

Outline:

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- RF Structure Fabrication & Testing
 - FXA Structures
 - FXB Structures
 - FXC & FXD Structures
- Strongback & Girders
- Milestones, Goals & Schedule

RF Technology Development (Conventional) Group

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Mission:

- Original mission was to develop industrialization of the structure manufacturing process. This included:
 - Developing vendors to supply structure component parts
 - Developing vendors to supply assembled structures
- Our mission has evolved into the above, plus as a higher priority, we are to supply test structures in support of the Eight Pack Program at SLAC

RF Structure Factory

•FNAL Structure Group's goals for the RF Structure R&D Factory:

- RF Design
- RF Disk Fabrication & Quality Assurance
- RF Structure Fabrication & Quality Assurance
- Infrastructure Setup for all above

•Major Infrastructure of the Factory are:

- Two Clean Rooms, RF QC Area, Work Area
- Two Vacuum Furnaces inside a soft sided Clean Room
- Clean Room Leak Detector, Clean Room Pumping Station, RGA, Anaerobic Chambers, etc.

Factory Infrastructure



RF Structure Fabrication & Testing

FXA Type RF Structures

• We have produced three 20-cm long traveling wave structures: FXA-001, FXA-002 and FXA-003

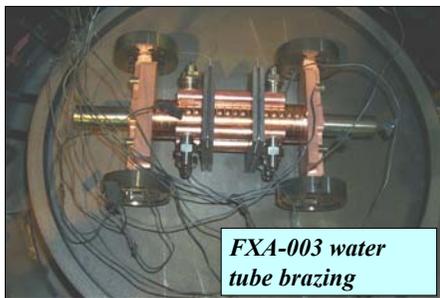


- Design is identical to SLAC T20VG5 structure (except brazing grooves in the disks)
- All brazed structures, no diffusion bonding
- Disks are precision machined, no diamond turning
- Couplers are precision machined with some diamond turned RF surfaces (iris area)

• FXA-001 was brazed at an outside furnace company

• FXA-002 couplers were brazed in Fermilab Small vacuum furnace and the rest of the brazing was done at an outside company

• FXA-003 was totally brazed and fabricated in Fermilab vacuum furnaces



FXA-003 water tube brazing

These structures were not high power tested. They were produced to evaluate the feasibility of the Factory Infrastructure and to learn & gain experience in RF structure fabrication

FXB Type RF Structures

• We have produced six 60-cm long traveling wave structures: FXB-002 and FXB-007.

• Five of the six structures (FXB-002, -003, -004, -006 and -007) have undergone high power testing at NLCTA

• FXC-006 achieved TRC R1 design requirement with 0.1 breakdowns in 1 hr. at 65 MV/meter gradient

• We have produced 9 full length dummy (no iris) structures for Girder studies and brazing / fixture tests

• Design is identical to SLAC H60VG3 structure (except brazing grooves in the disks).

• All brazed structures, no diffusion bonding. Brazing in Vacuum furnaces, no hydrogen

• Disks are precision machined, no diamond turning

• Couplers are precision machined with some diamond turned RF surfaces (iris area)

• Traveler Development (it is currently fully implemented & controlled)

From FXA to FXB structures:

• Disk OD was increased from 45 mm to 61mm. Structure length was increased from 20 cm to 60 cm (New Tooling)

• Fat-lipped design couplers to reduce the pulse heating (FXB-002 and FXB-003)

• Fermilab design waveguide (FWG) couplers (FXB-004 to FXB-006)

• Disk & Coupler Etching with SLAC C01 procedure

FXB Structure Production 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 design “fat-lipped” I/O couplers used.

