Early warning detection systems for Bioterrorism & Pandemic monitoring

By Stanislaw Koper Supervisors: Dr Dan McCluskey, Dr Ian Johnston, Dr Loic Coudron, Dr Shan Goh

Introduction

Viral aerosol sampling is a more complex compared with traditional sampling methods for collecting bacteria, fungi and other organic matter. The Covid-19 pandemic has shown that our current technologies were unable to confirm that SARS-CoV-2 was airborne until a year into the pandemic. Even now there is no ideal way of capturing viruses that is streamlined and effective.

This proposed research could help identify which steps and process are optimal for monitoring specific virus categories in hypothetical pandemic or bio-terrorist attack involving viruses. As viruses come in many different shapes and sizes, this study will investigate the use of multiple virus with varying morphologies. This can establish a framework to uncover if there is a correlation between virus types and how to effectively capture & detect them.

Aims

- Polystyrene microspheres & Bacteriophage (MS2, Phi8 & T4) aerosolisation.
- Aerosol sampling with UH devices & commercially available.
- Quantification by flow cytometry, various biological and bio-chemical assays.
- Compare UH aerosol samplers to commercially available. Identify optimal detection techniques.
- Apply knowledge use on Foot-and-Mouth-Disease virus (FMDV) with placement partner.
- Create a concept for automated detection system from collected data.

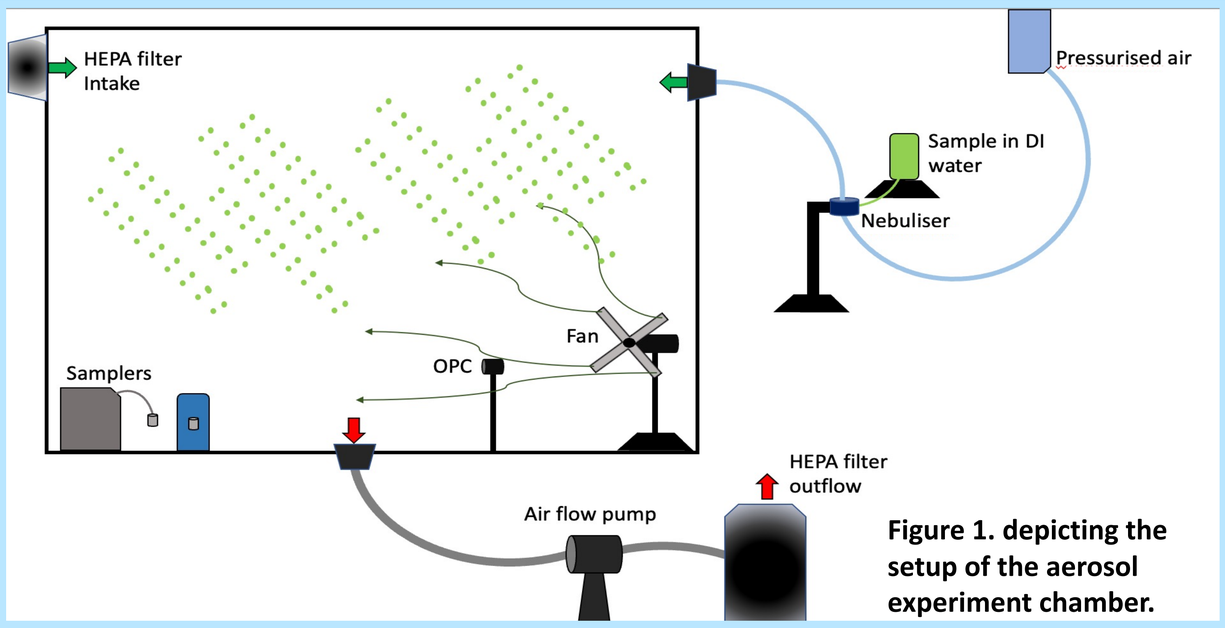


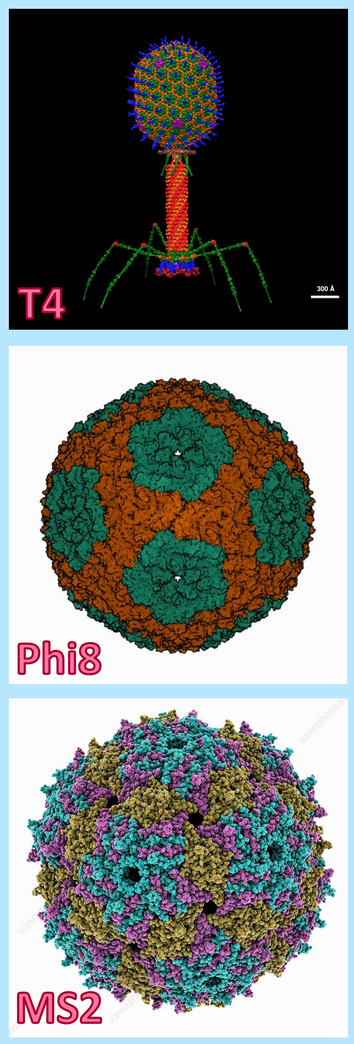
Figure 1. depicting the setup of the aerosol experiment chamber.

