THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

Writing Grant Proposals

Frontiers & Careers 2022

Evangeline J. Downie

Award:
PHY-2012940

Why Write Grant Proposals?

- Highly persuasive evidence of qualification for future faculty
  - Tenure is typically dependent on funding
- Also: applying for “small” grants will assist when applying for larger ones ☺ - no grant is too small!
  - Internal grants, fellowships, conference proposals etc.
- Grant management is evidence of:
  - Communication skills,
  - Budgeting planning and execution (if successful)
  - Project management
- Whatever your future, successful grant proposals will help!

How to Write Grant Proposals

Audience:

Who are you writing for?

What are they seeking to support?

How will they be evaluating your proposal?

Purpose:

Why this science?

Why this method?

Why now?

Why you?

Why here?

You need to build a convincing argument

Every part of your proposal should be working towards that aim!

Where to Begin

- Seek out information on funder:
  - *Who are they, what is their mission?*
  - *What kind of things have they funded before?*
  - *What are the typical funding levels / are there fixed funding levels?*
  - *Do I know anyone who has applied successfully before?*
- Read the FOA (Funding Opportunity Announcement) carefully:
  - *Which format / documents are required?*
  - *What are allowable expenses etc.?*
  - *What are the review criteria?*
- Check with your institution:
  - *Do you need / how do you get permission to submit a proposal? – may have to route through e-approval system*
  - *What documents and information are needed?*
  - *Are there assistance / resources available to you?*

Think About the Science, Write the Budget

- The science you can do will be limited by a finite budget
- Look at previous award amounts / the FOA for reasonable award levels
- Learn about institutional requirements: Overhead / IDC* – rates; fringe rates; minimum salaries etc.
- Put in everything you think you need, justify it carefully in the budget justification
- Don’t under-estimate, the cheapest option may not always be viable
- Make sure your budget and justification accord with the proposal narrative

*IDC = Indirect Costs – costs to cover things not directly attributable to a single project, but generally needed to perform grant-supported research

Budgeting Tips

- Seek advice / examples from:
  - Experienced principal investigators (PI)
  - Pre-award grant administrators
  - Department chairs / supervisors
- Some financial rules / policies are common and some vary by agency
- The budget should be realistic, well-motivated and support your science narrative (don't budget too tightly)

Example:
NSF allows broad latitude to move funds between budget categories that exist within your grant budget: fill as many plausible grant categories as possible, even with small amounts. DOE does not allow easy changes, so try to predict more closely what and how much you would need to spend

Other Documents

Submission Errors and Warnings Collapse

The following error(s) must be fixed prior to **submitting the proposal**.

Project Summary
- The Project Summary has not been provided and is required before submission

Project Description
- The Project Description has not been provided and is required before submission

References Cited
- The References Cited has not been provided and is required before submission

Budget(s)
- An Individual(s) identified in the senior personnel category needs months and funds entered for at least one year. Please remove them from the budget if you will not be requesting funds for them (George Washington University)

Budget Justification(s)
- The Budget Justification(s) has not been provided and is required before submission (George Washington University)

Facilities, Equipment and Other Resources
- The Facilities, Equipment and Other Resources has not been provided and is required before submission

Biographical Sketch
- The Biographical Sketch has not been provided for Evangeline Downie and is required for each Senior Personnel before submission

Current and Pending Support
- The Current and Pending Support has not been provided for Evangeline Downie and is required for each Senior Personnel before submission

Collaborators and Other Affiliations
- The Collaborators and Other Affiliations has not been provided for Evangeline Downie and is required for each Senior Personnel before submission

Data Management Plan
- The Data Management Plan has not been provided and is required before submission

Other Documents

- Many more documents than just proposal summary and narrative, examples include:
- **Facilities, Equipment & Other Resources:** What resources and facilities are available to you? Are they sufficient for the planned research. *Note: this is where you can include in-kind contributions for NSF applications.*
- **Biographical Sketch:** What are your qualifications and past work? Are you capable of what you are proposing?
- **Current & Pending Support:** What other projects are you involved in? Do you have enough bandwidth to do this?
- **Collaborators & Other Affiliations:** Who cannot review your proposal?
- **Data Management Plan**: How will you secure and share data created?
- **Postdoctoral Mentoring Plan** *(if funding a Postdoc)*: How will you help your postdoc's professional development and career progression?
- Start these documents early & check if your institution has standard text / resources
- Be aware that some have special requirements / software that can be finicky (SciENcv etc.)
- Use these document to help create a coherent package which supports your application

