Undulator Hall Ventilation at LCLS

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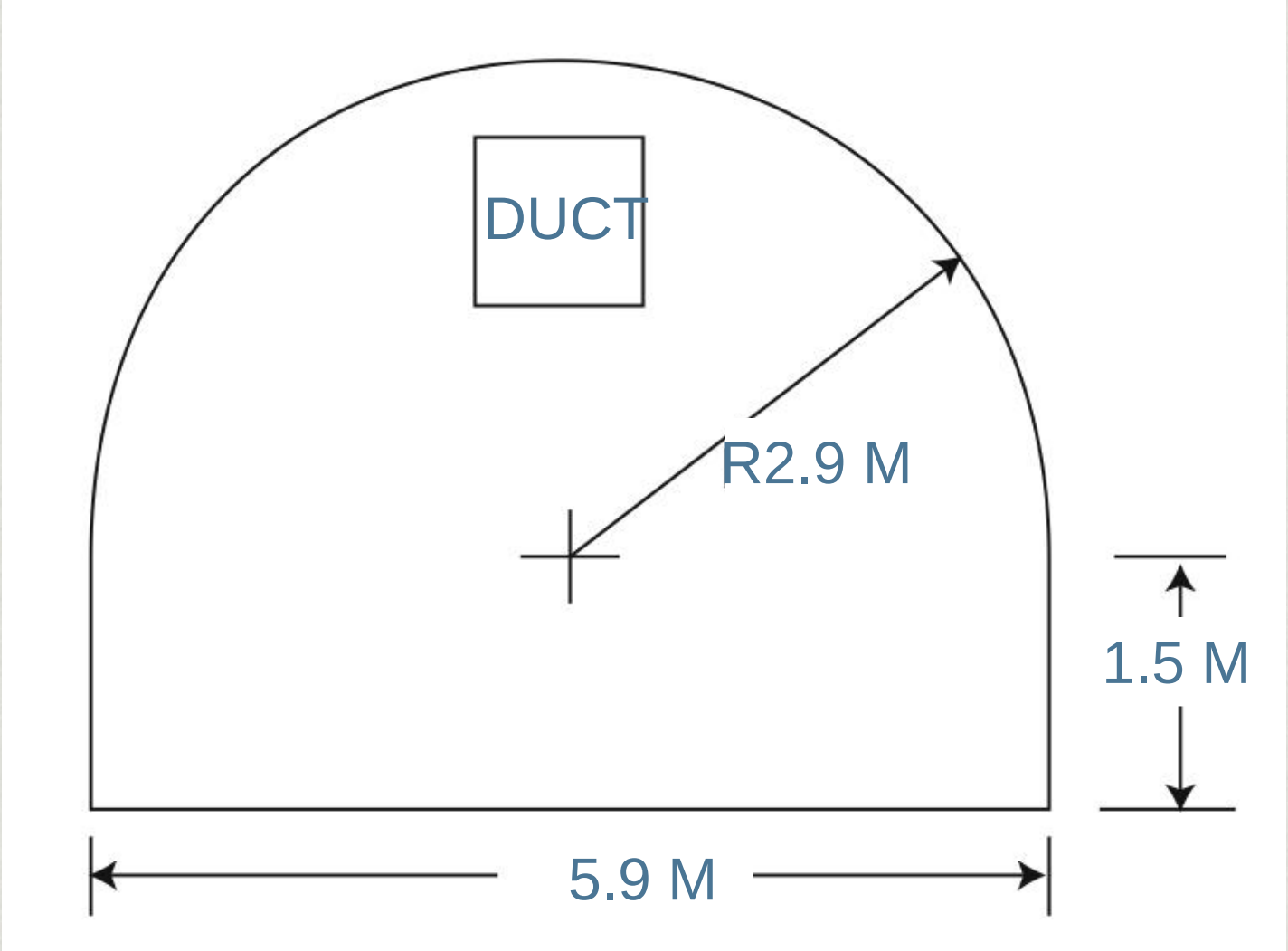
- Scheme
- Performance

