Erik Karlsson
CM
TEAM PROCESS

It’s not all about this:

And this:

It’s more about this:

Collaboration
TEAM MEETINGS

Good collaboration requires good communication:

Good communication requires meetings.

And good meetings lead to friendship.
THE BIG IDEA

- PIECES FITTING TOGETHER
- COOPERATION
- CAMPUS AS A PUZZLE
- CHALLENGE
- DISCOVERY
CONCEPT DEVELOPMENT

Design
Collaboration
Most Value
Building Health
VISUAL REPRESENTATION
Building Health

- Bicycle Storage and Shower Station
- Nap Room

Design

Multi-functional Room

Burn Calories, Not Electricity

- Take the Stairs!

Waste Management

- Our cafe is selling glass and plastic bottles, cans, compostable to go cups and containers.
- The users are guided to recycle step by step:
  - Step 1: Compostables
  - Step 2: Recycle
  - Step 3: Trash

The Cafe: Recycling Station
SECOND FLOOR

- Vertical Circulation
- Large Classrooms
- Storage
- Faculty Offices
- Faculty Lounge
- Auditorium
- Department Chair’s Office
- Senior Administrative Office
- Administrative Assistants
LARGE CLASSROOMS
THIRD FLOOR

- Vertical Circulation
- Large Classrooms
- Student Spaces
- Small Classrooms
- Seminar Rooms
- Storage
- Terrace
FACADE

12 Different Panel Sizes
ELEVATIONS

East Elevation

South Elevation
HURRICANE SHELTER
HURRICANE SHELTER

Operable Roof Covering

Typical Wall Section

Site Slope
EGRESS SIMULATION

Safegress Software
Emulates human behaviour in emergency situations.

Green:
Awareness of emergency situation.

Purple:
Communicating a need to leave.

Red:
Moving towards exits.
## BUILDING LOADS

<table>
<thead>
<tr>
<th>Use</th>
<th>Uniform psf</th>
<th>Dead (main)</th>
<th>Dead (auditorium)</th>
<th>Dead (cantilever)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lounge</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corridor</td>
<td>80-100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balcony</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditorium</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab</td>
<td>100</td>
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<tr>
<td>Assembly area</td>
<td>60-100</td>
<td></td>
<td></td>
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<tr>
<td>Storage</td>
<td>150-250</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stairs</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STRUCTURAL SITE CONDITIONS

**Seismic loads:** Base Shear = 1701 kips  
**Risk Category III:**  
Ss = 1.04 g  
S1 = 0.40 g

Wind loads: 160 mph

Hurricane season with high winds from NE.

High season is from August till October.

Soil profile: Bearing capacity = 5000 psf

Medium to Very Stiff Clayey Soil

Excavation: 11 feet

Water table: 17 feet
Concrete columns with post-tensioned slab with mushroom caps to prevent punching shear.

18’ cantilever on the entire perimeter

Thin slab – only 10” thick
GROUND FLOOR

Collaboration

Shear walls

16 x 16 "

18 x 18 "

Thickened foundation slab
FIRST FLOOR

Collaboration

Shear walls
- 16 x 16"
- 18 x 18"

Dropped panels
SECOND FLOOR

A B C D E F G H I J

20'-0" 8'-0" 10'-10" 18'-8"

31'-8" 31'-0" 31'-4"

18'-6"

18'-8" 12'-6" 5'-9" 0'-10" 0"

8'-11" 20'-1" 11'-3" 18'-8"

Shear walls
16 x 16 " columns
18 x 18 " columns
Dropped panels
12 x 24 " beams
THIRD FLOOR

Collaboration

Shear walls
- 16 x 16"
- 18 x 18"

Dropped panels
VERTICAL LOAD PATH
STATIC ANALYSIS

• Slab Deflection:

Does not satisfy the code requirement for deflection after curing and post-tensioning → coordination with CM.

• Tensile Stress – Long Term:

Satisfies the code requirements for the stress and inner forces.
LATERAL LOAD PATH

- Design
- Loads
- Tension
- Compression
- Ground reaction
DYNAMIC ANALYSIS

• Earthquakes:
  Enough shear walls in all directions to resist code prescribed EQs with small drifts.

• Wind:
  Compact structure with enough resistance in horizontal and vertical elements to withstand the strongest hurricanes.
FOUNDATION

Typical depth of the mat to offer enough support on stiff clayey soil.

Foundation above the water table: no need for drainage!

Small retaining walls instead of columns where needed.

Walls are anchored into the soil.

