Wood dust collection during robotic machining

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Dust collection during robotic grooving (Lermab)

Woodflex robot used for CNC wood machining (Lermab)

Partnership

- LERMAB: Laboratoire d'études et de recherche sur le matériau bois

Yechen DONG (IGE recruited from Nov 2021 to Fev 2023)

Anis BOUALI

Laurent BLERON

- LCFC: Laboratoire de Conception Fabrication et Commande

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- PIMM: Procédés et Ingénierie en Mécanique et Matériaux

Nazih MECHBAL

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Outline of the presentation

1. Context
2. Objectives
3. Materials
4. Methods
5. Results
6. Conclusion & Perspectives

Context of robotic woodworking

Impacts on health

- Wood manufacturing operations emit air pollutants and dust particles.
- When not properly removed, dust particles can cause problems in the machining systems: damage and immediate loss of performance (Baranski et al., 2016)
- Risk of nasal-sinusal cancers is 40 times higher in wood workers than in unexposed workers

(ARC: association pour la recherche sur le Cancer)

Dust collection during robotic sawing (Source INRS)

Barański, J., Jewartowski, M., Wajs, J., & Pikała, T. (2016). Experimental analysis of chip removing system in circular sawing machine. Trieskove a Beztrieskove Obrabanie Dreva, 10, 25-29.

Context of robotic woodworking

Impacts on climate change

- How Buildings Made Of Wood Can Help Fight Climate Change?

- What is the CO_2 gain in timber frame construction compared to traditional construction?


nature communications

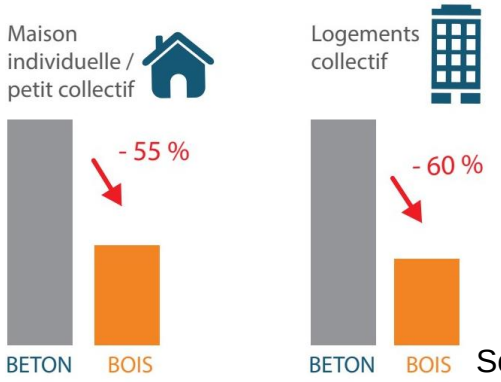
Article https://doi.org/10.1038/s41467-022-32244-w

Land use change and carbon emissions of a transformation to timber cities

Received: 18 November 2021
Accepted: 13 July 2022

Abhijeet Mishra[1,2], Florian Humpenöder[1], Galina Churkina[1], Christopher P. O. Reyer[1], Felicitas Beier[1,2], Benjamin Leon Bodirsky[1,3], Hans Joachim Schellnhuber[1], Hermann Lotze-Campen[1,2] & Alexander Popp[1]

Bouygues construction 30% of projects in wood by 2030



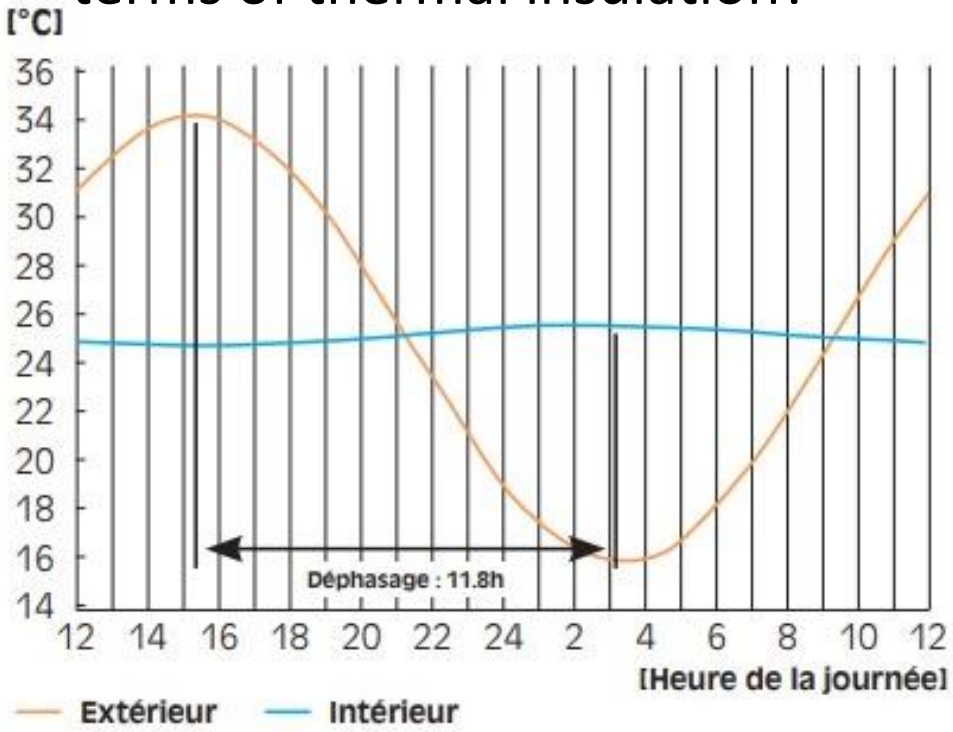
Source (Etude Carbone 4)

