

Negative Pressure Operating Theater Local Experience

Dr. Kitty Fung

Consultant Microbiologist

Infection Control officer

United Christian Hospital

Codes & Standards

- Facilities Guidelines Institute (FGI)
 - Guidelines for Design and Construction of Hospitals and Outpatient Facilities (2014)
- ASHRAE/ASHE Standard 170 – 2013
 - Ventilation of Health Care Facilities
 - ANSI/ASHRAE/ASHE Approved



Design Parameters of operating rooms

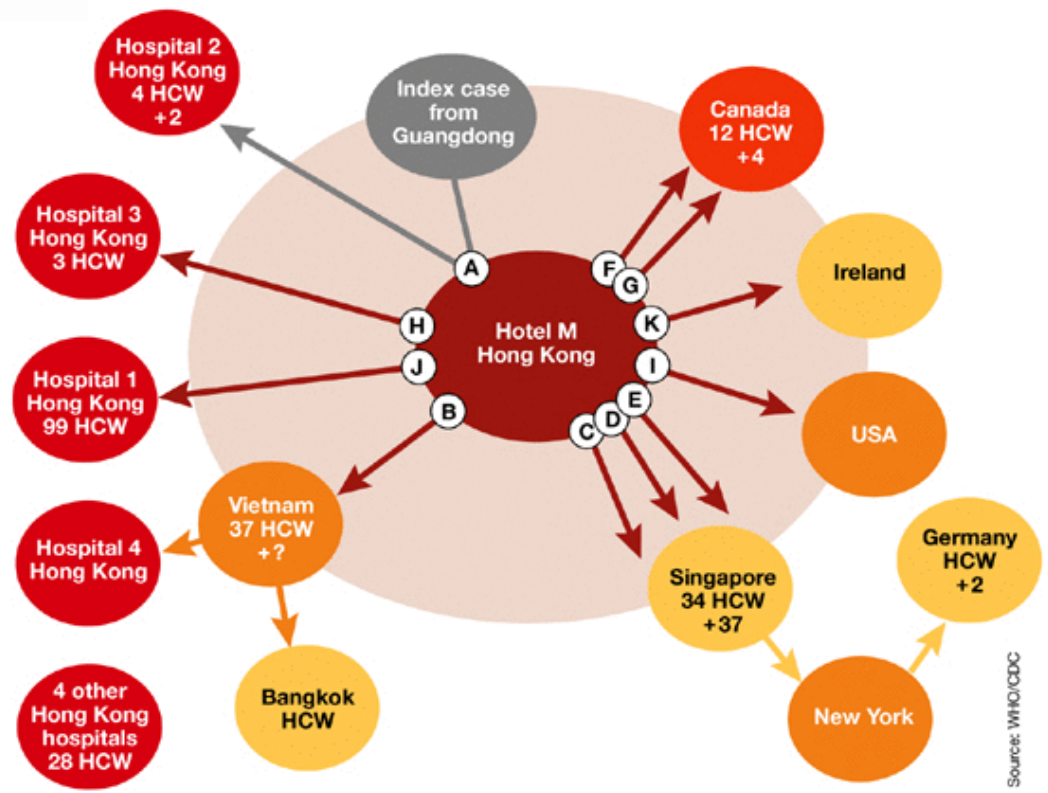
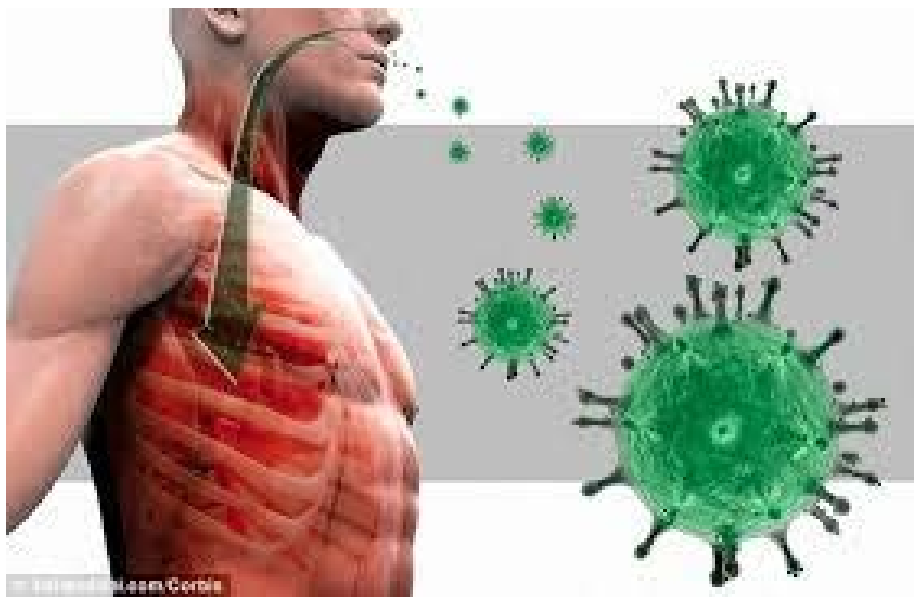
Facilities Guidelines Institute (FGI) 2014

Function of Space	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated by Means of Room Units (a)	Design Relative Humidity (k), %	Design Temperature (l), °F/°C
SURGERY AND CRITICAL CARE							
Operating room (Class B and C) (m), (n), (o)	Positive	4	20	NR	No	20–60	68–75/20–24
Operating/ surgical cystoscopic rooms, (m), (n) (o)	Positive	4	20	NR	No	20–60	68–75/20–24

Maintain **positive pressure** to all adjoining spaces at all times

In 2003

Something happened







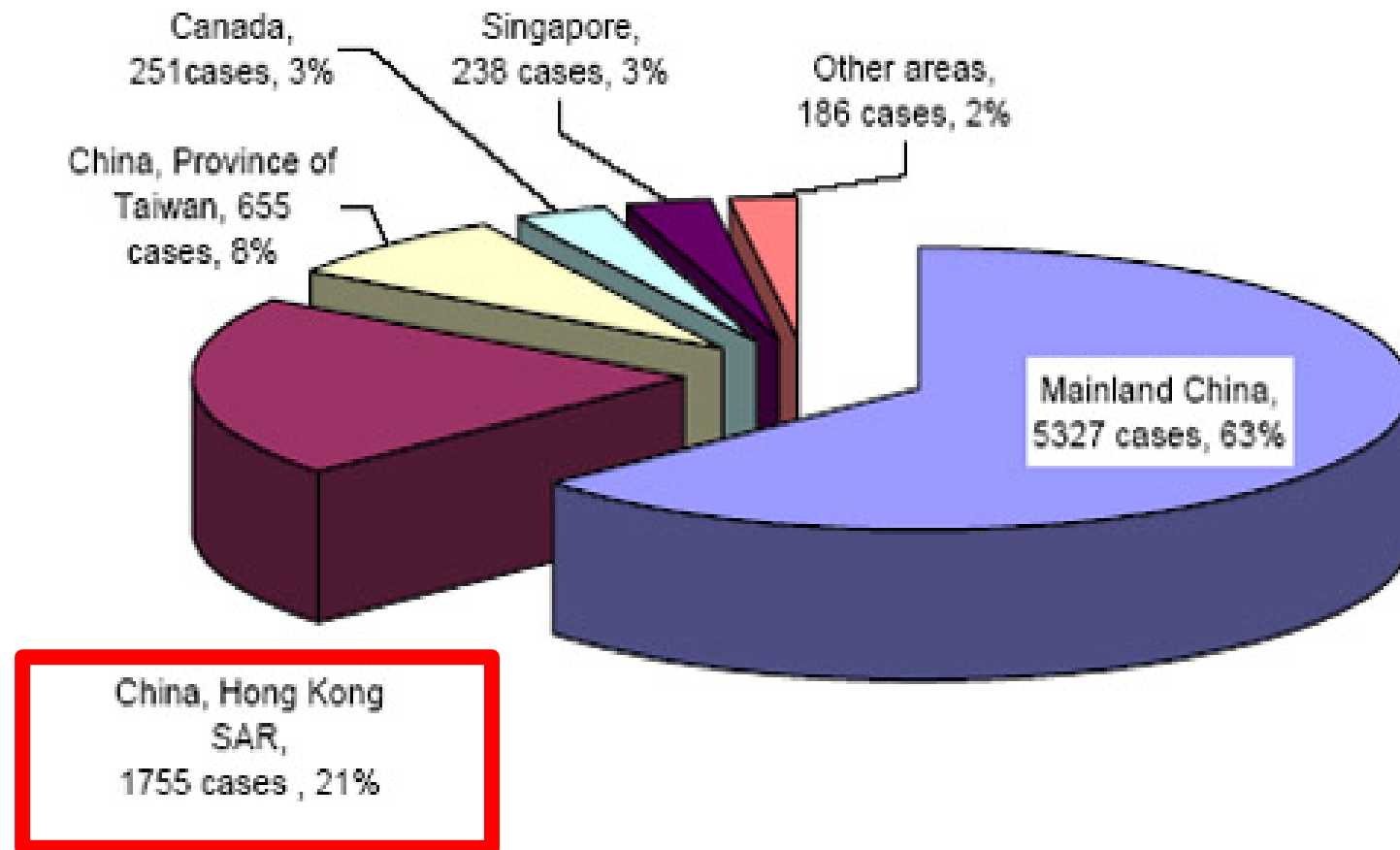
Time Flight	Destination	Gate	Status
17:00 GA 869	Singapore	16 Est at 19:10	
17:20 MU 598	Shanghai/Pudong	Cancelled	
17:45 KA 884	Shanghai/Pudong	Cancelled	
17:50 KA 430	Kashang	Cancelled	
17:50 KA 604	Xiamen	Cancelled	
17:50 KA 904	Beijing	Cancelled	
17:55 KA 700	Qulin	Cancelled	
17:55 MU 6030	Hanjiang	60 Now Boarding	
18:00 GA 430	Chongqing	64	
18:00 MU 204	Xian	20 Boarding Soon	
18:00 PR 307	Manila	24	
18:06 AI 315	Dubai	33 Boarding Soon	
18:05 KA 660	Ruzhou	Cancelled	
18:20 CX 432	Taipei	67	
18:25 MU 510	Shanghai/Pudong	19	
18:30 BO 898	Singapore	21 Boarding Soon	
18:35 KA 432	Hongzhou	Cancelled	
18:40 AC 908	Vancouver	Cancelled	
18:45 CI 816	Taipei	20	
18:50 TO 403	Bangkok	42	
18:55 KA 812	Hanjiang	Cancelled	
19:10 CX 111	Sydney	47	

Time Flight	Destination	Gate	Status
19:10 CX 135	Melbourne	Cancelled	
19:10 CF 088	Melbourne	18	
19:15 MU 150	Shanghai/Pudong	15	
19:15 NZ 070	Auckland	35	
19:20 KA 908	Beijing	Cancelled	
19:20 BO 899	Singapore	Cancelled	
19:25 BR 872	Taipei	Cancelled	
19:25 CZ 3078	Haitou	32	
19:40 SJ 119	Manila	21	
19:40 CA 116	Beijing	Cancelled	
19:40 CX 468	Taipei	Cancelled	
19:40 CX 813	Manila	Cancelled	
19:45 CI 642	Taipei	25	
19:50 MU 7002	Taiyuan	Cancelled	
20:00 CX 715	Singapore	Cancelled	
20:00 UA 802	Singapore	Cancelled	
20:05 CI 816	Singapore	20	
20:10 CZ 3078	Haitou	30	
20:10 CF 088	Haitou	Cancelled	
20:15 KA 908	Shanghai/Pudong	20	
20:15 TO 400	Taipei	Cancelled	
20:25 CX 107	Auckland	1	
BA 4951			

