

US MPGD User Facility @ Jefferson Lab

Kondo Gnanvo

US-FCC-PED NDGD Weekly Meeting – April 04 2023

US-MPGD Community in Snowmass2021 Instrumentation Frontier 5 (IF5)

List of US institutions involved in MPGD development / activities for experiments in different field of particle physics

Nuclear Physics

IF5 – WP2, M. Posik's talk

- Thomas Jefferson National Accelerator Facility, Newport News, VA 23606
- Univ of Virginia Physics Department, Charlottesville, VA 22904
- Florida Institute of Technology, Melbourne, FL 32901
- Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824
- Facility for Rare Isotope Beams, Michigan State University, East Lansing, MI 48824
- Temple University, Philadelphia, PA 19122
- Brookhaven National Laboratory, Upton, NY 11973
- Vanderbilt University, Nashville, TN 37240
- Hampton University, Hampton VA 23668
- Bates MIT, Middleton, MA 01949
- Stony Brook University, Stony Brook, NY 11794
- Yale University, New Haven, CT 06520

Dark Matter, Neutrinos and Physics Beyond the Standard Model

IF5 – WP3, C. O'Hare's talk

- University of Hawaii
- University of New Mexico
- Wellesley College
- Department of Physics, Duke University, Durham, NC 27708
- Triangle Universities Nuclear Laboratory, Durham, NC 27708
- University of Texas, Arlington, TX, 76019
- Department of Physics, North Carolina State University, Raleigh, NC 27695
- The University of North Carolina at Chapel Hill, Chapel Hill, NC 27599
- Fermi National Accelerator Laboratory, Batavia, IL 60510
- Department of Physics, Enrico Fermi Inst., [Kavli Inst. for Cosmological Physics](#), Univ. of Chicago, Chicago, IL 60637
- Mitchell Institute for Fundamental Physics and Astronomy, Texas A&M University, College Station, TX 77843
- Univ of Virginia Physics Department, Charlottesville, VA 22904
- Colorado State University, Fort Collins, CO 80523
- Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM 87545
- Department of Physics, Occidental College, Los Angeles CA 90041
- Canisius College, Buffalo, NY, 14208
- Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720

High Energy Physics

- Florida Institute of Technology, Melbourne, FL 32901
- University of Texas, Arlington, TX, 76019
- Yale University, New Haven, CT 06520
- University of Wisconsin-Madison, Madison, USA
- University of Hawaii, Department of Physics and Astronomy, Honolulu, HI 96822
- Department of Physics, Carleton University, Ottawa, ON, K1S 5B6, Canada
- University of Michigan,
- Rice University
- University of California at Los Angeles
- Texas A&M
- Wayne State
- Harvard University
- Boston University
- University of California at Davis
- Brandeis University

IF5 – WP4, WP5, WP6
A. Bellerive's talk
K. Black's talk
P. Lewis's talk

- ❑ 44 US-MPGD institutions that contributed to the Snowmass2021
- ❑ 5 White papers → listed per field
- ❑ For IF-WP3, institutions in the collaboration (not all actively involved in MPGDs)
- ❑ Astrophysics, Medical & Industrial application are not listed

US-MPGD Facility: Preliminary discussions

Meeting with J. Fast (JLab), S Vahsen and M. Titov at Seattle on Thursday, July 21st at Seattle before the IF5 MPGD session

- ❖ M. Titov and S. Vahsen → Conveners of Snowmass2021 IF5-MPGD
- ❖ Discuss various options for US-MPGD facility at JLab
 1. **Small scale** MPGD Fabrication Facility *a la* CERN MPT (**aka Rui's workshop**) for GEMs, Micromegas and uRWELL production **for R&D activities**
 2. MPGD Detector Development Lab *a la* CERN Gas Detector Development (GDD) lab (**aka RD51 R&D lab**)
- ❖ **Consensus is for the 3rd option with both a detector R&D and fabrication facility → The two are interdependent and complementary**
 1. A GDD-like lab gives opportunity for new ideas **from external groups** to be tested, developed and validated
 - create a strong community where ideas are exchanged, and technical problems find solution
 2. Fabrication facility is where the **new devices** from those new ideas are fabricated.
 - also lead to improvement or development of new fabrication techniques

