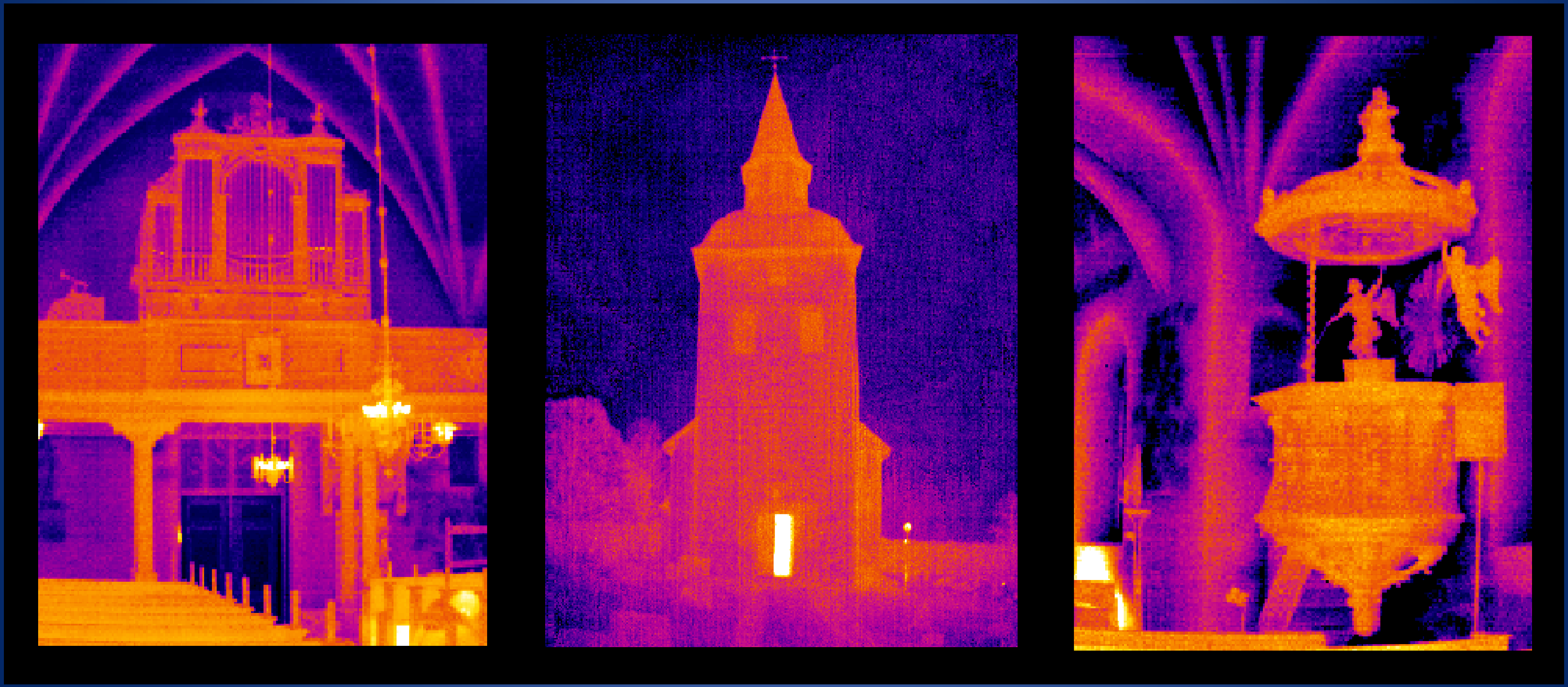
Energy saving and artifact preservation in historic monumental buildings – church project



