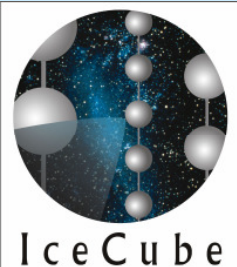
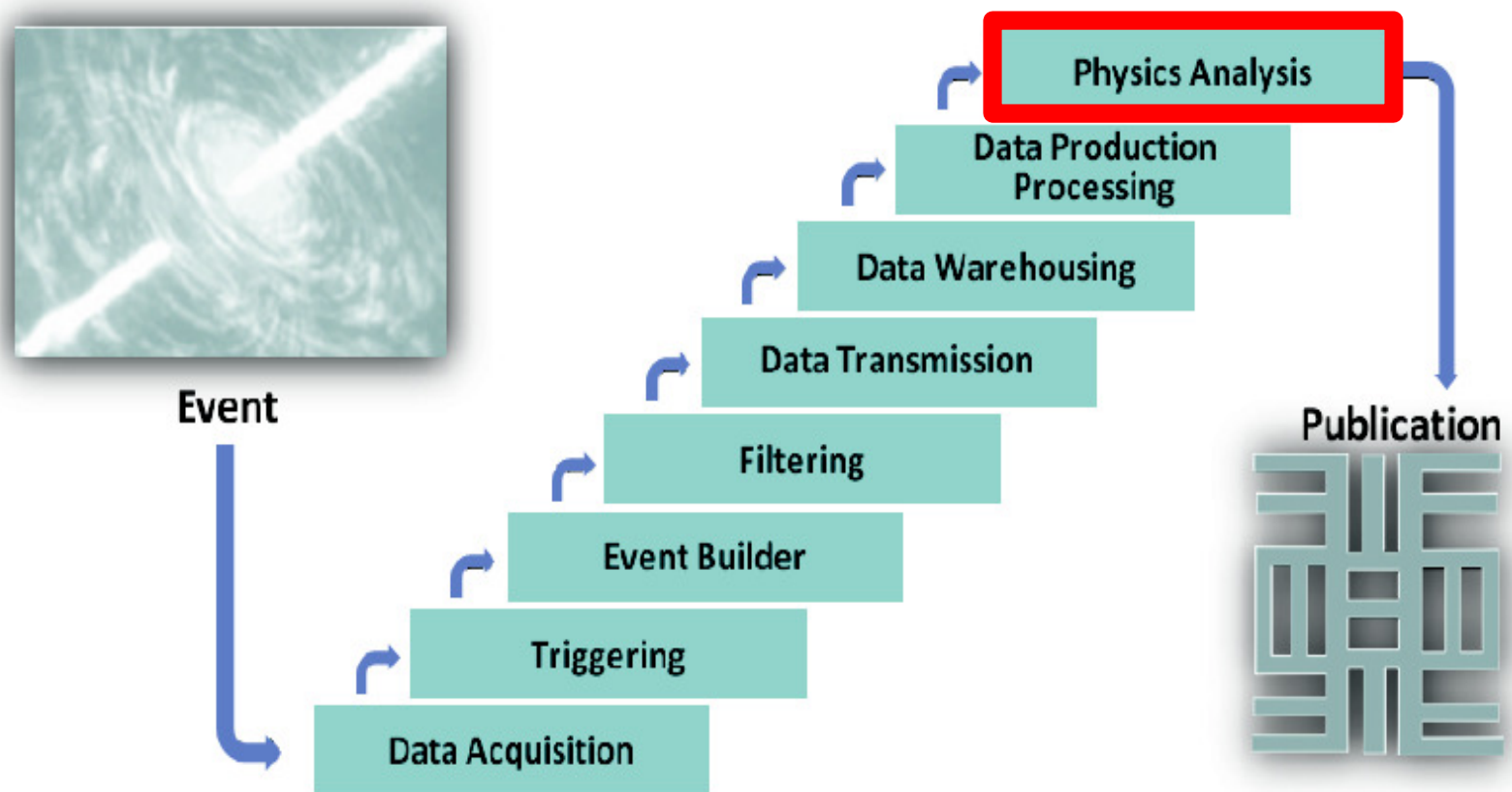


