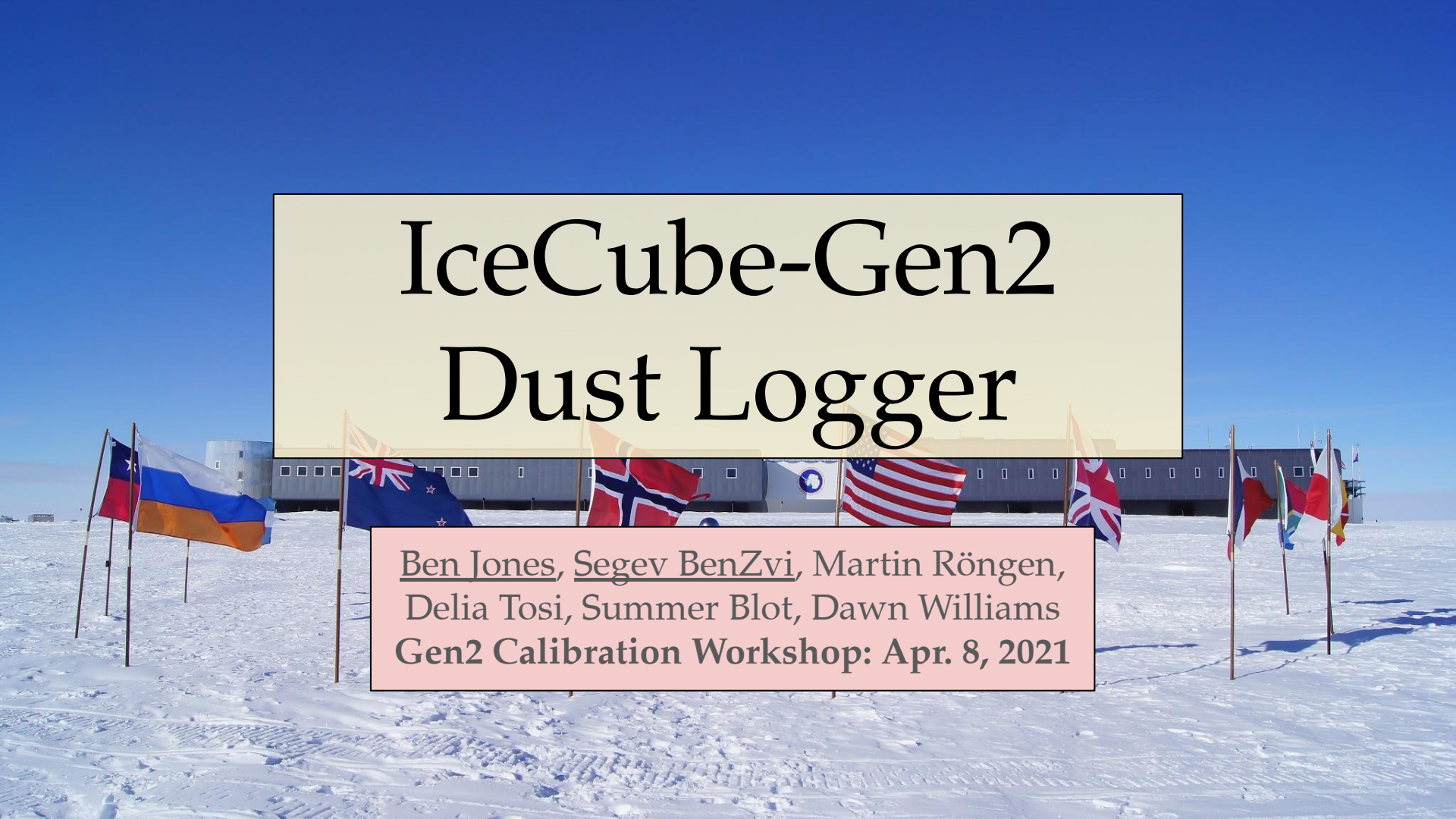

IceCube-Gen2 Dust Logger

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Delia Tosi, Summer Blot, Dawn Williams

