Presentation of MIPS Science

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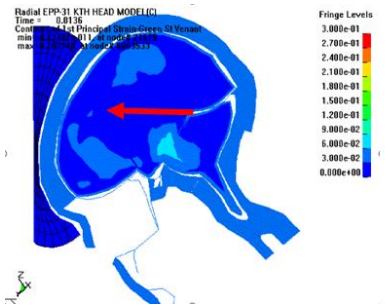
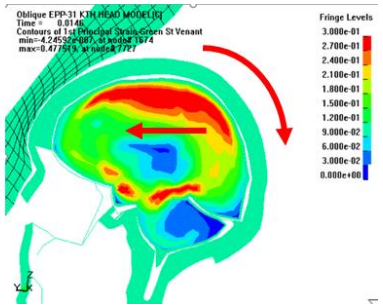
Outline

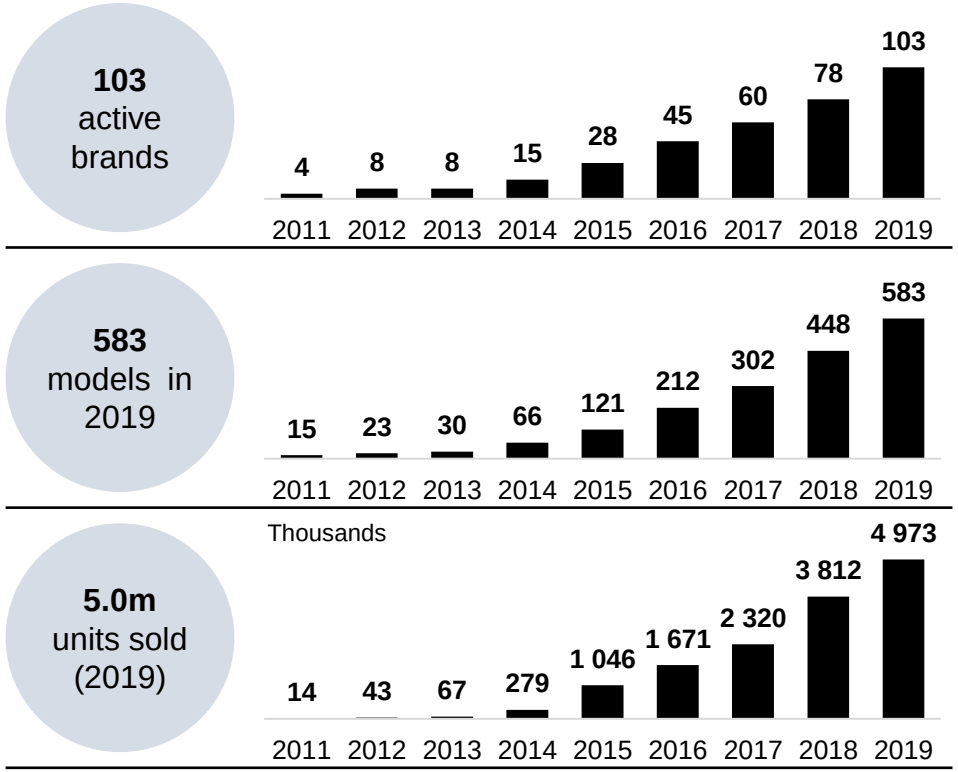
- Background to MIPS
- Research at the Royal Institute of Technology and FE model of the human brain
- MX accident reconstruction
- The Oblique test method
- MIPS test results





WORLD LEADING BRAND IN BRAIN PROTECTION SYSTEMS

- 103 helmet brands using the MIPS technology worldwide
- 583 helmet models
- 14m units delivered
- Established in three main categories:
    - Sports (Bike, Snow, EQ, Hockey and Mountaineering)
    - Moto (Road motorcycle and MX)
    - Safety (Industry and LEAF)



OUR HISTORY – FROM RESEARCH TO COMMERCIAL SUCCESS

1995
Swedish neurosurgeon Hans von Holst contacts University to discuss solutions

1996-1998
Initial testing and seed funding, set up and patent filing costs

2000-2001
First scientific publication regarding MIPS

2001-2007
In 2001 MIPS AB is founded, followed by a start-up phase including a Swedish launch of a helmet with a MIPS solution

2009
The first third party helmet with the MIPS Brain Protection System (BPS) is launched

2010
MIPS becomes a true ingredient brand offering a global solution

2014
Establishment of the BRG and MIPS collaboration

2015
MIPS achieves profitability

2016
The first street motorcycle helmet model with the MIPS BPS is launched

2017
March 23, MIPS IPO on Nasdaq Stockholm

2018
Major legal disputes settled
→ proven strong patent portfolio

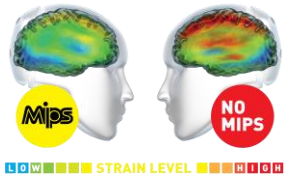
2019
More than 20 MOTO brands using the MIPS technology

Research | **Start-up phase** | **Growth / ingredient brand strategy** | **Scaling up / Cont. growth**

MIPS TODAY

25 Years of research at the Royal Institute of Technology and the Karolinska Institute.

4 Thesis and multiple research papers in international scientific publications.



World renowned Finite Element (FE) Model of the human brain

35,000 State of the art test facility for all helmet categories.

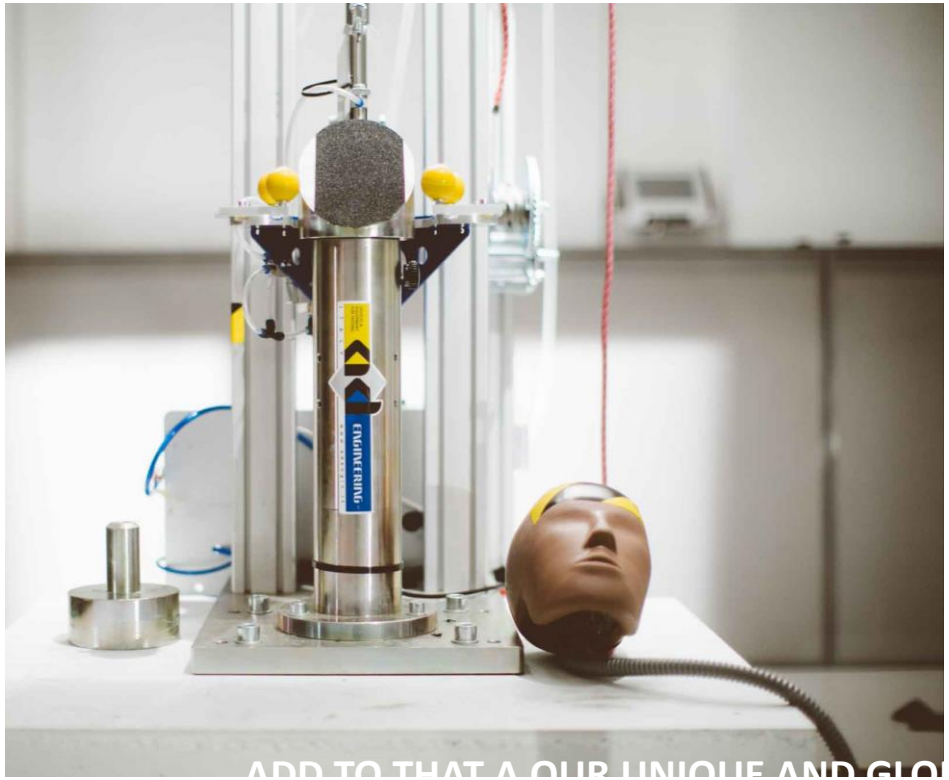
Reconstructions from real life accidents.

BIOKINETICS

External validation by 3rd party in US, Canada and Sweden.

