

U.S. MAGNET  
DEVELOPMENT  
PROGRAM

# Current Status of the US Magnet Development Program

*3<sup>rd</sup> US MDP Collaboration Meeting*

Soren Prestemon  
Director, US Magnet Development Program  
Lawrence Berkeley National Laboratory

- **Charge for the Technical Advisory Committee**
- **Goals for the Collaboration Meeting**
- **High level program overview**
  - Review of the program foundation
  - Management and technical oversight structure (short version)
  - Review of program goals and driving questions
  - Some context - reviews, strategy efforts, etc.
- **Overview of MDP-aligned collaborations**
- **Guidance to speakers**
- **Guidance to session chairs/moderators**

# Charge questions for the Technical Advisory Committee

1. The MDP priorities pursued over the last year are based on a balanced approach using available resources within funding constraints, but with a strengthening of the Technology section of the program. Do the priorities reflect a reasonable approach to address the Program Goals and Driving Questions given the current and projected funding levels and available resources? Are the priorities reflected in the efforts/progress presented?
2. What elements or results of the current plan are most likely to have the highest near term impact? Which elements are critical for longer term program success? Are near and longer term plans self consistent and defined at the appropriate level? Is the program managing expectations?
3. Comment on the progress on the HTS and Nb<sub>3</sub>Sn efforts. Are the plans and milestones sufficiently well defined to prepare the MDP for the planned International Workshop, recommended by the GARD review?
4. Comment on progress in integrating the program between the labs in the four key program areas. Are avenues for development/testing of program elements properly considered and evaluated?
5. Is the conductor roadmap adequate to address present needs and plan for future opportunities? Is the portfolio of activity balanced appropriately, especially in terms of material selection, prioritization to meet magnet needs, and positioning for opportunities?
6. Is the MDP approach to defining and monitoring international and industrial collaborations appropriate for a national program? Are opportunities for further collaboration being properly identified and pursued?

# Goals for the collaboration meeting are designed to keep the program focused on effectiveness

- Identify near and mid term milestones for each element of the program, clarify “ownership” and available resources to address them
- Discuss hurdles/issues encountered over the last year and solutions to address them in the future (lessons-learned)
- For technology developments, identify broader potential, i.e. beyond the core mission of MDP, where appropriate
- Identify infrastructure available to the MDP; identify investments needed, and prioritize them
- Identify near and mid-term conductor needs to provide guidance to LTSW

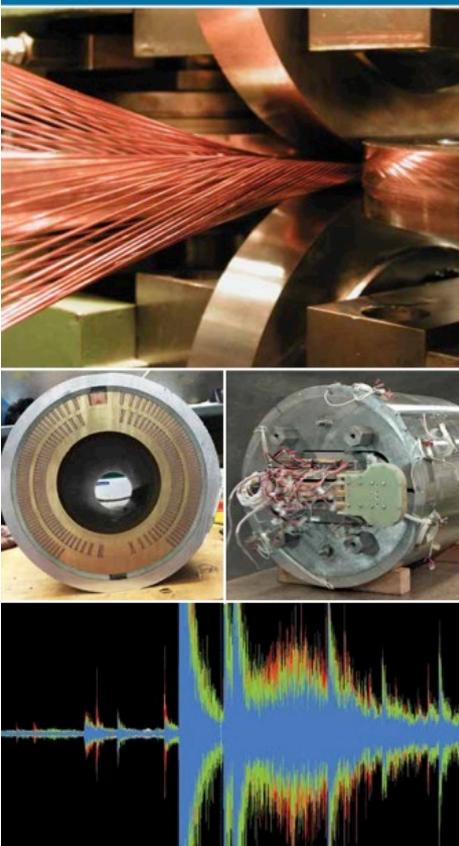


**U.S. MAGNET  
DEVELOPMENT  
PROGRAM**

# The US Magnet Development Program was founded by DOE-OHEP to advance superconducting magnet technology for future colliders



## The U.S. Magnet Development Program Plan



**S. A. Gourlay, S. O. Prestemon**  
*Lawrence Berkeley National Laboratory  
Berkeley, CA 94720*

**A. V. Zlobin, L. Cooley**  
*Fermi National Accelerator Laboratory  
Batavia, IL 60510*

**D. Larbalestier**  
*Florida State University and the  
National High Magnetic Field Laboratory  
Tallahassee, FL 32310*

JUNE 2016



Strong support from the Physics Prioritization Panel (P5) and its sub-panel on Accelerator R&D

A clear set of goals have been developed and serve to guide the program

Technology roadmaps have been developed for each area: LTS and HTS magnets, Technology, and Conductor R&D

### US Magnet Development Program (MDP) Goals:

#### GOAL 1:

Explore the performance limits of Nb<sub>3</sub>Sn accelerator magnets with a focus on minimizing the required operating margin and significantly reducing or eliminating training.

#### GOAL 2:

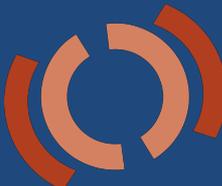
Develop and demonstrate an HTS accelerator magnet with a self-field of 5T or greater compatible with operation in a hybrid LTS/HTS magnet for fields beyond 16T.

#### GOAL 3:

Investigate fundamental aspects of magnet design and technology that can lead to substantial performance improvements and magnet cost reduction.

