Depth of Investigation with IP

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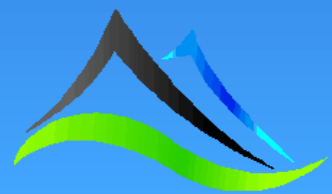
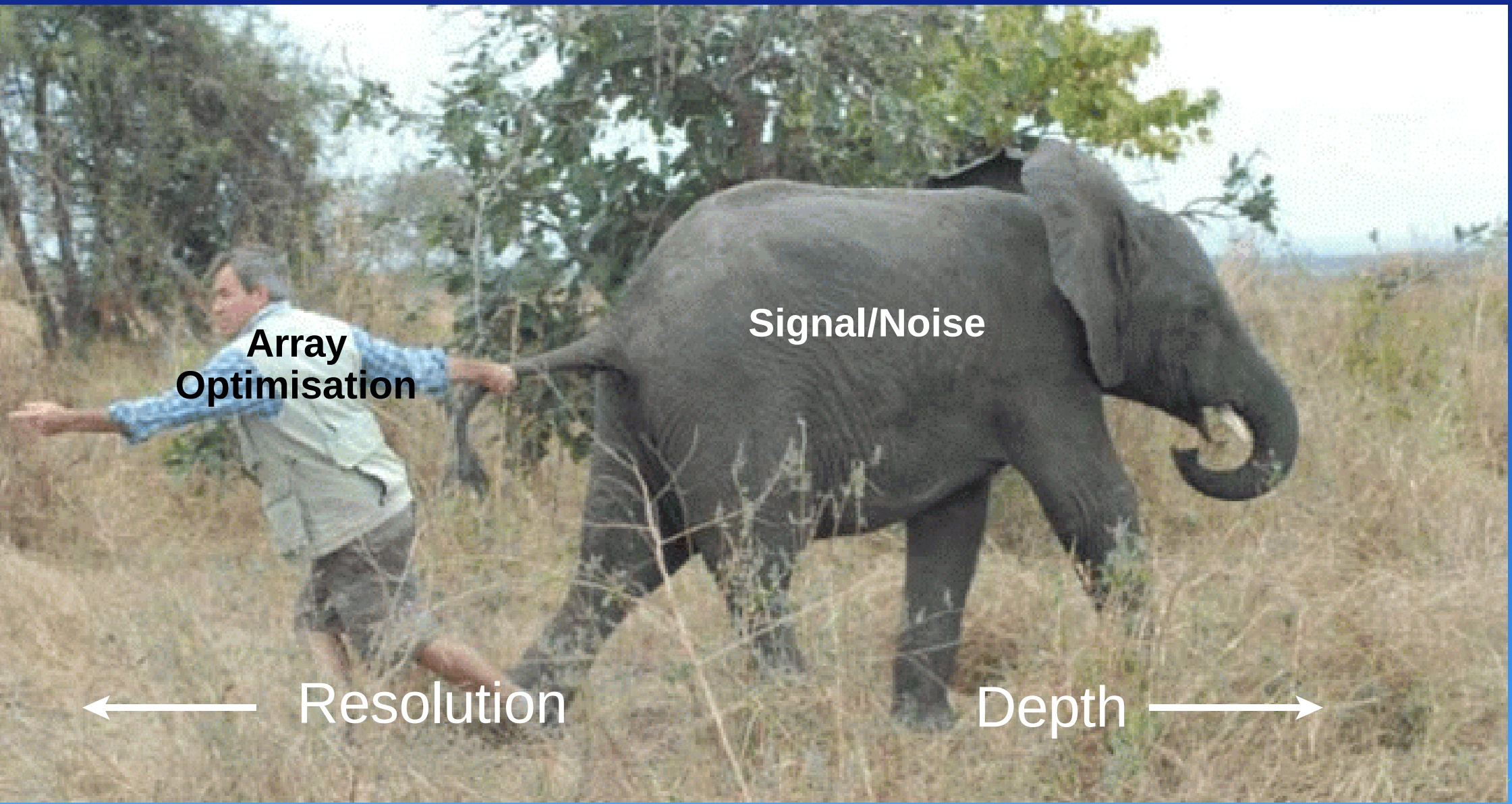
ExploreGeo

Modern 3D-IP surveying. Practical techniques and short cuts.

ASEG Conference - Perth 2015

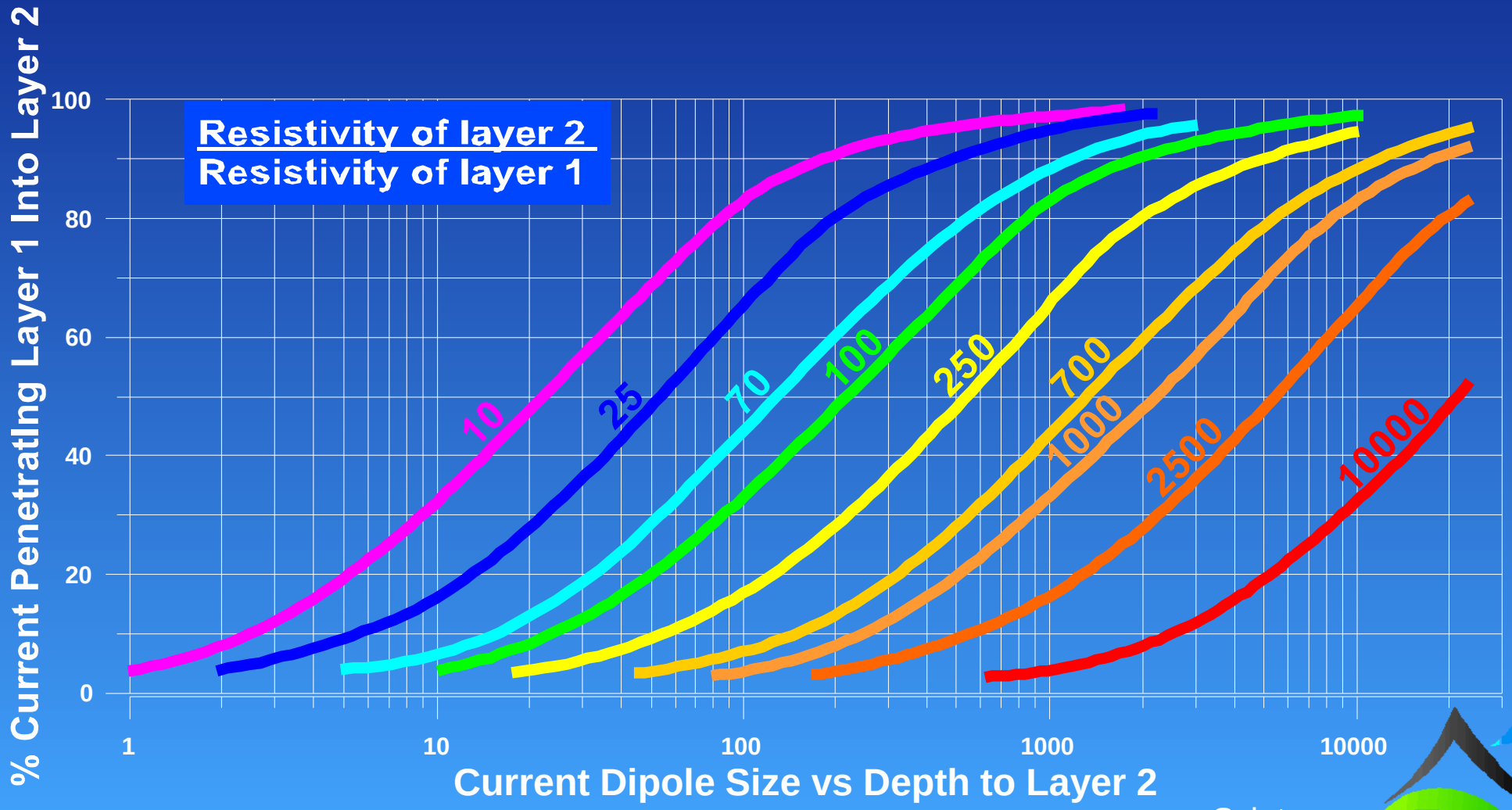


Can we have both deep penetration and resolution?



