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TOWARDS AUTOMATED REMOTE SQUID STATIONS FOR GEOMAGNETIC MEASUREMENTS

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Past, present and future...

- M2700 high-Tc SQUID magnetometer from STAR Cryoelectronics
- X - and Z – axis sensors (2 axis)
- Co-located (50 m) with INTERMAGNET magnetic observatory fluxgate magnetometers (10 pT DC noise)
- 16 Hectare, surrounded by light industry, residential housing and hospital with MRI equipment
- X axis aligned True North
- Extraction jig on pillar with 3 degrees of freedom
- One cryogenic probe per sensor



**SQUID located in Hermanus,
South Africa**

**Continuously operating
since November 2012**



System Overview:

Housing for SQUID sensor and near field environment

National grid power source terminates 25 m from SQUID

PC for SQUID control and output signals

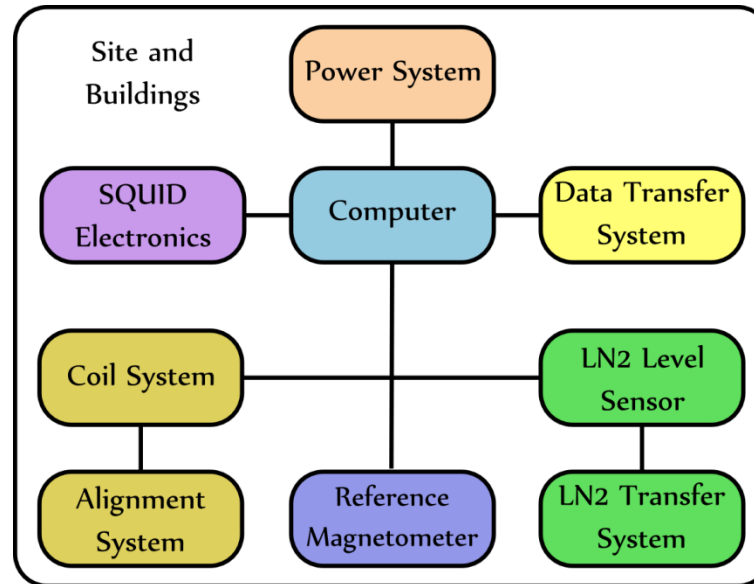
Cancelling of earth's field during cooling down

