Infrastructure Modifications for Environmental noise reduction

Proposed infrastructure changes

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Summary

- Subsystem overview
- Location of noisy components
- Environmental noise mitigations
- Motivations for changes not linked with noise mitigation
- Proposed solutions
- Prioritization: Level A, B and C
- Planning
- Manpower

Subsystem overview

IME

Realization of all the infrastructure works to reduce the environmental noise inside the experimental buildings.

Scientific motivations:

- identification of sources and major coupling paths/analysis of the mitigation works done; see internal notes: “Lessons from Virgo Commissioning” (VIR-019A-09), “Mitigation works during Virgo Commissioning” (VIR-018A-09) and available spare slides;
- Virgo Commissioning experience gave indications, cannot set precise constraints;
- reduction of noise from the identified sources at the level of anthropogenic background fluctuations in the sensitive components;

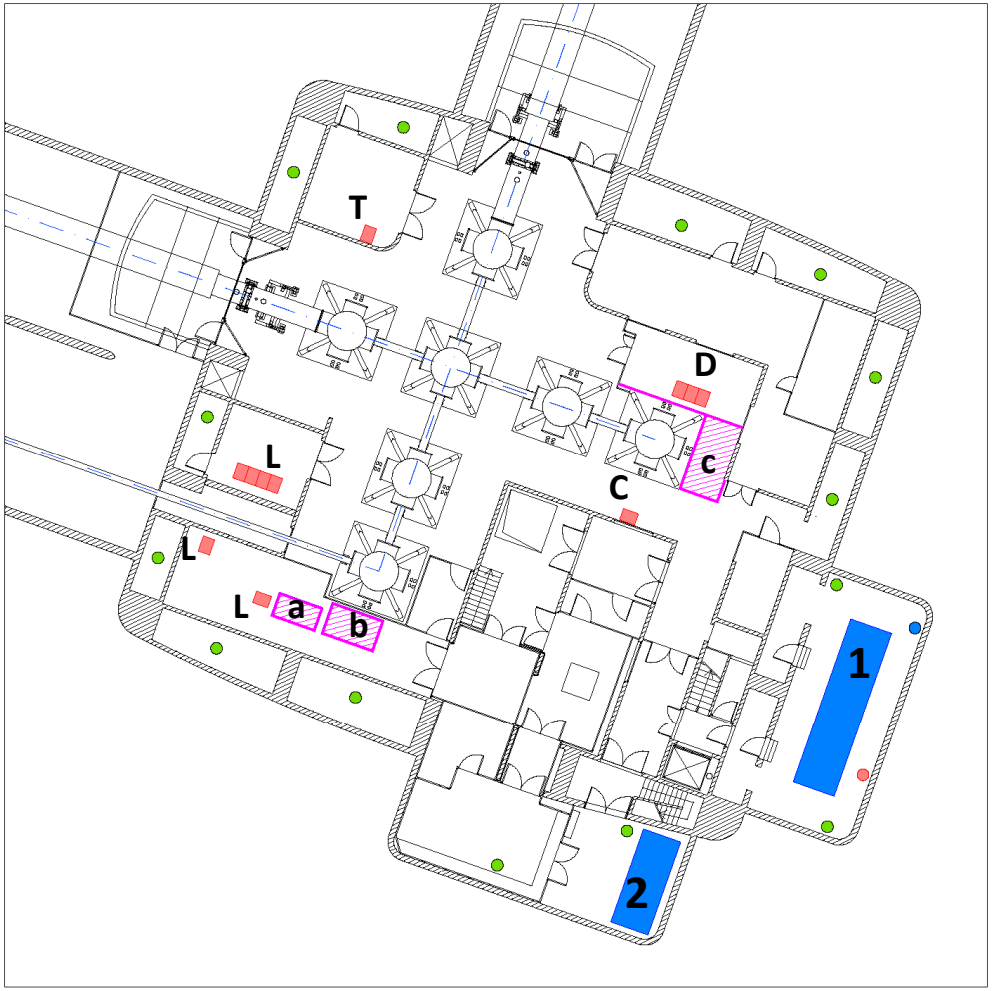
Main tasks:

- replacement/relocation of the HVAC machines;
- improvement of insulation of the air flow distribution systems;
- realization of acoustically isolated rooms.

Other tasks:

- reduction of the high reverberation time of the halls (this could become a main task);
- infrastructure works needed for other AdV installations (modification of electric power systems, basements for LN_2 tanks, support for towers displacement, etc.)

Location of noisy components: CB current status



Central Building – Level 0 Plan View

HVAC machines:
1 - CB hall
2 - clean rooms (CR) - laser lab (LL)

