



NORA Construction Sector Council Meeting, May 23, 2023

Hardhat & Helmet Research: Myth-Busters!

Michael Bottlang, PhD

Co-Founder, Legacy Biomechanics Laboratory, Portland, OR

Co-Owner, WaveCel LLC, Wilsonville, OR



Mission: Injury Prevention and Treatment

RESEARCH:

Legacy Biomechanics Laboratory

Co-Founder, Director: M. Bottlang

10 NIH grants

> 70 peer-rev. publications

> 7,700 citations

DEVELOPMENT:

➤ 31 utility patents

➤ 5 licensed products

- 4 fracture treatments

- **1 brain injury prevention**



WAVECEL

Brain Injury

Devastating

Life-long cognitive, psychological, emotional, functional impairments.

Costly¹

severe TBI, \$60K - \$1,8M / case.

Limited Treatment Options

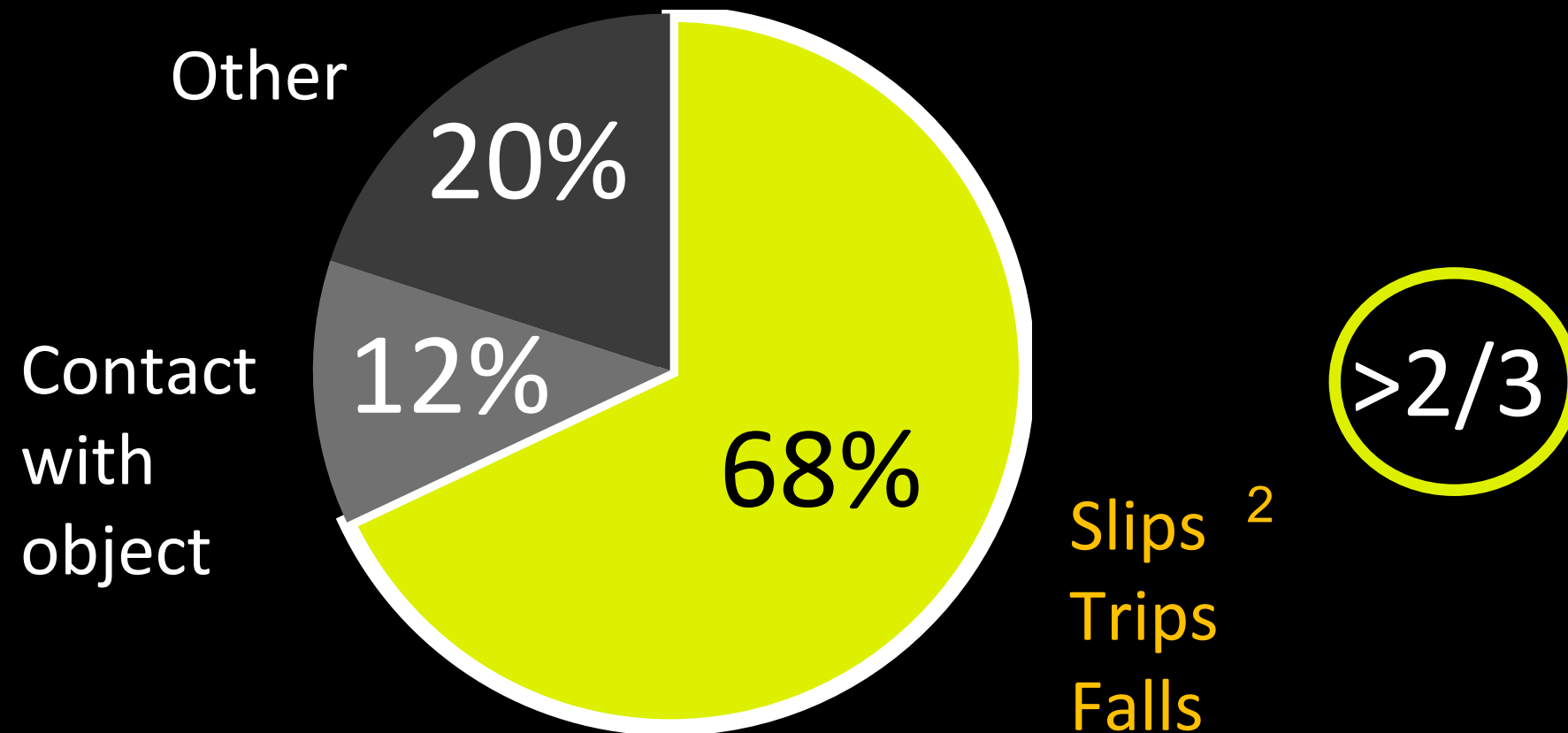
Prevention



[1] Fu TS, et al. Can J Neurol Sci 2016; 43(2):238-247.

TBI in USA: 223,000 hospitalization / year (CDC)
54,272 / year work-related (OSHA Report)

Construction industry: highest % of work-related TBIs of any industry (25%)¹



1. Tiesman HM, et al., Am J Prev Med 2011; 41(1):61-67.

2. OSHA Severe Injury Reports. US Department of Labor; 2021.

Myth 1

Hard Shell = Brain Protection





brain injuries
≠
skull fracture

90% of brain injuries
occur
without skull fracture

Munoz-Sanchez, et al., Brain Inj. 23:1, 2009

*“If rotational acceleration is the
cause of brain injury,
how does the helmet protect the brain?”*

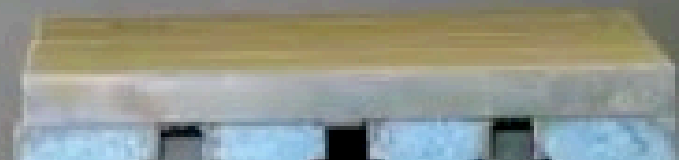
*Prof. Albert I. King,
Wayne State University*

King AI, et al. J Neurotrauma 1995; 12(4):651-658.



Brain tolerates
straight impacts

Brain is injured by
rotational forces



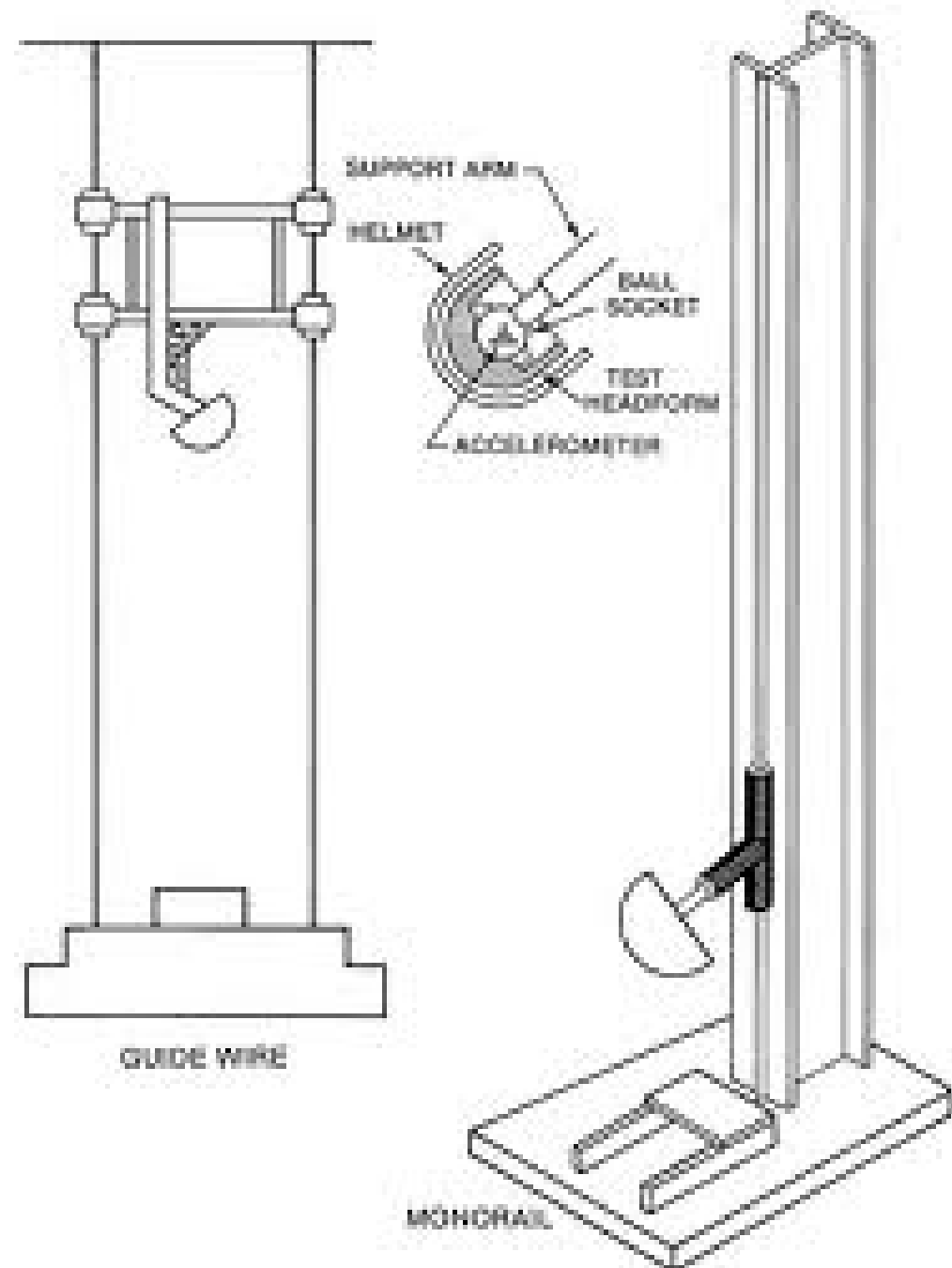
Rotational Force



ANSI Z89.1 Test Standard:

- Vertical drop
- Flat anvil
- No head rotation allowed
- No head rotation measured
- Pass/Fail: 300 g (linear only)

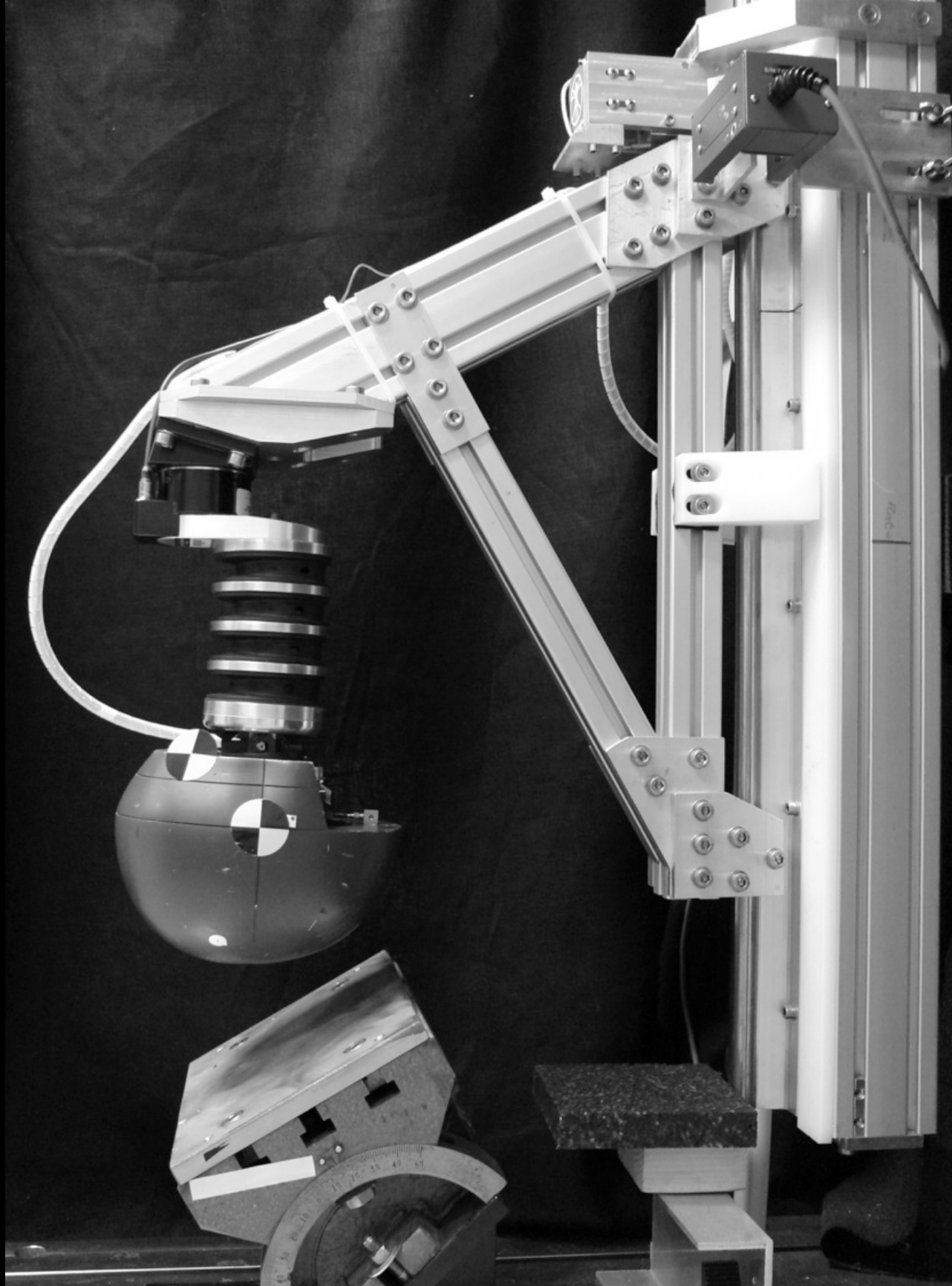
- CPSC §1203.17
- Vertical Impact
- Same for 30 years





