Current Status and Plans for SRF Cavity Processing for Project X

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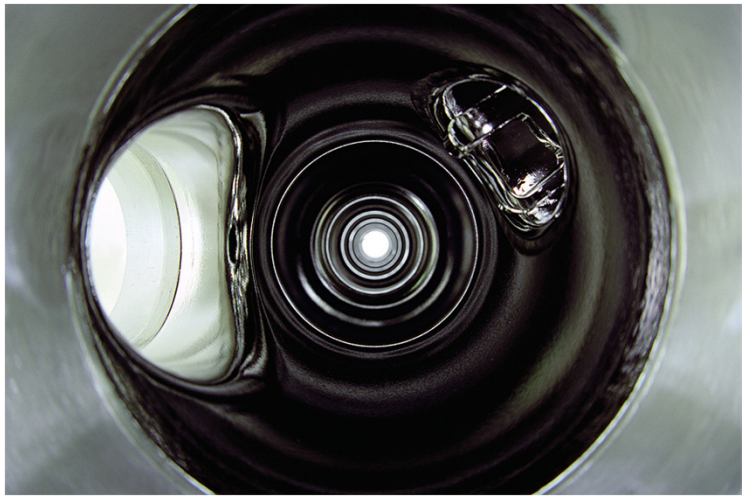


Outline

- Processing Overview
  - Cavity types & quantities
  - Planned processing recipes by cavity type
- Processing Capabilities & Plans
  - Existing Facility Summaries
  - Near-term plans for 1.3 GHz, SSR, 650 MHz
- Extra material---Project X Production
  - Production Processing Requirements & Capacities
  - SSR & Elliptical Production Plans
  - Required Infrastructure
  - Partnerships
  - Critical Questions

Cavity Types & Quantities

*Source: Vyacheslav Yakovlev

Section	Energy MeV	E_{acc} MV/m	B_{max} mT	Q @ 2K x10^9	Installed cavities	Processed Cavities
SSR0 (β_G=0.11)	2.5-11	9.0	66	6.5	18	22
SSR1 (β_G=0.22)	11-41	11.0	65	11	20	24
SSR2 (β_G=0.42)	41-179	10.0	69	13	44	53
650 MHz (β_G=0.61)	179 - 559	16.5	70	15	42	51
650 MHz (β_G=0.9)	559 - 3000	16.8	63	20	152	183
1300 MHz (β_G=1)	3000-8000	25	107	10	224	270

Elliptical Cavity Processing Recipe

1. Inspection – RF & Optical	10. Evacuate
2. Bulk EP **(or CBP)**	11. 120C Vacuum Bake 48 hrs
3. HPR	12. Vertical Test
4. 800 C Bake 2 hrs	13. Dress
5. RF Tuning	14. HPR
6. Light EP	15. Assemble
7. HPR	16. HPR
8. Assemble	17. Evacuate
9. HPR	18. Horizontal Test

SSR Processing Recipe

1. Inspection – RF & Optical	9. Evacuate
2. Bulk BCP	10. Vertical Test
3. HPR	11. Dress
4. 800 C Bake 2 hrs or 600C 10 hrs	12. HPR
5. RF Tuning	13. Assemble
6. Light BCP	14. Evacuate
7. HPR	15. Horizontal Test
8. Assemble	

