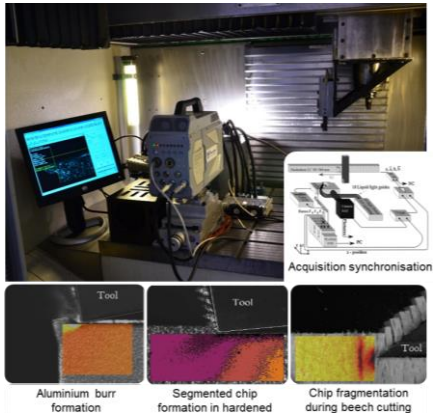
ARTS ET MÉTIERS ParisTech
Cluny

Exhibition

LaBoMaP
LABORATOIRE BOURGUIGNON DES MATÉRIAUX ET PROCÉDÉS



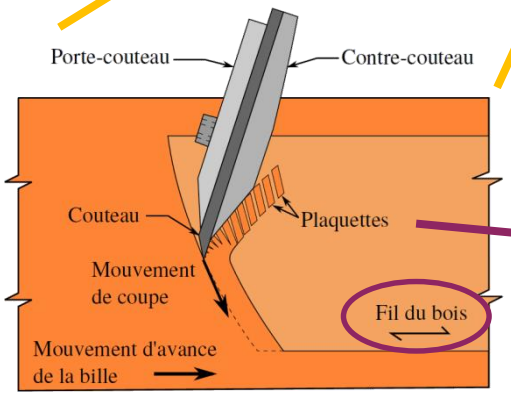
High speed imaging planing experiment synchronized with multiphysical measurements

Rémi CURTI, Bertrand MARCON

Chipper canter milling: context

Lumber mouvement

Cutting speed : 60 m/s
Chip section: 30 × 25 mm²



[Hernández 1995]

Plaquettes

Valorisation ?

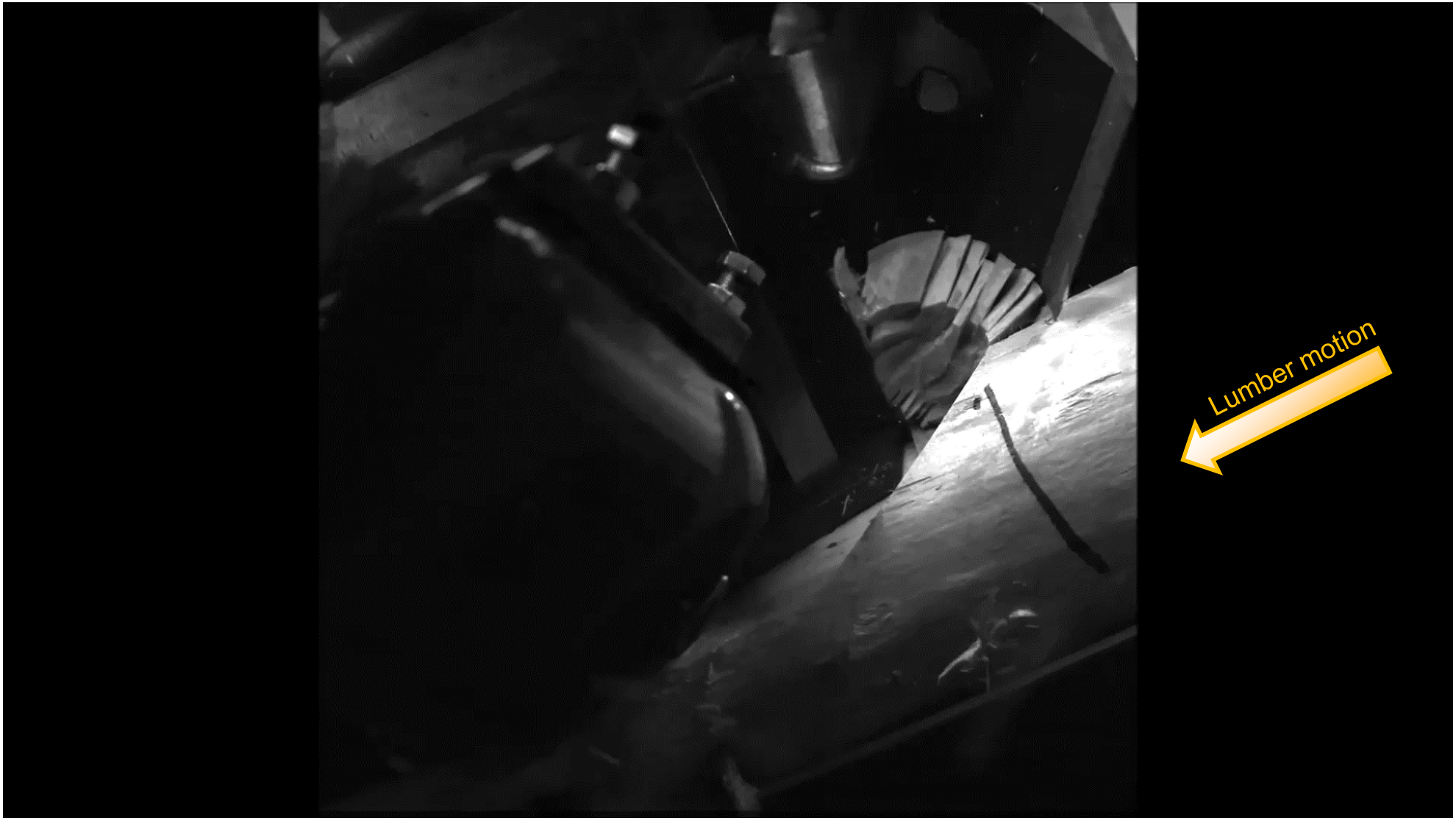
- Wood for energy
- Paper pulp

Renaud Pfeiffer, PhD
Rémi Curti, PhD

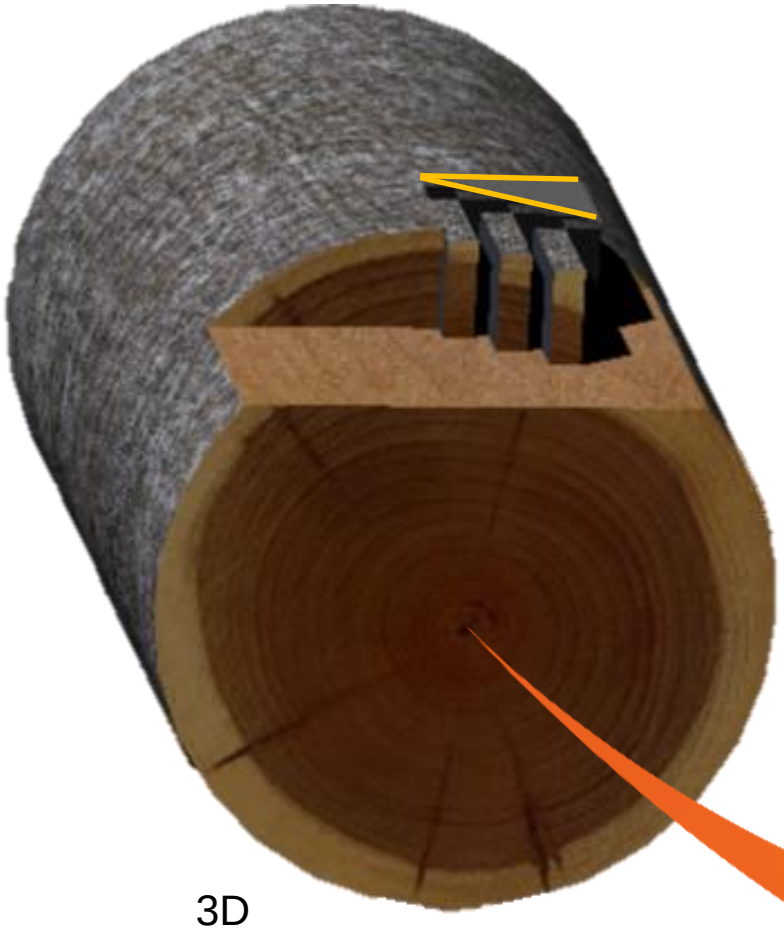
Improve the chip valorisation

Machined volume (≈ 30%) transformed into chips during the process

Usinage et fragmentation d'une dosse [Kuljich 2016]



