



RFD Pre-series Testing

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Outline

- Recap:
 - Prototypes:
 - Summary
 - Lessons learned
 - Test Prep. Workflow
- Pre-series:
 - Testing
 - Procedures reviews
 - Preparation status
- Path forward
- Summary



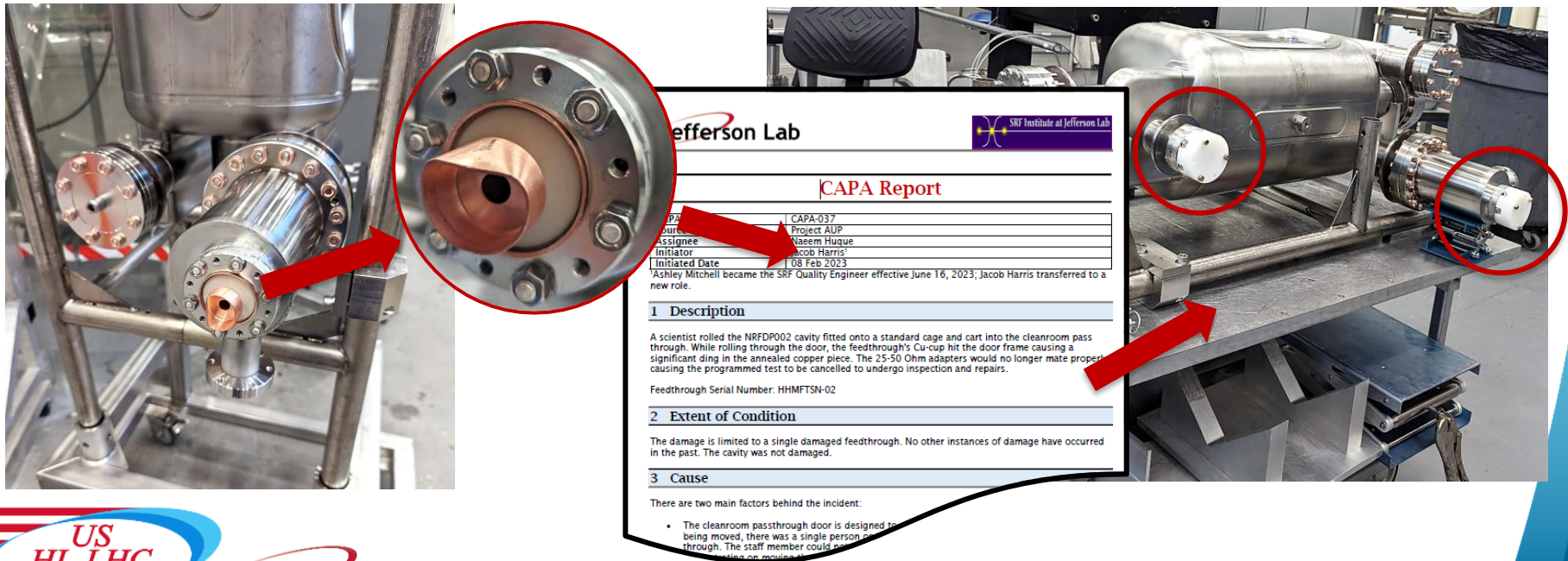
Prototypes: Lessons Learned

- Performance degradation due to bad seal (hardware/procedure updated)
 - CF leak seals were fixed with the correct hardware
 - RF-leakage on the HHOM connection degraded the test performance
 - Procedure update mitigates dated hardware
 - Updated hardware will be used for the production cavities
- Early field emission onset, mitigated with:
 - Hardware update (i.e. standardized sets of nuts/bolts and gaskets)
 - Refining procedures (HPR and assembly)

HHOM RF contact is critical for performance on the dressed cavities

Procedures Updated: Lessons Learned

- Corrective and Preventive Action (CAPA) triggered by HOM feedthrough hitting door frame during cavity transfer in test preparation, new procedure effective:
 - Feedthrough protectors on from cleanroom assembly until 120C bake
 - 2 person rule when moving through doors



Processing for Performance Test

Degreasing

Hand rinsing



Port rinsing

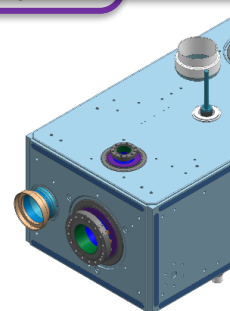
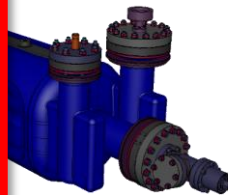
High Pressure Rinsing



Cooldown

No active B-field compensation

Test



Ongoing QA/QC

Travelers and procedures are placed in our internal systems and propagated as reports to MTF for CERN's evaluation

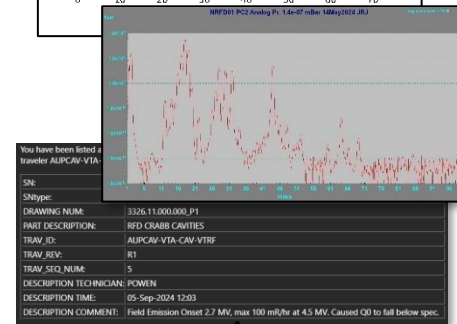
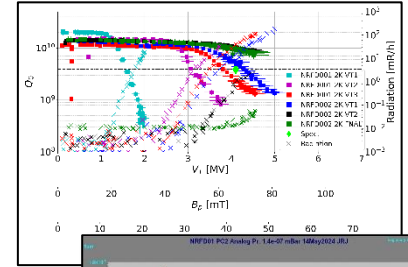
Equipment Folder: Manufacturing Workflow

Equipment Identifier: HCACFCA002-UP000001
Other Identifier: NRFD01
Description: RFD Bare Cavities Pre-Series & Series AUP

Actions: Add extra step

Workflow Diagram: No workflow diagram is defined for this equipment

Step ID	R/E	Other name	Description	Last Repeated	Status	Result	NC
978			LT + RF meas. after 120°C bake (MIP A-15)		Accepted	Ok	
980			Final release for shipping		Accepted	Ok	
981			Incoming inspection		Pending		
1005			HPR		Pending		
1010			Cold test & RGA in cleanroom		Pending		
1015			Bake out & RGA		Pending		
1020			Cold Test JLAB		Pending		
1021			Cold Test JLAB		Pending		
1022			Cold Test JLAB		Pending		
1023			Cold Test JLAB		Pending		
1025			Review of reports		Pending		
1030			Shipping to Zanon		Pending		

