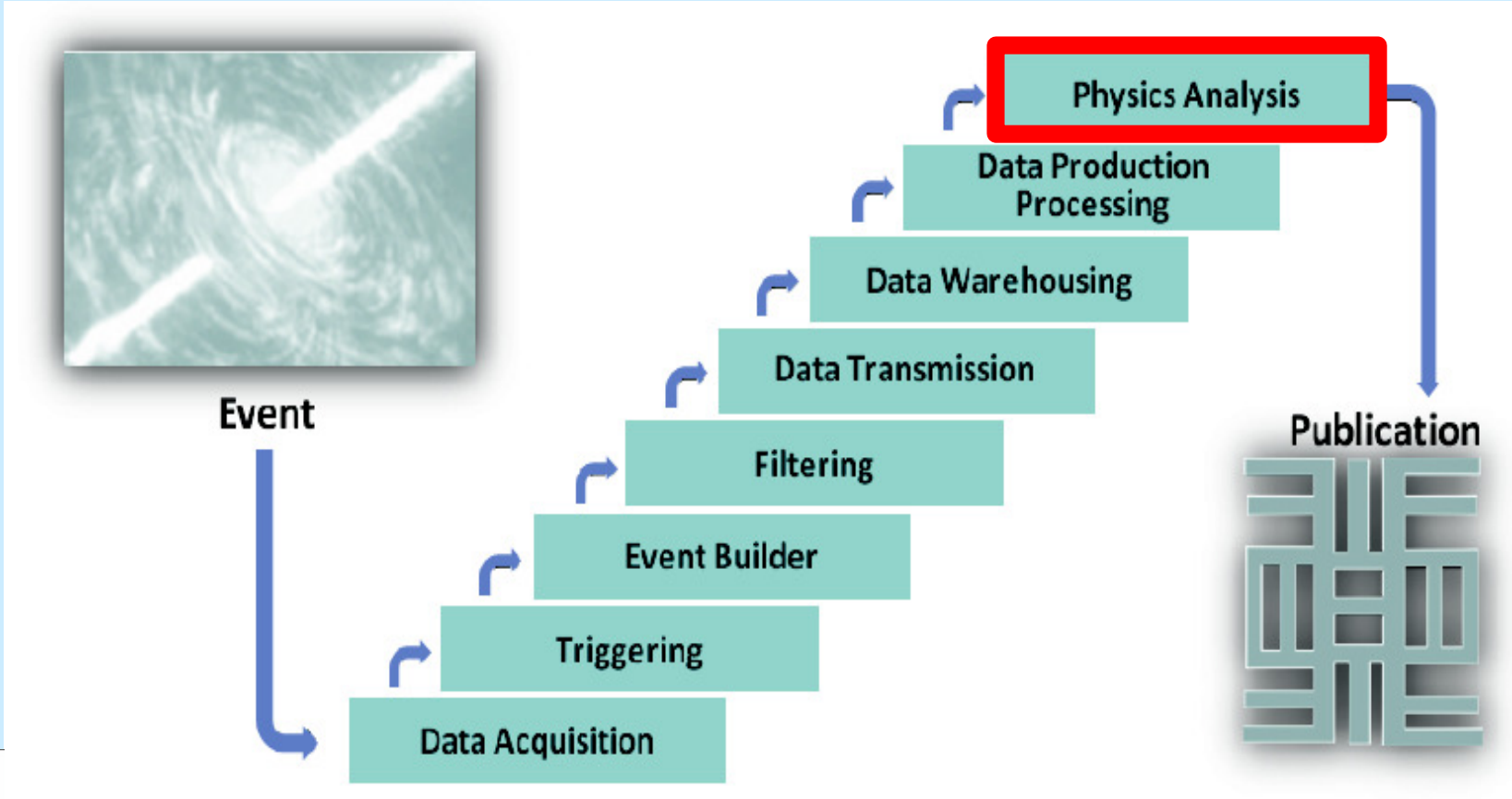
Data Analysis: Organization and Status



Elisa Resconi, MPIK

IceCube

IceCube Physics Runs: from ~April to ~April

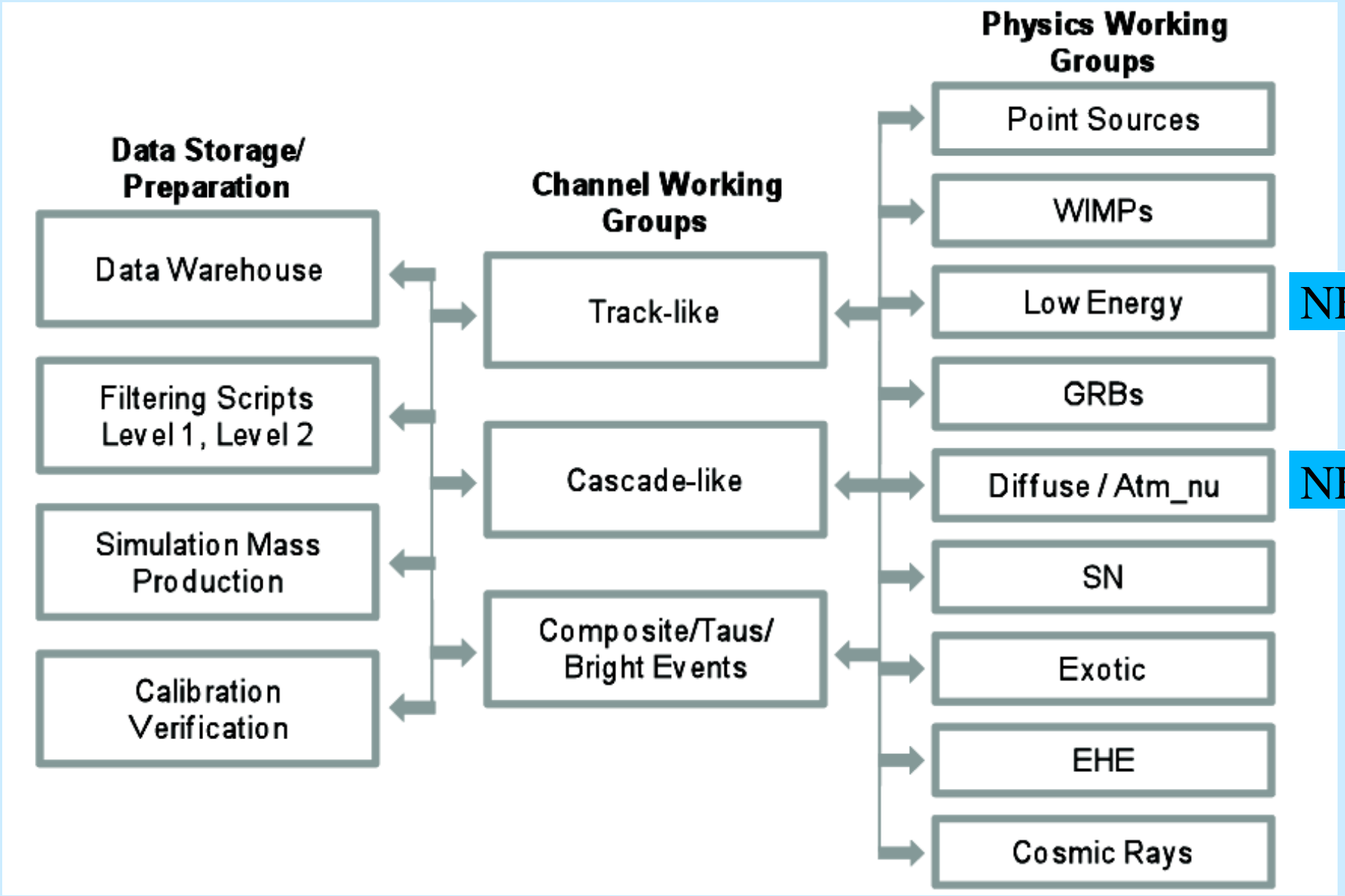
IceCube-9 strings (2006-2007)
Livetime: 137 days
Trigger rate: 80 Hz
On-line muon filter rate: 6 Hz