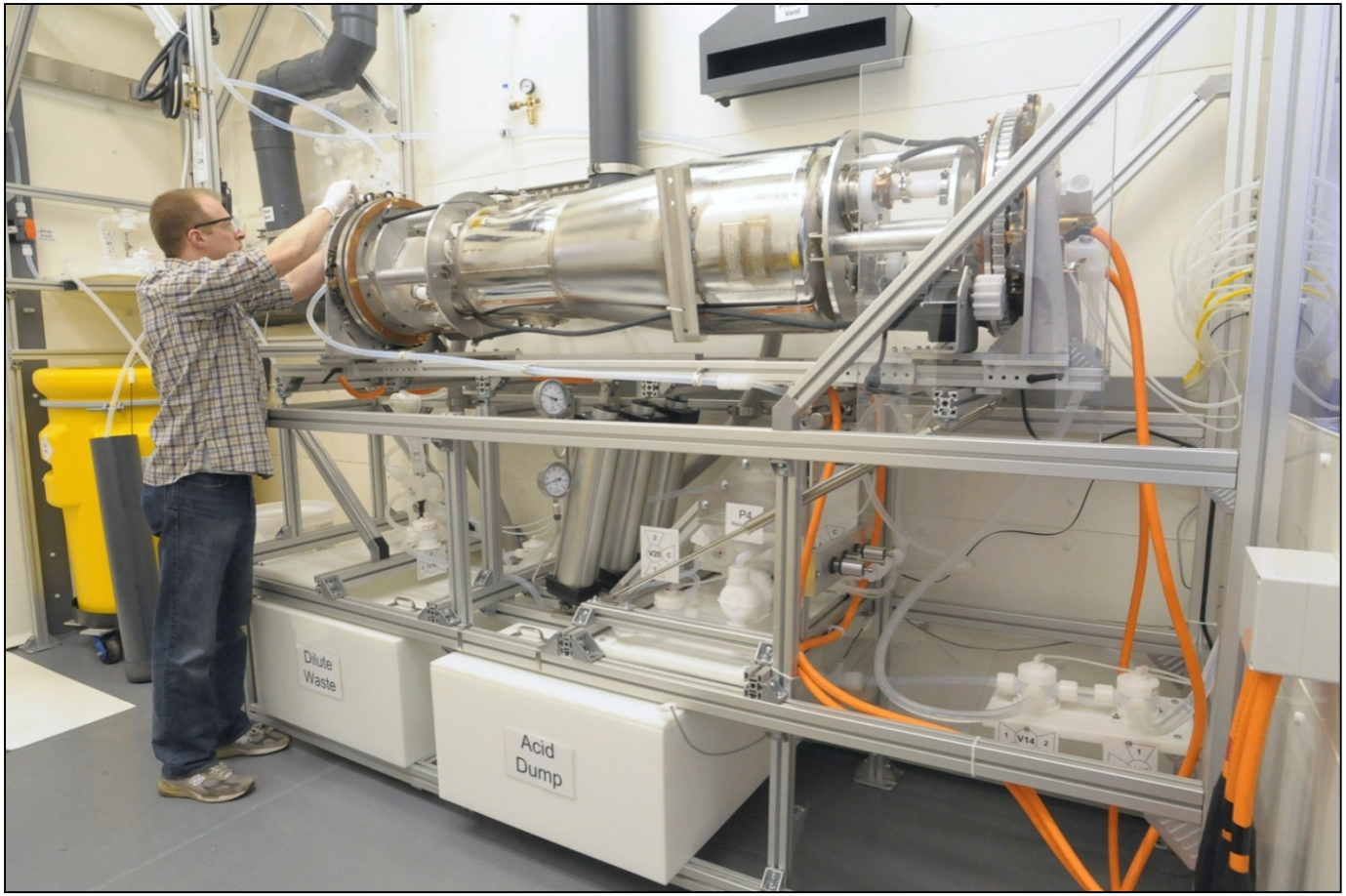
SCSPF Summary

- Capabilities – Current and Planned
  - Electropolishing
    - 1.3 GHz elliptical, 72.5 MHz Low Beta Quarter-Wave
    - 650 MHz 1-cell, 650 MHz 5-cell
  - Buffered Chemical Polishing
    - 1.3 GHz 1-cell, 1.3 GHz 9-cell, 650 MHz 1-cell
  - HPR & Clean Assembly
    - 1.3 GHz 1-cell, 1.3 GHz 9-cell, 72.5 MHz Low Beta Quarter-Wave
    - SSR0, SSR1, SSR2?, 650 MHz elliptical

