

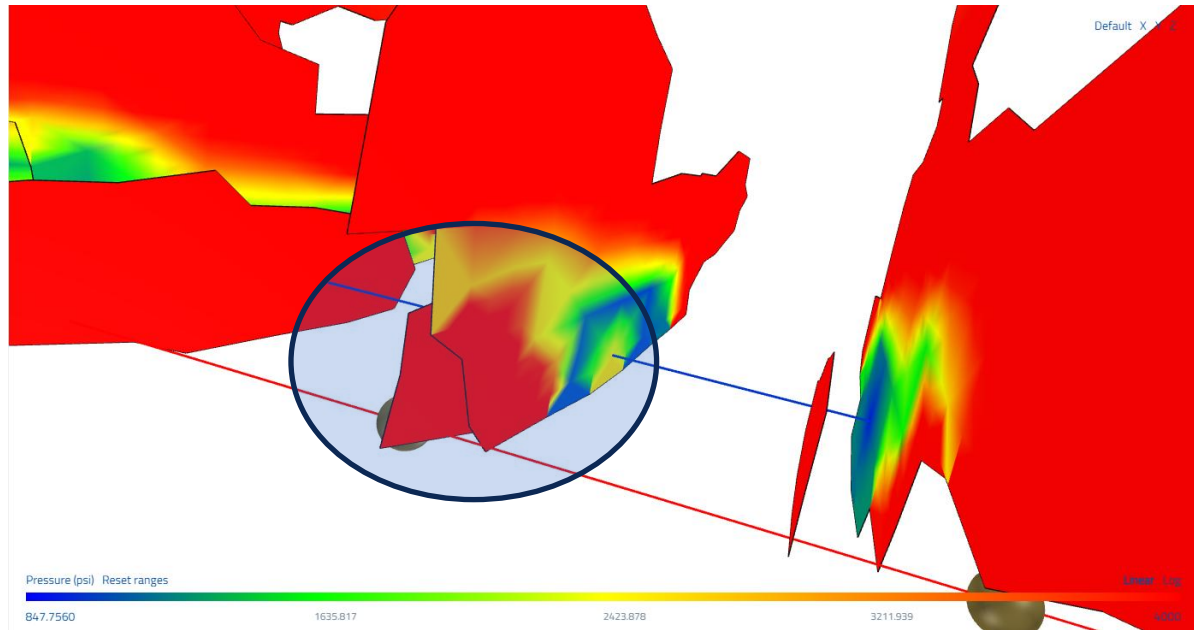
# Fracture Connections

Parameters that control how fractures collide with and connect (or don't) in the subsurface

# Fracture Interactions Parameters

1. Fractures can connect in virgin reservoir using the parameter 'Fracture Collision Distance' parameter.
2. Fractures can connect in depleted reservoir using the parameters 'Depleted Fracture Collision Distance' and 'Fracture Collision Depleted Stress'.
3. Fractures can hydraulically connect to an offset wellbore using the parameters 'Cased Well and Fracture Collision Distance' and the 'Conductivity of the connect frac through 'Cased well fracture collision distance'.
4. 'Fracture Initiation Randomness Distance' controls the distance the fracture initiates away from the cluster.
5. 'Measured Depth Boundary Conditions' will control the size of the frac hit by introducing extra volume to the system.

# Fracture Interactions – Virgin Rock



A newly created fracture immediately connects with an existing fracture. Note the pressure transfer through the new fracture into the existing fracture.