IceCube-22 strings (2007-2008)
Livetime: 276 days
Trigger rate: 450 Hz
On-line muon filter rate: 20 Hz

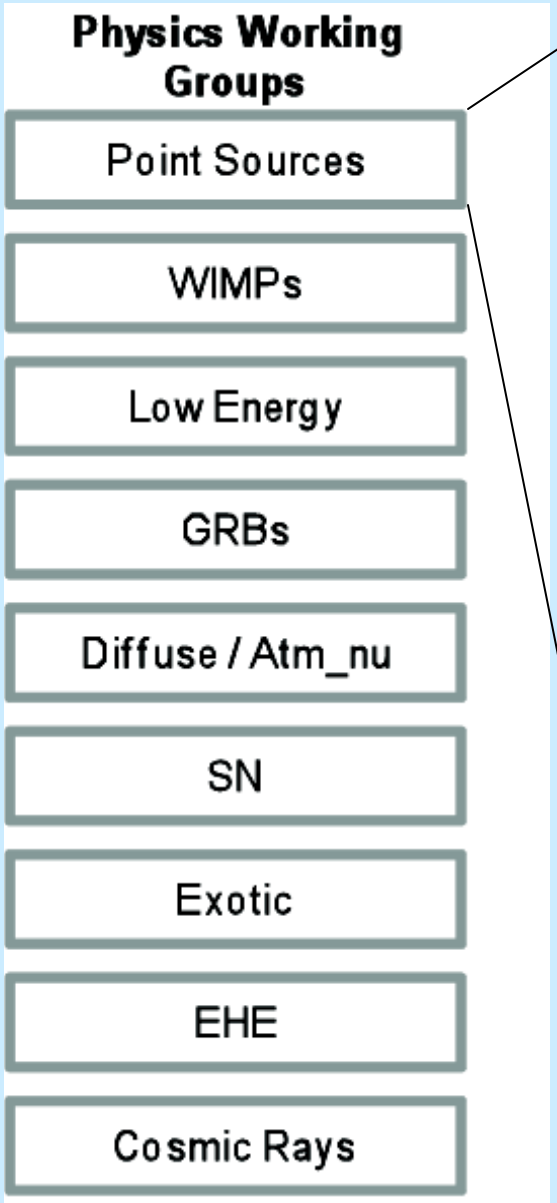
IceCube-40 strings (2008-2009)
Livetime: 330 days
Trigger rate: 1000 Hz
On-line muon filter rate: 23 Hz

IceCube-59 strings (2009-…)
Trigger rate: 1500 Hz
On-line muon filter rate: 34 Hz

IceCube Distributed Model



IceCube Distributed Model

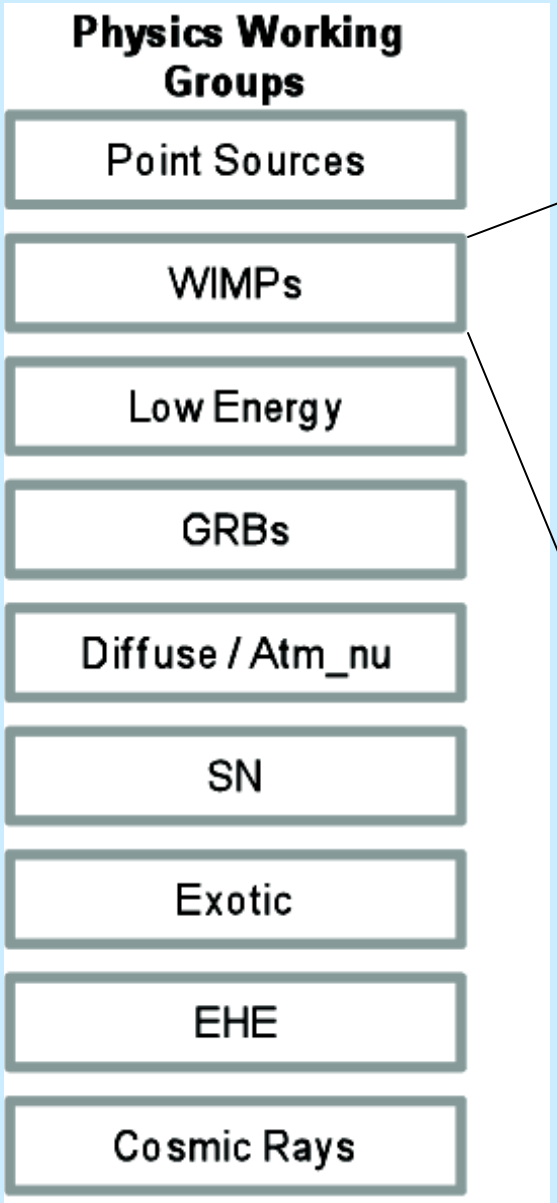


IC22, 3 steady searches,
soft spectra sources optimization
UHE, southern hemisphere optimization
flaring/periodic sources optimization
first paper submitted to ApJL

IC40, unblinding proposals under preparation

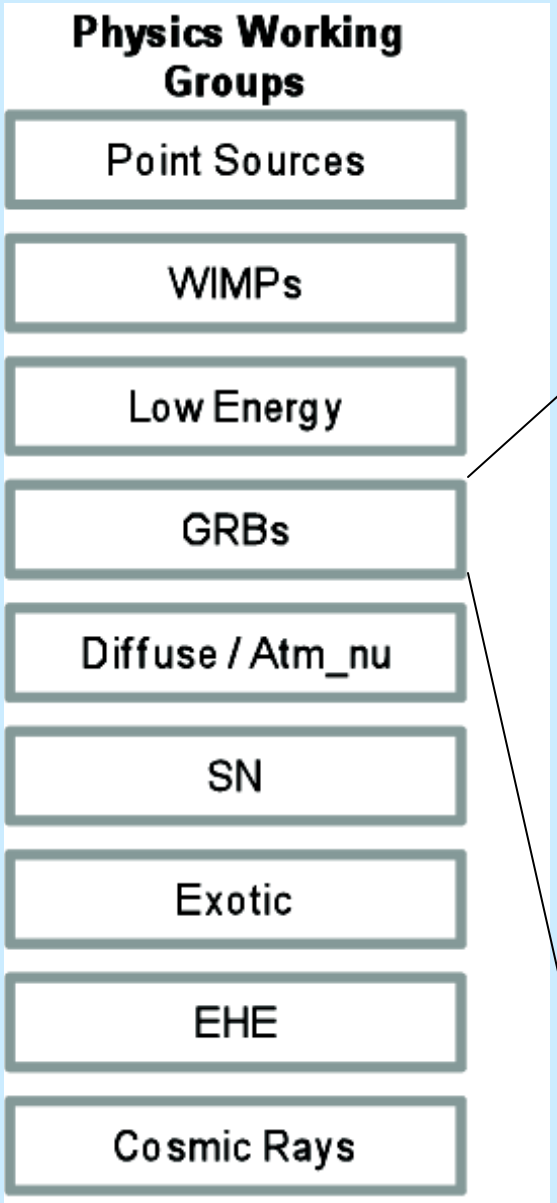
IC59, on-line filters submitted, under verification

