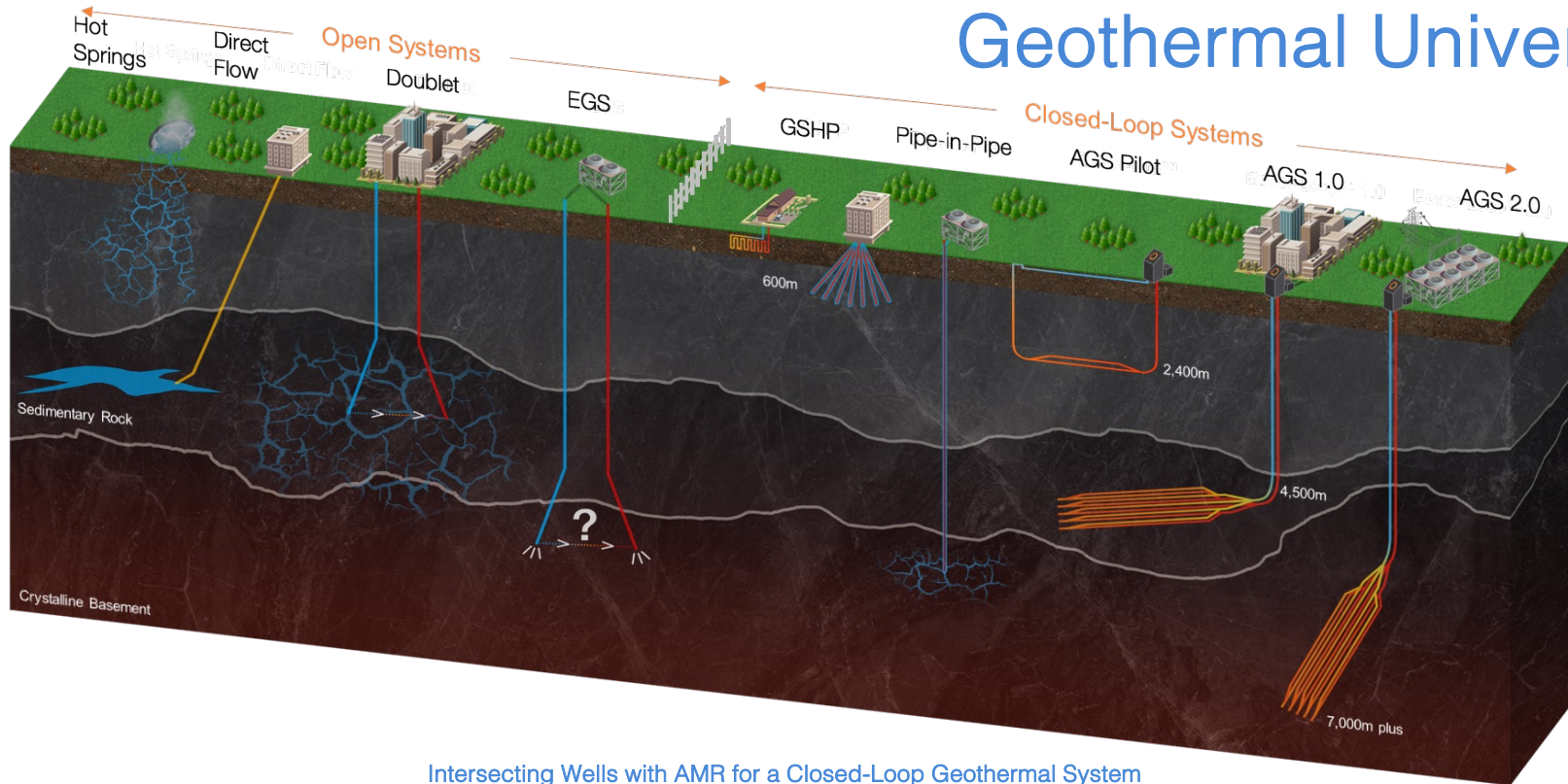




Intersecting Wells with AMR for a Closed-Loop Geothermal System

Ken Miller – Erdos Miller, Alex Vetsak – Eavor Technologies
Clinton Moss – Gunnar Energy Services, Ross Lowden - SLB

