



Report No. 10445

**Petrophysics for Mineral Discovery during Drilling: MinEx CRC
Project 4 – Phase 2**

Results of research carried out as MRIWA Project M10445

at Curtin University

by

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SPONSORING ORGANISATIONS

Imdex Ltd, The Minerals Research Institute of Western Australia, Rio Tinto Technological Resources Pty Ltd, South32 Group Operations Pty Ltd

ABOUT THIS PUBLICATION

This publication presents the results of work carried out under Project 4 of the Mineral Exploration Cooperative Research Centre (MinEx CRC) in relation to Commonwealth Milestone RP2.2.3: Prototype multi-sensor Coiled Tubing drilling logging-while-drilling platform integrated with steering software and tested during drilling.

Report DOI 10.71342/862275055376

KEYWORDS AND TAGS

Mineral exploration, geophysics, drilling, exploration drilling

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1. Introduction

1.1 Mineral Exploration Cooperative Research Centre

The Mineral Exploration Cooperative Research Centre (MinEx CRC) is the world's largest collaborative mineral exploration research venture. The CRC brings together thought leaders from industry, government and research organisations to discover and develop innovative technologies and methods to support the future success of Australia's mineral resources industry.

Over its 10-year lifetime from 2019 to 2029, the CRC's two-fold aims are:

1. To turn successful research outcomes into mining innovation, including integrating technological and business innovation to significantly improve Australia's mining competitiveness and manufacturing capabilities, and;
2. To facilitate commercialisation of intellectual property developed through the work of the CRC in such a manner as to ensure maximum benefit accrues to Australia, including the Australian mining industry, Australian manufacturing, the Australian environment and the Australian economy generally.

The activities of the CRC are organised under 3 primary research programs

1. Drilling Technologies – Developing engineering solutions to improve the productivity and safety, and reduce the cost and environmental impact of exploration drilling.
2. Data from Drilling – Developing and improving technologies for the capture and interpretation of geochemical, petrophysical and geophysical data during drilling to support timely decision-making within the exploration workflow.
3. National Drilling Initiative – Delivering drilling programs – including through the use of novel technologies developed by the MinEx CRC – to map regional geology and architecture to define mineral systems potential in areas of Australia where known prospective geology is concealed beneath cover rocks.

1.2 MRIWA Support of the MinEx CRC

The Minerals Research Institute of Western Australia (MRIWA) supports the work of the MinEx CRC in line with the Institute's priority of addressing the challenges of making significant new mineral discoveries in Western Australia.

MRIWA supports specific research projects under this participation framework identified as offering the potential to systematically advance knowledge and capability to improve mineral exploration productivity through detection, exploration technology and prediction performance.

In doing so, MRIWA aims to stimulate research outcomes that will inform the pre-competitive geological, geochemical and geophysical knowledge base of Western Australia and create exploration capability to:

- Position Western Australia as a global leader in exploration technology, and;
- Facilitate private sector investment in existing and newly identified Western Australian mineral provinces to develop the State's rich natural resources.

2. Research Context: Petrophysics for Mineral Discovery during Drilling

Executed as Project 4 under MinEx CRC Program 2 (Data from Drilling), *Petrophysics for Mineral Discovery during Drilling* seeks to improve geophysical technologies for

characterising sub-surface geology, and to incorporate such innovative sensing technology into a mineral exploration drilling system. The underlying vision is that this sensing package will deliver a capability for drillers to resolve key characteristics of the geological environment during drilling, allowing for near-real-time adaptation of drilling programs in response to the conditions encountered, supporting active vectoring towards a petrophysical target as a routine component of the exploration drilling workflow.

The physical and chemical properties of mineralised material often differ strongly from those of the barren rock in which such mineralisation is hosted. These distinctive properties are widely exploited in mineral exploration, with anomalies in regional frameworks of gravitational or magnetic field strength, electrical conductivity, geochemistry and other characteristics (collectively termed petrophysical properties) taken to define potential features of interest for targeting through drilling or other forms of sample extraction.

The strength of petrophysical signatures is strongly dependent on the distance of the detector from the distinctive or contrasting material boundary. Active sensing of how petrophysical signatures vary thus offers both expanded insight in real-time into the rock volume surrounding a drill hole, and a dynamic measure of the effectiveness of drill targeting as an anomalous rock mass is approached. Combined with real-time trajectory control of drilling¹, such feedback could offer the transformative potential of dynamic exploration targeting – where rather than simply executing a planned drill hole and assessing the outcome after the fact to plan the next hole, a sensor-equipped drill could be actively steered towards a target zone during the drilling process.

The real-time decision-making supported through such active sensing and geosteering of a drillhead offers to decrease the cost of evaluating a given exploration volume, expanding the economic limits of mineral exploration deeper beneath the surface.

To deliver on this value proposition, MinEx CRC Project 4 incorporates two linked streams of research:

1. The development of new geophysical sensors for real-time multiparameter logging while drilling with a Coiled Tubing (CT) drill rig, and;
2. Automatic subsurface lithological reconstruction based on that geophysical sensing-while-drilling.

3. Potential Value to Western Australia

Mineral exploration and discovery represent the foundations of Western Australia's successful mining sector. Maintaining the productivity of this key industry into the future will require the discovery and characterisation of ore bodies deeper below the surface and hidden from traditional methods of discovery, pushing industry to reduce both the cost and the environmental footprint of exploration technology.

By improving the accuracy of drill targeting and the quality of information returned from individual drillholes, the sensing technology which this research aims to develop could reduce the amount of drilling required to identify and define buried mineralisation. In addition to making it cheaper and easier to explore across the widespread covered areas of WA, this improved drilling efficiency would reduce the environmental impacts of mineral exploration in remote and sometimes ecologically fragile areas of the State.

¹ Real-time trajectory control of exploration drilling is a target of the companion research underway as Project 2 (Coiled Tubing Drilling for Definition of Mineral Deposits) under MinEx Program 1 (Drilling Technologies) and supported by MRIWA as Project M10444.

4. Project Structure

The outcome of sensor technologies to deliver real-time petrophysical characterisation is intended to be developed through three staged phases of research over the life of the MinEx CRC. MRIWA Project M10445 represents Phase 2 of this development program (Fig. 1).

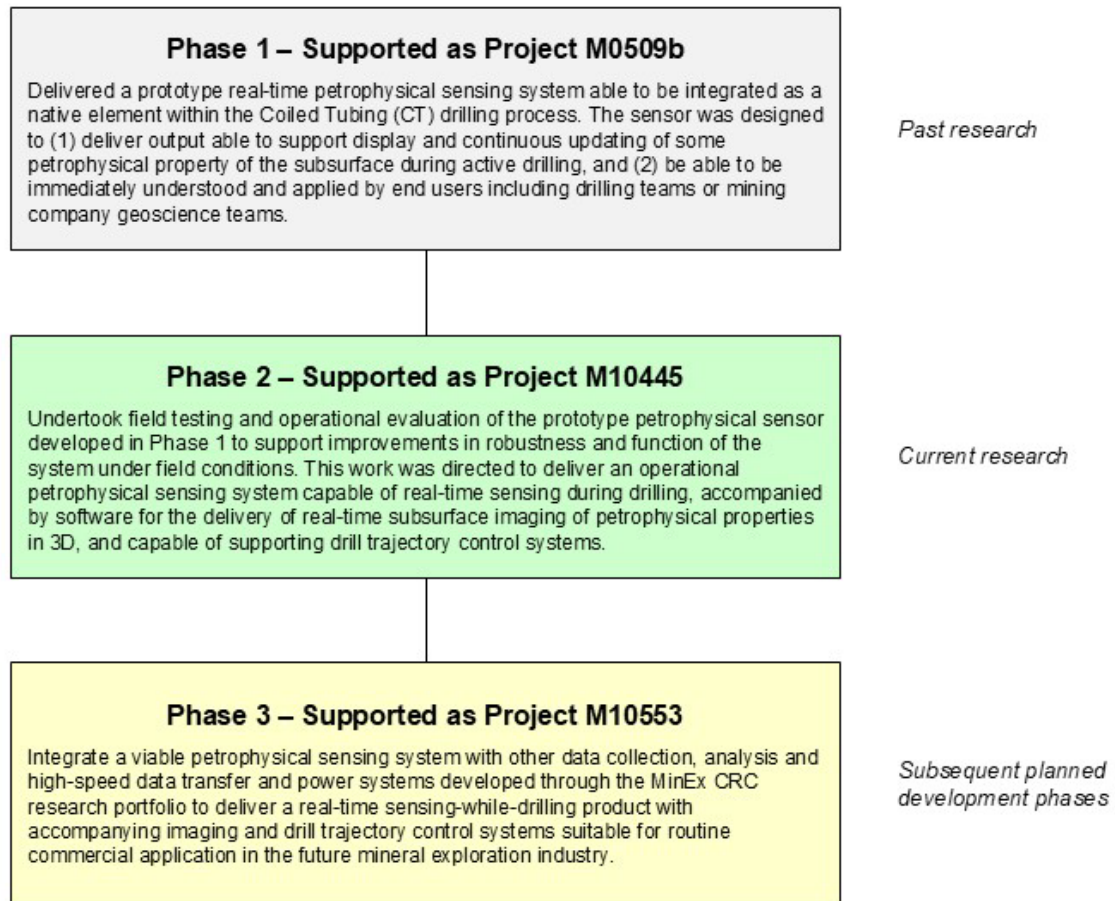


Figure 1: Phased development plan for MinEx CRC Project 4. The work supported by MRIWA as M10445 comprises Phase 2 of this program.

5. Overview of Project Outcomes

As summarised in **Appendix 1**, Project M10445 progressed the development of multiple prototype technologies towards achievement of MinEx CRC Commonwealth Milestone RP2.2.3: *Prototype multi-sensor Coiled Tubing drilling logging-while-drilling platform integrated with steering software and tested during drilling.*

Four discrete sensor technologies designed for application with the RoXplorer® coiled tubing drilling platform have been advanced through this work:

1. A total count gamma logging tool,
2. A frequency domain electromagnetic tool (FDEM),
3. A time domain electromagnetic tool (TDEM) and,
4. A downhole fibre optic DAS seismic technique.

An initial functional prototype of the total count gamma logging tool was evaluated at the Kapunda Mine test site as an integrated component within the RoXplorer® bottom hole assembly (BHA). The gamma tool delivered high-quality data capable of distinguishing rocks based on their contained abundance of radioactive elements (i.e., K, U and Th) which can be linked to changes in geological units, alteration and weathering characteristics, demonstrating key proof-of-concept for stream 2 of the research program in respect of automated subsurface lithological reconstruction.

The FDEM tool developed through this work cycles through dozens of EM frequencies during each measurement, creating a frequency dependent 'spectral' response. This effectively establishes dozens of data channels across a broad range of frequencies, with higher frequencies sensitive to rock properties close to the borehole wall (centimeters) and lower frequencies sensitive to rock properties further from the borehole wall (potentially >10m). This approach to electromagnetic measurement differs significantly from existing commercial tools, which typically operate in single or dual frequency mode. The prototype tool has been evaluated in the Curtin University test borehole producing results that are comparable with conventional EM logging tools (for the same source frequency) but with greater potential for identifying subtle geological features and off-hole rock properties

A provisional patent has been lodged to protect the novel aspects of this prototype 'Swept frequency' FDEM downhole tool.

Initial design-and-build work on the electrical components of a downhole TDEM tool has been completed. The first generation of the electrical board will be c.100mm wide – notably too wide for application in the RoXplorer® drilling platform – but further work will be undertaken to miniaturise the sensor once testing has confirmed functionality of key elements of the design.

A prototype system delivering seismic imaging during drilling was trialled to depths of 115m. The system utilises distributed acoustic sensing (DAS) technology from fibre optic communications cable incorporated within the coiled tubing drill string, with drilling noise from the percussion hammer and bit/rock interactions providing the seismic energy source. Although the trial yielded noisy data, seismic waves transmitted through the rock mass can clearly be identified, and can be used to construct a vertical seismic profile (VSP) and seismic velocity log.

Under the relevant contractual terms governing this research, intellectual property (IP) created through the project is owned legally by MinEx CRC, and owned beneficially by the Project Parties – including MRIWA on behalf of the WA State Government – in accordance with their respective Project Contributions.

The downhole FDEM and TDEM tools are likely to be unique product offerings in the downhole logging market. Market scope considered in relation to the project technology package (initially focused on CT drilling applications) has broadened to include all drilling methods, not restricted to hole depth or deployment method.

Index Ltd have emerged as the most likely (but not exclusive) potential partner for commercialisation of project outputs.

Any enquiries as to the technical detail of the project outcomes and current disposition of relevant IP should be directed to lead researcher Professor Brett Harris at Curtin University.

6. Future Research

In line with the staged research plan outlined in Section 4 above (Fig. 1), the outcomes of this project are being further developed by the MinEx CRC research team in a third (and final) phase of work.

Supported by MRIWA as Project M10553, this third phase will undertake an extensive program of field testing and operational evaluation of the prototype sensor to support further improvements in robustness and function of the system under field conditions.

7. Project Sponsors

Funding for this project was provided by the following sponsor organisations:

- Imdex Ltd
- The Minerals Research Institute of Western Australia
- Rio Tinto Technological Resources Pty Ltd
- South32 Group Operations Pty Ltd

Appendix 1

MinEx CRC Report 2025/53

Submitted as Commonwealth Milestone Report for Project 4: Petrophysical Logging While Drilling

June 2025

MinEx CRC Limited

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Commonwealth Milestone Report

Project 4: Petrophysics for Mineral Discovery During Drilling

Commonwealth Milestone RP2.2.3

Prototype multi-sensor Coiled Tubing drilling logging-while-drilling platform integrated with steering software and tested during drilling.
Recommended commercialisation pathway, including tool modifications and further field trials if required.

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¹MinEx CRC and ²Curtin University

Compiled by:

David Giles

CSO MinEx CRC, University of South Australia

Date: June 2025

MinEx CRC Report 2025/53

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Australian Government
Department of Industry,
Innovation and Science

Business
Cooperative Research
Centres Program

EXECUTIVE SUMMARY

This document is a compilation of three end-of-year Project Review Panel presentations produced by researchers within MinEx CRC Project 04 Phase 02 (Petrophysics for Mineral Discovery During Drilling) and Project OP4 (Distributed Sensing for Mineral CT Drilling). Together these presentations demonstrate progress towards and completion of Commonwealth Milestone RP2.2.3: Prototype multi-sensor Coiled Tubing drilling logging-while-drilling platform integrated with steering software and tested during drilling. Recommended commercialisation pathway completed, including tool modifications and further field trials if required.

The materials are presented in chronologic order to demonstrate progression of the underlying science and technology. MinEx CRC researchers have been developing four discrete sensor technologies designed for logging-while-drilling applications with the MinEx CRC RoXplorer® coiled tubing drilling platform, namely;

- 1) a total counts Gamma logging tool,
- 2) a frequency domain electromagnetic (FDEM),
- 3) a time domain electromagnetic tool (TDEM) and,
- 4) a downhole fibre optic DAS seismic technique.

This report highlights developments with respect to each sensor technology, with reference to relevant slides in the Project Review Panel presentations, and progress toward integrating the sensing technologies with positioning software to enable informed 'geo-steering' (that is, steering informed by geological or geophysical data). Recommended tool modifications and potential pathways to market are addressed in each presentation.

1. MinEx CRC Project 04 Phase 02 (incorporating OP04): Fifth quarterly Project Review Panel meeting Q1 2023 (April 2023)

Summarizes progress on all aspects of CM RP2.2.3 including:

- Fabrication, calibration and in-hole testing of the MinEx CRC prototype frequency domain electromagnetic sensor (FDEM) (slides 23 to 34). Our FDEM tool is different to any downhole tool in the existing market because it cycles through dozens of EM frequencies during each measurement, creating a frequency dependent 'spectral' response. Existing tools operate in single or dual frequency mode. The MinEx CRC tool produces dozens of data channels across a broad range of frequencies, with higher frequencies sensitive to rock properties close to the borehole wall (centimeters) and lower frequencies sensitive to rock properties further from the borehole wall (potentially >10m). The prototype tool has been tested in the Curtin University borehole producing results that are comparable with conventional EM logging tools (for the same source frequency) but with greater potential for identifying subtle geological features and off-hole rock properties.
- Progress on fabrication of a new metal housing for Version 2 of the MinEx CRC total counts Gamma sub (slides 36 to 39). Version 1 of the Gamma sensor tool, integrated with MinEx CRC "SmartBHA" positioning sub, was tested during a logging-while-tripping exercise at the Kapunda Mine in Q4 2021. The new metal housing will have greater pressure rating than the V1 prototype tool, allowing the new tool to be deployed to depths up to 1000m.
- Results from first field trials of a prototype seismic-while-drilling system utilising fibre optic DAS incorporated within the coiled tubing drill string communications cable (slides 41 to 52). The field trial took place in a Delamerian South National Drilling Initiative drill site with 270m of coiled tubing deployed in the drill hole. The energy source was a sledgehammer blow on a metal plate adjacent to the drill collar. The data are noisy, with a strong signal of (relatively slower) seismic waves transmitted along the drill string, however (relatively faster) seismic waves transmitted through the rock mass are also clearly seen. The later can be used to construct a vertical seismic profile (VSP) and seismic velocity log.
- Design of a second generation seismic-while-drilling system for CT drilling (slides 53 to 60) which will utilise a fibre optic 'slip ring' to connect from the rotating end point of the CT drill spool to the DAS interrogator. This will enable seismic data to be collected while active drilling takes place – potentially using drill bit noise as the seismic source. An energy source at the drill/rock interface will enable imaging in front of the drill bit, critical data on the path to geo-steering applications.

2. MinEx CRC Project 04 Phase 02: Eighth quarterly Project Review Panel meeting Q4 2023 (December 2023)

Summarises progress on all aspects of CM RP2.2.3 including:

- Processed data collected from Version 2 of the MinEx CRC total counts Gamma tool during the logging-while-drilling field trials at Kapunda in September 2023 (slide 16). The Gamma sensor delivered high-quality, depth-accurate data to a depth of 115m. The data can be used to distinguish subtle variations in K, U and Th abundance which can be matched to geological units, alteration and weathering characteristics.
- Results from field trials of our V2 prototype seismic-while-drilling system utilising fibre optic DAS incorporated within the coiled tubing drill string communications cable and connected to the DAS interrogator by fibre optic slip ring (slides 18 to 21). The field trial took place at Kapunda in September 2023 with 115m of CT drill string deployed in the drill hole. Drilling noise from the percussion hammer and bit/rock interactions provided the energy source. Although the data are noisy, seismic waves transmitted through the rock mass can clearly be seen and can be used to construct a vertical seismic profile (VSP) and seismic velocity log. We consider this work to be proof-of-concept of the fibre optic DAS seismic-while-drilling system. However, MinEx CRC Participants agreed to park this avenue of research and focus on development of the FDEM and TDEM downhole tools which they consider will have a broader potential market – not limited to drilling method, hole depth or deployment method (wire line logging, logging-while-tripping or logging-while-drilling).
- Preliminary tests of a calibration method for the MinEx CRC downhole EM tools at a test site in the Swan River (slides 22 to 26). Riverbed sediments, river water and air have well-characterised and highly contrasting electromagnetic properties which will be useful for fast-tracking calibration of the multiple tools under development in MinEx CRC.
- Announcing submission of a Provisional Patent covering the novel ‘Swept Frequency’ downhole FDEM tool being developed by MinEx CRC (slides 27 and 28). The Provisional Patent was prepared in collaboration with MinEx CRC Partner Imdex Ltd who have emerged as a front runner candidate for commercialisation of the ‘Swept frequency’ FDEM tool. Imdex Ltd consider IP protection to be an important component of the commercialization process and have provided services of their in-house patent attorney Natalee Taylor to help draft the patent application.

3. MinEx CRC Project 04 Phase 02: Twelfth quarterly Project Review Panel meeting Q4 2024 (December 2024)

Summarises progress on development of downhole FDEM and TDEM sensors. This reflects a narrowing of project focus to the EM tools which are deemed by Project Participants to have the most impactful combination of novelty and breadth of potential market. The presentation includes:

- Results from drill hole trials of the fourth generation ‘Swept frequency’ downhole FDEM tool conducted in the Curtin University test well (slides 24 to 34). The data are well-matched to current commercial EM logging systems at comparable source frequencies but offer a far richer (>150 channel) dataset with the potential to map subtle geological variations up to ~10m from the borehole wall.
- Announcing submission of a Revised Patent for the ‘Swept frequency’ downhole FDEM tool (slide 35) in November 2024. Imdex Ltd have continued to support the patent process with a view to potential commercialisation. The MinEx CRC Project 4 Phase 3 agreement includes potential licensing ‘take off’ points linked to project milestones designed to demonstrate reliability of the tool and geological value of the derived data. The preferred approach is to test the tool in multiple real-world drilling scenarios during the early stages of Phase 3 (2025).
- Planned locations for real-world field tests of the FDEM tool (slides 36 to 39) scheduled for 2025.
- Progress on design and build of the electrical components of the downhole TDEM tool (slides 40 to 44). The electrical board will be ~100mm wide in the first iteration – too large for the MinEx CT drilling platform – but will be miniaturised once testing has confirmed key elements of the design.


OBJECTIVE(S)	RESULT(S)
Demonstrate completion of Commonwealth Milestone RP2.2.3	A compilation of 3 Project Review Panel Presentations produced by the MinEx CRC Project 4 research team fulfills the requirements of the milestone.
NEXT STEP(S)	TIMING
Continuing field trials with improvements to the FDEM tool hardware, software and operating procedures. Development of a field prototype TDEM tool, followed by field trials.	2025-2027 inclusive
MINEX CRC MILESTONES	
CM RP2.2.3: Prototype multi-sensor Coiled Tubing drilling logging-while-drilling platform integrated with steering software and tested during drilling. Recommended commercialisation pathway completed, including tool modifications and further field trials if required.	
UTILISATION/COMMERCIALISATION OPPORTUNITIES	
The downhole FDEM and TDEM tools are likely to be unique product offerings in the downhole logging market. Our market scope (initially focused on CT drilling applications) has broadened to include all drilling methods, not restricted to hole depth or deployment method. Imdex Ltd have emerged as the most likely (but not exclusive) potential commercial partner.	
IP	
A provisional patent has been lodged to provide protection to novel aspects of the prototype 'Swept frequency' FDEM downhole tool.	
CONFIDENTIALITY	
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APPROVED BY	
<p>Prof David Giles Chief Scientific Officer MinEx CRC</p> 	

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Acknowledgements

The work has been supported by the Mineral Exploration Cooperative Research Centre whose activities are funded by the Australian Government's Cooperative Research Centre Program. This is MinEx CRC Document 2025/53.

