Design and Construction of an Instrumentation Pack for the Ring Vortex Complex Flow Phantom

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Background

- The ring vortex complex flow phantom has been in development, designed to assess quantitative flow medical imaging technologies, such as Doppler Ultrasound and MRI.
- The phantom consists of a motor, piston, and circular orifice connected to a tank of water. The piston pushes water through the orifice, generating a ring vortex in the tank. The device generates reproducible ring vortices to within 10%
- The primary objective of the project was the design and development of an instrumentation pack for the ring vortex complex flow phantom, which would allow characterisation of the ring vortices in real time.

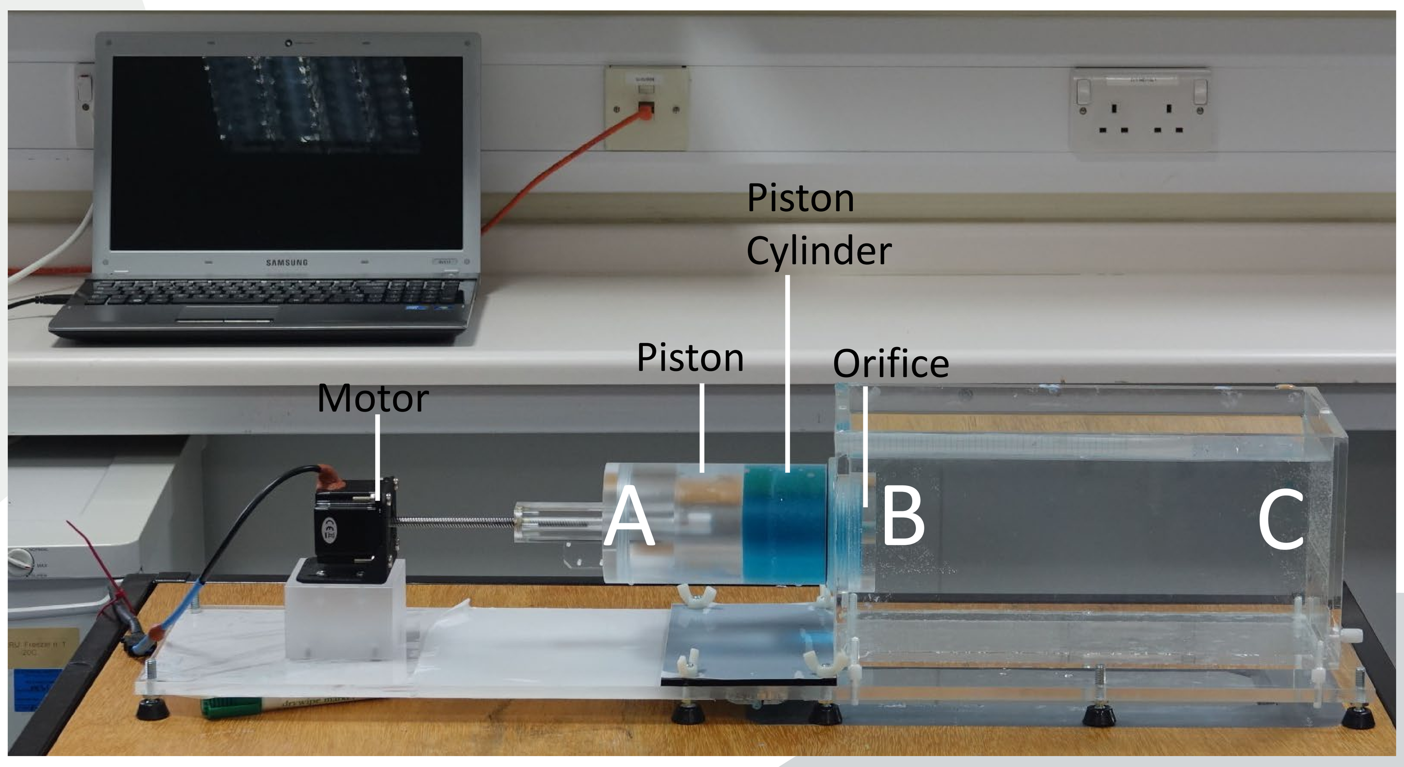

Fig1: The complex flow phantom.

Methods

The project was spilt into three components:

Encoder

- A linear encoder measures the displacement of the piston at 1kHz.
- A MATLAB programme was written to classify each velocity profile as normal or abnormal.

