# Thermo-mechanical Prototyping

Tim

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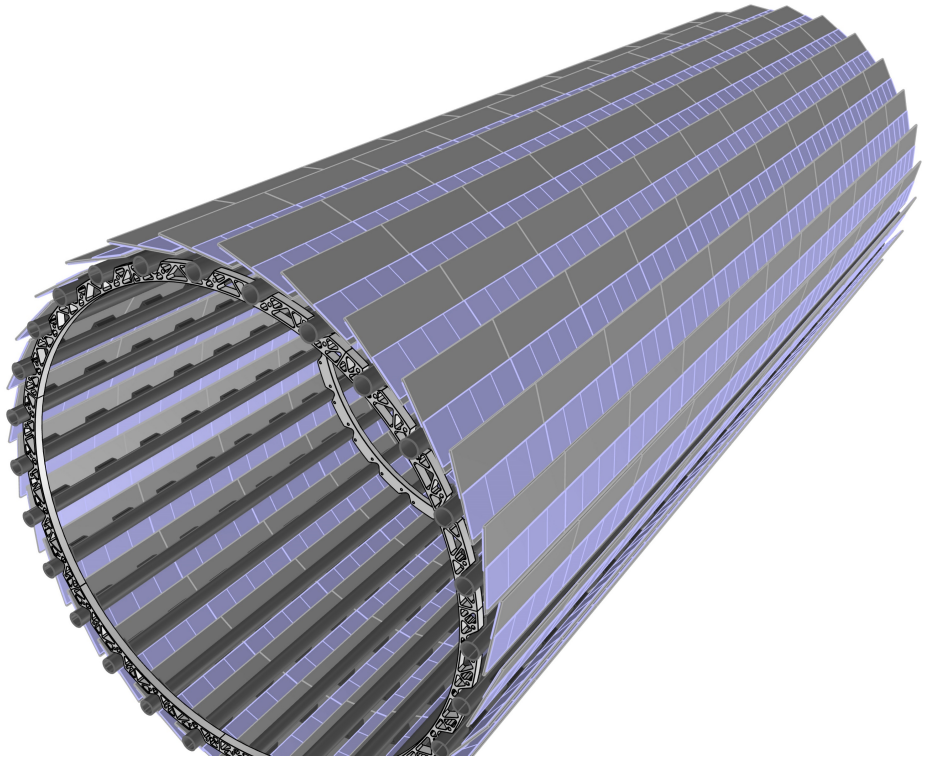
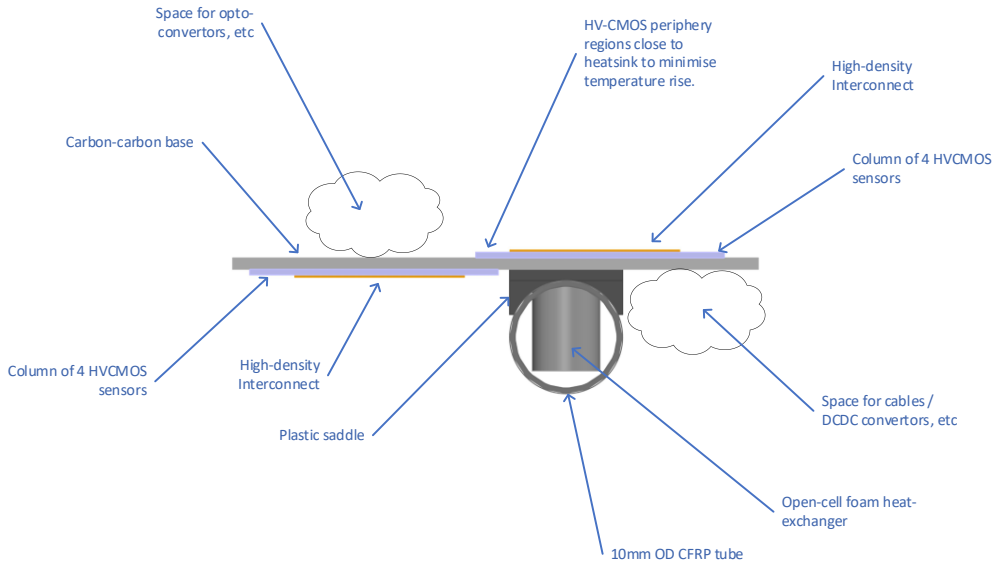
# Stave Concept

