

IF5: Instrumentation Frontier Topical group on Micro-Pattern Gaseous Detectors (MPGDs)

Conveners: Bernd Surrow, Maxim Titov, Sven Vahsen

<https://snowmass21.org/instrumentation/mpgd> <--- convenor contact info, mailing list

IF5 White Papers

	Topic	Executive Summary Length	White Paper Leads
1	MPGDs: Recent advances and current R&D	3	Klaus Dehmelt, Andy White
2	MPGDs for nuclear physics experiments	1.5	Kondo Gnanvo, Matt Posik
3	Recoil imaging for DM, neutrino, and BSM physics*	1.5+1.5+1.5 (IF+NF+CF)	Dinesh Loomba, Ciaran O'Hare
4	MPGDs for TPCs at future lepton colliders	1.5	Alain Bellerive
5	MPGDs for muon detection at future colliders	1.5	Anna Colaleo, Kevin Black
	Grand summary table + text	1	IF5 conveners

*Multi-frontier paper with Cosmic and Neutrino Frontiers








Basis for 10-page summary of IF5

- Advanced drafts of all white papers in place --- PDFs uploaded to Indico
- Thanks to the authors for their tremendous efforts!
- A bit more detailed status on following pages
- Feedback on missing items encouraged within next 2 weeks, please send directly to White Paper leads
- Aiming for 1.5-page executive summary for most WPs → combine into 10-page summary of IF5

IF05 Whitepaper 1:

WPLs: Klaus Dehmelt, Andy White

MPGDs: Recent advances and current R&D

LOI title	Contact	Status
Development of the Micro-Pattern gaseous detector technologies: an overview of the CERN-RD51 collaboration	awhite@uta.edu / klaus.dehmelt@stonybrook.edu	 Draft section
High precision timing with the PICOSEC micromegas detector	sebastian.white@cern.ch	 Draft section
Optical readout of MicroPattern Gaseous Detectors: developments and perspectives	florian.brunbauer@cern.ch	 Duplicate - removed
Pixelated resistive MicroMegs for high-rates environment	massimo.della.pietra@cern.ch	 Draft section
Trigger extensions for the scalable readout system SRS	hans.muller@cern.ch	 Draft section
A high-gain, low ion-backflow double micro-mesh gaseous structure	zhzhy@ustc.edu.cn	 Draft section
LOI from NSCL	cortesi@nscl.msu.edu	 Duplicate - removed

Outline: After discussions with RD51 Management – outline will use RD51 LOI as overall guide, use sections of submission to LHCC for RD51 detailed activities, and add in sections from the other six LOI listed above.

arXiv Preprint
February 17, 2022

Snowmass White Paper IF05
Whitepaper 1: MPGDs: Recent advances and current R&D

K. DEHMELT, A. WHITE, AND LOI AUTHORS (TO BE INSERTED)

ABSTRACT

Submitted to the Proceedings of the US Community Study
on the Future of Particle Physics (Snowmass 2021)

1

- 51 pages
- Mature text
- Missing
 - Integration of chapters
 - Table of contents
 - Executive summary

IF5 WP2: MPGDs for nuclear physics experiments

WPLs: Kondo Gnanvo, Matt Posik

LOI title	Contact
Advanced Micro-Pattern Gas Detectors for Tracking at the Electron Ion Collider	hohlmann@fit.edu
Development of large micro pattern gaseous detectors for high rate tracking at Jefferson Lab	kgnanvo@virginia.edu
LOI from NSCL	cortesi@nscl.msu.edu
The role of MPGD-based photon detectors in RICH technologies	Silvia.DallaTorre@ts.infn.it
Snowmass 2021 Expression of Interest: MPGD-based Transition Radiation Detector	yulia@jlab.org

Title: MPDG Roles in Nuclear Physics Experiments

Micro Pattern Gaseous Detectors (MPGDs) for Nuclear Physics

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Preprint submitted to Elsevier

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- 28 pages
- The structure is almost final
- Editing still ongoing

IF5 WP3:

Recoil imaging for DM, neutrino, and BSM physics

LOI title	Contact
CYGNUS: a nuclear recoil observatory with directional sensitivity to dark matter and neutrinos	sevahsen@hawaii.edu
Optical readout of MicroPattern Gaseous Detectors: developments and perspectives	florian.brunbauer@cern.ch
Towards directional nuclear recoil detectors: tracking of nuclear recoils in gas Argon TPCs	David Caratelli (davidc@fnal.gov)
Dual-Readout Time Projection Chamber: exploring sub-millimeter pitch for directional dark matter and tau identification in $\nu\tau C C$ interactions.	Elena Gramellini, elenag@fnal.gov
Directional detectors for CEvNS and physics beyond the Standard Model	Diff@oxy.edu Daniel Snowden Ifft
Trigger extensions for the scalable readout system SRS	Hans.Muller@cern.ch
The International Axion Observatory (IAXO): MPGD development	E. Ferrer Ribas esther.ferrer-ribas@cea.fr

Inter-frontier (Neutrino, Dark Matter, Instrumentation) White Paper on directional nuclear + electron recoil detection w/ dedicated executive summaries for each Snowmass topical group (including MPGD requirements for IF5)

<https://indico.fnal.gov/event/52282/>

Workshop held in December
Video available by request

White Paper on recoil imaging - Mini Workshop

Friday Dec 17, 2021, 9:00 AM → 1:00 PM US/Hawaii

Description Zoom: <https://uni-sydney.zoom.us/j/2980559069?pwd=MzJFZDYzRHh1WER2V2pvM3pMY3ZQQT09>
Overleaf document: <https://www.overleaf.com/4526947269qvdvnmnmhtml>

LOIs

- CYGNUS
- Gas Argon TPCs
- Scalable readout system
- Optical readout
- Dual-readout TPC
- IAXO
- CEvNS

9:00 AM → 9:20 AM	Dual-Readout Time Projection Chamber: exploring sub-millimeter pitch for directional dark matter and tau identification in $\nu\tau$ C interactions Speaker: Elena Gramellini (Fermilab)	20m	
9:20 AM → 9:40 AM	The International Axion Observatory (IAXO): MPGD development Speaker: Esther Ferrer-Ribas	20m	
9:40 AM → 10:00 AM	Optical readout of MicroPattern Gaseous Detectors: developments and perspectives Speaker: Florian Brunbauer (CERN)	20m	
10:00 AM → 10:20 AM	Towards directional nuclear recoil detectors: tracking of nuclear recoils in gas Argon TPCs Speaker: David Caratelli (Fermilab)	20m	
10:20 AM → 10:40 AM	Directional detectors for CEvNS and physics beyond the Standard Model Speaker: Daniel Snowden-Ifft (Occidental College)	20m	
10:40 AM → 11:00 AM	CYGNUS: a nuclear recoil observatory with directional sensitivity to dark matter and neutrinos Speaker: Sven Vahsen (University of Hawaii)	20m	
11:00 AM → 11:20 AM	Trigger extensions for the scalable readout system SRS Speaker: Hans Müller	20m	
11:20 AM → 11:40 AM	Recoil directionality in CF1 and NF10	20m	
11:40 AM → 12:10 PM	Discussion of plans Speakers: Ciaran O'Hare (University of Sydney), Dinesh Loomba (University of New Mexico)	30m	

Recoil imaging for dark matter, neutrinos, and physics beyond the Standard Model

Snowmass 2021 inter-frontier white paper:

CF1: Particle-like dark matter

NF10: Neutrino detectors

IF5: Micro-pattern gas detectors

Submitted to the Proceedings of the US Community Study
on the Future of Particle Physics (Snowmass 2021)

Abstract

Recoil imaging entails the direct measurement of one or more components of a recoiling particle's direction. This is a capability highly sought-after in detectors, with applications across particle and astroparticle physics. However, currently it seems to only be a practical goal for micro-pattern gas detectors (MPGDs). This white paper outlines the physics case for directional recoil detection, and puts forward a decadal plan to advance towards high definition recoil imaging, in the context of the MPGD topical group of the Snowmass 2021 Instrumentation Frontier community study. The science case covered includes the discovery of DM into the neutrino fog, directional detection of neutrino-electron scattering, the precision study of coherent-elastic neutrino-nucleus scattering, the measurement of the Migdal effect, as well as several other applied physics goals. We also describe several ongoing R&D projects that will test crucial ideas such as the use of negative ion drift in MPGDs, the possibility for sub-mm tracking in gaseous argon time projection chambers, as well as the readout and electronics systems needed for detector scale-up to the ton-scale and beyond.

