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Novel Approach for Anomaly Detection and Setpoint Optimization of Plunger Lift Gas Wells at Scale

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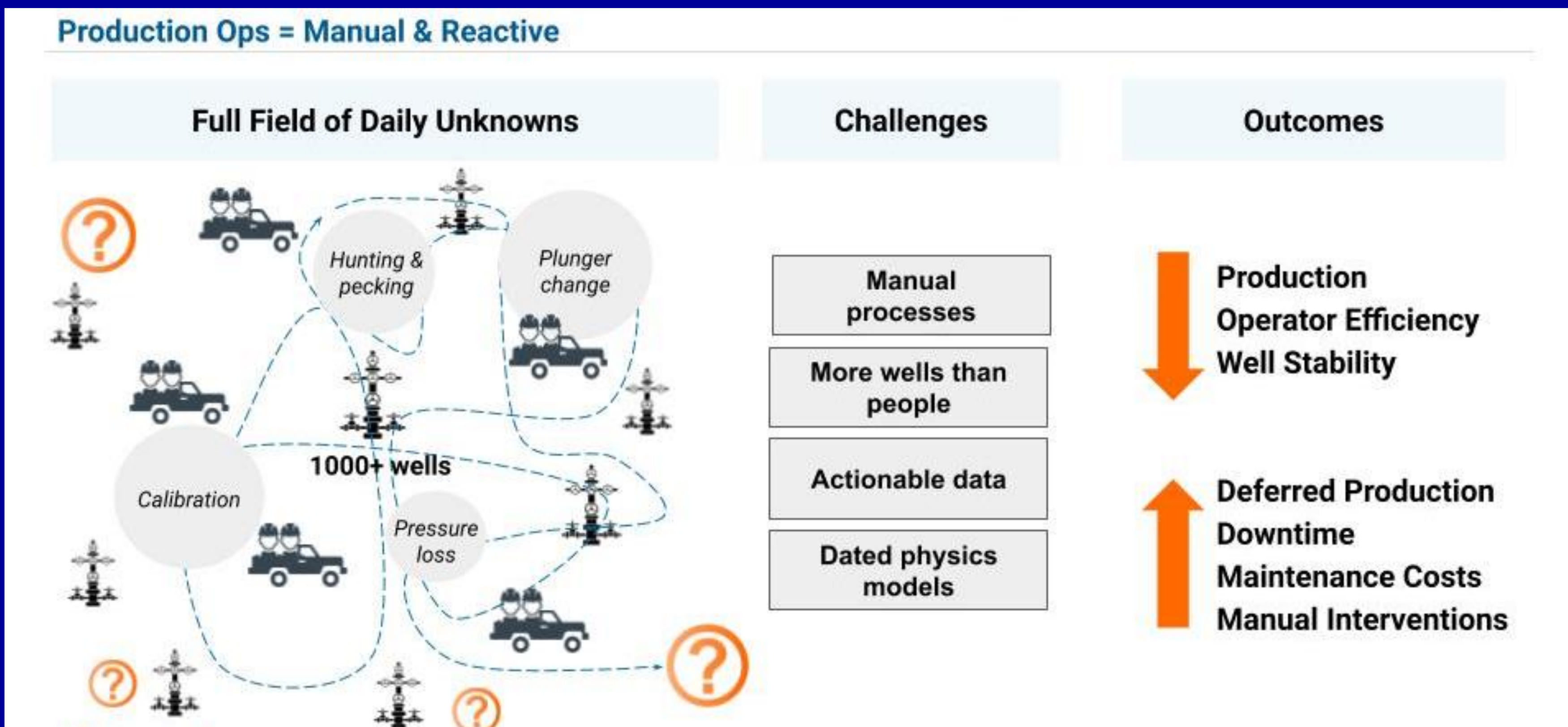
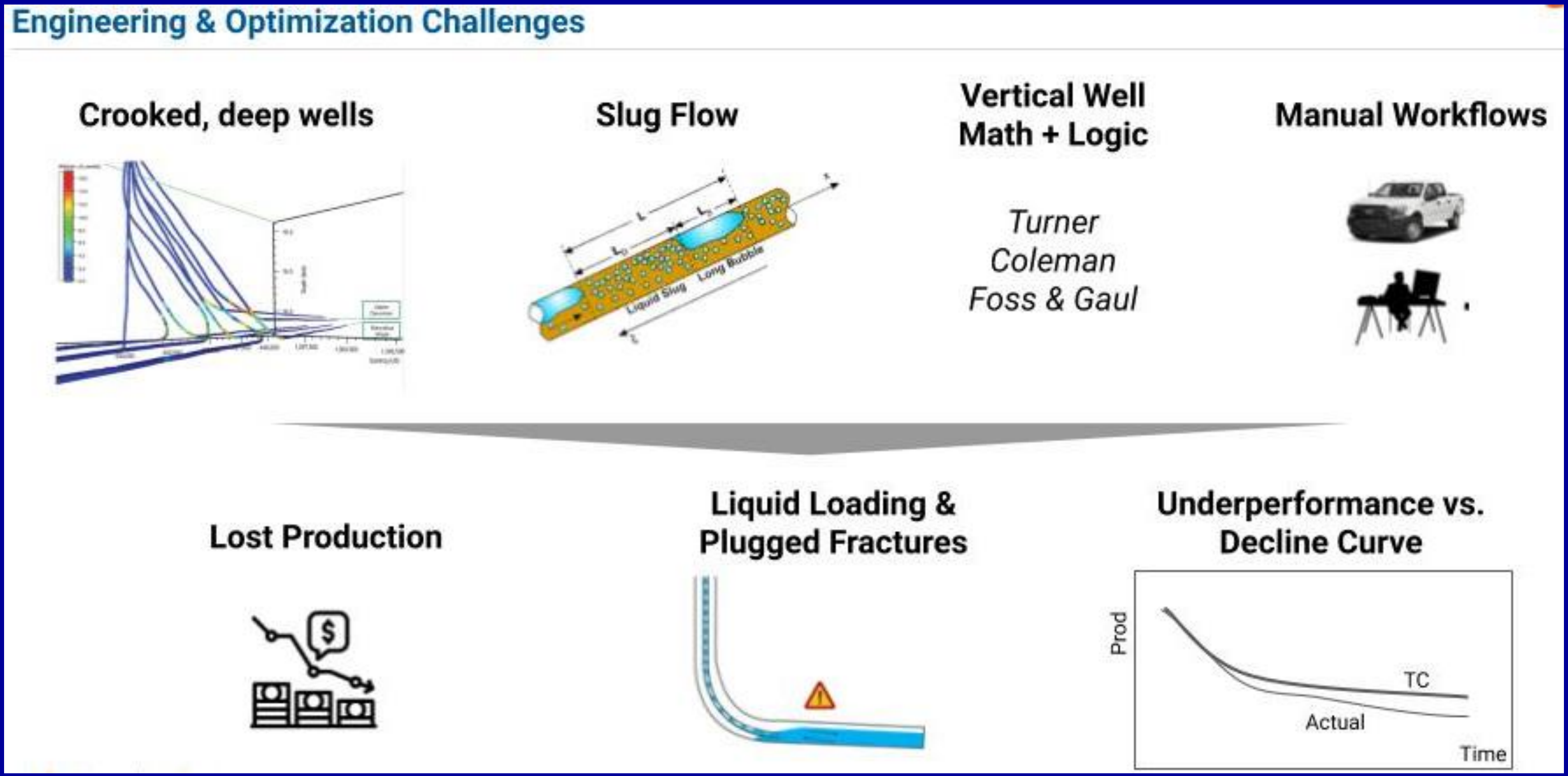
Agenda

