

Introduction to the Introduction to Fusion Energy and Plasma Physics Course



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First, a bit about myself

- From Bogotá, Colombia
- Started studying physics at the National University of Colombia at Bogota.
- Transferred to University of Texas at Austin where I finished undergrad (HOOK'EM HORNS!)



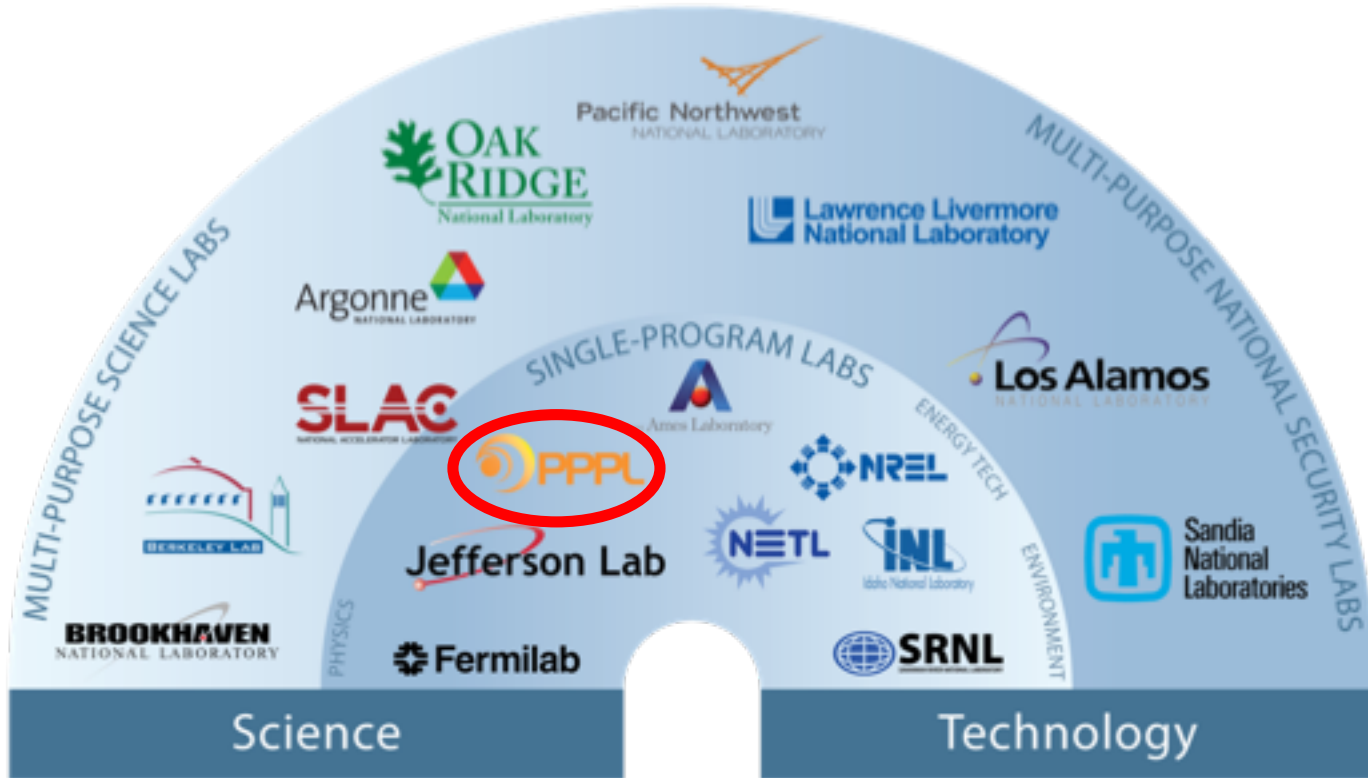
- Did my graduate work at MIT, in Boston on **fusion plasmas** (GO BEAVERS!)