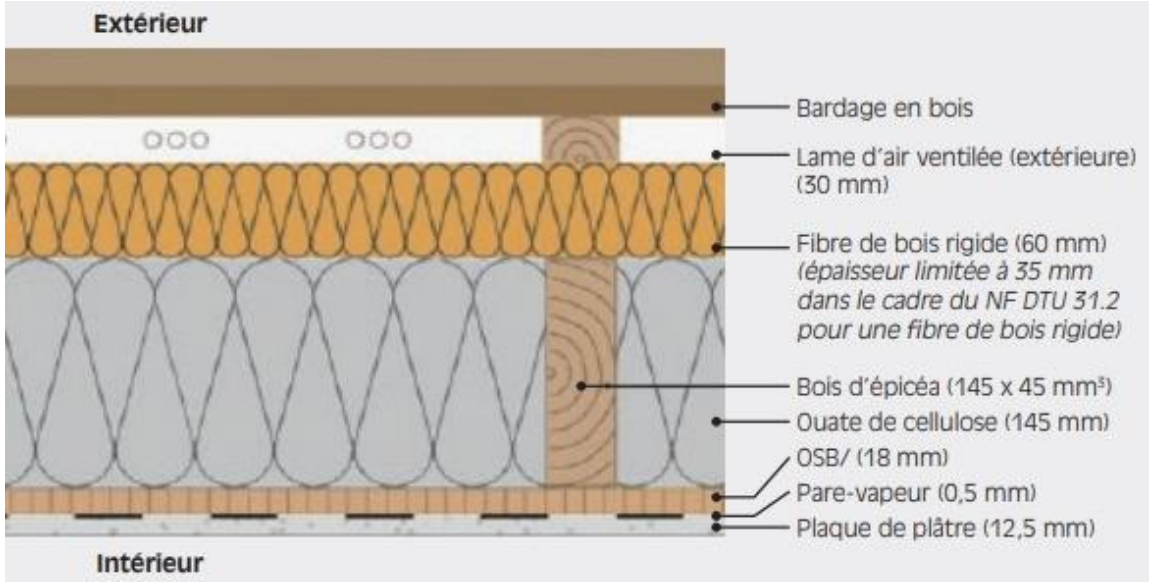
Mishra, A., Humpenöder, F., Churkina, G., Reyer, C. P., Beier, F., Bodirsky, B. L., ... & Popp, A. (2022). Land use change and carbon emissions of a transformation to timber cities. *Nature communications*, *13*(1), 1-12.

Context of robotic woodworking

Impacts on climate change

- What is the advantage of timber construction in terms of thermal insulation?





Phase shift : 11h50, Amplitude reduction : 95%.

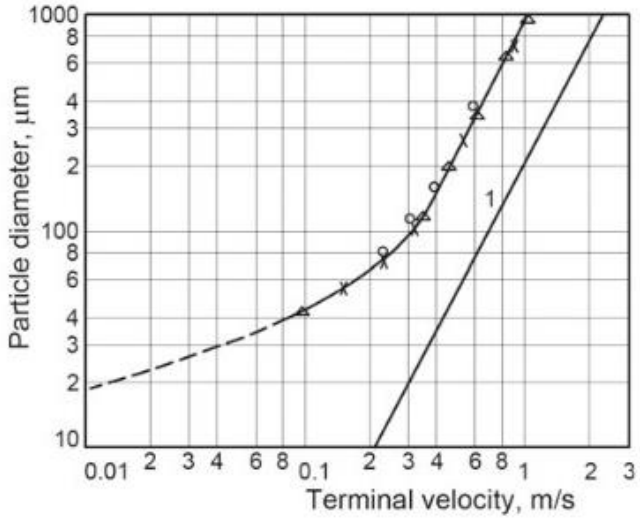
Orange curve: the evolution of the temperature of a summer day.
Blue curve: the phase shift of the heat wave and the reduction of its amplitude.

Source Construction bois et isolants biosourcés (Codifab 2021)

Objectives

- **Improve the efficiency** of wood dust collection during complex machining with CNC machines.
- **Technological bottleneck** : Current systems of collection are generally far from the source of emission (tool/material contact).

- **Scientific bottleneck** : It is difficult to predict dust emissions: direction, speed, size, quantity, depending on machining conditions and material. (Magoss et al. 2022)



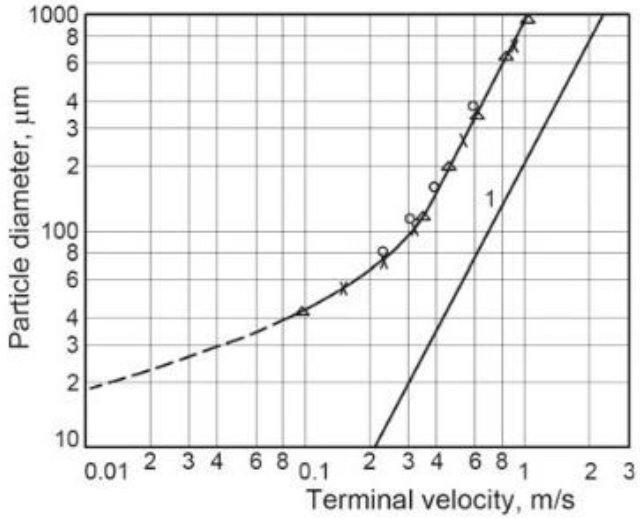
(Magoss et al. 2022)

Magoss, E., Sitkei, G., & Kocsis, Z. (2022). *Dust Extraction and Handling in the Wood Industry*. Springer Nature.

Objectives

- **Observe:** the wood dust emission in direction, speed, size, quantity, depending on machining conditions and material.
- **Model:** the motion of wood dust and predict the direction of emission

- **Construct:** a wood dust collector



(Magoss et al. 2022)

