SPUNK-G: Hardware Update 2: the DISC borehole logger

SPUNK Team

University of Kansas
RNO-g meeting
8 March 2021

Introduction

- The borehole closure rate turned out to be much higher than we expected.
- The fill level after 2006 drilling was measured (233 m); the fill level in 2013 has been inferred by Abby et al to have been **140 feet**.
- These numbers imply not just more rapid closure than we anticipated, but also more rapid closere than we've seen before on the South pole.
- Before proceeding to an in-ice pulsing run (if possible) in summer 2022, we need to try to log the borehole in summer 2021.
- On the next slides, we will give an update on all the ongoing activities related to our logger device (as being called BoraBora).

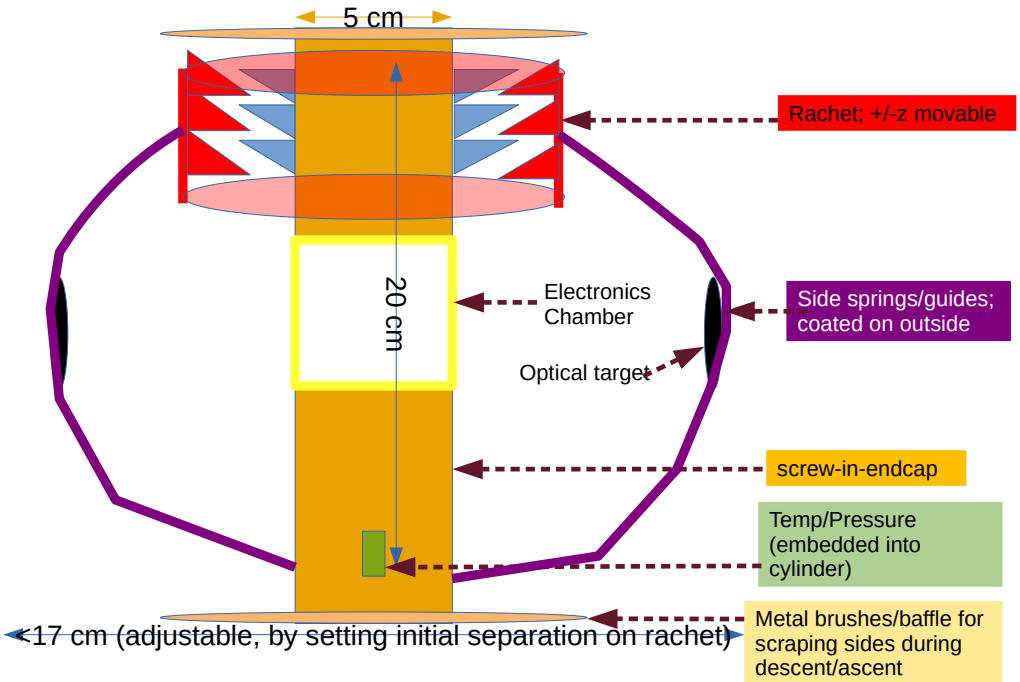
link to our previous presentations –
1. SPUNK-2020 Hardware
2. SPUNK-G: Hardware Update: the DISC borehole logger

the DISC borehole; Closure rate updates:

The Deep Ice Sheet Coring (DISC) parameters:

- final depth of 734.3 m
- final diameter=17 cm after deployment (2006)
- DRILLING FLUID – Isopar K, it is described as "clear water-white liquid".
- level of liquid in the borehole was 233 m below the surface after deployment (2006)
- **Abby: antenna into fluid at 140'=42.67 m depth (2013)**$\Rightarrow$ $z_{fluid,2006}$**=501.4 m;** $z_{fluid,2013}$**=698.7 m. Assuming no leaching:**
- $698.7 r_{2013}^2 = 501.4 \times 17^2 \Rightarrow < r_{2013} >$**=14.4cm**
- **Assuming constant volume loss per year**$\Rightarrow < r_{2021} >$**~10.7 cm**
- **in reality, "leaching begins at 80 m"**
- **only 3-4 mm clearance for SPUNK-1 (The outer diameter is ~ 10 cm)!**