- Background/overview
- Anomaly detection
- Physics engine
- Setpoint philosophy
- Baselining procedure
- Recommendation iterations

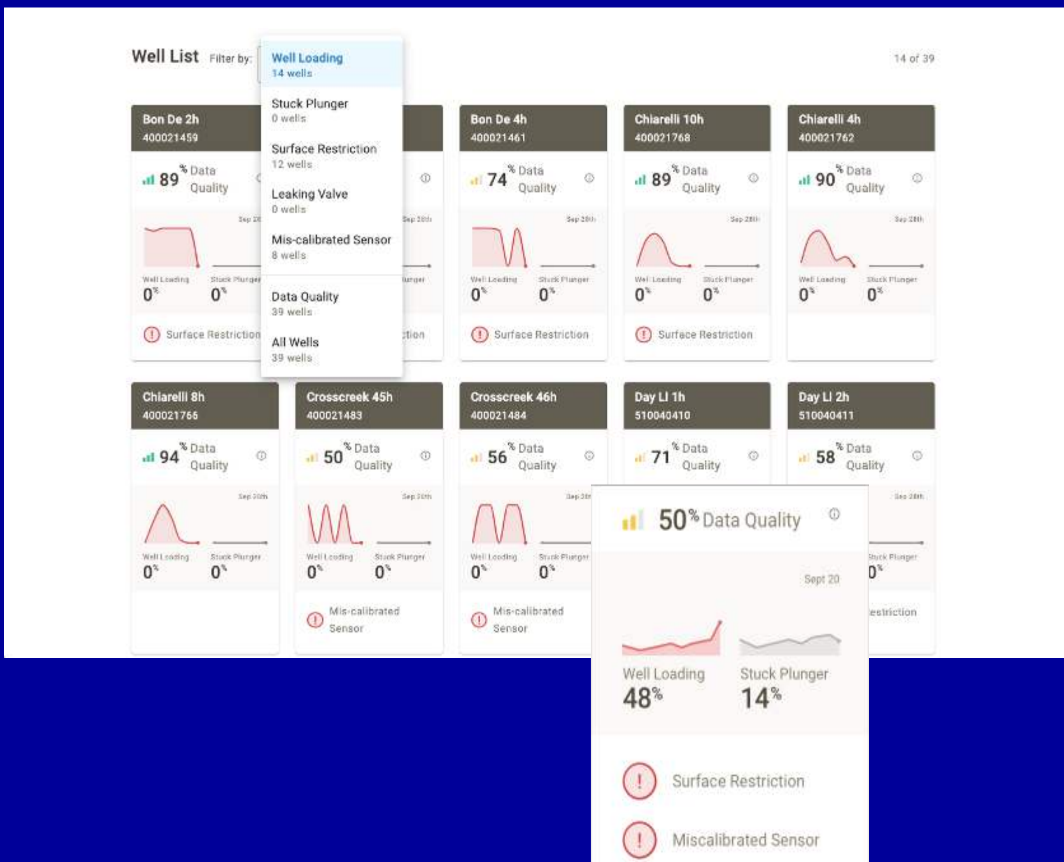
Production operations always in reactive mode, dealing with unknowns



Game has changed (10K ft HZ wells), but the tools haven't kept pace



Anomalies common; detection/remediation first step in optimization



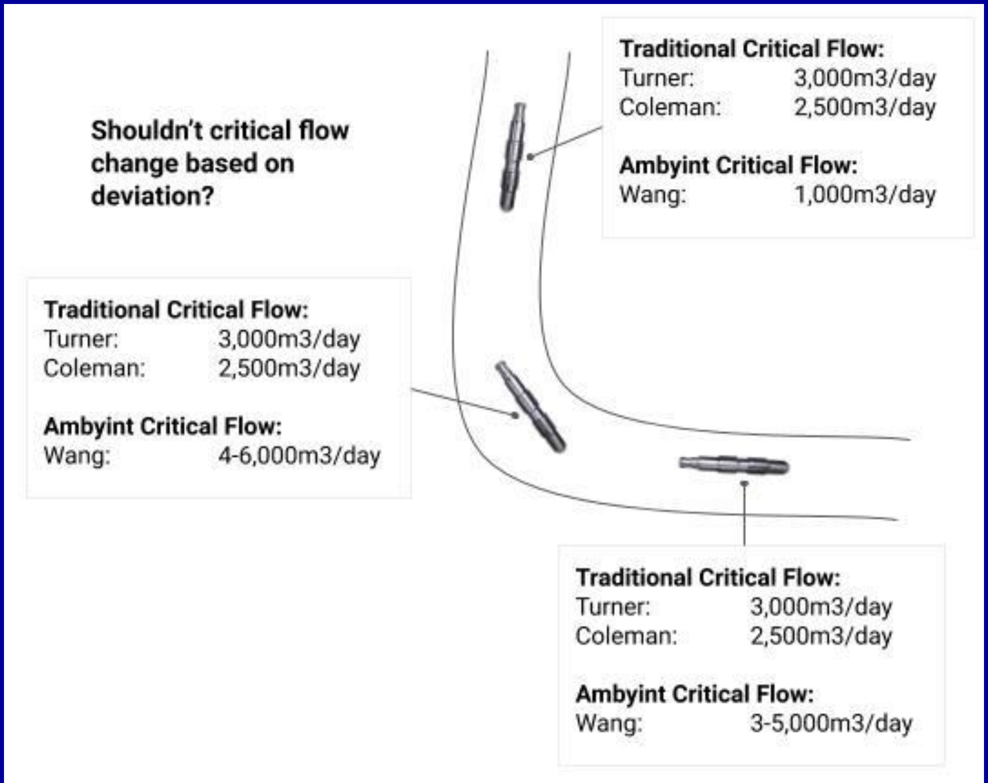
Empirically, up to 80% of wells struggle with anomalies leading to:

- Well instability
- Inability to optimize setpoints at scale

Anomaly detection of five key issues preventing setpoint optimization:

- Well loading
- Stuck plunger
- Surface restriction
- Leaking valve
- Mis-calibrated sensors

Better physics = better analysis = better results



SPE-189439-PA
Wang et al, Prediction of the Critical Gas Velocity of Liquid Unloading in a Horizontal Gas Well

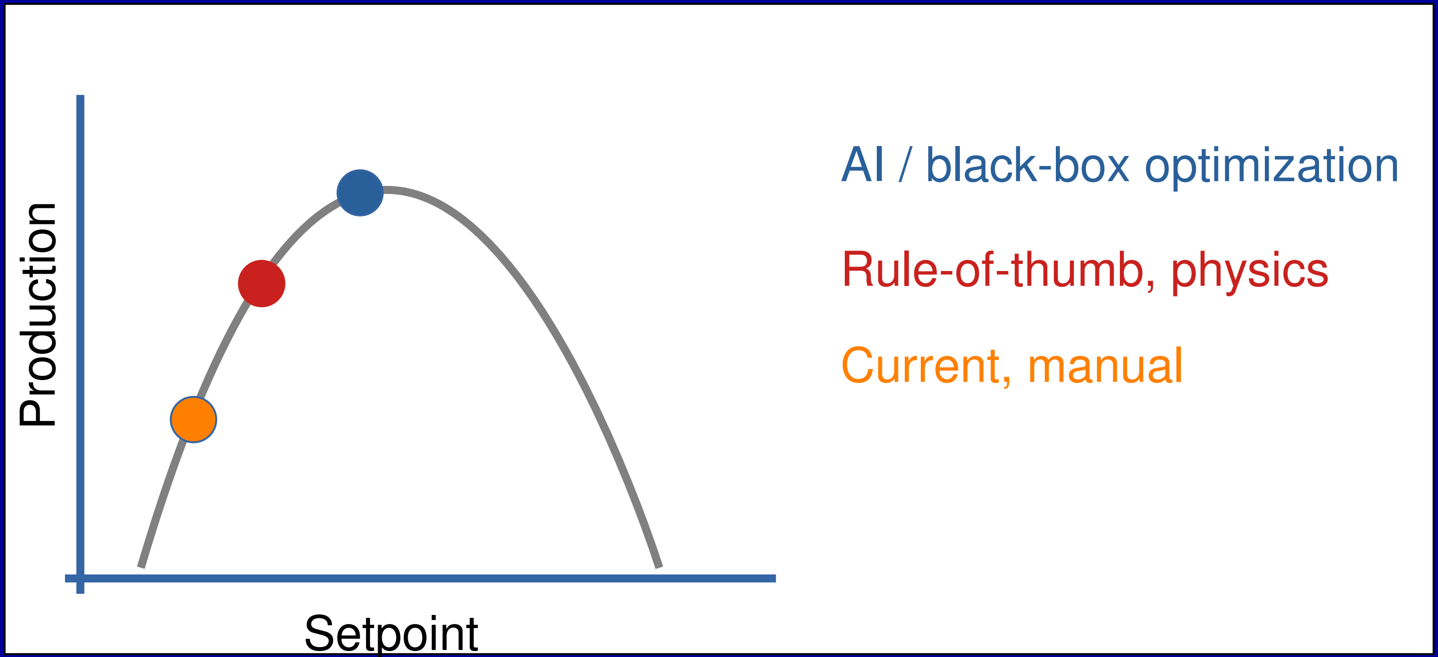
"Fudge factors" on Turner-Coleman or Foss & Gaul don't change with HZ deviation

- Off by >50% depending on deviation
- Manual heuristics not scalable
- Not systematic to drive consistent setpoint changes

Physics engine applies better math to setpoints which provides:

- More accurate assessment of downhole conditions
- Faster issue detection
- Standardized approach to setpoint management