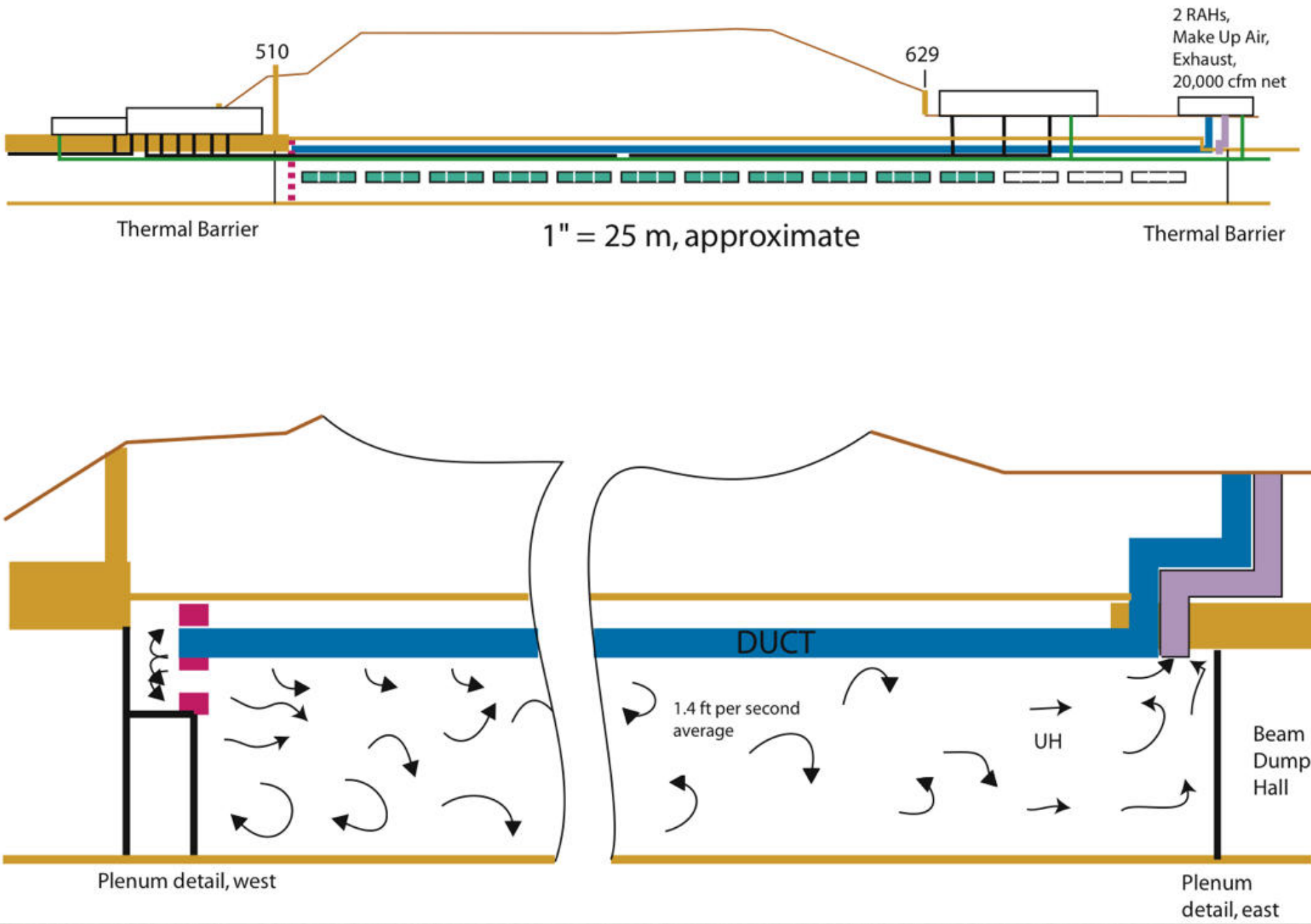
Requirements

- The Undulator Hall houses a 130 m long undulator which is the heart of the FEL
- It is made of temperature sensitive permanent magnets precisely aligned to microns.
- It has a separate air condition system from the rest of the laboratory.
- The temperature of the circulating air surrounding the undulator must be held within 0.5 C of 20 C at all times.
- In the event of any HVAC failure, including power failure, the temperature excursions must never be more than 5 C.

Tunnel

- 170 m long
- Above the water table




510
629
2 RAHs,
Make Up Air,
Exhaust,
20,000 cfm net
Thermal Barrier
1" = 25 m, approximate
Thermal Barrier
DUCT
1.4 ft per second
average
UH
Beam
Dump
Hall
Plenum detail, west
Plenum
detail, east

Parameters

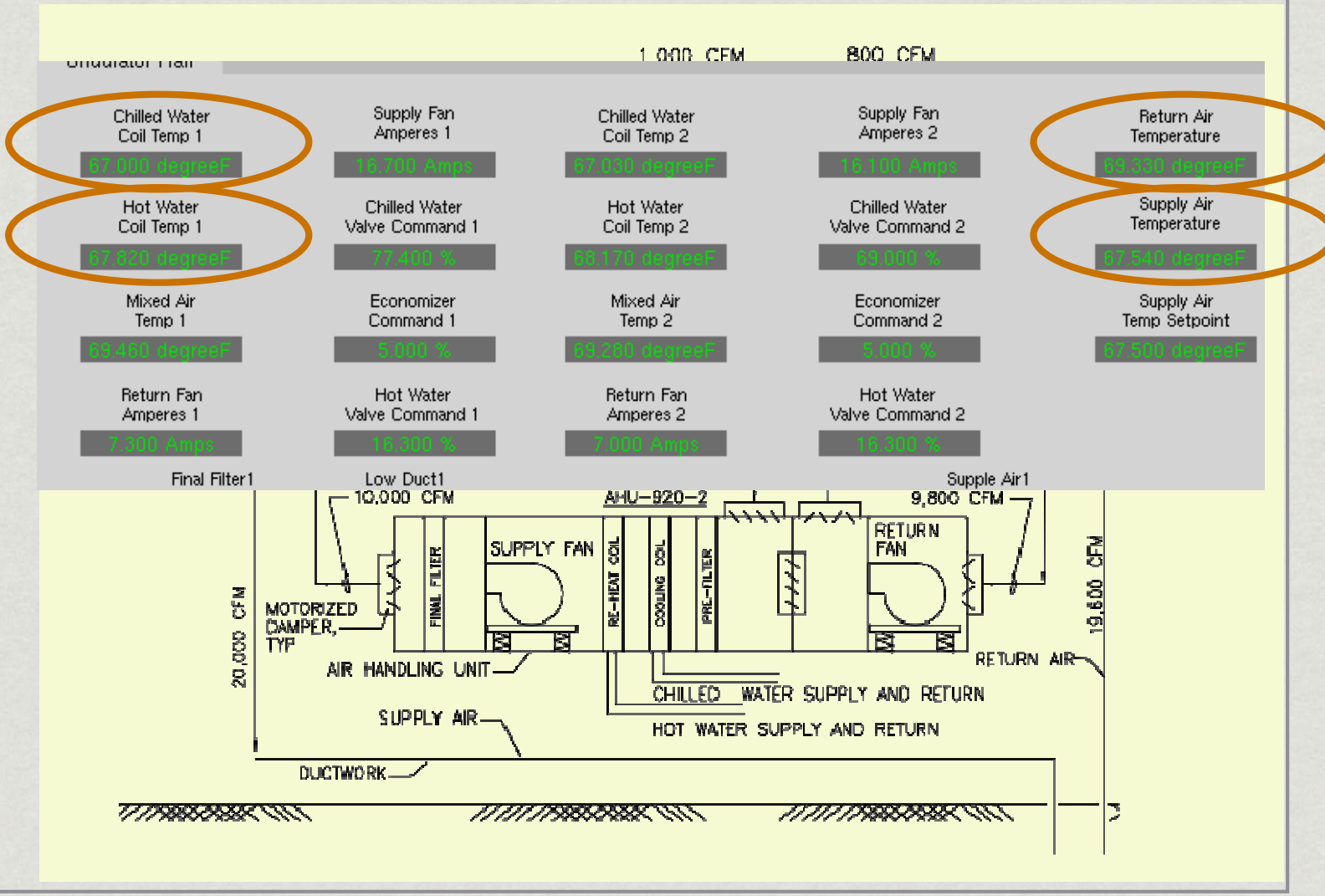
- 34,000 m^3/hr total from two air-handler units (AHU)
- Regulate on supply air temperature, with set-point adjusted to make average undulator 20C
- Average tunnel air flow velocity ~0.4 m/s
- recirculated, with 10% fresh air.