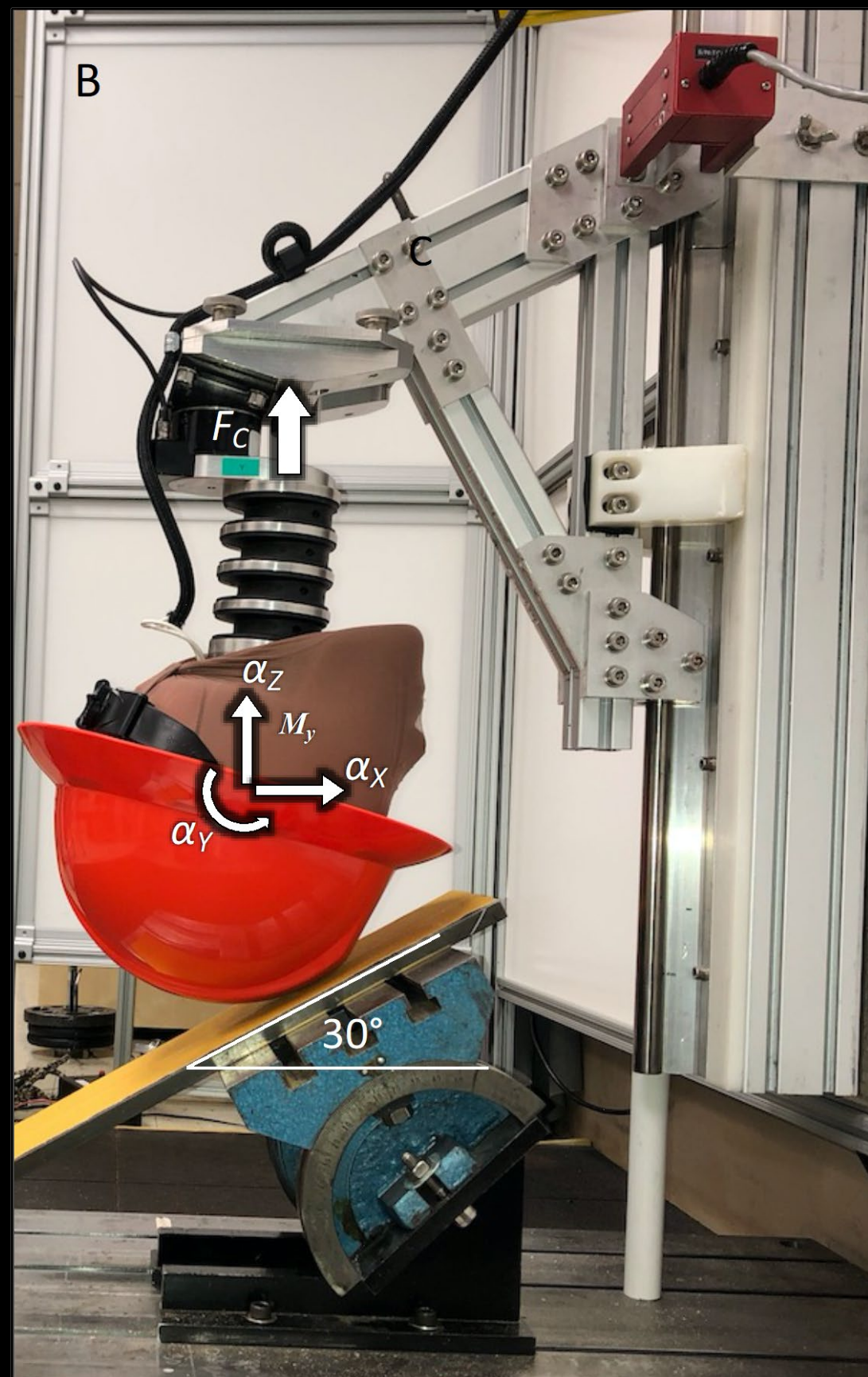
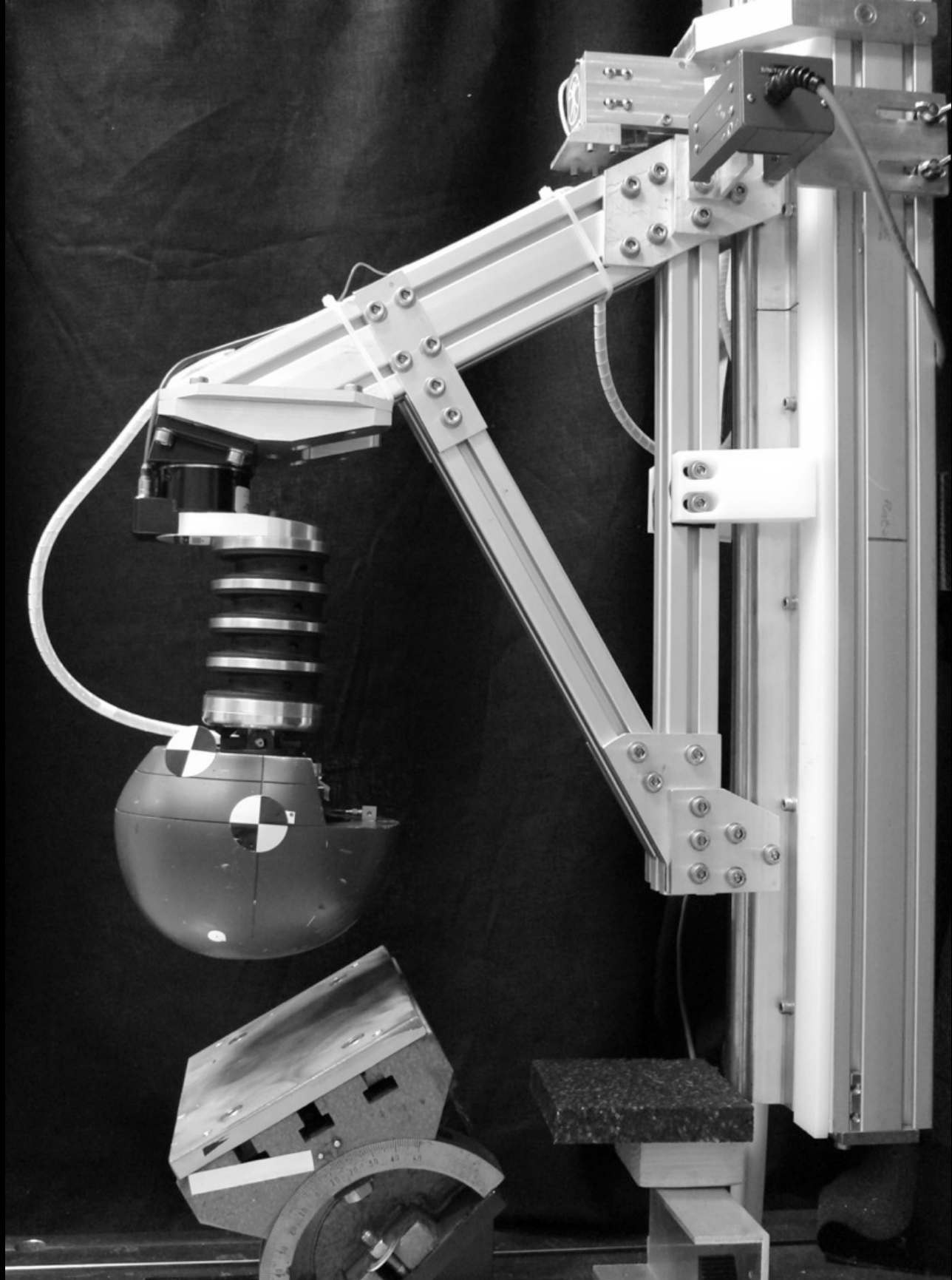
Helmet Impact Testing Facility

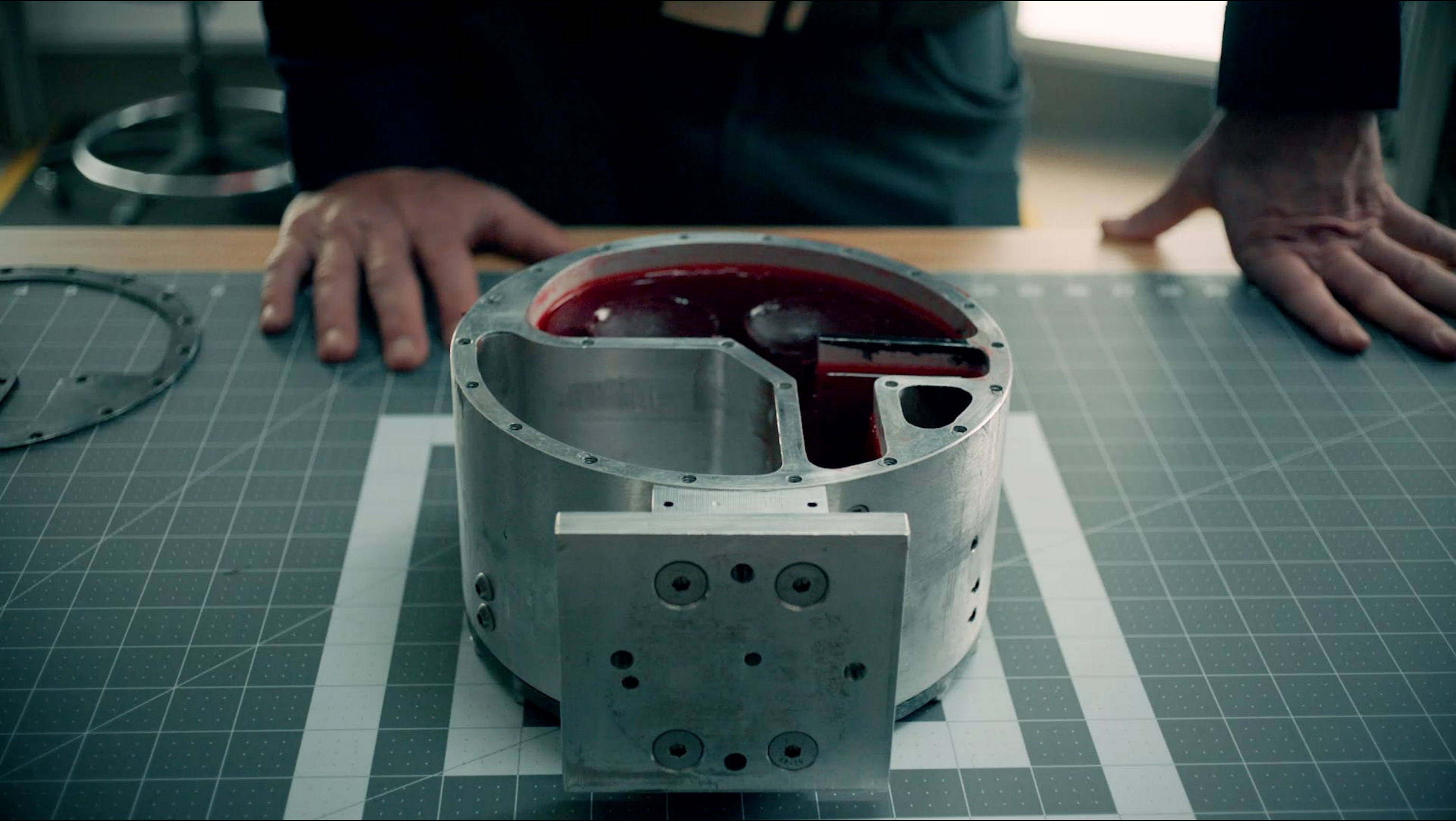




Advanced Impact Simulation

- Vertical drop tester
- Oblique impact
- Neck allows head rotation
- Lin + rot accelerations





WaveCell:

3-D structure absorbs
liner + rotational force



Fact 1

Hard Shell = Brain Protection?