Geothermal Universe

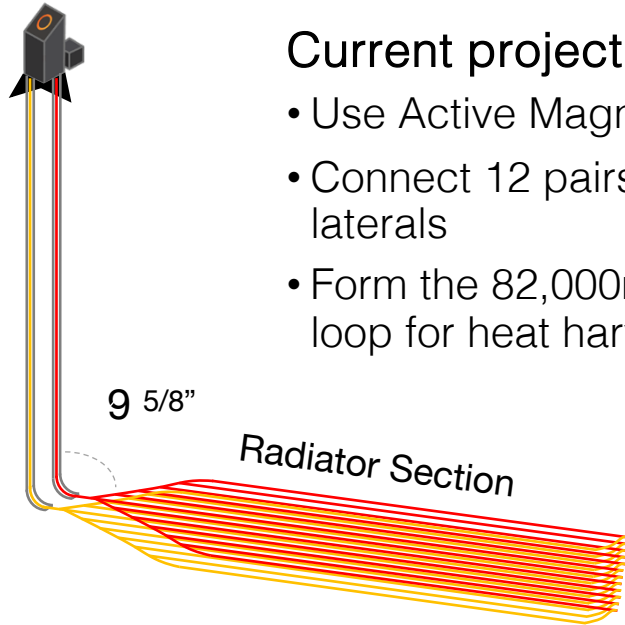


Intersecting Wells with AMR for a Closed-Loop Geothermal System

Closed-Loop Geothermal Well

Current project in Germany:

- Use Active Magnetic Ranging
- Connect 12 pairs of 3,000m laterals
- Form the 82,000m closed lateral loop for heat harvesting



Closed System

No need for permeable aquifer

Driven by natural thermosiphon, no pumping required

No fracking required, no induced seismicity

No GHGs or CO₂

Minimal continual water use, no brine production

OPEX is ~80% less than traditional geothermal

Low thermal output risk or uncertainty

Project cycle time 3 to 5 years

Baseload and Dispatchable



Wellbore geometry and placement challenges

8km MD

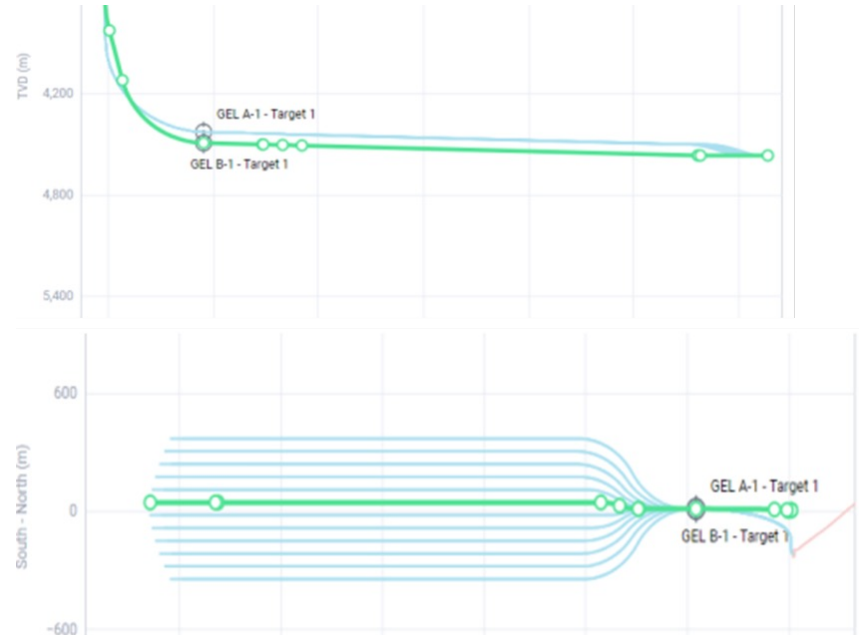
4.5k TVD

62/65m TVD/Lateral separation

Surveying tool limits

Ranging limits

Following the target well





AMR solutions in Germany

Short-range (near-bit) and long-range magnet tools in the BHA.

