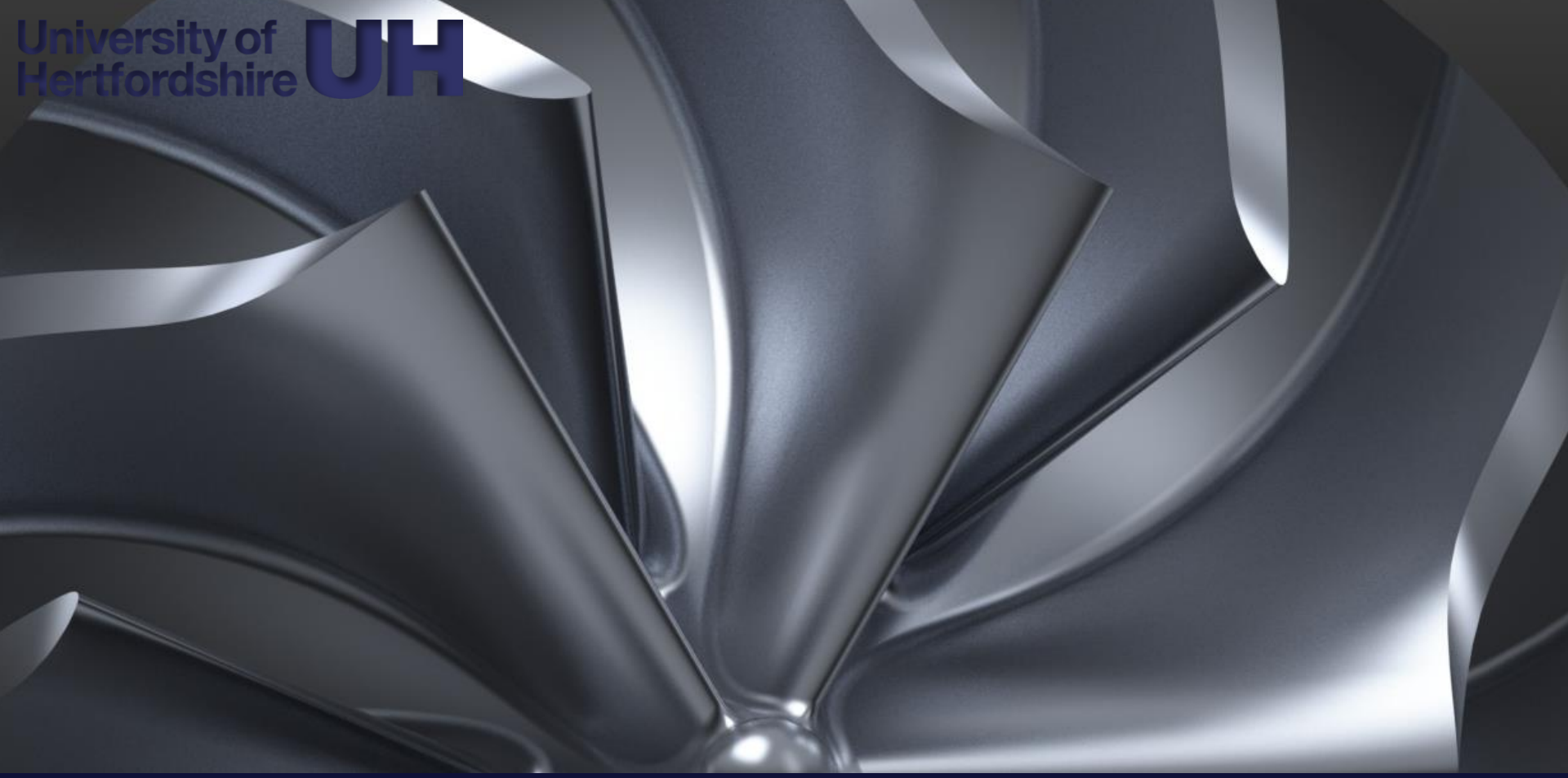

Design of a high efficiency cyclone for collection of rare and low concentration airborne pathogens

Baxter, R; Johnston, I; Kaye, R; Munro, I; Tracey, M; Day, R; & McCluskey, D

[1]University of Hertfordshire, MEMS research Group, Hatfield, UK

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Who we are

- University of Hertfordshire's MEMS group conducts applied research in microfluidics and micro engineering

  ➔Concept design

  ➔Experimental testing

  ➔System delivery

- BBSRC project - work package 4: Airborne spore trapping networks, improving understanding of spread and development of a distributed network (spore trapping)