Signal to Noise

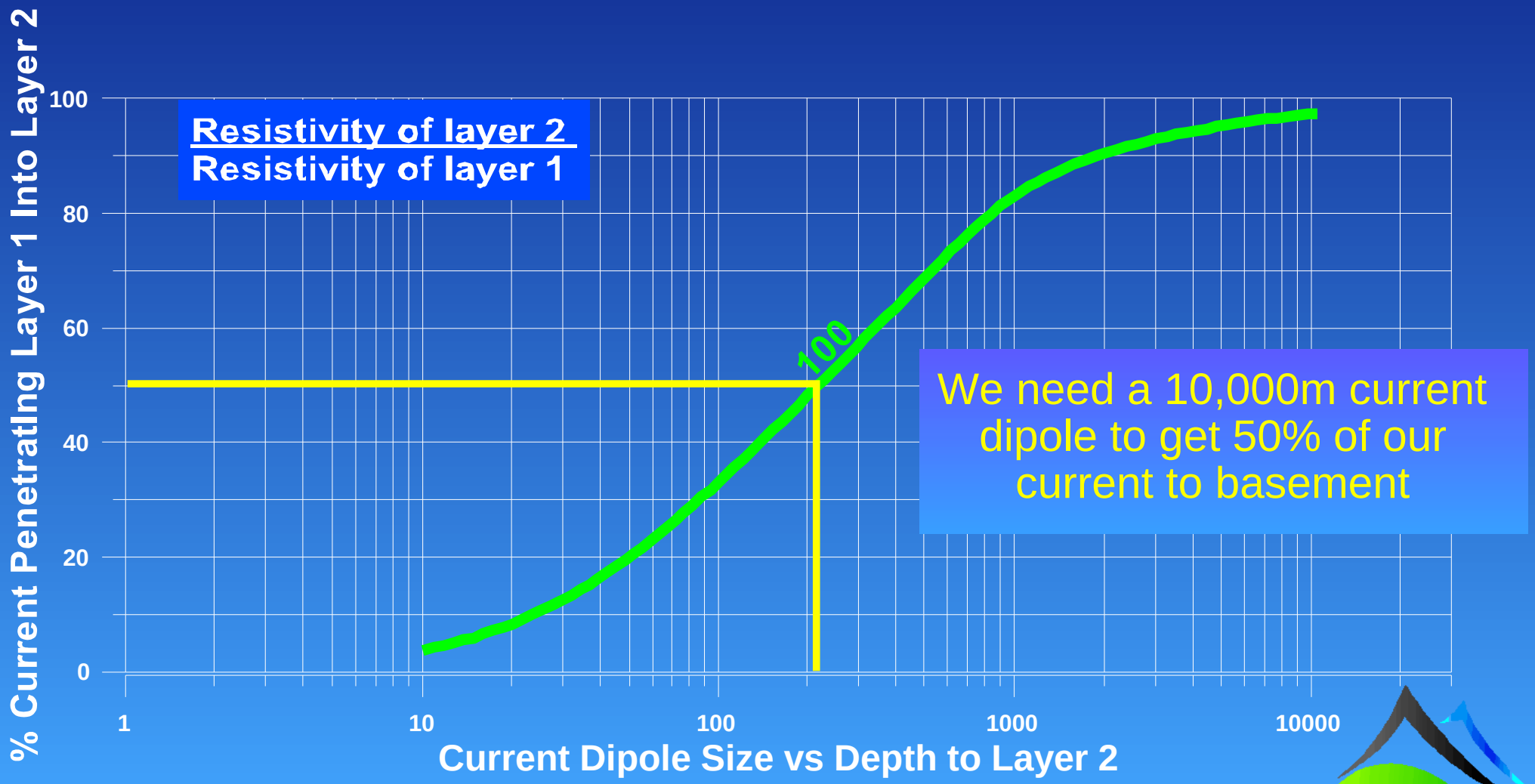
Signal into target below cover



Scintrex

Signal at the target

50m of 10 Ohm m overburden over 1,000 Ohm m basement



Signal at the target

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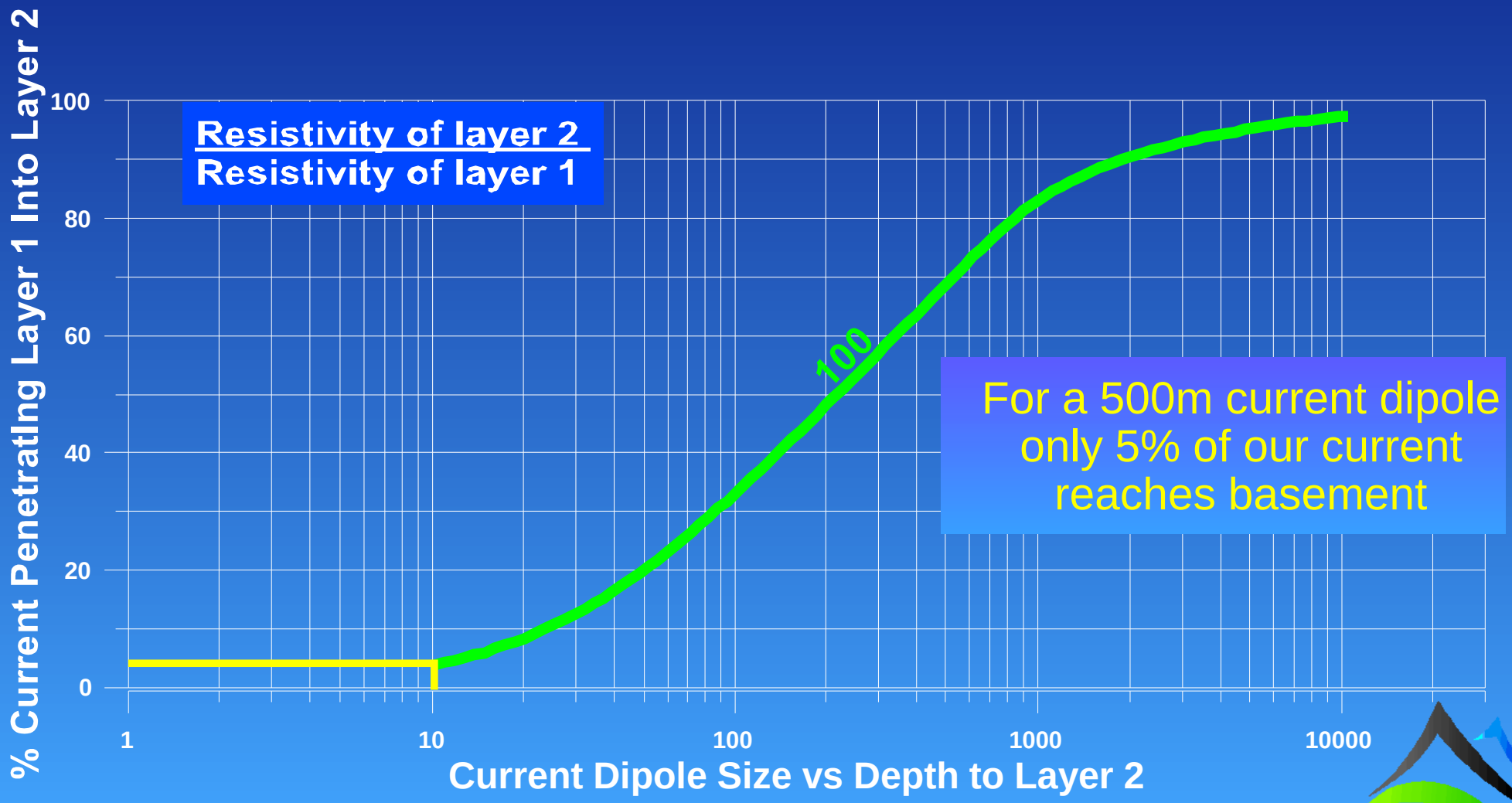
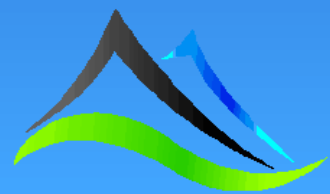


