

*Could the minimum curvature wellbore reconstruction lead to unrealistic wellbore positioning?*

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*A directional step-by-step approach enables to address this issue*



**DrillScan**

September 23<sup>rd</sup> 2010 ISCWSA Meeting – Florence –



**TOTAL**

# Introduction

## *Problem Positioning*

- 👉 In SPE paper 67616 , The minimum curvature is considered as the recommended, usual and worldwide accepted as the common method for wellbore reconstruction.
- 👉 The MWD Error Model and Gyro Error Model are based on the minimum curvature and the sources of errors listed lead to EOU around the wellbore trajectory.
- 👉 There is no error source considered for the position of the wellbore trajectory itself, meaning there is no error source corresponding to the reconstruction method of wellbore trajectory.
- 👉 EOU are therefore constructed on a “minimum curvature trajectory” which could be unrealistic !!
- 👉 The emergence of continuous survey has shown that the real wellbore path trajectory could be largely different from a minimum curvature reconstruction based on spaced survey, in particular while drilling with Motors or RSS system.

*This is also understood under the Slide/Rotate pattern phenomenon*



# Introduction

## *Objectives & Summary*

### **1** Theory of the Step-by-step Approach

*Workflow and Assumptions*

### **2** Case Study

*Results & Comparison between the minimum curvature wellbore placement and the Step-by-step methodology reconstruction*

