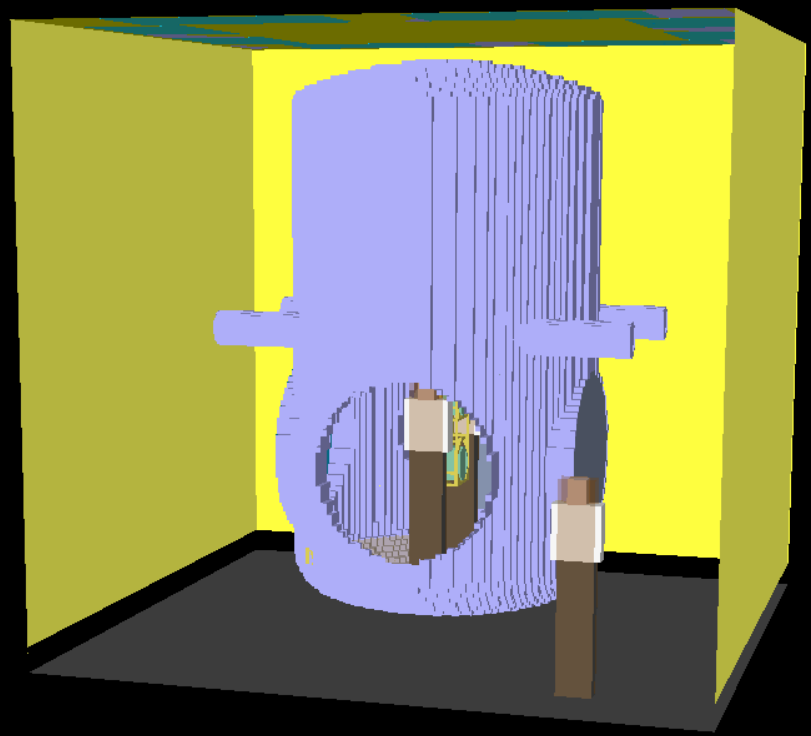
Contamination Control Study: BSC Chamber

LIGO Observatory



Project Number: FVMS0506-01
Baseline Results
August 9, 2006

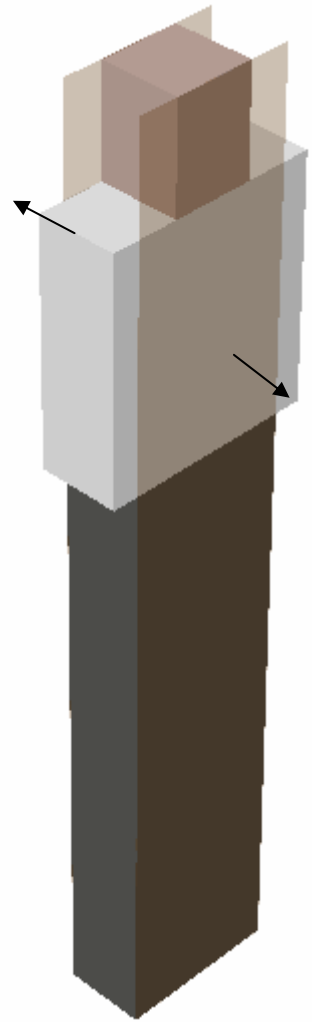
LIGO-T060204-00-D

Objectives

- Create a thermal/airflow FLOVENT model of the BSC Chamber and surrounding Cleanroom to determine airflow patterns and contamination concentration with respect to the following scenarios:
  - Scenario 1:
    - BSC Chamber Air Supply/Extract: OFF
    - Surrounding Clean Room Space Air Supply: ON
  - Scenario 2:
    - BSC Chamber Air Supply: ON
    - Surrounding Clean Room Space Air Supply: ON

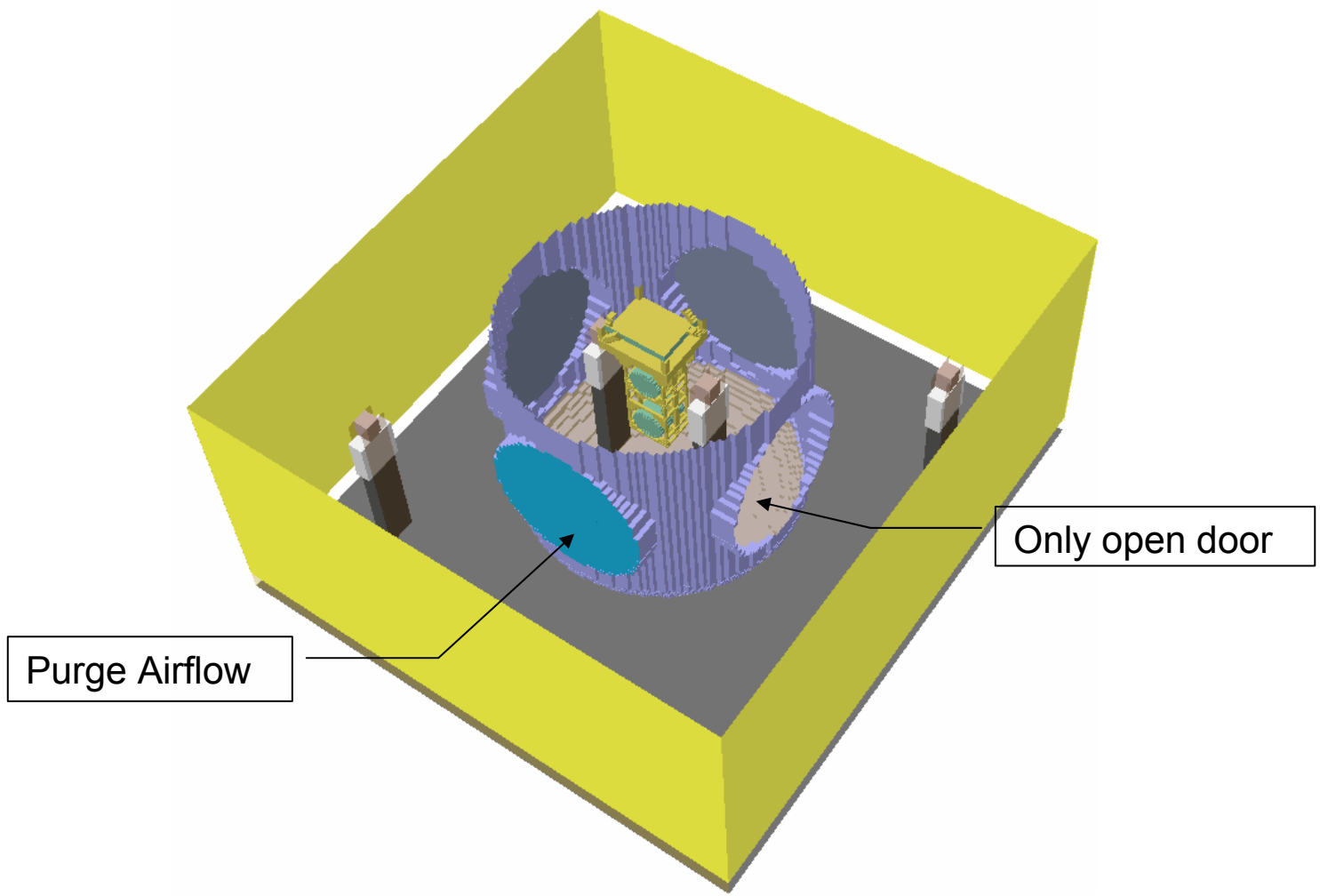
Personnel Assumptions

- Personnel:
  - 4 personnel: 2 in BSC Chamber, 2 in surrounding cleanroom
  - Contamination Generation rate: 3950 particles/sec (≥ 0.5um)
  - Heat Generation rate: 85 W sensible heat

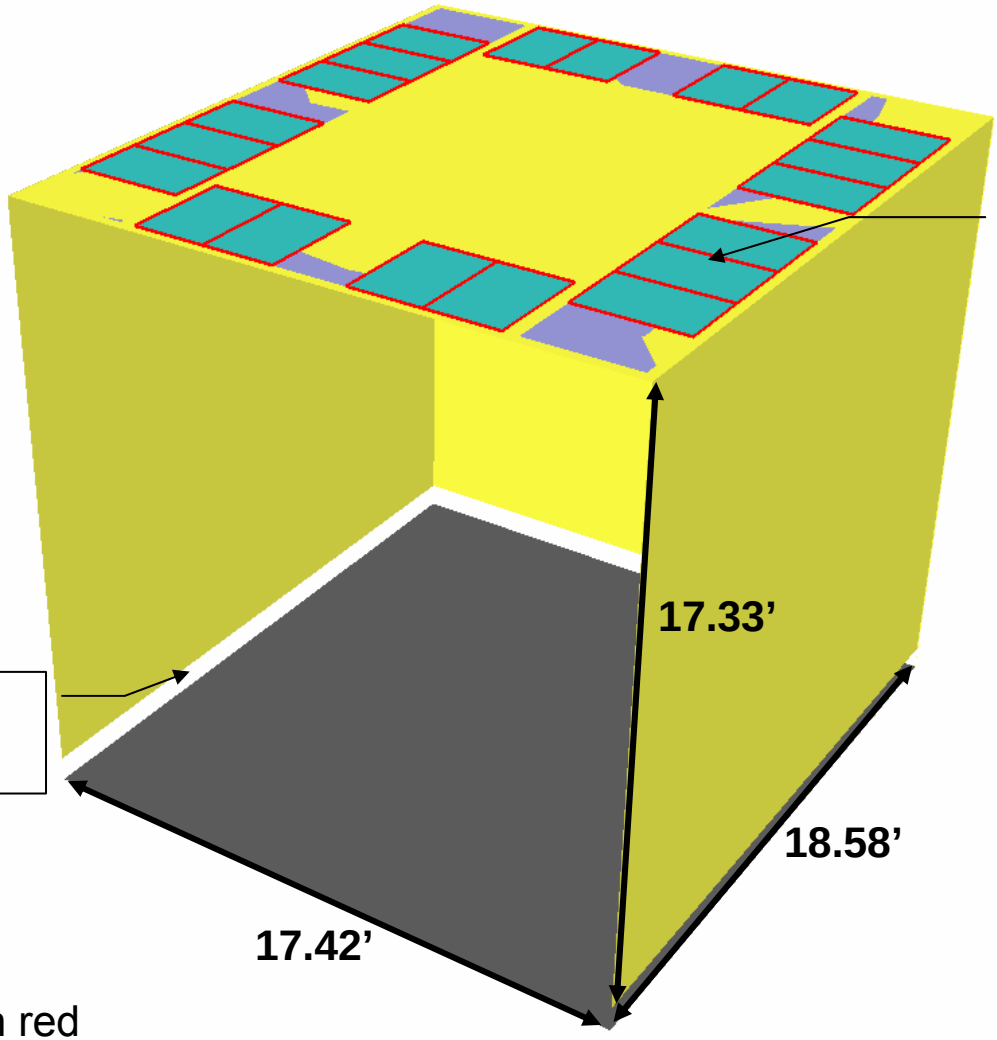


Contamination rate based on: high quality cleanroom clothing systems at 25 washes and moderate personnel activity (Cleanroom Clothing Systems: People as a Contamination Source, Ljungqvist and Reinmuller)