Lasers

- The lasers are used to calculate ring speed, as the rings cut each beam.
- An electronic circuit to detect the beam was designed and built.
- A MATLAB program was written to calculate the ring speed.

Doppler Probe

- A 5MHz Doppler Ultrasound Probe attached at one end of the phantom was used to detect the micro-velocities of the ring vortices.
- A MATLAB program was written to detect the correct frequency.

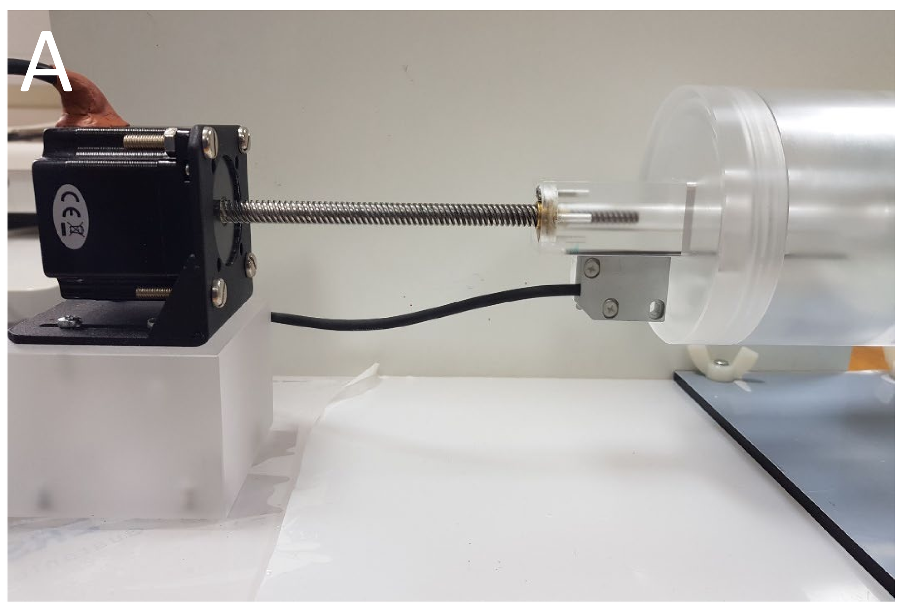

Fig.2: Linear Encoder used to measure piston displacement.

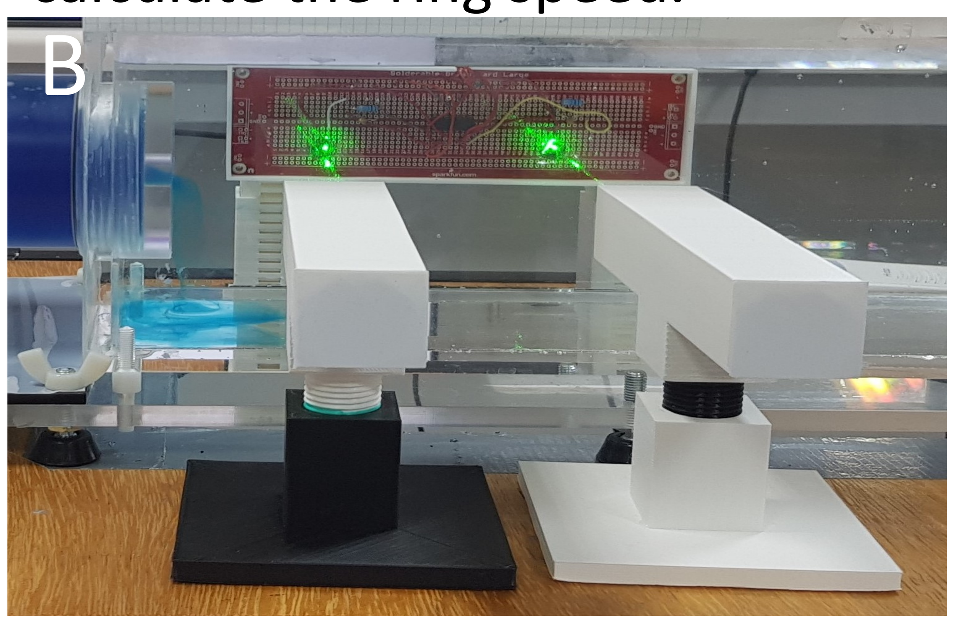

Fig.3: Laser setup used to calculate ring speed.

