

# The Oxford T6 Stalker Tunnel: Facility and some Final year research projects

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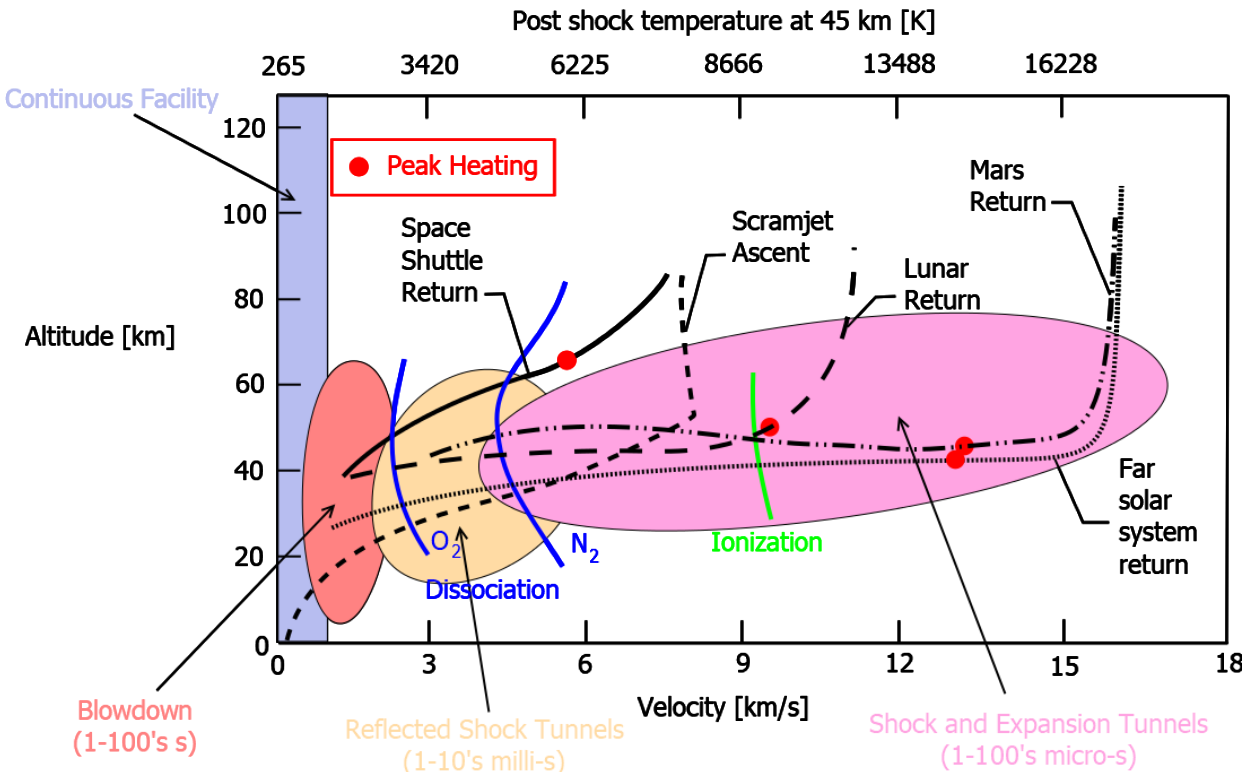
# Why ground testing and what type?



- Hypersonic flight testing is:
  - Sometimes impossible (planetary probes)
  - Prohibitively expensive
  - Cannot isolate effects
  - Impossible to measure most desired parameters
- However.... no single hypersonic ground facility can replicate flight
  - Power consumption in 10's GW required + many engineering challenges
- The following facility types exist:
  - Aerodynamic – classic + real gas
  - Aeropropulsion
  - Materials



# High Total Enthalpy Wind Tunnel

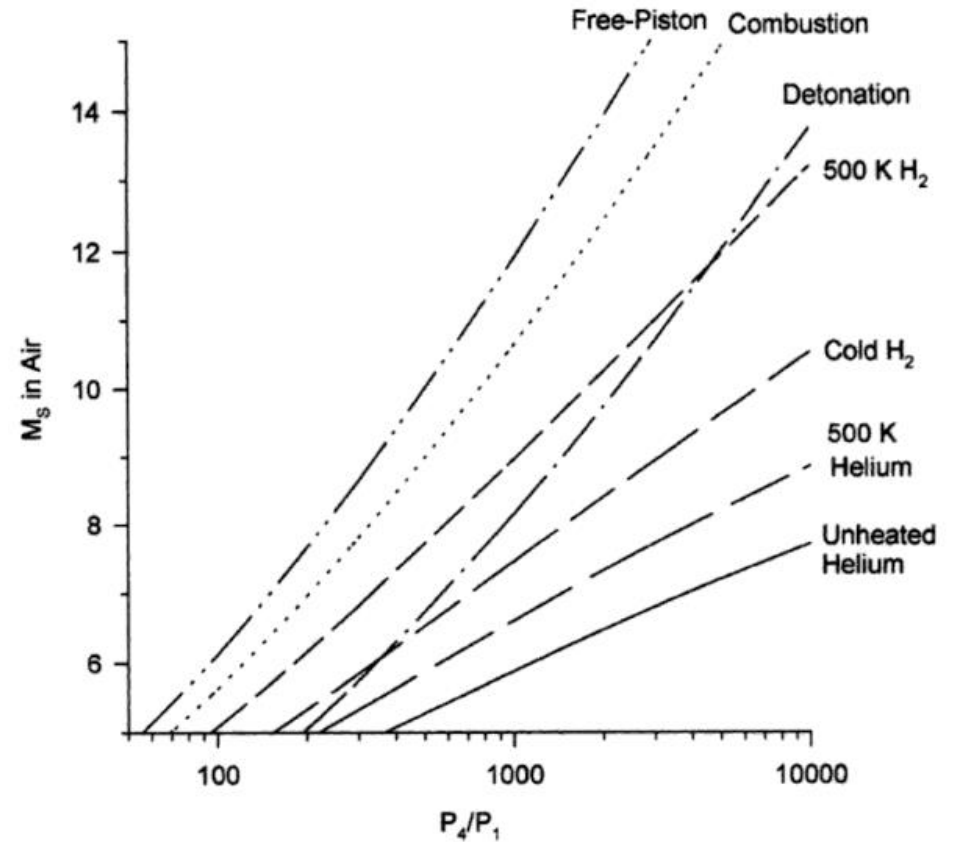
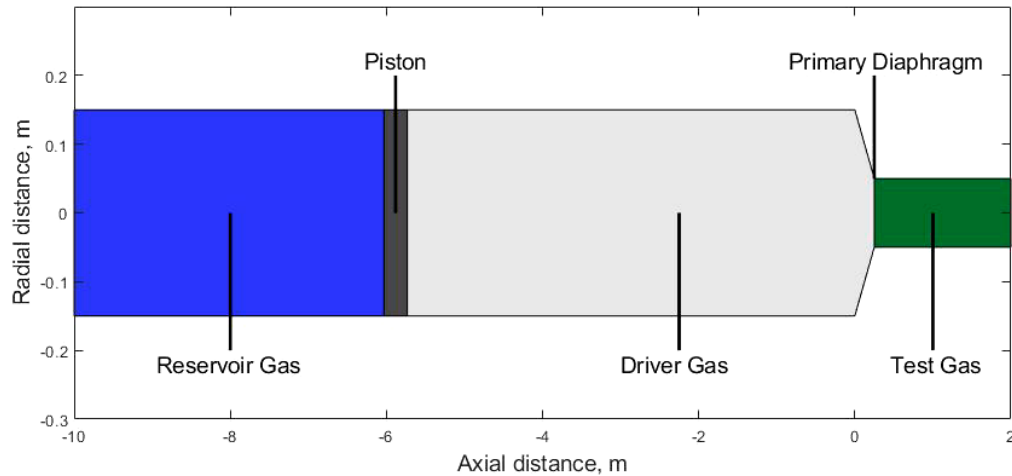
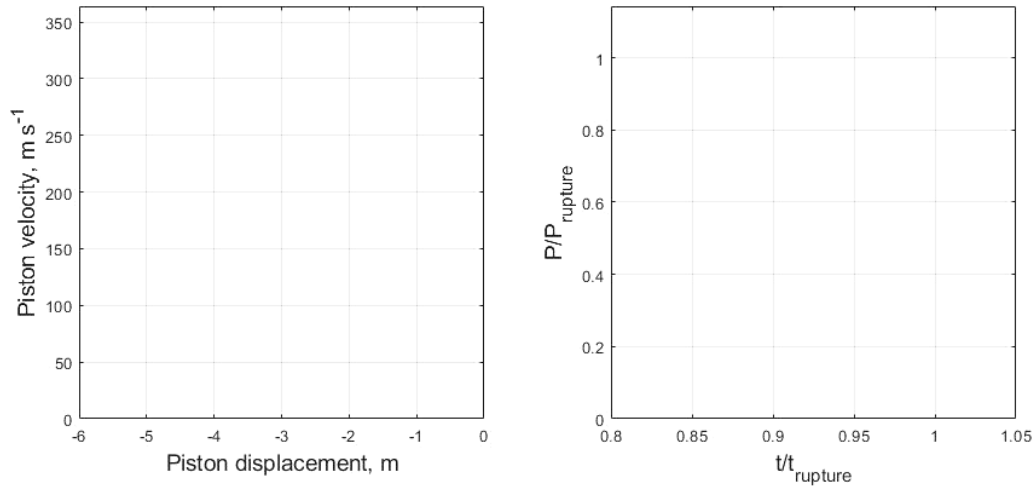


