MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

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The FY 2005 Budget Request for Major Research Equipment and Facilities Construction (MREFC) is $213.27 million, an increase of $58.30 million, or 37.6 percent, above the FY 2004 Estimate of $154.97 million.

Major Research Equipment and Facilities Construction Funding
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change Over FY 2004 Amount	Change Over FY 2004 Percent
Major Research Equipment and Facilities Construction	$179.03	$154.97	$213.27	$58.30	37.6%

The MREFC Account supports the acquisition, construction and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Initial planning and design, and follow on operations and maintenance costs of the facilities are provided through the Research and Related Activities (R&RA) Account.

There can be no doubt that a modern and effective research infrastructure is critical to maintaining U.S. leadership in science and engineering (S&E). The future success of entire fields of research depends upon their access to new generations of powerful research tools. Increasingly, these tools are large and complex, and have a significant information technology component.

Among Federal agencies, NSF is a primary supporter of forefront instrumentation and facilities for the academic research and education communities. In recent years, NSF has received an increased number of requests for major research facilities and equipment from the S&E community. Many of these requests have received outstanding ratings from research peers, program staff, management and policy officials, and the National Science Board. NSF's Request for the MREFC Account positions the agency to meet the future needs and opportunities of the research community.

Once a project has been submitted for MREFC funding, it must undergo a multi-phase review and approval process. The process begins with a review by the internal NSF MREFC Panel, which makes recommendations to the NSF Director with attention to criteria such as scientific merit, importance, readiness and cost-benefit. The Director then selects candidates for National Science Board (NSB) consideration. The NSB then approves, or not, projects for inclusion in future budget requests and establishes priorities. The Director selects from the group of NSB-approved projects those appropriate for inclusion in a particular budget request to OMB, and after discussion with OMB, to the Congress.

In order for a project to be considered for MREFC funding, NSF requires that it represent an exceptional opportunity that enables research and education. In addition, the project should be transformative in nature, in that it should have the potential to shift the paradigm in scientific understanding and/or infrastructure technology. NSF believes that all the projects included in this Budget Request meet these criteria.

As a general framework for priority setting, NSF assigned priority to projects based on the following criteria:

First Priority: Ongoing Projects – Projects that have received funding for implementation and where outyear funding for the full project has already been included in a Budget Request to Congress.

Second Priority: NSB-Approved New Starts – New projects that have received NSB approval for inclusion in a budget request but which have not yet been included in a budget request or received funding.

NSF believes that the highest priority within the MREFC Account must be the current projects. To that end, highest priority in FY 2005 is to continue to request funding for the Atacama Large Millimeter Array ($49.67 million); EarthScope: USArray, Plate Boundary Observatory and San Andreas Fault Observatory at Depth ($47.35 million); and the IceCube Neutrino Observatory ($33.40 million).

In addition, three new starts are requested in FY 2005 and two new starts in FY 2006. In priority order, these are: the National Ecological Observatory Network in FY 2005; the Scientific Ocean Drilling Vessel in FY 2005; Rare Symmetry Violating Processes in FY 2005; Ocean Observatories in FY 2006, and the Alaska Region Research Vessel in FY 2006.

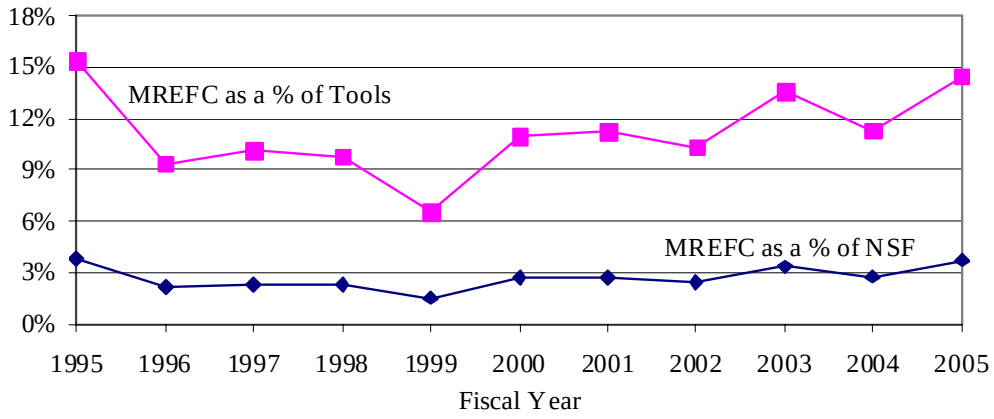
On January 14, 2004, the National Academy of Science released a study it conducted of NSF's processes for prioritization and oversight of activities funded through the MREFC Account. The NSF is now carefully evaluating the findings and recommendations contained in this study as it looks ahead to future activities in this area.