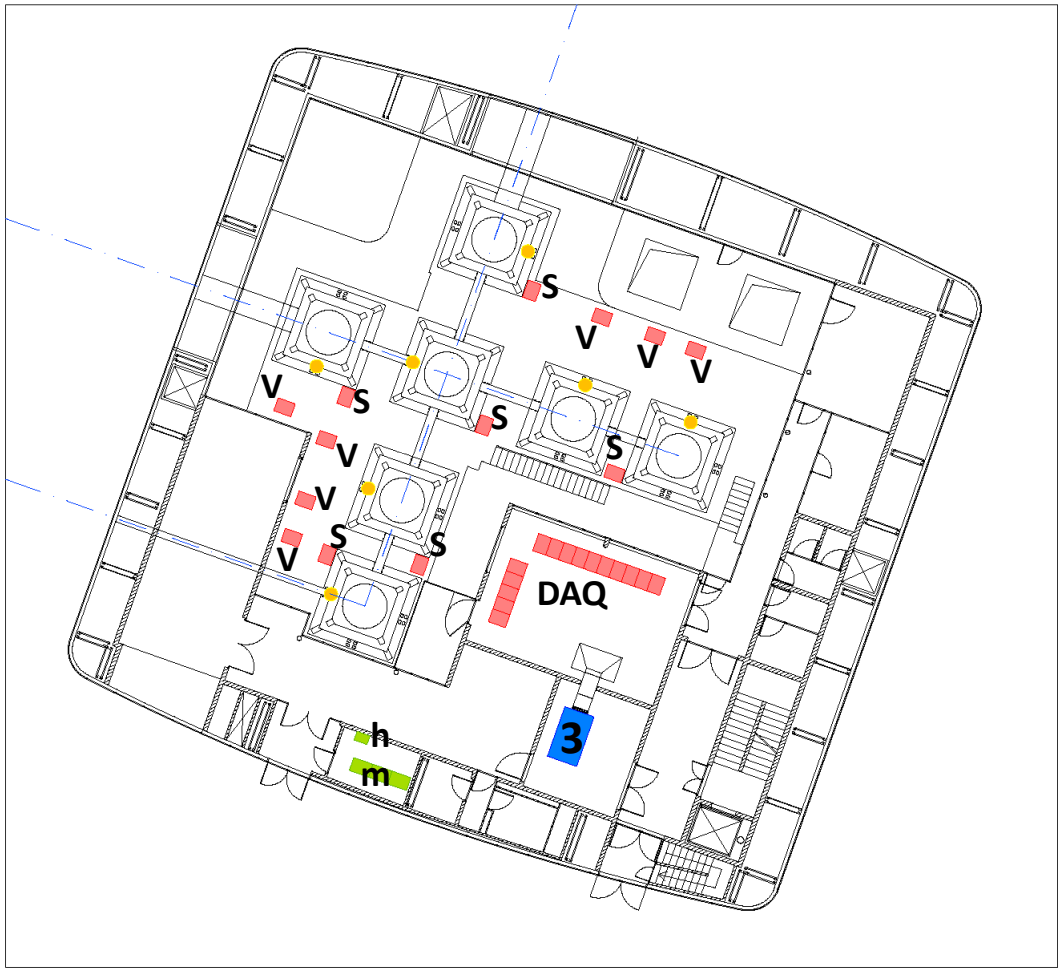
water pipes pumps

electronics racks:
L - Laser
D - Detection
C - Cryotrap
T - TCS

drainage pumps

acoustic enclosures:
a - laser bench
b - injection bench
c - detection bench

Location of noisy components: CB current status



Central Building – Level 1 Plan View

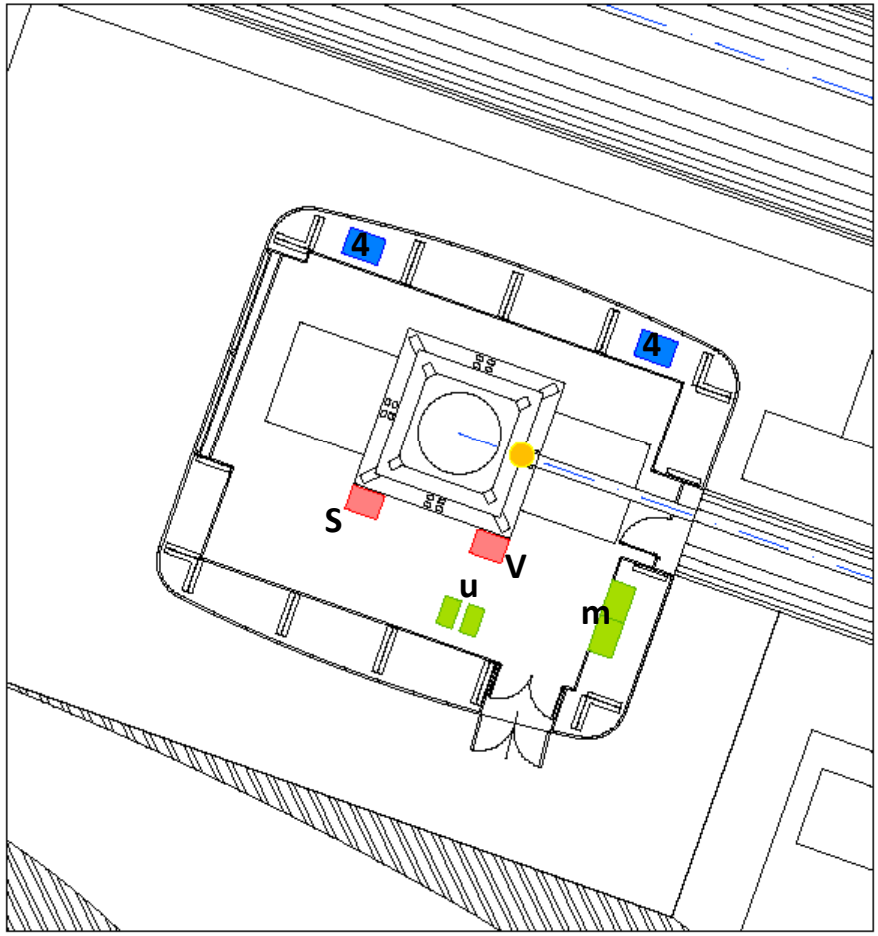
HVAC machines:
3 - DAQ

electronics racks:
S - suspensions
V - vacuum
D - DAQ

vacuum pumps

electric installations:
m - main boards
h - harmonic suppressor

Location of noisy components: MC current status



Mode Cleaner Plan View

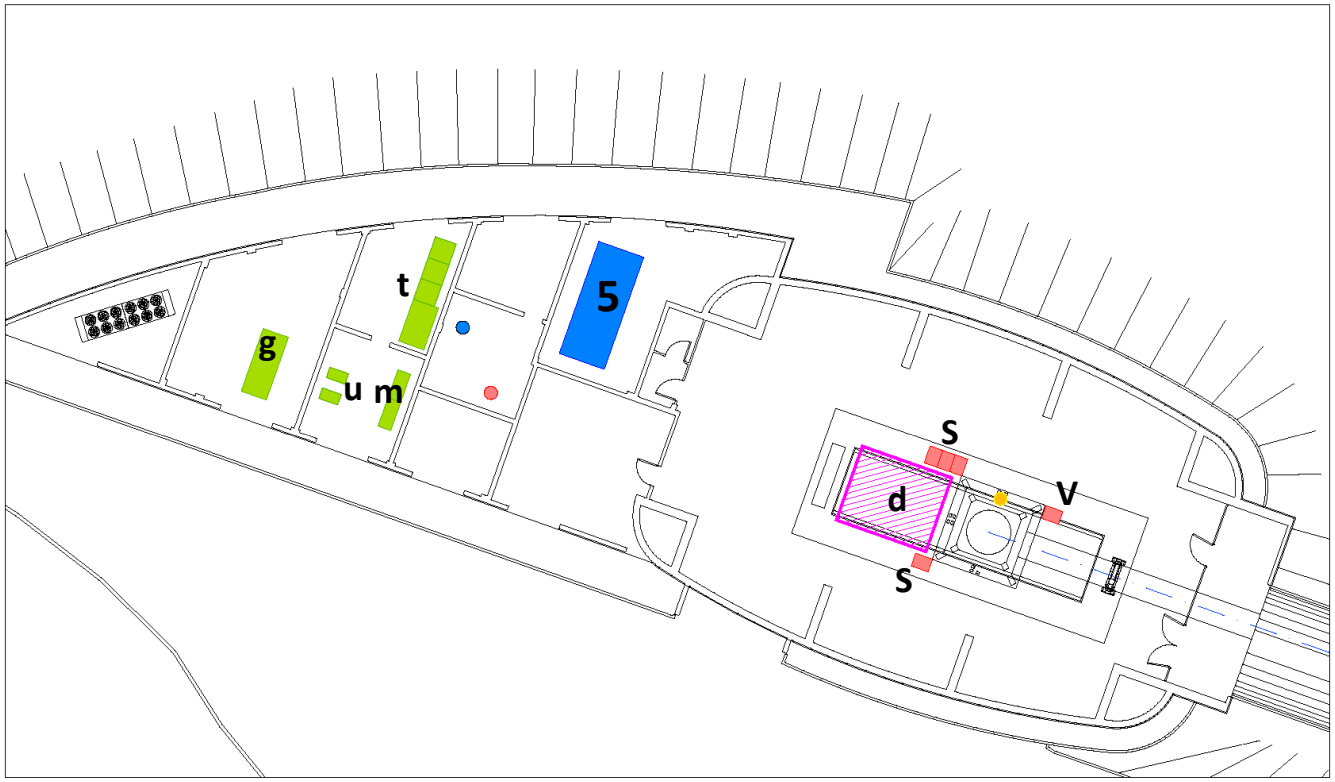
HVAC machines:
4 - MC hall

electronics racks:
S - suspensions
V - vacuum

vacuum pumps

electric installations:
m - main boards
u - UPS machines

Location of noisy components: EBs current status



West End Building Plan View

HVAC machines:
5 - WEB hall

water pipes pumps

electronics racks:
S - suspensions
V - vacuum

vacuum pump

acoustic enclosures:
d - west end bench

electric installations:
m - main boards
t - transformer
u - UPS machines
g - generator set

Further environmental noise mitigations (after V/V+ commissioning upgrade works)

Central Building:

- HVAC systems (CB hall, Clean Rooms) need further reduction of acoustic and seismic emissions in the experimental hall and LL (expected environmental noise reduction by a factor 2 below 50Hz);
- electronics racks need to reduce EM and acoustic emissions, which would require to displace them, or at least their noisiest components (AC/DC converters), in dedicated acoustically isolated places (expected acoustic RMS noise reduction by a factor 5);
- vacuum scroll pumps are very noisy devices and will run continuously for AdV, thus they should be displaced from towers in an acoustic and seismic isolated place.

