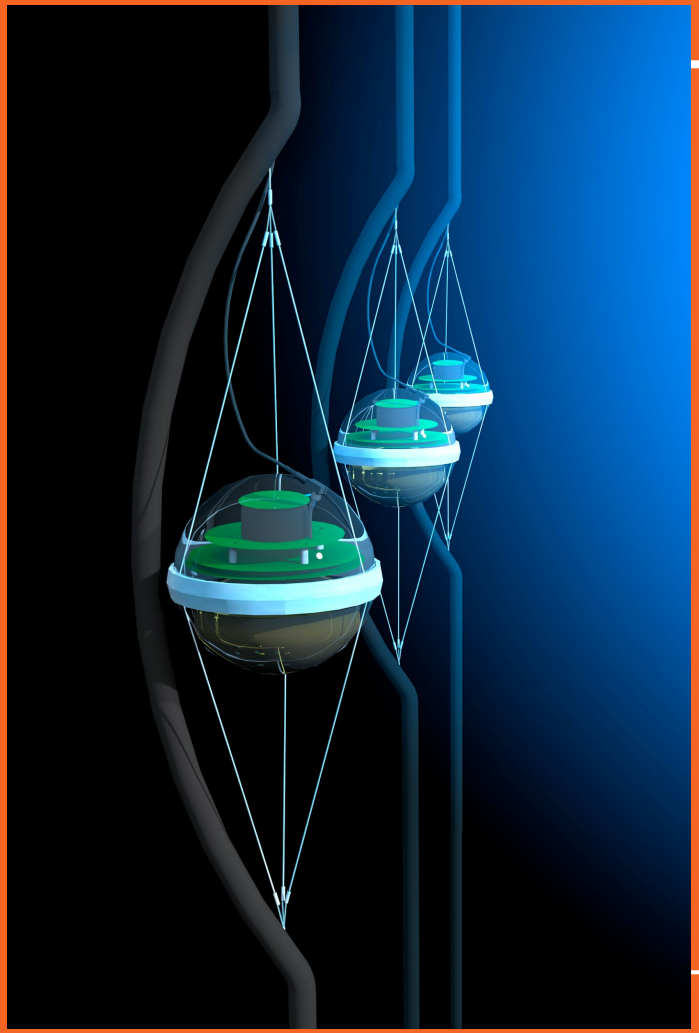
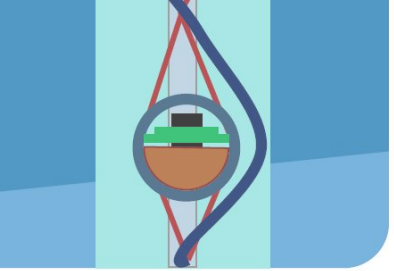


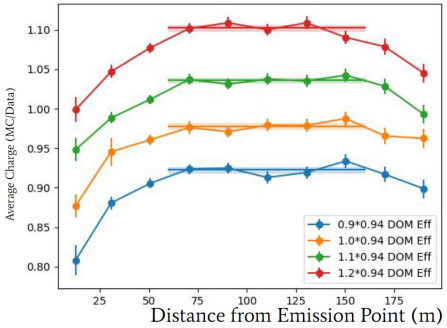
Discussions on detector & ice systematics

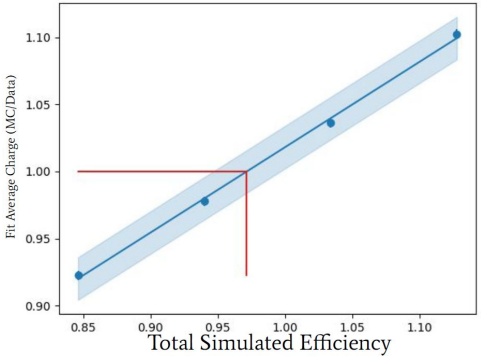
2021 Diffuse Global Fit Workshop

Erik Ganster, Martin Rongen



How we derive DOM efficiency uncertainty



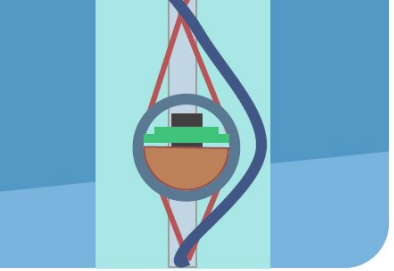


- Select minimum ionizing muons
- Match their average charge at a stable distance range to MC assuming different DOM efficiencies

- Complicated by systematics such as angular acceptance, distance dependent wavelength attenuation, fiducial volume ...