Hard Shell = Skull Protection

Rotation Damping = Brain Protection



Myth 2

EPS foam will protect the brain



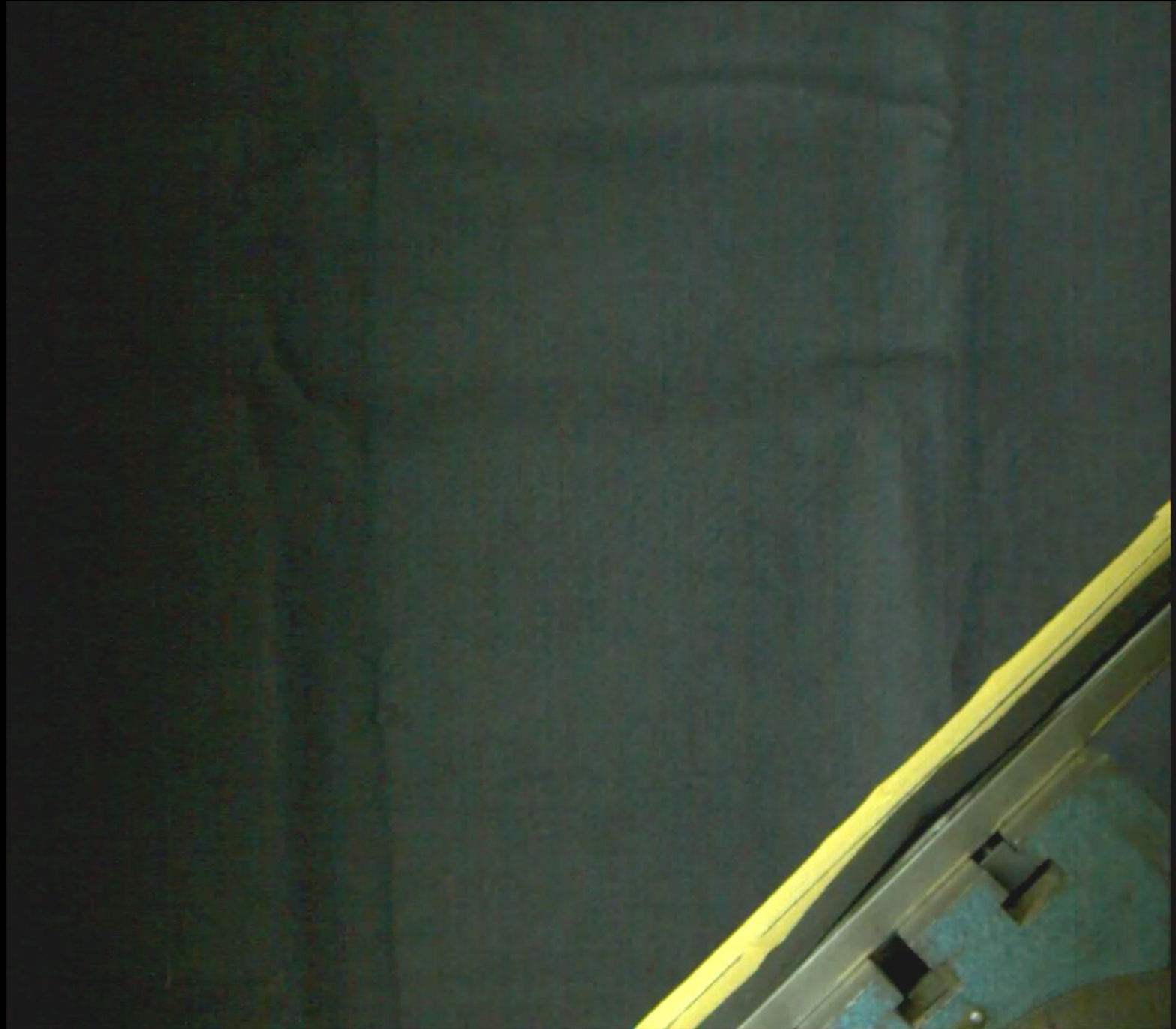
Rotational Force Absorption



Foam causes friction, may not absorb rotational forces.

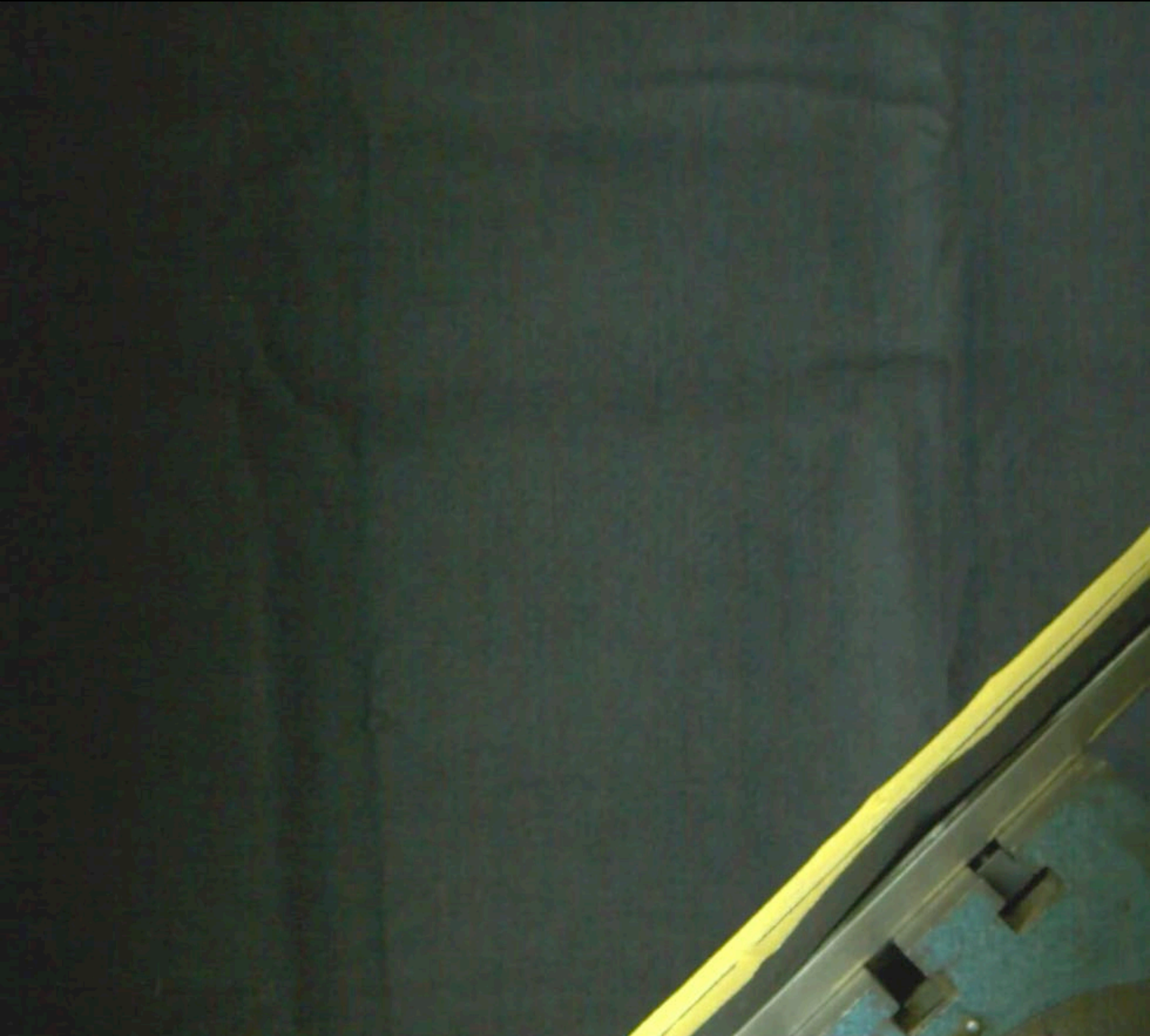
Rotational Force Absorption in Construction Helmets

EPS FOAM



Rotational Force Absorption in Construction Helmets

WAVECEL

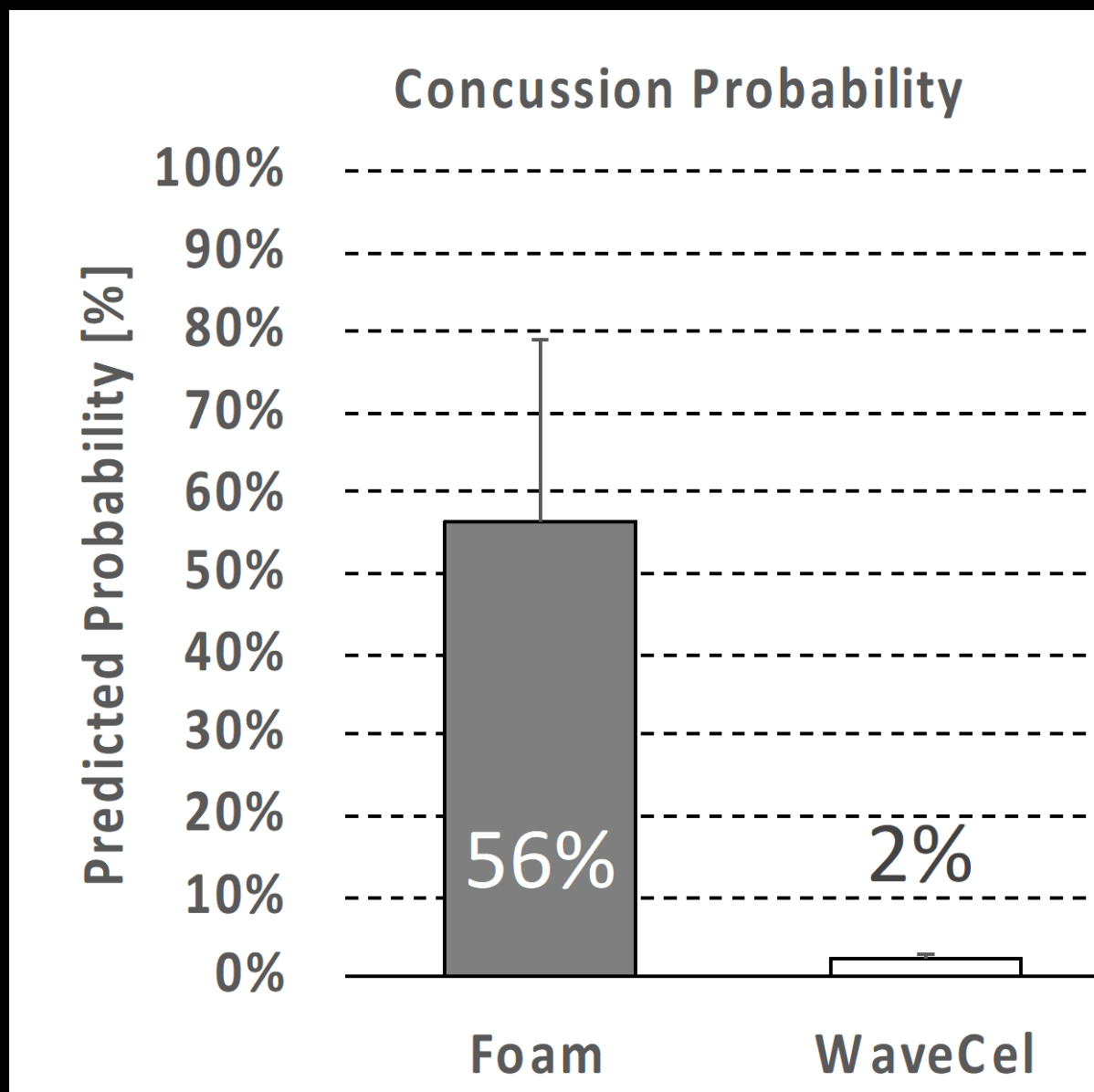


Effect of helmet design on impact performance of industrial safety helmets



Michael Bottlang^{*}, Gina DiGiacomo, Stanley Tsai, Steven Madey

Biomechanics Laboratory, Legacy Research Institute, Portland, OR, 97232, USA



Fact 2

EPS foam may not protect the brain from rotational force transmission.



