Accelerator R&D at Fermilab for Future Accelerators

David Finley

Fermilab Users Meeting
June 11, 2002

Outline

- Goals and Strategy
- Accelerator R&D Program
  - Linear Collider
  - SCRF (Superconducting RF)
  - Photoinjectors
  - Muon Facilities
  - Proton Driver
  - SC Magnets
- Budgets
- Summary

Goals & Strategy

(See Steve Holmes / Mike Witherell)

Goals

- To maintain strong research programs at Fermilab in the enabling technologies of High Energy Physics: magnets and rf
- To establish capabilities that will allow Fermilab participation as a leading partner in, and a credible host for, the construction and operations of the next forefront facilities for HEP
- To preserve a variety of options for future initiatives in accelerator based HEP.
- To advance knowledge in fundamental accelerator R&D and to partner with universities in the training of new students.

Goals & Strategy

Strategy

- Our strategy reflects the sequence of decisions we foresee on future facilities.
- There now appears to be a world consensus that one of our next goals should be the construction of an electron-positron linear collider as the next forefront HEP facility
- However, construction of a linear collider is far from being assured, either in the U.S. or at Fermilab.

Þ Priority is being assigned to R&D aimed at establishing Fermilab as a credible host/construction partner to a linear collider.

Þ Effort is targeted in the other areas because a)we need backup options, and b)Fermilab is likely to play the leading role in the U.S. contribution to any of these projects whenever wherever they are built.

Accelerator R&D Program

- Linear Collider
  - X-band (NLC collaboration)
  - Superconducting (TESLA collaboration)
- Superconducting RF beyond linear collider
  - Fermilab NICADD Photoinjector Laboratory (FNPL)
  - CKM
  - High Brightness Photoinjector (HBPI)
- Superconducting Magnets
- Muon Facilities
- Proton Driver

Note: Over the past couple of years, been placing increasing priority on linear collider activities at the expense of muons and (low field) superconducting magnet R&D.

Outline

- Goals and Strategy
- Accelerator R&D Program
  - Linear Collider
  - SCRF (Superconducting RF)
  - Photoinjectors
  - Muon Facilities
  - Proton Driver
  - SC Magnets
- Budgets
- Summary

Linear Collider at Fermilab !

- Fermilab Director, Mike Witherell, stated in his June 12, 2001 presentation to the DOE/NSF HEPAP subpanel:

  "We propose to the U.S. and to the international HEP community that we work together to build a linear collider at or near the Fermilab site."

- Fermilab activity in the US LC R&D program is increasing
- Goals : Develop the technology to support construction of a linear collider.
  - initial CM energy of 500 GeV
  - luminosity of at least 10^{34} cm^{-2} sec^{-1}
  - upgradeable to an energy in excess of 1 TeV.
  - Dave's Goal: Reliable Delivery Of Integrated Luminosity!

365 Days Later

Who's Who in LC R&D at Fermilab

- David Finley is in charge of LC R&D at Fermilab and he reports to Steve Holmes
- Bob Kephart is the head of the Technical Division and he is driven to make an informed technology choice for LC … he reports to Steve Holmes
- Steve Holmes (and anybody else who has a clue) points out that accelerators need magnets and RF … and this IS the Fermi National ACCELERATOR Lab
  - Peter Limon has seen to it that the Technical Division has a world class superconducting magnet R&D program
  - Victor Yarba recently has pushed for a world class RF R&D program
- Steve Holmes agrees with Victor Yarba … an there are two RF R&D prongs:
  - Helen Edwards takes care of superconducting RF
  - David Finley takes care of XBand RF
- David Finley heads the new (as of March 2002) RF Technology Development Group in the Technical Division and reports to Bob Kephart … through Victor Yarba … and supports Helen Edwards in the Beams Division
- All the above mentioned people do (much) more than just LC R&D …

Who's Who Summary: Holmes, Finley, Kephart, Edwards, Yarba

RFTD in Technical Division
(RF Technology Development)

These support these

- David Finley / Group Leader
- Nikolay Solyak / Physics
- Gennady Romanov / RF Engineering
  - Timer Khabiboulline
  - Ivan Gonin

- Harry Carter / XBand
  - Tug Arkan
  - Cristian Boffo
  - Evgueni Borrisov
  - Brian Smith
  - Marco Batistoni
- Iouri Terechkine / SCRF
  - Connections to others*

* Most XBand members support SCRF

* Others = BD and outside Fermilab

Linear Collider R&D Program

The directors of the U.S. laboratories have publicly stated their support for construction of a linear collider as an international endeavor based on the optimum technology. This view has also been expressed by HEPAP and by the corresponding European and Asian advisory panels.

Fermilab Goals

- Complete NLC R&D work leading up to a technology demonstration by late 2003 /early 2004.
- Understand TESLA and contribute to the technology decision
- Understand the ramifications of building a linear collider at Fermilab

NLC R&D
Goals through 2003

NLC Structures (Doin' OK)

- Complete structures fabrication facility **(Done June 24, I hope)**
- Assembly of ~three 0.6 meter high gradient test structures* for high power RF testing in the NLCTA at SLAC **(Lookin' good.)**
- Prepare to make ~5.4 meters of 0.9 meter (?) full feature structures* of the NLC main linac design for the 8-pack test** at SLAC in FY04 **(This is a REAL CHALLENGE!)**

RF (Goin' REAL slow due to cap on Fermilab NLC money and Run II.)

- Bring XBand power source into operation for testing of structures and RF components

* Note: KEK also makes structures for high power RF testing at SLAC

** The 8-pack test is a full power full pulse length demonstration of components needed for the basic NLC RF circuit … scheduled for FY04.

NLC R&D
Goals through 2003

NLC Civil/Site Studies (OK)

- Complete next iterations on N-S and/or E-W and establish a preferred Fermilab site
- **“Then what?” is the next problem … NEED DECISIONS!**

Support Girders (Starting out OK)

- Begin to develop the design for the girders supporting the NLC Main Linac RF structures and magnets
- Begin to understand how to achieve required vibration tolerances

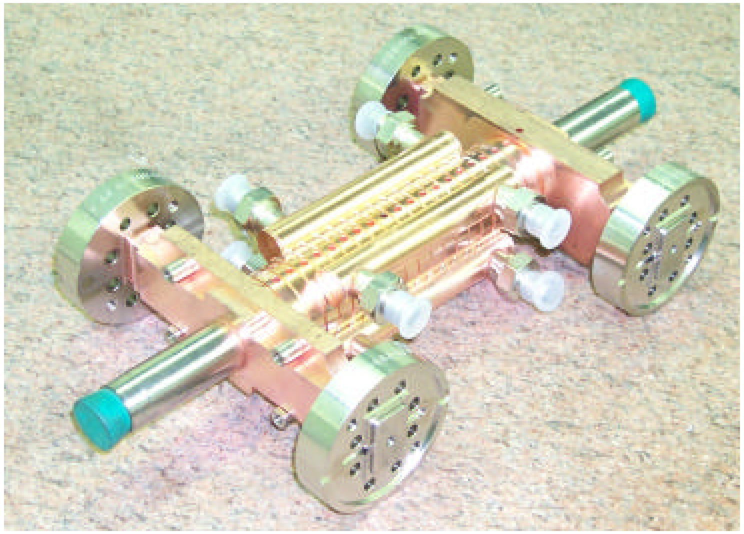
Permanent Magnets (Moving … s l o w l y in FY02)

- Continue radiation hardness studies in FY02 **(OK)**

Accelerator Physics <<< On Hold Until Run II Works

- Participate in simulations of beam behavior
- QA procedures and acceptance criteria for x-band structures
- Participate in Ground motion specifications for NLC and TESLA

NLC R&D
Structures Fabrication



FXA-001

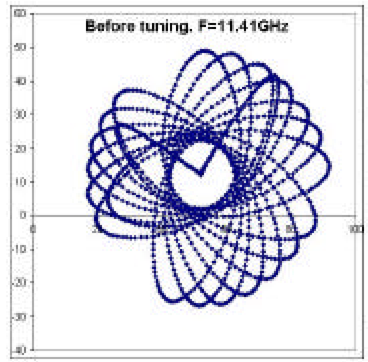
Small furnace and clean room B

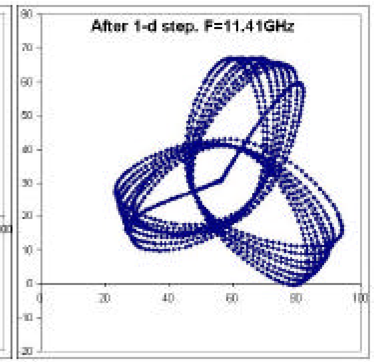
For a 45 minute tour: Contact David Finley
finley@fnal.gov 630.840.4620 … and bring friends.

