Linear Collider R&D: Production and Results of the X-Band RF Structures

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Outline

- A Brief History
- Structure Production and Performance Review
- Present Status of Structure R&D
- Present Status of Girder R&D
- Future Plans
- Conclusion

A Brief History

- **Original Mission:** The industrialization of X-band accelerating structures for the main linac of the Next Linear Collider.
- **Additional Responsibility:** The design and construction of the structure supporting girder assembly for the NLC main linac.

A Brief History

- **IB4 Factory and Structure History**
  - June 2000: Factory conceptualized and founded by N. Holtkamp and D. Finley
  - Nov. 2000: Decision to site factory in IB4
  - July 2001: FXA-001, the first structure built by FNAL (but not at FNAL) completed
  - Sept. 2001: Infrastructure established and factory operational with our small vacuum furnace
  - Mar. 2002: FXA-002 partially assembled at FNAL
  - June 2002: Large Vacuum Furnace installed and operational
  - Aug. 2002: First structure (FXA-003) constructed entirely at FNAL is completed
  - Nov. 2002: First FNAL built structure (FXB-002) undergoes high power testing at SLAC's NLCTA

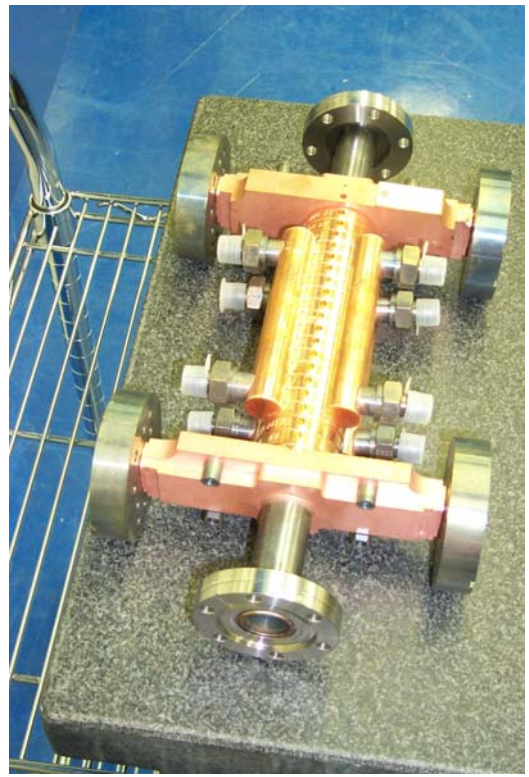
Structure Production and Performance Review: FXA Structures History

FXA series, aka T20VG5, 20 cm. long, 45mm o.d. cells, 120 degree phase advance traveling wave structures. Main purpose of these structures was for us to learn structure construction techniques and develop our processes. Three FXA structures were built, none were high power tested.

FXA-001: All-brazed structure assembled using a hydrogen furnace at AlphaBraze, Inc. in California.

FXA-002: All-brazed structure assembled using a hydrogen furnace at AlphaBraze.

FXA-003: All-brazed structure using our vacuum furnaces. First structure assembled entirely at Fermilab.

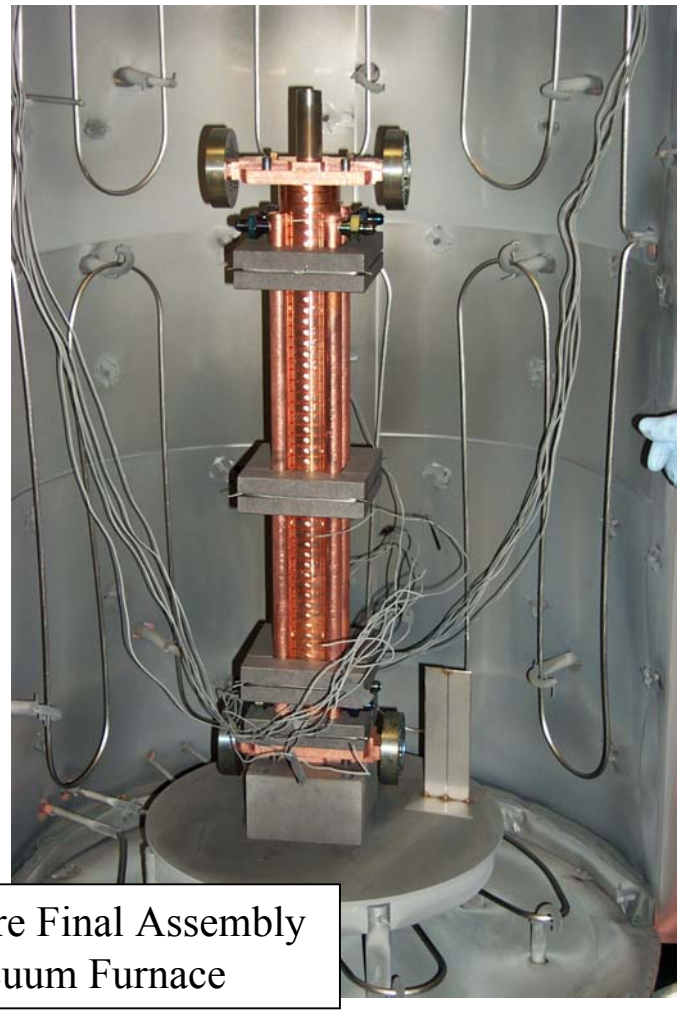


FXA-003

Structure Production and Performance Review: "Dummy" Structures

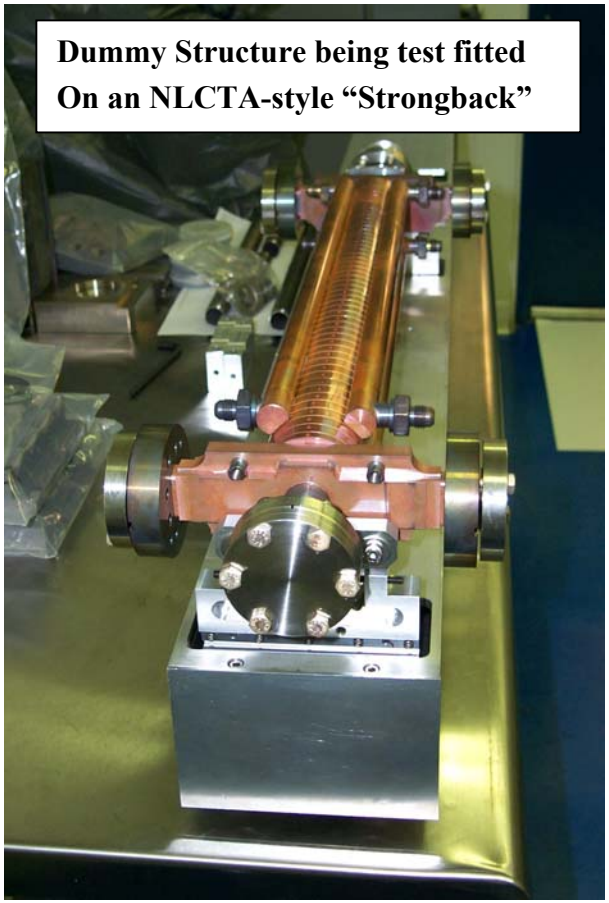
"Dummy" Structures and their components are used for:

- Qualifying furnace braze cycles prior to brazing actual structures
- Girder stability studies and vibration testing. Dummy structures have mechanical properties identical to real structures.
- We have produced nine (5.4 meters' worth) of these structures in support of girder studies.



