Establishing the need for Major Research Instrumentation

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The need for Major Research Instrumentation

- What are major instruments – NSF vs. PI perspective
- Three “needs” (considerations for developing the proposal).
  - Scientific
  - Broader Impact
  - Institutional
- Case studies:
  - “**Acquisition** of a stereoscopic particle image velocimetry system for dusty plasma studies”
  - “**Development** of a magnetized dusty plasma device”

What is "Major Research Instrumentation" – NSF perspective?

- The MRI Program is intended to assist with the **acquisition** or **development** of research instrumentation that is, in general, **too costly and/or not appropriate for support through other NSF programs**.

- Can be for a **single instrument** or for equipment that when combined serves as an **integrated research instrument** (physical or virtual).

- The MRI program **does not support** the acquisition or development of a suite of instruments to outfit research laboratories/facilities or to conduct independent experiments simultaneously.

- **Integration is the key feature of MRI proposals**.

What is "Major Research Instrumentation" – PI perspective?

- Research impact **MUST** be the key focus of all MRI proposals.
- Proposals **MUST** clearly demonstrate how the new instrumentation will impact (*transform*) current research activities and/or enable new research directions.
- Educational contributions are part of the broader impact – projects should NOT solely focus on equipping a teaching laboratory.
- However, demonstrating how the instrumentation positively impact both research and education IS an important feature of the proposal.
- **Integration is the key feature of MRI proposals.**

Establishing the scientific need for MRI funding

- **Scientific need 1**: most important feature of the proposal:
  Maps to: "Research Activities to be Enabled" (9 pages acq. / 4 pages dev.)

  - What are the current research capabilities – yours and your field?
    - What is the current baseline for experiments in your scientific field?
    - What is the current baseline for experiments in your laboratory?
    - What scientific information are you currently lacking?
    - Why is this information important to your laboratory / field?

  - What new research capabilities will be created by the instrument?
    - Are there new experimental parameter regimes that will be accessible?
    - Are there improved measurement capabilities – e.g., speed, reproducibility…?
    - Will there be enhanced spatial or temporal resolution?
    - Will new theoretical / computational models be tested by the new instrument?

Establishing the scientific need for MRI funding

- **Scientific need 2**: most important feature of the proposal:
  Maps to: "Research Activities to be Enabled" (9 pages acq. / 4 pages dev.)

  - Why is your laboratory suited to obtain this new instrument?
    - How will your laboratory integrate the new instrument into its existing infrastructure?
    - What skills / capabilities does your laboratory have to support the new instrument?
    - What new scientific contributions will your laboratory be able to make because of this instrumentation?
    - Who in your laboratory and/or field will be impacted by the measurements obtained by this instrument?

Establishing the scientific need for MRI funding

- **Scientific need 3**: most important feature of the proposal:
  Maps to: "Description of the Research Instrumentation and Needs"
  (2 pages acq. / 6 pages dev.)

  - What specifically will this instrument do?
    - What are the specific capabilities of the instrument?
    - How does this **specific instrument** help your laboratory accomplish its scientific mission; i.e., why this one instead of some other?

    - **For development proposals**: an extended discussion of the design methodology, expected new capabilities that will arise, etc.?

Establishing the broader impact "need" for MRI funding

- **Broader impact need**:
  Maps to: "Impact on Research Training and Infrastructure" (2 pages)

  - Who will make use of this instrumentation?
    - Will students, post-doctoral researchers, outside researchers have opportunities to use the instrument?
    - How will these personnel be trained to use the instrument?
    - How will the instrumentation be used to broaden participation to groups historically under-represented in the sciences?

Establishing the broader impact "need" for MRI funding

- **Broader impact need**:
  Maps to: "Impact on Research Training and Infrastructure" (2 pages)

  - Special **caution:**
    - *Proposals requesting **over $2 million** must address the potential impact of the instrument **at both the National level and on the research community of interest**. Concrete plans for enabling access by external users (including those from non-Ph.D. and/or minority-serving institutions) through physical access and/or cyberinfrastructure must be presented, and the uniqueness of the requested instrumentation must be described.*

