

Particle Tracing: Analysis of Airborne Infection Risks in Operating Theatres

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Major factors of postoperative infections

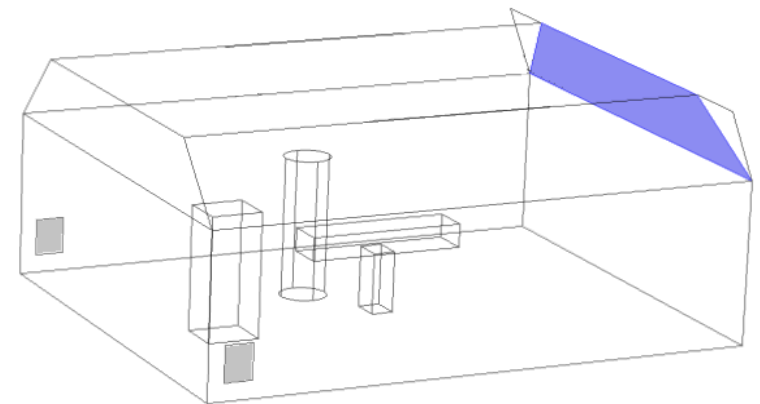
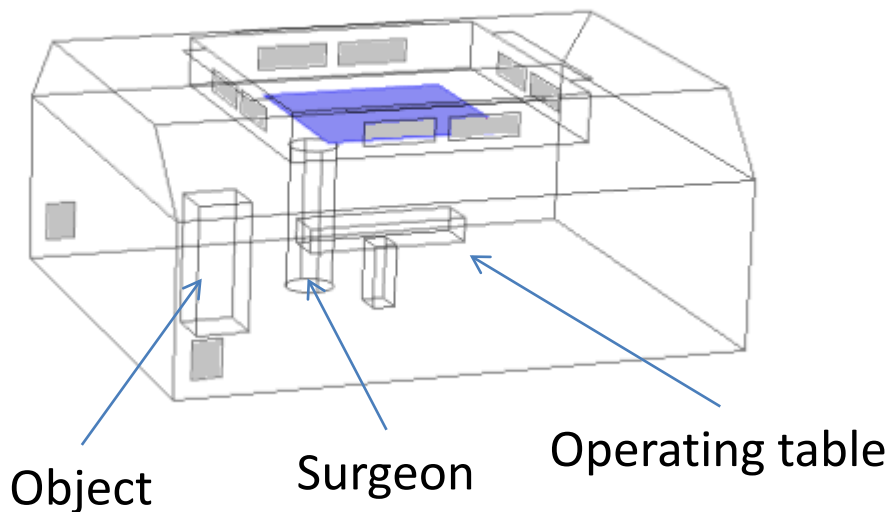
- Human skin generated particles, sizes of 5-6 μm .
- The operation staff may spread 10^4 particles per person per minute, of which ten percent are presumed bacteria-carrying.
- 8-10 personell at each operation.
- Rules of how personell should behave before, during and after an operation.
- Construction of ventilation system and it's interaction with objects and persons in the operating room.



Photo: glee442

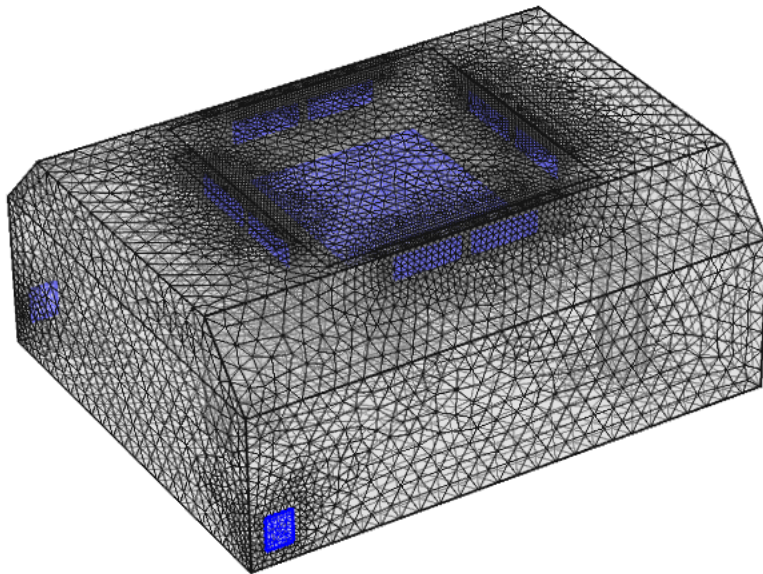
Operating theatres at Östra sjukhuset

- Simple models with some important objects in the room
- Laminar Air Flow ventilation
- Conventional mixed ventilation

