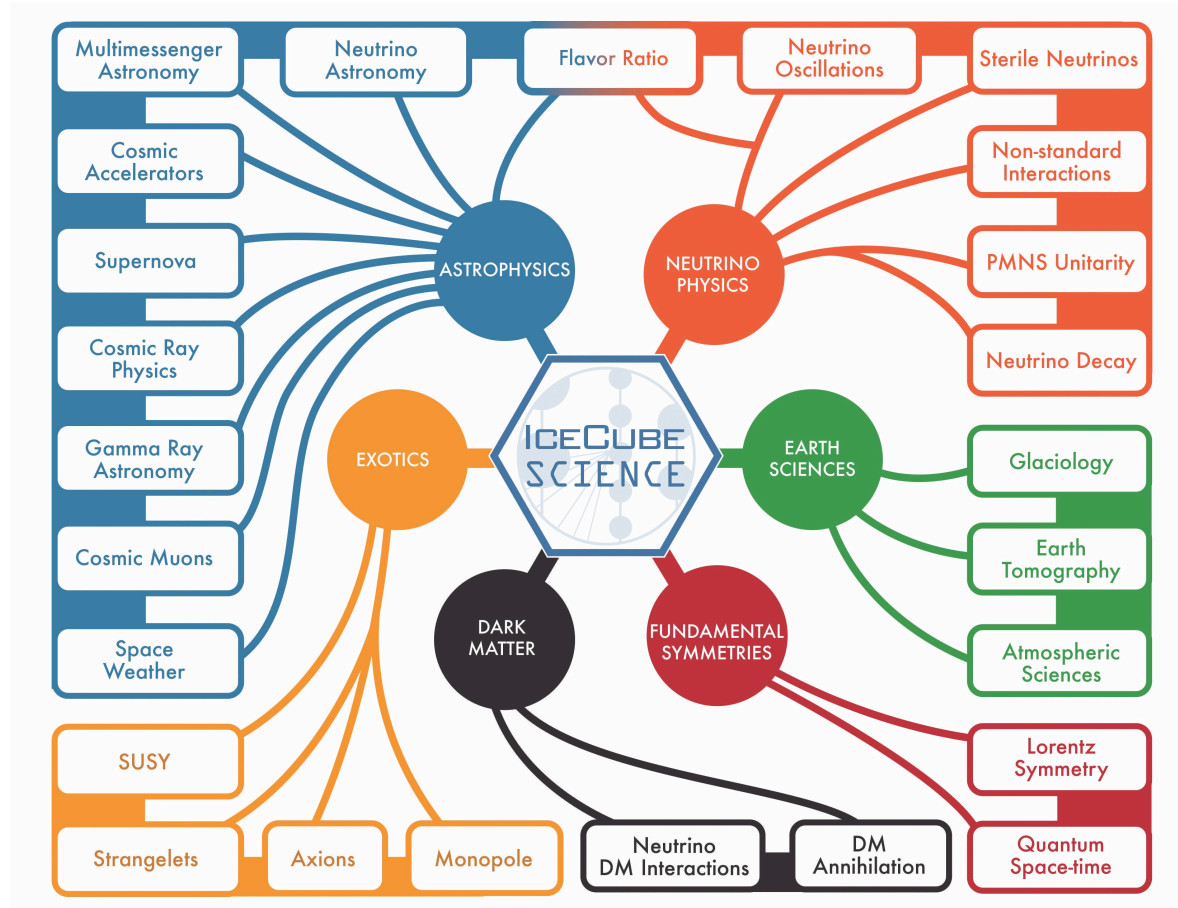


Analysis Coordination and Publications

Dawn Williams

Maintenance and Operations Mid-term Panel Review

Deliverable: high quality science results for publication/presentation, across many areas of neutrino physics and astrophysics.



Interface between M&O and Analysis

Data Storage/Preparation

Data Warehouse

Filtering Scripts
Level 1, Level 2

Simulation Mass
Production

Technical Working Groups

Calibration

Systematics
Reconstruction

Realtime

Reorganized in 2018

Physics Analysis Working Groups

Diffuse/Atmospheric

Neutrino Sources

Beyond
Standard Model

Oscillation

Supernova

Cosmic Rays

M&O delivers level 2 filtered data in the northern hemisphere, large scale simulated data in the same format as real data, calibration constants

Analysis working groups deliver high-level physics results for presentation and conferences and for publication

New WG structure as of 2018


Main motivations:

1. Consolidating topics
2. Improving communication between working groups on systematics
3. Moving some technical tasks out of overburdened working groups

Analysis WG	Convenor(s)
Diffuse	Claudio Kopper (MSU), Nathan Whitehorn (UCLA)
Neutrino Sources	Markus Ahlers (NBI), Ignacio Taboada (GA Tech)
Beyond Standard Model	Carsten Rott (SKKU), Anna Pollman (Wuppertal)
Cosmic Rays	Kath Rawlins (U. Alaska), Dennis Soldin (U. Delaware)
Oscillation	Juan Pablo Yanez (U. Alberta), Tom Stuttard (NBI)
Supernova	Lutz Koepke (Mainz), Segev BenZvi (Rochester)

Technical WG	Convenor(s)
Realtime	Erik Blaufuss (U. Maryland)
Calibration	Summer Blot (DESY Zeuthen), Keiichi Mase (Chiba)
Systematics and Reconstruction	Joshua Hignight (U. Alberta), Jakob Van Santen (DESY Zeuthen), Juanan Aguilar (ULB)
Systematics Coordinator	Nathan Whitehorn (UCLA)