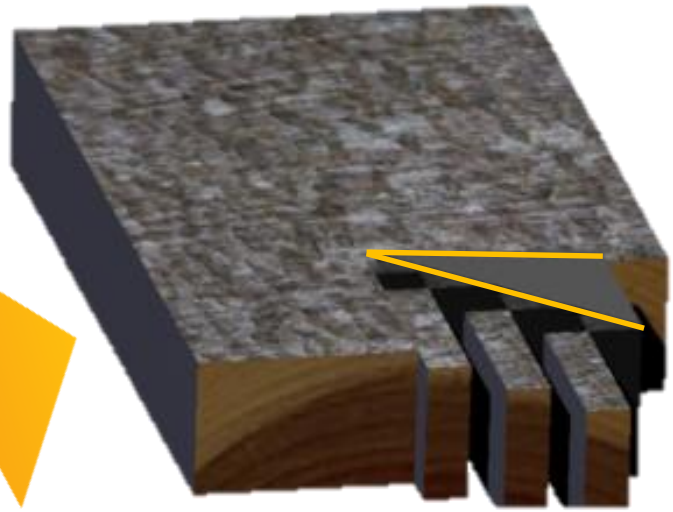
3D → 2D



3D
Industrial configuration

2D
Simplified configuration

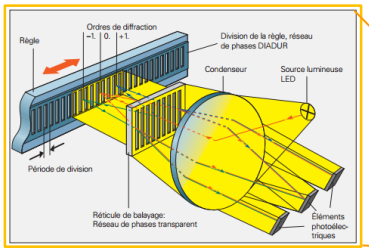
Asumptions:
Straight motion
Plane stresses
tool edge perpendicular to motion



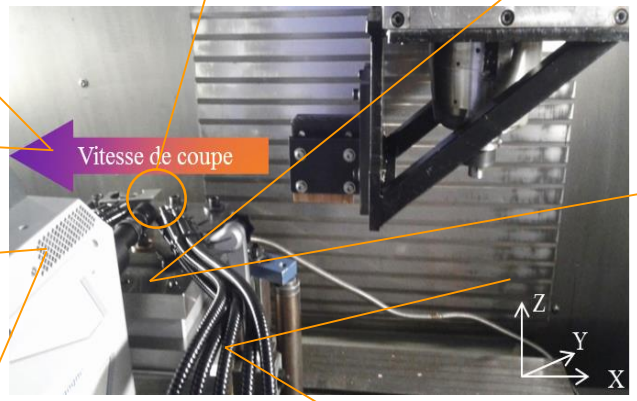
Experimental setup

Tool position measurement
Encremental encoder Resolution: 16 µm
Position known at 2 µm with interpolaton strategies
Frequency: 4000 Hz

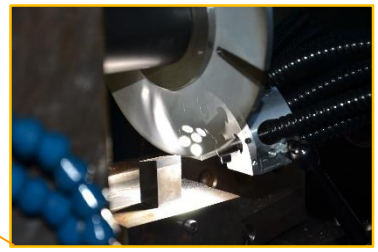
Axis positions and speed check
CNC Analog Outputs + encoders



Cutting tool



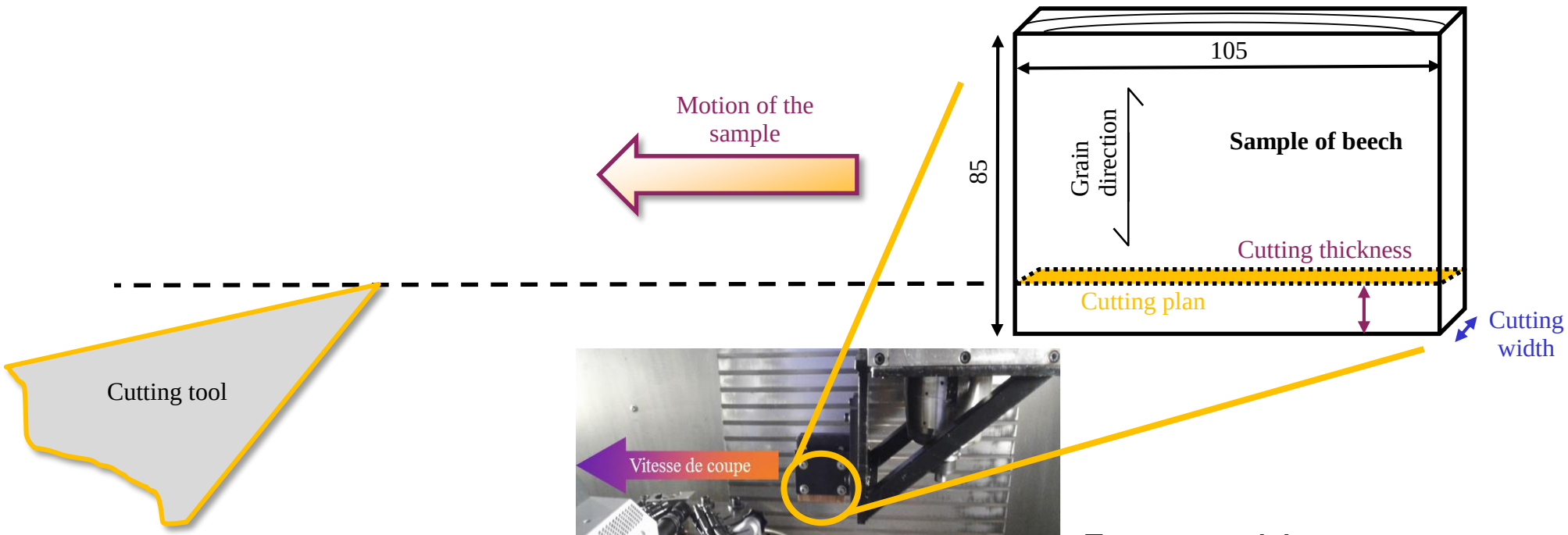
Cutting forces measurement
Dynamometer: Kistler 9255A
Maximum force Fz: 40 kN
Natural frequency: approx. 1.5 kHz



