Half-Wave Resonator Cryomodule Status

Zachary A. Conway

DOE Independent Project Review of PIP-II

15 November 2016

Zachary Conway

- **Half-wave resonator cryomodule project manager at Argonne National Laboratory.**

- **Relevant experience:**
  - **Superconducting radio frequency device development.**

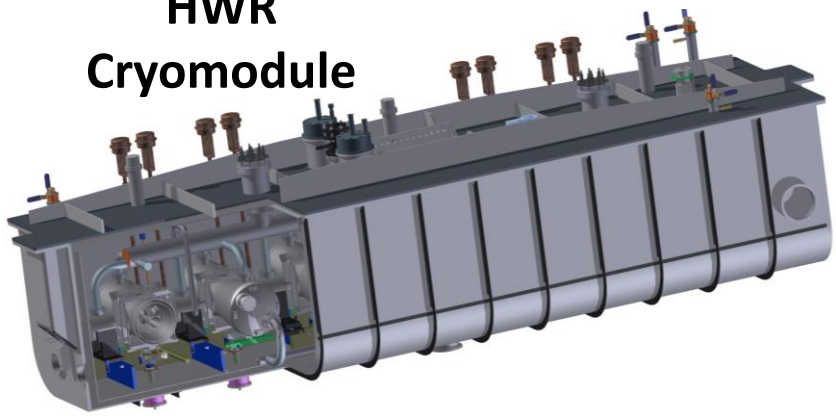
HWR Cryomodule, PIP2IT and PIP-II

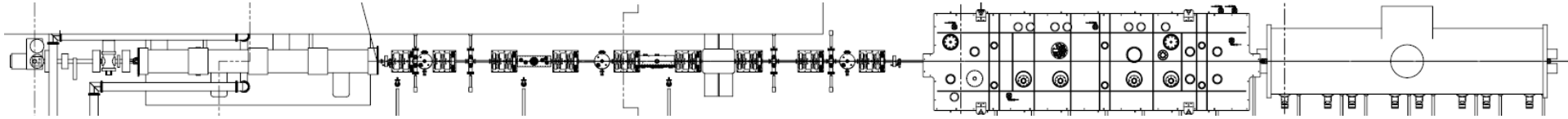
Charge Item: #2

Holmes, Lebedev, Derwent

- **The HWR is the first superconducting cavity cryomodule in the new 800 MeV injector.**
- **Located after the MEBT and before the first single spoke resonator cryomodule.**
- **Part of PIP2IT and will then move to PIP-II, no construction phase work.**

