

Princeton Collaborative Low Temperature Plasma Research Facility (PCRf) Report

Yevgeny Raitses

on behalf of PCRf team

Princeton Plasma Physics Laboratory

<http://pcrf.pppl.gov>

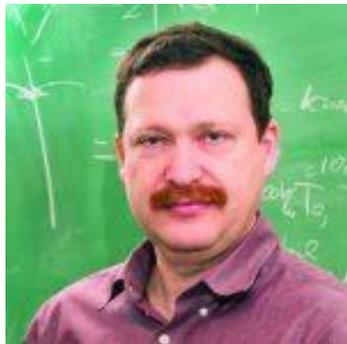
PCRF Team

Theory and simulations

← Experiments and diagnostics →



Mikhail Shneider
(co-PI) PPPL



Igor Kaganovich
(co-PI) PPPL



Sophia Gershman
PPPL



Shurik Yatom
PPPL



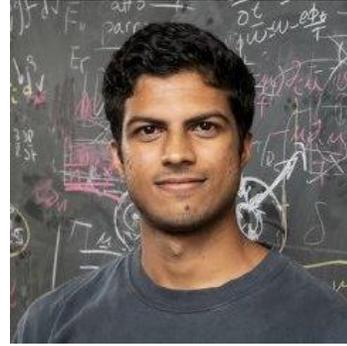
Arthur Dogariu
Princeton



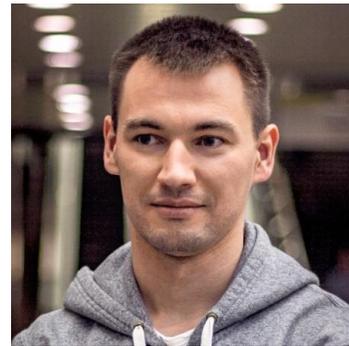
Yevgeny Raitsev
(PCRF PI/Director)
PPPL



Willca Willafana
PPPL (simulations)



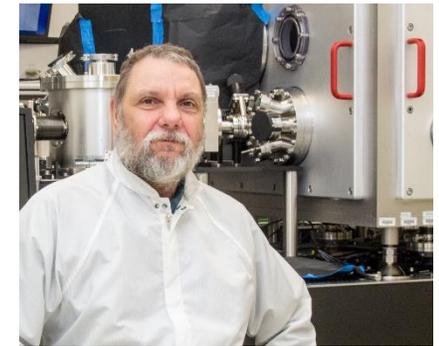
Nirbhav Chopra
PPPL (experiment)



Ivan Romadanov
PPPL (experiment)



Santosh Kondeti
PPPL (experiment)



Tim Bennett
PPPL/Princeton

Technical support

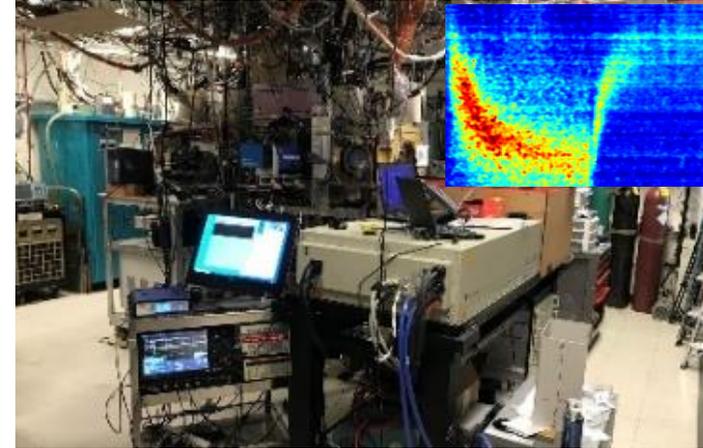
About PCRf

- Formed in 2019 from the existing Low Temperature Plasma (LTP) laboratories at the PPPL and the MAE Department of the Princeton University
- Supported by the Department of Energy, Fusion Energy Science
- Mission: to provide state-of-the-art research capabilities and expertise to advance understanding and predictive control of LTPs with focus on:
 - Plasma-liquid interactions
 - Plasma-solid interactions
 - Plasma-nanoparticle interactions
 - Transport and collective phenomena in LTPs
 - LTP in modern applications: materials, health, environments, aerospace etc.

