
# Heliophysics Division Research & Analysis Review

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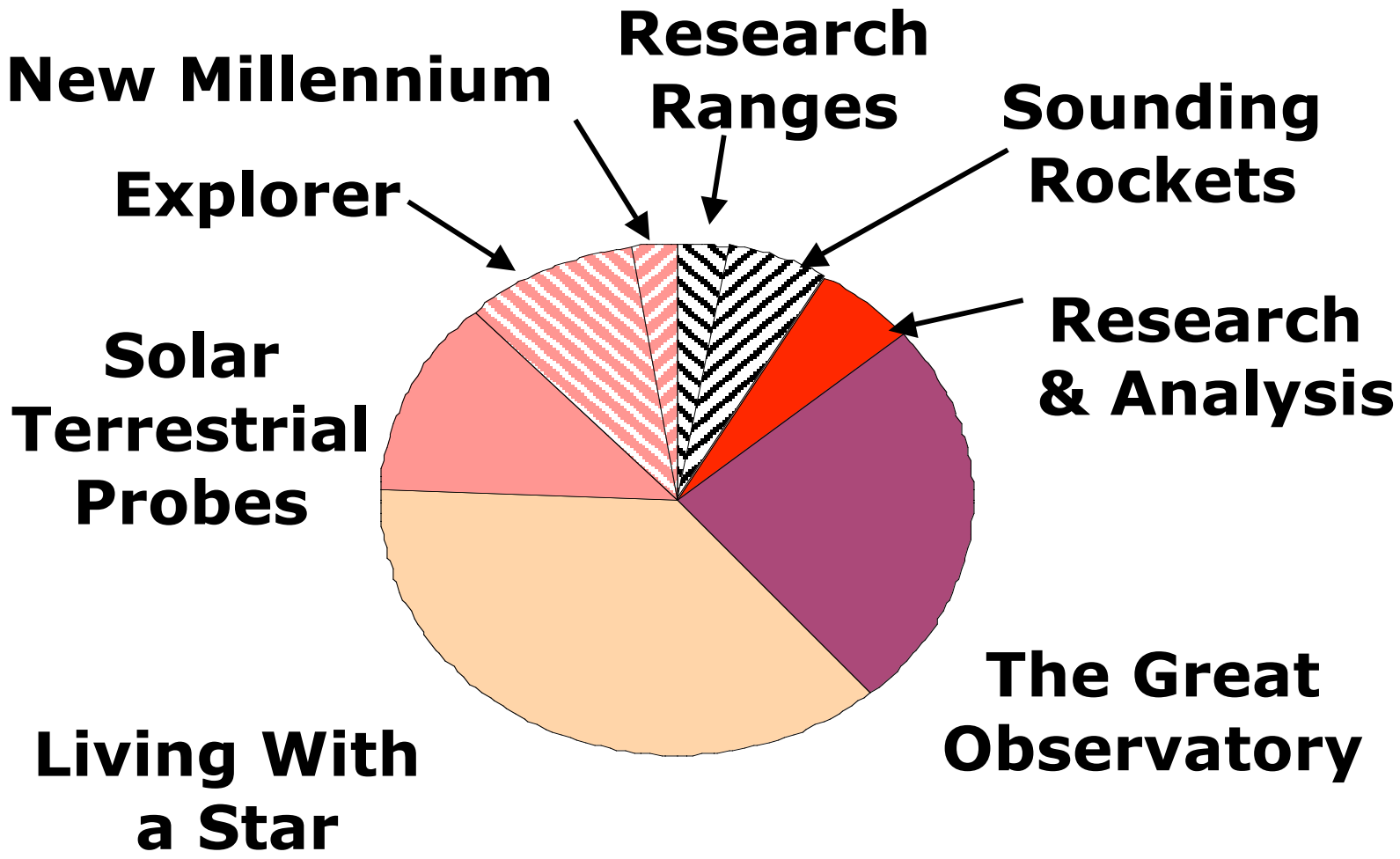
Heliophysics Division Director

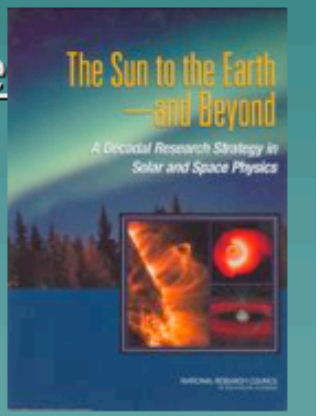
28 March 2008

# FY 09 Heliophysics Division Budget : Total 575,274 M$



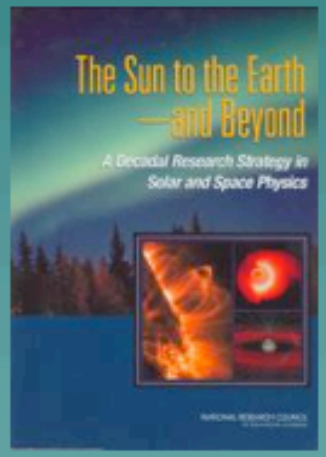
# Decadal Survey Goals (1)

- Challenge 1 (Sun)
  - *Understanding the structure and dynamics of the Sun's interior, the generation of solar magnetic fields, the origin of the solar cycle, the causes of solar activity, and the structure and dynamics of the corona.*
- Challenge 2 (Heliosphere)
  - *Understanding the heliospheric structure, the distribution of magnetic fields and matter throughout the solar system, and the interaction of the solar atmosphere with the local interstellar medium.*



# Decadal Survey Goals (2)

- Challenge 3 (Magnetospheres)
  - *Understanding the space environments of Earth and other solar system bodies and their dynamical response to external and internal influences.*
- Challenge 4 (Basic Physics)
  - *Understanding the basic physical principles manifest in processes observed in solar and space plasmas.*
- Challenge 5 (Space Weather)
  - *Developing near-real-time predictive capability for understanding and quantifying the impact on human activities of dynamical processes at the Sun, in the interplanetary medium, and in Earth's magnetosphere and ionosphere.*



# Roadmap Goals

- Understand the fundamental physical processes of the space environment - from the Sun to Earth, to other planets, and beyond to the interstellar medium.
- Understand how human society, technological systems, and the habitability of planets are affected by solar variability interacting with planetary magnetic fields and atmospheres.
- Maximize the safety and productivity of human and robotic explorers by developing the capability to predict the extreme and dynamic conditions in space.