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3

- 53 pages
- Some minor parts missing
- Some self-plagiarized text (plan to rewrite)
- Considering publishing the result

IF5 WP4: MPGDs for TPCs at future lepton colliders

LOI title	Contact
Belle II detector upgrades	for TPC: Peter Lewis; lewis@physik.uni-bonn.de
Time projection chamber R&D	qihr@ihep.ac.cn
A time projection chamber using advanced technology for the International Large Detector at the International Linear Collider	alainb@physics.carleton.ca
A high-gain, low ion-backflow double micro-mesh gaseous structure	zhzhy@ustc.edu.cn

1 MPGDs for TPCs at future lepton colliders

2 A. BELLERIVE

3 *Department of Physics, Carleton University, Ottawa, ON, K1S 5B6, Canada*

4 ABSTRACT

5 This submission will focus on advancements and advantages of Micro Pattern
6 Gas Detector (MPGD) technologies together with their applications for the con-
7 struction of a dedicated Time Projection Chamber (TPC) that can serve as an
8 excellent main tracker for any multipurpose detector that can be foreseen to
9 operate at a future lepton collider. The first portion of the report will be the 1.5
10 page executive summary. It will be followed by sections detailing on applications
11 of MPGDs specifically for the construction of the LCTPC for the ILD at ILC,
12 for a possible upgrade of the Belle II detector and for the design of a TPC for a
13 detector at CEPC. MPGD technologies offer synergy with other detector R&D's
14 and several application domains; a few examples will be provided in the context
15 of the long range planning exercise in the USA. Link to industrial partnership
16 and work with institutions in the USA will be highlighted when appropriate.

17
18
19 Submitted to the Proceedings of the US Community Study
20 on the Future of Particle Physics (Snowmass 2021)
21
22

- 15 pages
- Close to finished
- Reviewed by LOI submitters, feedback already incorporated
- For the final version (planned next Monday):
 - add references
 - minor grammar & text edits
 - add figure about GridPix (and make a stronger case for dE/dx and resolution)
 - add author list

WP#5: MPGD for tracking and Muon detection at future high energy physics colliders

WPL: A. Colaleo, K. Black

Title	LOI title	Contact(s)	Chapter
Introduction		Anna.Colaleo@cern.ch Kevin.Black@cern.ch	ok
	MPGDs for tracking and muon detection: progress review and updated R&D roadmap	hohlmann@fit.edu	No feedback from proponent.
High granularity resistive Micromegas for high rates	Pixelated resistive MicroMegas for high-rates environment	paolo.iengo@cern.ch	ok
Advanced GEM detectors for future collider experiments	Advanced GEM detectors for future collider experiments	Antonello.Pellecchia@cern.ch , Jeremie.Merlin@cern.ch	ok
μ -RWELL for HEP experiments	micro-RWELL detector	Giovanni.Bencivenni@Inf.infn.it	ok
Gas system for HEP		Beatrice.Mandelli@cern.ch Roberto.Guida@cern.ch	ok

Status

- We have recently combined four different articles in one document.
- We need to still some tweak to get uniform style, acronyms etc.
- Each chapter in very good shape
- Internal review of the authors is still on-going.
- Bibliography, list of author to be finalized.
- Link to the draft document:
- https://www.dropbox.com/s/013w5kqsttk8d13/Snowmass_all_WP5.pdf?dl=0

MPGD for tracking and Muon detection at future high energy physics colliders

Snowmass Instrumentation Frontier: MPGD White paper 5

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Submitted to the Proceedings of the US Community Study
on the Future of Particle Physics (Snowmass 2021)

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- 81 pages
- Introduction = executive summary?

