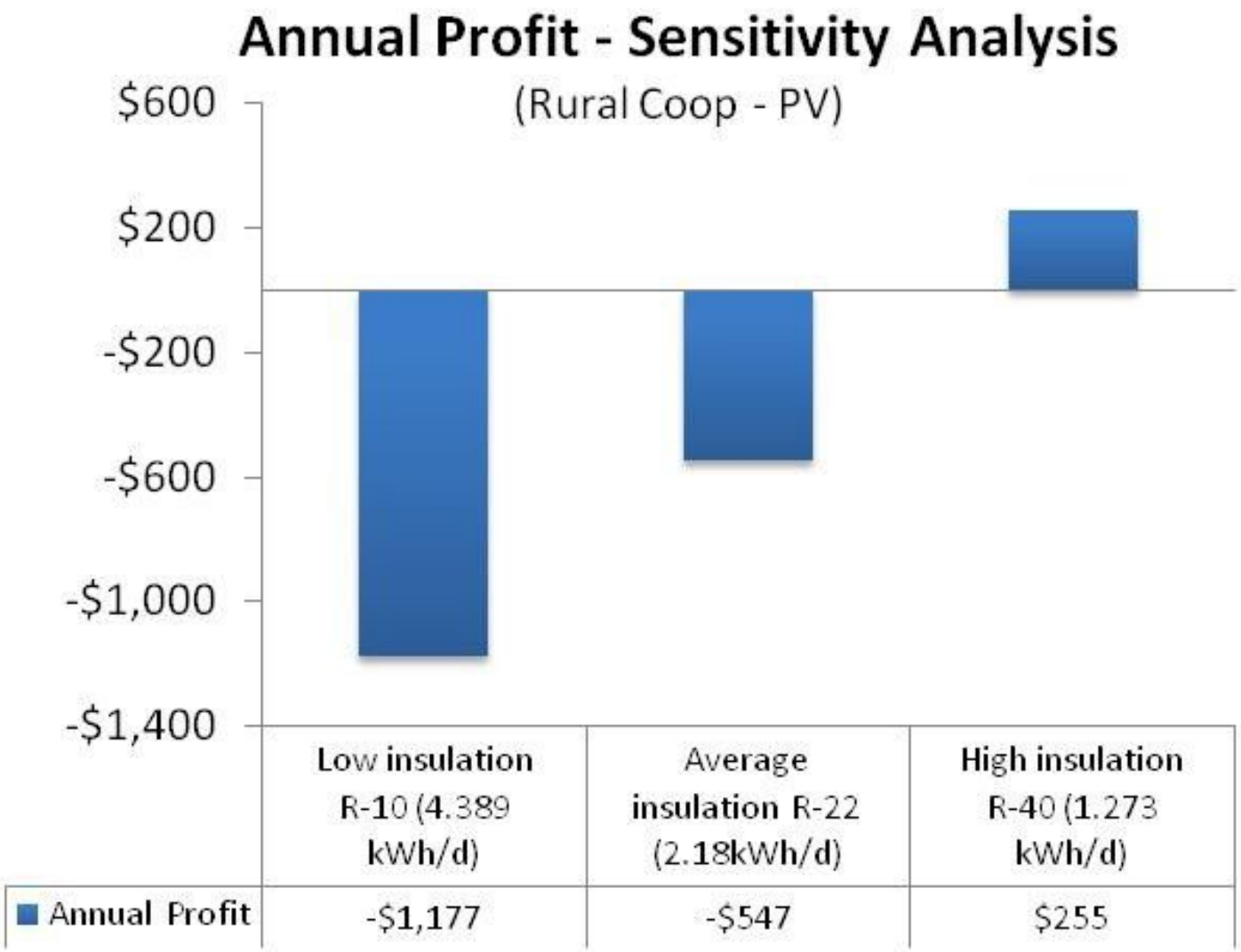
Cool Room Project

Arianna Rundquist, Daniel Sheeter, Michael Cunningham, Jingyan Wu

Project Background

- Location:Yabiavoko village, Ombokoro Parish in Manibe Sub-country, Arua District
- Goal: Reduce post harvest losses for farmers

Importance of Insulation



(Source: D-Lab I Cool Rooms in Uganda)

Limits of System

(Source: D-Lab I Cool Rooms in Uganda)

