

# 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) Princeton



Igor Kaganovich  
(co-PI) PPPL



Sophia Gershman  
PPPL



Shurik Yatom  
PPPL

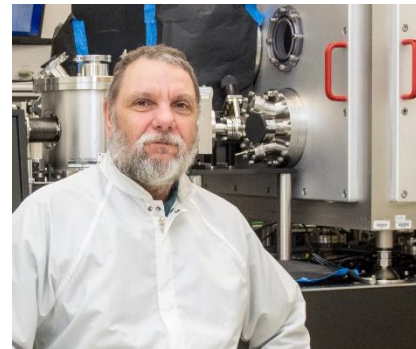


Arthur Dogariu  
Princeton



Yevgeny Raitses  
(PCRF Director)  
PPPL

Technical support



Tim Bennett  
PPPL/Princeton



# FY 20 PCRFB User Proposal Solicitation (first!)

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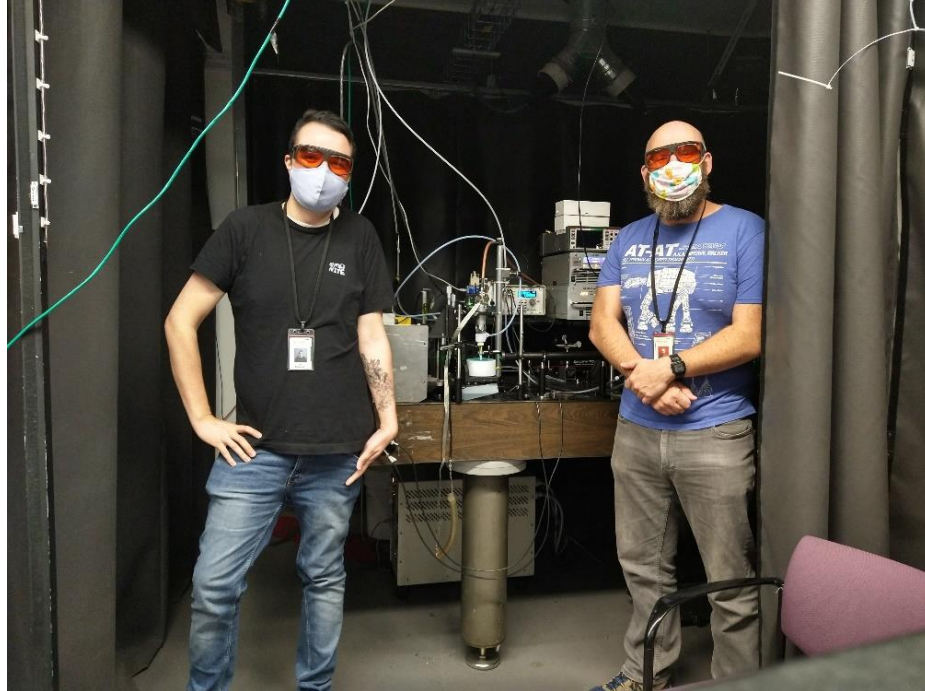
- **46 user proposal submissions from US and international academia, national labs and industry!**
- **Total # of proposals which received positive reviews: 36**
  - **Total # of proposals accepted for the runtime: 21\***
    - **14 proposals granted runtime and scheduled in FY20/21**
    - 5 user proposals offered the fast-track option (less than two weeks) in FY20/21
    - 2 user proposals moved to the waiting list or recommended for FY21/22

# FY20 User Projects

- **Current Status:**
- Completed PCRf runtime: 18 user projects
- Work in progress on the remaining user project delayed due to covid and laser issues
- Two projects scheduled for FY21
- Home research – in progress
- **Publications:**
  - 14 published journal articles
  - Several submitted and in preparations

# PCRF under covid lockdown

WUSL grad student T. Oldham, and PCRF Yatom at PPPL



UT Arlington Maddalena's grad students and postdocs with PCRF Dogariu at Arlington, TX



