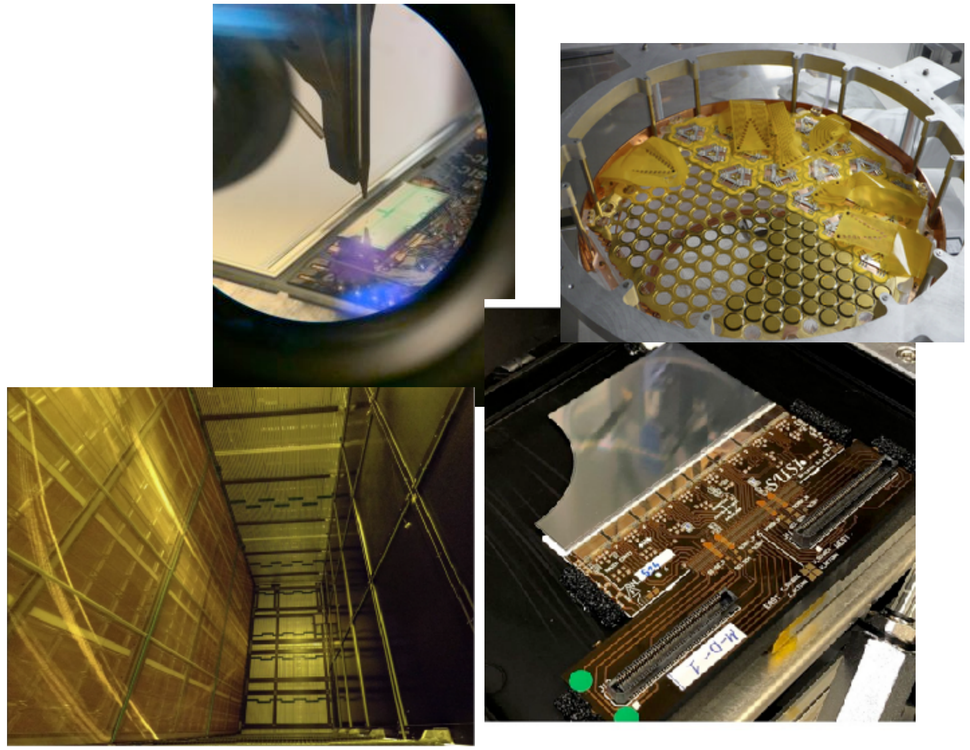

Petra Merkel, chair, FNAL

Jonathan Asaadi, vice-chair (University of Texas)

MARINA ARTUSO
SYRACUSE UNIVERSITY
RARE/PRECISION, SILICON

DAVID ASNER
BROOKHAVEN NATIONAL LABORATORY
INSTRUMENTATION

CARMEN CARMONA
PENN STATE UNIVERSITY
DM, LXE DETECTORS

NOAH KURINSKY
SLAC
QUANTUM SENSORS FOR RARE EVENT SEARCHES

KIM PALLADINO
OXFORD UNIVERSITY
DM, LXE

SALLY SEIDEL
UNIVERSITY OF NEW MEXICO
SILICON DETECTORS, RADIATION DAMAGE

MICHELLE STANCARI
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NEUTRINOS, LARTPC

ARITOKI SUZUKI
LBNL
CMB AND DM INSTRUMENTATION

The Coordinating Panel for Advanced Detectors

STEVE WORM
DESY ZEUTHEN
SILICON, COLLIDER AND ASTROPARTICLE INSTRUMENTATION, QIS

JINLONG ZHANG
ARGONNE NATIONAL LABORATORY
ENERGY, TDAQ

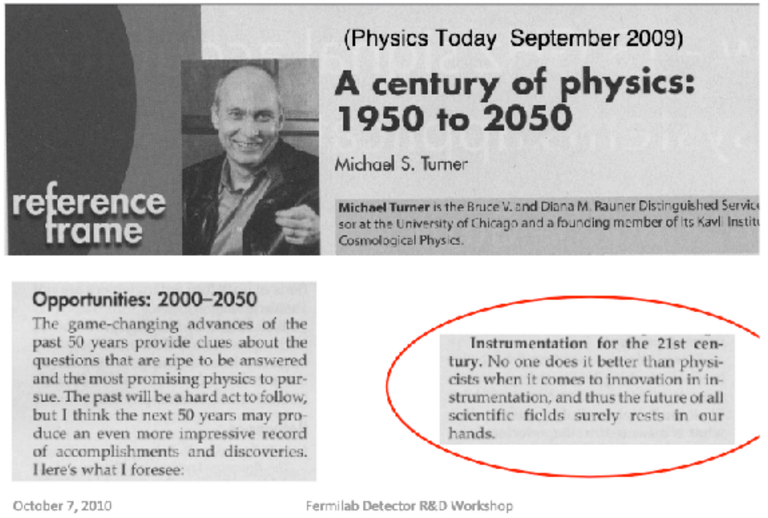
Why it was started?
CPAD's goals
New perspective: synergistic R&D initiatives to address basic research needs of future experiments
More information at https://cpad-dpf.org/