Summary & Questions

- MPGD Topical Group White Papers in good shape, nearly complete
 - Current PDF for all papers uploaded after this talk on Indico
 - Total of 228 pages!
 - **Thanks to the authors for their tremendous efforts!**
- Good time for feedback on missing contents / balance of contents. Please provide this no later than two weeks from now.
- Probably too early for feedback on typos and details.
- Questions from IF5 to Snowmass:
 - OK to submit white papers to journals after March 15? We assume yes.
 - Cross-referencing between white papers? Plan: use preliminary citations with full white paper names, working group, and number for now. Replace citations with arxiv citations after March 15.

BACKUP

Past IF5 activities

- We held bi-weekly meetings before the Snowmass pause
<https://indico.fnal.gov/category/1185/>
 - Collected input from the community
 - Reviewed technical presentations
 - Encouraged submission of Letters of intent (LOIs)
- 40 LOIs were submitted to IF5
 - <https://snowmass21.org/instrumentation/mpgd>
- We identified a few additional LOIs relevant to IF5
- Most LOIs were consolidated into five White Papers
 - A few LOIs passed on to other topical groups
- Restarted meetings focused on these White Papers in 2021

IF5 WP1

MPGDs: Recent advances and current R&D

LOI title	Contact
Development of the Micro-Pattern gaseous detector technologies: an overview of the CERN-RD51 collaboration	Silvia.DallaTorre@ts.infn.it
High precision timing with the PICOSEC micromegas detector	Christos.Lampoudis@cern.ch
Optical readout of MicroPattern Gaseous Detectors: developments and perspectives	florian.brunbauer@cern.ch
Pixelated resistive MicroMegas for high-rates environment	massimo.della.pietra@cern.ch
Trigger extensions for the scalable readout system SRS	Hans.Muller@cern.ch
A high-gain, low ion-backflow double micro-mesh gaseous structure	zhzhy@ustc.edu.cn
LOI from NSCL	cortesi@nscl.msu.edu

Scope of IF5

- This Snowmass 2021 topical group **will identify and document recent developments and future needs for Micro-Pattern Gaseous Detector (MPGD) technologies, driven by the availability of modern photolithographic techniques.**
- Current MPGD technologies include the Gas Electron Multiplier (GEM), the Micro-Mesh Gaseous Structure (MicroMegas), Thick GEMs (THGEMs), also referred to in the literature as Large Electron Multipliers (LEMs), the Resistive Plate WELL (RPWELL), the GEM-derived architecture (micro-RWELL), the Micro-Pixel Gas Chamber (μ -PIC), and the integrated pixel readout (InGrid).
- In recent years, there has been a surge in the use of MPGDs. MPGDs are now used in major ongoing particle-collider experiments (e.g., ATLAS, CMS, and ALICE at the LHCb) and are in development for future facilities (e.g., EIC, ILC, FCC, and FAIR). A majority of MPGD developers and users coordinate and collaborate as part of the CERN-RD51 collaboration.
- MPGDs are of interest for **particle/hadron/heavy-ion/nuclear physics, charged particle tracking, photon detectors and calorimetry, neutron detection and beam diagnostics, neutrino physics, and dark matter detection**, including operation at cryogenic temperatures. Beyond fundamental research, MPGDs are in use and considered for scientific, social, and industrial purposes; this includes the fields of material sciences, medical imaging, hadron therapy systems, and homeland security.

6 LOIs were co-assigned to IF5, but another TG should take the lead

IF3 IF5 Simone Mazza-175.pdf	High density 3D integration of LGAD sensors through wafer to wafer bonding	simazza@ucsc.edu	Suggest IF3
IF6 IF5 Laktineh-Calice-050.pdf	Timing semi-digital hadronic calorimeter (T-SDHCAL)	laktineh@in2p3.fr	Suggest IF6
IF8 IF5-NF10 NF0 Ben Jones-070.pdf	Scintillating and quenched gas mixtures for HPGTPCs	ben.jones@uta.edu	Focused on scintillation and gas physics. Let other TG take lead.
EF3 EF4-IF3 IF5-031.pdf	The IDEA drift chamber for a Lepton Collider	franco.grancagnolo@le.infn.it	IDEA drift chamber. Tracking. Suggest IF3.
EF4 EF0-AF3 AF0-IF3 IF5 GrahamWilson-119.pdf	Exploring precision electroweak physics measurement potential of e+e- colliders	gwwilson@ku.edu	Focused on physics, not MPGDs. Needs another TG.
IF7 IF5 H.MULLER-101.pdf	Trigger extensions for the scalable readout system SRS	Hans.Muller@cern.ch	Let IF7 take lead, but should also be discussed in IF5 whitepaper