Hypersonic flight replication in wind tunnels.



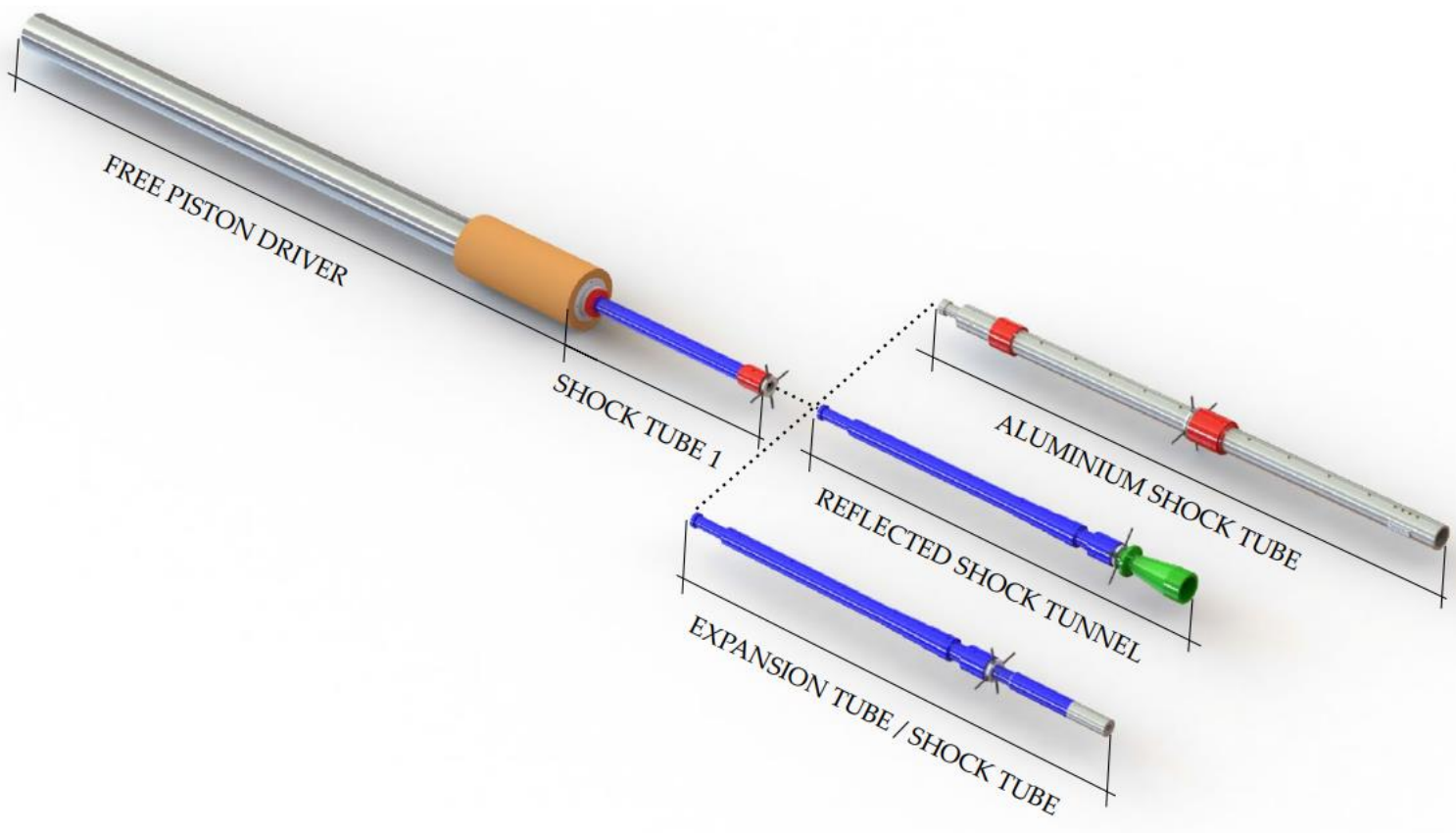
Oxford Hypersonic Wind Tunnels. T6 is on the left and the High Density Tunnel on the right .

# Free piston driver



Shock tunnel driver performance.

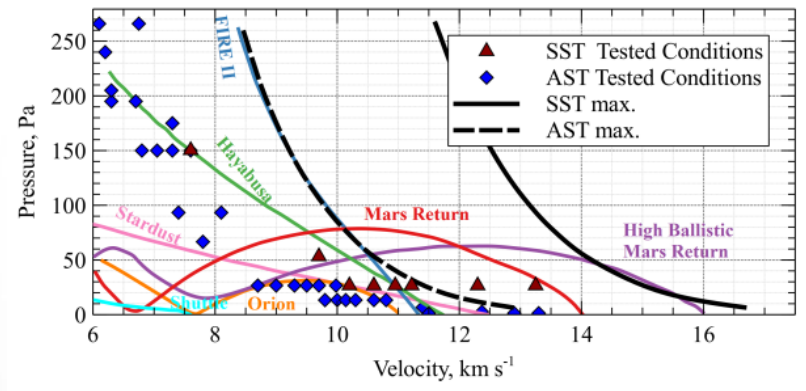
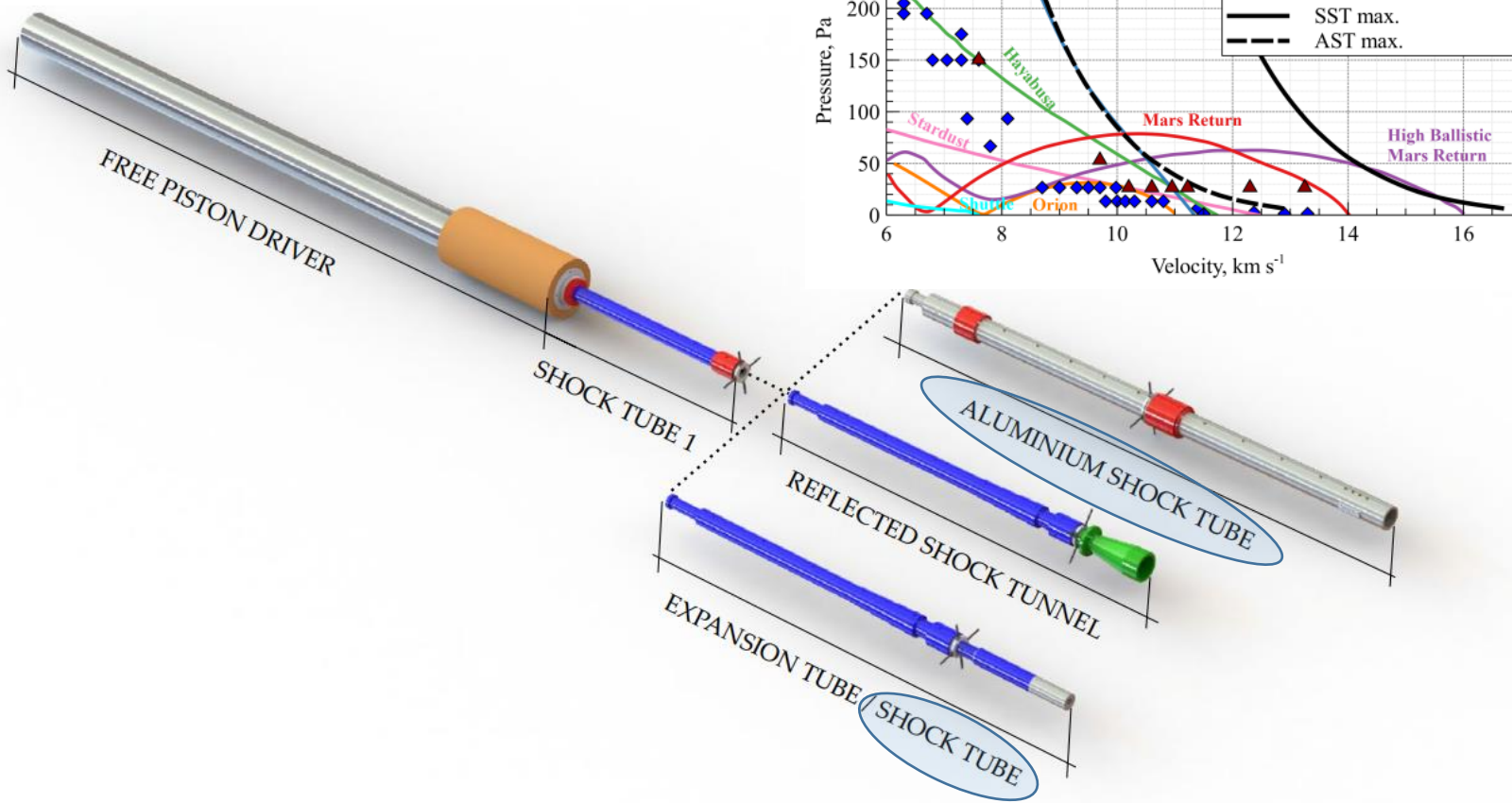
# Oxford T6 Multi-mode tunnel



