RDC6: US R&D Collaboration for Gaseous Detectors

Status and Future Plans

Sven Vahsen (Hawaii) and Prakhar Garg (Yale)

DRD1 Collaboration Meeting
June 18, 2024

Contents

- Background info on CPAD RDCs
- RDC white paper process and funding
- RDC6 status & plans

Some of the following slides are slightly modified versions of material presented by Jonathan Asaadi (US CPAD Chair) at the CPAD RDC Community Meeting, May 3: https://indico.fnal.gov/event/64324/

Background

- US R&D Collaborations (RDCs) are being formed under the Coordinating Panel for Advanced Detectors (CPAD)
- This process resembles formation of the ECFA DRDs, but with some important differences that I hope to clarify as part of this talk
- RDCs formation endorsed in the 2023 US P5 report, lagging behind the DRD formation process (endorsed by 2021 ECFA Detector R&D Roadmap) by ~2 years
- As a result, RDCs are still substantially less defined than DRDs at this time
- RDC6 covers gaseous detectors as does DRD1
- We should plan carefully how RDC6 will interact and integrate with DRD1
- The goal of this talk is to explain what is currently happening on the US side, and thereby to stimulate more dialog regarding optimizing the RDC6 / DRD1 interaction

https://www.usparticlephysics.org/2023-p5-report/

Some critical aspects from the P5 report

Jonathan Asaasi

The particle physics community has identified the need for stronger coordination between the different groups carrying out detector R&D in the US. We strongly support the R&D Collaborations (RDCs) that are being established and will be stewarded by CPAD, the Coordinating Panel for Advanced Detectors, overseen by the APS/DPF. The RDCs are organized along specific technology directions or common challenges, and aim to define and follow roadmaps to achieve specific R&D goals. This coordination will help to achieve a more coherent detector instrumentation program in the US, and will help to avoid duplication while addressing common challenges. International collaboration is also crucial, especially in cases where we want to have technological leadership roles. Involvement in the newly established Detector R&D Groups at CERN is encouraged, as are contributions to the design and planning for the next generation of international or global projects. Targeted future collider detector R&D in particular, such as for Higgs factories or a muon collider, is covered in Section 6.5.

The RDC's are in the P5 report as is participation in the DRD's

Area Recommendation 6: Increase the budget for generic Detector R&D by at least $20 million per year in 2023 dollars. This should be supplemented by additional funds for the collider R&D program.

Area Recommendation 7: The detector R&D program should continue to leverage national initiatives such as QIS, microelectronics, and AI/ML.

The American Physics Society (APS) and Division of Particles and Fields (DPF) Coordinating Panel for Advanced Detectors (CPAD)

Jonathan Asaasi

CPAD Mission and Goals:

- The Coordinating Panel for Advanced Detectors (CPAD), seeks to promote, coordinate and assist in the research and development of instrumentation and detectors for high energy physics experiments.
- By helping to coordinate the development of both evolutionary and transformative detector instrumentation across the national laboratories and with the university community, CPAD works to ensure the future of high-energy physics experiments.

It is out of these aspects of CPAD's mission and goals and the work of the Snowmass process which the concept of the formation of Research and Development Collaborations (RDC's) within CPAD was born

CPAD R&D Collaborations (RDCs)

RDC	Topic	Coordinators
1	Noble Element Detectors	Jonathan Asaadi, Carmen Carmona
2	Photodetectors	Shiva Abbaszadeh, Flavio Cavanna
3	Solid State Tracking	Sally Seidel, Tony Affolder
4	Readout and ASICs	Angelo Dragone, Mitch Newcomer
5	Trigger and DAQ	Jinlong Zhang, Zeynep Demiragli
6	Gaseous Detectors	Prakhar Garg, Sven Vahsen
7	Low-Background Detectors (incl. CCDs)	Noah Kurinsky, Guillermo Fernandez-Moroni, Daniel Baxter
8	Quantum and superconducting Detectors	Aritoki Suzuki, Rakshya Khatiwada
9	Calorimetry	Marina Artuso, Minfang Yeh
10	Detector Mechanics	Andy Jung, Eric Anderssen
11	Fast Timing	Gabriele Giacomini, Matt Wetstein

RDC6

https://cpad-dpf.org/?page_id=1549

What will the RDC's do?