LOIs that did not indicate IF5, but which are relevant to our White Papers

Authors of these LOIs agreed to contribute to White paper #3 (Recoil imaging)

IF8 IF0-NF10 NF6 Jacob Zetlemoyer-150.pdf	Towards directional nuclear recoil detectors: tracking of nuclear recoils in gas Argon TPCs	David Caratelli (davidc@fnal.gov)
IF/SNOWMASS21-IF9 IF8-NF3 NF10-CF1 CF0-145.pdf	Dual-Readout Time Projection Chamber: exploring sub-millimeter pitch for directional dark matter and tau identification in $\nu\tau$ C interactions.	Elena Gramellini, (Fermi National Accelerator Laboratory), elenag@fnal.gov
	Directional detectors for CEvNS and physics beyond the Standard Model	Diff@oxy.edu Daniel Snowden Ifft

Submitted LOIs: 24 (links below are clickable)

<https://snowmass21.org/instrumentation/mpgd>

1	CF/SNOWMASS21-CF1_CF0-NF10_NF4-IF5_IF4_Vahsen-189.pdf	31/08/2020
2	EF/SNOWMASS21-EF3_EF4-IF3_IF5-031.pdf	06/08/2020
3	EF/SNOWMASS21-EF4_EF0-AF3_AF0-IF3_IF5_GrahamWilson-119.pdf	30/08/2020
4	IF/SNOWMASS21-IF2_IF7_IF3_IF4_IF5_IF6-056.pdf	29/08/2020
5	IF/SNOWMASS21-IF3_IF5-EF1_EF4-183.pdf	01/09/2020
6	IF/SNOWMASS21-IF3_IF5_Simone_Mazza-175.pdf	31/08/2020
7	IF/SNOWMASS21-IF5-005.pdf	27/07/2020
8	IF/SNOWMASS21-IF5-EF4-007.pdf	07/08/2020
9	IF/SNOWMASS21-IF5_CF2_AF5_Ferrer-Ribas-020.pdf	27/08/2020
10	IF/SNOWMASS21-IF5_IF0-057.pdf	30/08/2020
11	IF/SNOWMASS21-IF5_IF0-184.pdf	01/09/2020
12	IF/SNOWMASS21-IF5_IF0-193.pdf	08/09/2020 late
13	IF/SNOWMASS21-IF5_IF0_Brunbauer-096.pdf	31/08/2020
14	IF/SNOWMASS21-IF5_IF0_C.Lampoudis-098.pdf	31/08/2020
15	IF/SNOWMASS21-IF5_IF0_Gnanvo_Hohlmann_Posik_Surrow-044.pdf	28/08/2020
16	IF/SNOWMASS21-IF5_IF0_Kondo_Gnanvo-159.pdf	31/08/2020
17	IF/SNOWMASS21-IF5_IF0_M_Hohlmann-040.pdf	28/08/2020
18	IF/SNOWMASS21-IF5_IF0_Marco_Cortesi-103.pdf	31/08/2020
19	IF/SNOWMASS21-IF5_IF3-015.pdf	24/08/2020
20	IF/SNOWMASS21-IF5_IF6-EF4_EF0_COLALEO-068.pdf	30/08/2020
21	IF/SNOWMASS21-IF5_IF9-EF0_EF0-168.pdf	31/08/2020
22	IF/SNOWMASS21-IF6_IF5_Laktineh-Calice-050.pdf	29/08/2020
23	IF/SNOWMASS21-IF7_IF5_H.MULLER-101.pdf	31/08/2020
24	IF/SNOWMASS21-IF8_IF5-NF10_NF0_Ben_Jones-070.pdf	30/08/2020