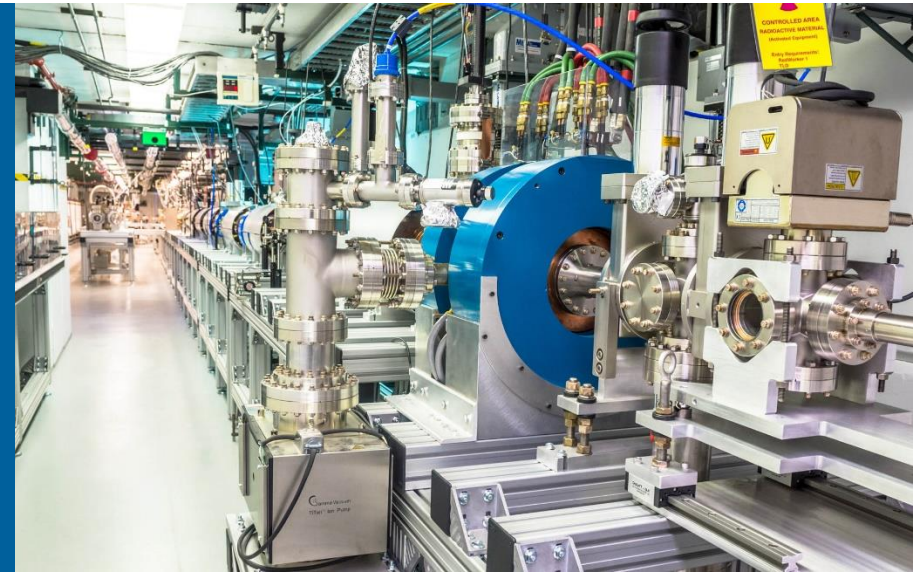


Photocathode Physics for Photoinjectors Workshop
Santa Fe, New Mexico October 15-17, 2018