MREFC Account[1]
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	FY 2006 Request	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
ONGOING PROJECTS							
ALMA Construction	29.81	50.70	49.67	48.84	47.89	46.49	37.37
EarthScope: USArray, SAFOD, PBO	29.81	43.24	47.35	50.24	26.80		
High-Performance Instrumented Airborne Platform for Environmental Research	13.00						
IceCube Neutrino Observatory	25.75	41.75	33.40	34.30	35.30	36.30	31.01
Large Hadron Collider	9.69						
Network for Earthquake Engineering Simulation	13.47	8.05					
South Pole Station	12.69	1.29					
Terascale Computing Systems	44.83	9.94					
NEW STARTS							
National Ecological Observatory Network			12.00	16.00	20.00	20.00	20.00
Scientific Ocean Drilling Vessel			40.85	59.94			
Rare Symmetry Violating Processes			30.00	42.66	44.00	20.25	8.00
Ocean Observatories Initiative				24.76	63.44	65.00	47.30
Alaska Region Research Vessel				49.32	32.88		
Totals	**$179.03**	**$154.97**	**$213.27**	**$326.06**	**$270.31**	**$188.04**	**$143.68**

NOTE: Totals may not add due to rounding.
[1]Does not include funding provided for early concept and development or follow-on operations and maintenance. These funds are provided through the R&RA Account and are discussed in the following individual Activity narratives and in the Tools chapter.
[2]FY 2003 Actual include $35.0 million in carryover from prior year appropriations for Terascale Computing Systems due to the NSB meeting schedule. The award was approved in October 2002, and the funds were subsequently obligated. $66.06 million appropriated in FY 2003 is carried over into FY 2004 for HIAPER ($12.53 million), the IceCube Neutrino Observatory ($3.67 million), the Large Hadron Collider ($33,819), the Polar projects ($49.71 million) and Terascale Computing Systems ($107,959). This FY 2003 carryover will be reflected in the Current Plan following an FY 2004 appropriation.

MREFC Funding As A Percent Of Tools And Of The Total NSF Budget



FIRST PRIORITY: ONGOING PROJECTS IN FY 2005

Atacama Large Millimeter Array

Project Description: Originally referred to as the Millimeter Array (MMA) in the United States, this international project will be an aperture-synthesis radio telescope operating in the wavelength range from 3 to 0.4 mm. ALMA will be the world's most sensitive, highest resolution, millimeter-wavelength telescope, combining sub-arcsecond angular resolution with the sensitivity of a single antenna nearly 100 meters in diameter. The array will provide a testing ground for theories of star birth and stellar evolution, galaxy formation and evolution, and the evolution of the universe itself. The interferometer will be located at 5000m altitude near San Pedro de Atacama in the Second Region of Chile, the ALMA host country.

Principal Scientific Goals: To function as the most capable imaging radio telescope ever built, ALMA will bring to millimeter and submillimeter astronomy the high-resolution aperture synthesis techniques of radio astronomy. ALMA will image at 1mm wavelength with the same 0.1" resolution achieved by the Hubble Space Telescope (HST) at visible wavelengths, and will form a critical complement to the leading-edge optical, infrared, ultraviolet and x-ray astronomical instruments of the twenty first century.

