Artificial Lift R&D Council

Rod pump monitoring and optimization:
New physics for today's problems

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Agenda

- Objectives and goals
- System presentation
- Case studies
  - Horizontal well slug flow control
  - Diagnosis using high resolution water leg monitoring
  - Virtual test battery and flow meter
- Conclusion

Objectives and goals

- Show the benefits of high-resolution field-wide monitoring, control and optimization
- Streamlining SCADA through widespread IoT
- Augment traditional dynacard approach with novel sensing
- Deploy real-time AI for analysing large streams of high-resolution sensor feeds

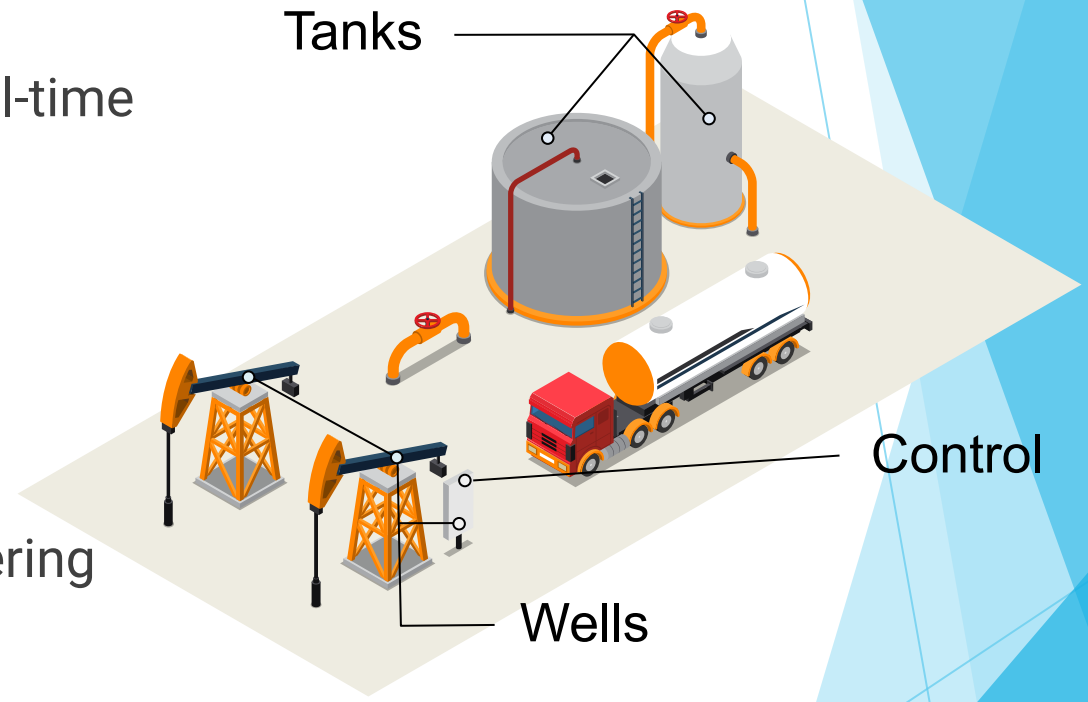
Initial target: large stripper fields

Market conditions accelerating adoption of automation

- **Lower oil prices in recent history** mean producers are still **focused on running leaner operations**
- **Higher and more stable oil prices** encourage adoption of new technologies in the field
- **Tighter regulations** tend to enforce new monitoring requirements and better practices
- With a stronger focus on ESG topics than ever before, **the industry's environmental footprint has to be continuously reduced**, especially gas emissions and liquid leaks

Our approach: A field wide solution

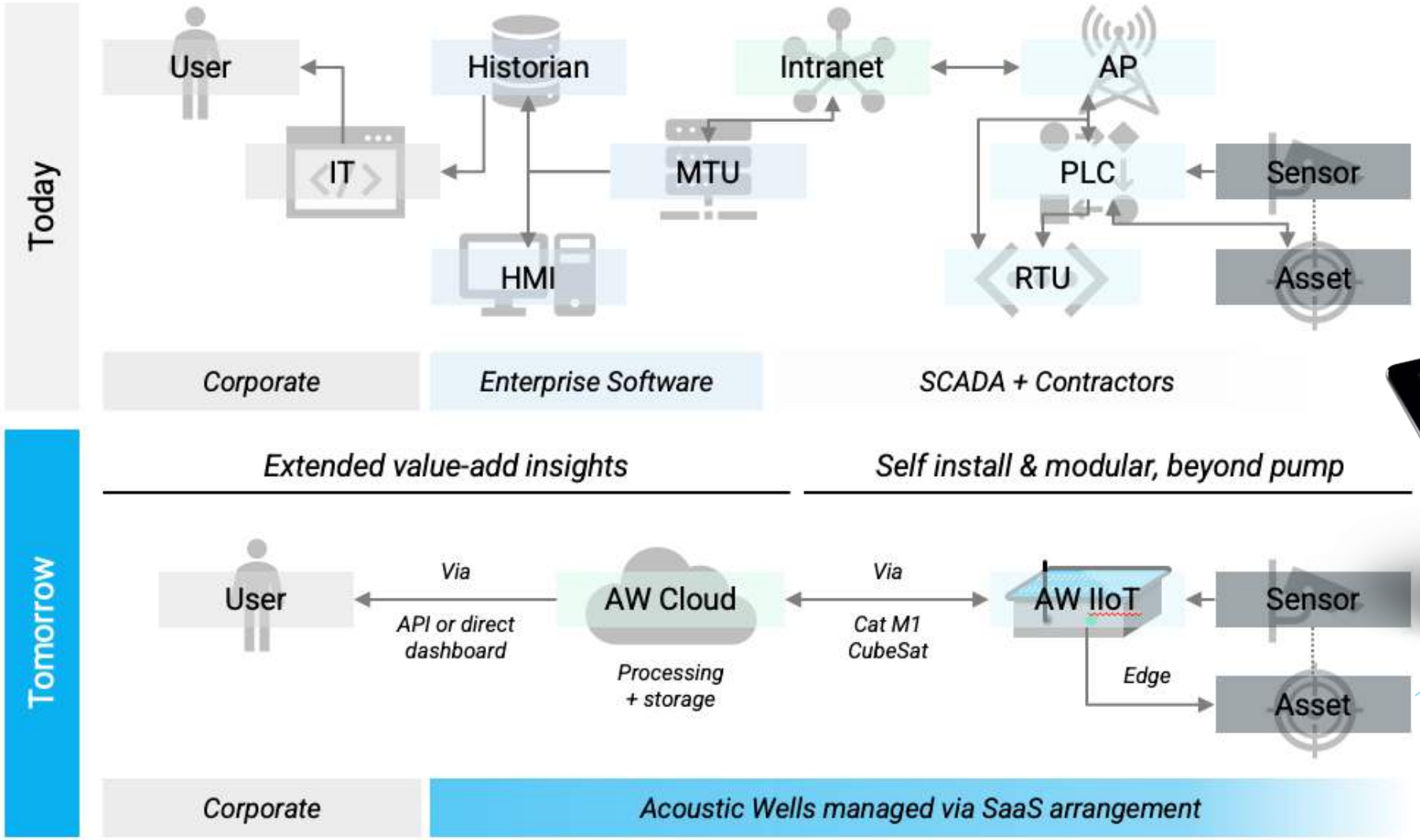
- **Upstream**
  - Underground pump monitoring and real-time optimization
  - Pumpjack surface issue detection
- **Midstream**
  - Tank monitoring & leak detection
  - Production allocation/virtual flow metering
- **Control**
  - Well runtime adjustments and automatic fail-safes
  - Routing and workflow optimization