Four Lenses

Design Challenge

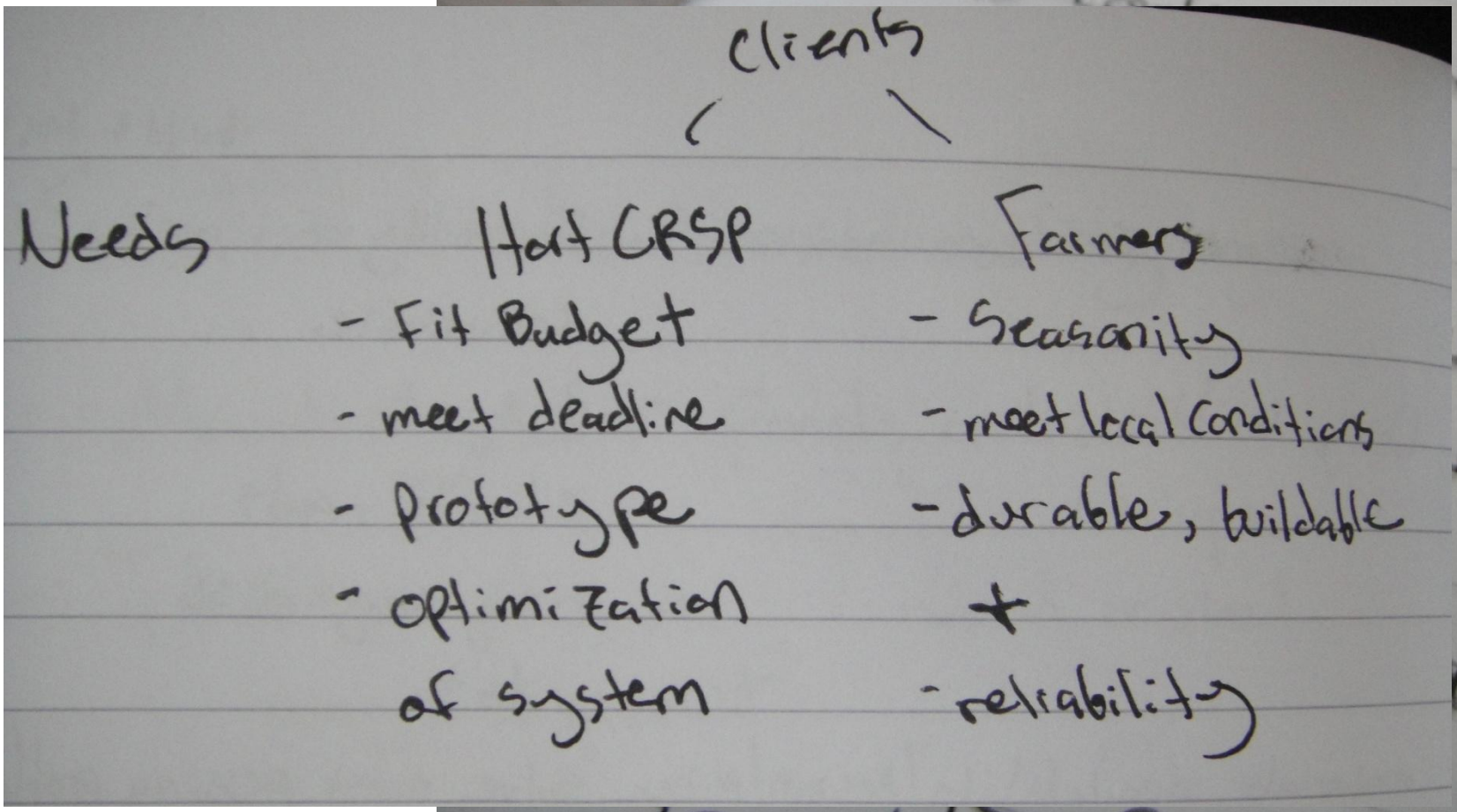
Initial Problem Definition

- Investigate the best possible site specific materials and structure for the cool bot building in the Arua district of Uganda. Investigate the different building materials and structures that decrease the cooling demand. Build and test a prototype that incorporates the group design recommendations at the student farm.

Information gathering – Skill Building

Install Solar Panel

Brainstormin'



Revised Problem Definition

High cost of solar panels and inverters

Improve energy efficiency

Decrease peak and base power demand

Decrease start-up power demand of air conditioning unit

SOFT STARTER

Identify effective insulation material

TEST R-VALUE

Idea Selection

Identify/test insulation material

optimize room structure: size, shape, materials

Energy storage

↳ test scenarios for PV system

small-scale testing of materials

sizing the room: max storage demands (according to crops)

Insulating ground/building as a whole

decreasing door size, whitewash

Design Criteria	Metrics
Portable	•Fit in a carry on bag: dimensions less than 22"x16"x8", weight less than 26 lbs •Does not require grid electricity •Fast
Effective Comparative Test	Calibrated model provides results within 10% of literature value
Accurate in different weather	Test effective when carried out in high humidity, direct sunlight, wind
Affordable	Total cost less than $50

Talk with Gloria and Michael on May, 12th

Revised Problem Definition

High cost of solar panels and inverters

Improve energy efficiency

Decrease power demand

Decrease start-up power demand of air conditioning unit

Provide good insulation and minimize cost

ROOF DESIGN

Identify effective insulation material

TEST R-VALUE

Revised Problem Definition

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ROOF DESIGN

Identify effective insulation material

TEST R-VALUE

What is the R-value of a material?

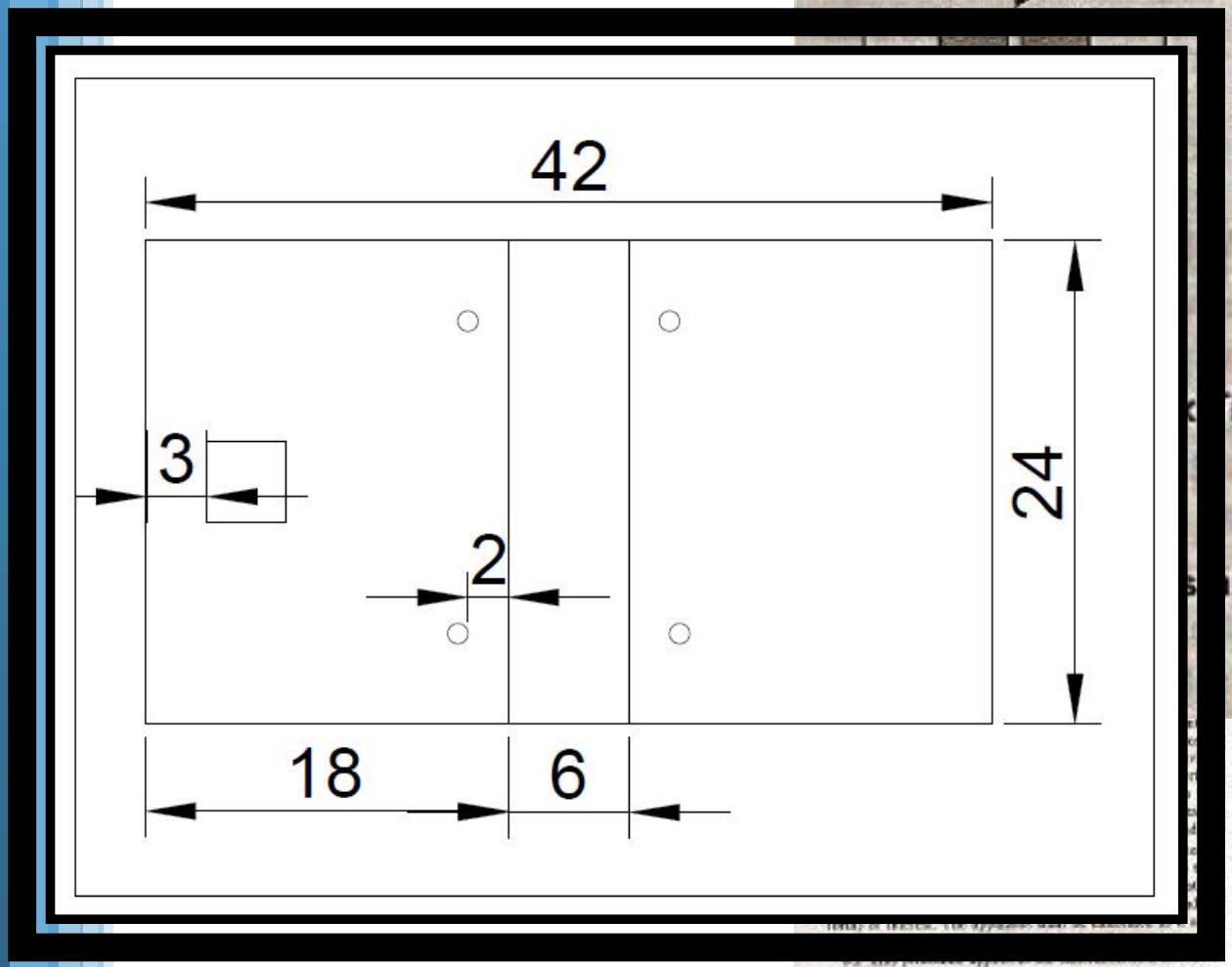
$$R = \frac{\Delta T}{\dot{Q}}$$

- Temperature difference across insulation material divided by the heat transferred

Parallel Designs with Similar Concept

- **Create a temperature difference across the insulation to compare R-value of different materials**
  - Hot Box uses sodium acetate packets
  - Glass tube uses a wire connected to a power source
- **Quantify the heat transfer across material with temperature sensors on both sides of insulation material**

Hot Box Concept



(Source: American Society for Testing and Materials (1993). Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus.)