The ALMA array operations site, located at 5,000 meter altitude near San Pedro de Atacama in the Second Region of Chile. *Credit: Division of Astronomical Sciences, NSF.*

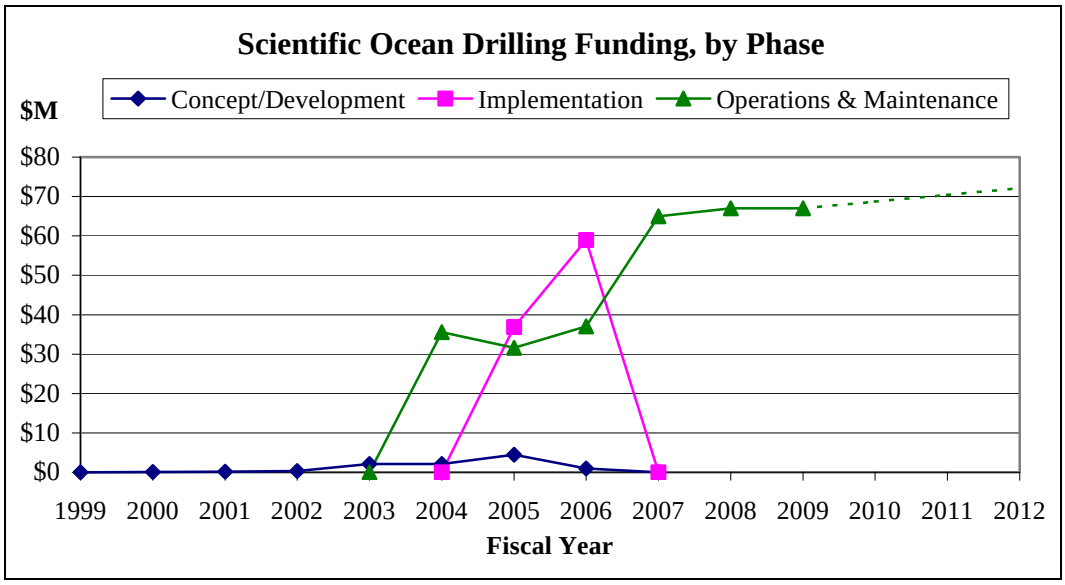
Principal Education Goals: ALMA will play a central role in the education and training of U.S. astronomy and engineering students; at least 15 percent of ALMA's ~1000 yearly users are expected to be students. There is already substantial involvement by graduate students in applied physics and engineering at universities participating in the ALMA Design and Development program.

Partnerships and Connections to Industry: North America and Europe are equal partners in ALMA. The North American side of the project, consisting of the U.S. and Canada, is led by Associated Universities,

planning for shore based support of the program, including core storage, data management systems, and logistics.

- Implementation: The MREFC funds in FY 2005-06 are requested for the vessel conversion, including construction of laboratory and other scientific spaces, equipping of laboratories with instrumentation, computers and support equipment, and modifications to the drilling equipment of the contracted vessel. Funding is also requested for vessel lease during modification and for sea-trial operations of approximately four months duration in FY 2006.

- Operations and Maintenance: Following conversion, the drillship will be managed, operated and maintained by JOI (and subcontractors) with funding from the R&RA account, for use in the Integrated Ocean Drilling Program. Operations cost estimates are based on NSF experience in management of the IODP precursor, the Ocean Drilling Program. Specific missions will be reviewed and prioritized by a science advisory committee composed of representatives from IODP member nations. Significant coordination and integration of planning, procedures and operations will be required with Japanese operators of their drillship in the IODP.



Future Science Support: Along with direct operations and maintenance support for IODP, NSF will support research performed at the facility, through ongoing research and education programs. The annual support for such activities is estimated to be about $31.0 million.

Rare Symmetry Violating Processes (RSVP)

Project Description: A collaboration representing almost 30 institutions from the U.S., Canada, Switzerland, Italy, Japan and Russia submitted a proposal through New York University for RSVP in FY 2000. This project will address new physics at the cutting-edge of the sensitivity frontier and represents an extraordinary opportunity to empower a large and growing community led by university-based groups to make major discoveries. Two major experiments are to be pursued through this proposal: MECO (Muon to Electron Conversion) and KOPIO ($K^{o}_{L} \rightarrow \pi^{o}$ ν ν-bar).