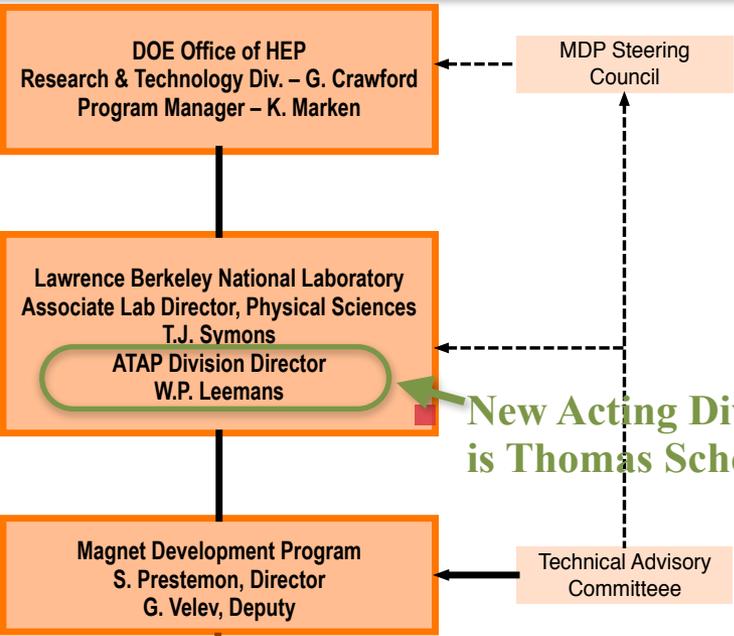
#### GOAL 4:

Pursue Nb<sub>3</sub>Sn and HTS conductor R&D with clear targets to increase performance and reduce the cost of accelerator magnets.



# One full year is now behind us...

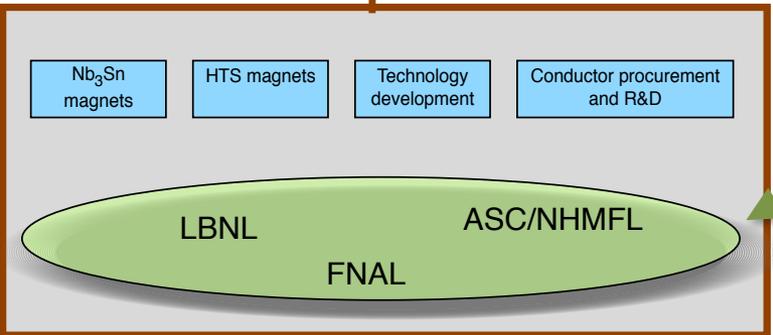
## The management structure of the MDP is well defined and the program is fully functioning



**Technical Advisory Committee**  
 Andrew Lankford, UC Irvine – *Chair*  
 Davide Tommasini, CERN => (calling in)  
 Akira Yamamoto, KEK  
 Joe Minervini, MIT  
 Giorgio Apollinari, FNAL  
 Mark Palmer, BNL

**New Acting Division Director is Thomas Schenkel**

**MDP Management Group**  
 S. Prestemon, LBNL  
 G. Velev, FNAL  
 L. Cooley, FSU  
 S. Gourlay, LBNL  
 D. Larbalestier, FSU  
 A. Zlobin, FNAL



**BNL is joining the collaboration now**

- Added to the MDP General Meeting mailing list
- K. Amm will join the MDP Management group

# Regular management and team meetings

- Internal management via “G6”:

- Prestemon (Director), Velev (Deputy), Cooley, Gourlay, Larbaestier, Zlobin
- Meets weekly via videoconference

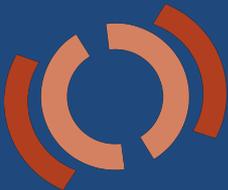
- Full MDP team meets ~biweekly with technical updates and discussion

- this is “organic”; should discuss if more rigor is warranted or not

The screenshot shows a calendar interface with two main categories: 'US-MDP Management Meetings' and 'US-MDP General Meetings'. The 'Management Meetings' category is described as 'The regular phone meetings of the US Magnet Development Program management team. Each meeting will be an event within this category.' The 'General Meetings' category is described as 'The regular phone meetings of the US Magnet Development Program collaboration in general. Each meeting is its own event within this category.' The calendar shows dates from December 2017 to January 2018, with specific meetings listed for January 24 and December 06, 2017.

The meeting agenda for 'US-MDP General Meeting' is chaired by Soren Prestemon (LBNL) and George Velev (Fermilab). It is scheduled for Wednesday, 5 December 2018 from 13:00 to 16:00 (US/Pacific) at a phone meeting. The support contact is Ms. Sreela Sen, LBNL, with email SSen@lbl.gov and telephone +1 510.486.4391 voice, .5392 fax.

Wednesday, 5 December 2018	
13:00 - 13:05	MDP news 5'
13:05 - 13:35	An experiment to study training in impregnated cables 30' Speaker: Christopher Kovacs (OSU) Material: <a href="#">Slides</a>
13:35 - 14:00	Update of the 10 stack R&D 25' Speaker: Steve Krave (FNAL) Material: <a href="#">Slides</a>



# The program has well-defined goals and is structured with leads who are responsible for delivery

Magnets	Lead
Cosine-theta 4-layer	Sasha Zlobin
Canted Cosine theta	Diego Arbelaez
Bi2212 dipoles	Tengming Shen
REBCO dipoles	Xiaorong Wang



**US Magnet Development Program (MDP) Goals:**

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Technology area	LBNL lead	FNAL lead
Modeling & Simulation	Diego Arbelaez	Vadim Kashikhin
Training and diagnostics	Maxim Martchevsky	Stoyan Stoynev
Instrumentation and quench protection	Emmanuele Ravaoli*	Thomas Strauss
Material studies – superconductor and structural materials properties	Ian Pog	Steve Krave