Improving Signal to Noise

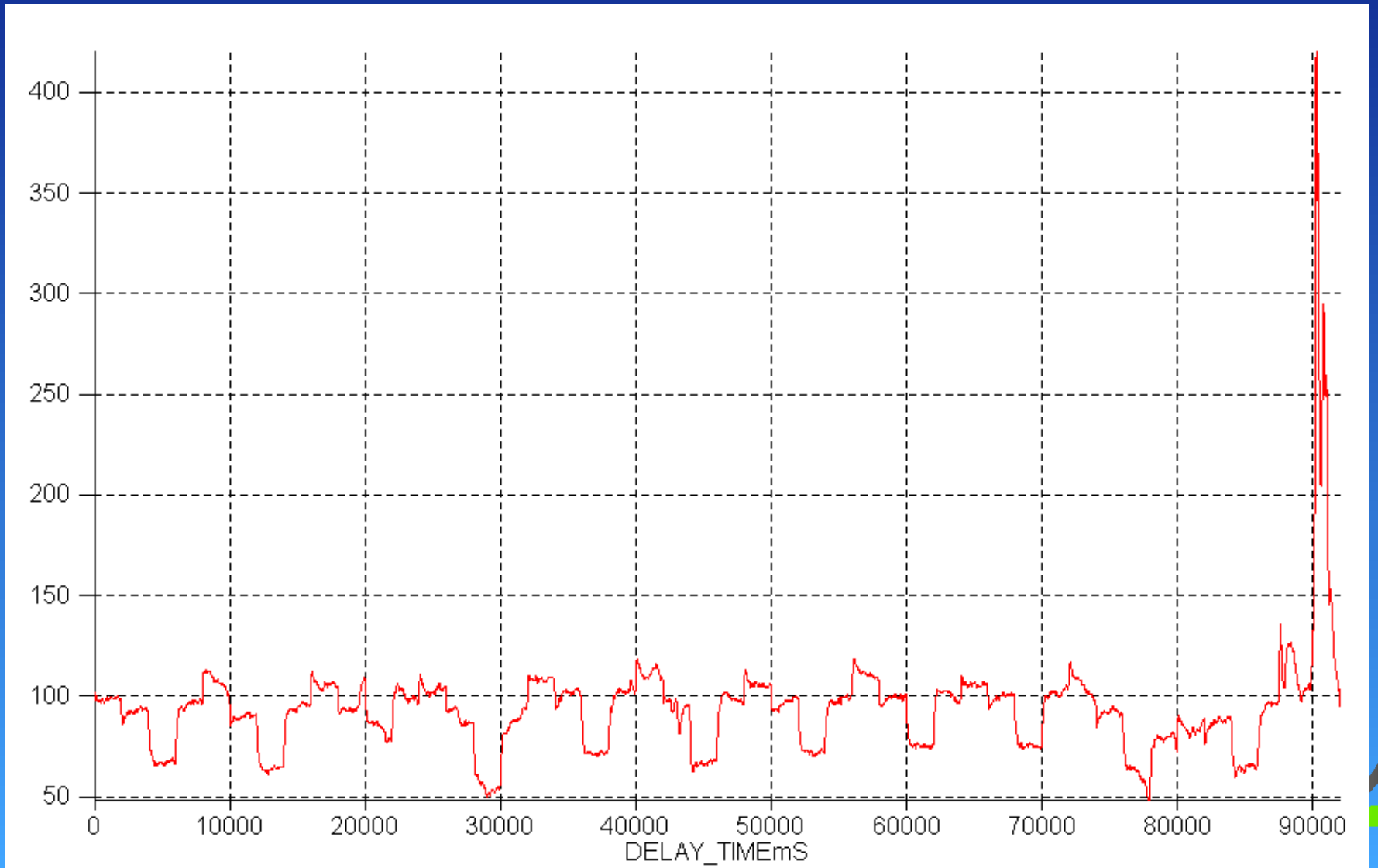
Assume noise is geological and environmental (e.g. lightning) and not something we can easily change. Not entirely true as pot selection and planting can effect noise level

- Stack longer. Improvement $\approx \sqrt{\#}$ stacks
- Stack smarter
- Put more current into the ground
  - Reduce the circuit resistance
  - Increase the Voltage
- Increase voltage resolution of receiver



