

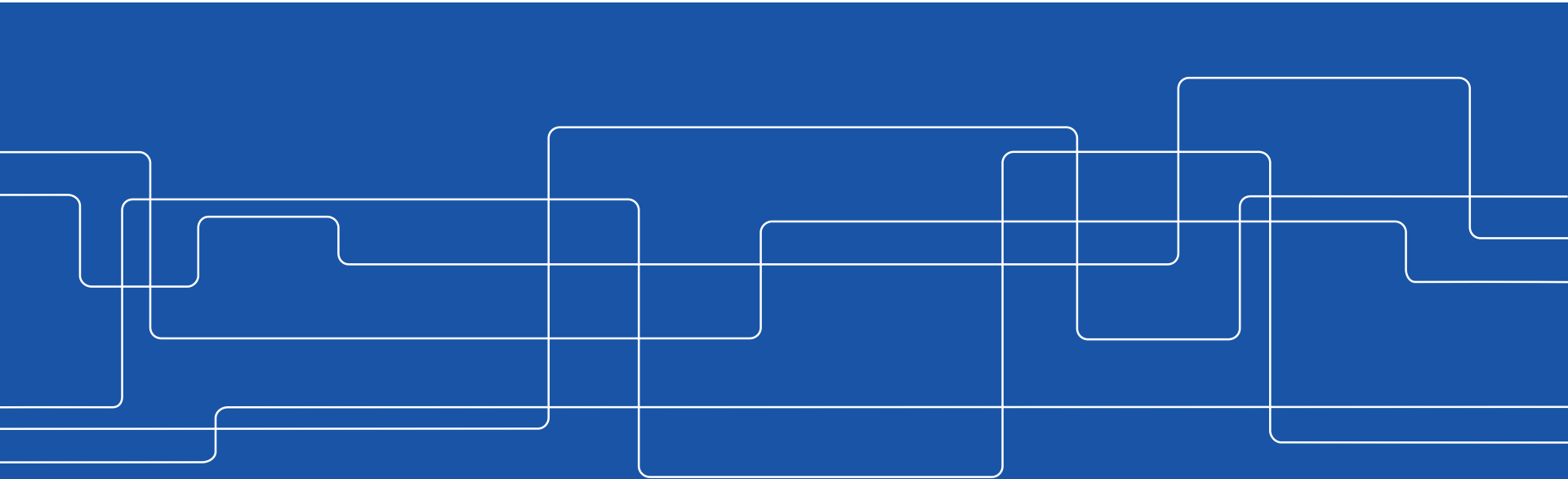


# Importance of the Bicycle Helmet Design and Material for the Outcome in Bicycle Accidents

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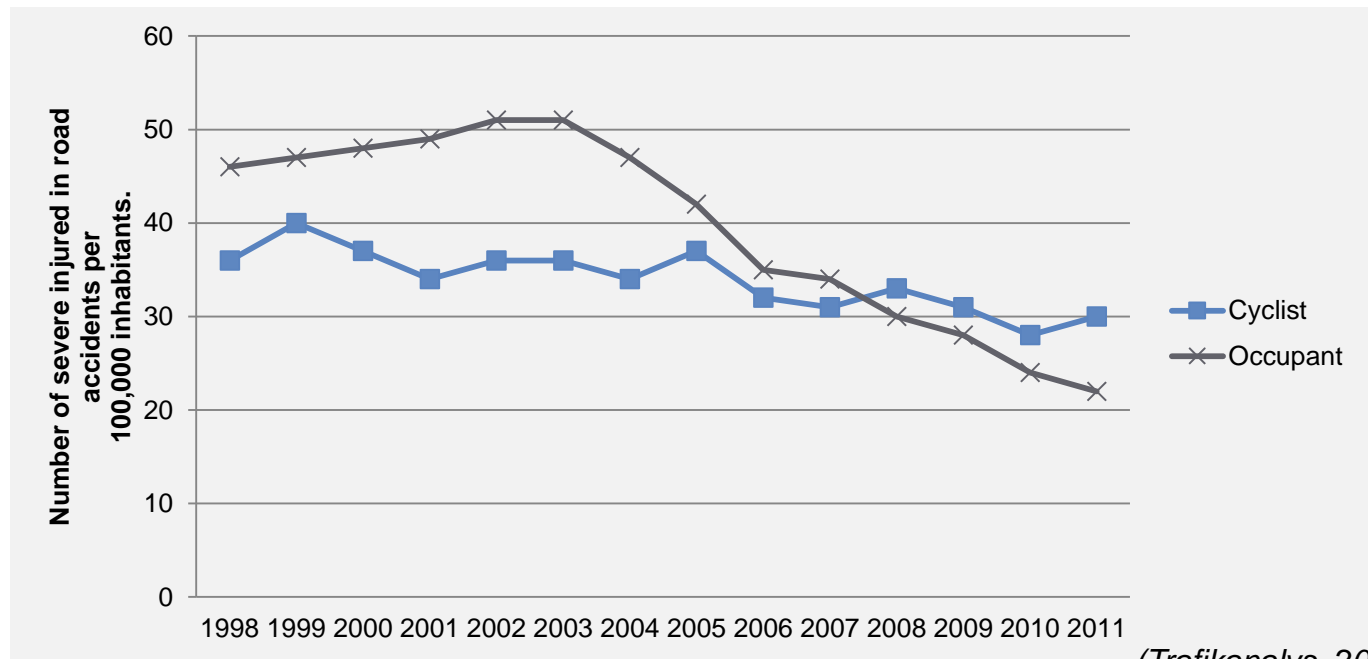
# Outline

