ARGONNE'S 72 MHZ QWR CRYOMODULE PERFORMANCE

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ARGONNE PERSONNEL WORKING ON THIS

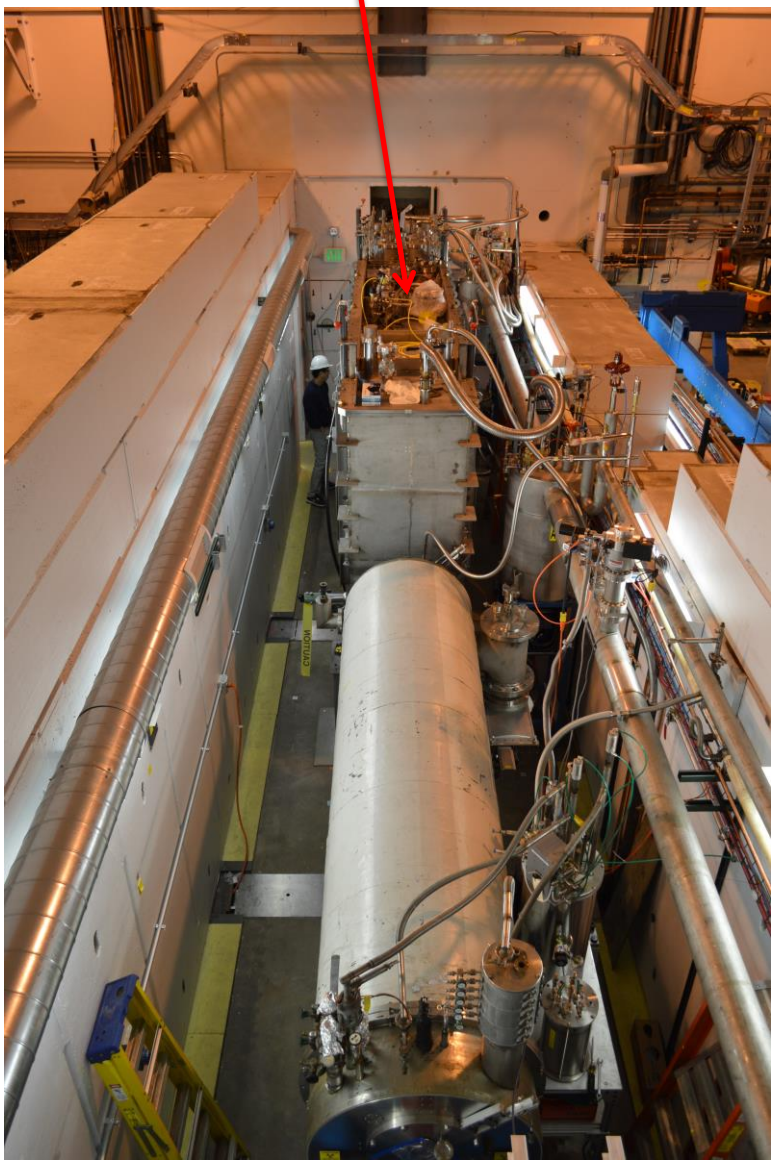
- Senior Physicists:
  - M.P. Kelly (PHY), and
  - P.N. Ostroumov (PHY).
- Physicists:
  - Z. Conway (PHY),
  - B. Mustapha, and
  - S.-h. Kim (PHY).
- Many thanks to FNAL for:
  - QWR hydrogen degassing.

- Engineers:
  - M. Kedzie (PHY),
  - M. Hendricks (PHY),
  - T. Reid (HEP),
  - B. Guilfoyle (HEP),
  - A. Barcikowski (NE),
  - K. Wood (HEP),
  - F. Skrzecz (HEP), and
  - W. Jansma (APS).
- Designers:
  - G. Cherry (NE).