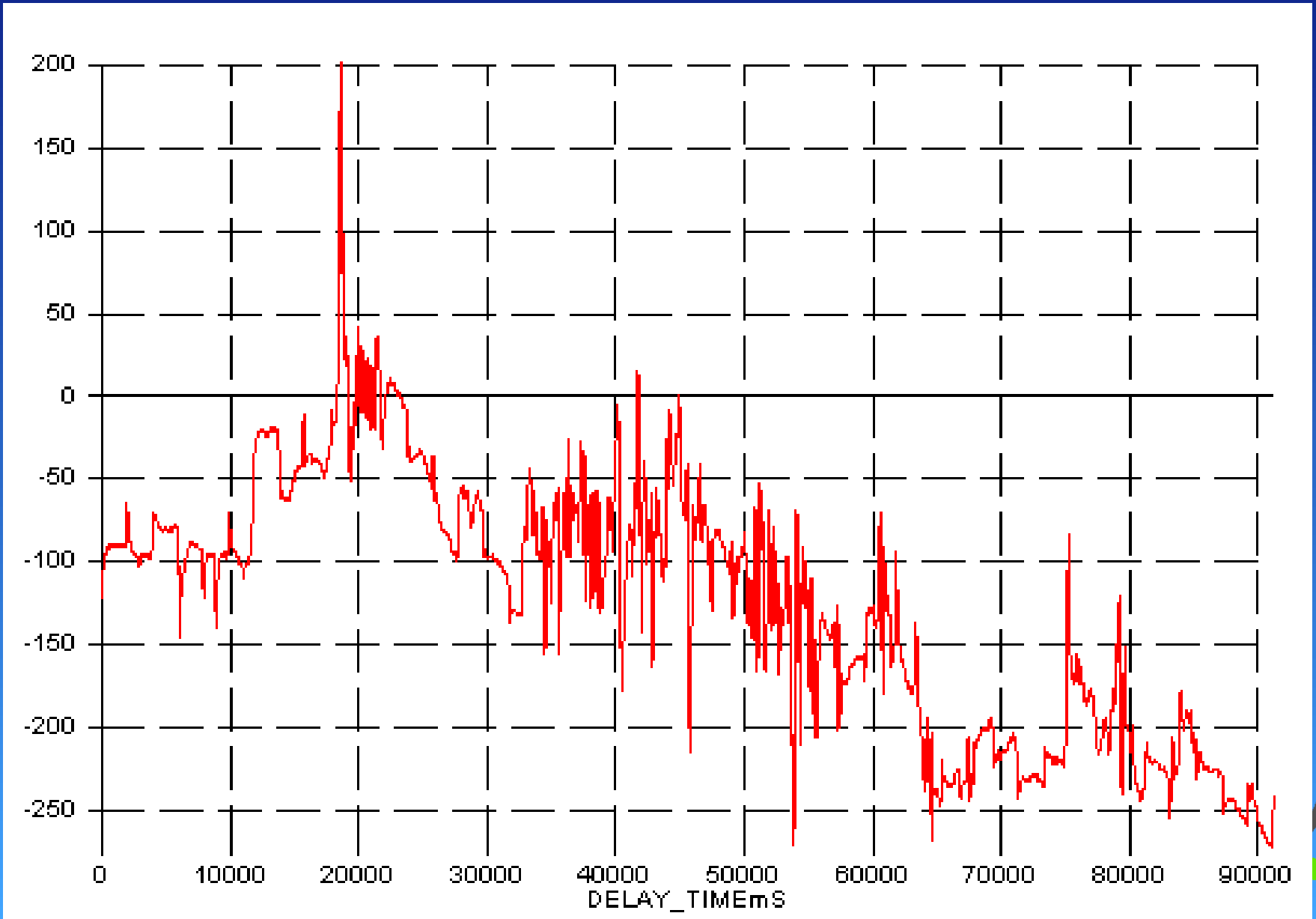
Noise

If the data look like this increasing the voltage resolution at the receiver should help