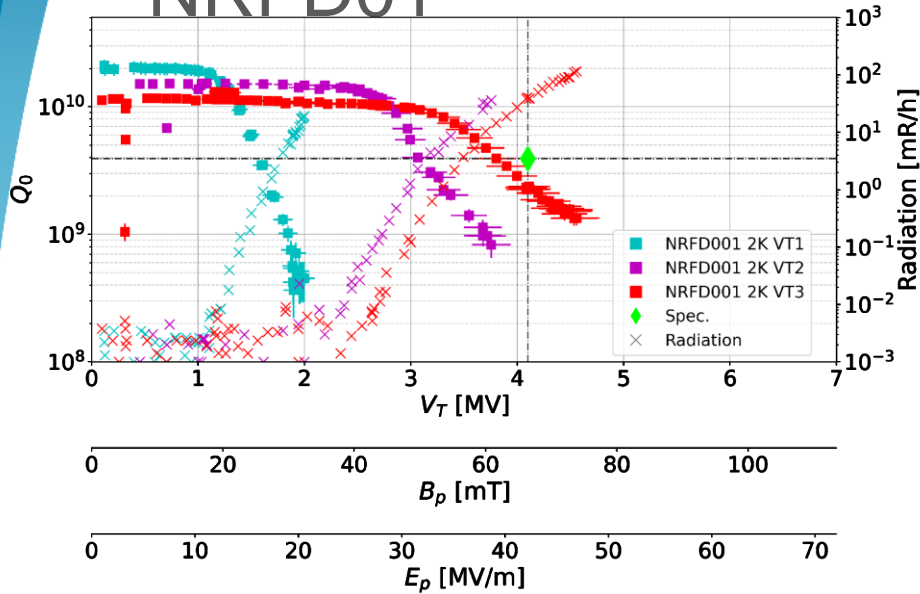


EDMS DOCUMENTS

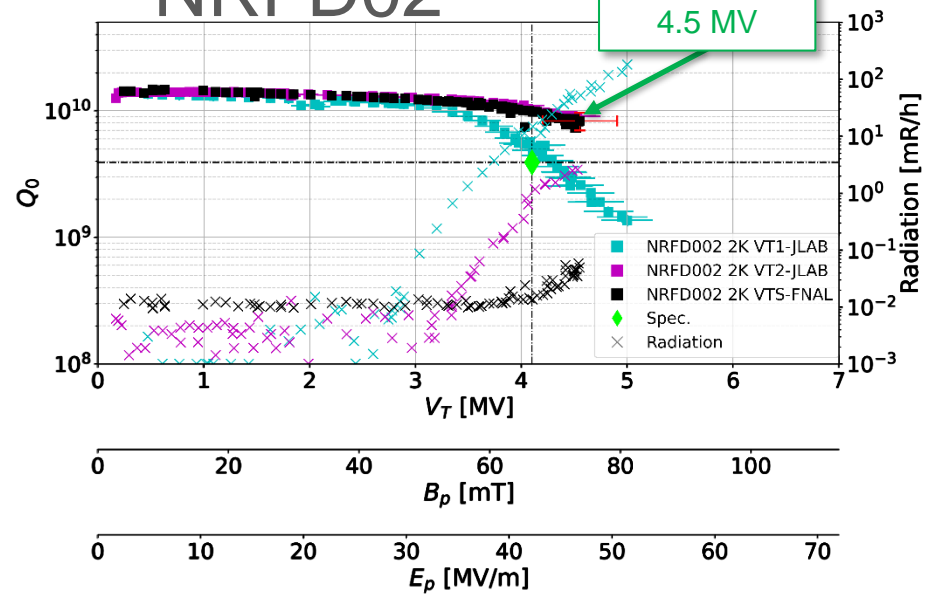
ID	Title	Status
> LHC-ACFCA-FR-0923 v.1	Cold Test JLAB VT1 - HCACFCA002-UP000001	In Work
> LHC-ACFCA-FR-0924 v.1	Cold Test JLAB VT2 - HCACFCA002-UP000001	In Work
> LHC-ACFCA-FR-0925 v.1	Cold Test JLAB VT3 - HCACFCA002-UP000001	In Work

Pre-series Preparation & Performance

NRFD01



NRFD02



Test Date	Cavity SN	Max Voltage [MV]	Q0 at 4.1MV	Low field Q0	Comments
04/30/24	NRFD01	2	NA	2.10E+10	FE onset @1.2MV, power limited to 1.9 MV
05/14/24	NRFD02	5	4.10E+09	1.44E+10	FE onset @2.85MV, administrative level @5MV
05/20/24	NRFD01	3.76	NA	1.51E+10	FE onset @2.4, power limited to 3.76 MV
06/12/24	NRFD02	4.5	1.00E+10	1.40E+10	FE onset @3.2MV, administrative level @4.5MV
06/14/24	NRFD01	4.5	2.20E+09	1.12E+10	FE onset @2.7MV, administrative level @4.5MV
08/26/24	NRFD02	4.5	1.00E+10	1.40E+10	FE onset @4.2MV, administrative level @4.5MV

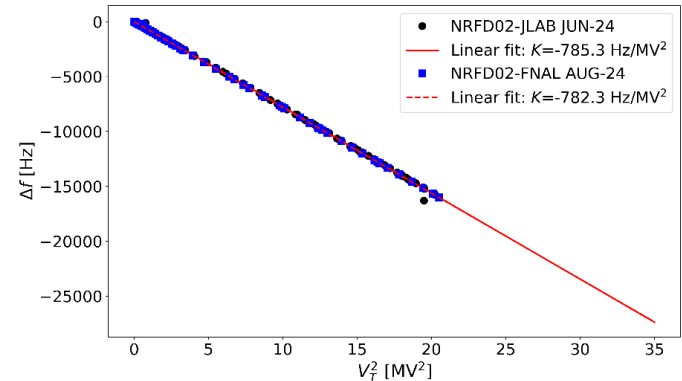
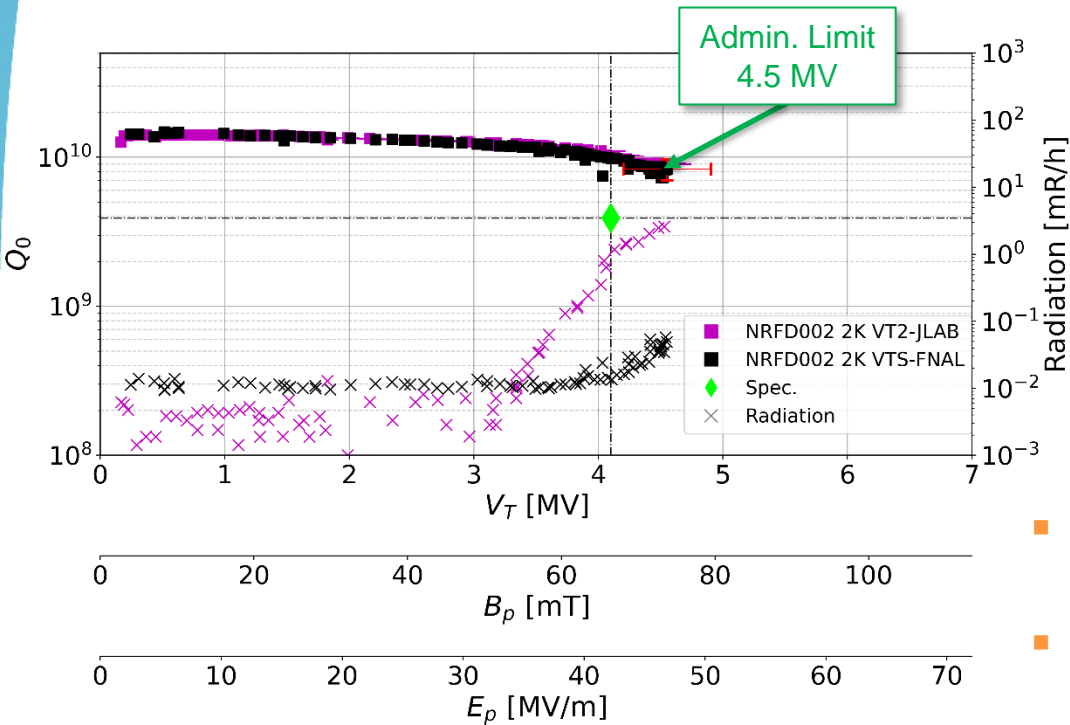
- Chemistry for both cavities at ZRI
- NRFD01's 1st assy. at ZRI + fast bleed at JLab

