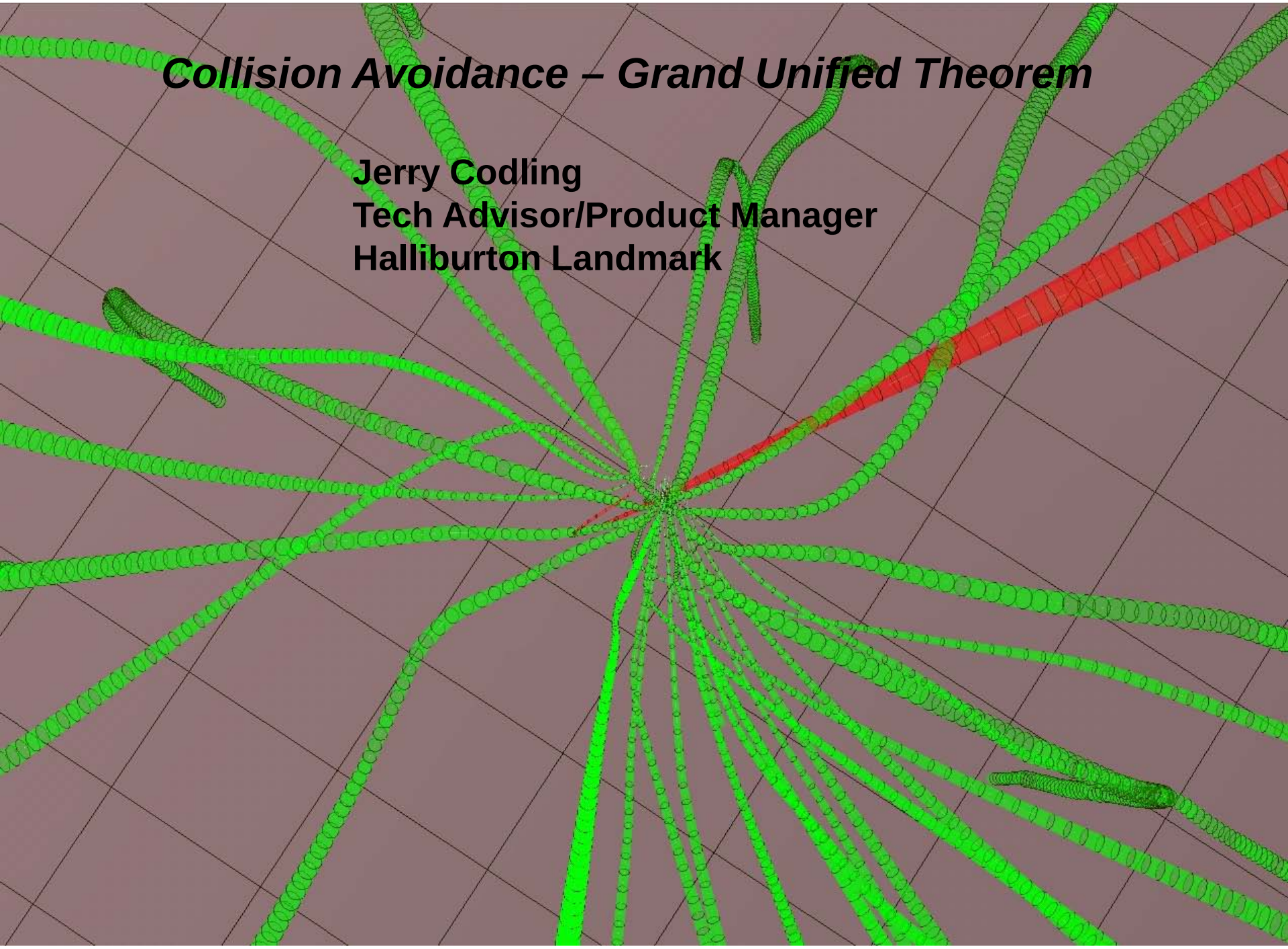
Collision Avoidance – Grand Unified Theorem



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Minimum Separation based on Risk

- What we want is a decision point – What is the minimum safe distance to drill close to an adjacent well?

- Variations (ratios) on the above

- Planning margin – Give the Directional Driller a margin to allow for normal steering close to the planned trajectory.

- Dispensation (ratios or risk level) Lower levels of low risk wells or ones that have been depressured.

What are the Alternatives?

