"launch on need" backup shuttle into an additional mission, STS-135, slated for launch this summer.

While NASA was effectively forced to add a shuttle mission to accommodate the AMS, project officials praised the space agency for their support for the experiment. Mark Sistilli, the NASA program manager for AMS, credited NASA associate administrator for space operations William Gerstenmaier for his efforts to get AMS back onto the flight manifest. "Without Bill Gerstenmaier we would not be here today."

Samuel Ting discusses the mission of the AMS, with a model of the experiment in the foreground, after an April 28th press conference at KSC. (credit: J. Foust)

Controversy and uncertainty

Perhaps sensitive to its brush with cancellation, the AMS consortium has stepped up its efforts to communicate its mission to the media and the public. For example, at the press conference last month before the scrubbed launch, the consortium distributed a nearly 200-page full-color glossy book about the experiment. (Curiously, one passage in the book referred to the launch of Endeavour carrying the AMS in the past tense: Ting and colleagues "spoke the long awaited words: 'AMS is Go For Launch'. Moment later AMS began its ascent towards the ISS.")

That PR push has not insulated

the AMS from controversy. Some scientists are skeptical about the utility of the experiment and whether it will be able to do cutting-edge science from its perch on the station. Among their concerns: the decision to replace the superconducting magnet originally planned for the AMS with a permanent magnet used on the version of the AMS flown on the shuttle. The permanent magnet will last the life of the station—potentially 10 years or more depending on how long the ISS continues to operate—whereas the superconducting magnet would have exhausted its supply of liquid helium in three years. The superconducting magnet, though, is several times as powerful as the permanent one, leading some to wonder about potential lost science. Others argue the money spent on AMS would have been put to better use on alternative terrestrial or balloon-borne experiments.

"To advance in physics is to push current knowledge aside," said Ting. "Exploring new territory with a precision instrument is the key to discovery. What we will really see nobody knows."

Among the skeptics is Gregory Tarlé, a physicist at the University of Michigan, who has been widely quoted as critical of many of the claims made by AMS supporters. He thinks if there were concentrations of antimatter elsewhere in the universe, they would be detected by other means, and positrons created by neutralino collisions could be explained by other means. "Given that it's not a conclusive experiment, the billions of dollars in expenditures—and the risk of lives in extending the shuttle program—is just not worth it," he told *Science* magazine last month.

Asked about Tarlé's criticism in particular at last month's KSC press conference, Ting gave a response best described as quixotic. "The University of Michigan is where I went to school. They used to have a very good football team. The last few years, the football team has gone to pot," he said to laughter from the assembled media. "I have no other answer."

Ting said that AMS's biggest discovery might come from a totally unexpected area. At the press conference he showed a table listing a number of major physics and astronomy facilities and the scientific rationale used to support their development. In each case, those facilities made key discoveries in areas that had not been anticipated when they were built. The Hubble Space Telescope, for example, helped astronomers discover the presence of dark energy in the universe, something not contemplated when the observatory was launched in 1990, let alone in the preceding decades of development.

"For AMS, I have mentioned that we can look for dark matter, look for antimatter, and look for strangelets," Ting said, referring to another hypothetical dark matter candidate. "But to advance in physics is to push current knowledge aside. Exploring new territory with a precision instrument is the key to discovery. What we will really see nobody knows."

Jeff Foust (jeff@thespacereview.com) is the editor and publisher of The Space Review. He also operates the Spacetoday.net web site and the Space Politics and NewSpace Journal weblogs. Views and opinions expressed in this article are those of the author alone, and do not represent the official positions of any organization or company, including the Futron Corporation, the author's employer, which does work with the FAA Office of Commercial Space Transportation.

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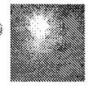

NASA'S $1.5 BILLION ROLL OF THE DICE

Shuttle Endeavour payload may unlock universe's mysteries — or not

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By Scott Powers and Mark K. Matthews, Orlando Sentinel
April 24, 2011

Stowed in the cargo hold of space shuttle Endeavour for its launch Friday is a science experiment that could upend astronomy in ways unparalleled since the Hubble Space Telescope. Or — if it flops — it could end up as a $1.5 billion hood ornament on the International Space Station.

It's called the Alpha-Magnetic Spectrometer. And once it is mounted on the station, scientists hope it will find and analyze high-energy cosmic rays and exotic and elusive space particles — including some that could help solve the most profound mysteries of the universe.