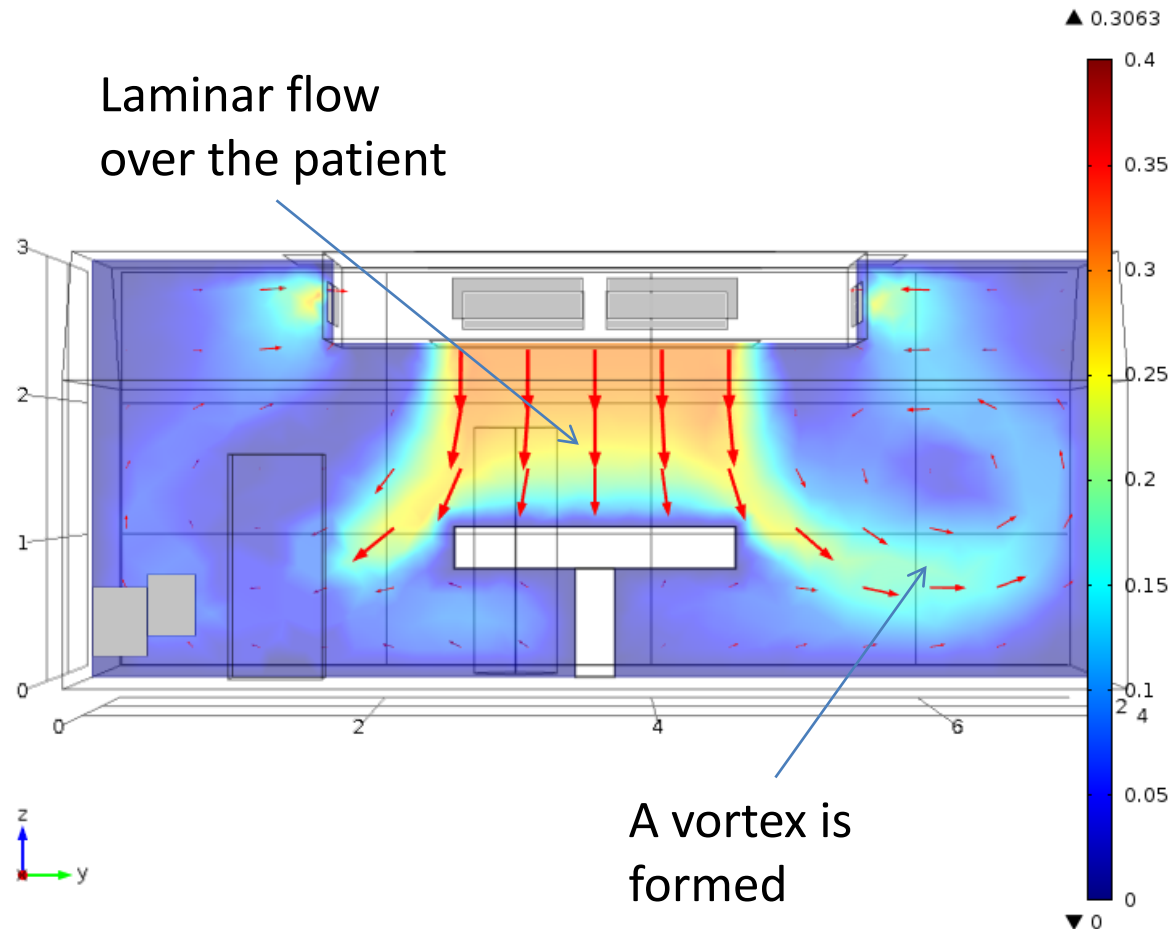


Simulations in COMSOL MULTIPHYSICS 4.2a

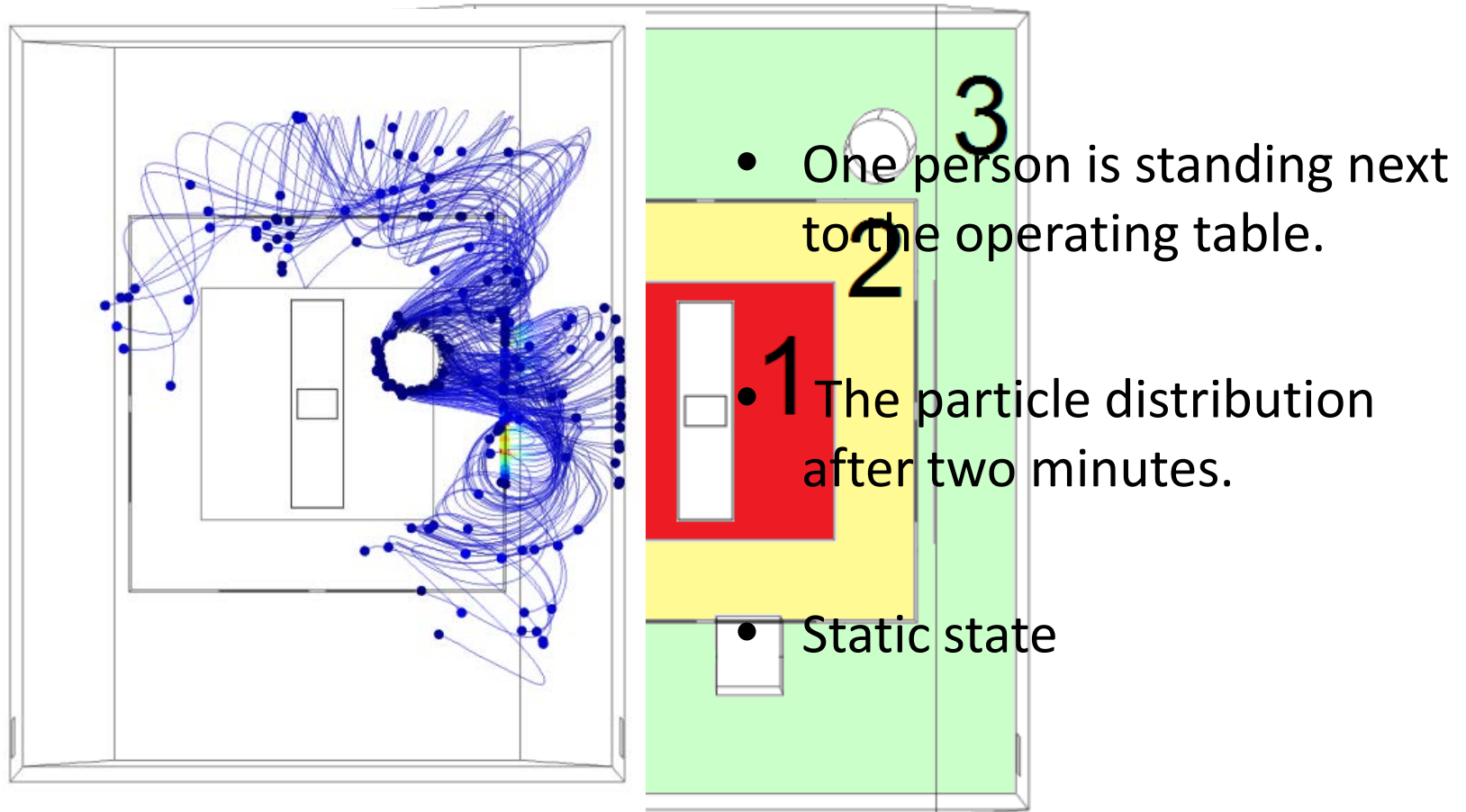
- Mesh: tetrahedral network with typical side length $\sim 28 \mu\text{m}$ (finer on critical surfaces)
- Simulation time of 1-2 hours
- Used finite element method to solve Navier Stokes equations
- Laminar:
 - *Laminar flow*
 - PARADISO (numerical method)
- Turbulent:
 - *Turbulent flow, $k-\epsilon$*
 - GMRES (iterative solver)
- *Heat transfer in fluids*
- *Particle Tracing for Fluid Flows*
 - Followed Newton's equations