Working group technical personnel

Role/Area	Tech Lead	Affiliation	Data Curator	Affiliation	Current Datasets
Neutrino Sources WG	Joshua Wood	UW-Madison	Liz Friedman 	UMD	Nu Sources Datasets
Oscillations WG	Philipp Eller	PSU			
Diffuse WG	Lu Lu	Chiba U.			
Cosmic Rays WG	Katherine Rawlins	U. Alaska			
Beyond Standard Model WG	Carlos Argüelles	MIT			

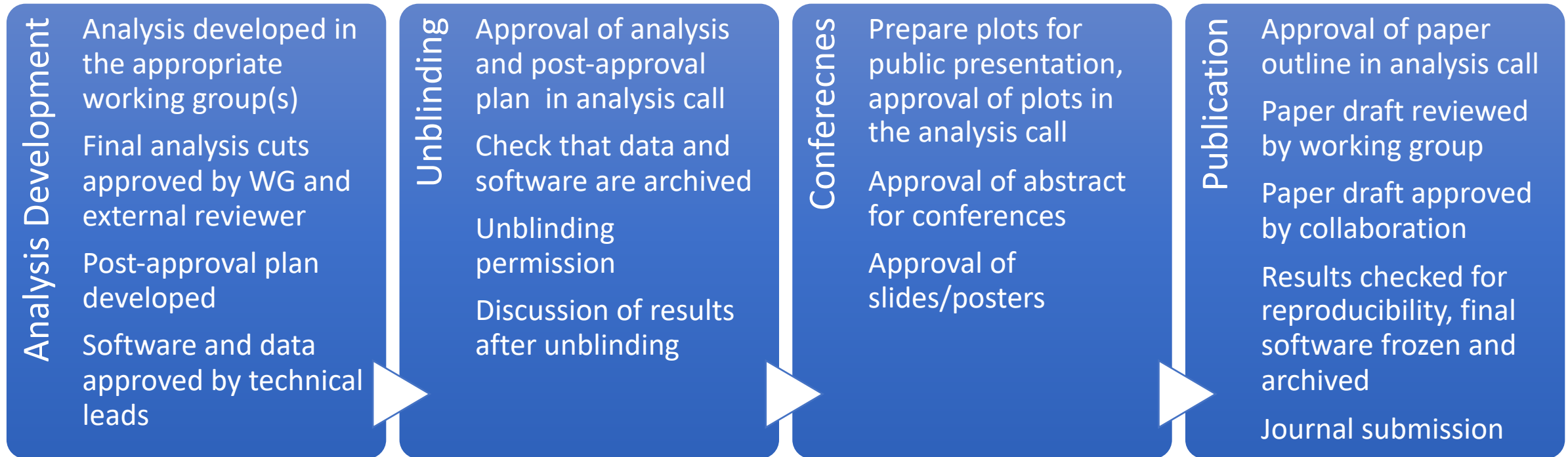
Physics analysis organization

- Physics working groups have weekly or bi-weekly teleconferences
- Most working groups also use dedicated Slack channels in between calls
- Weekly plenary “Analysis call” teleconference

IceCube Physics WG Analysis Products

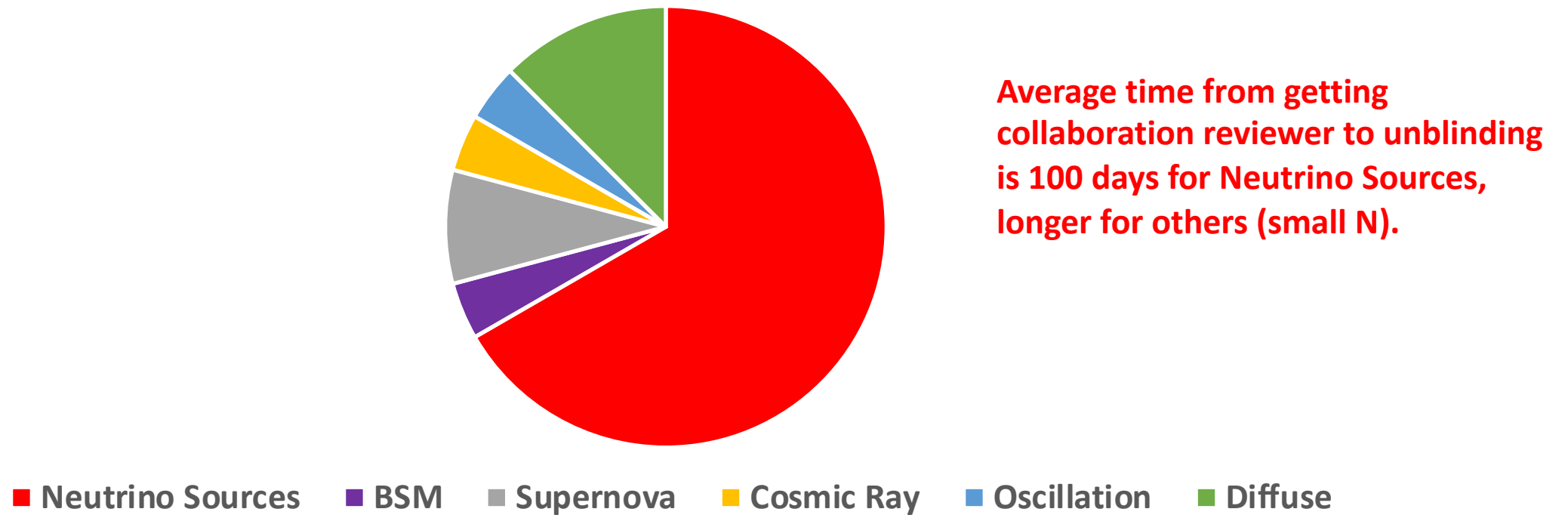
- High level data sets
 - L2 data (see B. Riedel's talk) is dominated by cosmic ray muons, background for most analyses outside of cosmic rays
 - Physics working groups produce signal-rich sets suitable for high level physics analysis and public release
 - Most high level data sets are used in multiple analyses
- Software
 - Core M&O software handles common filtering and reconstruction and simulation tasks
 - Physics working groups develop high level specialized analysis software, common software packages
 - Example: Skylab likelihood software for Neutrino Sources analyses
- Documentation
 - All analyses are required to produce documentation which is reviewed by the physics working group and by the collaboration, including archiving data samples and software
- Ultimately, conference presentations and refereed publications

