GAS DYNAMICS and PROPULSION

CNR-ICMATE
Gasdynamics of Propulsion Systems

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Facilities of the GPS lab:

- High enthalpy supersonic/hypersonic tunnel

  (simulation of high speed flight conditions)

- Gasdynamic accelerators

  (acceleration of projectiles and micrometric dust to hypervelocity)

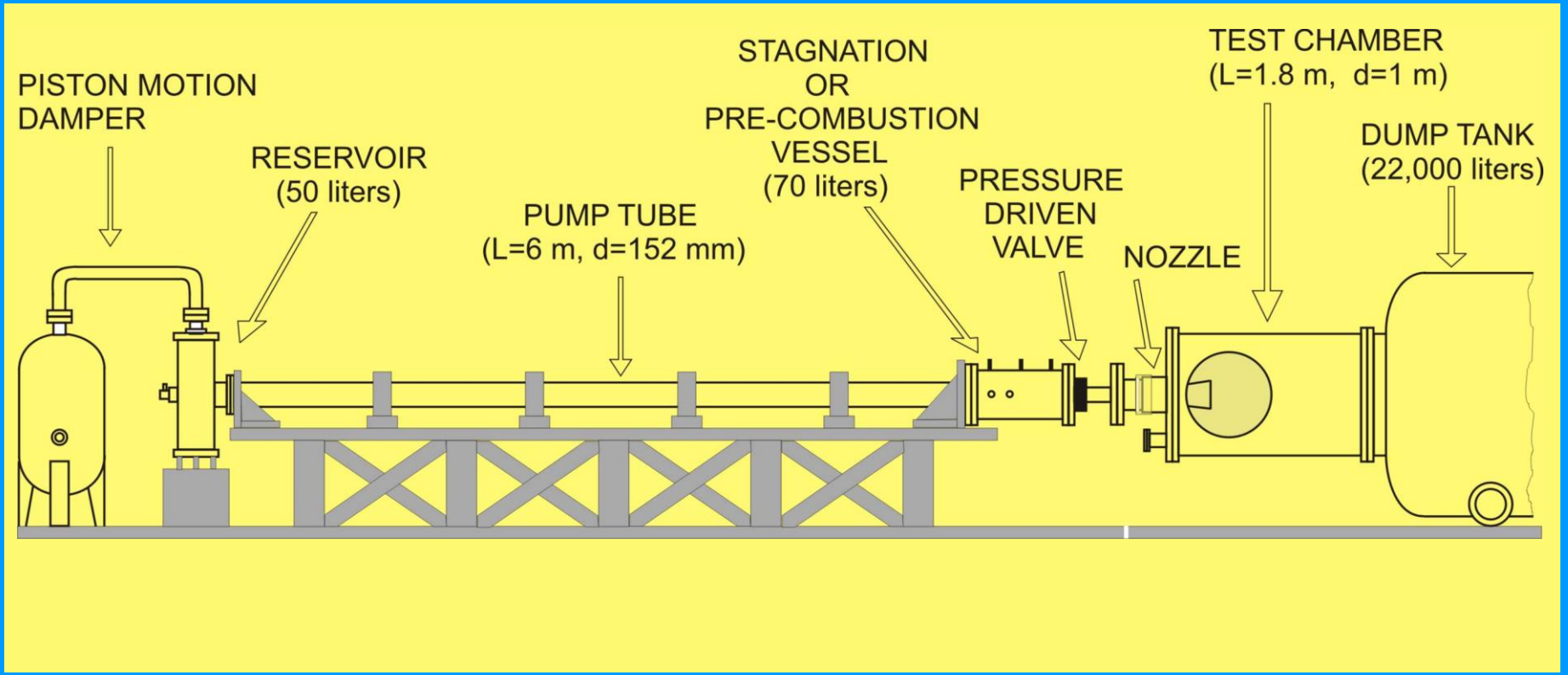
- Micrometric particles low-speed launcher

  (controlled deposition of micrometric particles on surfaces)

- Electrostatic removal of micro-particles from surfaces

  (evaluation of micro-particles adhesion forces)

Tunnel scheme / components



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Tunnel overall view

Hypersonic test facilities: velocity vs. test time map

(from "Advanced Hypersonic Test Facilities", Progress in Astronautics and Aeronautics, Vol. 198, 2002)