Time Flight	Destination	Gate	Status
20:25 KA 438	Kashang	Cancelled	
20:45 CX 484	Taipei	Cancelled	
20:45 TO 607	Bangkok	42	
20:50 CI 616	Taipei	Cancelled	
20:50 CF 2812	Qulin	32	
21:00 BR 898	Taipei	30	
21:05 PR 311	Manila	19	
21:10 CF 138	Sydney	19	
21:45 KA 434	Kashang	27	
21:45 KA 480	Taipei	Cancelled	
21:50 CX 408	Taipei	4	
21:50 CX 605	Manila	31	
21:55 CI 672	Kashang		
21:55 SO 002	San Francisco		
22:00 VH 763	Ho Chi Minh		
CX 763			
22:05 CI 686	Taipei	Cancelled	
22:05 CX 700	Bangkok	Cancelled	
22:25 EX 383	Bangkok	62	
22:25 EX 383	Dubai		
22:58 CX 482	Taipei	Cancelled	
23:10 VH 771	Manich	Cancelled	
NZ 4031			
23:20 CX 103	Cairo		
	Melbourne		



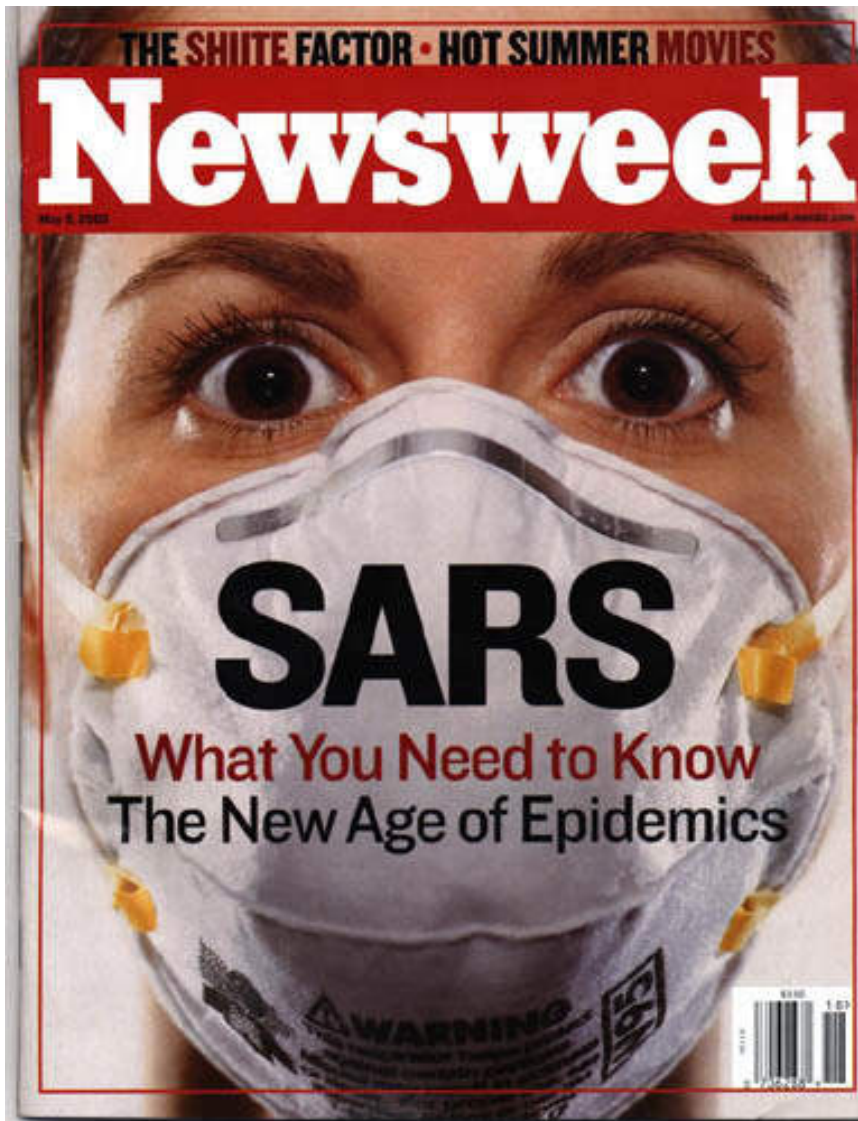
Number of patients with SARS worldwide on 7 Aug 2003 (WHO)



Number of SARS Cases in HK

	Infected	Dead
Overall	1,755	299
Community (Amoy Gardens)	1,369 (329)	293 (42)
Healthcare workers	386	6





Fear

Panic!!

8057MM - Enhancement of Infection Control Facilities
In the Public Hospital System (Batch B)
For United Christian Hospital (UCH) (SARS Mode)

Locations	Settings for Highest Standard (Fever Ward)
Operating Theatre	
Anaesthetic, Scurb	Pressure ~ -10 pa low-level exhaust c/w central HEPA filter 100% fresh air supply Temp. 20 deg. +/- 1 deg. Humidity 55% +5% Proprietary automatic air-tight sliding door with lead lining
Operation Room	Pressure ~ -15 pa low-level exhaust c/w central HEPA filter 100% fresh air supply 25 Air change Temp. 20 deg. +/- 1 deg. Humidity 55% +5% Proprietary automatic air-tight sliding door with lead lining
OT ...Jor	Pressure ~10 pa low-level exhaust c/w central HEPA filter 100% fresh air supply Temp. 23 deg. + / - 1deg. Humidity 55% +/- 10% Automatic swing door

A Computer Evaluation of Ventilation Performance in a Negative-Pressure Operating Theater

Tin-tai Chow, PhD*

Anne Kwan, FANZCA†

Zhang Lin, PhD*

Wei Bai, MSc*

BACKGROUND: A negative-pressure operating theater is required to limit the spread of respiratory diseases in patients with severe acute respiratory syndrome, tuberculosis, avian influenza, or similar infectious diseases. In Hong Kong, we converted a conventional operating theater into a negative-pressure operating theater that has been in service for more than a year. In this article, we introduce its ventilation design and evaluate the airflow performance in relation to different combinations of medical lamp configurations and modes of launching infectious particles into the room air.

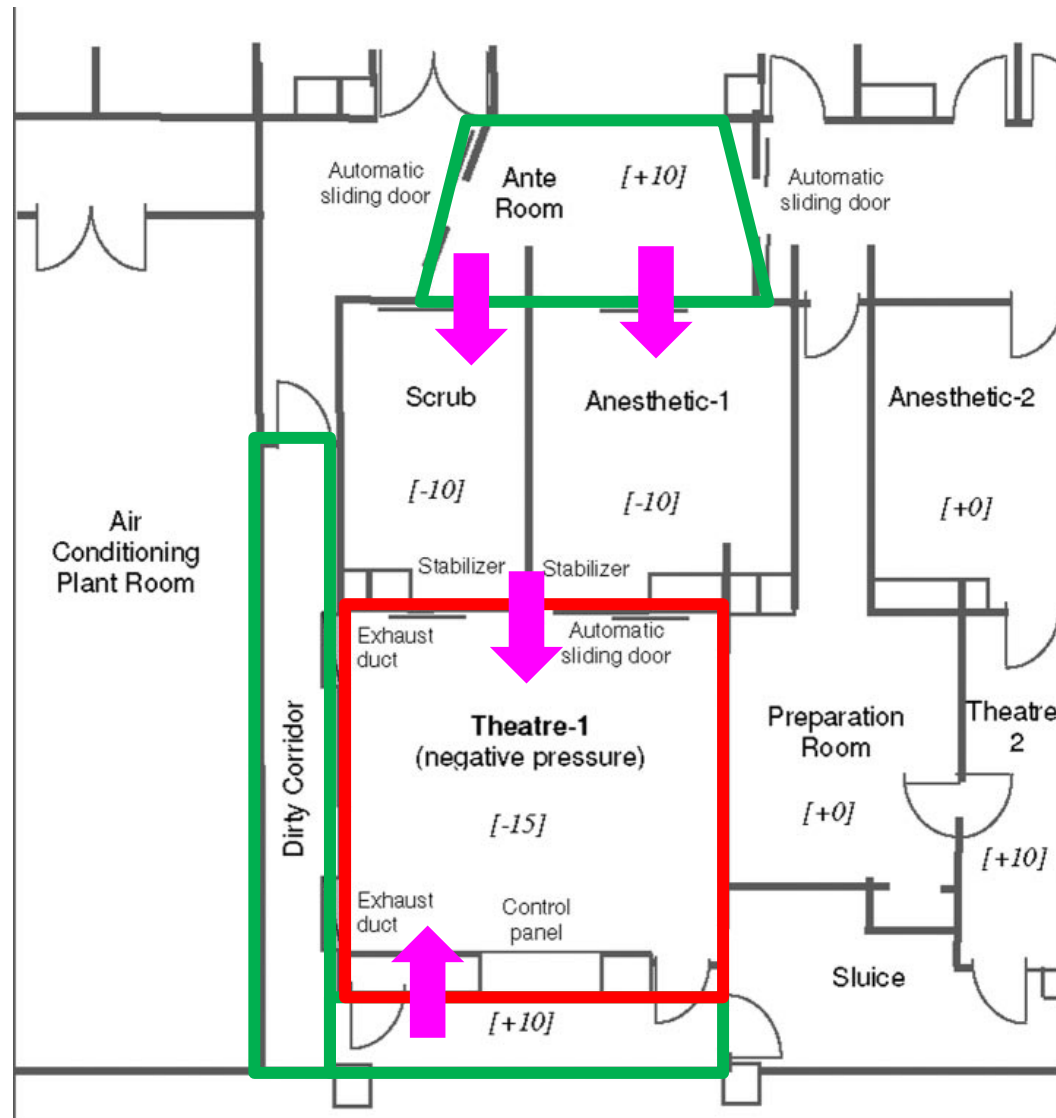
METHODS: We used a computational fluid dynamics technique for the numerical analysis.

RESULTS: Our analyses showed that the airflow performance in the negative-pressure operating theater was satisfactory and comparable to the original positive-pressure design. The airflow pattern effectively controlled the dispersion of infectious particles. Our calculations demonstrated that the airflow contained the dispersion of infectious particles released from the patient sufficiently to protect the surgical team, and *vice versa*.

CONCLUSIONS: Computational fluid dynamics can be used to assess airflow in a negative-pressure operating room and model the dispersion of infectious particles from the patient.