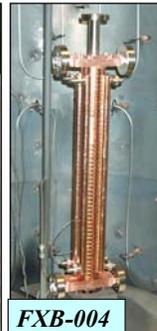
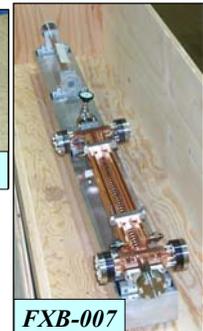
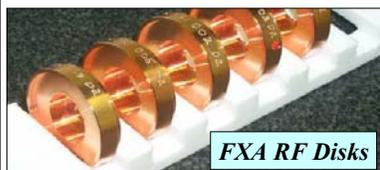
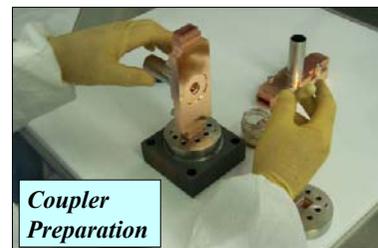
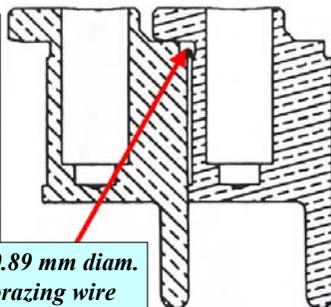
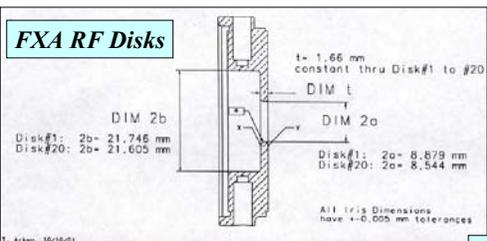
FXB-003: All-brazed structure assembled at Fermilab but subsequently processed with 100% hydrogen at 1-Torr partial pressure in a vacuum furnace at ATP. Fermilab design “fat-lipped” I/O couplers used.

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

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

FXB-006: Same as FXB-004 but disks were vacuum-fired at 1000 C for one hour prior to stack assembly & assembled structure was vacuum baked at 500 C for 72 hours. Achieved the TRC R1 breakdown rate design requirement.

FXB-007: Identical to FXB-006.



RF Structure Fabrication & Testing

FXC Type RF Structures

• We have produced five 60-cm long traveling wave structures: FXC-001 to FXC-005

• These structures will be used for Phase 2 of the Eight-Pack test at SLAC



• Design is identical to SLAC H60VG3S17 structure (except brazing grooves in the disks)

• 60 cm. long, 61 mm o.d. cells; 150 degree phase advance; 3% group velocity; slotted cells with .17 a/l

• All brazed structures (w/o hydrogen), no diffusion bonding. New brazing features were added to the disks

• Disks & Couplers are precision machined, no diamond turning (industrial vendors)

From FXB to FXC structures:

• HOM holes and keyhole slots were introduced to the RF disks; no HOM extractions

• Fermilab design waveguide (FWG) couplers and matching disks

• Tuning holes were increased from 2 to 4

• Rotational alignment feature on the RF disks

• Rosette shape dam instead of circular dam to stop the braze material flow into the RF volume

• 1000 degree C bake of the individual disks before brazing for grain growth

• 72 hrs final vacuum bake

Brazing Tests were successfully completed:

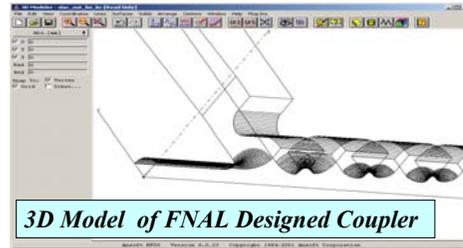
SLAC joins the RF disks with Diffusion Bonding. We also considered the same technique for FXC disks because of the HOM features.

