SRF CAVITY PROCESSING FOR PROJECT X

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Outline

- Processing Overview
  - Cavity types
  - Planned processing recipes by cavity type
  - Processing requirements
- Processing Capabilities
  - Facility Details
  - Required development
  - Other Lab/industrial involvement
  - Critical Questions for Processing
- Processing Development Opportunities
  - Centrifugal Barrel Polishing (CBP or Tumbling)
  - Pulse-Pulse Reverse Electropolishing
  - Chemical Mechanical Polishing (CMP)

Cavity Types & Quantities

*Source: Vyacheslav Yakovlev

Section	Energy MeV	E_{acc} MV/m	B_{max} mT	Q @ 2K x10^9	Number of cavities
SSR0 (β_G=0.12)	2.5-10	Emax= 53	59.5	9.5	26
SSR1 (β_G=0.22)	10-32	Emax= 34.4	50.8	14	18
SSR2 (β_G=0.4)	32-160	Emax= 33	54	18	44
650 MHz (β_G=0.61)	160 - 500	17.1	72	15	42
650 MHz (β_G=0.9)	50 - 2000	19.2	72	20	96
1300 MHz (β_G=1)	2000-3000	16.9	72	15	72
1300 MHz (β_G=1)	3000-8000	25	107	10	250

Spoke Cavity 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	

*Unknown fraction to be horizontally tested. Some dressed cavities may be vertically tested in lieu of horizontal testing.

Elliptical Cavity Processing Recipe

1. Inspection – RF & Optical	10. Evacuate
2. Bulk EP	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*

*Unknown fraction to be horizontally tested. Some dressed cavities may be vertically tested in lieu of horizontal testing.

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	26	29	31
SSR1	18	20	22
SSR2	44	48	53
650 B=0.6	42	46	51
650 B=0.9	96	106	116
1.3 GHz B=1	314	345	378
Totals	**540**	**594**	**651**

Cumulative Processes

Cavity Type	Bulk Chemistry	Light Chemistry	HPR Cycles	Oven Cycles
SSR0 (BCP)	31	35	101	31
SSR1 (BCP)	22	24	70	22
SSR2 (BCP)	53	59	171	53
650 B=0.6 (EP)	51	54	267	51
650 B=0.9 (EP)	116	123	610	116
1.3 GHz B=1 (EP)*	378	401	1988	378
Totals	**651**	**696**	**3207**	**651**

