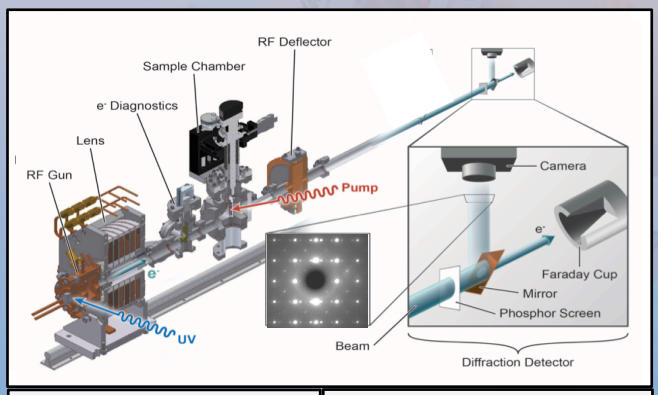
# Installation and Commissioning of an Ultrafast Electron Diffraction Facility as Part of the ATF-II Upgrade

M.A Palmer, M. Babzien, M. Fedurin, C. Folz, M. Fulkerson, K. Kusche, J. Li, R. Malone, T. Shaftan, J. Skaritka, L. Snydstrup, C. Swinson, and F. Willeke
*Brookhaven National Laboratory, Upton, NY*

## Ultrafast Electron Diffraction with MeV Electron Beams

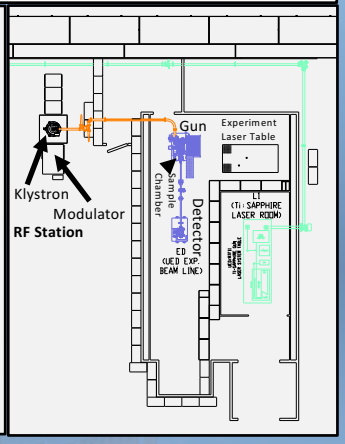



Beam source:
- 1.6 cell photocathode gun
- 2,856 MHz

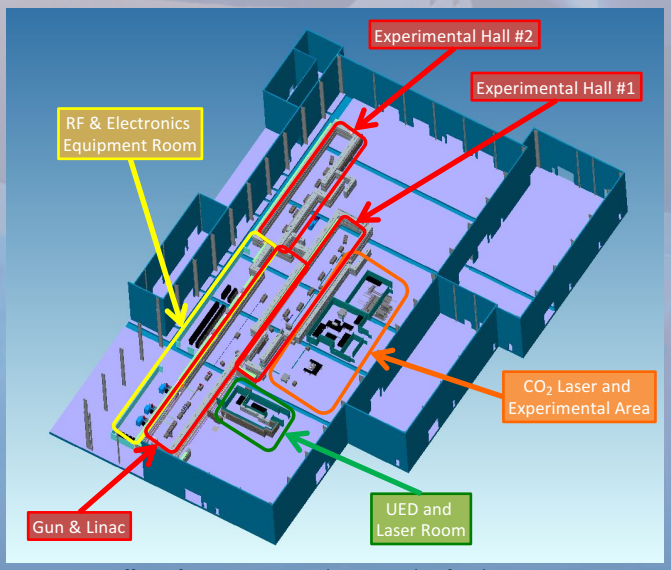
Operational beam energy:
2.8 MeV

Operational beam charge:
1 pC

Laser:
- Ti:Sapphire, 160 fs pulse
- 1 μJ at photocathode
- 100 μJ at sample chamber




## ATF-II Facility Plan – BNL Building 912

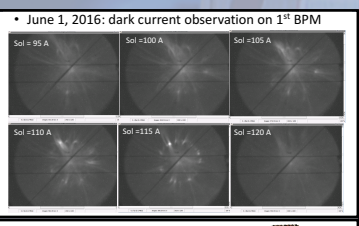


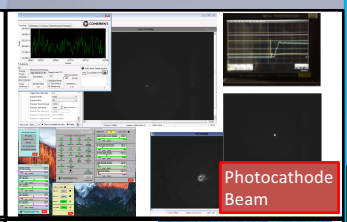

- ATF: A DOE Office of Science National User Facility for the ***Accelerator Stewardship Program***
  - Funded through the Office of High Energy Physics
  - Main facility operating in BNL Building 820
- ATF-II: Upgrade and move of the facility to BNL Building 912
  - Additional and more flexible experimental space
  - Allows space for significantly upgraded $CO_2$ Laser Capabilities
    - Higher Power (100 TW class is goal)
    - Shorter bunches (100 fs goal)
  - First operational element is the UED Facility
    - ATF focus is developing this accelerator-based capability to its fullest extent
    - Experimental station treated as a co-developed "beam line" for material science users
      - ***Required element to validate the accelerator capabilities***