Research Assistant :- Richard Baxter BEng MSc

Supervisor/Chief Engineer :- Dr Dan McCluskey

Head of group :- Professor Mark Tracey

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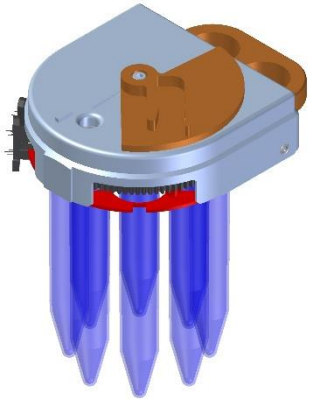
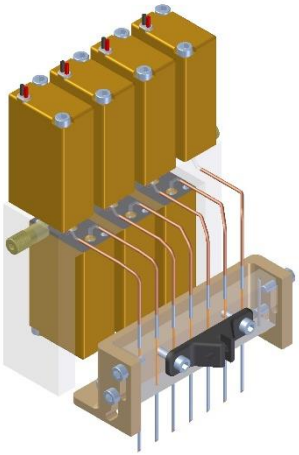
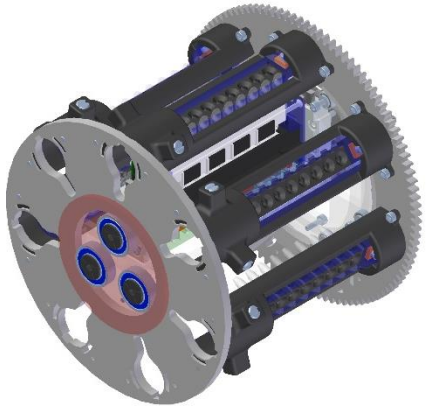
System overview

Target Pathogen is Chalara Fraxinea. This pathogen is responsible for Ash dieback that has been killing Ash trees in Europe and is now established in the UK

Air Sampling → Fluid Handling → Detection







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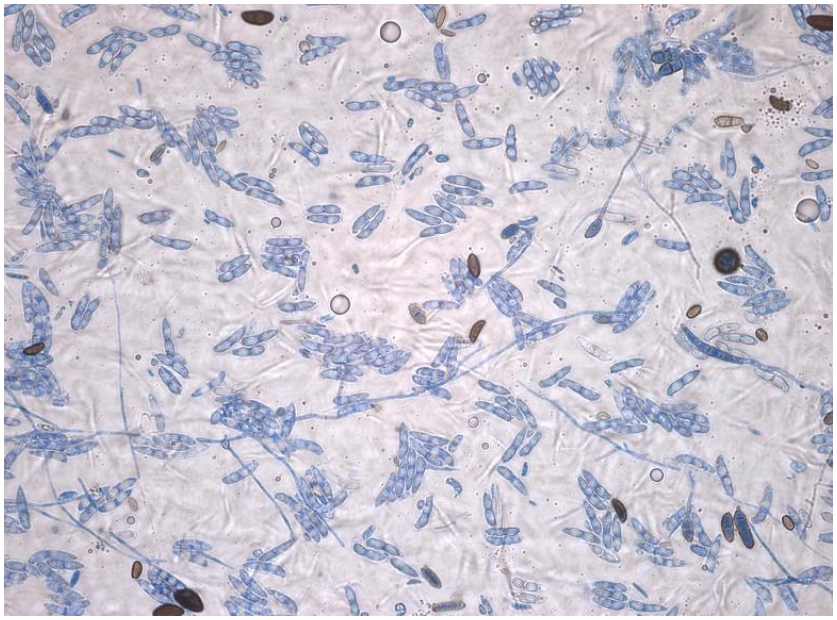
Chalara Fraxinea



CF spores dyed with cotton blue at x400 magnification, courtesy of Ian Britain, FERA

Spore size
Important to know the target specification for our Airborne sampler

Common name	Pathogen	Particle Size (µm)
Ash dieback	Hymenoscyphus fraxineus (Chalara Fraxinea)	17.6-28
Septoria leaf blotch	Septoria tritici	2x50
Yellow Rust	Puccina Striiformis	22x17
Brown Rust	Puccinia Triticina	22x27

Table of some economically important agricultural pathogens

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Cyclone design

Two main types of Cyclone:-

1. Axial
2. Reverse flow

Main Design Specifications:-

- 7 day sampling
- High volumetric air flow (100 L/min)
- Consumable part that can disposed of for contamination purposes
- High collection efficiency for the particle size range
- Chemically resistant (Teflon, Laser sintered PA 2200, Polypropylene)