MinEx Project 4 – PRP Meeting Notes: (CY2023Qtr1)

Topics:

1. 2023/24 Milestones: Review and Discussion
2. Patent discovery and assessment for Swept Frequency Tool
3. TEM tool (design and build: components coming)
4. Opportunity fund extension: OP4 - Progress and Next steps

- | | |
|---------------------------|--|
| (i) BHA | → Testing/integration of Gamma Sub in BHA → Field |
| (ii) Fibre | → Installation of fibre in Tubing → testing at UniSA → Field |
| (iii) Optical slip ring | → Installation of FORJ → testing at UniSA → Field |
| (iv) Opportunity fund Ext | → Definitive field test (LWD, VSP, RVSP, + surface source/geophone/fibre |



MinEx project 4 – PRP meeting - 2023 Quarter 1:

(Summary)

Meeting Objectives:

1. 2023/24 Milestones: Review and Discussion
2. Update: Patent discovery and assessment for Swept Frequency Tool
3. Brief update: TEM tool (design and build: components coming)
4. Opportunity fund EOI for extension to OP4 - Progress and Next steps
 - (i) BHA → Testing/integration of Gamma Sub in BHA → Field
 - (ii) Fibre → Installation of fibre in Tubing → testing at UniSA → Field
 - (iii) Optical slip ring → Installation of FORJ → testing at UniSA → Field
 - (iv) Opportunity fund → Definitive field test (operation/acquisition and analysis of a definitive/comprehensive field data set).

Meeting Date/Time: → Thursday 13th April 2023
Time - 11:00 am to 12.20 pm

Venue: Face to Face or On-Line (or WA-Kensington ARRC - B613-4H25)

Anticipated Attendees (PRP meeting):

Index: Fred Blaine (Chair), Natalee Taylor
Curtin: Brett Harris (Project 4 Leader), Michael Carson, Hoang Nguyen
MinEx CRC: Andrew Bailey (MinEx CRC - CEO), David Giles (MinEx CRC - CSO),
MIRWA: Geoff Batt
Rio-Tinto: Anna Purton, James Alderman, Benjamin Boland
South32 : Kim Cook, William Greenwood

Apologies:

South32: Fiona Best,
CSIRO: Yulia Uvarova (Program 2 Leader),

Overview

To improve exploration and mining workflows with real-time vectoring during drilling with a CT rig using new LWD sensors and automated subsurface reconstruction algorithms

Productivity Performance Target

Achieve real-time subsurface sensing during CT drilling to depths of 1000m and to provide real time imaging to assist geo-steering to within 30 m of a lithological target.

Outcomes

- i. Development of new sensors for real-time multi-parameter logging while drilling with a Coil Tubing drill rig
- ii. Automatic subsurface reconstruction for steering based on geophysical sensing while drilling. The real time trajectory control/vectoring component will systematically work towards the goal of providing the inputs needed to geo-steering CT drilling towards lithological targets. This research will extend the reach and value of every meter drilled into a 3D search space ahead of and around the drill bit

People

MinEx

- MinEx - Andrew, Dave
- MinEx - Program 2 Leader – Yulia

Curtin

- Brett Harris (Project Lead)
- Michael Carson
- Hoang Nguyen

Participant Reps

- Imdex – (Fred Blaine Project Chair)
- South 32 – Fiona Best
- MRiWA – Geoff Batt
- RioTino – Anna Purton
- Australia Government

Recap – Two highly significant outcomes

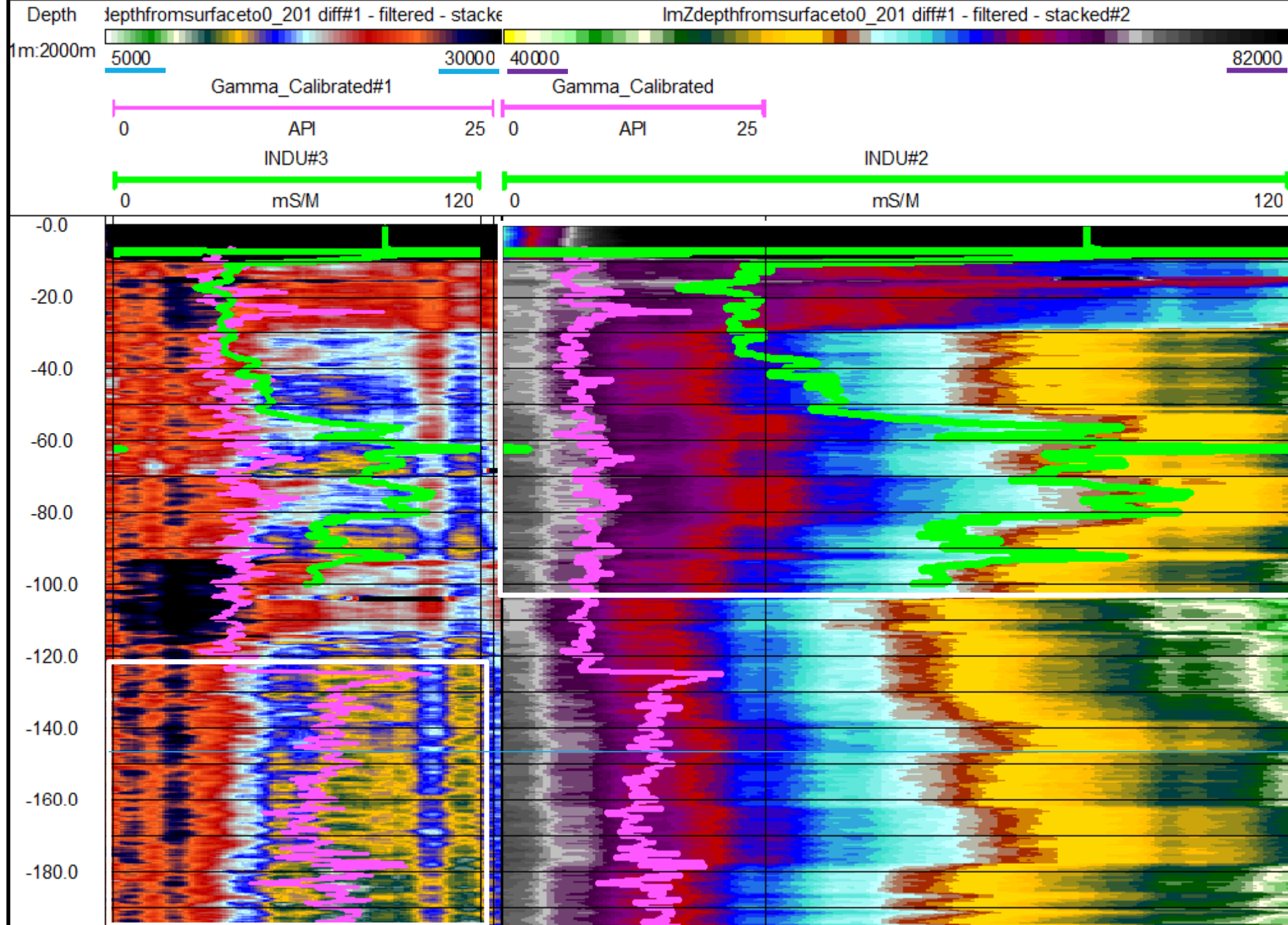
With Prototype - Field Demonstration DATA

Recap 1

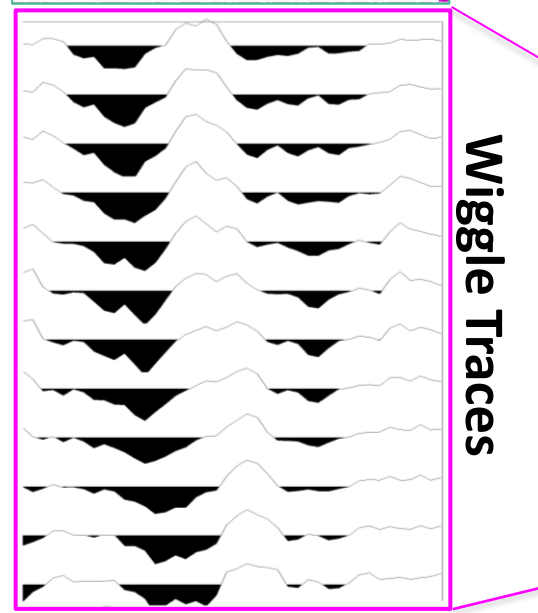
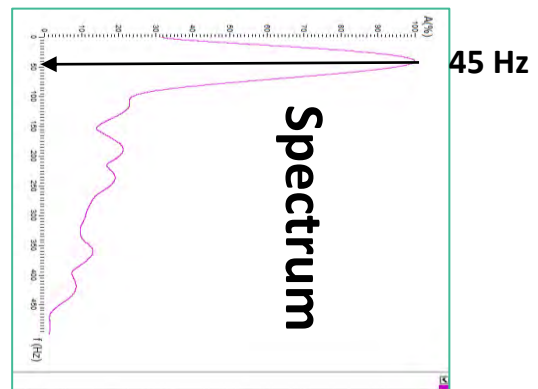
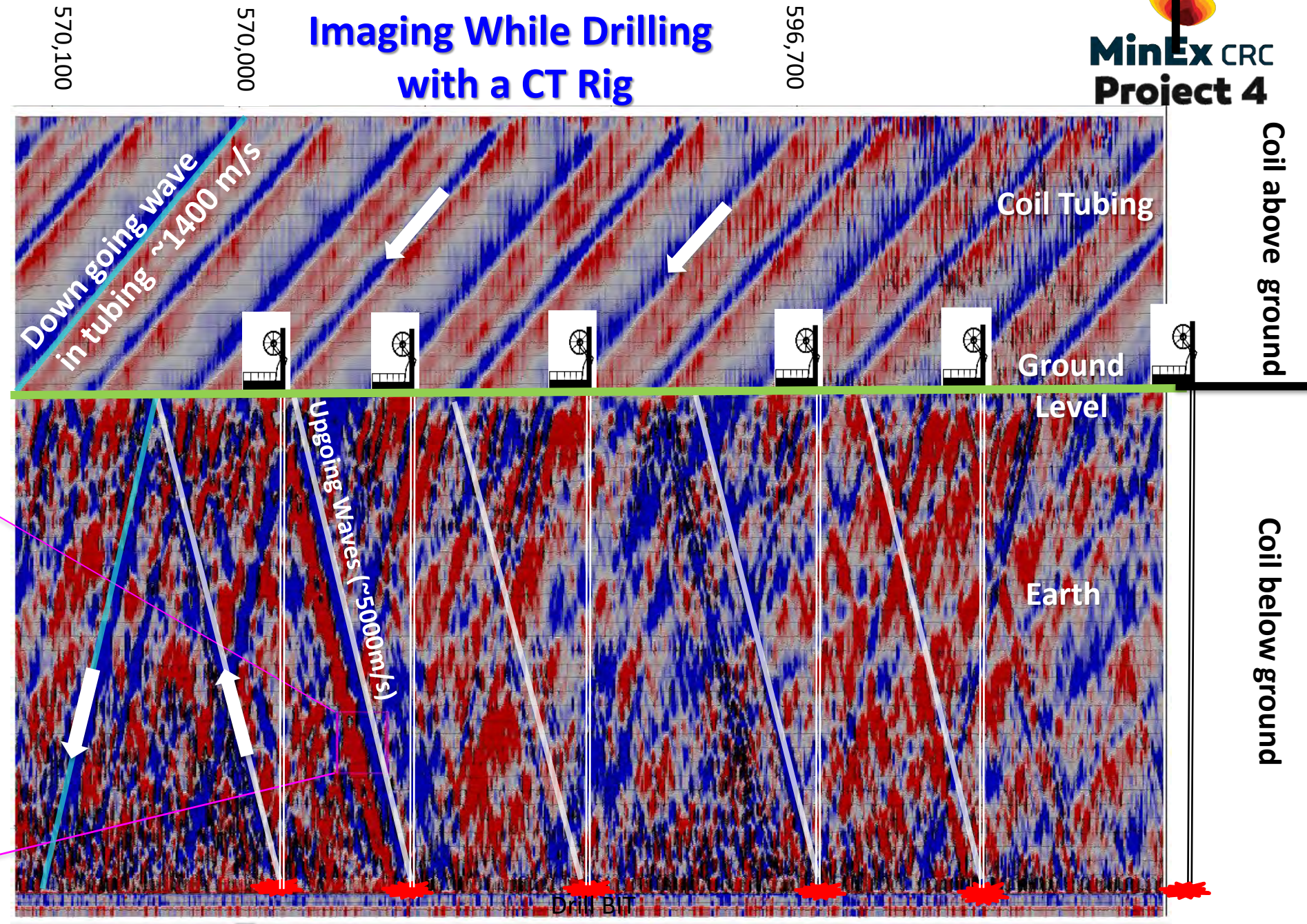
Sweep Frequency Logging looks like the image to the right/

Real DATA

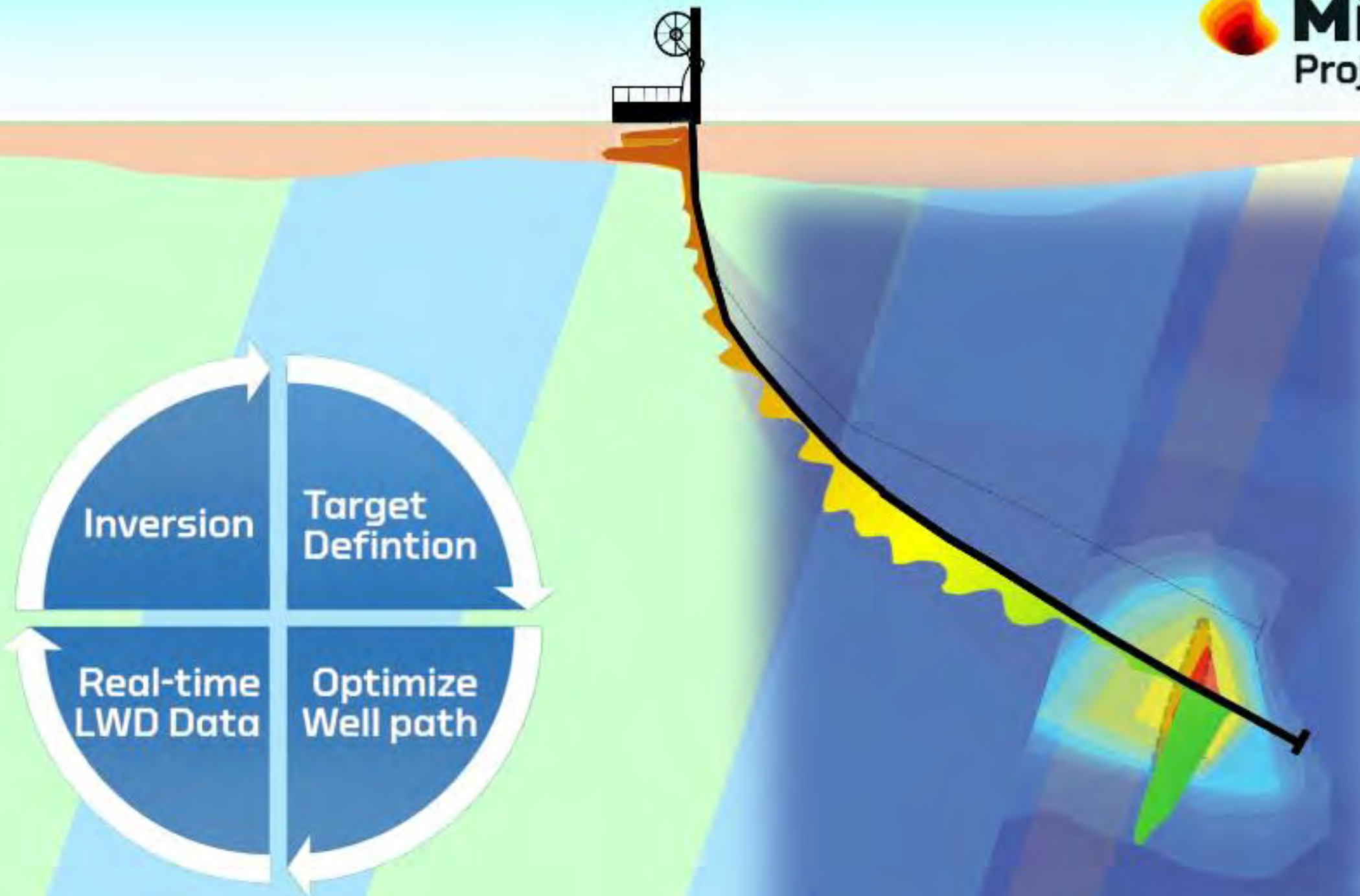
This is uncalibrated processed quadrature response from 2000 to 82000 Hz in steps of 400Hz in the Curtin Well



Recap 2 RVSP



Summary Diagram



1. Milestones for 2023

Milestones 2023 – set up in Knack

PJ04-Ph02-M20	CY23Q1 First patent disclosure materials provided.	CY22Qtr4 Done
PJ04-Ph02-M21	CY23Q1 Updated version of swept frequency tool completed (second sensor system built – Sensor to be demonstrated to PRP in Q1 meeting)	CY22Qtr4 Done
PJ04-Ph02-M22	CY23Q1 Convene meeting with Project 2 to assess viability of GammaSub for field deployment.	CY22Qtr4 Done
PJ04-Ph02-M23	CY23Q1 Prepare/test then send Gamma Sub to Project 2 team in SA for testing within BHA.	CY22Qtr4 Done
PJ04-Ph02-M24	CY23Q1 First design of time domain induction logging transmitter circuit complete.	CY22Qtr4 Done
PJ04-Ph02-M25	CY23Q1 KDP: is Gamma Sub system working (benchtop tests) and suitable for field deployment (e.g., review housing integrity).	CY22Qtr4 Yes?
PJ04-Ph02-M26	CY23Q2 Develop and test a calibration procedure for the swept frequency induction sensor system and present results to PRP panel for review.	CY22Qtr4
PJ04-Ph02-M32	CY23Q2 Complete commercial logging in NGL well.	CY22Qtr4
PJ04-Ph02-M33	CY23Q2 Second design of time domain induction logging circuit completed (compare results with first prototype and provide to PRP group)	CY22Qtr4
PJ04-Ph02-M34	CY23Q2 Draft patent is prepared – progress reported to PRP group.	CY22Qtr4
PJ04-Ph02-M35	CY23Q2 KDP: is a swept frequency tool patent viable.	CY22Qtr4

PJ04-Ph02-M36	CY23Q3 Hold MinEx Project 4 commercialization workshop at 2023 MinEx annual conference.	CY22Qtr4
PJ04-Ph02-M37	CY23Q3 Provide a comparison (to PRP) of commercial induction logging output with output from Swept Frequency Tool in Curtin's 900m well.	CY22Qtr4
PJ04-Ph02-M38	CY23Q3 KDP: is a LWT system with swept frequency sensor ready for field deployment.	CY22Qtr4
PJ04-Ph02-M39	CY23Q4 If patent is viable – provisional patent submitted.	CY22Qtr4
PJ04-Ph02-M40	CY23Q4 System for converting swept frequency tool outputs to a format suitable for commercial software is developed.	CY22Qtr4
PJ04-Ph02-M41	CY23Q4 Update commercialisation and IP Roadmap based on year 2 research (i.e., develop plan for year 3 and report to PRP)	CY22Qtr4
PJ04-Ph02-M42	CY23Q4 Test swept frequency tool in LWT mode on a CT Rig	CY22Qtr4

Milestones 2024 – (no modification yet)

PJ04-Ph02-M27	CY24Q4 Commercialisation and IP Roadmap outputs utilised to facilitate Phase III planning.	CY22Qtr4
PJ04-Ph02-M28	CY24Q4 CT-LWD-EM sub: CT-LWD_EM Sub tested on the CT rig.	CY22Qtr4
PJ04-Ph02-M29	CY24Q4 Trajectory control and real time imaging demonstrated: Multi-parameter real time imaging/Trajectory control system demonstrated.	CY22Qtr4
PJ04-Ph02-M30	CY24Q4 CT-LWD-Gamma sub: System integrated into CT drilling.	CY22Qtr4
PJ04-Ph02-M31	CY24Q4 Phase 2 Workshop: Complete Project 4/Project 2 Integration Workshop to focus on multi-parameter LWD and Drilling workshop (this could be internal or external depending on PRP).	CY22Qtr4

2. Patent discovery and assessment for Swept Frequency Tool

Papers and Patents etc:

Patents mostly talk about the end use first -- then then provide increasing detail and clarity about novelty/invention
Just three examples below are:

1. [CN203745547U - Automatic sweep-frequency type inductance measuring instrument - Google Patents](#)

China Patent: Title sounds similar but this is fundamental different wrt the receiver system.

2. US10036827B2 [Petrophysically-consistent calibration of full-tensor electromagnetic induction tools](#)

→ <https://www.patentguru.com/assignee/schlumberger-technology-corporation>

Patent relates to the method of calibration: -- (yes the example is for core: maybe consider a separate patent?)