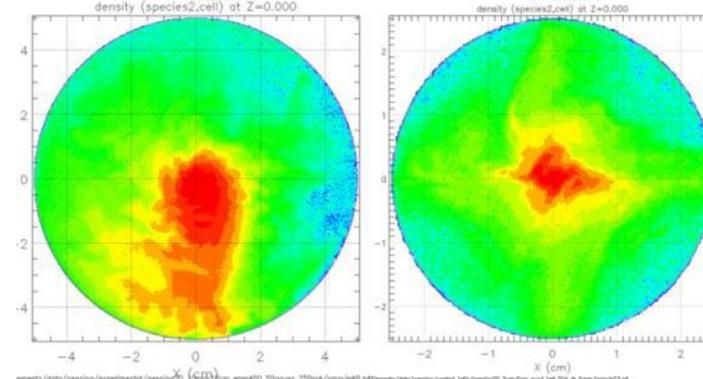
PCRF Core Expertise

- Spatially and temporally resolved diagnostics and modeling of low temperature plasmas in a broad range of conditions:
 - low pressure collisionless to high pressure collisional
 - non-equilibrium and thermal
 - magnetized and non-magnetized
 - DC, RF, pulsed, laser-generated
- Advanced fs-ns-cw laser diagnostics of plasmas, gas phase, nanoparticles, plasma-surface interactions
- Fluid, kinetic (PIC, Vlasov) and atomistic simulations