A NEW PHOTOCATHODE R&D PROGRAM AT THE ARGONNE WAKEFIELD ACCELERATOR FACILITY



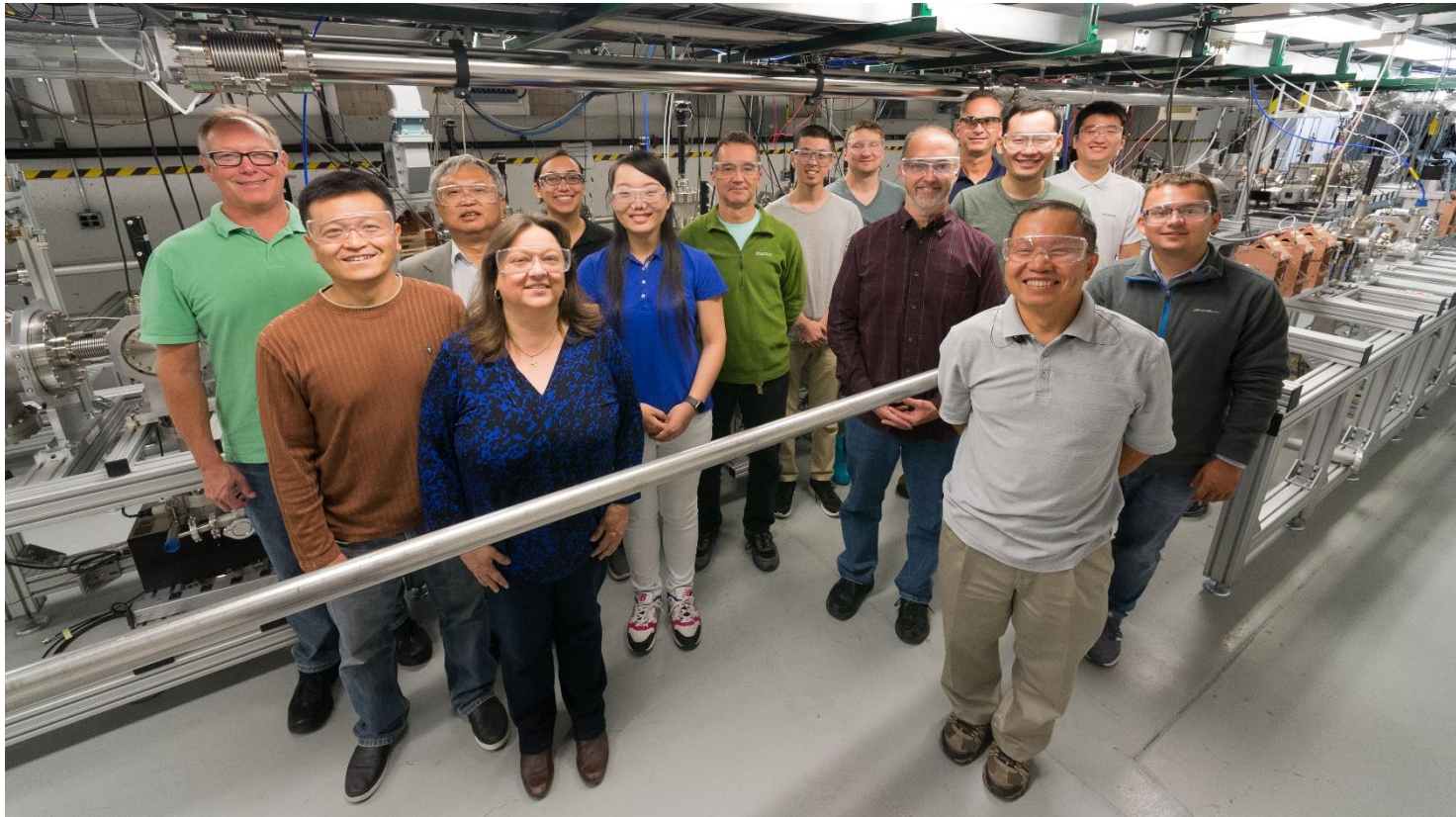
ERIC WISNIEWSKI

PHOTOCATHODE FABRICATION CHAMBER AND HIGH-POWER TESTING WITH A 1.3 GHZ NCRF INJECTOR TEST STAND

AWA RESEARCH PROGRAM

- **Research focus**

- Advanced Accelerator Concepts
- Beam physics
- Electron sources



AWA RESEARCH PROGRAM

- **Research focus**

- Advanced Accelerator Concepts
- Beam physics
- **Electron sources**

- **New photocathode R&D program at AWA**

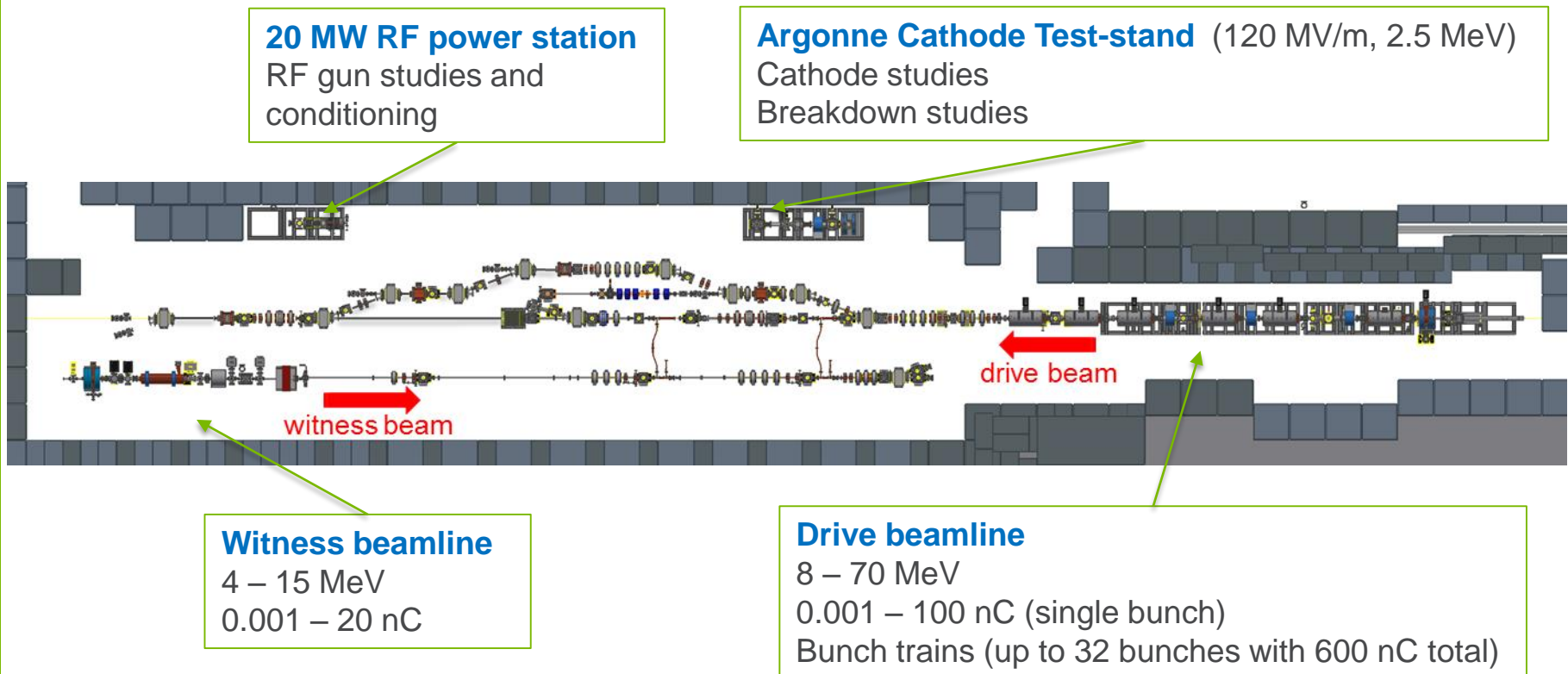
- A new Cs₂Te deposition chamber dedicated to production of research photocathodes (December 2018)
- Upgraded Argonne Cathode Test-stand (ACT)
- ANL/IIT/Euclid surface science resources