Be Aware of National / International Funding Priorities

- Read the relevant sections of:
  - The NuPECC Long Range Plan: http://www.nupecc.org/?display=pub/publications
  - The NSAC Long Range Plan: https://science.osti.gov/np/nsac
- Participate in / watch recorded funder webinars
- Speak with past / current awardees
- Speak with Program Officers / people who have served as reviewers (conferences are important ☺)
- Demonstrate how the proposal fits within these priorities

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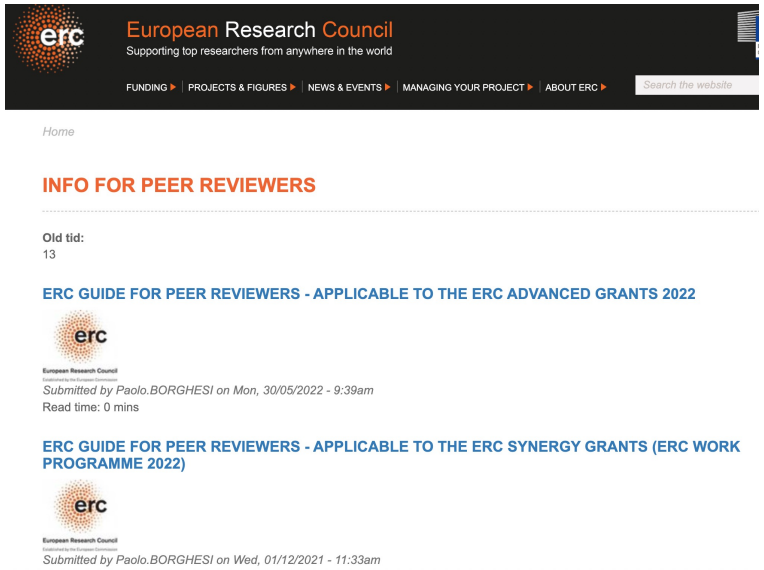
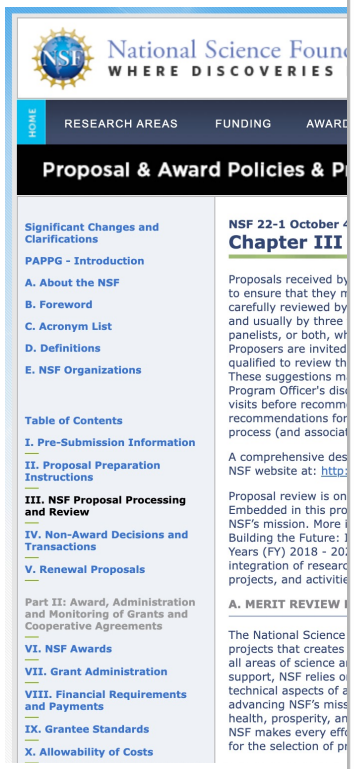


Review Criteria: Address Them Directly

- Large agencies tend to publish them, look for reviewer instructions
- Solicitation-specific criteria are included in the FOA
- Frequently harder to find for smaller funders
- Organize proposal to make the answers to the review questions obvious



When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit**: The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts**: The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to:

   a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and

   b. Benefit society or advance desired societal outcomes (Broader Impacts)?

2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?

3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?

4. How well qualified is the individual, team, or organization to conduct the proposed activities?

5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Review C
Address
Directly

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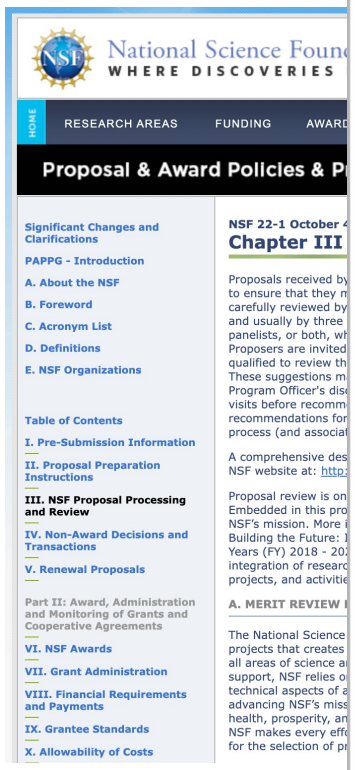