Personnel Locations

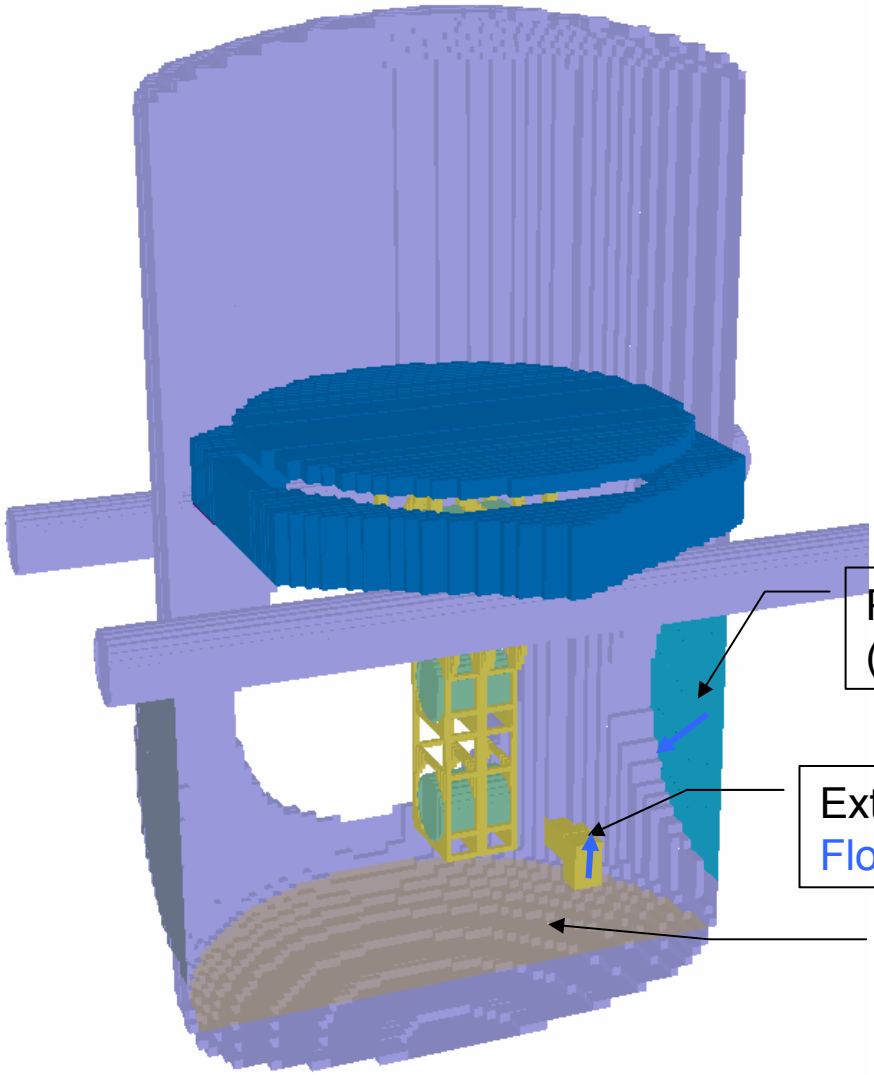


Cleanroom Overview



HEPA Filters outlined in red

BSC Airflow Overview

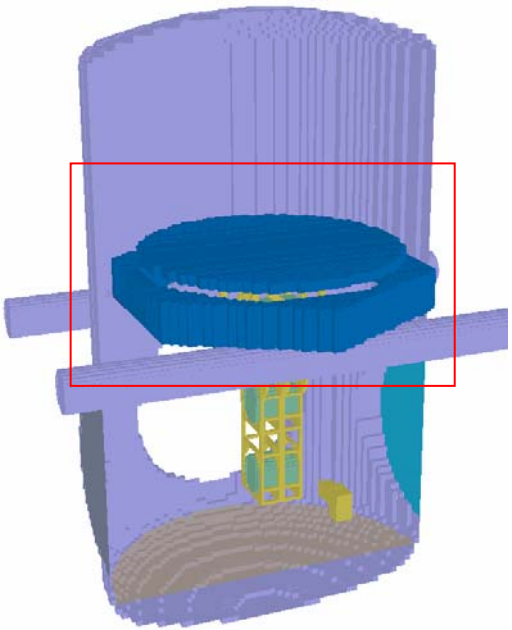


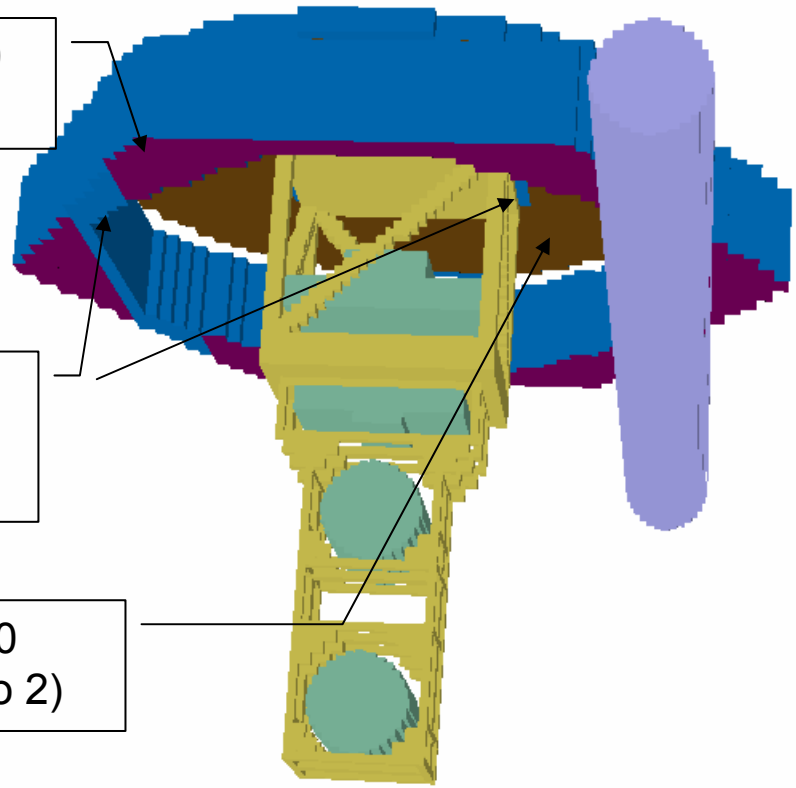
Purge Airflow: 0.012 m^3/s (25 cfm) Flow direction

Extract Flow: 2.8 m^3/s (scenario 2) Flow direction

Perforated Floor:20% Open

Air Shower Overview





Annular Flow: 2.0 m^3/s (scenario 2)

No Flow Area (Support rod hidden for clarity)

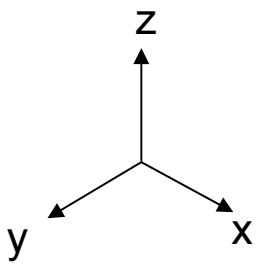
Core Flow: 1.0 m^3/s (scenario 2)

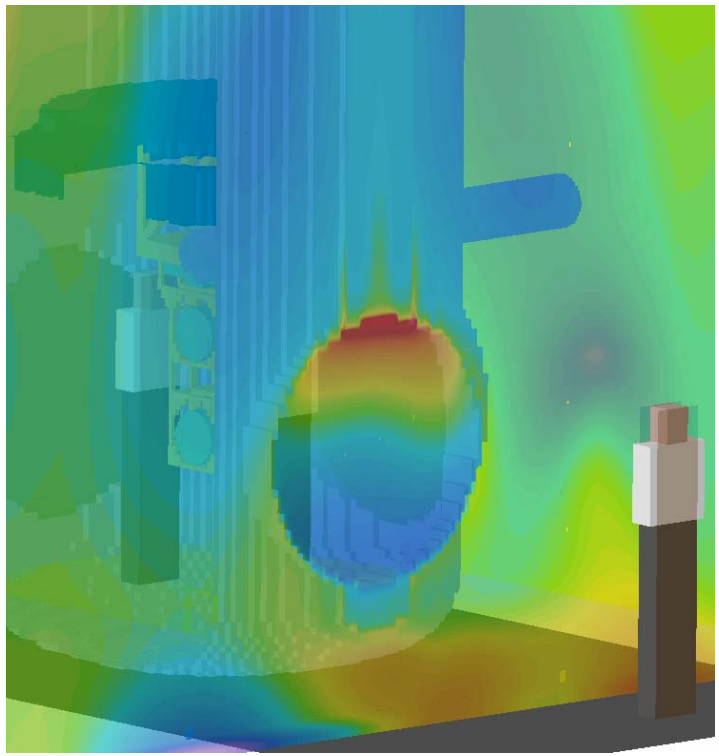
Core Flow and Annular Flow approximated with flow accelerated through 3/8” holes on 1” pitch (11% Open)

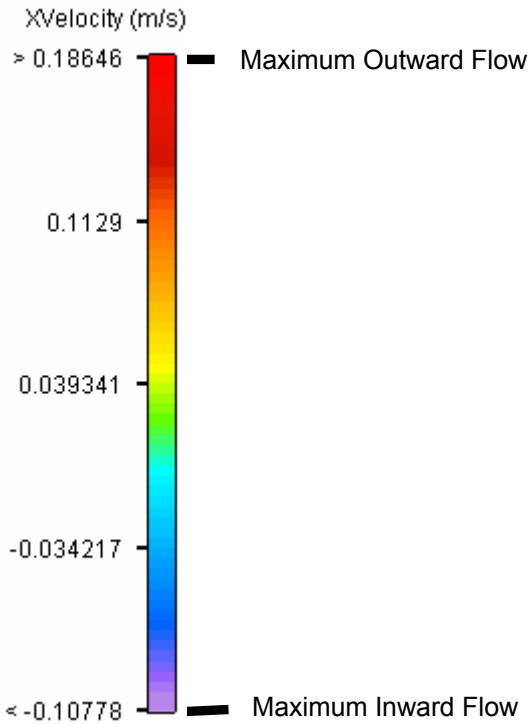
Simulation Results

BSC Chamber Air Supply and Extract Off

Speed Profile through the Chamber Door







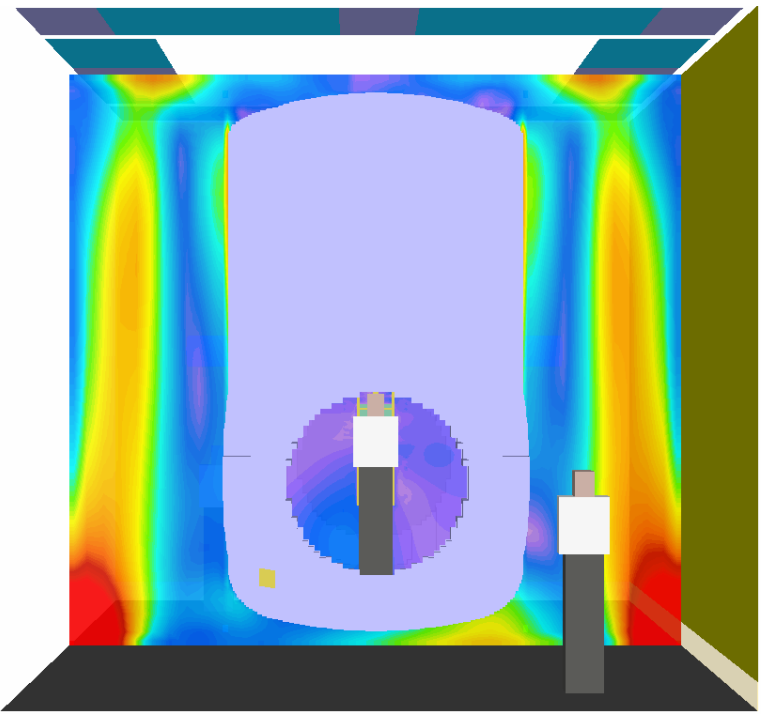
Flow Rates Through Chamber Door

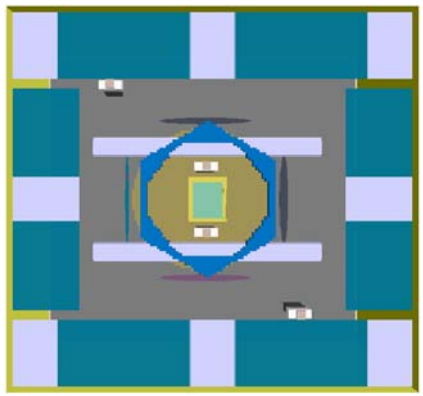
Volume Flow Out (m^3/sec)	Volume Flow In (m^3/sec)	Volume Flow Net (m^3/sec)
0.0471	0.0353	0.0118

The above table show a net airflow through the chamber of 0.0118m^3/sec.
However there is also an extra 0.0353 m^3/sec air exchange at the open door.