Glass Tube Concept

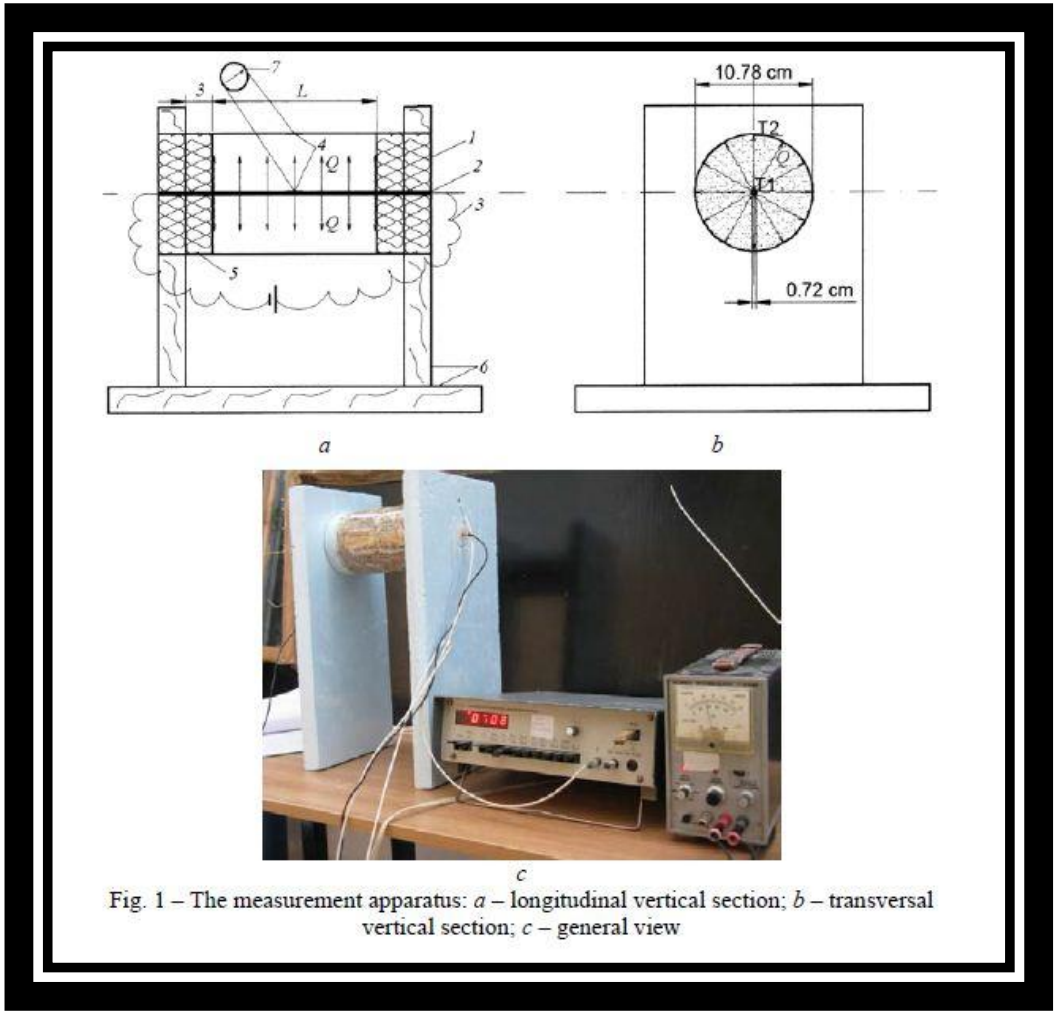


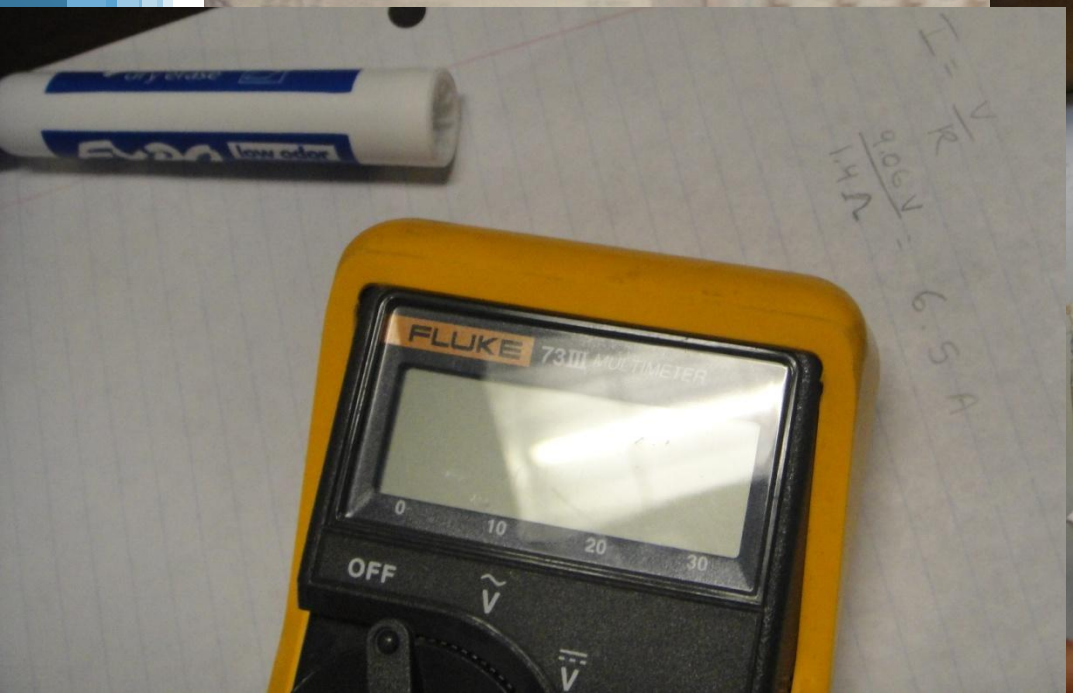
Fig. 1 – The measurement apparatus: *a* – longitudinal vertical section; *b* – transversal vertical section; *c* – general view