Parallel drilling with AMR checks along tangent sections.

Unique solution to intersect two wells with the motorized RSS BHA.

Gyro-MWD and survey corrections in laterals to reduce the EOU.

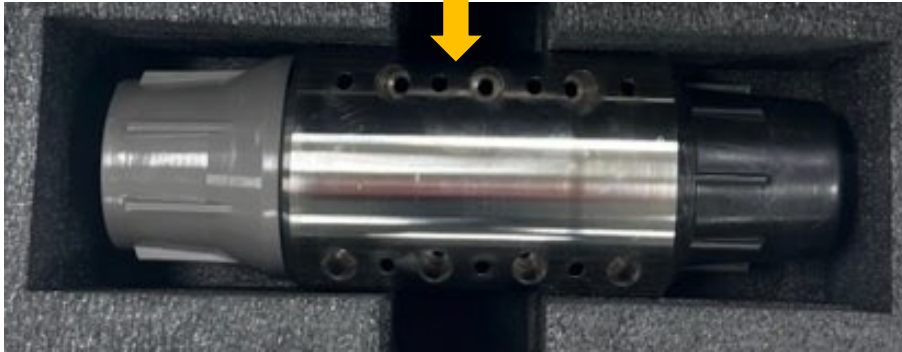
Pump down wireline-conveyed AMR sensors.

Customized ranging algorithms and procedures.

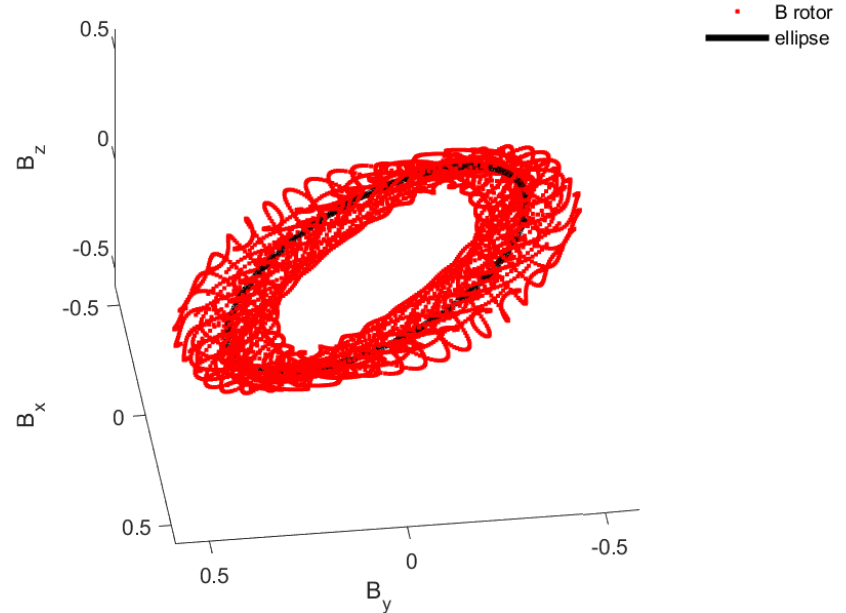
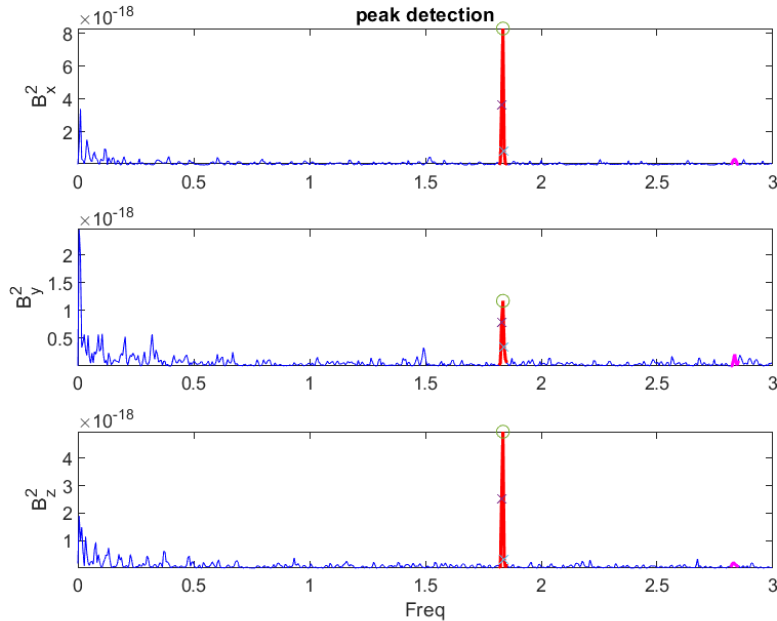
Rotating magnet subs in Germany

