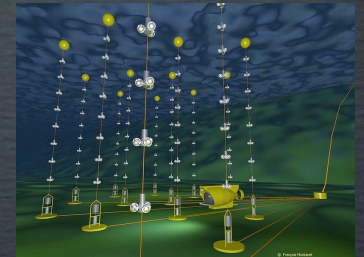


NEIL GEHRELS, SWIFT, AND THE DAWN OF HIGH-ENERGY NEUTRINO ASTRONOMY

DEREK B. FOX
PENN STATE UNIVERSITY

NEIL GEHRELS MEMORIAL SYMPOSIUM
NATIONAL ACADEMY OF SCIENCES
22 MAY 2018



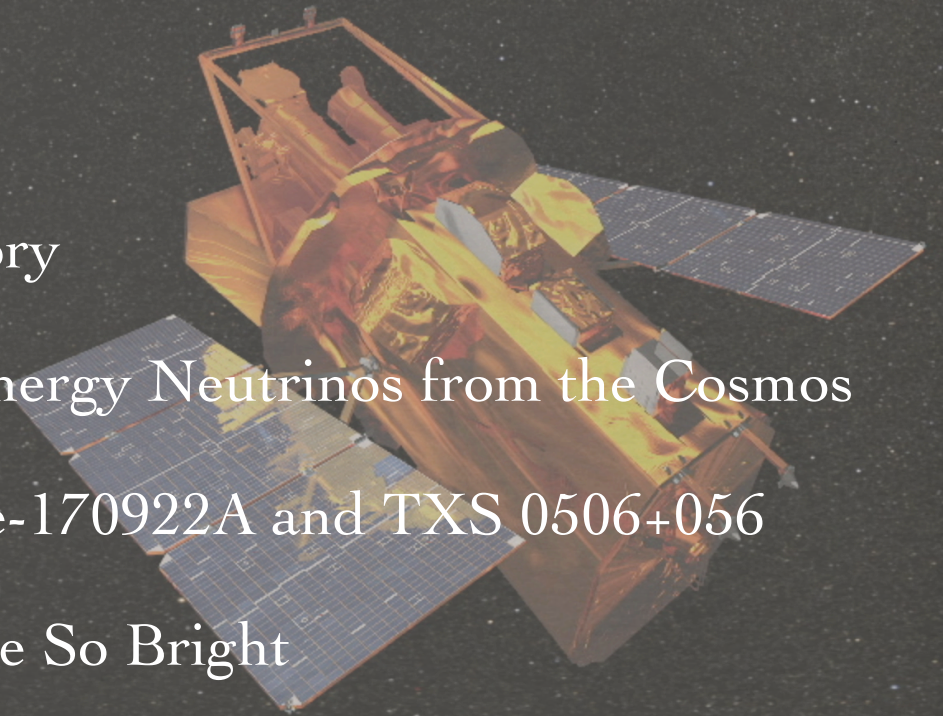


* Prehistory

* High-Energy Neutrinos from the Cosmos

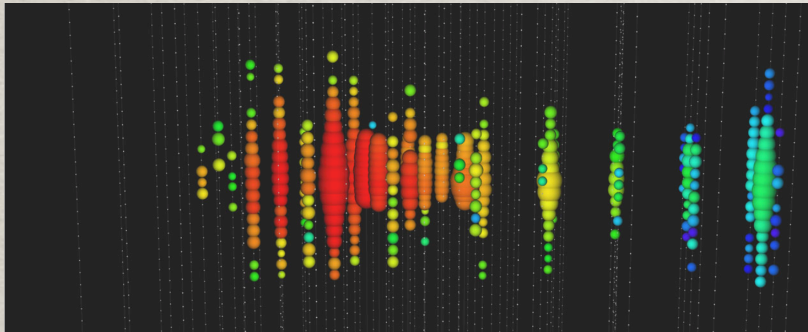
* IceCube-170922A and TXS 0506+056

* A Future So Bright

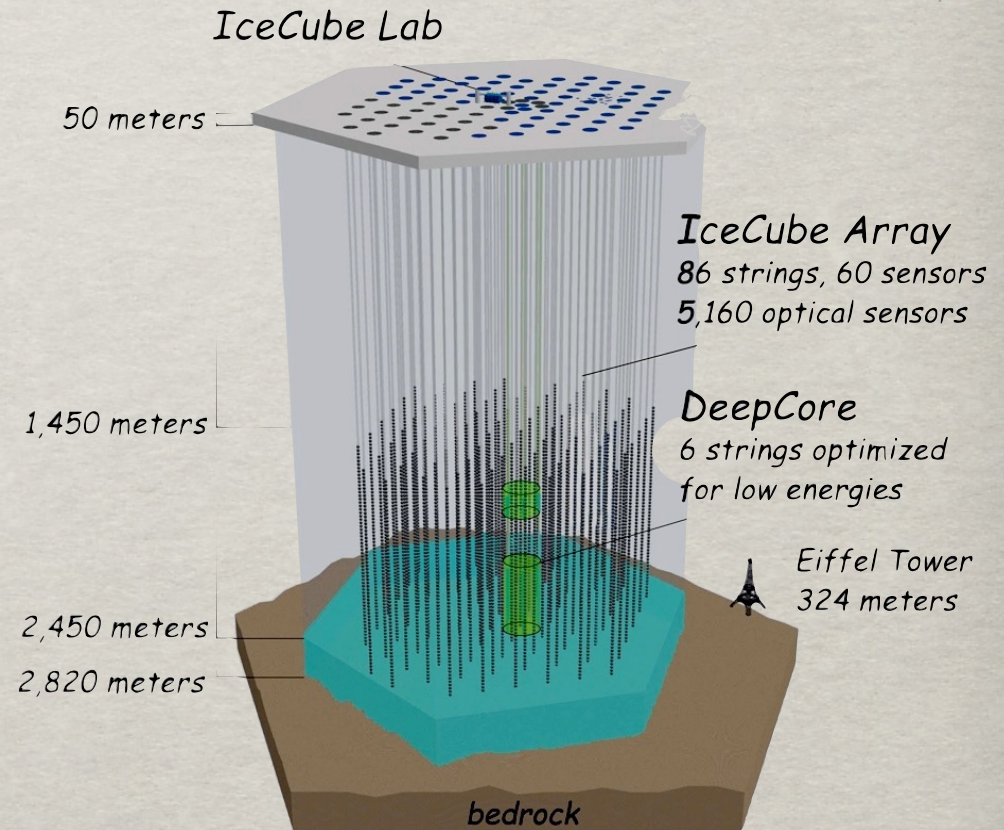
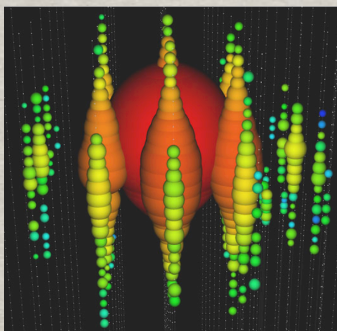


ICECUBENEUTRINO OBSERVATORY