SCSPF 1.3 GHz EP Tool

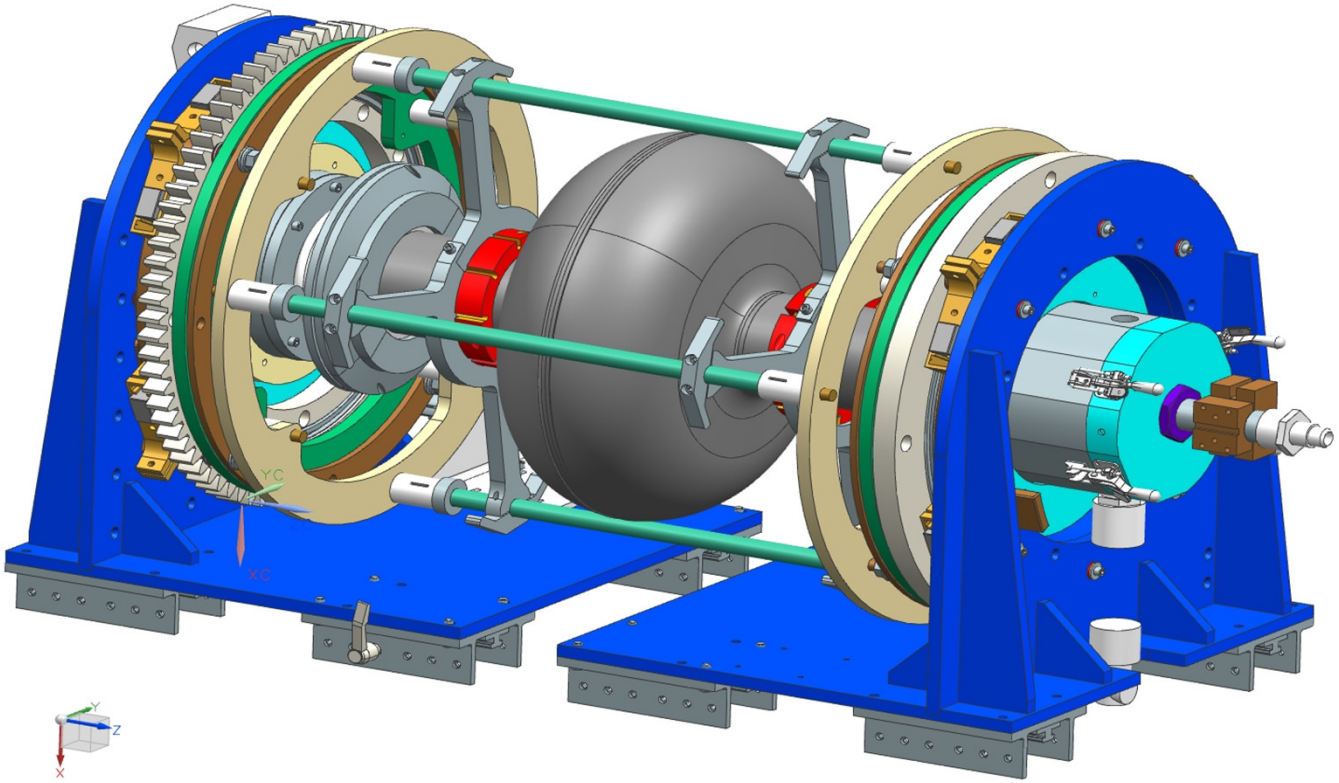
Current SCSPF EP Tool – 1.3 GHz setup to remain unchanged. Used for Project X & ILC R&D.

