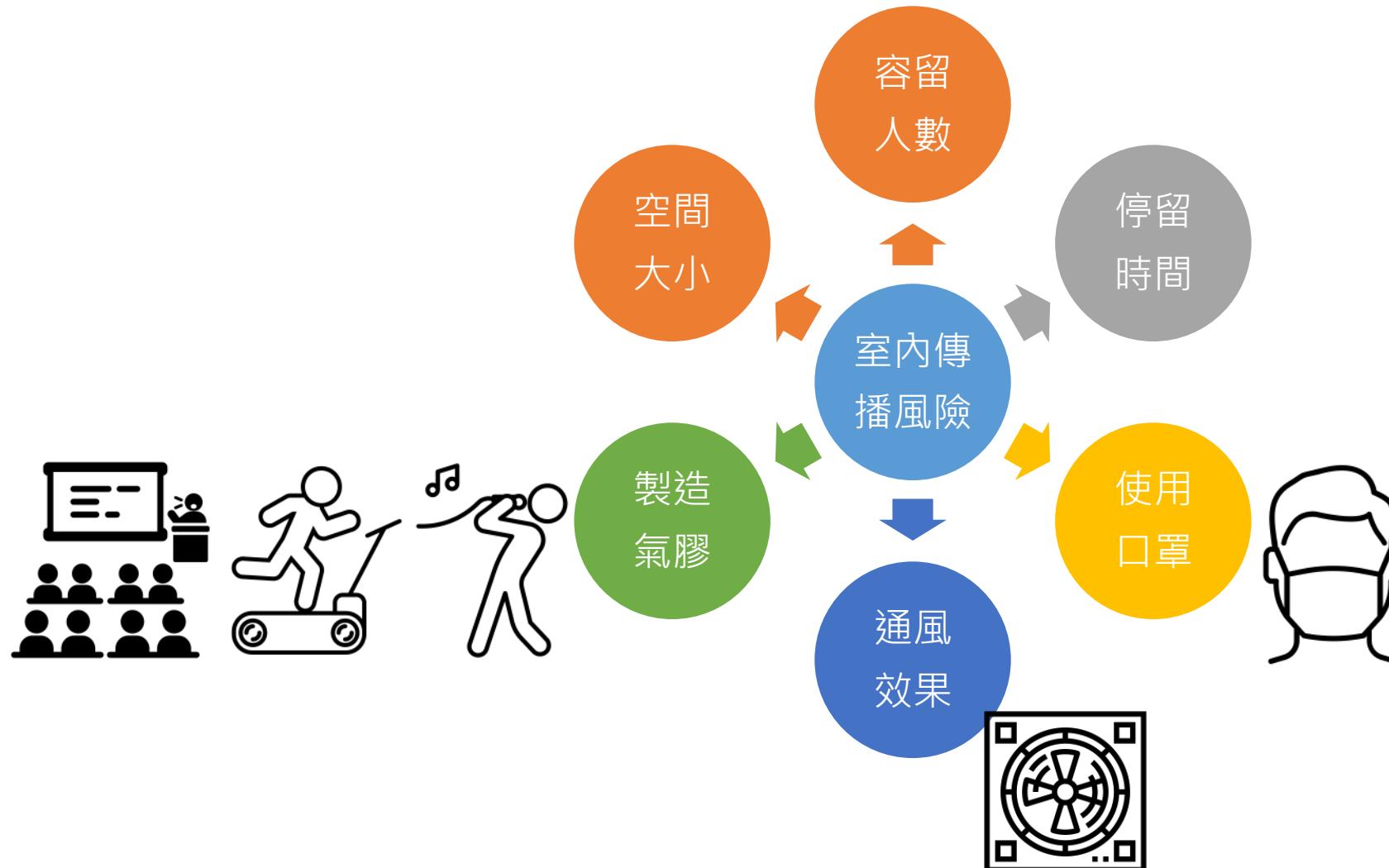


後疫情時代的生活 ～通風換氣篇～

國立臺灣大學 公共衛生學院
陳佳堃 副教授

COVID-19室內傳播的關鍵因素



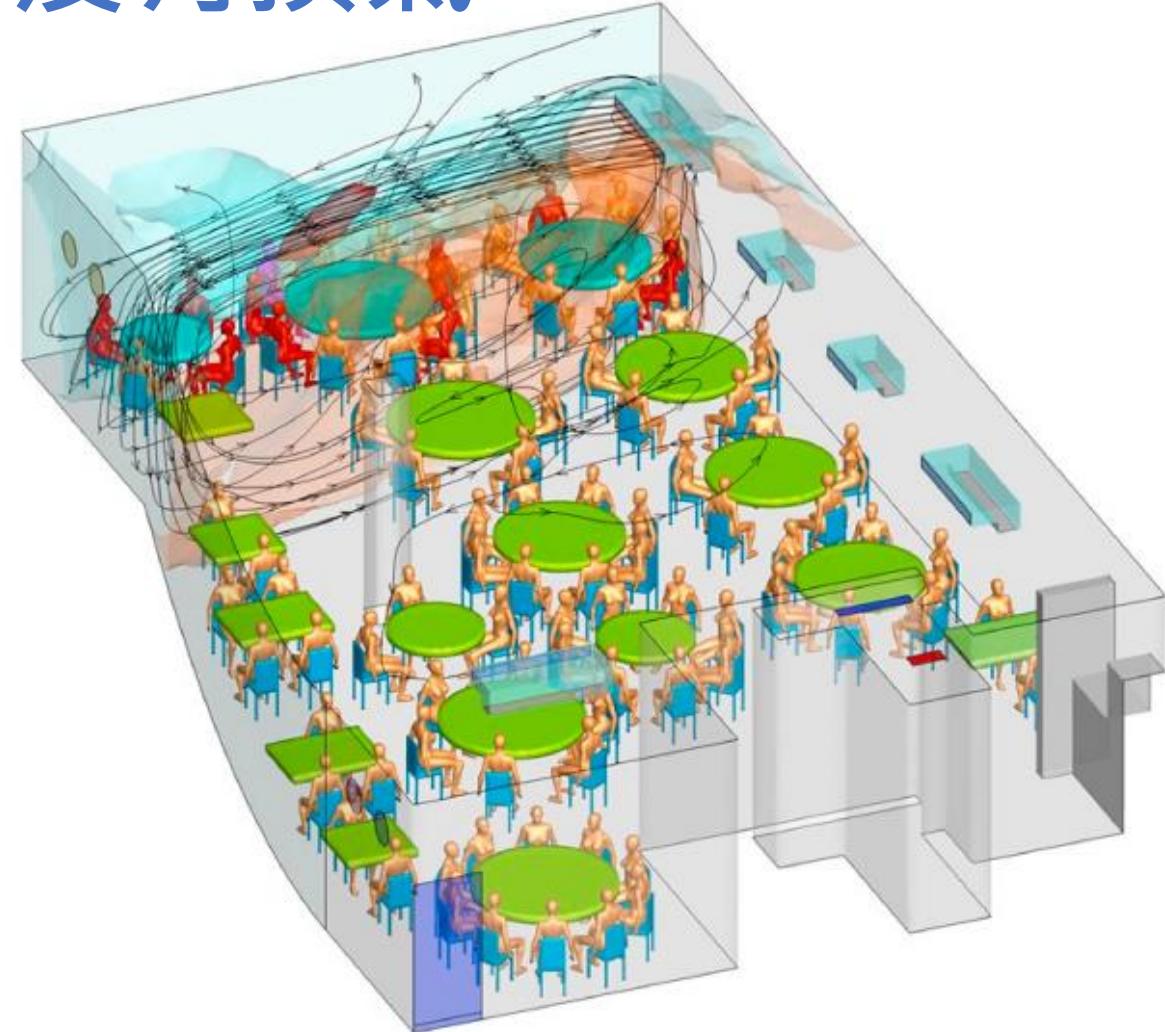
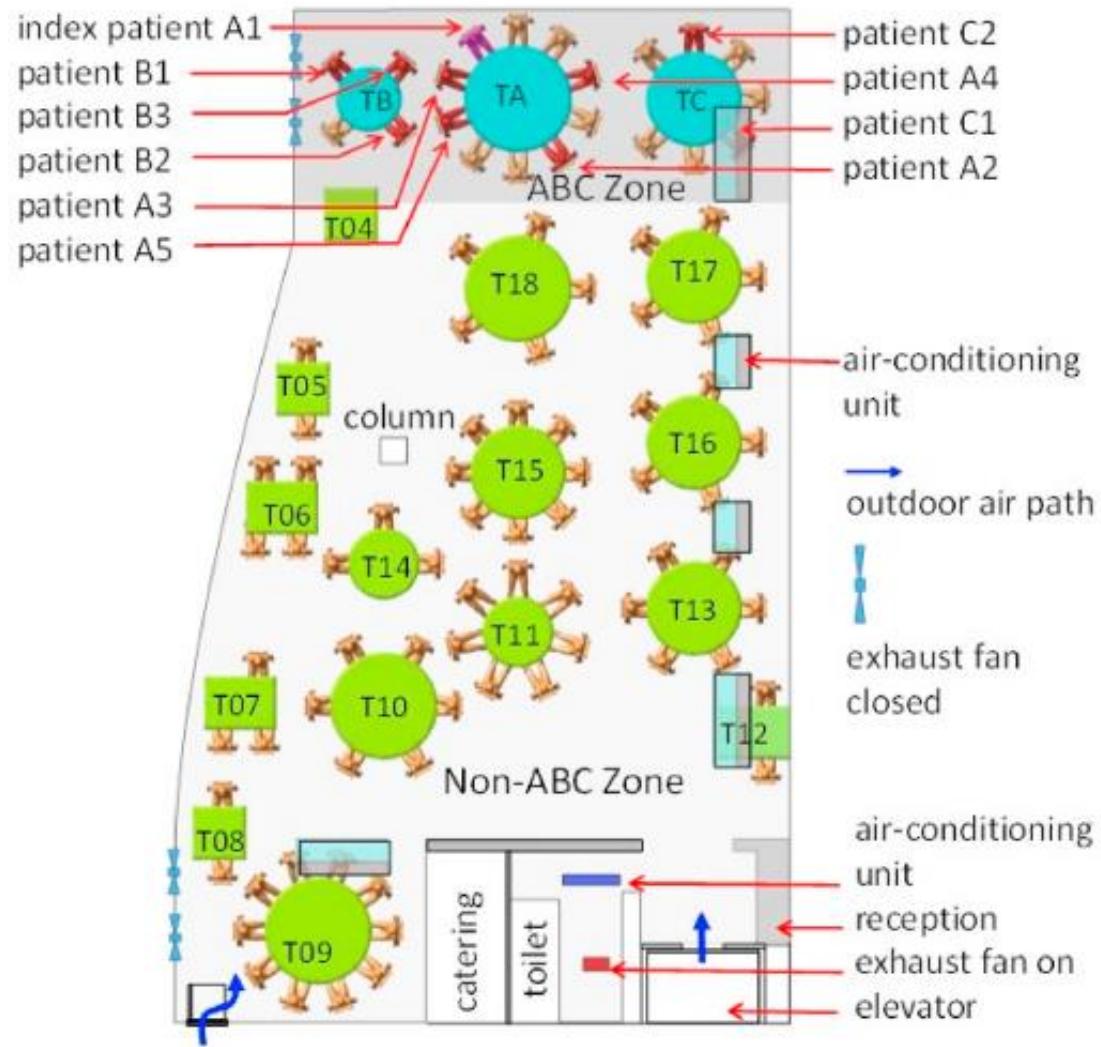
美國CDC於2021年5月7日更新：氣膠傳播是COVID-19傳染途徑

SARS-CoV-2 is transmitted by exposure to infectious respiratory fluids

The principal mode by which people are infected with SARS-CoV-2 (the virus that causes COVID-19) is through exposure to respiratory fluids carrying infectious virus. Exposure occurs in three principal ways: (1) inhalation of very fine respiratory droplets and aerosol particles, (2) deposition of respiratory droplets and particles on exposed mucous membranes in the mouth, nose, or eye by direct splashes and sprays, and (3) touching mucous membranes with hands that have been soiled either directly by virus-containing respiratory fluids or indirectly by touching surfaces with virus on them.

