

Portable Ultraclean Airflow Canopy for Local Surgical Protection



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Experiment-driven evaluation of open-cavity and conditioned-cavity architectures

MECH0073 | Group 22

1) WHY THIS MATTERS

- Surgical site infection remains a significant healthcare risk.
- Room-scale ventilation may not fully protect the wound or instrument table locally.
- We developed a portable canopy to deliver a focused zone of H14-filtered ultraclean air.

2) DESIGN GOAL

- Create a **portable** supplementary protection layer for conventionally ventilated theatres.
- Use **H14 filtration** and a 203 x 203 mm outlet.
- Target mean velocity: **0.3-0.5 m/s** at **30 cm**.
- Target high outlet uniformity: **CV < 0.25**.
- Keep the device **portable**: 10.4 kg, 0.14 m² footprint.

3) PROTOTYPE EVOLUTION

P1 - Feasibility

Verified integration and test method, but H13 filtration and sealing limitations.

P2 - Open cavity

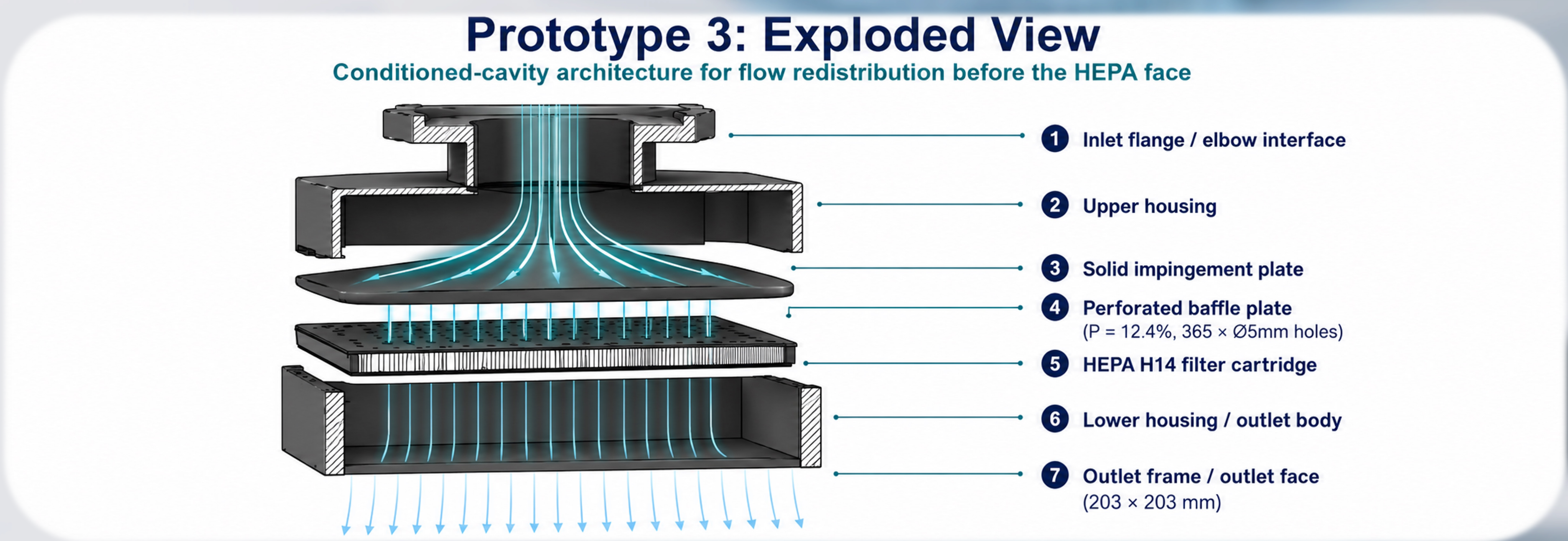
Strong centre jet
Weak edges
poor spatial uniformity.