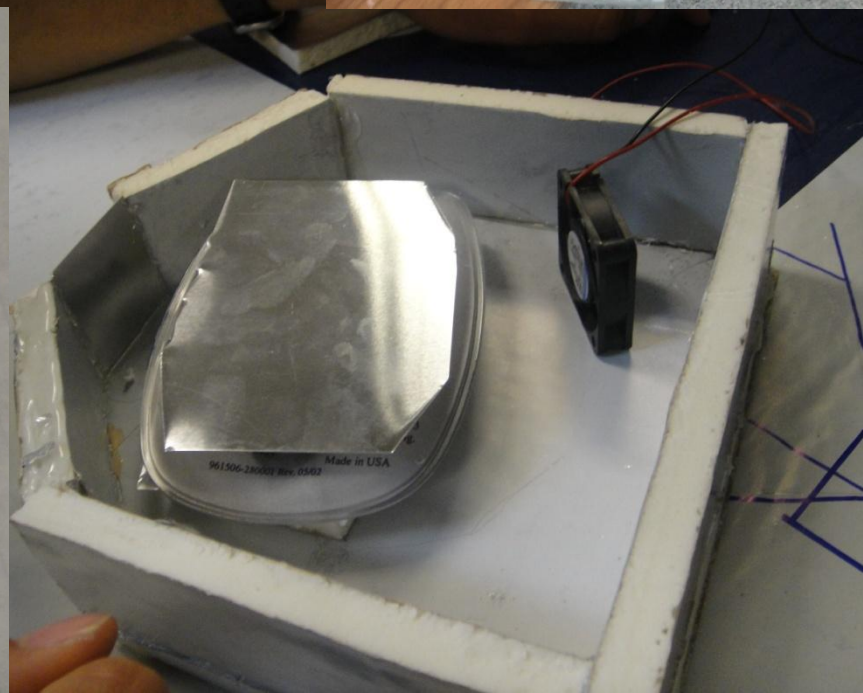
(Source: Marian Pruteanu- Investigations Regarding The Thermal Conductivity Of Straw)