Long term goal:

- Establish collaborations which can link together facilities, expertise, people, and experience to tackle technology challenges across HEP/NP
- Facilitate new funding mechanisms for R&D related to a specific technology area which will take place as part of the collaborations' activities
- Work with the CPAD executive committee, ECFA DRDs, and the broader R&D community to foster a collaborative, supportive, and coordinated environment for new ideas, blue sky efforts, and non-project specific R&D

What will the RDC's NOT do?

The RDC's will NOT:

- **Discourage single/small team efforts in R&D**
  - We still need for individual PI's to be able to work in their labs on their favorite ideas and leave room for innovation and unexpected solutions
- **Break up existing organizations / structures**
  - We already have communities within HEP/NP which coordinate on specific technological challenges (e.g. HEP-IC) and we want to utilize/leverage these efforts and communities to help make the CPAD-RDC's successful
- **Discourage project specific R&D**
  - There is some R&D which will/has reach(ed) a level of maturity that it is time to realize it for a specific implementation and the RDCs should encourage this transition from generic to specific R&D

Broadly speaking, for a given technology area, the scope of the **ECFA DRD** is a superset of the CPAD RDC one and all relevant project specific R&Ds

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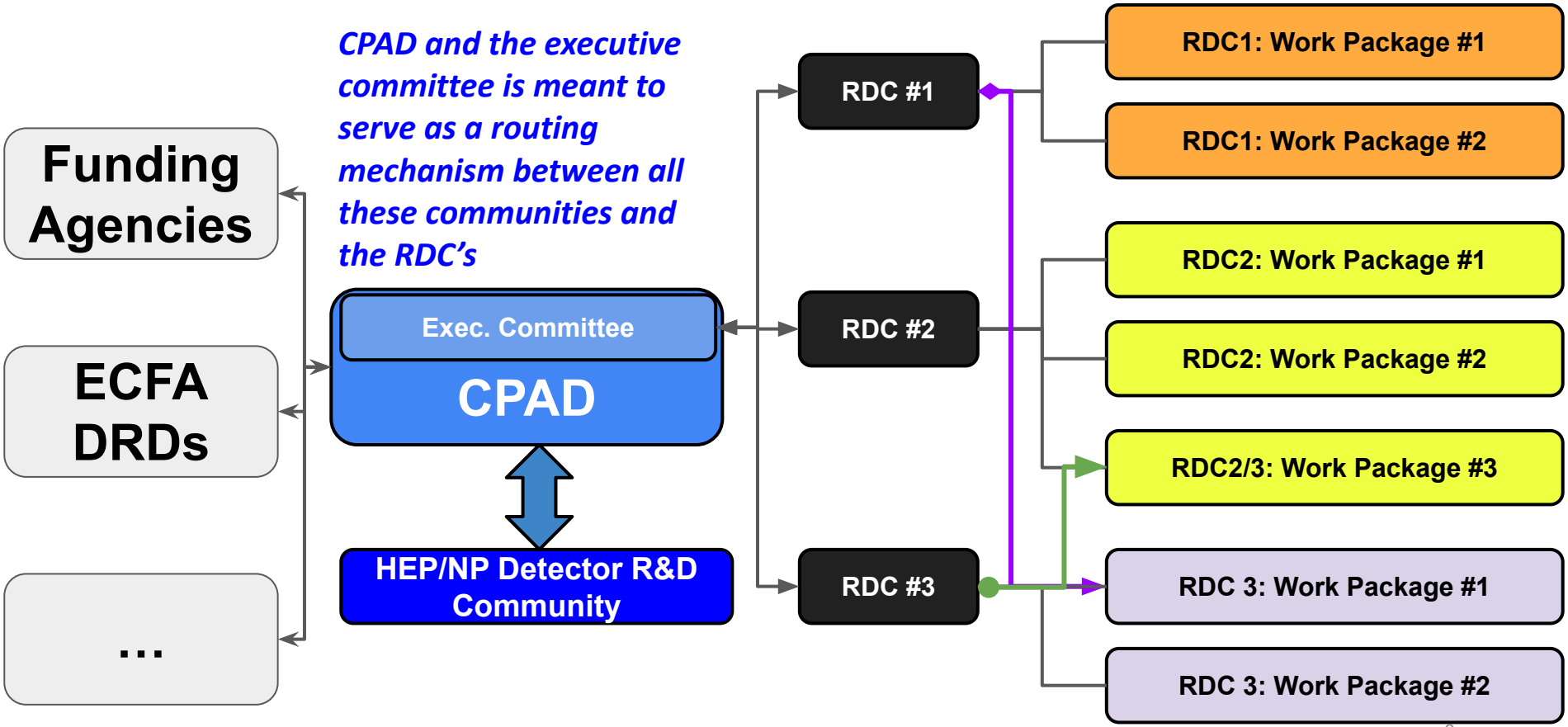
What is the envisioned structure (so far)