Typical Analysis review cycle

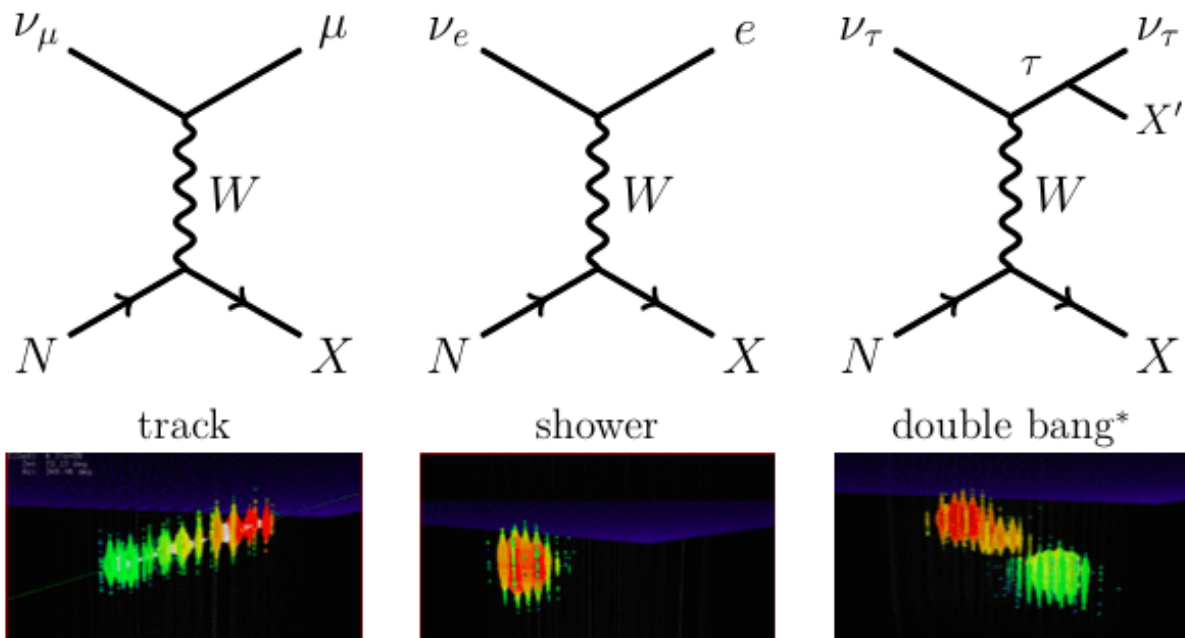


Analysis coordination metric: time to unblinding

Analyses That Entered Review and Were Unblinded in the Last Year



Neutrino signatures in IceCube

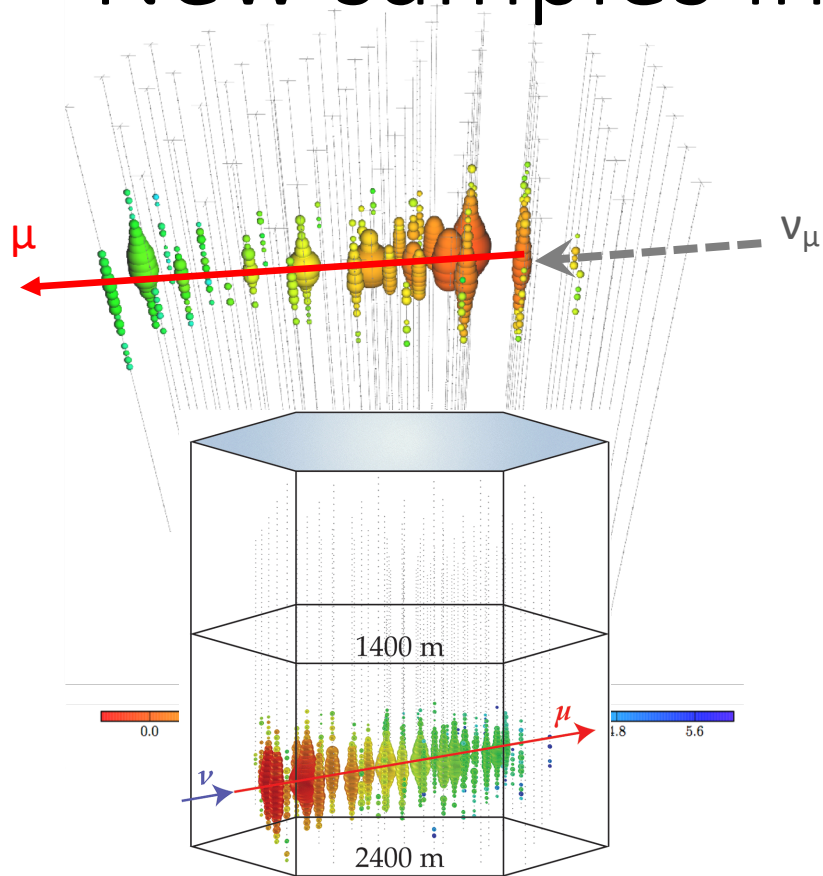


Red = early
Blue = late
Larger = more charge

Double bang signature only resolved in IceCube above 100 TeV energy

A shower is also seen for all flavor neutral current events

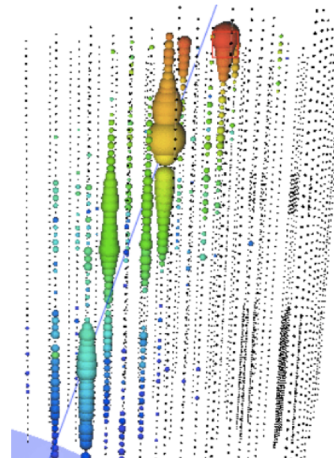
New samples in progress



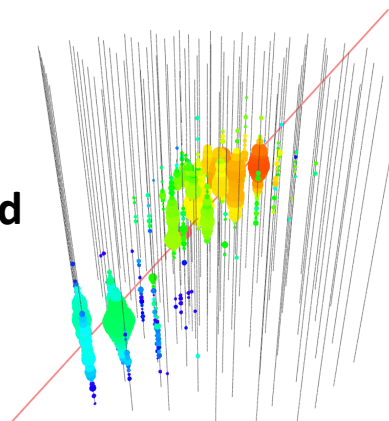
Samples used in astrophysical neutrino studies have been mainly starting and/or upgoing events, and have used track or cascade topology

New samples are pushing to higher energies, more complex topologies and the southern hemisphere.