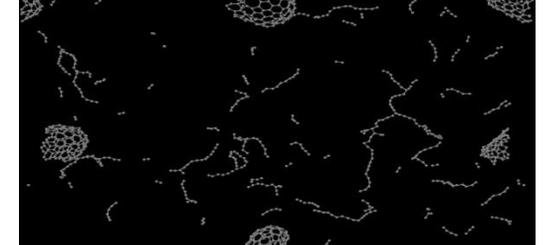
fs-TALIF of H in magnetized LTP



2-D PIC simulations of ExB plasma structures

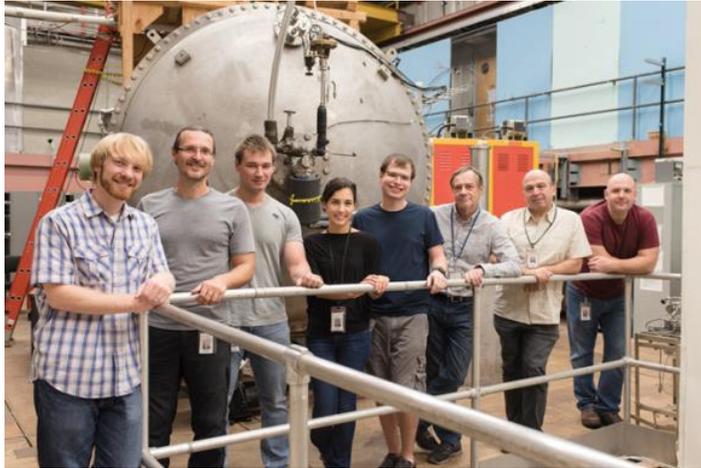


MD simulations carbon fullerenes



PCRF Facilities at PPPL and Princeton MAE

**Magnetized LTP experiments
(HTX, Penning etc.)**



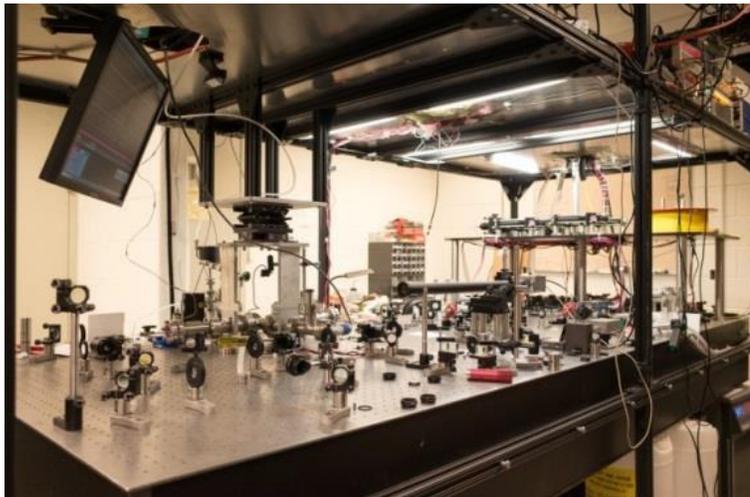
Laboratory for Plasma Nanosynthesis



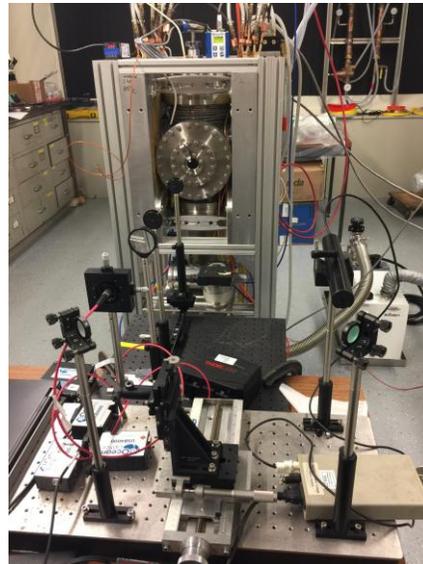
Applied Physics Lab (PU)



