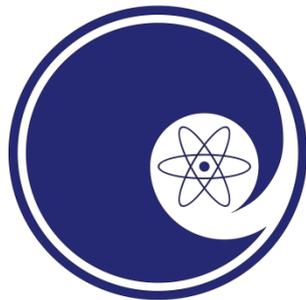


# Commercial Superconducting Linacs

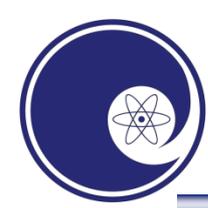
**Jerry Hollister**  
Chief Operating Officer

July 24, 2011



**NIOWAVE**

**[www.niowaveinc.com](http://www.niowaveinc.com)**



# Outline

- Company Details & Leadership
- Superconducting Electron Linacs
- Primary Customers and Uses of Superconducting Particle Accelerators
- Products for Superconducting Particle Accelerators
- Industrial Growth Potential
- Summary



- Privately Owned
- 45,000 square feet
  - Engineering & design
  - Machine shop
  - Fabrication & welding
  - Chemistry facility
  - Class 100 Cleanroom
  - Cryogenic test lab
  - Accelerator test facility



**Lansing, Michigan Headquarters**



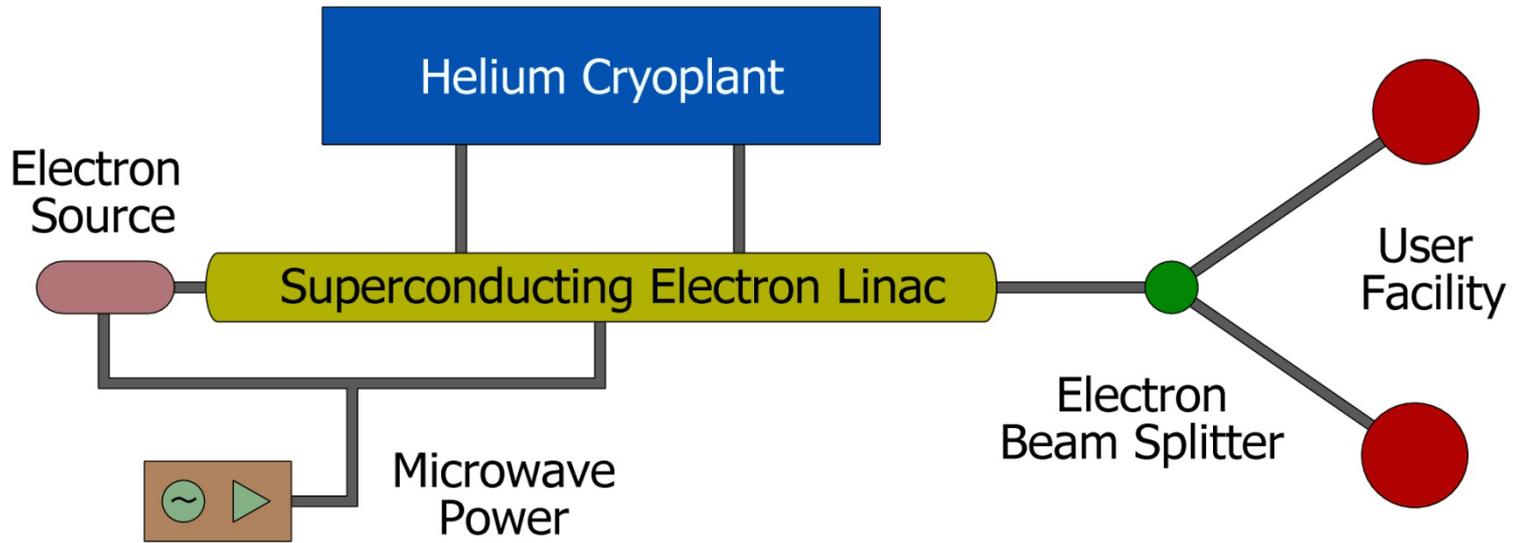
## Dr. Terry Grimm President & Senior Scientist

- PhD from Massachusetts Institute of Technology
- 20 Years experience in Department of Energy
  - Superconducting Super-Collider
  - National Superconducting Cyclotron Laboratory at MSU
  - Numerous contracts with DOE at Niowave



## Jerry Hollister Chief Operating Officer

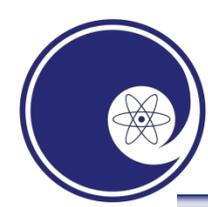
- Bachelors in Engineering from University of Michigan
- Active duty Naval Officer for 6 years
- Warranted Contracting Officer for US Navy
- Current Trustee at Lansing Community College



