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### **Assessing the hygrothermal performance of innovative wall and window systems**

Maref, W.; Rousseau, M. Z.; Manning, M. M.; Lei, W.; Abdulghani, K.; Nunes, S. C.

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## Assessing the hygrothermal performance of innovative wall and window systems

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**Maref, W. ; Rousseau, M. ;  
Manning, M.**

IRC-ORAL-745

October 11, 2006



National Research  
Council Canada

Conseil national  
de recherches Canada

Canada

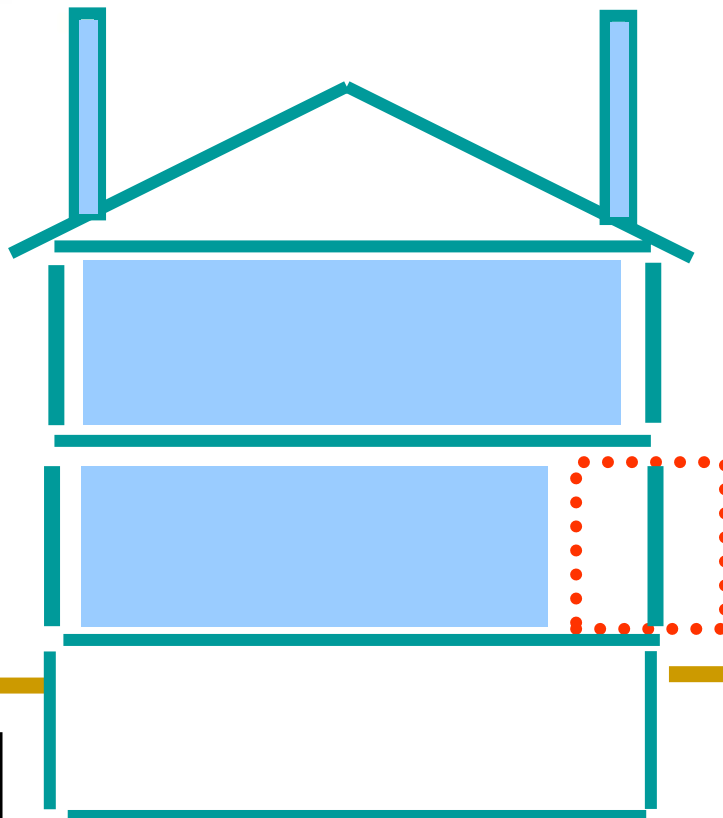
- Background
- Hygrothermal Performance of BES
  - Modeling
  - Field Experiments
  - Laboratory experiments
- Concluding Remarks and Future Work

# Research House No. 3

**HEATING AND  
VENTILATION  
FACILITY - IE**



*FY06/07 & 07/08 : Study  
& compare traditional &  
innovative HV strategies*



**FEWF- BES**

**Field monitoring**

Practice  
Review

Lab  
Exp.

**Numerical  
Modelling**











**FY06/07 & 07/08: Study  
& compare traditional &  
innovative BE strategies**

# Official Opening September 26, 2006



# FEWF Team

			
K. Abdulghani	W. Lei	M. Manning	W. Maref
			
M. Nicholls	S. Nunes	M. Rousseau	R. Berzins



# Ventilation Team

		
J. Reardon	Coop Students	I. MacDonald
		
D. Booth	G. Nong	

- Background
- **Hygrothermal Performance of BES**
  - Modeling
  - Field Experiments
  - Laboratory experiments
- Concluding Remarks and Future Work



# Hygrothermal Performance of Building Envelope Systems

Why?  
How?  
Which?  
What?

## **MODELING**

(i.e. IRC's HAM Tools  
hygIRC 1D & 2D,  
WeatherSmart)

## **FIELD**

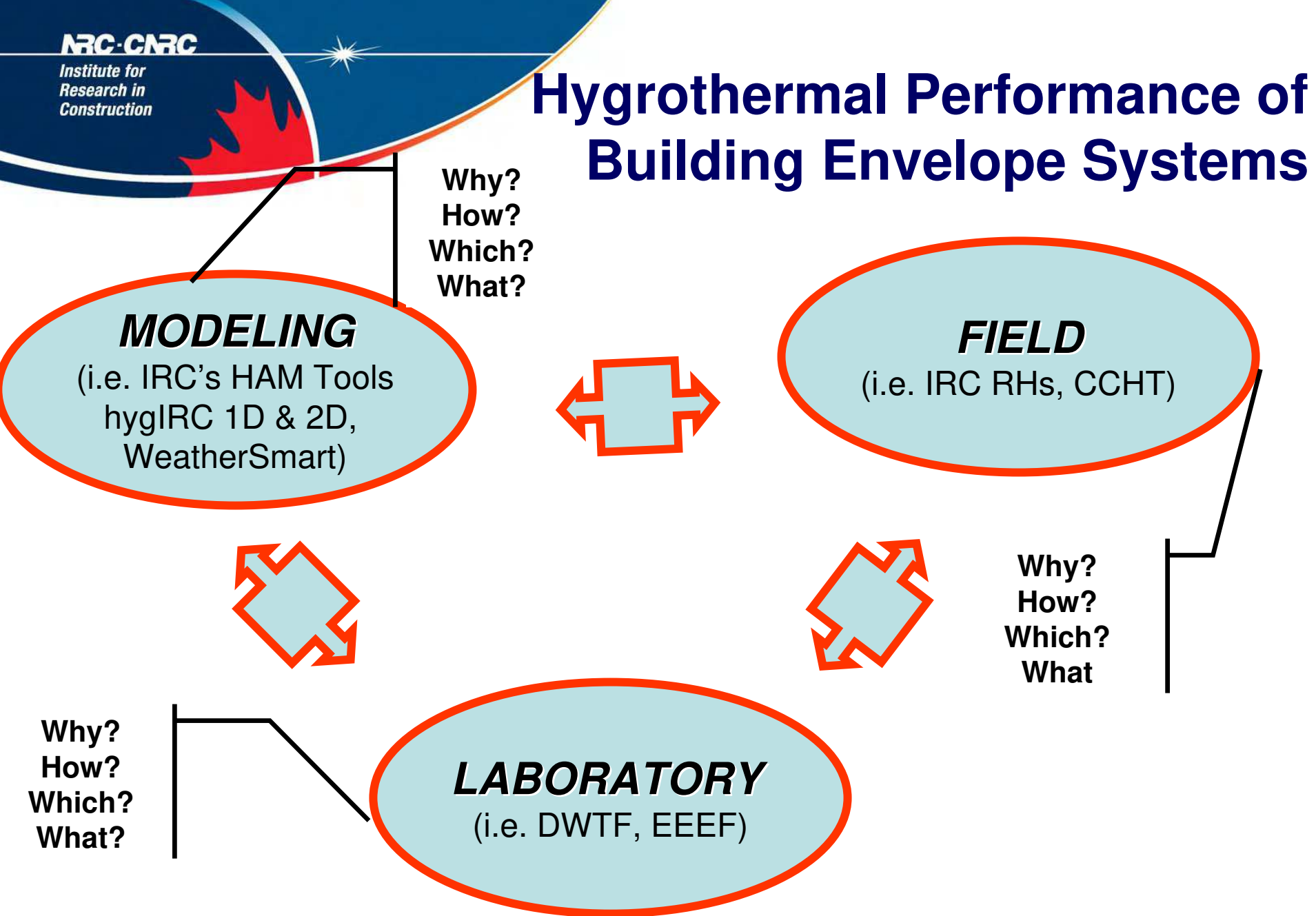
(i.e. IRC RHs, CCHT)

Why?  
How?  
Which?  
What

## **LABORATORY**

(i.e. DWTF, EEEF)

Why?  
How?  
Which?  
What?



- Background
- Hygrothermal Performance of BES
  - Modeling
  - Field Experiments
  - Laboratory experiments
- Concluding Remarks and Future Work

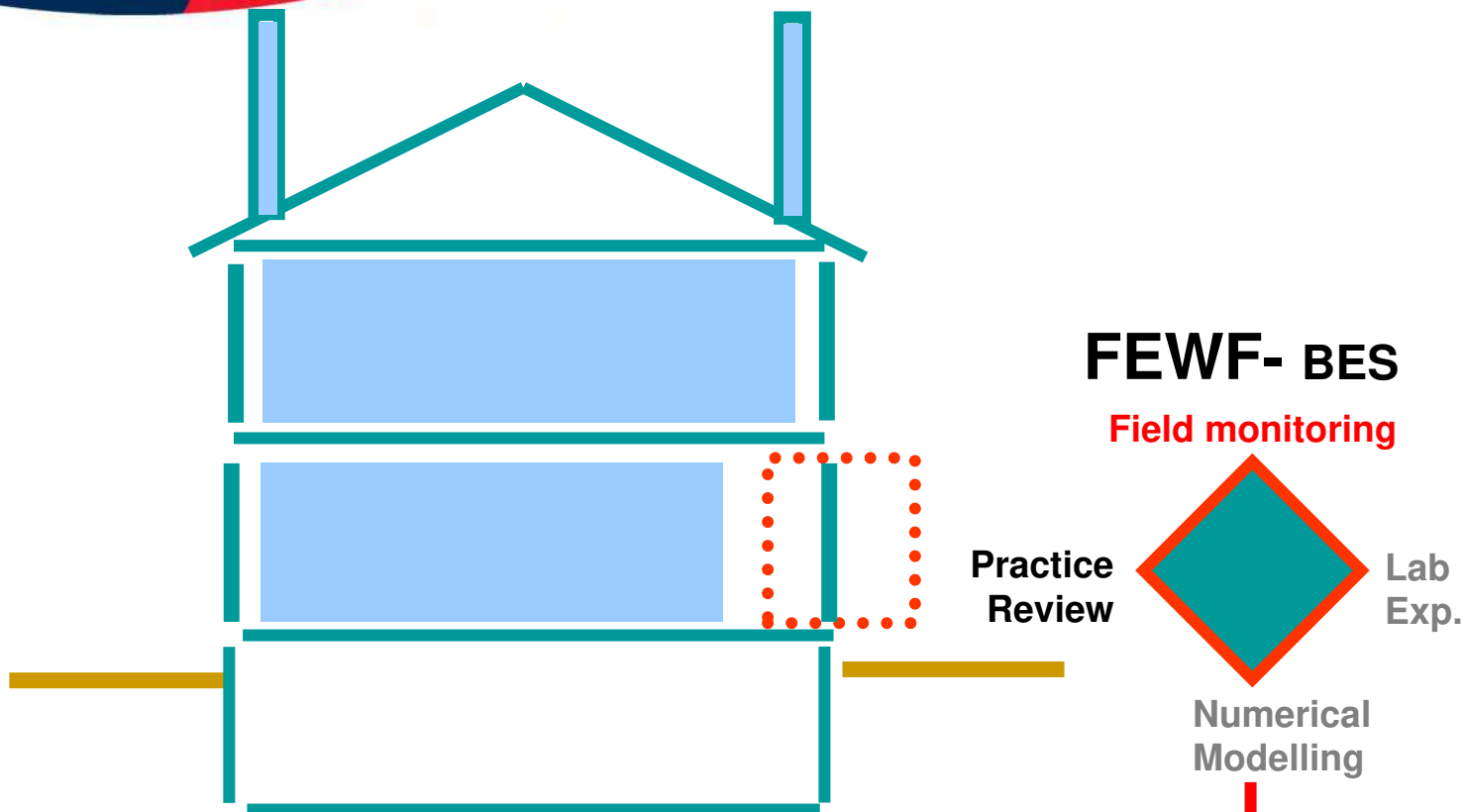
- Why to do modeling?
- How to model?
- Which model to use?
- What do you expect from modeling?

# Modeling: IRC's HAM Tools

- *hygIRC* 1-D V. 1.1 is a user-friendly, one-dimensional version of NRC-IRC's *hygIRC*, a state-of-the-art hygrothermal model.
    - ❑ 1-D *hygIRC* can be used for
      - parametric analysis: changing weather (locations), materials, for example
- For more information please visit *hygIRC* Website:  
[http://irc.nrc-cnrc.gc.ca/bes/software/hygIRC/index\\_e.html](http://irc.nrc-cnrc.gc.ca/bes/software/hygIRC/index_e.html)
- *hygIRC* 2D is the Advanced hygrothermal models
    - ❑ Best handled by *hygIRC* 2-D
      - air leakage
      - water leaks
      - gravity effects
  - *WeatherSmart*

- Background
- Hygrothermal Performance of BES
  - Modeling
  - **Field Experiments**
  - Laboratory experiments
- Concluding Remarks and Future Work

# Research House No. 3



FY06/07 & 07/08: Study  
& compare traditional &  
innovative BE strategies



# Field Experiments

- Why to do field experiment?
- How to do experiment?
- Which physical phenomena to investigate,..?
- What do you expect from experiments?

# IRC Field Exposure of Walls Facility (FEWF)



- **Objectives**

- Compare performance of different side-by-side wall assemblies
- improve understanding of HAM response of wall and window assemblies exposed to naturally occurring climate loads of Ottawa as well as to indoor environment loads of T, RH and P defined by occupancy and HVAC systems.
- Research the interaction between the building envelope and the indoor environment
- Complement IRC's controlled laboratory test and modeling simulations

# IRC Field Exposure of Walls Facility (FEWF)

- **Experimental Approach**

- **Year 1 (2006-2007)** Commission the facility by monitoring three identical test specimens of traditional construction (2x6) through Fall, Winter and Spring.
- **Year 2 (2006-2007)** Investigate the performance of two to three wall specimens of different innovative designs based on industrial collaboration/partnership.
- **Year 3 and beyond** Expand the program in collaboration with Indoor Environment to examine whole house performance issues.



South facade



North facade



West facade

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specimens

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Inst  
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- Background
- Hygrothermal Performance of BES
  - Modeling
  - Field Experiments
    - **Construction of the test bay**
    - Construction of the walls
    - Wall Assembly (Inside)
    - Wall Assembly (Outside)
    - Instrumentation
  - Laboratory experiments
- Concluding Remarks and Future Work



# IRC Field Exposure of Walls Facility (FEWF)





# IRC Field Exposure of Walls Facility (FEWF)



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# IRC Field Exposure of Walls Facility (FEWF)





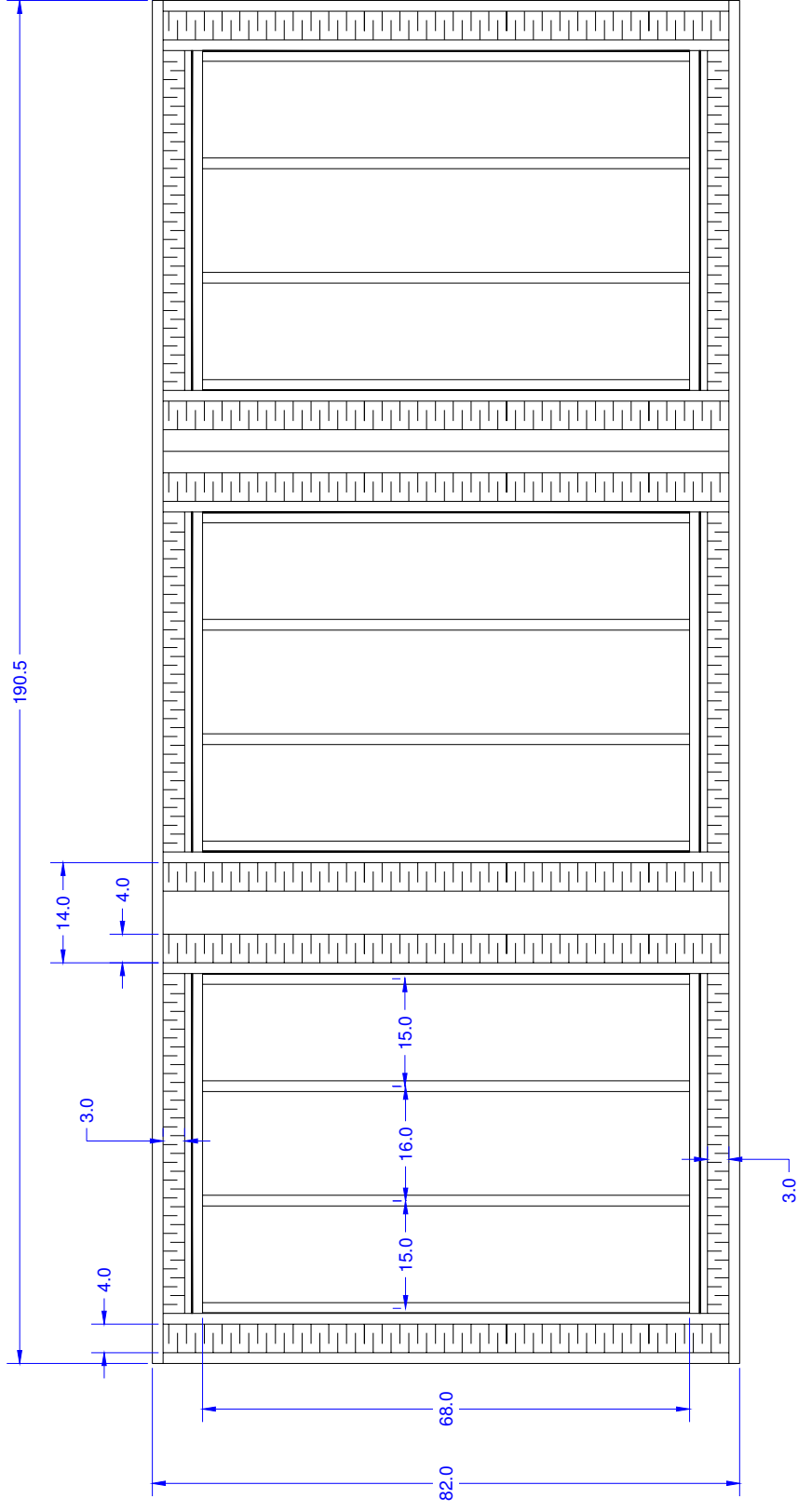
# IRC Field Exposure of Walls Facility (FEWF)



- Background
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  - Modeling
  - Field Experiments
    - Construction of the test bay
    - **Construction of the walls**
    - Wall Assembly (Inside)
    - Wall Assembly (Outside)
    - Instrumentation
  - Laboratory experiments
- Conclusion



