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Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
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- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
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111630900		

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Associated Universities Inc/National Radio Astronomy Observatory	1400 16TH ST NW STE 730 WASHINGTON, DC 20036-6225
AWARDEE ORGANIZATION CODE (IF KNOWN) 4001434000	
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE	ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE
PERFORMING ORGANIZATION CODE (IF KNOWN)	

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **The Frequency Agile Solar Radiotelescope**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 25,005,250	60 months	09/01/08	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

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- ☐ HISTORIC PLACES (GPG II.C.2.j)
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- ☐ VERTEBRATE ANIMALS (GPG II.D.5) IACUC App. Date ________ PHS Animal Welfare Assurance Number ________
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PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
	1400 16th Street NW Suite 730 Washington, DC 200362252 United States
PI/PD FAX NUMBER 202-232-7161	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Ethan Schreier	PhD	1970	202-462-1676	ejs@aui.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 08-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be dislosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Ethan Schreier	Electronic Signature	Jan 11 2008 2:59PM

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
202-462-1676	ejs@aui.edu	202-232-7161

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Project Summary

The *Frequency Agile Solar Radiotelescope* (FASR) is a priority facility recommended by the decadal reviews of the *Astronomy and Astrophysics Survey Committee* (AASC) and the *Solar and Space Physics Survey Committee* (SSPSC), both sanctioned by the National Research Council. The SSPSC considered the Sun, the heliosphere, space weather, and the Earth as an integrated system, and gave FASR a top priority ranking for small projects (<$250M) in recognition of the unique role it will play in addressing basic research questions, as well as its complementary role to other important instruments being developed and deployed to address the Sun-Earth system.

Intellectual Merit: FASR is a radioheliograph; that is, a radio telescope designed to observe the Sun. The central FASR innovation is to perform ultra-wideband radio imaging spectroscopy, imaging the Sun from the mid-chromosphere well up into the corona on a time scale of 1 s, and with an angular resolution as high as 1". In so doing, FASR enables a host of radio diagnostic tools and techniques that have been largely unavailable to date. These techniques will be used to address a number of key science objectives, including quantitative measurements of coronal magnetic fields, the physics of flares, drivers of space weather, and the physics of quiet Sun phenomena. While FASR exploits the extensive heritage provided by radio Fourier synthesis imaging techniques, as implemented through previous generations of radio telescopes, this innovative and wholly unique instrument opens a new observational regime.

Broader impact: FASR will play a transformative role in solar radiophysics, bringing a wide range of innovative and unique observations and techniques to bear on outstanding problems in solar, heliospheric, and space weather physics for the first time. It is anticipated to be one of the world's premier solar observatories for a generation. It will support the research of a broad scientific community. It will do so by pipelining data calibration and reduction, making FASR data, data products, and analysis tools available to as wide a user community as possible. As a university-run facility, FASR will provide extraordinary access to students, engineers, and postdoctoral scholars, and provide them the opportunity to participate in forefront science and technology. While FASR has been conceived as a basic research facility, it will likely provide a number of important data products to solar activity and space weather forecasting and "now-casting" programs. In this way, FASR's influence and role in society will extend beyond its basic research and education mission.

FASR will be constructed by a consortium formed under Associated Universities, Inc. (AUI). The FASR Consortium includes a number of university partners and a national facility (NRAO). As such, it includes the necessary scientific and technical knowledge and expertise to carry out the project successfully. The proposed duration of the project is five years at a cost of $25M. The instrument is being designed with long-term operational costs clearly in mind. The anticipated annual cost of core operations is approximately $2.5M.

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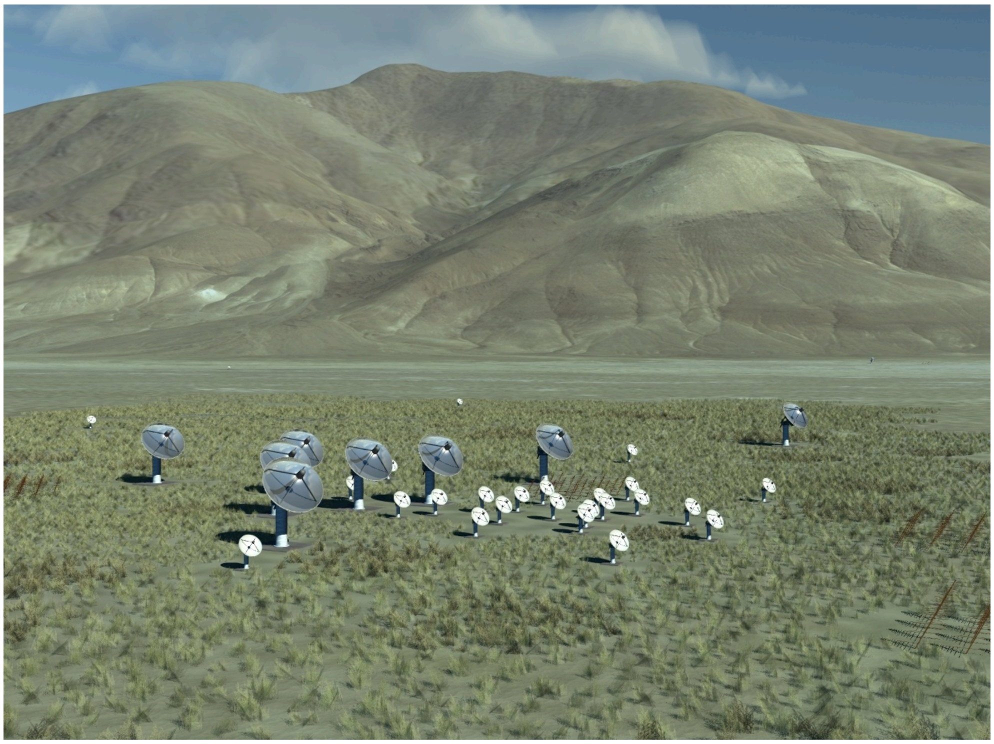
For font size and page formatting specifications, see GPG section II.C.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

THE FREQUENCY AGILE SOLAR RADIOTELESCOPE



A Preliminary Proposal to the

NSF Division of Atmospheric Sciences for the

Mid-Sized Infrastructure Opportunity

1 Introduction

Solar activity represents a uniquely accessible window on the ubiquitous processes of energy release and particle acceleration that occur on a wide range of contexts from the magnetosphere to the galaxy. Of more immediate significance, it is also the driver of many helio- and geophysical phenomena that have adverse impacts on modern space-based and ground-based technological systems. Solar activity is observable across the electromagnetic spectrum, and originates from a wide range of locations from the solar photosphere to the terrestrial atmosphere. Radio observations provide both a unifying perspective and a unique sensitivity to solar magnetic fields, the energy source for solar activity. As a result, radio emission provides a powerful source of diagnostic information with the potential for transformational insights into solar activity and its terrestrial impacts.

This is a proposal to construct the *Frequency Agile Solar Radiotelescope* (FASR), a solar-dedicated radio telescope that provides a unique combination of superior imaging capability and broad instantaneous frequency coverage to address a wide range of science goals. The potential value of such a facility has been recognized by high-priority recommendations for FASR from two separate major surveys of the future of science in the US conducted by the National Research Council. In particular the most recent decadal review of the *Astronomy and Astrophysics Survey Committee (2001),* sponsored by the *Board on Physics and Astronomy* and the *Space Studies Board,* recommended FASR as one of a its priorities for "moderate-sized initiatives" across all of astrophysics. The *Solar and Space Physics Survey Committee (2003),* sponsored by the *Space Studies Board,* made FASR its highest-priority "small project", in recognition of the unique and transformative role it will play in addressing basic research questions, as well as its complementary role to other important instruments being developed and deployed to address the Sun-Earth system.

FASR will be designed and constructed by a university-led consortium over a period of 5 yrs at a total cost of $25M. The consortium consists of experienced groups with expertise in all of the areas required to design and accurately cost the instrument, to carry out construction on schedule and on budget, and to facilitate its exploitation by a wide user community. The FASR Consortium has been organized under Associated Universities, Inc. (AUI), a not-for-profit science management corporation that manages the National Radio Astronomy Observatory (NRAO).

The design of FASR proposed here has been adapted to reflect the *MSI Opportunity* cost cap. Although the necessary de-scope has implications for some of the secondary science goals of the original project, the instrument design nevertheless addresses the primary science goals of the FASR project and accommodates expansion and upgrades, should further resources become available. In this preliminary proposal, we summarize the key science objectives that the proposed instrument addresses (Section 2), describe the user community (Section 3), present a brief technical description of the instrument (Section 4), and discuss the project organization, top-level schedule, and operations (Sections 5-7).

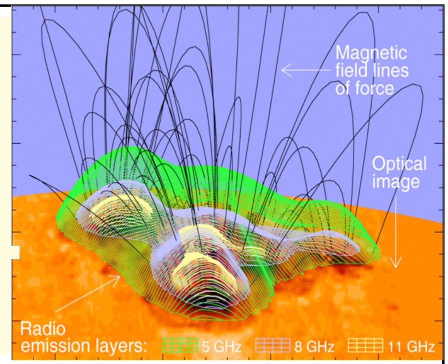
2 FASR Science

The major advance offered by FASR over previous generations of solar radio instrumentation is its unique combination of wide frequency coverage, high spectral resolution and high image quality. Observationally, it performs temporally-, spectrally- and spatially-resolved, broadband imaging spectroscopy over the full solar disk from centimeter to meter wavelengths. Radiation from this wavelength range probes the solar atmosphere from the middle chromosphere through to the middle corona and above in which a wealth of fundamental astrophysical processes occurs. FASR exploits this wavelength range to address a broad research program in contemporary solar physics, and in particular, phenomena with significant effects on the Earth and its atmosphere.

In this preliminary proposal we summarize the main science goals of the proposed instrument. The potential of FASR for breakthroughs in a wide range of science topics, resulting from extensive discussions among members of the solar and space physics community, is presented in detail in the book *Solar and Space Weather Radiophysics* (Gary & Keller 2004). In addition, a more complete description of the FASR science program is available online at http://www.fasr.org/FASR_Science.pdf. With its unique and innovative capabilities FASR also has tremendous potential for new discoveries beyond those presently anticipated.

2.1 The Nature and Evolution of Coronal Magnetic Fields

- *What is the nature of the coronal magnetic field?*
- *How does the magnetic field evolve in time and space?*
- *How is magnetic energy stored?*



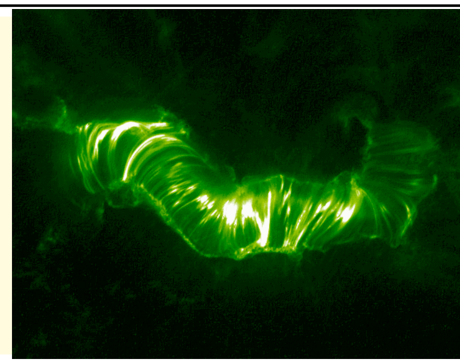
Quantitative knowledge of coronal magnetic fields is fundamental to understanding essentially all solar phenomena above the photosphere, including the structure and evolution of active regions, flares, coronal mass ejections, filaments, coronal heating, and acceleration of the solar wind. Yet useful quantitative measurements of the coronal magnetic field have been largely unavailable. Considerable resources are therefore devoted to observing the topology of the coronal field at EUV/SXR wavelengths and to measuring the vector magnetic field distribution at photospheric heights using spectral lines in the visible part of the spectrum and extrapolating the magnetic field into the upper chromosphere and corona under the assumption that it is potential or force-free. These extrapolations are difficult, depend sensitively on measurement errors, and rely on assumptions whose validity is unproven.

FASR will make measurements of active region coronal magnetic fields as accessible and as today's familiar photospheric magnetograms. The prime radio technique for doing so is the well-established gyroresonance method (e.g., White & Kundu 1997, White 2004). Such radio measurements, effective from 200-2000 gauss, allow coronal magnetic fields in active regions to be measured on the disk and above the solar limb. The gyroresonance method will be complemented by a variety of additional radio techniques, established over several decades, to measure coronal magnetic fields in a wide variety of physical environments: the use of free-free emission to measure the longitudinal magnetic field in the quiet Sun corona (e.g., Grebinskij et al. 2000, Gelfreikh 2004); the use of radio bursts (e.g., Dulk & McLean 1978) to measure fields in the middle corona; the use of gyrosynchrotron emission in flare loops and CMEs (e.g., Bastian et al. 1998, 2001); the use of mode coupling phenomena to place topological constraints on the coronal magnetic field (e.g., Ryabov 2004); and several other techniques (see Gary & Keller 2004). ***In order to exploit any of these techniques effectively, radio imaging spectroscopy over a broad and continuous range of frequencies with sufficient spatial and spectral resolution is required***, a capability that is not available on existing radio telescopes or radioheliographs. The fundamental innovation of FASR is to perform imaging spectroscopy over a range of frequencies suited to exploit these techniques for measuring magnetic fields in active regions and the quiet Sun. FASR will be wholly unique in this transformative capability.

In the view of the community, coronal magnetography is a top priority science objective, and so the de-scoped design has emphasized configuring FASR to make high-quality, high-resolution images at frequencies above 2 GHz to meet this objective (see Section 4).

2.2 The Physics of Flares

- *What is the physics of magnetic energy release?*
- *How are electrons accelerated?*
- *What are the relevant electron transport processes?*

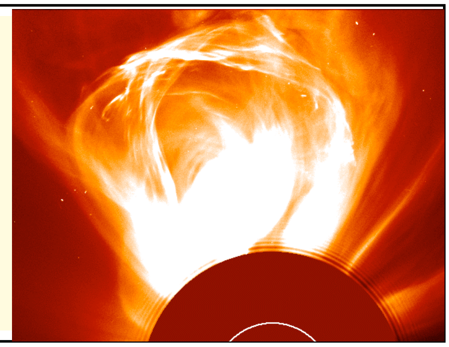


Outstanding problems in the physics of flares are those of magnetic energy release, particle acceleration, and particle transport, problems that extend to astrophysical problems well beyond the Sun. There has been significant theoretical progress in recent years on three-dimensional magnetic reconnection (see, e.g., Priest & Schrijver 1999 for a review) wherein reconnection can occur in a variety of magnetic topologies (spine reconnection, fan reconnection, separator reconnection and quasi-separatrix layer reconnection). Yet observational confirmation of 3D magnetic reconnection processes has remained elusive.

FASR will provide several unique avenues into the study of magnetic energy release, particle acceleration, and particle transport. Decimetric spike bursts and type-III-like bursts accompany impulsive energy release in flares (e.g., Aschwanden & Benz 1997). They are believed to be intimately related to the energy release process (Benz 1994; Bastian et al. 1998). Dynamic imaging spectroscopy is urgently needed to identify the location of these emissions. ***The transformative impact of FASR is that it effectively makes every time/frequency pixel in dynamic spectra available as a high-quality image***. If the source is confirmed to be closely associated with the energy release site, new and unique diagnostics of the magnetic energy release process will become available. Gyrosynchrotron emission from nonthermal electrons accelerated in flares provides the means of testing electron acceleration (Miller et al. 1997) and transport models (e.g., Melrose & Brown 1976, Aschwanden et al. 1997, 1998). Furthermore, gyrosynchrotron emission illuminates any magnetic coronal loop to which nonthermal electrons have access. Such loops provide a valuable topological tool, linking any site of particle acceleration to more distant sites to which accelerated particles are transported. Furthermore, FASR will also be able to exploit dynamic spectroscopic imaging to measure simultaneously both the magnetic field in flaring loops and the evolving electron energy distribution as a function of location, including anisotropies in the distribution (Fleishman & Melnikov 2003a,b). Additional and independent constraints on magnetic field in the flaring source may be available through radio observations of Razin suppression (Ramaty 1969), of coronal loop oscillations (e.g., Trottet et al. 1981, Aschwanden et al. 2004a and references therein) and through timing comparisons between microwave and HXR fine structures (e.g., Bastian 1999). These measurements will provide powerful new constraints on electron acceleration and transport mechanisms. FASR will therefore provide a ***comprehensive and integrated*** picture of the multitude of physical processes that occur during a flare.

2.3 The Drivers of Space Weather

- *How are coronal mass ejections initiated and accelerated?*
- *What is the origin of coronal shocks?*
- *How are solar energetic particles accelerated?*



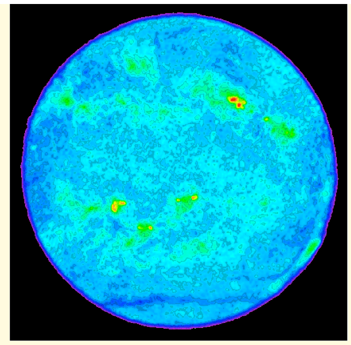
The term "space weather" refers to a vast array of phenomena that can disturb the interplanetary medium and/or affect the Earth and near-Earth environment (Lanzerotti 2004). The drivers of space weather are all solar in origin. An understanding of space weather phenomena lies, in part, in gaining a fundamental understanding of these drivers. FASR will be used to study a number of phenomena that drive space weather effects, including, but not restricted to, coronal mass ejections (CMEs), coronal holes (the origin of fast solar wind streams), and solar flares.