# Heliophysics Research Budget

For *FY2007*, the following aggregates the competed research budget, including Los Cost Access to Space (LCAS - Sounding Rocket Payloads)

- "SR&T"
  - LCAS, HP Theory program, LWS TRT … ……$63.0 M
- Data and Computing ……..$ 14.9 M
  - Applied Information Research Program (AISRP)
  - VXOs, and Theory Modeling and Data Services
- Mission Science Teams (other than "Astrophysics R&A") …….. $15 M
  - PI teams for missions and instruments selected through AO
  - Additional team members selected through competition
    - Participating scientists, interdisciplinary scientists, science working group members, etc.
- Extended Missions research and data analysis funding* ……..~ $ 55.4M
- Heliophysics Competed ~$148.3 M

* FY08 planning number - competed via Senior Review Process every two-three yrs.

# Heliophysics R&A Elements

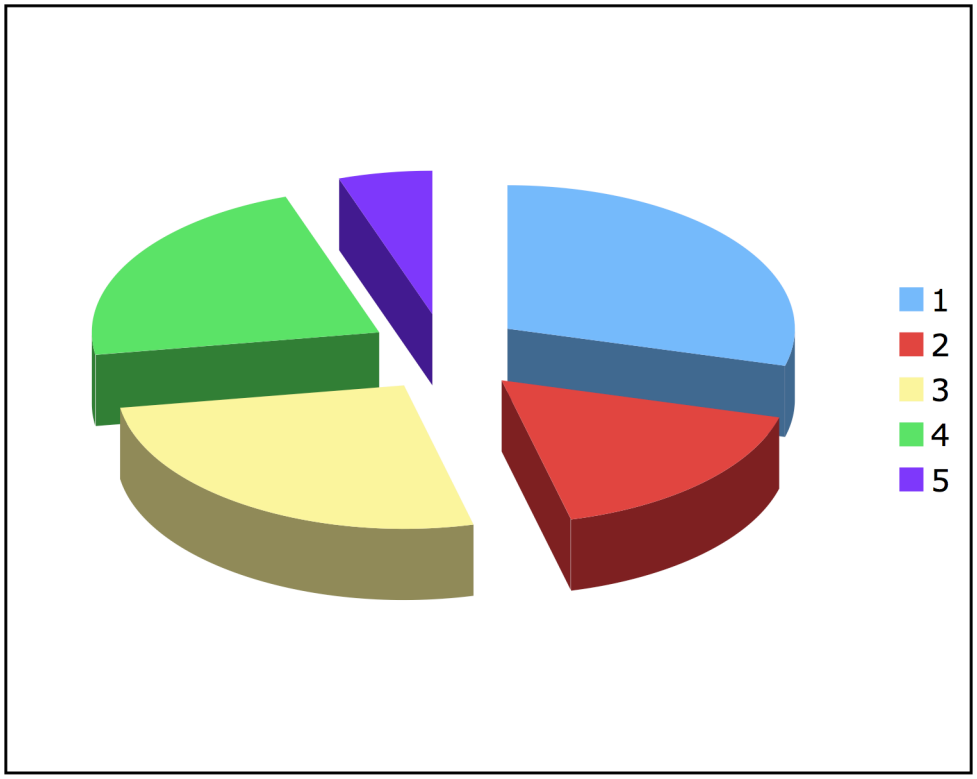
| Element | ~Value* (M$) | NRA |
|---|---|---|
| • Supporting Research & Technology (SR&T) | 63.6 | ROSES |
| – Solar-Heliosphere SR&T | | |
| – Geospace SR&T | | |
| – LWS Target Research and Technology | | |
| • Data and Computing | 14.9 | ROSES |
| – ASIRP | | |
| – VXO | | |
| – SEC Data and Modeling | | |
| • Guest Investigator Program | 11.5 | ROSES |
| – Geospace GI Program | | |
| – Solar and Heliospheric GI Program | | |
| – Total | 93.3 | |

# Helio Competed Elements

- **LWS Targeted Research and Technology**
- **Solar and Heliophysics SR&T**
  - Solar Magnetic Fields and Helioseismology
  - Solar Activity
  - Solar X- and gamma-ray
  - UV/Optical
  - IR/Sub-mm/Radio
  - Heliospheric Physics
  - Solar Wind
  - CME and Solar System Response
  - Advanced Tools and Techniques* (new ROSES task)
- **Geospace SR&T**
  - Inner and Outer Magnetosphere
  - Ionosphere
  - Mesosphere and Thermosphere
  - Particles and Fields
  - HP Theory Program
- **Low Cost Access to Space (Sounding Rocket Payloads)**
  - Solar and Helio SR Payloads
  - Geospace SR Payloads

