Budget Summary

1 Personnel

Successful integration of WestGrid as a D0 regional analysis centre will necessarily include software development and management contributions from the Canadian group. Development of tools to simplify and promote use of analysis CPU and storage at remote sites will be essential for the experiment to reach its physics goals. In order to best utilize the FNAL-resident expertise in D0 data handling and grid computing it is highly desireable to deploy a Canadian RA at the laboratory. This RA would then additionally serve as a liason between to onsite and offsite members of our group and will be in a better position to cover some of the routine service tasks required by the experiment (eg. taking a higher shift load than offsite members). We therefore request one RA posted at Fermilab for the duration of their employment. The employment is assumed to begin in September 2003. The RA must receive a cost-of-living allowance to accomodate the exchange rate. The "going rate" for an RA at Fermilab is approximately 40000 USD. We therefore assume a base salary of 45000CDN plus a COLA of 15000CDN.

D0 is a running experiment with tremendous physics potential. It is an excellent environment in which to train graduate students. In the first year we would like to add 2 graduate students to our group. They are assumed to start in September 2003.

Since our proposal involves intensive computing activity at SFU and TRIUMF we envision many exciting HEP software and computing projects for summer students. We have requested one student per summer beginning in the summer of 2004.

2 Travel

Shift requirements in the D0 collaboration are institute-based and are calculated using the number of institute members listed on the D0 masthead (not the authorship list). These requirements are re-assessed every six months. Based on the last 6 months our requirements would be 8 shifts per offsite member, 10 shifts per onsite member during a 6 month period. Our travel budget accounts for trips to cover these shift-taking periods. In addition there are appoximately 3 specially designated collaboration meetings per year which all collaborators should attend. The shift requirements plus collaboration meeting allocation is the minimum travel requirement that could be forseen. The experiment has "on-weeks" every second week including a full slate of meetings which take place from Wednesday to Friday afternoon. Nearly all of these meetings are videoconferenced and we have assumed that we will attend most of them by video only.

We plan on sending graduate students who have completed at least one year of study to Fermilab for the summer (3 months). This will give them better access to local experts in both their physics analysis and their service contribution to the experiment. It also allows them to make contacts which will serve them well upon return to SFU and remote analysis. Finally, it allows them to gain experience "close to the detector" including shift work, maintenance, cabling, etc.

Our RA posted at Fermilab has been allocated 2 trips to SFU per year.

3 Budget Tables

Simon Fraser University								
D0 OPERATING GRANT REQUEST								
TRAVEL: Rates and Trip costs								
Assumed US exchange=1.55CDN								
Travel to FNAL				3 months	1 month	3 weeks	2 weeks	1 week
Per diem (FNAL)	$62		airfare	$750	$750	$750	$750	$750
Hotel per day (FNAL)	$78		per diem		$1,736	$1,302	$868	$434
Car per day (FNAL)	$78		hotel		$2,170	$1,628	$1,085	$543
COLA/month (long stays)	$1,250		car		$2,170	$1,628	$1,085	$543
			COLA	$3,750				
			total	$4,500	$6,826	$5,307	$3,788	$2,269
Conferences in Canada	$1,700							
Conferences abroad	$3,000							
Travel from FNAL to SFU (RA)				1 week				
Per diem	$40		airfare	$750.00				
Hotel	$75		per diem	$280.00				
			hotel	$525.00				
			total	$1,555.00				