Also used for controlling secondary functions

Alignment of SQUID sensor with True North

Connectivity to internet

Alignment of coil system



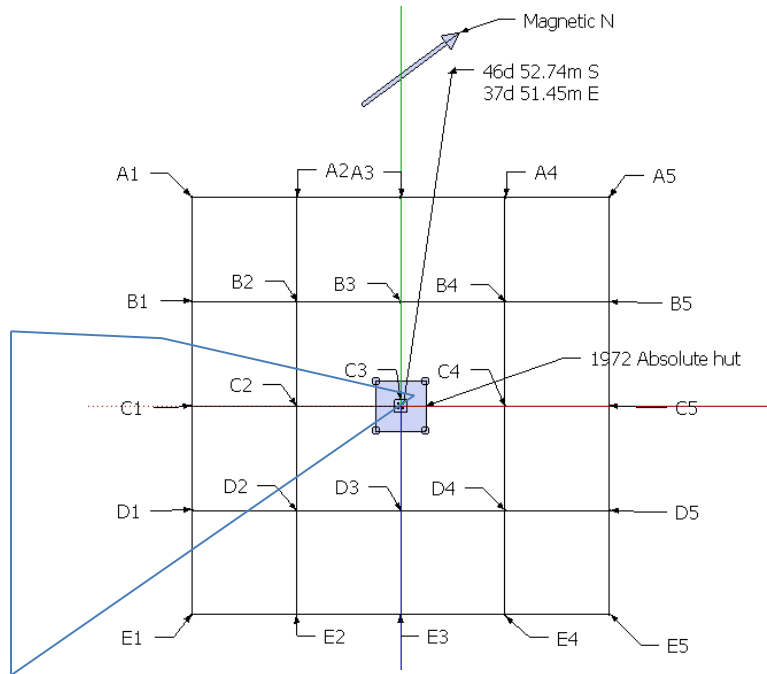
Measurement of liquid N₂ levels

Transfer of liquid N₂ to SQUID sensor dewar

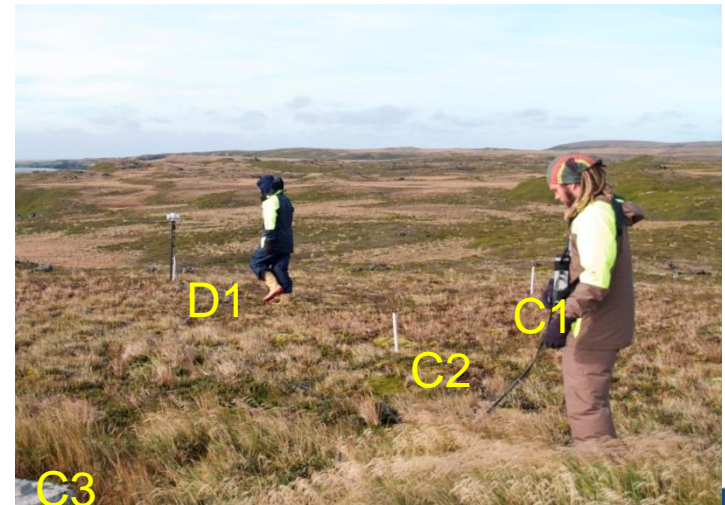
Reference fluxgate magnetometer

Magnetic survey of a possible new location for SQUID if co-located with reference fluxgate magnetometer

- Locate and avoid magnetic anomalies (Magnetic North reference and temperature affects)
- Use 2 absolute (total field) magnetometers, one as rover and other for the reference (background) measurement



E.g. use 2 GemSystems GSM 19
Or single GemSystems gradiometer

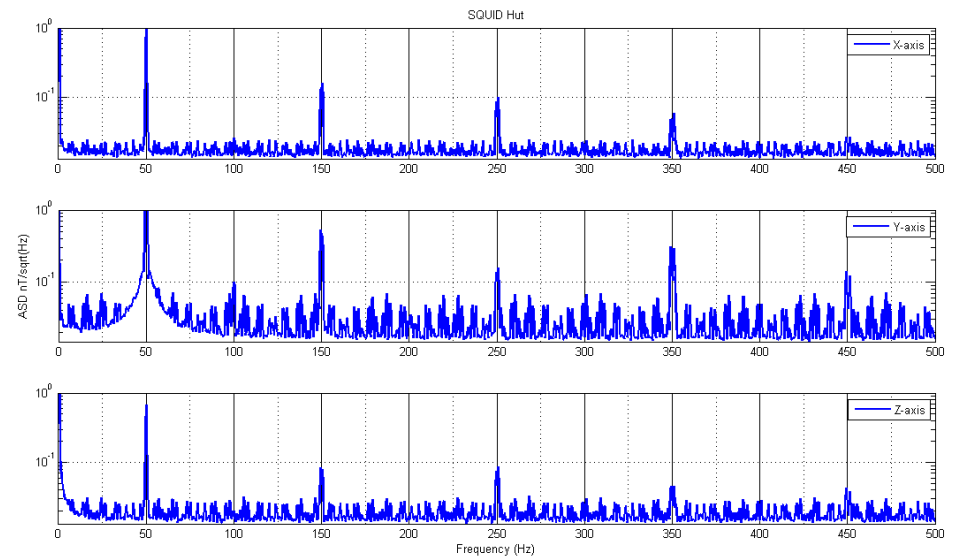


Spectrum analysis of magnetic measurements prior to SQUID installation



Measurements taken with magnetometer / spectrum analyser and compared to similar measurements at other possible sites