System presentation: IoT for all

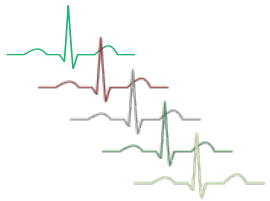
- **Bringing stripper fields into the 21st century**
- **No infrastructure required for telemetry**
  - New long range 5G network
  - High resolution 100Hz data 24/7
- **Lowering sensor and automation cost**
  - New, affordable sensor technologies
  - Fully wireless with years of battery life
  - Everything is recorded simultaneously: Rod load, current, vibration, acoustics, pressures,…
- **AI in the cloud and on the edge**

High quality data collection, made simple



Advanced signal processing of sensor feeds

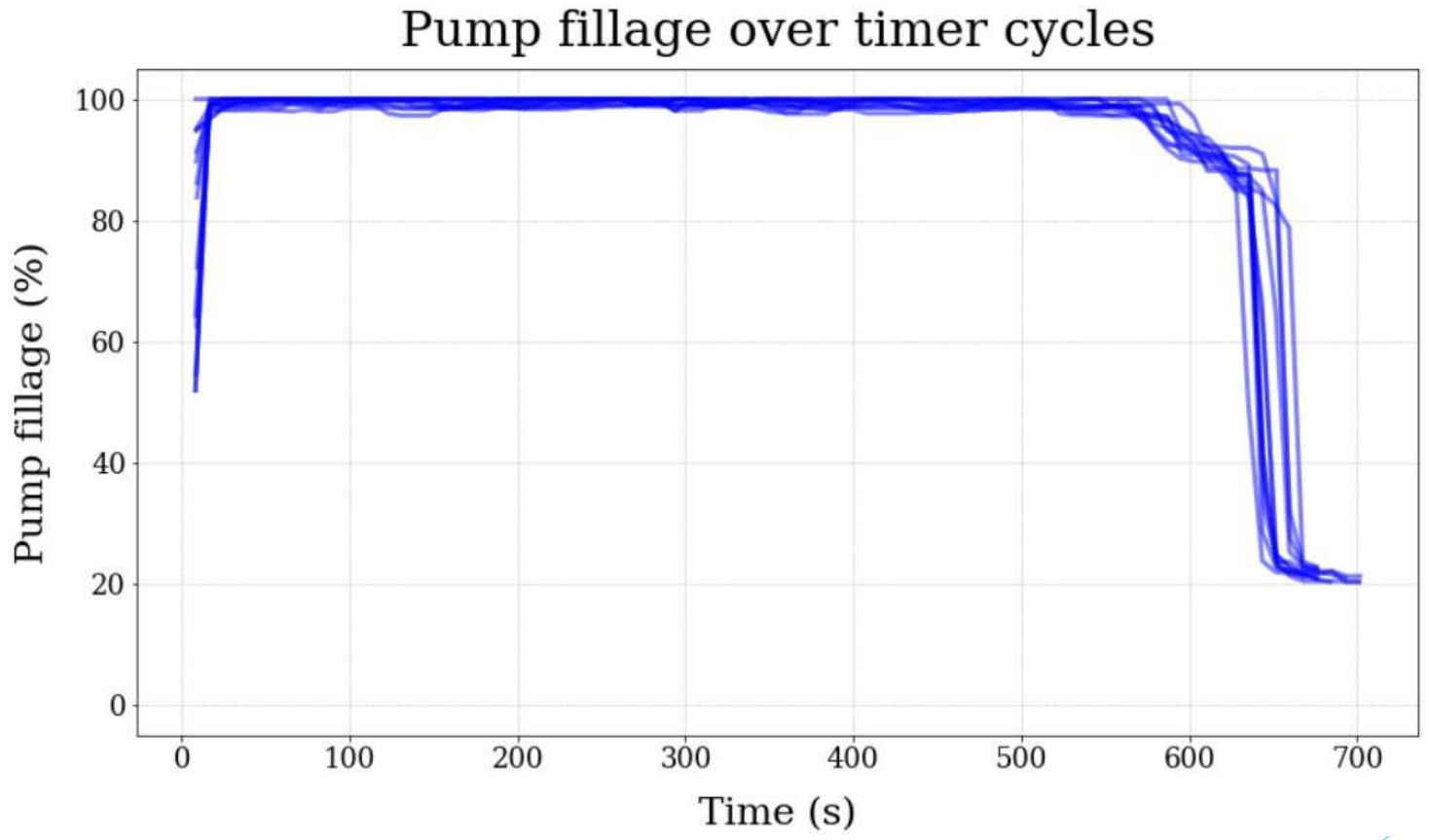
- High res signals require significant processing
- AI analyses every individual stroke on 10+ signals simultaneously!