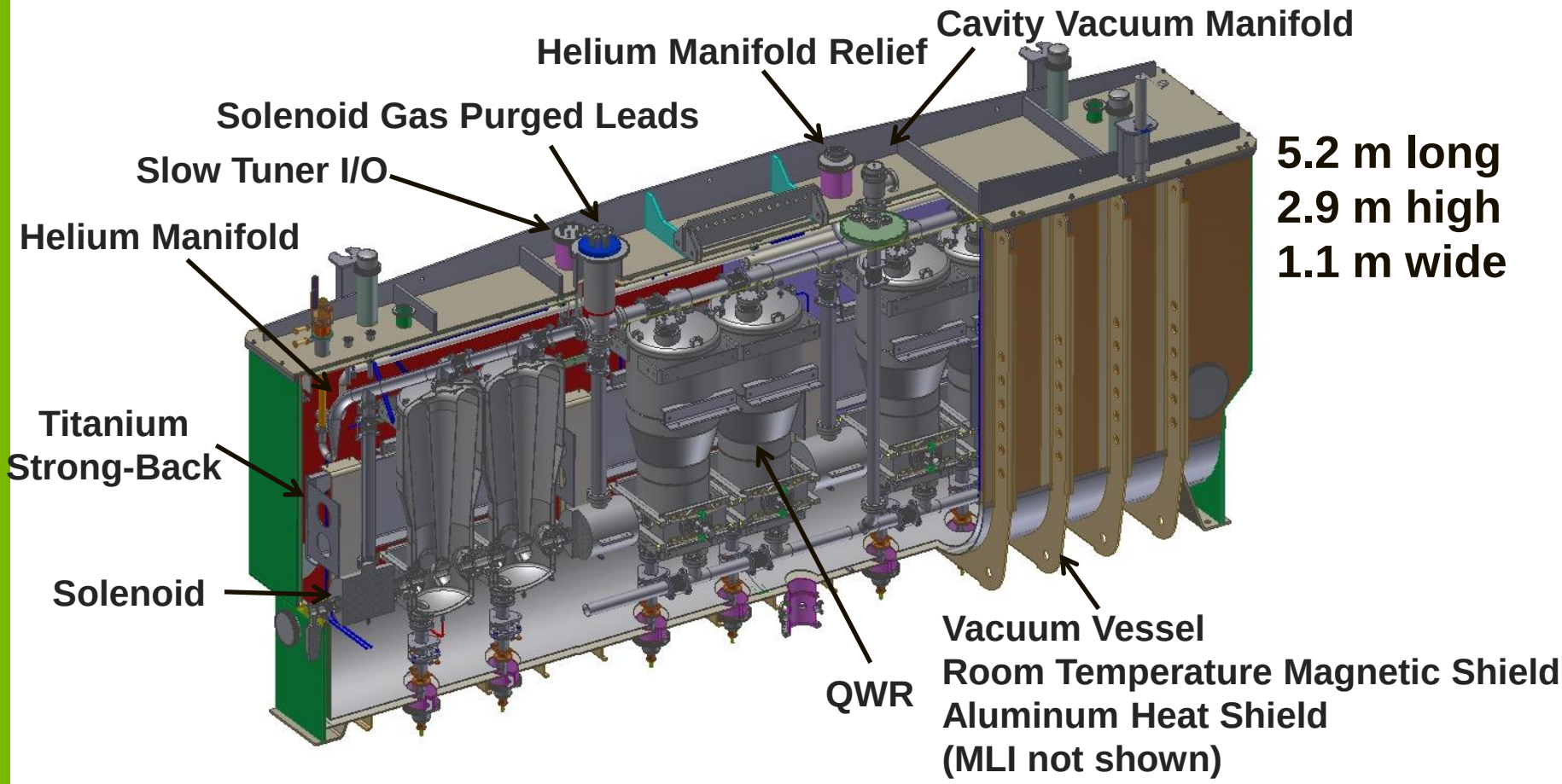
OVERVIEW

- ATLAS' intensity and efficiency upgrade.
- Quarter-wave resonator (QWR) design.
- QWR offline performance.
- QWR online performance and its evolution over time.

