U.S. MAGNET DEVELOPMENT PROGRAM

Fiber-optic diagnostics development at FNAL: status and FY22 plan

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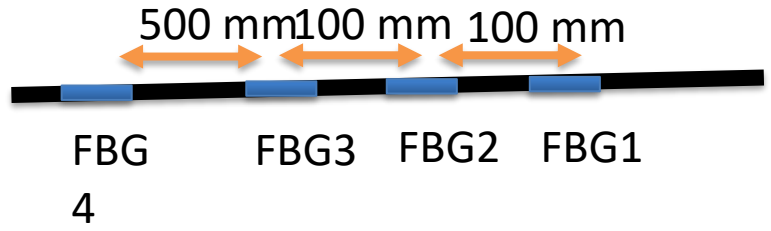
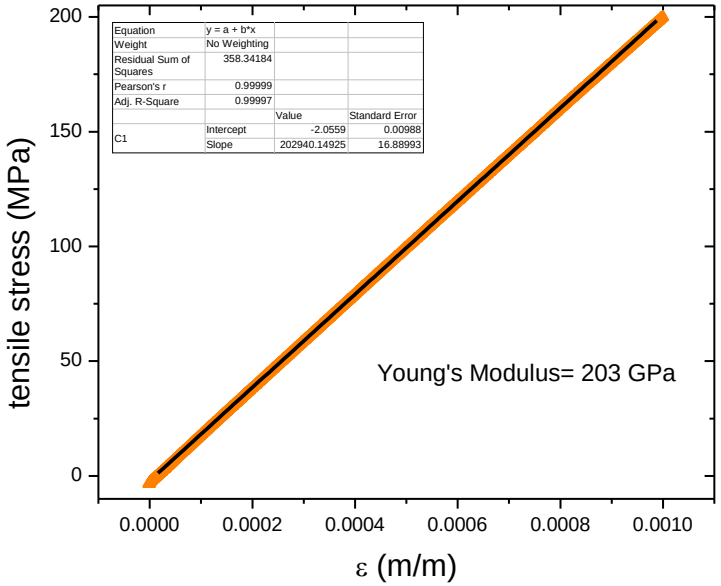
Outline

- FY 2021 results
- Plan for 2022
- MDP milestones and conclusion

FY-21 work: Tensile stress test on Ti and Steel at 300 K

- AISI 1080 steel and Ti
- Instron press in IB3 up to 200 MPa
- Fibers vs strain gauges
- Tensile vs Poisson strain





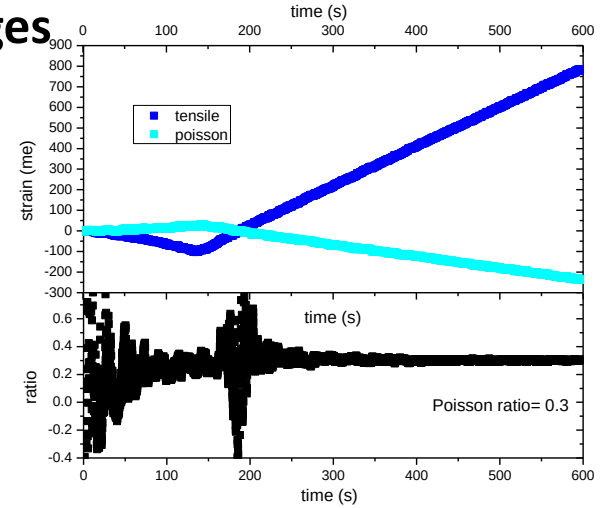
Conclusions

- Young modulus measured with FBG sensors is in very good agreement with what is expected for steel and Ti.
- Tensile stress tests performed at 300 K were successful
  - Gluing has been performed correctly

FY-21 work: Tensile stress test on Ti and Steel in LN

- AISI 1080 steel and Ti
- Instron press in IB3 up to 200 MPa
- Fibers vs strain gauges
- Tensile vs Poisson strain