- Geometry
  - R=160mm, L=800
  - 28 staves of active width 40mm
- Module
  - 8 HVMAPS sensors in two columns of 4 attached to base-board
- Cooling
  - Gas flow down 9mm ID tube
  - 6mm diameter foam heat-exchangers protruding into channel

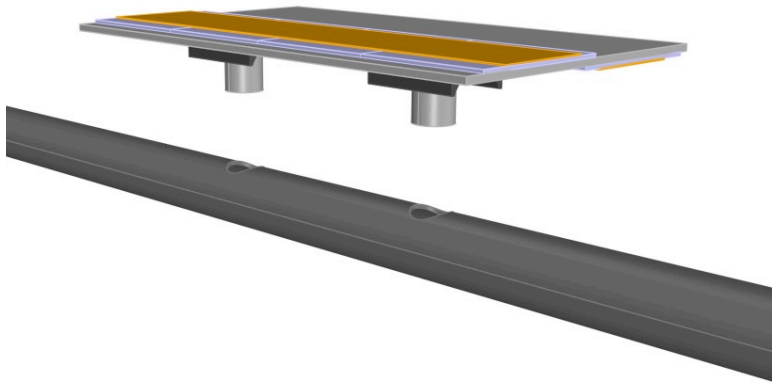


# Module Concept

- HVMAPS sensors glued to base
  - Asymmetric arrangement with peripheral areas as close as possible to the middle
- Base attaches to support tube via two saddles




- Saddles have apertures through which the foam heat exchangers pass and glue to the base
  - Heat flows from the HVMAPS into the base and into the heat exchangers.
  - Heat is removed from the heat exchangers via the passage of a gas.



# Prototypes

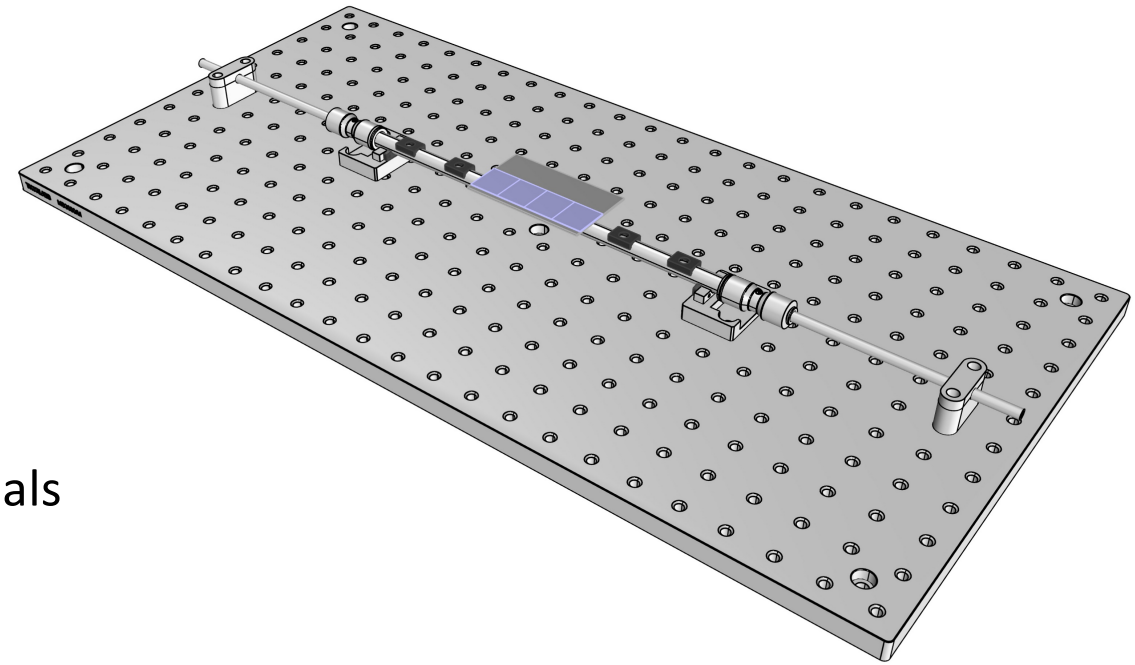
- Thermal
  - Investigate performance of high-thermal conductivity (eg Allcomp) foams as a heat exchanger
    - Combination of high specific area and increased stream velocity through foam should lead to high efficiency
  - Characterize performance (i.e. temperature rise vs power) for different flow velocities and
  - Develop FEA models simulating the fluid flow through foams
- Mechanical
  - Investigate structural properties of a ‘hamster-wheel’ support structure
  - Characterize performance in terms of:-
    - Gravitational Deflection
    - Vibrational response
  - Develop FEA models simulating general properties of such systems.
    - Probably lead to a need to model joints effectively.

