U.S. MAGNET DEVELOPMENT PROGRAM

Training Reduction

MDP Meeting
December 9, 2020

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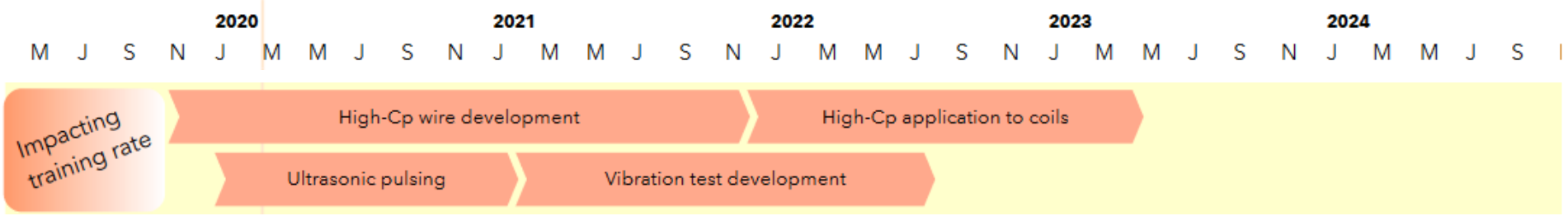
U.S. DEPARTMENT OF ENERGY | Office of Science

Official training reduction roadmap

Roadmap as in the official document:



https://science.osti.gov/hep/Community-Resources/Reports
MDP roadmap there

Training Reduction Milestones

Formally we don't have yet Milestones to report on, we'll comment on them later

Milestone #	Description	Target
AIIIe-M1	Commissioning of QCD	May 2021
AIIIe-M2	First Ultrasound based test	May 2021
AIIIe-M3	First high-Cp cable fabrication	September 2021
AIIIe-M4	First magnet test with QCD	September 2021
AIIIe-M5	Results from High-Cp cable studies	December 2021
AIIIe-M6	Optimized strand and cable FEM simulations	December 2021

