Chapter I

The Alpha Magnetic Spectrometer (AMS) on the International Space Station

AMS is a major collaboration between the Italian Space Agency (ASI), INFN, NASA and the U.S. Department of Energy (DOE) with a large international participation world-wide. It is the first large-scale physics experiment scheduled on the International Space Station.

The purpose of the AMS experiment is to perform accurate, large acceptance (~0.5 m^2sr), high statistics, long duration measurements of energetic (up to multi-TeV) primary charged cosmic ray spectra in space. Some of the physics goals are:

(1) **Dark Matter** : More than 90% of the universe is made up of Dark Matter. There are many theoretical suggestions that SUSY particles are at least part of the Dark Matter (some of the early work include J. Ellis et al., Phys. Lett. B, 214, 3, 1988, M. Turner and F. Wilczek, Phys. Rev. D, 42, 4, 1990, E.A. Baltz, J. Edsjo P.R. D59, 23511, 1999, T. Moroi, L. Randall, Nuc. Phys. B570, 455, 2000).

Collisions of Dark Matter in the galactic halo produce π, e^+ and γ via:

$$\chi + \chi \rightarrow \bar{p} + \ldots$$
$$\rightarrow e^+ + \ldots$$
$$\rightarrow \gamma + \ldots$$

The π, e^+, γ from these collisions will produce deviations from the smooth energy spectra. Therefore, the precision measurement of the e^+, $\bar{p}$, γ spectra will enable us to establish whether SUSY particles (for example neutralinos) are the origin of Dark Matter.

(2) **Antimatter** : The strong evidence supporting the Big Bang origin of the universe requires matter and antimatter to be equally abundant at the very hot beginning. The absence of sharp annihilation γ ray peaks excludes the presence of large quantities of antimatter within our cluster of galaxies. (There is no experimental information on the other 10^8 clusters of galaxies in the universe).

Theories (based on a new type of CP-violation, Baryon Violation, the Standard Model, and Grand Unification) which predict either the existence of antimatter in segregated domains or the total absence of antimatter, are highly speculative. To date, there is no evidence of a new type of CP-violation or proton decay. These theories have no firm foundation in experimental data.

The resolution of this important problem will require further data : from the current generation of particle colliders and the B Factories at SLAC and in Japan to improve our understanding of CP-violation; from the upgraded Tevatron and the LHC to provide clues to the correct extension or modification of the Standard Model; from new proton decay detectors in Japan and Italy to improve our understanding of proton stability and from this experiment to improve (by a factor of 10^3) the observational basis of our understanding of the matter-antimatter balance in the universe.

(3) **Cosmic rays** : AMS will collect ~ 10^9 nuclei isotopes of D, He, Li, Be, B, and C. Among the interesting issues in physics are:
Accurate determination of the ratio of boron to carbon over a wide range of energies provides crucial information regarding the propagation of cosmic rays in the galaxy. In particular, the ratio of ^{10}Be (mean lifetime of 2.3 x 10^6 years) to the stable ^{9}Be will enable us to extend excellent low-energy measurements of the Ulysses satellite to higher energies and to provide important information on the understanding of cosmic ray propagation.

The physics of AMS can be viewed with the following perspective:

In the last half century, there have been many fundamental discoveries in astrophysics measuring microwaves, X-rays and gamma rays. Some examples are:

(i) the discovery of pulsars by Ryle and Hewish (Nobel Prize, 1974).

(ii) the discovery of microwave background radiation by Penzias and Wilson (Nobel Prize, 1978).

(iii) the discovery of new types of pulsars, a discovery that has opened up possibilities for the study of gravitation, by Hulse and Taylor (Nobel Prize, 1993).

(iv) the many discoveries of ROSAT, COS-B, COBE, CGRO, ASCA, RXTE and the Hubble Telescope.

In recent years, there have been many outstanding experiments with balloons (BESS, IMAX, HEAT, CAPRICE, WIZARD, MASS, the RICH Experiment ...) and accurate non-magnetic experiments (HEAO-3-C2, Ariel-5,6, ACE, EPACT, Ulysses, Voyager 1 and 2 ...) on satellites. In addition, there are ingenious ground-base experiments such as CASA, GRAND and the future P. Auger project, and underground experiments, IMB, MACRO, Soudan-2, Super Kamyokande... The result of these experiments has and will continue to provide most important information on the understanding of the origin of cosmic rays. AMS is a complementary experiment to these great efforts.

AMS is a particle physics experiment in space. It was proposed in 1994, reviewed and approved by the U.S. Department of Energy (DOE) in 1995. Table 1 below and the correspondence included in Attachment I summarize the activities of AMS in the United States.

December 19, 1994	AMS Proposal submitted to DOE.
March 1995	First DOE review: mail review.
April 2-3, 1995	Second DOE review: Panel review with panelists : · Professor Robert K. Adair, Yale · Professor Barry C. Barish, CALTECH · Professor Stephen Olsen, Hawaii · Professor Malvin A. Ruderman, Columbia · Professor David N. Schramm, Chicago · Professor George F. Smoot, Berkeley · Professor Paul J. Steinhardt, Pennsylvania.
April 19, 1995	**Approval of AMS experiment by DOE.**
June 2, 1998	AMS launch on board Shuttle DISCOVERY for a 10-day mission in space.
March 15, 1999	Third DOE review: Panel review : · Professor Robert K. Adair, Yale · Professor Barry C. Barish, CALTECH · Professor Stephen Olsen, Hawaii · Professor Malvin A. Ruderman, Columbia · Professor George F. Smoot, Berkeley · Professor Paul J. Steinhardt, Pennsylvania. **Review of AMS-01 Results and Approval of AMS-02 Upgrade**
March 27, 2001	Presentation to DOE HEPAP
March 2004	AMS-02 on the International Space Station for 3-5 years.

Table 1 : AMS milestones.

The DOE and NASA Memorandum of Understanding (MOU) dated 20 September 1995, is based on a long-standing DOE and NASA agreement from July 1992 on "Energy Related Civil Space Activities" in which NASA supports many DOE activities in space. According to the MOU, DOE has the responsibility for assessing the experiment’s quality and merit and for the construction of AMS, and NASA provides two shuttle flights : one to test the AMS-01 experiment in space (the STS-91 flight from June 2-12, 1998) and the second to transport AMS-02 to the Space Station (scheduled on flight UF4 in March 2004). NASA is not involved in the construction of AMS.

According to NASA procedures in these cases, a NASA mission management office was established to ensure that AMS satisfied all strict flight safety regulations and provided guidance and integration of AMS into NASA systems including integrating AMS into the space shuttle at Kennedy Space Center and establishing the control and data collection centers.

After the first shuttle flight (AMS-01), and with the strong encouragement of NASA, the AMS magnet has been upgraded from a permanent magnet system made out of high-grade neodymium-iron-boron to a superconducting magnet. This was reviewed and approved by the DOE on the third DOE review of March 15, 1999 (see Figure 2).