Thickened flat plate under the columns to avoid puncturing the mat.
POST-TENSIONED CANTILEVERS

Problematic 18’ long cantilevers done in 10” thick concrete slab all over the perimeter of the building. Solved the problem with post-tensioned tendons in all directions:

\[ F = 231 \text{ kip/tendon} \quad \text{tendon} \to 7 \: Ø \: 1/2'' \]

Formwork for the slabs has to be raised by two inches.
DROPPED PANELS

Too much shear force for the thin slab itself so it must be thickened with dropped panels to **avoid the punching shear** at the column connections.
INTEGRATION

**GOALS:** Cheaper, healthier building with more open spaces that allow movable partitions.

**A:** Cores aligned with the Puzzle theme to allow more space for the auditorium and hurricane shelter.

**CM:** Faster construction with no beams.

**MEP:** Allignment for the third shaft, shear walls, raised floor and dropped panels.
FLOOR SANDWICH
Indoor Design Requirements:
- Supply Air: 62°F
- Temperature Set Point: 75°F
- Humidity Ratio: .012 lb/lb

Outdoor Air Design Conditions:
- Dry Bulb: 89.24°F
- Humidity Ratio: .026 lb/lb

Indoor Design Requirements:
- Supply Air: 62°F
- Temperature Set Point: 75°F
- Humidity Ratio: .012 lb/lb
All Energy Consumption is electricity use, no natural gas use.
**SUSTAINABLE TARGET VALUE**

<table>
<thead>
<tr>
<th>Carbon (kgCO2e)</th>
<th>Energy (MJ)</th>
<th>Water (kgH2O)</th>
<th>Targets</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>214%</td>
<td>32%</td>
<td>64%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>83%</td>
<td>128%</td>
<td>126%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Most Value**
- Solar panels
- Water reclamation
- Low flow sinks and toilets
- Decreased material use
- Solar water heating
- Green power
WATER RECLAMATION

Collects enough water for **one week** in case of natural disaster.
WATER HEATING

Solar collector works while cloudy with lower efficiency.
ROOF SECTION

- Photovoltaic panel
- Air Gap
- Saw-tooth Skylight

- 18°

- White EPDM
- Rigid Insulation
- Phase Changing Material
- Vapor Barrier
- Roof Slab
WALL SECTION

- Daylight Window (SHG≈0.3)
- Light Shelf
- Double Pane Low-E (R≈2.6, E=0.2)
- Operable Exterior Blinds
- Structurally Insulated Panels (R≈30)
MEP & SE COORDINATION

Second Floor Plan
MEP & SE COORDINATION
AEC (PBL) BIM Protocol – Island Team:
• Overview of project information requirements
• Folder structure conventions
• Dropbox as project sharing software
• Weekly process for BIM integration
BIM INTEGRATION PROCESS

BIM modelling and coordination → Integration in other disciplines for analysis → Finished estimations and analysis

ARCH → SE → MEP → DESIGN

SE → MEP → CM → LCFM → FINAL
MODELLING AND COORDINATION
INTEGRATION IN DISCIPLINES

Collaboration

Model export for SE to do structural analysis

Model export for MEP to do mechanical analysis

Schedule export for CM and LCFM for cost analysis
CLASH DETECTION

Allignment of structure and MEP

Still some noise clashes with nonstructural elements that are non-essencial (≈ 200).
LOCAL RESOURCES

- Poured concrete plant
- Prefab concrete plant
- Steel element plant
- Plastic recycling
- Electronics/cardboard/residential recycling
- Recycling building materials

Map showing local resources within 4 miles, 6 miles, 8 miles, and 10 miles of the construction site.
OFF-SITE LOGISTICS

Entrance ways to the construction site from the freeway.

Our construction site.
SITE LOGISTICS EXCAVATION

- Site office
- Material preparation area
- Loading off zone for instant deliveries
- Recycling and waste management area
- Drive-through site entrance
- Silt fence for erosion control
SITE LOGISTICS CONSTRUCTION
SITE LOGISTICS CONSTRUCTION
CONSTRUCTION SAFETY

First-Aid and fire extinguisher close to preparation areas to ensure safety.
Assembly area by site office in case of accidents.
PREFABRICATION

Concrete Structural Insulated Panels (SIPs) for exterior walls

Operable partition walls

Alucobond façade panels
CRITICAL CONSTRUCTION ZONES

Post-tensioned cantilevers with raised formwork requires precise construction.
CONSTRUCTION SCHEDULE

Construction period: 11 ½ months.