Myth 3

All Hard Hats Perform Similar



Hard Hats

1967

53 years!

2020



Hard Hats

1967

53 years!

2020



Hard Hats

Shell:

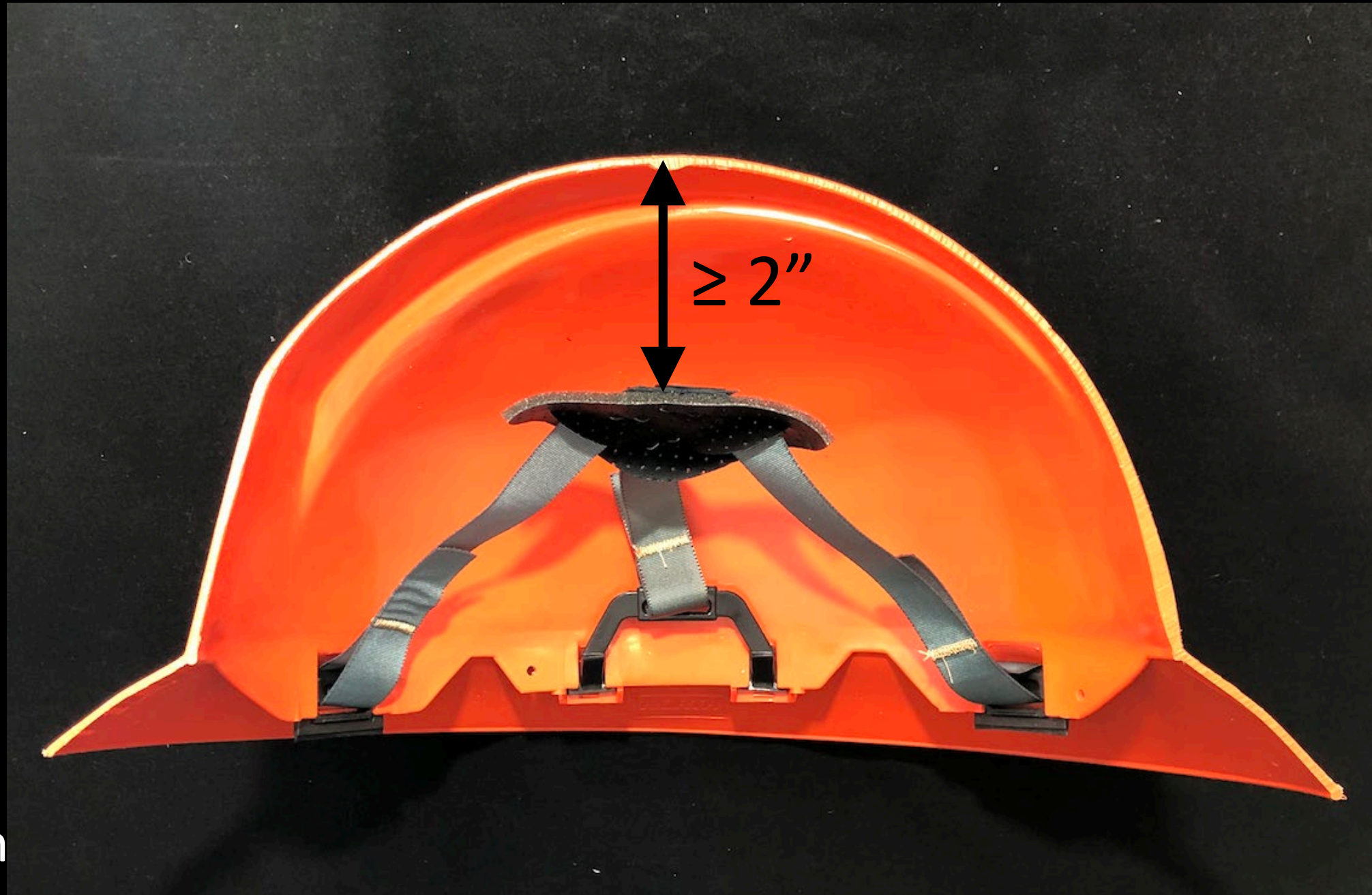
Thermoplastic (ABS, PE)

Suspension:

4, 6-point straps

Dome:

2" + Offset, crown deflection

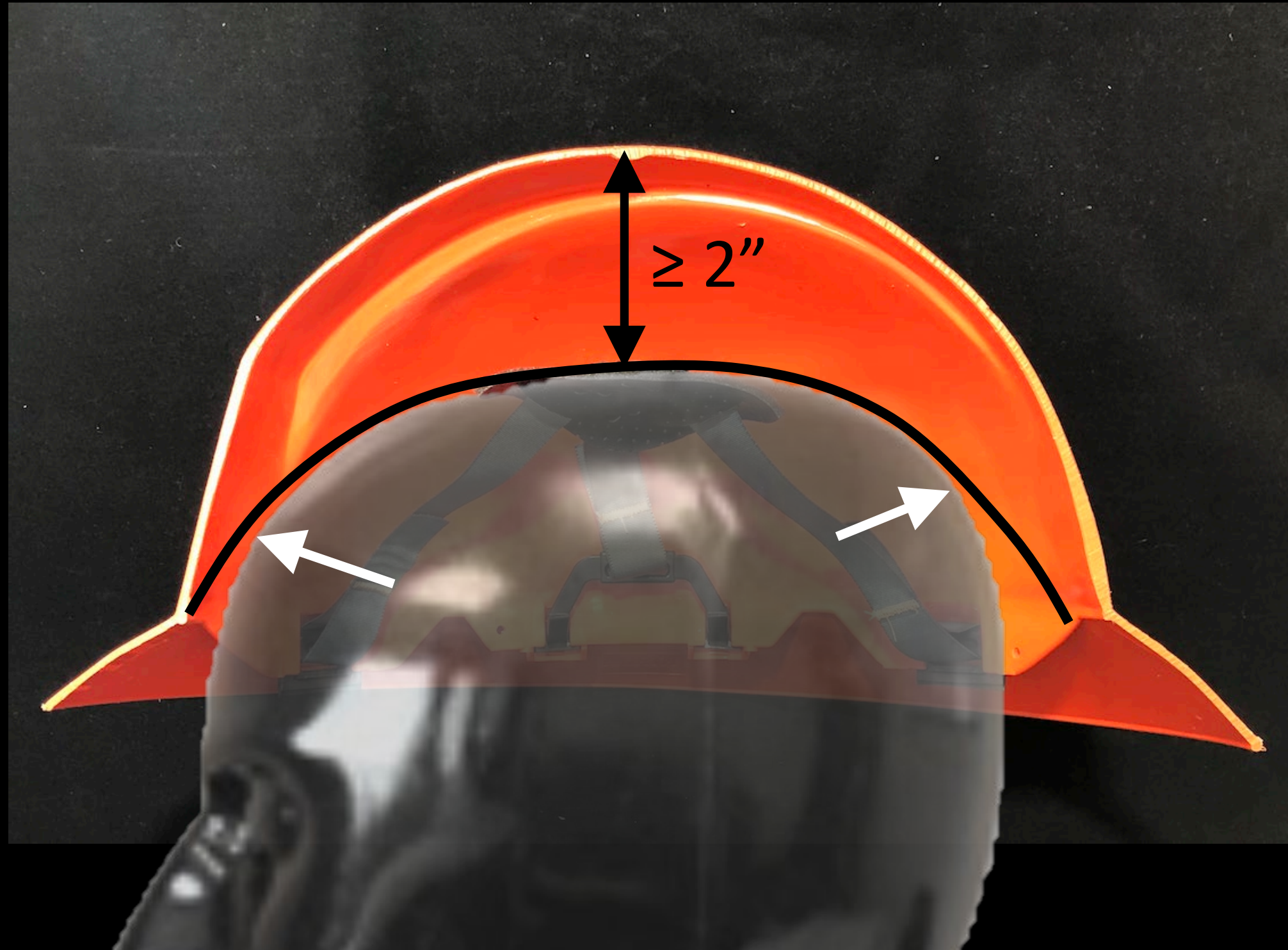


Hard Hats

ANSI TYPE 1:

Crown protection only,
from falling objects.

No side impact damping
for protection during
slips, trips, and falls.



Hard Hats

“52% - 62% of impacts occur to the helmet front and sides.”

Proctor TD et al. Journal of Occupational Accidents 1986; 8:181-191

“Industrial safety helmets (Type I) are practically useless against side, front and rear impacts, making a redesign necessary.”

Gilchrist A, Mills NJ. Journal of Occupational Accidents 1987; 9:199-211.

Type II Hard Hats

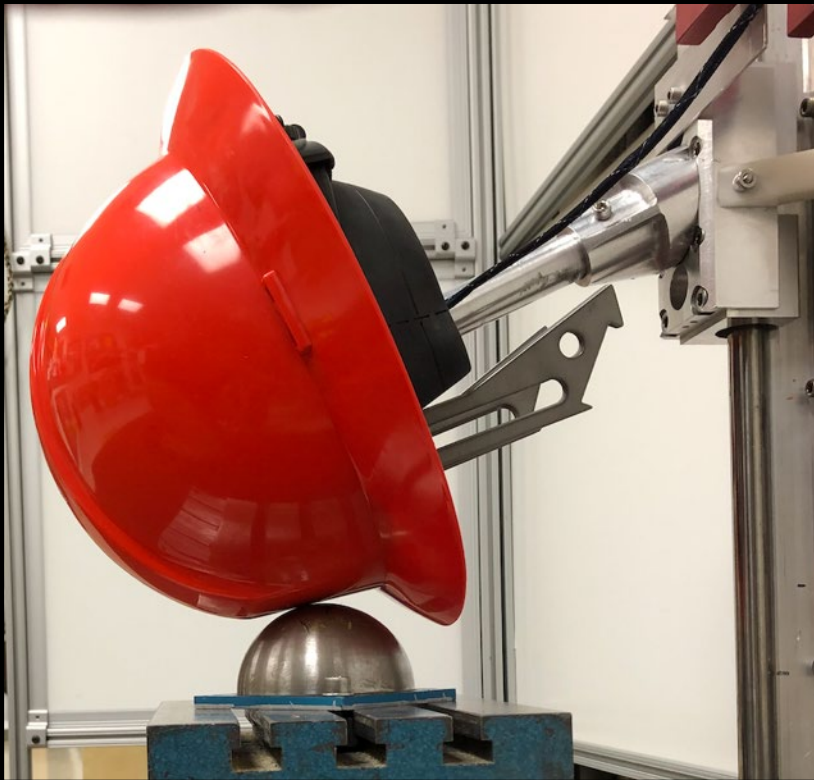
EPS liner:

Lateral Protection:
front, sides, back

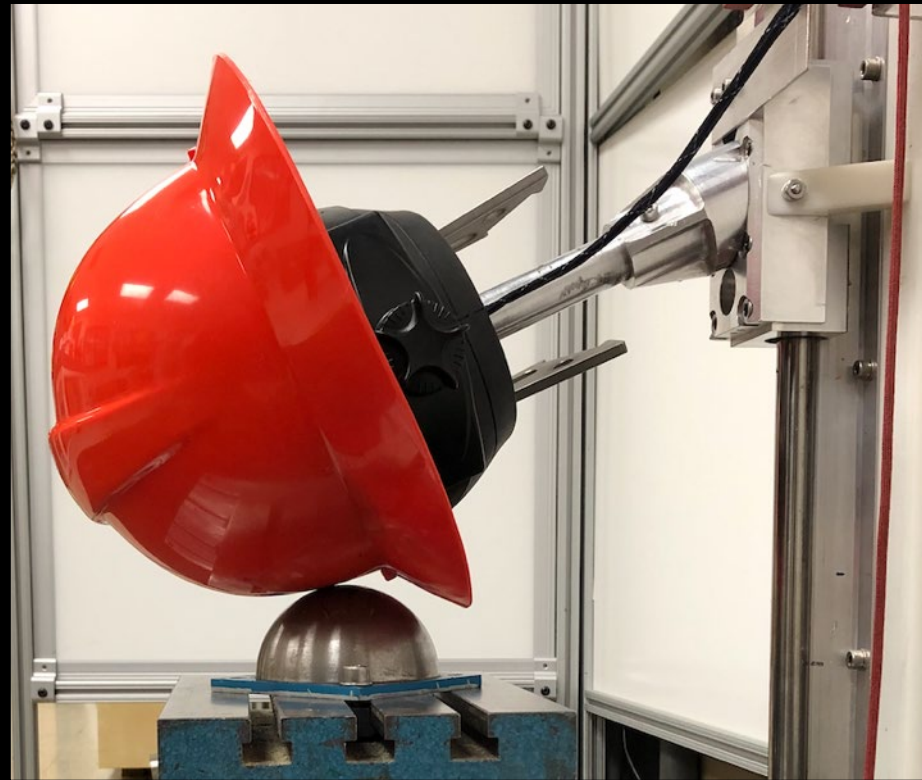


ANSI lateral impact comparison

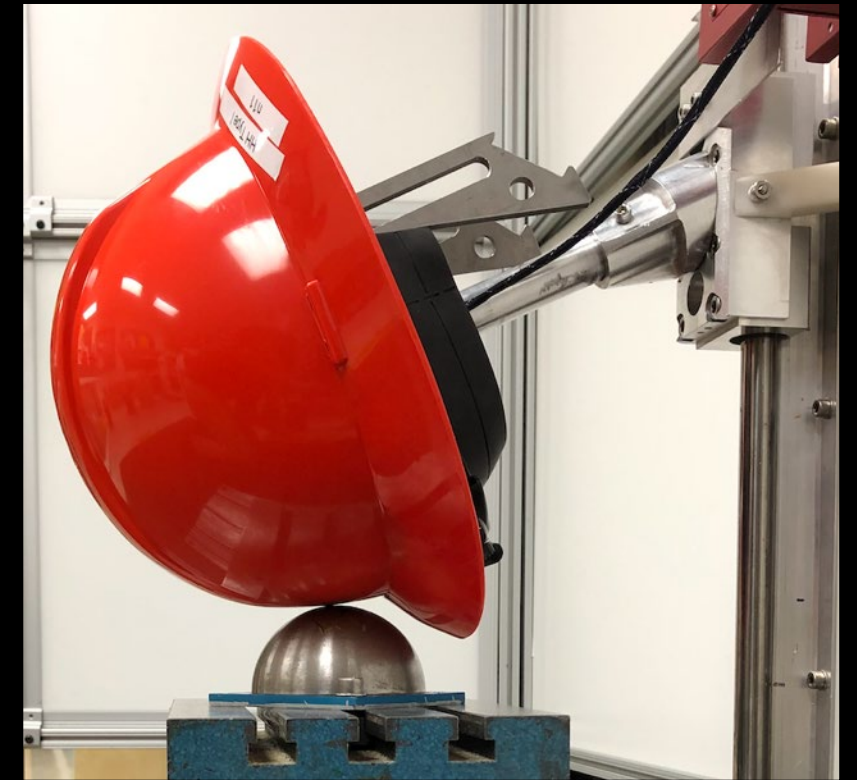
Front



Side



Rear



- Hard Hat: Type I vs Type II
- 3 lateral impact locations

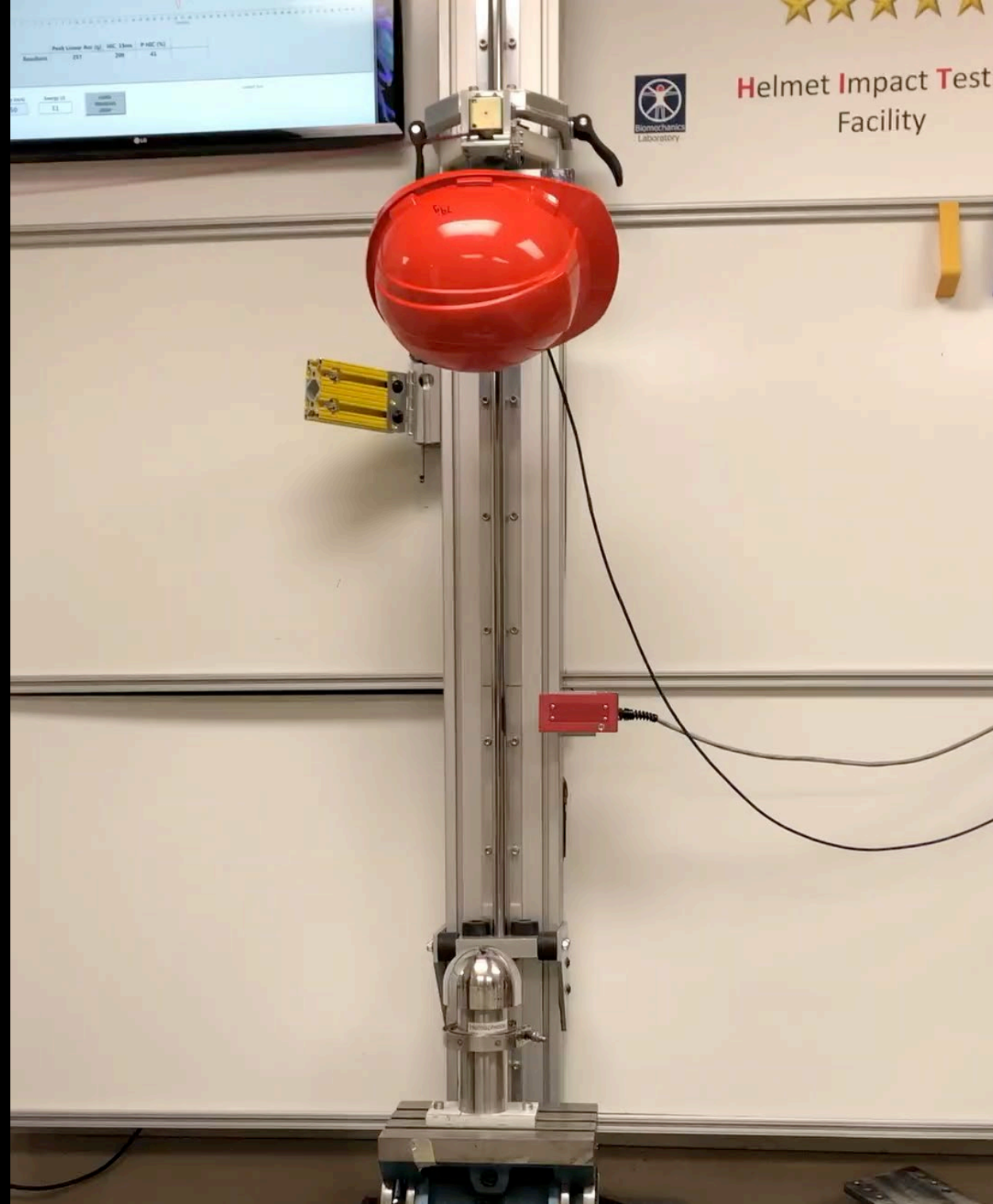
ANSI lateral impact comparison

ANSI Z89.1

Drop height:

0.6 m

2 ft

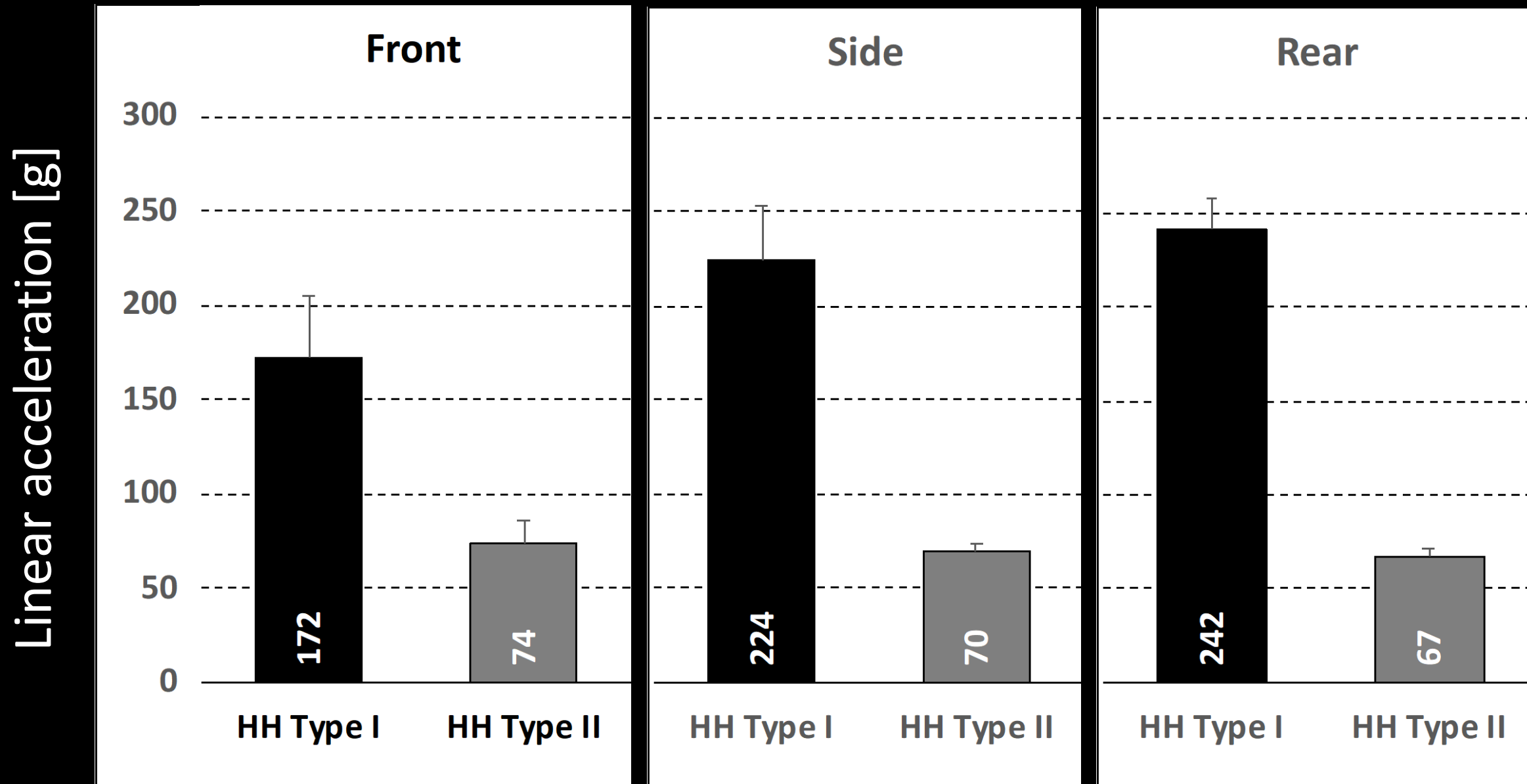


Type II vs Type I Hard Hats

>2x better

>3x better

>3.5x better



Fact 3

Type II hard hats provide 2-3.5 x better lateral protection.

Most impacts are lateral.

Myth 4

Modern Safety Helmets are safer
than modern Type II Hard Hats



Daily Labor Report ®

OSHA May Replace Inspector Hard Hats With Safer Helmets, Straps

By Bruce Rolfsen

Sept. 14, 2022, 4:41 PM



Why the Switch to Safety Helmets is a Good Decision

Aug 01, 2022

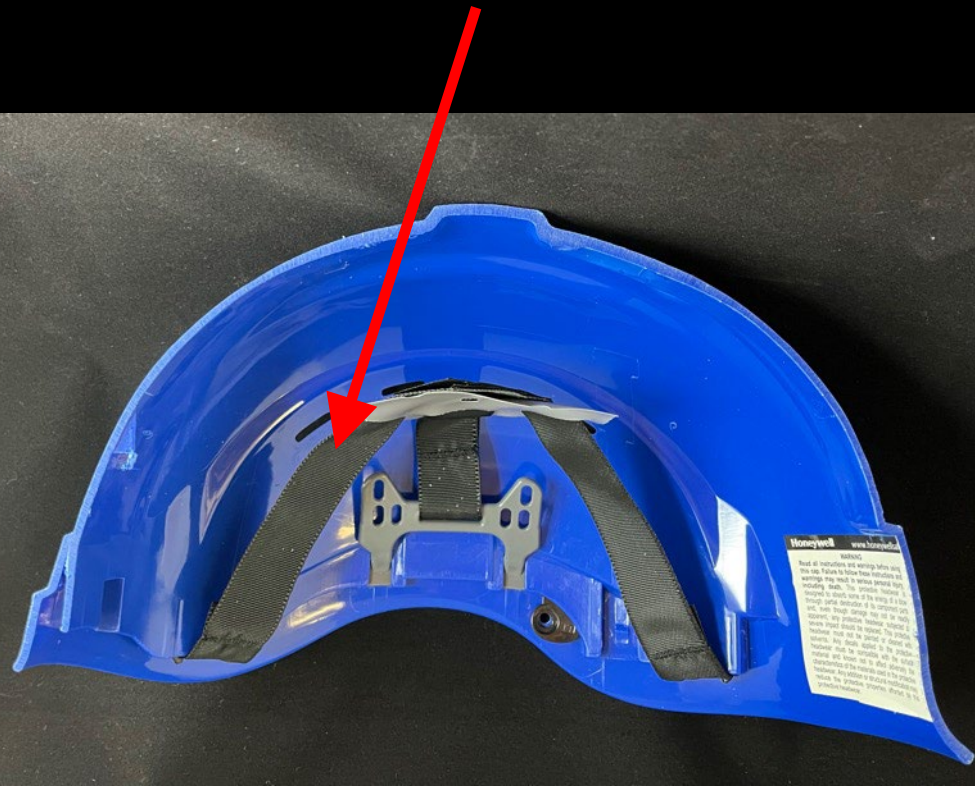
Is It Time to Rethink Your Head Protection?