# PCRF 2020 Accomplishments: *PPPL Modeling, Igor Kaganovich*

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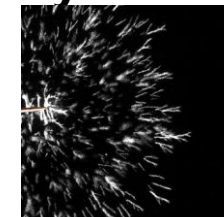
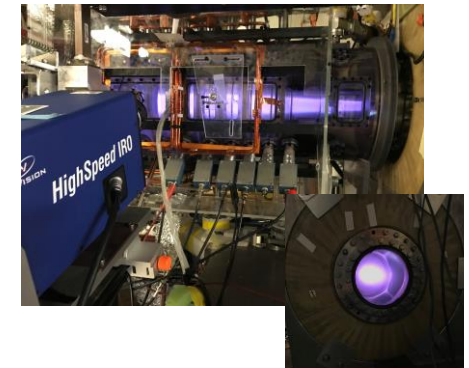
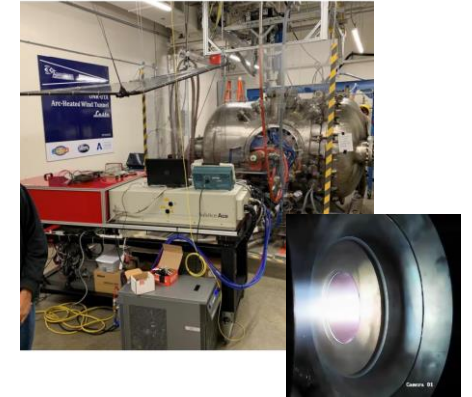
- **UIUC group project ( PI: Debbie Levin)** was interested in excitation of electrostatic solitary waves during beam neutralization. They used their group code Chaos to perform 2 and 3D PIC simulations. Extended verification of results was performed, new modes were discovered and are being analyzed.
- **Perdue University (PI: Sergey Macheret)** wanted a computational tool to simulate RF and MW discharges. They were given 1D EDIPIC and student taught to use it. Verification of results was performed; effect of cold electron formation was studied.
- **Sandia group (PI: Tiernan Casey)** wanted to use their mathematical techniques for physics problems. We suggested to study formation of hydrogen negative ions with a global model. Code for global model was given to them and they performed initial study of sensitivity of different reaction processes on formation of hydrogen negative ions.

# PCRF 2020 Accomplishments: PPPL OES, FTIR

- **South Dakota School of Mines and Technology (PI: Maria Carreon Garciduenas)** was interested in systematic intelligent selection of metal catalysts for plasma catalysis for the synthesis of ammonia. They used modeling predictions to select materials and we tested a range of metals in dielectric barrier reactors using Fourier Transform Infrared Absorption Spectroscopy to measure ammonia production. Selected materials were used in conjunction with mesoporous silica to study the most promising, packed bed reactors.
- **New Jersey Institute of Technology (PI: Gal Haspel)** collaborated with us on the study of the disinfection properties of flexible dielectric barrier discharges alone and combined with a plasma-activated chemical, hydrogen peroxide. Sterilization levels of surface decontamination have been achieved by the combined chemical-plasma action. The project has led to continued investigation of plasma biological effects on the scale of a whole organism using *C. elegans*, currently under investigation.

# PCRF 2020 Accomplishments: *PU fs-diagnostics, Arthur Dogariu*

- **Plasma generated atomic oxygen density measurements in liquid using TALIF**  
*PI: Katharina Stapelmann, North Carolina State University*
  - First measurements of O atoms in a liquid using fs-TALIF
- **Non-intrusive Measurements using Femtosecond Laser in Arc Jet Plasma Facility**  
*PI: Luca Maddalena, University of Texas at Arlington*
  - First demonstration of velocity measurement using FLEET in an arc jet plasma tunnel
  - First demonstration of O atoms measurements using fs-TALIF in an arc jet plasma tunnel
- **FS Laser control for high-voltage NS discharges**  
*PI: Andrey Yu. Starikovskiy, Princeton University*
  - Demonstration of streamer propagation control using FS laser induced blast wave
- **Non-invasive Neutral Concentration Measurements In A Mirror Plasma Device**  
(fast track)  
*PI: Samuel Cohen, Princeton Plasma Physics Laboratory*
  - First measurement of neutrals (H) in Princeton Field Reversal Configuration (PFRC-2) device
- **Waves of Electric Charge Generated by Pulse Corona of Alternating Polarity**  
*PI: Sergey Leonov, Notre Dame University*
  - Measurement of temporal and spatial E-field distribution in a corona discharge