After the approval by DOE, AMS was reviewed extensively by particle and astrophysicists in Switzerland, Germany, Italy, France, Finland, Russia ... as well as by the European Space Agency (see Attachment II).

Figure 1 shows the worldwide participation in AMS.

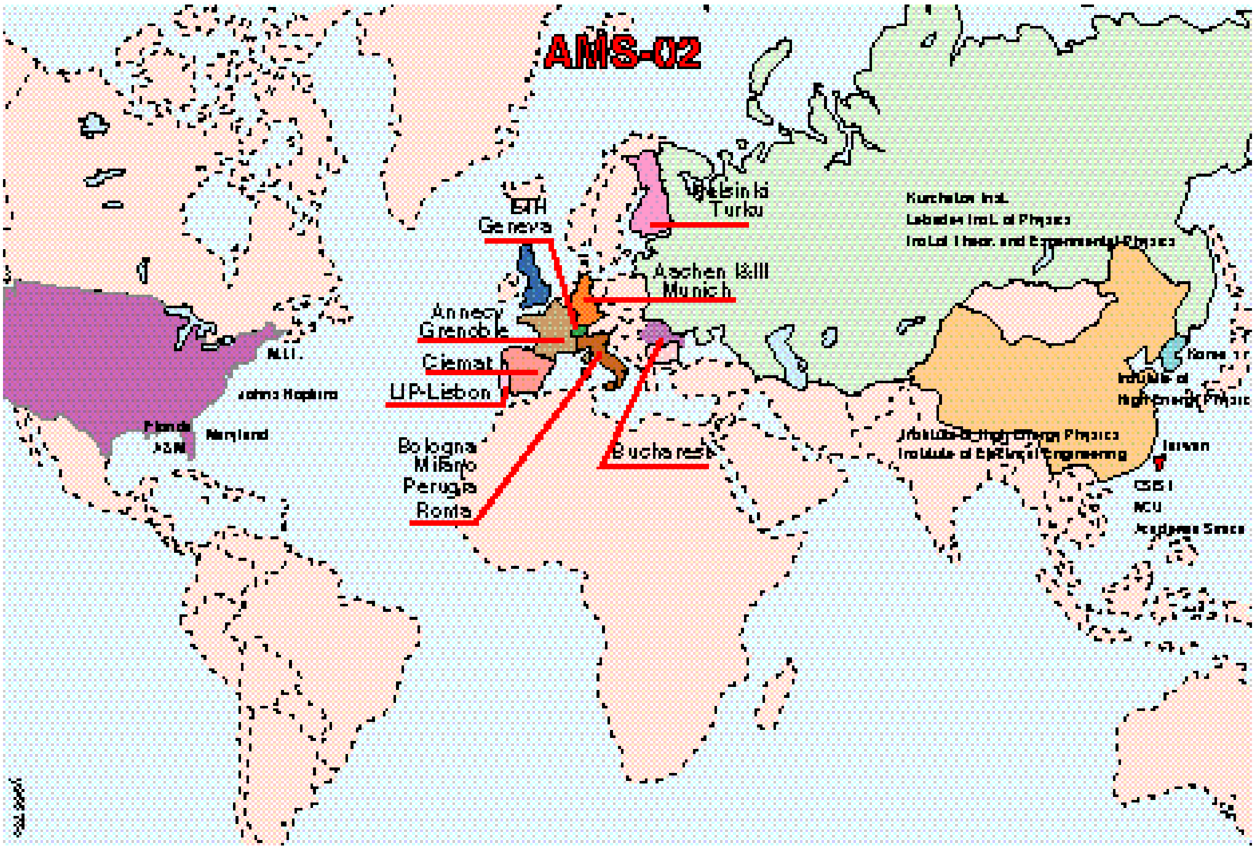


Figure 1 : Participation in AMS from the U.S.A., Europe and Asia.

Table 2 summarizes the funding of AMS-01 and the funding of AMS-02. Manpower refers primarily to technical support provided by non-US AMS institutes.

$M	AMS-01	AMS-02
Equipment	**17**	**70**
Manpower	**40**	**110**
Total	**57**	**180**

Table 2 : AMS Funding. This funding is sufficient to complete the AMS-02 experiment.

To perform a high accuracy measurement of energetic charged particles spectra in space, we have designed the AMS detector based on experience over the last thirty years from the study of leptonic decays of vector mesons from $\gamma + N \rightarrow N + (\rho, \omega. \varphi \rightarrow e^+e^-)$ at DESY and the discovery of the J particle from $p + N \rightarrow J (\rightarrow e^- e^+) + ...$. These experiments were successful because they have :

(a) minimal material in the particle trajectory so that the material itself is not a source of background nor a source of large angle nuclear scattering;

(b) many repeated measurements of momentum and velocity so as to ensure that background particles which had experienced large angle nuclear scattering from the detector itself be swept away by the spectrometer and not confused with the signal.

It was the strict adherence to this procedure that ensured that background rejection of 10^{10} was indeed possible and made these experiments successful.

Figure 2 shows the AMS-02 detector for the Space Station. It contains the following main components :