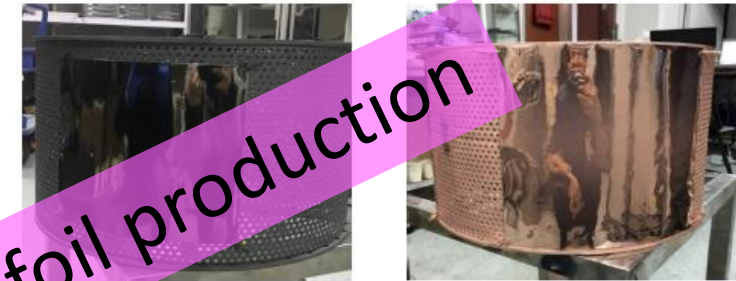
Continue the discussion during my presentation on Friday 22nd at the IF5 MPGD session

- ❖ Here too, there is a consensus among the community in the US for a need for the two legs of the US-MPGD facility
- ❖ Organize a US-MPGD Facility Workshop at JLab to discuss the scope of the facility with the broader MPGD community (NP, HEP, Astro)

US-MPGD Facility: MPGD Fabrication Workshop

CERN MPT Workshop model

- Possible solution: installation of a magnetron sputtering machine at CERN (co-funded by CERN, LNF-INFN and possibly by other European Institutions ...)
- The machine should have the following features:



As an example: DLC foil production



- Chamber size: $\Phi 800\text{mm} \times 900\text{mm}$
- Max foil size with good DLC uniformity: $\sim 50 \times 200\text{ cm}^2$
- Equipped w/automatic shutter, allowing the DLC and Cr/Cu coating in the same batch

- **CERN MPT workshop:**
Fabrication of large area
- GEM foils
- Micromegas
- μRWELL foils
- Complex flex PCB structures for MPGD readouts

US-MPGD Facility: MPGD Fabrication Workshop

SiDet model @ Fermilab

- ❖ SiDet is DOE model for a dedicated facility suitable for the development and construction of type-targeted, state-of-the-art, detector development
- ❖ Was originally built for the construction of the Tevatron (D) and CDF) silicon detectors.
- ❖ Subsequently it expanded significantly and many generations of silicon strip and pixel detectors, as well as other silico-based (CCD) and superconducting (MKIDs, SNSPDs, TES) detectors for Astro particle physics have been built.
- ❖ Funding for equipment came/comes partially from facility operations, and partially from projects, such as D0/CDF, CMS, DECAM, etc.

US-MPGD Facility: Detector R&D Lab

CERN GDD model: EP-DT-DD GDD Laboratory (Detector R&D)



Many breakthroughs in MPGDs over the last 10 years started with **R&D initiated in the GDD lab**

But breakthroughs in MPGDs over the last 10 years were **initiated by external groups with support from GDD lab**

Technical support
MPGD Detectors
Gas system and services
MPGD Readout electronics
Radioactive Sources

Interface with CERN services ([Thin Film and Glass Lab](#), [MPT Workshop](#), RP, gas, metrology, irradiation facilities, ...)

Major breakthroughs:

- Single mask technique for GEMs
 - Large area device
- Resistive Micromegas
 - Stability & large area
- μ RWELL structures
 - Fabrication simplicity
- PICOSEC Micromegas
 - Fast timing MPGD
- SRS readout electronics:
 - Test APV25 and VMM3a

US-MPGD Facility @ JLab: Where are we?