# IRC Field Exposure of Walls Facility (FEWF)



# IRC Field Exposure of Walls Facility (FEWF)



# IRC Field Exposure of Walls Facility (FEWF)







- Background
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    - Construction of the test bay
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    - Wall Assembly (Outside)
    - Instrumentation
  - Laboratory experiments
- Concluding Remarks and Future Work



















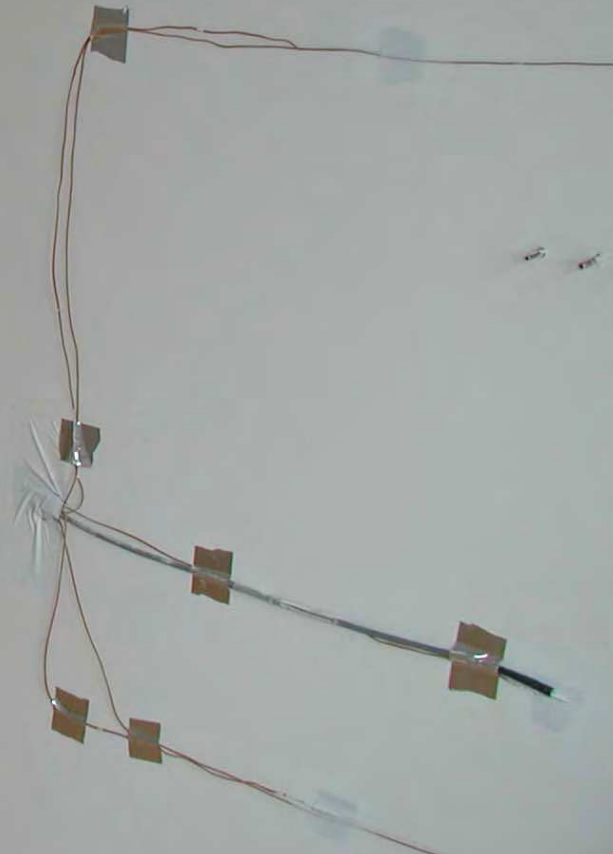






IRC Field Exposure of Mail Facility (FEWF)

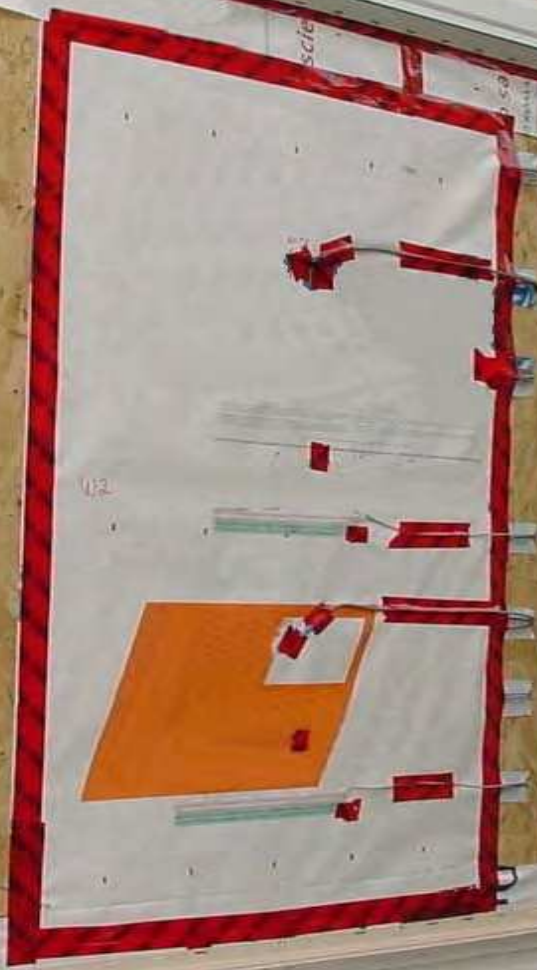
Installation d'exposition in-situ des murs de l'IRC (IEIM)



- Background
- Hygrothermal Performance of BES
  - Modeling
  - Field Experiments
    - Construction of the test bay
    - Construction of the walls
    - Wall Assembly (Inside)
    - **Wall Assembly (Outside)**
    - Instrumentation
  - Laboratory experiments
- Concluding Remarks and Future Work















M-24TH3

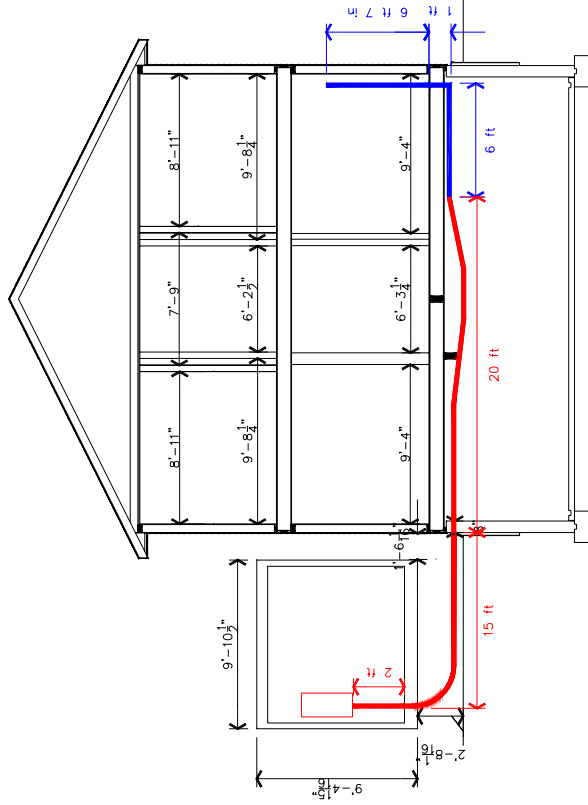


- Background
- Hygrothermal Performance of BES
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  - **Field Experiments**
    - Construction of the test bay
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    - Wall Assembly (Inside)
    - Wall Assembly (Outside)
    - **Instrumentation**
  - Laboratory experiments
- Concluding Remarks and Future Work



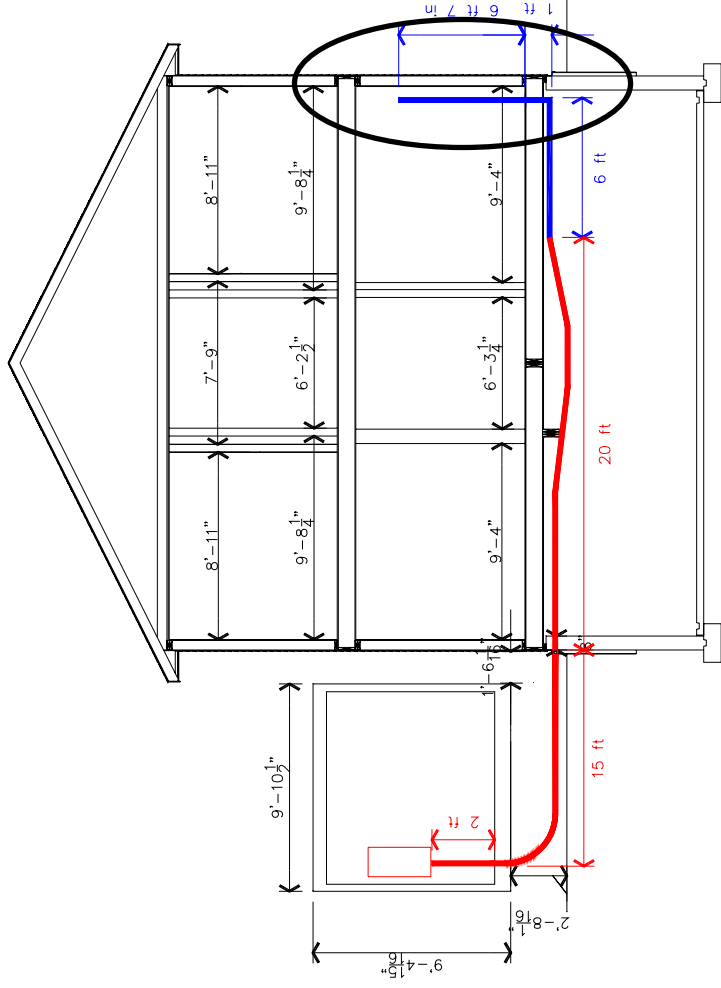
# FEWF Instrumentation

- First Floor
- Basement
  - Wall to Junction Boxes
- Trailer



# FEWF Instrumentation

- First Floor
- Basement
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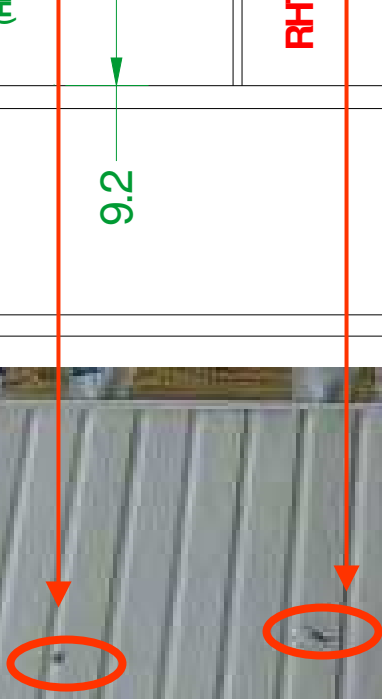




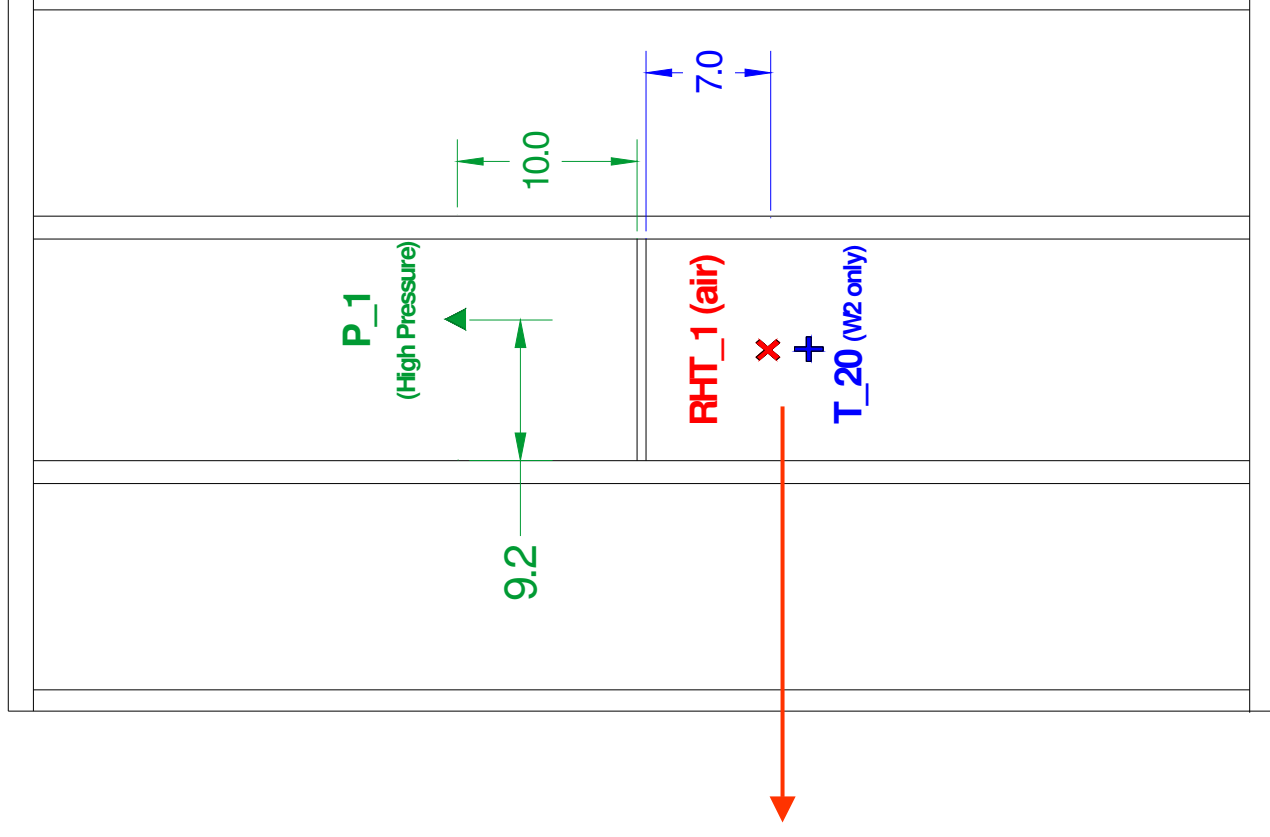
Rain Gauge



## A close-up photograph of a light-colored wooden plank, possibly a piece of lumber or a boardwalk. Two small, dark, circular spots are visible on the surface, which are circled in red. Red arrows point from the top of the image to these spots, indicating areas of interest or damage. The plank is part of a larger structure, with other wooden elements visible in the background.

