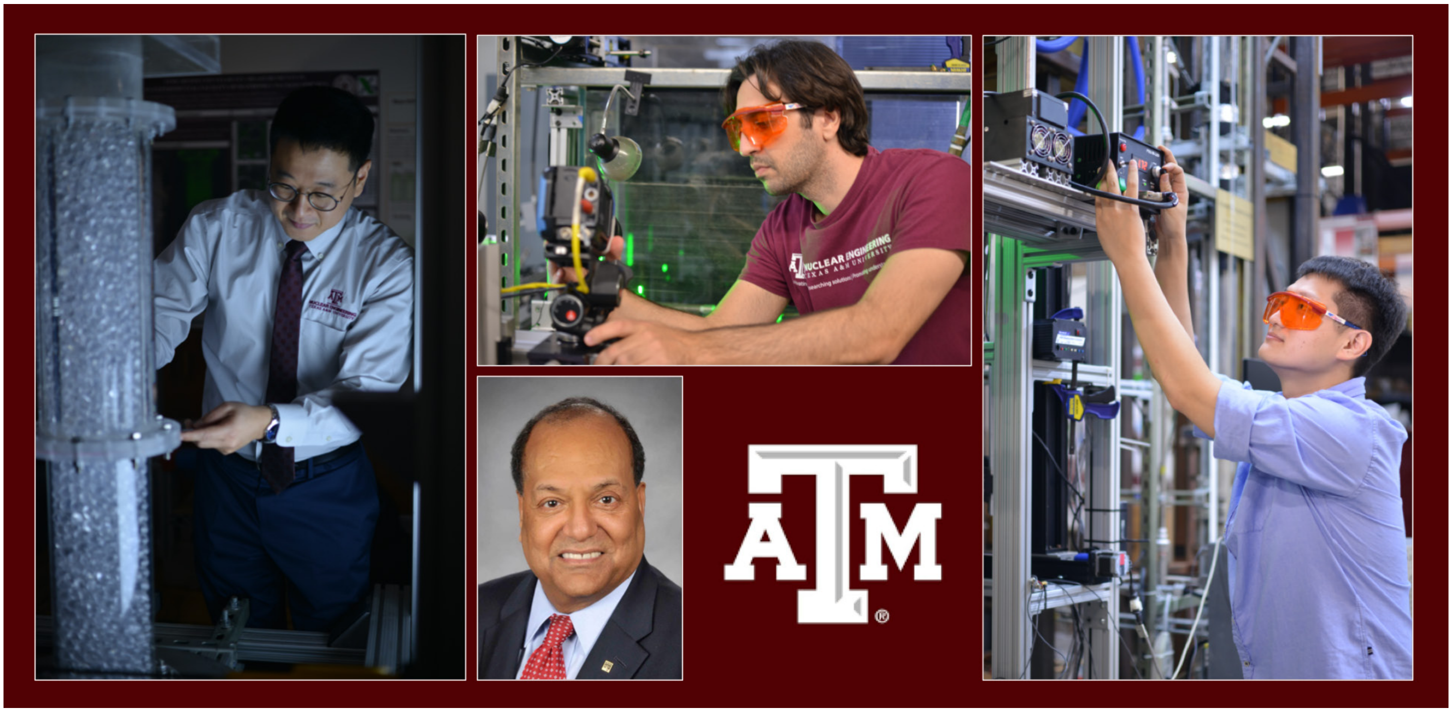


Dr. Yassin Hassan and his students at Texas A&M University: Se Ro Yang (left), Giacomo Busco (top center), and Joseph Seo (right).

# Nothing to Sneeze at: Nuclear Engineers Do Their Part in the Fight Against Coronavirus

by Paul Menser for DOE's Nuclear Energy University Program

When Giacomo Busco got a Saturday night call in spring 2020 from his professor, Dr. Yassin A. Hassan, he was expecting a conversation about thermal hydraulics, computational fluid dynamics, or multiphase flow. For a nuclear engineering student at Texas A&M University, these are what you typically talk about with your professor.

He did not anticipate the question to be, "What do you know about sneezing?"

But Hassan, whose honors include membership in the National Academy of Engineering and the American Nuclear Society's Seaborg Medal, had coronavirus on his mind. Because his research interests include fluid mechanics, turbulence and laser velocimetry, and imaging techniques, he thought it might be timely to pursue research into the mechanics of an everyday ah-choo!

More than coughing, a sneeze from an asymptomatic COVID-19 patient has the potential to disperse infected droplets and aerosol particles over a wide pattern. How widely in various conditions—hot, cold, dry, humid, smoggy—was what intrigued Hassan.

This curiosity resulted in a peer-reviewed article in Physics of Fluids, "Sneezing and Asymptomatic Virus Transmission." In addition to Busco, the main author, and Hassan, Se Ro Yang and Joseph Seo, also nuclear engineering students at Texas A&M, contributed. Since its publication in mid-July, it has had more than 6,400 views and been cited 22 times. Hassan has received calls from the National Institutes of Health and international organizations.

"The reception is unlike anything I've ever seen with one of my papers," said Hassan.