E.g. use Bartington SpectraMag 6
3-axis fluxgate and spectrum analyser



Construction of SQUID housing

- Typically 2 m (w) x 2 m(d) x 2.2 m (h)
- Use “non-magnetic” stone and bricks
- Separate foundations for wall, pillar for dewar and pillar for extraction hoist



Floor is isolated from wall and dewar- and hoist pillars

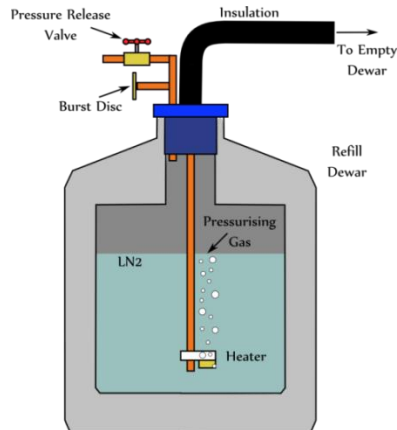
Isolation in walls and roof for temperature stability

“Good fit” between door and building to minimize airflow (during gusts)



N₂ Pump-over system

- N₂ cooling using Bio 34 dewar from Statebourne Cryogenic
- Previously: Poured from one dewar to the other: 3 people twice a month, losses was “undetermined”
- Risk of liquid N₂ burning
- Do not want to be dependent on pressurized air



Operated by 1 person using rechargeable batteries, 55 W



System losses: 2.5 % - 0.8 l for 34 l dewar

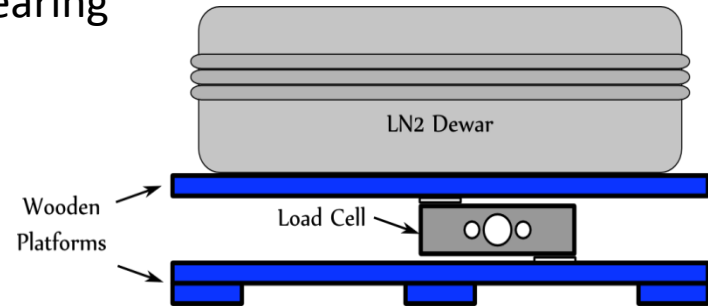
Operates 28 days between refills
(Cost of N₂ @ 2 Euro / litre)

N₂ Weighing system

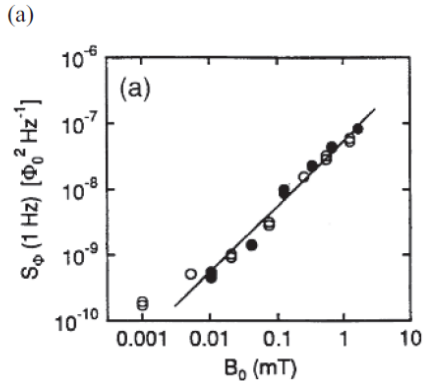
- Major hardware risk is liquid nitrogen reach critical level while SQUID is powered
- Currently: using plastic ruler – requires “good hearing”
Accuracy of measurement ± 450 ml

Systems investigated:

- Ultrasonic range finder
- Infra-red range finder
- Resistance wire
- Capacitance probe
- Load cell
- Output voltage calibrated to provide liquid N₂ level
- System activated once a day at a pre-determined time
- Accuracy of measurement ± 6 ml