Cond Proc and R&D	Lance Cooley
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**Ravaoli left for a position at CERN; Maxim M. is leading from LBNL**

**Design Teams:**  
**16 T Dipole design:**  
 Leads: Zlobin and Sabbi  
**Utility Structure design:**  
 Lead: Mariusz Juchno

*Efforts here slowed to focus on Cos-t completion*

# The program is steadily building strong programmatic interconnections

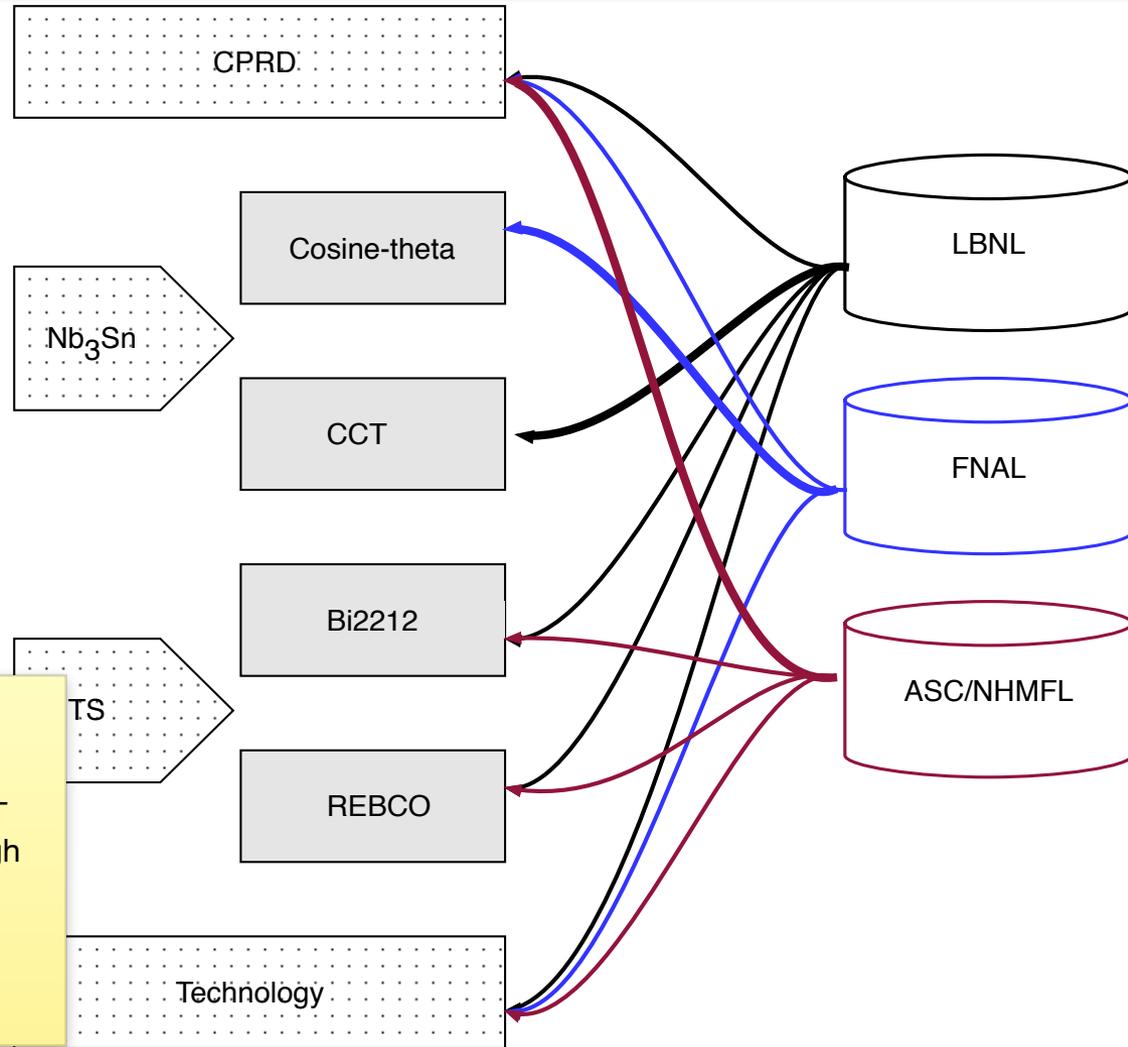
- Clear leadership roles in...

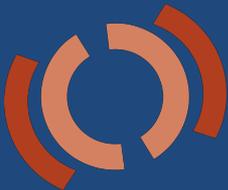
- Cosine-theta: FNAL
- CCT: LBNL
- CPRD: ASC/NHMFL

