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Kromek Automated Pathogen Scanner –Air Targeted (KAPscan^{TM}-AT)

A novel fully automated and autonomous platform to detect specific airborne pathogens

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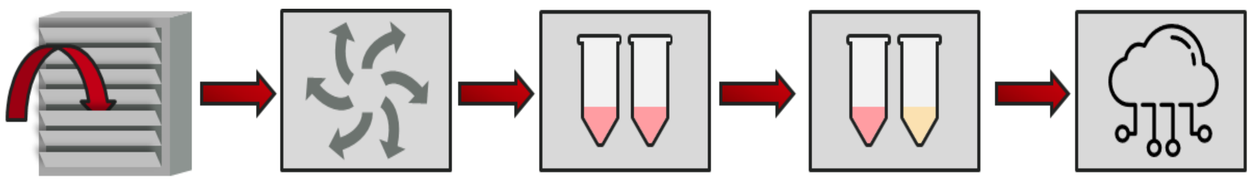
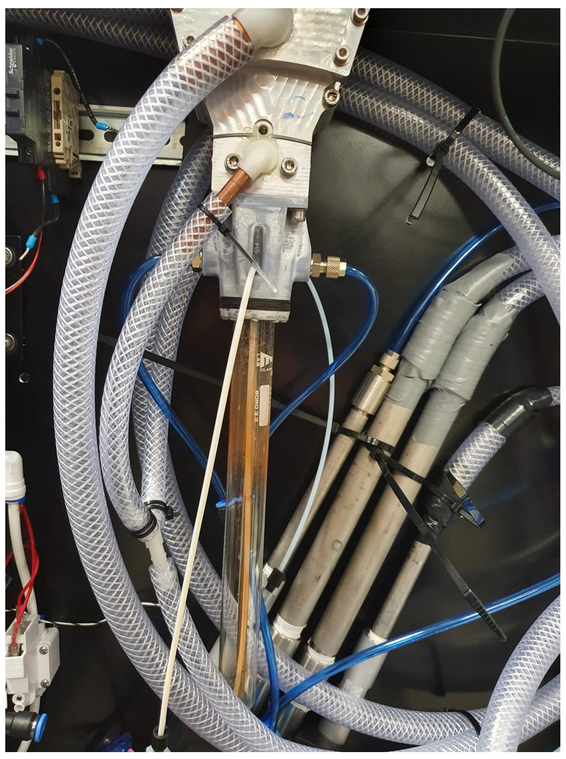
The need

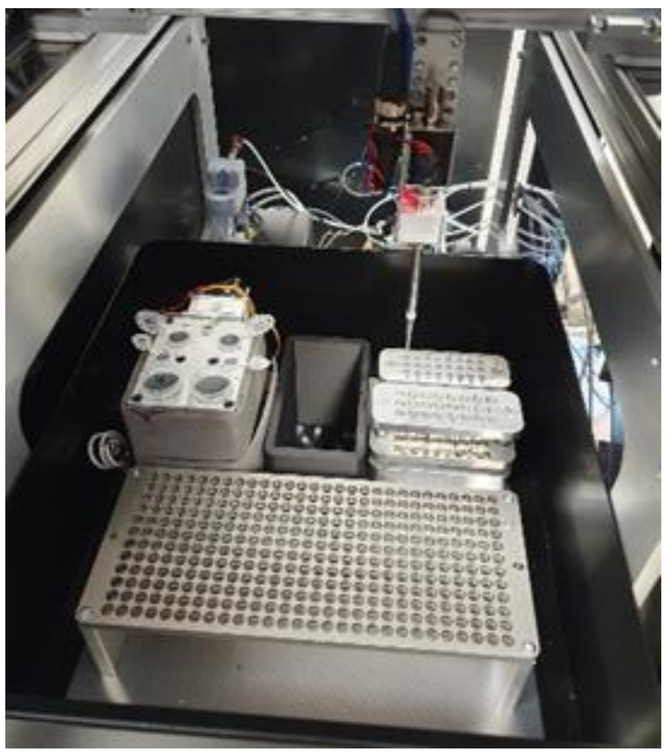
We developed a fully automated indoor biosensing system (**K**romek **A**utomated **P**athogen **Scan**ner–**A**ir **T**argeted (KAPscan^{TM}-AT)) that detects the presence of airborne pathogens using a molecular assay based on loop mediated isothermal amplification (LAMP). This building monitoring device mitigates the health, social and economic impacts of bioweapons and pandemics by detecting specific airborne pathogens. It creates an early alert for remote surveillance systems when a clean site is compromised, allowing for decontamination and Test & Trace processes to start immediately, reducing the chances of an exponential transmission from continuously monitored buildings. The system design can be easily adapted to any new and existing airborne biological threats (viral or bacterial) as single targets or multiplexed. First responders or military personnel already benefit from ultra-reliable DNA based lab analysis in the field. Existing solutions needed manual handling and were unsuitable for static autonomous building applications.