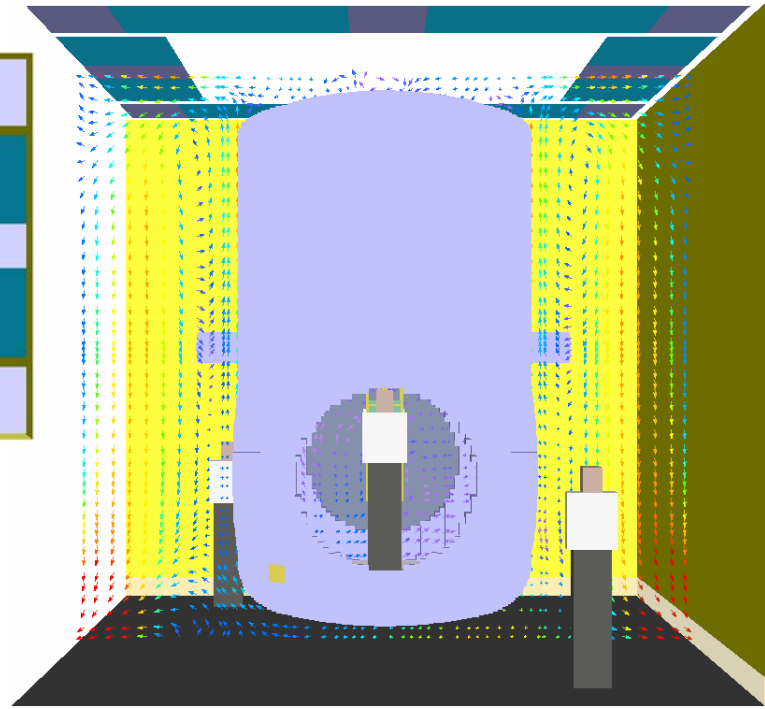
Plane taken at the cross-section of the chamber door

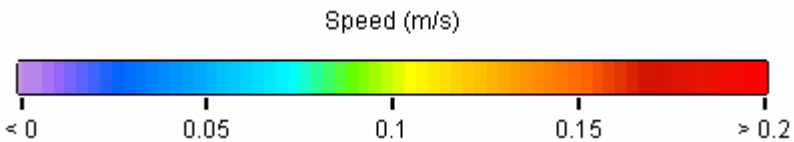
Room Airflow Profile





View Orientation

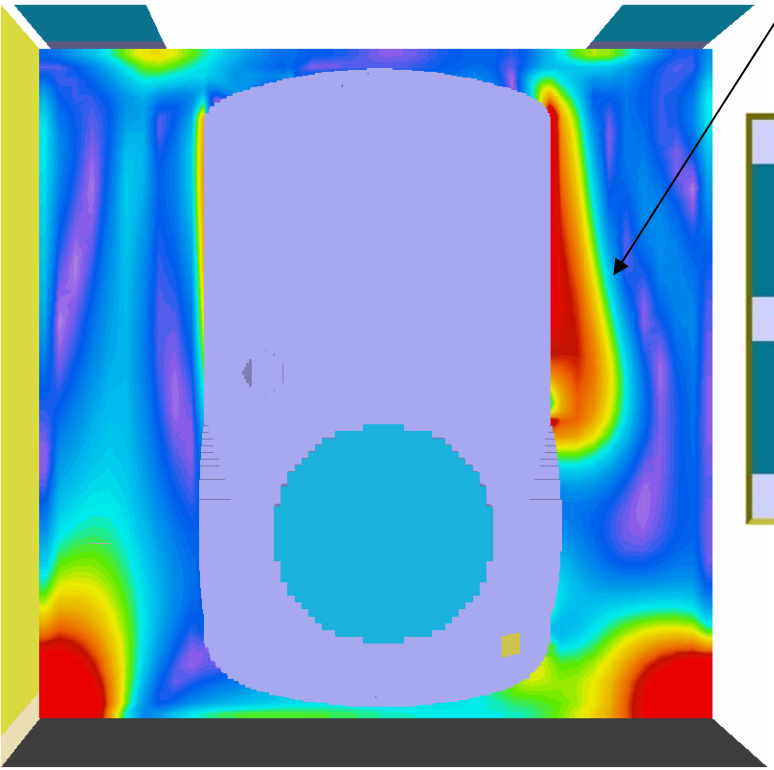


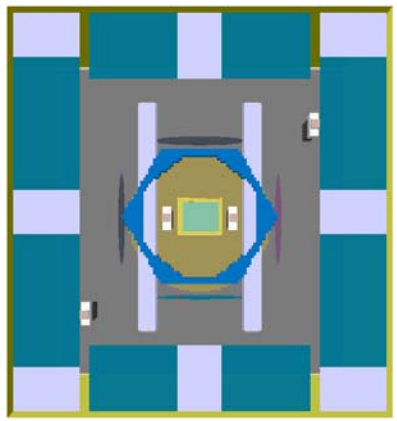


Plane taken at centerline of the room

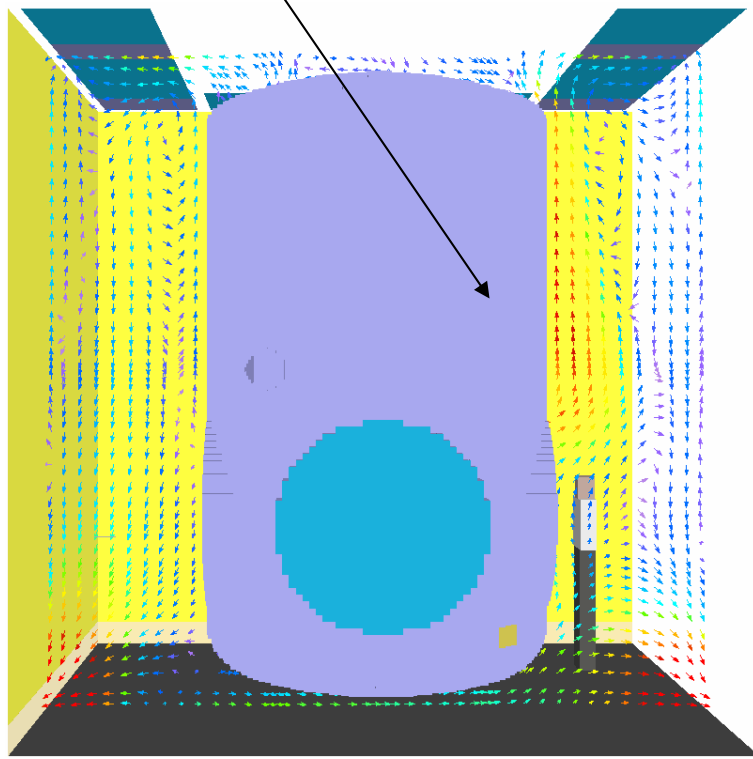
Room Airflow Profile

Heated air exhausting from the chamber has a strong effect on the airflow patterns of the room





View Orientation

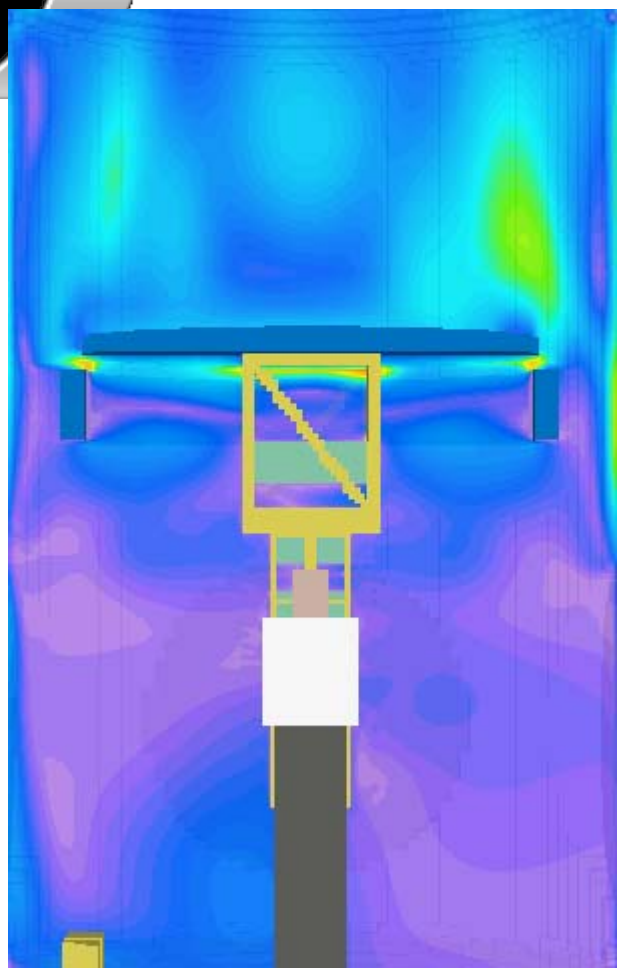


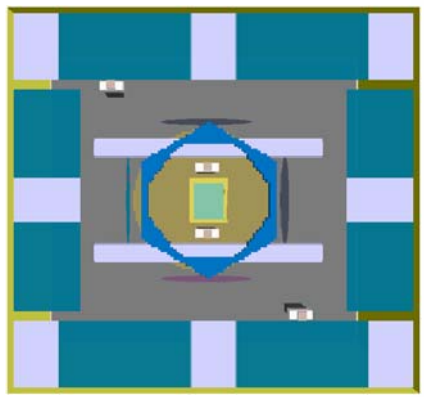
Speed (m/s)