3. US9880307B2 - Induction Logging Patent - Baker Hughes Holdings LLC etc –

Back <https://patents.google.com/patent/US9880307B2/en>

Relates to LWD with a large oil and gas type tool → again fundamentally different

Example of patent expressed in a general way:

1. [US7391210B2 - Integrated fluxgate-induction sensor](#)

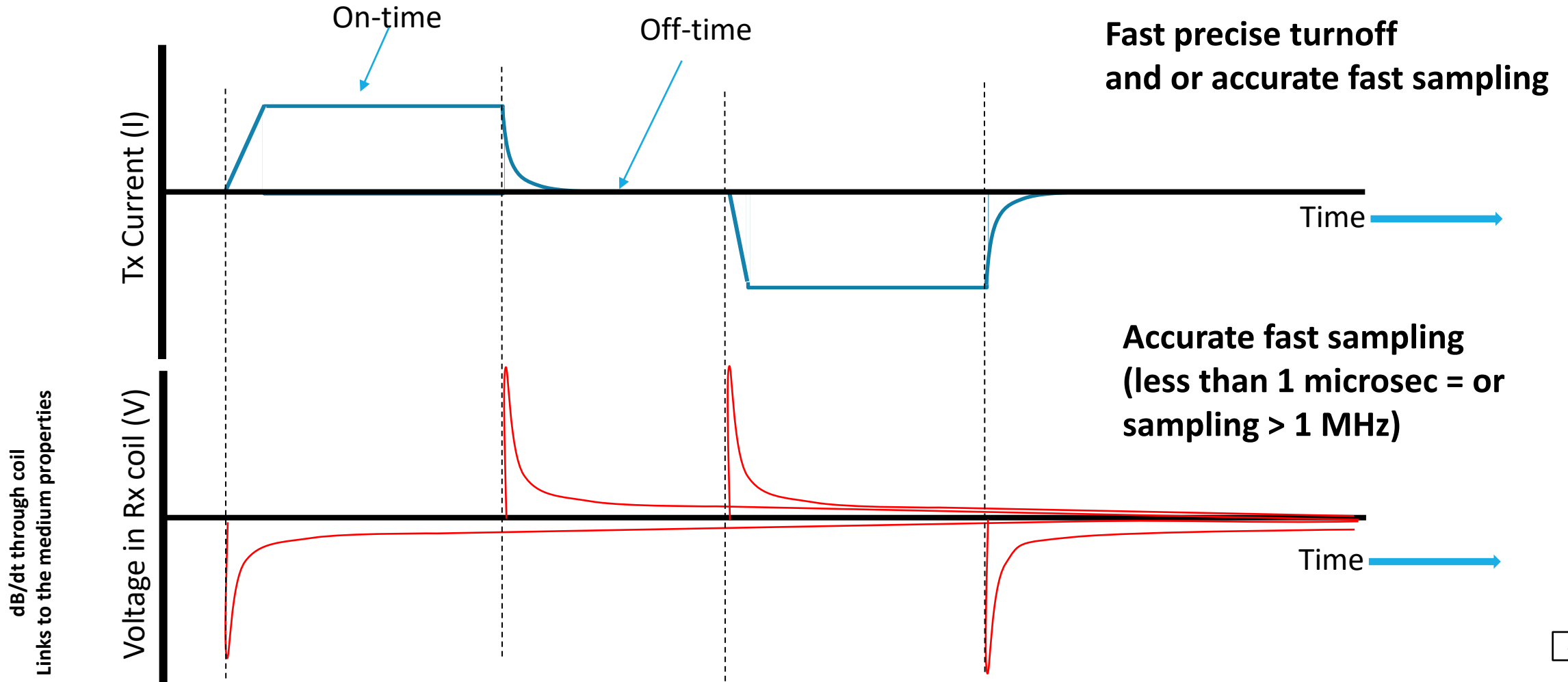
Relates to a sensor that can measure static and time harmonic magnetic fields ~ at the same time.

Although we'd note that the modern chips we use can measure static magnetic fields (i.e., accuracy is the issue)

3. TEM sensor system / Tool

■ Process:

- Fast design and build – to get a feel for what is possible
 - Review then optimise parameters – repeat:



4. OP4 - Progress and next steps

- (i) BHA → Testing/integration of Gamma Sub in BHA → Field
- (ii) Fibre → Installation of fibre in Tubing → testing at UniSA → Field
- (iii) Optical slip ring → Installation of FORJ → testing at UniSA → Field
- (iv) Opportunity fund → Funding for definitive field test – pre-cursor to commercial development

Imaging while/during CT drilling – next steps:

(i) BHA Gamma Sub:

1. Gamma Sub Testing at Curtin (Done). 2. Gamma Sub operation tested at UniSA in SA (Done) 3. TC gamma sensor needs to be tested with source 4. System needs to be testing in UniSA once fibre is in rig before going to field (i.e., collect and send some data) → 5. Testing while drilling.

*** remember that water invaded the housing as some point in the previous test ***

(ii) Fibre:

1. Needs to be drawn through tubing (being done) 2. needs to be tested with BHA. 3. needs to be tested with single mode fibre and engineered fibre 4. Needs to be tested with FORJ 5. Final test of everything at UniSA

(iii) Optical slip ring:

1. Needs to be installed on CT rig. 2: needs to be tested for comms to BHA, 3. needs to be tested with interrogator at UniSA 4. Final shake down at UniSA for comms and interrogator → 5. Deploy in Field

(iv) Opportunity fund: Funding for definitive field test + analysis of TB of data

(Extension to OP4 – next step) we need to avoid scope creep –

1. **OP4-extension - definitive field test for imaging while drilling with a CT rig.** – 2. Collect TB of data (including VSP, RVSP + surface sources/geophones/fibre while drilling) during drilling of multiple holes 3. Analyse TB data to image the subsurface (i.e., **this is a significant exceedingly high value research**) 4. Work towards true subsurface imaging while drilling

Future problems or risks that may delay or change in milestones:

Question, concerns, feedback by Panel and final comments:

Dates for next meeting (second week in July)



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MinEx Project 4 – PRP Meeting Notes: (CY2023Qtr4)

Topics:

1. Update: **Patent, TEM, FDEM calibration (sensitivity and parameter calibration),**
2. 2024 Milestone: **Order is Critical – Calibration then Field Trial – LWT ?**
3. Phase 3: **FDEM/TEM – Refinement, commercialization, implementation in the field?**
4. OP4 complete: **FORJ (slip ring) works – what's next – Integrated Field Trial (Ph-3)**
5. MinEx CRC Technology demonstration **OP4 + Project 4 + Project 2 + ?**
6. How/when will the above fit with Project 2 **(rig and external BHA)**
7. Workshop 2024: **Commercialization/Milestones/Phase 3 Workshop ??**

Presenters: Chair, Brett and Anyone who wants to contribute



MinEx project 4 – PRP meeting - 2023 Quarter 4:

Meeting Objectives:

1. Update: Chair to start meeting
2. Update: Quick update – Patent Documents, TEM, Lock in amplifier, FDEM Calibration
3. Update: Milestones 2024 – Timing for field demonstration relative to calibration is the key variable
- 4 Update: Workshop - Milestones, Phase 3, Commercialization – Straw man to be provided

Meeting Date/Time: → Thursday 25th January 2024
Time - 11:00 am to 12.00 pm

Venue: Face to Face or On-Line (WA-Kensington ARRC - B613-4H25 – Curtin Geophysics Board Room)

Attendees (PRP meeting):

Imdex: Fred Blaine (Chair), Natalee Taylor
Curtin: Brett Harris (Project 4 Leader), Michael Carson, Hoang Nguyen
MinEx CRC: Andrew Bailey, David Giles (MinEx CRC - CSO),
MIRWA: Geoff Batt,
South32 : Fiona Best, Kim Cook (apology)
CSIRO: Yulia Uvarova (Program 2 Leader),
RioTinto: Anna Purton

Overview

To improve exploration and mining workflows with real-time vectoring during drilling with a CT rig using new LWD sensors and automated subsurface reconstruction algorithms

Productivity Performance Target

Achieve real-time subsurface sensing during CT drilling to depths of 1000m and to provide real time imaging to assist geo-steering to within 30 m of a lithological target.

Outcomes

- i. Development of new sensors for real-time multi-parameter logging while drilling with a Coil Tubing drill rig
- ii. Automatic subsurface reconstruction for steering based on geophysical sensing while drilling. The real time trajectory control/vectoring component will systematically work towards the goal of providing the inputs needed to geo-steering CT drilling towards lithological targets. This research will extend the reach and value of every meter drilled into a 3D search space ahead of and around the drill bit

People

MinEx

- MinEx – Andrew (CEO), Dave (CSO)
- MinEx - Program 2 Leader – Yulia

Curtin

- Brett Harris (Project 4 Lead)
- Michael Carson (key researcher)
- Hoang Nguyen (key researcher)

Participant Reps

- Imdex – (Fred Blaine Project Chair)
- South 32 – Fiona Best
- MRiWA – Geoff Batt
- RioTino – Anna Purton

Australia Government

Note the below is a summary
Highlighting key discussion points only

Please bring up all items to be include in the Workshop Agenda

From Last PRP meeting

Quick review as a few people were away

Working towards a Perfect sensor

Yes, we can simulate what a perfect full spectrum sensor would measure

The challenge is to work towards the embodiment/reality of a perfect EM sensor

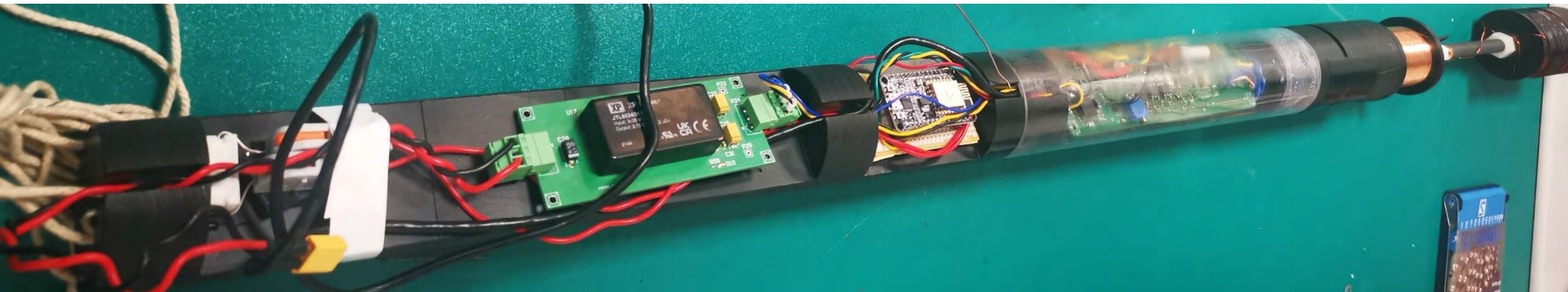
Frequency domain EM coil antenna – accurately measure Voltage (Amp and Phase – Real and Imaginary) at all frequencies

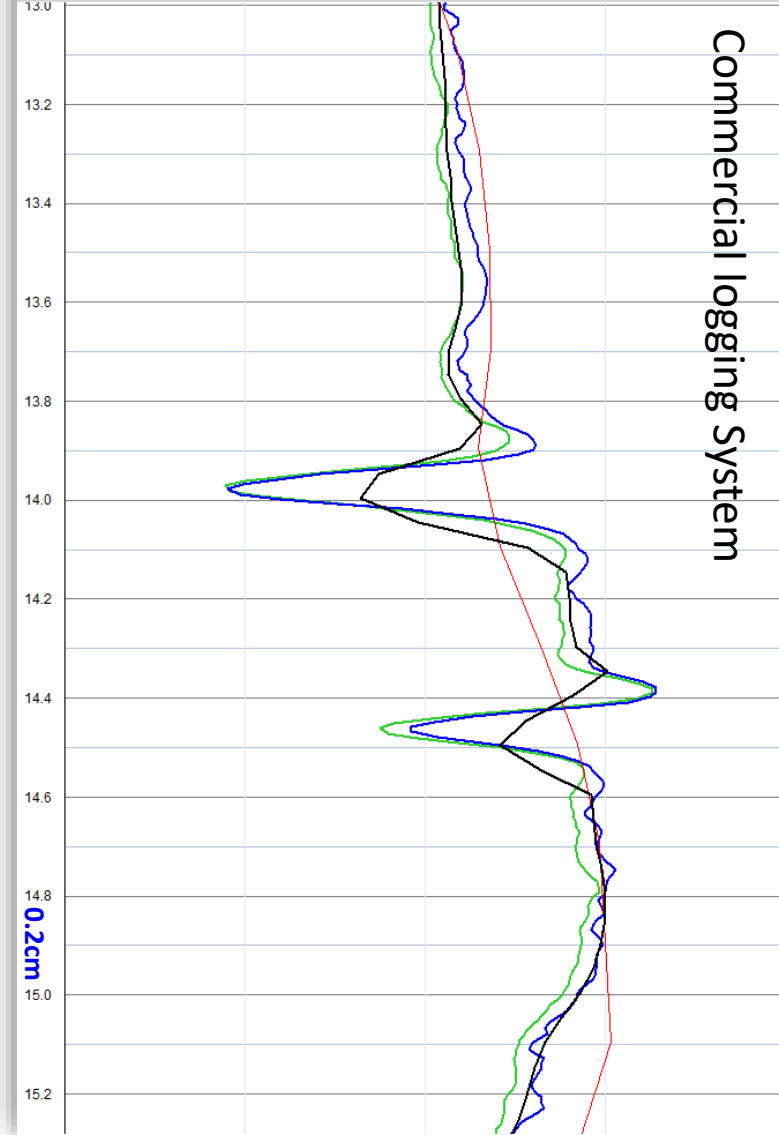
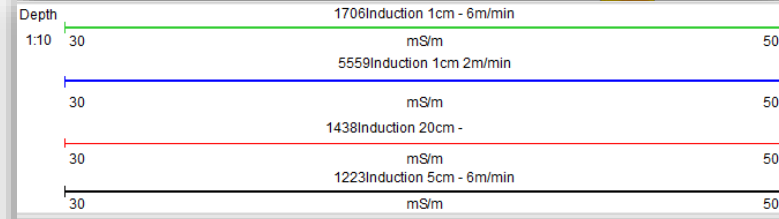
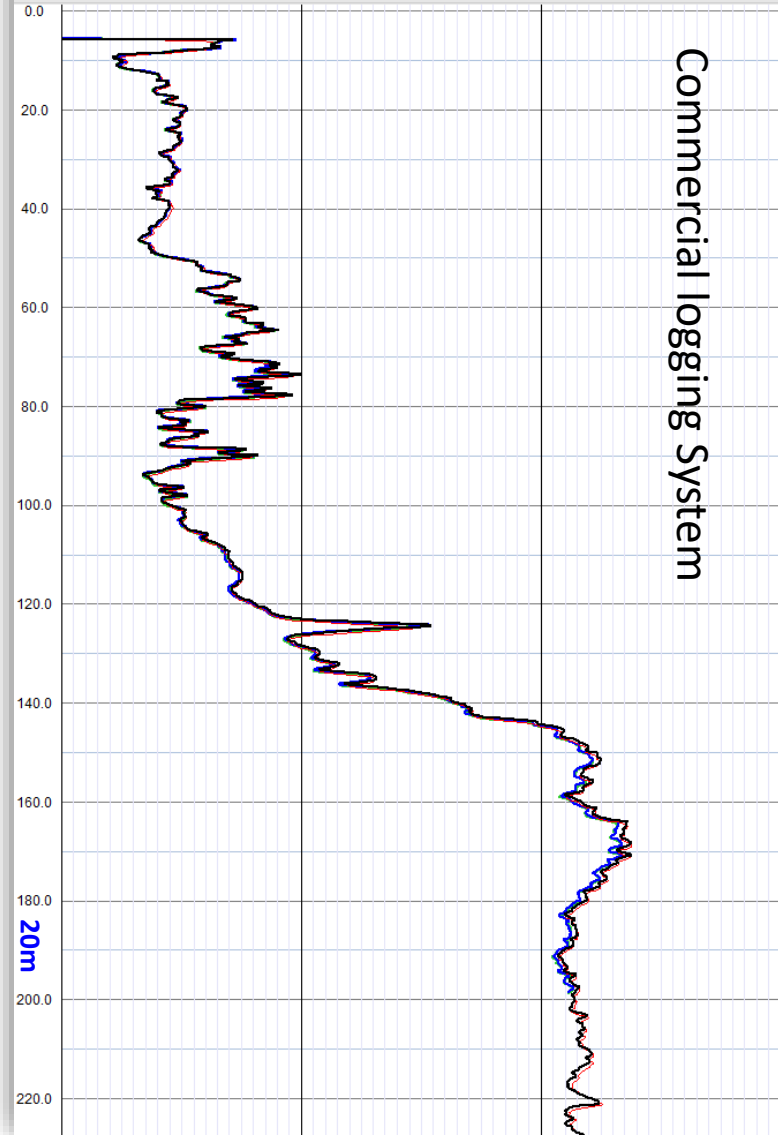
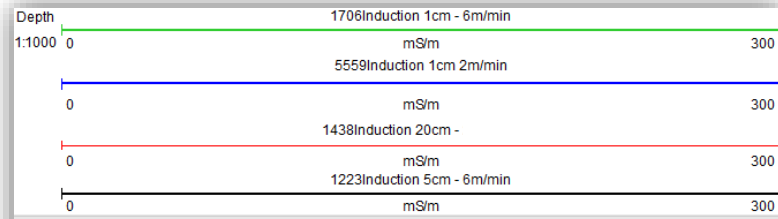
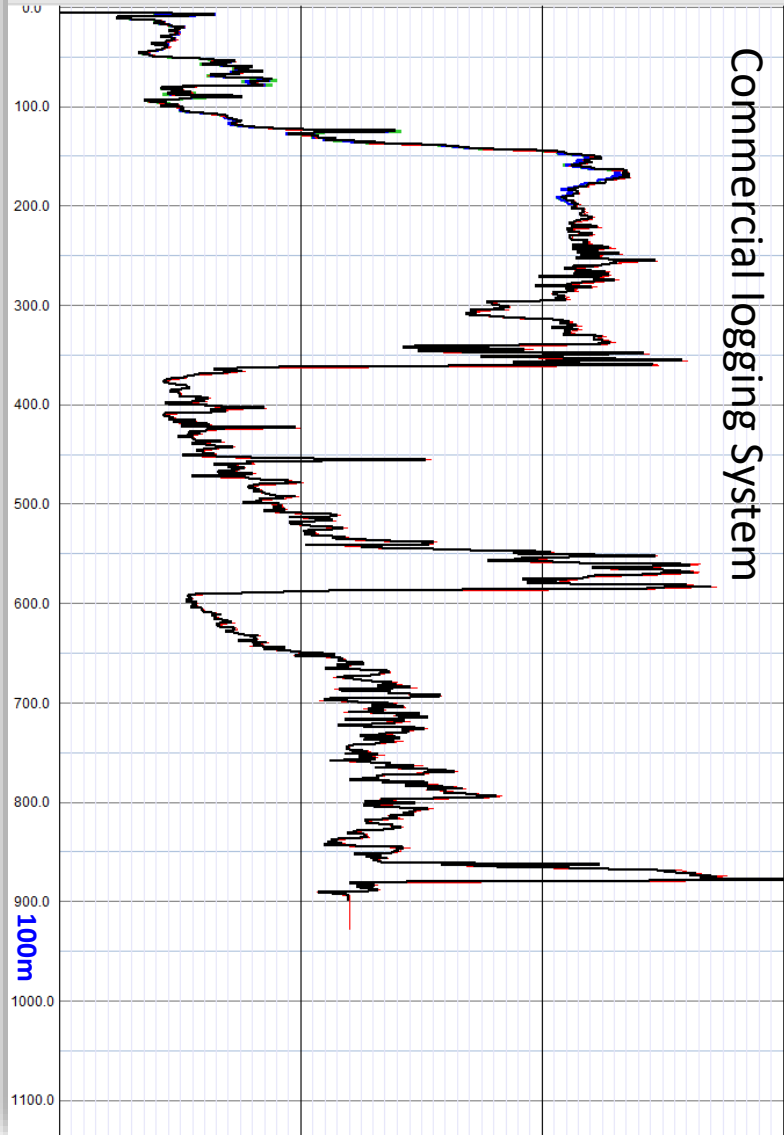
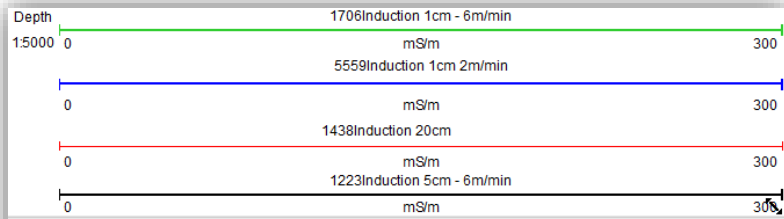
Time domain EM coil antenna – Transmit a perfect spike (step change in current) and accurately measure all voltages with time.