- Background
- Objectives
- Methods
- Results
- Limitations
- Conclusions



# Vulnerable Road Users

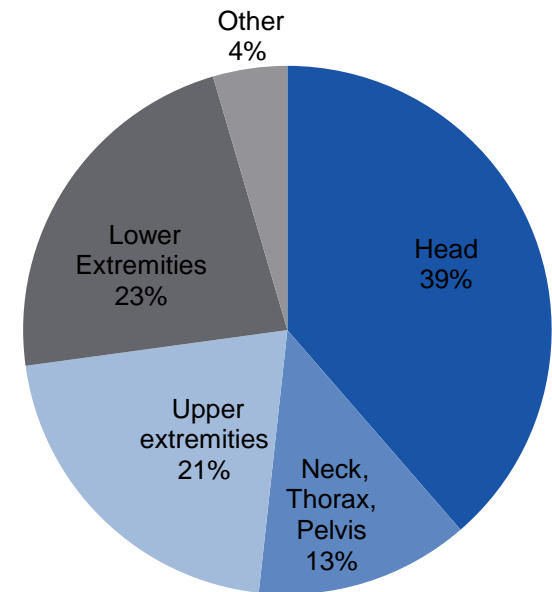
“...,less success in saving lives among vulnerable road users  
than amongst car occupants”  
(ITRAD, 2014)



(Trafikanalys, 2013)

# Injuries in Bicycle Accidents

- 42% of the severe impairment injuries (*Rizzi et al 2013*)



(*Trafikanalys, 2013*)