Our contributions

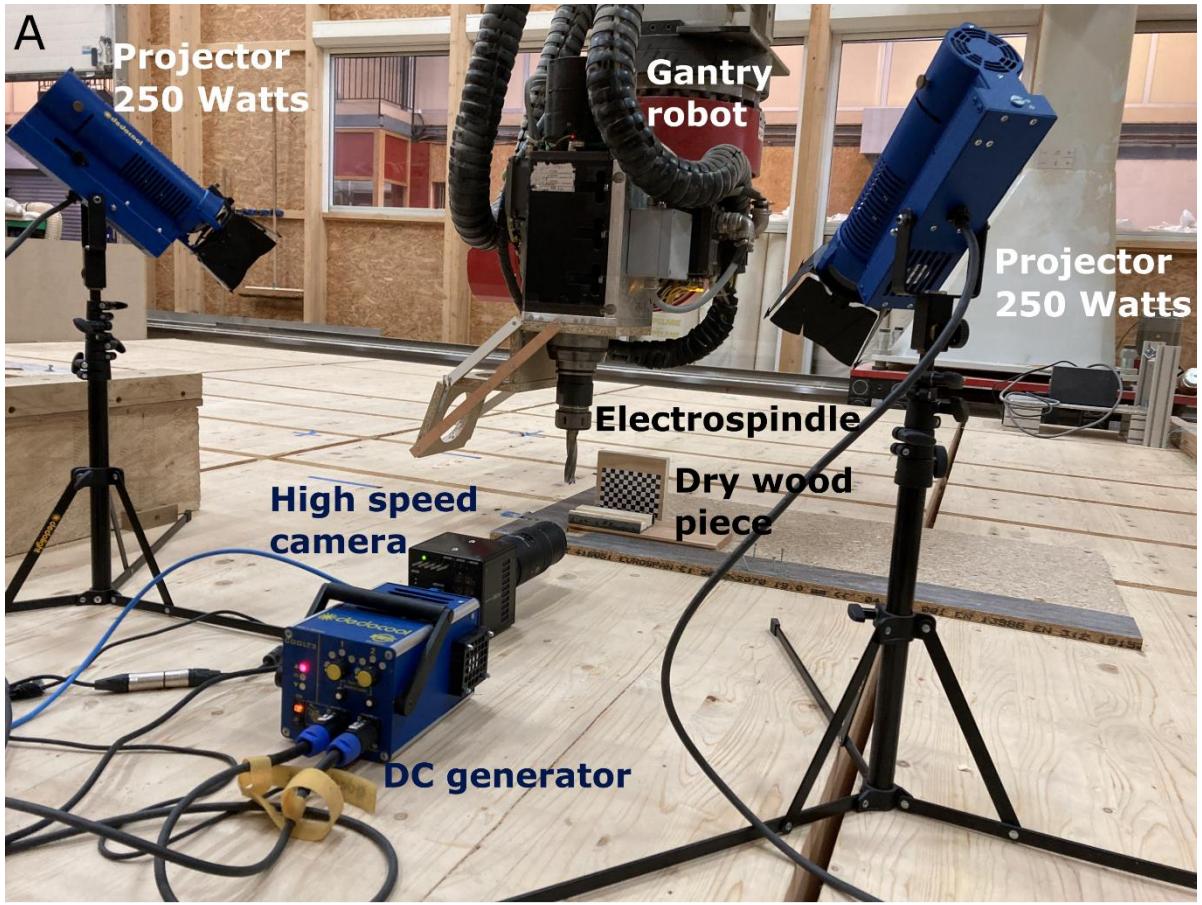
- **Set up** a platform to observe the emitted particles during **robotic grooving**.

- **Estimate and quantify** the velocity direction of wood chip emission near the tool-material contact.

- **Construct** two suction hoods and experimentally test the best chip collection.

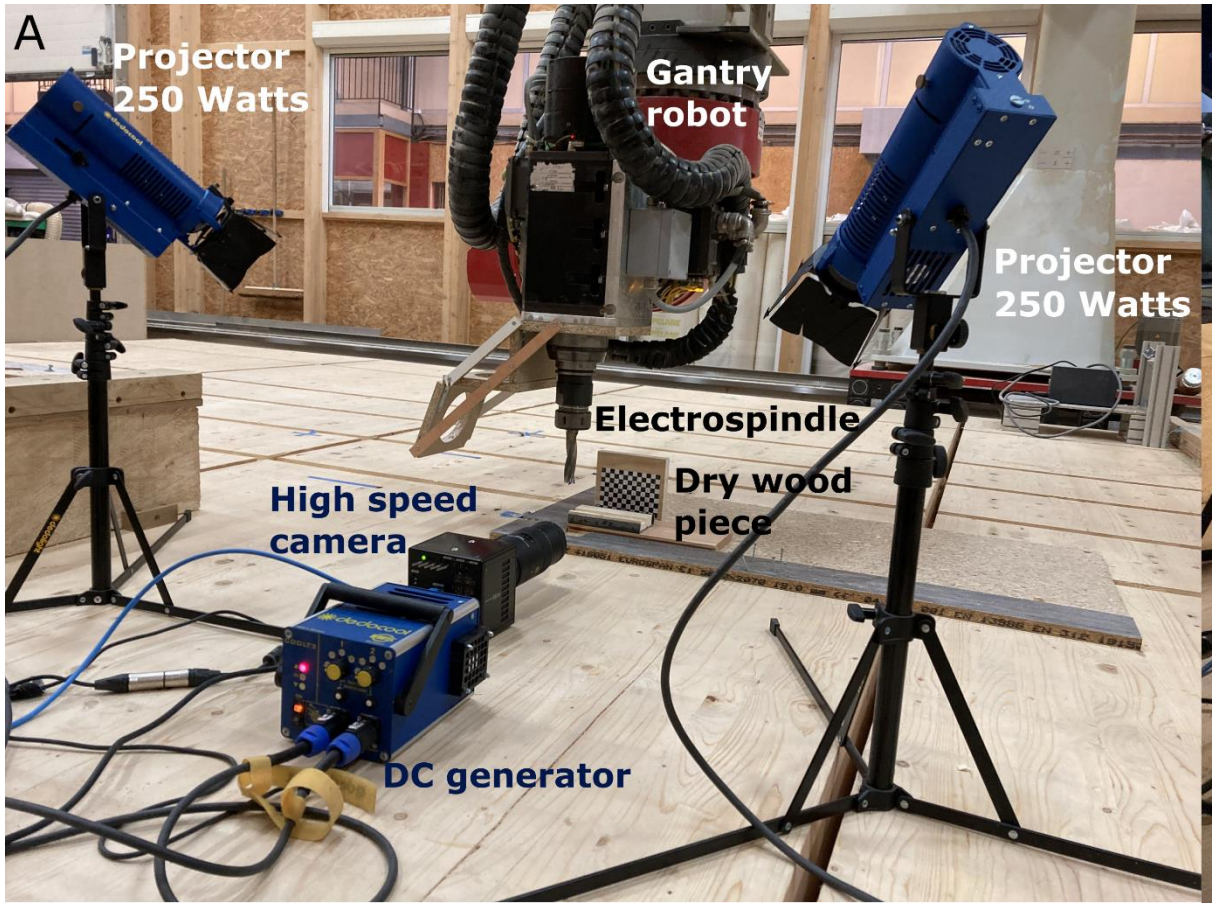
Dust collection during robotic grooving (Lermab)