- Joint advances on HTS and Technology

- Significant interaction on all fronts

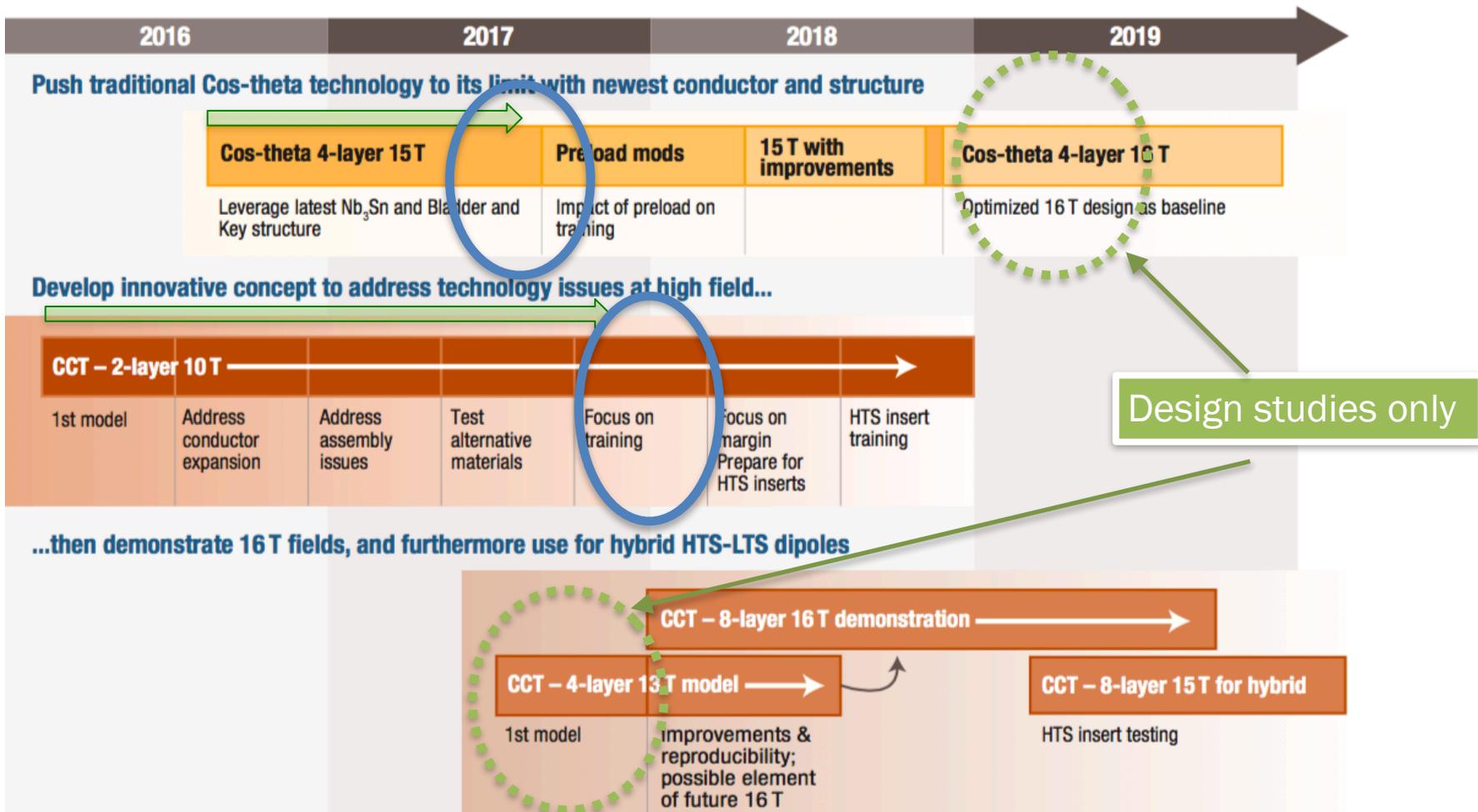
Need to add some links, eg LBNL to FNAL Cosine theta, FNAL link to CCT (subscale; dotted, as tentative through Krave)

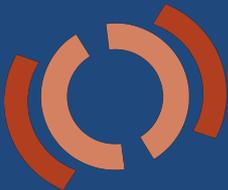




# The MDP Nb<sub>3</sub>Sn magnet efforts progressing as outlined in the MDP Plan document, ... but the plan needs updating