Section	Length (m)	Internal diameter (mm)	Outlet diameter (mm)
Reservoir	2.8	342.9	300.0
Compression Tube	6.0	300.0	76.2†
Shock Tube 1	2.8	96.3	96.3
Reflected Shock Tunnel	5.3*	96.3	220.0*
Expansion Tube/Tunnel	6.0*	96.3	236.0*
Steel Shock Tube	6.0	96.3	96.3
Aluminium Shock Tube	7.1	225.0	225.0



# Oxford T6 Multi-mode tunnel

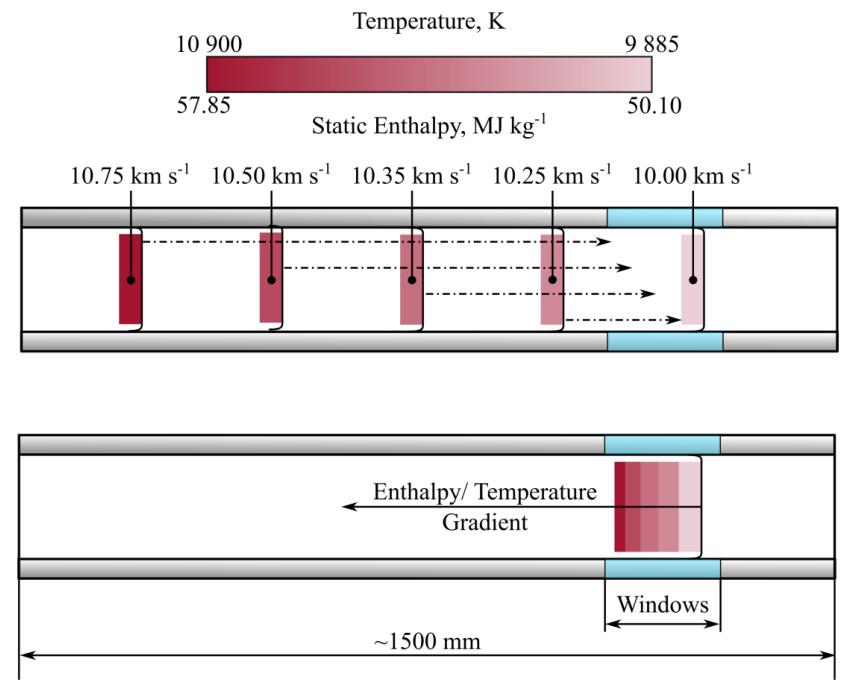


## SHOCK TUBE

$$U_{shock} = U_{flight}$$

$$\rho_{tube,fill} = \rho_{flight,\infty}$$

$$\chi_{tube,fill} = \chi_{flight,\infty}$$



# Oxford T6 Multi-mode tunnel



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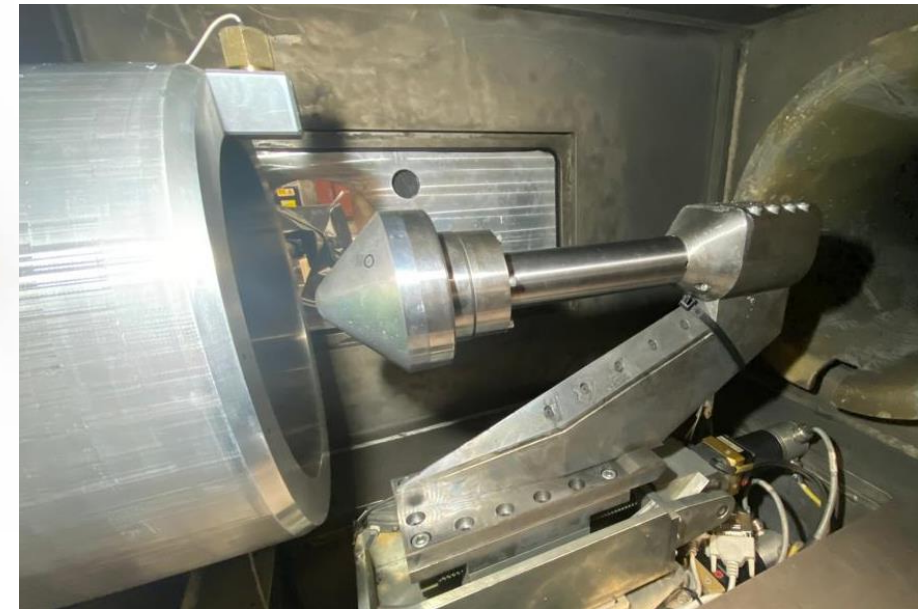
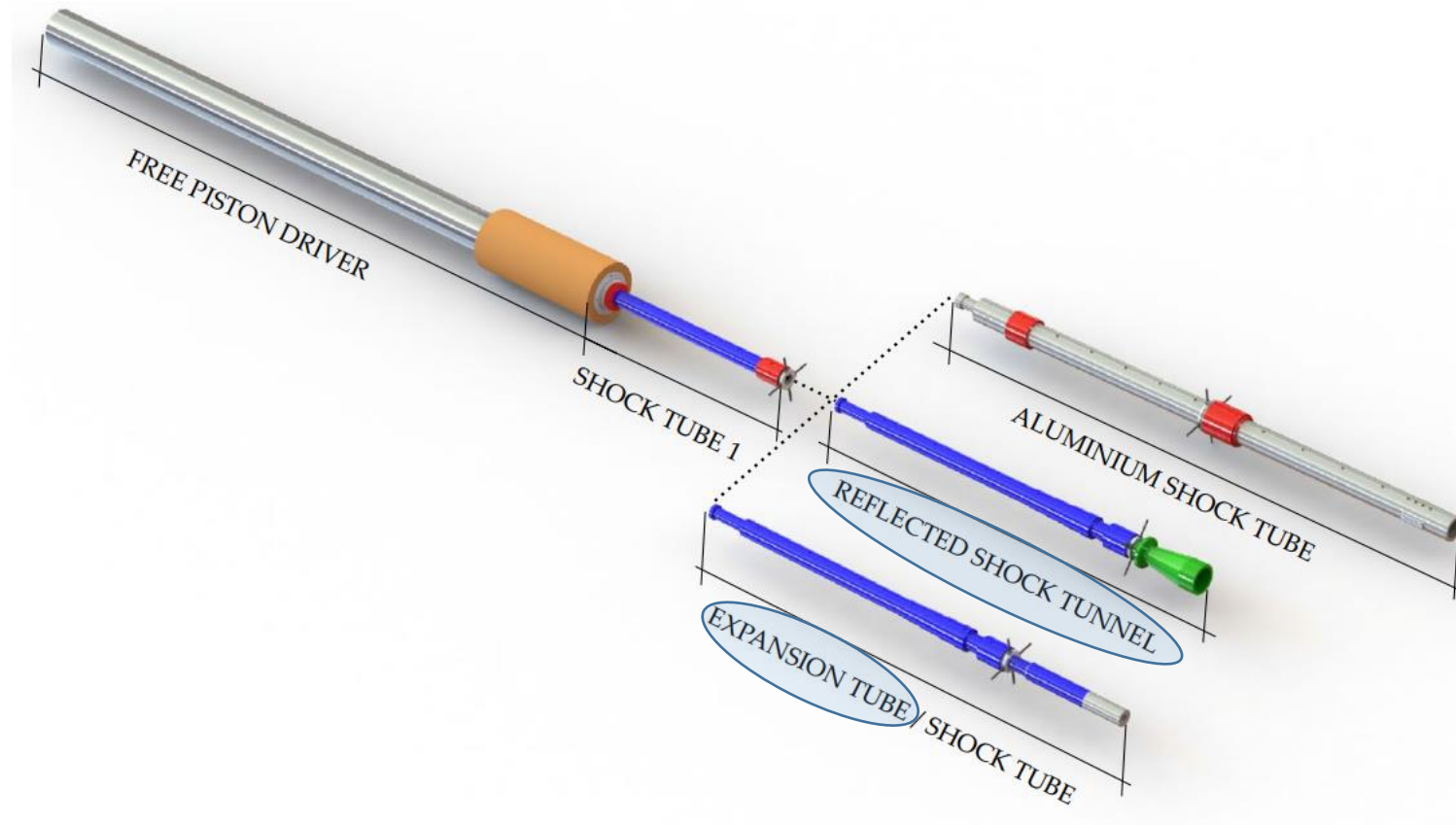
## RST & ExT