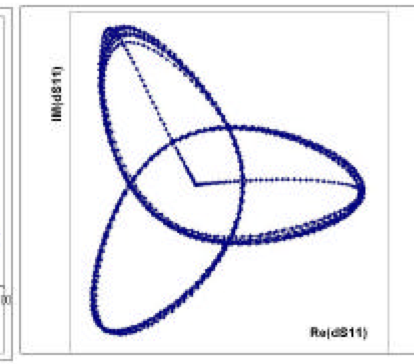
NLC R&D
FXA-001 RF Measurements

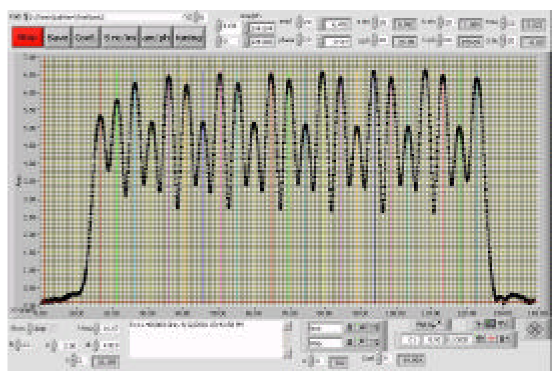
Before, during tuning

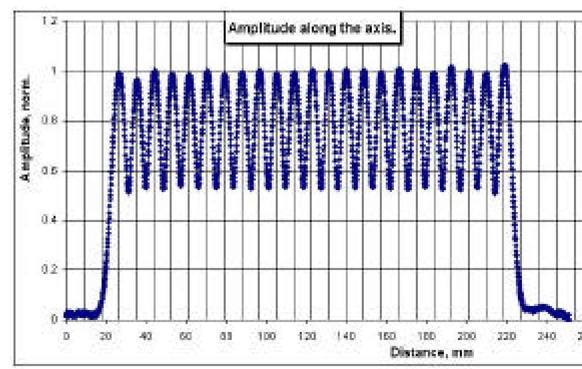
After tuning









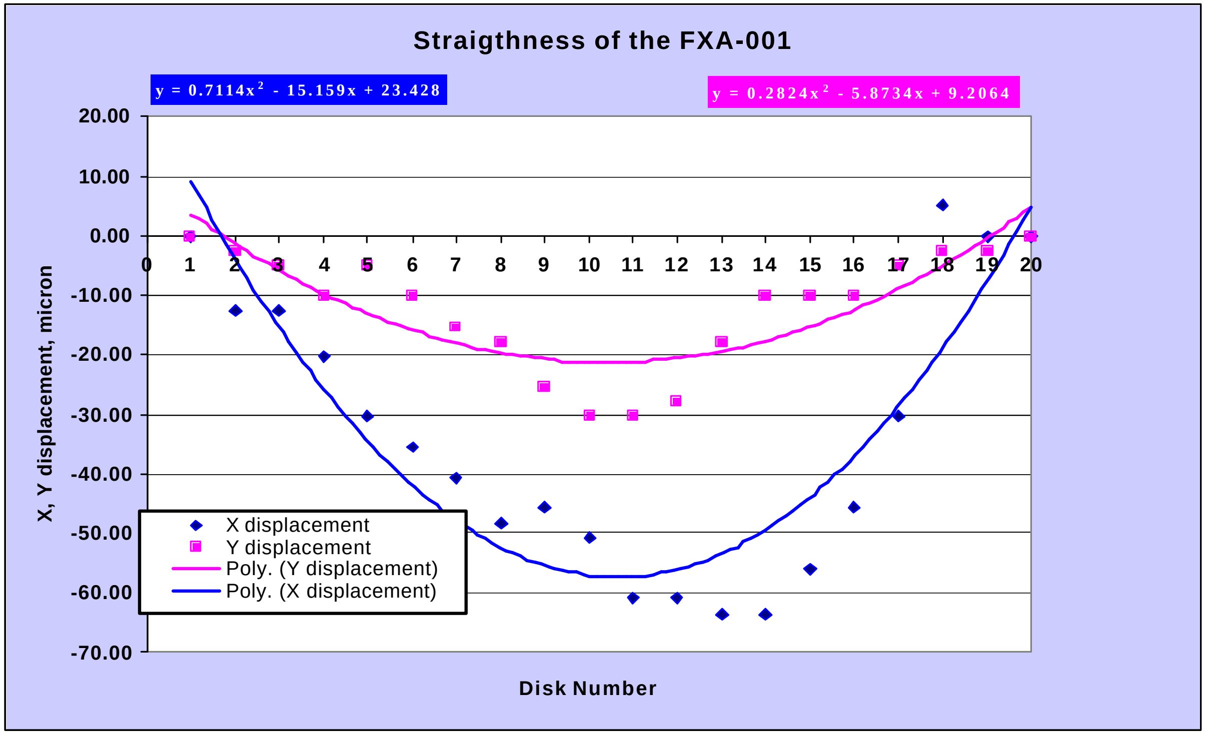


The bead pull takes about two minutes and is used to tune the structure.

NLC R&D

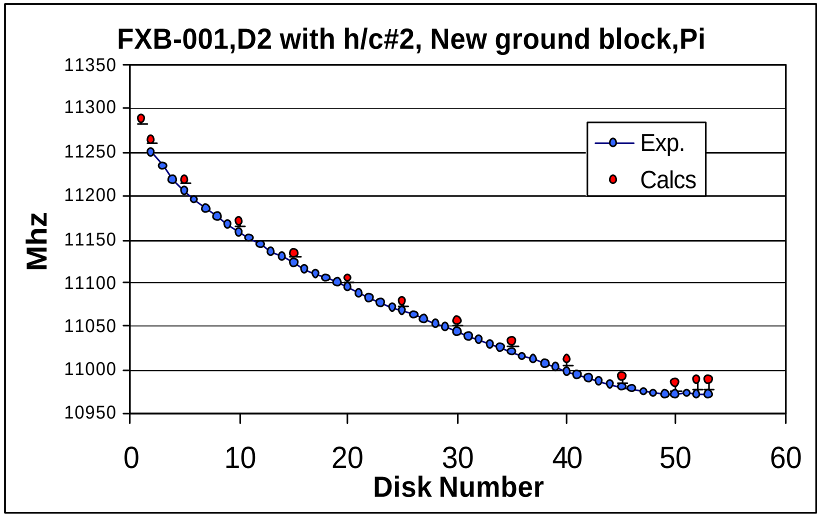
FXA-001 Mechanical Straightness Measurements

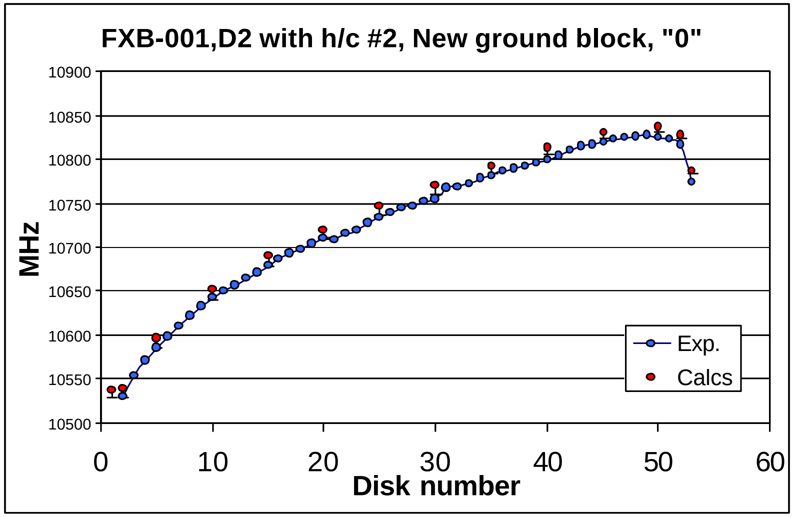
Straightness FXA-001 is shown below. In the new fixture, FXA-002 stack was aligned and brazed in carbon V-block. Measured straightness of 20 μm follows the V-Block straightness (bow). In final FXA-002 a jump of ~20 μm between the stack and coupler cells was found. Should be fixed on FXA-003.

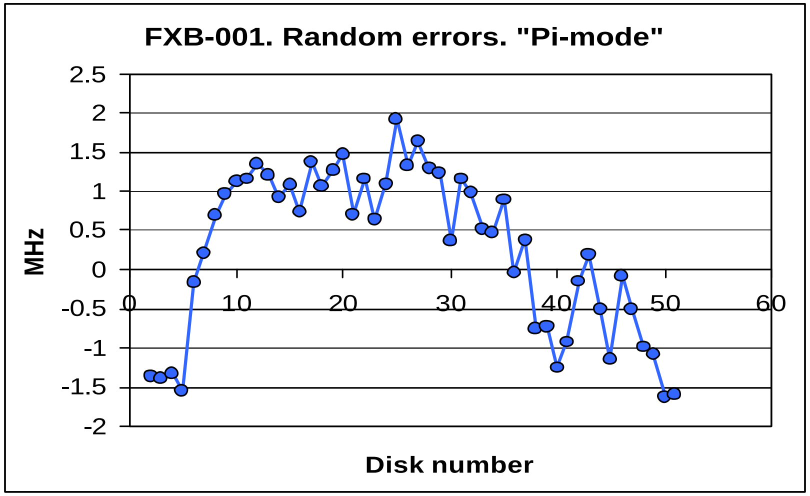


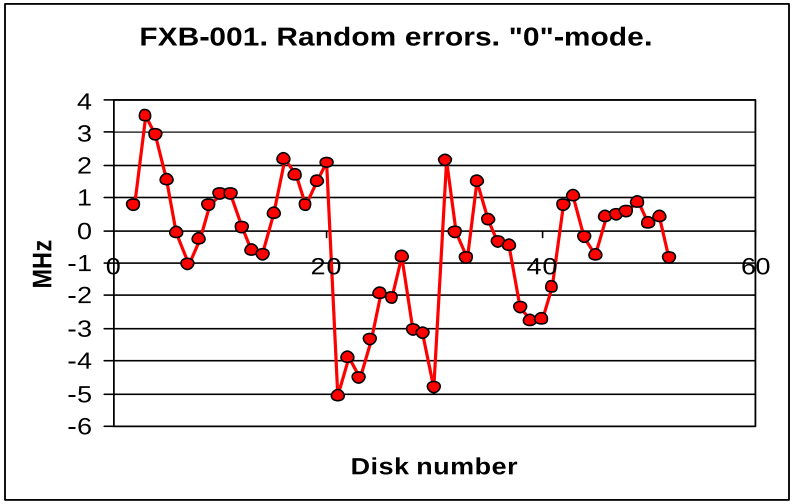
NLC R&D

FXB-001 RF Measurements



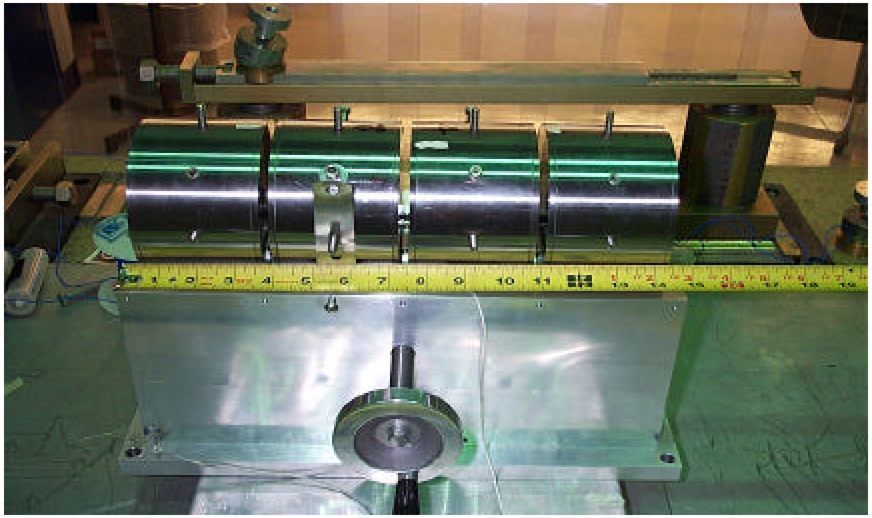




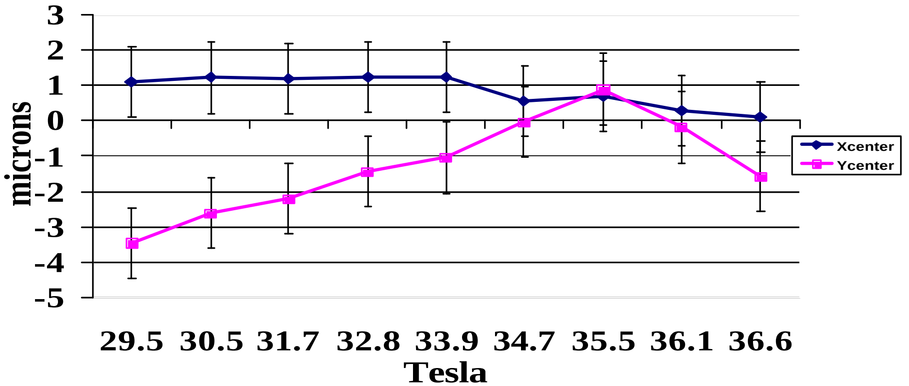


“NLC” R&D
Permanent or Adjustable Permanent Magnets
(See Jim Volk Anytime)

