High Energy Laser
Joint Technology Office (HEL-JTO)

Recent Developments and Current Projects in HEL Technology

October 9th 2013

Outline

- Introduction to HEL-JTO
- JTO Technology Thrusts
- JTO Accelerator projects

HEL-JTO Formation

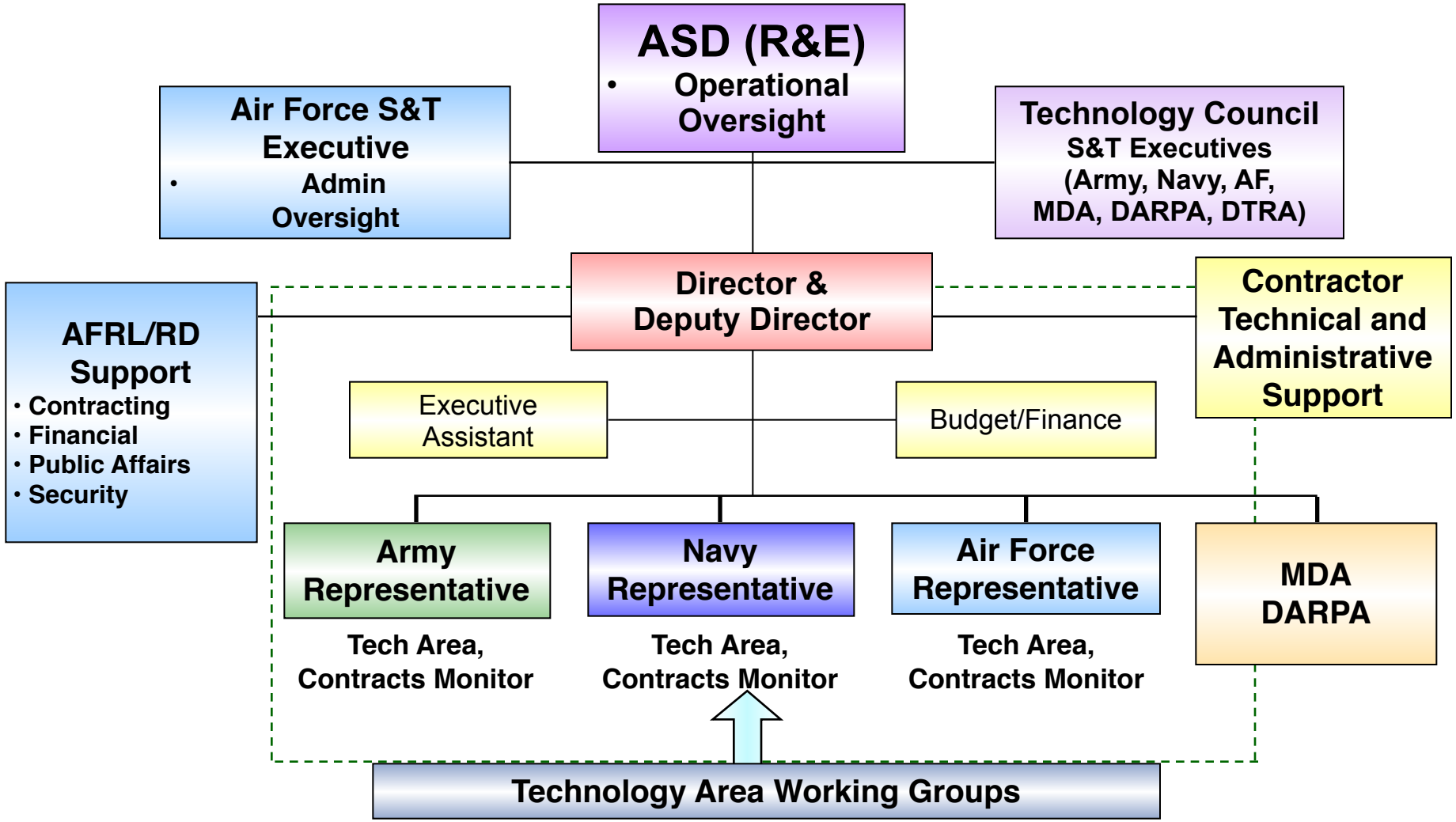
- FY00 National Defense Authorization Act request to develop laser plan
- FY00 High Energy Laser Executive Review Panel chartered