"Dummy" Structure Final Assembly in Our Large Vacuum Furnace

Structure Production and Performance Review: Strongbacks



Dummy Structure being test fitted
On an NLCTA-style "Strongback"

FXB-002 Mounted on NLCTA-style "Strongback"

- We produced nine long structure supporting systems known as "strongbacks"(six for NLCTA use at SLAC, and three for use in girder development at FNAL)
- We also produced 10 short strongbacks for use in the 8-Pack Project

Structure Production and Performance Review: FXB Structures History

FXB series, aka H60VG3, 60 cm. long, 61mm o.d. cells, 150 degree phase advance traveling wave structures. These structures were originally intended to be the ones used for Phase II of the 8-Pack project. 12 FXBs were originally planned for construction, in order to supply nine (5.4m) structures to be mounted on a 6m long NLC prototype girder. Ultimately, seven FXB structures were built. Their construction And testing history is shown on the next slide.

Structure Production and Performance Review: FXB Structures History

FXB-001: Damaged during construction. Became one of our "dummy" structures.

FXB-002: All-brazed structure assembled using a vacuum furnace at Advanced Thermal Processing (ATP). Fermilab "fat-lipped" I/O couplers used.

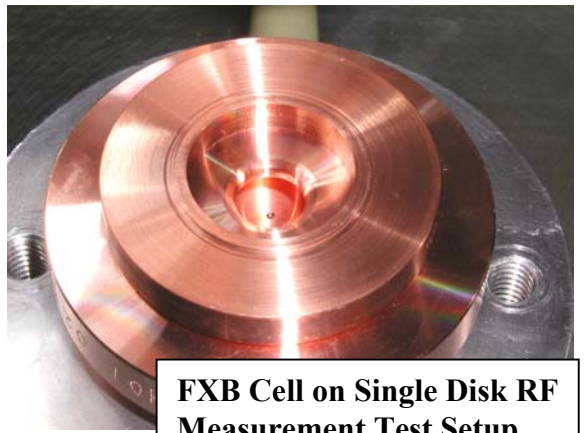
FXB-003: All-brazed structure assembled at Fermilab but subsequently processed with 3% hydrogen mixture in furnace at ATP. Fermilab "fat-lipped" I/O couplers used.

FXB-004: All-brazed structure in vacuum furnaces at Fermilab. Fermilab waveguide (FWG) I/O couplers used.

FXB-005: Same as FXB-004, but cell pretuning prior to assembly resulted in problem---not sent to SLAC for high power testing.

FXB-006: Same as FXB-004 but cells vacuum-fired at 1000 C for one hour prior to stack assembly. Presently installed in the 8-Pack test at NLCTA.

FXB-007: Identical to FXB-006. Presently installed in the 8-Pack test at NLCTA.

