# IF08 (Noble Elements) Status

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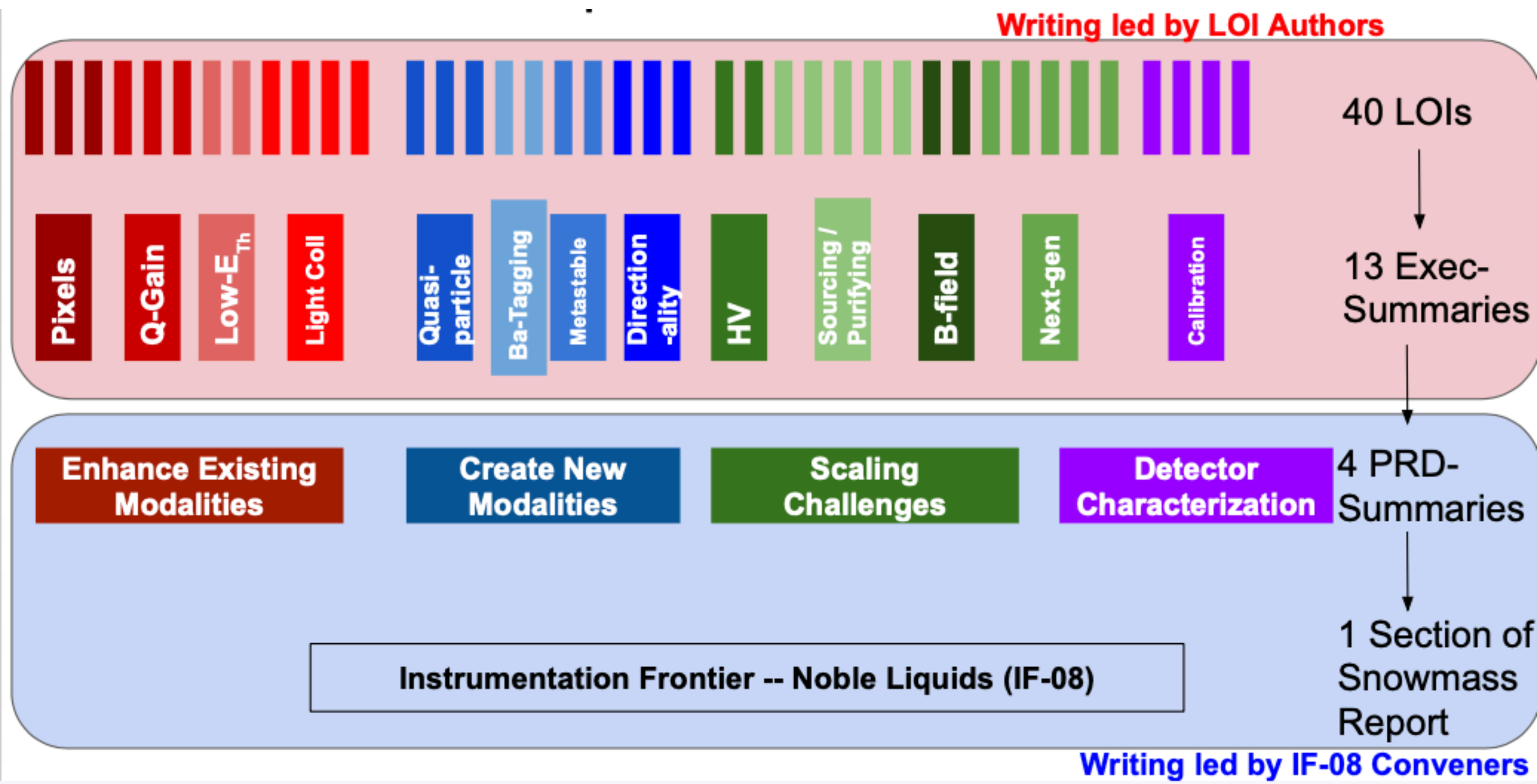
# Overview of the writing plan