Mode Cleaner:

- HVAC machines need to be replaced to eliminate disturbing magnetic noise, displacing them outside would help to reduce the large acoustic and seismic emissions.

End Buildings:

- HVAC systems emit large acoustic noise and affect external benches: they need to be modified for running at lower air flow (expected acoustic noise reduction by a factor 5 below 100Hz).

Air distribution improvements:

- duct sections could be increased in order to reduce the air and fans speed;
- air flow strengtheners and silencers could be added;
  (both actions: expected acoustic noise reduction).

Motivations for changes not linked with noise mitigation

IME involves works that are motivated not only by noise mitigation, but also by technical and functional reasons:

- improvement of the equipments efficiency and reliability, replacing heavily used machines;
- over or under-dimensioning of the current machines;
- flexibility for adjusting the running conditions of the machines (i.e. a lower regime might be required if the towers will be thermally insulated);
- separation of the systems to adjust independently the running conditions for different labs;
- relocation of the machines would allow a gain in time for installation, easier maintenance and better working conditions;
- improvement of the thermal insulation for energy saving.

Proposed solutions

A preliminary project of the IME infrastructure changes has been performed sorting the proposed actions by priorities. Such priorities are based on:

- the trade-off between cost and efficiency in terms of noise mitigation;
- the need for upgrades of old machines;
- the need for maintenance and further non-IME upgrades: cryotraps, monitoring of all machines (IMMS), modifications of spaces and electric systems for other SS installations

The proposed changes have been grouped into 3 packages with decreasing grade of priority: Level A, B and C.

The 3 packages are characterized by an increasing cost (A, A+B and A+B+C), even though such costs are based on rough evaluations at this stage of the project.

The considered planning and manpower profile concern the realization of all the proposed works.

Prioritization: Level A, B and C

Level A includes the following infrastructure changes:

A.1 evidenced by scientific observations

- new HVAC machines for CB (CB hall+LL+ Elect. Equip. Room) (ref. slides 17,18);
- relocation of the HVAC Clean Rooms machine;
- new HVAC machine for MC and relocation (ref. slides 17,22);
- insulated EE rooms for noisy racks and power supplies (LL+DET+VAC+SUSP+DAQ) in CB (ref. slides 20,22);
- insulated rooms for vacuum scroll pumps (ref. slide 21);
- improvements of the LL and DET lab insulation (ref. slides 17,18).

A.2 required for the above equipment re-arrangements and technical and functional reasons

- relocation of CB HVAC machines;
- new underground water pipes for CB HVAC;
- IMMS improvement;
- electric systems modifications for HVAC machines installation.

A.3 works for the other SS

- external areas for Cryotraps LN2 tanks;
- modifications of spaces and electric systems for other SSs installations.

Level B, as further improvements in addition to Level A, includes:

- new HVAC air distribution for all buildings;
- EB HVAC machines seismic isolation.

Level C, as further improvements in addition to Level B, includes:

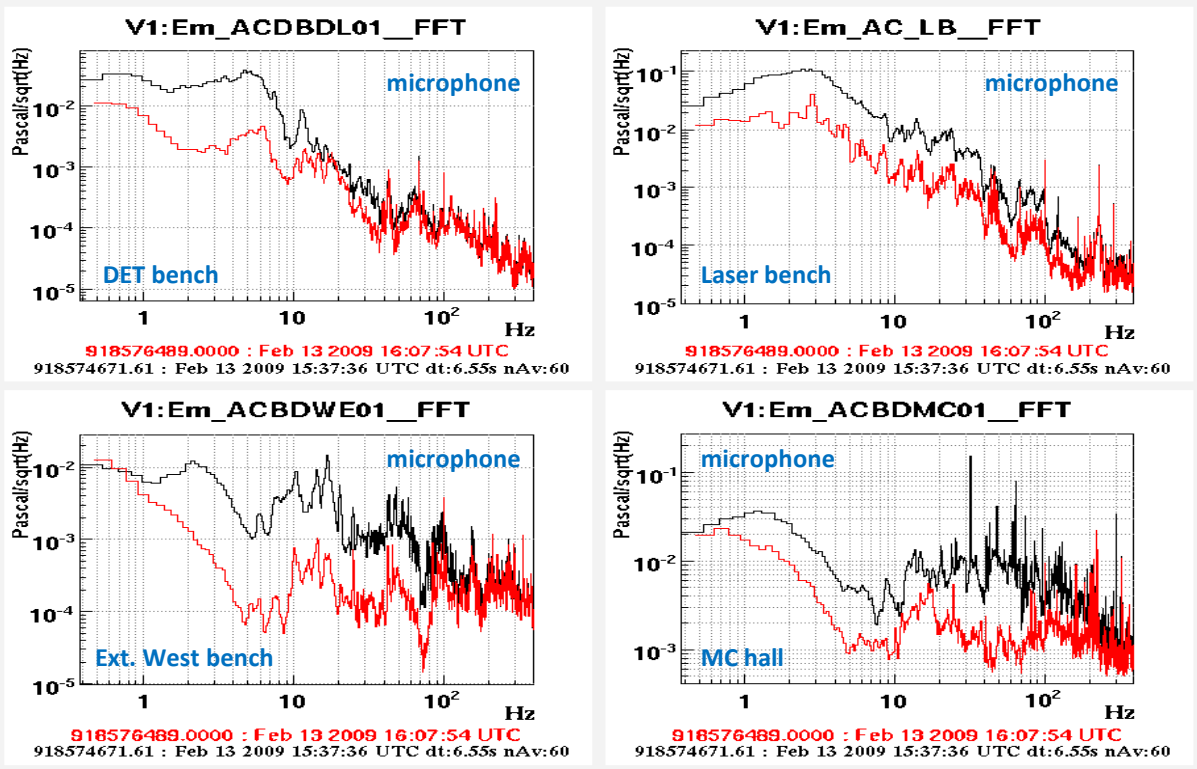
- experimental halls acoustic damping (if noisy electronics/pumps cannot be allocated in insulated rooms, the level of priority can be increased).