JTO Charter:

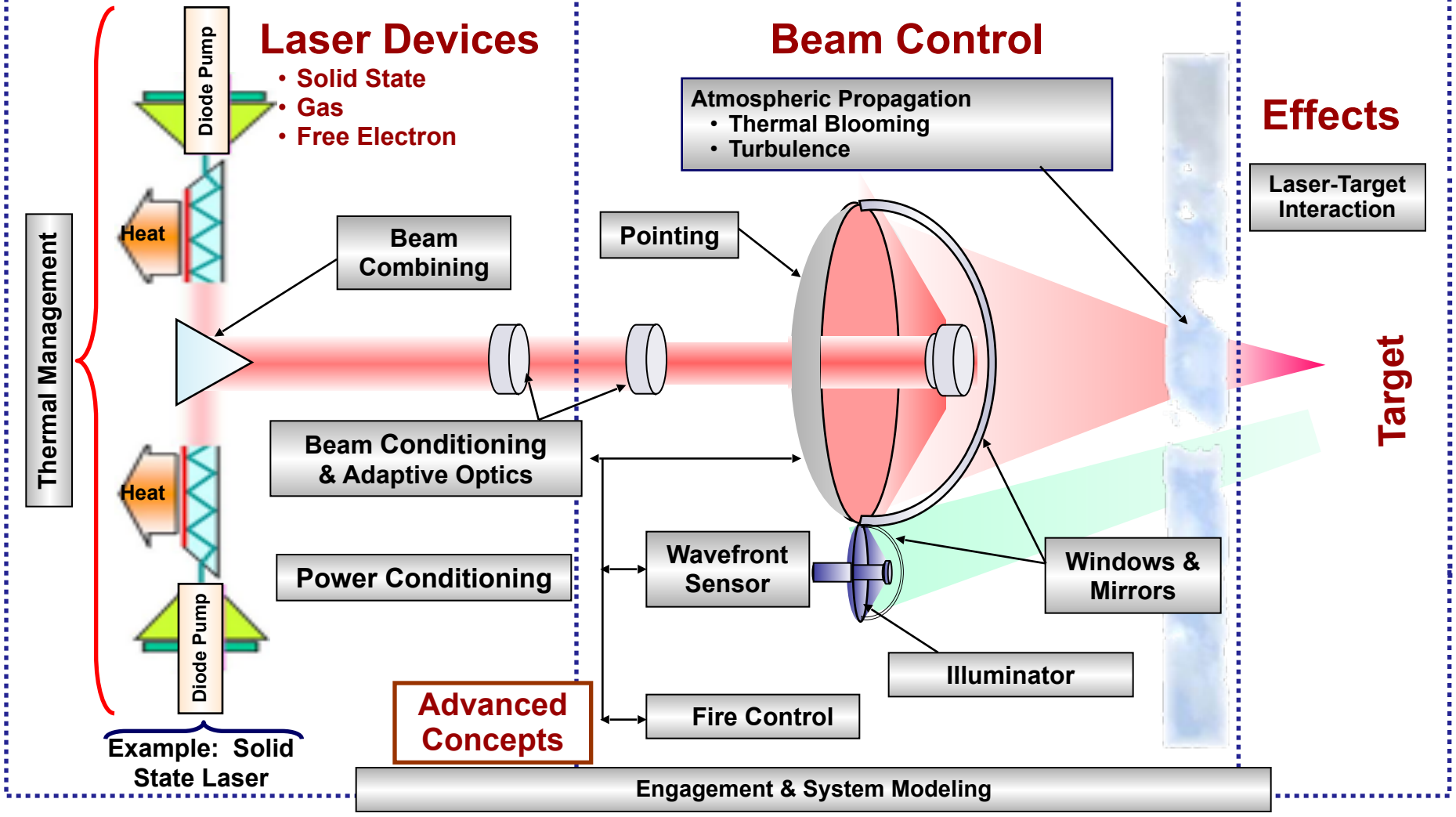
- <u>Advocate</u> HEL technology development for DoD
- <u>Coordinate</u> among the Services and Agencies
- <u>Develop</u> technology investment strategy for DoD
- <u>Manage</u> a portfolio of government/industry/academia R&D projects

