Niowave's Growth and the Role of STTR in its Development

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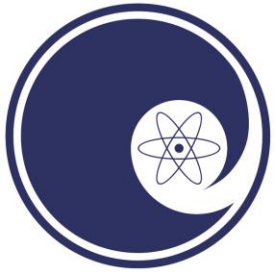

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Outline

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- Superconducting electron linacs & their applications
- Personal experience with SBIR/STTR
- Niowave's experience with SBIR/STTR
  - DOE (Office of Science, NNSA/others)
  - DHS (DNDO)
- STTR programs & effectiveness
  - Niowave's views & recommendations

Why Superconducting?

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- 10^6 lower surface resistance than copper
  - Most RF power goes to electron beam
  - CW/continuous operation at relatively high accelerating gradients >10 MV/m
- Large aperture resonant cavities
  - Improved wake-fields and higher order mode spectrum
  - Preserve high brightness beam at high average current (high power)

Superconducting Turnkey Electron Linacs

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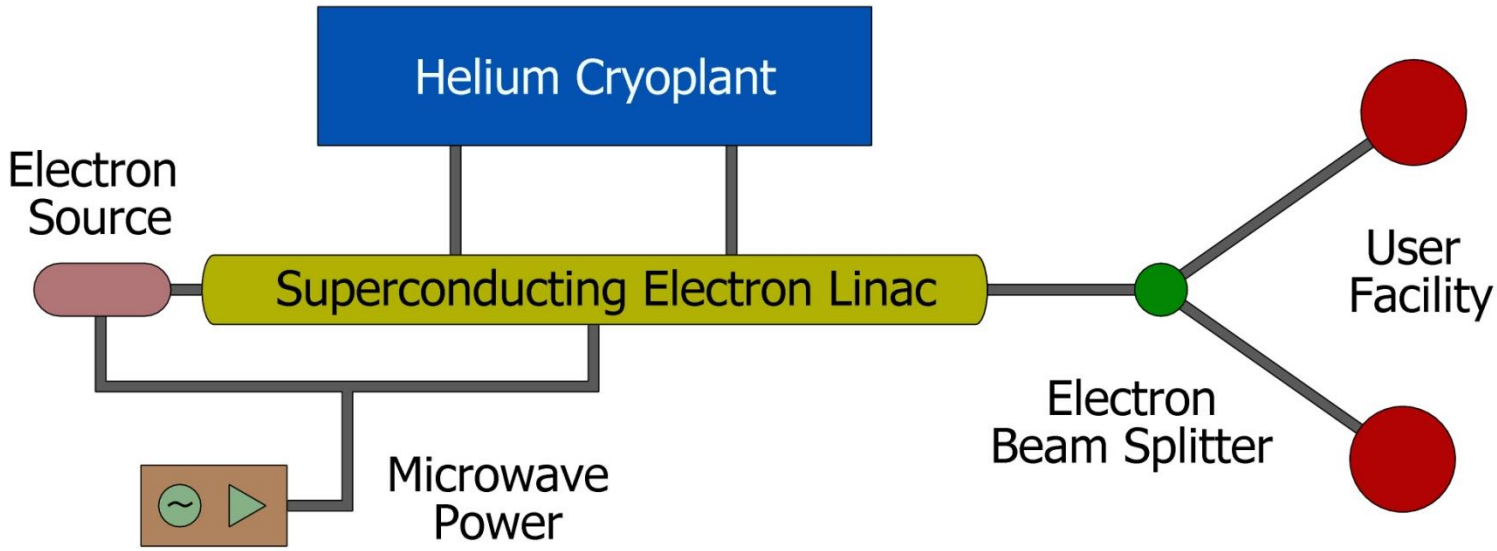

Turn-key Systems

- Superconducting Linac
- Helium Cryoplant
- Microwave Power
- Licensing

Electron Beam Energy	**0.5 – 40 MeV**
Electron Beam Power	**1 W – 100 kW**
Electron Bunch Length	**~5 ps**