SPARE SLIDES

Highlights of critical noise sources and paths identified during Virgo Commissioning (I.Fiori)

HVAC, acoustic noise

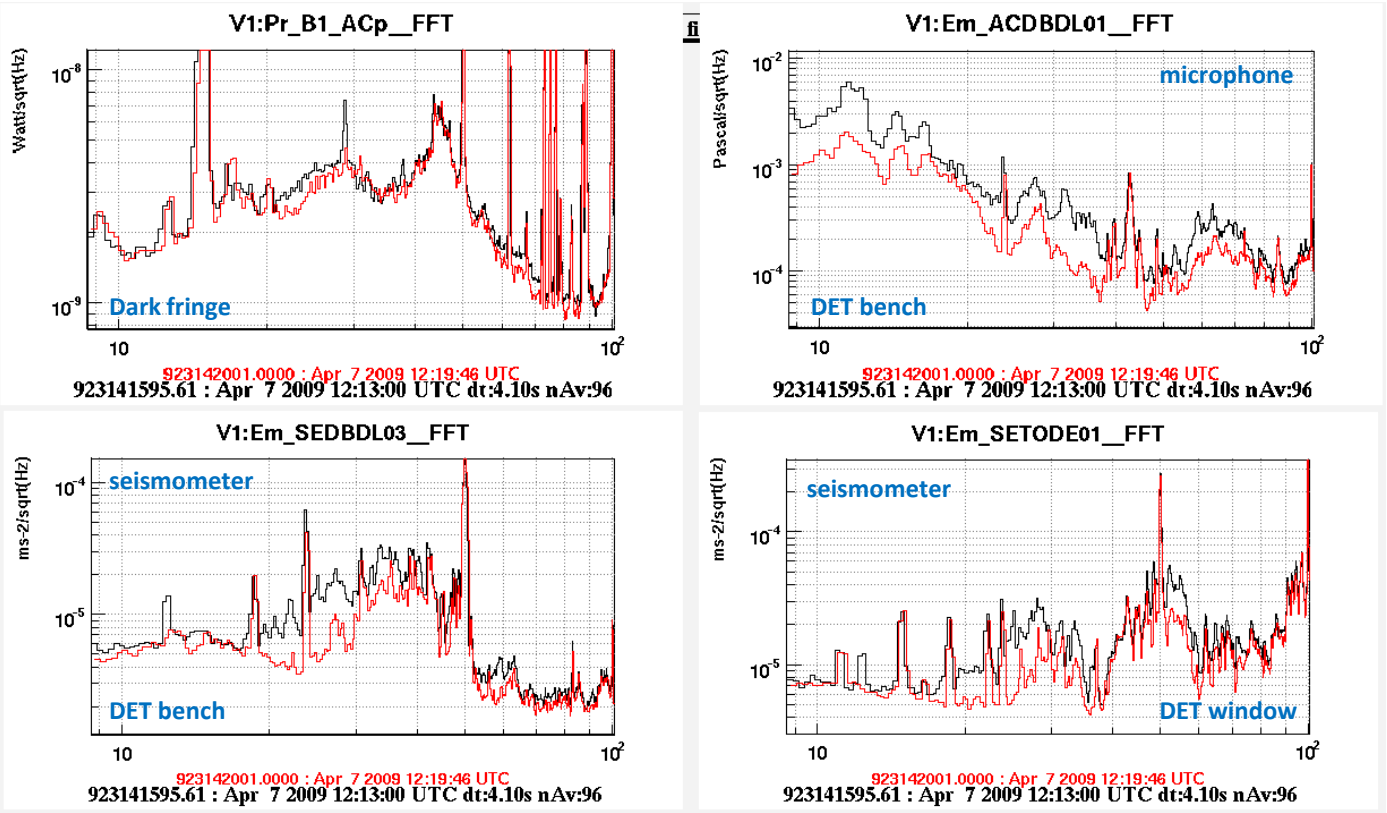
- Large residual noise up to 200Hz. Peaks at fans and engines frequency (also seismic). Coupling at external benches, via diffused light and beam jitter. Terminal buildings are the most critical. Large noise at MC building.
- Slow down of fans looks effective to reduce noise, might need increasing ducts size.



CB hall HVAC noise

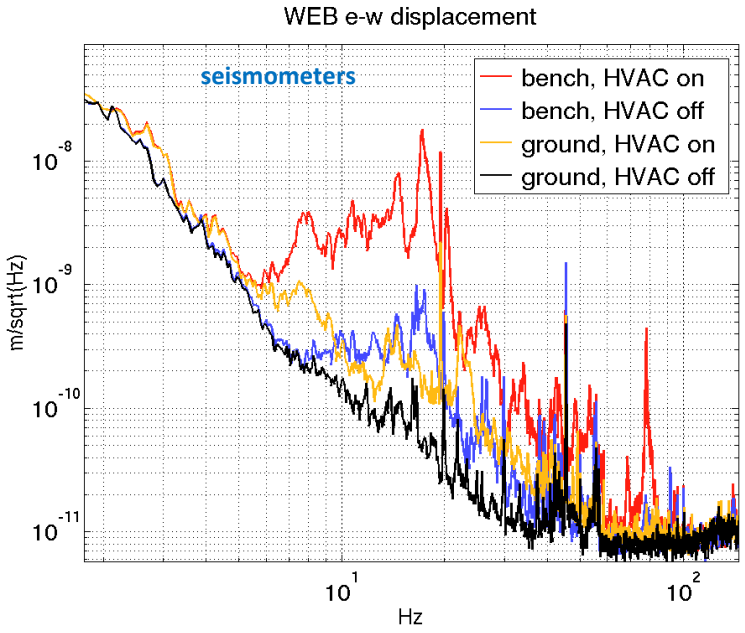
- Recent switch off test indicates that noise from CB hall HVAC is contributing to limit present (April data) sensitivity at low frequency. Suspected coupling at Detection, noise path is under study.

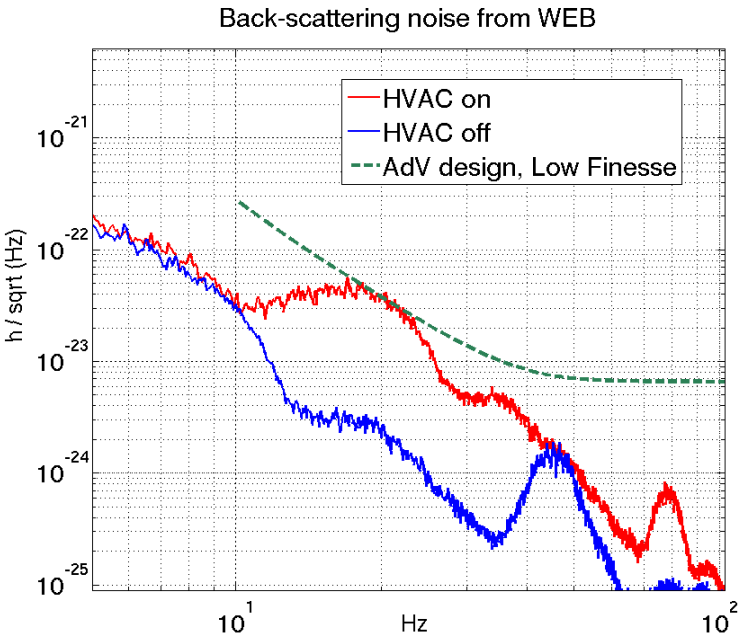
Environmental noise at DET from CB hall HVAC