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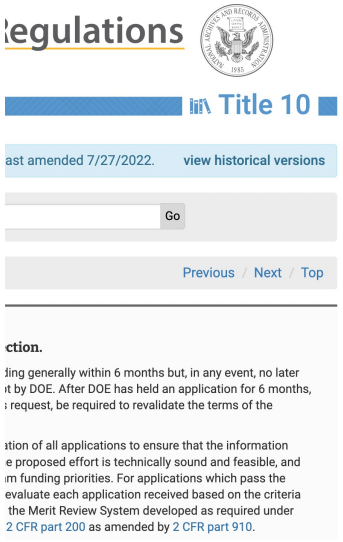

Review C
Address
Directly

Biosketch

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Facilities & Other Resources

Empathize With Your Reviewers

- Reviewers are reviewing multiple proposals
- Under time pressure (and frequently cabin pressure ☺)
- Make review easy:
  - ✓ *Directly address and answer review criteria*
  - ✓ *Highlight key sentences*
  - ✓ *Clear section headings*
  - ✓ *Judicious use of whitespace*
  - ✓ *Use color to highlight titles etc.*

PROJECT SUMMARY

The components of protons and neutrons: quarks and gluons, are held together by the strong force which is described by the theory of Quantum ChromoDynamics (QCD). At large energies or small distances it is possible to exactly calculate QCD, but at the distance scale of the nucleon such calculations are unattainable due to the strength of the binding in this "non-perturbative" region. As such, the NSAC Long Range Plan identifies the understanding of the internal landscape of the nucleon as one of the key questions of Nuclear Physics. The proposed program directly addresses this issue, producing **intellectual merit** by providing a new, systematically different, measurement of the proton scalar polarizabilities and the first ever individual experimental extraction of the four, as yet unmeasured, spin polarizabilities of the proton. These fundamental parameters characterize the internal structure and binding of the nucleon, enhancing understanding of QCD. Nucleon polarizabilities have wide application and therefore **broader physical impact** in fields of physics and astronomy as diverse as making appreciable corrections to the Lamb Shift in atomic physics and determining the properties of neutron stars.

Polarizabilities are parameters which describe the response of a medium to an external electric or magnetic field. They are commonly measured for macroscopic samples in other disciplines in order to characterize bulk materials, and give information on the "stiffness" of the internal structure and binding of an object. Determination of the nucleon polarizabilities is extremely challenging, requiring nucleon-scale electromagnetic fields and response measurement.

The polarizabilities will be accessed experimentally through their influence on beam and target polarization asymmetries measured in Compton Scattering ($\gamma p \to \gamma' p$). The experiments will be performed at MAMI (Mainz, Germany), with the CB detector system (a continuous-energy, tagged Bremsstrahlung photon beam of up to 1.5 GeV with highly segmented 4π detector coverage) and at HIGS (TUNL, Durham) with HINDA (a monoenergetic photon beam of up to ~100 MeV with eight large-volume, actively-shielded NaI detectors). This provides a pair of overlapping, systematically very different, data sets over a wide kinematic range, thereby minimizing both systematic error and model dependence in the final extraction of these fundamental parameters.

Measurement of the vector polarizabilities of the nucleon, although of great theoretical interest, was previously not experimentally feasible due the small signal cross section and the dominant background processes. The recent advent of highly polarised frozen spin targets capable of combination with extremely large solid angle detector systems and high flux photon beams make this unique experimental program possible. The scalar polarizabilities have been previously measured, but new theoretical studies suggest a proton magnetic polarizability twice as large as the accepted value. This project is therefore very timely.

Broader Impacts: The development of the necessary active polarised target is cutting-edge technology of key use in many future experiments, such as threshold π^0 photoproduction. The knowledge gained in the experiments will be transferred through peer reviewed publications and presentations at conferences, inspiring and informing others. Young doctoral and postdoctoral scientists will be trained and involved in the supervision and engagement of undergraduate students in international physics research, bringing both personal and professional development for all involved. The PI will ensure a widened understanding of nuclear physics, and this research in particular, through a program of school talks and science shows. Socio-economic and gender diversity in Physics will be actively promoted through the example of a new, internationally active, enthusiastic, well-qualified and communicative female assistant professor.