FASR will be able to study in quantitative detail the magnetic environments in which CMEs originate. FASR will image pre-CME environments on the disk and provide new constraints on their magnetic state. The most powerful CMEs produce a synchrotron signature that FASR may see at decimeter and centimeter wavelengths. (Bastian et al. 2001; Maia et al. 2007). Associated phenomena such as erupting filaments and prominences will also be imaged by FASR at higher frequencies.FASR will also make important contributions to the study of shocks in the corona, as manifested by type II radio bursts. The relationship between coronal shocks, their radio-spectroscopic signature, and other phenomena of interest such as the radio counterparts to "EIT waves" (see White & Thompson 2005), EUV coronal dimmings (Harrison et al. 2003), and the white light CME remains a matter of considerable interest and controversy (e.g. Gopalswamy 2000). With its unique ability to perform imaging spectroscopy, FASR will be able to simultaneously image the basic shock driver (flare or CME signature), the response of the atmosphere to the driver (chromospheric/coronal waves and coronal dimmings), and shocks that may form due to the flare or the CME via type II emission. The emphasis placed on FASR's ability to provide an integrated picture of the flare phenomena applies equally to space weather drivers.

The proposed instrument will image the CME precursor environment, eruption phenomena, certain higher frequency CMEs, and detect and track radio bursts of type II, type III, and type IV, providing detailed information about their timing, location, and relation to associated phenomena such as energetic particle events. FASR will therefore provide a comprehensive and quantitative observational picture of space weather phenomena and their drivers. We note that when paired with the space-based radio instrumentation on board STEREO, ***FASR and STEREO will provide radio coverage of space weather phenomena from their point of origin to 1 AU***. FASR is therefore expected to play an important role in space weather science, forecasting, and "now-casting". Similarly, when the *Solar Orbiter* and *Solar Sentinal* missions are deployed, FASR will be well-positioned to provide unique and complementary space weather data. Operational emphasis will be given to supplying real-time data products that will assist with such activities.

2.4 The Physics of the Quiet Sun

- *What is the thermal structure of the solar atmosphere?*
- *How are the chromosphere and corona heated?*
- *How does the corona extend into the heliosphere?*



In addition to observing the active Sun, free-free radio emission from the quiet Sun can be exploited by FASR to provide distinctive insights into several quiet sun problems. For example, resonance wave heating (e.g., Ofman, Klimchuk, & Davila 1998; Cranmer, van Ballegoojan, & Edgar 2007) represents one (of many) models for coronal heating and makes specific predictions of the location and time scales of energy deposition in coronal loops. Using free-free diagnostics, FASR observations of the resulting temperature changes can address the validity of such predictions. A second area is the role of "nanoflares" (Parker 1988). The energetics of such small events depends critically on their thermal properties and the role, if present, of accelerated electrons (e.g., Christe et al. 2007, Hannah et al 2007) . Again, the combination of FASR's frequency coverage and imaging can supply diagnostics to quantitatively address such issues. A third example is the strength, distribution and evolution of magnetic fields in prominences and filaments, as deduced from the polarization of free-free emission (e.g., Grebinskij et al. 2000, Gelfreikh 2004). FASR can use imaging spectroscopy to directly measure the longitudinal magnetic field in filaments and prominences. ***The exploitation of free-free emission to determine the temperature, density and magnetic fields in the quiet chromosphere, corona, and prominences is possible only as a result of FASR's unique attributes.***

3 The FASR Community

The FASR user research community will include, but certainly not be restricted to, scientists working in solar and heliospheric physics, space weather science, and ionospheric/exospheric science. Many of these users will not be familiar with radio interferometric techniques and to address this FASR will provide a wide range of fully-processed, calibrated data products, including light curves, dynamic spectra, and images, as well as coronal magnetograms, and coronal density and temperature maps derived from them. For users interested in collaborative studies, FASR will provide maps, light curves, and parametric maps (magnetic field, density, temperature) to match the user requirements, but that again do not require familiarity with interferometric techniques. In other words, FASR will mainstream the use of radio data, in the same way the use of soft x-ray and EUV images have become an integral part of solar studies as a result of Yohkoh, TRACE and SOHO/EIT data. With the launch of STEREO and *Hinode*, and the impending launch of SDO, new and extensive opportunities will become available for collaborative science, with FASR providing unique and complementary data to the rich data sets of these missions.

Since many of these data products could be made available in close to real time, FASR data may in addition, play an operational role in forecasting and now-casting solar activity and space weather effects that directly affect the Earth's atmosphere. It will therefore likely support additional constituents who do not necessarily have a research interest in the data but nevertheless have a keen interest in certain FASR data products and their timely delivery. Optimization of data processing for these applications may require additional sources of funding, but these are expected to be external to NSF.

Given its unique capabilities, its transformative potential, planned ease of use, and currently demonstrated interest, we anticipate that FASR will attract a large, diverse and international user base.

4 Technical Overview

FASR's design is driven by a number of factors. First, the instrument must meet the science specifications derived from the key science objectives outlined Section 2. Second, as discussed above, it is expected that a large and diverse scientific community will exploit FASR data. Since most users will not be radio interferometrists, they should not bear the burden of data calibration and reduction. As a result, these functions must be performed by pipeline data processing that delivers high-level, fully calibrated data products to a broad user community. Third, it is imperative to implement the project within the *MSI Opportunity* funding constraints and to control the long-term operating and maintenance costs. Finally, it is important to design an expandable/upgradable system in order to respond flexibly to opportunities presented by new resources, new technologies, and/or new science objectives. ***These broad drivers have resulted in a design that emphasizes simplicity, utility, reliability, maintainability, and expandability.***

A more detailed technical description of FASR, as represented by the FASR Reference Instrument (FRI) is available at http://www.fasr.org/FASR-OM-Plan.pdf . Although this document is based on a larger FASR implementation, the proposed FASR shares the same primary scientific objectives and incorporates the same design elements.

4.1 Instrument Specifications

The science objectives outlined in Section 2 flow down to the high-level science and technical specifications summarized in Table 1. These specifications reflect an optimized set of requirements designed to maximize scientific return within the *MSI Opportunity* cost cap. FASR is designed to perform Fourier synthesis imaging using well-established interferometric techniques. Observations in a given frequency range use an array of N antennas. Each antenna pairing, of which there are $\sim N^2/2$, measures a single Fourier component of the Sun's radio brightness distribution at a given frequency, time, and spatial frequency. The ensemble of antenna pairs, or *antenna baselines*, therefore measures many Fourier components.

Angular resolution	$20/\nu_{GHz}$ arcsec
Frequency range	50 MHz – 21 GHz
Number data channels	2 (RCP + LCP)
Total instantaneous BW	2 x 500 MHz
Frequency resolution	1% or 5 MHz
Time resolution	**A** (2-21 GHz): 3 s [snapshot 1 s] **B** (0.3-2.8 GHz): 1 s **C** (50-350 MHz): 0.2 s
Polarization parameters	IQ/UV
Number antennas	**A** (2-21 GHz): 45 **B** (0.3-3 GHz): 15 **C** (50-350 MHz): 15
Antennas correlated per integration cycle	30
Size antennas	**A** (2-21 GHz): 2 m **B** (0.3-3 GHz): 6 m **C** (50-350 MHz): LPDA
Array size	2.9 km EW x 3.8 km NS
Absolute positions	1 arcsec
Absolute flux calibration	<10%

Table 1: FASR Specifications

FASR observations will cover the required frequency range – 50 MHz to 21 GHz – using three separate sub-arrays of antennas, denoted as FASR-A, -B and -C Each sub-array provides frequency coverage over roughly a decade of bandwidth: 2-21 GHz (FASR-A); 0.3-2.8 GHZ (FASR-B), and 50-350 MHz (FASR-C). The antennas will be distributed over an area of approximately 3 x 4 km, providing a frequency-dependent angular resolution of 1" at 20 GHz. At all frequencies, the angular resolution is sufficient to spatially resolve all solar radio sources observed to date. The antenna size for each sub-array is determined by the competing needs of full disk imaging on the one hand, and sufficient sensitivity to calibrate the instrument against sidereal and/or artificial (satellite) sources on the other. Similarly, the number and configuration of antennas in each array is driven by the need to address key science goals in each of the frequency domains.

4.2 FASR Antennas and Feeds

As mentioned above, FASR uses three types of antennas to cover 50 MHz to 21 GHz, each type covering roughly a decade of bandwidth. For each band, FASR uses ultra-wideband dual-linearly polarized feeds to ensure good performance over the relevant frequency range without needing to refocus the optics. The only mechanical systems on the antennas are the drives needed to point the steerable paraboloids used for FASR-A and -B. FASR-C has no mechanical systems since it employs fixed stations of log-periodic dipoles (or similar) that are electronically phased and steered. There are 45 FASR-A antennas, 15 FASR-B antennas, and 15 FASR-C stations. The smaller number of antennas in FASR-B and -C will nevertheless be sufficient to study the bright, relatively compact sources produced by solar activity as discussed in Sections 2.2 and 2.3. Site infrastructure is being planned to allow straightforward expansion of the FASR-B and -C arrays, should additional funding from other sources become available.

4.3 Analog Signal Processing

For each sub-array, analog electronics at the antennas perform essentially the same functions: amplify the observed radio frequency signal (RF), inject calibration signals as needed, perform the first stage of phase switching as needed, and transmit the two analog linearly polarized RF signals via ultra-broadband fiber optic link to a central processing hub. The antenna electronics will be maintained in an environmentally secure and stable environment. They need not be cryogenically cooled, however, thereby simplifying the electronics and enhancing reliability. The transmission of analog rather than digital signals from the the antennas eliminates the need for fast digital samplers at the antennas themselves and so enhances the simplicity and reliability of field systems while also reducing the risk of producing unwanted radio frequency interference (RFI).Automatic attenuators are employed both at the antennas and in subsequent processing to ensure that the wide range of frequency- and time-dependent solar signal levels are within the dynamic range of processing electronics. Data analysis software uses the state of these attenuators to infer the original signal levels.

The bulk of FASR signal processing is located in the central processing hub, a fully shielded and environmentally controlled building. To make the most of available resources, both frequency and baseline mulitplexing are employed by which different frequencies and baseline combinations are processed in successive 20 ms time integrations. This compromise (not practical for sensitivity-limited systems) is well suited to strong solar radio signals. For a given correlator size, it enables the number of antennas to exceed the number of available correlator inputs, thereby maximizing image quality. In this case, 30 of the 45 FASR-A antennas are correlated at any instant (see Section 4.5).

For a given 20 ms correlator cycle, optical switches select a group of 30 antennas; their signals are demodulated from the optical carrier; a specific 500 MHz segment of RF bandwidth is selected and the RF signals converted to an intermediate frequency (IF) band (650-1150 MHz).

4.4 Digital Signal Processing

The IF signal is input to the Digital Signal Processing Unit (DSPU), which processes 30 antennas simultaneously. Automatic attenuators at the RF/IF conversion stage ensure that the signals going into the DSPU remain within sampler tolerances. Each analog signal is digitized with an 8-bit, 1.2 GS/s sampler. After digitization, the signals are passed through a digital filter bank that sub-filters the 500 MHz of bandwidth into 4000 sub-bands, each with a bandwidth of 128 kHz. Signal statistics for each antenna and for each sub-band are generated for subsequent use in automated RFI detection. Each sub-band is corrected for "coarse" and "fine" delay and fringe rotation, and a second stage of phase switching is applied as needed. Each pair of linearly polarized data channels from a given antenna is converted to a pair of circularly polarized data channels by means of a "digital hybrid".

For a given polarization the signal from each antenna pair is multiplied and accumulated in the correlator, whose raw output is one *complex visibility* (Fourier component) for each antenna baseline, circular polarization, and frequency sub-band. These data are transferred to a processor that excises frequency sub-bands that are corrupted by RFI, averages uncorrupted sub-bands in frequency to science resolution (nominally 1% or 5 MHz whichever is smaller), and computes the appropriate statistical weights assigned to the science visibility data. The data are then written to an interim archive where further data processing occurs offline. Finally, we note that a comprehensive monitor and control system will overlay the FASR system, providing system control and the means to monitor the health of the instrument, allowing the identification of faults or failures quickly during operations.

4.5 Frequency and Baseline Multiplexing

As noted in Section 4.3, FASR leverages enhanced performance via frequency and baseline multiplexing. The very broad frequency range covered by the FASR-A, -B, and -C antennas is sampled as a sequence of 500-MHz RF segments, each of 20 ms duration. The sampling sequence is fully programmable – hence, the *frequency agility* of FASR. Enhanced sampling of the aperture by FASR-A will be achieved by means of baseline multiplexing. FASR-A comprises 45 antennas, yet only 30 at a time can be processed by the DSPU. Although three successive cycles with different subsets of 30 antennas are needed to process all possible antenna pairs in FASR-A, baseline multiplexing more than doubles the number of visibility measurements over a 30-antenna array. Note that all 2 x 15 antennas of FASR-B and -C arrays can be processed together and simultaneously in this processing architecture. For a typical (programmable) baseline multiplex sequence, therefore, the resulting overall time resolution in FASR-A is 1 second for snapshot maps, 3 seconds for slowly varying sources requiring coverage by all antenna baselines, 1second for FASR-B and 0.2 seconds for FASR-C (Table 1).

4.6 Data Pipeline and Archive

FASR "mainstreams" the use of its multi-frequency radio data and derived data products, much as the *Yohkoh* and RHESSI missions mainstreamed the use of X-ray data, and the SOHO and TRACE missions mainstreamed the use of EUV data. To do so, FASR delivers data and data products that are easily accessible to the community without placing the burden of data calibration and reduction on the user. This is done through pipeline data calibration and reduction, and the production of an archive of applications databases. The scale of the archived database is about 50 GBytes per day. In addition an extensive suite of high level data products is made available online, for immediate use by the community. Of course, expert users always have access to the raw visibility data.

4.7 Technological Heritage and Readiness

FASR exploits a radio astronomical technique that has a long and fruitful history, namely, Fourier synthesis imaging using interferometry. The FASR design therefore builds on a solid technical heritage as well as a substantial heritage of calibration, mapping, and deconvolution techniques that provide confidence in the approach. Yet FASR is also pioneering the application of new and emerging technologies and techniques. Unlike previous generations of radio telescopes and radioheliographs, FASR requires the development and use of ultra-wideband feeds and receivers. By observing over a very large frequency bandwidth, FASR is exposed to RFI signals that must be identified and removed from the data. Finally, FASR uses a number of novel digital signal processing techniques to simplify the hardware design.

The development of these innovative hardware designs and signal processing techniques has been supported by three funding sources: the development of ultra-broadband devices has been supported through an ATM MRI grant to the NRAO and by ATM support of the FASR Design and Development Plan. The development of approaches to digital signal processing, including RFI mitigation techniques, and optimum correlation approaches, has been supported by an AST ATI grant to NJIT. The project is therefore well positioned to proceed with FASR construction.

4.8 Risk Mitigation

Although FASR draws upon substantial technological heritage and experienced personnel at the NRAO and the universities, as with any project there are potential technical and programmatic risks. The construction project will employ modern project management tools to identify risk elements in terms of their probability of occurring and their potential impact on project cost and schedule. Potential technical risks include innovations noted above; namely, the broadband feeds, receivers, certain signal processing techniques, and instrument stability requirements. These risk elements will be mitigated by rigorous testing in the laboratory prior to deployment, and field-testing with engineering prototypes (Section 5) prior to a full instrument build-out. In addition, a *Reliability Engineering* agreement has been initiated with the *Center for Advanced Life Cycle Engineering* (CALCE) at the University of Maryland to help establish the design, fabrication and operations framework necessary to meet performance and reliability goals.

5 FASR Project Organization

The FASR construction project will be carried out by the FASR Consortium. The FASR Consortium is a partnership between the NRAO and a number of U.S. universities with strong interest and experience in the science and/or technology elements of the project: the New Jersey Institute of Technology, The University of Michigan, the University of California at Berkeley, the University of Maryland, and the California Institute of Technology. These efforts will be organized under Associated Universities, Inc. (AUI), a not-for-profit science management corporation. AUI will be the interface to the NSF, form and operate the project office, and provide governance and oversight of the project through bylaws drawn up by AUI and the FASR Consortium. The FASR partners will assume a number of critical roles and responsibilities ranging from hosting the instrument site, to hardware design and production, software development, and operations planning. It is expected that university students and postdocs will be closely involved with the construction project and during subsequent operations. The specific roles and responsibilities of each partner are outlined in the budget and explanatory supplement. As such, the

Consortium draws upon a broad talent base with roots in both the radio astronomical and solar/heliospheric science communities.