- Usually interpret stat.+ syst. 1sigma error of analysis as systemtatic DOM efficiency uncertainty for discret sets

[Current status from Thomas]



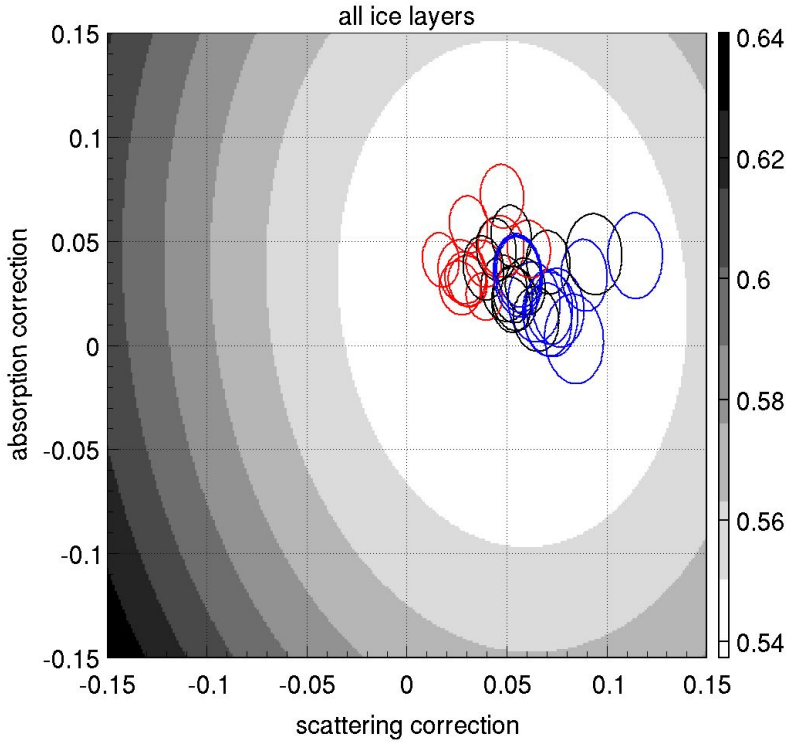
How we derive ice systematics

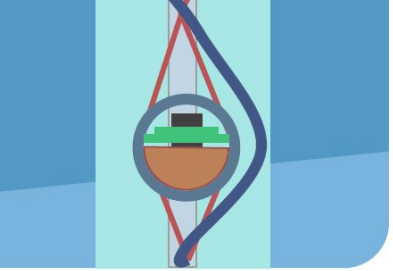
Refit global scaling of scattering & absorption for:

- Horizontal & tilted LEDs
- Different anisotropy assumptions
- Different relative DOM efficiencies
- Different angular acceptance curves
- Different flasher pulse timing profiles
- Different flasher angular emission templates
- Different scattering functions

Identify range that covers ~68% of deviations.

Latest full compilation here:
https://events.icecube.wisc.edu/event/106/contributions/1317/attachments/952/1035/ice_systematics.pdf





Different ways of providing & applying systematics

Our primary concern is avoiding biases

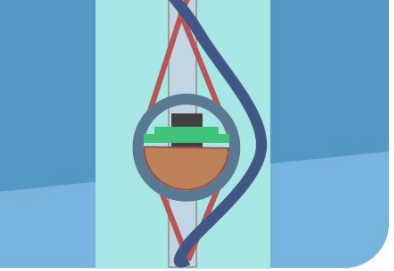
→ release improved ice models even if their uncertainty not fully evaluated

Ways to provide systematics

- Discrete sets, syst. error at analysis level is full decrepancy to baseline set
- Apply systematics as priors without fitting (requires PDFs to be provided)
- Fitting nuisance parameters (as also in SnowStorm) (may deviate from Baysian priors)

Systematics are no exact science… Consistency between analyses is more important.
So that techniques and their resulting sensitivities can be compared.