Turnkey Linac Subsystems

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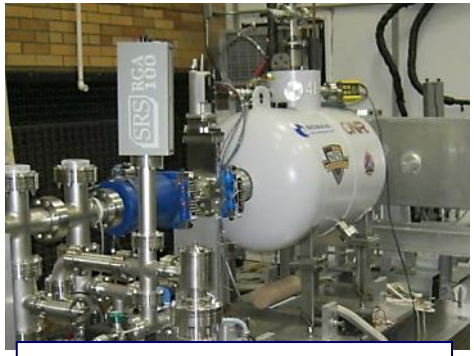
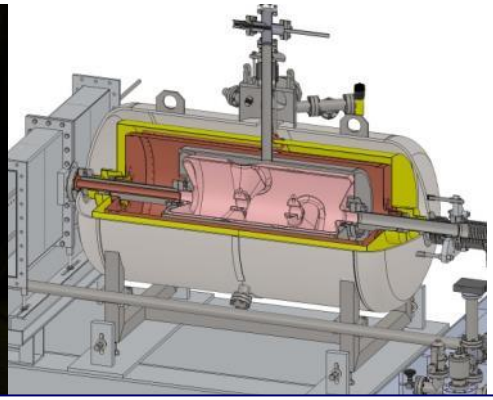


RF electron guns

Solid-state and tetrode RF amplifiers (up to 60 kW)



Superconducting cavities and cryomodules

High-power couplers

Commercial 4 K refrigerators (rugged piston-based systems, 100 W cryogenic capacity)

Superconducting Accelerating Cavities

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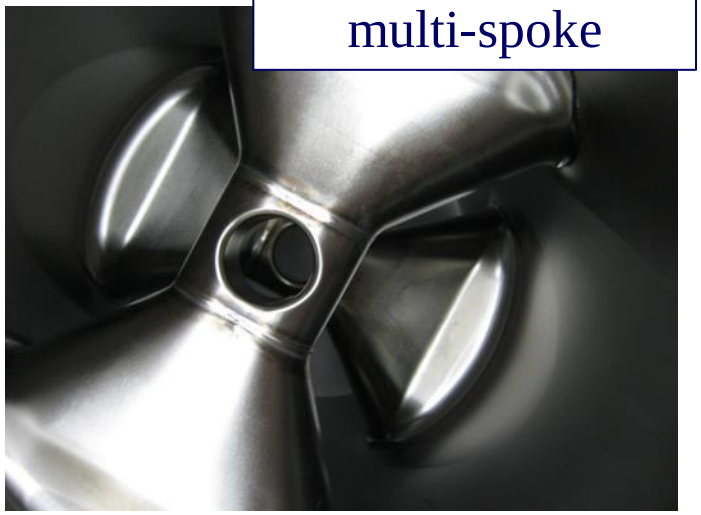
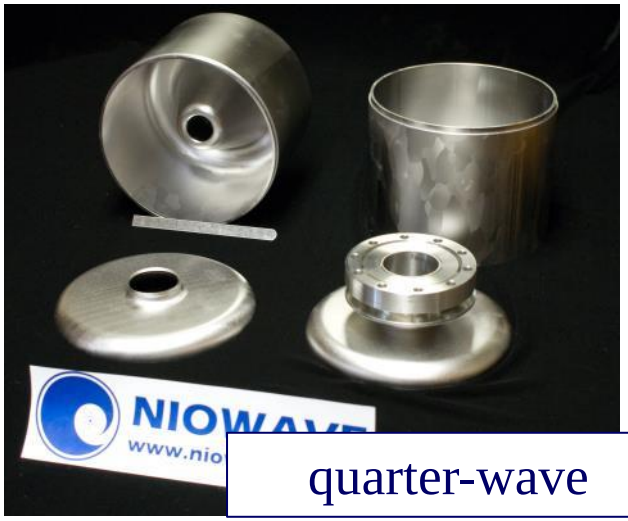
multi-cell elliptical

multi-spoke





quarter-wave

photonic bandgap

Variety of new SRF cavity shapes are allowing compact, low-frequency acceleration with high average beam power.