Continues for next years…

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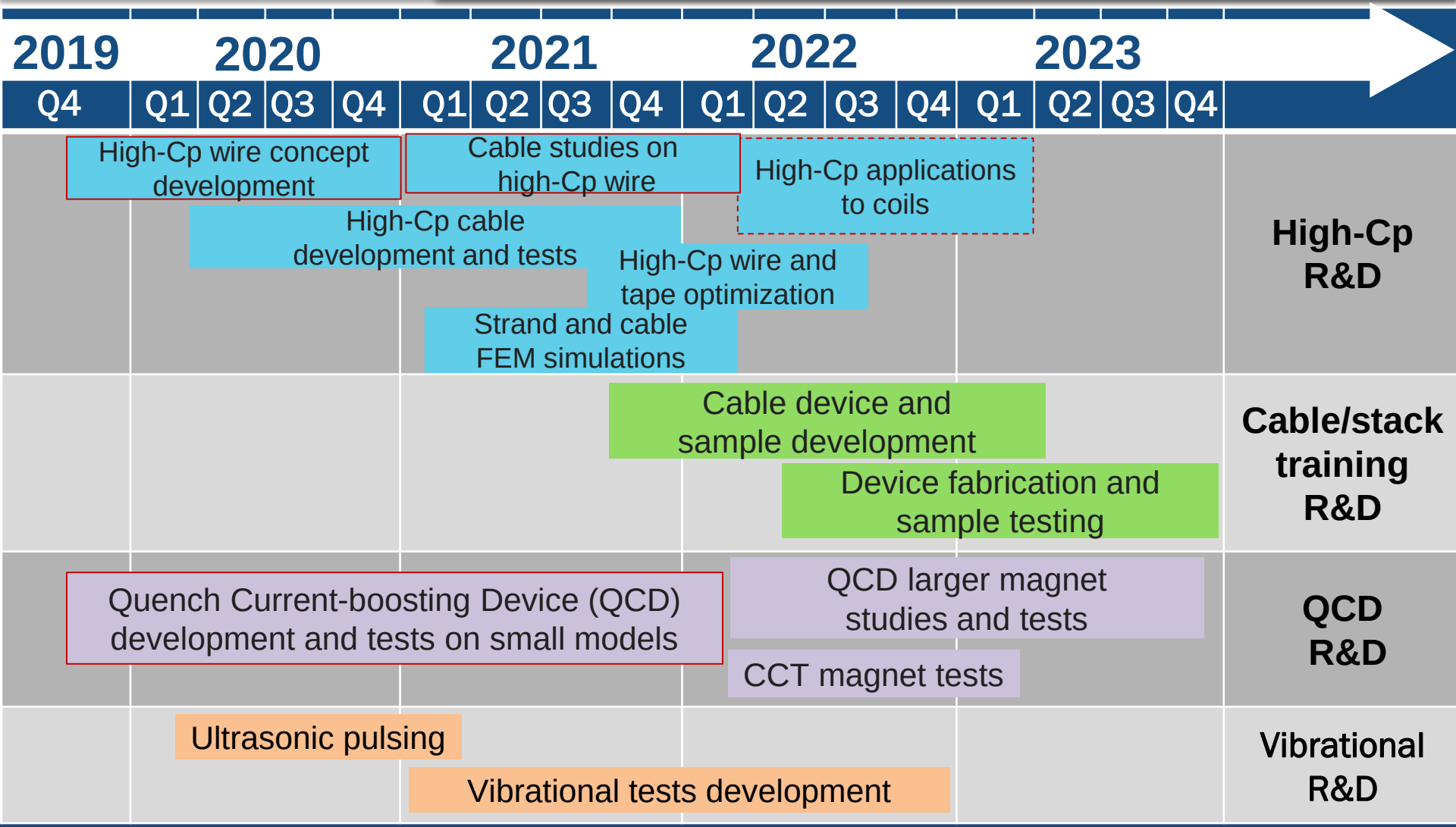
Training reduction roadmap (as presented earlier)



In red border lines – independent funding

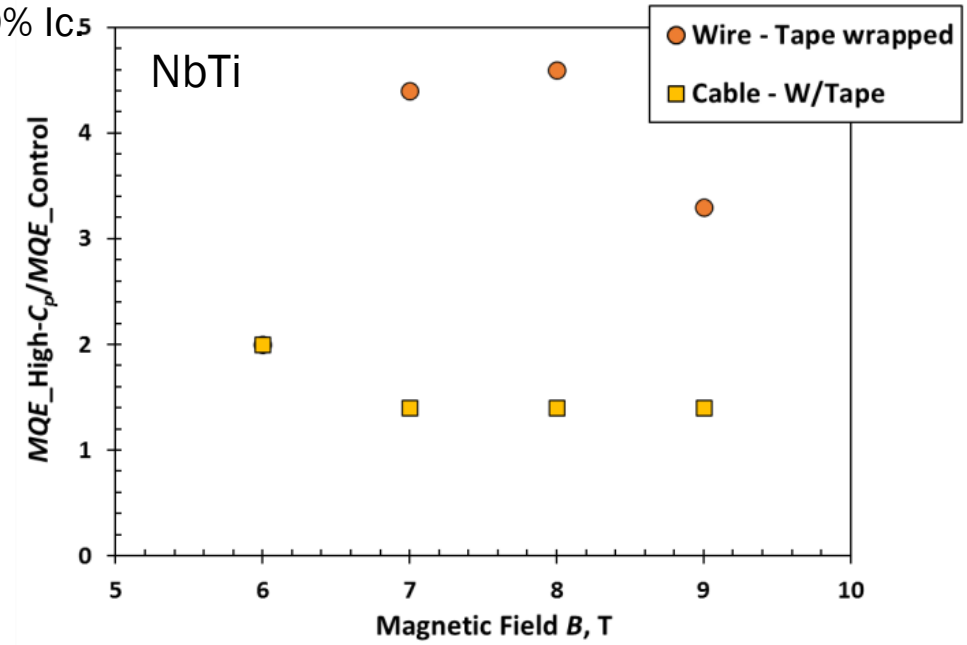
High Cp-wire studies status

- New high-Cp material Gd_2O_2S obtained
  - Supposedly much higher Cp than Gd_2O_3 which was obtained earlier
- Wires with both materials fabricated
- Steps up to and including heat treatment completed
- Further steps on hold
  - Testing has not been done yet
  - Possible schedule delay, trying to resolve the issue