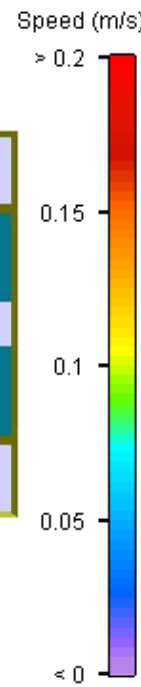
< 0 | 0.05 | 0.1 | 0.15 | > 0.2

Plane taken at centerline of the room

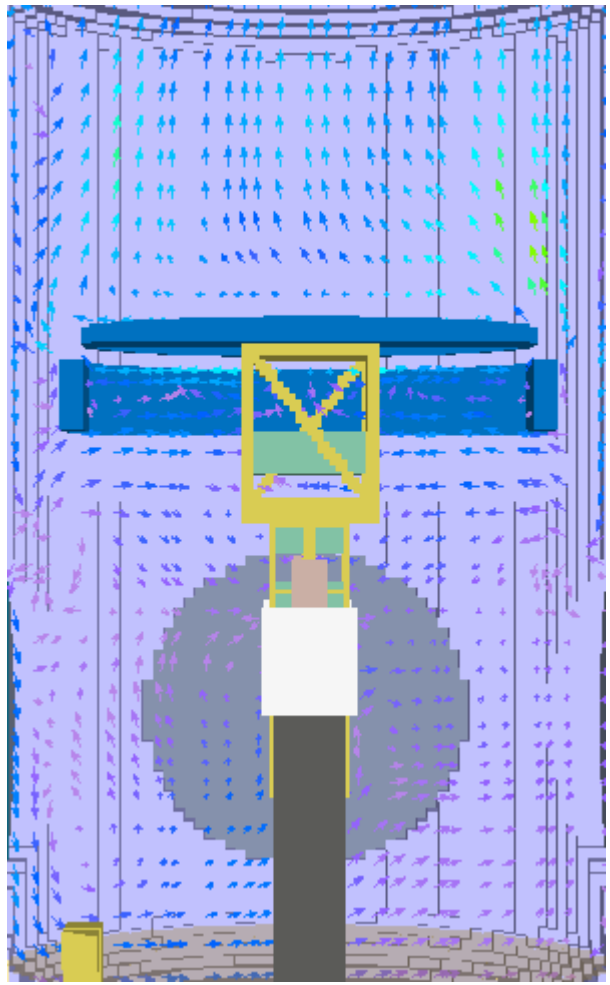
Chamber Airflow Profile





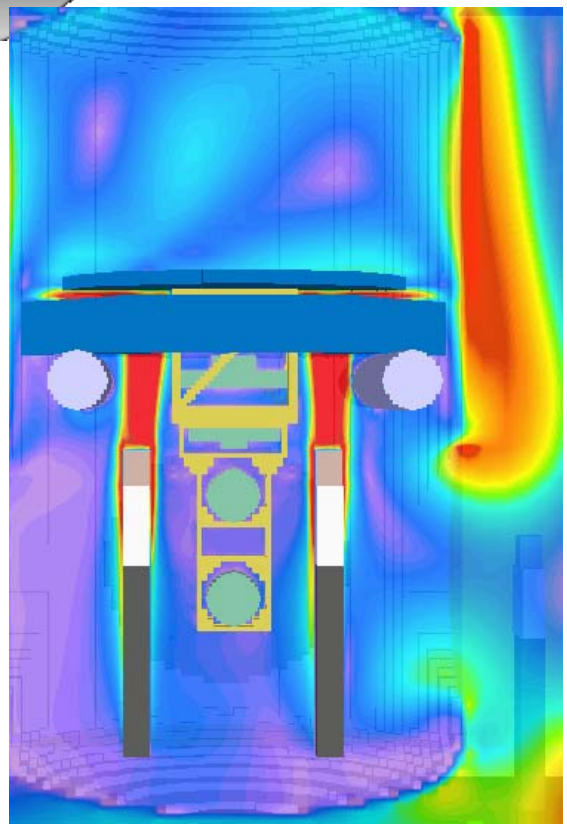


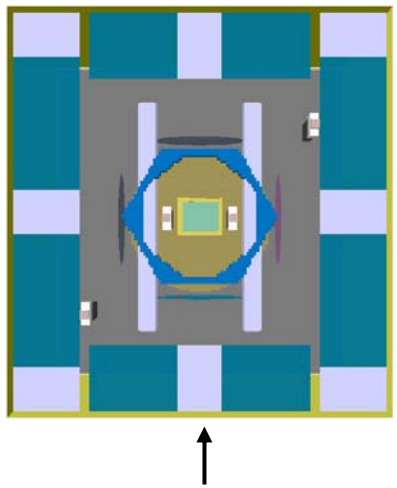
View Orientation

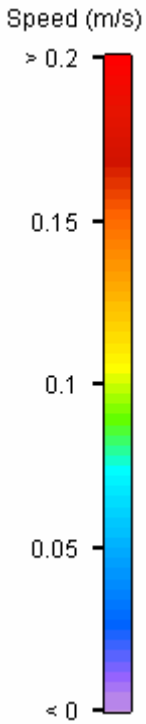


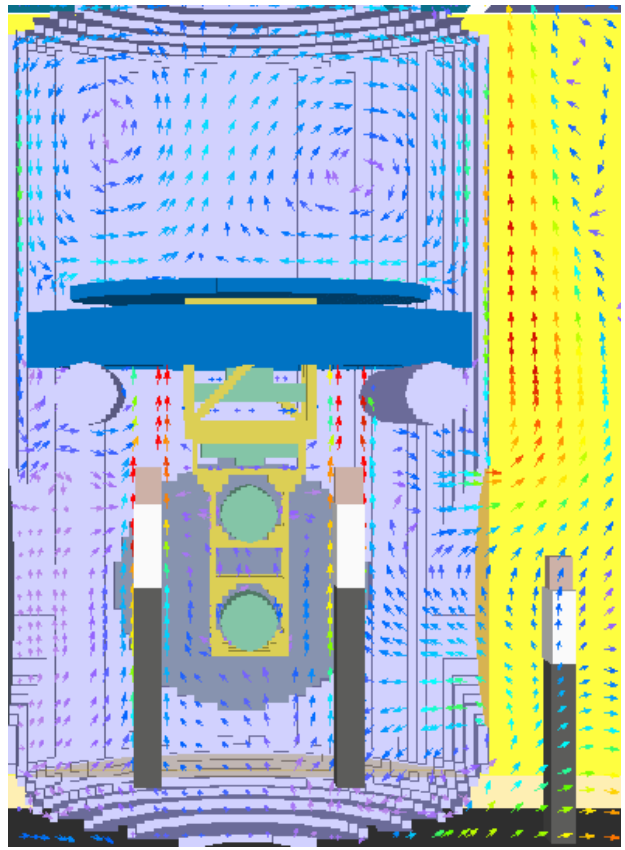
Plane taken at centerline of the chamber

Chamber Airflow Profile









We see that when the supply and exhaust in the chamber are turned off natural convection caused by the workers dominates the airflow patterns

Plane taken at centerline of the chamber

ISO Class Specifications

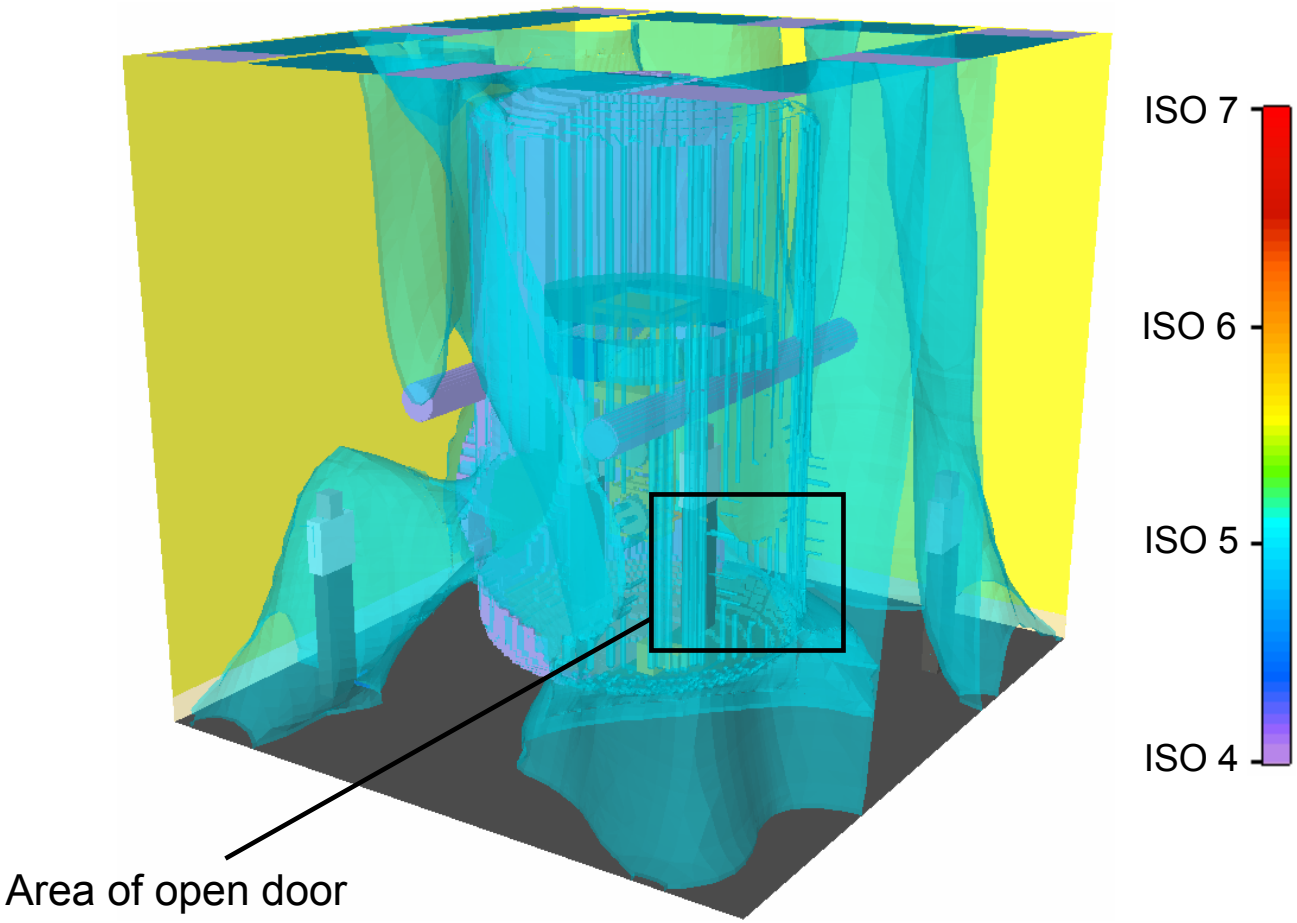
	Particle Density (particles/m^3)
ISO-5	3,250
ISO-6	32,500
ISO-7	325,000
ISO-8	3,250,000