Materials



- **The robot:** WoodFlex32, 5-axis CNC platform.
- **The electro-spindle:** rotational speed up to 18000rpm, feed speed up to 10m/s.
- **The high-speed camera:** Photron mini UX50 provides a 1280x1024 full resolution at 102400fps.
- **The lighting system:** 2 projectors provide 370000Lux at 50cm.
- **A wooden part:** resinous wood, 150mm long, 70mm in width, 20mm in height

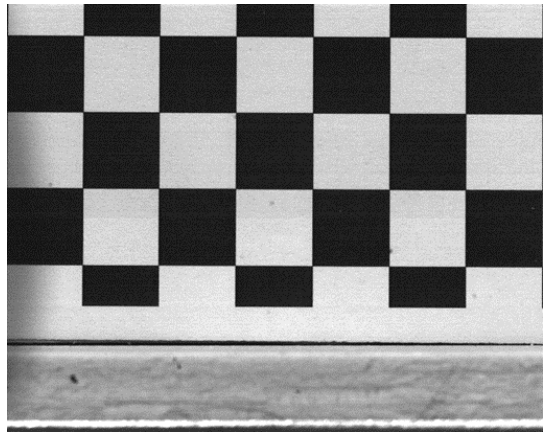
Materials


A
Projector
250 Watts
Gantry
robot
Projector
250 Watts
Electrospindle
Dry wood
piece
High speed
camera
DC generator


B
lighting system
activated

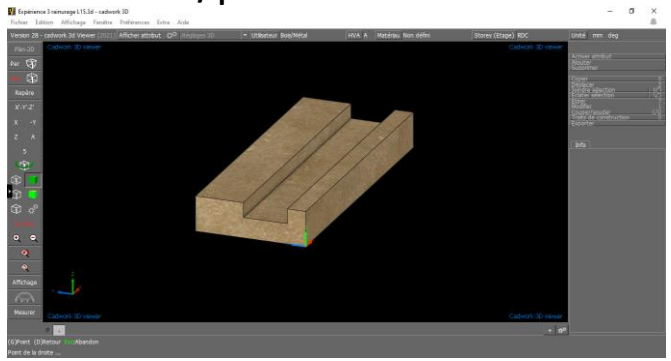
Methods

- **Camera calibration: 0.5m away from the machining origin**



Each square is 10mmx10mm
After calibration, we obtained the setting : 0.034mm/pixel

- **Wood piece modeling and electro-spindle path programming**

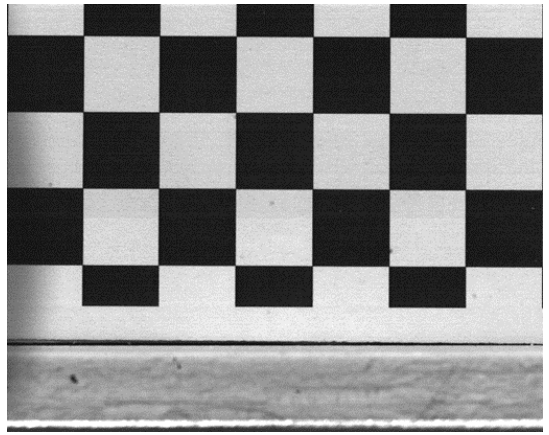


- **Woodworking parameters**

Machining parameters	Value	Unity
Rotational speed	18000	rpm
Feed speed	5	m/min
Feed width	24	mm
Feed depth	10	mm
Feed per turn	0.27	mm
Feed per tooth	0.093	mm

Methods

- **Camera calibration: 0.5m away from the machining origin**



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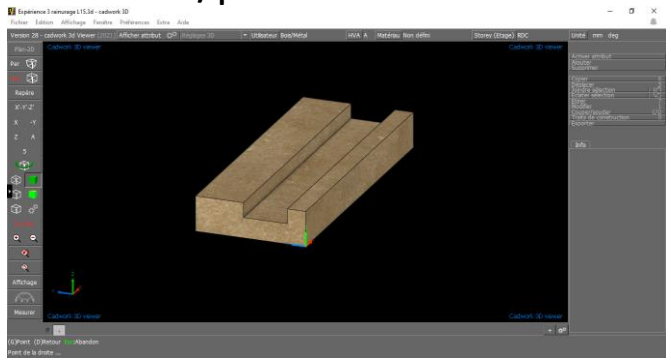