Noise from diffused light at external benches, tentative projection

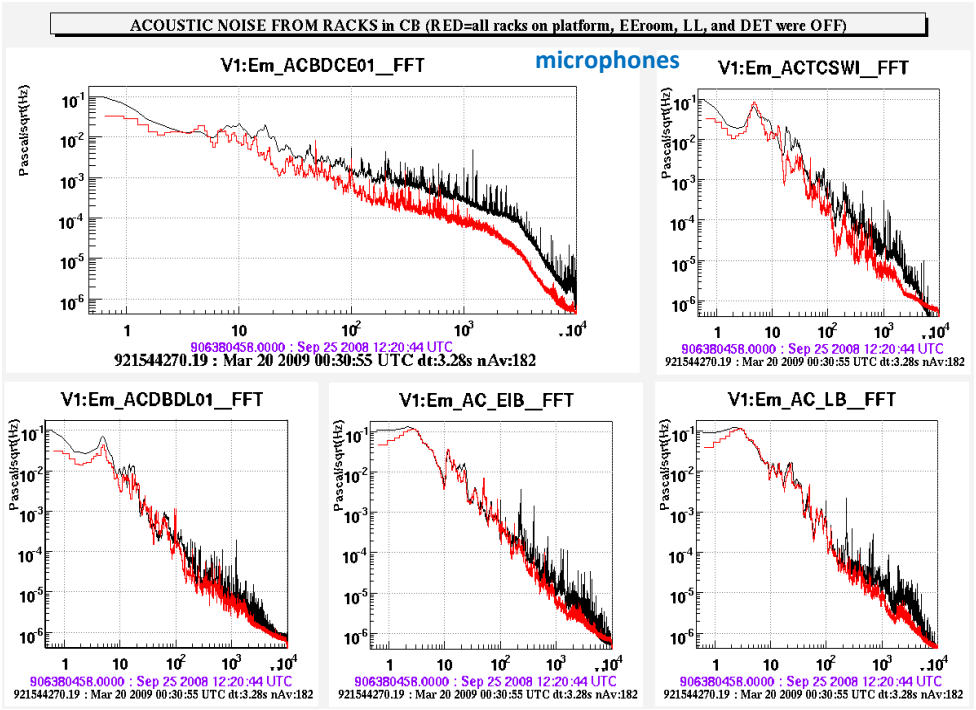
- Up-conversion noise from increased motion of external benches. Terminal and detection benches are most critical. Large acoustic coupling to benches.
- Bench stiffening or damping solutions are under study (V+MS), but necessitate of reducing HVAC acoustic and seismic (ground) emissions.

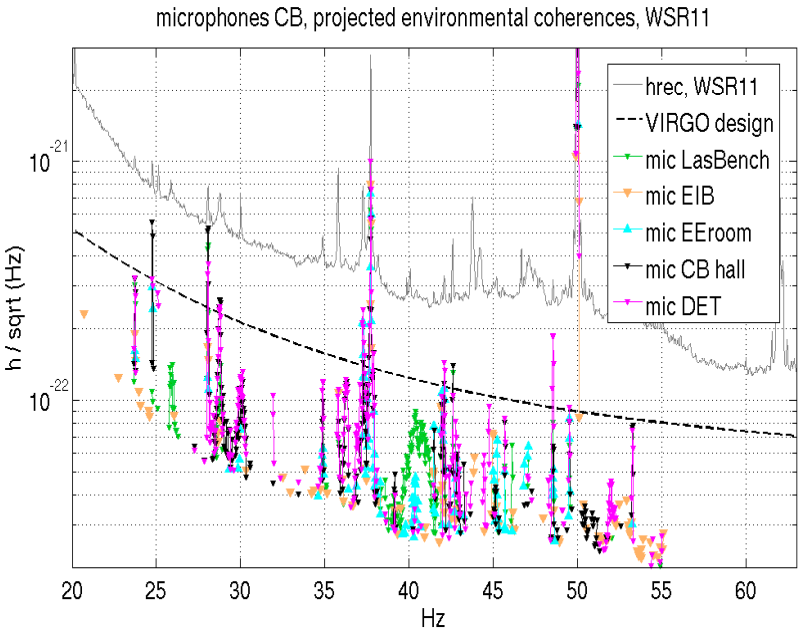




Racks, acoustic noise

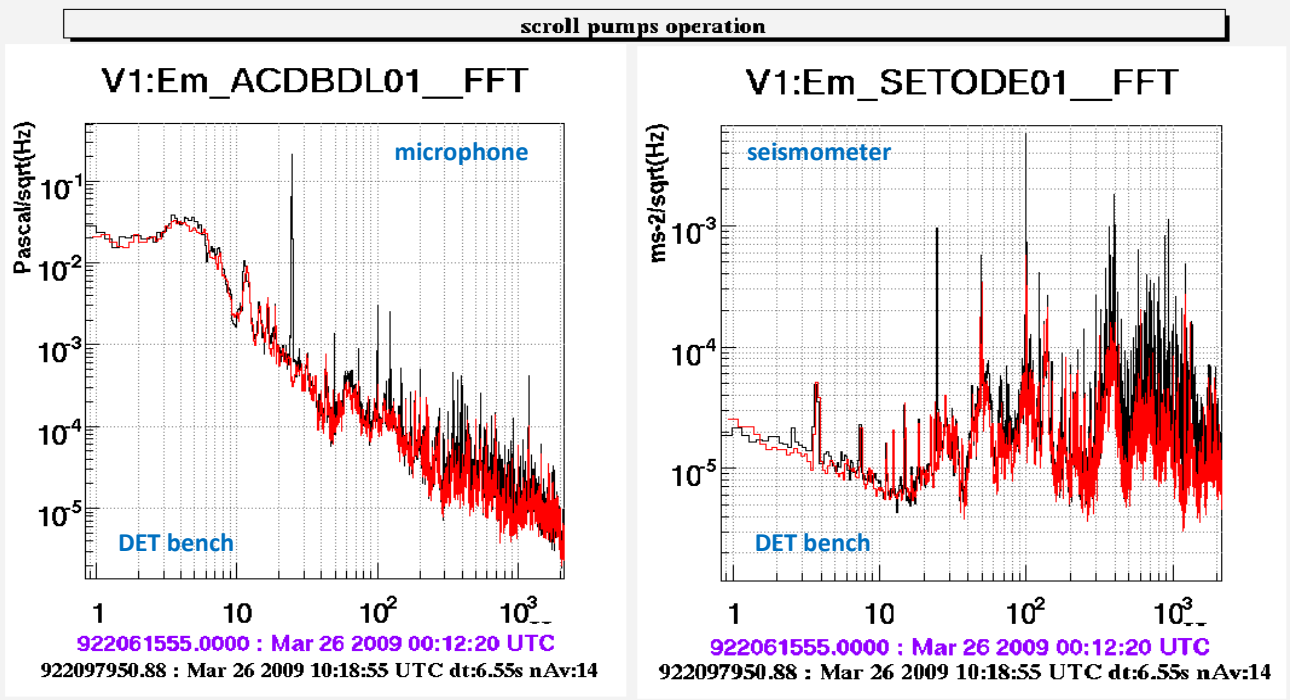
- Cooling fans, dominant in CB hall above ≈20Hz. Contributes to RMS noise and peaks. Couples at external benches and optical links via beam jitter and diffused light.
- Acoustic enclosures are not effective below 100Hz, not sufficiently effective above 100Hz. Need to move racks inside acoustic isolated rooms, or adopt conductive cooling to eliminate fans.





