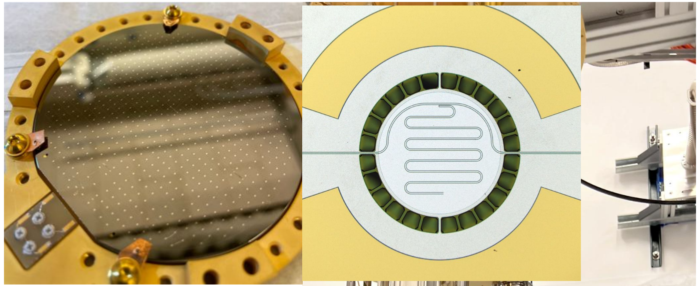
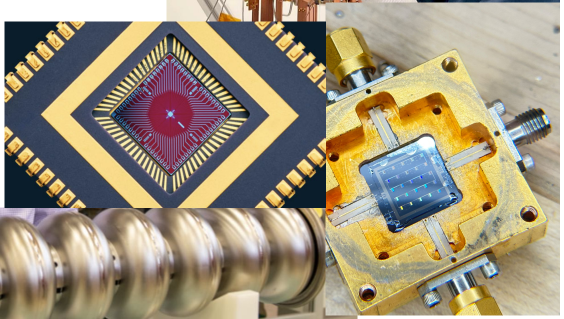
Welcome to

CPAD RDC8
Quantum & Superconducting Detectors



Rakshya Khatiwada & Aritoki Suzuki
11/19/2024



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.

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.

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

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.

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, (TBN)
6	Gaseous Detectors	Prakhar Garg, Sven Vahsen
7	Low-Background Detectors (incl. CCDs)	Noah Kurinsky, Guillermo Fernandez-Moroni
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