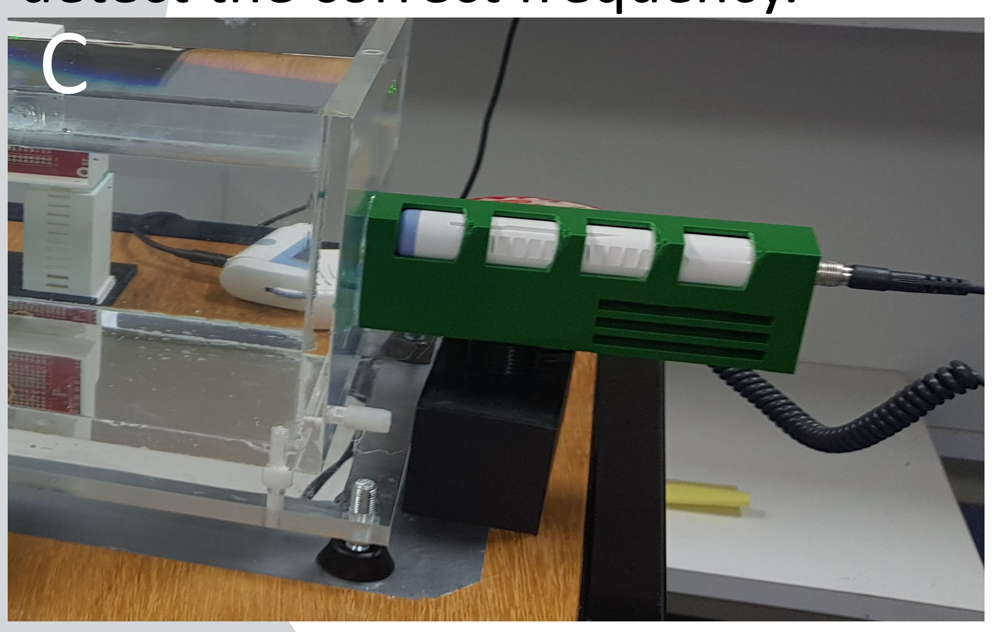

Fig.4: Probe used to detect ring.