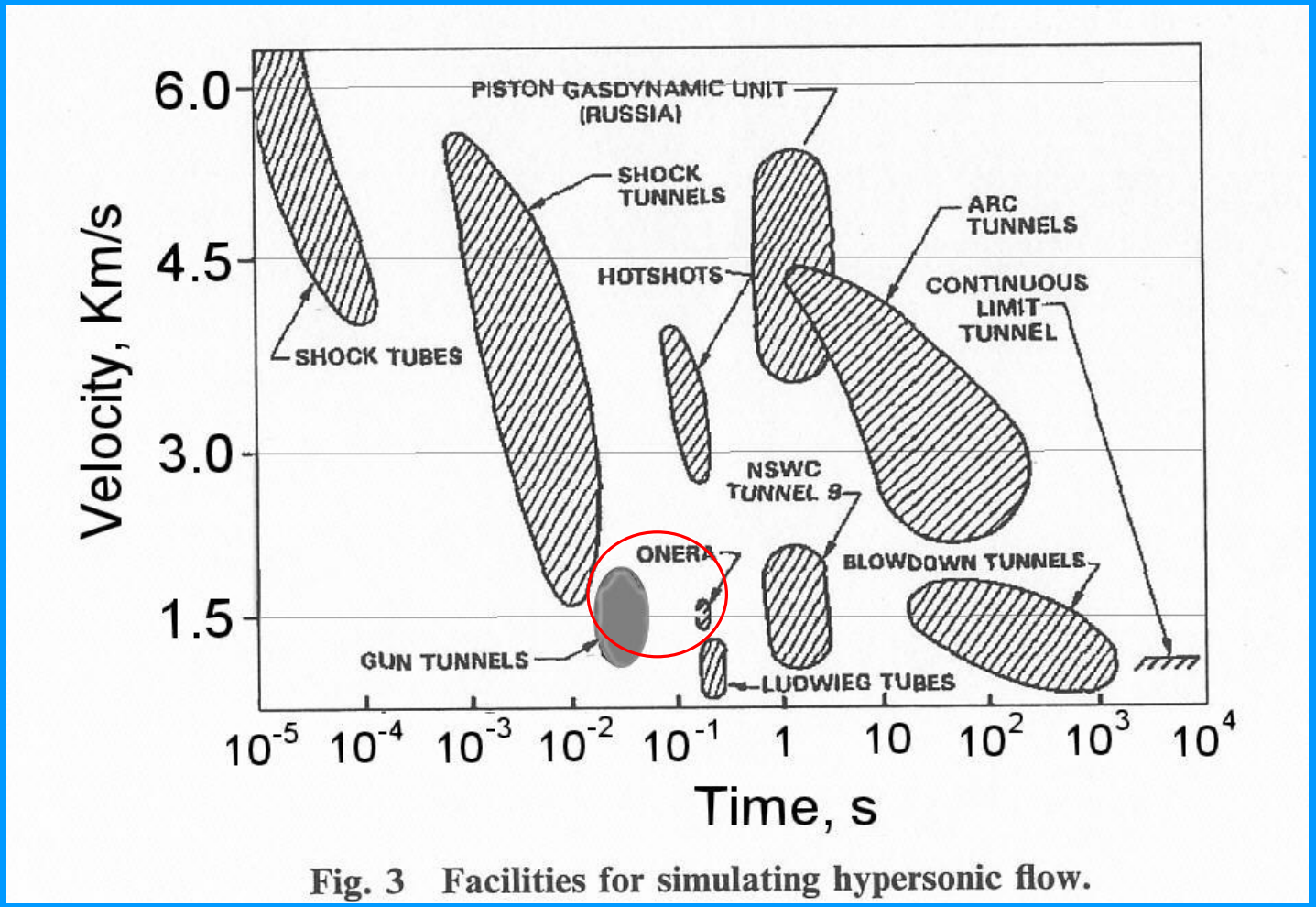
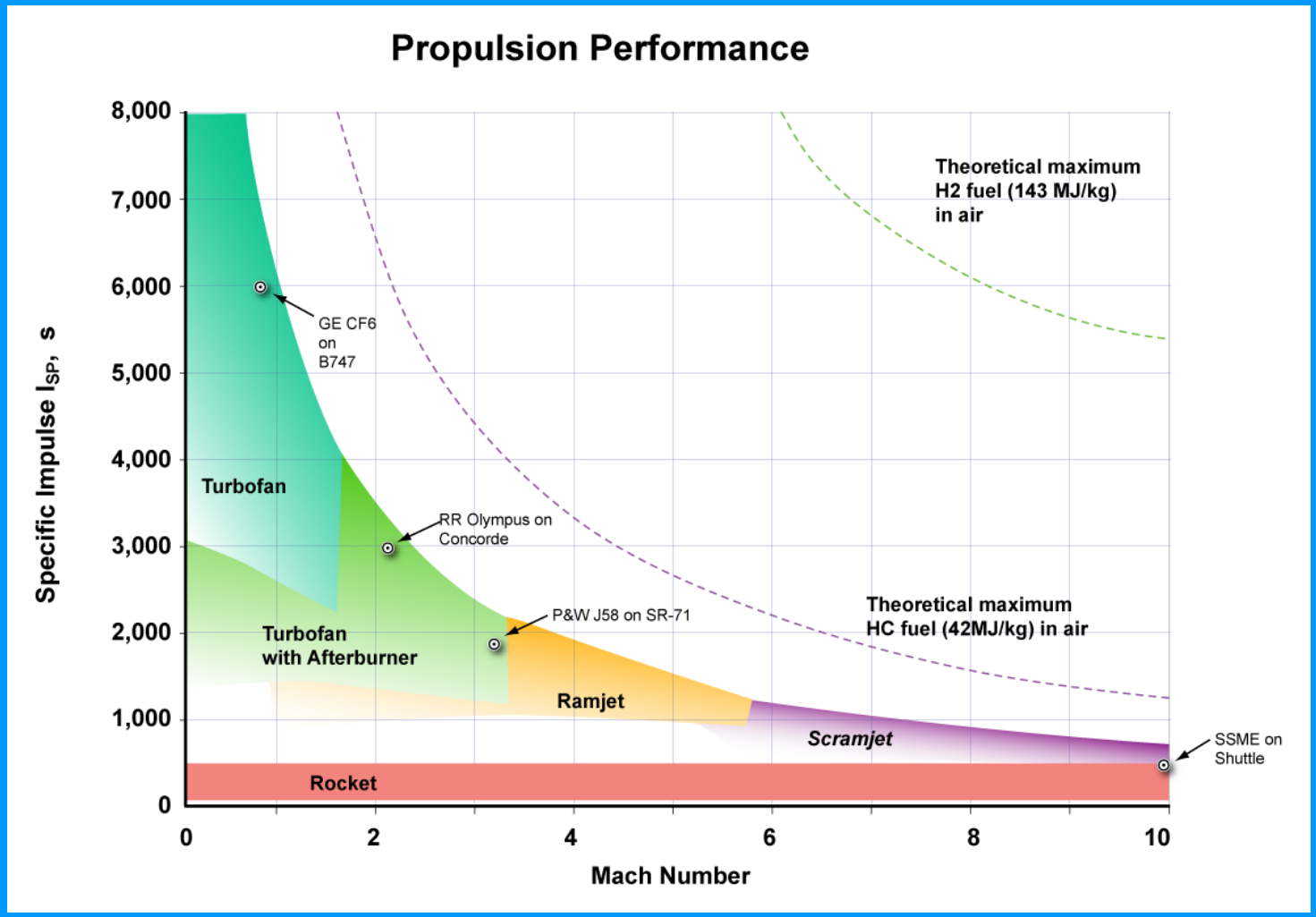


Fig. 3 Facilities for simulating hypersonic flow.

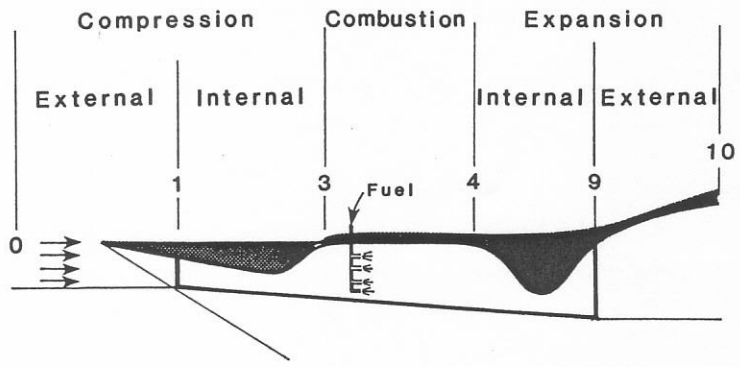
SPECIFIC IMPULSE vs FLIGHT MACH NUMBER

(Wikipedia: Specific impulse)