6 Schedule

The FASR construction project will be of five years duration. In the first two years, the detailed design of major subsystems will be completed, prototypes will be fabricated and tested, and an engineering prototype array will be deployed and tested at the proposed instrument site, the Owens Valley Radio Observatory (OVRO) in California. Hardware design and prototyping work will occur at the NRAO (analog systems) and UM (digital systems), where the relevant systems will be rigorously tested and validated in the lab and under field conditions. The FASR Engineering Prototype (EP) will then be deployed at OVRO during the second year of the project and at the beginning of year three. The FASR EP will enable the analog, digital, and software systems to be integrated and thoroughly tested. The EP will exploit existing site infrastructure and will itself require little site development. These steps will ensure that all FASR systems perform to specification and are well understood before committing to hardware production runs and the array build-out. Site development activities will commence in year one in anticipation of the EP, and in year two in preparation for the full array build-out. In years three and four of the project, hardware subsystems will go into production and the array will be assembled. This will include the deployment of antennas in the field, the analog and digital electronics in the hub, and deployment of the computing infrastructure. Year five will largely be devoted to commissioning FASR for operations. In parallel to these efforts, the FASR software and data management systems design and implementation will be initiated in year one and extend through year five. A high level schedule is shown presented with the budget justification.

7 FASR Operations

The core mission of the FASR Observatory is to operate the instrument in an optimum fashion, to make high quality data and data products available to the community in a timely fashion, and to provide the user community with the guidance and tools needed to do excellent science.

When FASR transitions to operations, it will be organized as a standalone observatory organized under AUI. FASR will be managed by AUI as an observatory independent of NRAO. The FASR Observatory will comprise two sites: the instrument site at OVRO and a science center. OVRO is located between Big Pine and Bishop, CA, approximately 400 km north of Los Angeles. A great deal of the necessary site infrastructure is already in place. The science center will be hosted by one of the university partners, to be selected during the construction phase. The science center will serve as administrative headquarters of the facility in addition to providing operations oversight and science support to the community.As part of FASR design and development planning, a detailed operations and maintenance plan was prepared (available at http://www.fasr.org/FASR_OM_Plan.pdf). The plan developed the FASR Reference Instrument (FRI) for use as a cost basis in planning. The FRI differs from the instrument described herein primarily in the number of antennas deployed. For the FRI the long-term annual FASR O&M costs are shown to be approximately $2.5M

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CURRICULUM VITA - ETHAN J. SCHREIER

(A) EDUCATION

City College of the City University of New York, B.S. *summa cum laude*, Physics (1964)
Massachusetts Institute of Technology, Ph.D., Physics (1970)

(B) POSITIONS HELD

2004 -	President, Associated Universities, Inc.
2003 - 2004	Executive Vice President, Associated Universities, Inc.
2001 - 2003	Vice President for Advanced Projects, Associated Universities, Inc.
2000 -	Adjunct Prof., Dept. of Physics and Astronomy, Johns Hopkins University
1981 - 2004	Astronomer, Space Telescope Science Institute 2001-04 leave of absence 2000-01 Head, Strategic Planning and Development 1998-99 Associate Director for NGST 1988-98 Associate Director for Operations 1981-88 Chief Data and Operations Scientist; Head, Operations & Data Management Department
1975 - 1981	Associate, Harvard College Observatory
1973 - 1981	Physicist, Smithsonian Astrophysical Observatory
1975 - 1981	Senior Project Scientist, Einstein Observatory
1973 - 1975	Co-Project Scientist, Astronomical Netherlands Satellite
1970 - 1973	Senior Scientist, American Science and Engineering, Cambridge
1966 - 1970	Research Assistant, Massachusetts Institute of Technology
1963 - 1965	Research Assistant, Institute for Space Studies, New York

(C) SIGNIFICANT PUBLICATIONS

functionally relevant to FASR:

2001 Building the Framework for the National Virtual Observatory, Proposal to the NSF ITR Solicitation, (P. Messina, A. Szalay, *etal*), 23 April 2001.

Other:

1972 Evidence for the binary nature of Centaurus X-3 from UHURU x-ray observations (E.J. Schreier, R. Levinson, H. Gursky, E. Kellogg, H. Tananbaum and R. Giacconi). Ap.J. (Letters), 172:L79-L89.

1979 Einstein observations of the x-ray stucture of Centaurus A: Evidence for the radio-lobe energy source (E.J. Schreier, E. Feigelson, *etal.*) Ap.J. 234:L39-L43.

1981 Detection of radio emission from the jet in Centaurus A (E.J. Schreier, J.O. Burns and E.D. Feigelson). Ap.J., 251:523-529.

1998 Evidence for a 20 parsec Disk at the Nucleus of Centaurus A (E.J.Schreier, A.Marconi, *etal.*), ApJ. 499:L143.

2001 Peering Through the Dust: Evidence for a supermassive black hole at the nucleus of Centaurus A from VLT spectroscopy (A. Marconi, A.Capetti, D.Axon, A.Koekemoer, F.D.Macchetto and E.J.Schreier) ApJ 549:915-937.

2001 HST Imaging in the Chandra Deep Field South: I. Multiple AGN Populations (E.J. Schreier, *etal.*) ApJ560:127S

2002 The Chandra Deep Field South: The 1 Msec Chandra Catalog (R. Giacconi *etal.*) ApJS139:369G.

2004 Prevalence of X-Ray Variability in the Chandra Deep Field-South (Paolillo, M., Schreier, E. J., Giacconi, R., Koekemoer, A. M., Grogin, N. A.) ApJ 611, 93.

(D) SYNERGISTIC ACTIVITIES

Acting Head, Office of Public Outreach, STScI (4/95-9/95)
Board Member, Atacama Large Millimeter Array (10/05-)
Virtual Observatory leadership
- Executive Committee, International Virtual Observatory Alliance (2002-)
- Executive Committee, National Virtual Observatory Framework Project (2001- 07)
- NSF Science Definition Team, National Virtual Observatory (2001)
- National Virtual Observatory Interim Steering Committee (2000-01)

Data and Information Systems leadership
- Earth Science Data & Information Systems and Services Subcommittee of NASA/ESSAC (2000-2004)
- "Bits of Power: Issues in Transborder Data Flow" NRC Committee (1994-96)
- Earth Observing System (EOS) Data and Information System, NRC Panel (1992-93)
- Steering Committee, Information Systems for Space Astrophysics in the 21st Century, NASA HQ (1990)
- Astronomy and Astrophysics Survey Committee Computing Panel, NAS (1989-90)
- Science Operations Management Operations Working Group, NASA HQ (1988-92)
- Steering Committee, Astrophysics Data System Study, NASA HQ (1987)
- Principal Investigator, Astronomy and Astrophysics Network Pilot Project (1986)
- Committee On Data Management and Computation, Space Science Board (1981-86)

AWARDS, HONORS
- Phi Beta Kappa
- Sigma Xi
- Cosmos Club – member since 1997

(E) COLLABORATORS/AFFILIATIONS

No close research collaborators in last five years other than those in last cited paper
No significant affiliations beyond those listed above or obvious via management of AUI/NRAO

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Associated Universities Inc/National Radio Astronomy Observatory**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Ethan Schreier**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Ethan Schreier - PI**	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (2) OTHER				250,000		
TOTAL SALARIES AND WAGES (A + B)				250,000		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				81,250		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				331,250		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **Prototype Antennas** $ 135,000						
TOTAL EQUIPMENT				135,000		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				12,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				0		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				2,200,000		
6. OTHER				150,000		
TOTAL OTHER DIRECT COSTS				2,350,000		
H. TOTAL DIRECT COSTS (A THROUGH G)				2,828,250		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Corporate Office Indirect Cost/Management Fee (Rate: 2.4600, Base: 2900000)**						
TOTAL INDIRECT COSTS (F&A)				71,340		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				2,899,590		
K. RESIDUAL FUNDS				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 2,899,590	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Ethan Schreier**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Ethan Schreier**				Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **Associated Universities Inc/National Radio Astronomy Observatory**	FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Ethan Schreier**	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ethan Schreier - PI**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**3**) OTHER				**388,200**	
TOTAL SALARIES AND WAGES (A + B)				**388,200**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**126,200**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**514,400**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **Prototype Antennas** **$ 350,000**					
TOTAL EQUIPMENT				**350,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**24,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**3,350,000**	
6. OTHER				**150,000**	
TOTAL OTHER DIRECT COSTS				**3,500,000**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**4,388,400**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Corporate Office Indirect Cost/Management Fee (Rate: 2.4600, Base: 4500000)**					
TOTAL INDIRECT COSTS (F&A)				**110,700**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**4,499,100**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **4,499,100**	$

M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $
PI/PD NAME **Ethan Schreier**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. NAME* **Ethan Schreier**	Date Checked / Date Of Rate Sheet / Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION: **Associated Universities Inc/National Radio Astronomy Observatory**				FOR NSF USE ONLY — PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Ethan Schreier**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Ethan Schreier - PI**	0.00	0.00	0.00	$ **0**	$	
2.						
3.						
4.						
5.						
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**		
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**		
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**		
3. (**0**) GRADUATE STUDENTS				**0**		
4. (**0**) UNDERGRADUATE STUDENTS				**0**		
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**		
6. (**3**) OTHER				**402,000**		
TOTAL SALARIES AND WAGES (A + B)				**402,000**		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**130,700**		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**532,700**		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **Production Antennas** **$ 1,100,000**						
TOTAL EQUIPMENT				**1,100,000**		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**30,000**		
2. FOREIGN				**0**		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**						
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				**0**		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**		
3. CONSULTANT SERVICES				**0**		
4. COMPUTER SERVICES				**0**		
5. SUBAWARDS				**4,530,000**		
6. OTHER				**150,000**		
TOTAL OTHER DIRECT COSTS				**4,680,000**		
H. TOTAL DIRECT COSTS (A THROUGH G)				**6,342,700**		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Corporate Office Indirect Cost/Management Fee (Rate: 2.4600, Base: 6500000)**						
TOTAL INDIRECT COSTS (F&A)				**159,900**		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**6,502,600**		
K. RESIDUAL FUNDS				**0**		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **6,502,600**	$	
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME: **Ethan Schreier**				FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: **Ethan Schreier**				Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 4

ORGANIZATION: Associated Universities Inc/National Radio Astronomy Observatory				FOR NSF USE ONLY: PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Ethan Schreier				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Ethan Schreier - PI	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (3) OTHER				415,800		
TOTAL SALARIES AND WAGES (A + B)				415,800		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				135,100		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				550,900		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Production Antennas $ 1,500,000						
TOTAL EQUIPMENT				1,500,000		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				30,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				0		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				5,000,000		
6. OTHER				150,000		
TOTAL OTHER DIRECT COSTS				5,150,000		
H. TOTAL DIRECT COSTS (A THROUGH G)				7,230,900		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Corporate Office Indirect Cost/Management Fee (Rate: 2.4600, Base: 7410000)						
TOTAL INDIRECT COSTS (F&A)				182,286		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				7,413,186		
K. RESIDUAL FUNDS				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 7,413,186	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME: Ethan Schreier				FOR NSF USE ONLY: INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: Ethan Schreier				Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 5

ORGANIZATION **Associated Universities Inc/National Radio Astronomy Observatory**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Ethan Schreier**				AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Ethan Schreier - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (3) OTHER				430,200	
TOTAL SALARIES AND WAGES (A + B)				430,200	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				139,800	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				570,000	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				30,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				2,850,000	
6. OTHER				150,000	
TOTAL OTHER DIRECT COSTS				3,000,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				3,600,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Corporate Office Indirect Cost/Management Fee (Rate: 2.4600, Base: 3690000)**					
TOTAL INDIRECT COSTS (F&A)				90,774	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				3,690,774	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 3,690,774	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Ethan Schreier**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Ethan Schreier**	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Associated Universities Inc/National Radio Astronomy Observatory

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ethan Schreier

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Ethan Schreier - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (14) OTHER				1,886,200	
TOTAL SALARIES AND WAGES (A + B)				1,886,200	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				613,050	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				2,499,250	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 3,085,000					
TOTAL EQUIPMENT				3,085,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				126,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				17,930,000	
6. OTHER				750,000	
TOTAL OTHER DIRECT COSTS				18,680,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				24,390,250	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				615,000	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				25,005,250	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 25,005,250	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ethan Schreier

ORG. REP. NAME*
Ethan Schreier

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C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Justification

The FASR Consortium

The budget reflects the organizational model adopted by the FASR Project. As a consortium that includes both universities and a national facility, the Project is under management by Associated Universities, Inc (AUI) and AUI is therefore the submitting organization on behalf of the Project, with AUI President Dr. E. Schreier serving as the principal investigator. The partner institutions and the group leaders in each case are, respectively, New Jersey Institute of Technology (Dr. D. Gary), the University of California at Berkeley (Dr. G. Hurford), the University of Michigan (Dr. C. Ruf and Dr. T. Zurbuchen), the University of Maryland (Dr. S. White), the California Institute of Technology (Dr. A. Readhead), and the National Radio Astronomy Observatory (Dr. T. Bastian).

Partner Roles and Responsibilities

AUI will be responsible for disbursement of funds received for the purpose of FASR construction. It will do so by means of sub-awards to the partner institutions. AUI will also be responsible for the formation and funding of the FASR Project Office, and for governance and oversight of the project. The project office includes the project director, project manager, and project engineer. The office will be provided business services support (contracts, procurement, invoicing) and project management support (budget control, scheduling, and analysis), and secretarial support. The Project Office will be responsible for planning and implementing the FASR construction project.

The NRAO will be responsible for the design, fabrication, and testing of all analog subsystems. See Section 4.3 of the project description.

The University of Michigan will be responsible for the design, fabrication, and testing of the Digital Signal Processing Unit. See Section 4.4 of the project description.

The University of California at Berkeley will be responsible for FASR software and data management systems, with participation by the University of Maryland. See Section 4.6 of the Project description.

The California Institute of Technology will be responsible for site acquisition and development activities.

The New Jersey Institute of Technology will be responsible for system validation and testing, and commissioning activities.

Each of these broad roles is subject to revision.

Budget Overview

The project is of five years duration. A provisional funding profile is summarized in Fig. 1 below. 2007 dollars are assumed throughout. The numerical values are in units of $1M. The project total is $25M.

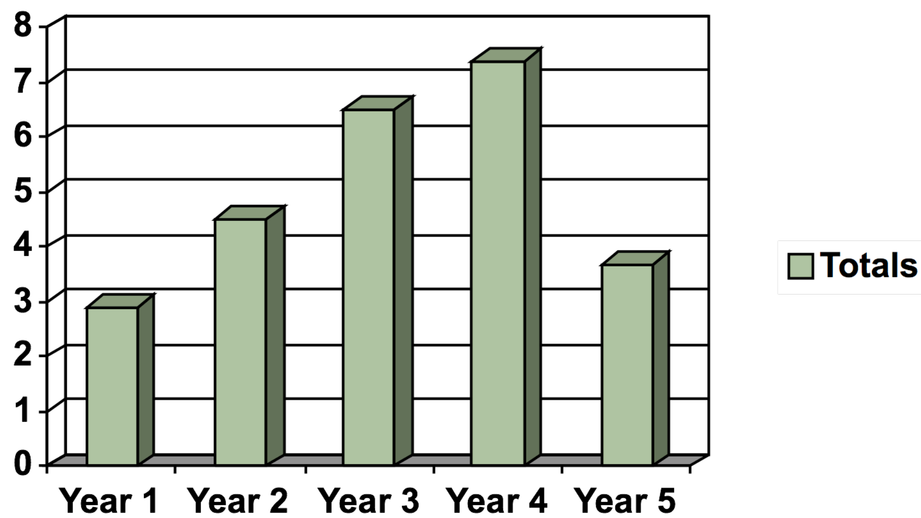


Figure 1

The fractional budgets according to major project activities and systems are summarized schematically in Fig. 2.

