Linac Girder Studies and Plans

Harry Carter

Fermilab, Technical Division

RF Technology and Development Group

Outline

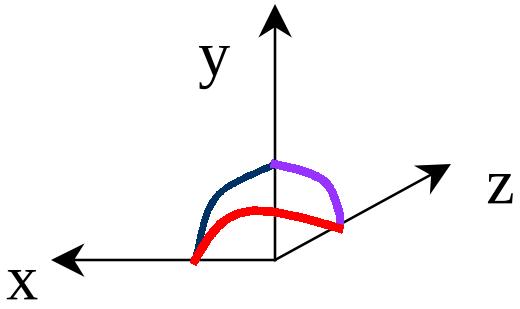
- **Brief Overview of Girders**
- **Past Work Done on Girders**
- **Work In Progress**
- **Future Plans**

Brief Overview of Girders

- Zero Design Report
  - Review Girder System Concept
    - Describe System Components
  - List Girder Requirements
- Comparison of Existing Girders
  - Girder Examples and Specifications
- Girders for NLCTA
  - Existing NLCTA System
  - Plans for 8-Pack System
    - Girder A System
    - Girder B System

ZDR: Girder Conceptual Layout

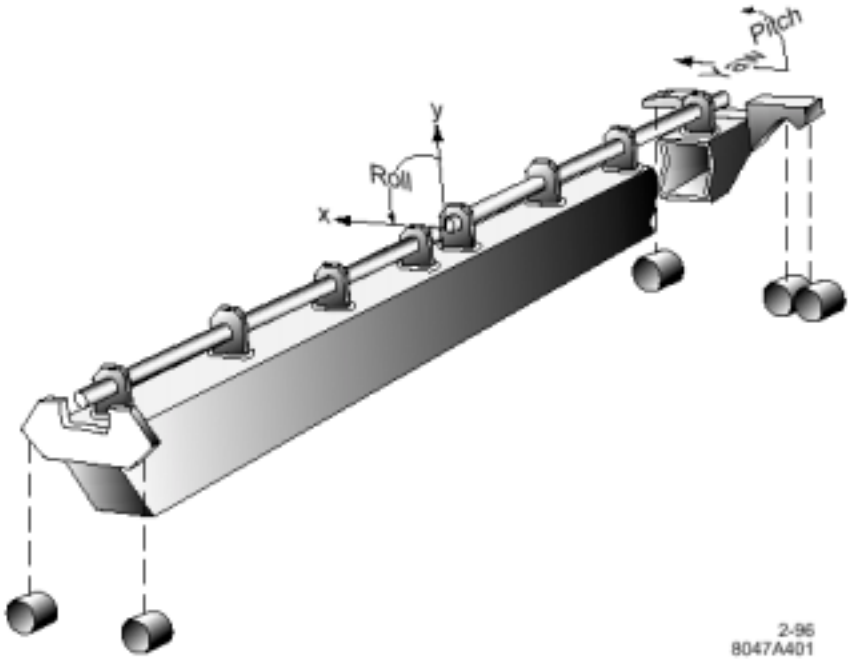
- **5 degrees of freedom (x,y, pitch, roll, yaw)**
- **Range of motion +/- 1.5 mm**
- **Max travel per step 0.25µm**



X-Y Roll

X-Z Yaw

Y-Z Pitch



NLC Girder Requirements

Requirements:

- Structure-to-Structure on spaceframe positioned to within 30-40 μm
- Spaceframe-to-Spaceframe on girders positioned to within 70 μm
- Initial Girder-to-Girder positioning to within 75 μm, then final alignment by beam-based system