A Coordinated Approach for HEL Weapons System Development

HEL-JTO Organization

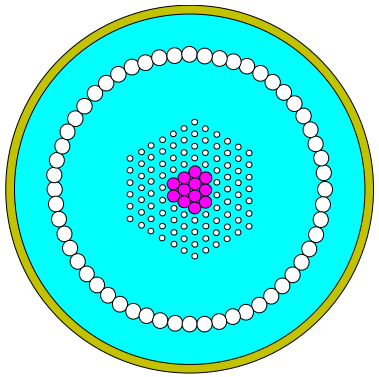


HEL-JTO Technology Thrust Area



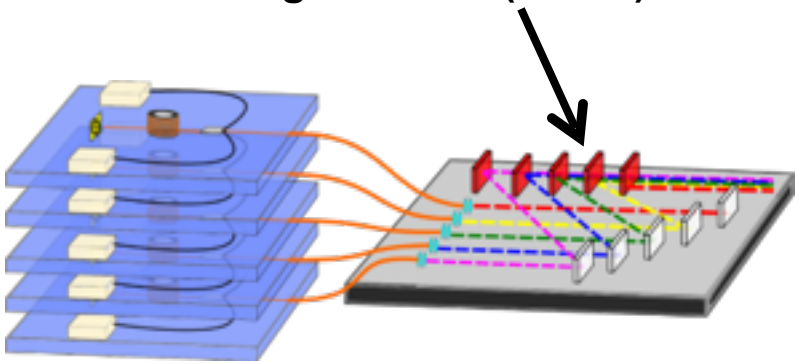
HEL-JTO Electric Laser Technology

- High power fibers
- Beam combining techniques
- High Power Fiber Components



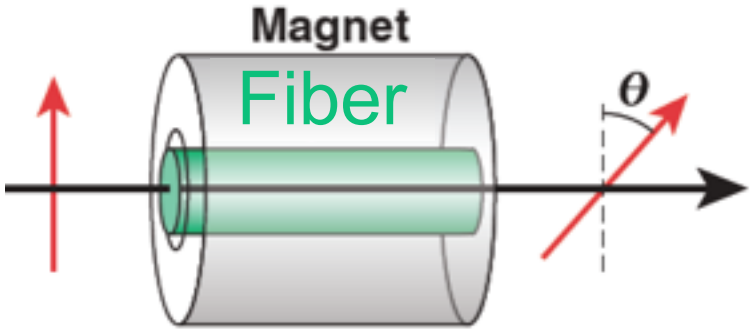
Er-doped PCF High Power Laser Fiber

Dielectric Edge Mirrors (DEMs)



Stacked Oscillators

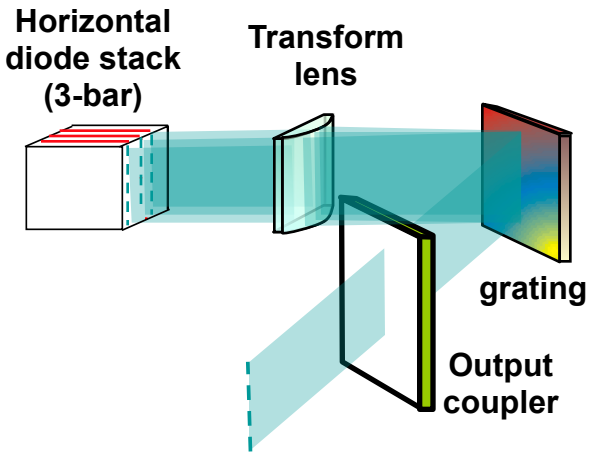
Beam Combiner



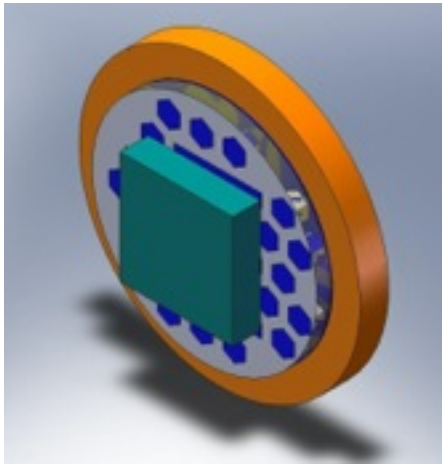
Fusion Spliced All-Fiber Isolator

HEL-JTO Electric Laser Technology

- Ceramic gain materials
- Eye safer wavelength (slabs and fibers)
- Efficient and High Temperature diode arrays