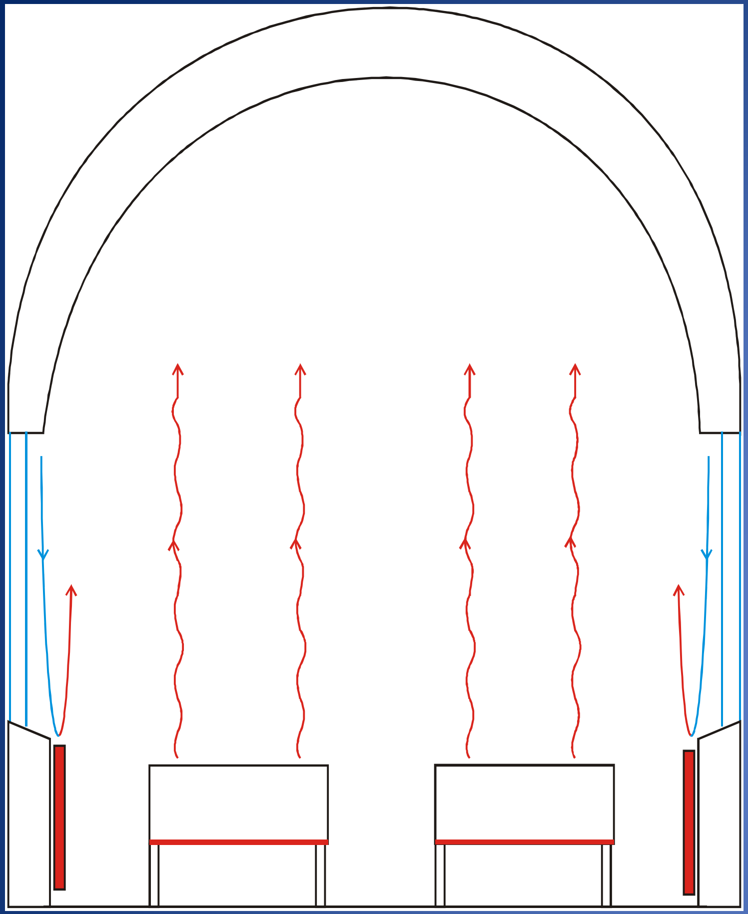
UNIVERSITY OF GÄLVE

Energy saving and artifact preservation in historic monumental buildings – church project

This research project concerns different aspects of energy saving in churches and similar buildings which constitute an important part of our cultural heritage, at the same time as preservation of historical and esthetical values is promoted. The project has particular focus on:

- Air infiltration (measurement methods, modelling, energy impact, leakage identification)
- Surface soiling due to particle deposition (particle sources, microclimate and soiling rate, preventive actions)
- Airing of the church space (esp. evacuation of air pollutions after services)
- Thermal environment (measurement aspects, thermostat regulation, comfort)
- Indoor air movements (convection currents at heating units, incl. fan convectors)
- Crawl space ventilation and dampness

The study involves extensive measurements in real objects in the field, but also includes modelling and experimental laboratory tests. The study is supported by the Swedish Energy Agency.

