DEFENCE ACADEMY
OF THE UNITED KINGDOM
Cranfield UNIVERSITY
Defence College of Management and Technology

Assessment of potential blunt trauma under ballistic helmets

Celia Watson, φAnnette Webb, Ian Horsfall
Impact and Armour Group, Cranfield University Shrivenham,UK.
φ Land Engineering Agency, Australian Department of Defence, Melbourne, Australia

c.h.watson@cranfield.ac.uk

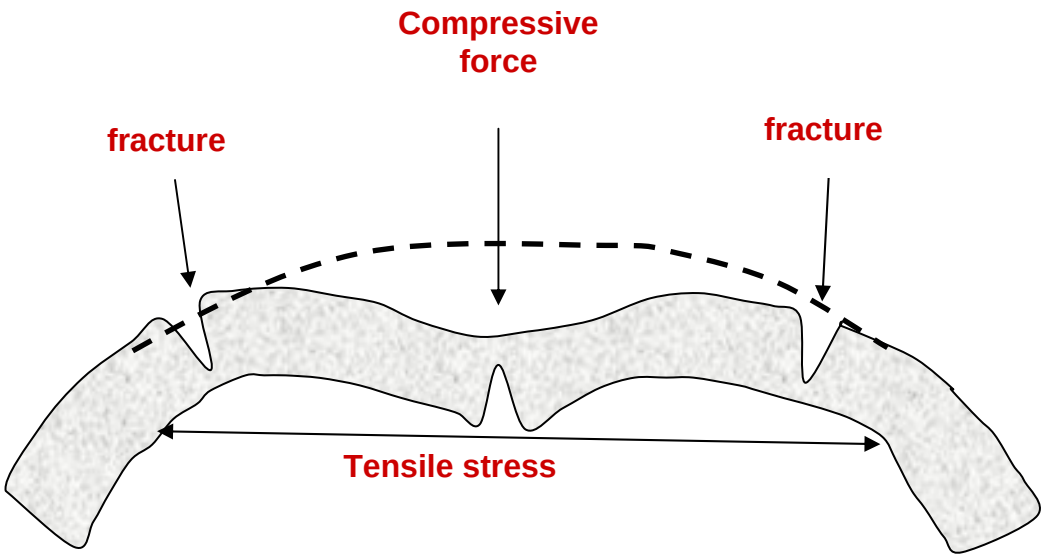
Aims:

To investigate force measurement techniques

Measure head contact loads from non-penetrating ballistic impact on helmets.

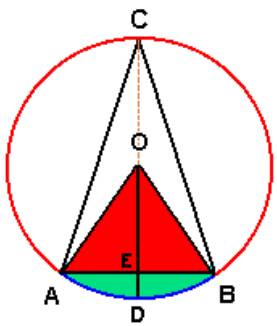
Use the force information to develop a simple method of force measurement for helmet testing.