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Investigating the Nucleon with Electromagnetic Probes

Project Summary

Overview: The majority of visible matter is composed of protons and nucleons, collectively known as nucleons. We can describe the collective, bulk properties of nucleons, and one can now even reliably predict the energy levels of light nuclei using effective field theories. However, there remain challenges to our understanding of the nucleon. In 2010, a measurement of the radius of the proton was made using muonic hydrogen: it proved to be the most precise experimental determination of the proton radius ever made, but was massively inconsistent with the accepted value at that time. This became known as the Proton Radius Puzzle (PRP). Since its inception, many physicists have tried to resolve the PRP, to no avail. MUSE (the MUon proton Scattering Experiment) will make the world's first measurement of the proton radius via elastic muon scattering at a precision which can address this 4% radius discrepancy.

In addition to determining the radius of the proton, and addressing many of the proposed causes of the PRP, this proposal will address the leading cause of theory uncertainty in the extraction of the proton radius: nucleon polarizabilities. Polarizabilities are parameters which describe the response of a medium to an external electric or magnetic field. They are commonly measured for macroscopic samples in other disciplines in order to characterize bulk materials, and give information on the "stiffness" of the internal structure and binding of an object. Determination of the nucleon polarizabilities is extremely challenging. These fundamental parameters will be accessed through their influence on beam and target polarization asymmetries measured in real Compton scattering (RCS), ($\gamma N \to \gamma' N$) at two very different facilities in the USA and Europe.

Intellectual Merit: MUSE will make simultaneous measurements of elastic μ^-/e^- and μ^+/e^+ scattering on the proton. By comparison of both charge states, MUSE will make a direct measurement of two-photon effects in muon and electron scattering, a postulated cause of the PRP. By simultaneously measuring muons and electrons in the same experiment, MUSE can extract any radius difference between muon and electron measurements with minimal systematic error. The MUSE apparatus was recently constructed, and is ready for data-taking. This project would support twelve months of measurement, spread over two years, and the data analysis necessary to potentially resolve the underlying cause of the PRP.

The RCS program will provide a set of overlapping, systematically very different, RCS data sets over a wide kinematic range, thereby minimizing both systematic error and model dependence in the final polarizability extraction. This data will significantly enhance the world database for RCS on the proton, ^{2}H, ^{3}He, and ^{4}He, leading to improved extraction of the polarizabilities of protons and neutrons.

Together, these measurements provide potential resolution of the PRP, and a clean test of theoretical models of nucleon structure and behavior as detailed in the 2015 NSAC Long Range Plan. In so doing, they help us to understand the individual characteristics of the nucleon, the building block of all matter.

Broader Impacts: The knowledge gained in the experiments will be transferred through peer reviewed publications, presentations at conferences, and public lectures, inspiring and informing others. Young doctoral and postdoctoral scientists will be trained and involved in the supervision and engagement of undergraduate students in international physics research, bringing both personal and professional development for all involved. All aspects of diversity, equity, and inclusion in physics will be actively promoted through the example and efforts of an internationally active, enthusiastic, well-qualified, and communicative female professor, who is currently the National Organizing Committee Chair of the APS Conferences for Undergraduate Women in Physics.

1

At what level should you write?

Select proof-readers to match your reviewer audience!

Check **review procedures / funder webinars** to establish **who** you are writing for

NSF / DOE / etc. standard grant: discipline specific experts – can be more technical

NSF / DOE / etc. broader grant such as CAREER / INCLUDES… : broader panel of experts, not so field specific, avoid field-specific jargon

Foundation Grant / Institution Internal Grant: typically field-adjacent reviewers, or foundation staff – more general explanation & motivation

Writing the Science Narrative

- Start very early!!! Leave plenty of time for review / revision
- Plan a section outline: where will you answer each review question?
- Start writing, and keep writing even if you “go long”, you should write then cut
- Add relevant diagrams to break up text and convey information
  - Presenting timelines, management structures etc. in diagrams makes information easier to digest
- Use whitespace / color / (bold / italics, sparingly) to make the proposal easier to parse and to highlight important things