<https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/sars-cov-2-transmission.html>

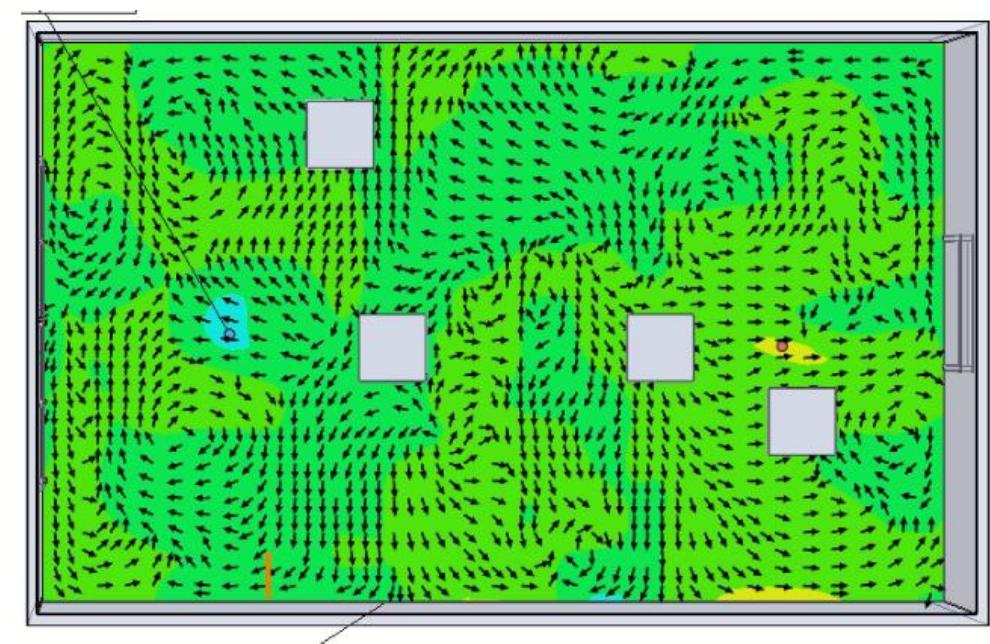
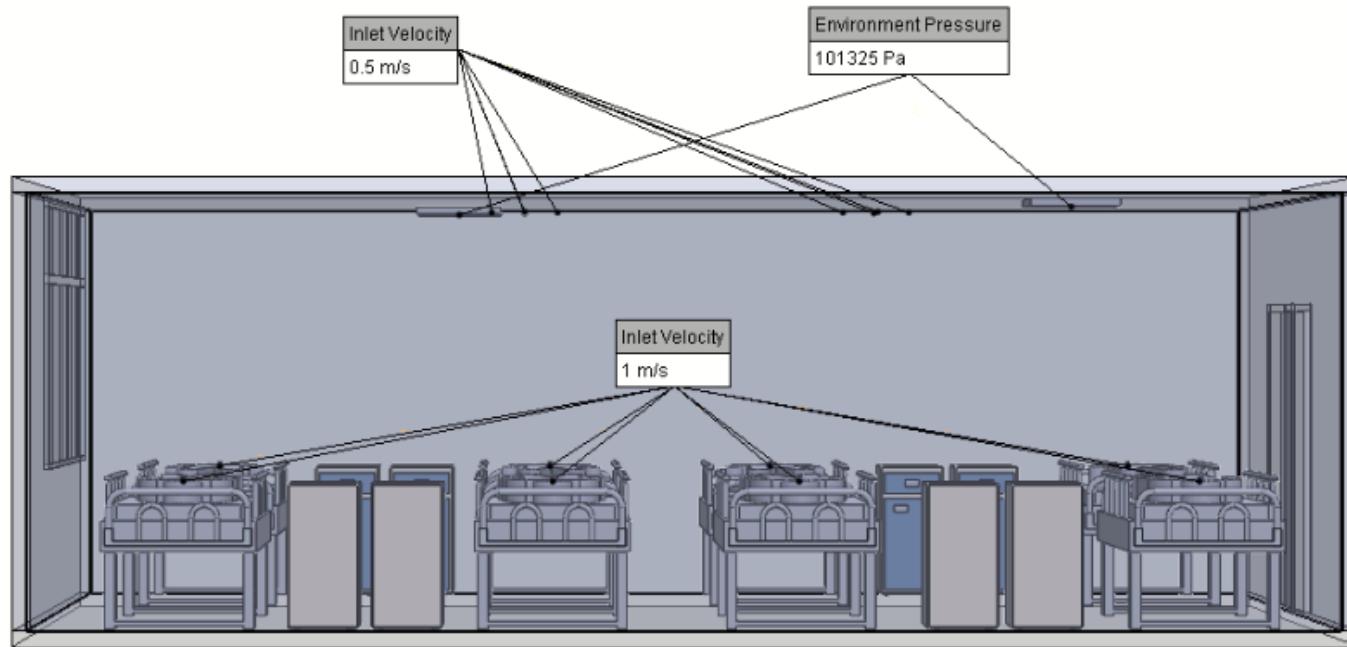
餐廳通風不良: 沒有換氣



(Li Y, Qian H, Hang J, et al. Build Environ. 2021 Jun; 196: 107788)

長照機構的室內狀況

- 關窗、關門、開冷氣



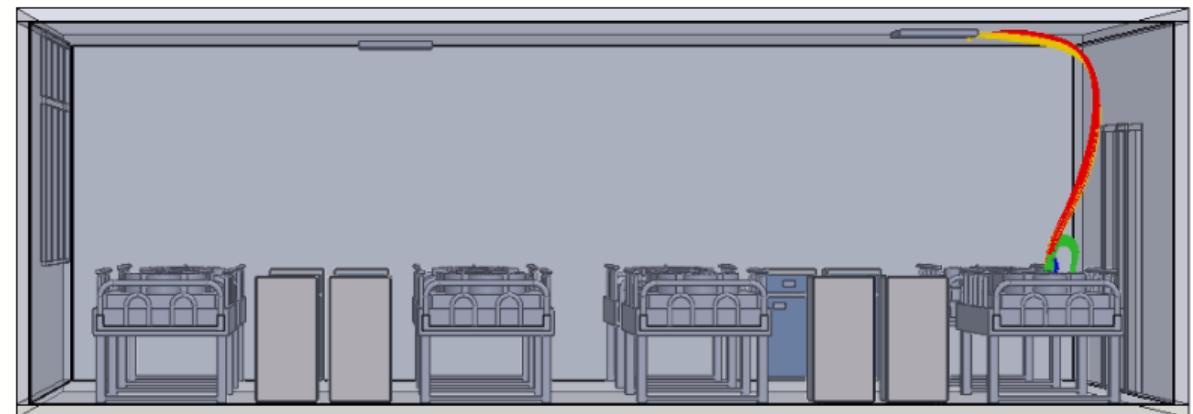
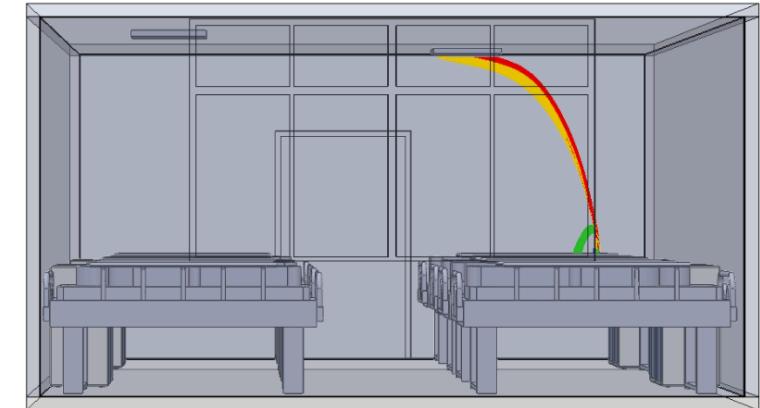
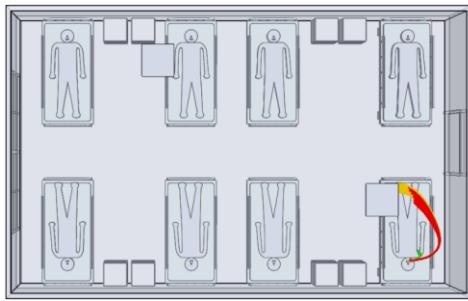
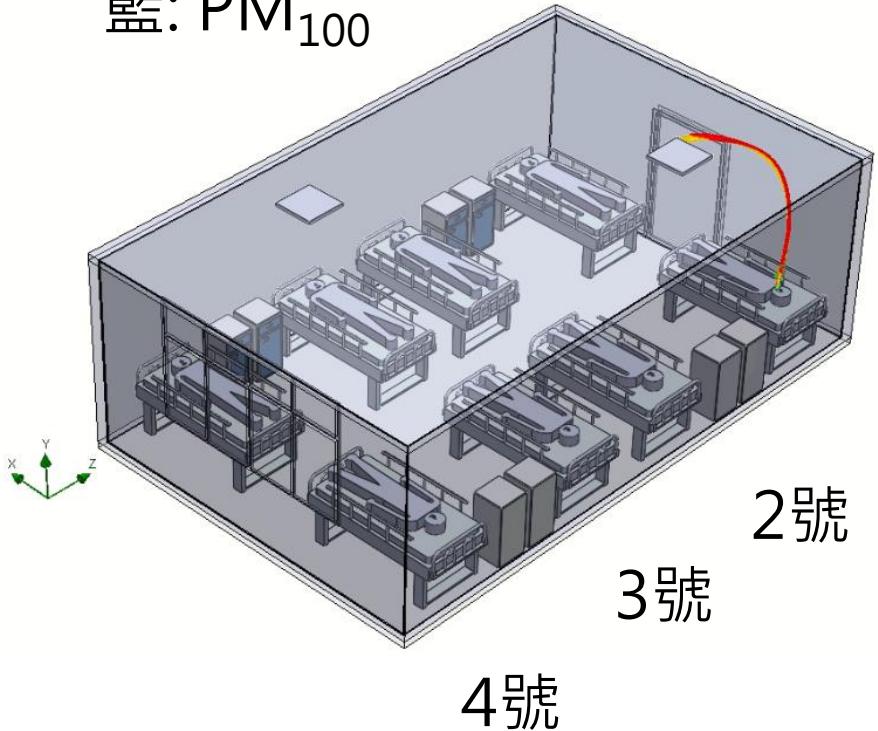
人呼吸產生的氣膠微粒(一號床)