Forensic analysis



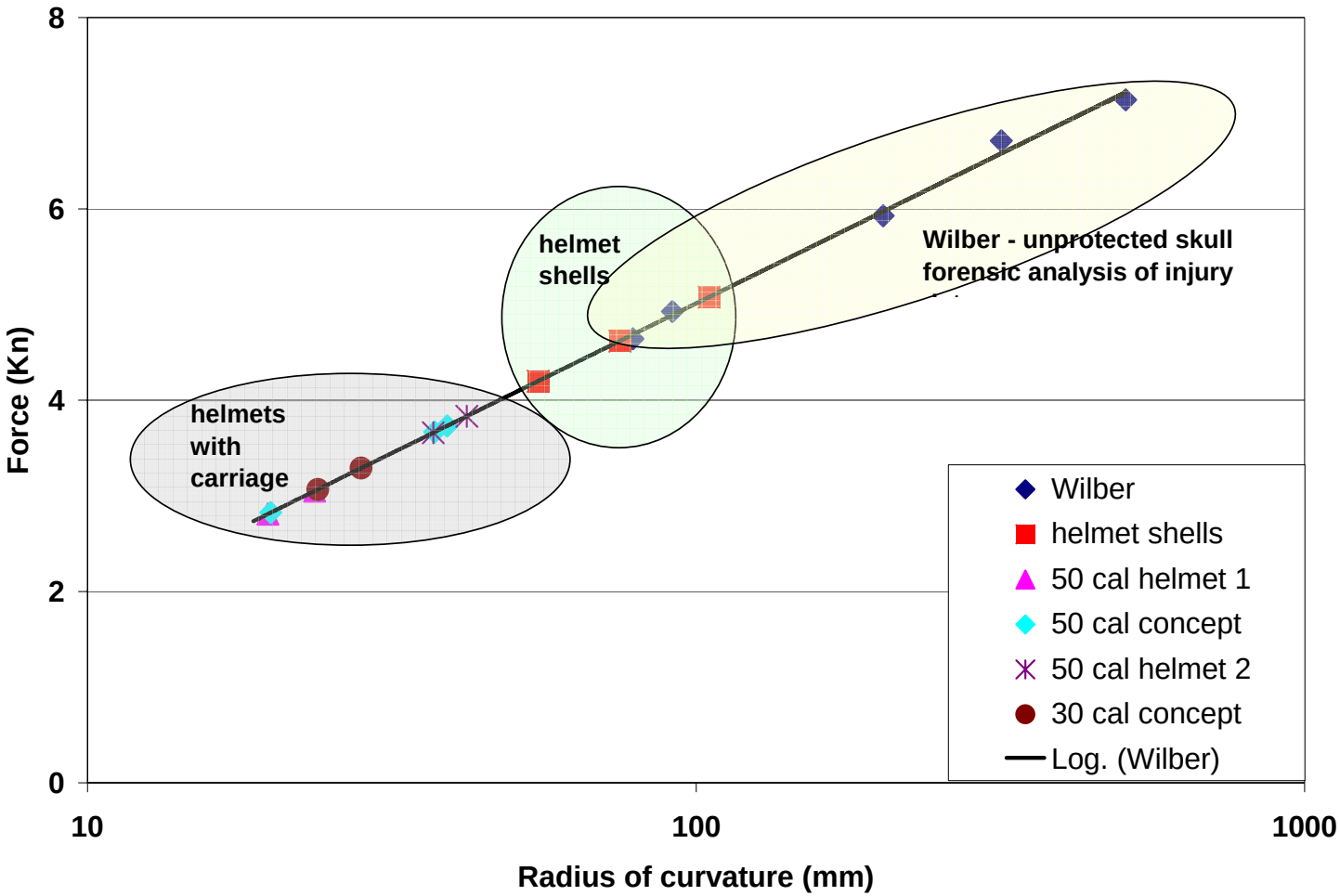
Wilber related the size and shape of fracture damage

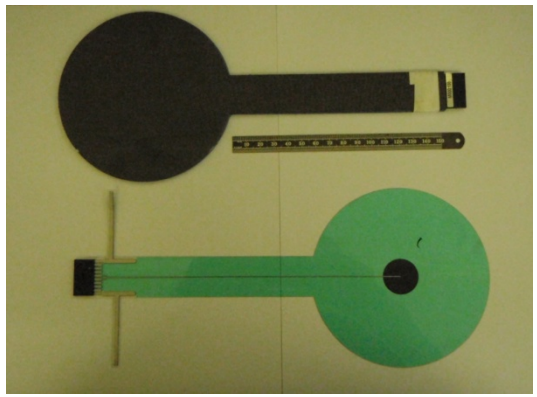
To the radius of curvature of the impacting weapon.



