SRF Cavity R&D – Enabling New Frontiers in High Energy Physics and Quantum Science

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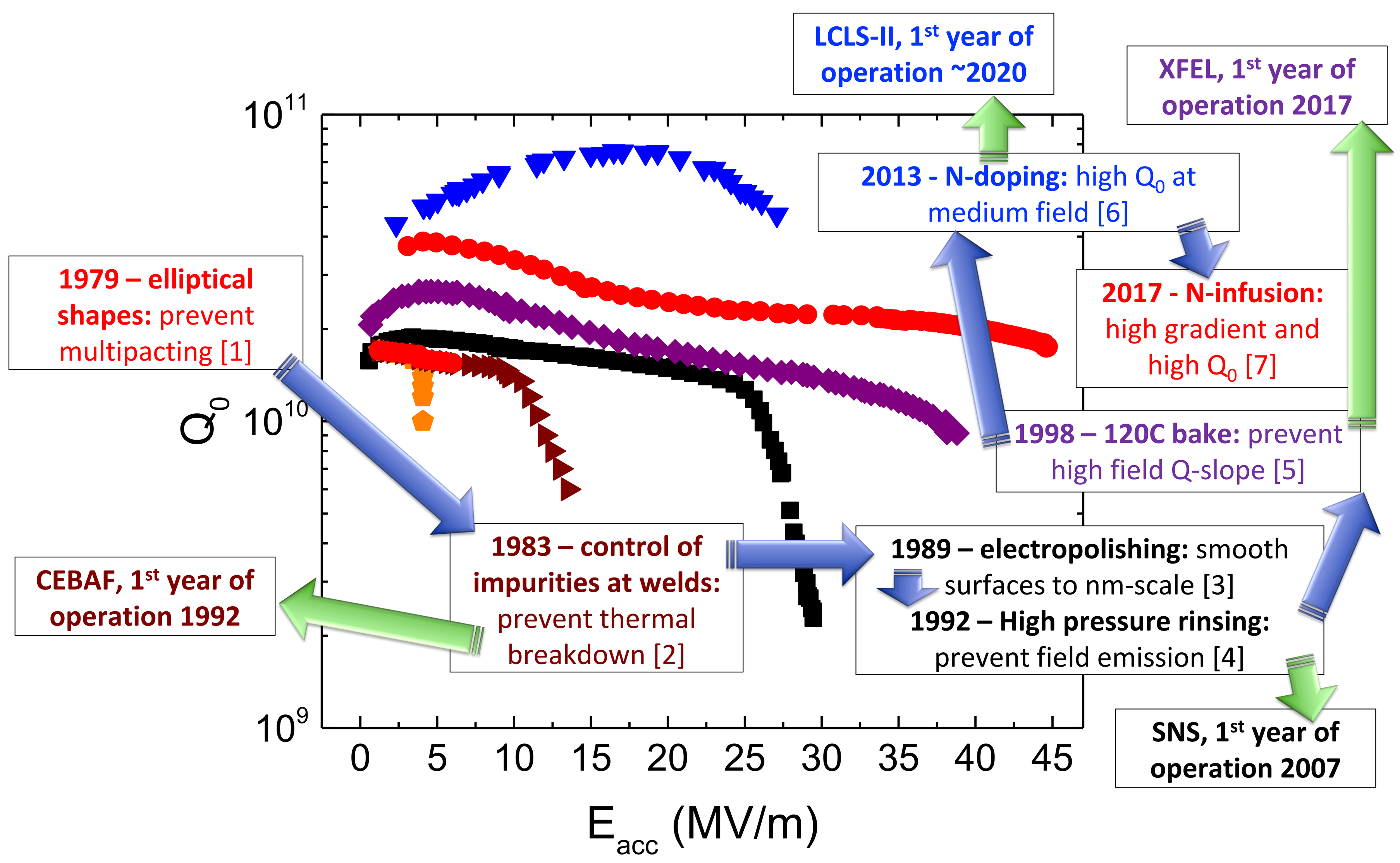
Two Key Figures of Merit