Wavelength Beam Combining of Diode Bars



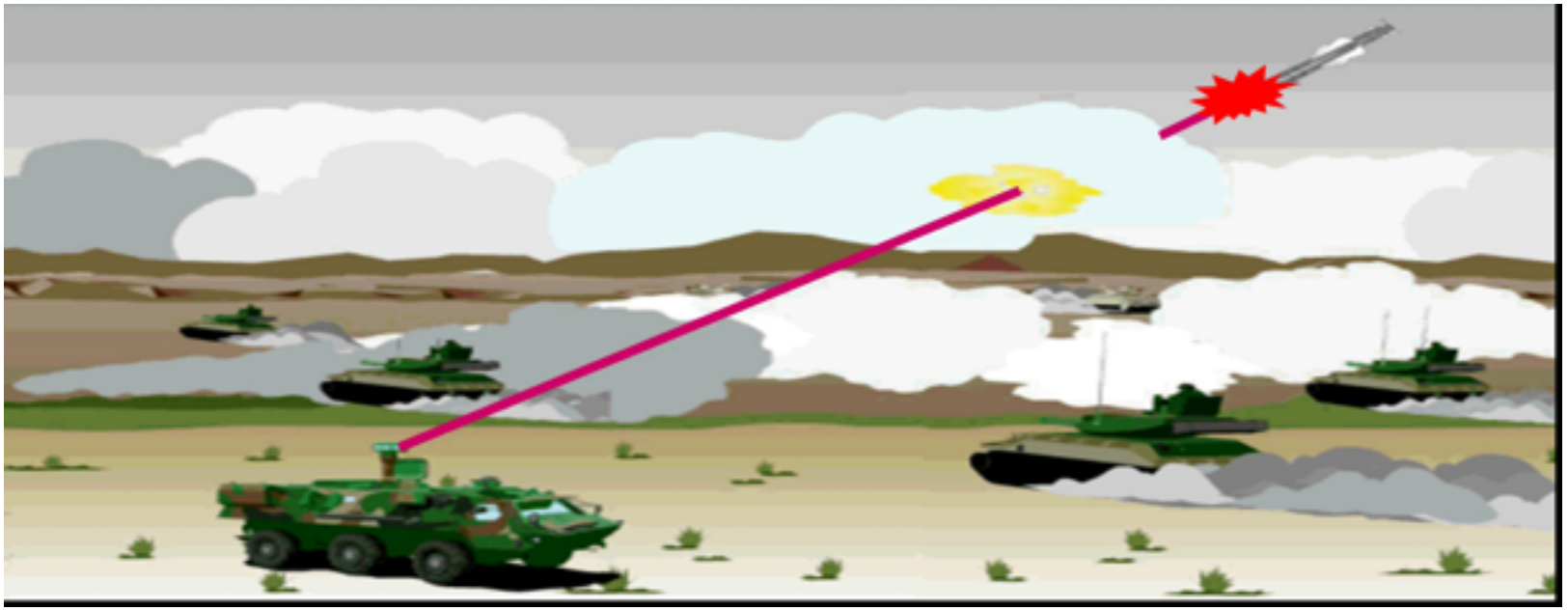
VCSEL Array assembled on Patterned Surface Composite Heat Spreader

10%Yb:Lu2O3 ceramic

Solid State Laser Thrust

SSL State-of-the-Art: (TRL 4 - 5)

- Efficient diode arrays – 50%=>70% diodes available
- High power fibers > 500W/fiber—combinable to KW's
- Ceramic Slabs – 100KW at 18% wallplug efficiency



Gas Laser Thrust

ATL: KW-Class Sealed Exhaust COIL for Tactical Applications

- Field Demonstrations Complete

ABL: MW-Class COIL for Strategic Applications

- Field Demonstrations Completed

Beam Control Thrust

BC State-of-the-Art: (TRL 6)