紅: PM_{2.5}

黃: PM₁₀

綠: PM₅₀

藍: PM₁₀₀



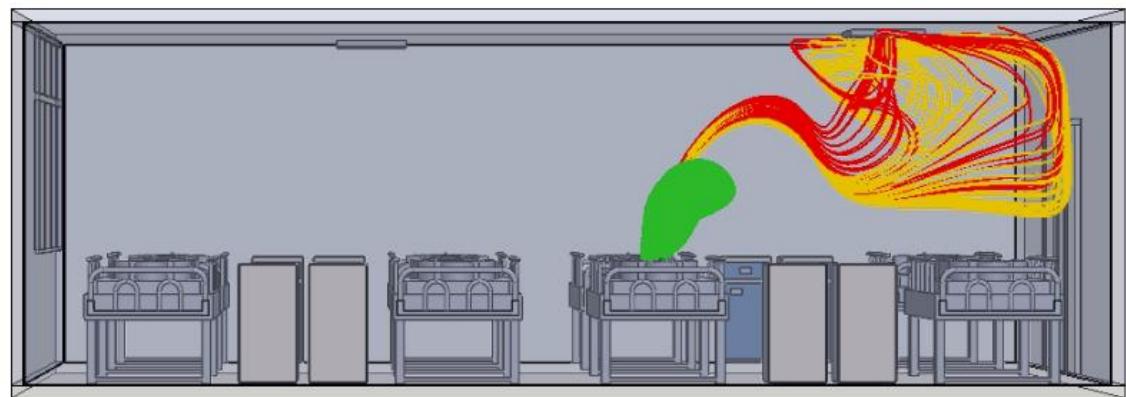
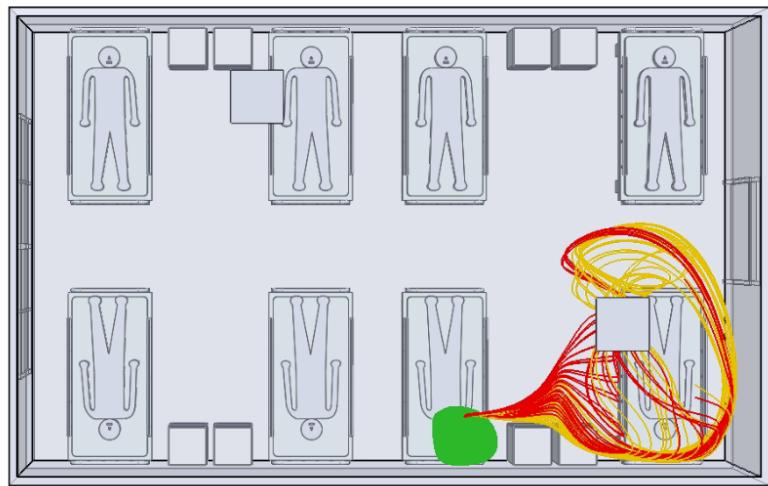
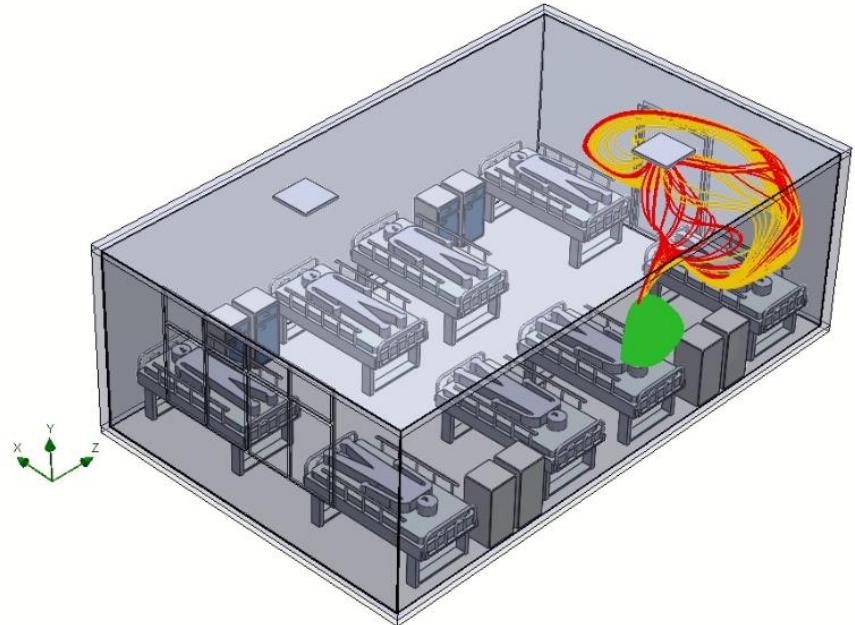
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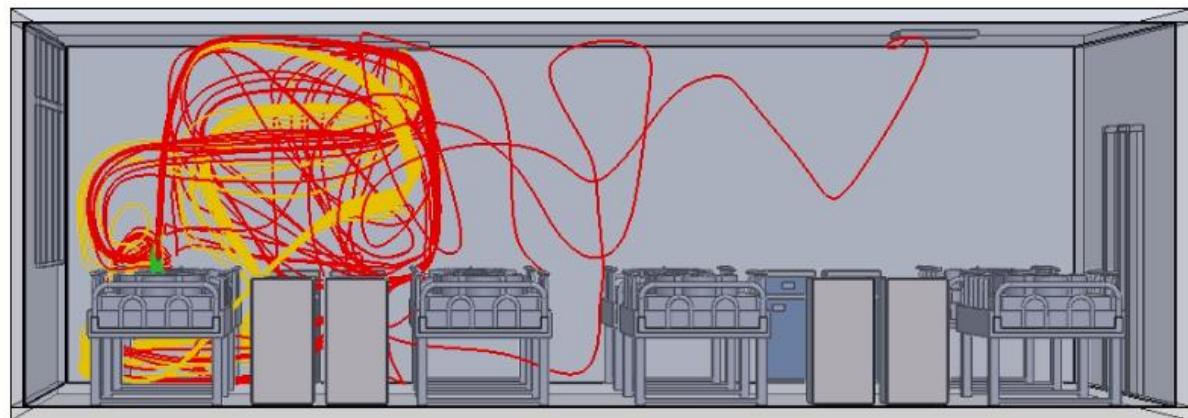
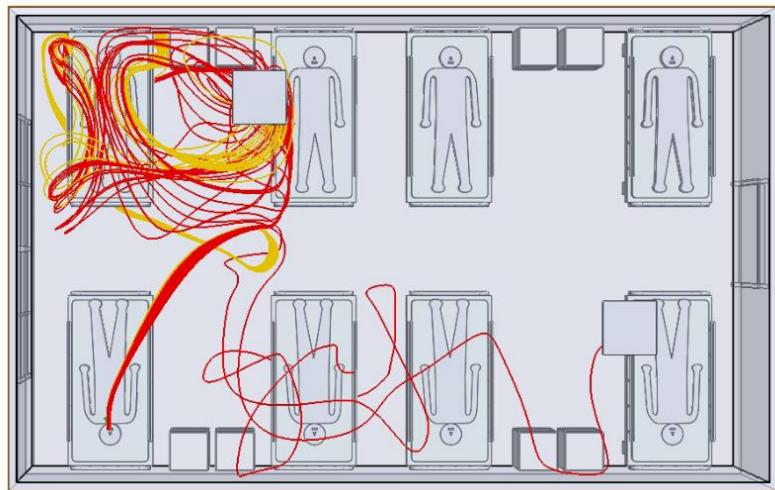
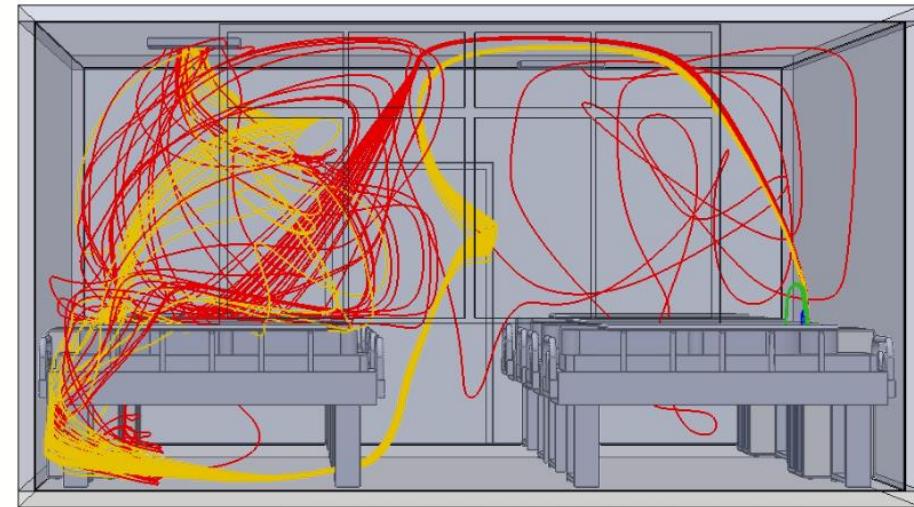
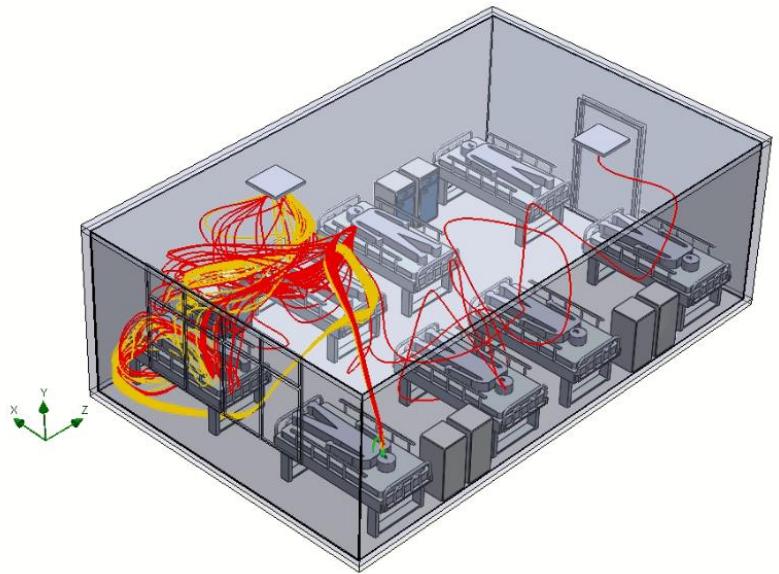
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1號