Equipment

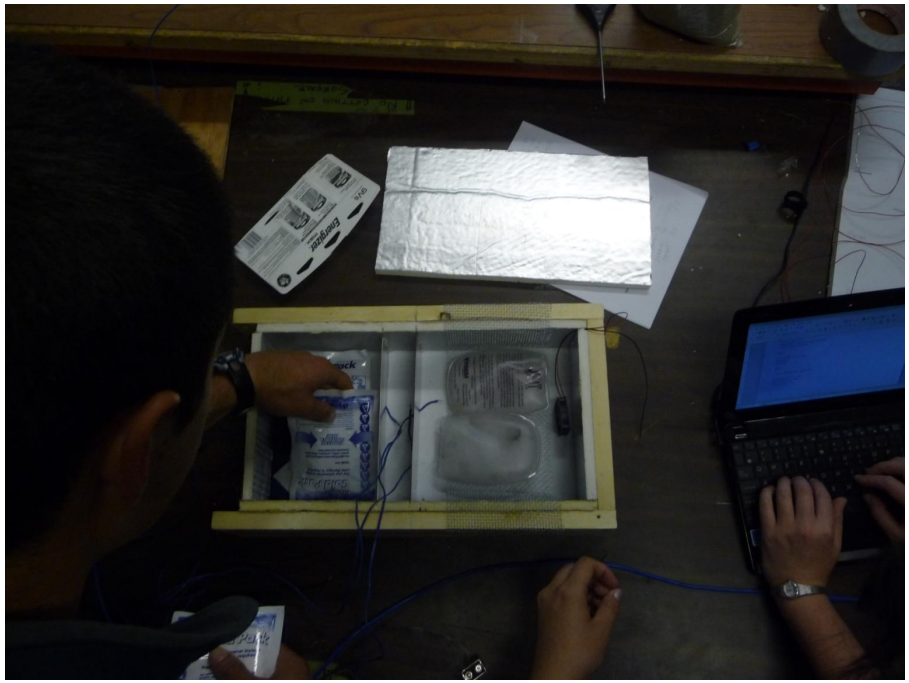

EXTECH
382213
DC REGULATED
POWER SUPPLY
VOLTAGE
CURRENT
OUTPUT
VOLT
AMP.
POWER
+ 12V −
− 5V +


OPTIMA
BATTERIES


FLUKE
73III MULTIMETER
OFF
0
10
20
30


Made in USA

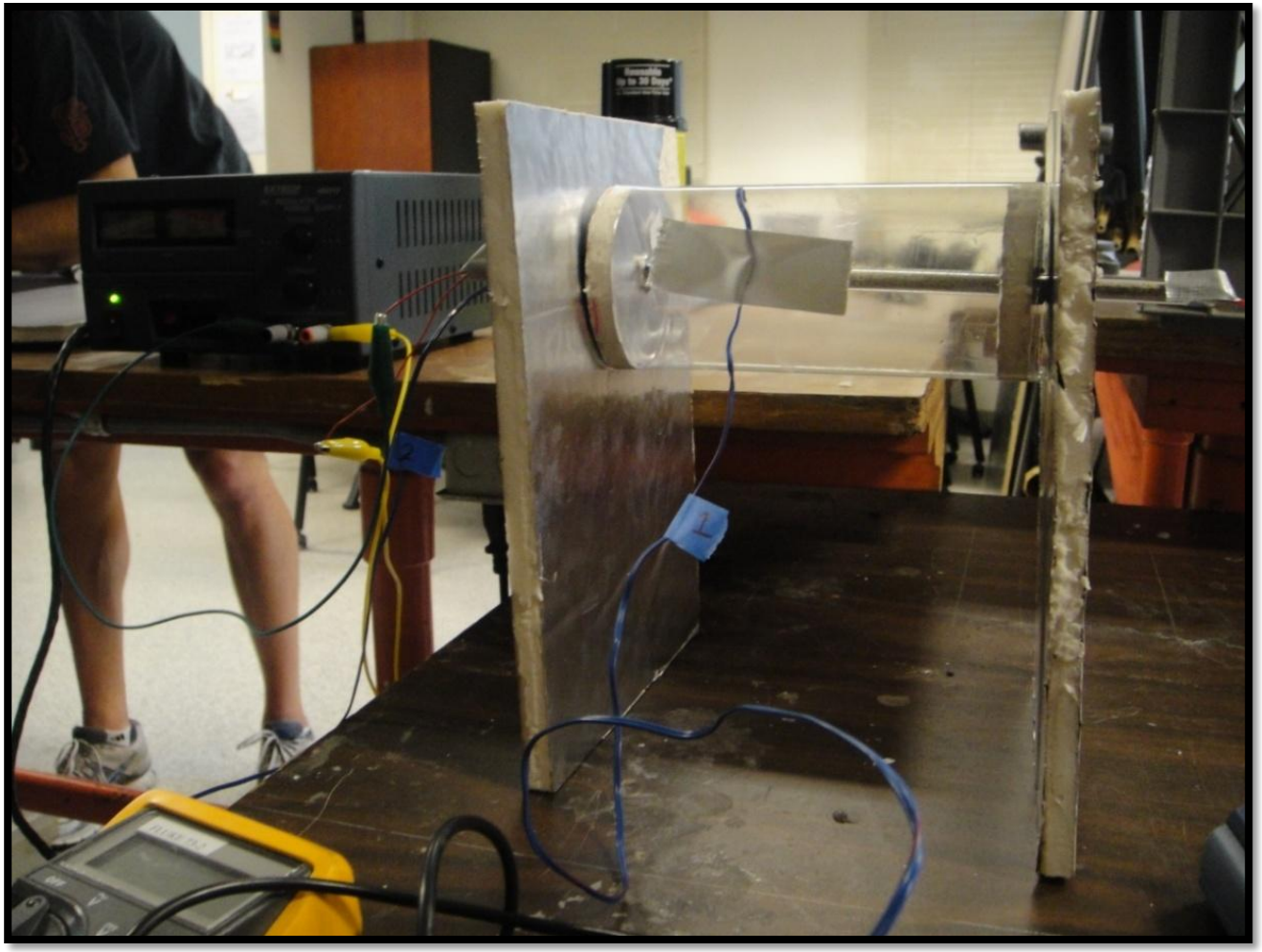
First Prototype and Evaluation



Evaluation

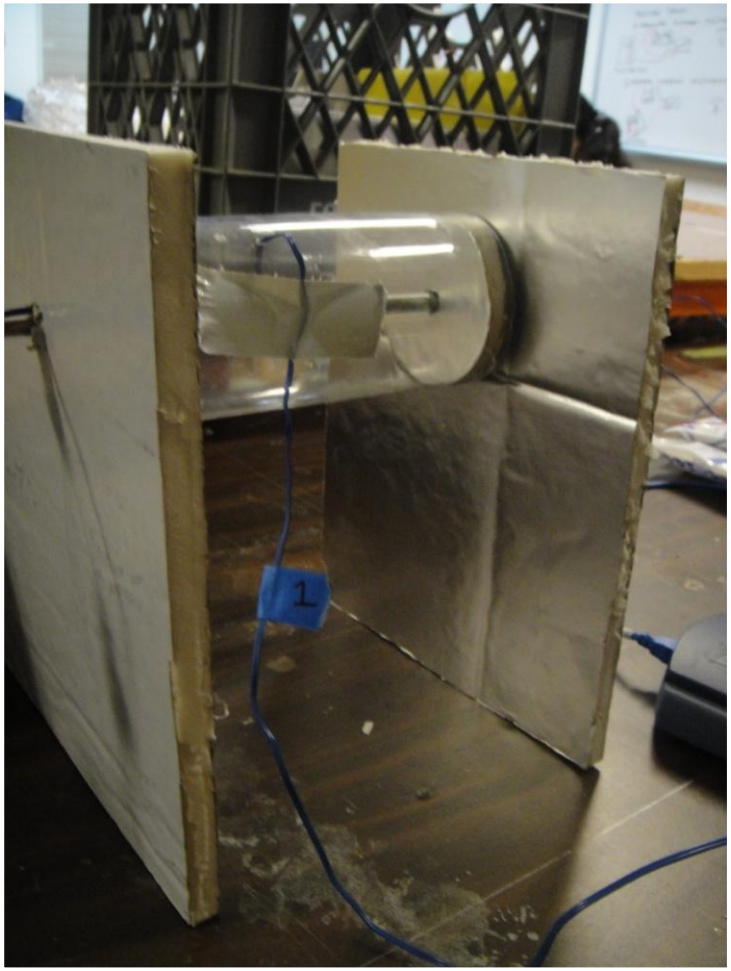
- hot and cold packs are reliable
- Temperature difference across increased after fan installation