- **Photocathode researchers are welcome to collaborate**

BEAMLINES AND TEST-STANDS

▪ Three L-band NCRF rf guns at AWA

- Drive gun: 1.5-cell, Cs_2Te , 0.001-100 nC single bunch, up to 600 nC bunch train
- Witness gun: 1.5-cell, Mg, low charge low emittance main beam
- ACT gun: 0.5-cell, fundamental rf breakdown/FE research and cathode test



BRIEF HISTORY OF AWA'S PHOTOCATHODE R&D

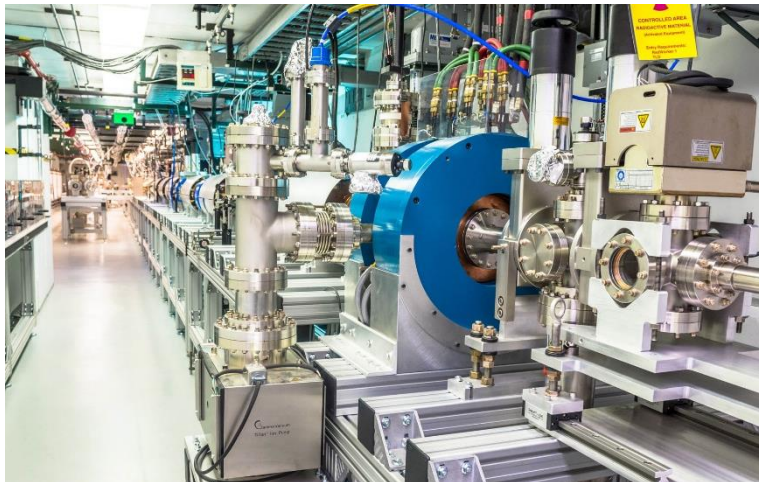
- **Witness gun (~2001-present)**

- Mg photocathode, conical slug set in a copper plug, designed for low to moderately high charge



- **Drive gun (~2013-present)**

- 2-8 ps FWHM 248 nm laser on Cs₂Te/Mo plug, 30 mm diameter, 60-75 MV/m
- World's highest charge photocathode: up to 600 nC with bunch train



Photocathode Fabrication Chamber



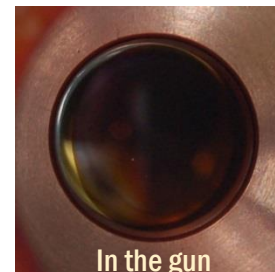
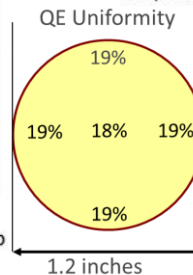
Thermal evaporators

Hg Arc lamp

Photocathode load-lock UHV transfer system



Deposition Configuration



In the gun

NEW PHOTOCATHODE R&D PROGRAM

▪ Motivation

“There is a great need for characterizing and validating photocathode concepts in a realistic injector/gun environment ... Gun-cathode-laser test facilities that are independent of user operations should be established...”

pp. 39-40, Report of the Basic Energy Sciences Workshop on the Future of Electron Sources, 2016



▪ The new program at AWA

- A new deposition chamber dedicated to photocathode R&D
- Upgraded ACT beamline: more flexibility, more diagnostics
- Start-to-end R&D capability: cathode fabrication, high power test in NCRF gun, surface characterization