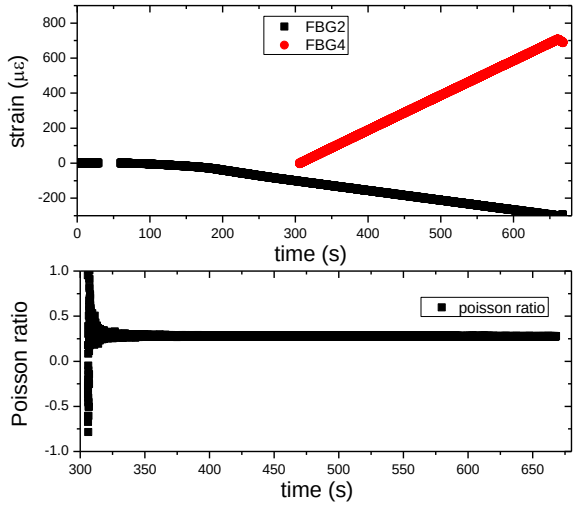
Strain gauges



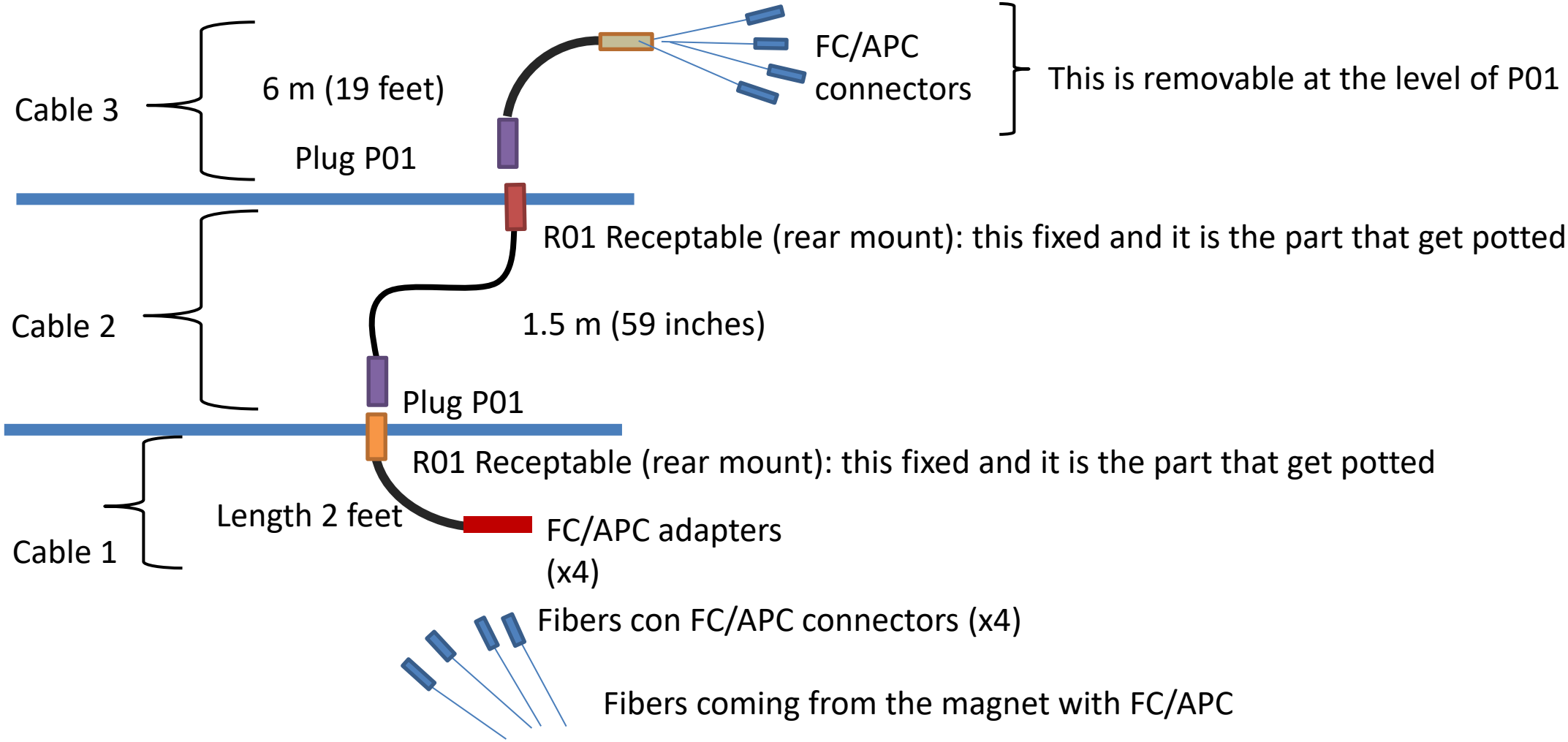
Conclusions

- Tensile stress was applied up to 200 MPa in Liquid Nitrogen
- Strain variation is around 800 με for both strain gauge and fibers
- Poisson ratio is 0.3