(Anesth Analg 2006;103:913-8)

Design pressure and part plan of the negative pressure operating theater (OT1) at the operating theater suite



Note: [xx] - design pressure in "xx" Pa

Routine air sampling on 30 Dec 2015, after HEPA filter change

MICROBIOLOGICAL AIR SAMPLING REPORT

Infection Control Unit, UCH

Location of sampling: OT 1
 Temperature (°C): reading/ set point 19.8/20.3
 Method: SAS Super ISO 180 Air sampler

Date / Time of Sampling: 30/12/2015
 Relative humidity (%): reading / set point: 57.7/54.9
 Volume of air sampled: 2 m³

Sampling site	No of persons present in room	Medium used	Total count* / (CFU / m ³)	Acceptable Level# (CFU / m ³)	Comments
Control	1	TSA	0	≤10	Satisfactory
OT 1a	1	TSA	15 (<i>Penicillium</i> species isolated)	≤10	Fail
OT 1b	1	TSA	25 (1 colony of coagulase negative staphylococcus isolated 1 colony of <i>Micrococcus luteus</i> isolated 23 colonies of <i>Penicillium</i> species isolated)	≤10	Fail

Incubation condition: Tryptone Soya Agar (TSA) (35°C for 2 days)

*Total count in cfu/m³ includes the total bacterial counts

#Reference: HTM 03-01, 2007; DH, UK

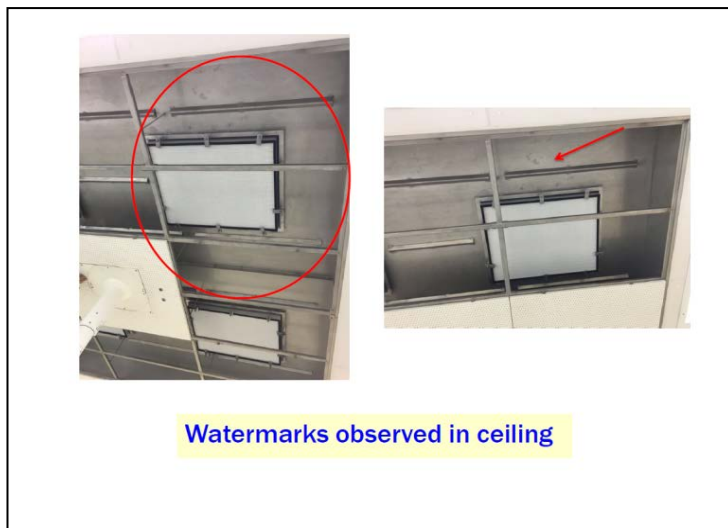
Overall comments:

After changing HEPA Filters, the air sampling of OT room 1 was done on 30 Dec 2015. All the results of air sampling were not satisfactory and were regarded as fail. ICT will repeat the air sampling in the noon of 3rd Jan 2016, after the completion of comprehensive checking and air duct cleansing, followed by 24 hours air out in OT 1.

Follow up actions

Date of sampling	Fungal count (cfu/m3)	Actions
30/12/15	19	HEPA filter checking, surface cleansing & disinfection
3/1/16	4, Leak test for HEPA filter failed	Review HEPA filter fitting + remedial measures
31/1/16	27	Comprehensive environment cleansing, attention to inner layer of false ceiling
7/2/16	8	Persistent presence of mold requires further corrective measures Repeat ceiling cleaning

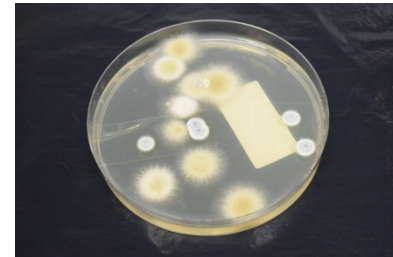
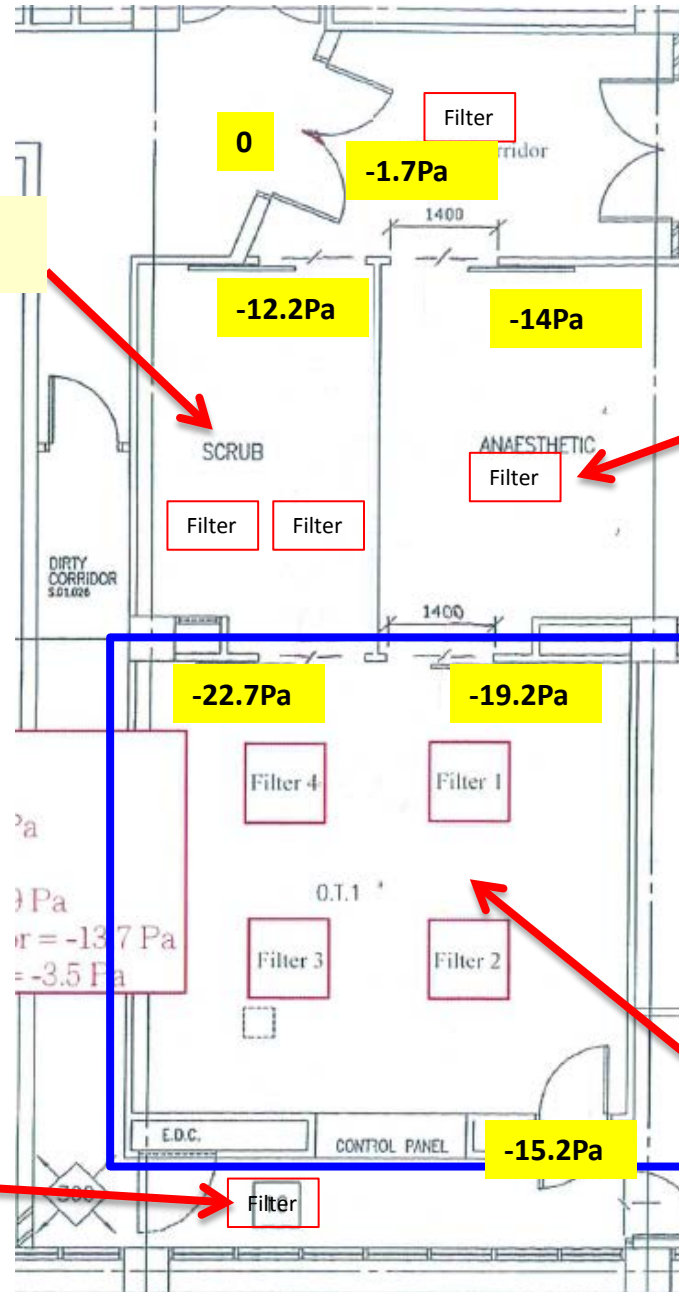
Some findings



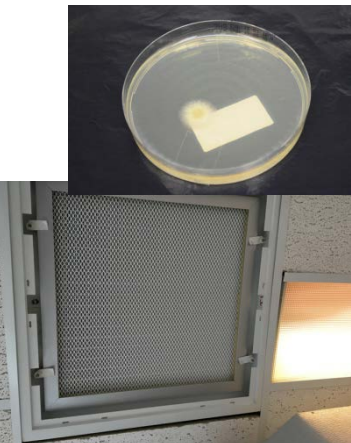
Result of air samples collected on 13 Feb 2016



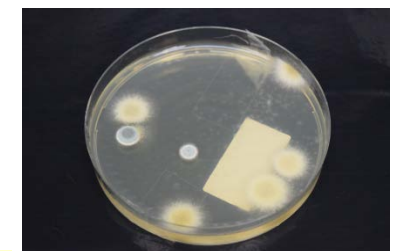
Total fungal count :30



Total fungal count :15



Total fungal count :1



Total fungal count :7

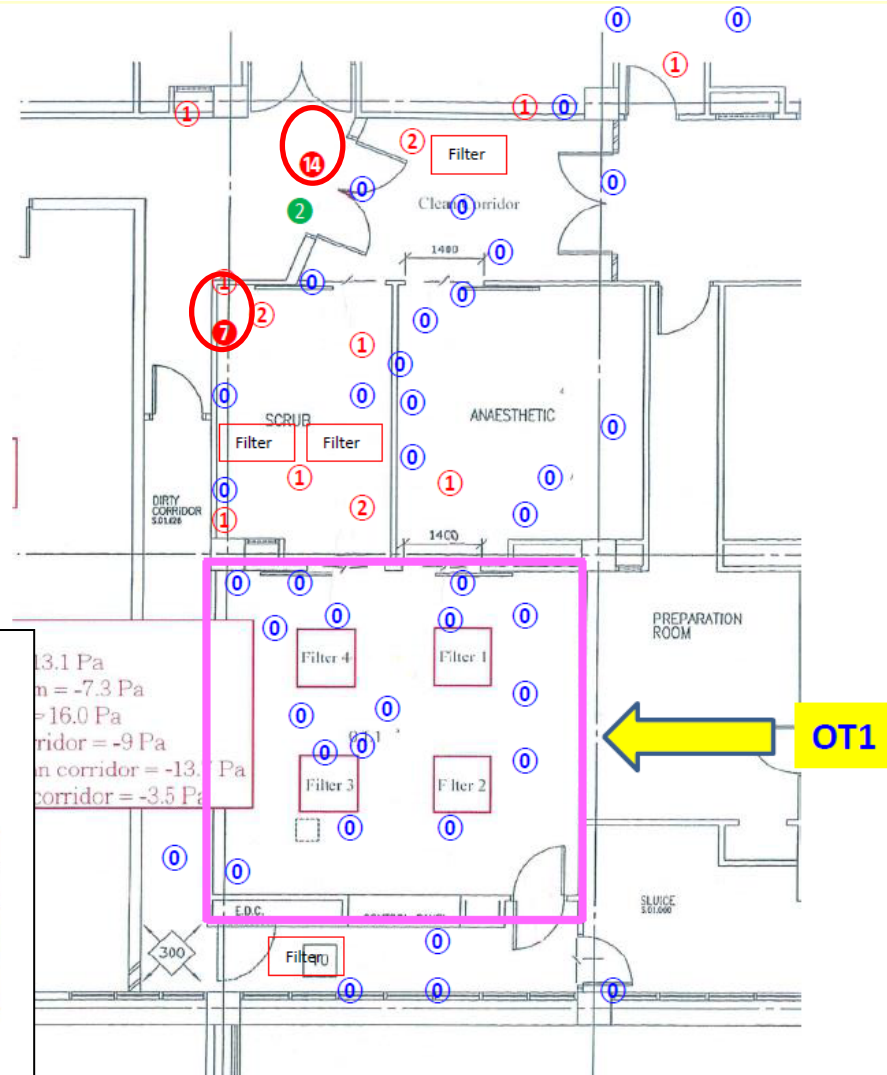


To map the distribution of fungal spores, environmental sampling performed (16 Feb)