THE NEW DEPOSITION CHAMBER

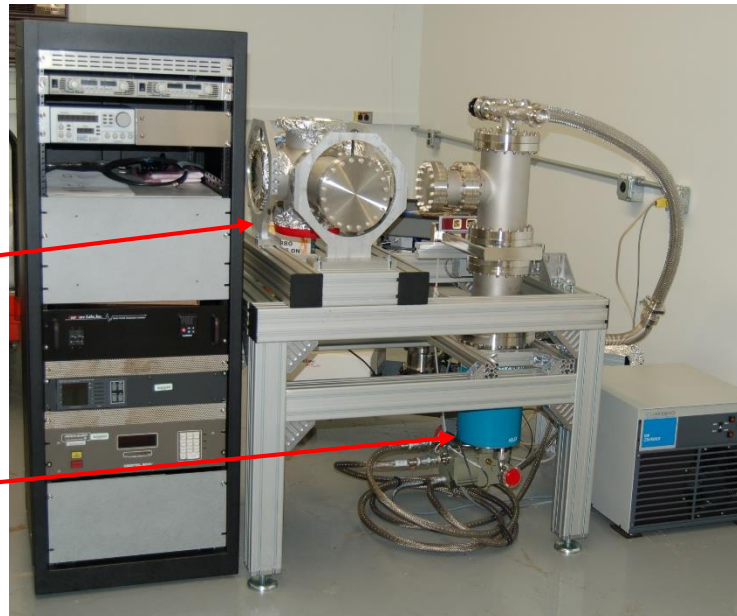
- **Dedicated to the new photocathode R&D program**

- Designed to make Cs_2Te photocathodes using the traditional method, similar to the primary AWA deposition chamber
- Features include a large cryo-pump and a load-lock system compatible with the ACT gun
- Also be available for researchers wishing to cesiate a photocathode surface.
- The possibility of producing other types of photocathodes in the chamber is being investigated

Power supplies →

Deposition chamber →

Cryo-pump →

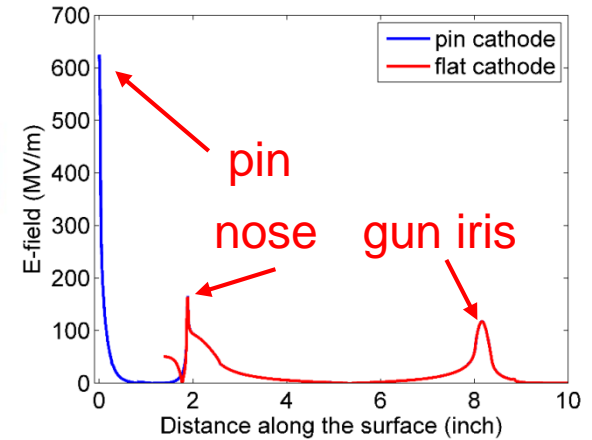
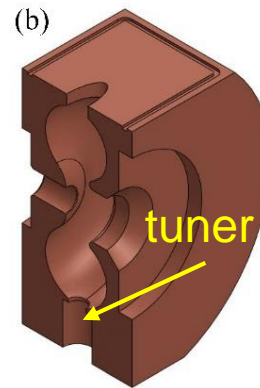
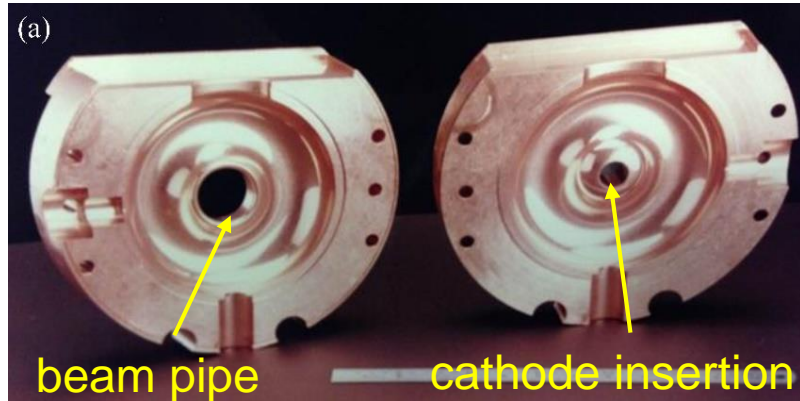


Under construction

ARGONNE CATHODE TEST-STAND (ACT)

- L-band single-cell rf gun

- High gradient (100-700 MV/m) with modest rf power (2.5 MW)