Radiation

- Undulator Hall air is separate from Beam Dump air
  - 5 W maximum continuous loss of beam used for radiation calculations for short-lived radionuclide calculations.
- Air exchange rate at (10% fresh air), about one air-change per hour, was deemed acceptable by radiation physics department.

Air Handlers

- "Tempered" water is made from chilled and hot water and used to control the air temperature.



Heating and Cooling Loads

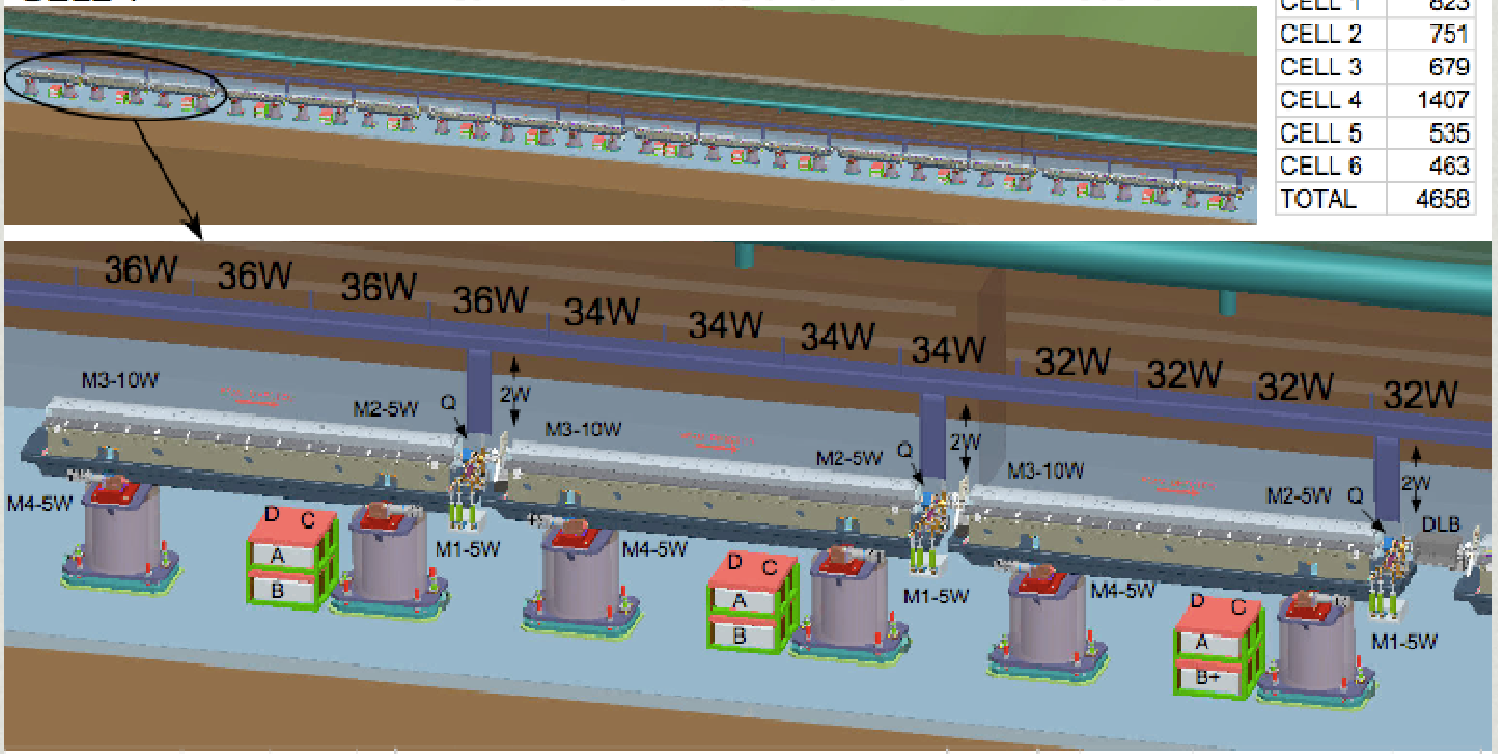
- Sources of heat
  - lighting (5 or 30 fc), wiring losses, hot water lines, etc.
  - undulator equipment - design limit 50 W/m
- Sources of cooling
  - tunnel walls and floor
  - chilled water lines passes through tunnel

Equipment Heat Loads

CELL 1

ASSUME WATER COOLED ELECTRONIC BOXES A,B,C,& D, AND WATER COOLED CABLE TRAY SUPPLIED FROM PRECISION CONTROLLED WATER SOURCE.

