Report from Instrumentation Frontier

October 8, 2020

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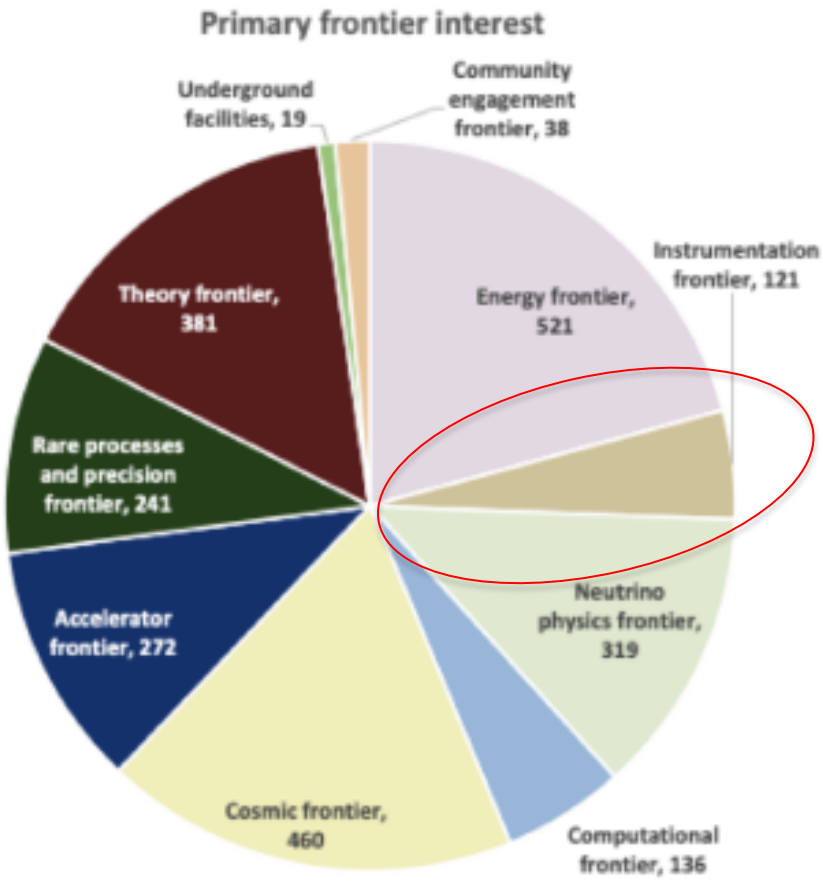
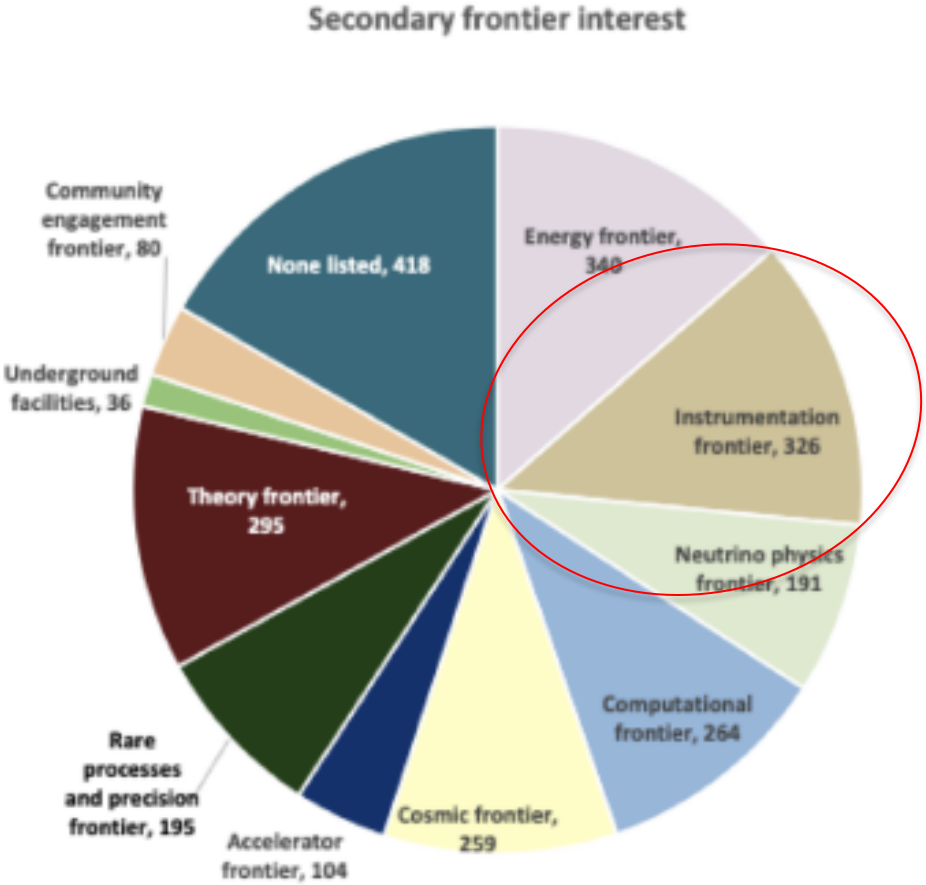
IF is geared to discuss detector technologies and R&D needs for future experiments in collider physics, neutrino physics, intensity physics and at the cosmic frontier, paying close attention to synergies between the different TGs, and with other frontiers and research areas outside HEP.





