PROPULSION DIRECTORATE

Monthly Accomplishment Report
January 2002

Contents ***Page***

Velocity Data Taken in Cavity of 6-Inch TVC 1

B-2 Lithium-Ion Battery Tested 1

Beam Honored for Technology Leadership 2

Advanced Compressor Flow Field Uncovered 3

Current-Carrying Capacity of YBCO Increased 4

Weimer Recognized for Advancing Electrical Technologies 4

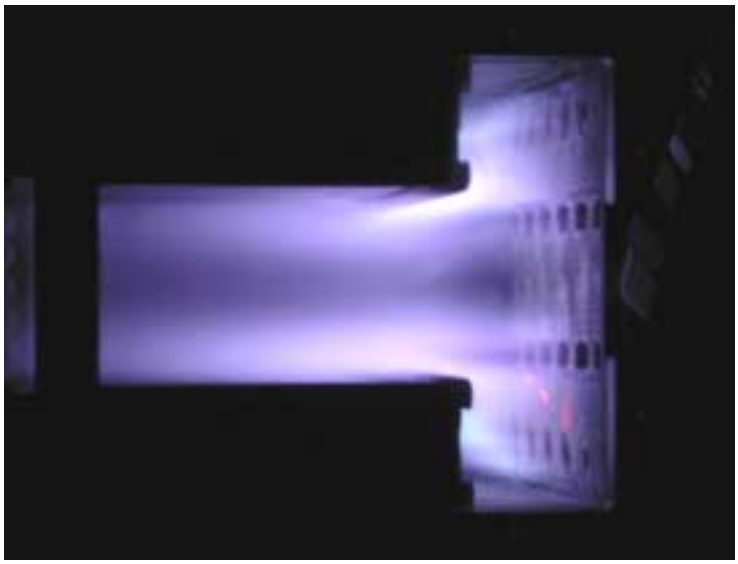
Compressor Rotor Success Earns Accolades for Sargent 5

Initial Low-Loss Conductor Fabricated 6

Visit to Positron Beam Scattering Facility 7

Chehroudi Honored by International Technical Society 8

VELOCITY DATA TAKEN IN CAVITY OF 6-INCH TVC: Representatives from the Propulsion Directorate's Combustion Sciences Branch (AFRL/PRTS) and Innovative Scientific Solutions, Inc, successfully made OH and velocity measurements in the cavity region of a modified 6-inch Trapped Vortex Combustor (TVC) operating on natural gas. The tests were conducted in Test Cell 151 of AFRL's Atmospheric-Pressure Combustor Research Complex at Wright-Patterson AFB, Ohio. The data were acquired for comparison with Computational Fluid Dynamics (CFD) models used by General Electric Aircraft Engines to evaluate the utility of these models for predicting flow patterns in the cavity region. These tests support dual-use technology development of the TVC for both the Integrated High Performance Turbine Engine Technology (IHPTET) Program as well as low-NO_x burners for stationary power generation. The OH measurements were made using planar laser-induced fluorescence (PLIF) of the hydroxyl radical. The OH radical is used to visualize the flame and mark the general location of the flame front. Particle Image Velocimetry (PIV) was employed for the velocity measurements. Micron-sized particles seeded into the combustor are illuminated with two laser sheets, and images of the light scattered by the particles yield two-dimensional velocity fields. It is believed that the majority of TVC-generated emissions (mainly NO_x) are produced in the cavities. Detailed studies of the cavity-flow behavior will lead to improved mixing and lower NO_x generation. Other groups associated with this research include GE Aircraft Engines, GE Contract Research Division, The Department of Energy, and GE Industrial Systems. (V. M. Belovich, AFRL/PRTS, (937) 255-4229 and J. R. Gord, AFRL/PRTS, (937) 255-7431)