CELL 1	823
CELL 2	751
CELL 3	679
CELL 4	1407
CELL 5	535
CELL 6	463
TOTAL	4658



CELL 1	CABLE TRAY	TOTAL WATTS
UNDULATOR 1	36	144
UNDULATOR 2	34	136
UNDULATOR 3	32	128
UNDULATOR MOTORS		
M1	5	15
M2	5	15
M3	10	30
M4	5	15

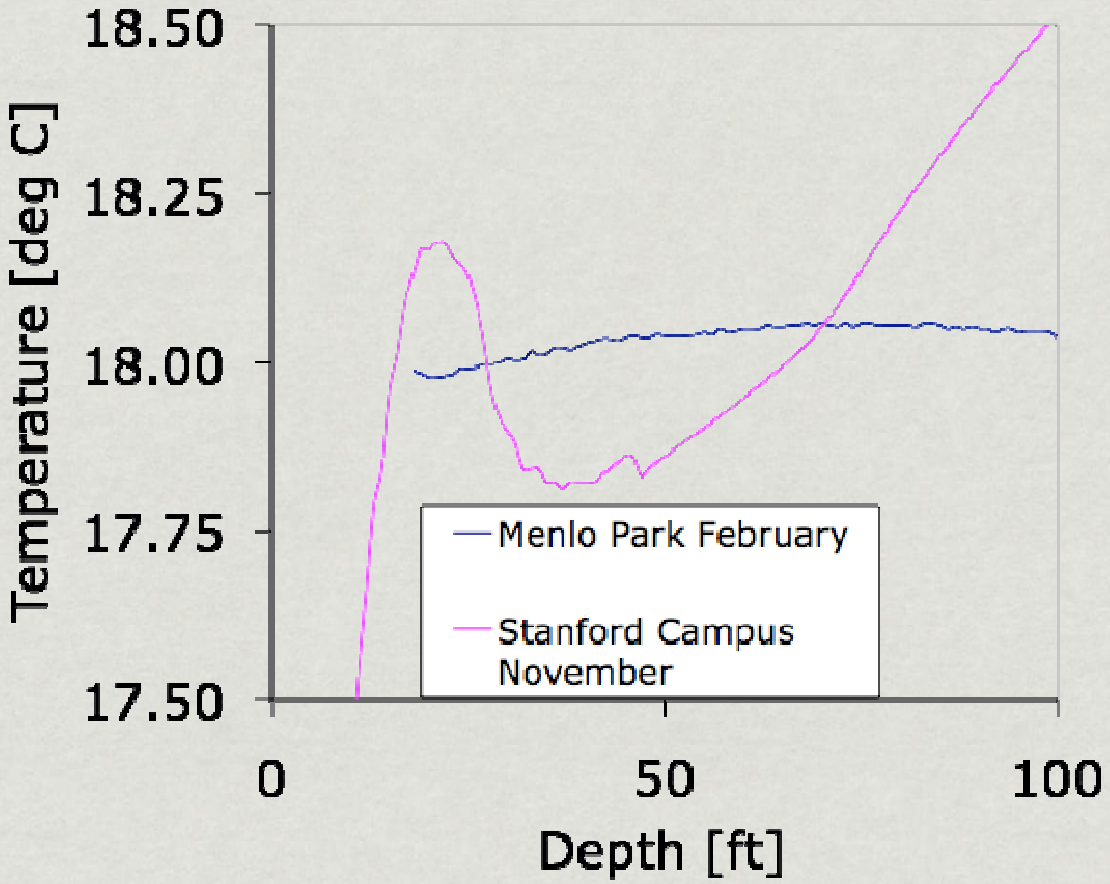
ELECTRONIC BOXES			TOTAL WATTS
A	20	BPM	80
B	12	BFM 5W / MOTION IOC 7W	24
B+	19	BFM 5W / MOTION IOC 7W / LB IOC 7W	19
C	25	PHOTO MULTI 10W / F/OPTIC RAD LOSS 5W / PHOTODIODE RAD LOSS 10W	100
D		ALIGNMENT	0
		TOTAL CELL WATTAGE	783