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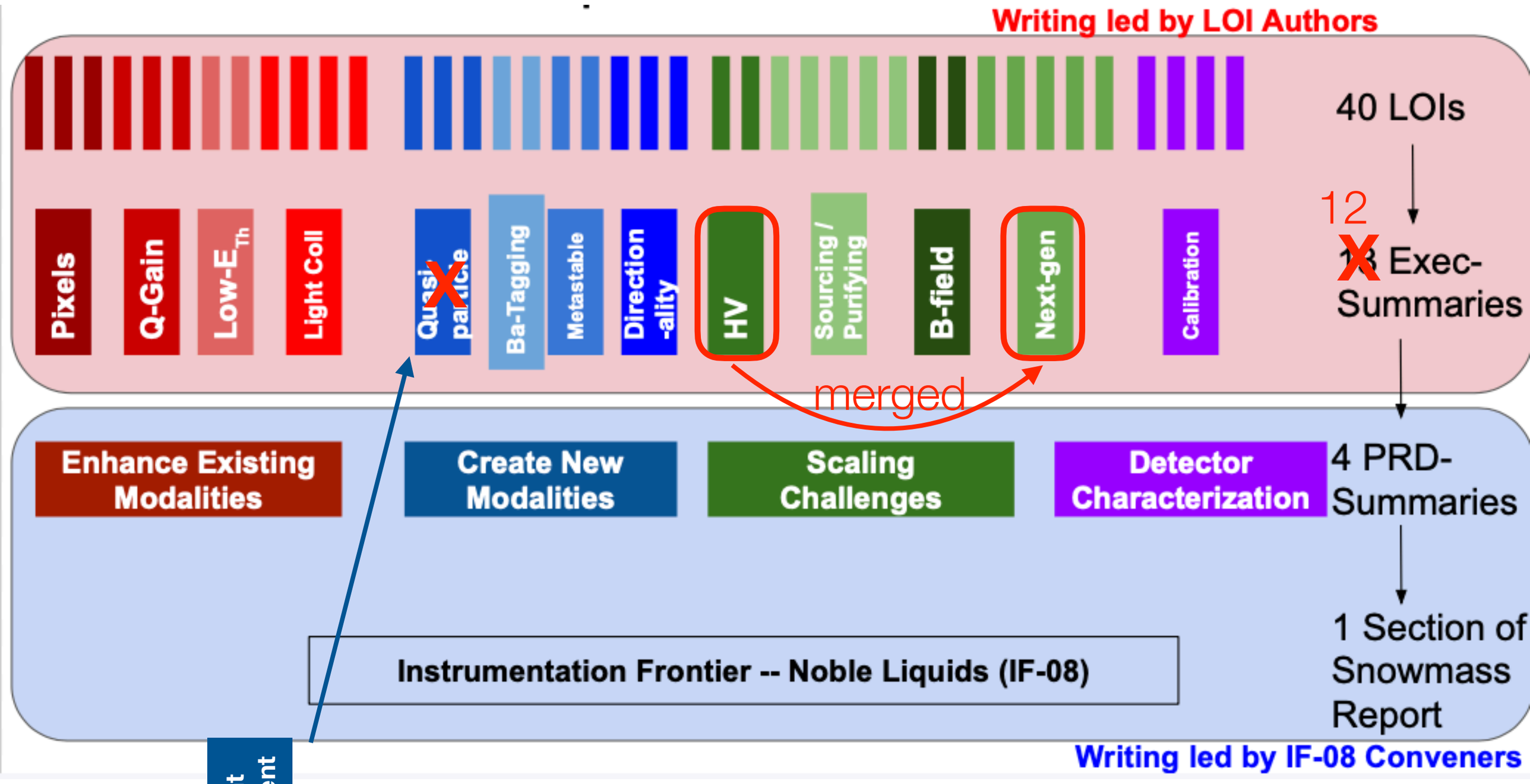


New category that brings new technologies to existing experiments to enhance their capabilities (replaces quasi-particles that moved to IF01)

# Discussion with IF05 & IF01

- **IF05**: LOI on Cygnus (directionality) is currently under IF05 for a "Multi-frontier White Paper" in progress. IF05 and IF08 should stay in contact about this to ensure proper referencing for both sections as this White Paper is complementary to the IF08-Directionality Executive Summary

- **IF01**: 2 LOIs on using LHe for phonon detectors for dark matter searches (TESSERACT and HERALD) were under IF08. While they can fit in the IF08-Low Thresholds, it is not a natural place to have them. They may be more appropriate in IF01?