HWR Cryomodule





Fermilab

PIP-II

Outline

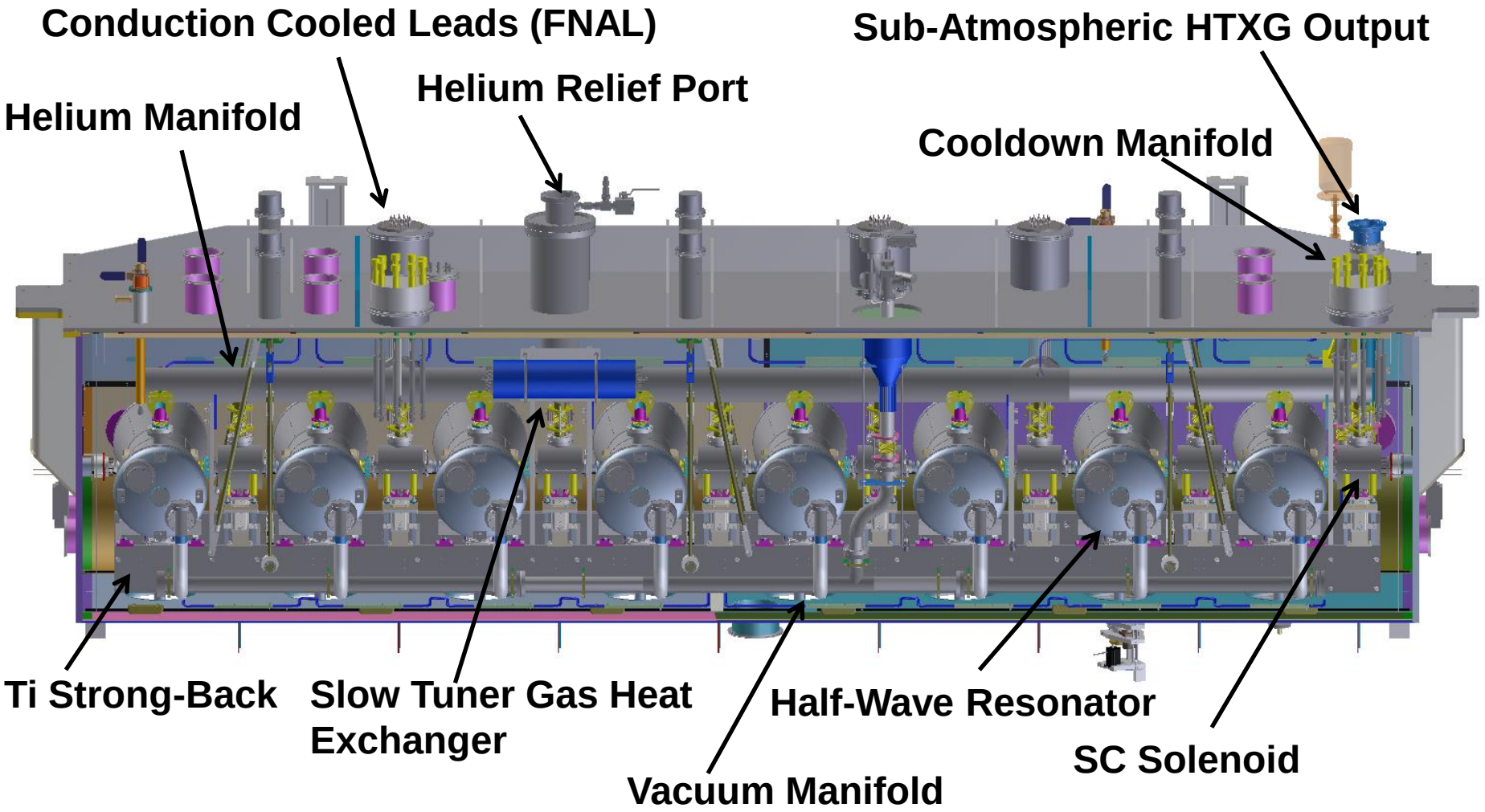
- **Scope of Work**
- **Half-Wave Resonator (HWR) Cryomodule Overview**
  - **Cryomodule Assembly Preparation**
  - **Half-Wave Resonator Processing**
- **Schedule to Finish HWR Cryomodule**

- **There are no construction phase follow-ups for this work. The final HWR cryomodule is intended to work in PIP-II.**

Scope of Work

- **ANL will design, fabricate and make ready for FNAL a HWR cryomodule for the acceleration of 2 mA H^- beams from 2.1 to ≥10 MeV.**
- **We have several formal agreements guiding this work:**
  - **Memorandum of understanding,**
  - **Statement-of-work,**
  - **Interface document, and**
  - **Functional requirements specification.**
- **HWR cryomodule design is compliant with both FNAL and ANL safety guidelines. FNAL experts sat in on all Argonne reviews in 2013.**
- **ANL is committed to delivering a working, high-performance HWR cryomodule to FNAL.**

HWR Cryomodule



2.2 m X 2.2 m X 6.2 m

FY16 Deliverables

Charge Items: #1 & 3

	Deliverables	Status
1	Complete fabrication of magnet assemblies.	Finished
2	Complete fabrication of sub-systems (RF couplers, slow tuners and BPMs)	Finished
3	Engineering cool down of the cryomodule to 80 K.	Finished
4	Complete RF surface processing of 7 production cavities.	In Progress
5	Testing of 7 production cavities individually in the test cryostat.	In Progress