- NRFD01's 2nd & 3rd assys. at JLab
- NRFD02: all assemblies at JLab & last test at FNAL

Benchmarking Test-stands

An important achievement for the project, was to demonstrate that:

1. We still can have **suppressed FE* test beyond the specification**
2. Cavity processing for test is consistent over several iterations (including handling and shipping)
3. FNAL & JLab test stands are interchangeable

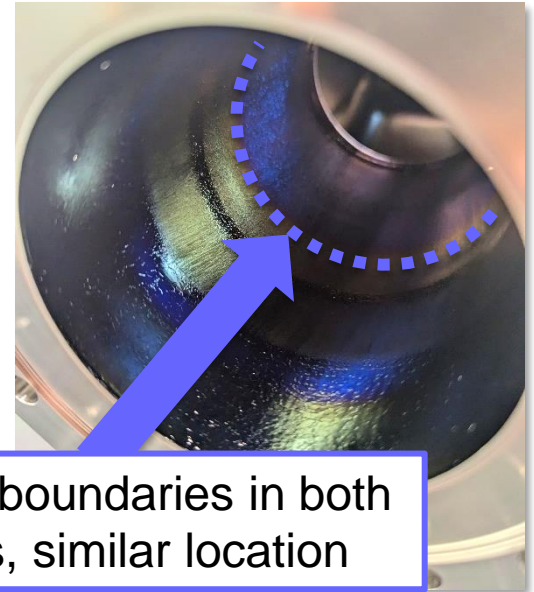
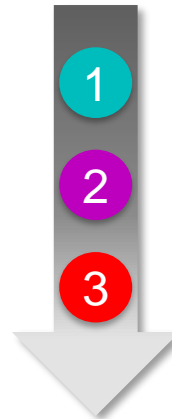
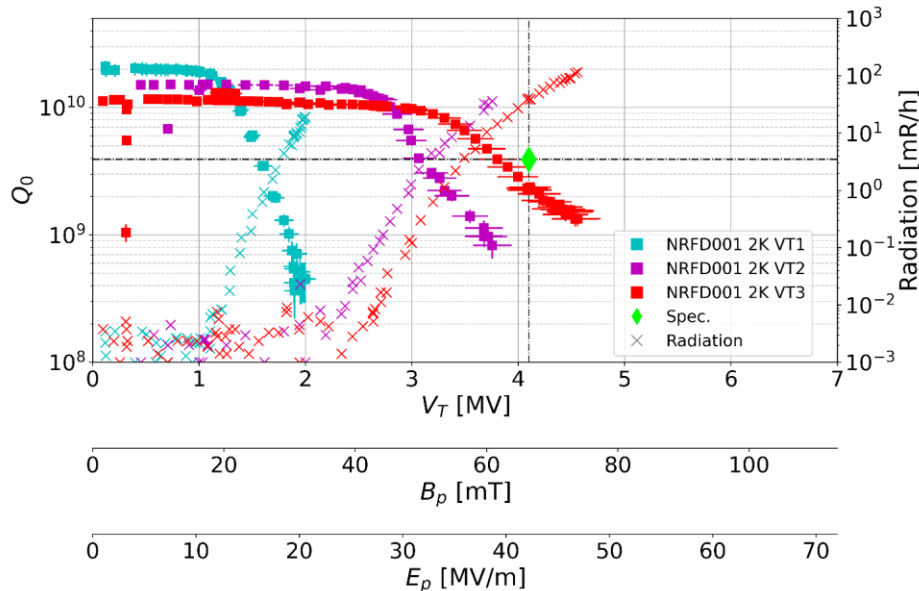


- The Q_0 -curves are identical both in average value and slope
- Both tests observed the 4.5 MV admin. limit
- LFD provides another consistency check

**this will be further corroborated with more tests*

NRFD01 – Blueing [1/2]

There seems to be a slow trend that indicates the lowering of the cavity's Q_0 after every processing:

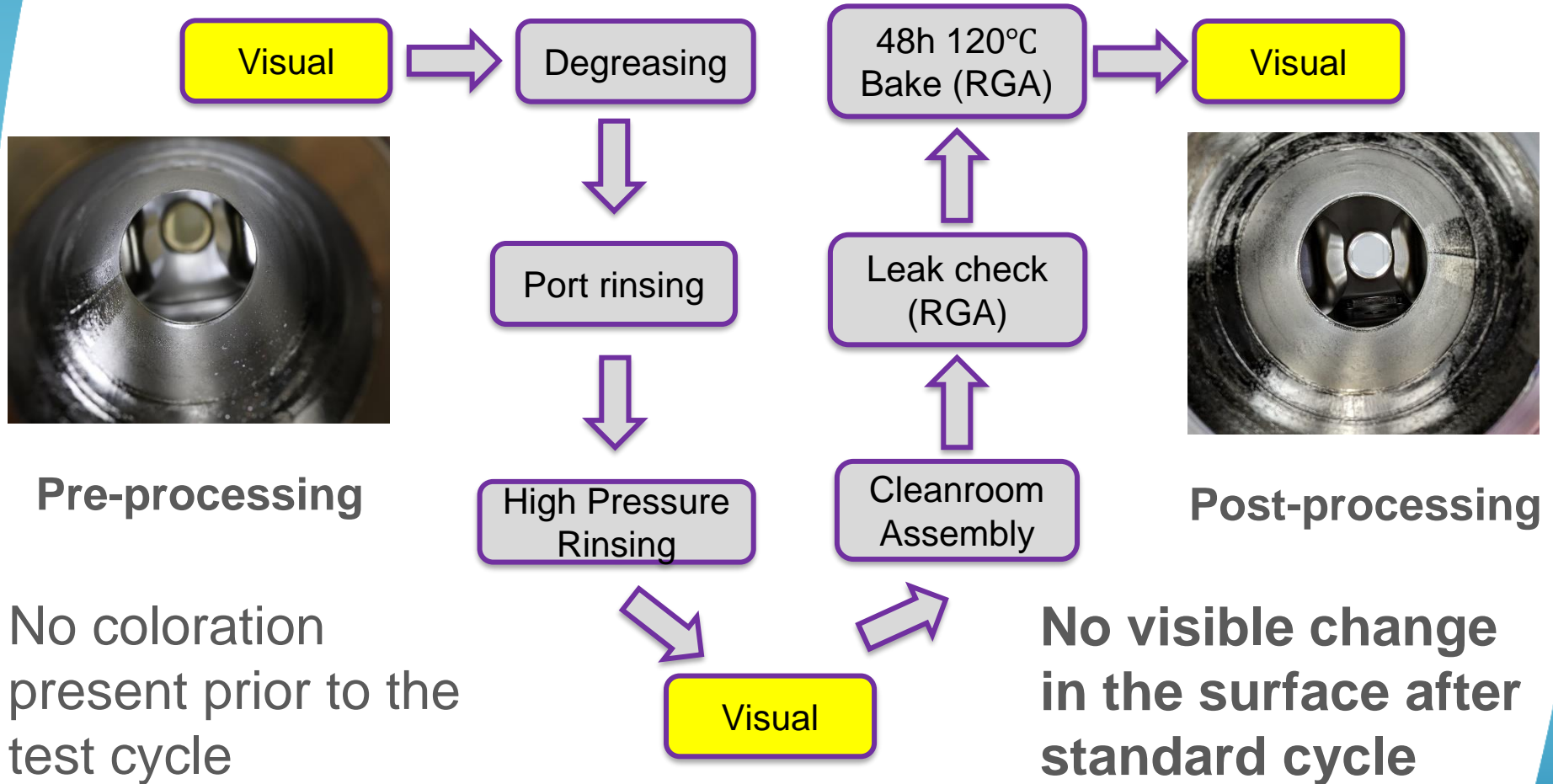


Very clear boundaries in both beampipes, similar location

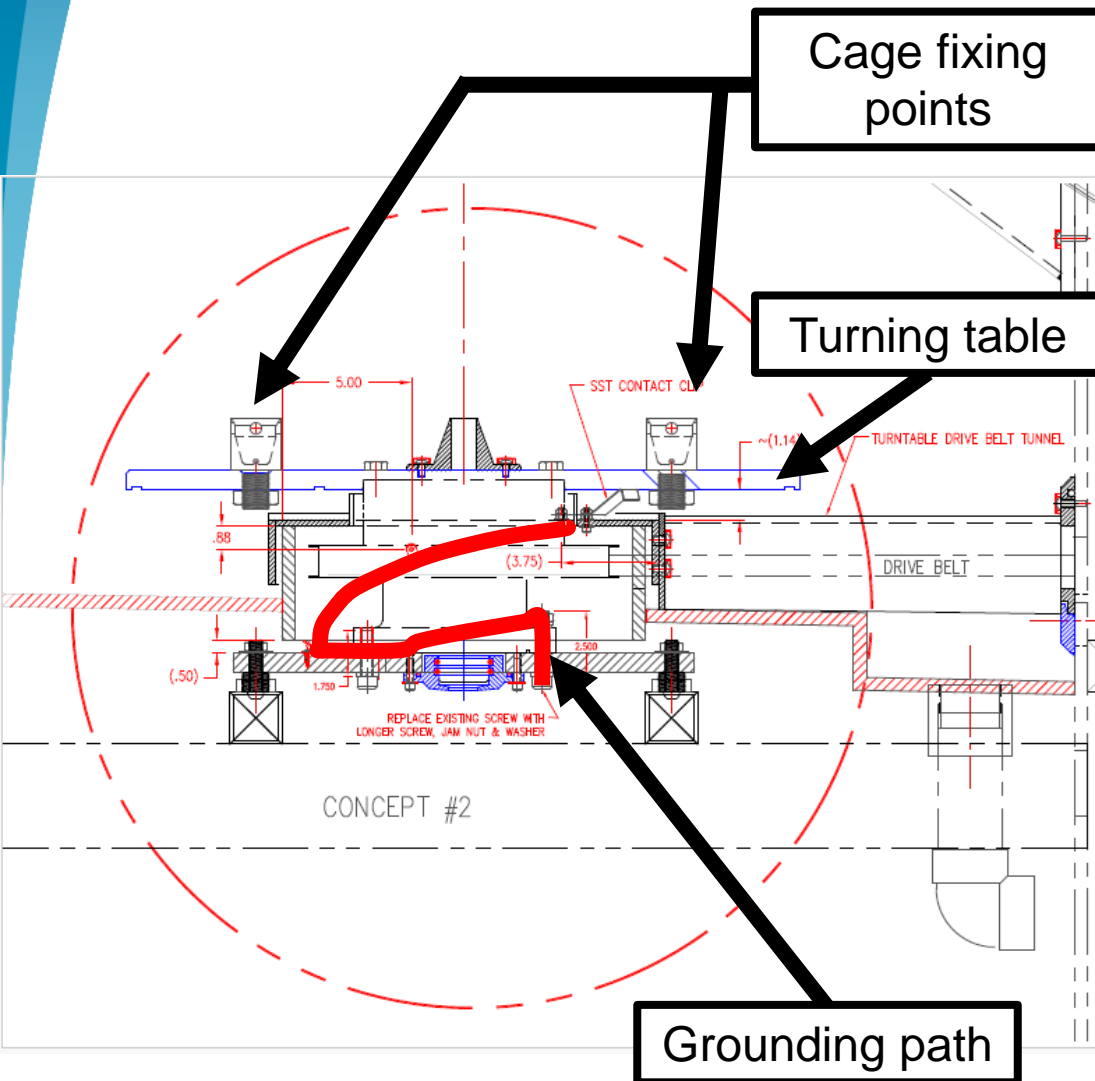
- Does this happened at the vendor or in-house?
- Is it relevant to the cavity's performance?
- Two main suspects:
 1. Bad grounding on the HPR (Galvanization)
 2. Nb_2O_X - build up due to repeated 120°C bake

NRFD01 – Blueing [2/2]

Using the LARP prototype to test our procedure:



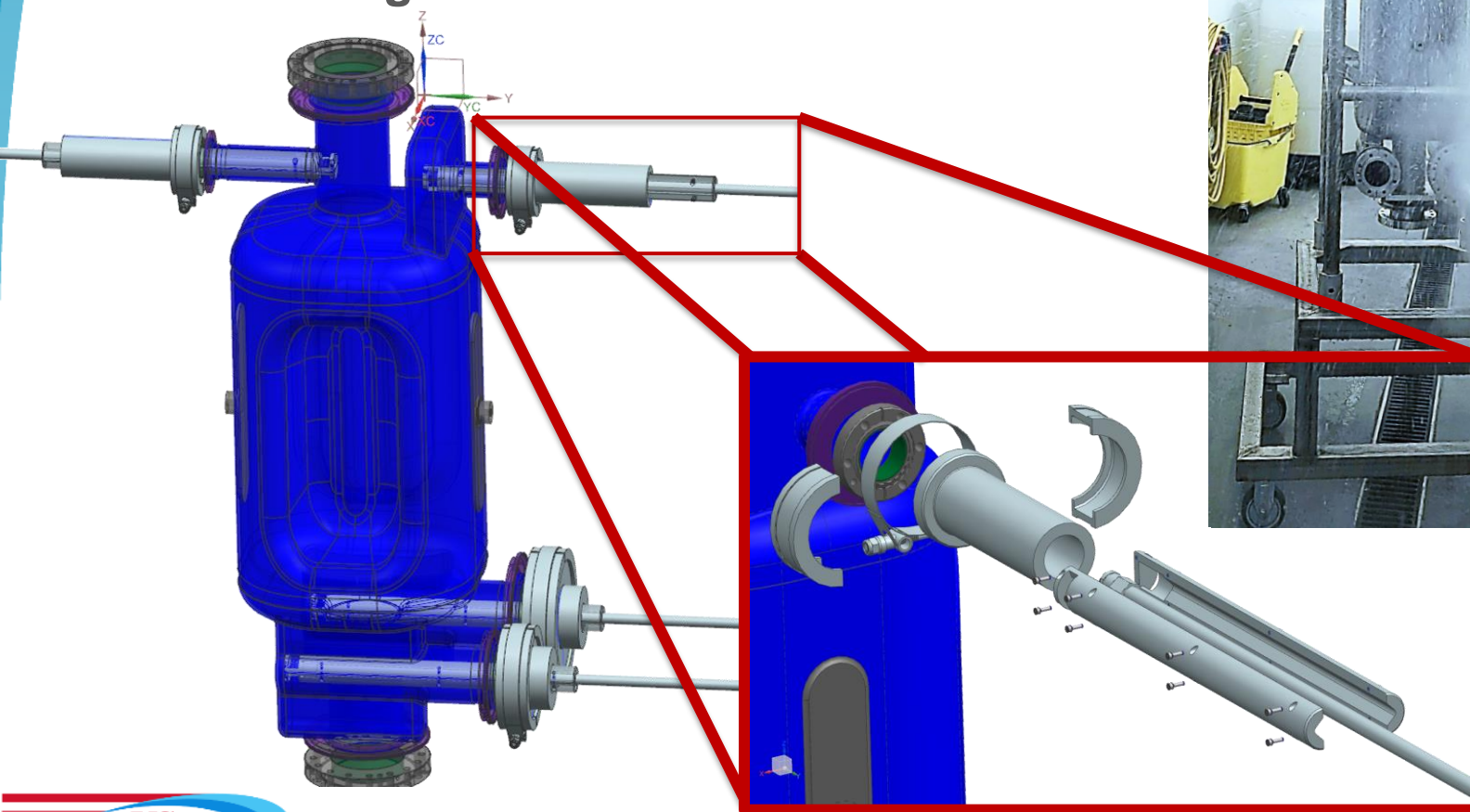
HPR - Grounding



- The cavity grounding prevents cavity galvanization
- Proper grounding was confirmed by electrical measurements
- **There is no indication that the problem initiated in-house**
- Visual and RF testing after light BCP of NRFD01 could shed light on correlation between blueing and compromised Q_0

Tooling: e.g. Hand port rinsing

- Side ports are virtually hidden from the high pressure rinse jet
- Custom tooling designed to safely and thoroughly clean the side ports manually
- **New tooling and hardware to reduce FE**



Tooling Heat Map

Tool	Design	Procurement	Manufacturing	Qualification	Ready
Rolling cart	Grey	Green	Grey	Green	Green
Holding fixture (Bare cavity)	Green	Grey	Green	Green	Green
Holding fixture (Tanked/Dressed cavity)	Green	Grey	Green	Green	Green
Port rinsing tool	Green	Grey	Green	Green	Green
Cleanroom lifters (2x)	Grey	Green	Orange	Yellow	ETA: Oct 2024
Lifting interface tool	Green	Grey	Orange	Yellow	ETA: Oct 2024
Testing cage	Green	Grey	Orange	Grey	ETA: Oct 2024
Dedicated Test stand	Green	Green	Green	Yellow	ETA: Oct 2024
Hardware kits (CERN)	Green	Green	Green	Green	Green



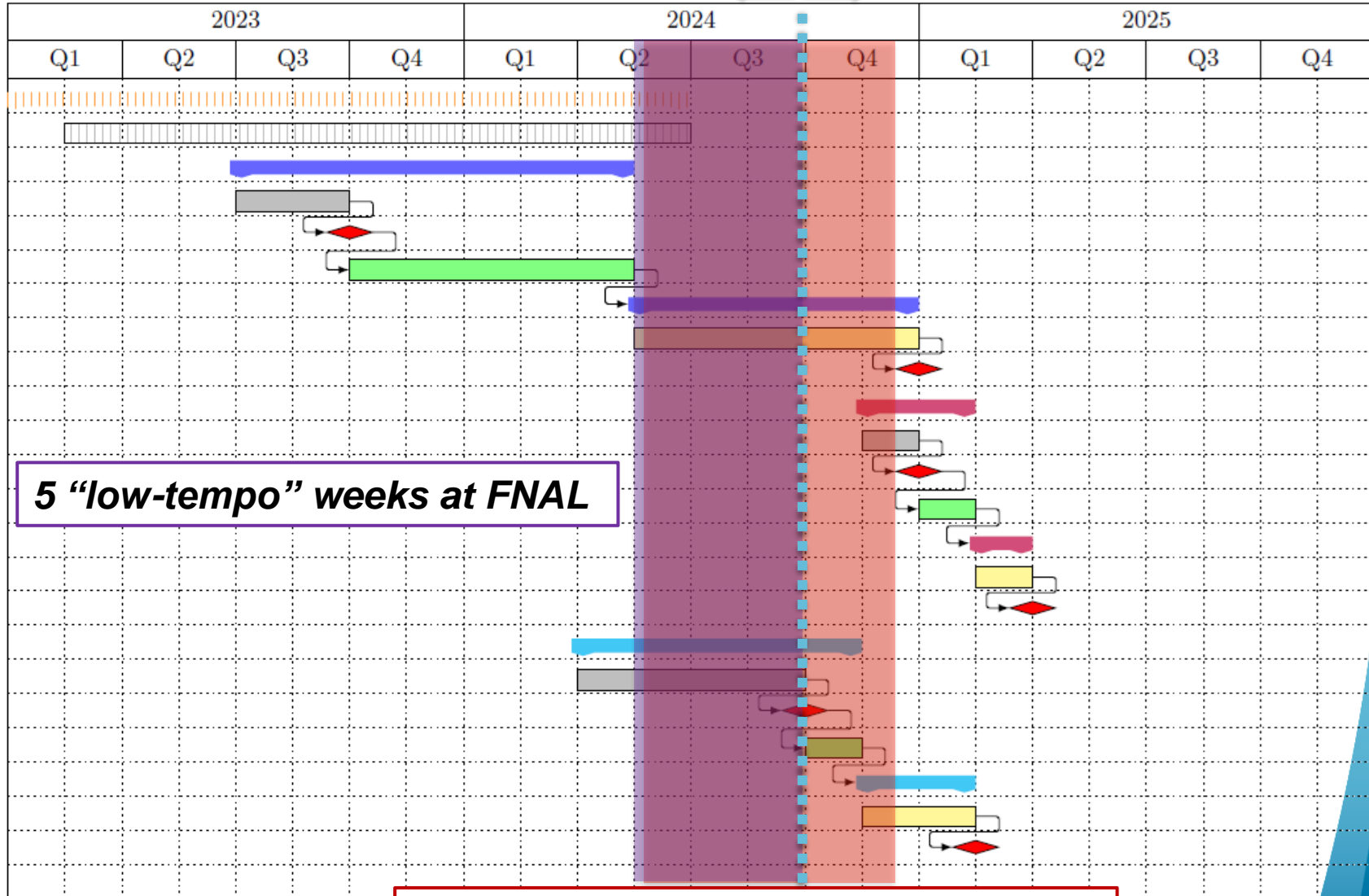
Critical Path

Adequate advance on tooling and procurement to keep the projected schedule, reduce technical risks, and boost cavity performance

Done	Green
Ongoing	Orange
Pending	Yellow
On hold	Red
NA	Grey

Schedule [1/2]