# PCRF 2020 Accomplishments: *PU Modeling, Mikhail Shneider*

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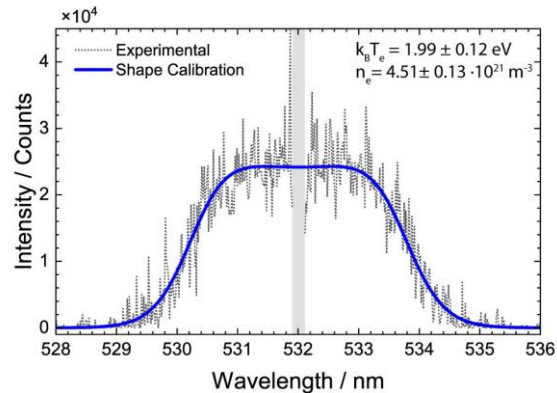
- **Sources of primary electrons in ns-breakdown in water, PI Xuewei Zhang** (Texas A&M -Kingsville)  
**Main results:** Proposed mechanism of primary electron generation and multiplication in ns breakdown in water  
**Publication:** J. Appl. Phys., 129 (103302), 2021; 2<sup>nd</sup> paper in preparation
- **Coherent Thomson scattering, PI Alexandros Gerakis (Texas A&M - College Station)**  
**Main results:** It is shown that the predicted signal of coherent Thomson scattering is tens of times higher than at conventional Thomson scattering under the same conditions  
**Possible applications:** remote measuring the electron temperature in plasma
- **Theory and modeling of nanocrystalline-amorphous transition in liquids, PI Alexander Fridman (Drexel University), Team members: Dmitri Vainchtein and Alexander Rabinovich**  
**Main objective:** How does adding plasma change the temperature of the N-A transition in water?  
**Main results:** The nanocrystalline-amorphous transition is an extended (occurring over a range of temperatures) 2-nd order-like phase transition; Adding plasma to water lowers the temperature of the transition up to about 10 degrees

# PCRF 2020 Accomplishments: *PPPL OES and LIF, Shurik Yatom*

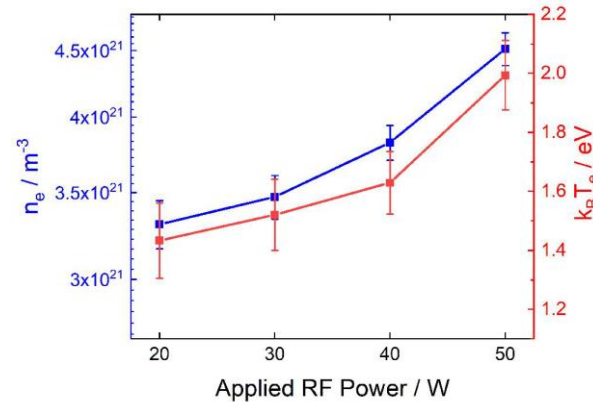
- **Correlation of Plasma Parameters to Reduction Potential at the Plasma-Water Interface (Elijah Thimsen, Washington University in Saint-Louis)**