At the sensitivity frontier, reactions occur very rarely and when they occur, they are accompanied by "noise" much larger than the sought after signal. Both of these challenges must be addressed by the

experiments, and if successful, they will push this frontier by many orders of magnitude. The scale of these experiments, both in cost and technical complexity, is set by the extraordinary sensitivity required to do this science.

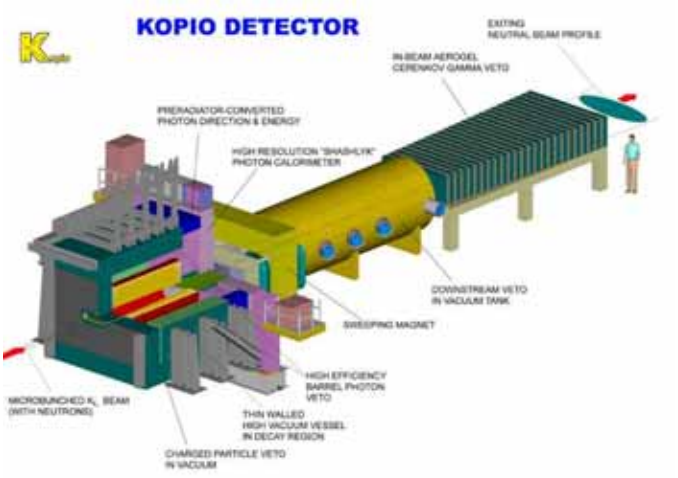
These experiments address two great mysteries, so that if the challenges are met, the rewards are great. Each of the reactions above has special properties that allow these experiments to uncover fundamental new physics relating to the unexplained absence of anti-matter in the universe, and to the postulated existence of "supersymmetric particles" that existed in the early universe and may be responsible for "dark matter." Most of the universe is known to be made of this mysterious dark matter. And anti-matter, thought to be approximately 50 percent of the universe at its birth, has mysteriously disappeared.

These experiments will be performed at the DOE's Brookhaven National Laboratory (BNL) Alternating Gradient Synchrotron (AGS), which has the highest beam intensity in the world at the energies required for these experiments. The AGS is currently being used as an injector for the Relativistic Heavy Ion Collider (RHIC), for which it is needed only a few hours per day. MECO and KOPIO will extend the sensitivity of probes of rare symmetry violating processes by many orders of magnitude.

Principal Scientific Goals: RSVP consists of two complementary experiments:

- MECO is a search for the conversion of muons to electrons and would be able to detect this process even if it is as rare as 1 event for 10^{17} detected muons. Electrons and muons are a part of a family of elementary particles called leptons, and the family relationship is not understood at a fundamental level. Supersymmetry is thought to underlie this relationship.
- KOPIO is a search for the decay of a neutral kaon (K^{o}_{L}) to a neutral pion, a neutrino and an anti-neutrino. The goal is to understand better a process called CP violation. This process needs to be understood in this universe, which contains matter rather than a mixture of matter and anti-matter.

Principal Education Goals: RSVP is planning the PRINCIPLES Project, a mathematics, science and technology educational enrichment program for fourth grade teachers and students. BNL, SUNY/Stony Brook and other partners will establish an Elementary Teachers Academy at BNL. The keystone of the Academy will be an in-service seminar course at BNL for elementary school teachers that will address the teaching of Mathematics, Science and Technology through investigations or projects by elementary students - focusing on the fourth grade level. Objectives are to show teachers first-hand (1) how and what general principles underlie specific inquiry-based learning activities, and (2) how recourse to such principles can support use of observation and reasoning by their students as they learn. The ultimate goal is to improve student performance in assessments requiring use of these skills. In addition, the strong university makeup of the RSVP collaborations lends itself well to student and postdoctoral educational opportunities. Each of the institutions will train undergraduate and graduate students and postdoctoral associates. They will receive a broad education in detector construction and operation and in data analysis and the interpretation of results.