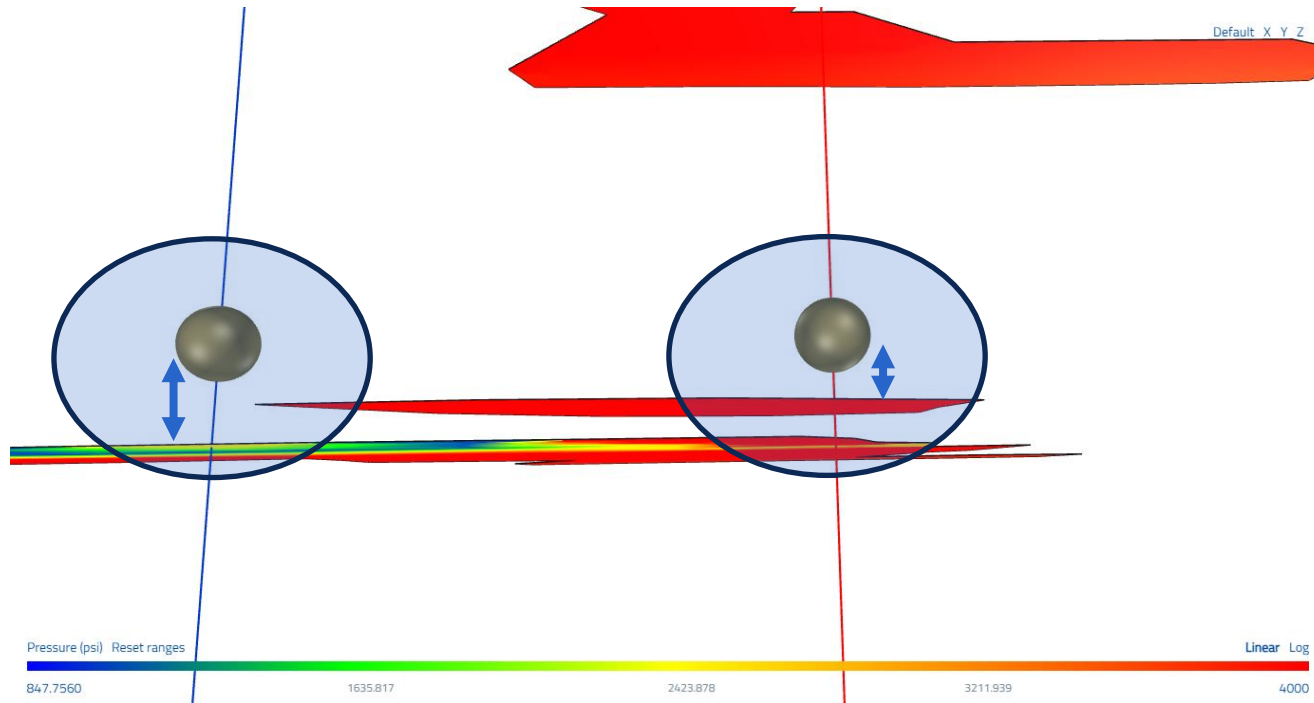
## ResFrac parameters

- Fracture collision distance (FCD)
- Fracture initiation randomness distance

Fractures can collide as they approach a specified distance in virgin reservoir (in any direction). The fracture collision distance is specified as a function of the fracture element length. For instance, if the fracture element length is set to 100' and the FCD is set to 0.02, then the fractures will collide when they come within two feet of each other. Typical values for allowing these fractures to collide would be 2-5'.

If simulating several wells with the same cluster and stage lengths, ResFrac will automatically place the perforations directly across from each other causing an automatic connection. Use the 'fracture initiation randomness distance' parameter to allow the fractures to deviate from the actual cluster location.