0.5 um diameter particles

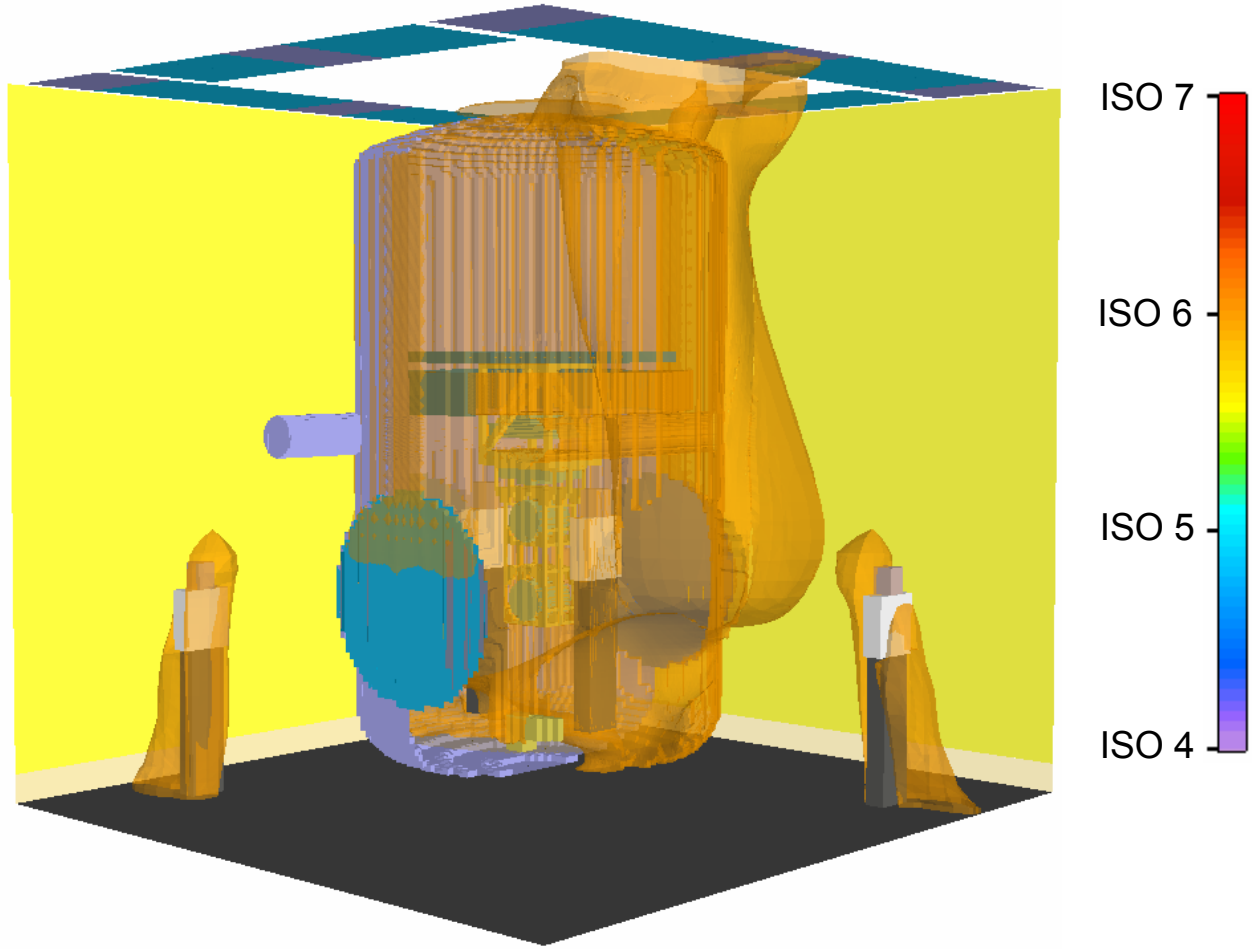
Maximum concentration:1,642,731 Particles/m^3 (ISO 8)

The following slides show the areas of the space at various uniform concentration levels.

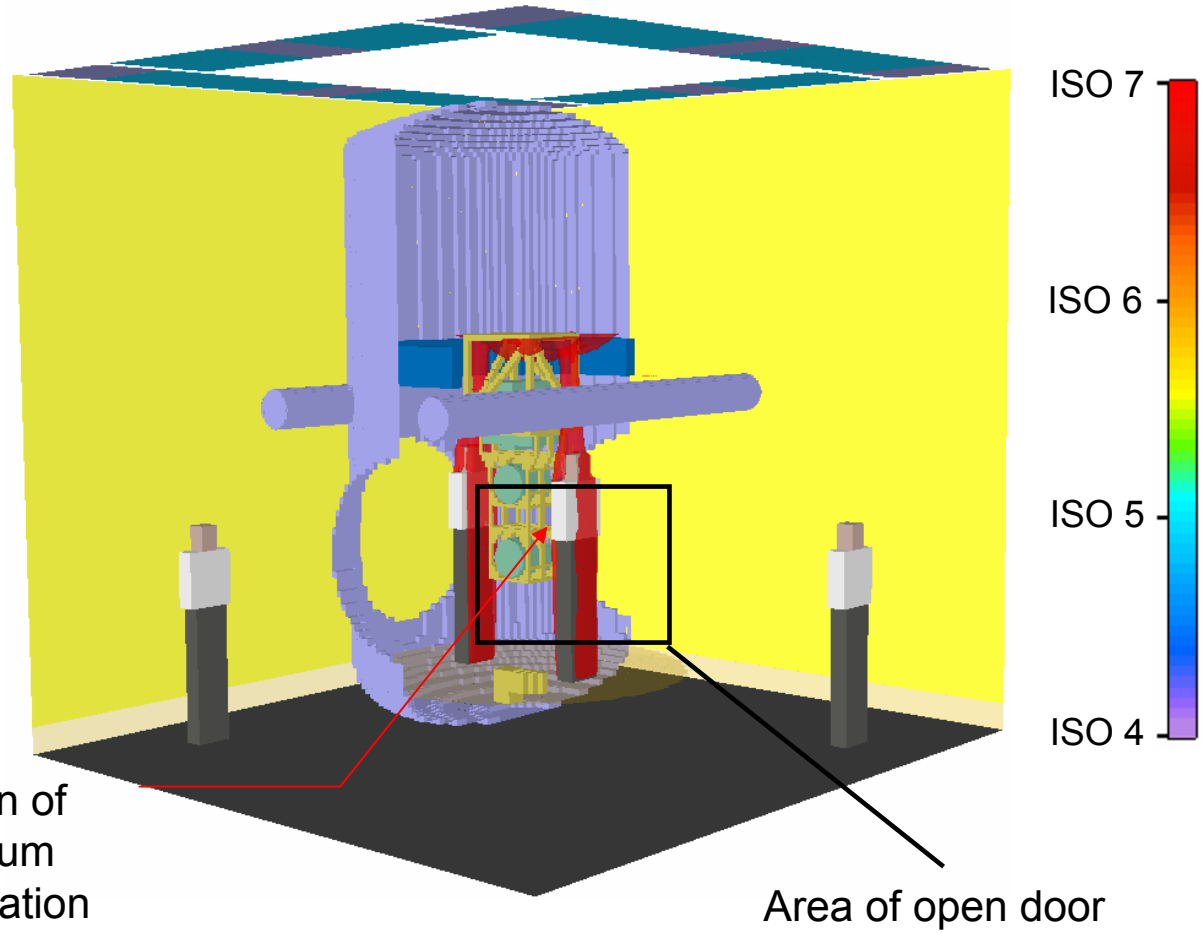
ISO Class 5



ISO Class 6



ISO Class 7

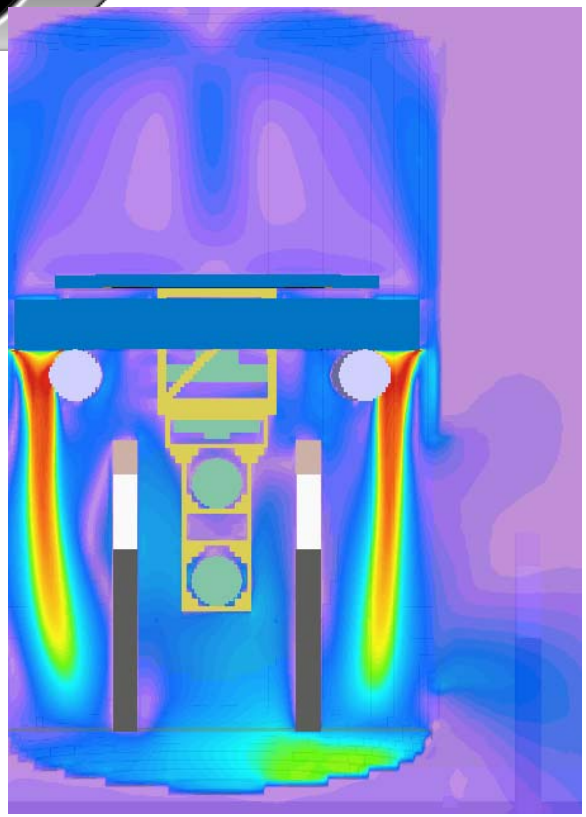


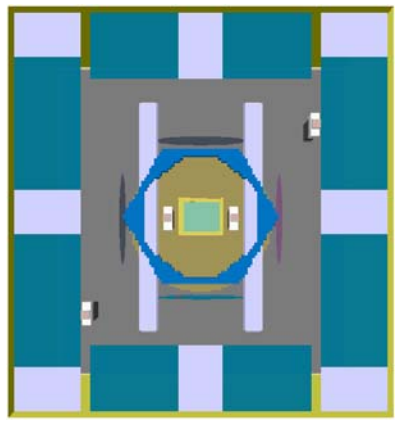
Chamber doors hidden for visualization purposes