The BoraBora design



Hardware

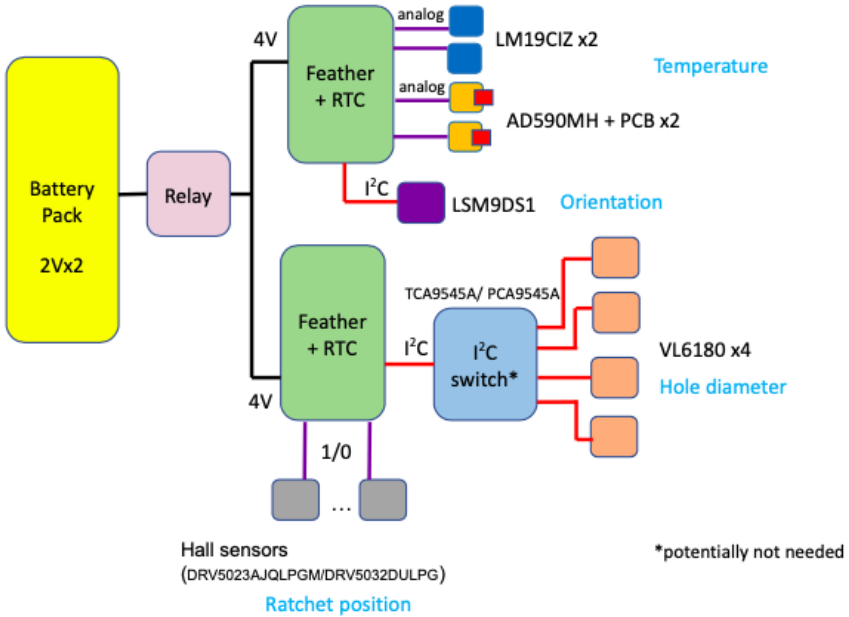
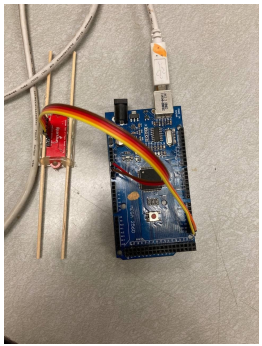


Figure 1: Scheme of all the equipment which goes inside BoraBora's PVA: sensors, control boards, batteries etc.

The VL6180 (TOF) distance sensors:

- Our main instrument to measure the borehole profile is four The VL6180 (TOF) distance sensors.
- Controlled by Feather board via I2C ("Wire") interface.
- Showed good response for 1-10 cm distance range.



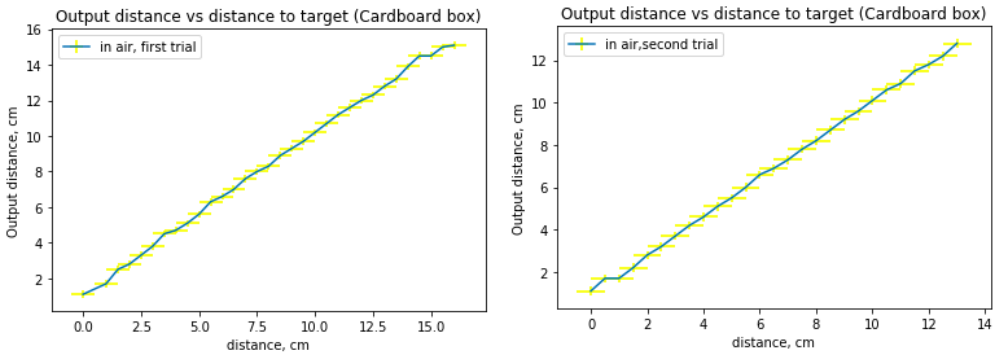


Figure 2: Output distance vs distance to target (Cardboard box)

- We've tested a single The VL6180 (TOF) distance sensor in Isopar-K medium with metal optic target.
- Soon we will start working on the data collection scripts which would manage simultaneously four sensors.