Writing Style & Structure

- Follow the formatting rules!!!!!!!!!!!!!
- Summarize the main background and aims in the introduction
- Write in short, uncomplicated sentences
- Language should be smooth and easy-to-read (avoid repetition of words or phrases)
- Proofreading: use both experts and readers more distant from the project
- When cutting, eliminate everything that does not build your argument
- Thoroughly spell- and grammar-check your proposal
  - Bad grammar and challenging presentation make it harder for the reviewer to find the arguments to support your proposal (or make reviewers very grumpy ☺)
- Ensure you have referenced appropriately & check references
  - Esp. think about potential reviewers – ensure you have referenced their relevant work!
- Typically use (almost) all (but not more!) of the allowed page limit

Writing the One-Page Summary

- Single page summary is crucial!
- **Not** simply a copy of the introduction
- Should convey major motivation, project & review elements
- Makes first impression on the Program Officer / Reviewer – make sure it indicates the seriousness and care with which you view the science
- Helps Program Officer select reviewers

Summary

What precisely are **you** doing?
Why are you doing it?
Why this method?
Why now?
Why you?
Why here?

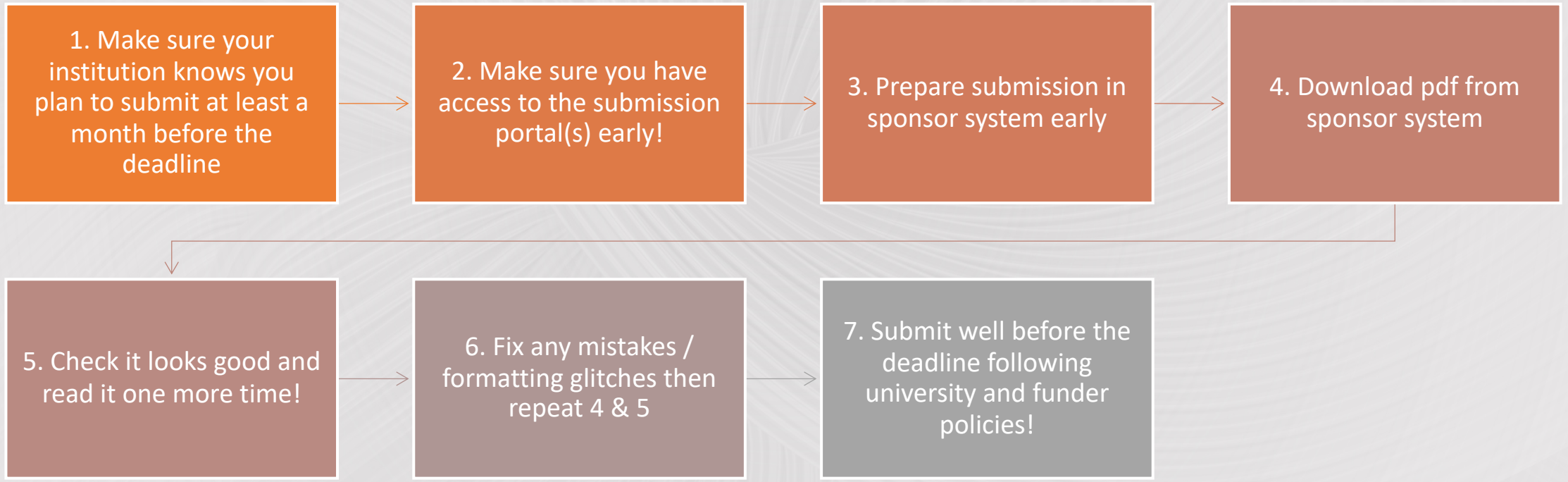
(Note: For NSF headers with "Intellectual Merit" & "Broader Impact" are required!)