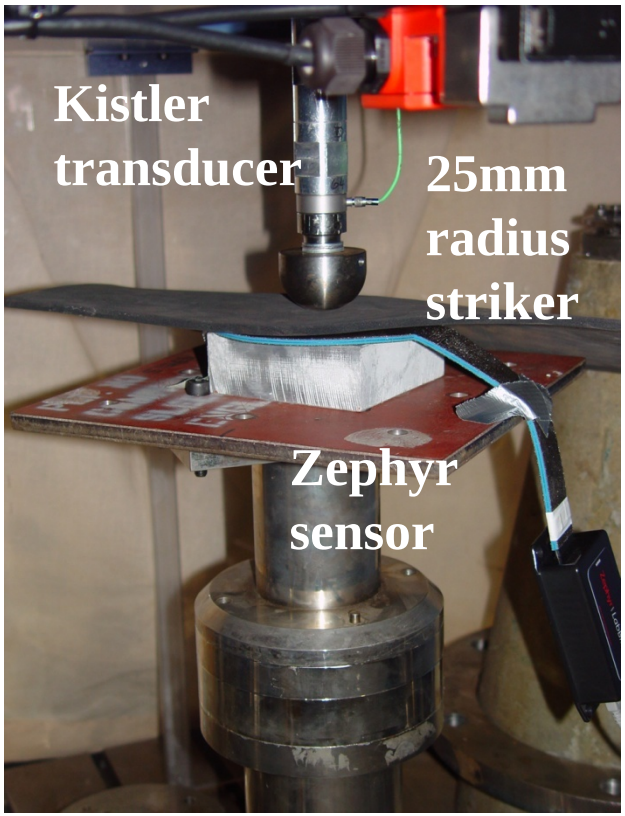
intersecting chord theorem

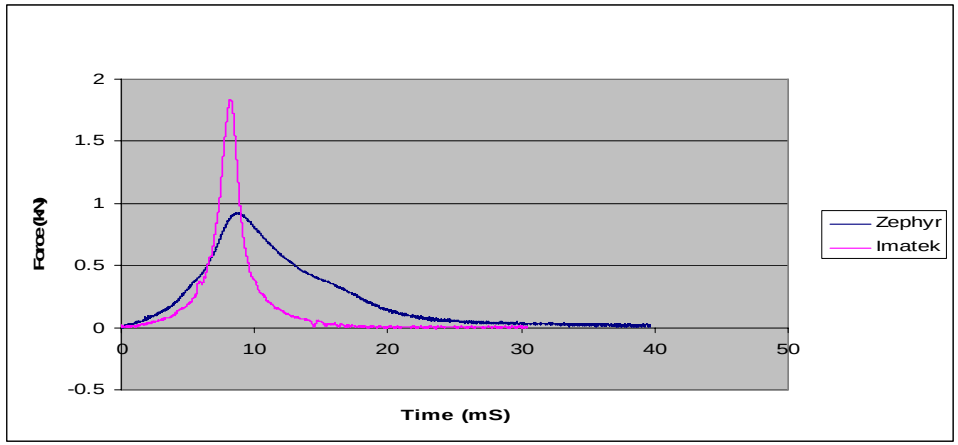
Force vs Radius of Curvature for Skull Fractures