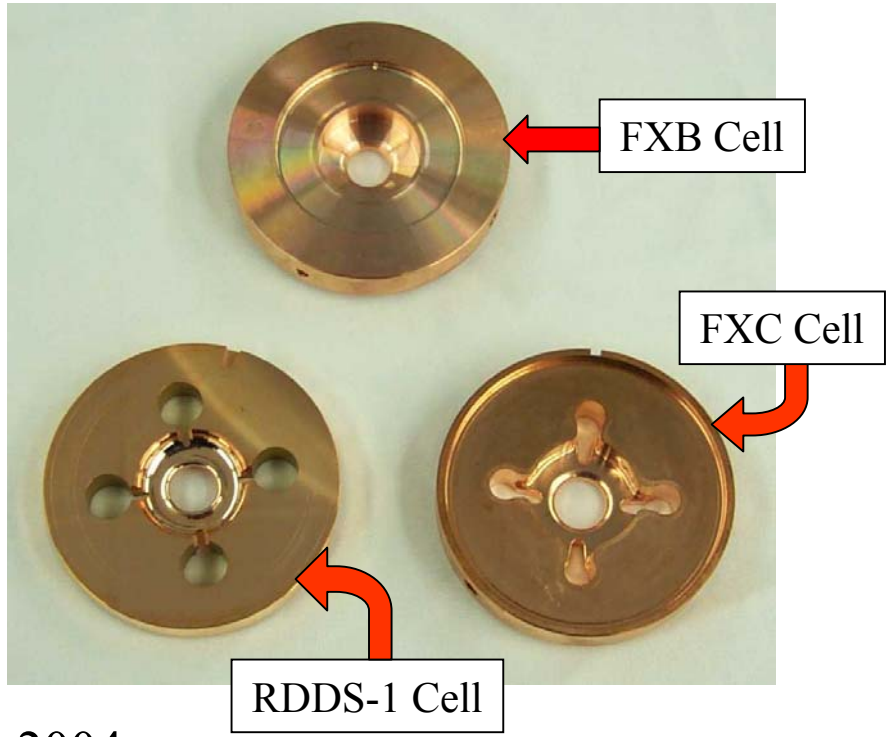


FXB Cell on Single Disk RF Measurement Test Setup

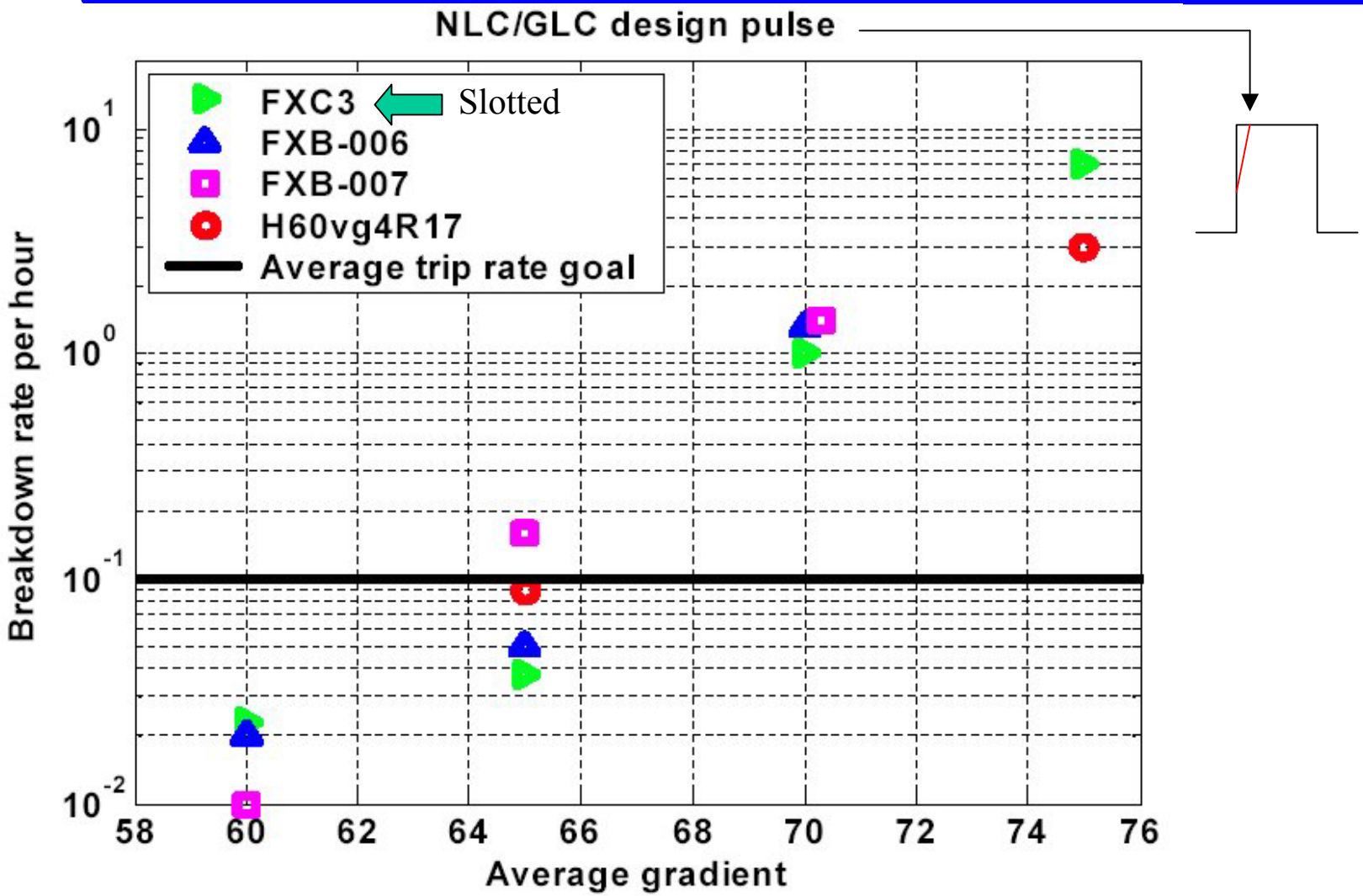
No H_2 Used

Structure Production and Performance Review: FXC Structures History

- FXC production
  - aka H60VG3S17, 150 deg. , no HOM extraction
  - 5 structures were produced
  - FXC-003 was the first damped, detuned structure to meet the TRC R1 requirement (65MV/m unloaded gradient, 400ns pulse width, <0.1 breakdowns/hr.)
  - Production concluded on April 6, 2004, with the shipment of FXC-005 to SLAC



Structure Production and Performance Review: High Power Test Results



Structures for the 8-Pack: Project Goals

Overall Project Goal: To Demonstrate an NLC Power Source

Two Phases:

8-Pack Phase-I: Multi-moded SLED II power compression

Produce NLC baseline power: 475 MW 400ns

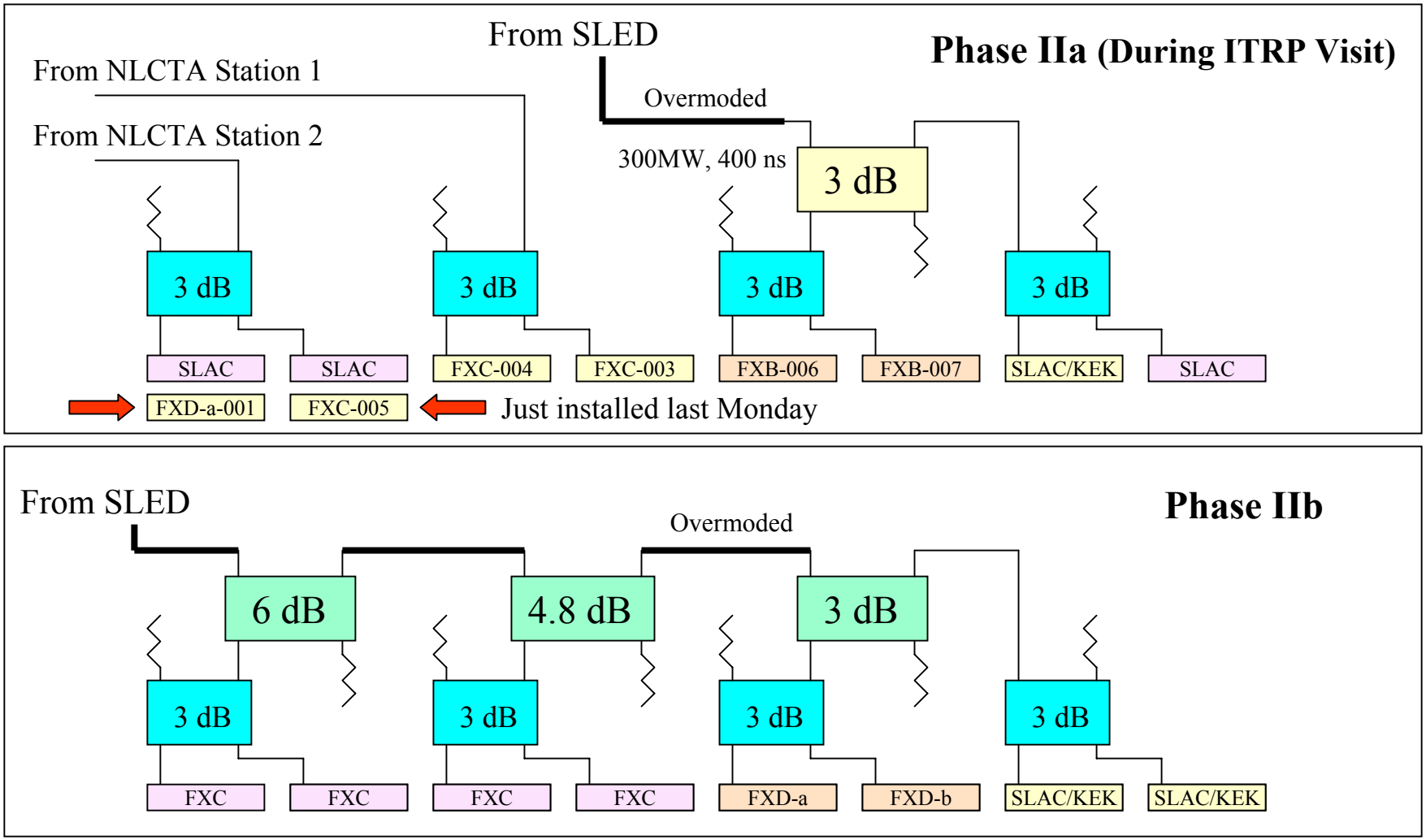
LC TRC R1 requirement for GLC/NLC:
'Demonstration of the SLED II pulse compression system RF power and energy handling capability at the design level.'