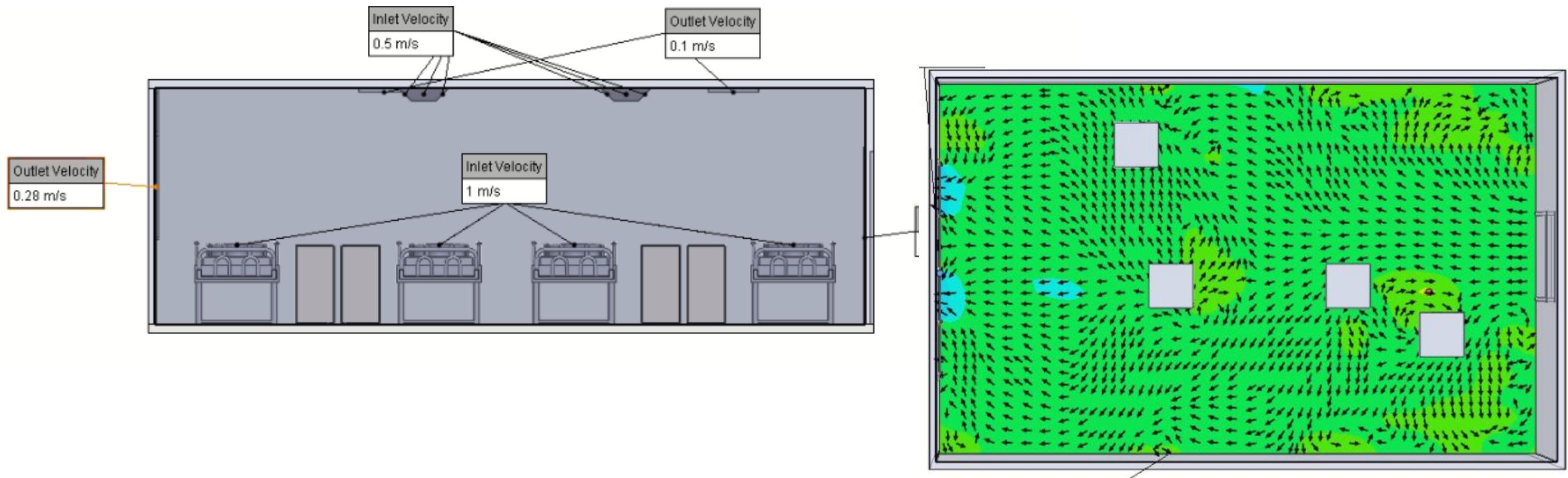
人呼吸產生的氣膠微粒(二號床)



人呼吸產生的氣膠微粒(四號床)



- 開窗，往外流速 0.28m/s (WHO 建議最小值: 60L/s per patient)
- 開門、開冷氣



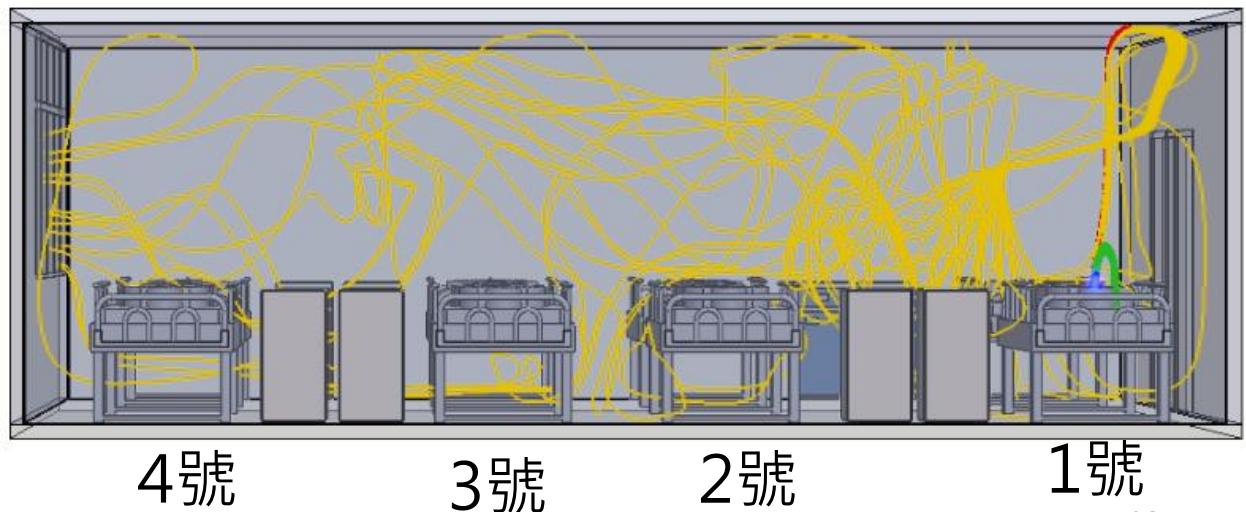
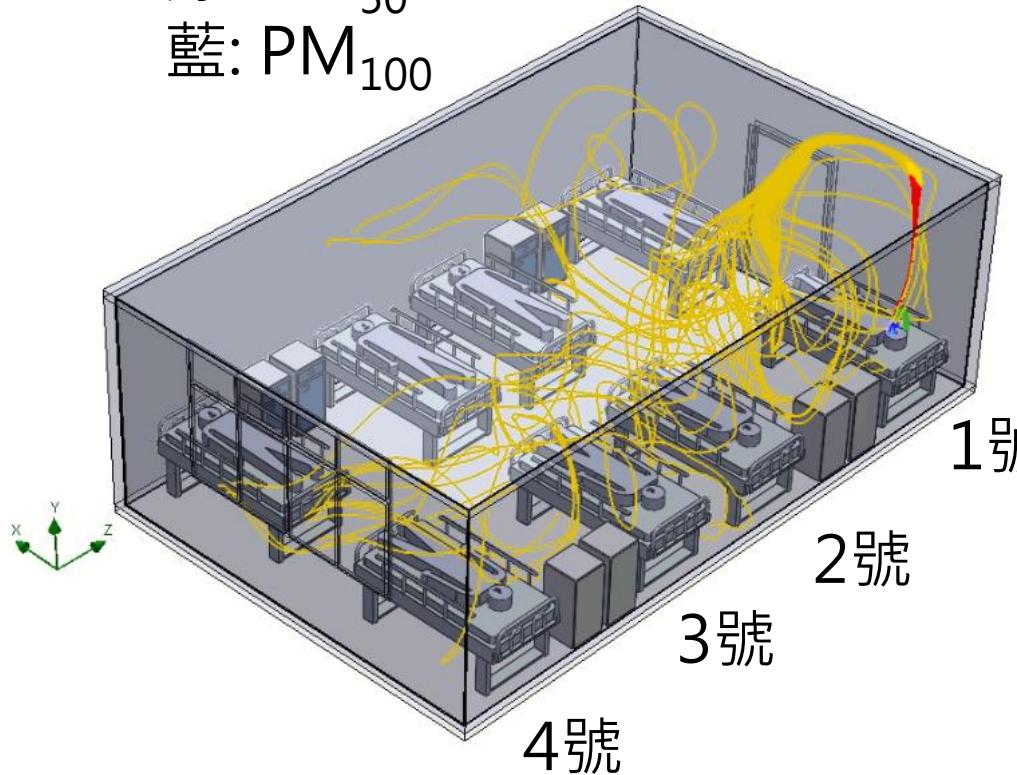
人呼吸產生的氣膠微粒(一號床)