Simulation Results

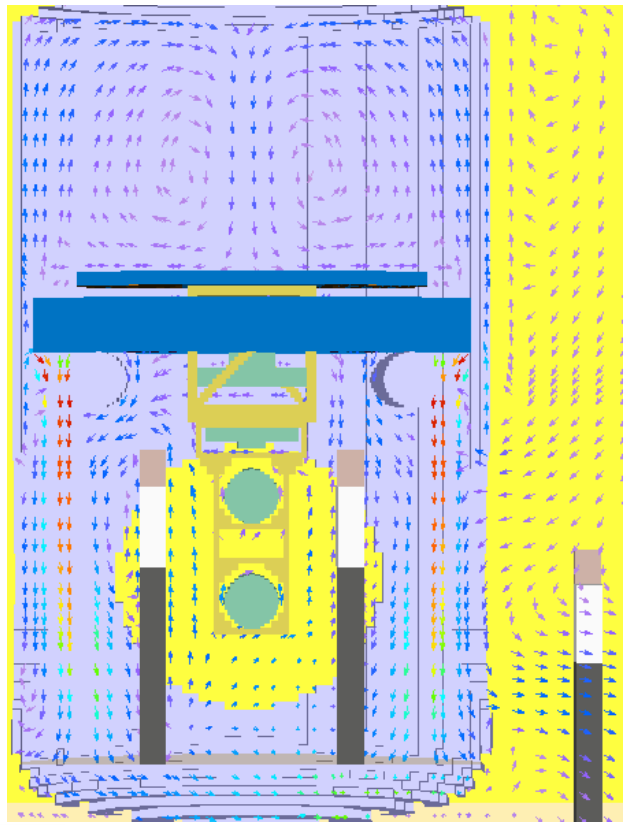
BSC Chamber Air Supply and Extract On

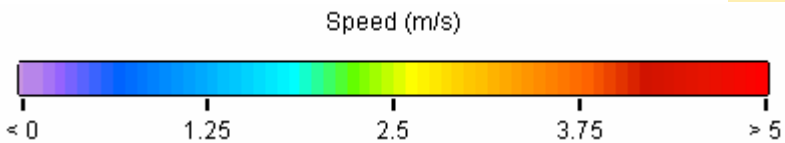
Chamber Airflow Profile





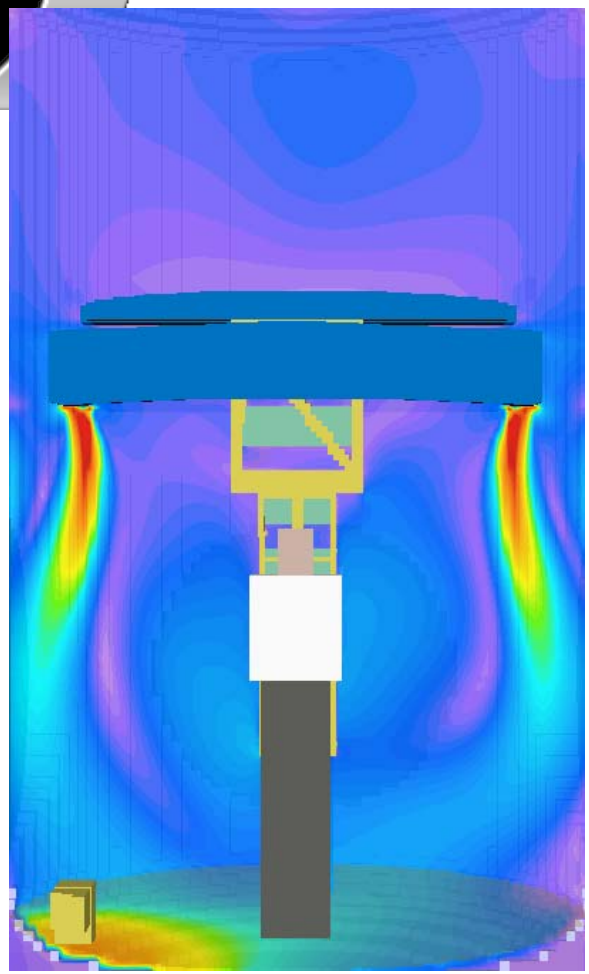
View Orientation

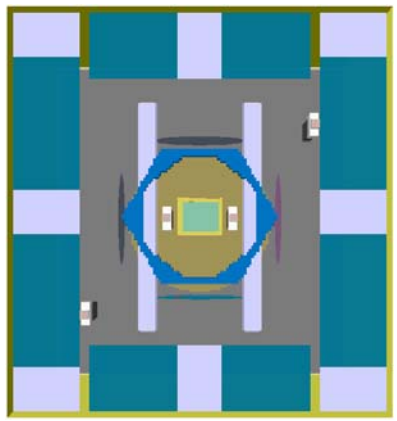




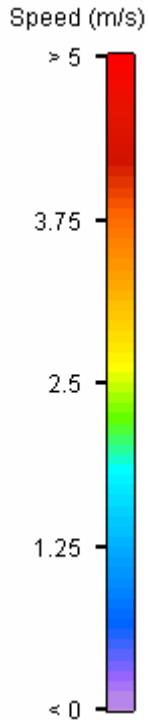
Plane taken at centerline of the chamber

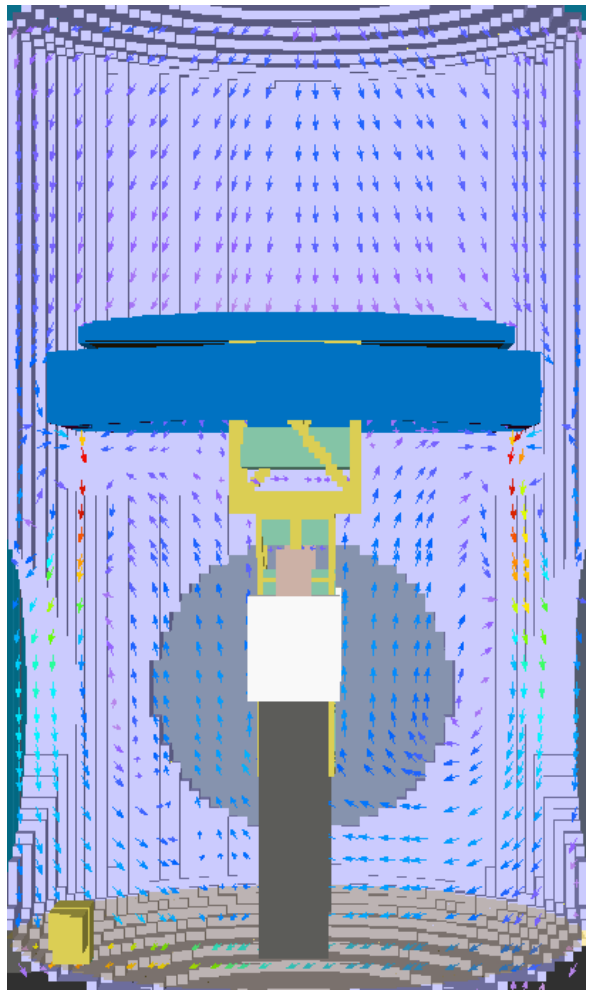
Chamber Airflow Profile





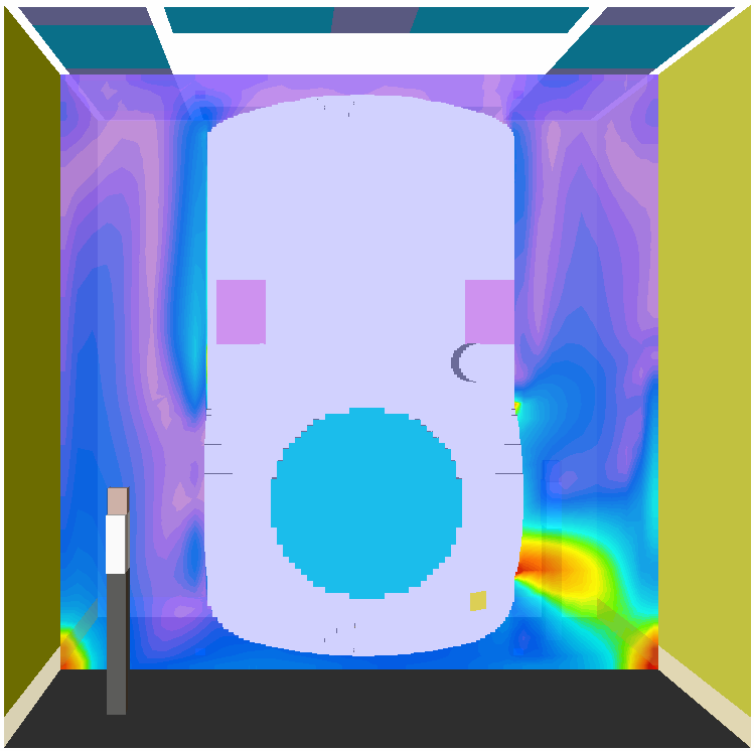
View Orientation

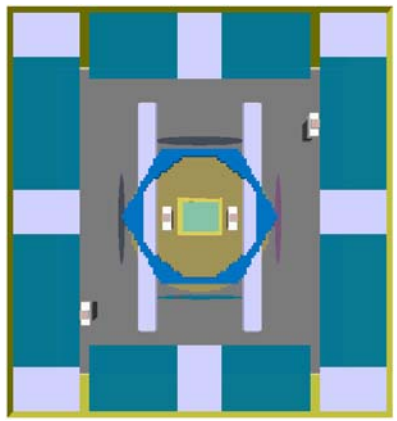




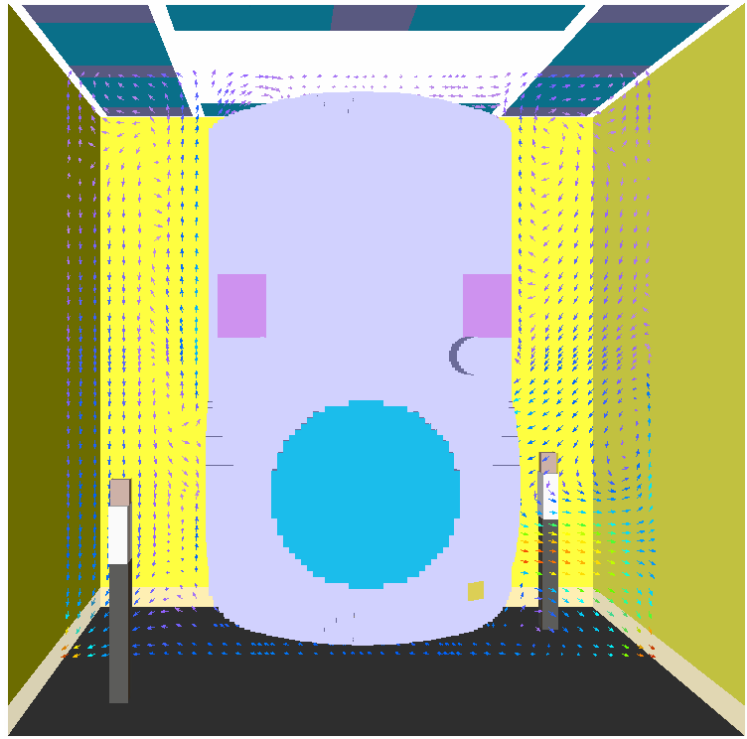
Plane taken at centerline of the chamber