Results

Encoder

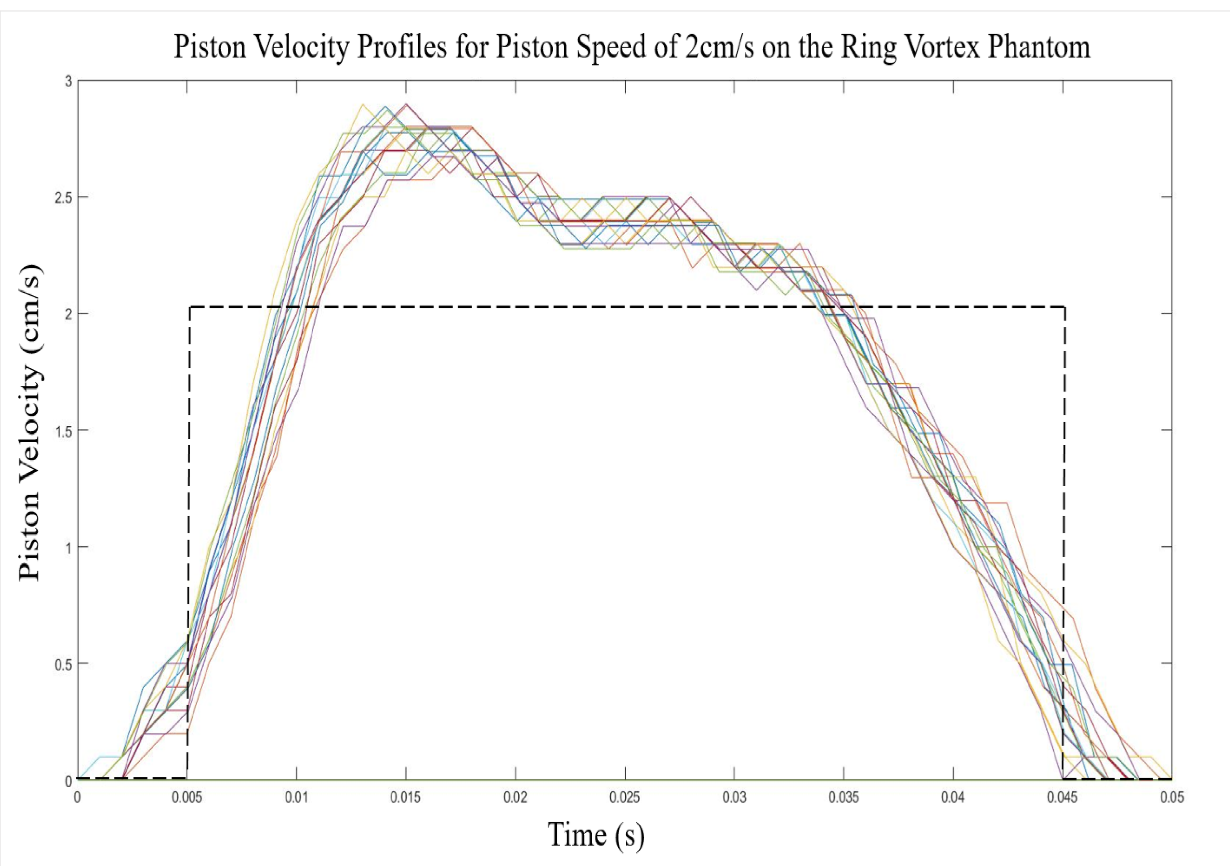

Fig. 5: Piston velocity profiles for piston speed of 2cm/s on the Ring Vortex Phantom. The dotted lines represent the ideal velocity profile. It can be seen that the velocity profiles of each ring are reproducible.

Lasers

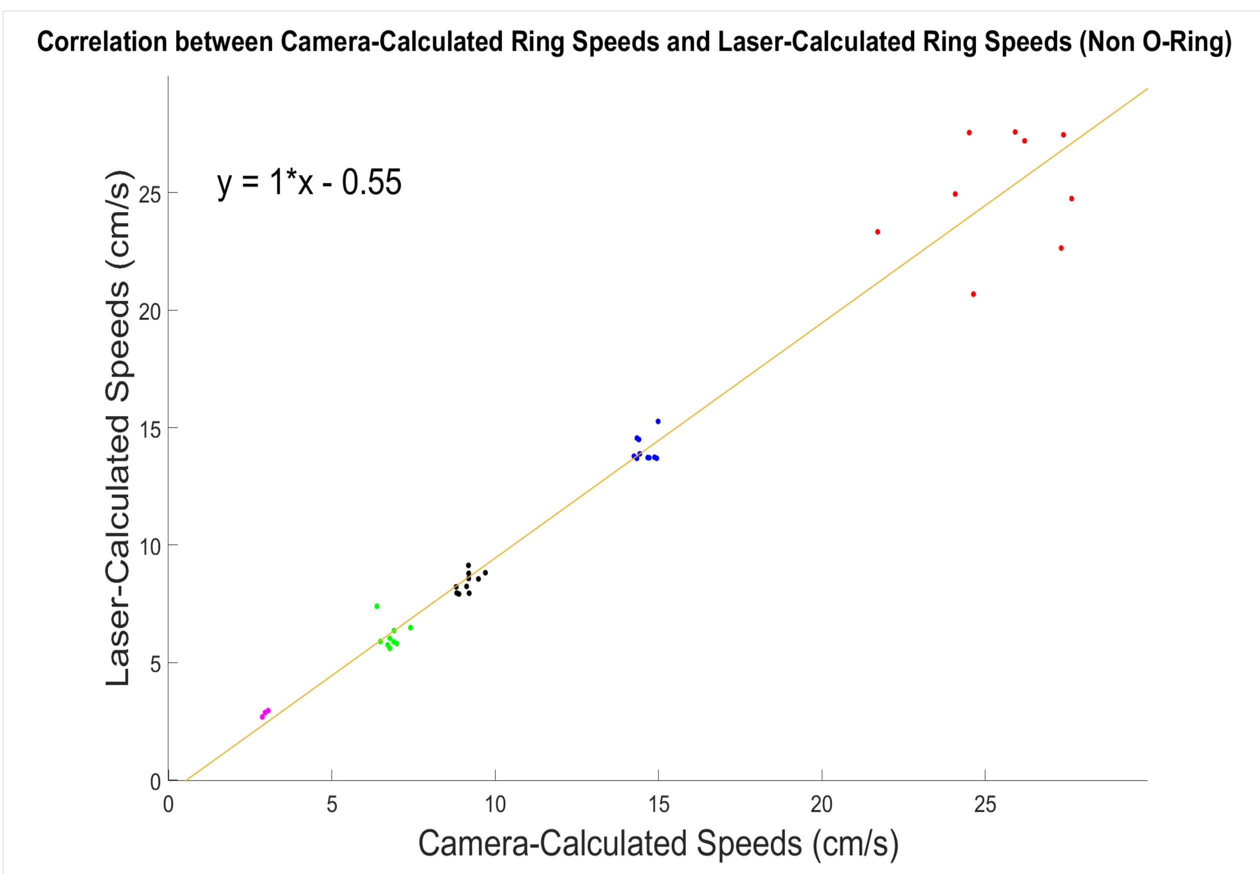

Fig. 6: Correlation between camera-calculated ring speeds and laser-calculated ring speeds. A positive correlation exists between the camera-calculated speeds and the laser-calculated speeds.