紅: PM_{2.5}

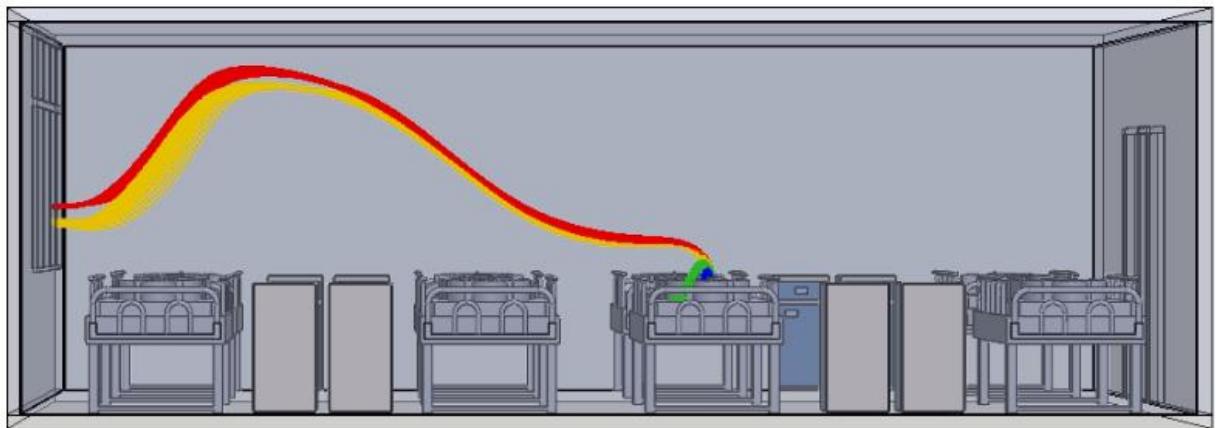
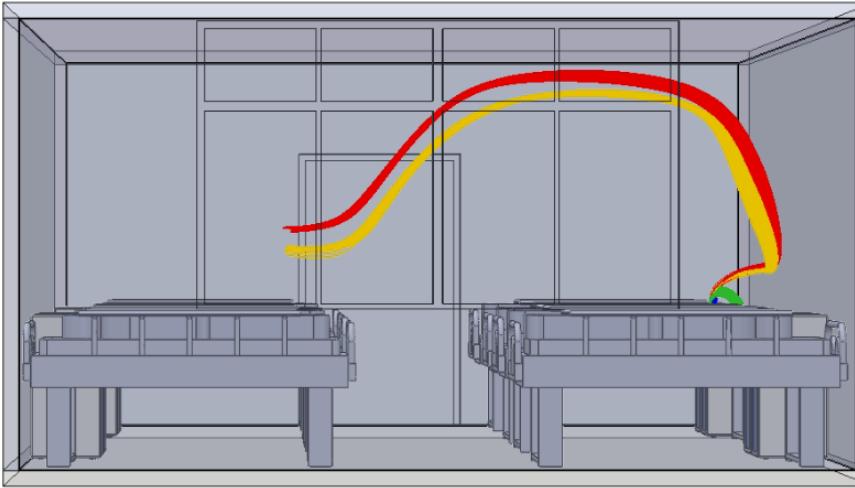
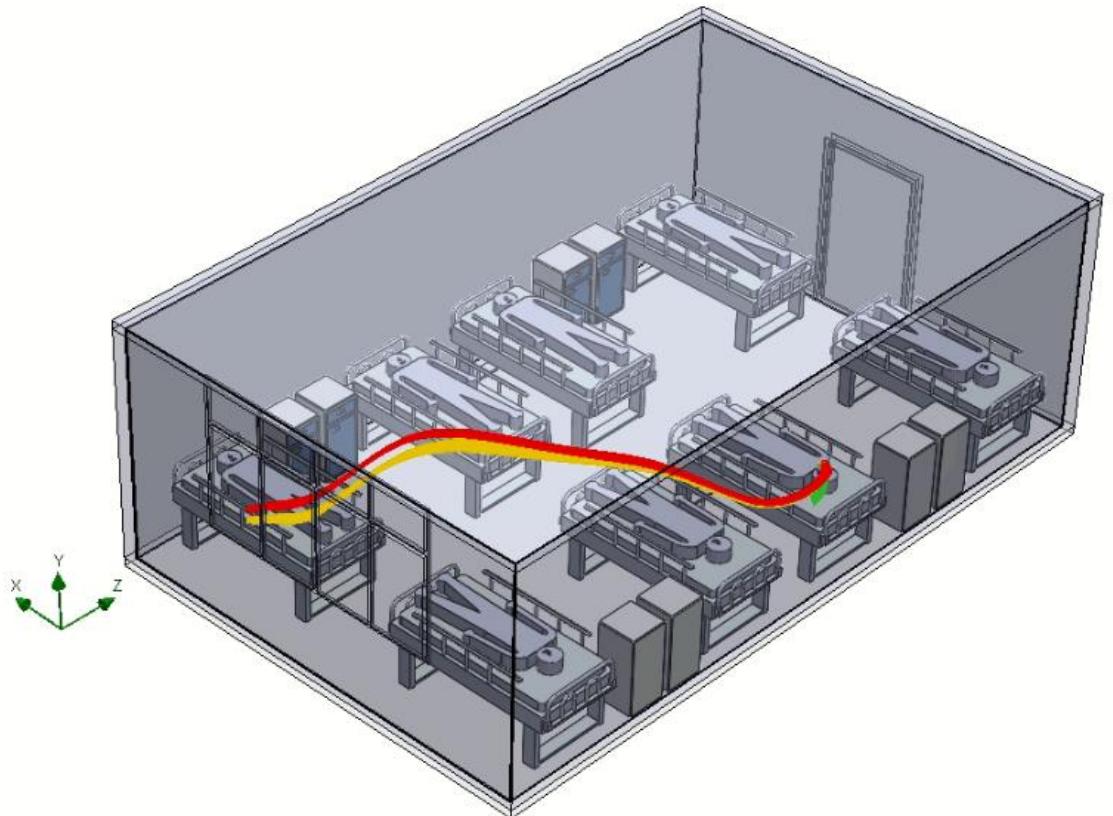
黃: PM₁₀

綠: PM₅₀

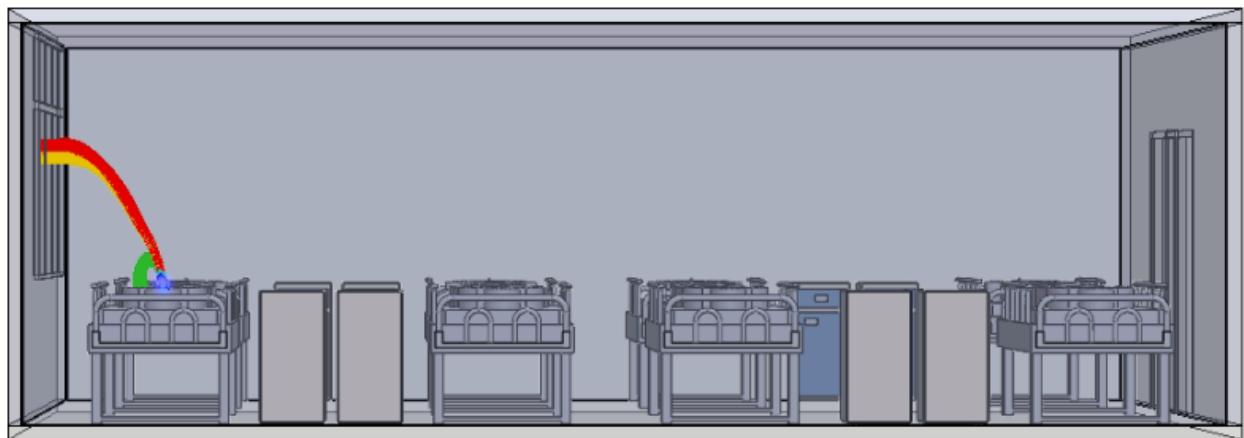
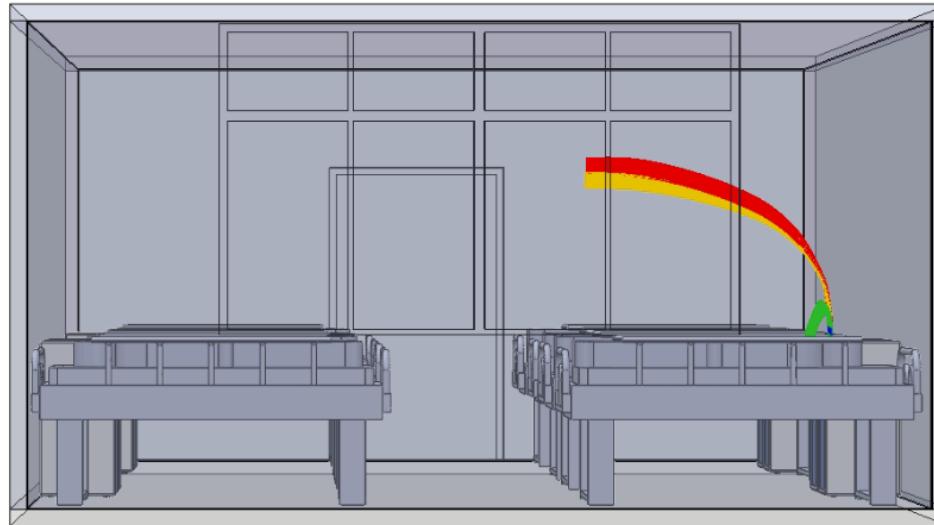
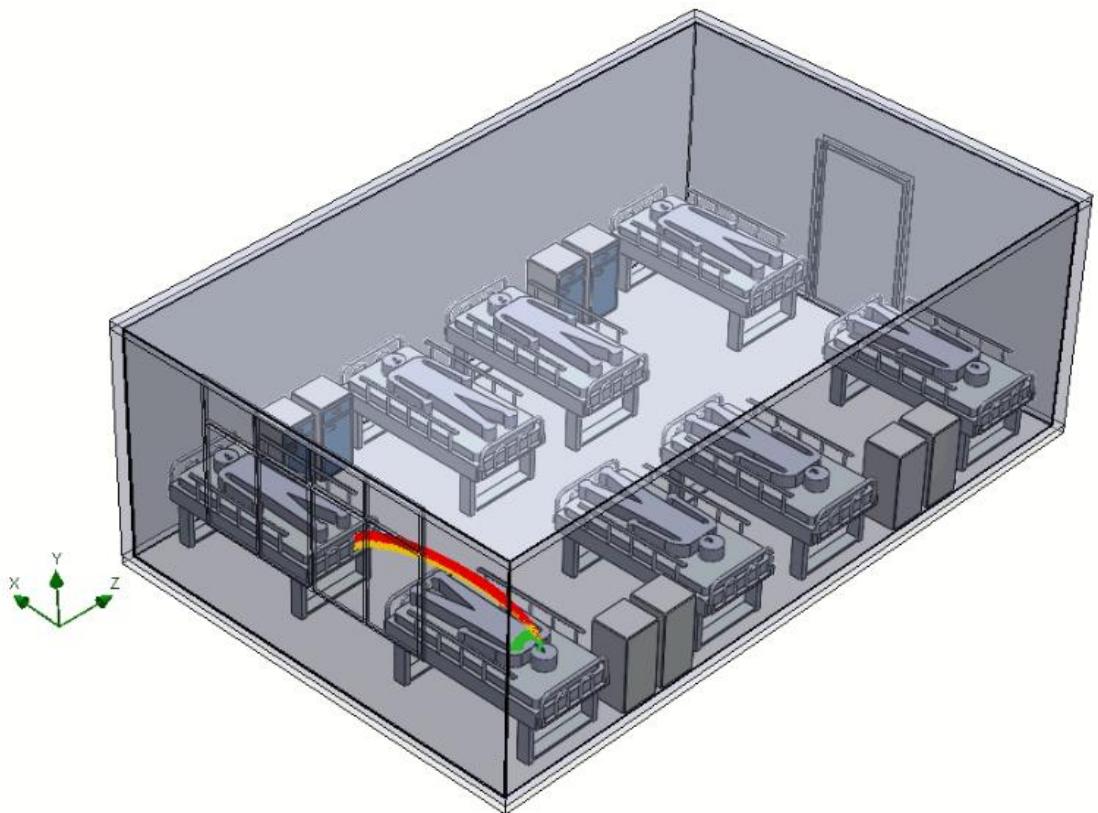
藍: PM₁₀₀