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

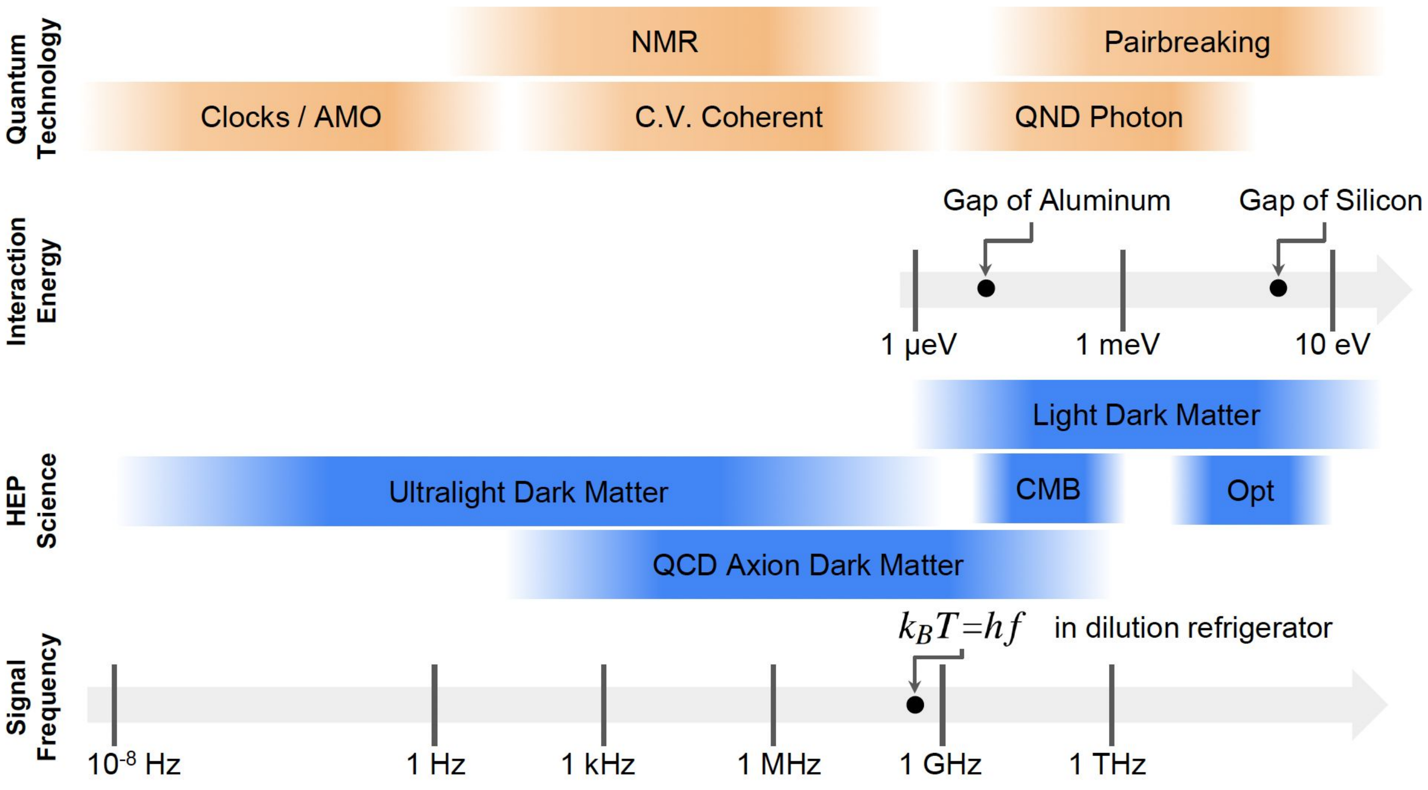
P5 support for RDC-8 technologies

The use of quantum sensors in particle physics experiments has grown extensively and the developments within particle physics have benefitted communications, computing, and many other areas. Quantum sensors have been used in searches for dark matter, fifth forces, dark photons, permanent electric dipole moment (EDM), variations in fundamental constants, and gravitational waves, among others, and they come in a wide range of technologies: atom interferometers and atomic clocks, magnetometers, quantum calorimeters and superconducting sensors. Quantum sensors are being deployed in all areas of particle physics. To advance these technologies further for the benefit of the particle physics community, we need to continue strong support for a broad range of quantum sensors.

Much of the growth in quantum sensors over the past decade has occurred in small, laboratory-based experiments. Support for such experiments should continue as a way to rapidly develop sensor technologies and help determine the areas where quantum sensors can have the greatest impact. Several recent developments have reached the point where plans for larger-scale, longer-term experiments can and should be conceptualized. These concepts can evaluate the potential reach that can be achieved in a larger effort and the scale of required technological development. Here, potential reach is meant in terms of our physics goals, enhanced sensitivities to the phenomena we are trying to measure; enhanced compared to traditional non-quantum technologies. We recommend mechanisms to support interactions outside of the particle physics program to enable collaborations with experts in other fields who have experience with quantum sensors, including QIS theory.

P5 report

Science Drivers and Energy Scale



Source: QIS for HEP report arXiv:2311.01930

RDC-8 Sub-Groups

RDC-8 covers broad topics, we brought in experts to help coordinate!

- **Pairbreaking sensors:** Clarence Chang, Matt Shaw
  MKIDs, TESes, SNSPDs, QCDs, SC Qubits and variants etc.

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

- **AMO, IF, NMR, OptoMech, clocks sensors:** Andrew A. Geraci, Timothy L. Kovachy, Swati Singh
  Neutral atoms, trapped ions, magnetometers, spin precession, optomechanical devices, optical-RF-magnetic levitation, cantilevers etc. entangled probes that beat SQL with optical readout etc.

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

RDC8 Activities

Formed in the summer 2023

Community Survey: September, 2023

- Collected info on interests, collaboration ideas, necessary and available resources/facilities

Survey Results: October 18, 2023

- Analysis of the survey - https://drive.google.com/drive/u/0/folders/0APWETKIp4FcXUk9PVA
- Subgroup organizations defined

CPAD workshop at SLAC: November 07-10, 2023

- Identified common needs and received input from the community
- Topics of general interest: ParaAmp, Simulation tools, etc.

Work Packages: May 30, 2024

- Drafted work packages

RDC8 Activities contd.