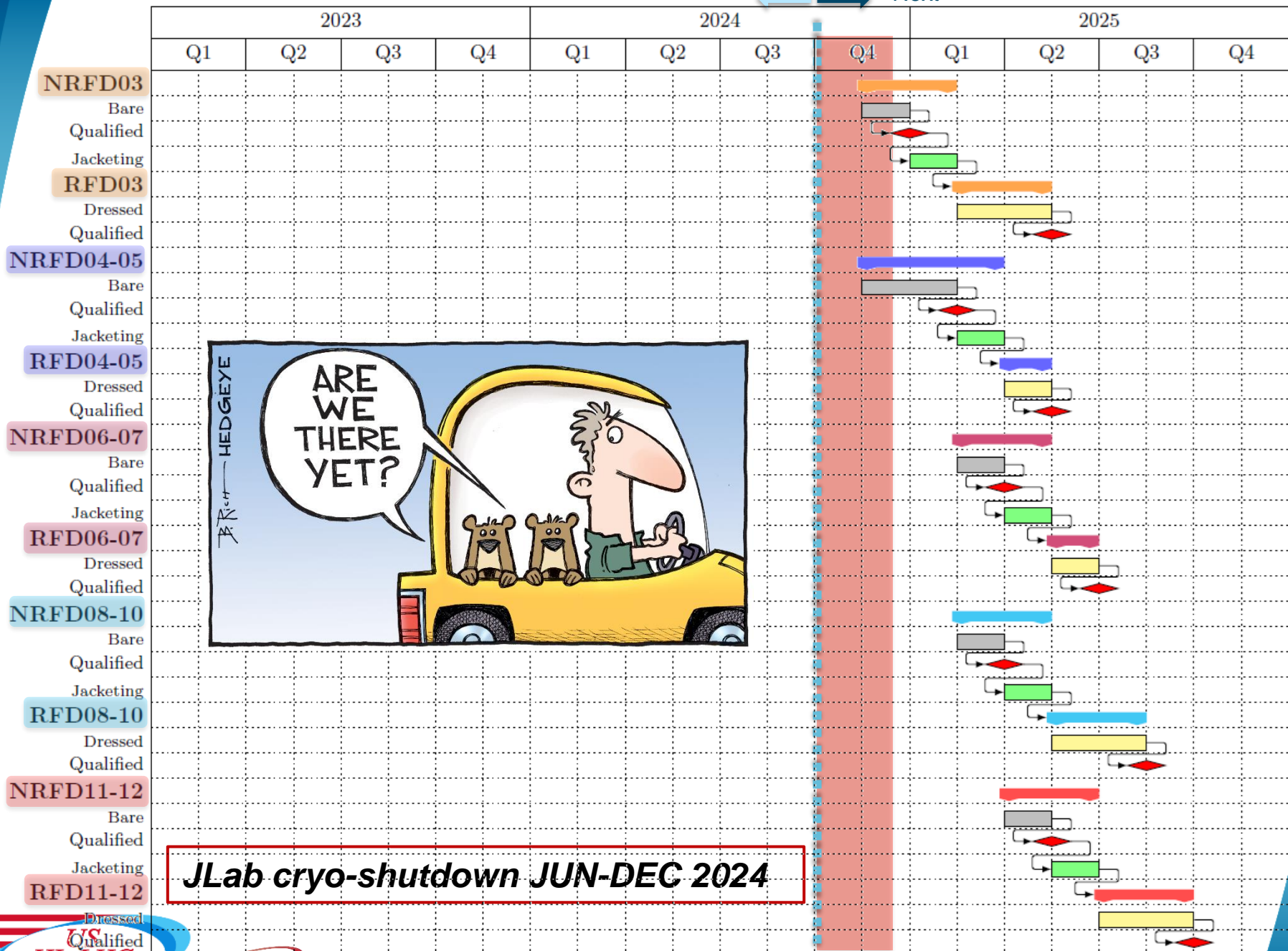
Past ← → Next



5 "low-tempo" weeks at FNAL

JLab cryo-shutdown JUN-DEC 2024





JLab cryo-shutdown JUN-DEC 2024



Summary

- **Prototypes:** Key lessons learned involve improving collaboration and communication between the vendor and the laboratories performing the work to maintain a tight QA
- **NRFD02 Tests:** Consistent, beyond-specification results at both JLab and FNAL demonstrate the robustness required for the production phase. Suppressed FE results that will be carefully benchmarked
- **NRFD01:** Will reinforce confidence on our procedures
- **Testing Resilience:** Despite challenges such as safety stand-downs and cryogenic shutdowns, significant testing has been successfully completed at both JLab and FNAL. The built-in redundancy between these institutions will be essential
- **Tooling & Schedule:** While some tooling is on the critical path, we are closely monitoring the schedule to ensure timely progress
- **Looking Ahead:** 2025 will be a busy year for the AUP and WP4, and we are ready for the challenges and opportunities that lie ahead

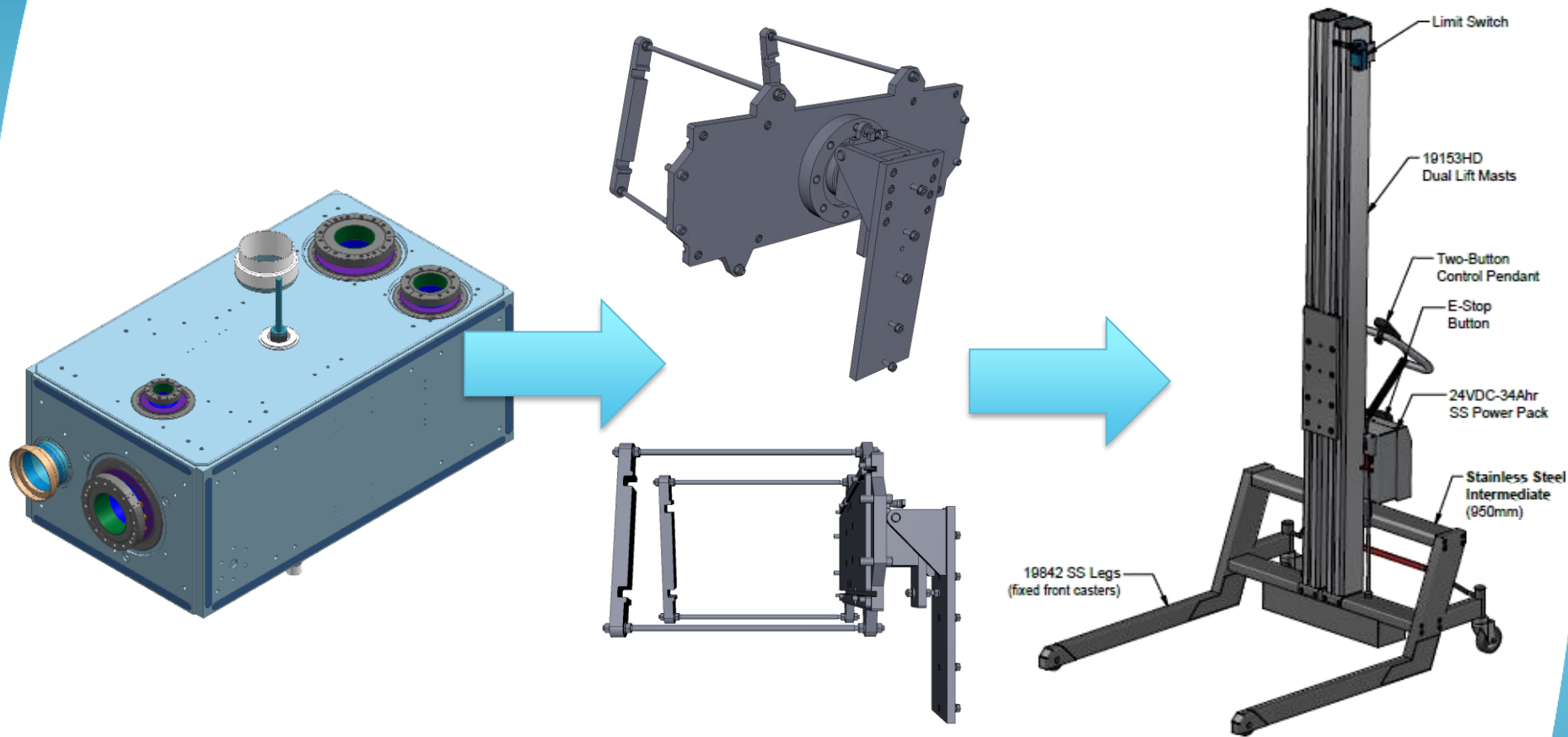
Thanks!