- Current: Separation Factor / Major Risk / Combined Covariance Methods (Statoil/OSF)

  – good for near surface

  - very pessimistic for deep well crossings

  - misleading values for high angle crossings

- Advanced: Risk based

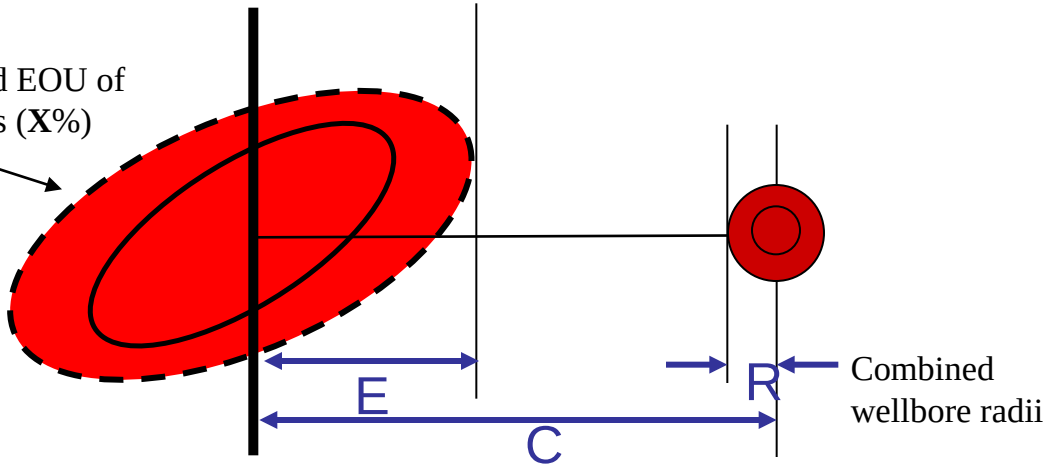
  - good for high angle, deep crossings

  - optimistic for parallel wells – near surface

  - Minimum separations fade out (dilution) at low risk levels

Definition of Terms
Separation Factor Formulae

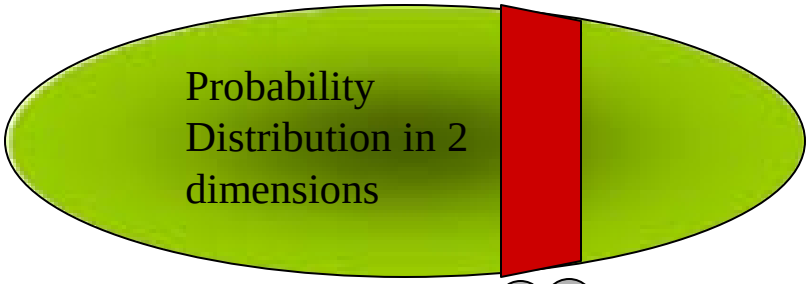
$$S.F. = \frac{C - R}{E}$$



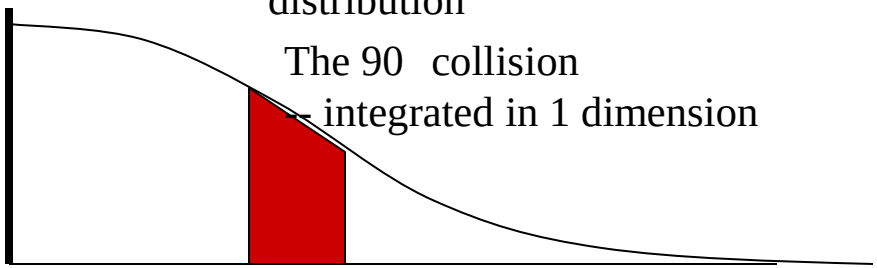
- View from Traveling Cylinders Plane
- C = Minimum Separation or Centre to Centre distance
- E = Combined Ellipsoid (sum covariance) dimension in direction between wellbores (other suitable vector)
- R = Combined Radii = (Hole Size of Reference Wellbore + Casing Size of Offset wellbore) / 2