High Cp-cable studies status

- Cu/Gd2O3 ribbons with ~30% of Gd2O3 powder and two different thicknesses were produced by Hyper Tech Research, Inc.
- Wire and cable samples outfitted with these high-Cp ribbons, or tapes, were prepared and tested at FNAL for the Minimum Quench Energy (MQE).

Gain values of wire wrapped with high-Cp ribbon and of cable outfitted with it as function of magnetic field for measurements performed at 90% I_c



- The NbTi cable test results with high-Cp tape on both sides compares well with the wire wrapped with the ribbon.

- Nb_3Sn cable test results with high-Cp tape on both sides will be compared with Nb_3Sn wire outfitted with tape soldered to it
- Then we can expect an MQE increase of ~50% in Nb_3Sn cable with a high-Cp tape as a core

Presented at ASC2020, sent for publication

High Cp-cable milestones

- M5 is in progress with MQE tests of wires and cables. Both NbTi and Nb3Sn used for these experiments since we are interested in relative effects of high-Cp tape. In a process of completing extensive MQE tests of a NbTi cable with distributed heat perturbation. In the plan by the deadline, tests of NbTi cable with local heat perturbation and Nb3Sn cable tests are included.
- M3 will depend on whether Hypertech will be able to produce high-Cp tape, which can be wrapped around a cable. LDRD application sent for this R&D. If we do not get it, then it will be up to MDP to fund it.
- M6: summer graduate students work was supposed to contribute to this part but with COVID19 it is not clear that we'll get any this coming summer. Still, we will try to meet the goals according to the roadmap.

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QCD

Quench Current-boosting Device is a capacitor-based device aiming to significantly increase magnet current at quench time and thus help reduce magnet training time

- After designing it, assembly work in AD continues, all main parts available
- The plan is to have the device at testing site in early January
- A work on an important digital logic card is transferred to APS-TD but still supervised by AD engineers
  - It should be completed (fabricated) by January
- Integration work to the power supply system is lead by T&I
  - Includes some upgrades (like test points) not part of the LDRD
  - Preparatory work runs in parallel to QCD
- We expect to commission the device in March 2020
- Mirror magnet (for initial QCD testing) assembly in progress
  - All parts available (except a few small steel blocks under fabrication)
  - Assembly readiness review coming in December
  - The magnet is to be assembled by March 2020 and then tested

We do have documentation delays at this point…

Milestones

- M1 and M4 are on track to be completed on-time
- M2 is delayed due to general schedule changes for superconducting magnet testing; however we plan to have it done by October in a different configuration (mirror magnet) and continue studies on the subject

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AIIIe-M5	Results from High-Cp cable studies	December 2021
AIIIe-M6	Optimized strand and cable FEM simulations	December 2021
AIIIe-M7	First CCT test with QCD	February 2022
AIIIe-M8	High-Cp wire and tape optimized versions	May 2022
AIIIe-M9	Fabrication of first coil with High-Cp conductor	September 2022
AIIIe-M10	Design of a dedicated device/technique using vibrational methods	September 2022
AIIIe-M11	Design of a "cable/stack" testing device and samples	January 2023
AIIIe-M12	QCD preparations and test on a large magnet	February 2023
AIIIe-M13	Fabrication of a "cable/stack" testing device	September 2023

It is too early to engage regarding the remaining points and no clear delays foreseen