SCSPF 72.5 MHz Low Beta QW EP Tool



*ANL designed/built—S. Gerbick

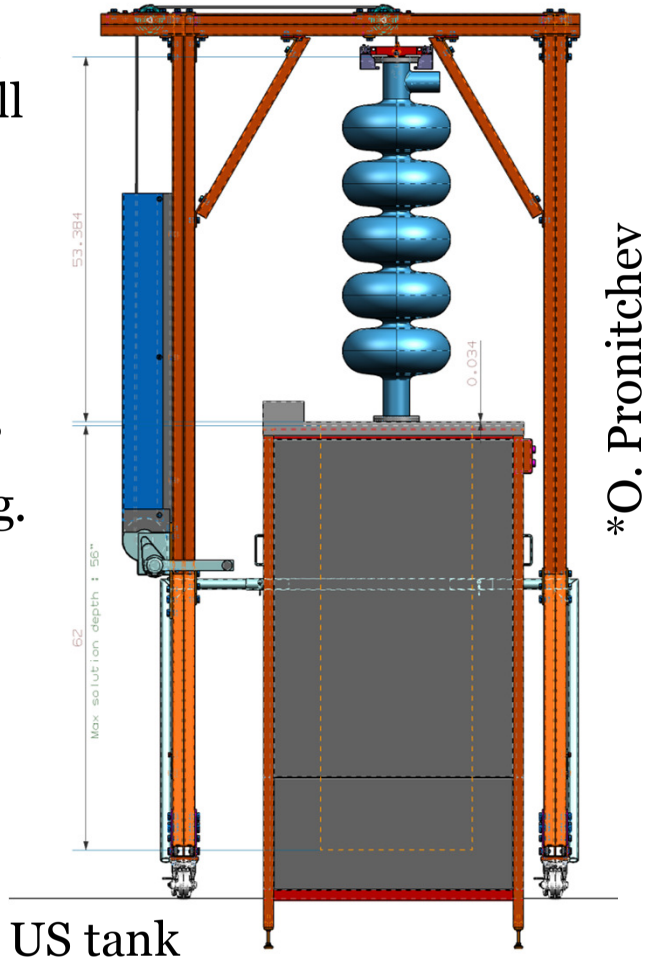
SCSPF 650 MHz EP Tool



Tool used to develop EP recipe for 650 MHz cavities. Fits into QW EP tool in SCSPF.
ANL—R. Murphy, S. Gerbick

SCSPF Capabilities: Ultrasonic Cleaner

Designed for 1.3 GHz use, but will work for 650 MHz, SSR0 & SSR1. SSR2 is too large in diameter to fit within 22” x 24” US tank opening.



*O. Pronitchev

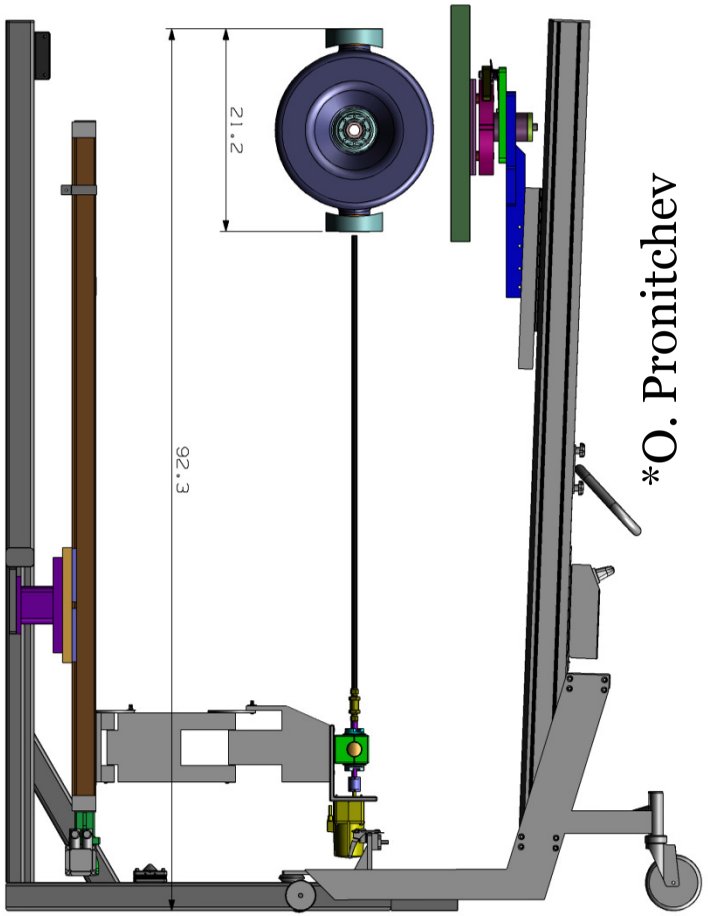
SCSPF Anteroom US tank

SCSPF High Pressure Rinse Tools

FNAL HPR Tool with 1.3 GHz 9-cell

-HPR of 1.3 GHz, and 650 MHz ok.

