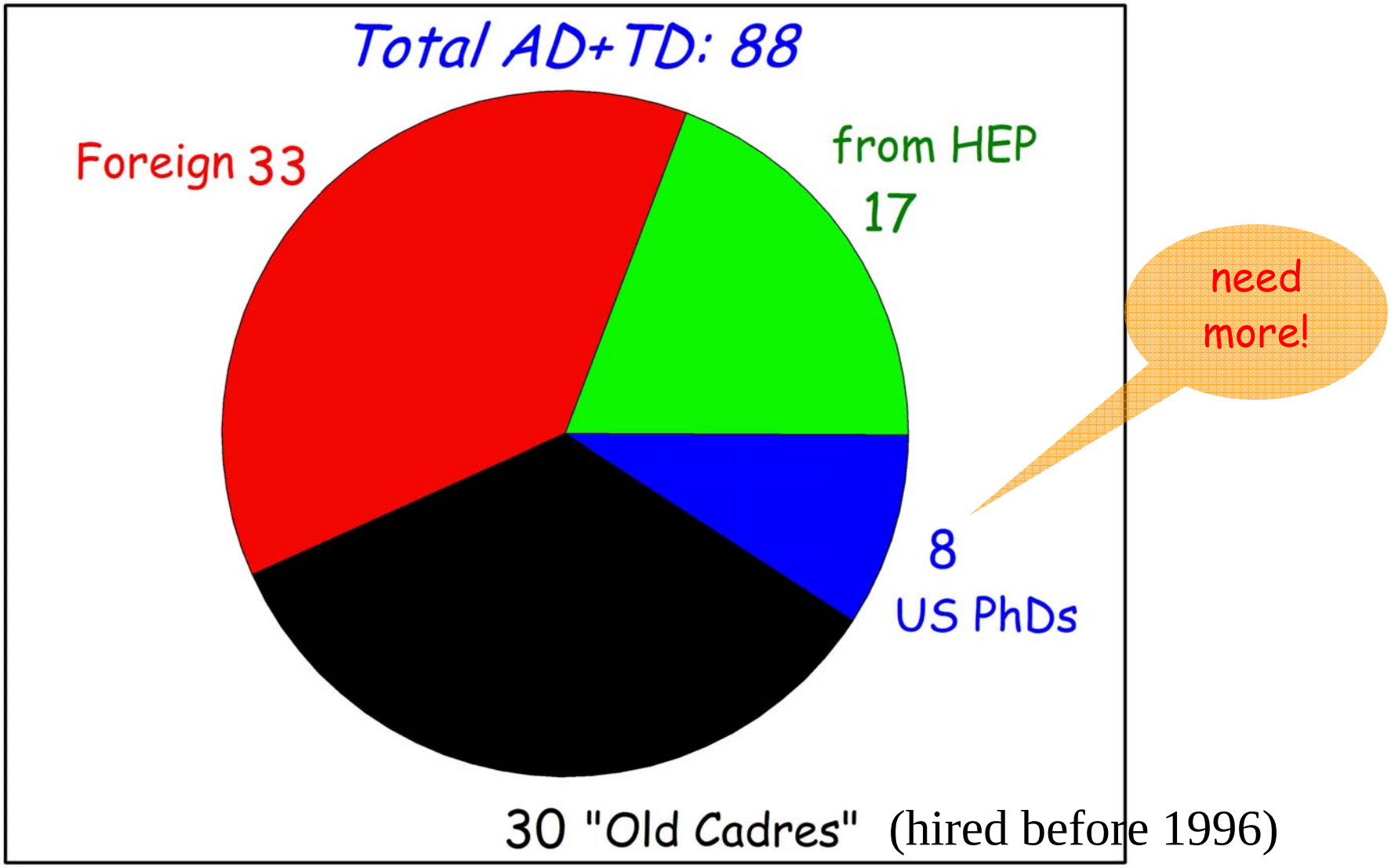
Accelerator Physics PhD Production in the US

