

Experimental characterisations of single cane reeds

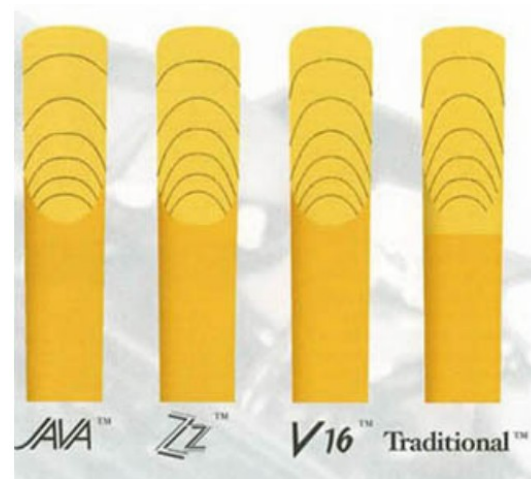
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- Musical acoustics
- Single reed woodwind instruments
 - Clarinet (cylindrical resonator)
 - Saxophone (conical resonator)
- Development of experimental tools for reed makers



- Reed ↔ beam with complex shape and material properties
- Material
 - Cane reed (natural)
 - Synthetic material (plastic, composite, ...)
- Shape : different cutting according to different musical styles



- Strength ↔ stiffness k
 - Given by a number, no physical units !
 - Table for knowing the equivalent strength of different manufacturers
 - The strength enables to adapt the reed to a mouthpiece tip opening

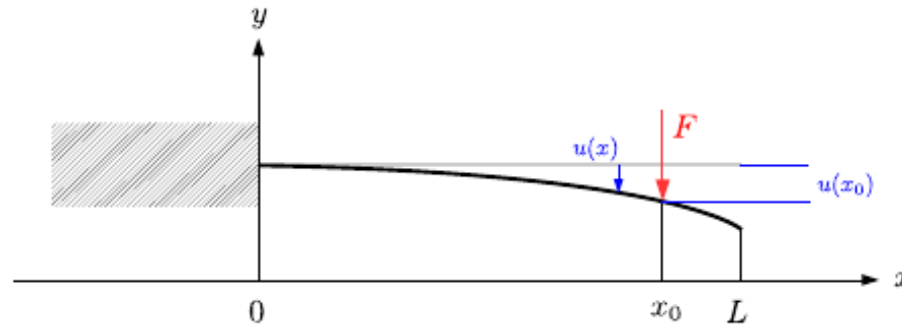
Brand	Strength												
	Soft												Hard
Vandoren Traditional	1	1.5	2	2.5	3	3.5	4	4.5	5				
Vandoren V12				2.5	3	3.5	4	4.5	5				
Vandoren 56 Rue Lepic				2.5	3	3.5	3.5+	4	4.5	5			
Vandoren V16		1.5	2	2.5	3	3.5	4	5					
Vandoren Java	1	1.5	2	2.5	3	3.5	4						
Vandoren Java Red	1	1.5	2	2.5	3	3.5	4						
Vandoren ZZ		1.5	2	2.5	3	3.5	4						
Rico		1.5	2	2.5	3	3.5	4						
Rico Royal	1	1.5	2	2.5	3	3.5	4	5					
Rico Grand Concert Select					2.5	3	3.5	4	4.5	5			
Rico Grand Concert Select Evolution				2	2.5	3	3.5	4	4.5	5			
Rico Select Jazz		2S	2M	2H	3S	3M	3H	4S	4M	4H			
Hemke			2	2.5	3	3.5	4						
La Voz			S	MS	M	MH	H						
Plasticover	1	1.5	2	3	3.5	4	5						
Fibracell			S	MS	M	MH	H						

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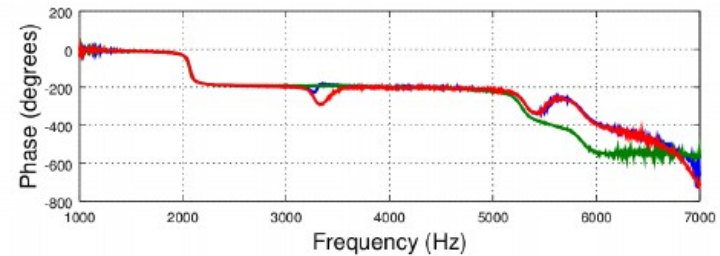
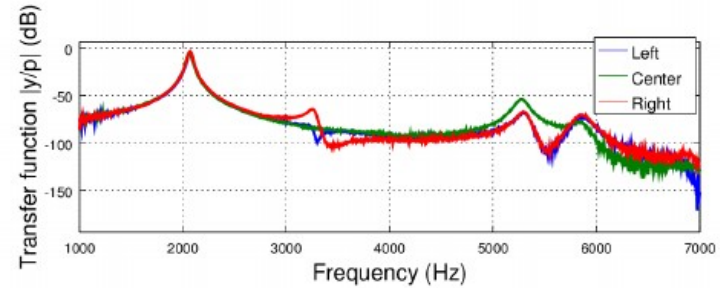
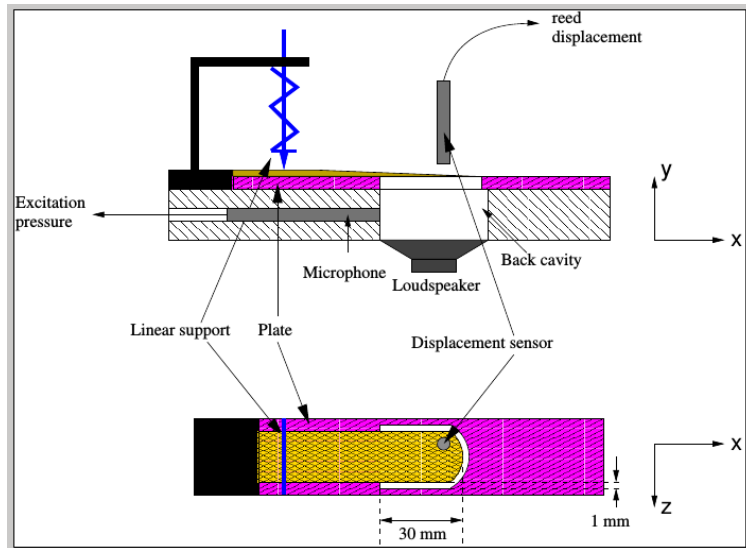
- **Reeds with same cut, same strength** produce strong differences in **subjective quality**
 - Can we measure objective parameters highly correlated with subjective descriptors?
 - Which parameters given by the physical models are the most relevant ?