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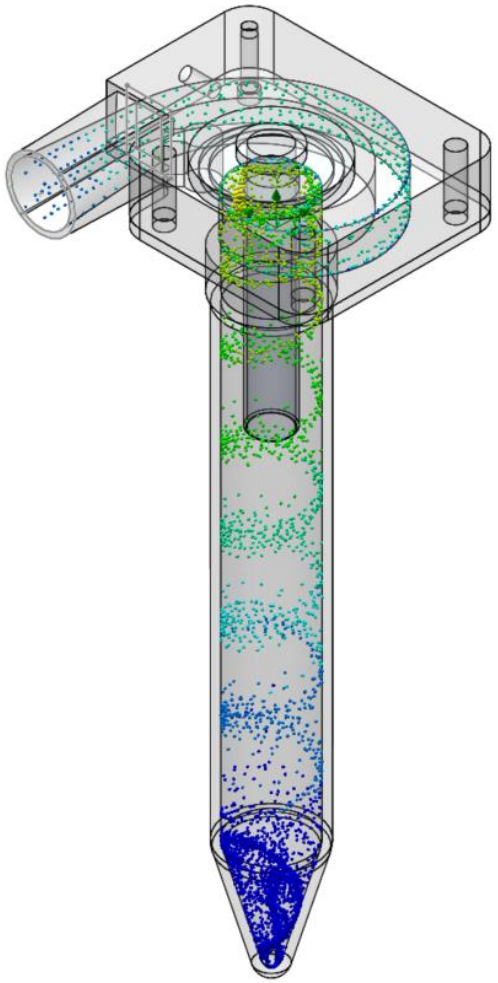
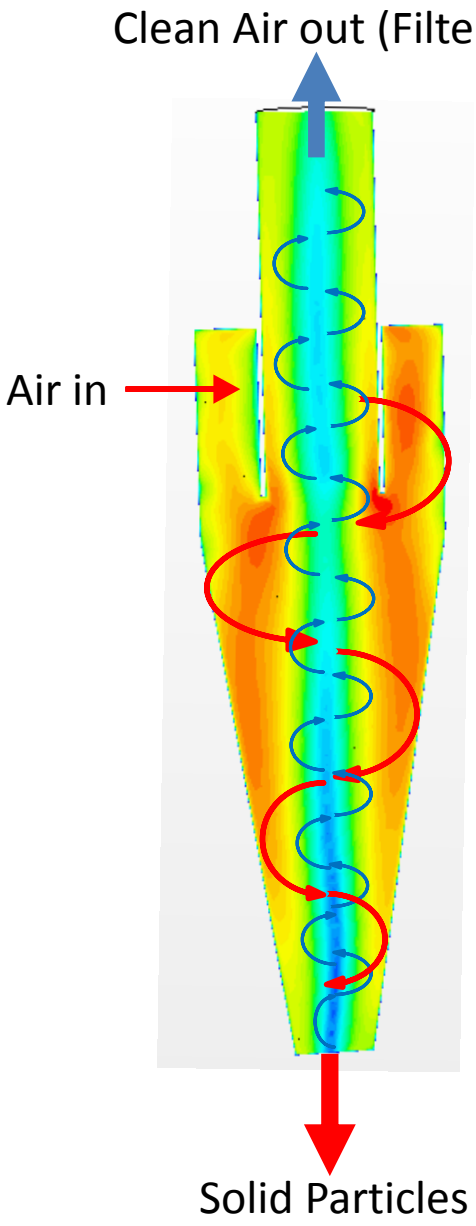
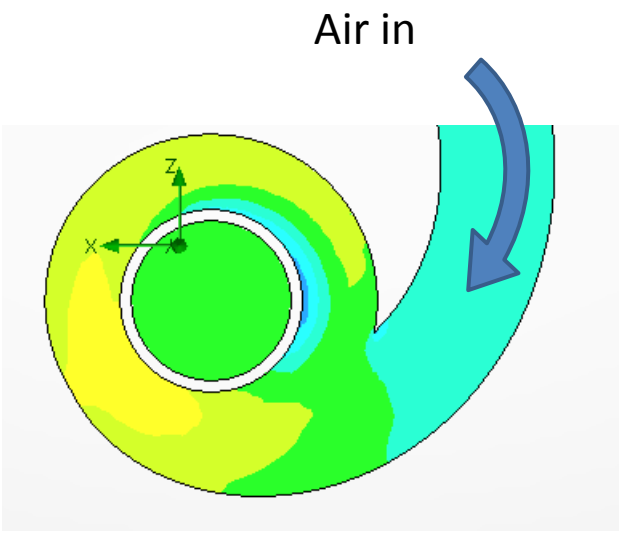
Cyclone theory







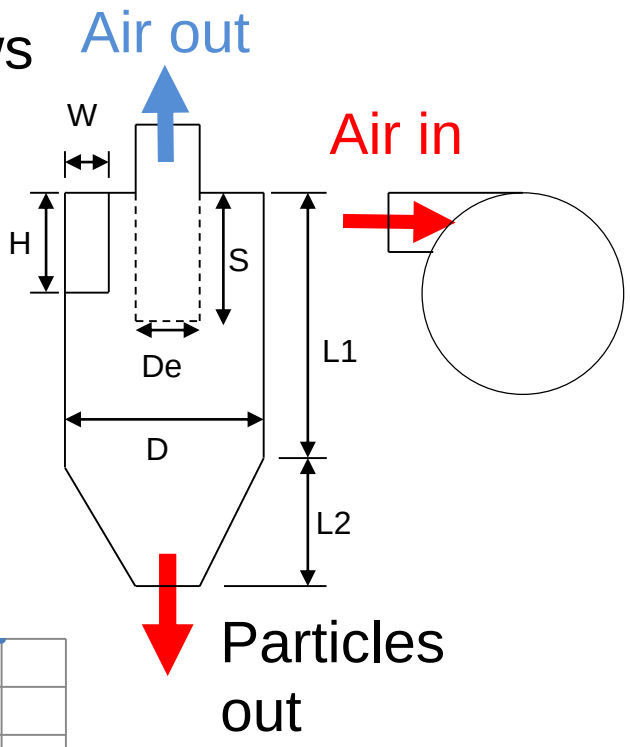
University of Hertfordshire has research licenses for