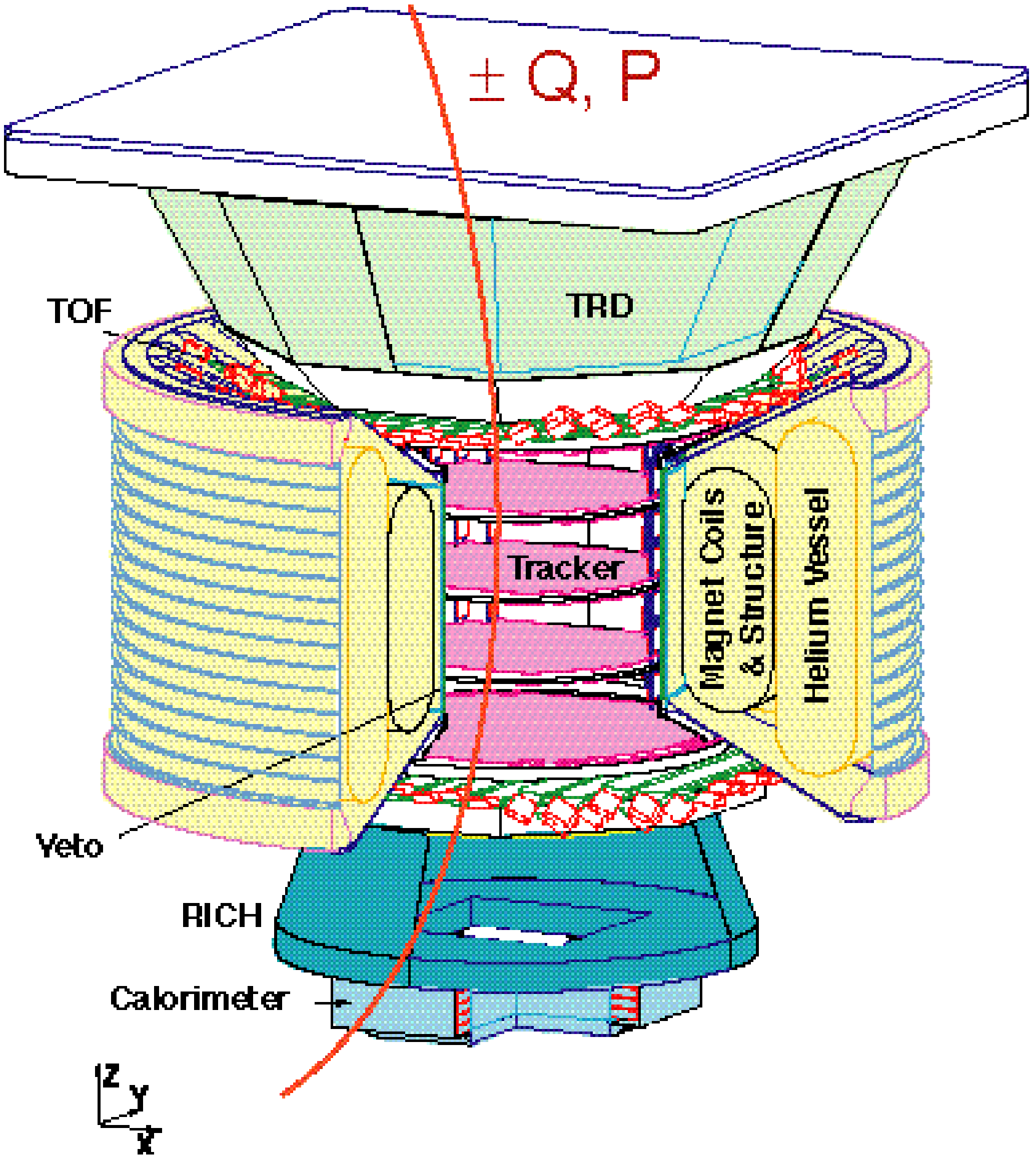


Figure 2 : **A TeV Detector in Space : AMS-02 on the Space Station**
The value of |Q| is measured independently in Tracker, RICH and TOF. The signed charge (±Q) and the momentum of the particle (P) is measured by the 8 layers of doubled-sided silicon tracker in the magnet. The velocity V is measured by the TOF, TRD and RICH.

(1) Twenty layers of Transition Radiation Detectors (TRD) identify positrons with a rejection factor of 10^2-10^3 against hadrons from 1.5 GeV to 300 GeV.

(2) Four layers of Time of Flight (TOF) hodoscopes provide precision time of flight measurements (~ 120 picoseconds) and dE/dX measurements.

(3) The superconducting magnet provides a bending power of $BL^2 = 0.86\ Tm^2$.

(4) Eight layers (6.45 m^2) of silicon tracker provide a proton rigidity resolution of 20% at 0.5 TV and a helium (He) resolution of 20% at 1 TV. Figure 3 shows the calculated resolution of AMS-02.

(5) Veto counters ensure that only particles passing the magnet aperture will be accepted.

(6) A Ring Imaging Cerenkov Counter (RICH) measures the velocity (to 0.1%) of particles or nuclei and |Q|. This information, together with the measurement of momentum in the magnet, will enable AMS to directly measure the mass of particles and nuclei.

(7) A 3-D sampling calorimeter (ECAL) made out of 15 X_o of lead and fibers measures the energy of gamma rays, electrons and positrons and distinguishes electrons and positrons from hadrons with a rejection of 10^4 in the range between 1.5 GeV to 1 TeV.

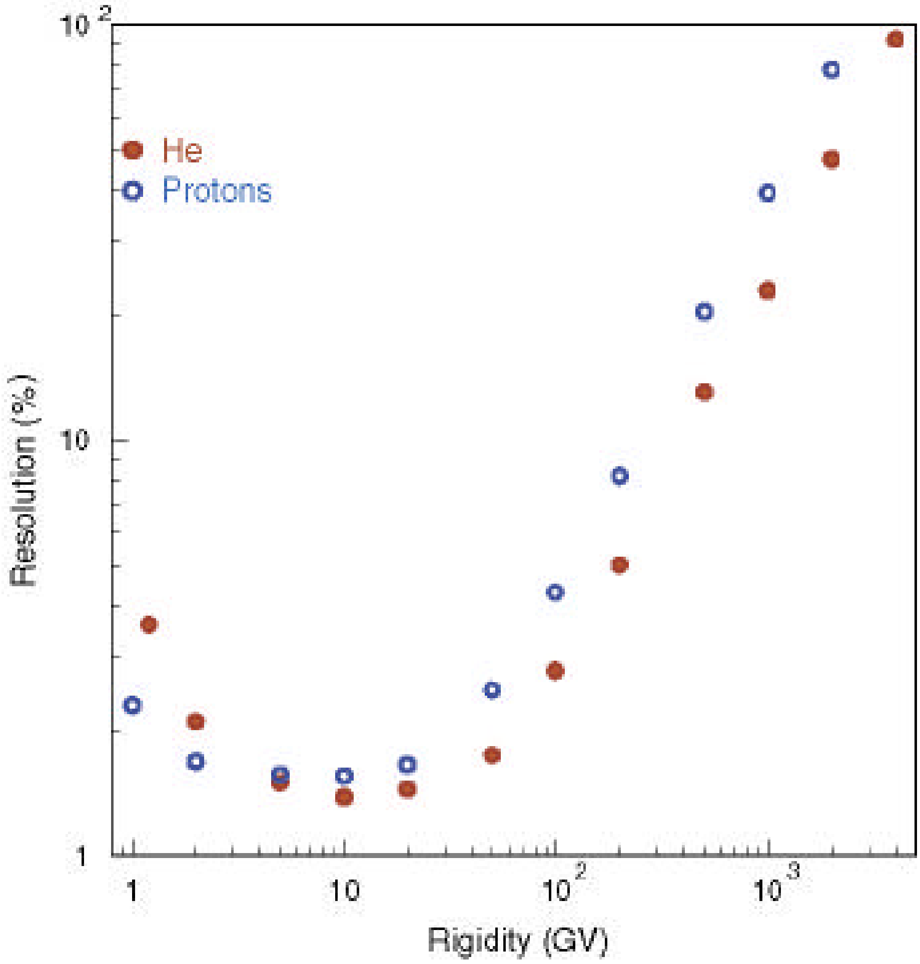


Figure 3 : Rigidity Resolution of P and He in AMS-02.

It should also be noted that by installing a Star-Tracker (which provides an excellent angular resolution of 2 Arc sec), AMS will become a sensitive high energy (up to 300 GeV) gamma ray detector. The measurement of $\gamma \rightarrow e^+ e^-$ will be done by the method similar to the one used in earlier work at DESY :

(i) No signal at the top layers of the TRD and Veto Counters.

(ii) Trajectory in the magnet measuring the opening angle and momentum of e^+, e^- from $\gamma \rightarrow e^+ e^-$ and

(iii) the energy measurement of E_{e+} and E_{e-} in ECAL.

