MIPS related results on motorcycle helmets

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OUTLINE

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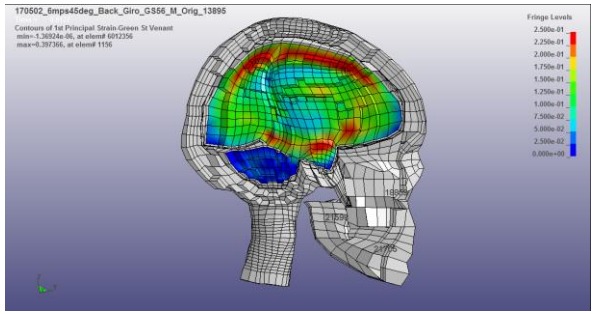
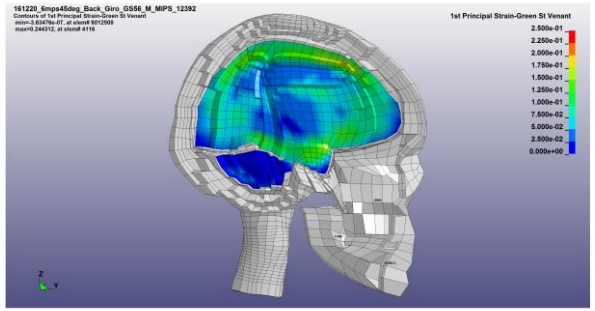
- MIPS BPS and other systems
- Reconstruction of MX accident
- Oblique helmet test methods
- MIPS Approval test method
- Example of results
- Summary





THE TEAM AT KTH & KAROLINSKA

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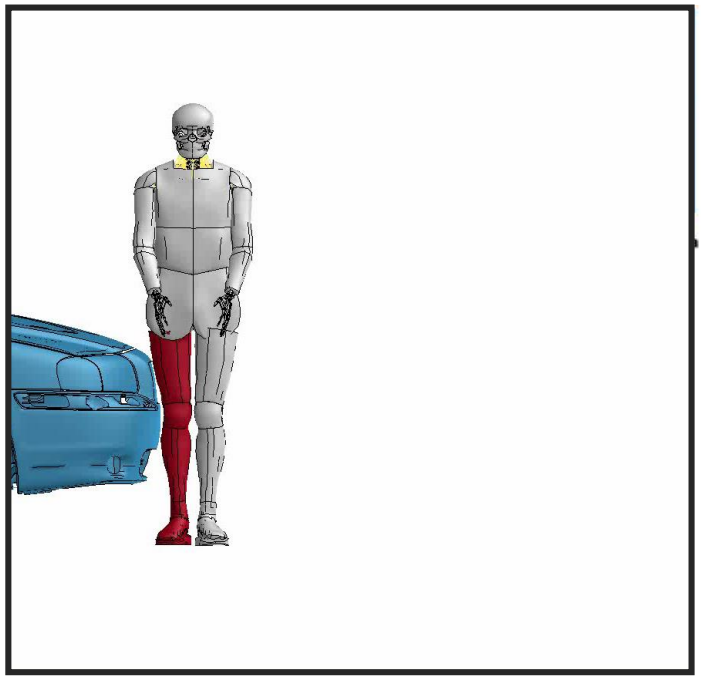
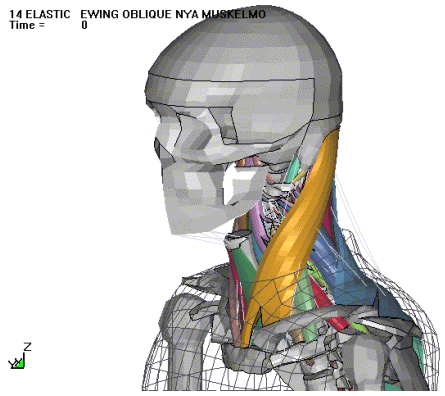
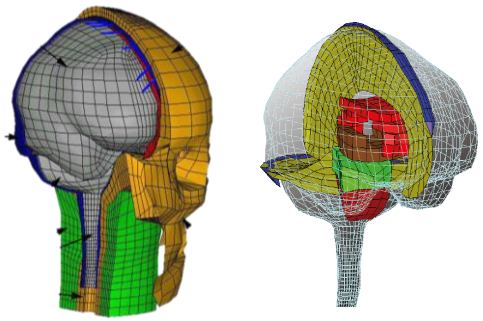
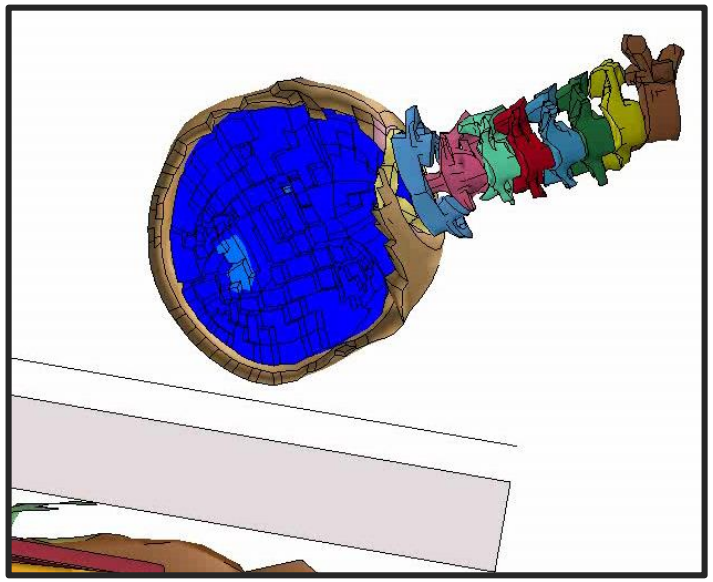
Hans von Holst
Professor at the
Karolinska Hospital

Svein Kleiven
Professor, KTH









THE DIVISION OF NEURONIC ENGINEERING

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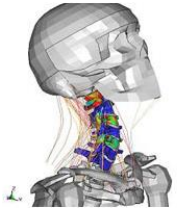

Neurotrauma + Mechanical Engineering

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Mats Nilsson

Xiaogai Li

Madelen Fahlstedt

Victor Alvarez

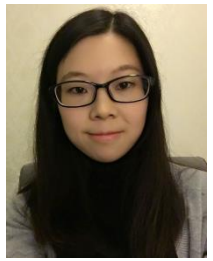
Chiara Giordano

Annaclaudia Montanino

Zhou Zhou

Shiyang Meng

Pooya Sahandifar



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Stanford University

UCD DUBLIN

KU LEUVEN

- Prevention & Treatment

Mips

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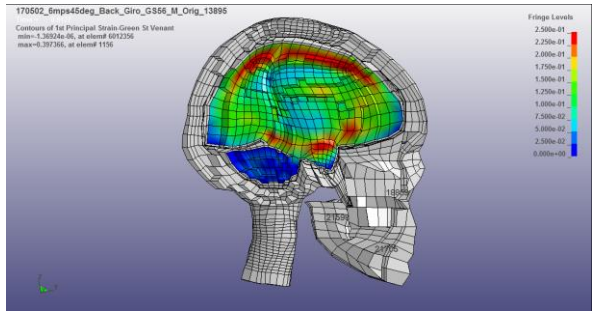

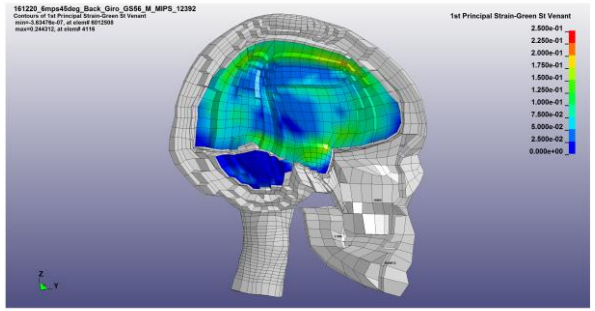

MIPS HISTORY

- from research to consumer product reducing risks of injury

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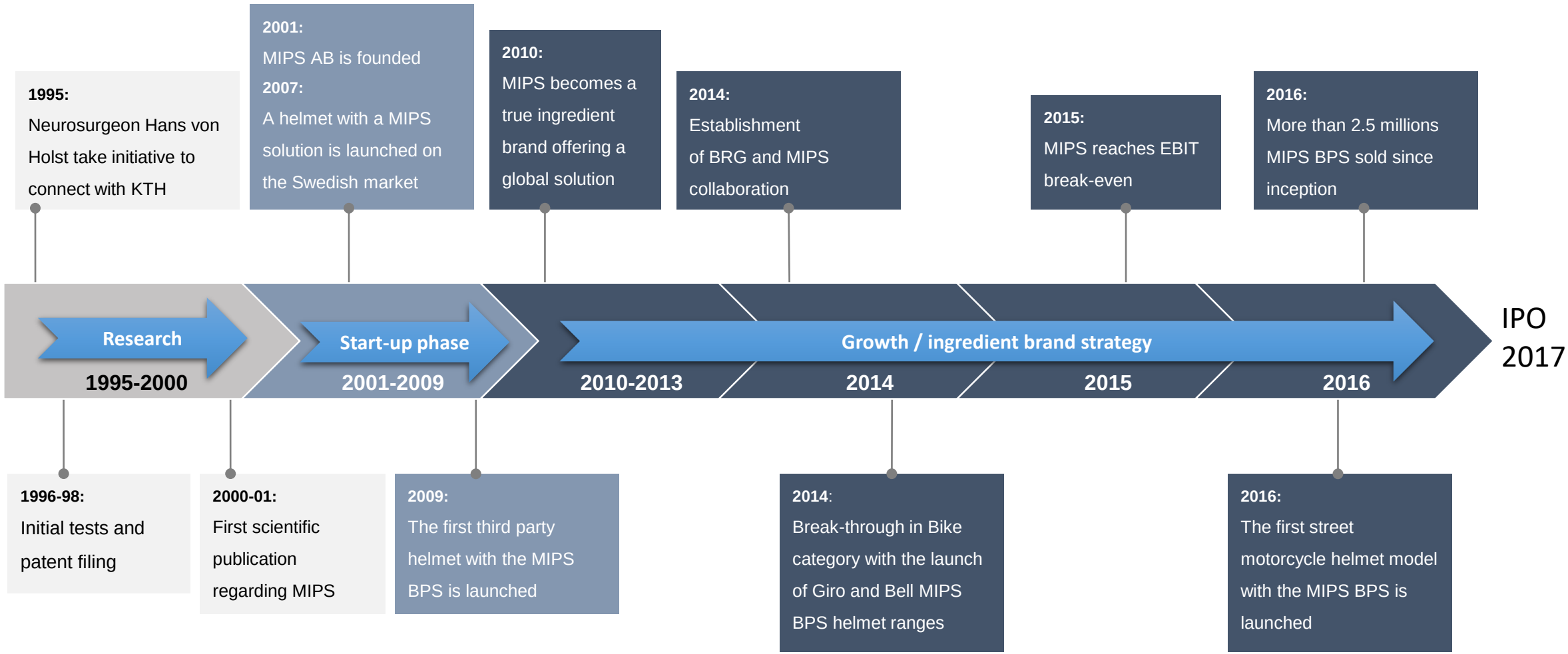

Rotational Helmet Concepts

- Phillips helmet (IP 1994), Launched 2009
- MIPS (IP 1998), Launched 2007
- 6D – MX helmet (2013)
- Leatt – MX helmet (2015)