# Head Protection for Cyclists



# Helmet Test Standards Today

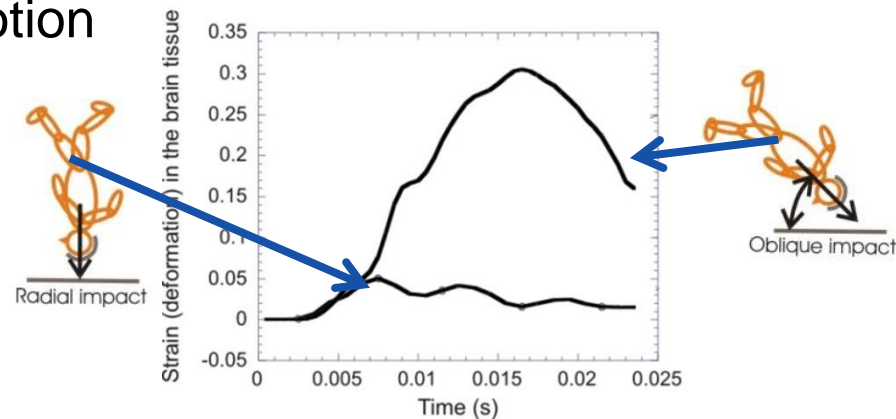
- Radial Impact



5.4m/s

< 250g

- Brain is more sensitive to rotational motion



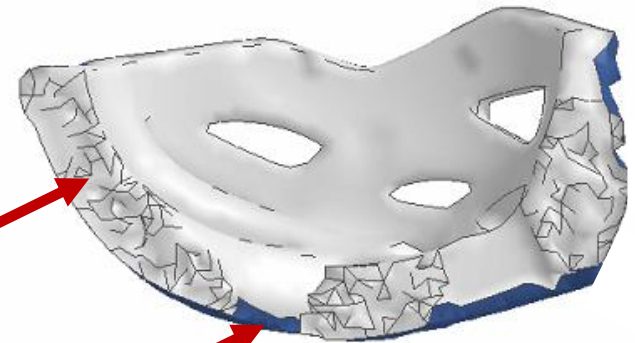
# Helmet Design



- Previous studies – few different impact situations

Liner

Outer  
shell



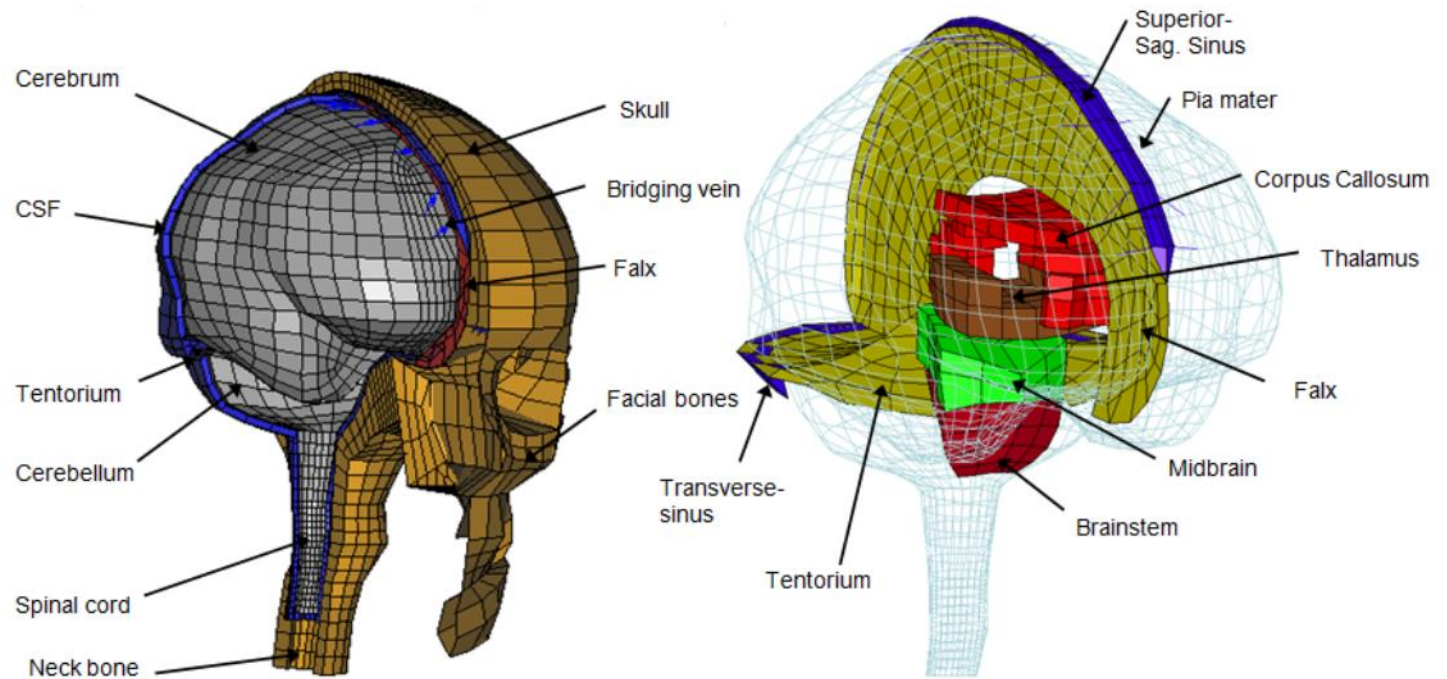


# Objectives of this Study

- Evaluate
  - the potential of a helmet
  - different helmet designs
  - different impact situations

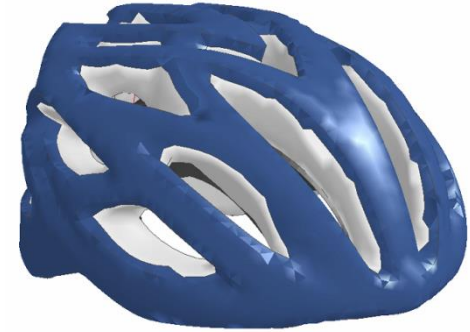


# The KTH Head Model

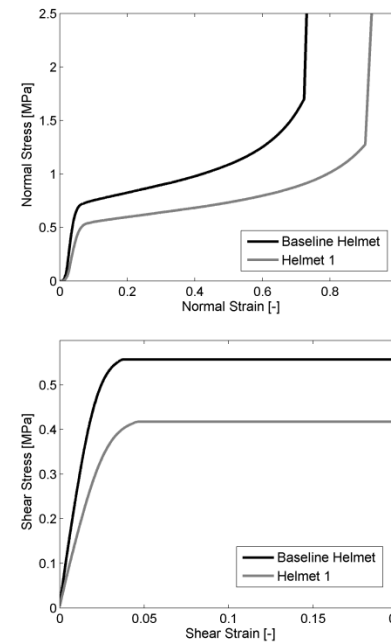


(Kleiven, 2007)

