RDC6 Kick-off meeting

Sven Vahsen and Prakhar Garg

(RDC6 coordinators)

Background and Introduction

- As part of the Snowmass 2021 decadal survey and the CPAD workshops, the US detector R&D community organized into topical groups
- The goal is to now build on these efforts to form R&D Collaborations (RDCs)
- RDC6 covers Gaseous Detectors
- The plan is that the RDCs will design specific work packages
- This is what we know so far:
  - There is likely to be DOE funding for a few such work packages
  - Initially via the comparative review process in Fall 2024
  - Later via dedicated FOAs
  - DOE encourages blue-sky rather than project-oriented R&D
  - DOE hopes RDCs will cover both HEP and NP

RDC 6: Gaseous Detectors

- RDC6 Coordinators
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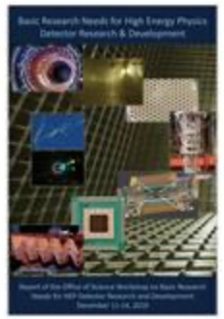
- RDC6 Email List
  - cpad_rdc6@fnal.gov
  - To subscribe:
    - Send an e-mail message to listserv@fnal.gov
    - Leave the subject line blank
    - Type “SUBSCRIBE cpad_rdc6 FIRSTNAME LASTNAME” (without the quotation marks) in the body of the e-mail message

Prakhar Garg
Yale University
- MPGDs
- TPCs
- Electron Ion Collider (EIC)

Sven Vahsen
University of Hawaii
- MPGDs
- TPCs for DM/ν/n detection
- Belle II

Background: BRN https://science.osti.gov/hep/Community-Resources/Reports

https://science.osti.gov/-/media/hep/pdf/Reports/2020/DOE_Basic_Research_Needs_Study_on_High_Energy_Physics.pdf



DOE Basic Research Needs Study on High Energy Physics Detector Research and Development

This report is based on a workshop on Basic Research Needs for High Energy Physics Detector R&D, which was held December 11-14, 2019. The goal of the BRN study was to assess the present status of the HEP technology landscape, and to identify strategic technology areas, aligned with the strengths of the US community, that future long-term R&D efforts should focus on in pursuit of the HEP science drivers identified in the 2014 P5 report. Across each of these areas, the study articulated a set of Priority Research Directions, together with research plans and infrastructure needs, to push the technology well beyond the current state of the art, potentially leading to transformative advances with broad-ranging applicability in HEP and beyond. Furthermore, the study identified a small set of high-impact instrumentation "Grand Challenges" where technological breakthroughs could lead to game-changing experimental capabilities in pursuit of HEP science goals.

PDF of this Report **Report Date: August 2020**

Does not explicitly cover gaseous detectors, and MPGDs not covered!

BACKGROUND: Snowmass Instrumentation Frontier

- Topical group IF5 focused exclusively on MPGDs
  - Both HEP and NP
  - Important to engage the wider (non-MPGD) gaseous detector community post- Snowmass
  - Convenors: Maxim Titov, Bernd Surrow, Sven Vahsen

Topical groups

- IF1: Quantum Sensors
- IF2: Photon Detectors
- IF3: Solid State Detectors and Tracking
- IF4: Trigger and DAQ
- IF5: Micro Pattern Gas Detectors (MPGDs)
- IF6: Calorimetry
- IF7: Electronics/ASICs
- IF8: Noble Elements
- IF9: Cross Cutting and Systems Integration
- IF10: Radio Detection

Additional topics, which are not explicitly covered by any of the groups above, but will be discussed nevertheless:

- Gravitational Wave instrumentation
- Neutron detection instrumentation

24 LOIs on MPGDs were submitted to Snowmass (links below are clickable)

https://atlaswww.hep.anl.gov/snowmass21/doku.php?id=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

- LOIs were distilled into five solicited White Papers
  - One additional White Paper has further detail
- Then summarized in final Snowmass report(s)