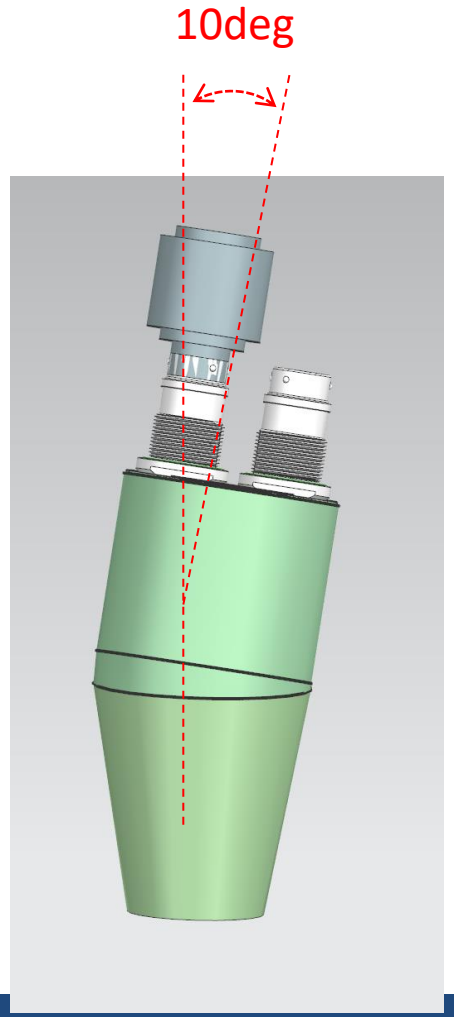
FBG sensors



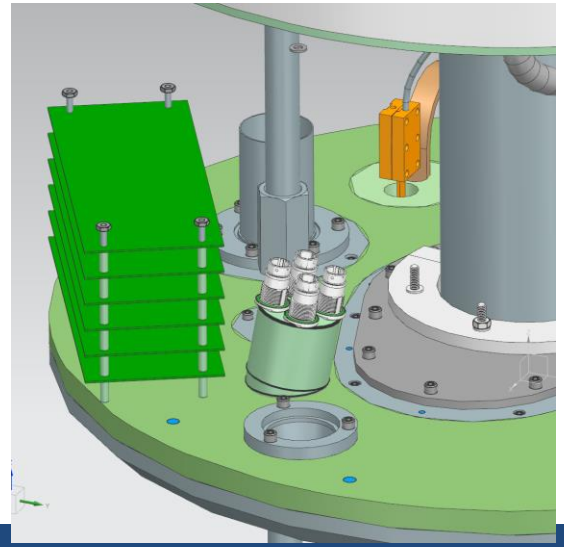
FY-21 work: VMTF modification

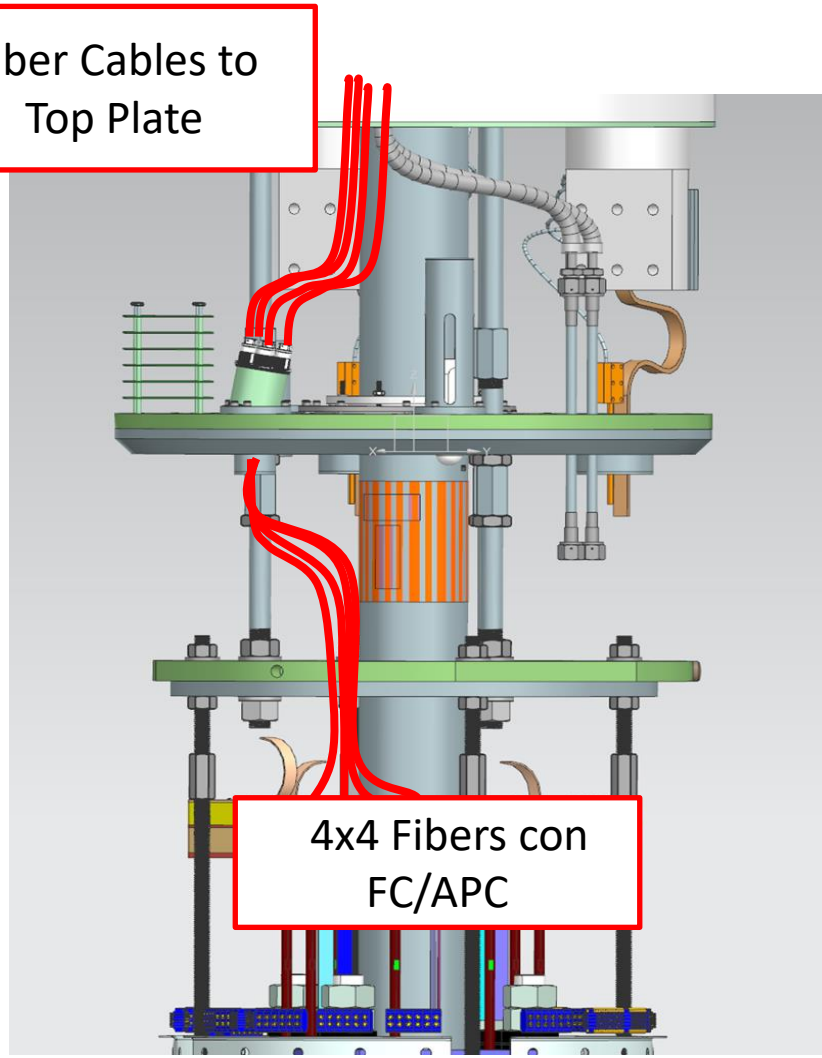


Fiber Optic Caple- Passing trough Lambda Plate on 30kA VMTF Top Plate

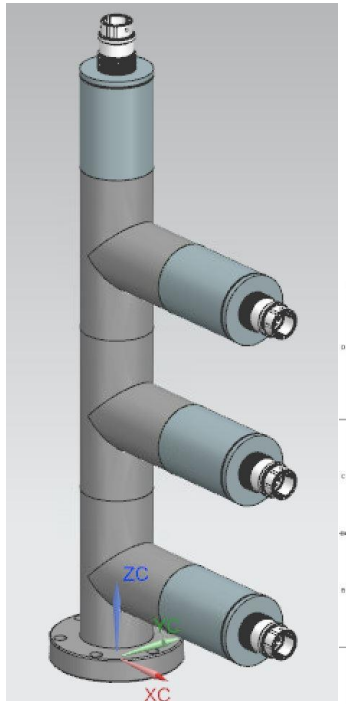


- G-10 Lambda Plug
- Offset at 10deg for low clarence with resistor boards
- Connector potted with Stycast 2850
- Cables tested- 1/(16) fiber has no response