IP

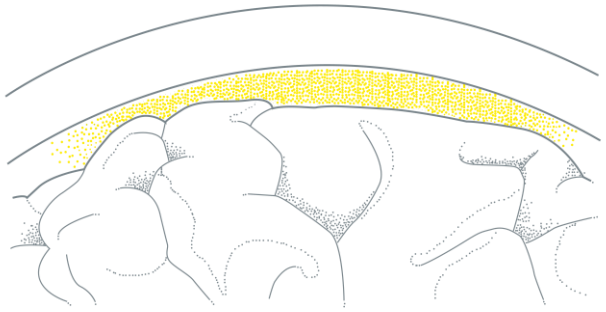
36 Patent families



Multi-directional Impact Protection System

The cerebrospinal fluid is our natural protection system that allows the brain to move relative to the skull.

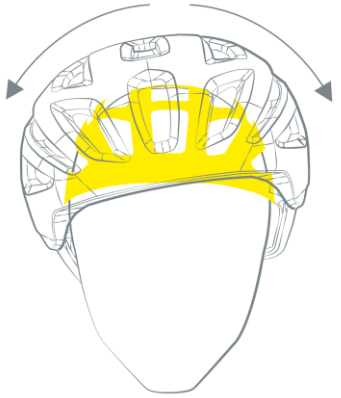
MIPS mimics the protective properties in the human brain and adds a layer of protection

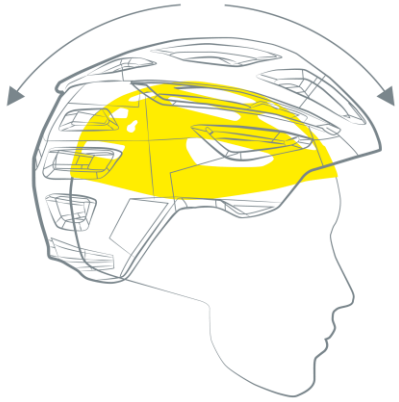


Skull

Cerebrospinal Fluid

Brain



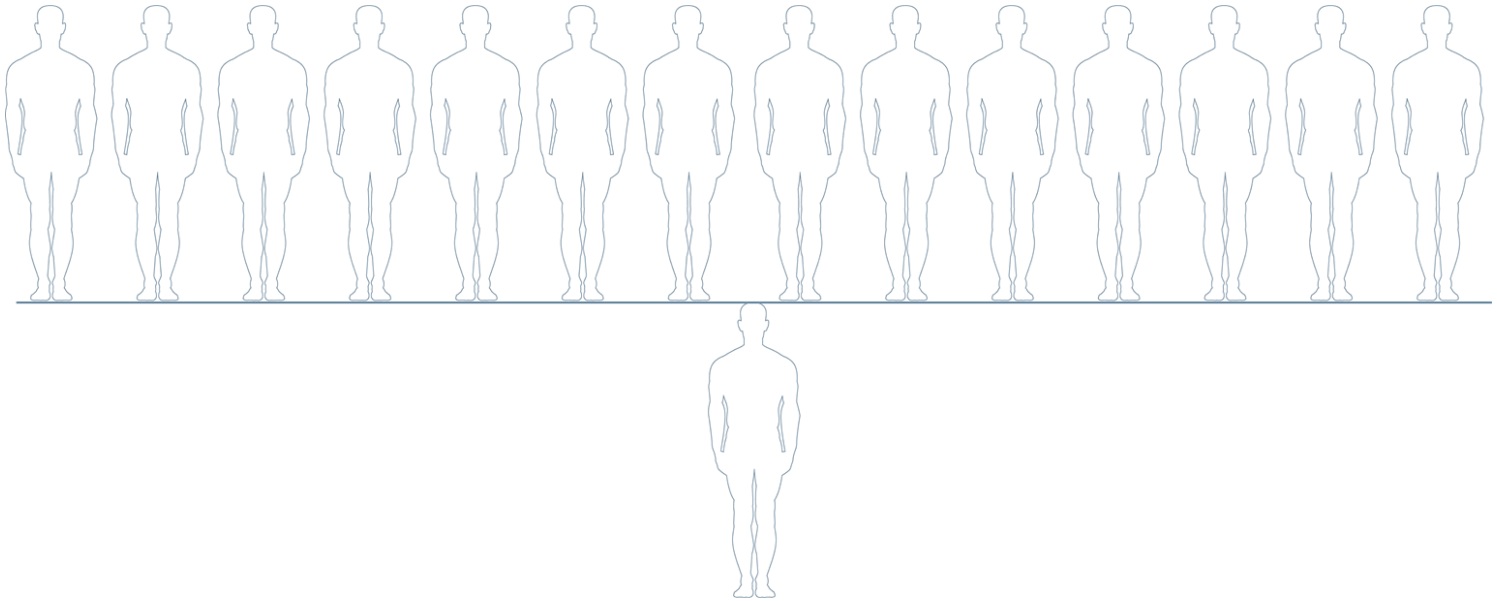


In the critical 5 -10 milliseconds of an impact ...

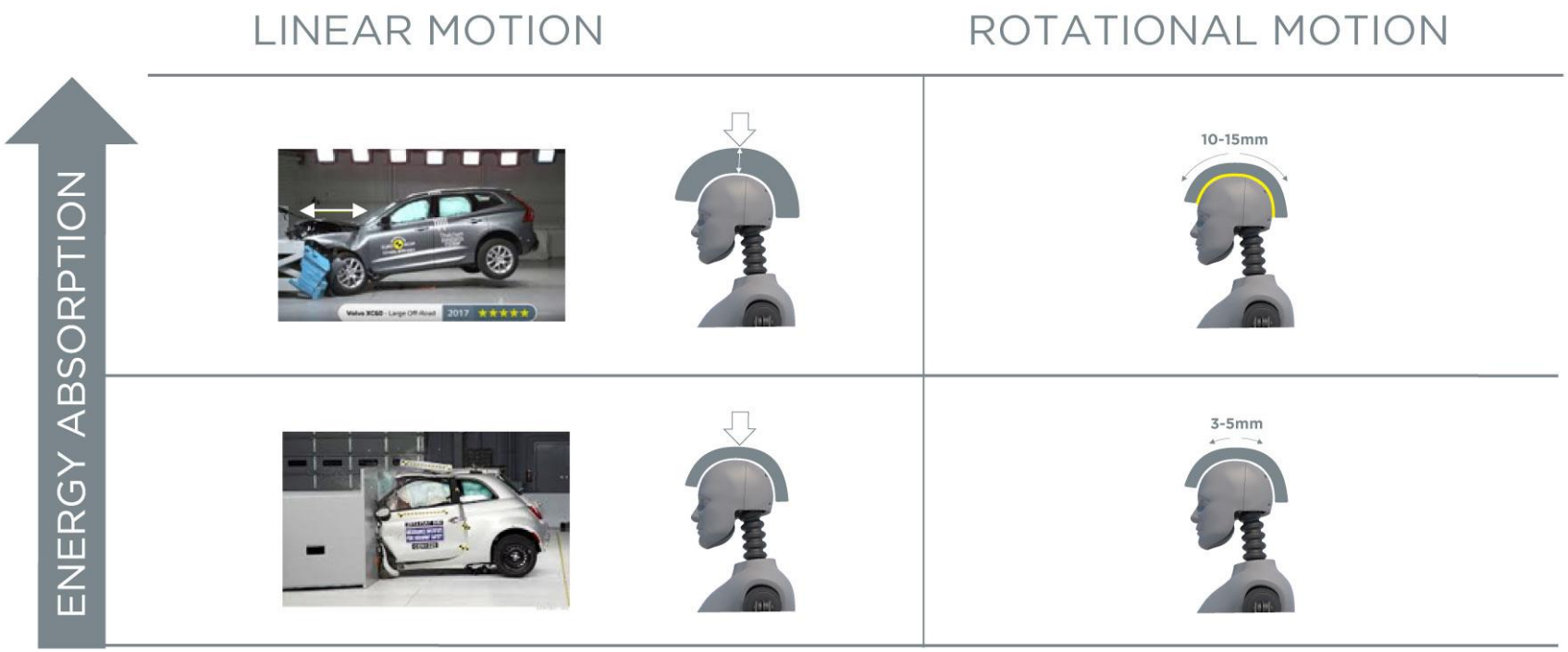
A blink of an eye lasts 100 milliseconds.

