

# Vernon Barger earns 2021 APS Sakurai Prize

Posted on [October 16, 2020](#)



Vernon Barger

University of Wisconsin–Madison Physics professor [Vernon Barger](#) has won the J.J. Sakurai Prize for Theoretical Particle Physics, the [American Physical Society announced](#) October 7.

The J.J. Sakurai Prize is considered one of the most prestigious annual prizes in the field of theoretical high energy physics. Barger, who joined the UW–Madison faculty in 1965, is a world leader in theoretical particle physics where theory meets experiment. He is one of the founders of collider phenomenology as it is practiced

today.

# Vernon Barger elected AAAS Fellow

Posted on [April 18, 2024](#)

*This story is modified from one [published](#) by University Communications*



Eight University of Wisconsin–Madison scholars – including physics professor [Vernon Barger](#) – have been elected [fellows of the American Association for the Advancement of Science](#), the world’s largest general scientific society.

Barger was elected for “seminal work in studying fundamental particles at colliders and leadership in particle phenomenology, where theory meets experiment.”



## Vernon Barger

**Vilas Research Professor and Van Vleck Professor**

[barger@pheno.wisc.edu](mailto:barger@pheno.wisc.edu)

(608) 262-8908

[5295 Chamberlin Hall](#)

[Publications](#)

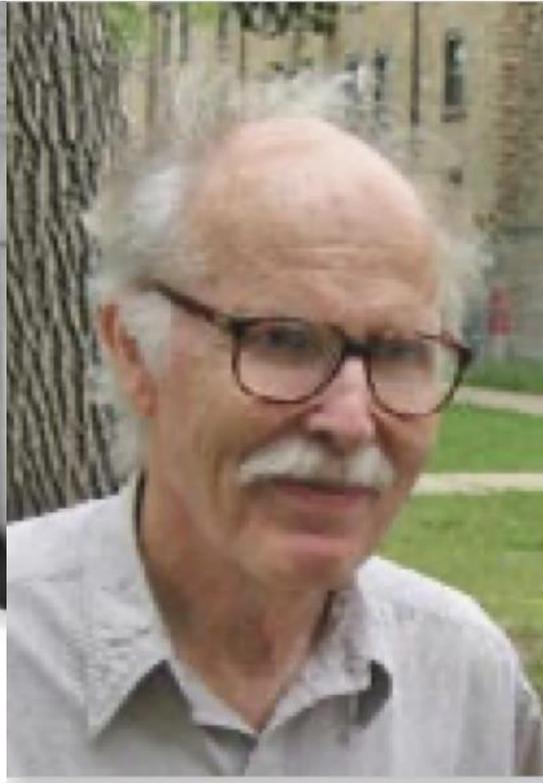
Website: [Phenomenology](#)

Research Interests: Collider physics phenomenology; unified models; Higgs bosons; supersymmetry; neutrino physics; cosmology

the nineteen sixties ....