***** These two perfect EM systems recover complete and identical information content *****

Calibration (Sensitivity) → to optimized sensitivity of the instrument to the desired measurement range:

Calibration (EM parameters) → to map the value recorded by the instrument to a known EM parameter:





TEM sensor developments

First Task: Make a Fast Turn of TEM Transmitter
(i.e., small coil antenna system)

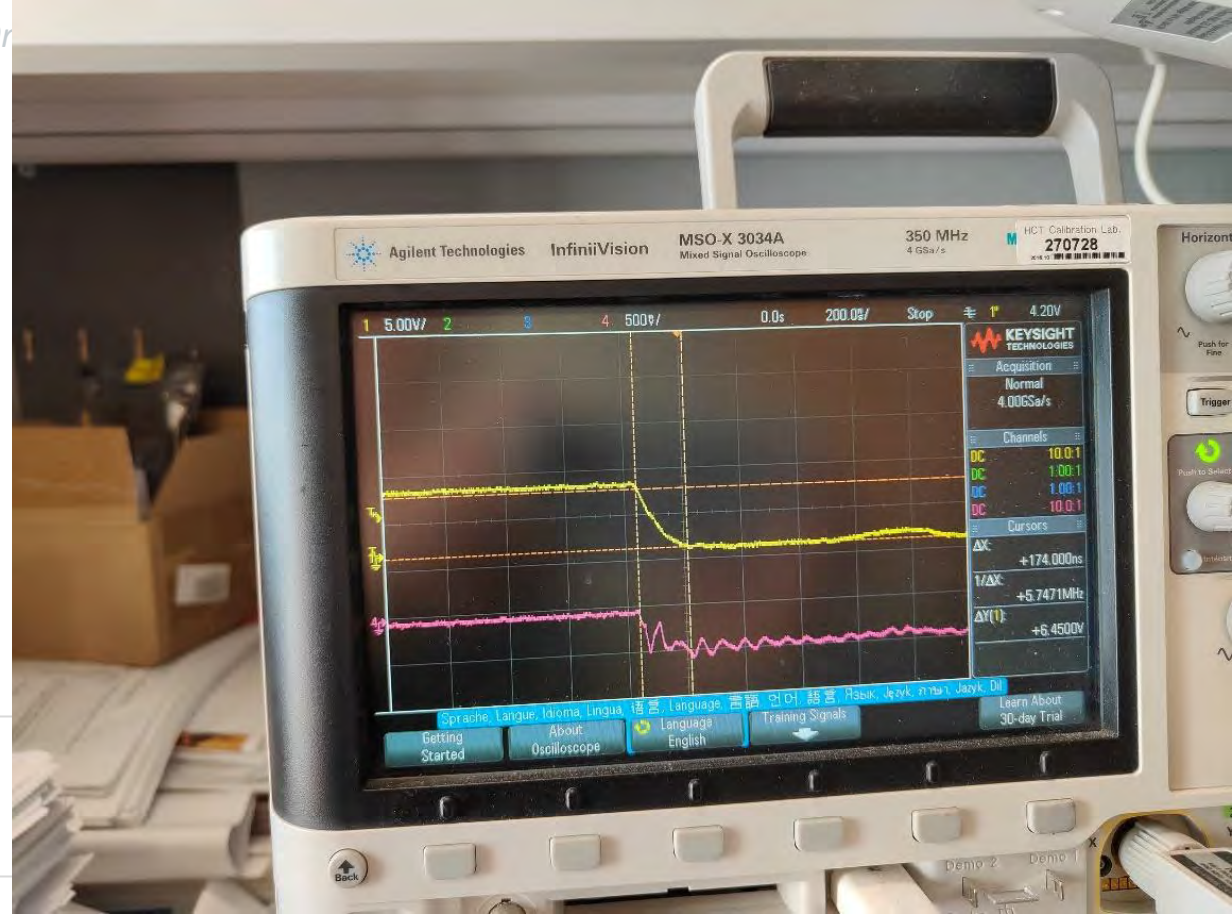
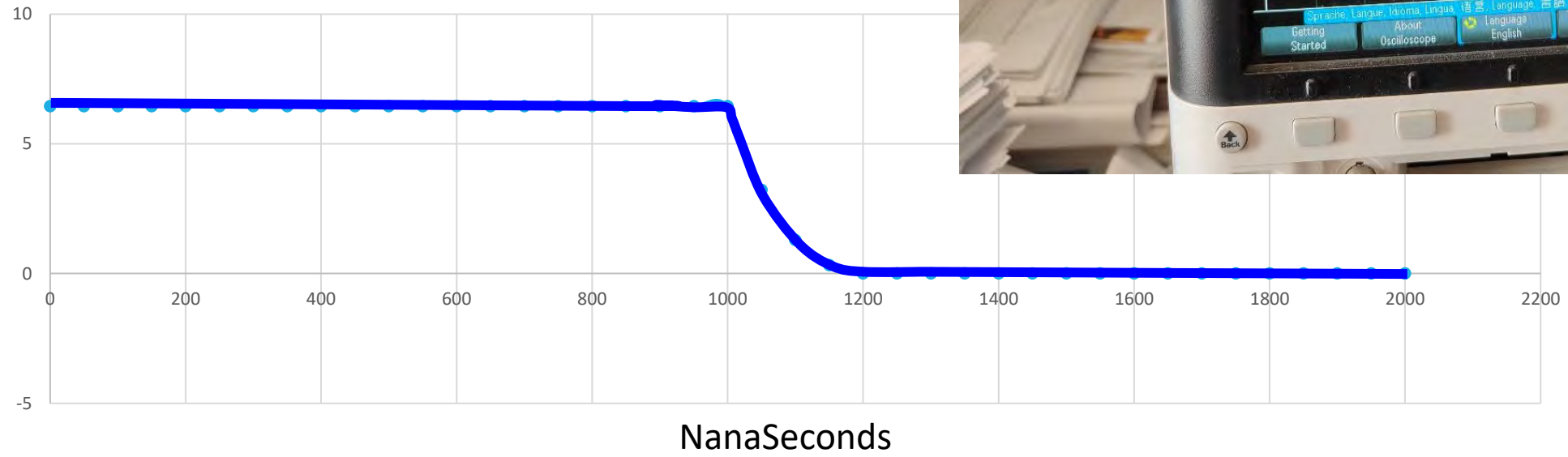
Decisions: Are needed regarding Tx and Rx waveform acquisitions (sampling of the voltage, chip, processing – real time or post-acquisition).
Base on simulations + electronics design constraints

TEM Logging Tool

Fast Turn off Tx experiments



Fast turn off trial Waveform

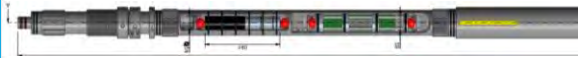


From Annual Conference 2023

Context

Gamma Sub

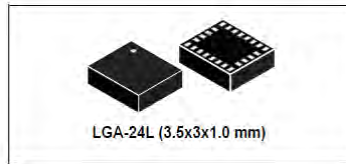
Total Counts Gamma



BHA

Temperature
3D Accelerometer
3D gyroscope
Magnetometer

-- Currently --
LSM9DS1
iNEMO inertial module:



LGA-24L (3.5x3x1.0 mm)

DAS (Seismic)



Tubing

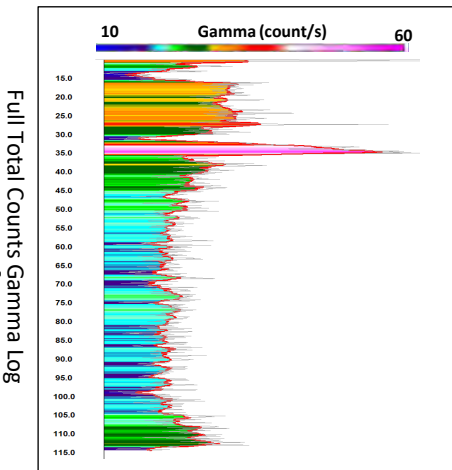
Velocity
reflectivity

FDEM + TEM

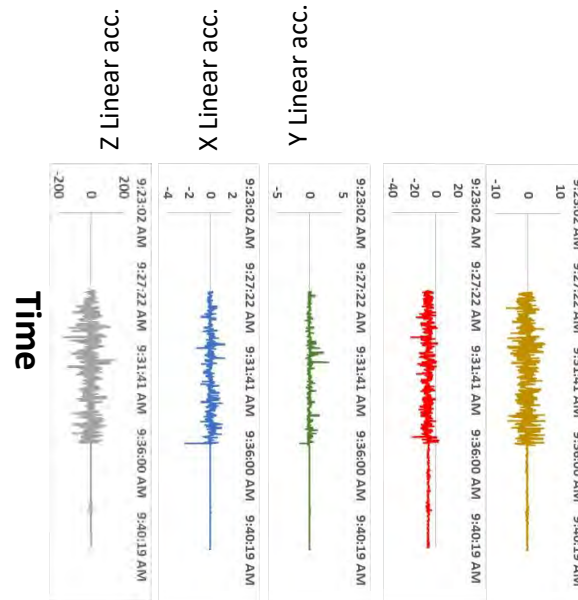
PROJECT 4



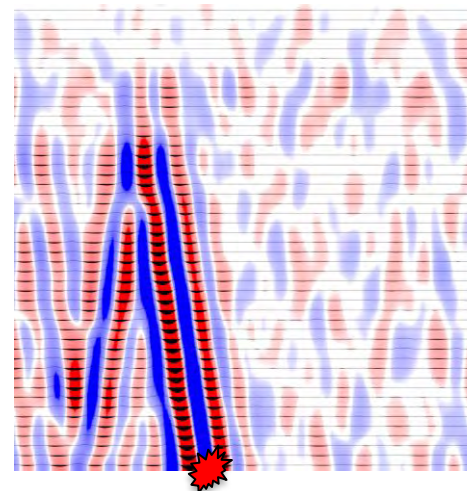
Universal Probe:
Cond.
Mag. Susc.



Full Total Counts Gamma Log

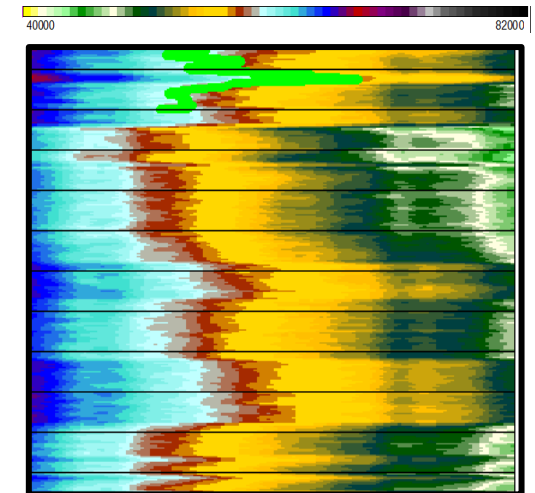


Time(msec)



Depth

Freq



Depth

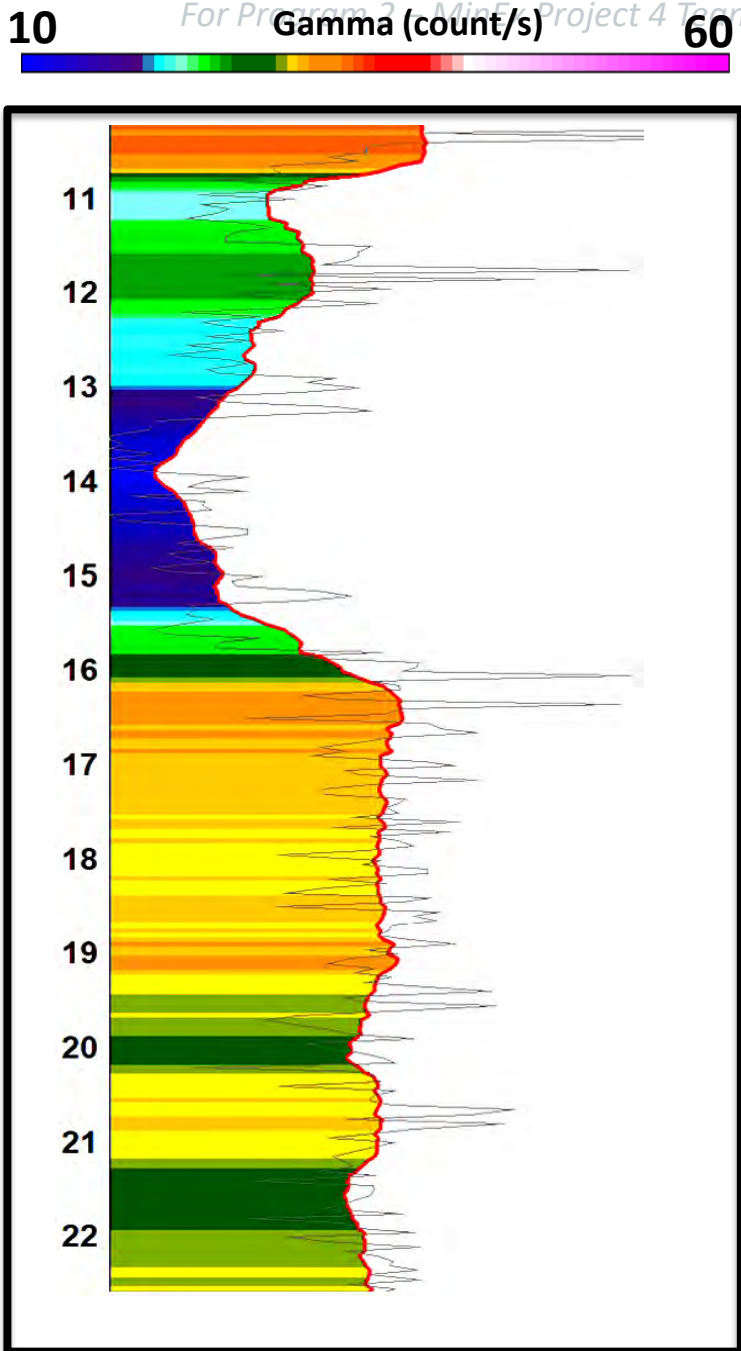
Gamma

Cover Thickness

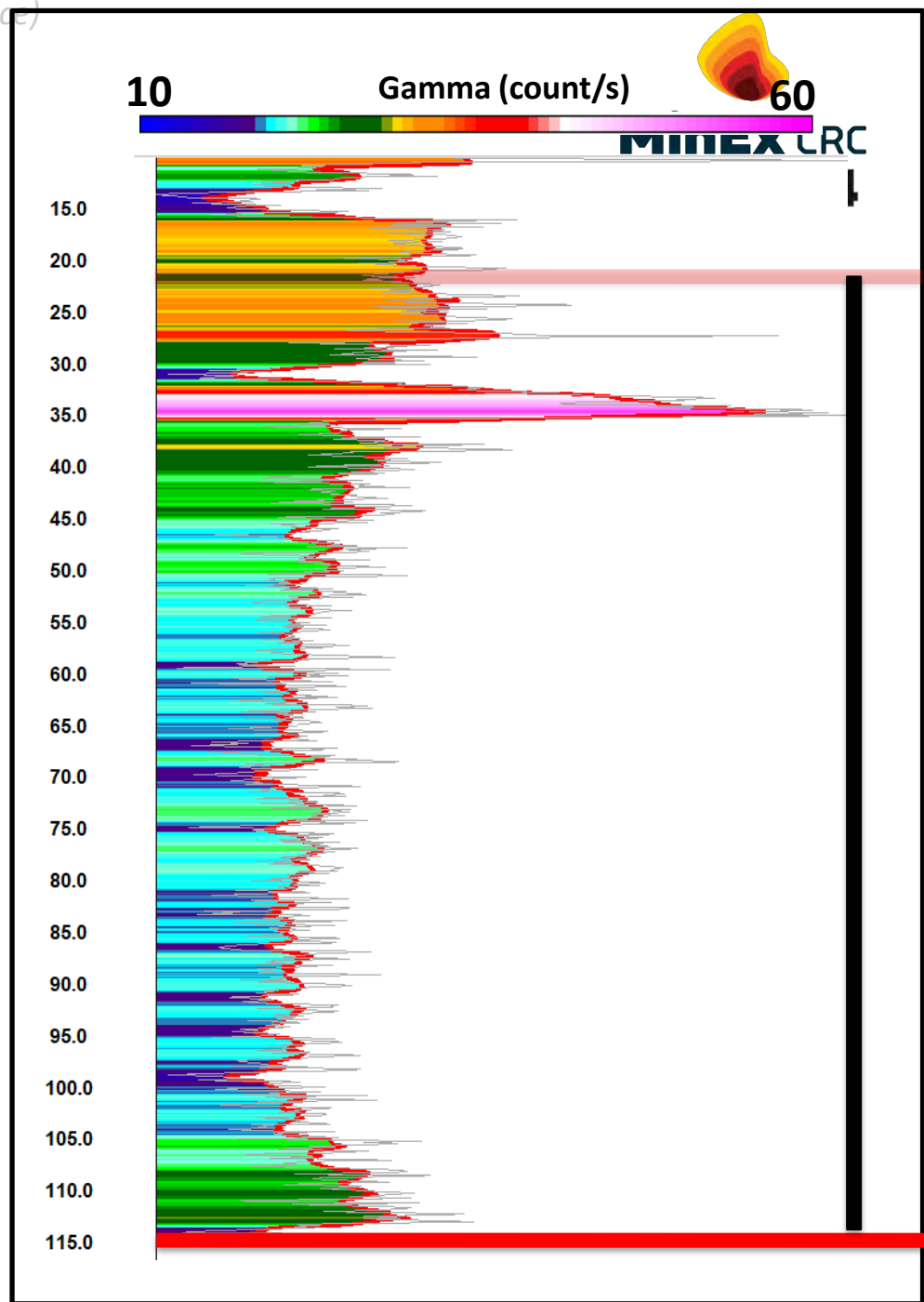
Basic Log

GAMMA

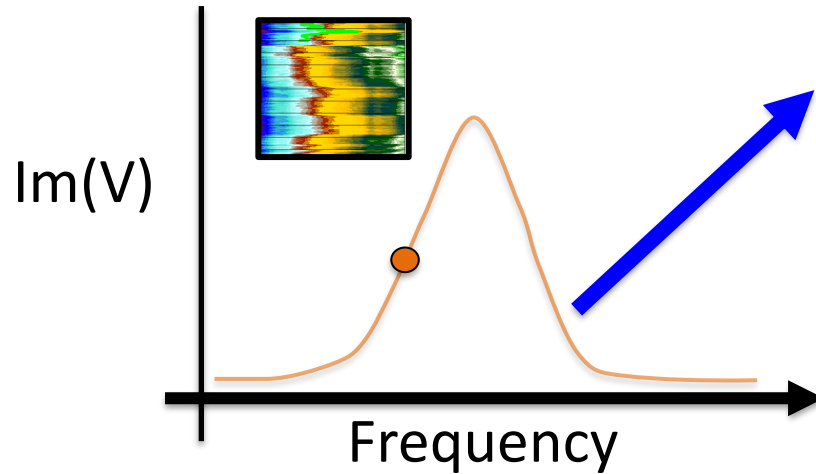
Gamma



Full Total Counts Gamma Log



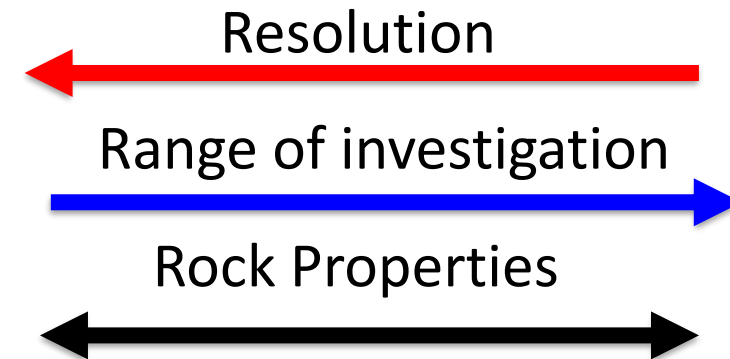
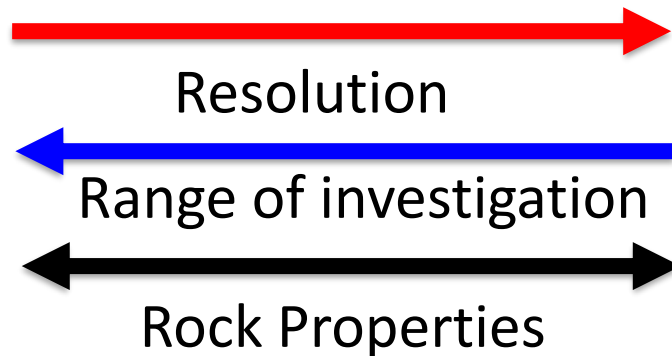
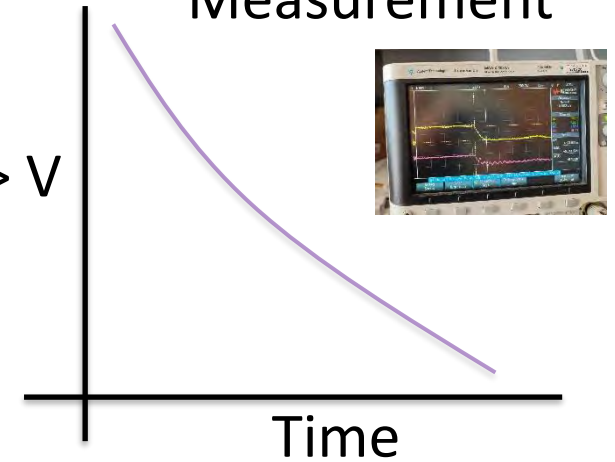
Freq Domain EM
Measurement



Cond
Mag Susc
IP

$Db/Dt \rightarrow V$

Time Domain
Measurement



P4-OP4 2023 FIELD TRIALS

FORJ (OPTICAL SLIPE
RING) – WORKS

LWD Gamma GEOSUB
WORKS

Multiple LWD
geophysical data sets
demonstrated in the
field →

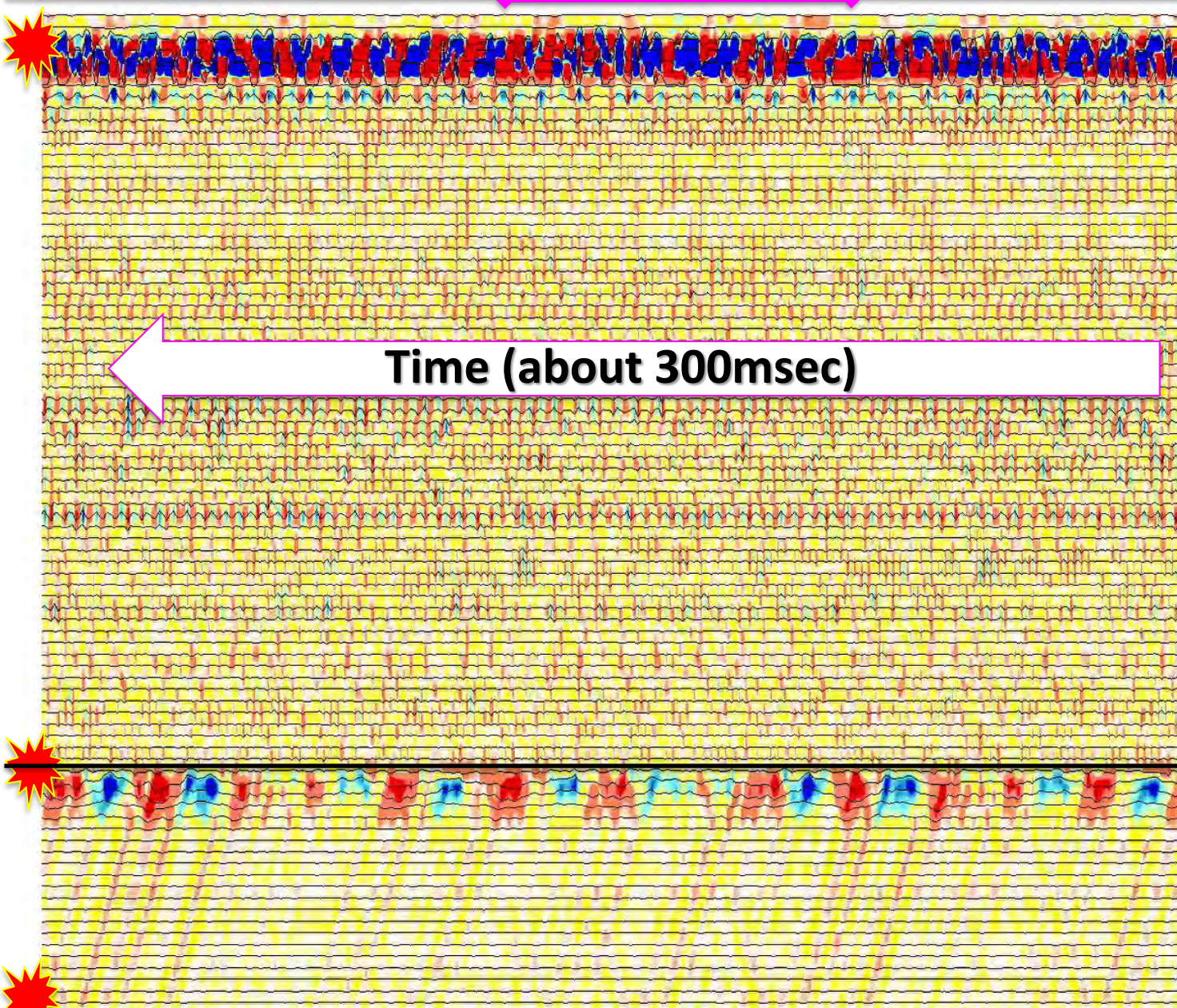
1. LWD Gamma +
2. DAS while drilling
demonstrated



