GNU Radio in the hands of Citizen Astronomers

Glen Langston
National Science Foundation
National Science Foundation Introduction

NSF Goal: Encourage active Citizen-Astronomy research answering important questions.

GNU Radio Astronomy Experience

Goal for this Conference: Start to build community consensus on a citizen science projects, and, eventually, receive compelling proposals.
NSF Mission

• Promote the progress of science
• Advance the national health, prosperity, and welfare
• Secure the national defense; and for other purposes
NSF Organization

National Science Board (NSB)

Director
Deputy Director

Office of the Inspector General (OIG)

Office of Diversity & Inclusion

Office of the General Counsel

Office of International & Integrative Activities

Office of Legislative & Public Affairs (OLPA)

Biological Sciences (BIO)

Computer & Information Science & Engineering (CISE)

Engineering (ENG)

Geosciences (GEO)

Mathematical & Physical Sciences (MPS)

Social, Behavioral & Economic Sciences (SBE)

Education & Human Resources (EHR)

Budget, Finance & Award Management (BFA)

Information & Resource Management (IRM)

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# NSF Budget: FY 2015 and FY 2016

<table>
<thead>
<tr>
<th>(dollars in millions)</th>
<th>FY 2015 Plan</th>
<th>FY 2016 Request</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research &amp; Related Activities (R&amp;RA)</td>
<td>$5,934</td>
<td>$6,186</td>
</tr>
<tr>
<td>Education &amp; Human Resources</td>
<td>866</td>
<td>963</td>
</tr>
<tr>
<td>Major Research Equipment &amp; Facilities Construction</td>
<td>201</td>
<td>200</td>
</tr>
<tr>
<td>Agency Operations &amp; Award Management (AOAM)</td>
<td>325</td>
<td>355</td>
</tr>
<tr>
<td>National Science Board</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Office of Inspector General</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total, NSF</strong></td>
<td><strong>$7,344</strong></td>
<td><strong>$7,724</strong></td>
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2015 Total Federal R&D Budget for the United States ($135.4 billion)

- Defense $64.4 (47.6%)
- Energy $12.3 (9.1%)
- Commerce $1.6 (1.2%)
- NASA $11.6 (8.6%)
- NSF $5.8 (4.2%)
- All Other $8.6 (6.4%)
- HHS $31.1 (23.0%)

*Dollar Amounts in billions

NSF in Perspective

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The NSF identifies key research areas, with the advice of community experts.
NSF process

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• The NSF writes a solicitation for ideas.
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• Investigators (You!) write proposals.
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The NSF writes a solicitation for ideas.
Investigators (You!) write proposals.
The proposals are reviewed by special panels and/or by NSF program officers.
A proposal is either recommended for funding or declined.
GNU Radio Approach

**NSF Goals:**
- Encourage *active* Citizen-Astronomy research to answer important questions.
- Research process should be easy/fun/entertaining
- Equipment have be flexible design and have multiple applications
- Citizens should be able to innovate and improve research

**How?:**
- Community gets consensus on science targets and approach
- Writes proposals to address questions
- Best proposal(s) funded by NSF, Benefactors, and Citizens
- Citizens contribute to effort, equipment and discoveries

**Who?**
- You!

NSF

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Example Solicitations
Types of Crosscutting Activities

• International

• Interdisciplinary research – theme-based (e.g., Designing Materials, Hazards and Disasters)

• People-oriented (e.g., ADVANCE, CAREER, REU, Work-Life Balance)

• Infrastructure (e.g., MRI)

• Translational (ICorps, SBIR)

• Workshops
NSF Opportunities

Go to: www.nsf.gov/funding

Crosscutting and NSF-wide Active Funding Opportunities

This site provides program information for activities sponsored by more than one NSF organization. In addition, all NSF organizations accept proposals that cut across organizational and programmatic boundaries. We suggest that those seeking support for interdisciplinary work not described here consult the NSF program site(s) closest to the science, engineering or education focus of the planned work and contact relevant program officers to discuss submission of a proposal.

Org: Crosscutting and NSF-wide
Status: Active

Sorted by Title. Click column headings to sort.
Key: Crosscutting | NSF-wide | Grants.gov submission required

<table>
<thead>
<tr>
<th>Title</th>
<th>Program Guidelines</th>
<th>Due Dates</th>
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</thead>
<tbody>
<tr>
<td>Academic Research Infrastructure Program: Recovery and Reinvestment (ARI-RIR)</td>
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<td>ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers</td>
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<tr>
<td>Algorithms for Threat Detection (ATD)</td>
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Current but no longer receiving proposals
Letter of Intent: August 11, 2014
Full Proposals: September 22, 2014
Waiting for new publication
RAPID/EAGER

Grants for Rapid Response Research (RAPID)

- Severe Urgency
- Up to $200K/one year
- Brief project description
- Internal review

EArly-concept Grants for Exploratory Research (EAGER)

- Potentially transformative
- Up to $300K/one year
- “High risk-high payoff"
- Internal review

Rare but occasional external review

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INCLUDES

(Inclusion across the Nation of Communities of Learners that have been Underrepresented for Diversity in Engineering and Science)

Foundational pillar to:
- Foster community & stakeholder engagement
- Spur a national conversation to identify “bold visions” for broadening participation

Pilot studies for 2016/2017: Networks for STEM Excellence Empowering All Youth for STEM

To Launch in FY 2016

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Major Research Instrumentation (MRI)

**Goals:**

- Support acquisition of major state-of-the-art instrumentation
- Foster development of the next generation of major instrumentation
- Integrate research with education
- Use, advance, expand the nation's cyber-infrastructure and/or high performance computing capability
- Promote academic & private sector instrument development partnerships
Workshops and INSPIRE

Workshop support proposals can be submitted at any time
Can be recommended for funding by Program Officers, without external review, if under cost cap. Must be approved, like all proposals, by a division director.