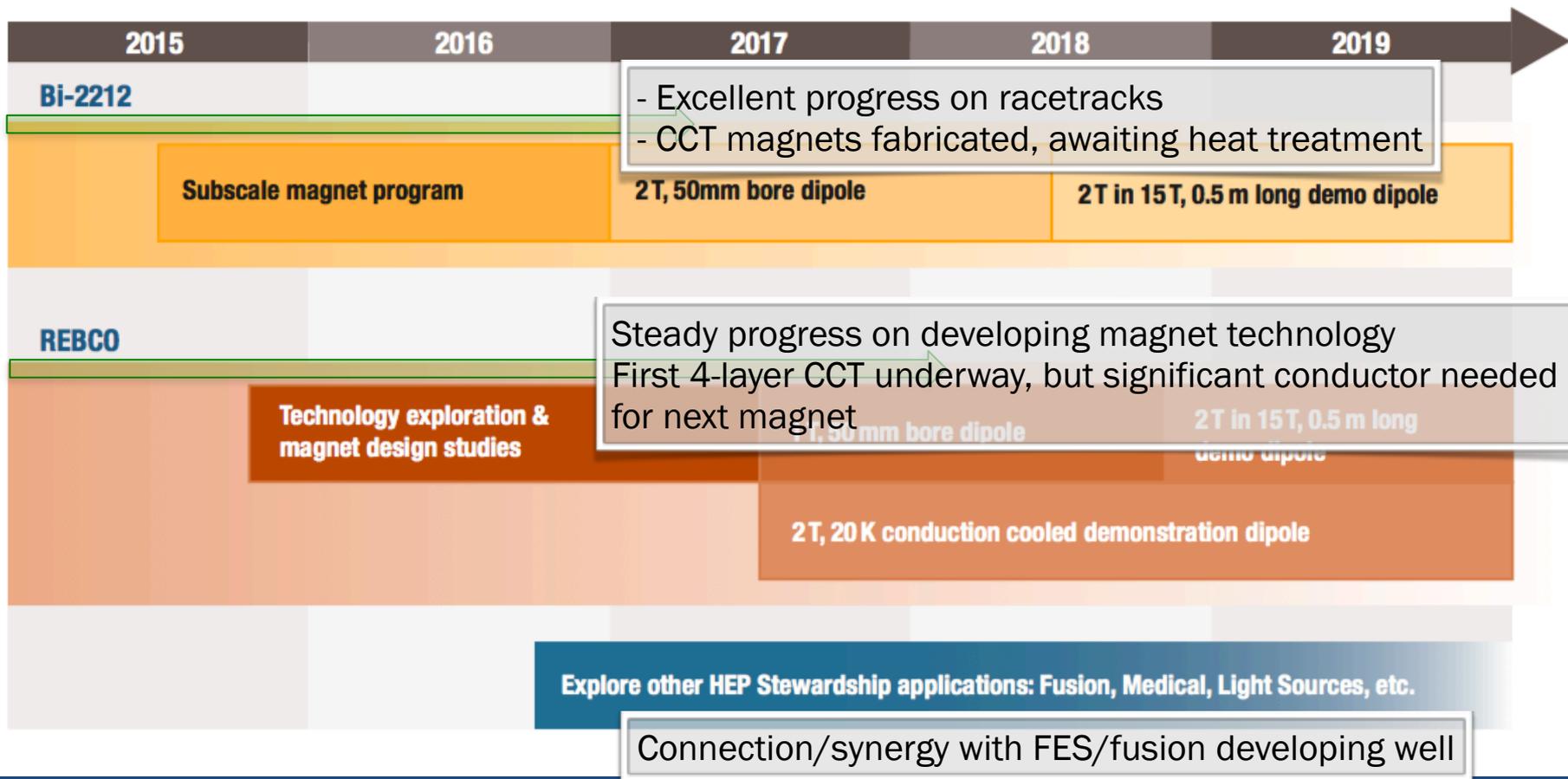
## Area I: Nb<sub>3</sub>Sn magnets

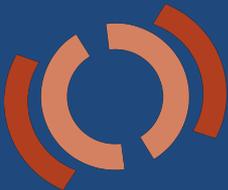




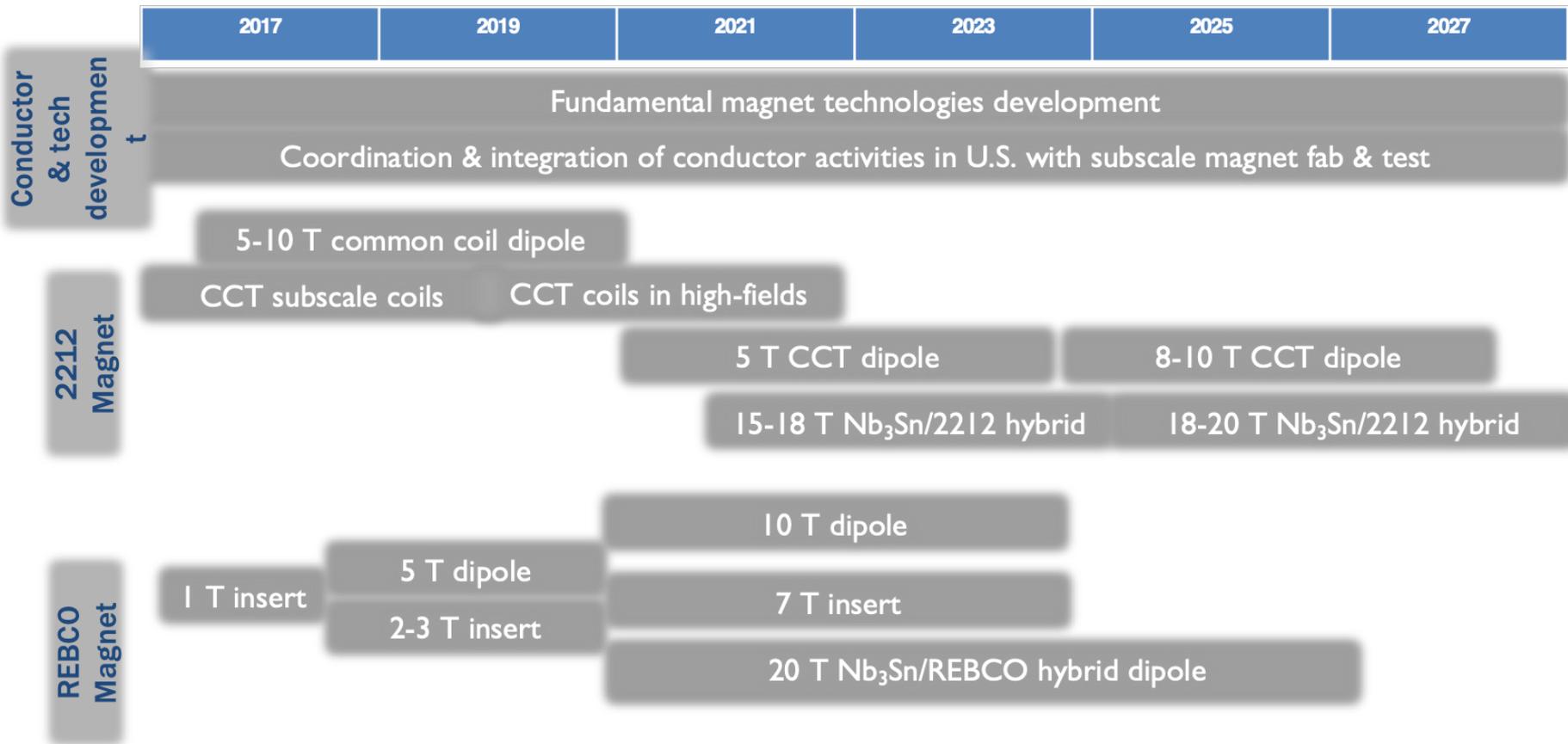
# The MDP HTS magnet development is progressing well, and the long-term vision is starting to be fleshed out

