

Search for Neutrino Transients Using IceCube and DeepCore

A Thesis
Presented to
The Academic Faculty

by

Jacob D. Daughhetee

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

School of Physics
Georgia Institute of Technology
December 2014

Search for Neutrino Transients Using IceCube and DeepCore

Approved by:

Professor Pablo Laguna, Committee
Chair

Professor Carol Paty
(Earth and Atmospheric Science)

Professor Ignacio Taboada, Adviser

Professor

Professor Nepomuk Otte

Professor

Date Approved _____

PREFACE

This dissertation is based on data acquired with the IceCube Neutrino Observatory whose maintenance and operation is the result of an immense international collaborative effort. The bulk of the work pertaining to experimental hardware, data acquisition, reconstruction algorithms, systematics, and simulation presented in this document can be attributed to many IceCube collaborators. However, the refinement of the event selection and subsequent analysis of the data are the original work of the author.

ACKNOWLEDGEMENTS

I want to thank my fellow graduate student office mates whose constant distractions helped me retain my sanity.

TABLE OF CONTENTS

DEDICATION	iii
PREFACE	iv
ACKNOWLEDGEMENTS	v
LIST OF TABLES	vii
LIST OF FIGURES	viii
SUMMARY	ix
I INTRODUCTION	1
II DETECTOR	2
III PREVIOUS POINT SOURCE SEARCHES	4
IV DATA ACQUISITION	5
V EVENT SELECTION	6
VI ANALYSIS METHOD	7
VII RESULTS	8
VIII CONCLUSION	9
APPENDIX A — APPENDIX PLACEHOLDER	10
INDEX	12
VITA	13

LIST OF TABLES

LIST OF FIGURES

1	Diagram of the IceCube Neutrino Observatory.	3
---	--	---

SUMMARY

Observations indicate that there is a correlation between long duration gamma-ray bursts (GRBs) and core-collapse supernovae (SNe). The leading model for GRB production assumes that relativistic jets are generated by the core-collapse within the progenitor star. Charged particles undergo Fermi-acceleration within internal shocks of these jets and subsequently give rise to gamma ray emission once the jets breach the surrounding stellar envelope. Very few SNe result in the occurrence of GRBs, however, but it has been suggested that a significant fraction of core-collapse SNe manage to produce mildly relativistic jets. These jets are insufficiently energetic to break through the envelope and are effectively 'choked' resulting in a lack of observed gamma ray emission. In both the failed and successful GRB scenario, neutrino production can occur if protons are accelerated in the internal shocks of these jets. These neutrinos may be detectable by the IceCube neutrino observatory and its low energy extension DeepCore. A dedicated search for temporal and spatial clustering of neutrino events during the 2012 data season aims to reveal the presence of any 'choked' GRB events within 20 Mpc.

CHAPTER I

INTRODUCTION

The expansion of traditional optical astronomy into wavelengths unobservable to the human eye revealed a myriad of phenomena previously unknown to science. Using wavebands of light spanning several orders of magnitude allows for the discovery of completely new astronomical sources. Additionally, it allows for the study of completely different physical processes within and around source objects. For all the vast advances in our understanding of the universe the opening up of the electromagnetic spectrum has brought us, though, it relies entirely upon the physical properties of its messenger particle, the photon.

CHAPTER II

DETECTOR

The IceCube Neutrino Observatory is km³-scale neutrino detector located deep within the glacial ice of the Antarctic ice sheet at the geographical South Pole. The detector consists of 5160 photo-multiplier tubes (PMTs) housed within glass pressure vessels.

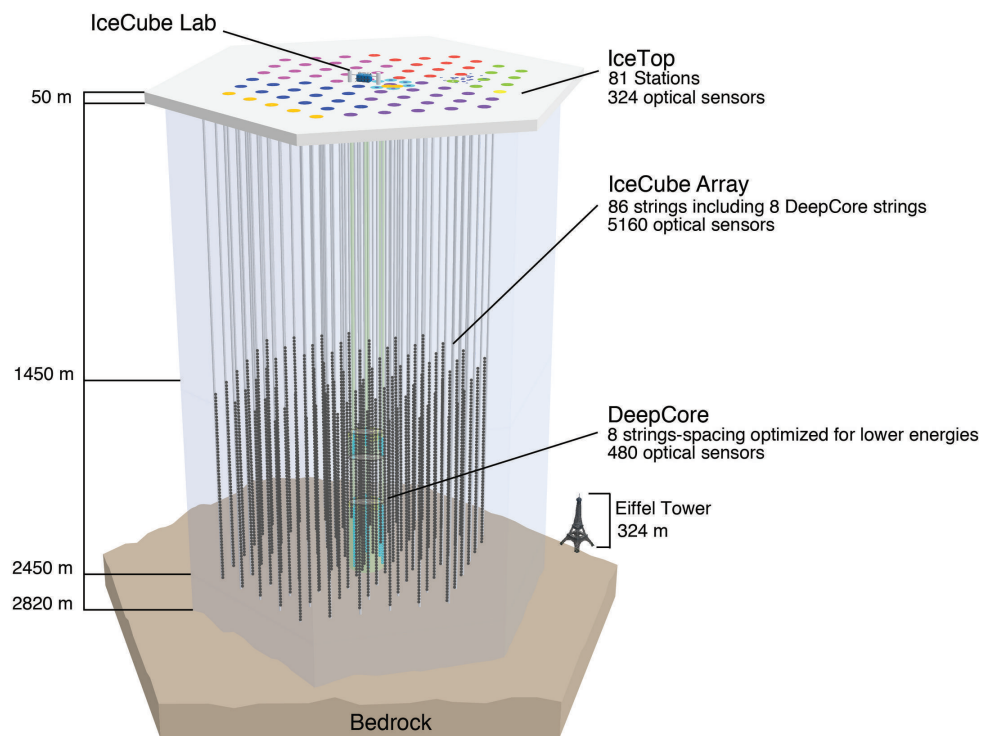


Figure 1: Diagram of the IceCube Neutrino Observatory.

CHAPTER III

PREVIOUS POINT SOURCE SEARCHES

CHAPTER IV

DATA ACQUISITION

Blah blah blah [1].

CHAPTER V

EVENT SELECTION

CHAPTER VI

ANALYSIS METHOD

CHAPTER VII

RESULTS

CHAPTER VIII

CONCLUSION

APPENDIX A

APPENDIX PLACEHOLDER

Ancillary material should be put in appendices, which appear just before the bibliography.

REFERENCES

- [1] THE ICECUBE COLLABORATION, “The IceCube Data Acquisition System: Signal Capture, Digitization, and Timestamping,” *ArXiv e-prints*, Oct. 2008.

INDEX

VITA