MISC.		TOTAL WATTS
Q	QUADS & CORRECTORS	35
DLB	5 MOTORS @ 5W / 1 MOTOR @ 5W / 1 CAMERA @ 6W	36
CABLE DROPS		6
WATTS		

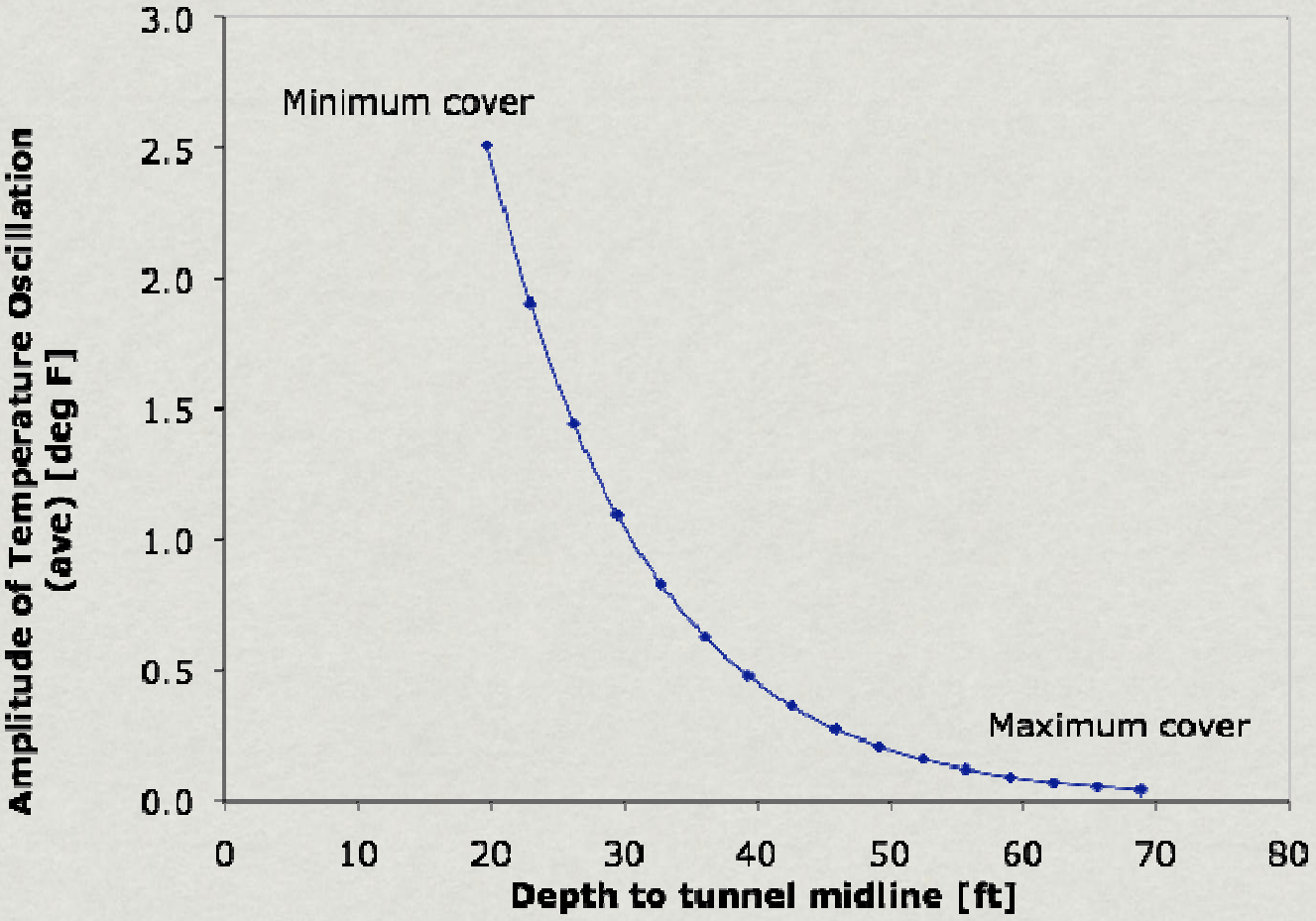
Loads and Temperature Profile

Total Heat Load	**All**	**8205**	**[W]**				
Undulator System		**7780**	**[W]**		45.8		
Conventional Facilities		**303**	**[W]**		1.8		
Distributed Load Parameters							
magnet water convective load	0	W/m	If two 2 in lines with no insulation at 19 C, should be -2.4 W/m.				
chilled water convective load	-5.2	W/m	the -5.2 value is based on 60% specification				
LCW for Beam Dump	7.2	W/m	Two 3 inch pipes 90 F, with 1 inch insulation				
Wall heating load	-24	W/m	varies slowly with time, -22 W is Kleyn est. 6 month after HVAC starts				
AC & DC Power line load	5.0	W /m	5 kW ave. transmitted AC power @ 3% loss, and 4.1 W/m for DC magnet wires				
Lighting load	19	W /m	19 W/m is 5 fc, lights out for normal operation				
Quad & corrector wires	0.09	W /m	per wire pair. 3.1 W/m for 18 units at full power, from A deLuca. I put in factor of 0.5 for opeational				
HVAC Parameters							
air flow (cfm)	20,000	cfm	design				
Max Temp Required	20.56	deg C	design				
Min Temp Required	19.44	deg C	design				
Discharge Temperature	19.50	deg C	design				
Temperature and Net Load Distributions						**Undulator System Estimate**	
Location Name	Location	Air Temperature	Delta Q		Integrated Q	Magnet Water Lines Convective load	Quad Power Lines (defunct)