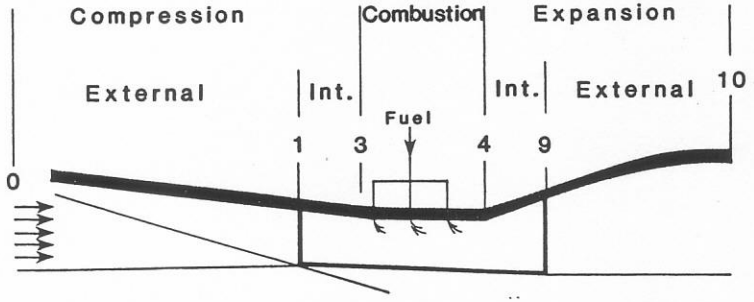


RAMJET vs SCRAMJET setup

(Heiser and Ptatt, "Hypersonic airbreathing propulsion")



Ramjet

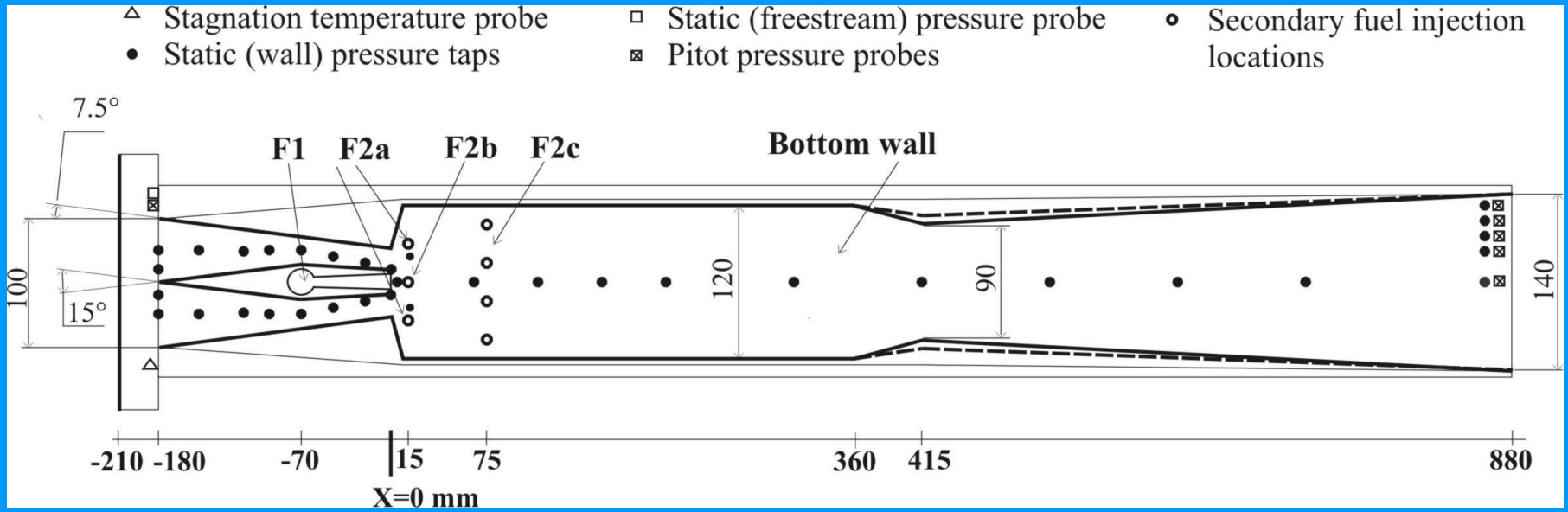


Scramjet

Fig. 4.1 Airbreathing engine reference station numbers and related terminology.

Model geometry and monitoring setup

(JPP, 2012)



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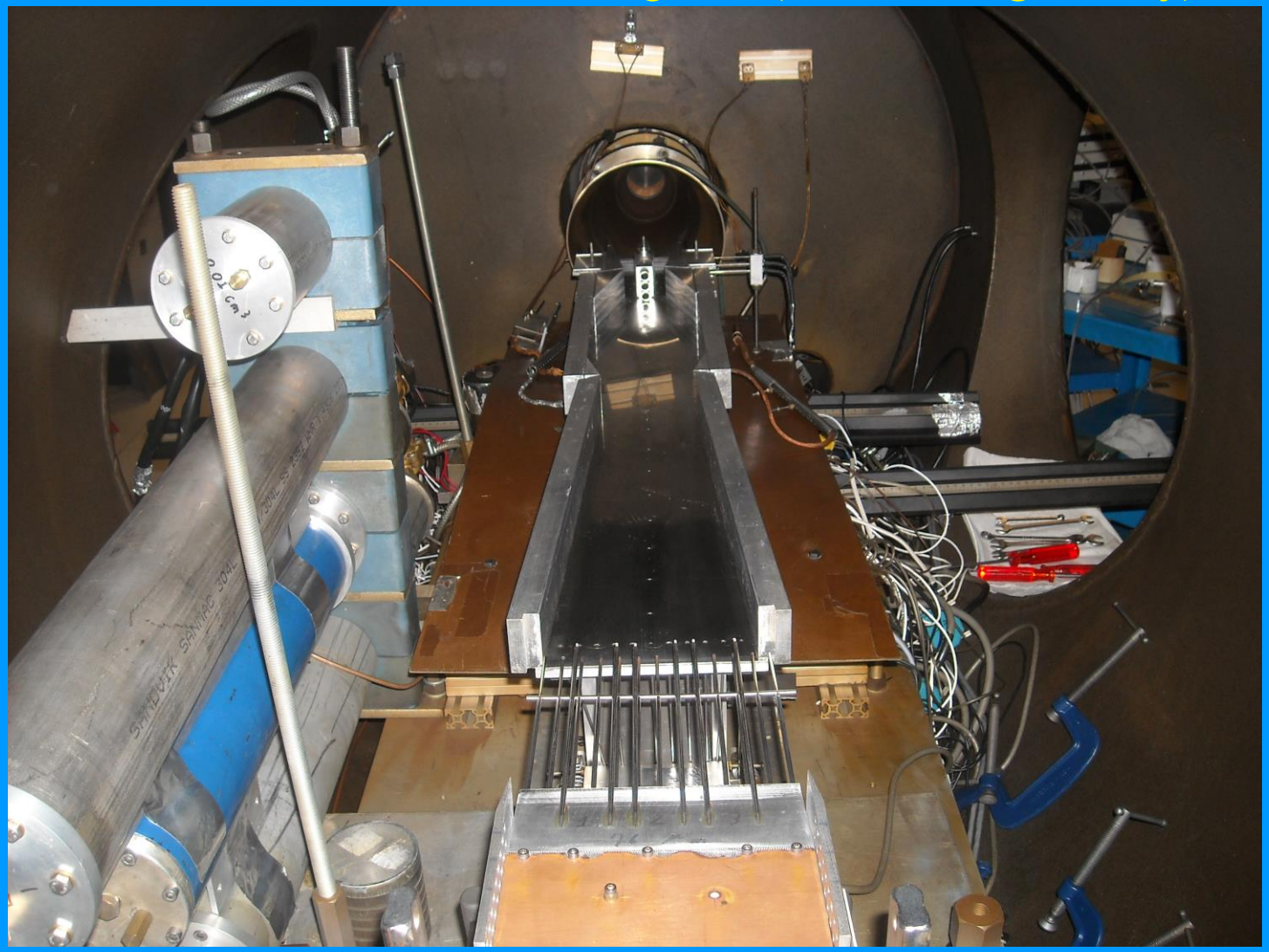
“Parametric” model engine – (2 – internal geometry)