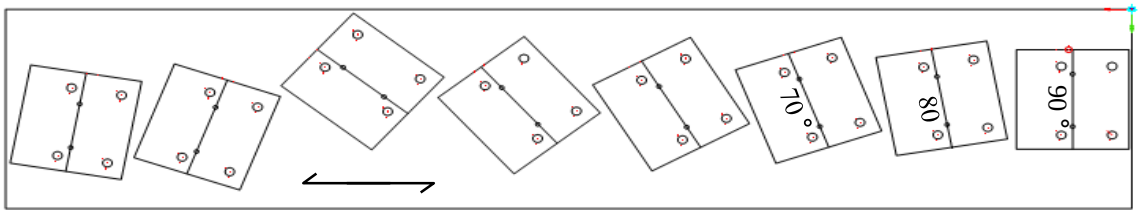
Ultra High Speed Imaging
Camera Photron SA-Z
Max. 20,000 fps at Res. 1024 x 1024 pxls²
Telecentric objectives (Mitutoyo)

Lighting
High Power LEDs 3200 lumens each
Optical fibers to enlight the observed area
Up to 12 spots LEDs and guides

Experimental setup



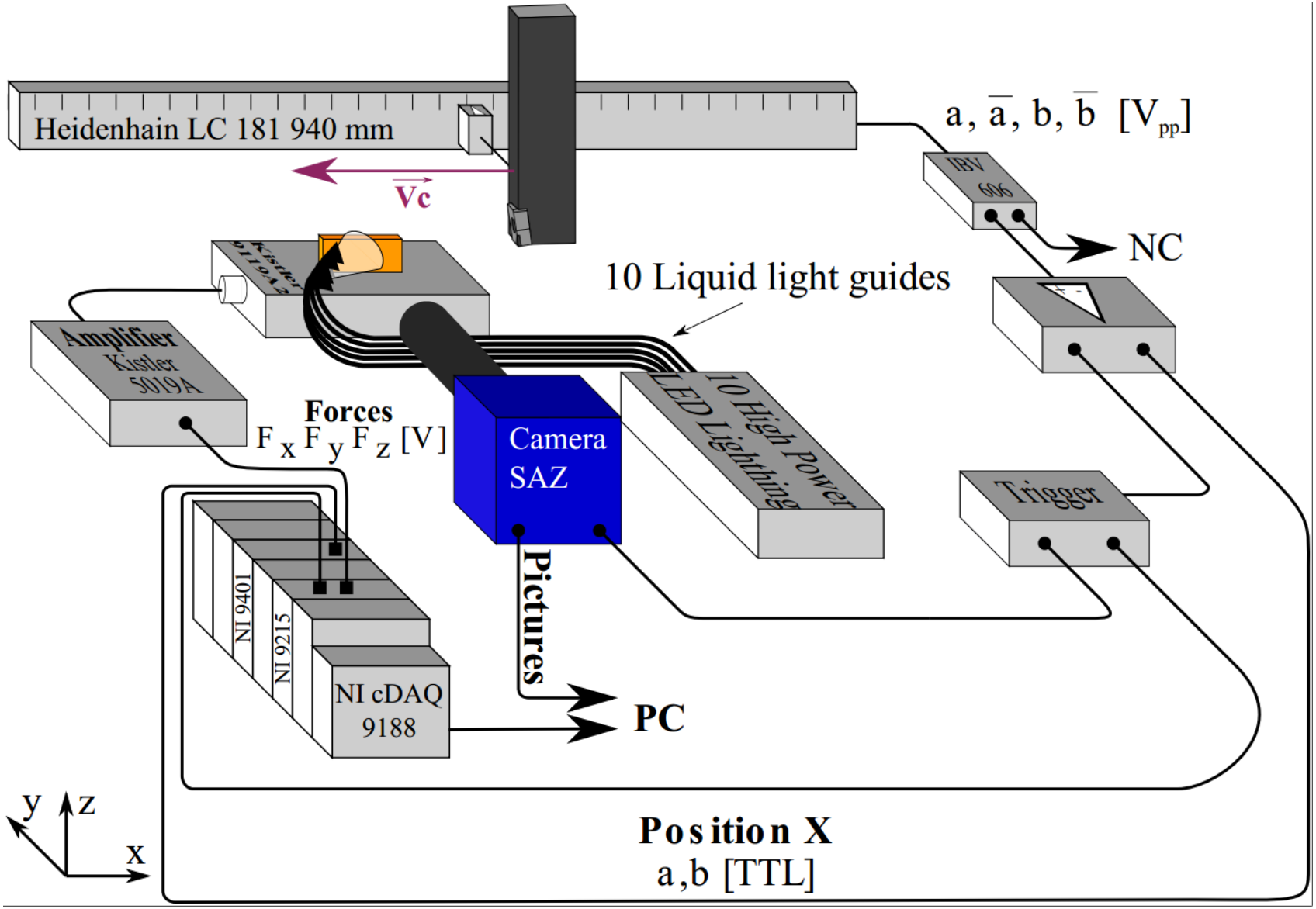
Samples orientations:



Usinage des éprouvettes dans une dosse

- **Measured data**
  - Cutting forces
  - Pictures (every 0.1 mm)
  - Positions (accuracy 2 µm)
  - Données de contrôle
  - Moisture content (after machining)
- **Studied parameters**
  - Cut section
  - Grain direction
  - Cutting speed
  - Cutting angle & Sharpness

Details about the signals synchronization strategy



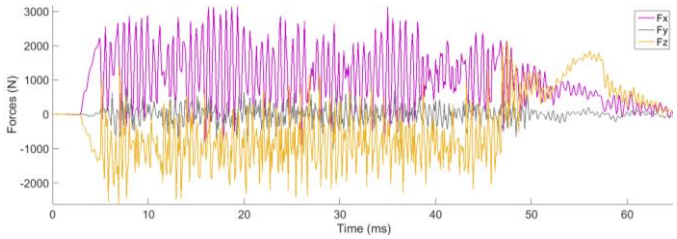
[2016 Baizeau T.]

DEMONSTRATION

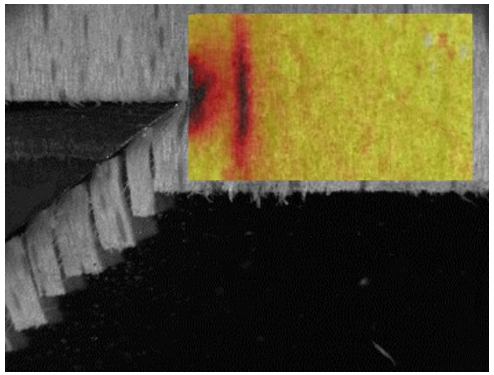
Oriented fiber composed materials: Wood, CFRP…