"This is not a run-of-the-mill mission," said Bill Gerstenmaier, NASA associate administrator for space operations. "It has the potential to return really earth-shattering science."

Yet there have been doubts about the AMS, as it's known, and delays. Six years ago, NASA nearly canceled the mission. It took an act of Congress to specifically fund this Endeavour launch.

And doubts remain.

The AMS is the scientific version of a lobster trap. A 15,000-pound supercooled magnet wrapped around an open cylinder, it's designed to sit outside the space station, catching and analyzing whatever floats or zooms through its magnetic tunnel, giving scientists the chance — just like lobstermen — of netting something big. Or not.

The powerful magnet will bend the paths of particles and cosmic rays that enter the tunnel, and a set of detectors will measure their size, charge, speed, energy, direction and spacing, allowing them to be identified. More than 300,000 data channels will collect and process the information and beam it back to Earth for further analysis.

Even the project's top scientist, Samuel Ting, admits the experiment is laced with uncertainty.

"If you do an experiment with such a large magnet ... you're entering a new domain. You don't know what you'll see," said Ting, a physics professor at the Massachusetts Institute of Technology who shared a 1976 Nobel Prize for discovering a subatomic particle.

Some scientists think the AMS won't see much at all. Among them: Gregory Tarle, a physics professor at the University of Michigan, who is convinced that what Ting is looking for either won't materialize or has already been caught and analyzed by other devices. He thinks the AMS will be about as useful as a hood ornament, certainly not worth the money and political capital needed to get it into space.

Tarle argued that there are better experiments worthy of that sort of money and political support, experiments listed as higher priorities by the National Academies of Science.

"There is little value in AMS," Tarle said. "It's actually a disgrace."

AMS supporters say that at a minimum, it will enable them to learn more about high-energy cosmic rays, which could help explain the formations and declines of stars and galaxies. But the hope is

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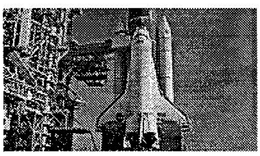

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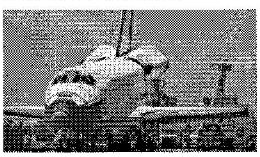

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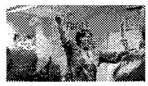
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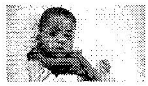
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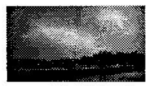
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- No

much grander: to discover materials key to the origin and makeup of the universe.

Astrophysicists' big-bang theory says the universe was formed from large quantities of matter and a substance called antimatter. Though matter's existence is obvious — everything from stars to starfish — proof of antimatter is limited to infinitesimal, flash-quick observances in laboratory experiments. It cannot survive on Earth because it is destroyed as soon as it comes into contact with matter.

Physicists theorize that antimatter might survive in space. Ting is hoping that "primordial antimatter," stuff left over from the big bang, will float through AMS' tunnel.

Then there's the bigger, elusive prize: evidence of dark matter, invisible stuff that scientists believe actually makes up 20 percent of the universe but which they have never seen — because it's invisible to all current astronomical tools.

So what are the practical potentials?

Think the warp drive of "Star Trek" powered by antimatter. Astrophysicists have observed space particles energized beyond easy explanation. If they could understand what's behind this, maybe they could harness it.

"How does nature manage to accelerate particles to huge energies, way beyond what you can do on Earth?" asked Michael Shull, professor of astrophysics at the University of Colorado. "Nature somehow manages, in some very exciting ways, to accelerate charged particles to enormous energies. This is one of the reasons the Department of Energy got interested in this stuff."

The U.S. Department of Energy is the primary sponsor of the AMS, heading a large collaboration of 56 institutions and 600 physicists in 16 countries.

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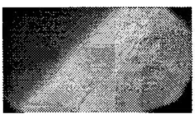
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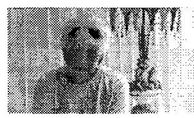
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International Space Station

Fact Sheet

Text Size

Alpha Magnetic Spectrometer - 02 (AMS-02) **04.25.11**

Overview | Description | Applications | Operations | Results | Publications | Images

Experiment/Payload Overview

Brief Summary

The Alpha Magnetic Spectrometer - 02 (AMS-02) is a state-of-the-art particle physics detector constructed, tested and operated by an international team. The AMS-02 uses the unique environment of space to advance knowledge of the universe and lead to the understanding of the universe's origin by searching for antimatter, dark matter and measuring cosmic rays.