Kapunda
26th 27th and 28th September 2023

36000- 35900- 100 msec 35800-

REC_X 34.304 83.310 132.315 181.321 230.327 279.333 328.338 377.344 426.350



FORJ
Sensors measuring vibrations in time

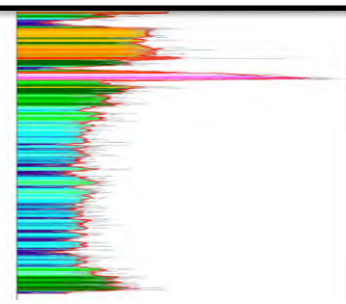
Coil Tubing

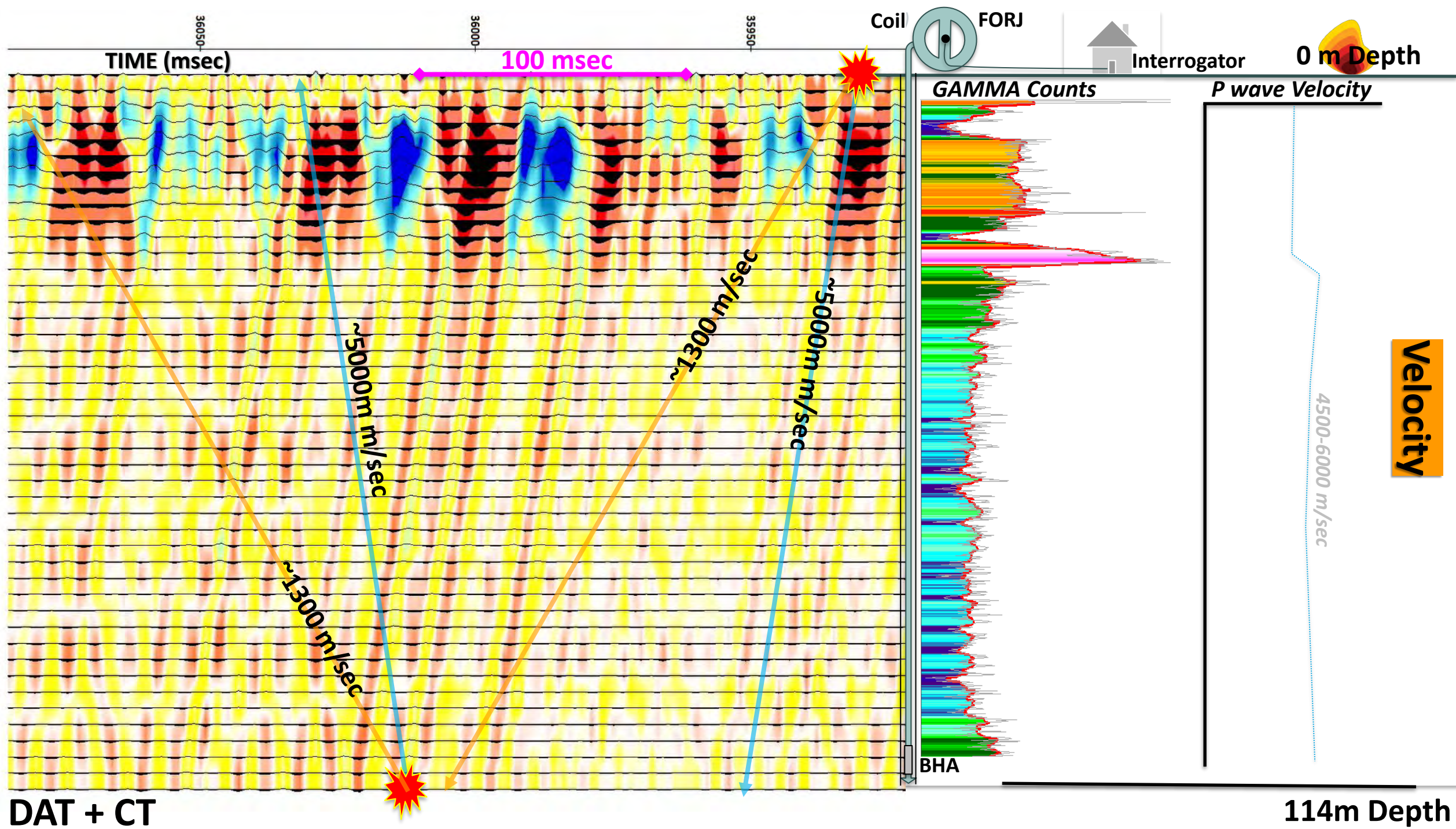


BHA



BHA





OP4 - Field Trial (2)

GammaSub worked
DAS while drilling worked

The field trials were completed on
26th 27th and 28th of September at the MinEx CRC - Kapunda Drill site

Update EM :

TEM: Working on fast sampling receiver (< than 1 microsecond)

FDEM: Complete new third working system is being assembled for full calibration Trials

Critical Challenges: 1: Temperature

2: Coils (moment versus inductance)

** Current coils are high inductance:

FDEM: Calibration:

We will have a universal EM system calibration procedure:

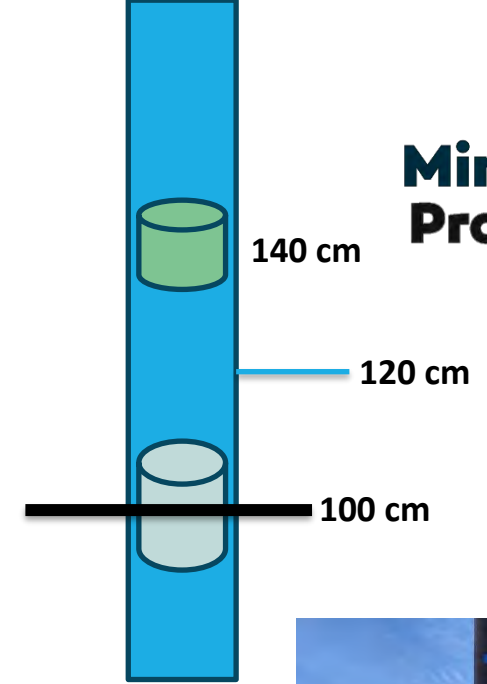
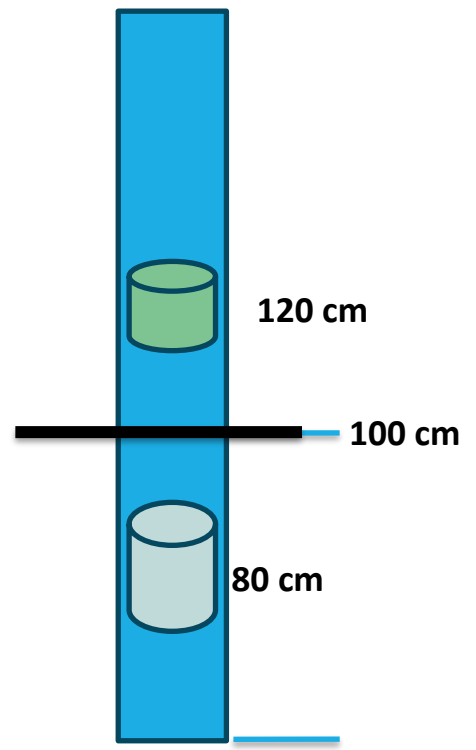
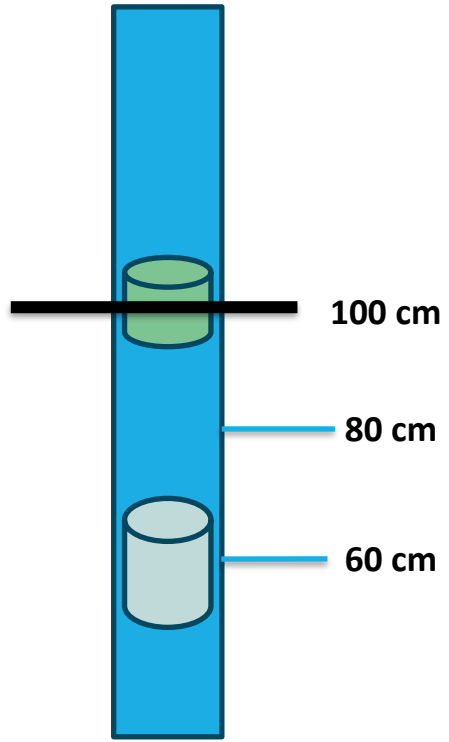
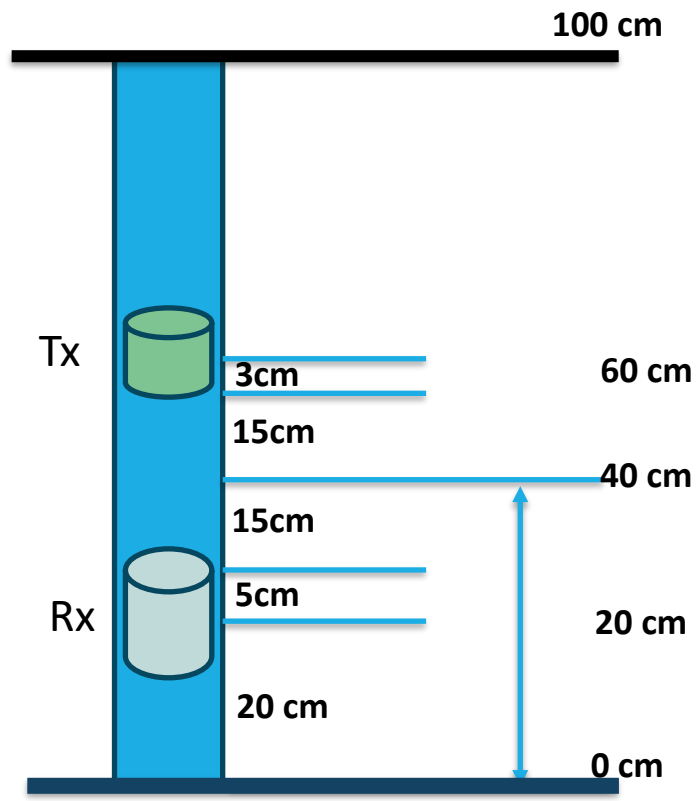
*** Completed pre-testing (identify challenges and design criteria)

1: Next - full trial



Local Pre-test of a calibration method (operability)

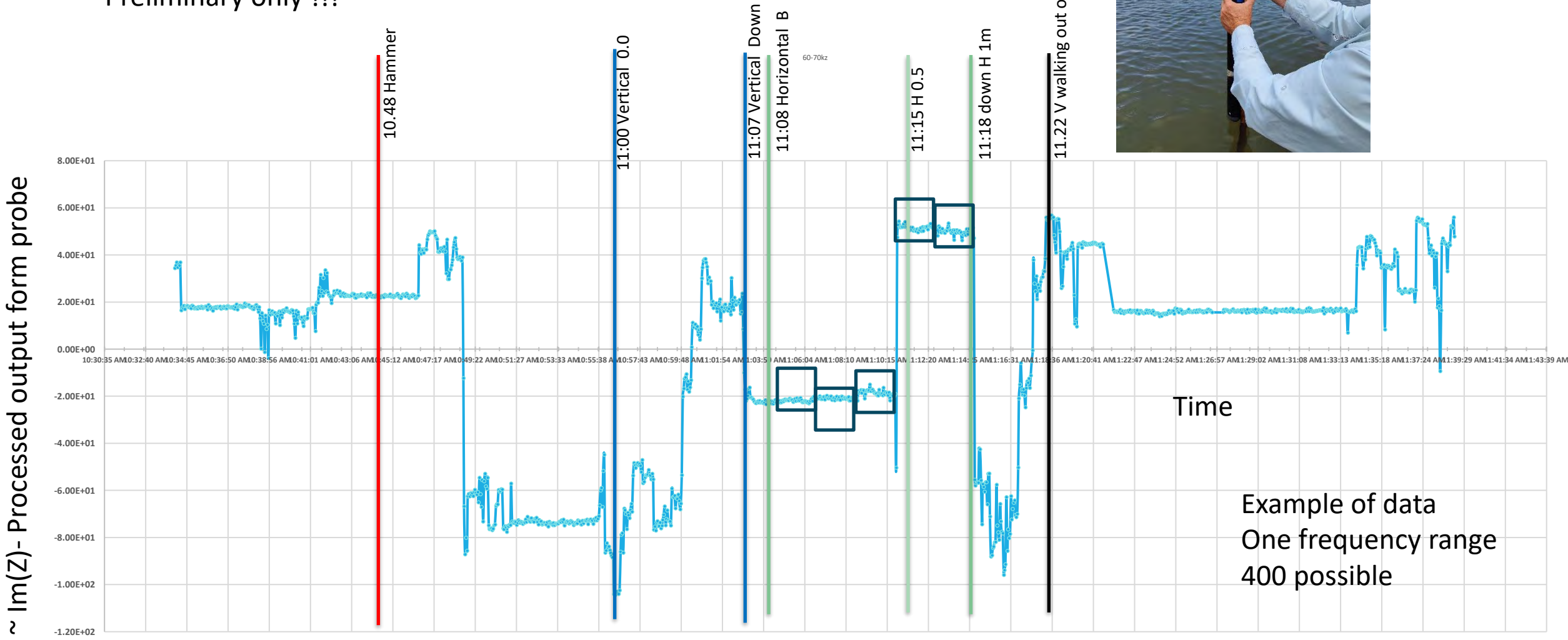
Just one possibility



-- Pre-test scouting --



Example of Data (example is between 60 and 70KHz)
This will be repeated for a full test in February (with two systems)
Preliminary only !!!



Example of data
One frequency range
400 possible

Calibration: Key point:

Current calibration system are not intended for the new types we generate (they will not work)

Major calibration test to come:

We will focus on TEM

In parallel – Calibration with three tools – (all with different set up – e.g different coils and arrangements)

This is to accelerated development and trouble shooting.



22 November 2023

Notice of filing for provisional patent application

FB Rice Pty Ltd
L 23
44 Market St
Sydney NSW 2000
Australia

Your reference: 205639PRV
Application number: 2023903753
Applicant name: MinEx CRC Ltd

Dear FB Rice Pty Ltd,

Thank you for filing a provisional patent application with IP Australia. This provisional patent application has a filing date of 22 November 2023.

Please review the details on the attached application summary to ensure they are correct. Please note that a complete application or PCT application must be filed on or before 22 November 2024 in order to claim priority with this provisional application.

Details of this patent application can be viewed on [Auspat](#), our Australian patent search database.

Yours sincerely,
IP Australia



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International: +61 2 6283 2999
www.ipaustralia.gov.au
ABN: 38 113 072 755

Patent Documentation

Electromagnetic surveying method and device

ABSTRACT

A device for performing an electromagnetic survey of a subsurface environment. The device comprises one or more transmitter coils and one or more receiver coils, the coils collectively configured to perform electromagnetic induction (EMI) on a material of the subsurface environment in response to the application of an excitation signal to the one or more transmitter coils. The device further comprises a control circuit that is configured to: (i) generate the excitation signal at a frequency that varies over time and incrementally over a frequency band; (ii) apply the excitation signal to the one or more transmitter coils; (iii) process a response signal induced within the one or more receiver coils from the EMI to generate electromagnetic data representing the material as a function of at least the frequency of the excitation signal; and (iv) process the electromagnetic data to determine one or more material specific parameters of the subsurface environment around the coils.

Key point:

Provisional patent applications has been submitted on behalf of MinEx CRC:

Inventor assignment documents to be completed:

Milestones 2024 – Commercialization – Phase 3

1. **Commercialization: Activities to dovetail/accelerate commercialization**
2. **Utilization: Utilization of Technologies – NDI/company - CT_rig drilling - Other**
3. **Phase 3: Trajectory control: LWD / Multiparameter sensing etc**
4. **MinEx CRC - Large scale integrated technology demonstration project in Phase 3 :**

Key Questions:

1. **First → The team will send proposed milestones for 2024 and suggestion for Phase 3.**
2. **Workshop to finalize - Milestones – Commercialization – Phase 3**
 1. **Dedicated meeting in March**
 2. **Expanded PRP in April**
 3. **Include in Mid-Year meeting scheduled for May ??**
 4. **Some combination of the above**

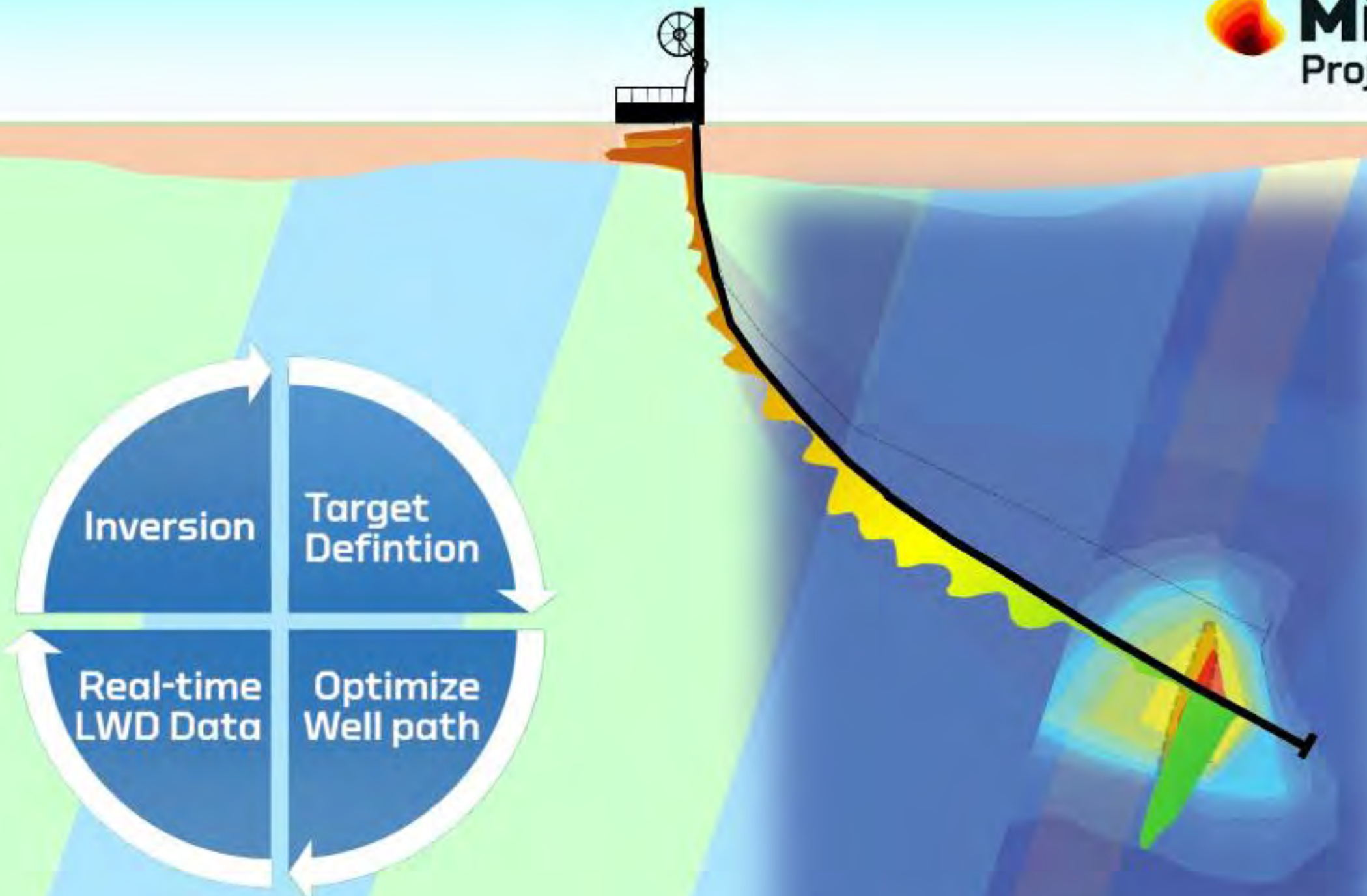
Future problems or risks that may delay or change in milestones:

Question, concerns, feedback by Panel and final comments:

Dates for next meeting (second week in October)

Annual conference 15th and 16th Nov

Summary Diagram





minexcrc.com.au

MinEx Project 4 – PRP Meeting Notes: (CY2024Qtr4)



Topics:

1. **FDEM: Patent Submission (huge milestone for the team)**
2. **TDEM: Three systems developed in parallel (reduce risk, accelerate research)**
3. **Testing: In the Curtin well – multiple tools +4000m logging – multiple data sets**
4. **Two student internships – David and Mathews – 12 weeks Dec to March**

Presenters: Chair, Brett plus anyone from the PRP / research team who wants to contribute



MinEx project 4 – PRP meeting - 2024 Quarter 4:

Meeting Objectives:

1. Update: Chair to start meeting
2. Update: Quick update – Patent update – FDEM device updates (processing workflow) – TEM updates (lab-based TEM work) – Curtin interns to commence
3. Update: MIRWA doc. - Phase 3 agreement complete -- Curtin interns commence
- 4 Update: Open discussion

Meeting Date/Time: →

Thursday 12th December 2024
Time - 11:00 am to 12.00 pm

Venue:

Face to Face or On-Line (WA-Kensington ARRC - B613-4H25 – Curtin Geophysics Board Room)

Attendees (PRP meeting):

Curtin: Brett Harris (Project 4 Leader), Hoang Nguyen
MinEx CRC: Andrew Bailey, David Giles (MinEx CRC - CSO),
MIRWA:

CSIRO: Yulia Uvarova (Program 2 Leader)

Imdex Fred Blaine
Imdex Natalee Taylor

Apologies:

Anna Purton (Rio Tinto), Geof Batt (MIRWA),

Overview

To improve exploration and mining workflows with real-time vectoring during drilling with a CT rig using new LWD sensors and automated subsurface reconstruction algorithms

Productivity Performance Target

Achieve real-time subsurface sensing during CT drilling to depths of 1000m and to provide real time imaging to assist geo-steering to within 30 m of a lithological target.