8-Pack Phase-II: Use the SLED II system for a Linac sub-unit test:

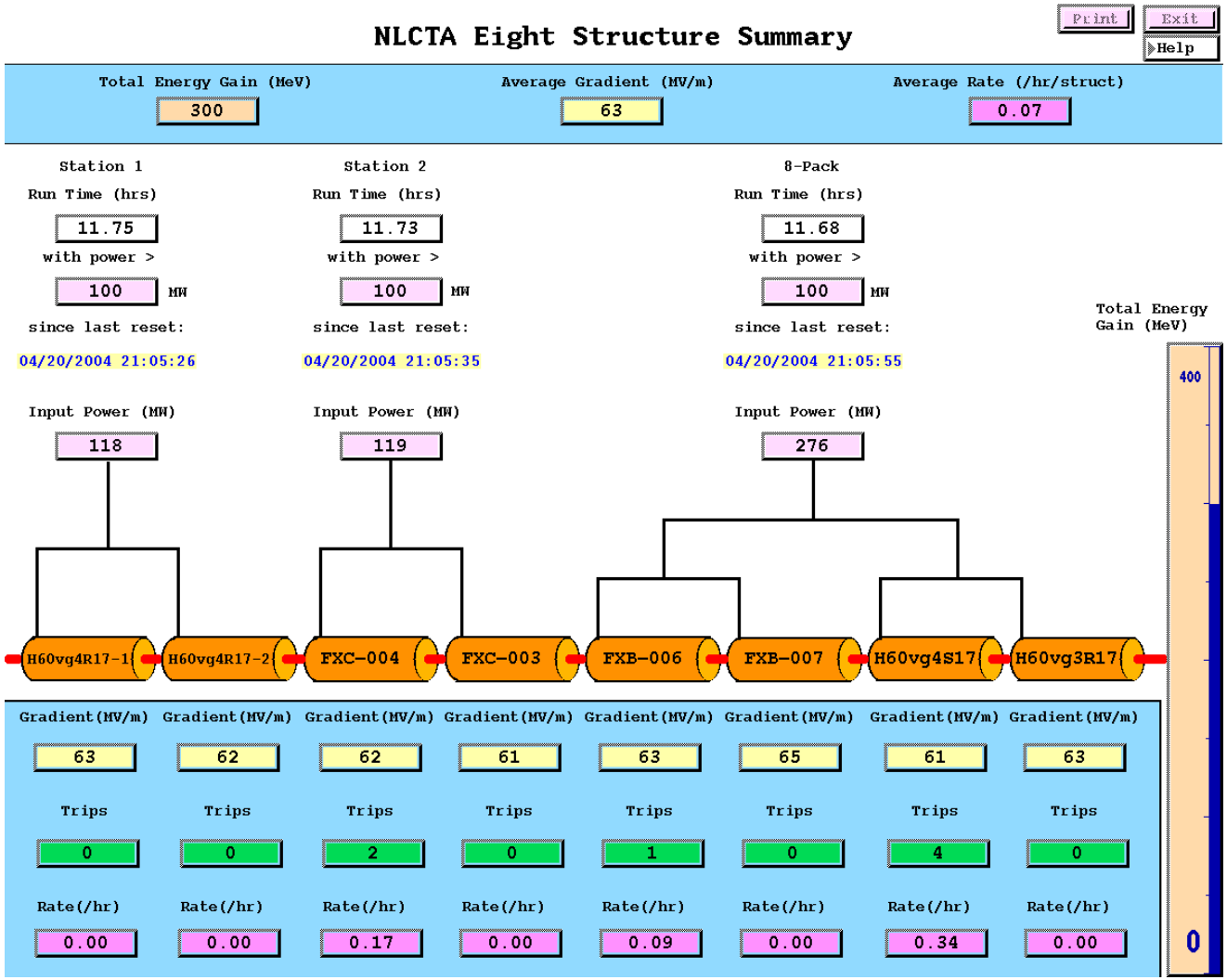
A full power demonstration of an RF feed to 4.8m of high gradient structures on the NLCTA beamline.

One of the LC TRC R2 requirements for GLC/NLC: 'A linac sub-unit test'