First Prototype for Glass Tube



Evaluation – Comments from Paul Polak

Refined Design



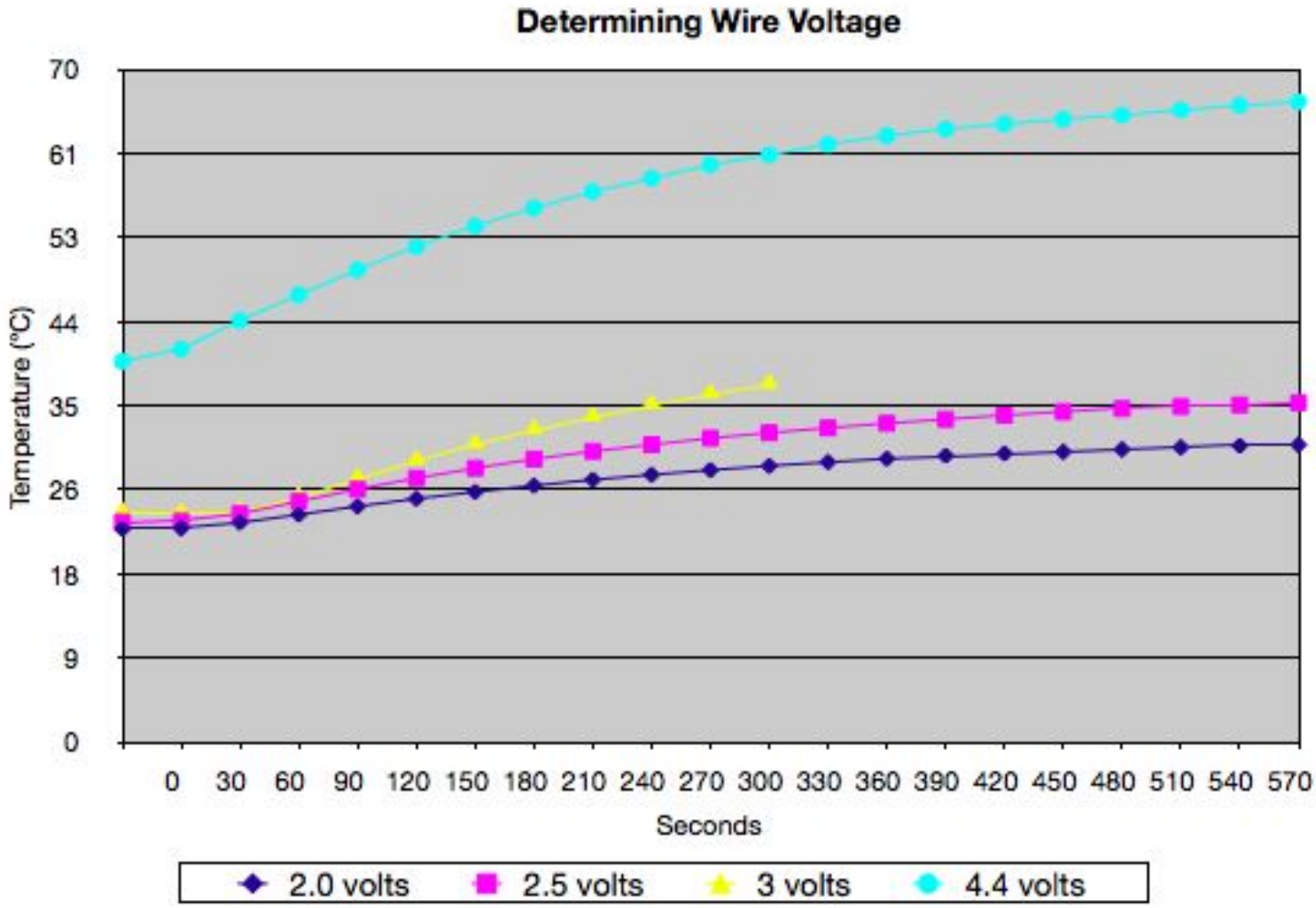
Glass Tube Procedure

- Measure wire resistance
- Fill tube with insulation material
- Set-up pico logger
- Turn on power source
- Record data

$$Q = \frac{U^2}{R}, \quad [\mathrm{W}],$$

$$\lambda = \frac{Q}{2\pi(T_1 - T_2)L} \ln\frac{D}{d}, \quad [\mathrm{W/m.^{\circ}C}]$$

Preliminary Test Results



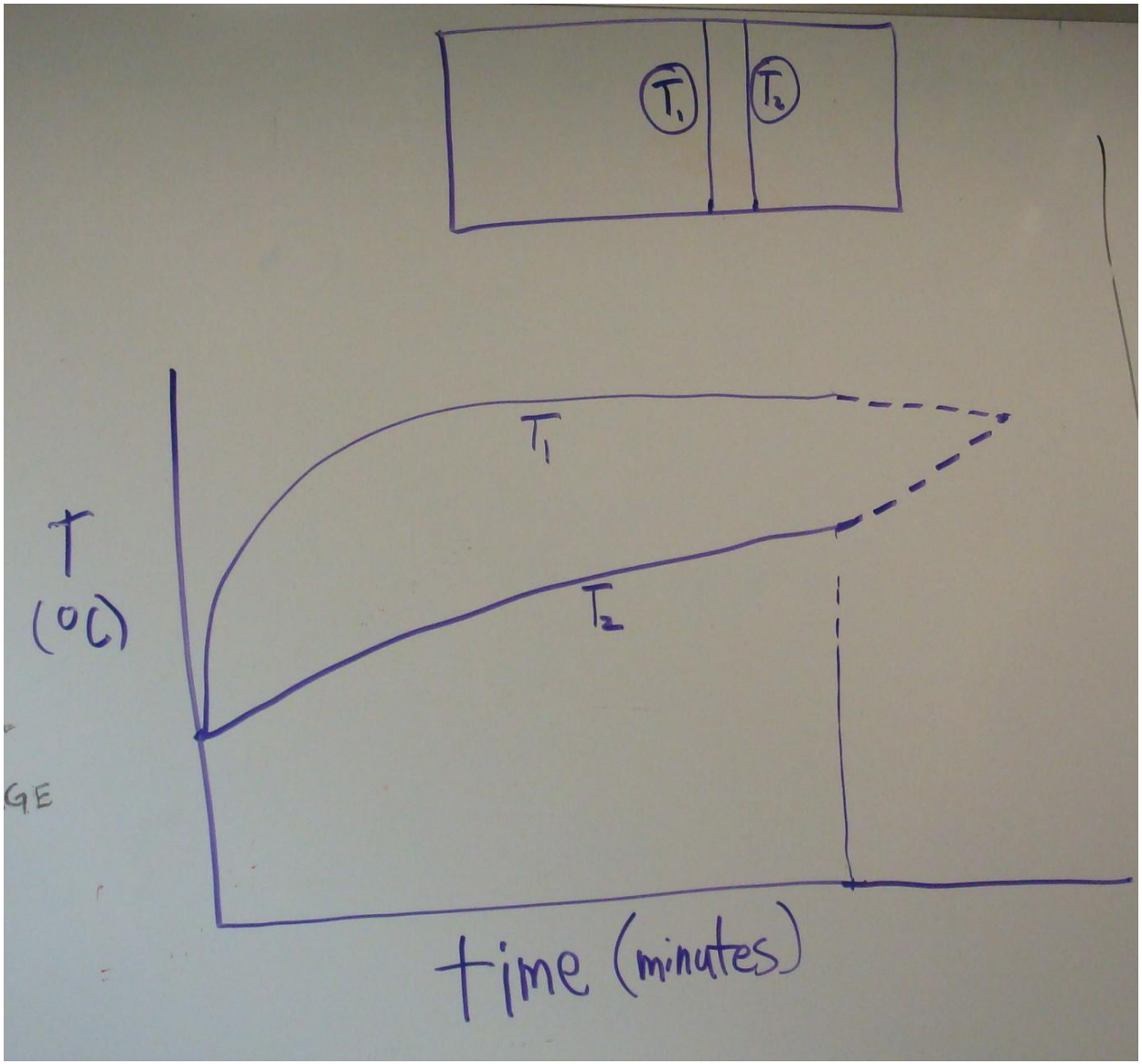
Revised Design of Hot Box

- Decrease cross-sectional area of aluminum to increase total heat transfer.