INSPIRE: Integrated NSF Support Promoting Interdisciplinary Research and Education

INSPIRE pilot supports bold interdisciplinary projects in all NSF-supported areas of science, engineering, and education research. Complementing existing NSF efforts, INSPIRE was created to handle proposals whose:

Scientific advances lie outside the scope of a single program or discipline, such that substantial funding support from more than one program or discipline is necessary. Lines of research promise transformational advances.

Grant Opportunities for Academic Liaison with Industry - GOALI

Promotes university-industry partnerships
Supplies project funds or fellowships/traineeships
Supports eclectic mix of industry-university linkages

Encourages Research that lies beyond that which industry would normally fund solo
Radio Astronomy History

Radio Astronomers have been active in GNU Radio.

With GNU Radio, Marcus Leech, of Science Radio Labs, is particularly notable. He inspired me with his tutorial document entitled “A budget Conscious Radio Telescope”. Peter W. East improved on his hardware.

Haystack Observatory and the National Radio Astronomy Observatory have worked with “Aficionados” to build versions of the Itty Bitty Telescope and Small Research/Education Telescopes.

SETI League and Jim Sky have described horns to do basic research

Thanks to all off you who have made contributions!
Can you see our Milky Way?

Peter W. East’s data
Initial Foray with GNU Radio

• Test the sensitivity of low cost receivers. Need calibration to compare with National Facilities

• System needs to be inexpensive to allow many citizens to participate

• Need Documentation – Great GNU Radio volunteers

• Need software – GNU Radio!
Astronomy requires Calibration

- Built a horn, which allows calibration.
- Used Gnu Radio Companion to create a basic data recording system
- Used hot cold load tests to measure performance. Performance was **pretty good!**
- Wrote a memo. Documentation is needed for science to progress.
FIGURE 2: WAVEGUIDE FEED HORN AND ELECTRONICS BOX SHOWN IN PROFILE (LEFT), WAVEGUIDE IN POSITION FOR OVERNIGHT ASTRONOMICAL TESTS (CENTER) AND WAVEGUIDE HORN INVERTED FOR CALIBRATION MEASUREMENTS (RIGHT). IN THE LEFT AND RIGHT FIGURES A 48” RULER IS SHOWN TO PROVIDE SCALE.
FIGURE 4: TWO PANELS OF THE NSFRECORD SOFTWARE INTERFACE TO THE AIPSYPY HARDWARE. THE LEFT PANEL SHOWS THE WIDE-BAND SPECTRAL DATA AND RIGHT PANEL SHOWS THE OBSERVER NOTES, WHICH ARE ADDED TO ASCII RECORDED DATA.
FIGURE 6: CALIBRATED ASTRONOMICAL OBSERVATIONS OF THE MILKY WAY GALAXY MADE WITH THE HORN SYSTEM. THE PLOTS SHOW CALIBRATED SYSTEM TEMPERATURE MEASUREMENTS, CALIBRATED, IN UNITS OF KELVIN, VERSUS EMISSION VELOCITY, IN KM/SEC. THE PLOTS ARE COMPUTED FROM THE OBSERVATIONS PRESENTED IN FIGURE 5. THE UPPER, RED, CURVE SHOWS EMISSION IN THE GALACTIC PLANE, WHILE THE LOWER, BLUE, CURVE SHOWS THE EMISSION AT THE DIRECTION IDENTIFIED AS THE COLD LOAD REFERENCE. THE PEAK IN THE UPPER CURVE, NEAR 10 KM/SEC, IS GALACTIC HYDROGEN
Conclusions

The NSF provides opportunities for investigators, who write creative proposals, to address important topics.

The GNU Radio project is an important collaboration, with many talented researchers working together to build very capable systems.

Can your community of Engineers, Programmers and Scientists reach out to much larger communities, who want to become Citizen scientists?

Can your community gain consensus to put forward a compelling Astronomy research plan and proposal?
Thanks!

Contact the NSF

Ask Early, Ask Often!

glangsto@nsf.gov
Getting Started
The Essentials
Proposal Development Strategies:

Who Should You Talk To?
How Should You Contact Them?

**NSF Program Officer:** Glen Langston, glangsto@nsf.gov

- Your proposed project
- Clarifications on specific program requirements/limitations
- Current program patterns

**Your organization’s sponsored projects office**

- University guidelines for applications
- Institutional Review Board “IRB” Approvals (IACUC approvals, etc.)
What to Look for in a Program Announcement or Solicitation

- Goals
- Eligibility Requirements
- Special proposal preparation and/or award requirements
- Review Criteria
Navigating www.NSF.gov
Five Key Elements

1. Great idea
2. Fit with current research expertise and career development plans
3. Ability to devise a strategy including benchmarks, timelines, and metrics
4. Adequate resources to accomplish your project
5. Assessment Plan
Developing your Proposal

Key Questions for Prospective Investigators

• What has already been done?
• What do you intend to do?
• Why is the work important?
• How is the work unique or cutting edge?
• How are you going to do the work?
• Do you have the right team?
Proposal Development Strategies:

What Do You Need Besides $ ???

• Prepare to do the project
  – Realistically assess needs
  – Determine available resources
  – Develop preliminary data
  – Present to colleagues/mentors/students

• Determine possible funding sources
  (NSF may not be the right or the only one)