Outcomes

- i. Development of new sensors for real-time multi-parameter logging while drilling with a Coil Tubing drill rig
- ii. Automatic subsurface reconstruction for steering based on geophysical sensing while drilling. The real time trajectory control/vectoring component will systematically work towards the goal of providing the inputs needed to geo-steering CT drilling towards lithological targets. This research will extend the reach and value of every meter drilled into a 3D search space ahead of and around the drill bit

People

MinEx

- MinEx – Andrew (CEO), Dave (CSO)
- MinEx - Program 2 Leader – Yulia

Curtin

- Brett Harris (Project 4 Lead)
- Hoang Nguyen (key researcher)

Participant Reps

- Imdex – (Fred Blaine Project Chair)
- South 32 – Fiona Best
- MRiWA – Geoff Batt
- RioTino – Anna Purton

Australia Government

Duplication of slides from quarter 3 presentation
(for recap and reference only)

Progress in Quarter 3

The below is a summary provided as prompts for PRP discussion

The Frequency Sweep (Programmable)

- **Frequency Range,**
- **Frequency Steps (intervals) and**
- **Hold Off Time between frequencies -- are all Programmable**

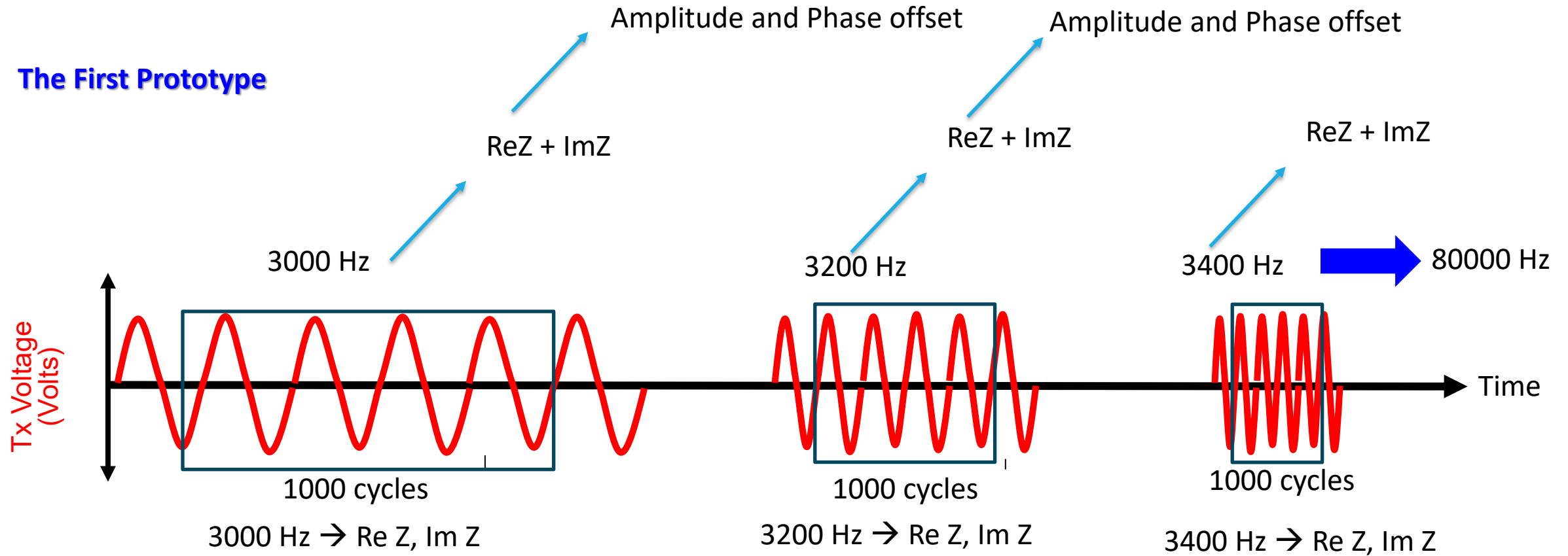
Demonstrated:

The version tested are:

- **Version 1** – 300 frequencies between 30000 and 80000 Hz with 200 Hz steps
- **Version 2** (GEN 3 and 4) – 151 frequencies between 5000 and 80000 Hz with 500 Hz steps

The first prototype (from 3000 to 80000 step 200Hz) (300 frequencies)

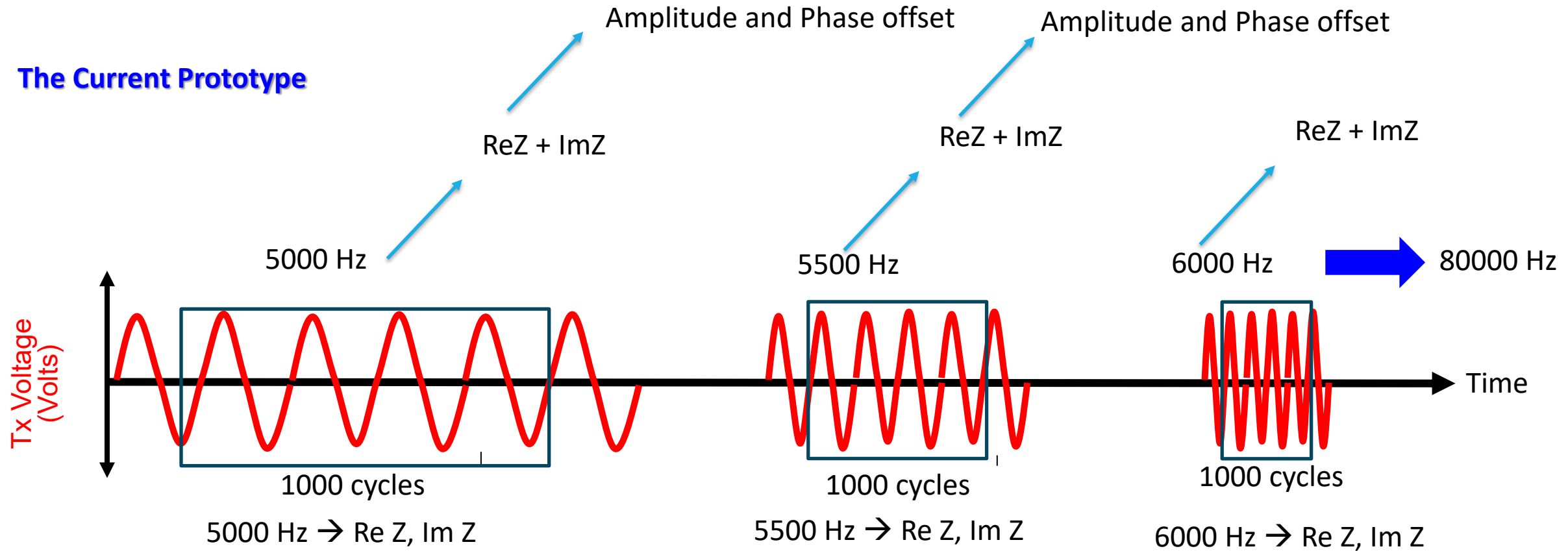
The First Prototype



Not to Scale

The Current Prototype (5000-80000 step 500Hz) (151 frequencies)

The Current Prototype



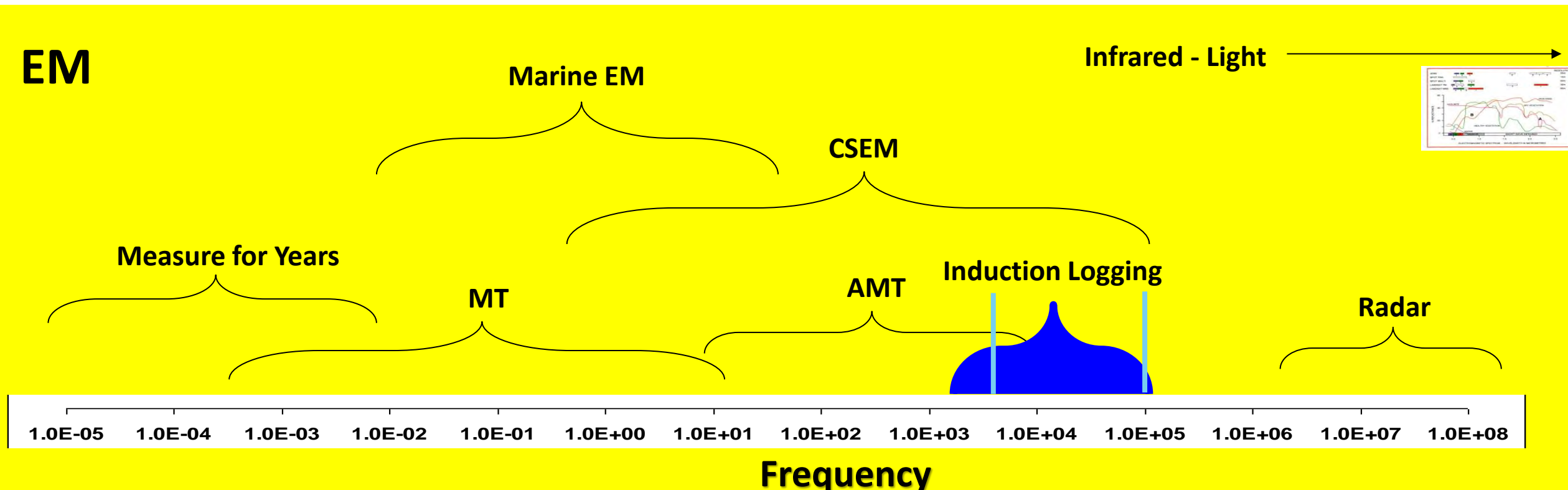
Not to Scale

EM for Geophysics



MinEx Induction logging:

Selectable range from less than 1000 Hz to more than 100000Hz



The Raw Impedance Measurement

Amplitude

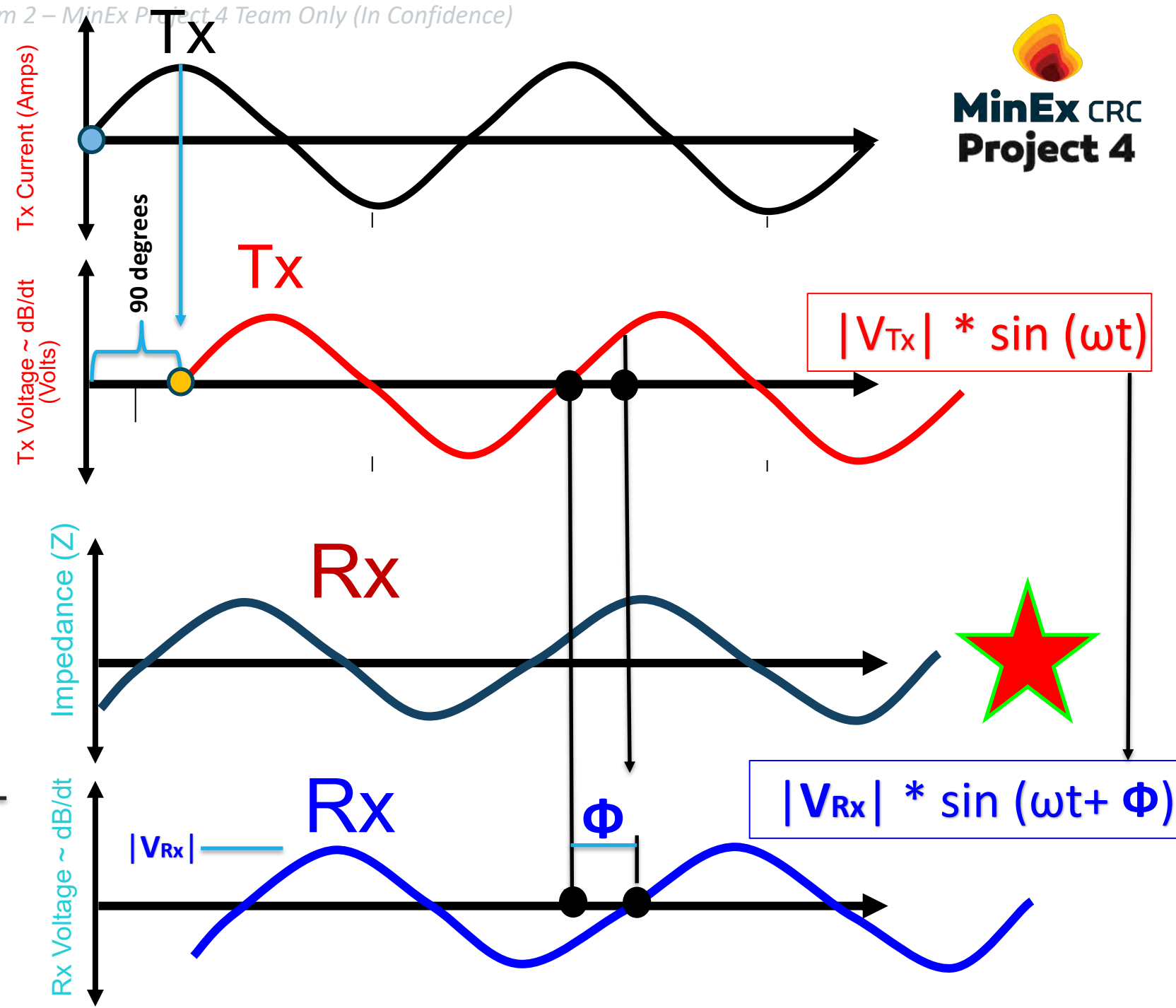
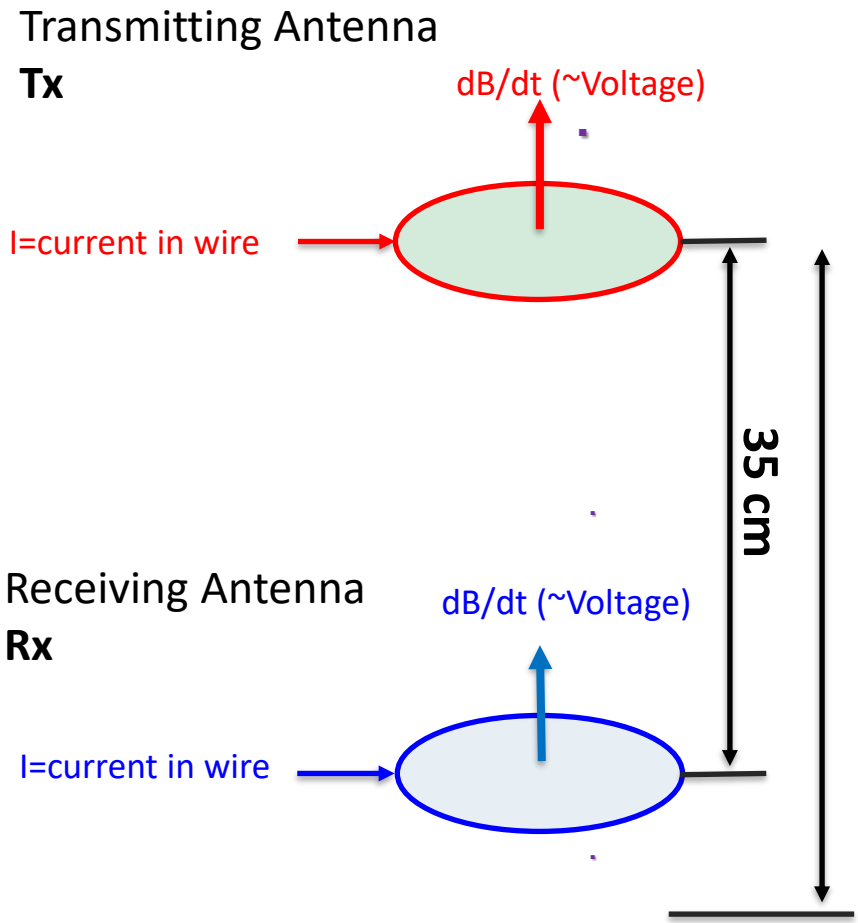
Phase

Frequency

$$|V_{Rx}| * \sin(\omega t + \Phi)$$

**This is what we want
after processing**

Ideally for simulation



We are working with Impedance

sort of:

Might be better to say:

Relative Residual Phase Offset

(we aim to get a relative phase offset)

Frequencies sweeps are computed at programmable time steps

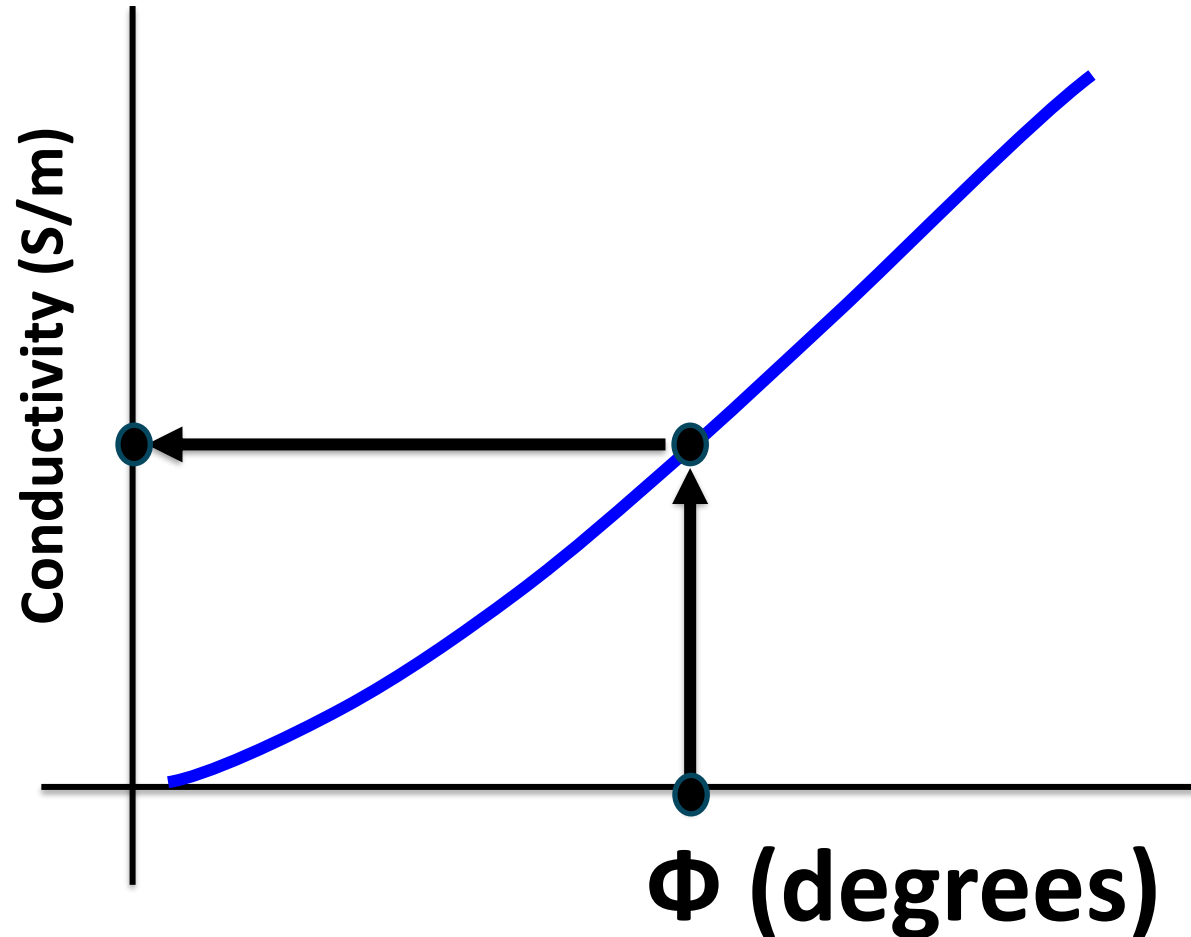
- Time steps (per measurement) are then converted to depth
- Time to depth algorithms – **demonstrated**
- Time to depth can be manual or automated (depth time encoder)
- Depth and tool measurements must be in accurate GPS time
- It might be possible to add a pressure sensor for depth

Time to Depth

Image redacted for reasons of commercial sensitivity

If Rx voltage phase offset (Φ) is known then Φ conversion to conductivity (apparent) is simple

A nomogram
for generating
conductivity



Questions someone might ask :

Is the self response temperature dependent?:

Yes -- the self response is of course temperature dependent (response in the absence of any medium will vary with temperature)

How big is the self response?: The self response is large compared to the signal we want to recover from the Earth (as expected).

How big is the temperature dependence?: The temperature dependence is larger compared to the signal from the Earth – It may also be non-linear

Can we recover the signal from the Earth (i.e., conductivity estimates) with sufficient accuracy?

Absolutely - Yes, this is already clearly demonstrated.

Can we recover the signal at all frequencies for all conductivities ?:

No - Earth response (e.g., phase offset) decreases with frequency (over the range of frequencies currently used) so eventually it will be too small to measure (it depends on Tx moment, Earth Medium Dependent Parameters, Tx-Rx offset, S/N, frequency and processing) --

****** Systems would be designed give space restrictions and desired conductivity ranges ******

Progress in Quarter 4 – Set up for transition to Phase 3

Significant New Advances:

TEM – Three Versions of the TEM system have been built:

1. Version 1: Lab only
2. Version 2: Field scale 40mm – Form factor first / cost
3. Version 3: Field scale 100mm – Design specification first /

FDEM:

1. Revised Patent Submitted
2. Focus is now on Amplitude part -- magnetic susceptibility (proxy for mmt content) – develop processing before field work.
3. Some hard rock field sites for testing - Know Geology – Simple Dolerite Dyke.

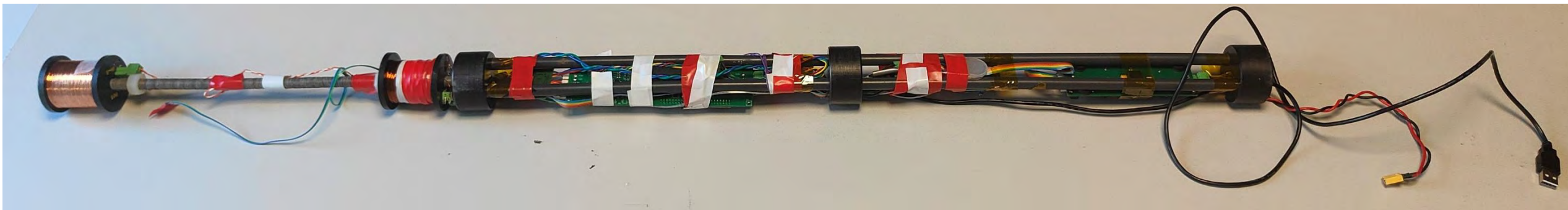
Field Testing * First coils in lab *****

1. Curtin Well -
2. Narrogin or Kojonup (waiting for crop to come off – casing is PVC and all glue and screw) need permission from farmer --

Two new student internships commencing:

1. Mathews Commences on 16th Dec 2024 and
2. David commence on 12th Dec 2024 (here today)

FDEM Gen4 version



Fit for purpose

The sensor system is small, light (less than 1kg), with independent power, independent data storage and a wireless communications system.