Independently, γ can be measured directly in the ECAL by triggering on :

(i) No signal in TRD and Tracker, TOF and Veto Counters.

(ii) One large shower in the shower counter.

The NASA computer simulation on the next photograph shows the location of the AMS-02 spectrometer on the International Space Station.

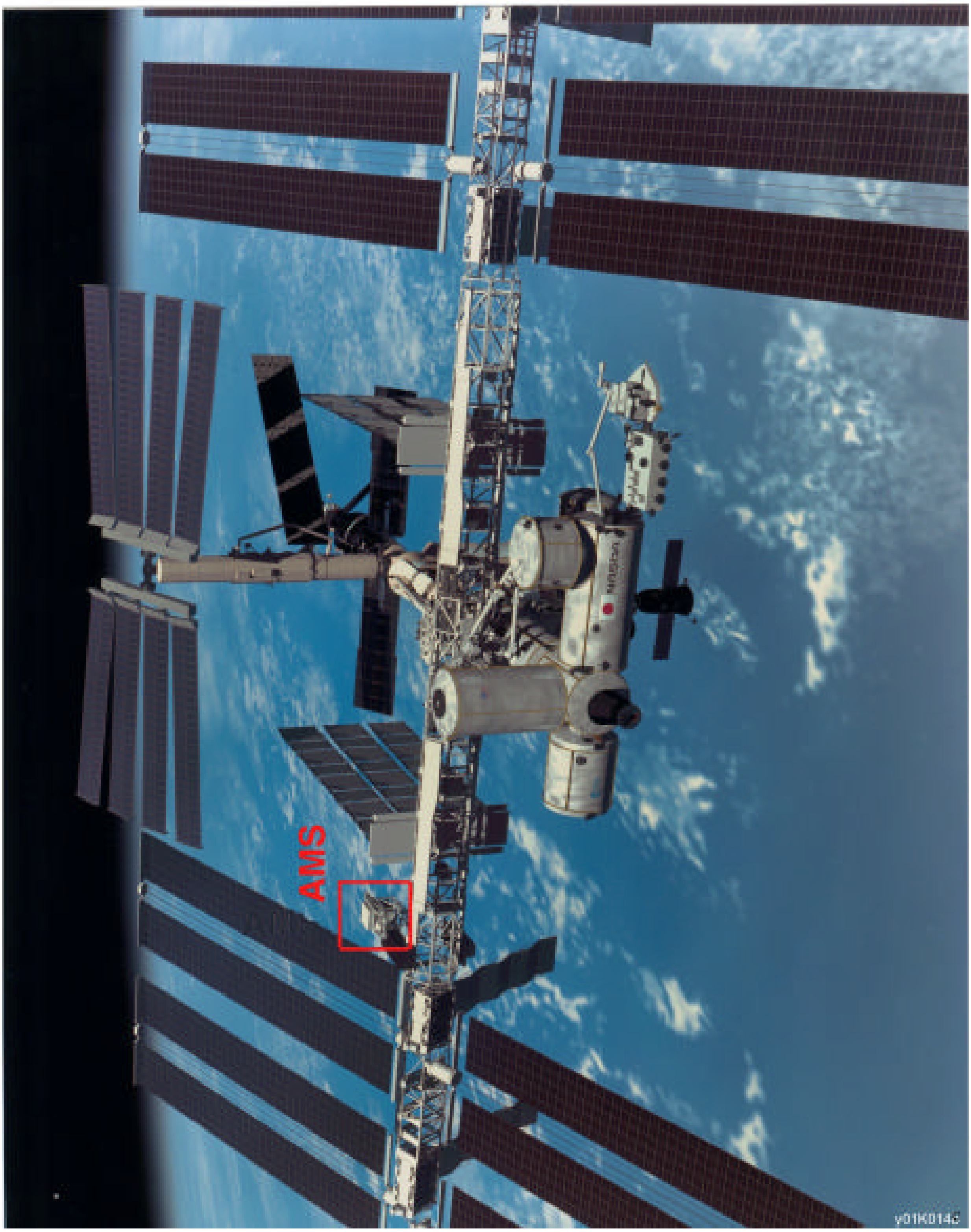
AMS is the only approved and scheduled large-scale physics experiment on the International Space Station. To ensure its success, NASA has organized an excellent mission management office (see Table 3). Table 4 is the NASA commitment to the AMS experiment : the shuttle first test flight for AMS-01 and the second flight to the International Space Station for a 3 to 5 year stay of AMS-02 on the space station.

The recent $10M grant from NASA to MIT is for AMS to build two identical superconducting magnet systems for safety tests and for the construction of thermal radiators on the Space Station for AMS-02.