Types of Collision

Perpendicular - deep



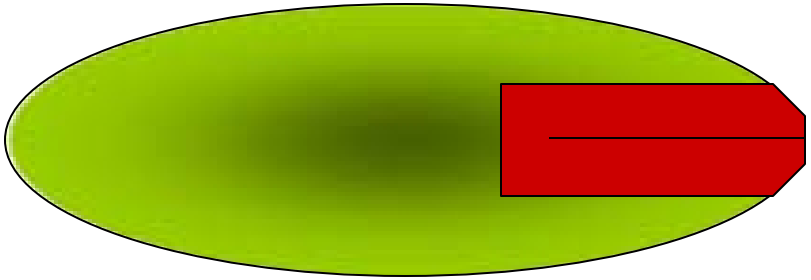
Integration of probability distribution

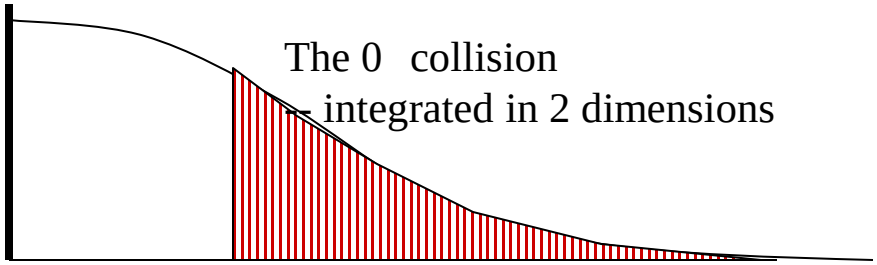


The 90 collision
-- integrated in 1 dimension

Parallel - shallow

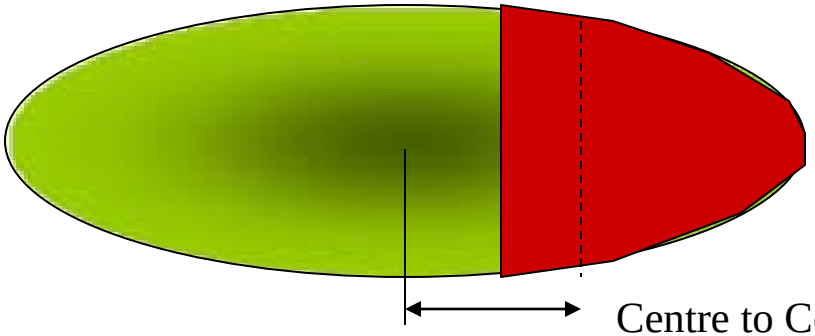
Casing + Hole Radii

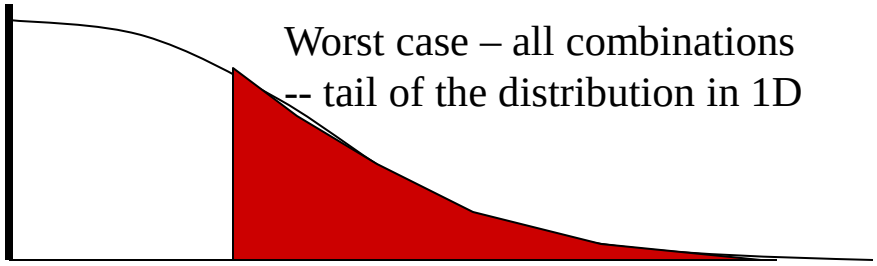




The 0 collision
-- integrated in 2 dimensions

All over the place – worst case





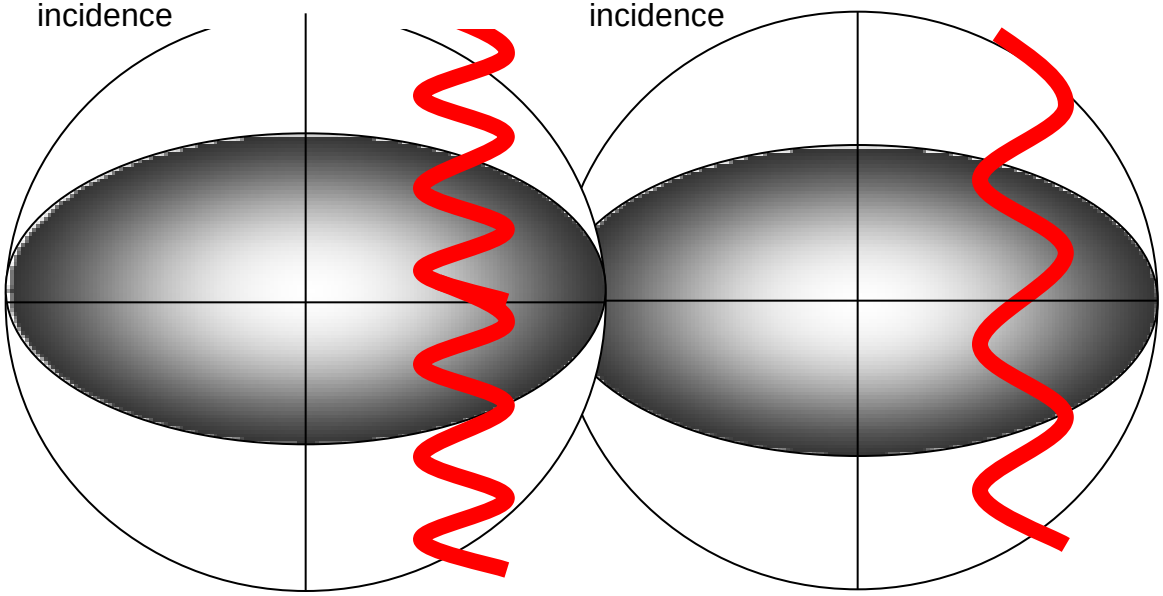
Worst case – all combinations
-- tail of the distribution in 1D