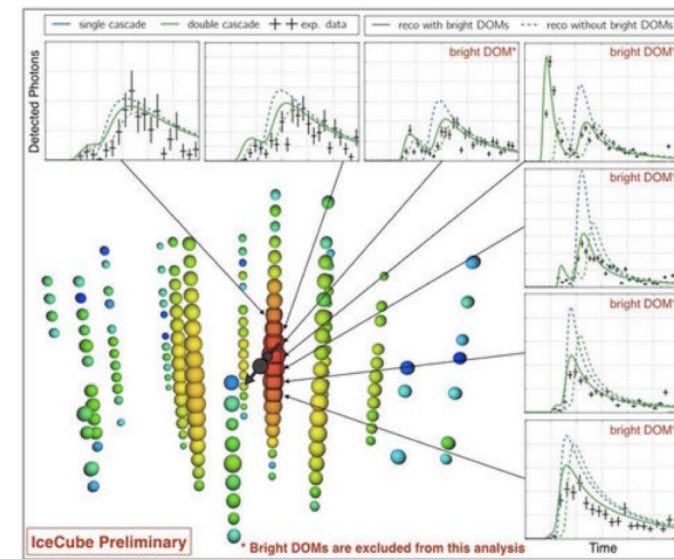
Downgoing uncontained muons



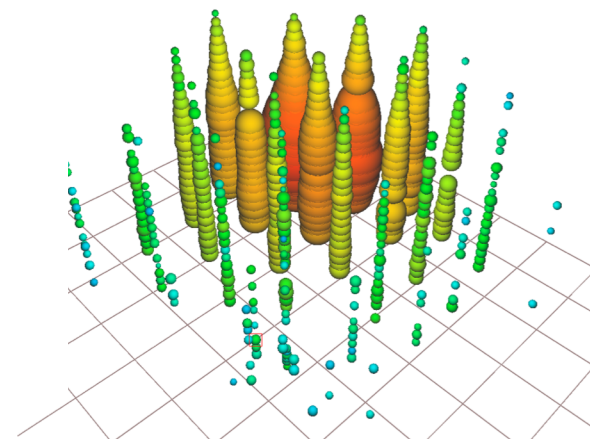
Lower energy contained muons



Tau Double cascades



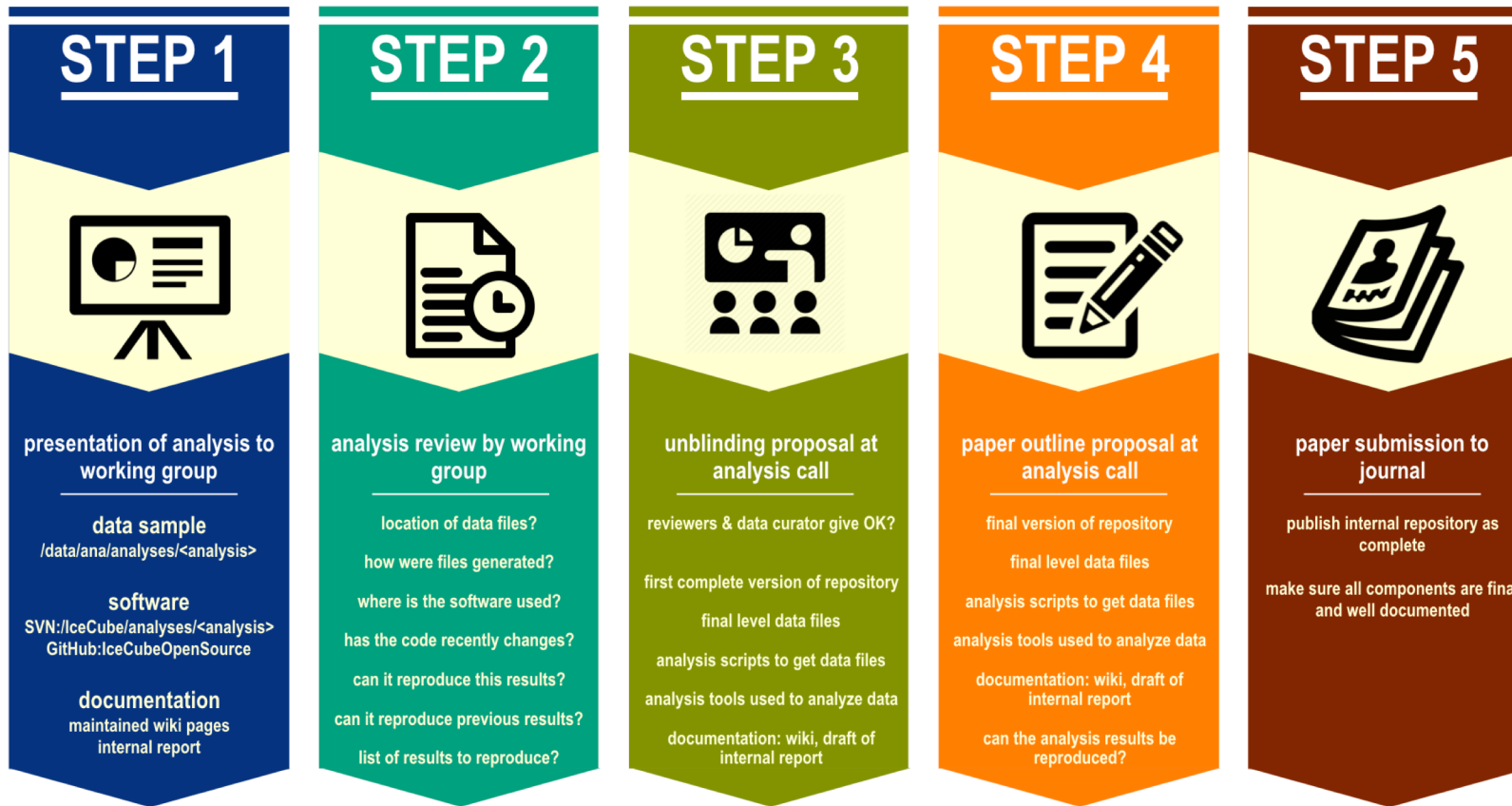
Partially contained cascades



Internal data release protocol

- For unblinding, **data sample** must be in the data warehouse and **software** (analysis scripts beyond core software) must be in SVN or GitHub, **documentation** must be complete
- Technical coordinator/data curator of analysis WG must sign off on this
- For publication, higher threshold: analysis must be able to be reproduced. This is only reproduction of high level results, not reproduction of all data processing

