PROPOSAL FOR FUNDING

OF THE ATLAS MUON DETECTOR

CONSTRUCTION AT THE

UNIVERSITY OF MICHIGAN

1.0 Overview

The Large Hadron Collider (LHC) being built at the European Organization for Nuclear Research will represent the premier tool in the world for the exploration of the new frontiers in particle physics when it is completed approximately six years from now. With this facility we expect to be able to address many fundamental topics concerning the origin of particle masses and composition of matter at the sub-quark level.

Twelve members of the University of Michigan High Energy Physics program (Bob Ball, Jay Chapman, Ed Diehl, Myron Campbell, Steve Goldfarb, Dan Levin, Shawn McKee, Homer Neal, Jianming Qian, Greg Tarle', Rudi Thu, and Bing Zhou) have committed to the ATLAS and are working on various aspects of the forward muon detector development. Michigan joins the Boston Muon Collaboration and University of Washington in this effort. The Michigan work will focus on two aspects of the detector development, the construction of the largest MDT tubes and the development of front-end electronics for these and other MDT tubes of the system. Rudi Thun is directing the tube construction project, Bing Zhou the chamber production, and J. Chapman is leading the electronics development aspects of the project. Other members are engaged in computing aspects of ATLAS not covered by this proposal. Homer Neal leads these computational projects, databases, collaboratory development, and networking. J. Chapman has committed to the testing of TRT electronics, also not covered by this proposal.

For 1998 the US ATLAS collaboration has initially provided a modest $62K of ATLAS detector funds for Michigan. A second allocation of funds to Michigan in 1998 was provided as a direct contract to Michigan from Brookhaven. With this second allocation, the total provided to Michigan for 1998 was $316K. This proposal is for $715.7K and represents the first full scale operation of the detector construction program at Michigan. The bulk of these funds, $562K, are for the establishment of the production site and tooling for the construction of chambers. The electronics development part, $153.7K, is for the development of a 10K channels test of the ATLAS front-end electronics. Michigan has coordination responsibility for the 10K channels test. The Task A proposal submitted as part of the University of Michigan base program presents the specifics for these projects. The deliverables and dollar specifics are contained in the attached Amendment to the Memorandum of Understanding between US ATLAS and the University of Michigan.

2.0 MDT Chamber Construction

The University of Michigan will be responsible for the R/D, prototyping, construction and testing of the "Monitored Drift Tube (MDT)" chambers in the forward muon spectrometer listed in the table below. In total, there will be of the order of 40,000 individual drift tubes that will have to be constructed for these chambers. Our efforts will include the design, analysis, manufacture, quality assurance and quality control of the drift tubes, their spac-

ers, their alignment, chamber environmental services, their assembly into chambers, and their delivery to CERN for installation.

TABLE 1. MDT Chamber Development Items

WBS Item	Deliverable	(k$)
1.5.1.2.1.	Tube Assembly Station	$33.0
1.5.1.2.2.	Tube Test Station	$49.0
1.5.1.2.3.	Chamber Assembly Station	$300.0
1.5.1.2.4.	Chamber Test Station	$80.0
1.5.1.2.5.	Handling/Transport Fixtures	$17.0
1.5.1.2.6.	General Equipment	$23.0
1.5.1.3	MDT Prototypes	$60.0
1.5.1. Total	Chamber and Tube Construction	$562.0

The drift tube assembly station development for automatic wire stringing, tensioning and crimping, automated endplug insertion and crimping, and leak testing of the chambers is essentially complete. Tube production for module 0 has begun. Since Michigan will build some of the longest tubes and chambers of the muon system, special considerations when handling and testing these tubes. To quantify the problems and develop a suitable response to the challenge of long tubes, Michigan has completed a study of the precision of measurements with these long tubes assuming that they are constructed as straight tubes with wires that sag under gravity and recommended to the collaboration that chambers be constructed in this fashion making use of software corrections to restore the desired resolution. This simple construction approach will surely be a cost savings.

Work is well underway for the preparation of a large, high-bay assembly area at the University of Michigan where the chambers will be constructed and tested over the period 1999 - 2003.This assembly area includes a 60,000lb precision granite table in an environmentally controlled room. A significant portion of this proposal's funding will be directed to the development of this chamber assembly area. The granite table has been delivered and is in position. Module 0 is scheduled to be constructed during late 1999 and early 2000.

3.0 MDT Electronics

The MDT chambers are fitted with cards, HedgeHog Cards, that provide the chamber connections and accept daughter cards, Mezzanine Cards, that contain Amplifier-Shaper-Discriminator, ASD, circuits and Time Digitizer circuits, TDCs. The remaining element in the front-end electronics chain is the ReadOut Driver module, ROD, which connects to several Mezzanine cards and communicates to the ReadOut Buffer modules located in the data acquisition system. Members of Michigan's ATLAS team have updated the specifi-

cations of the ROD module for the ATLAS muon system. In the process we have persuaded the collaboration that a design where the ROD is split into an on-chamber portion, the Chamber Service Module (CSM), and an off-chamber portion, the Tower Summary Crate (TSC). A VerilogHDL specification of the CSM has been completed at Michigan and the first prototype (CSM-0) is being constructed for a June checkout. Simulations of the data flow through the front-end system have been performed at Michigan in order to optimize the design. This work has led to CSM specifications that can be synthesized into FPGA directly from the code used in the simulations. We are constructing the CSM-0 from these synthesized FPGAs. The TSC will next be specified in VerilogHDL with the intent that the design will evolve from simulations done for the data-flow studies.

TABLE 2. Deliverables for MDT Electronics

WBS Item	Deliverable	(k$)
1.5.3.1.2.	**MiniDaQ readout of ASD/TDC**	**$68.9**
1.5.3.1.4.	**Test Station/PC/Crate/PS/Instrum**	**$64.8**
1.5.3.2.	**Prototype Electronics**	**$20.0**
1.5.3. Total	**Front-end Electronics for 10K Test**	**$153.7**

3.1 Concluding Remarks

The University of Michigan High Energy program is has established a significant role in the CERN ATLAS experiment. We have developed one of the 3 sites for forward muon chamber construction and are rapidly approaching parity with the other sites begun years earlier. We have accepted the coordination responsibility for development of the 10K channels development of the ATLAS muon front-end electronics and plan to send the first readout module, the CSM-0, to the test beam at CERN in August 1999 and to supply copies of this module to the construction sites for chamber testing. With the addition of several new Michigan scientists, the ATLAS effort at Michigan has become a major contributor to US ATLAS.