IceCube Distributed Model



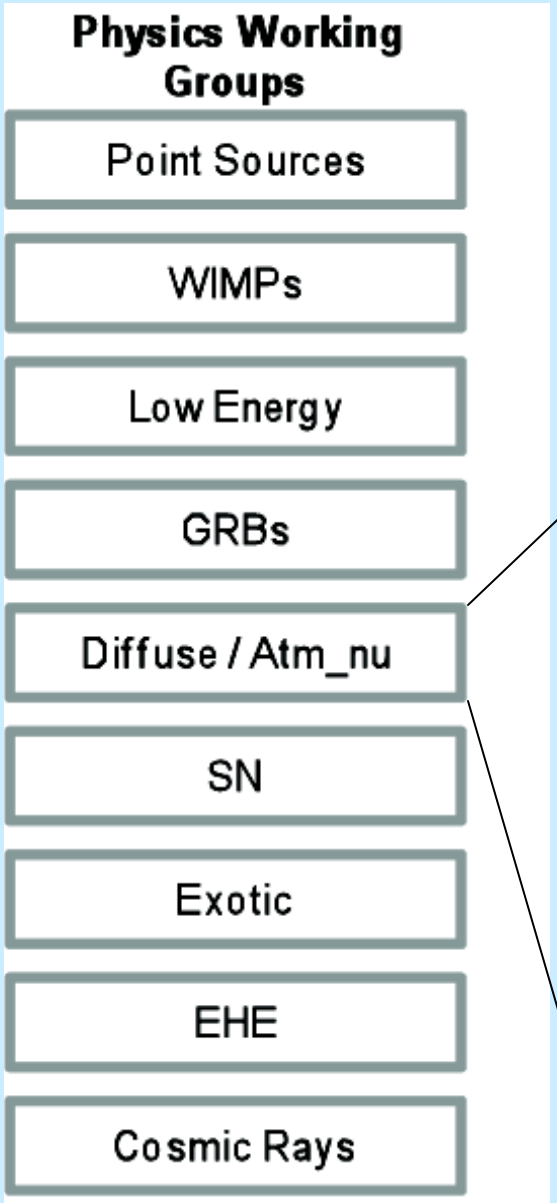
IC22, results published PRL
IC40, under preparation
IC59, on-line filters submitted, under verification
New: Earth and Galactic halo, Deep Core

IceCube Distributed Model



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

IceCube Distributed Model

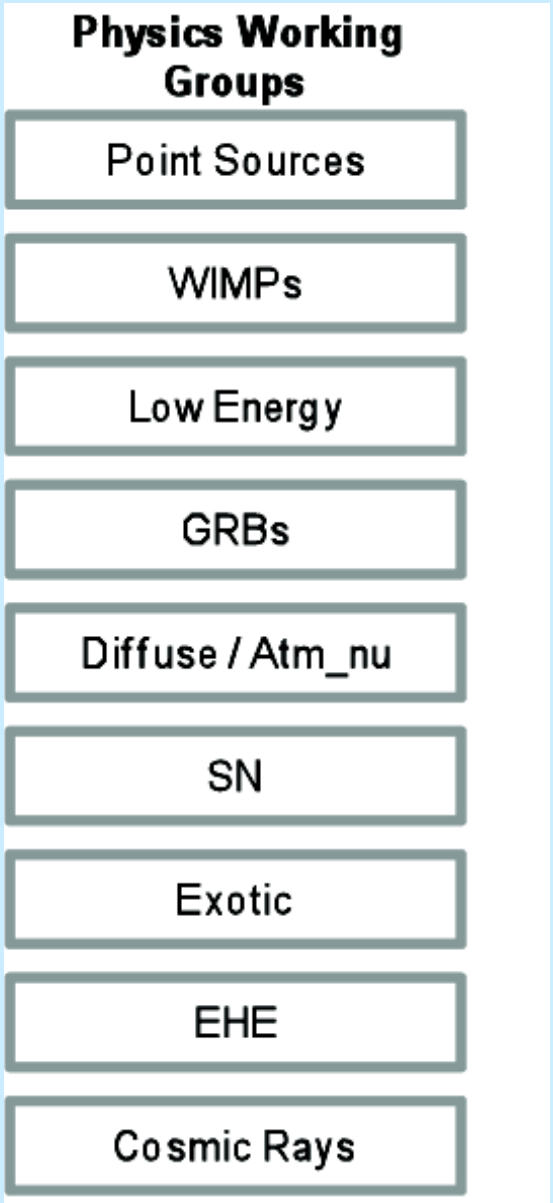


IC22, 2 analysis unblinded,
excess of events at high nch, in the bottom part of the detector.
Hidden systematic effects under study.
Cascades analysis under discussion.

IC40, unbinned analysis under preparation

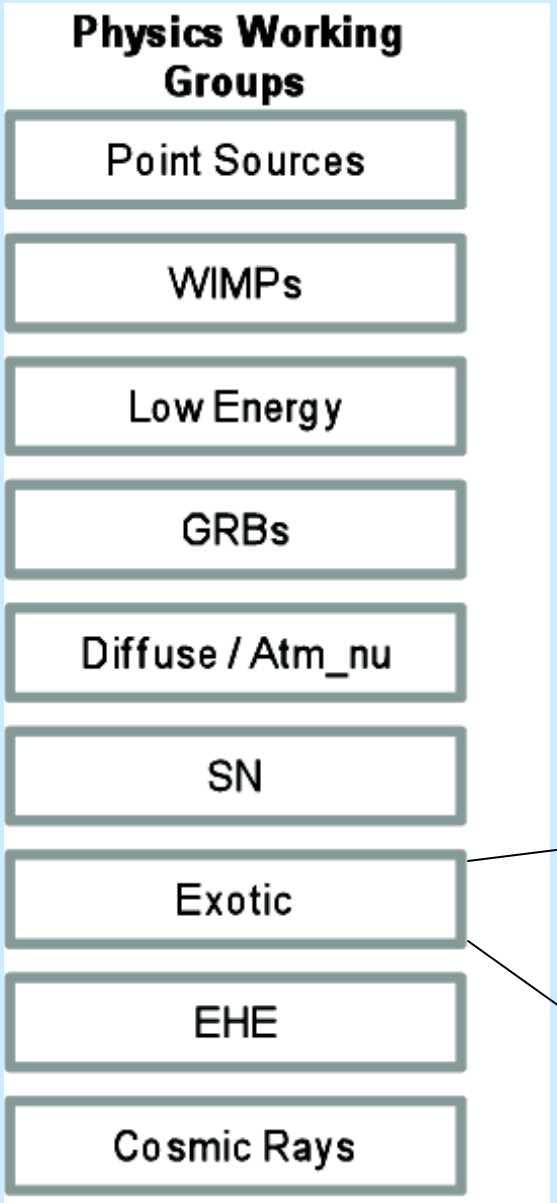
IC59, on-line filters submitted,
under verification

