Location of the electrical substation at P5: Noise impacts

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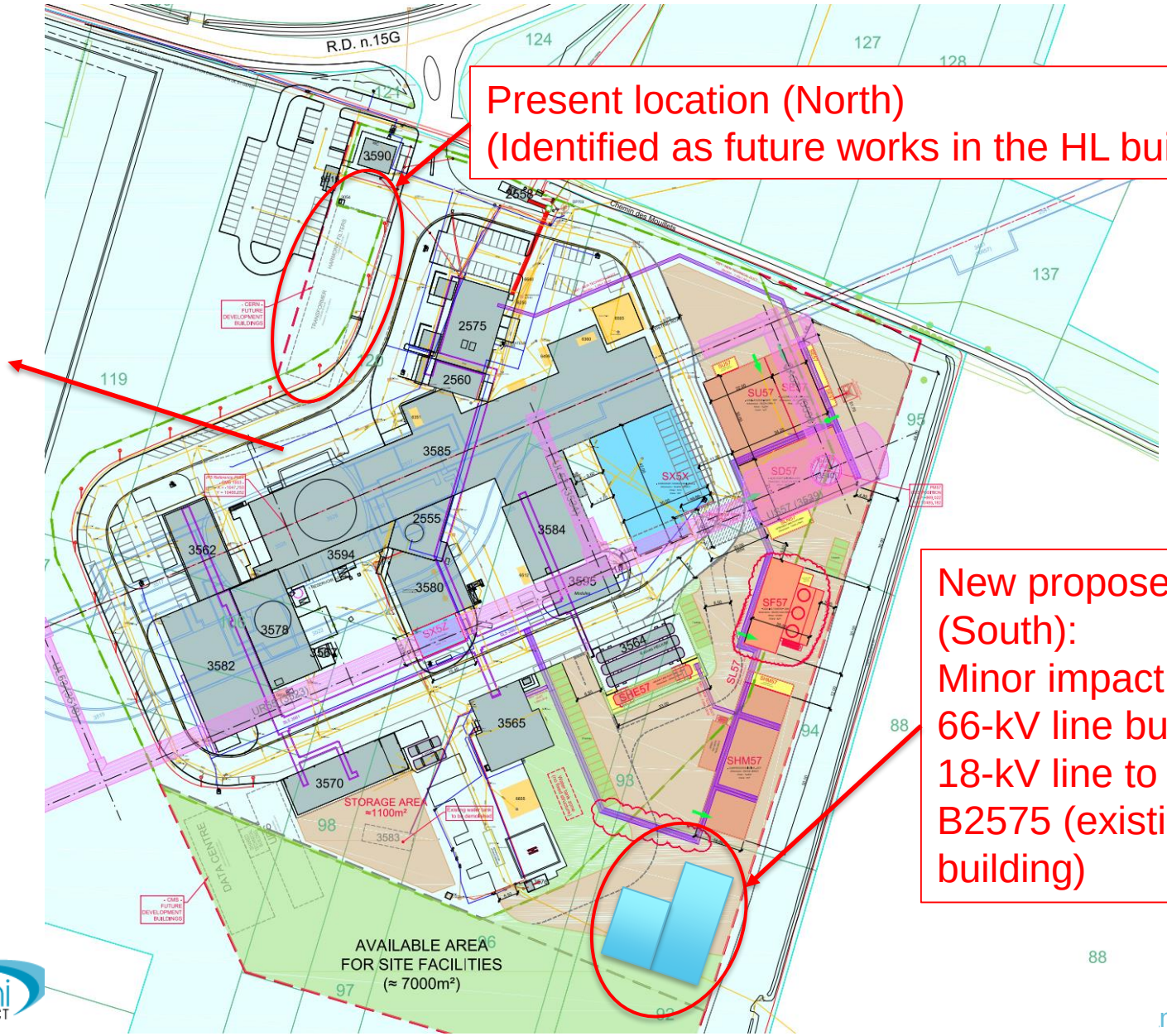
Based on DbVib Consulting report
CVI06718_AINDU_CMI_RA03