When assembled in its housing, the prototype tool has a length of ~1.7m and weight <5kgs making the prototype Swept Frequency tool lightweight, independent and easy to transport.

The assembled prototype has an outer diameter of 60mm. Significant further miniaturisation for future version of the tool is readily achievable.

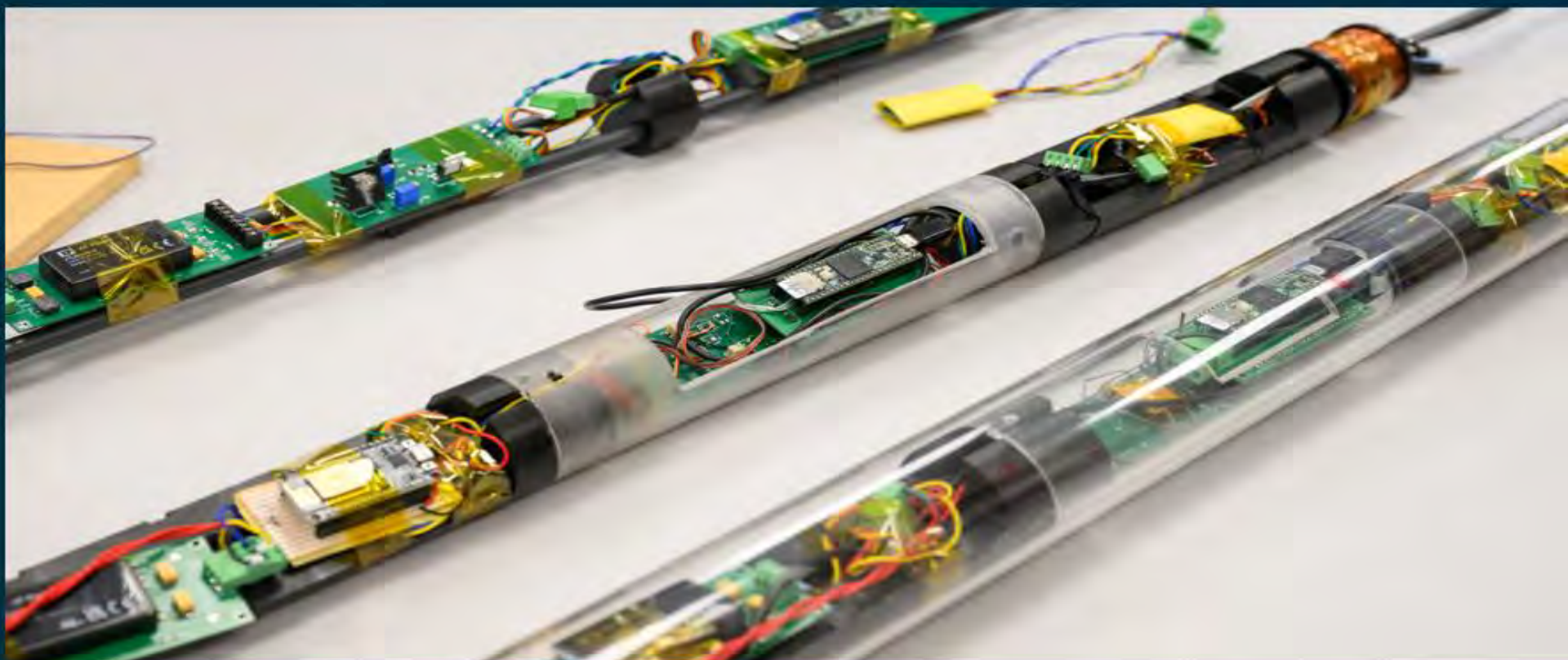
The tool will be driller deployable; either by wireline or by attachment to the drill string bottom hole assembly for logging-while-tripping applications.

Logging can be conducted in parallel with complimentary survey and geophysical logging techniques with little to no additional time penalty.

Reliable, quantified analyses

Test results and calibration of the MinEx CRC downhole swept frequency tool are underway. Several comparisons of the sensor response with conventional induction logging tool have been completed.

Ultimately standardised calibration procedures and processing methods will be provided to users to ensure accurate, precise analysis.



Prototype evolution of the downhole swept Frequency EM tool.



Rudimentary design stages of the downhole swept Frequency EM tool.

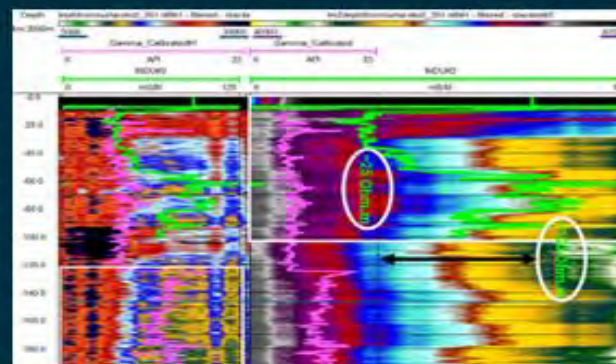


Image representations of uncalibrated data generated by the MinEx CRC swept frequency tool compared to single channel conventional gamma and induction wireline logs (the current swept frequency prototype swept frequency sensors generates 400 channels of data at each depth measurement).

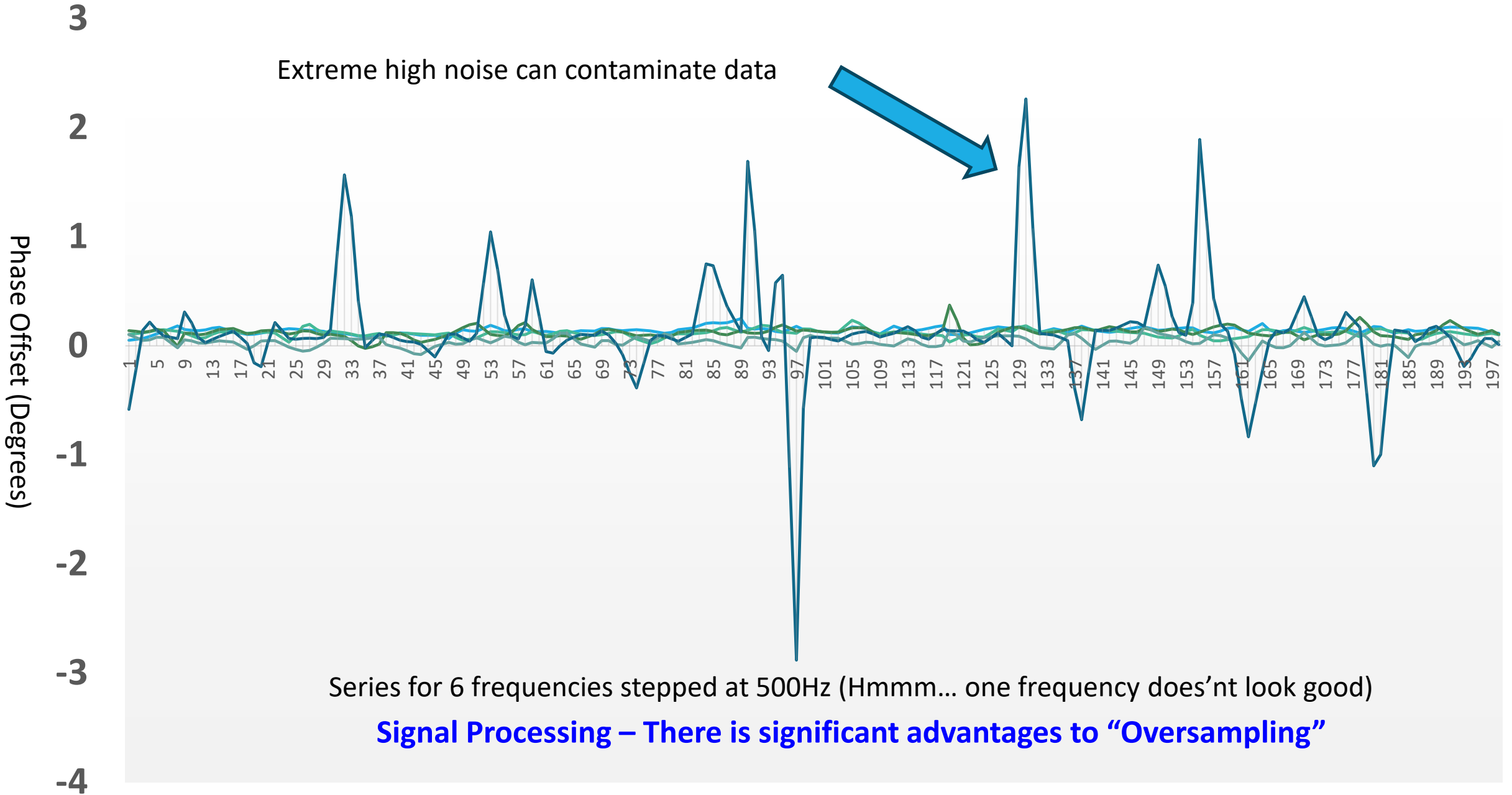
Additional Notes – For discussion only (some slides are from previous PRP meetings)

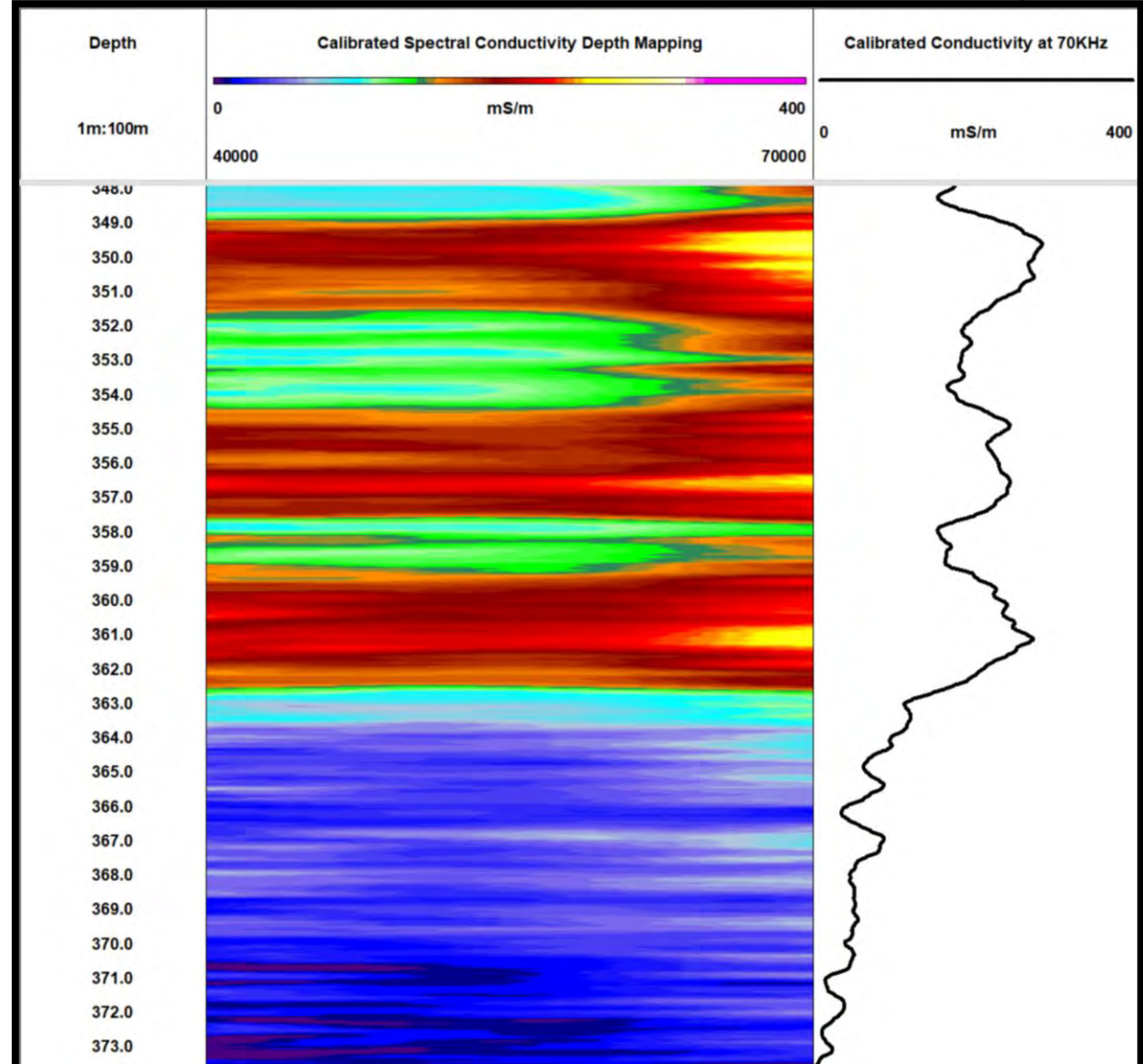
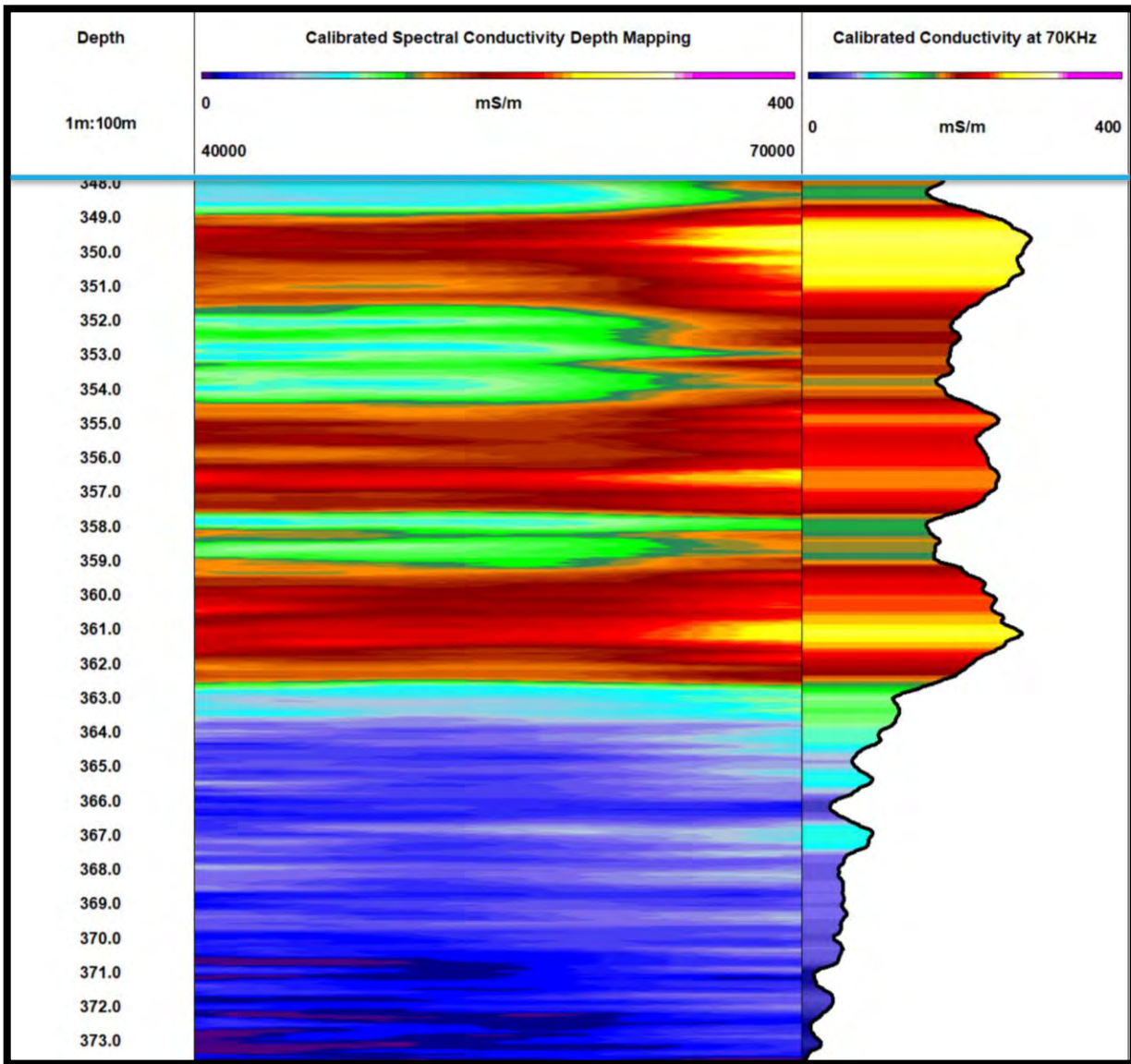
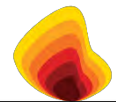
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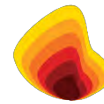
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Image redacted for reasons of commercial sensitivity