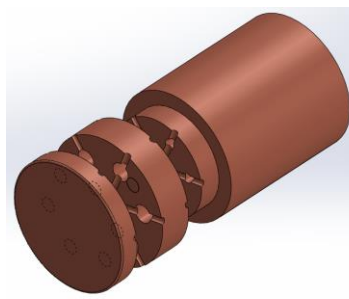
- Detachable cathode



Regular flat cathode
~Φ20 mm, metallic



Pin-shape cathode
~Φ1 mm, metallic



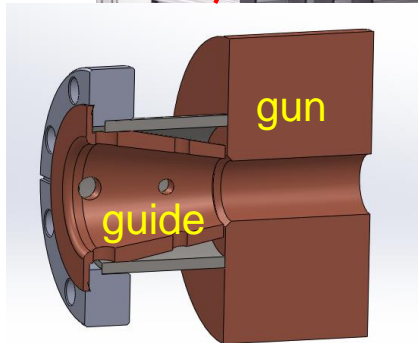
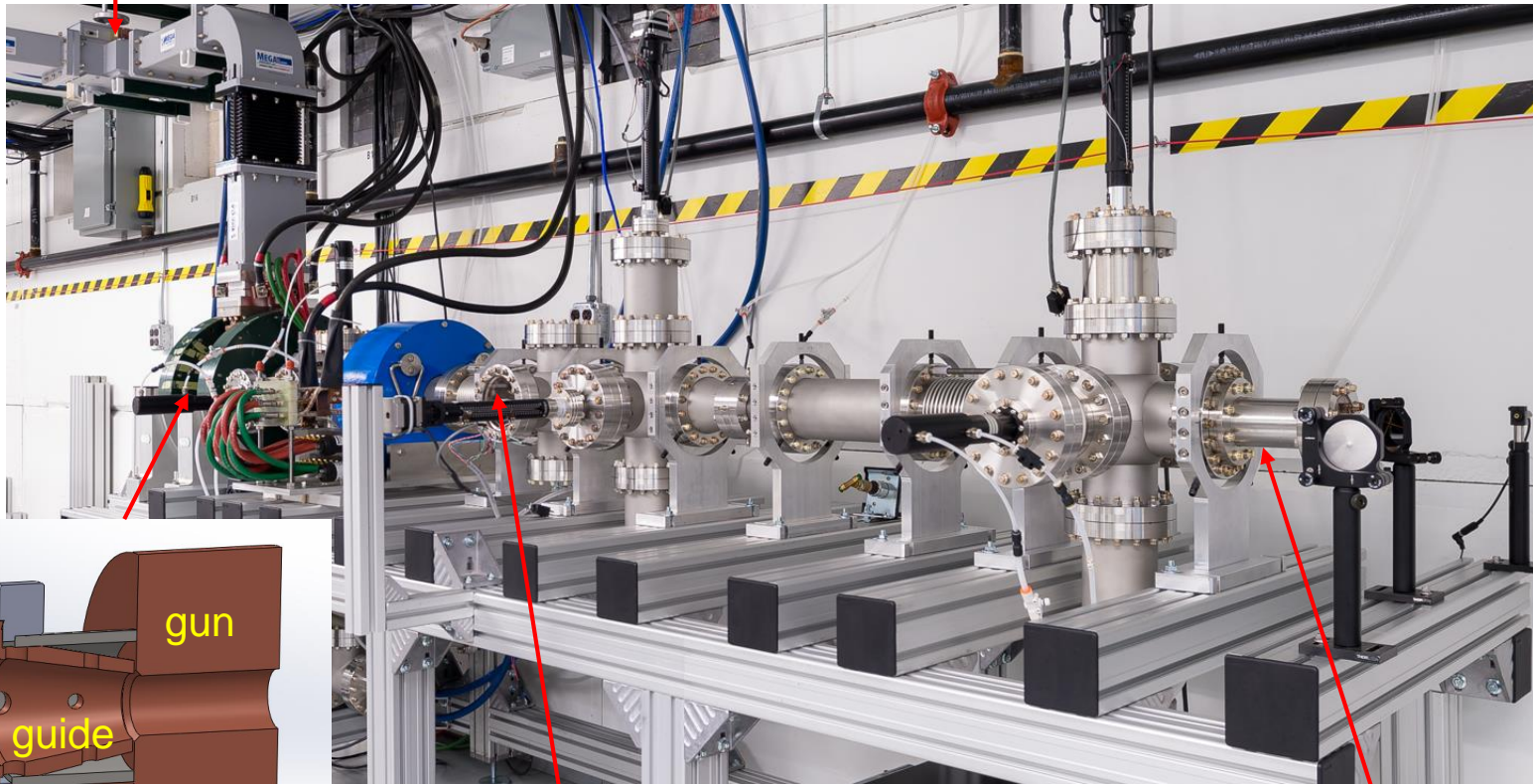
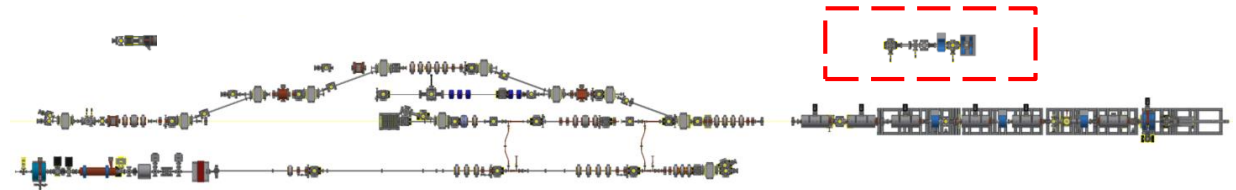
3-part cathode
metallic/advanced