BeechGreen state
Vc 120 m/min
h 10 mm
B 5 mm

Cutting forces measurement

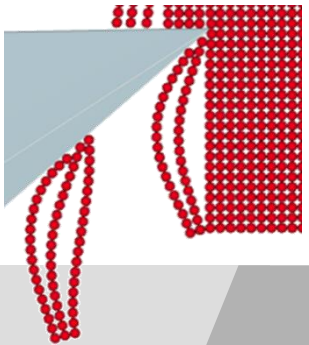


→ **Dynamic compensation**



Digital Image Correlation CorreliQ4

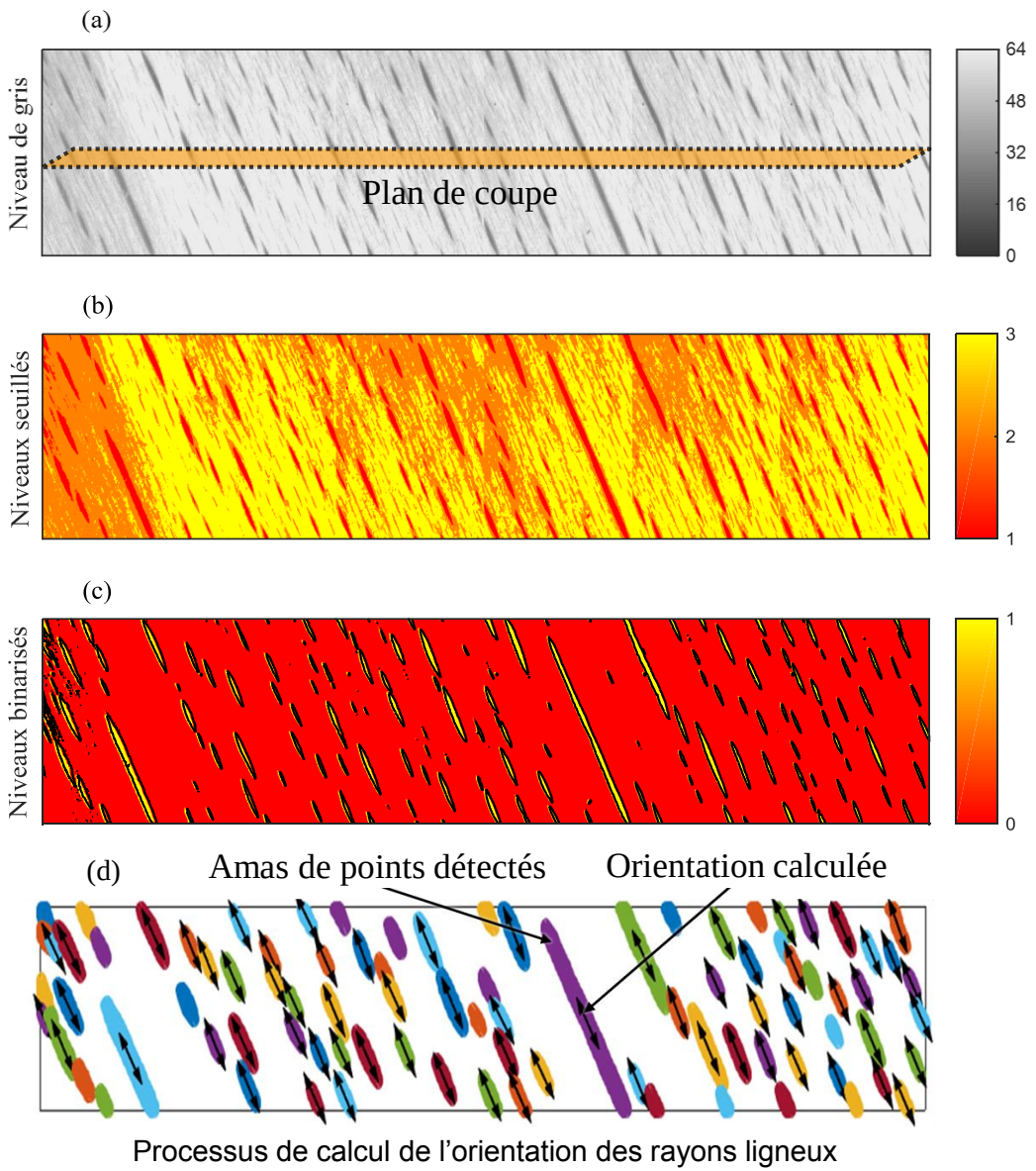
GOAL: Observe and validate a DEM for the serration of the chip (GranOO)



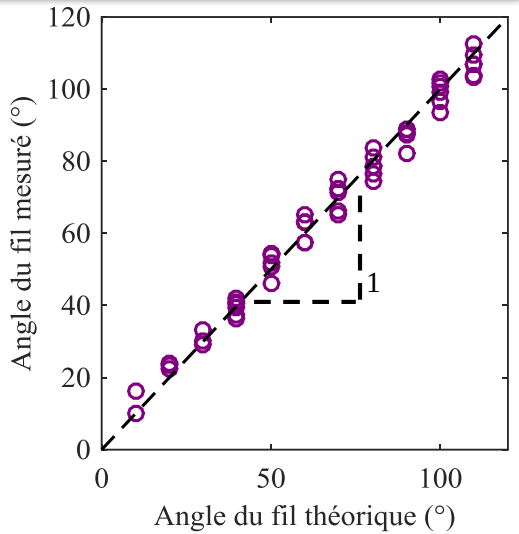
[2017 Curti R.]
[2018 Curti R.]