CHARACTERISATION OF REED ALONE

- Static stiffness measurement (reed maker)



- Dynamic stiffness measurement (mode 1)



- Results

- Samples : tests with clarinet reeds (50 + 150 reeds, 1 expert)
- Physical measurements
 - No difference between static and dynamic stiffness
- Perceptive tests
 - Effect of reed on perception is significant
 - Correlation between stiffness and “*ease of playing*” $R = 0.75$

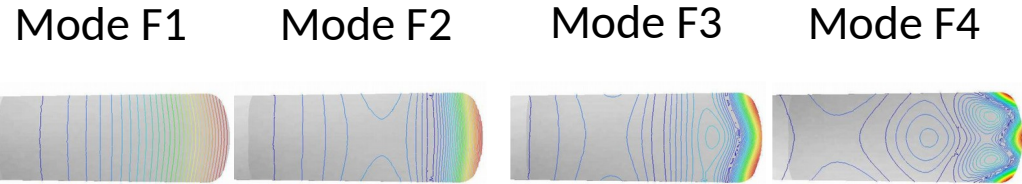
B. Gazengel, J. P. Dalmont, and J. F. Petiot, “Link between objective and subjective characterizations of Bb clarinet reeds,” Appl. Acoust., vol. 106, 2016.

J.-F. J. F. Petiot, P. Kersaudy, G. Scavone, S. McAdams, and B. Gazengel, “Investigation of the relationships between perceived qualities and sound parameters of saxophone reeds,” Acta Acust. united with Acust., vol. 103, no. 5, pp. 812–829, 2017.

- Modal analysis (digital heterodyne holography)

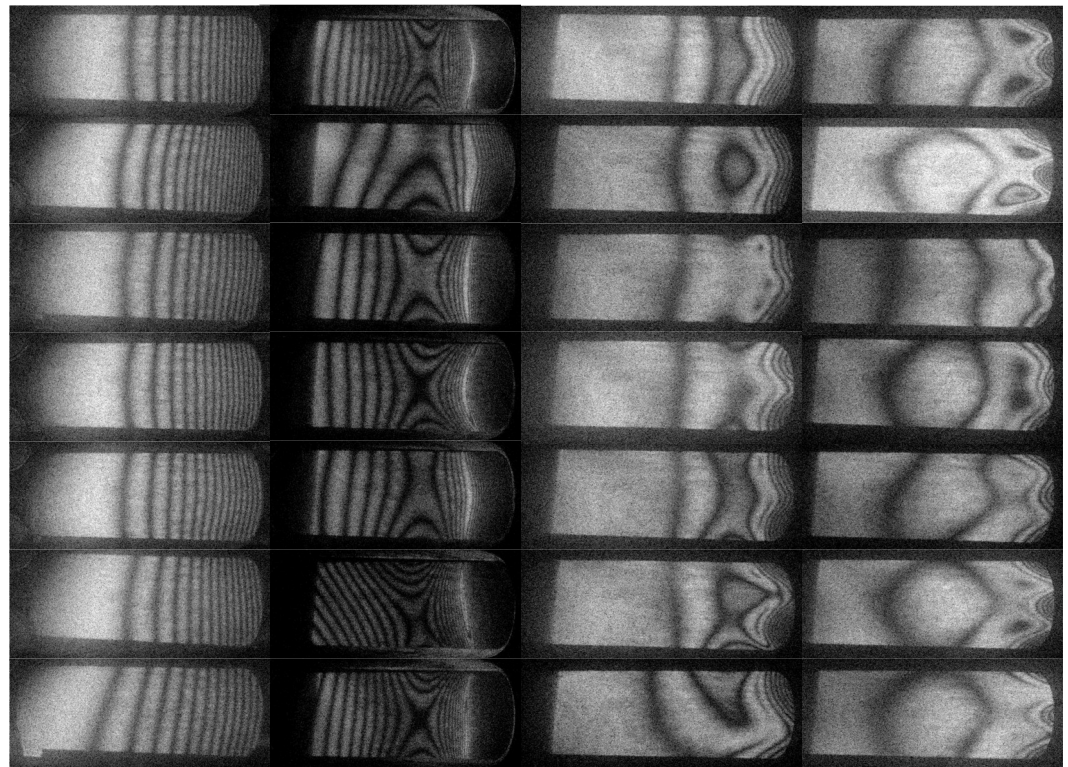
P.-A. Taillard, F. Laloë, M. Gross, J.-P. Dalmont, and J. Kergomard, "Statistical Estimation of Mechanical Parameters of Clarinet Reeds Using Experimental and Numerical Approaches," Acta Acust. united with Acust., vol. 100, no. 3, pp. 555–573, May 2014.

