

## 8<sup>th</sup> DOE/NREL Hands-On PV Experience (HOPE)

National Renewable Energy Laboratory | Golden, CO, USA

July 14-19, 2019



**NREL is a national laboratory of the U.S. Department of Energy,  
Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**

# SCHEDULE FOR DOE/NREL HANDS-ON PV EXPERIENCE (HOPE)

## Sunday, July 14, 2019

12:00 - 5:00: Room check-in Colorado School of Mines (CSM), Maple Hall, 1733 Maple St., Golden, CO 80401.

Dinner on your own. There are many restaurants within a 10- to 20-minute walk. There is a Safeway within a 10-minute walk.

7:00PM - Introductions and expectations for the week CSM, Maple Hall, Garden Level lounge  
"PV Jeopardy" game (Adele Tamboli, Silvana Ayala)

## Monday, July 15, 2019

7:00 Breakfast

7:35 Board shuttle bus CSM, from next to cafeteria

7:40 Shuttle bus will be departing

7:55 Check-in - NREL

### SERF Auditorium (C108)

8:05 Safety orientation (Doug Hiebert)

8:20 Welcome (Adele Tamboli)

8:30 Mini concentration construction project (Silvana Ayala)

9:30 Skills for writing scientific papers (Robert Klie)

10:30 Break

10:45 How to design a rooftop PV system (Deidra Hodges)  
*Please bring a copy of a utility bill – yours or someone else's*

11:45 Lunch SERF Auditorium/Solarium

12:45 Intro to technology areas - Silicon & III-Vs (Paul Stradins, Myles Steiner)

Open to all grad students @ NREL MCST

2:15 Break

2:30 Continued intro to technology areas - Perovskites & CdTe (Joe Berry, Matt Reese)

Open to all grad students @ NREL MCST

4:00 Poster session (SERF Solarium)

5:00 Shuttle bus (meet in SERF auditorium) will take everyone to dorms

Dinner on your own

## Tuesday, July 16, 2019

7:00 Breakfast

7:40 Shuttle bus will be departing CSM, from next to cafeteria

7:55 Arrive at NREL - SERF C108

Break into groups:

Group 1 (III-V/Si) Julia, Pascal, Saumya, Xiaodong

Group 2 (Perovskites A) Amy, Deborah, Gilbert, Laura

Group 3 (CdTe) Jinglong, Lily, Will W.

Group 4 (Perovskites B) Luis, Madeline, Rubaiya, William D.

8:00 Solar cell fabrication

Group 1 (III-V/Si) Myles Steiner - MOCVD deposition (SERF W128), Bill Nemeth & San Theingi - Si passivation and Sinton lifetime (PDIL)

Group 2 (Perovskites A) Fei Zhang (SERF W129)

8:00 Groups 3 & 4 (PV Module: Types of module packages, failures and how to test for them - Introduction in SERF Auditorium) Nick Bosco

8:45 Lamination of PV modules SERF E216 (Groups 3 & 4) Mike Kempe

9:30 Break - to be taken whenever convenient for each group

9:45 Tour of Outdoor Test Facility (Groups 3 & 4)  
Mike Deceglie

11:00 PV cell characterization SERF E221 (Groups 3 & 4) Tao Song

12:00 Lunch SERF Auditorium

1:00 Solar cell fabrication:

Group 1 (III-V/Si) - Kaitlyn VanSant, Michelle Young - III-V cell fabrication

Group 2 (Perovskites A) - Fei Zhang

Group 3 (CdTe) - Eric Colegrove, Dave Albin

Group 4 (Perovskites B) - Axel Palmstrom

2:30 Break - to be taken whenever convenient for each group

2:45 Continue solar cell fabrication

5:00 Shuttle bus (meet in SERF auditorium) will return to CSM. Pizza will be provided at the panel, so feel free to skip dinner.