# Fracture Interactions – Fracture Initiation Randomness Distance



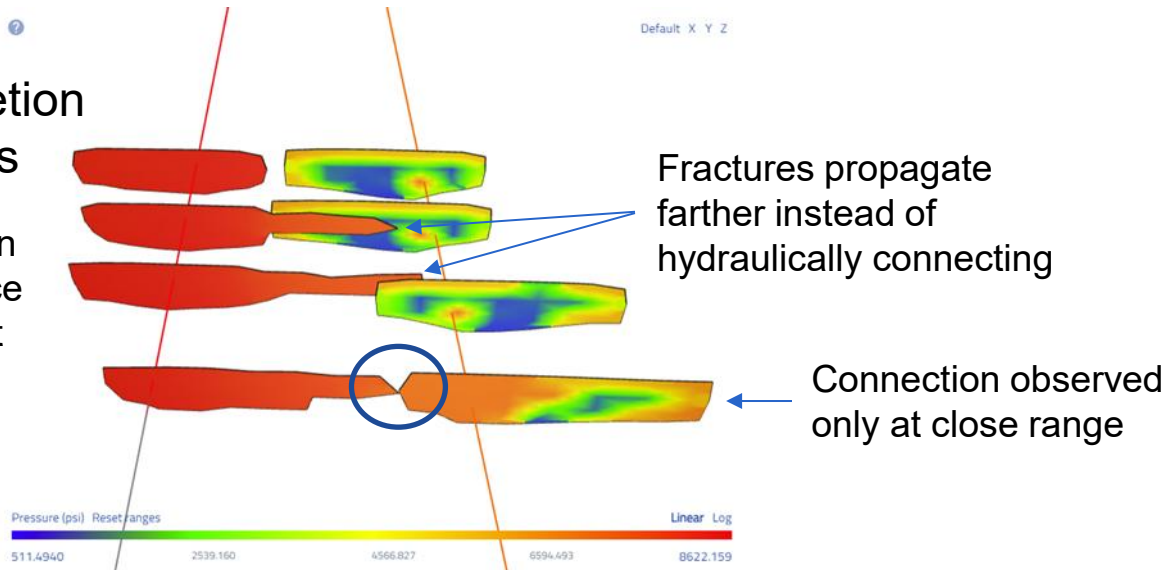
Setting the fracture initiation randomness distance allows the fractures to initiate away from the cluster as seen to the left.

When the stage length and cluster count are the same, the ResFrac wizard 'Wells Stages Setup Wizard' will place the clusters directly offset from each other and therefore the fractures will always connect. Since this is not usually desirable, this parameter can be set such the fractures initiate +/- this amount. Normally this value is set to 5-8' but the fracture connection distance should be taken into account.