traveldetails

Simon Fraser University											
D0 OPERATING GRANT REQUEST											
TRAVEL Details of individual travel											
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Trip**		**Trips/year**			
	2001-02	**2002-03**	**2003-04**	**2004-05**	**2005-06**	**Cost**	**0**	**1**	**2**	**3**	**4**
a) Conferences											
Mike Vetterli (on ATLAS)											
In Canada	$0	$0	$0	$0	$0	$1,700	0	0	0	0	0
Abroad	$0	$0	$0	$0	$0	$3,000	0	0	0	0	0
Mike Vetterli	$0	$0	$0	$0	$0						
Dugan O'Neil (on D0)											
In Canada	$0	$0	$1,700	$1,700	$1,700	$1,700	0	0	1	1	1
Abroad	$0	$0	$3,000	$3,000	$3,000	$3,000	0	0	1	1	1
Dugan O'Neil	$0	$0	$4,700	$4,700	$4,700						
SFU Post-doc											
In Canada	$0	$0	$0	$1,700	$1,700	$1,700	0	0	0	1	1
Abroad	$0	$0	$0	$3,000	$3,000	$3,000	0	0	0	1	1
SFU Post-doc	$0	$0	$0	$4,700	$4,700						
Grad students											
In Canada	$0	$0	$0	$3,400	$5,100	$1,700	0	0	0	2	3
Abroad	$0	$0	$0	$0	$0	$3,000	0	0	0	0	0
Grad Students	$0	$0	$0	$3,400	$5,100						
b) Field work											
Detector shifts (1wks)	$0	$0	$6,807	$6,807	$6,807	$2,269	0	0	3	3	3
Dugan O'Neil	$0	$0	$6,807	$6,807	$6,807						
Detector shifts (1wks)	$0	$0	$4,538	$6,807	$6,807	$2,269	0	0	2	3	3
Mike Vetterli	$0	$0	$4,538	$6,807	$6,807						
Summer at FNAL (3 months)	$0	$0	$0	$4,500	$4,500	$4,500	0	0	0	1	1
Student 1 (TBA)	$0	$0	$0	$4,500	$4,500						
Summer at FNAL (3 months)	$0	$0	$0	$4,500	$4,500	$4,500	0	0	0	1	1
Student 2 (TBA)	$0	$0	$0	$4,500	$4,500						
Summer at FNAL (3 months)	$0	$0	$0	$0	$4,500	$4,500	0	0	0	0	1
Student 3 (TBA)	$0	$0	$0	$0	$4,500						
c) Consultation with others											
Collaboration Meetings (1wk)	$0	$0	$6,807	$6,807	$6,807	$2,269	0	0	3	3	3
Dugan O'Neil	$0	$0	$6,807	$6,807	$6,807						
Collaboration Meetings (1wk)	$0	$0	$4,538	$4,538	$4,538	$2,269	0	0	2	2	2
Mike Vetterli	$0	$0	$4,538	$4,538	$4,538						
Visit to SFU (1 wk)	$0	$0	$3,110	$3,110	$3,110	$1,555	0	0	2	2	2
SFU Post-doc (TBA)	$0	$0	$3,110	$3,110	$3,110						
Collaboration Meetings (1wk)	$0	$0	$2,269	$4,538	$4,538	$2,269	0	0	1	2	2
Student 1 (TBA)	$0	$0	$2,269	$4,538	$4,538						
Collaboration Meetings (1wk)	$0	$0	$2,269	$4,538	$4,538	$2,269	0	0	1	2	2
Student 2 (TBA)	$0	$0	$2,269	$4,538	$4,538						
Collaboration Meetings (1wk)	$0	$0	$0	$0	$4,538	$2,269	0	0	0	0	2
Student 3 (TBA)	$0	$0	$0	$0	$4,538						
d) User workshops											

SIMON FRASER UNIVERSITY						
D0 OPERATING GRANT REQUEST						
TRAVEL						
	Note	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
	No.	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**
a) Conferences						
Dugan O'Neil				$4,700	$4,700	$4,700
Mike Vetterli						
SFU Post-doc					$4,700	$4,700
Grad Students					$3,400	$5,100
				$4,700	**$12,800**	**$14,500**
b) Field work						
Dugan O'Neil				$6,807	$6,807	$6,807
Mike Vetterli				$4,538	$6,807	$6,807
Student 1 (TBA)					$4,500	$4,500
Student 2 (TBA)					$4,500	$4,500
Student 3 (TBA)						$4,500
subtotal				**$11,345**	**$22,614**	**$27,114**
c) Consultation with others						
Dugan O'Neil				$6,807	$6,807	$6,807
Mike Vetterli				$4,538	$4,538	$4,538
SFU Post-doc (TBA)				$3,110	$3,110	$3,110
Student 1 (TBA)				$2,269	$4,538	$4,538
Student 2 (TBA)				$2,269	$4,538	$4,538
Student 3 (TBA)						$4,538
subtotal				**$18,993**	**$23,531**	**$28,069**
d) User workshops						
subtotal						
TOTAL				**$35,038**	**$58,945**	**$69,683**