Track $\sim 1^\circ$



Cascade $\sim 15^\circ$

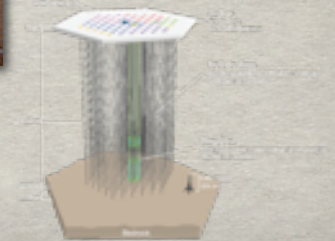
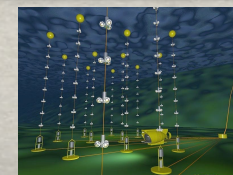
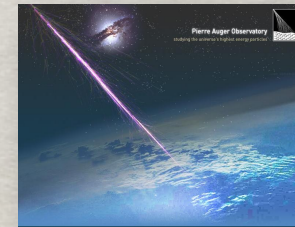


THE AMON IDEA

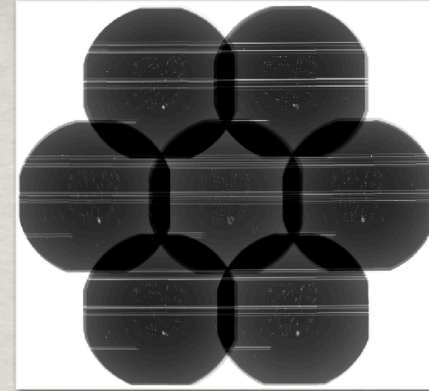
- **Astrophysical Multimessenger Observatory Network:** Multimessenger subthreshold coincidence searches
- **Evoke:** Discovery of transient multimessenger sources
- **Exploit:** Trigger follow-up observations to identify & study counterparts
- **Explore:** Archival analyses in search of multimessenger activity

