How useful are (quantum technology) gravity measurements for on-site inspection?

Dr. Daniel Boddice

(University of Birmingham, CTBTO 3TC participant)

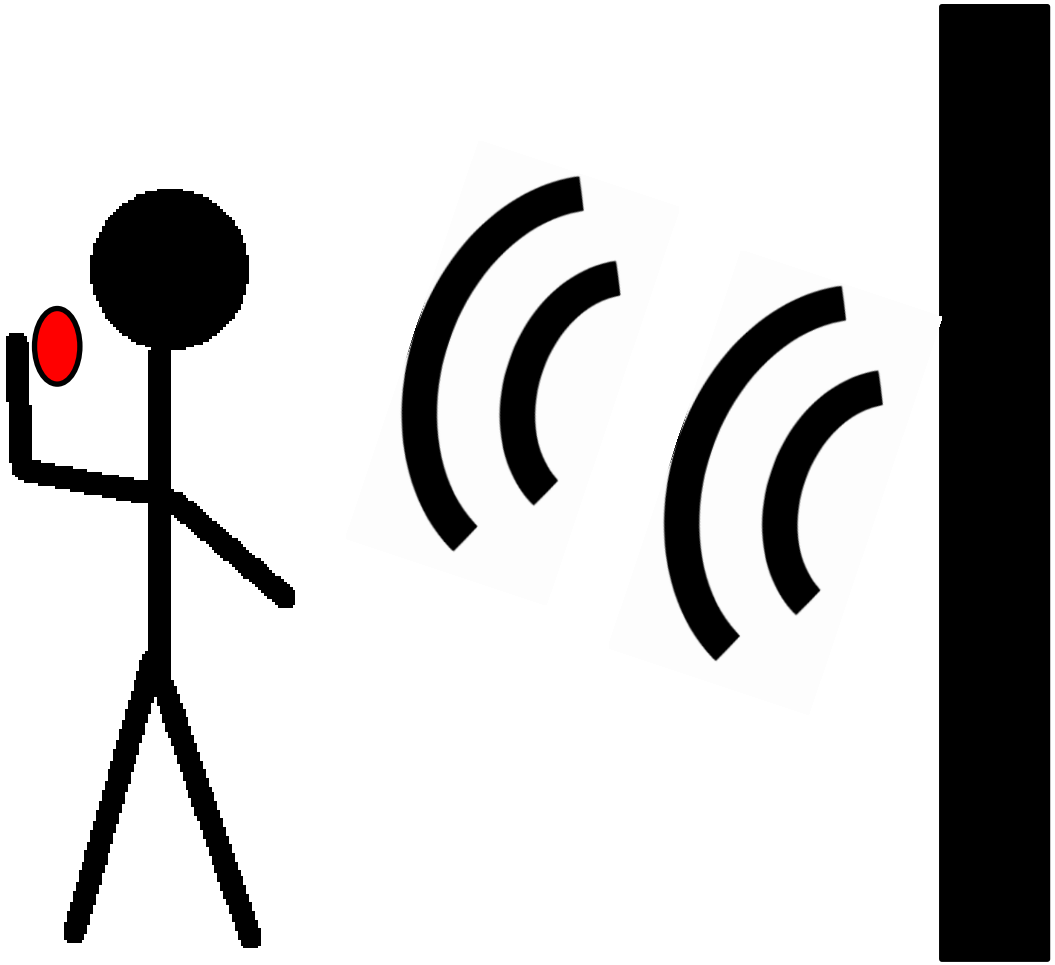
Prof. George Tuckwell

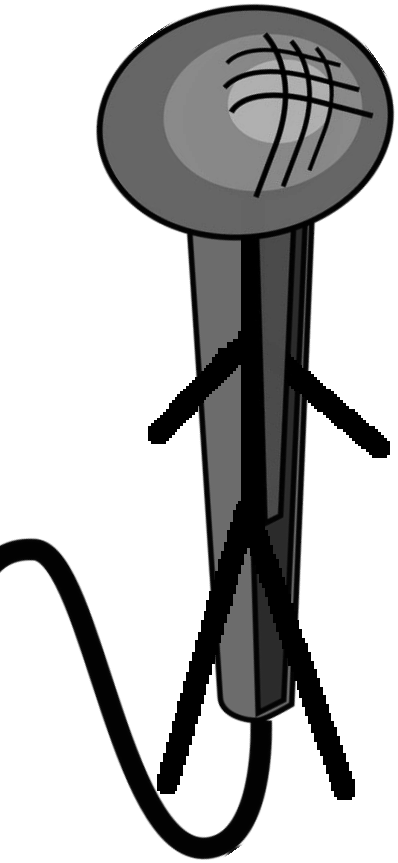
(RSK, University of Birmingham CTBTO Surrogate Inspector)