FY17 & FY18 Deliverables

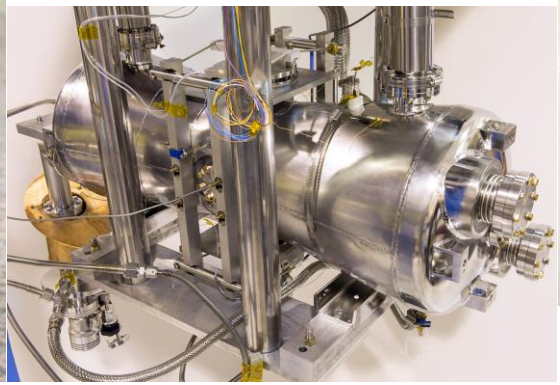
	Deliverables	Status
1	Assembly of the cryomodule.	Started.
2	Vacuum and cryogenic testing of the cryomodule.	Not started.
3	Delivery and installation at FNAL.	Not started.

Current Status – Select Sub Systems

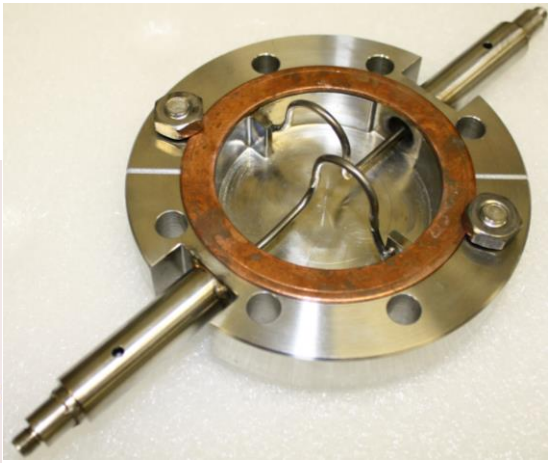
BPM

Beam Spool

Cavity w/ Slow Tuner

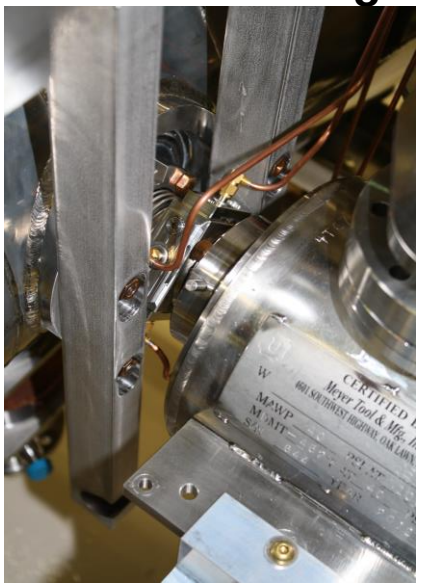


Cavity Pick-Up Probe

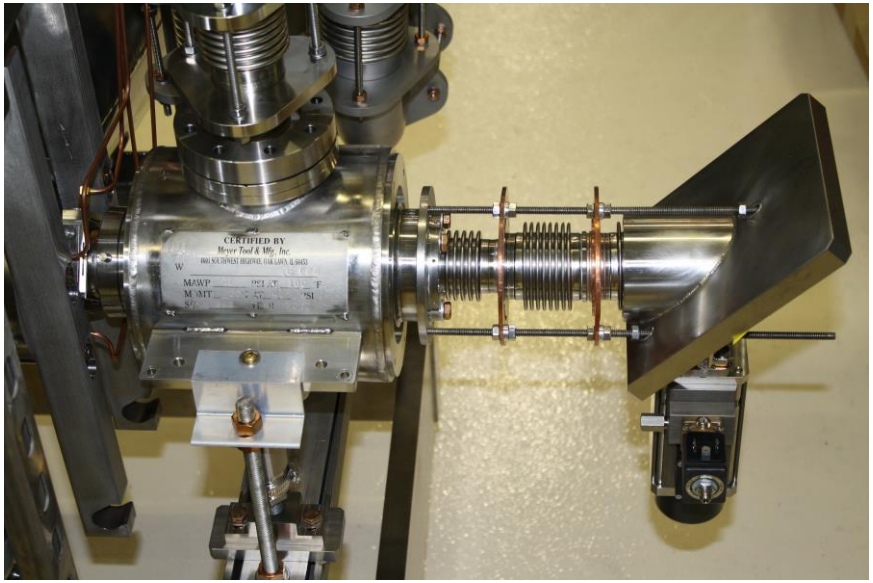


2/5 K Heat Exchanger

