ADVANCED ENERGY SYSTEMS, INC

Our Mission

To be the supplier of choice for advanced radiation sources, high brightness commercial accelerator applications, government accelerator projects, and integrated engineering services.

Our History

AES Headquarters in Medford, NY

On September 28, 1998, the former employees of Northrop Grumman's Advanced Energy Systems Group completed the formation of a new small business, Advanced Energy Systems, Inc. (AES). Incorporated in New York and purchased from Northrop Grumman as a legacy organization, AES retains all former assets including the skilled personnel, intellectual property, accelerator development laboratories, prototype machine shops, computational analysis systems and contracts. The new company can draw upon a 22-year experience base in accelerator and fusion technology to supply full service engineering and physics analysis & design, in addition to component fabrication. Our active customers include many US national laboratories, international laboratories, and commercial corporations. AES technical operations are conducted within a 7,800 ft2 facility in Medford, NY, that includes a machine shop and a 650 ft2 facility in Princeton, NJ. Specific areas of AES expertise include: electron accelerators and free electron lasers, advanced radiation sources, low energy ion accelerator systems for commercial applications, high power ion accelerator systems for government applications, and fusion systems.

Electron Beam Accelerators

Laser Electron Accelerator Facility for BNL

AES specializes in the design and fabrication of high-brightness electron accelerator systems with photocathode electron injectors. Both single shot and macropulse operating formats can be delivered. These AES systems find application in medical, free-electron laser, pulse radiolysis R&D and other applications.

The accelerator and beamline design can be tailored to the specifications of the particular application by trading off the performance parameters. For instance, some systems use bunch compression and phase space rotation in order to tailor the longitudinal phase space bunch length and energy spread parameters. The higher bunch charge values are associated with single shot operation in L-band and will have longer bunch length and higher emittance. Depending on the application and the photocathode drive laser specifications, these systems use either interchangeable metal cathodes or semiconductor cathodes with preparation

chambers. While most of our systems to date have operated in S-band, we can also produce L-band and X-band systems as well as systems with thermionic cathodes.

Monochromatic X-ray Imaging System (MXIS) Linac at Vanderbilt Univ.

Typical Performance Specifications:

- Output Energy 2 MeV to 50 MeV
- Bunch Charge < 0.5 nC to ~ 40 nC
- Trans. Emittance < 3 π mm-mrad rms norm. at 1 nC
- Spot Size <500µm simultaneously in all 3 dimensions
- Macropulse Repetition Rate < 1 Hz to > 20 Hz
- RF Micropulse Structure; Single shot to 10 µsec
- Laser/Bunch Rep. Rate < ~ 286 MHz

MXIS Electron Gun (Fabricated at AES to BNL Gun IV Design)

Free Electron Lasers

AES is actively involved in the development of free-electron lasers (FEL) for commercial, military and R&D applications. AES can supply compact room-temperature FEL systems, such as the mid-infrared FEL (MIRFEL), which has lased with ~ 0.5 W from 7-20µm. These devices can provide high-peak-power, tunable radiation for research, medical, biomedical and material processing applications. A wide parameter space across the complete IR spectrum can be accommodated with this type of low energy device that can be tailored to suit particular customer requirements.

Compact IR FEL Designed and Built by AES (current location Univ. of Maryland)

As a member of the Thomas Jefferson National Accelerator Facility Laser Processing Consortium, AES is involved in the development of FEL technology for high power commercial material processing applications. Many of these applications in metal and polymer processing, and micro-machining are proven, with their market insertion only impeded by the absence of a suitable affordable radiation source. Under contract to Jefferson Laboratory (JLAB), we are supporting the development of the 10 kW IR FEL upgrade that is principally funded by the Office of Naval Research. Among AES tasks is the design and fabrication of the optical klystron IR wiggler. In collaboration with JLAB, AES is also developing a prototype 100 mA injector under a BMDO SBIR contract.

Superconducting RF Accelerating Structures

AES has a long history of demonstrated performance as a supplier of superconducting accelerator systems and components. Between 1992 and 1996, as part of Northrop Grumman, AES was the responsible group for the manufacture of 373 superconducting dipole magnets and 432 quadrupole cold masses for Brookhaven National

AES 5-Cell 700 MHz S/C Cavity built for Los Alamos National Lab.

Laboratory (BNL) for the Relativistic Heavy Ion Collider (RHIC). In 1995, AES developed a superferritic wiggler for a 3rd harmonic seeded single pass FEL amplifier as part of a CRADA with BNL. Most recently, AES was the only US company to manufacture a 5-cell, 700 MHz superconducting RF cavity under contract to Los Alamos National Laboratory (LANL) as a part of the APT program.

An internally funded R&D program to fabricate two single cell cavities preceded successful manufacturing of the 5-cell cavity. As a result of this development work, AES employed a hydroforming process for half-cell production in the 5-cell cavity. In this case, hydroforming was more cost effective than the traditional deep drawing and also reduced wrinkling in the niobium. AES also designed and built a hydraulic branch pulling machine for LANL to form the drawn tube branches required in the beam tubes. This very successful machine has since been duplicated for Argonne National Lab (ANL) to support their superconducting accelerator efforts.