Gen2 Calibration Workshop: Apr. 8, 2021

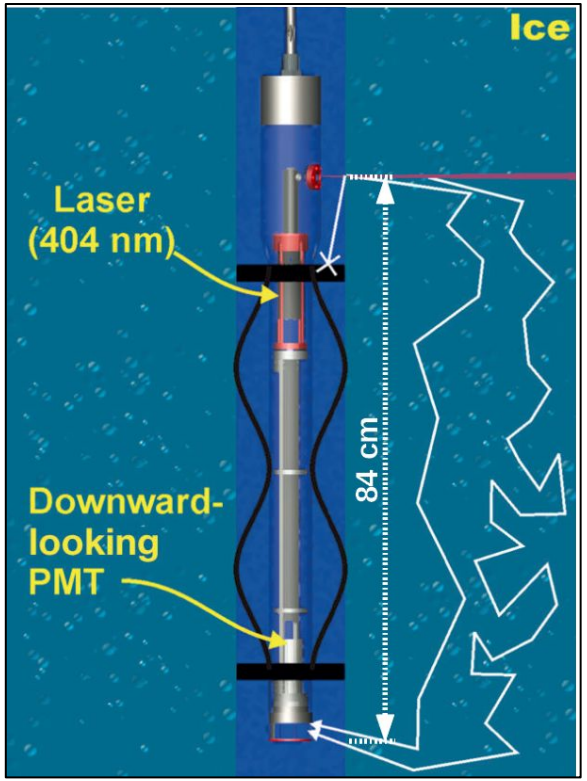
The “old” dustlogger

Single optical detector separated from bright, fan-beam laser light source by 84 cm.

The only way to provide IceCube’s tilt map - a centrally important part of optical array calibration.

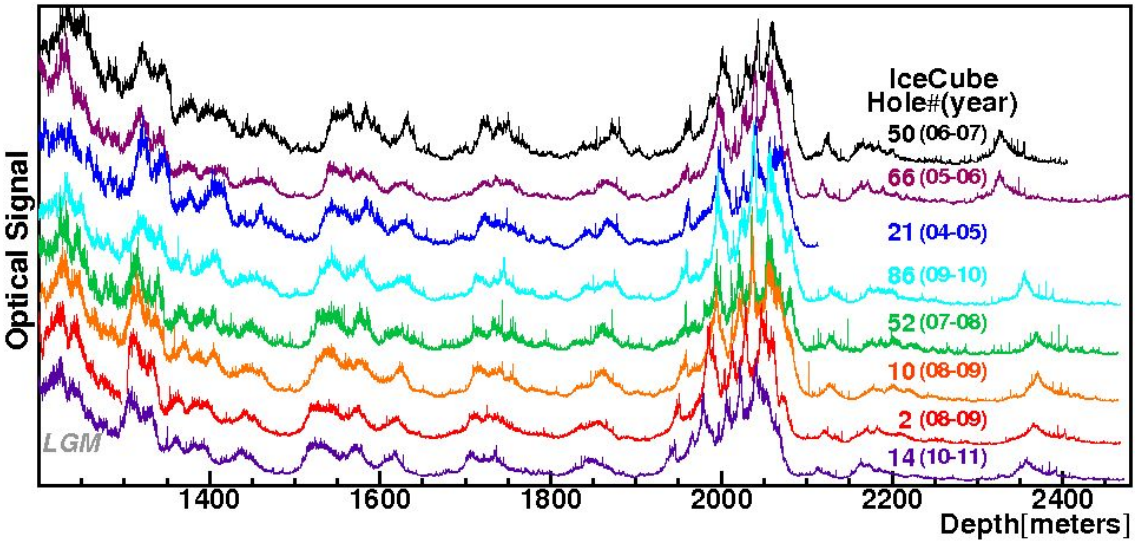
Beam projected a flat, 60 degree fan - originally a compromise solution due to difficult mechanics of more ideal 360 window.