Long-range parallel drilling up to 100m DoD

Intersection with a near-bit RSS-integrated sub.



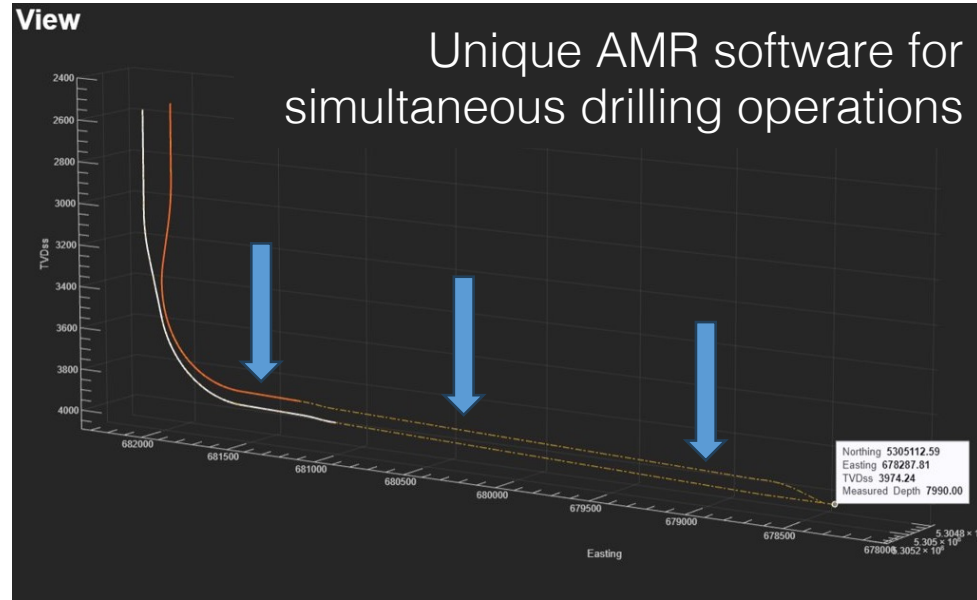
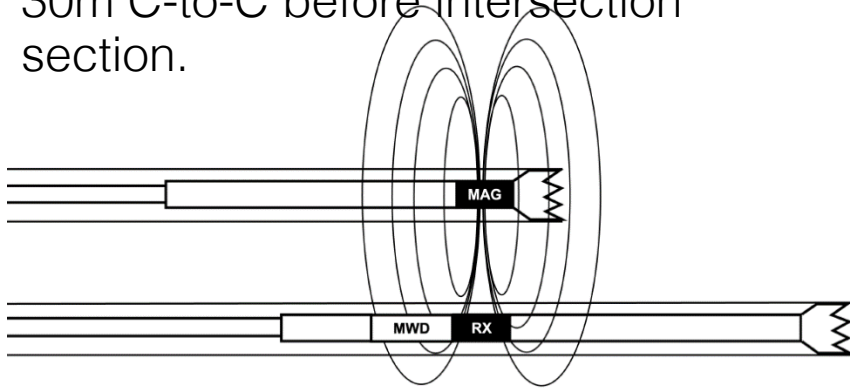
Long-range parallel drilling up to 100m DoD



