Technology Development

Overview and Outlook

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Outline

- R&D Goals
- Status to date
  - FY 11 Milestones *& beyond*
- Outlook

Technology Development
What it is

- Normal Conducting RF (in cooling sections)
  - MuCool program - MuCool Test Area
- Superconducting RF (in accelerators)
- Magnets
- Targets and Absorbers

Primary Goals

- Establish the viability of the concepts and components that will be used in the design reports
  - Neutrino Factory Reference Design Report (NF-RDR)
  - Muon Collider Design Feasibility Study Report (MC-DFSR)
- Establish the engineering performance parameters to be assumed in the design studies
- Provide a good basis for cost estimates.

Tech Dev Milestones

FY11	Complete engineering design for Be-wall rf cavity
	Complete engineering design for new 805 MHz pillbox
	Complete initial high power rf (HPRF) cavity beam test
	Initial analysis of target magnet specifications
	Fabricate and test small 400 Hz dipole model
FY12	Fabricate and begin testing Be-wall rf cavity
	Fabricate and test new 805 MHz pillbox
	Prepare rf test cavity with atomic layer deposition (ALD) coating
	Begin fabrication of 1.5 m 400 Hz dipole model
	Detailed analysis of target magnet specifications
	Complete conceptual design of IR quadrupole
FY13	Test 201-MHz cavity with coupling coil in MTA
	Detail design of HCC solenoid
	Complete test of 400 Hz dipole model
	Test ALD cavity
FY14	Detailed design of target solenoid
	HTS demo coil test with quench protection
FY15	Fabricate components for 6D cooling bench test
FY16	Complete components for 6D cooling bench test
	Assemble components for 6D cooling bench test
	Complete detailed design of > 30-T solenoid

RF Program

Primary Goal: *RF Down Selecting*

- Down selection of cooling RF cavities will be based on the outcome of our experimental studies.
  - The cavities must work at an acceptable RF gradient (requirements are, of course, dependent on the position along the channel, *i.e.*, phase rotation, bunching, initial cooling, final cooling, *etc*.) in a multi-Tesla magnetic field.
  - Engineering, fabrication, integration and cost of the cavity and RF power must also be considered
  - 2 Years out if we are lucky

Phase I RF Program
Status

- Complete first round of tests on Magnetic Insulation
  - Done
  - Second round with identical cavity, but with orientation E || B
- Beam tests of high pressure H_2 filled cavity
  - Beam line commissioning underway
  - First Test this month
- Retest refurbished 805 pillbox
  - Done. Unfortunately, the results were very poor. Investigating!
- Materials tests: Be
  - Button cavity test
    - Waiting on post-mortem of pillbox test
  - Be-wall cavity
    - All-seasons cavity
    - Complete new design
- Atomic Layer Deposition (ALD)
  - Button test with 805 pillbox
  - Special-purpose ALD cavity
- 201 MHz tests
  - Retest 201 with repaired couplers

RF Reports at This Meeting

- A. DeMello: 10+1 cavities for MICE under fabrication (not Tech Dev).
- D. Li: 201 and 805 MHz cavities for test; Be windows look good.
- J. Norem: RF breakdown at nanoscale mitigated by coating.
- Y. Torun: MTA operational!
- A. Tollestrup: Model of arcing in high pressure RF cavity.
- K. Yonehara: Beam test soon of high pressure RF cavity.
- A. Moretti: Box cavity test: 8% reduction in usable MV/m per deg between 3-T B field and surface.
- M. Jana: Box cavity + button test: > 50% reduction in usable MV/m when 3-T is perpendicular to surface.

Outlook:
RF Testing Queue

- Primary goal is to collect a lot more data with as many test vehicles as possible. Next 12-18 months:
  - 805 pillbox (modified & refurbished?)
    - Investigating
    - New series of materials & processing (Cu) tests with Buttons *(pending)*
  - Initial test of high power (HP) button cavity with proton beam
  - 201 MHz cavity coupler repair and re-test
  - 2nd HPRF beam test as needed
  - Rectangular box cavity with B ∥ E
  - 2nd rectangular box cavity with B ⊥ E
  - New pillbox is near ready (Muon's Inc.)
    - Can operate under pressure or vacuum
    - Has capability to replace end-walls (Be)
  - *Complete design of Be-wall cavity (maybe test in this time frame)*
  - ALD cavity
    - Special-purpose cavity for processing in-situ with Atomic Layer Deposition
  - Test MICE production 201 MHz cavity in realistic B field [> 18 months out]