## 3 Different Helmet Designs

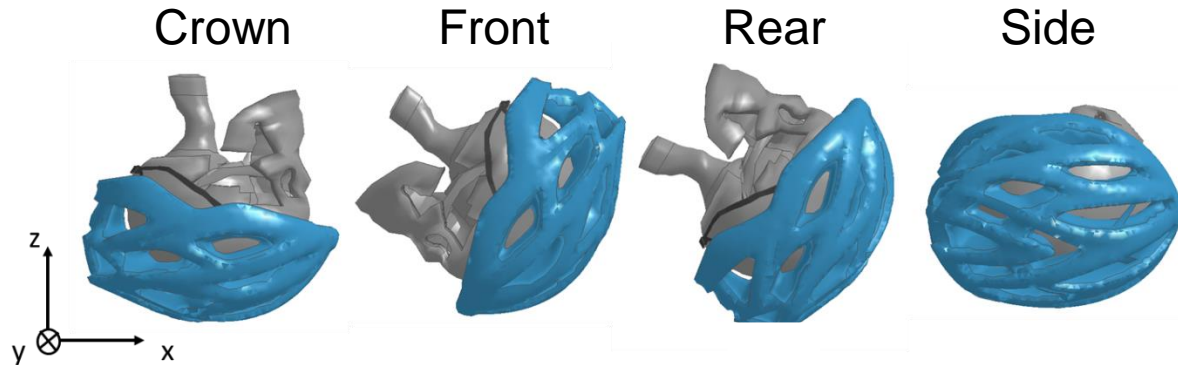


- No Helmet
- Baseline Helmet
- Helmet 1
- Helmet 2



Extra  
sliding  
layer

## Impact Situations

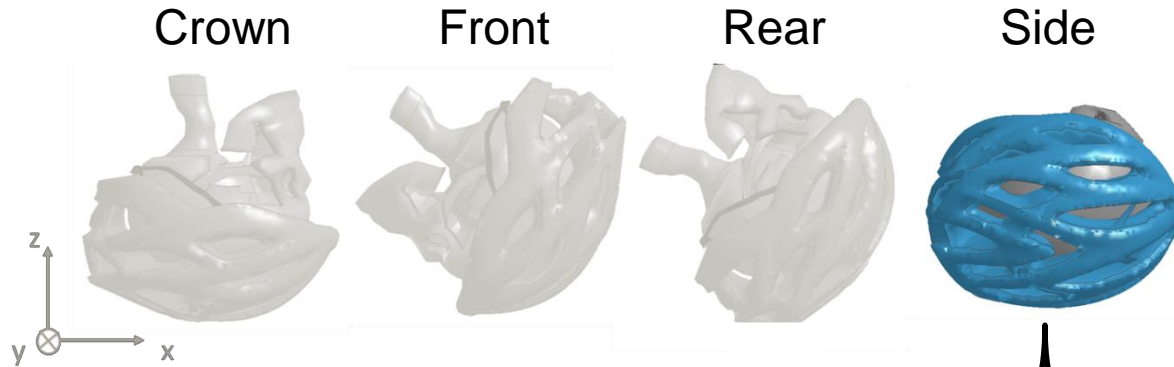


Impact Direction	$V_x$ [m/s]	$V_y$ [m/s]	$V_z$ [m/s]
1	-4.5	0	-4.5
2	4.5	0	-4.5
3	0	-4.5	-4.5
4	0	0	-6.4

Resultant velocity 6.4 m/s

# Example Crown

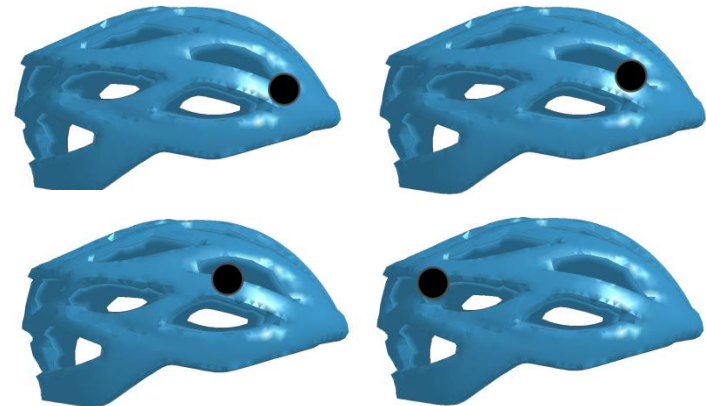
# Impact Situations



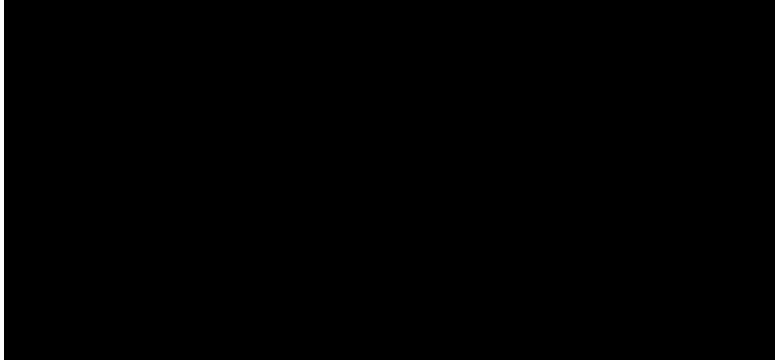
$v_x = 4.5 \text{ m/s}$  and  $v_z = -4.5 \text{ m/s}$   
+15, -15, -30 and -45 degrees