Establishing the institutional "need" for MRI funding

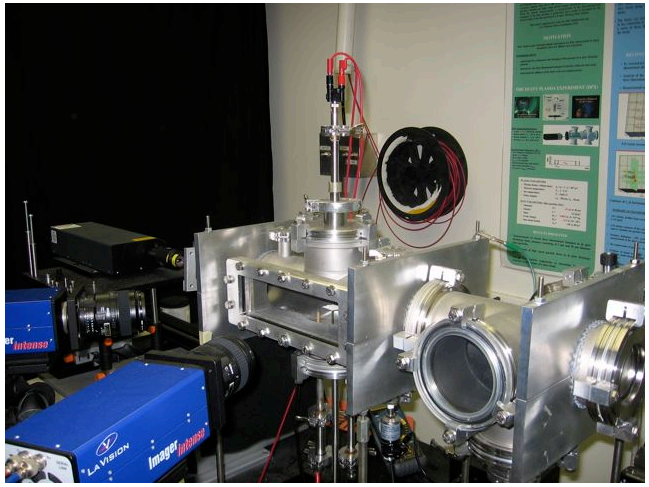
- **Institutional need**: the forgotten part of MRI proposals
  Maps to: "Management Plan" (2 pages acq. / 3 pages dev.)

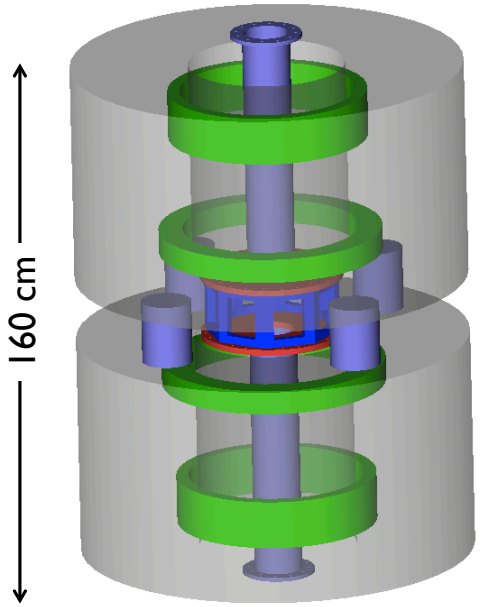
  - What is the relationship between the instrument and the university?
    - Where will the instrument be housed?
    - Does the facility have the necessary infrastructure to support the instrument (space, electrical power, HVAC, network capabilities, chilled water, etc.)?
    - If not, how will the organization provide for this infrastructure?
    - What long-term organizational resources are needed to support the instrument and where will these resources come from (e.g., expendables such as LN_2)?
    - How will the instrument be maintained and where will the funding come from to support maintenance and upgrades?
    - How will the university be impacted by having this instrument (leadership, prestige, etc.)?

MRI experiences:

- "**Acquisition** of a stereoscopic particle image velocimetry system for dusty plasma studies", PHY-0216421, 2002, $150k ($105k + $45k)

- "**Development** of a Magnetized Dusty Plasma Device", PHY-1126067, 2011, $2.1M ($1.488M + $653k)





Need for Stereo-PIV system (MRI acquisition):

Why us?

- Scientific
  - PI's group was the first to develop and apply 2D PIV to dusty plasmas
  - 2D PIV approach provided valuable information on transport, but limited to laser sheet plane.

New Science

- Stereo-PIV offers full three-dimensional velocity reconstruction.
- Enables potential to measure velocity distribution function.
- With distribution function, can obtain information on thermodynamic state of the dusty plasma.

Instrument features

- Stereo-PIV hardware had 2x improvement in spatial resolution compared to 2D PIV system.
- Improved calibration technique that provides auto-calibration of images.

Need for Stereo-PIV system (MRI acquisition):

- Broader impact
  - PI's group had a track-record of incorporating undergraduate students into dusty plasma research – including undergrad co-authors on papers.
  - Undergrads and grad students tasked with building support hardware and then operating the stereo-PIV system.
  - We offered to use 2D PIV system as a "traveling" diagnostic for other laboratories.

- Institutional impact
  - AU has +20 year record of plasma science research
  - Maintain leadership in a novel area of plasma science research
  - Opens new opportunities for collaborations at national labs and other universities – i.e., new funding opportunities.

Need for Magnetized Dusty Plasma Experiment (MRI Development):

Why us?