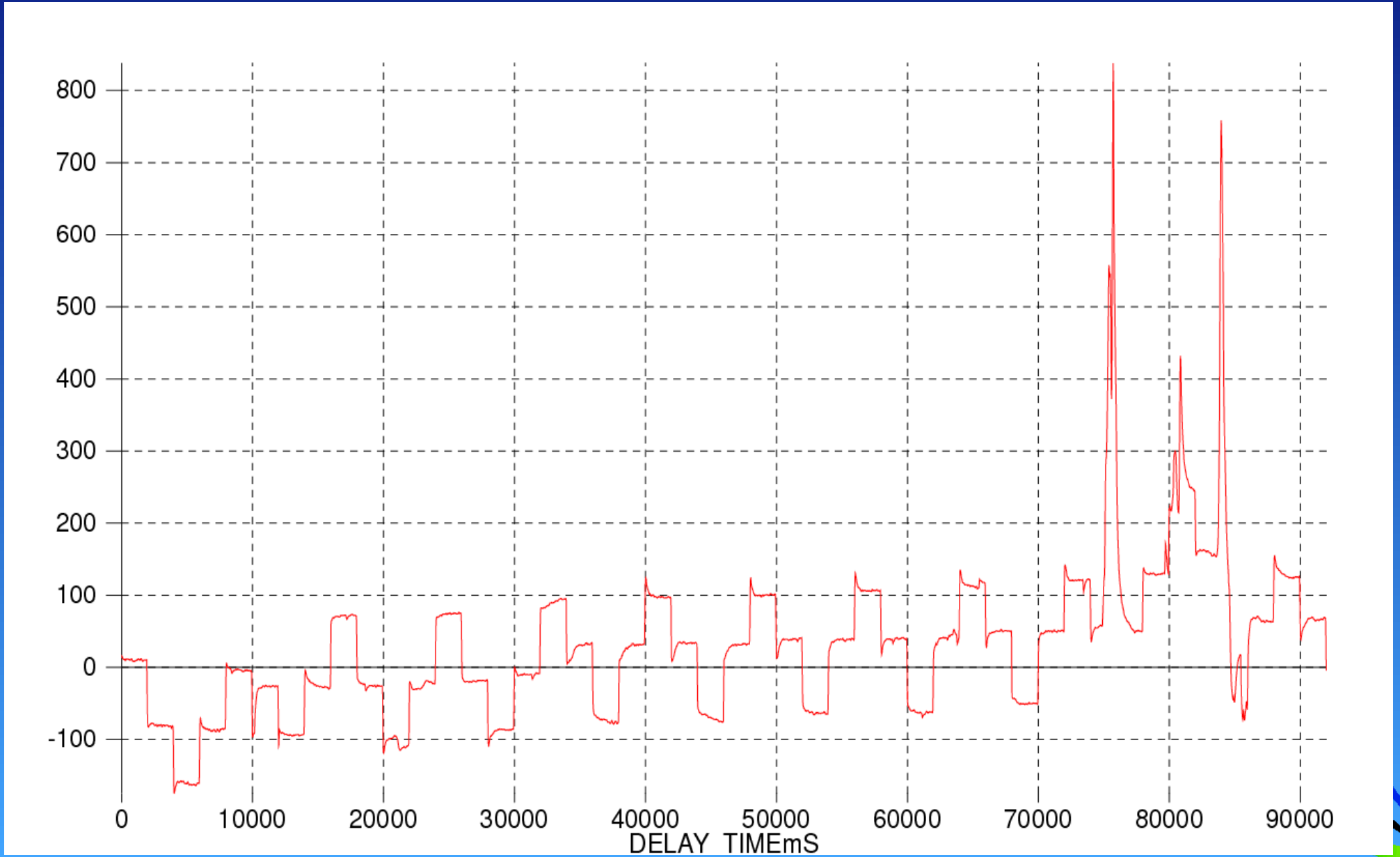
Noise

But not if the data look like this



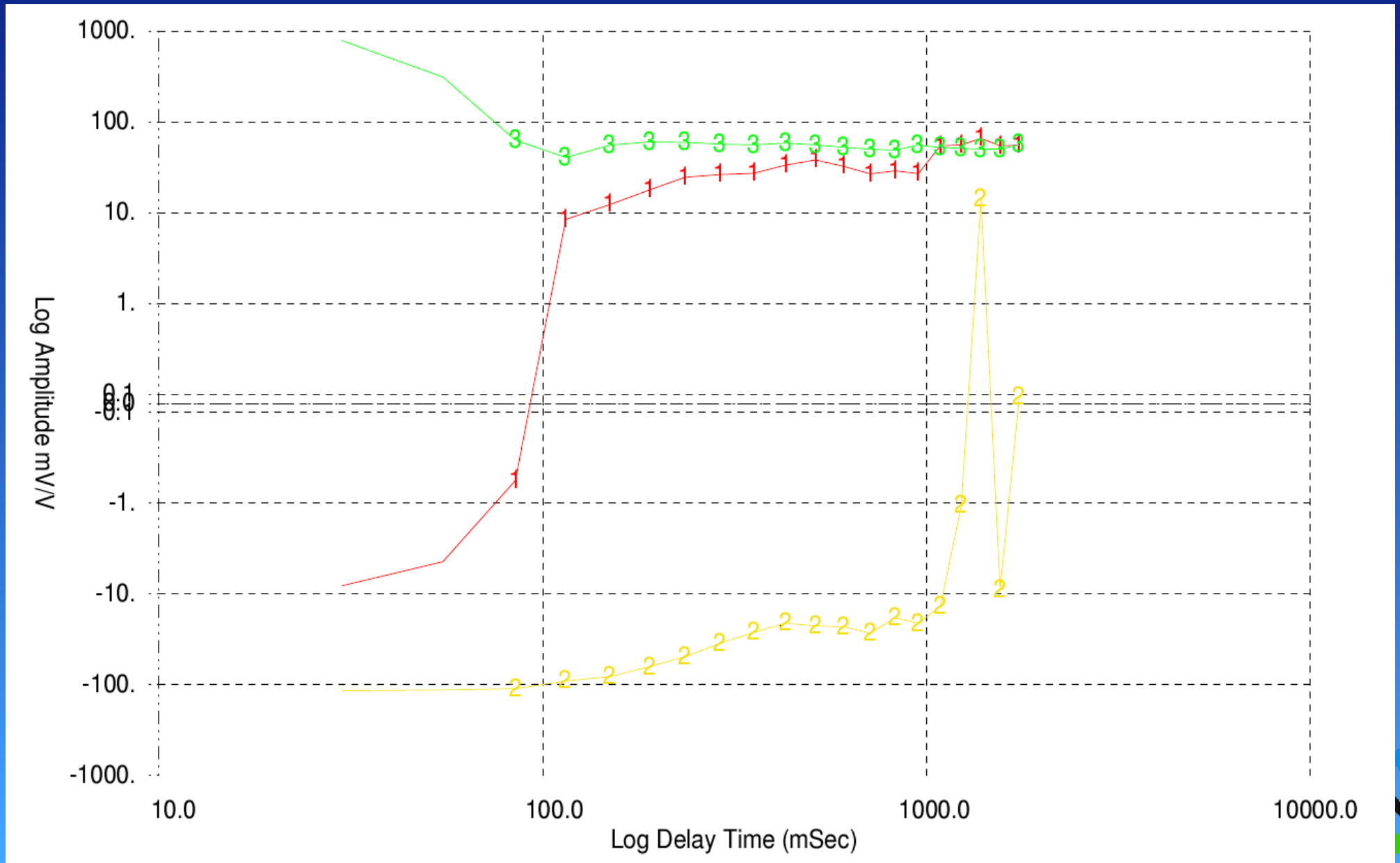
Signal vs Noise

Smarter signal processing?



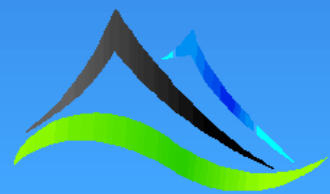
Signal vs Noise

Time series from previous slide - 3 different groups - 3 different answers



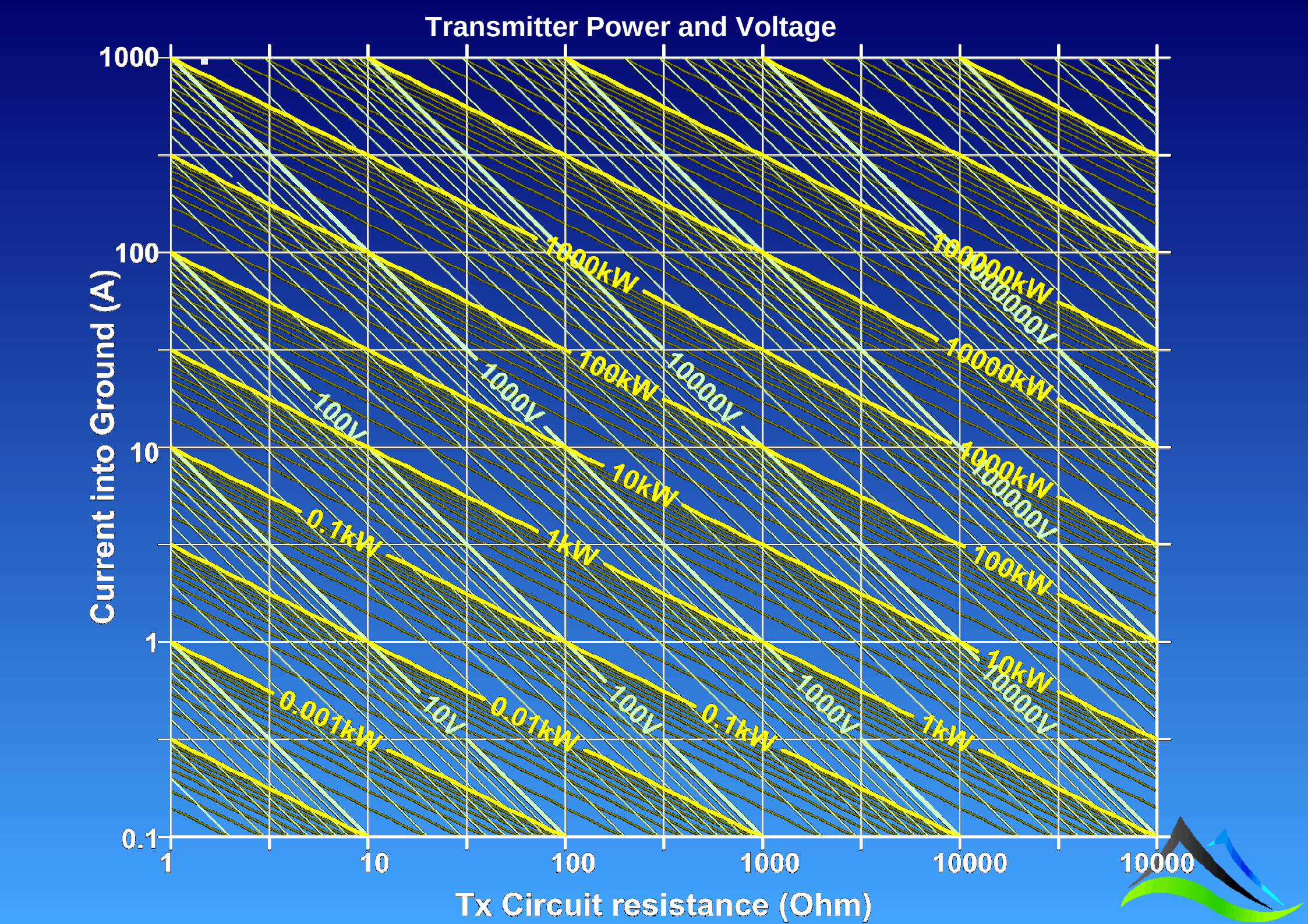
Signal vs Noise

- We can generally afford to stack longer.
- We definitely need to stack smarter
- We may be able to reduce our circuit resistance
- We **CAN** increase the voltage and power of our transmitters