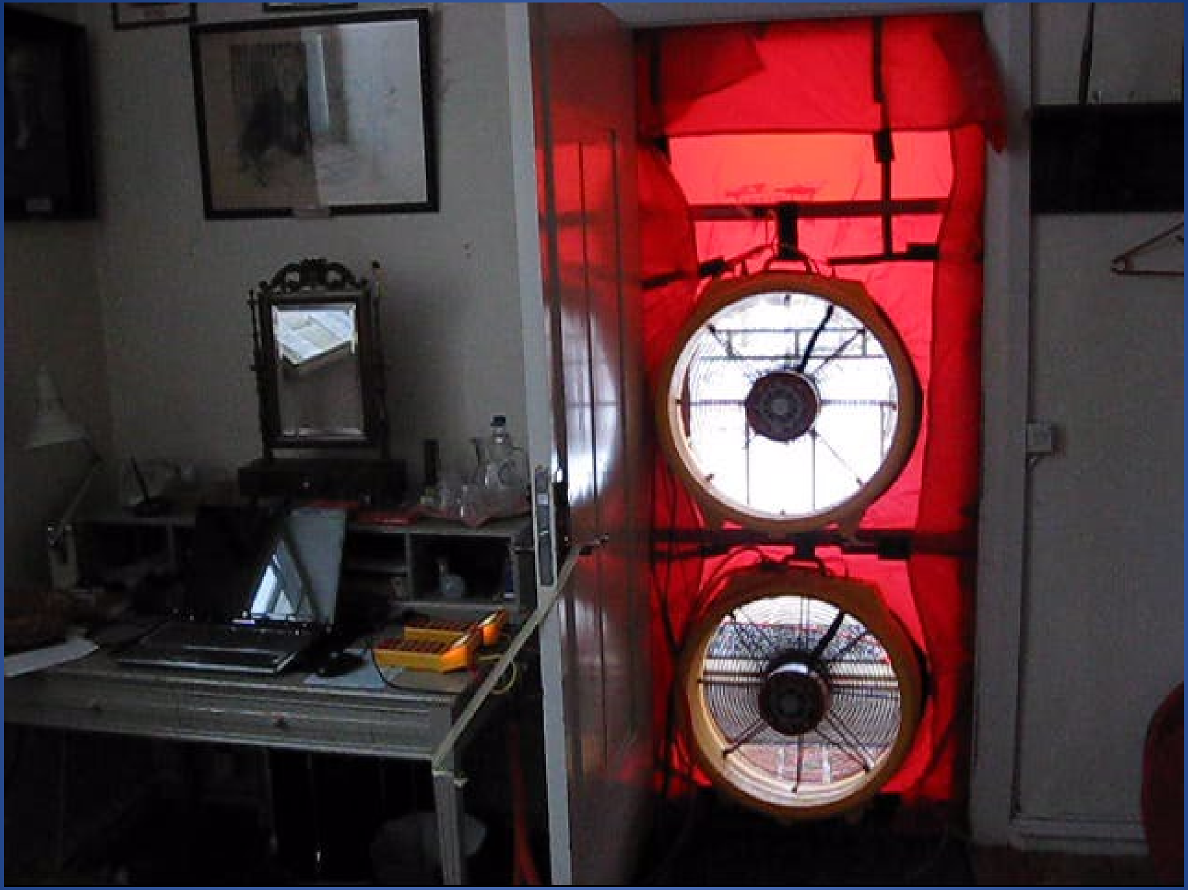


Swedish churches are usually heated by direct electricity radiators and/or bench heaters. Convective air currents from these, and downdraughts along walls and windows are responsible for most of the air movements in churches. These air movements, in turn, affect heat distribution and thermal comfort, but also deposition of airborne particles on surfaces.

Hamrånge church where comprehensive long term measurements are performed, including:

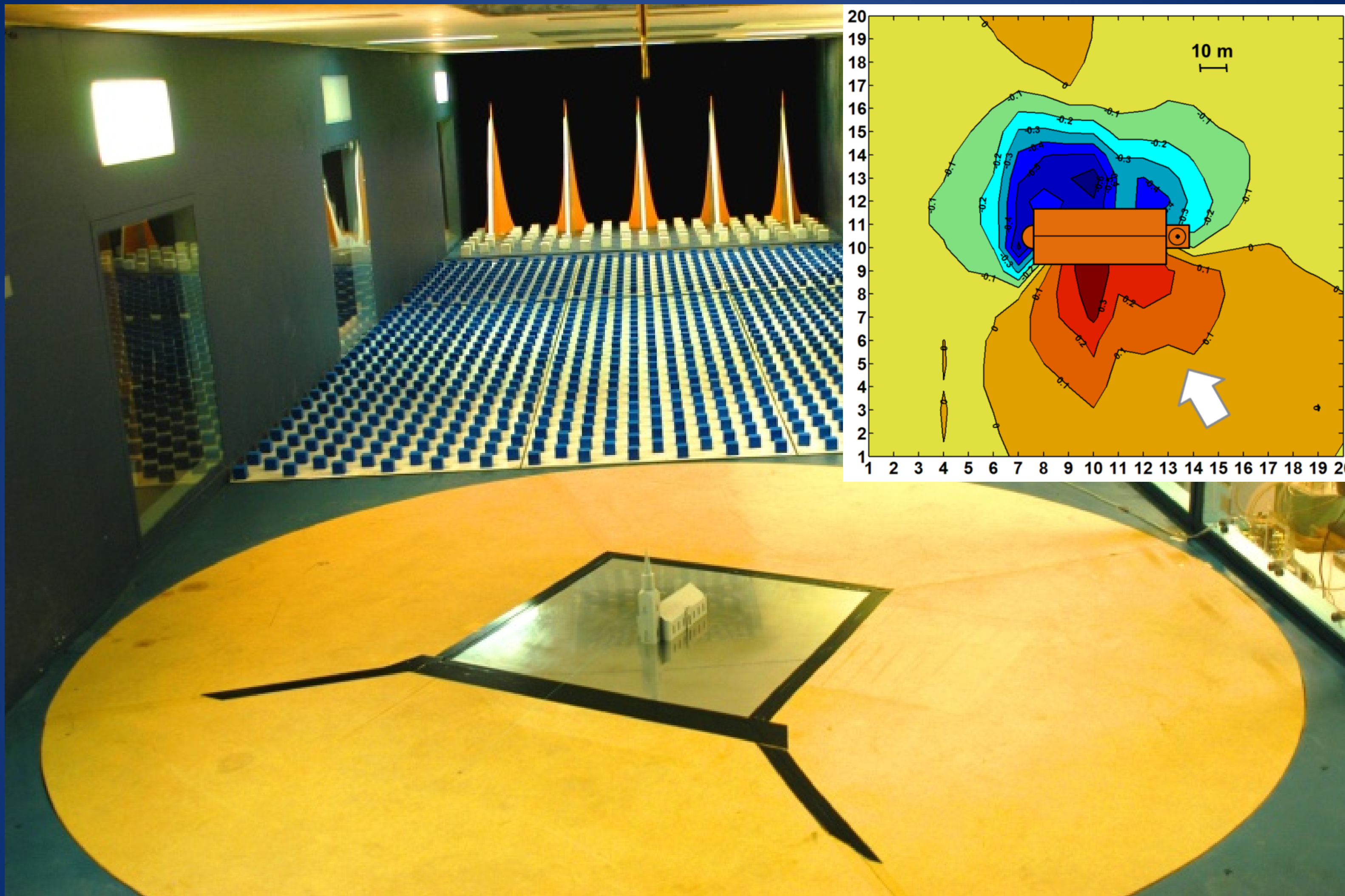
- Air temperatures, vertical and horizontal distributions
- Wall surface temperatures, vertical distribution
- Window surface temperatures
- Heating power
- Air humidity indoors, in crawlspace, attic and organs
- Air change rate
- Air leakage of building envelope
- Weather statistics from local weather station
- Façade and crawlspace pressures

Tracer gas measurements for quantifying air change rate in a church (left) and a local weather mast (top) giving input data for air infiltration modelling.