## Turn-key Systems

- Superconducting Linac
- Helium Cryoplant
- Microwave Power
- Target / User Facility
- Licensing

<b>Electron Beam Energy</b>	<b>0.5 – 50 MeV</b>
<b>Electron Beam Power</b>	<b>1 W – 1 MW</b>
<b>Electron Bunch Length</b>	<b>~50 ps</b>



# Primary Customers and Uses of Superconducting Particle Accelerators

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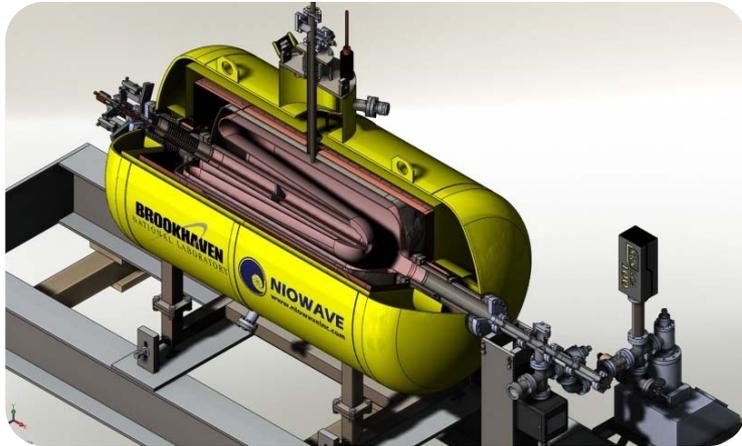
**NIOWAVE**  
www.niowaveinc.com

- **Large accelerators**
  - Current DOE projects: Brookhaven, Fermi, Jefferson Lab, Large Hadron Collider
  - Future: FRIB, eRHIC, Project-X, ILC & many more
- **X-ray sources**
  - Defense, Medical and Industrial
- **Free electron lasers**
  - Defense, Medical and Industrial
- **Radioisotope production**
  - Medical and Industrial

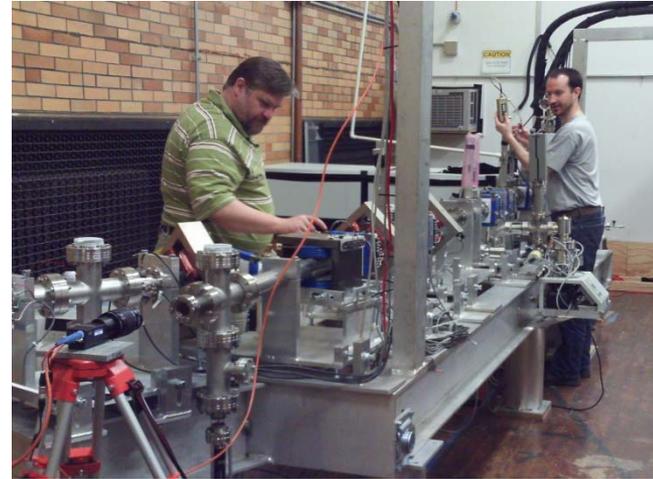


# Niowave Products for Superconducting Particle Accelerators

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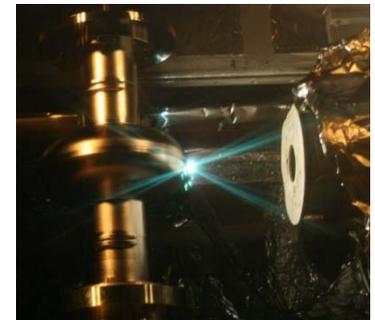
- Electron Guns & Injectors



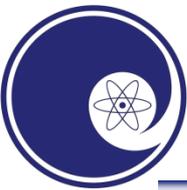
- Cryomodules & Turn-key Accelerators



- Niobium (In Stock)



- Niobium Superconducting Cavities



# Superconducting Cavities

Niowave produces superconducting cavities at a broad range of frequencies and geometries, and will customize to meet specific applications.

- Elliptical cavities
- Quarter-wave cavities
- Deflecting structures
- Single and Multi-spoke cavities



Single spoke cavity



80.5 MHz  
Quarter-Wave  
resonator

**Cavity frequencies**

**28 MHz to 9.5 GHz**



1.3 GHz 9-cell cavities for ILC



# Entry Level Niobium Superconducting Cavities

**NIOWAVE**  
www.niowaveinc.com

## Niobium Superconducting Cavities 1.3 GHz 9-Cell ILC/TESLA

Niobium  
in stock  
for quick  
delivery!



**\$49,999\***

\*Entry level niobium cavity delivered in 3 months (other options available).