Source: Pinterest

Cutting

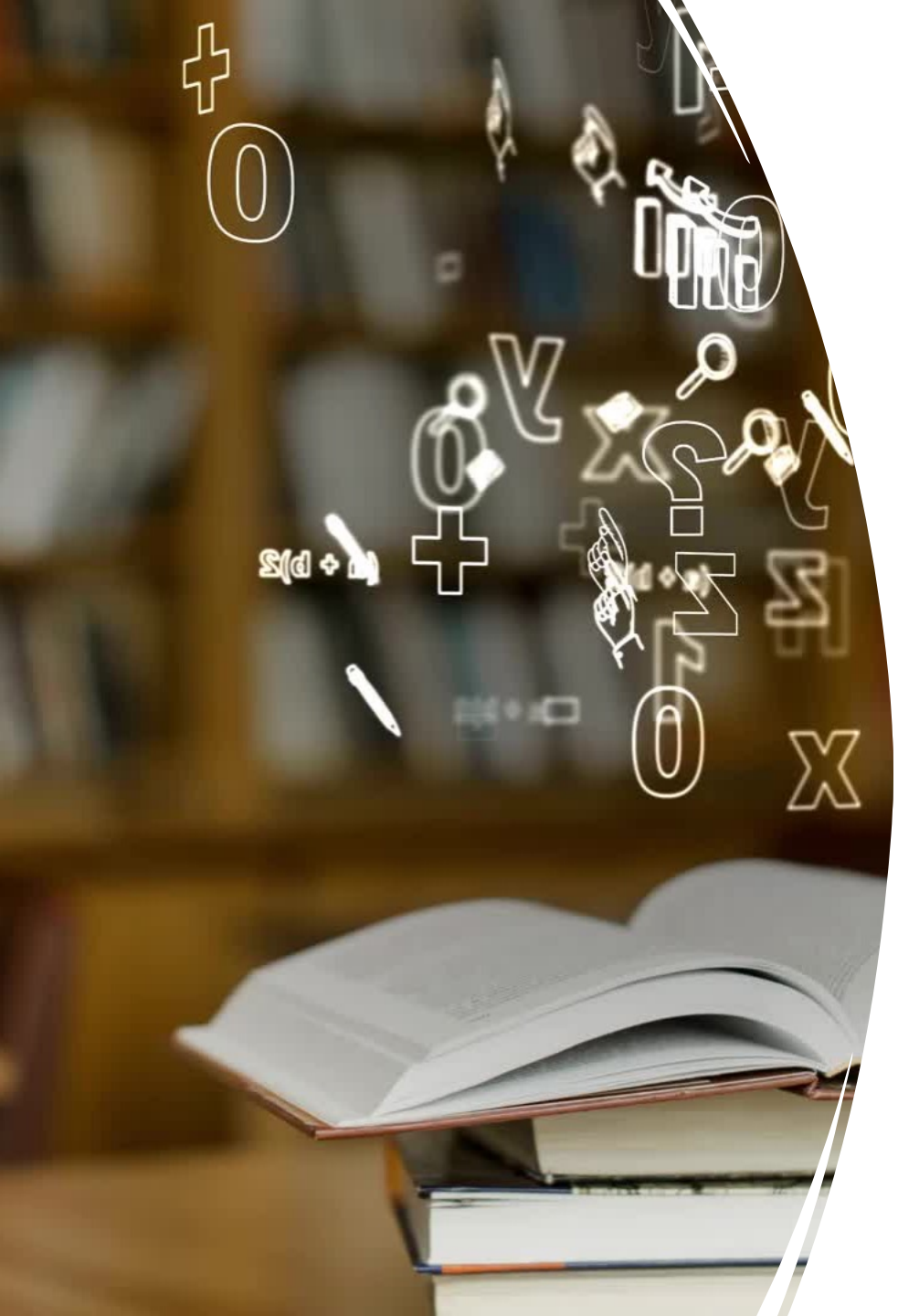
- Technical tips:
  - Look for paragraphs with half-lines at the end
  - \vspace{-20mm} is your friend! (But don't remove all whitespace!)
- Be merciless: cut everything which does not directly build the case / answer the review questions
- Put detail in other supporting documents, single sentence summary & ref. in body text:
  "We have access to a state-of-the-art detector lab, as described in Facilities & Other Resources."
- After cutting, use more distant proof-reader, supplied with review criteria, to look for missing / superfluous / confusing information

Submission


1. Make sure your institution knows you plan to submit at least a month before the deadline
2. Make sure you have access to the submission portal(s) early!
3. Prepare submission in sponsor system early
4. Download pdf from sponsor system
5. Check it looks good and read it one more time!
6. Fix any mistakes / formatting glitches then repeat 4 & 5
7. Submit well before the deadline following university and funder policies!

