Depending on the candidate’s skills, the work will include the next steps:

- A deep understanding of acoustic phenomena requires the derivation of a reliable and realistic model, followed by its robust and efficient discretization. We aspire to keep improving the existing pipe models (radiation condition, multimodal coupling, etc.) thanks to an experimental study of, first, simple, and then, complex shapes, via a collaboration with Samuel Rodriguez (entry impedance measurement, I2M, Bordeaux). We wish to extend the domain of validity of the reduced models (Webster equation with visco-thermal losses) thanks to state-of-the-art numerical methods (high order spectral FEM in harmonic and time domain), based on mathematical proofs of robustness for the proposed algorithms (energy-based for the time domain).
A crucial point is then to properly define the underlying design problem: what are the important objectives for the maker and for the musician? Which instrument parameters do we want to modify? We are lucky to work hand in hand with makers on this part of the project, because no matter the scientific quality of the work, its value for musicians is inseparable from this expert eye. Once the target cost function is established, we wish to implement the full waveform inversion procedure and compare it with various other optimization methods as neuronal networks (fed with direct numerical simulations), or more classical optimization techniques.

The optimal instruments will be prototyped by the makers using usual handcrafted techniques and/or additive manufacturing (3D printers). The prototypes will be evaluated quantitatively by acoustical measurements (entry impedance) realized in collaboration with I2M and actual sound played by real musicians. Perceptive tests will evaluate, in a musical context, the effects of the chosen modifications on the final sound and instrument's playability, in collaboration with the makers.

**Keywords:** full waveform inversion, optimal design, numerical analysis, wind musical instruments, manufacturing

**References:**


2. On the accuracy of bore reconstruction from input impedance measurements: Application to bassoon crook measurements, Jean-Pierre Dalmont and Marthe Curtit and Ahmad Fazli Yahaya, the Journal of the Acoustical Society of America, 131(1), 2012


4. Webster’s Horn Equation Revisited, S. Rienstra, SIAM Journal on Applied Mathematics, 65(6), 2005


**Skills**

**Required knowledge and background:** optimization, numerical analysis, psychoacoustics, musical acoustics, acoustic measurements, a pronounced taste for trans-disciplinary subjects, relation with non scientific actors

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport

**Remuneration**

2653€ / month (before taxes)