While under significant point loading

At the moment of impact the point load on the the head and the helmet is approximately 750 kg.

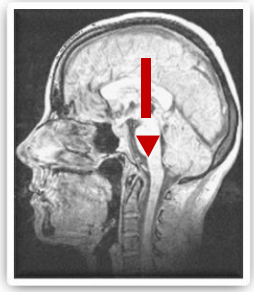


MIPS allows 10 – 15mm of relative motion between the head and helmet ...



Why do we need MIPS?

Type of Injury dependent on Impact

Impact direction:	Linear	Rotational (Angled & Tangential)
Acceleration direction:		
Type of injury:	• Fracture • Epidural hematoma (EDH) • Contusion	• Concussion • Subdural hematoma (SDH) • Diffuse axonal injury (DAI)
Conclusion:	Conventional helmets are tested by dropping them vertically onto a flat surface and they are designed with that testing in mind.	By adding rotational protection to the helmet you add protection from those angled impacts.

Holbourn 1943
Löwenhielm 1974,
Ommaya et al. 1967,
Ommaya and Hirsch 1971,
Gennarelli et al. 1982
McIntosh et al 2011
Kleiven 2007

The team at KTH & Karolinska

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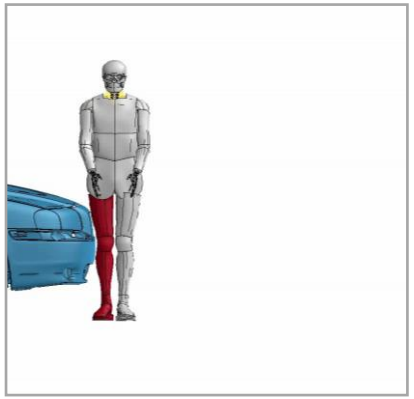
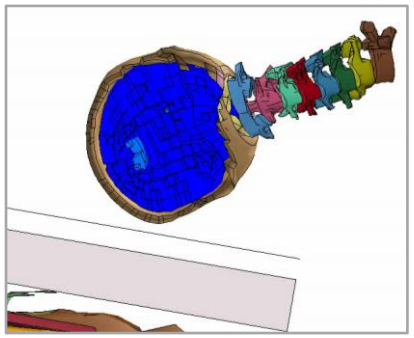
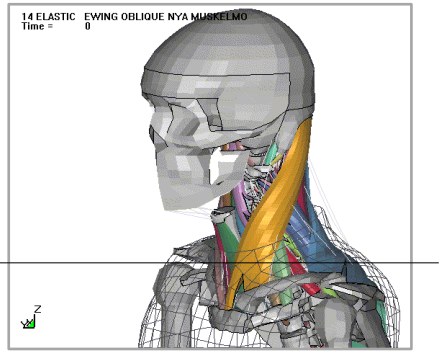
FOUNDER OF MIPS