- ❖ JLab management strongly supports hosting a US MPGD facility
 - ❖ Had a couple of discussions with **D. Cinabro** - DOE Program Manager for Facilities in Nuclear Physics
 - ❖ Included as explicit possibility in future budget planning
- ❖ An informal **JLab MPGD Whitepaper** was sent to DOE – NP to lay out the vision for the a user facility for the community (January 2023)
 - ❖ *“Jefferson Lab would be creating a centralized location for the concentration of MPGD development resources to serve as an asset to the nation’s scientific community.”*
- ❖ The Lab has the real estate, expertise, and some existing infrastructure to host an MPGD facility
- ❖ The JLab MPGD Facility idea is expected appear in the NSAC LRP 2023

JLab informal MPGD Whitepaper - sent to DOE-NP division

Envisioned Jefferson Lab Micropattern Gaseous Detector Resource and Development Center

Background

Micropattern gaseous detectors (MPGDs) are charged particle detectors that utilize the ionization of a gas caused by the passage of high energy charged particles. They are based on thin printed circuit board (PCB) type foils with photolithography produced electronic elements/openings. The openings result in sub-millimeter distances between anode and cathode electrodes. When a voltage potential is applied the small openings enable *In situ* strong electrostatic fields. Ionizing radiation (i.e. high energy charged particles) interacting with the gas produce ionization electrons and ions that drift apart and are accelerated via the applied voltage potential. Electrons accelerated in the regions of strong electrostatic field in the gas create avalanches of additional electron-ion pairs in regions leading to their detection by readout electronics. See Figure 1 for example.

In the research fields of nuclear physics, high energy physics, astrophysics and beyond MPGDs are the choice for cost effective instrumentation of large area detection and for continuous tracking of charged particles with minimal detector material. The various types of MPGDs differ in the way the electrostatic field is created. Below is a list of MPGDs in use or under development:

- Gas Electron Multiplier (GEM)
- Micro-Mesh Gaseous Structure (MicroMegas)
- Thick GEMs (THGEMs), aka Large Electron Multipliers (LEMs)
- Resistive Plate WELL (RPWELL)
- GEM-derived architecture (μ RWELL)
- Micro-Pixel Gas Chamber (μ -PIC)
- Integrated pixel readout (InGrid).

During the recent July 2022 Snowmass meeting, a ten-day international gathering of over 1000 particle physicists convened to discuss ways to advance the science [1]. The Snowmass meeting happens about every ten years. Associated with the meeting there were over 150 white papers submitted to be part of a larger report. Five white papers dealt solely with MPGDs [2]. One of those white papers summarized the role of MPGDs in ongoing and future nuclear physics (NP) experiments and discussed the development needed to meet the challenges of future NP experiments [3].

In the white paper’s section 4.4. *Need for MPGDs R&D facility in the US for the Nuclear Physics community* it states:

US-MPGD Facility @ JLab: What is missing?

- ❖ So far, a US-based MPGD facility is viewed as a need for the NP community and the DOE-NP is generally supportive of the idea for an JLab MPGD facility – but has not yet committed funds
- ❖ Currently, such a facility is viewed as to satisfy the needs for NP community
- ❖ Not clear if at the DOE-HEP level, there is the same level of awareness of the need of an MPGD facility by the HEP community
- ❖ US- HEP institutions involved in MPGD R&D need to make the case for the need of the US-based MPGD facility for their community to the DOE - HEP counterpart, support the NP effort
- ❖ MPGD facility language (or a sidebar?!) in the P5 could be the best vehicle to convey the message
- ❖ A mutual interest by the both the HEP and NP communities that will appear in the Snowmass 2022 Whitepaper, the NSAC LRP and in the P5 report will make a very strong case for a US (JLab) based MPGD User Facility

Backup

US-MPGD Facility: Detector R&D Lab

CERN GDD model: EP-DT-DD GDD Laboratory (Detector R&D)

Permanent Users (ALICE, ATLAS, ESS) station



Temporary Users Working station



Active (X-Ray) and Radioactive Sources



Cosmic Stands



Clean Room



Workshops



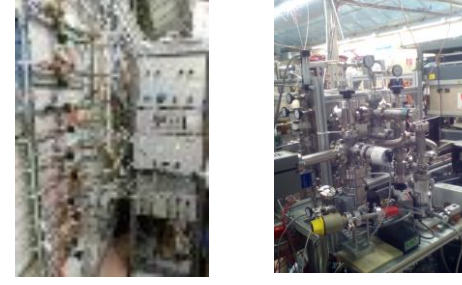
Optical Readout & Measurements



Vacuum Systems



Gas & Monitoring system



MPGD Electronics