Doppler Probe

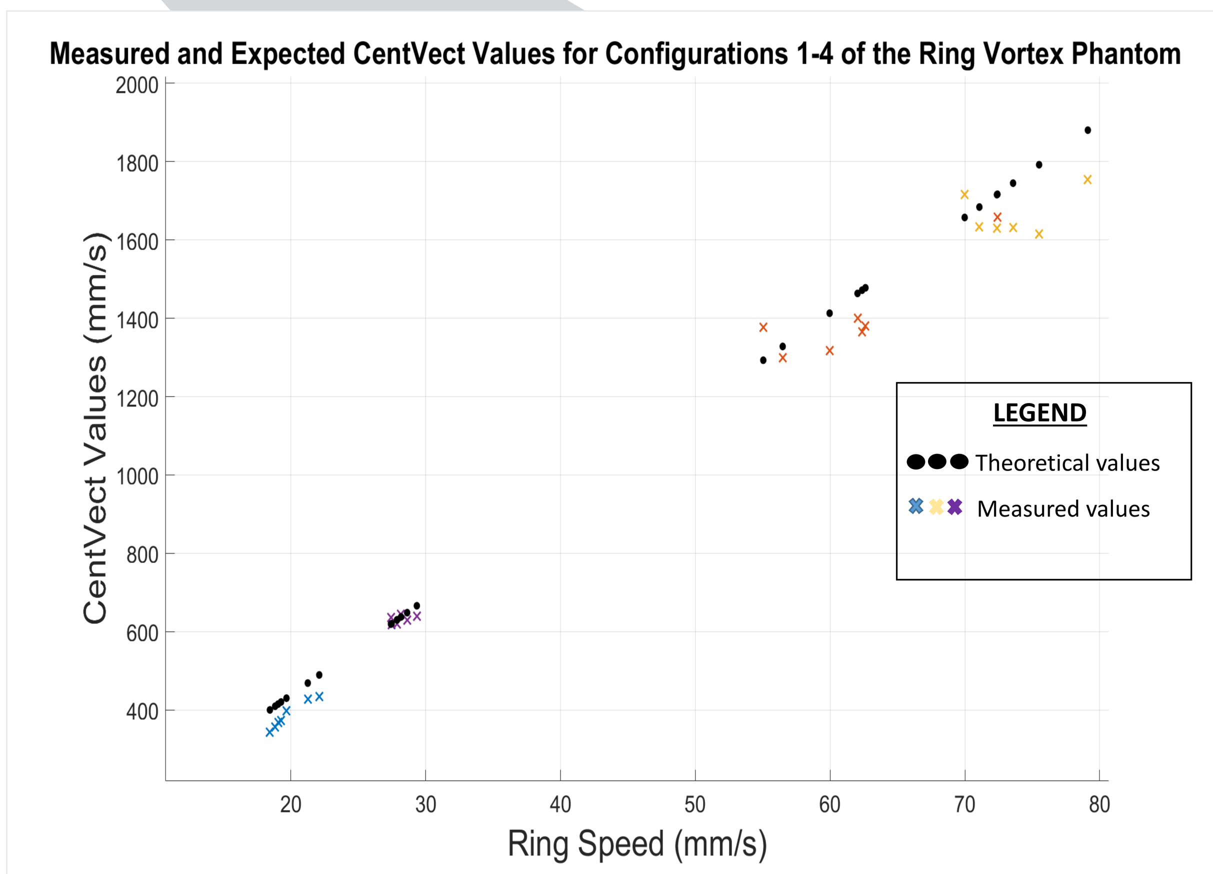

Fig. 7: Measured and expected micro-flow velocity values for different piston speed and orifice configurations. A positive correlation exists between micro-flow velocity values and ring speed. Measured values of configuration 2 are very close to its theoretical values.

Conclusions

- An instrumentation pack that characterized the phantom's piston velocity profile, ring vortices' speeds as well as micro-velocities was constructed and refined.
- The three parts of the project: encoder, lasers and probe, were all streamlined into one MATLAB user interface where the values of the desired parameters were displayed.
- This will help in future design alterations for the phantom.

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