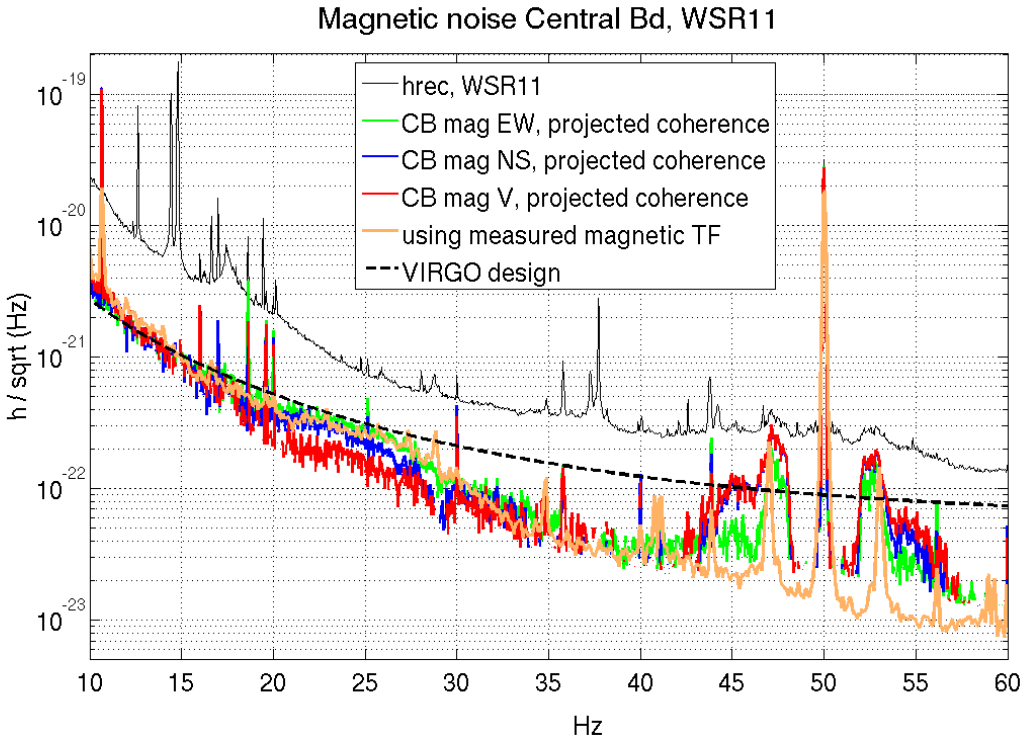
Scroll pumps

- Intense acoustic and seismic noise, peaks at pump frequency (24Hz) and harmonics. Coupling to benches and optical links. For Virgo they had been kept off and operated routinely for short times. AdV needs a few continously running. Necessary and technically feasible to displace them inside isolated rooms.



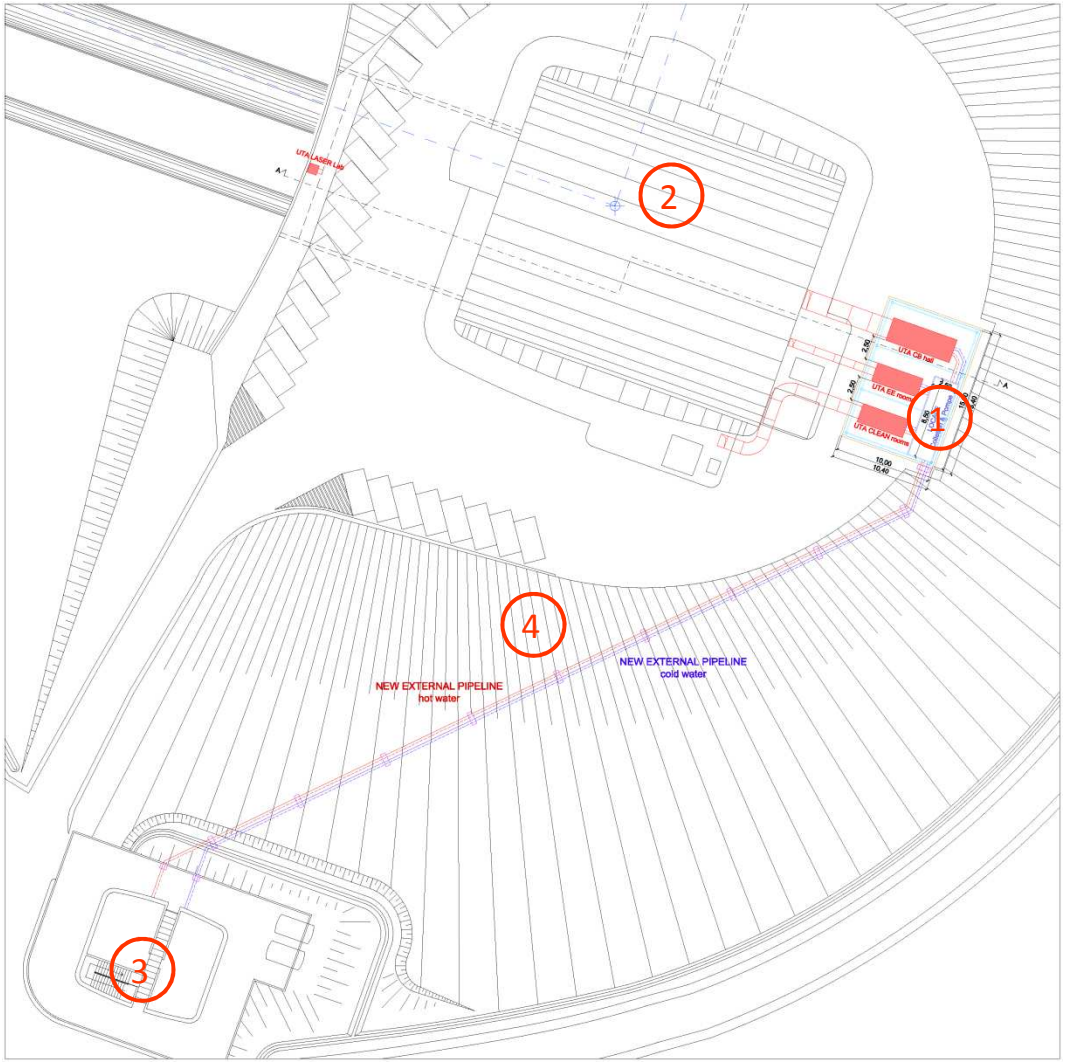
Magnetic noise

- Magnetic fields couple to mirror magnets. Present coupling is large, but should reduce with dielectric Reference Masses (V+MS).
- Major sources are (1) MC HVAC resistive heater polluting power line in CB, (2) racks AC/DC transformers.
- Needs: (1) substitute MC HVAC machine, (2) displacement of AC/DC transformers.