Input data: Vibration, position, Rod load, motor Volts & Amps, Tub/Cas pressure, tanks level,…

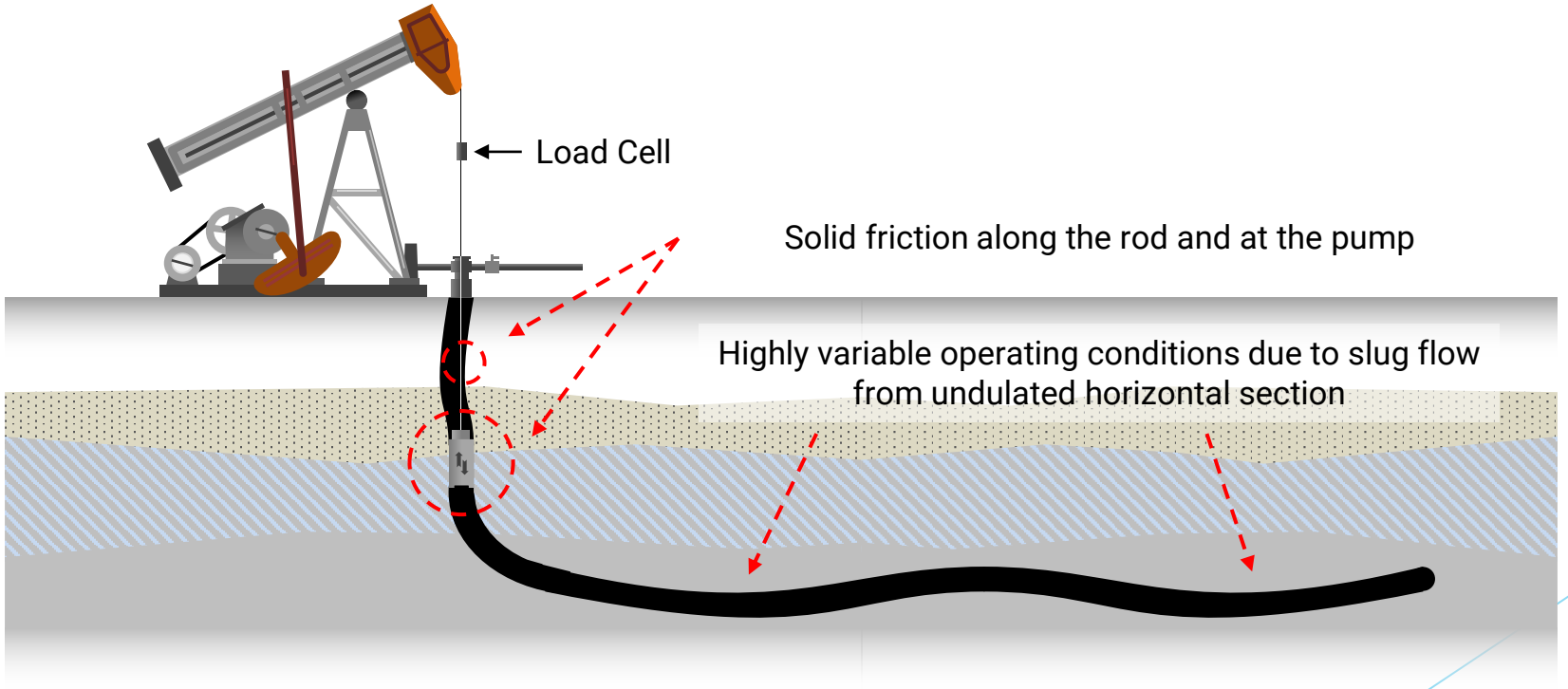
Stroke-by-stroke fillage analysis

- AI processes continuous signals (pump card included) and identify well pump-off condition while optimizing runtime
- Backbone of active control algorithms



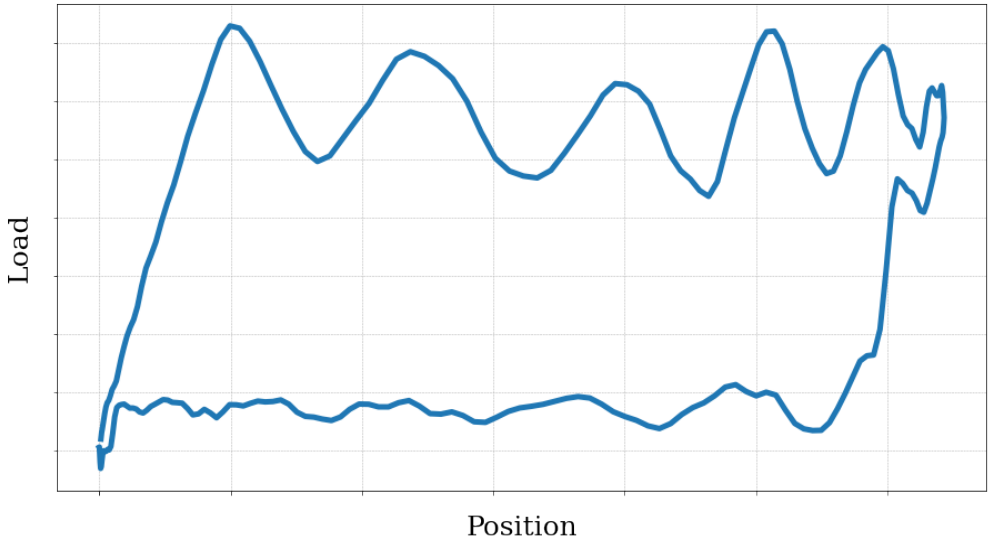
Case study 1: Slug flow in horizontal wells