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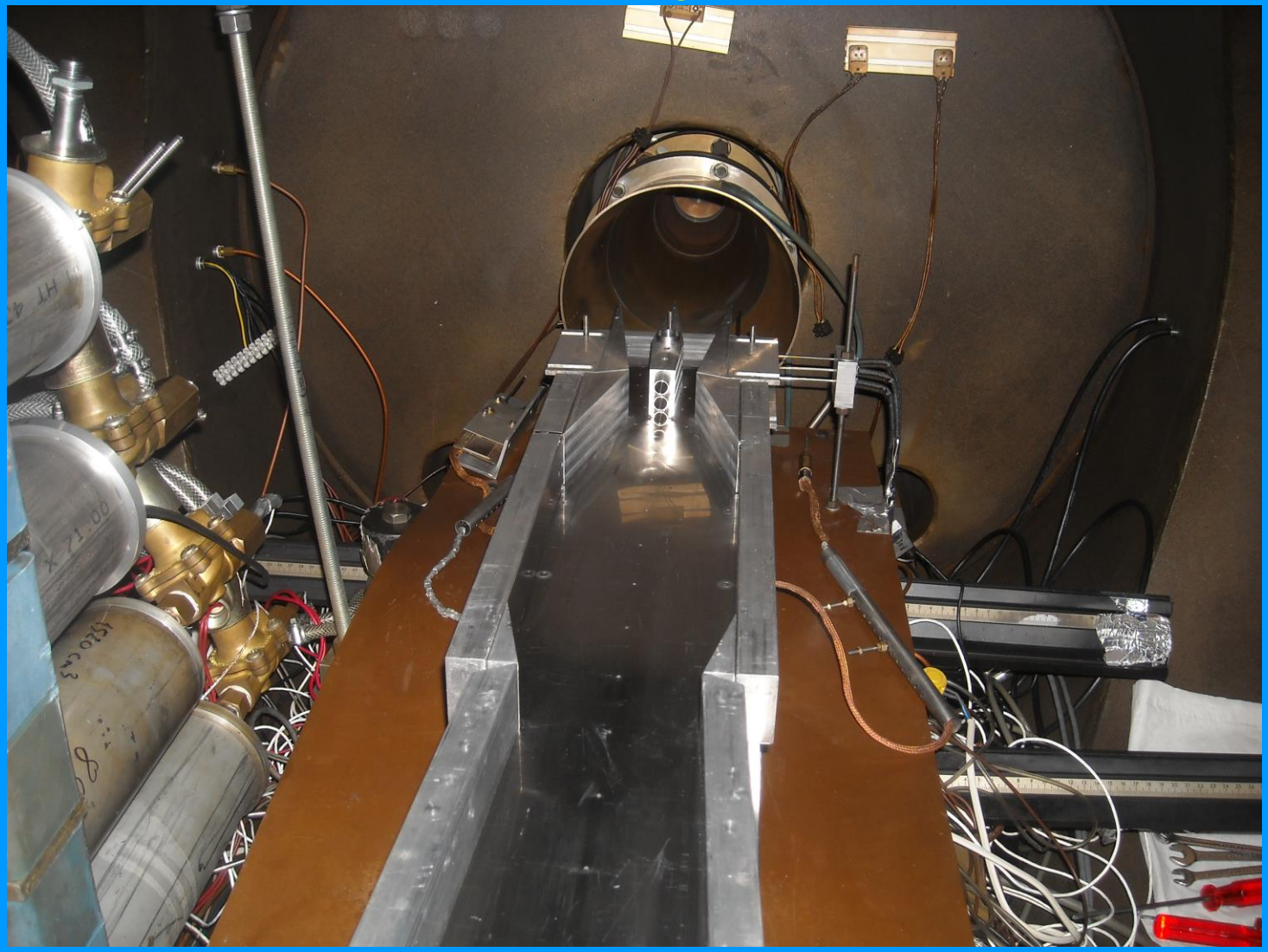
“Parametric” model engine – (3 – combustion chamber)



