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TIPS ON WRITING PROPOSALS IN ASTRONOMY

Most resources (money, observing time, and computing facilities) in astronomy are **competitively awarded**. This means that all astronomers must become adept at writing proposals to secure those resources.

The current national budget to support research in astronomy is over $400K per astronomer per year (see this table), which sounds more than ample. But individual investigators can acquire direct control over only a small portion of that amount in the form of grants. Most of the funding supports the design, implementation, and operation of a set of **large, shared facilities** (e.g. the Keck telescopes, ALMA, HST), and access to these is awarded almost exclusively through a proposal process.

Most of the following tips apply to all kinds of proposal writing, but they are specifically aimed toward university personnel proposing to obtain **research grants** from federal agencies or access to major **national facilities** (telescopes, computers).

Probabilities

Success rates for proposals in astronomy currently are generally **small**: rarely better than 30% and in the more competitive cases, only about 10%.

For NSF research grants, success rates are currently in the 15-20% range.

Since a success rate more in the range of 30-50% would be much more healthy for the field, this is **not a good situation** and has gotten worse over the last 30 years. It is a consequence of the large number of people who have been attracted to astronomy over that time coupled with small growth in the federal budget for astronomy.

For intra-department observing proposals for time on our guaranteed-access facilities, the success rate is typically 80%.

Effort

Writing a good proposal is time consuming, and (obviously) the effort increases in proportion to the scale of the project involved. Some rules of thumb:

- NOAO or NRAO/JVLA observing proposals (2 opportunities per year) might require 2-4 person-days.
- Moderate-scale HST (say 25 orbits) or NRAO/ALMA observing proposals (1 opportunity per year) might require 4-8 person-days.
- Large-scale personal research grant from NSF (>$200K; 1 opportunity per year): 10-20 person-days.
- Large-scale projects (e.g. NASA spacecraft), with budgets up to hundreds of $M, require over a hundred person-days of effort, usually involving private contractors. Simply organizing such proposals is a major undertaking in its own right, and institutions must commit significant funds just to mount a proposal effort. Most such proposals will fail, of course.

A recent survey of effort versus success was published by Ted and Courtney von Hippel (2015), who found that the average research grant proposal takes 116 PI hours and 55 Co-I hours to write and that the primary predictor of success is having had previous success.

Advance planning

- **TIMING:** "Unsolicited" proposals can be submitted at any time, but the vast majority of proposal opportunities are "solicited." That is, a "Request for Proposals" (RFP) or an "Announcement of Opportunity" (AO) is circulated, and there is a specific submission date after which proposals will not be accepted. Major programs operate on a fairly predictable cycle, typically with 1-2 opportunities per year.

- **ALLOCATION DELAYS:** For most ground-based facilities, observing time is awarded starting about 3 months after the proposal deadline. For space missions, the delay might be 6-18 months. NSF and NASA budget flows cannot be counted on for at least 6 months after the proposal deadline and possibly significantly longer.

  All this implies that **you must plan ahead**. That is particularly true if your project depends on hiring new personnel or paying existing personnel. Note that the proposal/award cycle is usually **not in phase** with the national hiring cycle (which begins in the fall), and this can result in serious practical complications.

  The **duration** of grant awards normally runs from one to three years in astronomy. A few opportunities are for five years. In most cases, you can obtain a **"no cost extension"** of an existing award, which allows spending past the originally intended end of the project but with no additional funds. In a small percentage of cases, it may be possible to extend a grant with a modest amount of supplementary funds. For major projects, such as space missions, there are formal reviews regarding continuation or supplementation of funds.

- **CO-INVESTIGATORS:** Almost all contemporary projects involve a team: anywhere from 3 to 100+ people. You must **organize** your team before you start to write the proposal. Team meetings with members outside your institution are normally held by teleconference.

  Be sure you have a consensus among Co-I's concerning overall goals and strategy for developing the proposal **before** beginning to write.

  Note that there can be only **one** "Principal Investigator" (PI), who becomes the single point of legal/financial contact with the sponsor if the proposal is successful and who normally has prime reponsibility for writing and submitting the proposal.

- **LETTERS OF INTENT:** some programs expect you to submit a Letter of Intent several months before the proposal is due. This is simply a statement that you, and your listed Co-I's, intend to submit a proposal. The LOI normally carries no legal obligation. It is mainly used by the agencies to assemble panels of independent reviewers well ahead of the proposal deadlines.