Flame in the Trapped Vortex Combustor


Prototype B-2 lithium-ion battery

B-2 LITHIUM-ION BATTERY TESTED: The prototype B-2 Lithium-Ion (Li-ion) Battery developed by Yardney Technical Products (YTP), Inc began preliminary EMD performance tests in the Propulsion Directorate's Battery Test Facility on 4 December 2001. These performance tests are designed to verify the battery performance from -60°C to +71°C. Tests include: 1) initial 100% capacity checks at room temperature (RT) and -40°C, 2) a series of tests to verify operational performance down to -60°C, 3) subsequent RT capacity checks

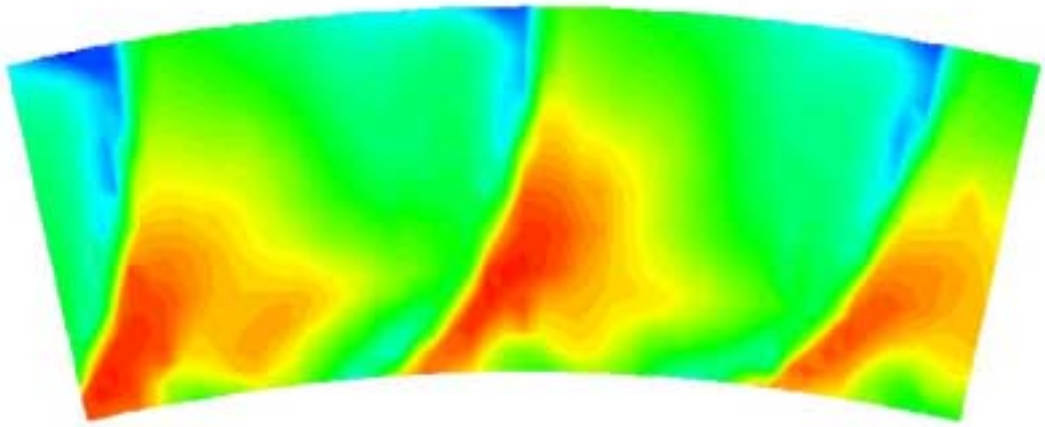
to verify any degradation in performance due to low temperature exposure, 4) a series of operational and capacity tests at elevated temperatures to ascertain any high temperature degradation rates, 5) life cycles to test the robust battery and electronics design selected for the B-2 battery, and 6) final capacity checks at RT and -40°C to determine end-of-life capacity and provide logistics data for replacement purchases. Tests to date have indicated satisfactory battery performance in the low temperature region. High-temperature tests will begin in January 2002 and life cycle tests should be completed by mid-May 2002. (J. Erbacher, AFRL/PRPS, (937) 255-7770)

BEAM HONORED FOR TECHNOLOGY LEADERSHIP: Dr. Jerry E. Beam was recently selected to receive the Meritorious Civilian Service Award in recognition of his distinguished service from 31 July 1991 to 30 September 2001. During this period, Dr. Beam served both as the Section Chief of the Thermal Technology Section and in his current position as the Deputy for Technology of the Propulsion Directorate's Power Division (AFRL/PRP). Dr. Beam has consistently demonstrated outstanding leadership in spearheading R&D efforts in aerospace thermal management technologies. He has led thermal management R&D efforts for the More Electric Aircraft (MEA) initiative, and his leadership has been critical to the success of this program. He also led the development of numerous spacecraft thermal management technologies, and he is recognized throughout DoD, NASA, and industry as an expert in this area. He is a prolific team builder, and he has vigorously pursued joint projects with numerous organizations to develop heat pipe technologies. Largely due to his efforts, heat pipes are now prevalent in the commercial marketplace; consequently, their cost for DoD applications has been significantly reduced. In his current position as PRP's Deputy for Technology, Dr. Beam is responsible for all of PRP's outside funded programs. He focuses on cultivating close ties to all government agencies with an interest in PRP's technologies, and he has been extremely successful in securing external funding. Dr. Beam is singularly responsible for the resurgence in the Air Force's space power program. He played a key role in the development of the first multimegawatt superconducting generator, which is a key technology for ballistic missile defense and Directed Energy Weapon (DEW) systems. He also drove efforts to develop thermal batteries, which are now replacing inferior zinc based batteries in Air Force tactical missiles and other weapons systems. Dr. Beam's outstanding leadership and record of achievement make him well deserving of this award. (Col C. Kimberlin, AFRL/PRP, (937) 255-6226)