2 & 10 MeV Injectors

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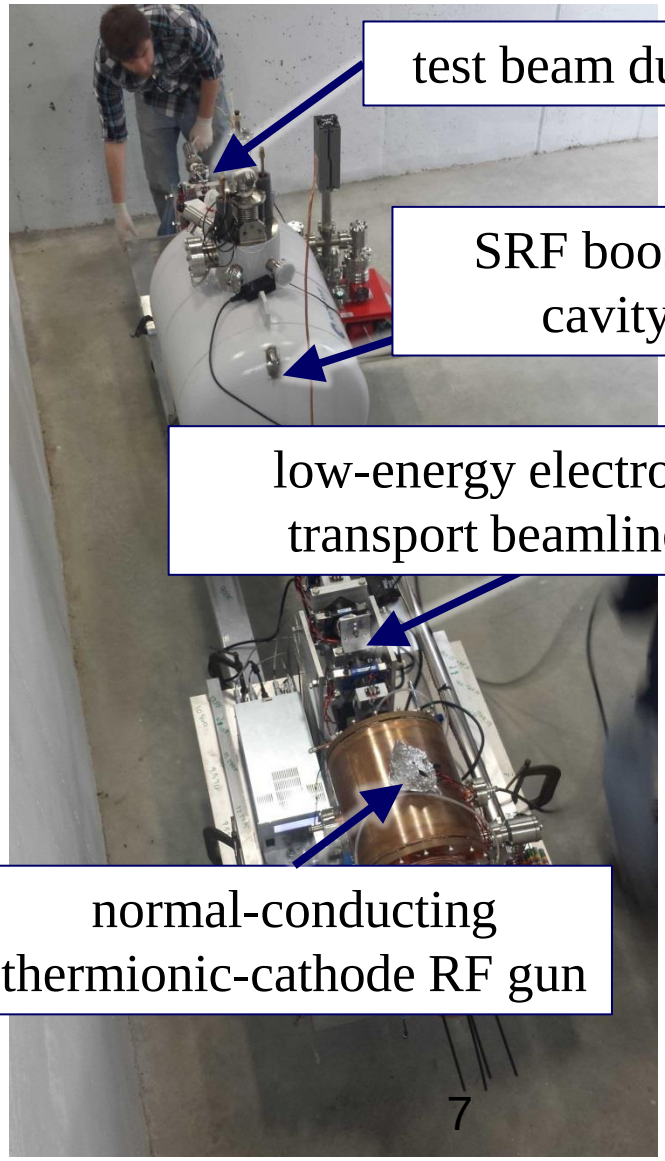

Parameter	2 MeV	10 MeV
cathode type	thermionic	thermionic
NCRF electron gun energy	100 keV	100 keV
SRF booster cavity energy	2 MeV	10 MeV
bunch repetition rate (gun, booster frequency)	350 MHz	350 MHz
transverse normalized rms emittance	3-5 mm mrad	3-5 mm mrad
bunch length @ 2 MeV	2-5 ps	2-5 ps
average beam current	2 mA	1-2 mA

Commercial Uses of Superconducting Electron Linacs

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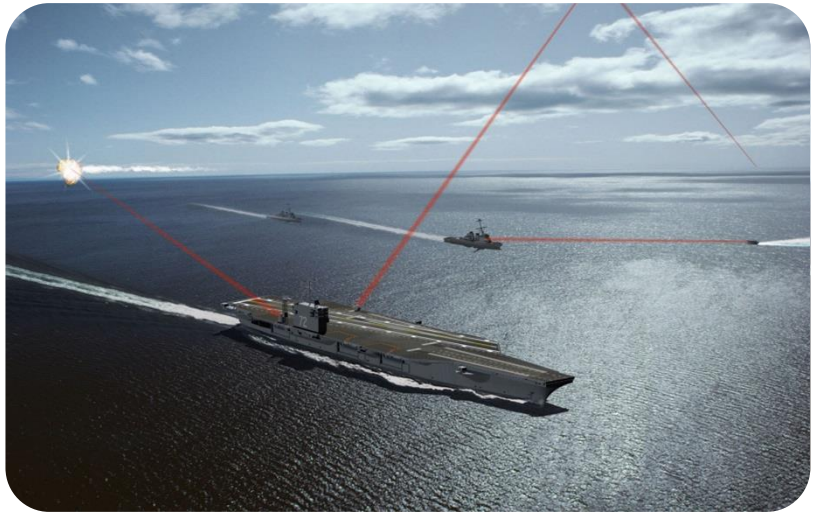
High Power X-Ray Sources