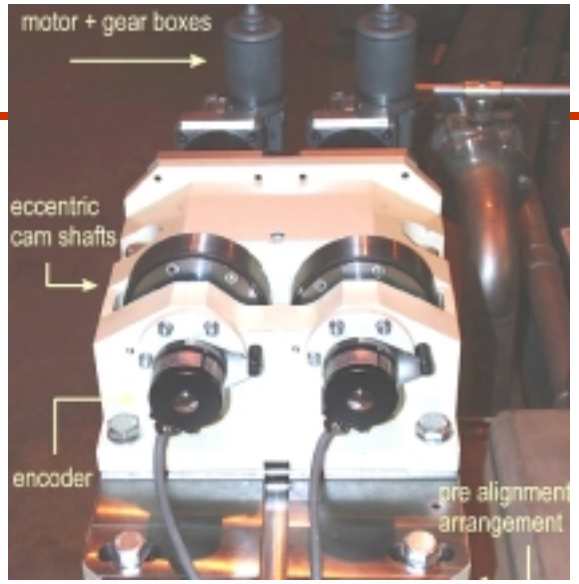
Comparison of Existing Girders

- **Linear Colliders:**
  - **NLC**
  - **CLIC**
  - **SLC**
- **Synchrotron Light Sources**
  - **SLS (Swiss Light Source – Switzerland)**
  - **APS (Advanced Photon Source – ANL)**
  - **ESRF (European Synchrotron Radiation Facility – France)**
  - **SPRING 8 (Super Photon RING 8 GeV –Japan)**
  - **VISA (Visible to Infrared SASE Amplifier – LCLS at LLBL)**

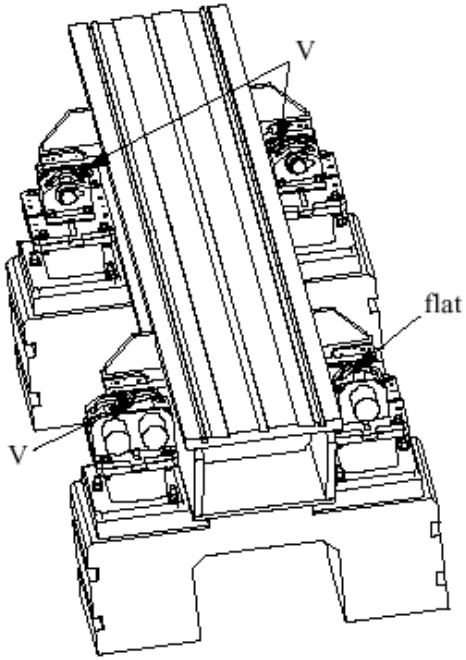
Comparison of Existing Girders

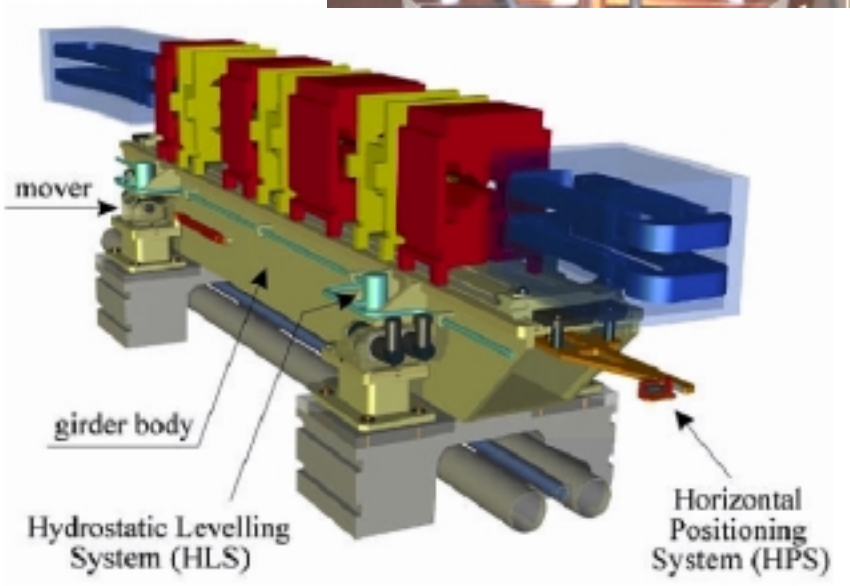
	NLC FFTB	CLIC CTF2	SLS	APS	ESRF	
DEGREES OF FREEDOM	3	3	5	3	3	
GIRDERS			48		96	
SYSTEM	3 Cams	3 Jacks	5 Cams	Jacks	Jacks	
MOTION RANGE	+/- 1 mm	+/- 5 mm	+/- 2 mm			
POSITIONING ACCURACY	5µm	10 µm	3 µm	*+/- 150 µm relative pos*	*10 µm rel. 100 µm Km*	
POSITION CONTROL	Pots BPM	HLS LVDT BPM	HLS HPS TILTmeter BPM	Dig. encoder	HLS	Plates
ALIGNMENT ON GIRDER	LVDTs CMM		Laser interf. CMM		Laser interf.	
ELEMENTS ON GIRDERS	Magnets	Magnets	Magnets	Magnets	Magnets	
MOTORS	Stepping Harm. drive	Stepping	Motor worm Planetary			

