ALFF: A Proposed VUV SASE-FEL User Facility at APS

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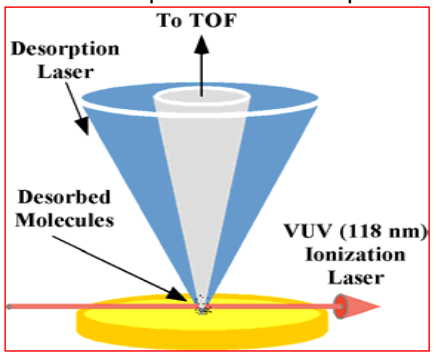
Present and Proposed Parameter List

Parameter	Existing (LEUTL)	Proposed (ALFF)
Photon Energy Fundamental Tuning Range (wavelength)	2-10 eV (600-120 nm)	2.8-22 eV (444-55 nm)
Bandwidth (FWHM)	≥ 0.4%	0.4-0.3%
Pulse Length (FWHM)	≤ 0.3 ps	≤ 0.3 ps
Photon Energy/Pulse Delivered to Experiment	10 μJ – 50 μJ	> 200 μJ
Saturation Length	< 18 m	< 18 m
Repetition Rate	6 Hz	30 Hz
User Beam Available (time relative to storage ring)	3%	96%
Availability (delivered time to scheduled time fraction)	NA	> 80%
Scheduled Time (1st operational year)	NA	1500 hrs

We propose to improve and convert the existing free-electron laser (FEL) in the Low-Energy Undulator Test Line (LEUTL) tunnel of the Advanced Photon Source (APS), with which high-gain FEL principles were successfully demonstrated for the first time in the visible and short wavelength region, into a user facility for applications and development of a high-gain FEL. Since a high-gain FEL is a linear arrangement, we will refer to it as ALFF (Argonne Linear FEL Facility). ALFF will provide coherent, high-intensity, tunable vacuum-ultraviolet photons with subpicosecond time resolution, allowing experimental techniques hitherto not feasible in this wavelength region. At the same time the ALFF will be an ideal place to develop and refine advanced concepts and capabilities of a high-gain FEL. To make optimal use of the existing accelerator hardware as well as a state-of-the-art mass spectrometer, the conversion will require improvement of the high-brightness electron system and a reworked undulator. Three scientific grand challenges and a set of other experiments have been identified, each of which can be studied by using the unique properties of the ALFF output. Five challenges in FEL and accelerator development have also been identified. These focus on the enhancement of the electron and radiation beam properties and capabilities. The first two scientific challenges and some FEL development work will be pursued during the three-year facility upgrade period. Afterward, ALFF will operate in the same manner as the BES-supported beamlines in the APS, for research in photon-application sciences as well as research in high-brightness electron beams and FELs.

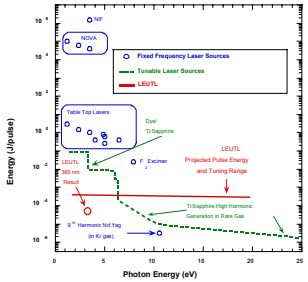
The synergistic progress at the ALFF in the use of and improvement of the newly developed FEL source will be an important contribution to the DOE core mission for developing advanced facilities for the benefit of science.

Basic Operational Concept



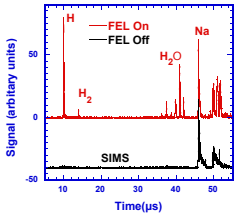
Comparison of Laser Light Sources

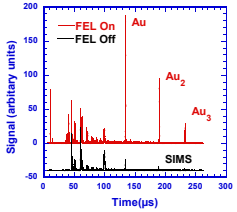
- **Few sources of VUV radiation**
- **Intensity and tunability needed for efficient photoionization**
- **ANL first in U.S. for VUV FEL**

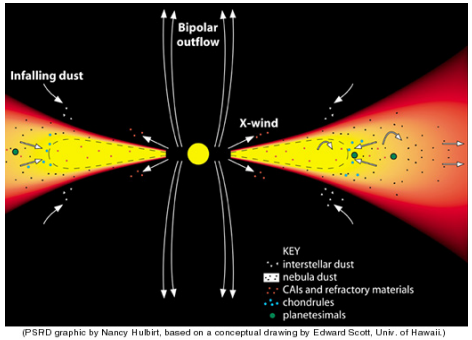


Photoionization of Gold and Gold clusters

- **Only secondary ions below the ionization potential (IP) of Au**
  - **FEL wavelength 127 nm (9.8 eV)**
  - **IP of Au equals 9.2 eV**
- **Light atoms and molecules are also observed**
  - **H peak may be due to fragmentation of molecules.**

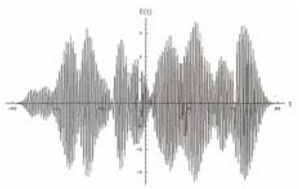






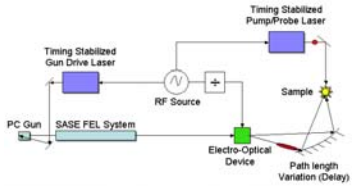
(PSRD graphic by Nancy Hulbirt, based on a conceptual drawing by Edward Scott, Univ. of Hawaii.)

Schematic drawing of X-wind emanating from a young Stellar Object. This model for the evolution of our solar system explains many recent meteoritical discoveries and can now be tested using solar wind samples from the Genesis spacecraft and the SPIRIT end station on the ALFF.

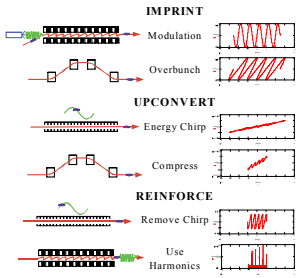


The SASE light consists of several coherent regions, also known as spikes, randomly distributed over the pulse length of the electron beam.

Timing Synchronizer



A possible scheme to synchronize the SASE FEL pulse to an external laser operating at an independent wavelength.



The concept of wavelength shifting.