Magnet R&D - Overview

- Neutrino Factory and Muon Collider accelerator complexes require magnets with quite challenging parameters
  - Target Capture Solenoid
    - What is the most effective scheme to protect the target solenoid from the radiation environment near to the target?
  - HTS solenoid R&D to assess the parameters that are likely to be achieved
    - What is the highest practical achievable solenoid field & what is the R&D required before these solenoids can be built?
  - HCC magnet R&D to assess the feasibility of this type of cooling channel and
    - Eventually build a demonstration magnet for a HCC test section (dependent on success of HP RF tests)
  - Magnet design R&D for collider ring and IR magnets that have to deal with the expected high level of energy deposition from μ decay electrons
    - What is the optimal design for the collider ring magnets that will enable them to operate in the presence of the decay electrons? Paper studies only (with D&S group)
  - Fast Ramping Magnets utilized in rapid-cycling synchrotron for final acceleration for the MC

Magnet Reports at This Meeting

- S. Virostek: MICE solenoid repair (not Tech Dev).
- K. Lee: Lithium lens simulations.
- R. Weggel: Conceptual design of 20-T target solenoid, and of open midplane dipoles for decay ring.
- R. Gupta: Vision of 20-T HTS solenoid.
- J. Tompkins: Two 4-coil segments of helical solenoid tested; YBCO coil tested in 14-T field.
- T. Shen: Round HTS conductor now to 600 A/mm^2 at 20 T and 4K.

Outlook: Magnets

- Next 12-18 months
  - HTS
    - 1st Small coil multi-element test reaches 10T
  - HCC
    - Test of 2nd R&D HCC 4-coil magnet
    - Conceptual design for HCC solenoids which meets specs
  - Accelerator
    - Conceptual designs for arc dipoles and quadrupoles
    - Conceptual design for IR quadrupole
  - RCS
    - Small prototype 400Hz dipole – fabricate and test
    - 1.5m dipole prototype – begin fabrication
  - Target Capture
    - Detailed analysis of insert and outsert solenoids; thermal, mechanical, and magnetic requirements *(maybe a bit further out than 18 months)*

Targetry

- All targetry activity now under Technology Development.
  - Design
    - Target solenoid array (Weggel)
    - Magnet and shielding layout (Graves)
  - Simulation
    - Magnetohydrodynamics of mercury jet (Samulyak)
    - Mercury flow through nozzle (Ladiende, Yan)
    - Particle production and energy deposition (Back, Ding, Souchlas (+ Hansen, Prior)
  - Engineering
  - Hardware Development

Targetry Reports at This Meeting

- R. Weggel: Conceptual design of 20-T target solenoid.
- N. Souchlas: Energy Deposition in the target system.
- R. Gupta: Vision of 20-T HTS solenoid.

Outlook: Targetry

- Revised baseline recently established
  - 20-T solenoid inner radius 120 cm, $\Rightarrow$ 3 GJ
- Emphasis on design and simulation for ≥ 6 months
  - Review choice of 20-T
  - Revise solenoid array accordingly
  - Initiate conceptual design of shield (+coolant flow).
  - Continue modeling of mercury jet: pipe flow, free jet flow, beam interaction.
- Engineering, costing for IDS RDR still several months away
  - Mercury flow loop, including collection pool
  - Beam windows
  - Tungsten carbide shield (+ water cooling)
  - 6-T room temperature copper magnet (+ services)
  - Superconducting solenoid array (+ cryo plant for ≈ 1 kW at 4K)
  - Remote handling system, hot cells
  - Civil construction
- Hardware tests of mercury jet and/or WC+water only if indicated by above

Summary

- The MAP effort in TD focuses on cooling
  - You All Know Why
- The RF program continues to take a multi-pronged attack
  - The MTA is now a smoothly running facility
    - Multi-frequency RF
    - SC magnet(s) & cryogenics infrastructure
    - Extensive RF diagnostic instrumentation
    - Clean room for RF cavity work
    - H_2 handling infrastructure
    - *p* beam line
  - However, this complexity (test area is now a "primary beam enclosure"), has added significant overhead to our operations at present
    - We are working with the Fermilab safety groups to try to make operations more efficient

Summary II

- Magnet program also focuses primarily on cooling issues
  - Final cooling via very-high-field HTS solenoids
  - HCC solenoids as potential option
- But also addresses the other critical magnet issues for the MC complex
  - Ring magnets
    - Open-plane dipoles, quads, etc
  - Acceleration
    - Fast-ramping magnets

This Year

- Well, FY11 is turning out to be a real “pleasure”
- Even with the uncertainties, we think we can
  - Complete initial suite of experiments with HPRF
  - Buttons?
  - Retest 201 MHz prototype with new couplers
  - Test new cavities
    - All seasons
    - Box with E parallel to B *(maybe)*
  - Magnets
    - HCC/HTS/ (Check with John)
    - 400 Hz prototype (Check with Don)

END