Community organization: May - September 2024

- Organized short talks on proposal and coordination ideas
- Helped coordinate collaboration for proposal submissions
- Solicited white-paper ideas relevant to various sub-groups

CPAD workshop 2024: November 18-22, 2024

- This workshop

Future

→ What should we focus on? How can we be more helpful?

For example:

- More short talks from RDC-8 members to inform what others are working on to help establish collaboration and reduce duplication?
- Summer school on RDC-8 related topics (simulators [HFSS, G4CMP, etc.], cryogenic basics)
- Hold meeting dedicated to best practices on common challenges (cryo, vibration, EMI, etc.)

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

Work Packages

Thank you for your inputs -
https://docs.google.com/document/d/1IcIXozIkaBEDgnQcAH3q_tUNpVFReUooNKZ4cWOEdA0/edit?usp=sharing

We are coordinating with CPAD chair to make this public through CPAD website.
We are also coordinating with CPAD to figure out what's next

RDC-8:

Quantum and Superconducting Sensors

Gianpaolo Carosi, Clarence Chang, Andrew Geraci, Rakshya Khatiwada, Timothy Kovachy, Matthew Shaw, Swati Singh, Aritoki Suzuki, Silvia Zorzetti

Table of Contents

Introduction

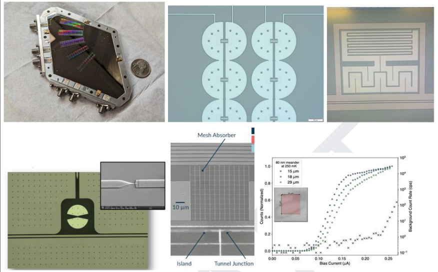
RDC-8 covers the development of quantum and superconducting sensors. This RDC addresses a broad spectrum of topics within this rapidly evolving field. To effectively cover the field, the RDC is divided into four sub-categories: Pair-breaking photon/phonon sensors, coherent wave sensors, AMO clocks, interferometry NMR, optomechanical sensors, and novel material and theoretical developments. In the subsequent sections, we outline the work packages for each subcategory, highlighting key developments aimed to advance the frontiers of fundamental physics research.

Pairbreaking, Photon & Phonon Sensors

This subcategory includes, but is not limited to, devices such as MKIDs TESes, MMCs, SNSPDs, QCDs , and SC Qubits.

RDC8-WP1a: Pairbreaking phonon and photon detectors and bolometers

We recommend the development of phonon and photon sensing detector technology that can significantly surpass present limits in one or more of the following metrics: (1) energy threshold for single-excitation sensing, spectral resolution, or noise performance (2) detection efficiency at the lowest energy thresholds (3) dark count rate, including low-energy backgrounds (4) active area and channel count. Such detectors may include single photon and phonon counters, as well as direct detectors and bolometers. These new sensor capabilities will enable transformative discoveries in the fields of direct dark matter, dark energy detection, and cosmology among other HEP science goals articulated in the P5 report. Successful proposals will incorporate aspects of sensor research and development, theory and materials research, scalable readout electronics, integration into experimental instrumentation, and mitigation of backgrounds. It is expected that a multidisciplinary team will be required to successfully address these technology development objectives.



Images of examples of pair-breaking detectors being developed for HEP experiments. Top left: Photo of a 4-pixel dual polarization mm-wave Microwave Kinetic Inductance Detectors (MKIDs) spectrometer for cosmological studies using mm-wave Line Intensity Mapping. Top center: Photo of a few low-Tc Quasiparticle-trap assisted Electrothermal-feedback Transition Edge Sensors (QETs) being developed for low-mass particle dark matter searches. Top Right: Photo of a low Tc MKID being developed for low-mass particle dark matter searches. Lower left: Photo of a transmon qubit based detector for use in either low mass dark matter or axion dark matter searches. Bottom center: Photo of a charge qubit based detector for use in axion dark matter and dark photon searches. Bottom right: Photo and data from a low threshold Superconducting Nanowire Single Photon Detector (SNSPD).

Coherent Wave Sensors

This subcategory includes, but is not limited to, devices such as JPA, TWPA, KIPA, Squeezed state receivers, microwave to optical transducers, SRF cavities, superconducting/LC circuits, rf quantum upconverters, mechanical tuning of cavities.

