



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Basic Research Needs Study on Dark Matter New Initiatives

Karen Byrum, Kathy Turner

*Experimental Research in HEP
Office of High Energy Physics*

Basic Research Needs Workshops (BRNs)

- ▶ SC's Office of Basic Energy Sciences initiated this approach with the *Basic Research Needs to Assure a Secure Energy Future* workshop in October 2002. This resulted in a comprehensive, 420-page report that identified 37 Proposed Research Directions.
<http://science.energy.gov/bes/community-resources/reports/>.
- ▶ Numerous (~20) subsequent topically-focused BRNs have helped to define directions and make the case for major new efforts such as Energy Frontier Research Centers and Innovation Hubs
- ▶ While there are some variations and there has been some evolution, many BRNs have involved:
 - ▶ Production of a Technology Perspectives Factual Document prior to the workshop
 - ▶ Definition of a set of Priority Research Directions that address the technology R&D challenges
 - ▶ Definition of a set of Science Grand Challenges that, if solved, might result in transformational changes



BRN process and structure

- ▶ Targeted topics defined by, and workshop charge issued by, SC program office
- ▶ **Attendance is limited and by invitation only**
- ▶ Participants have considerable work to do before, during, and after the meeting
- ▶ Workshop Chair and Co-Chairs develop agenda and select panel/working groups leads (with program office input)
- ▶ Typical structure: Opening plenary sessions, panel/working group breakout sessions that develop priority research directions, closing plenary session, and extended writing session – draft report completed before departure!
- ▶ Prompt output: final report released typically 60-90 days after the workshop



BRN impacts

- ▶ BRN reports are expected to serve as reference documents with a long shelf life, and to be readily accessible
- ▶ Post-workshop outreach activities often include communication of the results to the broader community by co-chairs and the SC program, and briefings by federal staff to other interested federal parties (within and beyond DOE)
- ▶ **BRNs may, individually or collectively, serve as the basis for subsequent funding opportunities.** Examples:
 - ▶ The 2003 workshop report on Basic Research Needs for the Hydrogen Economy was referenced in and supported an FY2004 solicitation on Basic Research for the Hydrogen Fuel Initiative.
 - ▶ An FY2007 FOA on Basic Research for Advanced Nuclear Energy Systems was based directly on the corresponding BRN, stating specifically that “The workshop report is a current source of information and summarizes the interests of BES.”
 - ▶ The original FY2009 solicitation for the Energy Frontier Research Centers (up to \$100M/yr total) centered on the 11 BRNs that SC-BES had held to date.
 - ▶ An FY2011 FOA from Fusion Energy Sciences on High Energy Density Laboratory Plasmas specifically sought applications addressing the research needs identified by the Basic Research Needs for High Energy Density Laboratory Physics workshop report and two prior reports.
 - ▶ The most recent FY2018 Energy Frontier Research Centers FOA (up to \$98.9M/yr total) *requires* that applications address Priority Research Directions in one or more of 12 reports, 11 of which were BRNs.



HEP Program Optimization

- ▶ HEP has undertaken several steps recently to help further optimize program plans and budgets (*for more details on the following, see Nov. 2017 and May 2018 HEPAP talks*)
 - ▶ Lab Optimization
 - ▶ Portfolio Reviews
 - ▶ **Basic Research Needs** workshops
 - ▶ Accelerator Technology Roadmaps
 - ▶ Computing Infrastructure Working Group
- ▶ Taken together these processes aim to:
 - ▶ Improve the effectiveness and efficiency of HEP research programs and supporting technology infrastructure
 - ▶ Identify currently operating experiments that have the highest impact on P5 science drivers
 - ▶ Identify research and technology R&D areas that are ripe for additional investments



→ HEP Small Projects Portfolio

HEPAP P5 Strategic Plan (2014), recommended:

- **Balanced Program (maintain diversity of project scales in the program, i.e. ensuring small projects too)**
- **The search for dark matter particles as high priority science**
 - ▶ HEP has funded a number of “small projects” and will continue to pursue timely physics opportunities with new experimental technique
 - ▶ Long list includes COHERENT, **ADMX-G2, HPS**, ...
 - ▶ Intermediate Neutrino Research Program workshop and FOA enabled PROSPECT, ANNIE
 - ▶ **Future Basic Research Needs (BRN) workshops may help define and prioritize additional opportunities for small project investments**
- Potential topic areas include: accelerator applications (compact accelerators), **Dark Matter**, detector R&D



HEP Dark Matter Status & New Directions

P5 (2014) recommended:

- Search for dark matter particles as high priority science
- Program of “generation 2” Direct Detection projects with NSF (“DM-G2”)
- R&D towards generation 3
- Maintain a diversity of project scales in HEP (i.e. ensuring small projects too)

Direct Detection searches:

Following P5, NSF & DOE selected 3 generation-2 (DM-G2) projects to move forward:

- ADMX-G2 - currently operating
 - LZ - in fabrication phase
 - SuperCDMS-SNOLAB (NSF is partnering on funding for this project); in fabrication phase
- R&D towards G3 is limited while getting G2's going

Other Dark Matter searches are continuing in:

- Cosmic Frontier – searches using cosmic-ray and gamma-ray data
- Energy Frontier – searches with LHC data
- Intensity Frontier – accelerator-based data and experiments (e.g. HPS at Jlab)

Theoretical Studies:

In recent years, efforts have been ramping up and point to new areas that should be searched.