Default

Item: Logs

- (17000#1)-(17000#2)v Amp
- (70000#1)-(70000#3) - amp#1

10000

10500

11000

11500

12000

12500

13000

13500

14000

14500

15000

15500

16000

16500

17500

18000

18500

19000

19500

20000

20500

21000

21500

22000

22500

23000

23500

24000

24500

25000

25500

26000

26500

27000

27500

28000

28500

29000

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31500

32000

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36000

36500

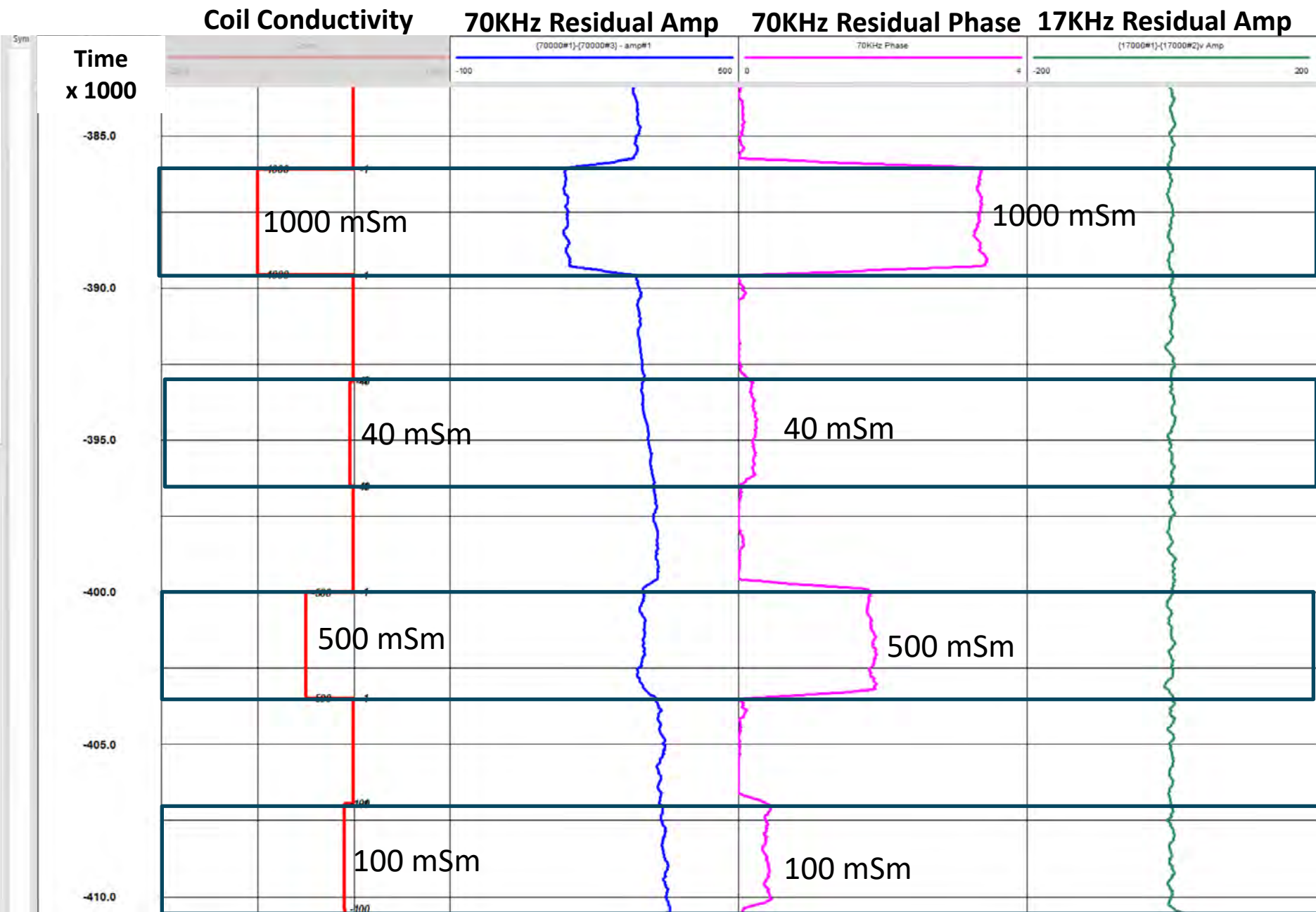
37000

37500

38000

38500

39000



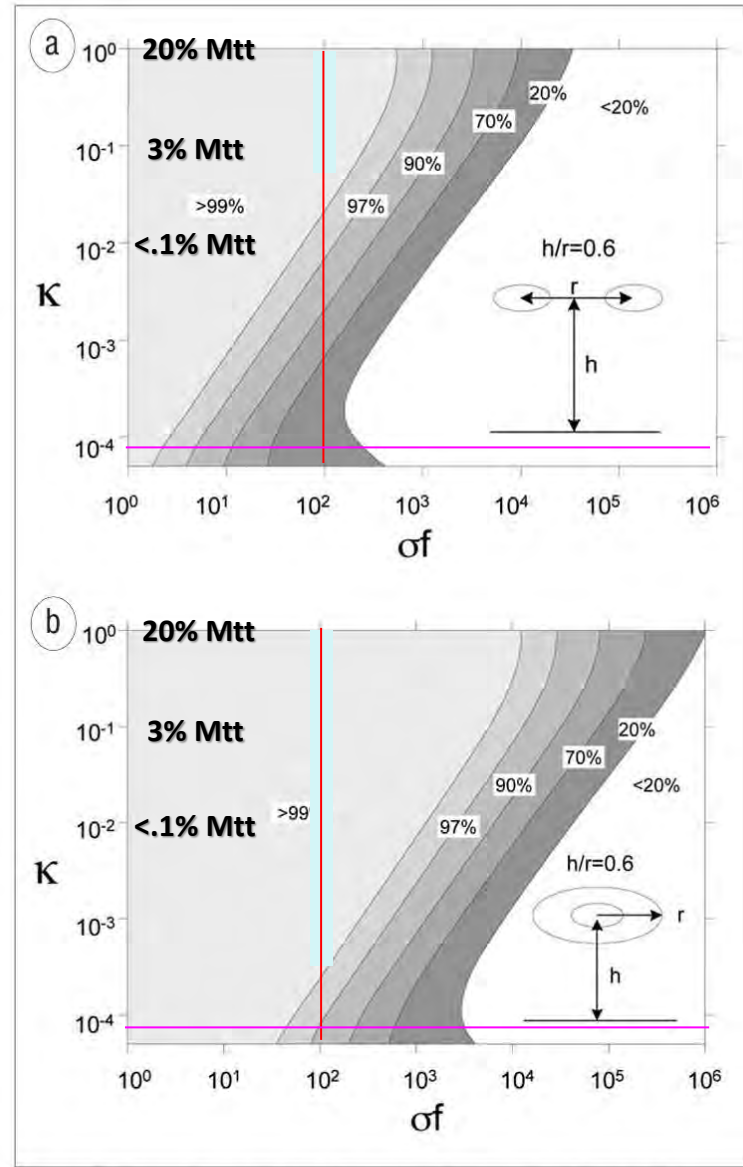
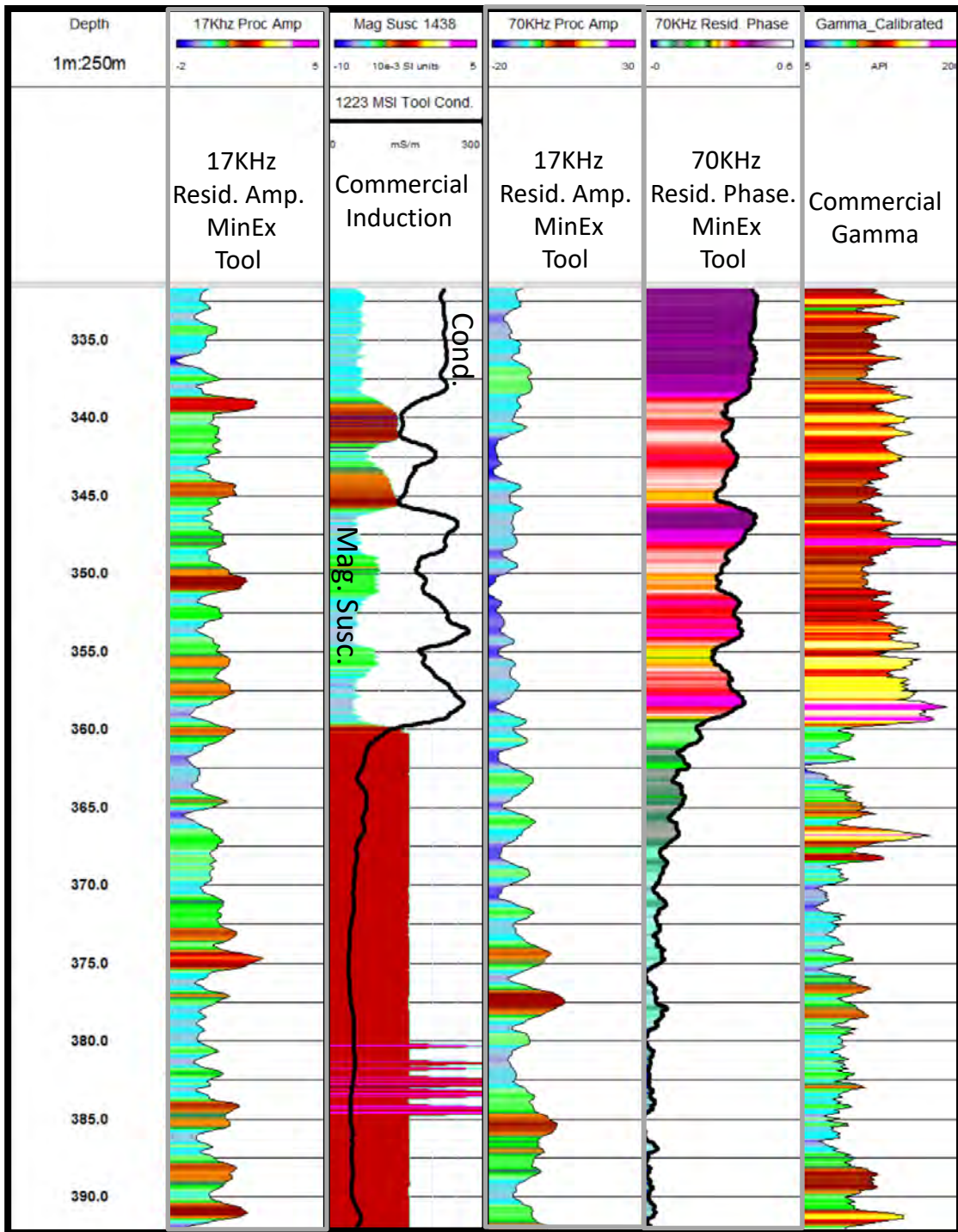


Figure 3. Percent precision of the susceptibility calculation as functions of the susceptibility κ and the product of frequency and conductivity of for (a) horizontal coplanar and (b) concentric coil configurations.

Images is modified from I. J. Won, Haoping Huang; Magnetometers and electro-magnetometers. *The Leading Edge* 2004.; 23 (5): 448-451. doi: <https://doi.org/10.1190/1.1756834>

High Mag. Susc
High Resistivity
Low Frequency

Say 0.01 mS/m
And 10000 Hz

is 100

PCT REQUEST

(Original in Electronic Form)



0	For receiving Office use only	
0-1	International Application No.	PCT/AU2024/051242
0-2	International Filing Date	22 November 2024 (22.11.2024)
0-3	Name of receiving Office and "PCT International Application"	RO/AU
0-4	Form PCT/RO/101 PCT Request	
0-4-1	Prepared Using	ePCT-Filing Version 4.14.008 MT/FOP 20241105/2.8
0-5	Petition	
	The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Australian Patent Office (RO/AU)
0-7	Applicant's or agent's file reference	205639PCT
I	Title of Invention	ELECTROMAGNETIC SURVEYING METHOD AND DEVICE
II	Applicant	
II-1	This person is	Applicant only
II-2	Applicant for	All designated States
II-4	Name	MINEX CRC LTD
II-5	Address	26 Dick Perry Avenue Kensington, Western Australia 6151 Australia
II-6	State of nationality	AU
II-7	State of residence	AU
II-10	e-mail	Natalee.taylor@imdexlimited.com
II-10(a)	E-mail authorization The receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority are authorized to use this e-mail address, if the Office or Authority so wishes, to send notifications issued in respect of this international application:	exclusively in electronic form (no paper notifications will be sent)

Revised patent Submitted

Thanks Nat

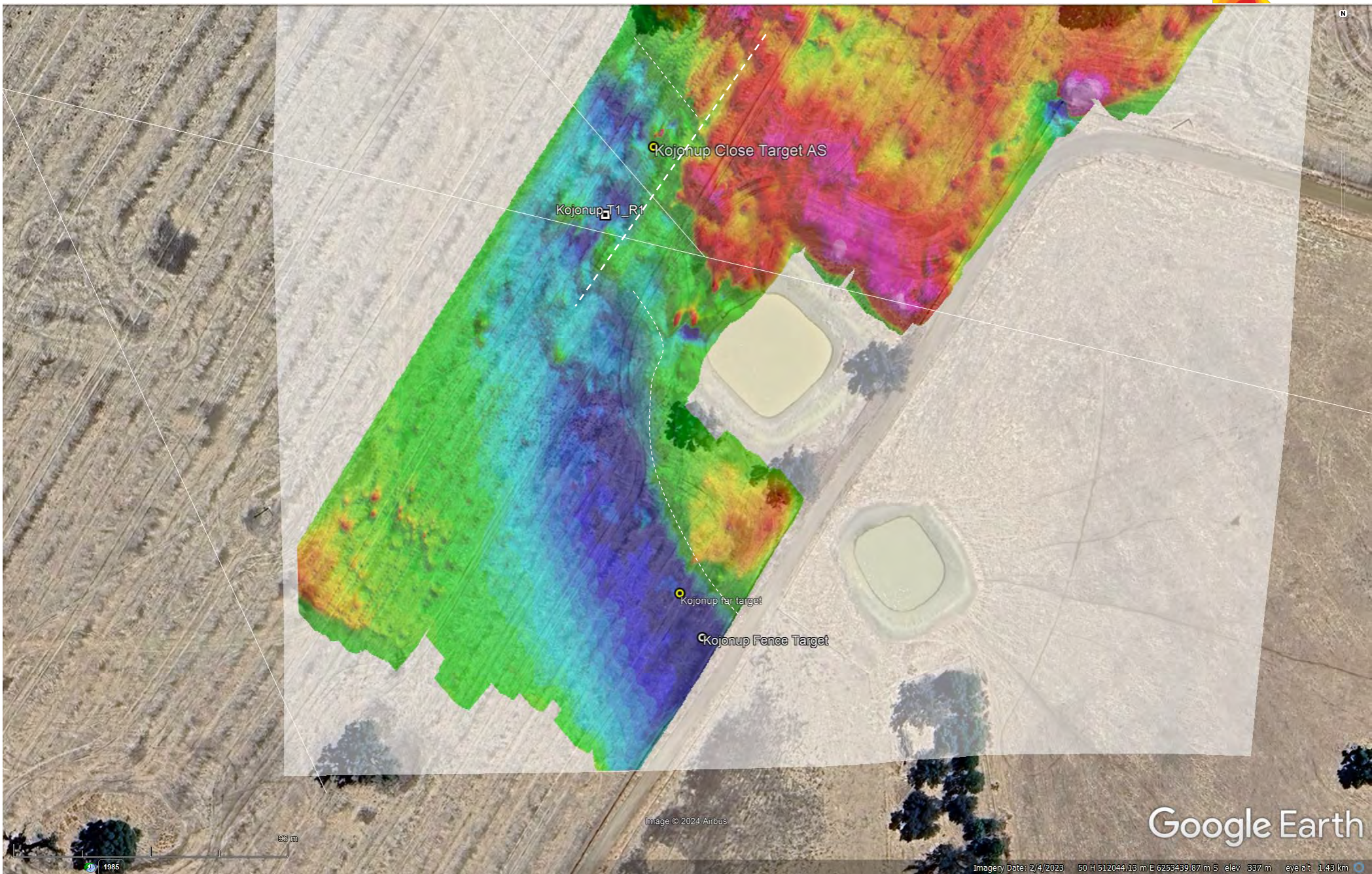
Quite a few improvements



Two 100m deep Holes
100m PVC -- Intersecting a Dolerite Dyke + Fractures

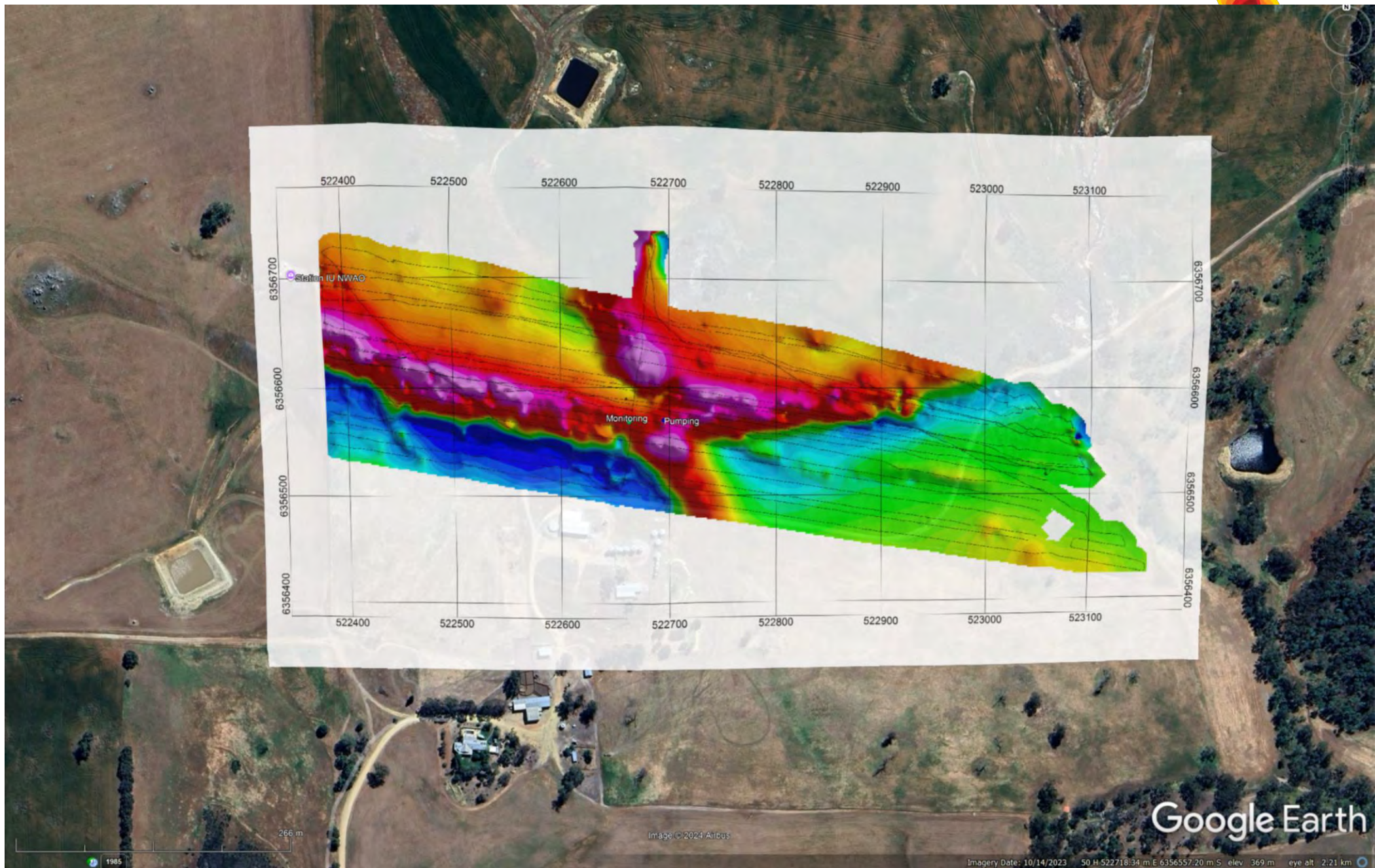


Two 100m deep Holes
100m PVC -- Intersecting a Dolerite Dyke + Fractures





Two 100m deep Holes
100m PVC -- Intersecting a Dolerite Dyke + Fractures



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TDEM

Strategy for TDEM – Reduce Risk – Save Time

Three Systems are being developed Simultaneously

Performance or Form Factor ????

Answer is Both

This is the most efficient way to proceed

Everything in parallel test with coils → then build the version 4 as close to perfect as possible.

Lab Only

Testing

VERSION 1

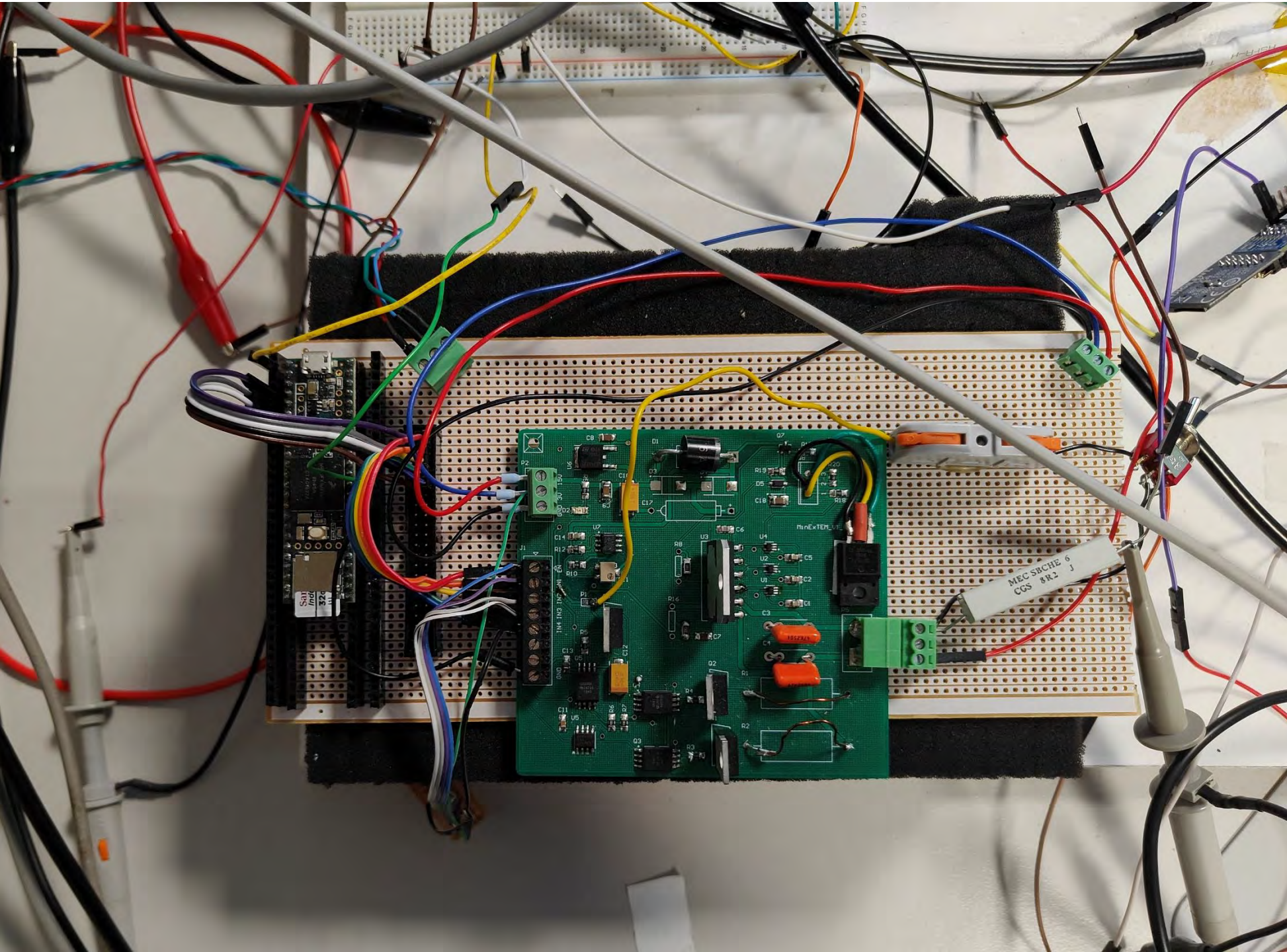


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Discussion Please

Future problems or risks that may delay or change in milestones:

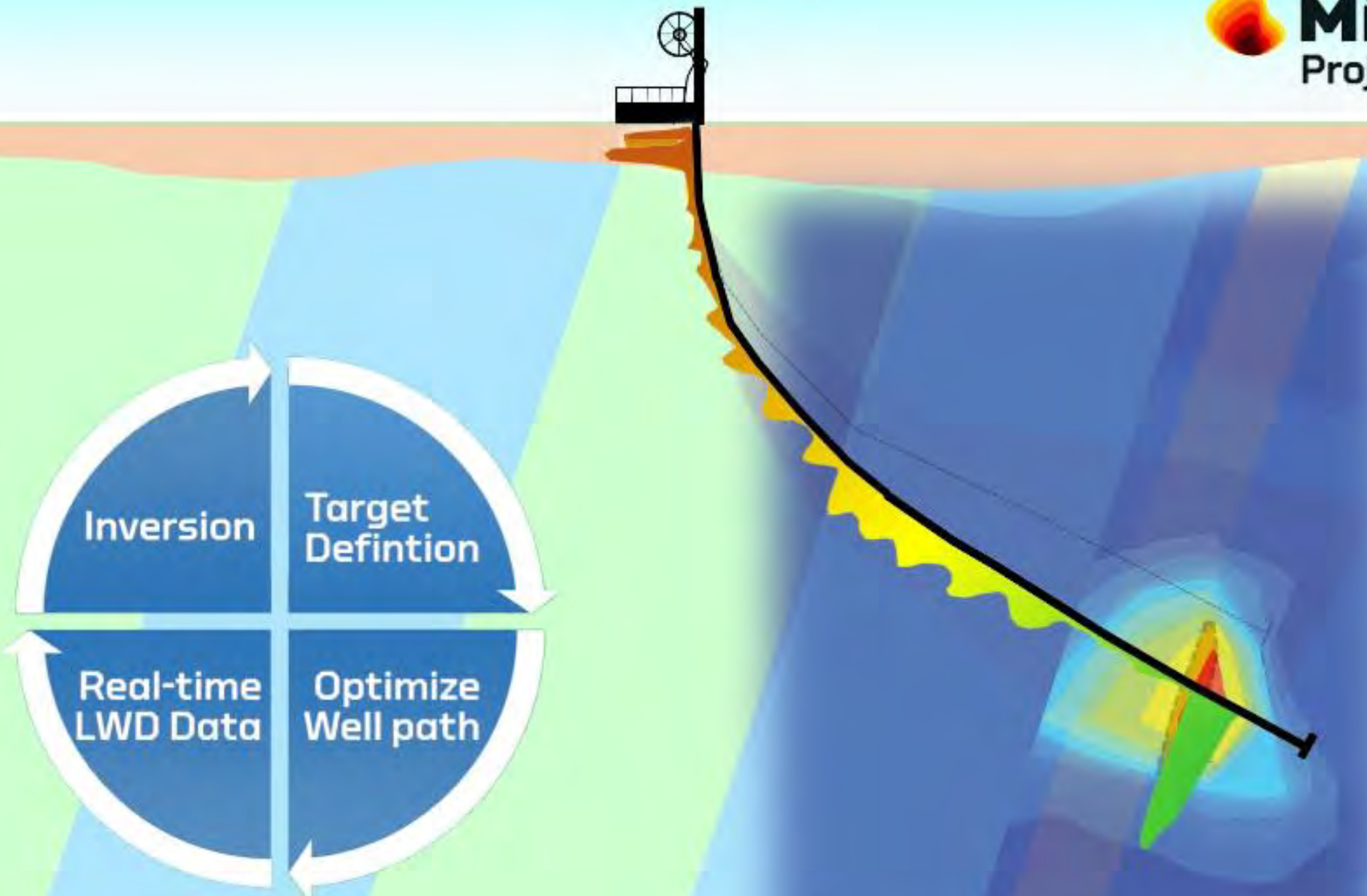
Question, concerns, feedback by Panel and final comments:

Dates for next meeting (second week in July)

Annual conference ?

Image redacted for reasons of commercial sensitivity

Summary Diagram





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