*Includes 2-3 GeV + 3-8 GeV LINACs. Does not include ILC demands

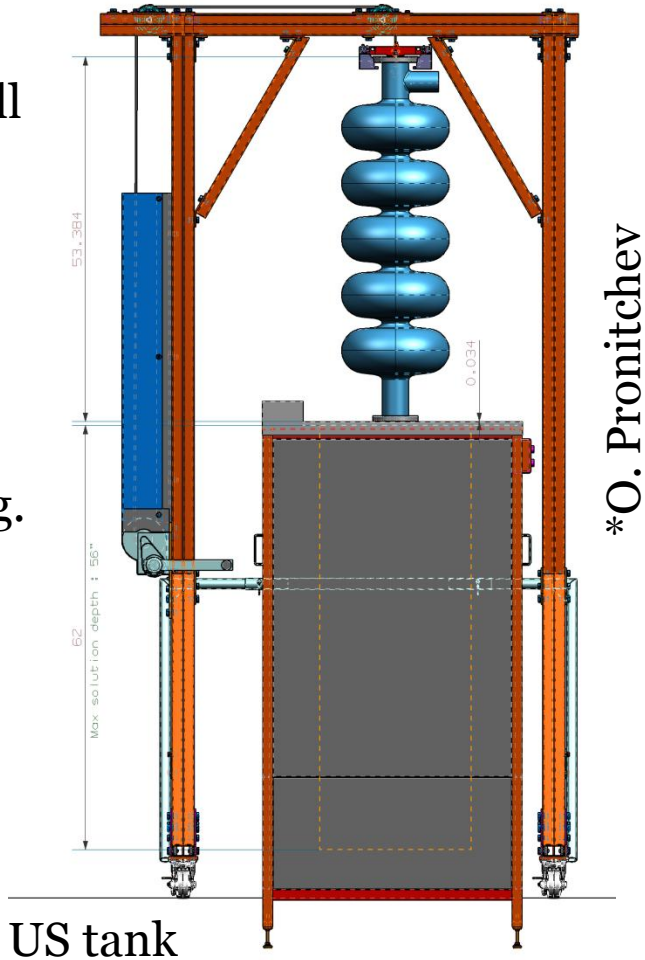
SCSPF + FNAL Planned Capacity

	BCP (SSR)	EP (elliptical)	HPR Cycles	Oven Cycles
Processes /month	1	10-12	16	16

- Insufficient for SSR, will require industrial involvement or new Lab BCP capabilities.
- May be adequate for 1.3 GHz and 650 MHz 2-3 GeV LINAC depending on production schedule and whether industry can complete bulk EP. 2nd HPR pump may be needed.
- 3-8 GeV LINAC requirements are not met.

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.

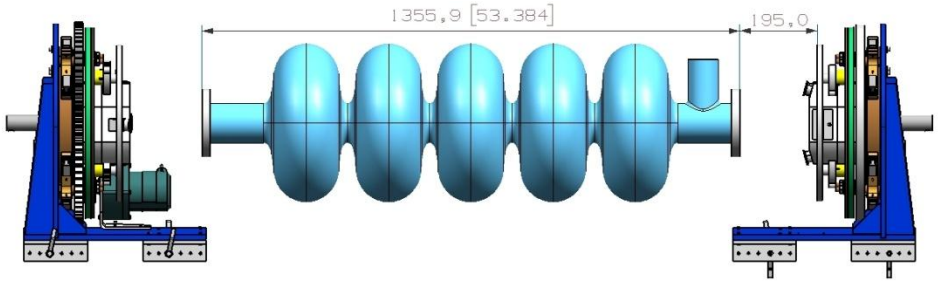


*O. Pronitchev

SCSPF Anteroom US tank

SCSPF Electropolishing Tools

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



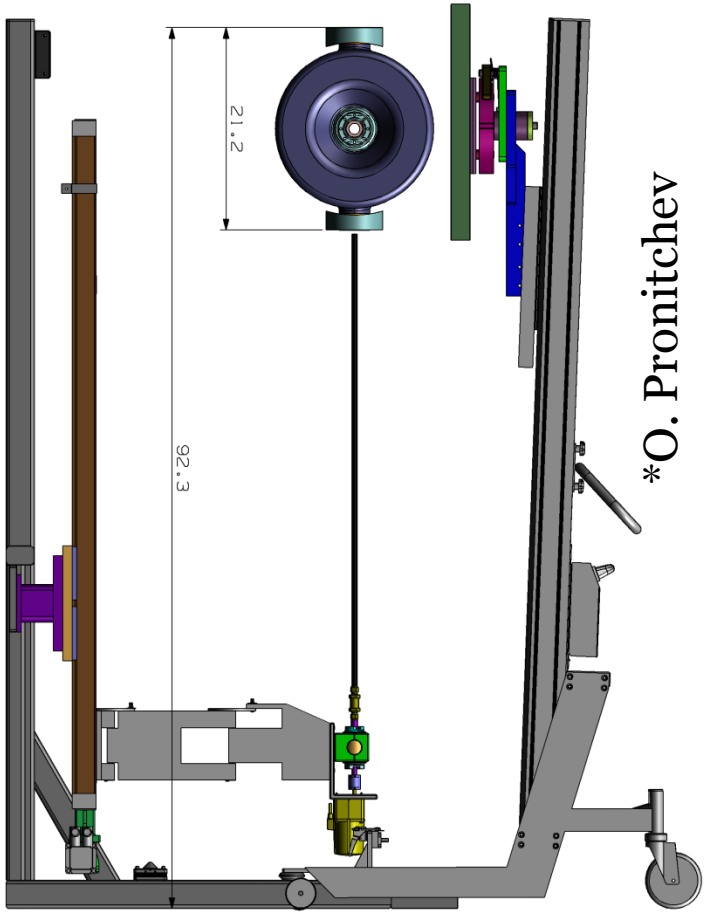
New SCSPF EP Tool
- QWR & 650 MHz setup

*O. Pronitchev

SCSPF High Pressure Rinse Tools

-HPR of 1.3 GHz, and 650 MHz ok.