Location of the electrical sub-station



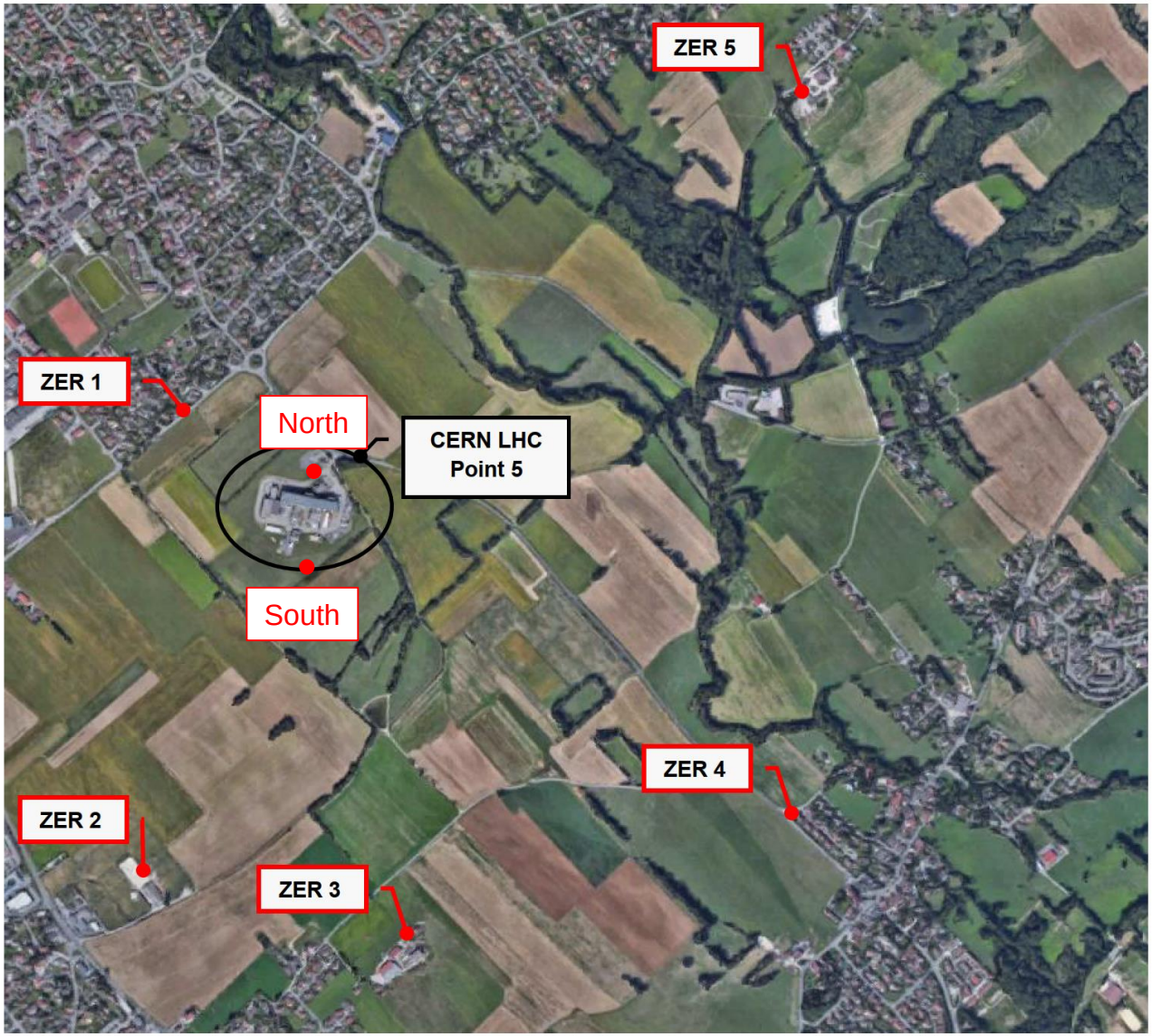
Financial Aspects

HL-LHC PA5

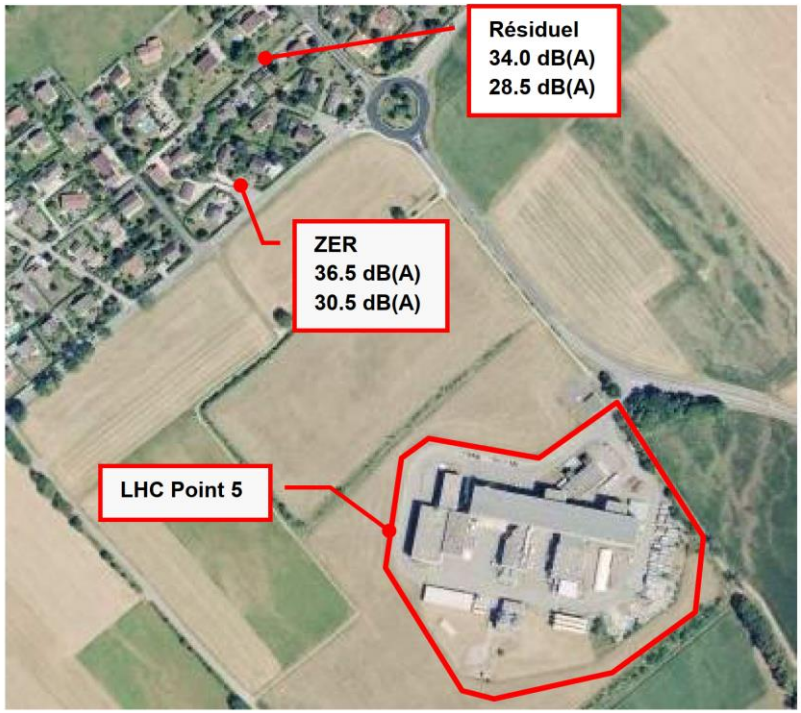
Comparison of different locations for 66 kV transformer and harmonic filters

	Nord-west	South
Length of 66kV cable	66 kV cable about the same length for both solutions	
Length of 18kV cable for transformer [m]	60	480
Length of 18kV cable HF [m]	60	480
real length of 18kV single-core cable for transfo	540	4320
real length of 18kV single-core cable for HF [m]	360	2880
real length of fouille [m]	40	450
Price for cable and cable installation (100 Eur/m)	90	720
Price for fouille (1000 Eur/m and 800 Eur/m)	40	360
Subtotal for cabling costs [kEur]	*130*	*1,080*
Subtotal for cabling costs [kCHF]	*150*	*1,242*
Overcost for cabling [kCHF]	***0***	***1,093***
Current 18kV side of transformer (15 MVA) [A]	482	482
Current of one HF (6 Mvar)	193	193
Losses		