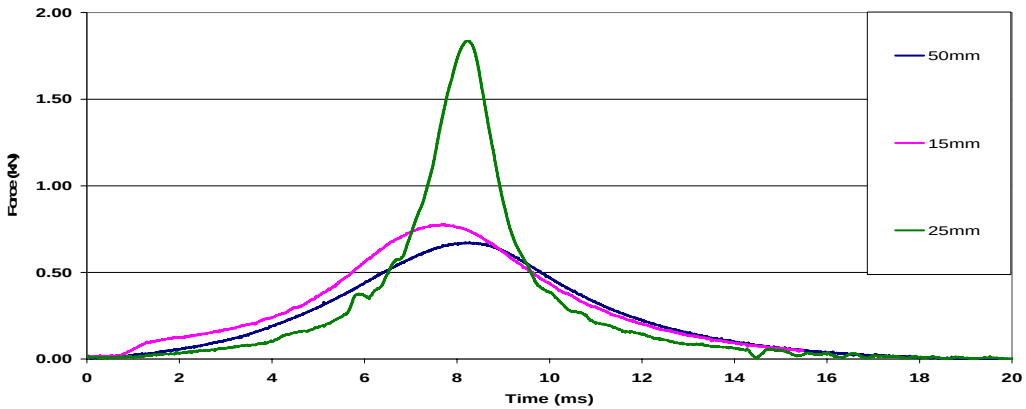


Zephyr® film sensor pads

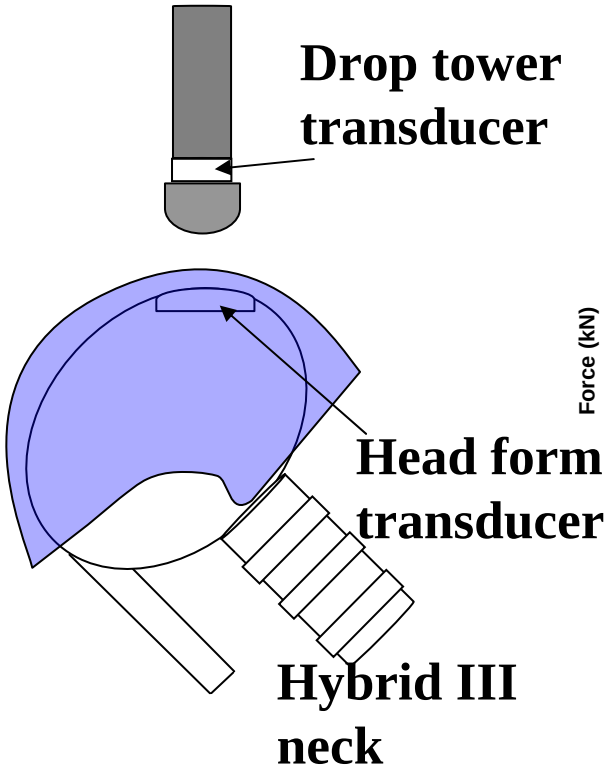


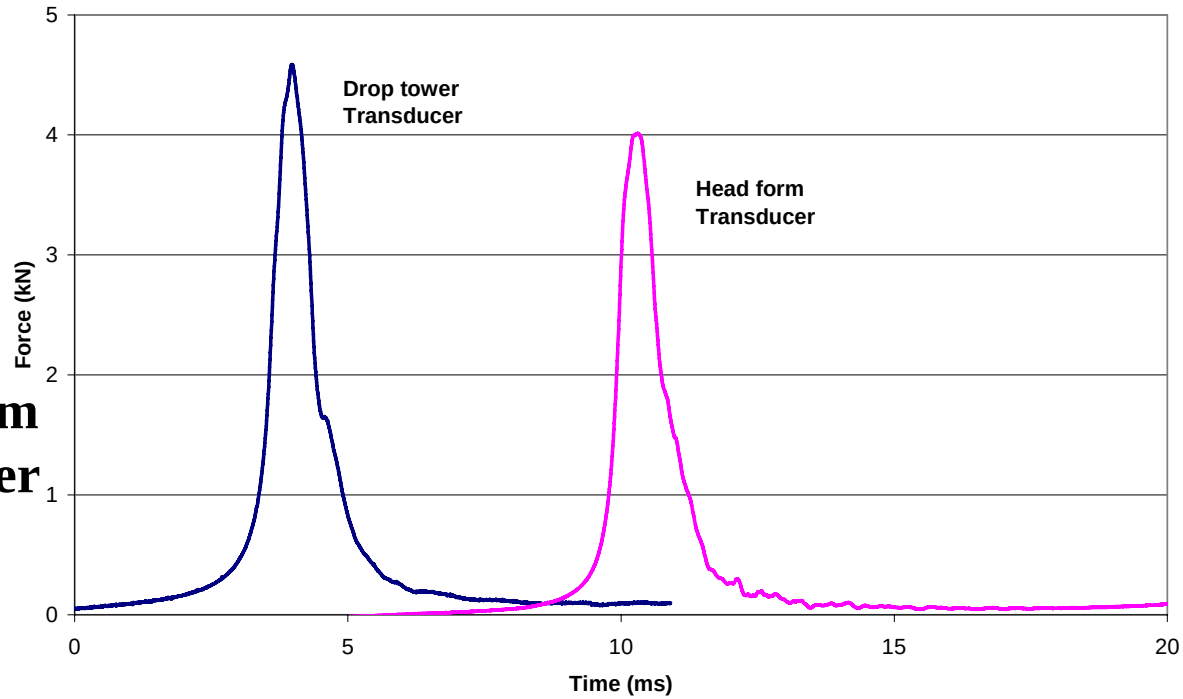


Force output from 9031A Kistler® load cell compared with Zephyr® sensors