~$59.6 M in FY2008

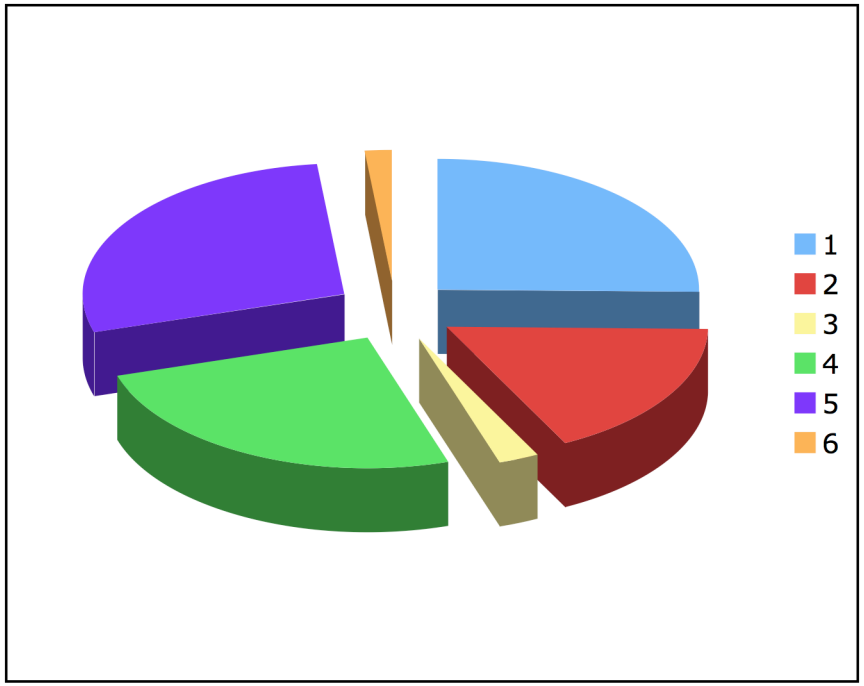
# Heliophysics SR&T/TR&T Distribution FY04-06




| | |
|---|---|
| TR&T | 17.3 M$ |
| ASIRP | 10.1 M$ |
| Solar and helio | 15.7 M$ |
| Geospace | 13.2 M$ |
| HPD Theory | 3.2M$ |

Total SR&T/TR&TCompeted programs: 69.6M$ FY08

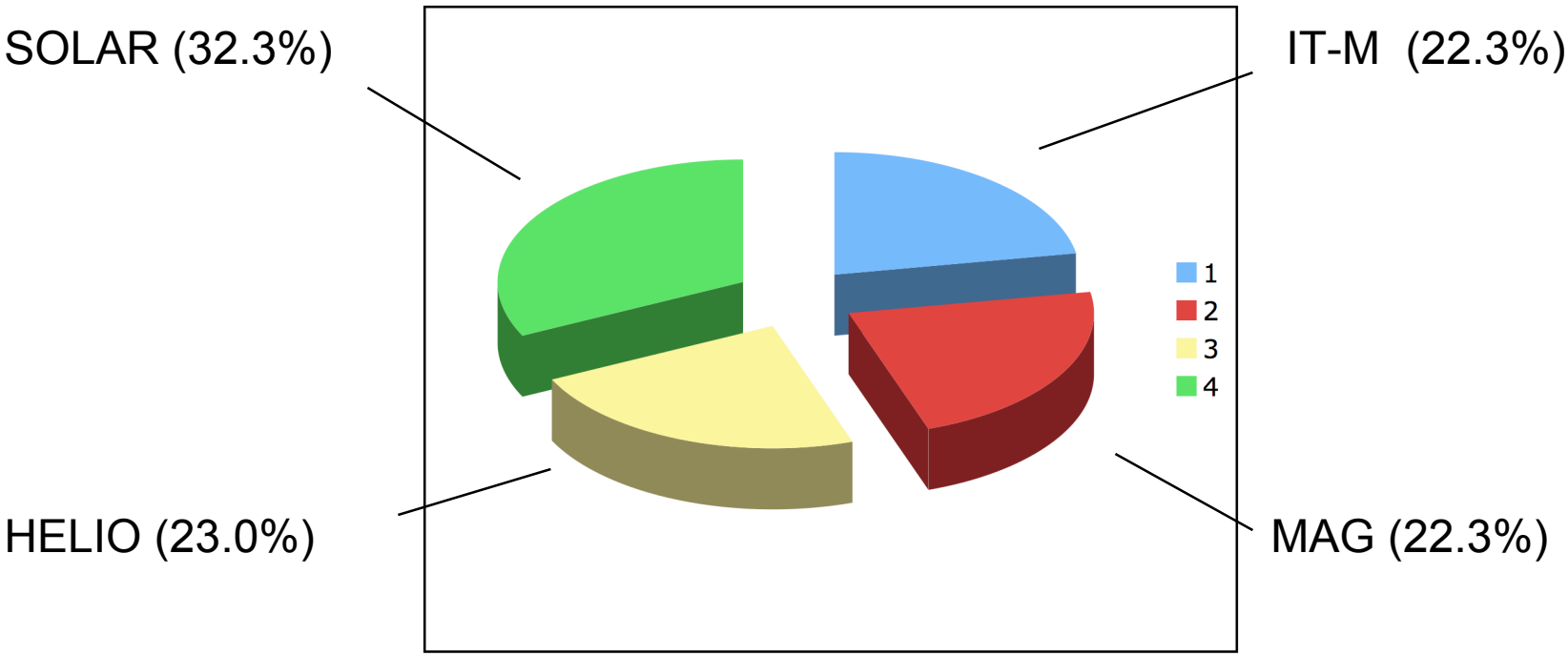
# Proposals by Discipline Included in Portfolio




| | |
|---|---|
| Solar and heliophysics | 107 |
| Geospace Science | 72 |
| Heliophsyics Theory | 10 |
| Heliophysics GI | 107 |
| LWS TR&T | 118 |
| VxO Heliophysics | 7 |

421 funded proposals through FY07

# Heliophysics Division Proposal Acceptance by Discipline: Balance




Proposals selected FY2005 - 2007

# HpD R & A Portfolio (FY2008)

**ROSES Elements for FY2008 (as of 3/19/2008)**

| | Number of Research Awards | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Roses Element** | **ITM** | **MAG** | **Helio** | **Solar** | **Total** | **% ITM** | **% Mag** | **% Helio** | **% Solar** | **% Total** |
| **Solar and Helio Physics** | 0 | 0 | 40 | 67 | 107 | 0% | 0% | 37% | 63% | 100% |
| **Geospace Science** | 36 | 36 | 0 | 0 | 72 | 50% | 50% | 0% | 0% | 100% |
| **Heliophysics Theory** | 2 | 3 | 1 | 4 | 10 | 20% | 30% | 10% | 40% | 100% |
| **Heliophysics GI*** | 17 | 29 | 25 | 36 | 107 | 16% | 27% | 23% | 34% | 100% |
| **LWS TR&Technology** | 38 | 23 | 29 | 28 | 118 | 32% | 19% | 25% | 24% | 100% |
| **VxO for Heliophysics Data** | 1 | 3 | 2 | 1 | 7 | 14% | 43% | 29% | 14% | 100% |