Parallel drilling with AMR along tangent sections

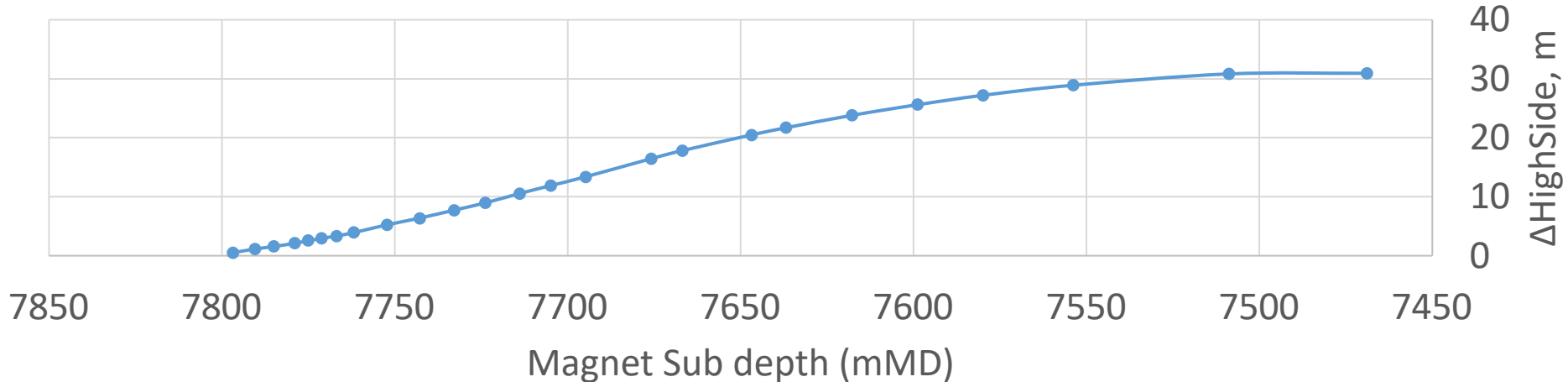
100m Depth of Detection after landing.

30m C-to-C before intersection section.