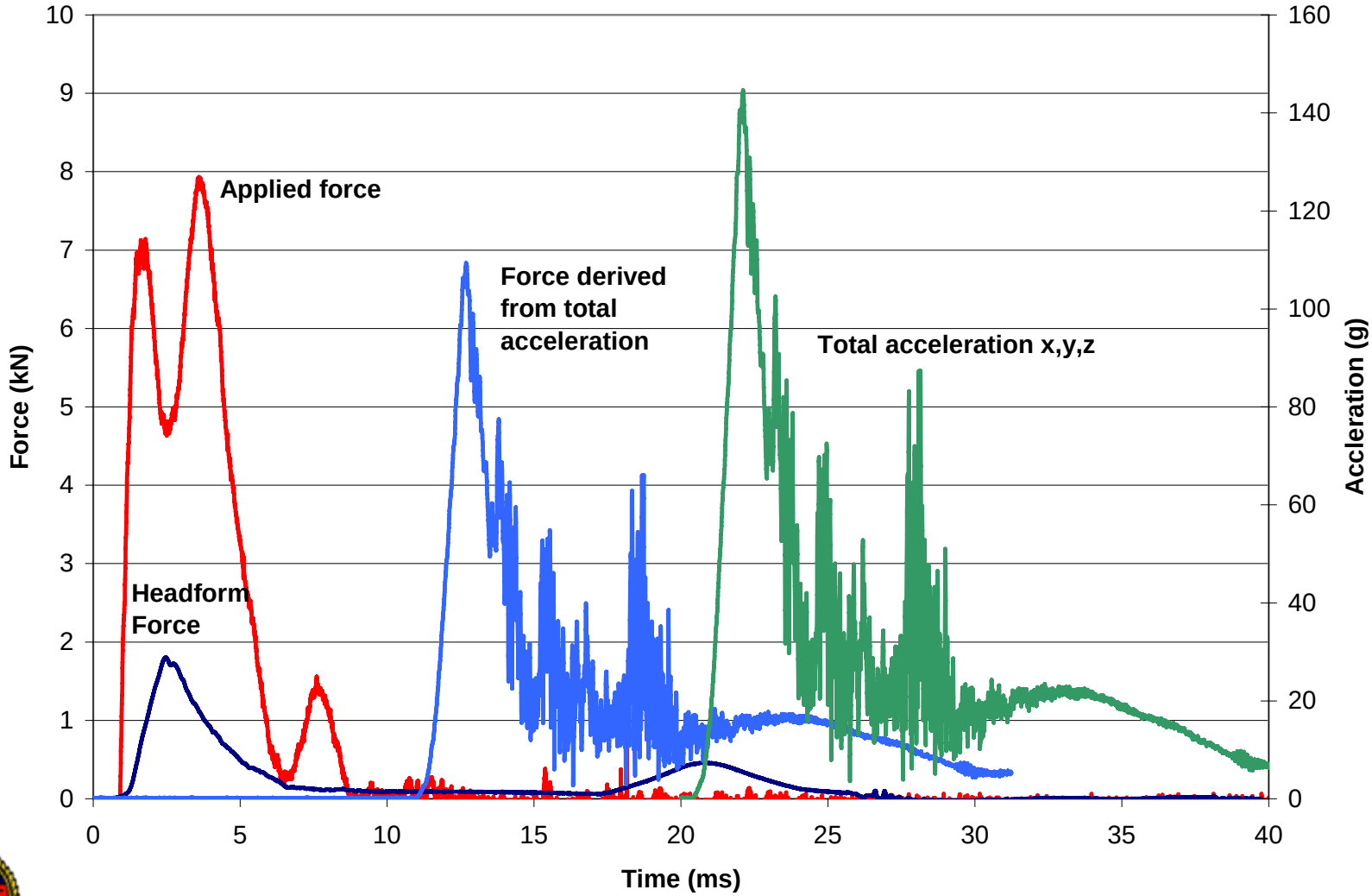


Effect of radius of different strikers





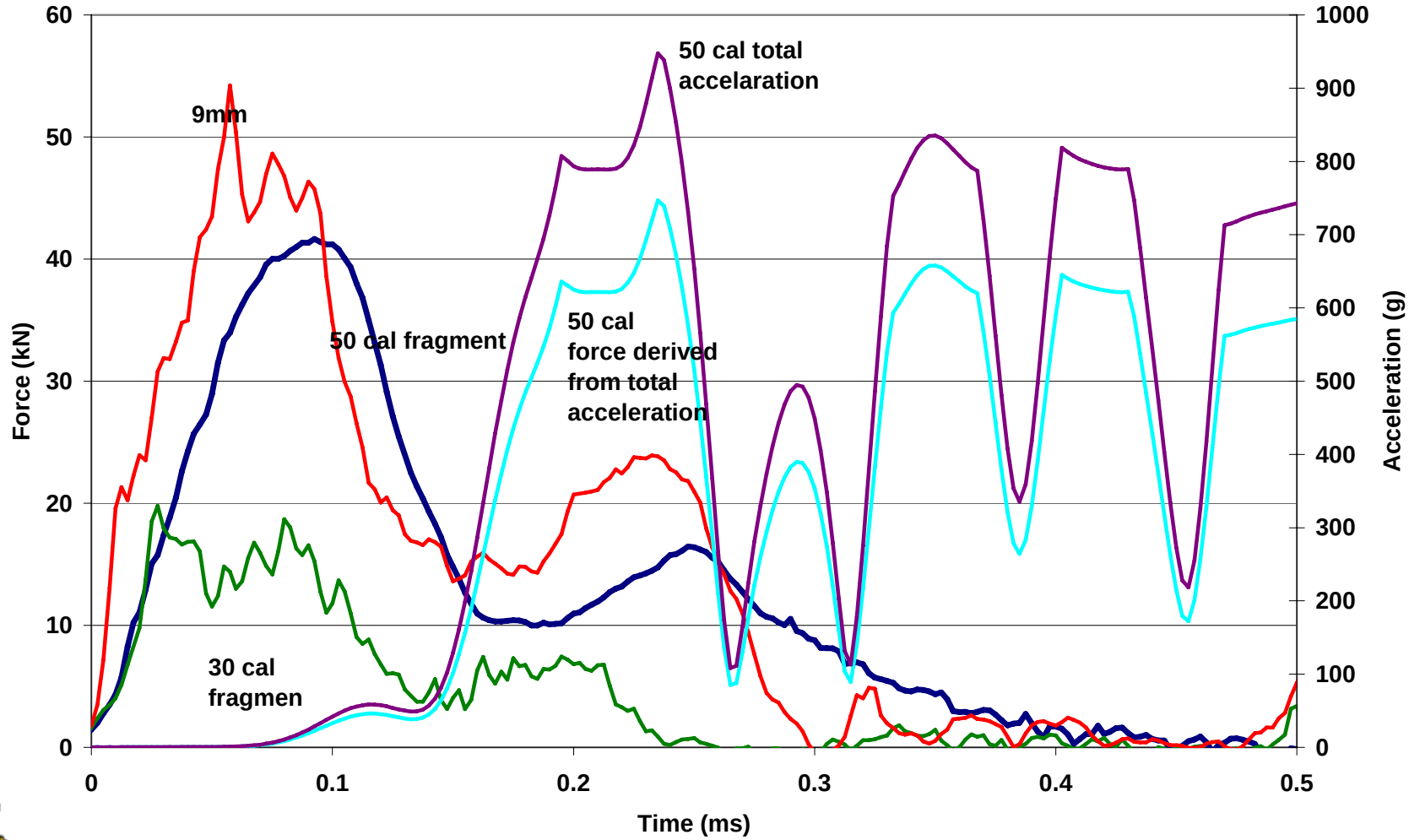
Force vs time - comparison of transducer outputs