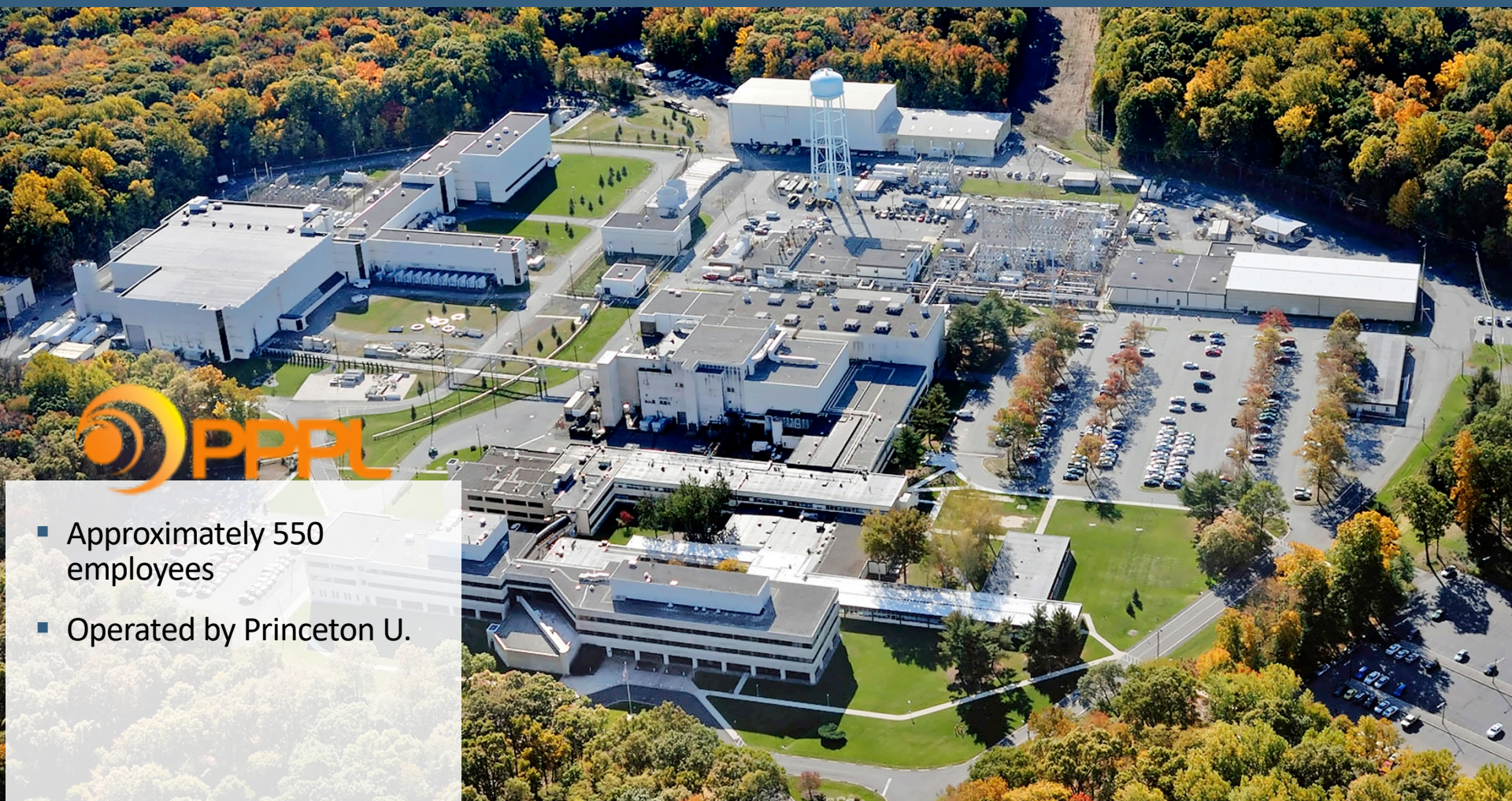


- Now I'm at the Princeton Plasma Physics Lab (GO TIGERS!)