MIPS IS MIMICKING THE EVOLUTION

- Multi-directional Impact Protection System

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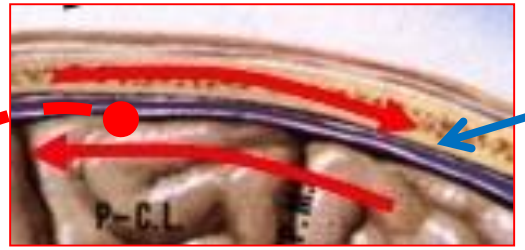
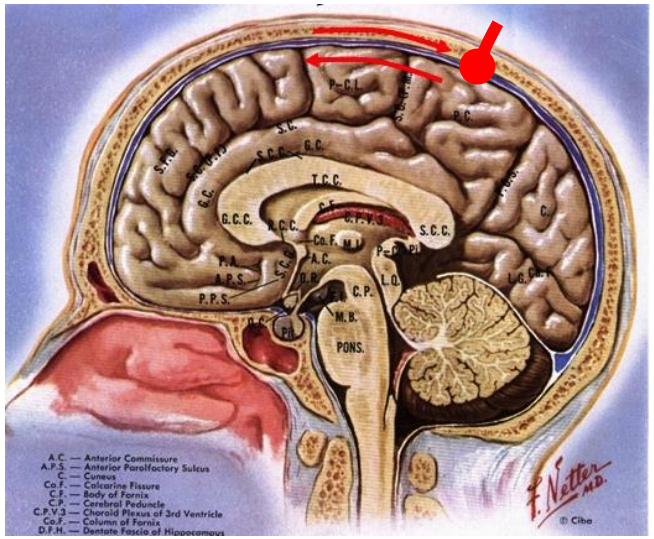
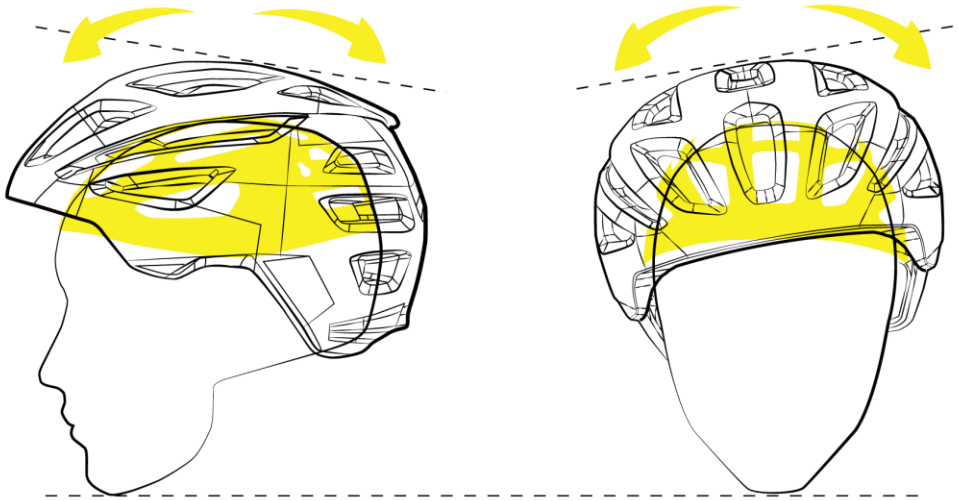
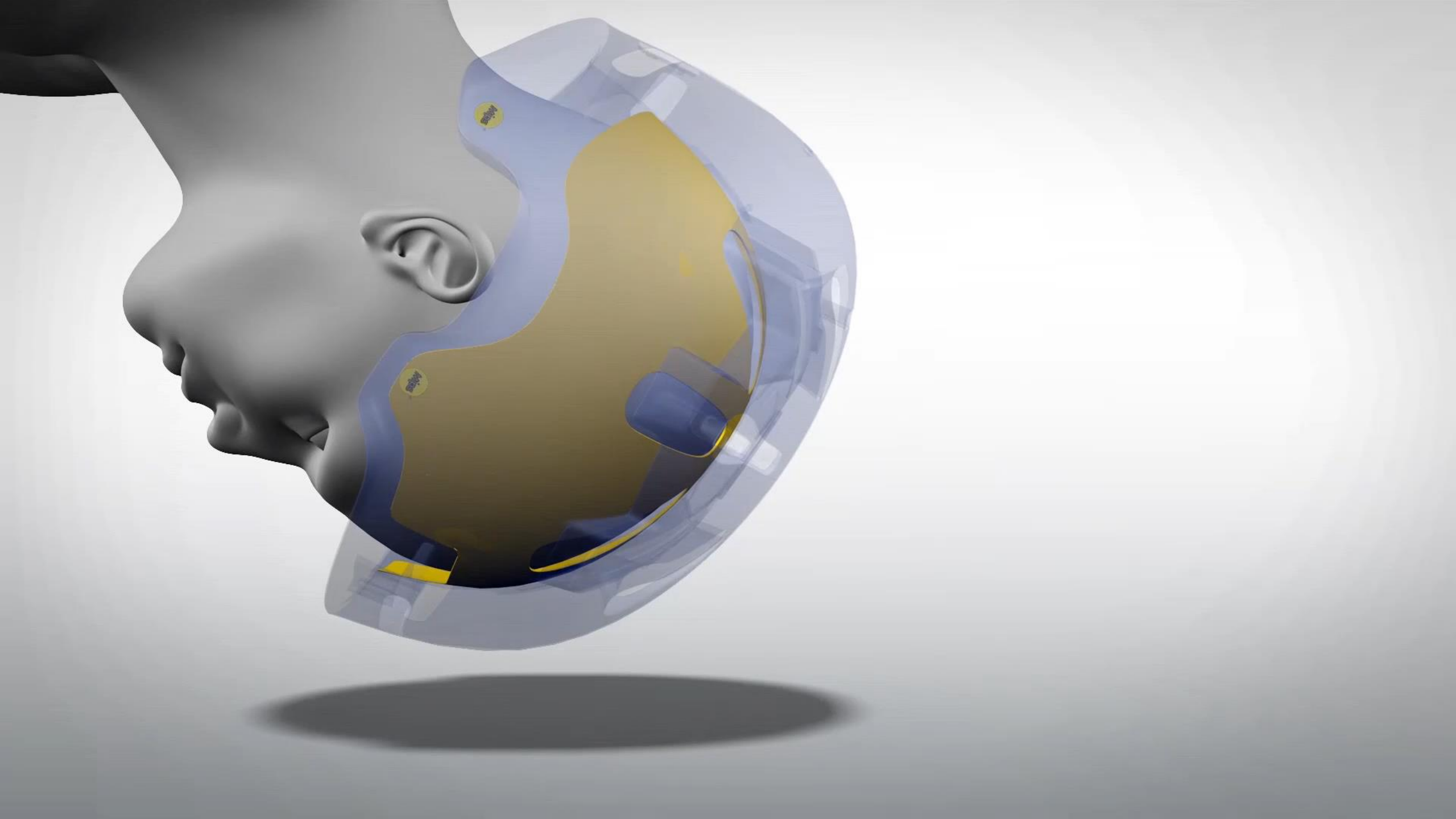


The cerebrospinal fluid surrounding the brain can absorb and redirect some the energy from angled impacts.





MIPS mimics the brains own protection system



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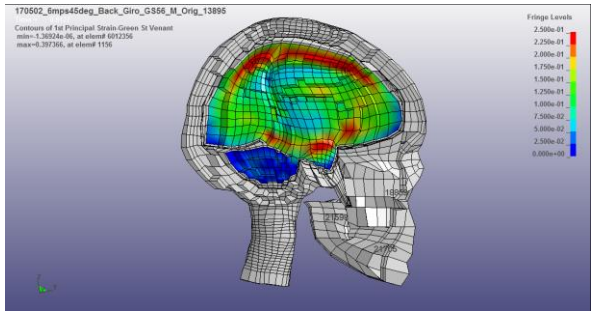

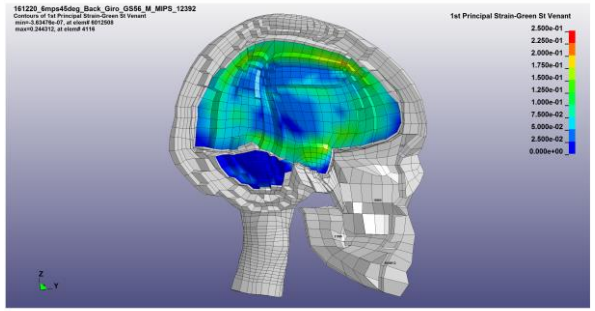

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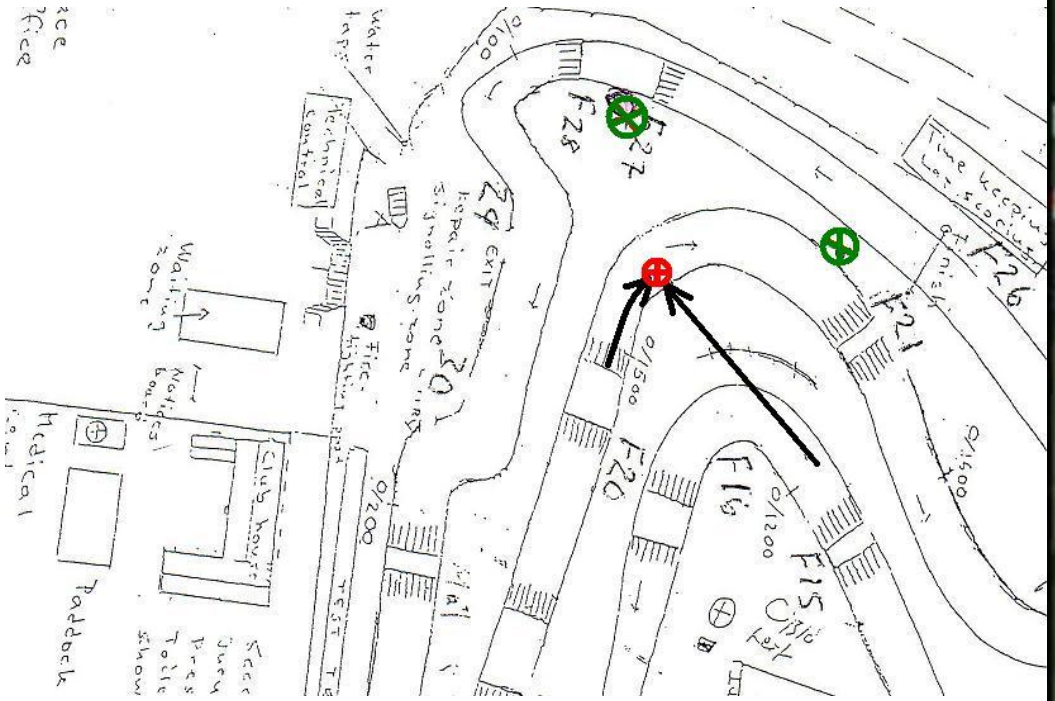
DETAILED RECONSTRUCTION OF MX ACCIDENT

BY PROFESSOR SVEIN KLEIVEN, 2007

ACCIDENT SCENARIO



- The velocity was about 50km/h for both riders.
- The impact was almost perpendicular.
- Two cameras documented the accident.

RECONSTRUCTION SET UP

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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

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Hematoma in frontal lobe

Hematoma along the tentorium

STRAIN PATTERN IN THE BRAIN

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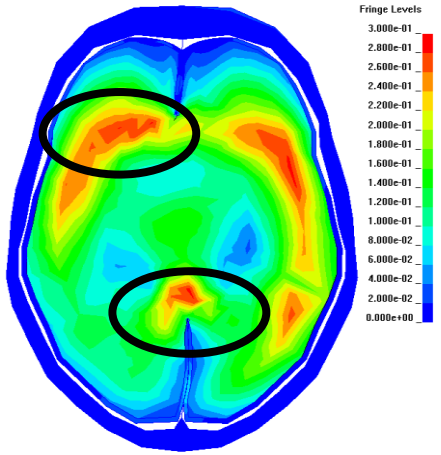
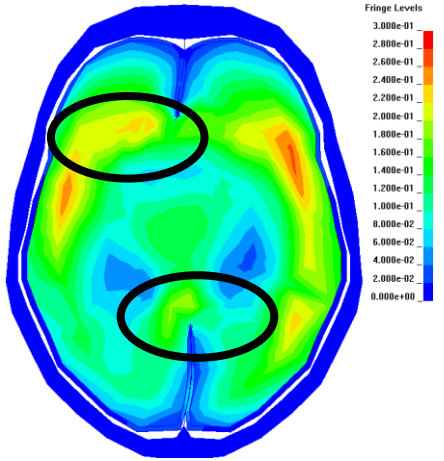
Regular helmet design