# Fracture Interactions – Depleted Fracture Collision Distance

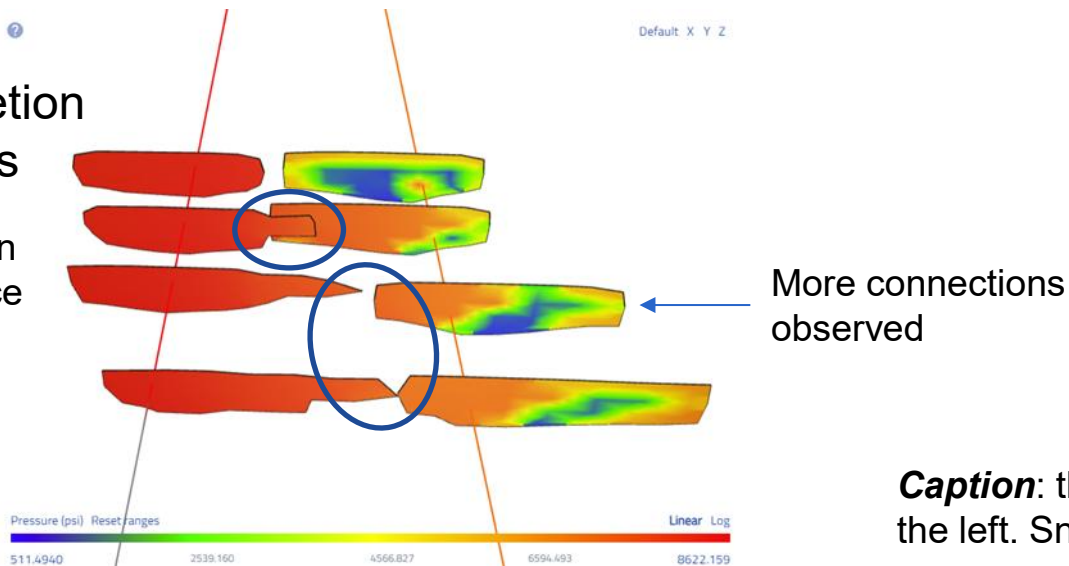
High Depletion Stress

collision distance is 2.8 ft



Low Depletion Stress

collision distance is 30 ft



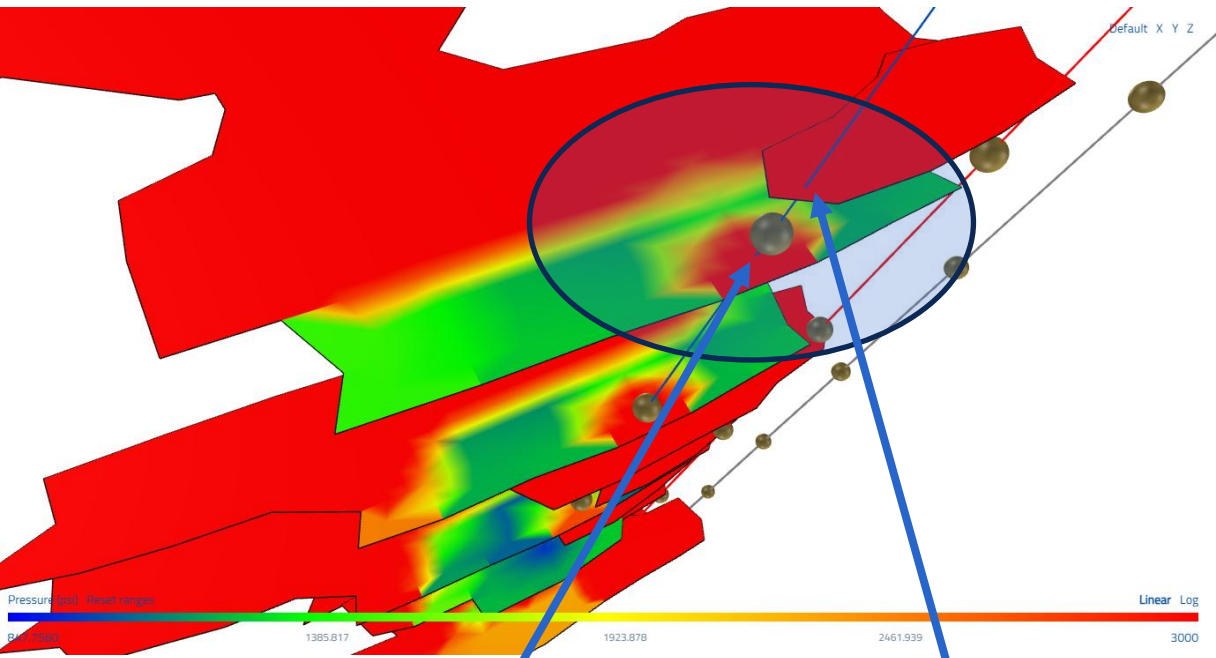
ResFrac parameters

- Depleted fracture collision distance
- Fracture collision depletion stress

Fractures can also be allowed to collide more readily in depleted rock, mimicking the fracture turning that might occur. Users must specify both the collision distance and the stress reduction threshold required for a fracture to be classified as 'depleted'. The typical values used are 30' and 150 psi of depletion, respectively.

**Caption:** the well on the right has 5 years of depletion prior to the child frac on the left. Snapshot is taken towards the end of the child frac.

# Fracture Interactions – Fracture to wellbore



A newly created fracture crosses the wellbore causing an increase in pressure in an existing fracture.

Additionally, fractures can intersect offset wellbore and become hydraulically connected behind casing through the annulus.

The distance and the conductivity of this connection can be controlled to match frac hit observations.