Centre to Centre distance

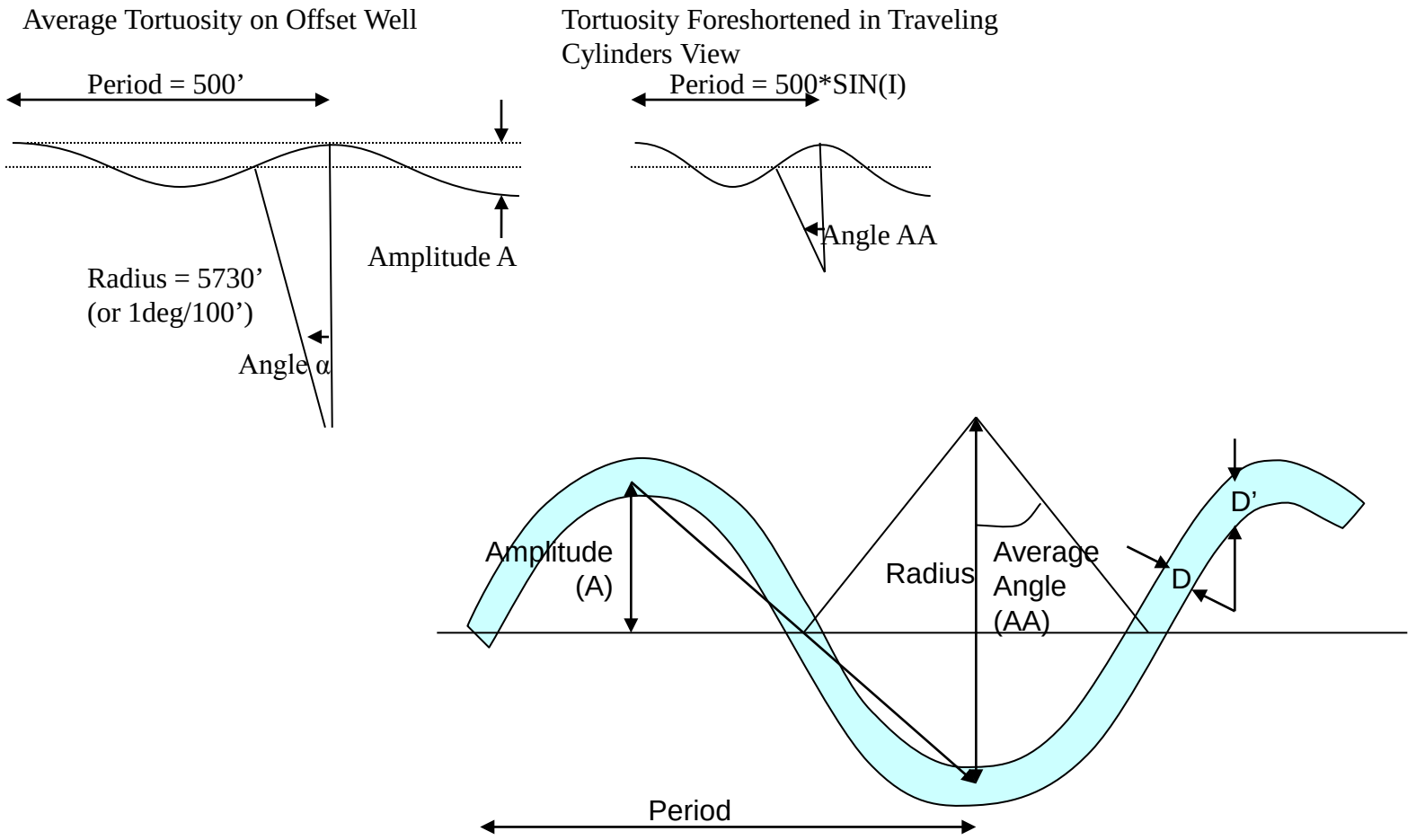
Multiple Hits - Tortuosity

Traveling Cylinder Plot Showing Wellbore with tortuosity at 1 degree incidence

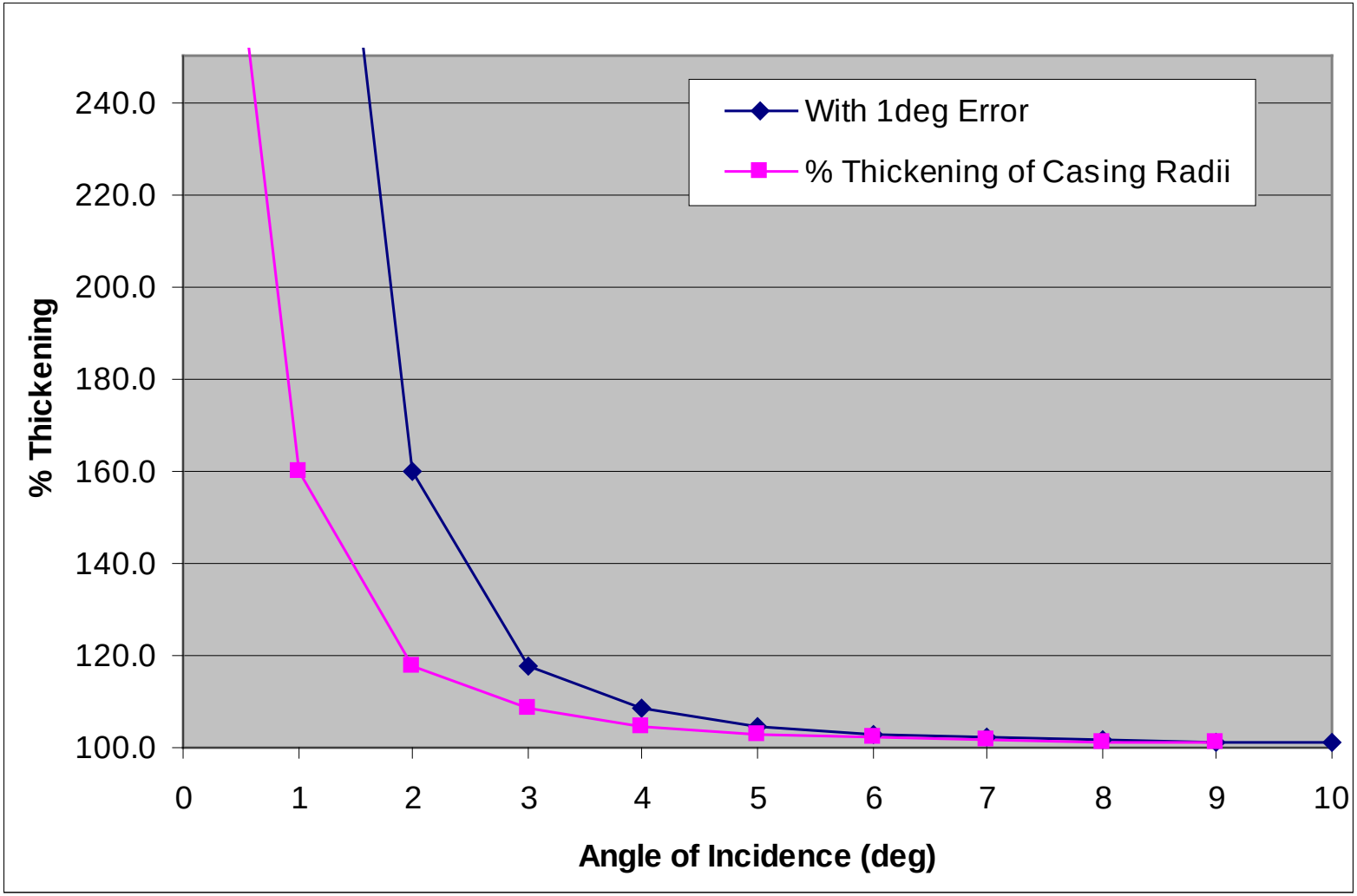
Traveling Cylinder Plot Showing Wellbore with tortuosity at 2 degree incidence



Thickening


Average Tortuosity on Offset Well
Period = 500’
Amplitude A
Radius = 5730’
(or 1deg/100’)
Angle α
Tortuosity Foreshortened in Traveling Cylinders View
Period = 500*SIN(I)
Angle AA
Amplitude
(A)
Radius
Average
Angle
(AA)
D
D’
Period