### **3** Field Validation

*Case study enabled to validate the theory*

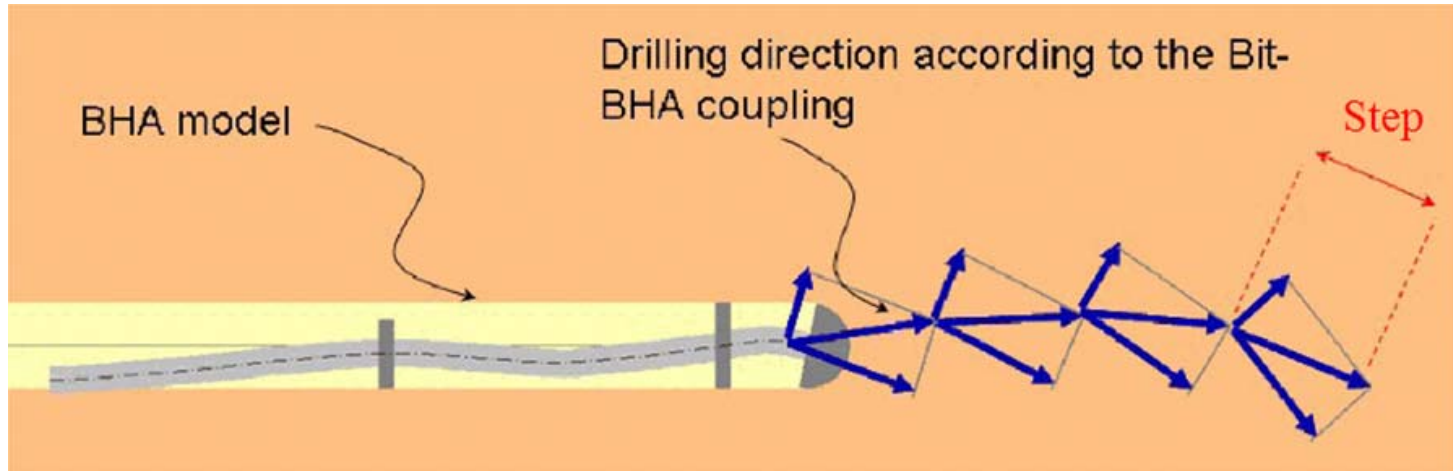
### **4** Open Question

*Should wellbore trajectory be questioned in the ISCWSA Error model ?*



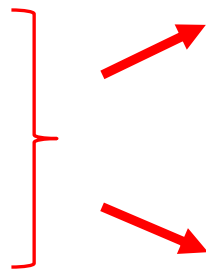
# Directional Drilling : Step by step

## *Approach description*



### Model

- BHA model
- BIT model
- Coupling



### Equilibrium curvature approach

- Global response



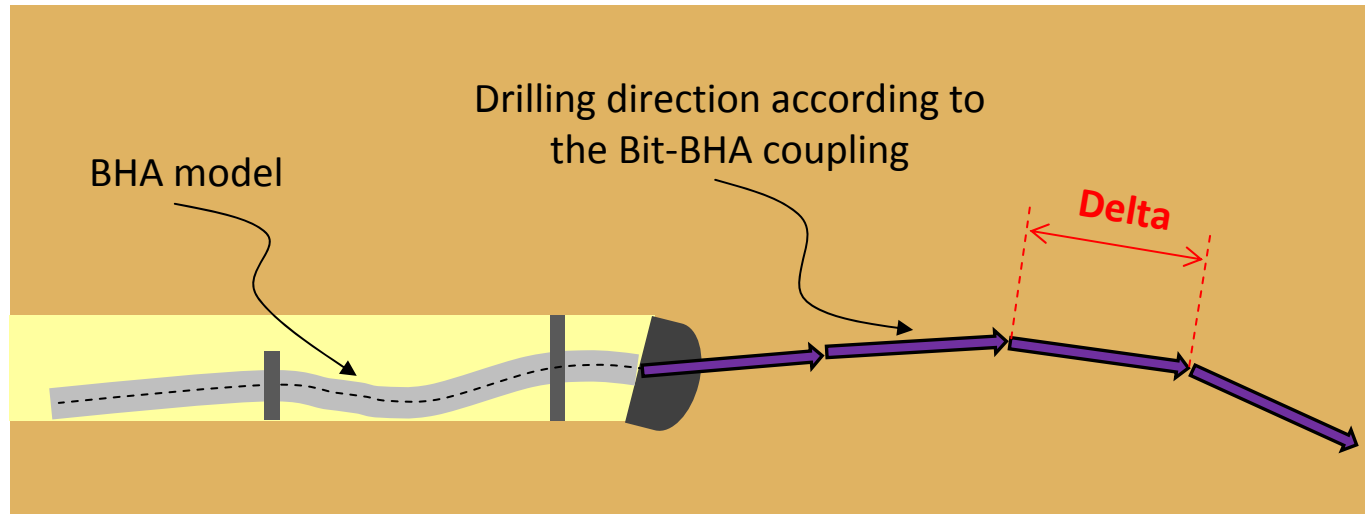
### Step by step approach

- Local response
- Hole quality



# Directional Drilling : Step by step

## *Coupling BHA & Bit Models – Step by step calculation*



### Step by Step process for a more realistic directional approach

- *New drilling direction computation performed at each step*



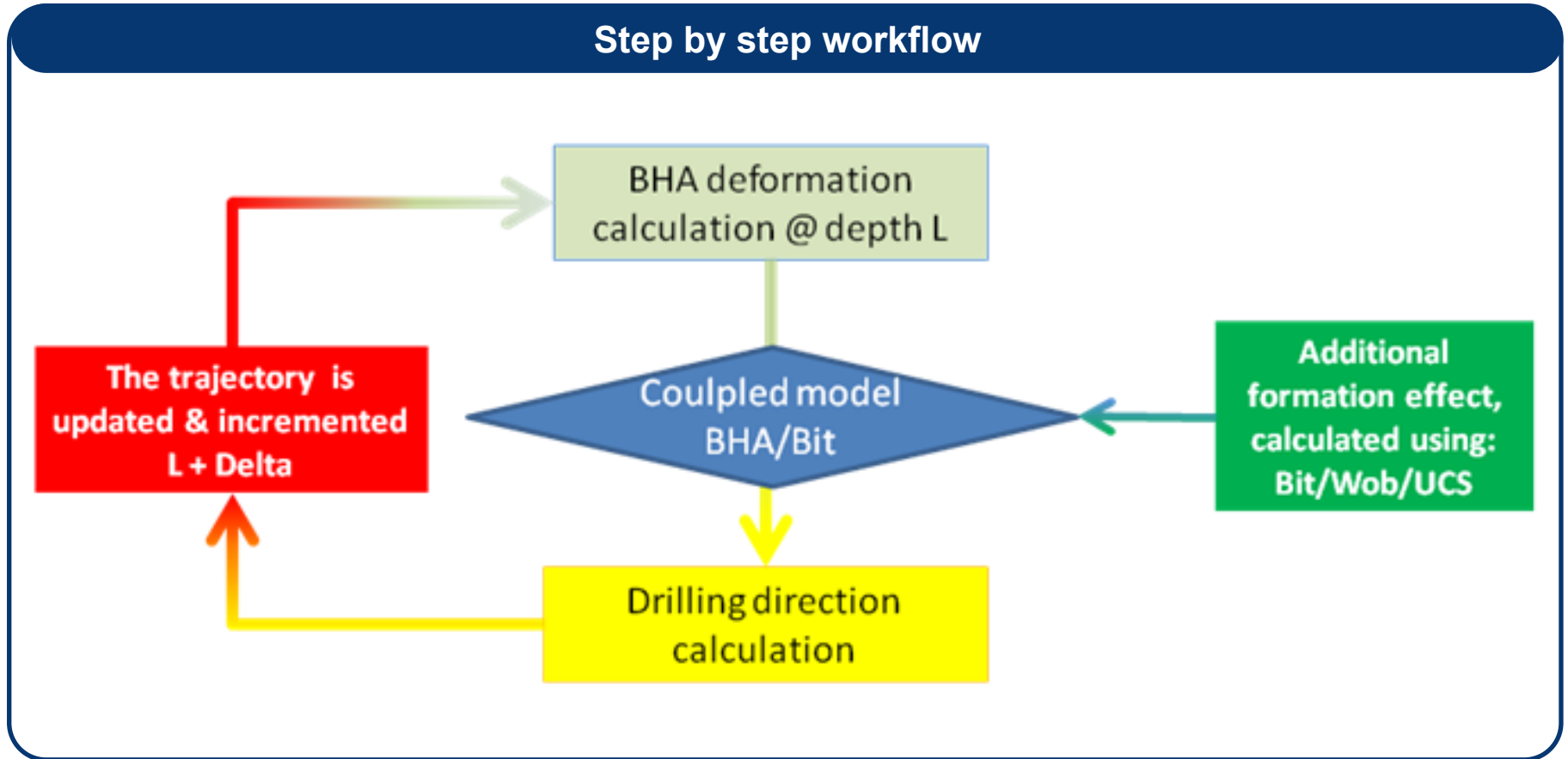
### Local doglegs calculation by taking into account local variations

- *Interbedded & anisotropic formations*
- *VGS, Steerable Motor & RSS settings modification*
- *WOB fluctuation*
- *Hole Overgauge / Caving effect*
- *Side tracks*



# Directional Drilling : Step by step

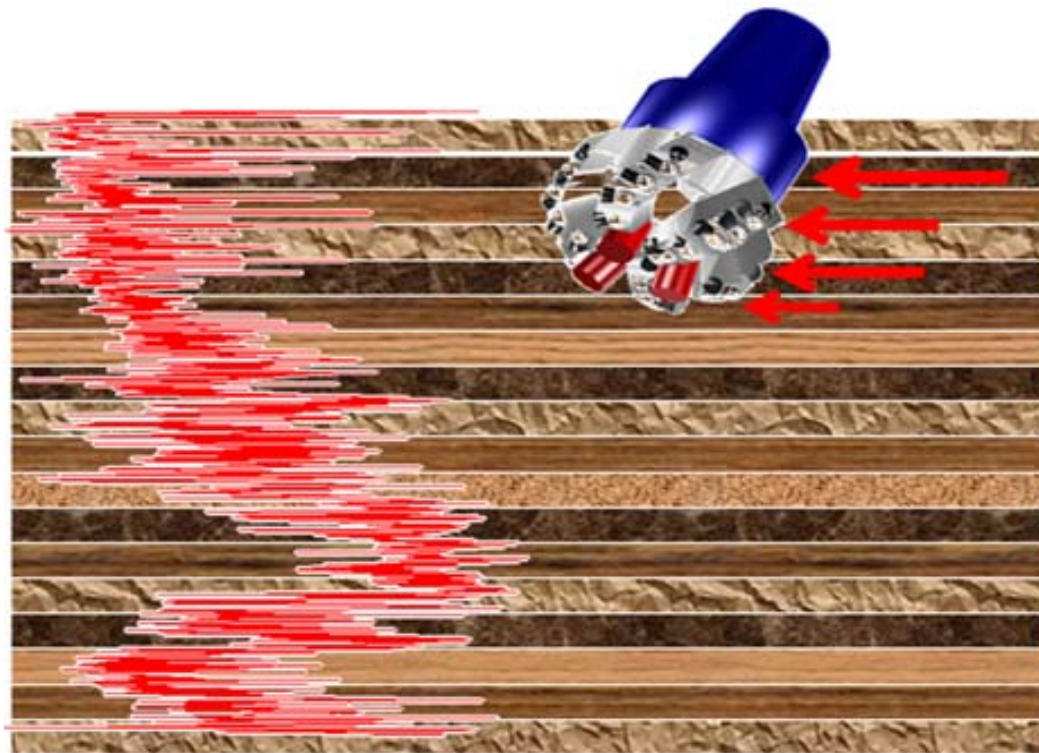
## *Coupling BHA & Bit Models – Step by step calculation*



# Directional Drilling : Step by step

## *Coupling BHA & Bit Models – Step by step calculation*

### Formation Anisotropy – Laminated Formations



*Lateral forces  
applied on the bit  
because of the rock  
hardness variation*

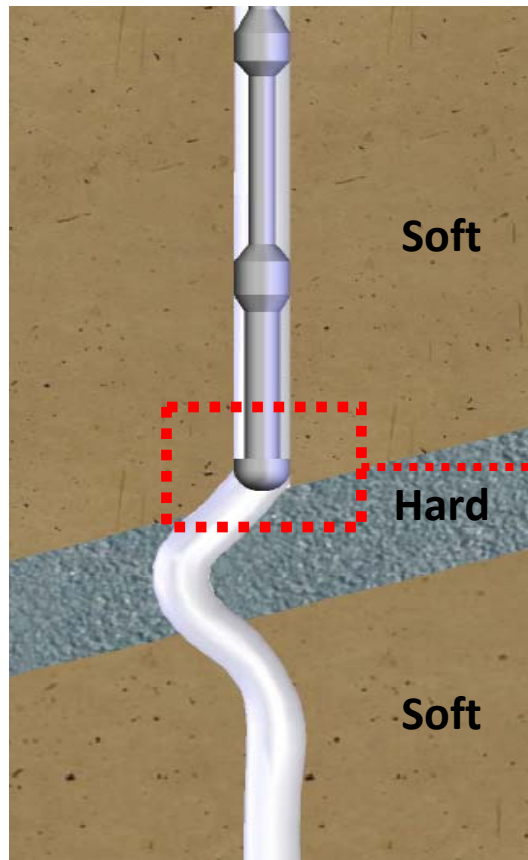
*UCS variation*



# Directional Drilling : Step by step

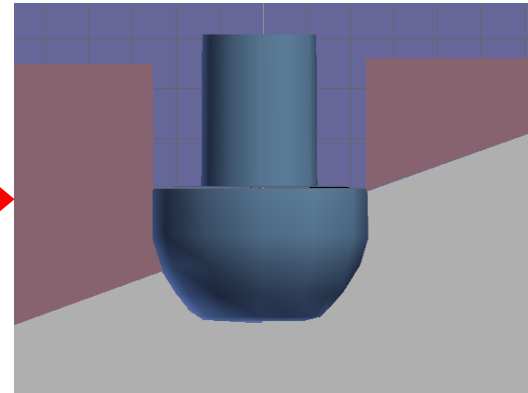
## *Coupling BHA & Bit Models – Step by step calculation*