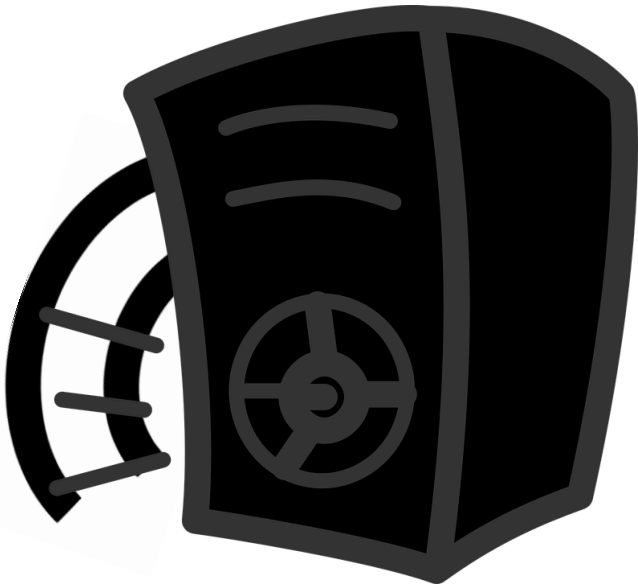
Prof. Nicole Metje

(University of Birmingham)

UNIVERSITY OF BIRMINGHAM



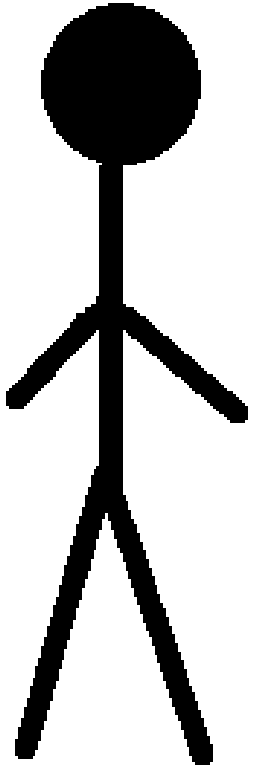


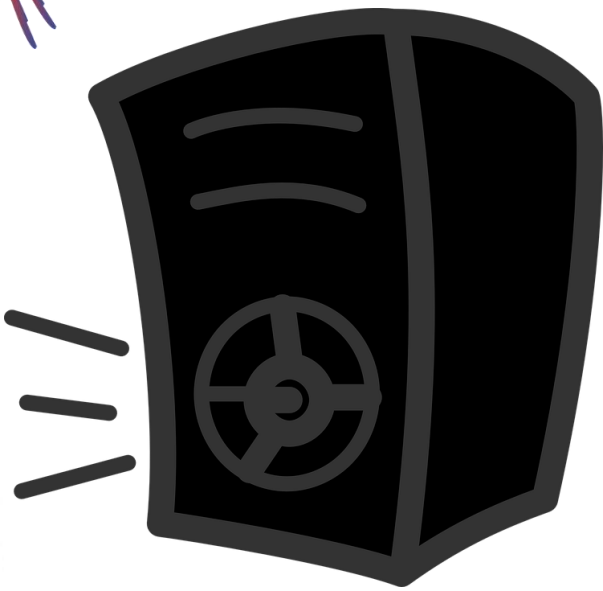


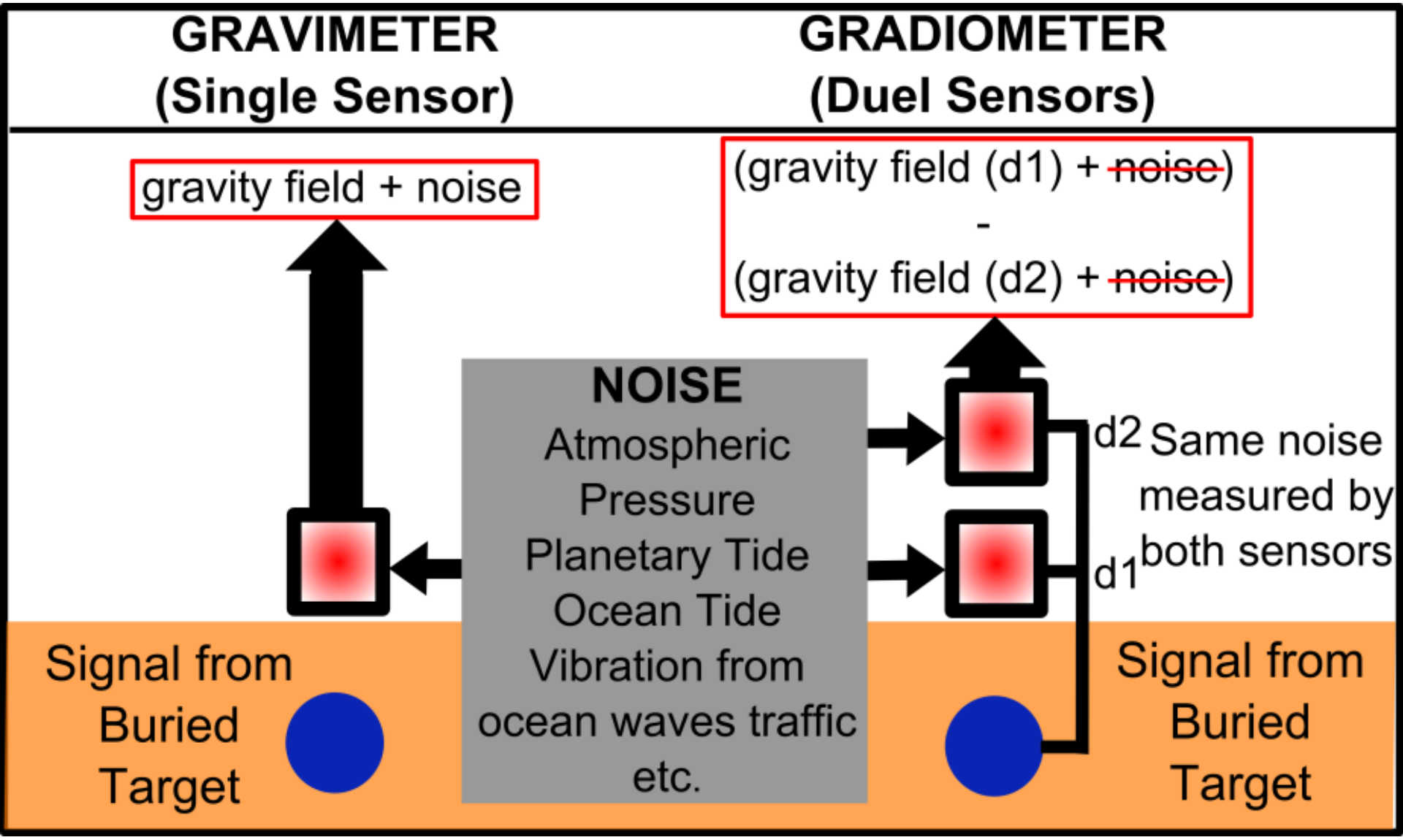

Metallurgy
& Materials
Caution
laser
Caution
Crush
Hazard

Would a 10 X more sensitive instrument be 10 X better at detecting OSI related observables?