Laboratory of Laser Diagnostics

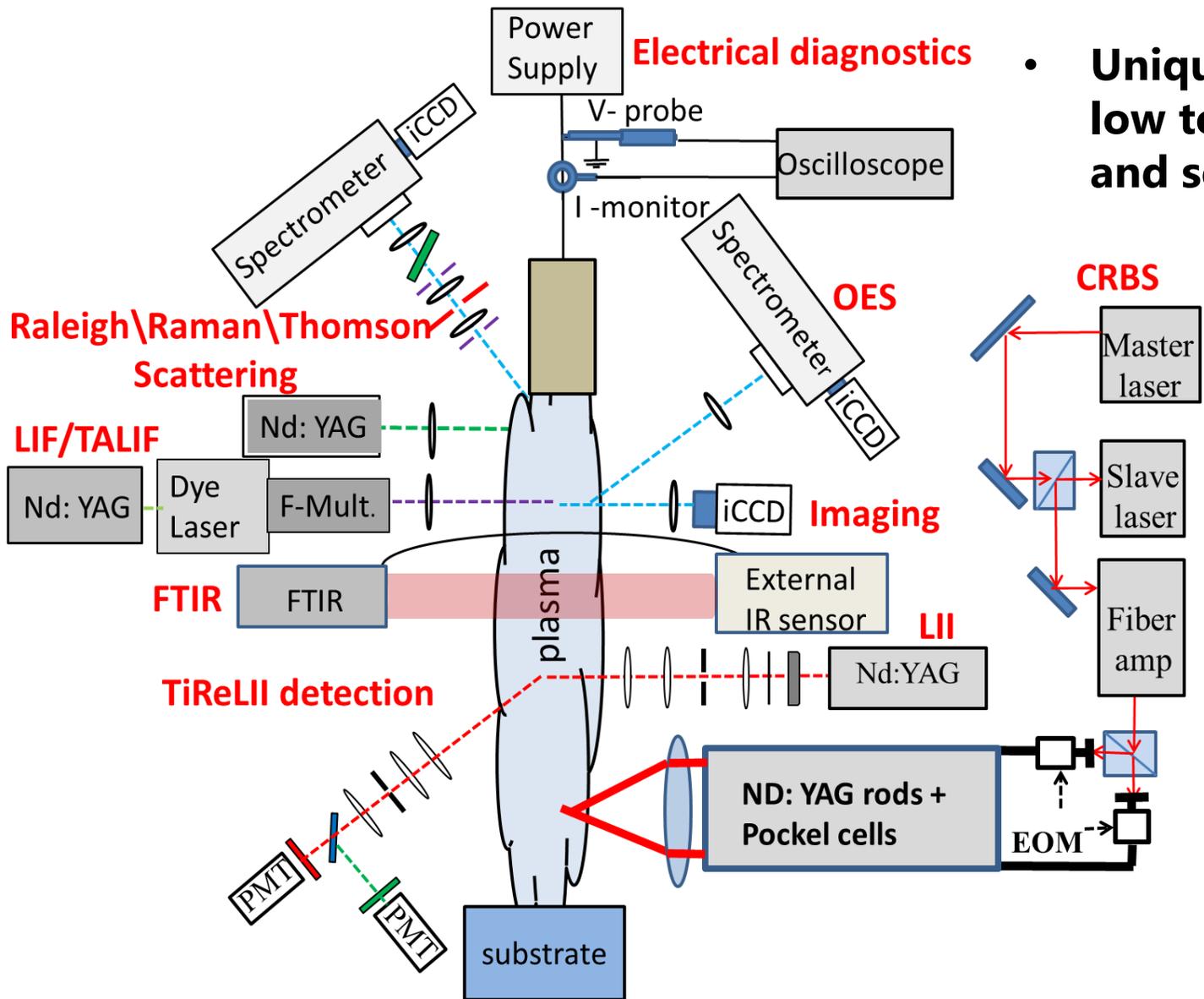


Plasma Sources Lab



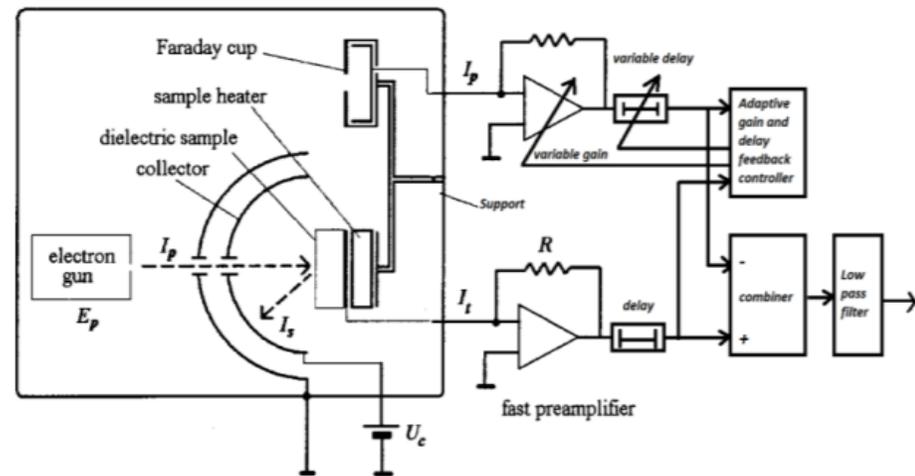
- Host unique plasma experiments and advanced diagnostics for LTP plasmas
- Leveraged from synergistic activities supported by DOE, DOD, industry

PCRF Diagnostics- PPPL



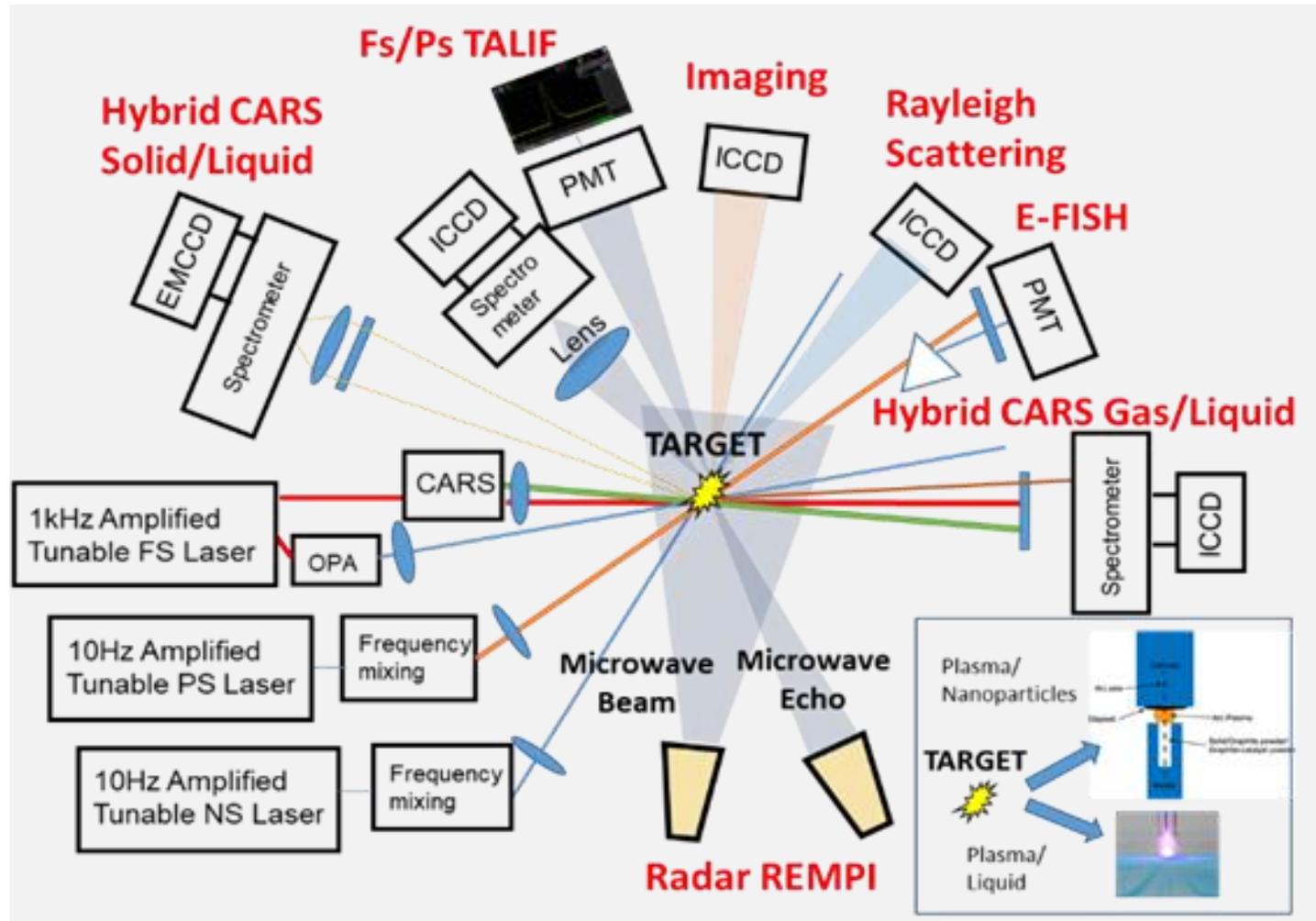
- Unique combination of ns/DC diagnostics of low to high pressure plasmas, nanoparticles and secondary electron emission & charging

