Welcome to

CPAD RDC8
Quantum & Superconducting Detectors

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Who are we?
**CPAD R&D Coordination (RDC) groups**

Brings together the CPAD community in a more persistent way than the annual workshops alone, to coordinate R&D efforts and to forge collaboration.

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Our Goal

1. Foster a collaborative, supportive, and coordinated environment for new ideas, blue sky efforts, and non-project specific R&D

2. Provide a platform to link together facilities, expertise and people to tackle technology challenges across HEP/NP

3. Facilitate new funding mechanism for R&D through development of work packages and proposals
RDC-8 Sub-Groups

1. **Pairbreaking sensors:**
   MKIDs, TESes, SNSPDs, QCDs, SC Qubits and variants etc.

2. **Coherent wave sensors:**
   JPA, TWPA, KIPA, Squeezed state receivers, microwave to optical transducers, SRF cavities, rf quantum upconverters, mechanical tuning of cavities, etc.

3. **AMO (interferometry, NMR, Optomechanical) clocks sensors:**
   Neutral atoms, trapped ions, magnetometers, spin precession, optomechanical devices, optical-RF-magnetic levitation, cantilevers etc. entangled probes that beat SQL with optical readout etc.

4. **Novel materials & Theory:**
   Quantum and metamaterials, Low bandgap materials (Dirac, Weyl, Sapphire), High Tc materials, spin liquids, NV centers etc. New theories/ideas that can be tested with detectors, specific technology model building etc.

- One of the largest CPAD RDCs
- We base collaboration and R&D ideas from Basic Research Needs (BRN) and particularly, QIS for HEP workshop, 2023.

Report  
Science Drivers and Energy Scale

Quantum Technology
- Clocks / AMO
- NMR
- C.V. Coherent
- QND Photon
- Pairbreaking

Interaction Energy
- Gap of Aluminum
- Gap of Silicon
- 1 μeV
- 1 meV
- 10 eV
- Light Dark Matter

HEP Science
- Ultralight Dark Matter
- CMB
- Opt
- QCD Axion Dark Matter

Signal Frequency
- $k_B T = h f$
- in dilution refrigerator

Source: QIS for HEP report arXiv:2311.01930
RDC8 Activities

Formed in the summer 2023

First meeting - August 31
- Introduction to CPAD RDCs

Community Survey - September
- Collected info on interests, collaboration ideas, necessary and available resources/facilities
- Solicited for subgroup leads
- Work package ideas

Second meeting - October 18
- Survey results shared
- Subgroup organizations refined
- Subgroup leads identified

Future (next year): Develop work packages, make it available to the community

Please bring up suggestions for future activities during our scheduled discussion!
CPAD Survey Results

Focused on interests, collaboration ideas, necessary and available resources
RDC8 representative Institutions

DOE Labs (22 responses)
- Argonne National Laboratory
- Fermilab
- Los Alamos
- Livermore
- LBNL
- Pacific Northwest National Laboratory
- Sandia National Laboratories
- SLAC

National Labs (6 responses)
- Jet Propulsion Laboratory
- NIST

University (11 responses)
- Boston University
- Caltech
- Cornell
- UC Santa Barbara
- University of Chicago
- University of Delaware
- University of Florida
- University of Oklahoma

Non-US University (2 responses)
- Humboldt University Berlin
- The University of Western Australia

Responses from both labs and universities as well as from international institutions
A lot of interest in **pair breaking and coherent groups**. Good overlaps between groups as well.
Synergy with other RDCs

Sample size: 31/42 (multiple answers possible)

1. Noble Element Detector : 3
2. Photodetectors : 21
3. Solid State Tracking : 2
4. Readout and ASICs : 13
5. Trigger and DAQ : 3
6. Gaseous Detectors : 0
7. Low Background Detectors : 21
8. This RDC
9. Calorimetry : 3
10. Detector Mechanics : 3

We have synergy with almost every other RDCs. Three RDCs stood out

We have a combined session with RDC 7 on Thursday
CPAD workshop organization and time table (Nov 7 ~ Nov 10)

Meeting notes: [https://docs.google.com/document/d/129Oliq_V0OTuqSFRCaFVPf3QEkJhxXqhy2nHNWLk/edit?usp=sharing](https://docs.google.com/document/d/129Oliq_V0OTuqSFRCaFVPf3QEkJhxXqhy2nHNWLk/edit?usp=sharing)

**Tuesday: RDC8 Session #1**
- Open/Intro (Rakshya/Toki)
- Pair breaking subgroup intro (Clarence Chang/Matt Shaw)
- Coherent subgroup intro (Silvia Zorzetti/Gianpaolo Carosi)

**Wednesday: RDC8 Session #2**
- ECFA DRDq (Mike Doser)
- AMO,clock, NMR subgroup intro (Swati Singh)
- Novel Material & Theory subgroup intro (Sinead Griffin)

**Wednesday: RDC8 Session #3**
- 8 contributed talks

**Thursday: RDC8**
- 6 contributed talks

**Thursday: RDC8 Session #4**
- 4 contributed talks
- 1.0 hour Work package discussion

**Thursday: RDC7+8 Low Backgrounds in Quantum Sensors**
- 3 contributed talks
- 1.0 hour Work package discussion

**Friday: RDC8 Session #5**
- 6 contributed talks
Discussions!!

Suggested topics for discussion

1. How can we collect/share information beyond survey?
2. Did the subgroup summary capture all of your interest/activities? If not, what are those?
3. What are common challenges we can tackle?
4. What should be the content/structure of work packages?
5. Suggestions on activities and how to efficiently hold discussions about work packages?
Supplementary Slides
Pair Breaking

Number of Interests: 34

Sub-group lead(s)
- Clarence Chang (Argonne), Matt Shaw (JPL)

Summary of topics
- Superconducting detector development (MKID, TES, SNSPD, Qubit / Quantum Capacitance), Readout electronics (Frequency-domain multiplexing, Cryogenic Electronics, ASIC development, High-density interconnects), New approaches to detector calibrations and backgrounds
- Dark Matter (wave and particle), cosmology, collider physics (ultra-fast timing, radiation hardness), neutrino physics.

Existing Collaborations
- SQMS, BREAD, SPICE/HERALD, TESSERACT, RICOCHET, SuperCDMS, SPT

Facility needs
- Nanofabrication, cryogenic testing, calibration and backgrounds

Ideas for work packages
- Scalable CMB Detector Arrays (Beyond CMB-S4). Low-threshold, large-area SNSPDs, Phonon-mediated MKIDs, Ultra-low-threshold TES, Qubit-based THz and mm-wave photon counting, quantum-limited parametric amplifiers.
Coherent

Number of Interests: 25

Sub-group lead(s)
- Gianpaolo Carosi (LLNL), Silvia Zorzetti (FNAL)

Summary of topics
- Precision measurements, axions (haloscopes, light shining through wall), dark matter, detection of keV mass, frequency converters, weak signals detection, wave-like DM

Science Targets
- DM, axion detection

Existing Collaborations
- ADMX, ORGAN, MAGIS-100, SQMS, BREAD
- Nat. Labs: SLAC, ANL, Fermilab, LBNL

Facility needs
- Dilution refrigerators, underground cryogenic facilities, cleanrooms, device fabrication, nanofabs, test and production facilities for superconducting devices.

Ideas for work packages
- Phonon physics, qubit-based detection, low noise amplifiers (low-frequency SQUID, JPAs), digital electronics, optomechanical systems, low dark counts single-photon detectors, microelectronics and ASICs, quantum entanglement and sensors networks