DOE Advanced Technology R&D Yearbook

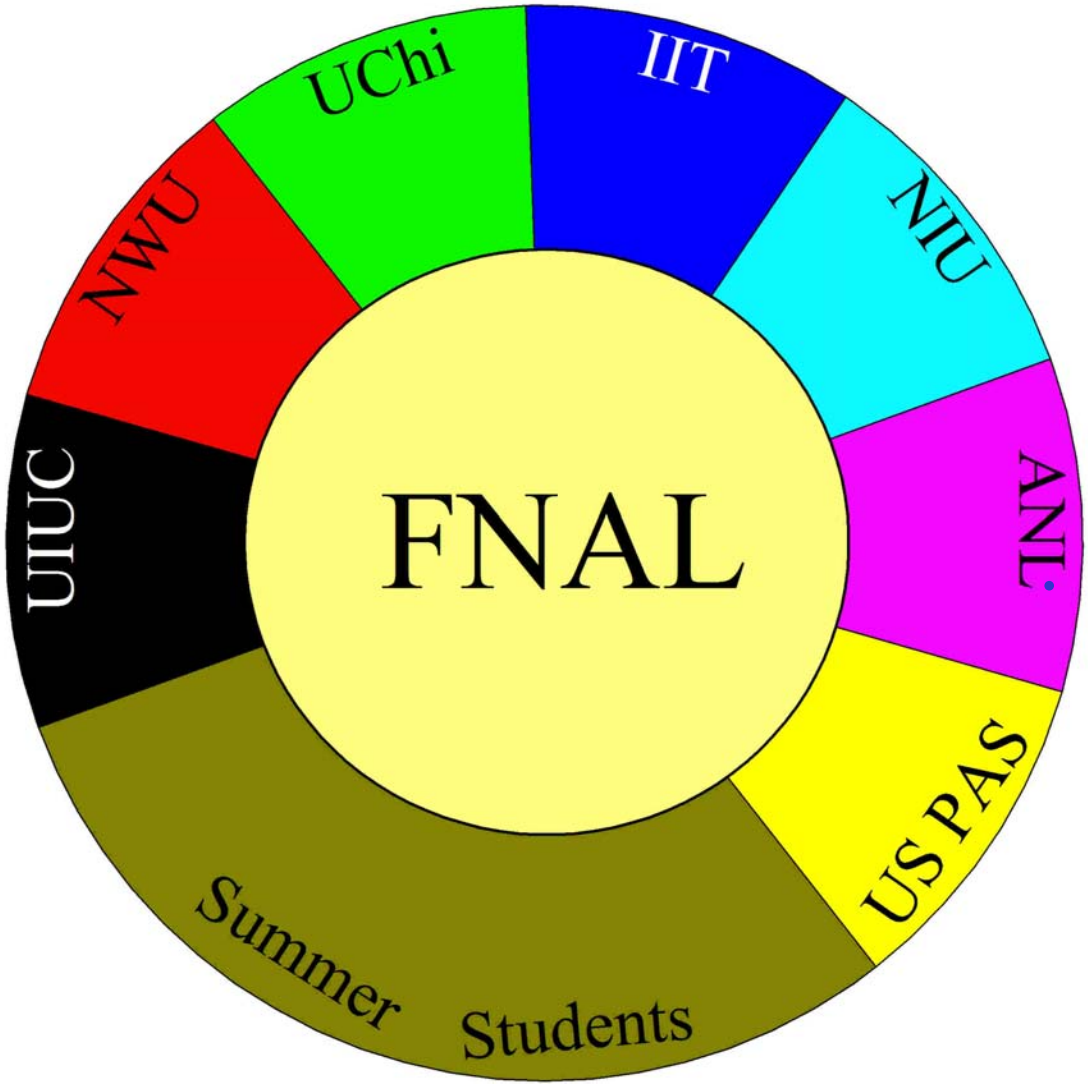
-www.science.doe.gov/hep/AdvTechR&D2005/TechR&D2005.pdf



Workforce of FNAL Accelerator Scientists



Future: FNAL-ANL-Univ. Consortium



- **Goals:**
  - **consolidate FNAL and US programs**
  - **attract graduate and undergraduate students**
  - **train and develop them into the accelerator scientists**
  - **double number of FNAL PhD students (10 →20)**
- **Principles:**
  - **undergrad summer jobs**
  - **Courses at FNAL by USPAS, FNAL, ANL scientists+U. Professors**
  - **students selection by a Committee of All (7)**
  - **Consortium Agreement**

Peoples Fellowship

Fermilab

for physicists

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FELLOWSHIP PROGRAM

John Peoples

Accelerator Science: Scientific Staff

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Peoples Fellowship Committee

Current Fellows

Name	Start Date
Katsuya Yonehara	Spring, 2007
Lionel Prost	Winter, 2006
Bob Zwaska	Fall, 2005

- **Established in 2001**
- **goal of attracting outstanding accelerator scientists early in their careers**
- **M.Church - chair**
- **APC hosts the Fellowship**

(but not all Fellows)