Sep 01, 2022

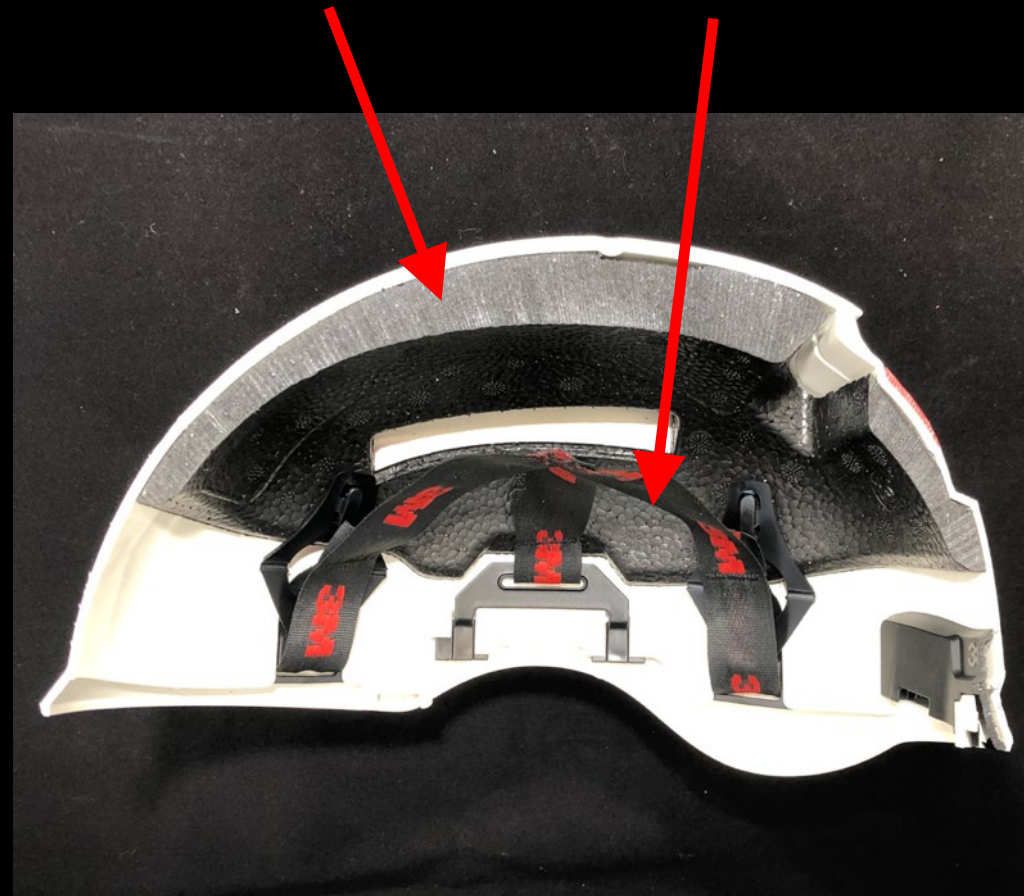
“By making a relatively simple switch to safety helmets, construction and industrial employers can help protect their employees better..”