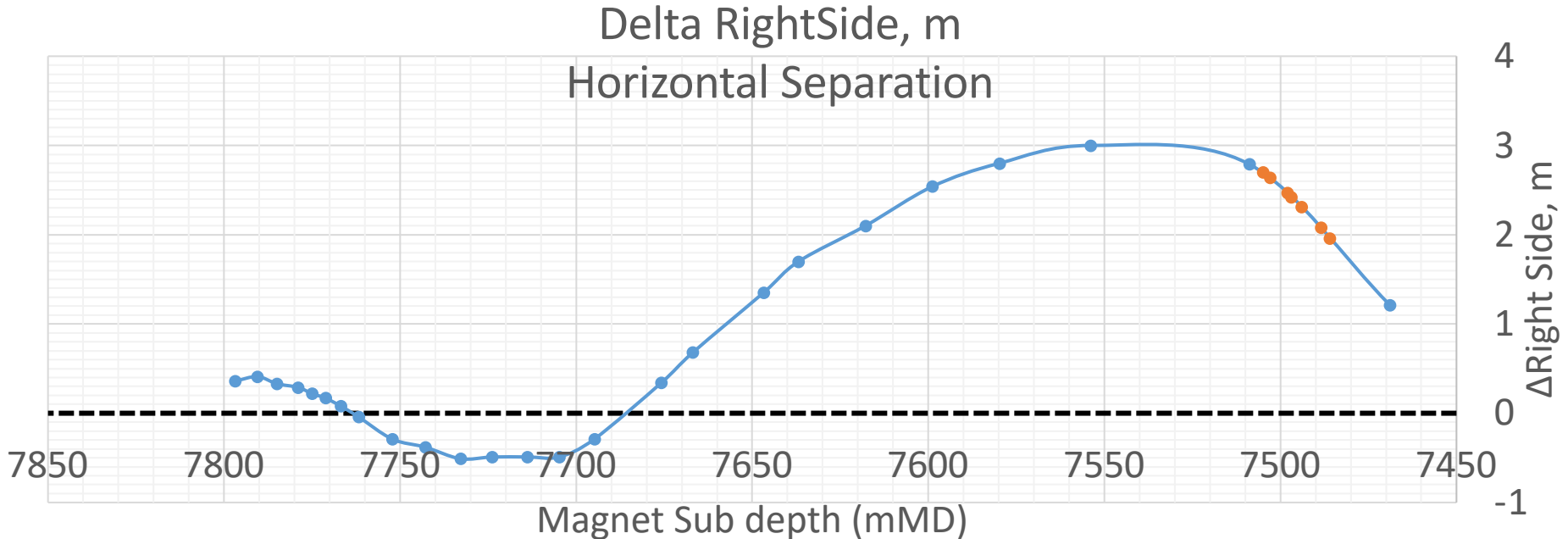


Intersecting with AMR surveys at 7450-7800m MD

Delta HighSide, m
Vertical Separation



Intersecting with AMR surveys at 7450-7800m MD



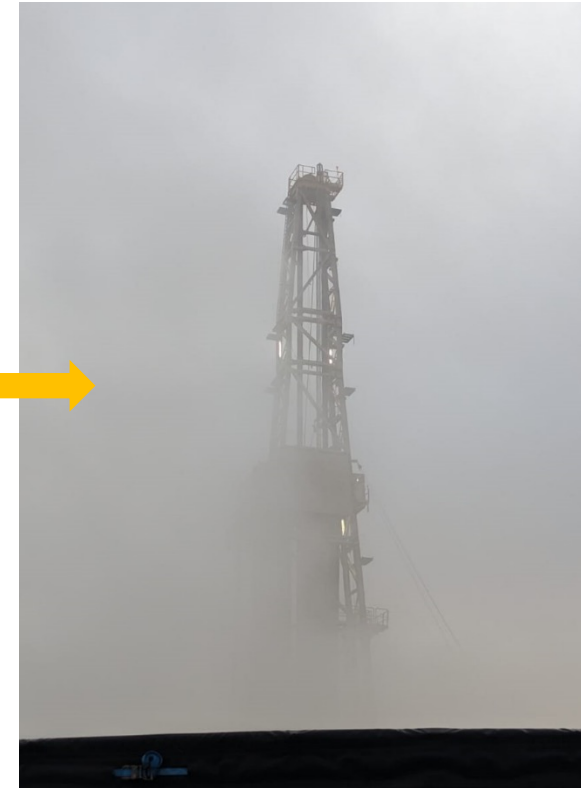
Results

1st-attempt intersection of two horizontal wells with AMR at 7,805m MD / 4,633m TVD.

Instantaneous hydraulic communication between two wells with hot fluid circulation due to a thermosyphon effect.

Coordinated teamwork of two rig crews and services.