Backups



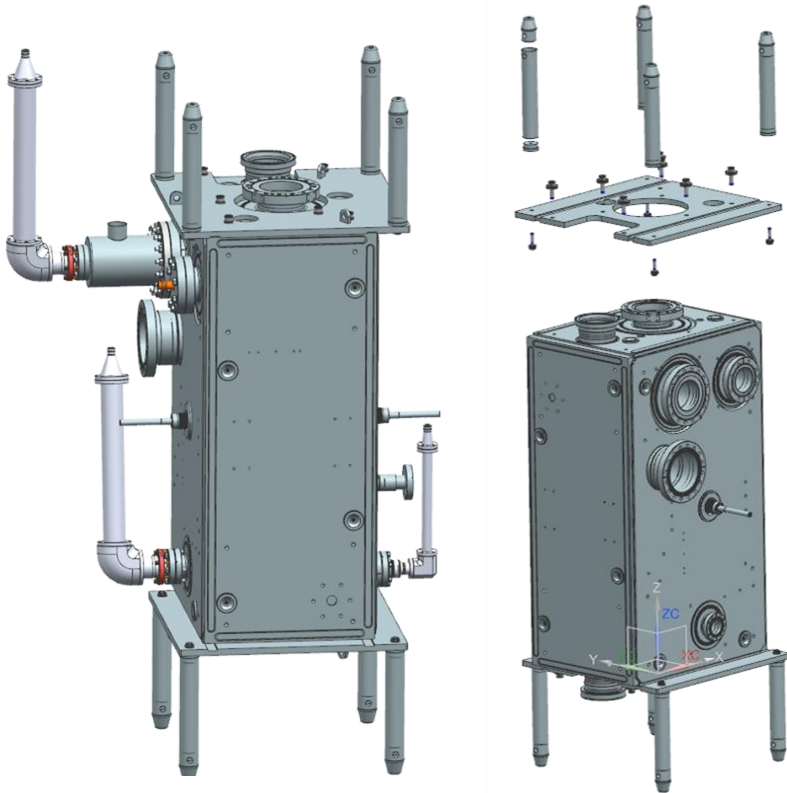
Tooling: Cleanroom activities



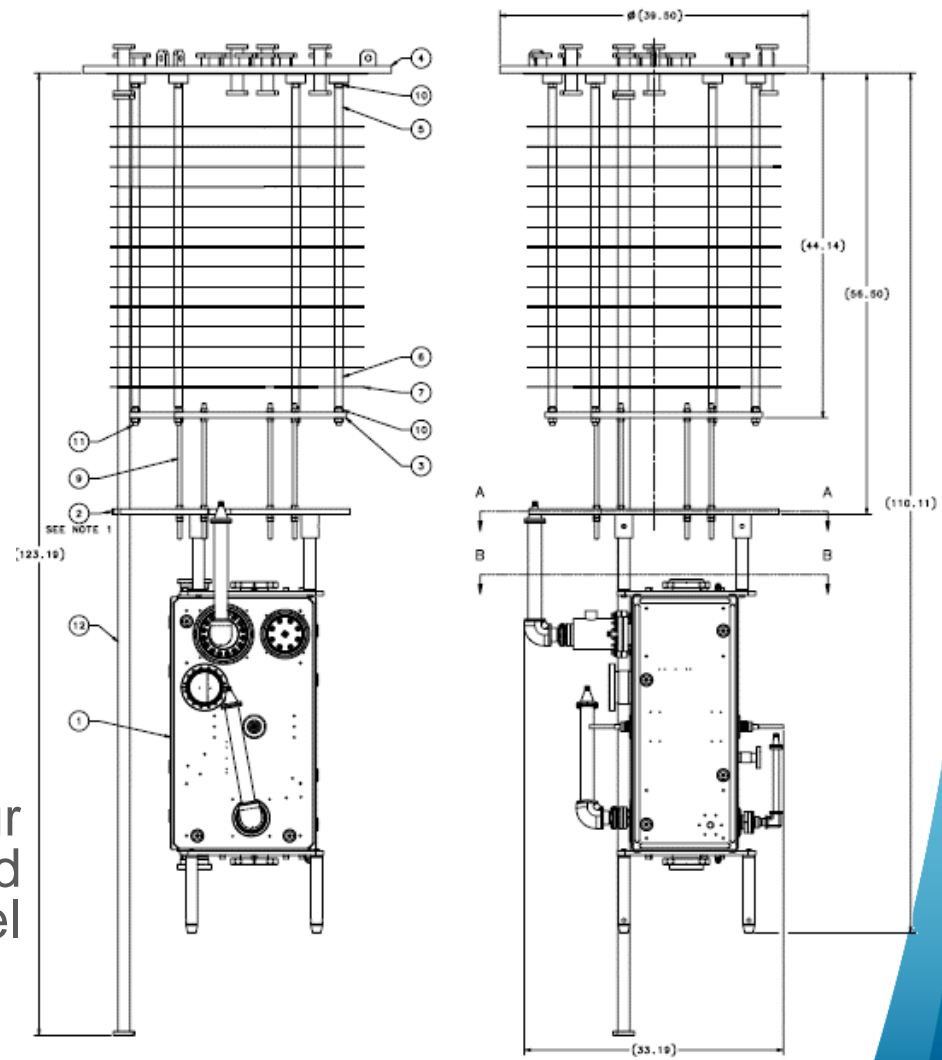
Procured 2 cleanroom compatible lifters capable of lifting the cavities (similar to those used at FNAL) at the necessary distance to install in the HPR cabinet (ETA: OCT 2024)