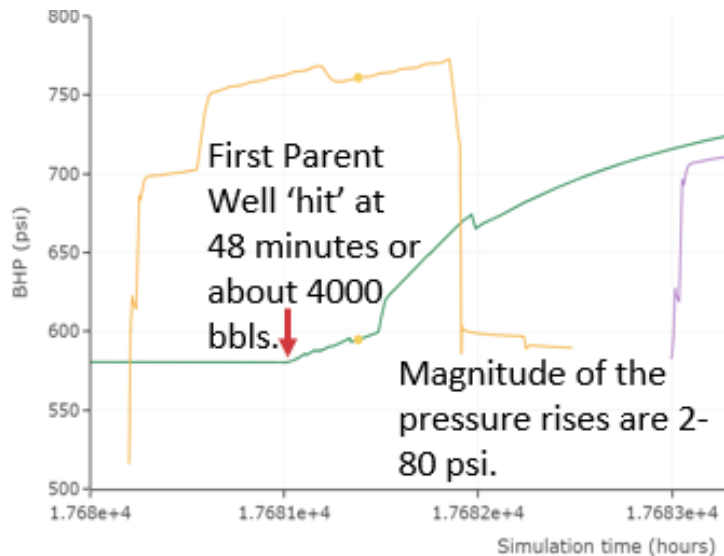
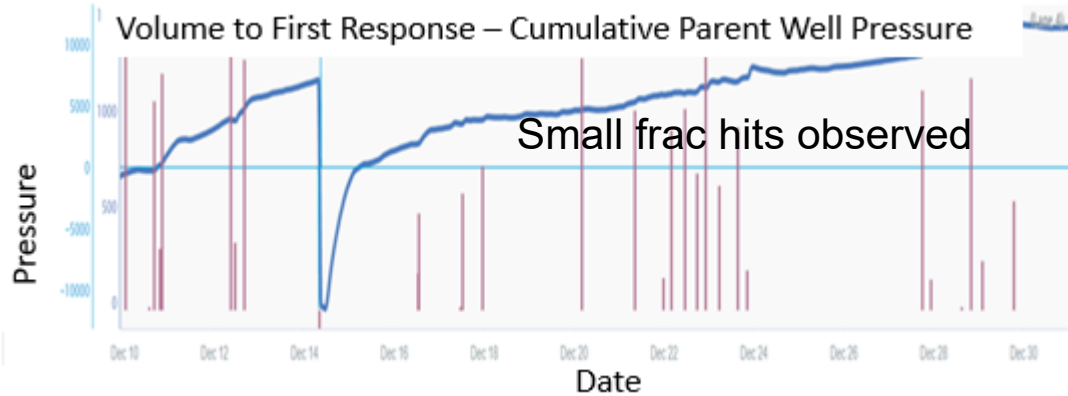
## ResFrac parameters

- Cased well and fracture connection distance, typical values range from 10' to 30'.
- Conductivity of the 'connect frac through' cased well and fracture connection distance with a typical values of 10,000 md-ft.

Typical observations that are matched using fracture interactions.