## UED Milestones

- December 2015: Layout was developed and approved
- January – February 2016: RF system and beamline were assembled in new location
- March 2016: RF system was commissioned, klystron and gun were conditioned to operational power, control system was ready for operation
- April 2016: UED readiness review; laser system commissioning
- May-June 2016: Beamline commissioning, dark current and first beam observed at detector
- June 2016: First diffraction pattern at detector
- July-August 2016: Updates for environmental stability in BNL Building 912
- September 2016: Preparation for User Experiments

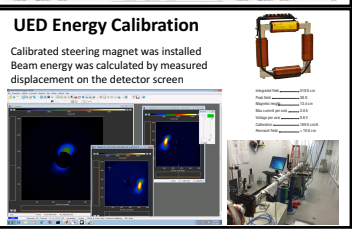
- June 1, 2016: dark current observation on 1st BPM



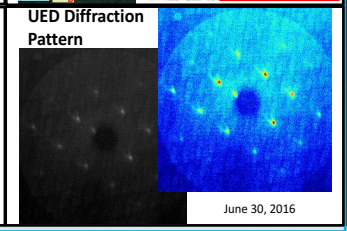




### UED Energy Calibration

Calibrated steering magnet was installed
Beam energy was calculated by measured displacement on the detector screen



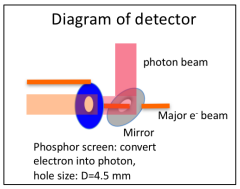
### UED Diffraction Pattern

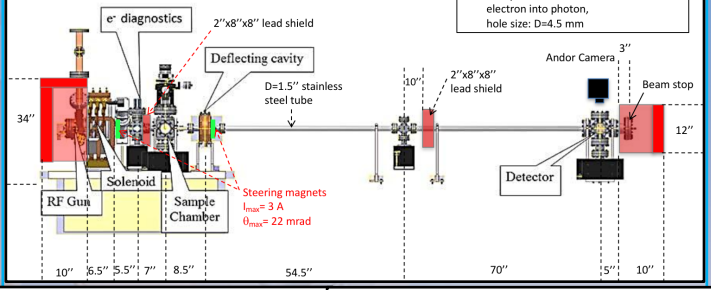



## UED Capabilities: Present and Future

Beam energy = 3 MeV,
Operational charge = 1 pC
Repetition rate = 1 Hz (<5Hz)

UED beamline diagnostics:
YAG screen at Gun has Basler camera and Faraday cup;
Detector has phosphor screen with Andor camera;
Faraday cup at beam dump.



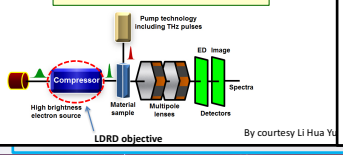

Compress 50 pC electron bunch (~$10^8$ electrons/bunch)
- Bunch Length: 160 fs
- Bunch Size: 30 microns

Application: UED, UEM

LDRD-Funded Upgrade Path

Test principle of the method to remove time jitter between laser and electron bunch

Accelerator based MeV electron microscopes,

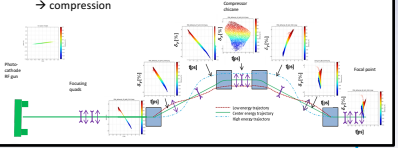



By courtesy Li Hua Yu

### LDRD UED Bunch Compressor in Space Charge Regime

Novel and non-conventional electron bunch compression scheme
- Utilize correlated energy spread and energy-dependent path length to compress the bunch length
- Space charge effect is used to generate the time-energy correlation

Compression technique developed for electron beam slicing :
Focusing → space charge energy increase at head (chirped bunch)
→ high energy particle comes earlier, but takes longer path ( R56>0 )
→ compression



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