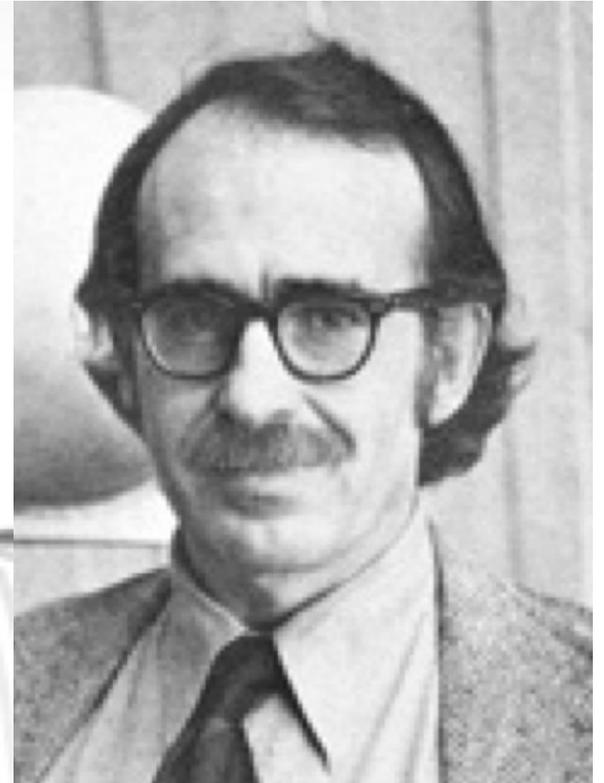
Vernon Barger



Marty Olsson at the 2005  
Alumni Celebration picnic.  
*Photo: Bob Morse*



Don Reeder

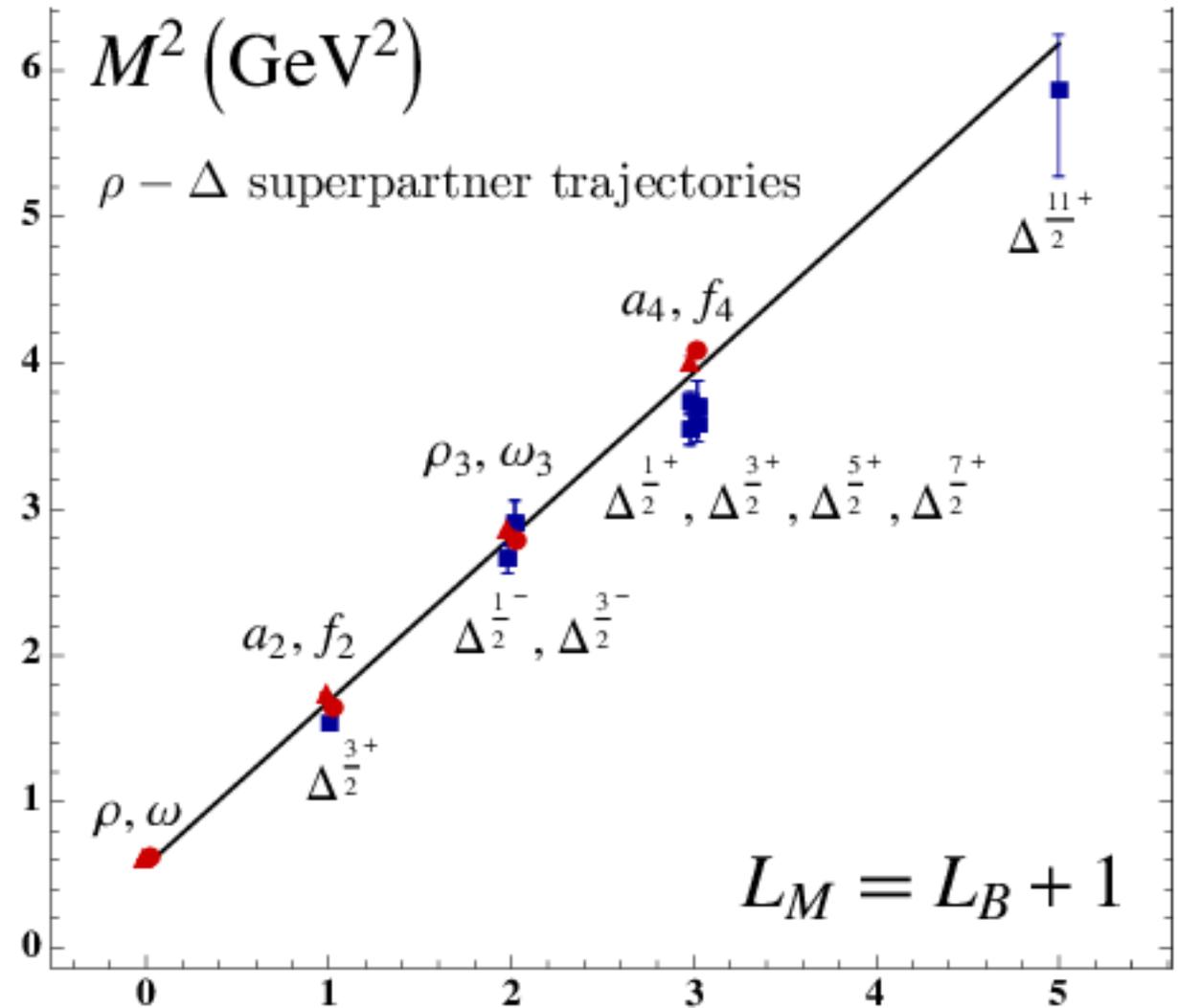


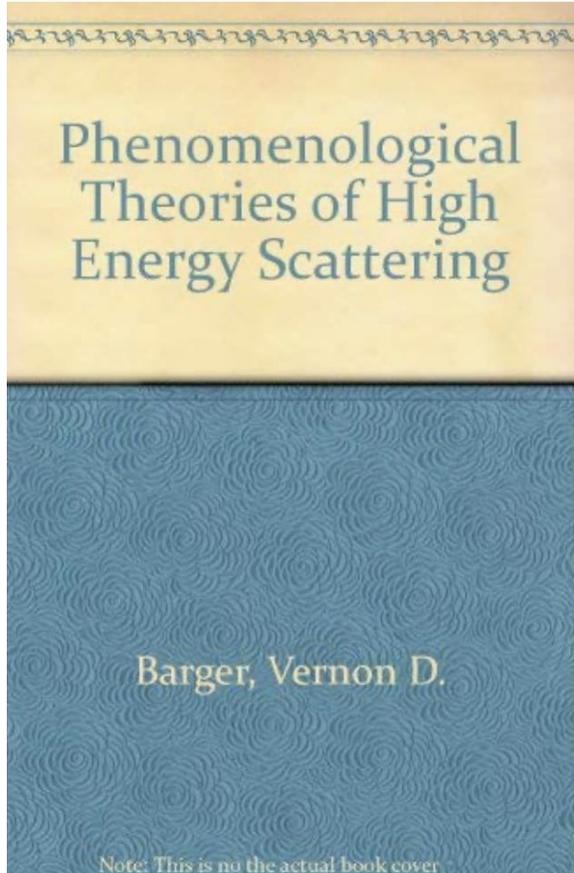
David Cline



Barger has done research on collider physics phenomenology (especially related to the Large Hadron Collider), Higgs bosons, supersymmetry, and grand unified theories, as well as "neutrino oscillations, particle dark matter, early universe cosmology, heavy quarks and the Regge pole model.

The phenomenology research program at the University of Wisconsin-Madison began in the mid-1960's as a collaboration of theoretical and experimental faculty. The Institute was created by the University in 1984 with support from the U.S. Department of Energy, with Vernon Barger and Francis Halzen as directors.





## Follow the authors i



V. Barger

Follow



D. Cline

Follow

Barger and Cline's rule, in the context of Dirac equation and bound states, refers to a prediction about the allowed energy levels of bound states for a Dirac particle with a specific type of spherically symmetric potential.

Specifically, it states that when the radial part of the wave function has no nodes, the corresponding bound state can only appear in the  $J = l + 1/2$  state, and not in the  $J = l - 1/2$  state. [↗](#)

Here's a more detailed explanation:

### Context:

The rule is applied when studying bound states of Dirac particles in a spherically symmetric potential. This potential is assumed to be short-range and behave in a certain way near the origin. [↗](#)

### J and l:

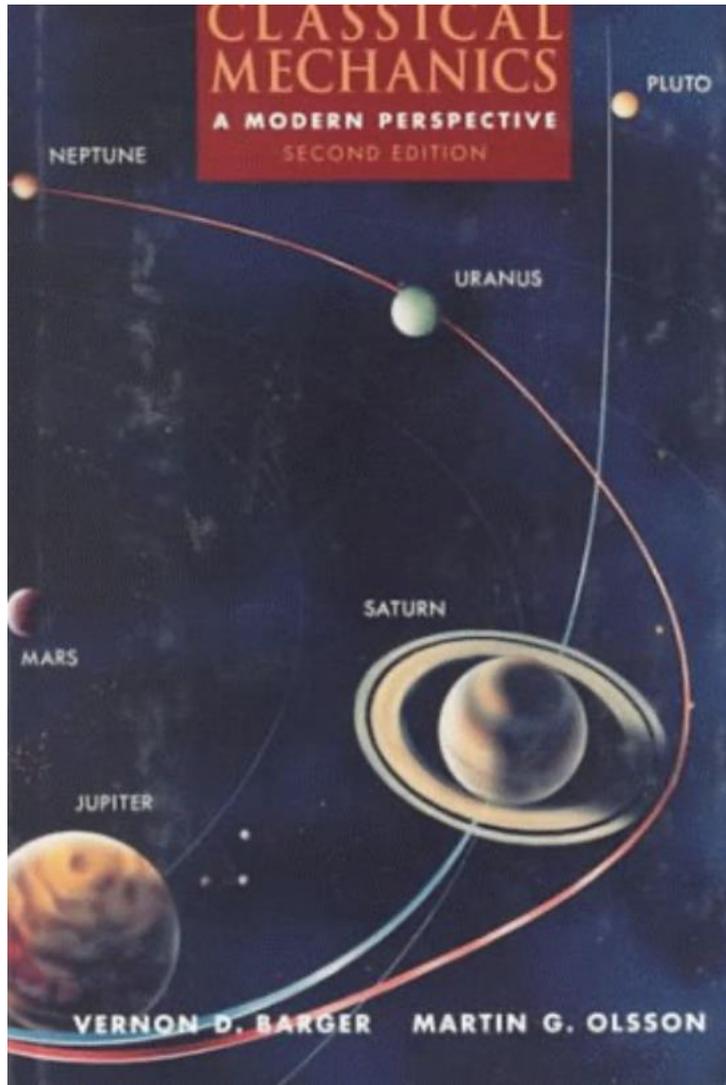
J represents the total angular momentum of the particle, while l represents the orbital angular momentum. In the Dirac equation, the two values of J,  $l + 1/2$  and  $l - 1/2$ , represent different spin orientations. [↗](#)

### No Nodes:

The "no nodes" condition means that the radial part of the wave function, which describes the particle's probability distribution with respect to distance from the center of the potential, does not change sign. [↗](#)

### Rule's Prediction:

Barger and Cline's rule predicts that when the radial wave function has no nodes, the lowest energy bound state for a Dirac particle can only exist in the  $J = l + 1/2$  state, and not in the  $J = l - 1/2$  state. [↗](#)



# Phenomenological Theories of High Energy Scattering

Barger, Vernon D.

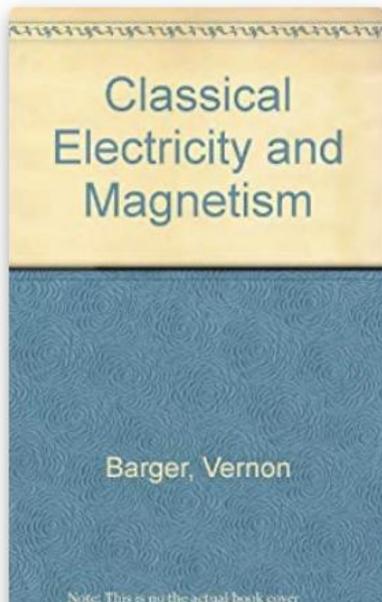
Note: This is no the actual book cover

# Classical Electricity and Magnetism

Barger, Vernon

Note: This is no the actual book cover

## Books by Vernon Barger



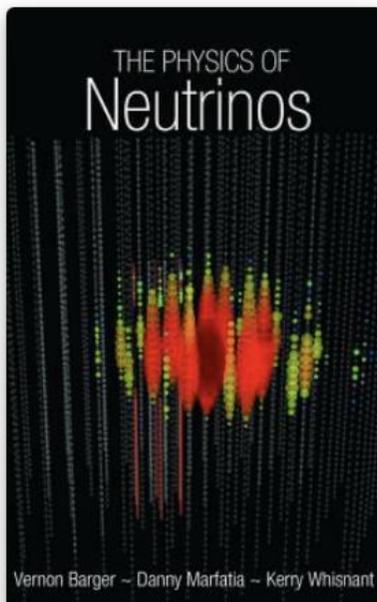
### Classical Electricity and Magnetism

Olsson, Vernon Barger

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### The Physics of Neutrinos

Vernon Barger, Danny

New

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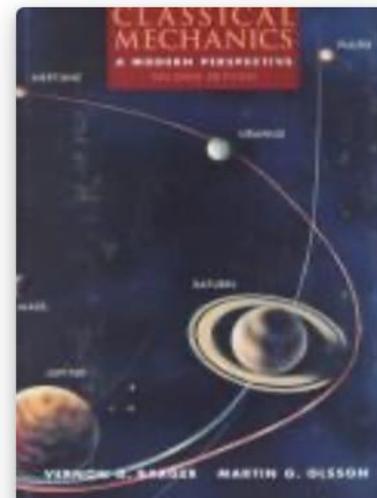
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### Classical Mechanics : A Modern Perspective

Vernon Barger, Martin

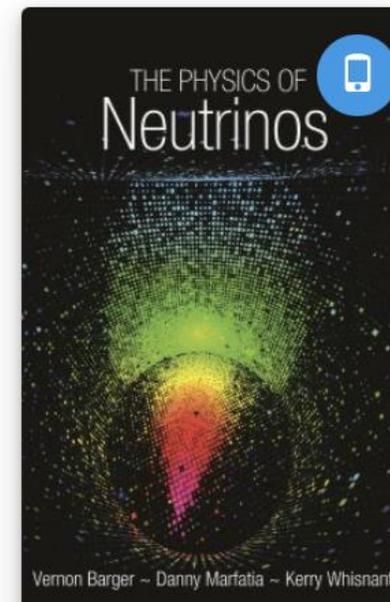
[See Details](#)