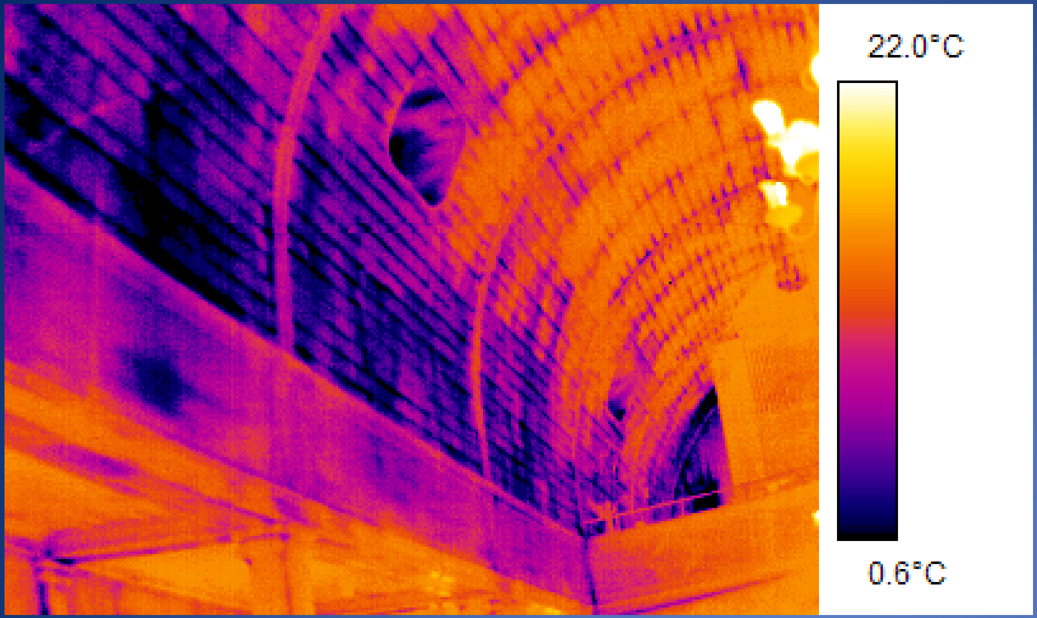


Measurement of the air leakage of the building envelope with standard *blower door* technique, here installed in the vestry of a church. With powerful fans the method seems practicable in most (Swedish) churches.

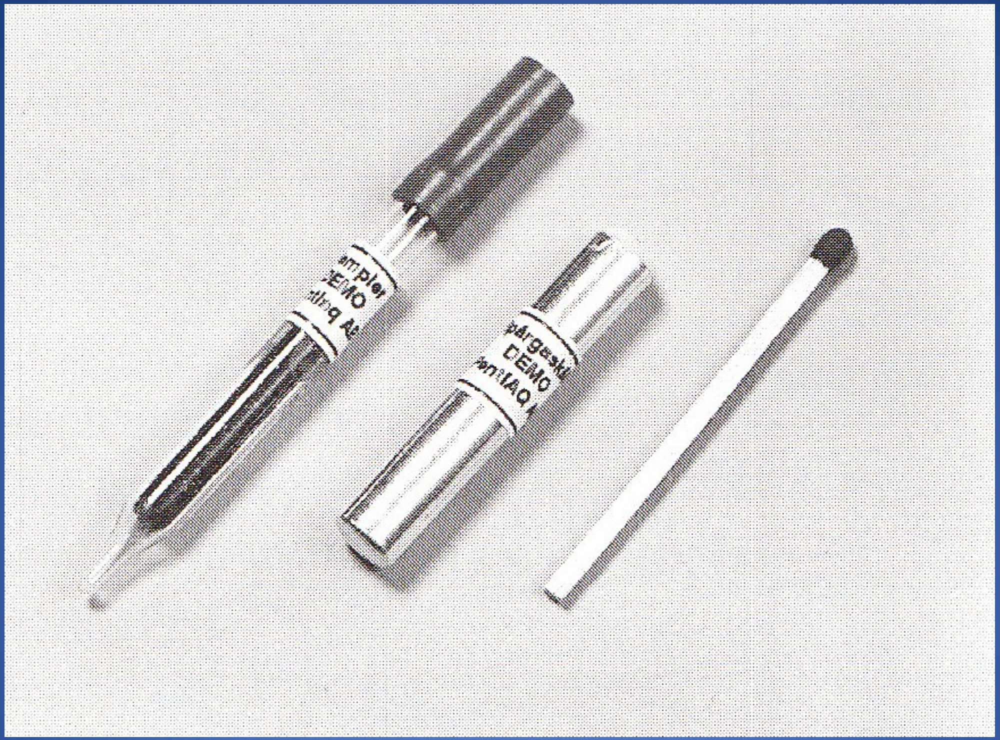
The *pressure pulse technique* for measuring air leakage of the building envelopes is being developed and evaluated in cooperation with University of Nottingham, UK. The technique is normally more accurate than the blower-door technique.



Wind tunnel used for measuring wind pressure distribution on the façade of a church model and on the surrounding ground. Top right: Example of pressure distribution occurring on ground at a certain wind angle.



Air leakage spotting by infrared thermography (top, church ceiling) and particle measurements (right). Assisting under-pressure is attained in the whole church volume by means of blower-door fans.