$$H_{tunnel} = H_{flight}$$

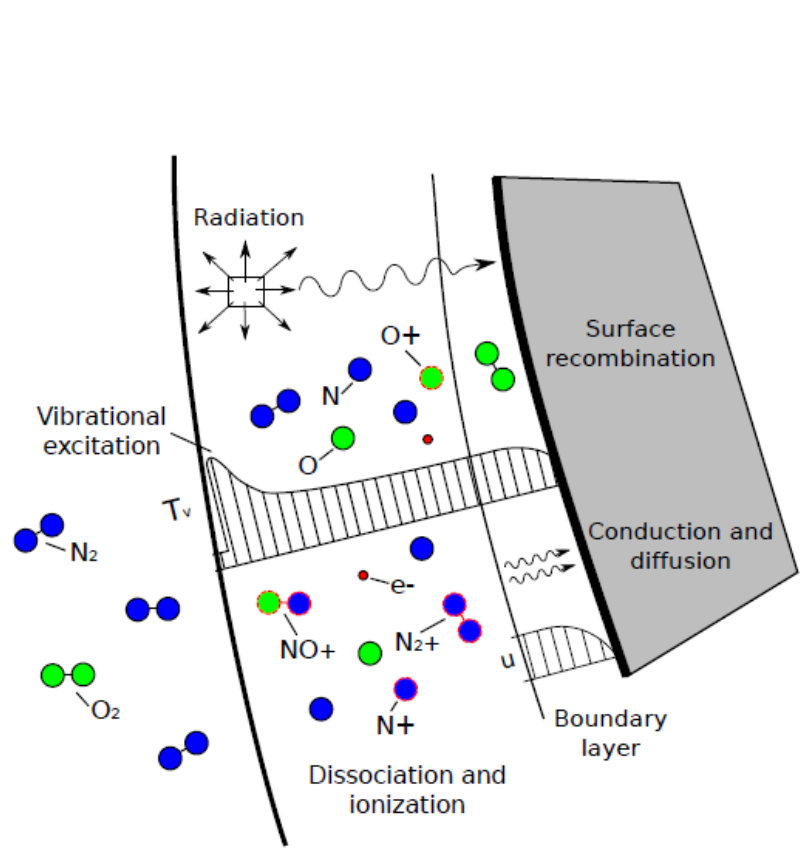
$$\rho L_{tunnel} = \rho L_{flight}$$

$$\chi_{fill} = \chi_{\infty}$$

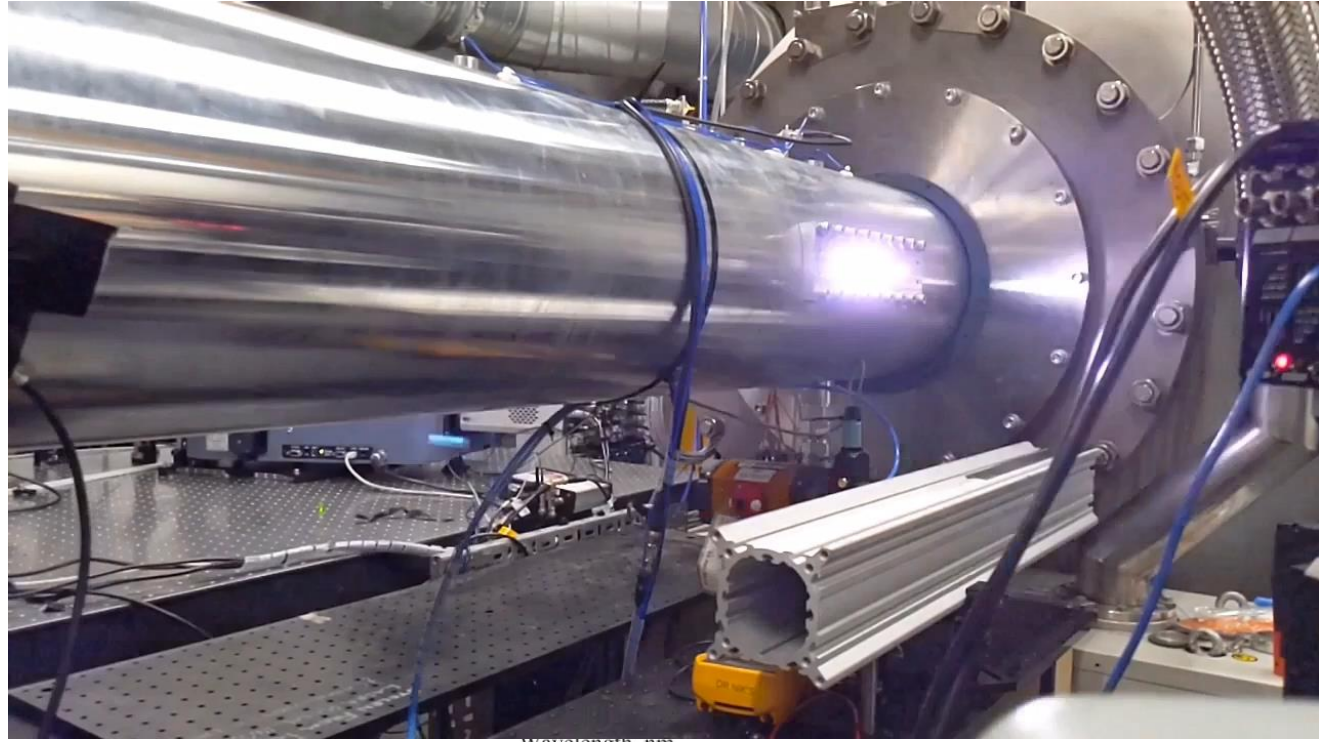
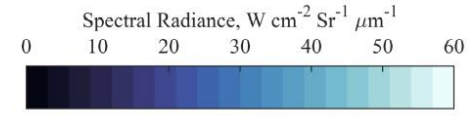
$$M_{tunnel} = M_{flight}$$