The difference in sensor's responses in air and in Isopar-K seems to be simply explained by their refractive indices ratio:

$$\frac{n_{IsoparK}}{n_{Air}} \approx \frac{Tof_{IsoparK}}{Tof_{Air}} \approx \frac{Slope_{IsoparK}}{Slope_{Air}} \approx 1.4$$

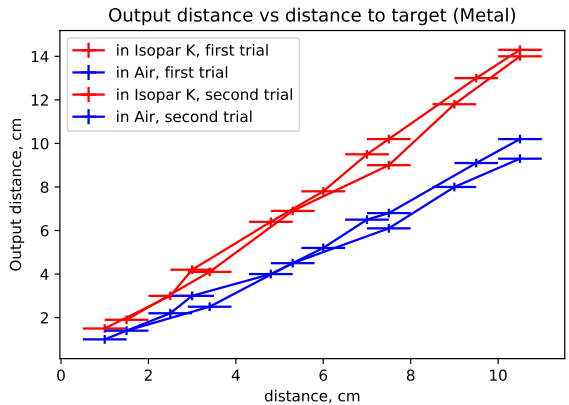
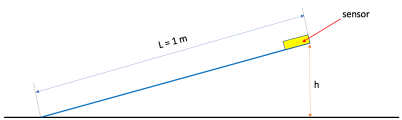


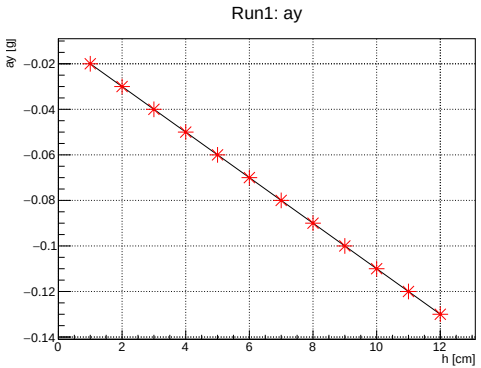
Figure 3: Sensor response, target - metal, medium - isopar-K

Orientation Logger Initial Tests: Inclination (accelerometer)