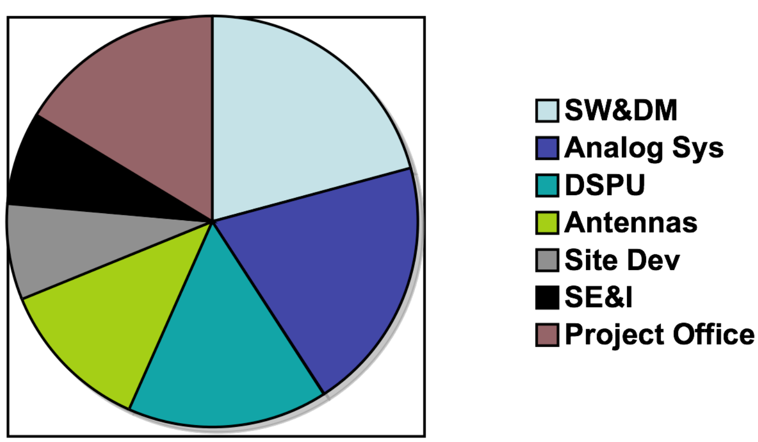


Figure 2

Project Schedule

A schematic schedule showing the phasing of planned activities is appended to this budget justification. Activities (IPTs) are listed in alphabetical order. An overview of these activities is provided in Section 5 of the project description.

Budget Detail

Year 1: The budget for the first year is $2.9M. The AUI portion is $0.7 M and includes funding for the project office (personnel, travel, and business services), acquisition of prototype antennas (commercial vendor), and the corporate office indirect costs/management fee. A value of $150k is used for "Business Support Costs" on line G.6. The sub-awards total $2.2M and are expected to be distributed as follows:

$0.6M for software and data management system definition
$1M for detailed design and prototyping of analog subsystems
$0.4M for detailed design of the DSPU
$0.1M for development of validation and testing procedures
$0.1M for site acquisition activities, EP site development

Year 2: The budget is $4.5M. The AUI portion is $1.15M and again includes funds for the project office, prototype antennas, and the corporate office indirect costs/management fee. Salaries are increased by 3.5%. The sub-awards total $3.35M and are expected to be distributed as follows:

$1.1M for prototype versions of M&C, DPP, and database management
$1.15M for prototype testing and deployment of the EP
$0.7M for COTS system for EP; detailed design of DSPU
$0.2M for SE&I of EP
$0.2M for site infrastructure prep

Year 3: The budget is $6.50M. The AUI portion is $2.0M and includes funding for the project office, production antennas, and the corporate office indirect costs/management fee. The sub-awards total $4.5M and are expected to be as follows:

$1.1M for testing and development of SW&DM with the EP
$1.25M for production module design, fabrication, and FASR B build-out
$1.35M for completion of DSPU design and module-level fabrication
$0.45M for FASR B SE&I
$0.35M for site prep for FASR build-out

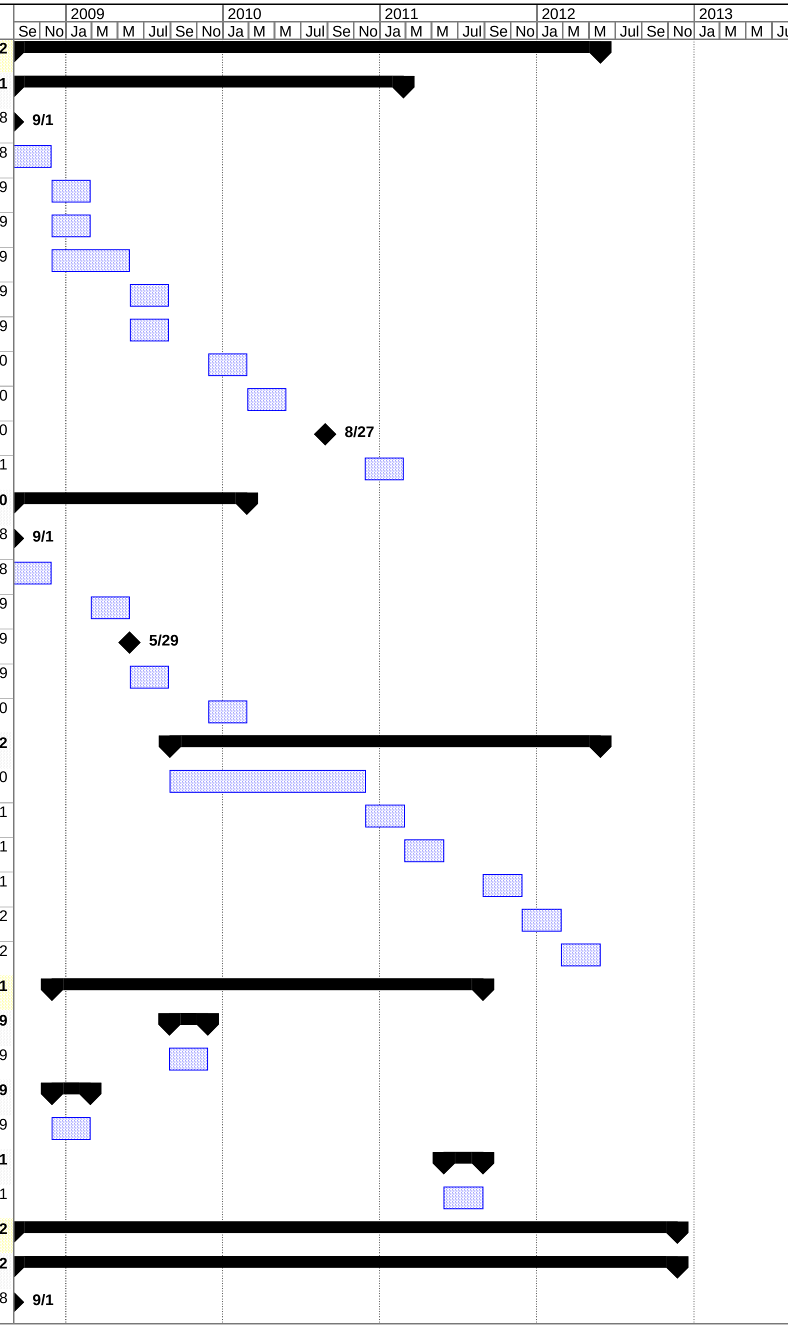
Year 4: The budget is $7.41M. The AUI portion is $2.41M and includes funding for the project office, production antennas, and the corporate office indirect costs/management fee. The sub-awards total $5M and are expected to be as follows:

$1.2M for software build-out of M&C, DPP, calibration, data analysis;   preliminary version of pipeline, preliminary version of user interfaces
$1.3M for production module design, fabrication, and FASR A build-out
$1.1M for DSPU integration and testing
$0.7M for FASR and B SE&I
$0.7M for site infrastructure and build-out

Year 5: The budget is $3.69M. The AUI portion is $0.84M and includes funding for the project office and the corporate office indirect costs/management fee. The sub-awards total $2.85M and are expected to be distributed as follows:

$1.2M for software systems testing and commissioning, refining user interfaces
$0.35M for production and deployment of FASR C systems
$0.45M for completion of DSPU installation and testing
$0.45M for SE&I and commissioning activities
$0.4M for completion of site infrastructure upgrades

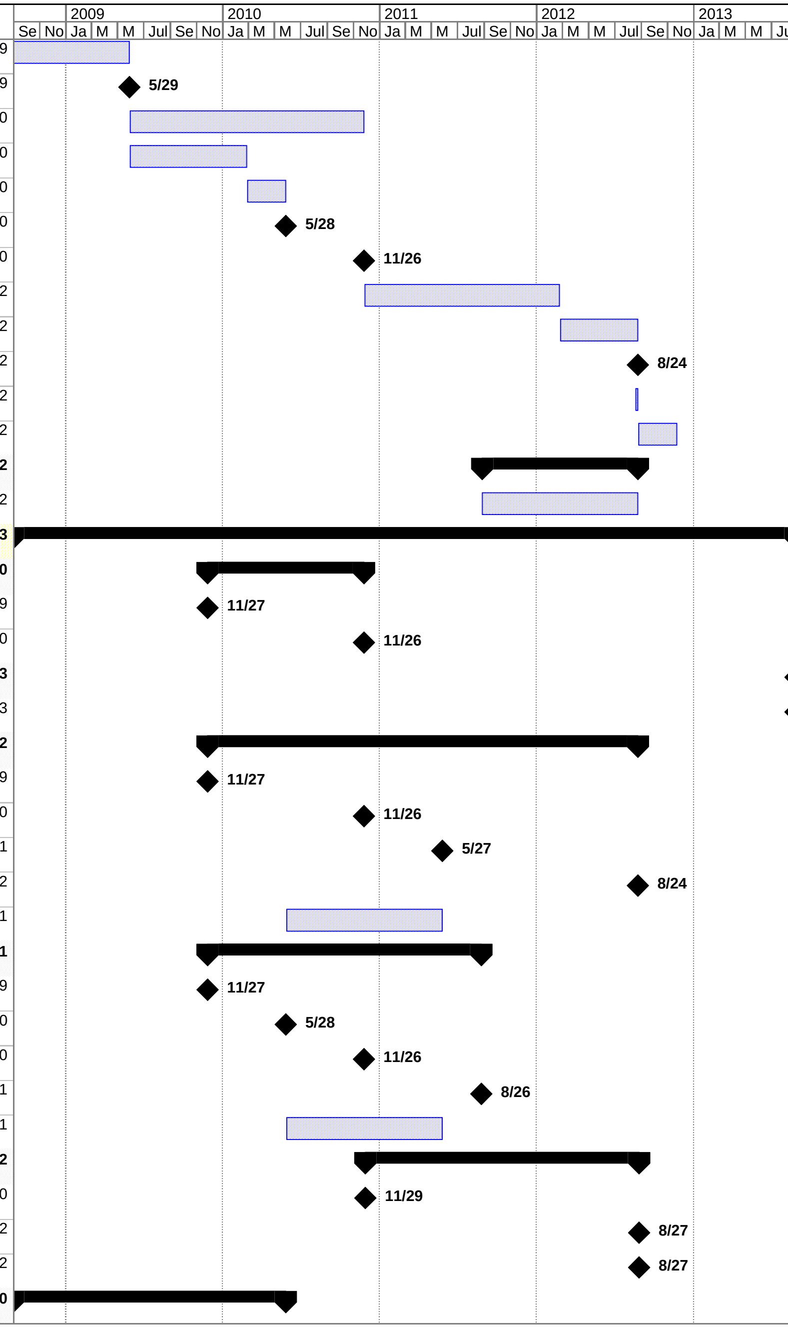
ID	Task Name	Predecessors	Start	Finish
	Analog Systems		**Mon 9/1/08**	**Mon 5/28/12**
	FASR-A		**Mon 9/1/08**	**Fri 2/25/11**
3	Evaluation of Fiber Sub-System @ 20GHz Complete		Mon 9/1/08	Mon 9/1/08
4	Develop/Fabricate FE RF board prototype	3	Mon 9/1/08	Fri 11/28/08
5	Develop/Fabricate BE RF/IF board prototype	4	Mon 12/1/08	Fri 2/27/09
6	Develop/Fabricate Feed prototype	4	Mon 12/1/08	Fri 2/27/09
7	Develop/Fabricate FE housing prototype	4	Mon 12/1/08	Fri 5/29/09
8	RF/IF lab testing	4,5,7	Mon 6/1/09	Fri 8/28/09
9	Site Preparation (GB)	8SS	Mon 6/1/09	Fri 8/28/09
12	Install Prototype Electronics on Antenna (GB)	11	Mon 11/30/09	Fri 2/26/10
13	System Evaluation (GB)	12	Mon 3/1/10	Fri 5/28/10
15	Sub-system pre-production designs completed	14	Fri 8/27/10	Fri 8/27/10
17	Pre-production sub-system installation	16	Mon 11/29/10	Fri 2/25/11
	FASR-B		**Mon 9/1/08**	**Fri 2/26/10**
26	Prototypes & Evaluation of Fiber Subsystem Complete		Mon 9/1/08	Mon 9/1/08
27	Site Preparation (GB)	26	Mon 9/1/08	Fri 11/28/08
29	Install Prototype Electronics on Antenna (GB)	28	Mon 3/2/09	Fri 5/29/09
30	Sub-system pre-production designs completed	28,29	Fri 5/29/09	Fri 5/29/09
32	System Evaluation (GB)	30	Mon 6/1/09	Fri 8/28/09
34	Pre-production sub-system installation	33,32	Mon 11/30/09	Fri 2/26/10
	FASR-C		**Tue 9/1/09**	**Mon 5/28/12**
45	Conduct Preliminary Design Activities	44	Tue 9/1/09	Mon 11/29/10
47	Evaluation of Prototype Station Hardware Configuration	46	Tue 11/30/10	Mon 2/28/11
48	Site Preparation (GB)	47	Tue 3/1/11	Mon 5/30/11
50	Design Beamformer and Receiver (GB)	49	Tue 8/30/11	Mon 11/28/11
51	System Evaluation (GB)	50	Tue 11/29/11	Mon 2/27/12
52	Design pre-production station	51	Tue 2/28/12	Mon 5/28/12
	Antennas		**Mon 12/1/08**	**Mon 8/29/11**
	FASR-A		**Mon 8/31/09**	**Fri 11/27/09**
10	Prototype Antenna deployment (GB)	9	Mon 8/31/09	Fri 11/27/09
	FASR-B		**Mon 12/1/08**	**Fri 2/27/09**
28	Prototype Antenna deployment (GB)	27	Mon 12/1/08	Fri 2/27/09
	FASR-C		**Tue 5/31/11**	**Mon 8/29/11**
49	Prototype Antenna deployment (GB)	48	Tue 5/31/11	Mon 8/29/11
	Digital Signal Processing		**Mon 9/1/08**	**Fri 11/23/12**
	DSPU		**Mon 9/1/08**	**Fri 11/23/12**
61	Digitizer Module FPGA Firmware & ADC Modules Complete		Mon 9/1/08	Mon 9/1/08



Project: 11Jan08_FASR_HighLevelSc
Date: Fri 1/11/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