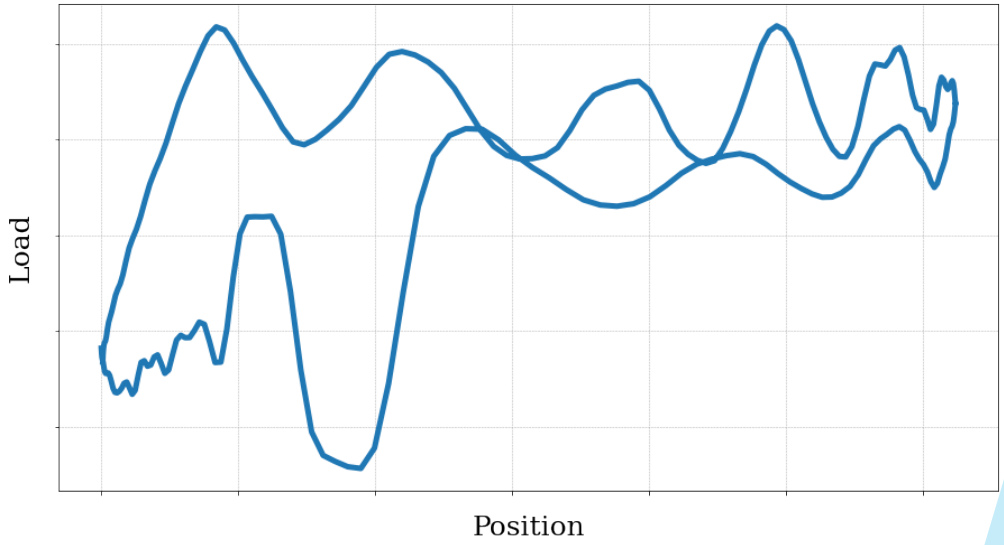
- Dynamic problem difficult to diagnose on the field with traditional tools
  - Pumper: ”One day the well is pumping fine and the next the pump is empty”
- Difficult to know the well’s true potential output



Case study 1: Slug flow in horizontal wells

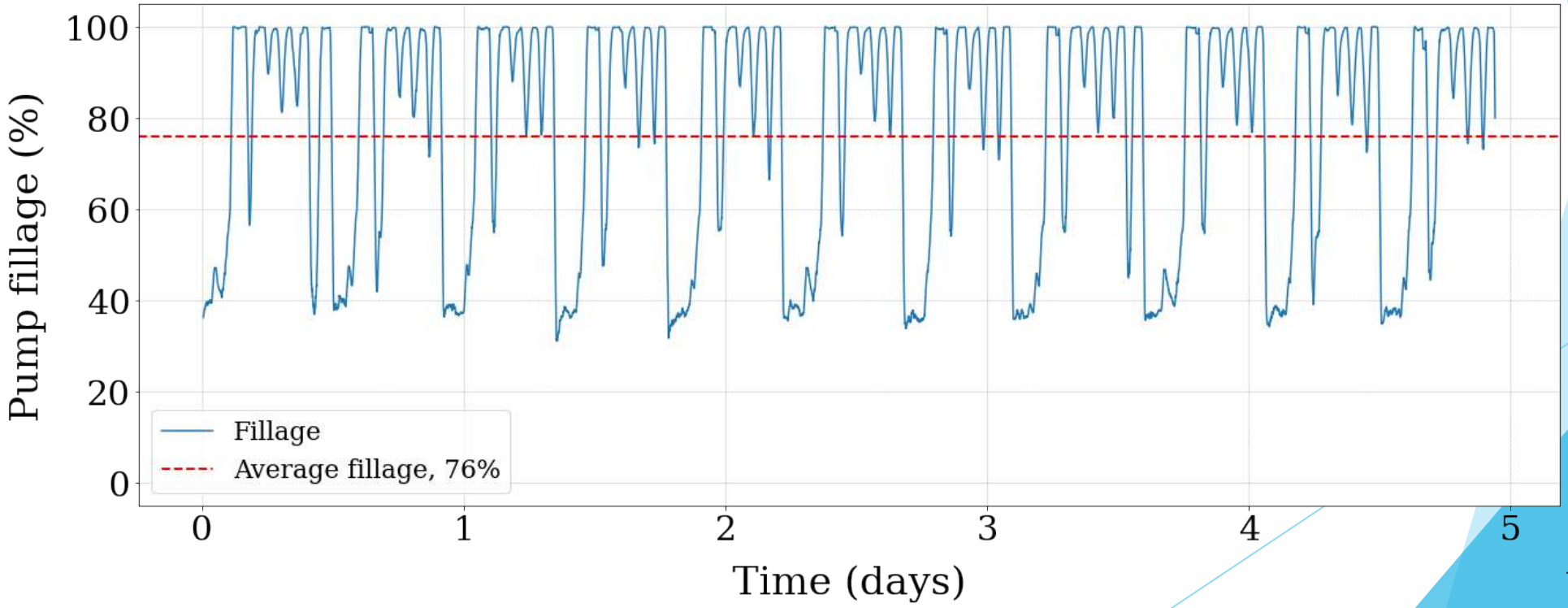
- Cards are all over the place, 100% fillage to 40%
- **Traditional controller confused**