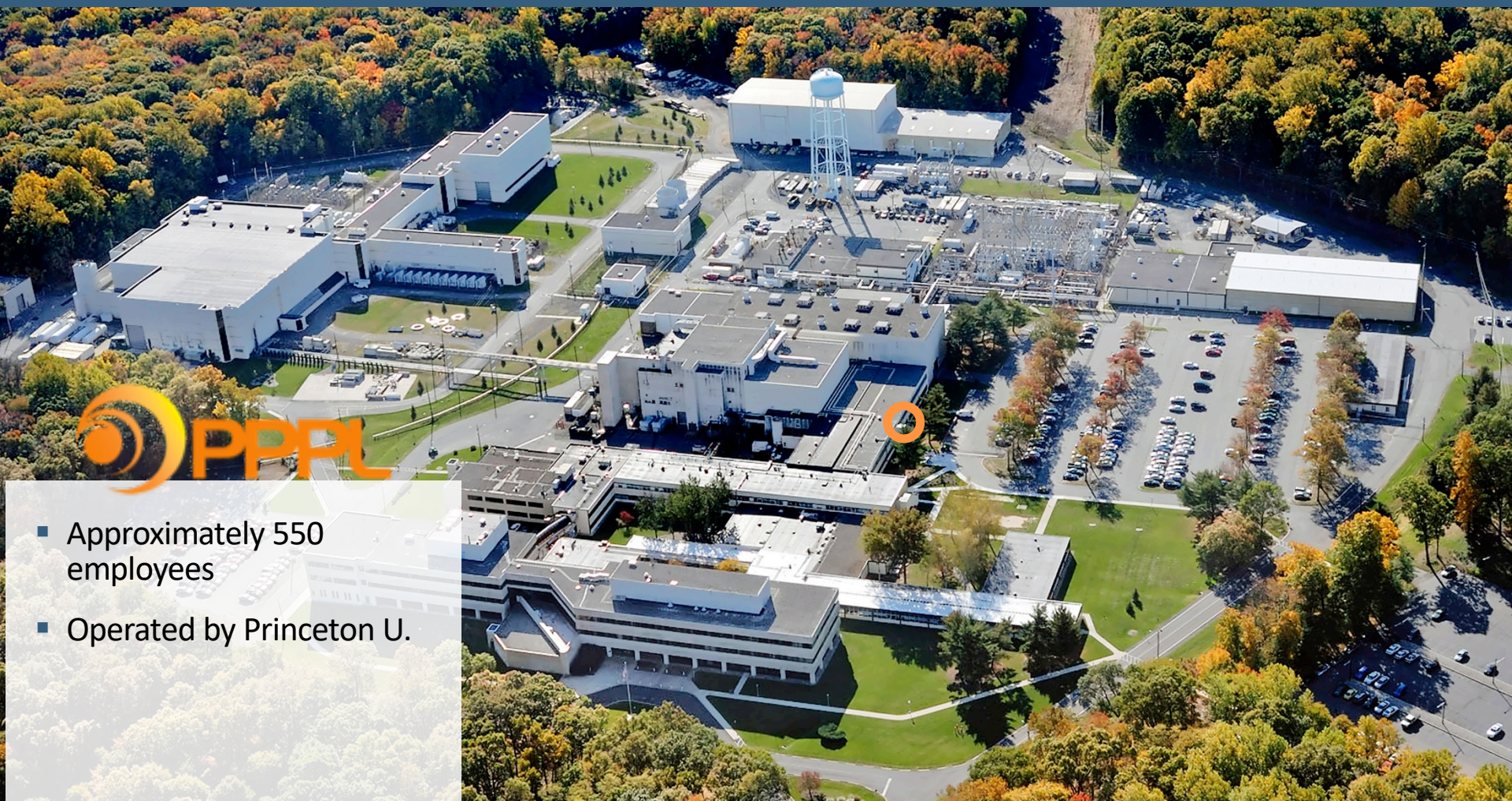


PPPL is one of 17 Department of Energy national laboratories





- Approximately 550 employees
- Operated by Princeton U.



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Lyman Spitzer started PPPL (originally Project Matterhorn) in 1951...Birthplace of US fusion

Inventor of the Stellerator

Founder of the lab



Made countless advances in plasma physics (his name is everywhere)

Proposed telescopes in outer space (hence the Spitzer Space Telescope)

| Second, a bit about yourselves



2018 PPPL Interns

| Number of enrolled students (~300)



All lectures are free to watch and will be posted

- All lectures will be streamed via Zoom Webinar. No registration is need.
- Enrollees, i.e. those who filled out the google form on the site and which we could fit, will have a Zoom-Brady-Bunch-Square, will get priority for questions, will participate in the polls and will join the networking events.
- Webinar participants can ask questions using the ask/chat feature.
- ALL written questions should be directed at the hosts and we will hold them for the Q/A portion.
- As has been done since 2015, the course lectures and the speaker videos will be posted on [the site](#).
- We plan to follow accessibility guidelines, including incorporating closed-captioning after an initial upload.

We had way more submissions than we could handle!