IceCube Distributed Model



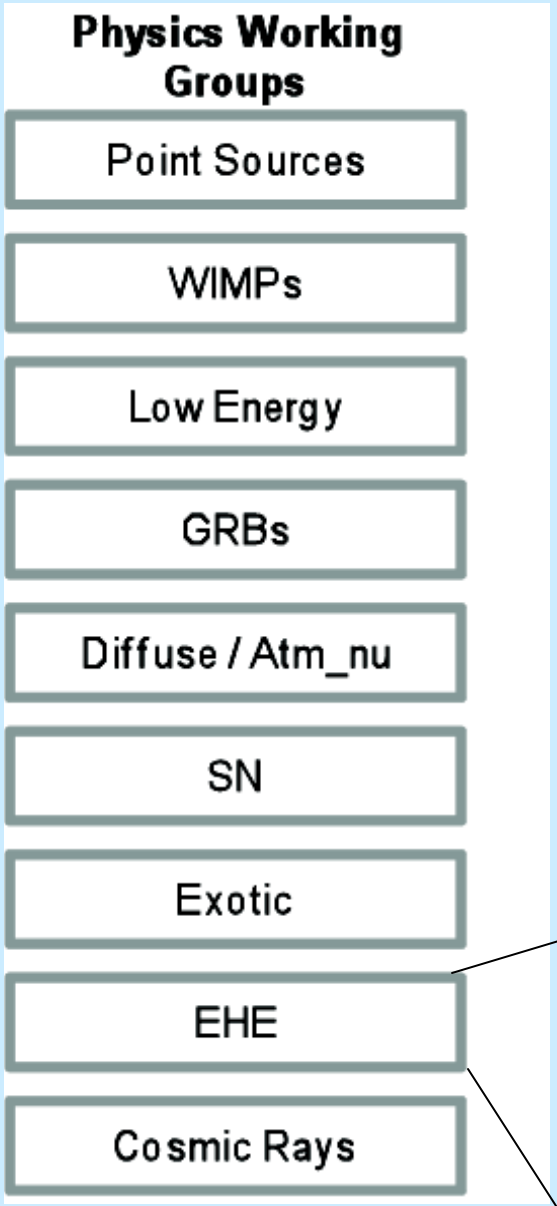
SNDAq extended to IceCube in 2007

IceCube Distributed Model



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

IceCube Distributed Model



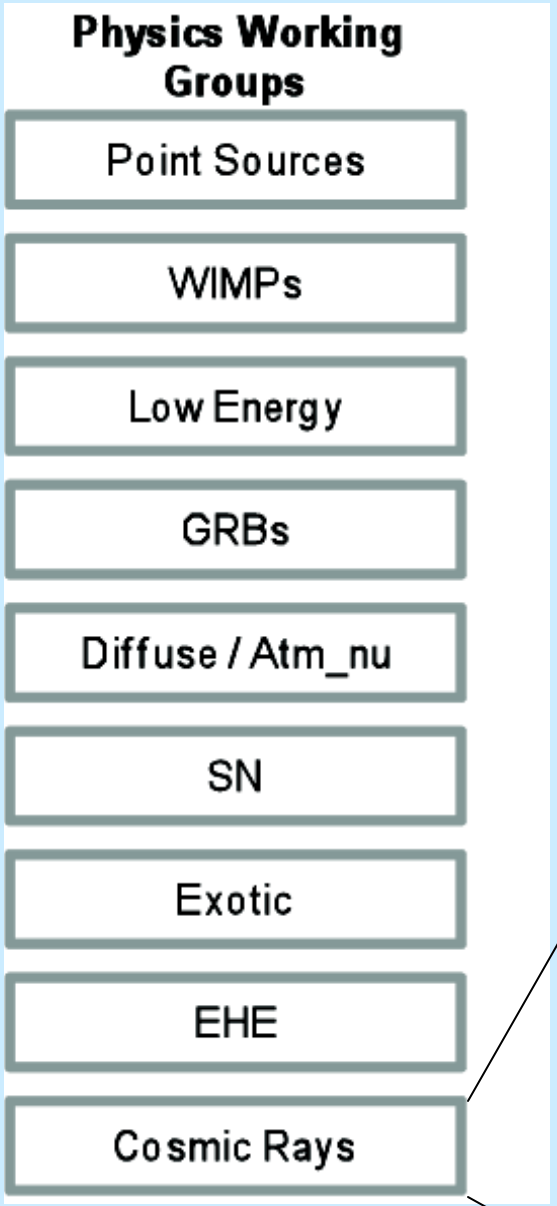
Independent simulation software

IC22, unblinding proposal approved

IC40, under preparation

IC59, on-line filter

IceCube Distributed Model



IC22, large scale anysotropy
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

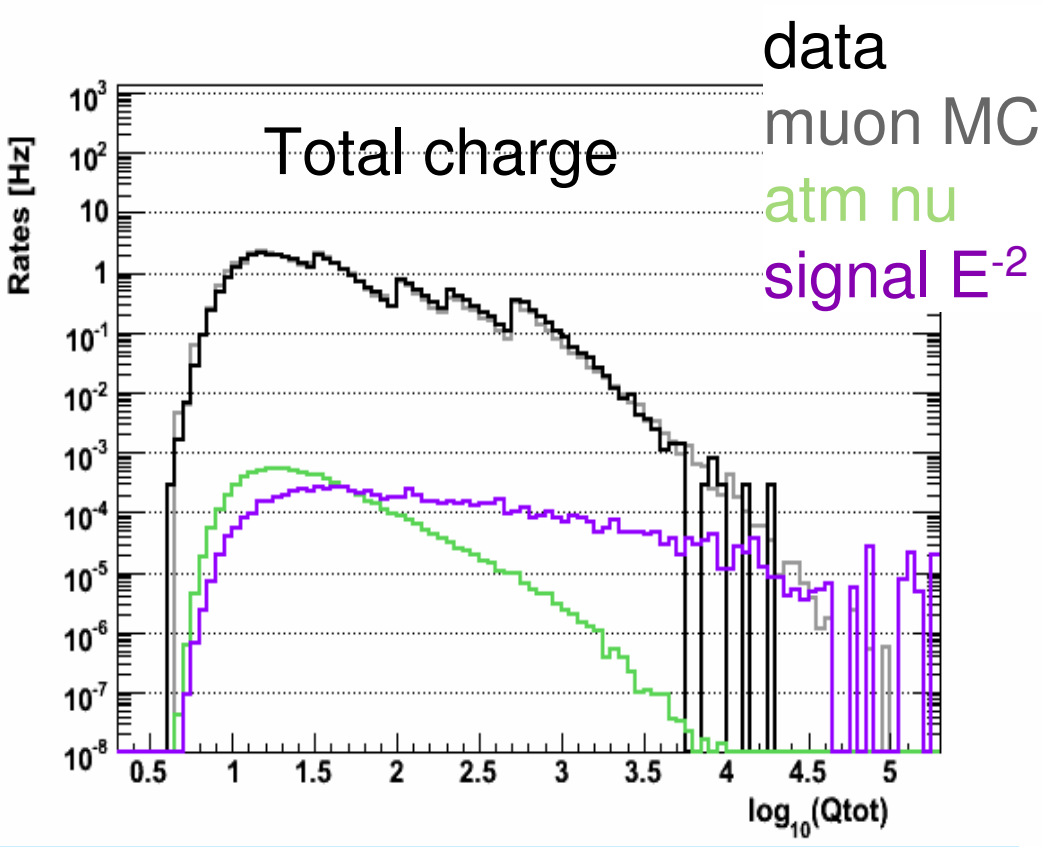
Incoming Direction: log-likelihood based reconstructions (with ice layers, analytic approximations)