### Classical Mechanics

Vernon Barger

[See Details](#)



### The Physics of Neutrinos

Vernon Barger, Danny

[See Details](#)

## Some New Aspects of Supersymmetry R-Parity Violating Interactions

#5

Vernon D. Barger (Wisconsin U., Madison), G.F. Giudice (Fermilab), Tao Han (Wisconsin U., Madison) (Apr, 1989)

Published in: *Phys.Rev.D* 40 (1989) 2987

 pdf  DOI  cite  claim

 reference search  675 citations

## New Constraints on the Charged Higgs Sector in Two Higgs Doublet Models

#6

Vernon D. Barger (Wisconsin U., Madison), J.L. Hewett (Wisconsin U., Madison), R.J.N. Phillips (Rutherford) (Oct, 1989)

Published in: *Phys.Rev.D* 41 (1990) 3421-3441

 DOI  cite  claim

 reference search  635 citations

## Status of muon collider research and development and future plans

#4

Charles M. Ankenbrandt (Fermilab), Muzaffer Atac (Fermilab), Bruno Autin (CERN), Valeri I. Balbekov (Fermilab), Vernon D. Barger (Wisconsin U., Madison) et al. (Aug, 1999)

Published in: *Phys.Rev.ST Accel.Beams* 2 (1999) 081001 • e-Print: [physics/9901022](#) [physics]

 pdf  links  DOI  cite  claim

 reference search  719 citations

## Supersymmetric grand unified theories: Two loop evolution of gauge and Yukawa couplings

#10

Vernon D. Barger (Wisconsin U., Madison), M.S. Berger (Wisconsin U., Madison), P. Ohmann (Wisconsin U., Madison) (Sep, 1992)

Published in: *Phys.Rev.D* 47 (1993) 1093-1113 • e-Print: [hep-ph/9209232](#) [hep-ph]

 pdf  DOI  cite  claim

 reference search  584 citations

## Bimaximal mixing of three neutrinos

#9

Vernon D. Barger (Wisconsin U., Madison), S. Pakvasa (Hawaii U.), Thomas J. Weiler (Vanderbilt U.), K. Whisnant (Iowa State U.) (Jun, 1998)

Published in: *Phys.Lett.B* 437 (1998) 107-116 • e-Print: [hep-ph/9806387](#) [hep-ph]

 pdf  DOI  cite  claim

 reference search  590 citations



DOE-ER/00881-152

July 1980

MATTER EFFECTS ON THREE-NEUTRINO OSCILLATIONS

V. Barger and K. Whisnant

Physics Department, University of Wisconsin, Madison, Wisconsin 53706 USA

S. Pakvasa

Physics Department, University of Hawaii-Manoa, Honolulu, Hawaii 96822 USA

and

R. J. N. Phillips

Rutherford Laboratory, Chilton, Didcot, Oxon, England

ABSTRACT

We evaluate the influence of coherent forward scattering in matter upon neutrino oscillations in the three-neutrino picture. We write down the exact solution and also approximate first-order solutions that exhibit general features more transparently. Oscillation characteristics in matter that could be observed in deep mine experiments are discussed and illustrated using an oscillation solution suggested by solar and reactor data.

Vernon and his collaborators pioneered

- structure functions
- global neutrino analysis
- the Durham theory institute

# Vernon Duane Barger

[MathSciNet](#)

Ph.D. The Pennsylvania State University 1963 

**Dissertation:** *Theoretical Calculations of  $K_1^0 - K_2^0$  and  $\pi^+ - \pi^0$  Meson Mass Differences*

Mathematics Subject Classification: 82—Statistical mechanics, structure of matter

Advisor 1: [Emil Kazes](#)

Students:

Click [here](#) to see the students listed in chronological order.

Sarma, V. L. Kuruganti 1967  
 Weiler, Peter R., Jr. 1971  
 Estabrooks, Penny G. 1971  
 Geer, Kevin Anderson 1972  
 Luthe, John Charles 1975  
 Weiler, Thomas J. 1976  
 Gottschalk, Thomas Donn 1978  
 Keung, Wai-Yee 1980  
 Whisnant, Kerry Lewis 1982  
 Baer, Howard A. 1984  
 Woodside, Jeffrey G. 1985  
 Ohnemus, James Edward 1987  
 Long, William Frederick 1988  
 Han, Tao 1990  
 Stange, Alan L. 1992  
 Cheung, Kingman 1992  
 Bhattacharya, Gour 1992  
 Ohmann, Paul R. 1994  
 Mercadante, Pedro 1997  
 Li, Tianjun 2000  
 Kim, YoungJae 2002  
 Wood, Benjamin P. 2002  
 Lee, Hye-Sung 2005  
 Shaughnessy, Gabe 2007  
 Tregre, Adam L. 2007  
 McCaskey, Mathew J. 2010  
 Gao, Yu 2011  
 Yencho, Brian M. 2011  
 Huang, Peisi 2013  
 Yu, Chiu-tien 2013  
 Peterson, Andrea Dawn 2014  
 Zhang, Kairui 2023

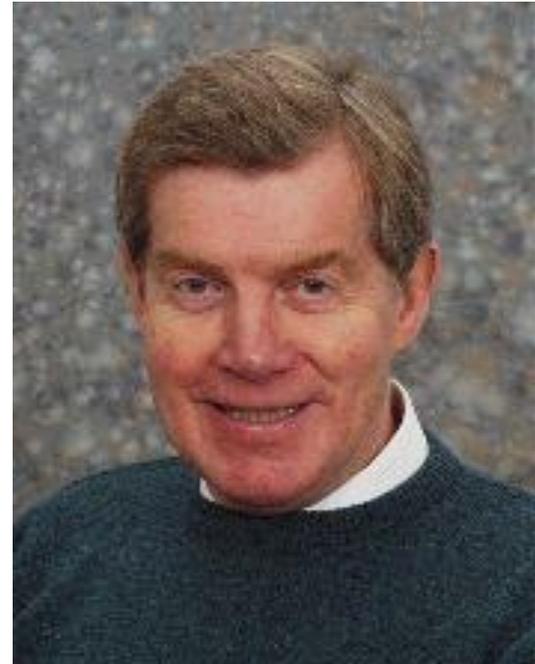


Roger Phillips:

Ernest Rutherford Prize & medal of the UK Institute of Physics:  
... Phillips, Hewett and Barger showed that the decay of a b-quark to an s-quark and a photon is a highly sensitive probe of a charged Higgs boson through its one-loop virtual contribution.



Sandip Pakvasa



Alan Martin



# Topical Workshop on Production of New Particles in Super High Energy Collisions

22-24 October 1979. Madison, WI, United States (C79-10-22)

Note: No pagination, listed on PPA Cum no 14, but not weeded

NEW PARTICLES, MADISON 1979

WORKSHOP: NEW PARTICLE, MADISON

## Lawrence Berkeley National Laboratory Lawrence Berkeley National Laboratory

### Title

RESULTS ON CHARMED BARYONS AND MESONS FROM THE SLAC-LBL MARK II DETECTOR AT SPEAR

) 15 contributions

### Permalink

<https://escholarship.org/uc/item/4b03p4q1>

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### Author

Goldhaber, G.

bosons, #1

### Publication Date

1980

Peer reviewed

CONF - 7910103 - - 4

SLAC-PUB-2435  
November 1979  
(T/E)

-2-

This talk was presented at the University of Wisconsin Topical Workshop on the Production of New Particles in Super High Energy Collisions. The spirit of the Workshop was speculative and this talk is in that spirit. The known leptons were discovered in very different ways and we can only speculate about the ways in which other and heavier leptons can be found. Indeed we do not even know if there are leptons beyond the tau.

#### 1. BEYOND THE $\tau$

##### 1.A. Status of the $\tau$ :

The status of the  $\tau$  has been recently reviewed in detail<sup>1</sup>; therefore I will give a brief and qualitative discussion. All measurements are consistent with the  $\tau$  having the following properties:

- a) spin 1/2, charged, Dirac, point particle;
- b) obeys conventional quantum electrodynamics;
- c) obeys conventional weak interaction theory;
- d) has no strong interactions; and
- e) has a unique, conserved lepton number.

Hence the  $\tau$  is a sequential<sup>2</sup> charged lepton to the best of our knowledge.

There are three interesting new pieces of data on the  $\tau$ .