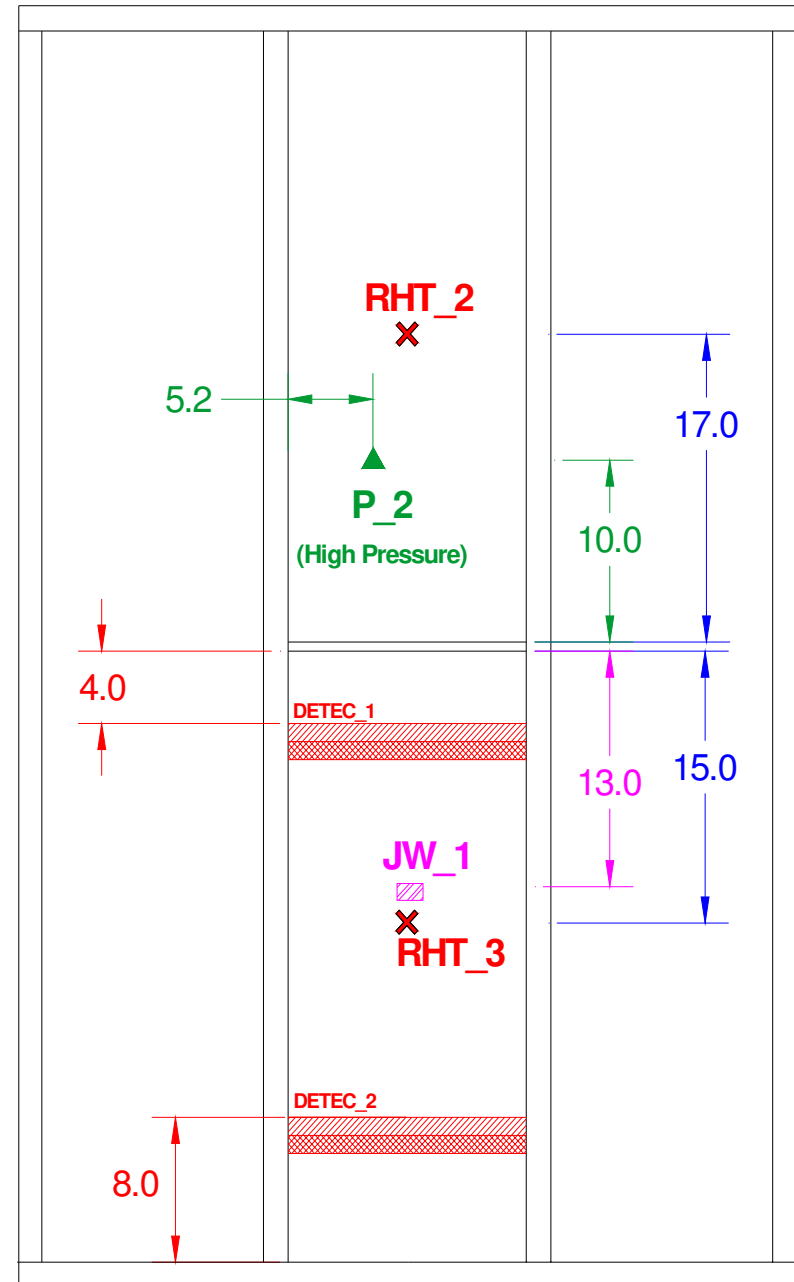


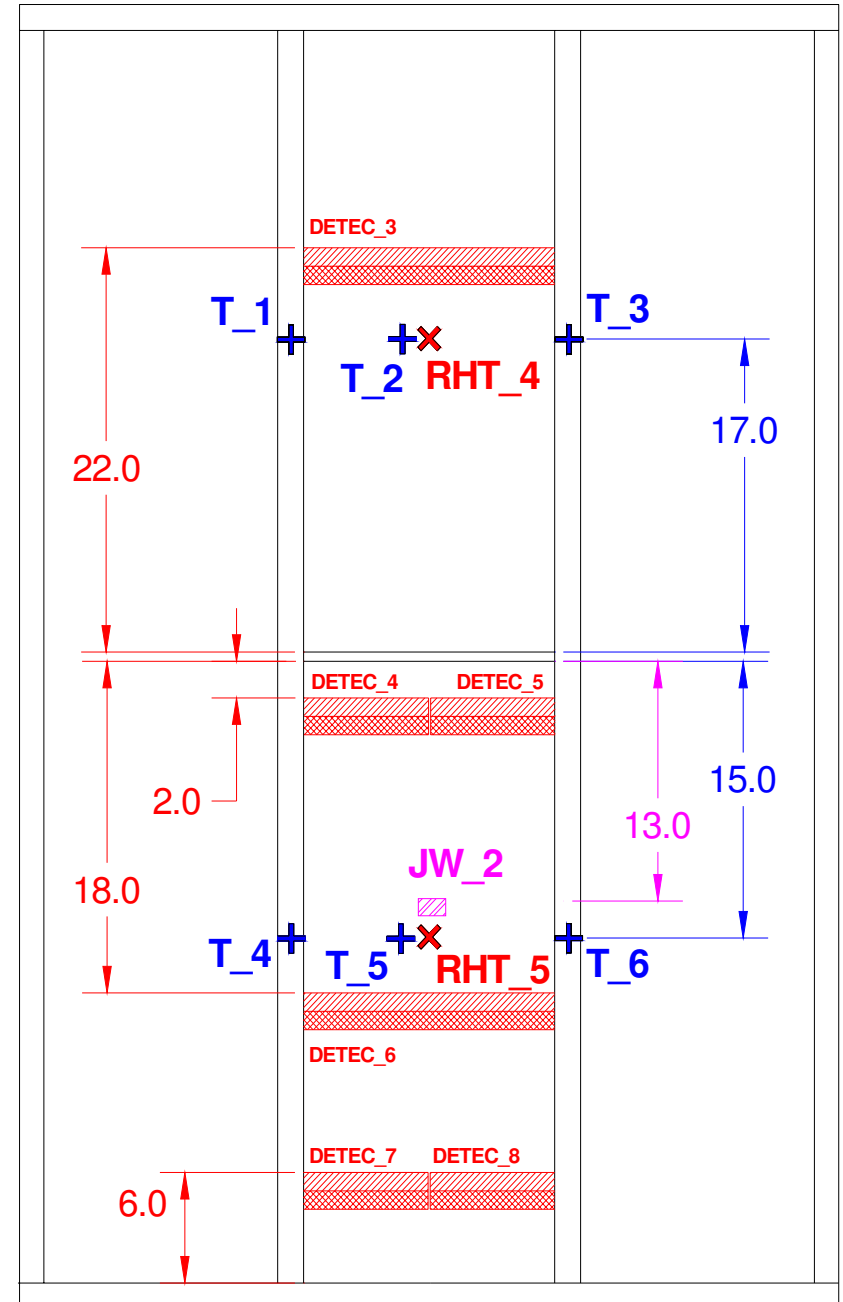
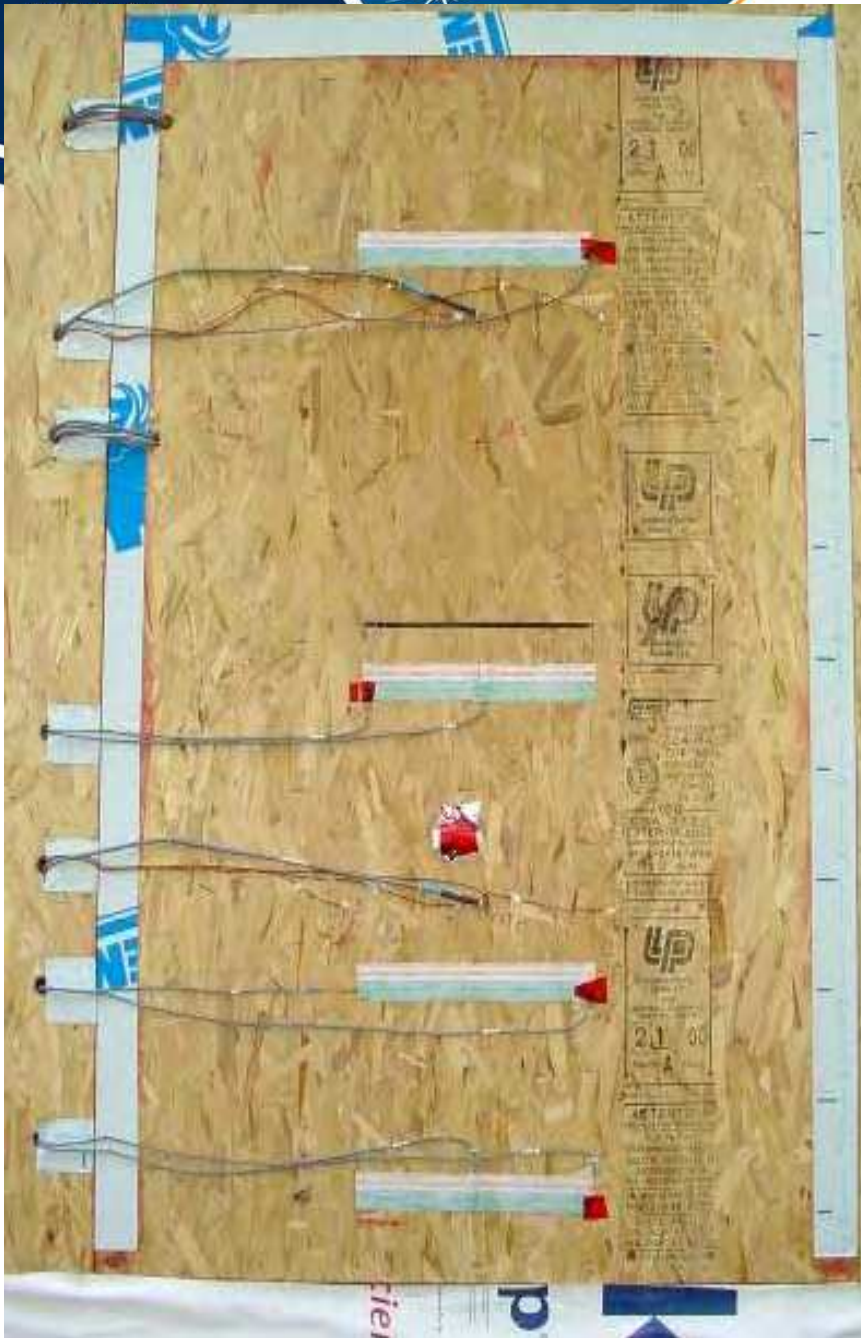
## LAYER 1 - Exterior Face of Vinyl Siding



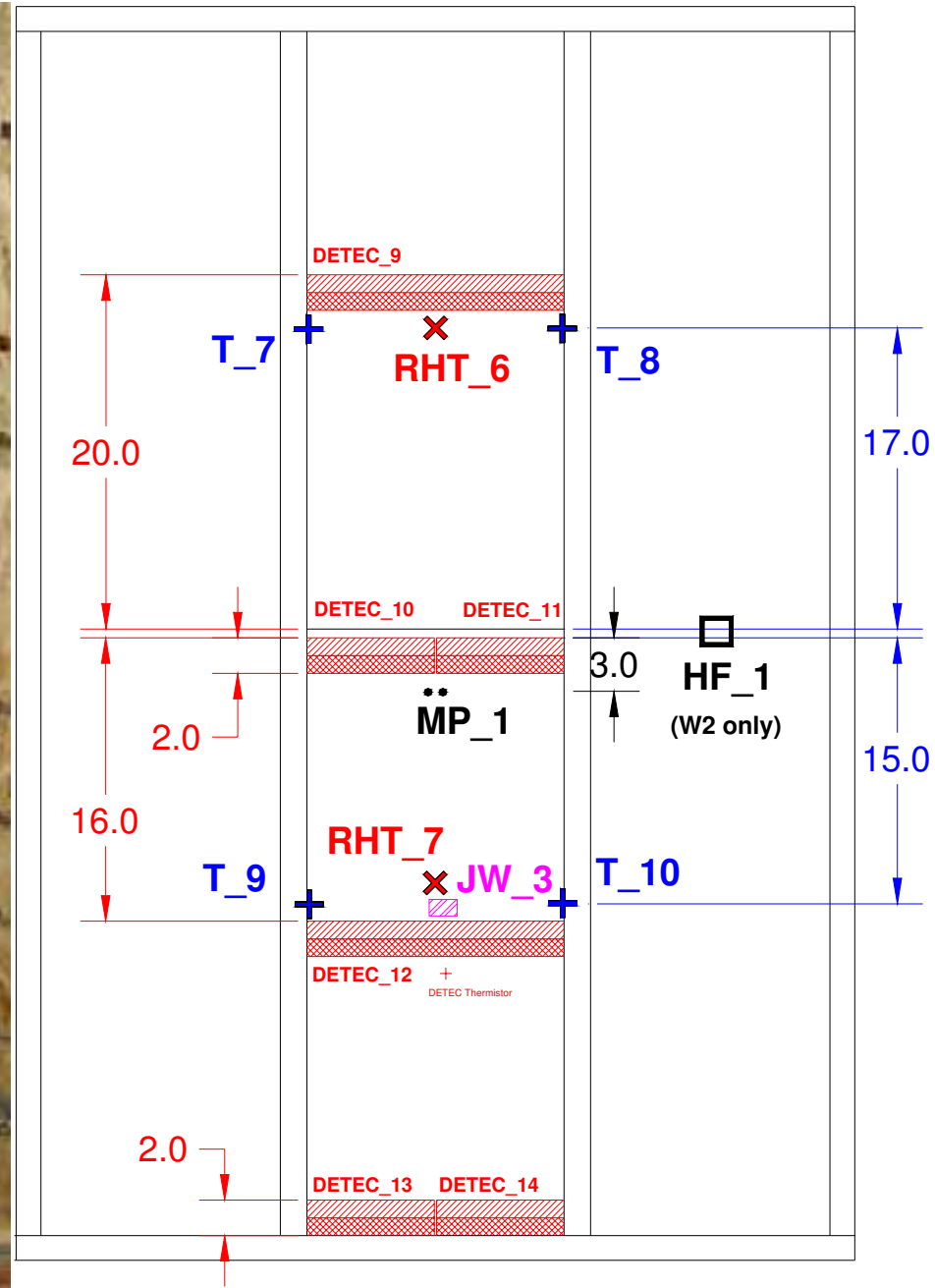


## LAYER 2 - Exterior Face of Sheathing Membrane

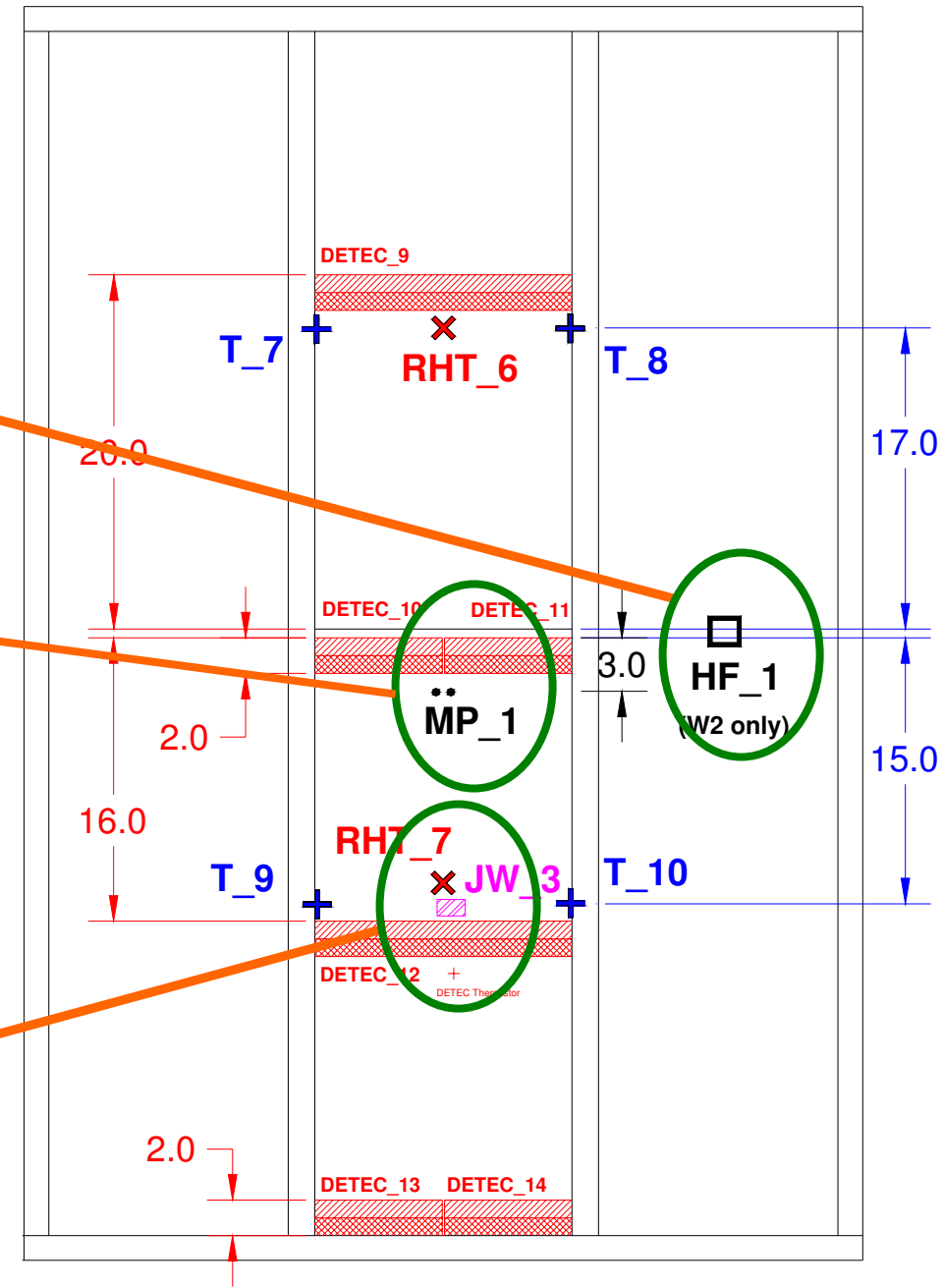
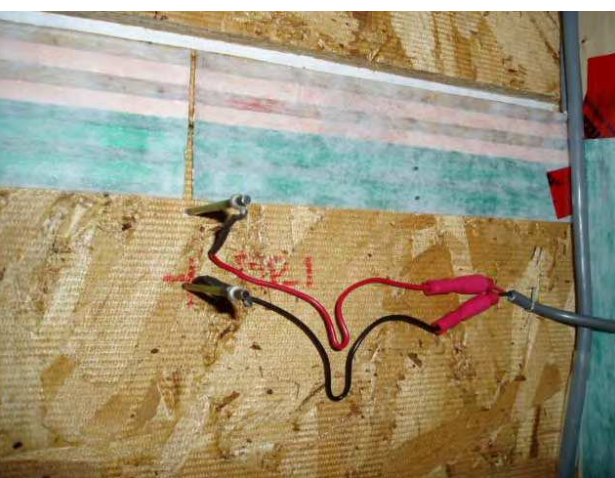