1. STAR CCM+
2. ANSYS CFX
3. Solidworks Flow Simulation

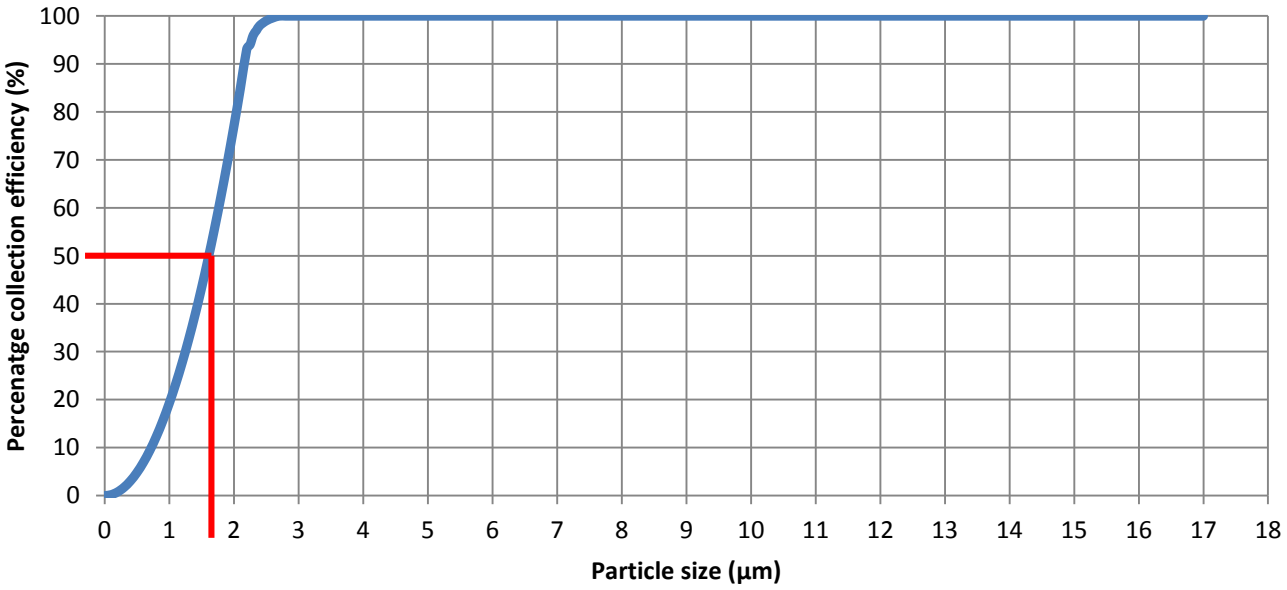
Cyclone theory

Initial Stairmand design ratio used as follows

Symbol	Description	Ratio	Stairmand
D	Body diameter		1
H	Inlet height	K_H = H/D	0.5
W	Inlet width	K_W = W/D	0.2
S	Outlet length	K_S = S/D	0.5
De	Outlet diameter	K_{De} = De/D	0.5
L1	Cylinder height		1.5
L2	Cone height		2.5



Calculated Cyclone Collection Efficiencies



50% Cut size = 1.613 µm

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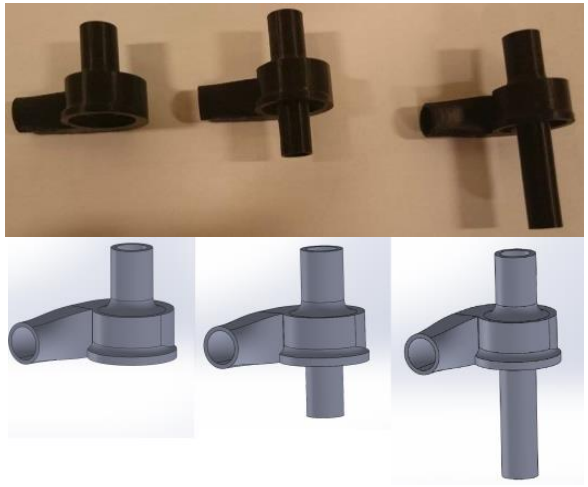
Design iterations

Many different designs were designed and tested

Centrifuge Tube	Inner Diameter	Outer Diameter	Length
50 ml	27.5 mm	29.5 mm	114.2mm
25 ml	21.9 mm	24.9 mm	90 mm
15 ml	**14.5 mm**	17.3 mm	120 mm
5 ml	14.2 mm	15.9 mm	57 mm