This work package aims to advance coherent wave sensors and measurement techniques to surpass the quantum limit sensitivity. The 2024 P5 report emphasizes the need to investigate the nature of dark matter across a broad mass range through experimental studies and collaborative research with Quantum Information Science (QIS) to achieve sensitivity beyond the Standard Quantum Limit (SQL).

RDC8-WP2a: High Q electromagnetic sensors and supporting technologies

RDC8-WP2a focuses on high-Q electromagnetic sensors and supporting technologies. It is recommended to support R&D regarding the design and optimization of high-Q resonators. These advancements are crucial for detecting dark photons, axions, or gravitational waves. Additionally, it is recommended to explore material science and R&D efforts to broaden current physics searches by extending coherence times (increase quality factor), achieving B-field tolerance, and maximizing frequency tunability in resonators designed for high coupling to dark matter or gravitational coherent sources.

RDC8-WP2b: Quantum techniques and devices to meet and surpass the SQL

RDC8-WP2b focuses on quantum techniques and devices aimed at surpassing SQL. Developing techniques for enhanced coherent signal detection is recommended, including correlated measurements, back action-evading methods (such as quantum upconverters), quantum nondemolition (QND) photon counters, and squeezed state receivers. Interesting technology R&D may include correlated arrays of quantum sensors or qubits to amplify the sensitivity of coherent dark matter detection, devices paired with techniques to evade the standard quantum limit, and correlated measurement techniques for enhanced coherent signal detection.

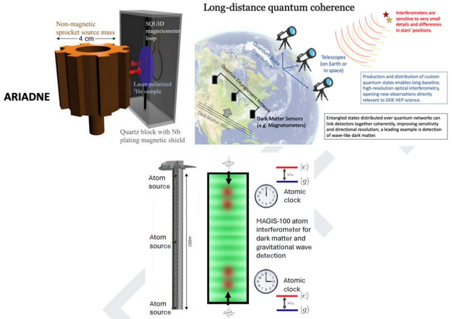
Photo of the Josephson Junctions in an RF Quantum Upconverter.

AMO, clocks, interferometry, NMR, Optomechanical Sensors

This subcategory includes, but is not limited to, techniques and devices such as AMO, clocks, interferometry, NMR, optomechanical sensors: neutral atoms, trapped ions, magnetometers, spin precession, optomechanical devices, optical-RF-magnetic levitation, cantilevers etc. entangled probes to beat the SQL with optical readout etc.

RDC8-WP3a: Optimizing detector sensitivity, scalability, readout and control

Research and development is needed to optimize the sensitivity and scalability for quantum sensors based on quantum ensembles or devices. Relevant examples of ensemble-based quantum sensors include atomic clocks, atomic interferometers, and spin-polarized samples, while device-based quantum sensors involve platforms such as optomechanical sensors or optical cavities. It is of interest to improve the signal-to-noise of these sensing platforms, including optimization of device design (e.g. by using larger volumes, higher density and/or polarization), readout (e.g.via quantum measurement, control and parameter estimation techniques), and overcoming noise (e.g. spin projection noise). Such optimized sensors can be used to search for a variety of physics beyond the standard model, such as dark matter and dark energy, along with tests of fundamental symmetries (e.g. CP violation), relativistic physics (e.g. gravitational wave detection) and the foundations of quantum mechanics. Gravitational wave detectors using atomic clocks and/or interferometers have the potential to provide a window into the high energy physics of the early Universe, which may enable studies of energy scales that are otherwise inaccessible.



Theory, Simulation & Novel Material

Advancing the theory, modeling, and simulation of sensors and materials is a crucial aspect of developing high-performance sensors.

RDC8-WP4a: novel/blue sky theory and simulation relevant to probe science drivers and materials.

Research and development needed in theoretical and simulation activities: 1) Theoretical development to explore experimental methods that utilize quantum and superconducting devices to probe fundamental physics. 2) Modeling of device physics and performance limitations in quantum sensors, including superconducting detectors, which encompasses the development of algorithms and simulation tools and techniques to enhance quantum sensing. For example, development of a simulation package for phonon propagation in crystals, study of low bandgap materials, exploration of novel quantum materials such as topological insulators, development of theoretical models of surface/interface physics of microfabricated devices, study of resource distribution across quantum networks, and protocols for back-action evasion.