- Disturbances
  - Atmospheric propagation Characterized to 100's KM
- Optical Components
  - Windows/Coatings for KW/cm2 power levels
- Aimpoint Maintenance
  - Precision tracking
  - Jitter control
  - Platform-dependent

Advanced Concepts Thrust

Advanced Concepts Thrust

- Novel Concept Exploration
- Too “Risky” for Other Thrusts
- Includes: USPL, Materials, Beam Combination

JTO Thrust Areas for FEL Research

- Injectors and Cathodes
  - Development of high current and high charge low emittance injectors
  - Explore robust superconducting RF photocathode and thermionic injector technology
  - MW RF input couplers and booster cryomodules for the SRF injector.
- Megawatt Electron Beam Physics and Engineering:
  - Basic and applied research on the physics and technology relevant to the ONR INP FEL and MW class FEL future systems.
  - Studies of MW electron beam and optical beam physics and modeling and simulation for FEL cathodes, injectors, accelerators, and architectures need to conducted. Design and development of FEL components based on these studies.
- FEL Sensor Development:
  - Basic and applied research on the design, development, characterization and of THz sources and detectors

Free Electron Laser

Capabilities:

- Provides effective and affordable point defense capability against:
  - Current / future surface and air threats
  - Future Anti-Ship Cruise Missiles and Tactical Ballistic Missiles
  - Swarm of small boats and asymmetric threats

- Provides discrimination and sensing capabilities greater than current Naval radar systems.

Warfighter Impact:

- Low life cycle cost
- Multi-mission / scalable
- All electric for deep non-explosive magazine

Technology Challenges for a MW Class FEL

- Reduce accelerator footprint and weight
- Develop High Power Optics
- Complete Room Temperature Injector Operation at High Current and High Energy
- Design Changes to Enable Shipboard Integration.

FY07 MRI Projects

- (MRI) Fundamental Understanding of Optical Coatings and Novel Strategies for Power Scaling of High Power Free Electron Lasers (FELs)
  - Colorado State University
- (MRI) Collective Beam Dynamics and Coherent Radiation Production from High Brightness Electron Beams: Application to ERL-Based Free-electron Lasers
  - UCLA
- (MRI) Research In Technology For High Average Power FELs
  - University of Maryland
- (MRI) High-Brightness Cathodes for High-Power FELs
  - Vanderbilt University

FY12 MRI Grants

- Electro-Optical Sampling System for a High-Power ERL-Driven FEL
  - Colorado State University, Biedron
- Investigation of Beam Source and Collective Effects and Instabilities Relevant to FELs
  - Naval Postgraduate School

FY10 BAA Projects

- MW Class On–Axis RF Coupler for SRF injector for NPS
  - Niowave (Selected for 2nd year funding)
- Novel FEL Cavity Optic
  - JLab (Selected for 2nd year funding)
- Halo and Radiation Simulations Thru Undulators/ ERL's
  - STIO