① settle plates with no growth

① Digit in the circle indicates fungal counts on Settle plate

① Digit in the circle indicates the fungal count by swab stick



Sites with highest fungal counts

14 fungal colonies: door frame of the Day Surgery



7 fungal colonies: ceiling over the clock at scrub room



Other findings

Dusted hood in the day surgery room



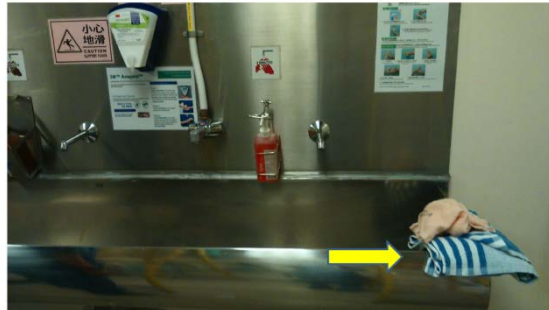
Ceiling over Anaes Room



waste left on the false ceiling of scrub room



Waste cloths left on the false ceiling



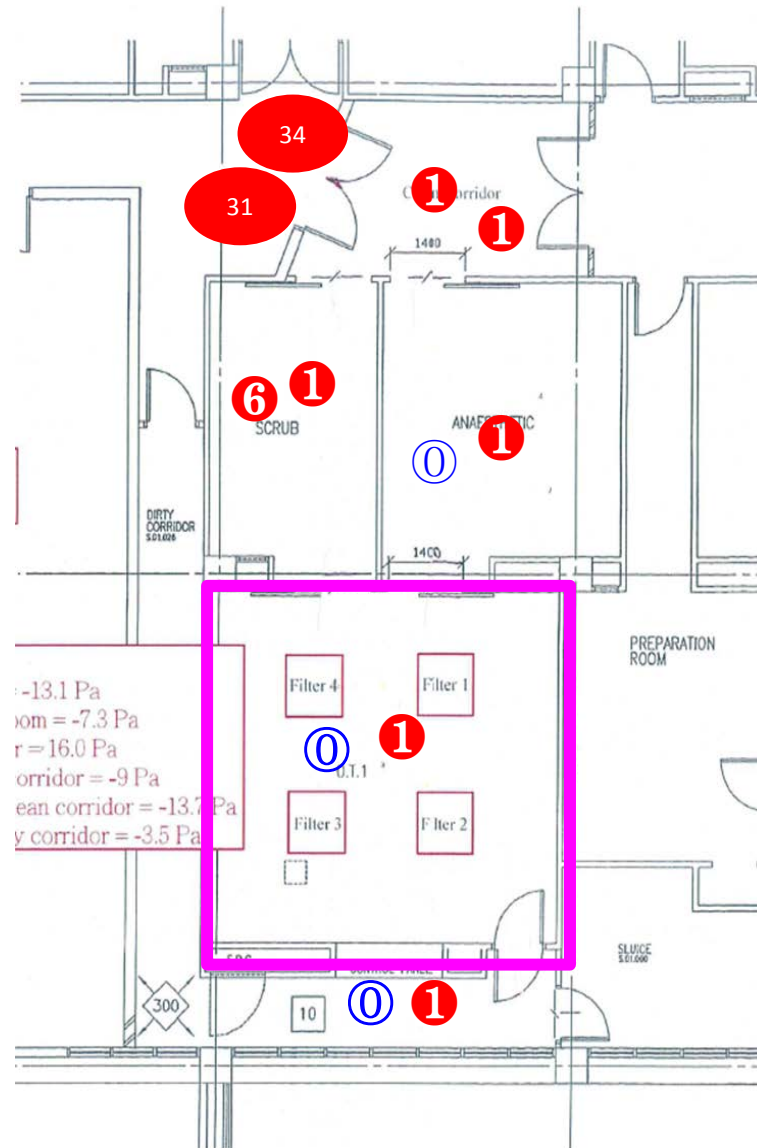
Screws & cigarette left on the false ceiling



Air sampling extended to day surgery area

① Sabouraud plates without fungal counts

1 Digit in the circle indicates the total number of fungal counts in the Sabouraud plate



Clean room = -13.1 Pa
 Room = -7.3 Pa
 Corridor = 16.0 Pa
 Corridor = -9 Pa
 Clean corridor = -13.7 Pa
 Dirty corridor = -3.5 Pa

Clean room = -13.1 Pa
 Room = -7.3 Pa
 Corridor = 16.0 Pa
 Dirty corridor = -9 Pa
 Clean corridor = -13.7 Pa
 Dirty corridor = -3.5 Pa

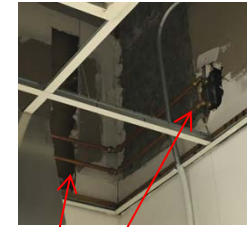
Remove and clean ceilings in green area on 27 Feb

Space enclosed by the green line = structural wall seen above false ceiling, except the red dots

Above the clock



Near the hood



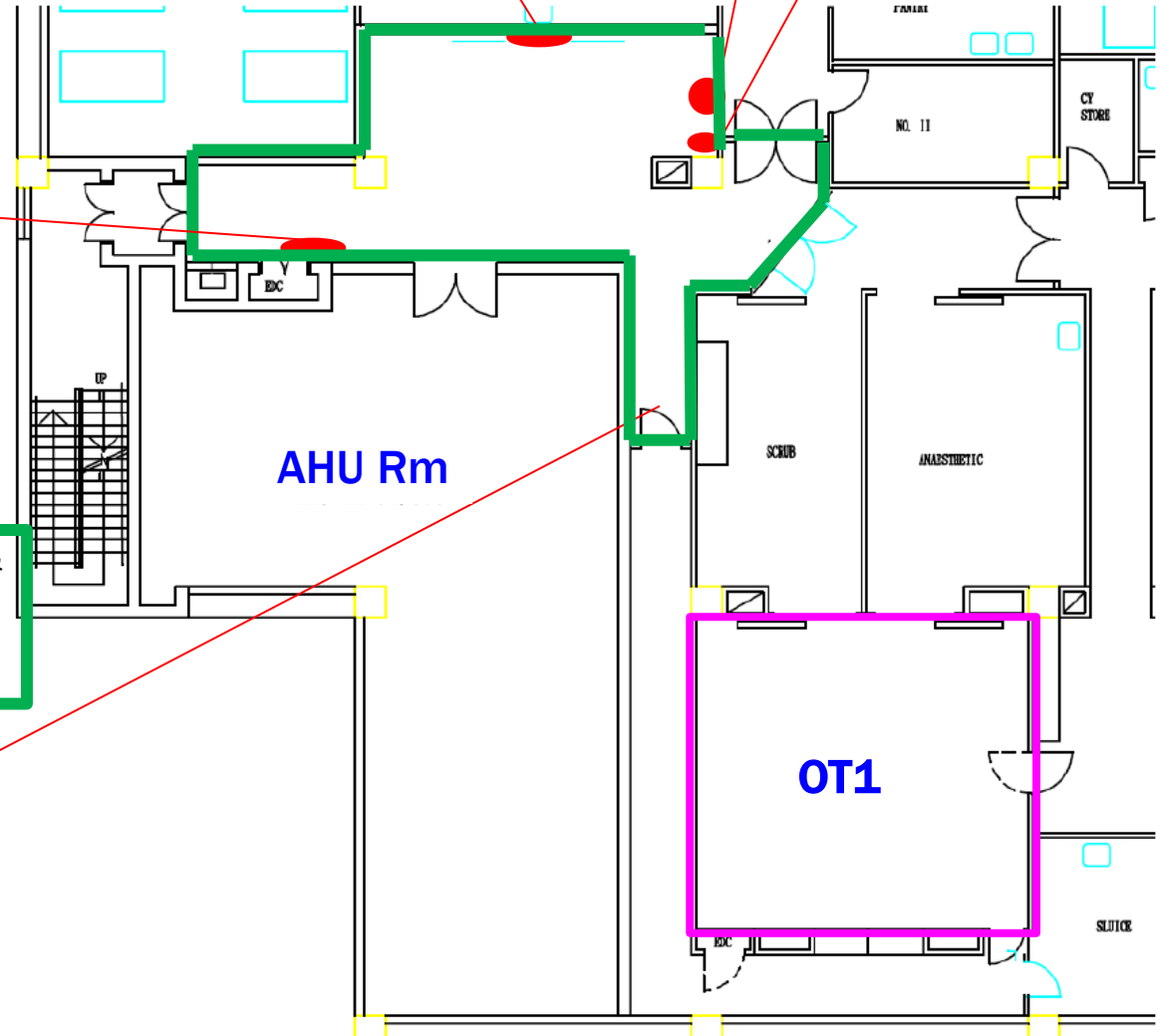
Towards AHU

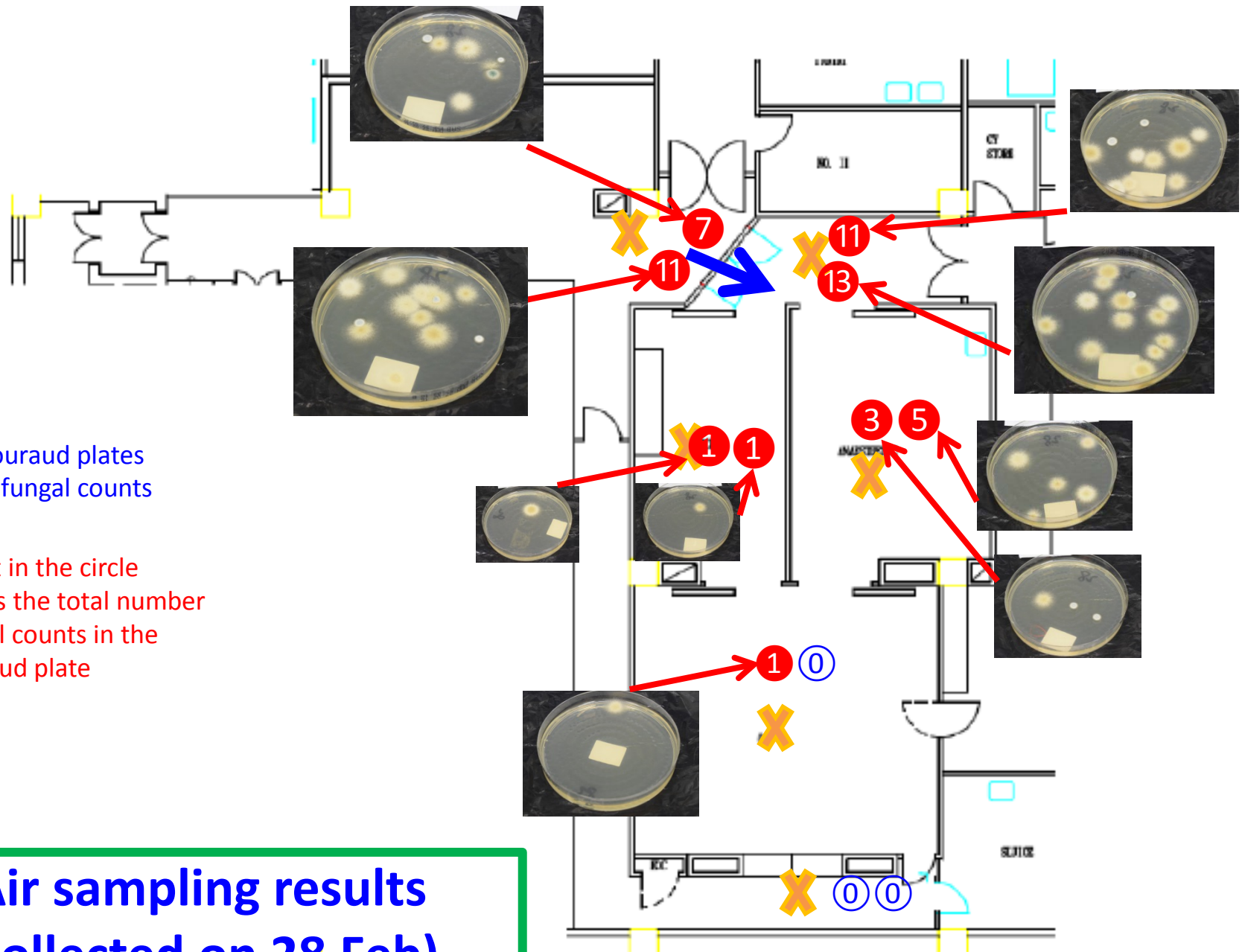
AHU Rm

Waste (insulation foam & cap) found upon removal of false ceiling above the D3 door exit



OT1





① Sabouraud plates without fungal counts

① Digit in the circle indicates the total number of fungal counts in the Sabouraud plate