Tooling: Dressed cavity

Interface fixtures



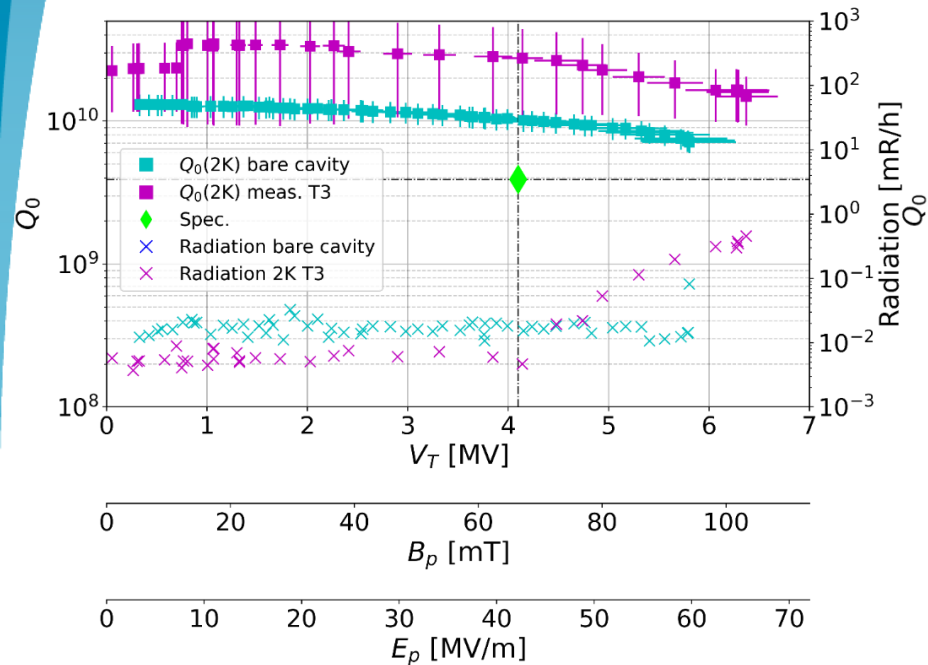
Dedicated Test stand



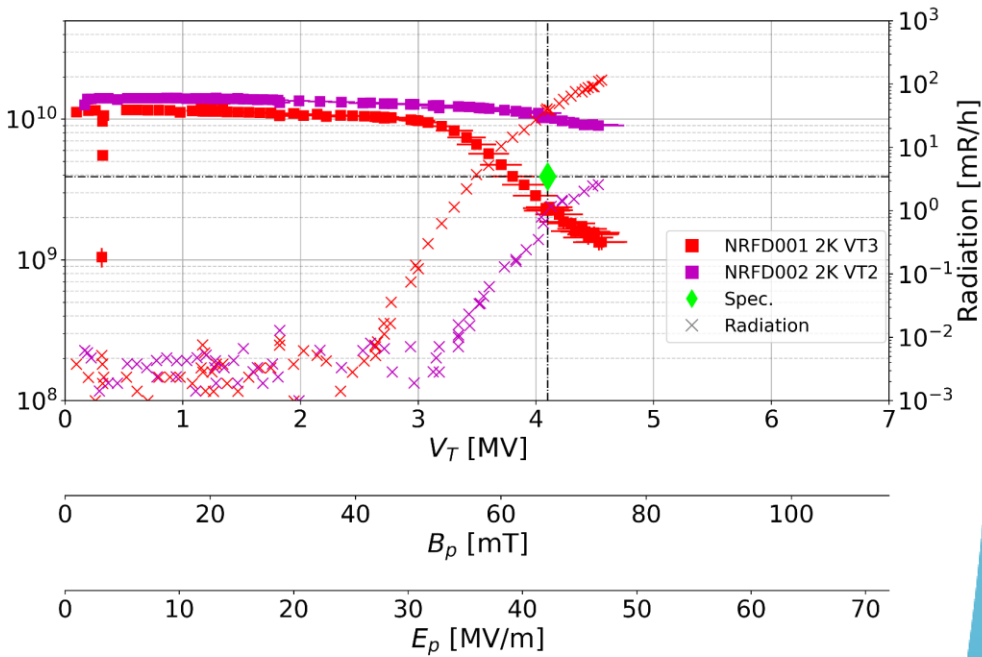
Designed compatible interfaces to our facilities and procured a dedicated spare test stand to allow for parallel cavity preparation and testing

Pre-series vs Prototypes

Prototypes

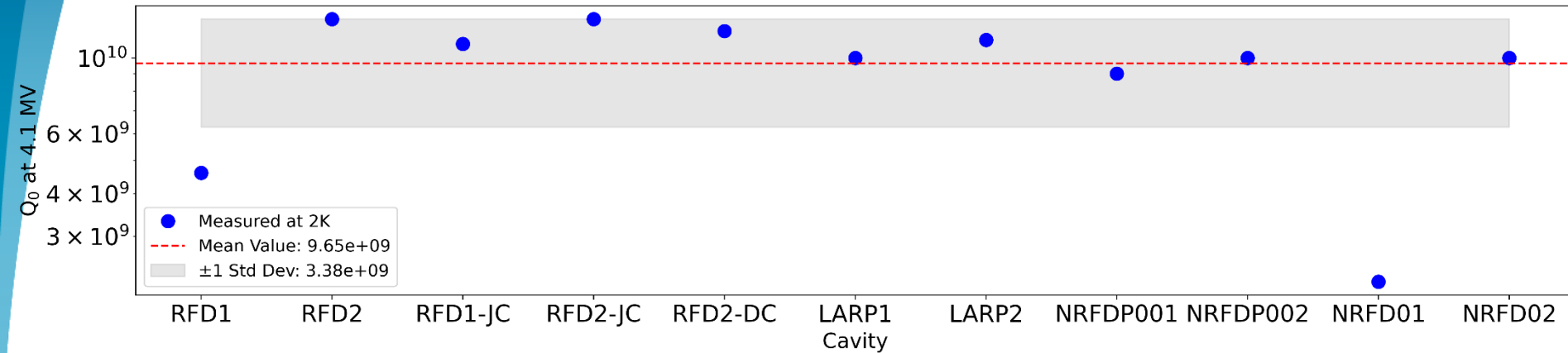


Pre-series

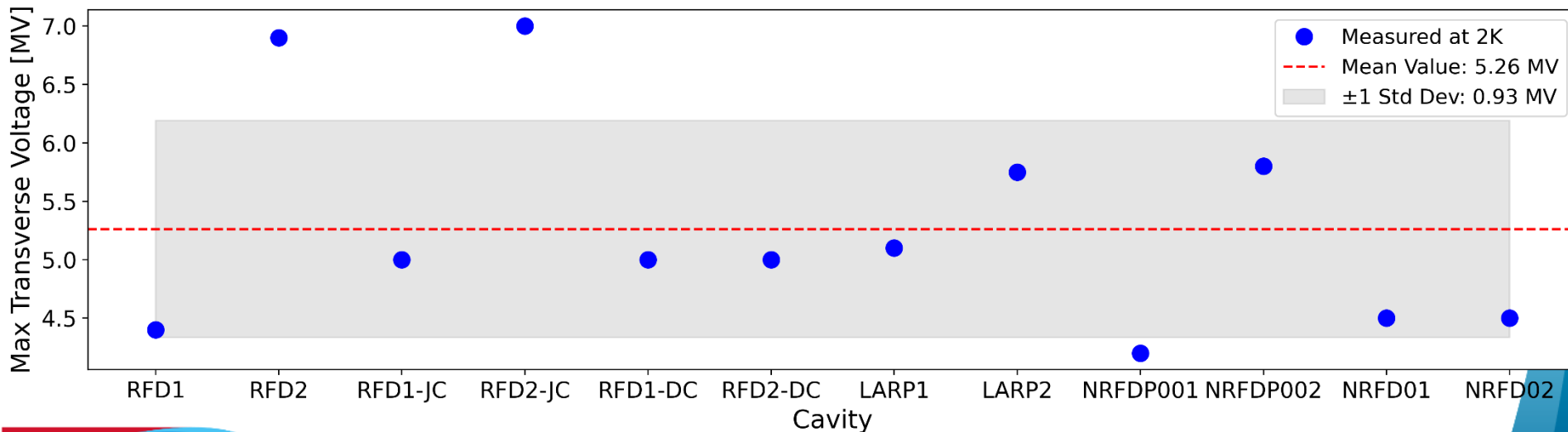


- Suppressed FE test demonstrated at FNAL & JLab for both bare and bare cavity + HOMs for the prototypes
- Constant improvement of preparation and performance demonstrated on the pre-series
- New tooling and hardware to provide better results

Project Experience on Testing RFDs [1/2]



On average, there is a tight distribution across all the different RFDs throughout the project's history, with a couple of excursions here & there, but well understood



Project Experience on Testing RFDs [2/2]