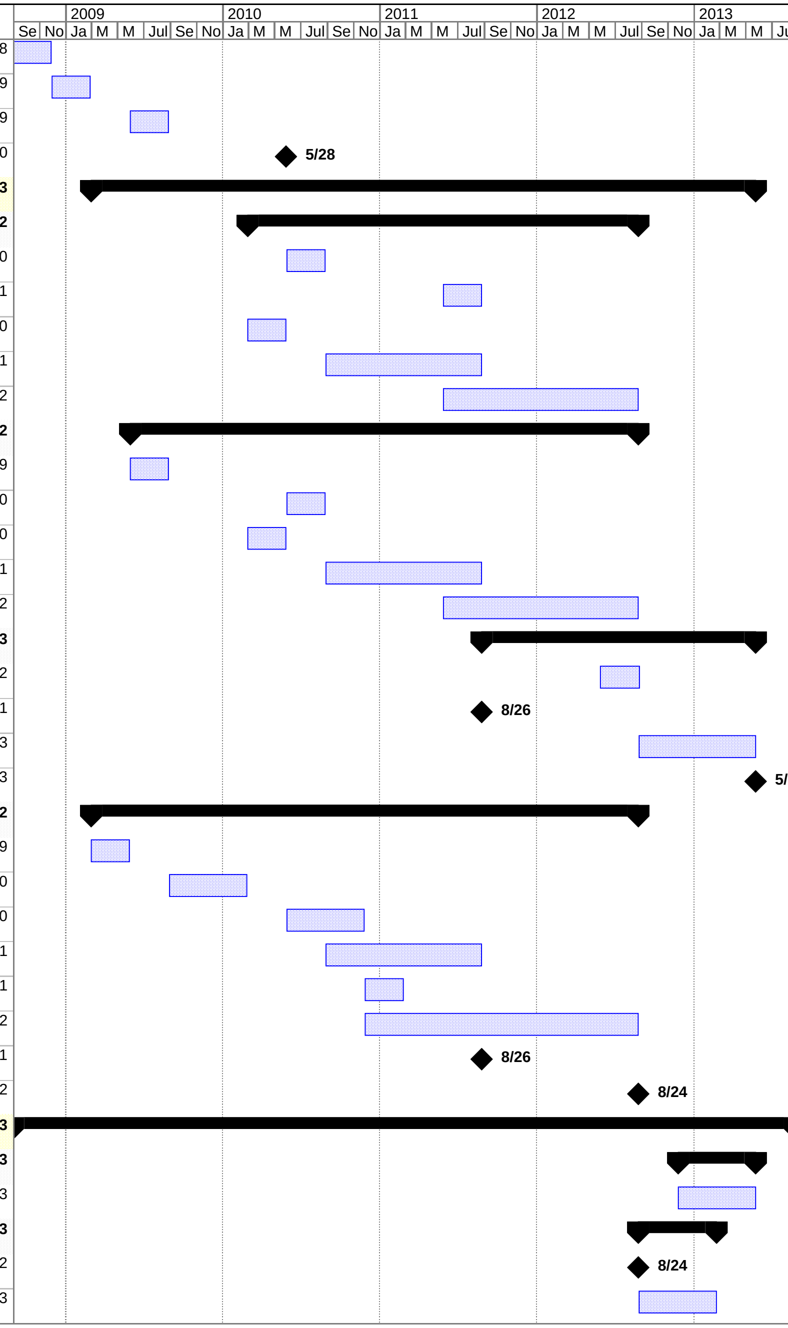
ID	Task Name	Predecessors	Start	Finish
62	Construct & Test COTS spectrometer	61	Mon 9/1/08	Fri 5/29/09
63	Dual Channel COTS Spectrometer delivered to GB	62	Fri 5/29/09	Fri 5/29/09
64	Detailed Design of DSPU	63	Mon 6/1/09	Fri 11/26/10
65	Design of 3-channel COTS correlator	62	Mon 6/1/09	Fri 2/26/10
67	Integration w/ COTS spectrometer	4SS+39 wks	Mon 3/1/10	Fri 5/28/10
68	3-station COTS Correlator delivered to OVRO	65,67	Fri 5/28/10	Fri 5/28/10
69	Detailed Design of DSPU Complete	64	Fri 11/26/10	Fri 11/26/10
71	Module level manufacturing of Subsystems	70	Mon 11/29/10	Fri 2/24/12
73	Sub-system Integration and testing	71	Mon 2/27/12	Fri 8/24/12
74	Sub-system Integration and testing Complete	73	Fri 8/24/12	Fri 8/24/12
75	Internal System Acceptance Review	74FF	Mon 8/20/12	Fri 8/24/12
76	Installation of 30 station DSPU @ OVRO	75,74	Mon 8/27/12	Fri 11/23/12
	FASR-B		**Mon 8/29/11**	**Fri 8/24/12**
72	Conduct preliminary commissioning w/ 3 station correlator	41,39,68	Mon 8/29/11	Fri 8/24/12
	Project Office		**Mon 9/1/08**	**Mon 8/26/13**
	DSPU		**Fri 11/27/09**	**Fri 11/26/10**
66	Preliminary Design Review (PDR) Complete	4SS+26 wks	Fri 11/27/09	Fri 11/27/09
70	Critical Design Review (CDR) Complete	69	Fri 11/26/10	Fri 11/26/10
	FASR GENERAL		**Mon 8/26/13**	**Mon 8/26/13**
105	FASR Project Completion - Array Operational	104	Mon 8/26/13	Mon 8/26/13
	FASR-A		**Fri 11/27/09**	**Fri 8/24/12**
11	Preliminary Design Review (PDR) Complete	10	Fri 11/27/09	Fri 11/27/09
16	Critical Design Review (CDR) Complete	5SS+13 wks	Fri 11/26/10	Fri 11/26/10
19	System design frozen	18	Fri 5/27/11	Fri 5/27/11
22	Deployment & Installation Complete	21	Fri 8/24/12	Fri 8/24/12
87	Place order for remaining FASR-A Antennas	86	Mon 5/31/10	Fri 5/27/11
	FASR-B		**Fri 11/27/09**	**Fri 8/26/11**
33	Preliminary Design Review (PDR) Complete	28,11SS	Fri 11/27/09	Fri 11/27/09
36	System design frozen	35	Fri 5/28/10	Fri 5/28/10
39	Critical Design Review (CDR) Complete	16SS	Fri 11/26/10	Fri 11/26/10
40	Deployment & Installation Complete	38	Fri 8/26/11	Fri 8/26/11
88	Place order for remaining FASR-B Antennas	86	Mon 5/31/10	Fri 5/27/11
	FASR-C		**Mon 11/29/10**	**Mon 8/27/12**
46	Preliminary Design Review (PDR) Complete	45	Mon 11/29/10	Mon 11/29/10
54	System design frozen	53	Mon 8/27/12	Mon 8/27/12
55	Critical Design Review (CDR) Complete	54	Mon 8/27/12	Mon 8/27/12
	SITE INFRASTRUCTURE		**Mon 9/1/08**	**Fri 5/28/10**



Project: 11Jan08_FASR_HighLevelSc
Date: Fri 1/11/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

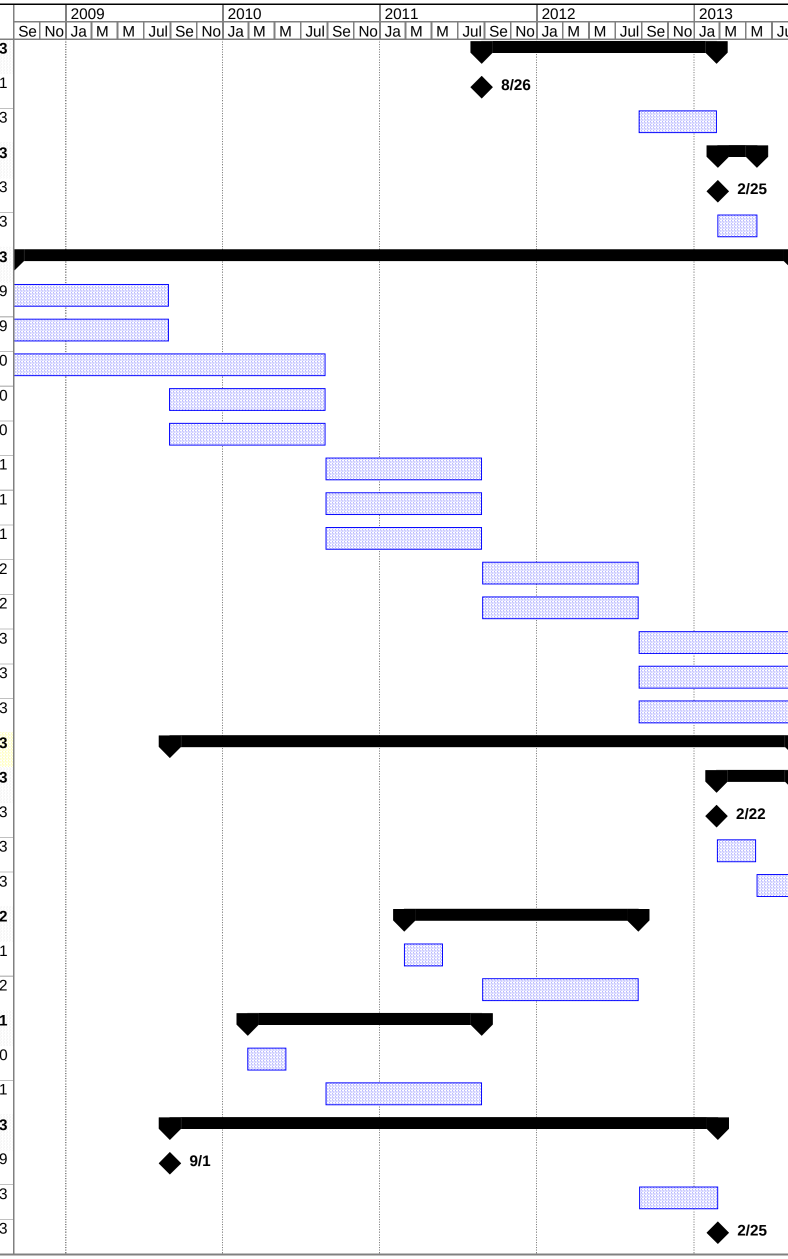
ID	Task Name	Predecessors	Start	Finish
79	Define FASR A & B Antenna Specs.		Mon 9/1/08	Fri 11/28/08
80	prep. & submit RFQ for FASR A/B Antennas	79	Mon 12/1/08	Fri 2/27/09
82	Place order for add'l prototype FASR A/B Antennas (3)	81	Mon 6/1/09	Fri 8/28/09
86	Antenna Critical Design Review (CDR) Complete	85,84	Fri 5/28/10	Fri 5/28/10
	Site Development		**Mon 3/2/09**	**Fri 5/24/13**
	FASR-A		**Mon 3/1/10**	**Fri 8/24/12**
14	OVRO Site Preparation for Prototype Antennas (3)	13	Mon 5/31/10	Fri 8/27/10
20	Prep. OVRO site for array expansion	19	Mon 5/30/11	Fri 8/26/11
84	Deploy FASR A prototype Antennas @ OVRO	83	Mon 3/1/10	Fri 5/28/10
91	FASR-A Pad Construction	37SS+13 wks	Mon 8/30/10	Fri 8/26/11
97	Delivery & Deployment of Remaining FASR-A Antennas	87	Mon 5/30/11	Fri 8/24/12
	FASR-B		**Mon 6/1/09**	**Fri 8/24/12**
31	OVRO Site Preparation for prototype Antennas (3)	30	Mon 6/1/09	Fri 8/28/09
37	Prep. OVRO site for array expansion	36	Mon 5/31/10	Fri 8/27/10
85	Deploy FASR B prototype Antennas @ OVRO	83	Mon 3/1/10	Fri 5/28/10
92	FASR-B Pad Construction	38SS+13 wks	Mon 8/30/10	Fri 8/26/11
98	Delivery & Deployment of Remaining FASR-B Antennas	88	Mon 5/30/11	Fri 8/24/12
	FASR-C		**Fri 8/26/11**	**Fri 5/24/13**
53	Prep. OVRO site for array expansion	52	Tue 5/29/12	Mon 8/27/12
96	FASR-C Cabling Complete	90	Fri 8/26/11	Fri 8/26/11
99	FASR-C Pad Construction	98	Mon 8/27/12	Fri 5/24/13
101	FASR-C Pad Construction Complete	99	Fri 5/24/13	Fri 5/24/13
	SITE INFRASTRUCTURE		**Mon 3/2/09**	**Fri 8/24/12**
81	Prep. Control Bldg. (Mayer) for prototype activities	80	Mon 3/2/09	Fri 5/29/09
83	Outfit Control Bldg. (Mayer) for prototype activities	81,82	Mon 8/31/09	Fri 2/26/10
89	Design auxiliary site bldg.	86	Mon 5/31/10	Fri 11/26/10
90	Construction of FASR-A,B&C Trenching/roads	37SS+13 wks	Mon 8/30/10	Fri 8/26/11
93	Outfit Mayer Bldg. Infrastructure for full array	90SS+13 wks	Mon 11/29/10	Fri 2/25/11
94	Construction of auxiliary site bldg.	89	Mon 11/29/10	Fri 8/24/12
95	FASR-A&B Pad & Cabling Construction Complete	90,91	Fri 8/26/11	Fri 8/26/11
100	Auxiliary site bldg. complete	94	Fri 8/24/12	Fri 8/24/12
	Software & Computing Systems		**Mon 9/1/08**	**Fri 8/23/13**
	DSPU		**Mon 11/26/12**	**Fri 5/24/13**
77	Conduct commissioning & software refinement activities	75,76	Mon 11/26/12	Fri 5/24/13
	FASR-A		**Fri 8/24/12**	**Fri 2/22/13**
23	Preliminary Software package complete	22	Fri 8/24/12	Fri 8/24/12
24	Conduct commissioning & software refinement activities	23	Mon 8/27/12	Fri 2/22/13



Project: 11Jan08_FASR_HighLevelSc
Date: Fri 1/11/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

ID	Task Name	Predecessors	Start	Finish
	FASR-B		**Fri 8/26/11**	**Fri 2/22/13**
41	Preliminary Software package complete	40	Fri 8/26/11	Fri 8/26/11
42	Conduct commissioning & software refinement activities	72	Mon 8/27/12	Fri 2/22/13
	FASR-C		**Mon 2/25/13**	**Mon 5/27/13**
58	Preliminary Software package complete	57	Mon 2/25/13	Mon 2/25/13
59	Conduct commissioning & software refinement activities	57,58	Tue 2/26/13	Mon 5/27/13
	SOFTWARE		**Mon 9/1/08**	**Fri 8/23/13**
107	Preliminary Functional & Interface Definitions (M&C, DPP, Database, Data Analysis)		Mon 9/1/08	Fri 8/28/09
108	Preliminary Definition of FASR Database	107SS	Mon 9/1/08	Fri 8/28/09
109	Preliminary definition & development of user interface (Website)	107SS	Mon 9/1/08	Fri 8/27/10
110	Code & Test (M&C / DPP)	107	Mon 8/31/09	Fri 8/27/10
111	Implement & Test preliminary version of FASR Database	108	Mon 8/31/09	Fri 8/27/10
112	Test & Develop M&C/DPP Software with Prototype	110	Mon 8/30/10	Fri 8/26/11
113	Develop final version of FASR Database	111	Mon 8/30/10	Fri 8/26/11
114	Implement CLI Interfaces & web-access tools	109	Mon 8/30/10	Fri 8/26/11
115	Continue software testing & database refinements during array expansion	112	Mon 8/29/11	Fri 8/24/12
116	Preliminary implementation of user interfaces	114	Mon 8/29/11	Fri 8/24/12
117	Test & Refine Software with FULL array	115	Mon 8/27/12	Fri 8/23/13
118	SOFTWARE: Test & Refine user interfaces	116	Mon 8/27/12	Fri 8/23/13
119	Generate user documentation	116	Mon 8/27/12	Fri 8/23/13
	Systems Engineering & Integration		**Tue 9/1/09**	**Mon 8/26/13**
	FASR GENERAL		**Fri 2/22/13**	**Mon 8/26/13**
102	Start of preliminary operations w/ FASR A & B	24,72	Fri 2/22/13	Fri 2/22/13
103	Conduct Preliminary Operations of 2-array FASR	102	Mon 2/25/13	Fri 5/24/13
104	Conduct Operations w/ FASR A, B and C	59,103,77	Tue 5/28/13	Mon 8/26/13
	FASR-A		**Mon 2/28/11**	**Fri 8/24/12**
18	Evaluation of 3-Antenna array	17	Mon 2/28/11	Fri 5/27/11
21	Fabricate, Deploy & Install remaining Ant & Sub-systems	20	Mon 8/29/11	Fri 8/24/12
	FASR-B		**Mon 3/1/10**	**Fri 8/26/11**
35	Evaluation of 3-Antenna array	34	Mon 3/1/10	Fri 5/28/10
38	Fabricate, Deploy & Install remaining Ant & Sub-systems	37	Mon 8/30/10	Fri 8/26/11
	FASR-C		**Tue 9/1/09**	**Mon 2/25/13**
44	Start of Preliminary Design		Tue 9/1/09	Tue 9/1/09
56	Fabricate, Deploy & Install remaining Ant & Sub-systems	55	Tue 8/28/12	Mon 2/25/13
57	Deployment & Installation Complete	56	Mon 2/25/13	Mon 2/25/13



Project: 11Jan08_FASR_HighLevelSc
Date: Fri 1/11/08

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

Current & Pending Support

Project/ Proposal Title	Support Source	Total Award	Support Type	Term	Person Months/Yr	Location
Operation & Maintenance of NRAO (FY08)	NSF	$52,740,000	current	10/1/07 - 9/30/08	5603	CA, HI, IA, NH, NM, TX, VA, VI, WA, WV
ALMA Construction (FY08)	NSF	$102,000,000	current	10/1/07 - 9/30/08	1342	AZ,NM,VA,WV, Chile
REU/RET	NSF	$1,112,898	current	10/1/03 - 9/30/08	3.5	NM,VA,WV
ALMA Japan	NSF	$5,629,000	current	1/29/07 - 9/30/09	169	VA, NM
ALMA Operations	NSF	$7,664,000	current	10/1/07 - 9/30/08	200	NM,VA, Chile

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory: See appended proposal.

Clinical: n/a

Animal: n/a

Computer: See appended proposal.

Office: See appended proposal.

Other: See appended proposal.

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

See appended proposal.

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.

Associated Universities, Inc.

Suite 730
1400 16th Street, NW
Washington, DC 20036
Phone: 202.462.1676
Fax: 202.232.7161

January 10, 2008

Dear Colleagues:

Associated Universities, Inc. (AUI) is pleased to submit this preliminary proposal to the MSI Opportunity program for the construction of the *Frequency Agile Solar Radiotelescope* (FASR). AUI is submitting this proposal on behalf of the FASR Consortium, a partnership including a number of U.S. universities and a national facility, formed for the explicit purpose of constructing and operating FASR. The Consortium has been organized under AUI, a not-for-profit science management corporation. AUI will serve as the interface between the Consortium and NSF, form the FASR project office, and provide governance and oversight of the project through bylaws drawn up by AUI and the Consortium. The Letter of Intent to establish the Consortium, signed by all the partners, is attached.