Losses in 3 cable system for transformer [kW]	1.1	8.9
Losses in 3 cable system for one HF (6 Mvar) [kW	0.5	4.3
Losses in 3 cable system for one HF (6 Mvar) [kW	0.5	4.3
Total transmission losses in cables [kW]	2.2	17.5
Total loss capitalisation in cables [kCHF], For 10 years: 10'000 CHF/kW	22	175
Delta in loss capitalisation [kCHF]		***153***
Total overcost [kCHF] +/-20%	***0***	***1,245***

ZER location



Study inputs: ZER maximum noise level requirement



- Noise level to be respected (according to the regulation)
  - During day period:
    34 dB(A) (residual) + 6 dB(A) (authorized emergence) = 40 dB(A)
  - During night period:
    28.5 dB(A) (residual) + 4 dB(A) (authorized emergence) = 32.5 dB(A)

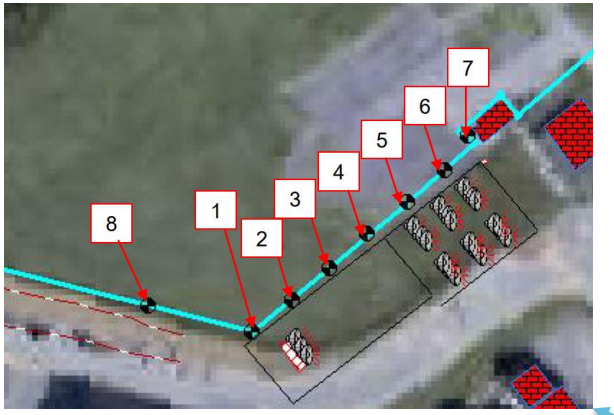
- Noise level to be respected (according the CERN management commitment)
  - No additional noise w/r to the existing one i.e.:
    36.5 dB(A) during day and 30.5 dB(A) during night