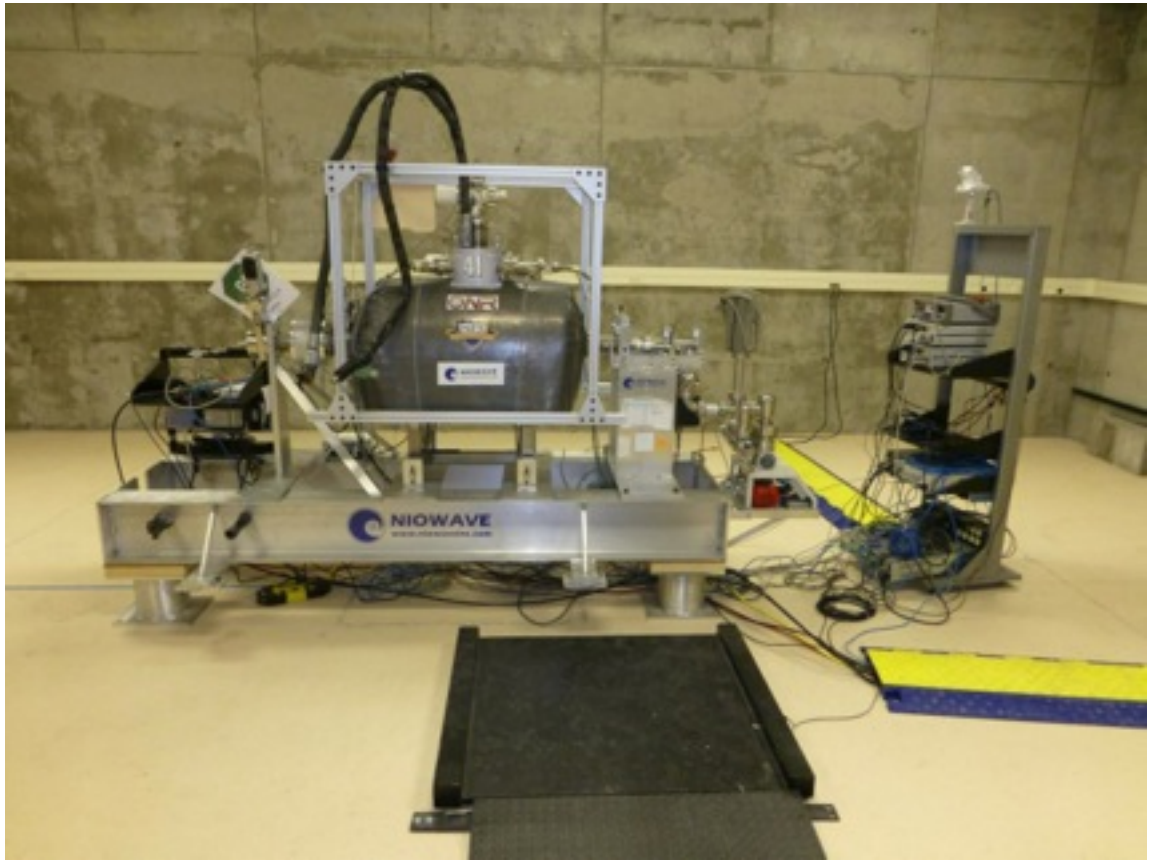
FY12 BAA Efforts

- Superconducting 700 MHz Multi-Spoke Injector for a MW class FEL
  - Niowave, Grimm
- Laser damage of optical coatings up to 2.5 microns for MW-class Free Electron Lasers
  - CSU, Menoni
- Modeling of High Average Power FEL Beamline Components through the Application of Fast, Accurate GPU-based Simulations
  - SAIC, Petillo