Some preliminary drawings of the proposed solutions

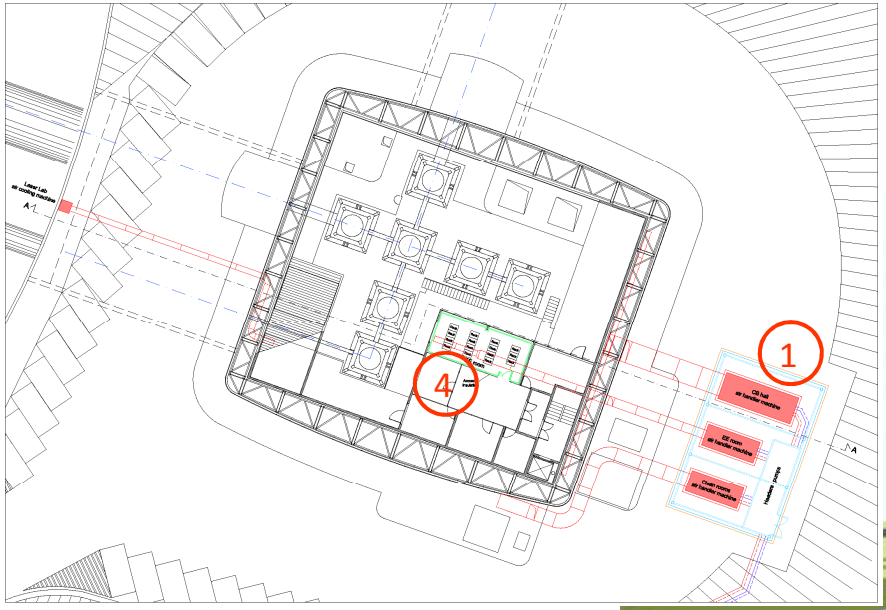
Some proposed solutions: Central Area



1. New external technical area
2. Central Building
3. Technical Building
4. New underground water pipes

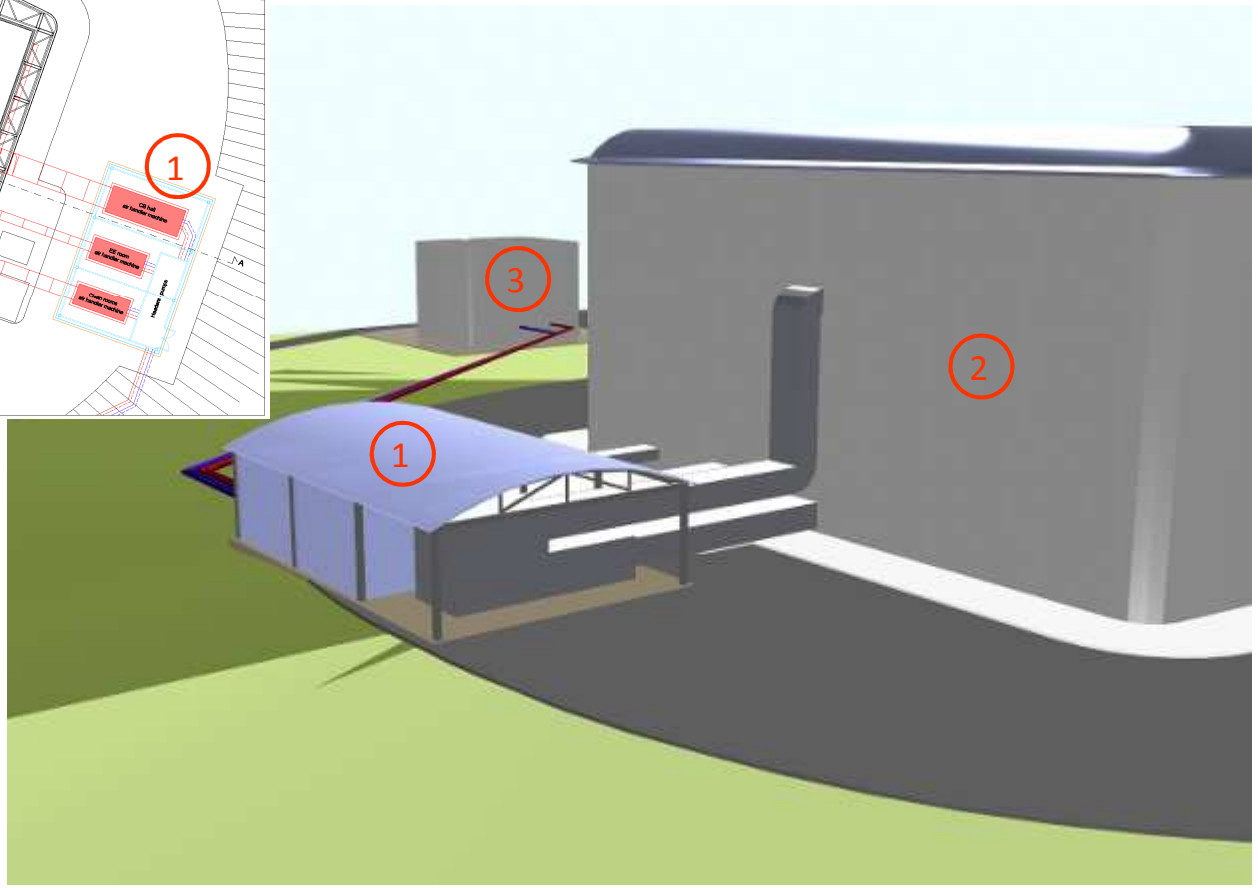
Plan view of the Central Area

Some proposed solutions: Central Building



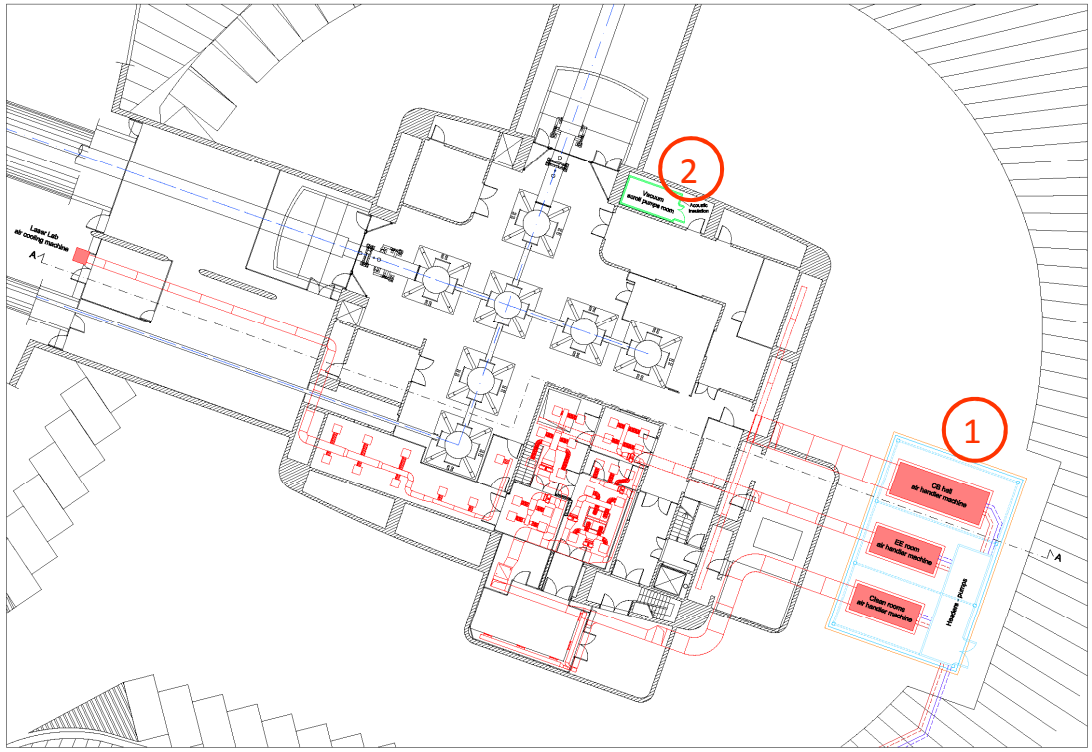
Plan View of the CB – Level 2

Perspective view of the Central Area



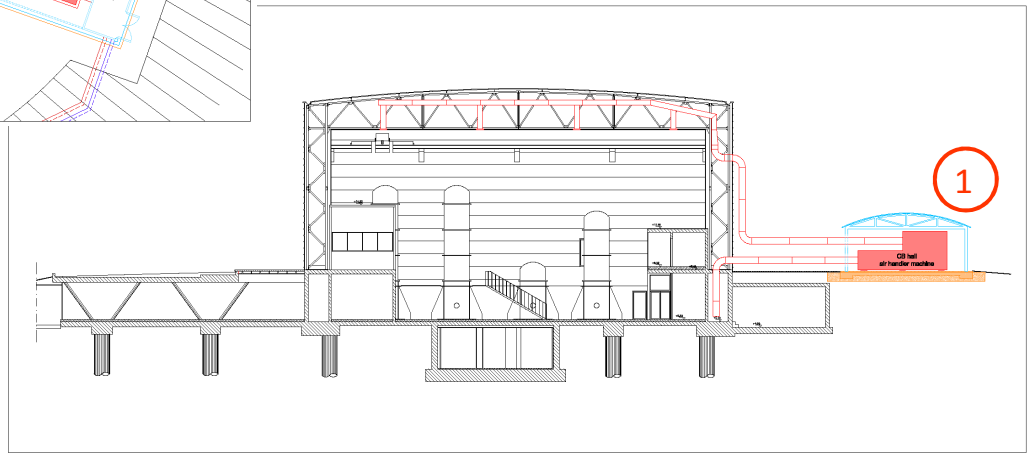
1. New external technical area