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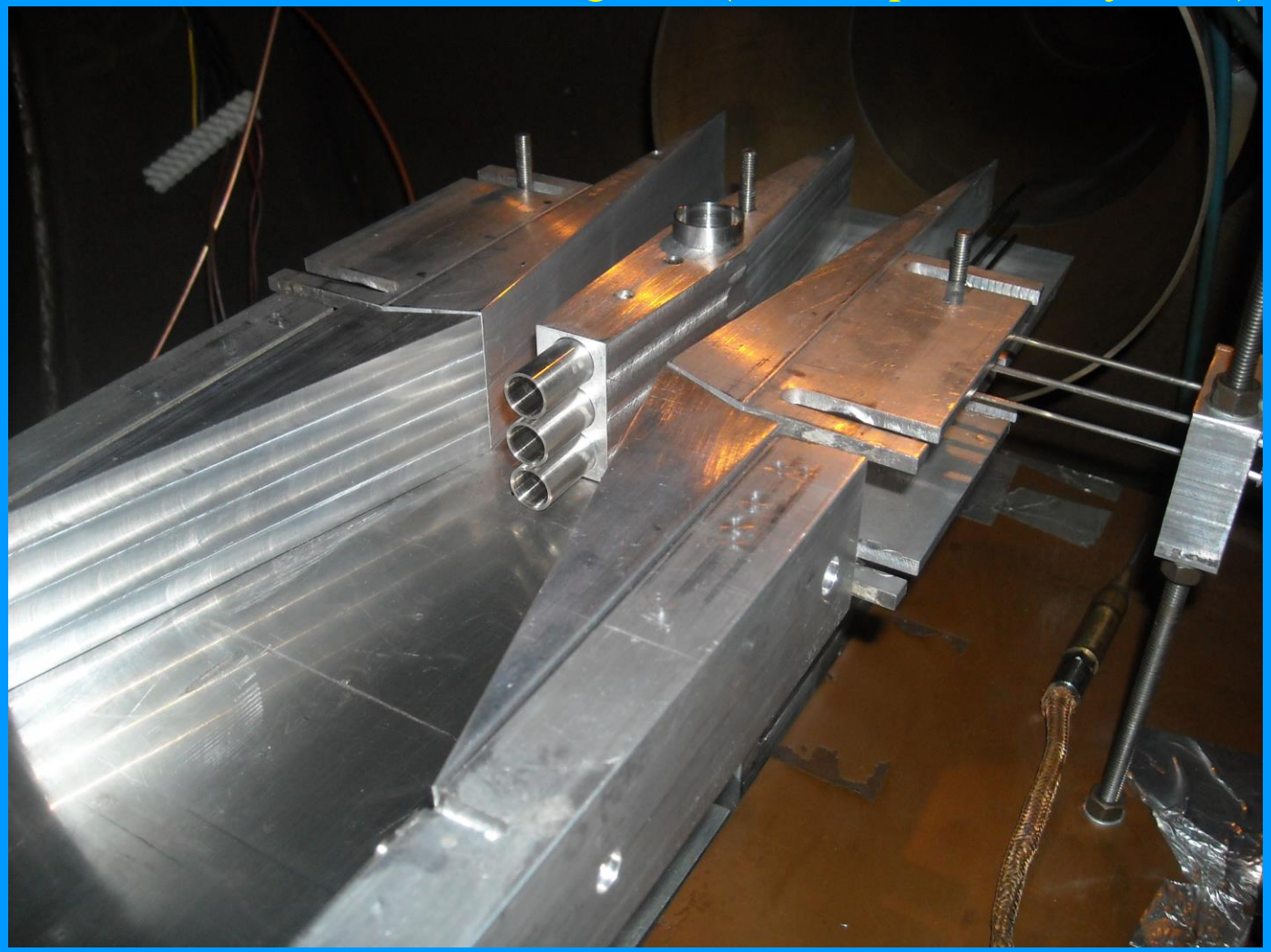
“Parametric” model engine – (4 – compressor - injectors)



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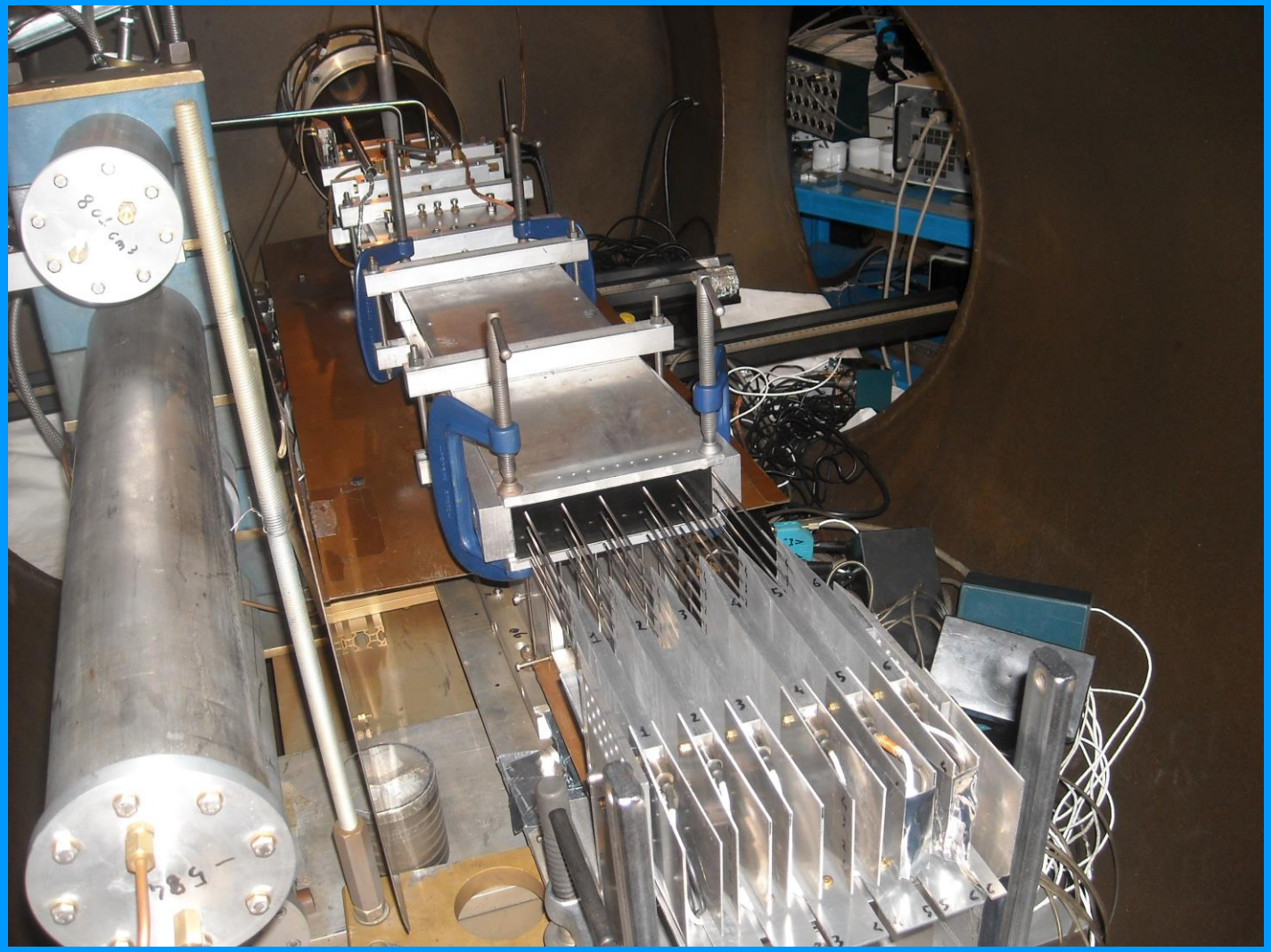
“Parametric” model engine – (1)