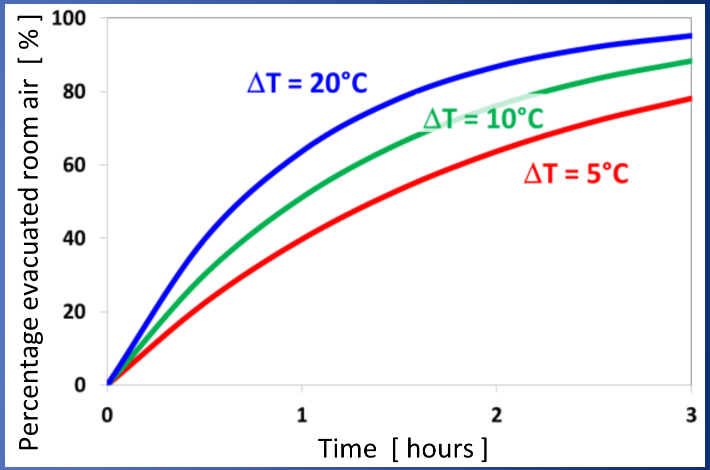


Passive tracer gas technique for measuring long term air change rate is evaluated. Small tracer gas samplers (left) and sources (right), are then distributed discretely within the church.

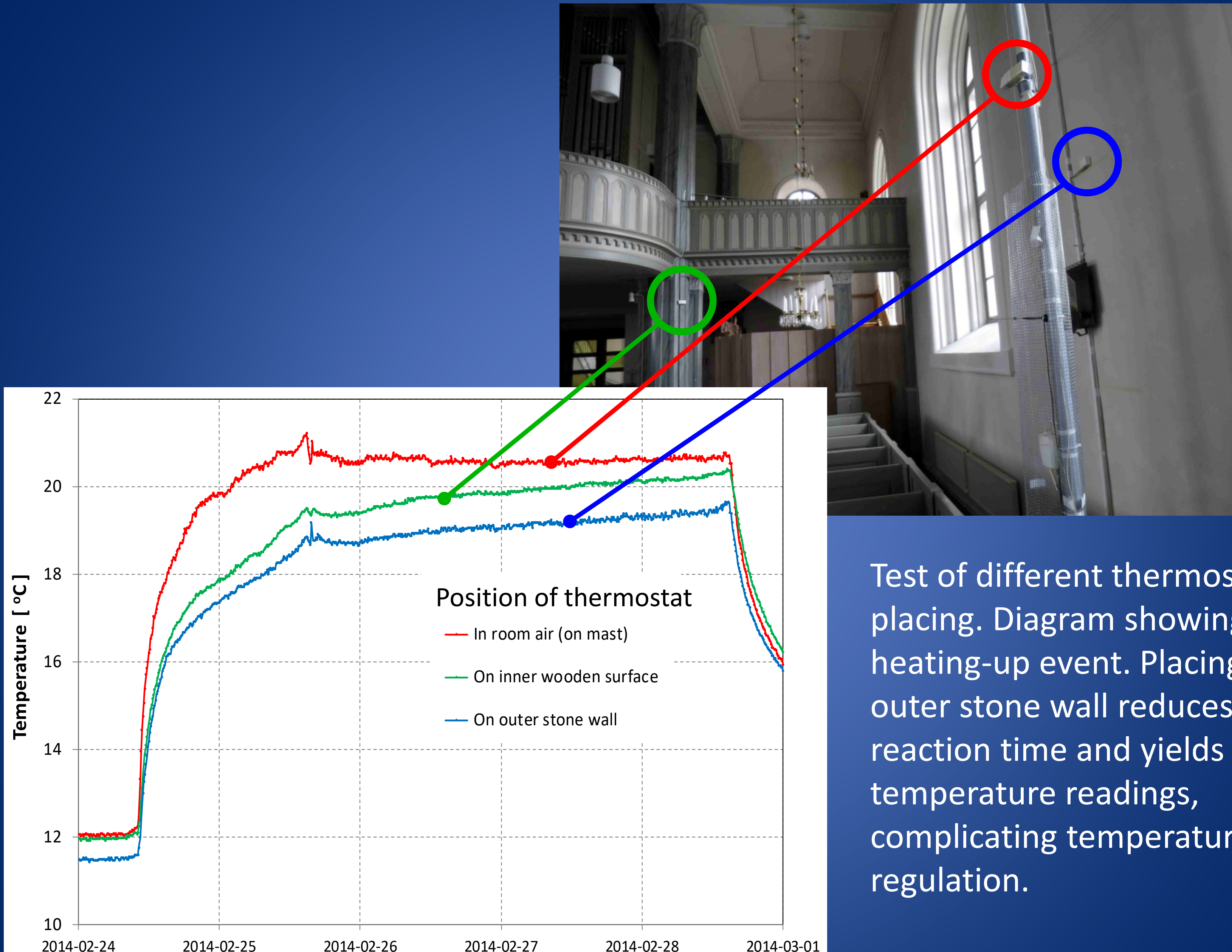
Airborne particles from infiltrated air, candle burning and visitors cause soiling of indoor surfaces, including historical artifacts. Enhanced particle deposition occurs on surfaces where there are cold bridges in the building construction – through the thermophoresis mechanism – like stones in the wall. IR-thermography indicating patch-patterned surface temperatures (left) and corresponding soiling pattern (right) with long term measurements taking place in two points of different temperatures and soiling rates.