The Consortium includes the National Radio Astronomy Observatory, the University of California at Berkeley, the California Institute of Technology, the New Jersey Institute of Technology, the University of Michigan, and the University of Maryland. This partnership represents a strong base with broad experience in both the science that is addressed by FASR and the technological expertise needed to successfully implement the project. AUI and the NRAO offer extensive project management experience and administrative support, with a demonstrated record of success in managing forefront radio astronomical projects including the VLA, VLBA, GBT, with EVLA under construction. AUI is also the North American Executive for ALMA, with NA project management at NRAO. The university partners will assume a number of critical roles and responsibilities ranging from hosting the instrument site, to hardware design, software development, and operations planning. It is expected that university students and postdocs will be closely involved with the construction project and during subsequent operations. FASR, when complete, will be operated by AUI, with the participation of the Consortium members, as a separate observatory.

This preliminary proposal to the MSI Opportunity calls for constructing FASR over a period of 5 years, at a total cost of $25M. It is anticipated that after commissioning and the transition to stable operations, the annual cost of FASR operations and maintenance will be approximately $2.5M. AUI and the FASR Consortium look forward to the opportunity to submit a full proposal for the construction of this priority facility.

Sincerely,

Dr. Ethan J. Schreier
President
Associated Universities, Inc.

Statement of Intent
To Propose for the
Frequency Agile Solar Radiotelescope

PURPOSE:

The purpose of this document is to express the intent of Associated Universities, Incorporated (AUI)[1], the undersigned university groups, and AUI's National Radio Astronomy Observatory (NRAO) to form a team to propose for the construction and operation of the Frequency Agile Solar Radiotelescope. The parties to this agreement believe it to be in the best interests of the research community for AUI to establish a new entity under its management to build and operate this new facility.

The Frequency Agile Solar Radiotelescope (FASR) is designed to provide ultra-wideband imaging spectroscopy of the solar atmosphere from the chromosphere to the outer corona, with temporal, angular, and spectral resolution matched to the physical processes that occur. FASR was recommended as a the number one small program (<$250M) by the 2002 Decadal Survey *The Sun to the Earth – and Beyond*, and also as a priority project in the 2000 Decadal Survey *Astronomy and Astrophysics in the New Millennium*. Both the NSF Atmospheric Sciences and NSF Astronomical Sciences Divisions have been supporting the technology and operations concept development for FASR. NRAO, AUI, and several university groups have been supporting and contributing to this effort.

FASR will be a facility that uses modern technology to provide a large multi-purpose database for use by the entire solar and heliospheric science community. A number of university groups have expressed substantial interest in the technology required by FASR as well as in the research to be enabled by FASR. NRAO, a facility of the NSF that is managed by AUI is a source of enabling technology and project management expertise for FASR.

CONCEPT

Via this agreement, AUI is establishing a consortium of academic institutions that have interest, expertise, relevant experience, and a desire to participate in the science research and/or technology development areas of FASR. These institutions include: New Jersey Institute of Technology, University of Michigan, the Space Science Laboratory of the University of California at Berkeley, the University of Maryland, the California Institute of Technology, and the National Radio Astronomy Observatory. These institutions will

[1] AUI is a not-for-profit research management corporation established to unite the resources of universities, research organizations and the Federal Government in the planning, construction, and operation of forefront scientific facilities that promote discovery and education while expanding our knowledge of the physical world.

participate in the construction of FASR as well as in the operations. Other institutions may be added as appropriate and as mutually agreeable.

The parties agree that AUI will be the legal entity responsible to NSF to build and operate FASR. AUI will involve the parties to this agreement in the construction and operation of FASR, and in the governance structure of FASR. We anticipate that NSF will issue a Cooperative Agreement for the construction and operation of FASR, in which case the AUI President will be the PI. AUI will establish a FASR Oversight Council (FOC), whose membership will comprise AUI Trustees and representatives named by the participating consortium members. Additionally, the President of AUI will be a voting member of the Council ex-officio.

A Project Director for the construction and commissioning phases will be named in the Proposal, likely a staff member at one of the participating institutions. The Project Director will be supported by funds from the Cooperative Agreement, and will be responsible to the FOC for the overall project.

The construction activities will be managed by AUI via NRAO. NRAO will, with the concurrence of the FOC and the Project Director, name a Project Manager who will be responsible for constructing FASR within programmatic constraints. The Project Manager will distribute work among the team partners in the most cost effective way and in accordance with the available skills of each partner. The Project Manager will report to the Project Director, with overall management oversight by the FOC.

Operations will be managed by AUI via a management structure separate from NRAO, with the FASR Director reporting directly to the AUI President, and with Management Oversight by the FOC. Operations will take place at two sites: an Operations Center at the proposed instrument site (the Owens Valley Radio Observatory, operated by the California Institute of Technology) and a Science Center, likely hosted by one of the participating universities (TBD). Staff at the two centers will be either AUI/FASR employees, or university staff working under contract to AUI. An open search for a FASR Director will be initiated by the FOC prior to the start of operations. He/she will be selected by the FOC and report administratively to the AUI President. An independent FASR Visiting Committee will be established by AUI.

For Associated Universities, Inc.:

(signature) Date: 8/27/07

For National Radio Astronomy Observatory:

(signature) Date: 8/22/07

For New Jersey Institute of Technology:

(signature) Date: 8/20/07

For University of Michigan:

(signature) Date: 8/12/07

For: Space Sciences Laboratory, University of California Berkeley:

(signature) Date: 7/23/07

For: California Institute of Technology

(signature) Date: 7/31/07

For: University of Maryland

(signature) Date: 8/16/07

Signatories :

Dr. Ethan J. Schreier
President
Associated Universities Inc.

Dr. Fred K. Y. Lo
Director
National Radio Astronomy Observatory

Dr. Fadi P. Deek
Dean, College of Science and Liberal Arts
New Jersey Institute of Technology

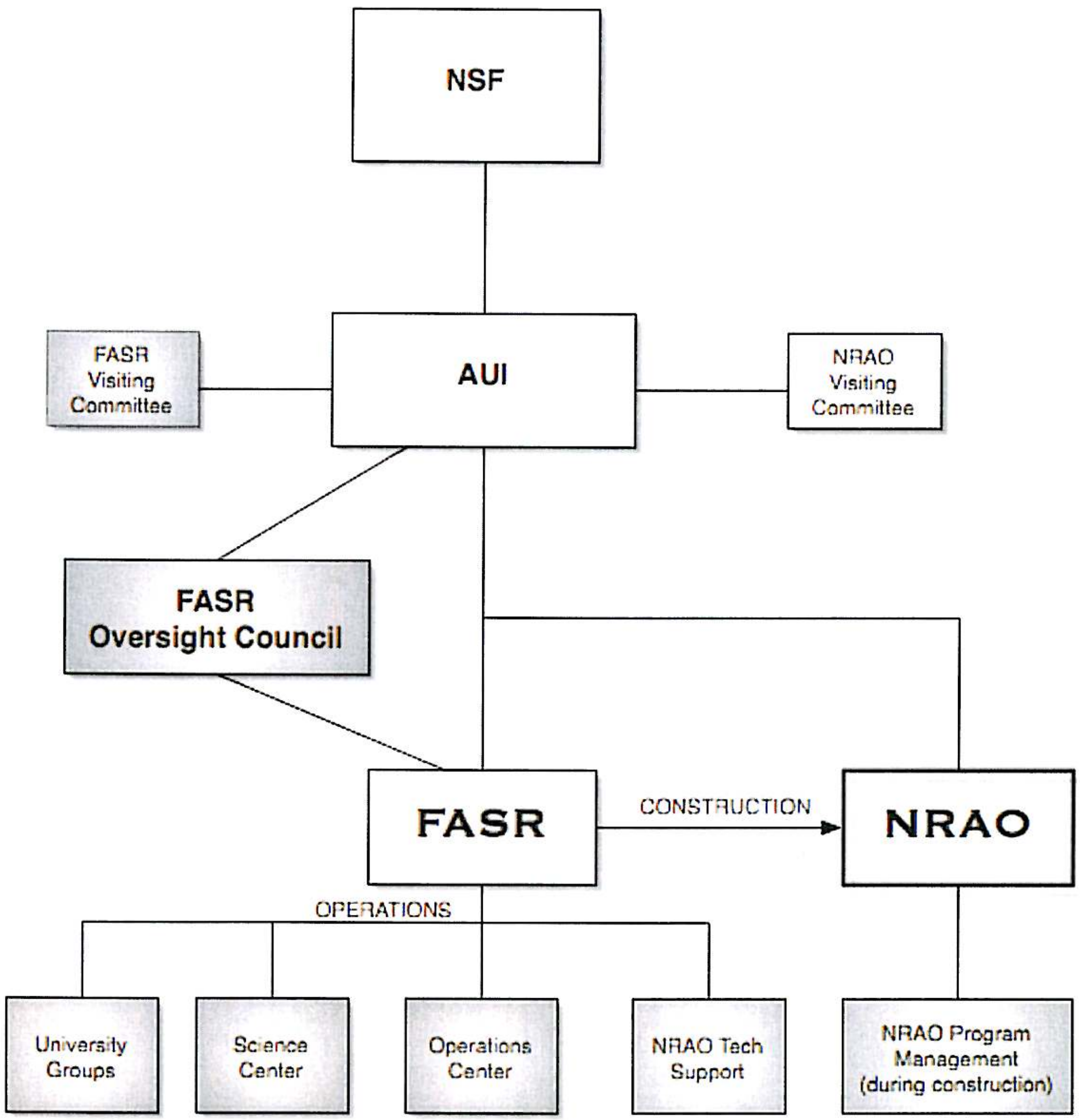
Dr. Jack Hu
Associate Dean for Research
College of Engineering
University of Michigan

Dr. Robert P. Lin
Director, Space Sciences Lab,
University of California, Berkeley

Dr. Thomas A. Tombrello
Chair, Division of Physics, Mathematics, and Astronomy
California Institute of Technology Pasadena

Dr. Mel Bernstein
Vice-President for Research
University of Maryland

Frequency Agile Solar Radiotelescope
Organizational Relationships



CURRICULUM VITAE

Timothy S. Bastian
National Radio Astronomy Observatory, 520 Edgemont Road
Charlottesville, VA 22903

EDUCATION

Ph.D. University of Colorado, Astrophysics, 1987
B.S. University of Chicago, Mathematics, 1978

APPOINTMENTS

2000-present	Adjunct faculty member, Astronomy Dept., University of Virginia
1999-2000	Visiting Professor, Paris University 7 and Paris Observatory
1995-present	Astronomer, National Radio Astronomy Observatory
1992-1995	Associate Astronomer, National Radio Astronomy Observatory
1990-1992	Assistant Astronomer, National Radio Astronomy Observatory
1987-1990	Jansky Fellow, National Radio Astronomy Observatory

PROFESSIONAL SOCIETIES

International Astronomical Union (IAU)
International Union of Radio Science (URSI)
American Geophysical Union (AGU)
American Astronomical Society (AAS)
Community of European Solar Radio Astronomers (CESRA)

AWARDS & FELLOWSHIPS

NATO Young Scientist Award, 1987
URSI Young Scientist Award, 1990
Foreign Research Fellow, National Astronomical Observatory of Japan, 1996

RESEARCH INTERESTS

Solar and stellar radiophysics; solar chromosphere and corona; solar and stellar flares; coronal mass ejections; coronal and interplanetary radio bursts; solar wind and heliosphere; radio emission from planets and exoplanets; wave propagation in random media; radiative processes; interferometry; data inversion

RECENT SYNERGISTIC ACTIVITIES

Scientific Editor, Astrophysical Journal, 2002-present
Principle Investigator, Solar Radio Burst Spectrometer project, 2003-2007
Faculty and co-organizer, AAS Summer School on *High Energy Solar Physics*, 2006

Co-organizer, workshop on *Space Physics and the Vision for Space Exploration*, 2005

RELEVANT PUBLICATIONS

Bastian, T. S., Fleishman, G. D., Gary, D. E. 2007 "Radio Spectral Evolution of an X-Ray-poor Impulsive Solar Flare: Implications for Plasma Heating and Electron Acceleration", *Astrophysical Journal* 666, 1256-1267

Bastian, T. S. 2007, "Synchrotron Radio Emission from a Fast Halo Coronal Mass Ejection", *Astrophysical Journal* 665, 805-812

Bastian, T. S. 2004, "Low-frequency solar radiophysics with LOFAR and FASR", *Planetary and Space Science* 52, 1381-1389.

Bastian, T. S., Pick, M., Kerdraon, A., Maia, D., Vourlidas, A. 2001, "The Coronal Mass Ejection of 1998 April 20: Direct Imaging at Radio Wavelengths", *Astrophysical Journal* 558, L65-L69

Bastian, T. S. 2001, "Radio Wave Propagation in the Corona and the Interplanetary Medium", *Astrophysics and Space Science* 277, 107-116.

Bastian, T. S., Benz, A. O., Gary, D. E. 1998, "Radio Emission from Solar Flares", *Annual Review of Astronomy and Astrophysics* 36, 131-188

Dulk, G.~A., Leblanc, Y., Bastian, T. S., Bougeret, J. L. 2000, "Acceleration of electrons at type II shock fronts and production of shock-accelerated type III bursts", *Journal of Geophysical Research* 105, 27343-27352.

Chiuderi Drago, F., Alissandrakis, C. E., Bastian, T., Bocchialini, K., Harrison, R.~A. 2001, "Joint EUV/Radio Observations of a Solar Filament", *Solar Physics* 199, 115-132.

Vourlidas, A., Bastian, T. S., Aschwanden, M. J. 1997, "The Structure of the Solar Corona above Sunspots as Inferred from Radio, X-Ray, and Magnetic Field Observations", *Astrophysical Journal* 489, 403.

COLLABORATORS/CO-EDITORS DURING LAST 4 YRS

R. Bradley, W. Desch, D. Gary, W. Farrell, G. Fleishman, S. Hawley, G. Hurford, E. Mastrantonio, C. Parashare, N. Reid, S. White, L. Wye

PH.D. ADVISOR

G. A. Dulk

STUDENTS

A. Vourlidas

T. S. Bastian

National Radio Astronomy Observatory

Current Support

Project Title: **FASR Design and Development**
Source of Support: NSF/ATM
Total Award Amount: $1,000,000
Total Award Period: 10/06-9/10
P.I. Support: 0-50%

Pending Support

Project Title: **The Frequency Agile Solar Radiotelescope (this proposal)**
Source of Support: NSF/ATM
Total Award Amount: $25,000,000
Total Award Period: 9/08-8/12
Co-I. Support: 50-100%

Curriculum Vitae: Dale E. Gary

Birth Date:	November 5, 1953 Flint, Michigan
Marital Status:	Married, two children
Education:	Ph.D., Astro-Geophysics University of Colorado, 1982
	B.Sc., Physics The University of Michigan, 1976

Employment:

Jul 2006 – present	Chair, Physics Department, New Jersey Institute of Technology
Sep 2002 – present	Professor, Physics Department, New Jersey Institute of Technology
Sep 2004 – Jan 2006	Associate Chair, Physics Department, New Jersey Institute of Technology
Jul 1997 – Aug 2002	Associate Professor, Physics Department, New Jersey Institute of Technology (tenure Sep 2000)
Sep 1990 – Jul 1997	Senior Research Associate in Astrophysics, Division of Physics, Math, and Astronomy, California Institute of Technology
Sep 1988 – May 1995	Lecturer in Physics (total of 5 terms during the period), Caltech
Nov 1985 – Aug 1990	Senior Research Fellow in Astrophysics, Division of Physics, Math, and Astronomy, California Institute of Technology
Nov 1982 – Oct 1985	Research Fellow in Astrophysics, Division of Physics, Math, and Astronomy, California Institute of Technology

Professional Societies:

1983 – present	American Astronomical Society (AAS)
1983 – present	American Geophysical Union (AGU)
1985 – present	International Astronomical Union (IAU)
1999 – present	International Union of Radio Science (URSI)
2006 – present	American Association for the Advancement of Science (AAAS)

Offices Held:

Jun 1995 – Jun 2001	Treasurer, Solar Physics Division/AAS

Patents:

2004	"THz Imaging System and Method," US Patent 6,815,683
2006	"Terahertz imaging for near field objects," US Patent 7,105,820

Awards:

May 2006	NJIT Harlan J. Perlis Research Award
May 2005	Thomas Alva Edison Inventor of the Year (NJ Research Council)
Jun 2001	NJIT Teaching Award—Upper Division Undergraduate

Most Relevant Publications—Dale E. Gary

2007 Liu, Z., Gary, D. E., Nita, G. M., White, S. M. & Hurford, G. J., A Subsystem Test Bed for the Frequency-Agile Solar Radiotelescope, *Publications of the Astronomical Society of the Pacific*, 119, 303