**Air sampling results
(collected on 28 Feb)**

Environmental swabs

Around the auto door between OT1 & Day Surgery



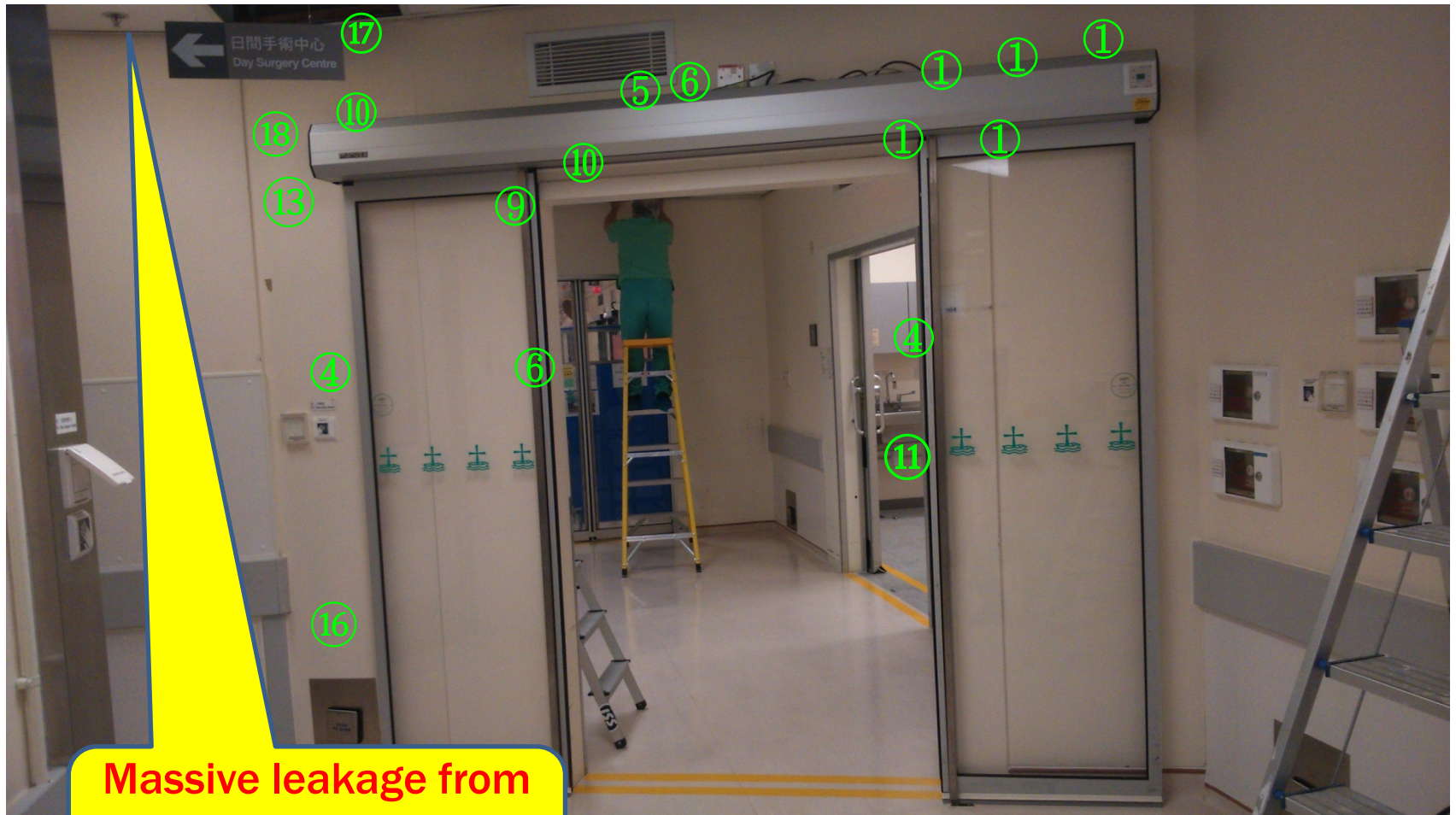
Environmental swabs

Around the auto door between OT1 & Day Surgery



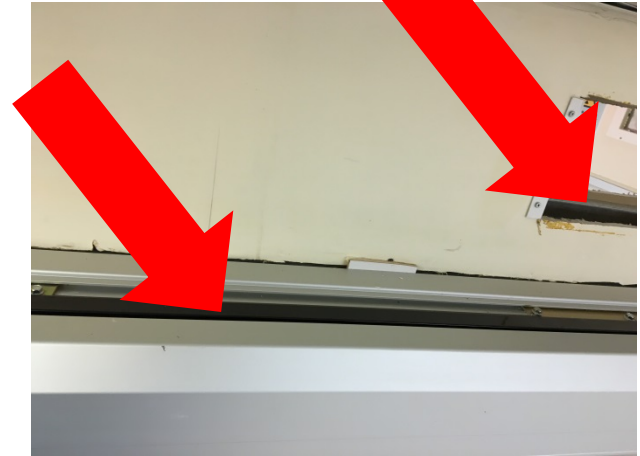
Environmental swabs

Around the auto door between OT1 & Day Surgery

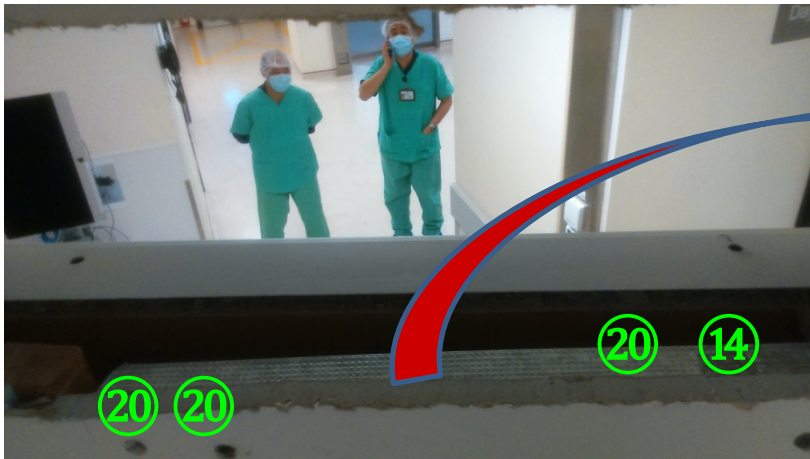
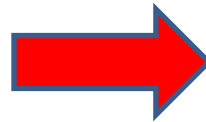
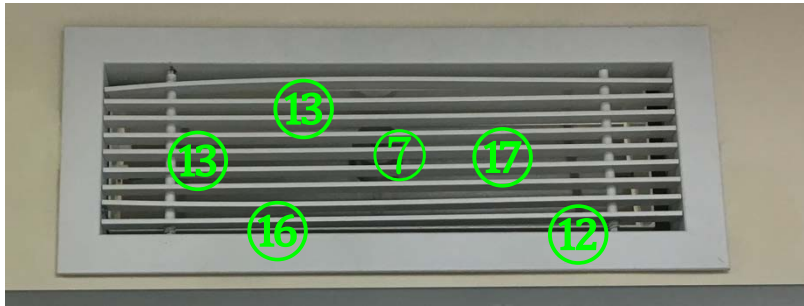


Massive leakage from ceiling water pipe a few months ago

Fungal colonies cultured from the wooden/plaster structures/gaps around the auto door



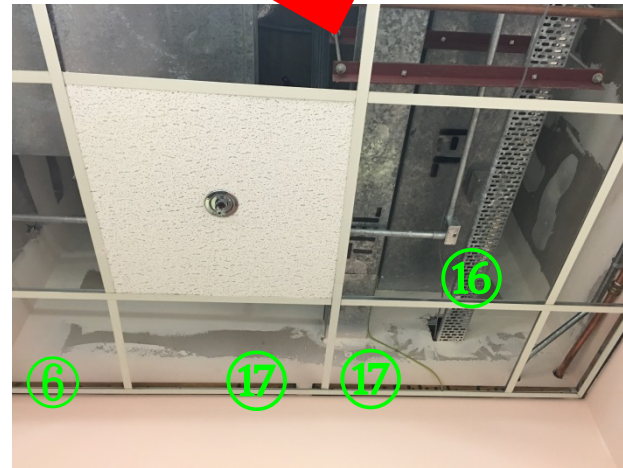
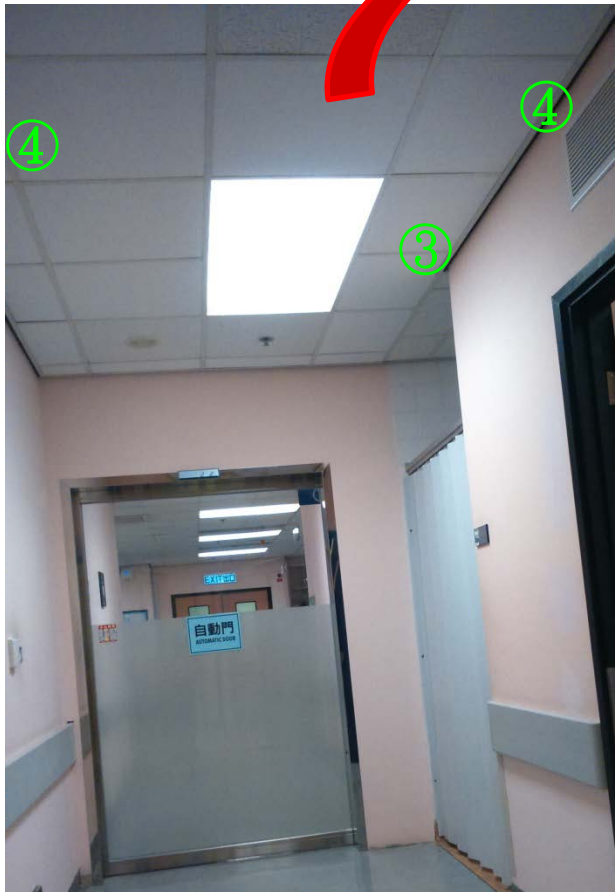
Around/inside the louver