Spare

Spare

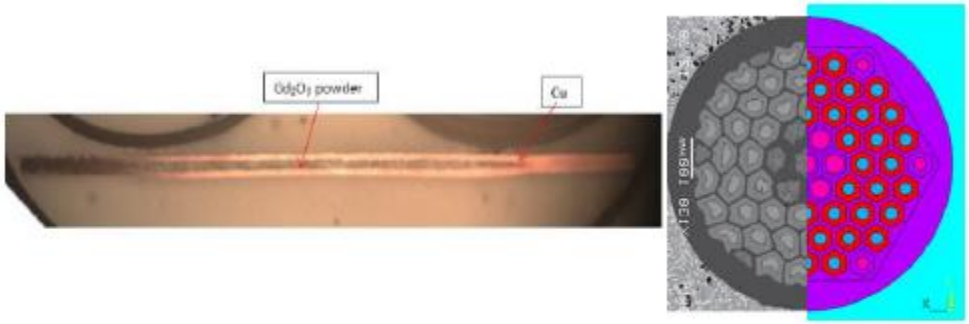

Fig. 1. Left: Cu tapes with Gd_2O_3 inside, 30% of the cross section is Gd_2O_3 (courtesy of Hypertech). Right: Hypertech Sn-in-Tube Nb_3Sn wire with 48 regular Nb-Sn subelements and 13 high-C_p ones made of Cu/Gd_2O_3.

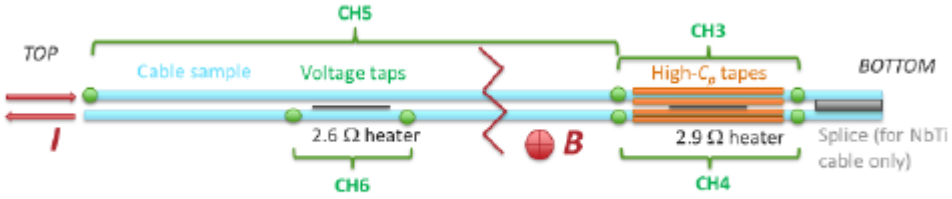

Fig. 7. Schematic of the instrumentation used for NbTi Rutherford cable tests.

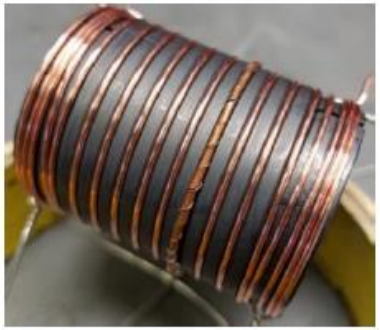

Fig. 3. Example of superconducting wire sample wrapped with Hyper Tech high-C_p tape cut down to ~1 mm width, along half a turn of the specimen.

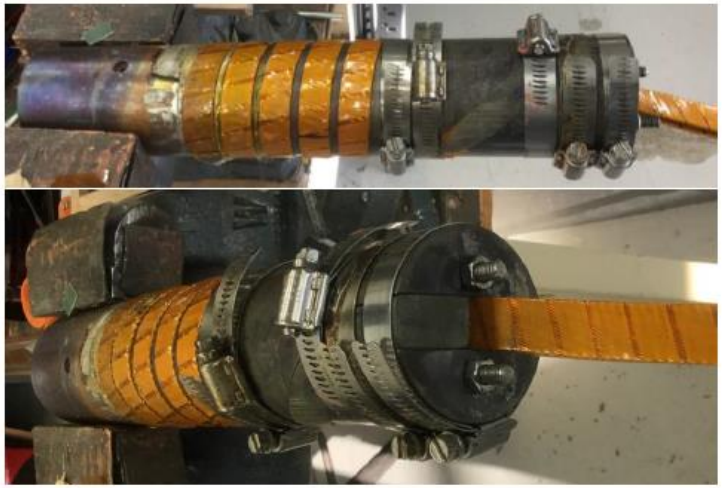

Fig. 10. NbTi cable sample assembly for *MQE* test of standard Rutherford cable and cable outfitted with high-C_p tape.

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