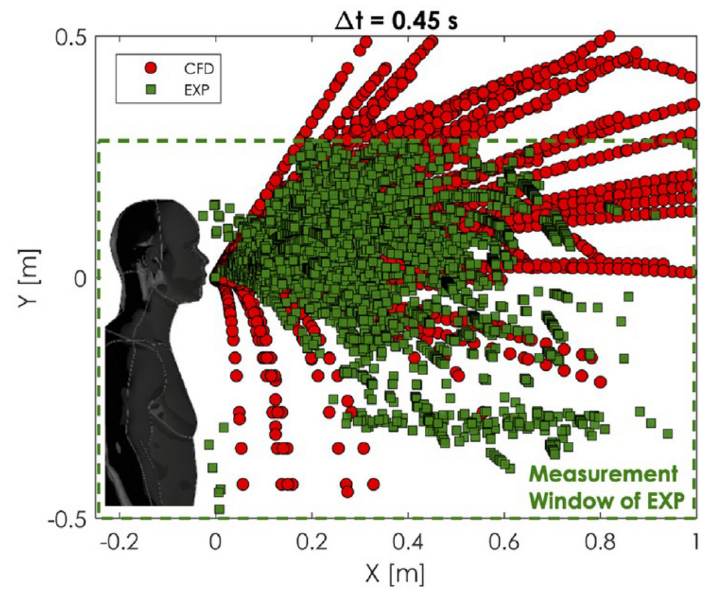
To accomplish this research, the team had the resources of Texas A&M's Thermal-Hydraulic Research Laboratory, which contains equipment funded through the U.S. Department of Energy's Nuclear Energy University Program. With state-of-the-art high-speed cameras and an infrared camera, they were able to use laser-diagnostics techniques, including particle image velocimetry and particle tracking velocimetry, to characterize flow dynamics of the sneeze.

The team's efforts were aided immeasurably by Yang and his rhinitis. While the journal Rhinology reported in 2002 that a normal person sneezes on average less than four times a day, Yang lets loose around 30 times a day. During the experiments, only Yang was allowed to be in the room. All surfaces were cleaned thoroughly with disinfectant after each sneeze.

Before their paper, existing models for studying sneezes treated the head as stationary and rigid, without any motion or individual variations affecting the predicted dynamics and spatial region covered by the sneeze. By including head motion, Yang and the team developed a more realistic sneezing model for studying complex coronavirus transmission scenarios.

A combination of experimental and computational techniques allowed the group to create a dynamic model that captured the flow characteristics of sneezes a healthy adult might produce. Human factors—specifically head motion and changes in pressure—were incorporated while treating the sneeze as a momentum source.

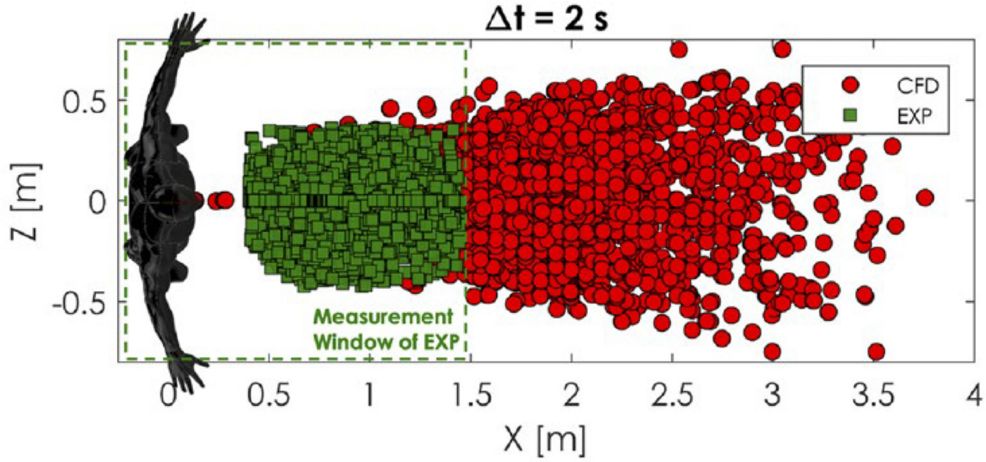
As they analyzed the cloud spread of a sneeze, they found that one cloud could cover twice as much space as what had been previously thought. The authors also used the technique to factor in humidity, temperature, and air pollution.

