

# Long Term Project Report : Interim/Final

## Summary Page

### 1. Beamtime Used

Please give a short summary of progress for each scheduling period for which beamtime has been allocated/used :

Scheduling period	Beamline(s) Used	Shifts Used	Summary of results obtained
2012 /II	ID17	15	<ul style="list-style-type: none"> <li>• Acute lung injury in rabbit: effect of mechanical ventilation mode and surfactant on regional lung function</li> <li>• Dosimetry study to determine minimal radiation dose for <i>in vivo</i> K-edge subtraction imaging</li> <li>• Imaging of phantoms carrying combinations of xenon and iodine at known concentrations for validation of theoretical studies</li> </ul>

### 2. Resources Provided by User team (financial, personnel, technical...):

- The research team co-finances a PhD student (Ludovic Broche) together the Université de Picardie Jules Verne (50%) and the ESRF. He participated in the experiment , and is also involved in in-house research at the beamline.
- Loan and implementation of a commercial patient mechanical ventilation system (Servo-i® by Maquet) from the University of Geneva Dept. of Anesthesiology (Prof. Habre) with the assistance of Maquet engineers.

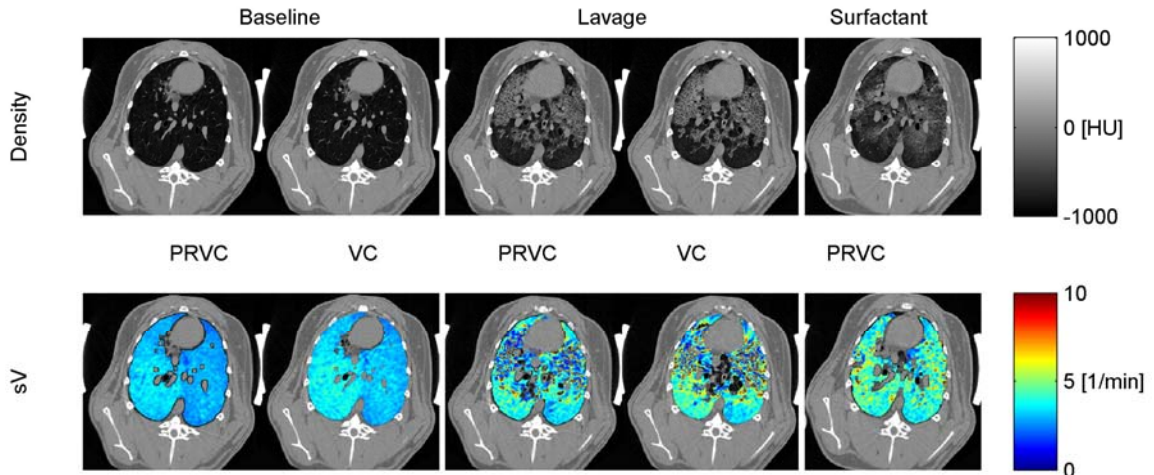
### 3. Technical and Scientific Milestones Achieved (in relation to the milestones identified in the original proposal):

Year 1

We are reporting the results of one 15 shift experiment that took place from December 5 to 10, 2012. There has therefore been very limited time for detailed analysis of the results. The scientific and technical achievements of this LTP experiment are as follows:

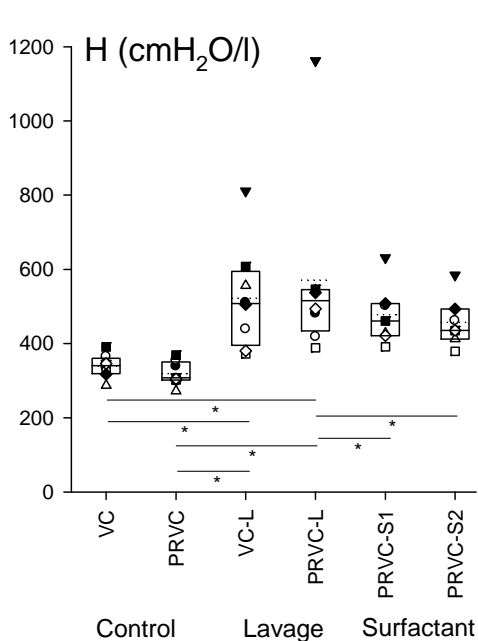
**1- Acute lung injury: effect of mechanical ventilation modes and surfactant replacement therapy on regional lung function (Scientific goal #4).** For practical reasons we scheduled the study of ventilator induced lung injury (VILI), initially planned for year 3. The goal of this study was to compare 2 modes of mechanical ventilation: pressure-regulated volume control (PRVC) and volume control (VC) and how they determine the mechanical behaviour of small peripheral bronchi and alveoli, in lavage-induced acute lung injury in rabbit. We subsequently assessed the effect of surfactant replacement therapy, a treatment of infant respiratory distress syndrome. These goals are significant because currently there is very little data on

how mechanical ventilation settings or surfactant administration affect regional lung function in normal or diseased lungs. We used a natural bovine lung extract containing phospholipids, neutral lipids, fatty acids, and surfactant-associated proteins (Survanta<sup>®</sup>, provided by Abbott laboratories). Analysis of the results is still proceeding. A full set of data were obtained in 8 rabbits and the effect of surfactant instillation alone was assessed in 2 healthy controls. An example of regional ventilation images in the different experimental conditions in a representative animal is shown in Figure 1.