Simulations by FEM



Holograms

Reed #1
 Reed #2
 Reed #3
 Reed #4
 Reed #5
 Reed #6
 Reed #7

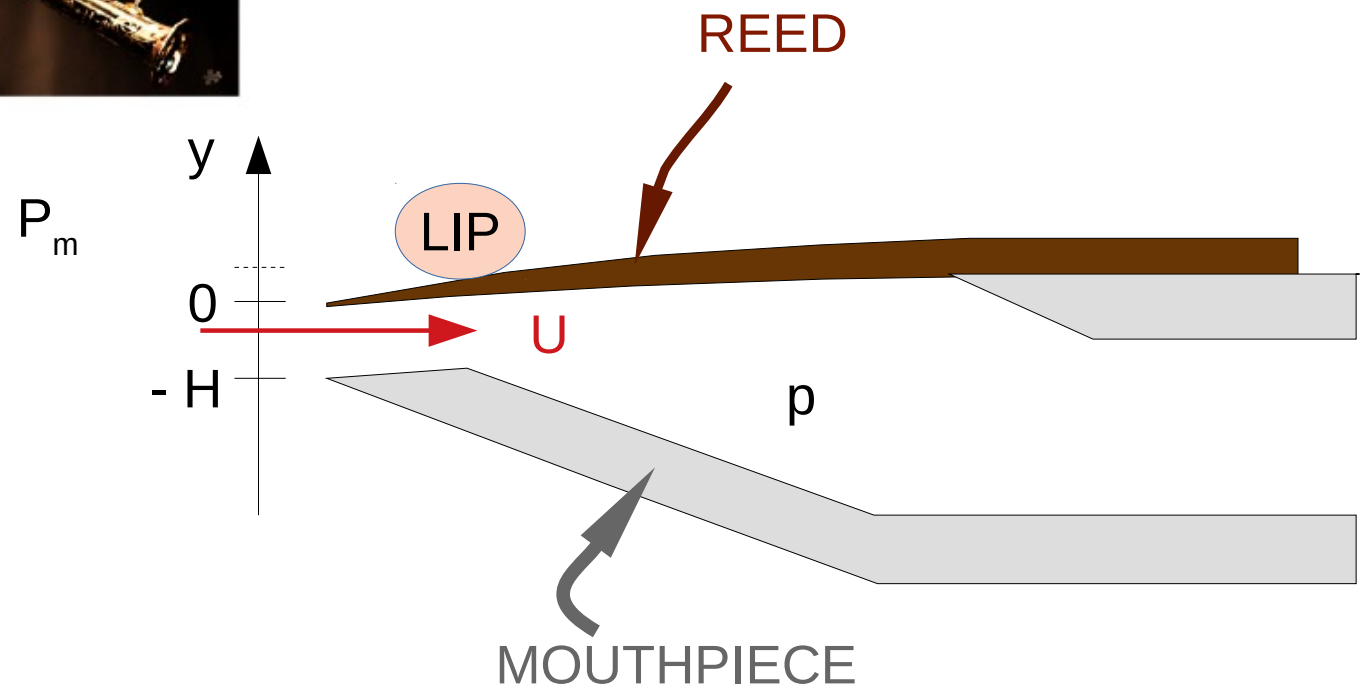


CHARACTERISATION OF REED ALONE

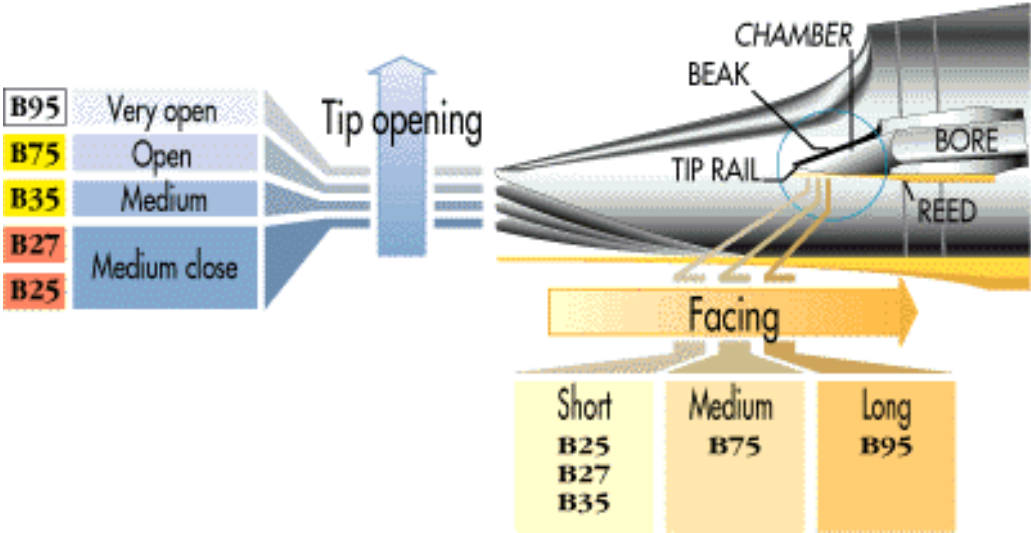
- Modal analysis by digital holography - positive results
 - A viscoelastic model of the reed-material allows to reconstruct quite correctly the observed resonance frequencies
 - Confirmation of the results by Guimezanes (PhD thesis 2008)
- Negative points
 - No evident relationship with the musical subjective evaluation by the clarinettist

Thomas Guimezanes. Etude expérimentale et numérique de l'anche de clarinette. PhD, thesis, Thèse de doctorat, Université du Maine, 2008.

- Summary
 - Static characterisation: which experimental conditions?
 - Dynamic characterisation:
 - Which experimental conditions?
 - Artificial boundary conditions (no bending of the reed against the lay, no lip)
 - Low acoustic pressure → small reed tip displacement (some μm)
- Needs characterisation of **exciter**.