Dr. Jerry E. Beam

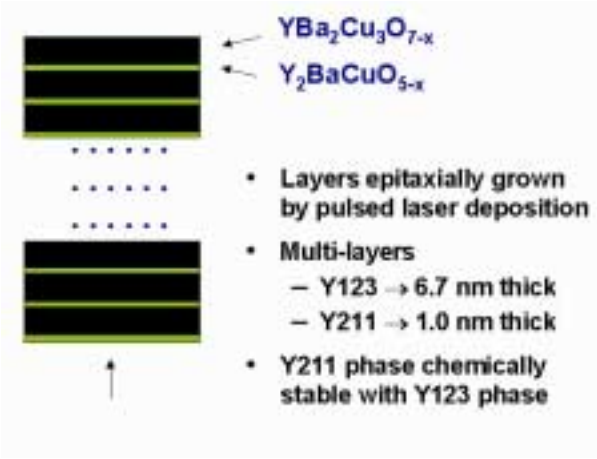
ADVANCED COMPRESSOR FLOW FIELD UNCOVERED: Detailed flow field measurements were acquired during recent testing of the Honeywell Engine Systems (HES) Joint Expendable Turbine Engine Concept (JETEC) Splittered Rotor at the Propulsion Directorate's Compressor Research Facility (CRF). This CRF test, conducted in support of the Integrated High Performance Turbine Engine Technology (IHPTET) Program, revealed the actual flow behavior of the splittered rotor design. To obtain these measurements, a unique traverse was designed and fabricated in-house to provide a precise method for positioning the sensor probe in the radial and circumferential directions. Under automated computer control, the traversing mechanism was moved to over 700 locations at each test condition to provide the details of the flow field. These flow field measurements provide insight into the pitch-wise stator exit flow field behavior. In similar traverses, the exit flow angle was measured. This exit flow angle was critical during the testing to define the appropriate stator angular position for data acquisition. Once the stator setting that produced the desired exit flow angle was defined, the optimum compressor map was achieved, demonstrating the IHPTET objective of the highest pressure ratio per stage ever achieved for an axial flow compressor. Now that the test is over, these detailed flow field measurements will be used to evaluate the computational design tool to see how well they matched the actual performance. This will lead to an updated Modeling & Simulation (M&S) design tool that will then be available to adapt this advanced compressor technology to future engine applications. (C. Williams, AFRL/PRTE, (937) 255-6802, ext. 253)

Test rig used to obtain compressor flow field measurements

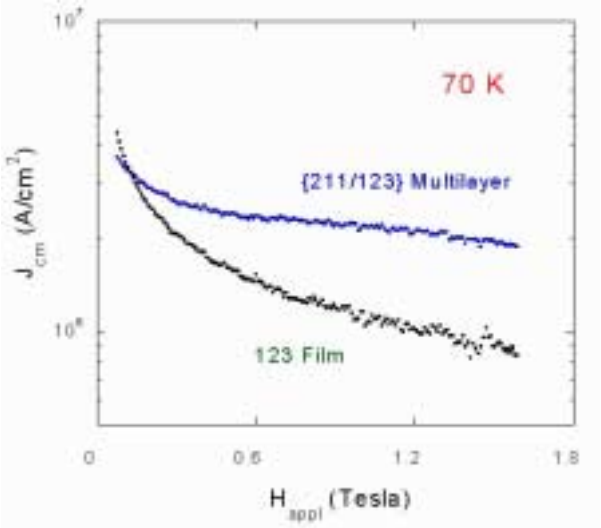


Total pressure variations at the trailing edge of two stator passages in this advanced compressor are shown. Regions of blue represent low pressure while regions of red represent high pressure. Differences in the stator wakes are clearly visible. These differences are probably due to machining differences in the blade geometry.

