

X-FAST USER FACILITY

XUV Femtosecond Absorption Spectroscopy Tabletop · University of Wisconsin–Madison (contact: Varun Mapara vmapara@wisc.edu)

Guidelines for Prospective Users — proposal scope, capabilities, and submission requirements (v1.0)

1. About X-FAST

X-FAST is a tabletop instrument at UW–Madison for ultrafast transient-absorption spectroscopy in the extreme ultraviolet range. It produces femtosecond XUV probe pulses by high-harmonic generation (HHG) over a continuous 40–72 eV window, paired with a synchronized 800 nm (or 400 nm) optical pump. Because this window spans the M-edges of 3d transition metals and O/N edges of heavier elements, a single measurement can follow electronic and structural dynamics at multiple elemental sites simultaneously. Built for high throughput and operational simplicity, the facility makes ultrafast core-level spectroscopy accessible to chemists and materials scientists without specialized ultrafast-laser expertise. More details are available at: <https://doi.org/10.1063/5.0146137>

2. Scientific Scope — Questions X-FAST Can Address

X-FAST is most powerful when the question requires element-specific, sub-picosecond information about how a material responds to photoexcitation. The themes below are illustrative; well-justified questions outside them are welcome.

Ultrafast carrier, lattice, and phase dynamics

- How does photoexcitation redistribute charge among atomic sites, and on what timescale does the system relax?
- Can a photoinduced phase transition (e.g. the austenite–martensite transition in shape-memory Heuslers) be tracked through transient edge structure, separating electronic from structural signatures?
- What roles do electron–phonon and electron–electron coupling play in the initial relaxation of hot carriers?

Element-specific magnetism

- How fast, and by what pathway, does optical excitation demagnetize a ferro- or ferrimagnet — and do distinct elemental sublattices respond on the same timescale?
- How does coupling between magnetism and structure (multiferroic or magneto-structural materials) evolve after excitation?

Excited-state chemistry and energy materials

- What is the transient oxidation state of a metal center after photoexcitation, and how does charge localize or delocalize around it?
- How do carrier trapping, recombination, and cooling in semiconductors and oxides depend on doping, strain, or interface quality?

3. Instrument Capabilities and Constraints

Proposals should be designed around the parameters below, drawn from the instrument as characterized in Ash et al., Rev. Sci. Instrum. 94, 073004 (2023). Where a requirement falls outside these ranges, state it explicitly and explain how the experiment would still succeed.

XUV probe range	Continuous 40–72 eV via HHG (Ne medium); 32–120 eV reachable with other gases/filters. Spectral resolution < 150 meV.
Temporal resolution	~59 ± 4 fs instrument response, currently pump-limited; XUV pulse itself estimated < 35 fs.
Optical pump	800 nm standard; 400 nm via BBO. other wavelengths via optical parametric amplification may be possible — discuss in advance. Typical fluence a few mJ/cm ² .
Geometry & samples	Transmission pump–probe under vacuum. Thin films (tens of nm) on XUV-transparent Si ₃ N ₄ membranes (50/100 nm)
Sample environment	Room temperature standard. N ₂ gas-cooling cell for dissipating pump induced heat; Cryostat(~20K) in commissioning
More details	https://doi.org/10.1063/5.0146137

Sample requirements

- **Format:** thin films on XUV-transparent membranes (commonly 50 nm Si₃N₄); a capping layer (~ 4 nm) may be needed to prevent oxidation.
- **Typical Frame size** (1) 5mm X 5mm (500 micron thick), membrane size 2mm x 2 mm, (2) 5mm X 5mm (200 micron thick), multiwindow membrane size 0.5mm x 0.5mm (3X3)

- **Homogeneity:** thickness should vary by only a few percent across the rastered region — spatial chirp in the HHG source demands good uniformity.
- **Readiness:** samples must be characterized (thickness, composition) before beamtime and tolerate vacuum and repeated excitation. X-FAST is not a synthesis or characterization facility. Bring spares; flag any hazards at proposal stage.

4. What Makes a Strong Proposal

- **A sharp, falsifiable question.** State one primary question the data can clearly answer — not an activity (“we will measure X”) but a question (“does the Mn sublattice respond faster than the Ni sublattice?”).
- **A hypothesis and expected signal.** Find which edge (Use CXRO (cxro.lbl.gov), what sign of change, on what timescale, and what each possible outcome would mean.
- **Justification of the method.** Explain why element-specific XUV transient absorption — and X-FAST in particular — is the right approach.
- **A feasible plan.** Identify samples and their status, pump conditions, edges and delay ranges, sample-environment needs, a realistic beamtime estimate.

5. Required Proposal Structure

Submit a single PDF, maximum two pages for the scientific case (references and cover page excluded), font ≥ 11 pt. Use the following sections:

1. **Cover information** — title; PI and team with affiliations; contact email; new or continuing; total beamtime requested.
2. **Background and motivation** — context and the gap being addressed (~half a page).
3. **Question and hypothesis** — the single primary question, hypothesis, and expected outcomes.
4. **Why X-FAST** — justification of the XUV transient-absorption approach and this facility.
5. **Experimental plan** — samples and status; pump conditions; edges and delays; sample environment; anticipated signal.
6. **Beamtime justification and readiness** — how the request divides across alignment, samples, and references; sample readiness; preliminary data; risks and mitigation.

6. Review Criteria and Submission

Proposals are evaluated by facility staff against four criteria, all carrying weight:

scientific merit (importance and originality of the question), **suitability** (does the question genuinely need element-specific, femtosecond, XUV information), **feasibility** (can it succeed within the requested beamtime given samples, signal levels, and instrument limits), and **readiness** (samples). Proposals are reviewed on a rolling basis, and applicants can typically expect a decision within a few weeks of submission. Proposals may be accepted, accepted with a modified allocation, returned for revision, or declined; written feedback is provided in all cases.

Submission and user responsibilities:

1. Contact facility staff before writing — a brief discussion of the material and question routinely strengthens the proposal.
2. Successful applicants coordinate scheduling, sample shipment, and safety arrangements with staff.
3. After beamtime, provide a brief report, acknowledge Wisconsin MRSEC and X-FAST in publications, and inform staff of resulting papers.

7. Pre-Proposal Contact and an Example

Prospective users are strongly encouraged to contact facility staff. A short description of the material, the scientific question, and the dynamics of interest is enough to begin a useful conversation about feasibility, sample design, and a realistic beamtime estimate.

Illustrative well-framed question. “In a strained X membrane, does the transition-metal sublattice show a transient edge shift within the first few hundred femtoseconds, and is its sign consistent with photoinduced charge transfer rather than purely thermal heating?” This names the sample, the observable (edge shift at a specific element), the timescale, and two competing hypotheses the data can distinguish — the structure every X-FAST proposal should aim for.

Note on specifications. All instrument values above reflect the X-FAST instrument as published in 2023; capabilities such as the NOPA pump and cryostat continue to develop. Confirm the parameters relevant to your experiment with facility staff at the pre-proposal stage.