Start: September 2, 2019.

Scheduled weather buffer: 2 weeks.

CONSTRUCTION SCHEDULE

Milestone 1
Finished substructure

Milestone 2
Building envelope finished
CONSTRUCTION SCHEDULE

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity Description</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Computer labs</td>
<td>25 dagar</td>
<td>må 20-03-02</td>
<td>fredag 20-04-03</td>
</tr>
<tr>
<td>26</td>
<td>Interior walls and doors</td>
<td>5 dagar</td>
<td>må 20-03-02</td>
<td>fredag 20-03-06</td>
</tr>
<tr>
<td>27</td>
<td>HVAC</td>
<td>10 dagar</td>
<td>må 20-03-09</td>
<td>torsdag 20-03-10</td>
</tr>
<tr>
<td>28</td>
<td>Water distribution</td>
<td>3 dagar</td>
<td>må 20-03-09</td>
<td>torsdag 20-03-11</td>
</tr>
<tr>
<td>29</td>
<td>Electricity</td>
<td>5 dagar</td>
<td>må 20-03-09</td>
<td>torsdag 20-03-13</td>
</tr>
<tr>
<td>30</td>
<td>Raised floor</td>
<td>5 dagar</td>
<td>må 20-03-23</td>
<td>fredag 20-03-27</td>
</tr>
<tr>
<td>31</td>
<td>finishes</td>
<td>5 dagar</td>
<td>må 20-03-30</td>
<td>fredag 20-04-03</td>
</tr>
<tr>
<td>32</td>
<td>Computer labs finished</td>
<td>0 dagar</td>
<td>fr 20-04-03</td>
<td>fredag 20-04-03</td>
</tr>
<tr>
<td>34</td>
<td>Underfloor MEP ground floor</td>
<td>10 dagar</td>
<td>må 20-03-02</td>
<td>fredag 20-03-13</td>
</tr>
<tr>
<td>35</td>
<td>Underfloor MEP first floor</td>
<td>10 dagar</td>
<td>må 20-03-16</td>
<td>fredag 20-03-27</td>
</tr>
<tr>
<td>33</td>
<td>Interior buildout (raised floor)</td>
<td>25 dagar</td>
<td>må 20-03-30</td>
<td>fredag 20-05-01</td>
</tr>
<tr>
<td>36</td>
<td>Underfloor MEP second floor</td>
<td>10 dagar</td>
<td>må 20-03-30</td>
<td>fredag 20-04-10</td>
</tr>
<tr>
<td>37</td>
<td>Overhead MEP ground floor</td>
<td>15 dagar</td>
<td>må 20-04-13</td>
<td>fredag 20-05-01</td>
</tr>
<tr>
<td>38</td>
<td>Underfloor MEP third floor</td>
<td>10 dagar</td>
<td>må 20-04-13</td>
<td>fredag 20-04-24</td>
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<tr>
<td>40</td>
<td>Overhead MEP first floor</td>
<td>15 dagar</td>
<td>må 20-05-04</td>
<td>fredag 20-05-22</td>
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<tr>
<td>41</td>
<td>Interior buildout (partitions)</td>
<td>15 dagar</td>
<td>må 20-05-04</td>
<td>fredag 20-05-22</td>
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<tr>
<td>42</td>
<td>Overhead MEP second floor</td>
<td>15 dagar</td>
<td>må 20-05-25</td>
<td>fredag 20-06-12</td>
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<tr>
<td>43</td>
<td>Interior buildout (finishes)</td>
<td>35 dagar</td>
<td>må 20-06-08</td>
<td>fredag 20-07-24</td>
</tr>
<tr>
<td>44</td>
<td>Overhead MEP third floor</td>
<td>15 dagar</td>
<td>må 20-06-15</td>
<td>fredag 20-07-03</td>
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<tr>
<td>45</td>
<td>MEP trimout</td>
<td>5 dagar</td>
<td>må 20-07-06</td>
<td>fredag 20-07-10</td>
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<tr>
<td>46</td>
<td>Ceiling panels</td>
<td>15 dagar</td>
<td>må 20-07-13</td>
<td>fredag 20-07-31</td>
</tr>
<tr>
<td>47</td>
<td>Commissioning</td>
<td>15 dagar</td>
<td>må 20-08-03</td>
<td>fredag 20-08-14</td>
</tr>
<tr>
<td>48</td>
<td>Handover</td>
<td>1 dag</td>
<td>fr 20-08-14</td>
<td>fr 20-08-14</td>
</tr>
</tbody>
</table>

**Milestone 3**
Finished computer labs

**Milestone 4**
Handover
EQUIPMENT SELECTION

POTAIN MC 310 K16
TOWER CRANE

Rental from Forteza Equipo,
Bayamón a 20 minute drive
from the site.