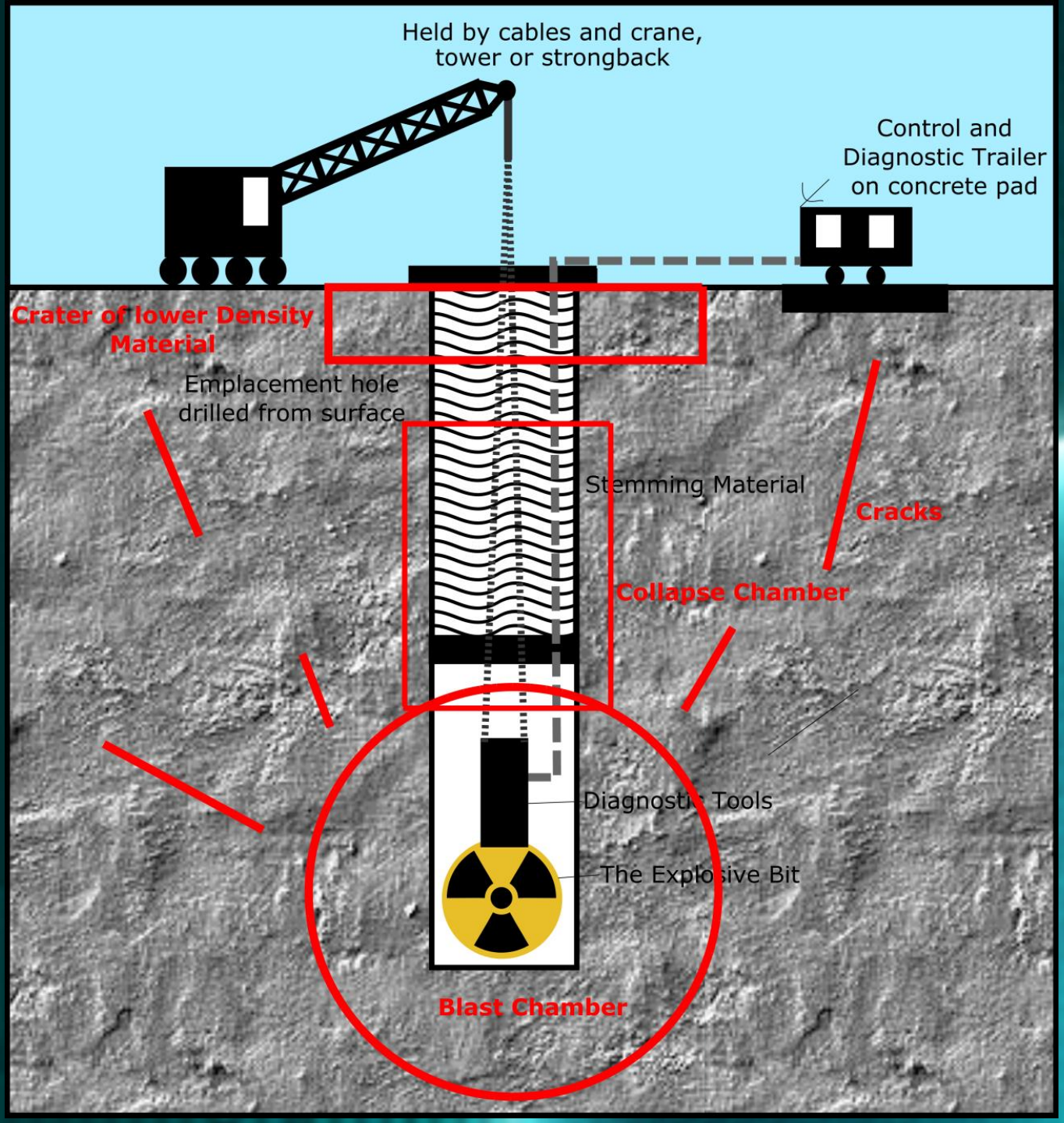
No



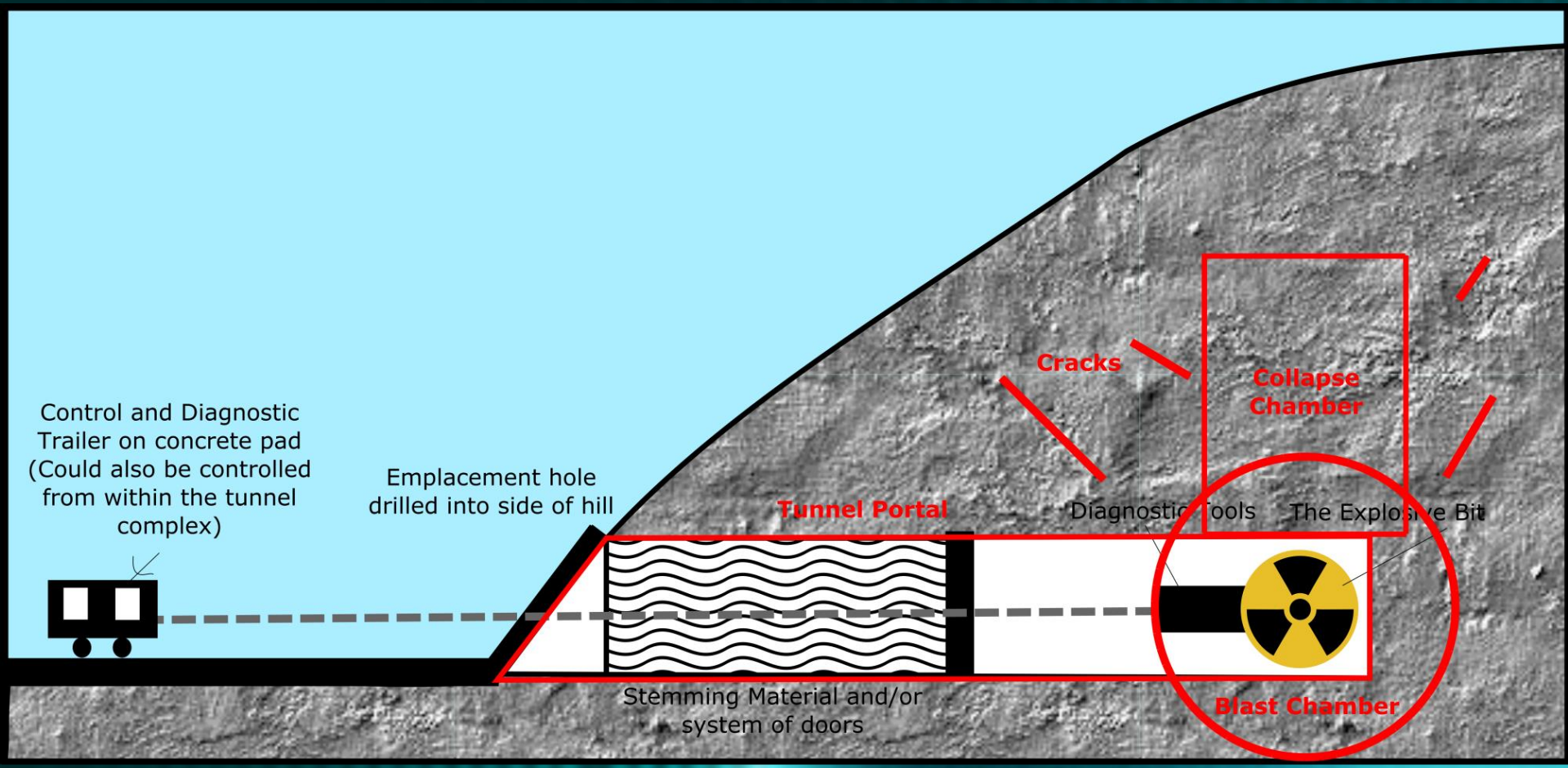


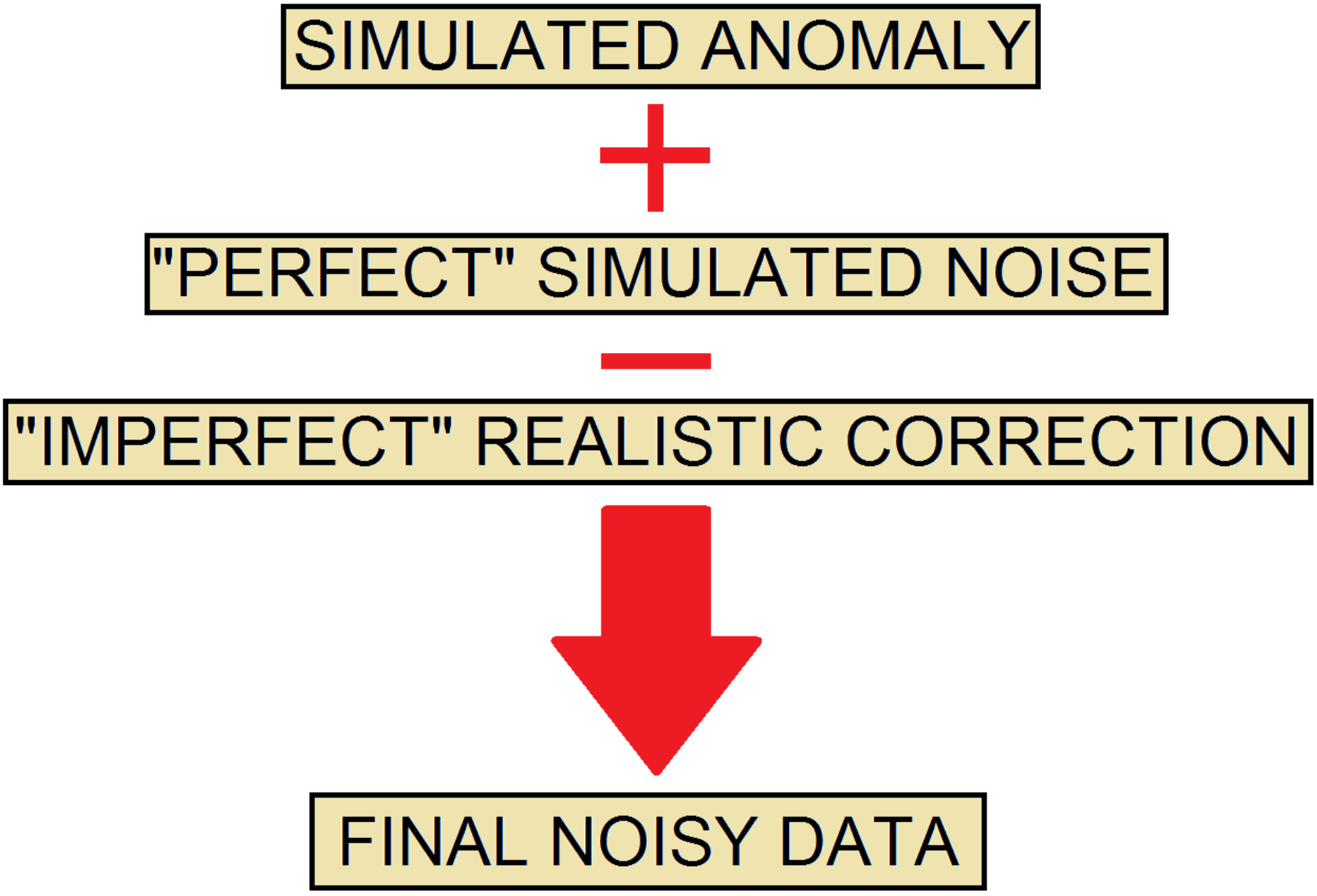

GRAVIMETER
(Single Sensor)
GRADIOMETER
(Duel Sensors)
gravity field + noise
(gravity field (d1) + noise)
-
(gravity field (d2) + noise)
NOISE
Atmospheric Pressure
Planetary Tide
Ocean Tide
Vibration from ocean waves traffic
etc.
d2
Same noise measured by both sensors
d1
Signal from Buried Target
Signal from Buried Target