1. Frac hits, sealed wellbore pressure monitoring, fiber
2. Pressure interference tests
3. Tracers

# Data Matching – Frac Hit Magnitude

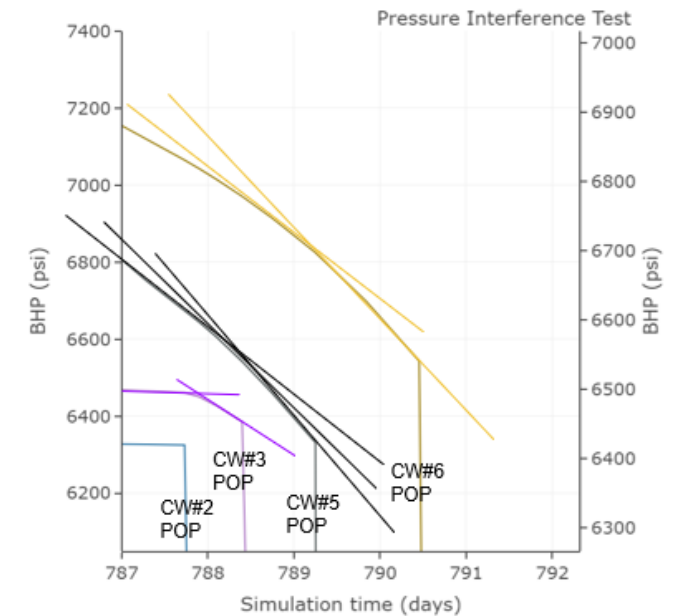
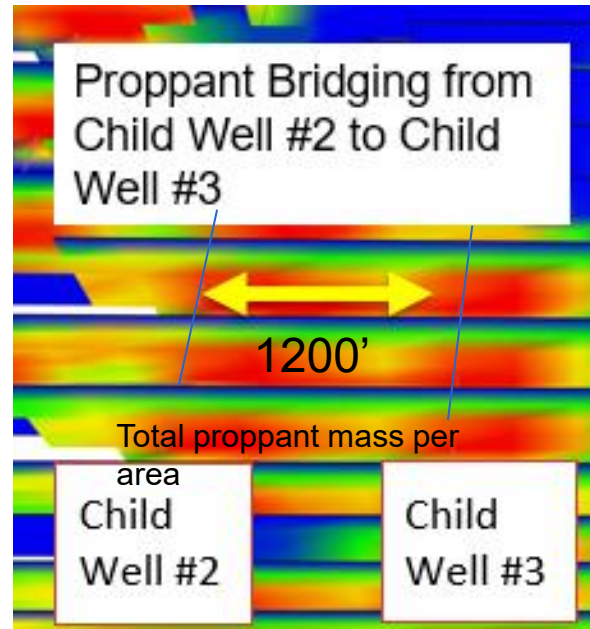
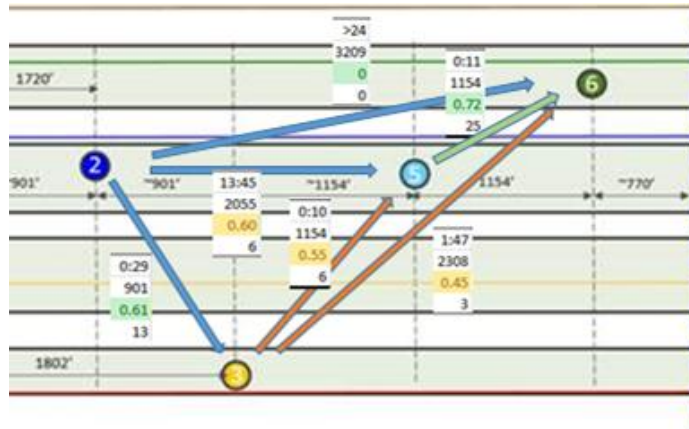


A special type of boundary condition, called a measure depth boundary condition, can be used to tune the magnitude of the frac hits. This allows the user to set the depth at which the production is reported, normally just up hole (towards the heel) a few hundred feet.

Fluid will be allowed to flow into and out of the boundary, but the boundary condition itself is treated like a tank with an associated volume. This volume can be used to simulate the intensity and crossflow that occurs during frac hits. A larger volume will 'mute' the intensity of the frac hits.