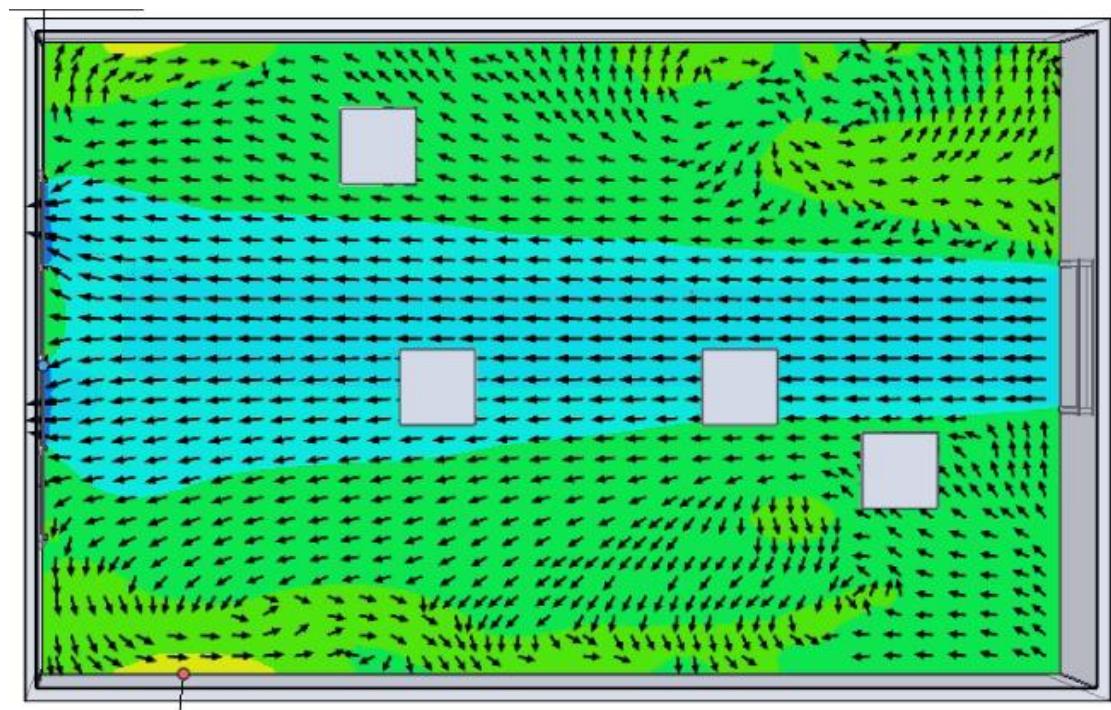
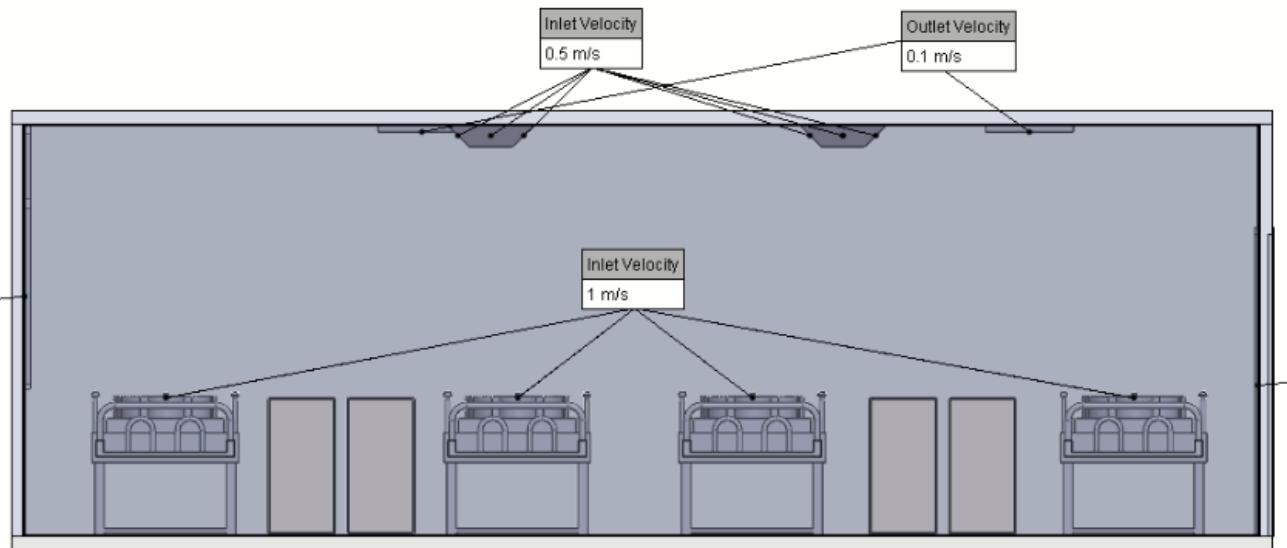
人呼吸產生的氣膠微粒(二號床)



人呼吸產生的氣膠微粒(四號床)



- 開窗，往外流速 2.0 m/s
- 開門、開冷氣



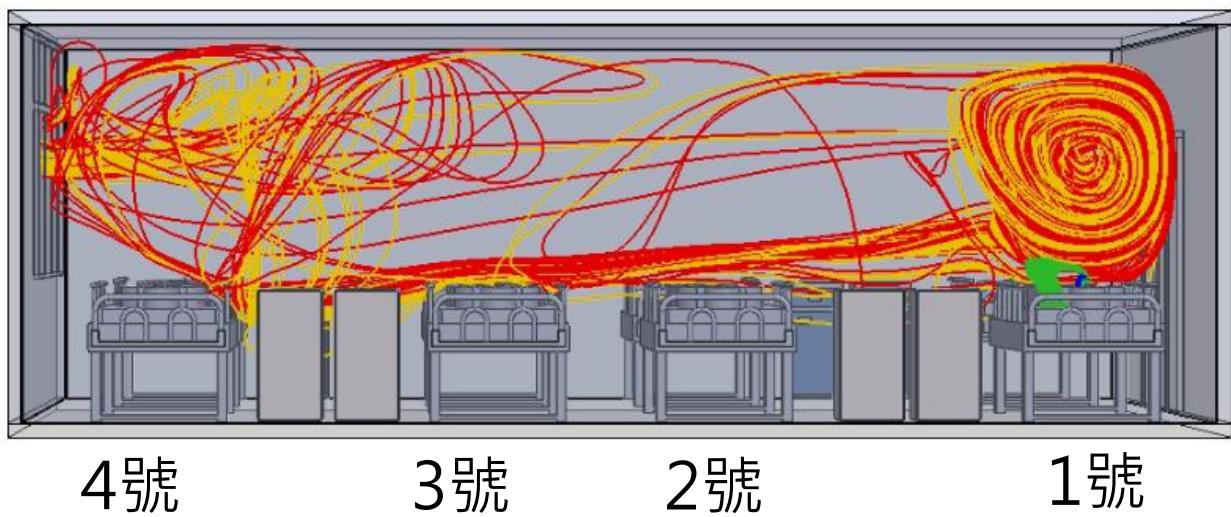
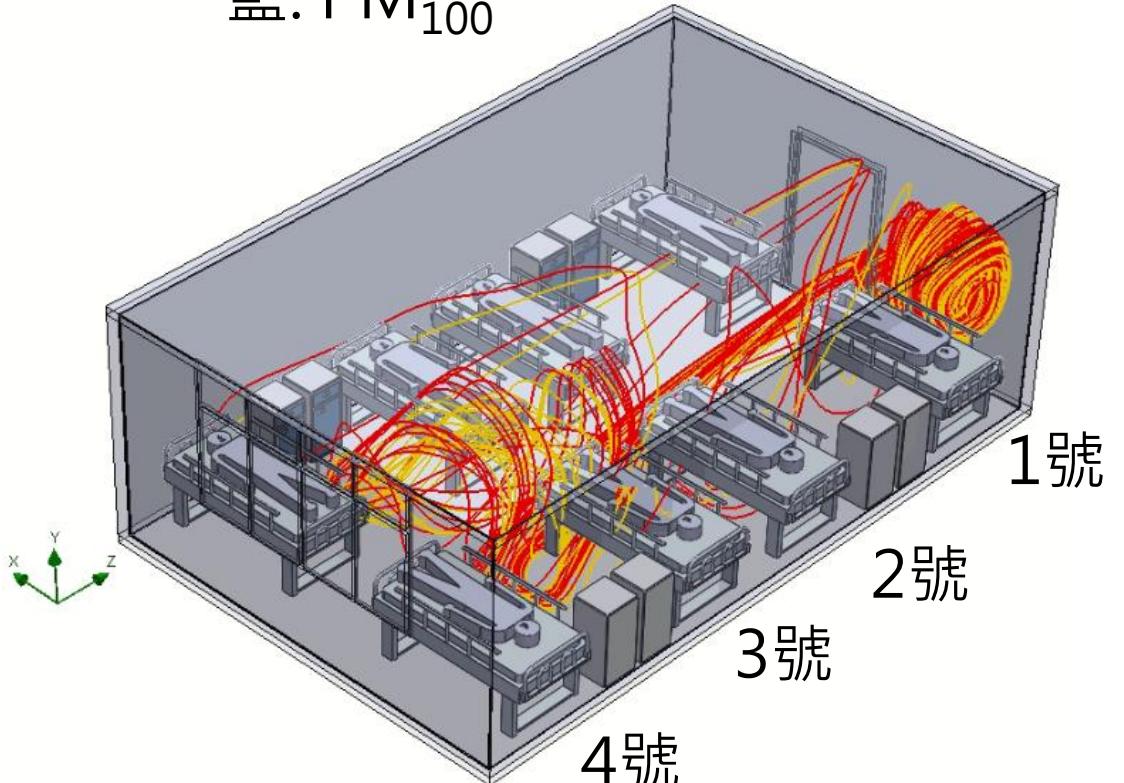
人呼吸產生的氣膠微粒(一號床)