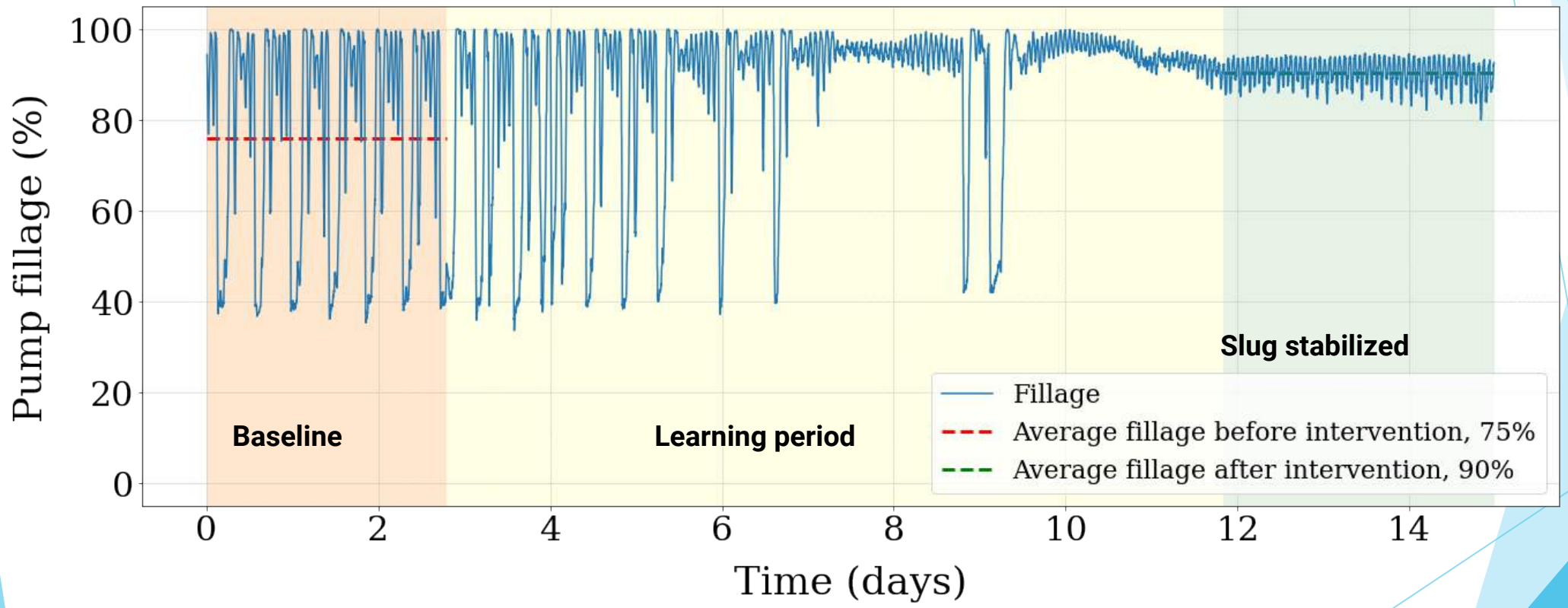


Case study 1: Slugging damages the well

- Average pump fillage appears reasonable, but actual fillage range is huge!
- **50% of runtime is with <60% gas in pump!**
- Gas pounding well



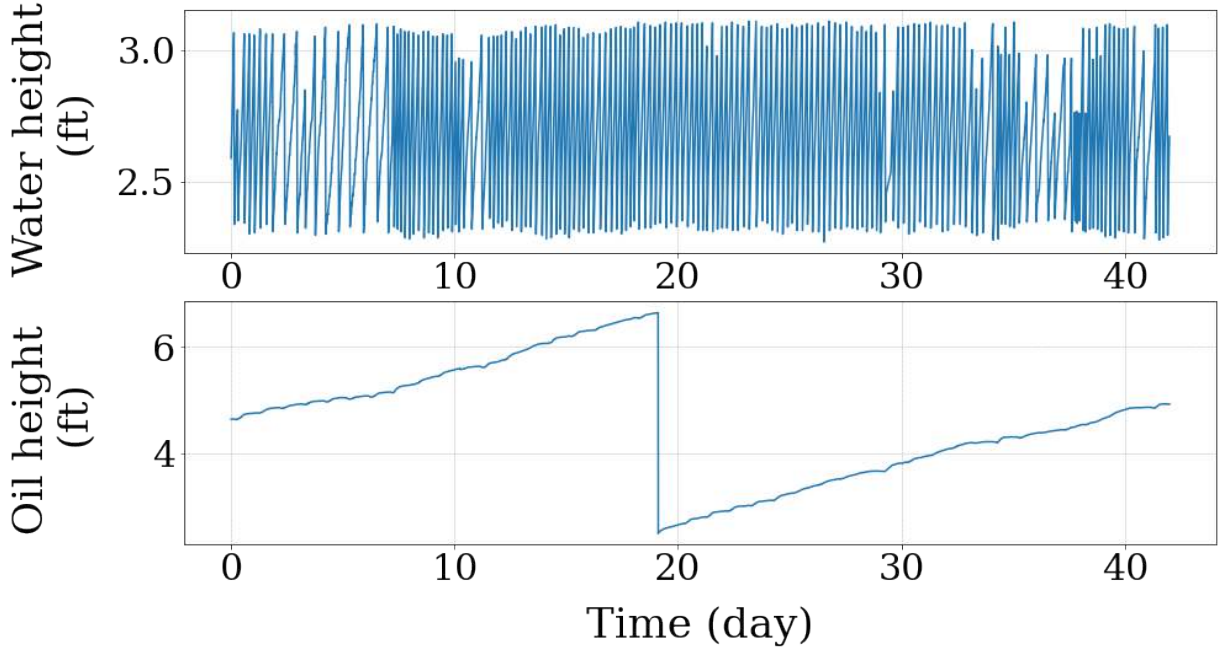
Case study 1: Slugging stabilized with the smart controller



Strokes reduced by 30%, production unchanged!

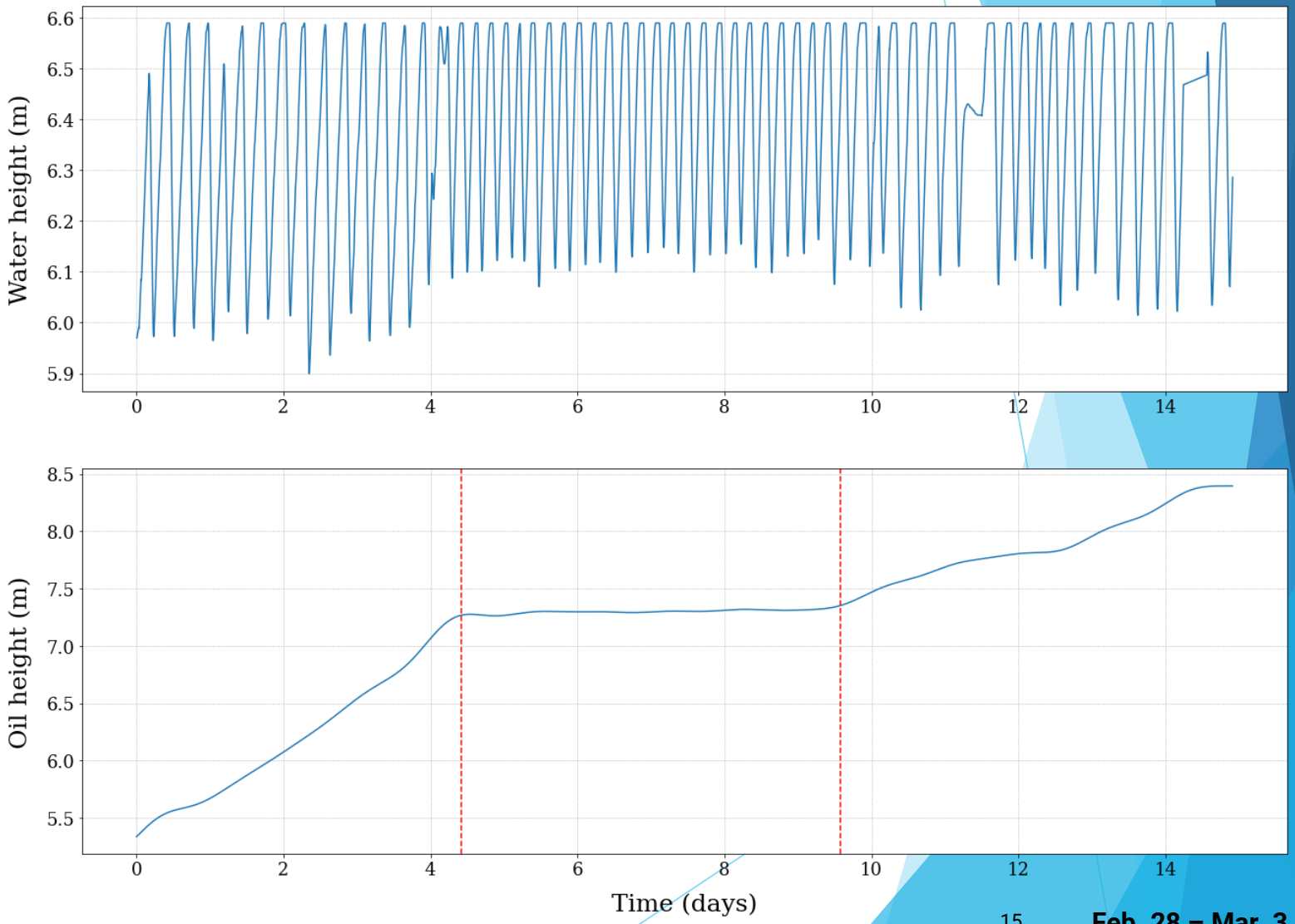
Case study 2: High resolution monitoring of oil AND water leg