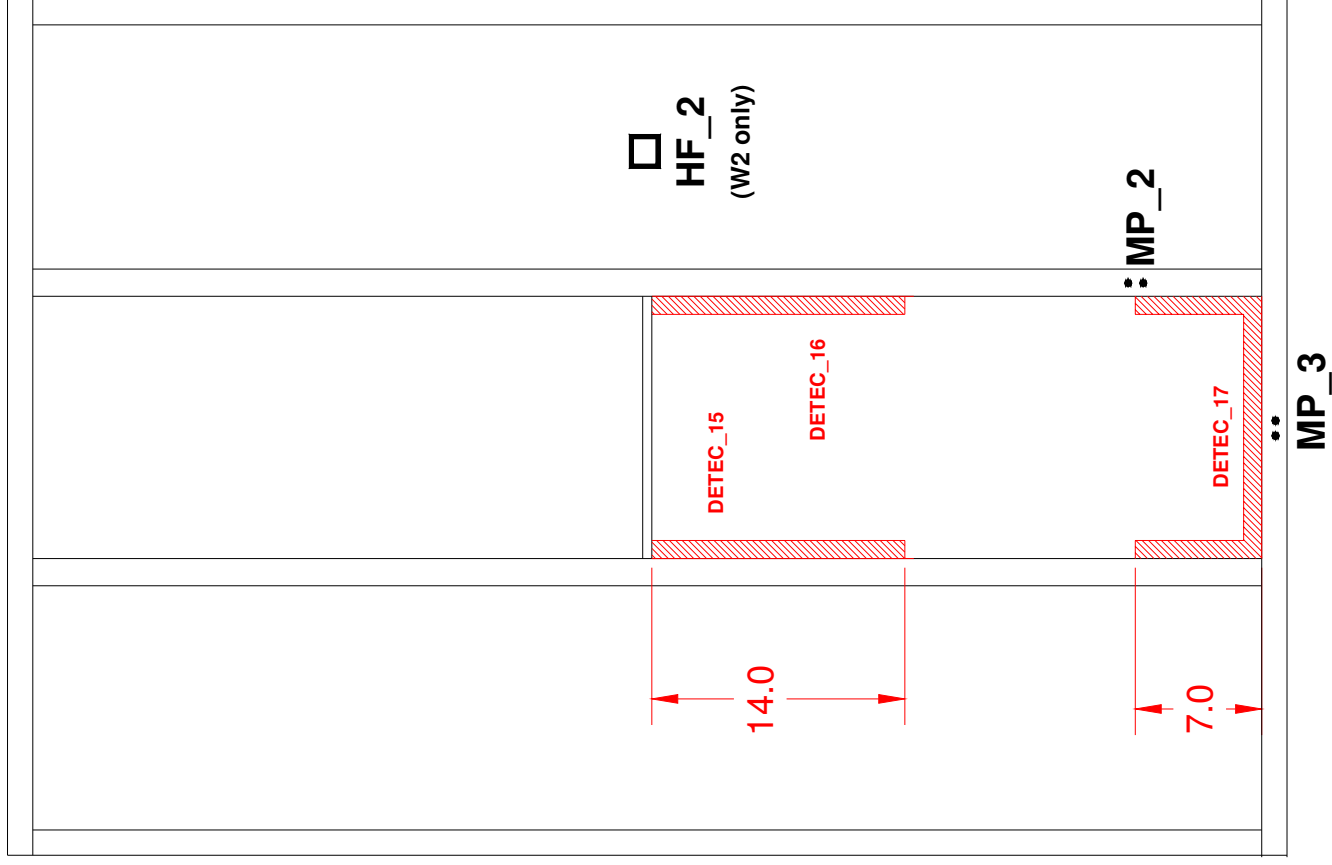




## LAYER 4 - Interior Face of OSB

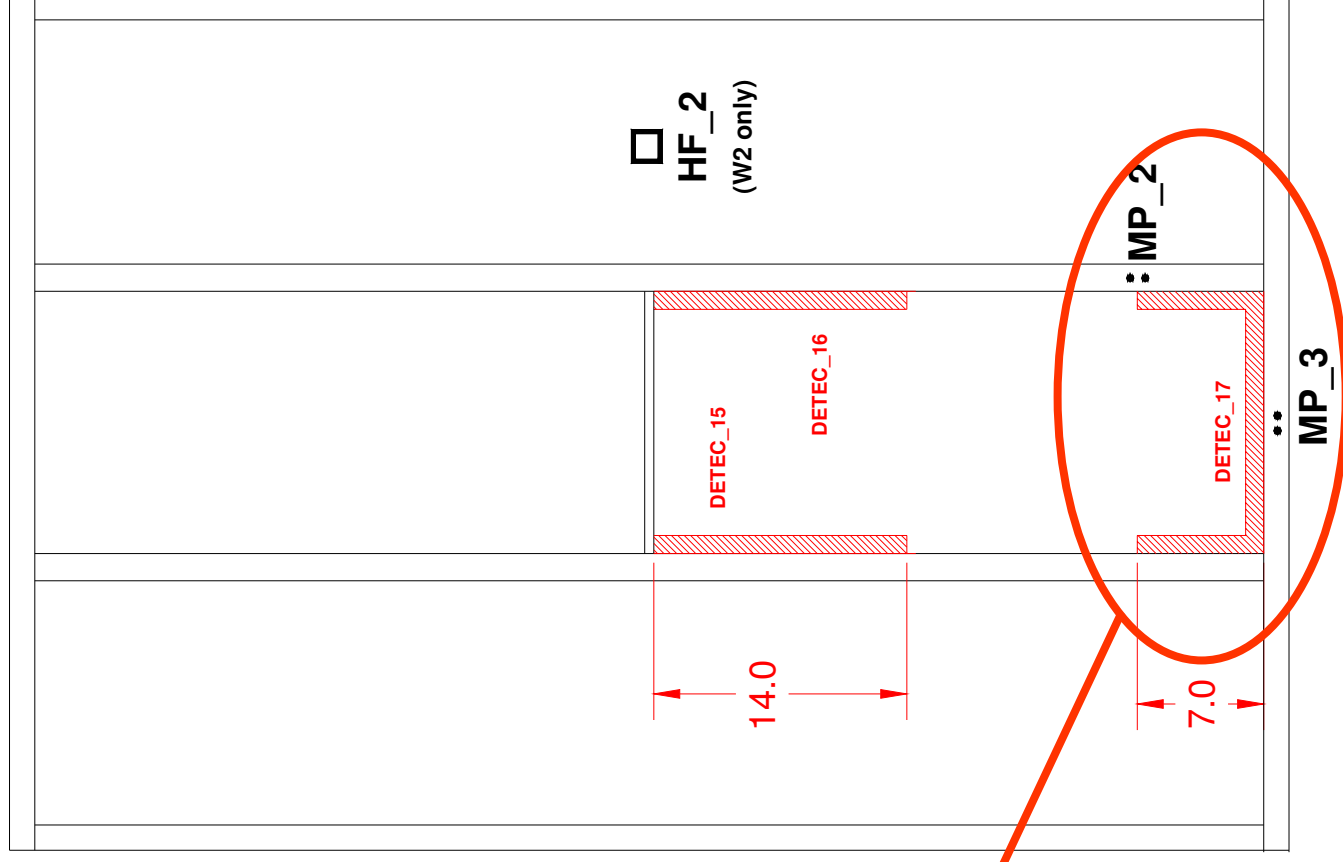


# LAYER 5 - Stud Cavity



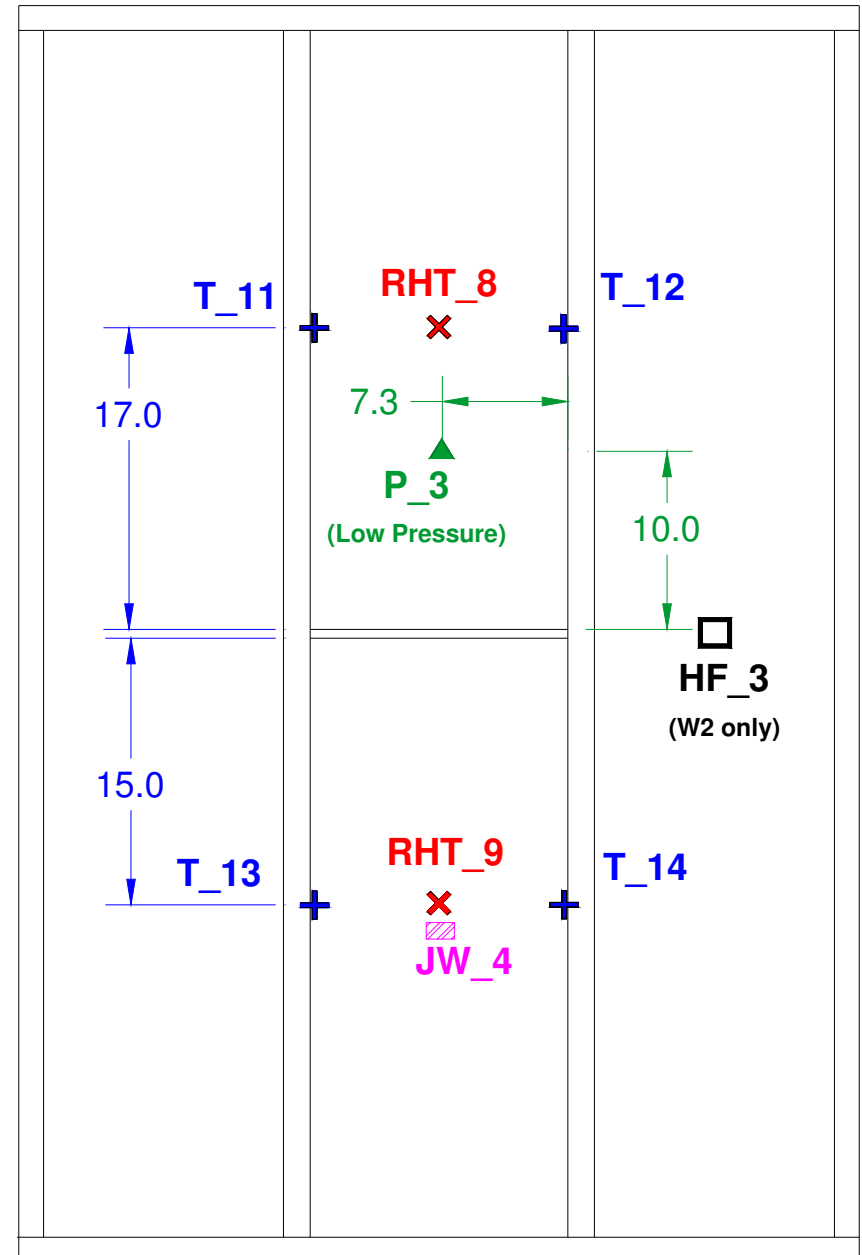


## LAYER 5 - Stud Cavity

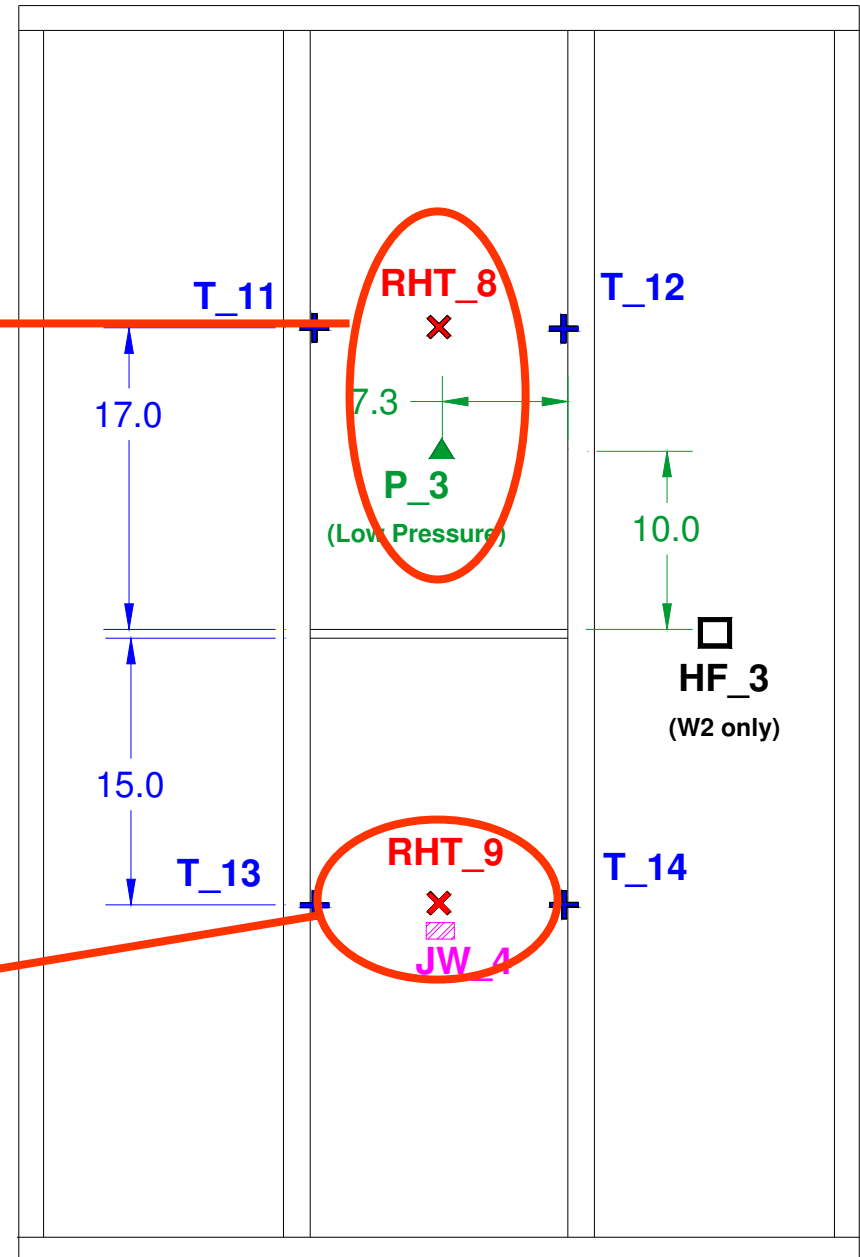




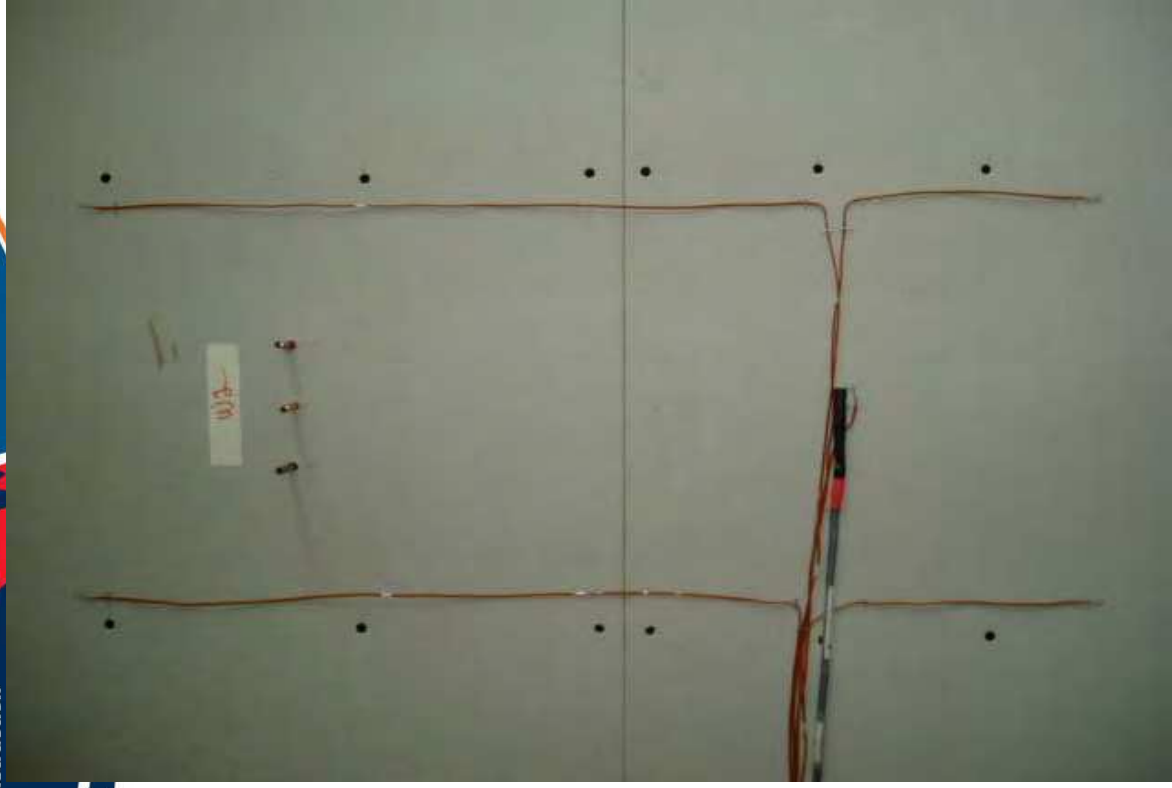
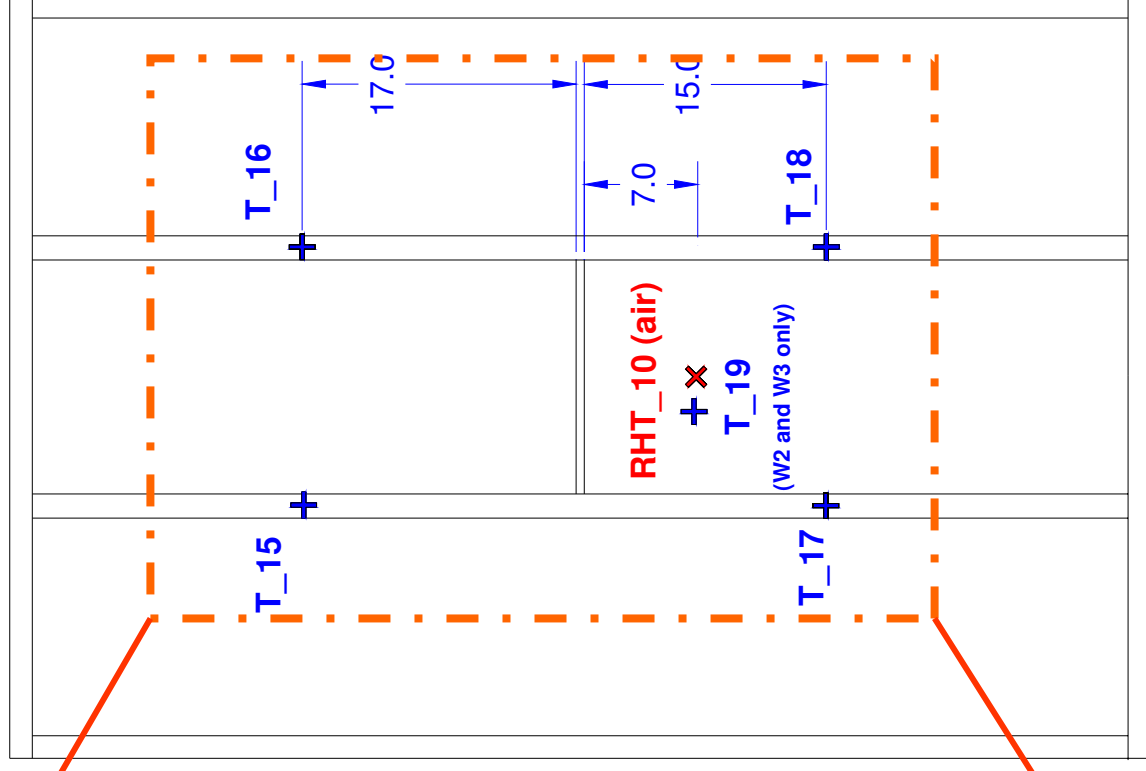
# LAYER 6 - Interior Face of Insulation & Stud Cavity (Exterior side of Vapour Barrier)