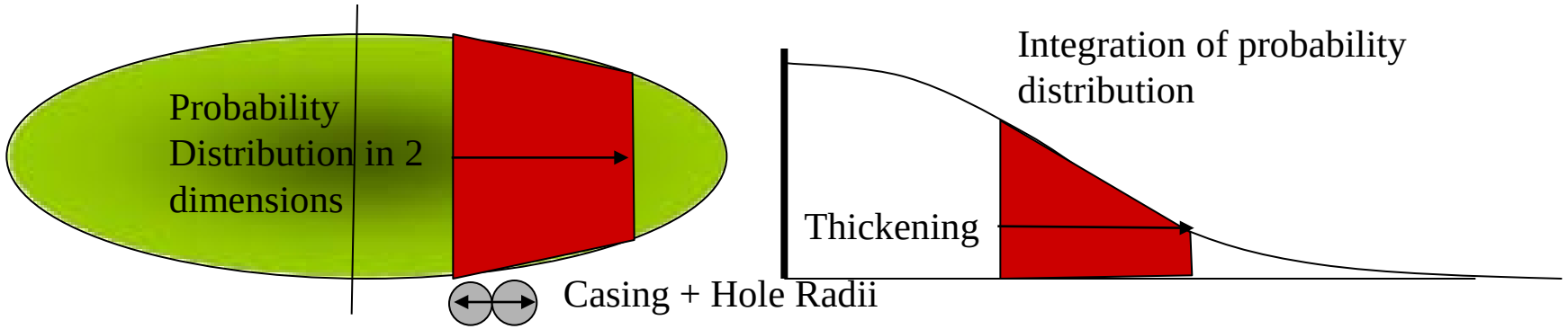
The Effect of Convergence Angle



Minimum Separation based on Risk Level

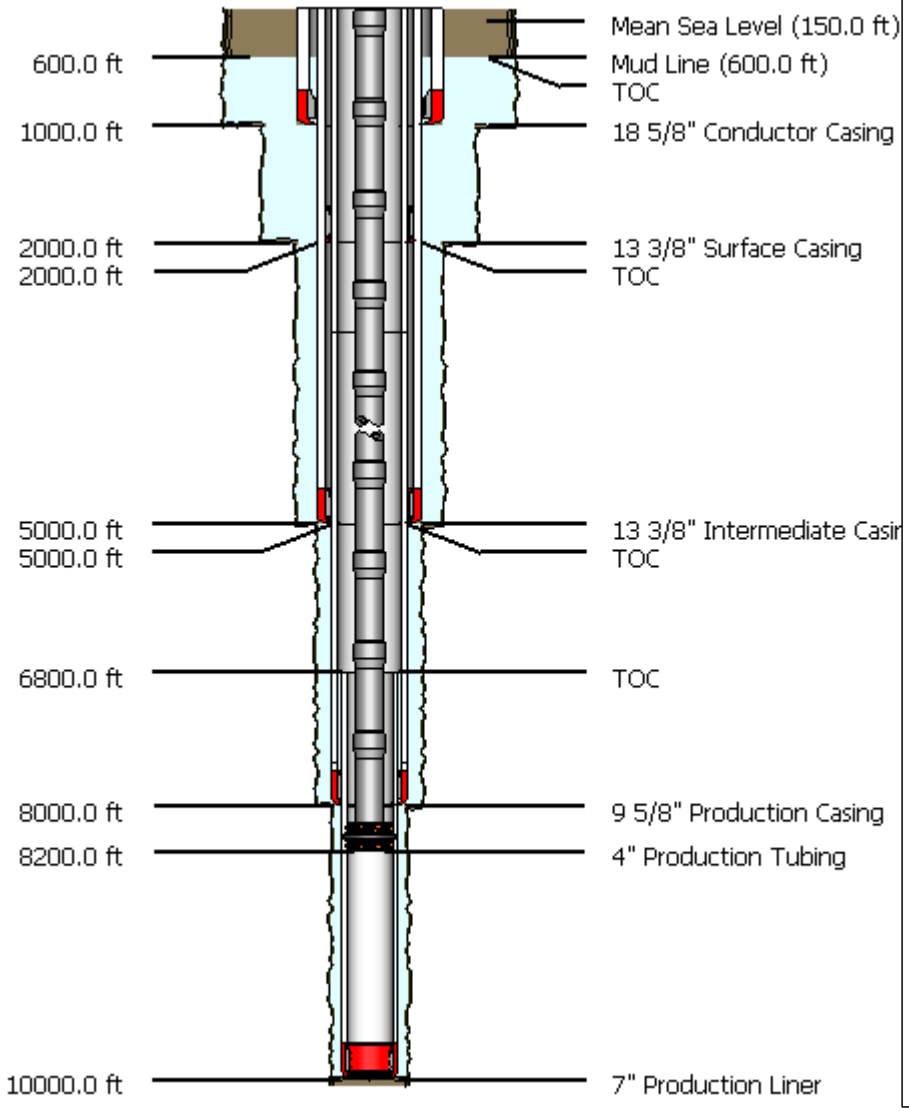
- Risk = NormSDist((Separation+Casing*Thickening) /EllipseDimension) – NormSDist(Separation /EllipseDimension)

- Minimum Separation = Inverse of the above (have to iterate, start using NormSInv)