Ongoing RDC White Paper Process

Some opening thoughts (I)

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- **<u>Long term:</u> the aim is to have different supporting mechanisms for collaborative instrumentation R&D which may have its own dedicated Funding Opportunity Announcement (FOA) and dedicated (new) funding**
  - For FY2025 submission, this is not in place.
  - Therefore, we are going to attempt to work with the community to start some of this type of collaborative R&D using the existing comparative review FOA
  - In the future, the process by which CPAD RDC's work to put together these collaborative proposals will be different
    - This will also be informed by how well this year's process goes

Overview of Timeline

Jonathan Asaasi

- **May 3:** Virtual Town Hall outlining RDC 2024 process
  - **We emphasize that this isn't the process for doing this in the future and instead is to get the ball rolling**
- **May - June:** RDC's are meeting and advertising and encouraging community to form proposals which match the constraints in number, structure, and scope.
  - A few, university lead, multi-institutional, generic ``blue-sky'' focused R&D with limited but growing budget profile
  - Proposal white papers are to be posted on CPAD website
- **Early July:** One day (online) workshop where proponents can present their proposed collaborative research to the community
- **Late July:** CPAD RDC and EC meet to deliberate in line with key R&D priorities
- **July 31st**: LOI's submitted to DOE
- **Sept 4th:** Submission of proposals to DOE

RDC6 topics

- RDC6 covers gaseous detectors (not just MPGDs)
- Topics of US community interest were solicited
  - During the BRN process
  - During the Snowmass process
  - At CPAD meetings
  - In RDC6 poll earlier this year
  - At RDC6 white paper meeting June 18, 2024: https://indico.fnal.gov/event/65195/

Snowmass

- 24 LOIs on MPGDs were submitted
- Distilled into five Snowmass White Papers
  (One additional White Paper has further detail)
- 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

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

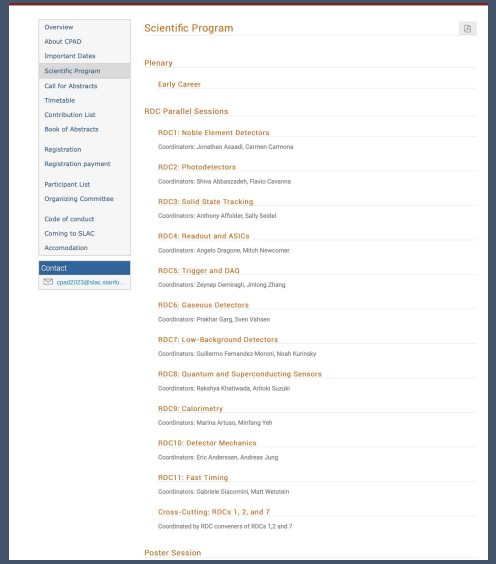
Five commissioned white papers on MPGDs were developed during the 2021 Snowmass decadal survey. These summarize R&D on MPGDs [1], the future needs for MPGDs in nuclear physics [2] and in three broad areas of particle physics: low-energy recoil imaging [3], TPC readout for tracking at lepton colliders [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].