- Surface charging and secondary electron emission

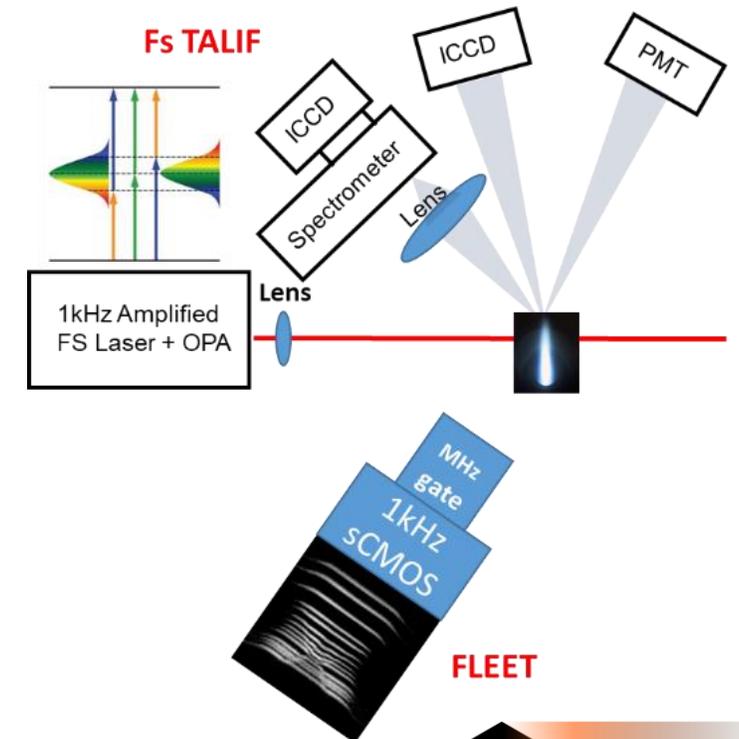


PCRF Diagnostics- Princeton MAE

Advanced fs/ps/ns laser, mw diagnostics of plasma, gas phase for detailed characterization of moderate to high pressure plasmas, negative ions, plasma-solid,-liquid interactions