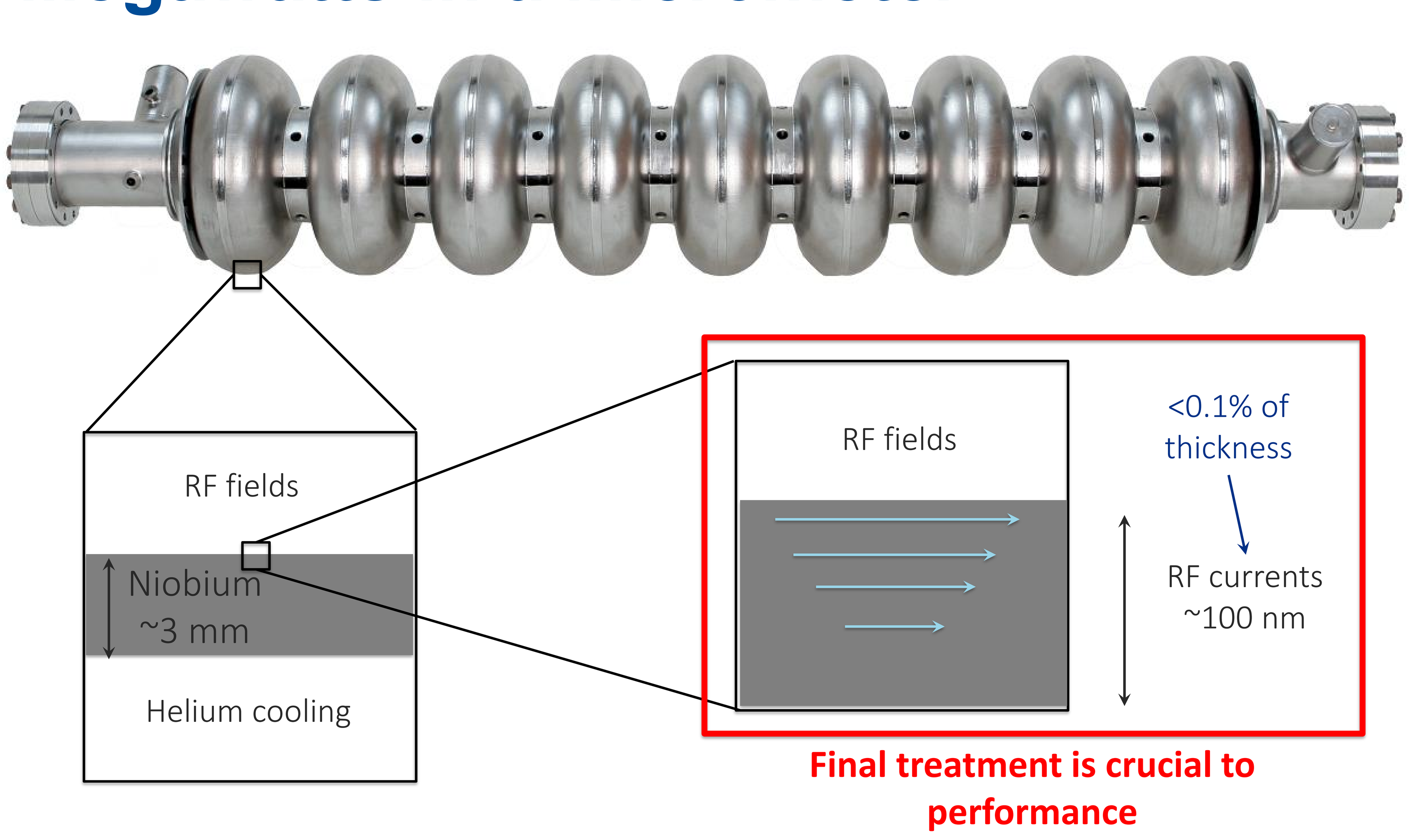
- Quality factor (Q_0): improving cavity efficiency, measured by Q_0 reduces costs for cryogenic plant infrastructure and operation
- Accelerating gradient (E_{acc}): improving gradient makes it possible to reach higher energy



Historical trends of SRF R&D leading to advances in cavity performance, which then enable new accelerator-based science

- Fermilab SRF R&D: focus on **transformational R&D** for pushing the boundaries of cavity performance

"Megawatts in a Micrometer"