# Shock Layer Radiation



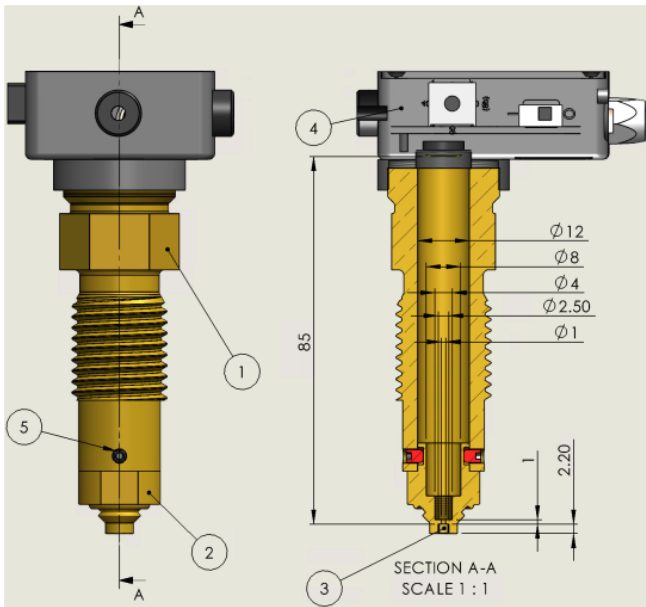
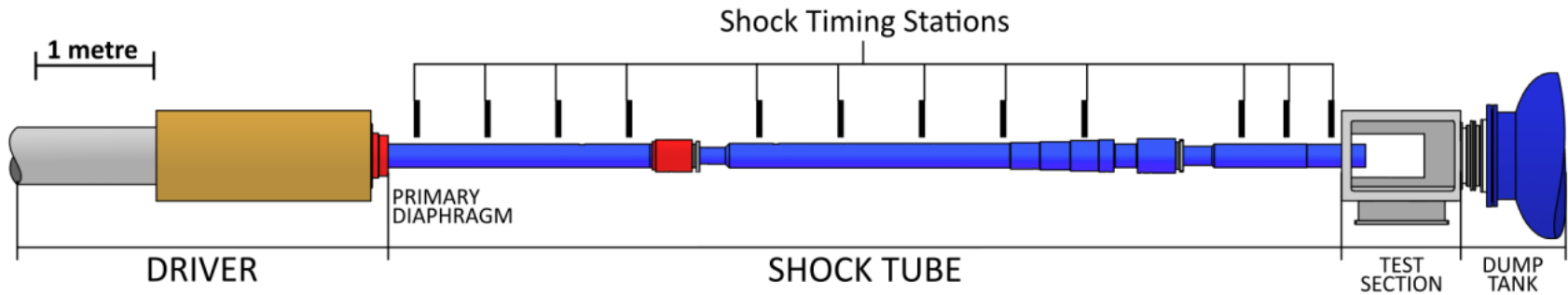
*Thermochemical processes in the shock and boundary layer for high speed vehicles.*



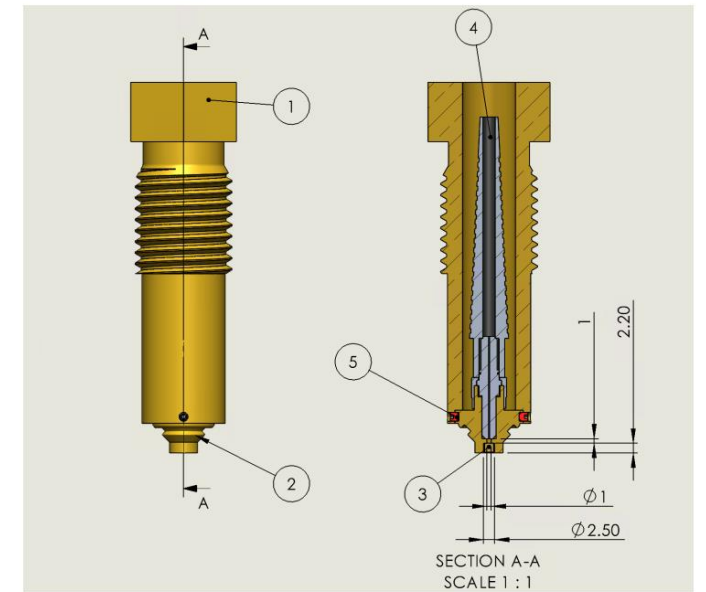
*Test in Oxford T6 tunnel in shock tube mode of air at 10 km/s @ 58 km altitude. Slow motion at 1/8<sup>th</sup> true speed.*