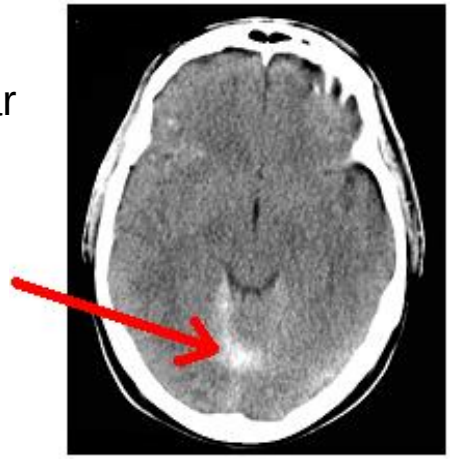
MIPS helmet design

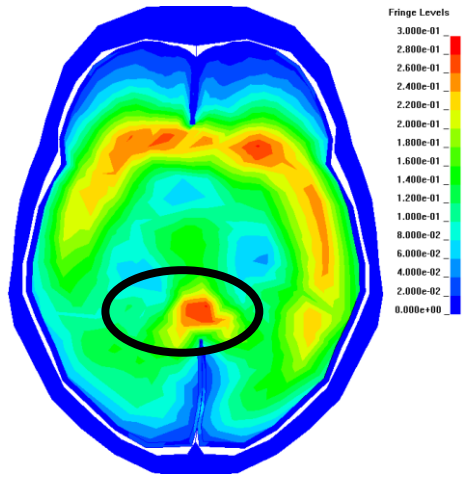
Hematoma in the frontal lobe

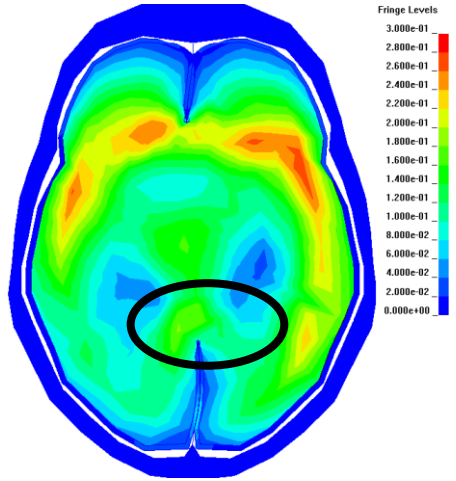




Hematoma in the rear part of the brain







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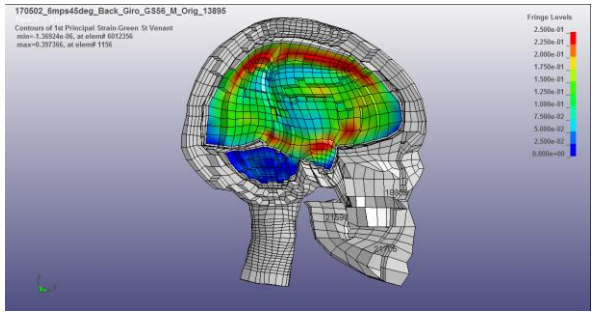

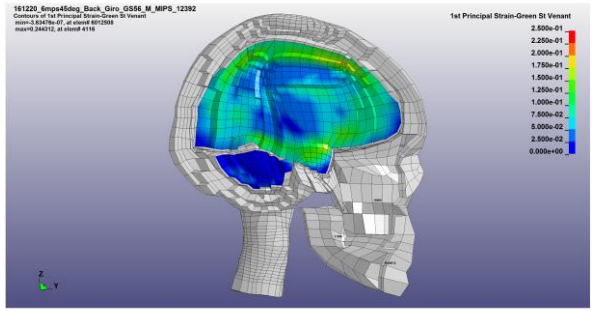

THE DIRECTION OF IMPACT BASED ON INJURY STATISTICS & ACCIDENTS REPORTS

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Bike

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

Equestrian

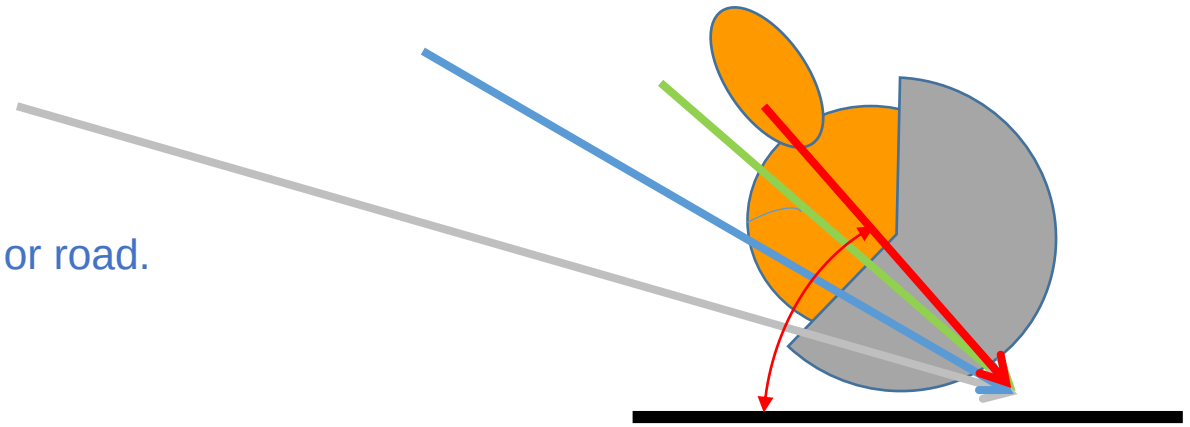
- Mellor and Chinn 2006
- 9m/s **37 degree**, hard grass.

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.



THE DIRECTION OF IMPACT

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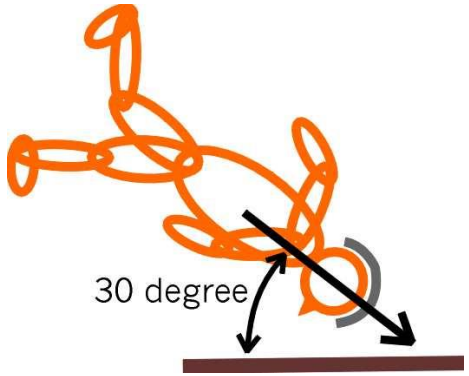
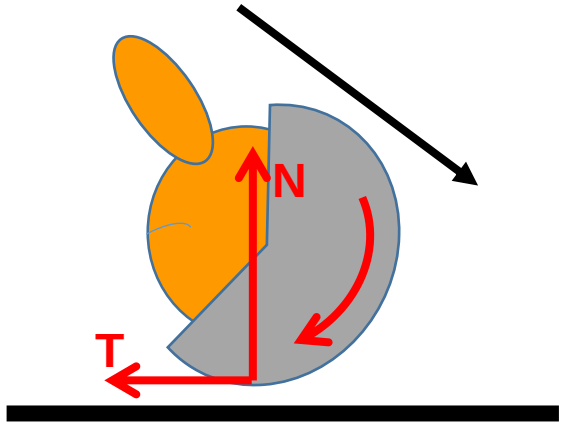
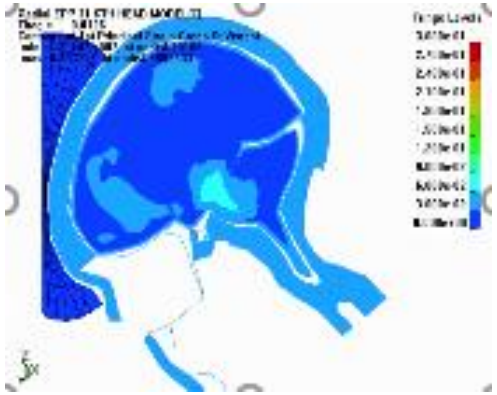
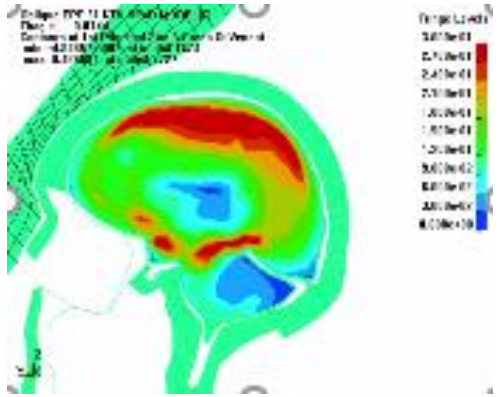
- Oblique impacts are common in most sports (Otte et al. 1999, Verschueren 2009, Mellor and Chinn 2006)
- Oblique impacts could lead to a tangential force, depending on the Normal force and the coefficient of friction.
- Tangential force -> rotation
- The brain is more sensitive to rotation than pure translational motion. (Holbourn 1943, Genarelli 1983, Marguiles and Tibault 1992, Fijalkowski et al. 2007, Kleiven 2007)









Oblique test methods development

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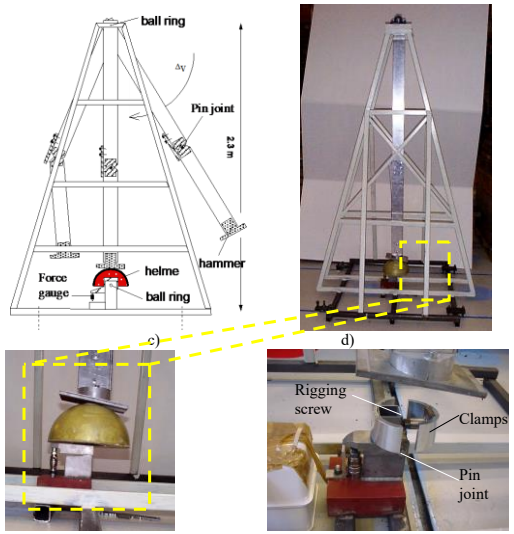
- 20 years of experiance in obliue testing of helmets.

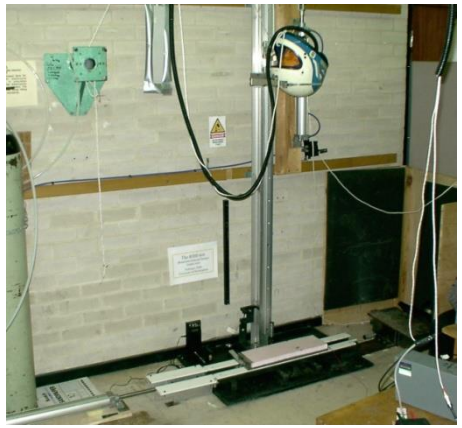
(Peter H. Halldin, Adam Gilchrist and Nigel J. Mills. *Rotational protection in motorcycle helmets*. International Journal for C

