



# 2020 ALRDC Artificial Lift Workshop

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

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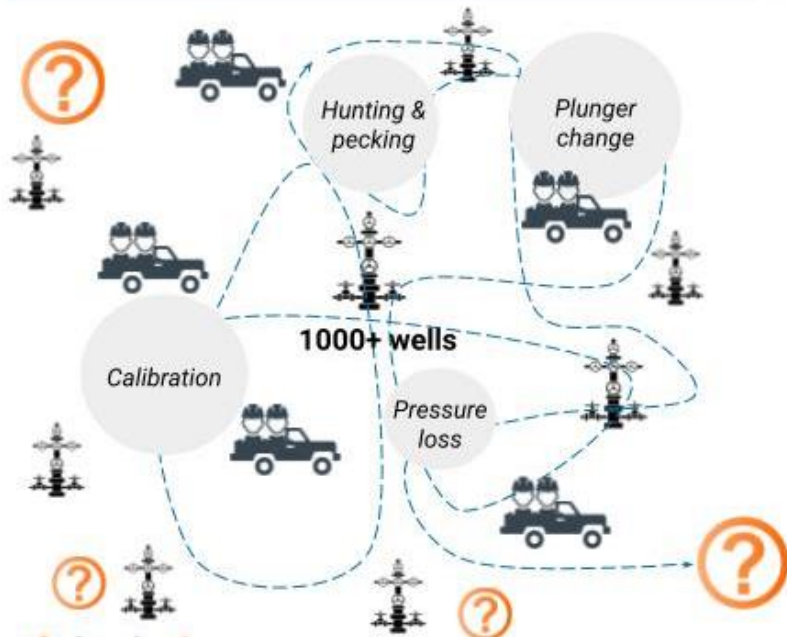
# Agenda

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

# Production operations always in reactive mode, dealing with unknowns

## Production Ops = Manual & Reactive

### Full Field of Daily Unknowns



### Challenges

Manual processes

More wells than people

Actionable data

Dated physics models

### Outcomes

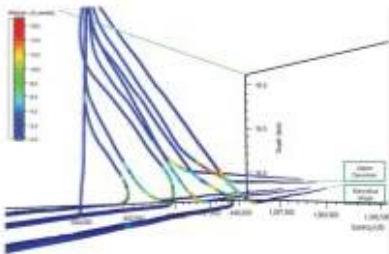
Production Operator Efficiency  
Well Stability

Deferred Production  
Downtime  
Maintenance Costs  
Manual Interventions

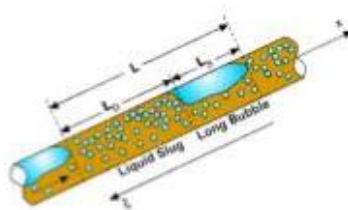
# Game has changed (10K ft HZ wells), but the tools haven't kept pace