72 MHz Quarter-Wave Resonator Cryomodule



72.75 MHZ QWR CRYOMODULE



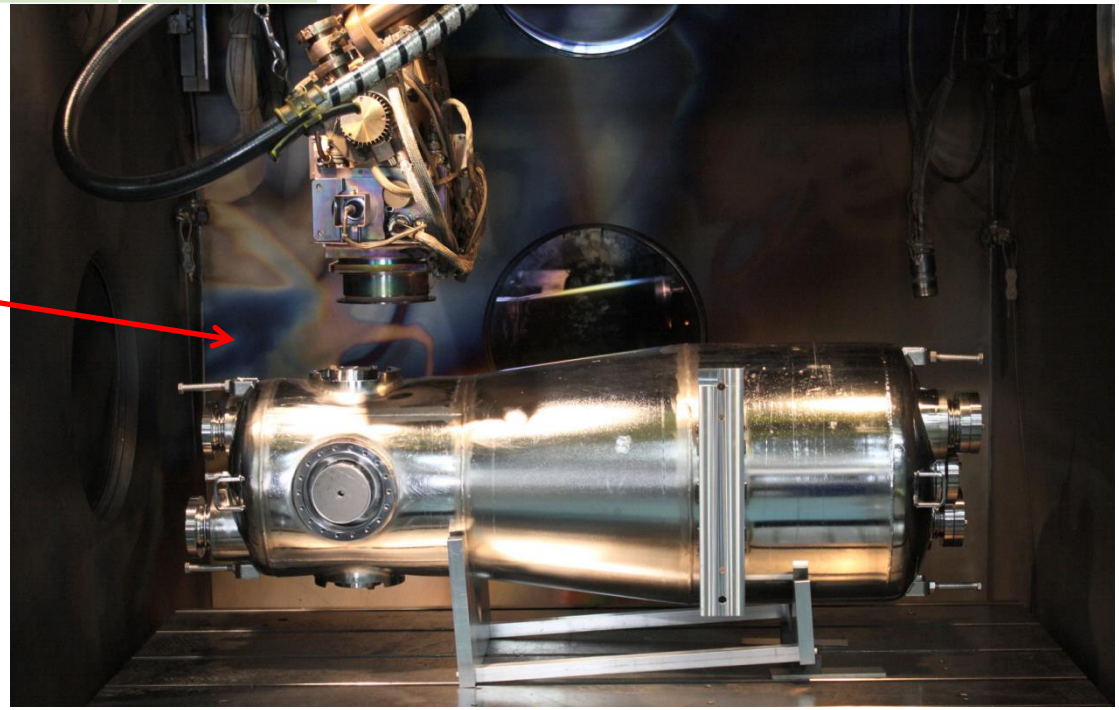
- The QWR cryomodule houses 7 superconducting 72.75 MHz, $\beta = 0.077$, quarter-wave cavities (QWR) and 4 superconducting 9T solenoids, all operating at 4.5 Kelvin.
- The cryomodule began operating online in the ATLAS accelerator facility at Argonne National Laboratory in March 2014.

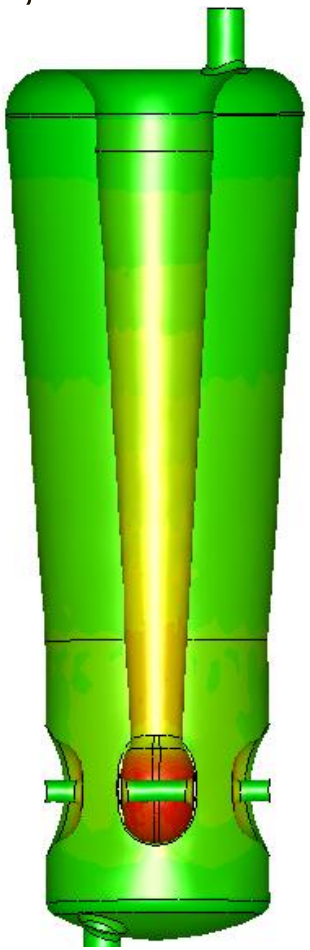
72.75 MHZ QWR ELECTROMAGNETIC DESIGN

Cavity Type	QWR
Freq. (MHz)	72.75
β	0.077
l_{eff} (cm, $\beta\lambda$)	31.75
E_{pk}/E_{acc}	5.2
B_{pk}/E_{acc} (mT/(MV/m))	7.6
QR_s (Ω)	26.4
R_{sh}/Q (Ω)	587

- Tapered inner/outer conductors roughly double the performance of these cavities relative to using straight cylinders.
- First tapered QWRs designed, built, and tested in the world.
- Cryomodule with 7 of these resonators has been in service since 2014.