Ground temperature

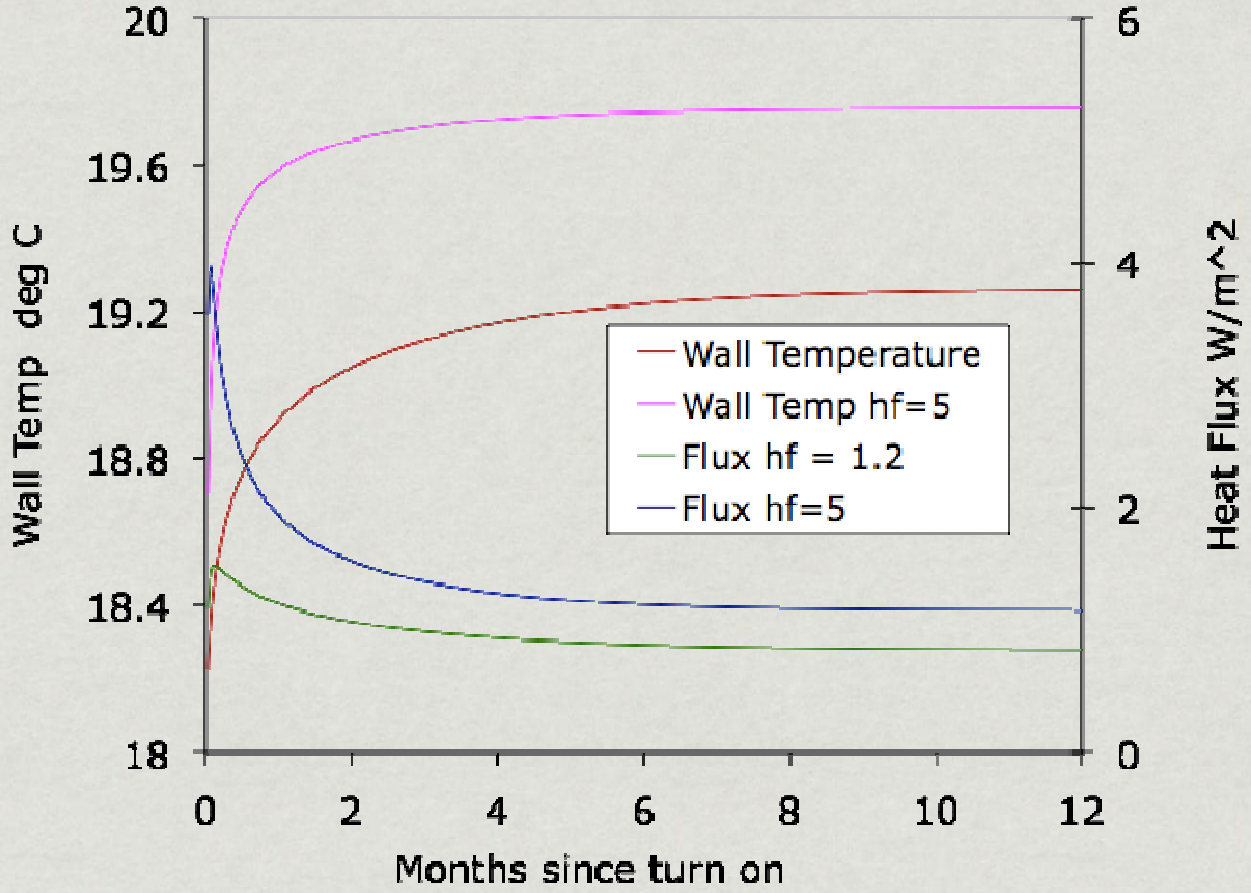


Ground temperature fluctuations (estimated)