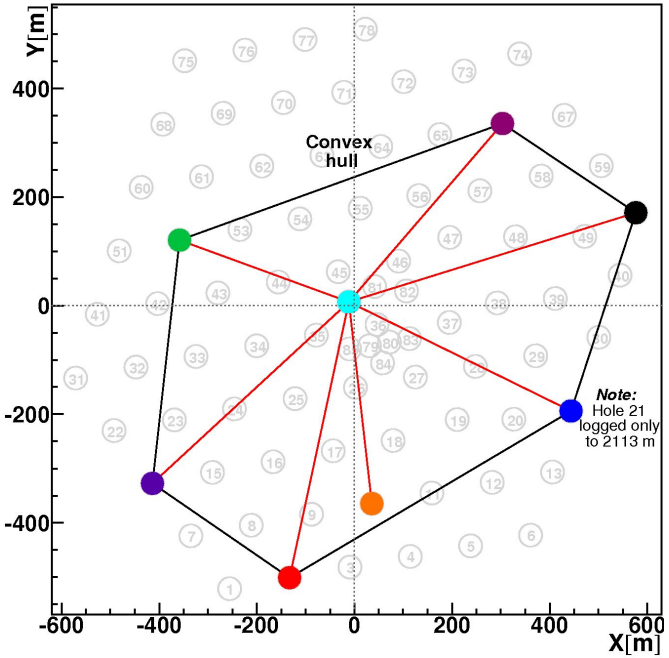
However, the compromise ultimately enabled new classes of measurements of scattering anisotropy.