Diffusion Bonding requires 2.5 micron flatness on the bonding surface which is impossible to achieve with precision machining. Disks have to be single point diamond turned in order to achieve the flatness requirement. This is a very costly approach

We decided to continue with brazing approach. We changed some features on the brazing groove design. With this approach, we eliminated the tight flatness requirement

RF Design & Testing

We have improved our “in-house” RF design capabilities through the purchase of more powerful software and hardware and through collaboration with our SLAC and KEK colleagues



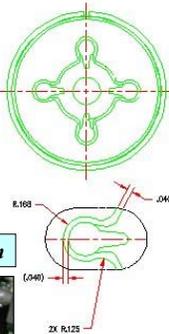
3D Model of FNAL Designed Coupler

Fermilab designs various waveguide couplers to be used with SLAC design RF structures

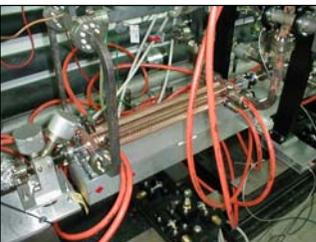


Single Disk RF QC Fixture

Single Disk RF QC is conducted on the disks after we receive them from our vendors. This is a very reliable, quick inspection of the disk quality



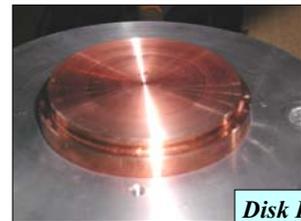
FXC Disk with Rosette Shaped Dam



FXC-001 at NLCTA



FXC-003



Disk RF QC



RF Structures are tuned with Bead-Pull Fixture after final brazing

FXC Structure Production History:

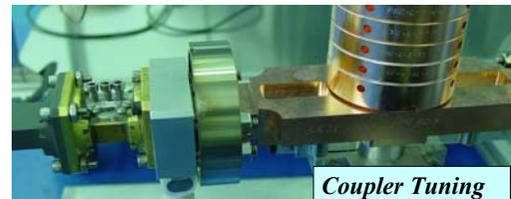
FXC-001: Completed on January 04. Disks were not hand deburred (brazing dam, keyhole radius). High frequency disks due to braze material leakage caused by burrs on the brazing dam. Did not perform well under high power testing.

FXC-002: Completed on January 04. All disks brazing dams were hand deburred except output coupler matching disk. High frequency output coupler matching disk due to braze material leakage cause by burrs on the brazing dam. No deburring around keyhole radius. Repaired with tuning pins brazing.

FXC-003: Completed on February 04. All disks brazing dams were hand deburred. Some disks were deburred around keyhole radius after inspection. Disks were etched twice. Achieved TRC R1 design requirement with 0.1 breakdowns in 1 hour with 65 MV/meter gradient.

FXC-004: Completed on March 04. All disks were hand deburred (brazing dam, keyhole radius). Disks were etched twice. Currently undergoing high power testing at NLCTA.

FXC-005: Completed on March 04. All disks were hand deburred (brazing dam, keyhole radius). Sent to SLAC for testing.



Coupler Tuning



HOM Extraction Design



Cell Tuning

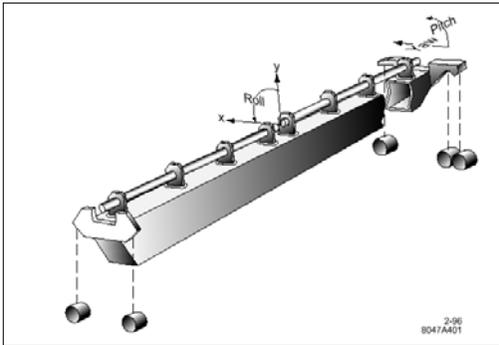
FXD Series of Test Structures

(aka H60VG4S17): 60 cm. long, 61 mm o.d. cells; 150 degree phase advance; 4% group velocity; tapered design with slotted cells and .17 a/l

FWG I/O couplers; I/O HOM extraction; twofold interleaving design feature

Girders for RF Structures

Girders serve as the supporting bases for RF structures. They can be of the more simple box beam “strongback” design in use at the NLC Test Accelerator (NLCTA) at SLAC, or a more complex design with a kinematic support system and multi-axis positioning capability.