Wall surface soling above a radiator (left) and visualization of the air flow pattern above a radiator (right). The warm, rising air flow from a radiator experiences a transition from laminar to turbulent flow at some distance above the radiator, coinciding with enhanced surface soiling. Small details like radiator mounting brackets trigger turbulence at an earlier stage, resulting in marked soiling stripes.

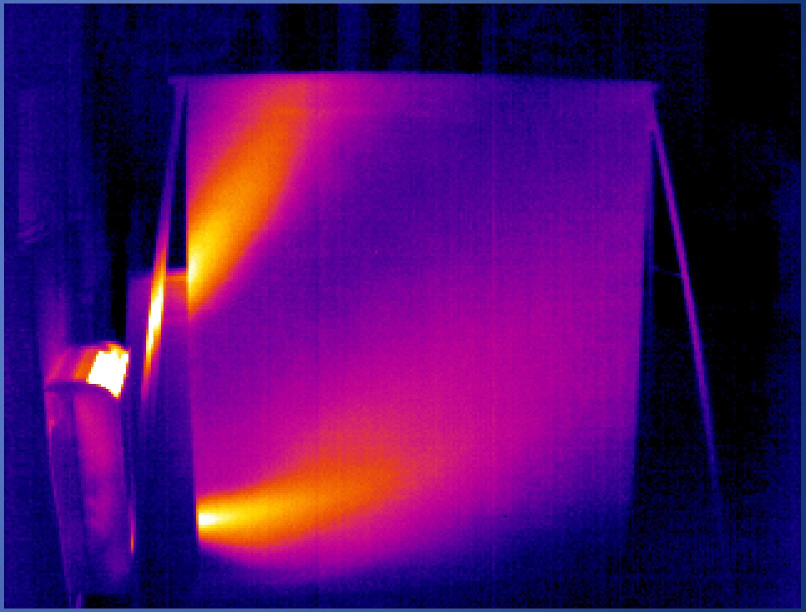
Measurements of the microclimate (left) and surface blackening (right) at the wall above a radiator. Verifies that air turbulence enhances surface soiling.



Intentionally enhanced airing of a church by opening the main porch. Tests with tracer gas measurements indicates that this is a practicable method to evacuate air pollutants, e.g. after a service occasion. The temporary heat loss is marginal. An airing guide has been produced; a typical airing diagram is shown on the right, where ΔT is the indoor-outdoor temperature difference.



Test of different thermostat placing. Diagram showing a heating-up event. Placing on outer stone wall reduces reaction time and yields lower temperature readings, complicating temperature regulation.



Smoke and IR visualization of supply air current from the fan convector of an air-to-air heat pump in a church.

Particulate air cleaning: Eight stand-alone air cleaners assembled on the balcony of a church. Measurements have indicated effective reduction of the amount of airborne particles.

Crawl space ventilation strategies and effects on dampness are tested. On the right, a humidity-controlled damper in a crawl space vent.

Low-emissivity film applied to window on Gävle municipal hall for reduced heat loss and improved thermal comfort. Installation tested with heat-box on site.

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