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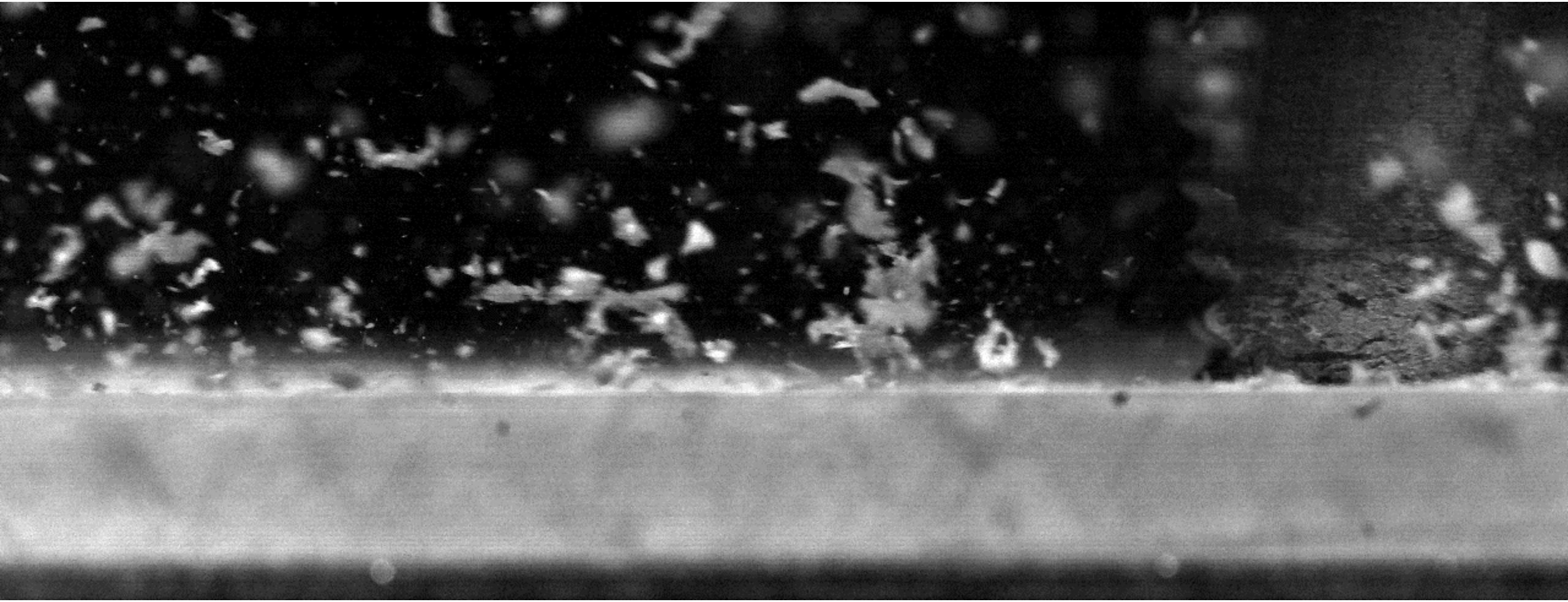
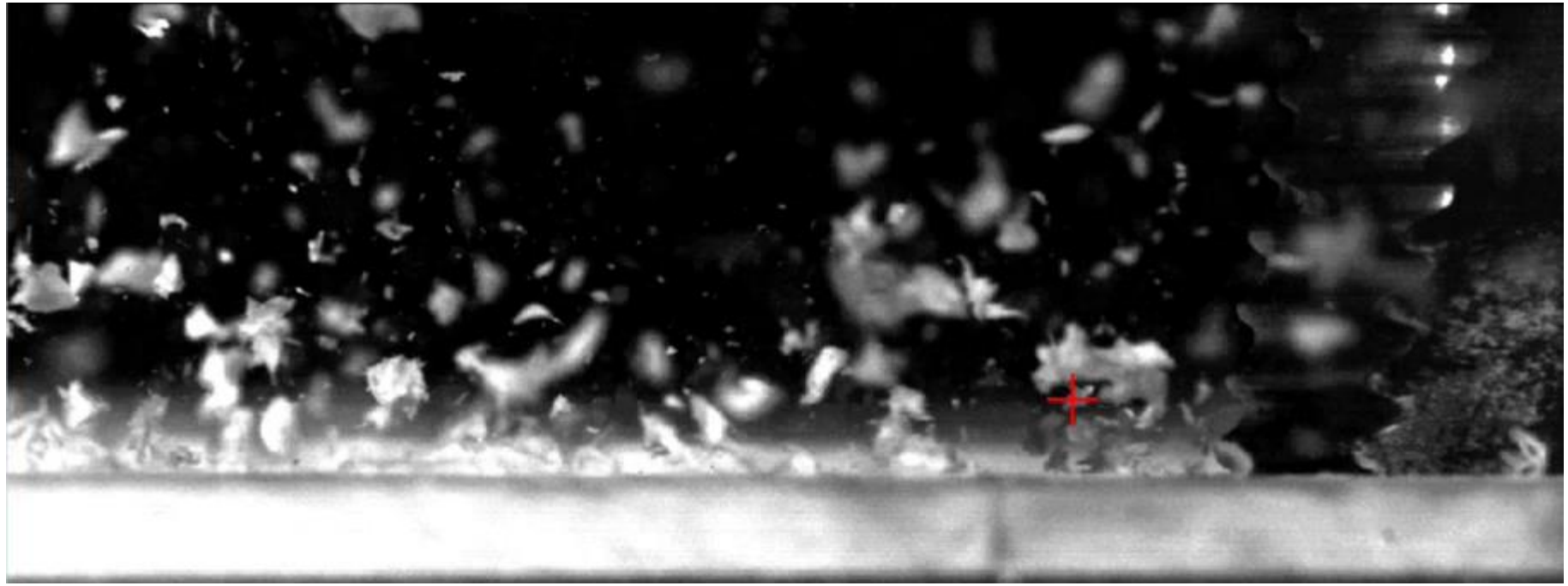
Results

(1) Set up a platform to observe the emitted particles during **robotic grooving**.