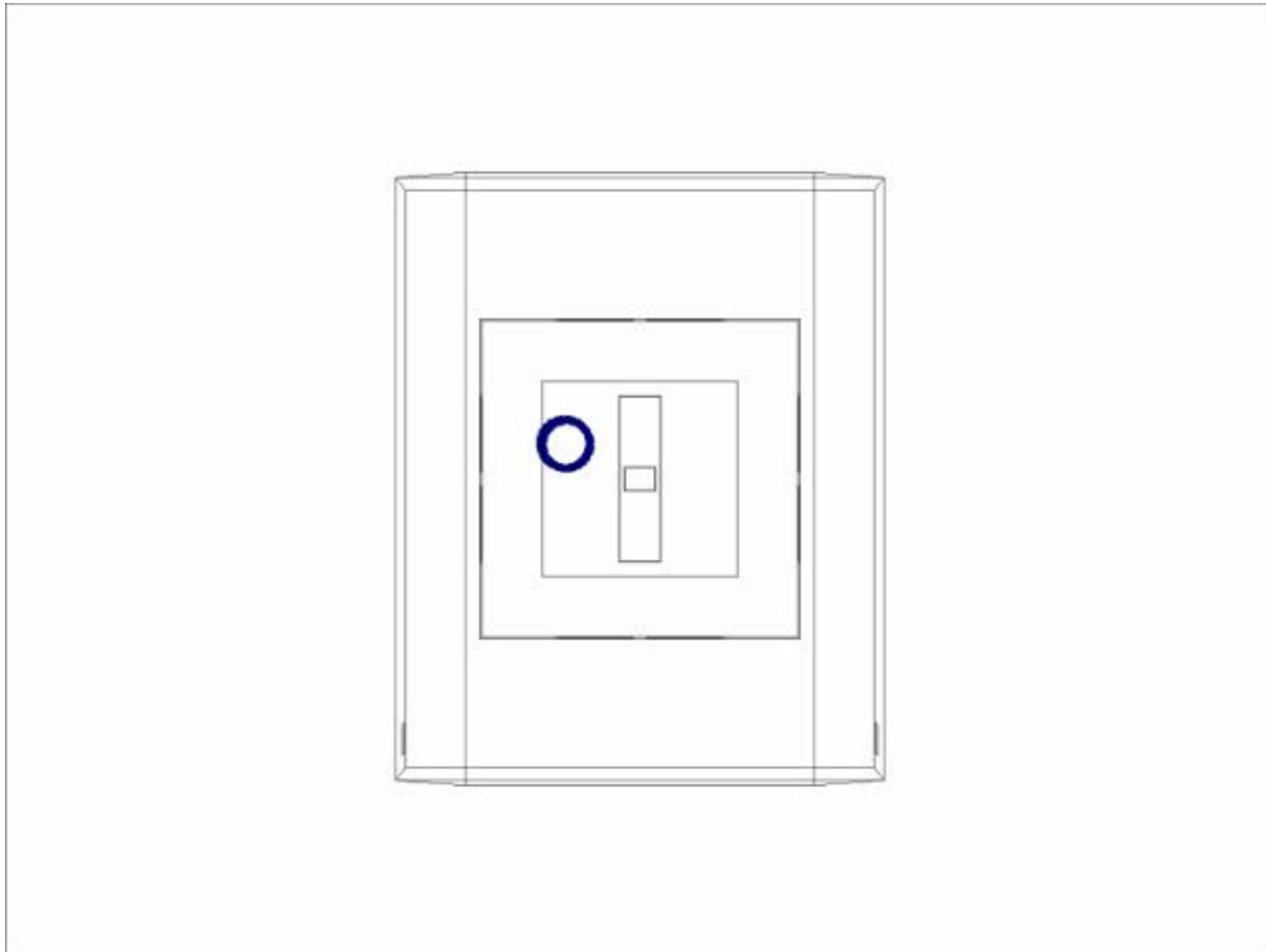


Simulation of the air flow in the Laminar Air Flow ventilation

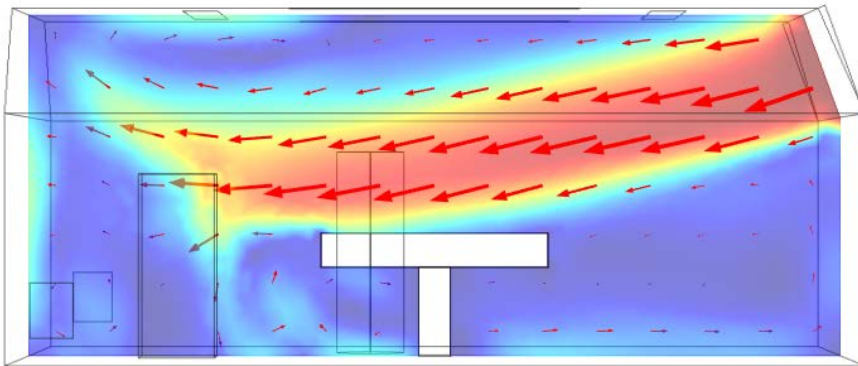