Internal data release protocol

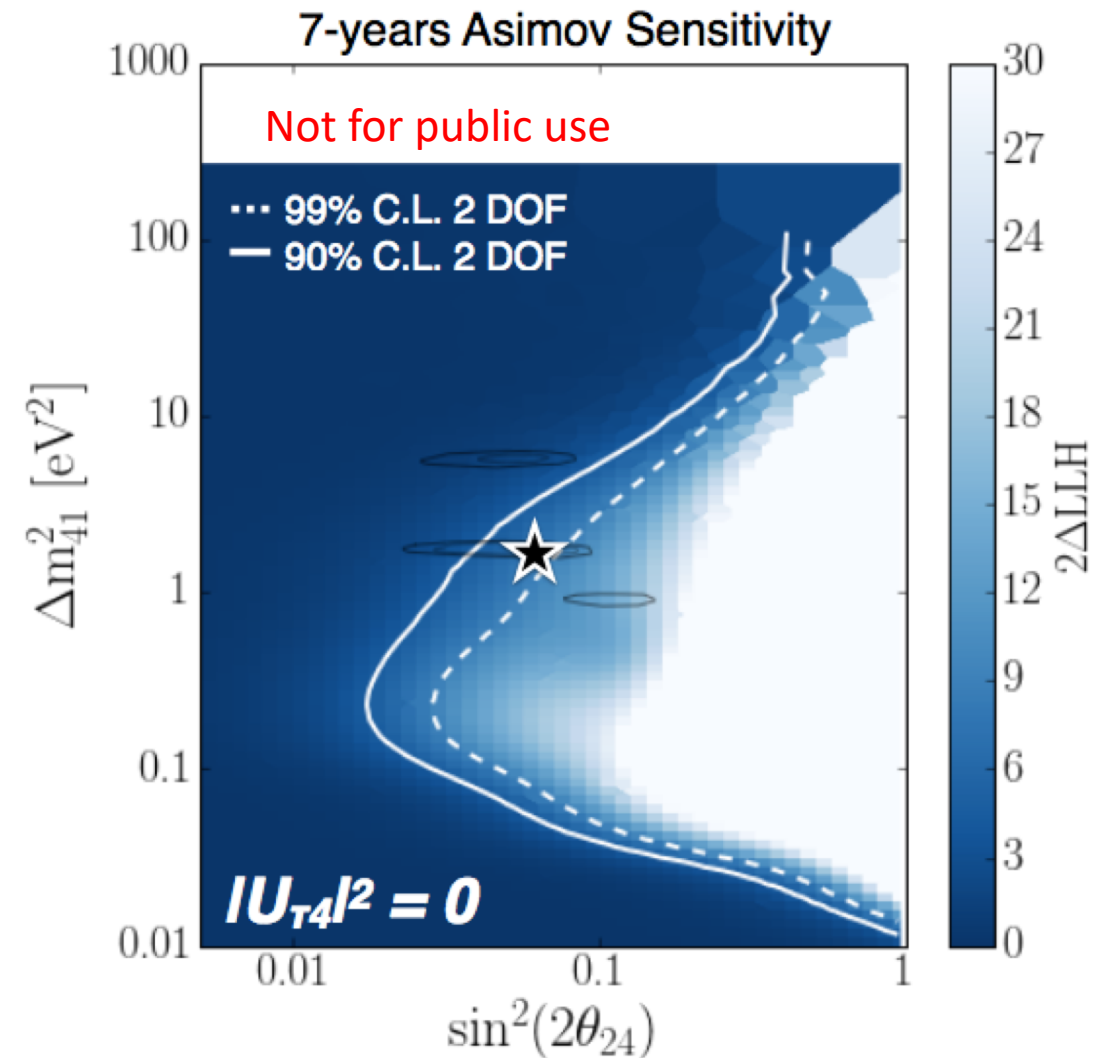


External data releases

- Text format data release of 3 years of tracks in October
- Looking into next generation of data releases: supporting versions, different types of data sets, database functionality
- A data release task force has been convened to look into this
- Possible solutions being investigated include High Energy Astrophysics Archive for NASA (HEASARC) and Italian Space Energy Space Science Data Center
 - We are in initial discussions with HEASARC, led by Marcos Santander at U. Alabama