HWR, Solenoid, BPM & Cabling



Beam Line Gate Valve

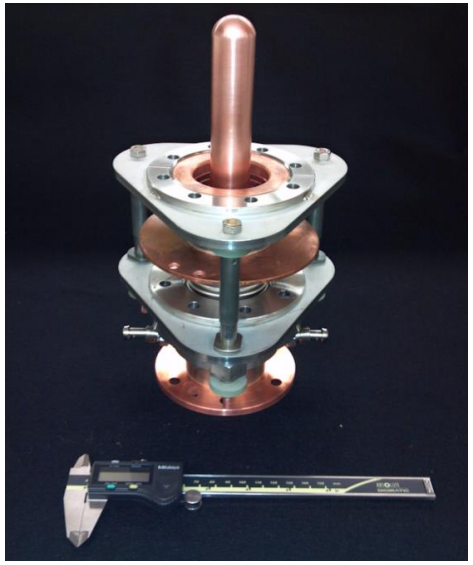


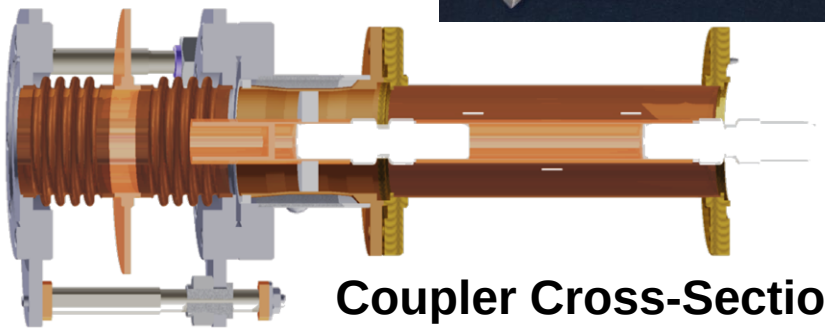
Fermilab

PIP-II

Current Status – Coupler Development

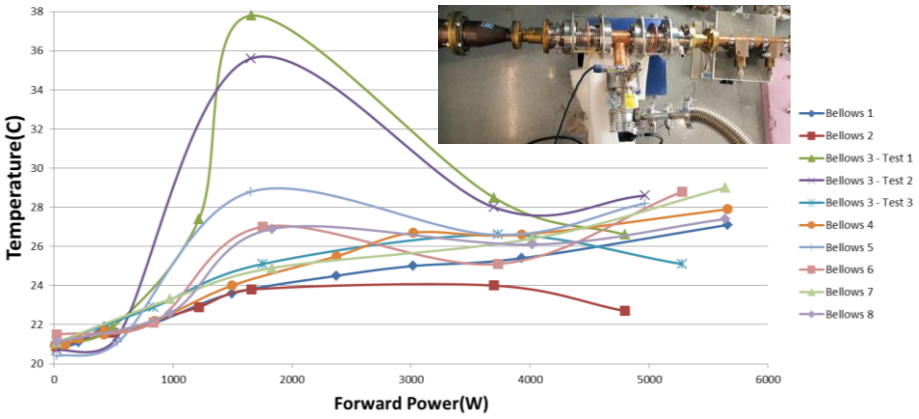
- **10 kW Forward Power, 50 Ω, ϕ50 mm Variable Co-Axial Coupler**
- **Coupler Comprised of 4 Regions With Separate Functions:**
  - **Warm RF Vacuum Window**
  - **Thermal Transition (Testing)**
  - **Cold RF Vacuum Window**
  - **2 – 5 – 70 K Variable Bellows**