- All RF currents are conducted in ~1 micrometer layer on inner surface of cavity
- Therefore final treatments have huge impact on Q_0 and E_{acc} – performance of an accelerator can be determined by surface processing

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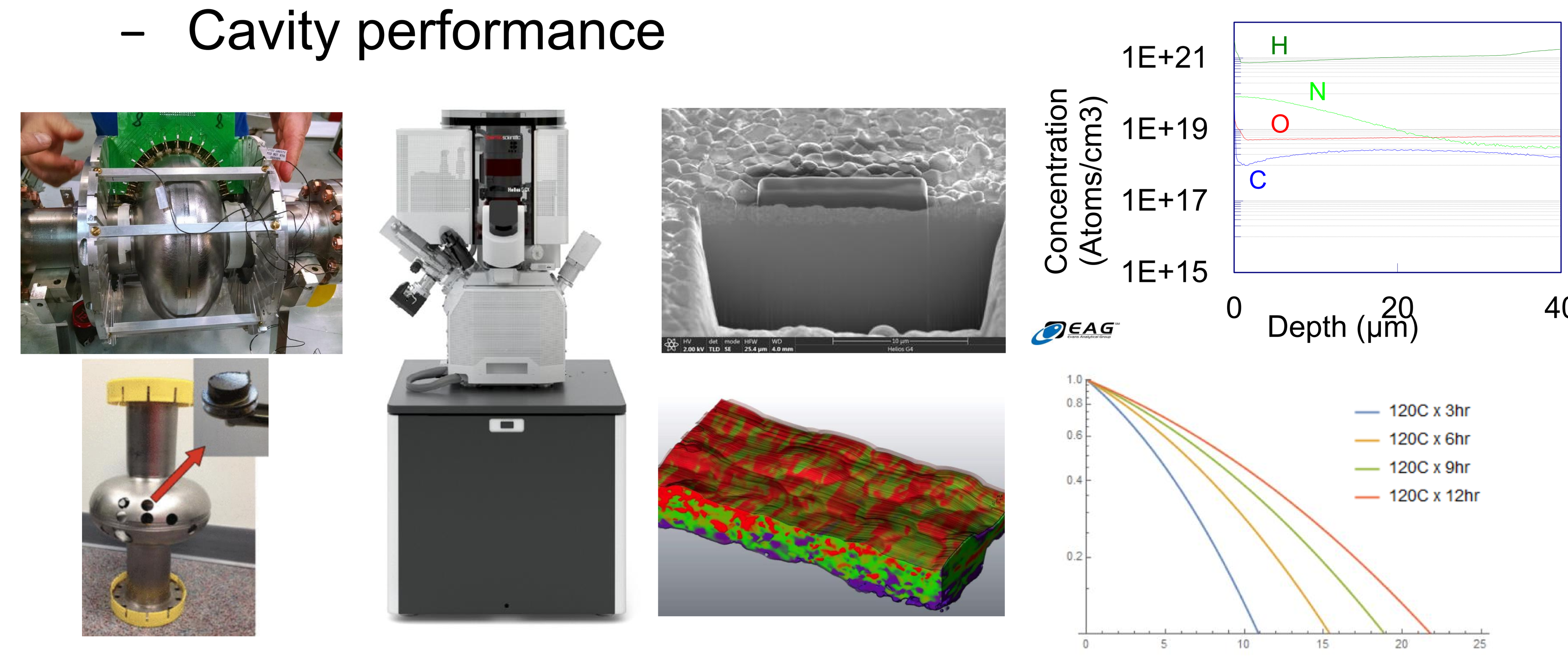
Materials Science to Connect Performance to Superconductivity

- Fermilab SRF research often emphasizes materials science, trying to make connections between:
  - Surface processing steps
  - Microstructure (impurities such as N, H, and O, dislocations, grain boundaries)
  - Cavity performance