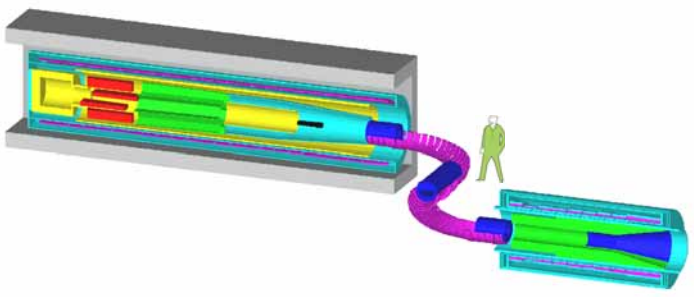
RSVP will address new physics at the cutting edge of the sensitivity frontier, and represents an extraordinary opportunity to empower a large and growing community to make major discoveries. Two major experiments are to be pursued through this proposal: MECO and KOPIO. A diagram of KOPIO is pictured above. *Credit: R. Ruggiero and E. Garber, Brookhaven National Laboratory.*

This opportunity is increasingly rare in particle physics, as most experiments are carried out by much larger collaborations.

Partnerships and Connections to Industry: RSVP will have strong connections to industry through instrument development and construction and through the MECO magnet construction.

Management and Oversight: RSVP will, through an NSF/DOE memorandum of understanding currently under development, be a university-led, NSF-supported activity, running concurrently with RHIC. NSF funding includes only incremental AGS operating costs. AGS "landlord responsibilities" rest with the DOE Nuclear Physics program. This sensitivity frontier program is an excellent example of the effective use of governmental facilities.

Management and oversight of RSVP will be provided through the Physics (PHY) Subactivity in the Mathematical and Physical Sciences (MPS) Activity. A designated Program Officer in PHY will maintain primary oversight responsibility, with assistance from an internal Project Advisory Team (PAT) with representation from MPS, the Office of Budget, Finance and Award Management, the Office of General Counsel, the Office of International Science and Engineering and the Office of Legislative and Public Affairs. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide advice and assistance. Additional staff may be required during construction, particularly staff trained in large project management principles.



A diagram of the Muon to Electron Conversion (MECO) Experiment, one of two experiments proposed as part of the Rare Symmetry Violating Processes project. MECO is a search for the conversion of muons to electrons. *Credit:*

A comprehensive Project Execution Plan (PEP) has been drafted and has been reviewed favorably, with minor improvements suggested. The collaboration has benefited from BNL's tested methodology for the development, management and oversight of large projects, with major university participation, at national laboratories. The successful experience of the U.S. Large Hadron Collider (LHC) detector project, now nearing completion, provides confidence in this methodology. The draft version of the PEP includes project-tracking elements such as detailed costs and schedules (Work Breakdown Structure format), milestones, oversight and reporting responsibilities and change controls. The plan includes experienced university-based project managers, a host laboratory role for BNL that involves Environment, Health and Safety responsibilities for the entire project, and review procedures by the experimenters, by BNL, and by the NSF. A direct reporting path from the Project Manager to the NSF Program Officer is part of this plan. NSF management and oversight includes periodic baseline, cost, schedule, and technical reviews for the project and subproject throughout its lifecycle.

Current Project Status: R&D is continuing on critical project components and is expected to continue through FY 2004. RSVP's construction schedule is still under review and discussion. From 2000 through 2003, NSF conducted cost, management, and scientific and technical reviews of RSVP. Each panel consisted of external reviewers, and each rated the project highly. The management reviews indicated areas of potential improvement, which have since been implemented by the collaborators. The last review of RSVP occurred on 20-21 January 2003. At this review, each experiment presented to the NSF review panel a detailed plan for achieving construction readiness. The panel strongly endorsed the plans and recommended that the NSF fund the R&D proposals of both KOPIO and MECO. The review panel

concluded that the roadmaps to construction readiness were well thought out and provided a basis for applying resources to bring the RSVP experiments to construction readiness in a timely way. The review panel recommended starting construction of RSVP as soon as possible after baseline reviews are conducted. The baseline reviews that establish the Work Breakdown Structures are expected to take place in Spring 2004.