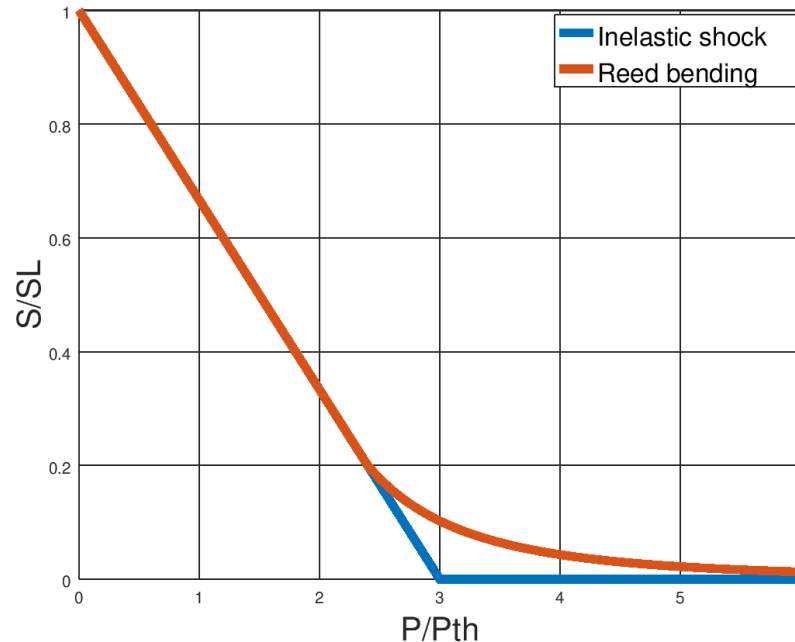


- Reed
 - Stiffness (strength)
 - Shape (cut)
 - Material
- Mouthpiece
 - Tip opening
 - Table length
 - Facing curve
- Musician's embouchure



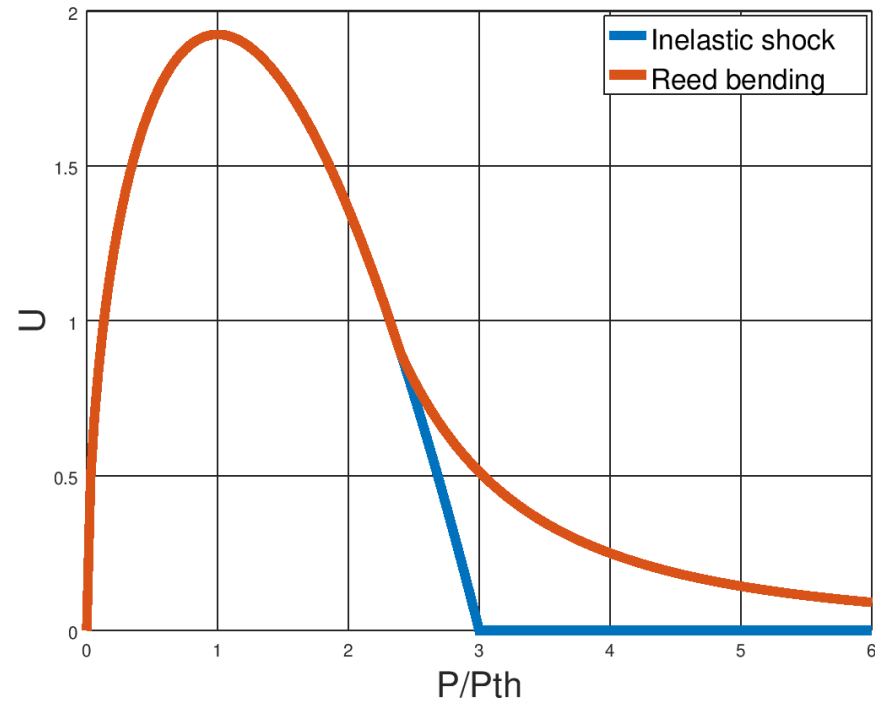
© Vandoren

- Exciter = reed + mouthpiece + lip
- S_0 : opening surface at rest (without lip pressure)
- S_L : opening surface with lip pressure
- Reed stiffness : inelastic shock or bending (non linear stiffness)

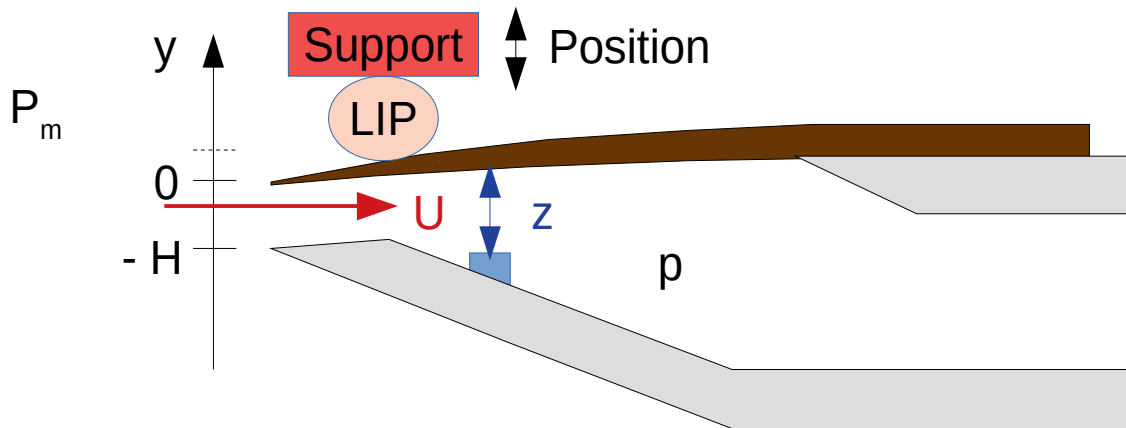


- Aeraulic section $S(\Delta p)$
- Flow rate entering the mouthpiece (Bernoulli's law)