New Areas to search for the future:

DOE lab and university community has been investing in developing concepts for small projects using a variety of new technologies and methods (with LDRD and Advanced Detector R&D funds)

– Efforts point to promise of significant leaps in science & capabilities



Dark Matter New Initiatives – Stages to Develop the program

Stage A: Background: March 2017 community workshop held to determine & identify scientifically compelling areas to search and whether there are possible concepts for new experiments or studies to address these. See *White Paper*: <https://arxiv.org/abs/1707.04591>

Stage B: HEP has started a **DM New Initiatives BRN Study** (2018-2019) and issued a Charge Letter:

- Assess the science landscape for dark matter particle searches, AND
- Identify which high impact science areas would be suitable to be pursued with small projects in the HEP program (i.e. that need HEP infrastructure and capabilities).
- Co-Chairs have been selected and are organizing BRN study efforts.
- Working groups have been formed & conveners selected; Regular phone meetings being held.
- **The BRN study will culminate in a workshop will be Oct 15-18 in Gaithersburg, MD.**
- The BRN's compelling report will inform HEP on the science case for new initiatives for small DM project(s).

What it's not:

- The BRN is not an official advisory (FACA) panel; no consensus or official recommendations
- It doesn't make priorities, #1, 2, 3 (but can group high impact priority areas)
- It won't consider or set specific priorities on which projects to or carry out.

Stage C+ (NOTIONAL): Depending on the case made and funding availability, next step would be a call (Funding Opportunity Announcement) for concept studies and near-term technology R&D that respond to high impact opportunities in the BRN (earliest this could get going would be mid to late FY2019). After successful concept development phase, this would be followed by development of small project(s), again depending on the science case and funding availability.



Dark Matter BRN – Chairs, and Convenors

BRN study Co-Chairs:

- ▶ Rocky Kolb (Univ. of Chicago)
- ▶ Harry Weerts (Argonne National Laboratory)

Working groups and conveners

- ▶ **Direct Detection: Low-threshold direct detections (roughly masses $>$ keV)**
 - ▶ Rouven Essig (Stony Brook University)
 - ▶ Dan McKinsey (Univ. of CA, Berkeley)
 - ▶ Kathryn Zurek (LBL)
- ▶ **Ultra-Low: Ultra-light DM, including the QCD axion space (\sim masses $<$ keV)**
 - ▶ Aaron Chou (FNAL)
 - ▶ Peter Graham (Stanford Univ.)
- ▶ **Accelerator: Accelerator production and detection for sub-GeV DM and new forces**
 - ▶ Natalia Toro (SLAC)
 - ▶ Richard Van de Water (LANL)
- ▶ **Cross-Cutting:**
 - ▶ Juan Estrada (FNAL)
 - ▶ Joe Incandela (Univ. of CA, Santa Barbara)
 - ▶ Tim Tait (Univ. of CA, Irvine)



Dark Matter BRN – Full attendee list

Name	Affiliation	Role
R.Kolb	Chicago	chair
H.Weerts	Argonne	chair
Natalia Toro	SLAC	convener
Richard van der Water	LANL	convener
Joe Incandela	UCSB	convener
Juan Estrada	FNAL	convener
Tim Tait	Irvine	convener
Dan McKinsey	Berkeley	convener
Rouven Essig	Stony Brook	convener
Kathryn Zurek	LBNL	convener
Aaron Chou	FNAL	convener
Peter Graham	Stanford	convener

Name	Affiliation	Role
Adam Bernstein	LLNL	participant
Adam Ritz	Victoria	participant
Alex Sushkov	Boston U	participant
Brian Batell	Pitt	participant
Eric Dahl	Northwestern	participant
Gordan Krnjaic	FNAL	participant
Gray Rybka	Washington	participant
Javier Tiffenberg	FNAL	participant
Jodi Cooley	SMU	participant
Karl van Bibber	Berkeley	participant
Kent Irwin	SLAC	participant
Lindley Winslow	MIT	participant
Marco Battaglieri	INFN	participant
Mariangela Lisanti	Princeton	participant
Matt Pyle	Berkeley	participant
Nhan Tran	FNAL	participant
Philip Schuster	SLAC	participant
Reina Marayama	Yale	participant
Rex Tayloe	Indiana	participant
Roni Harnik	FNAL	participant
Scott Hertel	Umass	participant
Stefania Gori	Santa Cruz	participant
Sunil Golwala	Caltech	participant
Surjeet Rajendran	Berkeley	participant
Tim Kovachy	Northwestern	participant
Tim Nelson	SLAC	participant
Yoni Kahn	Chicago/UIUC	participant