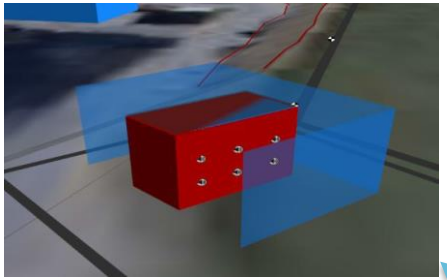
Study inputs: Noise level of equipment

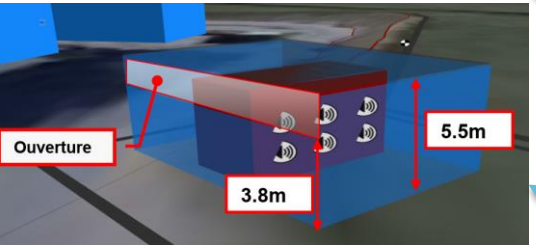
- Electrical sub-station:
  - Noise level of electrical transformer alone: 78 dB(A)
  - Noise level of refrigeration system alone: 84 dB(A)
  - Total noise level (transformer + refrigeration): 85 dB(A)
- Harmonic filters:
  - Noise level of filter coils: 52 dB(A) per unit (3 units in total)
  - Noise level of resistors: 52 dB(A) per unit (3 units in total)
  - Noise level of capacitor banks: 48 dB(A) per unit (3 units in total)

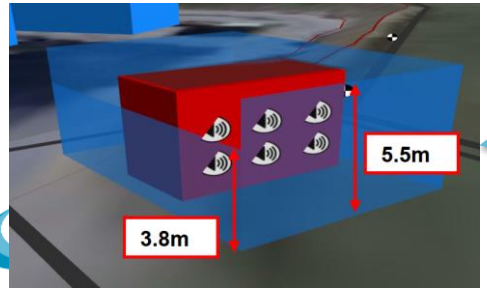
Study cases

8 points per location





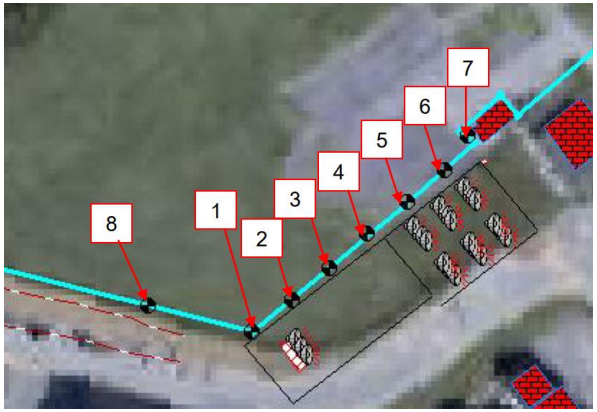




Location		North	South
Case 1: w/o protection	w/o refrigeration	X	X
	with refrigeration	X	X
Case 2: with U-wall protection	w/o refrigeration	X	X
	with refrigeration	X	X
Case 3: with 4-wall protection + roof	w/o refrigeration	X	X
	with refrigeration	X	X
Case 4: with 4-wall protection	w/o refrigeration	X	X
	with refrigeration	X	X

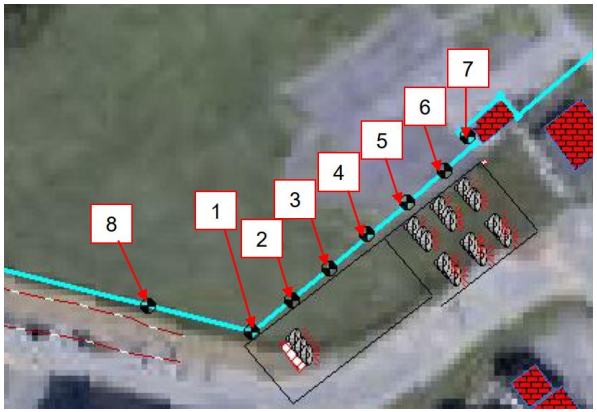
Study cases : Noise levels [dB(A)]
Existing + HL-LHC buildings