$$U = S(\Delta p) \sqrt{\frac{2|\Delta p|}{\rho}}$$

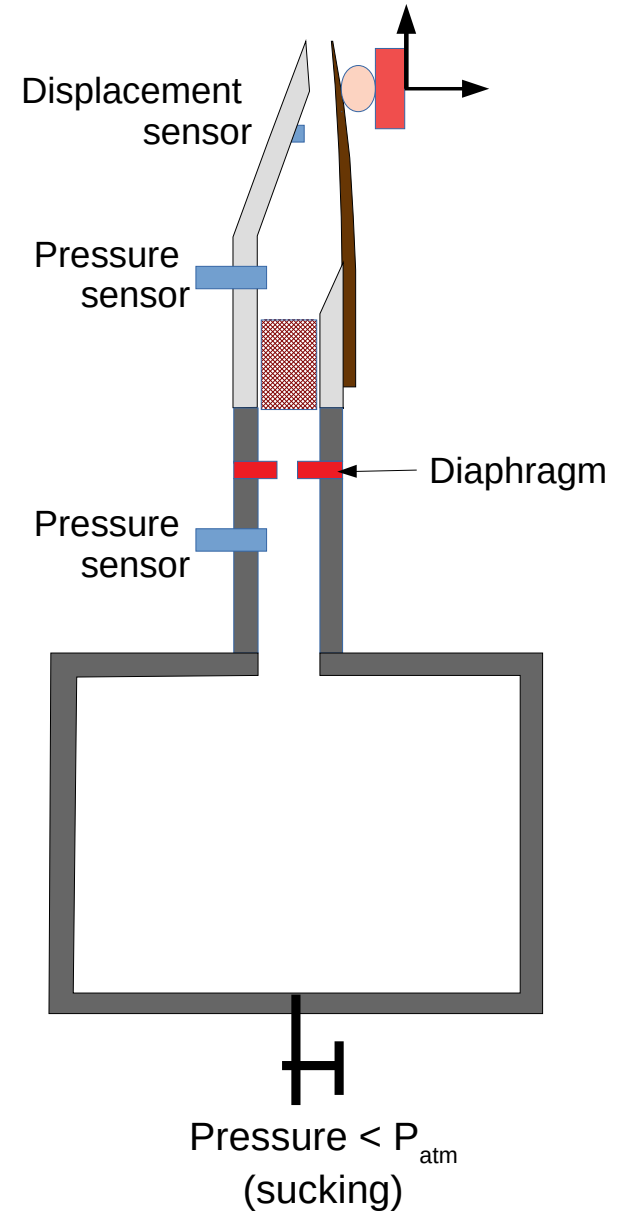


- Measurement of:
 - Pressure difference $\Delta p = p - P_m$
 - Reed tip deflection z (Δp , S_L)
 - Flow rate U (Δp , S_L)
 - Effective aerodynamic area $S(\Delta p)$

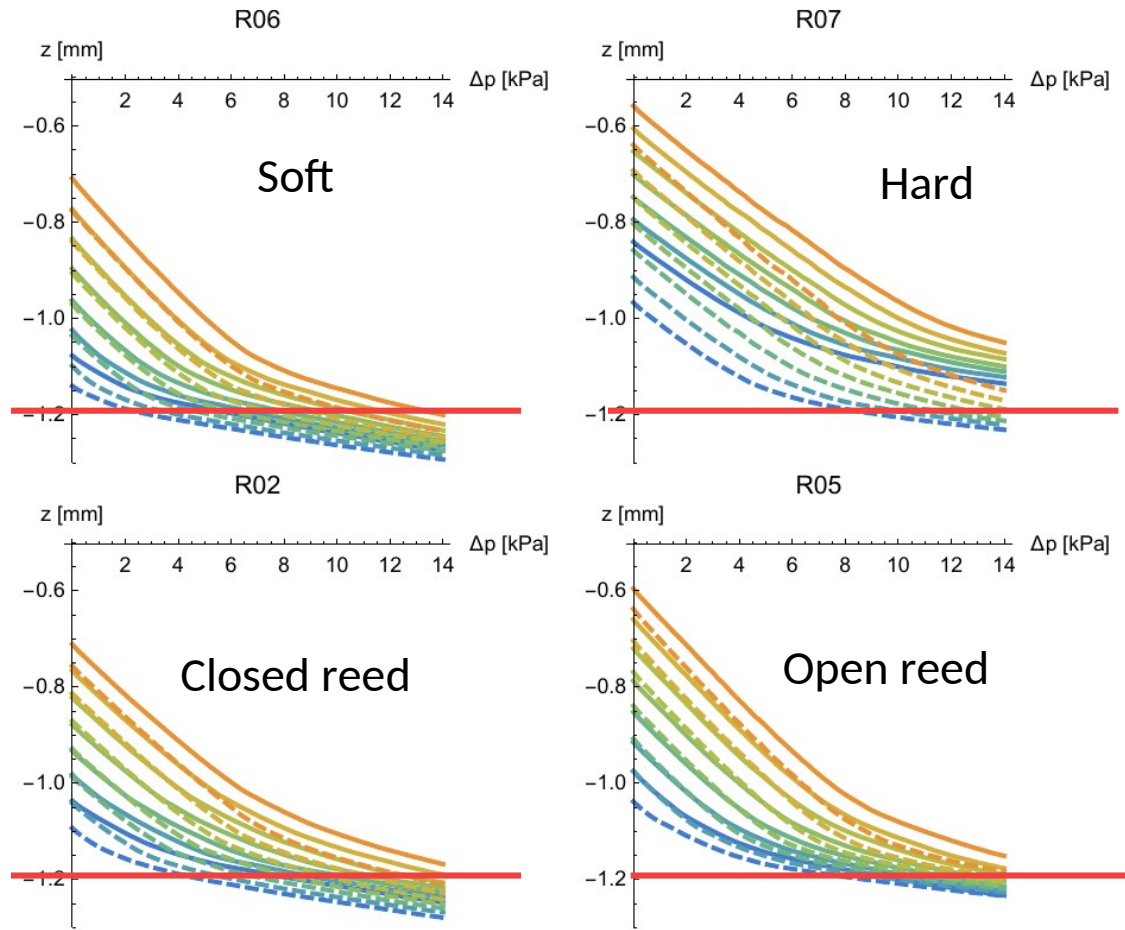


- **Quasi-static measurements**

- Negative pressure in the bottle (closed reed then opening of the reed)
- Foam (avoid oscillations)
- Measurement of pressures → estimation of flow rate
- Measurement of reed position at the tip (optical sensors)