NB: In Helio Physics there are: Helio/Instrum 4; Helio/LCAS 2
In Solar Physics there are: Solar/instrum 6; Solar/LCAS 8
In the VxO we have a single proposal which is interdisciplinary (i.e. "Other")

* The GI program includes 8 Stereo proposals (5 Solar and 3 Helio)

421 TOTAL PROP
FUNDING FOR : 59.6 M$
~142 K$ mean
26% acceptance
1 in 3.84 selection

# The Guest Investigator Program

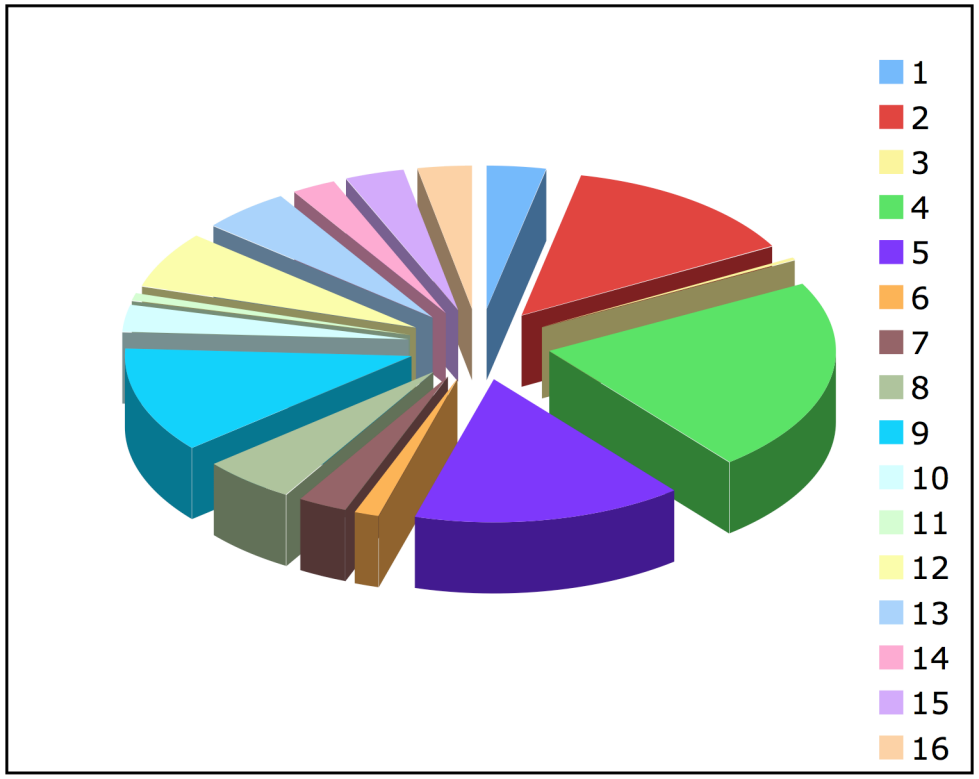
- 143 proposals submitted in May
  - Competition included a special STEREO GIP
- 48 selections announced prior to AGU
  - 21 awards to general Solar & Heliospheric investigations
  - 7 for the STEREO GIP
  - 20 selected for the general Geospace investigations

- Proposals for ROSES 2008 GIP will be due May 9.
  - Will include call for IBEX GIs.

# The Guest Investigator Program

1. MO&DA for currently operating missions
2. Guest Investigator Program
3. SEC Data and Modeling Services
   - SDAC and VSO,
   - SPDF (e.g. CDAWeb, OMNIWeb, etc.),
   - CCMC
   - New VxOs
   - Resident Archives
4. Multimission Operations Project at GSFC
   - Concentrates on control center functions and flight dynamics
   - Sustain operations and flight dynamics infrastructure
   - Promote new operations tools and architectures
   - Supports all Space-Science operations at GSFC

# Mission Costs (Est.) FY08




| | | |
|---|---|---|
| AIM | 2.6 M$ | |
| THEMIS | 11.1 | |
| IBEX | ? | |
| STEREO | 17.7 | |
| Hinode | 12.4 | Prime Ops |
| CINDI | 1.05 | |
| TWINS | 2.28 | |
| Voyager | 4.3 | |
| SOHO | 9.6 | |
| Wind | 2.5 | |
| Geotail | 0.6 | |
| Cluster II | 5.1 | Extended Ops |
| ACE | 4.1 | |
| Fast | 1.9 | |
| Trace | 2.7 | |
| Rhessi | 2.5 | |

# Senior Review 2008

- The 6th Senior Review for the operating HP missions will be held during the week of April 8.
  - Proposals and Mission Archive Plans received February 21.
  - The review will cover the period FY-09 to FY-12.

- 12 missions are participating in the review are
  - ACE, RHESSI, SOHO, STEREO, Voyager and Wind
  - AIM, Cluster, FAST, Geotail, THEMIS and TIMED
  - GIP performance and spacecraft usage by GIs is reviewed.

- The review will be conducted in the context of the Heliophysics Strategic Goals expressed in the 2007 SMD Science Plan and the 2006 HP Roadmap with the view of that there will be several new missions launched during this period:
  - SDO, IBEX, TWINS, and CNOFS/CINDI.

- The panel's report will be published in early June.