Impact Direction	$V_x$ [m/s]	$V_y$ [m/s]	$V_z$ [m/s]
1	-4.5	0	-4.5
2	4.5	0	-4.5
3	0	-4.5	-4.5
4	0	0	-6.4

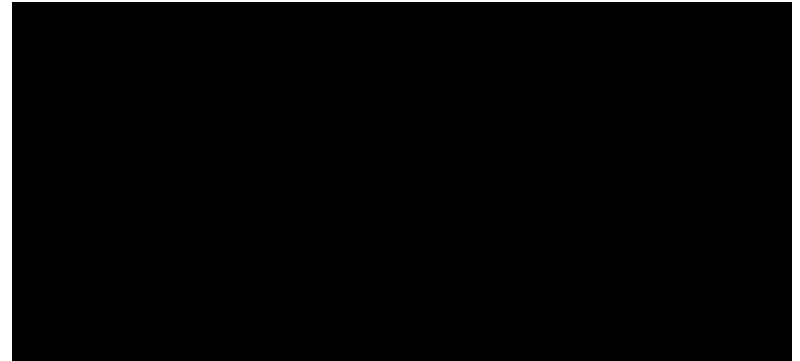
Resultant velocity 6.4 m/s



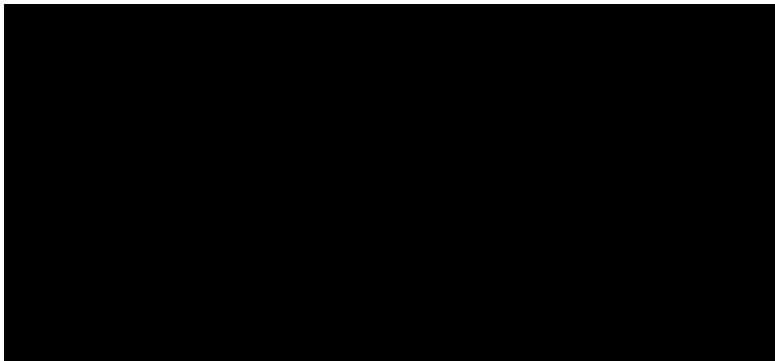
No Helmet