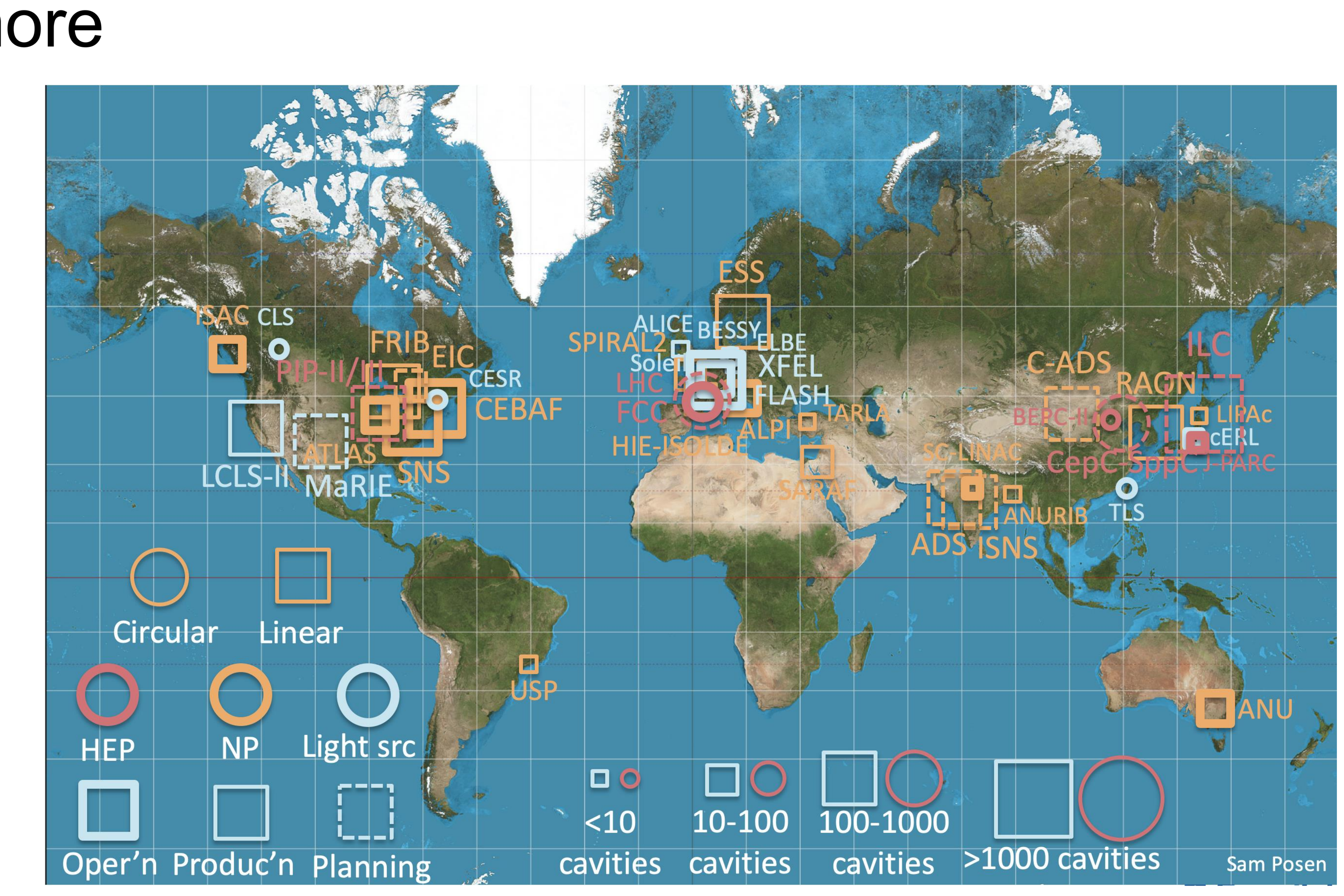


By mapping out dissipation over the surface of a cavity, samples can be prepared with specific knowledge of SRF performance, then analyzed with electron microscopy and other materials science tools

Impacts of Advances in SRF Science

Advances in SRF research at Fermilab have potential for impact in a wide variety of scientific fields:

- High energy physics (e.g. PIP-II, proposed colliders)
- Basic energy sciences (e.g. LCLS-II, LCLS-II HE)
- Nuclear physics (e.g. proposed MaRIE, EIC)
- Quantum Science (see quantum lab for details)
- Dark matter searches (e.g. ADMX g-2)
- Industrial particle accelerators for wastewater treatment, cancer treatment, isotope production, and more



Map of SRF accelerators around the world

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