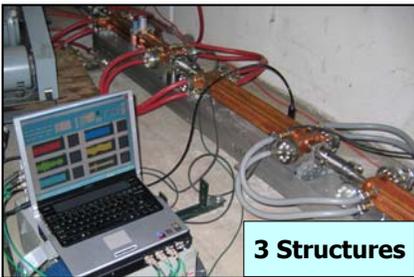
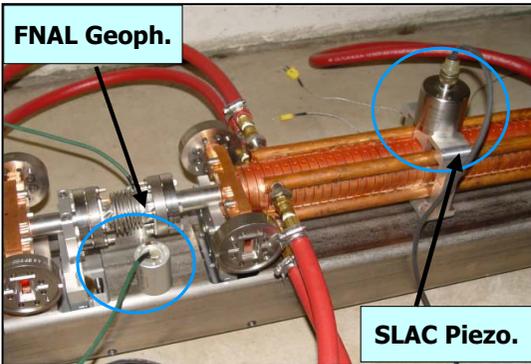
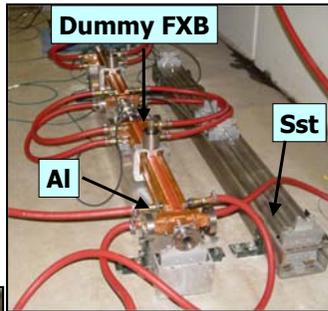
X-Y Roll
X-Z Yaw
Y-Z Pitch

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

Vibration Studies @MP8:

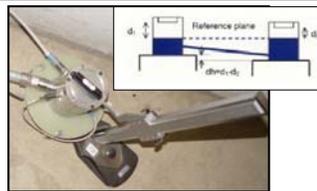
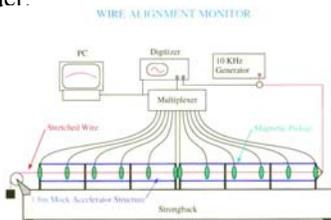
Studies:

- Effect of cooling water on structures stability
- Comparison of Al and SSt 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



Stability Measurements:

Study the effect of temperature variation and gradients on alignment of structures on a girder.



Eight-Pack Test @ SLAC

The 8 pack Project will construct an operating NLC spec. power source using a solid state induction modulator powering two 75 MW X-band klystrons, with a SLEDII pulse compression system. The system will be capable of producing the 450 MW 400 ns long pulse required by the NLC at each group of accelerator structures. In Phase I of the project, the SLEDII system will be commissioned to generate a 475MW 400ns pulse at its output. In Phase II, this power will be split to accelerator structures on the NLCTA beamline. In Phase II, a “pack of eight klystrons” will feed 11.424 GHz X-Band power into a Sled II system and power at least 5.4 meters worth of structures with the full power and energy required by the NLC design. The goal is to be operational by April 2004.

Fermilab is currently fabricating RF structures to support Phase II.

Milestones, Goals and Schedule

- The excessive maintenance effort required to keep our large vacuum furnace operational has been eliminated with the installation of the new furnace hot zone.
- FXB structure production was completed in FY03. Six FXB structures were produced.
- Nine “Dummy” FXB structures were produced in FY03.
- FXC structures cell fabrication and brazing tests were completed in FY03. FXC production is completed on schedule to deliver 4 structures by March 2004 in support of the Eight-Pack test at SLAC.
- FXD parts (disks & couplers) for six structures have been ordered. FXD-A parts were received. FXD-A-001 will be sent to SLAC by the end of March 04 for Eight-Pack test. Remainder of the FXD structure will have HOM extractions. RF Design work for FXD HOM extraction is completed, brazing tests are on going for mechanical design completion.
- FXE type RF structures design is under progress. This structure will be an all Fermilab design and will have HOM extractions.
- We continue to improve our RF Structure Factory Infrastructure and Structure production procedures with fully implemented travelers & documentation control (Interface Control Document for 8-Pack)
- We continue to improve our RF testing and measurement capabilities in support of structure production. We continue to improve our RF design and analysis capabilities.

Processing results from the 4 latest NLC/GLC prototype structures