	White Paper Topic	**White Paper Leads**
1	MPGDs: Recent advances and current R&D (and the European Strategy)	Klaus Dehmelt, Andy White
2	MPGDs for nuclear physics	Kondo Gnanvo, Matt Posik
3	Recoil imaging for directional detection of dark matter, neutrinos and BSM physics * Multi-frontier w/ CF1, NF10	Dinesh Loomba, Ciaran O'Hare
4	MPGDs for TPCs at future lepton colliders	Alain Bellerive
5	MPGDs for tracking and muon detection at future high energy physics colliders	Anna Colaleo, Kevin Black
6	A TPC-based tracking system for a future Belle II upgrade	Peter Lewis

Links to White Papers

- K. Dehmelt, A. White, M. Alviggi, M. T. Camerlingo, V. Canale, V. D'amico, M. DellaPietra, et al. ”MPGDs: Recent advances and current R&D“, arXiv:2203.06562 [physics.ins-det] (pdf).
- Kondo Gnanvo, Matt Posik, Fernando Barbosa, Daniel Bazin, Francesco Bossú, Marco Cortesi, Silvia Dalla Torre, et al. ”Micro Pattern Gaseous Detectors for Nuclear Physics”, arXiv:2203.06309 [physics.ins-det] (pdf).
- C. A. J. O'Hare, D. Loomba, K. Altenmüller, H. Álvarez-Pol, F. D. Amaro, et al. ”Recoil imaging for dark matter, neutrinos, and physics beyond the Standard Model”, arXiv:2203.05914 [physics.ins-det] (pdf). (also under NF10, CF01)
- Alain Bellerive, Jochen Kaminski, Peter M. Lewis, Paul Colas, et al. ”MPGDs for TPCs at future lepton colliders”, arXiv:2203.06267 [physics.ins-det] (pdf).
- K. Black, A. Colaleo, C. Aimè, M. Alviggi, C. Aruta, M. Bianco, I. Balossino, et al. ”MPGDs for tracking and muon detection at future high energy physics colliders”, arXiv:2203.06525 [physics.ins-det] (pdf).
- Andreas Löschcke Centeno, Christian Wessel, Peter M. Lewis, Oskar Hartbrich, Jochen Kaminski, Carlos Mariñas, Sven Vahsen. ”A TPC-based tracking system for a future Belle II upgrade”, arXiv:2203.07287 [physics.ins-det] (pdf).

Report of the Topical Group on Micro-Pattern Gaseous Detectors for Snowmass 2021

https://arxiv.org/abs/2209.05202

IF5 Key Points

Contributions to Snowmass

Five commissioned white papers on MPGDs were developed during the 2021 Snowmass decadal survey. These summarize R&D on MPGDs [1], the future needs for MPGDs in nuclear physics [2] and in three broad areas of particle physics: low-energy recoil imaging [3], TPC readout for tracking at lepton colliders [4], and tracking and muon detection at hadron colliders [5]. A white paper with further details on a proposed TPC tracker for Belle II was also submitted [6].

Key Points The IF05 topical group would like to communicate the following high-level findings to the wider particle physics community:

- **IF05-1**: Micro-pattern gaseous detectors (MGPDs) constitute an enabling technology that is key for large segments of the future U.S. NP and HEP programs, and which also benefits other communities. MPGDs provide a flexible go-to solution whenever particle detection with large area coverage, fine segmentation, and good timing is required.
- **IF05-2**: The technology is relatively young and should be advanced to performance limits to enable future HEP experiments. Support of generic and blue-sky R&D is required to achieve this.
- **IF05-3**: The global HEP community would benefit from U.S. strategy coordination with the ECFA detector R&D implementation process in Europe.
- **IF05-4**: In order to maintain and expand U.S. expertise on MPGDs, The U.S. NP and HEP communities would benefit strongly from a joint MPGD development and prototyping facility in the U.S.

how to map into work packages?