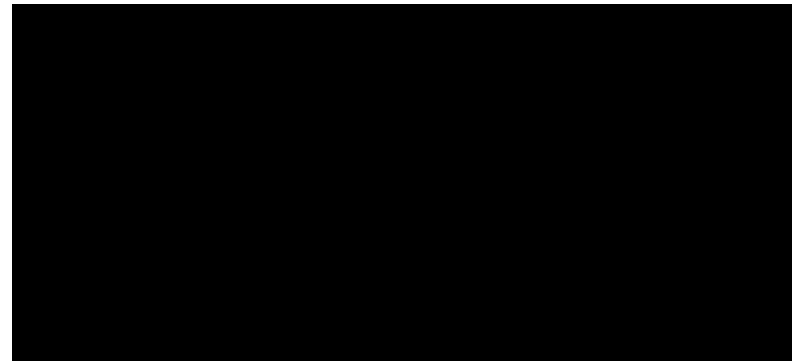
Baseline



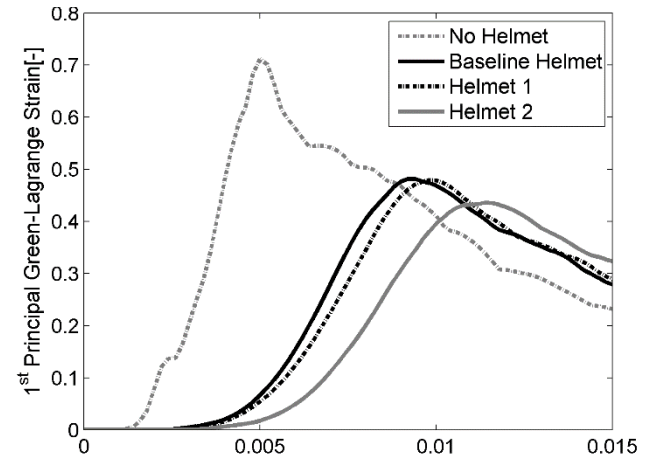
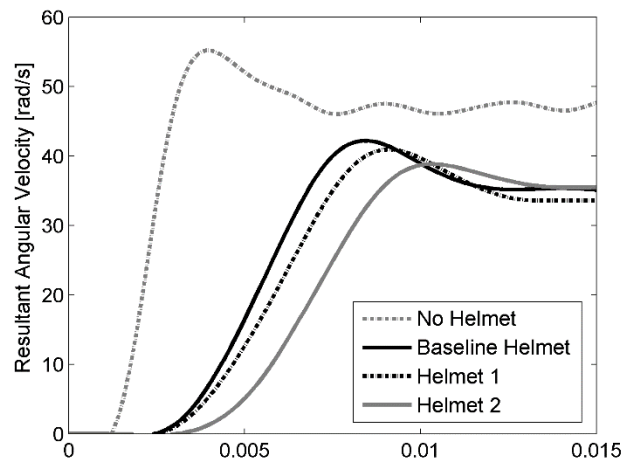
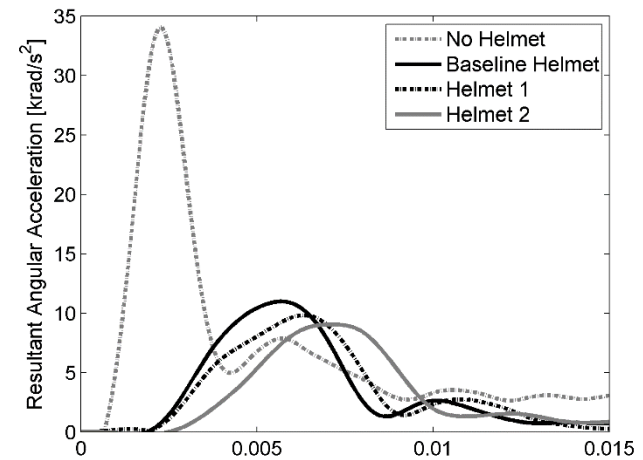
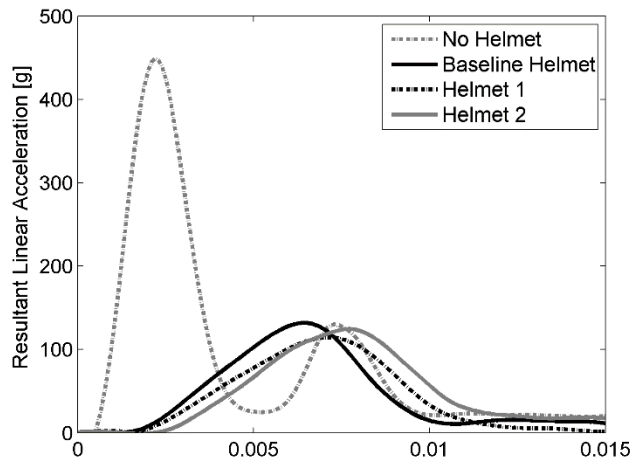
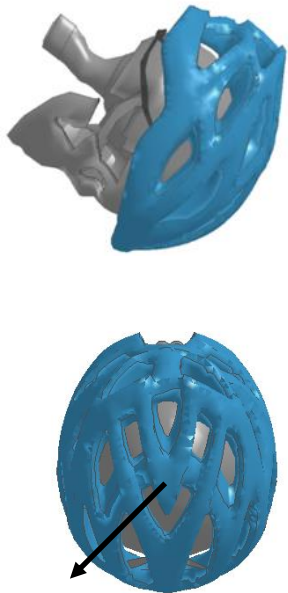
Helmet 1