Organization

Topical Group	Co-Conveners			
Quantum Sensors	Thomas Cecil (ANL)	Kent Irwin (SLAC)	Reina Maruyama (Yale)	Matt Pyle (Berkeley)
Photon Detectors	Chris Rogan (KU)	Juan Estrada (FNAL)	Mayly Sanchez (ISU)	
Solid State Detectors and Tracking	Tony Affolder (UCSC)	Artur Apresyan (FNAL)	Lucie Linssen (CERN)	
Trigger and DAQ	Darin Acosta (Florida)	Wes Ketchum (FNAL)	Stephanie Majewski (Oregon)	
Micro Pattern Gas Detectors	Bernd Surrow (Temple)	Maxim Titov (SACLAY)	Sven Vahsen (Hawaii)	
Calorimetry	Andy White (UTA)	Minfang Yeh (BNL)	Rachel Yohay (FSU)	
Electronics/ASICS	Gabriella Carini (BNL)	Mitch Newcomer (Penn)	John Parsons (Columbia)	
Noble Elements	Eric Dahl (Northwestern)	Roxanne Guenette (Harvard)	Jen Raaf (FNAL)	
Cross Cutting and System Integration	Jim Fast (JLab)	Maurice Garcia-Sciveres (LBL)	Ian Shipsey (Oxford)	
Radio Detection	Jim Beatty (OSU)	Abigail Vieregg (Chicago)		

Frontier	Liaison	
Energy	Caterina Vernieri (SLAC)	Maxim Titov (CEA Saclay)
Neutrino	Mayly Sanchez (ISU)	
Rare	Marina Artuso (Syracuse)	
Cosmic	Kent Irwin (SLAC)	Hugh Lippincott (UCSB)
Accelerator	Andy White (UTA)	

Frontier	Liaison		
Computational	Darin Acosta (Florida)		
Underground	Eric Dahl (Northwestern)	Maurice Garcia-Sciveres (LBNL)	
Community	Farah Fahim (FNAL)		
Early Career	Steve Butalla (FIT)	Katherine Dunne (Stockholm)	Jacob Zettlemoyer (FNAL)

Basic Research Needs

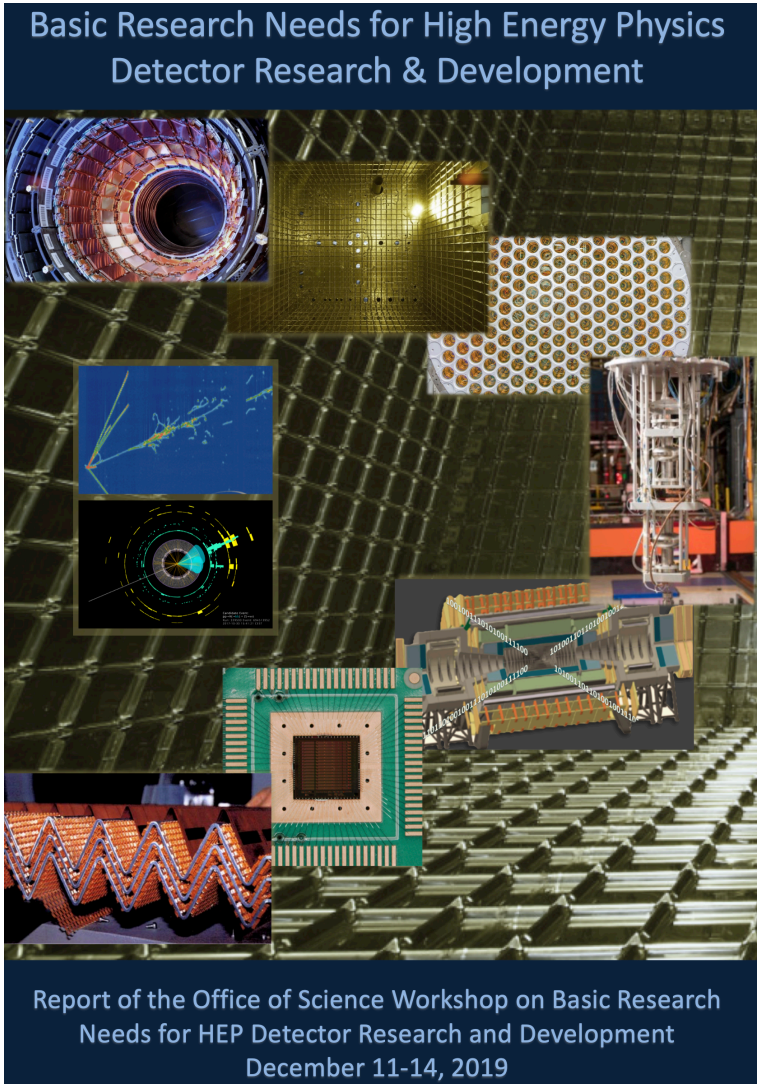
DOE Basic Research Needs Study on High Energy Physics Detector Research and Development