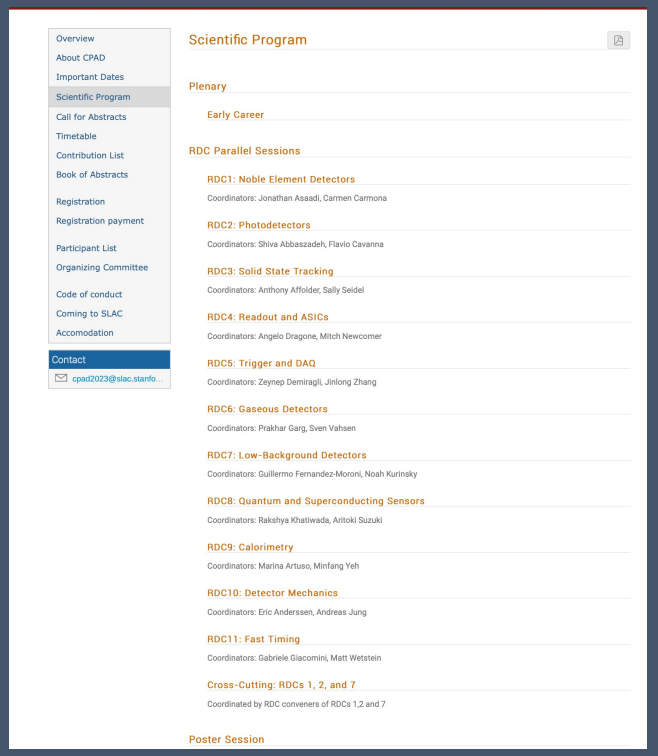
- Areas of R&D Priorities
  (based on Snowmass report, highly preliminary, biased, and non-exhaustive)

  - **Topic Area #1:** Advance gas TPC readout to performance limits, enabling new experiments
    (DM, neutrinos, existing and future lepton colliders, EIC)
    - Maximize sensitivity by achieving 3d single electron counting (incl. via negative ion drift)
    - Minimize background by developing radio-pure MPGDs
    - Develop matching, highly scalable front-end electronics and readout systems
    - Develop on-detector AI/ML and trigger-driven, highly multiplexed readouts

  - **Topic Area #2:** Advance MPGDs for high-background environments
    (Nuclear physics and future hadron colliders)
    - Develop cylindrical and exotic-shape tracking layers
    - Develop pico-second timing layers
    - Improve radiation hardness, rate capability, robustness against sparking and aging

  - **Topic Area #3**: Establish MPGD development/prototyping(/production) facility in the US

CPAD workshop



July 20, 2022, Snowmass CSS

- Scope widened to Gaseous Detectors

11:00	**MPGD as tracker for EIC**	*Sourav Tarafdar*	
	51/3-305 - Kavli 3rd Floor, SLAC		11:00 - 11:15
	sPHENIX TPC in the 2023 commissioning run	*Evgeny Shulga*	
	51/3-305 - Kavli 3rd Floor, SLAC		11:15 - 11:30
	Spark protection system for sPHENIX TPC GEMs	*David Baranyai*	
	51/3-305 - Kavli 3rd Floor, SLAC		11:30 - 11:45
	Digital RPC Gas Calorimetry for future colliders	*Yasar Onel*	
	51/3-305 - Kavli 3rd Floor, SLAC		11:45 - 12:00
12:00	**Compact TPC with TimePix Readout as a PID and tracking device**	*Prakhar Garg*	
	51/3-305 - Kavli 3rd Floor, SLAC		12:00 - 12:15

	Status and Future Developments of Micro-pattern Gas Detectors for low-energy nuclear physics applications at FRIB		
	Dr Marco Cortesi		
	Gaseous Detector R&D aimed at Recoil Imaging	*Sven Vahsen*	
	51/3-305 - Kavli 3rd Floor, SLAC		13:45 - 14:00
14:00	**High-resolution gas TPCs for next-generation intensity frontier tracking**	*Peter Lewis*	
	51/3-305 - Kavli 3rd Floor, SLAC		14:00 - 14:15
	A Gaseous Argon-Based Near Detector to Enhance the Physics Capabilities of DUNE	*Dr Tanaz Mohayai*	
	51/3-305 - Kavli 3rd Floor, SLAC		14:15 - 14:30
	NEXT-CRAB-0: a high pressure gaseous xenon time projection chamber with a direct VUV camera based readout		
	Ilker Parmaksiz		
	Machine Learning for Improved Analyses of High Resolution Gaseous Detector Data	*Jeffrey Schueler*	
	51/3-305 - Kavli 3rd Floor, SLAC		14:45 - 15:00
15:00	**First Light from the MIGDAL experiment: Results from Commissioning Data Using Fast Neutrons**	*Elizabeth Tilly*	
	51/3-305 - Kavli 3rd Floor, SLAC		15:00 - 15:15
	Overview and Status of DRD1 in Europe	*Maxim Titov*	
	51/3-305 - Kavli 3rd Floor, SLAC		15:15 - 15:30