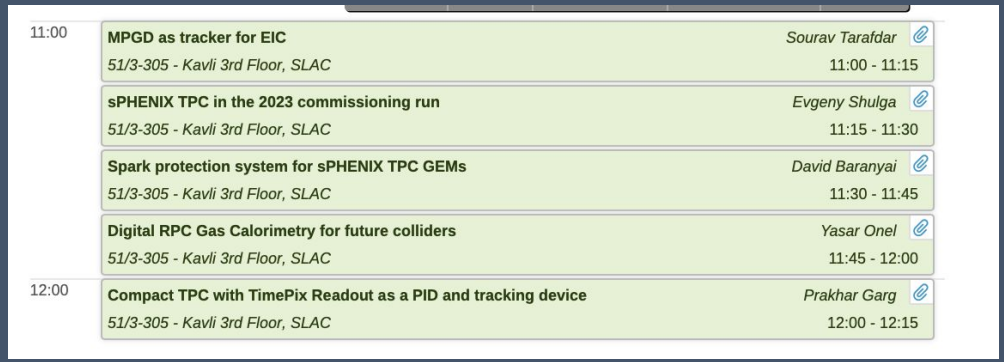
Key Points The IF05 topical group would like to communicate the following high-level findings to the wider particle physics community:

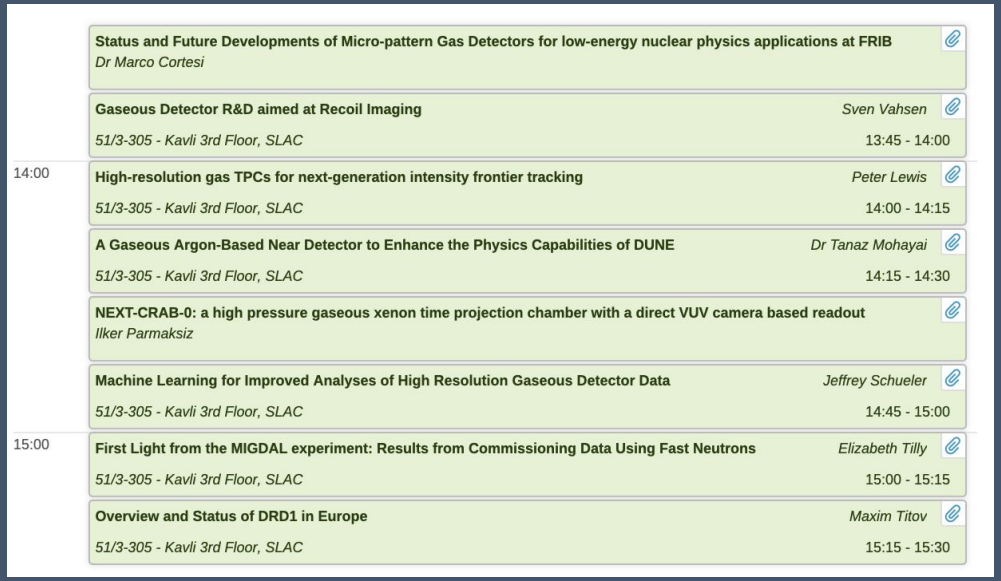
- **IF05-1**: Micro-pattern gaseous detectors (MGPDs) constitute an enabling technology that is key for large segments of the future U.S. NP and HEP programs, and which also benefits other communities. MPGDs provide a flexible go-to solution whenever particle detection with large area coverage, fine 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.