Location	North								South							
Point	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Existing	**44.6**	**43.4**	**42.6**	**43.3**	**46.1**	**53.1**	**54.9**	**48.9**	35.8	36.4	37.3	38.8	39.0	36.3	32.7	29.3
HL-LHC	21.3	21.3	21.2	21.3	21.5	22.4	23.5	21.0	**38.1**	**38.7**	**39.0**	**39.2**	**39.4**	**39.9**	**40.5**	**40.9**
Total	44.6	43.4	42.6	43.3	46.1	53.1	**54.9**	48.9	40.1	40.7	41.3	42.2	**42.4**	41.4	41.1	41.2



Already an existing equipment (RP monitoring) is generating noise at the limit of the north location

Additional noise [dB(A)] with sub-station in North location



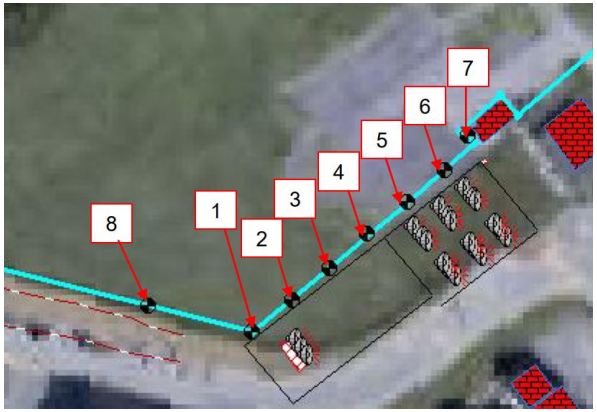
Site limit		North								South							
Point		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Case 1	w/o refrigeration	45.4	44.4	39.4	36.8	36.8	35.8	32.9	34.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	with refrigeration	48.0	56.5	51.6	47.9	45.4	43.4	41.8	37.7	3.6	3.8	4.0	4.2	4.5	4.7	4.7	4.8
Case 2	w/o refrigeration	32.9	32.8	31.3	32.4	35.1	34.5	31.2	26.0								
	with refrigeration	39.4	41.1	38.0	36.3	36.7	35.8	33.1	31.5								
Case 3	w/o refrigeration	34.7	34.3	31.0	32.2	35.0	34.4	31.0	25.8								
	with refrigeration	39.9	45.1	37.7	35.5	36.2	35.3	32.4	31.3								
Case 4	w/o refrigeration	33.0	32.8	31.0	32.2	35.0	34.4	31.0	25.9								
	with refrigeration	39.4	41.3	37.7	35.5	36.2	35.3	32.4	31.3								

Negative impact of the roof and of the addition wall

→ better to retain Case 2 (U-shape protection)

Negligible impact on the south limit

Additional noise [dB(A)] with sub-station in South location



Site limit		North								South							
Point		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Case 1	w/o refrigeration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.6	31.8	34.0	35.1	36.6	38.9	41.1	39.2
	with refrigeration	6.3	6.1	6.0	5.9	5.7	5.5	5.5	6.7	38.7	40.8	42.8	44.6	47.5	50.4	52.2	42.5
Case 2	w/o refrigeration									29.5	31.8	33.8	35.1	36.4	38.5	31.5	29.4
	with refrigeration									38.7	40.8	42.8	44.7	47.5	50.8	40.2	34.9
Case 3	w/o refrigeration									27.2	29.4	31.8	32.5	32.3	33.0	30.9	29.4
	with refrigeration									30.9	32.7	34.8	36.1	37.8	40.5	40.2	34.9
Case 4	w/o refrigeration									27.2	29.4	31.8	32.5	32.3	33.0	30.7	29.4
	with refrigeration									30.9	32.7	34.8	36.1	37.8	40.5	38.3	34.9

Negligible impact on the north limit

Positive impact of the additional wall (Case 4).
No additional gain with a roof (Case 3)
→ better to retain Case 4 (4-wall protection)

Total noise level at the site limit [dB(A)]

With the sub-station **in north** location

Site limit		North								South							
Point		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Case 2	w/o refrigeration	32.9	32.8	31.3	32.4	35.1	34.5	31.2	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	with refrigeration	39.4	41.1	38.0	36.3	36.7	35.8	33.1	31.5	3.6	3.8	4.0	4.2	4.5	4.7	4.7	4.8
Existing + HL-LHC		44.6	43.4	42.6	43.3	46.1	53.1	54.9	48.9	40.1	40.7	41.3	42.2	42.4	41.4	41.1	41.2
Total w/o refrigeration		44.9	43.8	42.9	43.7	46.4	53.2	54.9	48.9	40.1	40.7	41.3	42.2	42.4	41.4	41.1	41.2
Total with refrigeration		45.7	45.4	43.9	44.1	46.6	53.2	54.9	49.0	40.1	40.7	41.3	42.2	42.4	41.4	41.1	41.2