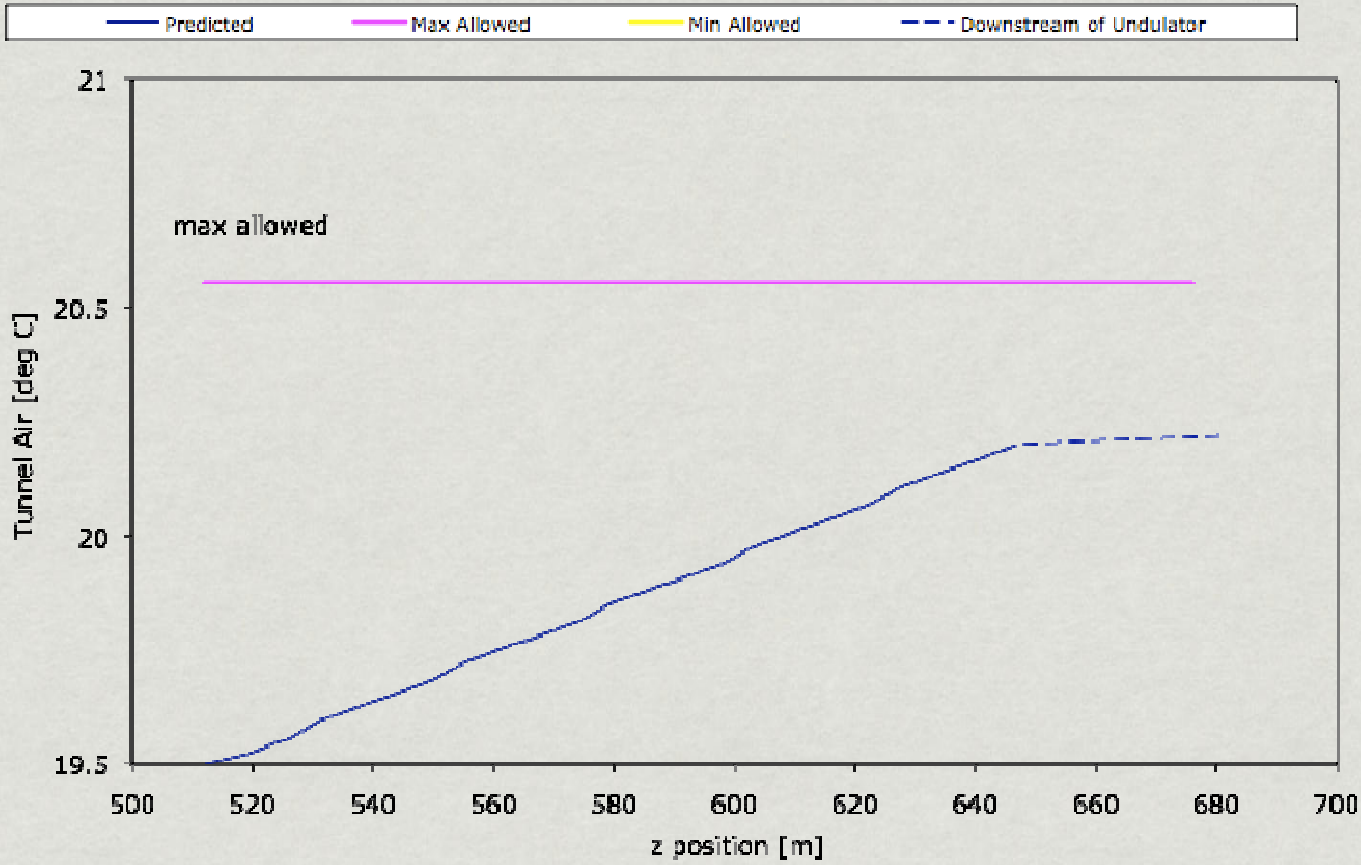



QuickTime™ and a
Microsoft Video 1 decompressor
are needed to see this picture.