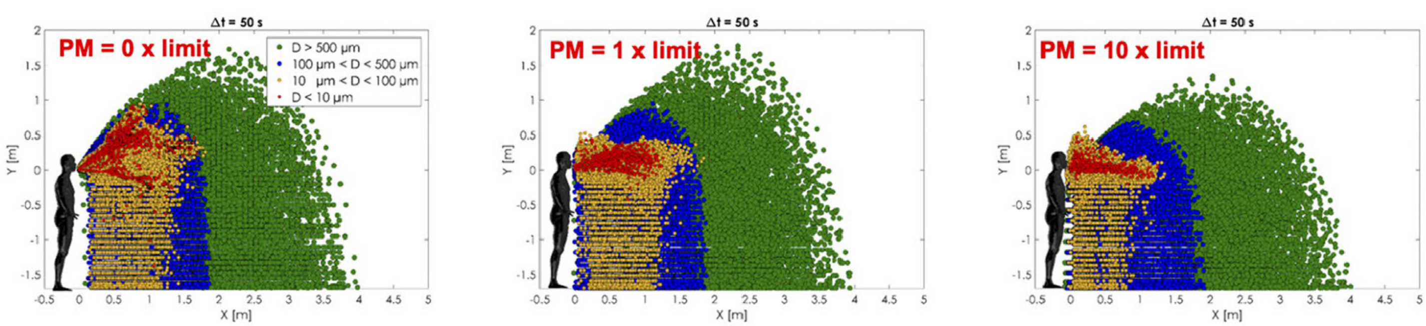



Comparison of cumulative time distribution of the sneezing droplets. Front view (above) and top view (below). Measurement window of the experiment (EXP) is the dashed line.

"Is it safer to sneeze in a hot, humid, and polluted city or in a cold, dry, and unpolluted suburb?" asked Busco. "Our study can answer this question."

Busco said he was interested in learning why industrialized northern Italy, where he lives, suffered more from COVID-19 than rural Sicily, at the southern end of Italy. Pollution could be one factor, which strengthened his belief that nuclear power can offer cleaner air and better health for everyone.



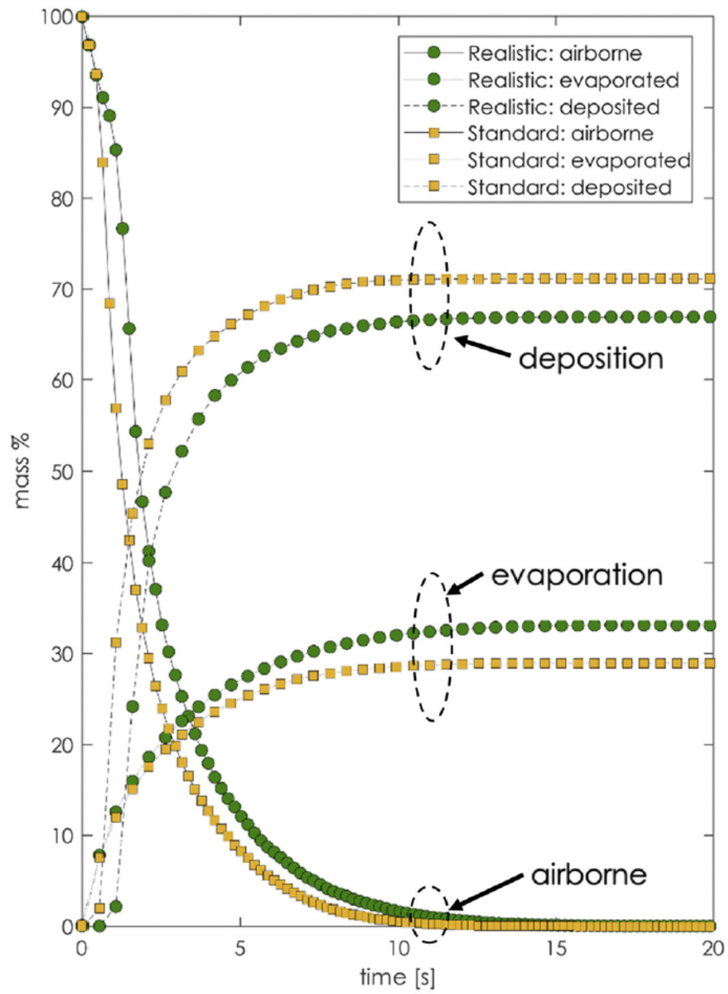




It is clearly seen that the air pollution simulated by particulate matter (PM) affects the droplets and aerosol spreading dynamics. Increased PM causes more drag and reduces the spread of the sneeze cloud. The above figures show the increase of pathogen concentration with PM10 & PM2.5. Direct transmission from the droplets and indirect transmission due to deposition of droplets to surfaces should be considered more seriously under the air pollution.

By customizing computational conditions to alter flow pattern like air circulation, the sneeze cloud model can be adapted to specific settings, such as a particular office or factory. The group is currently using their model to optimize some of their university classroom setups in anticipation of reopening, in addition to aiding the rail transport industry to manage seating.

Whether it's studying turbulent flow in a reactor or droplets and aerosols dispersed in a sneeze, the physical phenomena and the validations of the models through experimentation have similarities, Busco said. "Human factors are critical in nuclear operations and the spread of coronavirus. The physics are similar."

As members of the engineering research community, the team saw its role as an important one, developing tools and engineering solutions that might aid humanity in its defense against a deadly pandemic. "It is extremely important to create a modern, reliable computational framework that is able to simulate different scenarios while containing as much physics as possible," the article said.




Evaporation, deposition, and residual airborne percentage of the initial ejected mass. Comparison of the conventional (standard) model with the present (realistic) model.