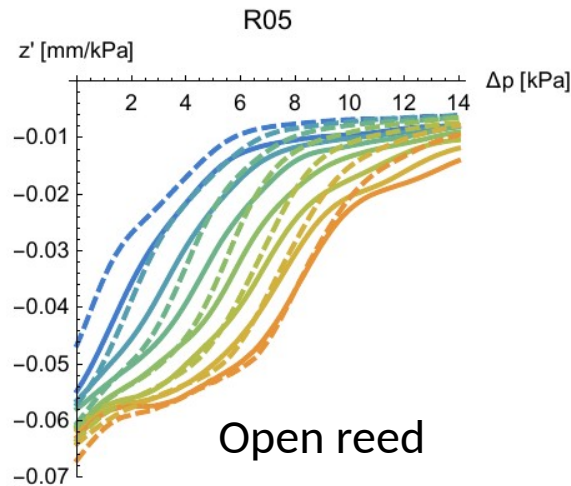
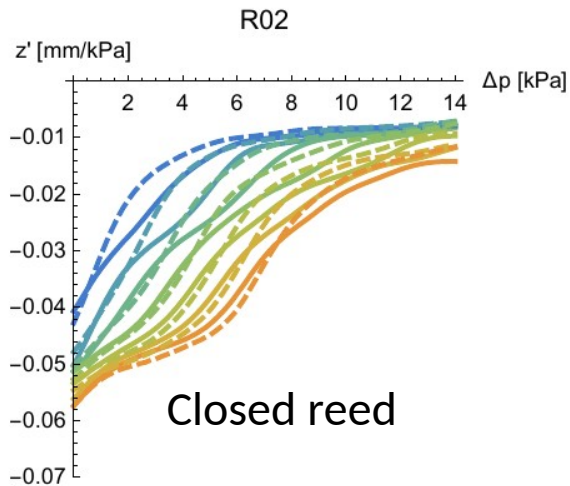
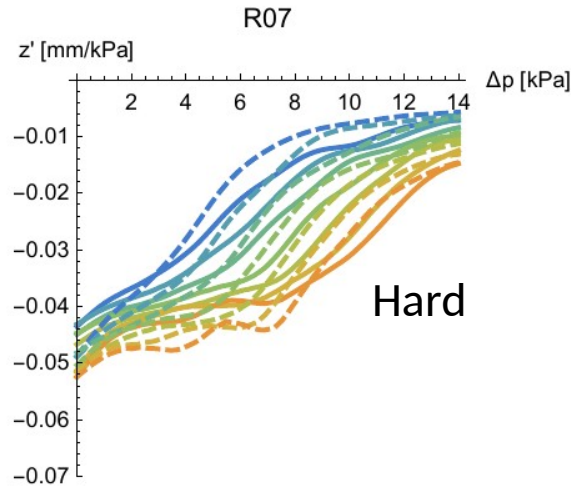
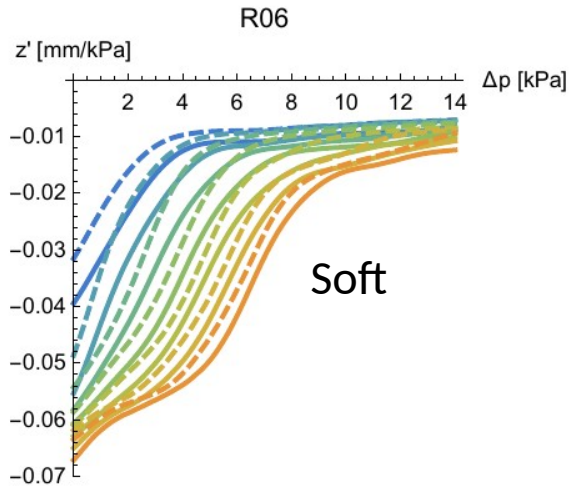


- Reed tip deflection



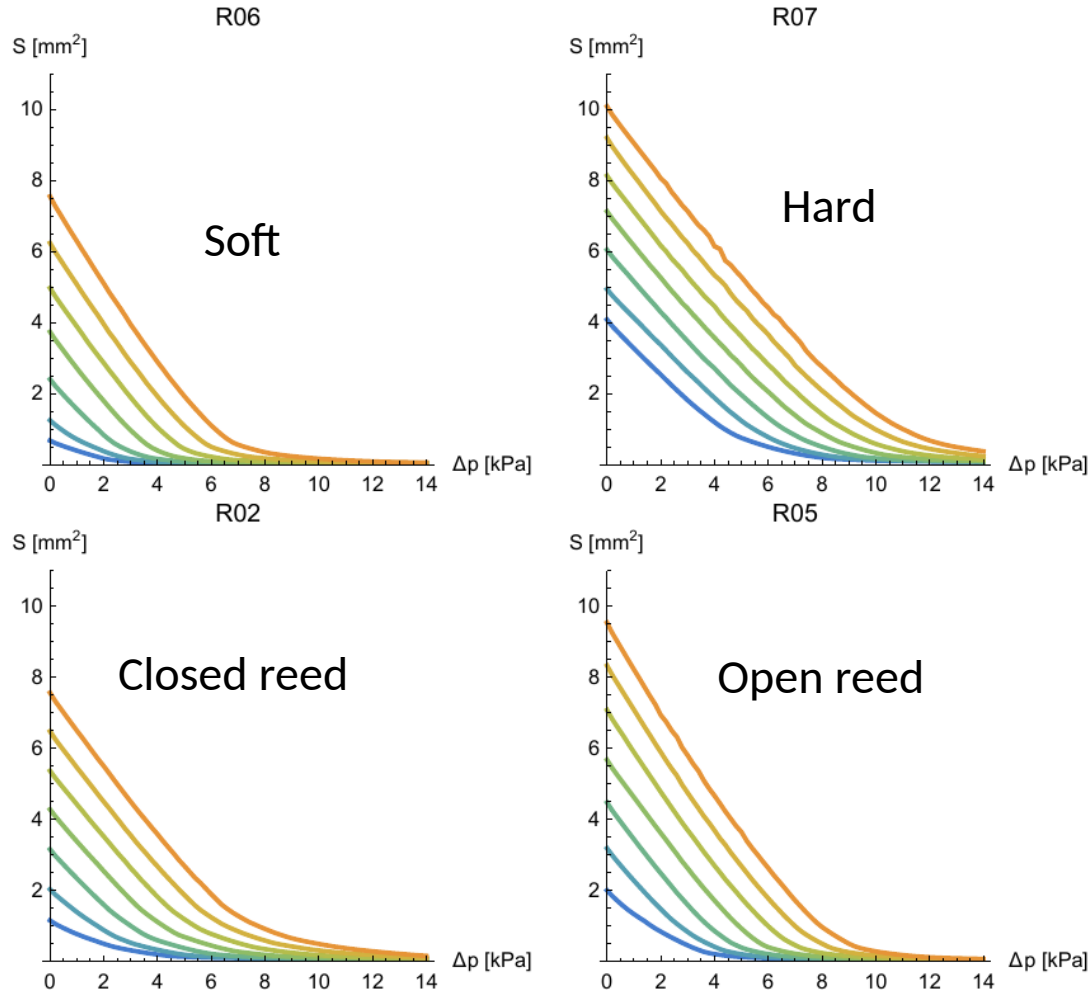
Results for
 different lip positions
 (S_L values)