Laminar Air Flow ventilation with particle simulation

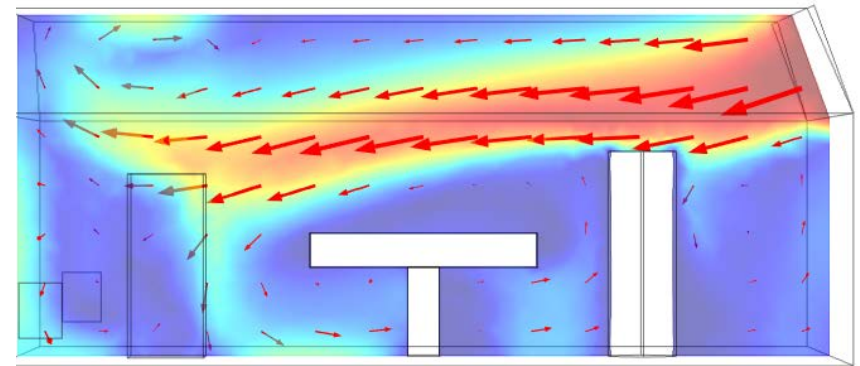




Simulation of Conventional mixed ventilation

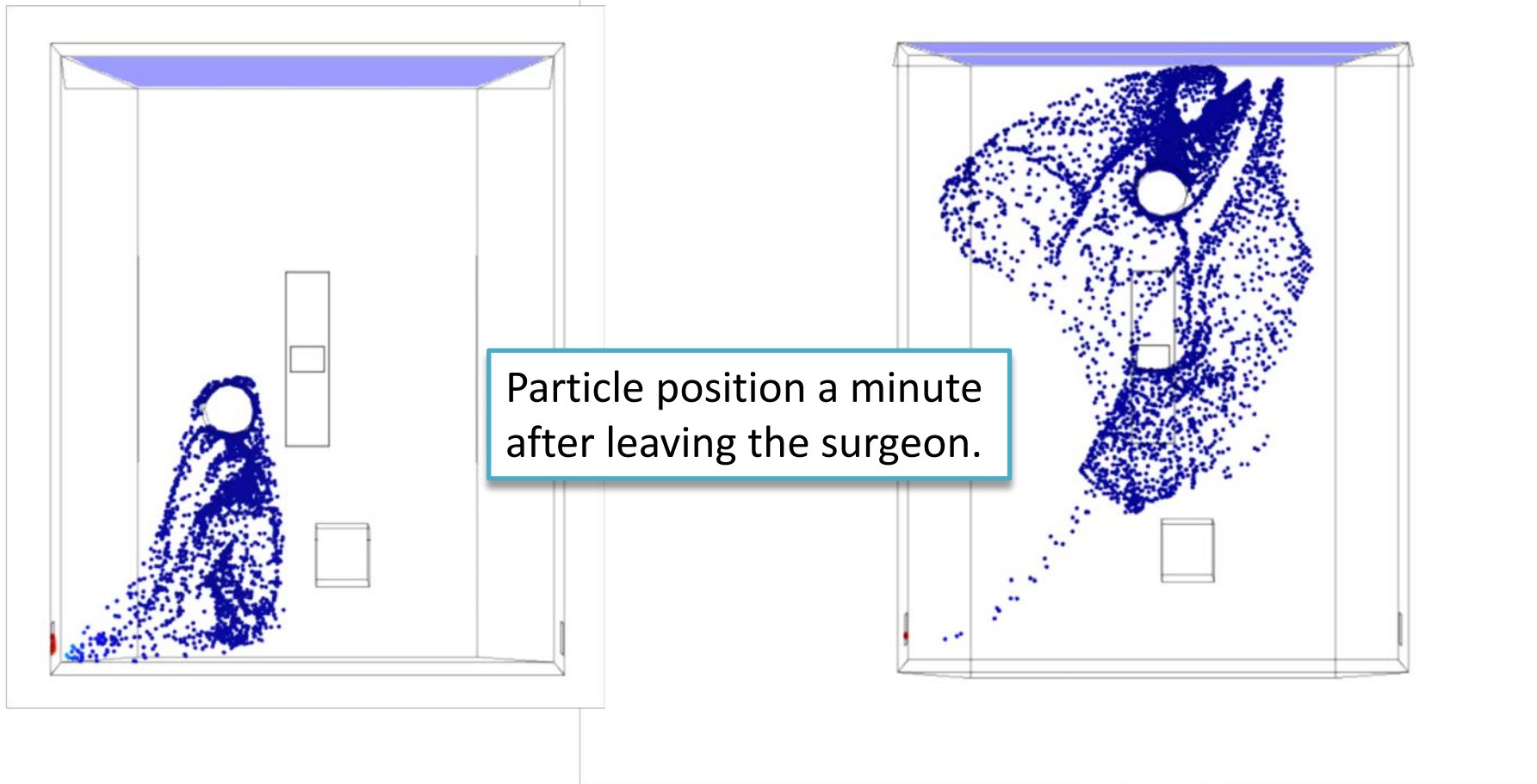


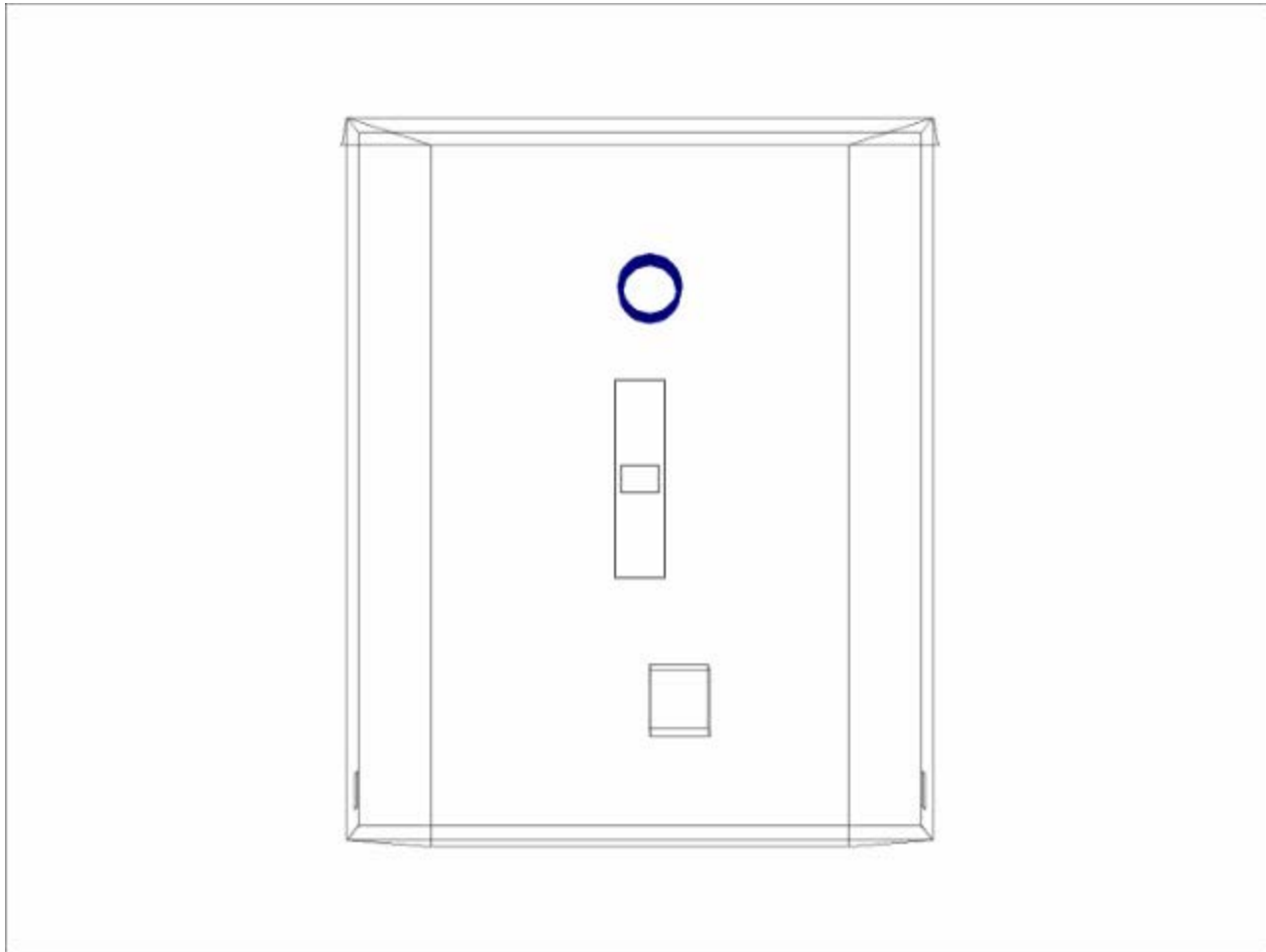
- Air travels a long distance from inlet before it reaches the patient.