## Area II: HTS magnet technology





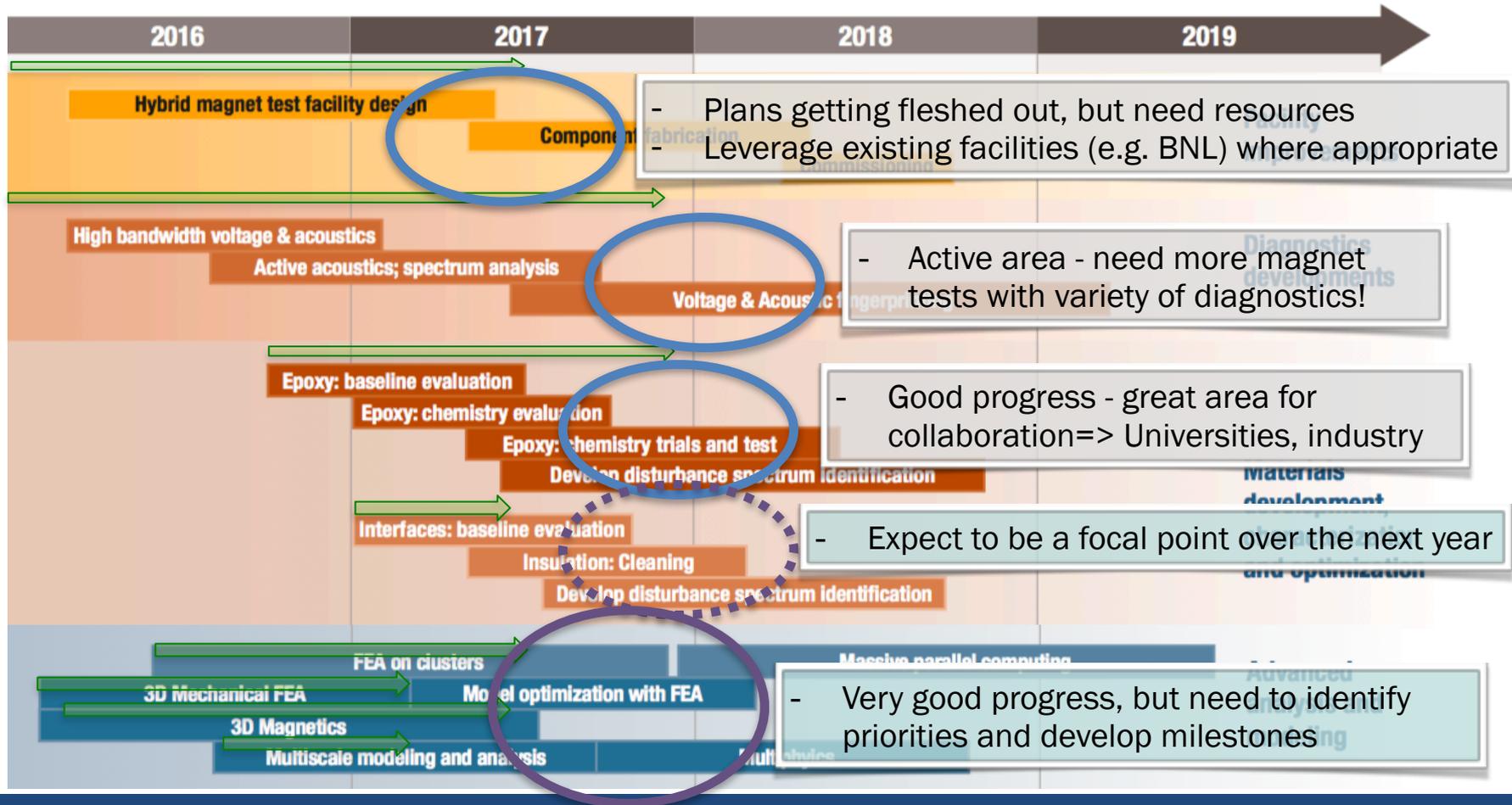
# A tentative updated 10-year HTS roadmap – two routes to 20 T dipole

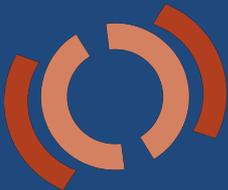




# Key science components of the MDP Plan are in the Technology Development arena

**Area III:** *The science of magnets: identifying and addressing the sources of training and magnet performance limitations via advanced diagnostics, materials development, and modeling*





# CPRD: Balanced effort of supplying sufficient conductor for magnet R&D and serving as catalyst for the next generation conductor

## Area IV:

*Continue the extremely successful paradigm of OHEP's Conductor Development Program*

The **research and development** purpose of CPRD is to anticipate future magnet development needs including both LTS and development leads magnet development by envision conductor needs 10 to 20 years out for magnets beyond the capability of Nb<sub>3</sub>Sn, liquid helium, since helium is likely to become

- Impressive recent progress on Nb<sub>3</sub>Sn
  - APC, Hf doping, high Cp,...=> significant potential worthy of investment; MDP is actively engaged with HEP and international community to find routes to get into wires
- Bi2212 wire is in procurement; should provide sufficient wire for near term program needs
  - Advances in Bi2212 powder processing + overpressure processing are being demonstrated in magnets with production length wires
- REBCO development focused on leveraging SBIR and complementary programs; MDP provides measurements and conductor performance feedback to developers and vendors
  - Procurement of conductors needed for the 6-layer magnet is under discussion



Lance Cooley, Ph.D.  
Head, Conductor Procurement and R&D Program  
US HEP Magnet Development Program  
Applied Superconductivity Center, National High Magnetic Field  
2031 E. Paul Dirac Dr, Tallahassee, FL 32310-3711 USA  
ldcooley@asc.magnet.fsu.edu

Roadmap for Conductor Procurement, Research and Development

October 6, 2017

Covering DOE FY 2018

May already need updating...!