# Material Choices…

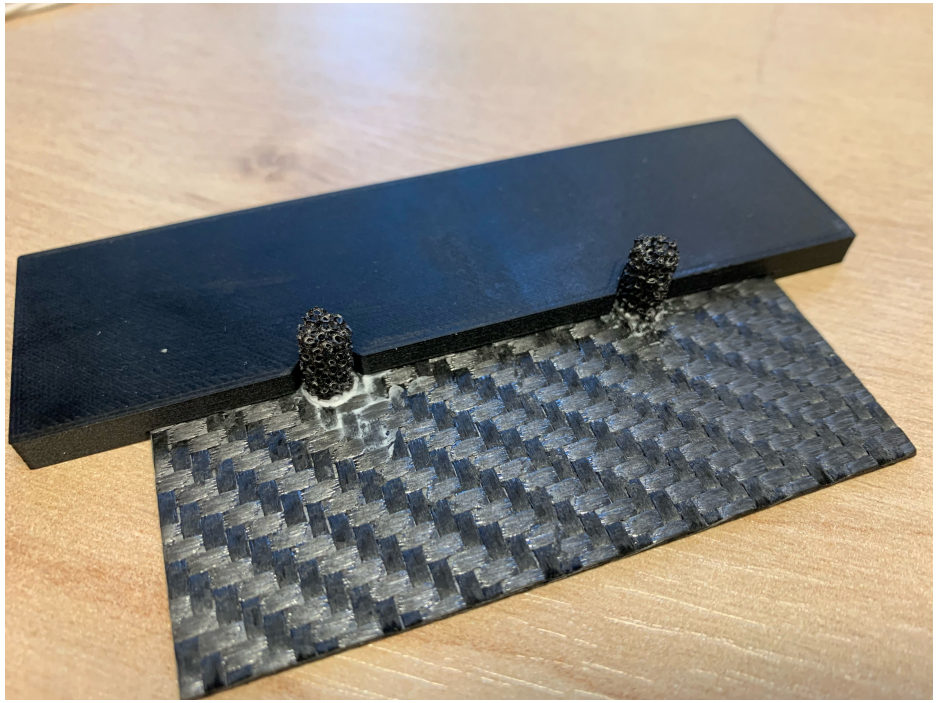
- Aim to use commercially-available parts
  - Not the lightest/stiffest but a  reasonable place to start
    - 10mmODx0.5mm wall CFRP tubes (EasyComposites)
    - 1.25mm thick CC (Goodfellow)
    - Carbon foam (Allcomp), plus metal foams, eg:- aluminium, copper (Goodfellow) – would never propose to use such things but they might help in tuning FEAs
- Extensive use of 3D printing
  - Markforged ONYX™ + CFRP
- Hope that by measuring tensile properties of test-tokens we can use as a basis for FEA. If model reflects reality (!) we can then extrapolate with some confidence to alternative materials / thinner sections etc.