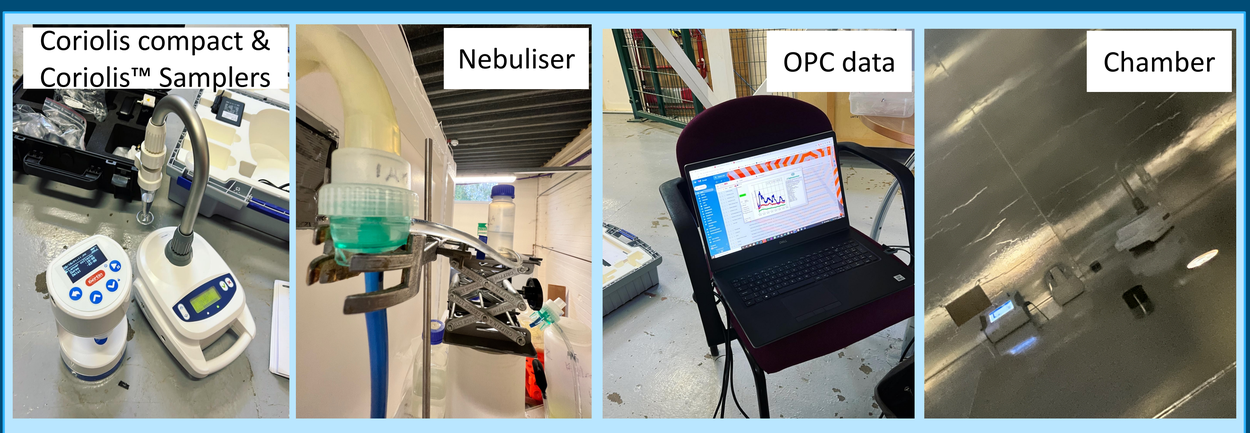
Project plan

1. Benchmark aerosol samplers with PSL and identify capture efficiencies.
2. Create bacteriophage aerosol launching procedures.
3. Identify which aerosol sampling techniques are the best for capturing viruses.
4. Optimise aerosol sampling procedures to model real life scenarios.
5. Identify if UH built aerosol samplers are more effective than commercially available samplers.
6. Apply biological techniques: NGS, LAMP, RT-qPCR, plaque assay.
7. Comparison enveloped & non-enveloped viruses.

The advantage of using phages as surrogates for pathogenic viruses

1. They can be easily produced in large batches with efficient purification processes
2. They pose no risk to human and safe for laboratory workers (CAT-1 organisms).
3. No specialised biocontainment is required.
4. Allows for eukaryote cross-study comparison due to genetic similarity.





Preliminary findings & Remarks

Coriolis™	Coriolis Compact
1 micron particle capture efficiency = 30% from 3000 L of air sampled at a concentration of 0.562 cm^3.	Recovery of PSL is very difficult – Could this be possible to electrostatic charging.
Coriolis™ capture medium could be changed to see if there is improved capture efficiency. Currently DI water is used.	Optimisation of recovery is required due to preliminary data showing variation in collection data.
Preliminary data shows that the Coriolis™ can capture PSL more effectively compared to Coriolis Compact. Same flow rate not yet tested.	Use of glass beads to more efficiently remove PSL from the walls of collector.
Improving capture efficiency for smaller particles will be critical for bioanalysis.	Optimisation required to reduce electrostatic charging in dry cyclone.

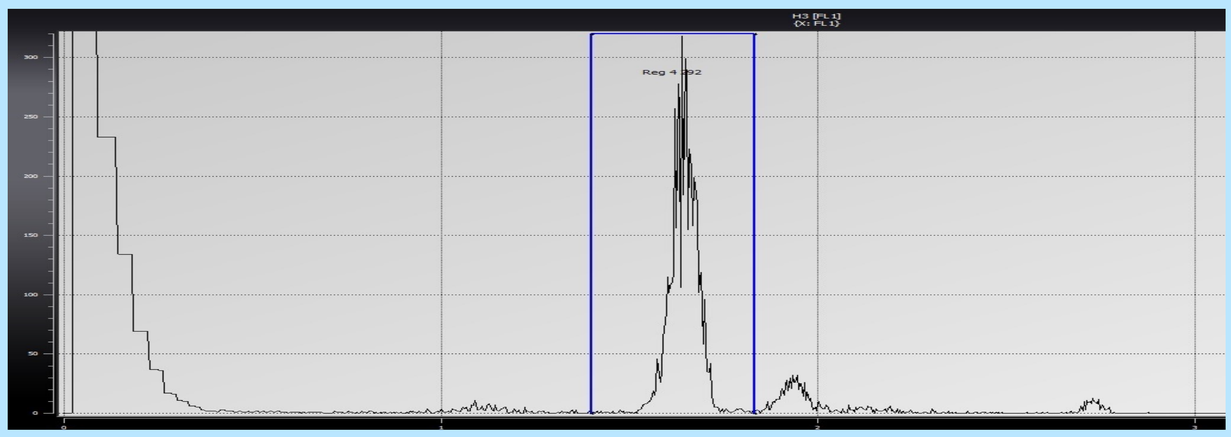


Figure 9. shows the fluorescence Peak of 1 micron PSL beads through flowcytometry.

References

(1)Coudron, L., McDonnell, M., Munro, I., McCluskey, D., Johnston, I., Tan, C. and Tracey, M., 2019. Fully integrated digital microfluidics platform for automated immunoassay; A versatile tool for rapid, specific detection of a wide range of pathogens. *Biosensors and Bioelectronics*, 128, pp.52-60.

(2) Liu, D., Van Belleghem, J., de Vries, C., Burgener, E., Chen, Q., Manasherob, R., Aronson, J., Amanatullah, D., Tamma, P. and Suh, G., 2021. The Safety and Toxicity of Phage Therapy: A Review of Animal and Clinical Studies. *Viruses*, 13(7), p.1268.

(3) Machado, G.T., Pinto, C.R.d.C., da Fonseca, L.A.V. *et al.* Bacteriophages as surrogates for the study of viral dispersion in open air. *Arch Microbiol* **203,** 4041–4049 (2021).

(4) Yap ML, Rossmann MG. Structure and function of bacteriophage T4. *Future Microbiol*. 2014;9(12):1319-1327. doi:10.2217/fmb.14.91