Applied force
Force derived from total acceleration
Total acceleration x,y,z
Headform Force
Force (kN)
Accleration (g)
Time (ms)
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40

Shots loaded the centre of Film sensors

No standoff other than the mitigation allowed by the carriage system

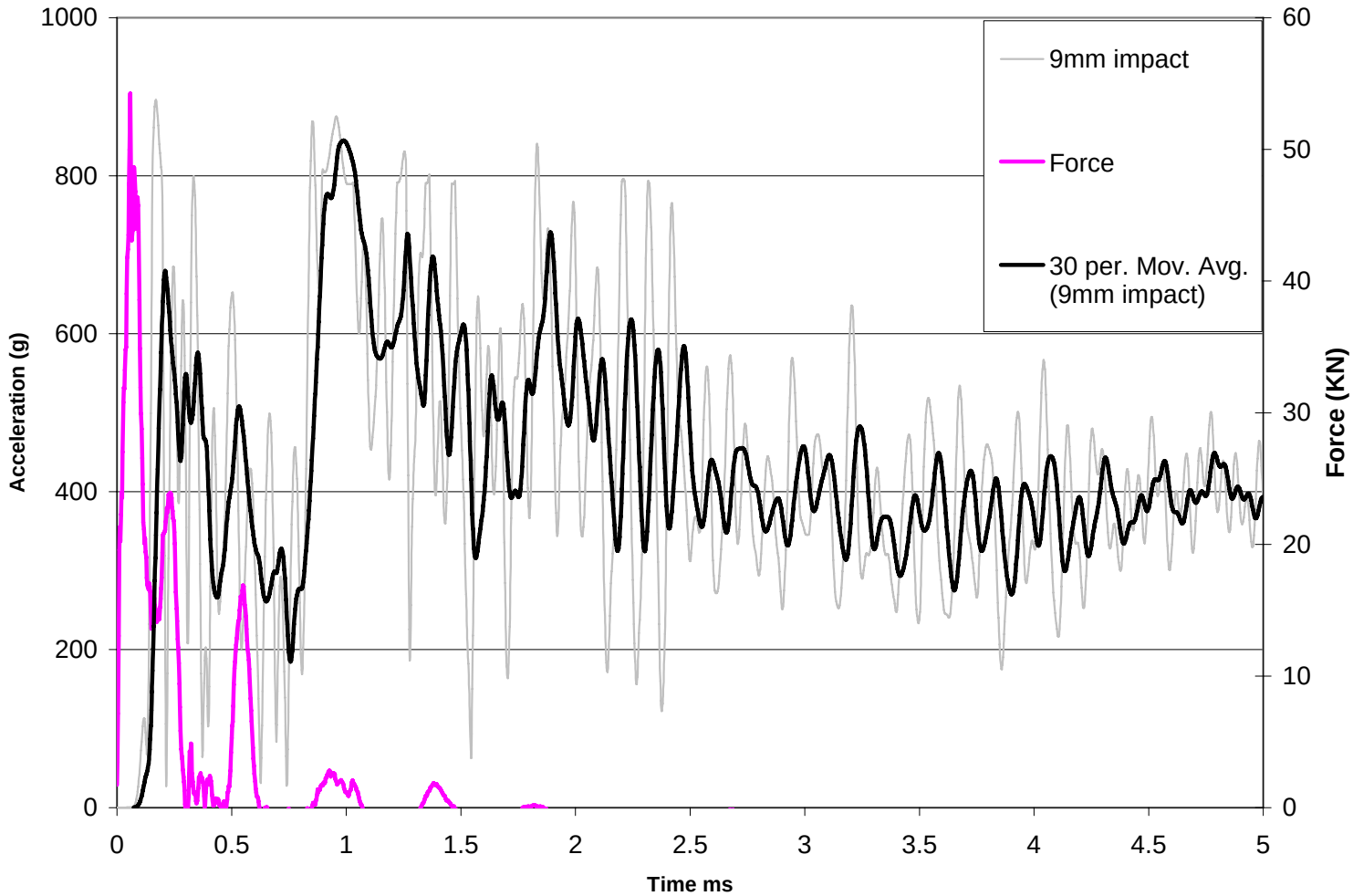
Kevlar helmet shell with carriage system showing position of Zephyr sensor on Aluminium head form and Hybrid III neck.