6:30 Pizza and Panel Discussion on "Career Directions Related to PV"  
CSM, Maple Hall Community Room  
Moderator: Adele

Panel:

1. Gabriel Menard, Assistant Professor of Chemistry, University of California, Santa Barbara
2. Deidra Hodges, Assistant Professor, Electrical & Computer Engineering, University of Texas at El Paso
3. Kelsey Horowitz, Researcher, Strategic Energy Analysis Center, NREL

## Wednesday, July 17, 2019

7:00 Breakfast

7:40 Shuttle bus will be departing CSM, from next to cafeteria

7:55 Arrive at NREL - SERF C108

8:00 Groups 3 & 4 (Perovskites B, CdTe) - Finish solar cell fabrication (Axel Palmstrom, Dave Albin, Eric Colegrove)

8:00 Groups 1 & 2 (PV Module: Types of module packages, failures and how to test for them - Introduction in SERF Auditorium) Nick Bosco

8:45 Lamination of PV modules SERF E216 (Groups 1 & 2) Mike Kempe

9:30 Break - to be taken whenever convenient for each group

9:45 Tour of Outdoor Test Facility (Groups 1 & 2)  
Mike Deceglie

11:00 PV cell characterization SERF E221 (Groups 1 & 2) Tao Song

# JULY 14–19, 2019

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- 12:00 Lunch (SERF Solarium)
- 1:00 Introduction to Measurements & Characterization (Harvey Guthrey & John Moseley)
- 2:00 Synchrotron based characterization methods – Luisa Whittaker-Brooks
- 3:00 Break
- 3:15 Measurement & Characterization Lab Sessions:
1. TEM (Andrew Norman) – Will D., Saumya
  2. PL & TRPL (Pat Dippo, Darius Kuciauskas) – Xiaodong, Will W, Laura, Deborah, Luis, Amy, Rubaiya
  3. Cell Imaging: PL, EL, DLIT (Dana Sulas) – Madeline, Lily, Pascal
  4. SIMS & TOF-SIMS (Steve Harvey) – Julia, Gilbert, Jinglong
- 5:00 Shuttle bus will return to CSM.

Dinner on your own

*Please watch video on spectral mismatch corrections in preparation for tomorrow! See HOPE website.*

## Thursday, July 18, 2019

- 7:00 Breakfast
- 7:40 Shuttle bus will be departing CSM, from next to cafeteria
- 7:55 Arrive at NREL – S&TF 127

Solar cell measurements

- 8:00 IV & QE Characterization: Predictions and Interpretations (Jim Sites)
- 9:15 Group 1 (III-V/Si) – San Theingi and Kaitlyn VanSant  
Group 2 & 4 (Perovskites A & B) – Giles Eperon  
Group 3 (CdTe) – Matt Reese
- 11:30 Discussion of measured data (Jim Sites plus technical leads)
- 12:30 Lunch: S&TF 127
- 1:30 Entrepreneurship & Technology Commercialization (Amy Prieto)
- 2:45 Break
- 3:00 Measurement & Characterization Lab Sessions:
1. CV & DLTS (Steve Johnston) – Madeline, Will W., Laura, Deborah, Luis – S&TF 135
  2. HVPE Tour & Testing Multijunction Solar Cells (Aaron Ptak, Myles Steiner) – Xiaodong, Julia, Lily, Pascal, Saumya – S&TF 203, SERF C211
  3. X-ray Methods (Annie Greenaway) – Amy, Will D., Jinglong – S&TF 136/137
  4. UV-Vis and Ellipsometry (Paul Ndione) – Gilbert, Rubaiya – SERF C211
- 5:00 Shuttle bus will return to CSM
- 5:45 Walk together to dinner
- 6:00 Dinner & “PV Mythbusters” Game  
Moderator: Deidra Hodges  
Sherpa House Restaurant, 1518 Washington Ave, Golden, CO