# Data Analysis: Organization and Status



Elisa Resconi, MPIK

# IceCube Physics Runs: from ~April to ~April

## IceCube-9 strings (2006-2007)

Livetime: 137 days

Trigger rate: 80 Hz

On-line muon filter rate: 6 Hz

## IceCube-22 strings (2007-2008)

Livetime: 276 days

Trigger rate: 450 Hz

On-line muon filter rate: 20 Hz

## IceCube-40 strings (2008-2009)

Livetime: 330 days

Trigger rate: 1000 Hz

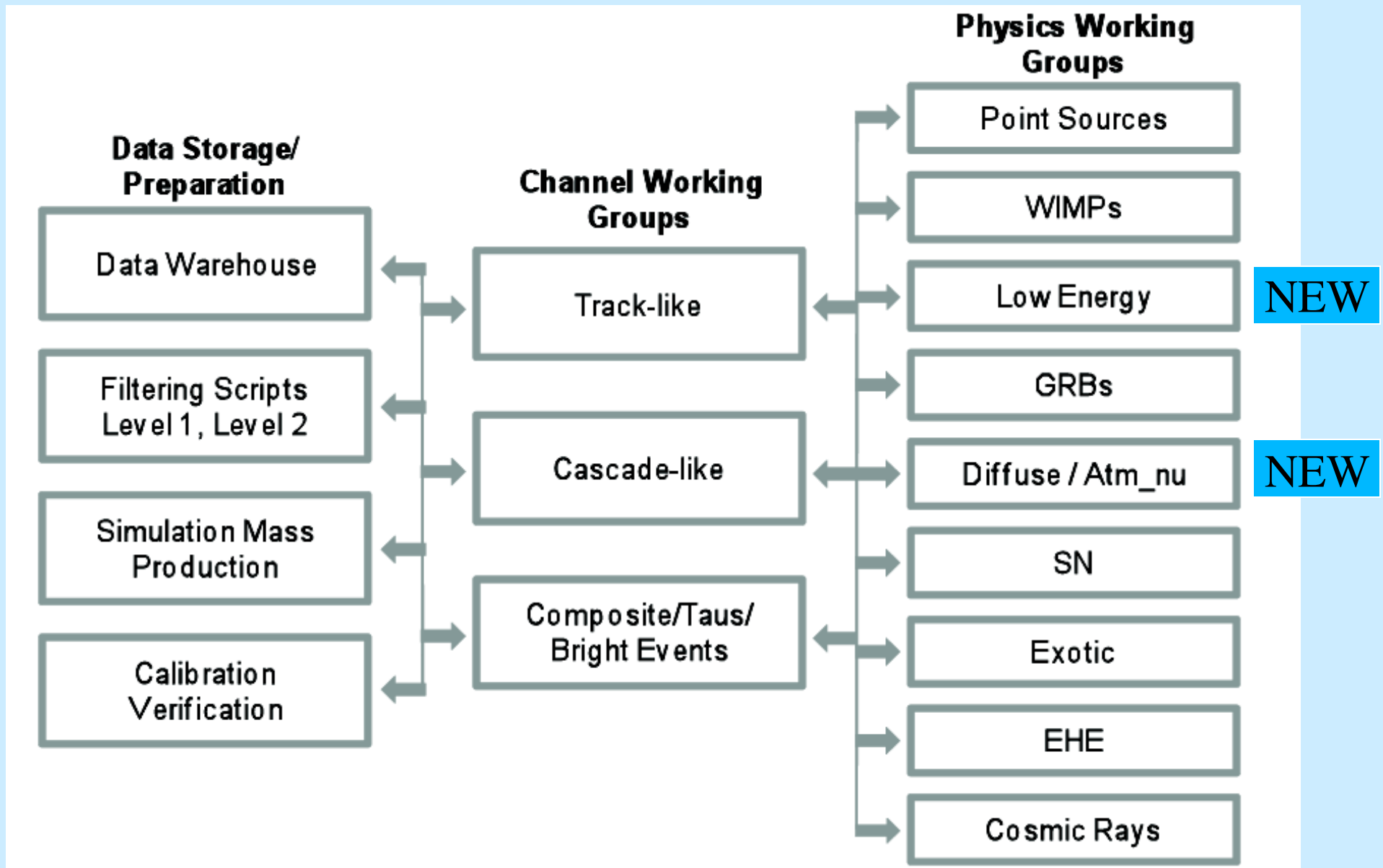
On-line muon filter rate: 23 Hz

## IceCube-59 strings (2009-...)

Trigger rate: 1500 Hz

On-line muon filter rate: 34 Hz

# IceCube Distributed Model



Elisa Resconi

# IceCube Distributed Model

## Physics Working Groups

Point Sources

WIMPs

Low Energy

GRBs

Diffuse / Atm\_nu

SN

Exotic

EHE

Cosmic Rays

IC22, 3 steady searches,  
soft spectra sources optimization  
UHE, southern hemisphere optimization  
flaring/periodic sources optimization  
first paper submitted to ApJL

IC40, unblinding proposals under preparation  
IC59, on-line filters submitted, under  
verification

# IceCube Distributed Model

## Physics Working Groups

Point Sources

WIMPs

Low Energy

GRBs

Diffuse / Atm\_nu

SN

Exotic

EHE

Cosmic Rays

IC22, results published PRL

IC40, under preparation

IC59, on-line filters submitted, under verification

New: Earth and Galactic halo, Deep Core

Elisa Resconi

# IceCube Distributed Model

## Physics Working Groups

Point Sources

WIMPs

Low Energy

GRBs

Diffuse / Atm\_nu

SN

Exotic

EHE

Cosmic Rays

IC22, GRB080319B search, published PRL

Northern GRBs, unblinded

Southern GRBs, unblinded

IC40, GCNs sent by IceCube to ROTSE

unblinding proposals under preparation

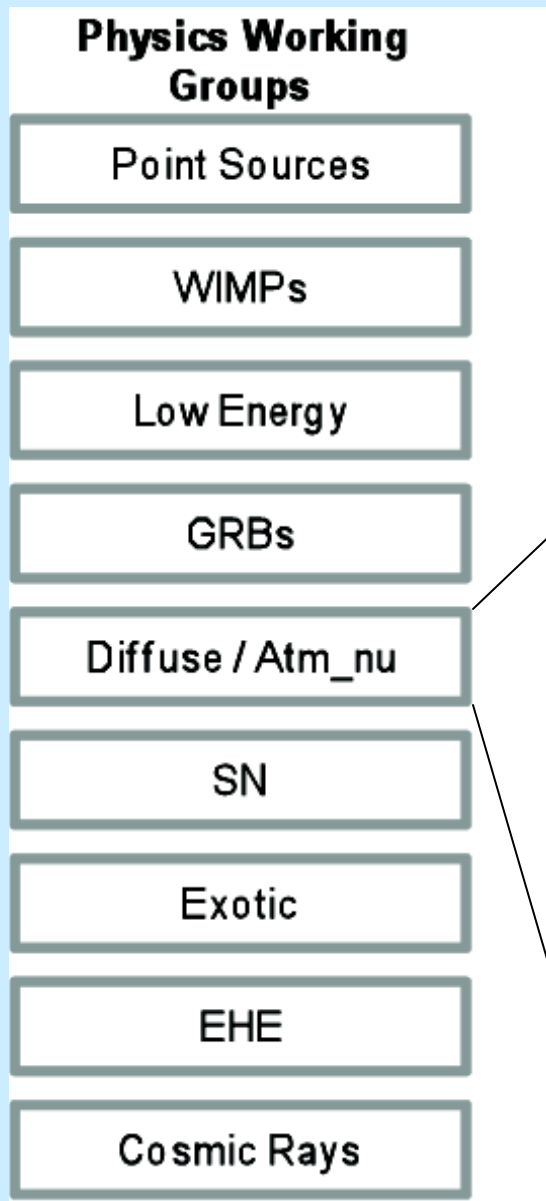
IC59, GCNs sent by IceCube to ROTSE

(updated)