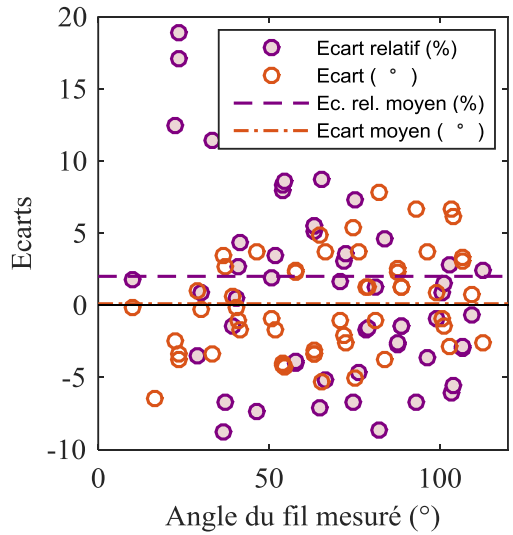
Effective grain direction assessment

Hypothèse : empilements des rayons ligneux et fibres alignés



Processus de calcul de l'orientation des rayons ligneux

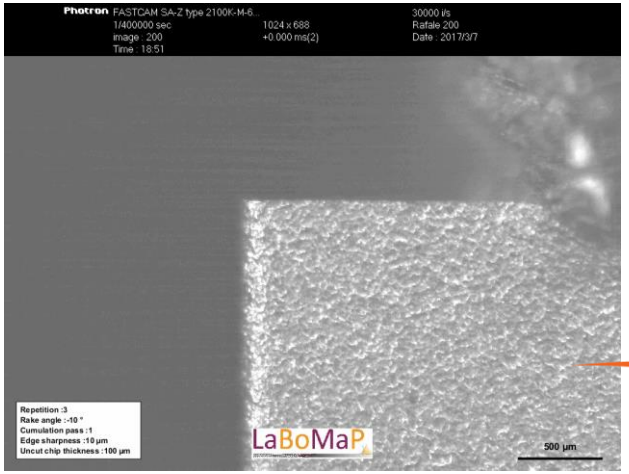




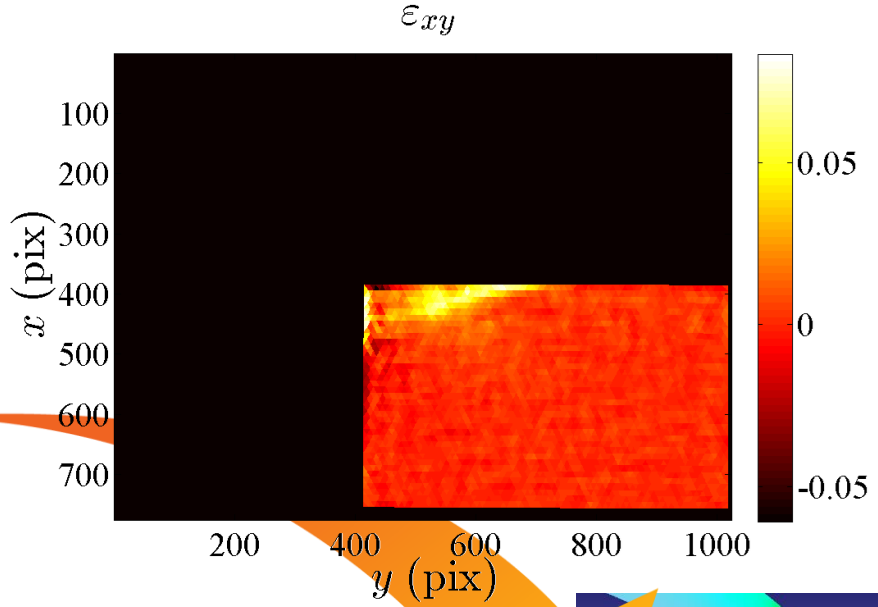
Other applications of the technique

Burr formation in Aluminum alloy machining

Experimental acquisitions
Images + Forces



Images Correlation
Correli Q4 software

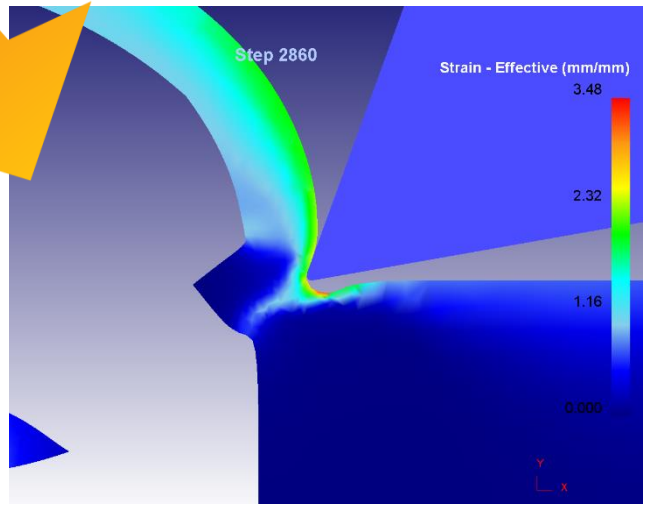


Understanding of burr formation modes

Simulation/Experiment Comparison

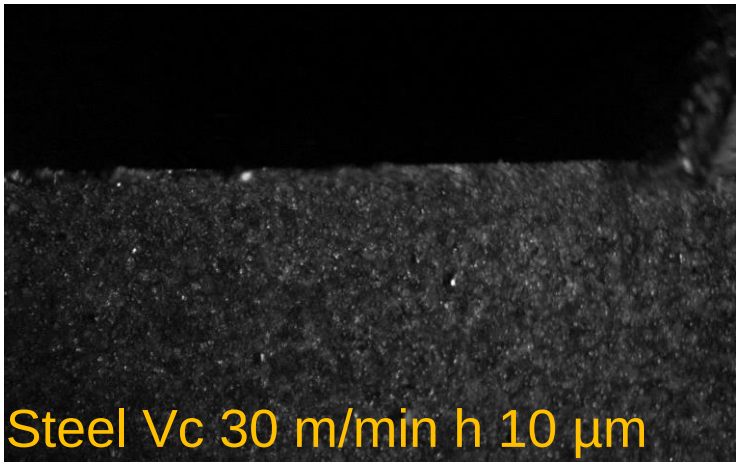
and

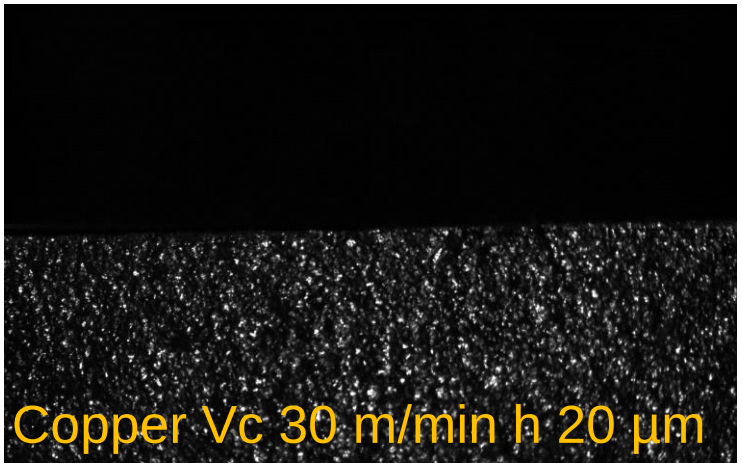
Strain field identification



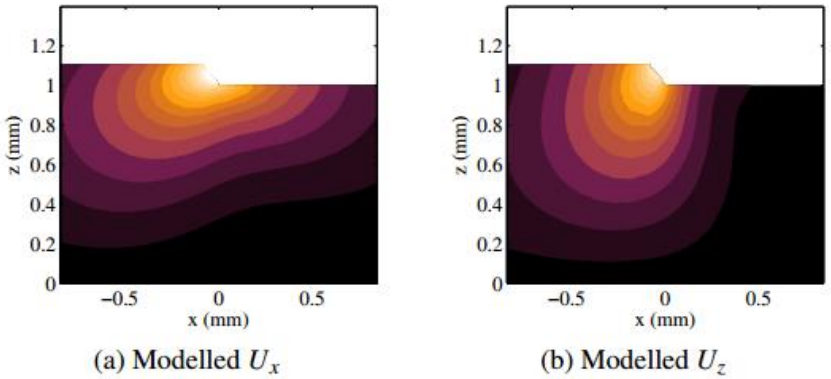
[2016 Régnier T.]

Surface Integrity characterization

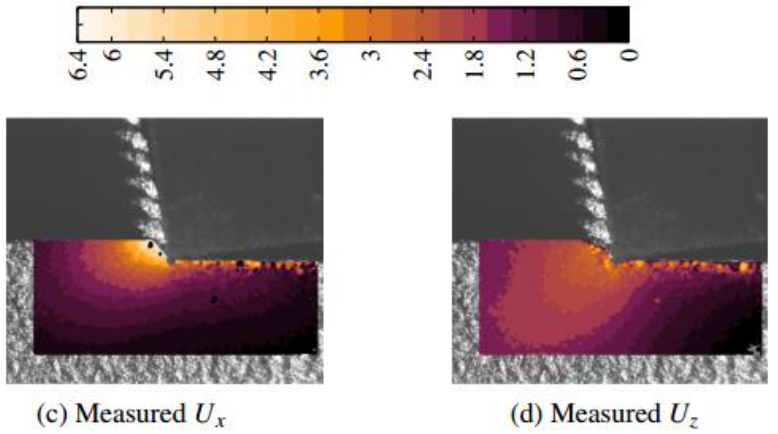


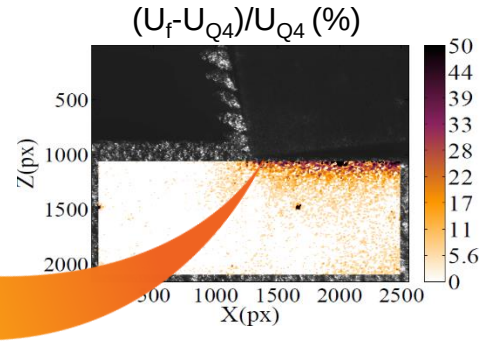


Analytical solution



DIC





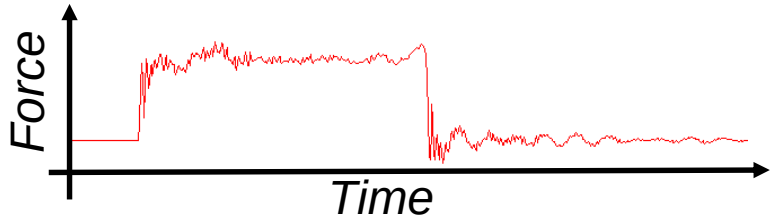
GOAL: Control the machining conditions to warranty/provide a targeted surface integrity

[2017 Baizeau T.]