SIMON FRASER UNIVERSITY						
D0 OPERATING GRANT REQUEST						
OPERATING						
	Note	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
	No.	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**2005-06**
Salaries and benefits						
a) Graduate students						
student 1 (TBA)				$11,000	$16,500	$16,500
student 2 (TBA)				$11,000	$16,500	$16,500
student 3 (TBA)						$16,500
subtotal				**$22,000**	**$33,000**	**$49,500**
b) Postdoctoral fellows						
R.A. (TBA)				$42,400	$63,600	$63,600
				$42,400	**$63,600**	**$63,600**
c) Technical/professional Assistant						
subtotal						
d) Other						
Summer student					$5,000	$5,000
subtotal					**$5,000**	**$5,000**
Subtotal				**$64,400**	**$101,600**	**$118,100**
Equipment or facility						
a) Purchase, rental, or user fees						
X-term/PC for students / RA				$7,500		$2,500
subtotal				**$7,500**		**$2,500**
b) Operation and maintenance costs						
subtotal						
Subtotal				**$7,500**		**$2,500**
Material and supplies						
Telephone, fax, courier, etc.				$5,000	$5,000	$5,000
Subtotal				**$5,000**	**$5,000**	**$5,000**

Simon Fraser University					
D0 OPERATING GRANT REQUEST					
PROPOSED EXPENDITURES FOR DIRECT COSTS OF RESEARCH					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
	2001-02	**2002-03**	**2003-04**	**2004-05**	**2005-06**
1) Salaries and benefits					
a) Graduate students			$22,000	$33,000	$49,500
b) Postdoctoral fellows			$42,400	$63,600	$63,600
c) Technical/professional assistants					
d) Other (summer students)				$5,000	$5,000
2) Equipment or facility					
a) Purchase, rental, or user fees			$7,500		$2,500
3) Material and supplies			$5,000	$5,000	$5,000
4) Travel					
a) Conferences			$4,700	$12,800	$14,500
b) Field work			$11,345	$22,614	$27,114
c) Consultation with others			$18,993	$23,531	$28,069
5) Dissemination costs					
a) Publication costs					
b) User workshops					
Total proposed expenditures			$111,938	$165,545	$195,283
Total cash support from industry					
Total cash support from University					
Total amount requested from NSERC			**$111,938**	**$165,545**	**$195,283**

Form 101 - Part II

4 The D0 Experiment

4.1 Introduction

The D0 collaboration consists of approximately 650 people from more than 70 institutions in 18 countries. The collaboration operates one of two general purpose experiments at the Tevatron accelerator at the Fermi National Accelerator Laboratory (Fermilab). The Tevatron is the world's highest energy collider producing proton-antiproton collisions at 1.96 TeV centre-of-mass energy.

The D0 experiment is currently operating in a data-taking period known as Run II. Previously (1992-1996) the data-taking period known as Run I provided many important physics results including the co-discovery of the top quark in 1995. For Run II both the accelerator and the D0 detector have undergone significant upgrades in order to extend the reach of the physics programme. The upgrades to the energy and the luminosity of the accelerator were accompanied by upgraded tracking, trigger and readout electronics at D0.

The D0 detector is a 4π device consisting of a silicon microstrip tracker and central fibre tracker in a 2 Tesla magnetic field, a Uranium-liquid argon calorimeter and a stand-alone muon system using a 1.9 Tesla toroidal field. The experiment has long been noted for its excellent Liquid Argon calorimetry. During Run II magnetic inner tracking and silicon-based vertex detection have been added to significantly improve the capabilities of the detector.

4.2 The D0 Physics Programme

The D0 physics programme is broad and varied. It includes the search for the Standard Model Higgs boson, the search for physics beyond the Standard Model, the measurement of the properties of the top quark, electroweak physics, QCD studies and B physics.

Understanding the origin of mass is one of the central quests in modern particle physics. Much of the experimental effort focuses on the search for the Higgs boson. The Standard Model Higgs boson has been excluded in a mass range up to approximately 115 GeV by direct searches at the Large Electron Positron collider (LEP). The Tevatron experiments provide the only opportunity to search for higher mass Higgs bosons before the commissioning of the Large Hadron Collider in 2007. The data set collected in Run II should allow the discovery (5σ) of the Higgs boson slightly beyond the current 115 GeV limit. If it is not there it should be possible to raise the exclusion limit to about 180 GeV (at 95% confidence) using this data set. Figure 1 shows the Higgs discovery potential using Tevatron Run II data as a function of luminosity. The Run IIa data taking period is defined by the collection of 2fb^{-1} of integrated luminosity per experiment at 1.96 TeV centre-of-mass energy. The target integrated luminosity for the Run II programme including Run IIb is 15fb^{-1} per experiment.