Principal Investigator

Executive Committee Chairman:

- Samuel Ting, Ph.D., Massachusetts Institute of Technology, Cambridge, MA

Executive Committee Members:

- Manuel Aguilar-Benitez, Prof., Centro de Investigaciones Energeticas Medioambientales y Tecnologicas (CIEMAT), Madrid, Spain
- Silvie Rosier, Ph.D., Institut National de Physique Nucléaire et de Physique des Particules (IN2P3), Laboratoire d'Annecy-le-Vieux de Physique des Particules (LAPP), Annecy-Le-Vieux, France
- Roberto Battiston, INFN and University of Perugia, Italy
- Shih-Chang Lee, Prof., Academia Sinica, Institute of Physics, Taipei, Taiwan
- Stefan Schael, Prof., Rheinisch-Westfälische Technische Hochschule (RWTH), I. Physikalisches Institut (B), Aachen, Germany
- Martin Pohl, Prof., Departement de Physique, Université de Genève, Geneve, Switzerland

Co-Investigator(s)/Collaborator(s)
Information Pending

Payload Developer

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University of Maryland, Institute for Physical Science and Technology (IPST), College Park
Yale University, Physics Department, New Haven

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Istituto di Ricerca sulle Onde Elettromagnetiche, IROE, CNR, Firenze
Sezione INFN and Dipartimento di Fisica, Universita degli Studi di Milano-Bicocca, Milano
Sezione INFN and Dipartimento di Fisica, Universita degli Studi di Perugia, Perugia
Laboratorio SERMS, Polo Universitario di Terni, Terni
Sezione INFN and Dipartimento di Fisica, Universita degli Studi di Pisa, Pisa
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National Taiwan University (NTU), Taipei
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Karlsruhe Institut fur Technologie (KIT), Universität Karlsruhe, Karlsruhe

Switzerland
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Universite Joseph Fourier (Grenoble 1), Laboratoire de Physique Subatomique et de Cosmologie (LPSC)
Université Montpellier II, Laboratoire de Physique Theorique and Astroparticules (LPTA)

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Academia Sinica, Institute of High Energy Physics, Beijing
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Shandong University, Tsinan
Southeast University, Nanjing
Sun Yat-Sen University, School of Physics and Engineering, Guangzhou

South Korea
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Portugal
Dep. de Fisica Universidade de Coimbra, Coimbra
Laboratorio de Instrumentacao e Fisica Experimental de Particulas (LIP), Lisbon

Mexico
Universidad Nacional Autonoma (UNAM), Instituto de Ciencias Nucleares, Mexico City

Romania
University of Bucharest, Bucharest-Magurele, Romania

Contributing Space Agencies
National Aeronautics and Space Administration (NASA):

- Johnson Space Center, Houston, TX
- Goddard Space Flight Center, Maryland, MA
- Kennedy Space Center, Cape Canaveral, FL
- Marshall Space Flight Center, Huntsville, AL

Italian Space Agency (ASI)
German Aerospace Center (DLR)
European Space Agency (ESA)
European Center for Nuclear Research (CERN)
National Space Organization, Taiwan

In addition, the following Institutes/Groups made important contribution to the construction of the AMS-02 experiment:

- Jacobs Sverdrup Engineering and Science Contract Group (ESCG), Houston, USA
- Florida State University, Tallahassee, USA
- Texas A & M University, Department of Physics, College Station, USA
- Johns Hopkins University, Baltimore, USA
- Aerospace Industrial Development Corporation (AIDC) - Taichung, Taiwan
- Max-Planck-Institut für Extraterrestrische Physik, Garching, Germany
- Nationaal Instituut voor Subatomaire Fysica (NIKHEF), Amsterdam, The Netherlands

Sponsoring Space Agency
National Aeronautics and Space Administration (NASA)

Supporting Organization:
National Laboratory Office - Other Government Agency (NLO-OGA)

ISS Duration:
March 2011 - September 2012

Expeditions Assigned
|27/28 |29/30 |31/32|

Previous ISS Missions

The precursor to AMS-02, AMS, was flown on STS-91 in 1998. During this precursor flight, the basic technology required to perform the measurements was proven.