On-line filters submitted, under  
verification

Elisa Resconi

# IceCube Distributed Model



IC22, 2 analysis unblinded,  
excess of events at high nch, in the  
bottom part of the detector.  
Hidden systematic effects under study.  
Cascades analysis under discussion.  
IC40, unbinned analysis under preparation  
IC59, on-line filters submitted,  
under verification

Elisa Resconi

# IceCube Distributed Model

## Physics Working Groups

Point Sources

WIMPs

Low Energy

GRBs

Diffuse / Atm\_nu

SN

Exotic

EHE

Cosmic Rays

SNDAQ extended to IceCube in 2007

Elisa Resconi



# IceCube Distributed Model

## Physics Working Groups

Point Sources

WIMPs

Low Energy

GRBs

Diffuse / Atm\_nu

SN

Exotic

EHE

Cosmic Rays

Simulation of very high energetic events, done IC22, IC40, Tau signature analysis, on going

Elisa Resconi

# IceCube Distributed Model

## Physics Working Groups

Point Sources

WIMPs

Low Energy

GRBs

Diffuse / Atm\_nu

SN

Exotic

EHE

Cosmic Rays

Independent simulation software  
IC22, unblinding proposal approved  
IC40, under preparation  
IC59, on-line filter

# IceCube Distributed Model

## Physics Working Groups

Point Sources

WIMPs

Low Energy

GRBs

Diffuse / Atm\_nu

SN

Exotic

EHE

Cosmic Rays

IC22, large scale anisotropy

IceTop26, CR energy spectrum

Coincident events for knee composition

... for systematic effects study?

# Channel: Muons

Neutrino-induced muon: CC muon neutrino interaction

- Point Source
- Diffuse
- WIMPs
- GRBs

Time resolution: ~2-3 nsec

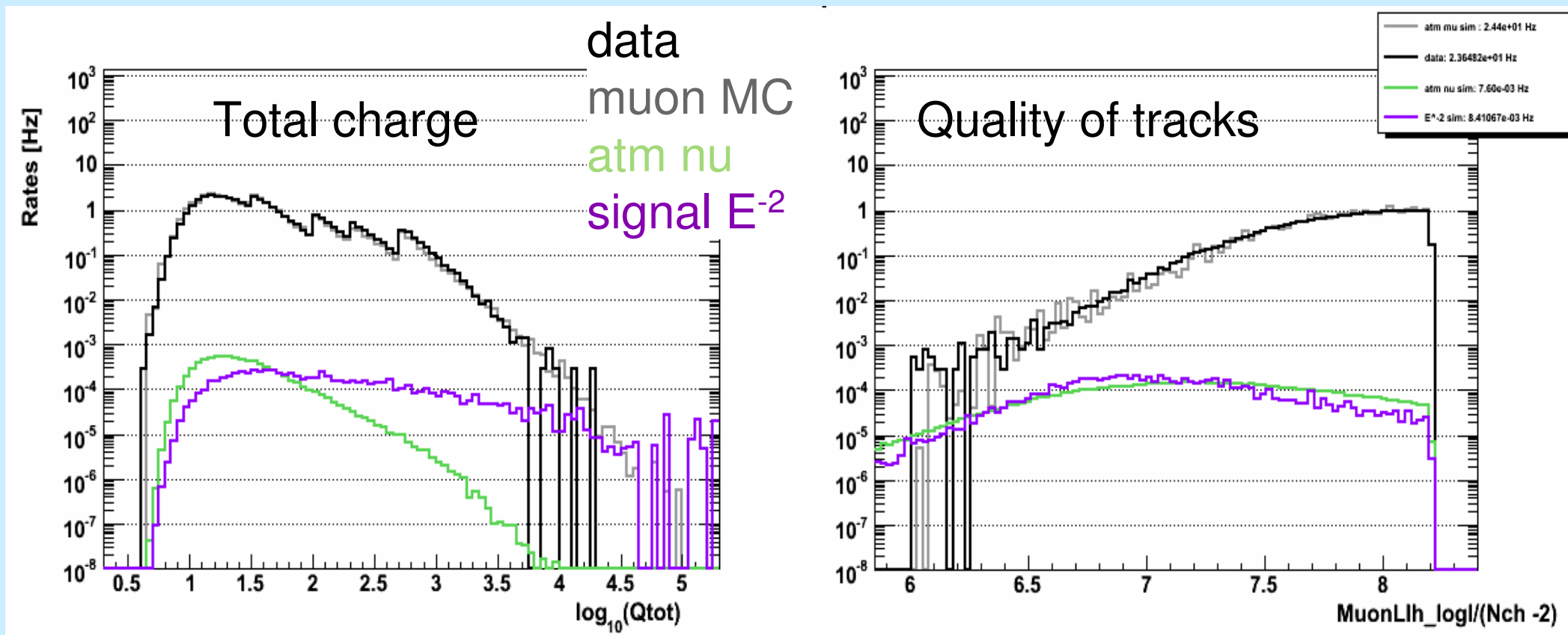
Incoming Direction: log-likelihood based reconstructions (with ice layers, analytic approximations)

Centralized Framework “Gulliver”:

- code reviewed
- set of standard projects
- constantly new implementations under test

# Channel: Muons

IC59 filtering (filter level): very encouraging



Total rate: 34.8 Hz (data) 34.7 (MC), 17 GB/d

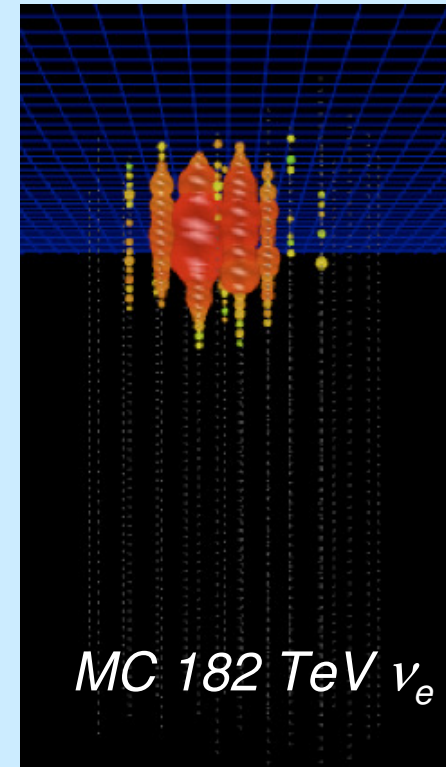
Not all the filters in IC40 and IC22 performed so well!