**Status:** Data collection and analysis are finished.

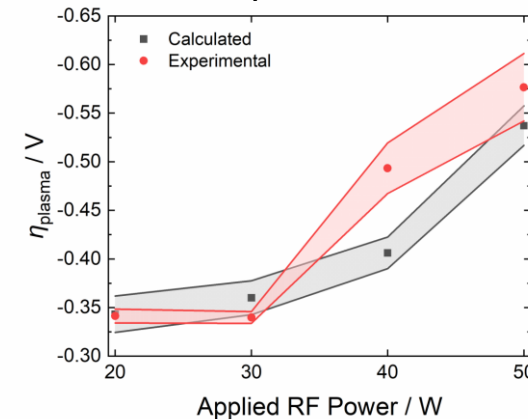
Thomson scattering on RF jet



Plasma parameters vs RF power



Plasma potential



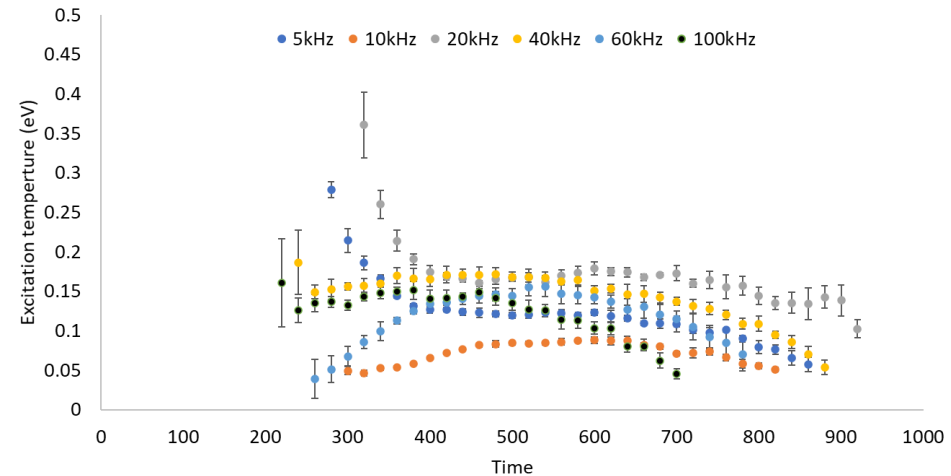
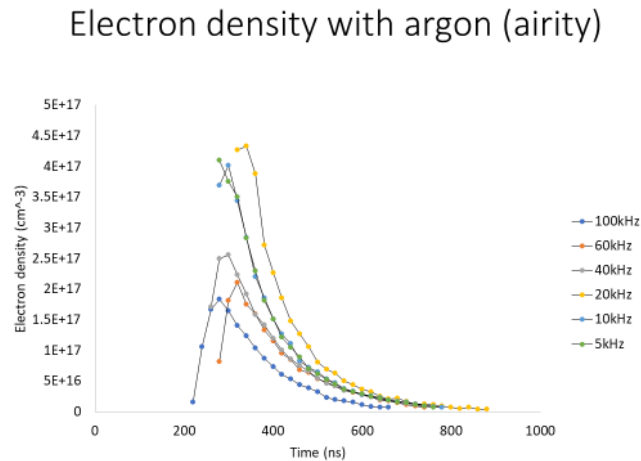
- **Probing metastable species in electron beam generated plasmas (Scott Walton, Naval Research Laboratory), project with PCRF, Y. Raitses**

**Status:** was postponed due to pandemic and laser issues, but is now started and set to be completed (runtime by FY22)

# PCRF 2020 Accomplishments: *PPPL OES and LII Shurik Yatom*

- **Time Resolved Optical Emission Spectroscopy of Nanosecond Pulsed Discharges in a Gas-Liquid Water Film Reactor (Bruce Locke, Florida State University)**

**Status:** PCRF runtime is completed, data collection is finished. Partial analysis is finished.



- **Investigation of the size of growing nanoparticles in Ar/C<sub>2</sub>H<sub>2</sub> plasma using laser induced incandescence. (Edward Thomas, Auburn University)**

**Status:** Postponed indefinitely by user due to staff changes (postdoc accepted a new job)

# Second Solicitation in FY21

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- ✓ **54 submissions:** experiments (36), modeling (18)
  - **US and international academia: 34**
  - **National labs (LANL, LBNL, LLNL, PPPL, and AFRL): 9**
  - **Small businesses and large companies: 11**
  - **Total proposals recommended for runtime: 33**
    - Accepted for FY21: **20 proposals** - *similar to FY20*
    - Accepted for FY22: **11 proposals** - *more than in FY20*
    - Move to Fast track: **2 proposals**
  - 5 Proposals recommended for other programs (e.g. Home Research)
  - **Initiated several awarded FY21 user projects**