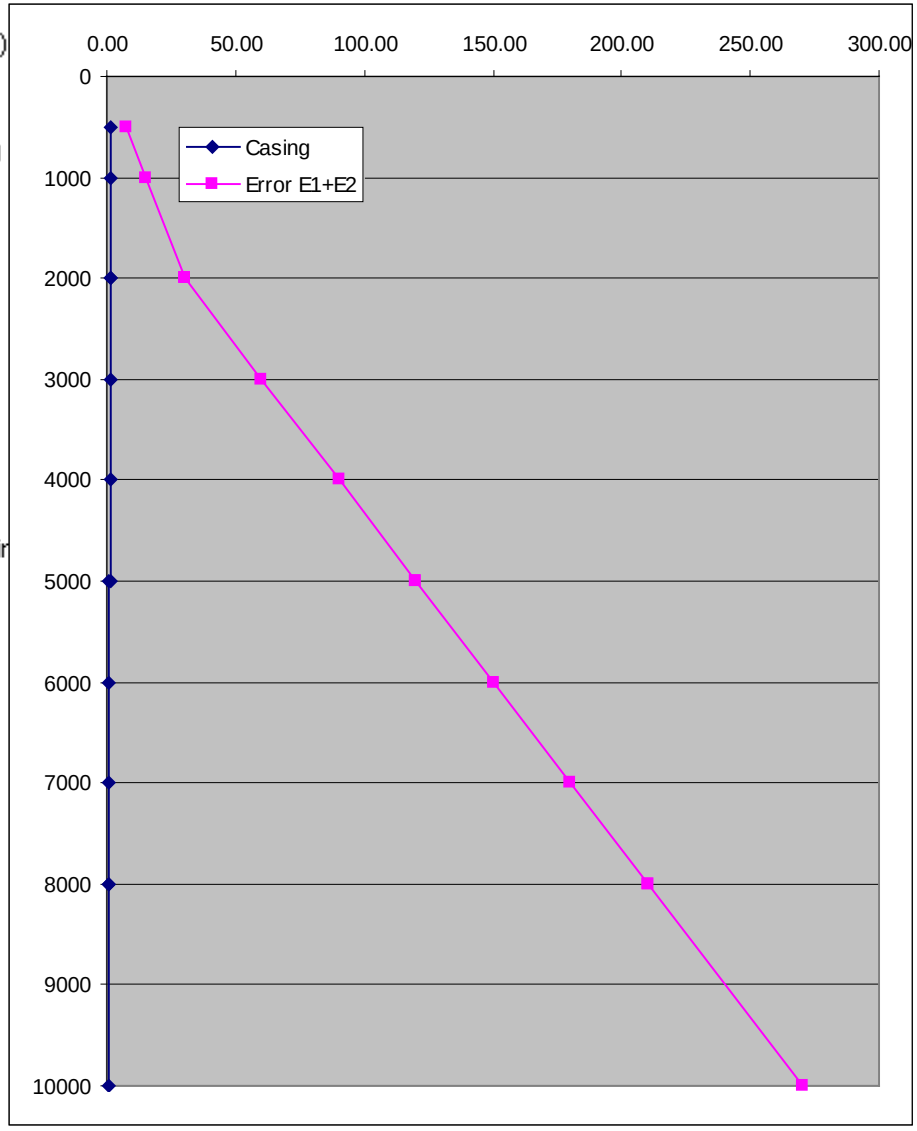


Example Data

Casing & Hole Sizes

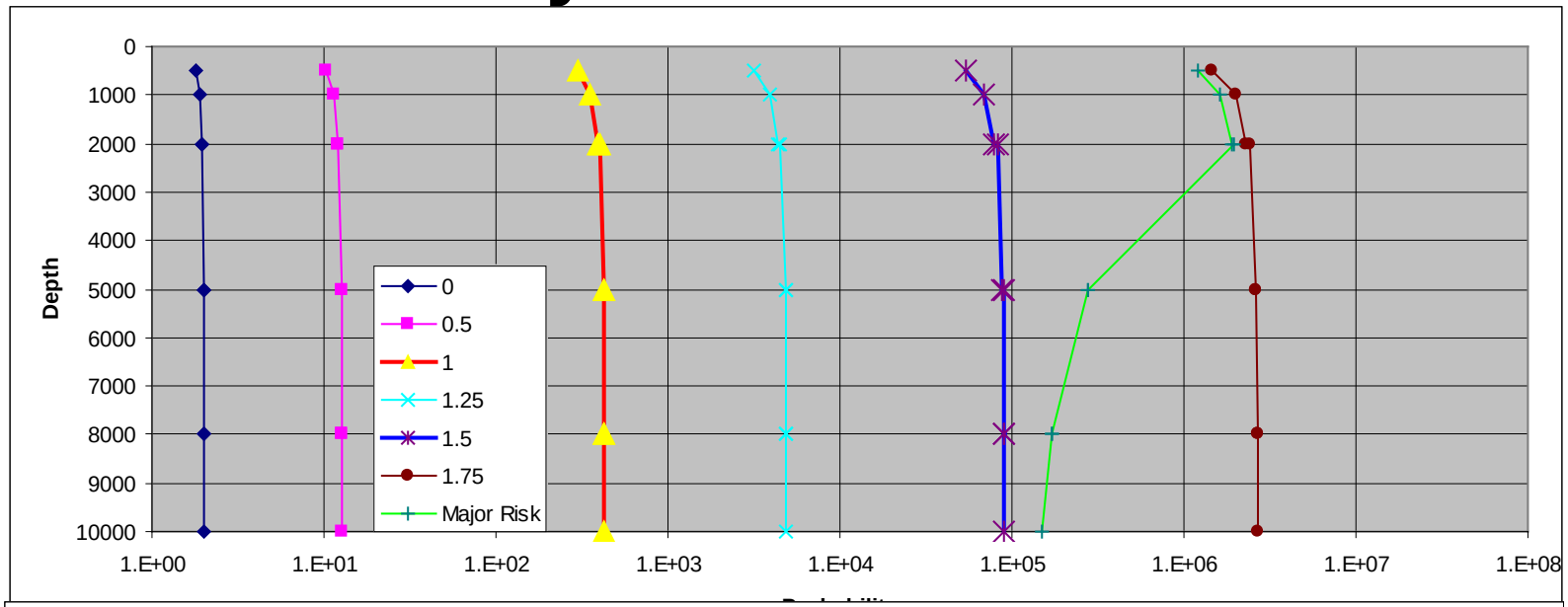


Combined Error Radii

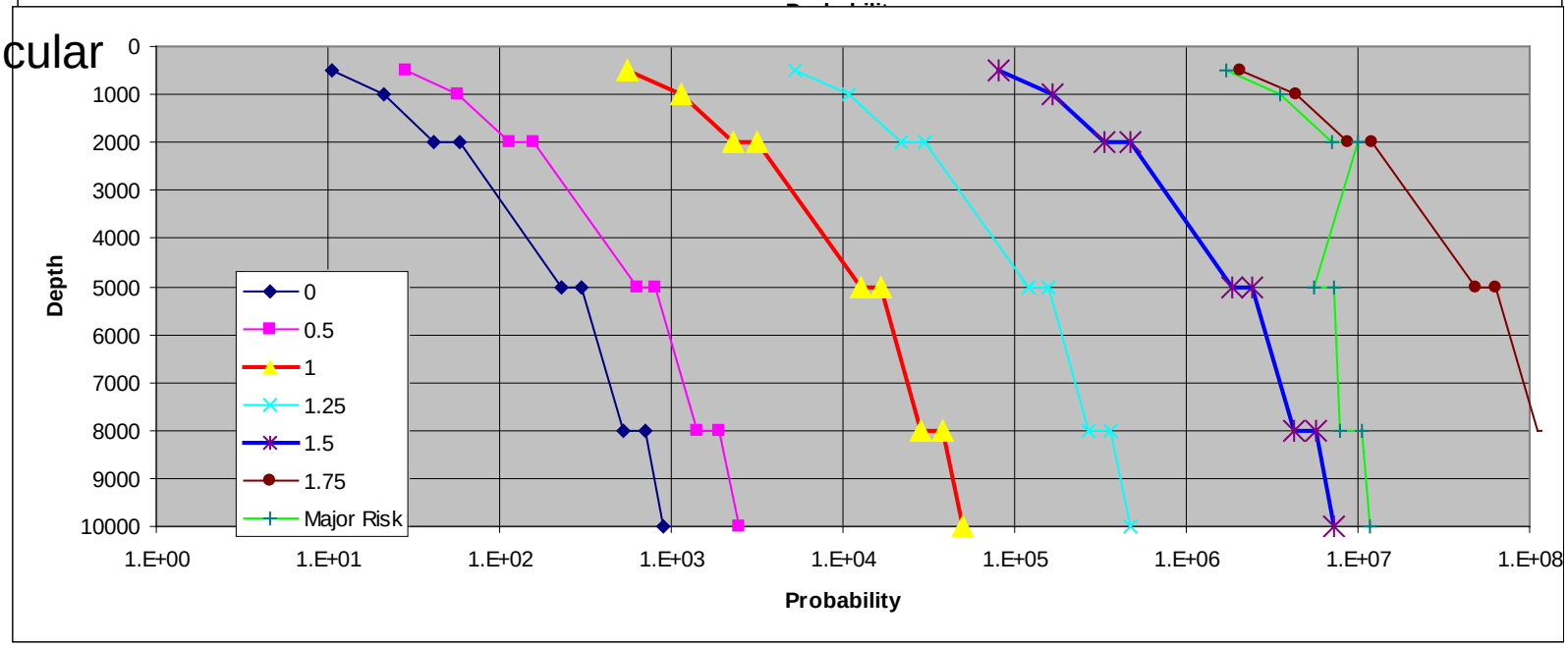


Probability of Intersection

Parallel



Perpendicular



Minimum Separations based on Risk