# The GI Program

- 143 proposals submitted in May
  - Competition included a special STEREO GIP
- 48 selections announced prior to AGU
  - 21 awards to general Solar & Heliospheric investigations
  - 7 for the STEREO GIP
  - 20 selected for the general Geospace investigations

- Proposals for ROSES 2008 GIP will be due May 9.
  - Will include call for IBEX GIs.

# GIP Budgets ($M)

| FY | 05 | 06 | 07 | 08 | 09 | 10 | 11 |
|---|---|---|---|---|---|---|---|
| Total Program | 13.7 | 10.0 | 11.5 | 11.8 | 16.2 | 15.7 | 16.0 |
| New Awards | 6.2 | 0 | 5.2* | 6.1• | 5.0° | 4.8 | 6.2 |

- ✻ Includes $540k for new Voyager Guest Investigators from 2005 Senior Review
- • New awards in FY-08 included ~$850k for STEREO Guest Investigators
- o New awards in FY-09 include ~$1000k for IBEX Guest Investigators

# LWS TR&T Strategic Plan

based on the LWS TR&T Science Definition Team report of November 2003

- LWS is a systematic, goal-oriented research program targeting those aspects of the Sun-Earth system that affect life and society.
- The TR&T component of LWS is to provide the theory, modeling, and data analysis necessary to enable an integrated, system-wide approach to LWS science.

TR&T Supports:

- Focused Science Teams
- Strategic Capabilities
- Cross-cutting Workshops
- Summer Schools

# LWS TR&T Strategic GOALS

- **Solar Storms** ...deliver the understanding and modeling required for useful prediction of the variable solar particulate and radiative environment at the Earth, Moon, Mars, and throughout the solar system

- **Sun Climate** ...deliver the understanding of how and to what degree variations in the solar radiative and particulate output contribute to changes in global and regional climate over a wide range of time scales

- **Near Earth Radiation** ...deliver the understanding and modeling required for effective forecasting/specification of magnetospheric radiation and plasma environments

- **Ionosphere-Thermosphere** ...deliver understanding and predictive models of upper atmospheric and ionospheric responses to changes in solar electromagnetic radiation, and to coupling above and below

# Proposals and Awards

- 155 current awards with average funding level of $121,000
  - 26% of these have separately funded co-Investigators
  - Most have 3 year duration (SC - 5 year duration)

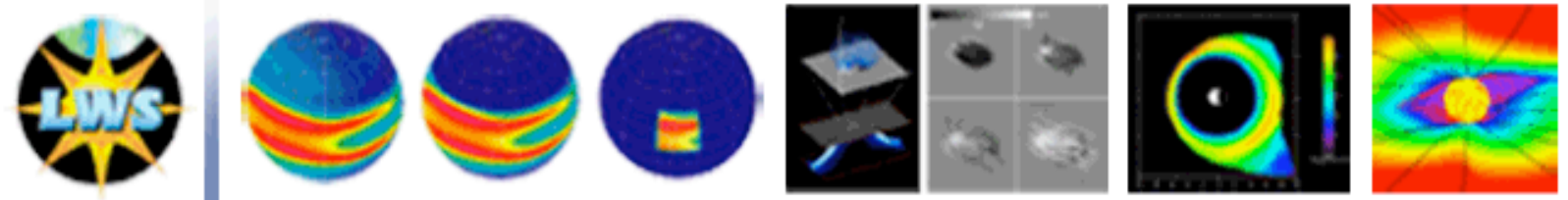
ROSES 2007

- 161 proposals submitted for TR&T, ~ $5 M available
- Proposal selection March 2008
- Partnership opportunity with Planetary Division - one Focus Topic

# LWS TR&T Focus Topics

| 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|
| Determine the solar origins of the plasma and magnetic flux observed in an ICME | Shock acceleration of SEPs by interplanetay CMEs | Predict emergence of solar active regions before they are visible | **Exploring the magnetic connection between the photosphere and low corona** |
| Determine the topology and evolution of the open magnetic field of the Sun connecting the photosphere through the corona to the heliosphere | Mechanism for solar wind heating and acceleration | Understand how flares accelerate particles near the Sun (i.e., through shocks and/or reconnection) and how they contribute to large SEP events | **Prediction of the Interplane1 tary Magnetic Field Vector Bz at L1** |
| Relate solar-energetic particles to their origin at the sun and inner heliosphere | Solar wind plasma entry and transport in the magnetosphere | Effects of ionospheric-magnetospheric plasma redistribution on storms | **Toward combined models of acceleration, loss and transport of energetic electrons and protons in the magnetosphere** |
| Determine the mechanisms responsible for the formation and loss of new radiation belts in the slot region in response to geo-effective solar wind structures | Storm effects on global electrodynamics and middle and low latitude ionosphere | Investigate the global distribution, sources and effects of large electron density gradients at middle and low latitudes | **Determine the sources of daily variability in the thermosphere and ionosphere** |
| Quantify the response of thermospheric density and composition to solar and high latitude forcing | Atmospheric abundance of greenhouse gases and dynamics of the upper atmosphere | Solar origins of irradiance variations | **Solar Modulation of the galactic cosmic rays and the production of cosmogenic isotope archives of long-term solar activity, used to interpret past climate changes** |
| Quantify the sensitivity of regional and global climate to solar forcing in the full context of the interactive climate system | | | **Extreme Space Weather Events in the Solar System** |