One of the great strengths of a general-purpose detector at a hadron collider is the ability to search for the unexpected. D0 is very active in searching for evidence of supersymmetry, large extra dimensions, leptoquarks and other sources of physics beyond the Standard Model. In addition D0 has pioneered techniques to search for new physics in a model-independent way. These techniques are being applied to our new data sets.

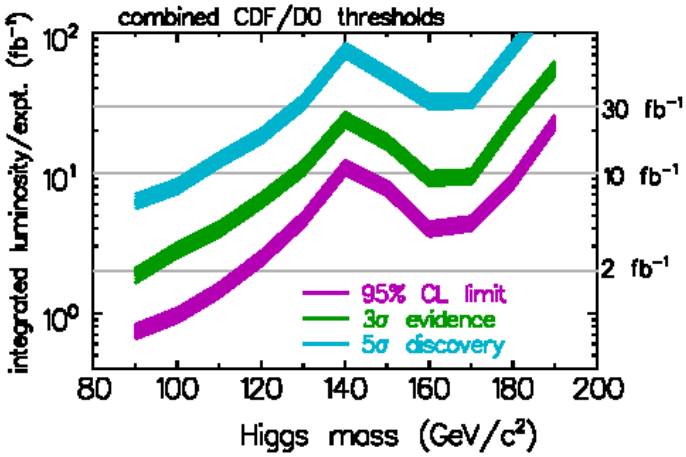

Figure 1: Higgs discovery potential during Run II at the Tevatron. The lowest (purple) line represents the 95% confidence exclusion limit. The middle (green) line represents the 3σ discovery threshold. The top (blue) line is the 5σ discovery threshold. The total integrated luminosity per experiment expected in Run II is approximately 15fb^{-1}. Taken from hep-ph/0010338: Report of the Tevatron Higgs Working Group.

The greatest accomplishment of the previous Tevatron run (Run I) was the discovery of the top quark. The utility of the Run I data set was limited by the small sample of top quark events available. The increase in accelerator centre-of-mass energy in Run II leads to a nearly 40% increase in top production cross-section over Run I. The integrated luminosity during the first phase of Run II (Run IIa) will be approximately a factor of 20 larger than that of Run I. The upgraded D0 detector is also capable of making better use of the top data taken during Run II with a greatly improved b-tagging ability. These factors combined lead to expected improvements in our knowledge of the top quark mass, cross-section, $t\bar{t}$ spin correlation, W helicity from top decay, and Electroweak top production. One of the highest priority physics goals for Run II is the measurement of the properties of the top quark. Detailed measurements of these properties, which can only be done at Tevatron experiments, have a direct impact on our understanding of the Standard Model(SM). As an example, constraints on the SM Higgs boson mass are strongly dependent on precision measurement of the top mass as shown in Figure 2.

D0 has a very active programme of Standard Model physics in addition to the measurements of top quark properties. This includes studies of the properties of Ws and Zs, B physics, and QCD studies at the highest available energies.

5 Canadian Contribution to D0

5.1 Ongoing Work

While there is currently no official Canadian presence in the D0 collaboration, D. O'Neil has been a member of the collaboration for 3 years while employed by Michigan State University. During this time he has been heavily involved in trigger software, offline computing and data

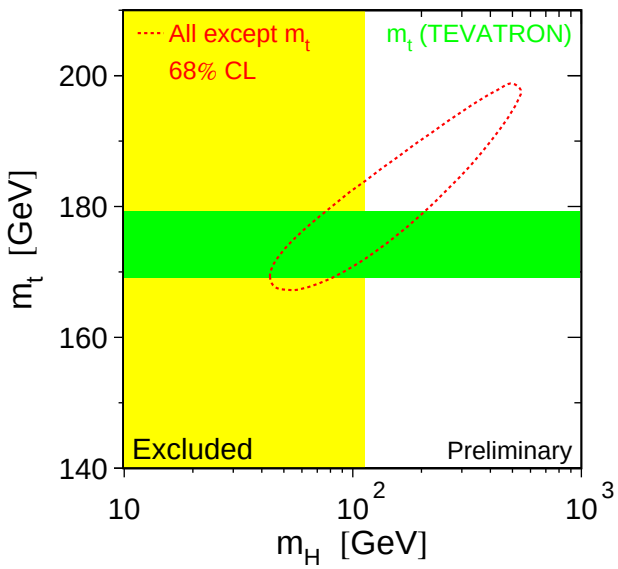

Figure 2: Constraints on the SM Higgs mass due to the precision measurement of the top quark mass. The horizontal band represents our current knowledge of the top quark mass. From the LEP EW working group.