Setpoint optimization using physics and AI



Selected Open/Close Triggers

- Open Triggers:
  - Plunger fall time / minimum close time → set once
  - CP-LP (lift pressure)
  - TP-LP
  - LF (load factor)

CP – modified Foss&Gaul [computed, but usage challenging in horizontal wells]

- Close Triggers
  - Max plunger rise time → set once
  - Close delay timer → set once
  - Max afterflow time
  - Critical flow rate
  - Percentage of critical flow rate

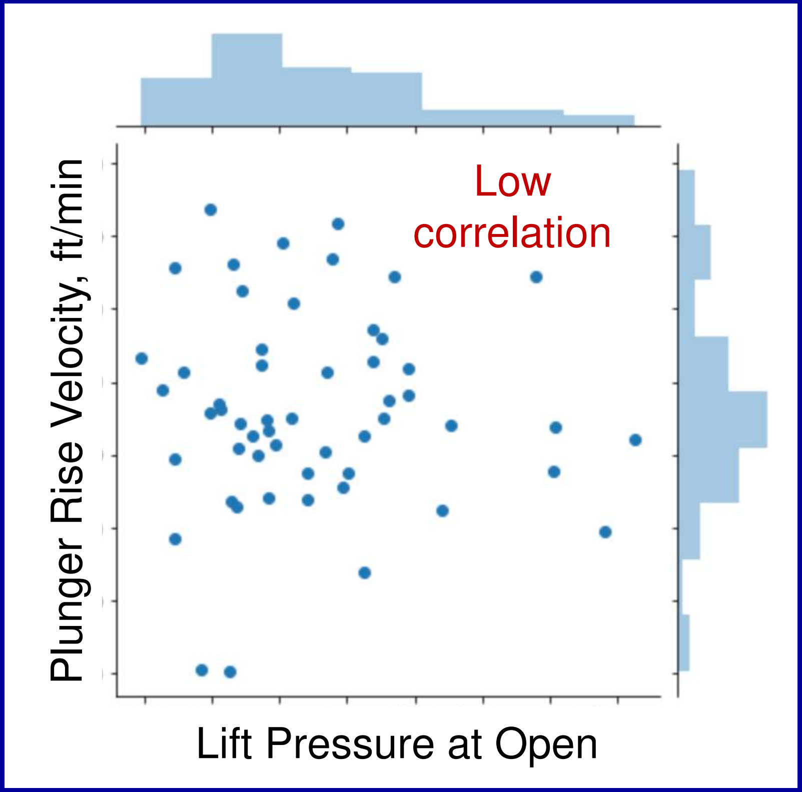
Setpoint optimization procedure, step 1

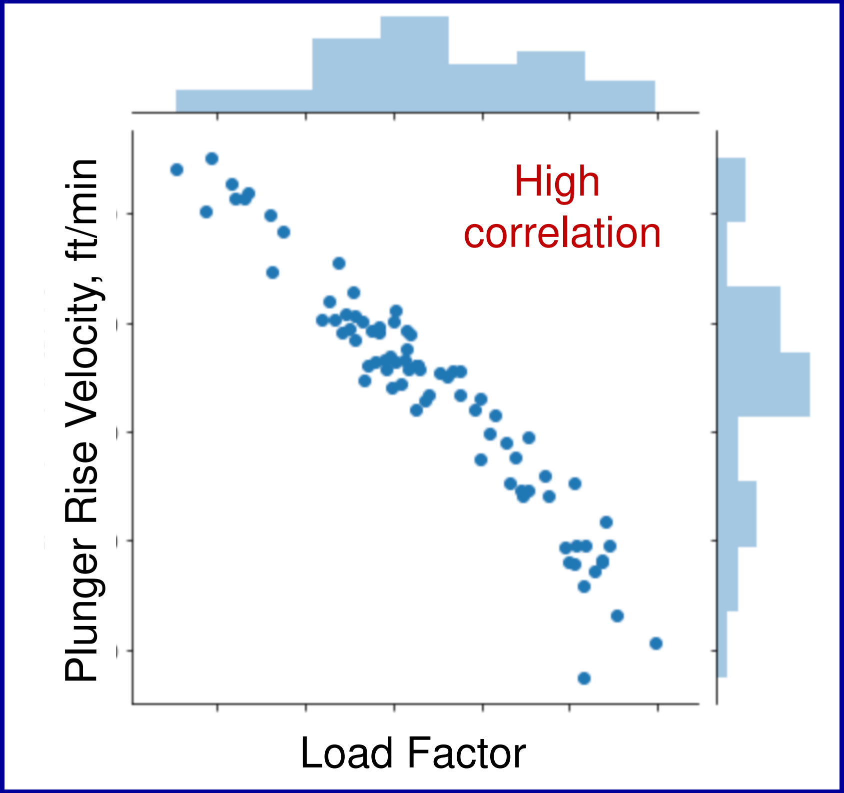
- Baselining for new well:
  - Evaluate current triggers
  - Provide setpoints aiming at stabilizing cycles

