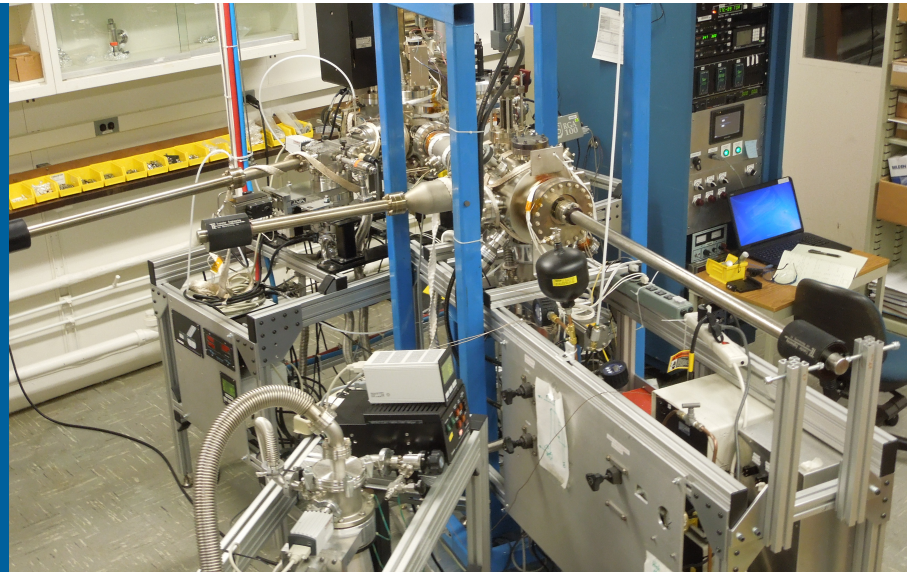
Argonne NATIONAL LABORATORY

MICROCHANNEL PLATE PHOTODETECTOR – FABRICATION & TESTING



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Detector R&D Group Leader
Argonne MCP Group Leader

Monday 24 Sept 2018
HEPD Independent Safety Review

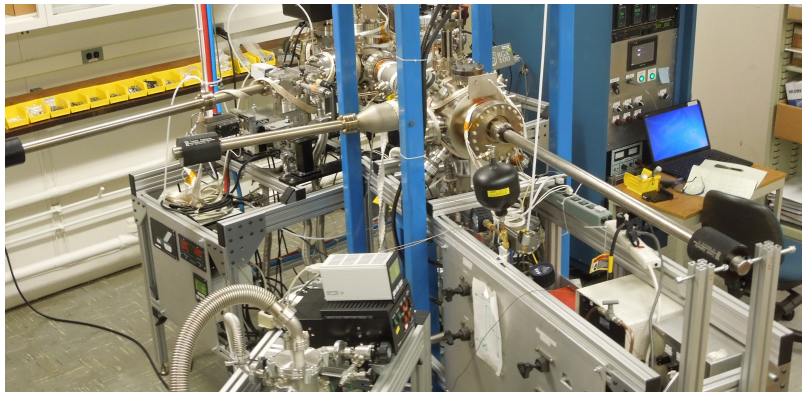
MCP PHOTODETECTOR PROGRAM OVERVIEW

Picosecond time and millimeter space resolution photon detection

- Program to develop transformational large area picosecond timing and millimeter spatial resolution **affordable** photodetectors
  - Borosilicate glass capillary arrays (10μm and 20μm pore) functionalized with resistive and emissive coatings via atomic layer deposition (ALD)
  - All glass package (except getters and shims) sealed with thermopressure indium seal
  - Capillary arrays fabricated by Incom, Inc. ALD to make MCPs done at Argonne or Incom. Currently purchasing 10μm pore 6cm x 6cm MCPs direct from Incom.
  - Fabrication of 6cm x 6cm active area MCP photodetectors done completely in-house at Argonne on Small Single Tube Processing System (SmSTPS)
    - Lab dedicated to vacuum transfer system for fabrication
    - Lab for materials cleaning and preparation
    - Lab for QE measurement; also currently re-locating vacuum oven from ALD lab area
    - Lab for characterization and testing using diode laser, UV LED and lamp