- a) The Mark J collaboration<sup>3</sup> at PETRA has measured the  $\tau$  pair production cross section  $\sigma(e^+e^- \rightarrow \tau^+\tau^-)$  up to  $E_{cm} = 31$  GeV. Within the statistics, which are still small, the cross section is consistent with the  $\tau$  being a spin 1/2, Dirac, point particle obeying conventional quantum electrodynamics. For example in an  $E_{cm}$  region near 30 GeV they find about 20 events and their measured  $\sigma(e^+e^- \rightarrow \tau^+\tau^-)$  in that region agrees with the  $\tau$  being a point particle. We assume a form factor<sup>2</sup>

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### SEARCHING FOR HEAVY LEPTONS \*\*

Martin L. Perl  
Stanford Linear Accelerator Center  
Stanford University, Stanford, California 94305

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  - D. Charged Leptons with Mass  $\geq 20$  GeV/c<sup>2</sup>
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5. References

<sup>\*</sup>Presented at the Topical Workshop on the Production of New Particles in Super High Energy Collisions  $\sqrt{s} = 10^2 - 10^5$  GeV; University of Wisconsin, Madison, Wisconsin, October 21-24, 1979.  
<sup>1</sup>This work was supported by the Department of Energy under Contract Number DE-AC03-76SF00515.

# NEW PARTICLES 1985

edited by  
**Vernon Barger**  
**David Cline**  
**Francis Halzen**

University of Wisconsin – Madison

World Scientific

a search for single photon events at PEP -- Supergravity constraints on monojets -- Standard model sources of missing  $p_T$  -- Dimuon events at the CERN pp-collider -- Production properties of the intermediate vector bosons at the SPS collider -- Searching for fourth generation quarks and leptons -- The fourth generation -- Recent results on new particle searches at PEP -- Eurojet: A QCD based Monte Carlo Program including perturbatively calculated higher order processes in pp interactions -- Unexpected observations of Muons from Cygnus X-3 -- Observation of Cygnus X-3 at energies of 1011 to 1013 eV using the atmospheric Cherenkov technique -- Cygnus X-3: is it unique? -- Evidence for underground Muons from Cygnus X-3 -- High-energy signals from Cygnus X-3. Theory review -- High energy neutrinos from CYG X-3 -- Is Cygnus X-3 strange? -- Comments on cosmic-ray sightings of Cygnus X-3 -- List of participants.

## Neutrino Masses and Neutrino Astrophysics: Including Supernova 1987...

### Neutrino Masses and Neutrino Astrophysics: Including Supernova 1987a : Ashland, Wisconsin 1987 (Telemark IV)

by [Vernon Barger](#) (Author), [Francis Halzen](#) (Author), [Marvin Marshak](#) (Author), [Keith Olive](#) (Editor)

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9971503670

ISBN-13



978-9971503673

Publisher



World Scientific  
Pub Co Inc

Publication date



May 1, 1987

Language



English

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Pheno conferences





→ 2004 IceCube funded



Department of Energy <i>(shared w/V. Barger, T. Han &amp; F. Petriello)</i>	514,571	2006 – 07
Department of Energy <i>(shared with V. Barger &amp; T. Han)</i>	471,000	2005 – 06
Department of Energy <i>(shared w/Barger, Han &amp; M.G. Olsson)</i>	485,000	2004 – 05
Department of Energy <i>(shared w/Barger, Han, Olsson &amp; D. Zeppenfeld)</i>	665,000	2003 – 04
☰	685,000	2002 – 03
	700,000	2001 – 02
Department of Energy Graduate Fellowship	\$56,590	1998 – 2001
Department of Energy <i>(shared with Barger, Han, Olsson &amp; Zeppenfeld)</i>	760,000	2000 – 01
	800,000	1999 – 2000
	785,000	1998 – 99
Department of Energy <i>(shared with Barger, Olsson &amp; Zeppenfeld)</i>	725,000	1997 – 98
	620,000	1996 – 97
	646,000	1995 – 96
	680,000	1995
Department of Energy <i>(shared with Barger &amp; Olsson)</i>	725,000	1994
	55,000	1993
	705,000	1992
	806,000	1991
	750,000	1990
	750,000	1989
	685,000	1988
	615,000	1987
	535,000	1985 – 86
	425,000	1984 – 85
	355,000	1983 – 84
	320,000	1982 – 83
	290,000	1981 – 82
	227,000	1980 – 81
Texas National Research Laboratory Commission <i>(shared with Barger, Olsson &amp; Zeppenfeld)</i>	100,000	1993 – 94
	100,000	1992 – 93
	130,000	1991 – 92

→ 1984 Pheno Institute created

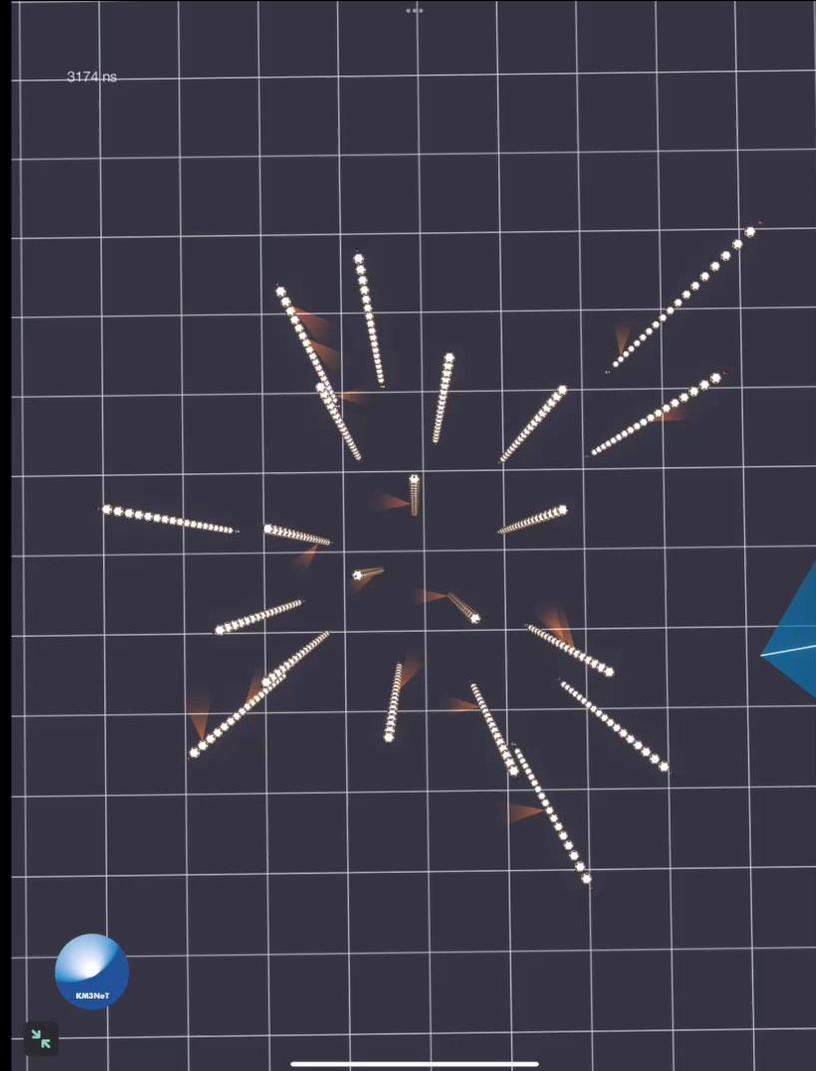
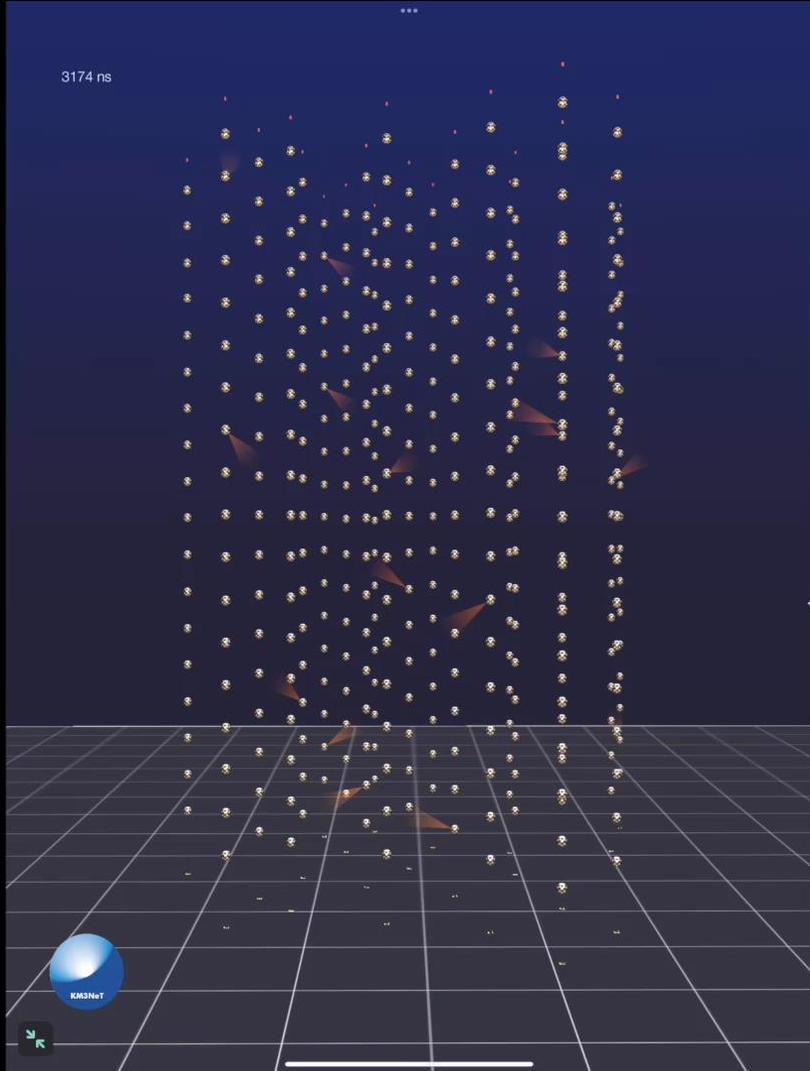
As a young post-doc at the Rutherford Laboratory, near Oxford, I worked on the phenomenology of two-body scattering - Regge poles, Regge cuts, absorption models, duality, finite energy sum rules, etc,...