https://science.osti.gov/-/media/hep/pdf/Reports/2020/DOE_Basic_Research_Needs_Study_on_High_Energy_Physics.pdf?la=en&hash=A5C00A96314706A0379368466710593A1A5C4482

Co-chairs: Bonnie Fleming, Ian Shipsey

Grand Challenges

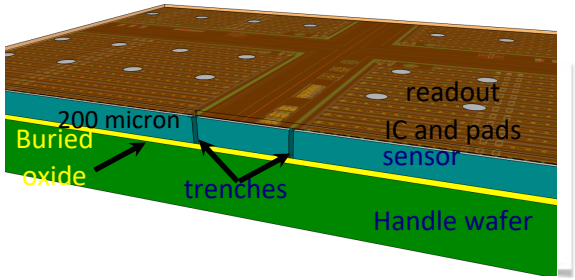
1. Advancing HEP detectors to new regimes of sensitivity
2. Using integration to enable scalability of HEP sensors
3. Building next-generation HEP detectors with novel materials and advanced techniques
4. Mastering extreme environments and data rates in HEP experiments

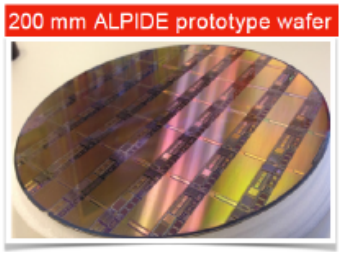


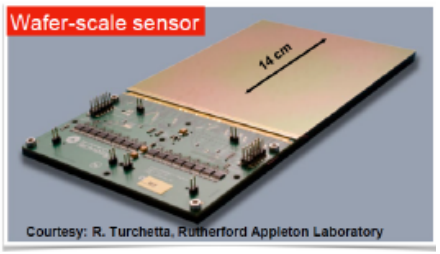
The BRN has done a significant amount of groundwork for future instrumentation needs

Cross Cutting Activities

Collider Physics (EF/RF/AF)







(**26**) Energy Frontier discovery machines

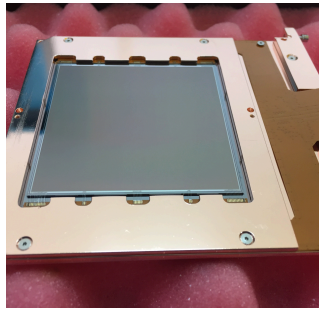
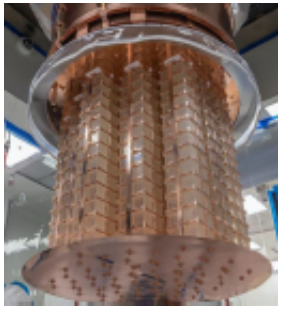
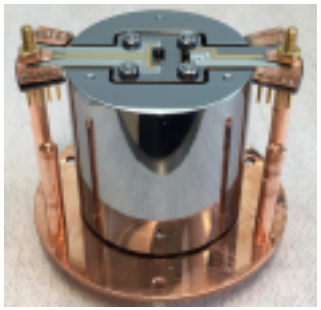
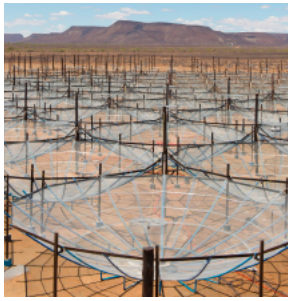
(**54**) Machine Detector Interface for future colliders