Structures for the 8-Pack: Power Handling Schematic

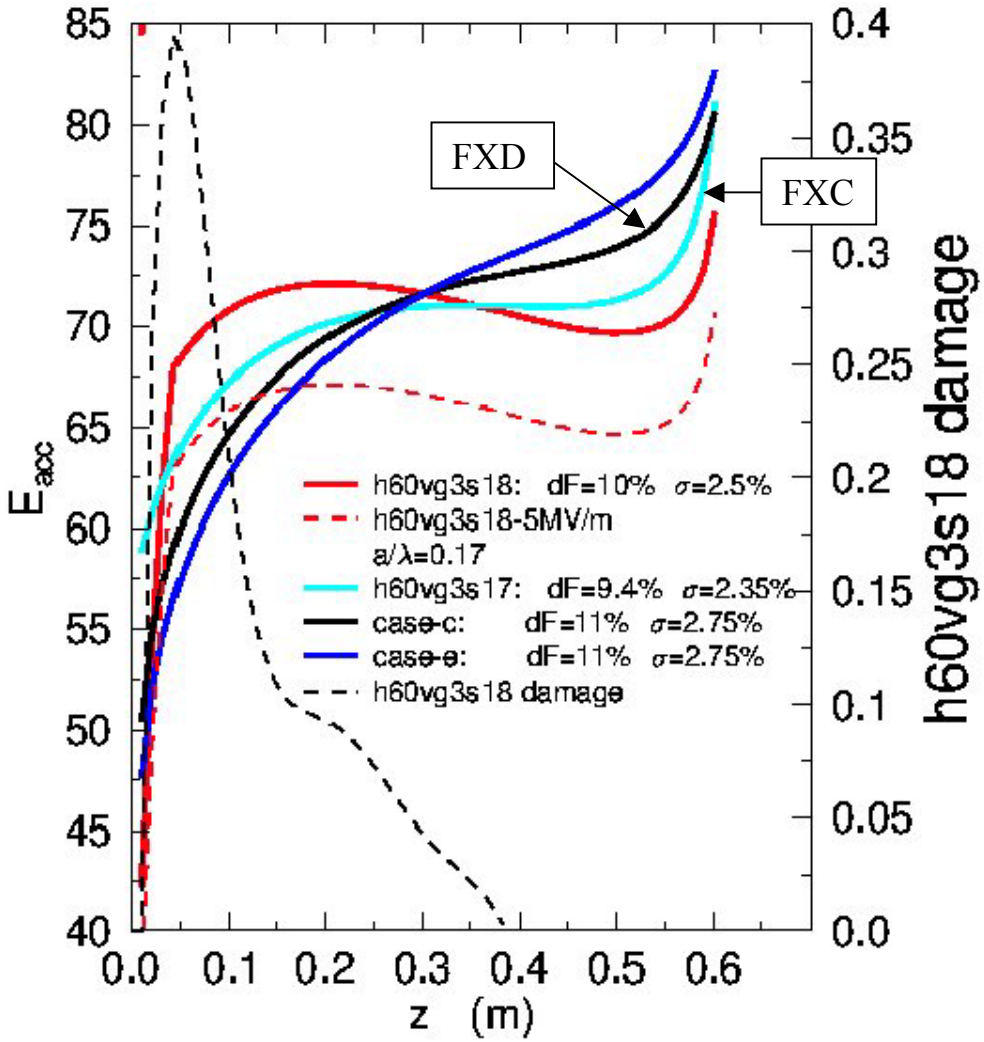


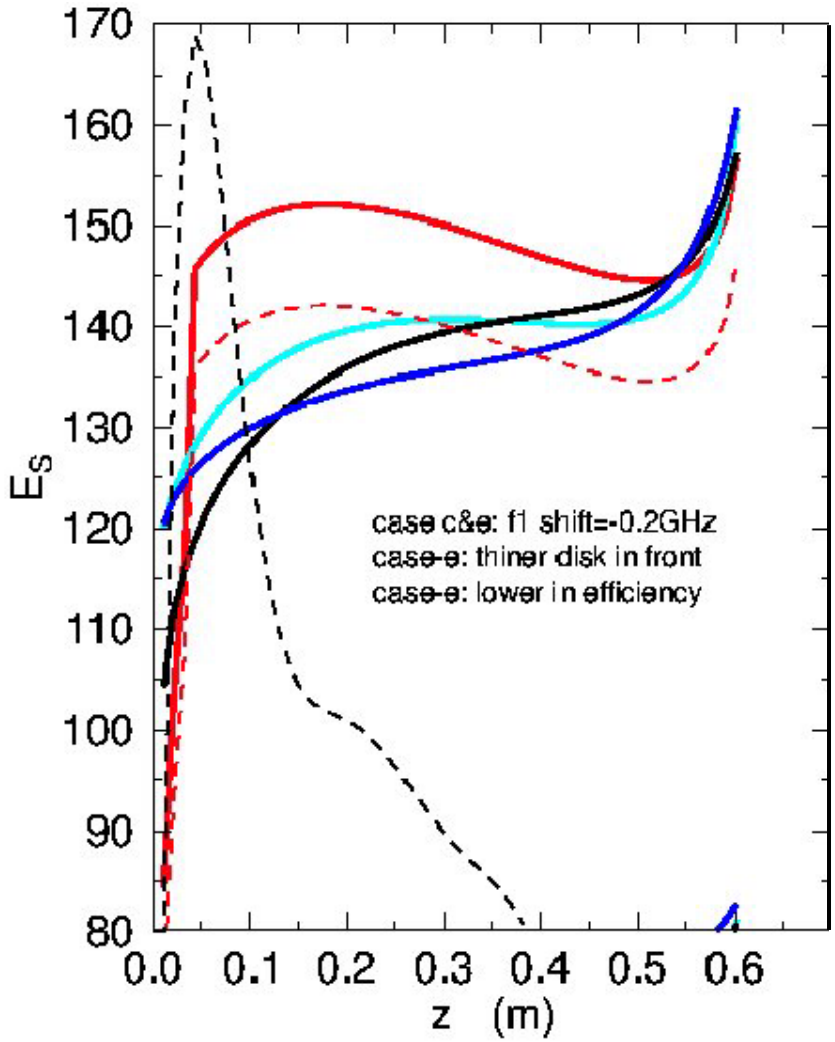
http://www-project.slac.stanford.edu/lc/local/Projects/NLCTA/nlctasumm.html



Present Status of Structure R&D: RF Design

Improving Eacc/Es With Dipole Detuning (Zenghai Li, June '03)