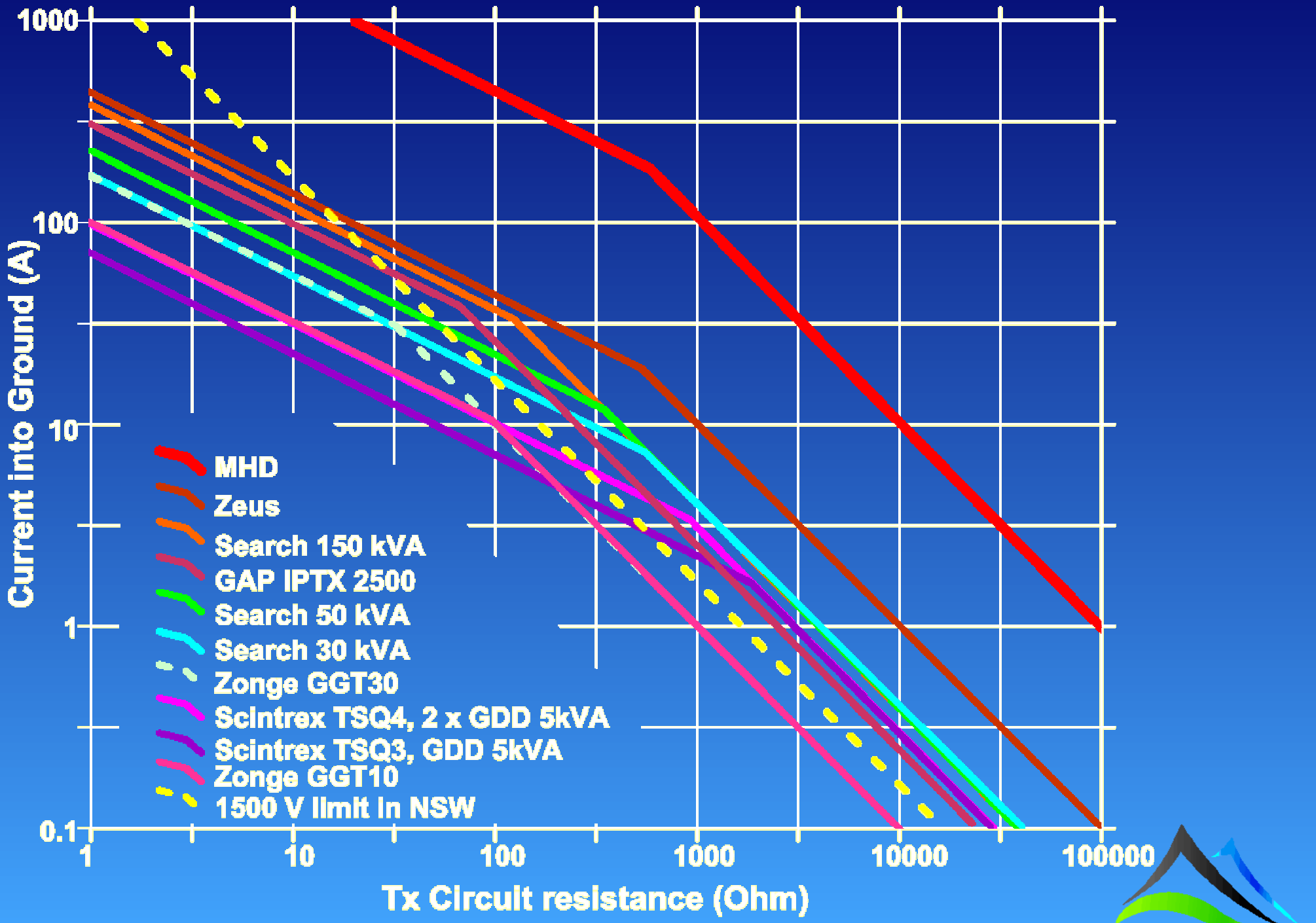


Transmitter Power and Voltage

If only 5% of your current is going into bedrock you want to start with a big number! Size does matter!


Transmitter Power and Voltage
Current into Ground (A)
1000
100
10
1
0.1
1
10
100
1000
10000
10000
Tx Circuit resistance (Ohm)
1000kW
100000kW
100kW
10000kW
10000V
1000V
1000000V
100V
10kW
1000kW
0.1kW
100000V
1kW
100kW
10kW
1000V
0.001kW
10V
0.01kW
100V
0.1kW
1kW

Operating limits for real systems - Assuming 100% efficiency in all cases



Resolution

Resolution is controlled by the electrode placement

Model the response of different arrays to the same target using Res3Dmodx64 and Res3Dinv.

Noise added to forward model and inversion data set clipped to remove low Vp readings prior to inversion

Target at a depth of 1300m -potential electrode spacing at surface 100m.

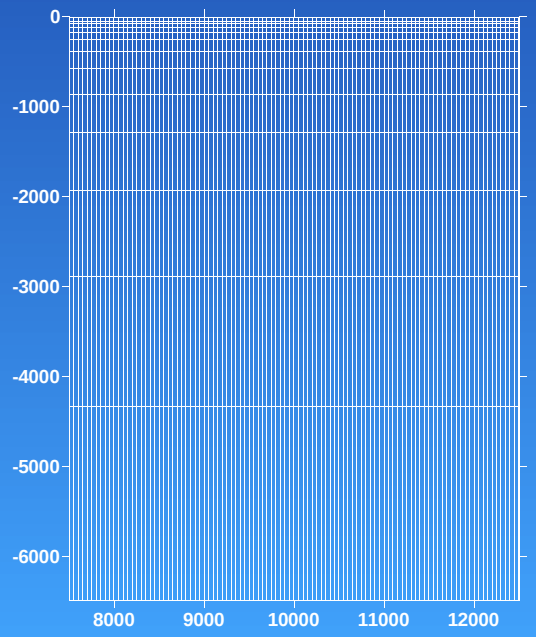
Host 10 mV/V, target 30 mV/V, images independently scaled, contours at 0.5 mV/V

Forward Modelling Details

Forward modelling was undertaken using Res3Dmodx64 routine developed by Meng Heng Loke

The mesh consisted of 50m x 50m voxels over a 21000m x 2000m area with 13 layers increasing logarithmically in thickness from 50m to 2162m to achieve a maximum depth of 6487m. All electrodes (current and potential) were included in the mesh. The mesh size was 420 x 40 x 13

Continues at 50m spacing to 0m



Continues at 50m spacing to 21000m

Inversion Details

Noise was added to the forward modelled primary voltage as follows:

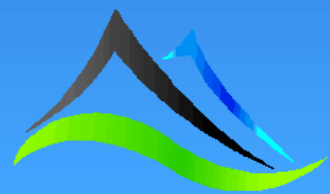
If $Vp > 0.1$ mV

$$Vp_{(noise)} = Vp + RN*Vp*0.1$$

If $Vp \leq 0.1$ mV

$$Vp_{(noise)} = Vp + RN*0.1$$

RN = Random number between -0.5 and +0.5



Inversion Details

The apparent resistivity was then recalculated.

The chargeability had noise added proportionally to the noise in the primary voltage.

$$m_{(noise)} = m * Vp_{(noise)} / Vp$$

The noise adjusted apparent resistivity and chargeability were input to Res3DinvX64 after clipping the data to $Vp_{(noise)} > 0.1$ mV

Specs

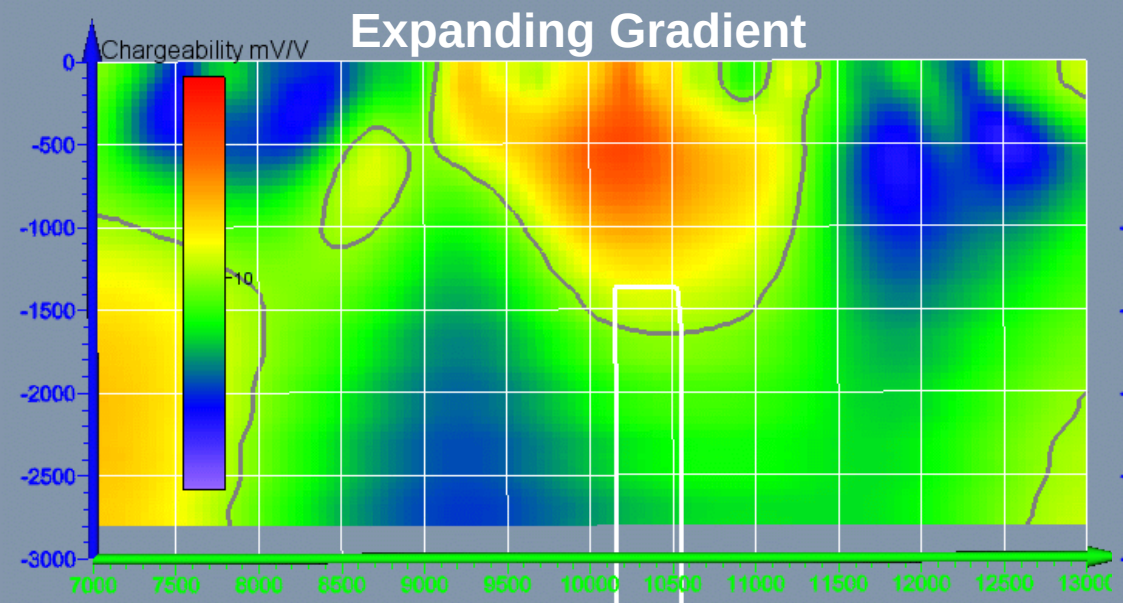
Expanding gradient - 100m potential electrode spacing, 6500m to 21000m Tx dipoles.