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AMON

ICECUBE DOUBLET



Monthly Notices

of the
ROYAL ASTRONOMICAL SOCIETY

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doi:10.1093/mnras/stv136

Swift follow-up of IceCube triggers, and implications for the Advanced-LIGO era

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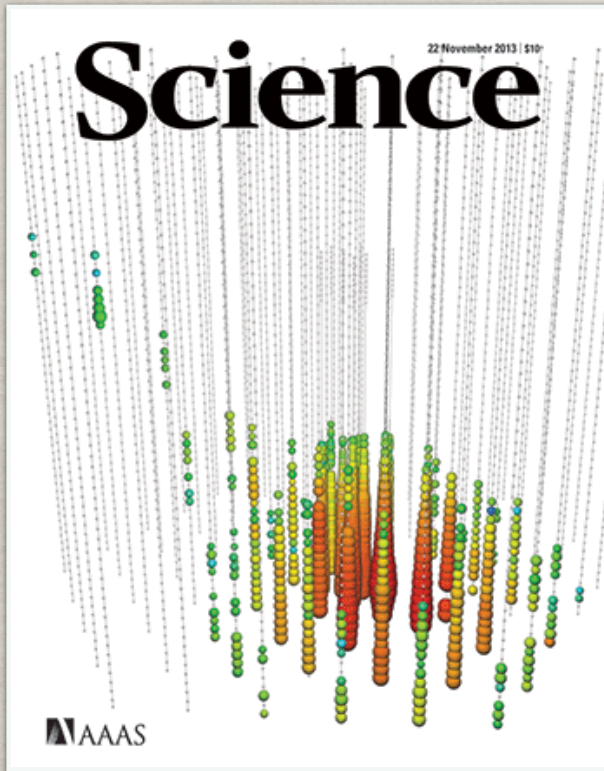
Table 1. Details of the 20 IceCube triggers followed up by *Swift* as of 2014 September 03.

Trigger #	Error radius (50 per cent conf)	Trigger time (UT)	Delay ^a (h)	Tiling type
1	0:7	2011-03-26 21:53:41	1.4	Manual
2	0:7	2011-09-27 12:23:29	7.5	Manual
3	0:3	2011-10-24 02:41:11	10.0	Automatic
4	0:7	2011-12-06 01:40:15	1.7	Automatic
5	1:1	2012-01-17 22:01:34	4.8	Automatic
6	0:5	2012-02-08 00:14:29	1.4	Automatic
7	1:8	2012-03-03 16:47:22	1.2	Automatic
8	0:7	2012-08-29 22:49:59	2.5	Automatic
9	0:9	2012-09-17 18:08:03	1.6	Automatic
10	0:8	2012-10-23 04:46:15	5.7	Automatic
11	0:4	2012-12-21 02:17:24	3.7	Automatic
12	1:4	2013-01-15 11:08:46	1.5	Automatic
13	0:7	2013-02-13 18:47:42	1.9	Automatic
14	1:2	2013-03-08 22:15:49	17.0	Automatic
15	0:9	2013-03-27 19:54:12	1.5	Automatic
16	1:3	2013-05-17 15:57:03	0.7	Automatic
17	0:8	2014-01-08 05:29:08	9.0	Automatic
18	0:7	2014-01-17 04:02:10	1.8	Automatic
19	0:3	2014-02-26 19:04:14	3.2	Automatic
20	0:7	2014-08-29 13:54:49	1.1	Automatic

Note. ^aThe time between the possible neutrino event detected by IceCube and the start of the first observation with the *Swift*-XRT.