# Channel: Cascades

Neutrino-induced cascades:

**NC and CC electron neutrino events,  
NC muon neutrino events, and starting events**

- Diffuse, atm nus
- Variable point sources
- GRB



Interaction vertex resolution:  $\sigma_x = 7 \text{ m}$   $\sigma_y = 7 \text{ m}$   $\sigma_z = 4 \text{ m}$

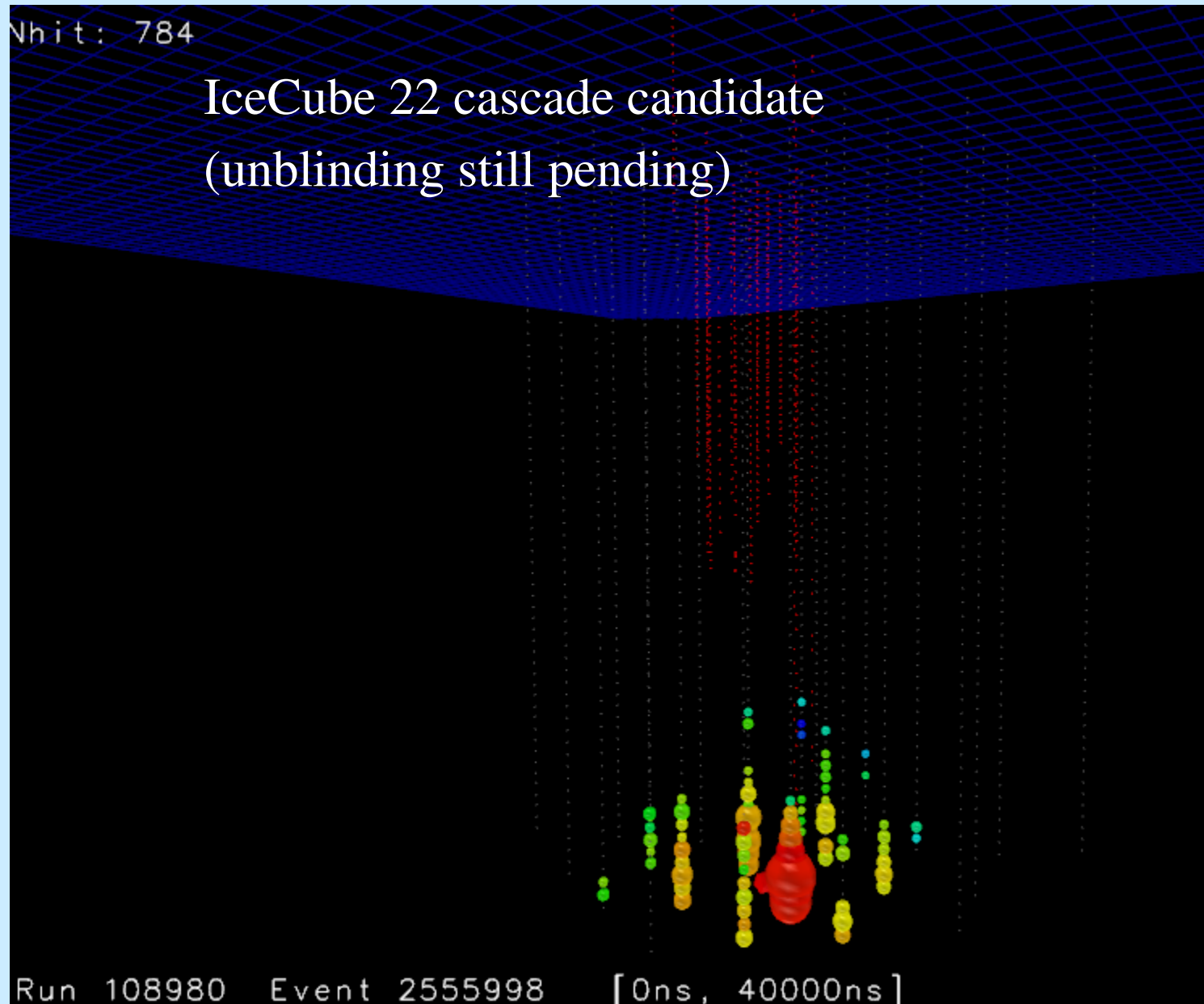
Energy reconstruction (using ice properties):

$\sigma(\log_{10} E) = 0.2$  (up to  $\sim 10 \text{ PeV}$ )