-HPR of 325 MHz under development. Operational fall of 2011.

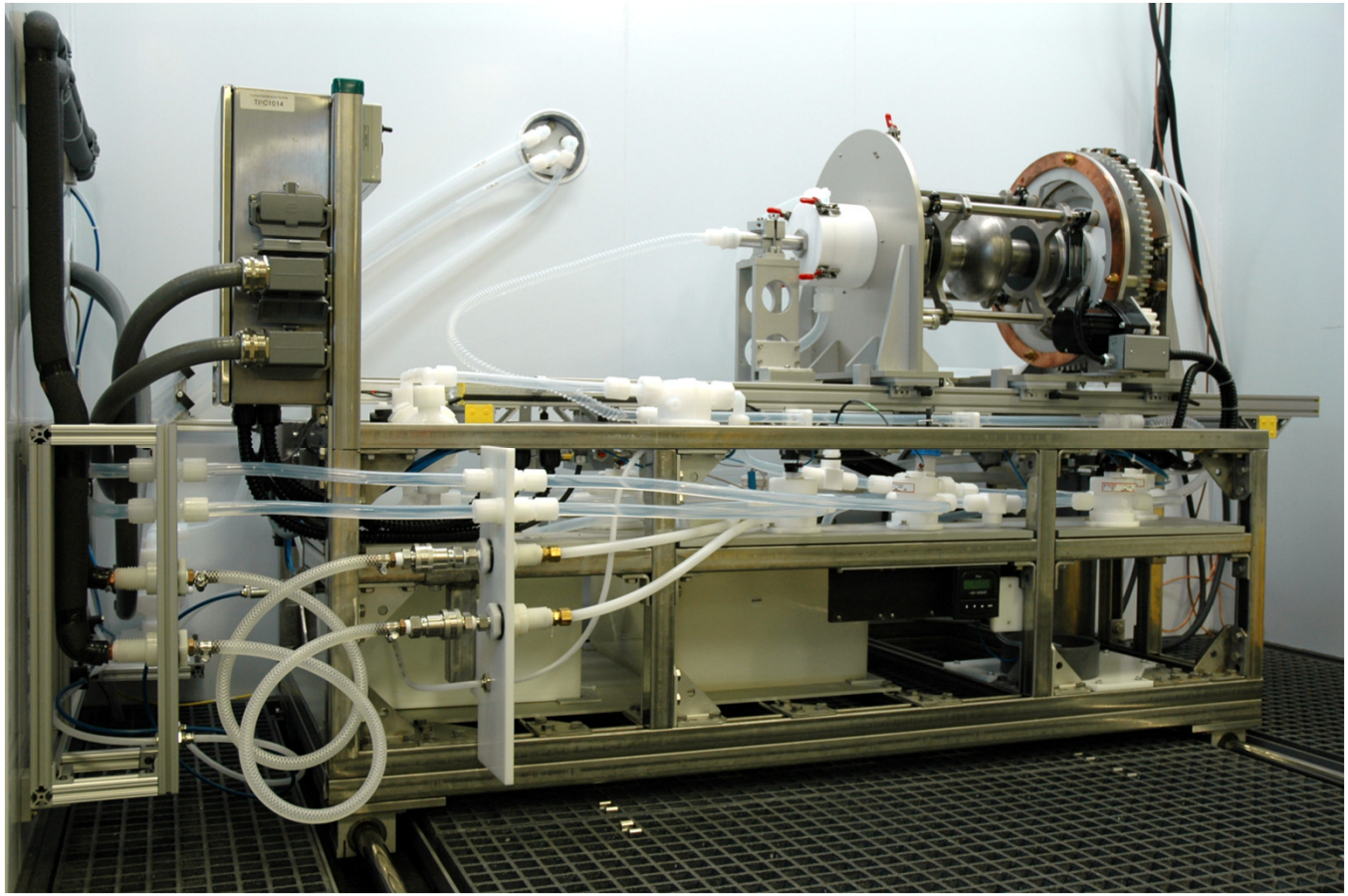


ANL HPR Tool—SSR2 shown

IB4 CPL Summary

- Surface Modification Side
  - 1.3 GHz 1-cell R&D Facility
  - EP—alternative electrolytes, etc.
  - 1.3 GHz cavity CBP development area
  - SRF advanced processing techniques (CVD, ALD?)
- Cleanroom Side
  - Standard HPR/clean assembly & preparations
  - Hydrogen degassing of 1.3 GHz cavities
  - UHV CR area/US cleaning (1.3 GHz + 650 MHz elliptical cavities)

IB4 CPL EP Tool (1.3 GHz 1-cell R&D)



Upgradable EP tool may accommodate 1.3 GHz 9-cell

IB4 CPL CBP Machine

Tumbles 2 cavities/run, 2 complete cycles/week

C. Cooper Recipe Media

IB4 CPL Cleanroom/HPR

HPR Tool, Clean Assembly Rail, Cavity Carts (Support CR's not shown)

FNAL Vacuum Ovens – Hydrogen Removal

IB4 Vacuum Oven—1.3 GHz

Manufacturer:
T- M Vacuum Products Inc.

*Source: M. Wong

Temp = 800C or 600C
Hold = 2 hrs or 10 hrs
Pressure < 1e-06 Torr
99% drop in H2 RGA peak

MP9 Vacuum Oven – 650 MHz, SSRs

Industrial Capabilities--AES

- EP Tool sized up to 650 MHz 5-cell. (commissioning phase)
- HPR up to 1000 lb structures. (commissioned)
- BCP up to 1000 lb. structures. (commissioned)
- CR Area (not adequate for cavity assembly yet)

Near-term Plans for 1.3 GHz Cavities

- Prepare full RF Unit worth of 35+ MV/m cavities with low FE through HTS
- 30+ cavities still to be delivered to FNAL this year. ~10 cavities in house awaiting processing
- Drive CBP processing recipe to maturity for bulk material removal
- 1.3 GHz 1-cell R&D will develop substantially with CPL ORC
- Develop 120C baking station for multiple cavities

Near-term Plans for SSR Cavities