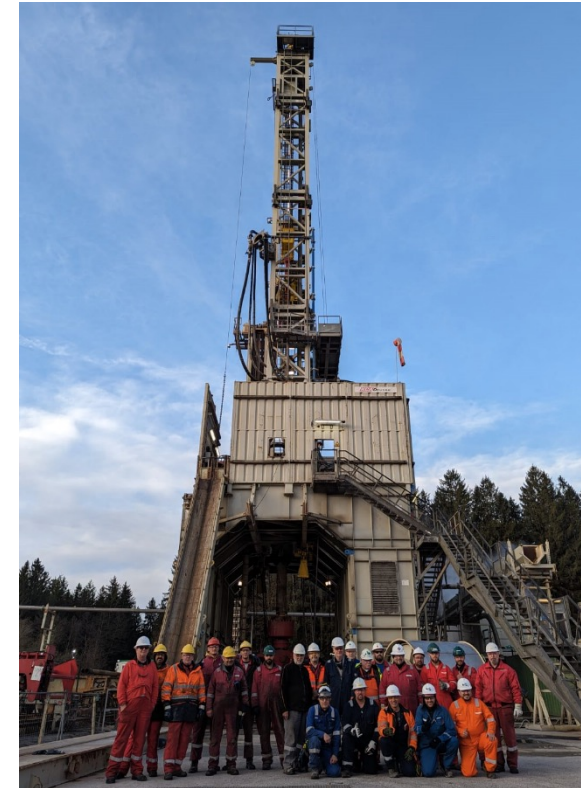
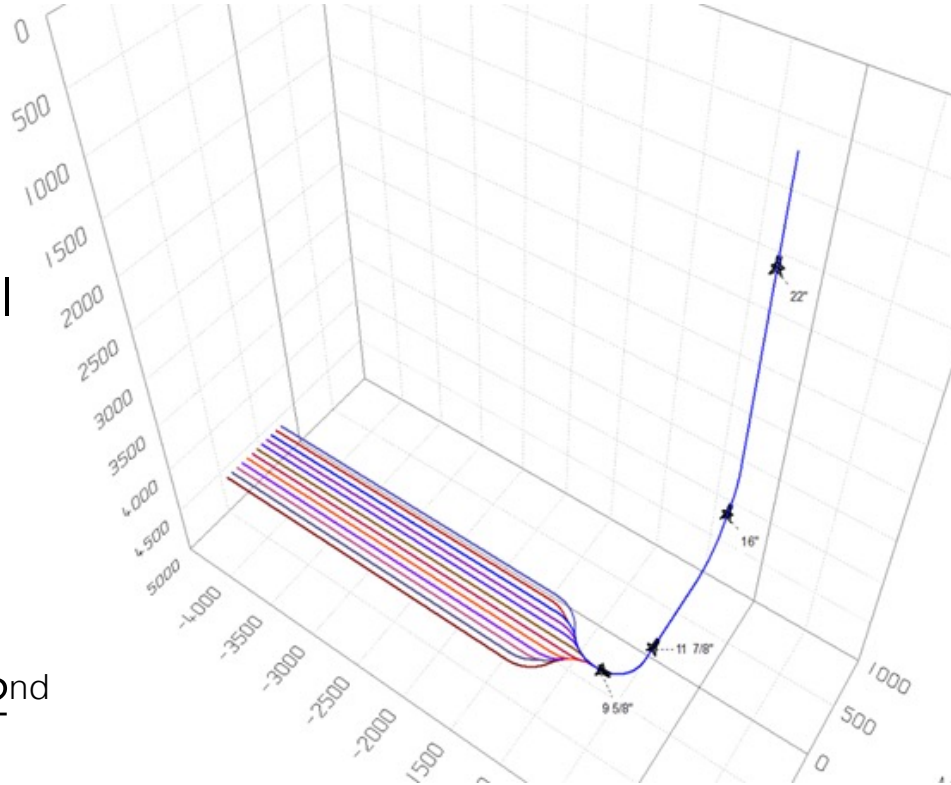
Lessons learned for AMR operations in multi-lateral wells.



Results

The 1st lateral loop is finished.

Currently drilling and ranging the 2nd lateral loop.



Next steps in AMR

Deploy a collar-mounted sensor as a part of the drilling BHA, to replace a wireline-conveyed sensor.

Prototypes manufactured and tested, in partnership with Gunnar Energy Services, Erdos Miller, SLB.

Enhanced downhole processing capacity of raw magnetometer and accelerator data sets.