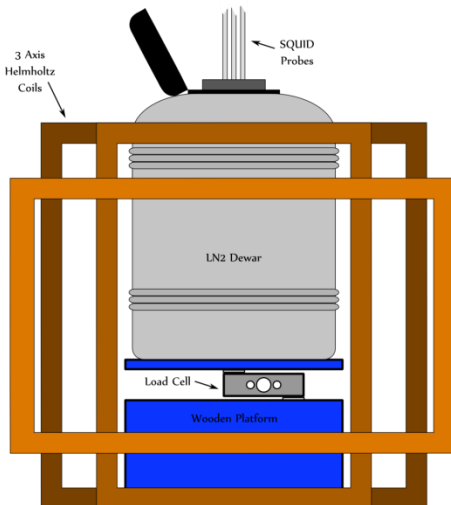
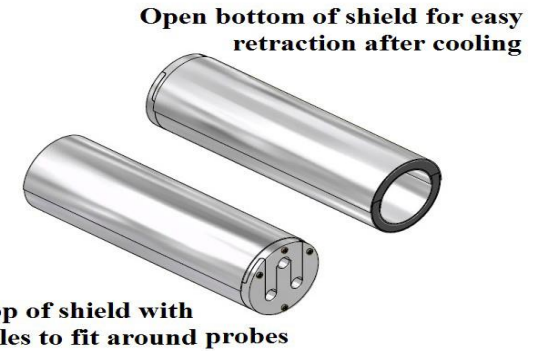
Cooling SQUID down in a zero ambient magnetic field



Ref: The SQUID Handbook: Vol. I, J. Clarke & A.I. Braginski, 2004

Zero field cooling reduces trapped flux and system noise.

- One option uses dual-walled high-permeability material (Shielding factor of 100x at 77K) to shield during cool-down; shields retracted for operation.
- Operation cumbersome due to icing and difficulty during removal



Newer design dynamically zeroes field using a 2-axis Helmholtz coil system
Results still outstanding

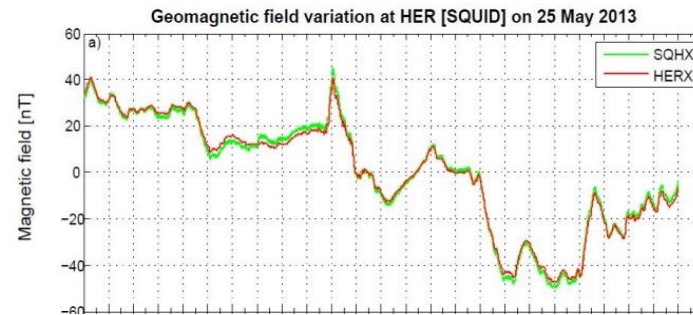


Alignment of SQUID with Observatory Fluxgate sensors (Vertical sensor very well aligned)

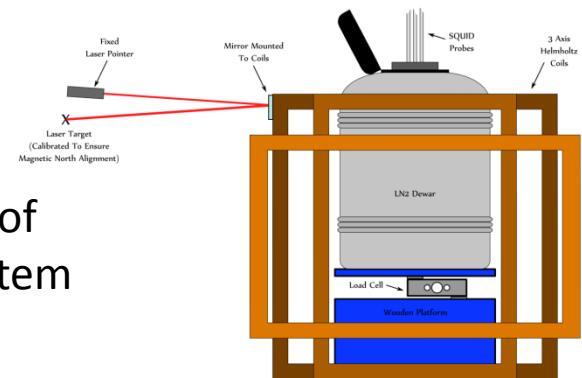


Alignment of X sensor's mechanical surface using accurate magnetic compass with telescope

Correlation = 0.9999
(Matlab corr function – uses Pearson's linear correlation coefficient)

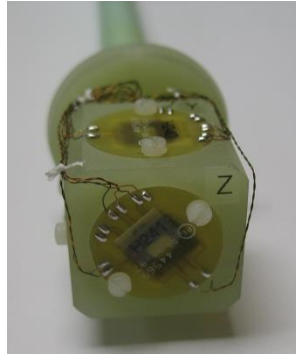


New method is being investigated of aligning using a Helmholtz coil system



Future work

- New 3-axis cube SQUID sensor on single cryogenic probe on order – expected delivery date around July 2014



3-Axis M1000 HT SQUID
from
STAR Cryoelectronics



- Aluminium dewar to be replaced with non-metal dewar to prevent possible eddy currents
- Investigate SQUID magnetometer station at the SANAE Base, Antarctica (great advantage of magnetic measurements at the poles)



Thank You

Merci