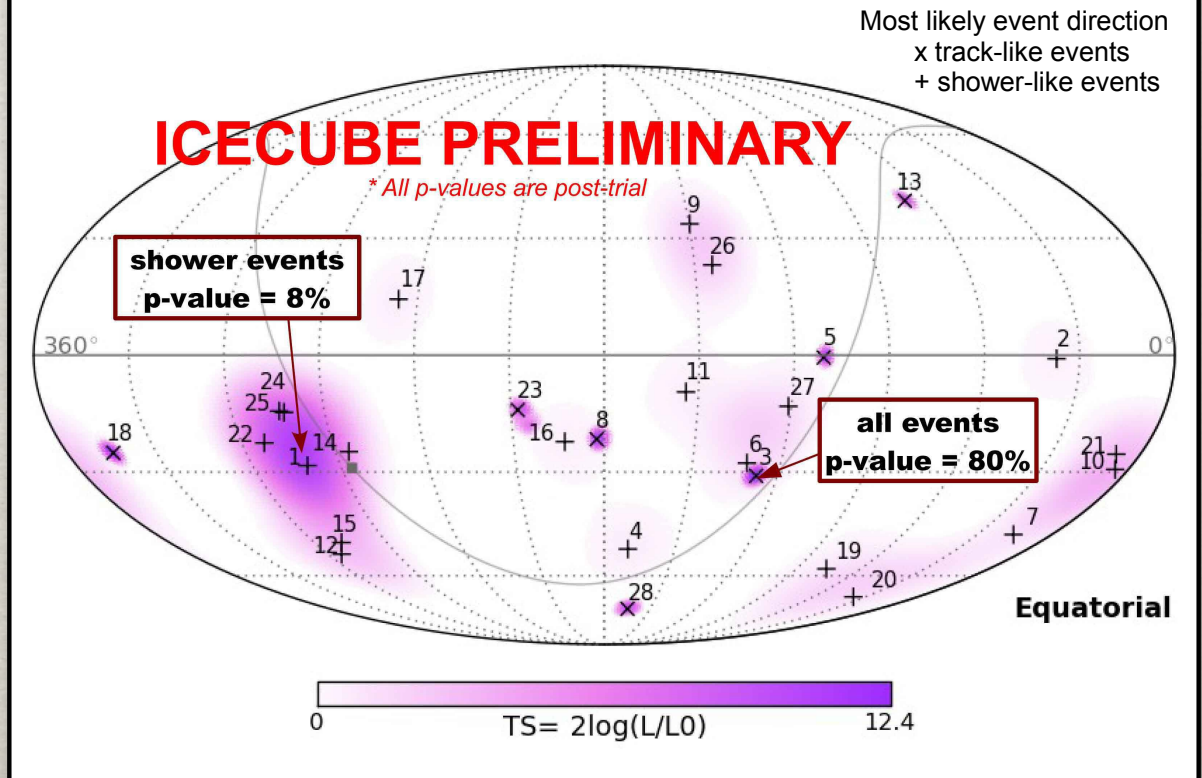
HE NEUTRINOS FROM THE COSMOS

22 Nov 2013



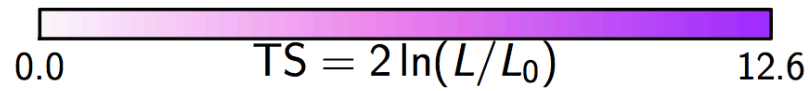
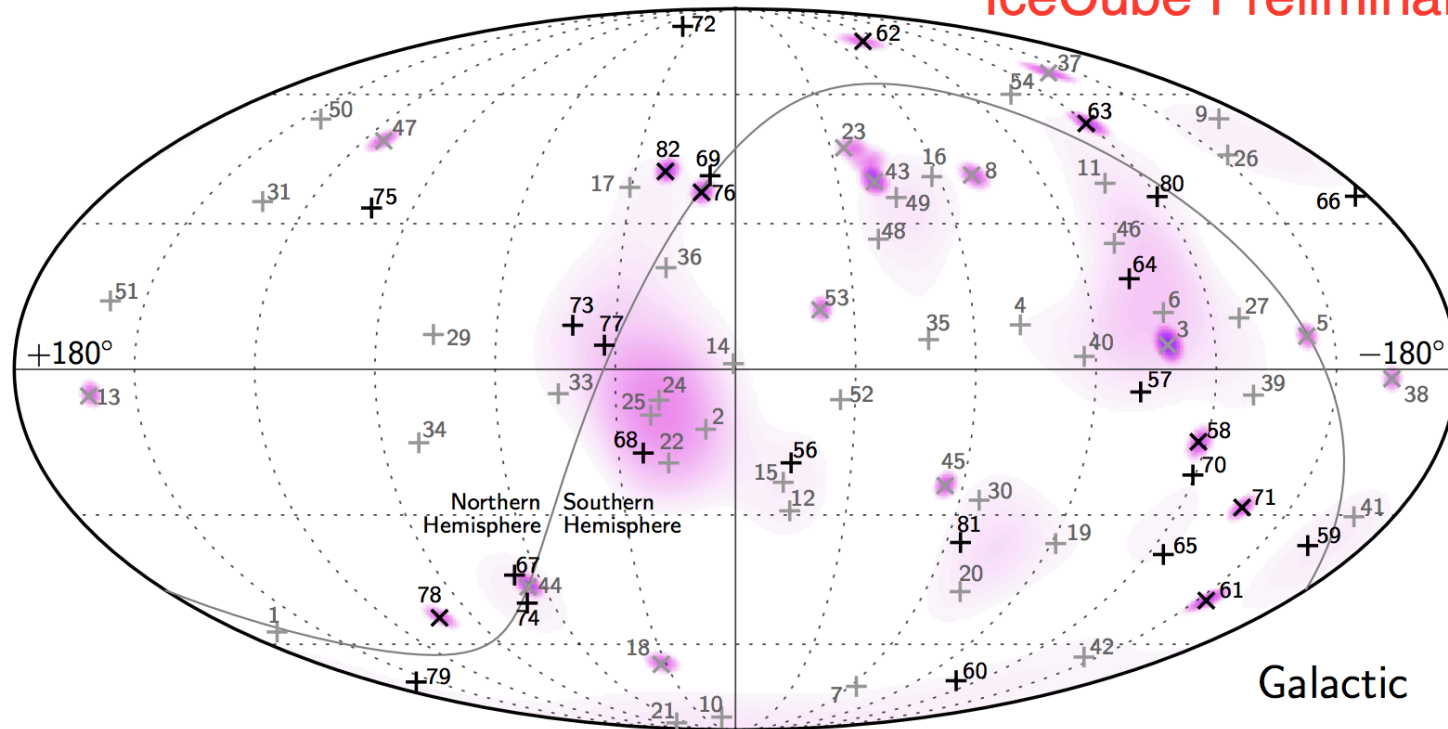
IceCube+13