# LAYER 6 - Interior Face of Insulation & Stud Cavity (Exterior side of Vapour Barrier)



## LAYER 7 - Interior Face of Drywall



# IRC Field Exposure of Wall Facility (FEWF)

## Material

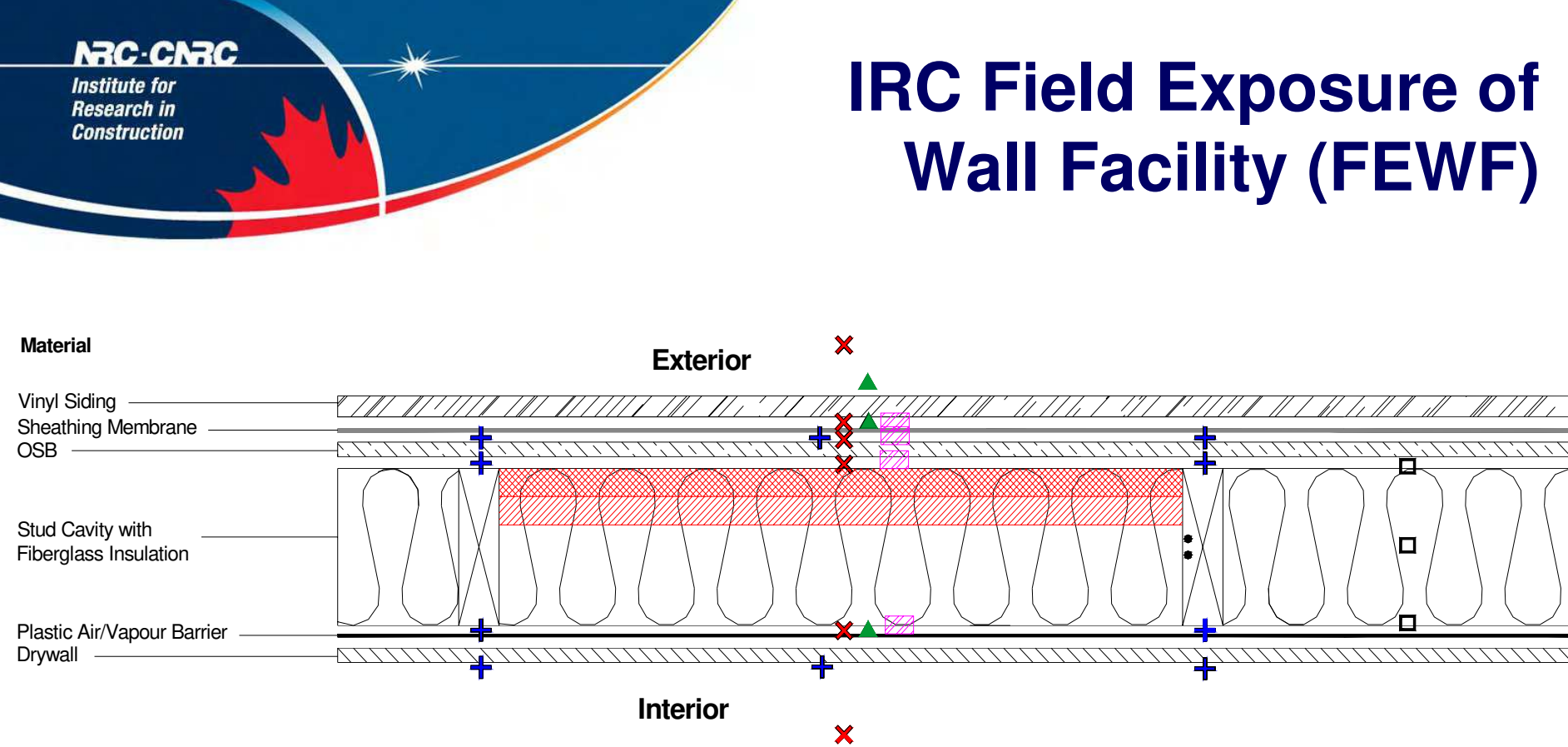
Vinyl Siding  
Sheathing Membrane  
OSB  
  
Stud Cavity with  
Fiberglass Insulation  
  
Plastic Air/Vapour Barrier  
Drywall

Exterior

Interior

## Instrumentation - Plan View

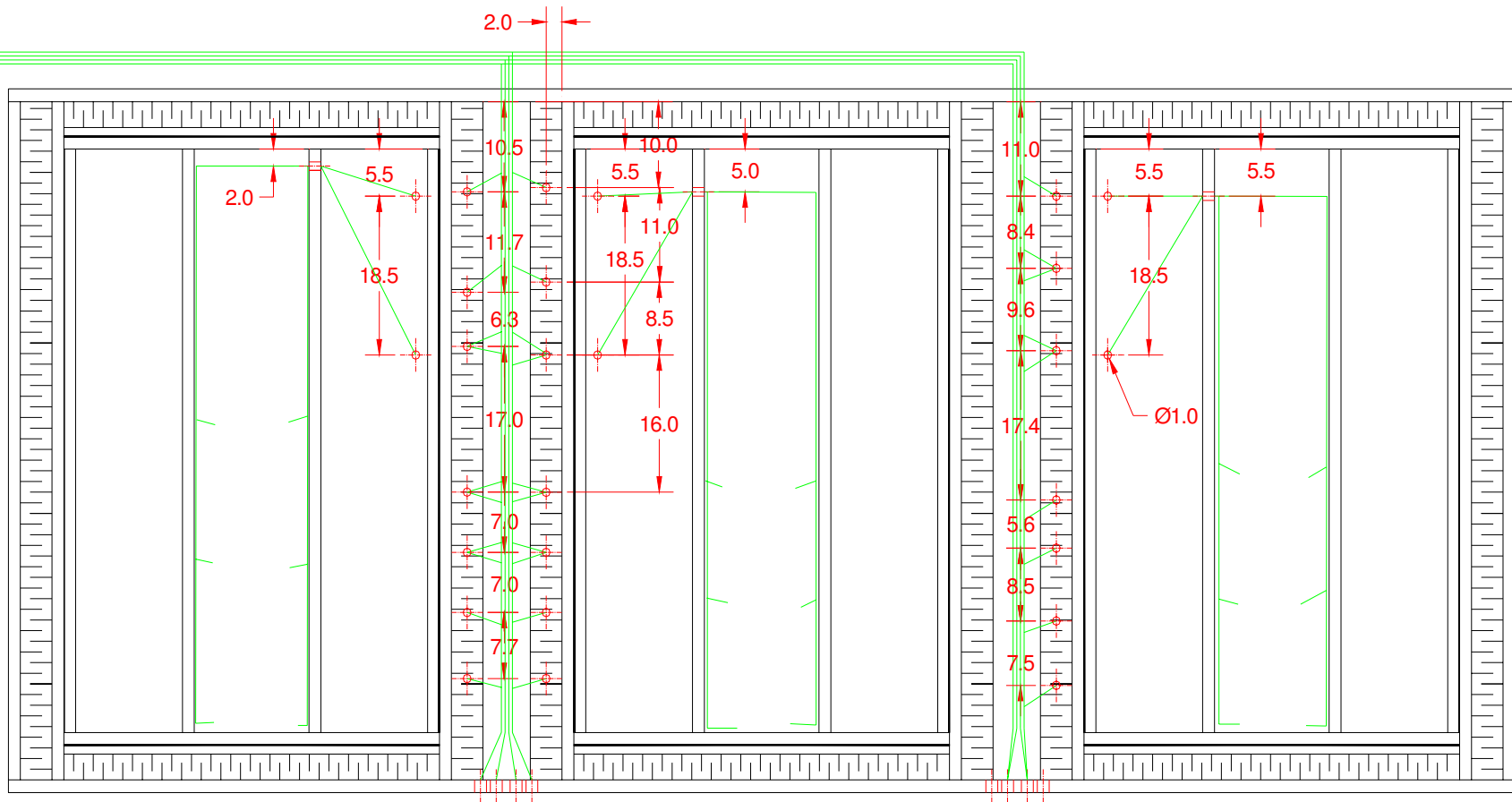
- ✕ RH and T sensors
- ✚ T sensors
- ▲ Air Pressure sensor
- Moisture Pins
- ▨ Jeld-Wen Wireless RH&T Sensors
- Heat Flux Transducer (for W2 only)
- ▩ DETEC







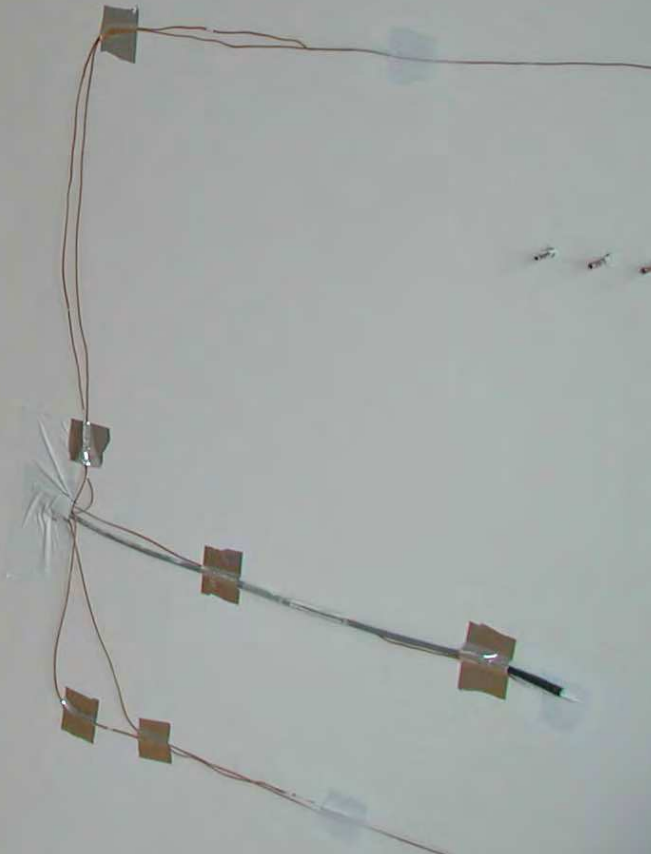
**Around 17000ft of cable**



View from interior of specimen. All dimensions in inches.

IRC Field Exposure of Wall Facility (FEWF)

Installation d'exposition in-situ des murs de l'IRC (IEIM)

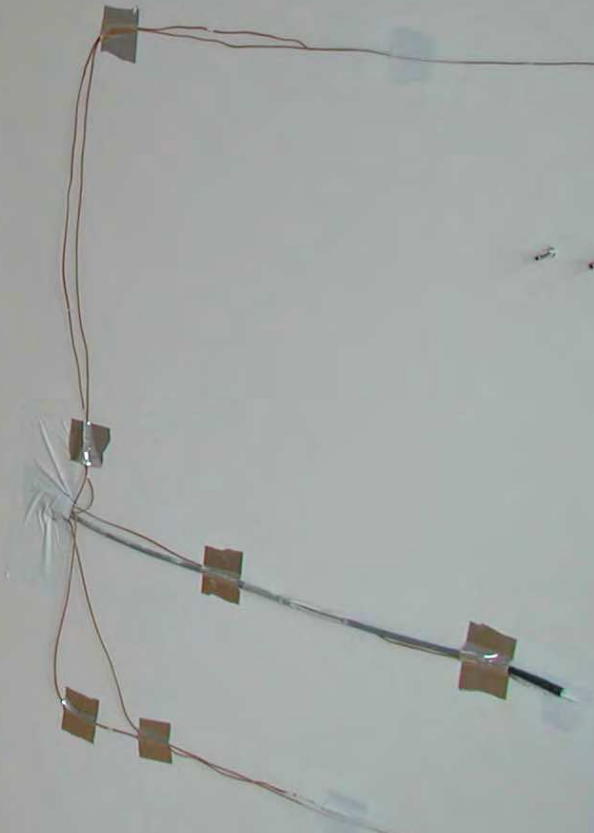




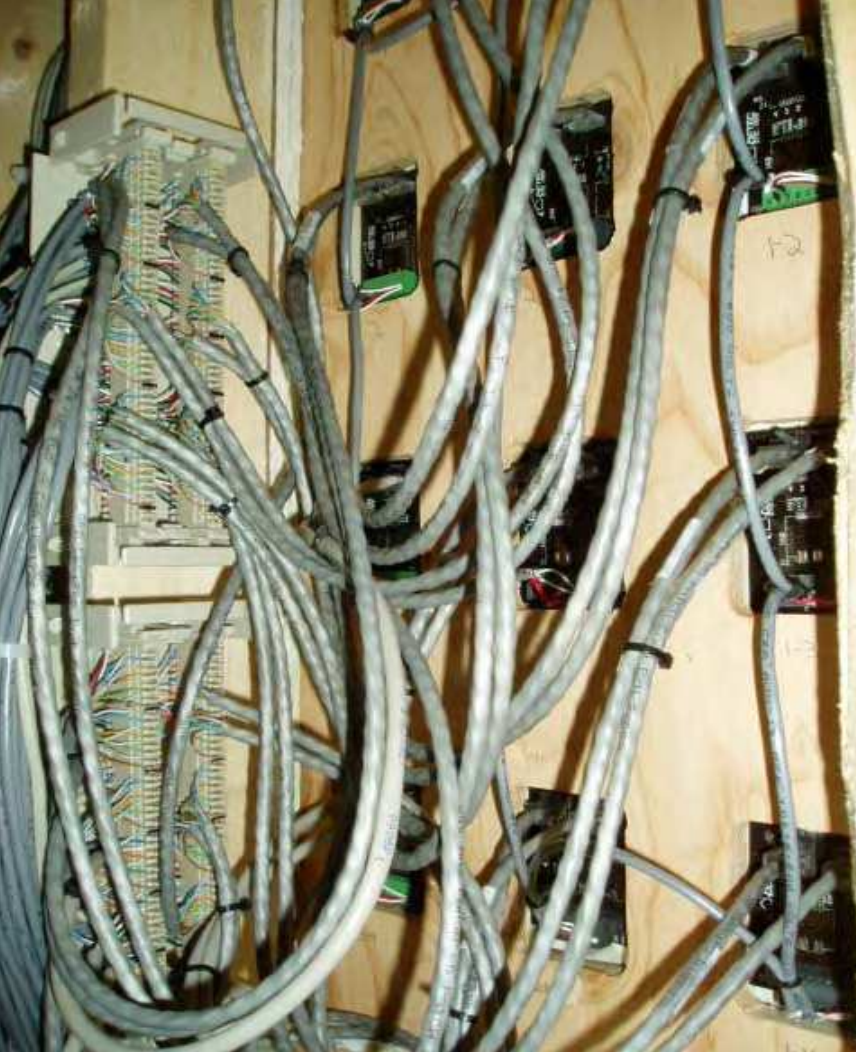


Installation d'exposition in-situ des murs de l'IRC (IEIM)

IRC Field Exposure of Wall Facility (FEWF)







**Board Layout -Rear**

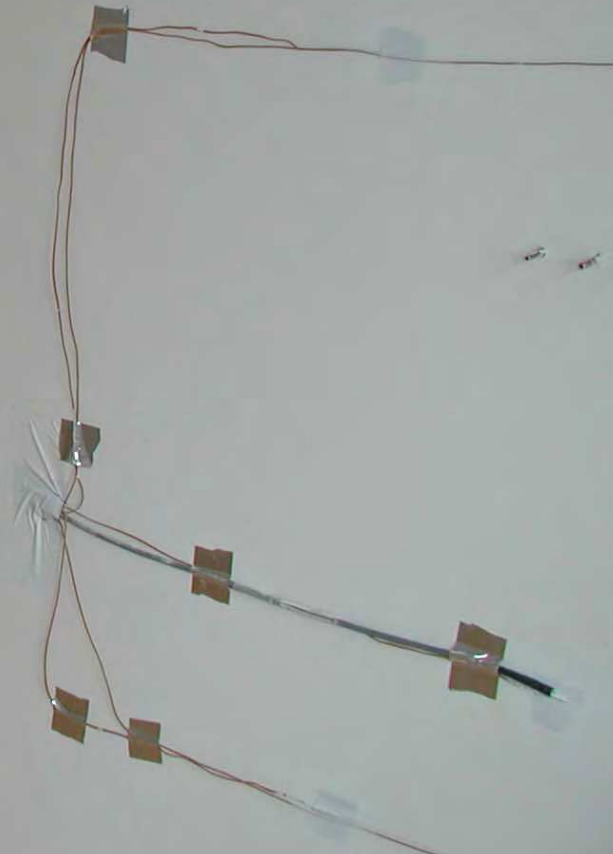
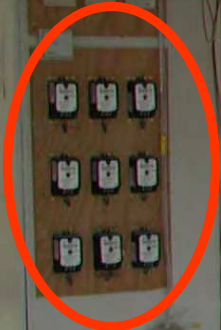


**Board Layout - Front**

**9 RMUs (Remote Monitoring Unit)  
9 x 8 zones inputs = (72 zones)**

IRC Field Exposure of Mail Facility (FEWF)

Installation d'exposition in-situ des murs de l'IRC (IEIM)



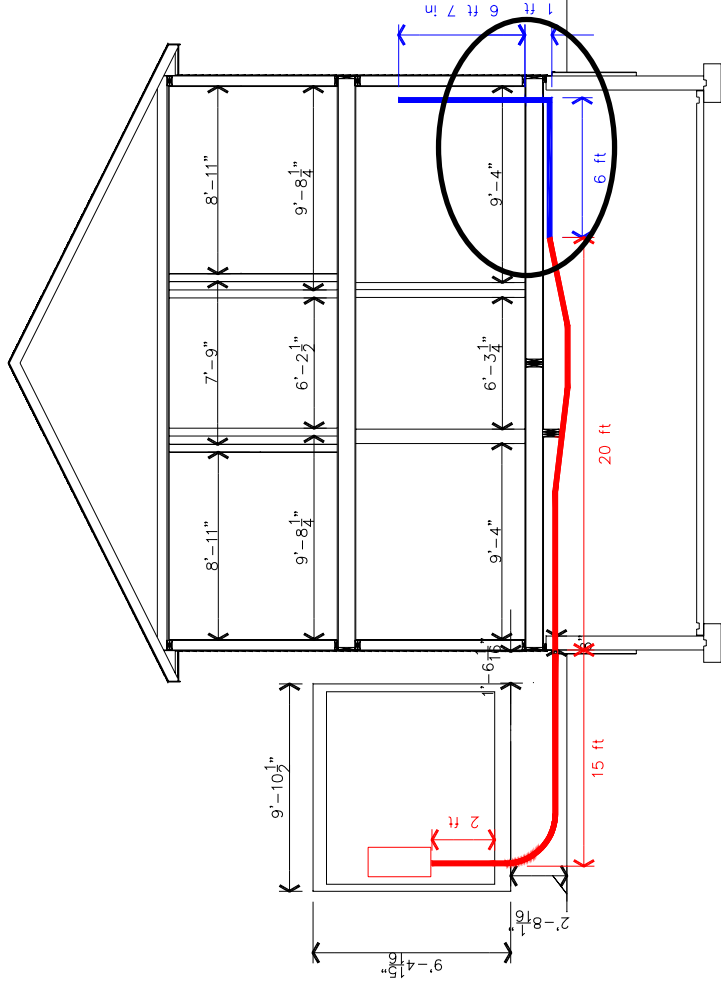




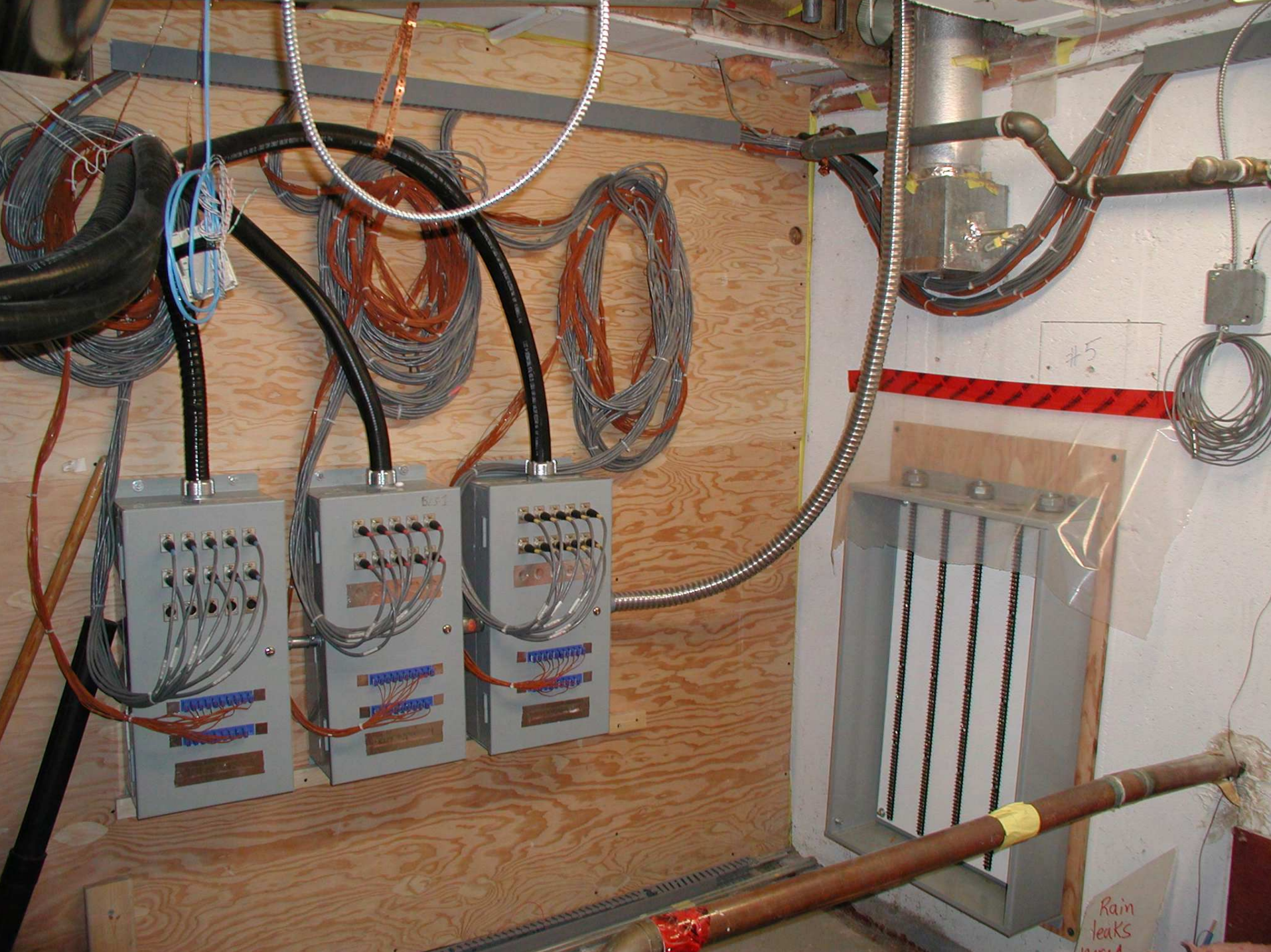
**9 Differential Pressure Transducers:  
3 DP of 0.25" WC  
6 DP of 2.5" WC**