Professor at
KTH, Royal Institute of Technology

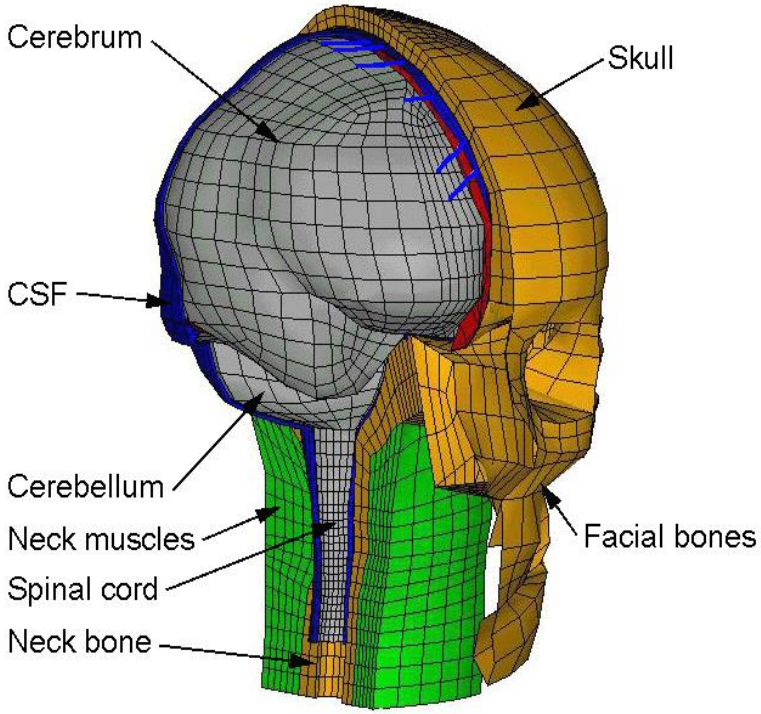
3-D model of the human brain

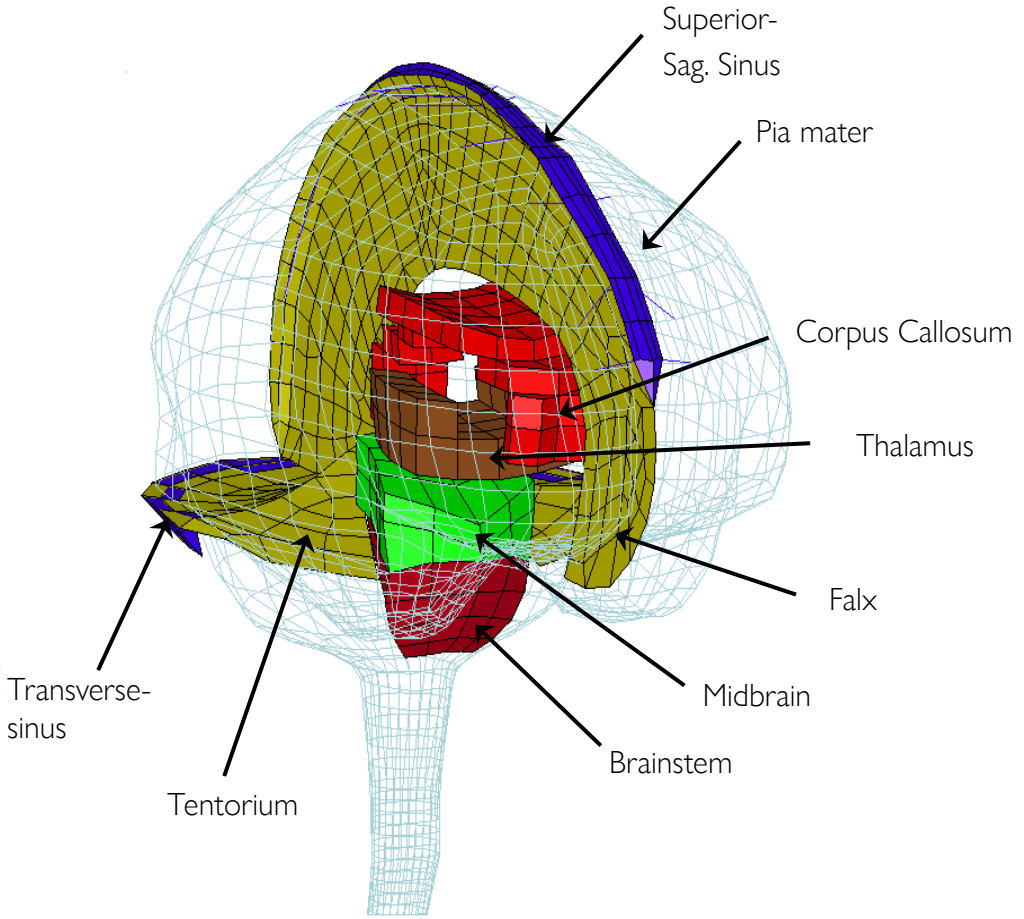






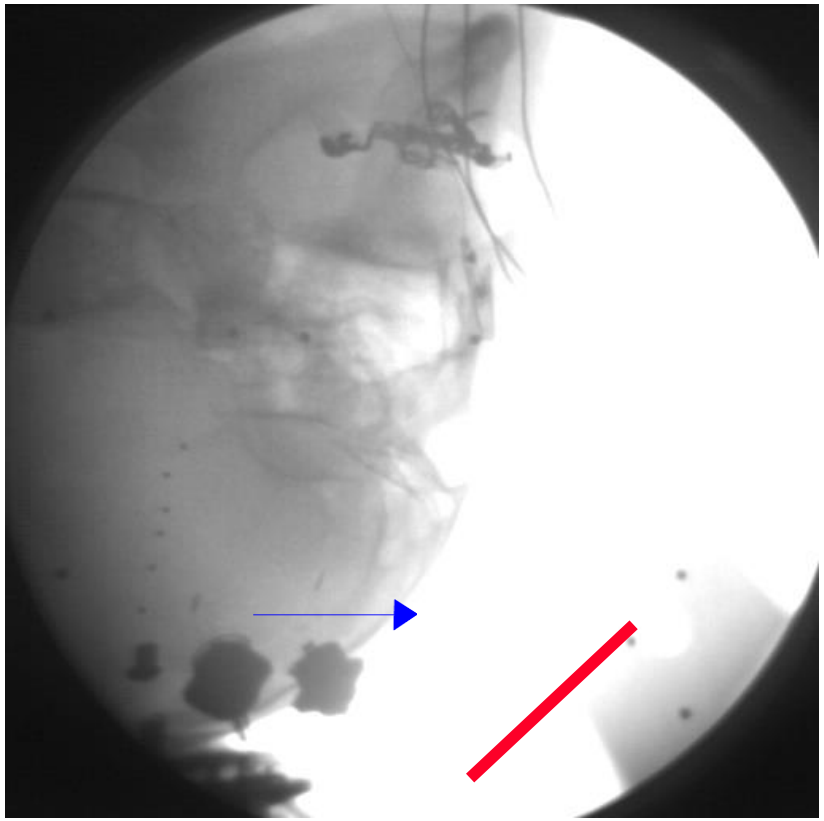
The KTH FE model of the human head and brain