Advances in methods for events identification

IceCube 22:  $\text{Rate}(\nu_e) \sim 15 / \text{day}$

# Channel: Cascades



# Channel: Composite/Bright Events

## Analysis Topics:

- Tau: Double Bang events  
(Learned & Pakvasa 1995)
- EHE /GZK

## Reconstruction:

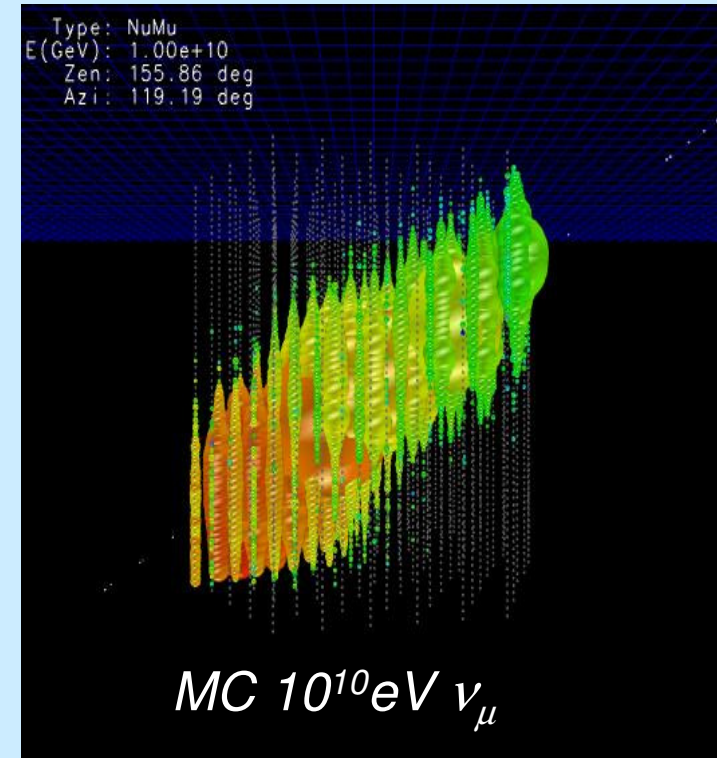
double-bang, other signatures  
under study on MC

Simulation: mass production started

Plans: 4 Tau analysis under going

EHE: IC22 analysis recently unblinded

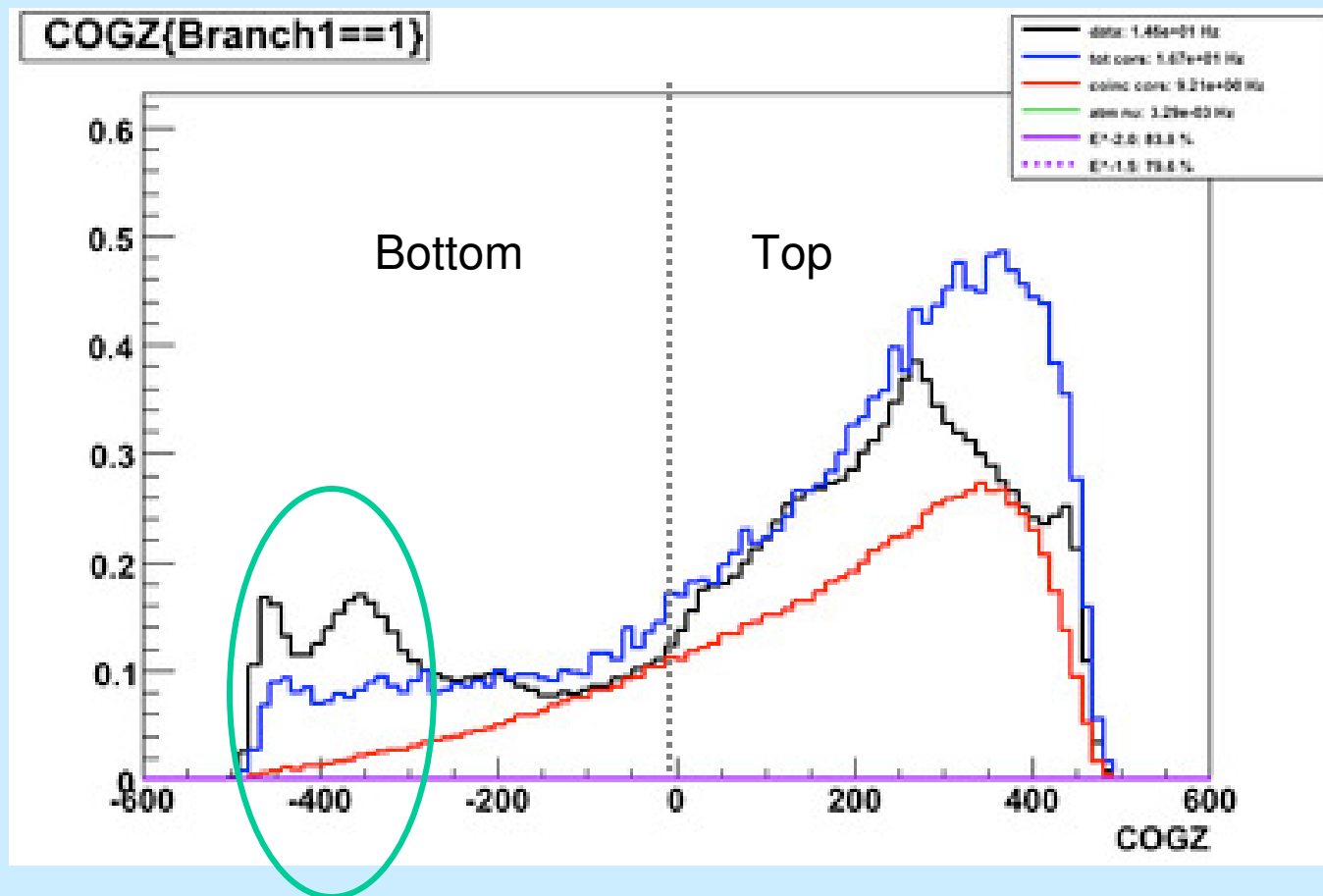
GZK: new test recently performed





# Systematic Effects in IceCube

- Study of systematic effects in IceCube: permanent activity
  - Calibration and verification wg
  - Problematic issues integrated and discussed at the analysis call
- For example: Center Of Gravity Z (COGZ) distribution of events do not match MonteCarlo



Data (IC40, L2a)