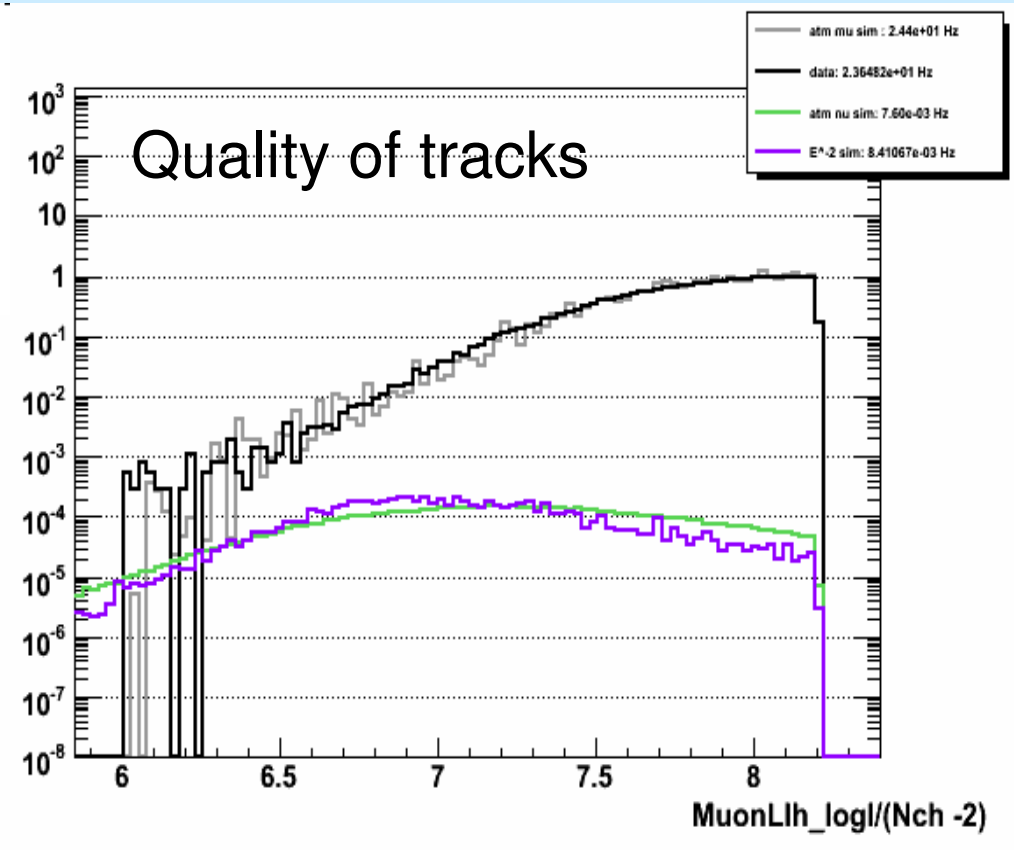
Centralized Framework “Gulliver”:

- 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!

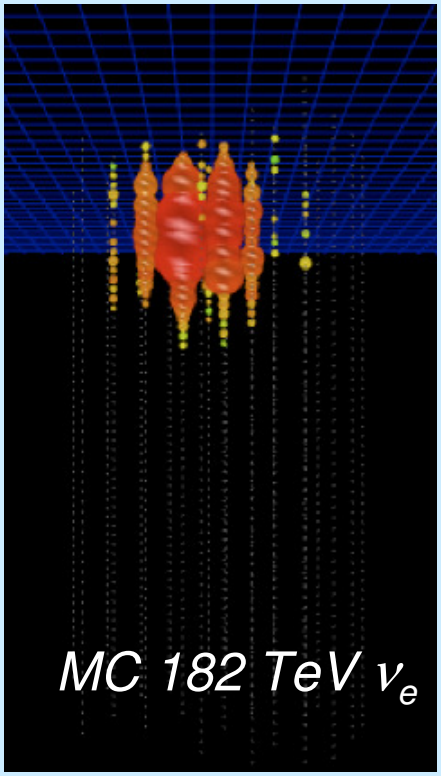
Channel: Cascades

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: $\sigma_x = 7$ m $\sigma_y = 7$ m $\sigma_z = 4$ m

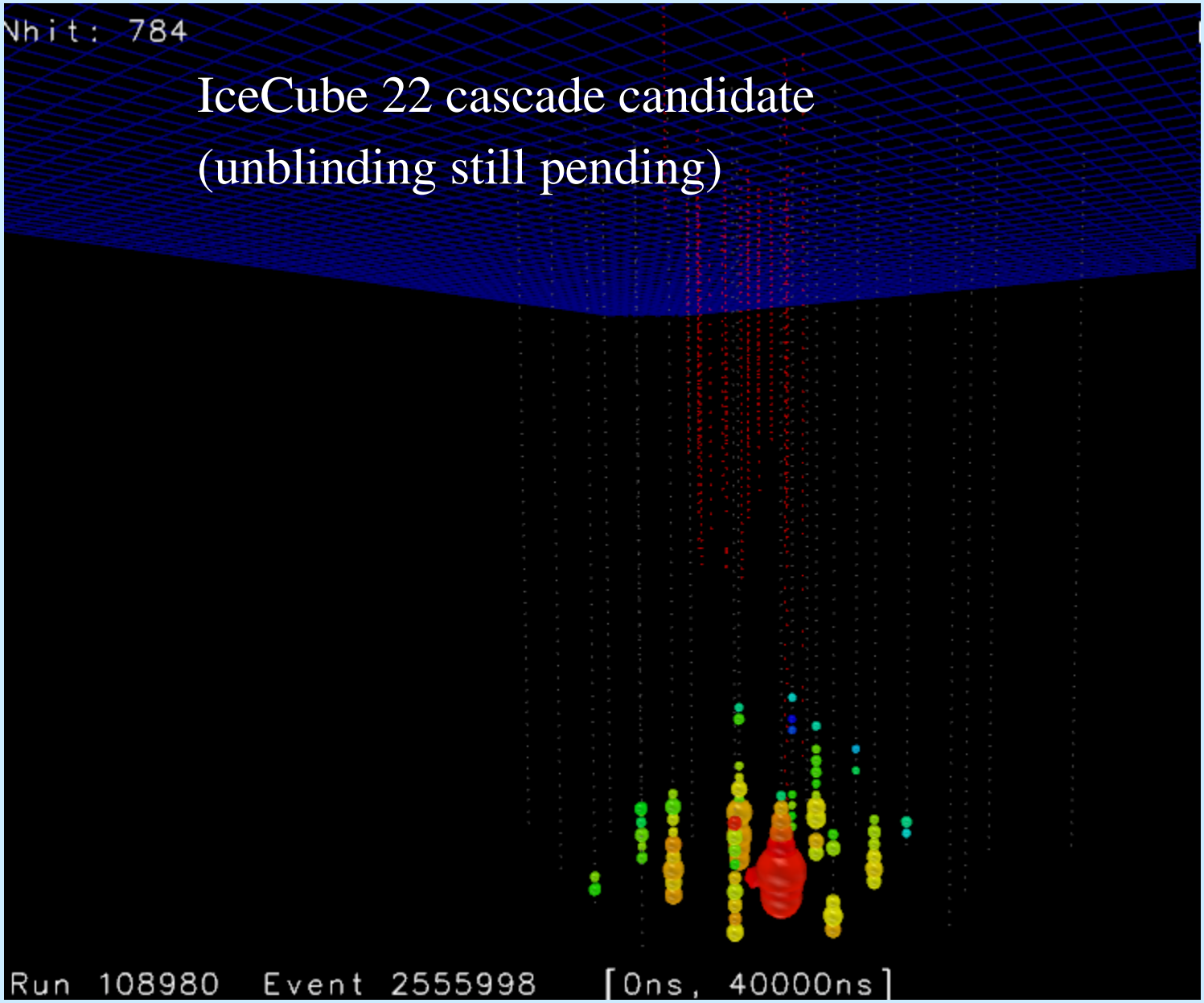
Energy reconstruction (using ice properties):

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

Advances in methods for events identification

IceCube 22: Rate(ν_e) ~ 15 /day

Channel: Cascades



Channel: Composite/Bright Events

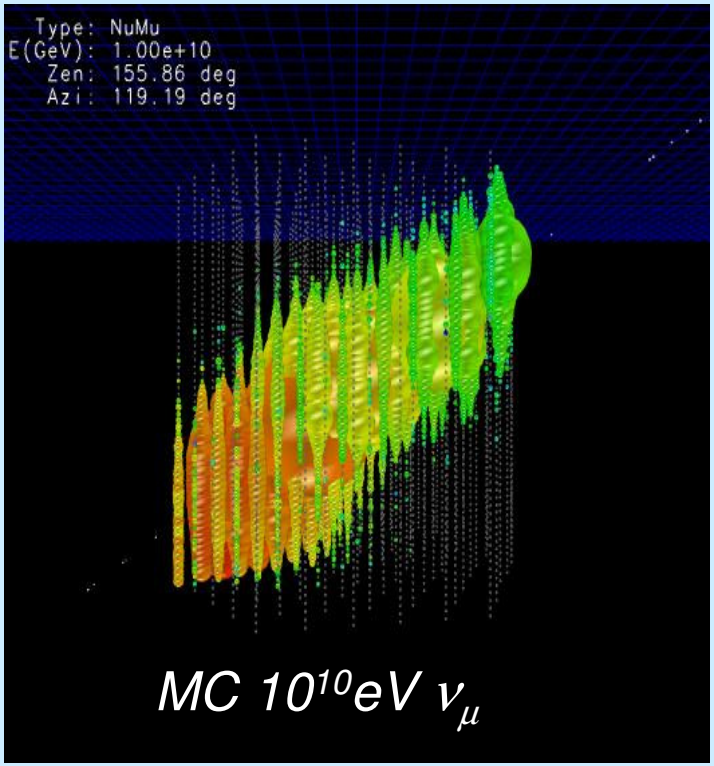
Analysis Topics:

- 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

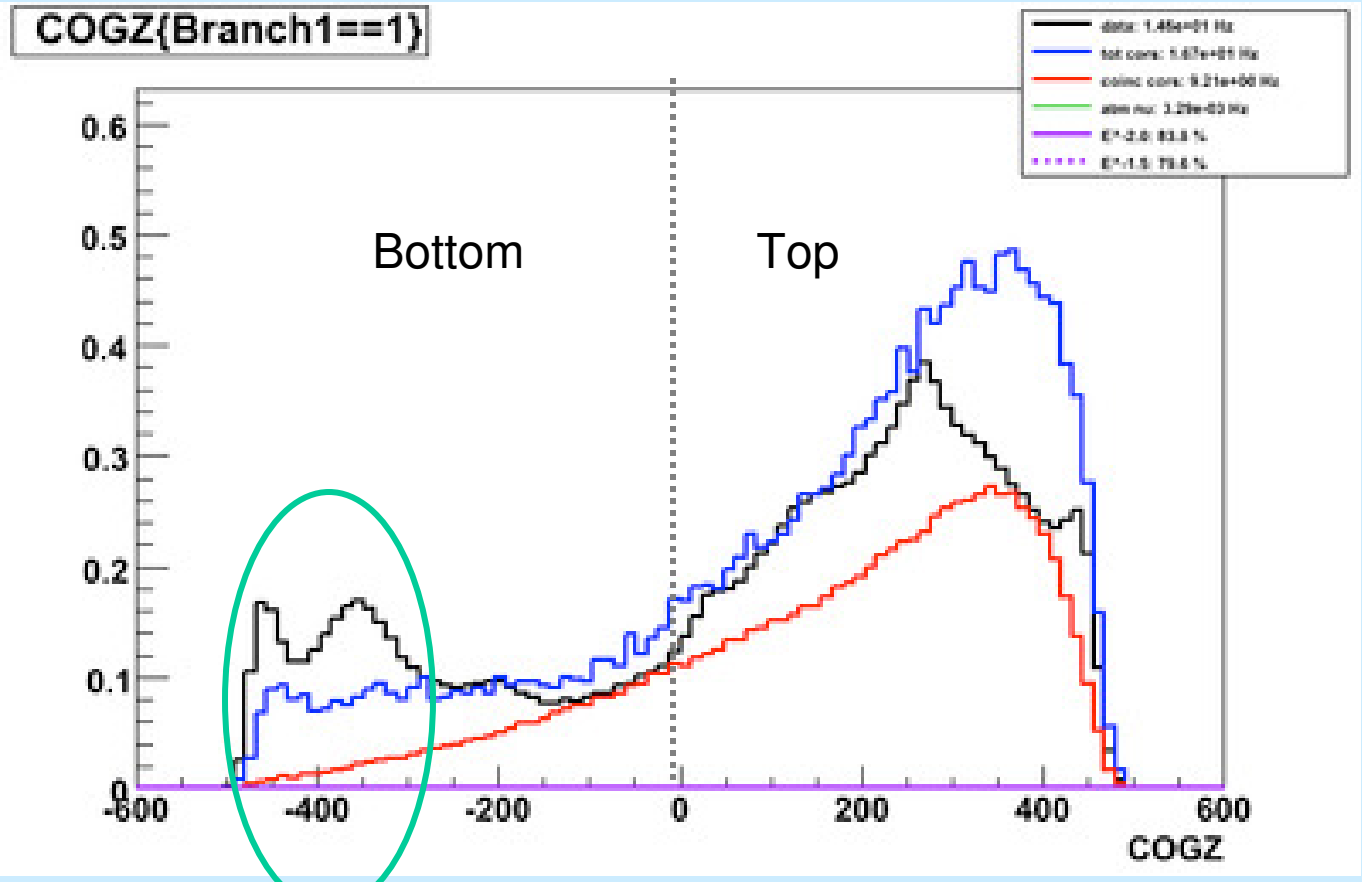
EHE: IC22 analysis recently unblinded

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

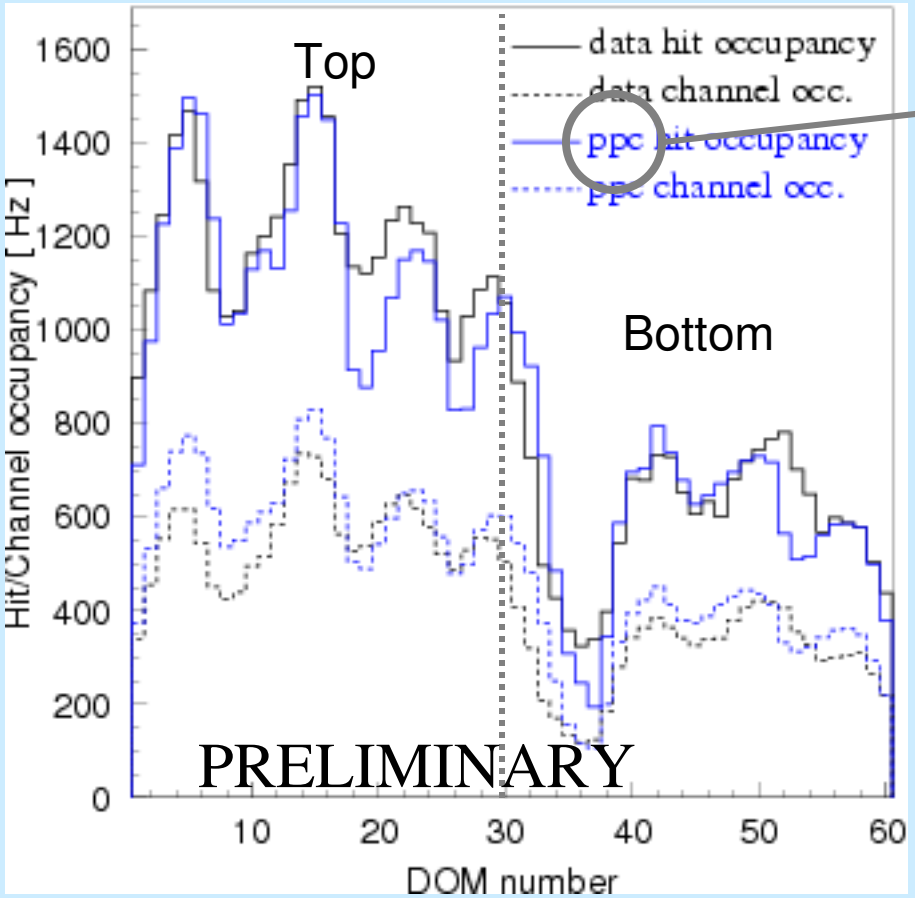
Coincident Corsika

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

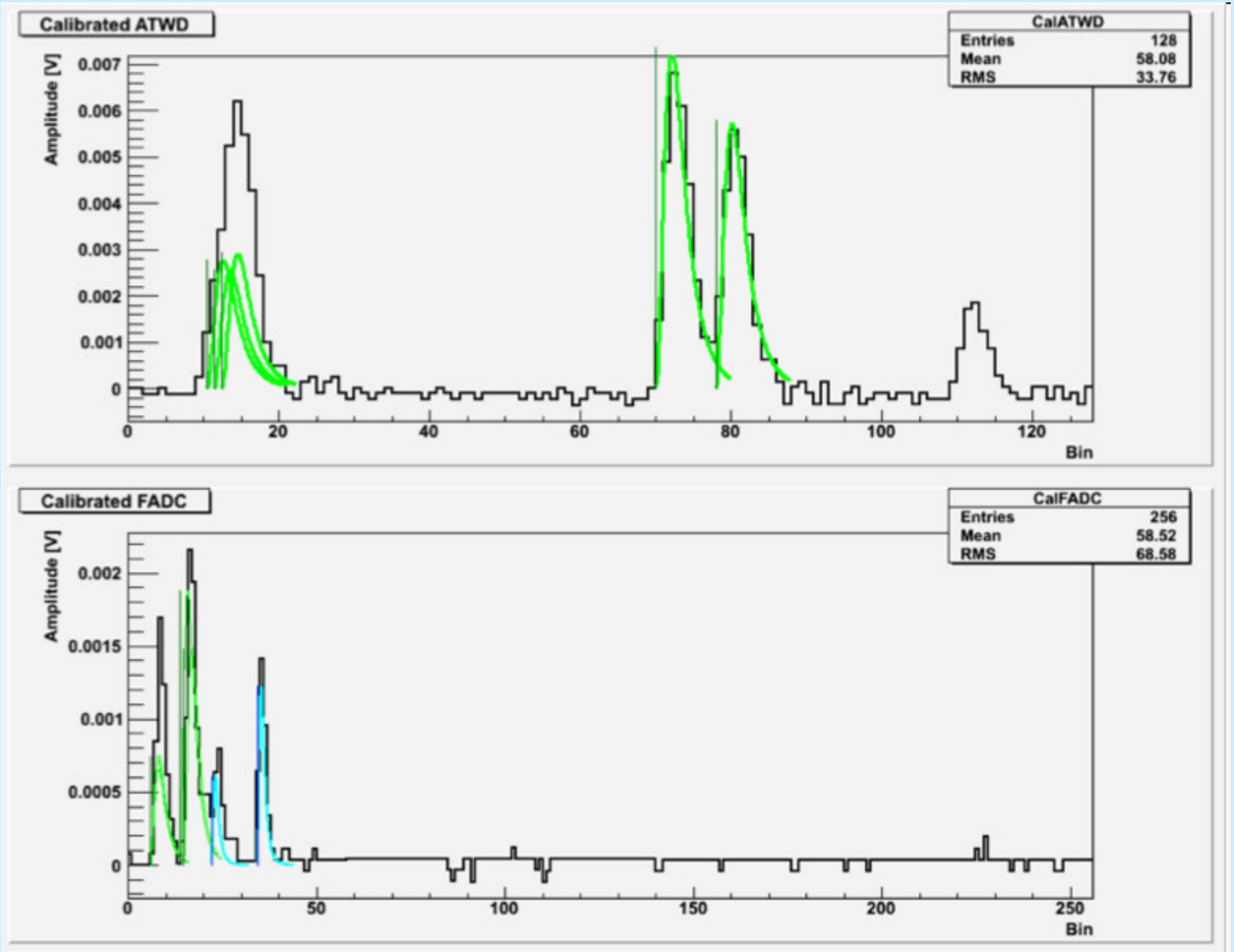
  new flasher runs planned;