Pieces of wooden
/plaster boards

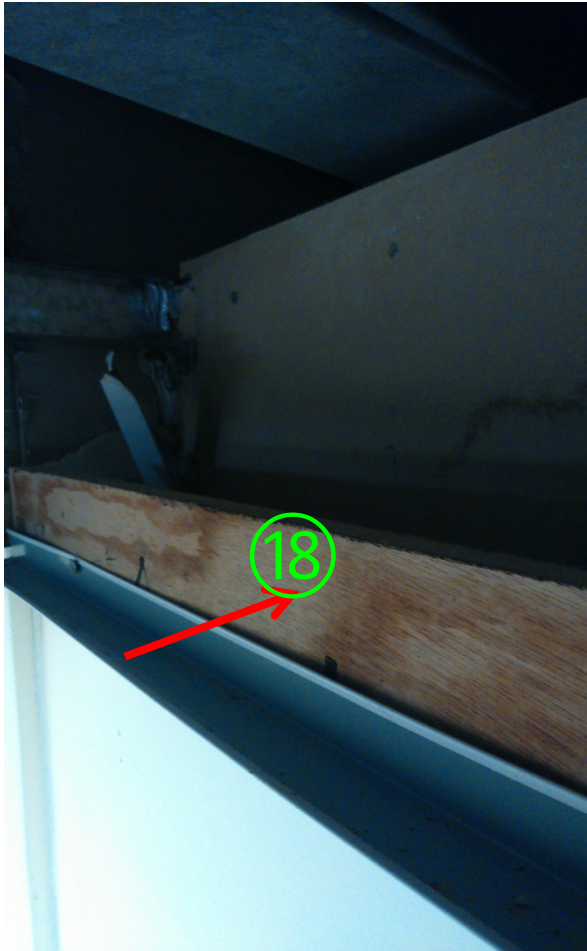


Ceiling of surrounding office corridor



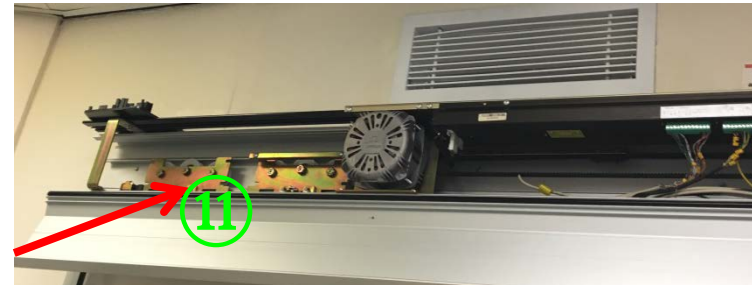
Environmental swabs

Ceiling of auto door between OT1 & Day Surgery



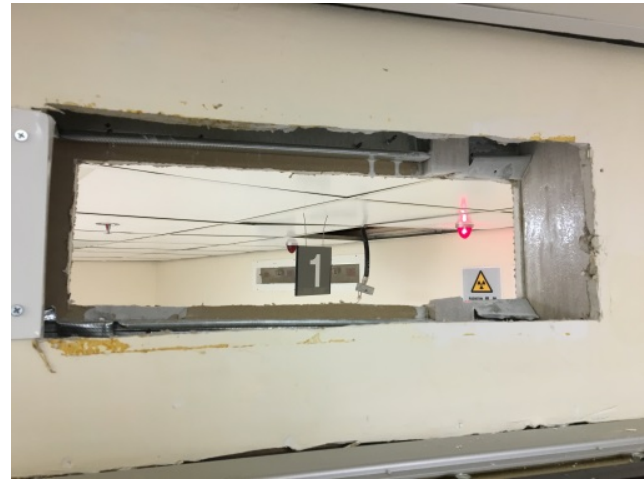
Environmental swabs

Ceiling of auto door between OT1 & Day Surgery

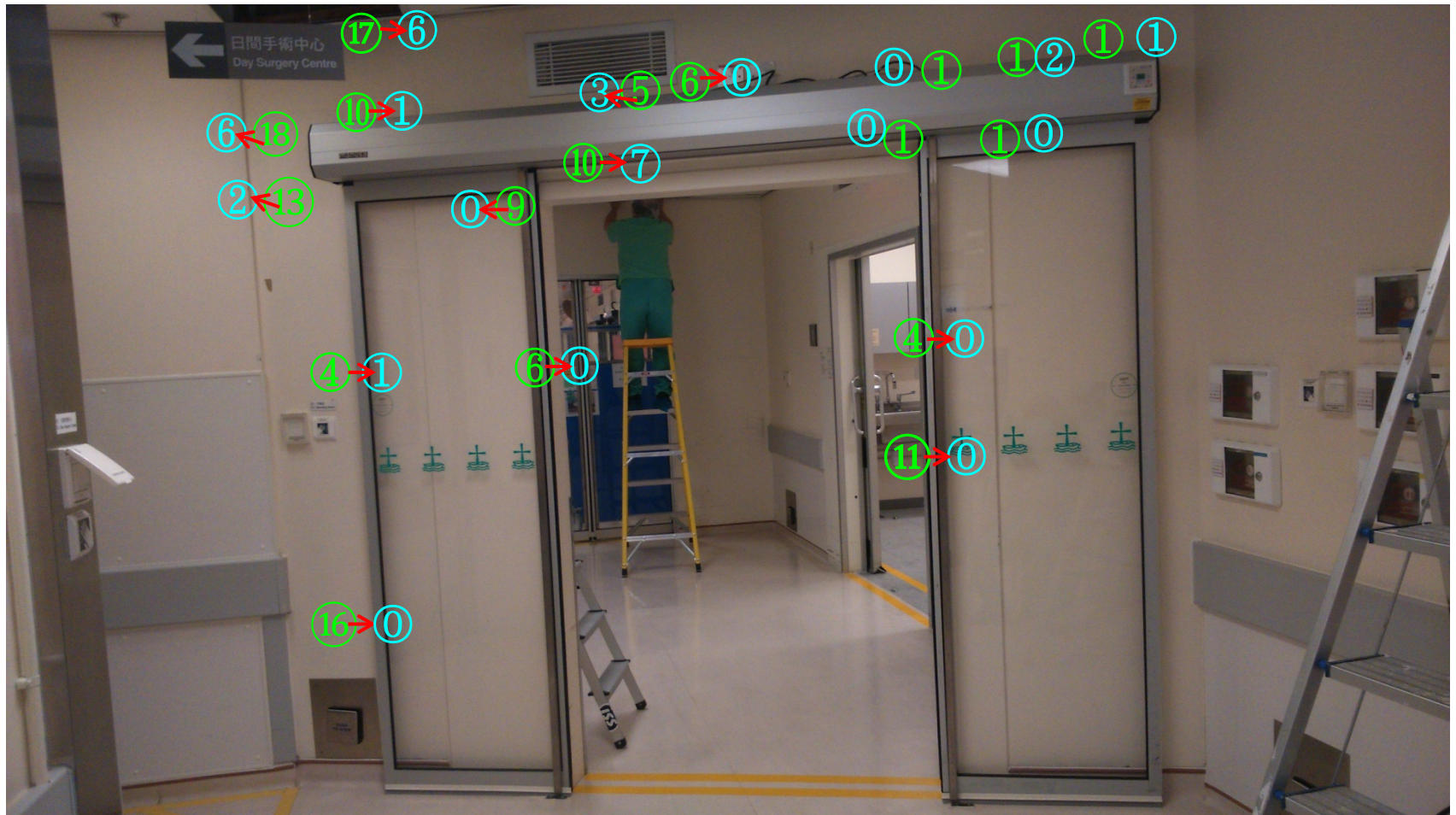


Actions taken

- Remove all seals of the auto door
- Remove the wooden/plaster structure in the false ceiling and louver where possible
- For those parts that could not be removed, coated with anti-mold painting and erect barriers to seal them from surrounding areas
- Comprehensive cleaning and disinfection
 - The ceiling and all surfaces in linkage area of day surgery and clean corridor outside OT1
 - All surfaces in scrub room, anesthetic room, OT1 and dirty corridor
 - All cleanable parts around auto door and louver
- Air-out 24 hours, repeat air and environmental sampling



Repeat environmental sampling



⑥ swabs on 1 Mar

⑥ swabs on 3 Mar

Environmental sampling on 3 Mar

Ceiling of auto door between OT1 & the Day Surgery



Hot
Zone

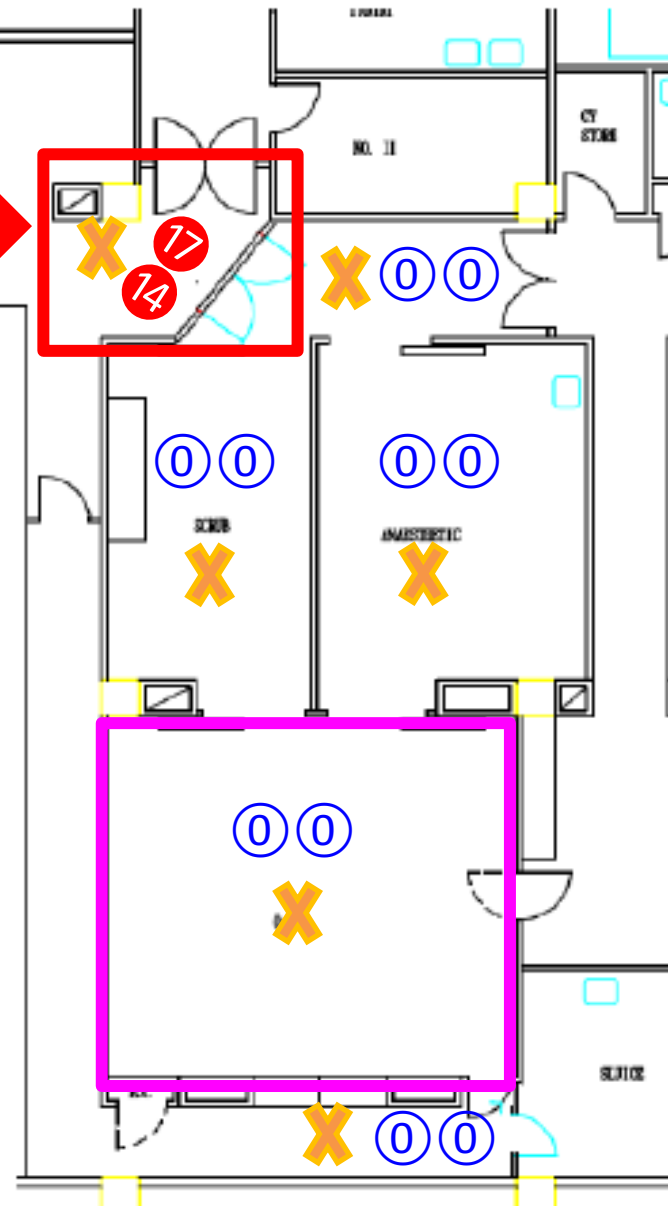
N=17



N=14



Results of air sampling
(collected on 4 Mar 16)



Short term measures

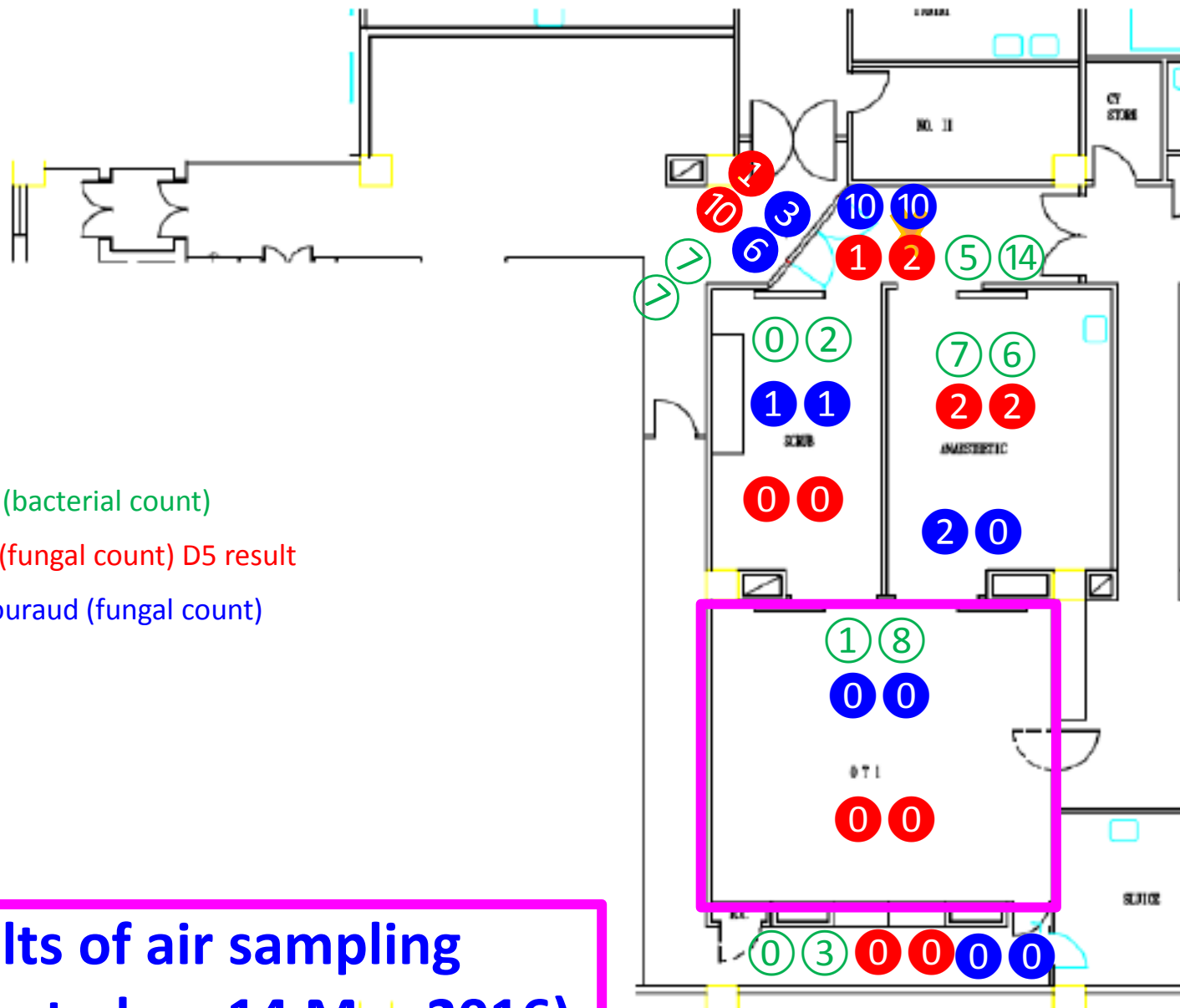
- Limited service in OT1, procedures requiring OT setting not recommended
- Enhance cleaning & maintenance to “hot zone”
- Close monitoring by settle plates
- Particular attention to incidence of water leakage