- Water leg is 90% of flow yet not accurately measured
- Water is most of LOE including electricity cost to move
- Raw data is unreadable by a human
- **System uses controller information AND tank measurements**



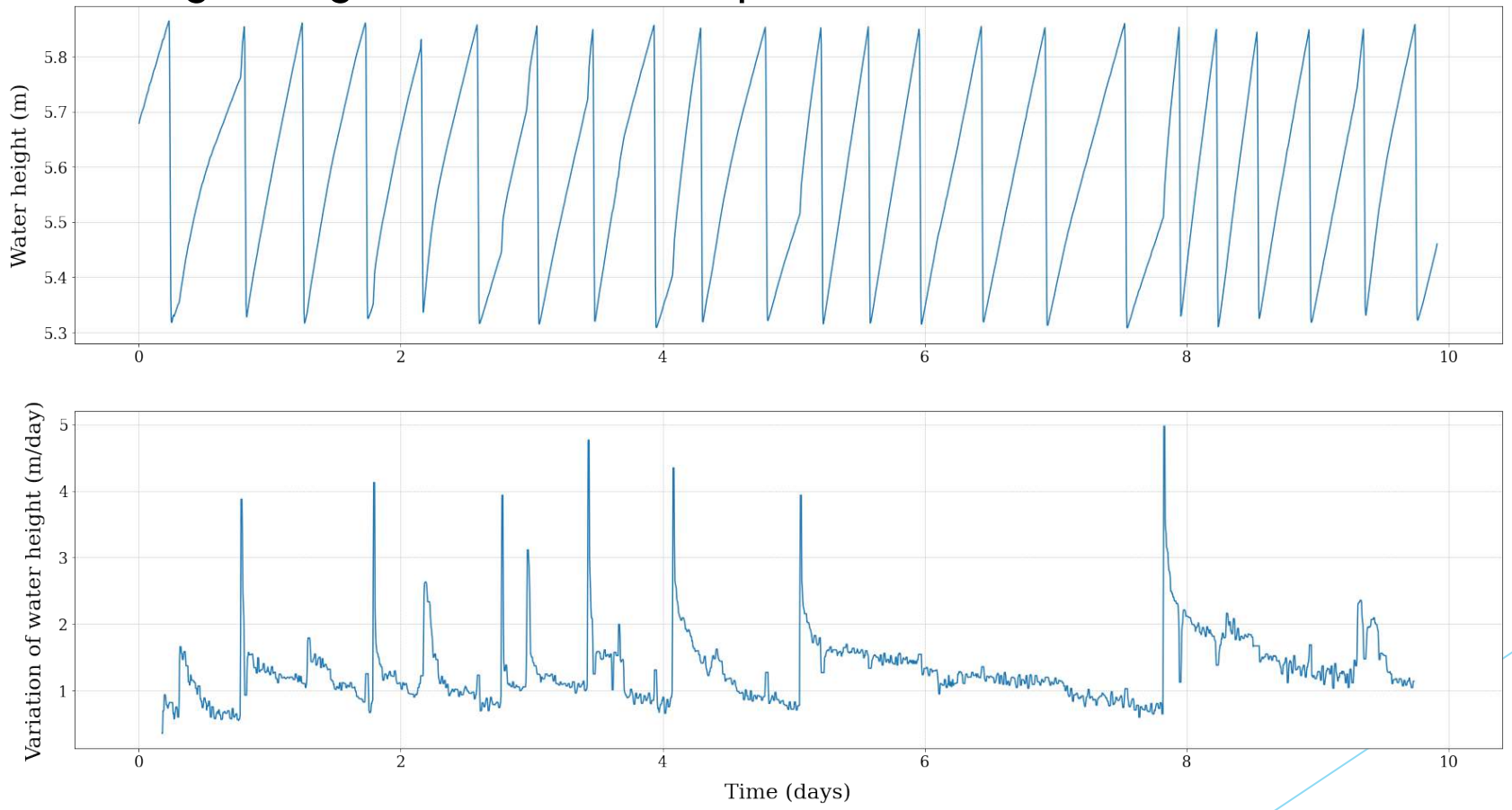
Case study 2a: Detection of abnormal conditions

- Oil production collapses
- Water production unaffected
- Alert for operator
- **Casing leak diagnosis**