- Four prototypes of differing designs constructed and measured
- Wide range of center stability over 20% tuning range: ±1 to 30 μm (NLC requires ±1 μm)
- In FY02
  - Modifications to existing wedge and rotating quad magnets, including investigation of electrical trim coils
  - Radiation damage studies



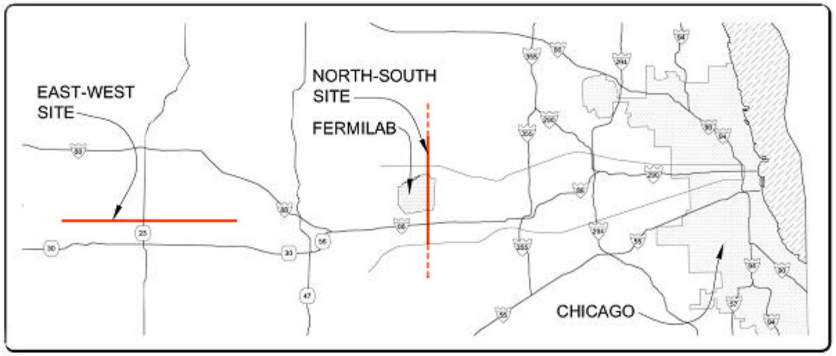
FSRQ001



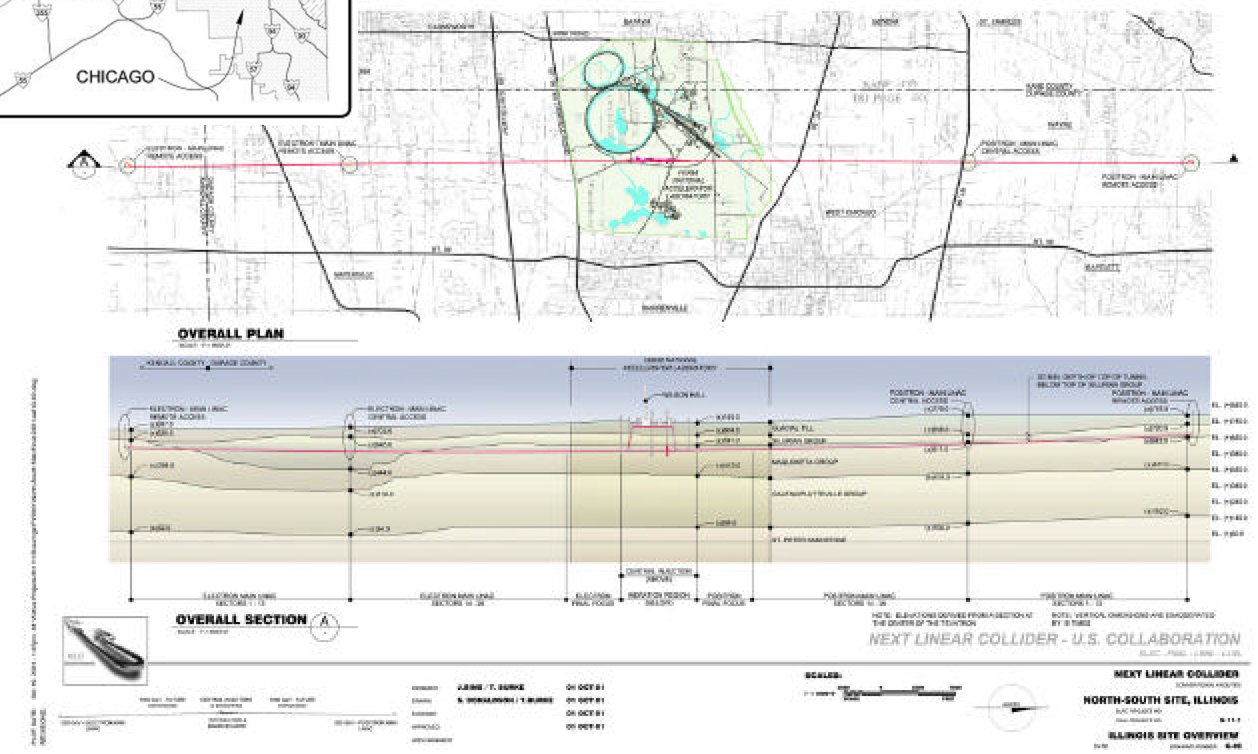
This is an area matched to University involvement in LC R&D

Linear Collider Site Studies

(See Judy Jackson's Talk Today)



On this scale NLC & TESLA are about the same



NLC R&D
Site Studies
(See Vic Kuchler Anytime)

- Goals for FY02
  - Complete N-S iteration.
  - Assemble all site/civil costing data in a common format.
    - (Includes Illinois, California, Hamburg)
  - Characterization of ground motion in the Main Injector 8 GeV tunnel (glacial till)
  - Preparation of installation of ground motion equipment in NuMI decay tunnel (Silurian and Maquoketa) <<< A good example of Universities already involved in LC R&D … Northwestern University in this case.

R&D for TESLA

(See Helen Edwards Anytime)

The **U.S. is in a unique position** as the only region in the world in which the technology choice for a linear collider does not appear to be "locked in". Furthermore, **Fermilab is in a unique position** as the only institution that is a member of both the NLC and TESLA Collaborations.

Strategy

- Develop a level of familiarity with SCRF technologies sufficient to allow informed participation in the LC technology decision,
- Position Fermilab to play a leading role in the international collaboration that must be formed to construct a linear collider no matter what technology is chosen

⇒In parallel, and synergistic with these activities, we have an expanding effort in SCRF and FNPL (described a few slides later)

R&D for TESLA

- Current activities directly related to TESLA include:
  - Modest continuing operational support for TTF
  - Engineering/cost study of the TESLA proposal
    - Fermilab led study with Argonne, Cornell, DESY, JLab and SLAC
  - Flat beam studies at FNPL
  - Global Accelerator Network (GAN) demonstration at FNPL
  - Identification of possible areas of collaboration on TTF-II
  - Potential equipment contributions to TTF-II
    - Modulators
    - 3rd harmonic cavity

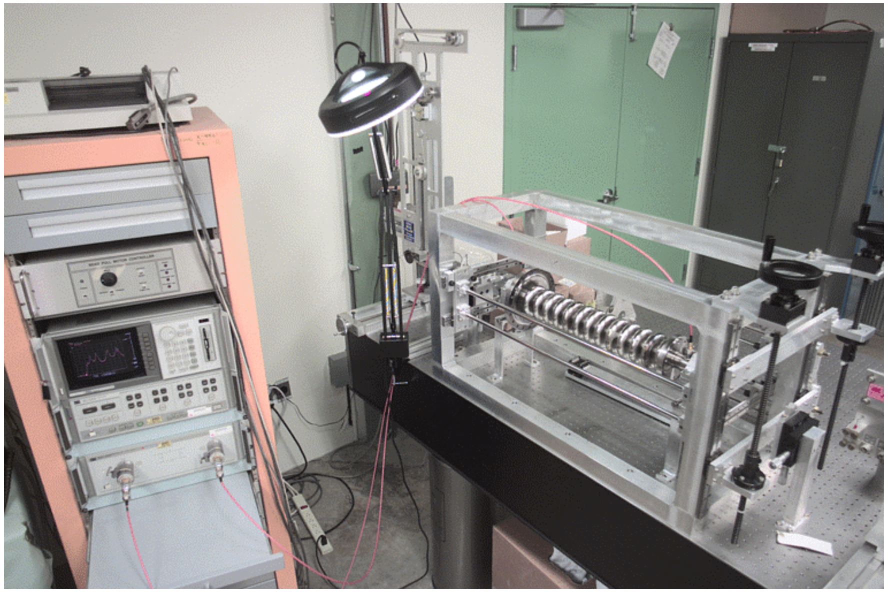
Outline

- Goals and Strategy
- Accelerator R&D Program
  - Linear Collider
  - SCRF (Superconducting RF)
  - Photoinjectors
  - Muon Facilities
  - Proton Driver
  - SC Magnets
- Budgets
- Summary

Accelerator R&D for Superconducting RF
CKM
(See Leo Bellantoni's Talk Yesterday)

Measurement of CP violation in $K^+ \rightarrow \pi^+ \upsilon \bar{\upsilon}$ (fixed target experiment E921) requires a few 10^{14} K^+

We will create a pure K^+ beam with ~ 6 meters of SCRF cavities operating at 3.9GHz in TM_{110} at 5MV/m P_{TRANS}



One and three cell structures have been run up to B_{MAX} of 85 to 104 mT on inside surface – compare TESLA TM_{010} mode (110 mT at 25 MV/m E_{ACC}); CKM separators need 77 mT.

13 cell prototype cavity

Nb shaped at Fermilab, e-beam welded at nearby contractor, chemical and heat treatment for prototypes done at Jefferson Lab.

Accelerator R&D for Superconducting RF

(See Helen Edwards Anytime)

- There are a number of activities relating to SCRF that are carried out in concert with each other
  - CKM cavity development
  - Fermilab/NICADD Photoinjector Laboratory operations
  - Concept for a high brightness photoinjector facility at Fermilab
    - The starting point for the concept is based on TTF-II
- Superconducting RF is in a growth stage at Fermilab now
  - Pierre Bauer is a new Peoples Fellow in the Technical Division and he and Bob Kephart et al are interested in Superconducting RF
  - There is a workshop here at Fermilab on niobium going on as we speak
  - A great time to join for a hands-on research physicist!