CPAD 2024 - RDC 8 sessions: Tuesday

Sessions	SubSection	Title
Tue 1st seesion	**RDC-8 Opening**	
Tue 1st seesion	**Coherent Overview**	
Tue 1st seesion	Coherent	Recent Results and Advances of GigaBREAD: Broadband Reflector Experiment for Axion Detection
Tue 1st seesion	Coherent	Receiver Noise In Axion Haloscopes
Tue 1st seesion	Coherent	Project 8: Cyclotron Radiation for Neutrino Mass
Tue 1st seesion	**AMO,INT,NMR,OptMech overview**	
Tue 1st seesion	AMO,INT,NMR,OptMech	Photon detection based on microwave-optical quantum transducer
Tue 1st seesion	AMO,INT,NMR,OptMech	Searching for Sterile Neutrinos with Mechanical Quantum Sensors and CMOS Sensors
Tue 2nd session	Quantum, Entanglement	The Advanced Quantum Network at Fermilab and the Larger Chicagoland Area — Synergies with HEP Scien
Tue 2nd session	Theory/ Simulation	Quantum Random Walk Simulator Using Ultrafast Optical Switches
Tue 2nd session	Theory/ Simulation	Simulation Tools to Estimate Energy Thresholds of Superconducting Qubit-based Athermal Phonon Detecto
Tue 2nd session	Theory/ Simulation	Understanding the Response of a Qubit Chip Using Novel Materials in the G4CMP Simulation Toolkit.

CPAD 2024 - RDC 8 sessions: Wednesday

Sessions	SubSection	Title
Wed 1st session	**Pairbreaking overview**	
Wed 1st session	Pair Breaking, TES	Probing Sub-GeV Dark Matter with SPICE
Wed 1st session	Pair Breaking, TES	Recent HeRALD Progress at UMass
Wed 1st session	Pair Breaking, MKID	Low-Tc phonon-sensitive hafnium microwave kinetic inductance detectors for light dark matter searches
Wed 1st session	Pair Breaking, MKID	Development of on-chip spectrometer Microwave Kinetic Inductance Detector arrays as a technology for m
Wed 2nd session	Pair Breaking, Qubit	Developing A Qubit-Based Sensor For Low Energy Particle-like Dark Matter
Wed 2nd session	Pair Breaking, Qubit	Quantum Capacitance Detectors for Ultralight Dark Matter searches.
Wed 2nd session	Pair Breaking, Qubit	First Measurements of Superconducting Quasiparticle-Amplifying Transmon (SQUAT) Sensors
Wed 2nd session	Pair Breaking, SNSPD	High Energy Particle Detection with Large Area Superconducting Microwire Array
Wed 2nd session	Pair Breaking, SNSPD	Searching for axions and dark photons with superconducting nanowire single photon detectors (SNSPDs) in
Wed 2nd session	Pair Breaking, SNSPD	Deep-IR Sub-eV SNSPDs for Axion and Dark Matter Detection
Wed 2nd session	Pair Breaking, SNSPD	Particle Detection with SNSPDs
Wed 2nd session	Pair Breaking, SNSPD	Large-format arrays of SNSPDs for time-resolved imaging and tracking
Combined Wed (3,4,7,8)	**Overview material talk (Filip)**	
Combined Wed (3,4,7,8)	Pair Breaking, Material	Non-equilibrium energy accumulation as a source of backgrounds in low threshold detectors
Combined Wed (3,4,7,8)	Pair Breaking, Material	Material properties of superconducting Hafnium films
Combined Wed (3,4,7,8)	Solidstate sensor	Measurement of Lattice Quantum effects in phonon assisted solid state detectors
Combined Wed (3,4,7,8)	ParaAmp	Development of Near Quantum limited Kinetic Inductance Traveling-Wave Parametric Amplifiers Using Four
Combined Wed (3,4,7,8)	ParaAmp	TWPA and JPA
Combined Wed (3,4,7,8)	Discussion session	ParaAmp, Low background material R&D, Fab Facility
Poster Wednesday	AMO,INT,NMR,OptMech	A novel sub-eV particle detection scheme using magnetic metrology of superconducting thin films using NV
Poster Wednesday	Coherent	Towards THz Axion Detection: Characterization of Waveguides for Cryogenic Quantum Device Calibration
Poster Wednesday	Pair Breaking, TES	Progress on Superconducting Bolometers for the RICOCHET Experiment

Please bring your ideas on common challenges, technology gaps, etc.