1996



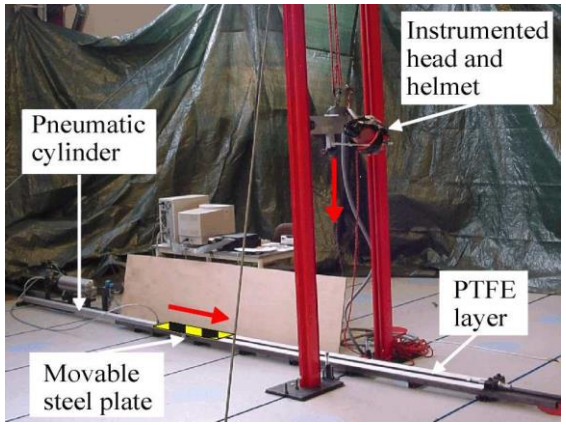
KTH

2000



Birmingham

2004-2014



KTH

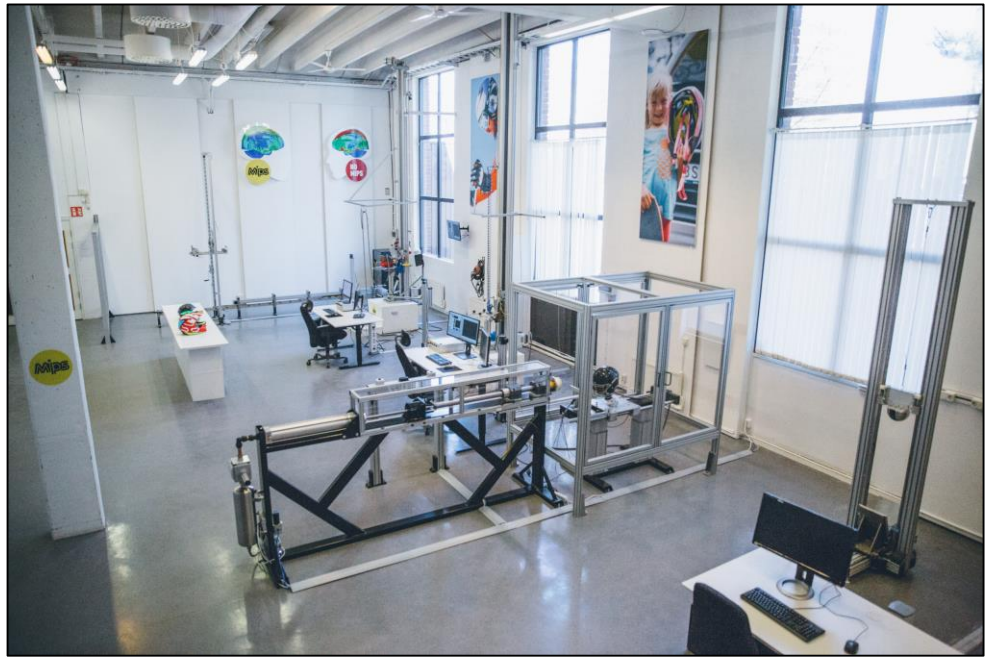
2015 -

KTH and MIPS

MIPS TEST LAB

KTH Teknik och hälsa

MIPS TEST LAB AT KTH 2001



MIPS TEST GLOBAL TEST LAG 2017

ONGOING WORK TOWARDS A NEW SPORT AND MOTOROCYCLE HELMET TEST METHOD

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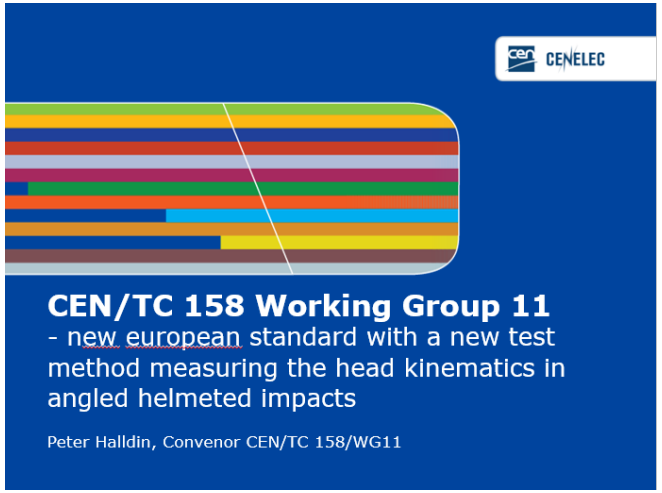
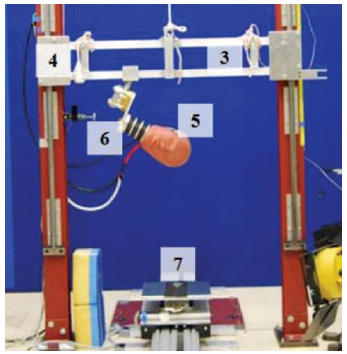
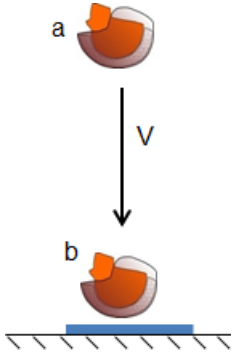
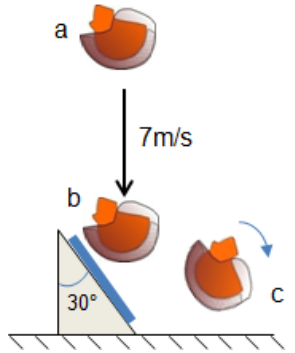
- Bike, Ski and EQ: **CEN TC158** (EU) New rotational test method.
- Motorcycle: **FIM** (Federation Internationale de Motorcyclisme)
- Bike: **Virginia Tech** (New rating methods including tangential impacts)
- **(**Motorcycle**: Australia**: New rating method for Motorcycle helmets)
- (Football: **NOCSAE** (DOC (ND)002-16))









Neck / no neck

Reference	Method	Test method	Difference/Correlation of rotational components
COST 327	Experimental study	HIII dummy v.s. HII head form	17%
Beusenberger et al 2001	Simulation of helmeted football impacts	MADYMO (1997)	Bad
Verschueren 2006	Reconstruction of Bike accidents	MADYMO HBM (2005)	Good to bad
Forero 2009	Reconstruction of Equestrian accidents	MADYMO HBM (2005)	Good to bad
Ghajari et al. 2012	FE simmulation of MC accident	Human FE model (THUMS)	20%
Halldin (ongoing)	FE simulation of MC and Bike helmet impacts	Human FE model (THUMS and HIII)	Good to bad

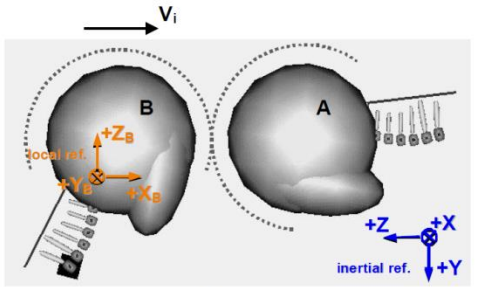
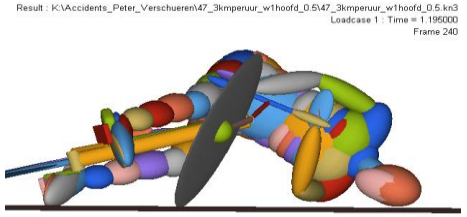
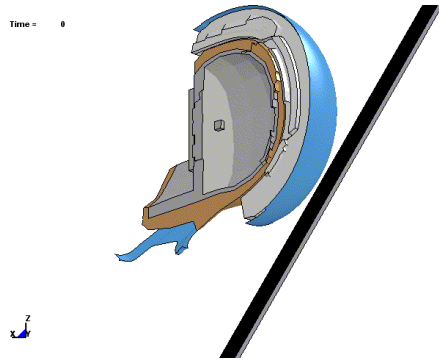
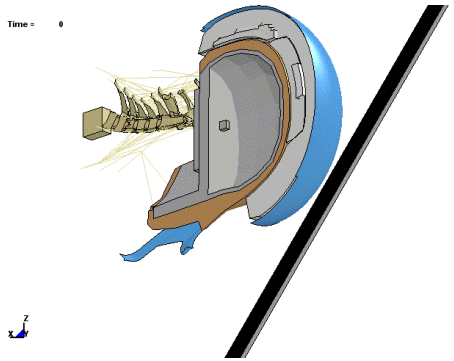
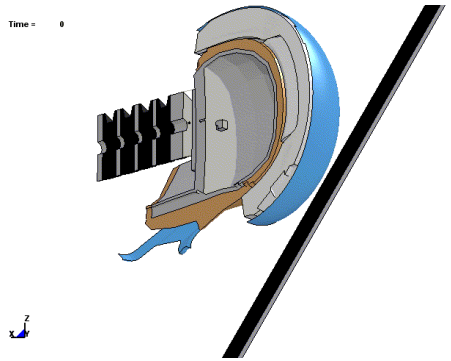


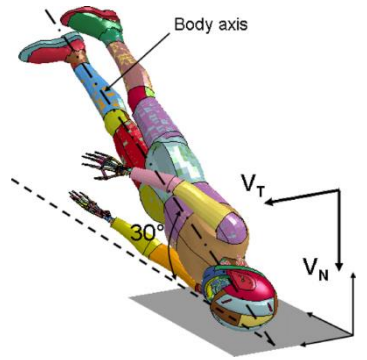
Figure 5: Basic model set-up



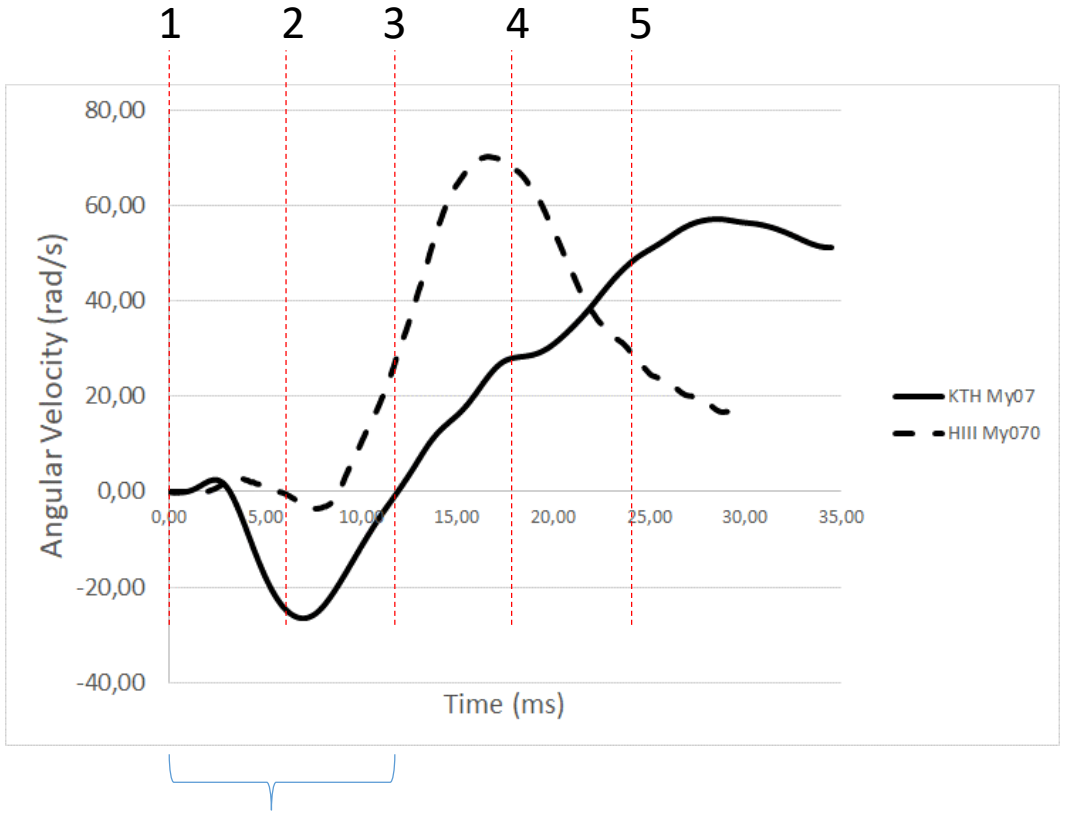




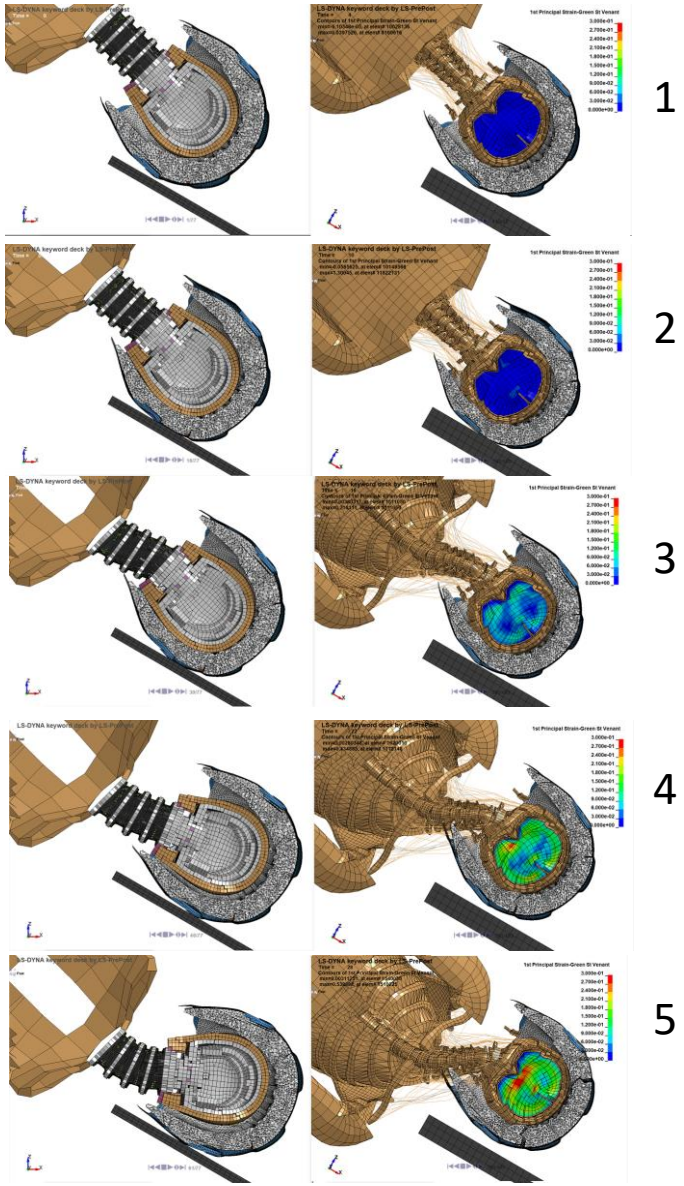




Human neck v.s. HIII neck



The HIII miss the rotation



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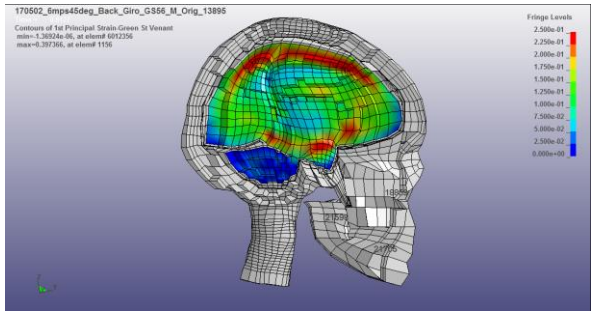
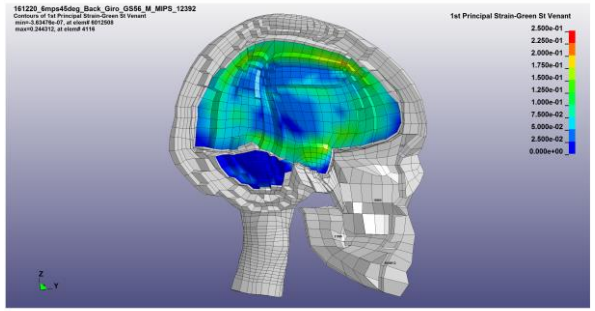
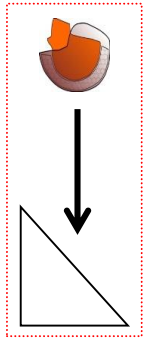