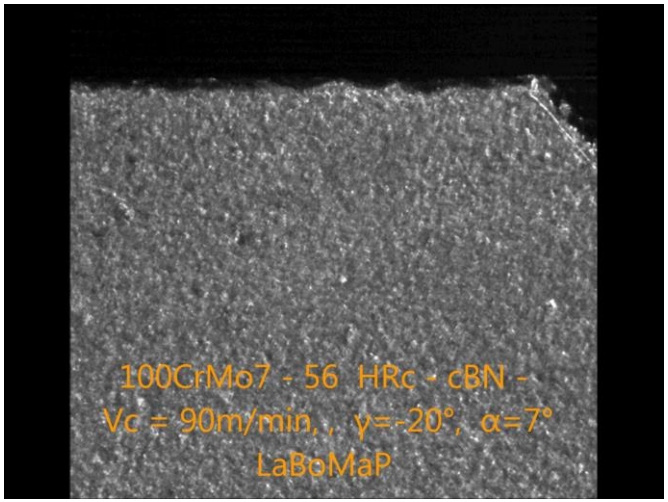
A novel solution to assess the forces in HSM

[2017 Baizeau T. et al]

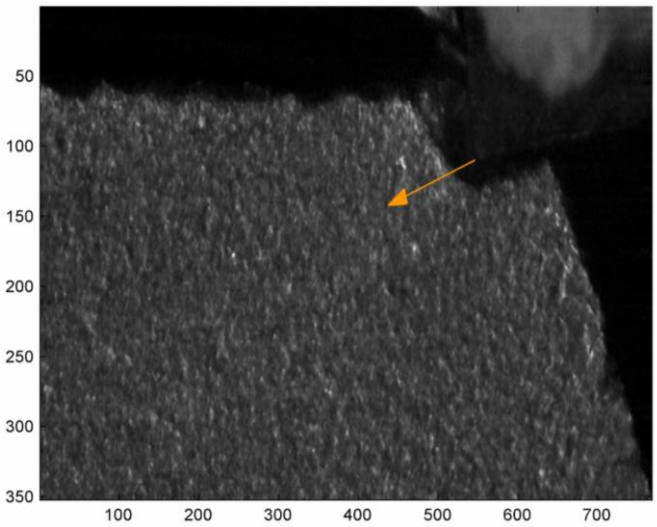
Cutting forces measurement
Dynamometer: Kistler 9119 AA2
Maximum force Fz: 4 kN
Natural frequency: approx. 4.5 kHz



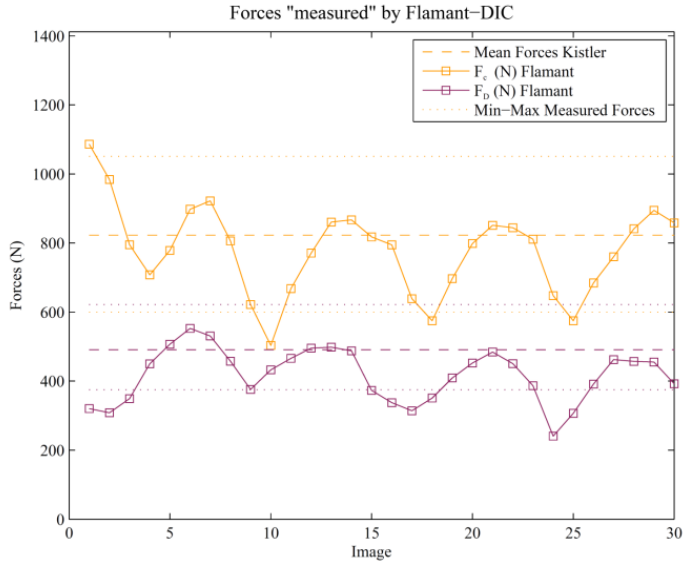
GOAL: Assess the cutting forces fluctuation measurement
→ **DIC as a Force sensor**



Strain field's evolution
(Hardened steel)



Results from DIC
coupled with an analytical model



High frequency force sensor

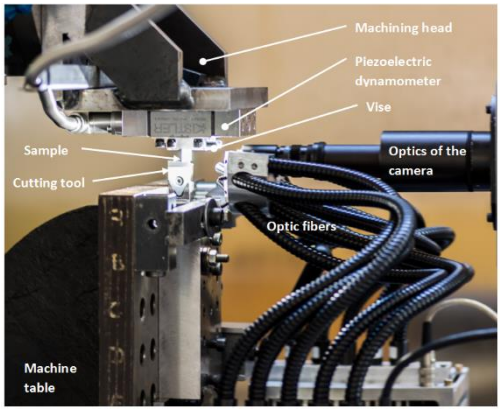
Influence of microstruture on machining properties

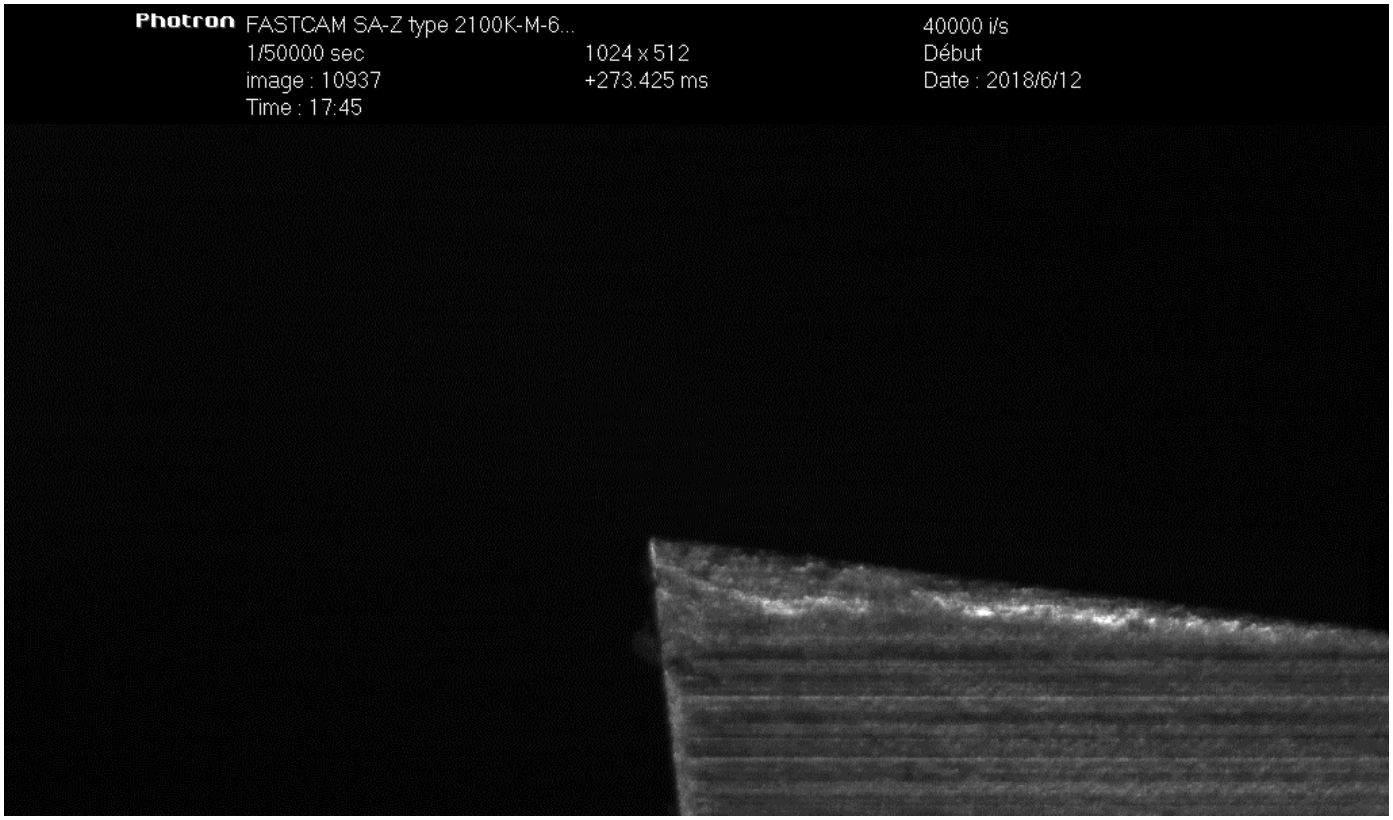
Titanium alloy with only beta phase (obtain by dedicated heat treatment)