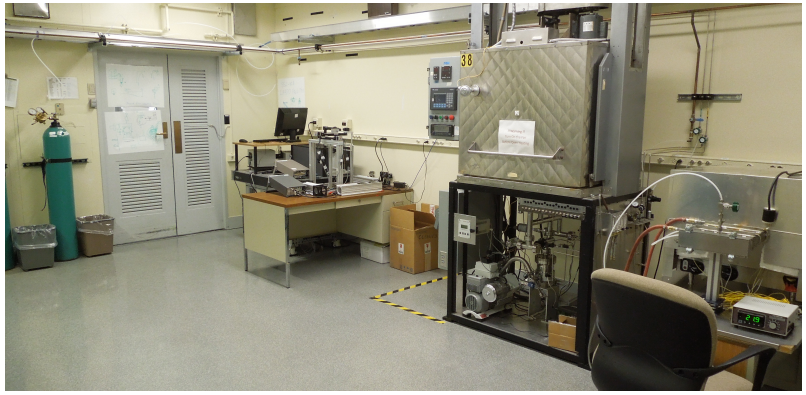
MCP PHOTODETECTOR PROGRAM
HEP LABS

Four labs associated with detector fabrication & characterization



MCP Photodetector Fabrication Lab

Wet Chemistry Lab – cleaning and preparation



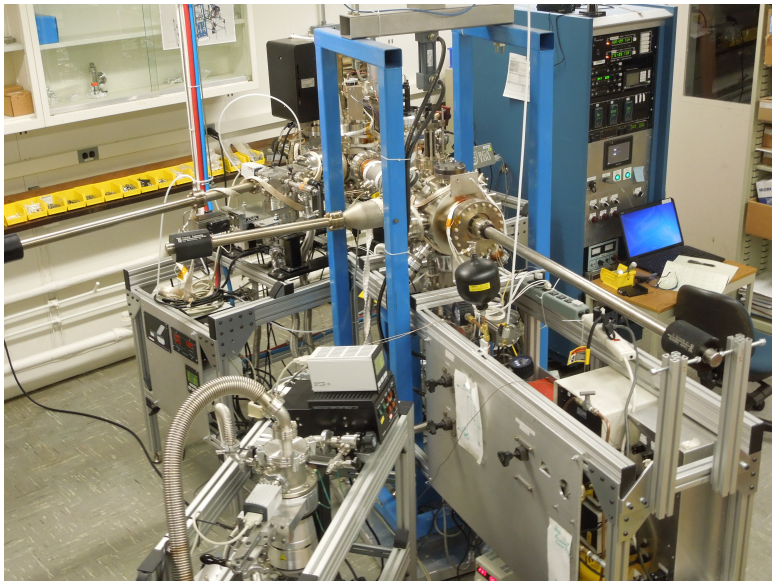
Photocathode Lab – QE measurement, Cathode source material preparation, re-location of vacuum oven

Photomultiplier Lab – characterization and testing: diode laser integrated in dark box, vacuum test chamber

MCP FABRICATION LAB

Vacuum Transfer System for degassing MCP assembly, photocathode evaporation, detector thermopressure sealing

- **Safety Considerations**
  - Category I vacuum system: commercial “off-the-shelf” components, safety glasses, training and instructional seminars, vacuum engineer mentor
  - High voltage or high current: shielded connections, training
  - Thermally hot surfaces: warning signs, badge access to lab
  - Alkali metals usage: small quantity (grams), sealed within vacuum system other than during loading (1-2/yr). training
  - Compressed gas: service floor cylinder storage, training
  - Flammable liquids (alcohol): small quantities in squirt bottles,flammable cabinet storage, nitrile gloves, satellite accumulation area, training
  - Laser (photocathode deposition monitoring): class 2, training



- **Work Control Documents**
  - Photocathode deposition in sSTPS (24782.3)
  - Operation of effusion cells in LAPPD sSTPS (24934.1.3)
  - Loading & unloading effusion cells in LAPPD sSTPS (24943.1.2)
  - Deposition of photocathode with pre-synthesized compounds (53519.0)

- **Other:** 6cm Photodetector Fabrication Schedule & Procedure (document)

WET CHEMISTRY LAB

Ultrasonic cleaning, plasma etch cleaning, vacuum and nitrogen desiccator storage, water purification system

- **Safety Considerations**
  - Category I vacuum system: commercial “off-the-shelf” components, safety glasses, training and instructional seminars, vacuum engineer mentor
  - Compressed gas (Oxygen, nitrogen, argon, air): service floor cylinder storage, training
  - Flammable liquids (alcohol & acetone): flammable cabinet storage, nitrile and heavy duty latex gloves, satellite accumulation area, training
- **Work Control Documents**
  - Using ultrasonic cleaning tanks in 360 C-248 (18958.3)
  - Plasma etcher operation (23217.3)

