

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 five 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 Consortium 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.

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. The third allocation of funds for 1999 totaled to \$715.7K and represented the first full scale operation of the detector construction program at Michigan. This proposal is for continuation of the construction of chambers and for the continued development of readout electronics for the 10K channels 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 ATLAS MDT construction task at UM

The University of Michigan will be responsible for the R/D, prototyping, construction and testing of 104 "Monitored Drift Tube (MDT)" chambers in the forward muon spectrometer (chambers EMS4, EMS5, EML1, EML3, EML4, EML5, EEL2). These 104 chambers require the construction of more than 40,000 drift tubes over the next 4 years. Our efforts include the design, analysis, manufacture, quality assurance and quality control of the drift tubes, their assembly and alignment in chambers, and chamber environmental services, quality assurance, as well as delivery to CERN for installation.

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The drift tube assembly station for automatic wire stringing, tensioning and crimping, endplug insertion and crimping, tube length measurement, wire tension measurement, leak testing, wire position measurement, and dark current testing is complete. This station has already been used for the production and testing of 400 tubes for module 0 (EMS5 chamber).

The chamber assembly station consisting of 21' granite table with 20 microns flatness in a temperature/humidity-controlled room, with overhead crane, and high capacity vacuum system has been completed. Tooling for chamber assembly (combs, stiffback, sphere blocks, spacer frames assembly table, glue machine) is undergoing final assembly and setup.

We are planning for a May 1 site review by the ATLAS muon management to approve our production site. We will assemble module 0 during May, 2000, and then move directly into series chamber production. We expect to produce 10 chambers during 2000.

In addition to the ATLAS project FY00 funds (total \$517.5) requested in the table below (ref. MoU 2000 between UM and BNL), the US ATLAS project management has also approved \$85,000 per year from the DoE ATLAS funds for the support for David Kouba, a senior technician, who will be responsible for chamber production. The total project funds for Michigan in FY2000 is \$602.5k.

TABLE 1. MDT Chamber Development Items

WBS Item	Deliverable	(k\$)
1.5.1.1.3.5	UM MDT chambers Mechanical Design	\$18.7
1.5.1.2.1.3	UM Tube Assembly Station	\$13.5
1.5.1.2.2.3	UM Tube Test Station	\$15.0
1.5.1.2.3.3	UM Chamber Assembly Station	\$50.0
1.5.1.2.4.3	UM Chamber Test Station	\$46.0
1.5.1.3.3	UM MDT Prototypes	\$54.7
1.5.1.4.1.3	UM Tube Production (EMS5)	\$130.0
1.5.1.4.2.8	EMS5 Chamber Assembly	\$121.1
1.5.3.1.2.2	Off Chamber Architecture	\$68.5
Total	Chamber and Tube Construction	\$517.5

3.0 MDT Electronics

The MDT chambers will be 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 on-chamber element in the front-end electronics chain is the Chamber Service Module, CSM, which connects to as many as 18 Mezzanine cards and communicates to the Tower Summary Crate, TSC, located in the Underground Service Area, USA-15 where personnel can be present during running. Members of Michigan's ATLAS team have updated the specifications for the readout sequence of the ATLAS muon system. A VerilogHDL specifica-

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tion of the CSM has been completed at Michigan and the first prototype, called the CSM-0, has been fabricated and bench tested. In the upcoming months the prototype will be further tested and 25 Revision B copies made for use at the various chamber construction sites. A special version of the FPGA code is being developed for the CSM-0 to permit it to

TABLE 2. Deliverables for MDT Electronics (duplicated in Table 1)

WBS Item	Deliverable	(k\$)
1.5.3.1.2.	CSM-0 readout of ASD/TDC	\$68.5
1.5.3. Total	Front-end Electronics for 10K Test	\$68.5

do tomographic x-ray histogramming at the CERN chamber testing facility. Operation of the CSM-0 at the CERN test beam is also anticipated during the Fall of 2000.