Tube Branch Pulling Machine and Test Samples

The completed 5-cell cavity was low power tested in-house at room temperature prior to delivery to LANL. During test at high RF field in the JLAB cryogenic facility the cavity displayed a flat Q of $3x10^{10}$ out to a E_{acc} of 9.5 MV/m far exceeding the APT specifications. This limit was due to available RF power. The cavity has since been returned to LANL for further testing where it is expected to achieve accelerating fields well above 10 MV/m.

Specialty Manufacturing

Advanced Energy Systems maintains prototype and limited production manufacturing capability in 3200 ft^2 in the Medford, Long Island, NY facility. Our equipment includes state-of-the-art CNC milling and CNC Turning capability as well as a large assortment of smaller NC and manual machines. AES maintains a temperature controlled machining area that houses the CNC Mill and CNC Lathe in order to achieve the tolerances necessary for our ion and electron accelerator products. In addition to precision machining, we have capability for sheet metal forming and fabrication, TIG, MIG, stick, gas, and orbital arc welding for ultra-high vacuum service, and vacuum leak testing services with capability to 1×10^{-11} scc/sec. We also maintain optical and laser metrology capability for precision assembly and installation.

Okuma 40" x 20" x 20" CNC Machining Center

AES has recently installed a clean room facility with 120 ft^2 certified to class 100 and another 95ft^2 area certified to class 10,000. The class 100 area is also equipped with a class 10 laminar flow bench. The clean room will see its first use in support of a DOE contract to design, fabricate, and test a fully superconducting RF electron gun.

Leveraging our internal manufacturing and engineering expertise, AES has established working relationships with many local and regional specialty service suppliers. Through these relationships we can offer fully integrated manufacturing solutions to our customers that include hydrogen, and

AES Clean Room

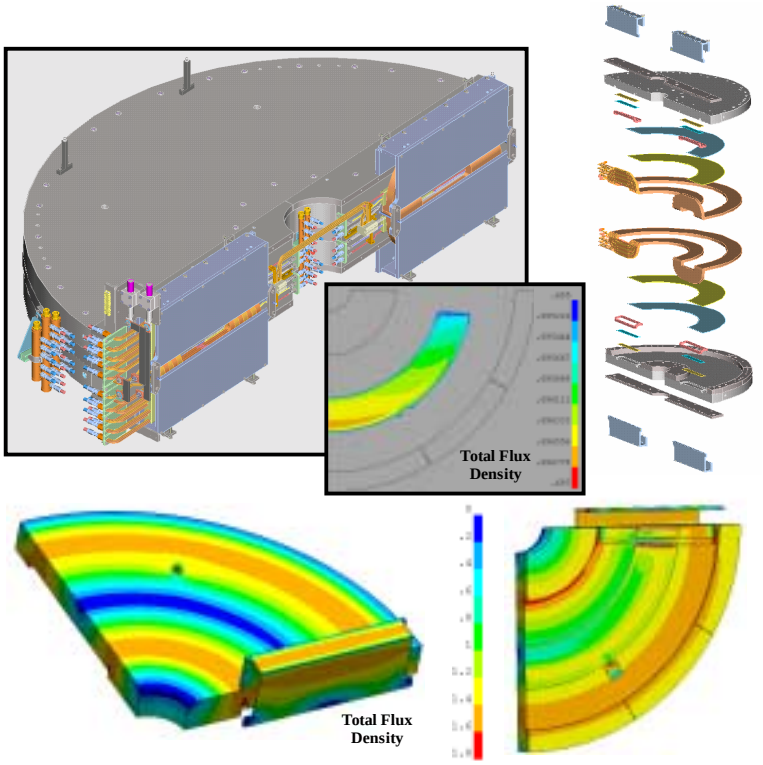
vacuum furnace brazing, electron beam welding, electroplating and electroforming, as well as others.

Recent manufacturing projects include a 50 MeV electron accelerator system for a commercial customer, electron accelerator components for BNL, custom tube forming machines for LANL and ANL. Also prototype RF power components for The US Department of Energy, flight test hardware and space simulation chamber components for Northrop Grumman Corp., and state-of–the-art space-based heat pipe systems for a DOD contractor.

Engineering Services

Because of the broad cross-section of engineering, special manufacturing, and management skills that are available at AES we can provide fully integrated solutions for our customers as well as specific technical services. Our skills include project management support and planning, design, analysis, costing and manufacturing. We specialize in the following areas:

- ⇨ Beam Physics
- ⇨ Simulation & Modeling
- ⇨ Systems Engineering
- ⇨ Mechanical and Structural Eng'g
- ⇨ Thermal/Cryogenic Engineering
- ⇨ RF Systems and Structures
- ⇨ Vacuum Technology
- ⇨ RAMI Analysis
- ⇨ Produceability
- ⇨ Tool Design & Prototyping



Pro/E Exploded Assembly and ANSYS Electromagnetic Analysis Results for 180° Dipole Magnet for the JLAB FEL Upgrade

The engineering team at AES has state-of-the-art codes and workstations integrated on a high-speed network that provides for efficient transfer and sharing of models and data files. We also have a T1 communication line for rapid transfer of data with remote locations.