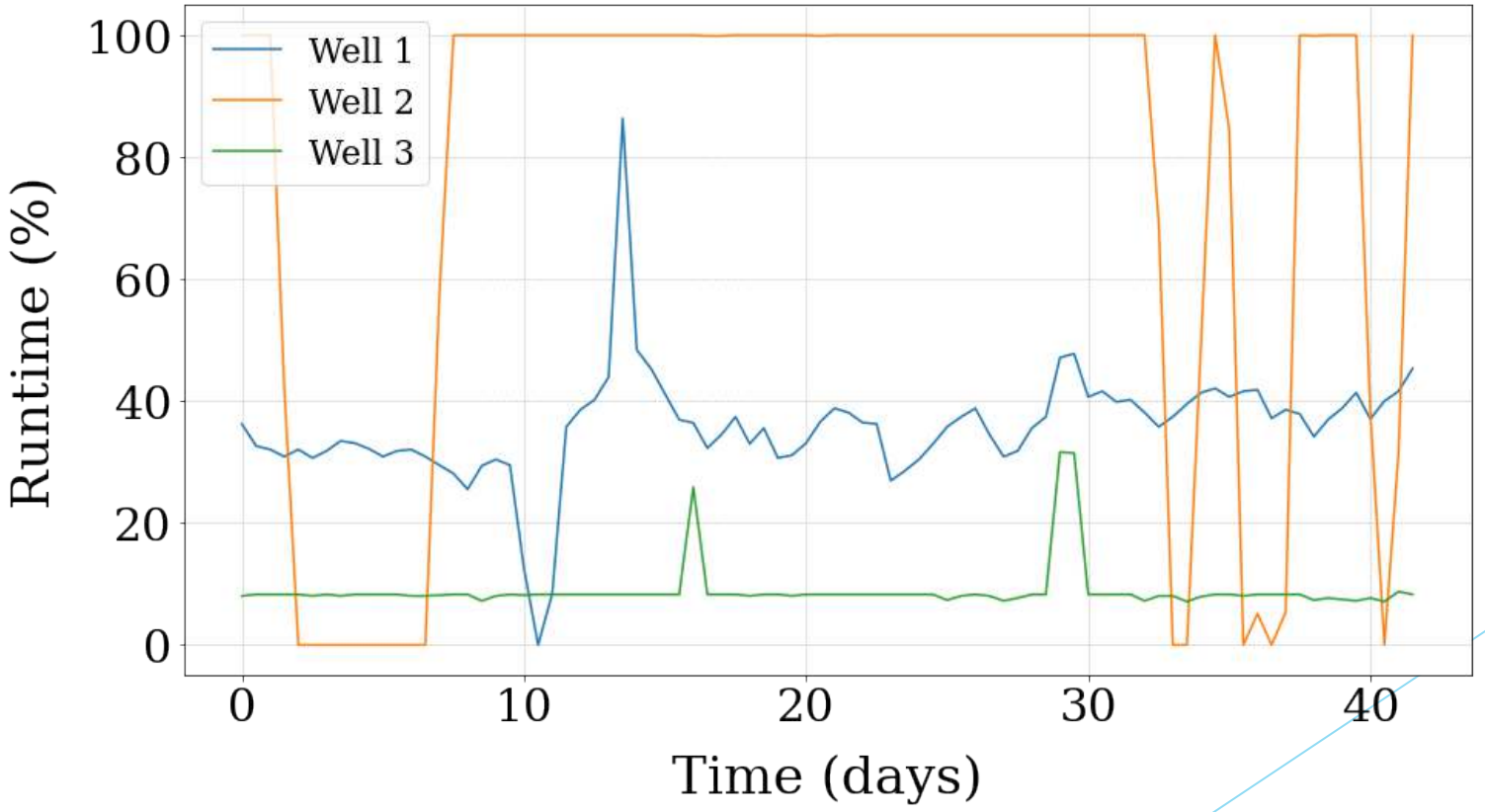
Case study 2a: High resolution monitoring of water flows to monitor changes in product composition

- Oil/water cut constantly changing
- Casing acting as a downhole separator



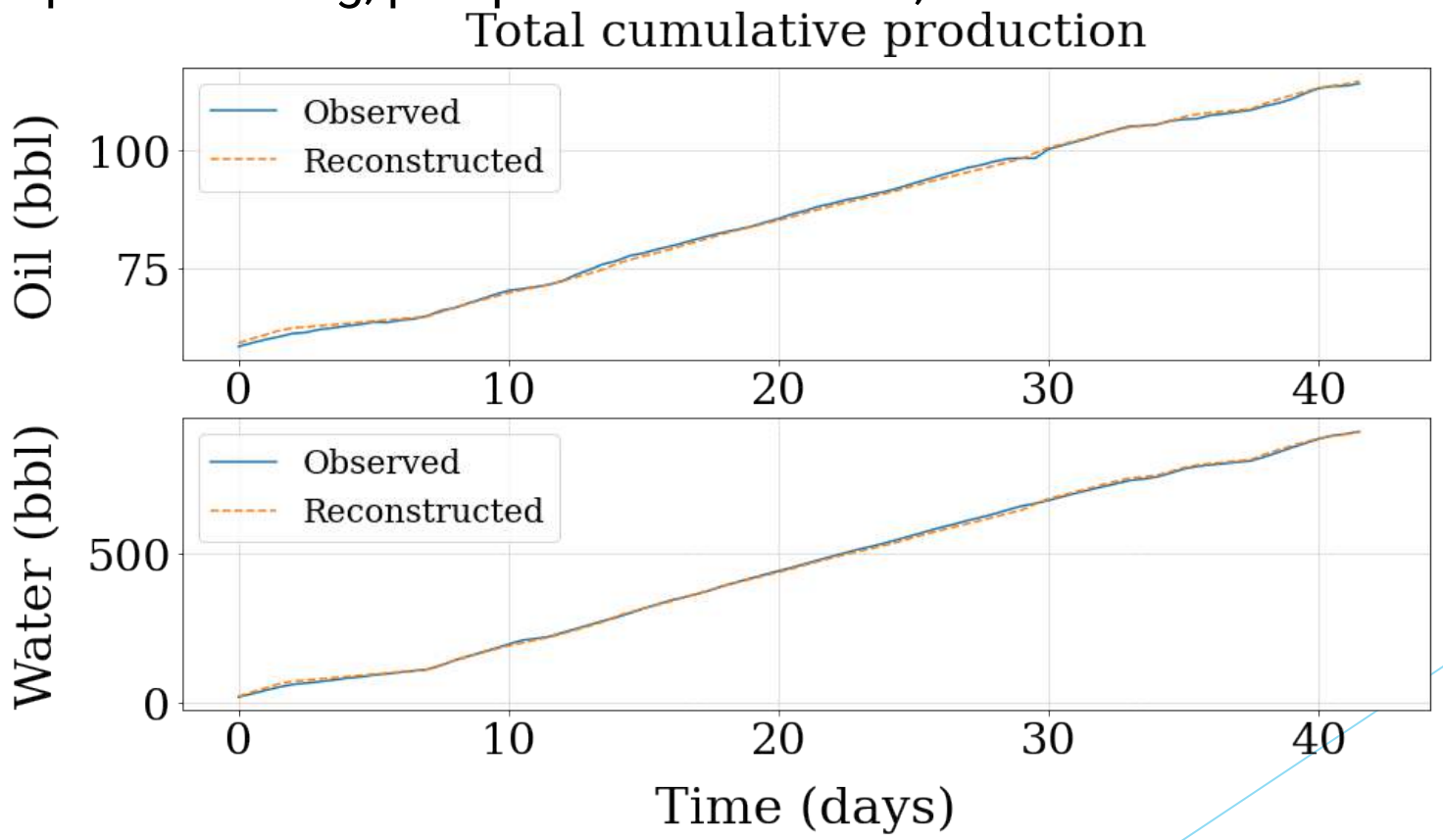
Case study 2b: Merging wellhead and inventory to perform production allocation