### Formation Anisotropy – Interbedded Formations

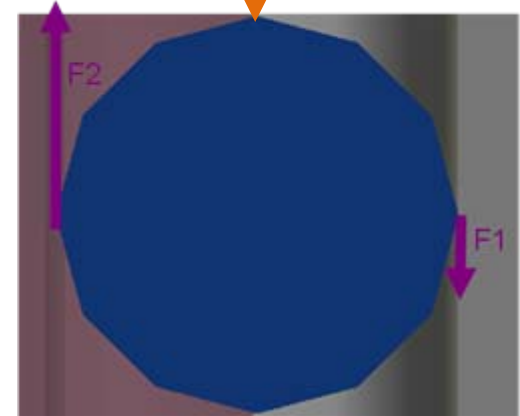


**Interbedded Formations**

**Interface  
zoom**



***Sudden Lateral force variation when passing  
the interface between formations***

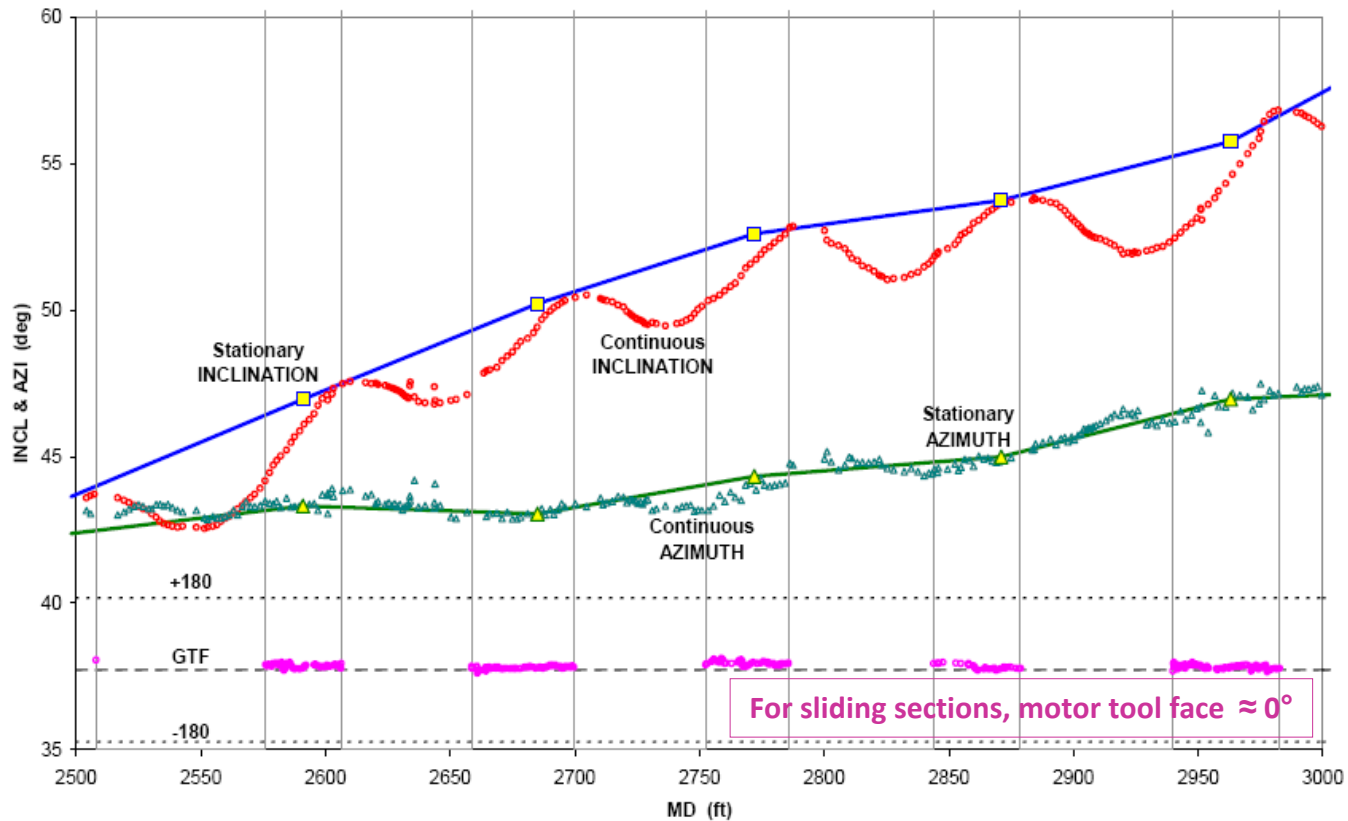




# Directional Drilling : Step by step

## *Application – Steerable motor*

### Comparison between Stationary & Continuous surveys



# 1 Theory of the step by step approach

*Workflow and Assumptions*

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*Case study enabled to validate the theory*

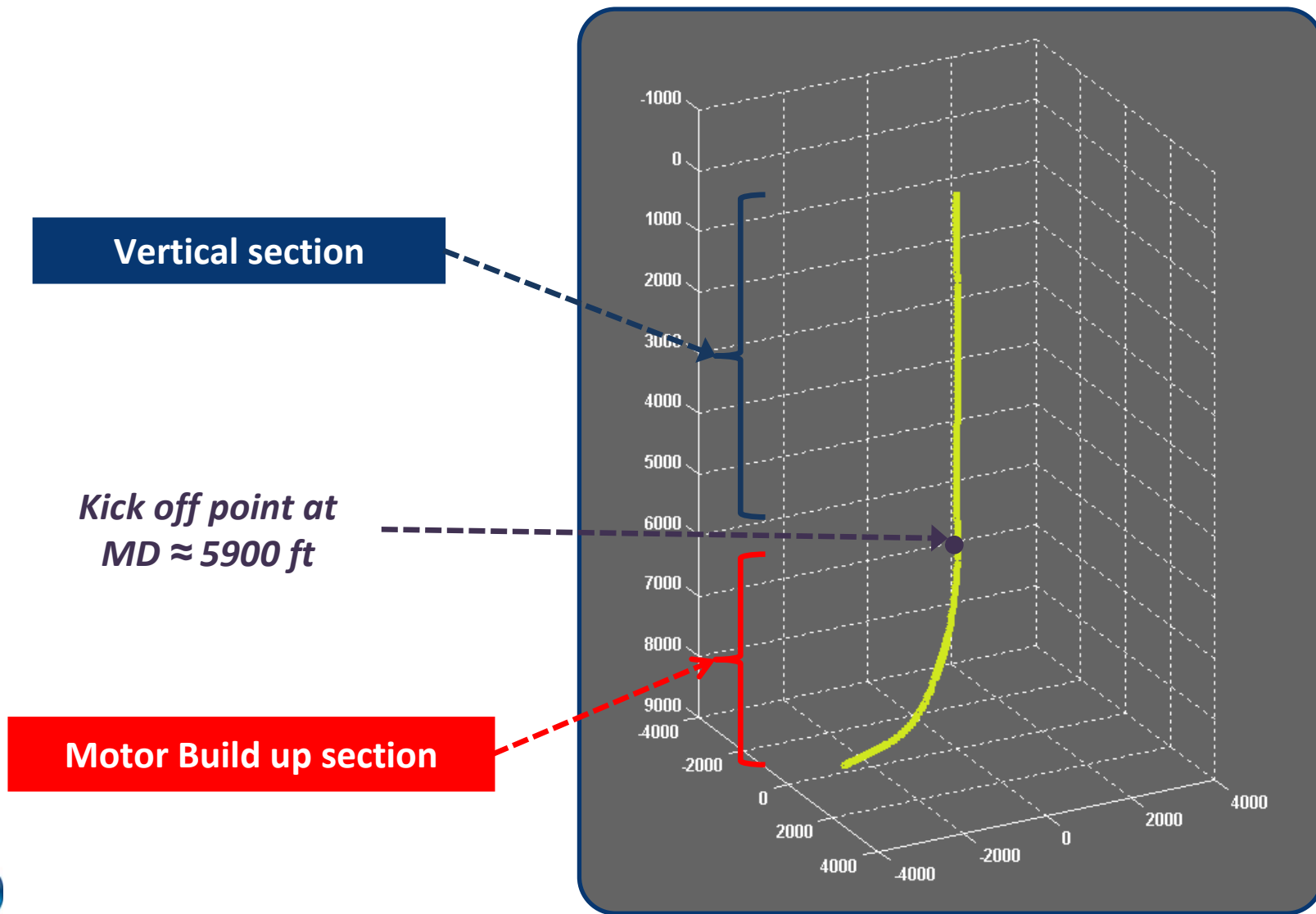
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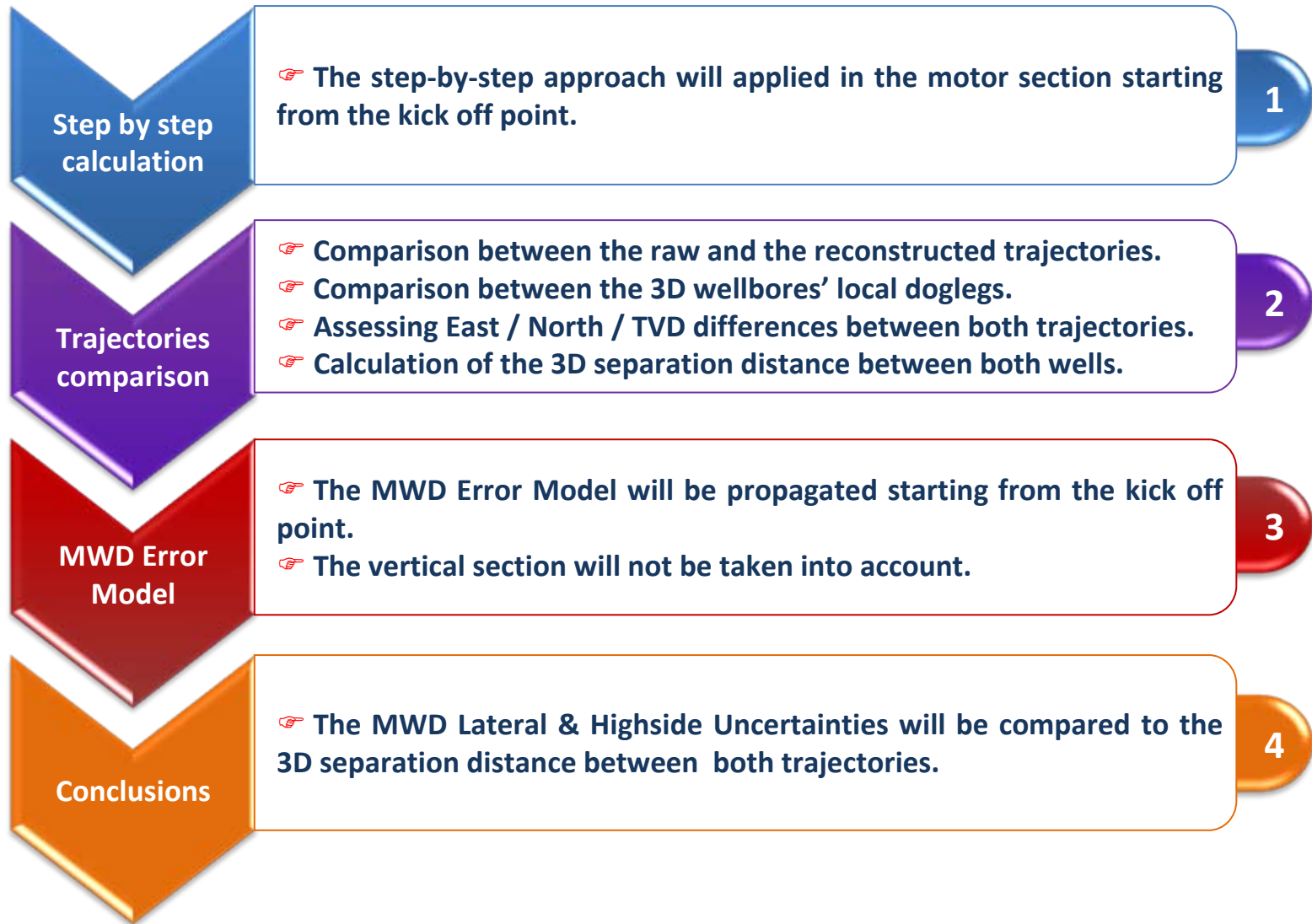
# Case Study