National Aeronautics and
Space Administration

S98-11010

Lyndon B. Johnson Space Center
Houston Texas 77058



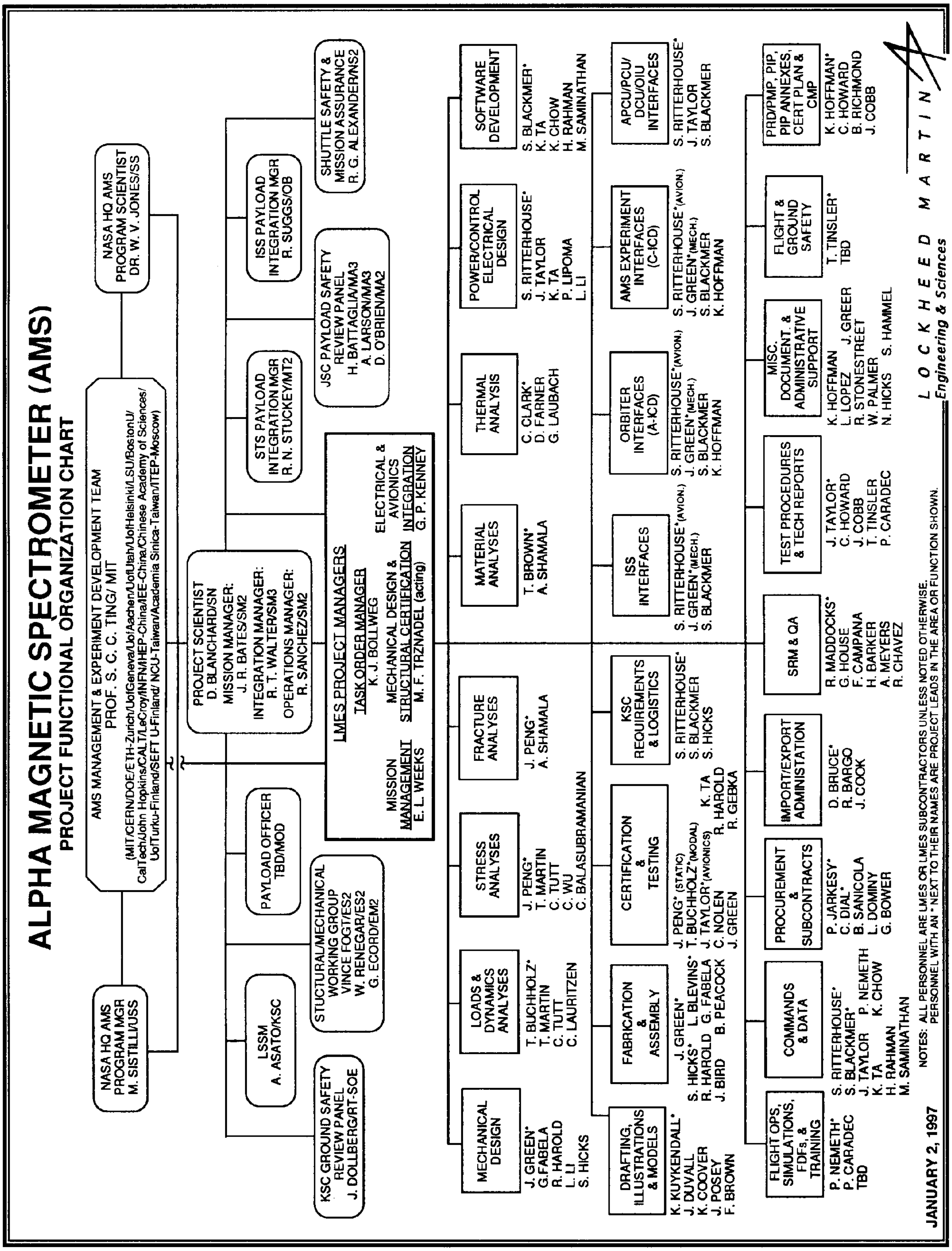


Table 3: AMS NASA Mission Management Office.

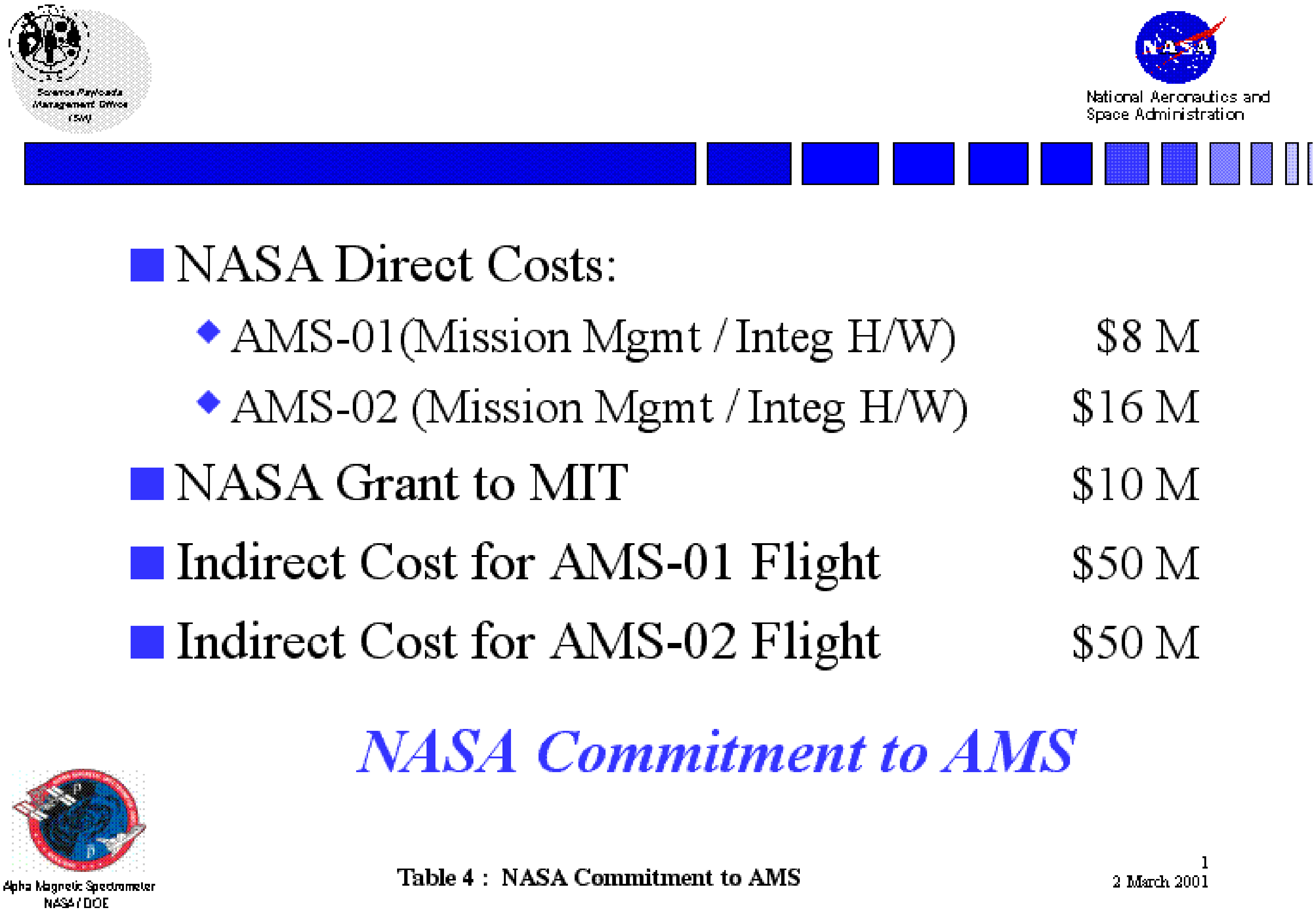


Table 4 : NASA Commitment to AMS

ATTACHMENT I

1. **Letter from Mr. Dan Goldin, Administrator of NASA, dated 14 July 1994, requesting DOE Review of AMS.**

2. **Letter from DOE dated March 16, 1995 containing instructions to AMS Review Panel Members.**

3. **DOE letter dated April 19, 1995 approving AMS.**

4. **DOE Letter to NASA dated April 24, 1995, requesting that NASA fly AMS.**

5. **Letter from P. Rosen (DOE) to D.S. Goldin (NASA Administrator) containing assessment of March 15, 1999 DOE Review and requesting an additional shuttle flight in case of slippage of construction of ISS.**

6. **Letter from NASA Associate Administrators, Arnauld Nicogossian and Joseph Rothenberg, reaffirms NASA's intention to fly AMS on ISS in 2003.**

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

JUL 14 1994

Professor Samuel C.C. Ting
Laboratory for Nuclear Science
Massachusetts Institute of Technology
Cambridge, MA 02139

Dear Professor Ting:

Thank you for your letter of May 12, 1994, in response to our discussions on May 9, 1994, concerning your proposal to fly an antimatter spectrometer experiment on the Space Station. Dr. Wesley Huntress' letter of June 1 has already addressed some of the points you raised, as did his fax message of May 13, but I would like to review them here sequentially for completeness and to ensure that NASA's policies and actions on your proposal are clearly understood. Recent discussions with the Department of Energy (DOE) have also resolved some points raised in previous correspondence.