Safety Helmets

Straps only



EPS + Straps

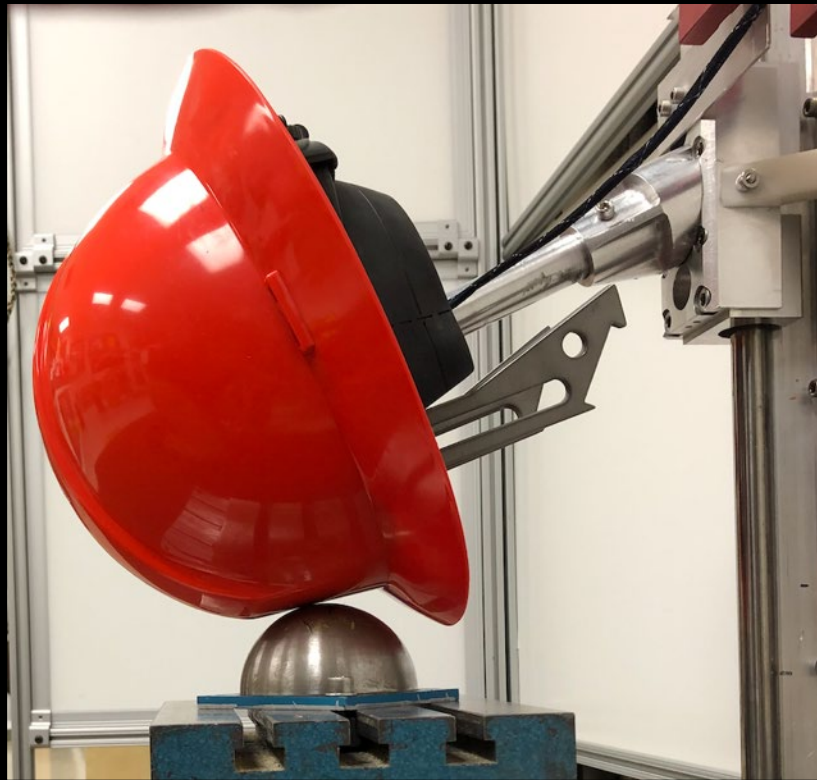


EPS only

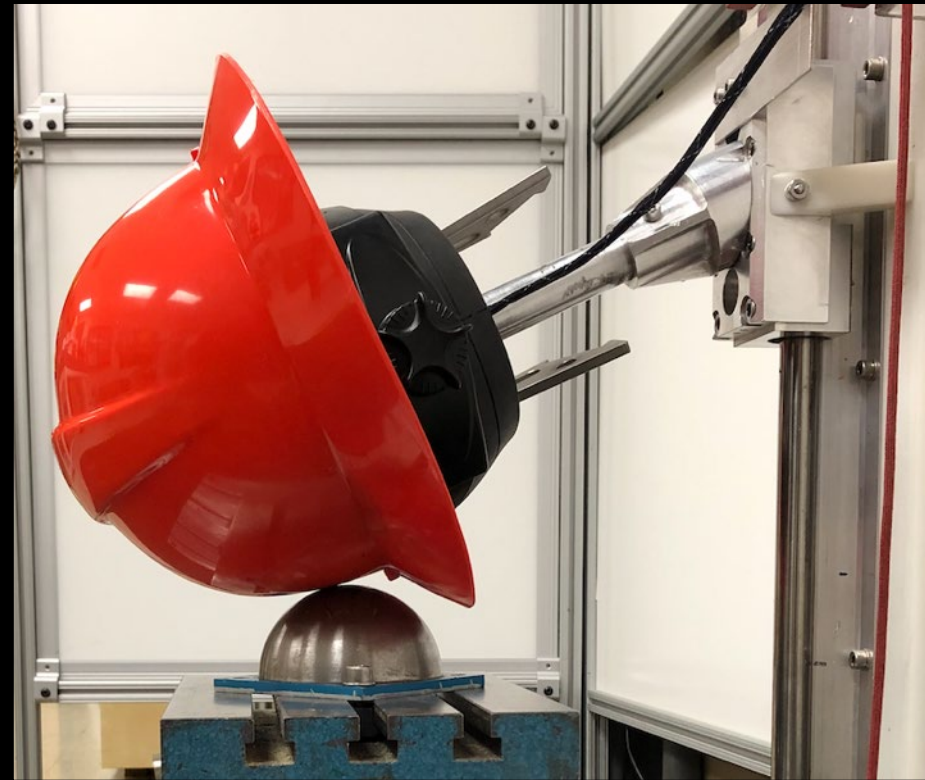


ANSI lateral impact comparison

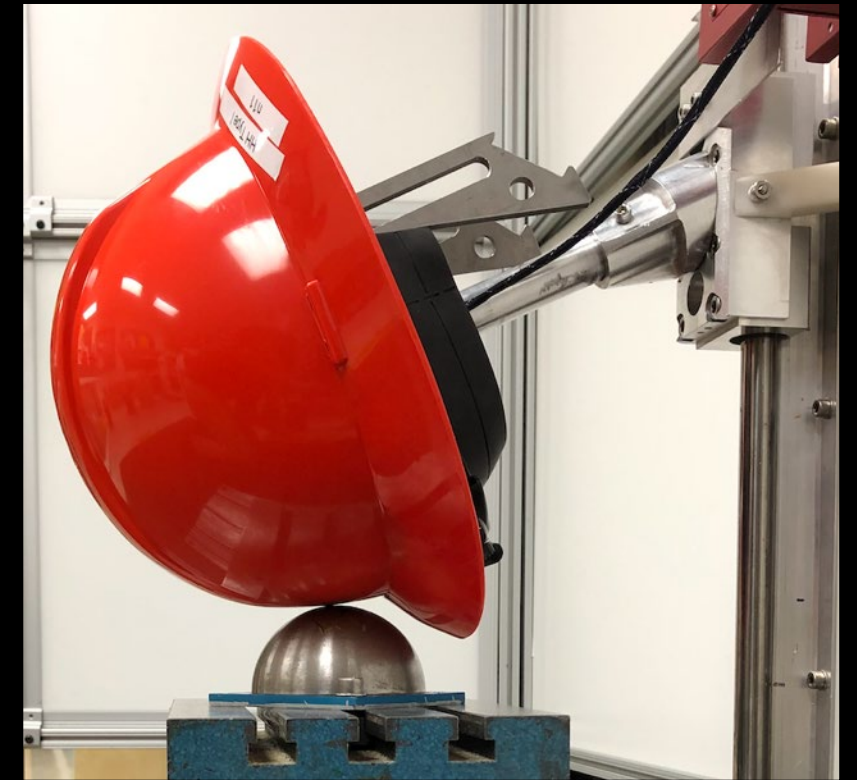
Front



Side

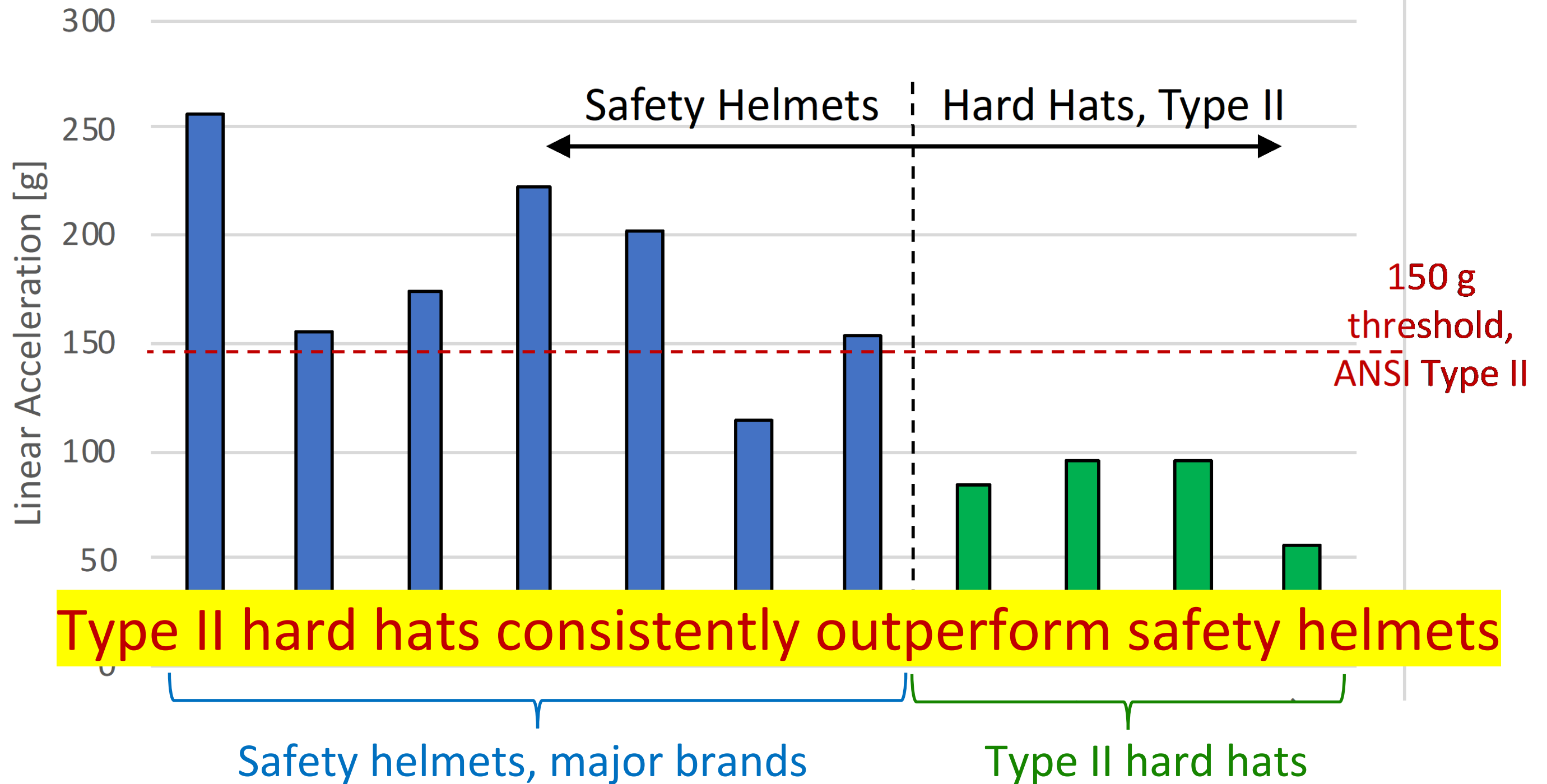


Rear



7 Safety Helmets vs 4 Type II Hard Hats

ANSI lateral impact score





EPS liner boundary



EPS liner boundary



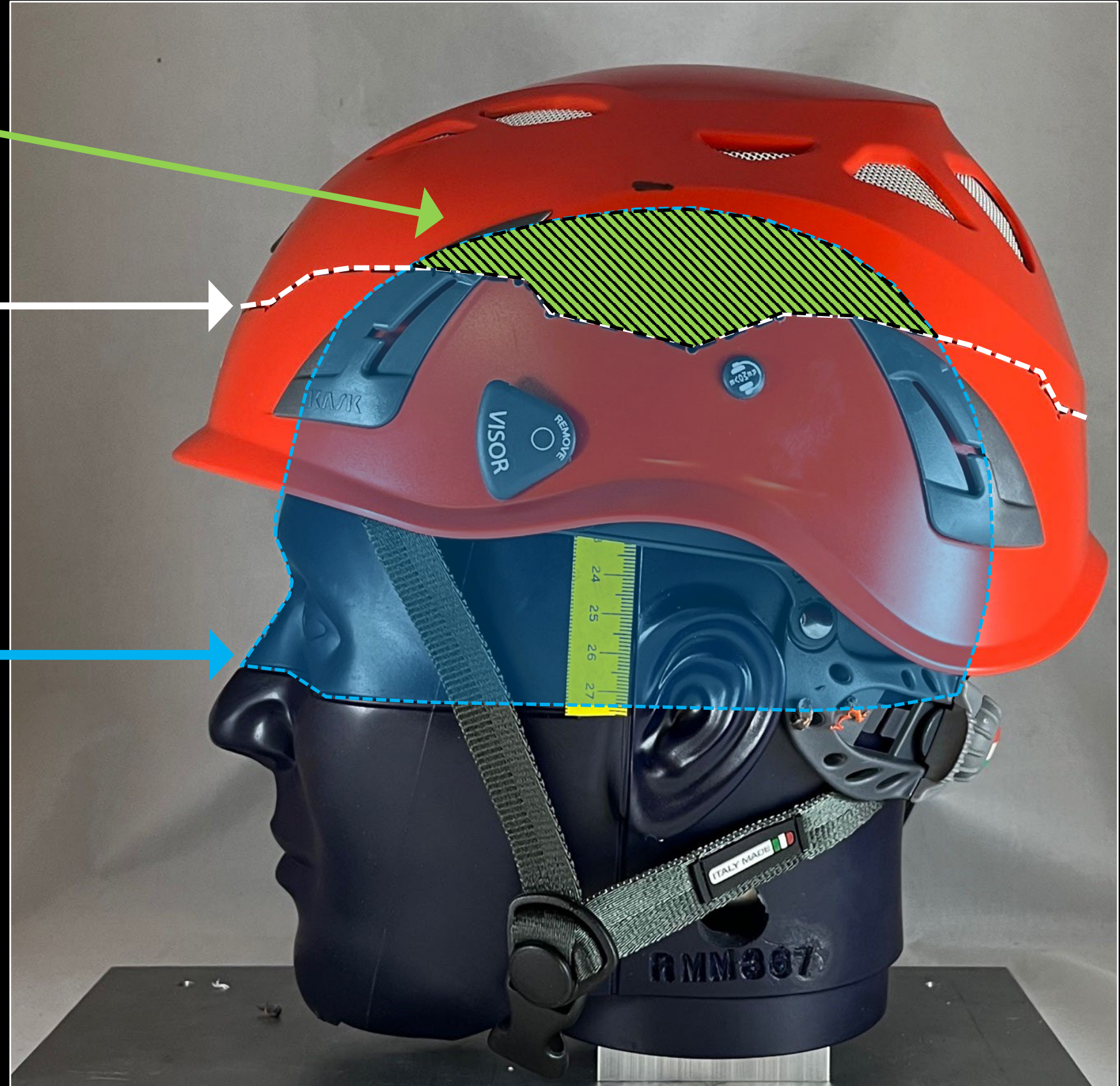
Head profile



Liner coverage area on lateral head profile

EPS liner boundary

Head profile

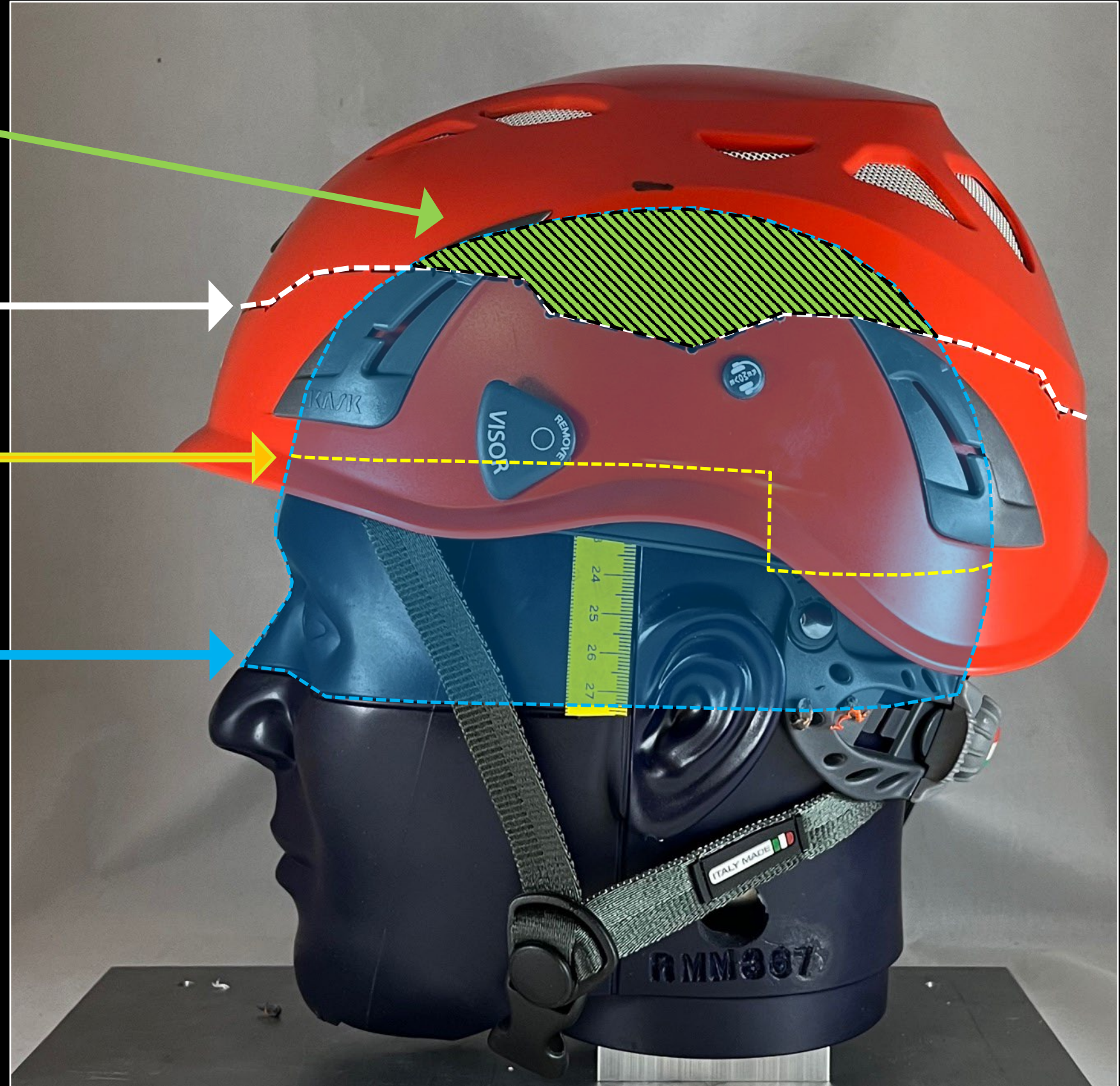


Liner coverage area on lateral head profile: **35%**

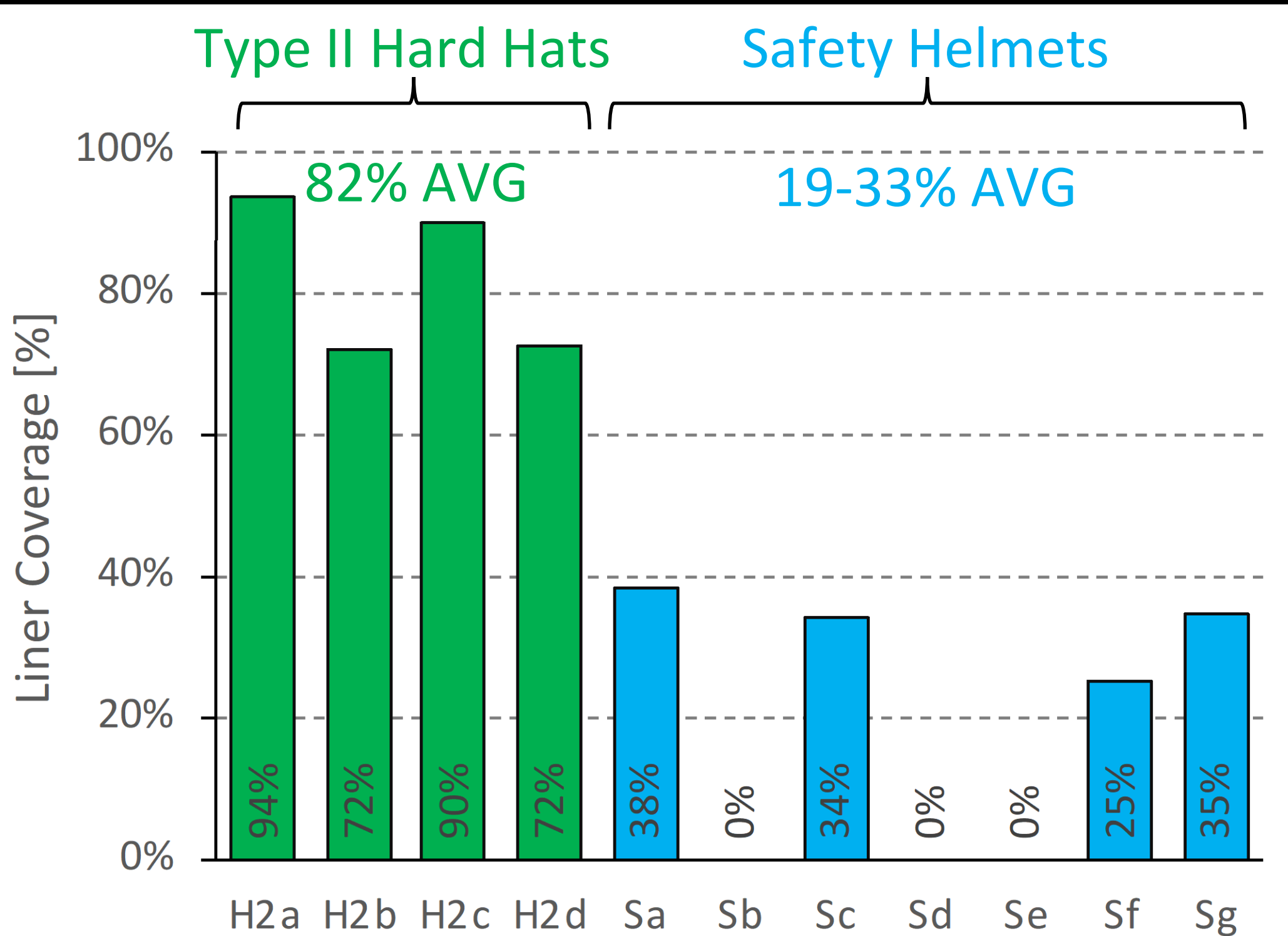
EPS liner boundary

ANSI test line

Head profile



Coverage of impact liner inside helmets



New type II safety helmets



Studson



Milwaukee



Kask



Ballard

Fact 4

Type II hard hats can outperform safety helmets.