## Engineering & Optimization Challenges

### Crooked, deep wells



### Slug Flow



### Vertical Well Math + Logic

Turner  
Coleman  
Foss & Gaul

### Manual Workflows



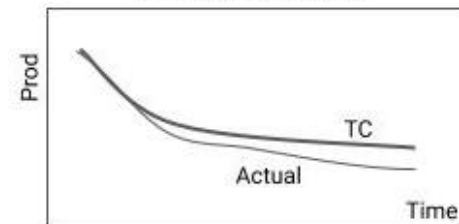
### Lost Production



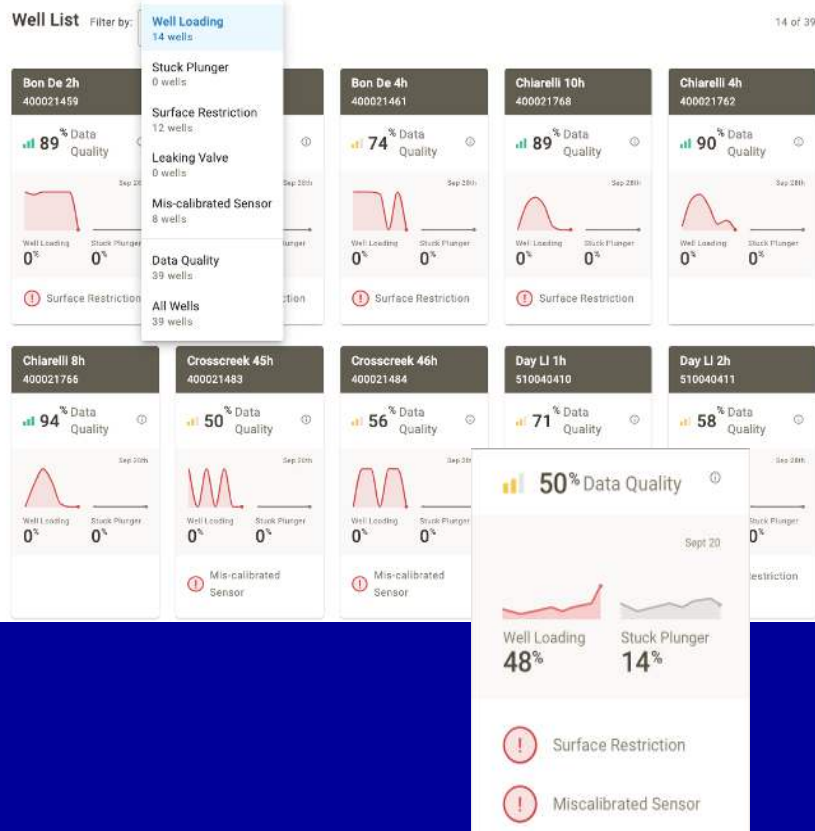
### Liquid Loading & Plugged Fractures



### Underperformance vs. Decline Curve



# Anomalies common; detection/remediation first step in optimization



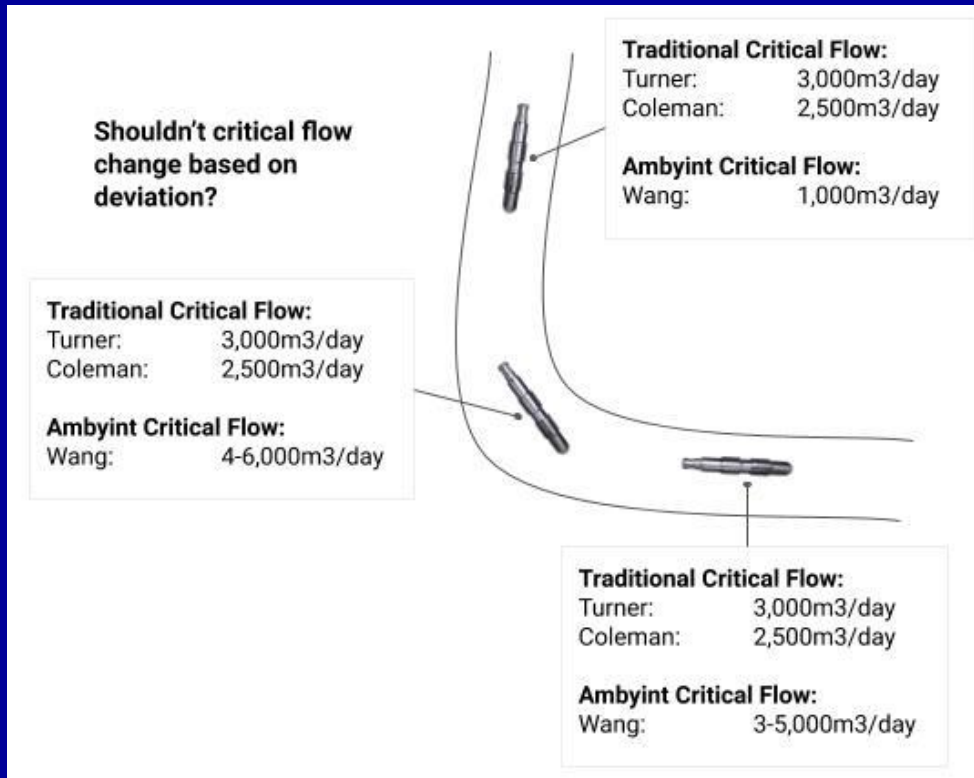
Empirically, up to 80% of wells struggle with anomalies leading to:

- 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



“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

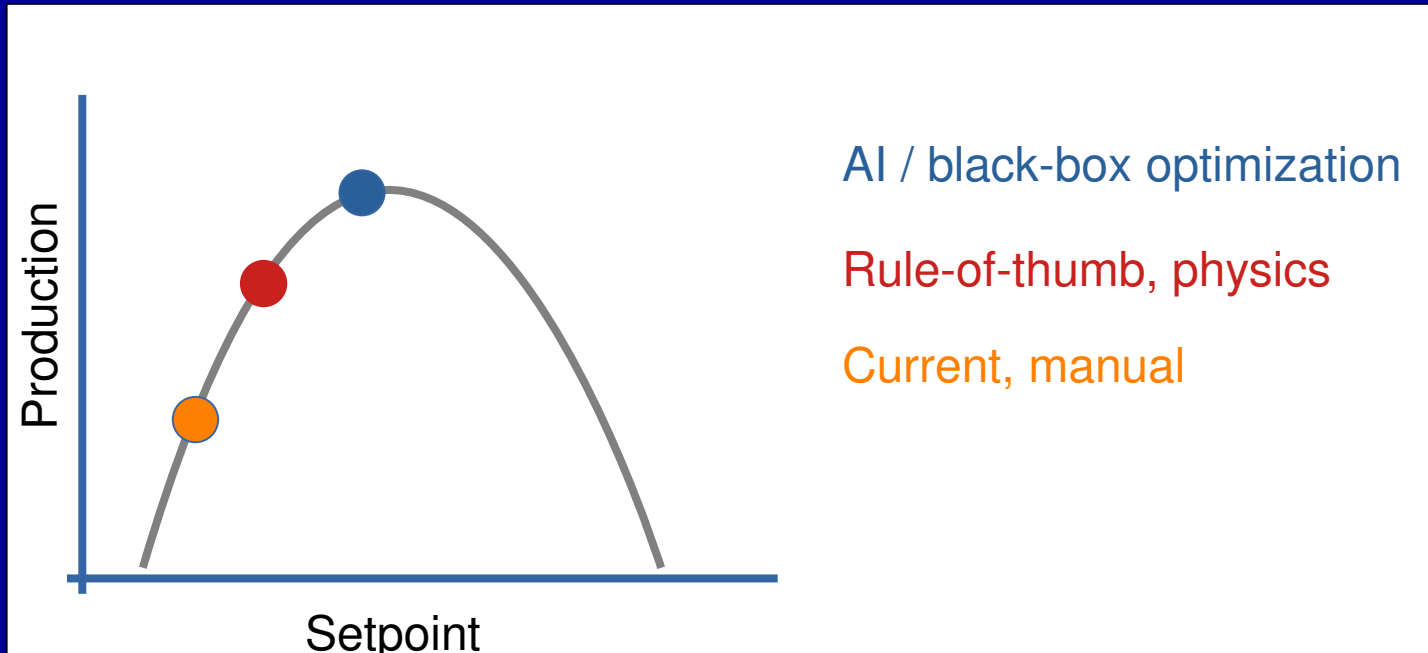
Physics engine applies better math to setpoints which provides:

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

## SPE-189439-PA

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

# 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

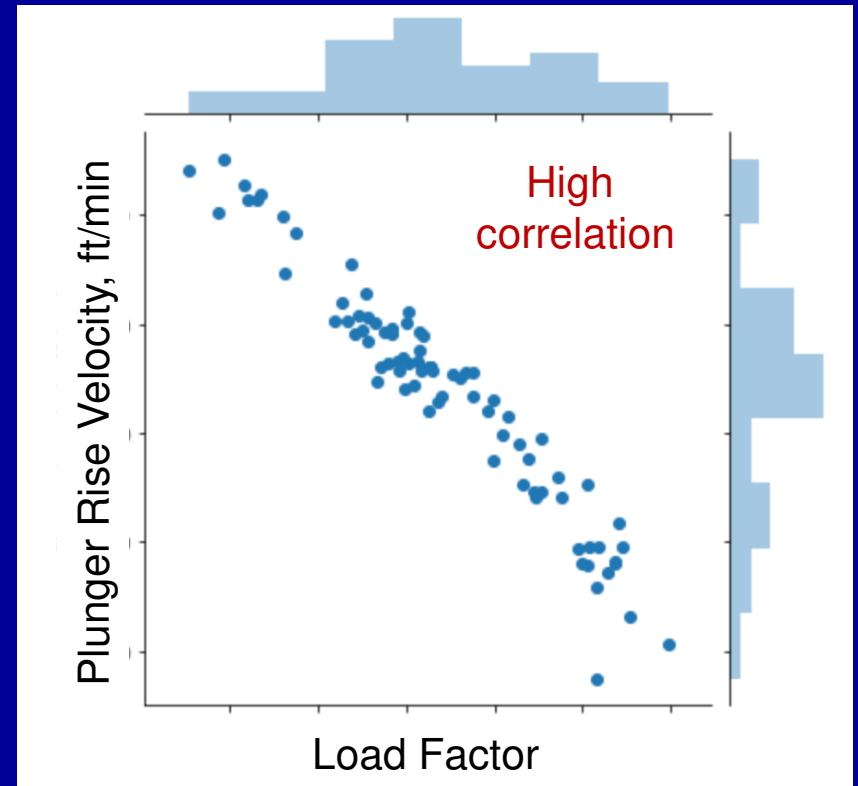
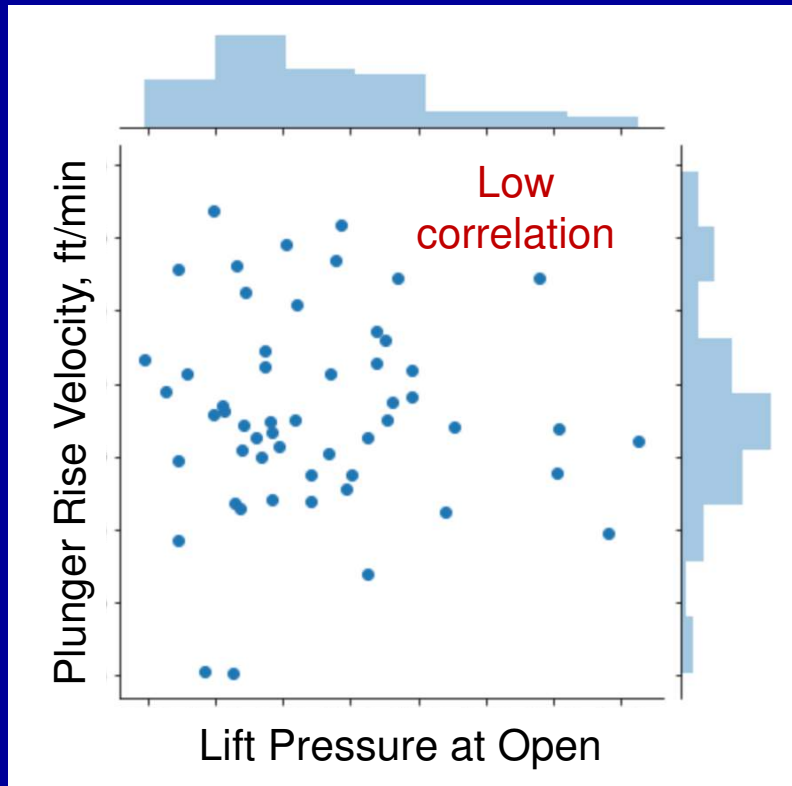
- Max plunger rise time → set once
- Close delay timer → set once
- Max afterflow time
- Critical flow rate
- Percentage of critical flow rate



# 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



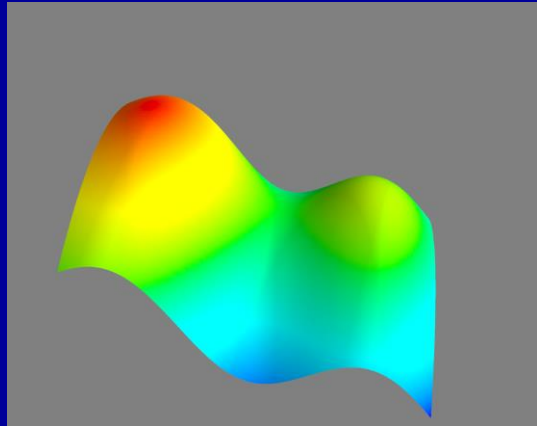
# Setpoint optimization procedure, step 2

