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Magnets for Muon 6D Helical Cooling Channels

Cooperative Research and Development Agreement Final Report

CRADA Number: FRA-2008-0006

Fermilab Technical Contact: Alexander Zlobin

Summary Report
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Fermi National Accelerator Laboratory / Kirk and Pine Street / P.O. Box 500 / Batavia, IL 60510 / 630.840.3000 / www.fnal.gov / fermilab@fnal.gov
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NOTICE

In accordance with Requirements set forth in Article XI.A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

CRADA number: FRA-2008-0006

CRADA Title: Magnets for Muon 6D Helical Cooling Channels

Parties to the Agreement: Muons, Inc. and Fermi Research Alliance, LLC

Abstract of CRADA work:

A helical cooling channel (HCC) consisting of a pressurized gas absorber imbedded in a magnetic channel that provides superimposed solenoidal, helical dipole, and helical quadrupole fields has shown considerable promise in providing six-dimensional cooling of muon beams. The analysis of this muon cooling technique with both analytic and simulation studies has shown significant reduction of muon phase space emittance. A particular channel that has been simulated is divided into four segments each with progressively smaller apertures and stronger fields to reduce the equilibrium emittance so that more cooling can occur. The fields in the helical channel are sufficiently large that the conductor for segments 1 and 2 can be Nb₃Sn and the conductor for segments 3 and 4 may need to be high temperature superconductor. This paper will describe the magnetic specifications for the channel and two conceptual designs on how to implement the magnetic channel.

Summary of Research Results:

In Phase I an engineering study showed the Helical Solenoid (HS) invention to be superior to the conventional approach to the HCC that would use three separate coil systems to provide the solenoid, helical dipole, and helical quadrupole fields required by the HCC. The MANX 6D muon cooling demonstration experiment, including the 4 m long cooling section and the upstream and downstream emittance matching magnets, was modeled using the HS approach in preparation for the engineering design and cost estimate needed for the MANX proposal. A correction coil invention was shown to allow larger coil radius for given HCC parameters to make room for required mechanical structures.

The Phase II program performed detailed studies of splice performance on YBCO. The 1st helical solenoid double-pancake model was fabricated and tested at both 77 K and 4.2 K successfully. The fabrication technology, including splicing and winding has been developed. The quench protection for testing at 4.2 K has been studied and developed. The model reached the reasonable performance. The YBCO tape used in the 1st model was unwound and rewound several times, and no degradation was found in the tape. The program was very successful and demonstrated a

scheme that allows YBCO to be used to generate the complicated fields needed for helical cooling channels.

Related Reports, Publications, and Presentations:

1. PAC07 paper MOPAN117
2. Final Report "Magnets for Muon 6D Helical Cooling Channels", Johnson, Rolland., Muons Inc., https://www.osti.gov/servlets/purl/1155008

Subject Inventions listing:

None

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Technical Contact at Fermilab: Alexander Zlobin

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