  we aim for a distributed effort in the collaboration

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.

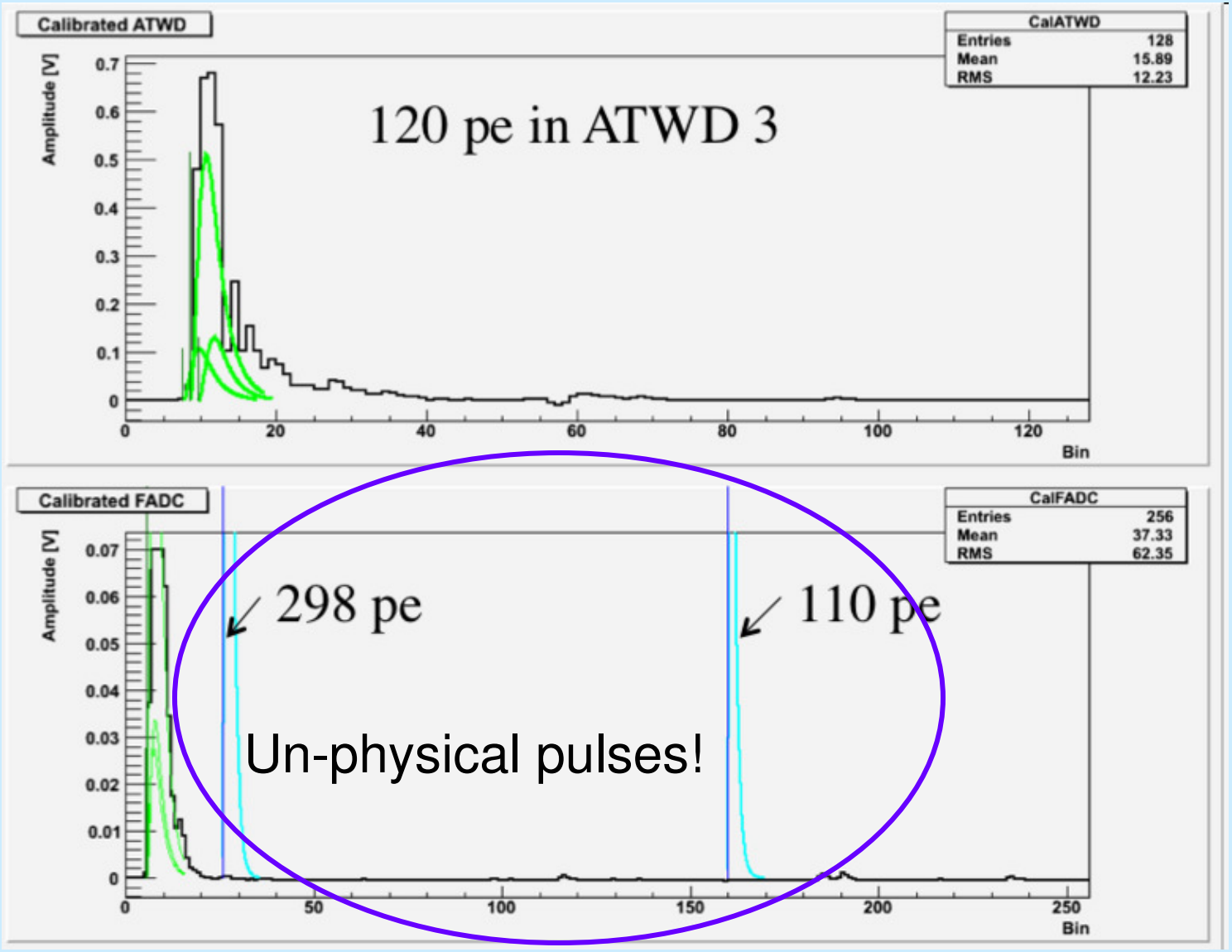
Systematic Effects in IceCube

Example of a “well” interpreted waveform



Systematic Effects in IceCube

Example of a problematic waveform



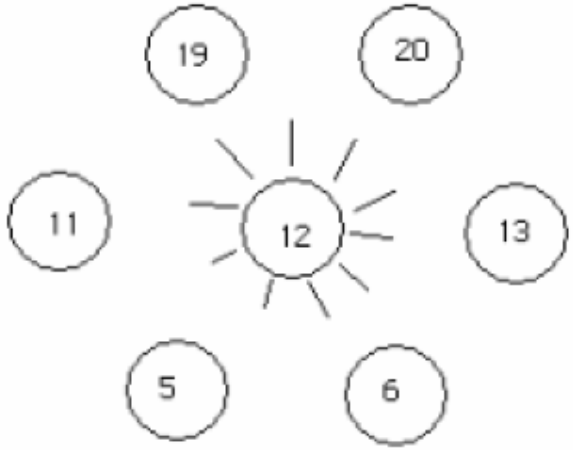
Bug recently “fixed”