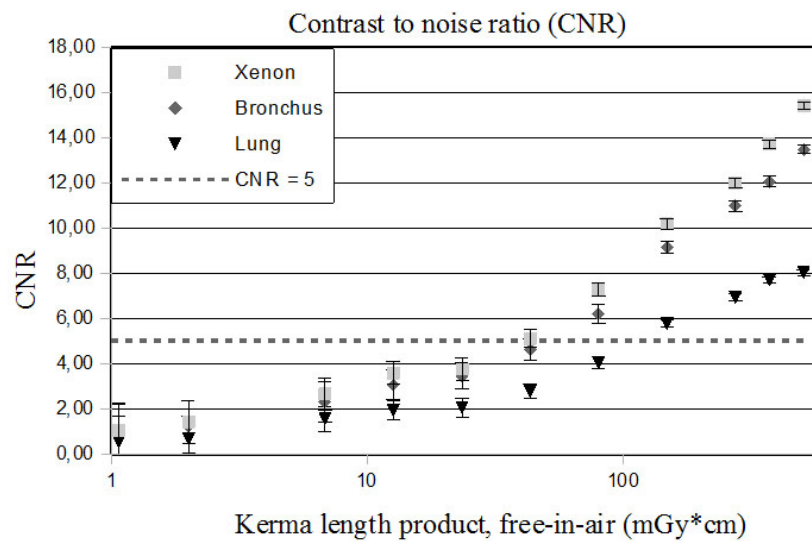
**Figure 1.** Tissue density images (upper row) and specific ventilation images (ventilation per voxel volume; lower row) in a representative rabbit at baseline, following lavage-induced lung injury, and after administration of exogenous surfactant.

Alongside KES imaging, respiratory mechanical parameters were measured using the forced oscillation technique. As an example, preliminary results showing the changes in respiratory tissue elastance ( $H$ ,  $\text{cmH}_2\text{O}/\text{ml}$ ) are shown in Figure 2.



**Figure 2.** Respiratory tissue elastance measured by forced oscillation technique under the different experimental conditions. \*:  $p < 0.05$  (one-way repeated measure ANOVA).

**2- Dosimetry study of *in vivo* K-edge subtraction imaging (Technical goal #2).** This goal is significant because for possible clinical application of KES, radiation dose needs to be minimized while maintaining an optimal image quality. We performed KES-CT imaging *in vivo* in an anesthetized and ventilated New Zealand rabbit with low (20%) inhaled xenon gas in O<sub>2</sub>. The radiation dose, defined as kerma length product (PKL), was measured free-in-air with a cylindrical ionization chamber. As a parameter of image quality, contrast to noise ratio (CNR) was calculated in different doses (PKL: 0.2-505.1 mGy·cm) from the subtracted xenon images. The following figure shows the dependency of CNR as a function of PKL. Rose criterion (CNR>5), which was used to define an adequate CNR value, is shown as a dashed line. As a conclusion KES-CT method can be potentially used in clinical functional lung imaging considering rather high image quality compared to the delivered radiation dose. Experiments are completed, and data-analysis is currently on-going.



**3- Imaging of phantoms carrying combinations of iodine and xenon at known concentrations for validation of theoretical studies (Scientific Goal #2).** A phantom containing dissolved xenon and iodine in a neutral medium was designed and tested. Phantoms with varying concentrations of up to 1.5 mg/ml iodine and 7 g/ml xenon were imaged at energies bracketing both iodine and xenon k-edge. These data will be useful for validating theoretical studies aiming at simultaneous quantification of both contrast agents.

In March 2013 following experiments are foreseen:

- Study the involvement of the parasympathetic and NANC pathways in small peripheral airway constriction in ovalbumin-sensitized rabbits. **(Scientific goal #2)**
- Experimental data for tomosynthesis method development **(Technical goal #1)**

Year 2

Year 3

#### **4. List of publications directly resulting from beamtime used for this Long Term Project:**

Given the limited amount of time since the acquisition of data in December 2012, so far only one abstract has been submitted:

S. Strengell, J. Keyriläinen, P. Suortti and L. Porra. Dosimetry and image quality of functional lung imaging using synchrotron radiation. 47th annual meeting of the Finnish Physical Society, Otaniemi, Espoo, March 14-16, 2013.

Analysis of all other obtained data is currently ongoing. We are preparing abstracts from the Acute Lung Injury –study to be submitted in European Respiratory Society Annual Congress 2013 (Barcelona, Spain 7-11.9-2013).