# FEWF Instrumentation: Cable Wiring

- First Floor
- Basement
  - Wall to Junction Boxes
- Trailer



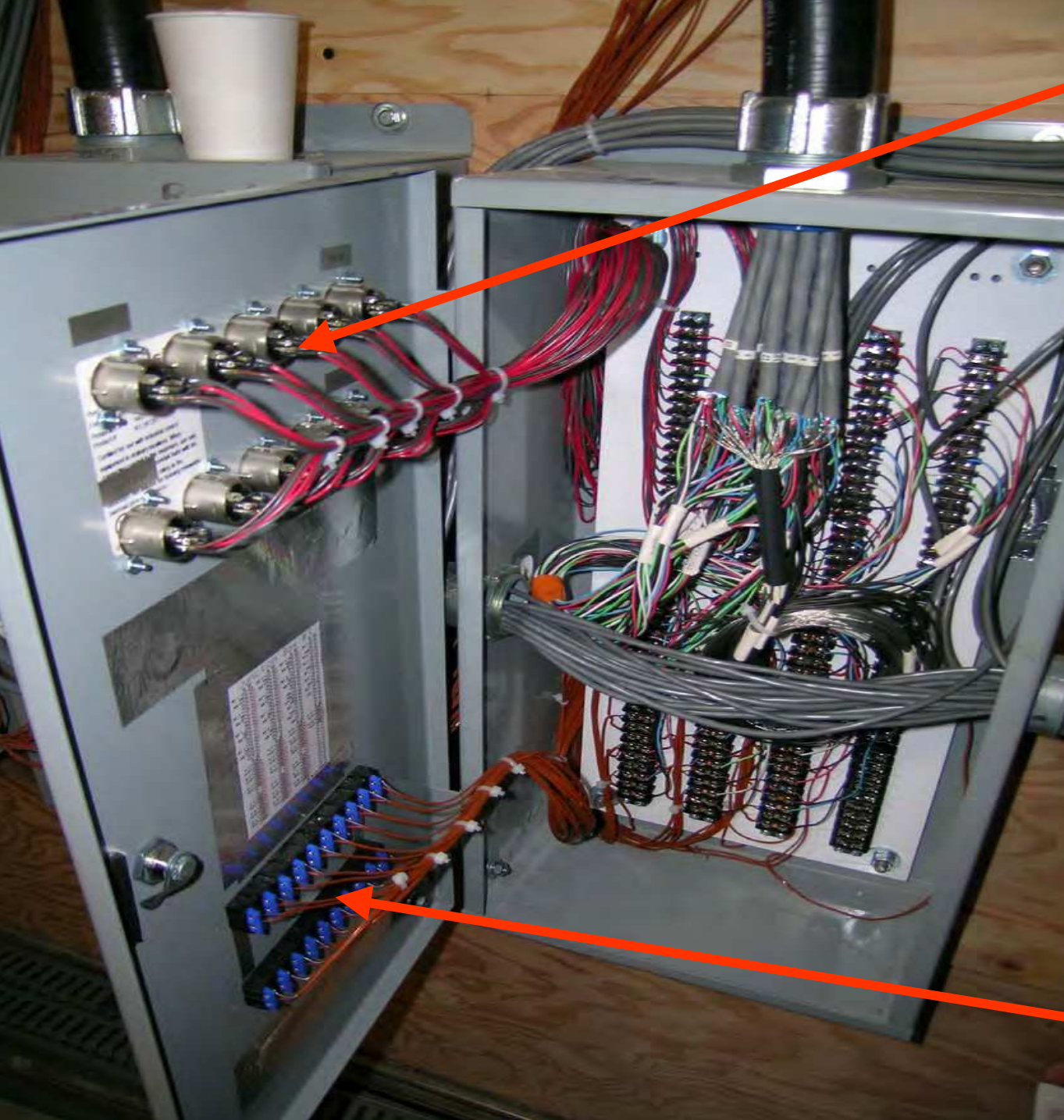




#5

Rain  
leaks  
inside





10 RHT Sensors



3 DP Transducers



3 MP Sensors



**Junction Box  
Wall 2**



3 HFT



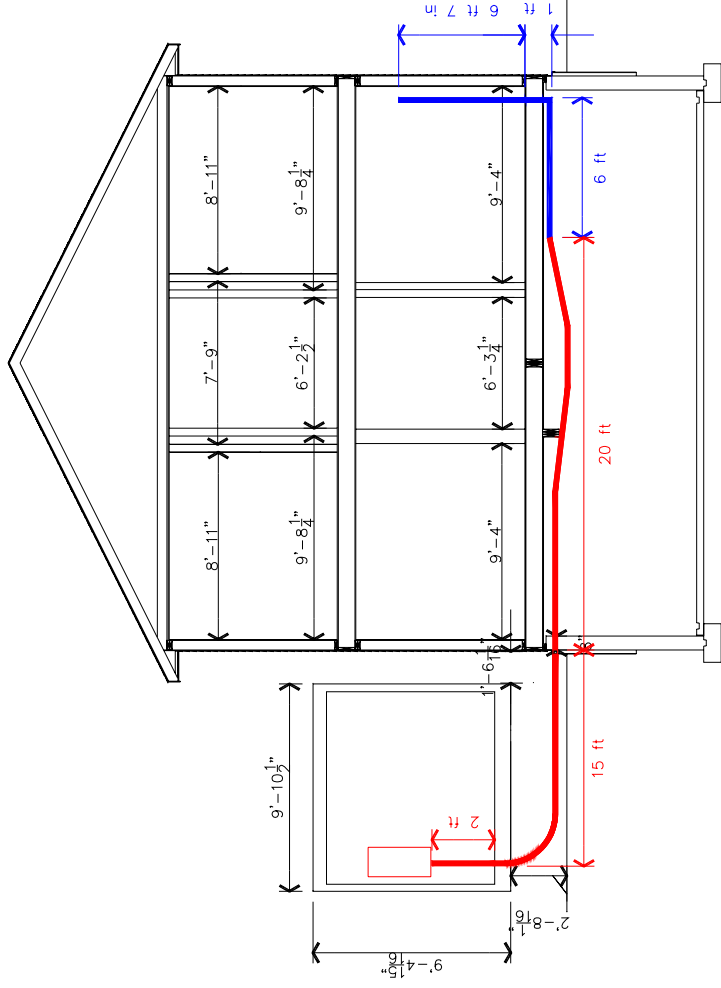
1 RTD as Ref



20 Thermocouples

# FEWF Instrumentation: Cable Wiring

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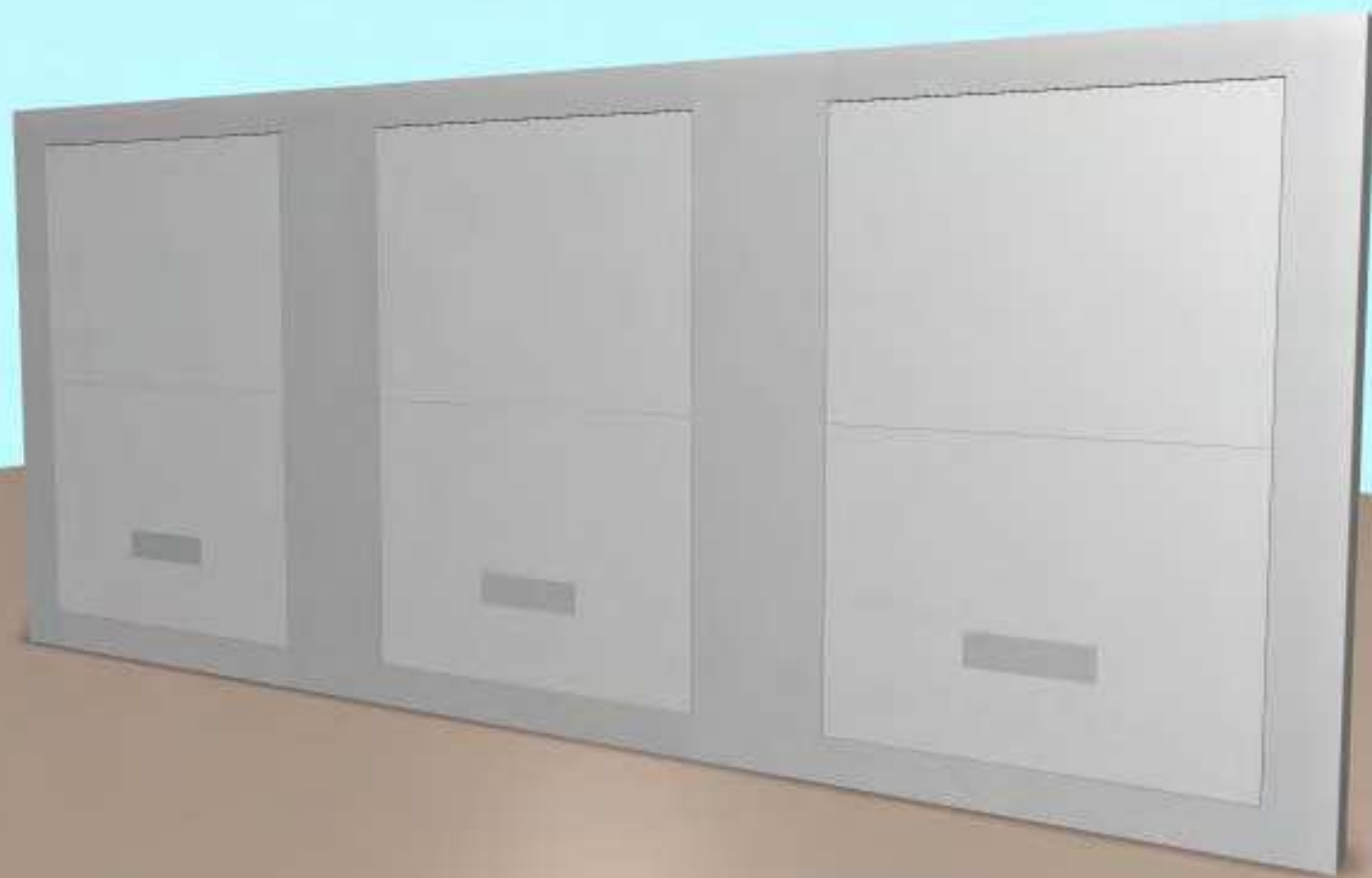


# Experimental Approach

- **The experiments will be in three phases:**
  - **Phase 1:** Commission the facility by monitoring three identical test specimens of traditional construction (2x6) through Fall, and part of the Winter under naturally occurring conditions.
  - **Phase 2:** Challenging the wall during the Winter
    - Stage 1- Create air leakage path and monitor under naturally occurring int. and ext. conditions on two of three specimens (1 week)
    - Stage 2- Increase indoor RH to 45% and induce 10 Pa positive pressure while air leak path is present in two specimens, for 2 weeks (?)
  - **Phase 3:** Return to naturally occurring conditions to monitor drying. Disassemble the indoor chamber

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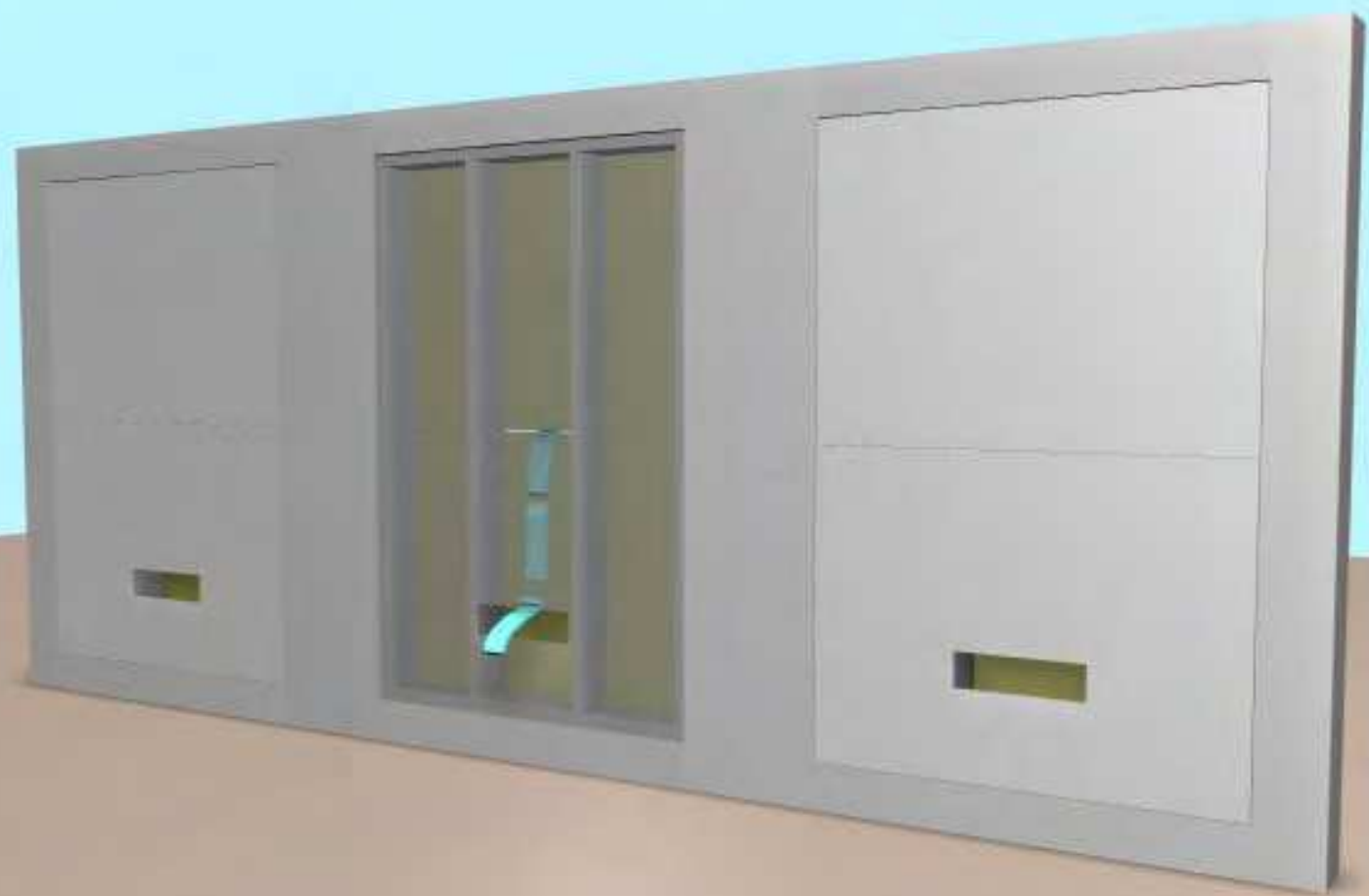