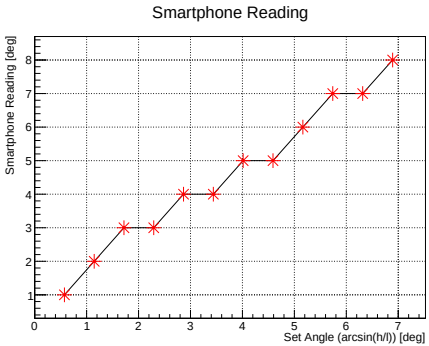


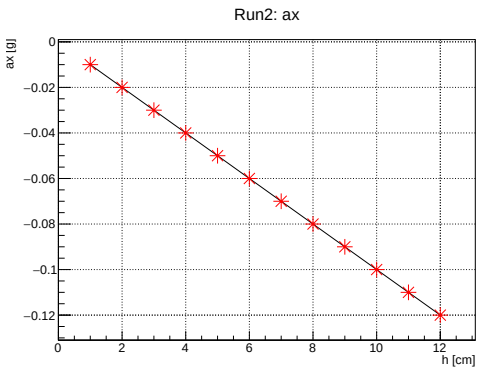
Run1:
- a_x is fixed
- a_y is changing

Run2:
- a_y is fixed
- a_x is changing

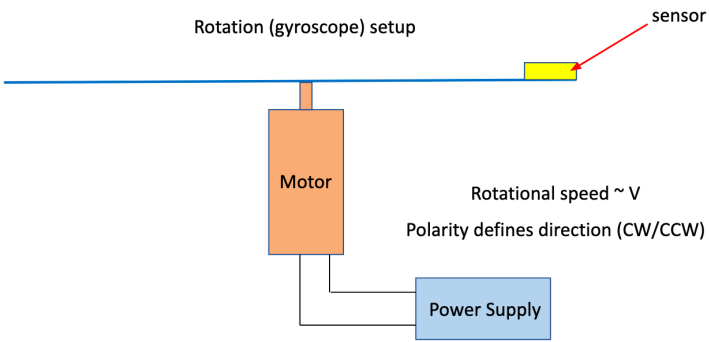


Crosscheck - smartphone sensor

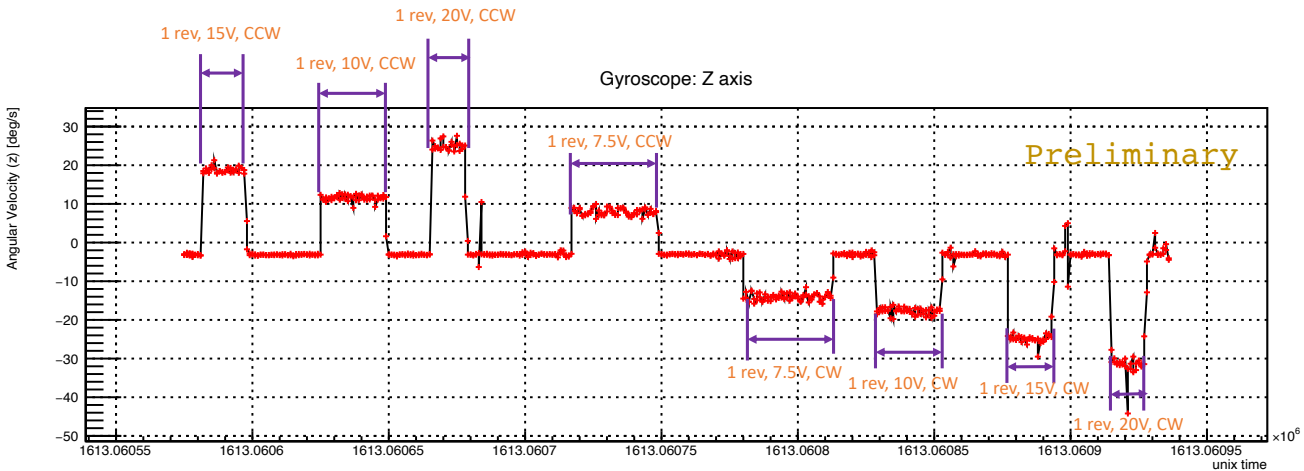




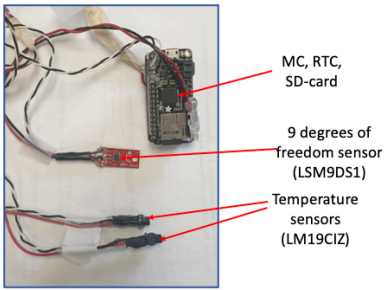
Orientation Logger Initial Tests: Rotation (gyroscope)



Orientation Logger Initial Tests: Rotation (gyroscope)



Orientation Logger



- Was prepared and tested (temperature chamber) for SPICE 2019;
- Runs autonomously on 'standard' SPUNK battery pack;
- A dedicated run is required;
- If the original (before the drop) position/orientation of PVA is tied to an object with known GPS coordinates, the absolute direction of inclination of the hole can be obtained.
- Undergoing (Planned) Activities:
  - Better calibration of the sensors with certified equipment; **we are planning to test an advanced temperature AD590 sensor in addition to our standard LM19CIZ:**
  - More detailed studies of the inclination/azimuth data.

Current plan for in-ice pulsing run?

Nylon PV: minimum inner diameters:

- Piezo + magic cable/bicone antenna: 50 mm
- HVSP + 50 Ohm terminator: 50 mm
- IDL + 50 Ohm terminator: 50 mm (*modification of the trigger board is required)

PVA (aluminium):

- IDL: 50 mm (*modification of the trigger board is required)
- HVSP: 50 mm
- CW + return loss measurements: 80 mm
- Only CW (a small usb one): 50 mm (* needs to be double-checked)

Timeline

- Shipping in May
- ??
- Bora-Bora run in July

Summary

- The implied borehole closure rate may be much higher than we expected
- We're going to have to make BoraBora as thin as possible. Currently, starting point of BoraBora's PVA is the batteries size (35 mm in diameter).

BoraBora minimum inner diameters:

- Temperature/inclination/azimuth vs time(which then can be used to get the depth): 35 mm
- Borehole caliber + logging the time (which then can be used to get the depth) where it decreases (the ratchet "clicks"): 35 mm + X mm required by the sensors