Cutting thickness h = 100 µm

Cutting width b = 3 mm

Cutting speed Vc = 10 m/min





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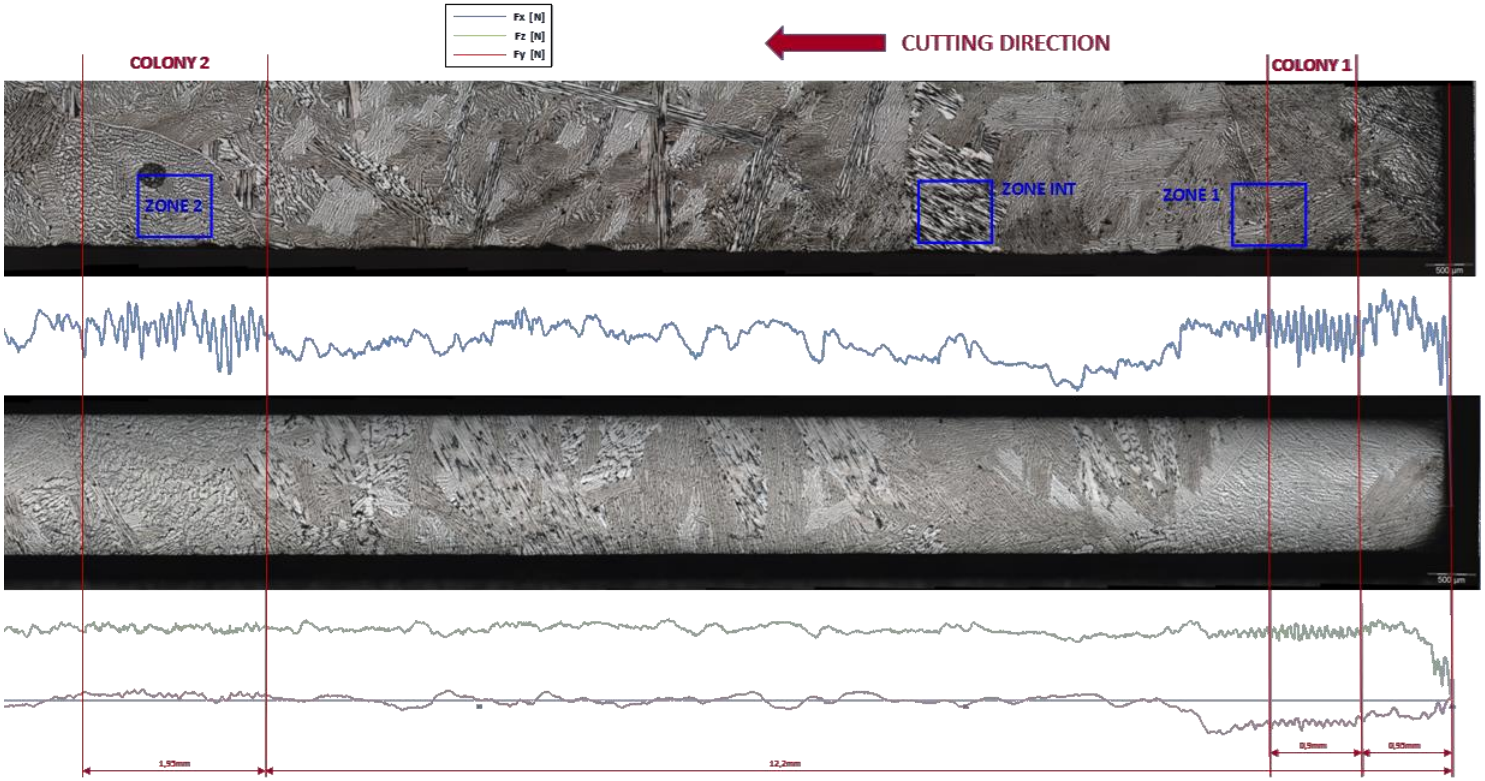
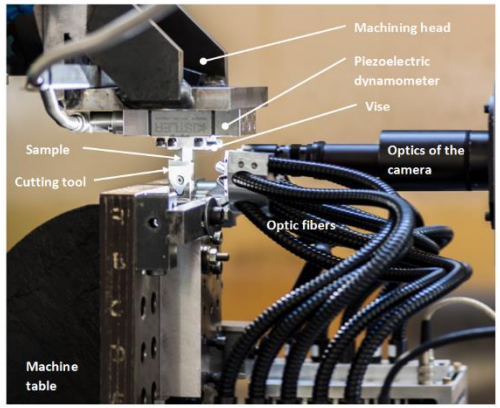
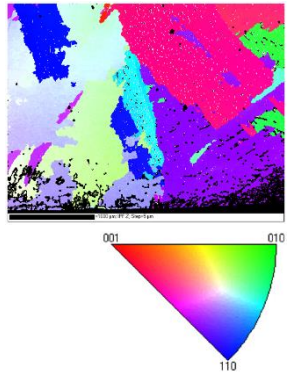
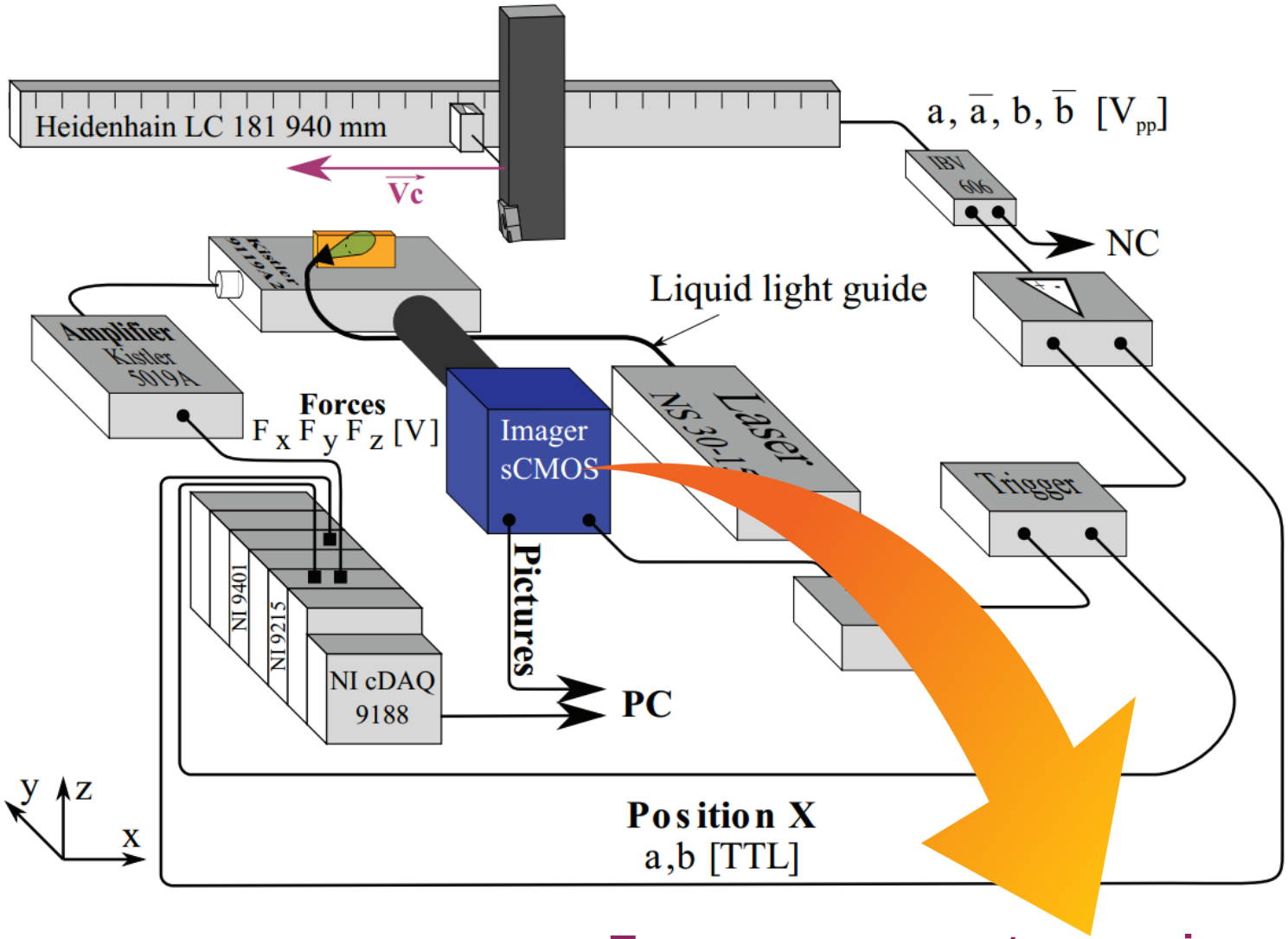