RDC6: Gaseous Detectors

Prakhar Garg
Sven Vahsen

RDC6 Concluding slide at CPAD 2023

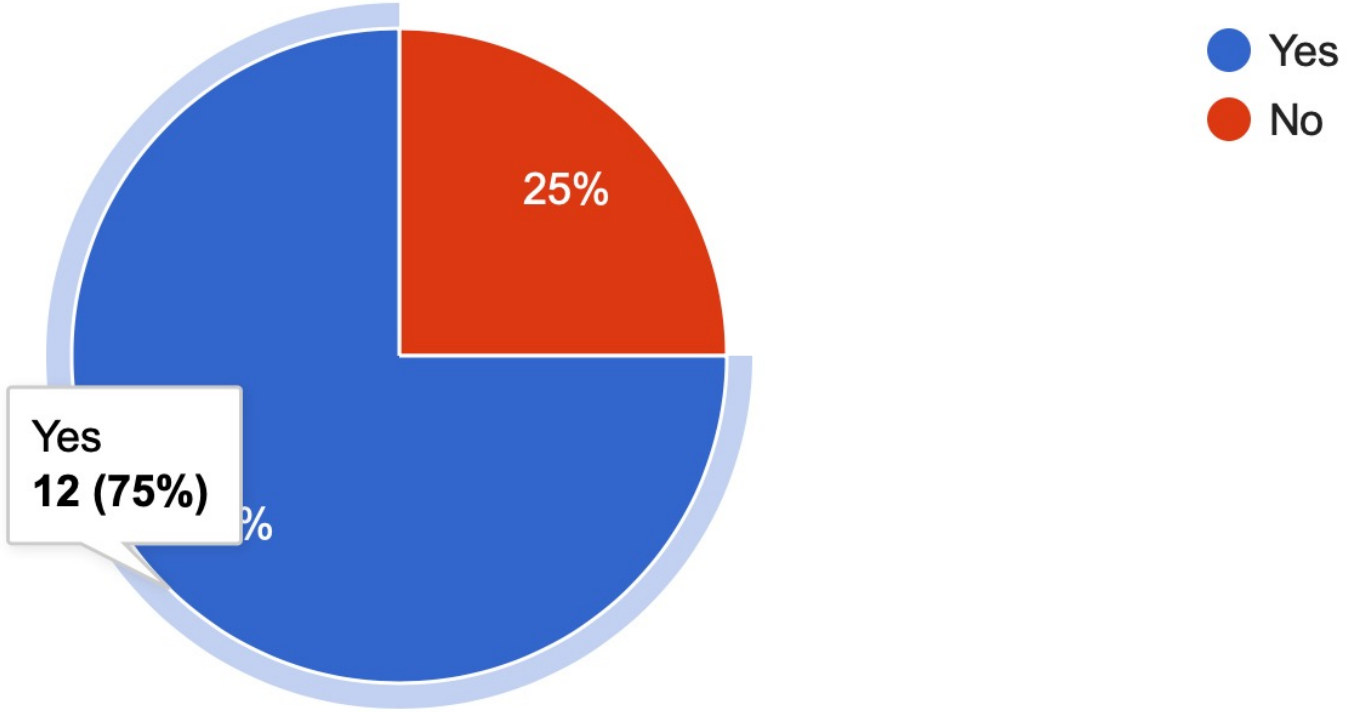
- 13 abstracts, 2 parallel sessions, 1 awards talk
- We plan to not replicated the large DRD1 structure in the US.
- Rather, we want to prepare work packages where US groups have specific expertise and strong interest, and then integrate these packages into the DRD1 plans.
- There are some obvious synergies between RDC6 groups working in different fields. For example, highly segmented MPGD-based charge readout schemes are foreseen at DUNE near detector, rare event searches, and at future collider detectors in HEP and NP.
- While specific work packages need proper discussion by the whole RDC6, preliminary ideas floated include:
  1. “Advancing gaseous TPC readout to the fundamental sensitivity limit”
  2. “Improved MPGD structures for nuclear physics and challenging environments” (for gases w/o quencher, negative ion drift, high charge density)
  3. “Achieving cost-effective scaling of gaseous TPCs“
- We will organize meetings to converge on 2-3 highest-priority work packages.
- Meetings will (only) be announced to the RDC6 mailing list. Sign up now! https://cpad-dpf.org/?page_id=1549