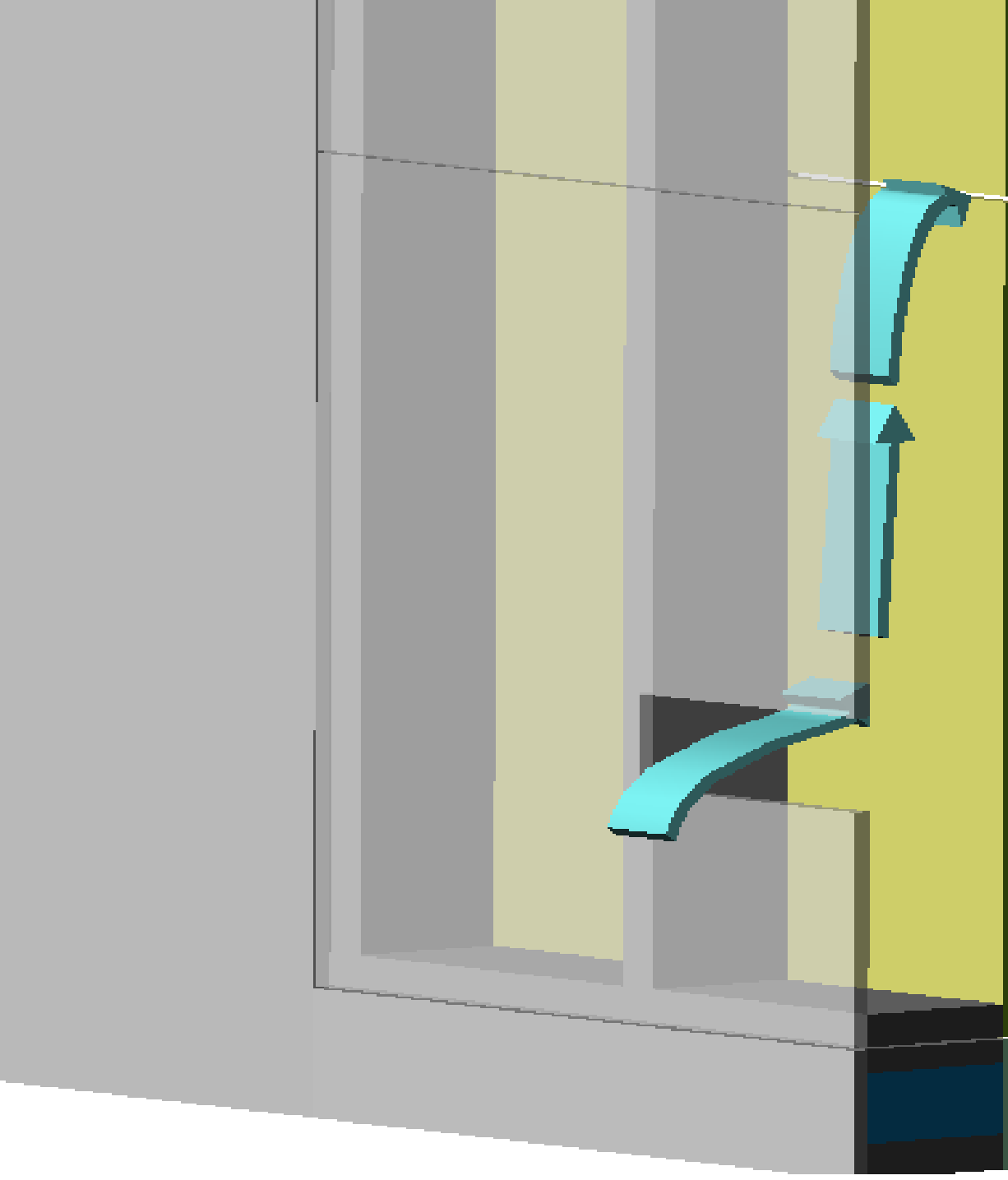
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**Drywall**



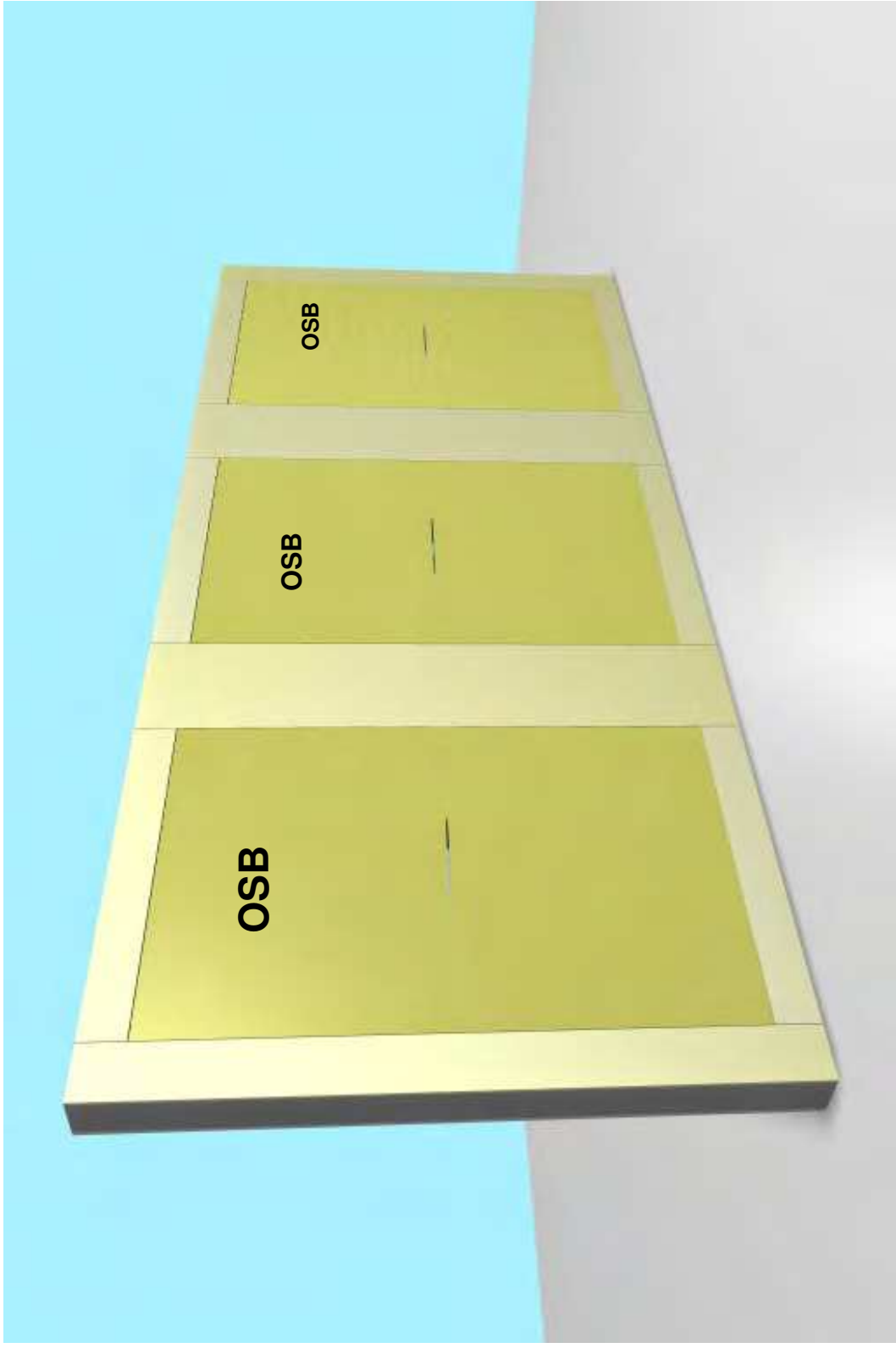




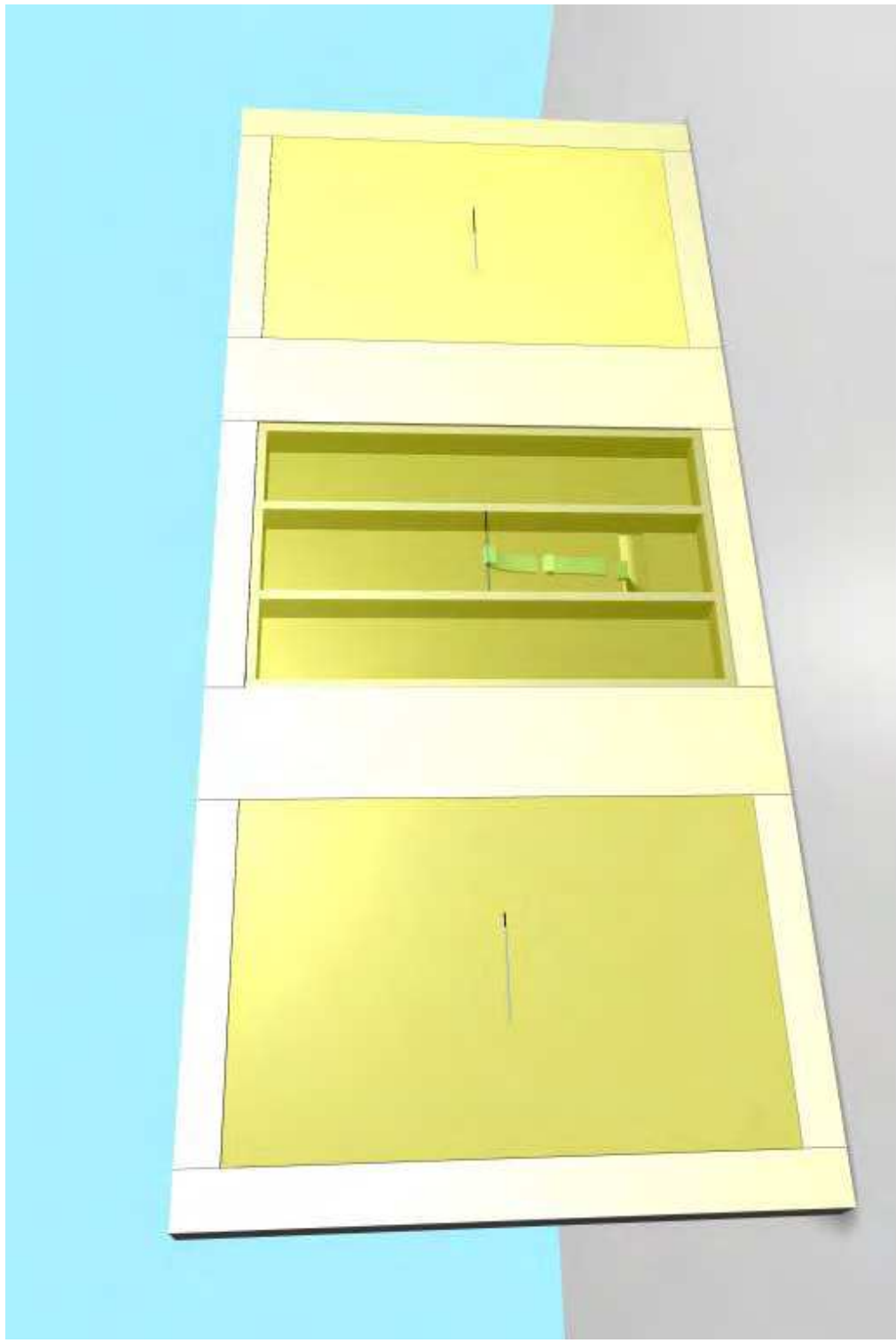
**Air leakage path:  
a 6 mm crack in the  
polyethylene air  
barrier element as  
well as in the OSB  
panel**



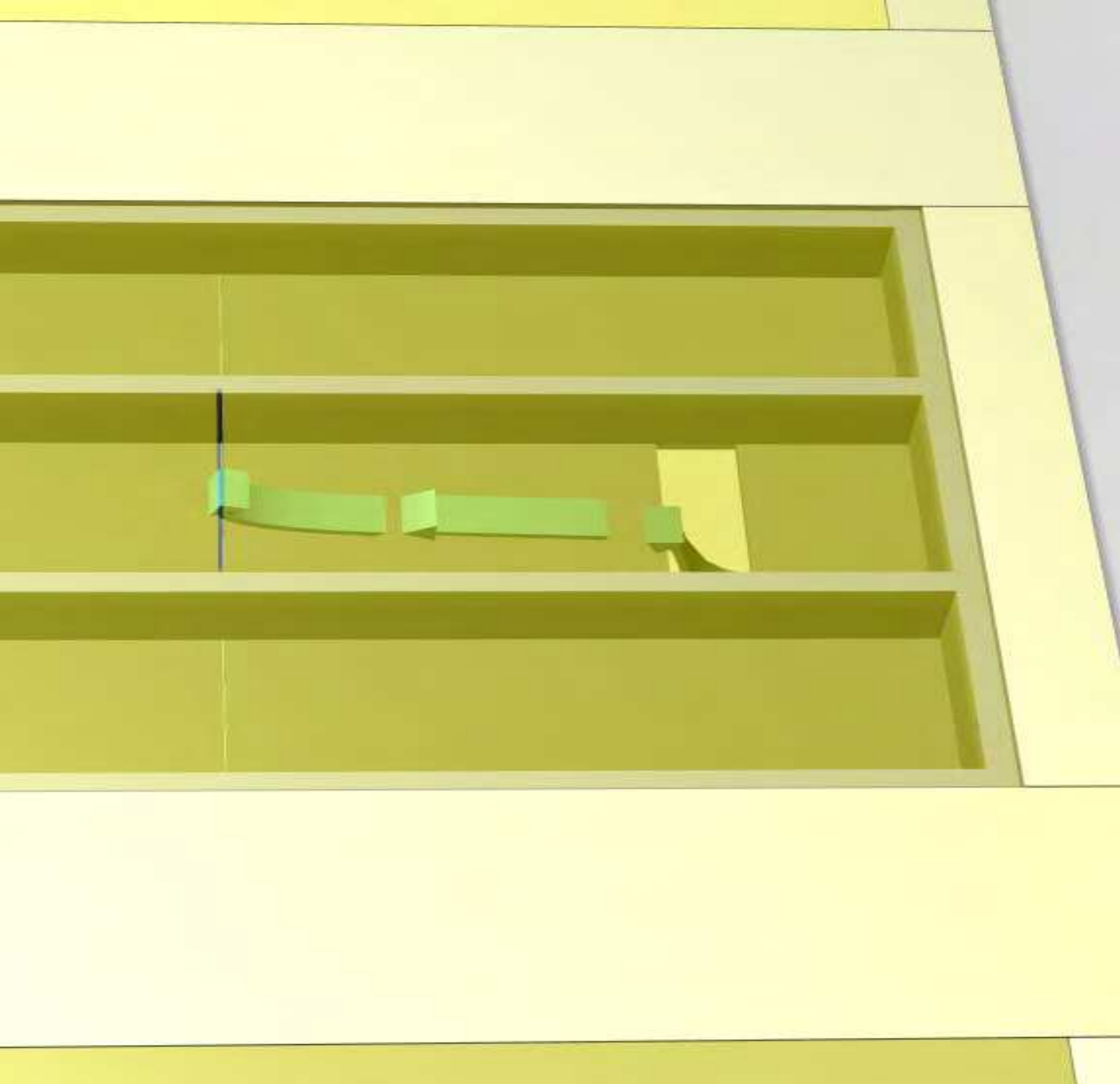
# View from the outside



# View from the outside



# Air Leakage Path



# Experimental Approach

- **The experiments will be in three phases:**
  - **Phase 1:** Commission the facility by monitoring three identical test specimens of traditional construction (2x6) through Fall, and part of the Winter under naturally occurring conditions.
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  - **Phase 3:** Return to naturally occurring conditions to monitor drying. Disassemble the indoor chamber





**Drywall**

# Conditioning Chamber on the Room Side



INT.

P

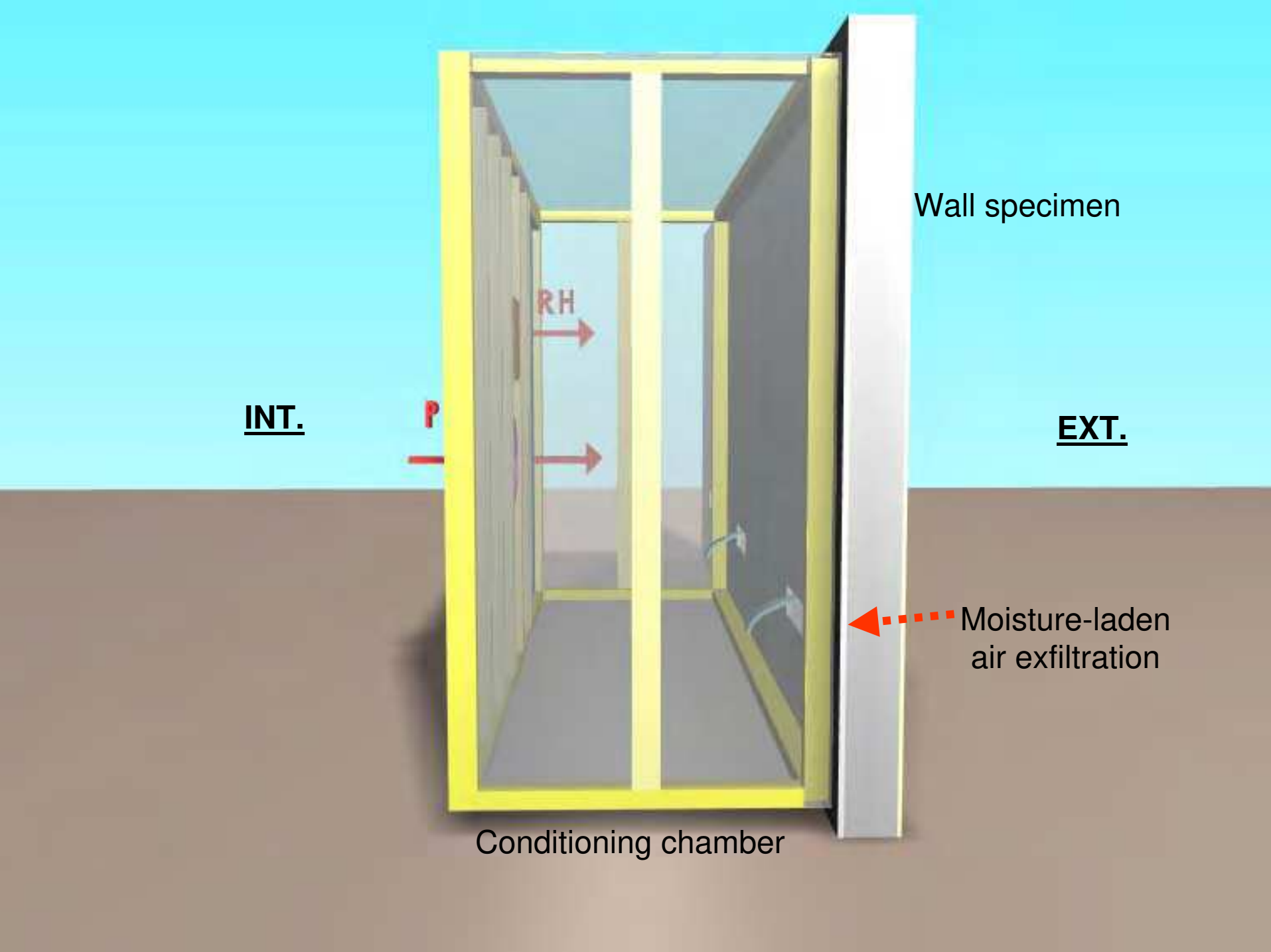
RH

EXT.