Roger Phillips, head of the group, worked with Vernon Barger in this area, and I met Vernon when he was a visitor to Rutherford Lab. I was invited by Vernon to spend 6 months at Madison - in 1969. Vernon was very welcoming - both personally and in scientific collaboration. I was a co-author on 3 papers, one being published in Phys Rev Letters. I was impressed by his paper-writing technique: he wrote a first draft of part of the paper, had it typed up, then modified it further,...

A few years later, Vernon offered me an Assistant Professor position; I declined but suggested that one of my co-workers, Francis Halzen, would be a good choice. I was right!

Chris Michael

# Uncharted Territory $E_\nu = 220 \text{ PeV}$

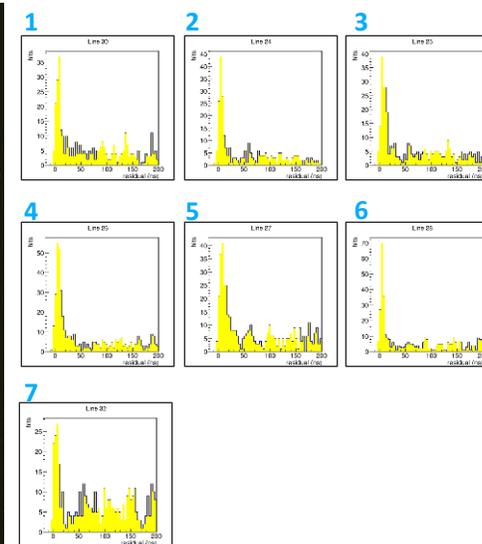
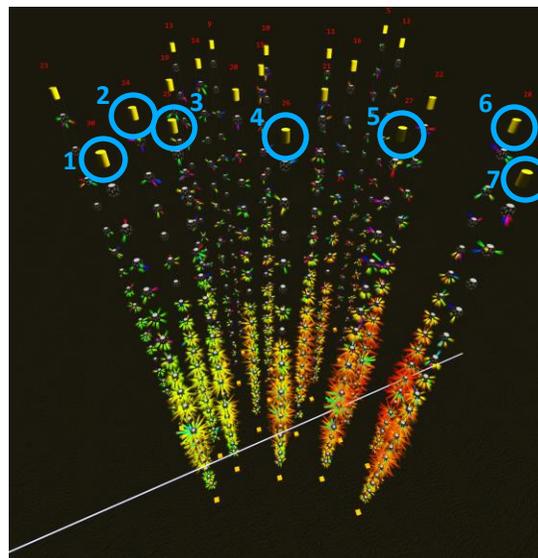
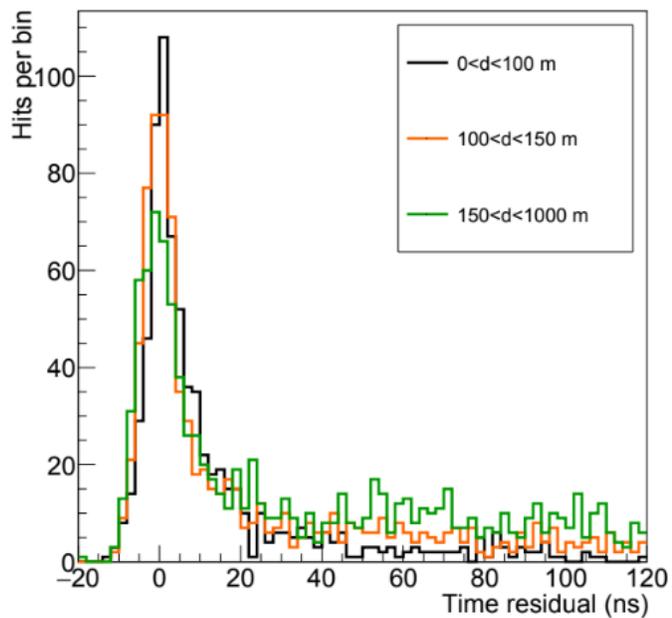




# KM3-230213A: Very well reconstructed muon

~28,000 photons, (35% of the ARCA21 detector)

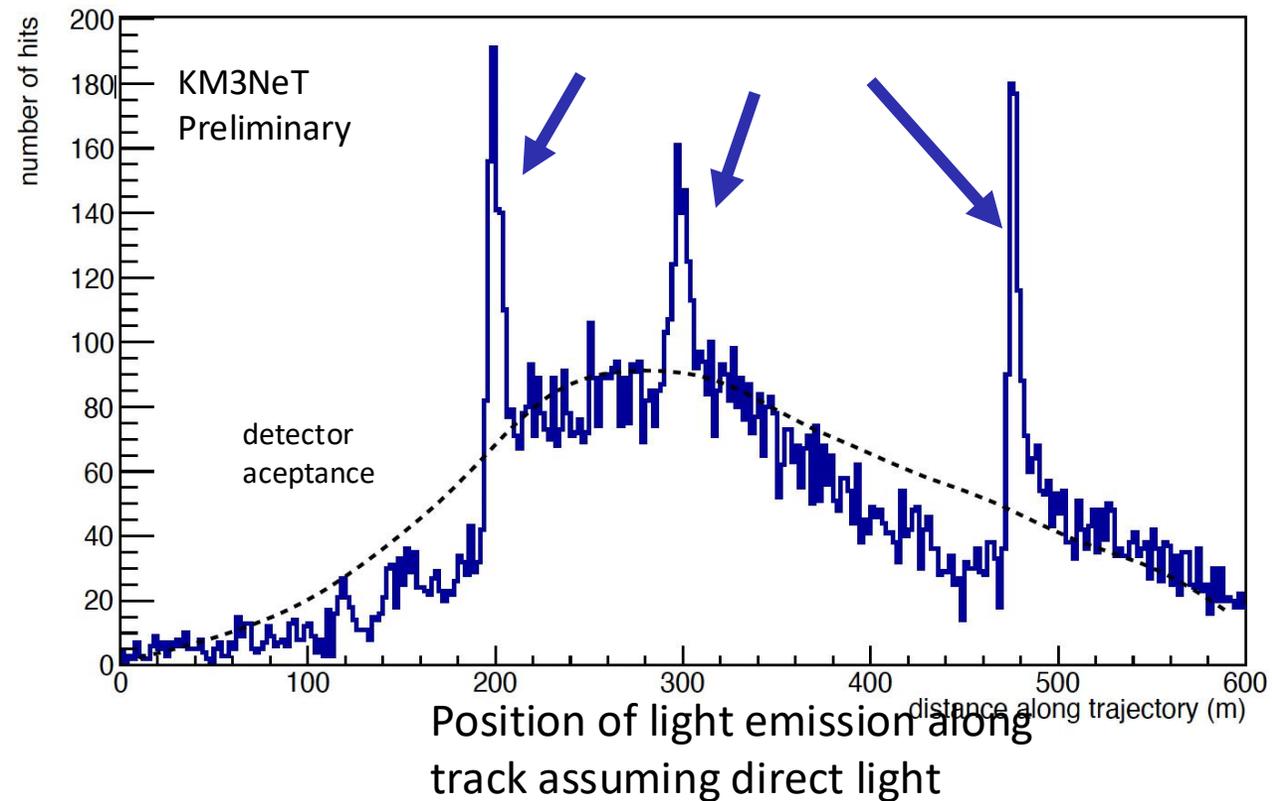
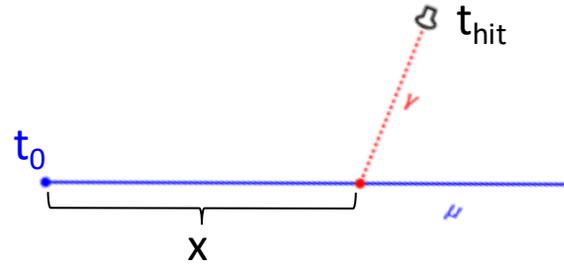
Measured with nano-second timing