- Upgrade SCSPF to accommodate SSR0,1 cavities in CR. New tooling and assembly techniques in development. SSR2 weight and size an issue with existing infrastructure.
- Finalize BCP/Processing recipe for SSR cavities (two new cavities entering system now)
  - Cavity performance testing at VTS and HTS
- Transfer BCP/HPR technology of bare SSR cavities to industry. Vendor interest already being pursued.

Near-term Plans for 650 MHz Cavities

- Develop EP recipe for 1-cell & 5-cell cavities
  - 1-cell cavities due at FNAL by end of Sept.
  - 5-cell cavity orders not yet placed
- Develop full complement of tooling and infrastructure at SCSPF and CPL CR to accommodate all HPR/Assembly & prep for 5-cell bare & dressed cavities.
- Obtain ORC for MP9 vacuum oven

Extra Material---Proj. X Production

Production Processing Requirements

- Assumed Yields
  - 97% at Inspection, 97% at VT, 97% at HT + 10% overhead production

Cavity Type	Quantity Installed	Quantity Needed	Quantity Produced
SSR0	18	20	22
SSR1	20	22	24
SSR2	44	48	53
650 B=0.6	42	46	51
650 B=0.9	152	167	183
1.3 GHz B=1	224	246	270
Totals	**500**	**549**	**603**

Cumulative Production Processes

Cavity Type	Bulk Chemistry	Light Chemistry	HPR Cycles	Oven Cycles
SSR0 (BCP)	22	24	70	22
SSR1 (BCP)	24	27	78	24
SSR2 (BCP)	53	59	171	53
650 B=0.6 (EP)	51	54	267	51
650 B=0.9 (EP)	183	196	965	183
1.3 GHz B=1 (EP)	270	288	1422	270
Totals	**603**	**648**	**2973**	**603**

Joint FNAL/ANL SCSPF Capacity/Week

Current

	EP/BCP Cycles	HPR Cycles	Test Assemblies
SSR0,1,2	0	0	0
650 B=0.61, 0.9	0	0	0
1.3 GHz	3	4	2
YEARLY TOTALS	150	200	100

Planned

	EP/BCP Cycles	HPR Cycles	Test Assemblies
SSR0,1,2*	0.5*	1	1
Elliptical (all)	3	4	2
YEARLY TOTALS	25, 150	50, 200	50, 100

*SSR cavities can be BCP'd in G150 on a limited, R&D basis.