CPAD: the beginning

- The start: a workshop at Fermilab on October 7-10, 2010 on detector R&D for HEP
  - Description: State of the art detectors are the critical tool probing and understanding nature, not just in the physical sciences but also most other fields of science. This workshop will examine the challenges for developing and deploying new detector technologies to meet the needs in the national program of particle and astro-particle physics and other closely related fields of science. The DOE Office of Science, the NSF Division of Physics, and their university programs together share the mission of fostering and delivering research and development for novel instrumentation .
  - Goal of the workshop: survey R&D carried at laboratories & universities, identify areas of greatest promise, and identify the current challenges and future needs

CPAD task force established by the DPF executive committee in Spring 2011, 1st report completed in October 2011

From H. Nicholson's talk



Main recommendation: establishment of Detector R&D coordination panel (under the DPF auspices) whose primary role is to promote, coordinate and assist in generic detector R&D nationally on behalf of the community.

CPAD major initiatives I

Connect a community of scientists working on instrument innovation

- **Create a forum where scientists working on detector R&D can brainstorm on new technologies and applications. 6 well-attended workshops provide an opportunity for vibrant exchanges [yearly, only exception 2020]**
  - Important research initiatives emerged, for example CPAD sponsored the Workshop on Quantum Sensing for High Energy Physics in December 2017. It originated a report that jumpstarted this vibrant field
  - Most recent workshop at Stony Brook in November 2022, with some emphasis on implementation of Snowmass IF findings, connection with European initiatives, included roundtable on US RD consortia.
  - Next CPAD workshop planned for fall 2023 at SLAC. Stay tuned!
- **Interface with Industrial R&D:** e.g. Coordination in Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) when requested by DOE

CPAD major initiatives II

Mission: educate, recognize achievements, disseminate knowledge

- CPAD seeks to nurture and recognize the talents of scientists developing the instruments for the future:
  - Graduate student award (GIRA) (with DOE)
  - DPF Instrumentation Award & Instrumentation Early Career Award
- CPAD gather experts to review promising technologies and their synergy with research needs and distill the findings in reports that are a reference for planning and brainstorming on new initiatives

Lessons from the BRN study

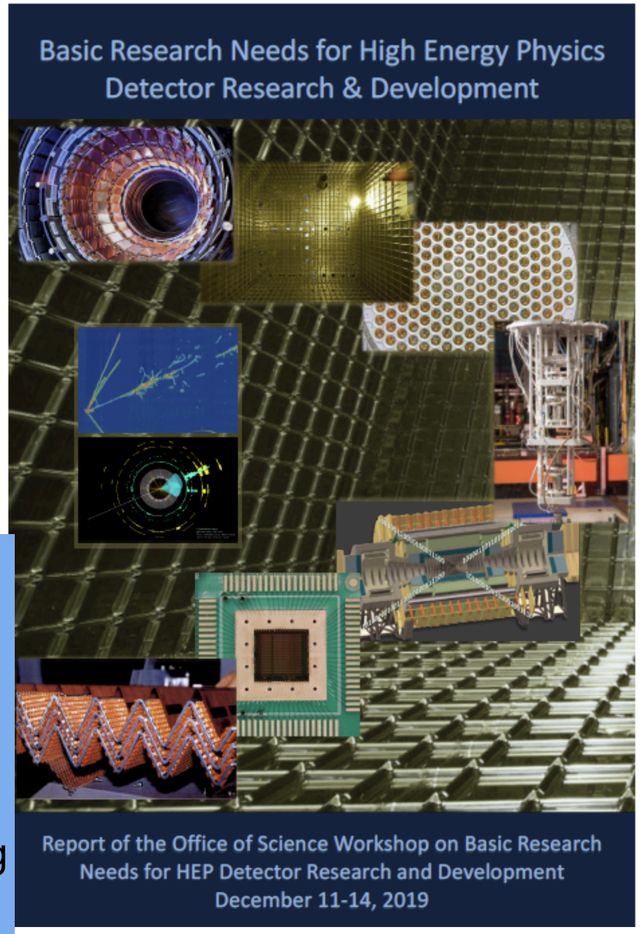
Basic research Needs for High Energy Physics Detector Research and Development

- Methodology:
  - examine connections between physics drivers and detector requirements, considering ALL the physics drivers

} Work organized around 2014 P5 Physics Drivers

  - Connect with current cutting-edge technologies and identify big ideas to support physics reach

1. Calorimetry
2. Noble elements
3. Photodetectors
4. Quantum sensors
5. Readout and ASICs
6. Solid State and Tracking
7. Trigger and DAQ
8. Cross-Cutting Research