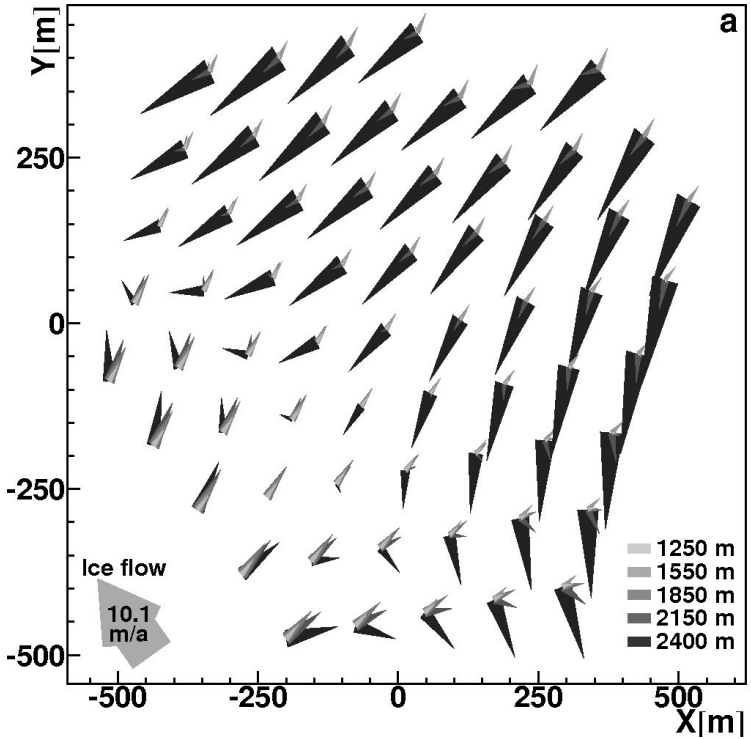
Dustlogger in IceCube

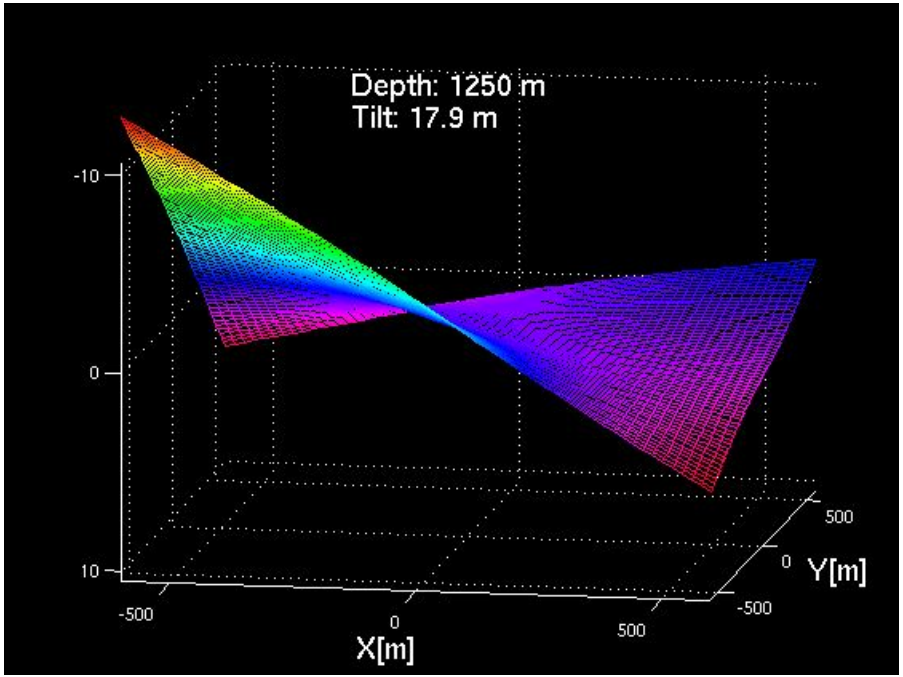
After depth matching, the optical signal from 8 dust-logged holes in IceCube-Gen1.





Tilt as fitted / extrapolated



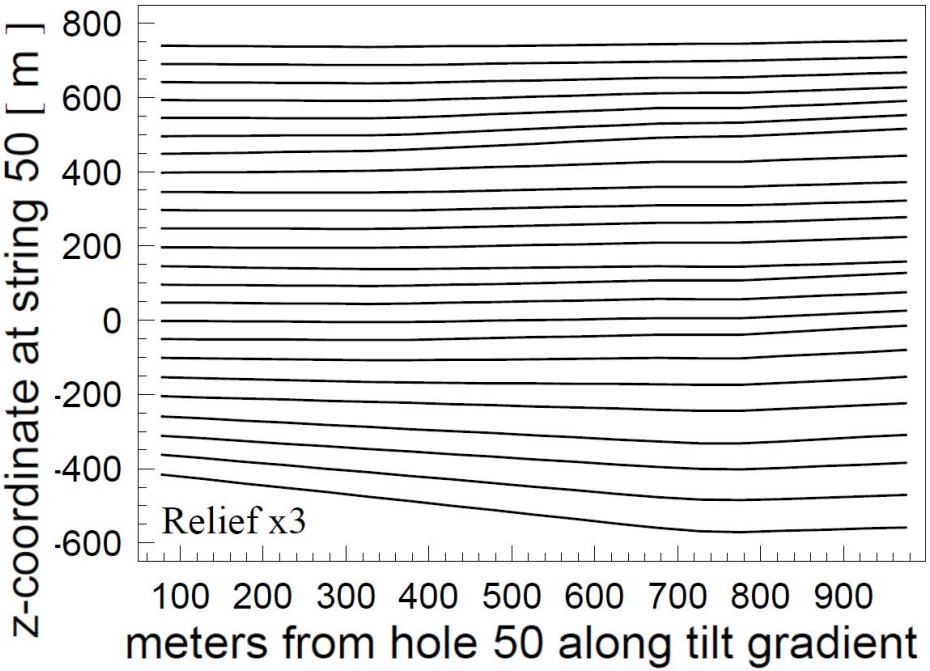


As implemented in the ice model

Raw data processed and used to extract tilt magnitude.

BJ and SB do not have experience with the data reduction, but it is nontrivial. Depth/pressure analysis was done by Ryan Bay in past deployments.

NB: We are not sure if anyone within IceCube has either the raw data or code to do this.