PHOTOCATHODE LAB

Photocathode source material prep, getter vacuum storage, QE measurement station, vacuum oven bakeout of MCPs

- **Safety Considerations**
  - Category I vacuum system: commercial “off-the-shelf” components, safety glasses, training and instructional seminars, vacuum engineer mentor
  - UV light generation: enclosures, safety glasses, training
  - Pressurized glovebox system: pressure relief valve, training
  - Alkali compounds usage: small quantity (grams) air stable compounds, glovebox handling. training
  - Compressed gas: service floor cylinder storage and in room storage, training
  - Thermally hot surfaces: badge access during off-hours

- **Work Control Documents**
  - Preparing source material for alkali metal deposition (23756.1.2)
  - Optical station operation (29072.2)
  - Glovebox operations (8742.2.1)

PHOTOMULTIPLIER LAB

Dark box with 408nm diode laser for photodetector characterization; Vacuum test chamber for measurement of varying MCP configurations

- **Safety Considerations**
  - Category I vacuum system: commercial “off-the-shelf” components, safety glasses, training and instructional seminars, vacuum engineer mentor
  - High voltage: shielded connections, operation in enclosed dark box, training
  - Diode laser: class 3b (current operating permit), operation in enclosed dark box, training
  - UV generating lamp and LED: shielded during operation, safety glasses
- **Work Control Documents**
  - HEP Laser Lab (24782.2)

MCP PHOTODETECTOR PROGRAM SAFETY RECORD

- 0 safety incidents in HEP MCP labs in 4.5 years of operation (first devices April 2014)
- 0 injuries for MCP program in 9 year operation (since August, 2009)
- 1 safety incident for MCP program in 9 year operation
  - Ignition of residual alcohol trapped in capillary array pores after cleaning during oven drying
  - **Response:**
    - No cleaning of capillary arrays or MCPs after delivery from Incom. They come clean from Incom and we strive to keep them clean:
      - Incom performs cleaning of capillary arrays after grinding and polishing
      - Capillary arrays and/or MCPs stored in low humidity desiccator cabinets fed by ultra-pure N2. Often keep in metal, sealed shipping containers until used.
      - Baking of capillary arrays and/or MCP plates done in high vacuum oven to desorb water, N2, CO, CO2
    - Capillary arrays and/or MCPs are **not** exposed to flammable liquids

MCP PROGRAM SAFETY PROTOCOLS (1)

- Physicists and engineers working in MCP labs have responsibilities commensurate with skills and training
- Use of equipment and execution of processes defined through Work Planning and Control documentation
  - Work is performed within scope defined by Work Control Document (WCD)
  - Work instructions generally are given in detail in WCD
  - Written work instructions document kept with equipment
  - Hazards are identified. Removed, mitigated, or controlled through engineered control, personal protective equipment, and administrative control
    - Examples:
      - "Galloping Gertie" relief system on glove box (resulted from visit to CSE gloveboxes to understand best practices)
      - To address possible large spills: cleanup kit, apron, heavy duty latex gloves on hand for ultrasonic cleaning area (in addition to standard use of nitrile gloves and safety glasses)
      - Labs are RFID access during off-hours; authorized personnel only signage
- Scheduled safety walk-throughs by division and PSE senior management and HSE (ex: satellite accumulation area inspections)

MCP PROGRAM SAFETY PROTOCOLS (2)

- In addition to WCD, work is discussed, planned, and prioritized at bi-weekly meeting
  - Generally begins with safety share and discussion relevant to our work, seasonal concerns, or home safety (Ex: Last share was CO home safety as we enter heating season)
  - Equipment problems and/or needs discussed
  - Detailed discussion of experimental approaches: mainly for assuring systematic approach to reliable and understood research results, but safety concerns are discussed. Examples:
    - Use of UV lamps, LEDs, or lasers
    - Inspections required for new equipment or processes
    - Any concerns of people doing the work
- Biggest challenge to safe work operation is to make sure performing routine tasks avoids overlooking potential existing or new hazards. No assured fix, but
  - Regularly remind group to take a few seconds before executing any task to think about what might go wrong or be a hazard
  - Follow instructions/procedure rigorously