Wall specimen

Moisture-laden  
air exfiltration

Conditioning chamber



# Experimental Approach

- **The experiments will be in three phases:**
  - **Phase 1:** Commission the facility by monitoring three identical test specimens of traditional construction (2x6) through Fall, and part of the Winter under naturally occurring conditions.
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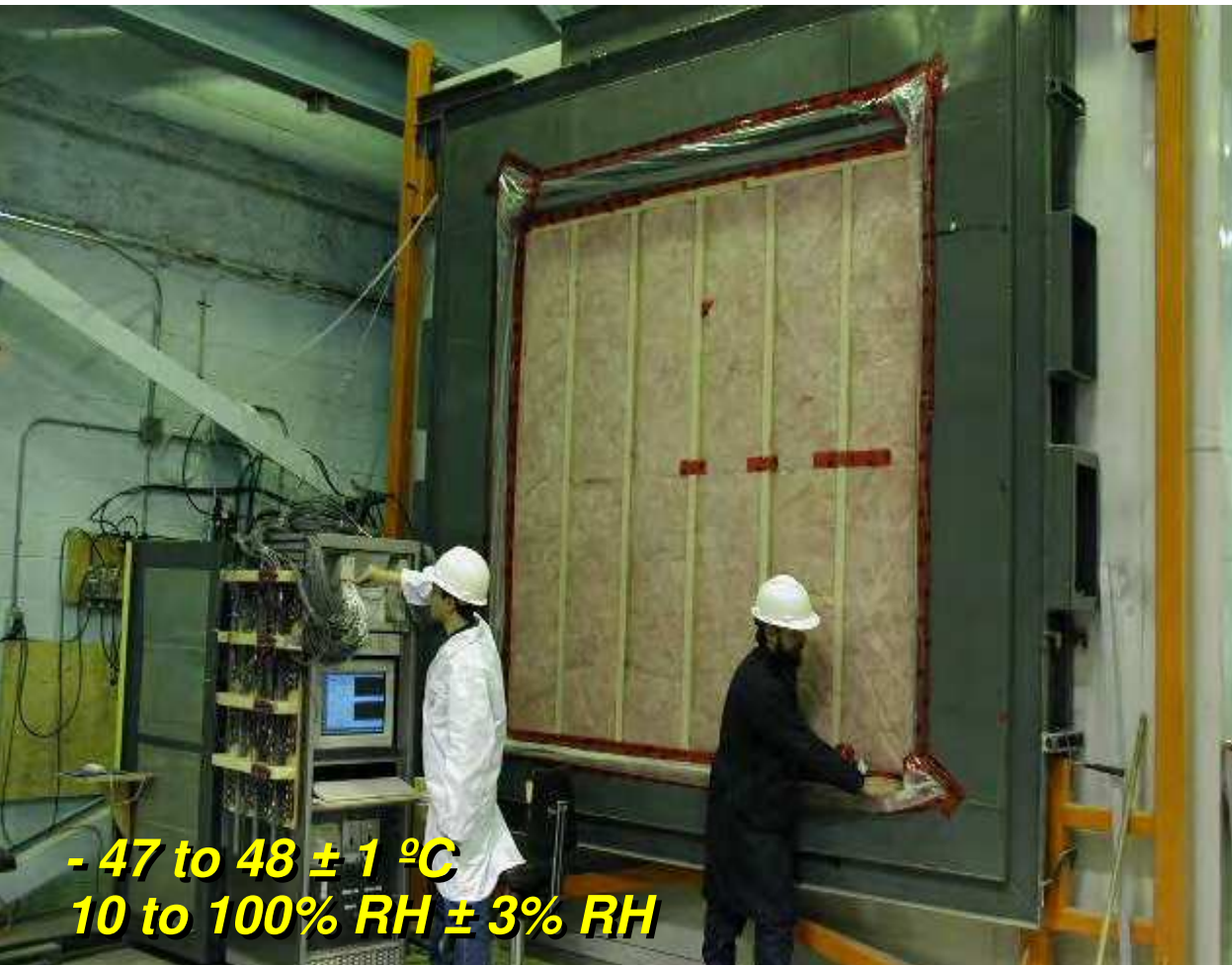


- Background
- Hygrothermal Performance of BES
  - Modeling
  - Field Experiments
  - **Laboratory experiments**
- Concluding Remarks and Future Work

# Laboratory Experiments

- Why to do lab experiments?
- How to do experiment?
- Which physical phenomena to investigate,..?
- What do you expect from experiments?

# Experiments — Apparatus - EEEF



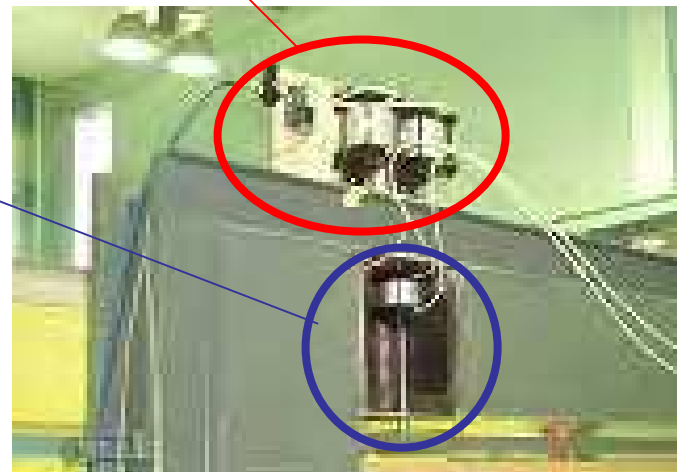
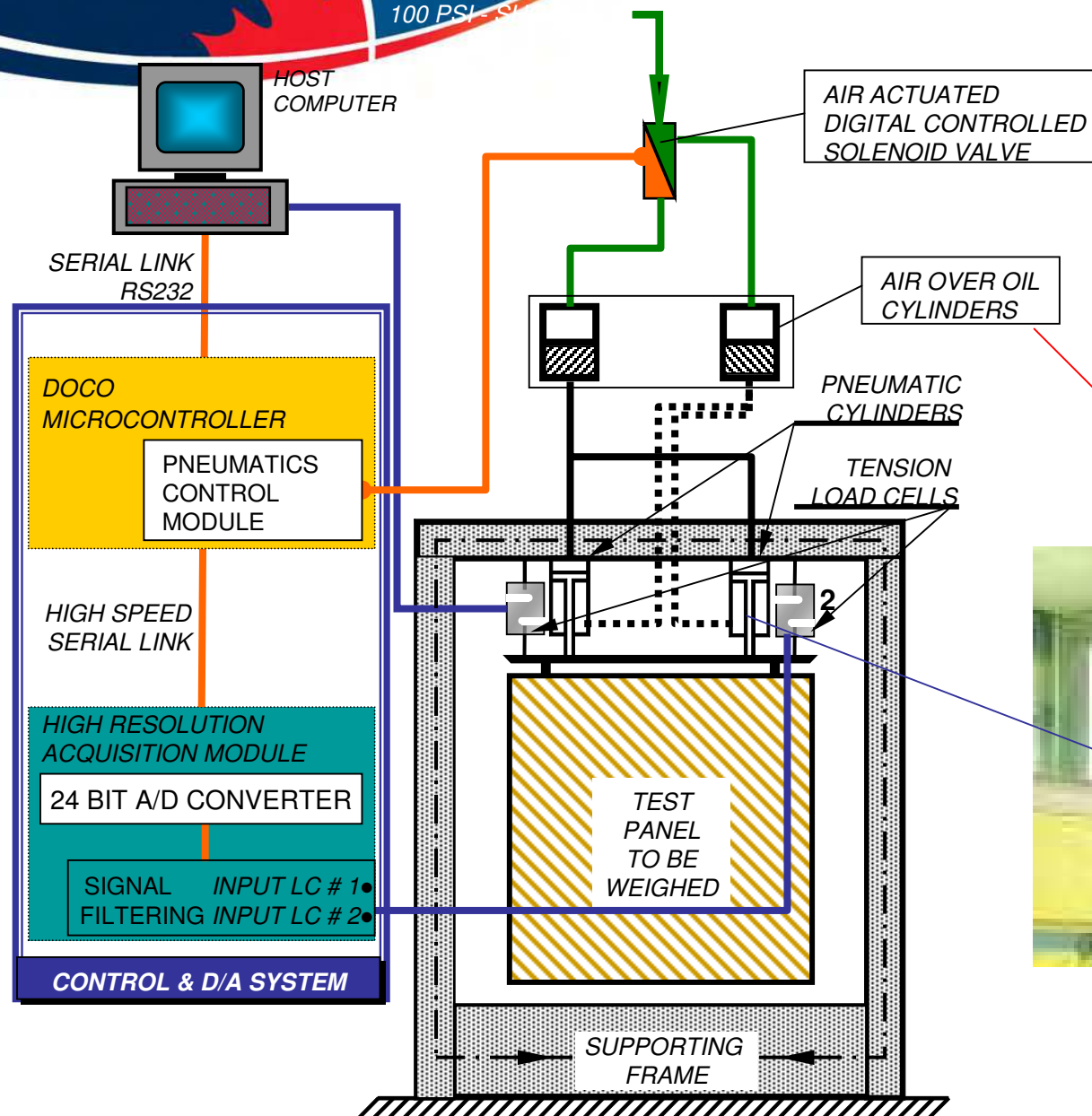
**- 47 to 48  $\pm$  1 °C**  
**10 to 100% RH  $\pm$  3% RH**

*Specimens and  
weighing apparatus  
are placed in EEEF*

*EEEF maintains  
T and RH profile  
over course of  
experiment*

Environmental Exposure Envelope Facility

# Experiments — Weighing System





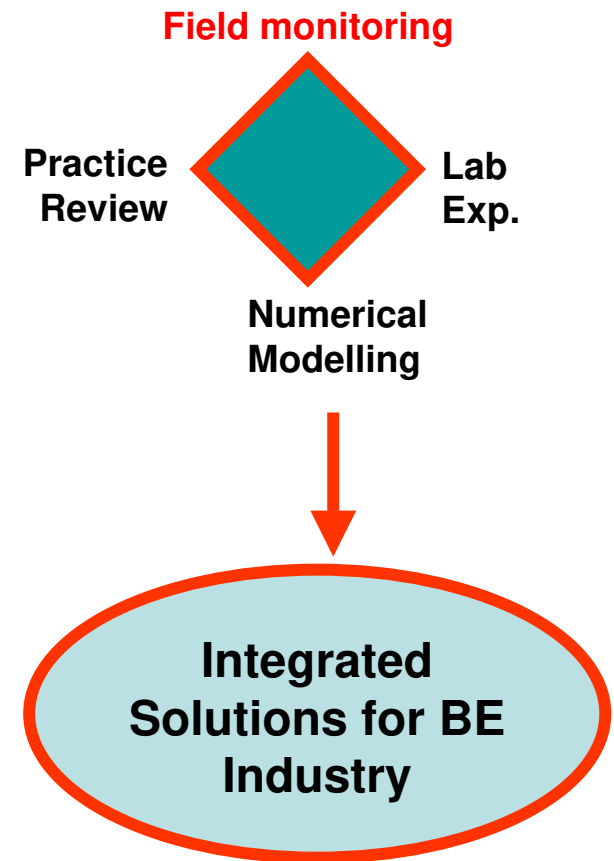
# Experiments — Apparatus - EEEF



- Background
- Hygrothermal Performance of BES
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# Concluding remarks

- FEWF is state-of-the-art field monitoring facility
- EEEF has demonstrated the capabilities of IRC's facilities to carry out a series of experimental works to mimic the exterior conditions effect on the moisture transport.
- Lab and/or Field Experiments help to benchmark models. Benchmarked models save time and money for doing parametric studies comparing to field and lab experiments
- Models, lab and field experiments complement each other

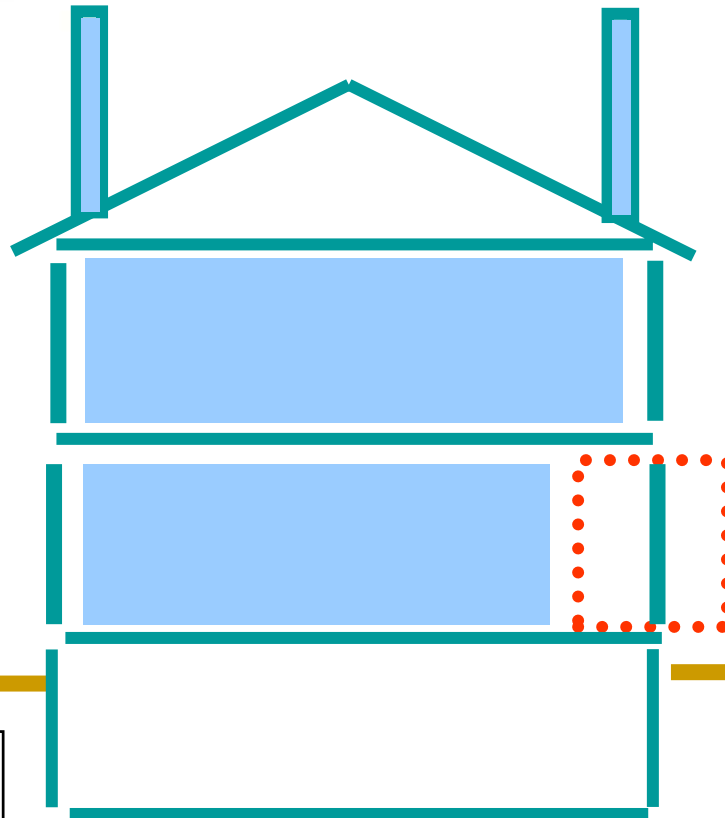


# Research House No. 3: Future Work

**HEATING AND  
VENTILATION  
FACILITY - IE**



*FY06/07 & 07/08 : Study  
& compare traditional &  
innovative HV strategies*



**FEWF- BES**

**Field monitoring**

Practice  
Review

Lab  
Exp.

**Numerical  
Modelling**



**FY06/07 & 07/08: Study  
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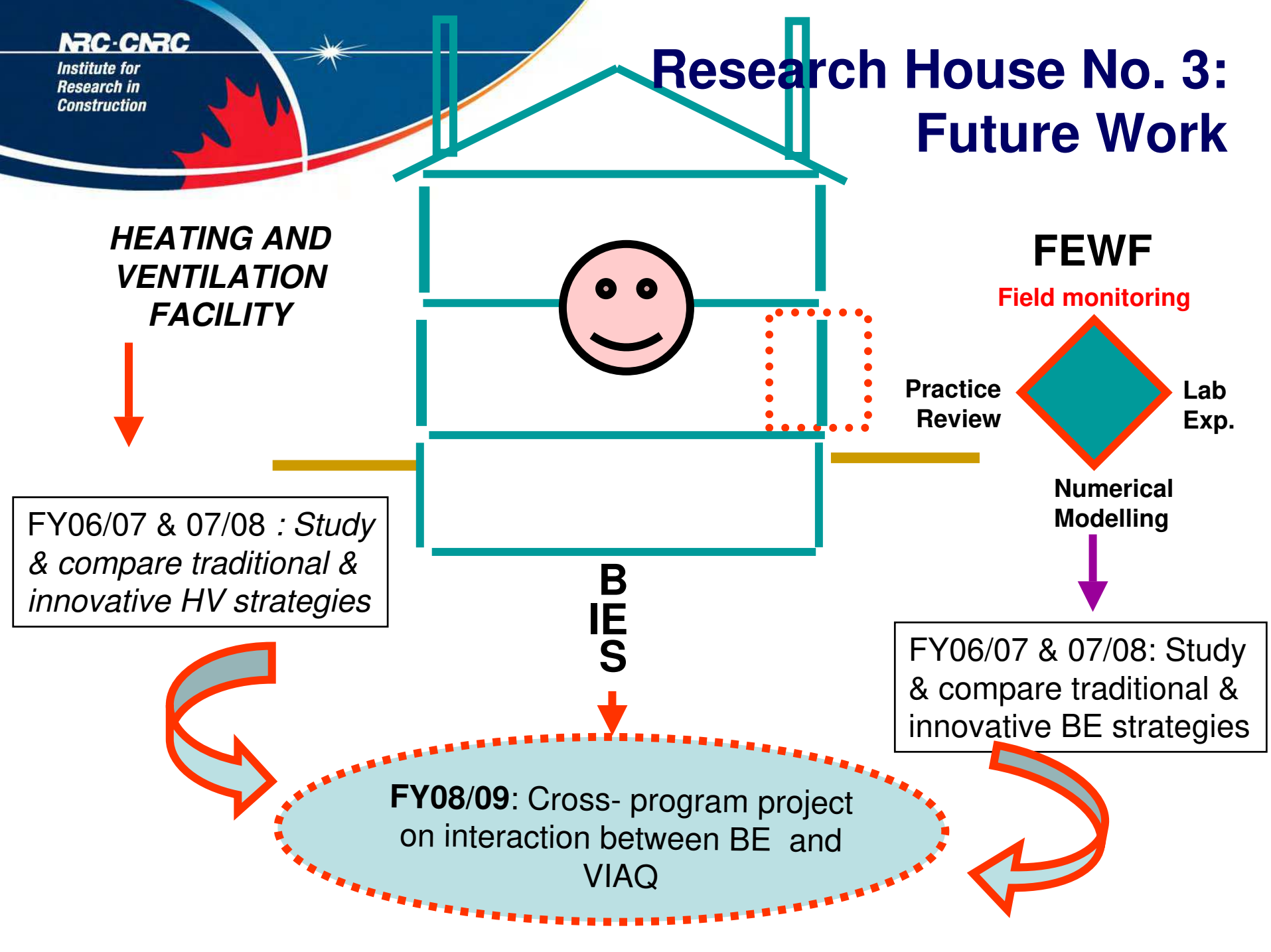
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**B  
I  
E  
S**

**FY08/09:** Cross- program project  
on interaction between BE and  
VIAQ





**Girls just want to have fun**



**Iain tries to help James to  
connect sensitive sensors**



**NRC-CNRC**

*From **Discovery**  
to **Innovation...***

# Thank you



National Research  
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de recherches Canada