MIPS Approval Test Method

KTH Teknik och hälsa

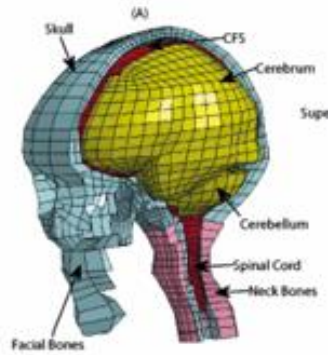
Set-up: A helmet with and without the system installed was compared.
Impact speed: Bike and Ski: 6m/s, MX: 7.5m/s
Impact angle: 45degrees
Impact surface: Grinding paper quality 40
Impact directions: X-Rot, Y-Rot and Z-Rot
Pass/Fail: Reduction of strain > 10%



X-Rot

Y-Rot

Z-Rot

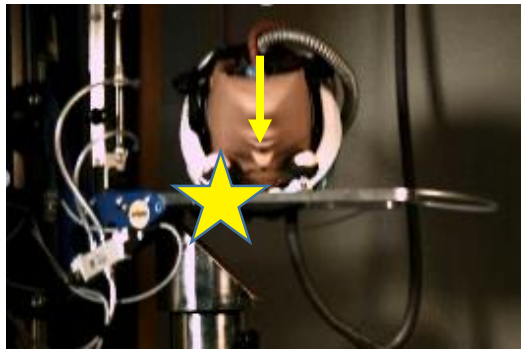


WHY WE MEASURE BOTH THE FORCE (ACCELERATION) AND THE ENERGY (VELOCITY)

KTH Teknik och hälsa

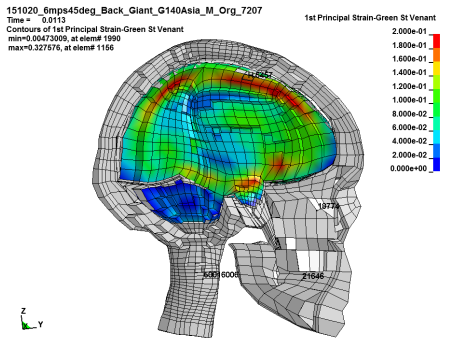
Understanding of the reality

Simulation of real accident in MIPS test lab



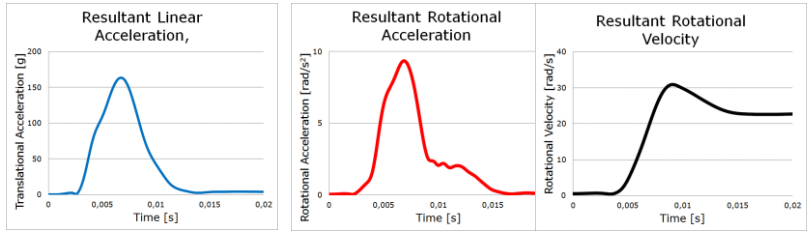
Understanding of brain injury

Advanced computer models



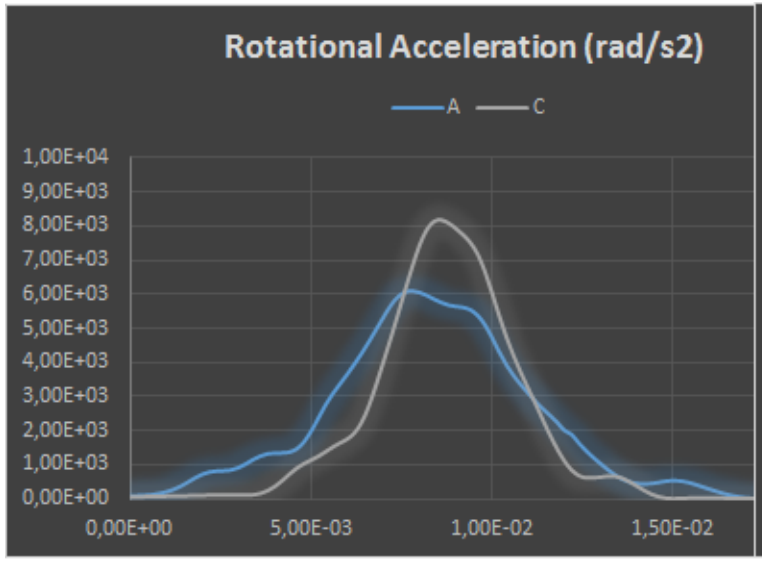
Experimental results:

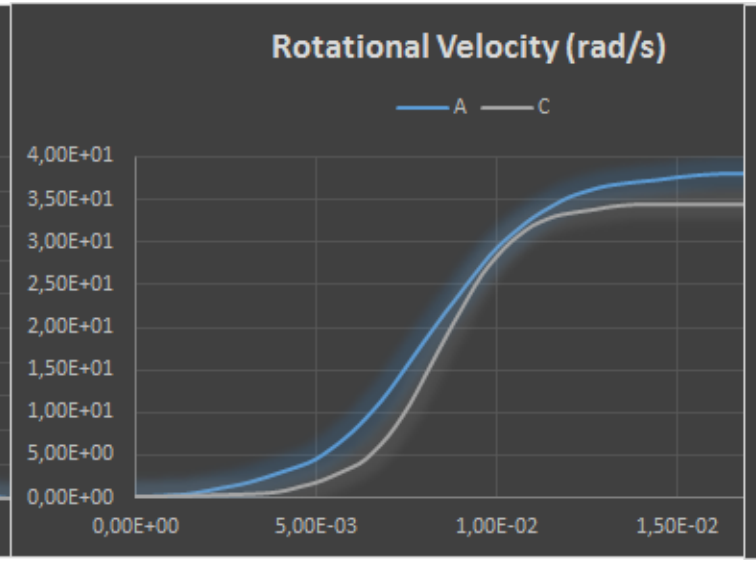
- Linear acceleration
- Rotational acceleration
- Rotational velocity