1. I am pleased to confirm the information in Dr. Huntress' letter that we have established points of contact at both Headquarters and the Johnson Space Center who have the background and authority to assist you in every way to ensure that you can successfully carry out a feasibility study, to be concluded in approximately mid-August 1994. Agreement has been reached with the DOE to provide $100K to help fund this effort. We understand that Dr. John O'Fallon of DOE will administer these funds along with any funds provided additionally by DOE for your study.

2. Since we expect DOE to provide support for the construction of your experiment, that agency has the responsibility for assessing the experiment's quality and merit. Should DOE endorse your experiment to us for flight and if the feasibility study shows no roadblocks or prohibitive support costs to NASA, we will consider flying the experiment through an interagency agreement between DOE and NASA for the use of the Shuttle and Space Station.

3. Should both NASA and DOE agree to fly your experiment, NASA will hold DOE responsible for its delivery to NASA specifications. Your responsibility as the Principal Investigator will be defined by the DOE.

4. NASA will determine if the cost to integrate your experiment is reasonable within the Agency's fiscal constraints and program priorities. If so, then consistent with the provisions of point 5 below, NASA expects to bear the costs of integrating your experiment into the Space Shuttle and/or Space Station.

5. Assuming that construction of your experiment is fully funded by DOE, that DOE endorses its space flight to NASA, and that its integration presents no insuperable programmatic difficulties or expenditures, NASA will make every effort to fly it on the Space Station. The earliest opportunity, based on the current Space Station development plan, would be around the year 2000. NASA can make no commitment to a test Shuttle flight of your experiment. A free-flying experiment would have to be competed in response to an open NASA Space Science Announcement of Opportunity.

6. Dr. Huntress' letter of June 1 identifies the points of contact needed for technical interface of your experiment. In particular, Mr. Mark Sistilli (202/358-2242) should be contacted for routine working matters. Dr. Edmond Reeves (202/358-2560) is next in line authority to handle any especially difficult issues that arise.

7. Dr. Huntress' letter identifies Dr. Reeves as NASA's point of contact and Dr. O'Fallon from DOE.

I again would like to express my appreciation to you for taking the time to apprise me and our senior scientific Headquarters staff of the exciting possibilities and importance of the experiment you propose. I look forward to hearing of the results of the feasibility study.

Sincerely,

Daniel S. Goldin
Administrator

Department of Energy
Germantown, MD 20874-1290

MAR 1 6 1995

Professor David N. Schramm
Department of Astronomy and
Astrophysics
University of Chicago
5640 S. Ellis Avenue
Chicago, Illinois 60637

Dear Professor Schramm:

Thank you for agreeing to serve as a consultant on our review of the proposal "An Antimatter Spectrometer in Space" (AMS), to be held at the Massachusetts Institute of Technology (MIT) on April 2-3, 1995. Professor Samuel C.C. Ting of MIT's Laboratory for Nuclear Science is the Principal Investigator for the AMS proposal.

The purpose of this review is to assess the potential of the AMS activity to make scientifically important contributions to the U.S. High Energy Physics (HEP) program. In carrying out this assessment, it would be helpful if you would specifically:

1) Evaluate the scientific merit and significance of the proposed research in the context of the national high energy physics program.

2) Comment on the technical feasibility, the cost, and the schedule of the proposed research.

3) If the scientific significance is high, and the project appears feasible, comment on the relative priority of this research in the national HEP program, considering the cost burden to the U.S. Department of Energy.

Shortly after the review has been completed, I would appreciate receiving a letter from you concerning your individual evaluation of AMS proposal.

Enclosed please find a list of participants at the review.

The review will start with a closed executive session at 8:30 a.m. Sunday morning in the Kolker Room (Room 414) on the 4th floor of Building 26 at MIT. If you are arriving by taxi, tell the driver to go to 20 Vassar Street, Cambridge, which is near Building 26. If you are unfamiliar with the MIT campus you should ask a passerby for the location of Building 26. It is expected that the presentations Sunday morning will cover the physics motivating the AMS proposal. Presentations Sunday afternoon will focus on technical aspects of the proposal. At 5:00 p.m. there will be an important closed session for the review committee (consultants and DOE) to discuss what they have heard. A no-host group dinner will be arranged for Sunday evening for those wishing to attend. Monday morning we will convene again for an executive session at 8:30 a.m. Adjournment will be at 4 p.m. on Monday. Hotel accommodations have been arranged through MIT, and your name has been provided to Lauren Saragosa (617-253-2387) in the travel office of the Laboratory for Nuclear Science at MIT. A room has been reserved for you for two nights, April 1st and April 2nd, at the Royal Sonesta Hotel, 5 Cambridge Parkway, Cambridge. The rooms have been reserved at the MIT Corporate Rate of $130 (plus tax) per night. If you have any questions about your hotel arrangements please contact Ms. Saragosa or call the hotel directly at (617) 491-3600.

We appreciate your willingness to help us in this important review process, and we anticipate a very informative and stimulating visit to MIT. If you have any questions about the review, please contact Pat Rapp at (301) 903-4801 or PAT.RAPP@MAILGW.ER.DOE.GOV.

Sincerely,

Robert Woods

for John R. O'Fallon
Director
Division of High Energy Physics

Enclosure

cc:
Robert Redwine, LNS
Samuel C.C. Ting, LNS

Department of Energy
Division of High Energy Physics
Review of Proposal: "An Antimatter Spectrometer in Space"

Massachusetts Institute of Technology
Laboratory for Nuclear Science
Building 26 - Kolker Room
April 2-3, 1995

CONSULTANTS

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P.K. Williams, ER-221

Department of Energy
Germantown, MD 20874-1290

APR 19 1995

Professor Samuel C. C. Ting
Department of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Dear Professor Ting:

This letter is to convey our official approval of your proposal, "An Antimatter Spectrometer in Space" (AMS), as it was submitted and reviewed, which includes both the flight on the shuttle and the flight on the International Space Station Alpha. This approval is accompanied by the caveat that in the present stringent fiscal climate it is very unlikely that the support provided by the Department of Energy can increase beyond the level requested in the proposal. We will be in contact with you soon to discuss details of your funding request. Of course, all funding commitments will be dependent upon adequate funds being appropriated by Congress.

The consultants who served on the two-day panel review of the AMS proposal formed a strong consensus around several general observations on the experiment. There was a strong feeling that the experiment should be carried out. If antinuclei are observed it will be a major step forward in our understanding of the early universe. There was general agreement that a null result from the antimatter search would confirm most people's prejudices, and probably would not lead to any new understanding. However, pushing the limits on antimatter down by several orders of magnitude is by itself well worthwhile, because exciting and unimagined discoveries are always possible whenever such new sensitivities are reached.

Considerable enthusiasm was expressed for some of the other measurements of cosmic ray spectra in low earth orbit. Some of these spectra might indicate the presence of dark matter in the Milky Way and there are also many other rich possibilities for advances in astrophysics. For example, a careful measurement of the Be-10 to Be-9 isotope ratio as a function of energy would greatly advance the understanding of cosmic ray propagation.