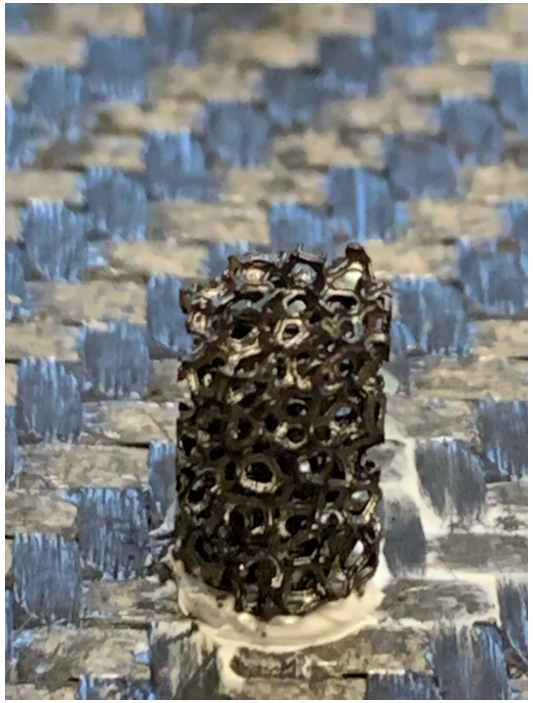
# Pre-prototype

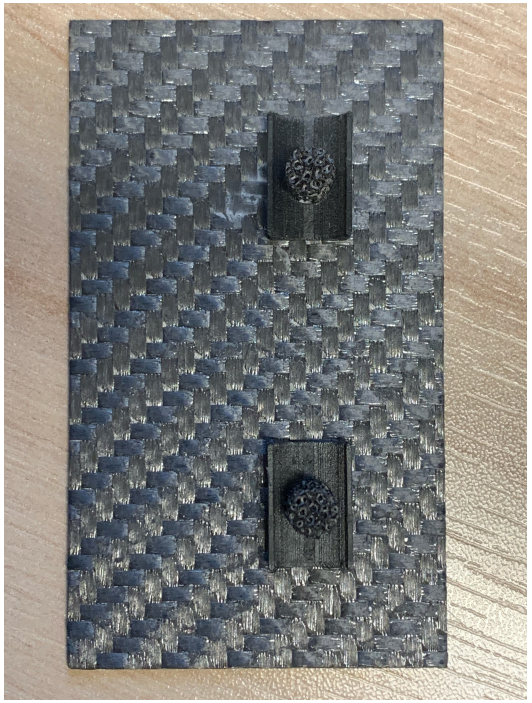
- 3-module section
  - Develop basic parts / tooling / assembly procedures
- Currently populated with single module
  - Rest of access holes for heat-exchangers taped up
  - Plan to make some initial cooling trials



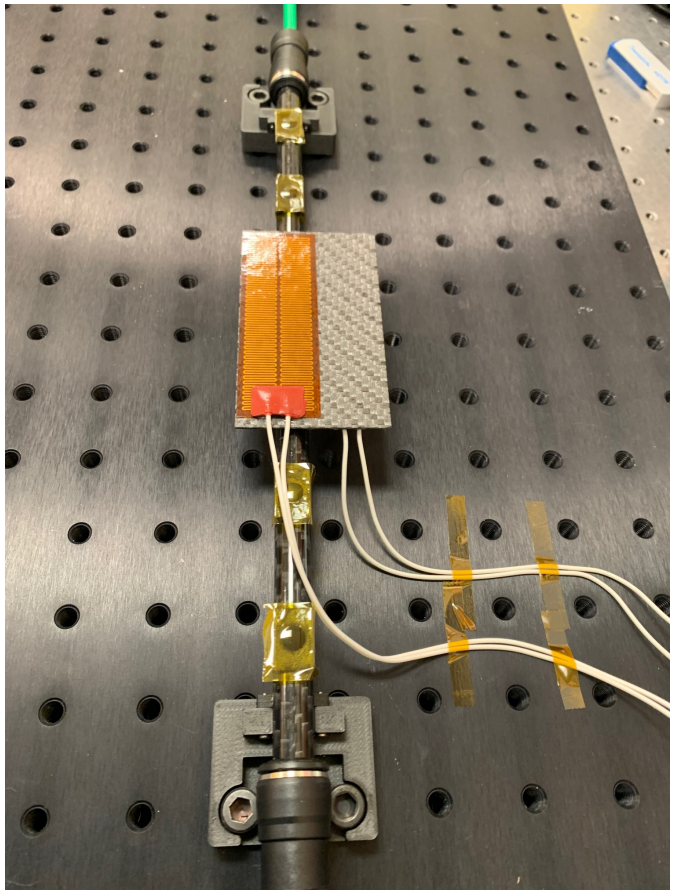
# Pre-prototype: Attaching Heat-exchangers