# Living With a Star
# Targeted Research and Technology



HOME | proposals | science results | reports | news | related sites | contacts

- strategic capability
- focus teams
- steering committee
- mowg

## LWS TR&T Focus Teams:

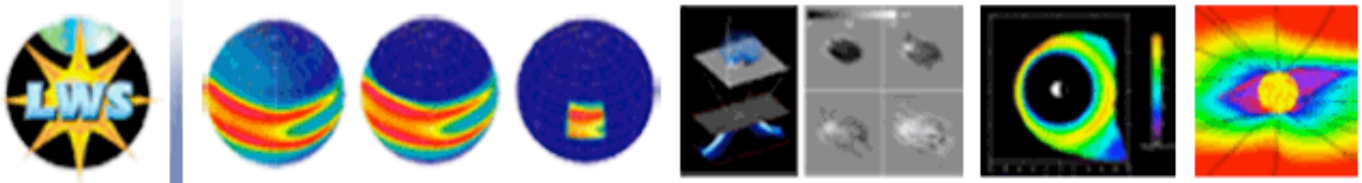
### 2006

- Predict Emergence of Solar Active Regions Before they are Visible
- Flares particle acceleration near the Sun and Contribution to large SEP events
- Effects of Ionospheric-Magnetospheric Plasma Redistribution on Storms
- Global Distribution, Sources and Effects of Large Electron Density Gradients
- Solar Origins of Irradiance Variations

### 2005

- Shock acceleration of SEPs by interplanetay CMEs
- Mechanism for solar wind heating and acceleration
- Solar wind plasma entry and transport in the magnetosphere
- Storm effects on global electrodynamics and middle and low latitude ionosphere

- TR&T website: http://lws-trt.gsfc.nasa.gov





## LWS TR&T Strategic Capability:

### 2006

- 3D Model of an Active Region Coronal Magnetic Field

A primary goal of the LWS Program is the development of first-principles-based predictive and specification models for the coupled Sun-Earth system. Such models are essential for making progress on the science priorities and to assist in the interpretation and linking together of the data that will be produced by the LWS missions, other NASA-SEC missions, and ground-based facilities. Models serve multiple purposes. They act as tools for science investigations, as prototypes and test beds for first-principles-based prediction and specification capabilities, as frameworks for linking disparate data sets at vantage points throughout the HP system, and as strategic planning aids for testing new mission concepts.
These efforts can leverage existing modeling resources, but will also likely require significant new code development and possibly multi- institutional collaborations. The primary function of such code development is to provide a tool for science and a prototype operational tool. Proposals for strategic capabilities are competed separately from the targeted investigations efforts. The defining characteristics of a successful proposal to provide a strategic capability should include, but need not necessarily be limited to, the following:

### 2005

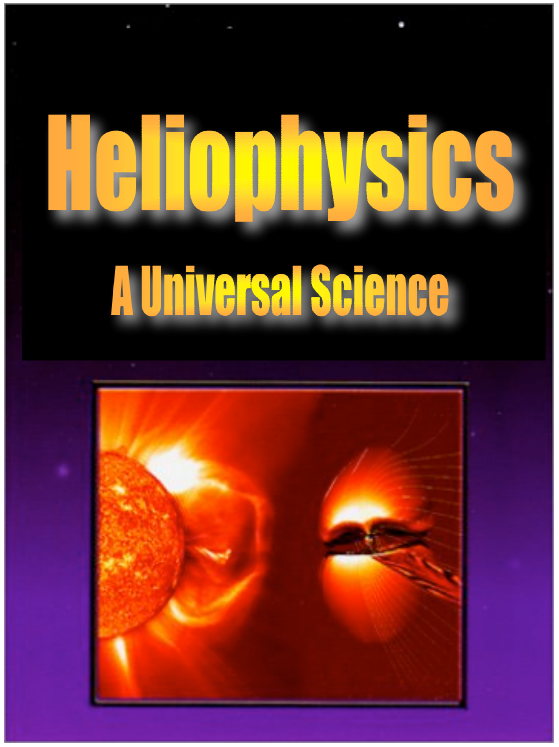
**NASA/NSF (AFOSR) Partnership for Collaborative Space Weather Modeling**

- A Comprehensive Magnetosphere-Ionosphere Model
- Time-Dependent 3D Model for the Corona and Ambient Solar Wind
- Earth – Moon – Mars Radiation Model

Space weather refers to conditions on the sun and in the solar wind, interplanetary medium, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems andcan endanger human life or health. Mitigation of these adverse effects requires understanding of the fundamental physical processes that affect the state of the Sun, solar wind, interplanetary medium, magnetosphere, ionosphere, and upper atmosphere. This understanding is being achieved by a variety of ongoing programs that address research, observations, and modeling of the space environment.

**Spontaneous Generation of Structures and Transients**
- Flux Ropes-Filaments
- Current Sheets
- Cellular Structures
- Turbulence
- Waves & Emissions

**Creation & Annihilation of Magnetic fields**
- Dynamos
- Diffusion
- Dissipation
- Reconnection




**Explosive Energy Conversions**
- Solar (Stellar) Flares
- CMEs
- Substorms
- Bursty Bulk Flows

**Magnetic Coupling**
- Non-Local (Non-Contact)
- Flow-Object
- Cross-Scale (Hierarchical)
- Neutral-Plasma
- Dusty Plasmas

**Generation of Penetrating Radiation**
- GCRs
- SCRs
- ACRs
- Radiation Belts

Coupling Sun, heliosphere, galactic environment, and planetary climate
- Dynamos in stars and planets
- Radiative and electromagnetic couplings

**Notional Scope of the TR&T Program**

# CHARACTERIZATION OF THE COMPETED ELEMENTS FY07

| ELEMENT | WIN RATE | AVE. AWARD $ | New Budget M$ |
|---|---|---|---|
| GI program | | | |
| GI-Geospace | 2.95 | 90,928 | 4.3 |
| GI-S&H | 3.28 | 92,857 | 5.2 |
| Geospace SR&T (w/LCAS) | | | |
| Geo-SR&T | 3.79 | 157,265 | |
| HP Theory Prog. | 2.88 | 417,085 | 3.9 |
| Solar-Heliospheric SR&T (w/LCAS) | | | |
| S-H SR&T | 7.85 | 90,705 | 2.8 |
| LWS - TRT | 3.57 | 90,705 | 3.9 |
| ASIRP,Data, Computing and Models | | | |
| ASIRP-A | N/A | N/A | 3.4 |
| ASIRP-H | 6.6 | 136,434 | 3.2 |
| VxO | 2.0+ | 85,182 | 2.1 |
| Grand Aggregate FY07 all elements | 3.94 | 140.243 | 22.3 |