Resulting Test Statistic Map



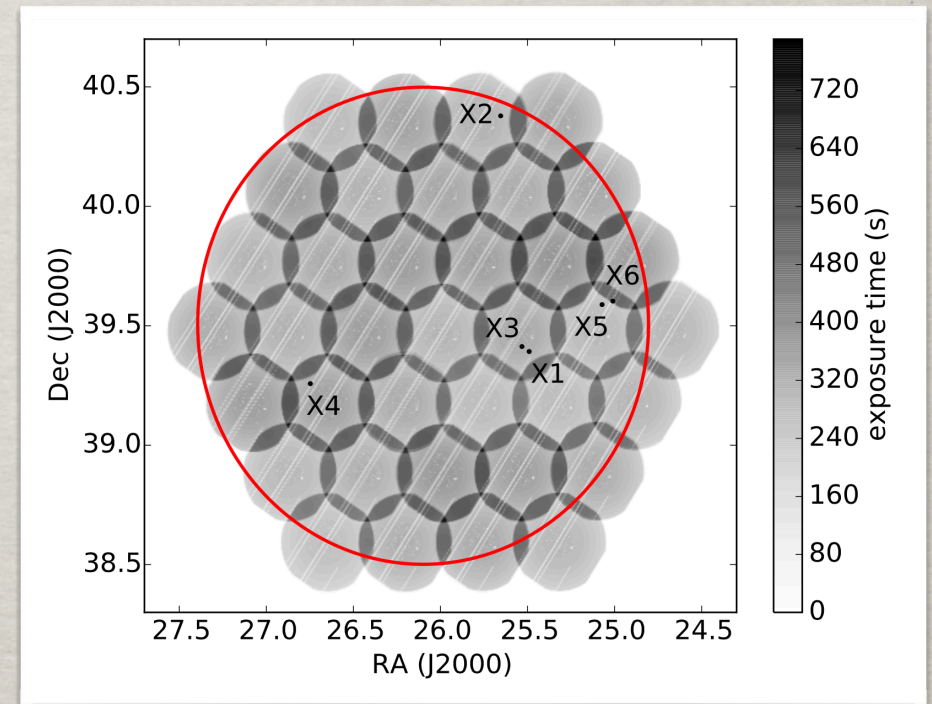
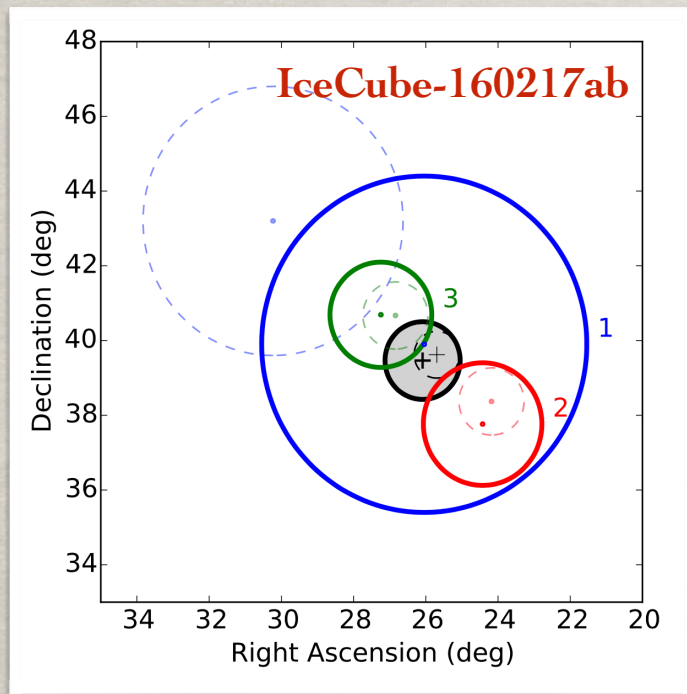
NEUTRINO ASTRONOMY