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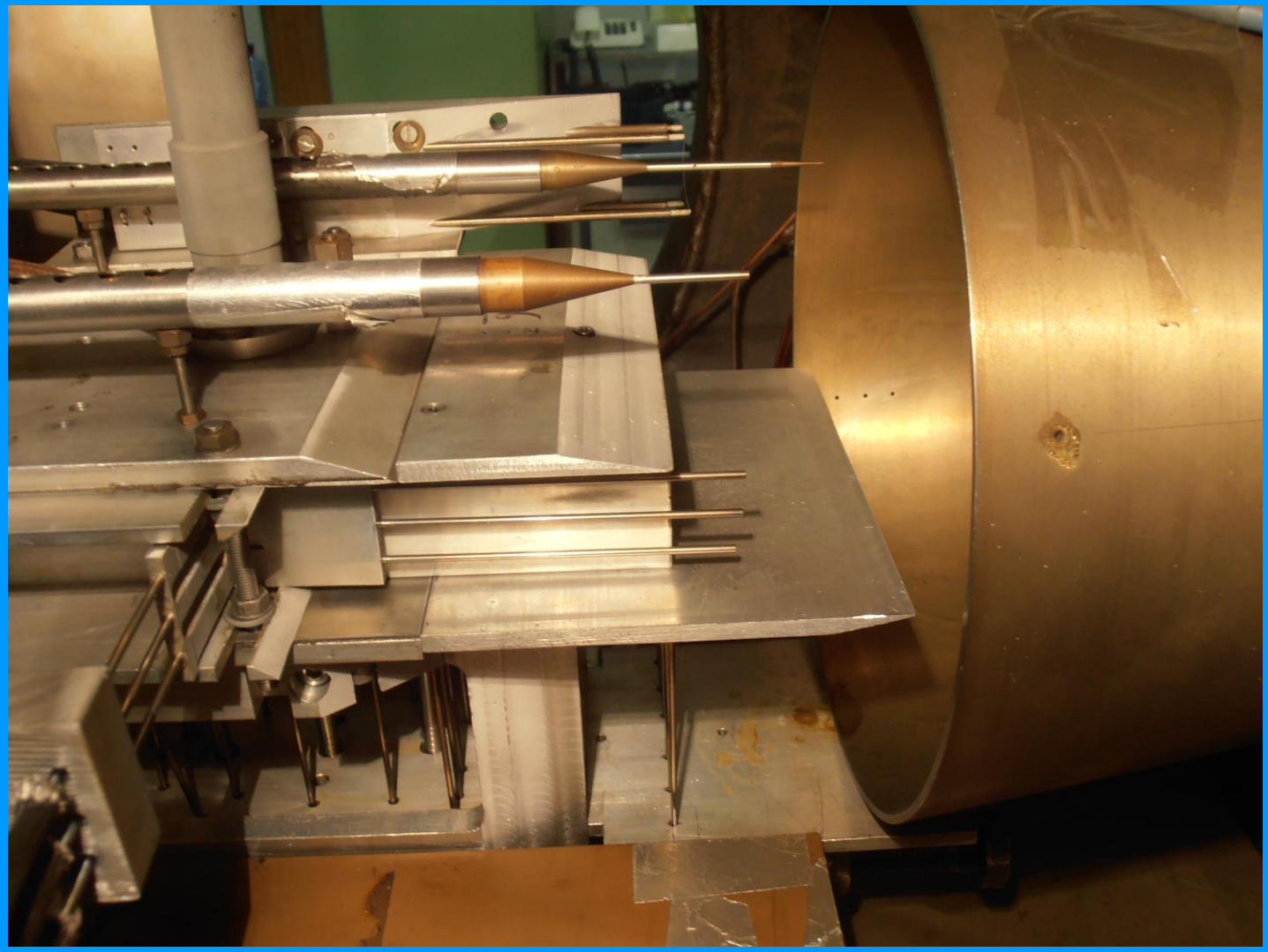
“Parametric” model engine (6 - Intake section / diagnostics)



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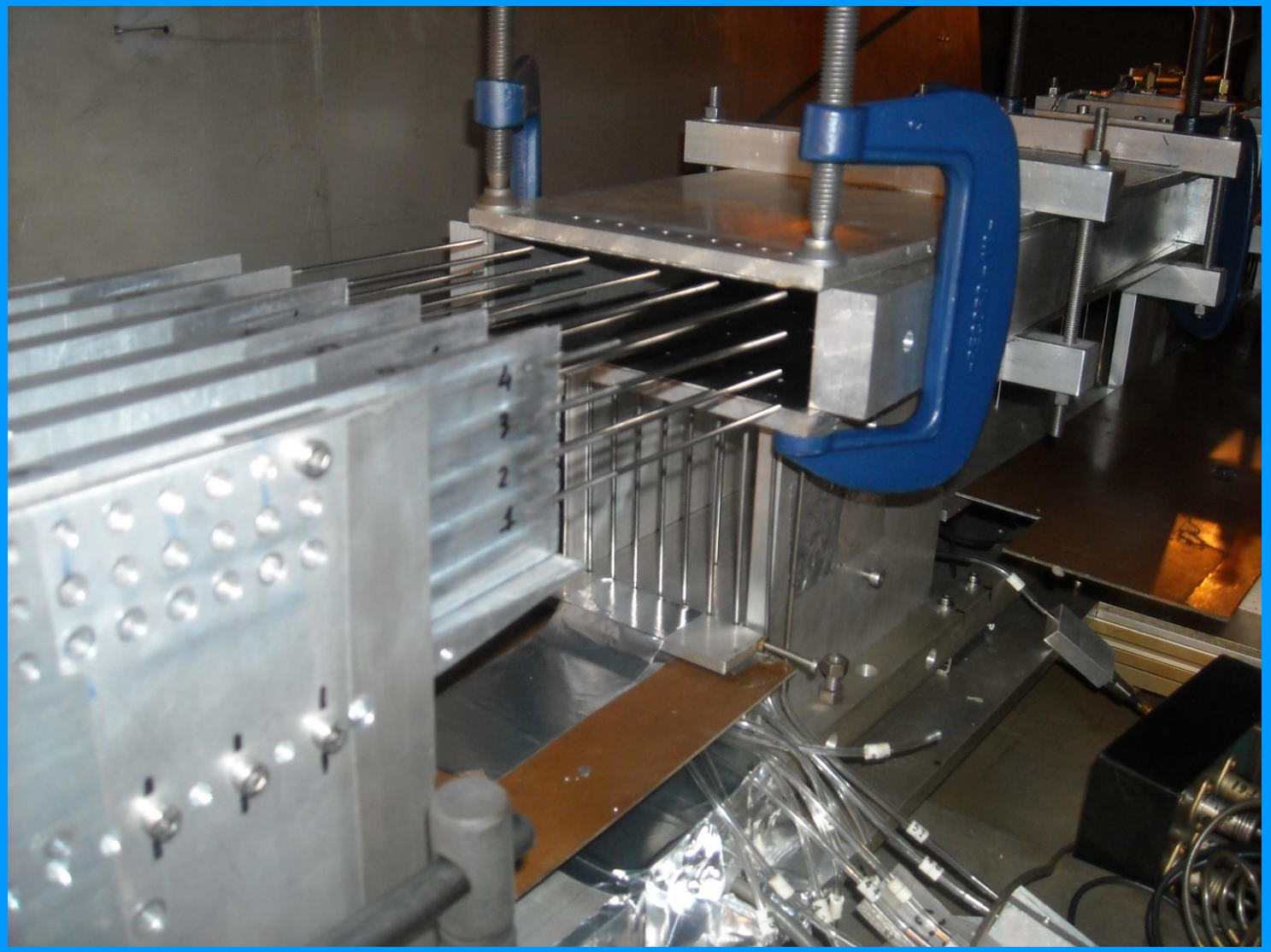
Exhaust section - diagnostics