- **ELECTRONIC SUBMISSION AND INFORMATION SYSTEMS:** Most opportunities now require electronic submission of proposals through special systems such as NSPIRES (NASA) or Fastlane (NSF). It's very important to

become familiar with the idiosyncracies of these well in advance of deadlines and to make **trial submissions**, assuming this is allowed.

For the major observatories, there are extensive **online resources** to help you plan your proposal (e.g. instrument handbooks and observation simulators). These are often dense, and you will find it advisable to set aside a week of time well ahead of the proposal deadline to become comfortable with the material and software.

- **BOILERPLATE:** A burden. Apart from the stuff that matters, you must normally provide brief CV's of all investigators, lists of previous successful proposals and resulting publications, a statement of existing grant support, investigator addresses, a list of cognizant university officials, your institution ID numbers, and so forth. Less reasonable demands can include lists of all your recent collaborators(!), drug-free certifications, data management plans, outreach plans, and more. Most of this material has little to no effect on the actual evaluation of the proposal, but it can't be ignored; and the problem is getting worse. A major time-sink: beware!

  One expected element that might appear to be "boilerplate" in NSF proposals --- but is not --- is the **"Broader Impacts"** section. This is mandated because of Congressional pressure on NSF to support only "relevant" research. Specifically: "The statement on broader impacts should describe the potential of the proposed activity to benefit society and contribute to the achievement of specific, desired societal outcomes." Details are given in the NSF proposal policies manual. This is taken seriously in proposal reviews, and a thoughtful effort here is strongly recommended. Ask for advice from colleagues.

- **BUDGET PREPARATION DETAILS:** Preparation is significantly more complicated if a budget is involved. If that's the case, your first step should be to acquire a good grasp of the details of your institution's policies on budgets: salaries, benefits, travel, F&A costs, restrictions on purchases, etc. There can be a steep learning curve here. On your first attempt, it is strongly recommended that you ask colleagues to see **examples** of budgets on successful proposals of similar scale from your institution.

  For UVa Astronomy Department budgeting guidelines on the department Wiki/Collab site, click here..

Budgets

- **AVAILABILITY:** Not all opportunities involve funding. Awards of observing time

on most ground-based facilities (supported mainly by NSF) do **not** carry associated funding awards, even for travel to the observatories. This is true for NOAO, Gemini, and most NRAO facilities. In order to obtain research funds to support work at those observatories, you must make a **separate** scientific program proposal to NSF. This is a **bad system** and has an unpleasant "double jeopardy" character.

One exception is for student observing projects at NRAO. Research supervisors are entitled to apply for "Student Observing Support Program" funds, which provide capped support for stipends, travel, and computer equipment during data acquisition and analysis.

Note that most of the leading astronomical journals require the author to provide **"page charges"** before papers can be published, so the general lack of funding support for ground-based observational programs is a serious impediment.

By contrast, observing time on most NASA facilities **does** carry associated research funding.

- **PRIORITY:** In most cases, budgets are of **secondary** importance in the success of a proposal. The **scientific justification is normally much more important**. Exceptions might be in the case of very ambitious programs, where the budget is a key feasibility criterion.

- **ESTIMATING:** Nonetheless, the budget is of primary importance in actually **doing the research**. You should ask for what you need. Don't skimp to impress an agency (because you won't) and don't assume your department will pick up any slack (because it won't, unless you have negotiated shared support in advance). Be sure that what you ask for is reasonable and well justified. A list of typical budget items is given below.

  It's better to slightly **over**-estimate than the converse. If the agency believes you have requested too much, it will negotiate a lower level with you; but you will never get more than you ask for.

  It's a good idea early in your career to become facile with using **spreadsheet programs**. Even simple budgeting can involve an array of possible configurations that you will want to explore within some outer envelope, and spreadsheets make that much easier. They cushion unanticipated last-minute iteration, too.

- **GOOD SENSE:** In cases where budget guidelines have been set in advance

by the agency, you clearly have to abide by these and **adjust the amount of work planned** accordingly. It is foolish to submit a proposal that seriously violates a funding limit or time scale which is explicitly stated in the RFP.

> If your budget comes in just slightly below a stated cap, you risk the impression that you have unrealistically cut corners and that you will not be able to produce what you claim.

- **UNIVERSITY APPROVAL:** Any submitted budget requires approval by your university. This takes time, and for inexperienced proposal writers it may require iteration. Allow **at least an additional week** for this. Normally, but not always, you can continue spiffing up the science justification while the budget is processed, as long as there are no changes to the budget requirements.