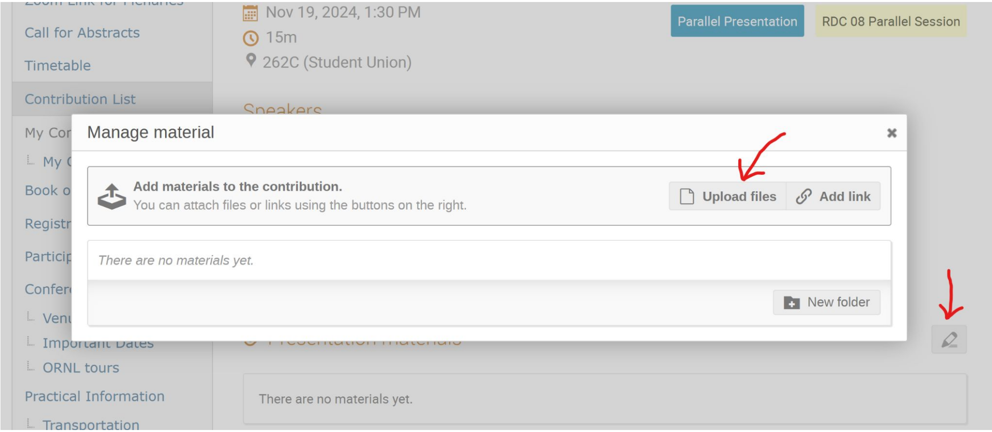
CPAD 2024 - RDC 8 sessions: Thursday

Sessions	SubSection	Title
Early career talk (Th plenary)	Pair Breaking, Qubit	Quantum Acoustic Devices for Low-Threshold Dark Matter Detection
Combined Th (7,8,9)	Pair Breaking, TES	Status of Commissioning and R&D for the Ricochet Experiment
Combined Th (7,8,9)	Sensor	Low-Threshold Phonon-Mediated Detectors with Background Discrimination
Combined Th (7,8,9)	Sensor	Toward sensitivity of radiopure NaI(Tl) to solar and reactor neutrinos and the possibility
Combined Th (7,8,9)	Discussion session	Low background test, Simulation need

Please bring your ideas on common challenges, technology gaps, etc.

Thank you for your contributions!

Please upload your talks to indico.
If you need help, send your slides to asuzuki@lbl.gov with session info



Let's enjoy talks and discussions over next four days

Supplementary Slides

Who are we?

RDC-8 Sub-Groups

- 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 arXiv:2311.01930

arXiv > hep-ex > arXiv:2311.01930

Search...
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High Energy Physics – Experiment

[Submitted on 3 Nov 2023]

Quantum Sensors for High Energy Physics

Aaron Chou, Kent Irwin, Reina H. Maruyama, Oliver K. Baker, Chelsea Bartram, Karl K. Berggren, Gustavo Cancelo, Daniel Carney, Clarence L. Chang, Hsiao-Mei Cho, Maurice Garcia-Sciveres, Peter W. Graham, Salman Habib, Roni Harnik, J. G. E. Harris, Scott A. Hertel, David B. Hume, Rakshya Khatiwada, Timothy L. Kovachy, Noah Kurinsky, Steve K. Lamoreaux, Konrad W. Lehnert, David R. Leibrandt, Dale Li, Ben Loer, Julián Martínez-Rincón, Lee McCuller, David C. Moore, Holger Mueller, Cristian Pena, Raphael C. Pooser, Matt Pyle, Surjeet Rajendran, Marianna S. Safronova, David I. Schuster, Matthew D. Shaw, Maria Spiropulu, Paul Stankus, Alexander O. Sushkov, Lindley Winslow, Si Xie, Kathryn M. Zurek