Measured/computed quantities

Uninstalled thrust

$$F = \left(\overline{\dot{m}v + pA}\right)_{out} - \left(\overline{\dot{m}v + pA}\right)_{in} - \bar{p}_{in}\left(A_{out} - A_{in}\right)$$

Combustion efficiency

$$\eta_c = \frac{\dot{Q}_c}{\dot{Q}_{c,\max}}$$

Wall heat flow

$$\dot{Q}_w = \sum_{j=1,106} \dot{q}_{w,j} A_j \qquad \text{being} \quad \dot{q}_w = St^* \rho^* v_e \left(h_{aw} - h_w\right)$$

Thrust increment (momentum)

$$\Delta F = F_f - F_{unf}$$

Thrust increment (load cell)

$$\Delta F_C = F_{C,f} - F_{C,unf}$$

Drag coefficient

$$C_D = -\frac{2\,F_{unf}}{\rho_{fs} v_{fs}^{\ 2} A_{capt}}$$

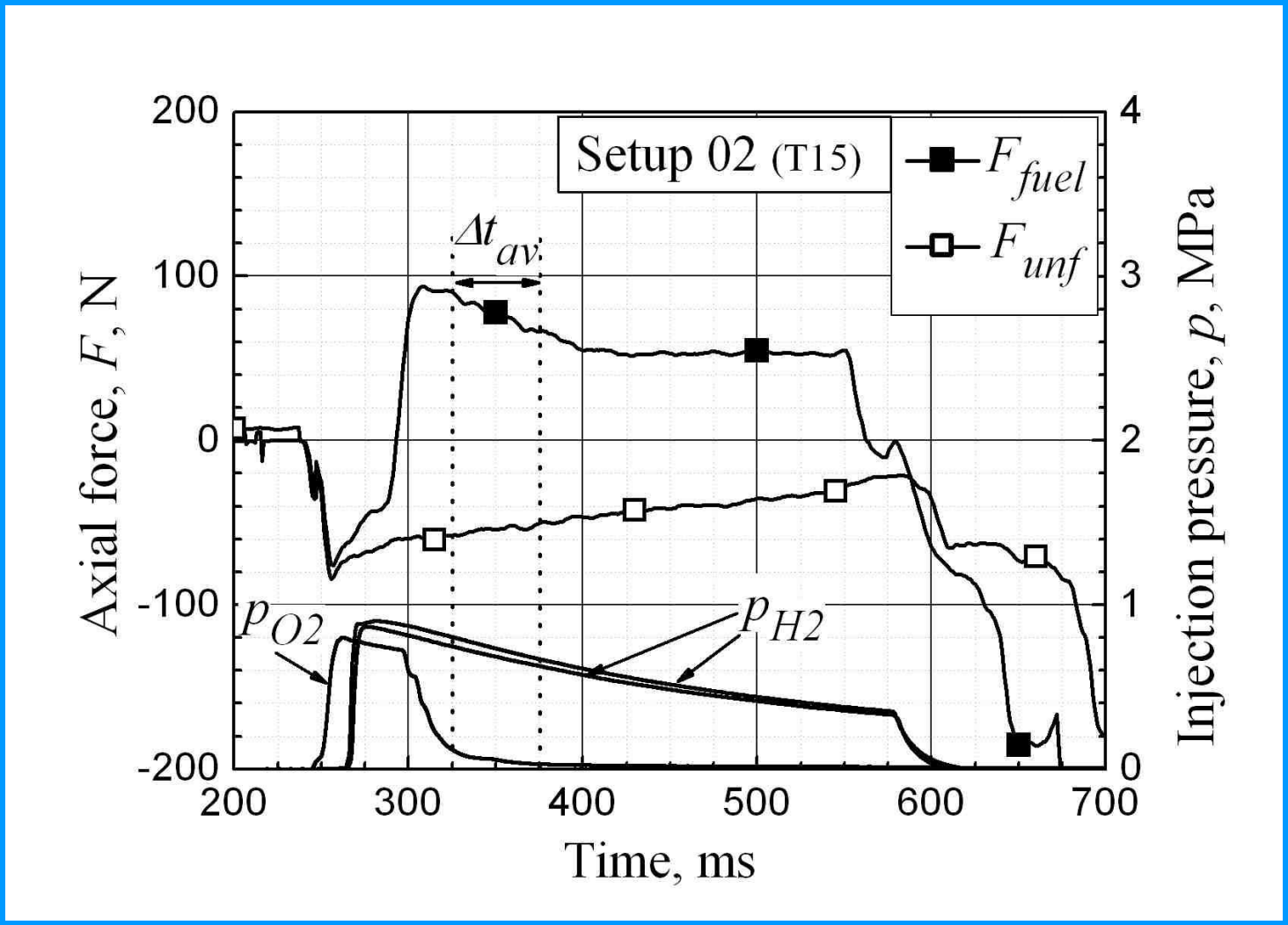
Specific impulse

$$I_{sp} = \frac{F}{\dot{m}_f}$$

Specific thrust

$$F_{sp} = \frac{F}{\dot{m}_{in}}$$

Results: uninstalled thrust (M=4.5)