Final Cavity Welding at Sciaky





Surface E-field

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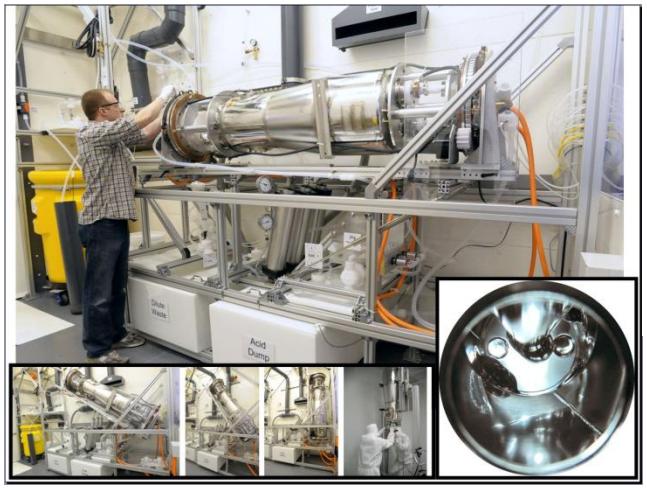
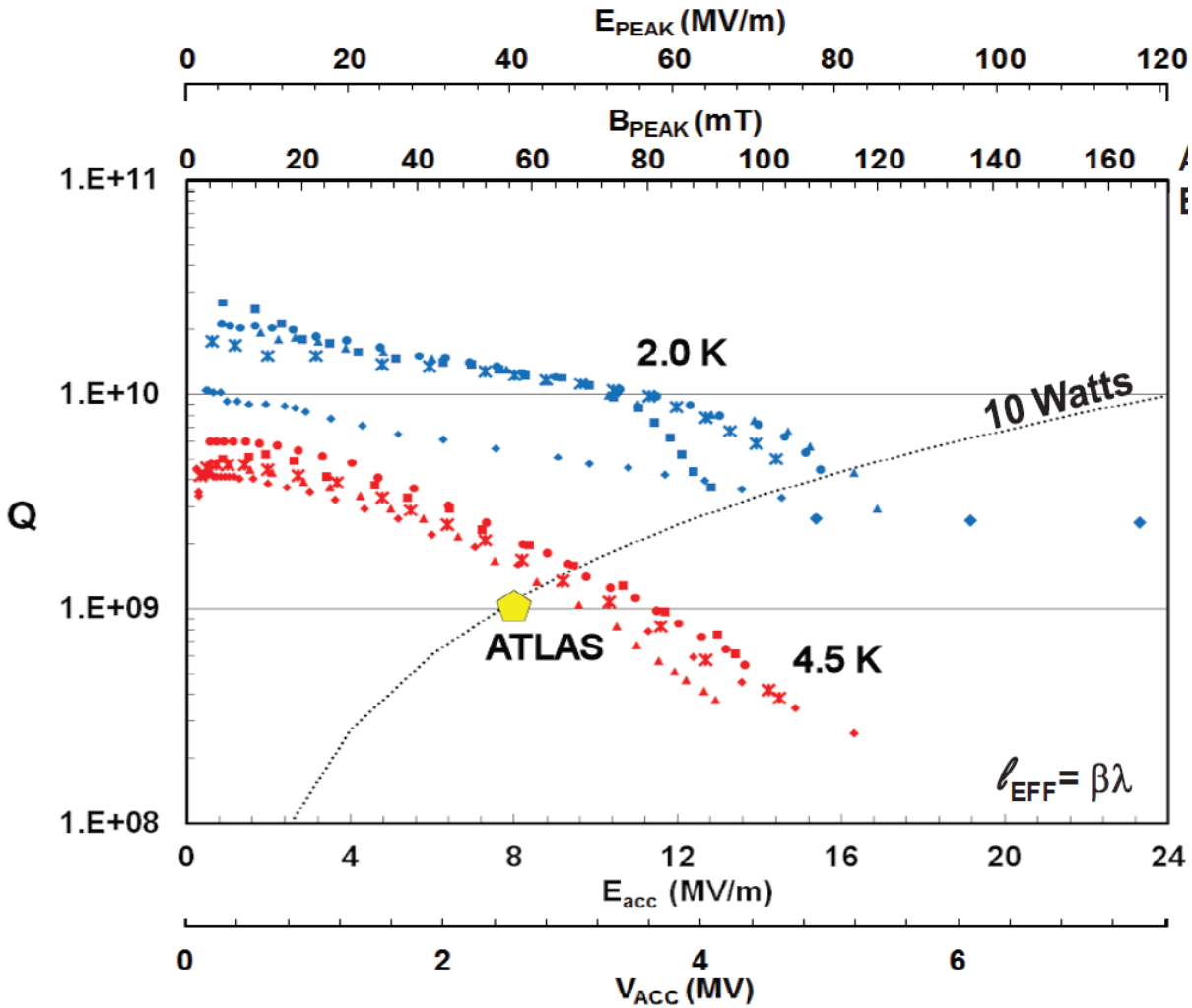
72.75 MHZ QWR OFFLINE PERFORMANCE