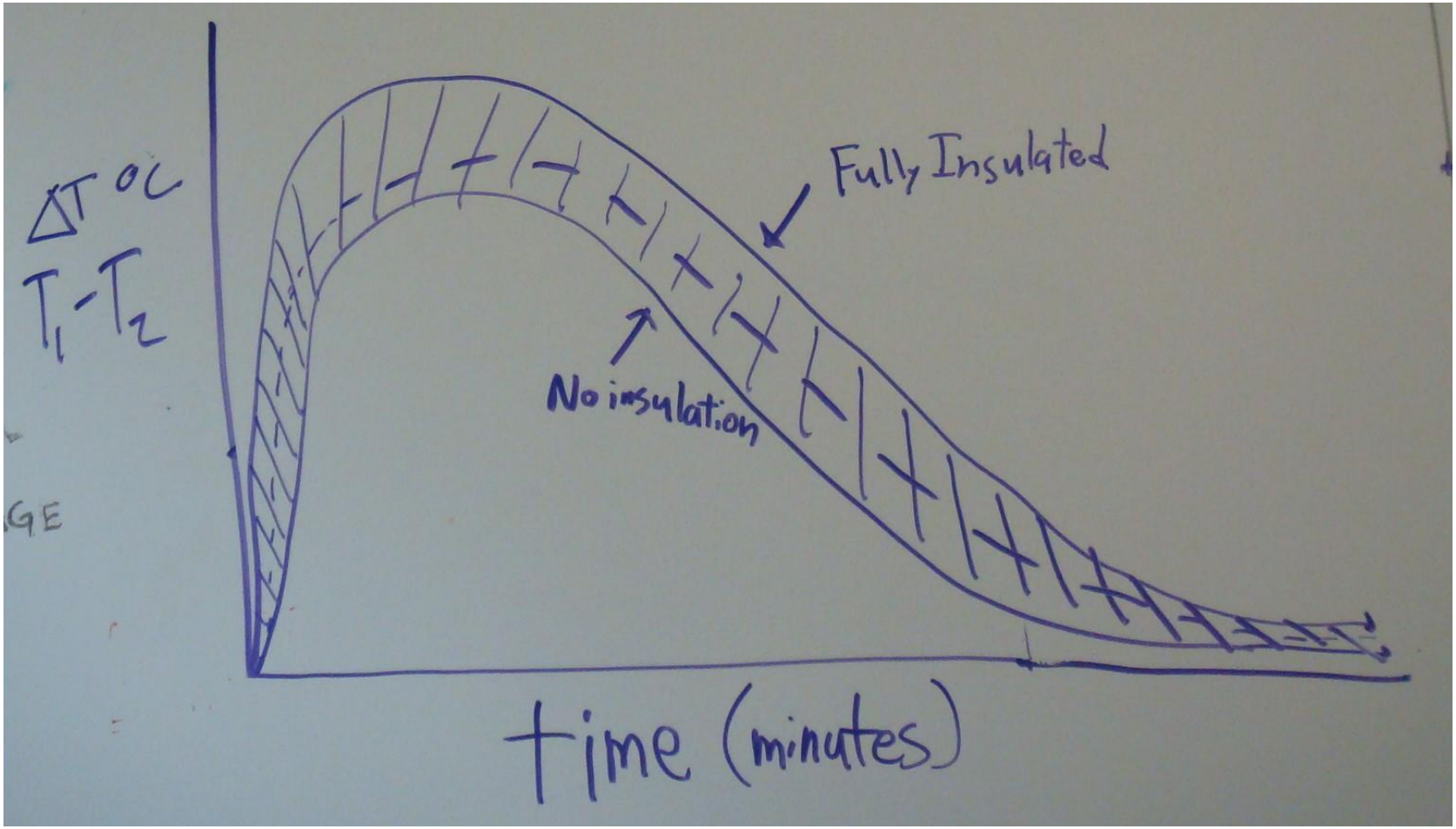
Procedure Hot Box

- Measure Temp across the insulation material
- Calculate total heat transferred on the cold side using properties of air
- “regenerate” test with cold pack