Results from Poll

16 responses so far… poll remains open…

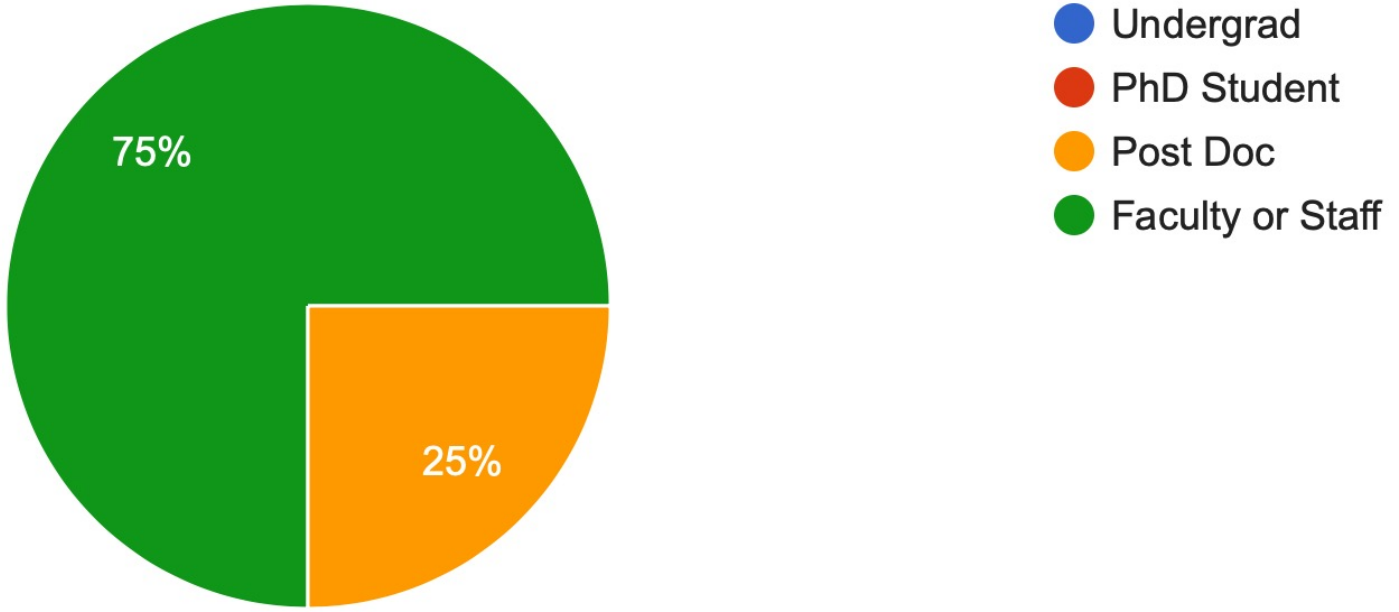
Are you based in US?