## Trajectory Presentation



# Case Study

## Calculations Workflow

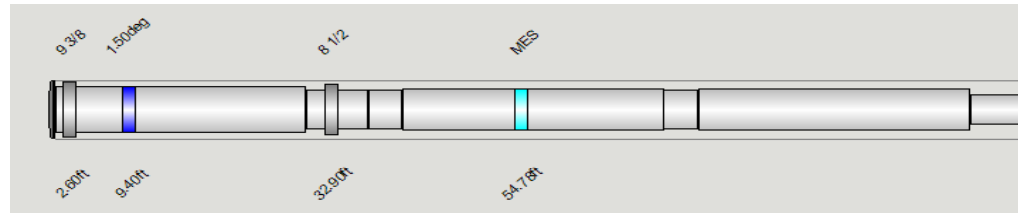


# Case Study

## Step-by-step Calculation – Slide & Rotate Pattern

Original survey – 100ft spaced survey

MD	Inclination	Azimuth
7468.00	38.30	154.40
7554.00	39.50	153.70
7649.00	41.20	153.60
7749.00	43.90	153.60
7842.00	46.30	153.40
7940.00	50.10	152.70



### Comparison between raw & step by step calculated inclination

#### Sag Management

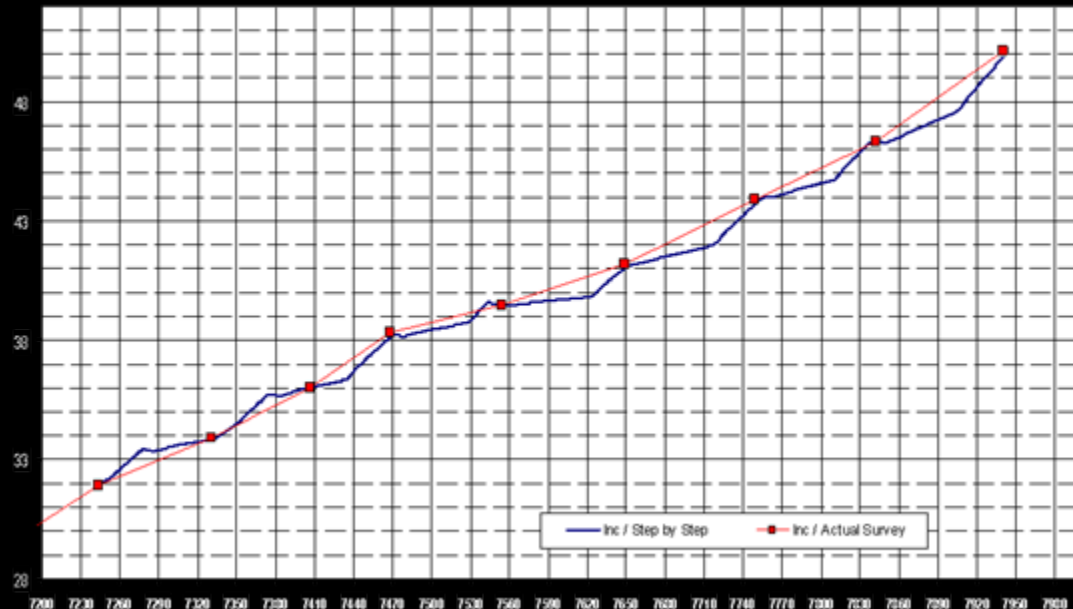
Correct the inclination by the BHA deflection at the sensor position at the given survey.

#### Slide Rotate pattern

Evaluate the local dog leg between survey stations due to the Motor BHA behavior. Computation was done with a step by step directional BHA Management analysis

Original Slide sheet

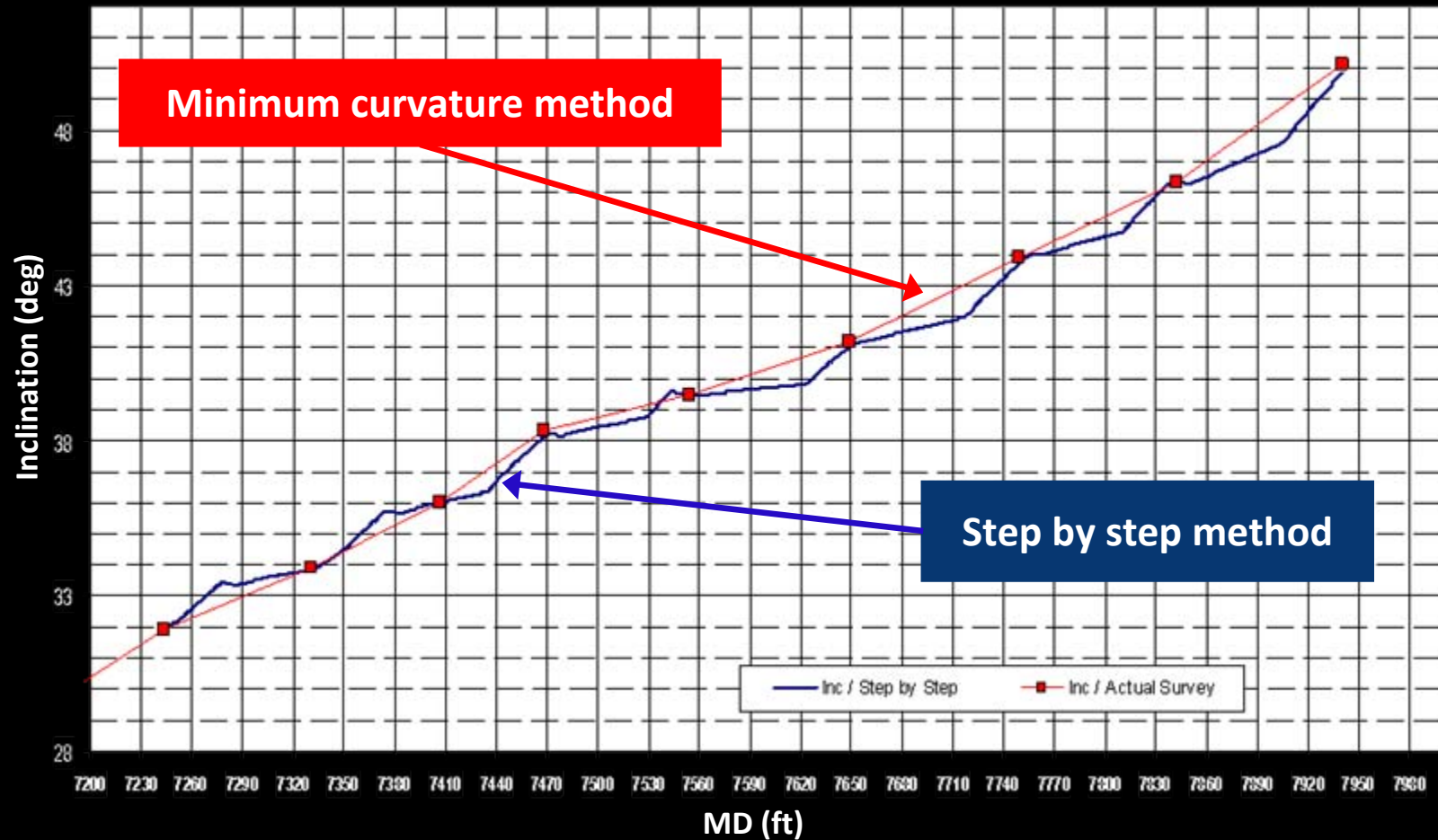
MD	TF	MD	Incl.	Azim.
7718	H.S	7749	43.9	153.6
7750	45			
7755	Rot			
7773	Rot			
7811	H.S	7842	46.3	153.4
7841	Rot			
7904	H.S	7940	50.1	152.7
7944				