IF1_IF8-CF1_CF0_Hertel-158.pdf
CF1_CF2-IF1_IF8-120.pdf

# Workshops

| Workshop Date | Focus areas | Relevant LOIs (main contact person) |
|---|---|---|
| October 18, 2021 ✓ | TOPIC 1: Enhance and combine existing modalities to increase signal-to-noise and reconstruction fidelity<br>• Pixels<br>• Charge gain<br>• Low-threshold TPCs (electron counting)<br>• Increasing light collection | • IF2_IF8-NF10_NF0_Gramellini-137 (E. Gramellini)<br>• IF7_IF8-NF10_NF0_Jonathan_Asaadi-079 (J. Asaadi)<br>• IF7_IF8-NF10_NF0-UF3_UF0_Dan_Dwyer-171 (D. Dwyer)<br>• CF1_CF0-IF8_IF0_Guillaume_Giroux-085 (G. Giroux)<br>• IF8_IF0-NF0_NF0-016 (D. Caratelli)<br>• IF8_IF5-NF10_NF0_Ben_Jones-070 (B. Jones)<br>• IF8_IF0_Shawn_Westerdale_and_Michael_Clark-133 (S. Westerdale)<br>• NF7_NF9-IF8_IF0_Kaixuan_Ni-011 (K. Ni)<br>• IF8_IF2_RGuenette-084 (R. Guenette)<br>• IF8_IF2_Andrzej_Szelc-145 (A. Szelc)<br>• IF3_IF8-NF2_NF9_Jing_Liu-095 (J. Liu)<br>• NF10_NF0-IF8_IF0_Zennamo-138 (J. Zennamo) |
| November 1, 2021 ✓ | TOPIC 2: Develop new modalities for signal detection<br>• Ultra-low-threshold (cryogenic) detectors with quasi-particle sensing<br>• Barium tagging<br>• Metastable fluids<br>• Directionality/Micron-precision spatial reconstruction | • IF1_IF8-CF1_CF0_Hertel-158 (S. Hertel)<br>• CF1_CF2-IF1_IF8-120 (D. McKinsey)<br>• IF8_IF0-CF1_CF0_sorensen-053 (S. Haselschwardt)<br>• NF5_NF3-RF4_RF0-IF8_IF0_William_Fairbank-120 (W. Fairbank)<br>• NF5_NF10-RF4_RF0-IF9_IF8_Ben_Jones-048 (B. Jones)<br>• IF8_IF0_Eric_Dahl-135 (E. Dahl)<br>• CF1_CF0-NF10_NF6-IF8_IF6_Matthew_Szydagis-012 (M. Szydagis)<br>• IF9_IF8-NF3_NF10-CF1_CF0-14 (E. Gramellini)<br>• IF8_IF0-NF10_NF6_Jacob_Zettlemoyer-150 (D. Caratelli)<br>• IF8_IF1_C._J._Martoff-092 (J. Martoff) |
| November 15, 2021 ✓ | TOPIC 3: Challenges in scaling technologies<br>• High voltage<br>• Sourcing/purifying noble gases<br>• TPCs with magnetic fields<br>• Next-generation large-scale detectors | • IF8_IF0-031 (L. Pagani)<br>• NF10_NF0-IF9_IF8_Xin_Qian-123 (X. Qian)<br>• NF5_NF3-RF4_RF0-IF8_IF0_Moore-027 (D. Moore)<br>• NF5_NF10-IF8_IF0_Zennamo-175 (J. Zennamo)<br>• IF8_IF0-CF1_CF0_Dongqing_Huang-152 (W. Lorenzon)<br>• IF8_IF0-UF3_UF0_Brian_Mong-144 (B. Mong)<br>• IF8_IF9_Giovanetti-163 (G. Giovanetti)<br>• IF8_IF9-153 (C. Montana)<br>• NF2_NF6-CF1_CF0-IF8_IF0_Bob_Wilson-079 (R. Wilson)<br>• CF1_CF2-NF5_NF4-IF8_IF0-CompF0_CompF0-UF2_UF3_Matthew_Szydagis-236 (R. Gaitskell)<br>• IF8_IF0-NF5_NF0-RF4_RF0_RGuenette-086 (R. Guenette)<br>• IF8_IF9_Westerdale-141 (S. Westerdale)<br>• NF10_NF6-IF8_IF9_DUNE-053 (R. Patterson)<br>• NF10_NF4-CF1_CF0-IF8_IF0-UF1_UF3-137 (E. Church) |
| December 13, 2021 | TOPIC 4: Improve the understanding of detector microphysics and characterization<br>• Calibration | • IF8_IF6_Michael_Mooney-192 (M. Mooney)<br>• IF8_IF0-NF5_NF10-CF1_CF0-CompF5_CompF7_Matthew_Szydagis-104 (M. Szydagis)<br>• IF6_IF8-NF4_NF9-CF1_CF2_Rick_Gaitskell-172 (R. Gaitskell)<br>• IF8_IF9-042 (C. Zhang) |
| January 10, 2022 | TOPIC 1 | Same group as October 18 |
| January 24, 2022 | TOPIC 2 | Same group as November 1 |
| February 7, 2022 | TOPIC 3 | Same group as November 15 |
| February 21, 2022 | TOPIC 4 | Same group as December 13 |