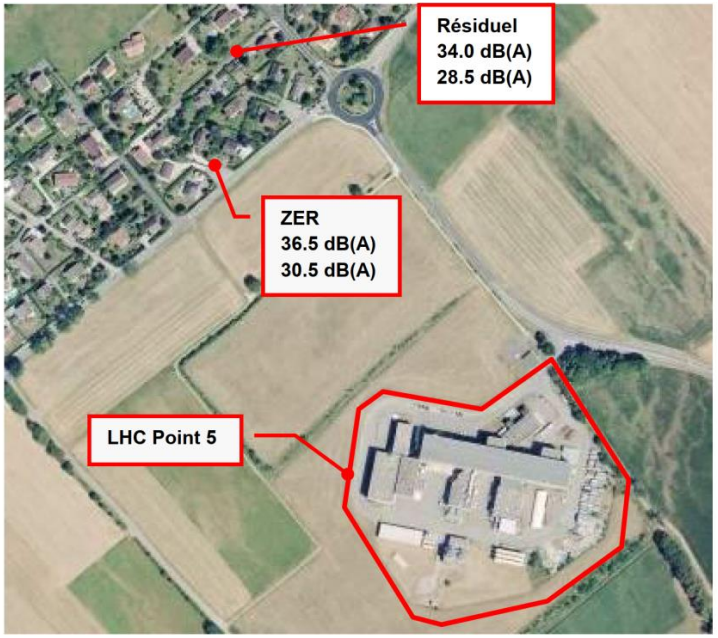
the maximum noise level identical between the two locations (54.9 dB(A)) mainly due to existing equipment.

With the sub-station **in south** location

Site limit		North								South							
Point		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Case 4	w/o refrigeration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.2	29.4	31.8	32.5	32.3	33.0	30.7	29.4
	with refrigeration	6.3	6.1	6.0	5.9	5.7	5.5	5.5	6.7	30.9	32.7	34.8	36.1	37.8	40.5	38.3	34.9
Existing + HL-LHC		44.6	43.4	42.6	43.3	46.1	53.1	54.9	48.9	40.1	40.7	41.3	42.2	42.4	41.4	41.1	41.2
Total w/o refrigeration		44.6	43.4	42.6	43.3	46.1	53.1	54.9	48.9	40.3	41.0	41.7	42.6	42.8	42.0	41.5	41.5
Total with refrigeration		44.6	43.4	42.6	43.3	46.1	53.1	54.9	48.9	40.6	41.3	42.1	43.1	43.6	44.1	42.9	42.1

What about noise level [dB(A)] in ZER1?

South location is more impacting the ZER1 than the North location! why?



Sub-station location ZER	North (Case 2) ZER1	South (Case 4) ZER1	Requirement	
			Regulation	CERN
Transformer w/o refrigeration	7.2	7.5		
Transformer with refrigeration	11.3	13.0		
Existing noise (Day-ligth)	36.5	36.5		
Existing noise (nigth)	30.5	30.5		
Total w/o refrigeration (Day)	**36.51**	**36.51**	**40**	**36.5**
Total with refrigeration (Day)	**36.52**	**36.52**		
Total w/o refrigeration (Night)	**30.52**	**30.53**	**32.5**	**30.5**
Total with refrigeration (Night)	**30.6**	**30.6**		

- Total noise fulfils the regulation thresholds,
- W/r to the CERN commitment, a maximum increase of 0.1 dB(A) is calculated (but probably within the measurement accuracy)

Conclusion

- Noise level consideration of the new electrical sub-station at P5 does not allow:
  - to choose between North and South location,
  - to justify the additional cost of 1.2 MCHF.
- Other considerations:
  - Engineering value? → North location better
  - Efficiency of the filters? → North location definitely better
  - Cohabitation with CMS? → South location better
  - Visual impact? → South location better
  - Politics: relations with French Authorities?

Thank you !