3D Printed ABS plastic

PA 2200 Laser sintered cyclone with PEEK tube

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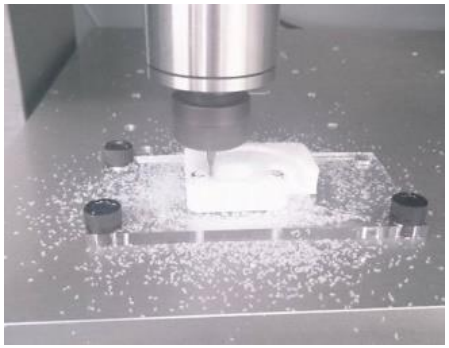
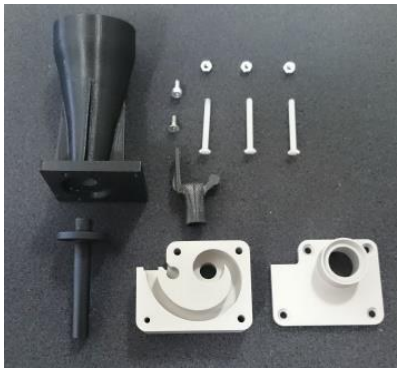
Final Design

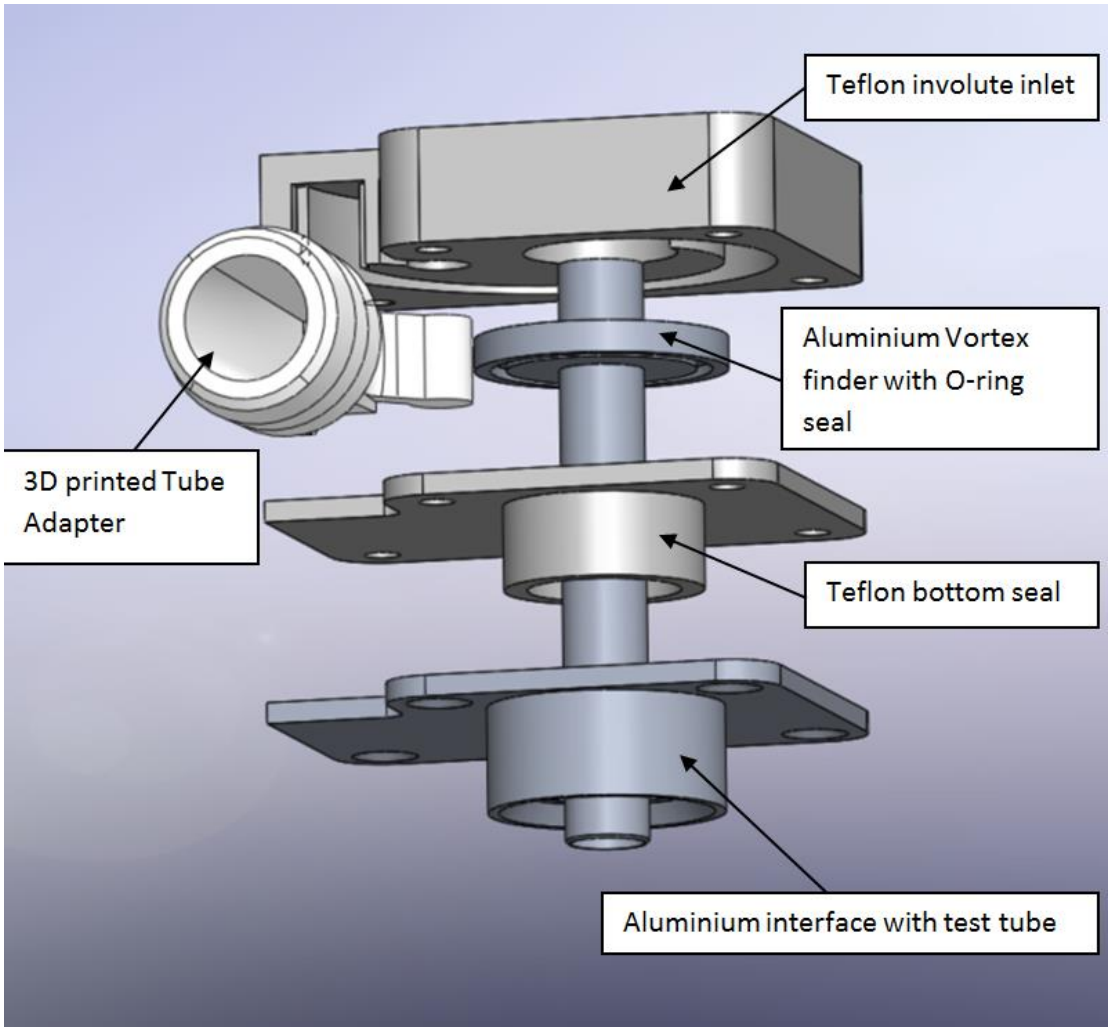
3D printing

In House Manufacturing



3 Axis CNC





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Cyclone Testing

- Particle deposition on falcon tube

	3µm	5µm	50µm
Flow rate (L/min)	150	150	150
Collection Efficiency	96.1%	98.3%	99.1%