# Status and plan

- We have held 3 of the 4 *First Workshops*
- The groups are now in touch and we have discussed (and clarified) the process with them
- For the next ~2.5 months, they will work on the executive summaries together
  - Submitting a White Paper along with the Executive Summary is optional, but welcome
- At the *Second Workshops*, they will present their drafts to allow comments/inputs from the community and conveners before finalizing their documents
- As conveners, we will present the coherent view of all executive summaries to IF08 working group, to allow a last round of input

# Challenges

- Some LOI's points of contact have been unresponsive to the Executive Summary teams. We have informed the teams to reach out to us when this happens so we can follow-up, but **what will we do with LOIs authors who do not participate?**

- As our frontier focuses on the Instrumentation, the physics case made in our report section will be light, leveraging the Physics Topical Groups. **We need to ensure a close discussion with the Physics Topical Groups to ensure all science topics needed for the IF are documented or included**.

# Summary

- We have entered a busy writing period in IF08

- We will have 12 sub-group Executive Summaries (1-2 pages) by early March 2022 that will be merged into 4 Summaries related to the 4 identified Topics (BRN Priority Research Directions):
  - ➡ Enhance and combine existing modalities to increase signal-to-noise ratio and reconstruction fidelity
  - ➡ Develop new modalities for signal detection
  - ➡ Challenges in scaling technologies
  - ➡ Improve the understanding of detector microphysics and characterization

- We will use those as the primary input to the IF08 contribution to the Snowmass report

# Topics

| | | | | |
|---|---|---|---|---|
| **Enhance and combine existing modalities to increase signal-to-noise and reconstruction fidelity** | | | | |
| | **Pixels** | | | |
| | | IF2_IF8-NF10_NF0_Gramellini-137.pdf | Multi-modal pixels for noble element time projection chambers | elenag@fnal.gov |
| | | IF7_IF8-NF10_NF0_Jonathan_Asaadi-079 | Q-Pix: kiloton-scale pixelated liquid noble TPCs | jonathan.asaadi@uta.edu |
| | | IF7_IF8-NF10_NF0-UF3_UF0_Dan_Dwye | An R&D collaboration for scalable pixelated detector systems | dadwyer@lbl.gov |
| | **Charge Gain** | | | |
| | | CF1_CF0-IF8_IF0_Guillaume_Giroux-085. | Search for low mass WIMPs with spherical proportional counters | gg42@queensu.ca |
| | | IF8_IF0-NF0_NF0-016.pdf | Electron multiplication in liquid argon TPC detectors for low energy rare event physics | D. Caratelli (FNAL) |
| | | IF8_IF5-NF10_NF0_Ben_Jones-070.pdf | Scintillating and quenched gas mixtures for HPGTPCs | ben.jones@uta.edu |
| | **Low-threshold TPCs (electron counting)** | | | |
| | | IF8_IF0_Shawn_Westerdale_and_Michael | R&D for low-threshold noble liquid detectors | shawest@princeton.edu |
| | | NF7_NF9-IF8_IF0_Kaixuan_Ni-011.pdf | Noble liquids for the detection of CEvNS from artificial neutrino sources | nikx@physics.ucsd.edu |
| | **Increasing Light Collection** | | | |
| | | IF8_IF2_RGuenette-084.pdf | Cost-effective solution for increased light collection in noble-element detectors with meta | guenette@fas.harvard.edu |
| | | IF8_IF2_Andrzej_Szelc-145.pdf | Wavelength-shifting relfector foils in liquid Argon neutrino detectors | A.Szelc |
| | | IF3_IF8-NF2_NF9_Jing_Liu-095.pdf | COHERENT: Instrumentation development | jing.liu@usd.edu |
| | | NF10_NF0-IF8_IF0_Zennamo-138.pdf | Improving large LArTPC performance through the use of photo-ionizing dopants | jaz8600@fnal.gov |
| **Develop new modalities for signal detection** | | | | |
| | **New modalities in existing detectors** | | | |
| | | IF8_IF0-CF1_CF0_sorensen-053.pdf | A crystalline future for dual phase xenon direct detection instruments | scotthaselschwardt@lbl.gov |
| | | | HydroX | |
| | **Barium Tagging** | | | |
| | | NF5_NF3-RF4_RF0-IF8_IF0_William_Fair | Barium tagging for a nEXO upgrade and future 136Xe 0vbb detectors | fairbank@colostate.edu |
| | | NF5_NF10-RF4_RF0-IF9_IF8_Ben_Jones | Barium tagging in Xenon gas for neutrinoless double beta decay | ben.jones@uta.edu |
| | **Metastable fluids** | | | |
| | | IF8_IF0_Eric_Dahl-135.pdf | Enabling the next generation of bubble-chamber experiments for dark matter. and neutri | cdahl@northwestern.edu |
| | | CF1_CF0-NF10_NF6-IF8_IF6_Matthew_S | Metastable water: breakthrough technology for dark matter & neutrinos | mszydagis@albany.edu |
| | **Directionality / micron-precision spatial reconstruction** | | | |
| | | IF9_IF8-NF3_NF10-CF1_CF0-145.pdf | Dual-readout time projection chamber: exploring sub-millimeter pitch for directional dark | elenag@fnal.gov |
| | | IF8_IF0-NF10_NF6_Jacob_Zettlemoyer-1 | Towards directional nuclear recoil detectors: tracking of nuclear recoils in gas Argon TP | davidc@fnal.gov |
| | | IF8_IF1_C._J._Martoff-092.pdf | Instrumentation and R&D for the Global Argon Dark Matter collaboration | martoff@temple.edu |

