Technology Development
Overview and Outlook

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MAP Collaboration Meeting
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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 $E \parallel B$
• 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 $B \parallel E$
  – 2nd rectangular box cavity with $B \perp E$
  – 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 \( \mu \) 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/mm² 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)*
• 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.
Outlook: Targetry

• Revised baseline recently established
  – 20-T solenoid inner radius 120 cm, $\Rightarrow$ 3 GJ
• Emphasis on design and simulation for $\geq$ 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 $\approx$ 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
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