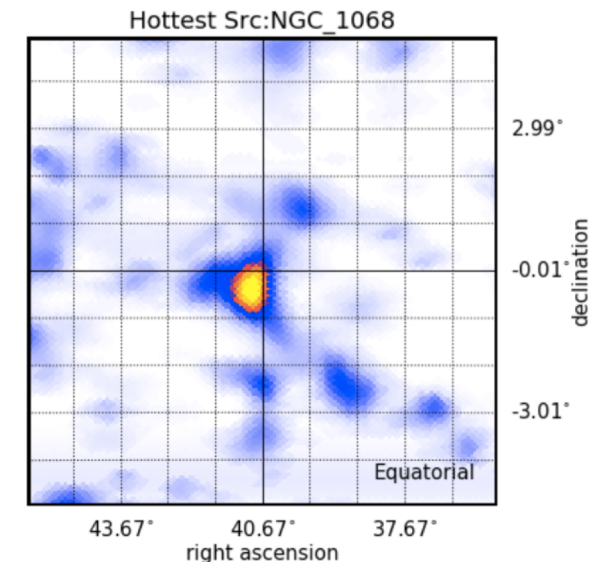
Selected Analyses on the horizon

- Multi-flare blazar search and many more multimessenger and realtime campaigns
- Lower energy starting tracks from Southern Hemisphere
- Updated sterile neutrino analysis
- OscNext oscillation analysis
- Global fit of multiple diffuse neutrino data samples



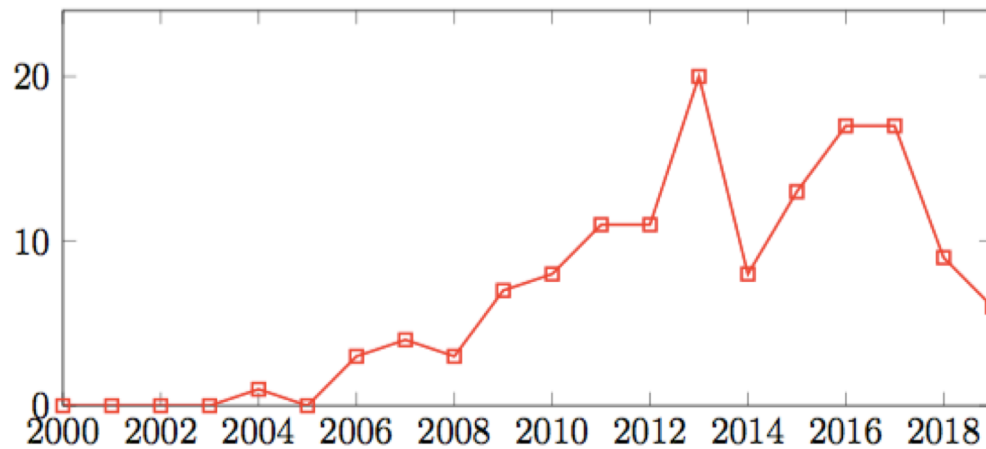
M77 (NGC 1068)

- Recent result: combined muon sample with updated catalog, showed a warm spot near M77, 2.9σ
- Result communicated as preliminary to MOU partners, promptly due to the source leaving FOV of air Cherenkov observatories soon
- Private communication based on time integrated result, not public release or realtime
- Publication in progress

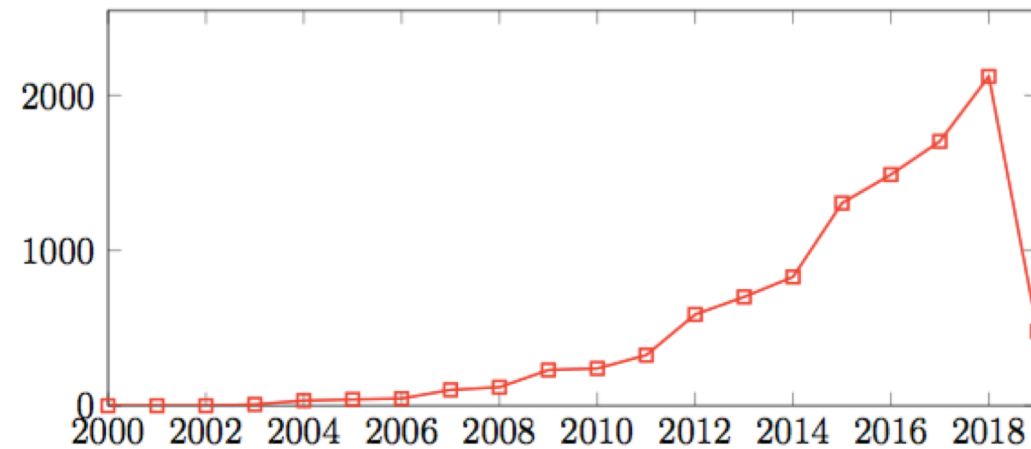


Publications summary

published papers



citations (no self-cit.)