CURRENT-CARRYING CAPACITY OF YBCO INCREASED: The AFRL Superconductivity Group (AFRL/PRPG section) has developed a new method for flux pinning of the Yttrium Barium Copper Oxide (YBCO) coated substrate used for high temperature superconductors (HTS). Magnetic flux can be pinned inside these conductors to improve current transport properties at higher fields. In an initial sample created by this new method, the critical current density was more than doubled over that of a normally prepared sample at 70 K and 1-2 Tesla applied field. The slight drop at lower fields is not important since it is the overall current carrying ability of the conductor that matters in rotating machinery (up to 5 Tesla). This flux pinning mechanism drew considerable attention at three recent conferences: the Materials Research Society Fall Meeting, the American Ceramic Society PACRIM Conference, and a US-Japan Workshop on HTS coated conductors. The approach used by the AFRL/PRPG section is to deposit multilayer coatings with very thin alternating layers of an HTS and non-superconductor. Note that the layers were deposited in this fashion, but the final structure is not yet clear. The incorporated non-superconducting layers are only 1-5 nm in width. A key element is the use of non-superconducting interlayer compounds that are not chemically reactive with the HTS compound. This requirement is critical as many compounds diffuse and react with the HTS material during high temperature processing when the layer thickness is ~ 1 nm. The multilayer process was demonstrated using pulsed laser deposition for HTS material $YBa_2Cu_3O_{7-x}$ and the non-superconducting Y_2BaCuO_5; however, the process could be applied to other HTS materials and using other thin film deposition or coating techniques. Research is now being conducted to fully understand the pinning mechanism and optimize the method. (P. Barnes, AFRL/PRPG, (937) 255-4410)



Multilayer coatings are made up of thin alternating layers of a high temperature superconductor and a non-superconductor



Results showing that critical current density more than doubled over that of a normally prepared sample

WEIMER RECOGNIZED FOR ADVANCING ELECTRICAL TECHNOLOGIES: Mr. Joseph Weimer was recently selected to receive the Meritorious Civilian Service Award in recognition of his distinguished service from 31 August 1991 to 30 September 2001. During this period, Mr. Weimer served both as a project engineer and in his current position as Chief of the

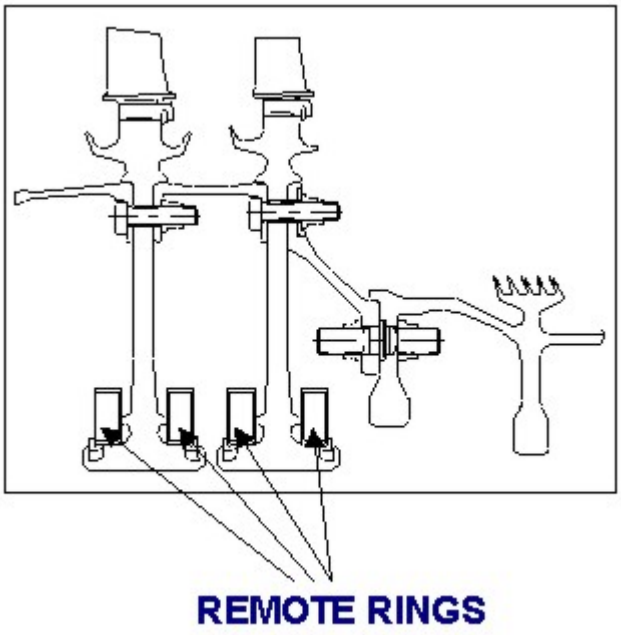
Propulsion Directorate's Electrical Technology and Plasma Physics Branch (AFRL/PRPE). He leads his branch in the planning and execution of a $90 million annual budget, and he also manages over 20,000 square feet of state-of-the-art research laboratories. Mr. Weimer is recognized throughout industry and DoD as an expert in aircraft electrical subsystem technologies, and he is often sought out to investigate and solve problems. He has led the development of numerous aircraft and missile electrical power system technologies, and he is singularly responsible for planning and leading the development of power management and distribution (PMAD) technologies for the More Electric Aircraft (MEA) and for Directed Energy Weapon (DEW) systems. On another front, Mr. Weimer built the nation's leading capacitor research program, which is developing key capacitor technologies for numerous commercial and military applications. His branch led the development and transition efforts for a new polymer dielectric (Fluorene Poly Ester or FPE) with twice the temperature rating and energy density of polycarbonate dielectric, which is currently the best military grade high temperature polymer. The FPE dielectric will replace polycarbonate dielectric material in over 4,000 different military capacitors used in numerous DoD weapons systems. His branch also formulated the nation's only diamond-like carbon (DLC) capacitor research program which is producing DLC coated capacitor grade aluminum foil using a unique in-house developed process. DLC capacitors are an enabling technology for many DEW applications, and the Scientific Advisory Board has lauded this project for its innovation and potential payoffs. Mr. Weimer's outstanding leadership and technical contributions make him well deserving of this award. (Col C. Kimberlin, AFRL/PRP, (937) 255-6226)