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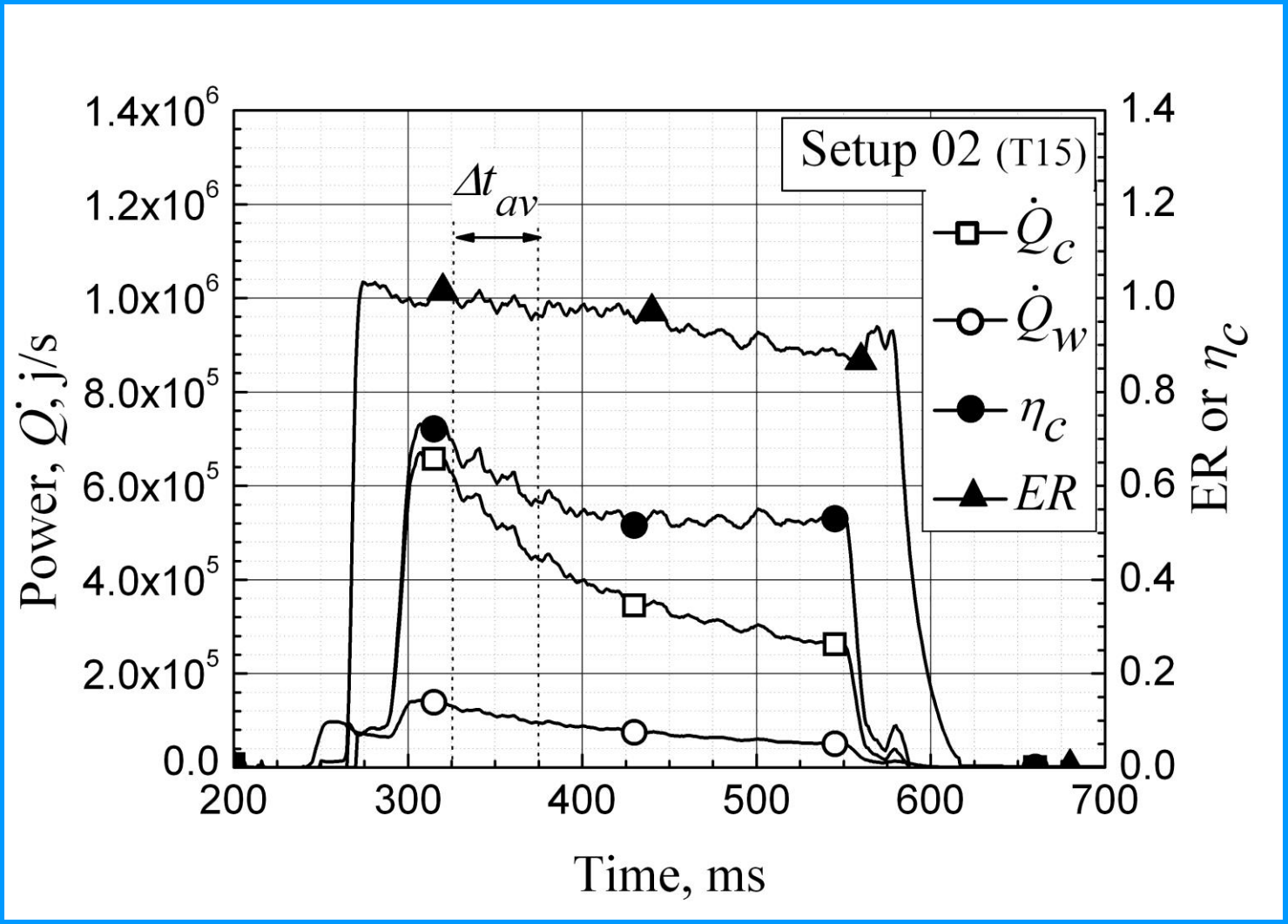
Results: powers, combustion efficiency (M=4.5)



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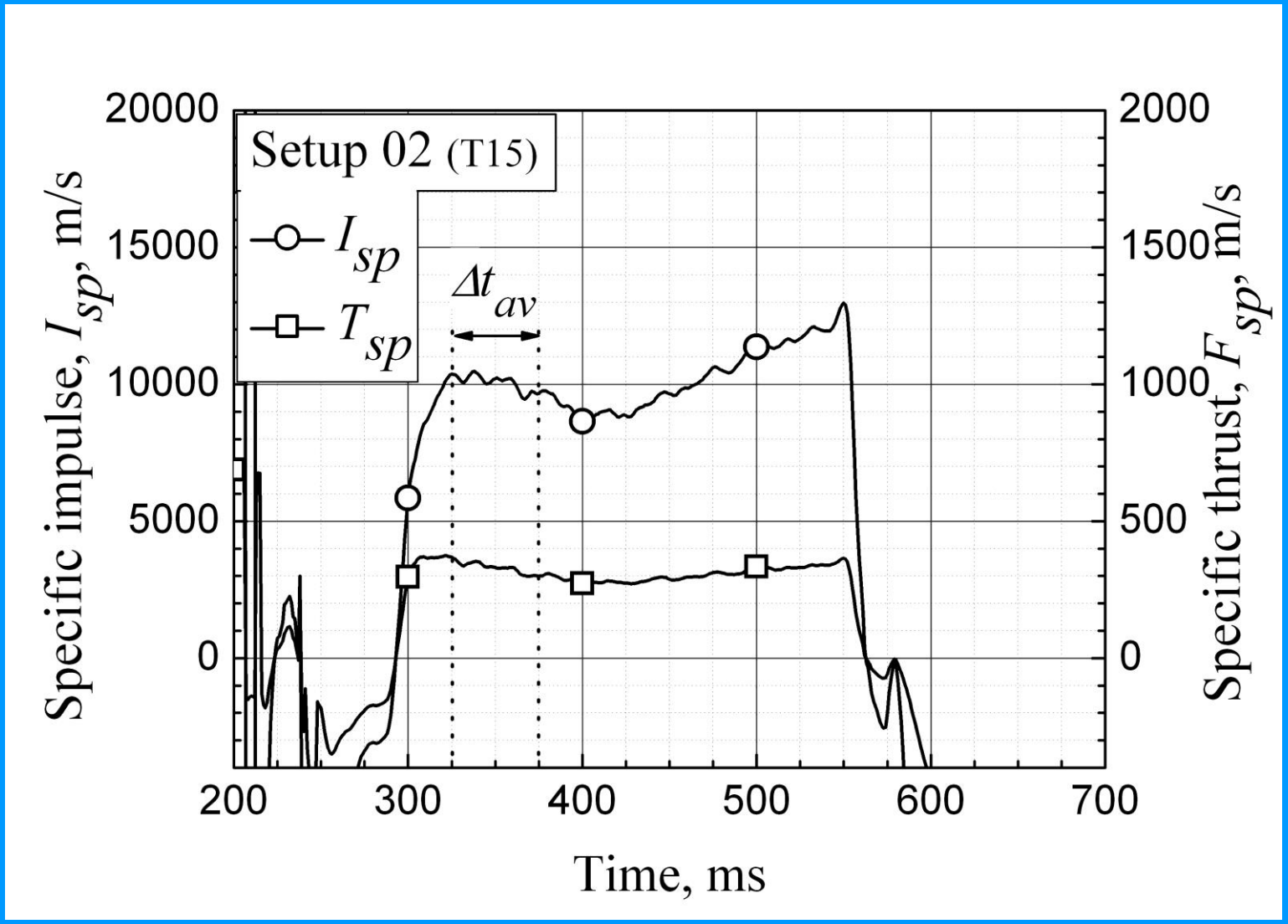
Results: specific impulse, specific thrust (M=4.5)



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Results: summary of time averaged data (M=4.5)