The milestones listed below are preliminary and will likely be revised as the project's schedule is finalized.

FY 2004 Milestones:
- Complete MECO magnet acquisition plan.
- Begin KOPIO beam studies at AGS.
- Begin MECO detector studies

FY 2005 Milestones (Requested Construction Start):
- Complete KOPIO and MECO AGS and beam design modifications.
- Begin KOPIO detector construction.
- Begin MECO detector design and construction.
- Complete MECO magnet engineering design and start construction

FY 2006 Milestones:
- Begin KOPIO delivery of modules
- Begin MECO trigger and data acquisition design
- Begin MECO magnet coil production.

FY 2007 Milestones:
- Complete construction of AGS beams for KOPIO and MECO
- Begin KOPIO and MECO detector installation
- Complete design of the KOPIO and MECO data acquisition and trigger systems

FY 2008 Milestones:
- Complete data acquisition system and trigger construction and installation.
- Complete delivery and installation of MECO magnet coils.
- MECO Magnet acceptance tests
- KOPIO Trigger and data acquisition tests

FY 2009 Milestones:
- Complete construction and installation
- Perform engineering runs

FY 2010 Milestones:
- First data runs

Funding Profile: Through FY 2003, $4.0 million has been spent for concept and development of RSVP through the R&RA Account. The total construction cost of the project is estimated at $144.91 million over five years. The current funding plan is presented below.

Requested MREFC Funding for RSVP
(Dollars in Millions)

FY 2005 Request	FY 2006	FY 2007	FY 2008	FY 2009	Total
$30.00	$42.66	$44.00	$20.25	$8.00	$144.91

RSVP Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation[1]		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2001	0.90						$0.90		**$0.90**
FY 2002	1.20						$1.20		**$1.20**
FY 2003	1.90						$1.90		**$1.90**
FY 2004 Estimate	6.00						$6.00		**$6.00**
FY 2005 Request				30.00				$30.00	**$30.00**
FY 2006 Estimate				42.66				$42.66	**$42.66**
FY 2007 Estimate				44.00				$44.00	**$44.00**
FY 2008 Estimate				20.25	5.30		$5.30	$20.25	**$25.55**
FY 2009 Estimate				8.00	8.50		$8.50	$8.00	**$16.50**
FY 2010 Estimate					8.50		$8.50		**$8.50**
FY 2011 Estimate					13.50		$13.50		**$13.50**
FY 2012 Estimate					15.00		$15.00		**$15.00**
Subtotal, R&RA	$10.00				$50.80		$60.80		
Subtotal, MREFC				$144.91				$144.91	
Total, each phase		**$10.00**		**$144.91**		**$50.80**			**$205.71**

NOTE:. The estimated operational lifetime of the experiments will be least 10 years after the end of construction. A steady state of about $15.0 million in operations support is expected to occur on or about FY 2012. Operations estimates for FY 2008 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

[1]The total project cost for RSVP has had several reviews. However, the total shown is still an estimate, and the funding stream has not yet been baselined. A baseline review is scheduled for June 2004.