This has not been the case for a while now, with people interpreting the discret sets in different ways. Aim to provide guidance for PDF based approaches. Full consistency not possible anymore.



Recommended ice model and systematics

https://wiki.icecube.wisc.edu/index.php/Ice_models

Moving from discrete sets to recommending priors so to support Baysian analyses.

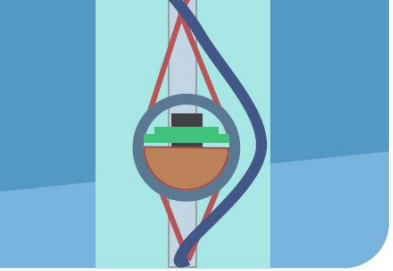
SpiceBFRv2 for new datasets, legacy support for Spice3(.x) but being phased out

DOM efficiency: rectangular flat prior between 0.9 and 1.1 (until update by Thomas)

Absorption/scattering: 2D Gaussian with individual standard deviations of 5% each

Anisotropy: Analysis dependent. If critical and BFR can not be used, test 0% to ~10% in Lea/3.2.
BFR uncertainties currently being evaluated.

Hole ice: Analysis dependent. Unified Hole Ice Model with p0=-0.27 & p1 = -0.042 as default.
Flat rectangular priors between p0=[-0.5, 0.3] and p1=[-0.1, 0.05]
(Exact cable positions known for some time now, but still requires implementation and testing.)

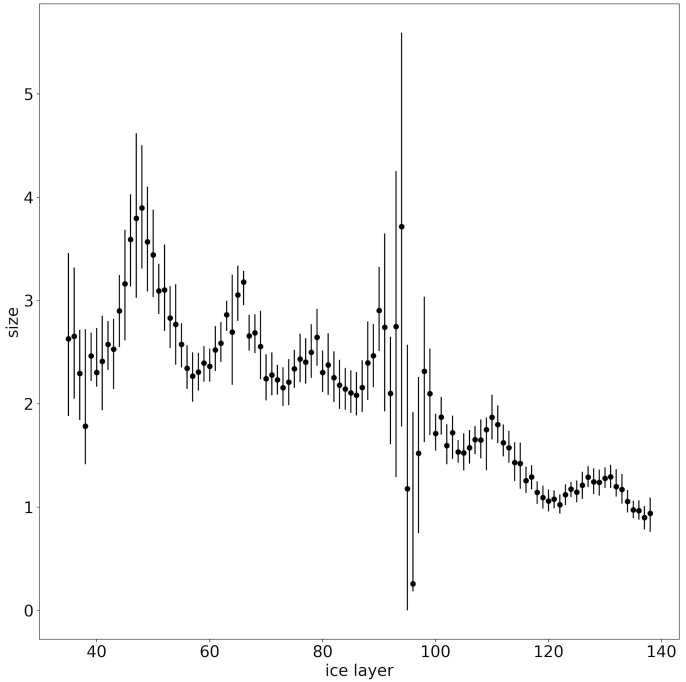


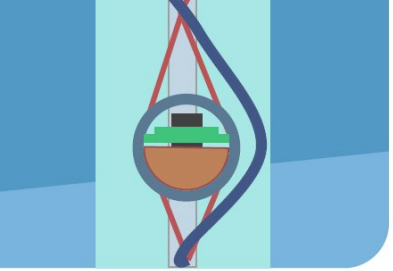
Anisotropy uncertainty

For SpiceBFRx models: no well established method yet

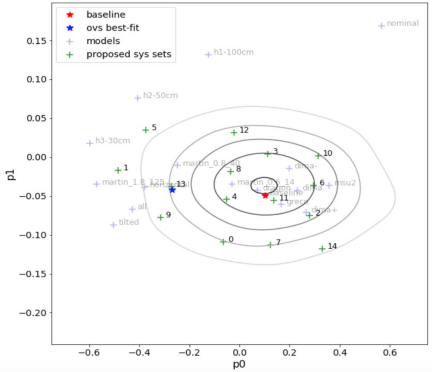
the granularity (size) parameter serves as the primary scaling parameter, the average relative uncertainty is ~15%,
this could be used as the std. of a Gaussian.