16 responses



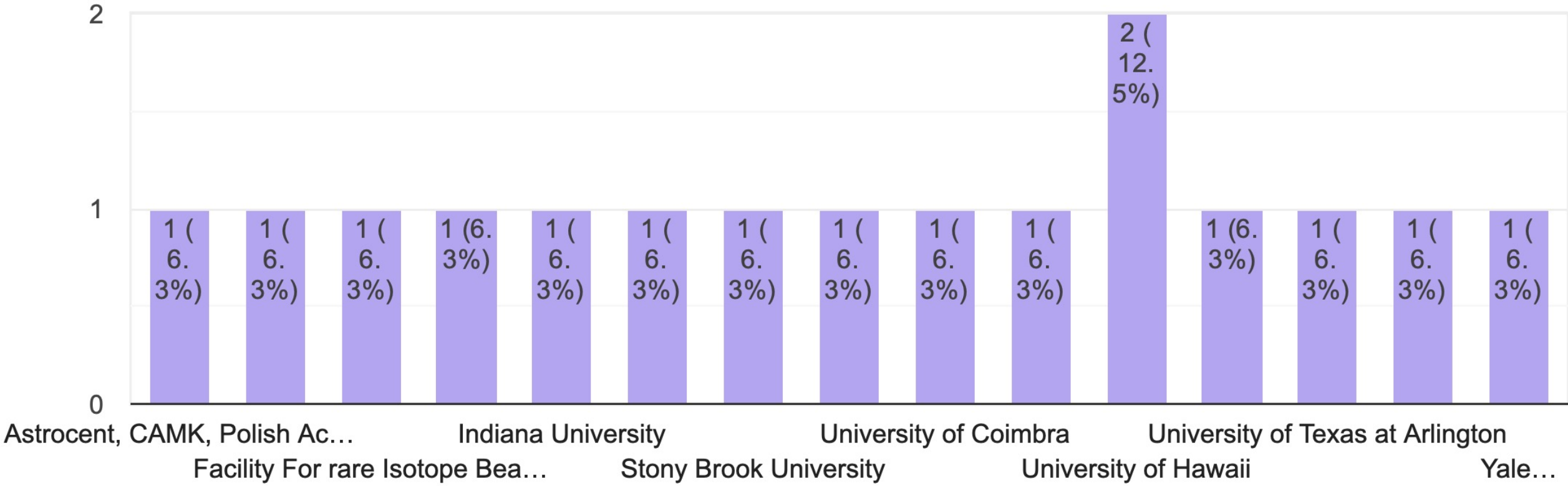
What is your career stage? (undergrad / PhD student / postdoc / faculty or staff)