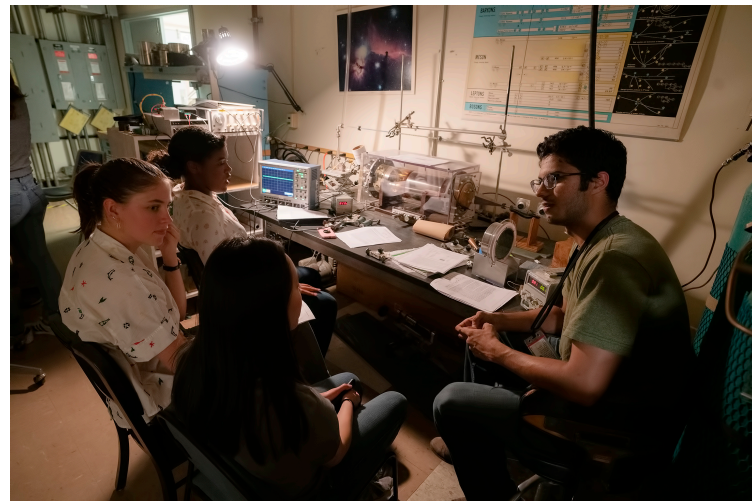
- We were pleasantly surprised by the number and breadth of enrollment submissions!
- Submissions included undergraduate students, grad students, postdocs, researchers, professors and general public.
- Because of technical limitations, we could only enroll ~300 participants so priority has been given to undergraduates conducting fusion/plasma research.
- Nonetheless, we'll be giving non-admitted enrollees the chance to participate in other activities which I'll discuss at the end of this talk.

A birds-eye view of the undergrads

Undergraduate enrollees are students at more than 130 colleges, including international students in Australia, India, Costa Rica, and more!

Many enrollees are conducting internships/summer research. Some of the programs are:

- Science Undergraduate Laboratory Internship Program (SULI) and Community College Internship (CCI), run by DOE. (students from at least 9 labs)
- NSF funded REUs
- Students doing internships at their own colleges (at least 30 schools)
- Private companies developing fusion



2019 Intro Course Participants



WELCOME!!



These are not normal times and we should
acknowledge this

- The reason the course is remote is because we are living during a pandemic.
- All talks are recorded and will be posted, so practice self-care. Take rests, sit out when you're exhausted, stretch, stay hydrated, etc.
- **YOUR HEALTH AND WELL BEING ARE THE PRIORITY!**

A healthy culture of diversity, equity and inclusion is needed for the future of fusion energy and plasma physics

- The US fusion energy and plasma physics community has a poor record on diversity, equity and inclusion, as evidenced by the few women and underrepresented minorities in the field as compared to other physics and engineering fields.
- Recent community-wide strategic plans have, for the first time, acknowledged these problems and put forth initial plans to address them. But an inclusive climate is the only way to start.

| Code of conduct

Since this is a public forum we ask speakers and participants to:

- Make participation in our community a harassment-free experience for everyone
- Act in ways that contribute to an open, welcoming, diverse, inclusive, and healthy community
- We align with the [Contributor Covenant Code of Conduct](#)

Code of conduct: Unacceptable Behaviors

- The use of sexualized language or imagery, and sexual attention or advances of any kind
- Trolling, insulting or derogatory comments, and personal attacks
- Public or private harassment
- Other conduct which could reasonably be considered inappropriate in a professional setting

Code of conduct: Positive Behaviors

- Demonstrating empathy and kindness
- Being respectful of differing opinions and experiences
- Giving and gracefully accepting constructive feedback
- Accepting responsibility and apologizing to those affected by our mistakes, and learning from the experience

| Code of conduct: Positive Behaviors

- Respect the pronouns of others
- Recognize that intent is not equal to impact
- **Self-Care is revolutionary!**

| History of the Intro to Fusion/Plasma Course

- Originally started in 1992* by Prof. Nat Fisch and former assistant director (and former congressman) Rush Holt, as part of the National Undergraduate Fellowship (NUF).