VOLVO EC140 Excavator

Rental from BlueLine Rental,
Toa Baja a 25 minute drive
from the site.
## CRANE TRADEOFF

<table>
<thead>
<tr>
<th></th>
<th>MOVES PER DAY</th>
<th>TIME PER MOVE</th>
<th>DELAYMENT OF CONSTRUCTION TIME</th>
<th>TOTAL CRANE COST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROVE MOBILE CRANE</strong></td>
<td>1</td>
<td>30 MIN</td>
<td>2 ½ WEEKS</td>
<td>$457,000</td>
</tr>
<tr>
<td><strong>POTAIN TOWER CRANE</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$435,000</td>
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</tbody>
</table>

**GROVE TMS700E MOBILE CRANE**

**POTAIN MC 310 K16 TOWER CRANE**
## COST AND TARGET SUMMARY

<table>
<thead>
<tr>
<th></th>
<th>ESTIMATED VALUE</th>
<th>TARGET VALUE</th>
<th>VALUE DELTA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>$6,708,616</td>
<td>$9,300,000</td>
<td>$2,591,384</td>
</tr>
<tr>
<td>A Substructure</td>
<td>$117,012</td>
<td>$465,000</td>
<td>$347,988</td>
</tr>
<tr>
<td>B Shell</td>
<td>$2,211,417</td>
<td>$2,790,000</td>
<td>$578,583</td>
</tr>
<tr>
<td>C Interiors</td>
<td>$1,076,121</td>
<td>$1,674,000</td>
<td>$597,879</td>
</tr>
<tr>
<td>D Services</td>
<td>$1,847,944</td>
<td>$2,976,000</td>
<td>$1,128,056</td>
</tr>
<tr>
<td>E Equipment and Furnishing</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F Specialty Construction</td>
<td>$180,200</td>
<td>$186,000</td>
<td>$5,800</td>
</tr>
<tr>
<td>G Building Sitework</td>
<td>$37,970</td>
<td>$372,000</td>
<td>$334,030</td>
</tr>
<tr>
<td>H General Conditions</td>
<td>$1,237,952</td>
<td>$837,000</td>
<td>$(400,952)</td>
</tr>
</tbody>
</table>
• Cost data from **two reference projects** from in Universidad de Puerto Rico.
  - One new construction project and one renovation project.

• Cost per square foot new construction project: $168.
• Cost per square foot our project: $170.
COST ESTIMATE DISTRIBUTION

- **G Building Sitework**: $37,970 (1%)
- **F Specialty Construction**: $180,200 (3%)
- **E Equipment and Furnishings**: $0 (0%)
- **D Services**: $1,847,944 (27%)
- **H General Conditions**: $1,237,952 (18%)
- **A Substructure**: $117,012 (2%)
- **B Shell**: $2,211,417 (33%)
- **C Interiors**: $1,076,121 (16%)
TARGETS DISTRIBUTION

- C Interiors: 18%
- B Shell: 30%
- D Services: 32%
- E Equipment and Furnishings: 0%
- F Special Construction: 2%
- G Building Sitework: 4%
- H General Conditions: 9%
- A Substructure: 5%

Collaboration Most Value
WHOLE LIFE CYCLE COSTS

- Extra Income: $8,753,055
- Rent: $20,013,333
- Construction Costs: $6,708,616
- O&M: $7,049,413
- Replacement: $2,745,311
- Risk Charge: $2,439,872

Design Collaboration Most Value

- Extra Income: 14%
- Rent: 40%
- Construction Costs: 18%
- O&M: 14%
- Replacement: 6%
- Risk Charge: 8%
WHOLE LIFE CYCLE COSTS

- Expenses per Year
- Income per Year

Break-Even in Year 9
WHOLE LIFE CYCLE COSTS

Design
Collaboration
Most Value

2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045

O&M Risk Charge Replacement Income Rent

$0 $500,000 $1,000,000 $1,500,000 $2,000,000 $2,500,000 $3,000,000 $3,500,000 $4,000,000

80
COST SAVINGS DURING DESIGN PROCESS

- Design
- Collaboration
- Most Value
- Building Health

- Base
- Post Tensioned Slab
- Energy Savings
- Water Savings
- Wastemanagement
- Operable Sun Protection
Café

