Ice Drilling Program Office

Dartmouth – University of New Hampshire – Colorado School of Mines

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Science Requirements: RAMARA DRILL

Background:
The IDPO Long Range Science Plan 2016 identified science goals for ice drilling that spanned a wide range of science needs. For field projects that need access holes in firn and ice for neutrino detectors, an agile rapid-access drill is needed to create dry 10-cm to 15-cm diameter holes in firn and ice to depths of approximately 50m to 200 m, for deployment of neutrino detectors. Drill logistics, budget and drilling rate must be considered before a final determination of the required hole depth and diameter. From discussions organized by IDPO with iterative interactions between IDPO, scientists, and IDDO staff, the following are the science requirements for the drill:

Scientific Requirements

1. Drill to rapidly produce holes in firn and ice with a nominal diameter of 10 cm to 15 cm and depth of 50m to 200 m at the South Pole. A depth of 50 m is seen as minimum, 200 m as desirable. See additional comments at end of document.

2. The drill should be capable of drilling 3 to 10 holes per 10 hour work day including transportation to / from field site (if needed), daily startup, movement between holes, and daily shutdown.

3. The drill should be field portable so that it can be transported over rough terrain near the South Pole with South Pole heavy equipment without requiring a road.

4. Drill control should be simple and intuitive for use in the field. Two trained drill operators should be able to set up and do the drilling operations in the field, with a third trained person assisting if needed.

5. The drill shall be operable in ambient temperatures down to -30° C and winds of up to 20 knots

6. The drill should be designed for use in ice with temperature range from -25°C to -55°C.

7. Setup time for the drill should be within a day or two after initial unpacking on site.

8. The drill shall have stand-alone capability for operation at small field camps at remote sites with no heavy equipment except that used for transport. (The default scenario is drilling holes at distances up to 5km, in the farther future up to 10 km from the South Pole station.)

9. The drill should be easily maintainable in the field by drill operators, and instructions and parts for maintenance in the field should be included with the drill.

10. The drill should be transportable with the entire drill system with no more than one LC-130 flight, or with ground traverse.

11. The hole must be dry for its entire depth.

12. The hole sidewall must be smooth to allow for deployed equipment to smoothly slide down into place.

13. The hole must be straight to less than the diameter of the hole. Alternatively, if deviations are larger, a logging information is provided that describes the geometric path of the hole in x-y-z coordinates to a precision of 15cm would also meet the science requirements of knowing the coordinates of the instruments.

Notes:
During the original development of the IDPO Science Requirements, this drill was called the "15-cm RAM drill", but in order to avoid confusion with the other, smaller and more agile RAM drill used to create shot holes, this drill has been renamed the "Ramara Drill".

This drill is intended to perform at depths from 50 m to 200 m at sites near South Pole, and it is intended to be a faster, cheaper, less risky and more reliable means than hot water drilling for creating access holes for radio neutrino detectors.

The tradeoffs between diameter, depth, and rate of hole production are complicated, but here are a few simple aspects that could help in coming up with a metric for the drill. While the ideal holes would deliver 3 holes per day to a depth of 200m and 15cm diameter, it is important that the drilling meets the requirement to be much easier to use than the hot water drill that we have used. To understand the trade-offs, we give here some dependencies to the science:

- Depth: A 200m deep hole has roughly 1.5 times more science yield of a 100m deep hole which in turn is about 1.5 times higher than a 50m hole. In other words, for every 10 holes at 200m depth we need about 15 holes at 100m depth or 20 holes at 50m depth. However, more holes will also increase the cost of instrumentation. A full scale first generation neutrino detector would require about 100 holes at 100m depth, and correspondingly more or less for different depth. The performance increases with the density of the ice with depth.
- Diameter: A 15cm diameter hole is approximately twice as "good" as a 10cm hole. 10 cm is a hard minimum requirement. 15 cm allows deployment of better and more instruments.
- Hole drilling rate: The desired hole drilling rate should be at least 3 holes per day to support the installation of a larger neutrino detector. Once the drilling create exceeds the rate of 2 per day, the construction effort will be dominated by instrument deployments. This is ideal. The drilling should not be the limiting factor and should not be the cost driver. The current water drill can, at best, make one 200m deep 15cm diameter hole per day. The rate for a 50 m hole is required to be 3 times faster than the rate for a 200m hole. Required rates are
    - 200m: 3 holes/day
    - 100m: 5 holes/day
    - 50m: 7 holes/day