SLS Girder System



- **Alignment:**
  - **Laser interferometer**
  - **CMM**
  - **HLS (+/- 3 μm repeatability)**
  - **HPS (+/- 1 μm repeatability)**

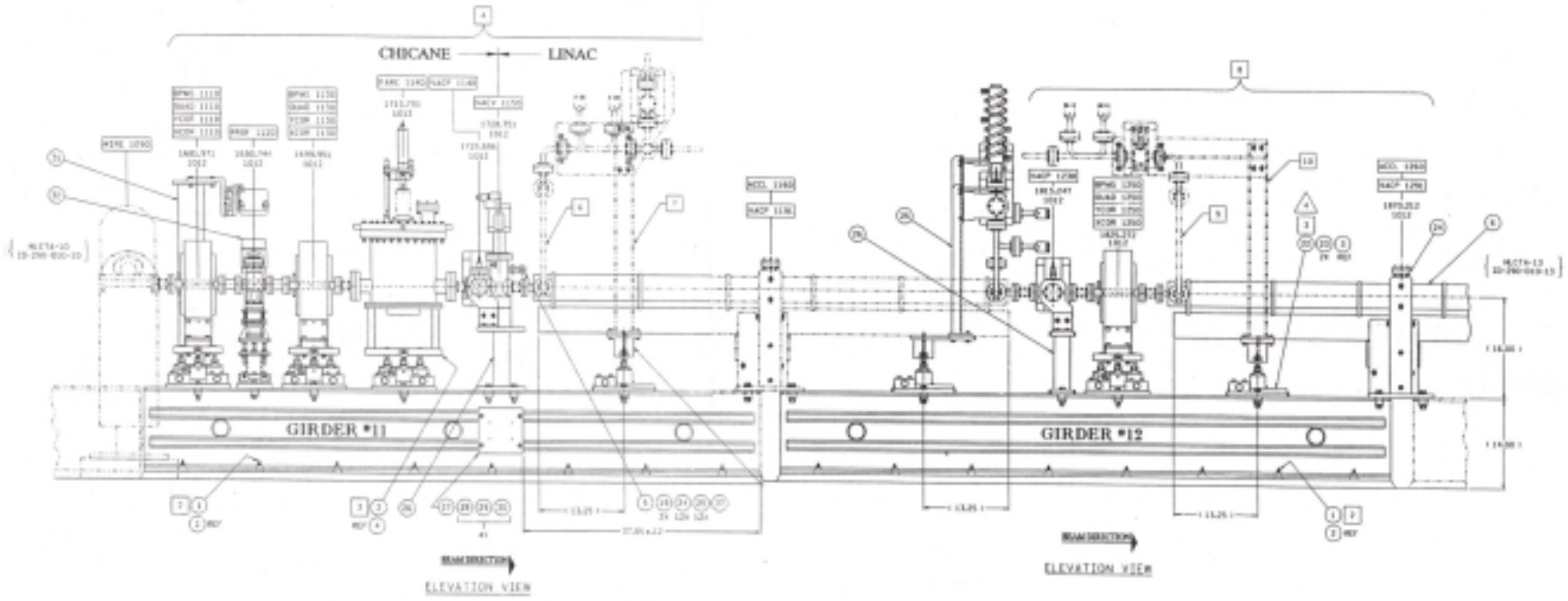




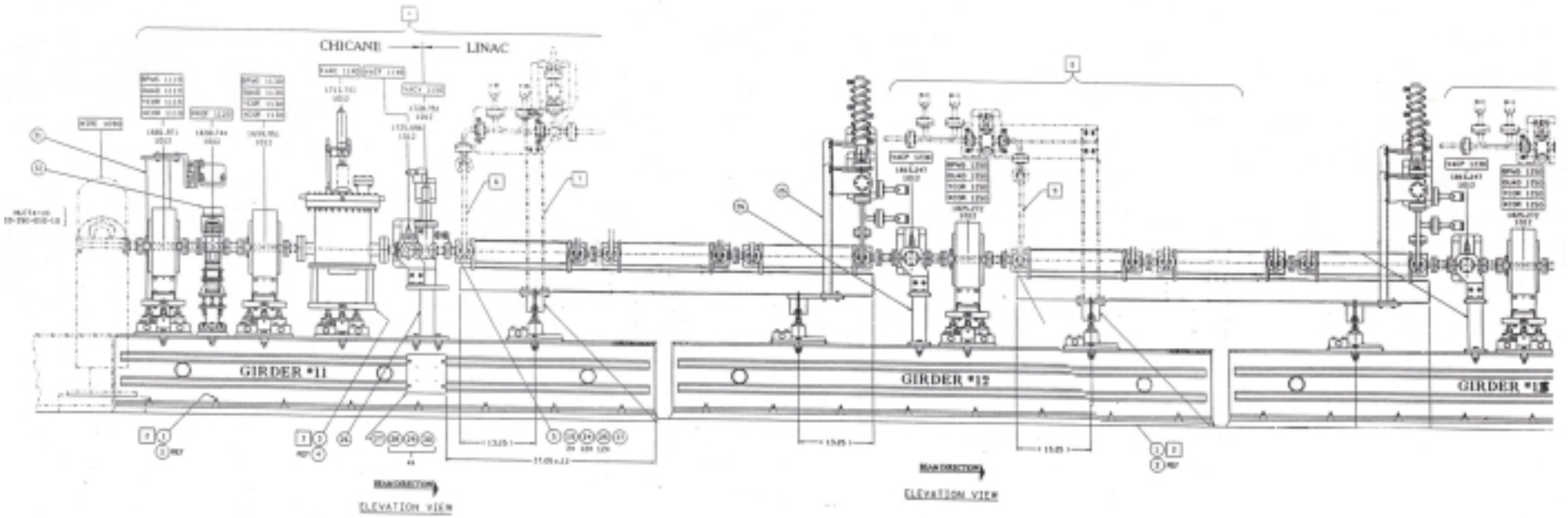
Girders for NLCTA

- Existing System at NLCTA
  - Present layout (elevation view)
  - Describe nomenclature
- Girder A System
  - Actually three NLCTA-like “strongbacks”, A1’-A3, each containing three 0.6 meter long high gradient (FXB) structures
  - Slightly different spacing of quadrupoles to accommodate three structures per “strongback”
- Girder B System
  - One 6.0 meter long NLC-style girder containing six 0.9 meter long prototype accelerating (FXC) structures
  - 5-axis motion system
  - Horizontal leveling system
- Eight-Pack Project Structures Layout in NLCTA