16 responses



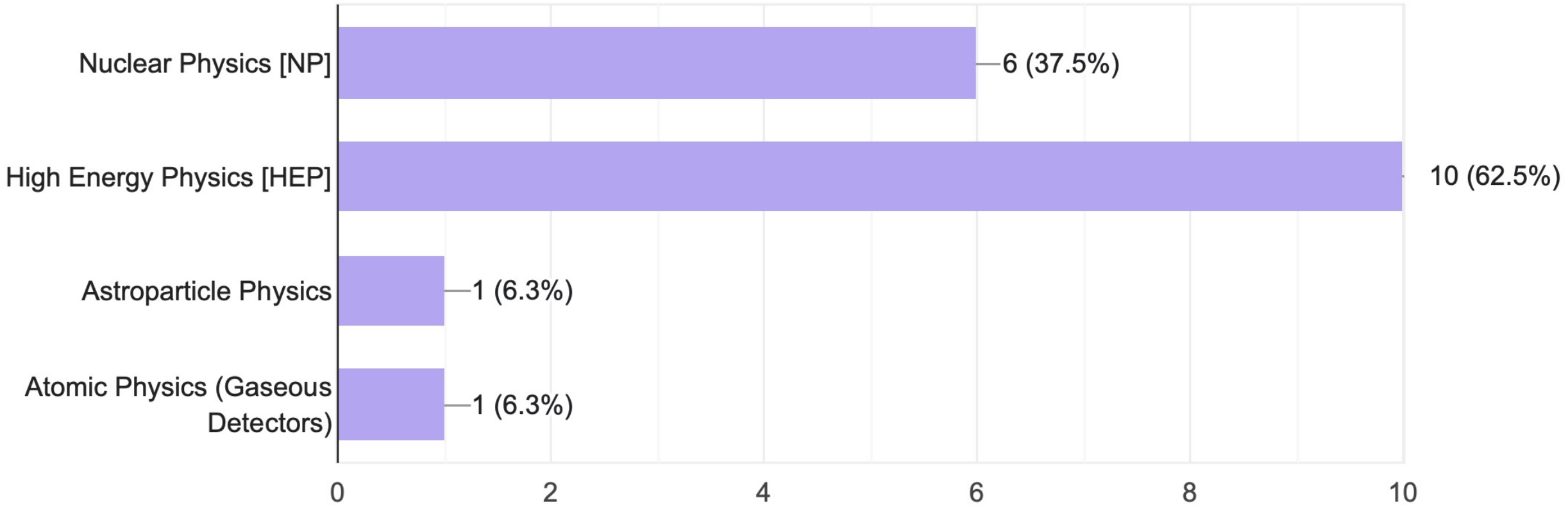
Institute Name

16 responses



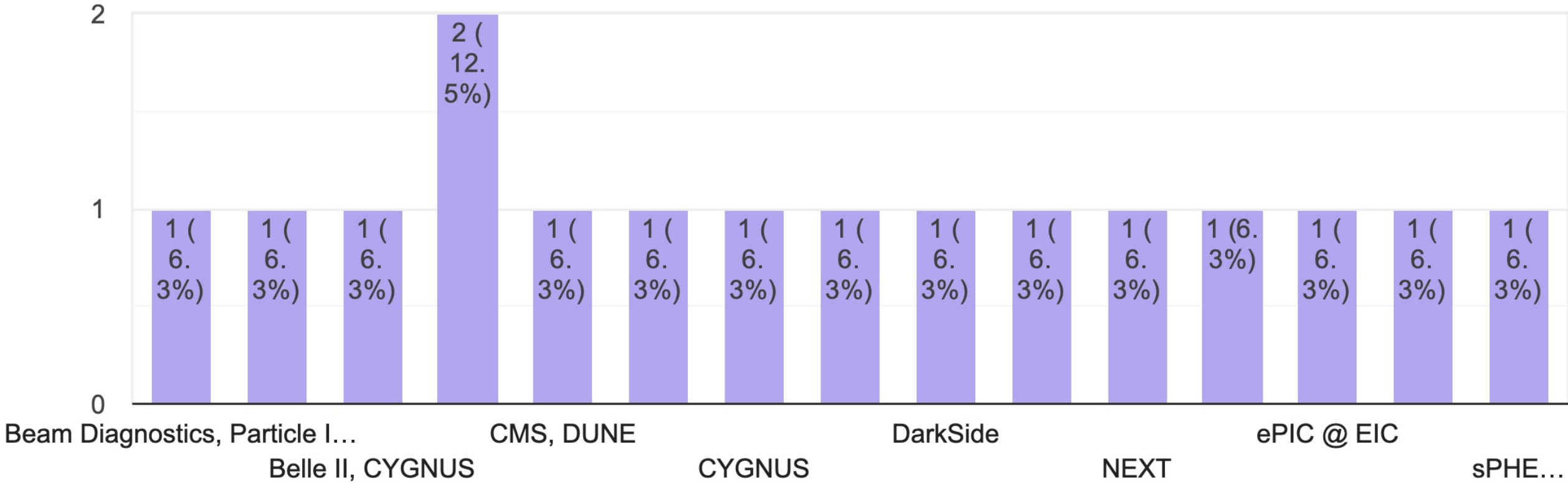
Your area of Research

16 responses



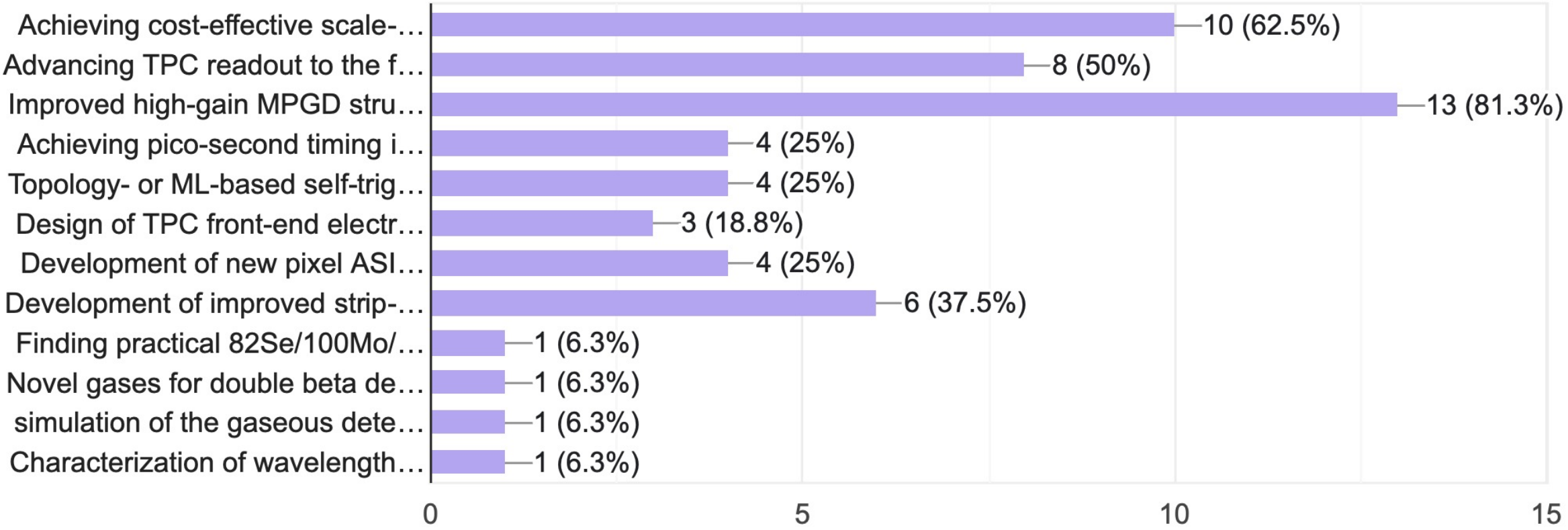
Which Experiment and Detector you are involved with (if any)

16 responses



Which work Package would you like to contribute for RDC6 (click all that apply)

16 responses



RDC #6 Gaseous Detectors --- Final Thoughts

- The most important goal: reach consensus on work packages well before funding opportunities
  - Secondary goal: integrate with DRD1 in Europe
- Tentative plan
  - Keep going with bi-weekly or monthly meetings as needed.
  - Welcome US gas detector proponents to present possible R&D *work packages* suitable for US funding opportunities
- Work packages
  - Should reflect strengths and desires of active US R&D community
  - Not replicate project-based efforts, but think more broadly and ambitiously
  - More than two packages may be unrealistic considering DOE priorities, number of RDCs and funding constraints
- The push for a DOE (NP+DOE) MPGD production facility or exploration of industrialized production can occur outside of work packages

DISCUSSION TIME

BACKUP

RDC 6: Roadmap

- Short-term plans to engage the community
  - Currently not planning dedicated poll. We already have the Snowmass input and are part of the several strongly engaged communities.
  - Instead, **please email Prakhar and Sven with proposed additional topics or any concerns.**