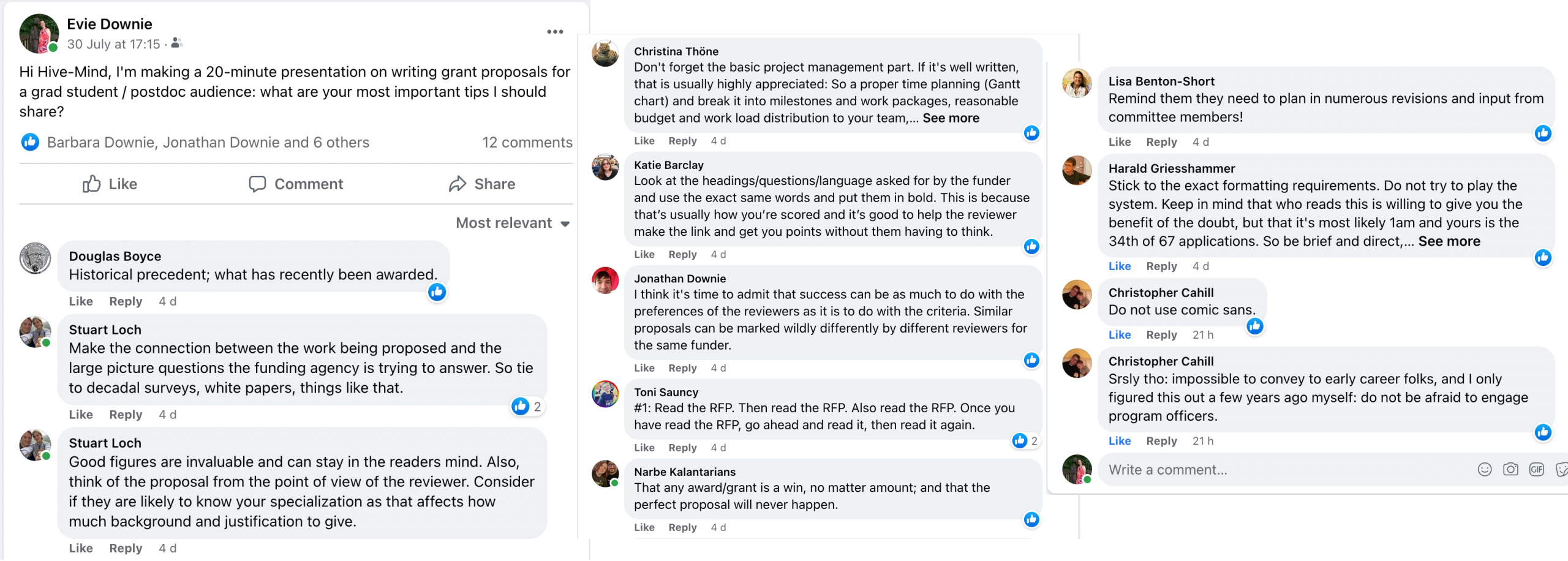
Anticipation & Results

- Review can take from weeks to ~6 months (sometimes longer)
- After science review complete, budget / admin can delay announcement of results
- When results come, read the substance of the reviews
- If successful, immediately notify your institution so they can guide you through award setup
- In unsuccessful this time, use substance of the reviews to strengthen your next submission / project design, don’t be discouraged or take it personally, there is far more great physics than physics money!
- Never give up! Keep trying!



Final Thoughts

- Grant-writing is hard, but rewarding work
  - Helps you think through your science and prioritize
  - Crucial evidence of many valuable skills
  - Gives you money to do awesome physics
- Start early & use every source of information & resource available to you: FOA, webinars, past award information, past awardees, funding officers, institutional grant-writing support etc.
- Be peer-reviewers for each other, giving critical and constructive feedback
- Volunteer to serve as a reviewer / panelist to gain more insight



Advice from some Physicists, Astronomers, Chemists, Translation & Interpreting Gurus, Geographers, & Historians of Emotion!

Thank you for the invitation, and to all the funding reviewers over the years, and to many kind peer-reviewers!

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