ANL Low-β Cavity HPR



ANL Low-β Cavity EP Tool



M.P. Kelly et al, SRF'13

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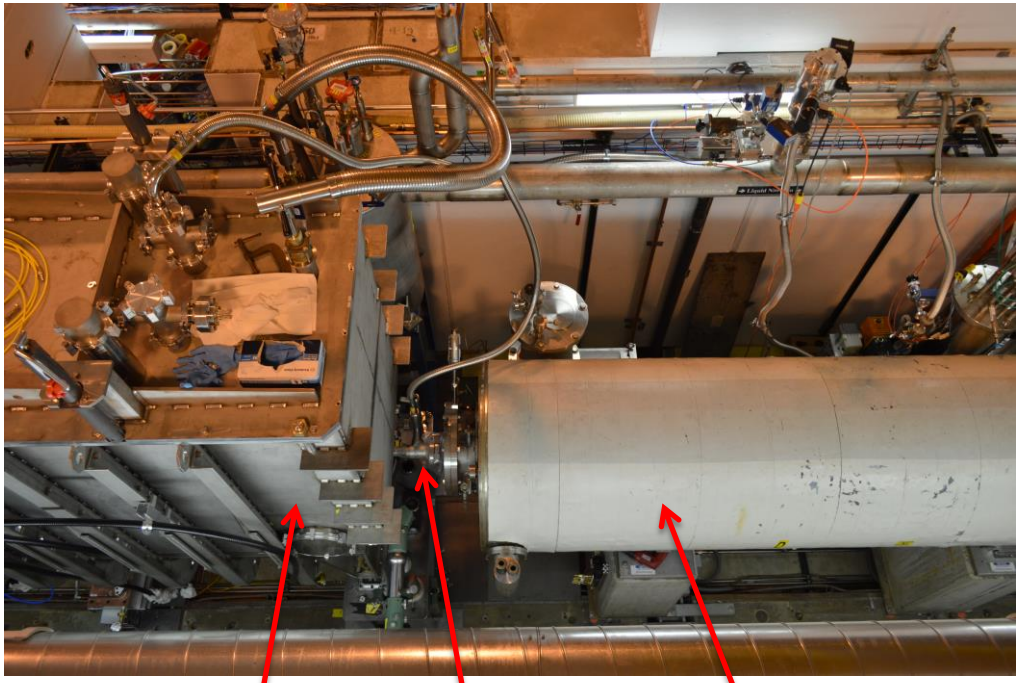
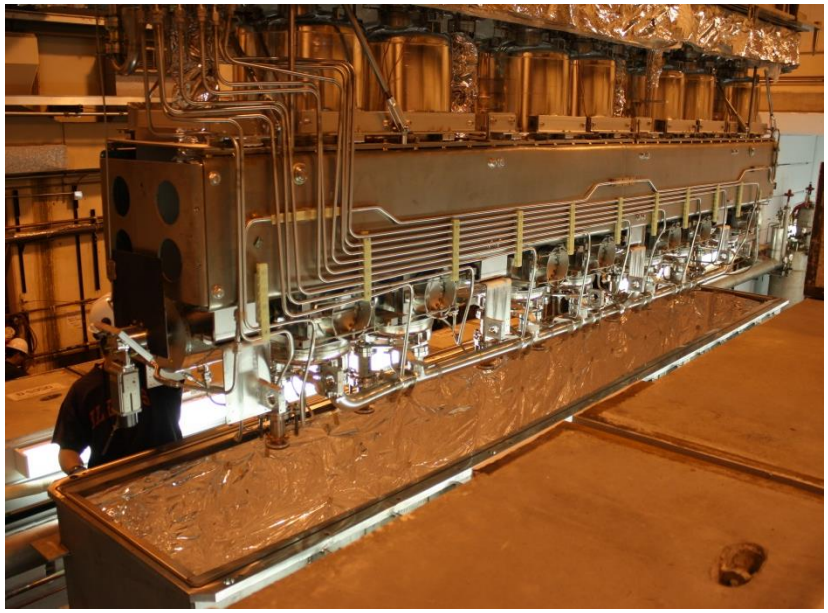
PROTECTION AND MAINTENANCE ON THE QWR CRYOMODULE

- Diffuser based mass flow controller for evacuating/venting cryomodule.
- Beam line cold traps.
- Slow closing valves.
- Major work after the clean assembly:
  - replaced all of the QWR pick-up probes,
  - replaced a beam line gate valve,
  - replaced the clean cavity turbo pump twice, and
  - hit the exit beam-line gate valve with an 80 MeV, 2 euA, ^{12}C beam during health physics radiation surveys.