SO_2 (Silica) spheres
Mean = 3 µm
σ = +/- 0.8 µm

SO_2 (Silica) spheres
Mean = 5 µm
σ = +/- 1.9 µm

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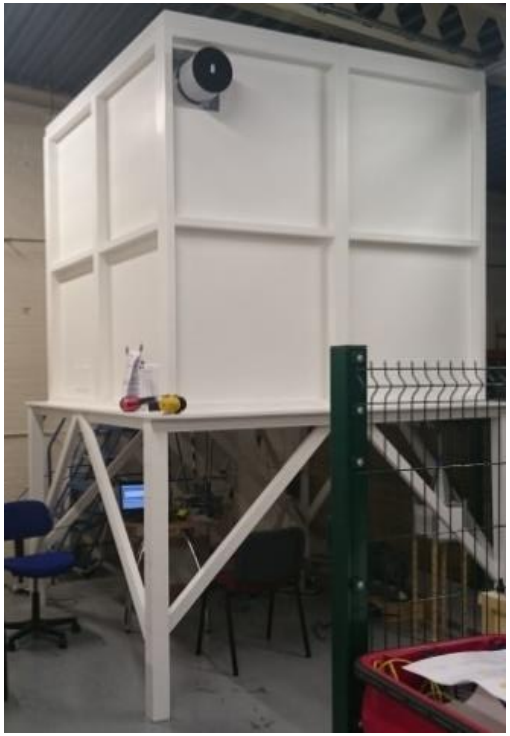
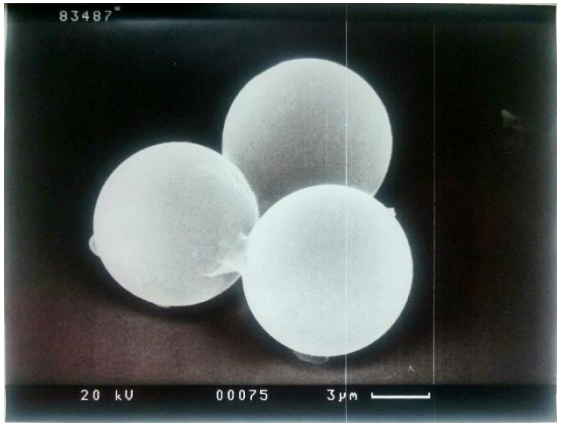
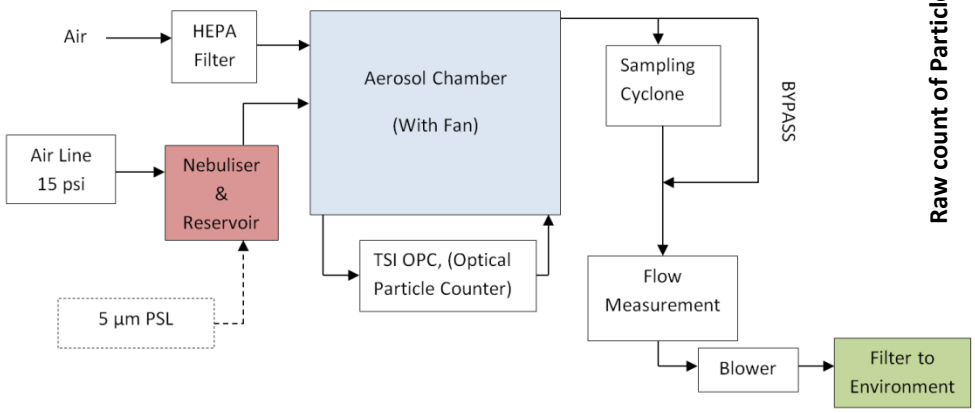
Aerosol Chamber Testing