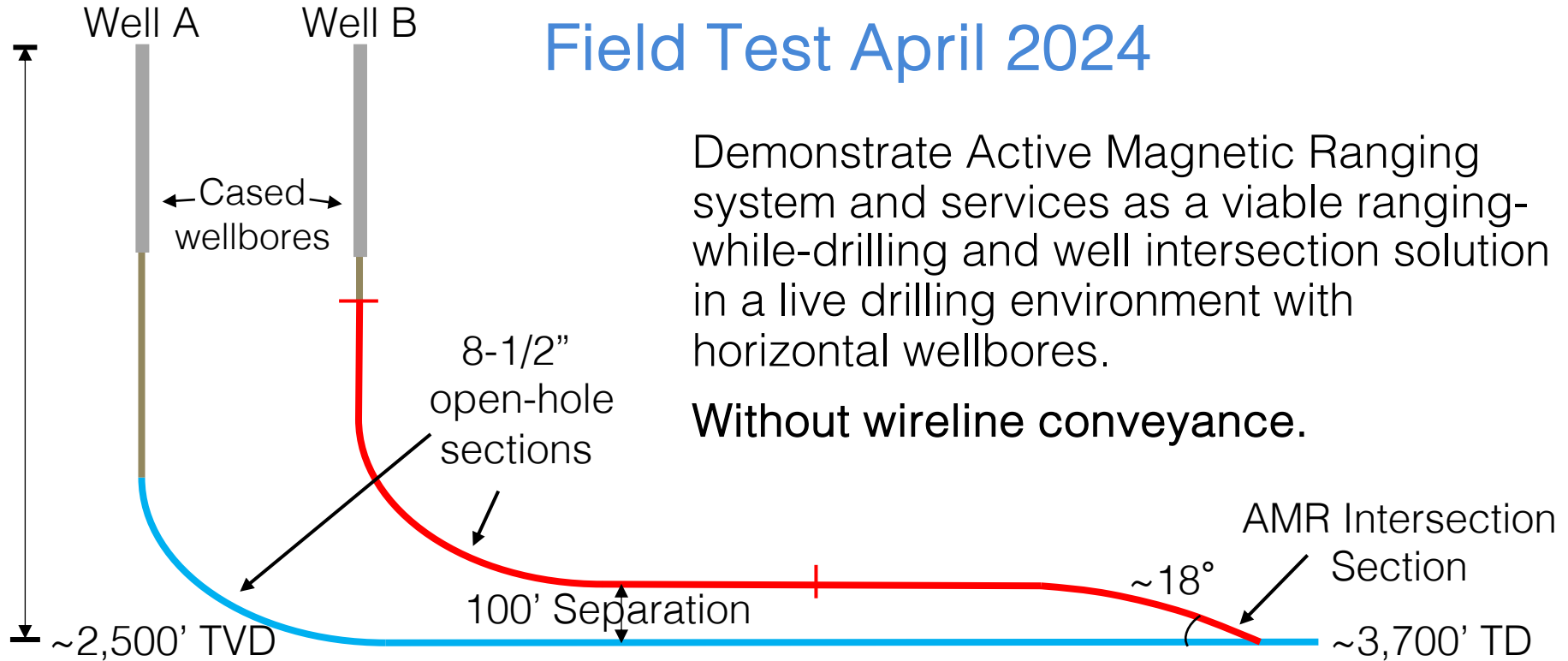
Improved active magnetic ranging algorithms for trajectory optimization of two wells in real-time.



Field Test April 2024

Demonstrate Active Magnetic Ranging system and services as a viable ranging-while-drilling and well intersection solution in a live drilling environment with horizontal wellbores.

Without wireline conveyance.



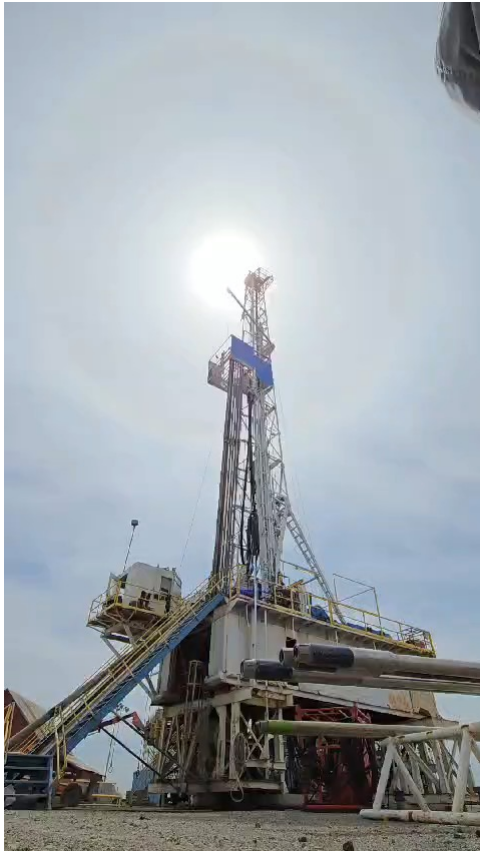


Field Test April 2024

In partnership with:  **Eavor**[™]



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Questions?