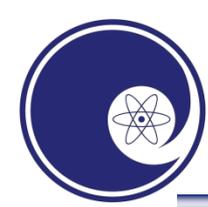
Let us help you customize the exact niobium structure you need from 28 MHz to 3.9 GHz and beyond.



**NIOWAVE**  
*Accelerating Your Particles*

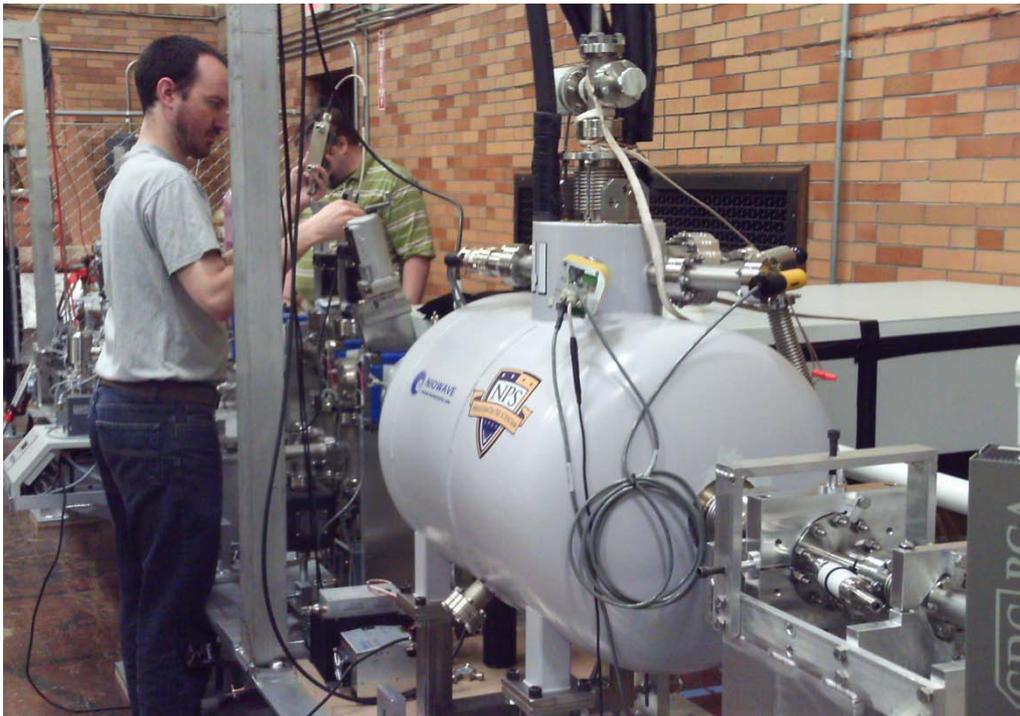
www.niowaveinc.com  
sales@niowaveinc.com  
517.999.3475

**Contact us to discuss your needs**

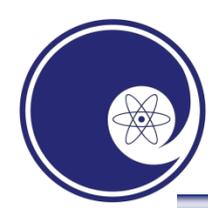


- **NPS-Niowave 500 MHz SRF Injector**

- First superconducting linac designed, fabricated and tested entirely within industry
- First delivery of an SRF beam source to a US Navy facility
- First cool-down and characterization of an SRF beam source at a US Navy facility
- First industrial delivery and acceptance of an SRF beam source in the US



Published Results:  
Harris, et al,  
“Design and operation of a  
superconducting quarter-  
wave electron gun,”  
Phys Rev STAB 14 (2011)



# Helium Cryogenics

**NIOWAVE**  
www.niowaveinc.com

Niowave offers several options, depending on the required cooling load and planned operating schedule.

- Batch filling
  - Use liquid helium Dewars
  - Standard sizes: 100, 250 and 500L
- 5W Cryocooler at 4.4K
  - Smaller systems or low duty cycle
  - Integrated into linac
- 100W Refrigerator/Cryoplant at 4.4K
  - Larger systems or high duty cycle / CW operations
  - 24 hrs / 7 day operations



Batch filling with a 250L helium Dewar



100 W Cryoplant



# RF / Microwave Sources

Niowave offers a broad range of options, depending on the frequency, power and electrical efficiency requirements.

- Solid State Amplifiers
  - Low power : ~ 1 kW
  - High reliability
- Tetrodes
  - Intermediate power: ~10 kW
- Inductive Output Tubes (IOTs)
  - Medium power: ~100 kW
- Klystrons
  - High power: ~1000 kW (1 MW)



10 kW Tetrode



90 kW IOT



- Niobium Supplier

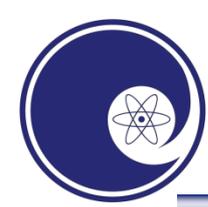
- Large and fine grain niobium in a variety of RRR values.