# Case Study

## Step-by-step Calculation – Slide & Rotate Pattern

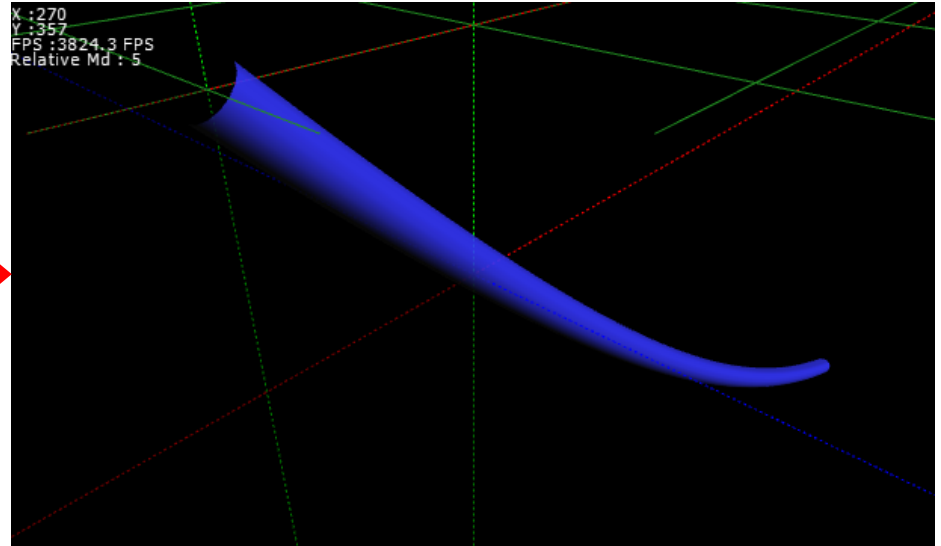
Comparison between raw & step by step calculated inclination



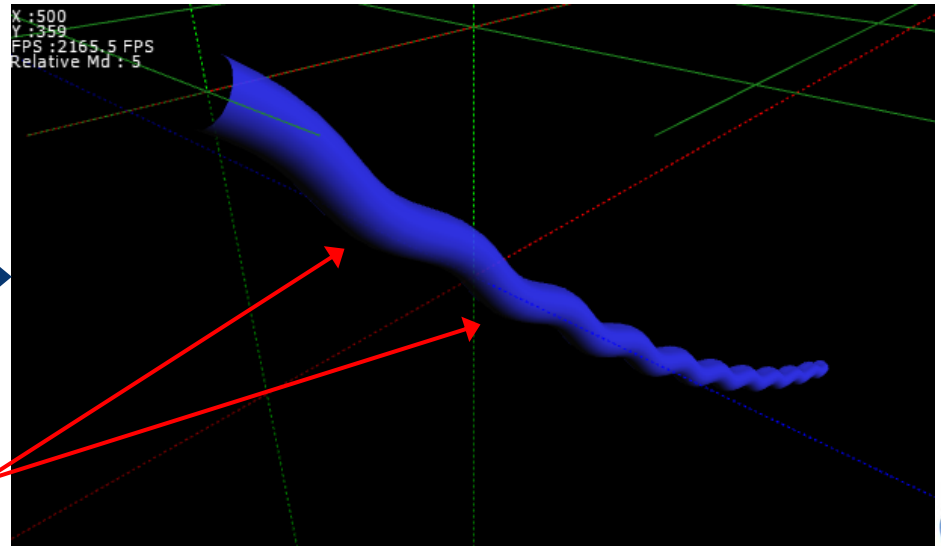
# Case Study

## Trajectories Comparison – 3D Local doglegs comparison

Trajectory reconstructed using  
Minimum curvature method



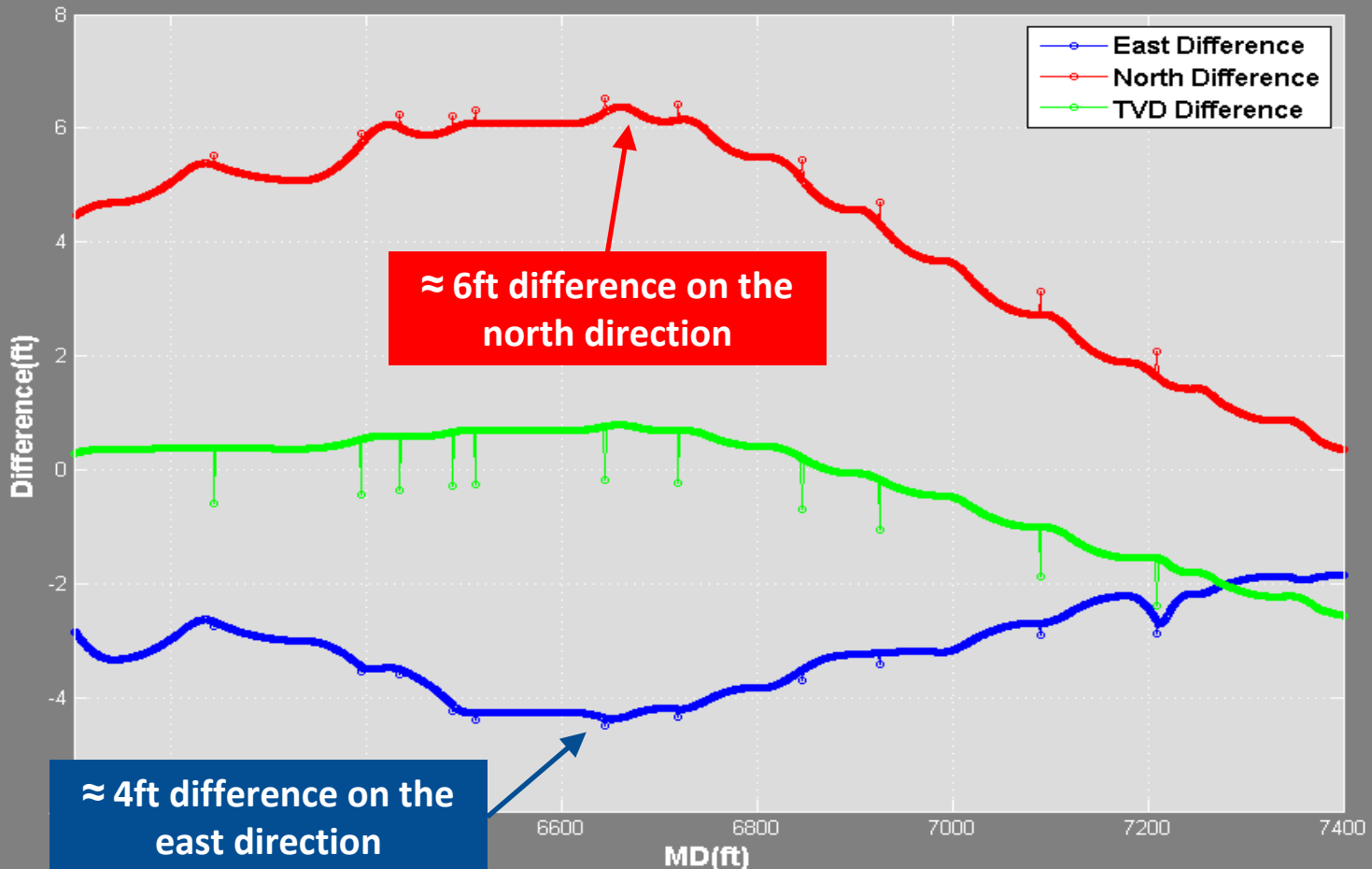
Trajectory reconstructed using  
Step by step method