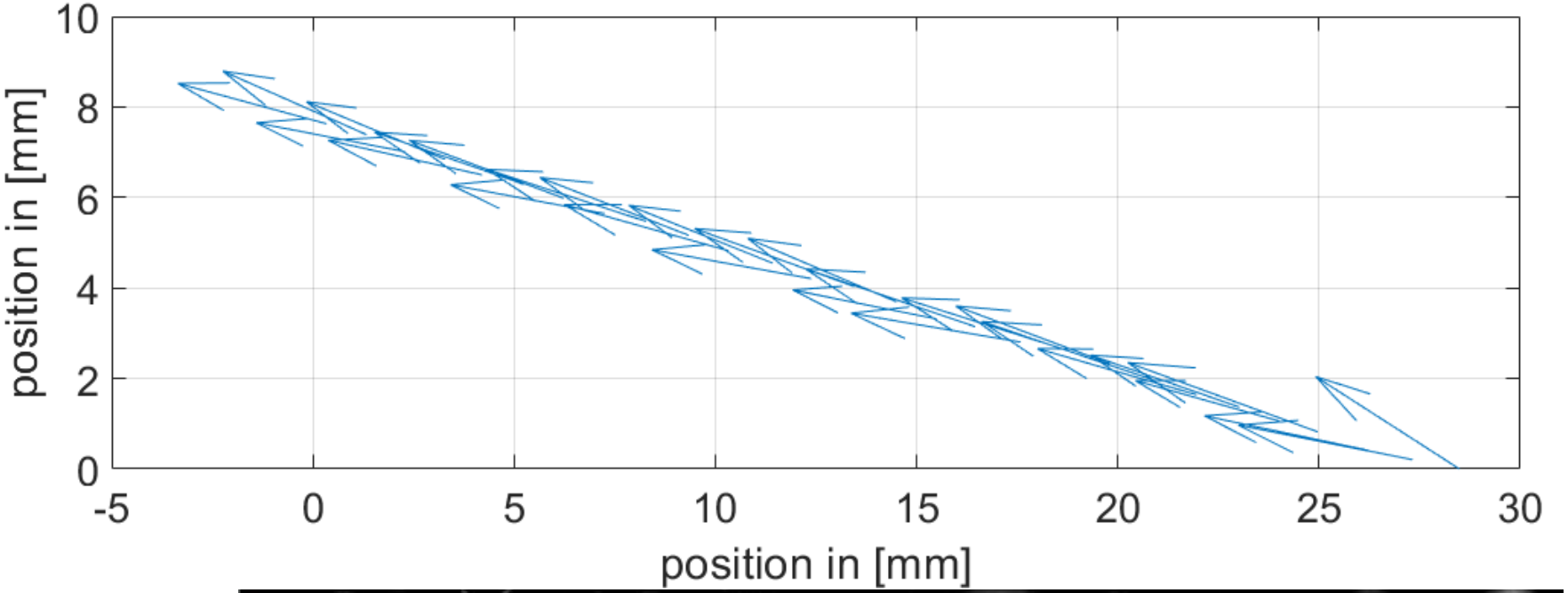
Results

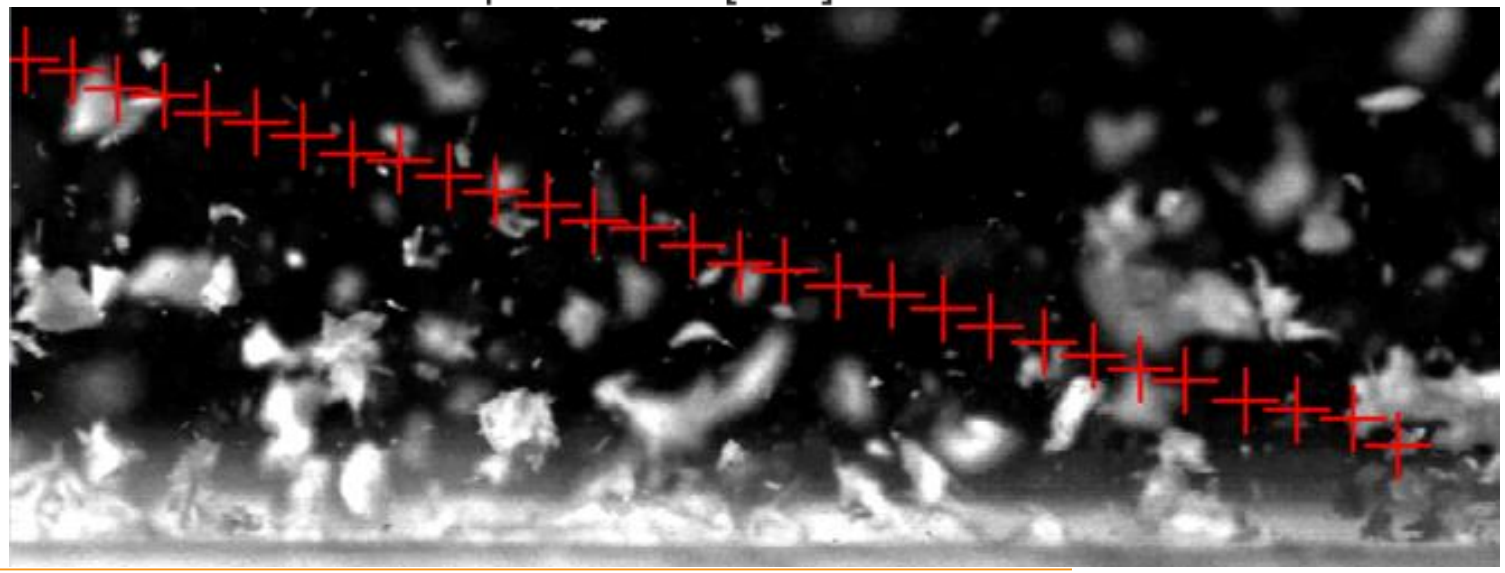


Offline trajectory tracking of a wood chip and during thirty frames (5000fps).

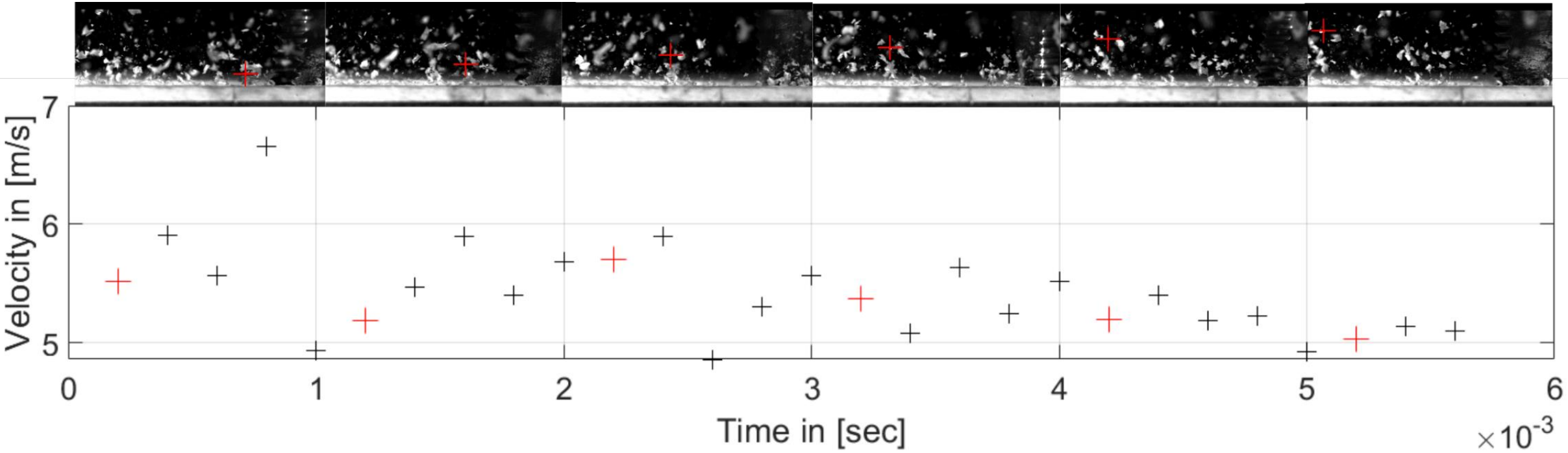
Results

(2) Estimate and quantify the velocity direction of the wood chip emission.