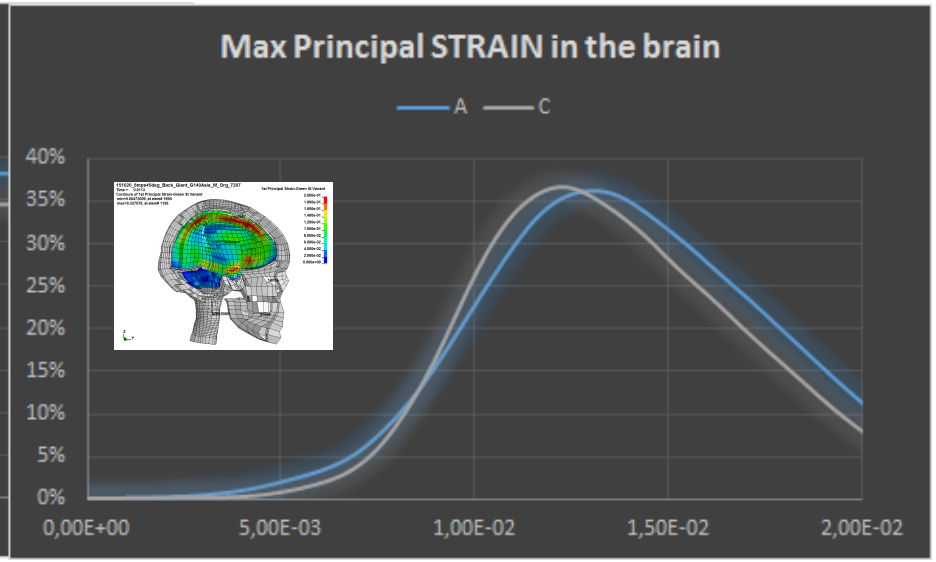


DURATION AS IMPORTANT AS AMPLITUDE

KTH Teknik och hälsa

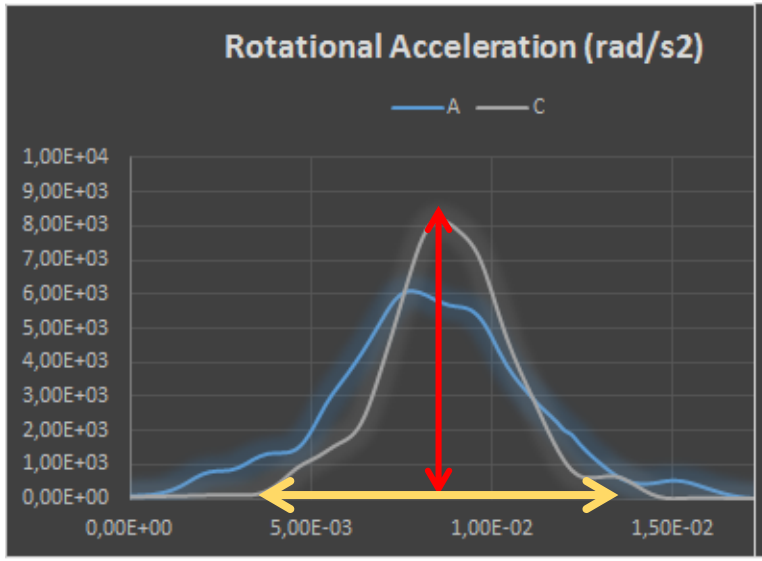


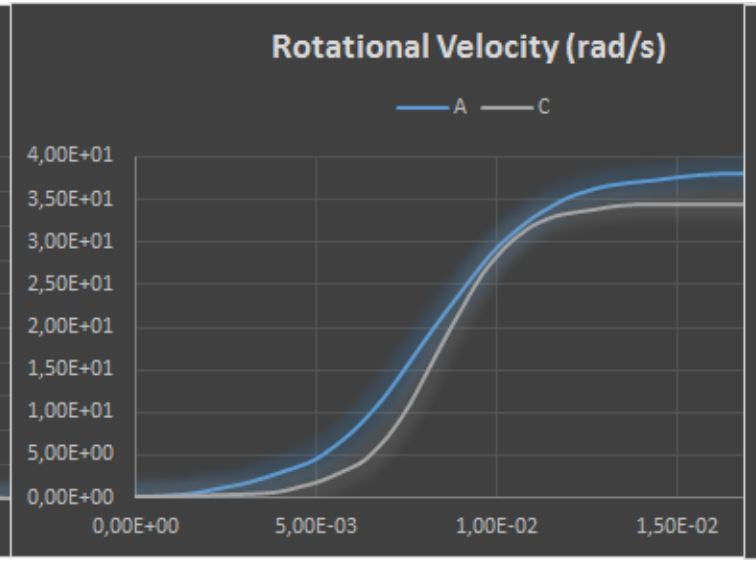


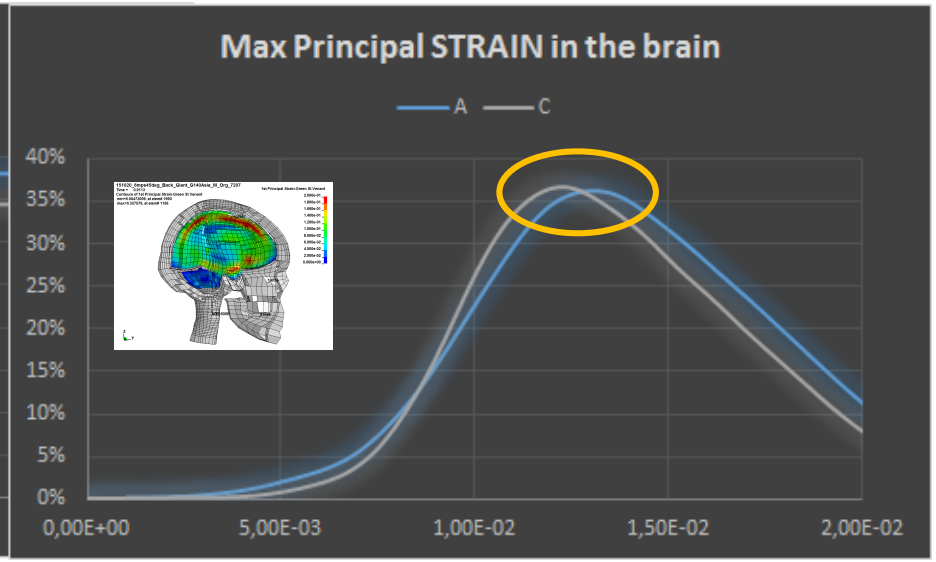


DURATION AS IMPORTANT AS AMPLITUDE

KTH Teknik och hälsa

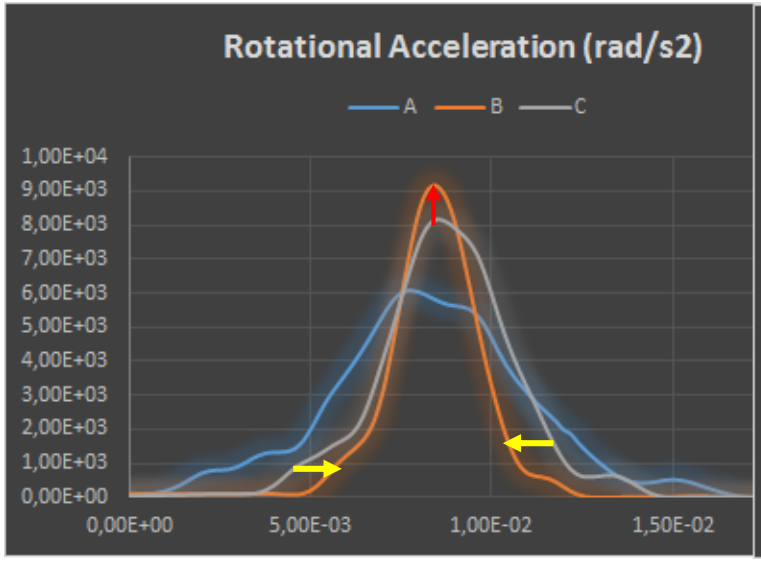


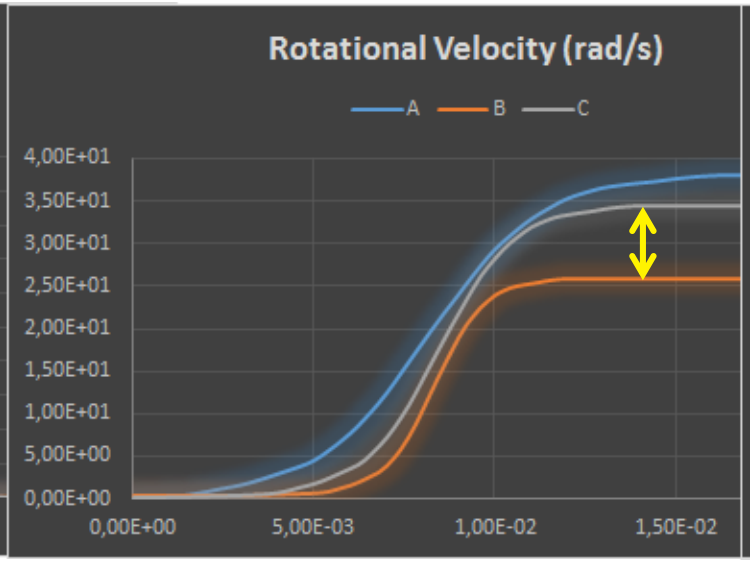


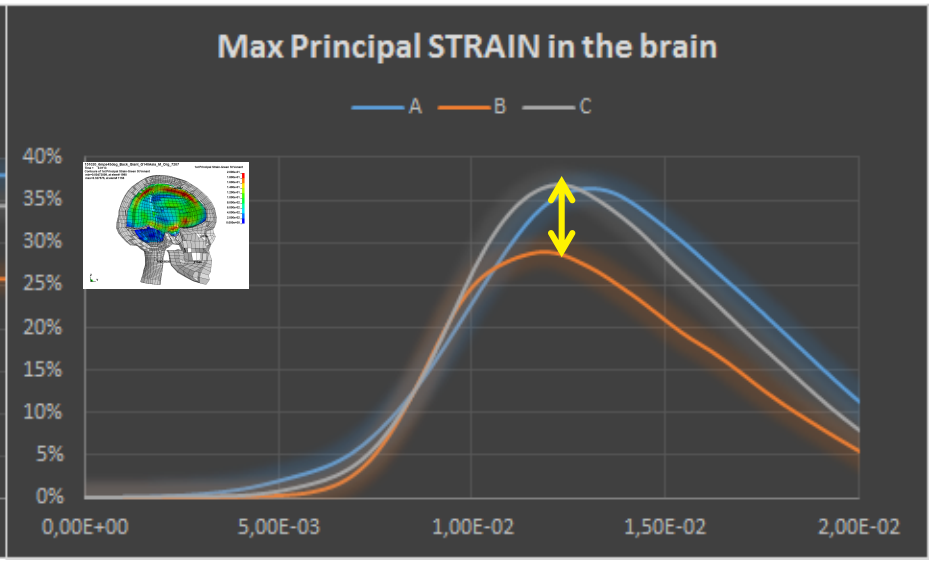


DURATION AS IMPORTANT AS AMPLITUDE

KTH Teknik och hälsa

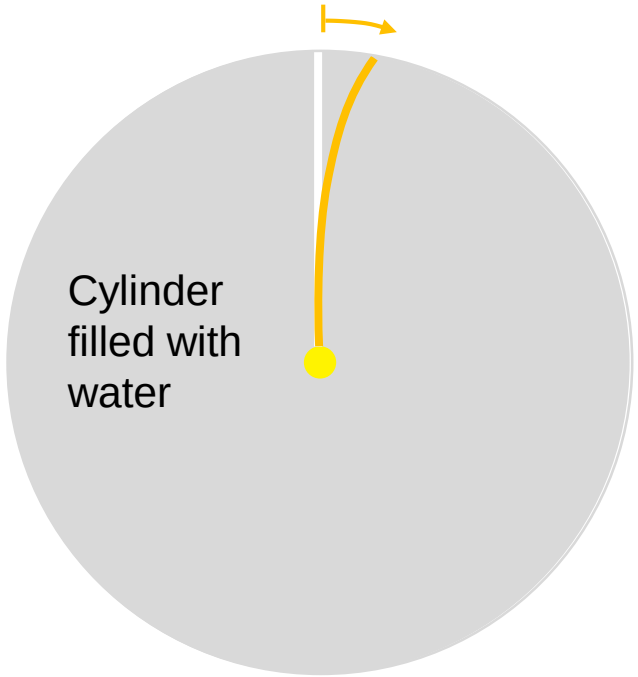


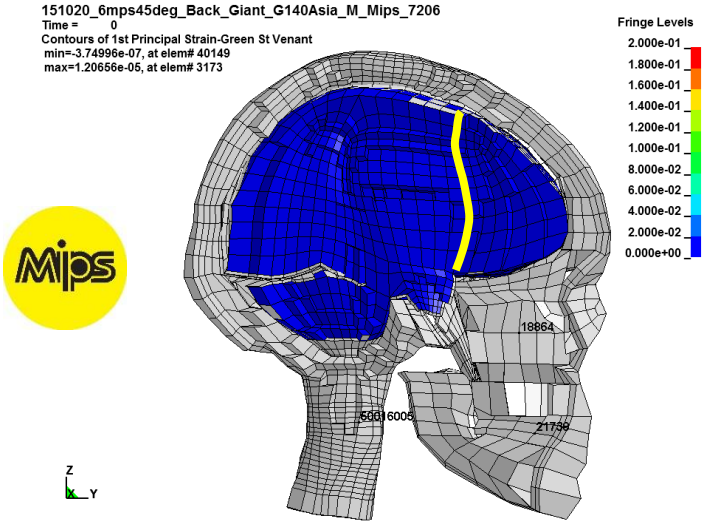


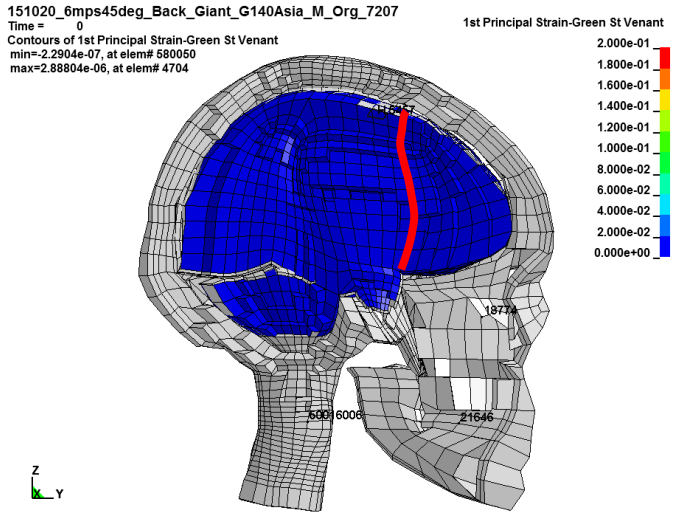


- The Red curve has higner amplitude **but** shorter duration
- Resulting in lower rotational velocity and significantly lower strain in the brain