Example of priority research directions

Solid state tracking

PRD	Thrust	
Develop high spatial resolution pixel detectors with precise per-pixel time resolution to resolve individual interactions in high-collision-density environments	1: small pixel size $\approx 10\mu m$ 2. timing O(10 ps). → ~1ps 3. Extreme radiation ($10^{18} n_{eq}/cm^2$)	Lepton colliders, LHCb Upgrade 2 Hadron colliders
Adapt new materials and fabrication/integration techniques for particle tracking	1. Adapting new materials and novel configuration sensors with new industrial partnerships 2. Develop readout electronics matched to new sensors characteristics, including new processing such as 3D integration	Lepton and hadron colliders Charged lepton flavor violation
Realize scalable, irreducible mass trackers	1. Highly integrated monolithic active sensors 2. Scaling of low mass detector systems 3. System for special applications (space/dark matter/rare processes)	Lepton and hadron colliders, heavy flavor experiments at hadron machine, dark matter, charged lepton flavor violation

The message from Snowmass Instrumentation frontier

The recommendations

IF overview by J. Zhang

1. Advance performance limits of existing technologies and develop new techniques advance performance limits of existing technologies and develop new techniques and materials, nurture enabling technologies for new physics, and scale new sensors and readout electronics to large, integrated systems using co-design methods.
2. Develop and maintain the critical and diverse technical workforce, and enable careers for technicians, engineer and scientists across disciplines working in HEP instrumentation, at laboratories and universities.

   Workforce Development Gabriella Carini
3. **Double the US Detector R&D budget over the next five years, and modify existing funding models to enable R&D consortia along critical key technologies for the planned long-term science projects, sustaining the support for such collaborations for the needed duration and scale.**
4. Expand and sustain support for blue-sky R&D, small scale R&D, and seed funding. Establish a separate agency review process for such pathfinder R&D, independent from other research reviews.
5. Develop and maintain critical facilities, centers and capabilities for the sharing of common knowledge and tools, as well as develop and maintain close connections with international technology roadmaps, other disciplines and industry. Connection with industry and impact beyond HEP Shih-Chieh Hsu Hsu Industry and Medical applications Farah Fahim

The CPAD RD initiative

- Goals:
  1. Create a robust R&D program towards the technologies needed to enable discoveries in future HEP detectors and foster innovation in instrumentation
  2. Allow for more streamlined and synergistic collaboration between university teams and laboratories to share expertise, tools, and facilities, and avoid duplications in light of limited funds
  3. Facilitate easy communication and connections between participants in US RDC & CERN DRD + other relevant partners (e.g. HEPIC.org.)
- First step: organize research consortia & organize workshops to develop proposals for innovative R&D work that connects different communities

Planning Detector Research Consortia

To sign up go to More Information

RD	Topic	Mailing list	Current subscribers
RDC1	Noble elements Detectors	cpad_rdc1@fnal.gov	43
RDC2	Photodetectors	cpad_rdc2@fnal.gov	62
RDC3	Solid State Tracking	cpad_rdc3@fnal.gov	71
RDC4	Readout and ASICs	cpad_rdc4@fnal.gov	64
RDC5	Trigger and DAQ	cpad_rdc5@fnal.gov	28
RDC6	Gaseous Detectors	cpad_rdc6@fnal.gov	29
RDC7	Low-background detectors	cpad_rdc7@fnal.gov	38
RDC8	Quantum and Superconducting Sensors	cpad_rdc8@fnal.gov	62
RDC9	Calorimetry	cpad_rdc9@fnal.gov	46
RDC10	Detector Mechanics New		JUST ADDED

Picosecond timing across technologies consortium is under consideration

Conclusions and outlook

- CPAD, the coordinating panel for advanced detectors, has worked for more than one decade to coordinate and assist in the research and development of instrumentation and detectors for high-energy physics experiments, promoting synergies and exchanges of ideas, recognition of talented individuals who are contributing to this scientific endeavor, and education of the next generation of detector builders
- We are in the process of launching 10 RDCs to advance the instruments that will support the challenging requirements of future experiments
- In the next few months, we will launch workshops to prepare R&D plans
- We hope that this community will grow and will achieve exciting breakthroughs in the next decade and beyond

The end

Last P5 Recommendation on Instrumentation

Recommendation 27: Focus resources toward directed instrumentation R&D in the near-term for high-priority projects. As the technical challenges of current high-priority projects are met, restore to the extent possible a balanced mix of short-term and long-term R&D.

Recommendation 28: Strengthen university-national laboratory partnerships in instrumentation R&D through investment in instrumentation at universities. Encourage graduate programs with a focus on instrumentation education at HEP supported universities and laboratories, and fully exploit the unique capabilities and facilities offered at each.