For Spice3.x models: Uniform prior between 0%
(best timing) to ~10% (best charge)





Hole ice (angular acceptance) uncertainty

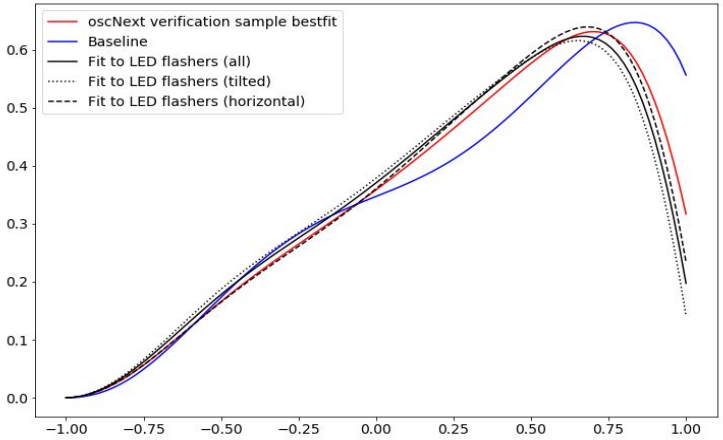


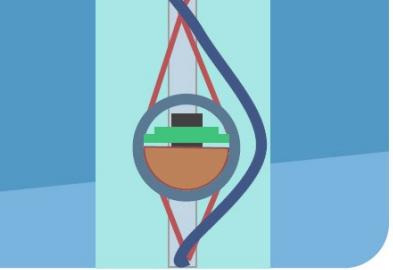
Most recent conclusive experience from [OscNext verification sample].

They use Philipp Eller's [Unified Hole Ice parametrization].
Which spans ranges not accessible to MSU and Dimas function.

Suggest to use OscNext best fit (which yields a rather sensible looking angular acceptance curve)
as recommended single value.

Philipp Eller suggested a flat rectangular prior between p0 (-0.5, 0.3) and p1 (-0.1, 0.05),
which has been confirmed by [flasher study]





DOM efficiency

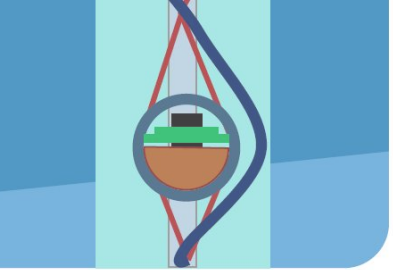
For the DOM efficiency we currently recommend ±10%.

Muon analyses yield smaller statistical errors, but last complete analysis is on rather outdated ice, recos, detector simulation…
This interconnection is a somewhat historic caution, may be dropped as we now see ice model photon yields to be extremely compatible (sub%)

Would opt to stick with a conservative uncertainty. For example uniform from 0.9 to 1.1.

This was critized for being less conservative than a Gaussian prior. May be revisited.

SPICE3 analysis by Thomas ongoing. Preliminary results indicate 95% for IceCube DOMs and 90% for DeepCore. SpiceBFR should have no impact, but needs to be checked.



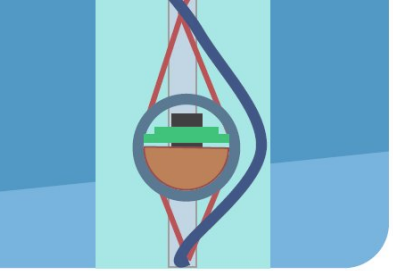
Cable / DOM orientation

As released is just the DOM LED orientation.

For the cable which is the relevant effect, the attachment uncertainty has to be taken into account -> 5-10deg Gaussian???

(as this is significantly smaller than the uncertainty of the cable shadow analysis a perturbation on this level is probably irrelevant -> does not need to be varied)

Two implementation schemes: Direct simulation (oversizing 1 specific) or backward propagation after hit (also possible at higher oversizing). clSim implementations lacking.



Items not currently considered

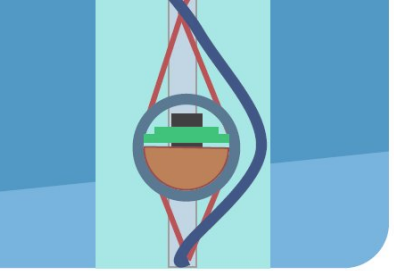
Direct hole ice: SpiceHD orientations discredited as cable correlated.
Analysis by Dima ongoing. New orientations, size and scattering length seem reasonable.
First release with SpiceBFRv2 → wait until at least tested by LowEn-Group

Ice stratigraphy: Per-layer uncertainty as deduced by Dima and applied as random scatter is subdominant. Perturbation as considered in the FFT ice model still under investigation.