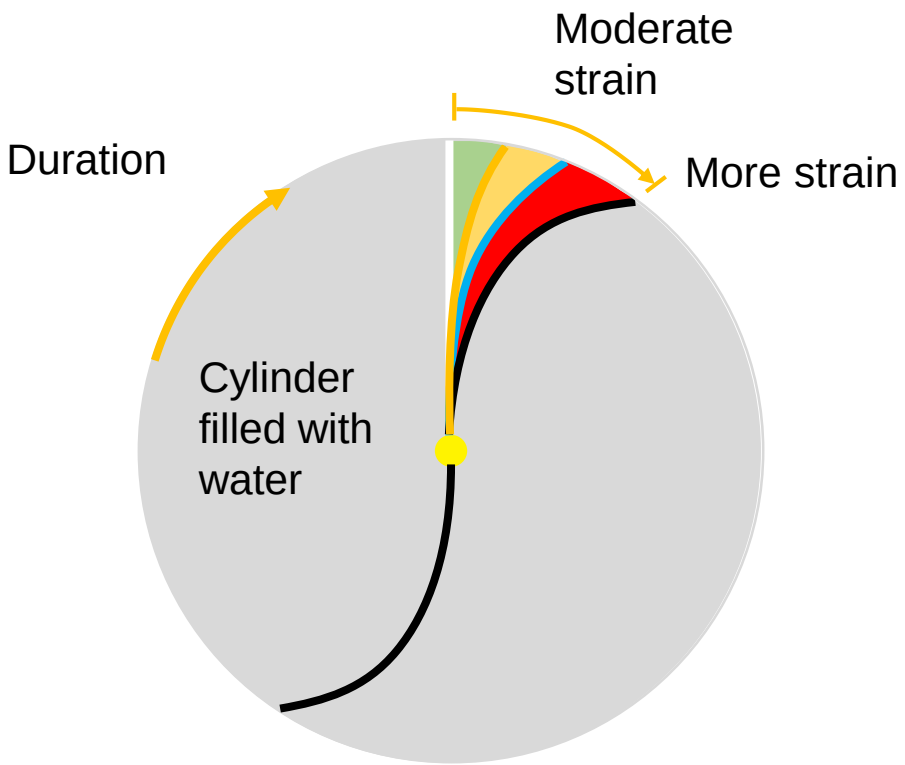
ALL TOGETHER CASUING STRAININ THE BRAIN

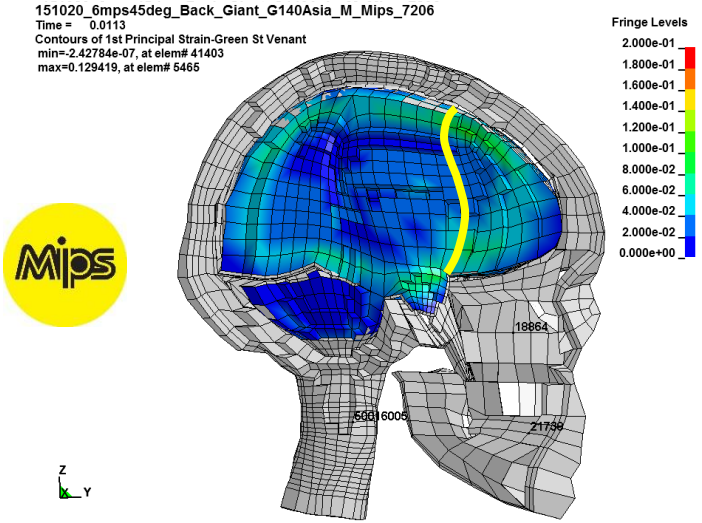


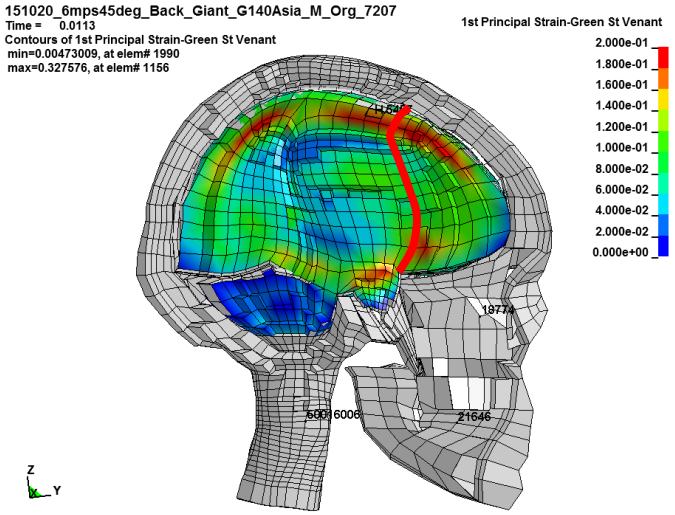




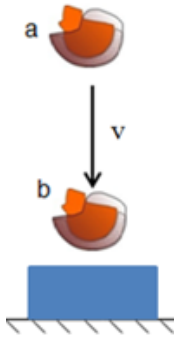
ALL TOGETHER CASUING STRAININ THE BRAIN







MIPS APPROVAL TEST PROTOCOLL



Ski helmet test standard
EN1077

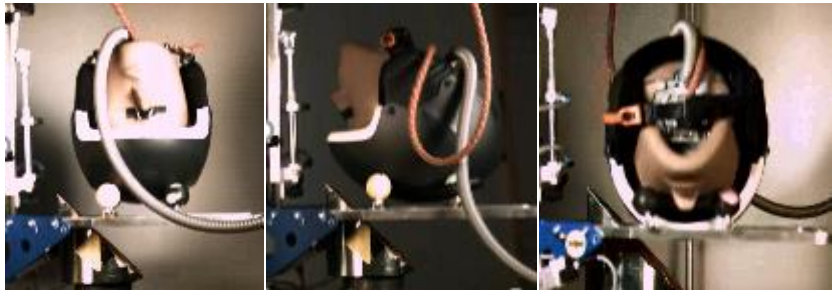
Linear acceleration
< 250G

CE

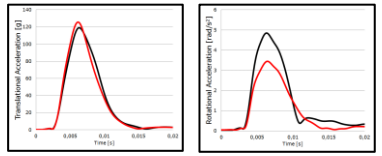
MIPS

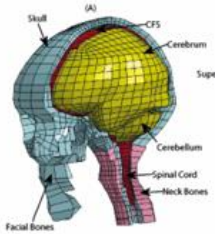
No MIPS

Yrot Xrot Zrot



Linear acceleration +
Angular acceleration

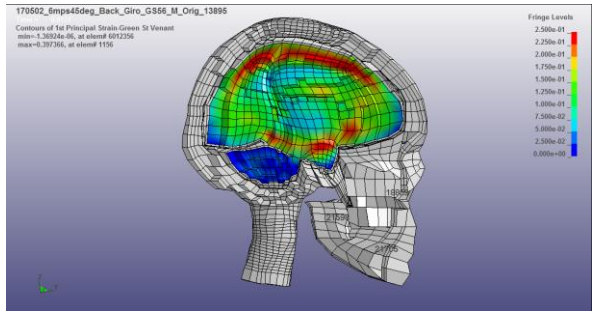


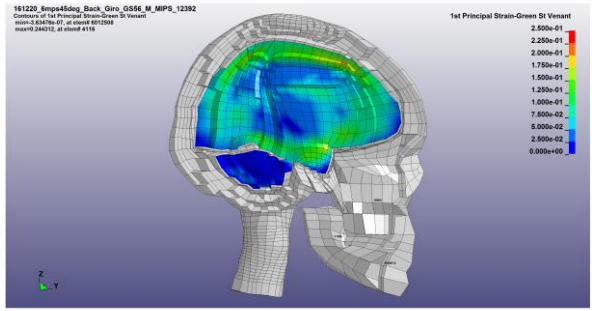


Strain reduction >
10%

OUTLINE

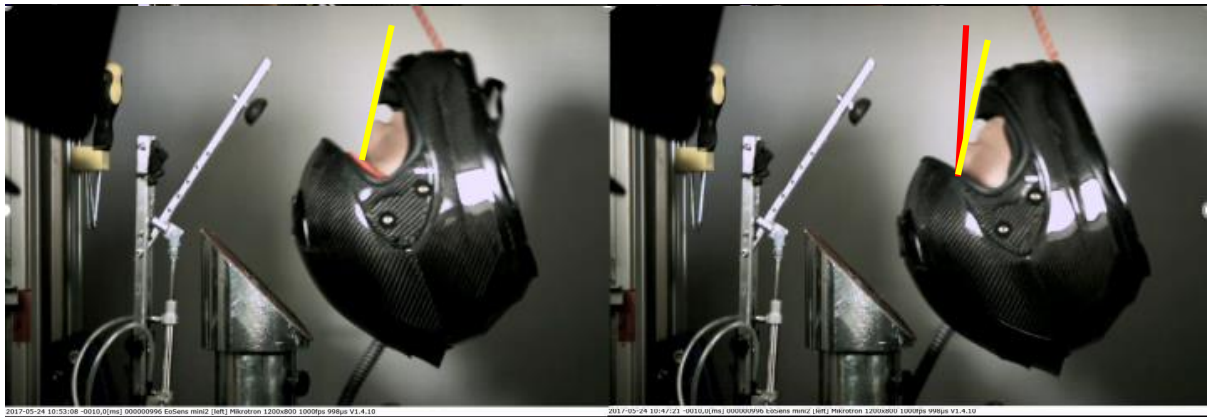
- Intro KTH
- MIPS BPS and other systems
- Reconstruction of MX accident
- Oblique helmet test methods
- MIPS Approval test method
- **Example of results**
- Summary