- Compliance



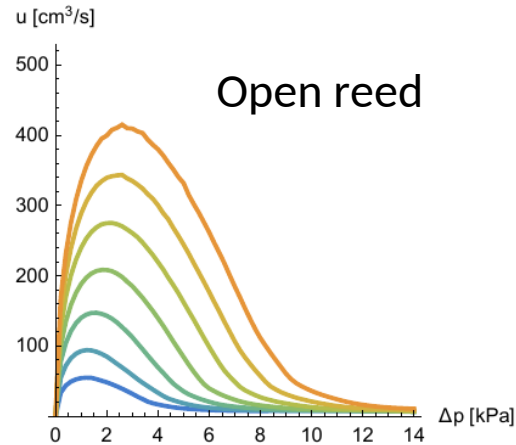
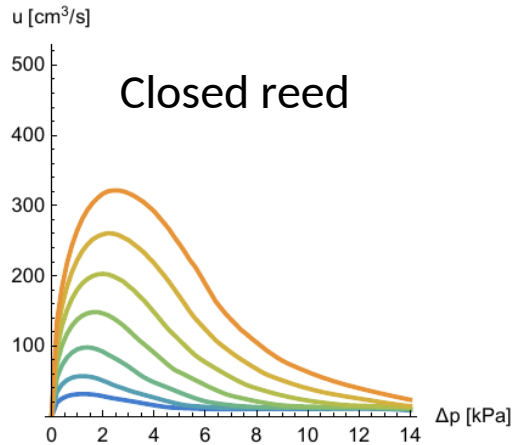
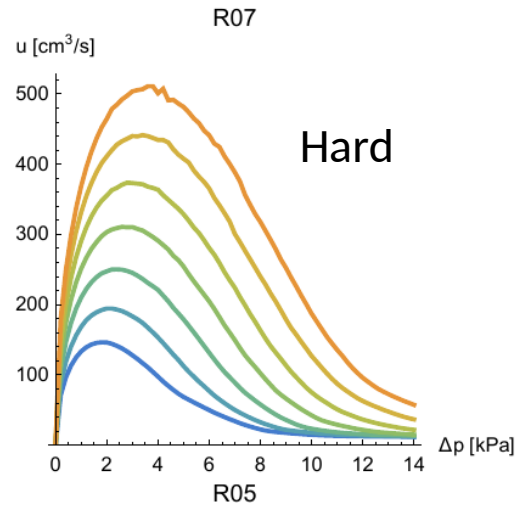
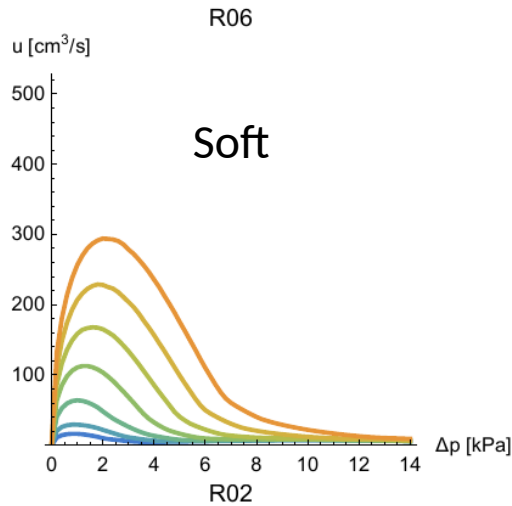
Results for
 different lip positions
 (S_L values)