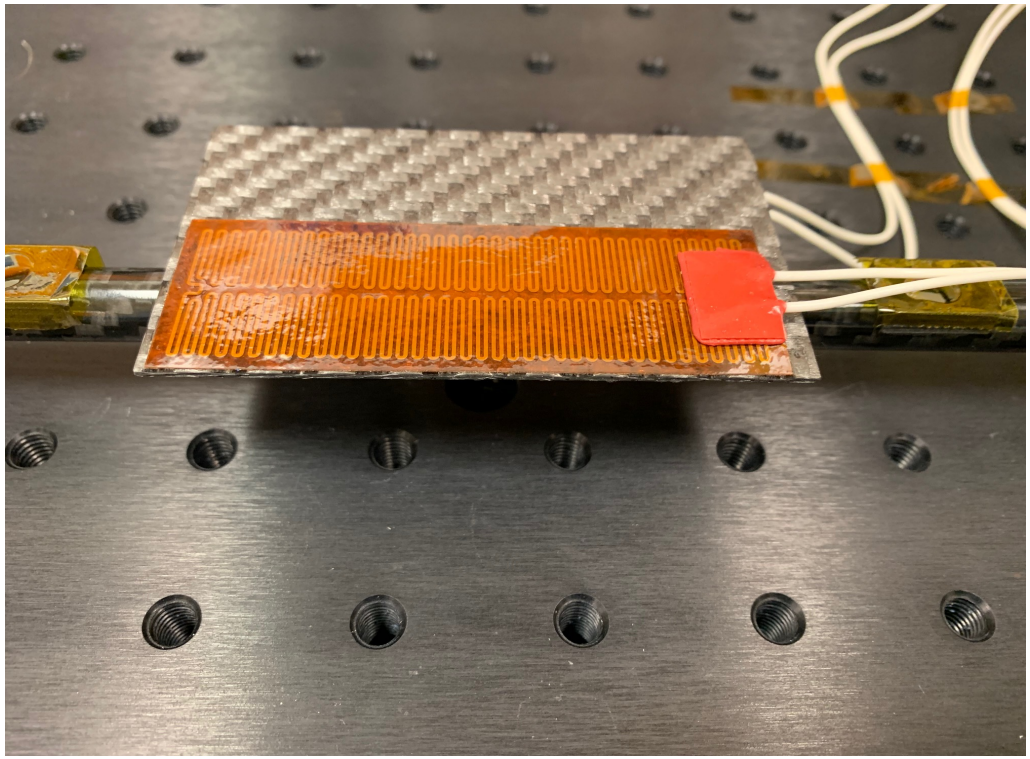






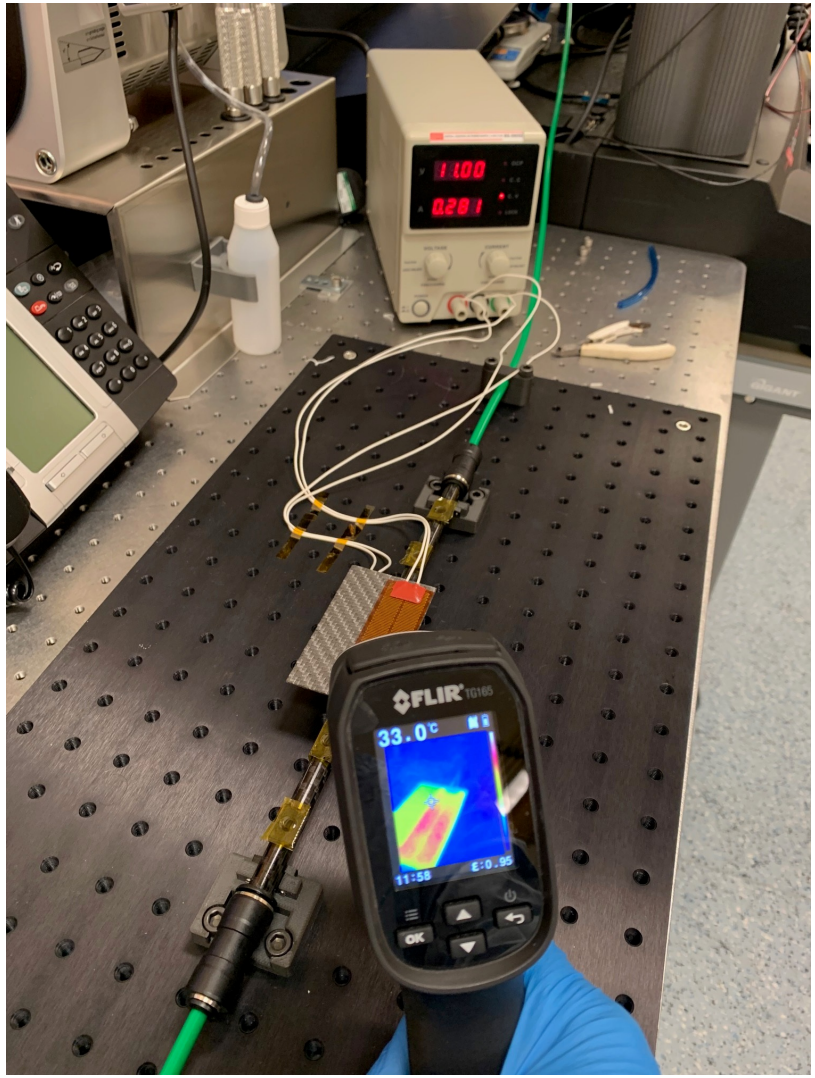
# Pre-prototype: Base attached to tube & heaters on





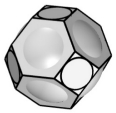
# Pre-prototype: First Results …

- Power = 3.1W
  - Module area = 80 x 40 mm (ish) so at 0.1W/cm$^2$ expect 3.2W
- Fluid is CDA from wall supply fed via needle valve
  - No idea what the pressure or volume flow rate are