- Sheets from 1mm to 35mm
    - Ingots and rods
    - Niobium-Titanium also in stock



- Residual Resistivity Ratio (RRR) measurements

- Only company in the world that offers service
  - Qualified materials for: Cabot, HC Starck, ATI Wah Chang, Heraeus, Plansee and CBMM (Brazil)



- **Commercial Superconducting Linac Opportunities**
  - Numerous applications are now viable to be commercialized
    - X-ray sources & sterilization
    - Isotope production
    - Free Electron Lasers
  - New commercial enterprises are emerging
- **The US Industrial Accelerator Research Hub**
  - Niowave is the US Industrial leader
    - Only company in the world capable of testing superconducting linacs in-house
    - Two of three operational superconducting injectors in the world built by Niowave
    - International 2010 IEEE Award for Research & Entrepreneurship in Superconductivity
    - Department of Energy 2010 Small Business of the Year
  - MSU/NSCL is a national laboratory with a world-wide reputation



- Michigan Intellectual Capability
  - Niowave research
  - MSU Cyclotron Lab (NSCL/FRIB)
  - U of M and MSU partnerships
  - Lansing Community College



- Michigan Industrial Capability
  - *Niowave is the ONLY company worldwide capable of building and testing superconducting linear accelerators*
    - License from State of Michigan & Nuclear Regulatory Commission
  - Highly skilled and available workforce
  - Manufacturing expertise & capacity
  - Facility & equipment availability

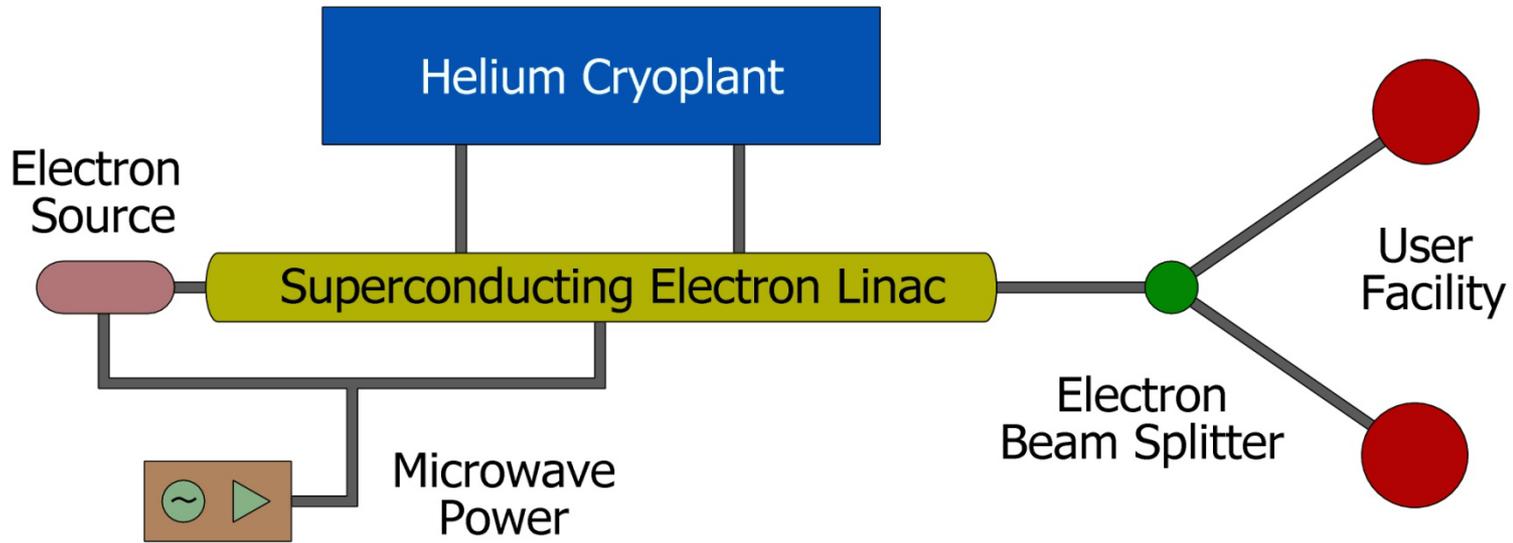


- Autos to Accelerators

- Making Mid-Michigan the “Silicon Valley” for superconducting accelerators



# Summary



**Niowave is developing the compact superconducting linacs needed for the emerging applications of our industry**