Mr. Joseph Weimer

COMPRESSOR ROTOR SUCCESS EARNS ACCOLADES FOR SARGENT: Ms. Kathleen Sargent of the Propulsion Directorate's Components Branch (AFRL/PRTC) has been chosen as PR's Employee of the Month for November 2001. Ms. Sargent was instrumental in the recent successful demonstration of a new design concept, a Metal Matrix Composite (MMC) Remote Ring Compressor Rotor. This concept, which allows two MMC rings to be used at the bore without being embedded into the monolithic rotor material, has a number of advantages over the state of the art. Among these advantages are a dramatic increase in material strength and temperature capability, reduced weight, and a major fabrication simplification which can reduce production and maintenance cost reductions by more than 10%. Ms. Sargent was responsible for bringing the design concept of the remote ring rotor to fruition by creating and leading a government and industry panel to address the shortcomings of this technology area. Prior to her involvement, numerous MMC rings had been manufactured unsuccessfully, resulting in rings of

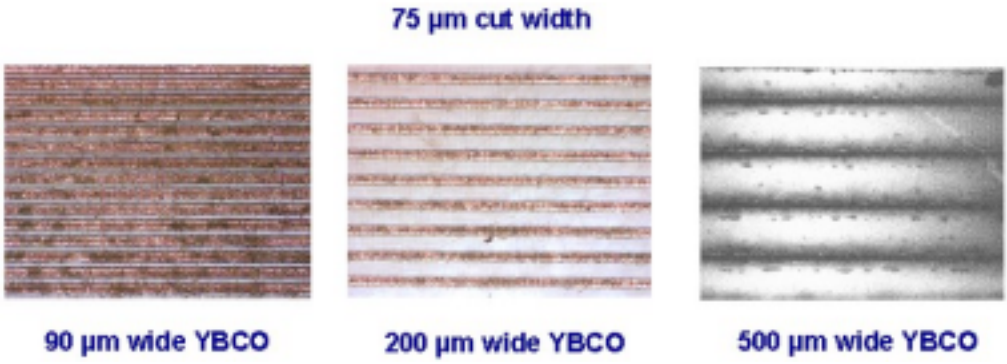
poor quality that failed in spin tests below the proof and burst margin design requirements. Ms. Sargent used her personal contacts and knowledge of the advanced composites area to organize a panel of materials and composites experts to review the MMC ring fabrication process. As a result, a new method for fabricating the rings was devised. Progress since Ms. Sargent's involvement in the program has been impressive, with 5 acceptable rings out of 5 fabrication trials versus 0 acceptable rings out of 11 trials prior to her involvement. Furthermore, three tests have been recently completed, and in each of these three tests, the MMC rings exceeded design expectations. These tests, which ran the remote ring compressor rotor to 19,100 rpm at 700°F, successfully demonstrated the feasibility of the remote ring concept, a vital step in transitioning the design to the XTC 76/3 test. Ms. Sargent's technical background, personal contacts, leadership skills, and programmatic expertise were evident throughout this task, which provides a technology vital to meeting the Phase III goals of the Integrated High Performance Turbine Engine Technology (IHPTET) Program. (T. Fecke, AFRL/PRTC, (937) 255-2351)