Summary

- **Likely source of fungal contamination**
 - Wooden & plaster boards after soaking of water leaked from ceiling pipes a few months ago
 - Contaminated air moved into –ve pressure OT1 via corridor & scrub/anesthetic rooms
- **Principles of control**
 - Remove sources
 - Measures to prevent air movement into OT1

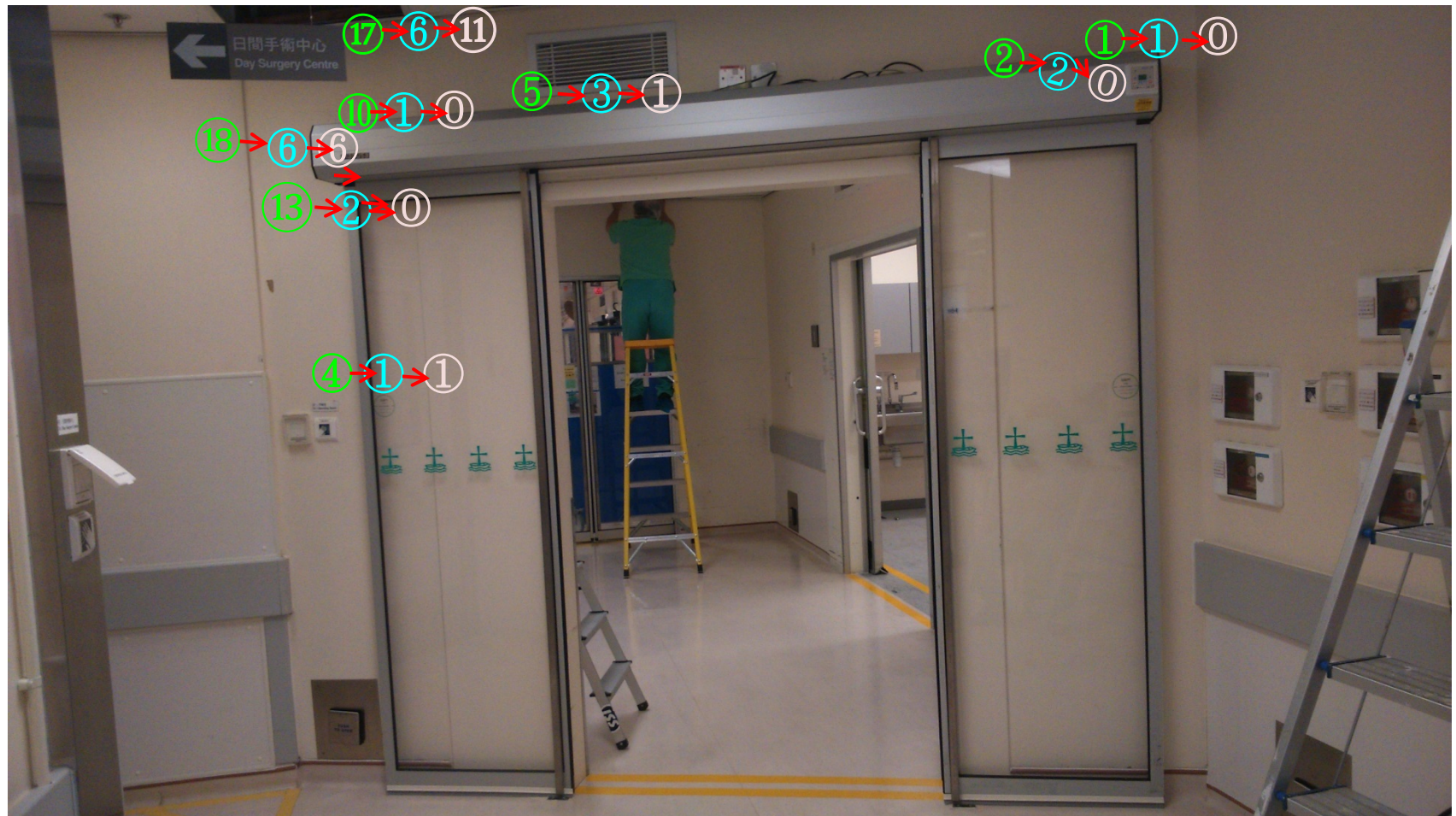
Long term measures

- **Remove sources: wooden/ plaster boards**
- **Measures to prevent air movement into OT1**
 - Convert OT1 to positive pressure with +25 Pa
 - Air exhaust from scrub/anaes room
 - Build air tight doors at corridor to stop air leak
- **Implications on future contract**
 - Ensure absence of waste & proper cleaning/ sealing after completion of work
 - Ensure proper fitting of HEPA filters (no air leakage)
 - Do not use organic materials (e.g. wood/ plaster) above ceiling in OT or high risk setting
 - Avoid negative pressure OT



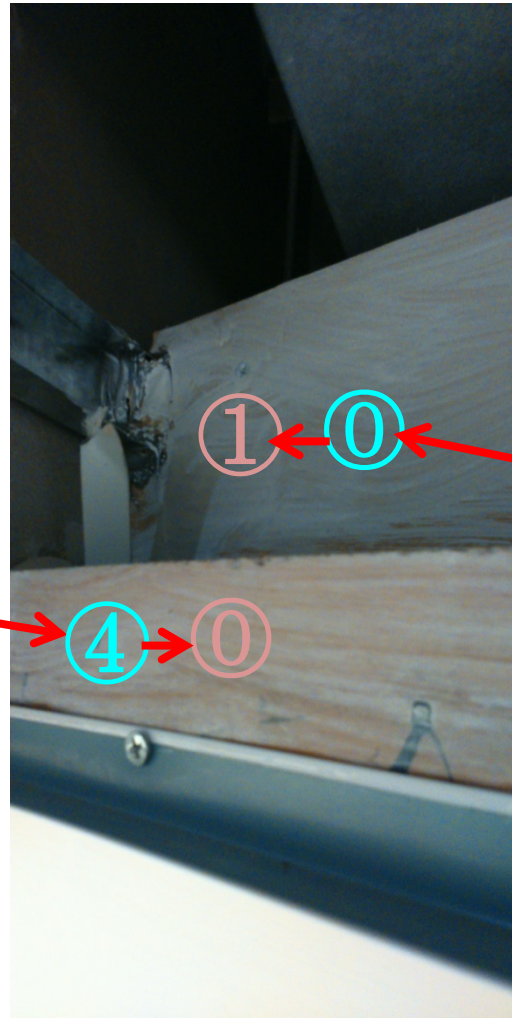
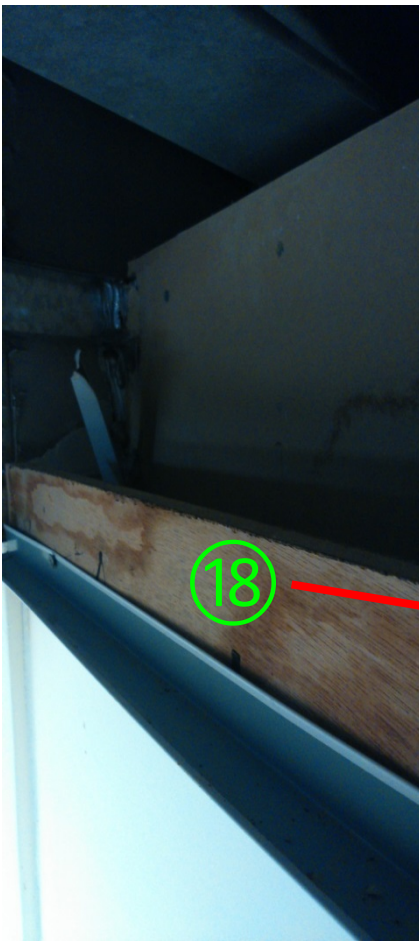
**Results of air sampling
(collected on 14 Mar 2016)**