Cooling rate by walls and floor

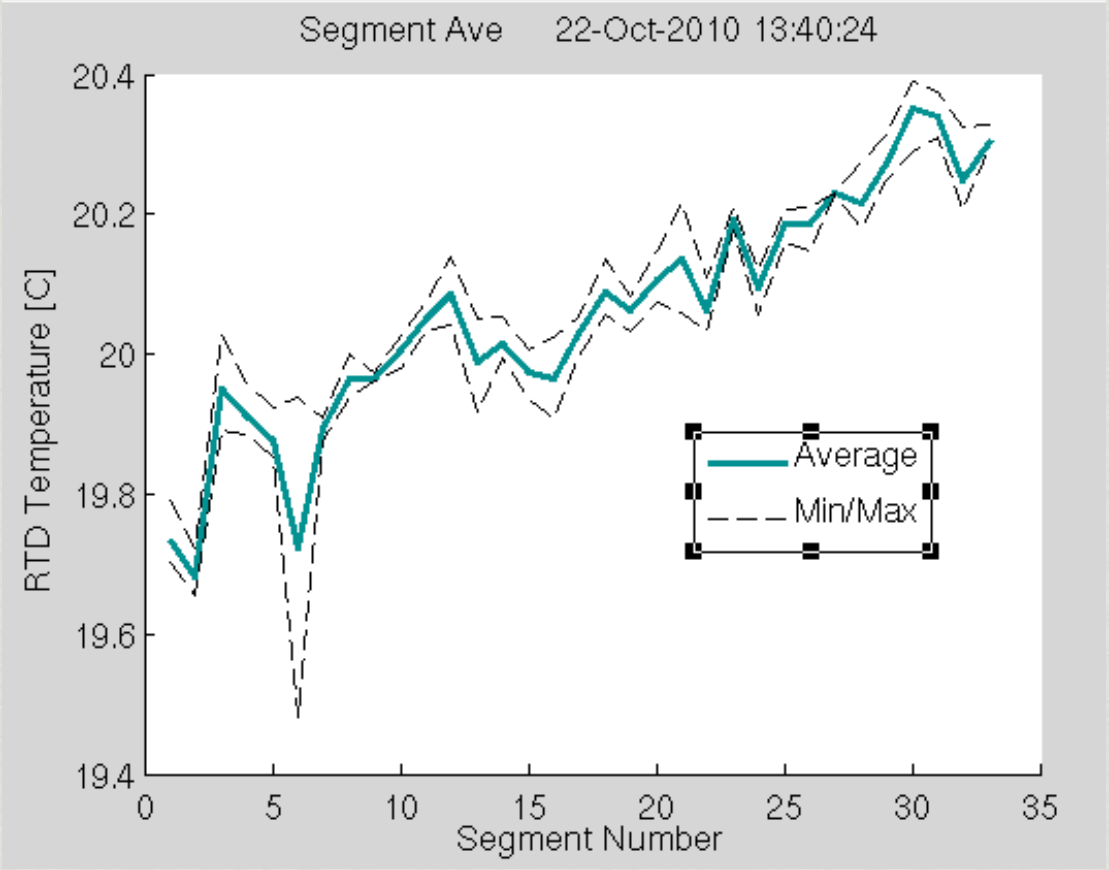


Net estimated temperature profile



Spatial uniformity measured

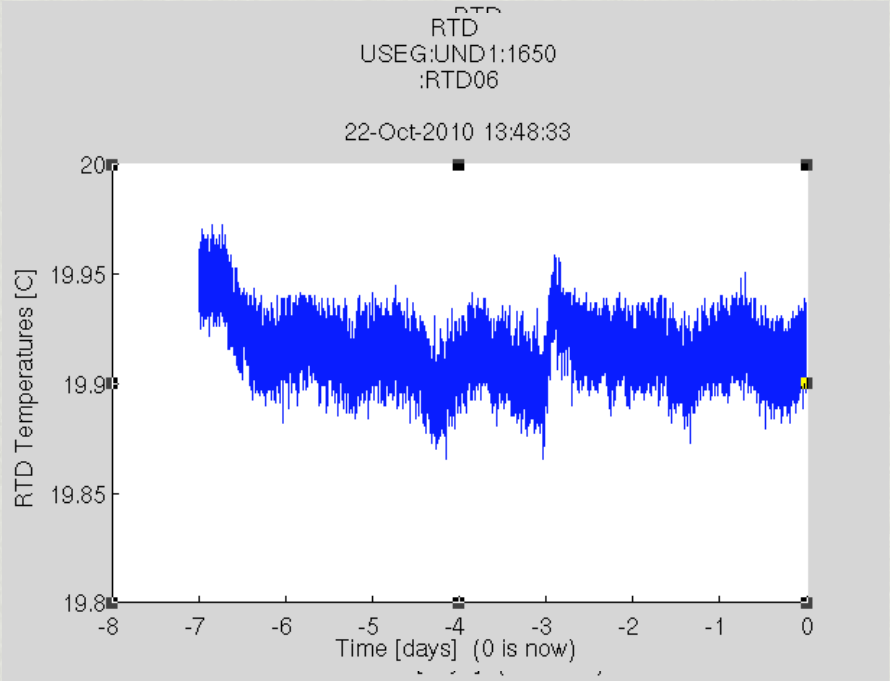
33X12 PRECISION RTD THERMISTORS



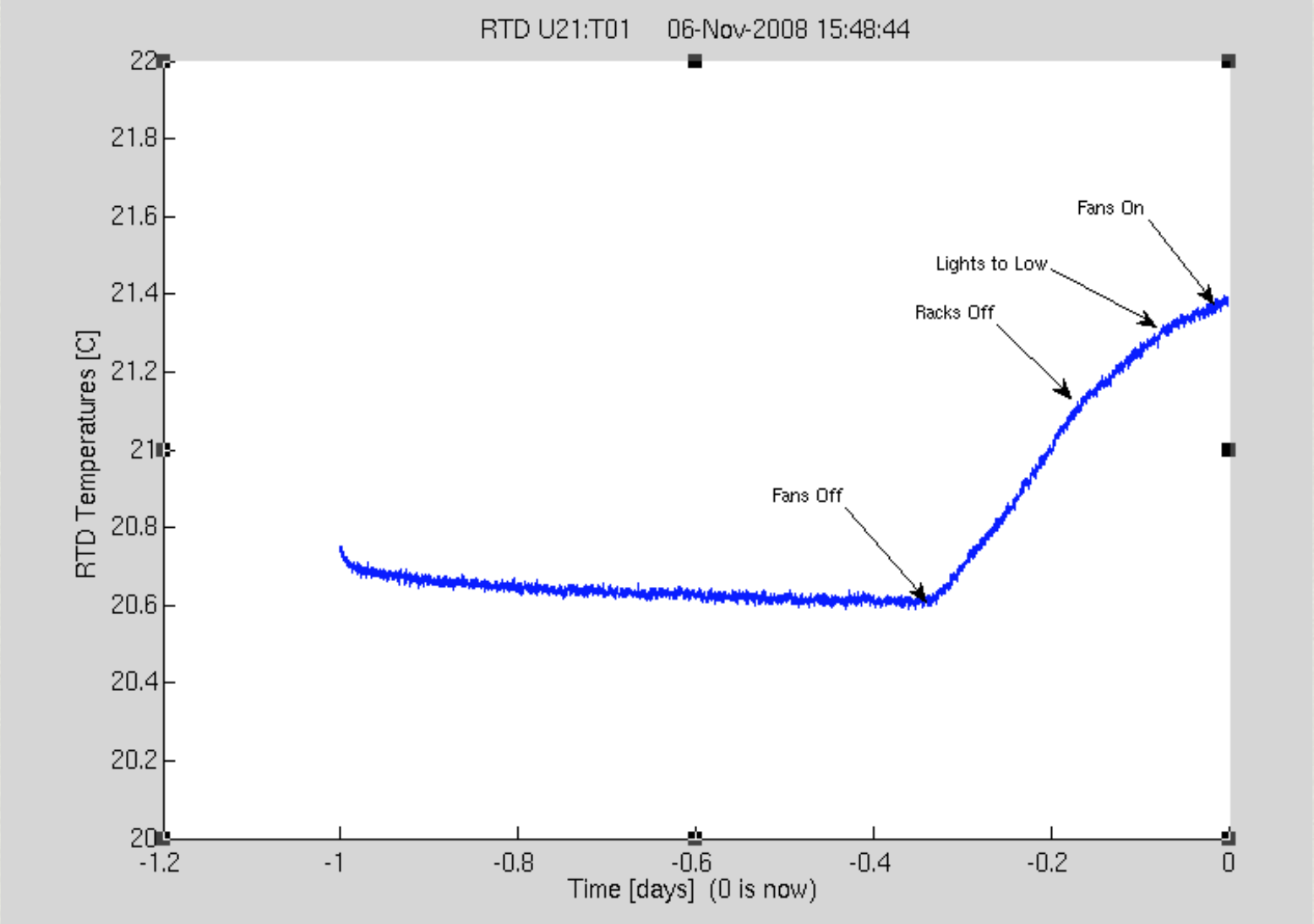
AIR FLOW

Temperature Stability

- 1 week during normal operation, include 1 day of beam-off for accelerator maintenance.



Transient response



Humidity

- There is no direct humidity control
- Benign climate, no mold, comfortably dry year round.
- Recent (light rain outside) 57%

Summary

- Very satisfied with the performance
  - excellent stability, especially temporal
  - fault tolerant
  - low maintenance, no down-time
- Limited heat load budget affects accelerator upgrades.