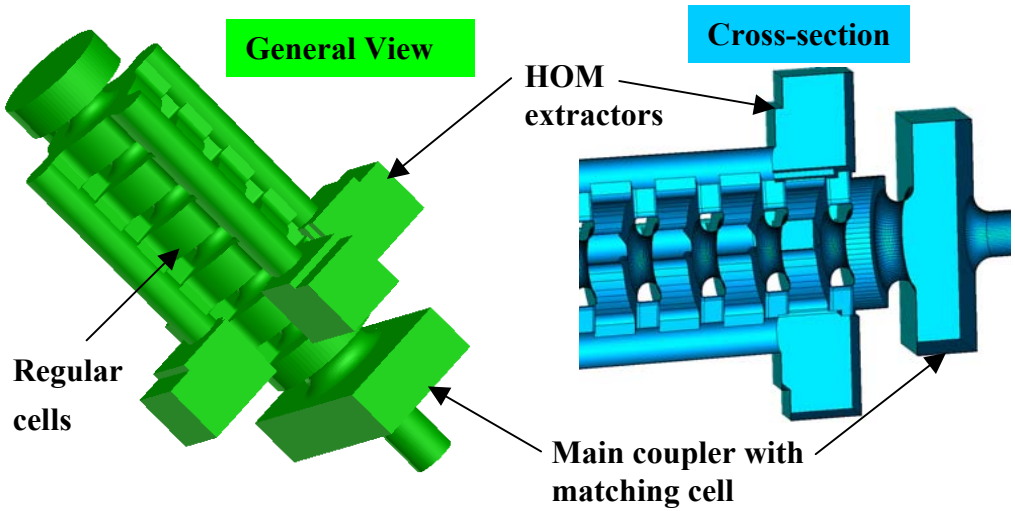


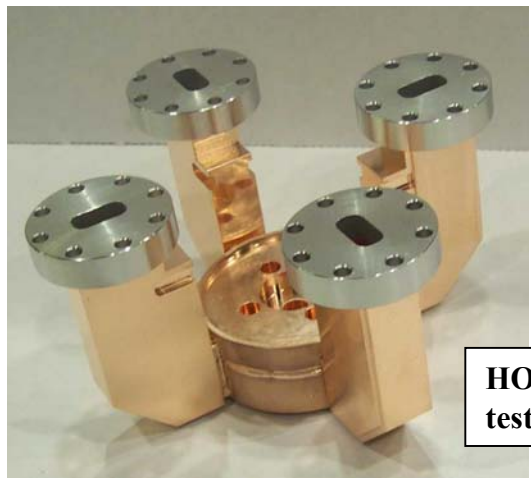


Present Status of Structure R&D: FXD Series

- We have parts for the FXD series structures (H60**VG4**S17, 150º, with **I/O HOM extraction**)
  - Cells for 6 structures, 3 sets of the -a variant and 3 sets of the -b variant (for two-fold interleaving) have been procured
  - FXD-A-001 was completed in March and is currently undergoing high power testing at NLCTA
  - Additional FXD-A and FXD-B production will commence as soon as our clean room HVAC controls upgrade is completed (~ 1 week)