Strong motivation for investing in quantum sensing arises from the need to investigate phenomena that are very weakly coupled to the matter and fields well described by the Standard Model. These can be related to the problems of dark matter, dark sectors not necessarily related to dark matter (for example sterile neutrinos), dark energy and gravity, fundamental constants, and problems with the Standard Model itself including the Strong CP problem in QCD. Resulting experimental needs typically involve the measurement of very low energy impulses or low power periodic signals that are normally buried under large backgrounds. This report documents the findings of the 2023 Quantum Sensors for High Energy Physics workshop which identified enabling quantum information science technologies that could be utilized in future particle physics experiments, targeting high energy physics science goals.

Comments: 63 pages, 8 figures, Quantum Sensors for HEP workshop report, April 26-28, 2023
Subjects: **High Energy Physics - Experiment (hep-ex)**; High Energy Physics - Phenomenology (hep-ph); Quantum Physics (quant-ph)
Cite as: arXiv:2311.01930 [hep-ex]
(or arXiv:2311.01930v1 [hep-ex] for this version)
https://doi.org/10.48550/arXiv.2311.01930

1) **Pairbreaking sensors**: Matt Shaw, Clarence Chang
   MKIDs, TESes, SNSPDs, QCDs, SC Qubits and variants etc.
2) **Coherent wave sensors:** Silvia Zorzetti
   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 T_c materials, spin liquids, NV centers etc. New theories/ideas that can be tested with detectors, specific technology model building etc.

RDC8 representative Institutions

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

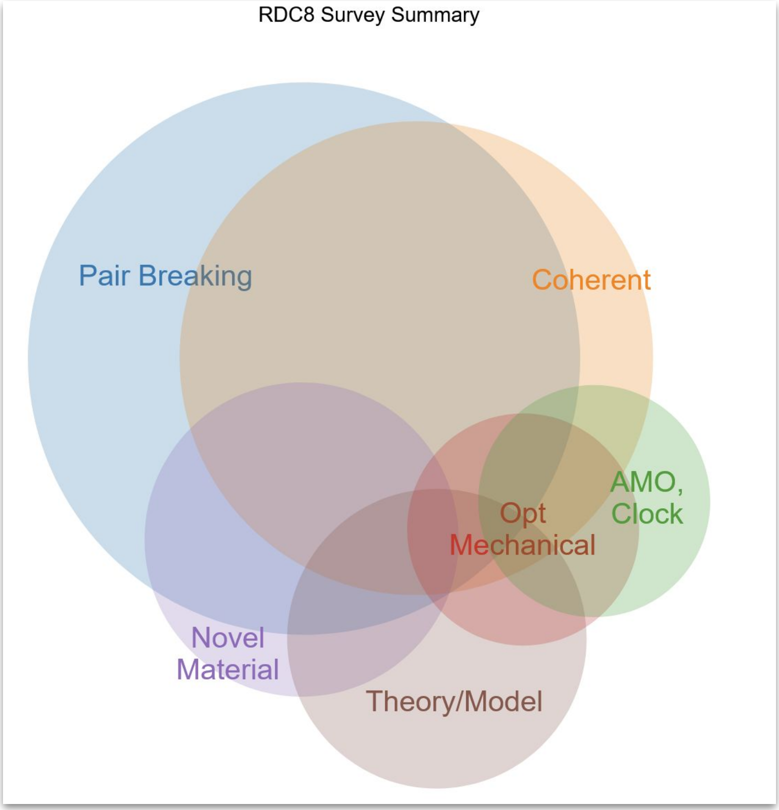
National Labs (6 responses)
- Jet Propulsion Laboratory
- NIST

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

RDC8 Interests



Sample size: 42

Pair breaking : 34

Coherent : 25

AMO, Clock : 6
Opt Mech : 6

Novel Material : 11
Theory : 10

Other : 1

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
11. Fast Timing : 6

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/129Olig_V0OTugSFRCaFVPf3QEk9fxQJhXqhy2nHNWLk/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?

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
  Science Targets
- 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