After removal of wooden / plaster boards

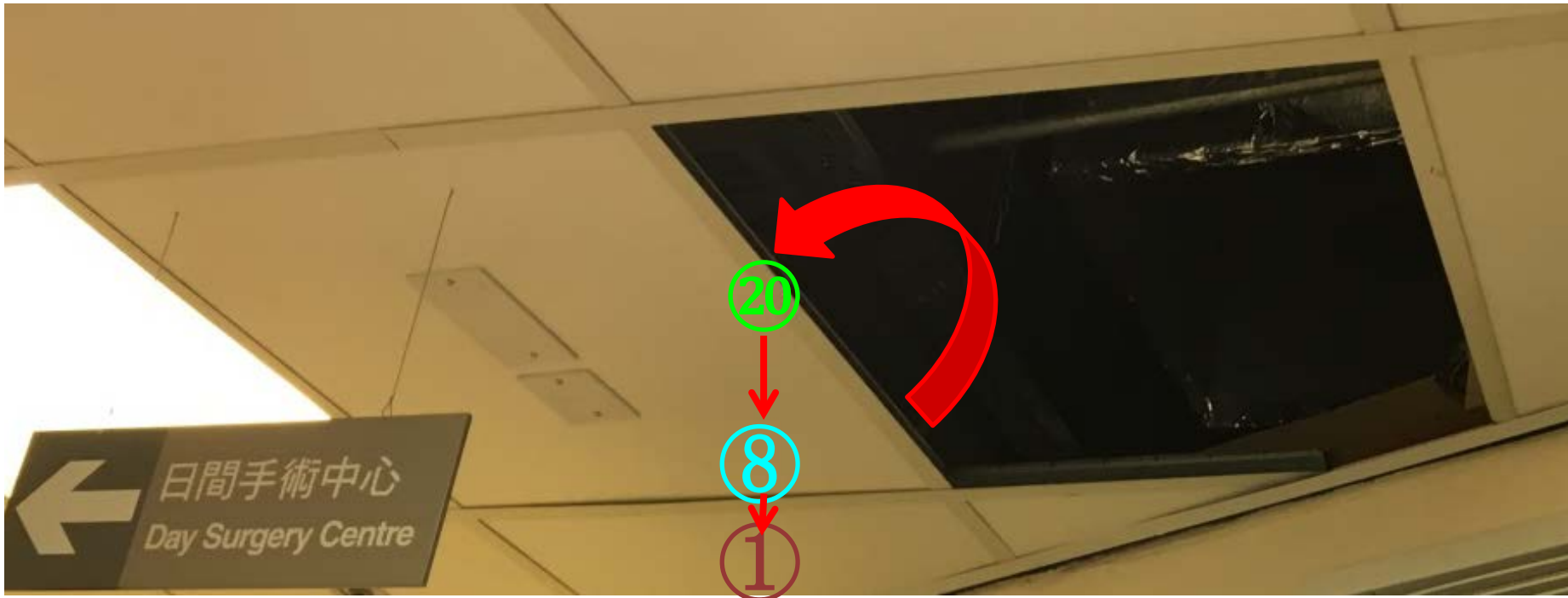


⑥ swabs on 1 Mar ⑥ swabs on 15 Mar
⑥ swabs on 3 Mar

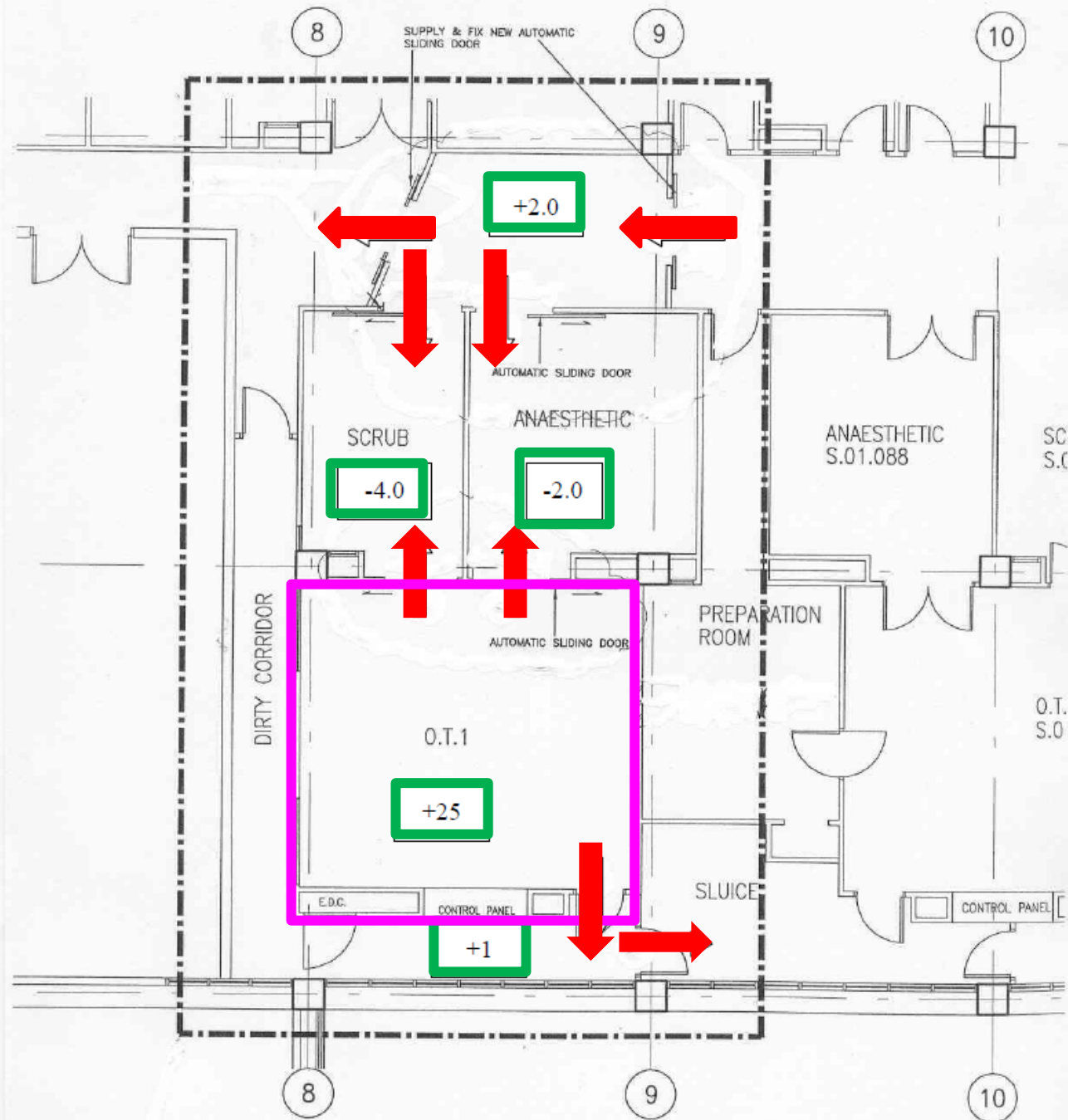
After removal of wooden / plaster boards

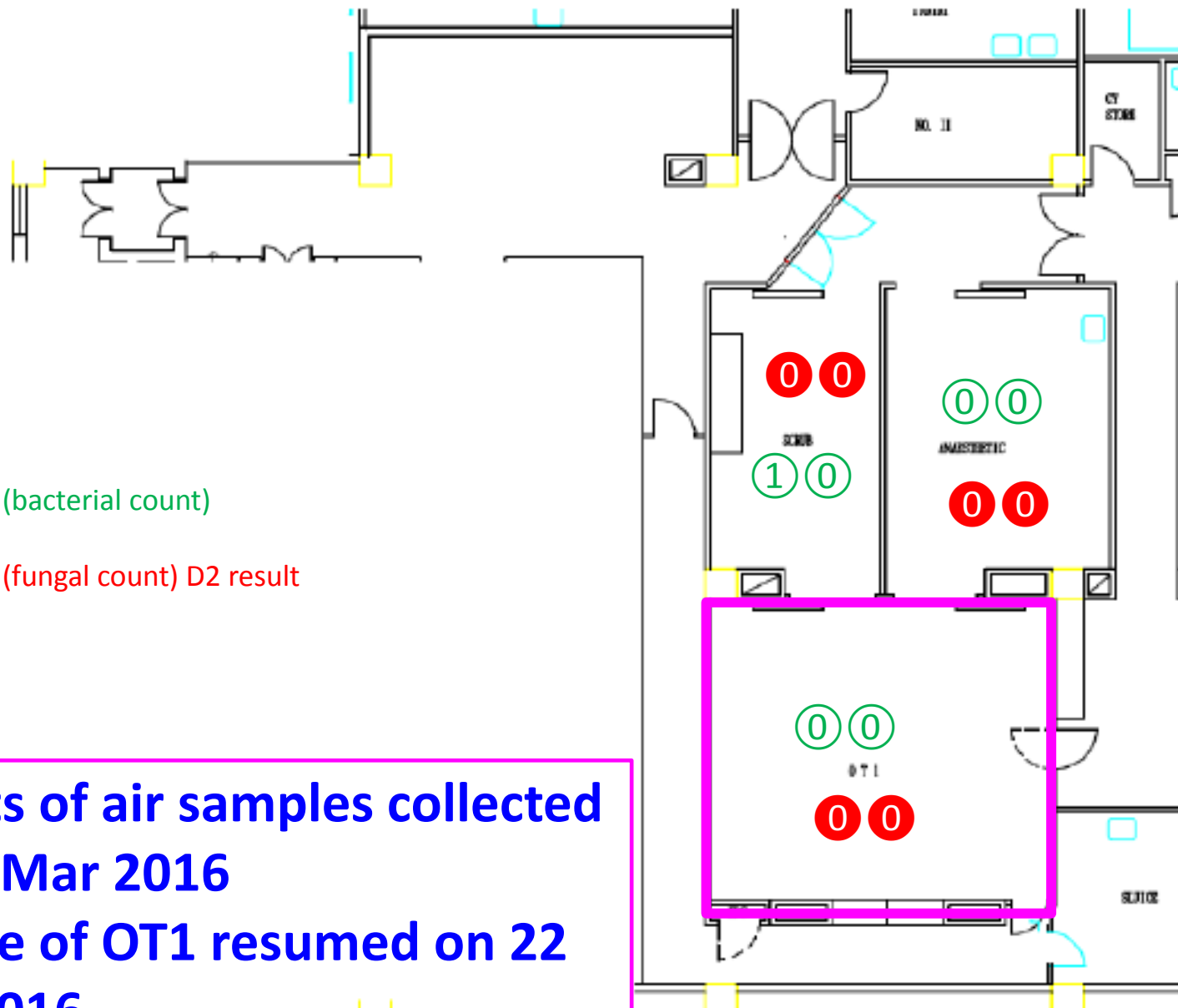


After removal of wooden / plaster boards



**Air flow
after
readjustment**





① TSA (bacterial count)

② TSA (fungal count) D2 result

**Results of air samples collected
on 17 Mar 2016
Service of OT1 resumed on 22
Mar 2016**

United Christian Hospital Expansion Project



KEY DESIGN ISSUES - INFECTION CONTROL



GENERAL PRINCIPLES

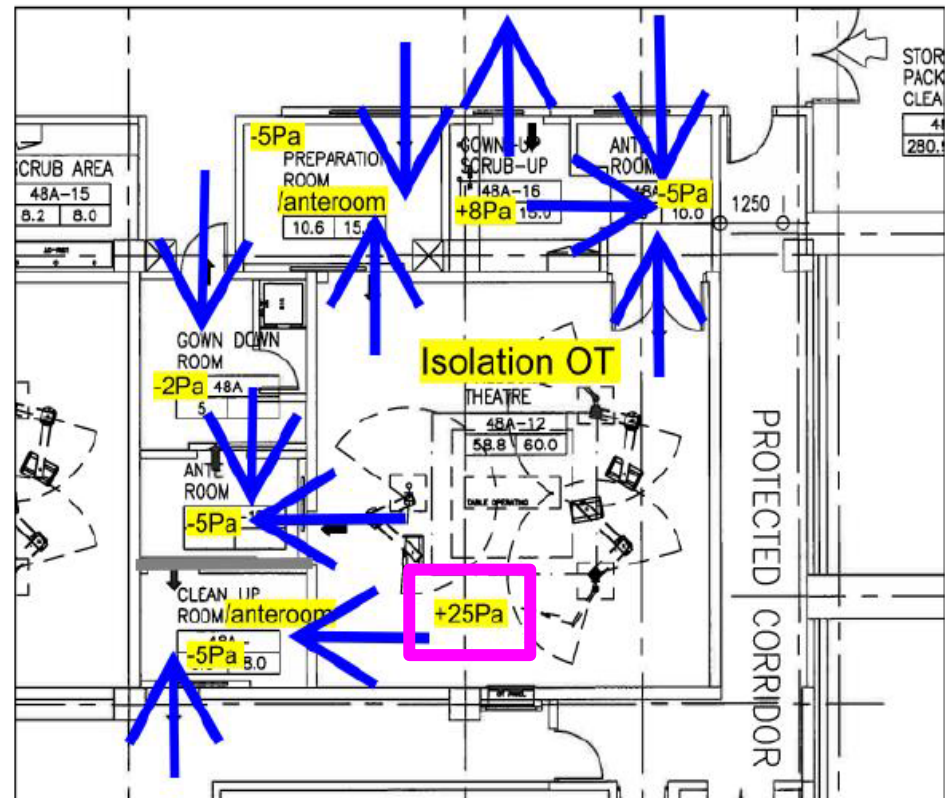
- Room air-tightness
- Airflow from clean zone to dirty zone
- Separate air handling system (prevent air mixing)
- Adequate air change rate
- Power supply from essential power generator
- Mechanical standby equipment
- Pressure monitoring device
- Exhaust Air Discharge via HEPA filter



Ventilation Design for Isolation OT



- OT Room – same as normal OT (laminar flow HEPA ceiling, 100% Fresh Air Supply, +25Pa, min 25ACH, one OT one AHU, etc.)
- Anterooms to act as barrier to prevent air from OT room to outside corridor



Thank You