EBSD Analyse



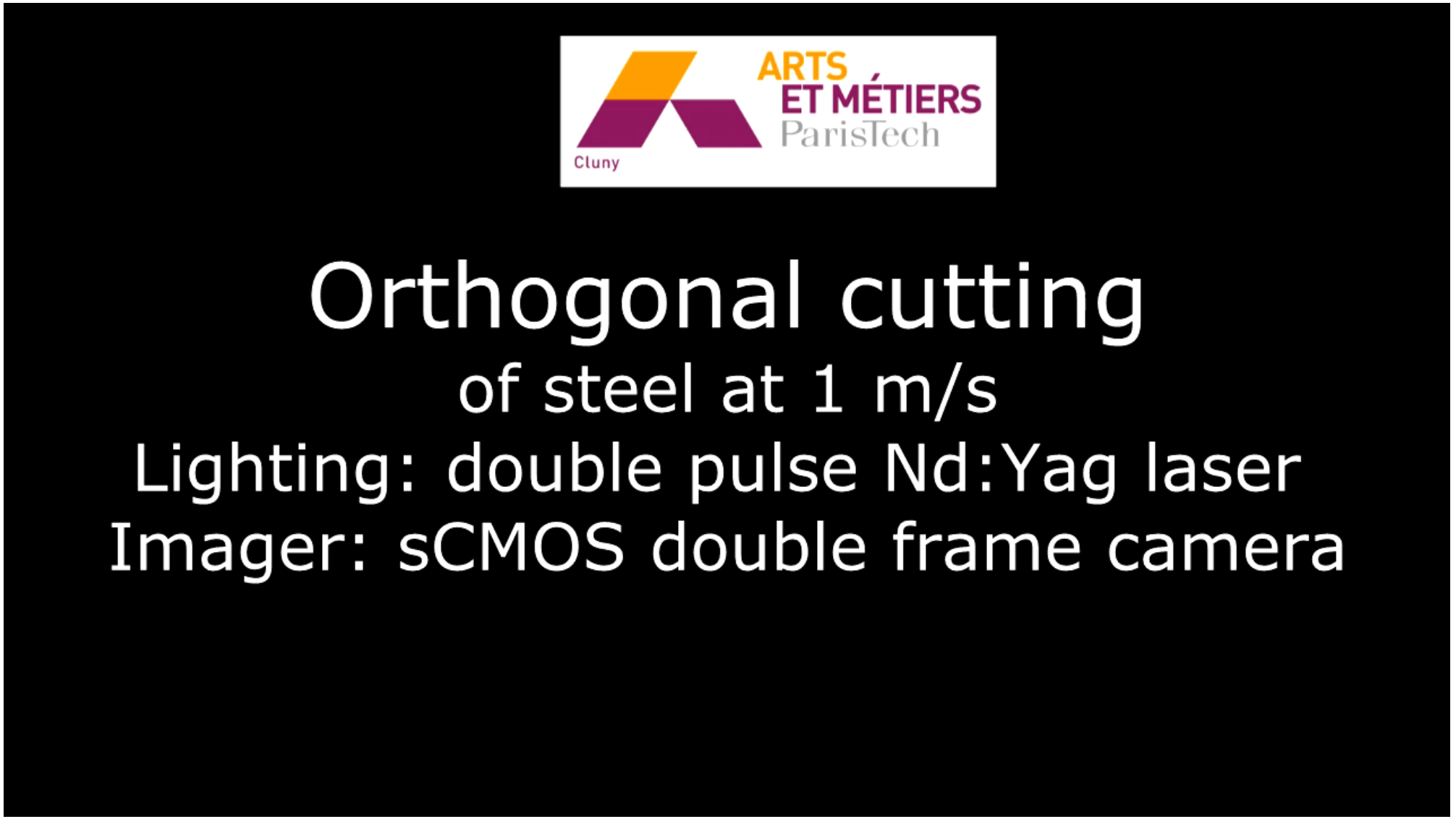
Another Ultra Hight Speed observation media



Even more accurate experimental set-up to obtain very accurate DIC strain fields

[2017 Baizeau T.]

Another Ultra Hight Speed observation media



sCMOS LaVision Camera + pulse Nd:Yag Laser

[2017 Baizeau T.]