- Aeraulic section



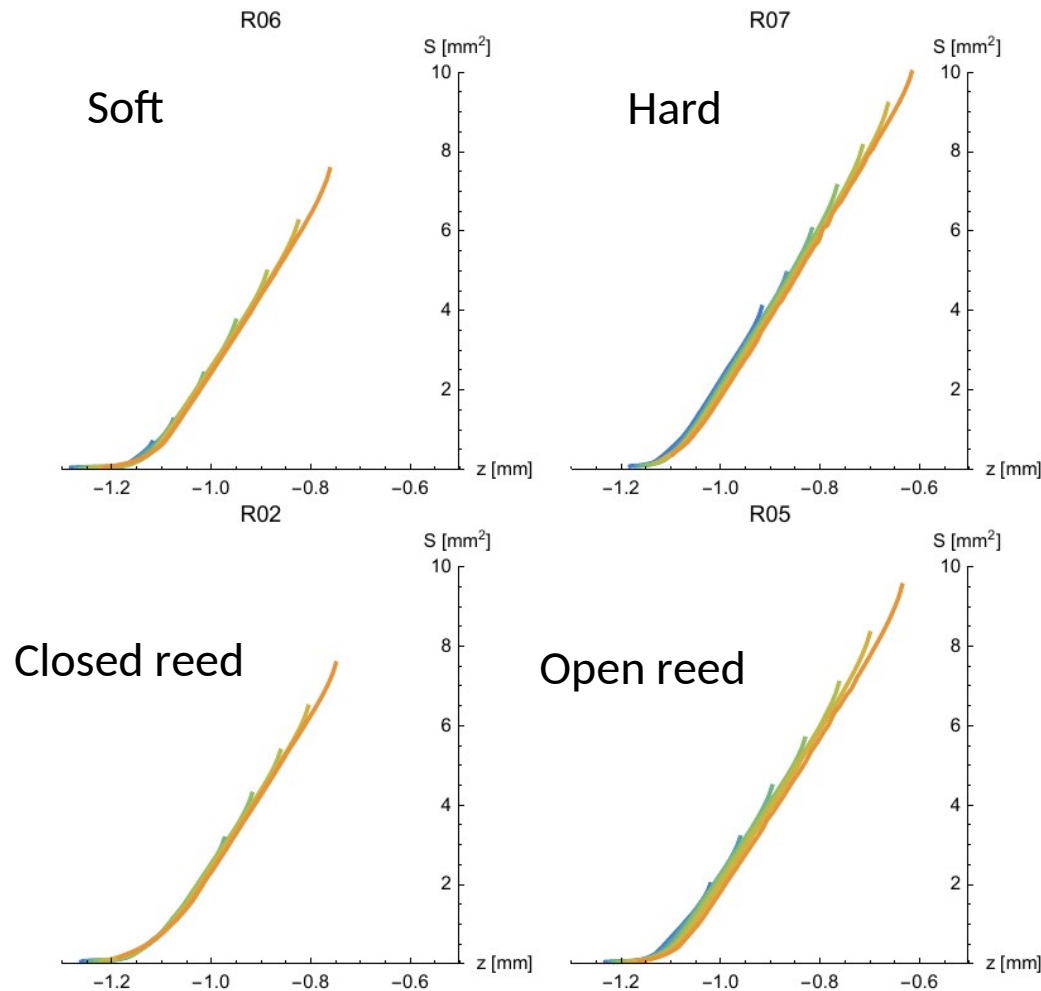
Results for
 different lip positions
 (S_L values)

- Volume velocity



Results for
 different lip positions
 (S_L values)

- Equivalence pressure / lip position

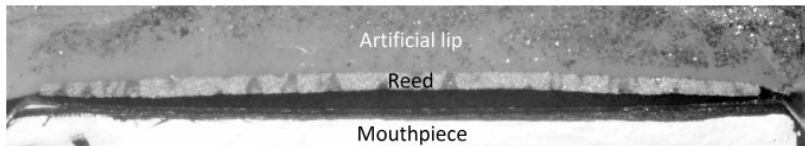
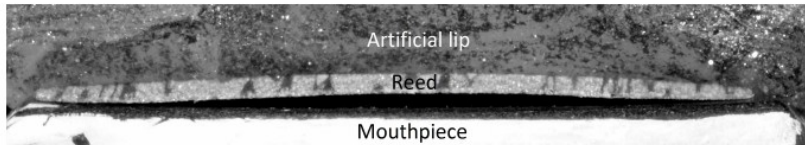


Equivalence
 between lip
 position Ψ and
 pressure p

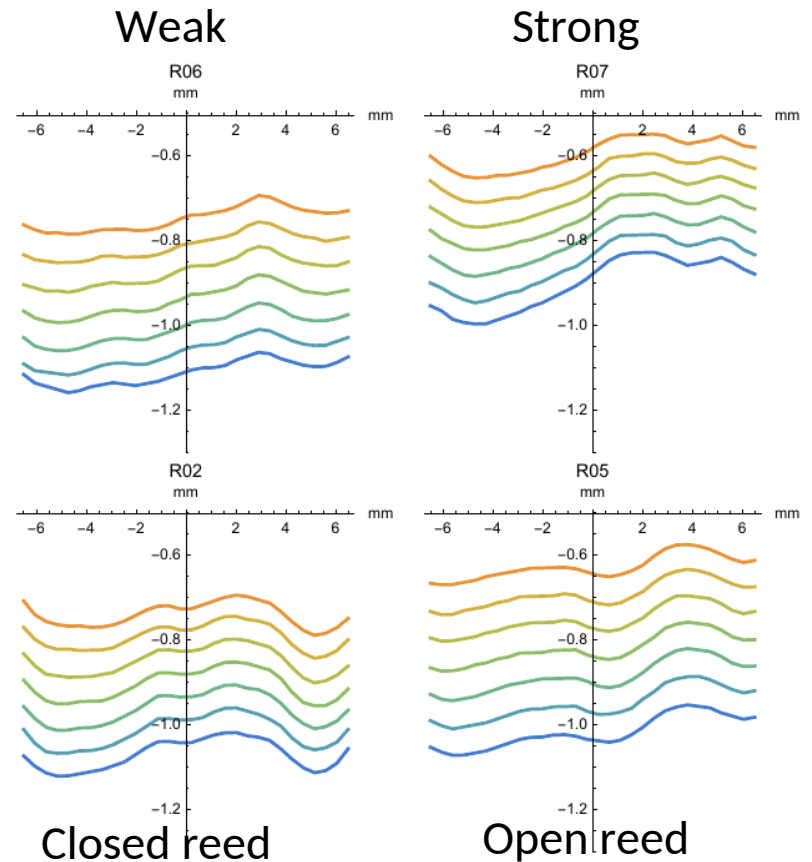
$$x = \Delta p + a(\Psi - \Psi_0)$$

CHARACTERISATION OF EXCITER ALONE

- Static measurements
 - Photography of reed channel



Photos of the reed R14 before and after break-in for an embouchure



Channel height measured by photo for 4 different reeds and 7 embouchures

Pierre-André TAILLARD, "Theoretical and experimental study of the role of the reed in clarinet playing," PhD thesis, Le Mans Université, 2018

- Results from measurements
 - Characterisation of reed alone not enough
 - Characterisation of exciter (reed + mouthpiece + lip) needed. Static characterisation is enough (channel photography)
 - Lip force equivalent to acoustic pressure
 - Important parameters
 - 1) Opening surface at rest (without lip pressure)
 - 2) $K(\Delta p, S_L) \leftrightarrow$ evolution of the stiffness between the tip and the vamp of the reed
- Perspectives
 - Transfer to reed makers