https://docs.google.com/spreadsheets/d/1uqv388h6jfKB5dPT2T75FpHsNdouG7_IQi_Tkw9VvjA/edit?usp=sharing

# Topics

| | | | | |
|---|---|---|---|---|
| **Challenges in scaling technologies** | | | | |
| | **High Voltage** | | | |
| | | IF8_IF0-031.pdf | High voltage cable feed-through | lpagani@ucdavis.edu |
| | | NF10_NF0-IF9_IF8_Xin_Qian-123.pdf | Development of LArTPC vertical drift solutions with PCB anode readouts for DUNE | xqian@bnl.gov |
| | **Sourcing / purifying noble gasses** | | | |
| | | NF5_NF3-RF4_RF0-IF8_IF0_Moore-027.p | Kilotonne-scale Xe TPCs for 0vbb searches at 10^30 yr half-life sensitivity | david.c.moore@yale.edu |
| | | NF5_NF10-IF8_IF0_Zennamo-175.pdf | DUNE-Beta: searching for neutrinoless double beta decay with a large LArTPC | jaz8600@fnal.gov |
| | | IF8_IF0-CF1_CF0_Dongqing_Huang-152. | Charcoal-based radon reduction systems for ultra-clean rare-event detectors | lorenzon@umich.edu |
| | | IF8_IF0-UF3_UF0_Brian_Mong-144.pdf | Using metal organic frameworks for Krypton and Radon removal in low-background Xen | bung@slac.stanford.edu |
| | | IF8_IF9_Giovanetti-163.pdf | Applications for underground Argon | gkg1@williams.edu |
| | **TPC with magnetic field** | | | |
| | | IF8_IF9-153.pdf | Magnetizing the liquid Argon TPC | cmontana@fnal.gov |
| | | NF2_NF6-CF1_CF0-IF8_IF0_Bob_Wilson- | ICARUS in the next decade | wilson@colostate.edu |
| | **Next-generation large scale detectors** | | | |
| | | CF1_CF2-NF5_NF4-IF8_IF0-CompF0_Co | The exploitation of Xe large scale detector technology for a range of future rare event ph | gaitskell@brown.edu |
| | | IF8_IF0-NF5_NF0-RF4_RF0_RGuenette-( | High-pressure xenon gas time-projection chambers for neutrinoless double-beta decay s | guenette@fas.harvard.edu |
| | | IF8_IF9_Westerdale-141.pdf | Instrumentation and R&D for the Global Argon Dark Matter collaboration | shawest@princeton.edu |
| | | NF10_NF6-IF8_IF9_DUNE-053.pdf | DUNE near detector | rbpatter@caltech.edu |
| | | NF10_NF4-CF1_CF0-IF8_IF0-UF1_UF3-1 | Low background kTon-scale liquid Argon time projection chambers | eric.church@pnnl.gov |
| **Improve the understanding of detector microphysics and characterization** | | | | |
| | **Calibration** | | | |
| | | IF8_IF6_Michael_Mooney-192.pdf | Precision calibration of large LArTPC detectors | mrmooney@colostate.edu |
| | | IF8_IF0-NF5_NF10-CF1_CF0-CompF5_C | NEST, The Noble Element Simulation Technique: a multi-disciplinary monte carlo tool ar | mszydagis@albany.edu |
| | | IF6_IF8-NF4_NF9-CF1_CF2_Rick_Gaitsk | Nuclear recoil calibration techniques for dark matter and neutrino experiments | gaitskell@brown.edu |
| | | IF8_IF9-042.pdf | Investigations of fundamental parameters of liquid argon for particle detection | czhang@bnl.gov |