P3 - Conditioned cavity

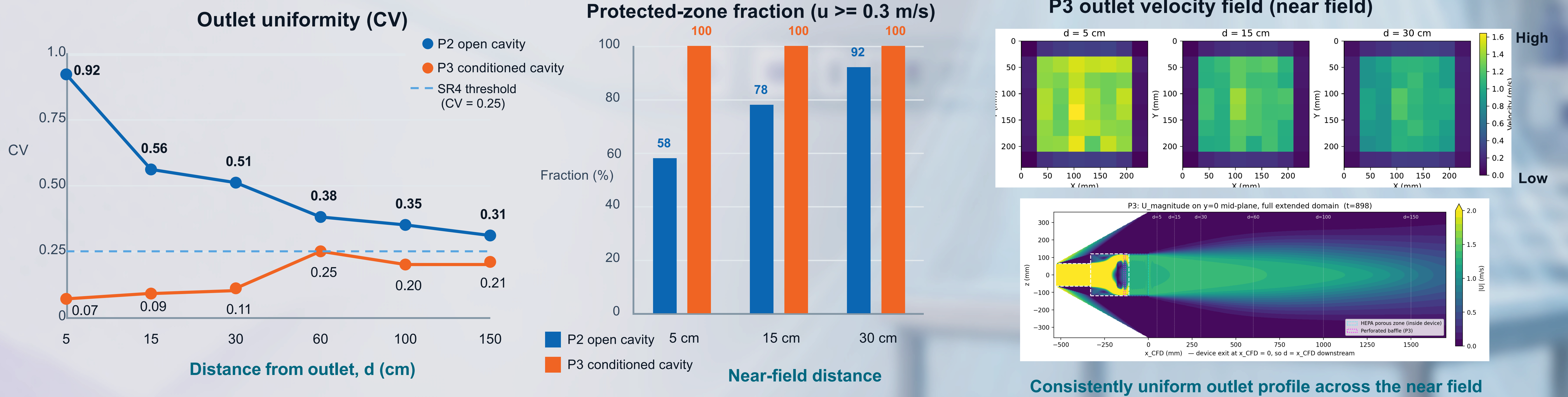
Added an impingement plate and perforated baffle to redistribute flow before the HEPA face.

4) CONTROLLED COMPARISON

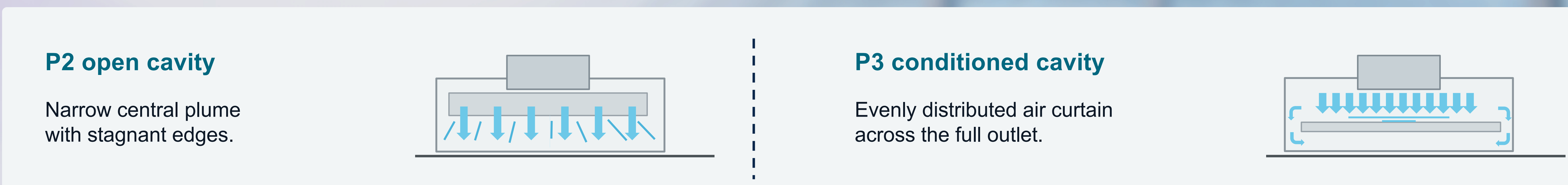
P2 and P3 share the same blower, filter, outlet size and test method. The key change is the in-cavity flow-conditioning assembly, so the comparison isolates architecture rather than hardware.



5) KEY RESULTS



Airflow pattern comparison (conceptual)



6) BIG TAKEAWAYS

13x better uniformity at 5 cm

CV reduced from 0.92 to 0.07.

100% near-field protected zone

At 5, 15 and 30 cm for P3.

~3 orders of magnitude lower edge-centre particle gap

At 30 cm, indicating much more even protection.

5 / 8 system requirements met

Met H14 filtration, portability, serviceability and outlet-uniformity targets; velocity and noise require tuning.

7) LIMITATIONS AND NEXT STEP

- Mean velocity at 30 cm is still high: 0.98 m/s vs target 0.3-0.5 m/s.
- Noise at 1 m remains above target: P2 66.1 dB(A), P3 ≈ 64 dB(A), target ≤ 53 dB(A).
- Next prototype: increase baffle open area to 18-25%, reduce fan speed by 30-40%, and add acoustic lining.

8) CONCLUSION

Uniformity, not raw flow magnitude, is the governing design objective.

The perforated-baffle architecture is the recommended direction for the next portable ultraclean canopy.