Vertical Installation

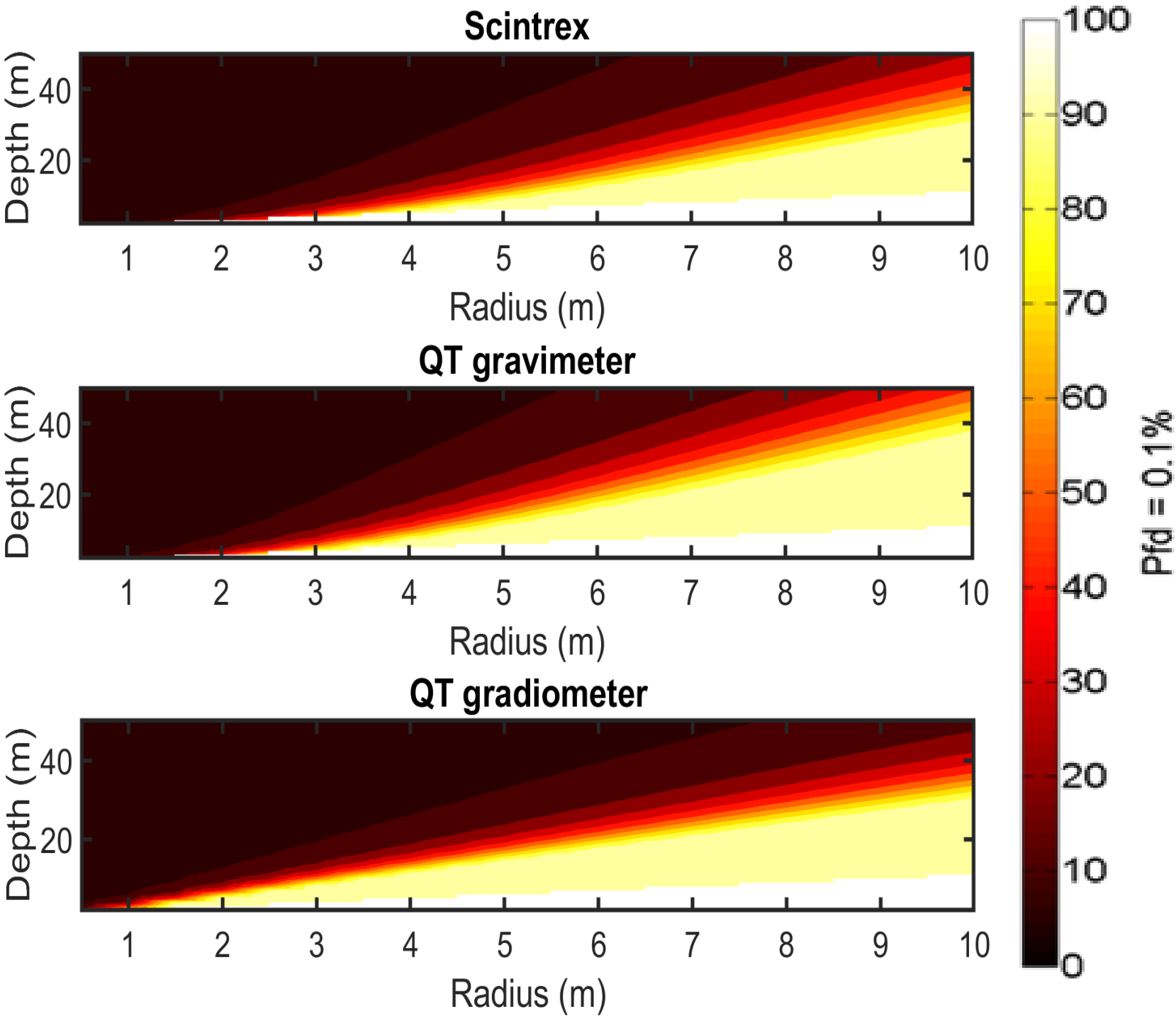


Horizontal Installation




SIMULATED ANOMALY
+
"PERFECT" SIMULATED NOISE
=
"IMPERFECT" REALISTIC CORRECTION
FINAL NOISY DATA

Tunnels


Scintrex
Depth (m)
40
20
1
2
3
4
5
6
7
8
9
10
Radius (m)
QT gravimeter
Depth (m)
40
20
1
2
3
4
5
6
7
8
9
10
Radius (m)
QT gradiometer
Depth (m)
40
20
1
2
3
4
5
6
7
8
9
10
Radius (m)
100
90
80
70
60
50
40
30
20
10
0
Pfd = 0.1%