# Shock Layer Radiation



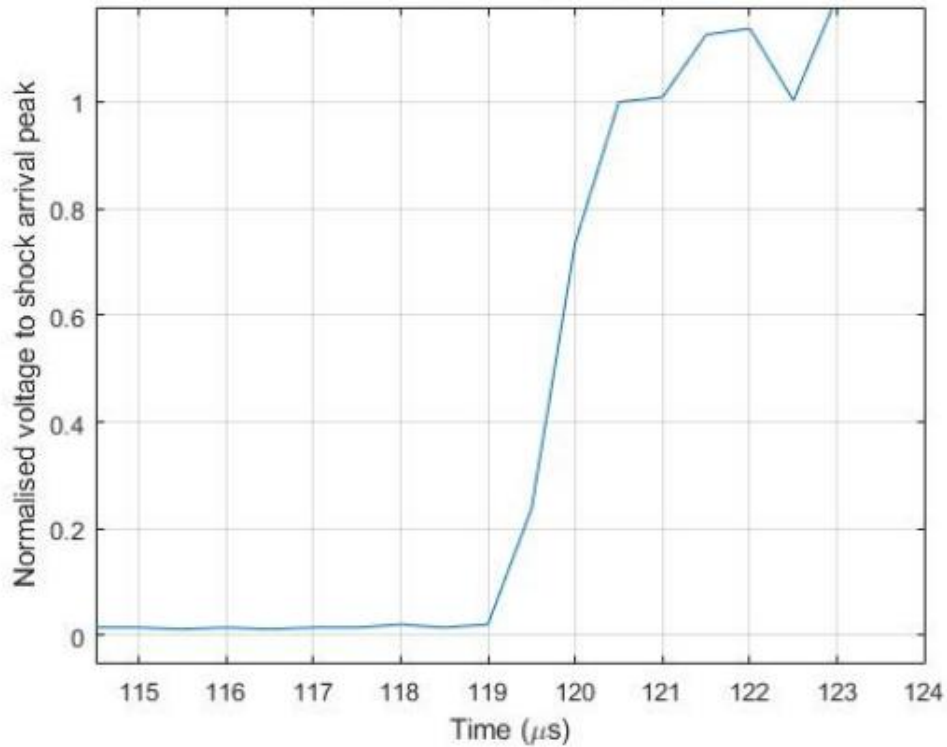
*Direct coupled probe to PMT or PD.*



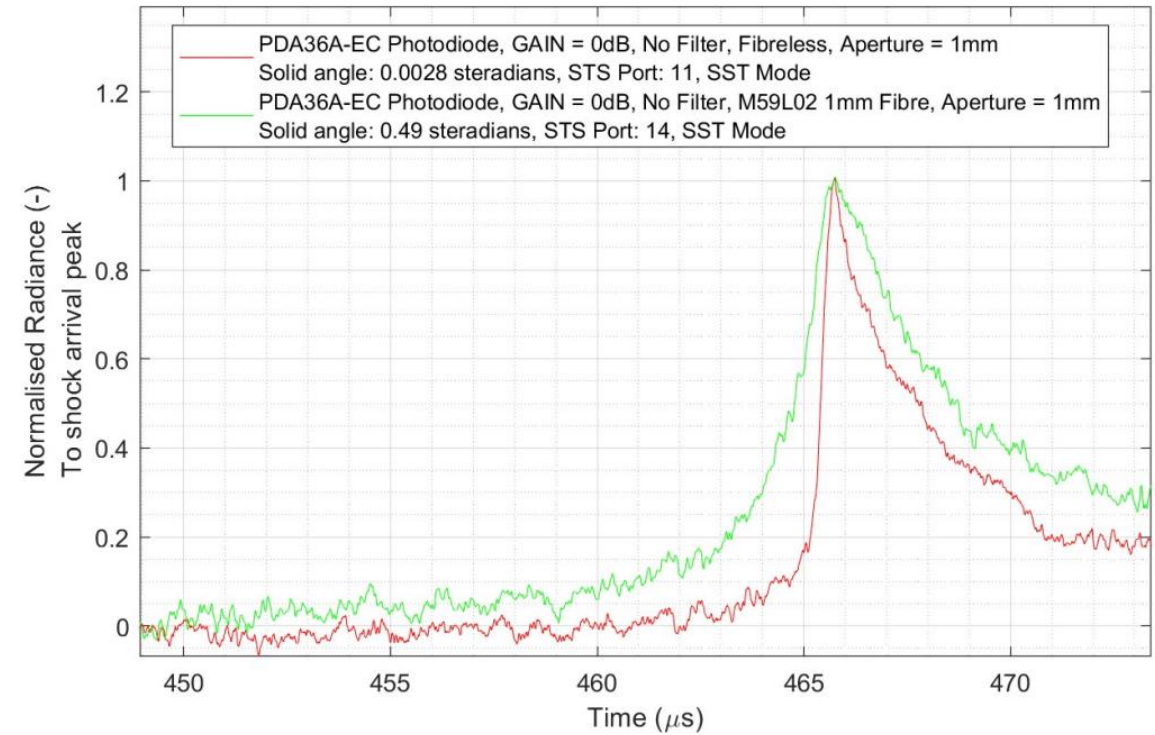
*Fibre coupled probe to PMT or PD.*

# Shock Layer Radiation

$$U_s = \frac{\Delta x}{\Delta t}$$

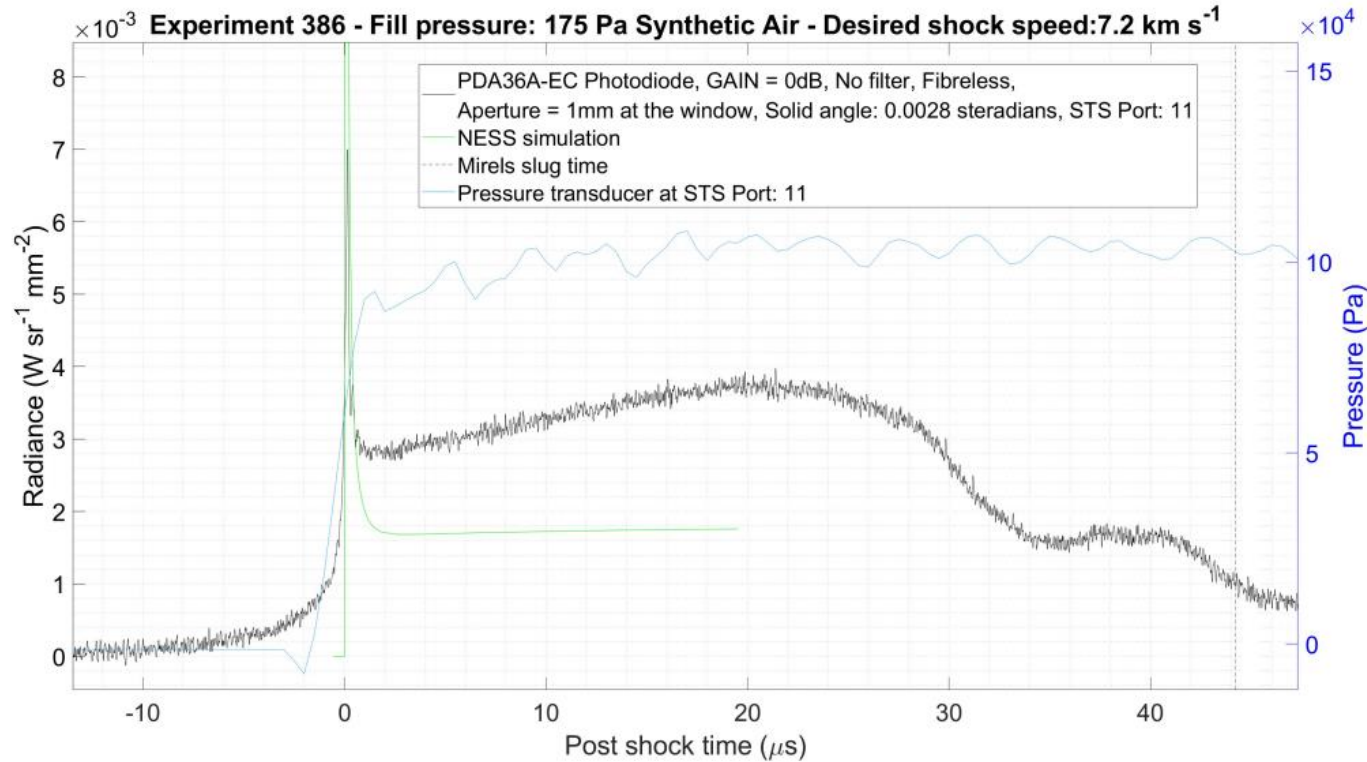


*Pressure transducer response*

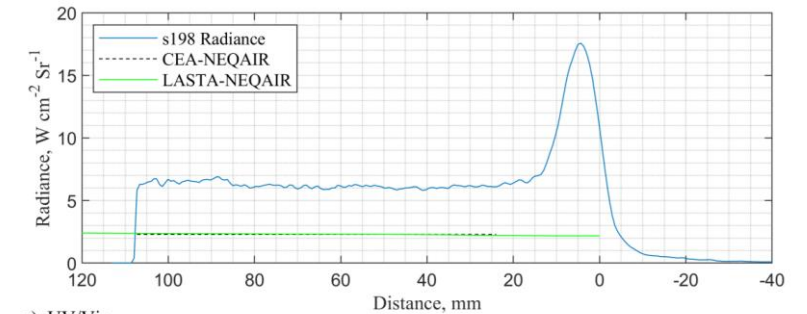


*Photo diode response*

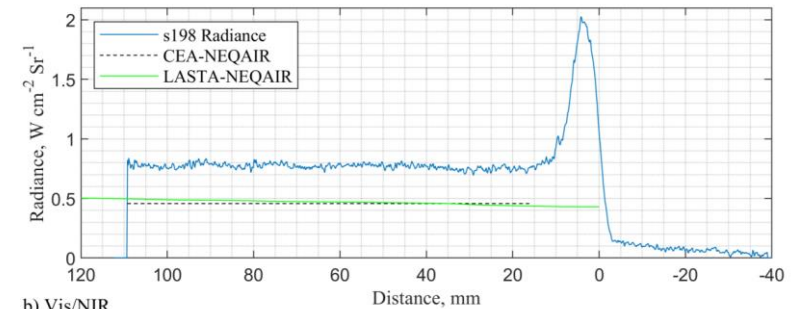
# Shock Layer Radiation



*Radiation from photodiode vs pressure transducer and NESS simulation*