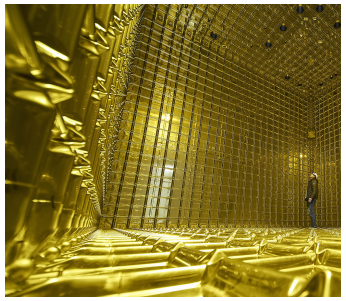
(**130**) Enabling Technologies for low mass and ps timing detectors (silicon trackers)

(**131**) Physics requirements for HEP detectors at colliders

Cross Cutting Activities

Astro and Neutrino Physics (CF/NF)

(**51**) Requirements for low background and underground detectors

(**69**) Instrumentation for future optical surveys

(**70**) Instrumentation for future sub-mm surveys

(**71**) Instrumentation for future radio intensity mapping surveys

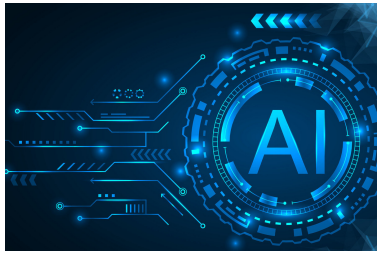
(**77**) Quantum sensors for wave and particle detection

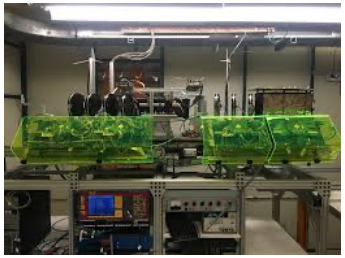
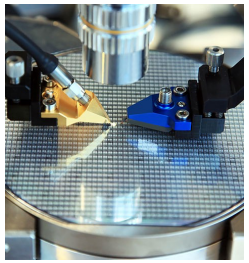
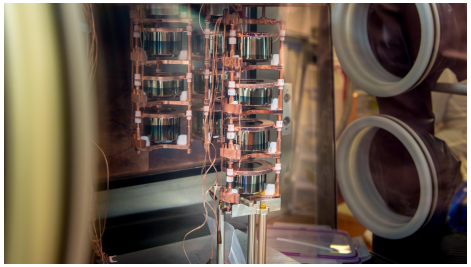
(**137**) High and ultrahigh energy neutrino experiments

(**140**) Future medium to ultrahigh energy gamma-ray detectors

Cross Cutting Activities

Across




(**57**) Connection with industry and manufacturing

(**102**) The role of QIS in HEP

(**118**) Cross-community mobility in science

(**119**) HEP workforce, careers and training

(**122**) Capabilities needed to execute underground experiments in a broad range of research categories

(**123**) Data handling and AI/ML

Some Takeaways

- Wish for US-based R&D collaborations on specific topics, similar to CERN's RDxx
- Need for technology roadmap for future collider detectors, value of intermediate "demonstrator" experiments
- Systems design also to keep in mind unusual signatures (e.g. LLP)
- Discussion about pros and cons of single-purpose vs multi-purpose detectors; synergies in instrumentation important
- QI not just for sensing, also consider readout, infrastructure, and to use QI to understand physics of sensors
- Atomic techniques (e.g. GW detectors) provide new windows and complementary technology challenges
- QIS needs closer collaboration between sensors, theory and algorithm development
- AI/ML is moving onto the detector; collaboration across experiments and frontiers needed
- Suggestion to "facilitize" multiple smaller underground efforts into larger enterprises
- Discussion about improvement opportunities in SBIR model and sustainability of partnerships with industry for small, specialized silicon runs; case for split-fab
- Need for high-level overview of existing facilities (test beams, irradiation, ultra-low noise, etc.)
- Need to boost visibility/prestige of careers in instrumentation; challenge to train next generation when experiment phases last decades (colliders)

Next Steps

- Regular Topical Group meetings to discuss individual LOIs and start collating towards white papers
  - https://snowmass21.org/instrumentation/start

- Workshops:
  - MultiHEP: November 10-12, 2020
    https://indico.physics.lbl.gov/event/1217/overview
    - Organized by IF09: Cross Cutting
  - CPAD: mid March 2021
    parallel sessions with topical groups, and cross fertilization with NP (EIC) and QIS
    - Touch point for white paper planning
  - IF + NF workshop: mid March 2021

Summary

Instrumentation Frontier received ~340 LOIs across 10 topical groups

Very fruitful inter-frontier discussions these last two days, will continue in regular IF/TG meetings and workshops

Recent BRN for Detectors did great groundwork, but some gaps and missing pieces already identified

Please get involved!

No new science without cutting-edge detectors!