3.1 Concluding Remarks

The University of Michigan High Energy program 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 of the ATLAS muon front-end electronics and have designed the readout module, the CSM-0, for chamber certification and for use at the CERN test beam. We anticipate providing copies of this module to the construction sites for chamber testing in Summer 2000. Michigan scientists have become major contributors to US ATLAS.

Organization/Task	Person Months			Funds	Funds
Principal Investigator	Calendar	Academic	Summer	Requested	Granted
A. Senior Personnel					
1. Robert Ball	4			\$22,000	
2. Pietro Binchi	5			\$14,583	
3.				\$0	
4.				\$0	
5.				\$0	
6 () List on Budget Explanation Page					
7 () Total Senior Personnel				\$36,583	
B. Other Personel (Show Numbers in Brackets)					
1. () Post Doctoral Associates					
2. () Others (Technicians/Programmers)					
3. () Graduate Students					
4. (1) Undergraduates (12% 9mo. 100% 2.5mo.)		1.1	2.5	\$4,654	
5. () Secretarial - Clerical					
6. () Other					
Total Salaries and Wages (A + B)				\$41,237	
C. Fringe Benefits (If charged as direct costs)				\$11,546	
Total Salaries, Wages, and Fringe Benefits (A + B + C)				\$52,784	
D. Permanent Equipment (List Items and Amount for Each)					
Total Permanent Equipment				\$0	
E. Travel 1. Domestic				\$1,200	
2. Foreign					
Total Travel				\$1,200	
F. Trainee/Participant Costs					
1. Stipends					
2. Tuition and Fees					
3. Trainee Travel					
4. Other					
Total Participants () Total Costs				\$0	
G. Other Direct Costs					
1. Materials and Supplies				\$381	
2. Publication Costs/Documentation/Dissemination					
3. Consultation Services					
4. Computer Services (Misc computer parts)					
5. Subcontracts					
6. Other					
Total Other Direct Costs				\$381	
H. Total Direct Costs (A through G)				\$54,365	
I. Indirect Costs (\$54,682 x 0.26)					
Total Indirect Costs				\$14,135	
J. Total Direct and Indirect Costs (H + I)				\$68,500	
K. Residual Funds					
L. Amount of this Request (J-K)				\$68,500	

Organization/Task					
Principal Investigator	Person Months			Funds	Funds
A. Senior Personnel	Calendar	Academic	Summer	Requested	Granted
1.					
2.					
3.					
4.					
5.					
6 () List on Budget Explanation Page					
7 () Total Senior Personnel				\$0	
B. Other Personnel (Show Numbers in Brackets)					
1. () Post Doctoral Associates					
2. (4) Others (Technicians/Programmers)	48			\$238,906.50	
3. () Graduate Students					
4. (3) Undergraduates	4			\$15,000	
5. () Secretarial - Clerical					
6. () Other					
Total Salaries and Wages (A + B)				\$253,907	
C. Fringe Benefits (If charged as direct costs)				\$71,094	
Total Salaries, Wages, and Fringe Benefits (A + B + C)				\$325,000	
D. Permanent Equipment (List Items and Amount for Each)					
Tube Assembly Station				\$13,500	
Tube Test Station				\$15,000	
Chamber Assembly Station				\$50,000	
Chamber Test Station				\$46,000	
Total Permanent Equipment				\$124,500	
E. Travel 1. Domestic					
2. Foreign					
Total Travel				\$0	
F. Trainee/Participant Costs					
1. Stipends					
2. Tuition and Fees					
3. Trainee Travel					
4. Other					
Total Participants () Total Costs				\$0	
G. Other Direct Costs					
1. Materials and Supplies					
2. Publication Costs/Documentation/Dissemination					
3. Consultation Services					
4. Computer Services					
5. Subcontracts					
6. Other (Machine Shop 15 month X \$4160/month)					
Total Other Direct Costs				\$0	
H. Total Direct Costs (A through G)				\$449,500	
I. Indirect Costs (Specify Rate and Base)	(26% X \$324653)				
Total Indirect Costs				\$84,500	
J. Total Direct and Indirect Costs (H + I)				\$534,000	
K. Residual Funds					
L. Amount of this Request (J-K)				\$534,000	