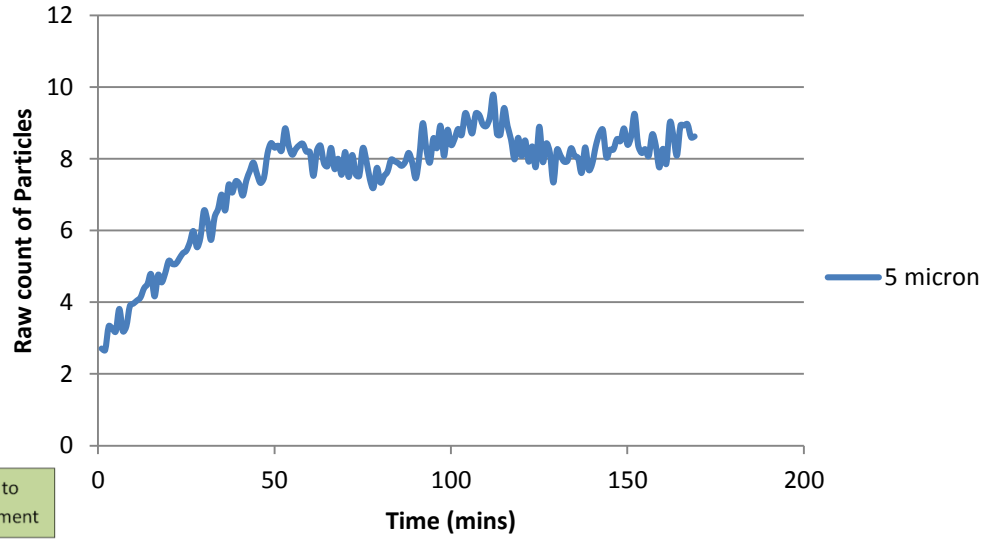




PSL
Mean = 2.9 µm
Uniformity = <5%

PSL
Mean = 5 µm
Uniformity = <5%





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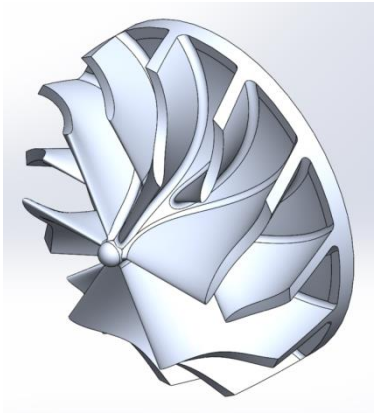
Impellers

Main Design specifications :-

- Low power
- Flow rate of 100 L/min
- Pressure requirements

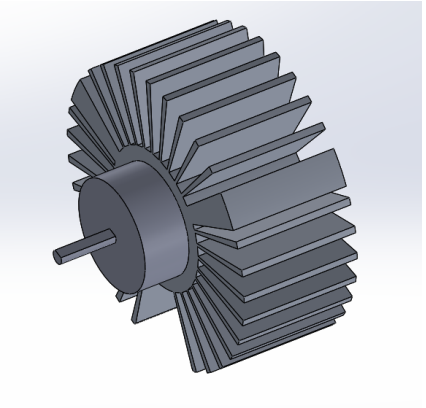


Impeller

High rpm ~ 20,000 rpm
Pressure ratio of 1.2

Volute

Compact
Good pressure recovery



Motor and Heat sink

Brushless Motor
Aluminium heat sink

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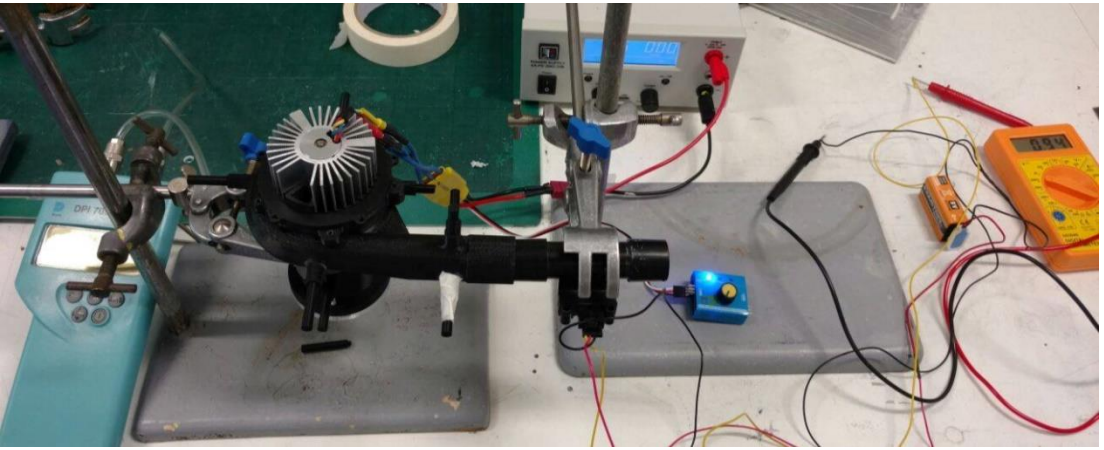
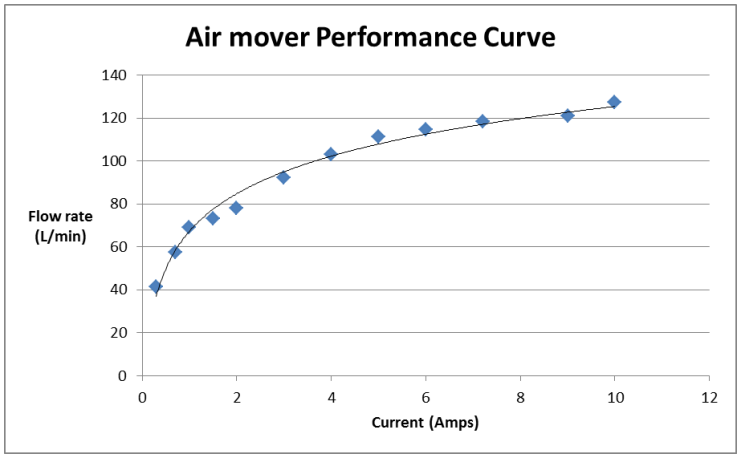
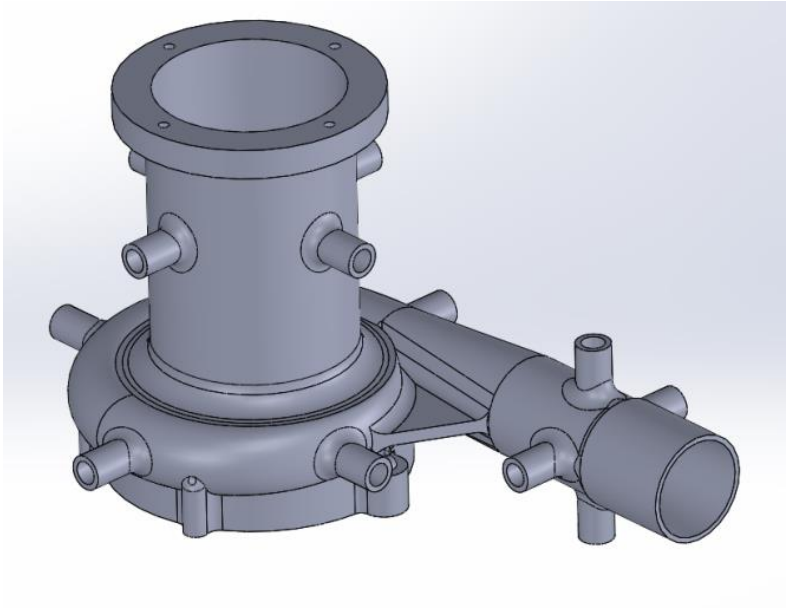
Impeller Testing