# Issues and concerns: Technology

- Early investment in technology is beginning to pay off:
  - New diagnostics are being incorporated throughout MDP, and beyond;
  - *Need more data, and more data analysis, to understand and feedback on design => need magnet tests!*
  - Modeling developments are impacting design work throughout MDP, and beyond;
  - *Need to identify most important future needs => roadmap for developments in this arena*
- Other areas of technology that are in early development and need high priority:
  - Magnet materials, and in particular interfaces; adhesion, surface cleaning/prep, etc
  - Machine learning applied to magnet diagnostics data
- We are investing more in technology areas, and these are ripe for collaboration
  - leverage capabilities and expertise, internal “tech transfer”;
  - build next generation of scientists;
  - great area for Universities and for industrial partnerships (SBIRs?)

# Issues and concerns: Flat funding

- Programmatic funding is essentially flat for FY19
  - lack of growth means our progress further lag from the original plans
- But some one-time investments have been provided for specific critical elements (e.g. Bi2212 furnace) - *much appreciated!*

- DOE OHEP continues to pursue avenues to increase the program - this is excellent opportunity for international leadership in the field. We (MDP) need to continue to provide evidence that...
  - their investments are effective, and
  - enhanced funding would translate into faster progress

# Issues and concerns: Infrastructure

- Some investment in infrastructure is needed to allow rapid development of the technology
  - Thanks to HEP, we have support for expanded Bi2212 furnace at ASC
    - top near-term priority for ASC to get furnace upgrade in place
  - Support for test pit with larger diameter cryostat at FNAL to provide access to 1.8K testing of MDP high field magnets => under discussion with HEP (tied to FES interest...)
  - Investment in new liquifier for faster, more efficient test throughput at LBNL (benefits MDP as well as other DOE-SC programs; working with lab management)
  - Two-PS based testing capabilities for hybrid magnets (IGBT-based extraction systems, active protection circuits, etc)

- Over the last year we developed detailed plans for infrastructure upgrades:
  - clear justification for need
  - well defined scope of work
  - detailed cost and schedule
- Where appropriate, working with lab management and DOE-OHEP to identify funding source(s)

# International and industrial collaborations are underway in support of the MDP mission

- A “living” spreadsheet of collaborations is maintained by MDP to define, monitor, and communicate collaborations for HEP
  - See presentation by Steve on Friday morning
  - May also provide a mechanism to maintain a living list of MDP technical “needs” that can help outside elements (Universities, industry) align proposals with the national program

# Guidance to speakers and session moderators is designed to support goals of the collaboration meeting (*See Indico site for guidance document*)

- **Moderators and speakers for magnet sessions:**

- **Nb<sub>3</sub>Sn magnets:**

- What are the near-term needs for testing the Cos-theta magnet? Who is responsible for the magnet preparation? Who is responsible for testing? What support is needed, and who's help is requested?
- What are the scenarios for the 15T, and how do we respond to the various cases? What spares do we have, and are there investments we should make now, or plan for in the near future, to maximize the value of the 15T investment?
- What design efforts are being/should be undertaken in the near-term for Nb<sub>3</sub>Sn magnets? What are the figures-of-merit for designs? What "technology" developments/data are most valuable in developing next designs (materials properties? Modeling capabilities? Test data analysis?)
- ○ We need to plan a workshop (recommendation from the GARD comparative review) once sufficient data is obtained from the Cos-t and CCT efforts. What criteria should trigger that workshop?

- **HTS magnets:**

- What are the near-term priorities for HTS magnets: Hybrid or all-HTS? Field strength? Quench protection? Current-sharing? Degradation
- What are the conductor needs: quantity, quality/characteristics; what are priorities in terms of conductor development, and who should lead those efforts?

# Guidance to speakers and session moderators is designed to support goals of the collaboration meeting

## •Moderators of the Technology session:

- Are the current efforts in technology development properly prioritized?
- Are there clear goals for each area? Can we define specific milestones to track progress?
- What facilities are available within the MDP collaboration to make progress, and what facilities/capabilities are missing?

## •Moderators of the Superconductor session:

- Summarize the near and mid-term conductor needs for the program, based on magnet sections of the program
- Do current conductor developments have clear goals and roadmaps to achieve them?
- Are the conductor developments sufficiently supported? What additional facilities/expertise can be applied to facilitate the developments?