Coupler Cross-Section

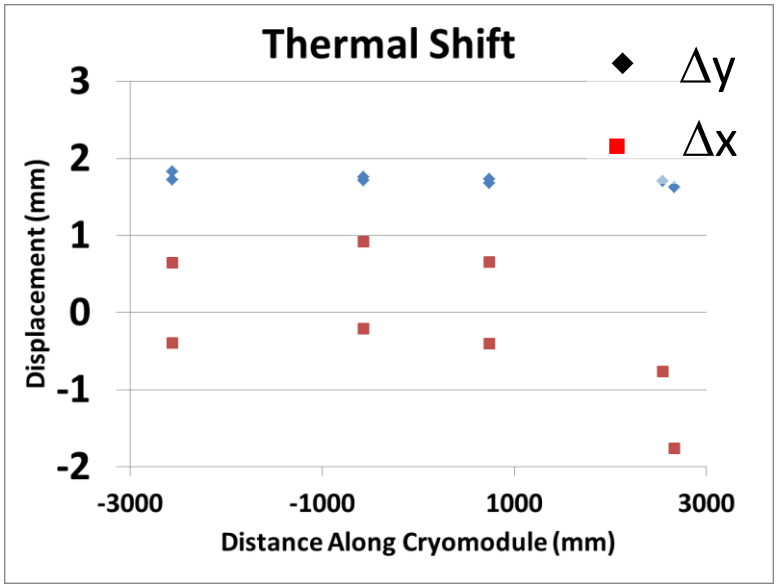
Coupler "Cold" Component Testing



Engineering Cool-Down Results

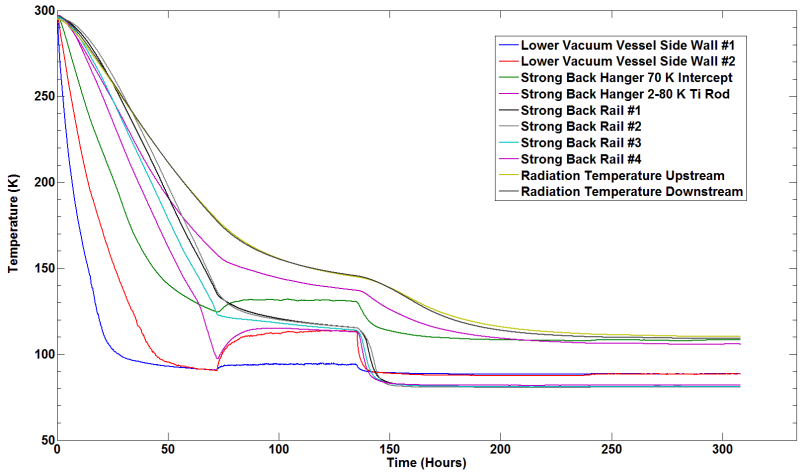
Cryomodule Alignment

Alignment Measurements

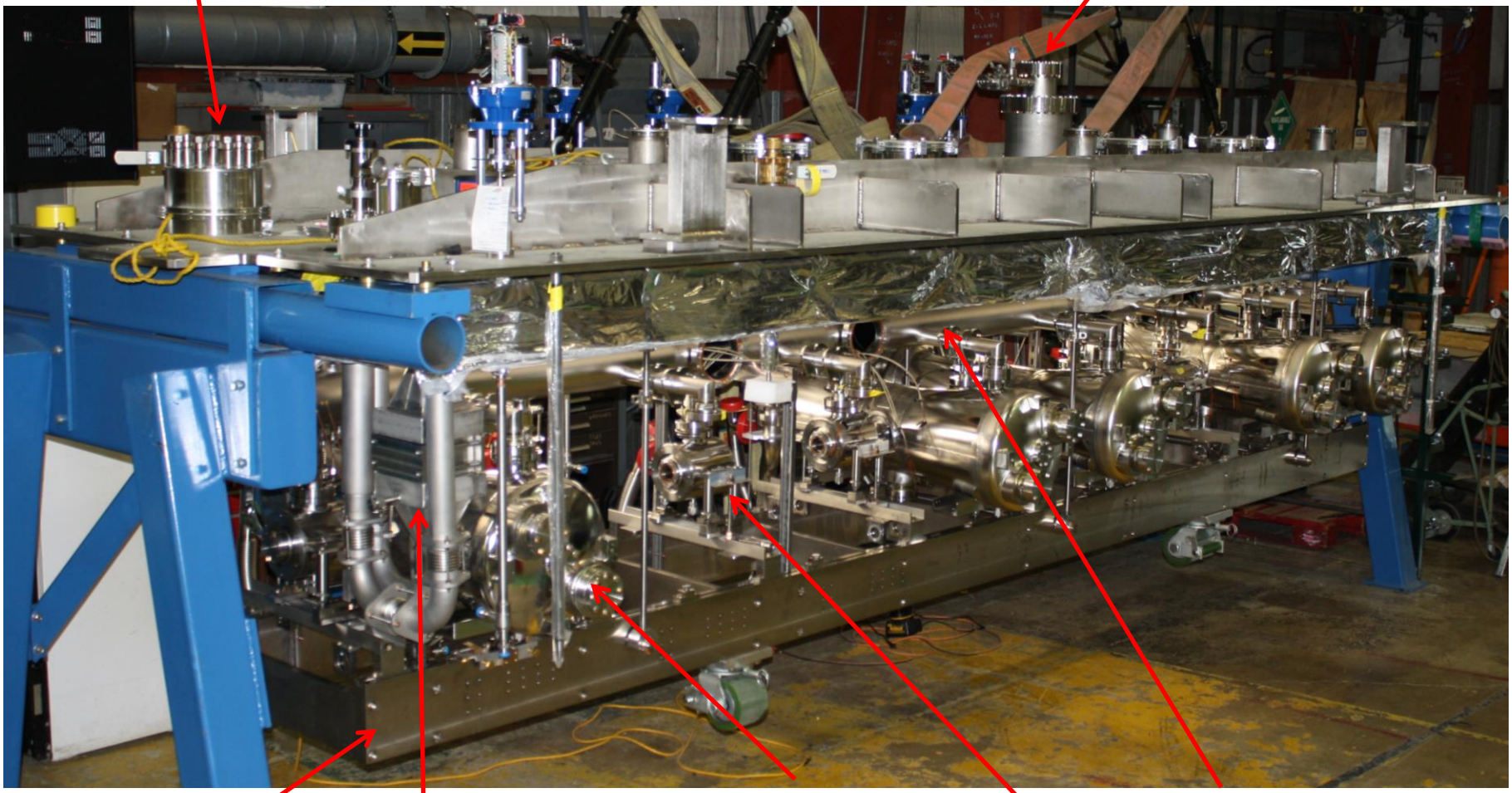


Cryomodule Assembly

Cool Down Data



Current Status – Cryomodule Preliminary Assembly



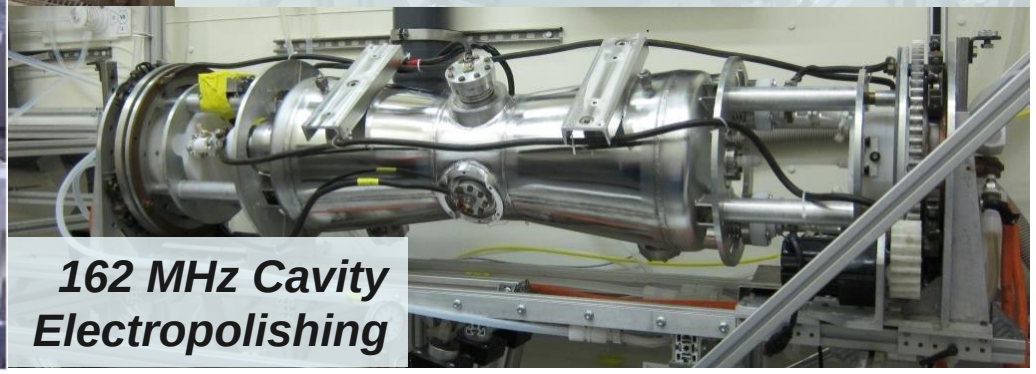
Half-Wave Resonator Processing & Testing

- **Remaining tasks to finish the HWR processing and testing:**
  - **QTY = 3 of 9 half-wave resonators remain to be finished.**
  - **Hydrogen degas the half-wave resonators.**
  - **Light (~20 μm) electropolish after hydrogen degassing.**
  - **Resonators cleaning and assembly for testing.**
- **Finished pre-bake of the half-wave resonator baking frame parts on 26 October 2016.**
- **The next half-wave resonator hydrogen degassing will be done after baking the frame components @ FNAL.**
- **We expect to finish all of this work by the end of February 2017.**