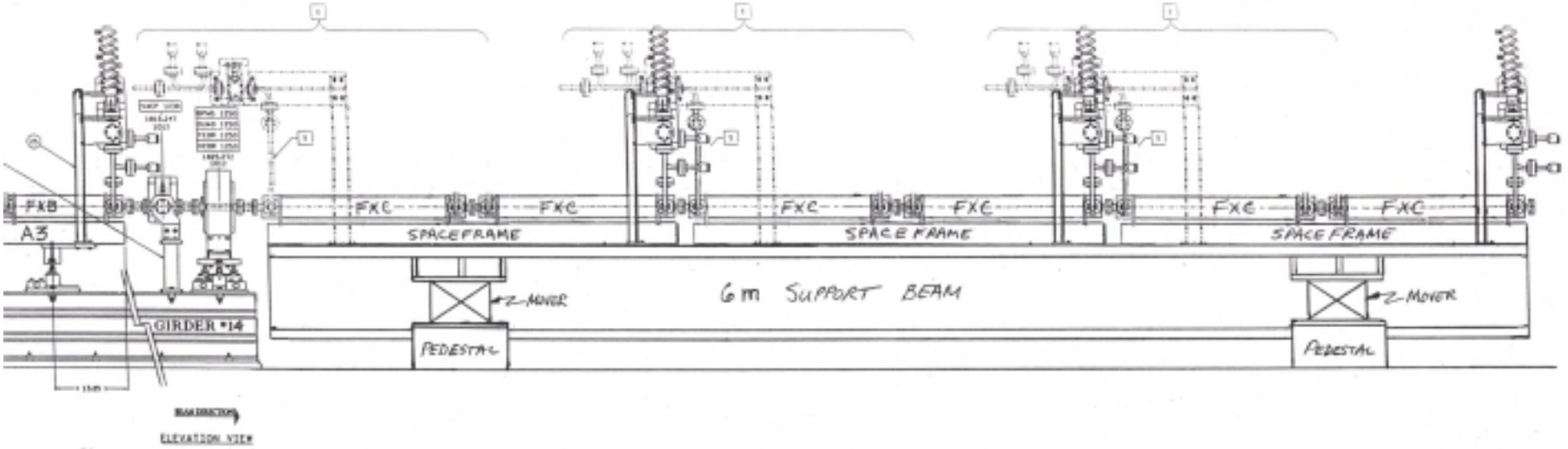
Existing System at NLCTA



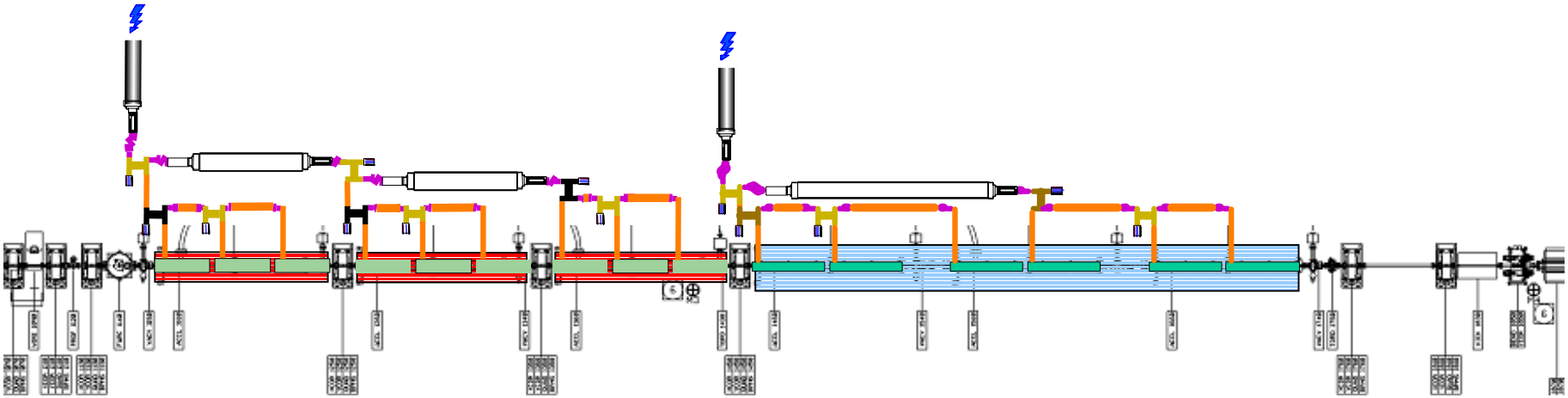
Girder A System



Girder B System



Eight-Pack Project Structures in NLCTA



High Gradient Structures
On NLCTA-type Strongbacks
(Girder A)

NLC Prototype Girder
(Girder B)

Past Collaboration Work Done on Girders

- Stability Studies
  - Performed approximately two years ago at SLAC by C. Adolphsen
- Design Work and Studies
  - G. Bowden girder mover system design
  - M. Browne, et. al., “Mover Electronics” study and cost estimate in May 1999
- 1st Engineering team meeting on girders was held at SLAC in Feb. ’02
  - Engineering team members
  - Describe goals of meeting