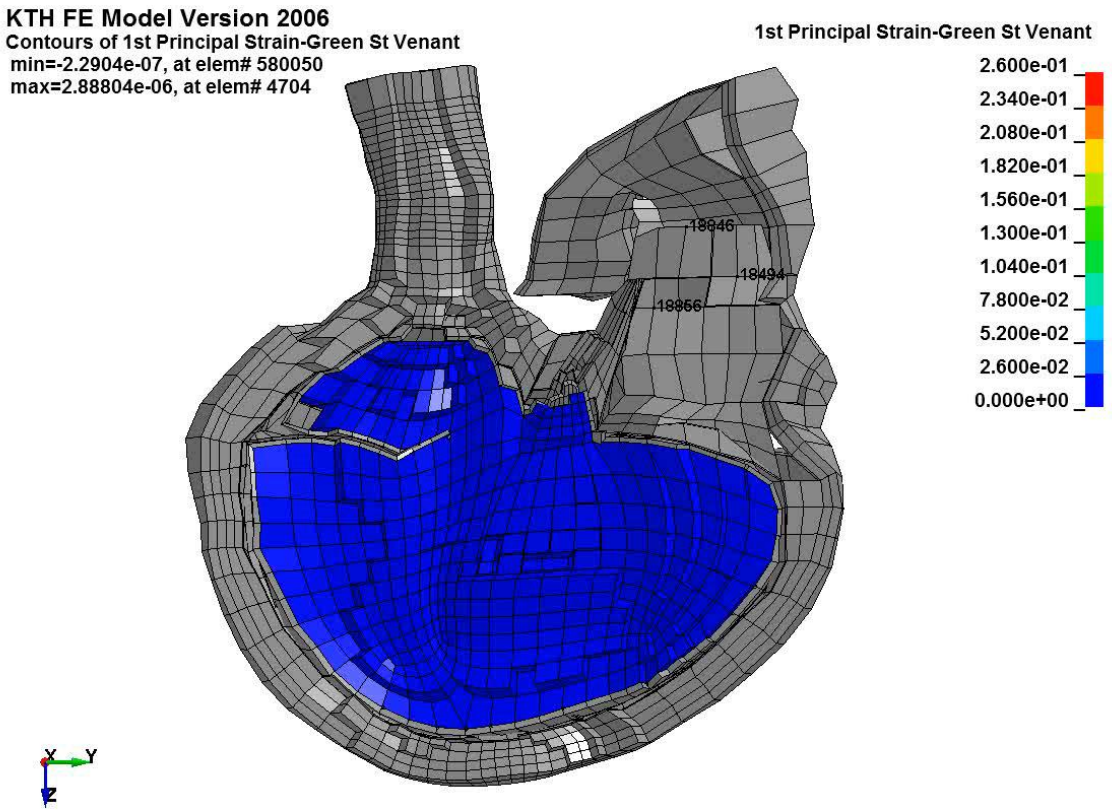




Kleiven et al. 2006

Validation of the KTH head model





Kleiven and Hardy, Stapp Car Crash Journal 2002

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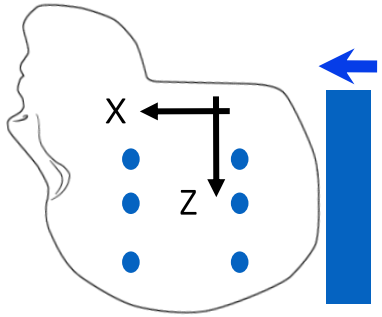
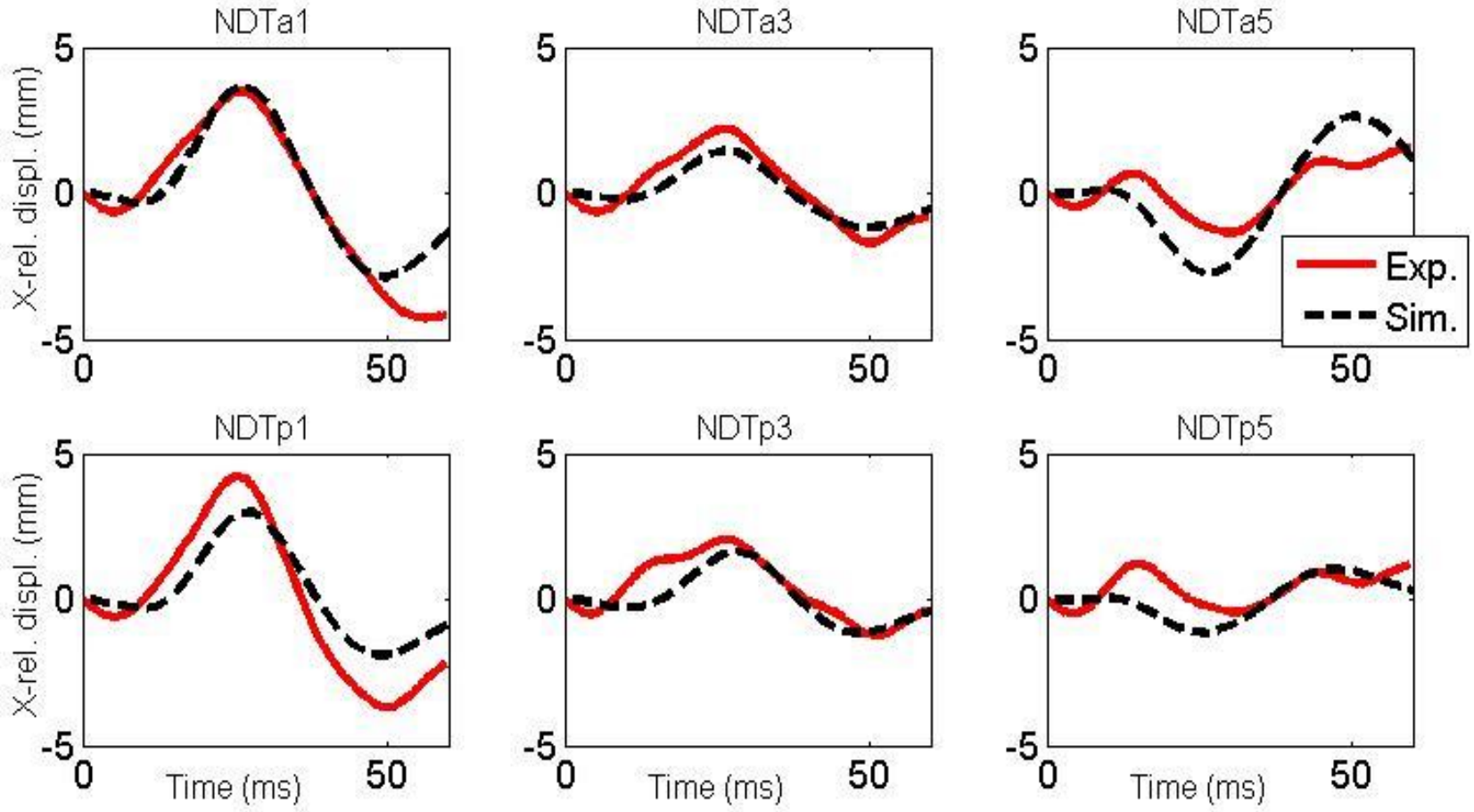
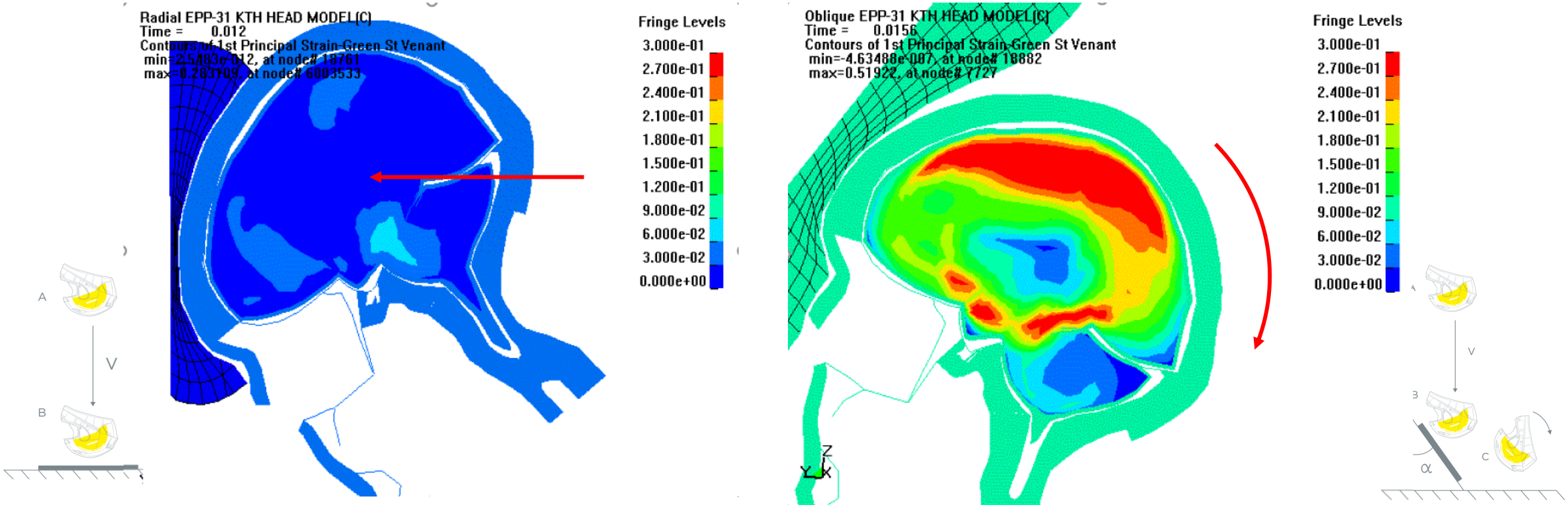




Kleiven and Hardy, Stapp Car Crash Journal 2002

Comparing Radial v.s. Oblique impact



Kleiven, Enhanced Safety of Vehicles 2007

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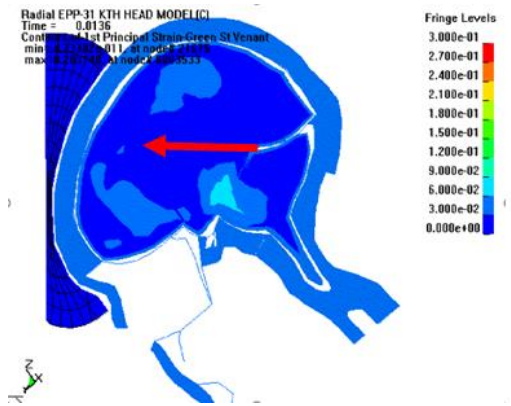
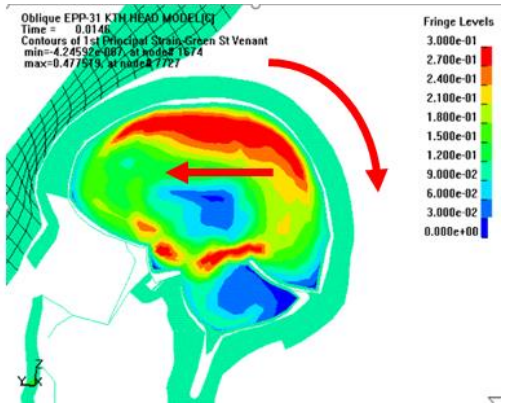
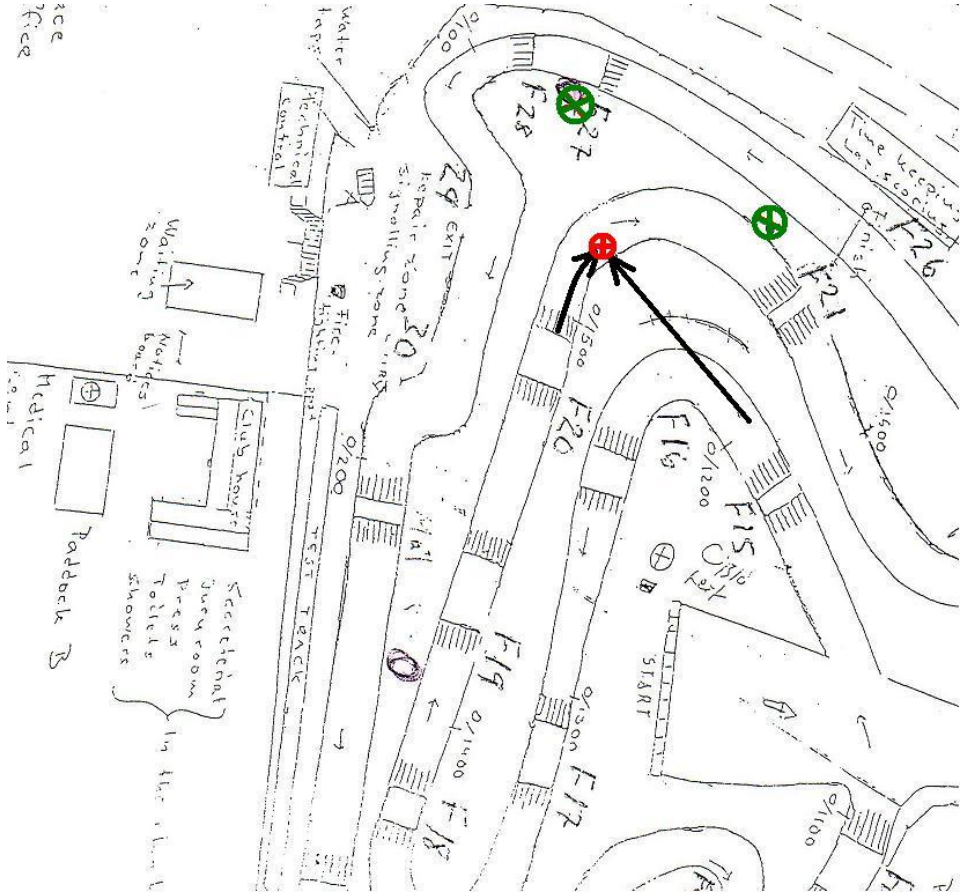




Accident scenario



The velocity was about 50km/h for both riders.