Publications committee chaired by Markus Ackerman (DESY Zeuthen)

Members: Juan Antonio Aguilar, Jenni Adams, Segev BenZvi, Doug Cowen, Chad Finley, Jason Koskinen, Carsten Rott, Subir Sarkar, David Seckel, Darren Grant (ex-officio), Dawn Williams (ex-officio)

Publications summary

Top 10 in none self-citations in 2018/2019:

Title	Journal	# cit.
Multi-messenger Observations of a Binary Neutron Star Merger	Astrophys.J. (2017)	576
Evidence for High-Energy Extraterrestrial Neutrinos at the IceCube Detector	Science (2013)	157
Observation of High-Energy Astrophysical Neutrinos in Three Years of IceCube Data	Phys.Rev.Lett. (2014)	150
Observation and Characterization of a Cosmic Muon Neutrino Flux from the Northern Hemisphere using six years of IceCube data	Astrophys.J. (2016)	100
First observation of PeV-energy neutrinos with IceCube	Phys.Rev.Lett. (2013)	85
A combined maximum-likelihood analysis of the high-energy astrophysical neutrino flux measured with IceCube	Astrophys.J. (2015)	80
Neutrino emission from the direction of the blazar TXS 0506+056 prior to the IceCube-170922A alert	Science (2018)	68
Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A	Science (2018)	59
Searches for Sterile Neutrinos with the IceCube Detector	Phys.Rev.Lett. (2016)	56
Evidence for Astrophysical Muon Neutrinos from the Northern Sky with IceCube	Phys.Rev.Lett. (2015)	51

Just published!

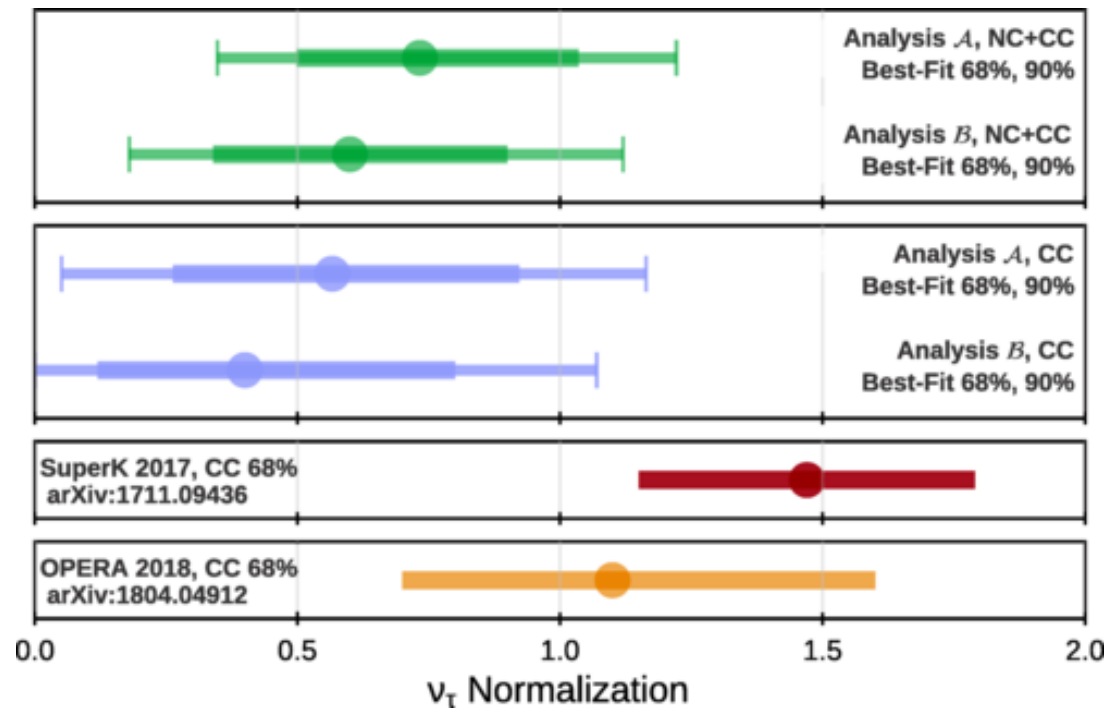
PHYSICAL REVIEW D
covering particles, fields, gravitation, and cosmology

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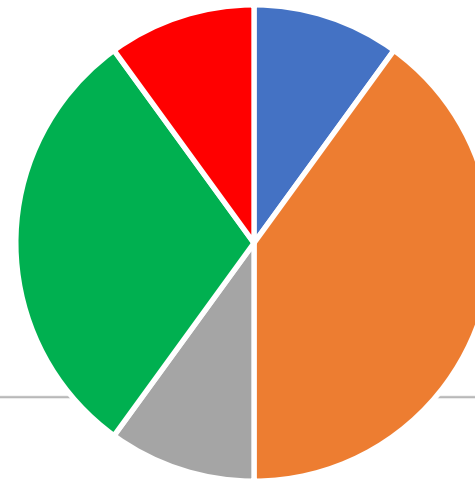
Measurement of atmospheric tau neutrino appearance with IceCube DeepCore