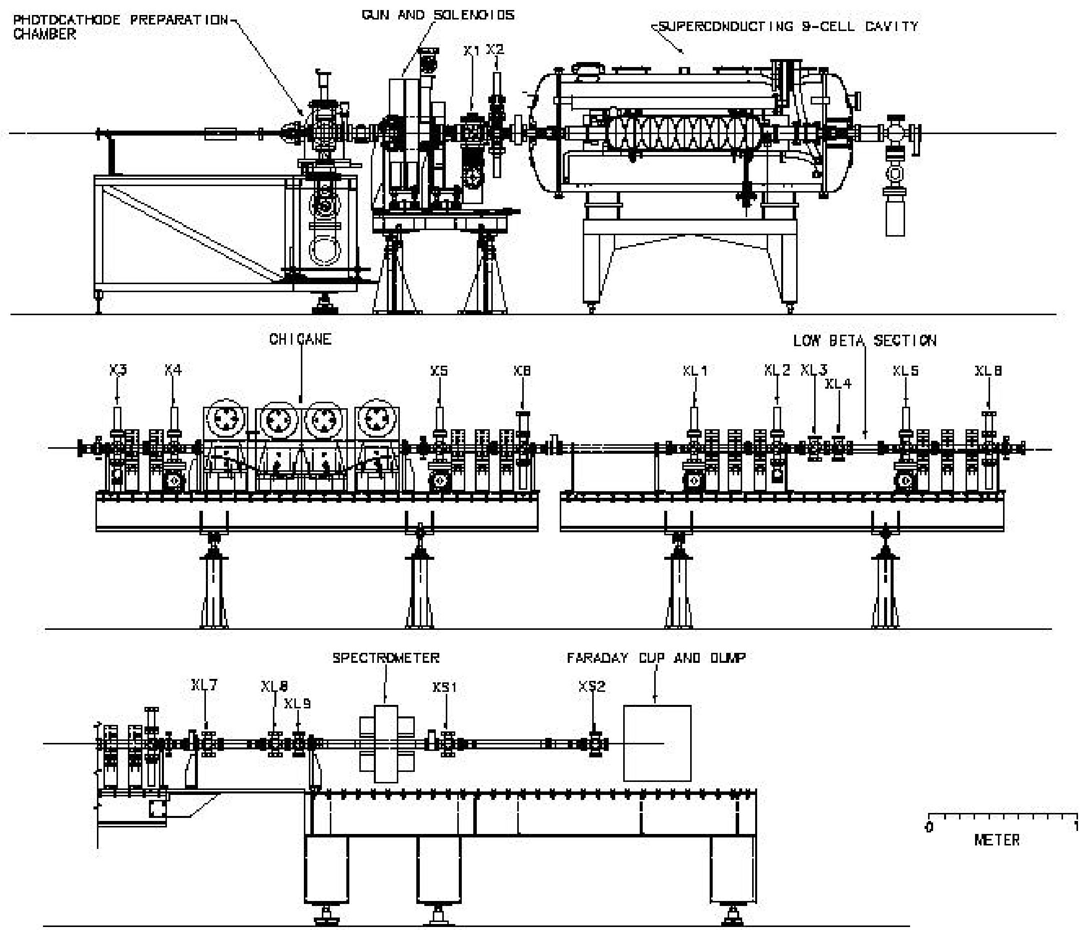
Superconducting RF R&D
FNPL

(See Jerry Blazey's Talk Next Today … and/or See Helen Edwards Anytime)

The Fermilab/NICADD Photoinjector Laboratory (FNPL) is operated jointly by Fermilab and the Northern Illinois Center for Accelerator and Detector Development (NICADD).

Participating Institutions:

- Fermilab
- NIU
- UCLA
- Chicago
- Rochester
- DESY
- LBNL



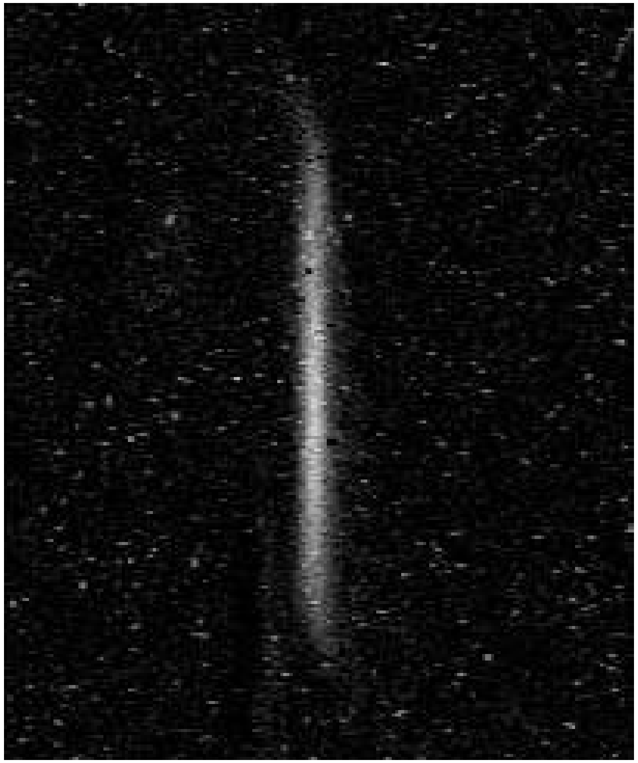
Outline

- Goals and Strategy
- Accelerator R&D Program
  - Linear Collider
  - SCRF (Superconducting RF)
  - Photoinjectors
  - Muon Facilities
  - Proton Driver
  - SC Magnets
- Budgets
- Summary

FNPL R&D
Flat Beam Experiment

- Goal
  - Utilize the FNPL photoinjector to generate a flat beam with an emittance ratio tailored to future linear collider requirements.

    $\Rightarrow \varepsilon_H/\varepsilon_V \approx 100$

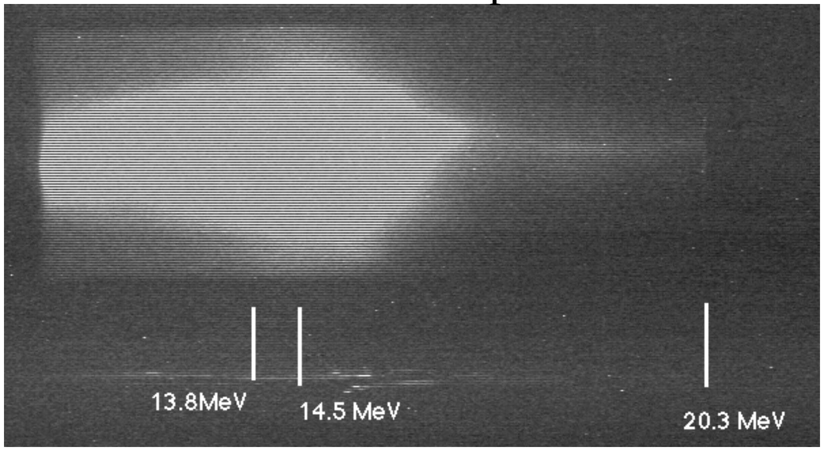


- Typical emittance ratio achieved thus far is ~40 @17 MeV and 1 nC
- Next step is to increase emittance ratio by decreasing space charge.
- If this research pans out and can reliably provide flat enough beams it will be a big deal because it will reduce the costs of LC damping rings.

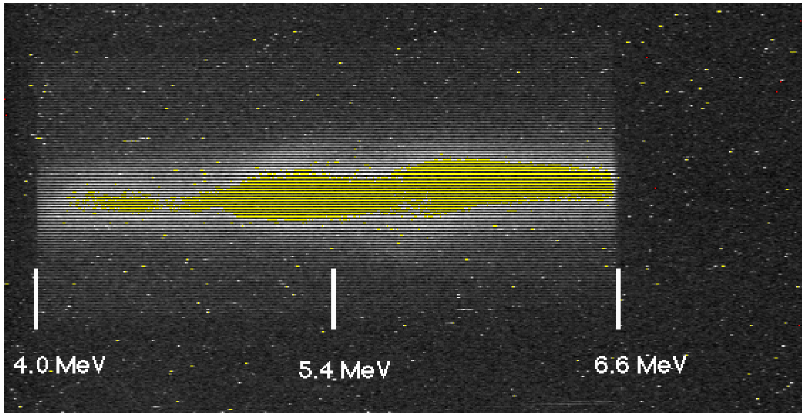
FNPL R&D

Plasma Acceleration Experiment

Accelerated electrons up to 20.3 MeV

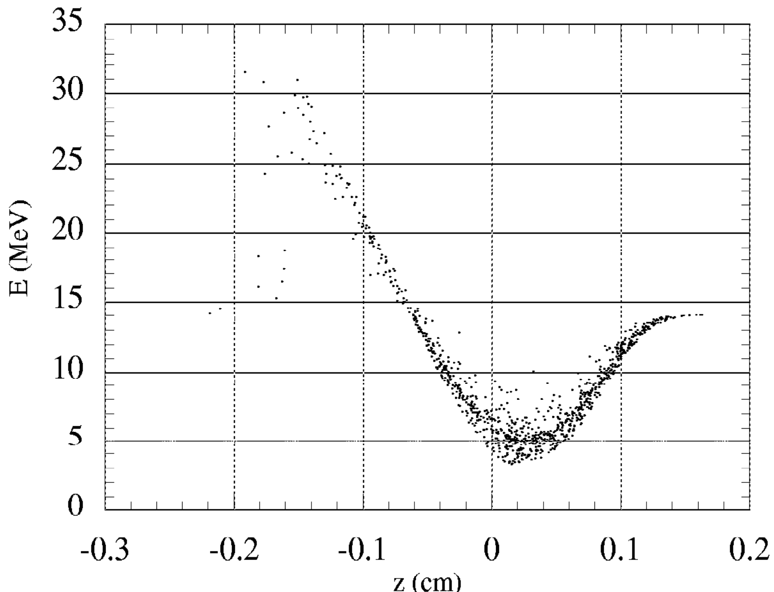


Decelerated electrons down to ~3 MeV:



Parameters:

- Charge: 6-8 nC
- Bunch length: < 1 mm RMS
- Plasma: L=8cm, 10^{14}/cc density
- Initial energy: 13.8 MeV
- Acceleration gradient: 72 MeV/m



Simulation result: final energy spectrum

FNPL R&D
Energy Fragmentation from Bunch Compression

- Data taken February 6, 2002 by Philippe Piot via remote operation from DESY
- FNPL remote operations for data collection also from LBNL

Beam Energy ~ 15 MeV, Bunch Charge ~1 nC

FNPL
Potential PhD Topics

(Get a PhD in Accelerator Physics >>> Get Great and Varied Job Opportunities)