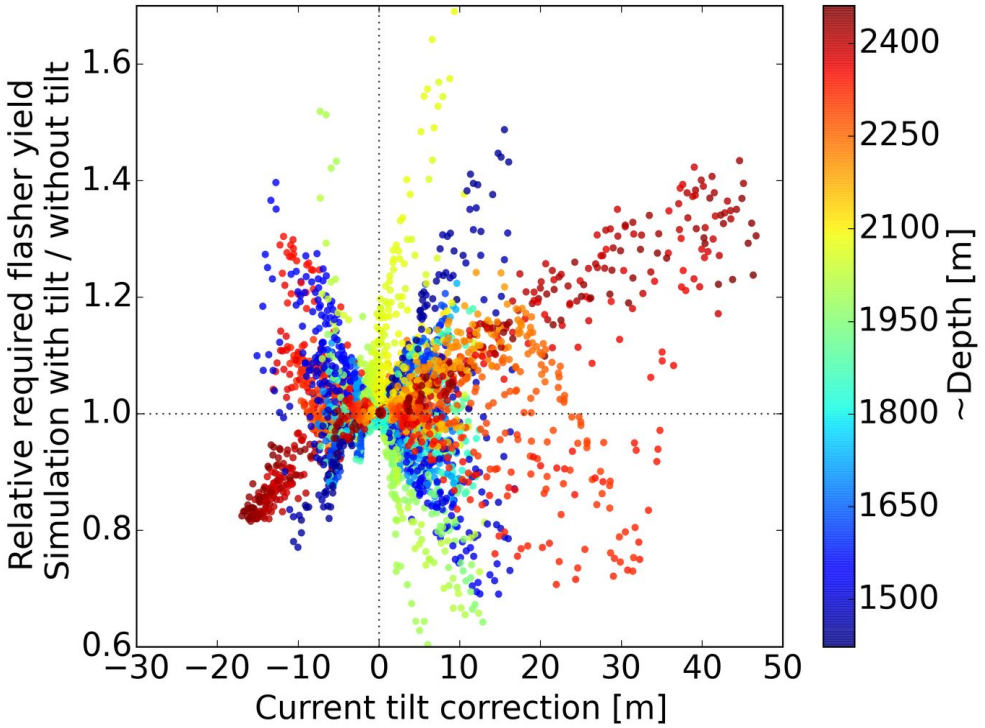
Flasher study to gauge the effect
(all of this is well known, but a good reminder)

- Primary effect is on cascade energy resolution
- Use flashers (horizontal LEDs) to mimic cascades

- Run full detector ice model (BFRv2) evaluation with and without tilt, the flasher photon yield (cascade photon number) being left to float as nuisance parameter to match data
- The relative photon yield per DOM is the relative energy error introduced by not taking into account the simulated tilt correction at each DOM position

Flasher study to gauge the effect
(all of this is well known, but a good reminder)

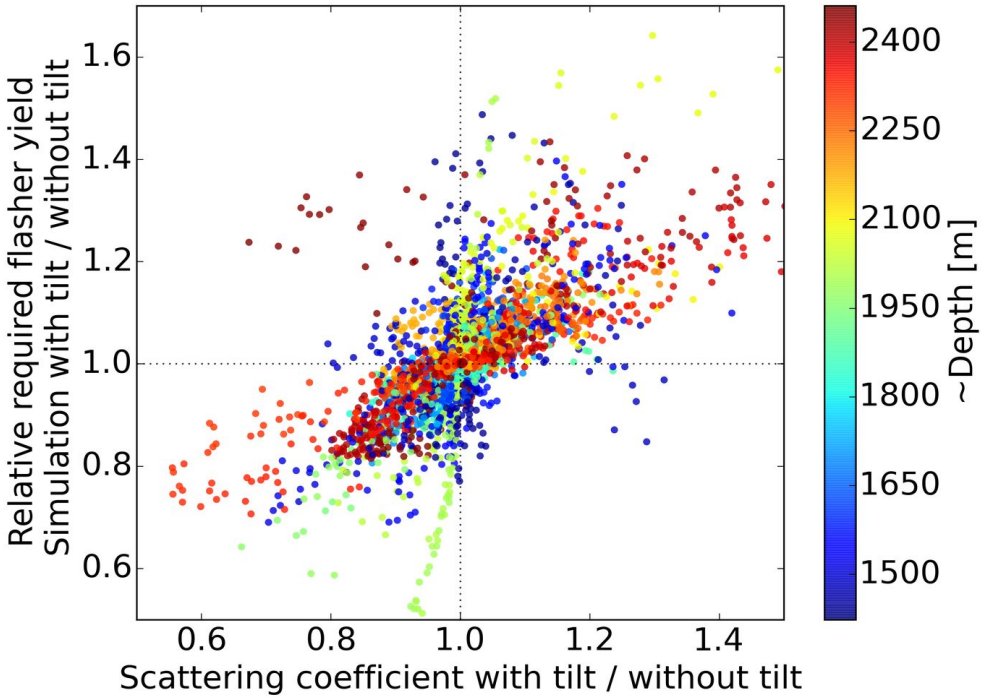
- Plot looks messy as tilt does not consistently shift into better/worse ice
  → plot vs. ice quality change