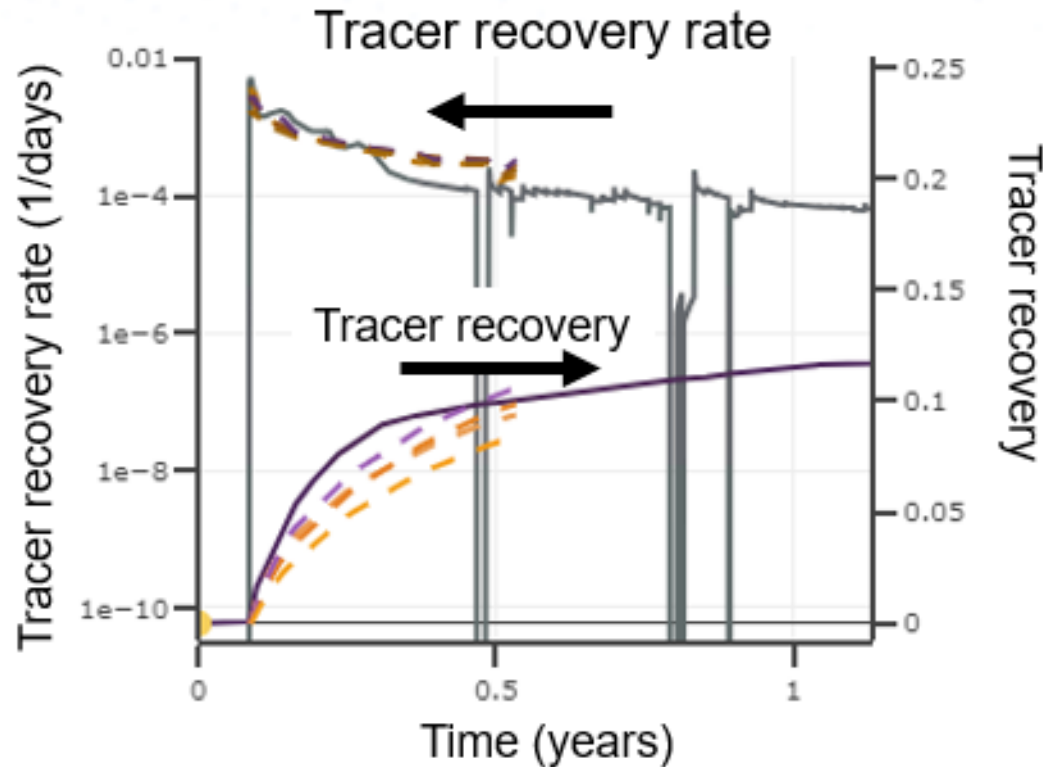
SPE-209152– Modeling of Parent Child Well Interactions, Ratcliff et al., 2022. Co-authored with Devon, modeled primary production, frac-hit-induced production losses, and damage remediation in a single continuous model.

# Data Matching - Pressure Interference Testing



Pressure interference trends can be simulated, and quantified, in ResFrac the same way a 'real world' test would be set up. Pressure interference between wells is normally controlled by the pathway, or proppant bridge, created between wells. A fracture connection must take place, either through fracture-to-fracture connections or, more likely, through cased well and fracture connections to allow proppant to bridge over longer distances.