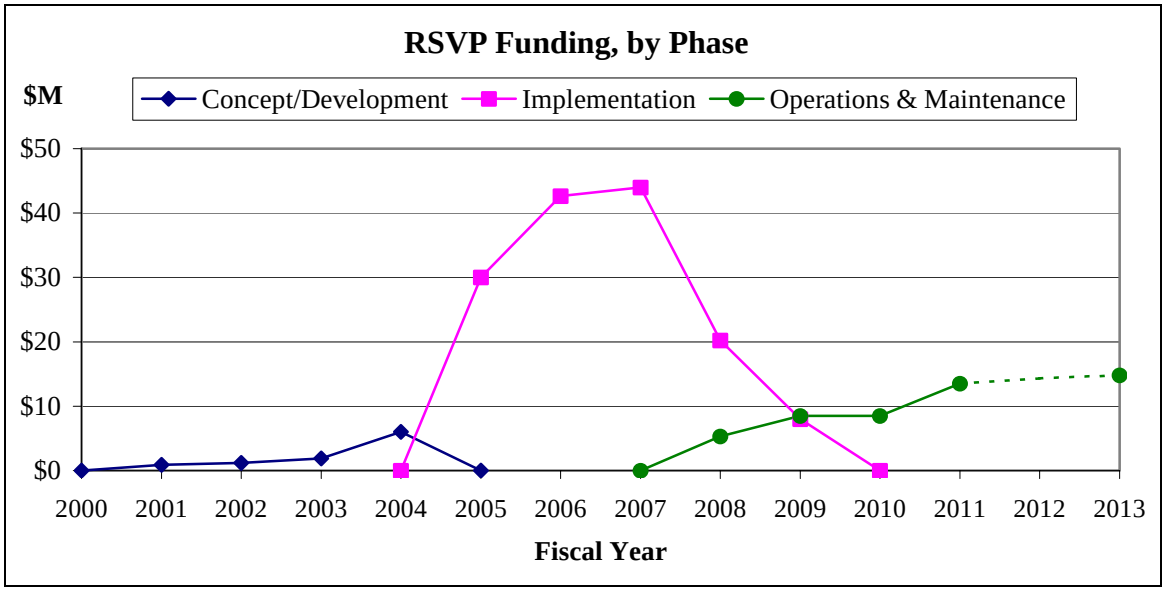
Information on the data in the table is provided below.

- Concept/Development: The technical needs of RSVP require a strong R&D program that is now in progress. R&D teams have been formed, and prototype detector elements have been built and tested. In addition to R&D on all KOPIO and MECO components, a major component of MECO is a sequence of high-field, superconducting solenoids appropriately instrumented for particle detection and readout. These solenoids have very tight and challenging field requirements, and the MECO collaboration, with a group at the MIT Plasma Science and Fusion Center, has completed a detailed conceptual design of the magnet system that proves its feasibility and lays the groundwork for industrial production. KOPIO requires a low-energy, time-structured K^o beam, which allows a precise determination of the incident kaon momentum on an event-by-event basis using time-of-flight techniques. R&D is underway on the KOPIO Alternating Gradient Synchrotron (AGS) modifications. All R&D is under periodic review by technical panels.

- Implementation: Funding during this phase of the project will provide support for the construction of two beamlines at the AGS and associated beam instrumentation at the site. This work will be

performed by BNL personnel. For the KOPIO detector, universities will construct the critical beam, catcher, radiator and veto counter assemblies. The MECO superconducting magnets will be constructed by industry after a conceptual design is complete, but MECO collimators, targets, beam stops, and calorimeters will be constructed at universities.

- Operations and Maintenance: Support for operations and management will phase in as the project is under construction. Initial funds provided through R&RA will support project managers for MECO and KOPIO and a project management office. Test beam operations can begin in FY 2008 and will ramp up as detector elements are completed. Full operations costs are expected to be approximately $15.0 million beginning in about FY 2012.



Future Science Support: Along with direct support for operations and maintenance, NSF will also support physics research performed at this facility, through ongoing physics research and education grants. Support for such activities is presently estimated to be about $4.0 million per year from NSF, once the facility reaches full operations.

Ocean Observatories Initiative (OOI)

Project Description: This project will construct an integrated observatory network that will provide the oceanographic research and education communities with continuous access to the ocean. The OOI will have three elements: 1) a regional cabled network consisting of interconnected sites on the seafloor spanning several geological and oceanographic features and processes, 2) relocatable deep-sea buoys, and 3) an expanded network of coastal observatories, developed through new construction or enhancements to existing facilities. The primary infrastructure for all components of the OOI consists of an array of seafloor junction boxes connected to cables running along the seafloor to individual instruments or instrument clusters. Depending upon proximity to the coast and other engineering requirements, the junction box is either terminated by a long dedicated fiber-optic cable to shore, or by a shorter cable to a surface buoy that is capable of two-way communications with a shore station. The observatory infrastructure of the OOI will be operated as a shared-use facility with open community access to data.