- Scientific
  - A 3-year community effort, led by PI's, to build consensus for the need for a unique, next-generation, multi-user device
  - Builds on knowledge-base of existing labs and exceed their capabilities

New Science

- First studies of waves in magnetized dusty plasma.
- Extensive new studies of para-, ferro- magnetic dusty plasma systems
- New studies of charge screening effects parallel and perp to magnetic field

Instrument features

- First extended device with over 10x larger plasma volume that previous ones.
- Potential for direct imaging of nanometer sized particles.
- Independent superconducting coils -> extensive magnetic field shaping
- Extensive use of cyber-infrastructure including remote operation

Need for Magnetized Dusty Plasma Experiment (MRI Development):

- Broader impact
  - Research team includes national and international researchers – PhD and undergrad schools, national labs, industrial partner
  - Incorporates plasma, astrophysics, fusion, engineering
  - Partner with national lab on education and outreach

- Institutional impact
  - Establishes a new, one-of-a-kind research instrument – a national and international multi-user experiment.
  - Enhance scientific leadership in a research field.
  - Auburn hiring a new faculty member, technical staff to support project, release time (part of cost share).
  - Auburn committing additional $250k (above cost share) to build a new laboratory facility.

Establishing need: MRI lessons learned

- Know your local audience:
  - Is there an internal “competition”?
  - Who will be reviewing the internal competition?
  - What is the timing of this competition?
  - When do you need to begin negotiations for cost sharing?
- Language: what is important to NSF may not always be important to the internal competition!
- Commitment: Criticism of a project can be good, if you use it to strengthen the proposal!

Results from MRI-2010 – Panel Summary (not awarded)

The reviews were generally quite supportive of this MRI proposal. The ratings received were **3 E's, 4 VG's & 1 G.**

All reviewers thought the area of magnetized dusty plasmas to be important and of fundamental scientific interest, and some noted it was relatively unexplored, thus adding to their level of support for the project. All felt that this proposed multi-user, multi-institutional user facility would be the first of its kind in the US and truly world class. Most reviewers also felt the team of PI / Co-PIs to be very solid, each with a well established track record. A few of the reviewers thought that more should have been said about the other fields where the research would have an impact (e.g. fusion plasmas & astrophysics) and more done regarding outreach to such non-dusty plasma communities.

The broader impacts were noted by the reviewers to include the reach to a national and international cadre of researchers, training of students, and the broad diversity of the fields that the enabled research would influence.

On balance, the reviewers supported funding this proposal, based upon its intellectual merit and broader impacts. The panel agreed, recommending "Fund if Possible" for this proposal.

Results from MRI-2011 – Panel Summary (awarded)

This MRI project proposes the development of a new multi-user experimental research instrument -- a magnetized dusty plasma device -- that will enable laboratory investigations of phenomena relevant to plasma physics, astrophysics, and soft condensed matter physics. The focus of the research that would be enabled by this instrument would be to address the following questions: 1) As a dusty plasma is taken from an unmagnetized system through a progression of regimes where first the electrons, then the ions, and then charged microparticles become magnetized - how do the structural, thermal, charging, and collective properties of the system evolve? 2) If a dusty plasma is composed of microparticles that have paramagnetic or ferromagnetic properties, how do the properties of the dusty plasma evolve in the presence of uniform and non-uniform magnetic fields?

The reviews were quite supportive of this MRI proposal. The ratings received were **2 Es, 1 E/V & 2 Vs**. All reviewers thought the area of magnetized dusty plasmas to be important and of fundamental scientific interest, and some noted it was relatively unexplored, thus adding to their level of support for the project. All felt that this proposed multi-user, multi-institutional user facility would be the first of its kind in the US and truly world class. All reviewers also felt the team of PI / Co-PIs to be very solid, each with a well established track record. The broader impacts were noted by the reviewers to include the reach to a national and international cadre of researchers, training of students, and the broad diversity of the fields that the enabled research would influence. All the reviewers supported funding this proposal, based upon its intellectual merit and broader impacts. **The panel agreed, recommending a rating of "Must Fund" for this proposal.**

Establishing need: **final thoughts**

- Establishing needs “thought process” is similar for acquisition and development proposals – although the balance of the proposal will be different.
- MRI is limited submission by institutions – make sure you know the **internal deadlines**, know your **cost-share category** and have discussions with your local leadership to build support for your project.
- For large or complex projects, get research community buy-in. This may take time – START EARLY!
- Talk to the NSF program managers!