- **CO-I SUPPORT:** Primary funding for a successful project will usually flow through the PI's institution. External Co-I support may be passed through the PI institution, or it may be sent directly from the sponsor to Co-I institutions after separate sub-budgets are submitted by them. In many cases, the PI is expected to submit a consolidated funding proposal including all the details of Co-I support.

- **TWO-PHASE PROPOSALS:** Because of the hassle involved in preparing budgets and the low probability of success, it is (thankfully) more common now for agencies (e.g. STScI) to break the proposal process into two parts and to request budget submissions only from successful proposers. NASA missions may also separate the requirement for detailed targeting information and observing sequences into a "Phase II" submission. To minimize pain, some programs use a simple, non-negotiable funding allocation, based, for instance, on the number of observing hours you are awarded.

- **F&A WARNING:** Your institution will charge "facilities and administration" (F&A) costs to cover its general support expenditures on all external grants. (These used to be called "overhead" or **"indirect" costs** and can cover a broad array of items including office & lab space, utilities, support staff, Internet services, central administrative services, and so forth. They are re-negotiated by universities with government agencies on a regular basis.) F&A costs are charged as a **specific fraction** of the "direct" costs of a proposal and must be **explicitly included** (by you) as part of your budget. Since the total amount of grant funds available is capped, F&A charges effectively **reduce** the amount of money that can be used for actual research and over which you will have direct control.

  > At UVa, F&A charges have recently been in the range 50-60% of the

direct costs in the grant. At private universities, they may range up to 80-100%; in industry, yet higher. Some agencies restrict the size of F&A awards, in which case you will have to negotiate with your institution to be sure your budget is approved.

When you include benefits, travel, publications, and other incidental costs, and then apply the F&A multiplier for a postdoc salary, for instance, the amount you would have to request to fund a postdoc can easily be **double** the salary.

- **TYPICAL BUDGET ITEMS**: Agency and institutional expectations regarding budget formatting vary widely, so only general guidelines are given here. Budgets are normally broken out by year.

  Budget narrative: a general description/justification for the budget. For larger projects, you may have to supply a "work breakdown structure" -- i.e. a full list of task assignments for all personnel.

  Personnel: (list by category: PI, Co-I, student, postdoc, data tech, lab tech, clerical, etc.).

    Number people, person-months of effort, salary per month for each category

    Benefits: (health, Social Security, retirement, etc). Usually quoted as a percentage of salary, but depends on category of personnel.

  Travel: sometimes justification is required in nightmarish detail, especially for foreign travel.

  Student tuition

  Computing equipment and services

  Lab equipment and services

  Supplies (technical, lab, office)

  Telecommunications services (phone, Internet, etc.)

  Subcontracts for special services; in some cases this could cover external Co-I's

  Publications: estimated number of pages, publication charges per page,

special preparation costs, etc.

F&A Charges: entered as a percentage of total costs in all but a few excluded categories. [Note also that any item ostensibly covered by your institution's F&A charge cannot be included as a direct cost in your budget.]

Proposal Review

- **PEER REVIEW:** essentially all proposal review in NSF and NASA is by anonymous peer review, not by agency officials. The old "sweetheart" system, where a single agency grants officer decided on the award of funds, sometimes without any peer input, has faded away, except for a few corners of the government and private sectors.

- **COMPETITIVE REVIEWS:** Major solicited proposal programs, which can yield over 1000 proposals, now usually hold competitive reviews, where groups of 5-10 referees read each of, say, 50 proposals. Two reviewers are chosen to be "prime" or "secondary" reviewers on each proposal; they look more carefully at their proposals, write summaries, and record comments from the group. The whole committee meets and systematically compares the proposals to each other and to the available budget and produces a rank-ordered list of proposals to support. This system works surprisingly well, and produces the closest thing possible to an objective review (though you will not always think so).

  TRIAGE: the proposal burden is so large in many programs (e.g. HST), that "triage" is performed. Before the meeting, all reviewers skim each proposal and determine whether it is above the 30th percentile. Votes are collected remotely. Proposals below this cut are not considered further. Proposal titles, abstracts, Co-I lists, and illustrations are the most influential elements affecting the triage outcome.

  The burden on reviewers is now large enough that NSF, for instance, is considering whether to restrict the number of proposals that individual scientists can submit over a given period of time or concerning a given subject.

- **FEEDBACK:** Most, but not all, programs will give you feedback concerning the reviewers' opinions of the strengths and weaknesses of your proposal. This can be very useful in making improvements for the next round. Sometimes only small changes can produce success on the next iteration. Unfortunately, with a little experience, you will begin to detect a significant **random component** in proposal evaluation. This is human nature; grit your teeth and try again.