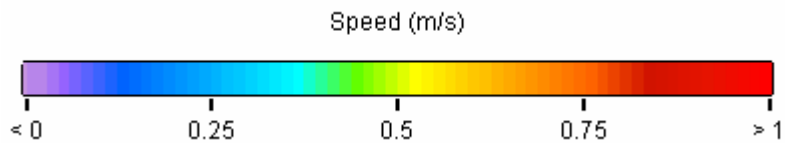
Room Airflow Profile





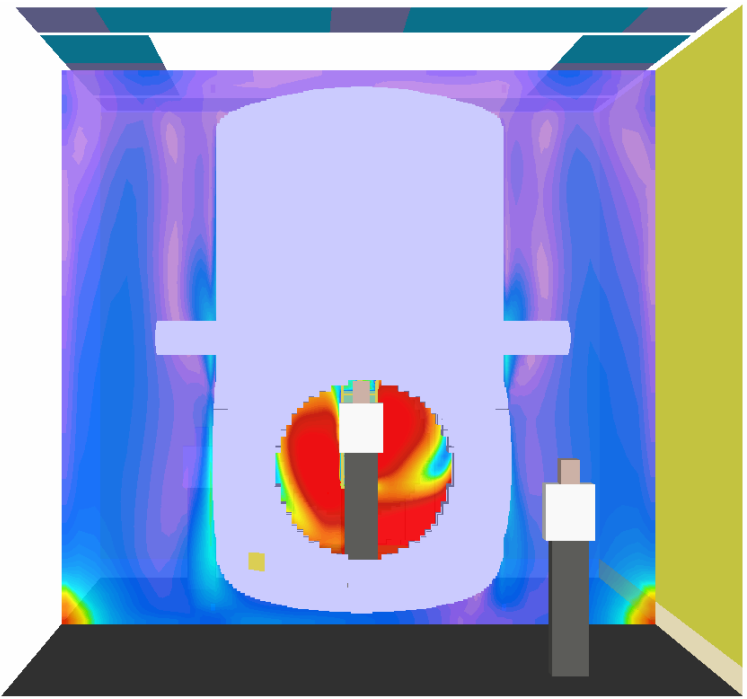
View Orientation

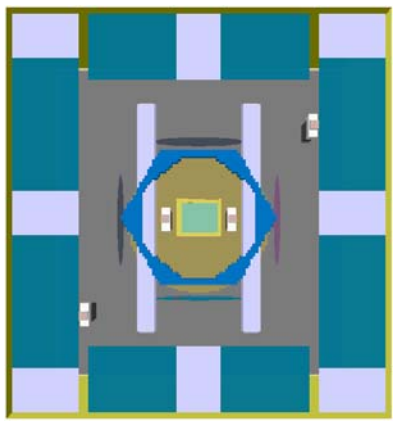




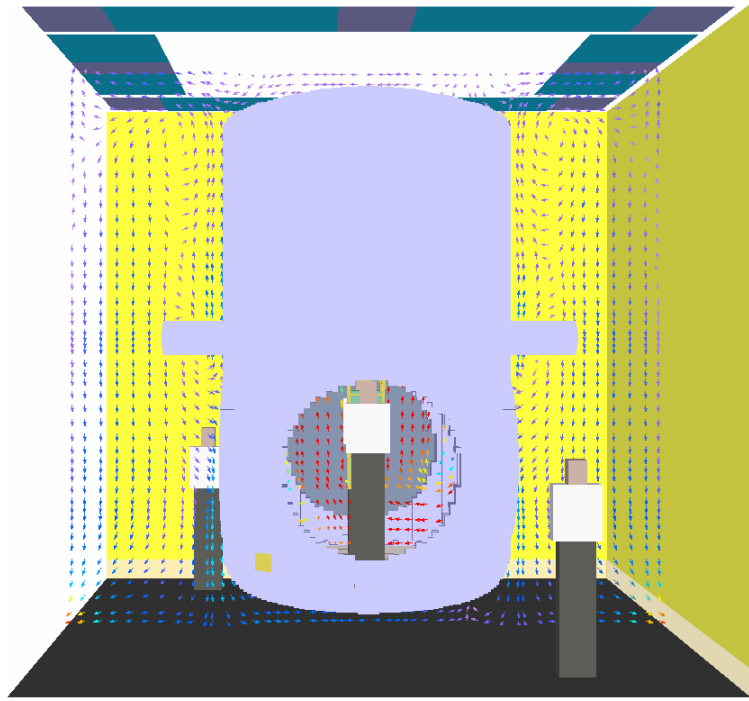
Plane taken at centerline of the chamber

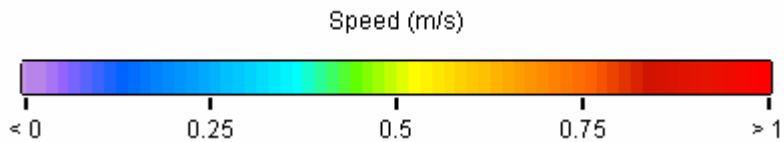
Room Airflow Profile





View Orientation

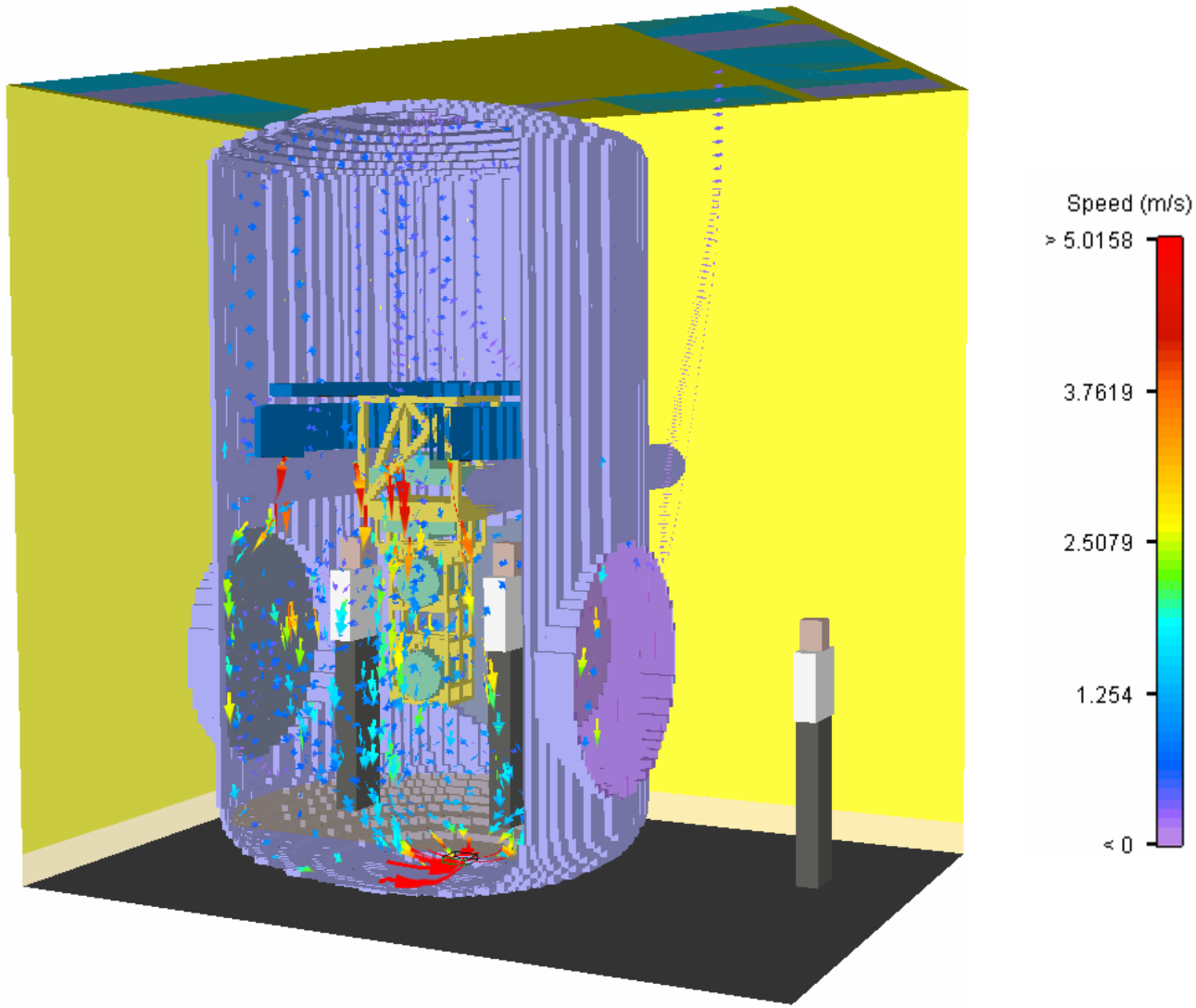




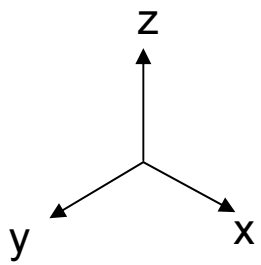
Plane taken at centerline of the chamber

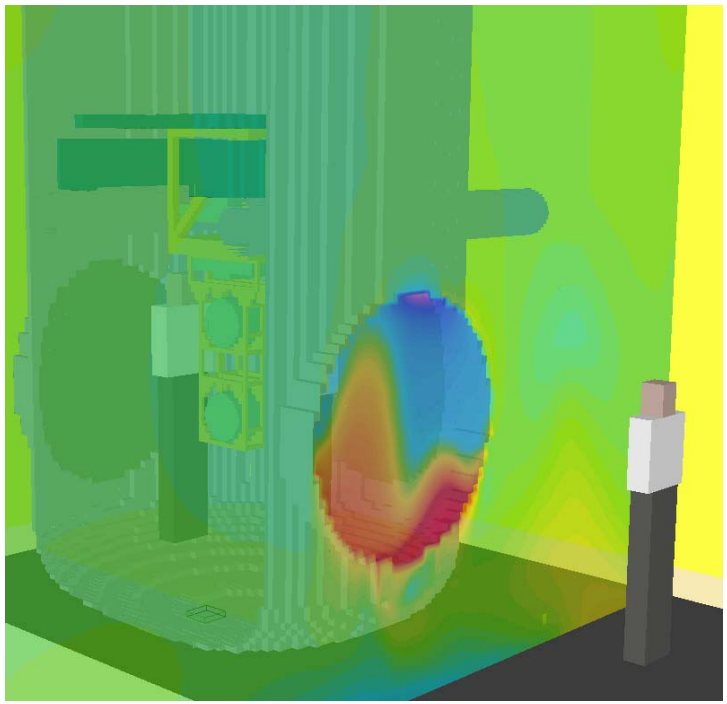
Flow Path to Extraction Tube

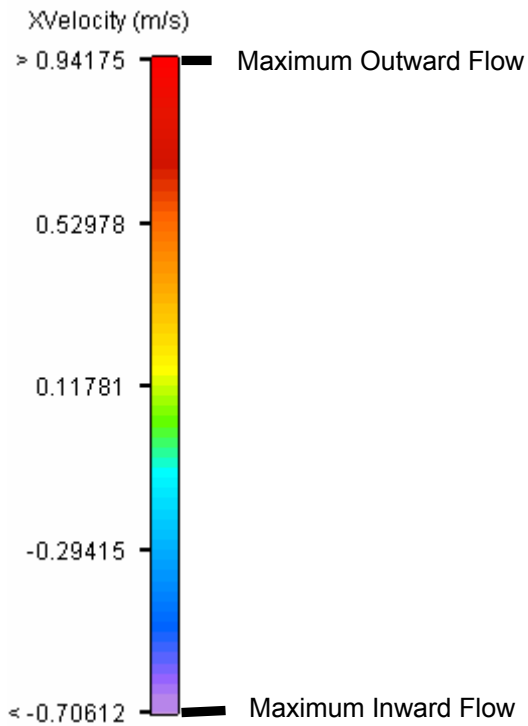
The picture on the right shows streamline paths from the core and annular flow areas to the extraction tube. Note that a small amount of air is flowing into the chamber though the top of the chamber door.