1994 NUF class



Rush Holt





Nat Fisch

| Changes for this year





- Fully Remote
- 2 weeks long, but 4.5 hours a day
- Shorter talks (45+5 minutes, vs. 90 minutes)
- Many more talks (36 speakers vs. 15 in the past)!
- Many more participants!
- Broader scope, covering the full spectrum of topics under the Fusion Energy Sciences and Plasma Physics umbrella

Today (6/15) we'll begin with Fusion

Eastern Time	Day 1 (6/15/20)	
12:30 PM	Introduction to the Course <i>Dominguez</i>	
1:30 PM	Energy Context <i>Umstattd</i>	
2:30 PM	Break	
3:00 PM	Intro to Fusion I <i>Cowley</i>	
4:00 PM	Intro to Fusion II <i>Cowley</i>	





- Dr. Ryan Umstattd (Fusion Industry Association) will motivate the US and global need for fusion energy by discussing the current energy context.
- Prof. Steve Cowley (PPPL) will present the promise and challenges of fusion energy science and technology.

Tomorrow (6/16) we will talk Plasma

Eastern Time	Day 2 (6/16/20)	
12:30 PM	Introduction to Plasma Physics <i>Dominguez</i>	
1:30 PM	Single Particle Motion <i>Fox</i>	
2:30 PM	Break	
3:00 PM	Waves in Plasmas <i>Diem</i>	
4:00 PM	Turbulence in Plasmas <i>Mordijck</i>	




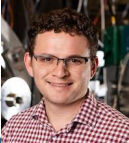
- I will give a broad intro to plasma physics and it's fundamental parameters.
- Dr. Will Fox (PPPL) will describe plasma particle motion in E&M fields.
- Prof. Steffi Diem (UW Madison) will highlight the role of waves in plasmas.
- Prof. Saskia Mordijck (College of William and Mary) will discuss another ubiquitous plasma phenomenon, turbulence.

Wednesday (6/17) will focus on astrophysical plasmas

Eastern Time	Day 3 (6/17/20)	
12:30 PM	Reconnection Cassak	
1:30 PM	The Sun and the Heliosphere Reeves	
2:30 PM	Break	
3:00 PM	Plasma Astrophysics Zweibel	
4:00 PM	Laboratory Plasma Astrophysics Brown	





- Connecting Day 2 with 3, Prof. Paul Cassak (WVU), will discuss magnetic reconnection.
- Dr. Kathy Reeves (Harvard-Smithsonian CFA) will talk about astrophysical plasmas close to home.
- Prof. Ellen Zweibel (UW Madison) will discuss astrophysical plasmas broadly.
- Prof Mike Brown (Swarthmore College) will show how we're studying astrophysical plasmas in the lab

Thursday (6/18) we will concentrate on magnetic fusion energy and its configurations

Eastern Time	Day 4 (6/18/20)	
12:30 PM	Tokamaks and STs <i>Battaglia</i>	
1:30 PM	ITER <i>Laggner</i>	
2:30 PM	Break	
3:00 PM	Stellarators <i>Bader</i>	
4:00 PM	Alternative configurations <i>Sutherland</i>	

- Dr. Devon Battaglia (PPPL) will start with the most studied configuration, the tokamak, as well as the spherical torus.
- Dr. Florian Laggner (PPPL) will discuss the flagship machine of the international fusion community, ITER.
- Dr. Aaron Bader (UW Madison) will present on the second most studied MFE machine, the stellarator.
- Dr. Derek Sutherland (CTFusion Inc) will explore other magnetic configurations and discuss alternative paths towards fusion.

Friday (6/19) will focus on diagnostics and enabling technologies (and a bit of HEDP)





Eastern Time	Day 5 (6/19/20)	
12:30 PM	Measurements and Diagnostics <i>Reinke</i>	
1:30 PM	Auxiliary heating <i>Pinsker</i>	
2:30 PM	Break	
3:00 PM	High Temperature Superconductors <i>Sorbom</i>	
4:00 PM	Pulsed power and Z-pinches <i>Sefkow</i>	

- Dr. Matt Reinke (ORNL) “pictured” here will describe how we can actually measure physical quantities in multi-million degree environments.
- Dr. Bob Pinsker (GA) will discuss how we can increase the power and control of plasmas using waves and beams
- Dr. Brandon Sorbom (CFS) will present on a new technology that may revolutionize the field, HTS.
- Prof. Adam Sefkow (U. of Rochester) will start the topic of the high energy density plasmas that will be covered more fully on Day 10 by presenting pulsed power machines and Z-pinches

| Saturday and Sunday, we rest



Day 6 (6/22) will begin the fusion materials and technology section

Eastern Time	Day 6 (6/22/20)	
12:30 PM	Plasma-Material Interaction: Boundary Plasmas <i>Donovan</i>	
1:30 PM	PMIs and the Development of Solid PFCs <i>Lasa</i>	
2:30 PM	Break	
3:00 PM	PMIs and the Development of Liquid PFCs <i>Allain</i>	
4:00 PM	Blanket design <i>Kessel</i>	