- The airflow is sensitive to people being in the way.
- More vortices is formed in the room.
- A wake with almost no moving air is created above the patient.

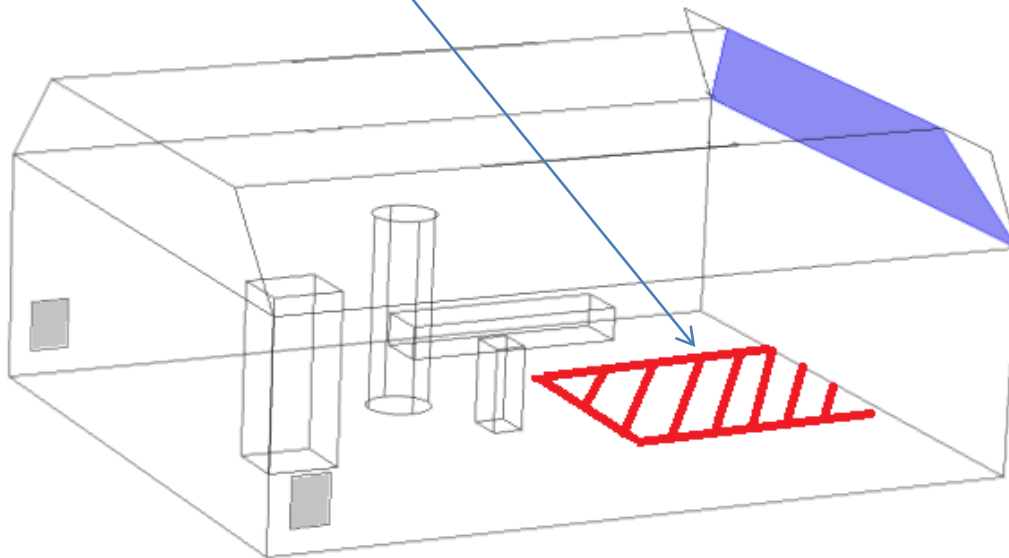
Conventional mixed ventilation with particle simulation



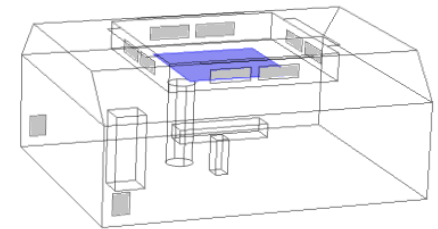


Conclusion

Highlight this area



Extend the minute of silence in the room with Laminar Air Flow ventilation.



Laminar Air Flow ventilation is, from the risk of infection, better than Conventional mixed ventilation.

Be few – be quiet – stand still

Improvements to reduce risks of infection

- Particle detectors
- Hood to pull down
- Robots



Further development of the study

- Dynamic solution
 - Personell movements
- Consider how new ventilation systems can look like
- Study how an over-all geometry change of the operating room affects the air flow



Photo: UCDDMedicine

A blue-tinted photograph of an operating room. In the center is a surgical table covered with a dark cloth. To the left is a cart with various medical devices. In the background, there are monitors and other medical equipment. The room is brightly lit with overhead lights.

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**Thank you for your
attention!**

- The operating theater with three personell.
- Shows particle positions after two minutes.