- Computational steps:
  - Compute physics parameters for well
  - Analyze historical data

- Outputs:
  - Most suitable set of triggers for each well
  - Recommended setpoints for all triggers
  - Setpoint upper and lower boundaries

Data-driven open/close trigger selection





Setpoint optimization procedure, step 2

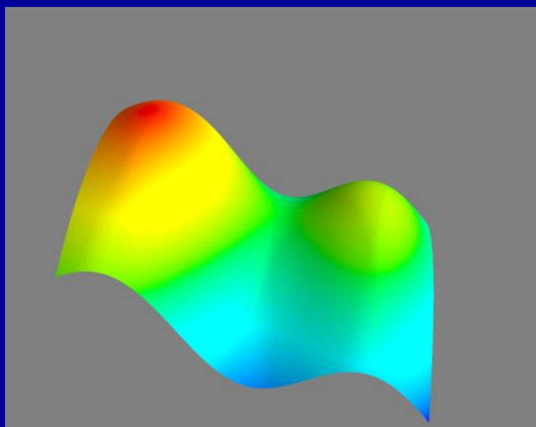
- Black-box optimization:
  - Provide setpoints aiming at increasing production

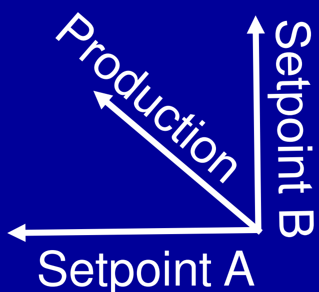
- Computational steps:
  - Create safety box around setpoints
  - Iteratively optimize setpoints within safety box
  - Output: setpoints for all triggers

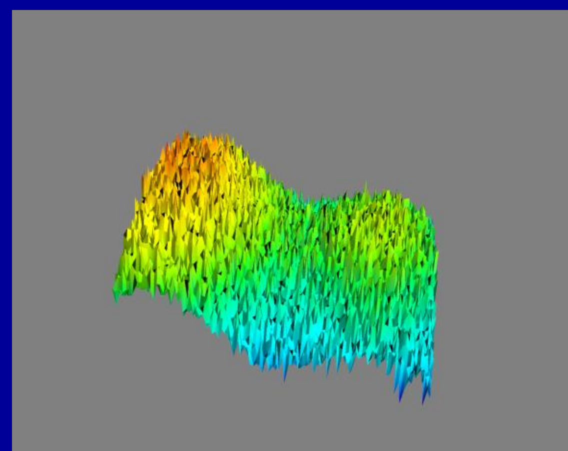
Setpoint optimization procedure, recap

- Baselining: Use physics and data analytics to stabilize plunger cycles
- Production optimization: Use AI / Numerical Optimization to iterate on setpoints to optimize production