Results

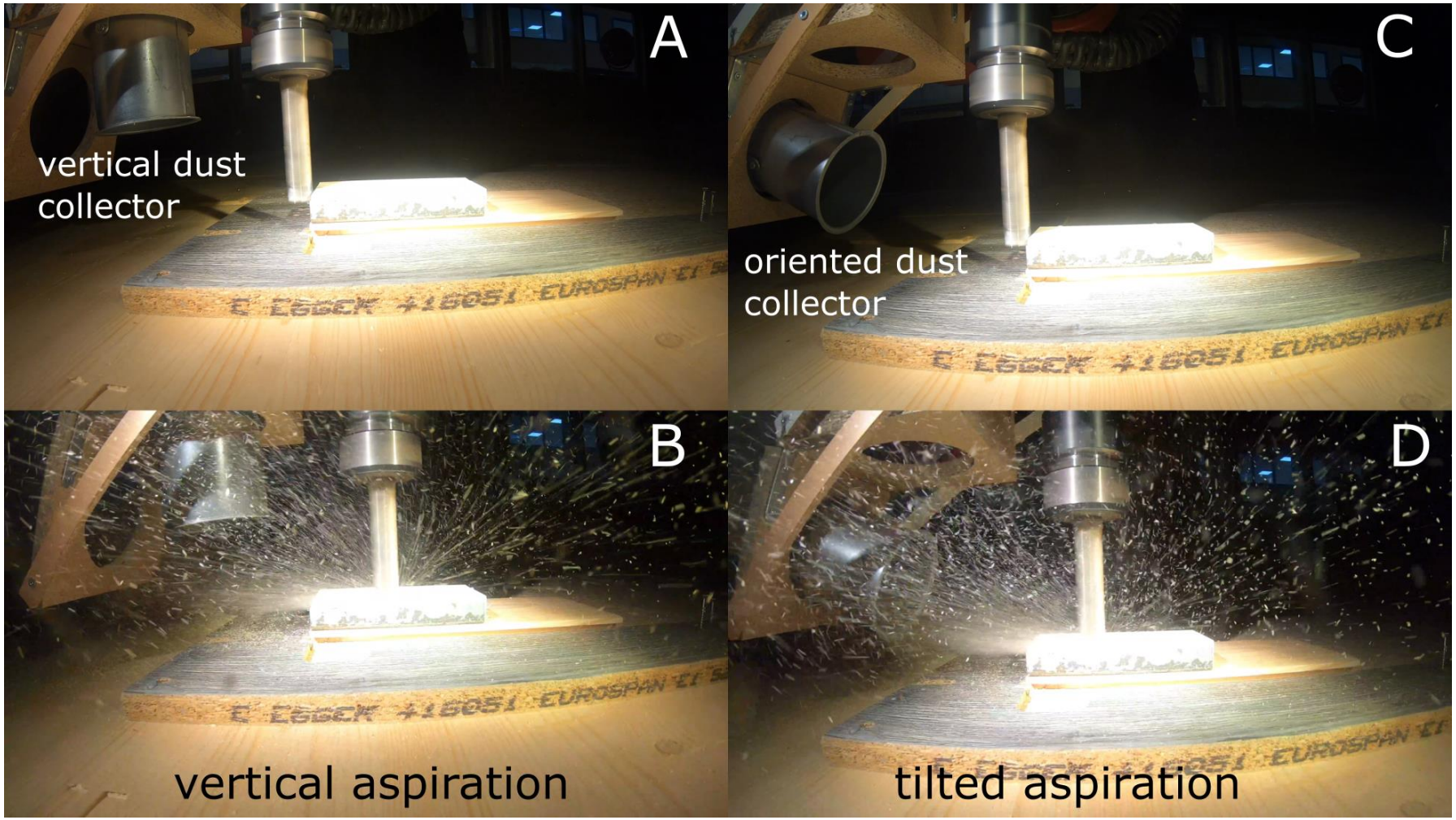


Experimental estimation of the wood chip velocity magnitude.

We estimated the instantaneous velocity magnitude during thirty images.