  - Planning Topic area meeting late August (after University summer breaks), to be announced via our mailing list, to summarize community interest and obtain any further input.

- 1-2 year goals for the RDC 6:
  - Planning to organize targeted work packages and to ask for R&D funding.
  - Topical area #1 on previous page might be suitable for “seed projects”
  - There appear to be two clusters of interested US collaborators focused on gas TPCs
    - TPC-based Low background experiments, incl. use of negative ion drift (MIGDAL, CYGNUS, CEvNS/neutrinos, neutrons)
    - TPC readout via grid-pix-style technologies (EIC, Belle II)

RDC 6: overlap with other RDCs / DRDs / existing collaborations

- Plan to collaborate and integrate with European RD51 (now DRD1) effort
  - Prakhar and Sven both members of RD51, Sven of DRD1

- Topic areas #1-2 overlap with
  - ongoing R&D activities and needs of EIC
  - R&D needs of CYGNUS / gas-based CEvNS and similar gas-based DM and neutrino experiments based on the principle of nuclear recoil imaging

- Synergies with ongoing projects on charge-readout technologies being developed for DUNE (such as LArPix and Q-Pix) and other charge-detection R&D covered by RDC1, Topic Area #1

- Large-scale TPC readout plane development and AI/ML on front end has strong synergies with synergies with RDCs #4,5

Please email us with proposed additional R&D topics or any concerns.

ECFA Strategy