# Minimising flow losses within the pulse tube of a Stirling pulse tube cryocooler

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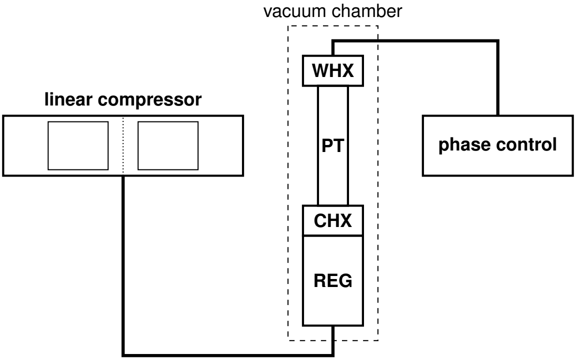
# Outline

- Stirling pulse tube cryocooler
- Numerical model
- Alternative designs
- Results: temperature
- Results: velocity
- Results: average pressure
- Conclusions and future work

# Stirling pulse tube cryocooler (SPTC)

- Small low temperature refrigerators, typically 50 K to 80 K (single stage)
- Provide cooling for infra-red sensors and superconducting devices
- The pulse tube within an SPTC acts as a gas spring and replaces the cold end displacer used in traditional Stirling cryocoolers.
- Phase control can be achieved via an orifice, an inertance tube or a warm end displacer
- **Gas within pulse tube needs to remain stratified and flow mixing must be minimised**

# Stirling pulse tube cryocooler (SPTC)



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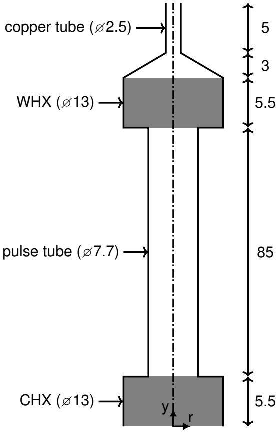
- 2D axis-symmetric model
- $u_{\mathrm{WHX}} = 31.7 \sin(2\pi f t)$ m/s
- $P_{\mathrm{CHX}} = 28 + 3 \sin(2\pi f t + 4\pi/3)$ bar
- Operating frequency $f = 60\,\mathrm{Hz}$
- Cold end temp $T_c = 80\,\mathrm{K}$
- Warm end temp $T_h = 300\,\mathrm{K}$
- Standard $k - \varepsilon$ RANS turbulence model
- Carried out in CONVERGE CFD (`convergecfd.com`)




**Design A**

# Alternative designs

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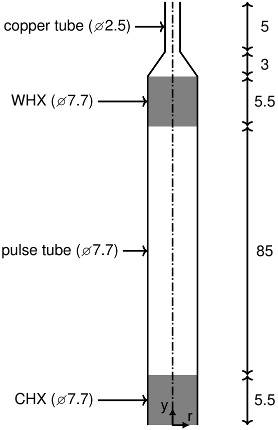
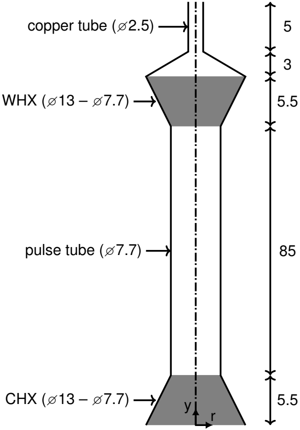
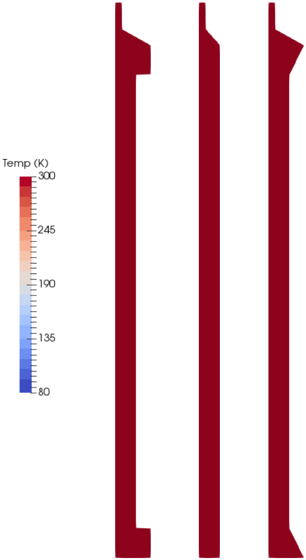