handling and the measurement of the properties of the top quark. Some of this work will continue once he moves to Simon Fraser University (SFU). D. O'Neil will continue to act as overall manager of offline trigger software for the experiment after moving to SFU. However, he will cease coordination of the L1 and L2 trigger software subsystems and involvement in detailed design and coding in these projects. He will continue to serve as a member of the D0 computing policy board and Offsite Analysis Task-Force and will, in fact, be increasing effort in data handling and grid computing. He will continue to contribute to ongoing analyses in the top group.

5.2 Technical Contributions to D0

Our group intends to make use of the WestGrid facility to contribute computing resources to meet the data analysis needs of the D0 experiment. WestGrid is a network of high-performance computing facilities being set up in BC and Alberta. It will include a network storage facility at SFU and a linux cluster at UBC/TRIUMF initially consisting of 500 dual nodes, each containing two 2.4 GHz Xeon processors. Significant disk and tape resources will also be available at the UBC/TRIUMF site including 10TB of disk and 70-100 TB of tape. The management of the D0 experiment has indicated that the use of a fraction of this facility as a D0 regional analysis centre (RAC) would constitute an in-kind contribution to D0 by the Canadian group which would be used in lieu of cash or common fund contributions. D0 management will also welcome the membership of both D. O'Neil and M. Vetterli to the experiment (pending a vote by the D0

institutional board).

The use of WestGrid in this manner provides significant overlap with the needs of the ATLAS collaboration. Data handling and remote analysis tools and experience developed as a part of the D0 collaboration will directly (and immediately) advance the progress of ATLAS data handling efforts using WestGrid. D0 data sets and the D0 computing model provide the best available training ground for personnel in the lead-up to the LHC.

The experience and expertise in our group is well suited to contribute to D0 offsite analysis and computing. M. Vetterli is one of the WestGrid project leaders and Simon Fraser University is one of the deployment sites for WestGrid facilities. He is also involved in Grid computing for ATLAS which will overlap significantly with his D0 contribution. D. O'Neil is a member of the D0 Computing Policy Board which drafted the 5-year computing plan for the experiment including planned use of offsite resources. He is also a member of the Offsite Analysis Task-Force which is currently working to commission the first offsite Regional Analysis Centre (see the description of the D0 computing model below). He has been managing a cluster of more than 200 linux-based analysis desktop machines at D0 for the last 2 years. The D0 data handling and delivery system which will be used offsite is installed on this cluster both for testing the data handling system and for delivering data to users.

5.2.1 The D0 Computing Model

D0 is widely recognized as a leader among HEP experiments in the utilization of offsite computing resources. All of the Run II Monte Carlo production for the experiment is currently done at remote institutions. The current capacity is approximately 200 thousand fully simulated and reconstructed events per day collected from about half-a-dozen sites in the US and Europe. This system has been in place for several years with data handling and cataloging managed by the SAM (Sequential Access via Meta-data) system. If WestGrid dedicates 100 cpus to production of fully simulated and reconstructed D0 events the overall D0 production capacity would increase by approximately 40%.

The experiment is currently building on the success of the offsite simulation effort by designing a multi-tiered offsite computing plan based on the creation of regional analysis centres (RACs). Figure 3 illustrates this multi-tiered structure. Regional analysis centres are expected to provide approximately half of the analysis computing needs of the experiment and all of the data reprocessing. The functions of a regional analysis centre could include

- data reprocessing
- distribution of D0 software
- batch processing
- data delivery
- database access
- MC production and processing
- MC storage