* Partial data available

647/164

# FY 2006 Summary

# Status of Current Missions

| Mission | Launch | Phase | Extension to * | Dec | Jan | Feb | Mar | Remarks |
|---|---|---|---|---|---|---|---|---|
| Polar | 2/24/96 | Extended | Apr 30, 2008 | | | | | Exhausted hydrazine fuel on Februay 11 |
| Ulysses | 10/06/90 | Extended | **≤ July 1, 2008** | | | | | Spacecraft operations to conclude NLT July 1, 2008 |
| FAST | 8/21/96 | Extended | Jul 2008 | | | | | |
| Geotail | 7/24/92 | Extended | Jul 2008 | | | | | |
| TRACE | 4/01/98 | Extended | **> Nov 2008** | | | | | Will terminate operations after launch of SDO |
| STEREO | 10/25/06 | Prime | Feb 2009 | | | | | |
| THEMIS | 2/17/07 | Prime | Mar 2009 | | | | | 1st "Tail" season. |
| AIM | 4/25/07 | Prime | June 2009 | | | | | Safehold on Feb 7, recovery nearly complete |
| Hinode | 9/23/06 | Prime | Nov 2009 | | | | | Switched to S-band for downlink |
| Cluster | 7/16/00 | Extended | ~ 2010 | | | | | |
| ACE | 8/27/97 | Extended | > 2013 | | | | | |
| RHESSI | 2/05/02 | Extended | > 2013 | | | | | |
| SOHO | 12/02/95 | Extended | > 2013 | | | | | |
| TIMED | 12/07/01 | Extended | > 2013 | | | | | GUVI scan motor stopped on December 8. |
| Voyager 1 + 2 | 8/20/77 | Extended | > 2013 | | | | | |
| Wind | 11/01/94 | Extended | > 2013 | | | | | |

* Extension date subject of future Senior Reviews: 2008, 2010, etc.

# IONOSPHERIC PHYSICS

## Current Assets





| | (Goal F2) Radiation Dynamics | (Goal F3) Plasma / Neutral | (Goal H2) Prediction / Specification | (Goal H3) Solar Coupling |
|---|---|---|---|---|
| AIM | | | | Mesosphere |
| TIMED | | | Mesosphere | Mesosphere |
| FAST | Ionosphere | | Ionosphere | |
| CINDI | | Ionosphere Thermosphere | Ionosphere Thermosphere | Ionosphere thermosphere |

| Science Progress | No Application | Very Limited | Address Some Goals |
|---|---|---|---|

# MAGNETOSPHERIC PHYSICS

## Current Missions

| Mission | F1 Recon | F2 Acc/Trans | H2 Environ | J1 SW Extr | J4 Rad Env |
|---|---|---|---|---|---|
| ACE Solar Wind | | | | | |
| Wind Solar Wind | | | | | |
| GEOTAIL Outer Mag | | | | | |
| THEMIS Mag | | | | | |
| FAST Auroral Zn | | | | | |
| CLUSTER Outer Mag | | | | | |

| Color Key | No Application | Limited | Good |
|---|---|---|---|

# Current Assets Heliosphere Science

| Mission | D1 Causes of Solar Activity | D2 Heliosph. Structure, LISM Interact. | D3 Drivers of Earth Space Environment | D4 Basic Principles | D5 Near Real Time Pred. | R1 Space Env. Pred. | R2 Under-standing | R3 Safe-guarding Journey |
|---|---|---|---|---|---|---|---|---|
| ACE | | | | | | | | |
| Cluster | | | | | | | | |
| SOHO | | | | | | | | |
| STEREO | | | | | | | | |
| Ulysses | | | | | | | | |
| Voyager | | | | | | | | |
| Wind | | | | | | | | |
| Cassini | | | | | | | | |
| GOES | | | | | | | | |
| Messenger | | | | | | | | |
| N. Horizons | | | | | | | | |
| Polar | | | | | | | | |
| Sampex | | | | | | | | |