# Case Study

## Trajectories Comparison – Impact on well positioning

Evolution of the North & East difference between raw and reconstructed trajectories

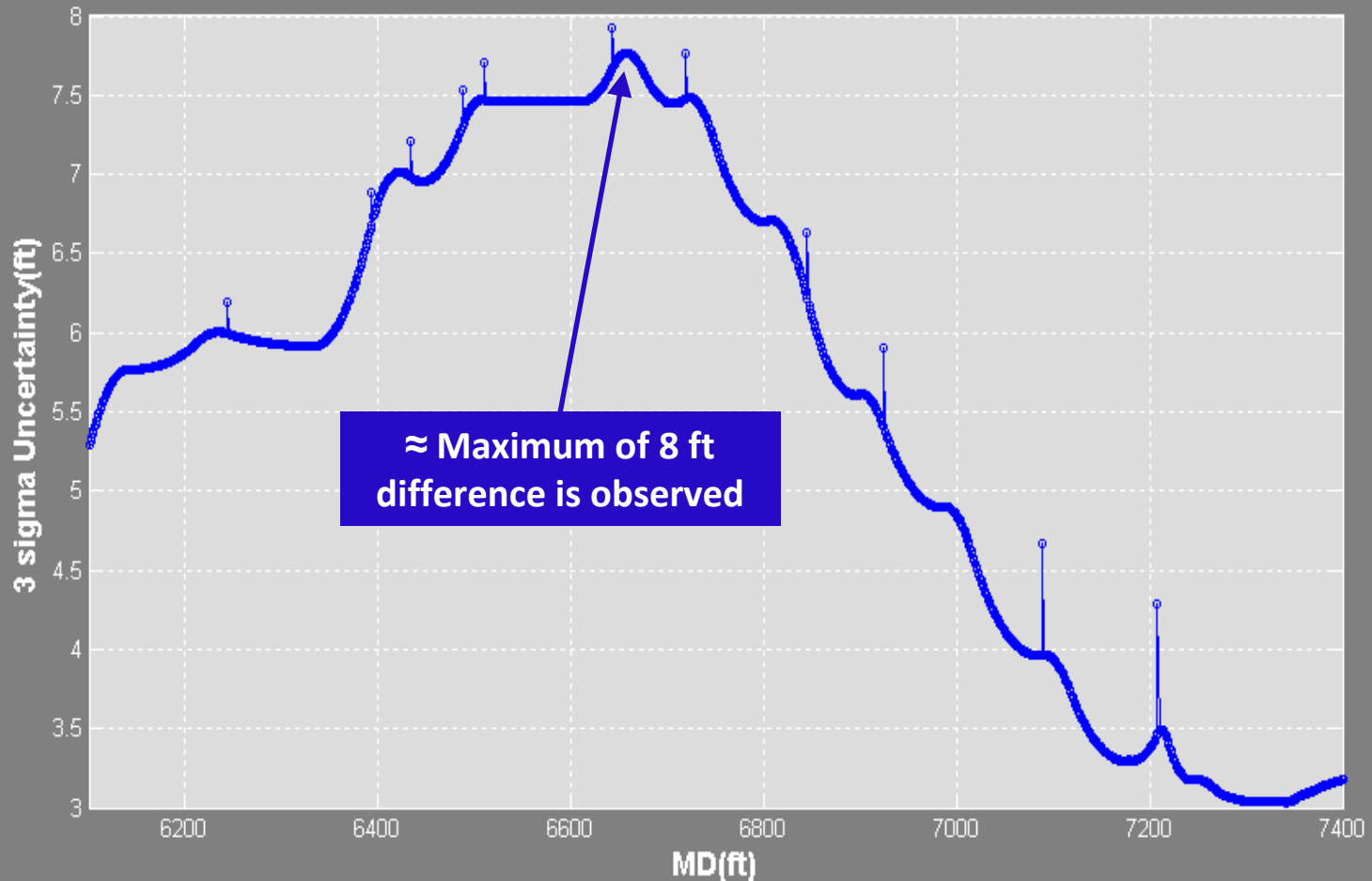




# Case Study

## Trajectories Comparison – 3D Separation distance

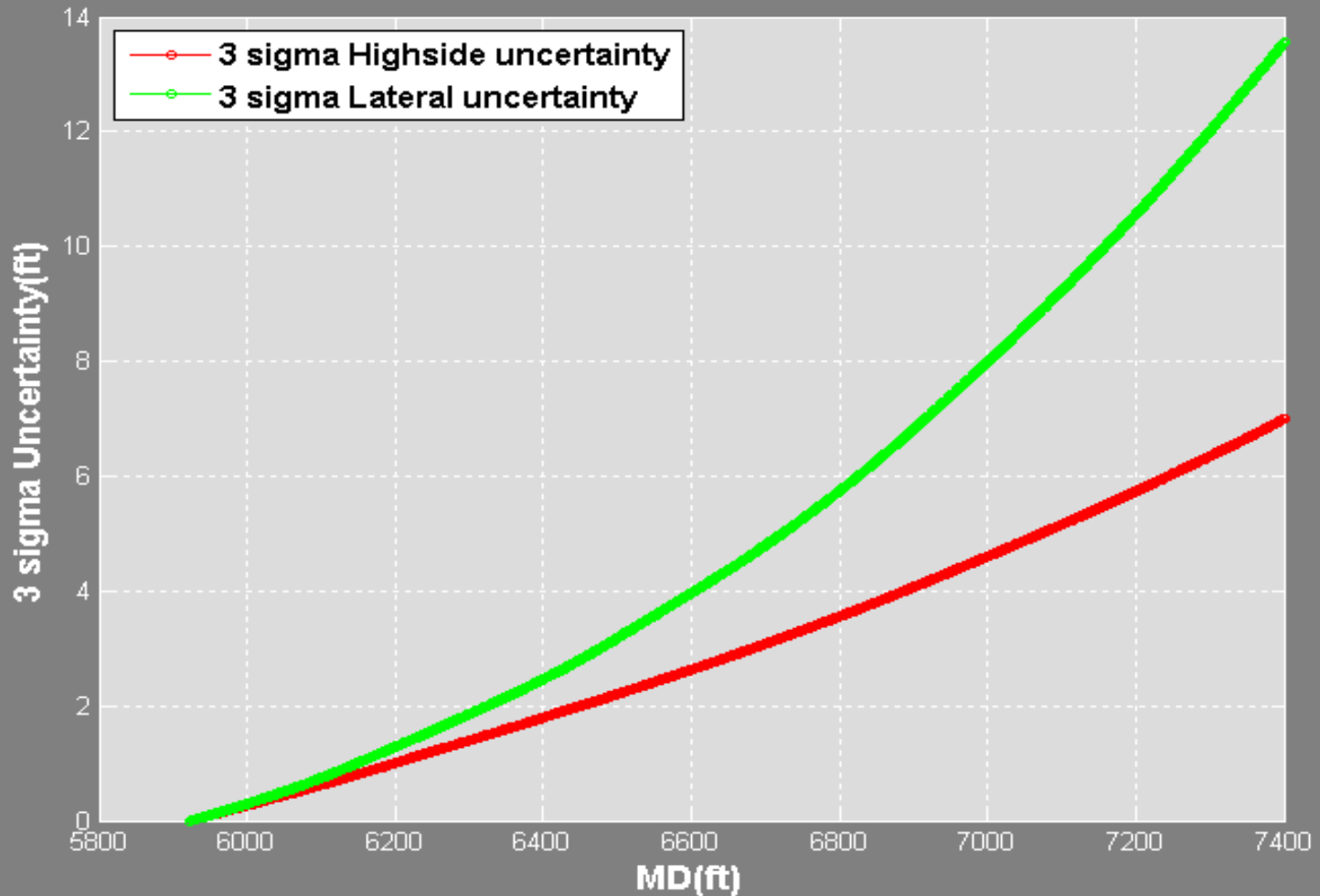
3D separation distance between the raw and the reconstructed trajectories