IceCube Preliminary



IceCube+17

A NEUTRINO MULTIPLER



Multiwavelength Follow-Up of a Rare IceCube Neutrino Multiplet

IceCube, **AMON** et al. 2017, A&A, 607, 115

Corresponding author: N. L. Strotjohann

LIKELY-COSMIC SWIFT NEUTRINO CAMPAIGNS



A. Keivani & AMON 2017

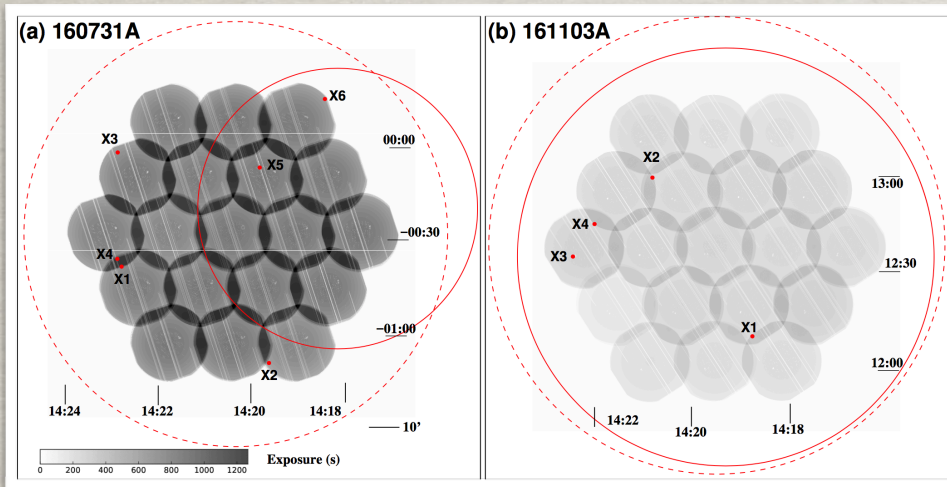
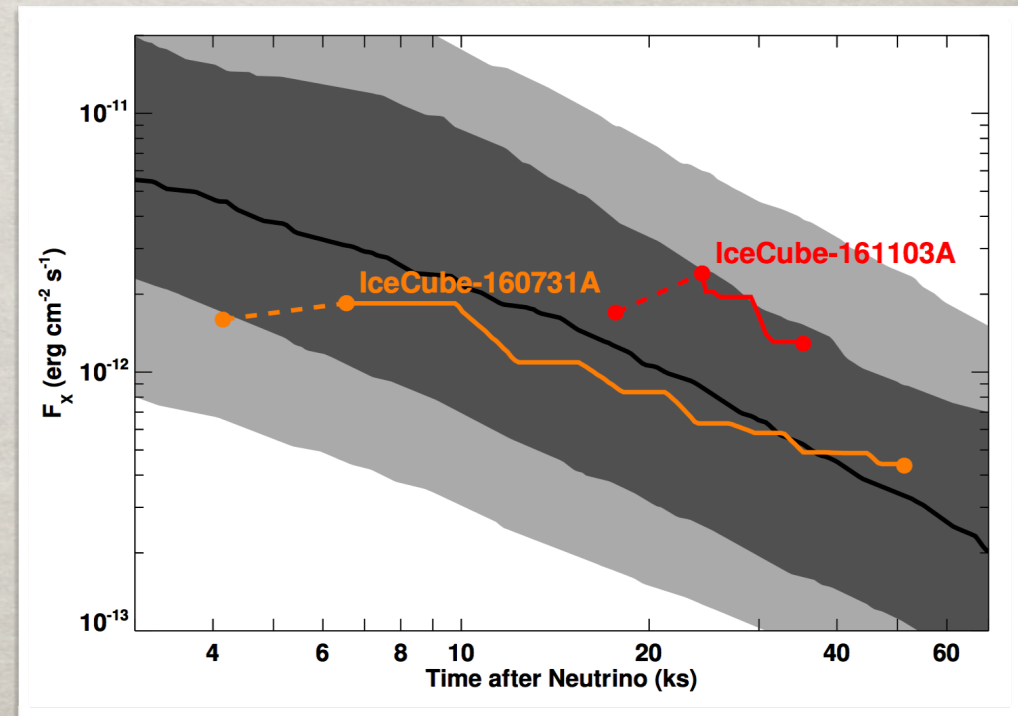
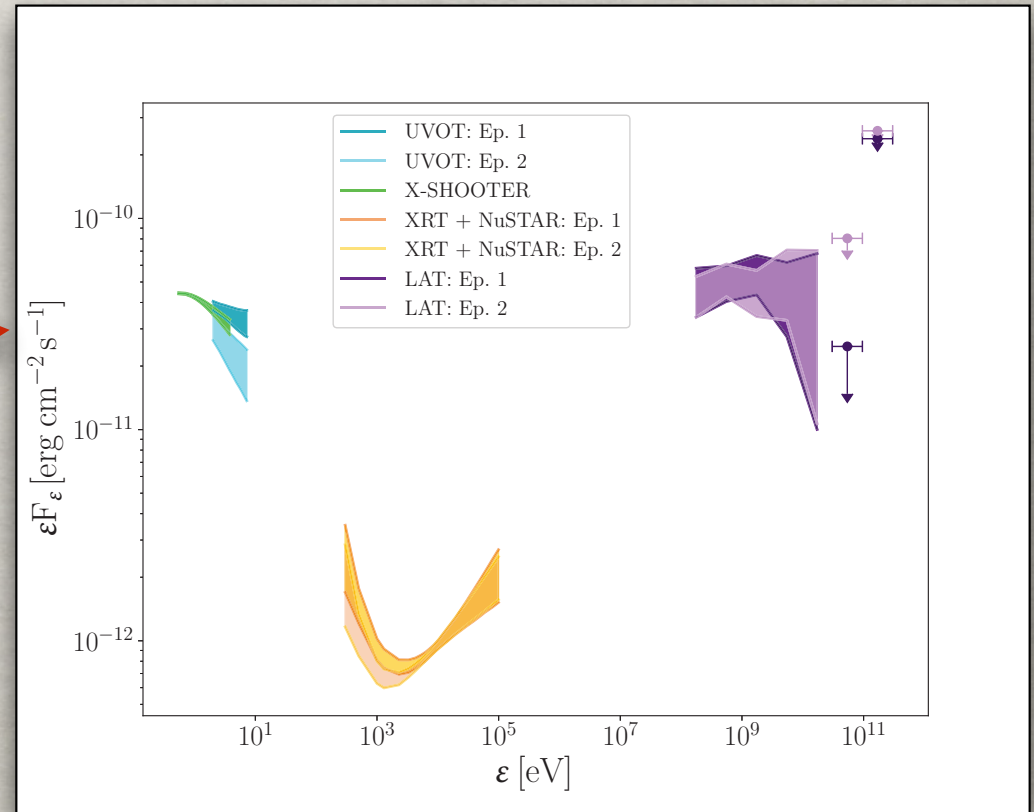