There is also a strong consensus around several points concerning technology and the infrastructure of the collaboration. The experiment is timely, in the sense that it pushes the parameters of a relatively new technology, the rare earth permanent magnets made of neodymium, iron, and boron. The experiment takes state-of-the-art particle physics detector technology into space. Finally, there is unanimous agreement that the experimental team, under your leadership, is outstanding, with a proven record of scientific judgment and technical accomplishment. You are, perhaps, uniquely qualified to lead a project and an organization of this international complexity.

y97635_1

In closing, let me say that we are all hoping that you do see anticarbon and revolutionize the conceptual framework that integrates particle physics with astrophysics and cosmology. I wish you all the best of luck on your venture into space.

Sincerely,

John R. O'Fallon

John R. O'Fallon
Director
Division of High Energy Physics

cc:
W. N. Hess, Energy Research

y97635_2

Department of Energy
Germantown, MD 20874-1290

April 24, 1995

Dr. Harry C. Holloway
Associate Administrator for Life and
Microgravity Sciences and Applications
NASA Headquarters
300 E Street, S.W.
Washington, D.C. 20546

Dear Dr. Holloway:

On September 13, 1994, you wrote me that NASA had finished its feasibility study for the AMS experiment and found no technical show stoppers for space flight in either STS or international Space Station. Since that time DOE has carried out an intensive review of the AMS experiment and has recently notified Professor Samuel Ting that the experiment is approved and that we will fund the payload development (see Enclosure A).

The Department of Energy and NASA will proceed to enter into an agreement to fly the Antimatter in Space experiment of Professor Samuel Ting on Space Station Alpha. There have also been discussions about flying this same experiment on the Shuttle before putting it on the Space Station. We at DOE feel that this is a very important step and we want to urge NASA to support the Shuttle experiment.

There are several reasons why it is very important to do this. Such a Shuttle flight would demonstrate that the detector works in space and would measure the background that the detector must reject to see the real antimatter events. This flight would uncover any problems that the detector might have and would allow for some redesign if needed. It would also make measurements on the antiproton and positron fluxes in space. This could provide very useful information in the search for dark matter in our galaxy's halo.

Enclosure B is a document "AMS on the Shuttle" that explains in more detail the reasons for doing the Shuttle experiment.

The question was raised whether DOE could pay for part of the Shuttle launch costs if we decided to go ahead with the Shuttle flight. I have explored that question and the answer is that we cannot pay for launch costs.

We urge NASA to do everything they can to carry out this Shuttle flight for AMS. It is very important to the overall success of the experiment.

Sincerely,

Wilmot N. Hess
Associate Director for
High Energy and Nuclear Physics
Office of Energy Research

Enclosures

cc:
S. Ting, MIT
E. Reeves, NASA
J. O'Fallon, ER-22

Department of Energy
Germantown, MD 20874-1290

May 18, 1999

Dr. Daniel S. Goldin
Administrator
National Aeronautics and Space Administration
300 E Street, S.W.
Washington, D.C. 20546

Dear Dr. Goldin:

The Division of High Energy Physics (DHEP) of the U.S. Department of Energy (DOE) supports the request by Professor Samuel C.C. Ting and the Alpha Magnetic Spectrometer (AMS) Collaboration for a second shuttle flight of the AMS detector and requests that the National Aeronautics and Space Administration (NASA) provide the space on an appropriate shuttle flight.

This request is based on our assessment of the achievements of the AMS Collaboration since our approval of the original AMS proposal, the plans for improvements and upgrades of the AMS detector, and the reaction of the DOE AMS Committee to the AMS status report presented by Professor Ting and his collaborators on March 15, 1999. We recognize that the original NASA/DOE Implementing Arrangement concerning the AMS called for only one shuttle flight prior to the flight to place the AMS detector on the international space station. However, in view of the tremendous achievement in building the detector in a very short time, its nearly flawless performance, as demonstrated by the cosmic ray phenomena observed during the previous flight, the significant upgrades whose performance should be verified on a shuttle flight, and the slippage of the scheduled date for launch to the space station, we believe that a second shuttle flight is scientifically justified and should be carried out if feasible.

We recommend that the division of responsibilities between NASA and DOE remain as they were stated in the original Implementing Arrangement, i.e. NASA provide the launch vehicle and DOE, through Professor Ting and the AMS Collaboration, be responsible for the detector.

y99234_1

We hope that NASA will be able to further the AMS scientific program by approving this request by the DOE for a second shuttle flight for the AMS experiment.

Sincerely,

S. Peter Rosen

S. Peter Rosen
Associate Director for
High Energy and Nuclear Physics
Office of Science

cc: Martha Krebs, DOE
Ernest Moniz, DOE
John O'Fallon, DOE
Samuel Ting, MIT

National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

Reply to Attn of: UM

JUN 21 1999

Dr. S. Peter Rosen
Associate Director for
High Energy and Nuclear Physics
Office of Science
U.S. Department of Energy
19901 Germantown Road
Germantown, MD, 20874

Dear Dr. Rosen:

The purpose of this letter is to provide a response on behalf of the National Aeronautics and Space Administration (NASA) with regard to your U.S. Department of Energy (DOE) request dated May 13, 1999, (Enclosure 1) for a second Shuttle flight for the Alpha Magnetic Spectrometer (AMS). After thorough review of the current manifest and available resources, NASA has determined that in order to accommodate your request a new STS mission would have to be inserted in the 2002 plan. NASA finds that the prospects for obtaining funding for a second Shuttle flight for AMS are unlikely in the current budget climate. Given the requested timely submission of missions and the 6 month separation of the already manifested International Space Station (ISS) STS flight, NASA believes that, in accordance with the existing NASA/DOE AMS Implementing Arrangement, all efforts should be focused to the use of the ISS mission for AMS as opposed to a new Shuttle flight. In this regard, NASA reaffirms the intent to fly the AMS to the ISS, currently planned in 2nd Quarter, calendar year 2003.

Allowing for both the increased complexity associated with the upgraded AMS, as well as the lack of a second Shuttle test flight for AMS, NASA strongly recommends to DOE that the upgraded AMS on ISS be designed for modular on-orbit change out to the extent possible allowing for cost and engineering constraints. Such an approach will take full advantage of the performance provided by the ISS and its crew, which is not possible in the case of robotic missions. This flexibility is the hallmark of human intervention associated with ISS and STS missions and definitively can benefit Professor Ting's experiment in the longer range. Such AMS design considerations could lessen the necessity of a premature AMS return to earth from the ISS because of any unplanned AMS systems problems. Also, NASA will actively study the accommodation on ISS of a 13,500 pounds AMS/carrier combination (not including contingency). Until the study is completed, NASA cannot guarantee the accommodation of any AMS/carrier weight combination beyond the 9,860 pounds weight limit (Enclosure 2). NASA of course will update DOE should additional weight capabilities become available on either the shuttle or ISS and we wish to ensure you that we are aggressively pursuing the resolution of this issue.