- Average lease with 3 wells and 1 separator + tank battery
- Runtime change because of maintenance downtime + system control

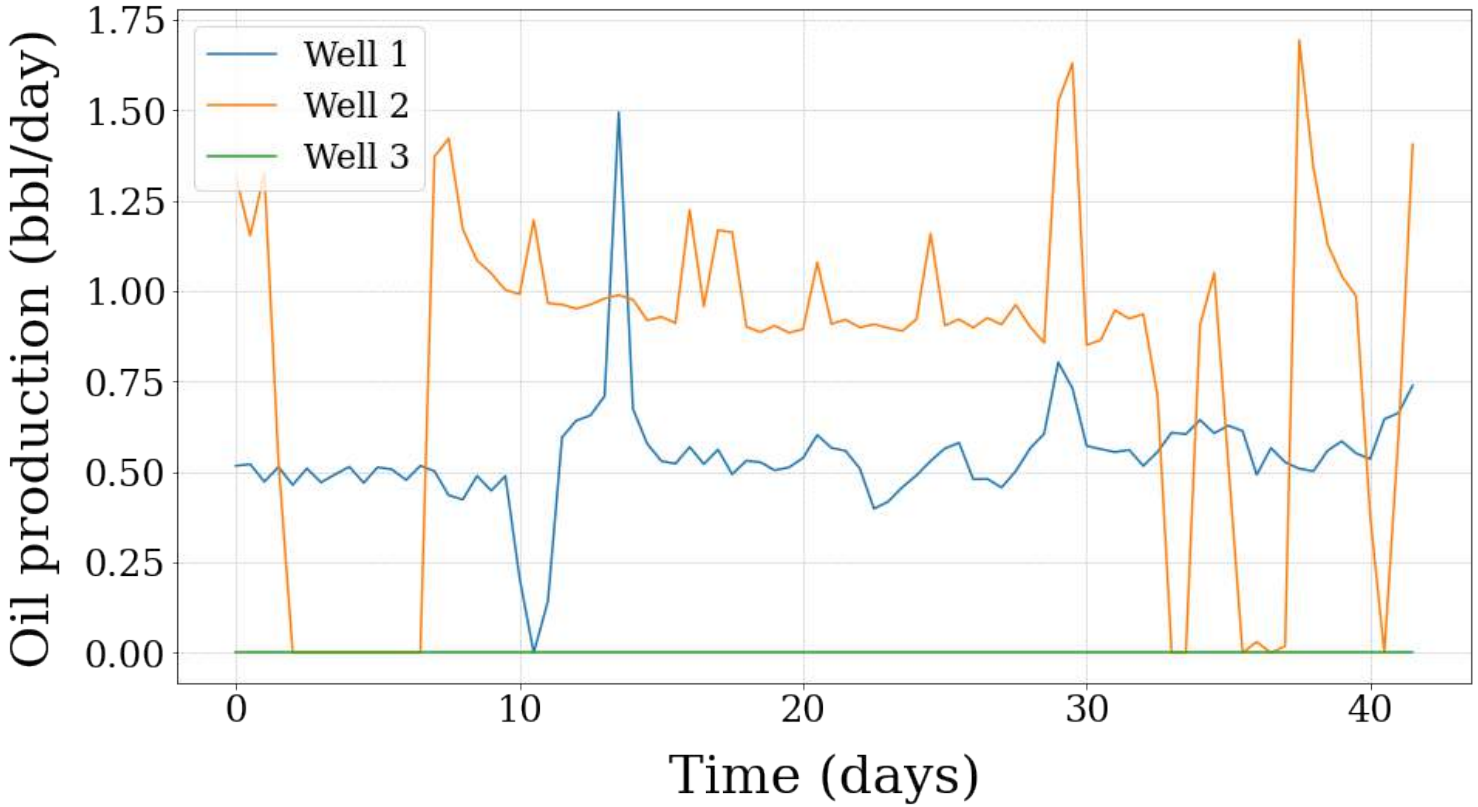


Case study 2b: AI used as a virtual flow meter

- AI able reconstruct system flow without flowmeters with high accuracy
- Works on oil and water legs with many wells per tank battery
  - Helps with billing, pump wear calculation,….



Case study 2b: Live dual phase flowmeter on every well



- Real time oil and water flow on each well
- Identify troublesome wells
- Potential to optimize control scheme between wells producing from the same formation
- Enables triage for well pulling & maintenance

Next steps

- Advanced control of slug flow wells to increase production
- Reservoir scale control
- Gas wells

Conclusions

- With 5+ high resolution sensor streams per well, we are able to get a complete picture of well & pump conditions
- Advanced algorithms are necessary to process and apply this amount of data 24/7
- Slugging can be mitigated using control and not just gas separators and downhole tools
- Amount of required hardware on sites can be reduced using virtual flow metering that leverages the right advance data

Thank you

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