# Rich detail

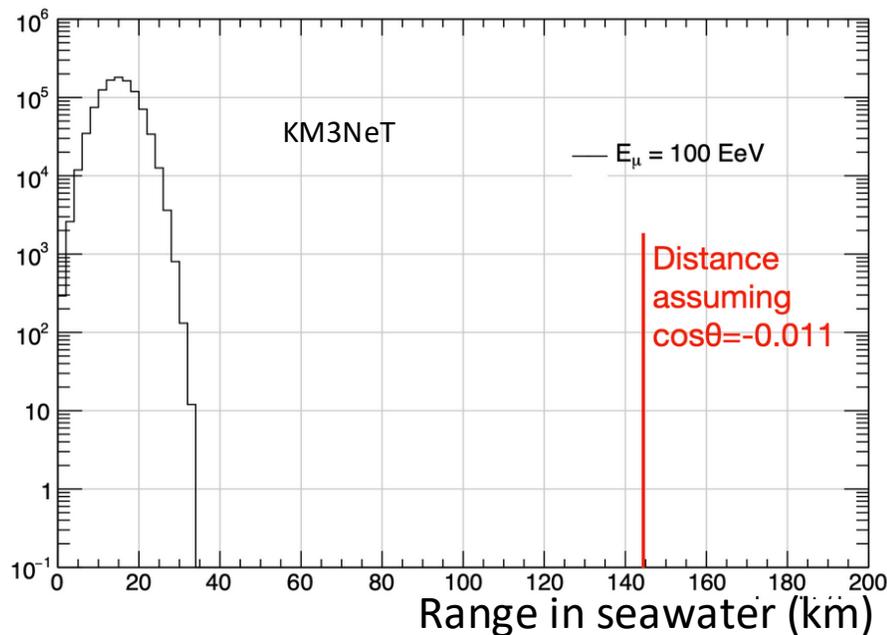
- Light profile consistent with at least 3 large energy depositions along the muon track
- Characteristic of stochastic losses from very high energy muons





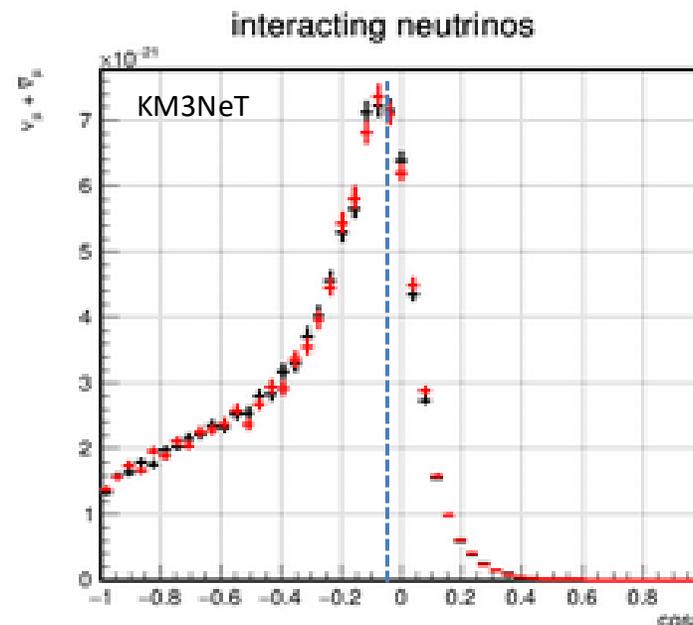
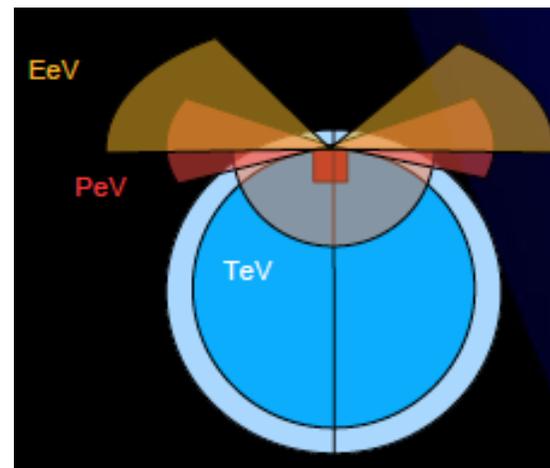
# KM3-230213A: Not an atmospheric muon

w.e. distance much larger  
due to continental shelf



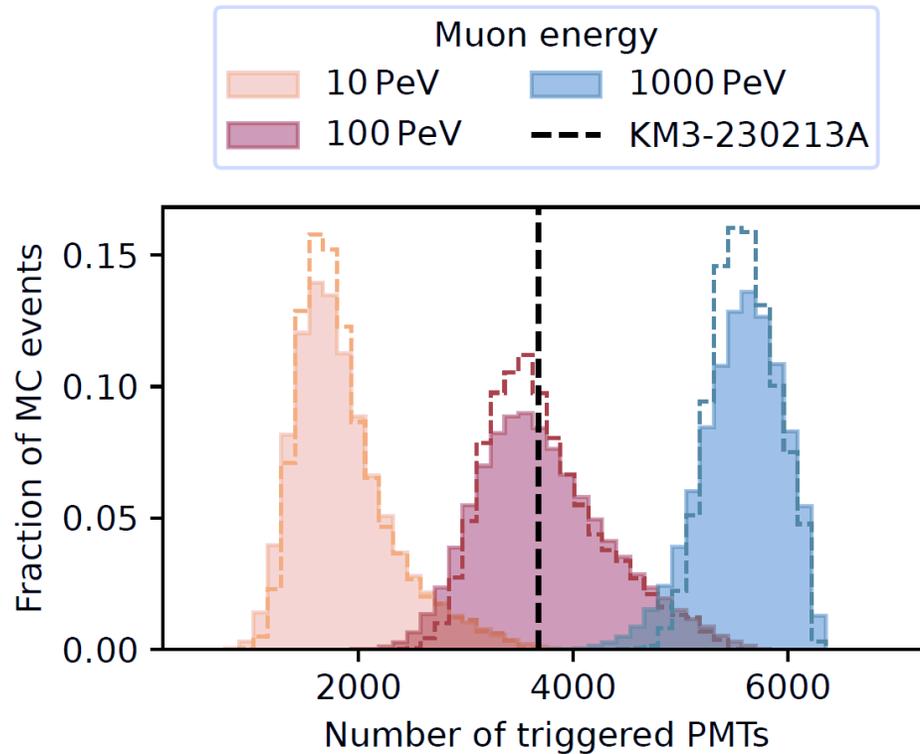
Expected atmospheric muon contamination @ 100 PeV:  
 $\ll 10^{-10}$  event/year within  $2\sigma$  of reconstructed direction

Expected rate of atmospheric neutrinos  $> 100 \text{ PeV}$ :  
 $\ll (1-5) \times 10^{-5}$  event/year