- We are still following the MDP roadmap, but a modified version is due in order to align with the current program vision, and with actual schedule development
- We have a fully functioning management structure
  - The MOA is signed and the first Steering Council meeting is imminent!
- We have regular management and technical staff meetings
  - Working to develop a strong team spirit
- We are balancing our efforts to maintain progress on multiple fronts within a limited budget - leveraging aligned efforts across SC in the interest of the program (SBIRs, University programs, other SC programs...)
- A coherent conductor R&D roadmap has been fleshed out, but recent developments are generating challenges and opportunities

# Backup



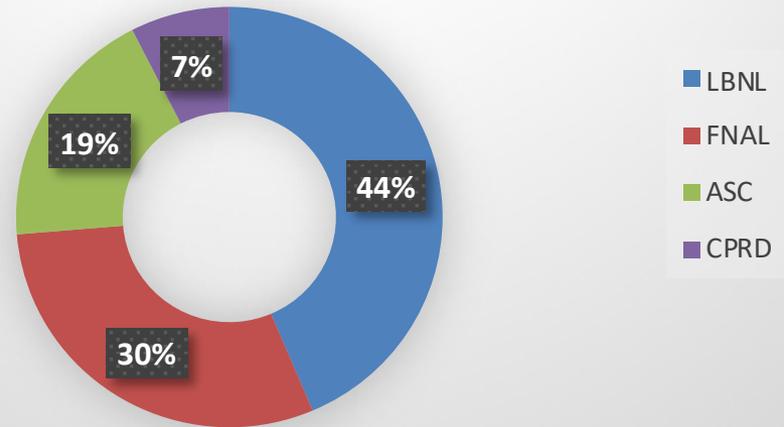
# How we addressing TAC feedback: Priorities

- ***Priorities should be owned across the program, e.g., 15T demonstrator***
  - This is still work in progress, but there is integration in diagnostics for testing, and active participation by MDP collaborators in the assembly readiness review
- ***Intermediate milestone/deliverables needed to gauge progress***
  - This collaboration meeting has been organized to strengthen this:
    - each session is tasked with identifying milestones, leads, and resources needed to accomplish them
- ***Be prepared to build more coils for 15T demonstrator***
  - Some level of spares exist, and plans to address various performance scenarios will be presented
- ***CCT concept possibly has huge potential. We encourage rapid progress.***
  - There has been good progress, but it is resource-limited. To maximize technical value the near term plan is to focus on CCT sub-scale, until the International Workshop is held to flesh out larger plans

# MDP funds distribution by collaborating institution

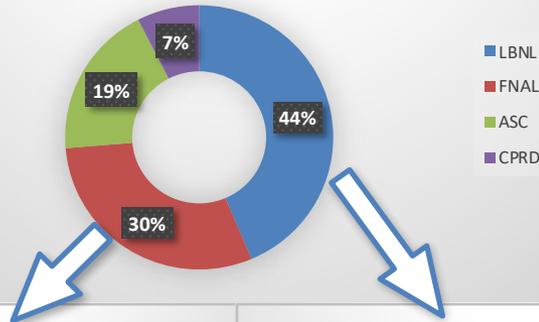
- Funds shown here are DOE-OHEP support for MDP distributed to LBNL, FNAL, and ASC/FSU
  - Other aligned university funding not shown
- CPRD funds are sent to LBNL, but “reserved” for allocation by CPRD lead

## Funds distribution among collaborators

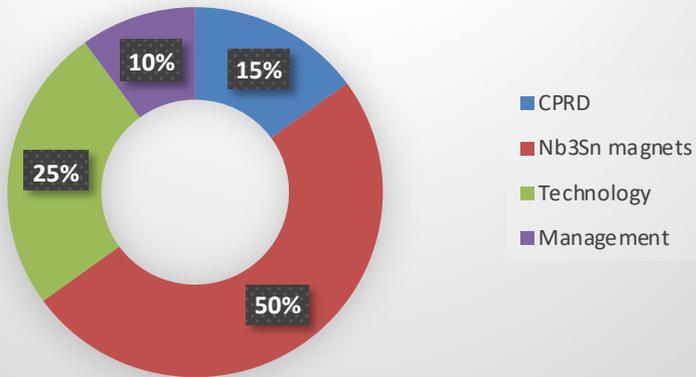


# Distribution of funds between program elements within FNAL and LBNL (2019)

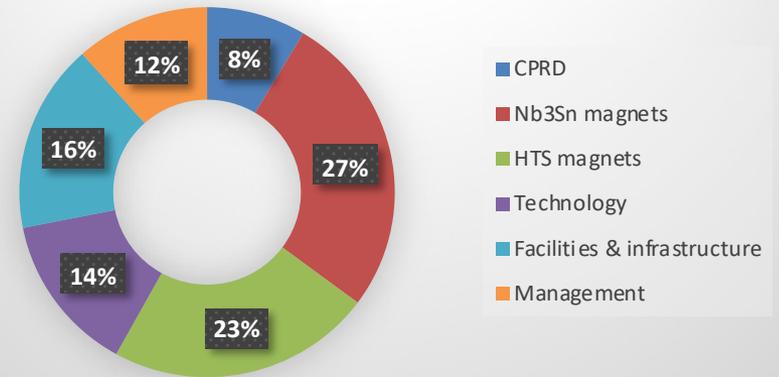
Funds distribution among collaborators



Funding distribution at FNAL



Funding distribution at LBNL



FNAL has growing effort in technology

LBNL effort distributed across program areas

# Summary of the US-MDP CM2018: Action items

- All hands on deck to bring Cosine-theta magnet to first test
  - Tight attention to detail to make sure all coils progress well, structure is fully understood before applied to coils, etc.
  - Make sure all diagnostics are thought out, proper analysis is performed in advance to fully leverage them, etc.
- Move forward with utility structure design - group effort by LBNL and FNAL
- Move rapidly on CCT5 to see impact of proposed changes on training
  - Have mini-review with CCT program review committee
  - Make critical improvements to LBNL test facility in advance of test (switch to IGBT-based switch, upgrade controls software, etc.)
  - If possible invest in improved acoustic acquisition hardware
- Flesh out, and act on, plans for Bi2212 furnace at FSU
- Move forward with Bin4&5
  - Need technician resources at LBNL
-