3D Pole-dipole - 200m potential electrode spacing with active current electrode in the centre of a 2 dipole x 2 dipole square and remote at 10 km.

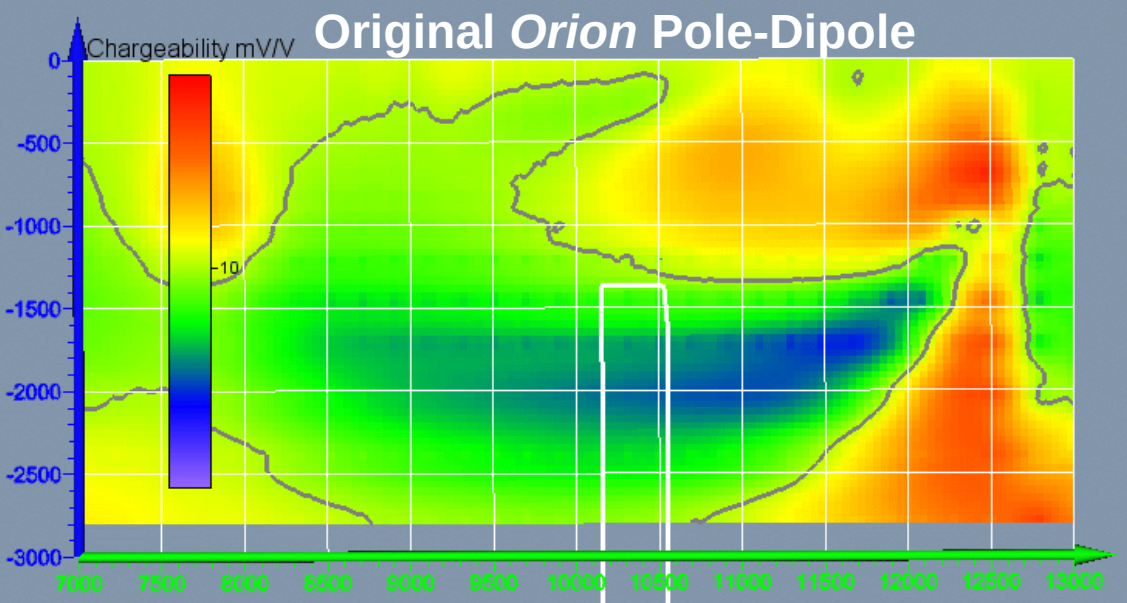
Offset Dipole-Dipole - 100m Rx dipoles, 200m Tx dipoles

All sections are along line 1000 over the top of the body and use linear colour stretch applied to the section being displayed with 0.5 mV/V linear contours