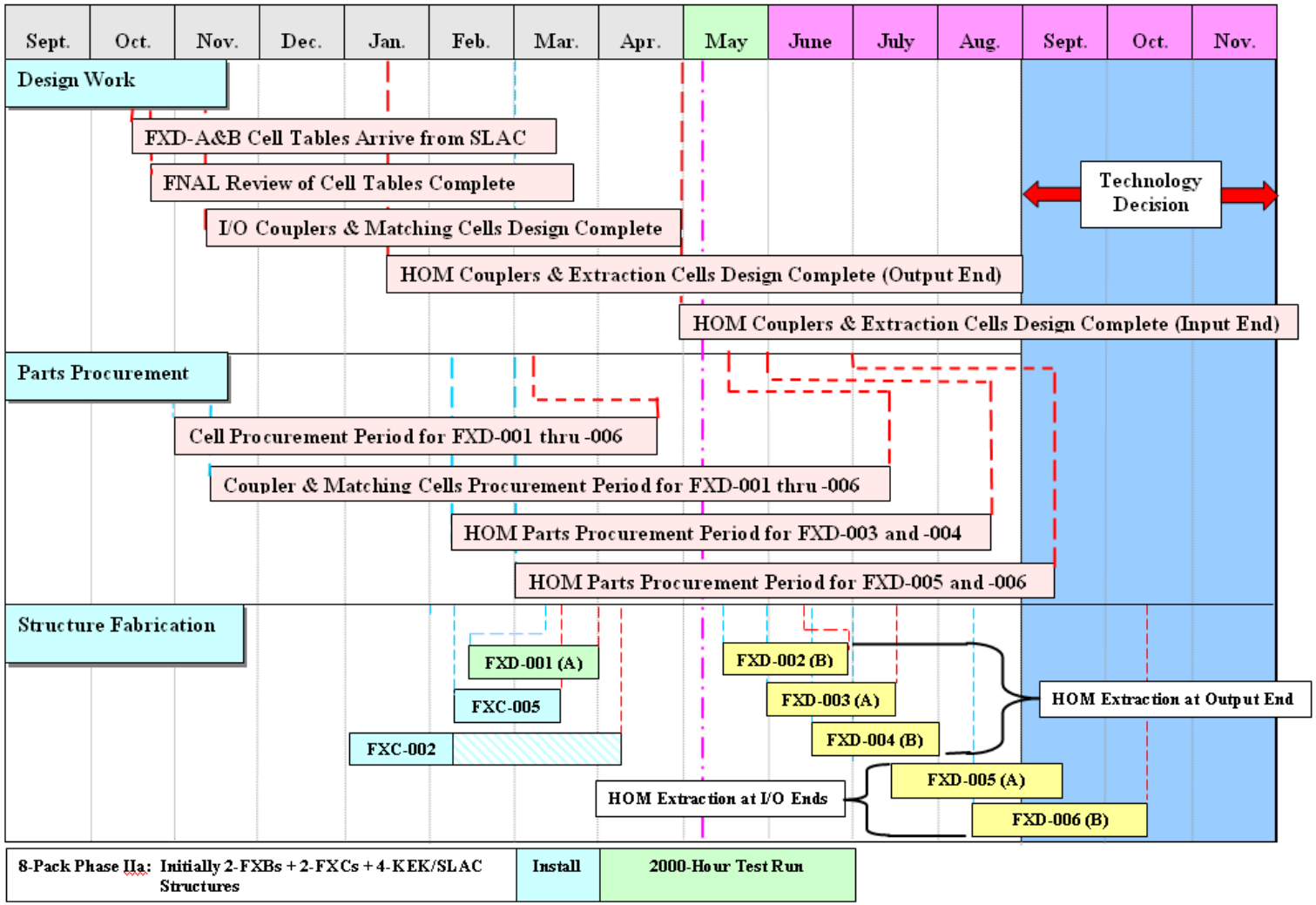
HFSS Solid Model of HOM Extractors





HOM extractor test assembly

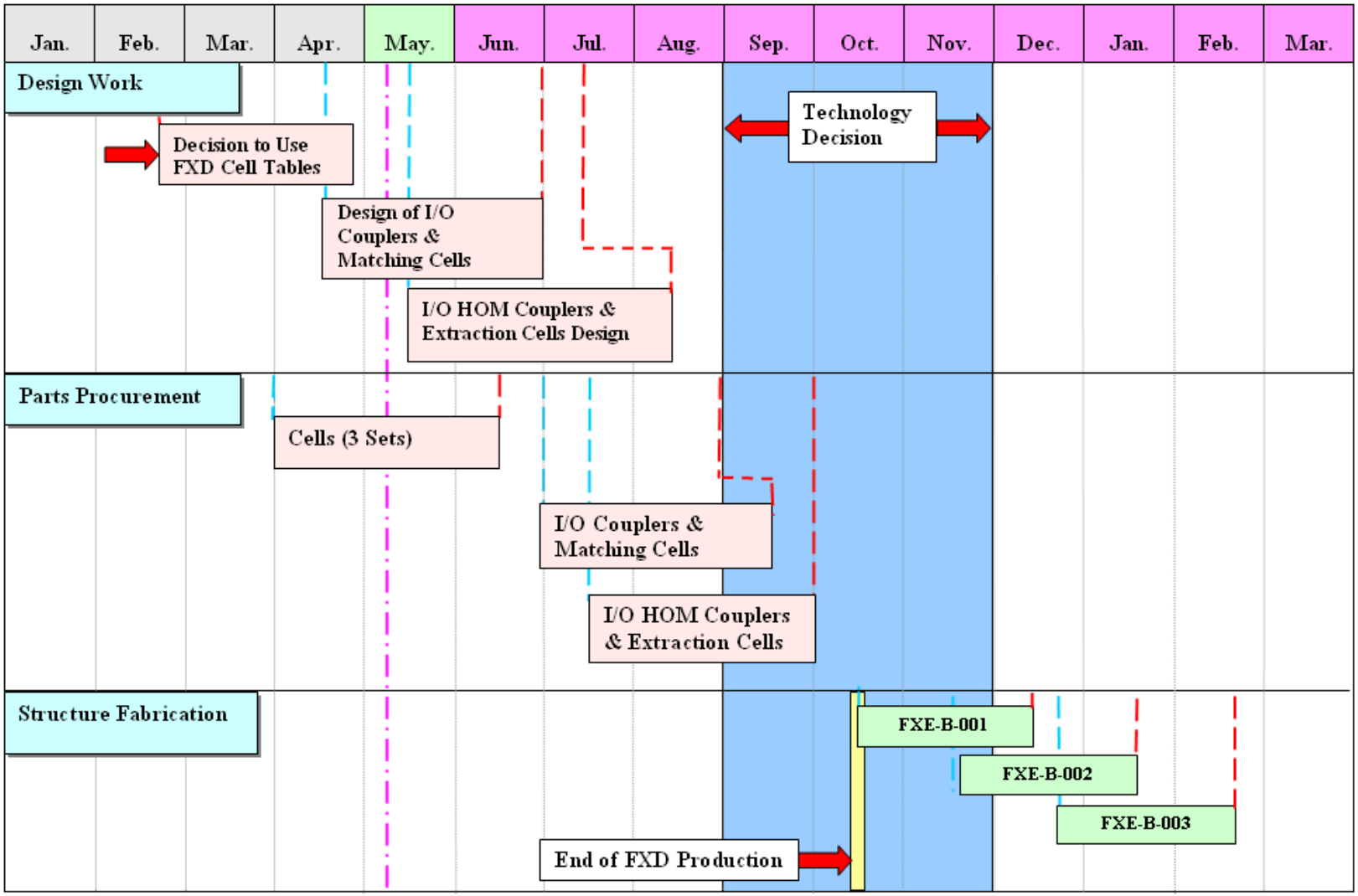
FXD Structure Fabrication Schedule



Present Status of Structure R&D: FXE Series

- Currently in the design stage
- We will use the FXD-B disk set design for the body of the structure, thus it will have the same electrical design as the FXDs, (H60VG4S17, 150 deg. , with I/O HOM extraction)
- Cells for 3 structures have been ordered
- The Fermilab "fat-lipped" coupler design will be used in order to regain the lost accelerating gradient that occurs with the waveguide coupler design. A single RF input coupler design will be developed, while the output coupler will employ either two or four output RF flanges.
- Internal silicon carbide loads are being investigated for the HOM manifolds.

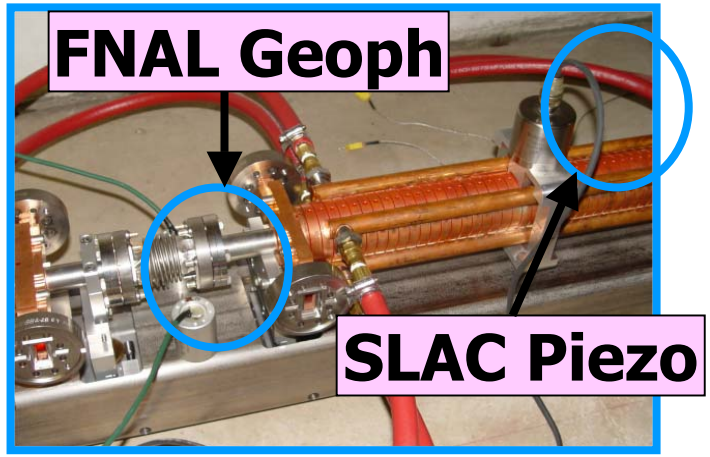
FXE Structure Fabrication Schedule

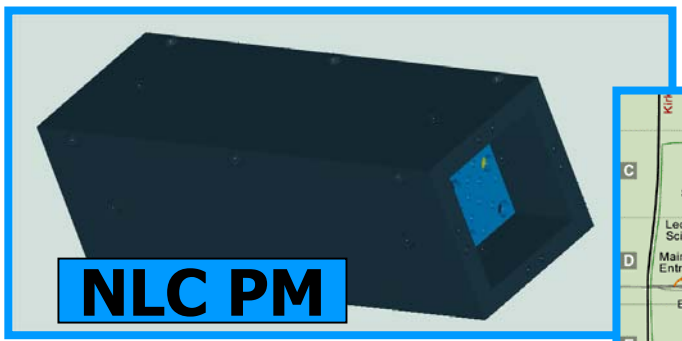


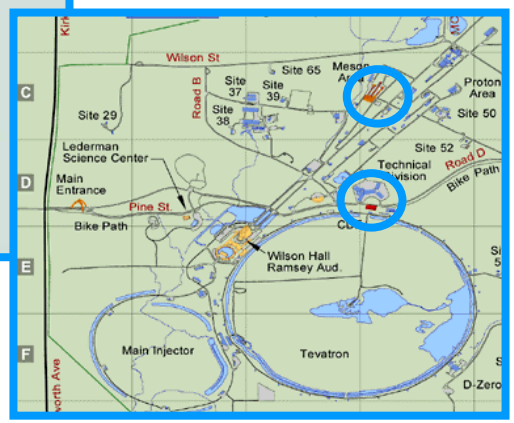
Present Status of Girder R&D: Vibration Studies

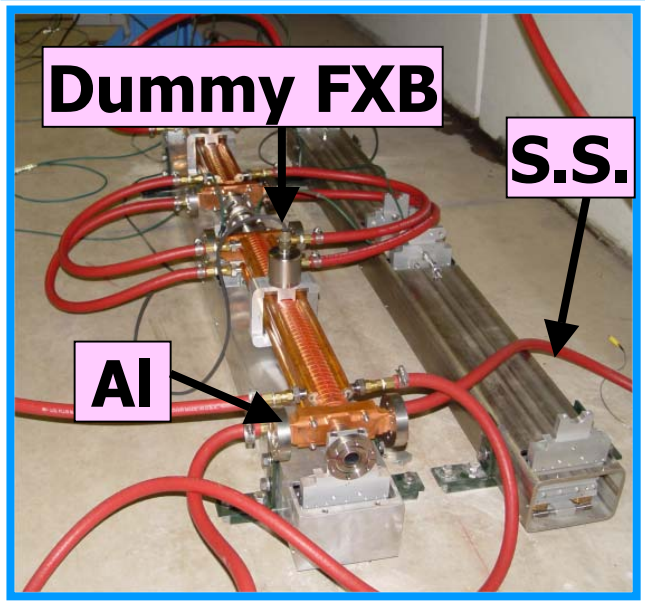
Studies:

- Effect of cooling water on structures stability
- Comparison of Al and Stn.Stl. strongbacks
- Effect of vacuum on vibration transmission
- Transmission of vibration to quads (PM EM)
- Study on more realistic supports
- Effect of movers on structure stability
- Adding more constrains: waveguides

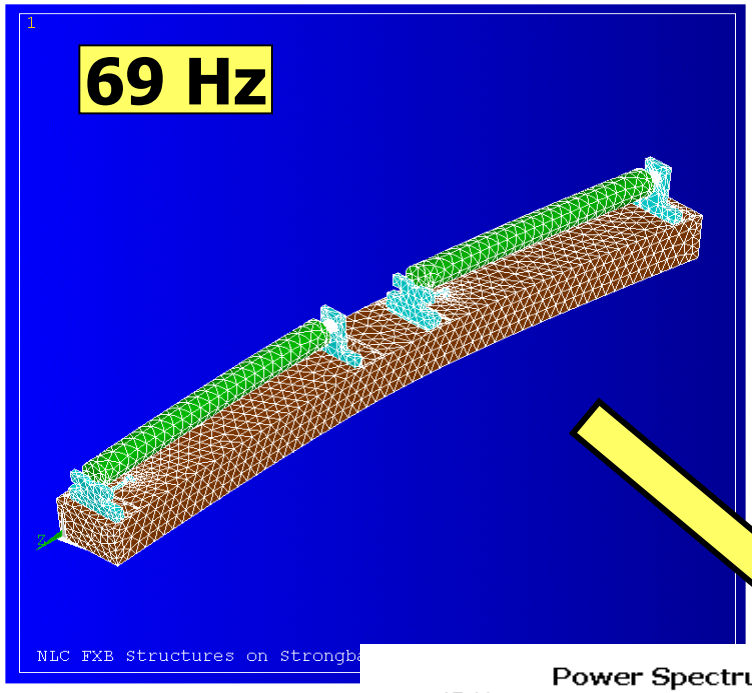


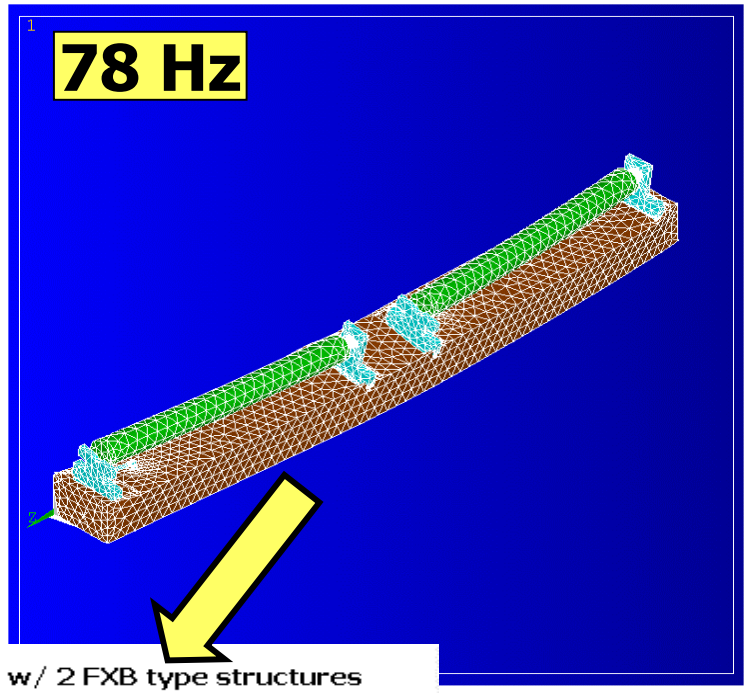


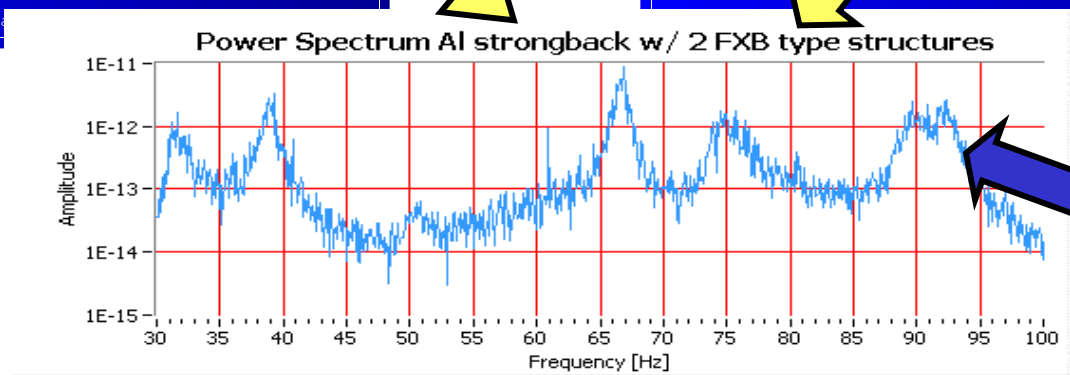




Present Status of Girder R&D: 3-D Modeling and Analysis (C. Boffo)







87 Hz
95 Hz

Future Plans

The Technology Decision and Its Impact---The decision will come too late to significantly influence FY05 funding. Our guidance is to assume flat funding for FY05. If the decision is COLD, we will:

- Complete FXD Structure Series
- Build Our Next Structure: FXEs
- Girders---Complete R&D and Build Prototype

Once this work is completed, we would ceased further X-band R&D.

Future Plans

The Technology Decision and Its Impact: If the decision is WARM, we will:

- Complete FXD Structure Series
- Our Next Structure: FXEs
- Girders---Complete R&D and Build Prototype
- Get back to our original mission---industrialization of structure production
- X-Band Power at Fermilab (Joint effort between TD and AD)
- Initiate planning and design work for an ETF

Conclusion

- I have given you an overview of what we have accomplished, our ongoing work, and our future plans. Even if the technology decision is cold, we will continue our X-band effort through the end of this calendar year.
- I encourage you visit our facility if you haven't already done so, we are always happy to give tours.
- Any Questions?