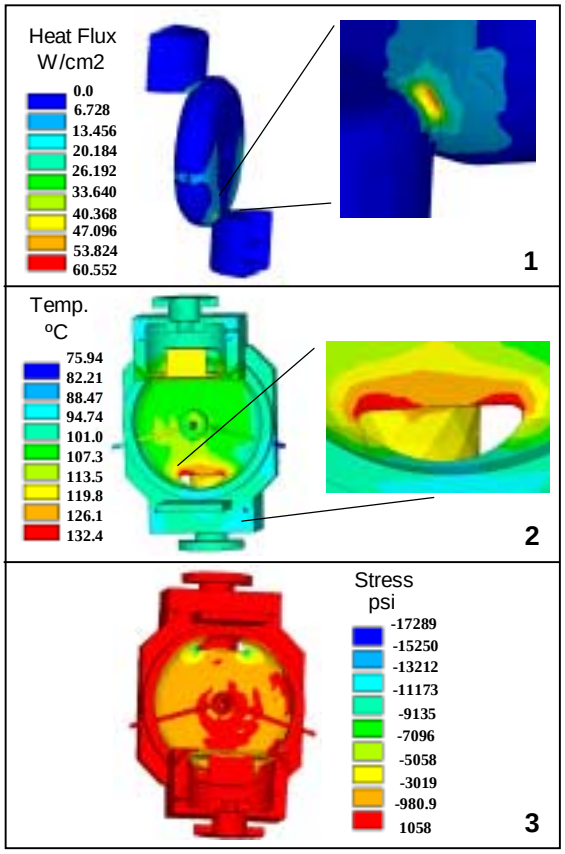
AES uses both industry standard and proprietary tools to facilitate seamless design and analysis integration utilizing our multiple software tools. Our primary mechanical design software is Pro/ENGINEER, a fully parametric solid modeling package. From Pro/E we send solid model geometry to our finite element code, ANSYS using the IGES translator. Our ANSYS analysis capability includes thermal, structural, and both high frequency and low frequency electromagnetics. A recent LANL contract required a fully coupled high frequency RF analysis followed by transient thermal analysis and both

elastic and plastic structural analysis of a CW RF cavity. This work was performed using fully internal transfer of loads between the different phases of the analysis.

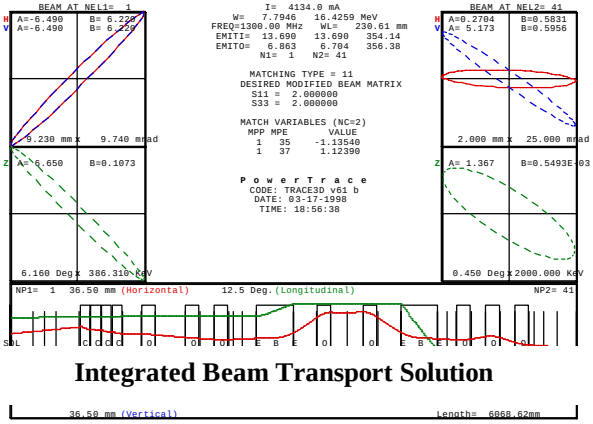
Our RF analysis/design codes are also industry standards, SUPERFISH and MAGIC. We have developed tools to rapidly utilize the output of these codes in our mechanical engineering analysis and design software. Automatic transfer of heat loads to ANSYS and of geometry data to Pro/E are used routinely. For instance, SUPERFISH output of modified drift tube dimensions can be ported into Pro/E to automatically update a complete DTL drawing package.

A significant computer modeling and simulation capability, applicable to accelerators in energy research and design, exists at AES. This capability spans beam dynamics and optics, source and gun modeling, as well as radio frequency (RF) structures. The initial scoping design of accelerating structures is typically performed using AES proprietary models. Thereafter, the beam dynamics modeling proceeds with the community standard PARMTEQ, PARMILA, and PARMELA codes, as appropriate. In addition to PARMELA, the MAGIC code is used to design electron guns.

A principle tool in our beam dynamics and optics capability is the AES developed TOPKARK code. TOPKARK can model beam propagation and performance to high-order with the effect of space charge included. It and TRACE 3D are useful for beam transport studies involving high current or high-order effects.



ANSYS E/M Model (1) Calculates Heat Loads for Thermal Run (2) In-Turn Providing Loads for Structural Analysis (3) (Los Alamos CCDTL Analysis)



Integrated Beam Transport Solution

For further information contact:

Advanced Energy Systems, Inc.

New York Headquarters

27 Industrial Boulevard, Unit E
Medford, NY 11763
Phone: (631) 345-6264
FAX: (631) 345-0458

Princeton Office

P.O. Box 7455
Princeton, NJ 08543-7455
Phone: (609) 514-0316
FAX: (609) 514-0318

http://www.aesys.net