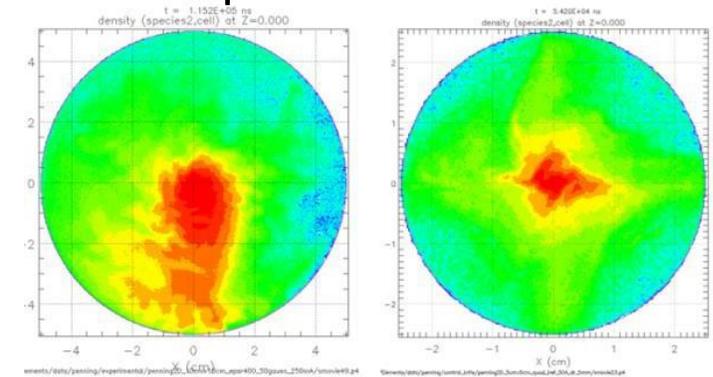
- Flow velocity, density of species



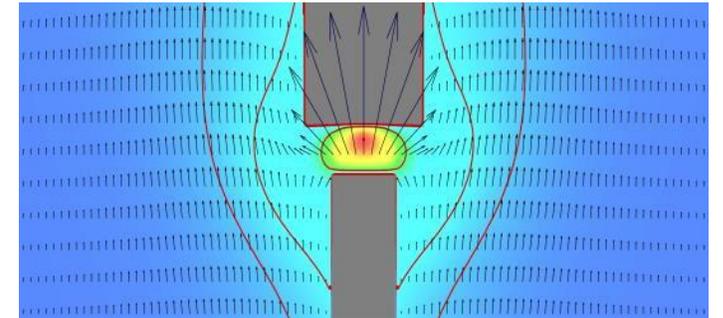
PCRF Computational Tools for LTP Modeling-PPPL

- **Particle-in-cell codes (2D EDIPIC, 3D commercial and PPPL codes)**
 - state of the art collision models and plasma-surface interaction, validated by numerous benchmarks
- **Fluid codes (3D ANSYS)**
 - implemented sheath models, MHD effects, surface interface
- **Molecular Dynamics (DFT-TB)**
 - DFT codes: full and tight binding approximation, CMD (classical potentials), KMC –kinetic Monte Carlo, and thermodynamic code for chemical composition.

ExB LTP plasma



High pressure arc



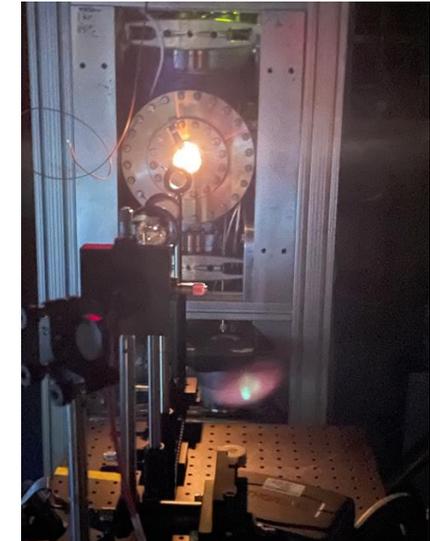
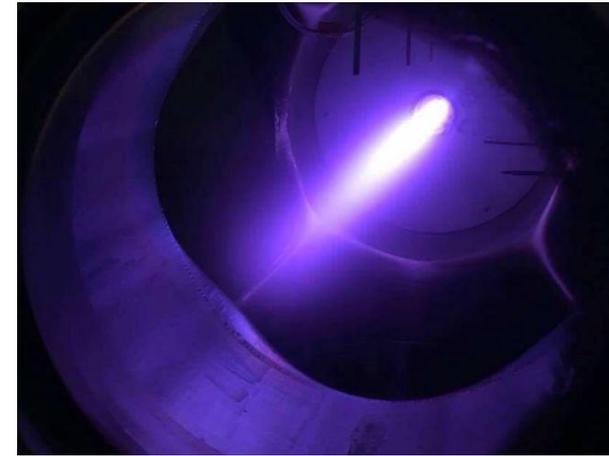
Nanoparticles grow



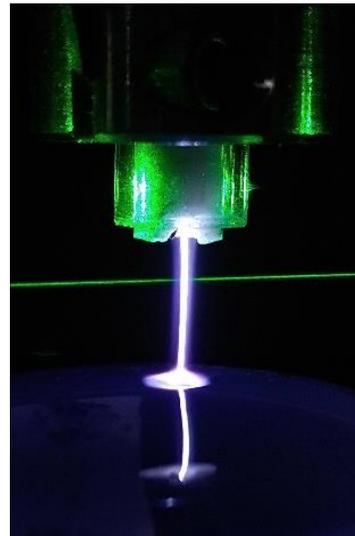
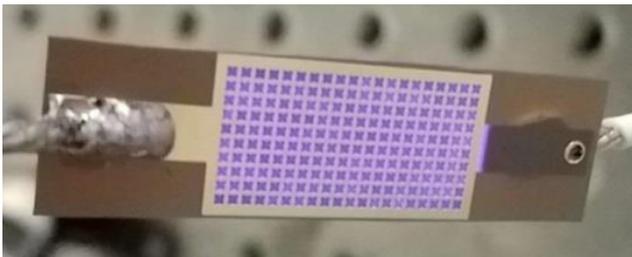
PCRF Plasma Sources

- **With control of Electron Energy Distribution Function**
 - E-beam and non-thermal electrons < 100 eV
- **With control of Ion Energy Distribution Function:**
 - Sub keV, 0.1-1 A/cm²
- **Atmospheric pressure non-equilibrium and equilibrium plasma sources:**
 - DBD, arcs, jets,...