Results - Tunnels

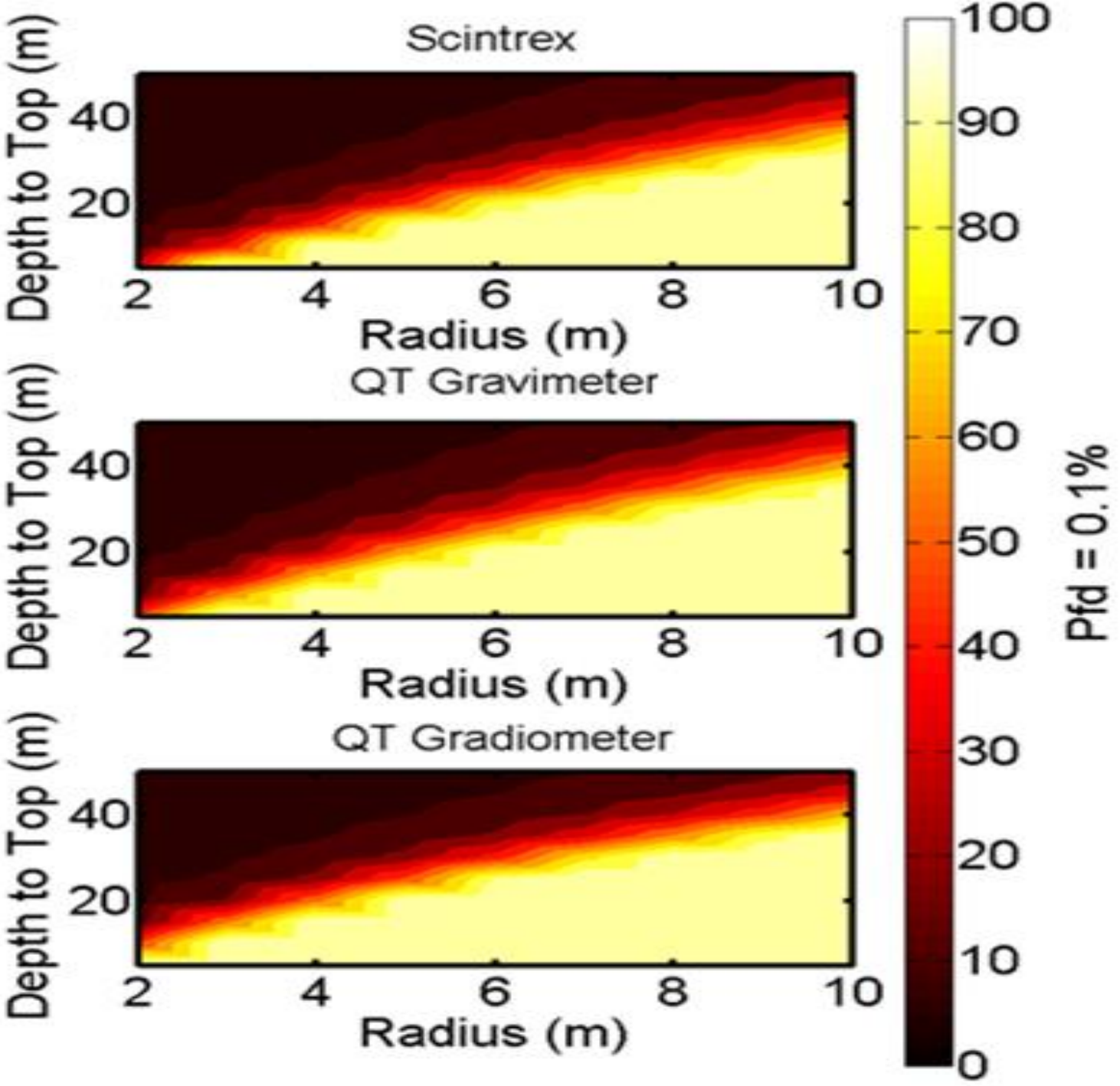
Size of object needed to give 75% chance of detection

Scintrex		QT gravimeter		QT gradiometer	
Depth (m)	Radius (m)	Depth (m)	Radius (m)	Depth (m)	Radius (m)
5	3.51	5	3.07	5	1.67
10	4.93	10	4.32	10	3.19
15	6.09	15	5.34	15	4.69
20	7.13	20	6.25	20	6.18
30	9.08	30	7.96	30	9.14
40	>10	40	9.63	40	>10
50	>10	50	>10	50	>10