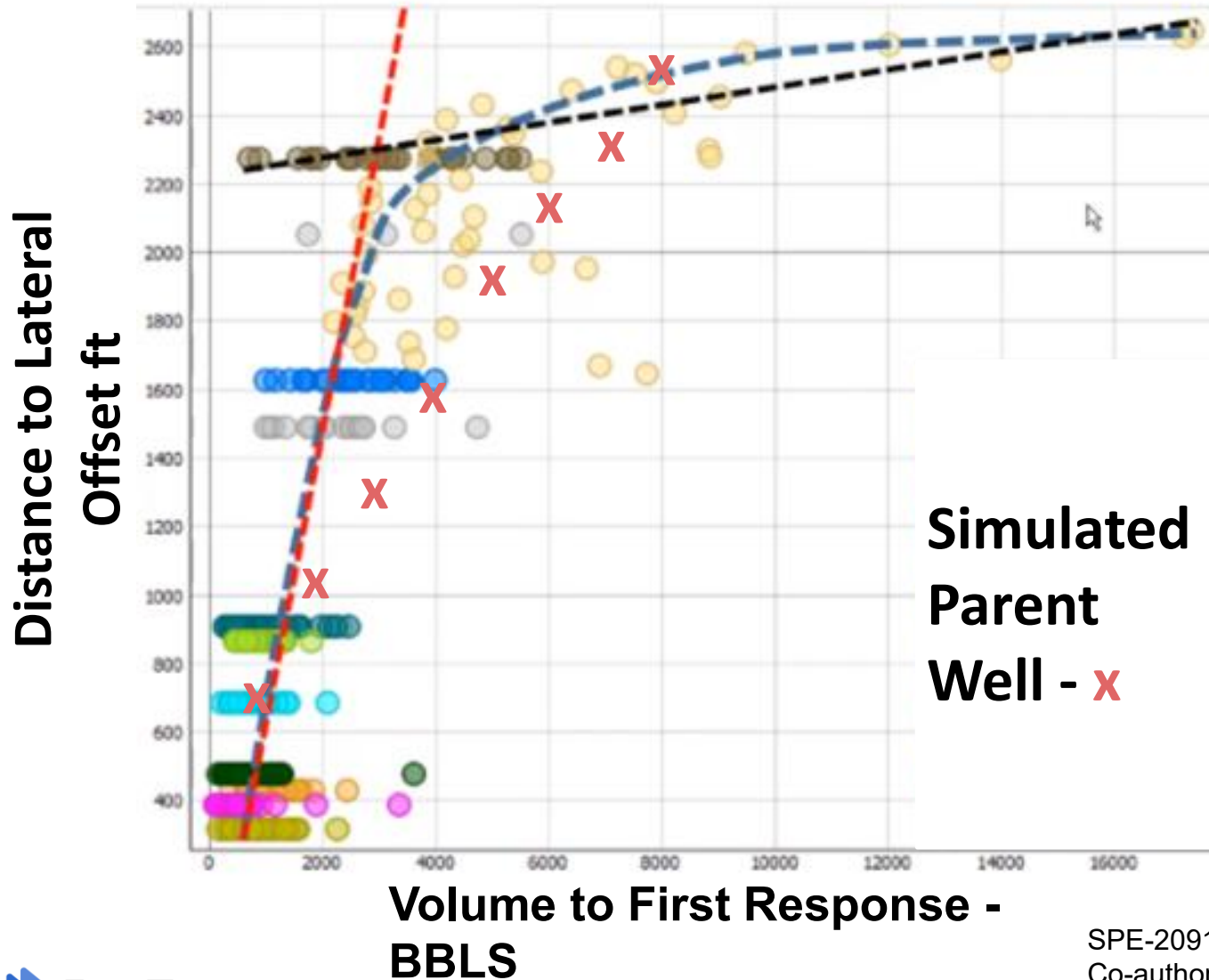
# Data Matching – Tracers



Tracers can be added to any frac fluid as an 'inert' fluid. This fluid can be tracked as it is injected from one well and produced from offset wells. This can't happen without adequate pathways for flow caused by fracture connections.

Albrecht, Magdalene, Borchardt, Shannon, Murphree, Chase, McClure, Mark, and Janz Rondon. "Using Quantitative Tracer Analysis to Calibrate Hydraulic Fracture and Reservoir Simulation Models: A Permian Basin Case Study." Paper presented at the SPE/AAPG/SEG Unconventional Resources Technology Conference, Houston, Texas, USA, June 2022. doi: <https://doi.org/10.15530/urtec-2022-3724108>

# Data Matching – Sealed Wellbore Pressure Monitoring and Fiber



Sealed wellbore pressure monitoring data from offset pads provided data for matching propagation rates and lengths.

A combination of toughness, relative fracture toughness, viscous pressure drop, and pressure dependent perm can be used in the simulator to control the propagation rates.

ResFrac will output the volume to the first response from any 'pair' of wellbores using the 'Volume to First Response Tracker' table.



# Thank You!

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