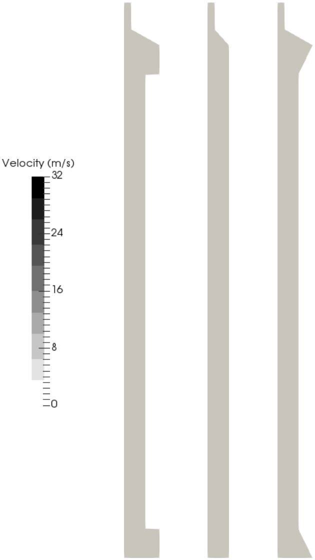

**Design B**




**Design C**

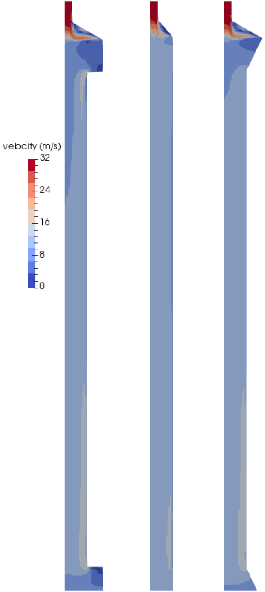
# Results: temperature and velocity



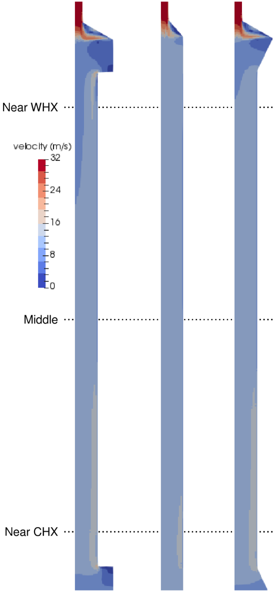



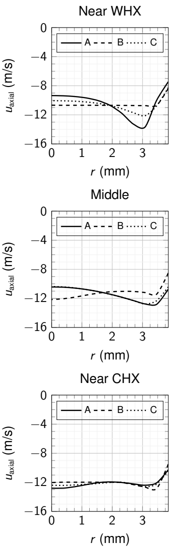
# Results: velocity (WHX to CHX)



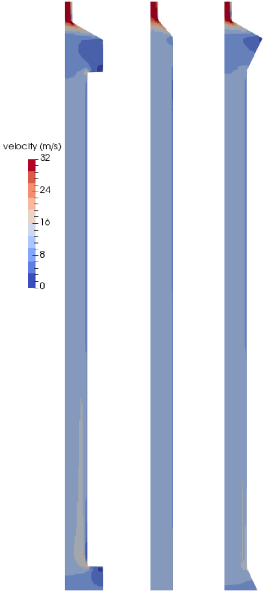


# Results: velocity (WHX to CHX)

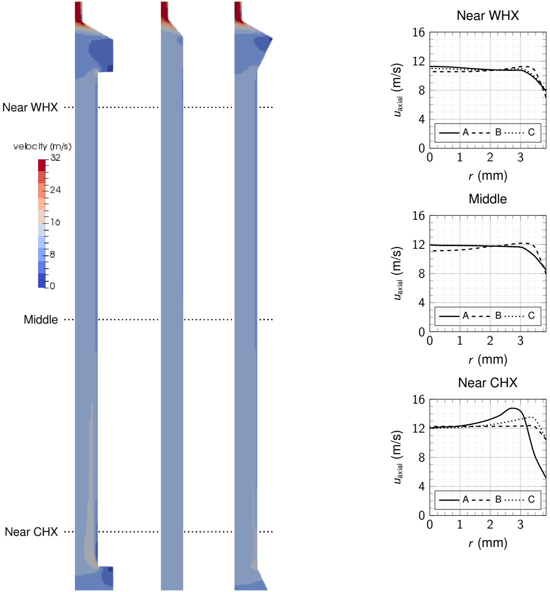


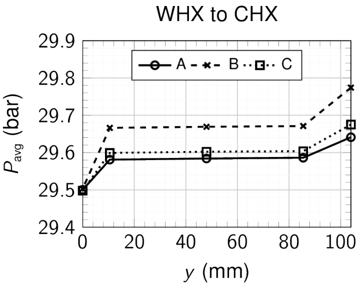
# Results: velocity (CHX to WHX)

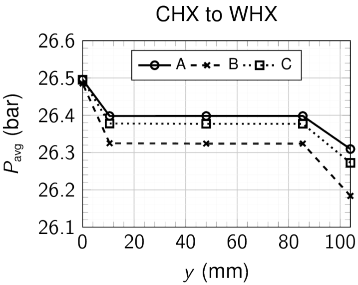


# Results: velocity (CHX to WHX)



# Results: average pressure



# Conclusions

- With the aid of the numerical simulations, a new inlet/outlet has been designed that will reduce flow mixing within the pulse tube
- Based on the velocity profiles, design B is the clear favourite
- However, design B results in a higher pressure drop which **might** have a significant effect on the overall cryocooler efficiency
- Design C is a compromise solution that reduces flow mixing in the pulse tube with a marginal increase in pressure drop

# Future work



- The performance of the three different designs needs to examined experimentally
  - Does increased pressure drop have a significant effect on overall cryocooler efficiency?
- The accuracy of the porous media modelling needs to be examined
  - How does the pressure drop vs mass flow compare against experimental data?
- Expand investigation to see how different wire mesh (i.e. porosities) affects the results
  - Replace 50 wires per inch with a coarser/finer mesh

Thank you for your attention

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