Past Collaboration Work : Girder Engineering Team

- Team Members
  - FNAL: C. Boffo, E. Borrisov, H. Carter
  - SLAC: C. Rago, N. Yu
  - Consultants: C. Adolphsen, G. Bowden, J. Cornuelle, K. Jobe, D. Schultz
- Feb. ’02 Meeting Goals
  - Discuss Specifications for Girders
  - Define FNAL Scope of Work
  - Discuss Girder Installation Details
  - Discuss Schedule

Work In Progress

- Girder A System
  - Design
  - Schedule

- Vibration Studies
  - Concerns about flow induced vibrations and vibrations from other water system sources in structures are being addressed (A. Seryi, T. Himel, et.al).

Work in Progress: Girder A Schedule Highlights*

Task Name	Duration	Start	Finish
Girder A (actually A1+A2+A3+A1')	324d	Mon 4/8/02	Fri 7/3/03
Design, Fabricate, and Assemble Girder A1	51d	Mon 4/8/02	Fri 6/17/02
Mount FXB-001 on Girder A1 and ship to SLAC for NLCTA Testing	9d	Mon 8/12/02	Fri 8/22/02
• FXB-001 and Girder A1 Arrives at SLAC			Thu 8/22/02
Design, Fabricate, and Assemble Girders A2, A3, and A1'	75d	Mon 5/20/02	Fri 8/9/02
Mount FXB-002,-003, & -004 on Girder A2 and Ship Girder A2 to SLAC	9d	Mon 11/25/02	Thu 12/5/02
• Girder A2 Arrives at SLAC			Thu 12/5/02
Mount FXB-005,-006, & -007 on Girder A3 and Ship Girder A3 to SLAC	9d	Mon 3/10/03	Thu 3/20/03
• Girder A3 Arrives at SLAC			Thu 3/20/03
Mount FXB-008,-009, & -010 on Girder A1' and Ship Girder A1' to SLAC	9d	Mon 6/23/03	Thu 7/3/03
• Girder A1' Arrives at SLAC			Thu 7/3/03

* Excerpted from MS Project Schedule, "FNAL Schedule in Support of 8-Pack Project", H. Carter 5/02/02

Work in Progress: Vibration Studies

NLC - The Next Linear Collider Project

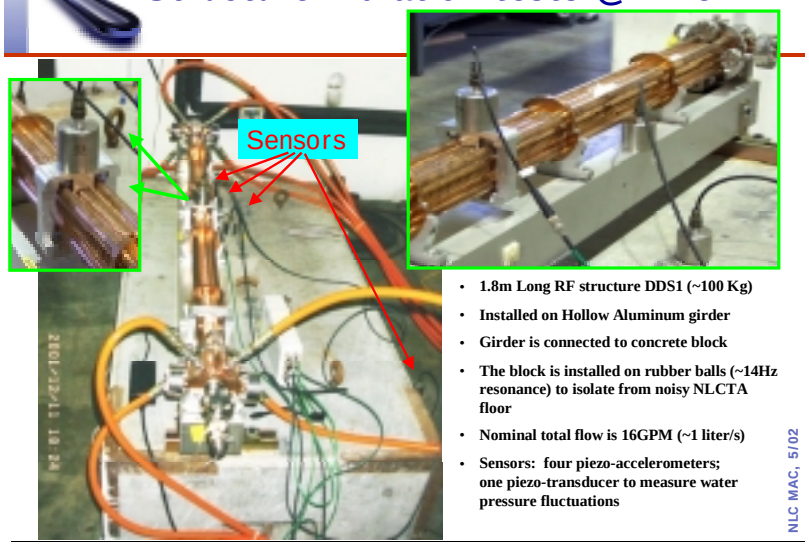
Linac girder studies at SLAC,

Frederic Le Pimpec, Andrei Seryi
Fred Asiri, Gordon Bowden, Eric Doyle,
Bobby McKee, Nancy Yu
Stefano Redaelli (CERN)
Sri Adiga (Stanford Univ.)

MAC meeting, FNAL
May, 2002

NLC - The Next Linear Collider Project

Structure vibration tests @ NLCTA



- Present results indicate vibrations in structures with amplitudes ~1 micron or less are primarily NOT flow induced in origin but rather come from other water system sources (pumps, etc.).