Corsika

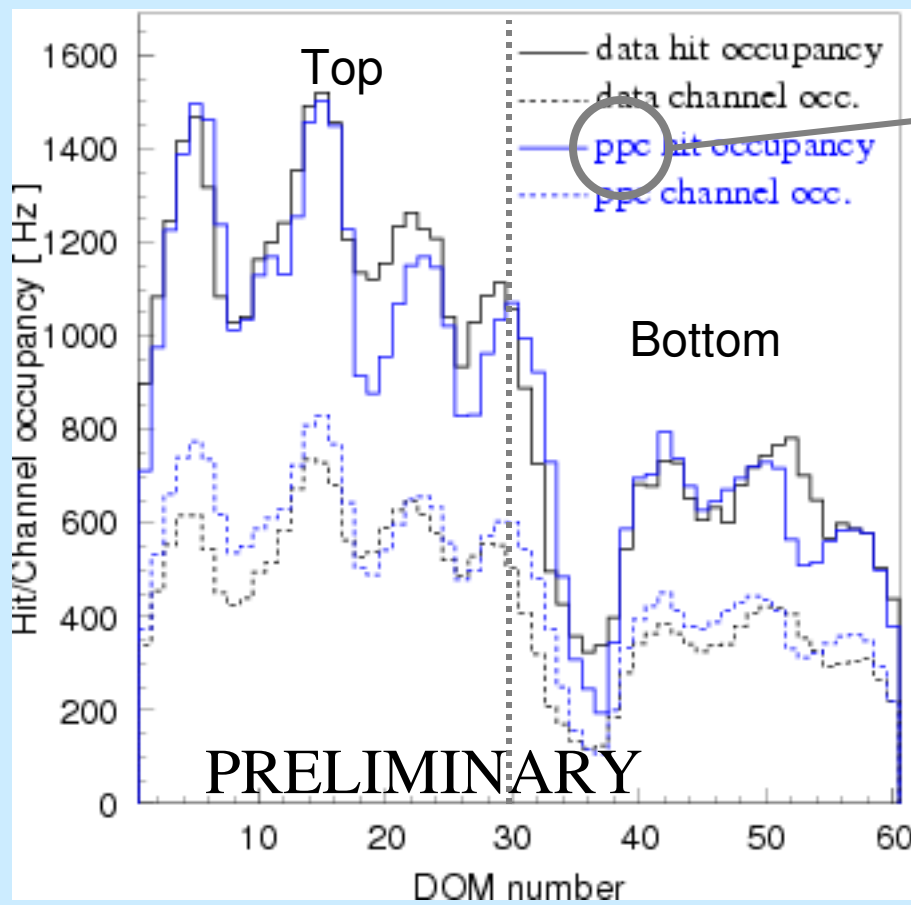
Coincident Corsika

# Systematic Effects in IceCube

Always the same suspect:

are the properties of the ICE understood?

good indications that might be the case ...



## Photon Propagation Code

(Simplified Simulation)

- Photon tables not included
- Only single muons
- Waveform not included

The problem(s) could be somewhere else

# Systematic Effects in IceCube

We are reviewing and integrating material about ALL the possible source of systematic errors; here few examples:

## 1- Natural Materials:

- Atmosphere

correlation of rates in IceCube with long and short term variations in the South Pole atmosphere

- Bulk Ice, Hole Ice

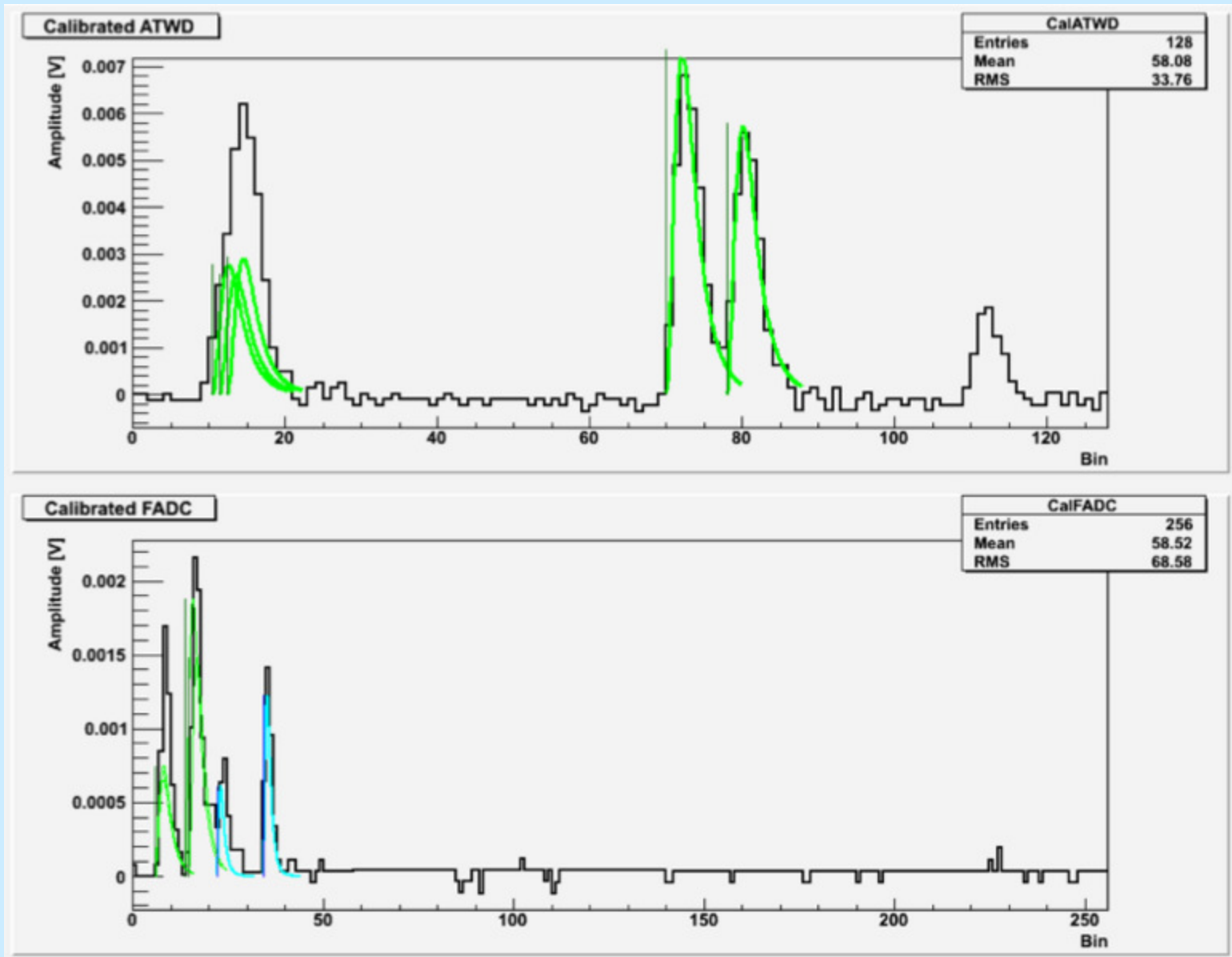
new flasher runs planned;  
we aim for a distributed effort in the collaboration