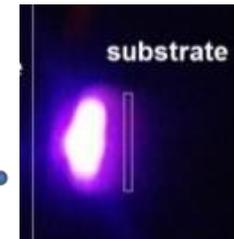
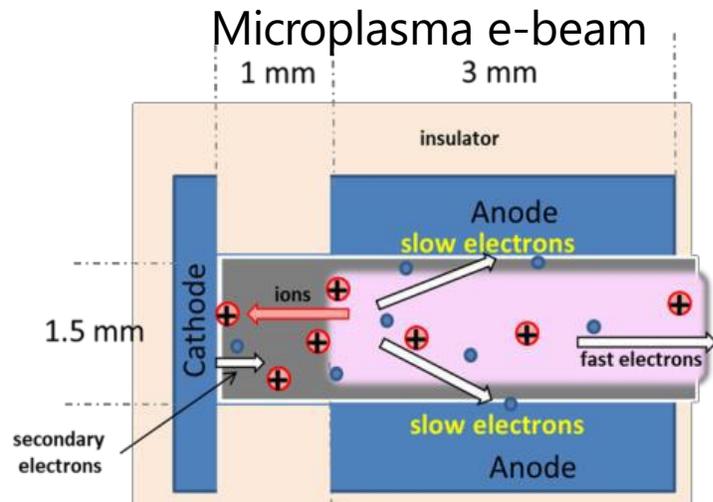
Magnetized LTP for processing of materials and nanomaterials