-HPR of 325 MHz under review. All rinse orientations are not possible with current HPR tools.



*O. Pronitchev

FNAL HPR Tool with 1.3 GHz 9-cell

ANL HPR Tool—SSR2 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
10x drop in H2 RGA peak

MP9 Vacuum Oven – 650 MHz, SSR

Additional Facility Capabilities

- ANL Bldg. 203 Rm G150
  - Small number of SSR cavities can be BCP'd & HPR'd. Not to be used for production run.
- IB4 ICPA
  - 1-cell R&D for 1.3 GHz, 650 MHz under consideration.
  - Tumbling for 1.3 GHz, EP, BCP possible with new tool. Changes ICPA scope.
  - Full cleanroom & HPR capabilities for 1.3 GHz 1-cell & 9-cell + 650 MHz 1-cell work. Multi-cell 650MHz under consideration.

Required Infrastructure Development

- SCSPF – 1.3 GHz, 2-3 GeV LINAC = none
  - 3-8 GeV LINAC some quantity can be produced here, but not all. Additional facilities/industrial partners required.
- SCSPF 650 MHz & SSR---everything!
  - EP Tool
  - HPR Tool
  - Handling equipment
  - Assembly fixtures
  - Vacuum/leak detection system
  - Facility chemical capacity
  - Process parameter & control

Required Infrastructure Dev. cont…

- Industrial Infrastructure
  - 1.3 GHz—none required for Proj. X, but will have capability.
  - SSR
    - Complete BCP hardware
    - HPR—first pass capability
    - Handling & tooling hardware
  - 650 MHz
    - 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?
  - Discussions in early stages.
- 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?
- Where are the 3-8 GeV cavities going to be processed?
- Do cavity and processing development timelines match Project X's timelines?
- Are alternative processes an option?

Centrifugal Barrel Polishing (Tumbling)

IB4 Machine CBPs 1.3 GHz Cavities Only

Pulse-Pulse Reverse Electropolishing

5-20% H_2SO_4 Electrolyte!

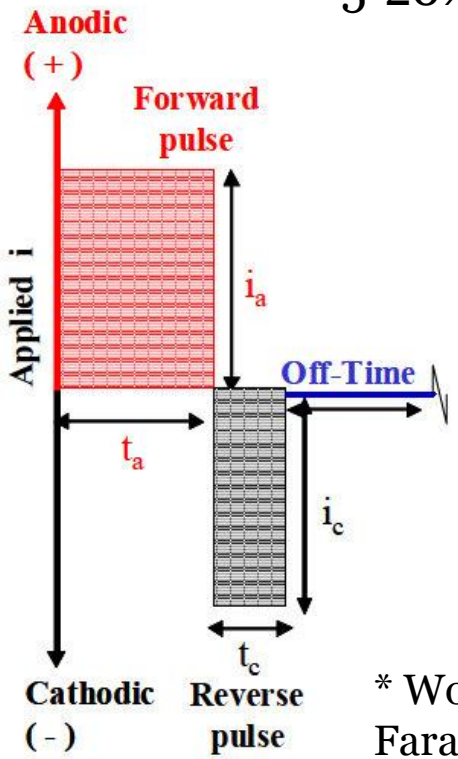
"Tuned" to:

Enhance mass transfer

Control current distribution for electrochemical polishing, deburring, machining.

"Tuned" to:

Depassivate surface thereby eliminate the need for HF and eliminate pitting.



The FARADAYIC ElectroPolishing waveform.

"Tuned" to:

Facilitate heat removal.

Allow diffusion of "acceptor" to the surface.

Allow diffusion of reaction products away from the surface.

* Work done in collaboration with Faraday Technologies Inc., Clayton, OH via ARRA Eco-friendly Processing R&D project

Chemical Mechanical Polishing

- Combined with CBP (bulk material removal)
- Non-HF final polishing step (20 um or less)
- Surface finish ~ 450 Å rms or better!
- EP surface finish ~ 5000 Å rms
- Oxidizer + silica/alumina slurry + mechanical force
- Work done in collaboration with Cabot CMP, Addison, IL, via ARRA Eco-friendly Processing &D project