# KM3-230213A: Energy measurement



- **Energy is measured from the amount of light:**

$$E_{\mu} = 120_{-60}^{+110} \text{ PeV}$$

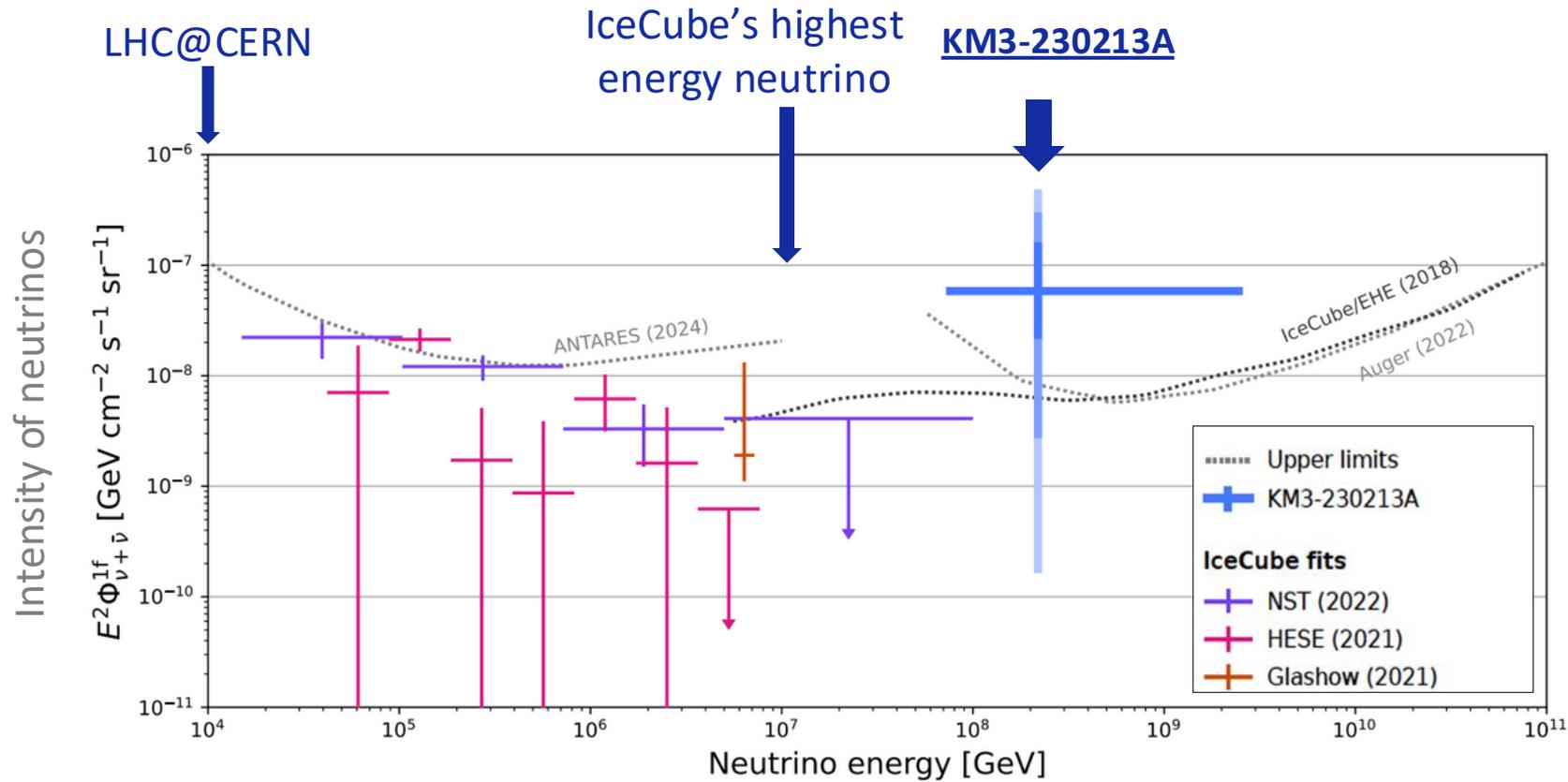
- **The neutrino Energy is higher:**

$$E_{\nu} = 220_{-100}^{+570} \text{ PeV}$$

( assuming an  $E^{-2}$  source spectrum )



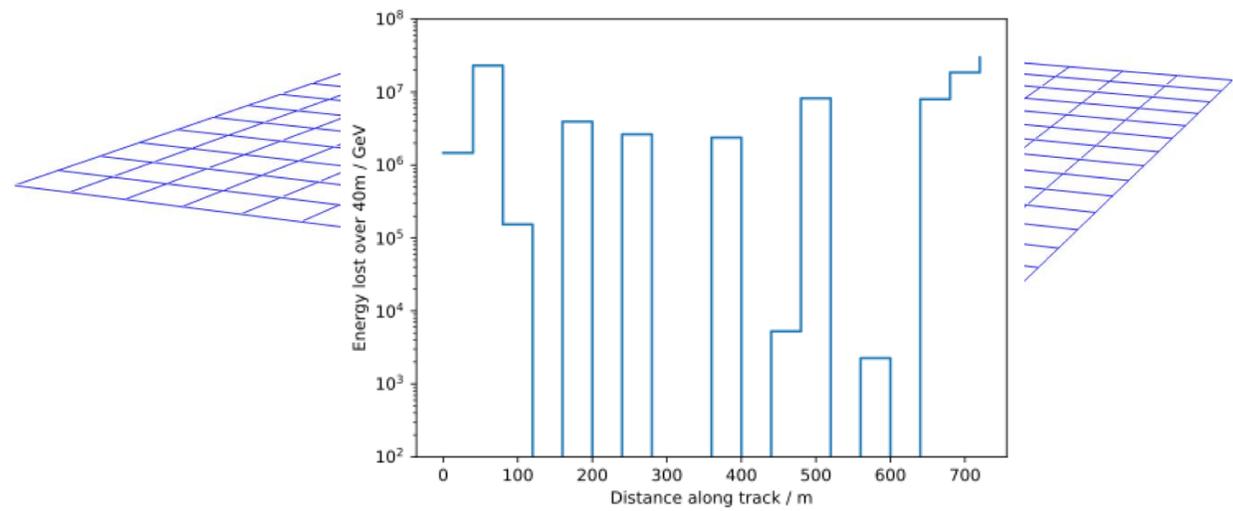
# KM3-230213A: Unexplored energy region



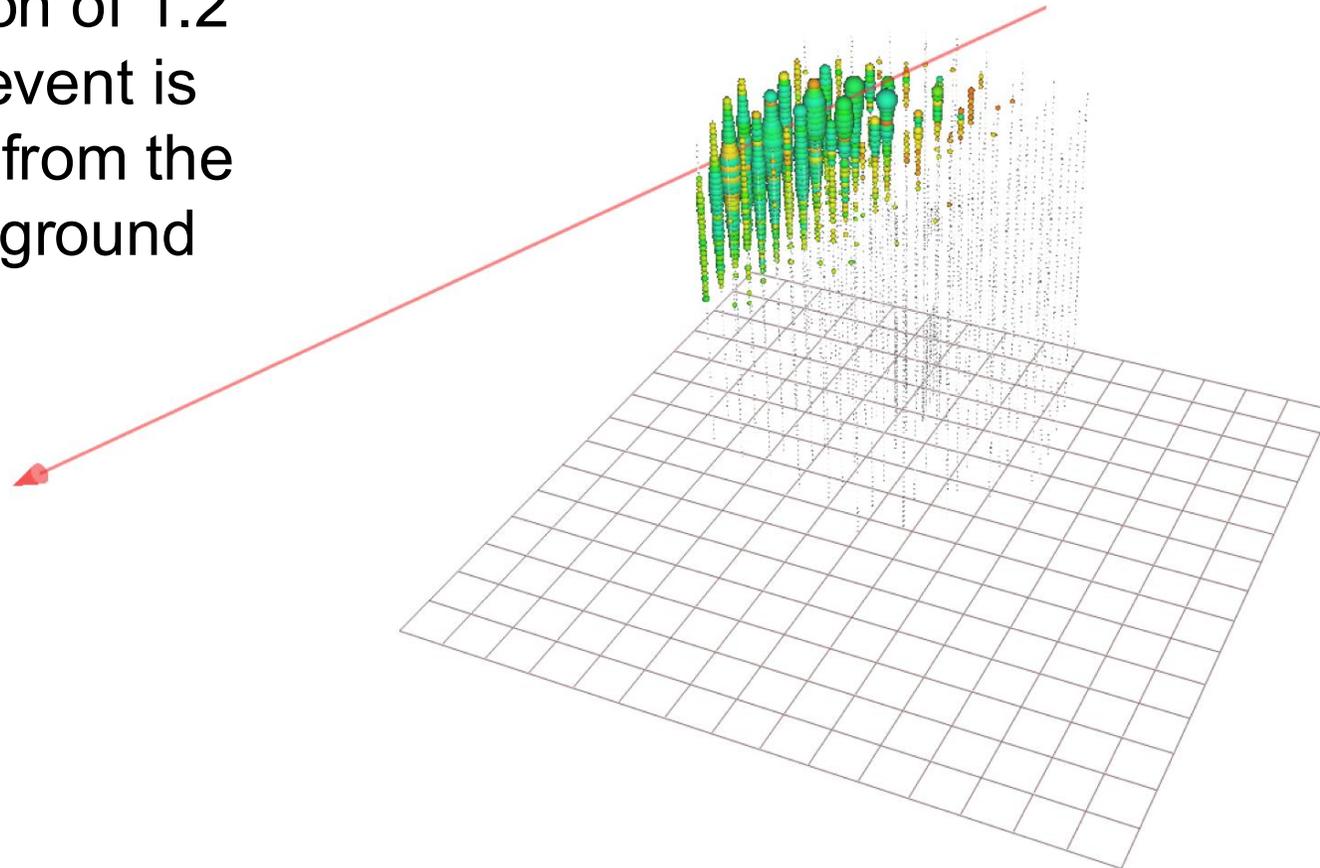
$$E^2 \phi_{\nu} = 5.8 \times 10^{-8} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$