## 2- Detector:

- **DOM Sensitivity:** Absolute SPE, Angular sensitivity, Wavelength dependence  
Flasher runs for in-situ calibrations
- **Time resolution and timing offsets:** high precision, stability
- **Charge measurement (fADC, ATWD):** gain calibration, PMT saturation and linearity.

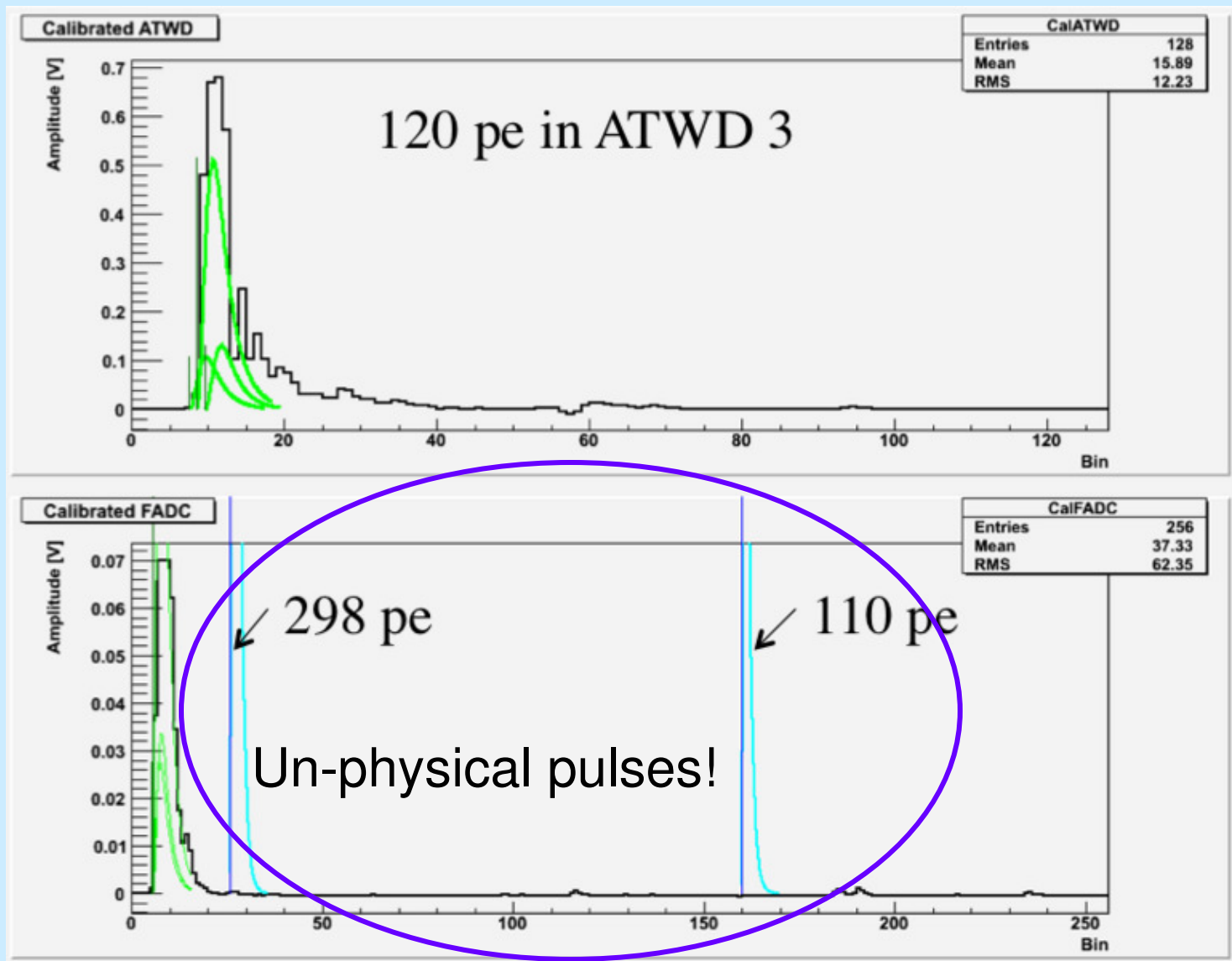
# Systematic Effects in IceCube

Example of a “well” interpreted waveform



# Systematic Effects in IceCube

Example of a problematic waveform



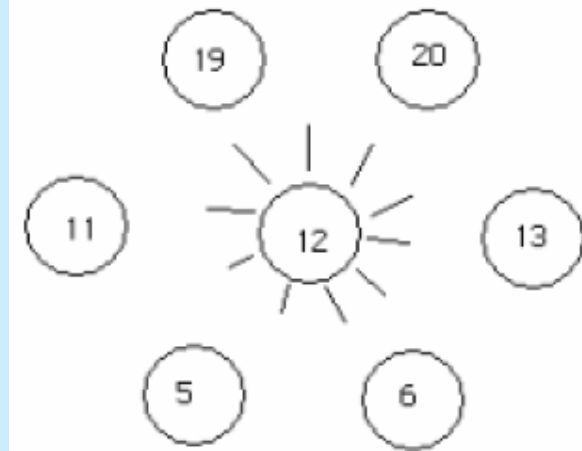
Bug recently “fixed”

Question: can we exclude to have other issues like this?