CONCLUSION

Optimal Head Protection:

Rotational Force Absorption (Brain)

+

Linear Force Absorption (Skull)

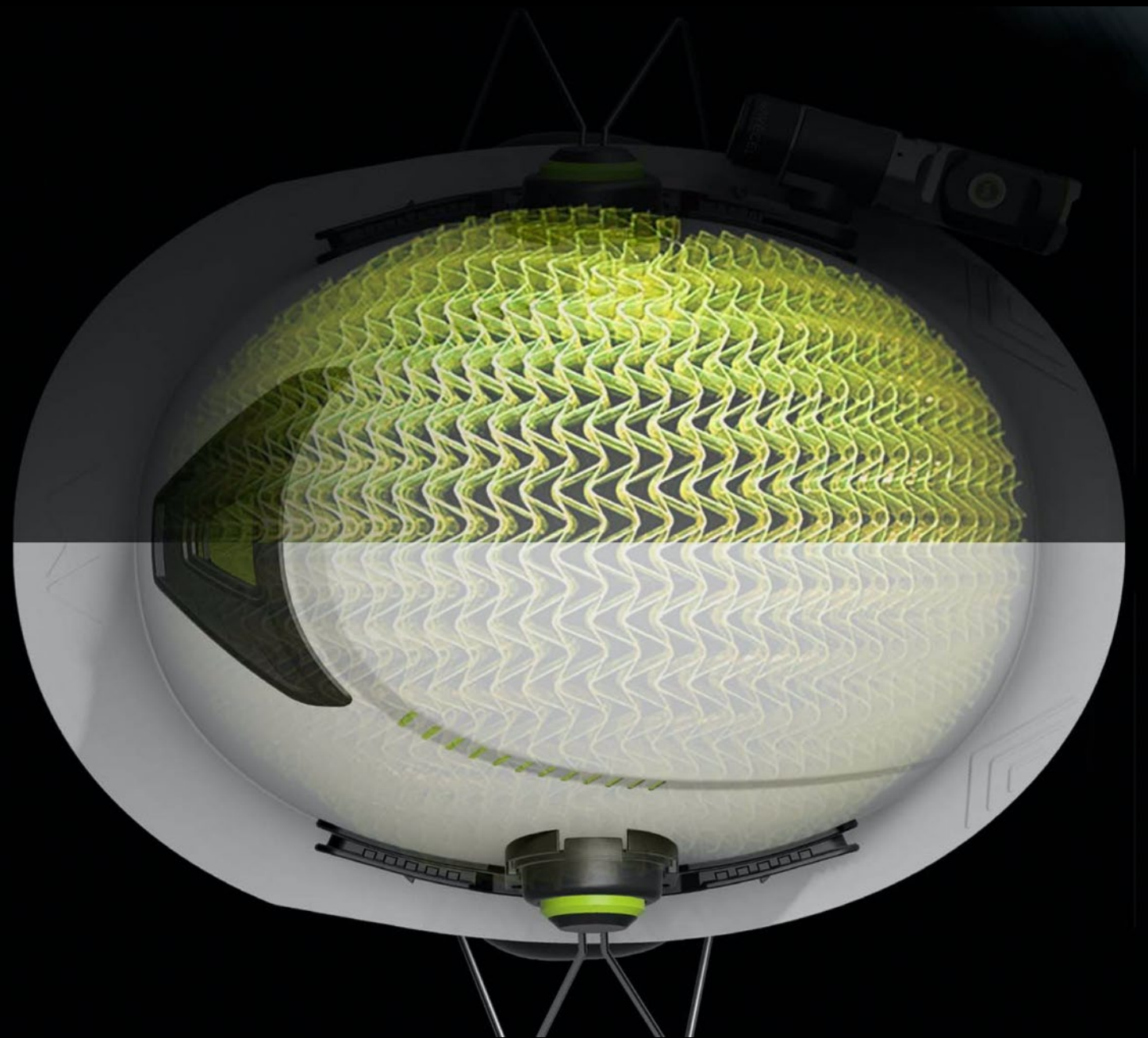
+

360° Protection (Type II)

MIPS



Outlook



Wavecel

03-03-22

A new hard-hat material could reduce concussions by up to 98%

Made with a material called WaveCel, the hard hats aim to greatly reduce traumatic brain injuries on construction sites.



[Image: courtesy WaveCel]

- Facebook icon
- Twitter icon
- LinkedIn icon
- Email icon

BY NATE BERG 5 MINUTE READ

The plastic hard hat is one of the most recognizable pieces of equipment on any construction site. That's partly because of safety regulations that require workers to wear them. But it's also because for the last half century, the design of the hard

Innovation in 50 years, prevents injury

by davidc@ccr-mag.com



Hard hats have not changed in over 50 years, until now. WaveCel announces a new material to better protect workers against traumatic brain injury (TBI), one of the most common and serious injuries on the job by the U.S. Department of Labor's Occupational Safety and Health Administration. TBI is a possible danger for head injury and is a worker's first line of defense against injury. Through science and rigorous testing, WaveCel is a spatial cellular structure that can absorb energy from a blow to the head and is made from a collapsible material that absorbs energy from a blow to the head in superior ways. The WaveCel hard hat is designed for various industries, including construction, engineering, manufacturing, aerospace, mining, gas, oil and forestry.

WaveCel first debuted in the sports industry in Treks cycling helmets and other sports helmets. In sport helmets, WaveCel has been proven to absorb up to 73% of the energy from a blow to the head and can reduce the predicted risk of a concussion by up to 98% [1].

WaveCel has been dedicated to chasing the safest head protection, especially in the construction industry. "There has been no advancement made to hard hat technology in five decades," said Dr. David C. Cramer, WaveCel Co-Founder and Biomechanical Engineer. "The WaveCel hard hat has been strategically designed to ensure an increase in safety of employees in the construction industry where risk of TBI is high."

WaveCel is designed to absorb energy from a blow to the head in superior ways. In fact, work-related traumatic brain injury (TBI) accounts for 18% of all TBIs that occur in the United States annually [2] and can cost anywhere from \$100,000 to \$1 million per case [3]. The construction industry faces the highest number of work-related TBIs in the U.S., accounting for 25% of all work-related TBIs [4]. WaveCel is needed to protect against skull fractures occurring from objects falling from heights. WaveCel also accounts for the rotational force and impact from slips and falls, which are much more common than falling objects and carry a greater risk. WaveCel is a network of hundreds of interconnected shock

DOUBLE ISSUE NOV. 30 / DEC. 7, 2020

TIME

THE BEST INVENTIONS OF 2020

100 INNOVATIONS CHANGING HOW WE LIVE





SAFER:

Superior protection from brain injury



COOLER:

WAVECEL's 93% porosity allows air to circulate freely



LOWER:

20% lower profile equates to less bumping & clipping

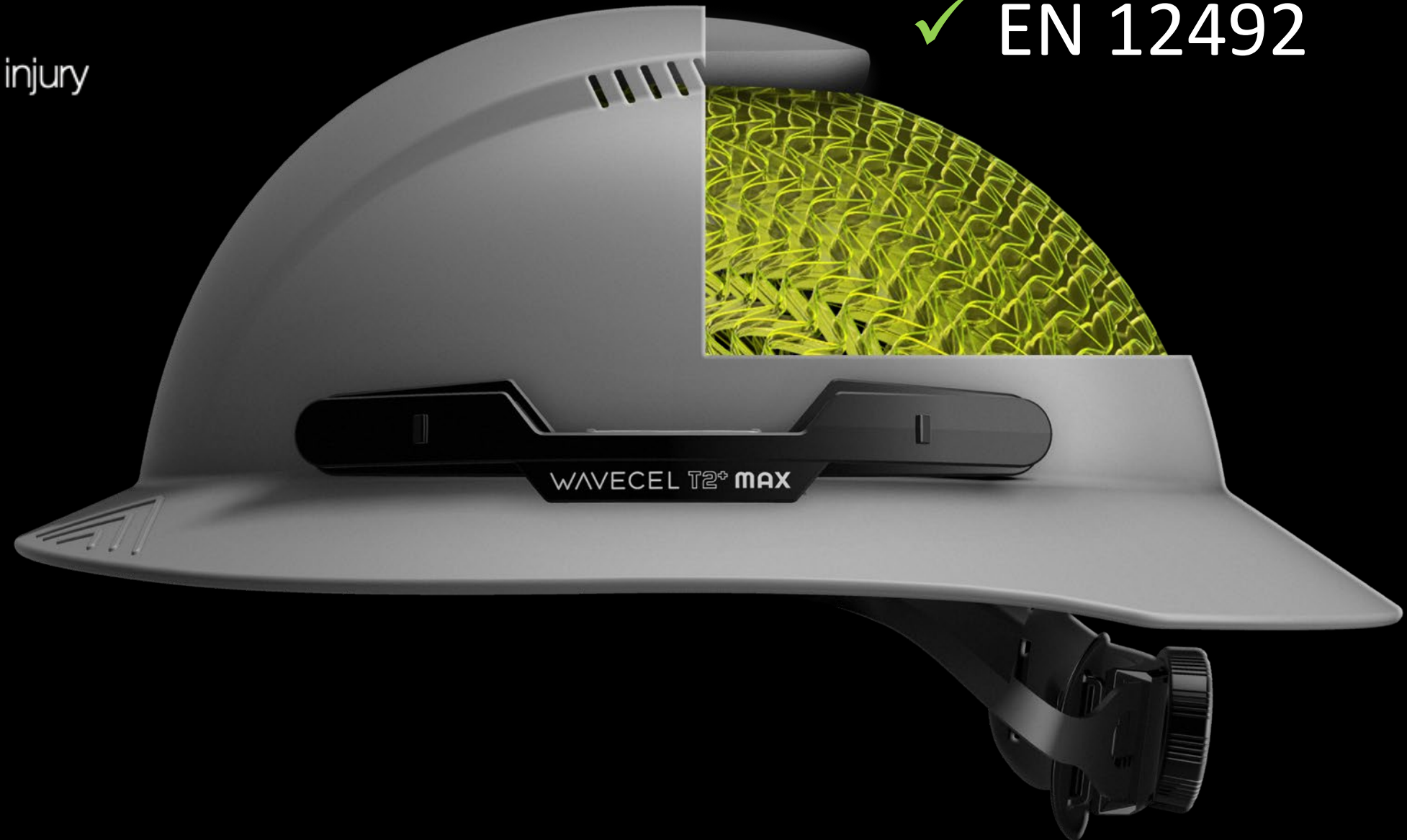


LIGHTER:

Weight optimized for all-day comfort

✓ ANSI Type II

✓ EN 12492





WAVECEL

Safety Beyond Standards

MADE
IN USA



Thank You!