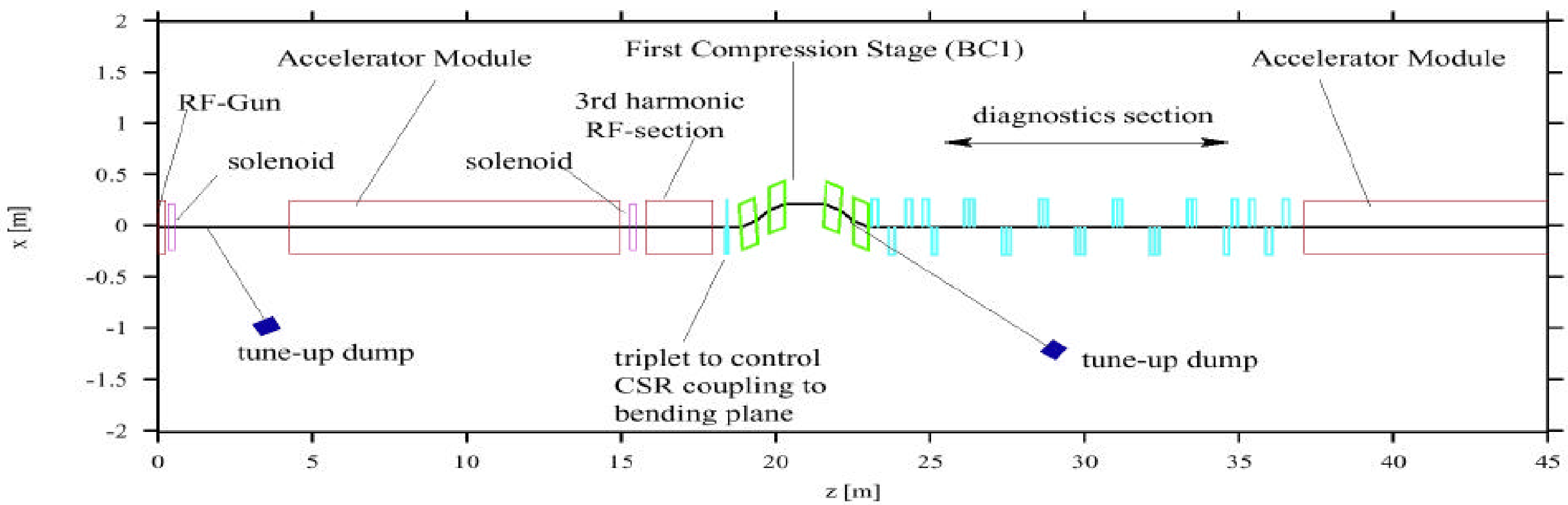
- Flat-Beam "Optimization" (have U. Chicago student)
- Plasma-Wakefield Acceleration
- Laser Acceleration (have U. Rochester student)
- Electron-Beam Diagnostics
  - electro-optic crystal
  - Michelson interferometer
  - diffraction-radiation
  - deflecting srf cavity
- Superconducting RF Cavities
  - "kaon-separator" (deflecting) cavity
  - "beam-shaper" (accelerating) cavity
- RF Gun
  - high-duty-factor (srf?)
  - polarized beam
  - dark current and photocathode quantum efficiency
- Fundamental Studies of Space Charge, Coherent Synchrotron Radiation

Contact David Finley or Walter Hartung (Michgan State University) if interested in these …

THIS IS FOR YOU!

FNPL
High Brightness Photoinjector

Fermilab, Argonne, LBNL, DOE, and NSF are in receipt of an EOI to construct a new photoinjector at Fermilab.



Elements: SRF cryomodules, dipoles, solenoids, and quadrupoles.

Specs: rms normalized emittance 1μm, rms bunch length <50 μm, energy 150 → 300 MeV.

FNPL
High Brightness Photoinjector

EOI Signatories
- Fermilab
- ANL
- LBNL
- Chicago
- Michigan
- NIU
- Northwestern
- Pennsylvania
- Rochester
- UCLA

⇒ Offer of initial cryomodule by DESY

Motivations

- Basic Beam Physics
  - Wakefield & Laser Acceleration
  - Bunch Compression
  - Flat & Polarized Beams
  - Emittance Compensation
- Support for the new generation of LCs, FELs, and synchrotron radiation sources
  - Platform to study generation of required beams,
  - And, demonstrate that specifications can be met.
- As proposed would utilize TESLA cavities
  - Foster U.S. development of superconducting RF cavities,
  - Gain local & Midwest expertise.
- Training Ground for Accelerator Physicists

Outline

- Goals and Strategy
- Accelerator R&D Program
  - Linear Collider
  - SCRF (Superconducting RF)
  - Photoinjectors
  - Muon Facilities
  - Proton Driver
  - SC Magnets
- Budgets
- Summary

Accelerator R&D For Muon Beams

(See Steve Geer et al Anytime)

Goals

- Establish an R&D path that could develop the technologies required to support initiation of construction of a muon storage ring based neutrino facility sometime around the end of the current decade.
- Explore options for interim facilities that could be constructed at Fermilab to support both R&D and programmatic goals.

Status

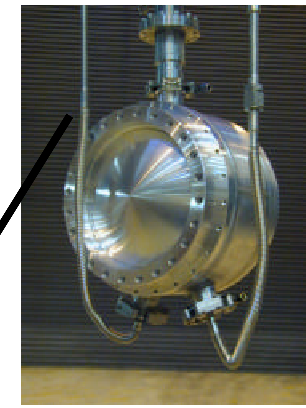
- This program is currently under severe financial pressure. Fermilab is not providing any direct M&S support in FY02.
- Fermilab is able to provide people in support of activities, primarily in MUCOOL/Linac Test Area, that the Muon Collaboration wishes to support.
  - FNAL/MC MOU in preparation to cover this.
- Strategy is to focus effort in areas where we can make progress with people, for example cooling and Proton Driver studies.

R&D for Muon Beams
MUCOOL Accomplishments

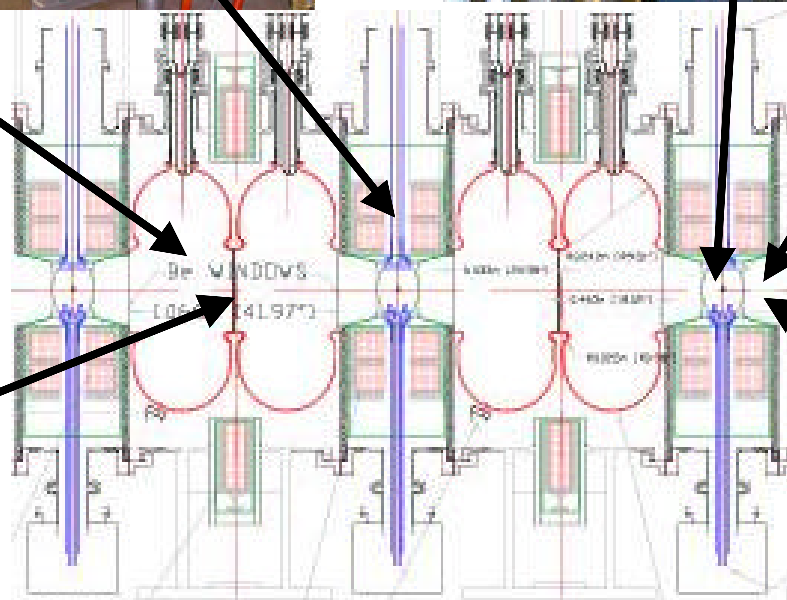
5T Cooling Channel Solenoid – LBNL
& Open Cell NCRF Cavity operated at Lab G – FNAL

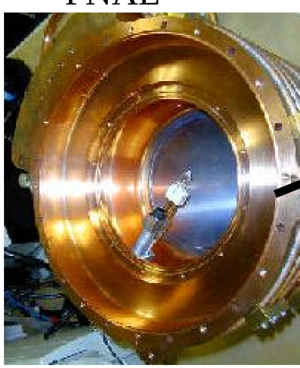
Bolometer detectors for Window Beam profile Measurements– U. Chicago

High-Gradient RF Tests in High Magnetic Field – FNAL



Liq.H Absorber – KEK
To be tested at FNAL

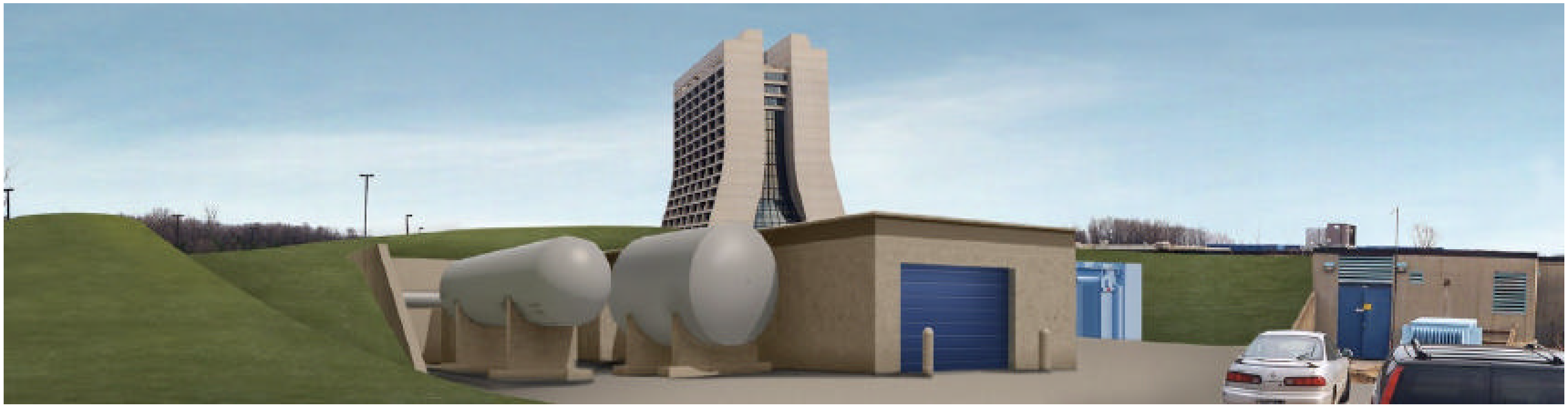




Tested Be-Windows for RF Cavities -- LBNL

Thin absorber windows Tested – new technique – ICAR Universities

R&D for Muon Beams
MUCOOL Test Facility



MUCOOL Test Facility at end of Fermilab 400 MeV Linac

- Fill Liq. H absorbers: U.S. prototype & Japanese prototype
- High-Power tests of 201 MHz & 805 MHz Cavities
- Full engineering test of Absorber – Cavity –Solenoid system
- Development of new beam diagnostics
- Eventual engineering test in high-intensity Linac beam

Longer term: Fully international (US-Europe-Japan) collaboration has been formed to propose a cooling demonstration experiment.

Outline

- Goals and Strategy
- Accelerator R&D Program
  - Linear Collider
  - SCRF (Superconducting RF)
  - Photoinjectors
  - Muon Facilities
  - Proton Driver
  - SC Magnets
- Budgets
- Summary

Accelerator R&D for a Proton Driver

(See Steve Holmes Anytime)

The Proton Driver represents an option for development of the Fermilab complex in the event that a linear collider is not constructed in our vicinity, or is delayed so that a bridge project is needed ~ 2005..