12%

15-50%

Collapse Chambers



Results – Collapse Chambers

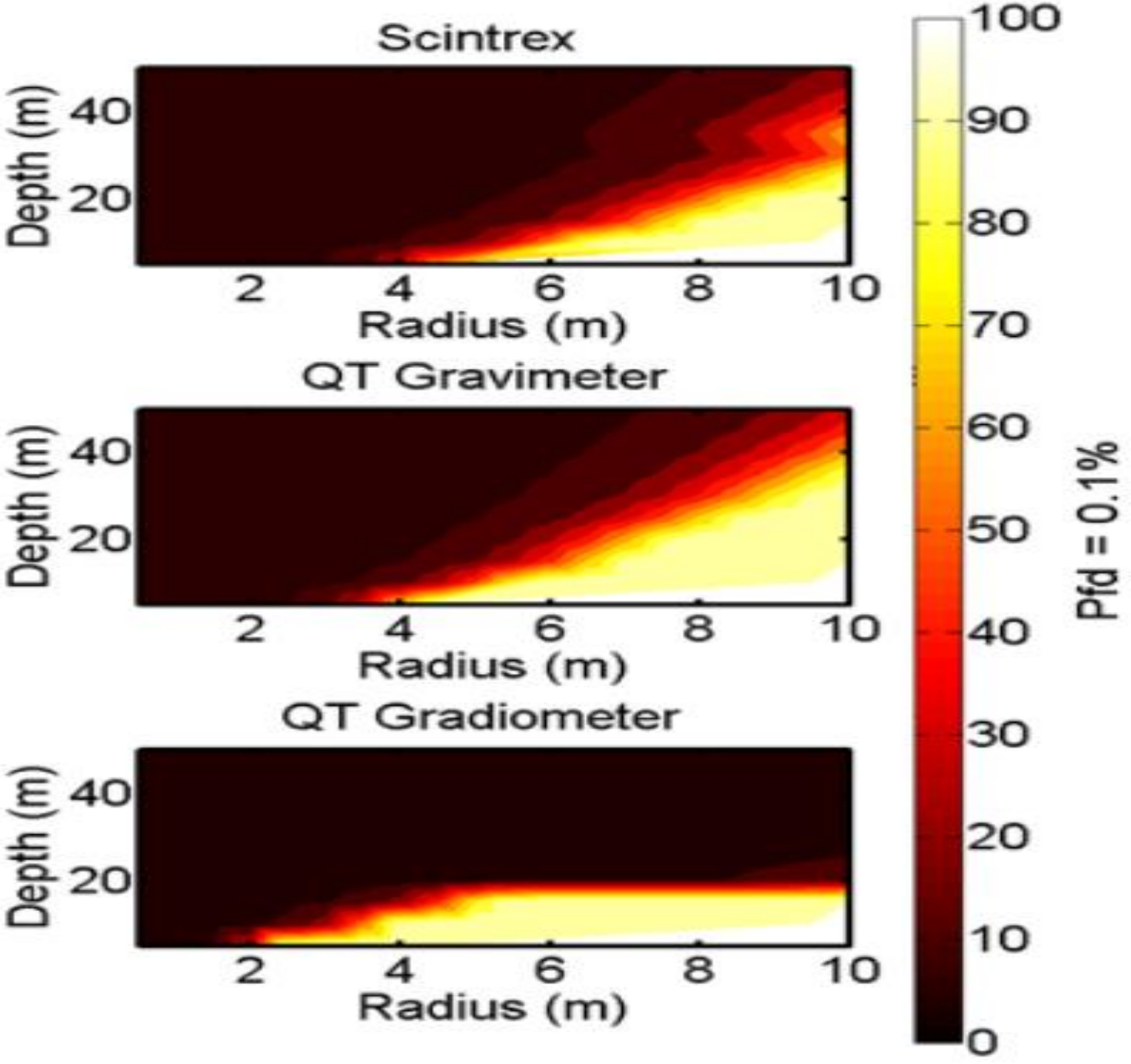
Size of object needed to give 75% chance of detection

Scintrex		QT gravimeter		QT gradiometer	
Depth (m)	Radius (m)	Depth (m)	Radius (m)	Depth (m)	Radius (m)
5	2.62	5	2.49	5	1.3
10	3.4	10	3.34	10	2.5
15	4.5	15	4.15	15	3.4
20	5.69	20	5.18	20	4.26
30	8.33	30	7.50	30	6.94
40	9.49	40	8.35	40	> 10
50	> 10	50	> 10	50	> 10

5-10%

20-25%

Blast Chambers



Results – Blast Chambers

Size of object needed to give 75% chance of detection

Scintrex		QT gravimeter		QT gradiometer	
Depth (m)	Radius (m)	Depth (m)	Radius (m)	Depth (m)	Radius (m)
5	4.45	5	4.05	5	2.43
10	6.25	10	5.41	10	3.65
15	7.62	15	6.59	15	4.92
20	8.47	20	7.19	20	-
30	< 10	30	8.93	30	-
40	< 10	40	< 10	40	-
50	< 10	50	< 10	50	-

10-15%

35-45%

Conclusions

Gradiometer for shallow targets = increased OSI speed and accuracy

Gradiometer is poor at deeper targets (>20m)

Variometer?

Other Noise reduction methods?


WE HAVE A SPECIFIC SET OF SKILLS
AND WE WILL FIND YOU