紅: PM_{2.5}

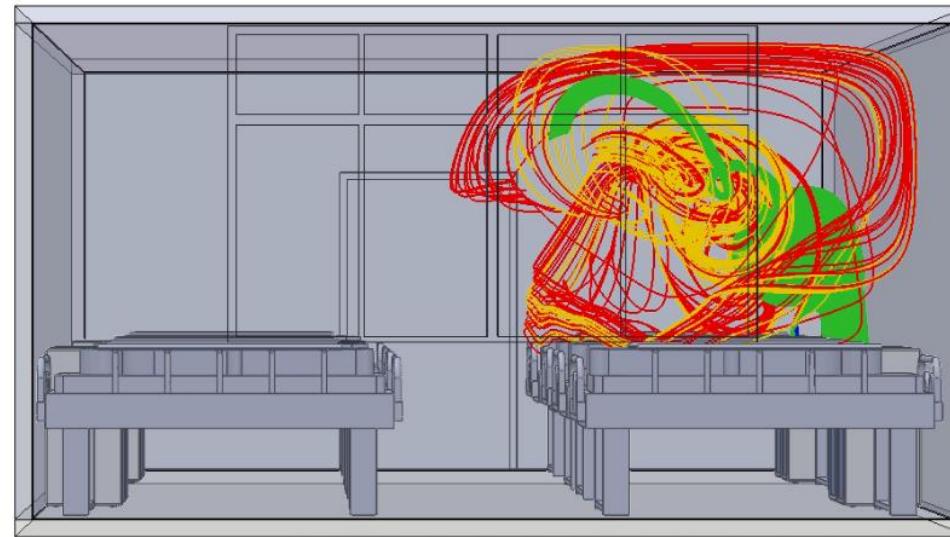
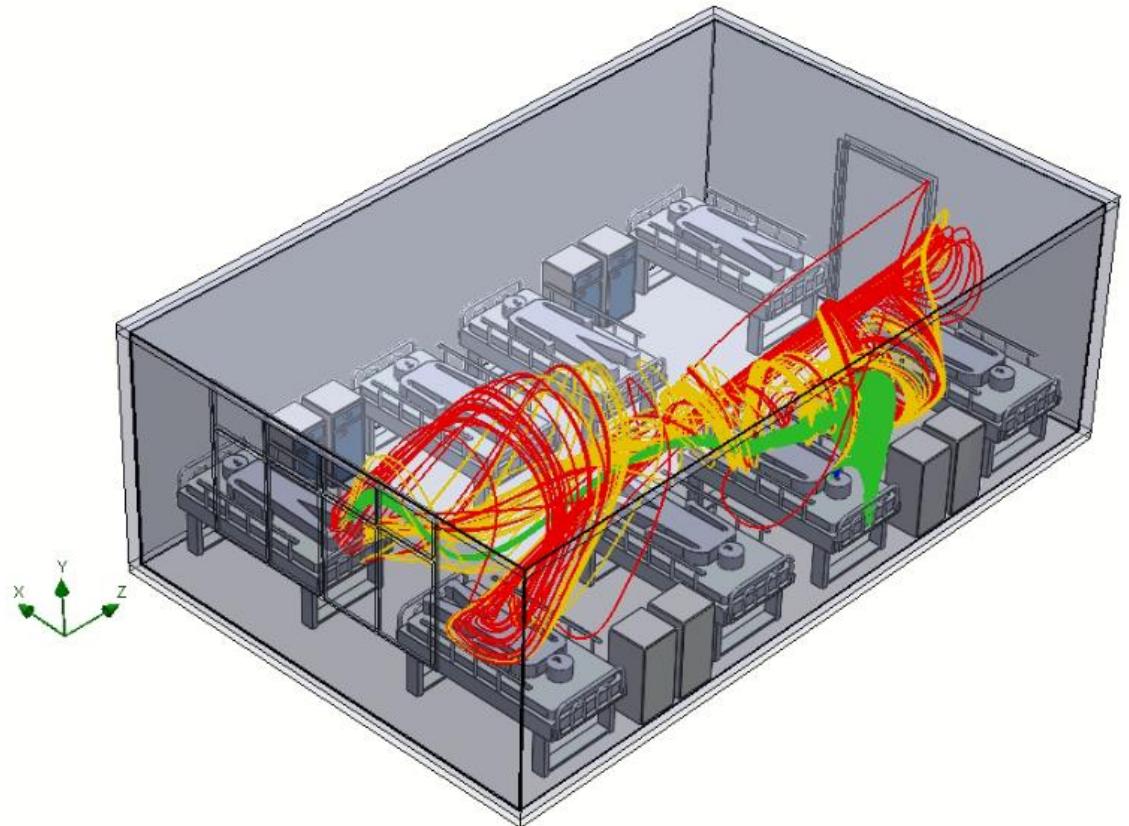
黃: PM₁₀

綠: PM₅₀

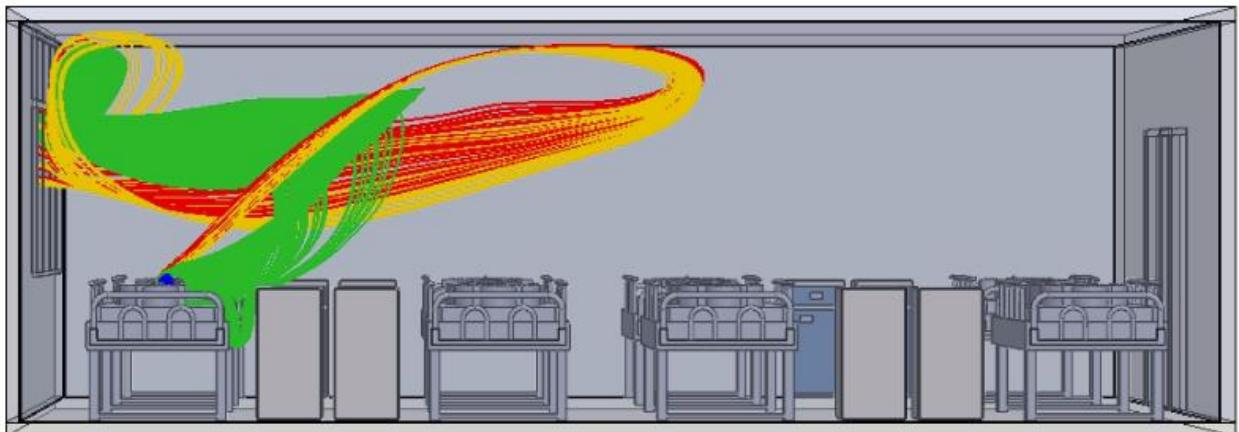
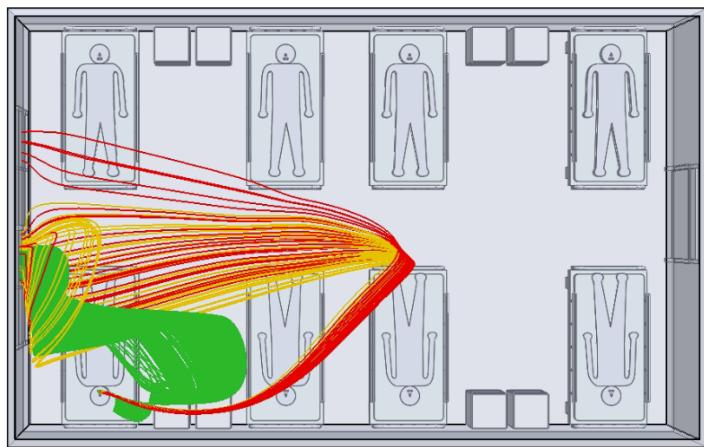
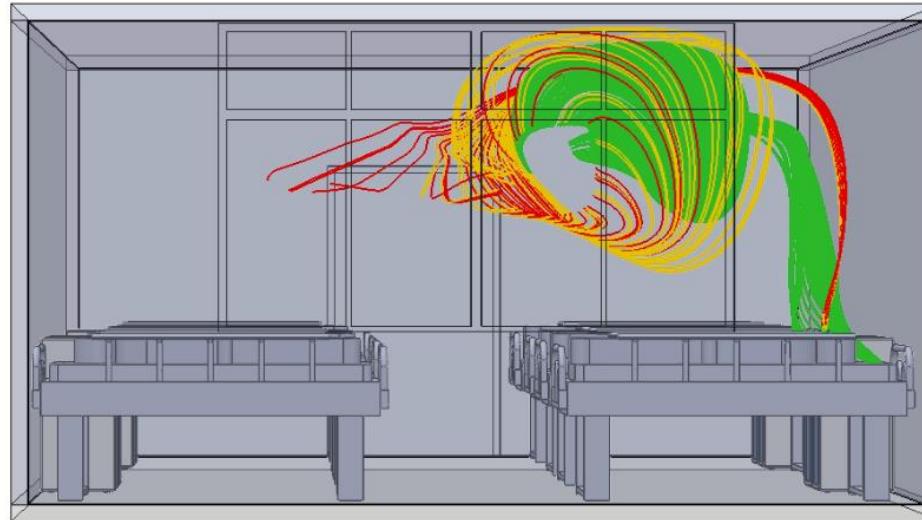
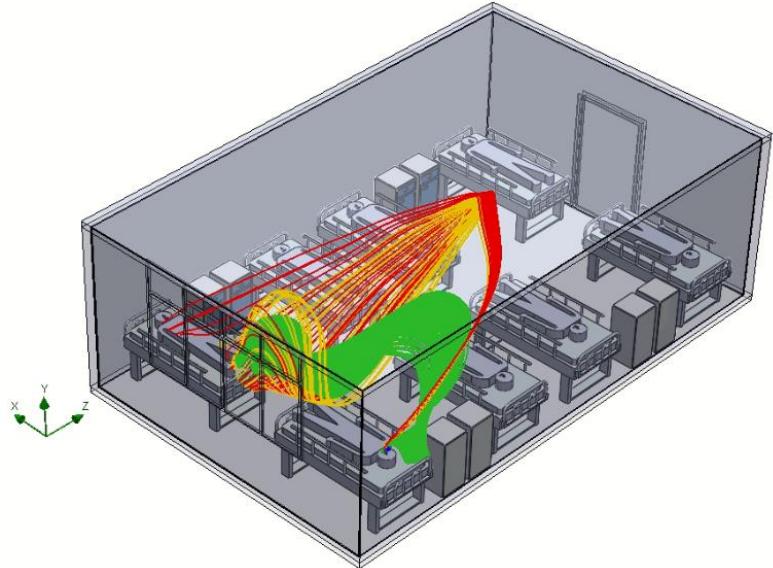
藍: PM₁₀₀



人呼吸產生的氣膠微粒(二號床)



人呼吸產生的氣膠微粒(四號床)



監測室內空氣品質：二氣化碳



- 一般職場或公共空間： $<1,000\text{ppm}$
- 唱歌、大聲說話、有氧運動： $<800\text{ppm}$



A	B	C	D	E	F	G	H
依現況或需求輸入			實測輸入		計算結果		
	容留人數 (人)	停留時間 (小時)	室內CO2濃度 (ppm)	外氣CO2濃度 (ppm)	R ₀	R ₀ 下界	R ₀ 上界
1							
2							
3	例1	20	8	650	400	1.488461057	0.6872621717
4	例2	10	8	500	400	0.5686119079	0.2613921409
5	例3	20	4	650	400	0.7594068103	0.3467960195
							2.254606765
							0.8650308716
							1.162890608