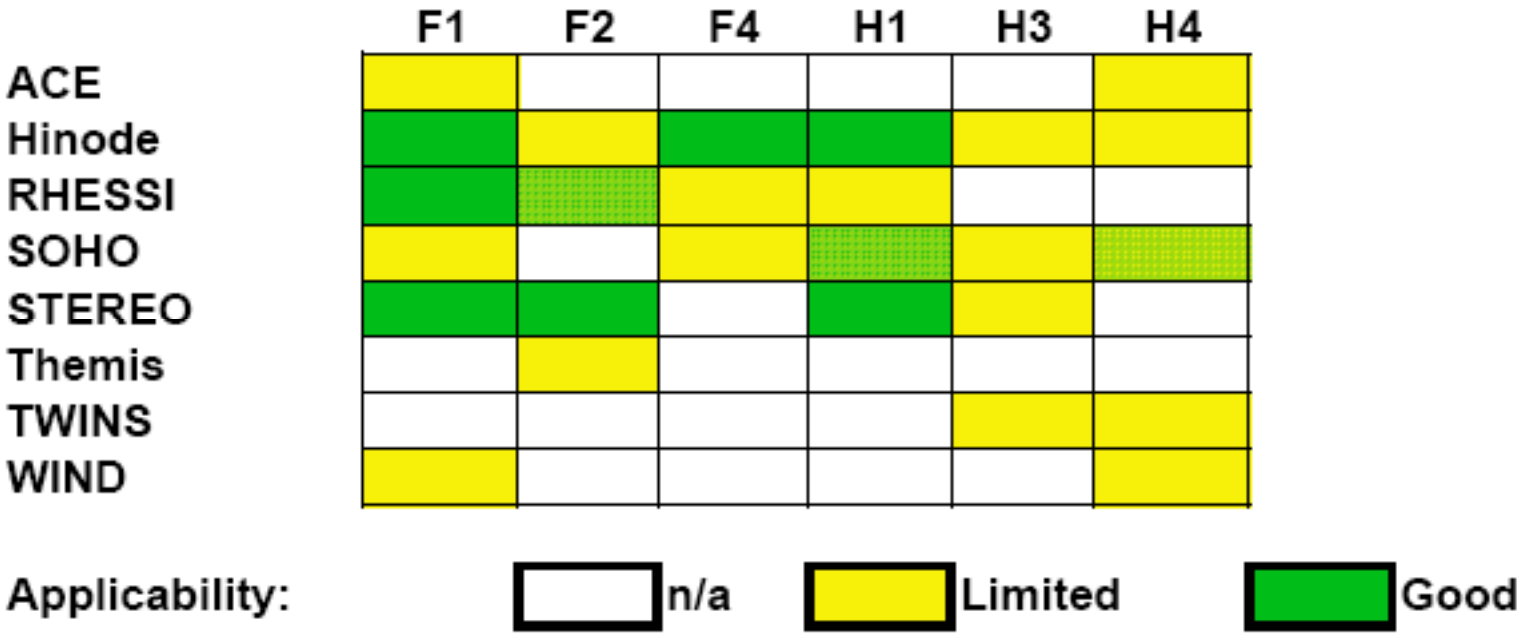
HPD Assets, Non-HPD Assets

partially addresses RFA

fully addresses RFA

# Current Missions and Solar Physics
## (Substantial progress only)

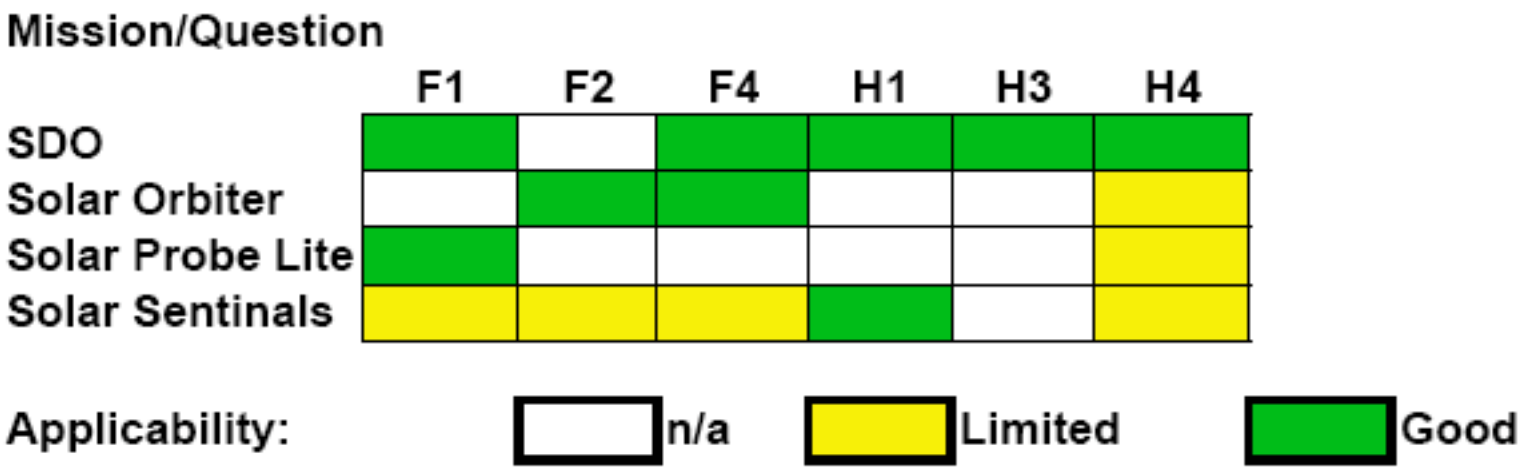
**Current Mission Matrix (as of 3/2008)**
**Applicability for Solar Physics**




Note that there are other missions not mentioned here: these are the ones that are assessed to contribute most significantly to advancing solar physics.

# Future Assets - where we want to go…

**Future Near-term Mission Set**
**Applicability for Solar Physics**




The missions listed are the ones which are in the FY2009 Presidential Submission onl

# CHARACTERIZATION OF THE COMPETED ELEMENTS FY06

| ELEMENT | WIN RATE | AVE. AWARD | TOTAL BUDGET | |
|---|---|---|---|---|
| | | $ | k$ | |
| GI program | | | | |
| GI-Geospace | 2.95 | 99,928 | 5,900 | |
| GI-S&H | 4.02 | 123,877 | 4,643 | |
| Geospace SR&T (w/LCAS) | | | | |
| Geo-SR&T | 4.10 | 157,265 | 13,629 | |
| HP Theory Prog. | 2.88 | 417,085 | 3,760 | |
| Solar-Heliospheric SR&T (w/LCAS) | | | | |
| S-H SR&T | 3.92 | 155,415 | 15,152 | |
| LWS - TRT | 3.38 | 97,595 | 18,727 | |
| ASIRP,Data, Computing and Models | | | | |
| ASIRP-A | N/A | N/A | 5,233 | |
| ASIRP-H | 5.99 | 162,185 | 5,723 | |
| SEC Data Serv-ugrade | 3-5 | Variable | 2,632 | |
| VxO | 2.27 | 85,182 | 1784 | |
| Grand Aggregate FY04-FY07*, all elements | 3.79 | 133,018 | 81,699 | 704/2673 |

* Partial data available

# Other R&A Programs

- **Guest Investigator Programs**
  - Geospace GI Program — 8.4
  - Solar and Heliospheric GI Program — 6.5

  ~ $15 M in FY2007

- **Data and Computing and Models**
  - ASIRP — 10.9
  - VXO — 1.4
  - SEC Data, Computing, and Modeling Services — 2.6

  ~ $15 M in FY2007

# TR&T within LWS and NASA