The impact was almost perpendicular.

Two cameras documented the accident.


TCR. 00:00:19:03*
V
A

Reconstruction set up

Based on the helmet and video from the accident we made a reconstruction of the accident by using our unique FE model.

The helmet with impact points

FE model of the impact

CT images from akademiska sjukhuset, uppsala

Hematoma in frontal lobe

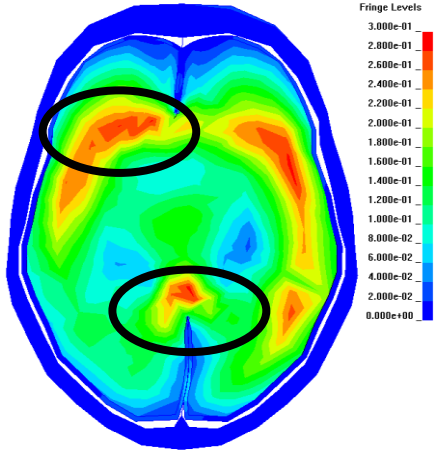
Hematoma along the tentorium

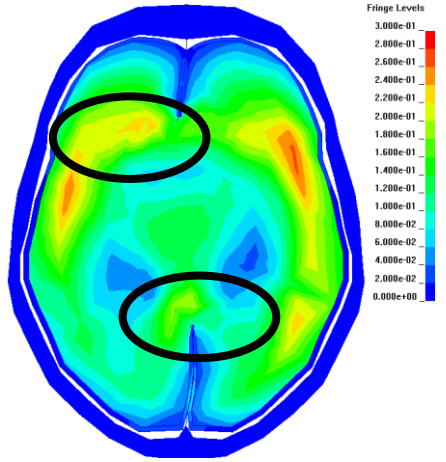
Strain pattern in the brain

Regular helmet design

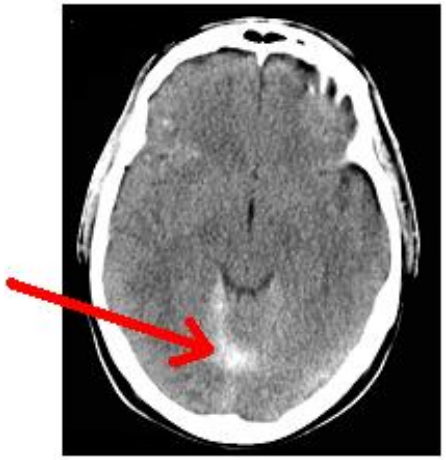
MIPS helmet design

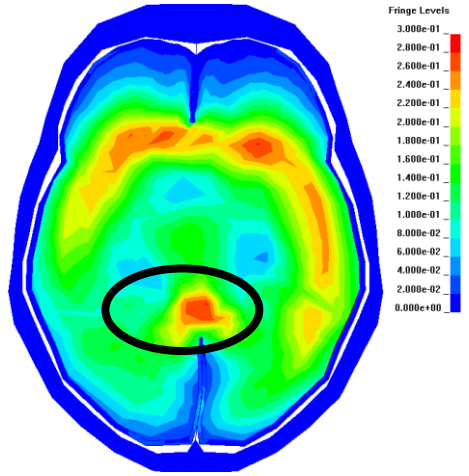
Hematoma in the frontal lobe

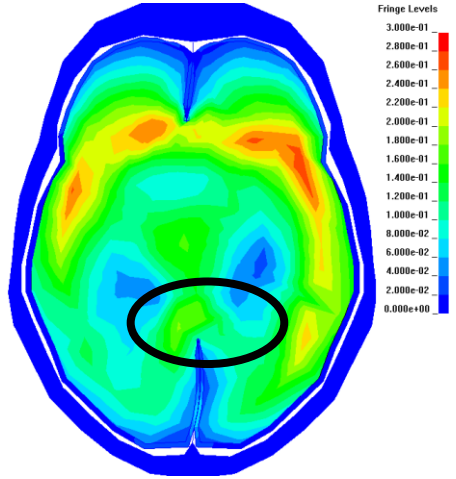




Hematoma in the rear part of the brain







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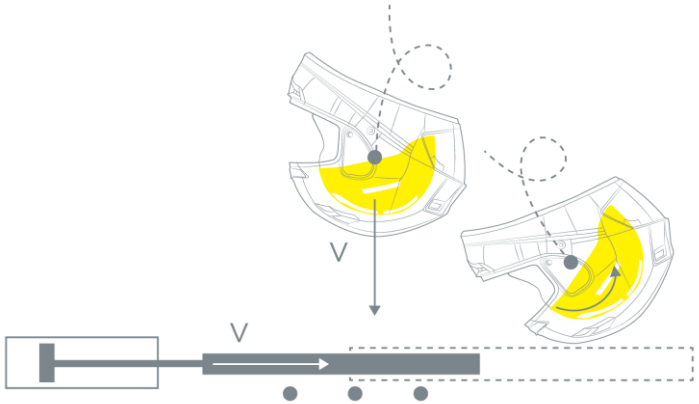
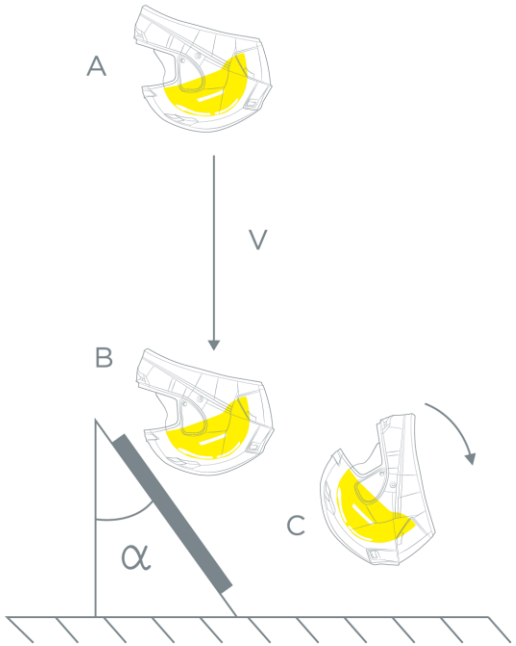




The direction of impact based on injury statistics & accidents reports

Bike

- Verschueren 2009, Bourdet et al. 2012
- 6,5m/s. 45 degree, road.

Equestrian

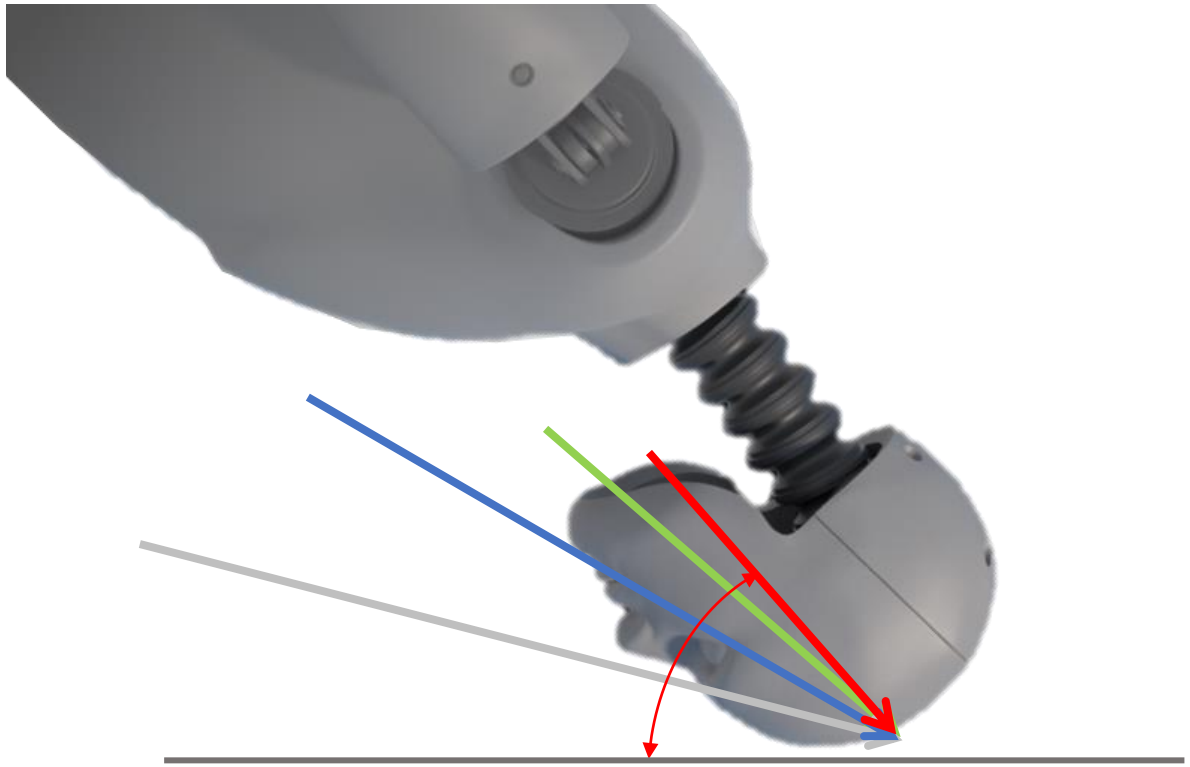
- Mellor and Chinn 2006
- 9m/s 37 degree, hard grass.