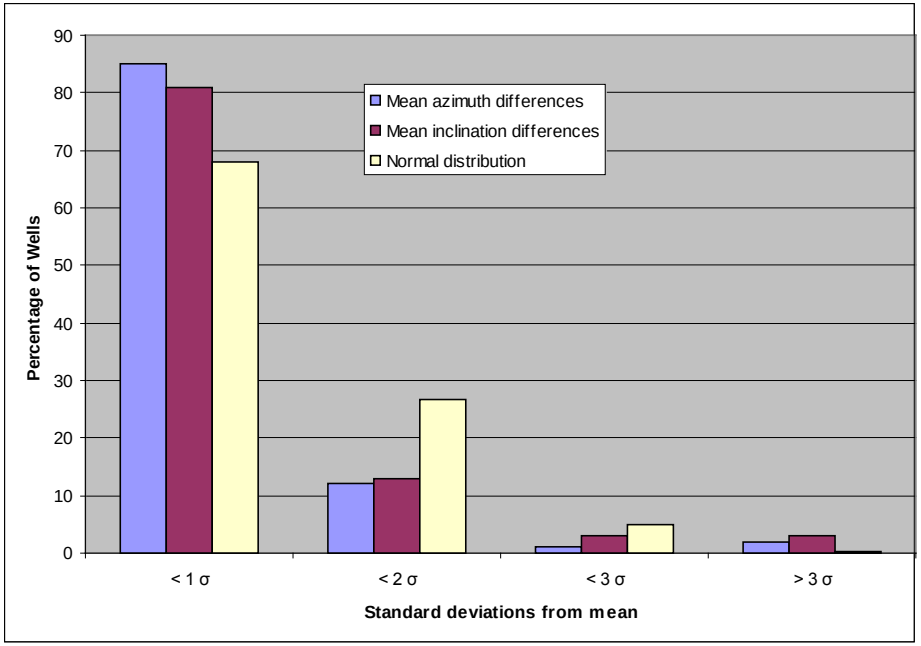
Parallel

Perpendicular

Problems

- Not Normally Distributed?

  Outliers/Misruns



- Low Angle Errors – Misalignment

  (random or systematic)

- Gyros (0.03 to 0.06 deg)
- MWD (0.06 deg)
- Vertical Comparisons 0.20 deg + 0.05 deg/casing
- Inrun/Outrun 0.10 deg

Questions?