Flasher study to gauge the effect
(all of this is well known, but a good reminder)

- Coefficient averaged over ±20m depth range
- Still messy, but correlation as expected

- **Gen1 level tilt introduces up to ~50% energy bias when not handled (correctly)**



Reclaiming the Knowledge of the Ancients

The raw data used to make IceCube's existing tilt map is not presently available to us, or to the community.

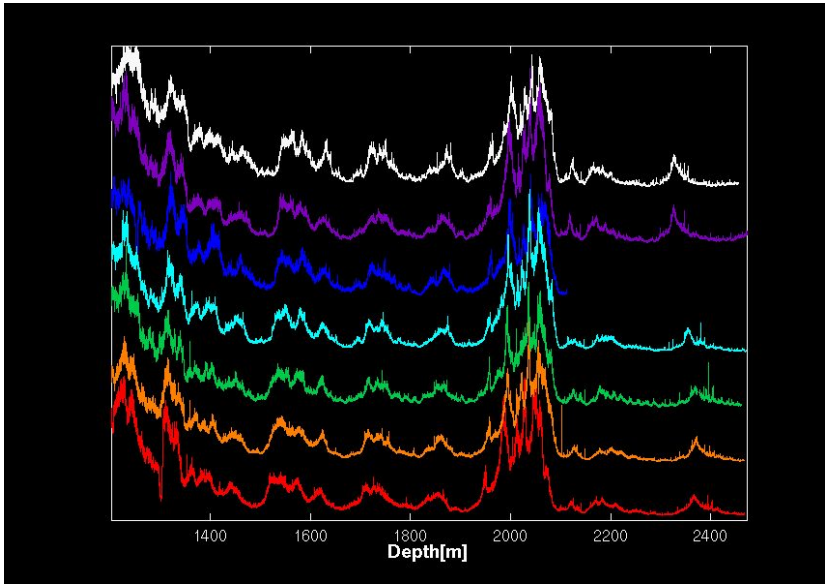
This is a hole that we think should probably be filled.

Proposal: produce a retrospective data release, providing minimally processed raw dust logger data and scripts to make a tilt map.

Finding / running old code may be challenging, though going from old data to a new tilt map seems achievable.

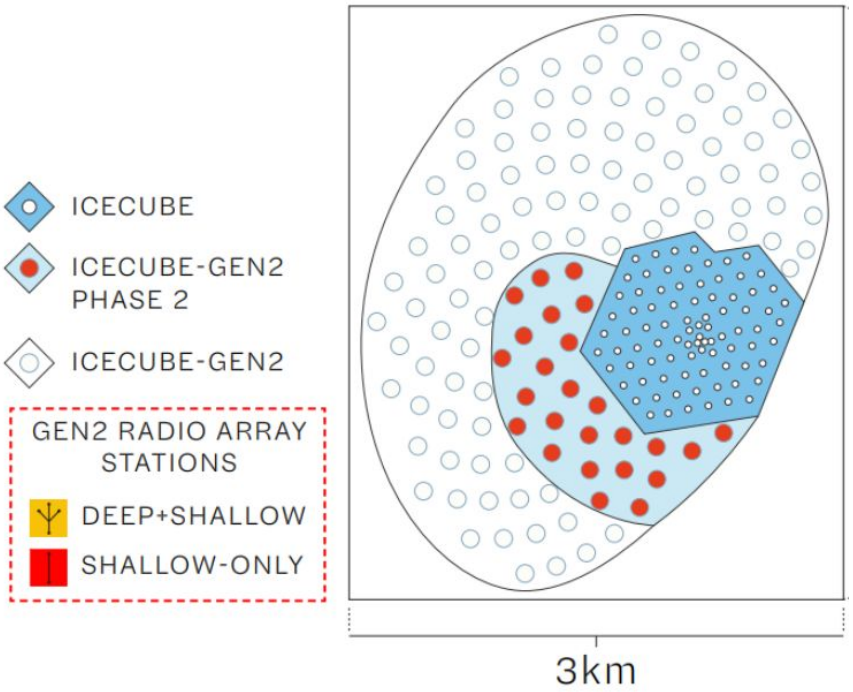
We hope the original raw data can be found.