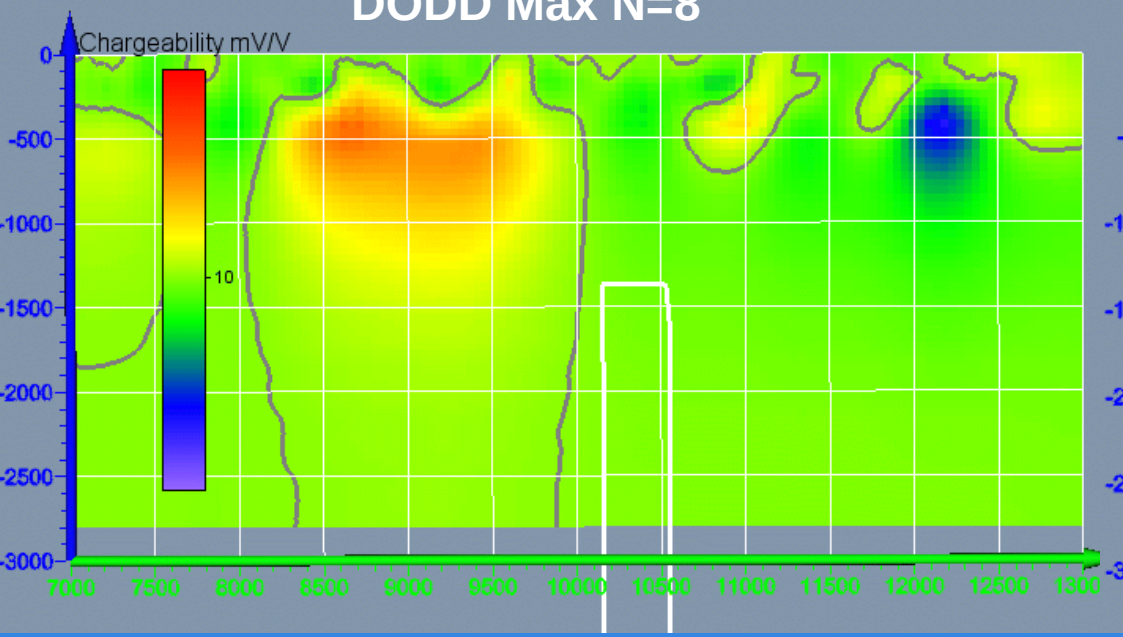
Expanding Gradient



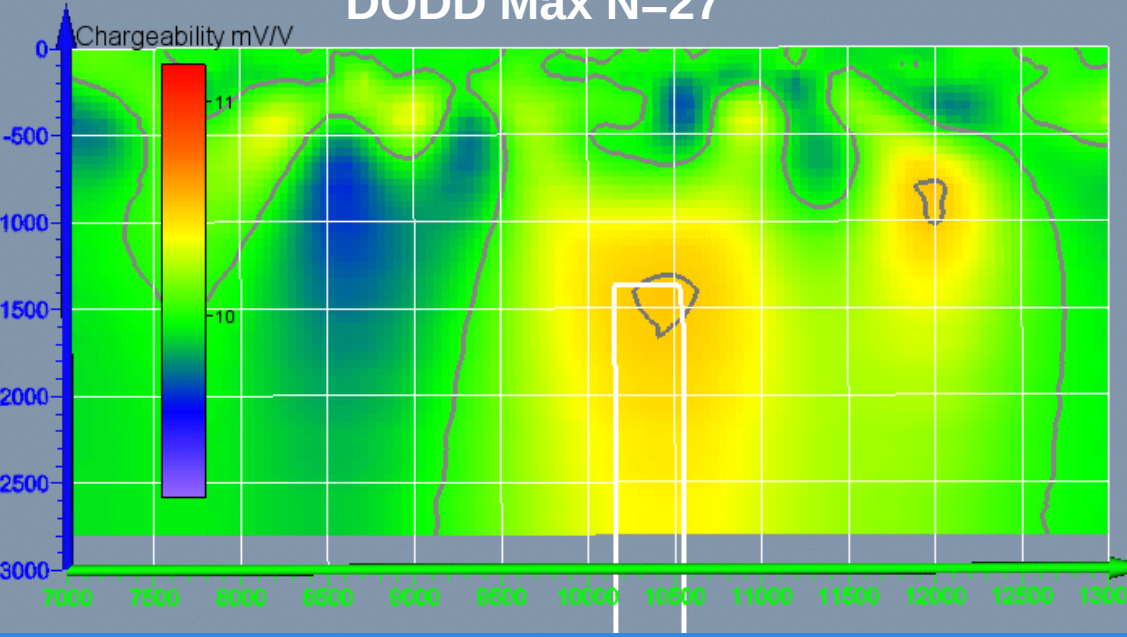
Original *Orion* Pole-Dipole



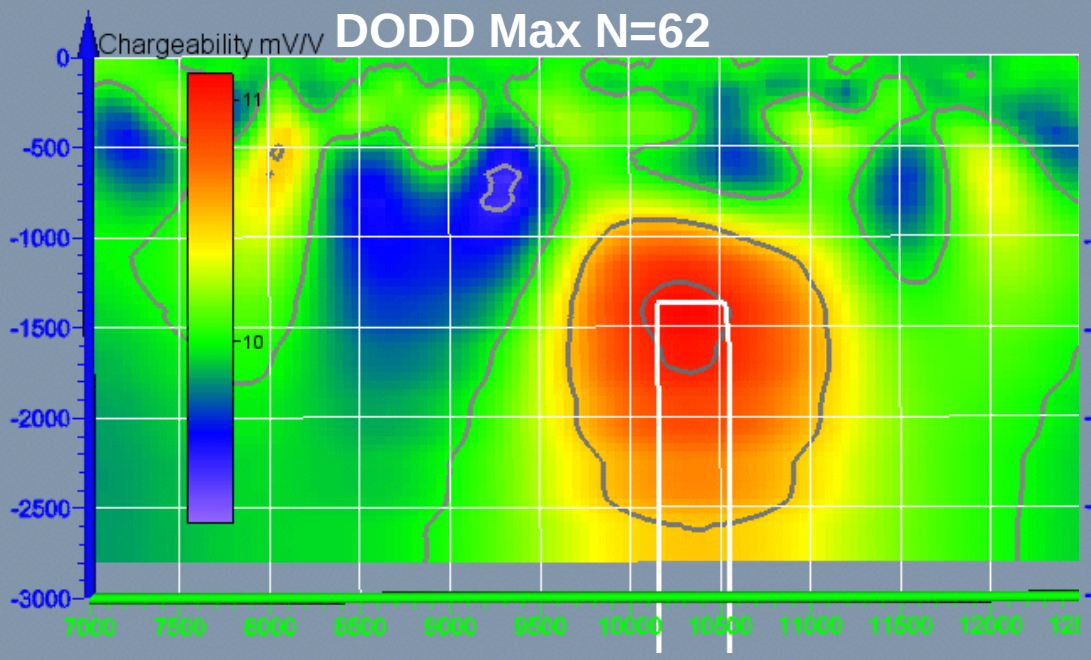
DODD Max N=8

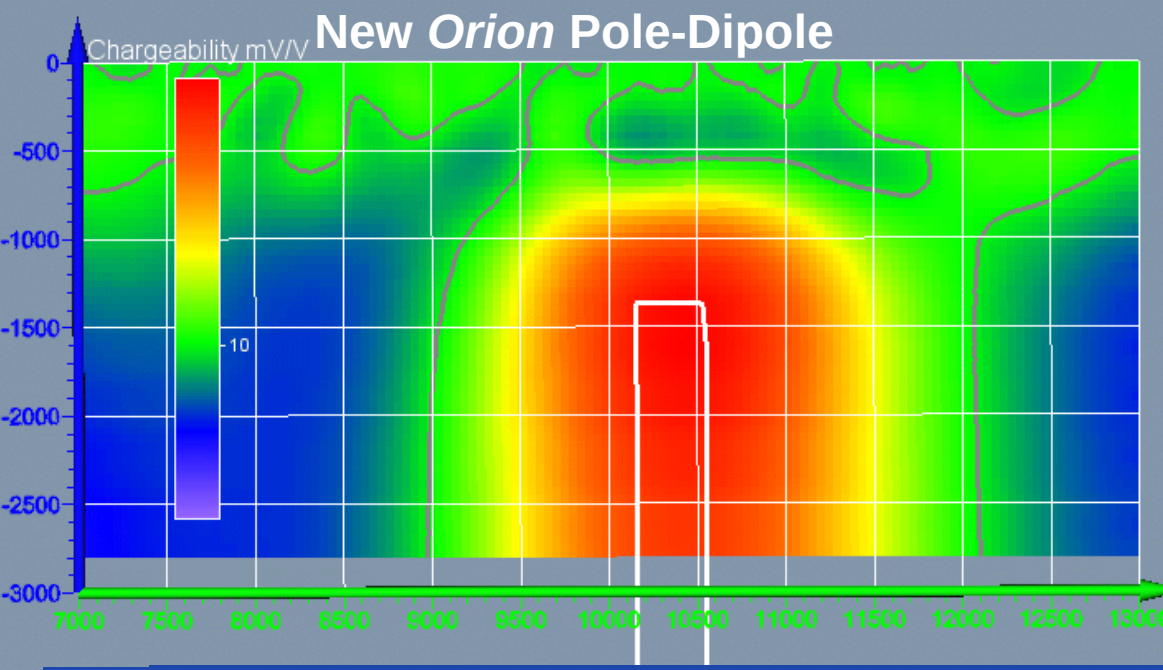


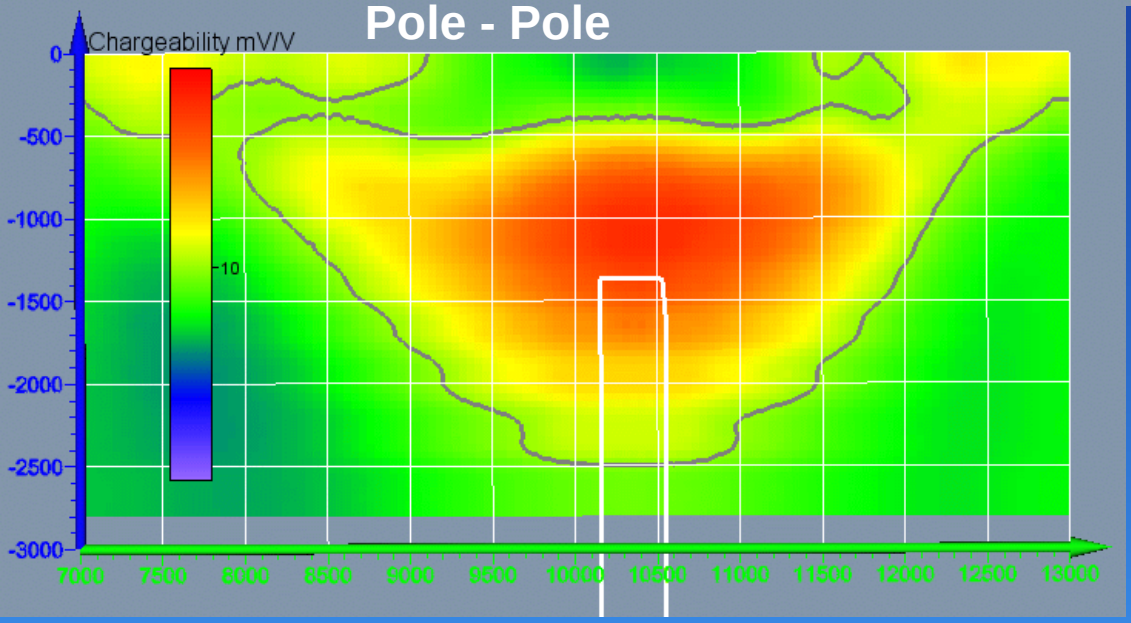
DODD Max N=27



None of the above could be considered a success - perhaps not surprising given 100m dipoles and 1300m to top of target!







Maybe in with a chance by reading to very long offsets but still probably not detectable in real data. However of the arrays tested long offset DODD appears to offer the best chance.

Use “Multipoles” to improve penetration and resolution

From 100m spaced electrodes acquire multiple dipole sizes - preferably simultaneously.

The examples below use 100m electrodes to acquire 100m, 200m, 300m and 400m dipoles for the same array