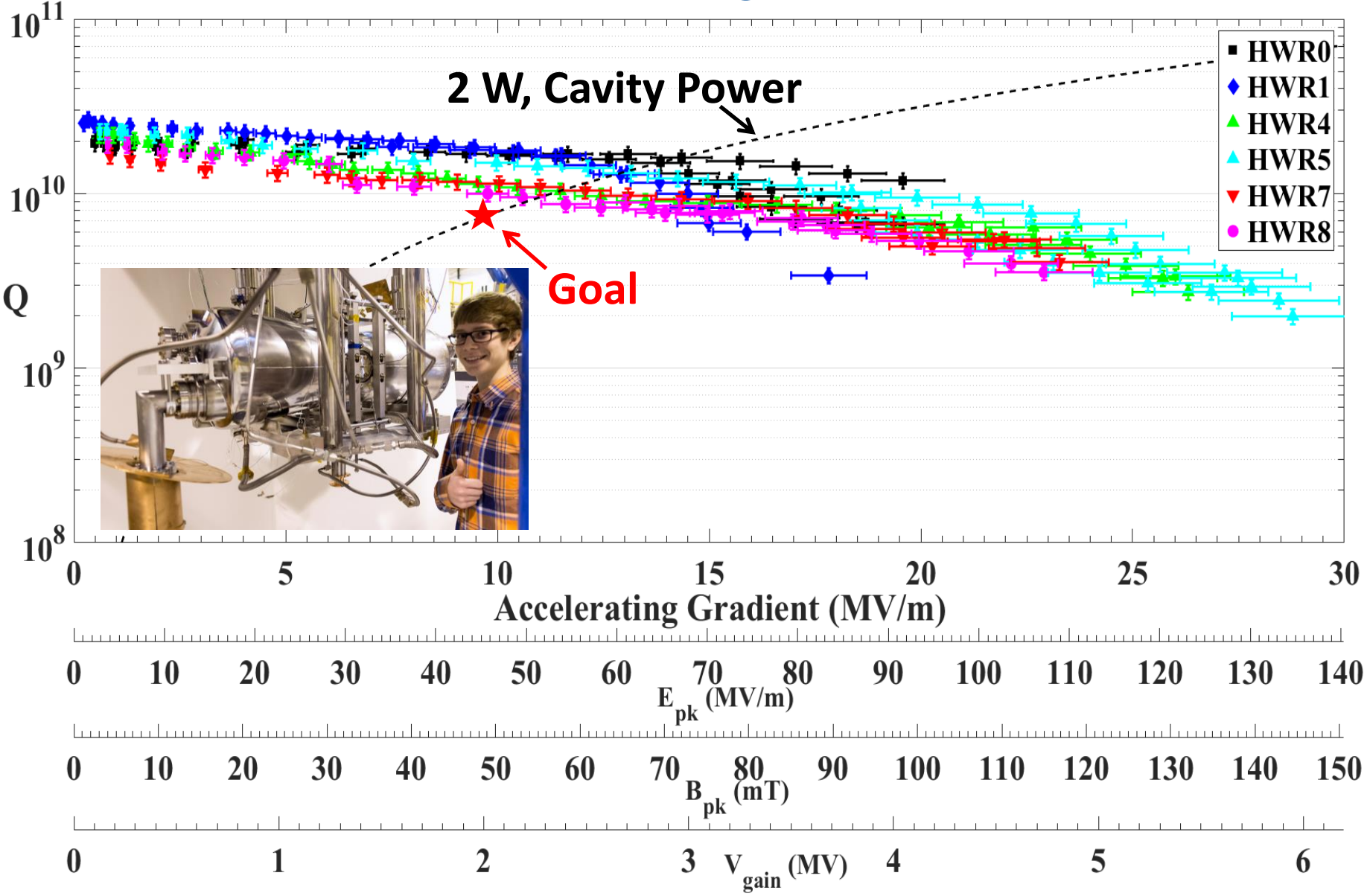
ANL/FNAL Collaboration on SRF Cavity Processing