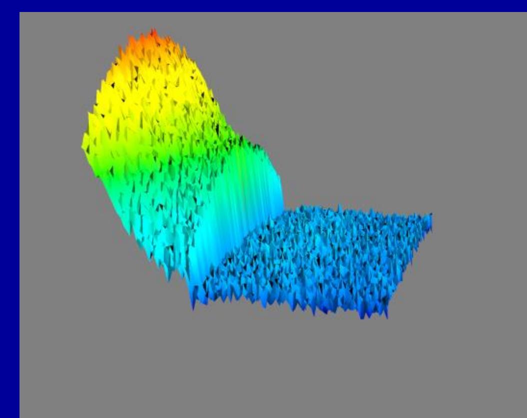
Dependence of production on setpoints





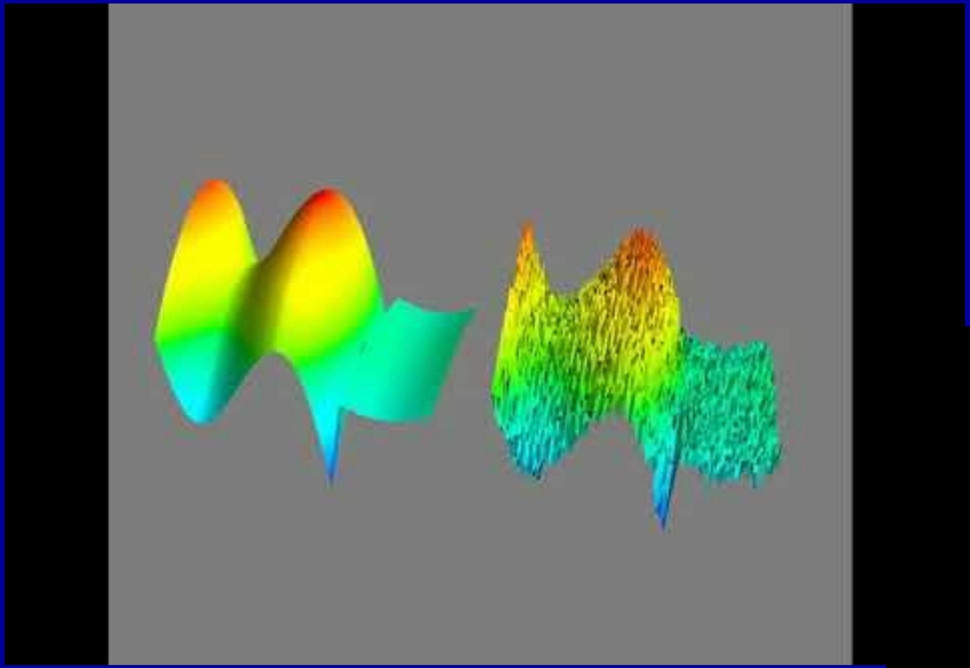


Production is noisy

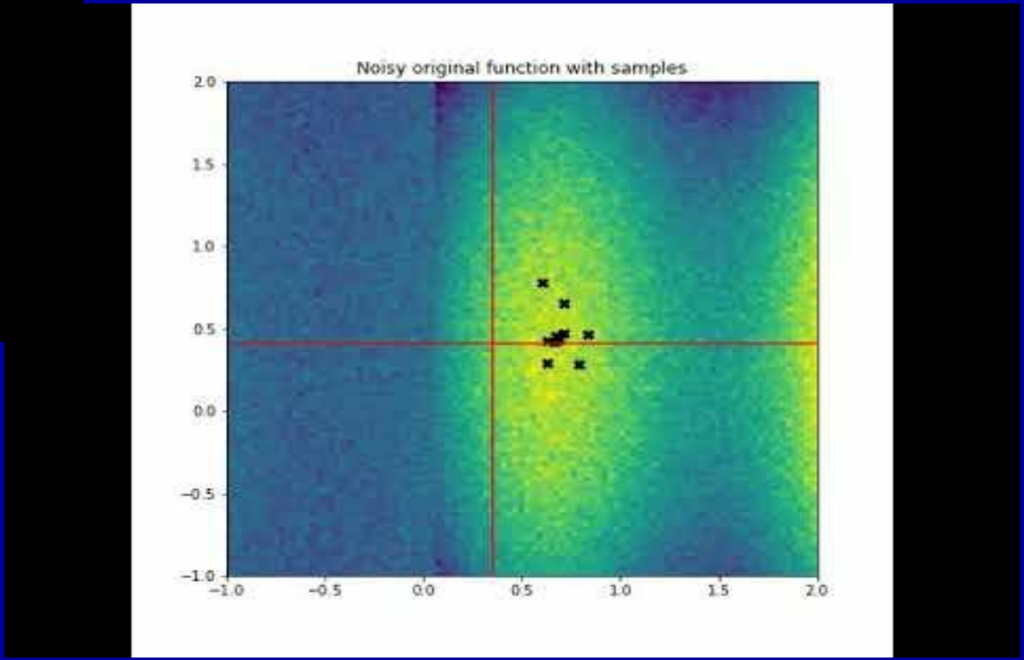


Discontinous
functional dependence of
production on flow rate

Setpoint optimization of noisy production on a decline curve using AI



Functional form of production changes over time



AI tracks combination of setpoints maximizing production

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