Geometry: Potential ~10% effect on for example high energy direction reco known for some time. Muon analysis by Matti ongoing. Flasher analysis so far unsuccessful.

Relative DOM efficiencies: Flasher study by Dima recently updated.
Dedicated studies with muons ongoing.

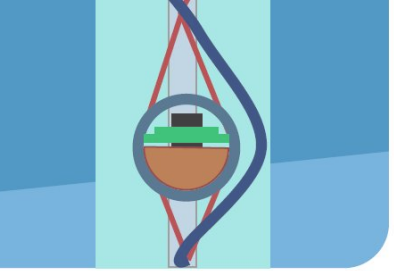
Now for the SnowStorm specifics



SnowStorm Photon Propagation

- Perturbation of detector + ice systeamtics during photon propagation

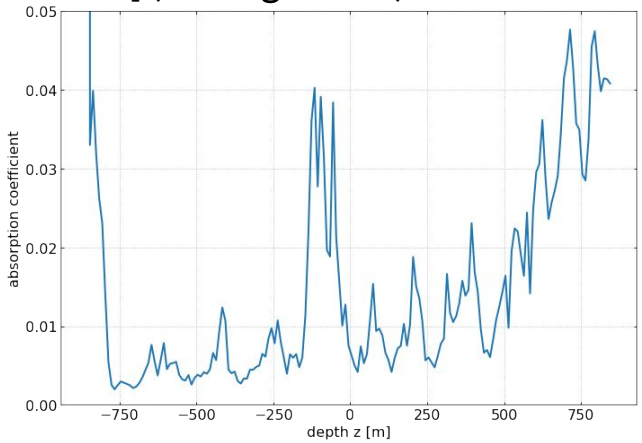
  a. Define all SnowStorm parameters to use and their sampling distributions
  b. Load a baseline ice-model
  c. Dice SnowStorm ice-model parameters and update CLSim's photon propagation kernel
  d. Process a bunch of frames with these ice-model settings (~ 100 – 1000)
  e. Dice + load new SnowStorm ice-model parameters
  f. Repeat steps d + e



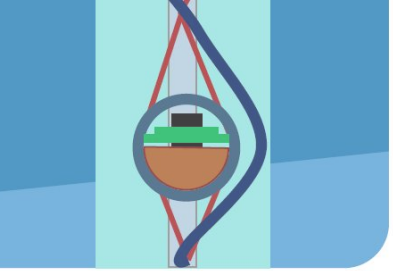
SnowStorm Parametrizations

- (Global) scaling of the bulk ice scattering + absorption coefficient
  - In the actual code, the scattering/absorption length is scaled by 1/x

- Currently: uniform sampling [0.9 - 1.1] (scaling factor)



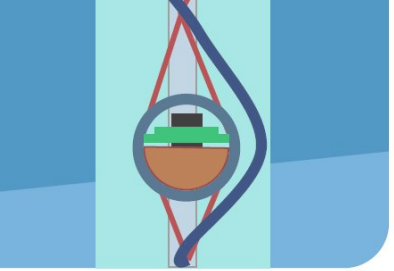
IceAbsorption
IceScattering
AnisotropyScale
DOM Efficiency
HoleIce Forward (unified)
IceWavePlusModes