Original tilt map is available for validation.



What to expect in Gen2

Favored geometry extends the array primarily **in the tilt direction**.



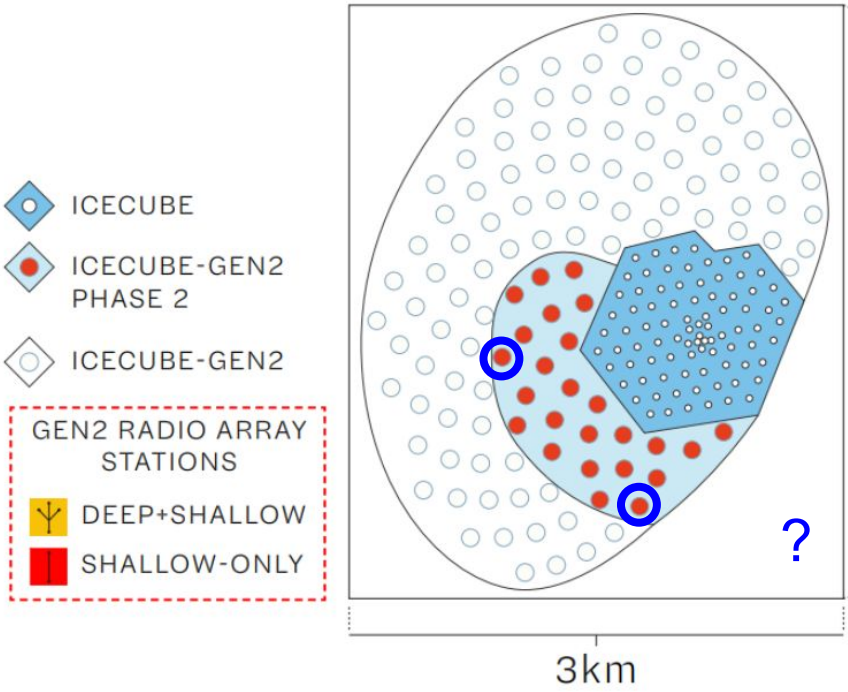
What to do in Gen2 - Basic Goal

The truly non-negotiable output the dust logger must produce is the **extended tilt map**. Needs:

- Bright, **collimated** beam.
- **Sensitivity+run-time** for photon statistics.
- **Vertical precision** sufficient to place layers within ~1 m absolute.

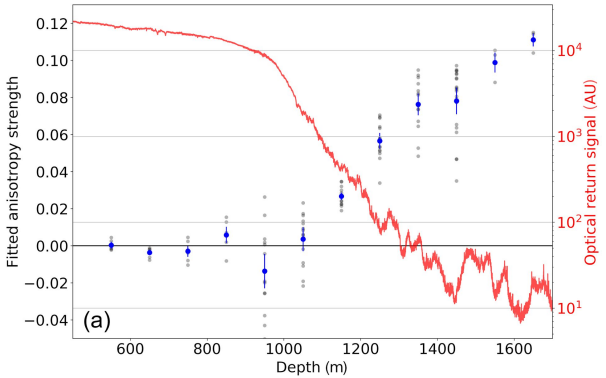
Achievable with a device like Gen-1 logger, but:

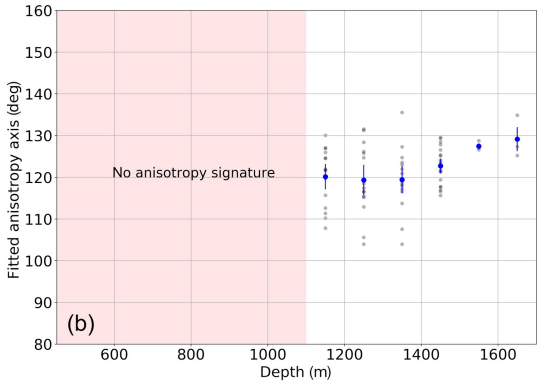
- Require **updates** to enhance mechanics / electronics to modern standards.
- At the moment Gen2-Phase2 plan includes 2 logged holes. Some **study of whether this is enough** is probably needed.



What to do in Gen2 - Extending dust logger science

- There are ways to expand the dust logger science program.
- A great example is the work by Martin, Ryan, Summer on directly probing anisotropy with an oriented logger.
- Certainly it would make sense to ensure the future dust-logger has orientable capability.
- But there also potential to do more.

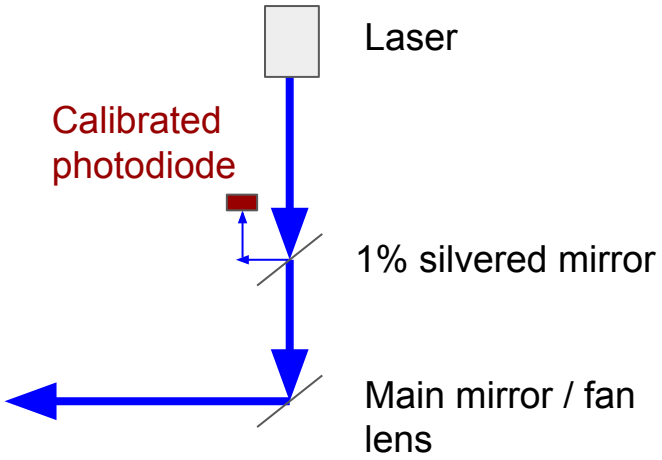




What to do in Gen2 - Upgrading the logger design

Intensity monitoring of the output beam

- No absolute calibration of present dust log.
- Laser driver power was manually adjusted to avoid saturating the optical detector.
- This is fine for tilt map; where only vertical peak positions needed.
- Absolute calibration **is** possible if we monitor the light with a pickoff probe and calibrate across temperatures.
- ~Simplest possible improvement to the logger, and easy to implement.



What to do in gen2 - New ideas

<u>We can get cleverer too.</u> Plan to execute simulations and R&D to study both viability and benefit of the following extended dust logger capabilities

- **Monitoring polarization / depolarization** of returned light to obtain ice fabric information in parallel to tilt map
  - MC needed to assess if this gives useable information - studies are planned.
- **Multi-colored logger** to pursue spectral studies not advanced since AMANDA
  - Past attempt to use a green logger in addition to blue laser failed due to laser temperature dependence. Local R&D on light sources and detectors in cold conditions planned at UTA / Rochester to explore this further.
- **Pulsed operation and timing** information
  - Plausible to pulse the beam and monitor timing to study scattering profile.
  - We suspect returned light timing may carry only limited information; **needs study**.

Pragmatic Next Steps (and Questions)

- Obtain as much original information on Gen-1 dust logger as possible
  - *Does anyone in IceCube have the drawings, designs, circuit schematics, code, etc? Can we get it?*
  - *How about original raw data? code?*
- Study 2-hole tilt mapping capability for Gen2-Phase2 to define specs for baseline dust logger
  - *New UTA student recruited, who will to begin this work in August*
- Begin bench R&D on direct intensity monitoring including in cold conditions for absolute calibration of dust logs for new holes.
  - *We are prepared to commit to implementing this feature in the Gen2-Phase2 logger*
- Begin MC simulations of potential advanced dust logger capabilities.
  - *It is likely that at least one of the proposed directions will yield valuable information - but which one should be the focus, given limited money, data taking time, and real-estate? Simulations are needed.*