https://docs.google.com/spreadsheets/d/1uqv388h6jfKB5dPT2T75FpHsNdouG7_IQi_Tkw9VvjA/edit?usp=sharing

# Other Frontiers LOIs

- These are outside our direct remit, but would be mentioned in the report briefly, referring to other sections

| Topical Groups / Covered by other Frontiers | | | | |
|---|---|---|---|---|
| **Computing** | | | | |
| | CompF1-NF10-IF8-002.pdf | Wire-cell toolkit | B. Viren |
| | CompF2_CompF1-NF1_NF5-CF1_CF2-IF | Fast simulations for noble liquid experiments | monzani@stanford.edu |
| | CompF3_CompF2-NF1_NF5-CF1_CF2-IF | The future of machine learning in rare event searches | monzani@stanford.edu |
| **New TPC Physics Applications** | | | |
| | CF7_CF1-NF7_NF10-IF8_IF0_Shutt-224.p | A next-generation LAr TPC-based MeV Gamma ray instrument | tshutt@slac.stanford.edu |
| | NF7_NF9-IF8_IF0_Kaixuan_Ni-011.pdf | Noble liquids for the detection of CEvNS from artificial neutrino sources | nikx@physics.ucsd.edu |
| | NF6_NF4-IF2_IF8-139.pdf | Inelastic neutrino-nucleus interaction measurements with COHERENT | kate.scholberg@duke.edu |
| | NF10_NF3-IF2_IF8-UF1_UF3_Zelimir_Dju | Searches for proton-decay with additional signatures from nuclear deexitations and with | zdjurcic@anl.gov |
| **Facilities** | | | |
| | UF0_UF0-NF0_NF0-RF4_RF3-CF1_CF0-I | The Sanford underground research facility | jaret@sanfordlab.org |
| | UF6_UF0-NF10_NF0-RF4_RF0-CF1_CF0 | Solution-mined dalt caverns as sites for underground physics experiments | benjamin.monreal@case.edu |
| | NF9_NF5-CF1_CF0-IF8_IF0_JNewby-108 | ORNL neutrino sources for future experiments | newbyrj@ornl.gov |
| | NF6_NF9-CF1_CF0-TF11_TF0-IF2_IF8_K | Neutrino opportunities at the ORNL second target station | kate.scholberg@duke.edu |
| **Quantum Sensors** | | | |
| | IF1_IF8-CF1_CF0_Hertel-158.pdf | Calorimetric readout of a superfluid 4He target mass | shertel@umass.edu |
| | CF1_CF2-IF1_IF8-120.pdf | The TESSERACT dark matter project | daniel.mckinsey@berkeley.edu |

https://docs.google.com/spreadsheets/d/1uqv388h6jfKB5dPT2T75FpHsNdouG7_IQi_Tkw9VvjA/edit?usp=sharing

# Executive Summary Template

## Topic

Authors

## Executive Summary (~1 page)

### Instrumentation requirements to achieve physics goals (list)

E.g., Achieve track resolution of better than X microns to see CEvNS with E~ XX keV
E.g., Reduce noise by an order of magnitude to achieve XX physics

### Significant instrumentation challenges (list)

E.g., SiPM quantum efficiency maximum is currently XX

### Relevant physics areas (e.g., low-mass DM, solar neutrino oscillations, CEvNS)

### Relevant cross-connections (e.g., other topical groups, other white papers)

### Further reading (e.g., reference for existing TDR, reference paper, etc.)