  - Opening / closing the valve has the expected effect
  - Temperature rise (at some flow) ~ 10°C
- It sounds a bit noisy !
  - Suspect there's a leak round a saddle or maybe it's just what happens when lots of air rushes through a foam cylinder!
- Plenty more to do ☺

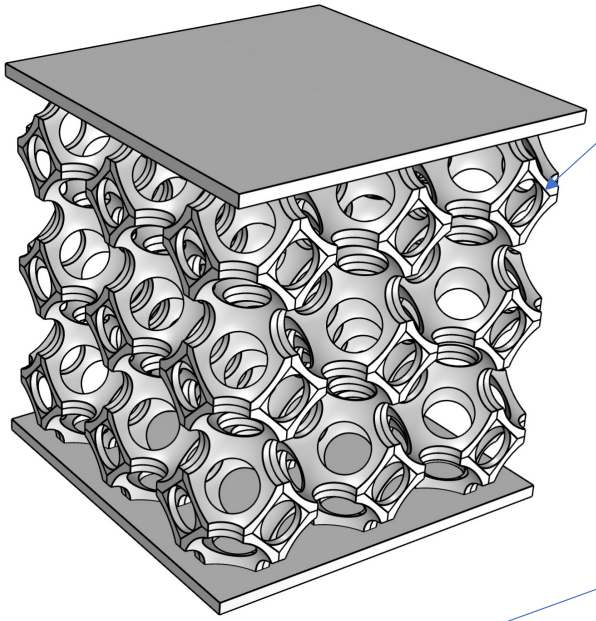


# FEA (Thermal)

Tetrakaidecahedral cell
(8 hex + 6 square faces)



3 x 3 x 3 array



3 x 3 x 3 array
Scaled down to
0.25mm cell size