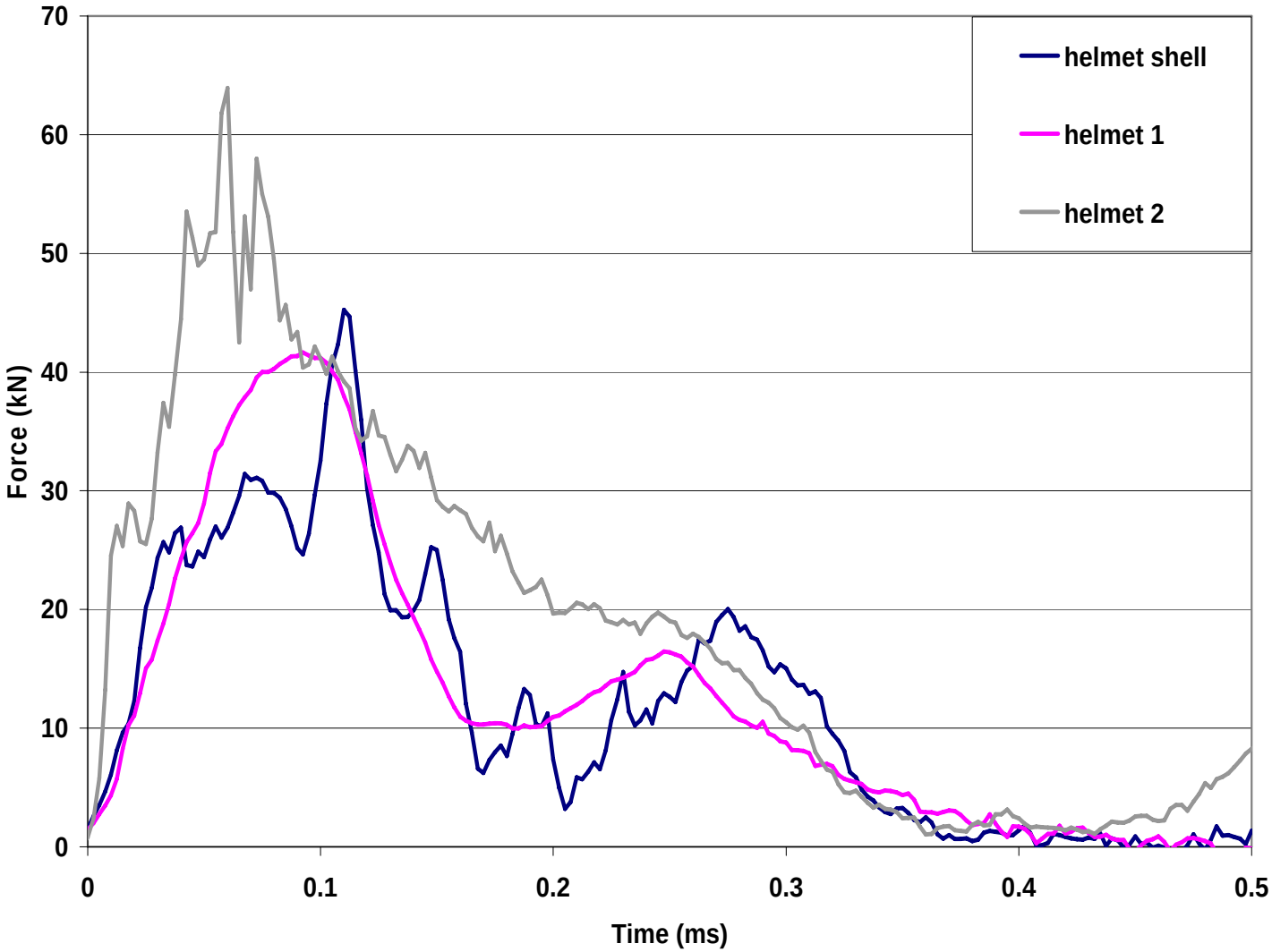

9mm
50 cal total accelaration
50 cal fragment
50 cal force derived from total acceleration
30 cal fragmen
Force (kN)
Acceleration (g)
Time (ms)
0
10
20
30
40
50
60
0
100
200
300
400
500
600
700
800
900
1000
0
0.1
0.2
0.3
0.4
0.5