SnowStorm Parametrizations

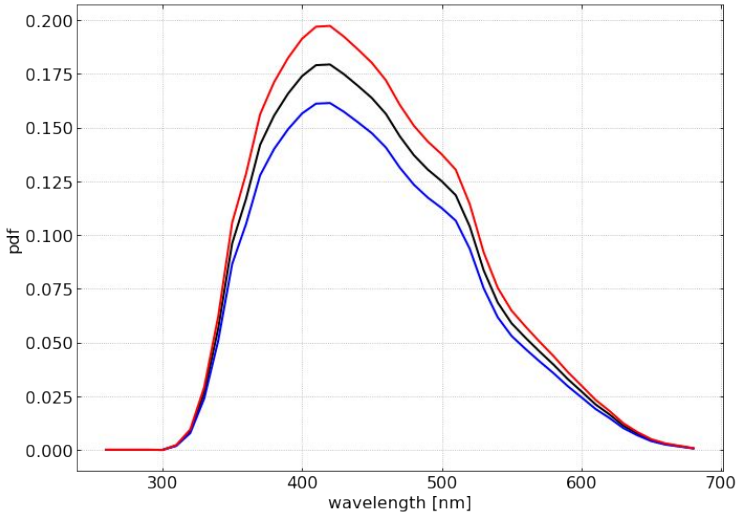
- Scaling of the 2d ice anisotropy ellipse
- Currently: uniform sampling [0.0 - 2.0] (scaling factor)
  - Corresponds to 0 - 15% anisotropy

IceAbsorption
IceScattering
AnisotropyScale
DOM Efficiency
HoleIce Forward (unified)
IceWavePlusModes

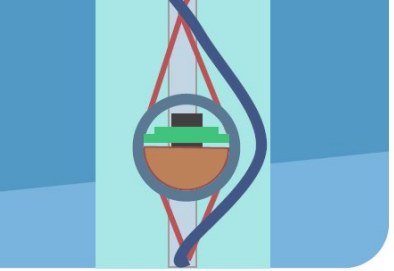


SnowStorm Parametrizations

- Direct scaling of the DOM's wavelength acceptance
- Currently: uniform sampling [0.9 - 1.1] (scaling factor)

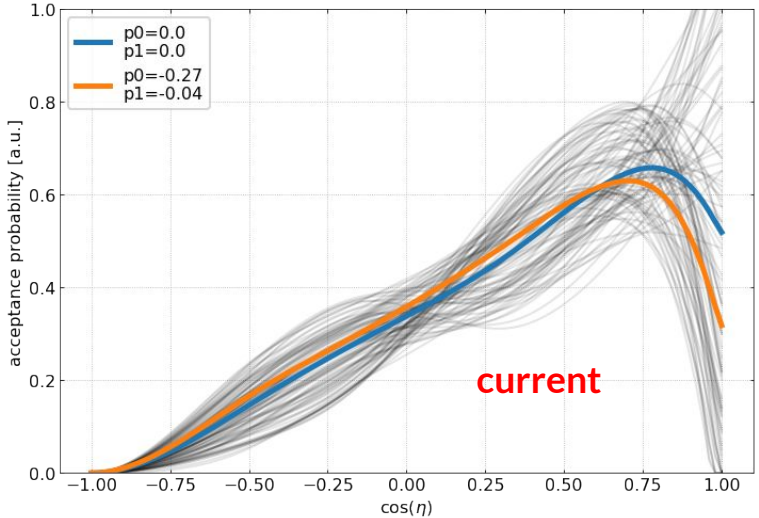


IceAbsorption
IceScattering
AnisotropyScale
DOM Efficiency
HoleIce Forward (unified)
IceWavePlusModes

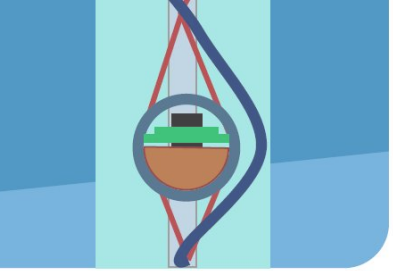


SnowStorm Parametrizations

- Using the unified HoleIce model from Phillipp Eller
- Independent uniform sampling of both parameters
  - p0 = [-1.0, +1.0]
  - p1 = [-0.2, +0.2]



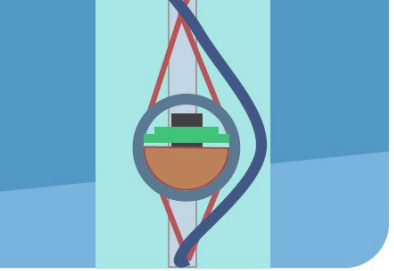
IceAbsorption
IceScattering
AnisotropyScale
DOM Efficiency
HoleIce Forward (unified)
IceWavePlusModes