horizontal event  
 $\sim 10^3$  PeV  
IceCube

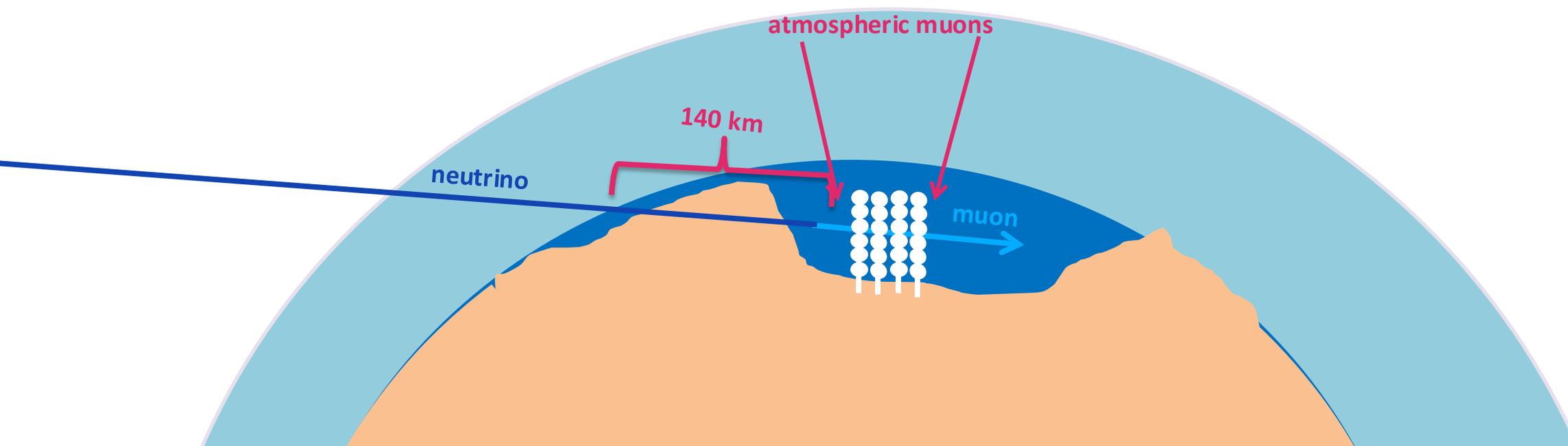
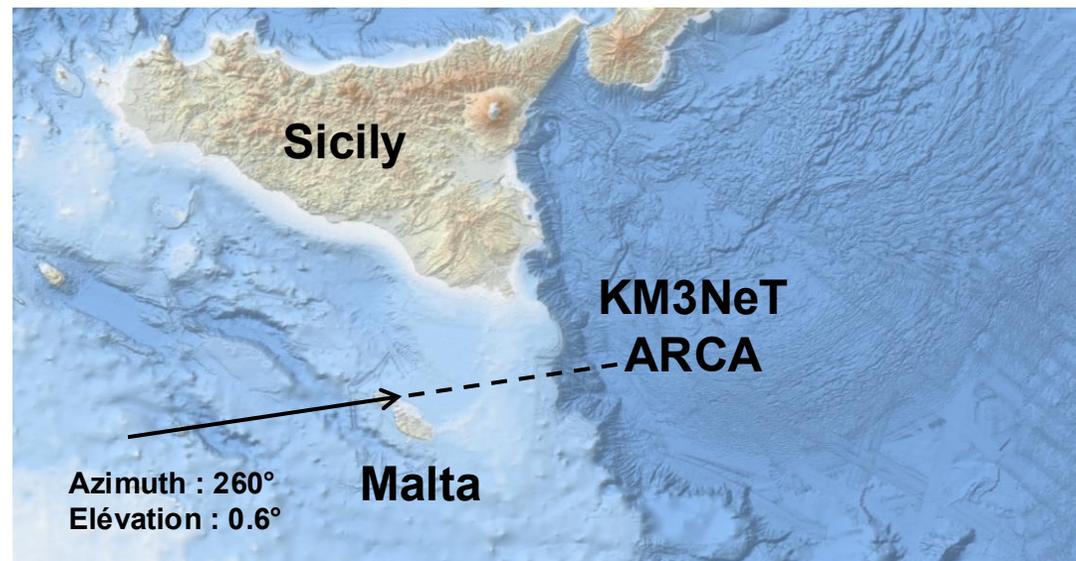


with an angular resolution of 1.2 degrees the KM3NeT event is separated by  $\sim 3$  sigma from the downgoing muon background





# KM3-230213A: A horizontal muon



# IC190331: 5300 TeV deposited inside the detector

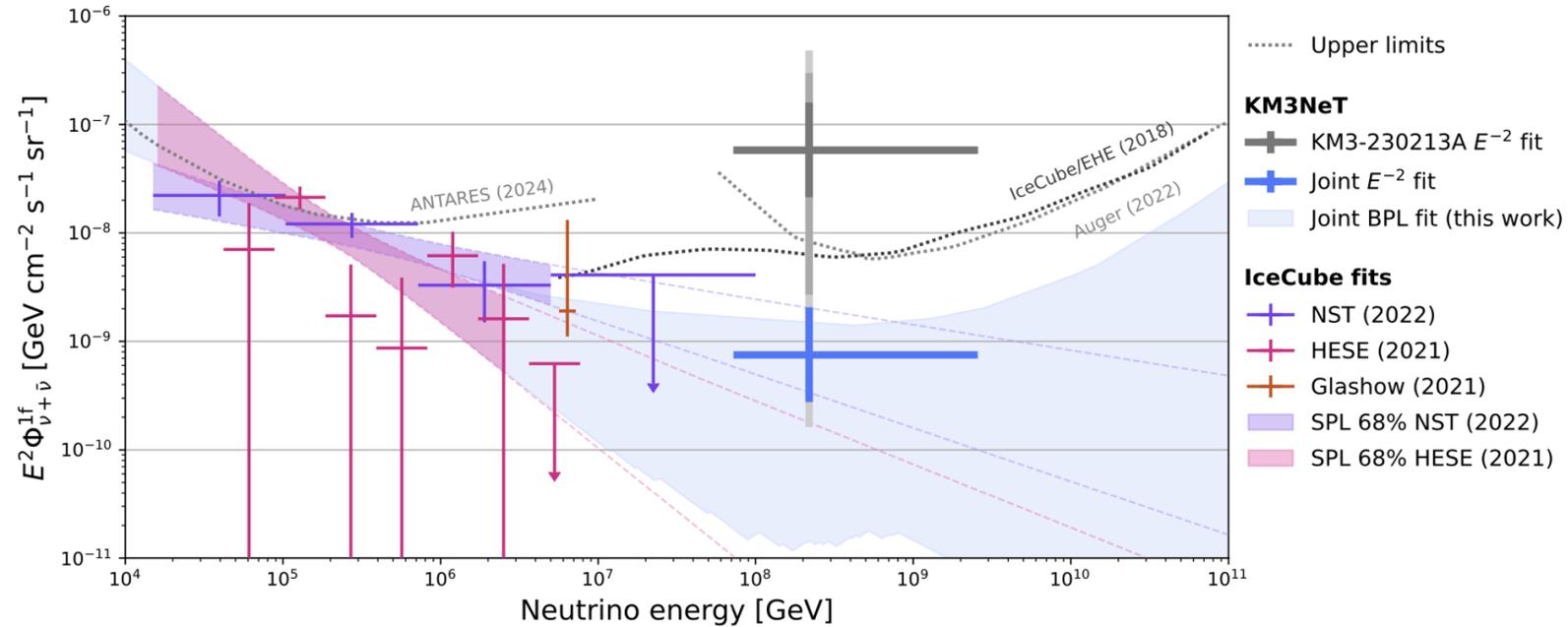
Event 132379/15947448  
Time 2019-03-31 06:55:43 UTC  
Duration 2269967.8 ns



initial neutrino energy 11.4 pm 2.5 PeV



# KM3-230213A: Global fit



Accounting for IceCube & Auger non-observations:

$$E^2 \phi_{\nu} = 5.7 \times 10^{-10} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

Tension at 2.5 sigma level