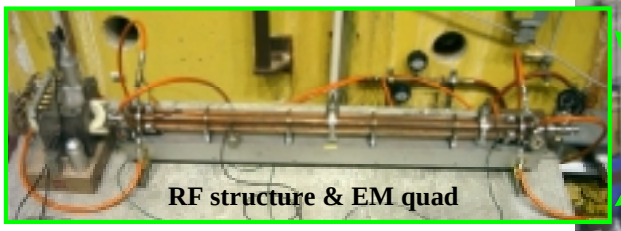
Vibration Work: Additional Studies

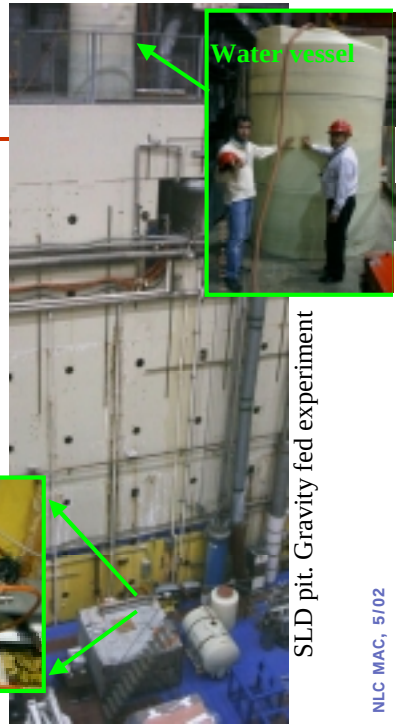
- **Some Concerns:**
  - **Vibration coupling, even tiny, from RF structure to a quadrupole* (nm tolerance)**
  - **The full length girder should be designed so that damping is increased and low F resonances are avoided**
  - **The cooling water supplying system may need to be made more quiet**
    => Need to study
    What is feasible?

NLC - The Next Linear Collider Project

More studies

- Study vibration of the girder with gravity-fed "quiet" water
- Study vibration transmission to quadrupole in a structure-quad assembly





Future Plans

Near Term (next 6-8 months):

- Continue Vibration Studies at SLAC and Initiate Studies at FNAL
- Begin Production of Type-A Girders
- R&D for Girder B
  - Repeat C. Adolphsen's girder work here at Fermilab (at MS5) as a basis for beginning the R&D effort.
- Motion Control/Movers- ($$$)
  - Purchase/Construct one or more girder movers and test for accuracy and positional repeatability.
- Hydrostatic Leveling System (HLS)- ($$$)
  - Acquire a system and conduct measurements on it.
- Structure Mockups
  - Construct six 0.9 meter long FXC-style structure mockups to facilitate girder studies

Longer Term (12-24 months):

- Complete R&D Work and Design, Construct, and Test Girder B

Girder B Schedule Highlights*

Task Name	Duration	Start	Finish
Girder B (NLC Prototype Girder)	450d	Mon 6/3/02	Fri 2/20/04
Conduct R&D for Girder B	180d	Mon 6/3/02	Fri 2/7/03
Design Girder B	60d	Mon 2/10/03	Fri 5/2/03
Procure Parts for Girder B	90d	Mon 5/5/03	Fri 9/5/03
Construct Girder B	90d	Mon 9/8/03	Fri 1/9/04
Test Girder B	30d	Mon 1/12/04	Fri 2/20/04
• Girder B Completed			Fri 2/20/04
Install FXC Structures on Girder B	10d	Wed 5/5/04	Tue 5/18/04
Align FXC Structures on Girder B	10d	Wed 5/19/04	Tue 6/1/04
Ship Girder B Assembly to SLAC	10d	Wed 6/2/04	Tue 6/15/04
• Girder B Assembly Arrives at SLAC			Tue 6/15/04