- 輸入實測而得的CO₂濃度，可反推適當的最大容留人數及最長留置時間，使R₀降到1以下
- 室內通風排氣量越低，CO₂濃度越高



某學校會議室，六人，沒有對外窗，只有空調。

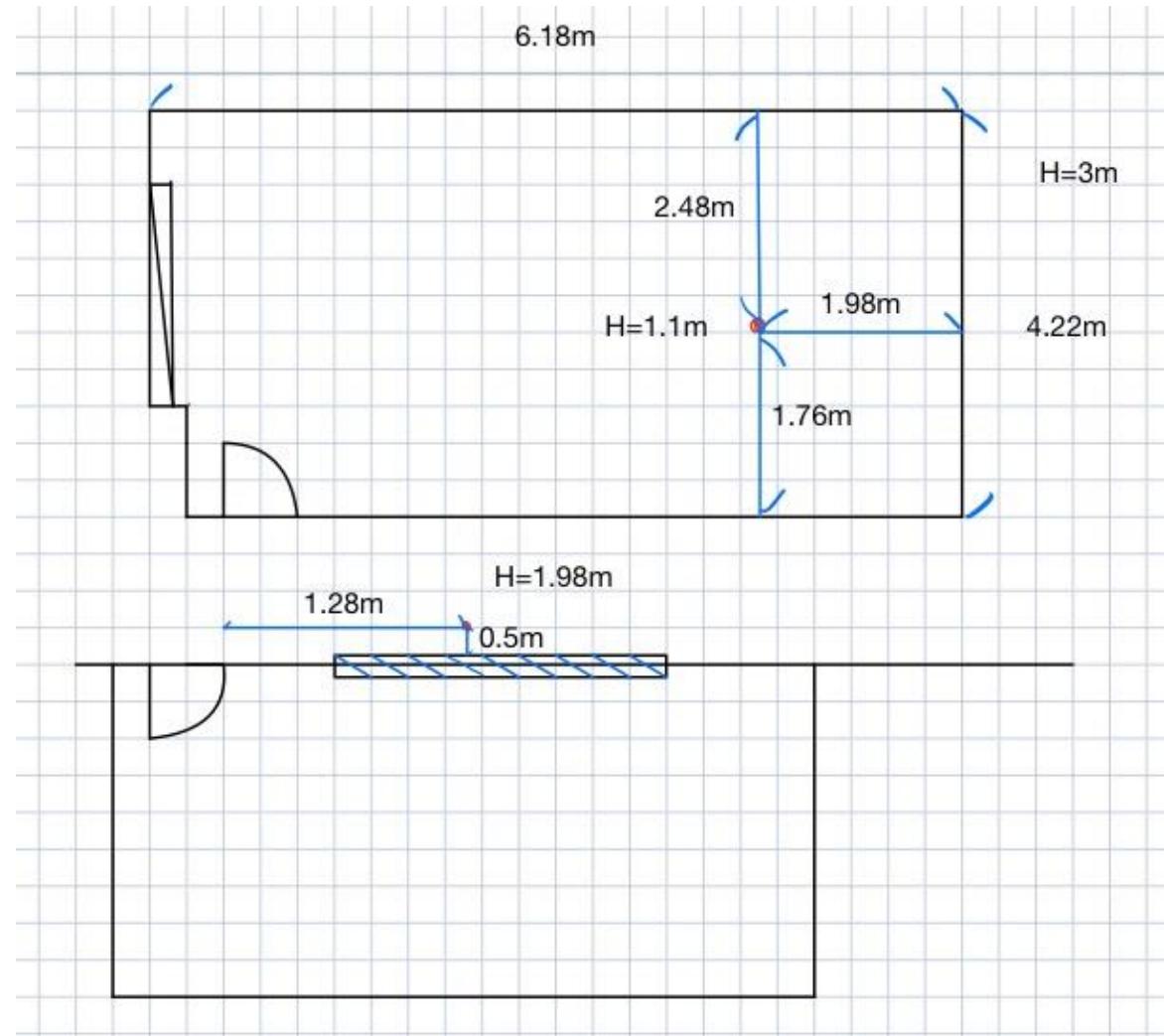


Figure5 The location of the sampling point

室內二氧化碳的濃度

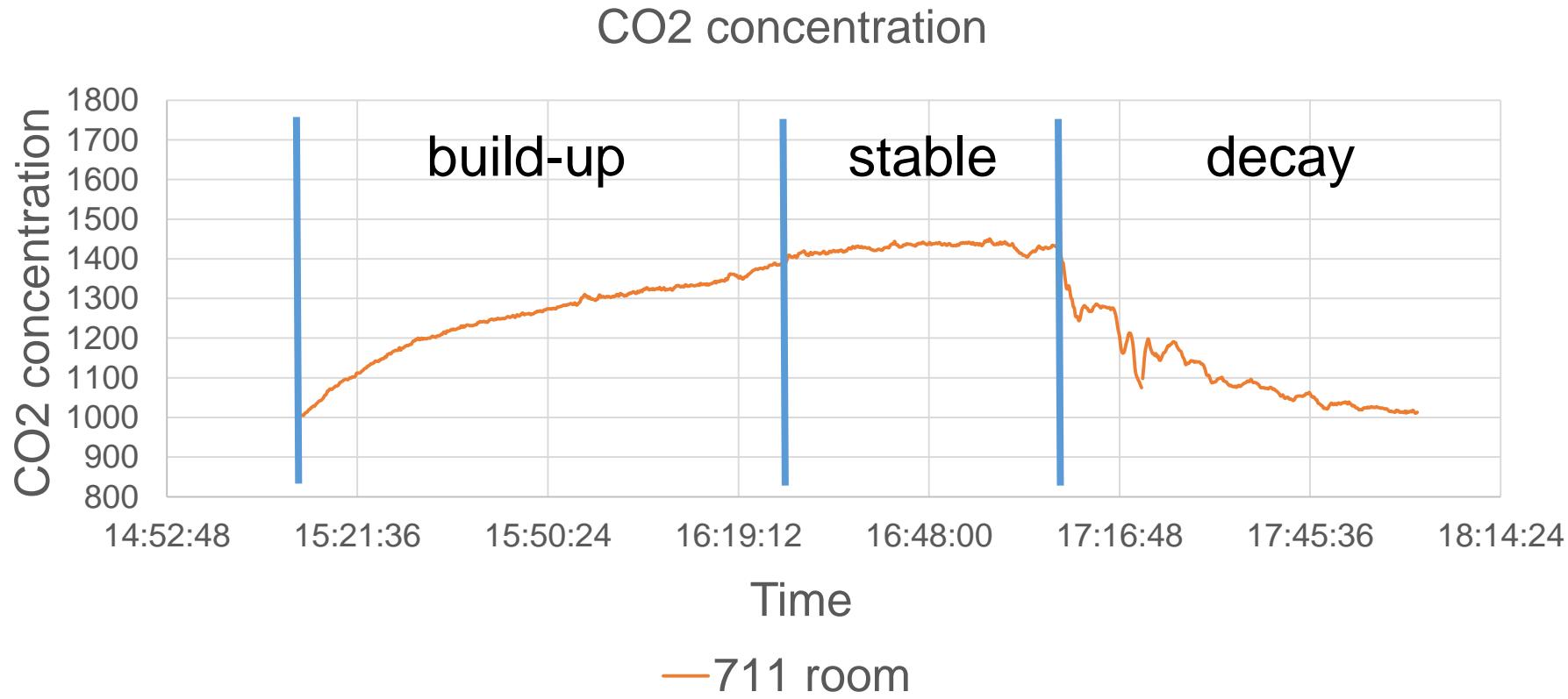
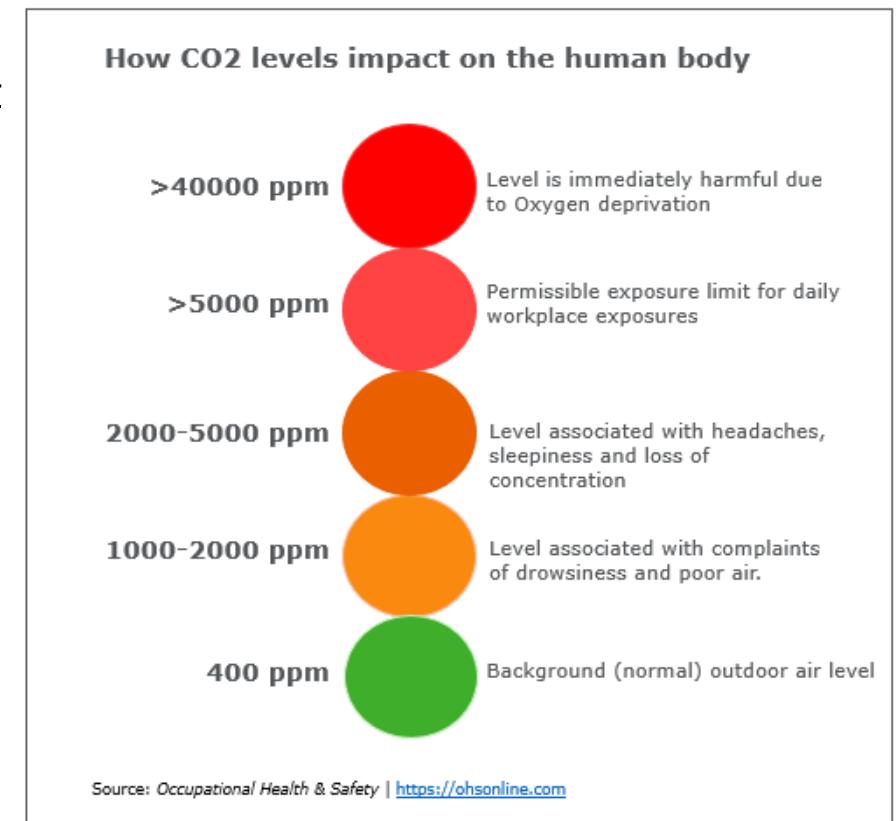


Figure1 Typical CO₂ concentration changes over time

CO₂ monitoring

- 室內 CO₂ 濃度隨居住者數量及其活動水平的變化相當可靠
- 如果 CO₂ 水平隨著時間的推移而增加，則意味著沒有足夠的新鮮室外空氣進入房間供在場人數
- 目前台灣參考大多數國家標準值訂定二氧化碳標準為 1000 ppm (八小時值)



CO₂濃度 800 ppm

Source	Document Type	CO ₂ Action Limit
American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)	Guidance from professional organization	1000-1200 ppm.
Federation of European Heating Ventilation and Air Conditioning Associations (REHVA)	Guidance from professional organization	Notes that green-yellow threshold should be reduced to 800 ppm for pandemic conditions.
UK Scientific Advisory Group for Emergency	Public health guidance document	Spaces with CO ₂ levels >1500 ppm should be prioritized for remediation. Spaces with aerosol-generating activities should aim for 800 ppm CO ₂ .
US Centers for Disease Control and Prevention	Public health guidance document	A portable air cleaner should be considered for spaces that cannot be maintained below 800 ppm.

結論

1. 建議監測室內二氧化碳濃度，以保護室內人員。
2. 開冷氣時，保持機械換氣
3. 有門窗的空間，保持門窗開啟至少十公分。
4. 減少室內人數低於 $1/2$ 。
5. 在保持換氣的前提下，開放的場所採預約制且分時段。