ARGONNE CATHODE TEST-STAND (ACT)

- Beamline

Waveguide switches



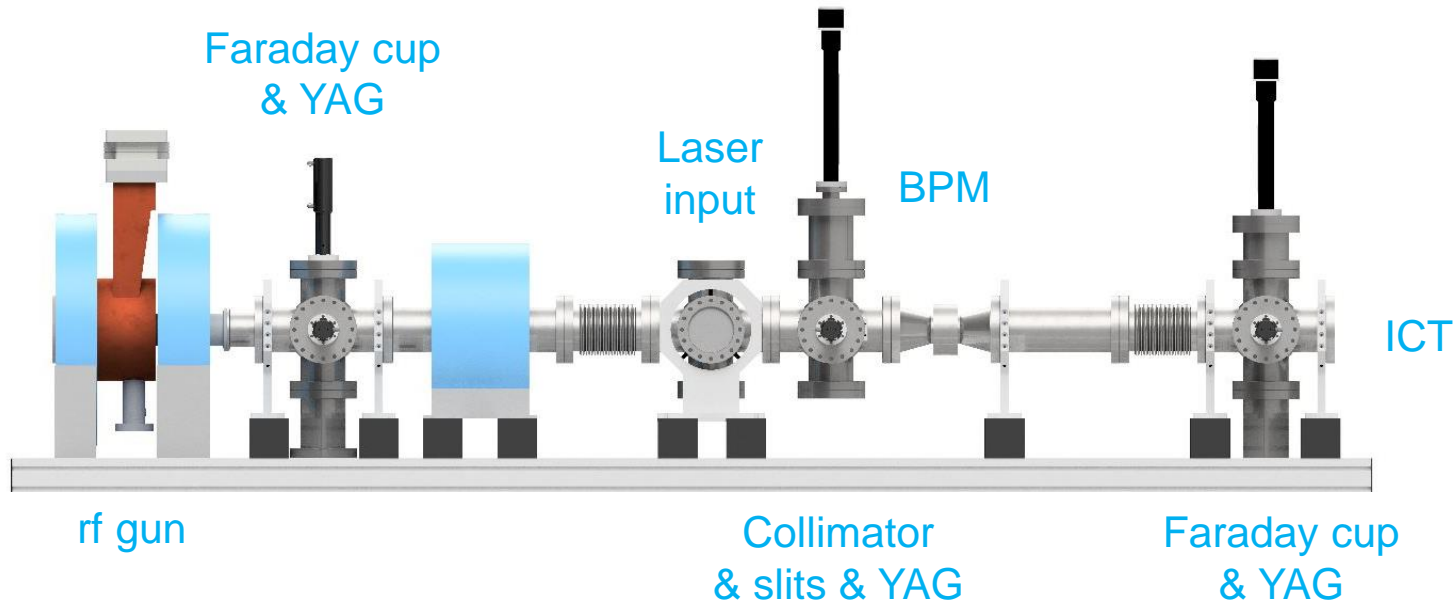
248 nm, ps laser

Available for future extension

ARGONNE CATHODE TEST-STAND (ACT)