FY11 S&A Projects

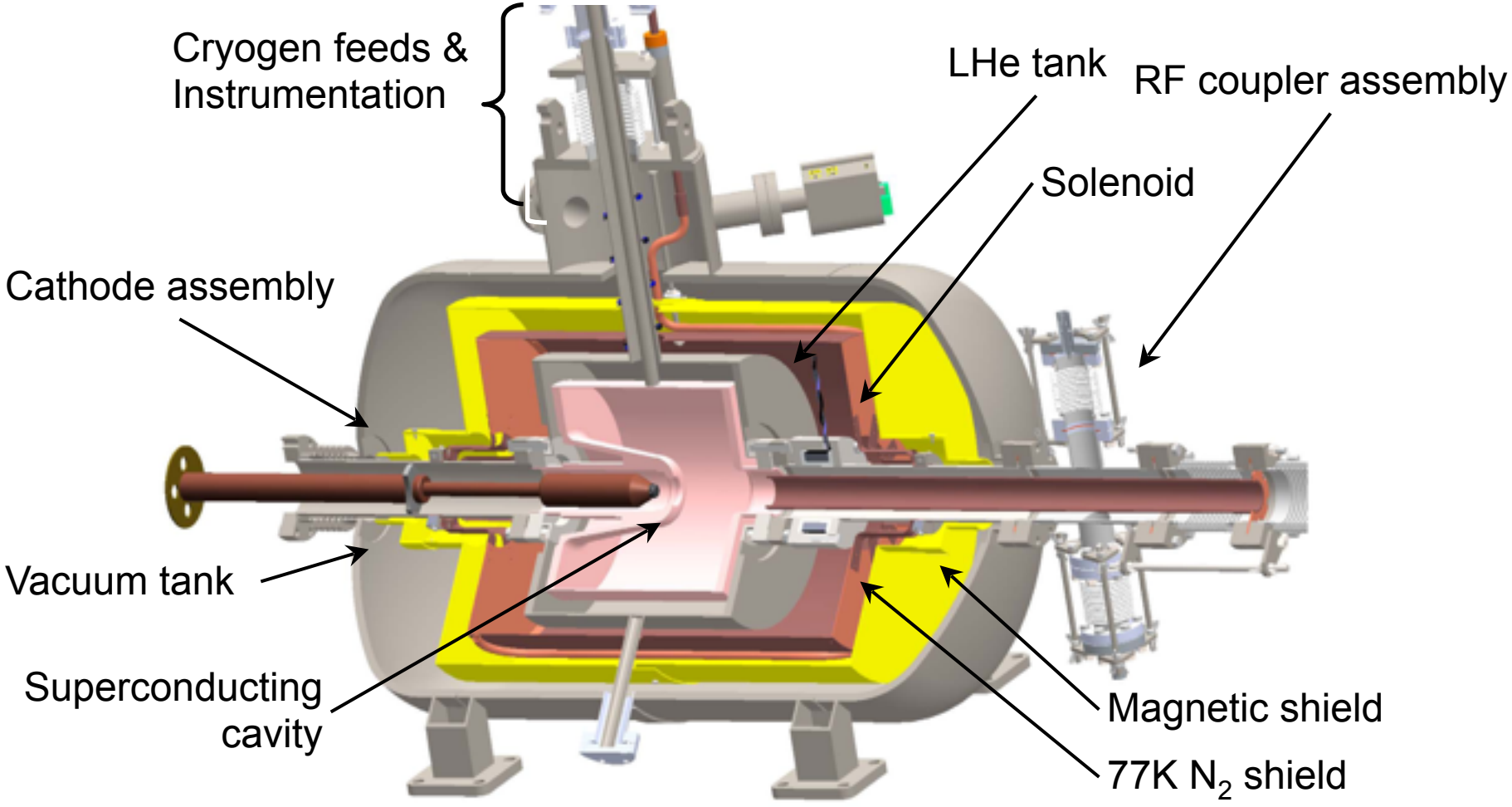
- Emittance and Bunch Shape of Diamond Amplified Pulsed Electron Sources
  - NRL
- High-Average Current Injectors for MW Class FELs
  - NRL
- Expanding Superconducting Radio-Frequency Photonic Band Gap Structures Accelerator Technology to 2.1 GHz
  - LANL

The Mark I QW SRF Gun at NPS



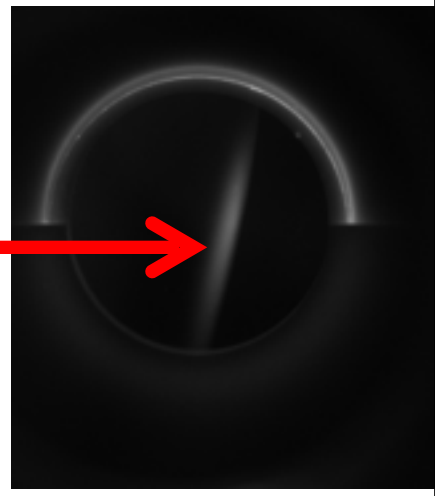
Nov 2012 – in operation in vault with radiation shielding

The Mark I QW SRF Gun



Mark I Progress and Status

- The Mark I was built and tested at Niowave, results published in 2011
- Low-power testing was performed at NPS while awaiting safety approvals for high-power operation
- In Sept 2012 the first beam was generated
- In Oct 2012 the Mark I was moved into the vault
- In Nov 2012 the Mark I was operated in the vault at full field (750 kV gap voltage). With 70 mR/hr inside the vault, nothing detectable outside



The Mark I is ready to be used as a platform for testing cathodes in a superconducting gun

Summary

- Technology maturation is an enabler for high power FEL
- In previous years, JTO has supported the development of technologies and components to:
  - Understand and model the physics of Space-Charge, CSR, Halo, Beam Break-up, Cathode Surface Science and Optical Thin Films
  - Establish technical basis to support MW Class Shipboard FEL