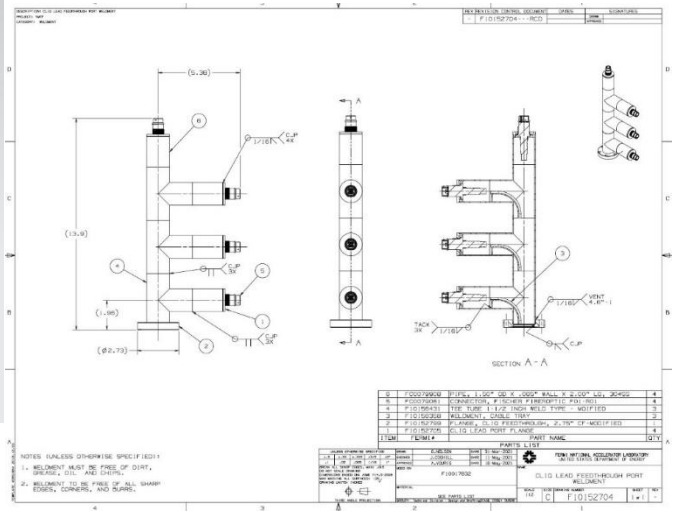


Fiber optics instrument tree

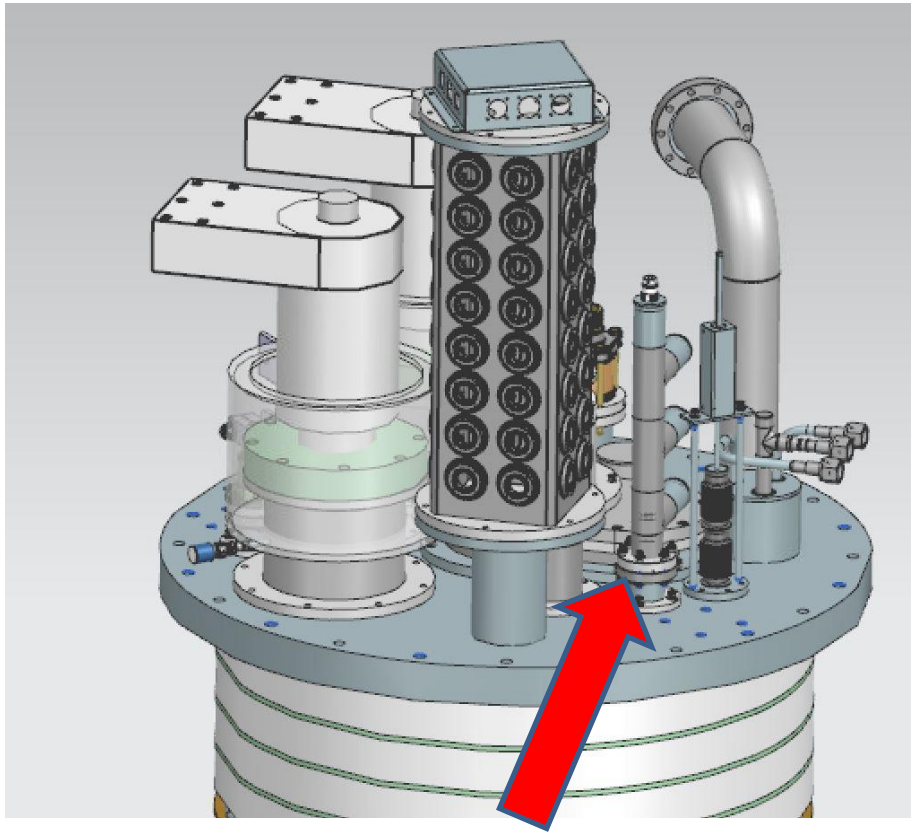


Remove & Replace CLIQ Lead with Fiber Optic Instrumentation Tree

Fiber Optic Connectors Internally
Potted with Stycast



Picture
Courtesy of
V. Nikolic
A. Vouris

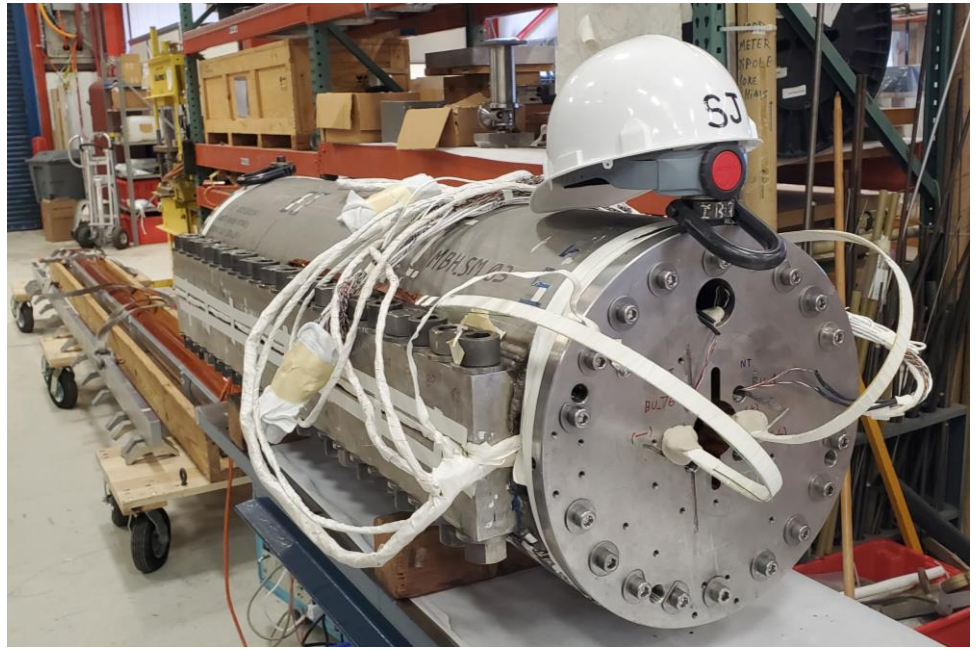


Test the feedthrough system in November

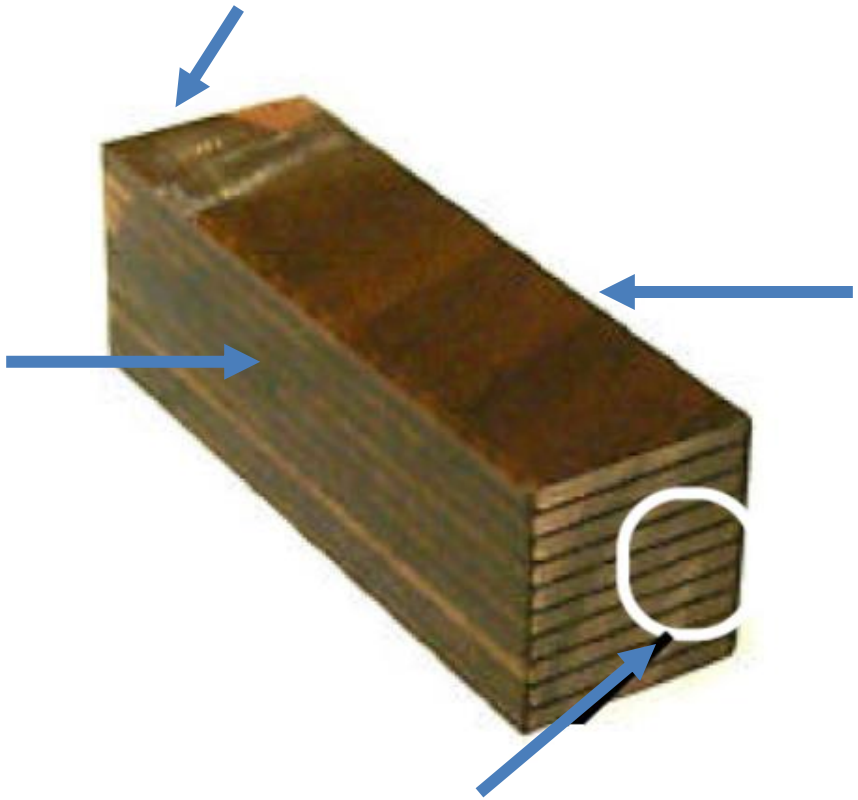
FY-2022 plans

December/January

- Glue fiber on the shell of FNAL mirror magnet for QCD
- Test the fibers during magnet test **by Jan 22**



ShFY-2022 plans



Apply load on a ten stack cable

Use an impregnated Nb3Sn ten stack cable