2007 Nita, G. M., Gary, D. E., Liu, Z., Hurford, G. J. & White, S. M., Radio Frequency Interference Excision Using Spectral Domain Statistics, *Publications of the Astronomical Society of the Pacific*, 119, 805

2007 Bastian, T. S., Fleishman, G. D. & Gary, D. E., Radio Spectral Evolution of an X-ray Poor Impulsive Solar Flare: Implications for Plasma Heating and Electron Acceleration, *Astrophysical Journal*, 666, 1256

2007 Liu, C., Lee, J., Gary, D. E. & Wang, H., The Ribbon-like Hard X-Ray Emission in a Sigmoidal Solar Active Region, *Astrophysical Journal* , 658, 127

2006 Cerruti, A. P., Kintner, P. M., Gary, D. E., Lanzerotti, L. J., de Paula, E. R., & Vo, H. B. 2006, Observed solar radio burst effects on GPS/Wide Area Augmentation System carrier-to-noise ratio, *Space Weather*, 4, 10006

Additional Publications—Dale E. Gary

2007 Reiner, M. J., Krucker, S., Gary , D. E., Dougherty, B. L., Kaiser, M. L., Bougeret, J.-L. 2007, Radio and White-Light Coronal Signatures Associated with the RHESSI Hard X-Ray Event of 2002 July 23, *Astrophysical Journal*, 657, 1107

2007 Cho, K.-S., Lee, J., Gary, D. E., Moon, Y. -J. and Park, Y. D. 2007, Magnetic Field Strength in the Solar Corona from Type II Band Splitting, *Astrophysical Journal*, 665, 799

2007 Jing, J., Lee, J., Liu, C., Gary, D. E., Wang, H. 2007, Hard X-ray Intensity Distribution along Hα Ribbons, *Astrophysical Journal Letters*, 664, L127

2006 Bandyopadhyay, A., Stepanov, A., Schulkin, B., Federici, M. D., Sengupta, A., Gary, D. E., Federici, J. F., Barat, R., Michalopoulou, Z-H & Zimdars, D., Terahertz interferometric and synthetic aperture imaging, *Journal of the Optical Society of America A* , 23, 1168

2004 Gary, D. E. & Keller, C. U. (editors), "Solar and Space Weather Radiophysics – Current Status and Future Developments," *Astrophysics and Space Science Library*, Vol. 314, Kluwer Academic Publishers, Dordrecht

Collaborators in last 48 months—Dale E. Gary
J. Lee, J. Qiu, C. Liu, Z. Liu, G. Nita, H. Wang, T. Bastian, S. White, G. Hurford, L. Lanzerotti, G. Fleishman, M. Reiner, M. Kaiser, P. Kintner, S. Krucker, K. Cho

Former Students—Dale E. Gary

J. Lee (Caltech, now at NJIT),	A. Silva (Berkeley, now at IMPE, Brazil)
T. Kucera (U Colorado, now at GSFC)	Z. Liu (NJIT)
L. Belkora (U Colorado)	G. Nita (NJIT)

Ph.D. Thesis advisor for D. E. Gary—G. Dulk

GORDON HURFORD - CV

Professional Preparation

B.Sc.	McGill University (1959-63)	First Class Honours in Physics
M.A.	University of Toronto (1963-1964)	(Theoretical) Physics
	Massachusetts Inst. of Technology (1964-66)	(Nuclear) Physics
Ph.D.	California Institute of Technology (1968-74)	(Space) Physics

Appointments

1998– Research Physicist, Space Sciences Laboratory, University of California, Berkeley.
1977-98 Assoc Scientist to Senior Scientist &
Member of the Professional Staff, Solar Astronomy, Caltech.
1974-77 Research Fellow, Solar Astronomy, Caltech.
1968-74 Graduate Student, Space Radiation Lab, Caltech
1966-68 Lecturer, Physics Department, Xavier College, Sydney, Nova Scotia

Selected Publications

Proposal-related:

- D.E. Gary, G.J. Hurford, **Radio Spectral Diagnostics** in Solar and Space Weather Radiophysics**,** ed: D.E. Gary and C.U. Keller, Kluwer Academic Publishers, 71-87, 2004.
- R.A. Schwartz, A. Csillaghy, A.K. Tolbert, G.J. Hurford, J. McTiernan, D. Zarro, **RHESSI Data Analysis Software: Rationale and Methods**, Solar Phys. 210, 165-192, 2002.
- G.J. Hurford, **Solar Radio Instrumentation**, in The Sun: A Laboratory for Astrophysics, ed: J. T. Schmelz and J. C Brown, Kluwer Academic Publishers, 411-422, 1992.
- G.J. Hurford, R.B. Read, H. Zirin, A **Frequency-Agile Interferometer for Solar Microwave Spectroscopy**, Solar Phys, 94, 413-, 1984.
- Marsh, K.A. and Hurford, G.J., "**High Spatial Resolution Solar Microwave Observations",** Ann. Rev. Astron. Astrophys. 20, 497-516, 1982

Other:

- G.J. Hurford, R.A. Schwartz, S. Krucker, R.P. Lin, D.M. Smith, N. Vilmer, **First Gamma-Ray Images of a Solar Flare**, Ap.J. 595, L77-L80, 2003.
- G.J. Hurford, E.J. Schmahl, R.A. Schwartz, A.J. Conway, M.J. Aschwanden, A. Csillaghy, B.R. Dennis, C. Johns-Krull, S. Krucker, R.P. Lin, J. McTiernan, T.R. Metcalf, J. Sato, D.M. Smith, **The RHESSI Imaging Concept**, Solar Phys. 210, 33-60, 2002.
- E.J. Schmahl, G.J. Hurford, **Observations of the Size Scales of Solar Hard X-Ray Sources**, Solar Phys., 210, 273-286, 2002.
- D.E. Gary, G.J. Hurford, "**Coronal Temperature, Density and Magnetic Field Maps using the Owens Valley Solar Array**", Ap.J. 420, 903-912, 1994.
- Zirin, H., Baumert, B.M. and Hurford, G.J., "**The Microwave Brightness Temperature Spectrum of the Quiet Sun**", Ap.J. 370, 779-783, 1991.

Synergistic Activities

- 1998-present: As Imager Scientist, led the efforts in optical design, calibration and data analysis software for RHESSI, a NASA mission for imaging/spectroscopy of solar x-rays and gamma-rays.
- 1997-1998: Member, NAS-NRC Task Group on Ground-Based Solar Research
- 1995-present: Charter participant in the development of the Frequency-Agile Solar

Radiotelescope

- 1993-1998: Conceived and co-developed the Solar Radio Burst Locator, an automated system for monitoring solar activity at microwave wavelengths
- 1980-1998: Conceived and co-developed the Owens Valley Frequency-Agile Interferometer and its evolution into the Owens Valley Solar Array, for microwave imaging/spectroscopy of solar flares and active regions

Advisors

Graduate Advisor: E. C. Stone
Post-doctoral sponsor: H. Zirin

Recent Co-authors and Collaborators:

M.	Aschwanden	Lockheed-Martin	Z.	Liu	unknown
T.	Bastian	NRAO	E.	Kontar	University of Glasgow
S.	Bale	UC, Berkeley	A.M.	Massone	CNR-INFM,LAMA
A.	Benz	ETHZ, Zurich	M.C.	McConnell	University of New Hampshire
S.	Boggs	UC, Berkeley	J.	McTiernan	UC, Berkeley
J.C.	Brown	University of Glasgow	R.J.	Murphy	Naval Research Lab
S.	Christe	UC, Berkeley	G.M.	Nita	NJIT
A.	Csillaghy	UAS, Windisch	R.	Pernak	NASA/GSFC
B.R.	Dennis	NASA / GSFC	M.	Piana	Univ di Verona
A.G.	Emslie	Oklahoma State University	M.	Prata	Univ di Modena e Reggio Emilia
M.	Fivian	UC, Berkeley	E.J.	Schmahl	SWRA
D.E.	Gary	NJIT	R.A.	Schwartz	NASA / GSFC
I.G.	Hannah	UC, Berkeley	G.S.	Share	Naval Research Lab
G.D.	Holman	NASA / GSFC	A.Y.	Shih	UC, Berkeley
H.	Hudson	UC Berkeley	D.M.	Smith	UC, Santa Cruz
K.	Hurley	UC, Berkeley	P.	St. Hillaire	UC, Berkeley
S.	Kane	retired	A. K.	Tolbert	NASA / GSFC
S.	Krucker	UC, Berkeley	N.	Vilmer	Observatoire de Paris
J.W.	Lee	NJIT	S.	White	UMd
R.P.	Lin	UC, Berkeley	Y.	Xu	unknown

DR. GORDON HURFORD: CURRENT AND PENDING SUPPORT

A. Current Support

Project Title: *High Energy Solar Spectroscopic Imager (HESSI) Investigation*
Sponsor and POC: NASA (Small Explorer); NAS5-98033
P.I. Robert Lin
Period and Amount: 11/19/97-02/28/08; $55,515,870
FTE Work-Years: up to 0.50/year

Project Title: *Advanced Topics in Solar Gamma-Ray Imaging and Spectroscopy*
Sponsor and POC: University of California, Santa Cruz (NASA); Dr. David M Smith
Period and Amount: 03/01/05-04/30/08; $135,539
FTE Work-Years: 0.20/year

Project Title: *Broadband RF Transmission Characterization and Phase Stabilization for FASR*
Sponsor and POC: New Jersey Institute of Technology (NSF); Dr. Dale E. Gary
Period and Amount: 09/01/04-08/31/08; $182,500
FTE Work-Years: 0.25/year

Project Title: *Statistical Survey of Hard X-ray Footpoints in Solar Flares*
Sponsor and POC: NASA; T. Kucera
Period and Amount: 12/01/06-11/30/08; $201408
FTE Work-years: 0.083/year

Project Title: *Technology Development for the Spectrometer/Telescope for Imaging X-rays (STIX) Instrument on Solar Orbiter*
Sponsor and POC: University of California (Calspace); R. Anderson
Period and Amount: 12/01/06-11/30/08; $47772
FTE Work-years: None

B. Pending Support

Project Title: *Frequency Agile Solar Radiotelescope (this proposal)*
Sponsor and POC: National Science Foundation
Period and Amount: 10/01/08-09/30/013; $25,000,000
P.I.: E. Schreier, AUI
FTE Work-years: 0.5/year

Biography

CHRISTOPHER S. RUF

Professor of Atmospheric, Oceanic & Space Sciences
and Electrical Engineering & Computer Science
Director, Space Physics Research Laboratory
The University of Michigan
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http://www.sprl.umich.edu http://ktb.engin.umich.edu

Education

Ph.D.	1987	Electrical and Computer Engineering, Univ. of Massachusetts at Amherst
B.A.	1982	Physics, Reed College, Portland, OR

Professional Experience

May 2006 - present	*Director*, Space Physics Research Laboratory University of Michigan, Ann Arbor, MI
Sep 2004 - present	*Professor*, Departments of AOSS and EECS University of Michigan, Ann Arbor, MI
Jul 2000 – Aug 2004	*Associate Professor*, Departments of AOSS and EECS University of Michigan, Ann Arbor, MI
Sep 2000 – Dec 2000	*Guest Professor*, Department of Electromagnetic Systems Technical University of Denmark, Lyngby, DK
Jul 1997 - Jun 2000	*Associate Professor*, Department of Electrical Engineering Pennsylvania State University, University Park, PA
Jan 1992 - Jun 1997	*Assistant Professor*, Department of Electrical Engineering Pennsylvania State University, University Park, PA
Jul 1988 - Dec 1991	*Member of Technical Staff*, Microwave Observational Systems Jet Propulsion Laboratory, Pasadena, CA
Jun 1987 - Jun 1988	*Visiting Professor and Research Engineer* Department of Electrical and Computer Engineering University of Massachusetts, Amherst, MA

Former and Present Ph.D. Students

Justin Bobak, M.S. 1994, Ph.D. 1998
Sandra Cruz-Pol, Ph.D. 1998
Shannon Brown, Ph.D. 2005
Hirofumi Kawakubo, Ph.D. *in progress*
Boon Lim, Ph.D. *in progress*
Jinzheng Peng, Ph.D. *in progress*
John Puckett, Ph.D. *in progress*

Former and Present postdocs

Haley Gu, 2006 - 2007

Professional Affiliations and Service

Member, National Academies NRC Committee on Spectrum Allocation, 2006-present
Member, National Academies NRC Committee on Earth Science and Applications from Space, 2005-2006
Member, National Academies NRC Committee on Radio Frequency, 2000-2003
Fellow, Institute of Electrical and Electronics Engineers (IEEE)
Member, American Geophysical Union (AGU)
Member, American Meteorological Society (AMS)
Member, International Union of Radio Science (URSI), Commission F
Associate Editor, AMS Journal of Atmospheric and Oceanic Technology (2006-present)
Associate Editor, IEEE Transactions on Geoscience and Remote Sensing (2001-present)
Guest Editor, IEEE Trans. Geosci. Remote Sens. (2005-2006)
Editor, *IEEE Geoscience and Remote Sensing Society Newsletter* (1997-2000)
Guest Editor for *Radio Science*, American Geophysical Union (1997-1998)
Associate Editor, *Radio Science*, American Geophysical Union (1992-1997)

Honors and Awards

1997: IEEE Transactions on Geoscience and Remote Sensing Prize Paper Award
1999: IEEE Judith A. Resnik Technical Field Award
2001: Fellow, IEEE "*For contributions in the development, calibration and remote sensing applications of microwave radiometers*"
2006: IEEE Geoscience and Remote Sensing Society Symposium Prize Paper Award

Most Relevant Publications

Ruf, C.S., S. M. Gross and S. Misra, "RFI Detection and Mitigation for Microwave Radiometry with an Agile Digital Detector," IEEE Trans. Geosci. Remote Sens.,**44**(3), 694-706, 2006.
Ruf, C.S. and J. Li, "A Correlated Noise Calibration Standard for Interferometric, Polarimetric and Autocorrelation Microwave Radiometers," IEEE Trans. Geosci. Remote Sens., **41**(10), 2187-2196, 2003.
Ruf, C.S. "Constraints on the polarization purity of a Stokes microwave radiometer," Radio Science, **33**(6), 1617-1639, 1998.
Ruf, C.S., "Digital correlators for synthetic aperture interferometric radiometry," IEEE Trans. Geosci. Remote Sens., **33**(5), 1222-1229, 1995.
Ruf, C.S., "Numerical annealing of low redundancy linear arrays," IEEE Trans. Antennas and Propag., **41**(1), 85-90, 1993.
Ruf, C.S., "Error analysis of image reconstruction by a synthetic aperture interferometric radiometer," Radio Science, **26**(6), 1419-1434, 1991.
Ruf, C.S., C.T. Swift, A.B. Tanner and D.M. Le Vine, "Interferometric synthetic aperture microwave radiometry for the remote sensing of the earth," IEEE Trans. Geosci. Remote Sens., **26**(5), 597-611, 1988.