a) UV/Vis



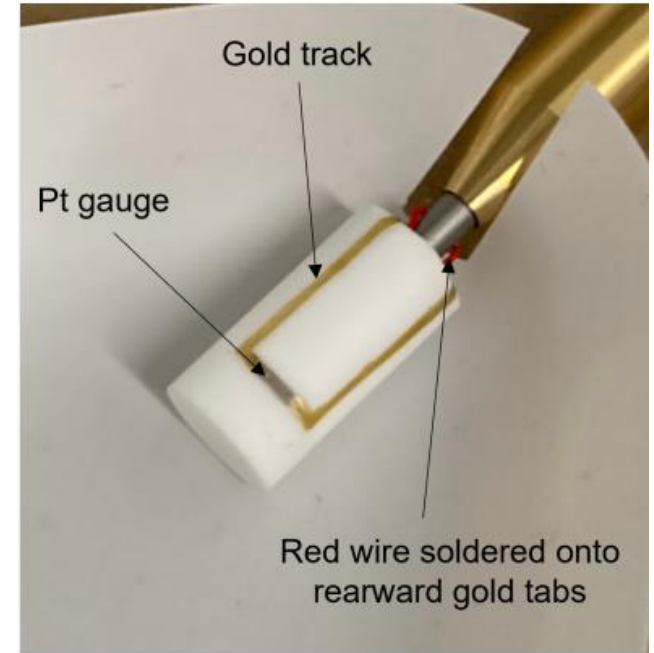
b) Vis/NIR

*Spectrometer data vs CEA/LASTA simulation*

# Satellite Demise



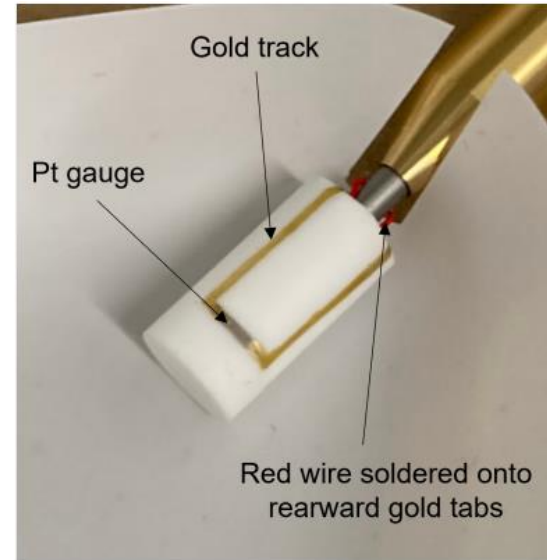
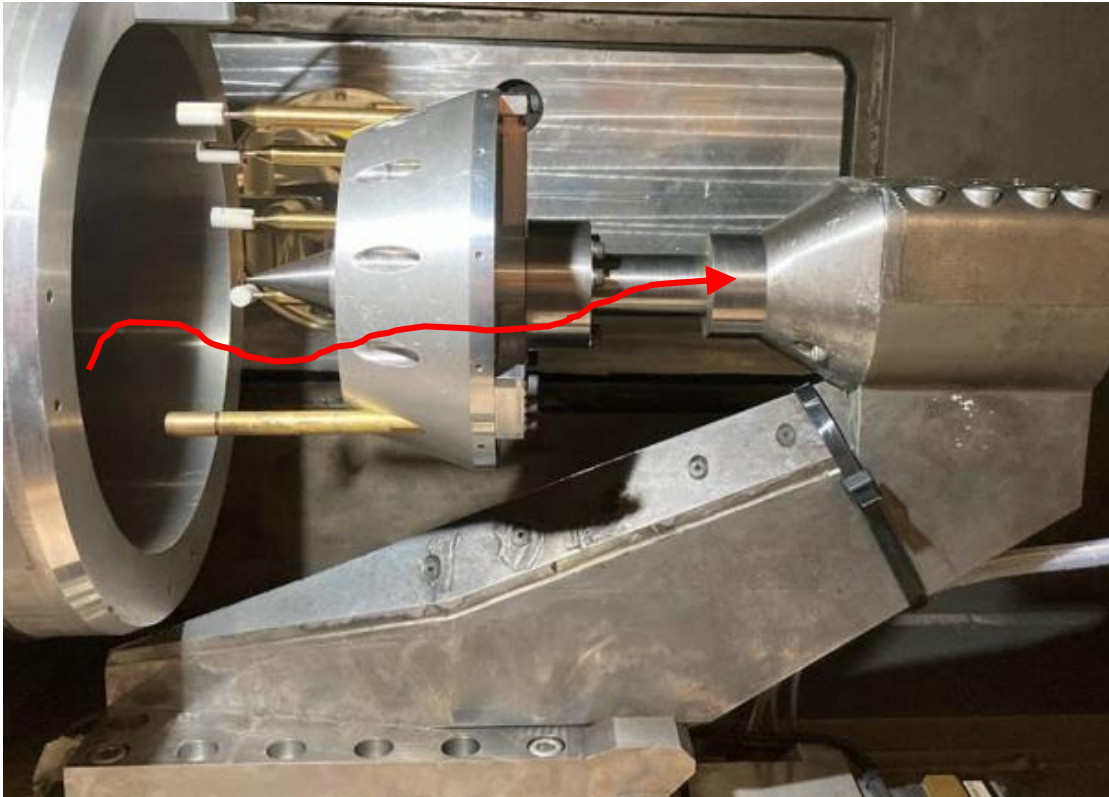
*Automated Transfer Vehicle - ATV1  
(4.5 m diameter, 9 m long)*



*Subscale model of cylinder  
(10 mm diameter, 20 mm long)*



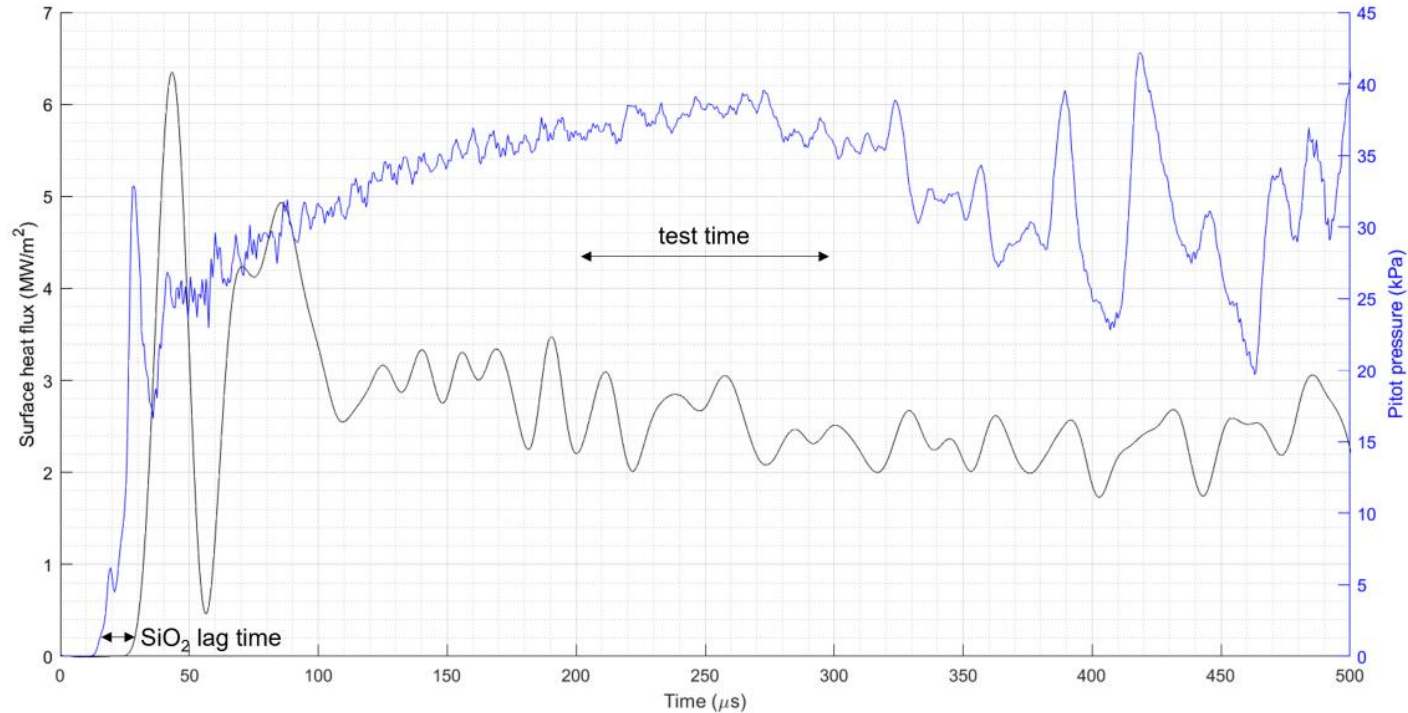
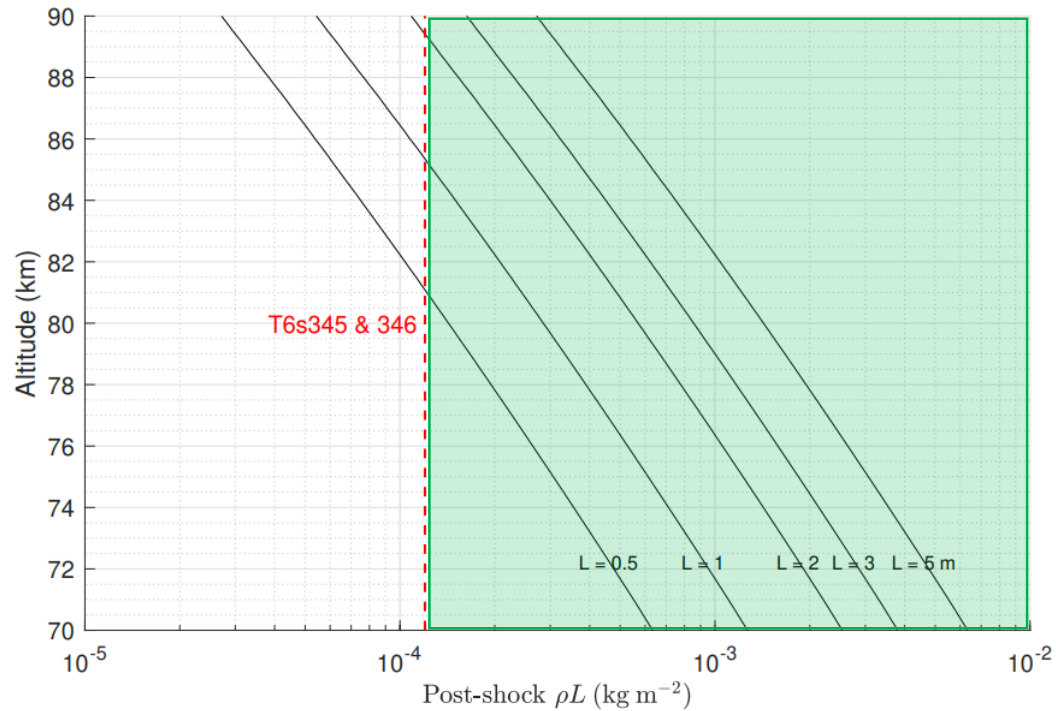
# Satellite Demise