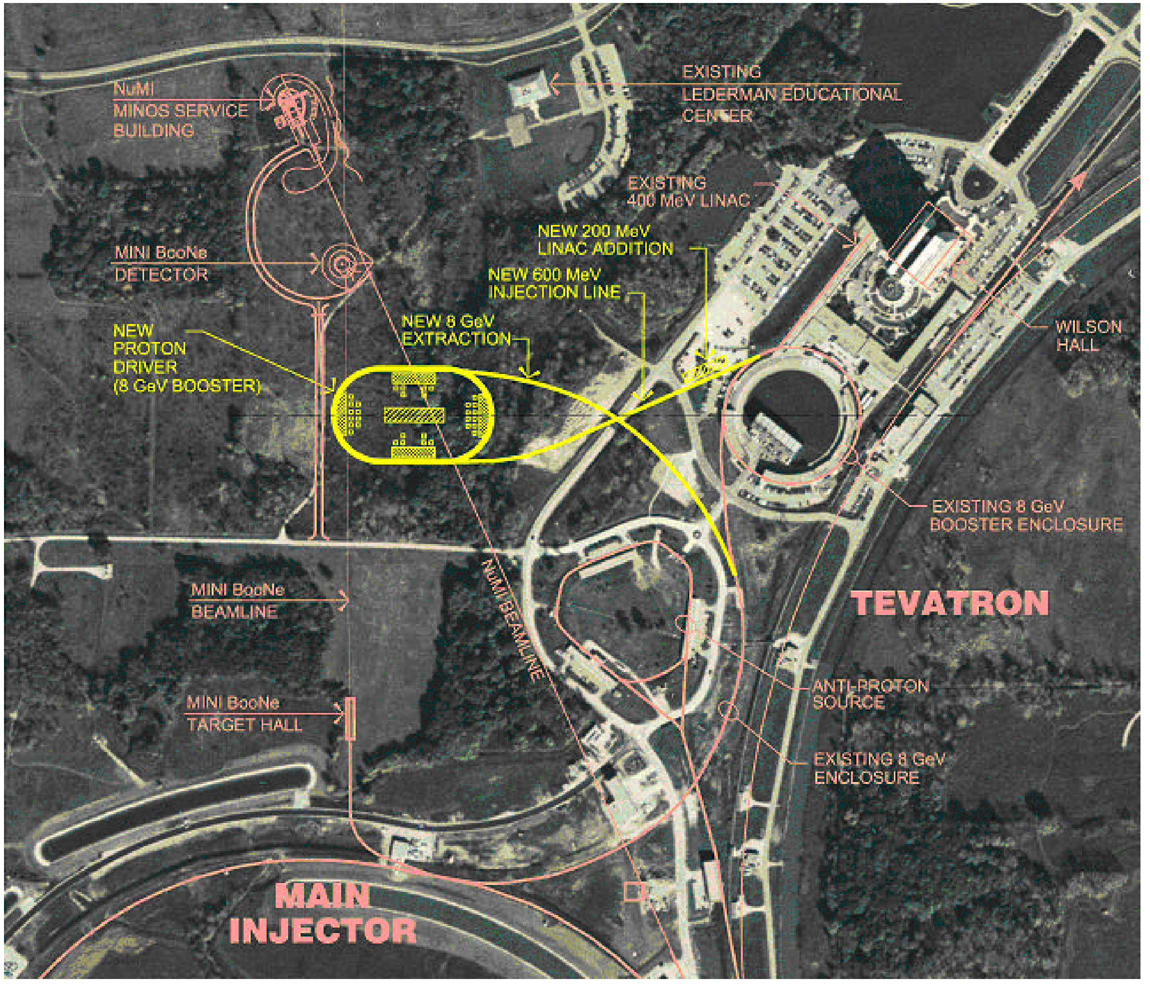
- We are undertaking a second Proton Driver Design Study.
  - Second iteration of synchrotron based facility
  - Initial iteration of a superconducting linac based facility
  - Study of design improvements required to reach 1.5×10^{14} protons per pulse in Main Injector (Factor of five increase.)
  - Includes establishment of cost windows for each implementation
  - Report due any time now.

Note: We need to address issues relating to maintainability of existing linac and Booster high intensity limitations independent of PD II Study.

Proton Driver
Synchrotron Option
(See Weiren Chou Anytime)

- Proton Driver Study II (PD2) is for an 8 GeV, 0.4 MWatt synchrotron, upgradeable to 2 MW. It is smaller, but also cheaper, than PD1.
- Design features: **(See photo on next slide)**
  - Same size as the present Booster (474.2 m).
  - Racetrack shape in a new enclosure.
  - Transition-free lattice with zero-dispersion long straights.
  - Reuse of the existing 400 MeV linac, addition of another 200 MeV RF $\rightarrow$ Total linac energy 600 MeV
  - 3×10^{14} protons per second at 8 GeV (=380 KW)

Proton Driver
Synchrotron Possible Siting



Proton Driver
Synchrotron Parameter Table

Parameters	Present Proton Source	Proton Driver
Linac (operating at 15 Hz)		
Kinetic energy (MeV)	400	600
Peak current (mA)	40	50
Pulse length (μs)	25	90
H^- per pulse	6.3×10^{12}	2.8×10^{13}
Average beam current (μA)	15	67
Beam power (kW)	6	40
Booster (operating at 15 Hz)		
Extraction kinetic energy (GeV)	8	8
Protons per bunch	6×10^{10}	3×10^{11}
Number of bunches	84	84
Protons per cycle	5×10^{12} (*)	2.5×10^{13}
Protons per second	7.5×10^{13}	3.75×10^{14}
Normalized transverse emittance (mm-mrad)	15p	40p
Longitudinal emittance (eV-s)	0.1	0.2
RF frequency (MHz) (for β=1)	53	53
Average beam current (μA)	12	60
Beam power (MW)	0.1(*)	0.5

(*) This is a design value, not the actual performance. Although the magnets run at the originally designed 15 Hz for operation from the beginning, the Booster RF has never delivered beam at 15 Hz continuously. It has run as high as 2.5 Hz average. In the near future it needs to run at 7.5 Hz for the MiniBooNE experiment

Proton Driver
8 GeV Superconducting Linac Option
(See Bill Foster Anytime)

- New idea incorporating concepts from both SNS and TESLA.
  - Copy SNS Linac design up to 1.3 GeV
  - Use "TESLA" Cryomodules from 1.3 $\rightarrow$ 8 GeV
  - H^- Injection at 8 GeV in Main Injector

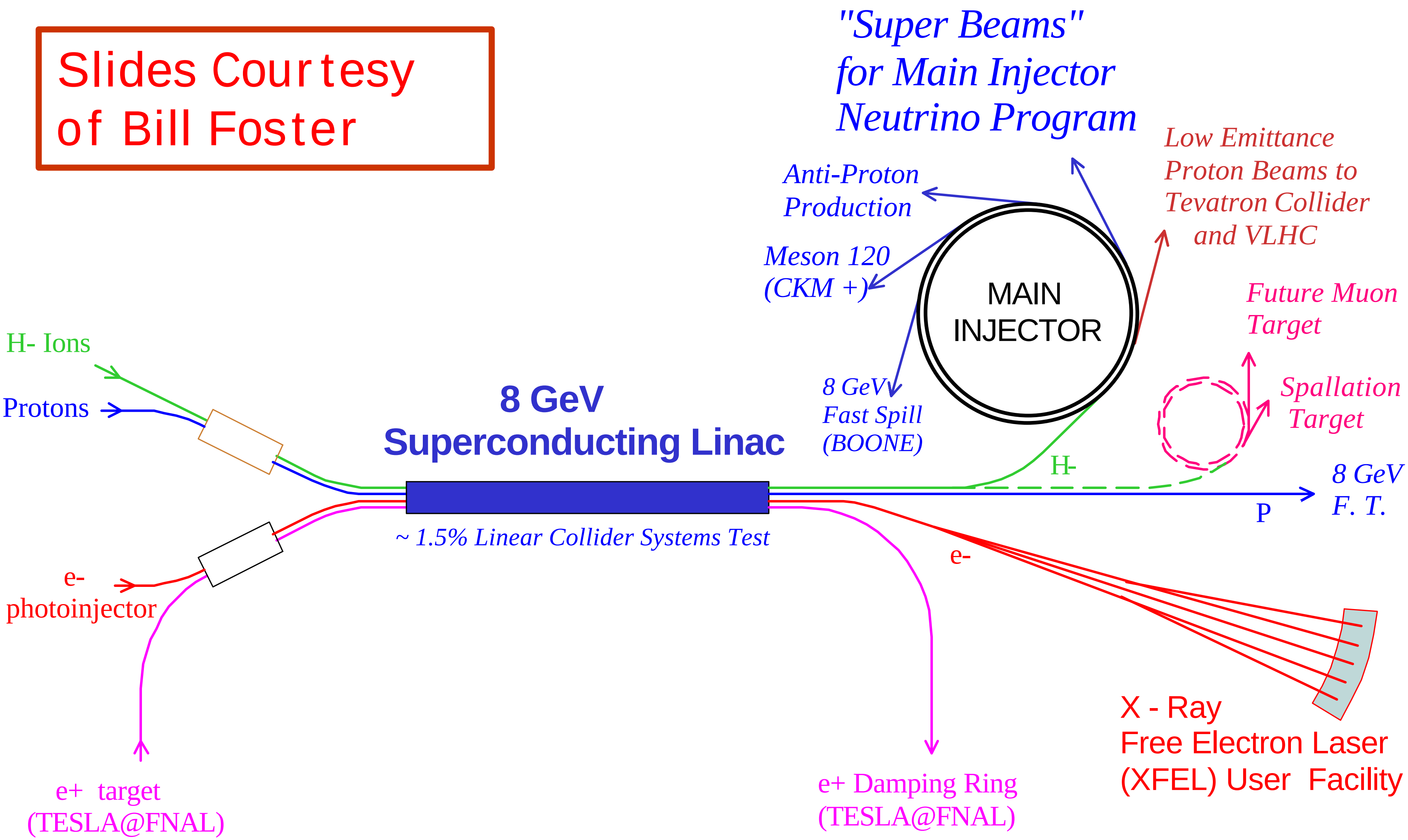
$\Rightarrow$ "Super-Beams" in Fermilab Main Injector:

2 MW Beam power, small emittances, and minimum (1.5 sec) cycle time

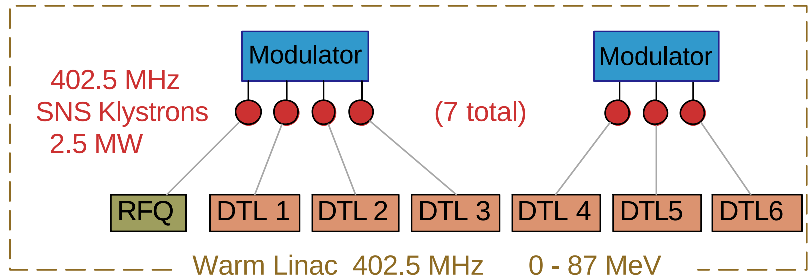
- Other possible missions for unused linac cycles:
  - 8 GeV electrons can drive XFEL
  - 8 GeV ν program, Spallation Neutron or Muon sources, etc.
  - 8 GeV Linac can eventually become e+ preacc for TESLA @Fermilab
- Near Term Physics Missions while providing 1.5% Scale LC Test Bed

Multi-Mission 8 GeV Injector Linac

Slides Courtesy of Bill Foster

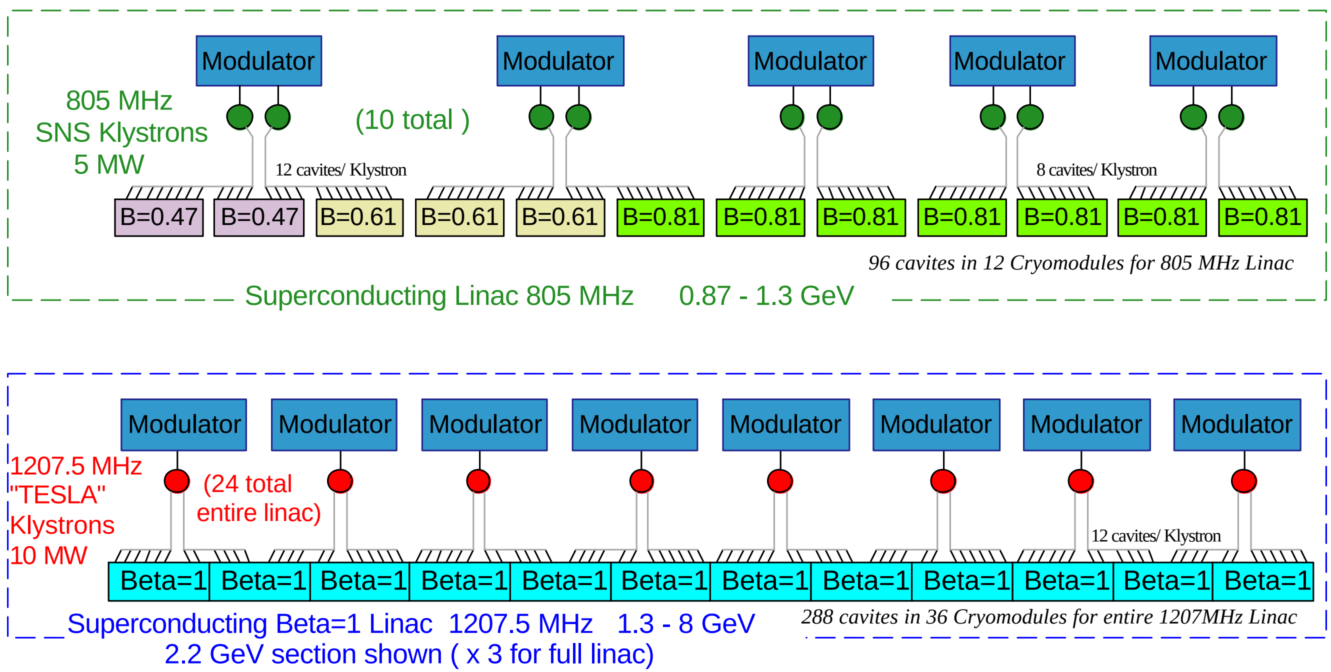


8 GeV Superconducting Linac
Conceptual Layout



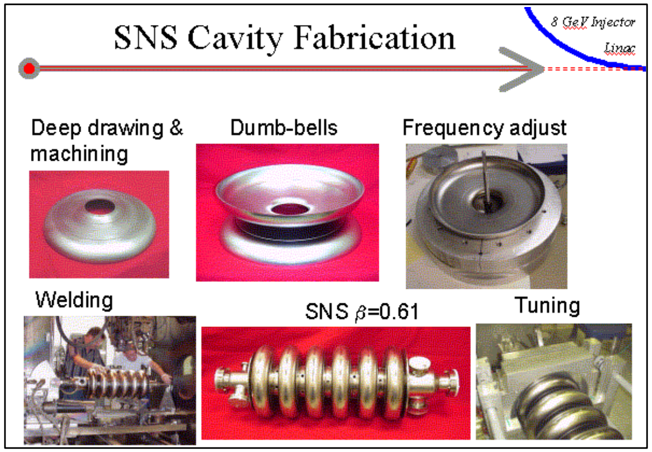
8 GeV RF LAYOUT

41 Klystrons (3 types)
31 Modulators 17 MW ea.
7 Warm Linac Loads
384 Superconducting Cavities
48 Cryomodules



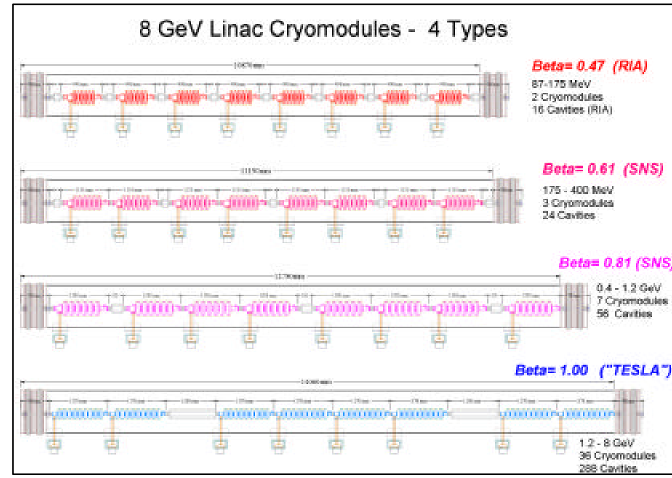
8 GeV Superconducting Linac

TECHNICAL SUBSYSTEM DESIGNS *EXIST* AND *WORK*

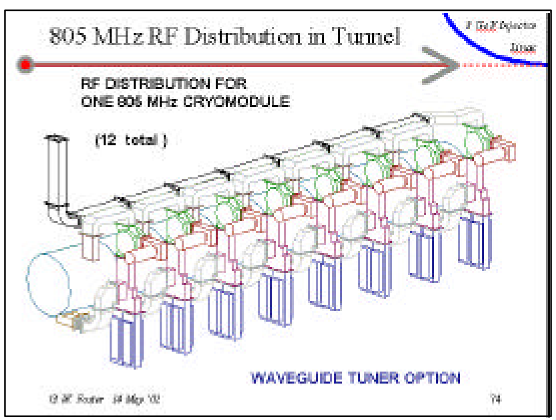


SNS Cavites

FNAL/TTF Modulators

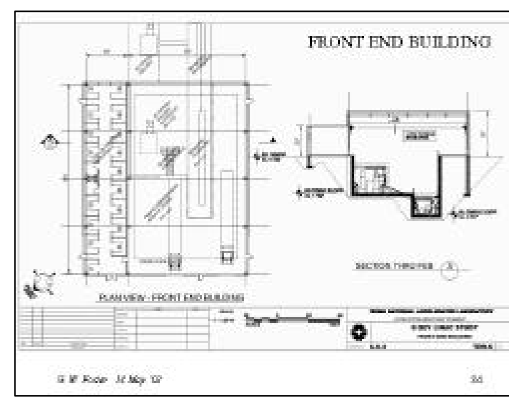


"TTF Style" Cryomodules

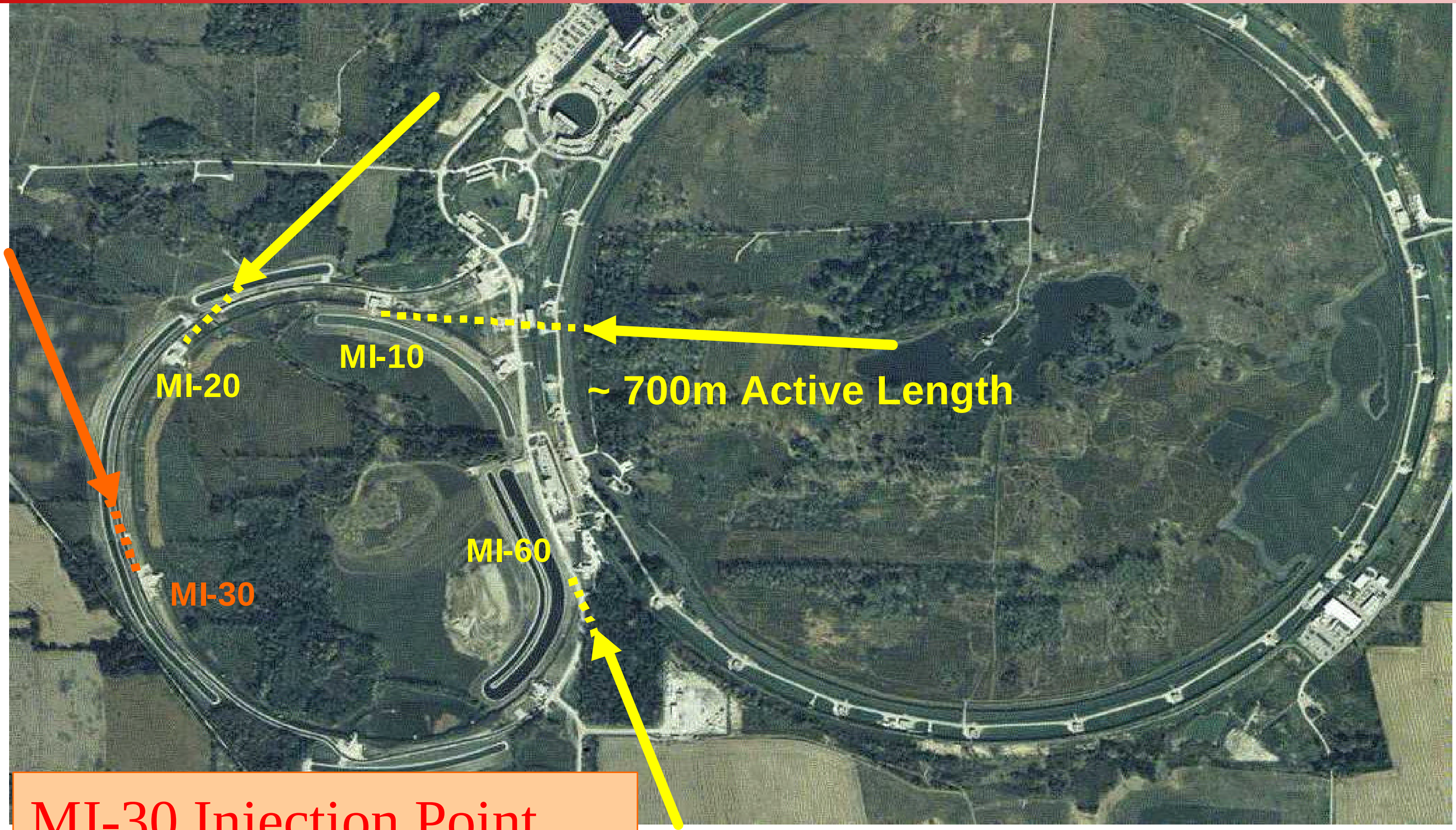


RF Distribution

Civil Const. Based on FMI



8 GeV Superconducting Linac
Possible Sitings



MI-30 Injection Point
Chosen for Design Study

8 GeV Superconducting Linac
Parameters

Project Info:
tdserver1.fnal.gov/project/8gevlinac

8 GeV LINAC

Energy	GeV	8	
Particle Type	H- Ions, Protons, or Electrons		
Rep. Rate	Hz	10	
Active Length	m	671	
Beam Current	mA	25	
Pulse Length	msec	1	
Beam Intensity	P / pulse	1.5E+14	(can be H-, P, or e-)
	P/hour	5.4E+18	
Linac Beam Power	MW avg.	2	
	MW peak	200	