2023 CPAD workshop

- Scope widened to Gaseous Detectors







RDC6: Areas of R&D Priorities (Preliminary)

Prakhar Garg
Sven Vahsen

A. Advance gaseous TPC readout to the fundamental sensitivity limit
   E.g. electron counting, negative ion drift (NID), ps timing, ASIC readout

B. Develop new gas amplification structures for challenging environments, E.g. for gases w/o quencher, NID, high charge density

C. Achieve cost-effective scaling of gaseous TPCs
   E.g. data reduction and multiplexing via AI/ML on frontend, new materials and mechanical structures, strip readout, modularization schemes

D. Establish an MPGD development and prototyping facility in the US

Current RDC6 white paper topics, to be completed in June

	Topic / Work Package (from https://indico.fnal.gov/event/65195/)	R&D Prior.	Syn. RDCs
1	**Novel materials for gaseous detectors**	B,C	10
2	**Machine learning on and near the front end**	C	4,5
3	**GridPix/Twingrid/Gating**	A	4,5,10
4	**Advancing low-energy TPC readout to the performance limit**	A	4,5,10,7
5	**Achieving cost-effective scaling of gaseous TPCs**	C	4,5,10
6	**Characterizing Novel Charge Readout Structures in High-Pressure Gaseous TPCs**	B	10
7	**Advanced gas amplification structures**	B	10, 11
8	**Development of μRWELL-PICOSEC detector**	A,B	11, 10
9	**US manufacturing of MPGDs**	D	10
10	**Electron-drift TPCs with 82-Se for 100-T-scalable 0vbb**	A,B,C	1

Conclusion

- RDC6 white papers and work packages currently being defined
- Compared to DRD1 work packages
  - Much less comprehensive scope & less formal process
  - More limited to blue sky R&D
  - Process being tailored to expected funding: preference for blue sky and multi-RDC
- Open question: best way to align DRD1 and RDC6? Would like to discuss this more with the DRD1 Management Board.
- Meanwhile, **we encourage all US gas detector enthusiasts** to
  - Engage in the relevant DRD1 working groups
  - Engage with RDC6 and the white paper process
  - Subscribe to 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

BACKUP

Some opening thoughts (II)

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- **A Reminder: At time of writing, there is no new funding available to the HEP budget for generic detector R&D. This means that new proposals for CPAD R&D collaborations (RDC's) that are to be submitted to the comparative review FOA need to be limited in number, structure, and scope.**
  - Number: small; we expect that the RDCs and the community can converge on a few most suitable proposals for this year under these constraints
  - Structure: These should be university lead, multi-institutional proposals with a light-weight collaboration structure (not a structure like the very formal DRD collaborations)
    - These teams can include national labs
    - Where appropriate the multi-institutional teams should designate one lead institution with all other team members proposed as subrecipients.
  - Scope: The proposals should focus on generic R&D (as opposed to project specific), ``blue-sky'' (having a high-risk high-reward outcome), and have limited but growing budget profile
    - The most important point is to develop the proposals with a strong and coherent technical scope
    - Very likely the most competitive proposals would have components that live in multiple RDC's and are coordinated by multiple RDC groups

CPAD and RDCs

Jonathan Asaasi

- **APS DPF Bylaws: CPAD** has the responsibility to promote excellence in the research and development of instrumentation and detectors to support the national program of particle physics in a global context through the organization of the annual topical meeting on detector research and development; the nomination and selection of the annual DPF Instrumentation Awards and the Graduate Instrumentation Research Award; the promotion of educational programs to further the understanding of detectors and their instrumentation; the organization of multidisciplinary workshops; and the development of new activities consistent with its mission.
  - Therefore CPAD facilitating activities of instrumentation and detectors for all ongoing and future HEP experiments, with the goal of continuously articulating and addressing the HEP detector R&D priorities and needs
- **CPAD R&D Collaborations** (**RDCs**) cover major technology areas in line with the 2019 BRN with the goal to bring together the community in a more persistent way than the annual CPAD workshops alone, to coordinate R&D efforts, and to forge collaboration.
  - Therefore RDCs focus on generic, blue-sky (high-risk high-reward), long-term topics
    - Note that the main goal of RDCs is to identify priorities and define work packages, to coordinate efforts and forge collaboration
    - Facilitating FY2025 proposal preparation is just a near-term action (later discussion) and not our primary function