## Friday, July 19, 2019

- 7:00 Breakfast
- 7:40 Shuttle bus will be departing CSM, from next to cafeteria
- 7:55 Arrive at NREL – S&TF 127
- 8:00 Measurement & Characterization Lab Sessions:
1. SEM, CL, and EBIC (John Moseley, Harvey Guthrey) – Saumya, Pascal, Lily, Madeline, Jinglong
  2. XPS & UPS (Elisa Miller) – Julia, Deborah, Luis, Amy, Will W., Rubaiya
  3. Module Coring (Helio Moutinho) – Xiaodong, Gilbert, Laura, Will D.
- 10:00 Break
- 10:15 Fellowship and job opportunities for students & postdocs (Annie Greenaway – NREL Director’s Fellow, Peter Lobaccaro – DOE Fellow)
- 11:15 Designing PV for high specific power markets (Matt Reese)
- 12:00 Lunch - S&TF 127
- 1:00 Student preparatory time – presentations to take back home (Adele)
- 1:30 Student informal presentations of what they’ll take back to home institution (5 min. each) (students)
- 3:00 Afternoon Tea (keep posters up) – SERF Solarium
- 3:30 Meet with NREL scientists (arrange in advance)
- 4:30 Review of HOPE and students’ suggestions for how it could be improved in future years - S&TF 127 (Adele)
- 5:30 Shuttle bus will return to CSM from front of S&TF.

Dinner on your own

## Saturday, July 20, 2019

**Check out (by 10:00 AM)**  
**Students are welcome to coordinate hikes or other activities before returning home.**

## Participants

| Student's Name             | University                              | Professor              | Technology Group |
|----------------------------|---|------------------------|------------------|
| Amy Brown                  | Boston University                       | Malika Jeffries-EL     | Perovskites      |
| Deborah McGott             | Colorado School of Mines                | Matt Reese             | Perovskites      |
| Gilbert Annonhene          | Virginia Commonwealth University        | Gary Tepper            | Perovskites      |
| Jinglong Guo               | University of Illinois at Chicago       | Robert Klie            | CdTe             |
| Julia D'Rozario            | Rochester Institute of Technology       | Seth Hubbard           | III-V/Si         |
| Laura Flannery             | University of Utah                      | Luisa Whittaker-Brooks | Perovskites      |
| Lily Moloney               | Colorado State University               | Amy Prieto             | CdTe             |
| Luis Eduardo Valerio Frias | The University of Texas at El Paso      | Deidra Hodges          | Perovskites      |
| Madeline Peterson          | University of California, Santa Barbara | Gabriel Menard         | Perovskites      |
| Pascal Jundt               | Colorado State University               | Jim Sites              | III-V/Si         |
| Rubaiya Murshed            | University of Nevada Las Vegas          | Shubhra Bansal         | Perovskites      |
| Saumya Gulati              | University of Louisville                | Joshua Spurgeon        | III-V/Si         |
| William Delmas             | University of California, Merced        | Sayantani Ghosh        | Perovskites      |
| William Weigand            | Arizona State University                | Zachary Holman         | CdTe             |
| Xiaodong Meng              | Arizona State University                | Mariana Bertoni        | III-V/Si         |

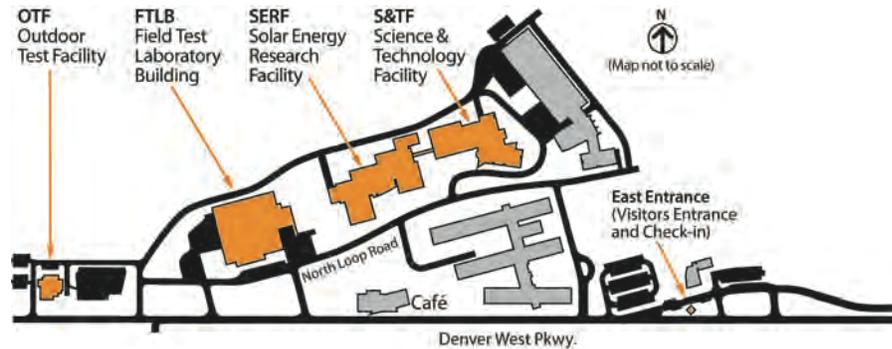
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## NREL Laboratory Locations



### National Renewable Energy Laboratory

15013 Denver West Parkway, Golden, CO 80401  
303-275-3000 • [www.nrel.gov](http://www.nrel.gov)

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