Motorcycle:

- Otte et al. 1999 (Cost 327)
- 12m/s, < 30 degree, side of a car or road.

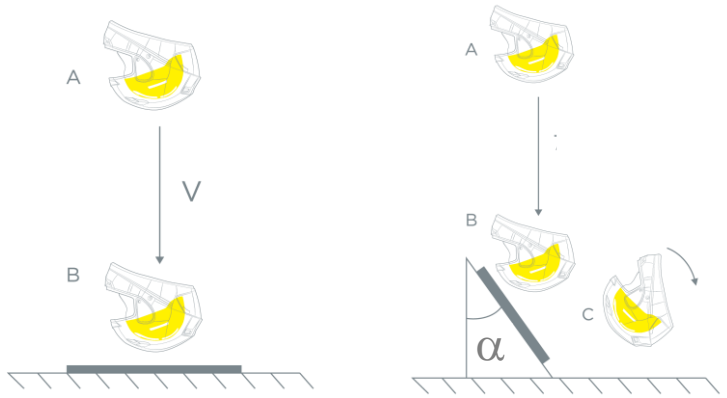
Snow

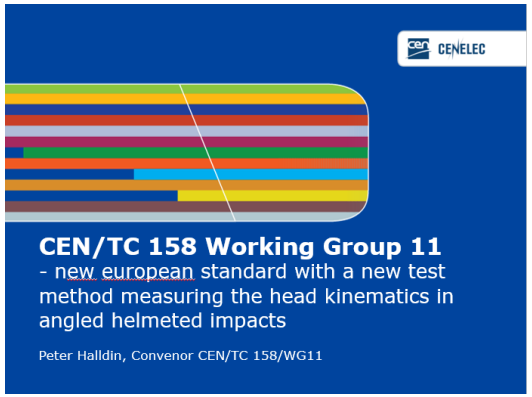
- DH and Super-G
- Ongoing FIS study
- 19m/s, 21 degree, hard snow.

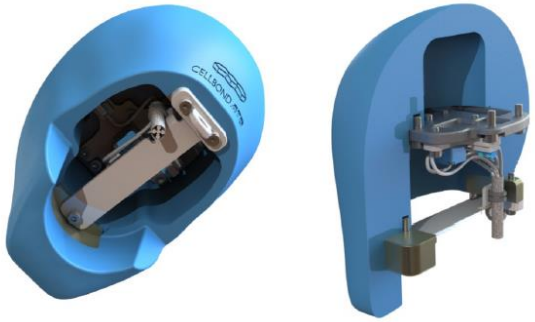


Ongoing work towards a new sport and motorocycle helmet test method

- Bike, Ski and EQ: **CEN TC158** (EU) New rotational test method.
- Motorcycle: **FIM** (Federation Internationale de Motorcyclisme)
- Motorcycle: **ECE 22.06** (European Motorcycle standard)
- Bike: **Virginia Tech** (New rating methods including tangential impacts)







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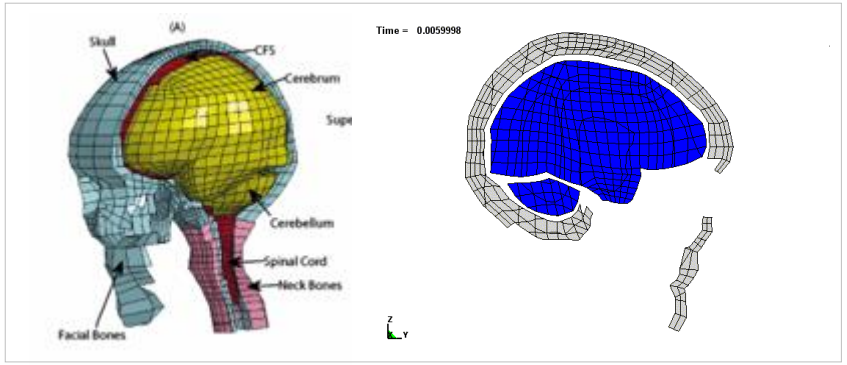
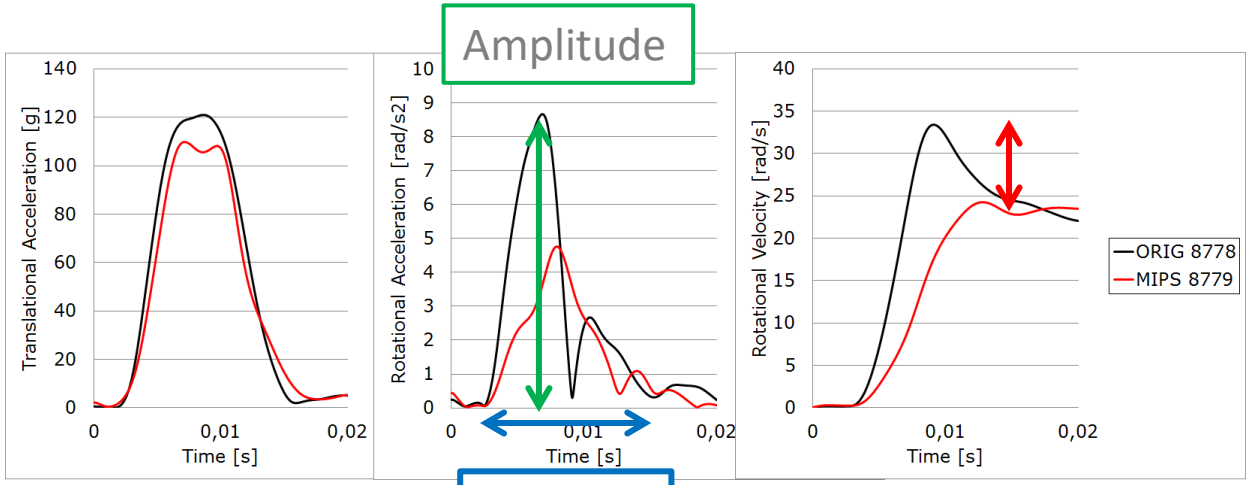
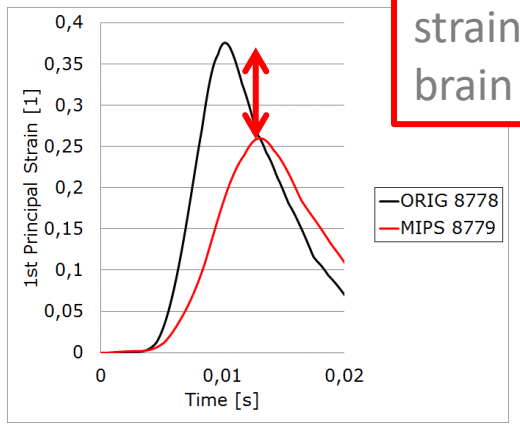
Example of test results with MIPS