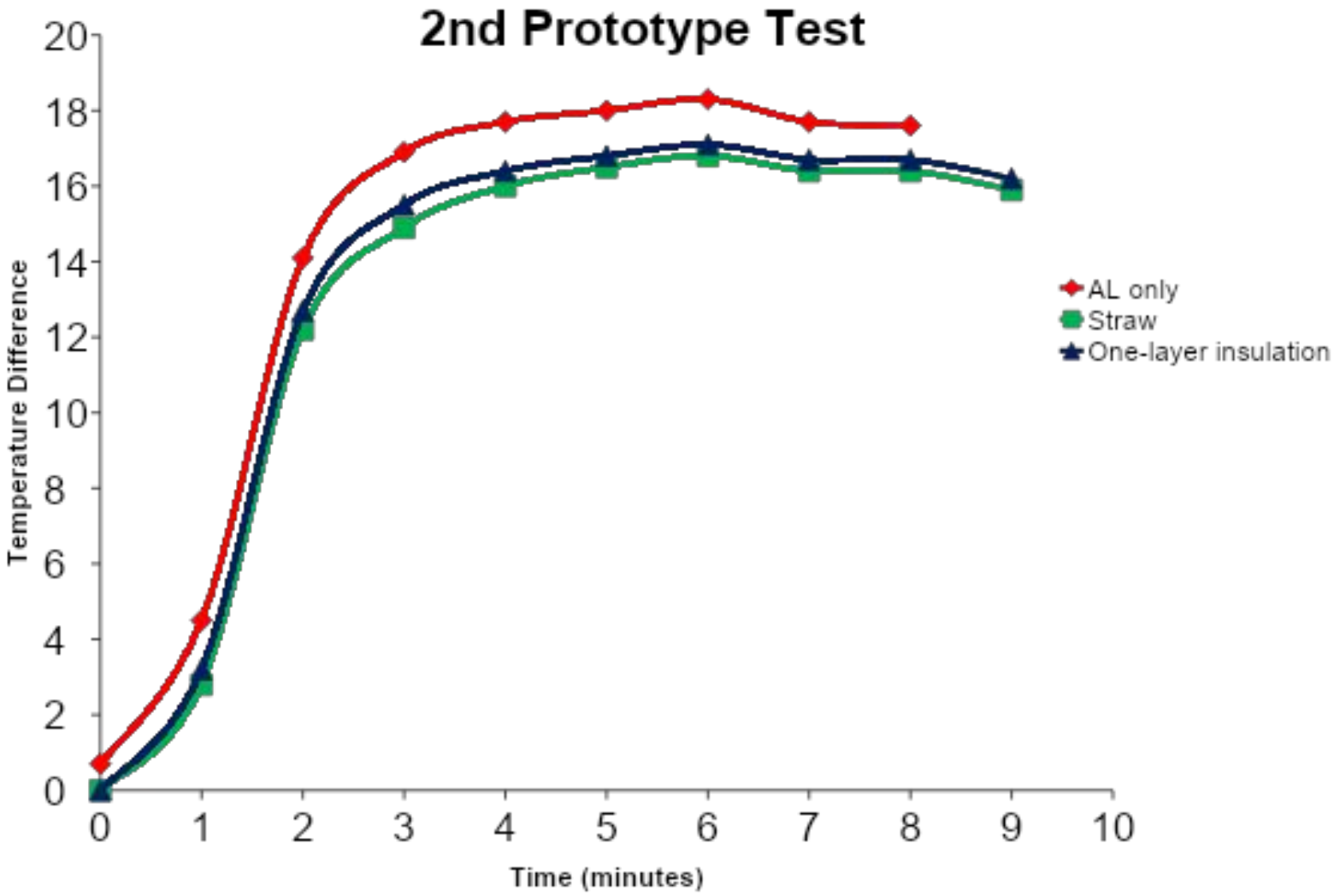
What we expect to happen…



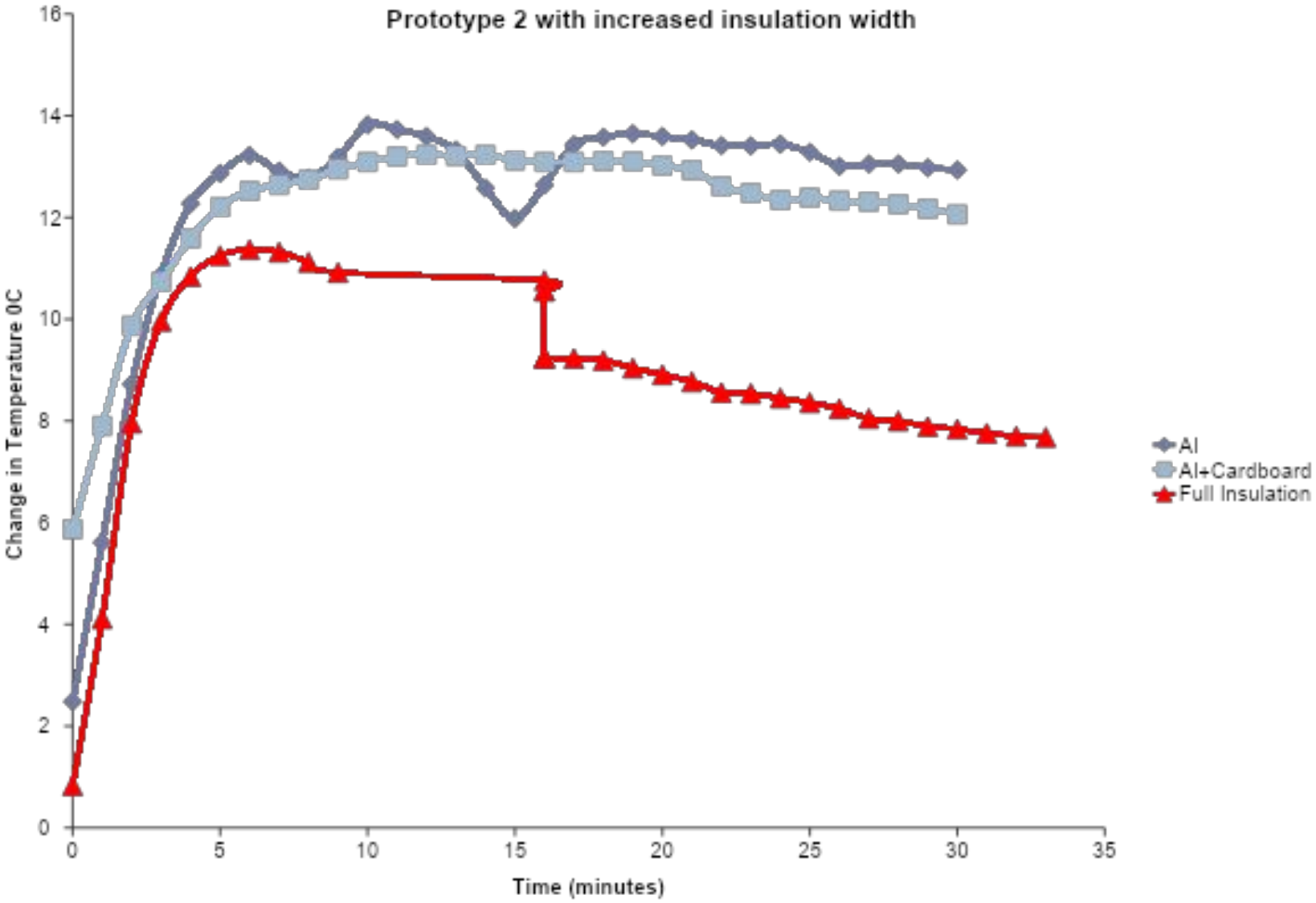
What we expect to happen…..



Results


2nd Prototype Test
Temperature Difference
0
2
4
6
8
10
12
14
16
18
20
0
1
2
3
4
5
6
7
8
9
10
Time (minutes)
AL only
Straw
One-layer insulation

Results


Prototype 2 with increased insulation width
Change in Temperature 0C
Time (minutes)
0
2
4
6
8
10
12
14
16
0
5
10
15
20
25
30
35
Al
Al+Cardboard
Full Insulation

Roof Design Criteria and Metrics

Criteria	Metric
Affordable	Total Cost Less than $250
Fits local needs	Round roof design that prevents water from entering structure during heavy rain

Roof Design Recommendations

Recommendation 1

- Square ceiling on top of existing structure.
- 2-3 foot knee wall on one side to catch rafters.
- Ample room for insulation between ceiling joists and rafters.

Recommendation 2

- Build circular ceiling.
- Progressively narrow the brick wall, igloo-style to seal off the roof.
- Ample room for insulation between ceiling and igloo-style brick roof.

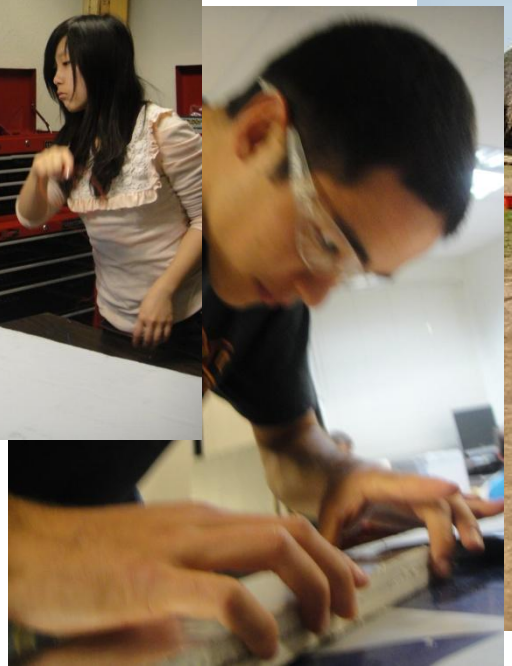
In Sum…

Goal: Design, build, and bring insulation testing device/procedure to Uganda

- **Informative data?**
  - Yes, further testing still needed
- **Met Design Brief?**
  - Nope, not yet!
- **Is this procedure useful?**
  - Yes, it could be!

Next Steps

- Calibrate/test working prototypes
- Complete working device
- Send to farmers in Uganda



Reference

- Pruteanu, M. (2010). "Investigations Regarding the Thermal Conductivity of Straw." The Bulletin of the Polytechnic Institute of Jassy, Construction. Architecture Section **LVI (LX)**(3): 9-16.
- American Society for Testing and Materials (1993). Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus. Philiadelphia, ASTM.

Thank you!