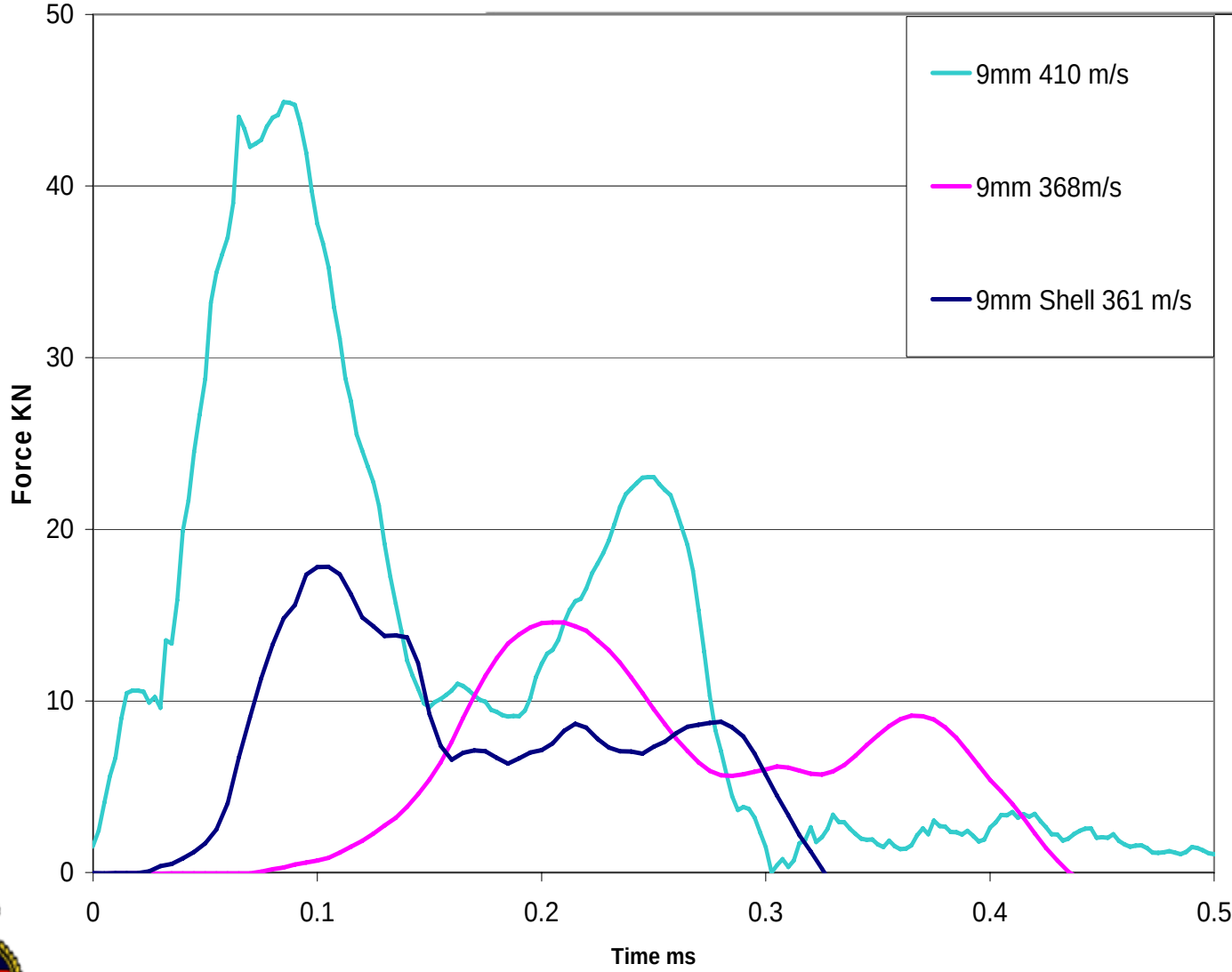
9mm impact on helmet

Initial impact

Complete impact motion


1000
800
600
400
200
0
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Acceleration (g)
Force (KN)
Time ms
9mm impact
Force
30 per. Mov. Avg. (9mm impact)


70
60
50
40
30
20
10
0
Force (kN)
0
0.1
0.2
0.3
0.4
0.5
Time (ms)
helmet shell
helmet 1
helmet 2


50
40
30
20
10
0
Force KN
0
0.1
0.2
0.3
0.4
0.5
Time ms
9mm 410 m/s
9mm 368m/s
9mm Shell 361 m/s

Summary

The head form was robust

Peak force results were repeatable.

Time histories of Force and acceleration correlated with high speed video and similar work by other researchers

0.05ms duration of the peak force from ballistic impact is a higher rate than the 15.0ms duration rate accepted as suitable for the HIC

Head form not bio-fidelic and compliance issues will be investigated in further work.

Film sensors show promise but need further development