▪ Beamline

- A test-stand for photoemission as well as field emission study

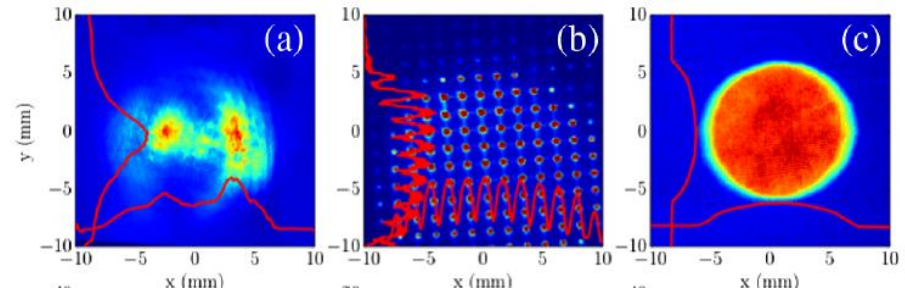
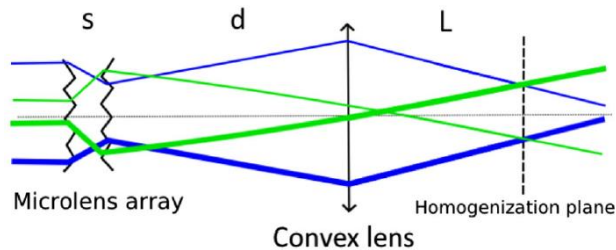


▪ Measurable properties

- Photoemission: current, current density, QE, emittance, lifetime
- Field emission: current, emitter location, current density, lifetime, and field enhancement factor

RECENT PHOTOCATHODE STUDY

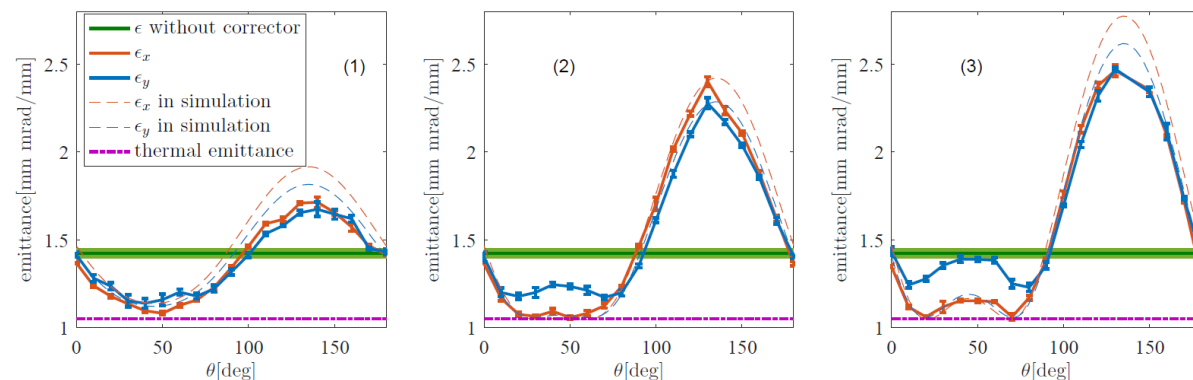
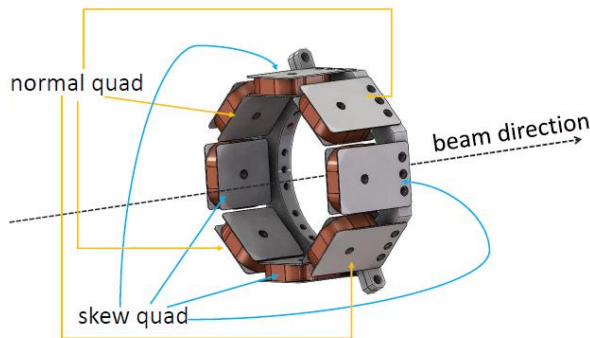
- **Micro-lens Array – laser homogenizer** - Obtain uniform or pattern beam
example application- QE and thermal emittance maps