Radioisotope Production



Free Electron Lasers

High Flux Neutron Sources

Personal Experience with SBIR/STTR

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- First 20 years of my career I was a research scientist with DOE
  - Reviewer for SBIR/STTR proposals for ~10 years
  - Exposed me to opportunities and applications of my research
  - Accepted companies as research partners, as opposed to parts suppliers
  - Involved companies in my research

Niowave's Experience with SBIR/STTR

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- Niowave would not exist without the SBIR/STTR program
  - Very complicated technology
  - Long, expensive R&D path
  - New or nonexistent commercial markets
    - Very limited private sector funding
  - SBIR/STTR funding bridged 10 year "valley of death"
  - DOE research partners
    - transfer knowledge, AND
    - give huge credibility to our undertaking

Niowave's Experience with STTR

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- Multiple SBIR/STTR grants from
  - DOE (Office of Science, NNSA/others)
  - DHS (DNDO)
- STTR
  - Main advantage is the level of involvement from the research organization, especially the PI/co-PI
    - More engaged as PI than as a subcontractor
    - Sometimes this is the only way to get their involvement

Superconducting Multi-Spoke Cavities (started as DOE SBIR/STTR)

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- Advantages for low frequency, high current linacs
  - **Mechanical stability** (stable against microphonics)
  - **Compact geometry** for improved real-estate gradient and low-frequency operation at 4 K
  - **Improved higher-order-mode (HOM) spectrum** and damping

ONR
Revolutionary Research . . . Relevant Results

Joint Technology Office
High Energy Lasers

NPS
Praestantia per Scientiam

Los Alamos
National Laboratory

Old Dominion University

STTR programs & effectiveness

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Niowave's views & recommendations

- Economic outcomes
  - Niowave is viable and growing
- Impact and experiences creating collaborations with DOE labs and universities
  - Invaluable
- Transferring technologies and establishing IP agreements
  - Each lab and university handles this differently. In this area, the labs and universities are non-profit companies competing for limited R&D funds
  - RECOMMENDATIONS
    - Standardize terms and paperwork
    - Minimize IP costs until revenue and profits are generated, then share with labs and universities
- Application process
  - DOE: Letter of Intent and limit to number of proposals annually, helpful
    Published program timelines (e.g. selection announcement, award start), helpful
  - DHS: Single portal for submission and administration, helpful

Niowave Headquarters [1]

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- Prototype and commission
  - 40 MeV superconducting electron linac
  - Isotope production target
- 2012 Dedication of testing facility
  - Keynote speakers: Senator Carl Levin, Senator Debbie Stabenow, Rear Admiral Matthew Klunder and MSU Provost Kim Wilcox

Niowave Headquarters [2]

NIOWAVE
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- Total 60,000 SF
  - Full in-house design, manufacturing, processing and testing capability
  - 3+ megawatts power
  - 60 kW RF power systems
  - Two 100 W helium refrigerators
  - Licensed to operate up to 40 MeV and 100 kW

A superconducting linac being installed in a Niowave testing tunnel

Interior of Niowave testing facility

Niowave Airport Facility

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- New manufacturing facility under construction
  - Beneficial occupancy in March 2015
  - Production & distribution of isotopes
    - 24/7 operation
  - Additional expansion space available