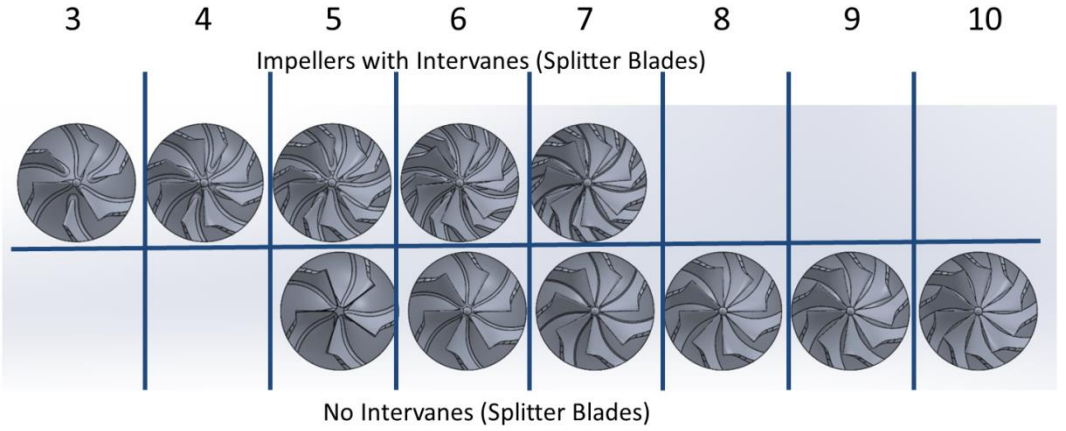






Test rig for impellers

Number of Vanes



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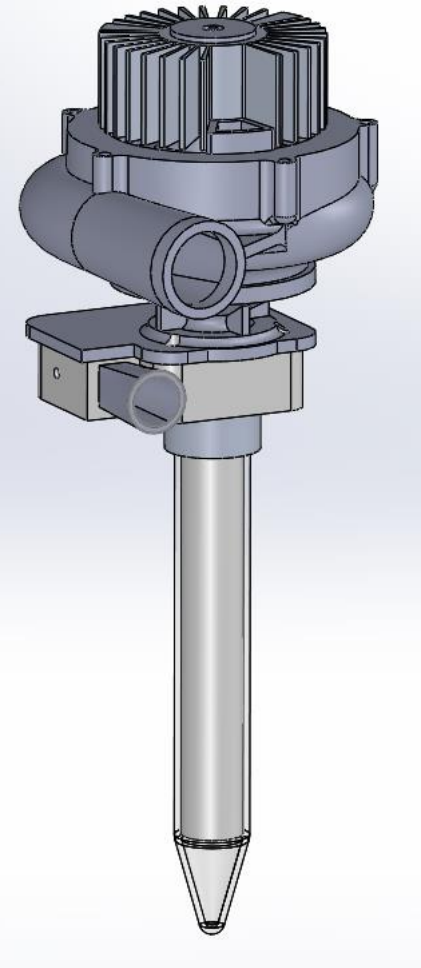
Summary



Presented today was Airborne collection of spores in the Chalara Fraxinea size range

- Novel Cyclonic collector
- Energy Efficient Air mover

Further optimisation of the efficiency and operation of the cyclone is a focus of ongoing work.

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Thank you for listening