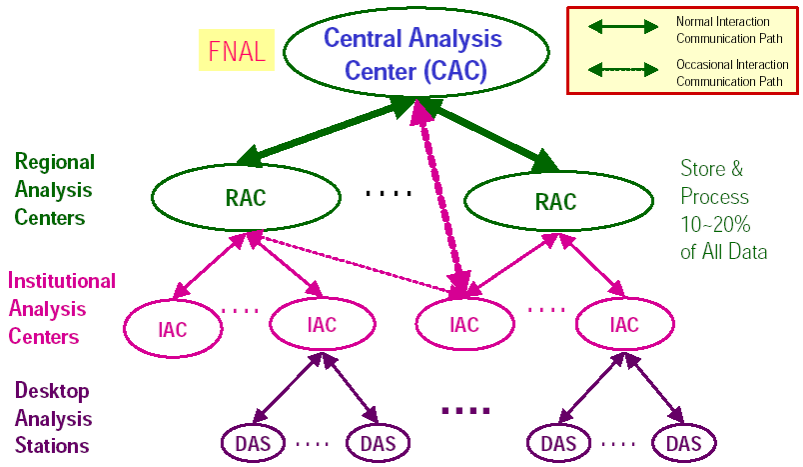

Figure 3: The D0 remote analysis model.

Each RAC may serve a subset of these functions. One of the most important features of a RAC is local storage of large data sets for distribution to smaller centres in the same geographic region. For example, using WestGrid as a RAC would improve accessibility of data for D0 collaborating institutes in the western United States. Desktop analysis can then be carried out at all institutes in the region without impacting network bandwidth to Fermilab.

The first regional analysis centre is currently being tested at Gridka in Germany (Karlsruhe). A second centre in France (Lyon) has recently been given administrative approval. At this time no US centre has been established, though proposals for funding are being written. D0 has established an Offsite Analysis Task-Force in order to coordinate the establishment and testing of the first RACs by the spring of 2003. D. O'Neil is a member of this task-force. D0 management and members of the task-force support the establishment of a RAC in Canada using the WestGrid facility.

The D0 computing plan, including the plan for RACs was subject to an external review during the summer of 2002. The reaction of the review committee was very favourable towards the D0 plan. Other experiments at FNAL have been urged to adopt components of the D0 proposal.

5.3 Physics Analysis Contributions to D0

D0 provides one of the most exciting places to do high energy physics research over the next 5 years. The unprecedented energy and luminosities provided by the Tevatron open a wide range of physics topics for study. D. O'Neil has been involved in an analysis of the W helicity from top quark decays. He intends to continue this study through (at least) 2003. He is also interested in the study of other top quark properties and intends to continue to contribute to these efforts. D. O'Neil is also currently serving on the editorial board of a top mass paper in progress and intends to continue this work as well. M. Vetterli is still considering the options but will likely also contribute to the top group and the QCD group where he could make best use of the experience he gained in HERMES.

The computing infrastructure contributed to D0 by Canada will allow excellent access to data

and Monte Carlo samples in Canada as well as the computing resources needed to analyze them. We intend to use these resources to ensure that our physics interests are well-served.

6 Training of Personnel

We believe that our role in D0 provides an excellent environment for the training of graduate students and research assistants. The experiment is based at a hadron collider which provides the closest existing approximation to the Large Hadron Collider (LHC) in analysis environment and physics potential. Like the ATLAS experiment, the D0 detector design relies on high-quality liquid argon calorimetry. There is no other running experiment with this level of commonality with ATLAS. RAs and students will be well equipped to jump straight from D0 to ATLAS and will be a valuable resource for Canadian high energy physics.

The proposed Canadian role in the experiment is based on cutting-edge grid computing technology and facilities. This provides excellent skill-sets for graduate students wishing to find employment in industry or future experiments such as ATLAS. The distributed nature of the D0 computing model is most similar to the model for LHC computing among existing experiments. It is worth noting that D0 software has completely migrated to an object-oriented framework with all code written in C++ and python. The coding and analysis environment at the experiment is therefore similar to that of ATLAS or industry standard.

In this proposal we have requested salary and travel money for 2 graduate students and one research associate in the first year. In the third year we propose to add another graduate student.

7 Allocation of Research Time

D. O'Neil and M. Vetterli each intend to contribute to both D0 and ATLAS throughout the period addressed in this request. We expect significant overlap in our contributions to the two experiments in the area of grid computing. This makes it somewhat difficult to accurately quantify percentages of research time on each experiment. However, a reasonable estimate is that D. O'Neil will spend roughly 75% of his research time contributing to D0 while M. Vetterli will contribute roughly 33% of his research time to D0.