- **STRATEGIC IMPLICATION:** Given this atmosphere, you must design your proposal to impress harried reviewers who have only a **few minutes** to read each proposal and who are looking for **reasons to reject**.

Writing the Proposal

- **Never violate stated limits** on length, font sizes, number of figures, and so forth. Not complying with guidelines will not only annoy the more finicky reviewers, but in some cases it will result in **mandatory rejection**. If you can't present your case in the expected space, reviewers will think you don't know what you're doing. Likewise, never omit some piece of information or boilerplate you are asked to supply.

- A compelling proposal must be **clearly, persuasively, and concisely written** and must demonstrate:

    1. That the questions you are asking are **important and interesting**;
    2. That the program is technically **feasible**;
    3. That you are **competent** to execute it; and
    4. That it will provide a **definitive answer** to the questions posed.

- Write for people who are generally well informed but who are **not specialists** in the field. Clearly explain the main issues. Be sure to define all acronyms and abbreviations. Place in the larger context. Make sure claims for importance or uniqueness are defensible; don't exaggerate.

- Keep it **short and clear, clean and uncluttered**:

    Remember that it is not easy to be simultaneously informative and terse. *"...Writing briefly takes far more time than writing at length."* (Carl Friedrich Gauss).

    Use subheadings, short paragraphs, topic sentences, large fonts.

    Don't present barely digestible blocks of text. Don't crowd text.

    Minimize use of multiple font types, but do use bold face (sparingly) to highlight key points.

    It's normal and unobjectionable to adopt a compressed style for literature citations in a proposal to save space. But be sure to include the important literature, because its authors could easily be on your review panel!

- **Put key points up front**. Don't make the reviewer read to the 10th paragraph before you state what you're planning to do.

- Work hard to be sure the **abstract captures all the key points** clearly and succinctly and in good prose style. The reviewers' first (and in some cases, only) impression will come from the abstract.

- Be sure you have considered all the possible **weaknesses** in the proposed work and have implicitly responded to those issues and to common misapprehensions about your subject. Your Co-I's are a good resource here.

- **Don't waffle**: where ambiguities exist, state clearcut choices and how you intend to resolve the issues involved.

- **Illustrations** (images, plots) can quickly clarify issues for the reader. They add interest and "tangibility" to the project. They can represent nice summaries of your earlier work on the topic. They can substitute for lengthy text. **Strongly recommended.**

    Note that figure captions can use smaller fonts---a good way to squeeze in a little extra information.

    You can include color figures in proposals if your RFP allows it. Many reviewers will read your proposal electronically from a PDF file and will see the color versions. But some prefer to read from a hardcopy and may not care to use a color printer. It's best if you adjust figures so they will be easily interpretable if viewed in greyscale. Be sure figures are reproduced at an easily viewed scale.

- Especially for your earlier efforts, ask colleagues to **review** the proposal and offer suggestions for improvement. Do this far enough in advance of the deadline to accommodate major changes, if needed. In larger teams, assign a couple of Co-I's to be responsible for a full, critical review of the writeup, but be sure to circulate drafts to the whole team.

- Essential: **proofread line by line from paper**, not a computer screen. Try to put yourself in the mind of a skeptical/harried reviewer as you read. Always **spell-check**.

- Leave yourself sufficient reserve to be sure you can submit comfortably ahead of the **deadline**. Beware last minute computer glitches. Competition is so heavy for the large programs that the submission deadline is usually a hard (electronic) cutoff.

Advice for Graduate Students

Practice! Get experience writing proposals before you leave the shelter of grad school. Write the observing proposals for your thesis research in collaboration with your advisors. Volunteer to help with their larger grant proposals as appropriate. The more exposure you get to the process, the better.

Web links

Federal Budget for Astronomy, 2016

UVa Astronomy Department Info on Grant Preparation (Collab login required)

NSF 1995-2016 Budget Breakout

NSF 2011 Budget Breakout (detailed)

NSF Projected Budgets (to 2019)

NSF Proposal Policies Manual

NASA 2016 Budget Request & Projections

NSPIRES (NASA proposal submission/info site)

FastLane (NSF proposal submission/info site)

O'Connell's Tips for Success in Observational Astronomy

O'Connell's Tips on Writing CVs

Susan Finger advice on writing proposals for NSF

Julianne Dalcanton advice on writing observing proposals

A "perfect" 2-page proposal that inaugurated an entire field of astronomy (from *Physics Today)*

ASTR 8500 (Sp 16) course on professional development for graduate students

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*Last modified **July 2017** by rwo*