ICPA Capacity/Week

Planned

	CBP Cycles	EP/BCP Cycles	HPR Cycles	Test Assems	Bake Cycles*
650 MHz	2	0	2	1	3**
1.3 GHz	2	0	2	2	3
YEARLY	100, 100		100, 100	50, 100	150, 150

Upgrade Capacity

	CBP Cycles	EP/BCP Cycles	HPR Cycles	Test Assems	Bake Cycles*
650 MHz	2	1	2	1	3**
1.3 GHz	2	1	2	2	3
Yearly	100, 100	50, 50	100, 100	50, 100	150, 150

*IB4 and MP9 Ovens included, **SSR cavities included

SSR Production Processing Plans

- Industrial Vendor(s) must perform a minimum of bulk BCP + 1 HPR.
- Final BCP in Lab requires NEW dedicated BCP tool. ANL G150 is inadequate for production effort.
- SSR HPR/Assembly relies on ANL CR availability. Unlikely, since CR/EP operation for ANL devices keeps their people busy.
- New CR/HPR dedicated to SSR production safest route.
- Could develop industry to provide testable SSR cavities like XFEL production if new in-house facility isn't built.

Elliptical Cavity Production Plans

- Infrastructure/effort is highly dependent on production schedule.
- Industrial Vendor(s) must perform a minimum of bulk BCP + 1 HPR on all elliptical cavities.
- If 650 MHz BCP is req'd, new Lab-based BCP facility capable of 650 MHz cavities is needed.
- Explore XFEL optimized industrial recipe where cavities are delivered testable---leaves reprocessing to FNAL.

Required Infrastructure Development

- SCSPF –SCSPF 650 MHz & SSR
  - 650 MHz EP Tool—in procurement
  - HPR Tool—modify 1.3 GHz, or utilize ANL Tool
  - Handling equipment—mostly designed, some procured.
  - Assembly fixtures—mostly designed, in
  - Vacuum/leak detection system—ANL side needs capability.
  - Process parameter & control. We'll find out!

Required Infrastructure Dev. cont…

- Industrial Infrastructure
  - 1.3 GHz—bulk material removal a minimum requirement.
  - SSR—one vendor nearly ready. Will need another.
    - Complete BCP setup
    - HPR—first pass capability
    - Handling & tooling hardware
  - 650 MHz—one vendor nearly ready. Will need another.
    - Horiz. EP
    - Bulk & light BCP
    - HPR
    - Handling & tooling hardware

Processing Partner Capabilities

- Increased need for industrial partners.
  - BCP limitations within FNAL/ANL complex.
  - Horiz. EP for 1.3 GHz and 650 MHz
  - Industrial involvement increases likelihood of successfully meeting parallel cavity processing requirements.
- Jefferson Lab
  - Has expressed interest in 650 MHz efforts. May include processing R&D?
  - Currently working on B=0.61 1-cell cavities.
  - TEDF needs work---may pitch to do lots of cavity processing.
- Cornell
  - Process development. Vertical EP for 650 MHz?
- International Collaborators

Critical Questions

- Can standard 1.3 GHz processing recipe be used for 650 MHz cavities of both β?
- Can current BCP processing recipe for SSR cavities be used for all shapes?
- Will industrial/international partners be able to meet BCP and HPR requirements of SSR cavities?
- What processing model will be used for the 3-8 GeV LINAC? Something similar to XFEL where FNAL is responsible for re-processing only?
- Do cavity and processing development timelines match Project X's timelines?
- Are alternative processes an option for the elliptical (CBP, CMP. Bi-polar EP)?