Ph.D. Thesis Advisor

Calvin T. Swift

Current & Pending Support for Christopher Ruf

Source	Role	Title	Award Amount	Award Period	Commitment (Person-Mo/Yr)
Current Support					
NASA GSFC NNG04HZ28C *Jennifer O'Connell* *(301)614-5605* *Jennifer.A.Oconnell* *@nasa.gov*	PI	Aquarius: Development of the Aquarius Science Algorithm and Calibration/Validation Plan	$630,100	7/04 - 2/12	0.6
NASA JPL 1267460 *Edgar Murillo* *(818) 393-3027* *Edgar.M.Murillo@jpl* *.nasa.gov*	PI	Calibration & Validation of Microwave Radiometer Wet Path Delay Retreivals for Topex/Poseidon, JASON, & OSTM	$293,430	11/04 - 9/08	0.4
NASA NNG05GL97G *Edward Torres* *(301)286-3404*	PI	Development of an Agile Digital Detector for RFI Detection and Mitigation on Spaceborne Radiometers	$1,483,681	5/05 - 6/08	1.2
NOAA DG133E06CN0134 *Marilyn Whaley* *(301) 713-3478 x143* *Marilyn.Whaley@* *Noaa.gov*	PI	NPOESS (National Polar-Orbiting Operational Environmental Satellite System)	$184,980	7/06 - 11/07	0.6
SWRI (MSFC) 699040X *Maria Ortiz* *(210)522-6345*	PI	JUNO Science Support Phase B Activities	$50,000	1/06 - 6/08	0.4
NASA University of Alabama SUB2006-271 *Steve Parker* *(256) 824-2654* *parkerjs@uah.edu*	PI	Hurricane Imaging Radiometer (HiRad) Unmanned Aerial Vehicles (UAV)	$190,444	9/06 - 2/08	0.6
JPL NASA 1292494 *Edgar Murillo* *(818) 393-3027* *Edgar.M.Murillo@jpl* *.nasa.gov*	PI	Digital Spectrometers for Microwave Radiometers	$30,516	1/07 - 1/08	0.0
NASA NNX07AD69G Richard Lawrence (301)286-2392 Richard.J.Lawrence @nasa.gov	PI	Intercalibration of Global Precipitation Constellation of Radiometers	$385,156	1/07 - 12/09	0.6
Pending Support					
NASA ROSES-07	PI	Synthetic Thinned Array Radiometer at 3 cm for Severe Weather and Precipitation Science	$420,107	1/08 - 12/09	0.6

NSF ATI 2007	Co-I	New Synthesis of Laboratory and Field Testing in Radio Astronomy	899,984	05/01/08 – 04/30/10	0.6

Curriculum Vitae

Stephen M. White

Business Address:
Department of Astronomy
University of Maryland
College Park MD 20742
Telephone: 301 405 1547
E-mail: white@astro.umd.edu

Home Address:
8529 58th Avenue
Berwyn Heights, MD 20740

November, 2007

Education

Ph.D. in Theoretical Physics, University of Sydney, 1979–84

B. Sc. with honours, first class (majoring in Theoretical Physics, Physics and Pure Mathematics), Australian National University, 1975–78

Essendon High School (dux, 1974), Melbourne, Australia

Appointments

Associate Research Scientist, Department of Astronomy, University of Maryland, 1991-present

Faculty Research Associate, Department of Astronomy, University of Maryland, 1987–1991

Alexander-von-Humboldt Scholar, Max Planck Institut fur Astrophysik, Garching-bei-Munchen, West Germany, 1986–87

Faculty Research Associate, Astronomy Program, University of Maryland, 1985–86

Tutor in the School of Physics, University of Sydney, 1980–83

Publications

Publications most relevant to this proposal:

129. *"Radio Measurements of the Height of Strong Coronal Magnetic Fields Above Sunspots at the Solar Limb"*, J. W. Brosius & **S. M. White**, Astrophys. J. Lett., 641, L69, 2006.
131. *"A Subsystem Testbed for the Frequency Agile Solar Radiotelescope"*, Z. Liu, D. E. Gary, G. M. Nita, **S. M. White**, & G. J. Hurford, Proc. Astron. Soc. Pacific, 119, 303, 2007
124. *"High–Resolution Millimeter–Interferometer Observations of the Solar Chromosphere"*, **S. M. White**, M. Loukitcheva & S. K. Solanki, Astron. Astrophys., 456, 697, 2006.
123. *"Updated Expressions for Determining Temperatures and Emission Measures from GOES Soft X–ray Measurements"*, **S. M. White**, R. J. Thomas & R. A. Schwartz, Solar Physics, 227, 231, 2005.
119. *"Close Association of an EUV Sunspot Plume with Depressions in the Sunspot Radio Emission"*, J. W. Brosius & **S. M. White**, Astrophys. J., 601, 546, 2004.

Other significant publications:

121. *"High Cadence Radio Observations of an EIT Wave"*, **S. M. White** & B. J. Thompson, Ap. J. Lett., 620, L63, 2005.

120. *"Radio Observations of Rapid Acceleration in a Slow Filament Eruption/Fast CME Event"*, M. R. Kundu, V. I. Garaimov, **S. M. White**, P. K. Manoharan, P. Subramanian, S. Ananthakrishnan, & P. Janardhan, Astrophys. J., 607, 530, 2004.

116. *"NoRH and RHESSI observations of the X 1.5 flare of April 21, 2002"*, M. R. Kundu, V. I. Garaimov, **S. M. White**, & S. Krucker, Astrophys. J., 600, 1052, 2004.

115. *"Radio and Hard X–ray Images of High–Energy Electrons in a Compact X-class Solar Flare"*, **S. M. White**, S. Krucker, K. Shibasaki, T. Yokoyama, M. Shimojo & M. R. Kundu, Astrophys. J. Lett., 595, L111, 2003.

97. *The Absolute Abundance of Iron in the Solar Corona*, **S. M. White**, R. J. Thomas, J. W. Brosius M. R. Kundu, Astrophys. J. Letters 534, L203, 2000.

Synergistic Activities

Maintain the archive for the Green Bank Solar Radio Burst Spectrometer at **http://gbsrbs.nrao.edu/**, mirrored at **http://www.astro.umd.edu/∼white/gb**

Maintain a web site on solar and stellar astrophysics at **http://www.astro.umd.edu/∼white/**.

Collaborators in last 48 months

Collaborators who haved worked on a publication with S. M. White in the last 48 months are: M. R. Kundu, J. Brosius, S. K. Solanki, M. Loukitcheva, A. Nindos, G. Nita, K. Shibasaki, J. Lee, Z. Mikić, G. Nita, J. Zhang, D. E. Gary, K. D. Leka, T. Bastian, G. Hurford, J. Chapman, B. Koribalski, L. Sui, S. Krucker, R. P. Lin.

Ph. D. Thesis Advisor

D. B. Melrose, University of Sydney

Students

Jie Zhang, University of Maryland, 1998-2000

PRINCIPAL INVESTIGATOR: Stephen M. White

Current Support: (as Principal Investigator)

1. Source of Support: NJIT subcontract from an NSF ATI grant
   Project Title: "Broadband RF Transmission Characterization and Phase Stabilization for FASR"
   Total Award Amount: $121906
   Period Covered: 09/01/04 – 08/31/07
   Committment of P.I. to this project: 0.24 MY

2. Source of Support: NASA SEC GI program
   Project Title: "X–ray and Radio/Millimeter Images of High Energy Electrons in Solar Flares"
   Total Award Amount: $175265
   Period Covered: 01/01/05 - 12/31/07
   Committment of P.I. to this project: 0.33 MY

3. Source of Support: NASA LWS TR&T program
   Project Title: "The Green Bank Solar Radio Burst Spectrometer: A Resource for LWS Studies"
   Total Award Amount: $119339
   Period Covered: 05/24/06 - 5/23/09
   Committment of P.I. to this project: 0.21 MY

Current Support: (as Co-Investigator)

None. Additional suppport is received from the College Park Scholars program and the CARMA project.

Pending Support: (as Principal Investigator)

1. Source of Support: NASA LWS TR&T Program
   Project Title: "Coronal Magnetic Fields from Radio Observations"
   Total Award Amount: $204716
   Period Covered: 05/01/08 - 4/30/11
   Committment of P.I. to this project: 0.33 MY

Pending Support: (as Co–Investigator)

None.

Curriculum Vitae: Thomas H Zurbuchen

Birth Date:	1968, Habkern, Switzerland
Marital Status:	Married, two children
Education:	Ph.D., Physics (with highest honors), University of Bern, Switzerland, 1996
	M.S. Physics, Mathematics, and Astronomy (with highest honors), University of Bern, Switzerland, 1992

Employment:

2007 – present	Director, Center for Entrepreneurship, College of Engineering, UM
2003 – present	Associate Professor, University of Michigan
2002-2003	Senior Associate Research Scientist, University of Michigan
6-7/2000, 7/2001	Senior research scientist, International Space Science Institute (ISSI), Bern, Switzerland
1998-2002	Assistant Research Scientist, University of Michigan
1996-98	Research Fellow, University of Michigan
1992-94	Consultant in Space Industry, Oerlikon Contraves, Switzerland
1990-92, 1994-96	Research Assistant, University of Bern
1990–92, 1994-96	Teaching Assistant, University of Bern

Professional Societies:

American Astronomical Society (AAS)
American Geophysical Union (AGU)
American Society for Engineering Education (ASEE)
International Society for Optical Engineering (SPIE)

Awards:

2006	NASA Group Achievement Award, Ulysses Mission
2005	UM College of Engineering 2005 Service Excellence Award
2004	National Science and Technology Council (NSTC) Presidential Early Career for Scientists and Engineers (PECASE) Award.
2001	Research Scientist Excellence Award, University of Michigan, College of Engineering
1996-1997	Swiss National Science Foundation, Young Researcher Award

Most Relevant Publications

Andrews, B., T. H. Zurbuchen, et al., The Energetic Particle and Plasma Spectrometer instrument on the MESSENGER spacecraft, *Space Sci. Rev.*, in press, 2007.

Fisk, L. A., T. H. Zurbuchen, and N. A. Schwadron, On the coronal magnetic field: Consequences of large-scale motions, *Astrophys. J., 521*, 868, 1999.

Gloeckler, G., J. Geiss, N. A. Schwadron, L. A. Fisk, T. H. Zurbuchen, et al., Interception of comet Hyakutake's ion tail at a distance of 500 million kilometers, *Nature*, *404*, 576, 2000.

Gloeckler, G., L.A. Fisk, J. Geiss, N.A. Schwadron, and T. H.Zurbuchen, Elemental composition of the inner source pickup ions, *J. Geophys. Res.,* 105, 7459, 2000.

Zurbuchen, T. H., S. Hefti, L. A. Fisk, G. Gloeckler, and N. A. Schwadron, Magnetic structure of the slow solar wind: Constraints from composition data, *J. Geophys. Res*., *105*, 18,327, 2000.

Zurbuchen, T. H., L. A. Fisk, G. Gloeckler, and N. A. Schwadron, Element and isotopic fractionation in closed magnetic structures, *Space Sci. Rev., 85*, 397, 1998.

Zurbuchen, T. H., et al., On the fast coronal mass ejections in October/November 2003: ACE-SWICS results, *Geophys. Res. Lett., 31*, L11805, doi:10.1029/2005GL019461, 2004.

Zurbuchen, T. H., I. Richardson, In-situ solar wind and magnetic field signatures of interplanetary coronal mass ejections, *Space Sci. Rev.,* 123, 31, 2006

Zurbuchen, T. H., Heliospheric physics: Linking the Sun to the magnetosphere, *Space Sci. Rev.,* 124, 77, 2006.

Zurbuchen, T.H., A new view of the coupling of the Sun and the heliosphere, *Ann Rev. of Astron. and Astrophys., 45*, 297, 2007.

Collaborators in last 48 months

L.A. Fisk, G. Gloeckler, M. Liemohn, A.D. Gallimore, S. Antiochos, S. Lepri, J. Slavin, T. Krimigis, R. Mewaldt

Former Students

Patrick Koehn (EMU)
Alysha Reinhard (NOAA)
Susan Lepri (U-M)
Kelly Korreck (Harvard, Smithsonian Institute)
Benjamin Lynch (UC-Berkeley, SSL)

Current Support

Project Title: **Constraining Solar Wind and CME Models Using in Situ Ionic Composition Observations**
Source of Support: NSF
Total Award Amount: $311,621
Total Award Period: 1/05-12/08
P.I. Support: 0%

Project Title: **Technology Development Effort for Heliospheric Composition Instrument**
Source of Support: NASA
Total Award Amount: $535,034
Total Award Period: 3/03–2/08
P.I. Support: 2.1%

Project Title: **SWICS and SWIMS Instruments for the Advanced Composition Explorer (ACE): Mission Operations and Data Analysis**
Source of Support: Caltech/NASA
Total Award Amount: $500,000
Total Award Period: 7/06-2/08
P.I. Support: 10%

Project Title: **Ionic Charge States of the Solar Wind and ICMEs: ACE, Ulysses**
Source of Support: NASA
Total Award Amount: $248,755
Total Award Period: 4/05-3/08
P.I. Support: 0%

Project Title: **Pickup Ion Composition Spectrometer (PICS) on Mars Atmosphere and Volatile EvolutioN (MAVEN)**
Source of Support: NASA
Total Award Amount: $155,045
Total Award Period: 5/07-4/08
P.I. Support: 0%

Project Title: **Supporting Theoretical Studies of the Processes that Control the Topology and Evolution of the Open Magnetic Flux of the Sun**
Source of Support: NASA
Total Award Amount: $400,881
Total Award Period: 7/05-7/08
P.I. Support: 8.6%

Project Title: **The Origin and Composition of the Solar Wind and Interstellar Pickup Ions Using Data from the Solar Wind Ion Composition Spectrometer (SWICS) on the Ulysses Mission**
Source of Support: JPL/NASA

Total Award Amount: $1,235,500
Total Award Period: 1/05-9/08
P.I. Support: 13.5%

Project Title: **The Comprehensive Corona and Heliosphere Model**
Source of Support: NSF
Total Award Amount: $470,000
Total Award Period: 9/06-8/11
P.I. Support: 1%

Project Title: **Quantitative Validation and Assessments of Solar/Heliospheric 3D Model Codes Using Empirical Data from Remote-Sensing and In Situ Measurements**
Source of Support: NASA
Total Award Amount: $230,000
Total Award Period: 12/06-11/11
P.I. Support: 5%

Project Title: **The Comprehensive Corona and Heliosphere Model**
Source of Support: NASA
Total Award Amount: $525,000
Total Award Period: 1/07-12/11
P.I. Support: 1%

Project Title: **Fast Imaging Plasma Spectrometer (FIPS) in Support of the Energetic Particle and Plasma Spectrometer (EPS) Investigation for the MESSENGER Mission to Mercury: Phase E**
Source of Support: Carnegie Institute of Washington / NASA
Total Award Amount: $240,801
Total Award Period: 9/04-9/08
P.I. Support: 7.1%

Project Title: **Heliospheric Signatures of the Evolution of the Solar Magnetic Field**
Source of Support: NRL
Total Award Amount: $300,000
Total Award Period: 6/07-6/10
P.I. Support: 3.1%

Project Title: **Software Development for Cyberinfrastructure**
Source of Support: NSF
Total Award Amount: $105,000
Total Award Period: 10/07-9/10
P.I. Support: 3%

Project Title: **The Virtual Heliospheric Observatory**
Source of Support: NASA
Total Award Amount: $70,000

Total Award Period: 10/07-9/10
P.I. Support: 0%

Pending Support

Project Title: **Fast Imaging Plasma Spectrometer (FIPS) in Support of the Energetic Particle and Plasma Spectrometer (EPS) Investigation for the MESSENGER Mission to Mercury: Phase E**
Source of Support: Carnegie Institute of Washington / NASA
Total Award Amount: $1,009,262
Total Award Period: 10/07-9/11
P.I. Support: 6.6%

Project Title: **New Operational Mode for Space-Borne Quadrupole Mass Spectrometers**
Source of Support: NASA
Total Award Amount: $357,652
Total Award Period: 6/08-5/11
P.I. Support: 1.9%

Project Title: **Low Cost Network of Robust, Autonomous Miniaturized Interferometer for Monitoring Emissions (MiniME) Space Weather Sensors**
Source of Support: Michigan Aerospace Corporation
Total Award Amount: $35,000
Total Award Period: 9/07-5/08
P.I. Support: 0%

Project Title: **Source Regions of the Slow Solar Wind: a Joint SOHO/UVCS and ACE/SWICS Abundance Study**
Source of Support: NASA
Total Award Amount: $105,000
Total Award Period: 1/08-12/10
P.I. Support: 5.1%

DISCLOSURE OF LOBBYING ACTIVITIES

Complete this form to disclose lobbying activities pursuant to 31 U.S.C. 1352

(See reverse for public burden disclosure.)

Approved by OMB 0348-0046

1. Type of Federal Action:	2. Status of Federal Action:	3. Report Type:
[C] a. contract b. grant c. cooperative agreement d. loan e. loan guarantee f. loan insurance	[C] a. bid/offer/application b. initial award c. post-award	[B] a. initial filing b. material change **For Material Change Only:** year 2007 quarter 3 date of last report 7/20/06

4. Name and Address of Reporting Entity:	5. If Reporting Entity in No. 4 is a Subawardee, Enter Name and Address of Prime:
[X] Prime [ ] Subawardee Tier ______, *if known*: Associated Universities, Inc. 1400 16th Street, N.W. Suite 730 Washington, DC 20036 **Congressional District,** *if known*:	N/A **Congressional District,** *if known*:
6. Federal Department/Agency: National Science Foundation Mathematics & Physical Science	**7. Federal Program Name/Description:** CFDA Number, *if applicable*: 47.049
8. Federal Action Number, *if known*: AST-0223851	**9. Award Amount,** *if known*: $ approx. $100M annually
10. a. Name and Address of Lobbying Registrant (*if individual, last name, first name, MI*): Lewis-Burke Associates 1341 G Street, N.W. 8th Floor Washington, DC 20005	**b. Individuals Performing Services** (*including address if different from No. 10a*) (*last name, first name, MI*): Burke, April L. Ledford, Michael L.
11. Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when this transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less that $10,000 and not more than $100,000 for each such failure.	Signature: [signature] Print Name: Cynthia L. Allen Title: Corporate Controller Telephone No.: (202) 462-1676 Date: 7/24/07

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