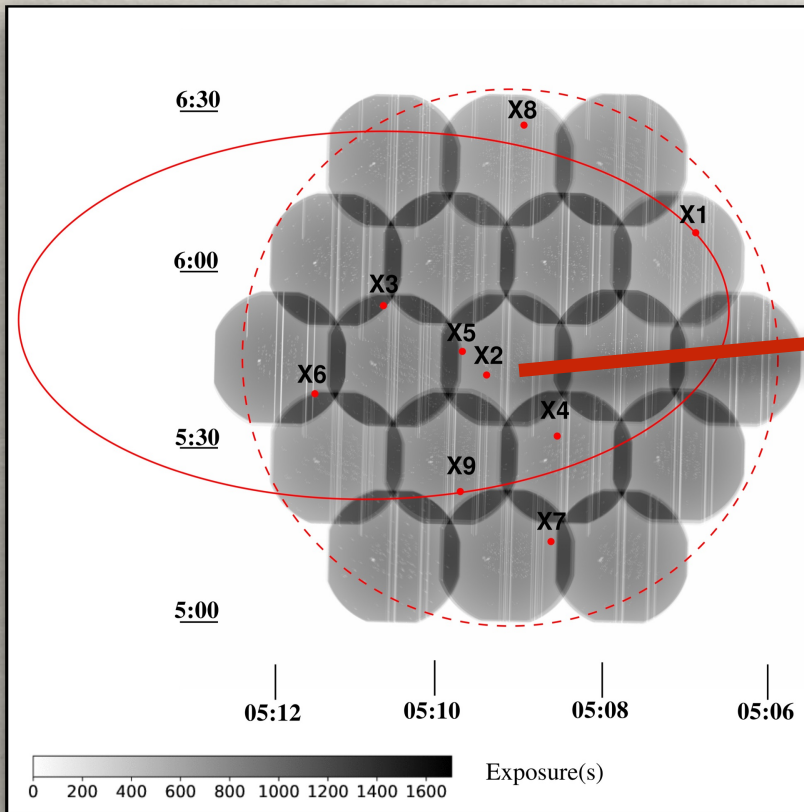


Table 3. Characteristic Probabilities for Neutrino Follow-Up Campaigns

Event	p_S	$p_{\Omega, X}$	$p_{\Delta t, X}$	p_{total}
IceCube-160731A	91%	64%	65%	38%
IceCube-161103A	30%	68%	30%	6%



ICECUBE 170922A AND TXS 0506+056



A. Keivani & AMON 2018

MULTIMESSENGER MODELING OF TXS 0506+056

Eked out ~0.01 IceCube event!