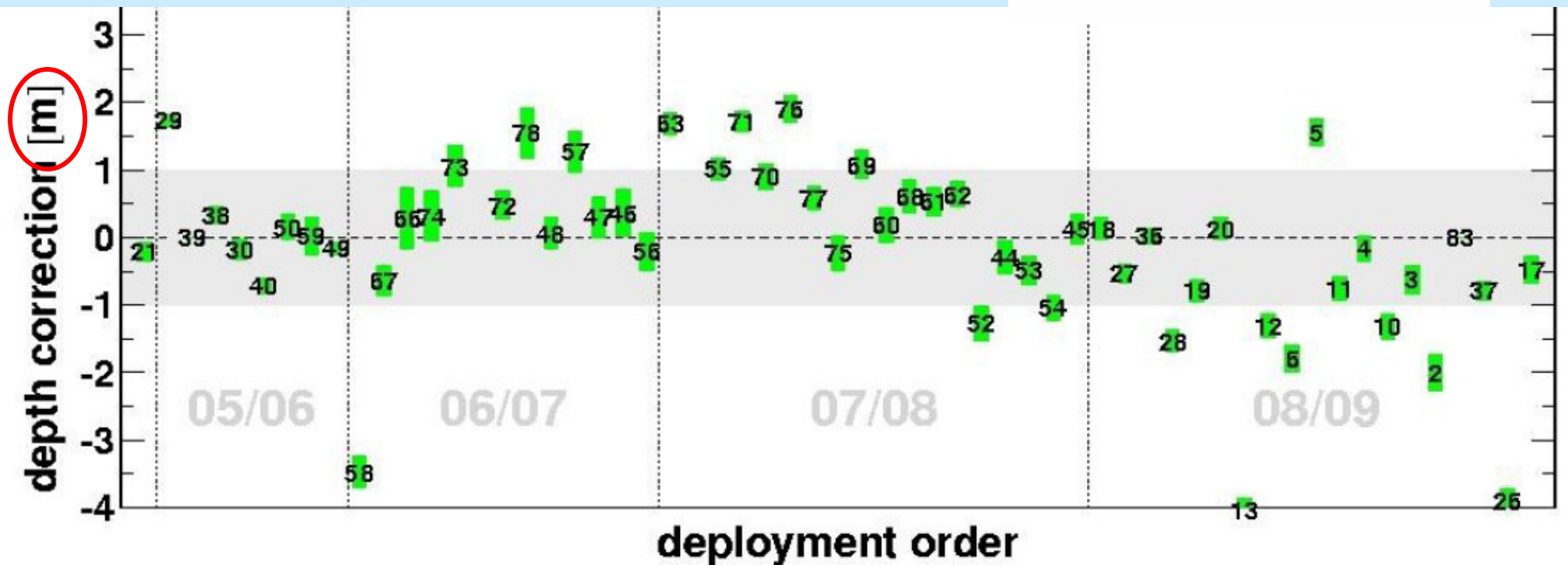
# Systematic Effects in IceCube

- Geometry stage-1: from deployment (Survey data, Drill data etc)
- Geometry stage-2: from flasher data

Flash 6 DOMs and  
read out surrounding strings



The geometry of IceCube is well understood!



# Systematic Effects in IceCube

## 3- Theoretical Uncertainties:

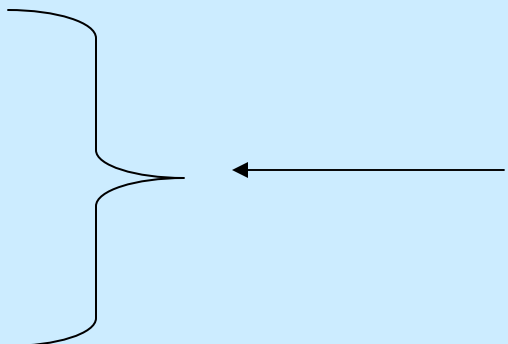
- Fluxes
- Charm component of cosmic ray showers

## 4- Analysis Methods: introduced biases

### - Reconstruction:

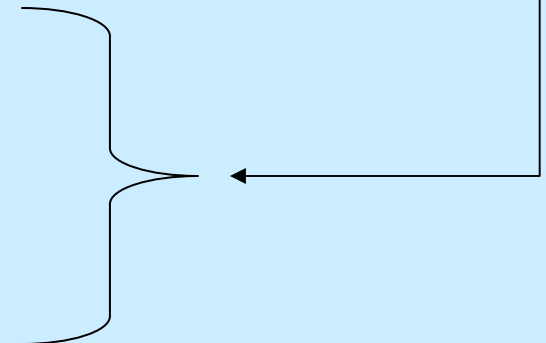
- type of events,
- direction,
- energy

Verification of performances:  
more is needed



## 5- Simulation:

- Photonics: tables interpolation still open issue
- Low level detector simulation need verification



# Systematic Effects in IceCube



Our directions in order to improve:

- Integration of systematic checks
- Increase the distribution of this task
- More checks at lower level,  
not analysis oriented, search for biases
- More data quality verification at low level
- Suggestions are welcome ....



# Procedures

Data Analysis: from the idea to the unblinding approval

- 1- Working group discussion, internal referee
- 2- Approval from working group
- 3- Plenary presentation of the unblinding proposal at the analysis call
- 4- Independent referee process
- 5- Final approval comes from the entire collaboration
- 6- Results

Publication:

- 1- First draft circulated to the entire collaboration
- 2- Internal Referee: new draft
- 3- New draft to the collaboration

# Prospects

- Maintain flow of the analysis
- Maintain/integrate/distribute efforts towards study of systematics effects
- Continue feedback distributed model
- Operate IceCube towards discovery!

# Backup

## IceCube-58+1 interstring (surface) distances

