Fermilab U.S. DEPARTMENT OF ENERGY Office of Science

Automating SRF Cavity String Assembly

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5 minutes - 5 slides

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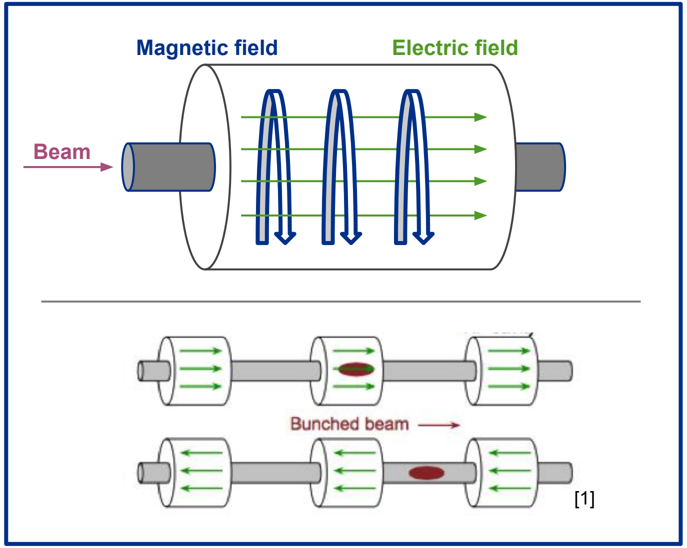
Powerful and efficient accelerators will require SRF cavities



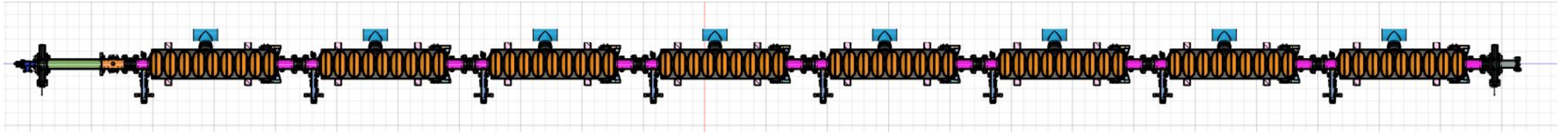
Option	Super-conducting	Normal Conducting
Q_0	2×10^9	2×10^4
r_a/Q_0 (Ohm/m), rf frequency = 500 MHz	330	900
P/L (Watt/m) for $E_{acc} = 1$ MV/m	1.5	56,000
AC Power (kW/m) for $E_{acc} = 1$ MV/m	0.54	112
AC Power (kW/m) for $E_{acc} = 5$ MV/m	13.5	2,800

[2]

- RF cavities are at the heart of most accelerators--they add energy to particle beams effectively accelerating particles
- How fast and how robust acceleration can be is limited by multiple parameters including power dissipations, field emissions, and multipactor effects

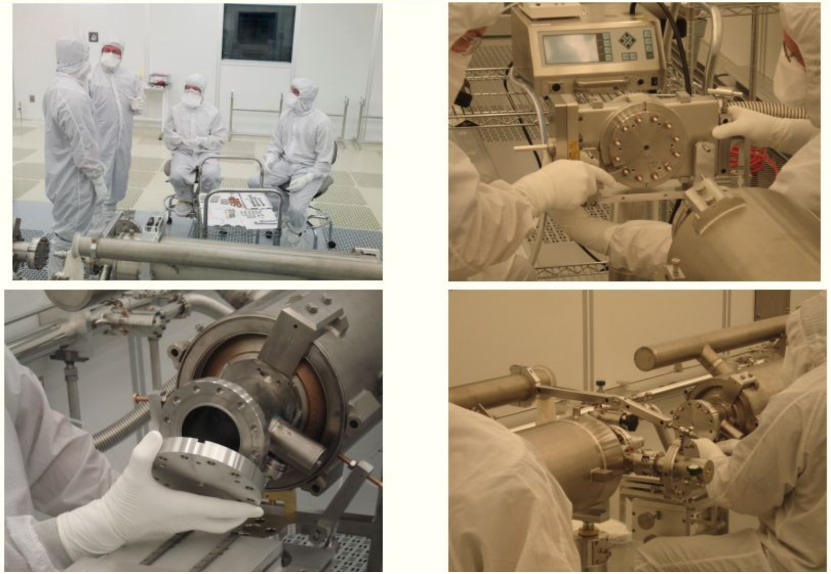
Demand for high quality cavities from FNAL will continue to increase

- LCLS-II, PIP-II, and HL-LHC are among the ongoing large-scale research programs benefiting from SRF technology [3]
- While FNAL's leading research program in SRF technology has made significant breakthroughs in the past few decades, a primary focus is to move SRF cavity production from R&D to Production & Operations



String of eight 9-cell cavities (LCLS-II 1.3 GHz CM)