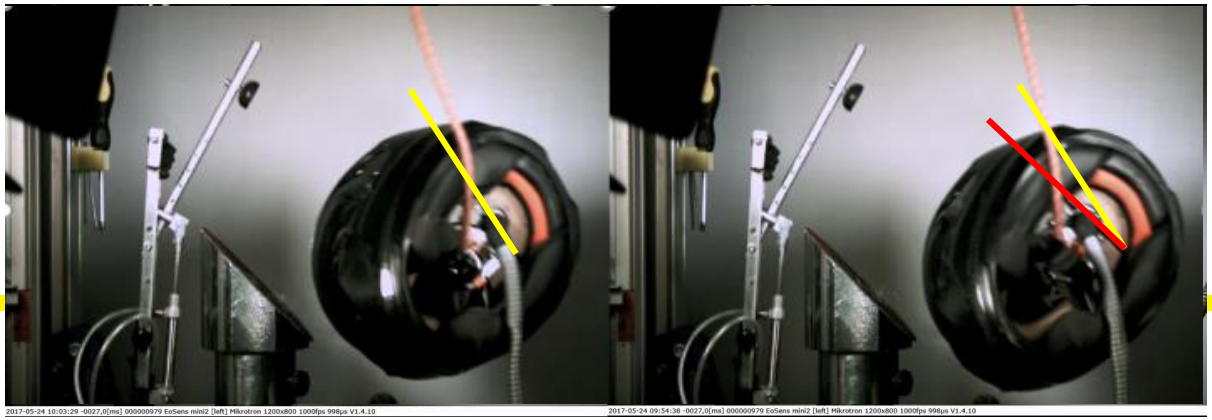




Original

With MIPS BPS

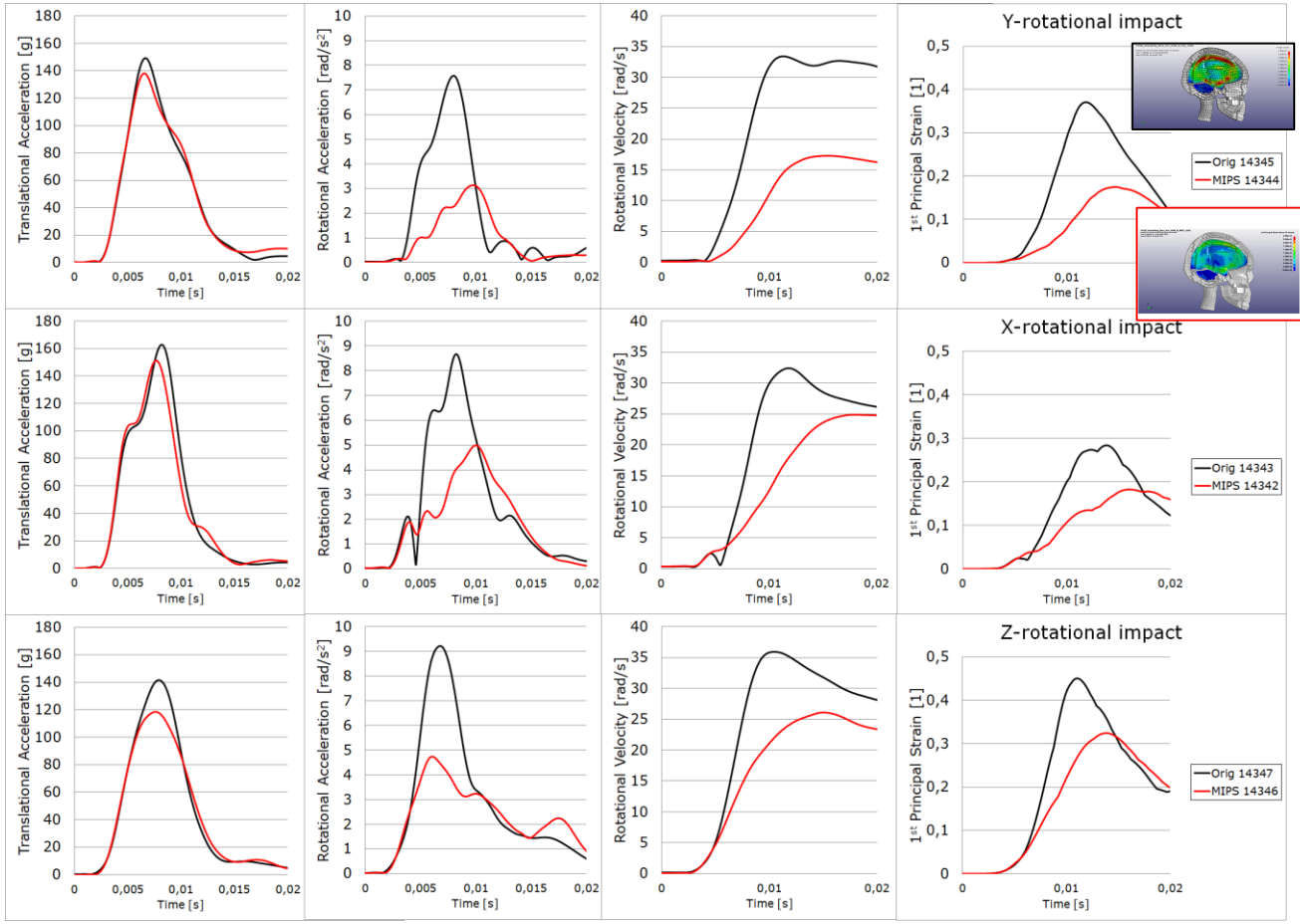




Example of results Motorcycle helmet 7.5m/s impact speed

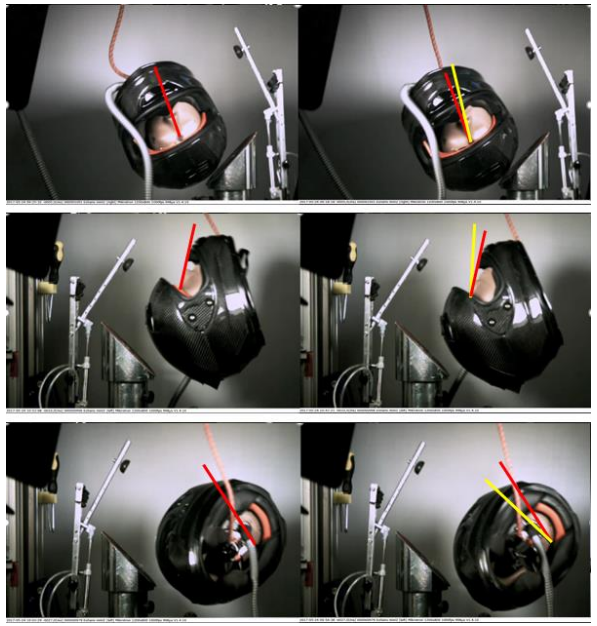
KTH VETENSKAP OCH KONST

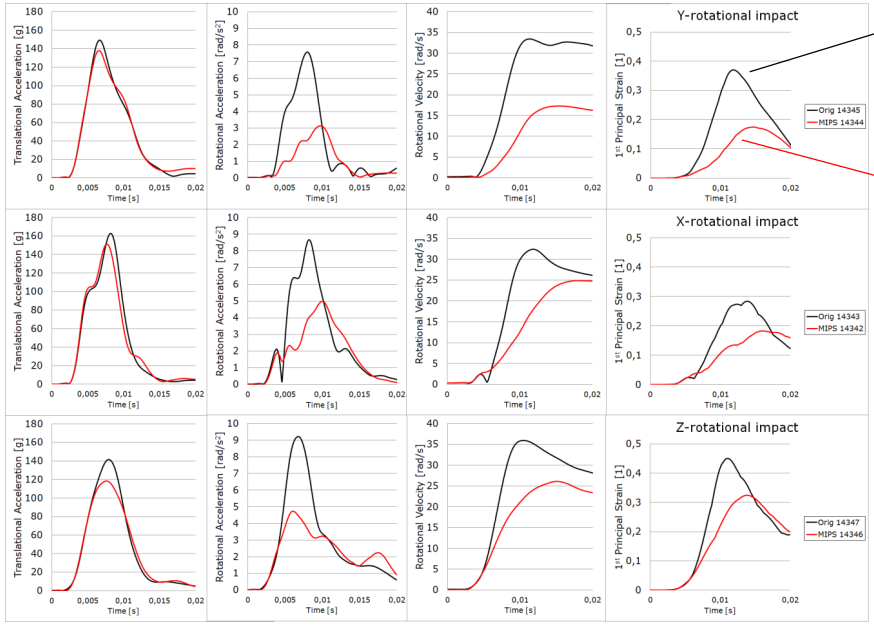
KTH Teknik och hälsa

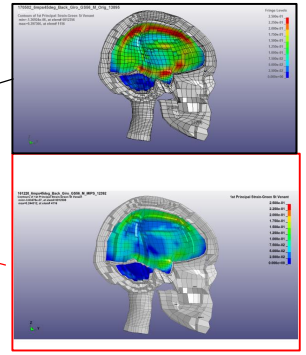


Example of results - Motorcycle helmet 7.5m/s impact speed

KTH Teknik och hälsa

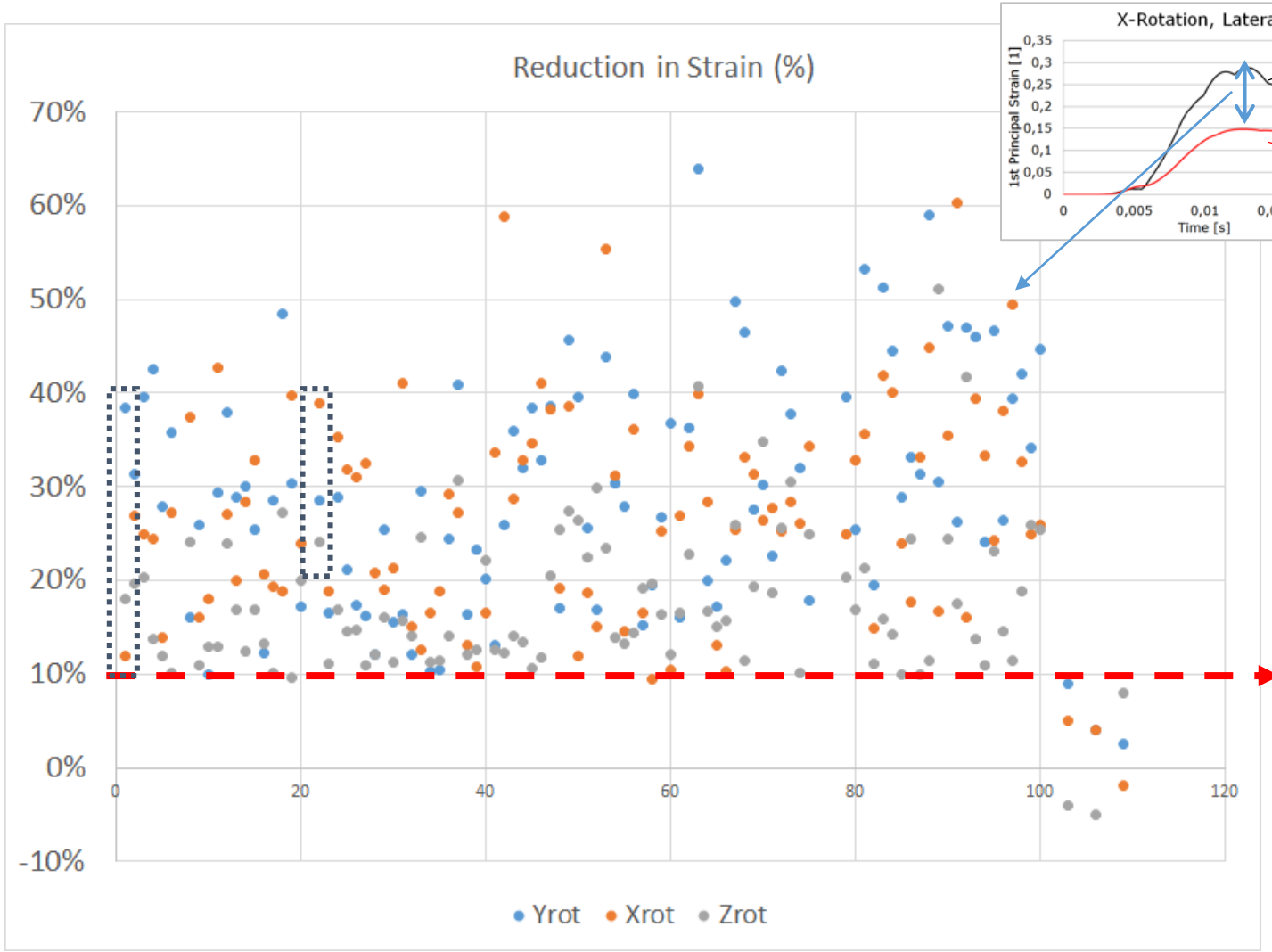


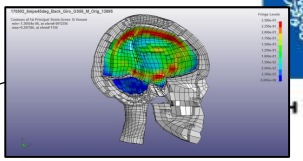


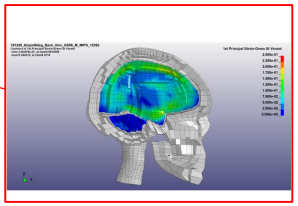


Impact	Equipped with MIPS	Resultant Translational Acceleration [g]	Resultant Rotational Acceleration [krad/s^2]	Resultant Rotational Velocity [rad/s]	1st Principal Strain [1]	BrIC	Relative Difference Resultant Translational Acceleration	Relative Difference Resultant Rotational Acceleration	Relative Difference Resultant Rotational Velocity	Relative Difference 1st Principal Strain	BrIC
Yrot	MIPS 14344	137,9	3,1	17,3	0,17	0,32	7,5%	58,6%	48,2%	53,0%	48,4%
Yrot	Orig 14345	149,1	7,6	33,5	0,37	0,62					
Xrot	MIPS 14342	151,3	5,0	24,9	0,18	0,42	7,2%	42,4%	23,2%	35,7%	22,2%
Xrot	Orig 14343	163,0	8,7	32,4	0,28	0,54					
Zrot	MIPS 14346	118,6	4,7	26,1	0,32	0,61	16,1%	48,5%	27,5%	28,2%	25,6%
Zrot	Orig 14347	141,3	9,2	35,9	0,45	0,82					

Results from 100 MIPS Approval tests







Benchmark of 9 MC helmets from Swedish market

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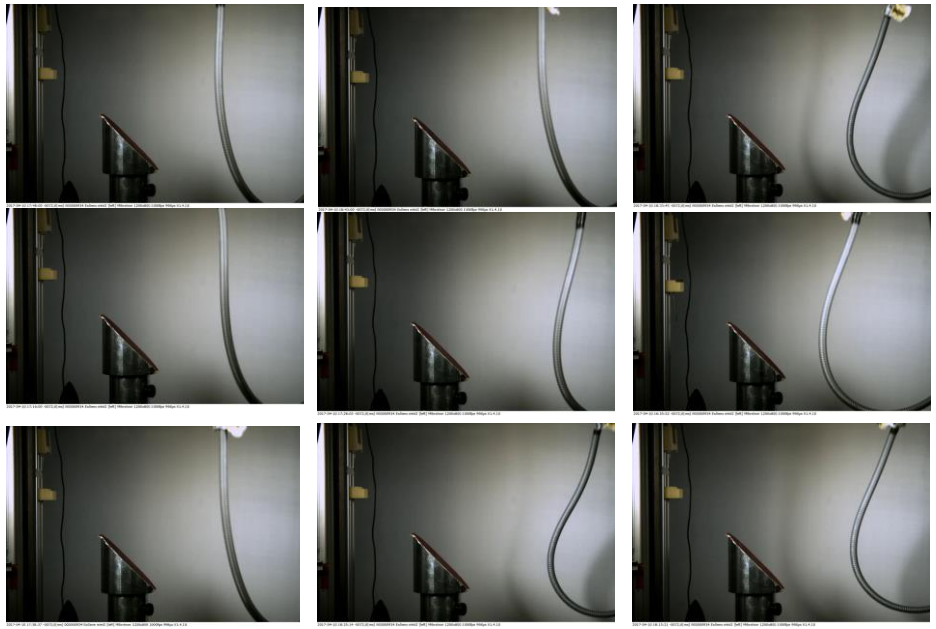
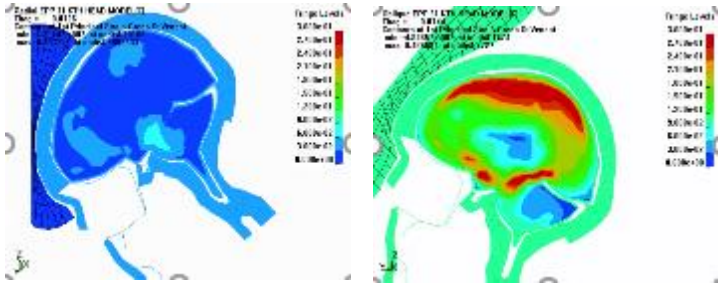
All tested in 7.5m/s

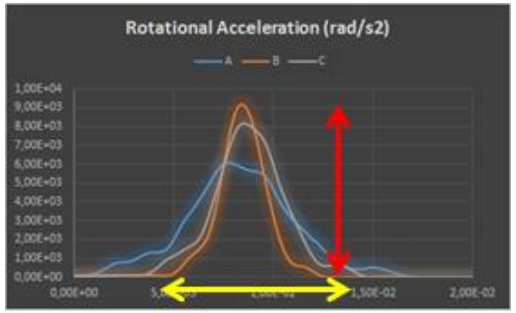


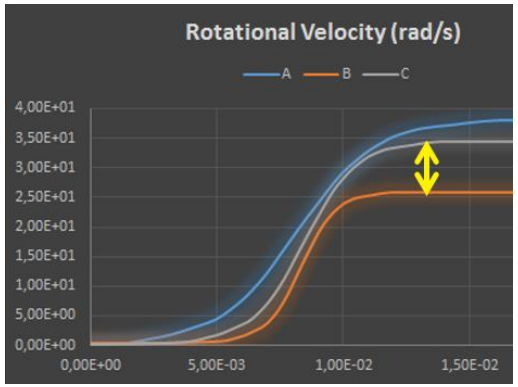
Helmet	Resultant Translational Acceleration [g]	Resultant Rotational Acceleration [krad/s2]	Resultant Rotational Velocity [rad/s]	1st Principal Strain [1]
1	122,7	3,2	26,2	24%
1	128,3	5,2	30,3	25%
2	141,3	6,5	33,0	35%
2	146,8	7,5	32,0	36%
3	127,8	6,7	35,2	36%
3	134,4	6,3	34,2	36%
4	145,6	7,7	33,1	36%
4	125,8	6,4	35,6	37%
5	140,8	6,9	34,4	37%
5	109,8	6,9	35,1	38%
6	121,8	6,7	34,2	38%
6	111,6	8,0	37,3	41%
7	155,4	9,2	37,2	41%
7	157,0	9,3	37,6	42%
8	116,8	7,8	39,6	43%
8	128,6	8,7	39,9	43%
9	125,7	9,1	40,3	44%
9	131,7	9,2	40,0	44%

SUMMARY

- The human brain is more sensitive for rotation than linear motion
- To evaluate helmets like MIPS a new helmet test method is needed (ECE 22.05)
- 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







Any questions could be sent to:

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- Peterh@kth.se
- Peter.halldin@mipshelmet.com