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

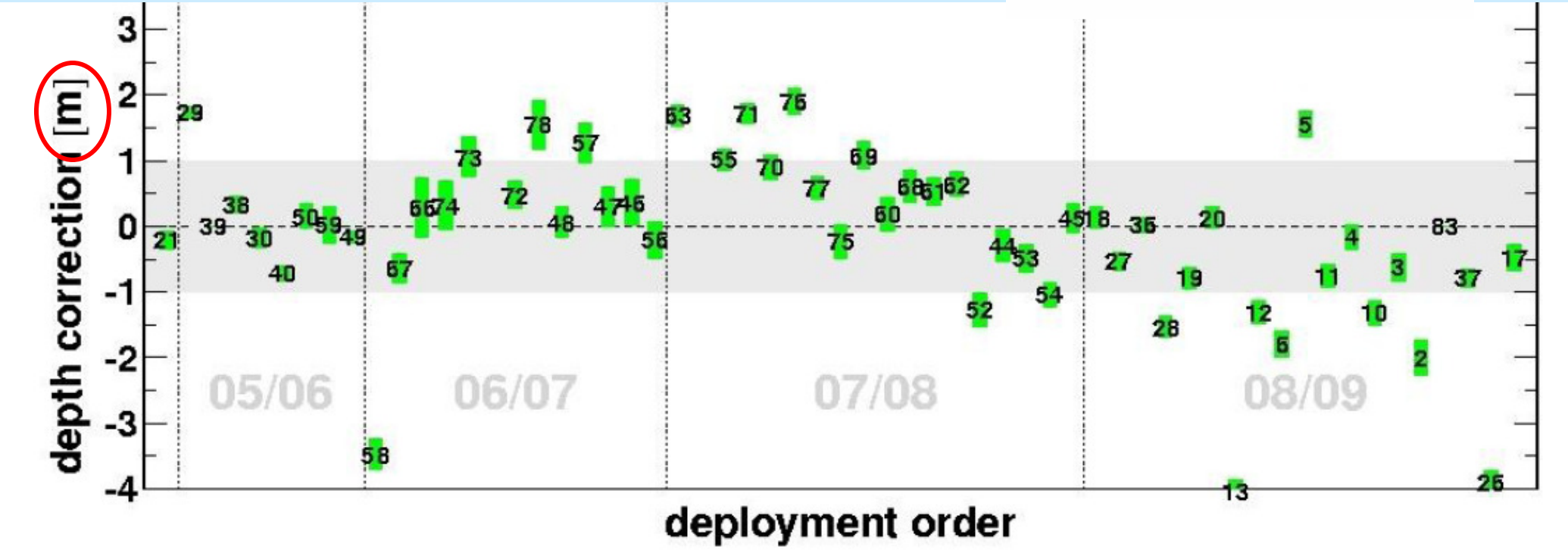
Systematic Effects in IceCube

- 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

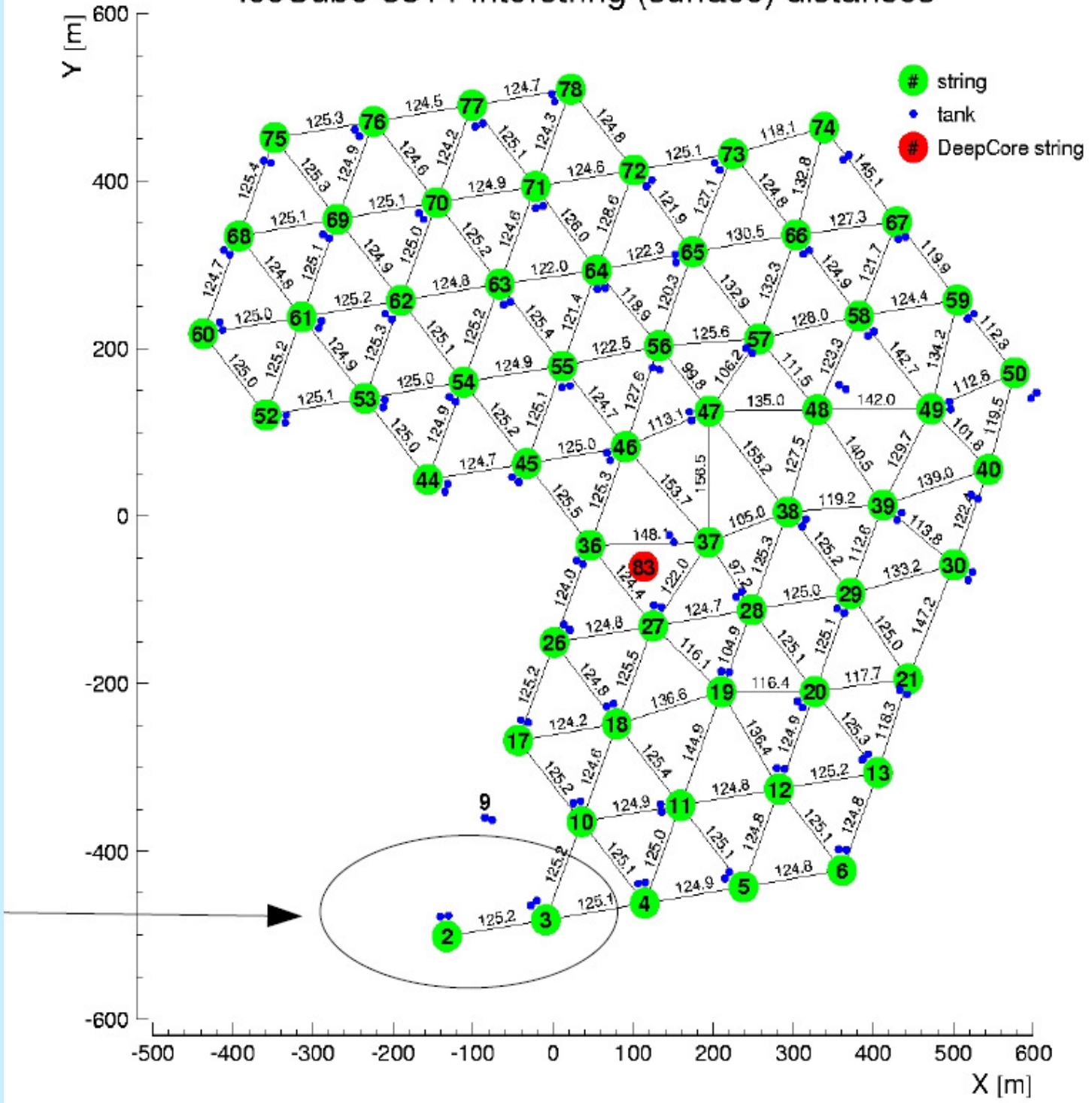
-2- Internal Referee: new draft

-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
Y [m]
X [m]
string
tank
DeepCore string
600
400
200
0
-200
-400
-600
-500
-400
-300
-200
-100
0
100
200
300
400
500
600

Evidences that the Ice Model is good:

- ❑ Ppc
- ❑ Stretched ice test
- ❑ Bottom ice: ~40% more transparent then AMANDA ice
- ❑ More events expected in the bottom part of the detector

but MonteCarlo do not reproduce correctly this

- ❑ In this plot: dust layer position match but absolute peak values no