A. Halavanau, Q. Gao, G. Ha, et al., PRAB 20, 103404 (2017)

- **Quadrupole corrector**

- Eliminate emittance growth due to coupled transverse dynamics aberrations



L. Zheng, J. Shao, Y. Du, et al., to be submitted

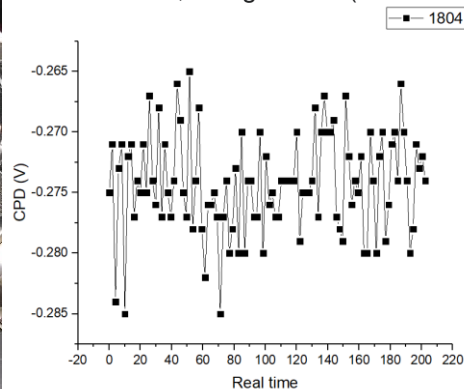
SURFACE CHARACTERIZATION

Various instruments at ANL/IIT/Euclid

Work function: Kelvin probe



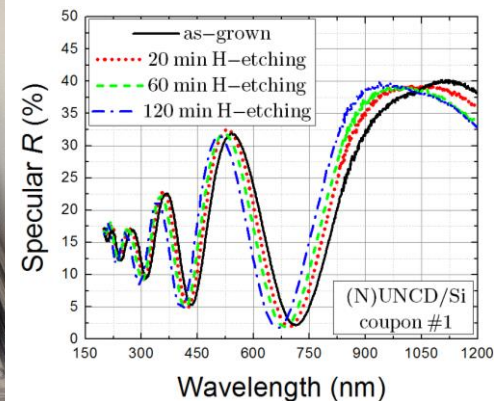
From Chen, Gongxiaohui (IIT/Euclid)



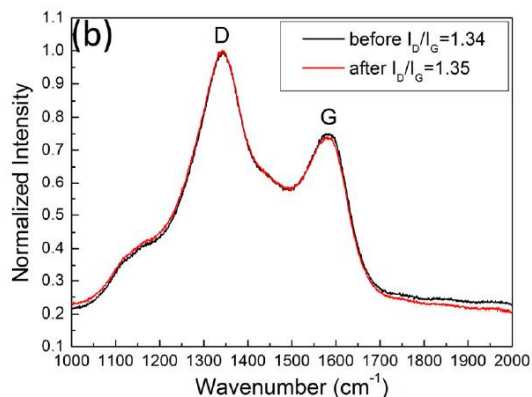
Reflection: UV-vis



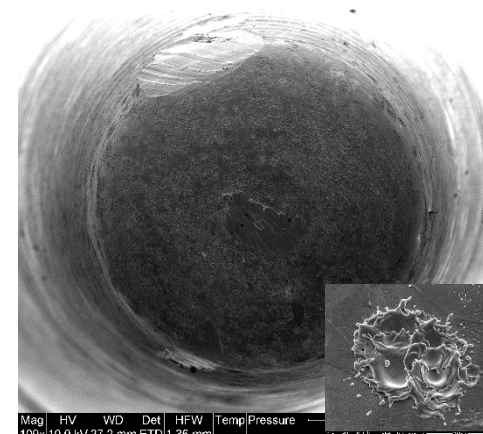
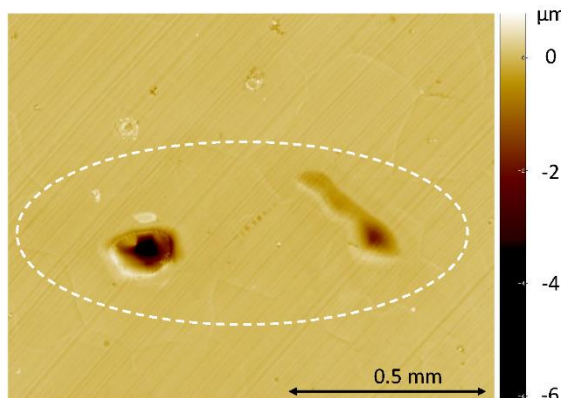
From Chen, Gongxiaohui (IIT/Euclid)



Chemistry: Raman spectrometry



Morphology: WLI and SEM



INVITATION TO COLLABORATE

- **AWA wishes to extend an invitation to photocathode researchers interested in utilizing some or all of our available resources:**
 - Cathode fabrication and cesiation
 - High power test in rf gun
 - In-situ characterization: QE, emittance, charge, charge density, ...
 - Ex-situ characterization: work function, reflection, chemistry, morphology,...

- **Please feel free to contact us anytime. We will provide you with detailed information on working with AWA:**
 - Vacuum requirements
 - Cathode specifications
 - Diagnostics
 - One-page research proposal

SUMMARY

- **AWA has a nascent photocathode research program**
 - A new Cs₂Te deposition chamber dedicated to production of research photocathodes (December 2018)
 - Upgraded Argonne Cathode Test-stand (ACT)
 - ANL/IIT/Euclid surface science resources
- **Photocathode researchers are welcome to collaborate**



<https://www.anl.gov/awa>

THANK YOU FOR YOUR ATTENTION

Funding sources:

Argonne, a U.S. Department of Energy Office of Science laboratory, is operated under Contract No. DEAC02-06CH11357. The new cathode deposition chamber is funded in part through Laboratory Directed Research and Development program of Los Alamos National Laboratory under project number 20150394DR. Los Alamos National Laboratory is operated by Los Alamos National Security, LLC, for the National Nuclear Security Administration of the U.S. Department of Energy (contract DE-AC52-06NA25396).