Ms. Kathleen Sargent

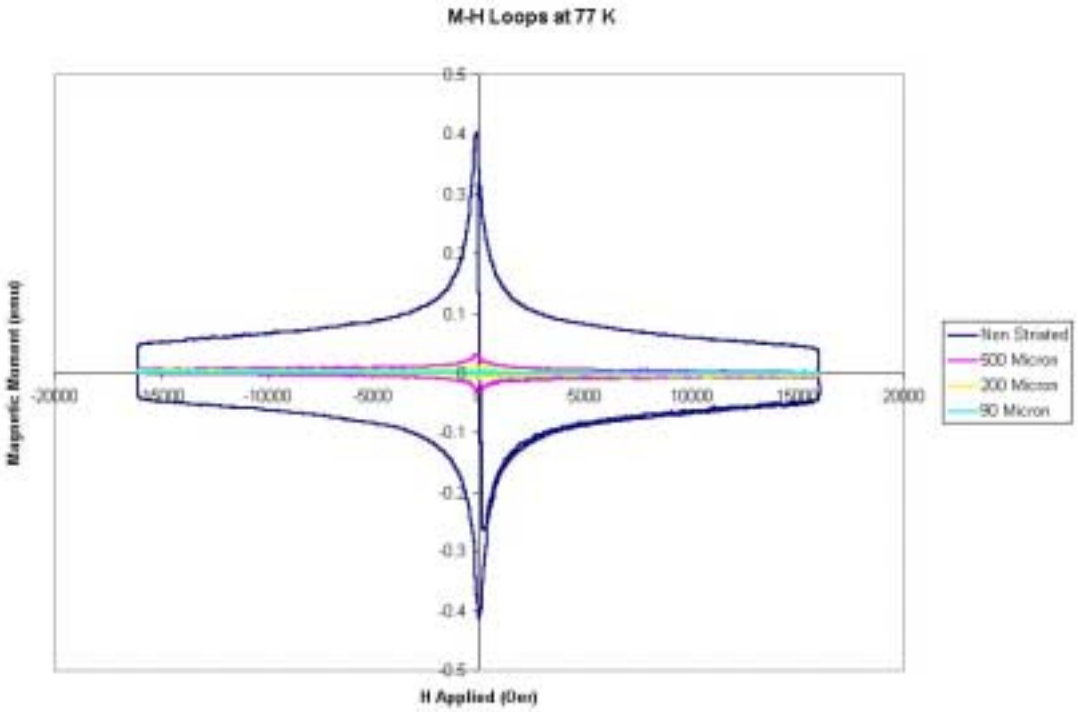


Schematic of the remote ring concept

INITIAL LOW-LOSS CONDUCTOR FABRICATED: The Propulsion Directorate's Superconductivity Group recently created the first successful samples of finely striated Yttrium Barium Copper Oxide (YBCO) for low ac loss testing. These samples were created based on previously modeled sub-divided YBCO incorporated into a megawatt armature design for power generation. The reduction in hysteresis loss was as projected. The design of lightweight superconducting generators requires a high-speed rotor (thousands rpm), a high magnetic flux density (a couple Tesla), and high frequency (several hundred Hz). These conditions make it very difficult to minimize ac losses in the normally wide superconducting tape. The striated YBCO configuration acts to decouple the filaments, unlike the metallic matrix of low temperature superconductors that permits significant coupled currents induced by perpendicular applied fields. (P. Barnes, AFRL/PRPG, (937) 255-4410)