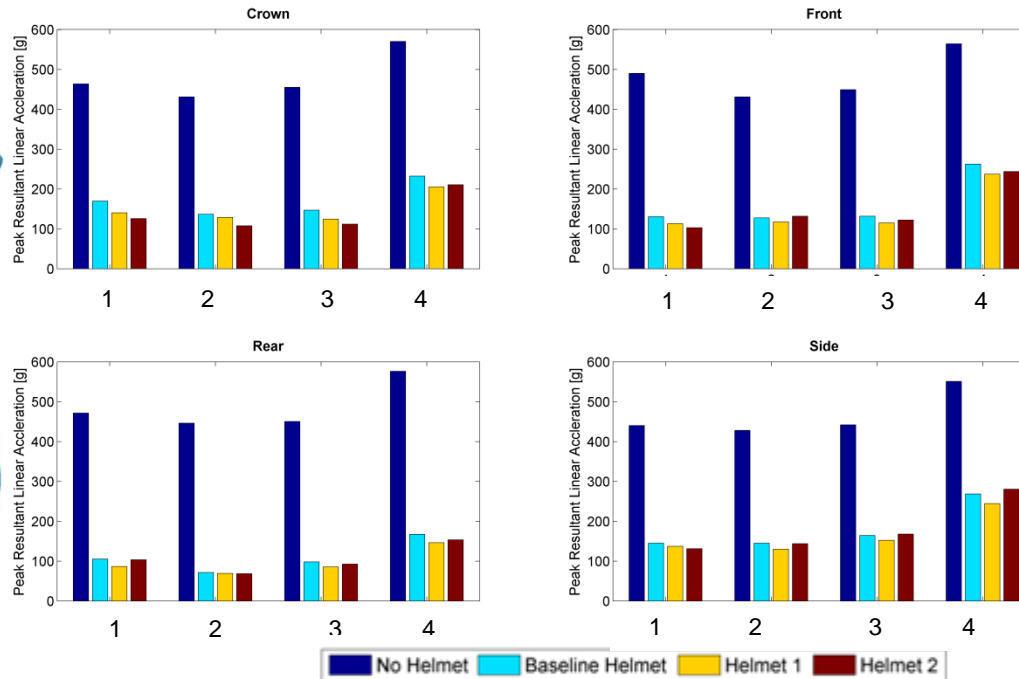
Helmet 2



# Example of an Impact



# Linear Acceleration

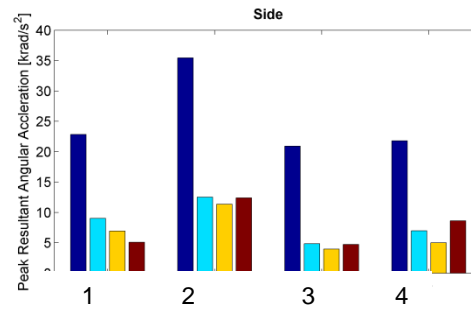
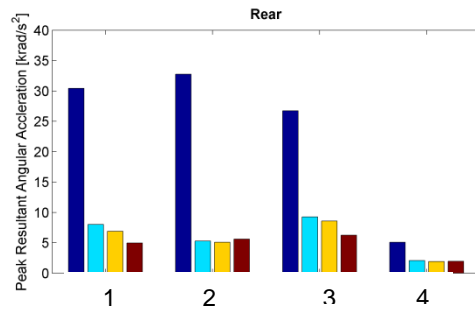
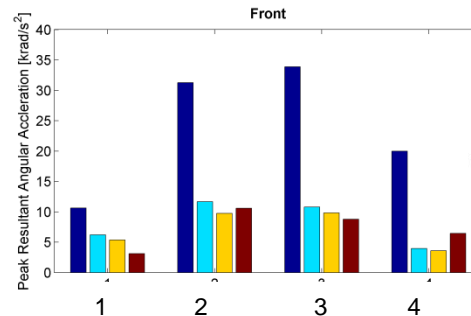
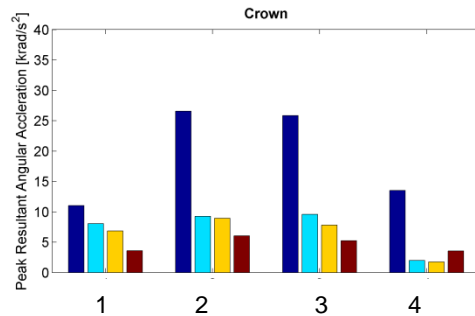