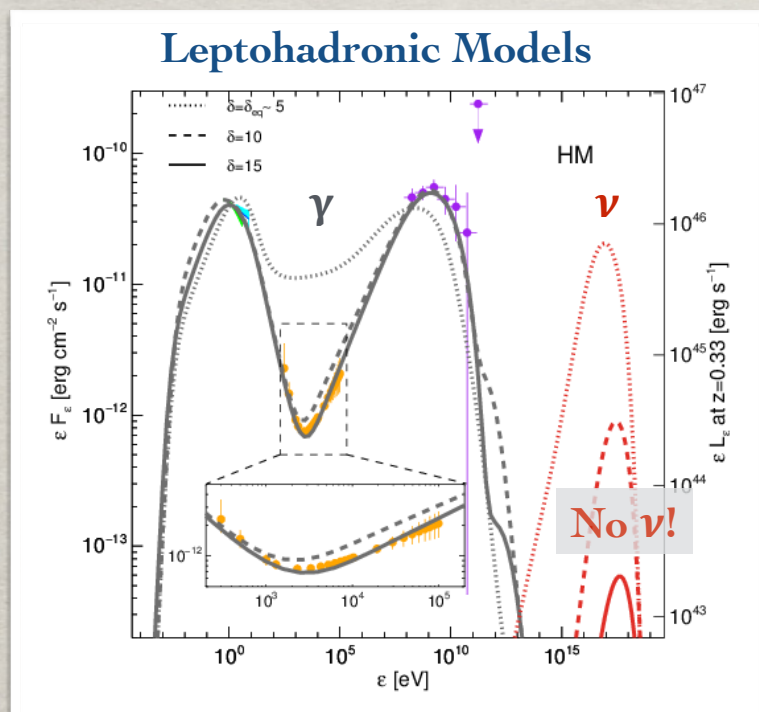
A. Keivani



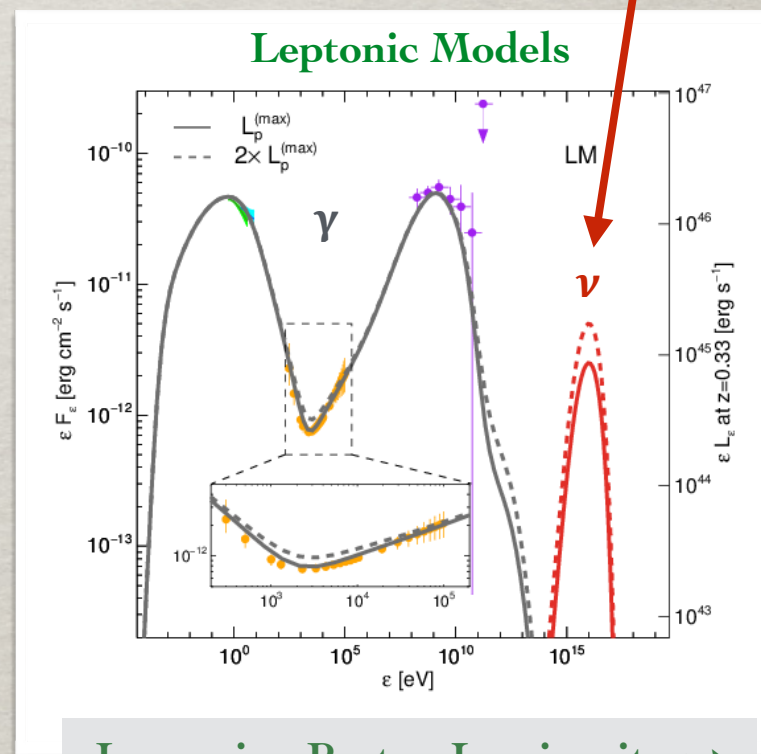
K. Murase



M. Petropoulou
+ DBF, et al.



Decreasing Doppler Factor \rightarrow
Increasing Neutrino Luminosity +
X-rays (Swift+NuSTAR)



Increasing Proton Luminosity \rightarrow
Increasing Neutrino Luminosity +
X-rays (Swift+NuSTAR)

A FUTURE SO BRIGHT...

1. *Swift* responds to multimessenger alerts
2. *Swift* contributes to first likely source identification for a high-energy neutrino
3. *Swift* yields crucial constraints on neutrino production and cosmic ray acceleration

THANK YOU, NEIL
THANK YOU, ELLEN