Speed Profile through the Chamber Door





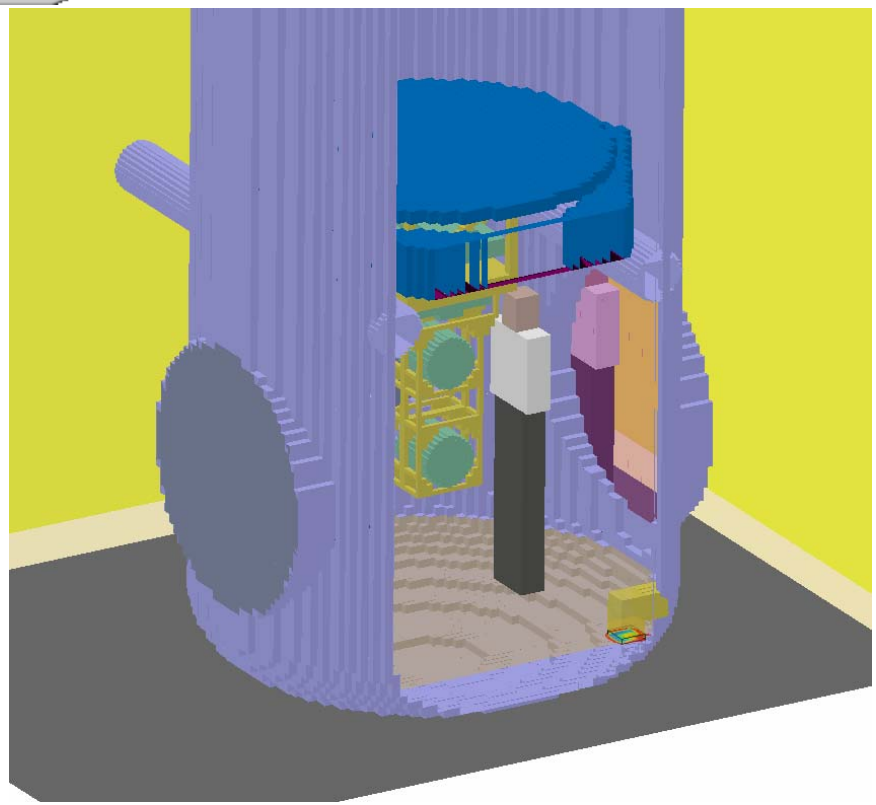


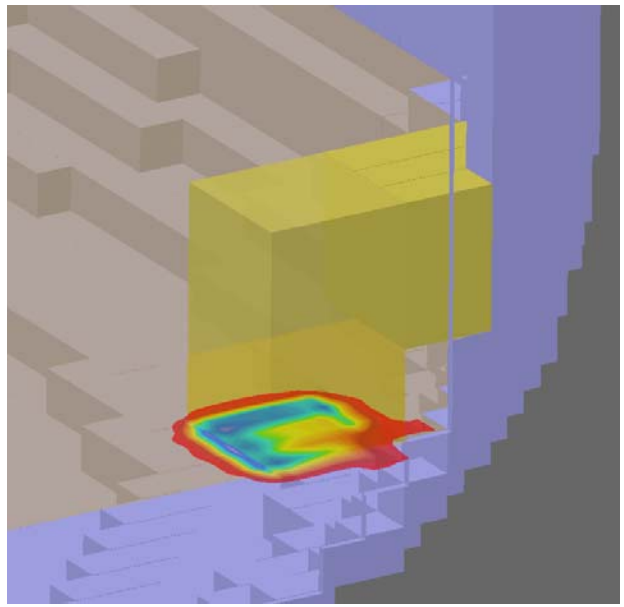
Flow Rates Through Chamber Door

Volume Flow Out (m^3/sec)	Volume Flow In (m^3/sec)	Volume Flow Net (m^3/sec)
0.3761	0.1616	0.2145

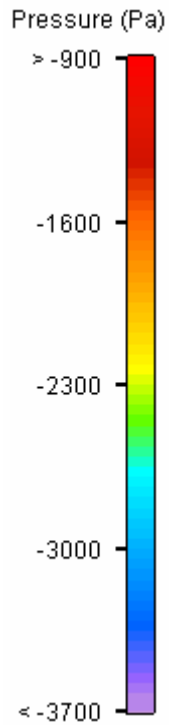
Plane taken at the cross-section of the chamber door

Extraction Pressure





The above plane shows pressures ranging from -900 Pa to -3700 Pa



The above plane is taken at the inlet to the extraction nozzle, and illustrates the pressure required to achieve a flow of 2.8 m^3/sec and assumes the nozzle is venting to atmosphere

ISO Class Specifications

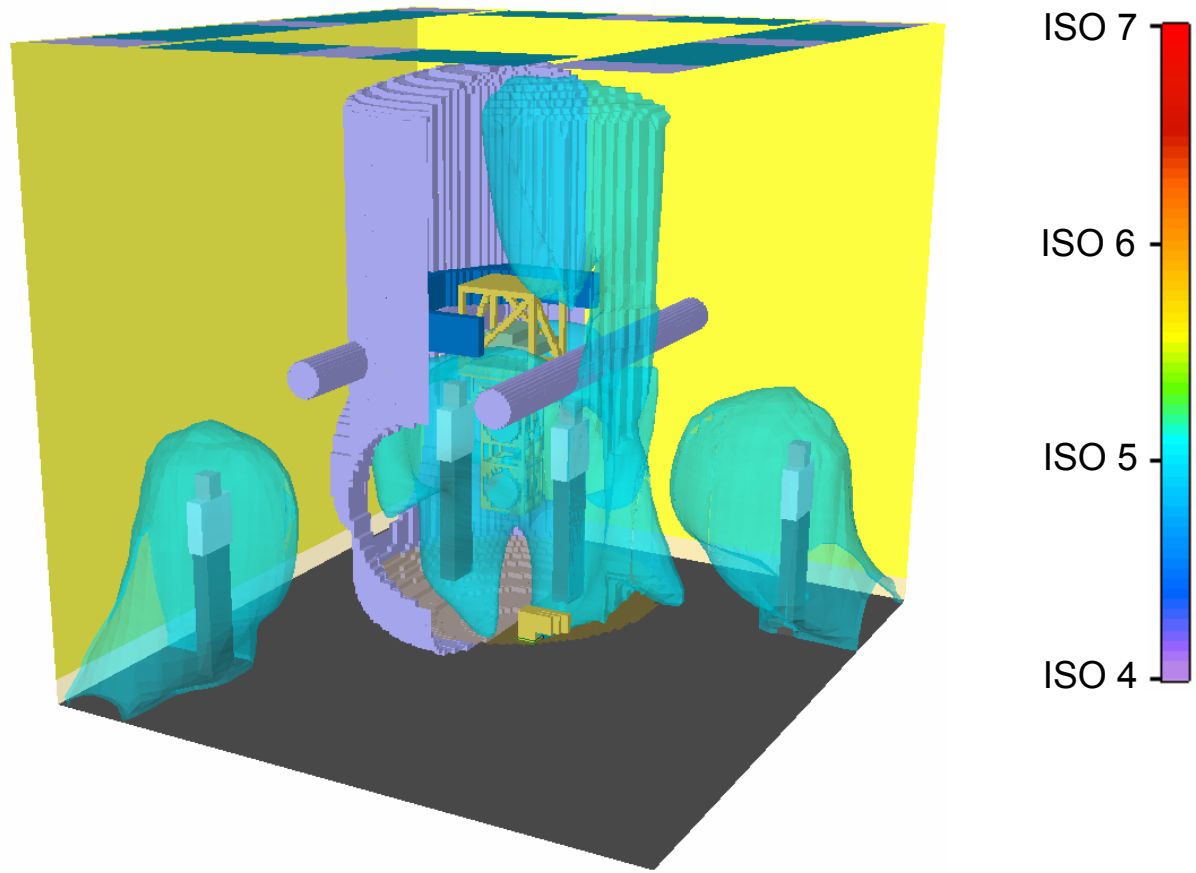
	Particle Density (particles/m^3)
ISO-5	3,250
ISO-6	32,500
ISO-7	325,000
ISO-8	3,250,000

0.5 um diameter particles

Maximum concentration: 199,055 Particles/m^3 (ISO 7)

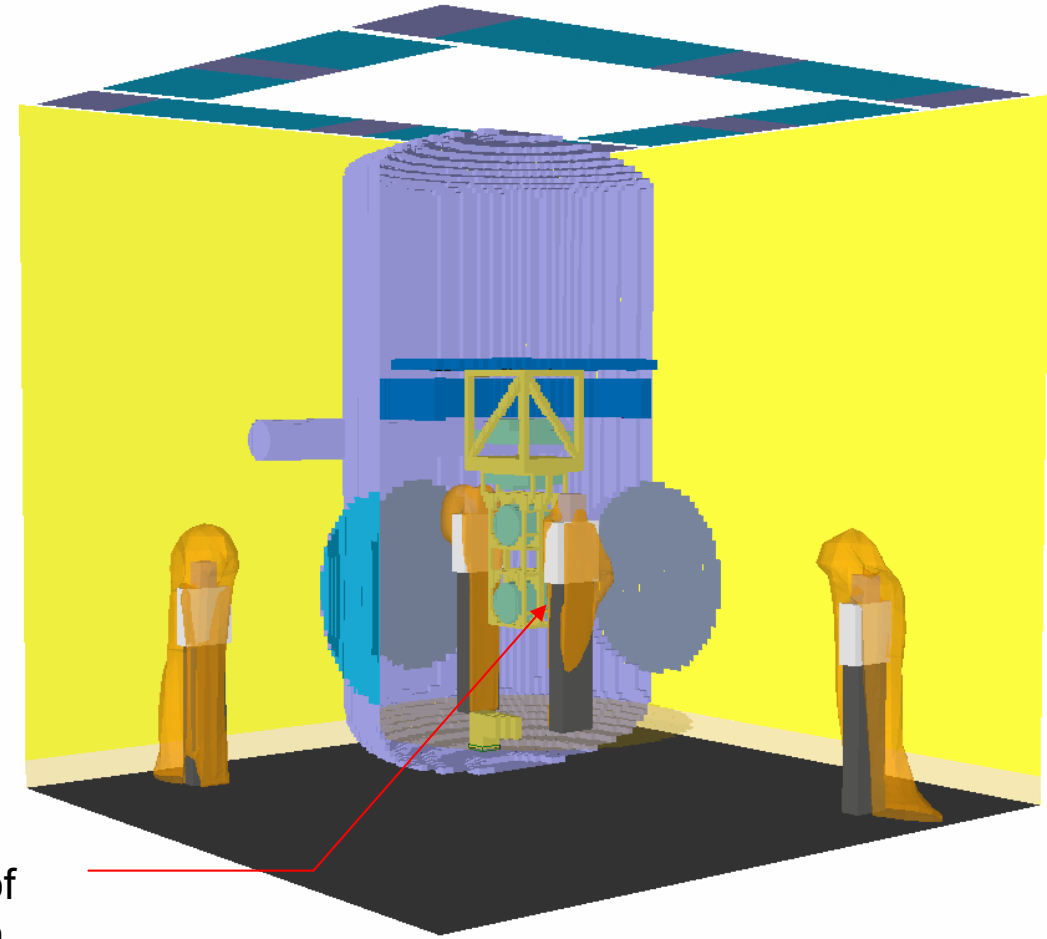
The following slides show the areas of the space at various uniform concentration levels.

ISO Class 5



Chamber doors hidden for visualization purposes

ISO Class 6



Location of maximum concentration

Summary

A thermal/airflow FLOVENT model of the BSC Chamber and surrounding Cleanroom has been created and simulated to determine airflow patterns and contamination concentration with respect to the following scenarios:

- Scenario 1:
  - BSC Chamber Air Supply/Extract: OFF
  - Surrounding Clean Room Space Air Supply: ON
  - Maximum Concentration: 1,642,731 particles/m^3
  - BSC Chamber open door in-flow: 0.04 m^3/sec
- Scenario 2:
  - BSC Chamber Air Supply: ON
  - Surrounding Clean Room Space Air Supply: ON
  - Maximum Concentration: 199,055 particles/m^3
  - BSC Chamber open door in-flow: 0.16 m^3/sec