The concept



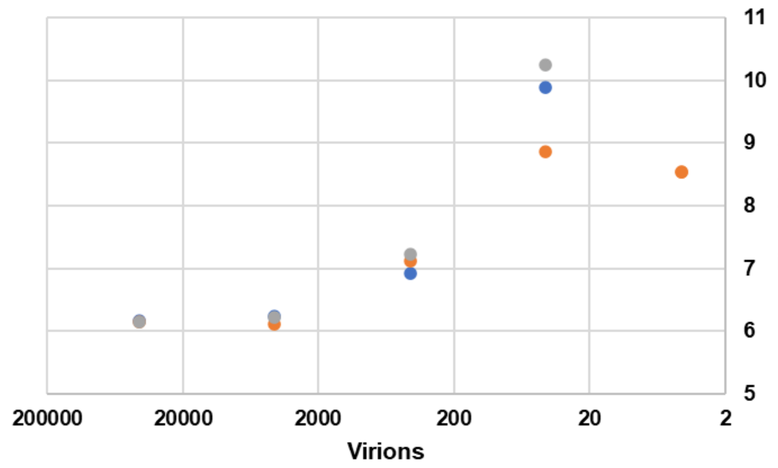
KAPscan^{TM}-AT is the world's first autonomous SARS-CoV-2 detector using automated air sampling, processing in combination with a targeted molecular assay. The process (see above) takes 60 minutes from sampling to reporting of results. It continuously delivers new results every 30 minutes and runs autonomously for up to 24 samples per day. Its flexible LAMP platform allows the quick development of new assays targeting new and emerging pathogens. The assay is designed to detect a genomic region with a low mutation rate, not associated with known phenotypic and pathogenic viral traits and therefore with high probability of detecting variants. The assay is rapid (30 minutes) with a colorimetric readout. For quantitative purposes, the detection can be performed with fluorescent intercalating dyes.





The air inlet and bespoke Impinger air sampler (left). The robotic arm and LAMP assay are placed in an enclosure (right).

Testing lysis, extraction and fluorescent LAMP assay ability in detecting 40 copies of attenuated SARS-CoV-2 viruses.



The assay was run in triplicates and the time to detection was recorded. No false positives were detected, and each concentration of virus was performed in triplicate. Every repeat series is represented in a different colour. Only one out of the three series gave a result for 4.2 virions as starting material.

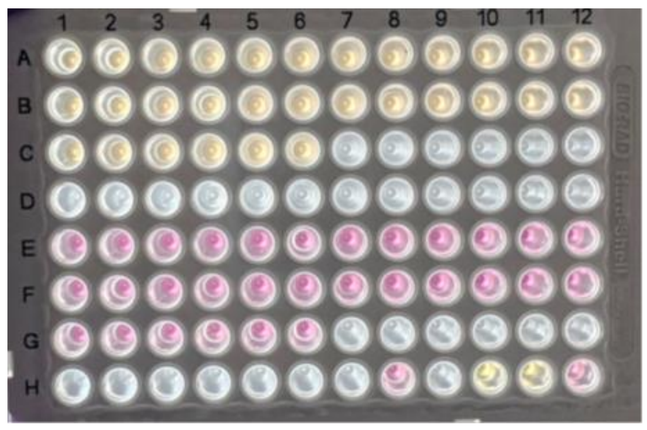
The upper bound of the lower limit of detection (LOD) of the assay against attenuated virus with our lysis protocol is 40 viral copies. In other laboratory tests the assay has shown specificity of 100% (90/90) when tested against other viral RNA, bacterial RNA or RNA from other parts of the SARS-CoV-2 genome.

Units have been installed in various locations ranging from airports, schools (right), to hospitals and wastewater plants (bottom left).

LAMP assay is as accurate as 'Gold Standard' TaqPath RT-qPCR assay, but much faster

The assay was tested by an independent laboratory, the Integrated COVID Hub in the North-East (ICHNE), on clinical samples of α and β variants of SARS-CoV-2 isolated with the ICHNE laboratories protocol and compared to their PCR diagnostic assay (TaqPath COVID-19 CE-IVD). The assay showed excellent specificity and sensitivity (30/30 negatives and 30/30 positives) on clinical samples that ranged from high to low viral load. It was able to detect down to the lowest sample viral load of 100 viral copies. It outperformed the diagnostic PCR in terms of speed (30 mins versus 45 mins).

Colorimetric output of the LAMP assay post-run (right) shows the plate, immediately after completion. Positive samples (yellow), as determined by the TaqPath RT-qPCR assay, are in wells A1-C6. Negative samples (pink) are in wells E1-G6. The no-template control (NTC) is in well H8 and the three positive controls are in wells H10-H12.



Coverage and efficiency of indoor air sampler

In order to plan tests for the KAPscan^{TM}-AT indoor air sampler, we placed particle counters around a model flat, sprayed salt aerosol for 2 mins and then assessed the best place for air sampler position. In a closed indoor setting of approx. 50-100 m^3, with the HVAC system both on and off, the aerosol quickly (within minutes) reached a stable distribution around the room, regardless of particle size. Therefore, for a 30 mins batch sample, we have no concern about spatial distance for this setting.

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