# Case Study

## *MWD Error Model Propagation*

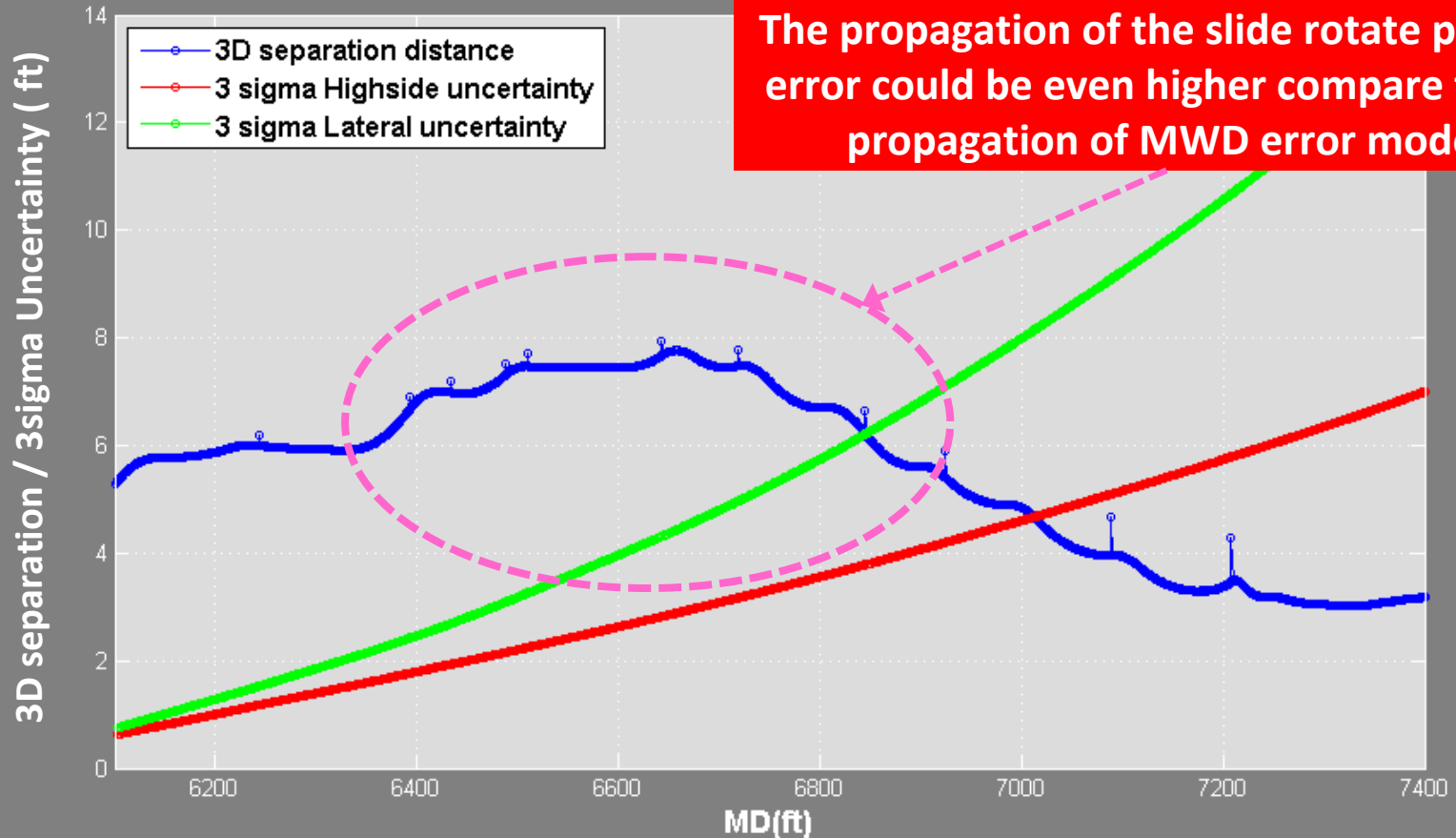
MWD Error Model propagation starting from the kick off point



# Case Study

## Comparison between 3D Separation & MWD Uncertainty

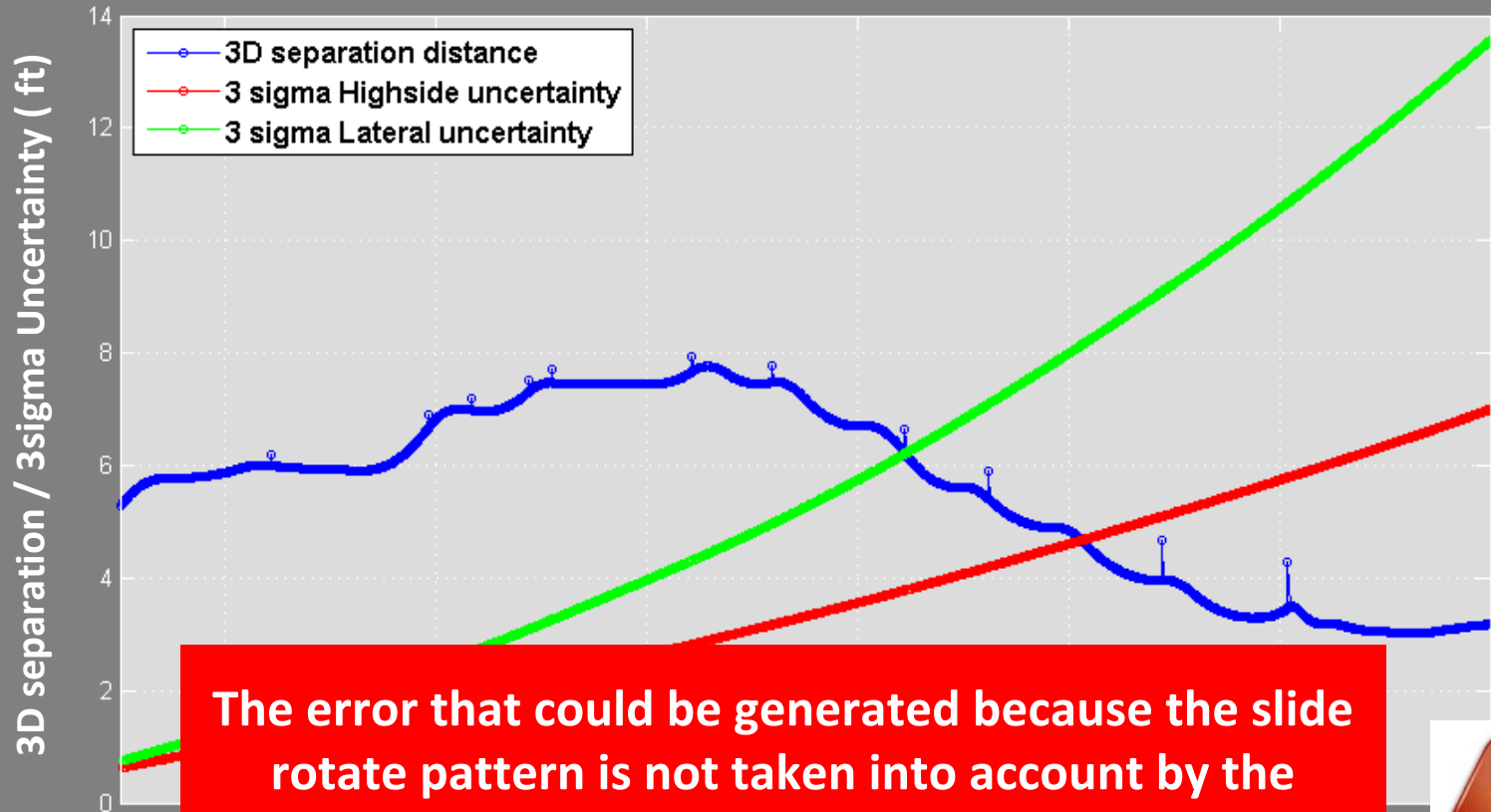
Comparison between 3D separation and the MWD uncertainty propagation



# Case Study

## Comparison between 3D Separation & MWD Uncertainty

Comparison between 3D separation and the MWD uncertainty propagation



**The error that could be generated because the slide rotate pattern is not taken into account by the current Error Model even it has the same magnitude level as the MWD Error budget!!**