CPAD and RDCs

Jonathan Asaasi

- Future projects highlighted in 2023 P5 report will likely have separated R&D organizations, so called **targeted R&D**s, which are anticipated to have coordination by their relevant project
  - For example, FCC-ee, DUNE Phase-2, etc
  - RDCs will work closely with these areas of targeted R&D to optimize the resources and promote the work being done
    - There are ongoing R&D projects/activities that comprise both generic and targeted aspects, and RDCs will work with those for smooth evolvement and transition as appropriate
- Broadly speaking, for a given technology area, the scope of the **ECFA DRD** is a superset of the CPAD RDC one and all relevant project specific R&Ds
  - Please engage the relevant DRD activities and communicate with the RDCs
  - CPAD will establish regular communication with DRD organization, develop the coherency in due time
- We are all eagerly waiting new guidance from the office of science and DOE following the P5 report

A proposal for how this will work

Jonathan Asaasi

- **The RDCs will work with the community to converge on a few multi-institution proposals (only in 2024) from across the RDC's to submit to the comparative review FOA**
- **The process will be clearly communicated, transparent, and have a clear and defined timeline**
  - Note: This doesn't mean that everyone in the community has to engage in it. The comparative review is open to any eligible PI who would like to submit any HEP detector R&D proposal
- **The outcome of this process (which will only be the process in 2024), will be a few proposals identified as the areas of high priority research within the community**
  - **These proposals and priorities will be communicated with the community and the funding agencies**

May 3 Meeting

Jonathan Asaasi

- **We open submission for 2-3 page “white papers” from the community to ensure we gather input from any interested parties**
  - Many of the RDC’s have already started this process, we just need to collect this information in a “standard template” (see example here)
  - Your ideas should be communicated through the RDC coordinators
  - These “white papers” will be posted to CPAD RDC webpage
  - Period of submission is two months (May and June 2024)
  - We anticipate RDC coordinators are holding meetings between May and June to both advertise this process and work with proponents articulate their research
- **Early July 2024 we will hold a meeting and invite a large number (all?) of the white paper submitters to present their idea to the community and RDC coordinators will collect feedback and synthesize the proposals**
- **Late July 2024 the RDC coordinators and the CPAD Executive Committee will convene to encourage a few of these proposals**
  - These results are then posted on the CPAD website and we will work with proponents for proposal preparation to the comparative review

CPAD R&D Collaboration White Paper Template 2024

Title:
(Put your title here)
Institutions:
PI # 1 Name, Institution
PI # 2 Name, Institution
PI # 3 Name, Institution
…

Abstract:
(Explain what your R&D is and what are the outcomes if successful…. 2-3 paragraphs)

Collaboration:
(Outline the teams (who and where)

the collaboration structure (which institution is responsible for what),

and the links to the relevant CPAD RDC's (list the relevant RDC's and the match to their areas of research priorities))

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Timelines:
(Give a rough outline of the timeline for the R&D with any known milestones or deliverables during the proposed 3(4) year funding period 2025 - 2028(9))

Links on the CPAD Website

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2024 RDC Collaborative Proposals

For the 2024 Comparative Review, CPAD and the RDC's aim to put forward a small number of university lead, multi-institutional proposals focused on generic "blue-sky" R&D

To this end, we are open to submission of community lead "White Papers" which outline proposals for such consortia. These white papers will be used to help CPAD coordinate and promote groups intending to submit to the DOE Comparative Review in September 2024

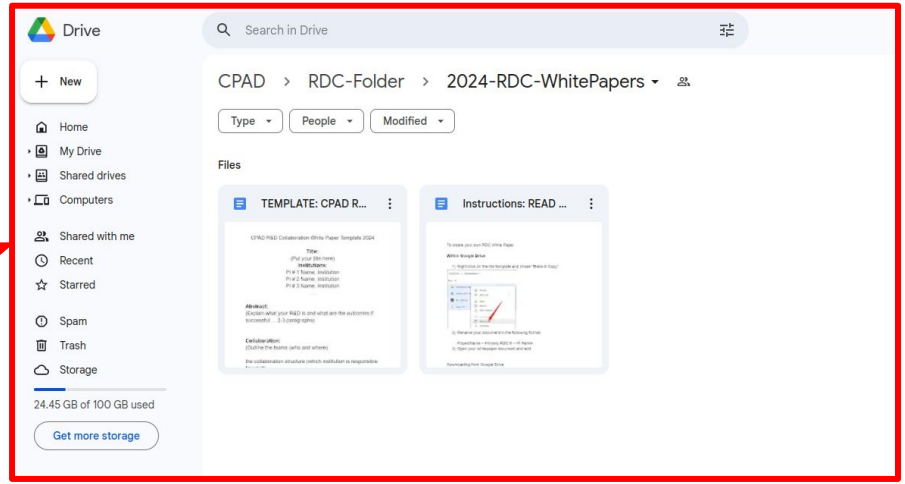
Relevant Links:

- **Comparative Review FOA:** https://science.osti.gov/hep/-/media/grants/pdf/foas/2023/DE-FOA-0003177-000001.pdf
- **2024 RDC White Paper Google Drive** https://drive.google.com/drive/folders/1b7HJZcH2vpf9Di_HSyruXDAP-zgzDo8o?usp=sharing
- **2024 RDC White Paper Template** https://docs.google.com/document/d/1cU7nccoCaFCvFRBffVfNVDLOSciNHzg0VR1ppNZmiRw/edit?usp=sharing

Link to CPAD RDC General Meetings

May 2024 RDC Community Meeting: Indico Link

July 2023 RDC Kickoff Meeting: Indico Link



https://cpad-dpf.org/?page_id=1549

July Meeting

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- **Early July 2024 we will hold a meeting and invite a large number (all?) of the white paper submitters to present their idea to the community**
  - This is a one day virtual workshop
  - We expect active community feedback on these ideas, which will be collected and synthesized by RDC coordinators
- **Late July 2024 the RDC coordinators and the CPAD EC will convene to deliberate**
  - These results are then posted on the CPAD website, communicated with the community and the funding agencies
  - We will work with proponents for proposal preparation to the comparative review

Short-term action items

Jonathan Asaasi

Take a look at the proposed white paper template and send comments or questions

a. Google Drive Folder: https://drive.google.com/drive/folders/1b7HJZcH2vpf9Di_HSyruXDAP-zgzDo8o?usp=sharing
   i. Note: People can only add/edit (not delete)
   ii. The drive folder is backed up automatically every 24 hrs
b. The goal is to have something light weight, which captures everything we will need to understand what the proposed collaborative research is without making people write a lot of text

Note: will collect a series of Google Docs in a Google Drive folder (no fancy database) with proper access

Principal Ideas behind the RDCs

- Detector R&D in many different technology areas is essential to realize many of the future planned experimental efforts spanning all of the frontiers in High Energy / Nuclear Physics

- Much of the efforts needed require **collaboration** and **coordination** in order to realize the technologies required
  - **Collaboration**: The required expertise/resources/new ideas often live within multiple people, institutions, labs and only by bringing these pieces together can we hope to realize the technological challenges
  - **Coordination**: We live in a resource limited funding environment and so we need efforts to be coherent, minimize duplication, and to build off of progress happening elsewhere (both in other technologies and in other places)

Principal Ideas behind the RDCs

- Detector R&D in many diffe
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Collaboration

Where the RDC's can work to identify needed R&D, put together work-packages, and aid in the execution of the work

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Principal Ideas behind the RDCs

- Detector R&D in many diffe… …e many of the future planned… frontiers in High Energy /N…

Coordination

This is what CPAD is meant to help provide and why these collaborations are being formed within our structure/charge

- Much of the efforts needed require **collaboration** and **coordination** in order to realize the technologies required
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  - **Coordination**: We live in a resource limited funding environment and so we need efforts to be coherent, minimize duplication, and to build off of progress happening elsewhere (both in other technologies and in other places)

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-EF0_EF4-IF3_IF5-031.pdf	06/08/2020
3	EF/SNOWMASS21-EF4_EF0-AF3_AF0-IF3_IF5_Graham%Ilison-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
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13	IF/SNOWMASS21-IF5_IF0_Brunbauer-036.pdf	31/08/2020
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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

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).