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Experiment/Payload Description

Research Summary

- The Alpha Magnetic Spectrometer - 02 (AMS-02) is a high profile space-based particle physics experiment.
- Orbiting the Earth at an altitude of 200 nautical miles attached to the International Space Station (ISS), AMS-02 will pioneer a new frontier in particle physics research.
- As the largest and most advanced magnetic spectrometer in space, AMS-02 will collect information from cosmic sources emanating from stars and galaxies millions of light years beyond the Milky Way.

Description
Excerpt from "Alpha Magnetic Spectrometer - A Physics Experiment on the International Space Station" by Dr. Susan Ting: The Alpha Magnetic Spectrometer (AMS-02) is a state-of-the-art particle physics detector constructed, tested and operated by an international team composed of 60 institutes from 16 countries and organized under United States Department of Energy (DOE) sponsorship. The AMS-02 will use the unique environment of space to advance knowledge of the universe and lead to the understanding of the universe's origin by searching for antimatter, dark matter and measuring cosmic rays.

Experimental evidence indicates that our Galaxy is made of matter; however, there are more than 100 hundred million galaxies in the universe and the Big Bang theory of the origin of the universe requires equal amounts of matter and antimatter. Theories that explain this apparent asymmetry violate other measurements. Whether or not there is significant antimatter is one of the fundamental questions of the origin and nature of the universe. Any observations of an antihelium nucleus would provide evidence for the existence of antimatter. In 1999, AMS-01 established a new upper limit of 10^{-6} for the antihelium/helium flux ratio in the universe. AMS-02 will search with a sensitivity of 10^{-9}, an improvement of three orders of magnitude, sufficient to reach the edge of the expanding universe and resolve the issue definitively.

The visible matter in the universe (stars) adds up to less than 5 percent of the total mass that is known to exist from many other observations. The other 95 percent is dark, either dark matter (which is estimated at 20 percent of the universe by weight or dark energy, which makes up the balance). The exact nature of both still is unknown. One of the leading candidates for dark matter is the neutralino. If neutralinos exist, they should be colliding with each other and giving off an excess of charged particles that can be detected by AMS-02. Any peaks in the background positron, anti-proton, or gamma flux could signal the presence of neutralinos or other dark matter candidates.

Six types of quark (u, d, s, c, b and t) have been found experimentally, however all matter on Earth is made up of only two types of quarks (u and d). It is a fundamental question whether there is matter made up of three quarks (u, d and s). This matter is known as Strangelets. Strangelets can have extremely large mass and very small charge-to-mass ratios. It would be a totally new form of matter. AMS will provide a definitive answer on the existence of this extraordinary matter. The above three examples indicates that AMS will probe the foundations of modern physics.

Cosmic radiation is a significant obstacle to a manned space flight to Mars. Accurate measurements of the cosmic ray environment are needed to plan appropriate countermeasures. Most cosmic ray studies are done by balloon-borne satellites with flight times that are measured in days; these studies have shown significant variations. AMS-02 will be operative on the ISS for a nominal mission of 3 years, gathering an immense amount of accurate data and allowing measurements of the long term variation of the cosmic ray flux over a wide energy range, for nuclei from protons to iron. After the nominal mission, AMS-02 can continue to provide cosmic ray measurements. In addition to the understanding the radiation protection required for manned interplanetary flight, this data will allow the interstellar propagation and origins of cosmic rays to be pinned down.

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Applications

Space Applications
AMS-02 will provide a plethora of cosmic ray data that will help to advance and perhaps redefine much of what we know about the Low Earth Orbit space radiation environment.

Earth Applications
This unique scientific mission of exploration seeks to understand fundamental issues shared by physics, astrophysics and cosmology on the origin and structure of the universe. Although the AMS-02 is specifically looking for antimatter and dark matter, as the largest magnetic spectrometer in space, AMS-02 has and will collect information from cosmic sources emanating from stars and galaxies millions of light years beyond the Milky Way.

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Operations

Operational Requirements
AMS-02 will collect data 24 hours a day, 7 days a week, and 365 days a year. As long as the experiment has power provided by the ISS, the detectors will be on and measuring data at a rate of 7 Gigabits per seconds. This is equivalent to filling a 1 Gigabyte USB memory stick every second! Using sophisticated filtration and compression techniques, the advanced 600 computer processors located on AMS-02 are able to reduce the amount of data down by a factor of 3000. This data is sent from the ISS to the ground where researchers around the globe will compile and analyze data.

Operational Protocols
The AMS-02 will be launched on the Space Shuttle to the ISS on mission ULF6. AMS-02 will be mounted to the ISS S3 Upper