- Prof. David Donovan (UT Knoxville) will begin the day by discussing the interface between the boundary plasmas and the walls.
- Dr. Ane Lasa (UT Knoxville) will focus on the development of solid plasma facing components.
- Prof. JP Allain (Penn State) will discuss liquid metal plasma facing components
- Dr. Chuck Kessel (ORNL) will move away from the first wall and talk about the requirements and state of the art of the blanket that surrounds the reactor




Day 7 (6/23) will continue the fusion materials and technology section

Eastern Time	Day 7 (6/23/20)
12:30 PM	Safety Considerations of Building a Fusion Pilot Plant <i>Humrickhouse</i>
1:30 PM	Fusion relevant structural materials <i>Garrison</i>
2:30 PM	Break
3:00 PM	Closing the fuel cycle <i>Xiao</i>
4:00 PM	Integrated optimization of fusion power plants <i>Guttenfelder</i>






- Dr. Paul Humrickhouse (Idaho National Lab), will discuss safety concerns of a fusion pilot plant
- Dr. Lauren Garrison (ORNL) will discuss the extreme conditions that structural materials must endure and the current state of the art.
- Dr. X. Steve Xiao (Savannah River National Lab) will discuss the tritium cycle in a fusion reactor
- Dr. Walter Guttenfelder (PPPL) combines the scientific and engineering challenges presented to discuss how a fusion power plant would ultimately look like.

Day 8 (6/24): Computation, Private Industry, and Networking

Eastern Time	Day 8 (6/24/20)	
12:30 PM	Clean Coding <i>Murphy</i>	
1:30 PM	Computational Frameworks <i>Smith</i>	
2:30 PM	Break	
3:00 PM	Commercialization of Fusion Energy <i>Mumgaard</i>	
4:00 PM	Networking Coffee Hour	

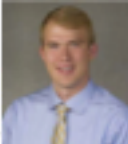



- Dr. Nick Murphy (Harvard-Smithsonian CFA) will discuss ways of optimizing scientific coding.
- Dr. Sterling Smith (GA) will discuss computational frameworks to deal with complex systems
- Dr. Bob Mumgaard (CFS) will talk about the role of private industry in moving fusion towards commercialization

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- At 4pmET, we will have breakout rooms moderated by graduate students to give enrollees a chance to discuss different topics, both, technical, as well as cultural in the Fusion Energy Sciences and Plasma Physics community.
- Details of this will be provided later (when we can sort them out)

Day 9 (6/25): Low temperature plasma day

Eastern Time	Day 9 (6/25/20)	
12:30 PM	Low Temperature Plasmas <i>Baalrud</i>	
1:30 PM	Plasma Propulsion <i>Raites</i>	
2:30 PM	Break	
3:00 PM	Complex Plasmas <i>Kostadinova</i>	
4:00 PM	LTP applications and technologies <i>Lopez</i>	


- Prof. Scott Baalrud (U of Iowa) will begin with a discussion of the physics of low temperature plasmas (LTPs)
- Dr. Yevgeny Raites (PPPL) will focus on the physics and engineering of plasma thrusters
- Prof. Eva Kostadinova (Baylor) will discuss the physics of dusty plasmas
- Prof. Jose Lopez (Seton Hall) will present the myriad industrial applications of LTPs

Day 10 (6/26): Finish the course with a High Energy Density Plasma Physics day

Eastern Time	Day 10 (6/26/20)	
12:30 PM	Inertial Fusion Energy <i>Ma</i>	
1:30 PM	Relativistic HEDP <i>Geddes</i>	
2:30 PM	Break	
3:00 PM	Astrophysical HEDP <i>Kuranz</i>	
4:00 PM	Course Adjournment	

- Dr. Tammy Ma (LLNL) will begin by discussing inertial fusion energy
- Dr. Cameron Geddes (LBNL) will focus on the very energetic extreme of plasmas, relativistic HEDP
- Prof. Carolyn Kuranz (U. of Michigan) will close the course with a discussion of super novae and other HEDP astrophysical plasma systems
- I will adjourn the course with another opportunity for students to network with each other

Poll Everywhere will be a way of getting feedback

- Throughout the course, we've encouraged all speakers to engage with the audience via PollEverywhere.