- Apply fiber sensors on each side of the ten stack, across and along the cable

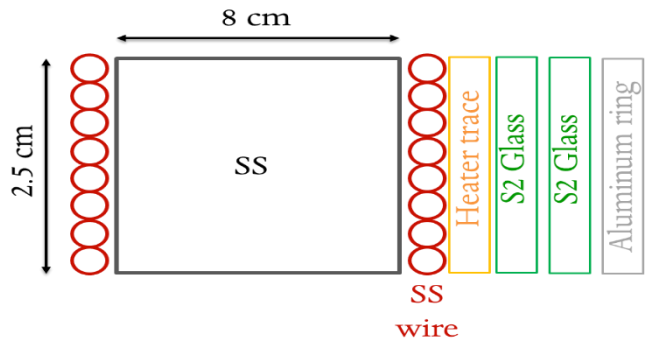
GOALS

- apply a load at 300k and in LN2 on a “simulated coil”
- Distinguish between epoxy and Nb3Sb behavior (spectra)

Test performed **by March 2022**

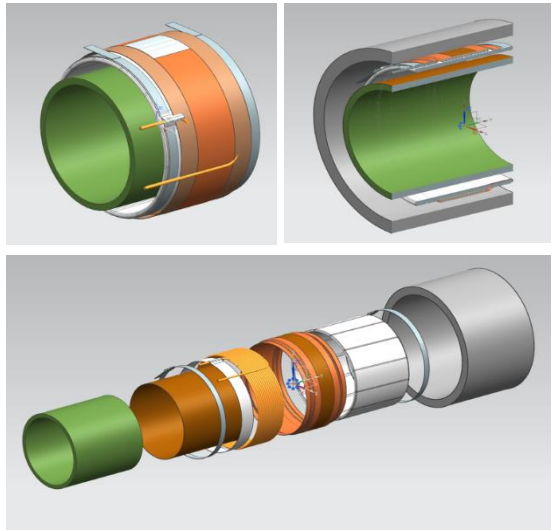
FY-2022 plans

Simulate quench conditions



Use small solenoid made of cheap NiCr or NbTi leftover wires:

- Wound one fiber with the wire and impregnate coils with epoxy



Fabrication by May 2022
Test in June-july 2022

GOALS

- Simulate quench conditions:
  - Use a spot heater
  - Identify quench position and travelling
  - Encapsulate fibers: temperature variation for energy spectrum analysis

Small solenoid design and impregnation have been already tested for AUP coil insulation strength studies

conclusion

AIIId-M12	**Calibration of FBG fibers in a small cryostat (...). Installation on an MDP magnet and strain measurement during a quench (...). Design a proof of principle experiment for quench 3D spatial detection and coil azimuthal strain mapping and install fiber on MDP magnet (...). Use fibers for energy spectrum analysis and HTS quench detection(...).**

By Dec 2022

- Fiber development with FBG sensors for strain measurements
- Design and perform proof of principle experiment with small coil