Results

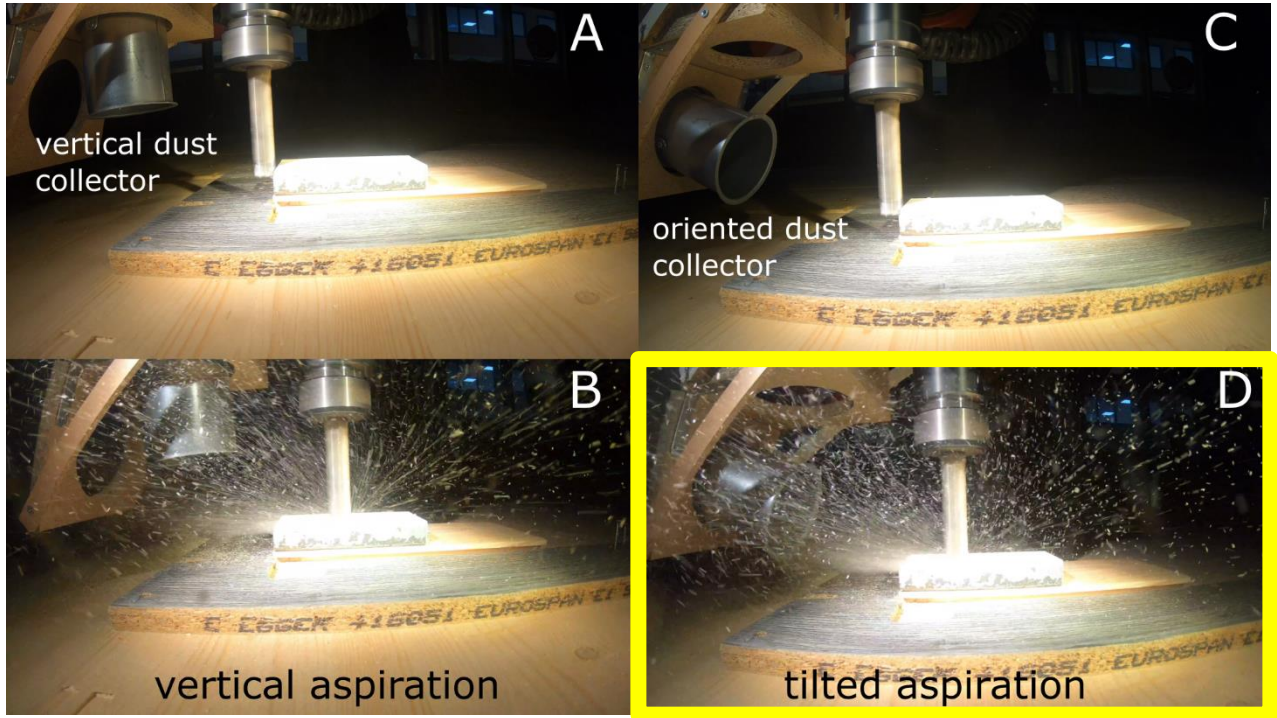
(3) Construction of two suction hoods and test the best chip collection.



Tests of the wood dust collection near the tool-material contact.

A) the device is vertically oriented, C) the device is tilted on the side of the electro-spindle.

Results (3) Construction of two suction hoods and test the best chip collection.



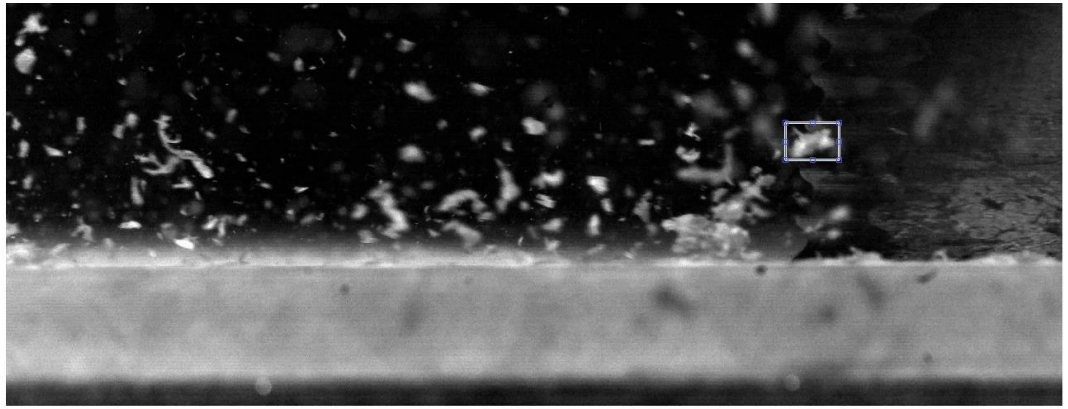
N° test	Aspiration mode	Weight of dust [g]
Test 1	without aspiration	6.2588
Test 2	without aspiration	6.3847
Test 3	vertical aspiration	4.2752
Test 4	vertical aspiration	4.0799
Test 5	vertical aspiration	5.2196
Test 6	tilted aspiration	3.6749
Test 7	tilted aspiration	2.7766
Test 8	tilted aspiration	2.3449

Extracting the wood particles near the tool-material contact improves dust capture efficiency.

Conclusion

We analyzed the physical properties of chips by observing the motion behavior with a single high-speed camera.

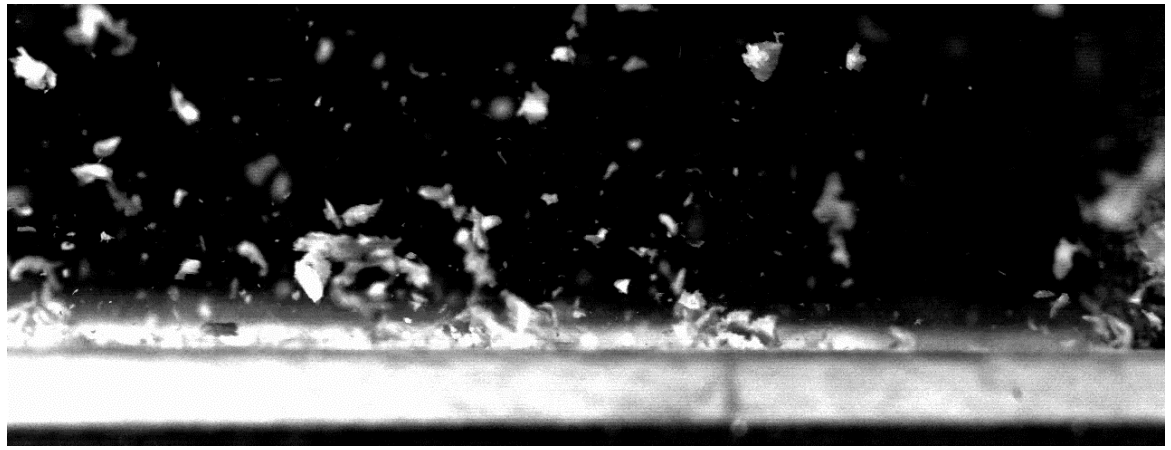
(i) **Offline estimation of velocities** of wood chips (magnitude and direction) during robotic grooving by using a high-speed vision system,



(ii) **Improvement of the dust capture** by using a suction hood near the tool-material contact.

Perspectives

(i) **Predict** the fine wood chip and wood dust emissions in real time,



(ii) **Construct a robotic appendage** attached to the machining tool to collect the dust as close as possible to the tool/material contact.

Thank you for your attention