- 49-85%
- 26% variation
- Skull fracture

Oblique impacts – 1,2,3  
Radial impact - 4



# Angular Acceleration

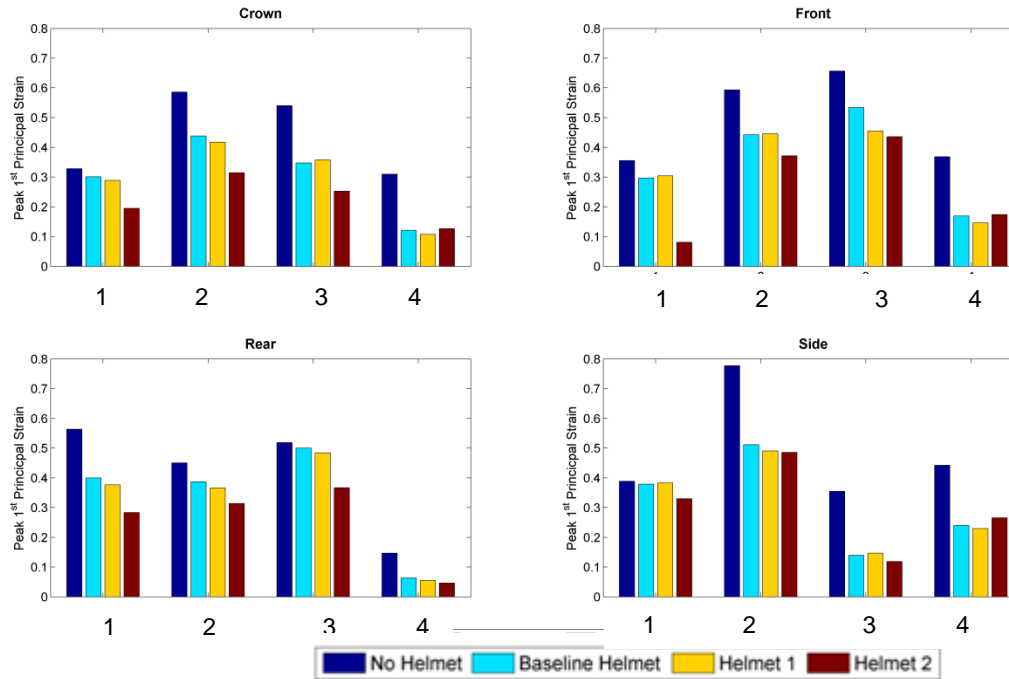


■ No Helmet ■ Baseline Helmet ■ Helmet 1 ■ Helmet 2

Oblique impacts – 1,2,3  
Radial impact - 4

- 27-87%  
- 55% variation

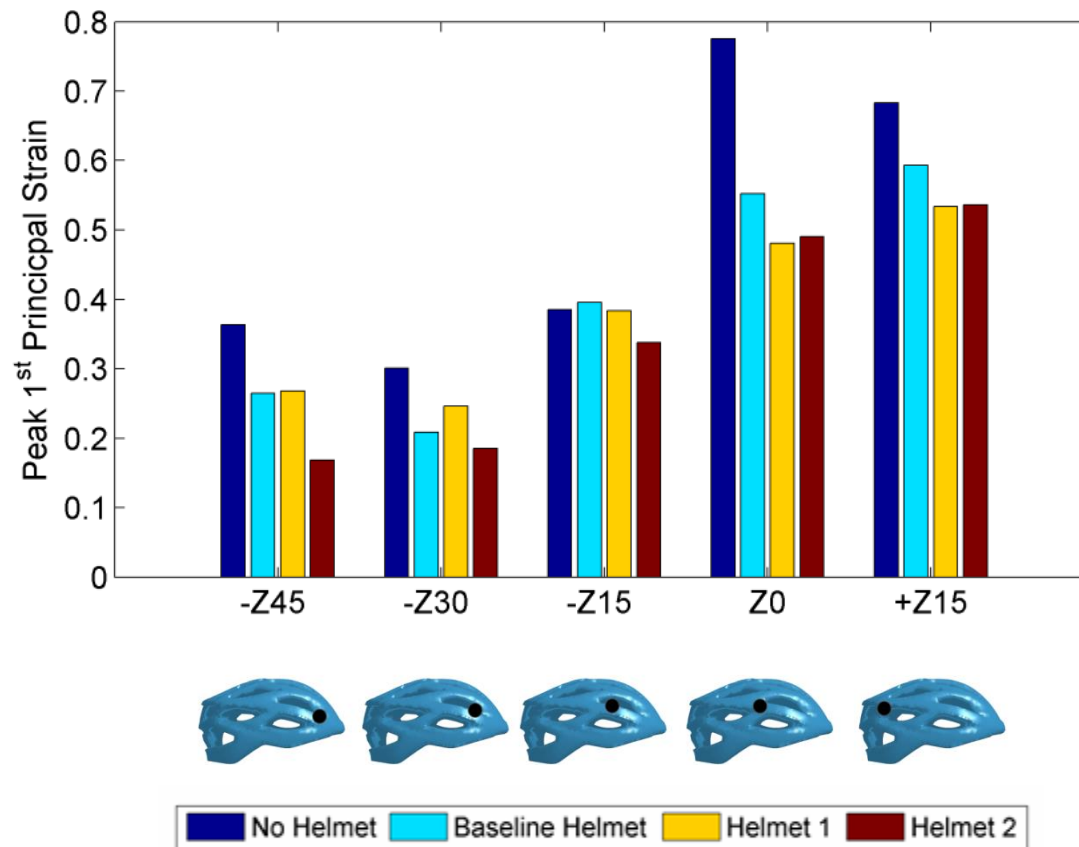
# 1<sup>st</sup> Principal Strain



- 2% - 77%
- Differences among helmet designs
- Concussion: 21-26% (Kleiven 2007)

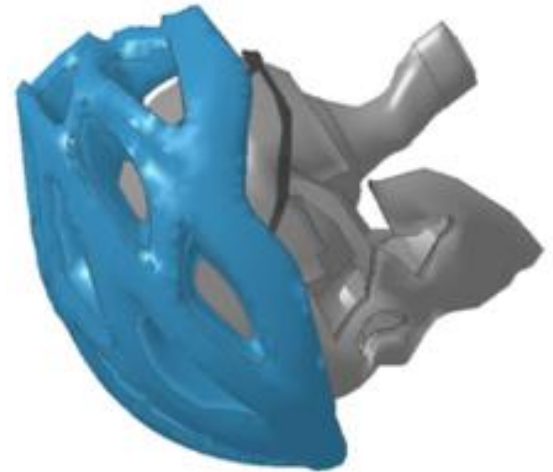
Oblique impacts – 1,2,3  
Radial impact - 4

# Sensitivity Study



# Limitations

- Limited parameter study
- One geometry
- Head only simulations
- No chin strap and comfort foam
- 1 of 3 helmets validated



# Conclusions

- Reduced risk of injury
  - Linear Acceleration: 49-85%
  - Strain: 2-77%
- Larger differences among helmets for oblique impacts
- Possibility to improve helmet test standard and helmet design



# **Thank for Your Attention, Any Questions?**

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