72 MHz QWR Connection to Split-Ring Resonator Cryostat

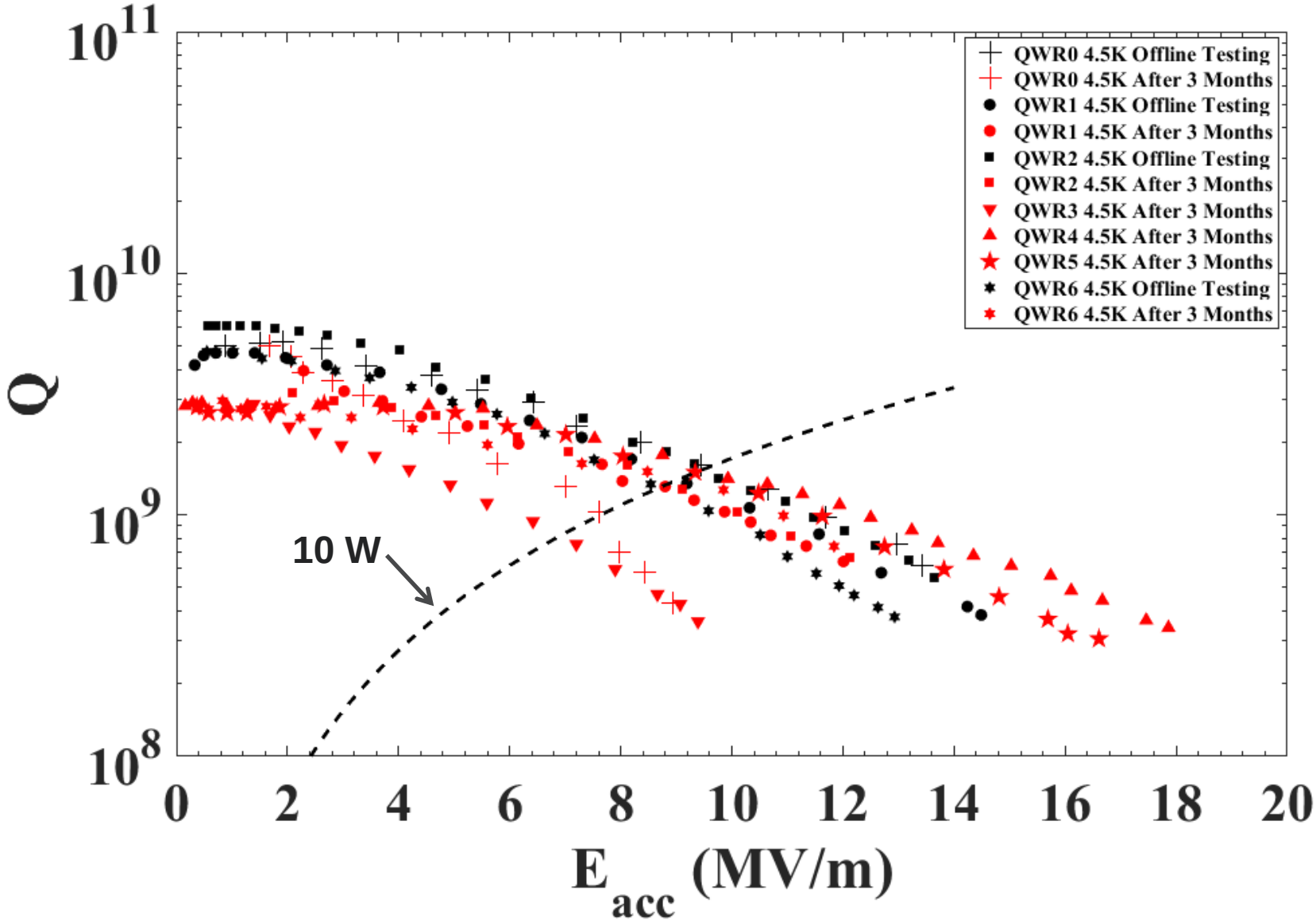


INITIAL ONLINE PERFORMANCE



Dynamic Load for 2.5 MV Operation	Measured Value
Single Cavity Dynamic Load (Measured Off-line)	5 – 8 W (46±7WDynamic)
Design: Cryomodule Dynamic Load	70 W (Dynamic)
Measured: Cryomodule Dynamic Load	33 W (Dynamic)