*** Excerpted from MS Project Schedule, "FNAL Schedule in Support of 8-Pack Project", H. Carter 5/02/02**

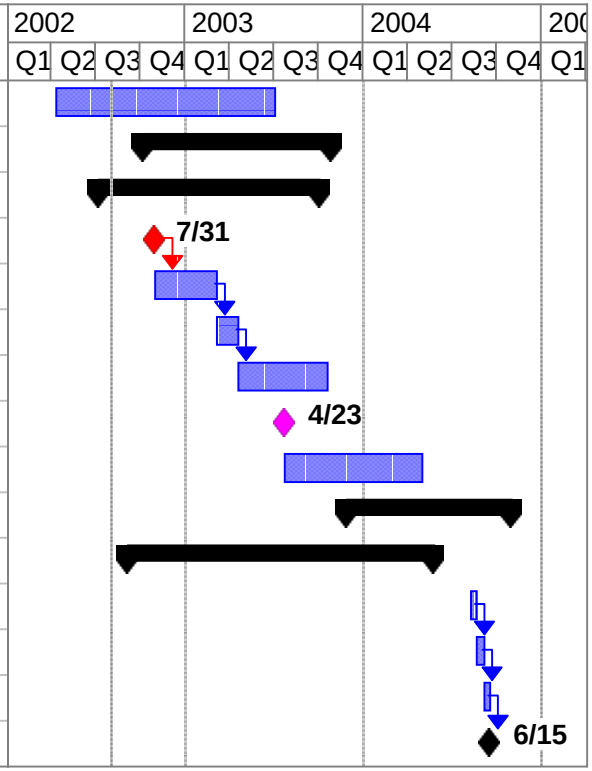
FNAL Schedule in Support of 8-Pack Project

- Review of Schedule
  - Very little slack time in schedule
  - Failure to meet milestones = schedule slippage
  - Insufficient funding = schedule slippage

- Funding Scenarios and Consequences
  - Original FY03 Guidance: $4.0M
  - FY03 Bare Min. to Meet Schedule: $3.3M
  - Most Recent FY03 Guidance is
    Flat Funding (same as FY02): $2.0M
    Shortfall: $1.3M What do we give up?

FNAL Schedule in Support of 8-Pack Project

ID	Task Name	Duration	Start	Finish
1	Parts Procurement for FXB Structures	322 days	Mon 1/7/02	Tue 4/1/03
2	**FXB Series Structure Production (0.6m)**	**275 days**	**Mon 7/8/02**	**Fri 7/25/03**
14	**Girder A (actually A1+A2+A3)**	**324 days**	**Mon 4/8/02**	**Thu 7/3/03**
36	**Design for FXC Series Structures Complete**	0 days	Wed 7/31/02	Wed 7/31/02
37	Parts Procurement for FXC Prototype	90 days	Thu 8/1/02	Wed 12/4/02
38	Construct FXC Protype	30 days	Thu 12/5/02	Wed 1/15/03
39	Test FXC Prototype at SLAC	130 days	Thu 1/16/03	Wed 7/16/03
40	**FXC Prototype Proves to be Good**	0 days	Wed 4/23/03	Wed 4/23/03
41	Parts Procurement for FXC Series Structures	200 days	Wed 4/23/03	Tue 1/27/04
42	**FXC Series Structure Production (0.9m)**	**240 days**	**Wed 8/27/03**	**Tue 7/27/04**
51	**Girder B (NLC Prototype Girder)**	**450 days**	**Mon 6/3/02**	**Fri 2/20/04**
58	Install FXC Structures on Girder B	10 days	Wed 5/5/04	Tue 5/18/04
59	Align FXC Structures on Girder B	10 days	Wed 5/19/04	Tue 6/1/04
60	Ship Girder B Assembly to SLAC	10 days	Wed 6/2/04	Tue 6/15/04
61	**Girder B Assembly Arrives at SLAC**	0 days	Tue 6/15/04	Tue 6/15/04



Summary

- Development and construction an NLC prototype girder system containing all the requisite features represents a significant challenge to the FNAL collaboration of the NLC project. We are prepared to meet this challenge.
- We are poised to begin R&D efforts at Fermilab and this effort will increase substantially over the next six months, culminating in a complete design specification and the onset of construction of a prototype. A schedule leading to this goal has been presented.
- Funding will more than likely become a critical issue for this work to progress in a timely manner.