2. Central Building
3. Technical Building
4. EE Room (indicative location)

Some proposed solutions: Central Building



Plan View of the CB – Level 0

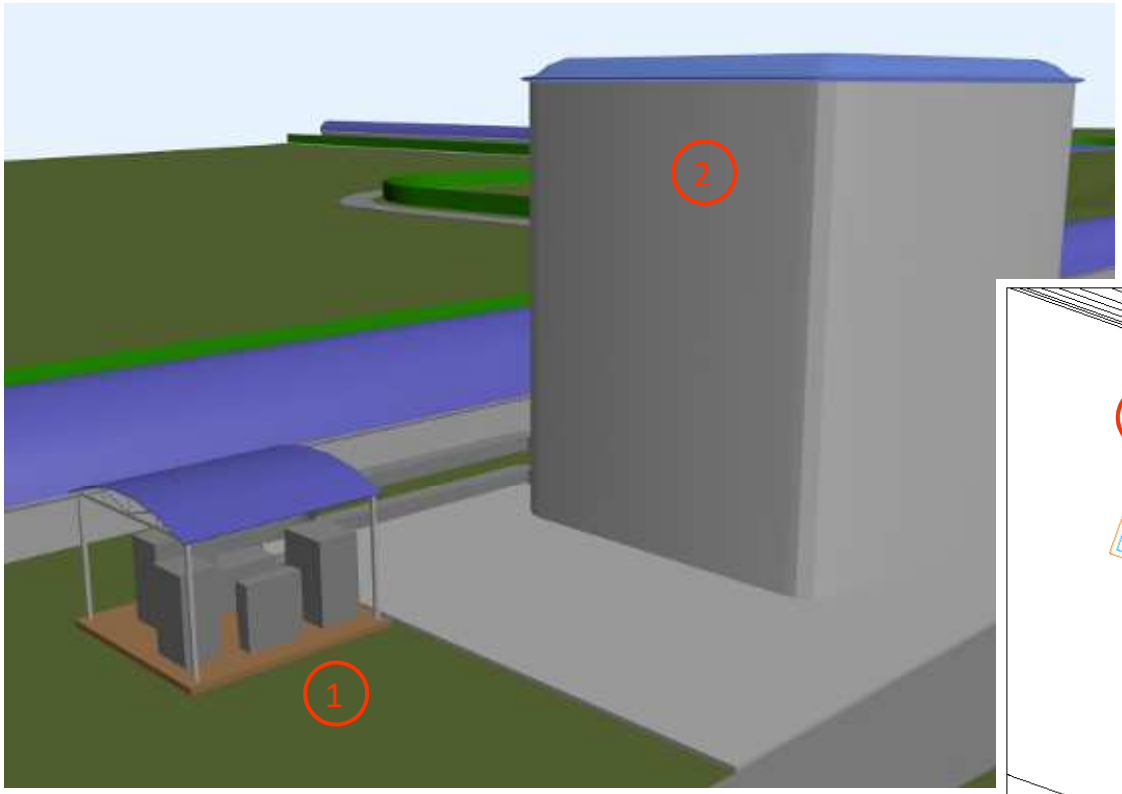
Cross section of the CB



1 New external technical area

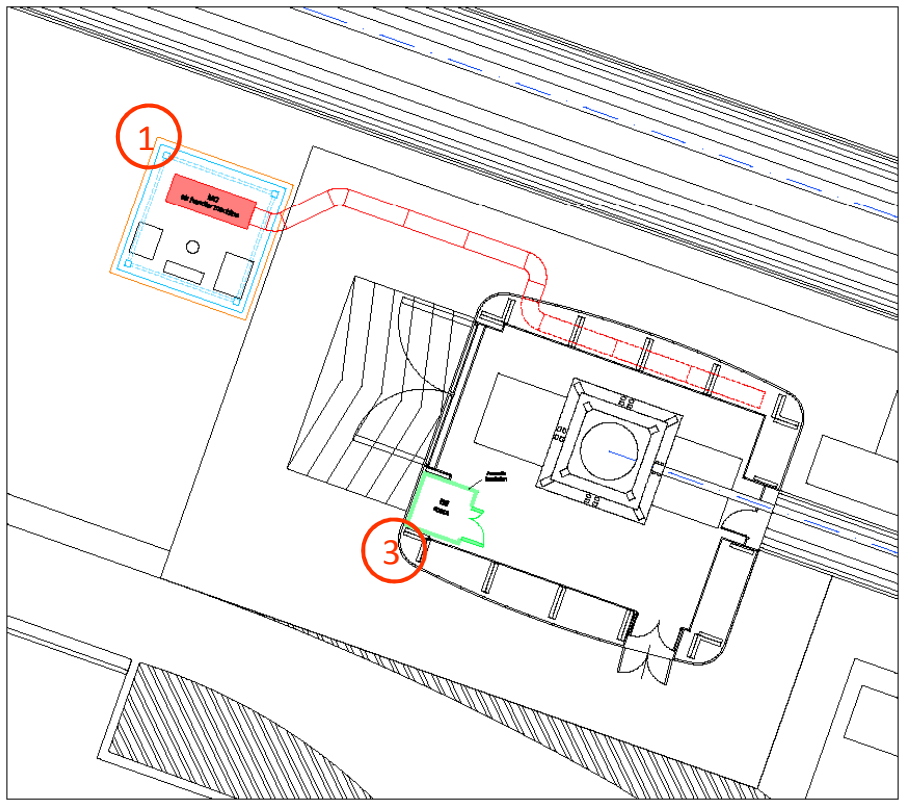
2 Vacuum pumps Room (indicative location)

Some proposed solutions: Mode Cleaner



Perspective view of the MC

Plan view of the MC



1. New external technical area
2. Mode Cleaner Building
3. Vacuum pumps Room (indicative location)