- All enrollees have been given the PollEverywhere link with which to participate.
- Most talks will start with a set of questions that will be answered throughout the talk. At the end, the audience will be given the questions again....hopefully there's improvement!

First polling question (12am-12m 6/15)

Where will you be watching the lectures from? Click on the map or, if outside the US, in a box on the right



Total Results: 155

We've started a Discord server for the incoming fusion/plasma community!



- We've created a venue to let the participants of this course, and, in general, undergrads and grads just starting out in the road of fusion and plasma physics, talk to each other and learn about summer opportunities (and hopefully beyond summer!)
- With the help of PPPL summer interns (especially Nigel DaSilva), we've created a Discord server for this purpose...enrollees have been invited. [Click here to join!](#)



Nigel DaSilva, RPI undergrad,
PPPL summer SULI intern

Continue the conversations with the speakers!

- Some speakers will be able to stick around after their talks to continue discussions. We have shared a “Hallway Discussions” zoom link with enrollees. We will announce if speakers will be available and when.
- We will also have Discord channels for each talk to continue discussions and we’re inviting the speakers to join (we’ll also send them the questions that arise there).

Breaking news about APS-DPP!!



- The American Physical Society Division of Plasma Physics (APS-DPP) meeting, scheduled for the week of November 9-13 @ Memphis, TN, WILL NOW BE HELD ENTIRELY REMOTELY!
- As with every year, undergraduates are invited to present their research at a dedicated poster session. But the abstract submission deadline is June 29!
- **Undergrads will be allowed to submit a provisional place-holder abstract (title, author, affiliation, email) by June 29, and update their abstract by July 10**
- Registration and APS membership is free for undergrads, and now that there's no travel, there's no excuse! (except not having anything to present)

Thanks to the “Intro Course Brain Trust”

The Intro Course Brain Trust is the group of scientists from different topical groups and institutions, that helped with the speaker/topic selection and format of the course. Thank you!



Steffi
Diem



Will
Fox



Walter
Guttenfelder



Eva
Kostadinova



Florian
Laggner



Ane
Lasa



Oak
Nelson

Thanks to Deedee and Olivia

Special thanks to my colleagues,
Deedee Ortiz, Program Manager at
the Science Education Department,
and **Olivia Merrill**, A/V Technician.

If the logistics for this course works,
it's because of their hard work.



Finally, of course, thanks to all of the speakers!



Prof. JP Altain

Penn State



Prof. Scott Bastrand

U of Iowa



Prof. Eva Kostadinova

Bayler U



Prof. Carolyn Kuranz

U of Michigan



Dr. Matt Reinke

OWS



Prof. Adam Seifow

University of Rochester



Dr. Nick Murphy

Harvard Southwestern OSA



Dr. Bob Pinaker

General Assembly



Dr. Arturo Dominguez

OWS



Prof. David Donovan

U of Knoxville



Dr. Aaron Bader

UW Madison



Dr. Devon Berthiaume

OWS



Dr. Florian Laggner

OWS



Dr. Ana Lusa

U of Knoxville



Dr. Sterling Smith

General Assembly



Dr. Brandon Borison

Commonwealth Fusion Systems



Dr. Yevgeny Rubins

OWS



Dr. Kathy Reeves

Harvard Southwestern OSA



Dr. Lauren Garrison

OWS



Dr. Will Fox

OWS



Prof. Mike Brown

Swarthmore College



Prof. Paul Casadei

West Virginia U



Dr. Cameron Geddes

OWS



Dr. Walter Guttenfelder

OWS



Prof. Jose Lopez

Staten Hall



Dr. Tammy Ma

UCLA



Dr. Derek Sutherland

CTD Center for



Dr. Ryan Umstadtd

Future Industry Association



Prof. Steven Cowley

OWS



Prof. Staffi Dean

UW Madison



Dr. Paul Humrickhouse

OWS



Dr. Chuck Kessel

OWS



Prof. Saskia Montjck

William & Mary



Dr. Bob Mungwand

Commonwealth Fusion Systems



Dr. X. Steve Kiao

OWS



Prof. Ellen Zeebui

UW Madison