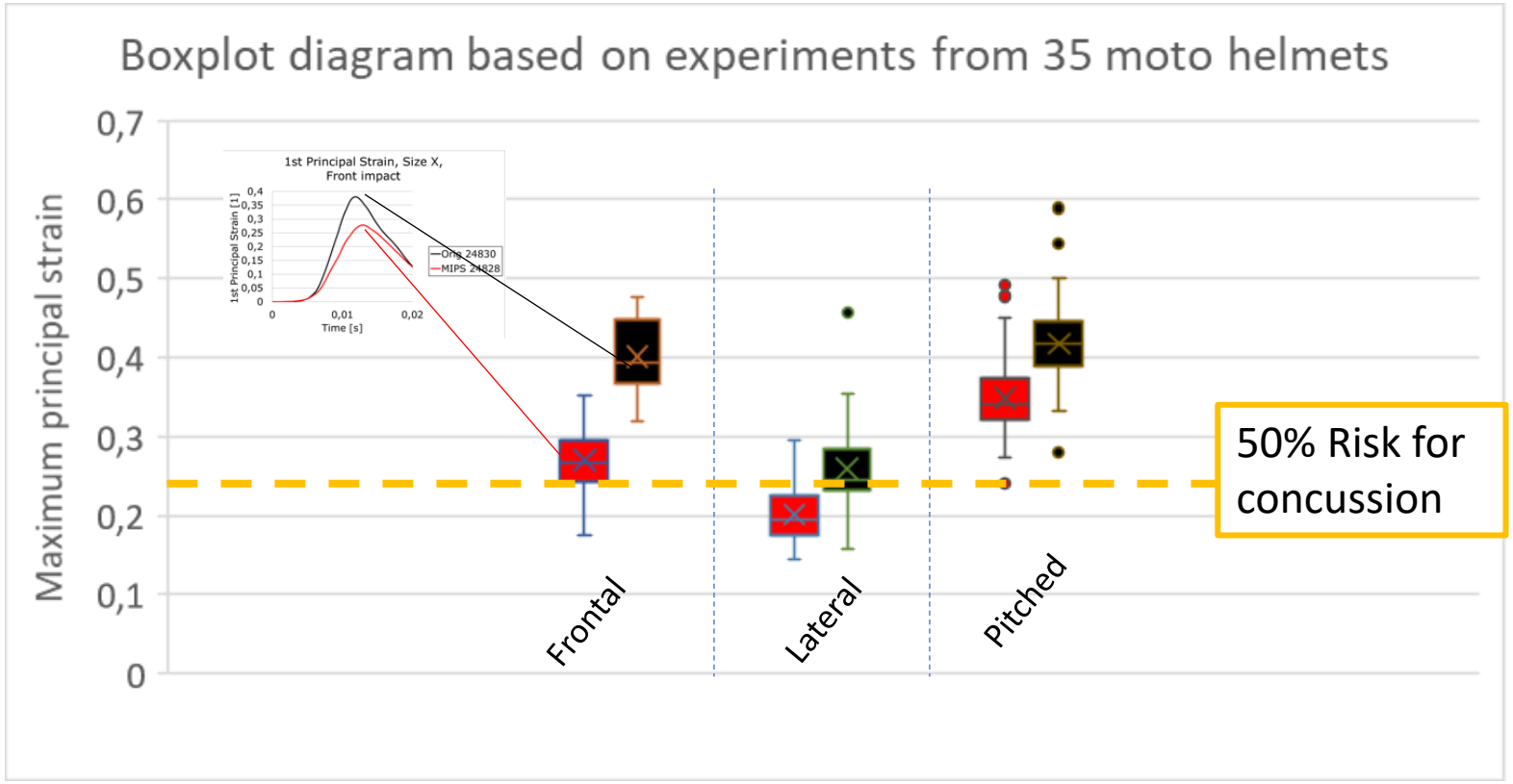


Duration



Reduction of strain in the brain

Results from 35 Moto helmets with and without MIPS

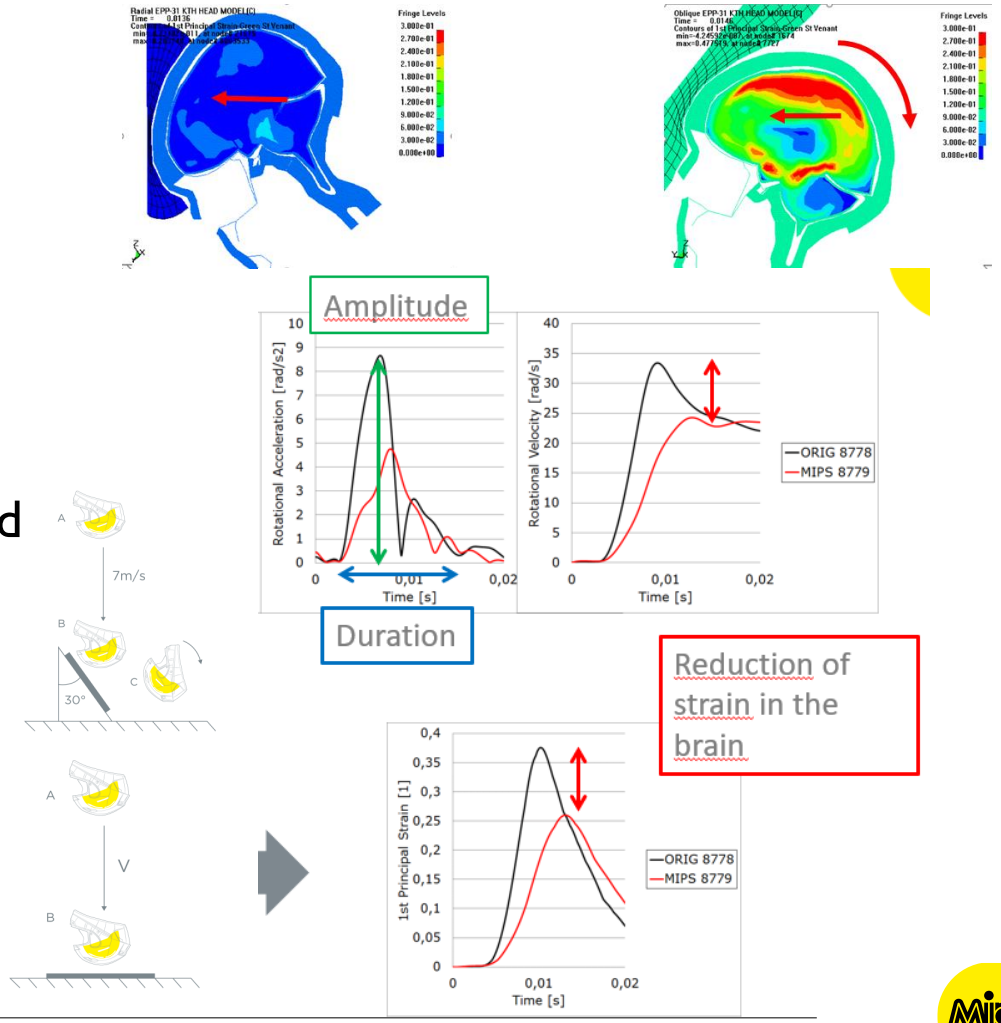


This boxplot diagram shows the strain for helmets with MIPS compared to the same helmet without MIPS installed.

The reduction that we see in strain is a measurement on the reduction of energy transmitted to the brain for the specific impacts (7.5m/s; 45degrees impact angle).

Summary

- The human brain is more sensitive for rotation than linear motion
- MIPS is a proven technology to reduce the strain in the brain
- MIPS results in a 10-15mm relative motion between the head and the helmet (Not seen in other technologies)
- To tell how a helmet impact effects the brain, you need to analyze the rotational acceleration over time including both the **amplitude** and the **duration** of the pulse
- FIM are testing with the same test method as MIPS. The only difference is the head form and the impact points on the helmet.



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Brain Protection System