Update on the Status of DUMAND II

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ABSTRACT

The DUMAND project is in the final construction phase for a $20,000m^2$ deep ocean muon array, due to begin installation in October 1993. We review progress, plans, and update some aspects of the scientific prospects for the array.

1. INTRODUCTION

DUMAND II is an array of 216 optical modules to be deployed in nine vertical strings placed in an octagonal configuration of $100m$ diameter with one string in the center. It will be located at a depth of $4760m$ at the bottom of the ocean $25km$ West from the island of Hawaii. The primary purpose of the experiment is to search for astronomical sources of very high energy (VHE) and ultra high energy (UHE) neutrinos. We expect to begin data-taking this Fall when the first three strings with 72 optical modules are scheduled for deployment.

The unexpected observation by GRO of intense gamma-rays in the $100MeV$ to $10GeV$ region, emitted by over a dozen active galaxies, demonstrated that these sources emit more power at high energies than in any of the lower energy spectral bands. One of the GRO sources, $Mrk421$, apparently radiates substantial γ flux at TeV energies. These sources are probably radiating very high energy neutrinos of comparable or greater luminosity. Models of the central engines of active galaxies strongly suggest that these are also sources of VHE and UHE neutrinos that will be detectable by the nine string DUMAND II array (Stenger, Learned, Pakvasa and Tata).

2. SUMMARY OF THE STATUS OF DUMAND II CONSTRUCTION

The design of DUMAND II is complete and components for the first three strings are being assembled and tested (March 1993). Optical modules from Japan (Alexander, *et al.*) and Europe (Bosetti *et al.*) are being shipped to Hawaii for final testing and incorporation in the strings. We make final testing of the OMs in Hawaii in a $15m$ long water tank using $10m$ trigger scintillation counters loaned to us by the MACRO group at CalTech. String hardware components are all on hand as of March 1993, and final assembly is about to begin. The instrumentation on each string consists of 24 OMs, plus 1 or 2 laser calibration modules (on alternating strings), 5 hydrophones, and some environmental monitoring transducers. There is a floatation package at the top, with beacons and recovery hardware. The string base has anchoring, an acoustic release for emergency retrieval (which can also be accomplished with a submersible), an umbilical cable and connectors. The first $100m$ above the anchor is left uninstrumented. The OMs are spaced $10m$ apart, and the floats occupy another $60m$ above, for a total string length of $390m$.

Signals from the modules for each string are transmitted via multi-mode fiber optics to a string electronics package, located in the geometric center of each string. A 27-channel pipelined VLSI digitiser chip with $1ns$ resolution has been designed and tested (Hasen, *et al.*). It records the arrival time and duration of each OM pulse, with appropriate buffering, and passes 2 words every $80ns$ to a $40bit$ parallel to serial converter for transmission to shore at $500Mbd$. A specially designed cable carrying 12 single mode fibers and capable of delivering $10kW$ of power has been constructed. On shore the data is corrected to Universal Time and passed to digital trigger processing units. There are several triggering algorithms, but the basic first level simply looks for nearest neighbor coincidences along strings. The second level seeks various combinations of such coincident hits. The shore station is presently under construction, but a pipe for bringing the cable through the surf zone has already been installed.

An acoustic positioning system (Wilkes *et al.*), which will allow for continuous determination of the position of the elements of the array to within $10cm$, is undergoing final testing. The hydrophones will also be employed to search for acoustic pulses associated with UHE interactions (Learned *et al.*).

Deployment, slated for October 1993, will begin with placement of the central string of instruments, an enviromental package with TV and lights at its base, and a junction box at the bottom. The junction box carries the shore cable termination, seawater return electrode, and 12 electro-optic connection ports (of which we have two spares). The main cable will then be laid in to shore. The instruments will be monitored for functionality during the operation. The process is designed to be reversible if problems are encountered. Following this, two more strings will be put into position on the ocean floor, $50m$ away from the junction box. In the final step, a submarine, or alternatively a deep ocean remotely controlled vehicle, will be employed to pull umbilical cables from the string bases to the junction box and make the electro-optic connections. There are also 4 outrigger transponding packages to be connected to the junction box from their $300m$ distant locations. The connection operation was successfully practiced at the DUMAND site in October 1992.

Much effort has been devoted to reliability considerations in design and testing, with particular attention to corrosion resistance. For the latter purpose, most seawater contacting components are either non-metalic or made of Titanium. Pressure and temperature cycling of all components is a requirement.

3. CAPABILITIES OF THE THREE STRING ARRAY

The full nine strings of DUMAND II are needed to obtain the high effective area ($20,000m^2$ at $3TeV$) and angular resolution (mean $1°$) needed to begin serious very high energy neutrino astronomy (see the DUMAND II Proposal). Yet, the three strings to be deployed this Fall will have some limited capabilities. Monte Carlo calculations (Stenger) indicate that through-going muons can be reconstructed with reasonable precision and with good background rejection for those events that produce multiple coincidences on adjacent modules in all three strings. For example, we can demand that two strings have at least a three-fold coincidence, while the third string as at least a two-fold. Or, we can demand a five-fold and two two-folds. In this case, the background of fake events will be sufficiently low to allow for the detection of a signal of ten events per year from a point source.

The effective area and angular resolution for events reconstructed according to these criteria are strong functions of energy. While the nine-string octagon has good capabilites down to $100GeV$, the three string Triad requires muons of at least $3TeV$ for significant detection efficiency and pointing accuracy. The effective area at $10TeV$ is about $3100m^2$ and scales roughly with $E_\mu^{0.9}$. Note that our definition of effective area includes all identified efficiencies through reconstruction of events. The median pointing accuracy is 5.5^0 at $1TeV$ and $3.6°$ at $10TeV$. The atmospheric neutrinos, which are the primary background for extraterrestrial sources, have a much steeper spectrum than expected from these sources. The Triad will also have substantial capability for discovery of UHE cascades at distances of several hundred meters, and could provide the first evidence for diffuse AGN fluxes.

Muon detection also permits studies of downgoing cosmic ray muons for muon astronomy and cosmic ray composition studies. Upcoming muons will be examined for evidence of neutrinos from WIMP anihillations. Other than searching for muons and cascades (point sources of light and light from particles travelling at c), we will have triggers to search for slow moving sources ($\beta > 10^{-3}$), and for time clusters of high amplitude hits in OMs (possible supernova detection).

CONCLUSIONS

The DUMAND II construction has made great progress since the last ICRC, and we hope that by the time of the next meeting we will be able to report actual data, and with luck the beginning of high energy neutrino astronomy.

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