SRF cavity string assembly is long and tedious



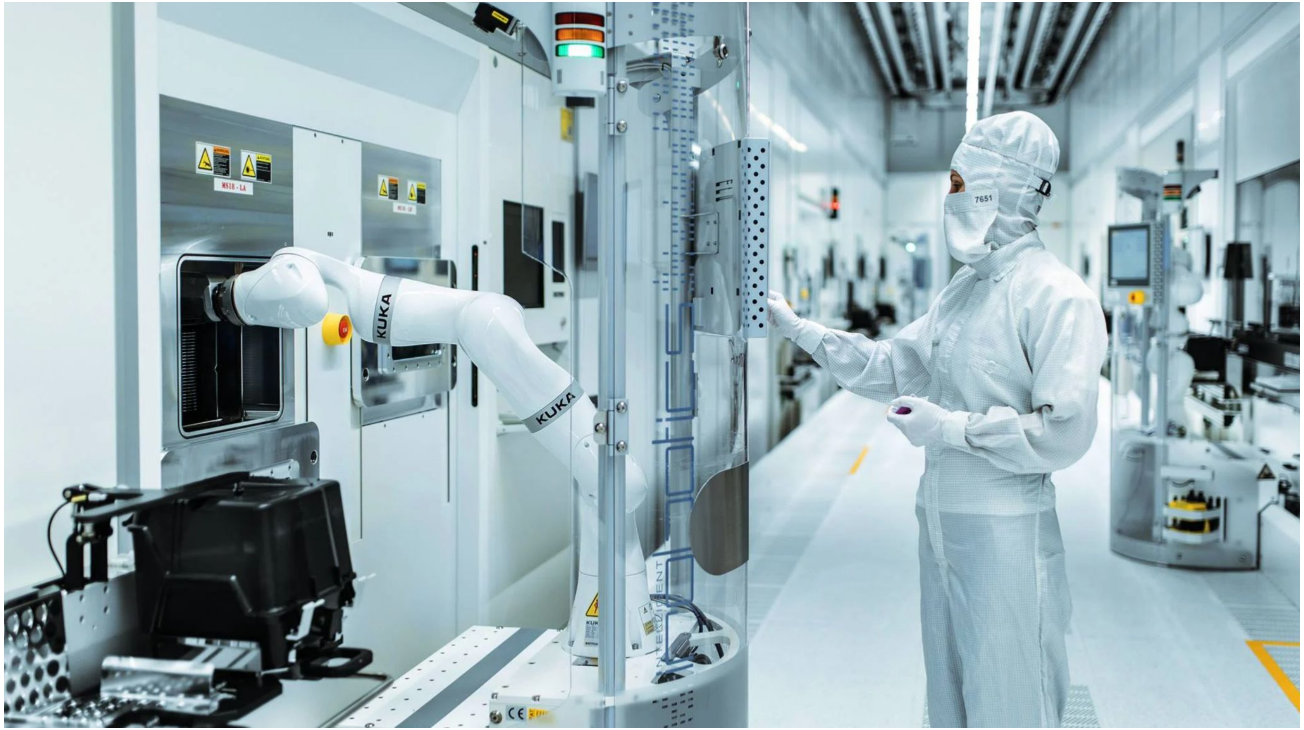
[4]

1	Align cavity #1 and gate valve on rail
2	Vent cavity to normal air pressure
3	Connect gate valve to cavity #1
4	Pump down and leak check unit
5	Vent cavity and gate valve to normal air pressure
6a	Align cavity #N on rail
6b	Align bellow and beam tube flange long side
6c	Clean beam pipe flange cavity long side
6d	Remove beam tube flange
6e	Connect bellow to beam tube long side
7a	Clean beam tube short side flange
7b	Align bellow and beam tube flange short side
7c	Remove beam tube short side
7d	Connect bellow to beam tube side short
8	Repeat step 6a to 7d for cavity #2 to #8 and BPM Quadrupole unit
9	Adjust coupler distance
10	Pump down string and leak check unit
11	Vent string to normal air pressure

[5]

Particulate contamination during string assembly is one of the main sources of field emissions

Microchip fab shows us that the technology for automating cleanroom processes already exists



[6]

Full assembly automation will take significant investment, but the goal of this project is to design a first-iteration system

Weeks 1-2	Weeks 2-3	Weeks 3-5	Weeks 6-9	Week 10-end
Background research	**Define technical problem**	**Design critical module**	**Review and analysis**	**Finalize design and documents**
Consolidate prior work, identify stakeholders, conduct field interviews	Define technical requirement, identify risks, set timelines, set budgets	Identify strategies, develop and evaluate concepts, define a most critical module from best concept	Feedback-design cycle, perform analyses and simulations	Synthesize BOMs, consult vendors, consult fab & engineering teams

Sources

[1] https://news.fnal.gov/2015/09/resonant-cavities-acceleration-charged-particles/
[2] RF Superconductivity for accelerators; Hasan Padamsee 1998 p. 7-8
[3] https://opss.fnal.gov/projects-programs/
[4] https://indico.desy.de/event/1096/contributions/3536/attachments/2512/2889/CAF-Arkan-Saclay_May_2008.pdf
[5] https://accelconf.web.cern.ch/SRF2011/papers/tupo041.pdf
[6] https://www.kuka.com/en-us/industries/electronics-industry/automation-in-semiconductor-fabrication