# 1 Theory of the step by step approach

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# Field Validation

*Magnetic Ranging To support step by step approach*

## Magnetic Ranging Operation

Reference Well

Ranging Tool

Minimum distance between both wells

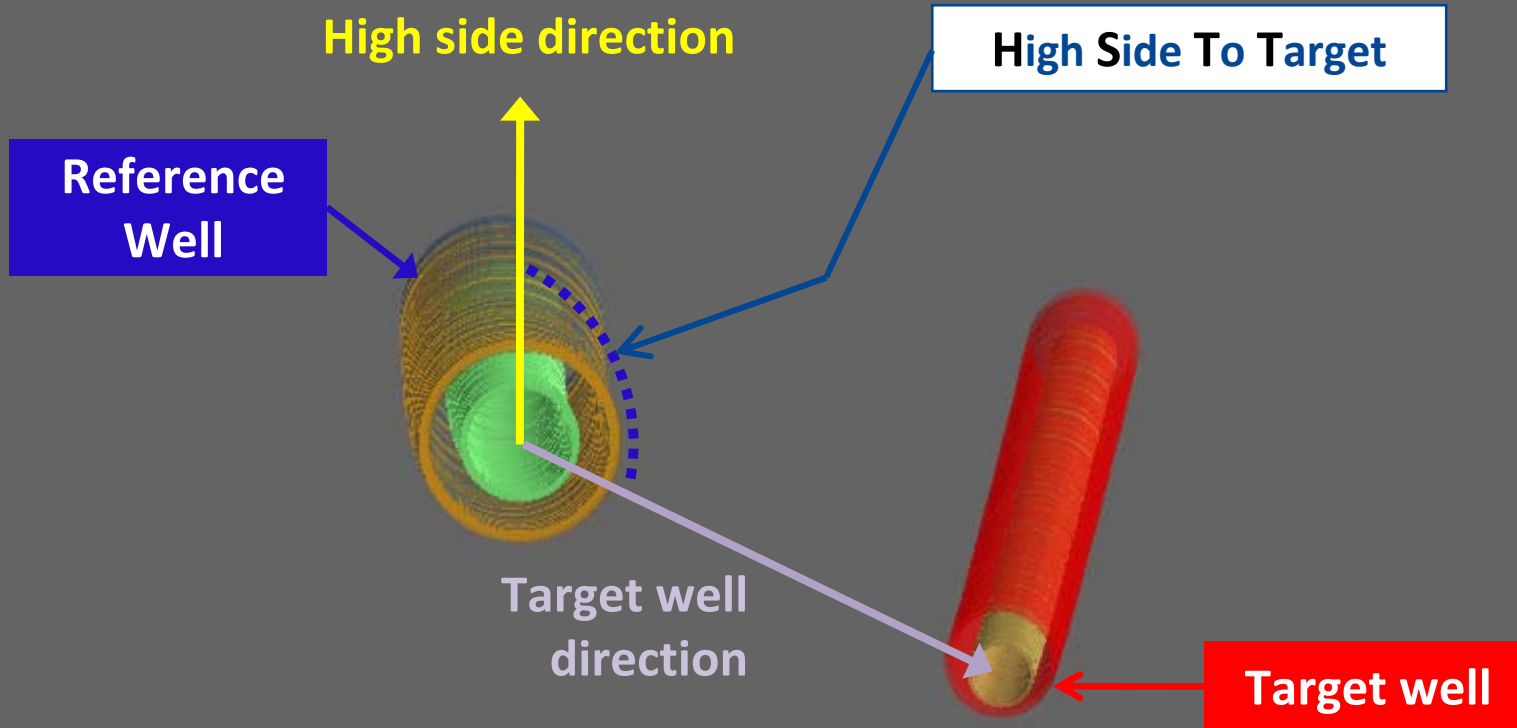
Target well



# Field Validation

*Magnetic Ranging To support step by step approach*

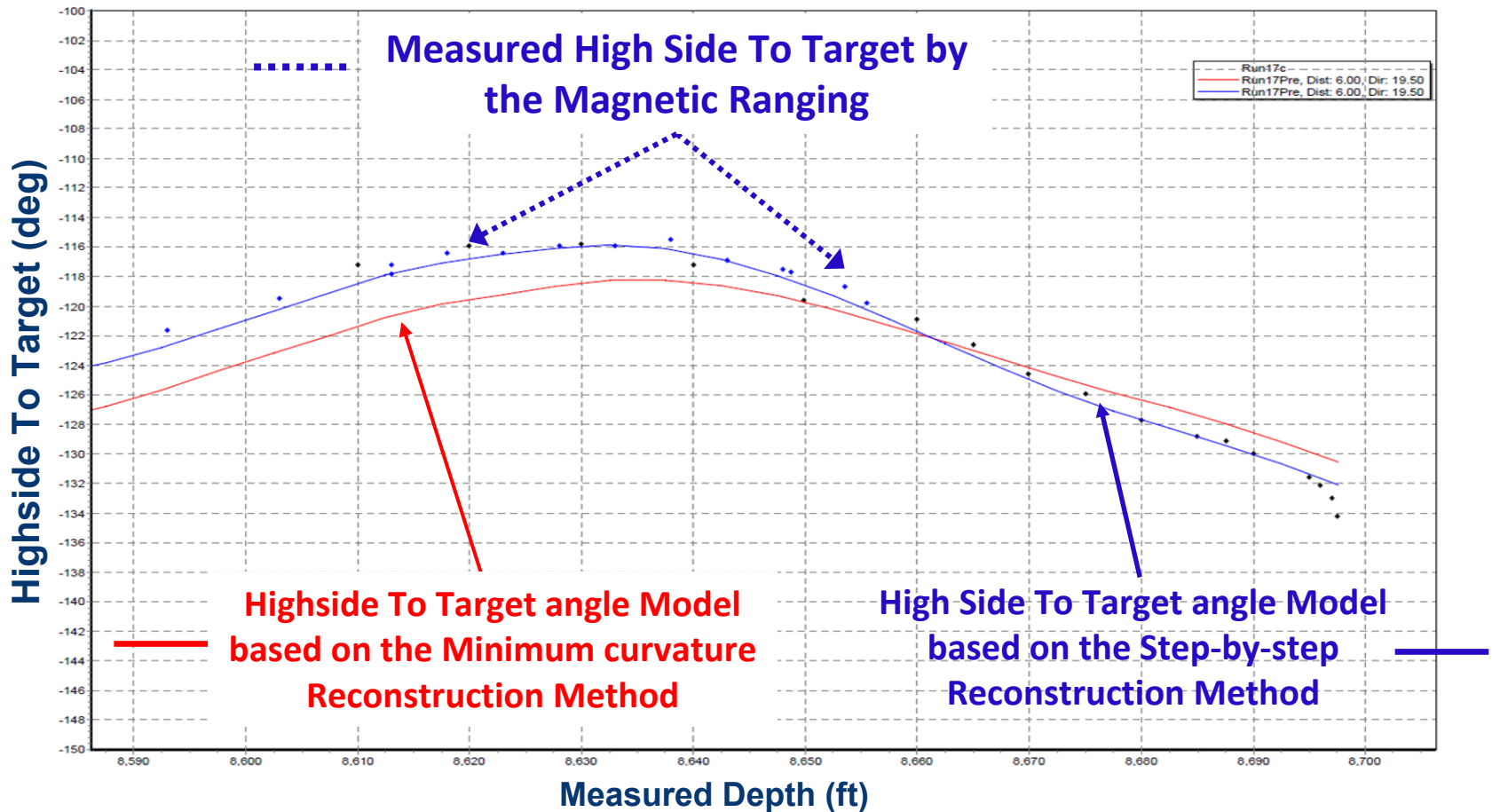
“High Side To Target” angle between both wells



# Field Validation

## *Magnetic Ranging To support step by step approach*

Highside to Target Angle between the Reference & Target wells – Model versus Data





# Field Validation

## *Magnetic Ranging To support step by step approach*

- Minimum curvature Trajectory Model could not fit the data
- High Magnetic Ranging Uncertainty because the trajectory is not adequate.
- The Step-by-step trajectory has allowed better fitting of the measured data
- If Minimum curvature Trajectory was kept, Side-track or reduced spacing ranging would have been required



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*Should wellbore trajectory be questioned in the ISCWSA Error model ?*



# *Open Discussion*

- 👉 Should wellbore trajectory construction be questioned in the ISCWSA Error model ?
- 👉 Should the Step-by-step approach be recommended for the high-accuracy wells ?
- 👉 What are the recent enhancements and evolutions of the continuous surveying ?



# Thank you for your attention

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## Any Questions?



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**TOTAL**