Atmospheric flexDBD for disinfection



Plasma jet to water



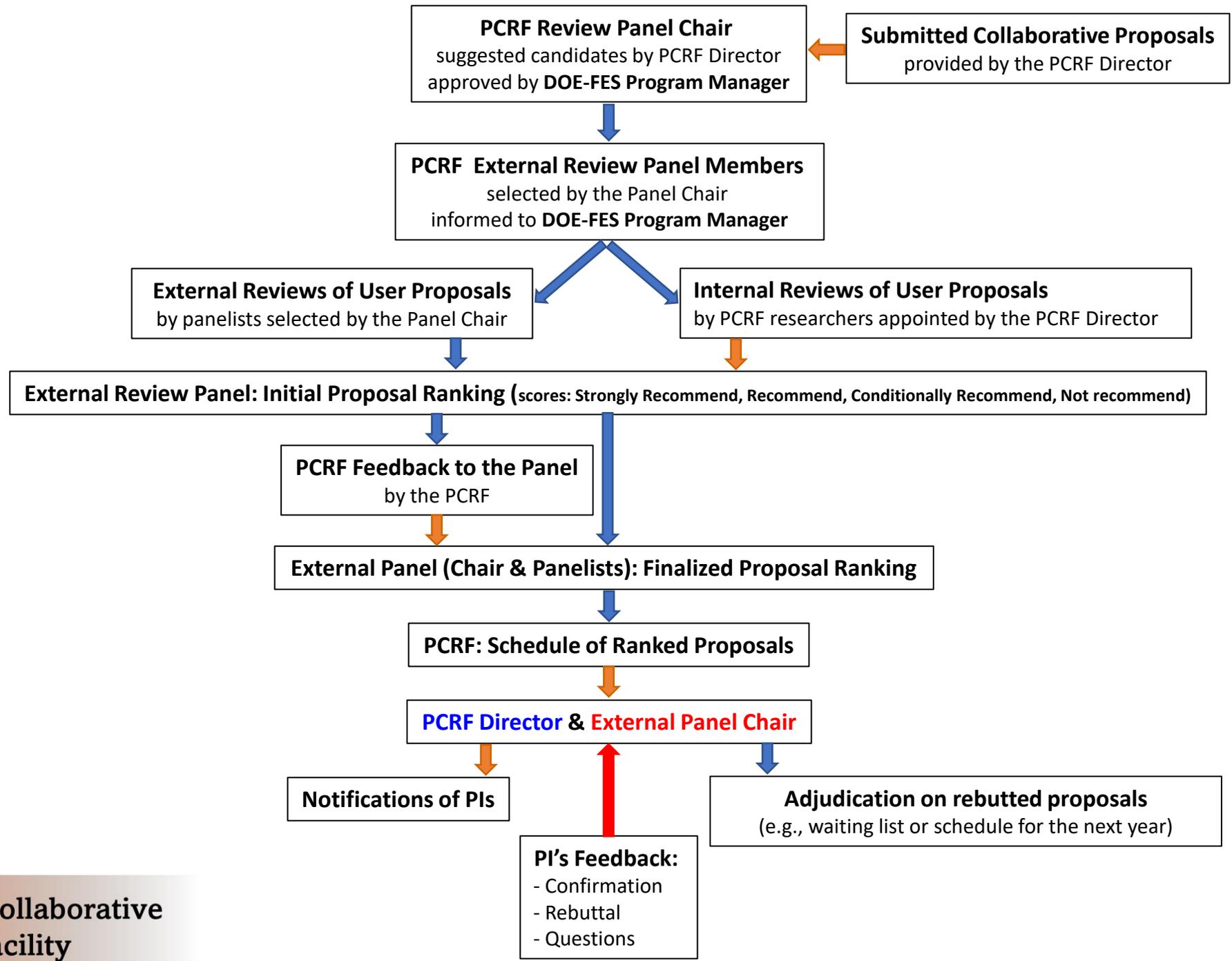
PCRF Organization

Advisory Board

Stewart Prager, Chair, Princeton University
Amy Wendt, University of Wisconsin-Madison
Uwe Kortshagen, University of Minnesota
Michael Keidar, George Washington University

User Organization

Bruce Locke, Chair, Florida State University
Tiernan Casey, Sandia National Labs
Michael Keidar, George Washington University
Danil Dobrynin, Drexel University



2020-2022 PCRF User Projects Status, August 2022

- Total user projects since 2020 (three solicitations): **63**
- Completed user projects: **29**
- In progress projects: **16**
- Scheduled projects, but not started yet: **12**
- Schedule TBD: **1**
- Canceled: **5**

Publications: 28 (total): 22 (published) + 6 (submitted)

PCRF Projects from FY21 Solicitation



PCRF FY21

1. Michael. Campanell, LLNL
2. Kai-Mei Fu, U Washington
3. Benjamin. Rubin, Veeco (industrial)
4. Josh Coleman, LANL
5. P. Yushmanov, TAE (industrial)
6. Valerian Nemchinsky, Keiser Univ.
7. Thomas Schenkel, LBNL
8. Probir Roy, LANL
9. Kentara Hara, Stanford
10. Albina Tropina, Texas A&M
11. Sergey Leonov, Univ. Notre Dame (from FY20)
12. Carmen Guerra-Garcia, MIT
13. Sam Cohen, PPPL
14. T. Ombrello, AFRL/Univ. Central Florida
15. Gal Haspel, NJ Inst Technol.
16. Carles Corbela, GWU
17. Katharina Staplemann, NCSU
18. Selma Mededovic Thagard, Clarkson U
19. Mohan Sankaran, Univ. Illinois U-Ch
20. Howard Stone, Princeton University
21. Daniel Dobrynin, Drexel (from FY20)

PCRF FY22

1. Malcolm Carroll, PPPL
2. Mark Cappelli, Stanford
3. Michael Keidar, GWU
4. Deborah. Levin, Univ. Illinois UC
5. S. Gimelshein, MassTech (small business)
6. Lorenzo Mangolini, Univ California Riverside
7. Zhili Zhang, UT Knoxville
8. Angela Capece, The College NJ
9. John Foster, U Michigan
10. Bruce Locke, Florida State Univ.
11. Rebecca Anthony, Michigan State Univ.

Completed: 10

In progress: 13

Scheduled: 5

Schedule TBD: 1

Canceled: 3

Total runtime for FY21-22: 32

Princeton Collaborative Research Facility (PCRF): <http://pcrf.pppl.gov>



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Apply to do research at PCRF!

The Princeton Collaborative Low Temperature Plasma Research Facility (PCRF) provides the entire scientific community access to specialized, world-class diagnostics, computational tools, and expertise in plasma physics.

[Learn how to submit a research proposal here.](#)

New Solicitation of User Proposals to open: October 12, 2022



The **Princeton Plasma Physics Laboratory (PPPL)** is a U.S. Department of Energy national laboratory managed by Princeton University. To learn more, visit pppl.gov.

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