*Different cylinder orientations and TFHTG locations*

*Subscale models mounted in ring which allows up to 12 models to be tested at once and avoid particulate damage from steel diaphragm fragments. Mounted on traverse which can give +/- 20° AoA & +/-5° AoY .*

# Satellite Demise



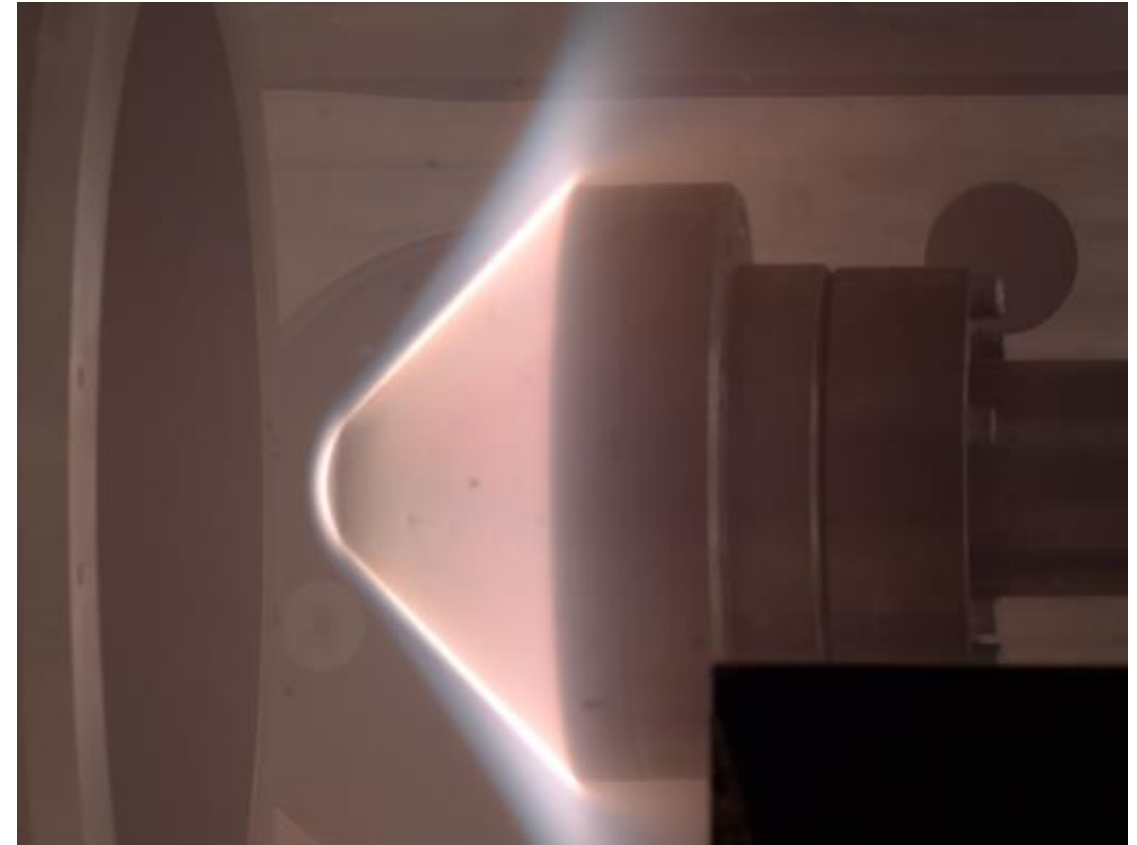
*Tested condition in T6  $\rho L$  capability for air at 6.5 km/s in axial configuration. Green area shows region that is easily achievable.*

*Heat flux (stagnation point, cross-flow) and Pitot pressure time histories*

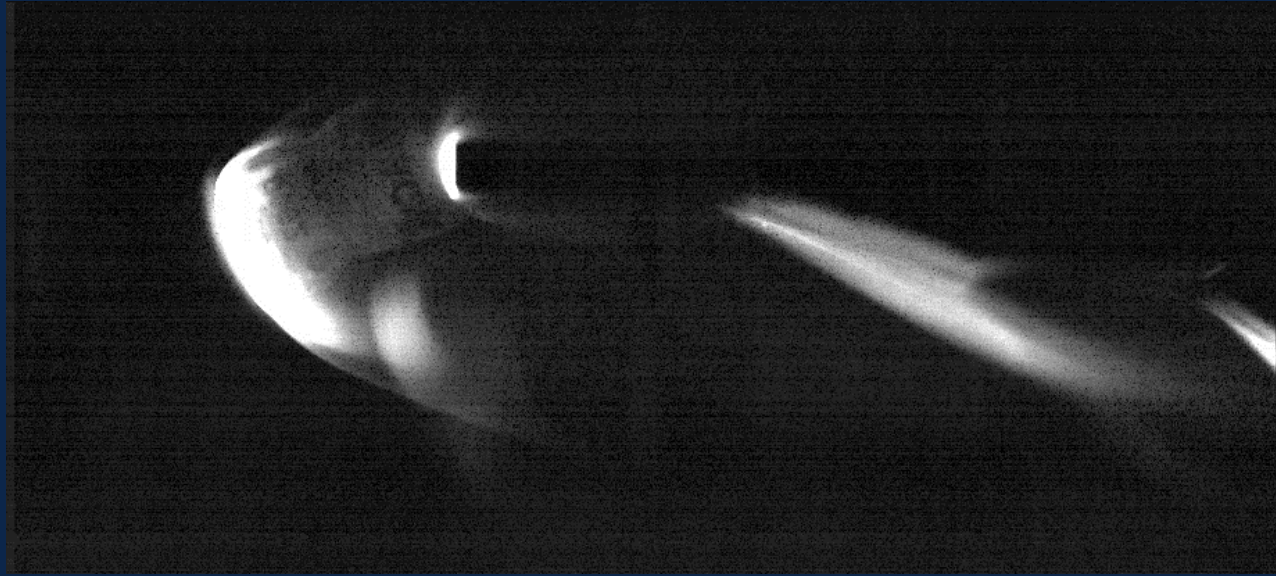
# Conclusion & Outlook



- T6 is a multi-mode shock tunnel which is the highest speed facility in Europe
- T6 has now been commissioned and used in all modes of operation
  - As of today, 350 tests undertaken in facility
- Facility has been used for a wide range of research programmes, including 4<sup>th</sup> year Masters projects
  - Shock speed/shock layer radiation measurements
  - Satellite demise convective heating
- Upcoming tests:
  - Ice Giant shock layer radiation
  - Mars return VUV shock layer radiation
  - Weakly ionised air flows
  - Boundary layer transition at high total enthalpies



*Testing of a Ice Giant Entry vehicle at 18 km/s*



*World's fastest champagne cork  
Oxford T6 Stalker Tunnel, 13.2 km/s.*

Thank you - any questions?