SnowStorm Parametrizations

- Depth dependent scaling of the ice absoprtion + scattering using the icewave ice-model from icetray
- Only varying the IceWavePlusModes, 12 modes, 2 parameters (amplitude, phase) each
- Not used/applied in first SnowStorm production sets:
  - Minor changes of single modes were yield to ice-models 15-30 sigmas away from the flasher best fit model: slides

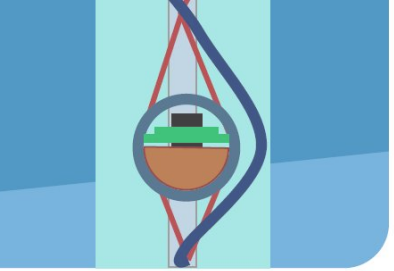
IceAbsorption
IceScattering
AnisotropyScale
DOM Efficiency
HoleIce Forward (unified)
IceWavePlusModes



SnowStorm Systematics - Overview

- Overview of all currently “snowstormable” parameters
- All SnowStorm parameters are based on *Spice3.2.1* as baseline ice-model
  - The baseline model gets loaded/initialized before any perturbations gets applied
  - HoleIceUnified baseline: p0 = p1 = 0.0

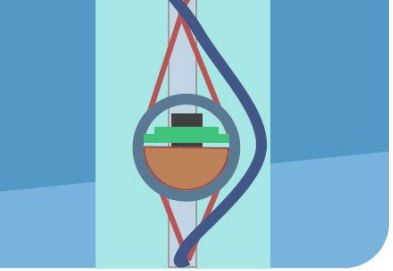
Systematic	Sampling Distribution	Range
IceWavePlusModes	2x 12 Gaussians	- - -
Scattering	uniform	[0.9, 1.1]
Absorption	uniform	[0.9, 1.1]
AnisotropyScale	uniform	[0.0, 2.0] (= 0-15%)
DOMEfficiency	uniform	[0.9, 1.1]
HoleIceForward_Unified	uniform	p0 [-1.0, +1.0] p1 [-0.2, +0.2]



SnowStorm Systematics - Outlook

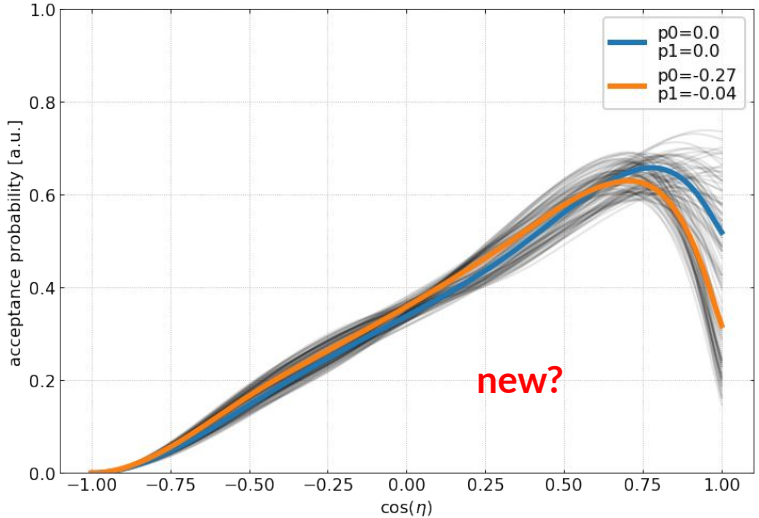
- Update the baeline ice-model from Spice3.2.1 to SpiceBFR (v1)
  - Do we need to modify the existing parametrizations?
- Update HoleIce baseline to new values
- Adjust sampling distributions?

Systematic	Sampling Distribution	Range
IceWavePlusModes	2x 12 Gaussians	- - -
Scattering	uniform	?
Absorption	uniform	?
AnisotropyScale	uniform	?
DOMEfficiency	uniform	?
HoleIceForward_Unified	uniform	?



SnowStorm Parametrizations

- Using the unified HoleIce model from Phillipp Eller
- Independent uniform sampling of both parameters
  - p0 = [-0.5, +0.3]
  - p1 = [-0.1, +0.05]



IceAbsorption
IceScattering
AnisotropyScale
DOM Efficiency
HoleIce Forward (unified)
IceWavePlusModes