- 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

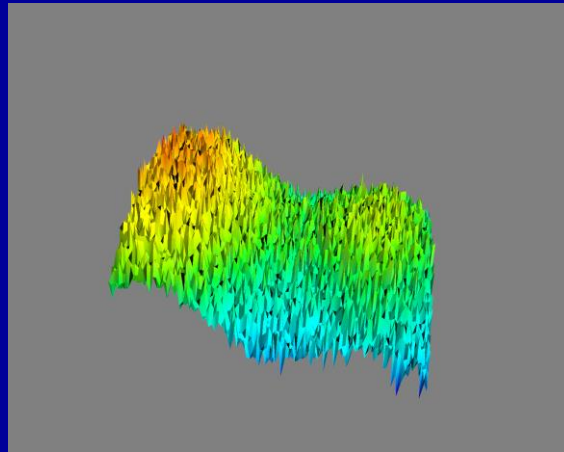
# Setpoint optimization procedure, recap

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

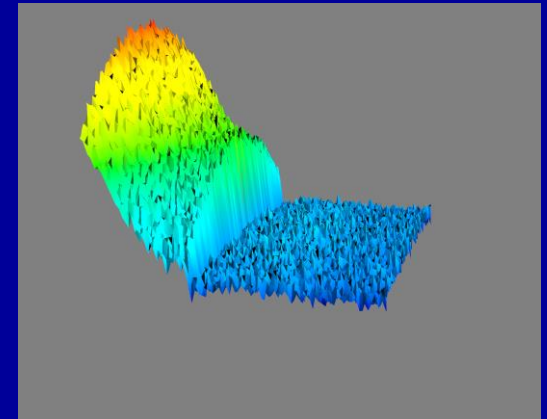
# Dependence of production on setpoints



Production  
Setpoint B  
Setpoint A

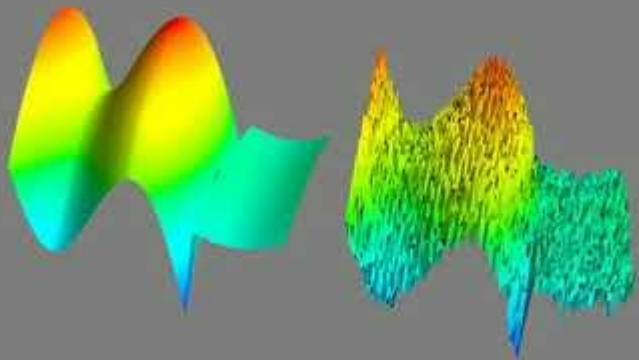


Production is noisy

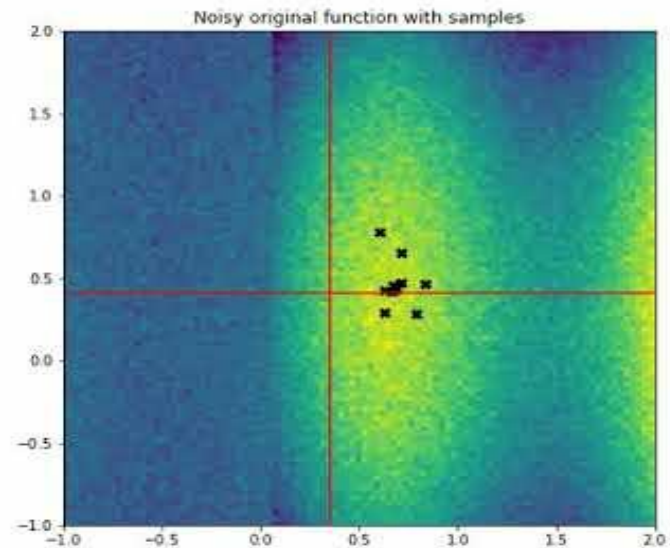


Discontinuous  
functional dependence of  
production on flow rate

# 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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