Samples of finely striated YBCO for low ac loss testing

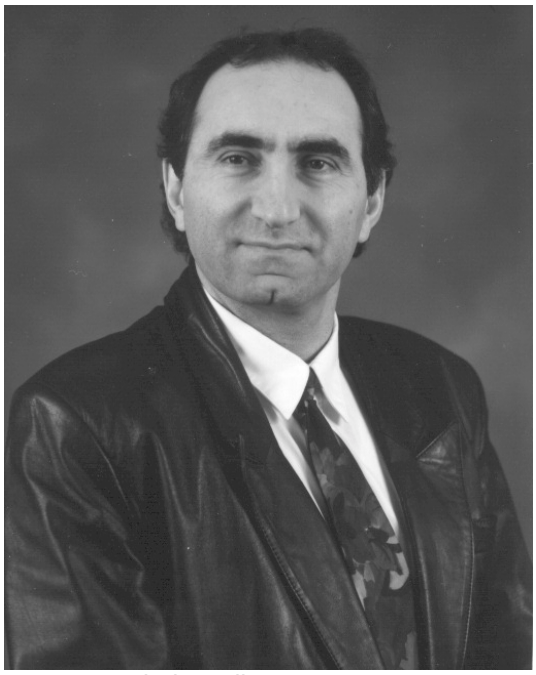


The reduction in hysteresis loss was as projected

VISIT TO POSITRON BEAM SCATTERING FACILITY: A new in-house experimental design is under consideration by the Propulsion Directorate's Power Division (AFRL/PRP) to use positron scattering in plasmas containing nanoparticles and also to explore the possibilities of trapping antimatter in a Coulomb lattice, which can be formed under certain conditions in plasmas. Two types of positron beam sources are currently available; they are produced either in particle accelerators or from a radioactive source. The complexity trade-off for operation and maintenance favors the use of a radioactive source for the AFRL/PRPE research section's experimental conditions and support infrastructures. In order to evaluate the experimental requirements and the radiation safety issues of handling the radioactive source, Dr. Bish Ganguly (AFRL/PRPE) visited the Physics Department laboratory at Wayne State University, Detroit, Michigan, on 7 December 2001. This laboratory currently has three different experimental setups for positron beam line using a Na^{22} source and uses radioactive sources from 20 mCurie up to

100 mCurie (as received) range. Professors Walter Kauppila and Bert Stein discussed the detailed layout of the source design and the source handling procedures, which were developed based on Nuclear Regulatory Commission guidelines for handling radioactive sources. They also discussed the moderator design considerations along with the magnetic field guided beam transport instrumentation. Based on the information gathered during this site visit, it appears to be quite feasible to setup an experiment for positron beam scattering and antimatter trapping in plasmas containing nanoparticles and Coulomb lattice. (B. Ganguly, AFRL/PRPE, (937) 255-2923)

CHEHROUDI HONORED BY INTERNATIONAL TECHNICAL SOCIETY: Dr. Bruce Chehroudi was recently selected by the Society of Automotive Engineers (SAE) International to receive the Forest R. McFarland Award. SAE's Engineering Meetings Board (EMB) grants this award in recognition of outstanding services rendered to SAE and the EMB. In particular, the McFarland Award recognizes outstanding efforts in the organization of SAE meetings and conferences and in the development of advanced seminars. This award specifically cites Dr. Chehroudi's leadership and contributions to the Continuing Professional Development Group. Presentation of the McFarland Award will take place at the Honors Convocation Luncheon during the 2002 SAE World Congress at the Cobo Center in Detroit, Michigan, on 5 March 2002. Dr. Chehroudi is an on-site contractor with ERC Inc supporting the Propulsion Directorate's Aerophysics Branch (AFRL/PRSA) at Edwards AFB, California. (B. Chehroudi, AFRL/PRSA (ERC), (661) 275-6175)



Dr. Bruce Chehroudi