325 MHz Spoke Cavity BCP

650 MHz Cavity Electropolishing



Half-Wave Resonator Testing

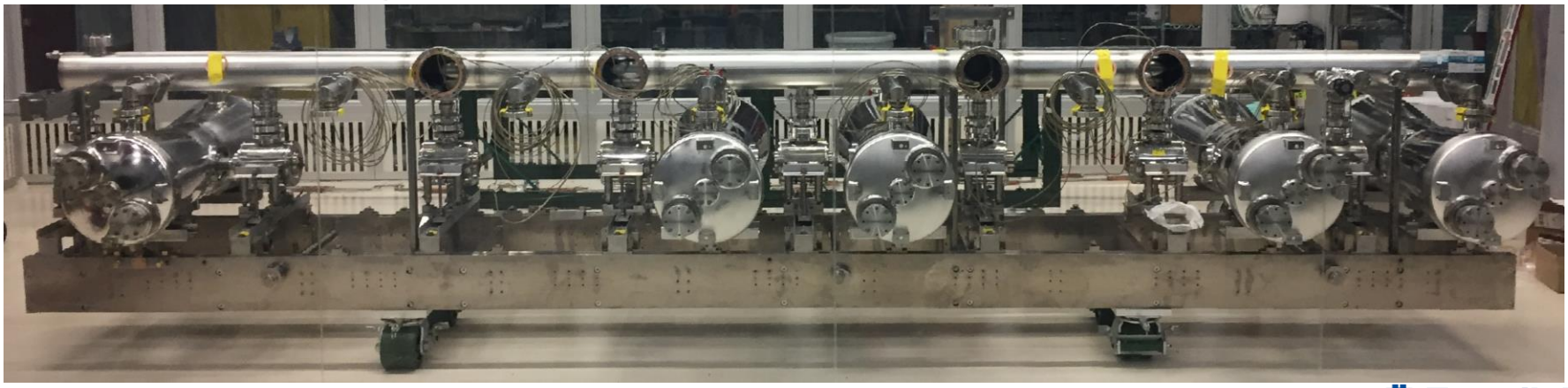


Schedule to Finish – FY17

- **Q2FY17:**
  - **Finish the cryomodule preliminary assembly.**
  - **Finish the hydrogen degassing and surface processing of the remaining 3 half-wave resonators.**
- **Q3FY17:**
  - **Finish testing of the 3 half-wave resonators.**
  - **Disassemble the preliminary cryomodule assembly.**
  - **Begin cleaning of all beam line components for the final cryomodule assembly.**
- **Q4FY17:**
  - **Finish cleaning all beam line components for the final cryomodule assembly.**
  - **Start cryomodule clean assembly.**

Schedule to Finish – FY18

- **Q1FY18:**
  - **Finish the cryomodule clean assembly.**
  - **Finish the cryomodule assembly.**
- **Q2FY18:**
  - **Final testing of the cryomodule at Argonne.**
    - **Leak test of all systems,**
    - **Operation of all sub-systems, and**
    - **Possible cold testing if time permits.**
  - **Transfer cryomodule to FNAL.**



Argonne Personnel Working on This Project

- **Senior Physicists:**
  - **M.P. Kelly (PHY).**
  - **P.N. Ostroumov (PHY).**
- **Physicist:**
  - **Z. Conway (PHY).**
  - **S.-h. Kim (PHY)**
- **Many thanks to FNAL for:**
  - **HWR Hydrogen Degassing**
  - **Cryomodule Hardware**
  - **Engineering Advice**
- **Engineers:**
  - **M. Kedzie (PHY).**
  - **T. Reid (HEP).**
  - **B. Guilfoyle (HEP)**
  - **A. Barcikowski (NE).**
  - **K. Wood (HEP).**
  - **F. Skrzecz (HEP).**
  - **W. Jansma (APS).**
- **Designers:**
  - **G. Cherry (NE).**
- **Technicians - TBD.**

Summary

- **All major sub-components for the HWR cryomodule are in-hand. A few are still being tested but progress is good for the funding we have.**
  - **We are performing a preliminary assembly of the cryomodule now.**
  - **10 kW couplers testing is on-going.**

- **The HWR cryomodule work at Argonne is advancing steadily.**

- **Delivery is planned for the second quarter of FY18.**