In view of the exciting new AMS science results from the completed STS-91 mission, NASA looks forward with great anticipation to addition of the upgraded AMS to the ISS in 2003.

Arnauld E. Nicogossian, M.D.
Associate Administrator for Life
and Microgravity Sciences and Applications

Joseph H. Rothenberg
Associate Administrator for
Space Flight

Enclosures

cc:
B/Mr. M. Peterson
M-4/Mr. M. Hawes
M-7/Mr. W. Readdy
U/Dr. B. McCormick
UM/Mr. M. Uhran
Mr. M. Sistilli
Massachusetts Institute of Technology/Dr. S. Ting

ATTACHMENT II

AMS Review Reports from

- German Space Agency
- Russian Academy of Sciences
- European Space Agency

L. Phys. Inst. RWTH
POSTEINGANG
2 5. APR. 1996

DARA DEUTSCHE AGENTUR FÜR RAUMFAHRT-ANGELEGENHEITEN (DARA) Gmb

22. April 1996

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Herrn
Prof. Dr. K. Lübelsmeyer
I. Physikalisches Institut
Sommerfeldstr. 28
52056 Aachen

Tel.: 350
U. Z.:
WE1/196/rg
O. Röhrig

Ihr Vorschlag: Alpha Magnetic Spectrometer - AMS

Geschäftszeichen: WE 96/03

Sehr geehrter Herr Prof. Lübelsmeyer,

Ihr Vorschlag für eine Beteiligung am Alpha Magnetic Spectrometer wurde vom Gutachterauschuß "Extraterrestrik" auf seiner Sitzung am 14.03.96 beraten.

Der Ausschuß kam zu dem Ergebnis, Ihr Vorhaben als "von sehr hohem wissenschaftlichen Wert" einzustufen und ihm im Hinblick auf die Erfordernis der Durchführung eine sehr hohe Bedeutung beizumessen.

Ergänzend merkte der GA an:

1. Es ist vom Antragsteller nachzuweisen, daß auch in Deutschland wissenschaftliches Interesse an den Daten besteht, und daß auch deutsche Wissenschaftler sich an der Datenauswertung beteiligen wollen (Erweiterung des deutschen Teams). Der Zugang zu den Daten ist (z.B. per Agreement) sicherzustellen.

2.Die technische Verifikation birgt u.U. finanzielle Risiken, die vom Antragsteller zu tragen sind (Mehraufwand).

3. Es wird davon ausgegangen, daß die Phasen 2 und 3 jeweils vor Beginn erneut vom GA zu beraten sind.

Dieses Beratungsergebnis präjudiziert nicht die Förderentscheidung der DARA.

Amtsgericht Bonn
HRB 4900

Geschäftsführung:
Dr. jur. Jan-Baldem Mennicken, Generaldirektor
Dipl.-Ing. Klaus Berge

Vorsitzender des Aufsichtsrats:
Ministerialdirektor
Dr. Ludwig Baumgarten

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Konto-Nr. 0258004

Wir empfehlen Ihnen, einen offiziellen Förderantrag vorzubereiten. Aufgrund der angespannten Budgetsituation im lfd. Haushaltsjahr bitten wir Sie jedoch, Ihr Vorhaben auf Einsparpotential in 1996 zu prüfen. Einzelheiten sind im Vorfeld mit dem DARA-Vorhabensbearbeiter, Herrn Bartmann (-338) abzusprechen.

Mit freundlichen Grüßen

i.A. F. Dahl   i.A. O. Röhrig

Translation

Russian Academy of Sciences

PRESIDIUM

RESOLUTION

14 March 1995 Reference # 52

Moscow

Members of the Presidium of the Academy of Sciences and other invited participants have heard a report by Professor Samuel C.C. Ting, Foreign Member of the Academy, on "Search for Antimatter in Space on the International Space Station Alpha."

Academicians V.L. Ginsburg, R.A. Sunyaev and A.E. Chudakov took part in the discussion.

In his conclusion, Academician Yuri S. Osipov thanked Professor Samuel Ting for his interesting scientific report.

The Presidium deemed the proposed "AMS" experiment to search for antimatter with the help of a unique magnetic spectrometer to be one of the most important fundamental problems of modern elementary particle physics and cosmology.

The Presidium also considered it advisable to help in every possible way realize this project and support the participation of Russian Research Institutes and organizations in this project.

Signed by
Academician I.M. Makarov
Chief Scientific Secretary

Signed by
Academician Yuri S. Osipov
President of the Russian Academy of Sciences

РОССИЙСКАЯ АКАДЕМИЯ НАУК

ПРЕЗИДИУМ

ПОСТАНОВЛЕНИЕ

14 марта 1995 г. № 52

Москва

Протокольно. Члены Президиума РАН и все присутствующие заслушали научное сообщение иностранного члена РАН профессора Сэмюэла Тинга "Поиск антивещества в космосе на международной космической станции "Альфа" .

В обсуждении приняли участие академики Гинзбург В.Л., Сюняев Р.А., Чудаков А.Е.

В заключение академик Осипов Ю.С. поблагодарил профессора Сэмюэла Тинга за интересное научное сообщение.

Президиум РАН счел предлагаемый группой "AMS" эксперимент по поиску антивещества с использованием уникального магнитного спектрометра одной из важнейших фундаментальных проблем современной физики элементарных частиц и космологии. Президиум РАН также счел целесообразным всячески содействовать реализации этого проекта и поддерживать участие в нем российских институтов и организаций.

Президент
Российской академии наук
академик Ю.С. Осипов

Главный ученый секретарь
Российской академии наук
академик И.М. Макаров

FPAG(97)2
CERN, 18 February 1997

EUROPEAN SPACE AGENCY

FUNDAMENTAL PHYSICS ADVISORY GROUP

The Alpha Magnetic Spectrometer (AMS)

The AMS will be the first magnetic spectrometer in orbit, scheduled for flight on the Shuttle in 1998 and on the International Space Station (ISS) in 2001. One of the most challenging scientific objectives of this experiment is to search for antimatter ($\overline{He}$, $\overline{C}$) in space with a sensitivity of 10^4 to 10^5 better than current limits. Therefore, the AMS also belongs to the discipline of Fundamental Physics in Space.

Following a presentation by the AMS Principal Investigator, Prof. S.C.C. Ting, the FPAG, at its meeting on 17-18 February 1997 at CERN, reviewed the scientific objectives, experimental technique and international collaboration aspects of the AMS, and concluded that the AMS is a very important and presently unique experiment and that the strong European involvement in the AMS, which to a large extent is already in place, is highly desirable.

The FPAG noted that the preparation for the Shuttle flight was nearly complete but that further efforts for the full-scale Space Station experiment are still needed.

The remaining development work for the experiment on the ISS would greatly benefit from ESA's knowledge and expertise in space instrument qualification and mission and science operations. The FPAG therefore recommends that ESA should explore ways and means to make this expertise available to the AMS experiment.

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