- Healthy Surrounding
- Healthy Food
- Higher Rent

Hourly Rental

- Auditorium
- Seminar Rooms
- Computer Labs
- Small and Large Classrooms
- Comparable Rent to surrounding Buildings
MAJOR RISKS

- **Construction Phase**
  - Hurricane Construction: 9.82%
  - Input Resources: 0.53%
  - Theft: 0.23%
  - Earthquakes Construction: 0.17%

- **Operation Phase**
  - Hurricane Operation: 10.32%
  - Vandalism: 3.48%
  - Earthquake Operation: 1.66%
  - Income Hourly Rental: 0.66%
  - Income Cafe: 0.66%
  - Operation: 0.61%
  - Maintenance: 0.56%

Overall, the highest risk is Hurricane Operation with 71.97%.
HURRICANE TREATMENT

3% Reduction of Damages at the Building

- Without Treatments: 16.0%
- Facade Panels: 14.0%
- Shades: 12.0%
- Windows with Security Film: 10.0%
- Panel over Atrium: 8.0%
- PV on Roof: 6.0%
- Egress: 4.0%
- LCD Walls: 2.0%
- Design: 0.2%
- Collaboration: 0.5%
- Most Value: 0.6%
- Building Health: 0.3%
HURRICANE RISK CHARGE

- Number of Hurricanes from 1860 to 2013: 109
- Average Probability of Occurrence per year: 68%
- Most likely Damage without Treatments: 31%
- Most likely Damage with Treatments: 28%

Legend:
- Tropical Storm & Category 1
- Category 2 & 3
- Category 4 & 5
HURRICANE RISK CHARGE

WITHOUT our Treatments

Mean Value over the Contract Period of $2,607,939
HURRICANE RISK CHARGE

WITH our Treatments

Mean Value over the Contract Period of $1,973,977

23% Saving in Risk Charge
BUILDING HEALTH

1
2
3
4
5
6

Design
Collaboration
Most Value
Building Health
WATER CONSERVATION

Design
Collaboration
Most Value
Building Health
ENERGY CONSERVATION
BUILDING HEALTH

1. Bicycle racks & Showers
2. Use of daylight & maximized views
3. Outdoor gathering spaces
4. Healthy food options
5. Organic roof gardening
6. Nap room

Design
Collaboration
Most Value
Building Health

Air filters
Green cleaning policies
No smoking policy
Low VOC Materials
WATER CONSERVATION

1. Rainwater Reclamation

2. Native plants

- Tap diffusers
- Low flow showers
- Automatic sinks

Dual flush toilets

Water Sense appliances
EN能GY CONSERVATION

Energy Star appliances

Duct insulation

1 Photovoltaic panels

2 Commissioning & retro-commissioning

Occupant survey & feedback plan

3

GreenPower
Accredited Renewable Energy
# Expected LEED Certification

<table>
<thead>
<tr>
<th>LEED Criteria</th>
<th>Points Available</th>
<th>Expected Points Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrative Process</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Location and Transportation</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Sustainable Sites</td>
<td>10</td>
<td>8</td>
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<tr>
<td>Water Efficiency</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Energy and Atmosphere</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>Materials and Resources</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Indoor Environmental Quality</td>
<td>16</td>
<td>13</td>
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<tr>
<td>Innovation</td>
<td>6</td>
<td>3</td>
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<tr>
<td>Regional Priority</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>110</strong></td>
<td><strong>77</strong></td>
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</tbody>
</table>
COLLABORATIONS

• FACADE
• HURRICANE SHELTER
• FLOOR SANDWICH
• ROOF
• OCCUPANT COMFORT CONTROL
• TOILETS
• PREFABRICATION
• COST EFFECTIVE DESIGN
“Although we have the technology it does not mean that we have the means.”

“Get to know each other. Everything becomes so much easier then.”

“After tired comes stupid.”

“When every team member is passionate about what they are doing, the project starts to be about having fun.”

“Everyone gets stressed. Find support in your teammates.”

“There are no bad ideas.”
THANK YOU

Eric Kneer  Mike Miller  Humberto Cavallin  Forest Olaf Peterson  Greg Luth  Daniel Gonzales

John Nelson  Miloš Todorović  Glenn Katz  Tomo Cerovšek  Kourosh Salehzadeh  Sarah Russell-Smith

Ronnie Haagersen  Kyle Adams  Renate Fruchter  Mattias Erlich  Björn Wundsch  Pablo Cabral

Maria Frank  ...and other local mentors