MAIN INJECTOR WITH 8 GeV LINAC

MI Beam Energy	GeV	120	
MI Beam Power	MW	2.0	
MI Cycle Time	sec	1.5	filling time = 1msec
MI Protons/cycle		1.5E+14	5x design
MI Protons/hr	P / hr	3.6E+17	
H-minus Injection	turns	90	SNS = 1060 turns
MI Beam Current	mA	2250	

Note: A New Proton Driver Will Require …
Main Injector and Beam Line Upgrades

Main Injector Parameters	Present	Upgrade
Injection kinetic energy (GeV)	8	8
Extraction kinetic energy (GeV)	120	8 - 120
Protons per cycle	3×10^{13}	1.5×10^{14}
Cycle time at 120 GeV (s)	1.867	1.533
Average beam current (μA)	2.6	16
Beam power (MW)	0.3	1.9

Goals:

- Intensity increased by a factor of 5
- Cycle time reduced by 20%
- Beam power increased by a factor of 6

System upgrade:

- RF: Major upgrade. Need a second power amplifier for each cavity and 4 more cavities.
- Power supply: moderate upgrade.
- Magnet: Ok.
- Cooling capacity: Ok for magnet, but need to be doubled for rf.
- Gamma-t jump system: New.
- Large aperture quad: New.
- Collimation system: New.
- Passive damper and active feedback: New.
- Stop band correction: New.
- Shielding: Ok.
- NuMI and other 120 GeV Beam lines: Under study.

Outline

- Goals and Strategy
- Accelerator R&D Program
  - Linear Collider
  - SCRF (Superconducting RF)
  - Photoinjectors
  - Muon Facilities
  - Proton Driver
  - SC Magnets
- Budgets
- Summary

Superconducting Magnet R&D

(See Peter Limon Anytime or Jim Strait Anytime)

Goals

- Develop the superconducting magnet technology that could support a very large hadron collider in the post-LHC era.
- Maintain a U.S. center of excellence in sc magnets for the benefit of both Fermilab's and the broader world's HEP program .

Status and Plans

- Major components of the Fermilab program are:
  - LHC low beta quadrupoles
  - Low Field dipole R&D (coming to an end this year)
  - High Field dipole R&D
- Strong connection between the high field program and the LHC Accelerator Research program will likely emerge over the coming years.

This program is also under severe financial pressure. As a result the low field program will come to an end this year.

➢ Completion of low field magnet/power supply test in FY02.

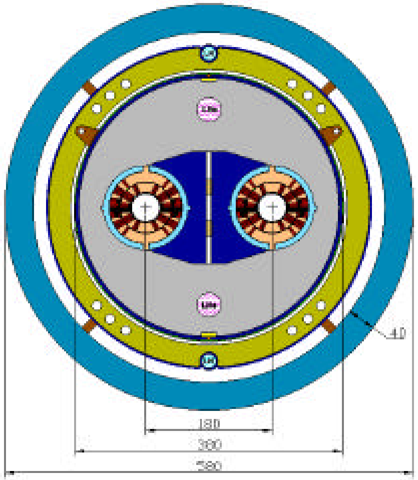
Superconducting Magnet R&D
VLHC Design Study

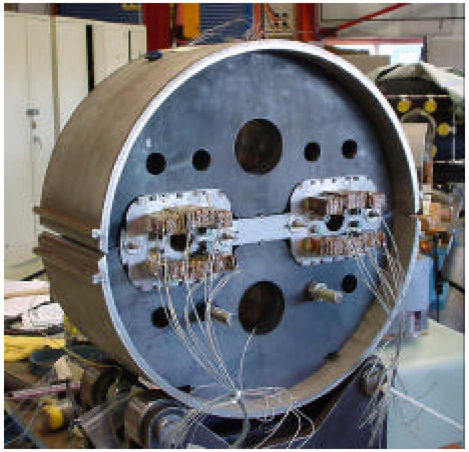
- Completed June '01
- 92 Authors, 4 National HEP Labs, 8 Institutions.
- Establishes technical feasibility of staged scenario (40 TeV $\rightarrow$ 200 TeV)
- Stage 1 Cost Comparable to Linear Collider
- Favorably received by community and HEPAP Subpanel for 201x start.

Fermilab-TM-2149Web:
WWW.VLHC.ORG

Superconducting Magnet R&D
High Field

- This program is pursuing both cosθ and common coil designs. Both are based on Nb_3Sn.
- Objectives
  - 10-12 Tesla accelerator quality dipole field
  - Minimize magnet size and cost
- Design approaches
  - cosθ vs. block type coils
  - low vs high current coils
  - vertical vs horizontal bore
  - cold vs warm iron yoke

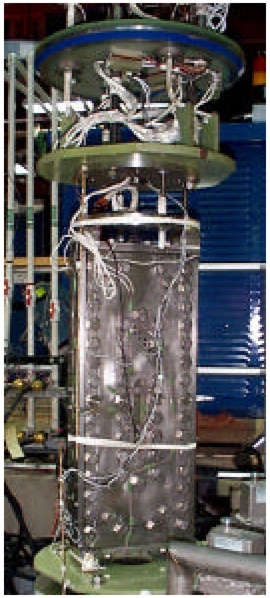




Superconducting Magnet R&D

High Field short model R&D status

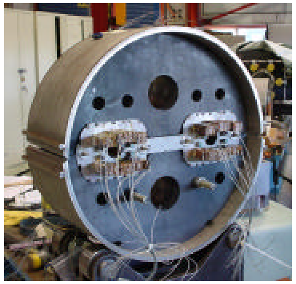
(See Alexander Zlobin Anytime)



- **Two-layer cos-theta models based on the “Wind & React” technique**
  - Two mechanical models were fabricated and tested
  - HFDA01-04 were fabricated and tested
  - HFDA05 fabrication started in May 2002

- **Single-layer common coil models based on the “React & Wind” (R&W) technique**
  - Two mechanical models were fabricated and tested
  - HFDB01 and HFDB02 (R&W racetracks) were fabricated and tested
  - HFDC01 based on R&W technique is being fabricated
  - HFDC02 based on R&W or W&R approach is being optimized

- **Issues: magnet fabrication technology, mechanics, quench performance, field quality, reproducibility**



Accelerator R&D Budgets

(See Steve Holmes Anytime or Dennis Hastert Anytime)

Funding Levels (Dollar amounts in millions, Direct costs only)

	FY00	FY01	FY02	FY03(a,b)	FY04(b)
Linear Collider/NLC	$1.2	$2.5	$2.5	$2.5	$5.0
SCRF (FNPL, CKM, TESLA)	$0.7	$0.8	$2.3	$5.0	$7.0
SC Magnet (c)	$3.0	$3.1	$3.6	$3.9	$4.0
Muons(d)	$3.1	$1.7	$0.5	$0.6	$0.5
TOTAL	$8.0	$8.1	$8.9	$12.0	$16.5

(a) Consistent with maintaining NLC “cap”
(b) Makes no assumption about linear collider technology choice, but does assume that the position of LC as a future project has been consolidated. If LC looks to be far off, then expect significant redistribution between NLC, SCRF, and SC Magnet, Proton Driver. Assumes positive action on HBPI.
(c) Includes initial buildup of LHC Accelerator Research Program at $0.1, 0.3, 0.5M over FY02-04
(d) Includes Muon Collaboration funding and Proton Driver.

Summary

The future accelerator R&D program at Fermilab is not receiving the support required to maintain viable programs in all areas that we have been trying to pursue over the last several years. This has finally led us to a situation where we have had to curtail efforts in certain areas in order to support higher priority activities. However, it would still be a stretch to characterize the "higher priority" activities as "healthy"--in fact *all programs are on the edge of viability*.

Framework

- RF and superconducting magnets are the two enabling technologies of high energy physics. Our priorities are based on developing and maintaining expertise in these two areas.

Strategy

- Pursue, as they arise, potential opportunities that align well with our high energy physics mission and our expertise.
- Don't put all our eggs in one basket, not even if the basket looks solid.

Summary

Tactics

The linear collider probably represents the next opportunity for construction of a new forefront facility for HEP. Because of this we are emphasizing accelerator R&D in the following areas:

- Linear collider technologies (including Photoinjectors), with the goal of establishing Fermilab as a credible host lab for a linear collider, and nurturing nascent accelerator R&D programs in the universities.
- Superconducting magnets, primarily in the area of high field magnet development.
- Conceptual development of a new proton source, because of uncertainty in the prospects for any new multi-billion dollar HEP project in the U.S., and in support of longer range opportunities based at Fermilab.

Question: How Can You Get Involved?
Answer: Listen to me, Talk to Steve Holmes!

- There are three prime entry points for a physics career in accelerators:
  - "Sure, it's only for two years or so" … but if you like it, you'll stay with it.
  - R&D, Projects and Operations
  - Very few people are good at all of these
  - Some of the best people move from one to the other
    - … again and again and again …
    - … and that's the best way to make progress

- Trust me: Getting Run II to work is a perfectly good entry point for any of the accelerator R&D areas described in this talk!!! (At least that's how I got started 10 x 2 years ago.)
  - See Steve Holmes
  - Wilson Hall East Side Second Floor
  - holmes@fnal.gov
  - 630.840.3211
  - Tell him "Dave sent me."

More Questions?

- FYI, this talk is at

http://tdserver1.fnal.gov/Finley/020611UsersMeeting.pdf