M. G. Aartsen *et al.* (IceCube Collaboration)
 Phys. Rev. D **99**, 032007 – Published 15 February 2019



Papers in Progress

Papers in Progress By Working Group



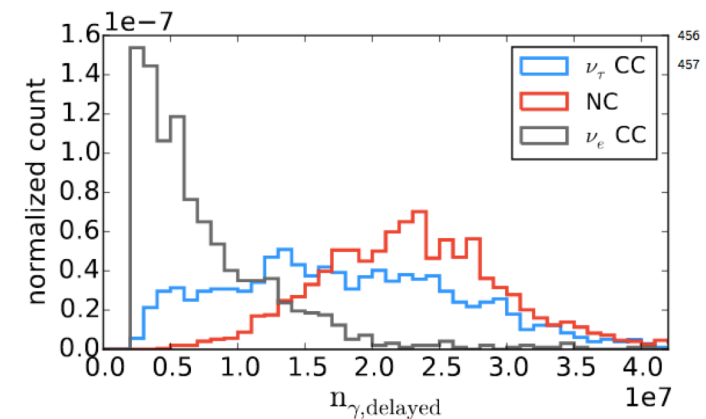
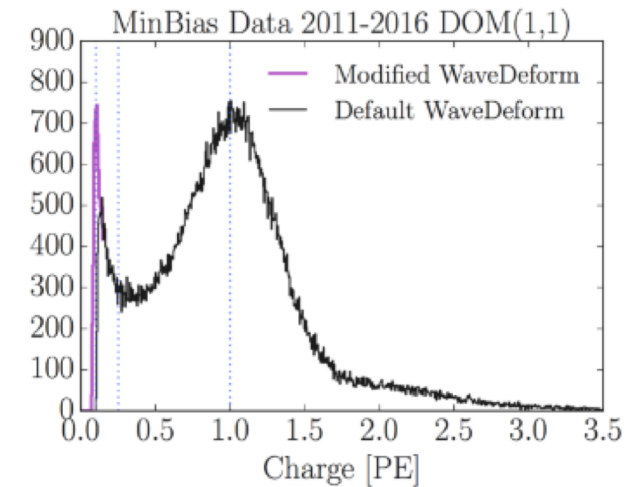
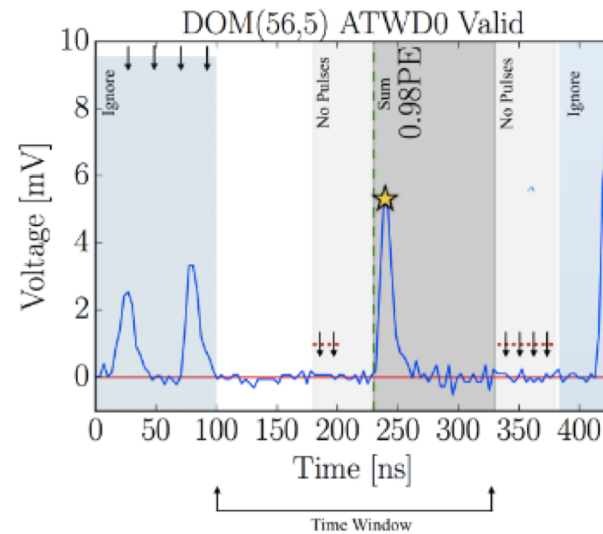
■ Oscillation ■ Cosmic Rays ■ BSM ■ Neutrino Sources ■ Calibration

Papers in Progress

- [JUNO and PINGU NMO analysis paper](#) Added 2019-01-07
- [FRB search with Level2 tracks and SNDAQ](#) Added 2018-12-05
- [Cascade Type Distinction](#) Added 2018-10-30
- [Non-Poissonian Template Fitting](#) Added 2018-10-11
- [SPE Templates Paper](#) Added 2018-09-22
- [Density of GeV muons in air showers measured with IceTop](#) Added 2018-09-22
- [Search for PeV Gamma Rays with 5 Years of Data from the IceCube Observatory](#) Added 2018-09-22
- [3 Year Energy Spectrum and Composition](#) Added 2018-09-22
- [Search for Large Scale Northern Sky Cosmic Ray Anisotropy with 6 Years of IceCube Atmospheric Neutrinos](#) Added 2018-09-22
- [Neutrino Mass Ordering Paper with 3 Years of DeepCore \(DRAGON and GRECO analyses\)](#) Added 2018-08-03
- [Upper Limits on High Energetic Neutrinos from Core Collapse Supernovae using the IceCube Neutrino Telescope](#) added 2017-11-01

Technical and new methods papers

- New SPE Templates
- Application of Non-poissonian template fitting to point source searches
- Cascade type distinction
- Forthcoming: deep neural network reconstruction of IceCube cascades



Recently approved paper outlines

- Neutrino sources
 - Pulsar Wind Nebula Stacking
 - 10 year time integrated point source search (includes M77 result)
- Diffuse
 - Contained cascade paper
 - HESE 7 year paper
- Future technologies
 - IceACT demonstrator paper
 - JUNO/PINGU combined NMO sensitivity

Selected Paper outlines expected soon

- First hint of the Glashow resonance in IceCube data, including technical details of the reconstruction in a supporting paper
- Multiple papers derived from HESE sample including first tau neutrino candidate
- Neutrino cross section with cascades and HESE

Paper review process

- Initial drafts are reviewed in the working group, this can take 1 month to > 2 years
- Publications committee is working on defining draft/response cycles and setting deadlines for comments in the working group to keep reviews on track, although some delays are unavoidable, i.e. when bugs are found
- Papers are usually submitted to journals 3-6 weeks after entering collaboration review phase

Summary

- IceCube continues to deliver high quality science results
- Majority of analyses coming from Neutrino Sources group, reflecting IceCube's core mission as an astrophysical neutrino detector and prominent member of multimessenger astrophysics community
- High profile analyses and publications continue in all areas of IceCube science
- New data release is out, next generation data release planning in progress
- Time to unblinding is averaging 3 months for most analyses once they enter review
- Papers are submitted 3-6 weeks after entering collaboration review, procedures are being developed to keep the working group review process on track

Backup