QWR PERFORMANCE AFTER 3 MONTHS ONLINE



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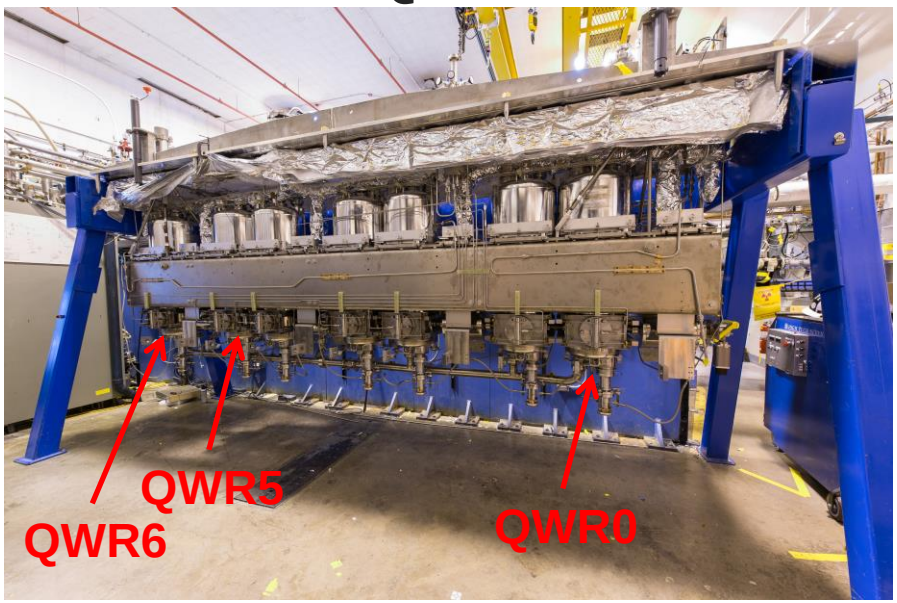
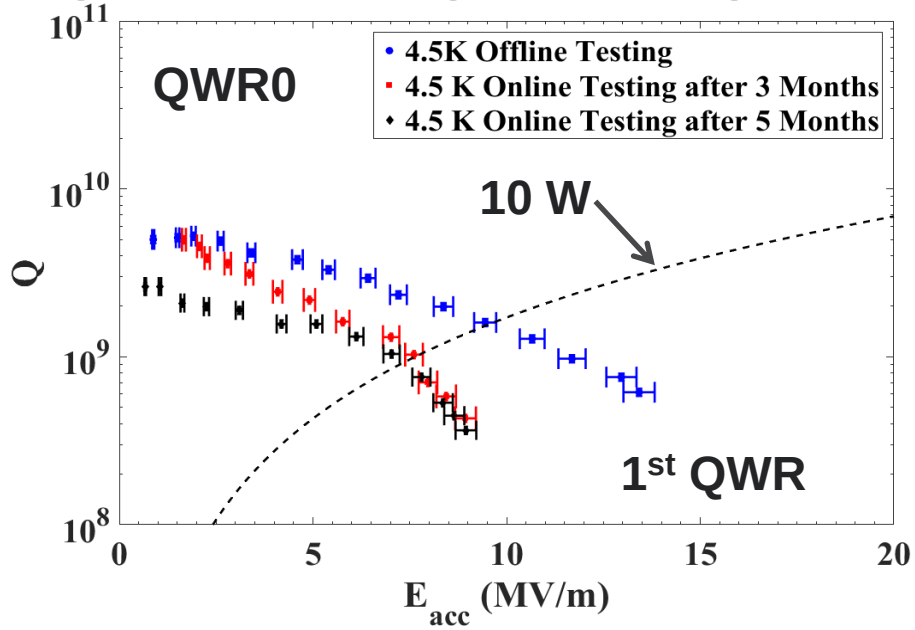
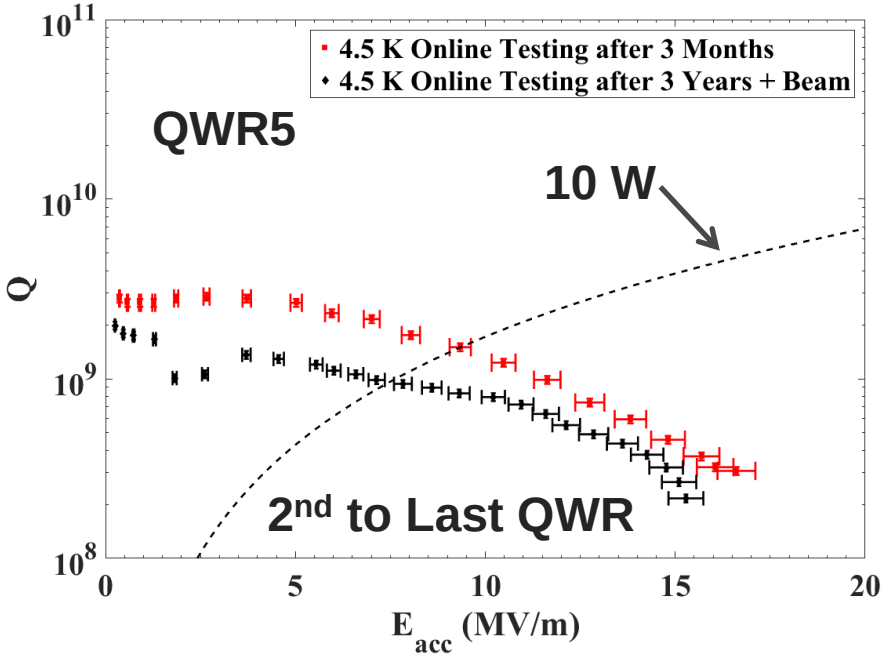
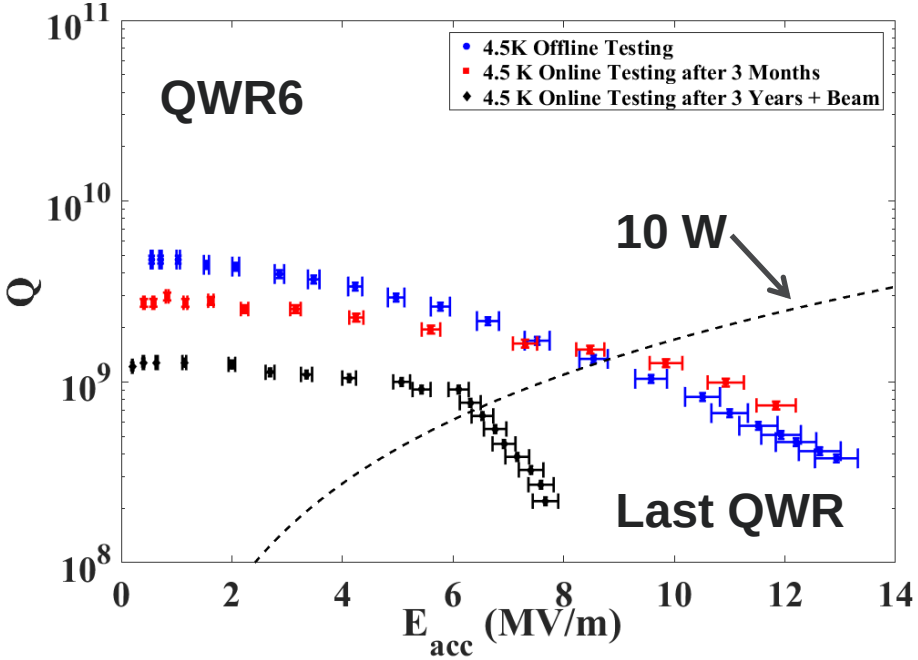
72.75 MHZ QWR CRYOMODULE PERFORMANCE









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SUMMARY

- Our clean techniques preserve the cavity performance pretty well between the initial offline single cavity tests and the final cryomodule assembly.

- Our online performance would benefit from stronger collaboration with ATLAS operations, which we have already begun:
  - Cross training ATLAS ops personnel in clean room techniques.
  - Working with ATLAS personnel to develop procedures.
  - Etc.

- Details of clean room work tomorrow.

72 MHz QWR and Split-Ring Resonator Cryomodules in Shielded Area