

# LLNL collaboration on NSTX-U: status and plans

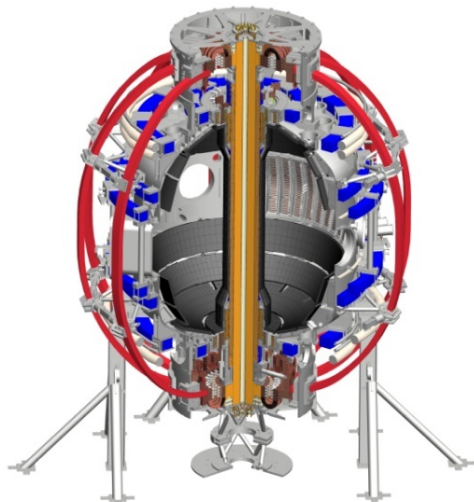
**Vlad Soukhanovskii**

*Principal Investigator*

*Leader of the LLNL Collaboration on NSTX-U*

**NSTX-U Collaborator Research Plan Meetings**  
**PPPL – LSB B318**  
**5 May 2014**

Coll of Wm & Mary  
 Columbia U  
 CompX  
 General Atomics  
 FIU  
 INL  
 Johns Hopkins U  
 LANL  
 LLNL  
 Lodestar  
 MIT  
 Lehigh U  
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 Chubu U  
 Fukui U  
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 KAIST  
 POSTECH  
 Seoul Natl U  
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 CIEMAT  
 FOM Inst DIFFER  
 ENEA, Frascati  
 CEA, Cadarache  
 IPP, Jülich  
 IPP, Garching  
 ASCR, Czech Rep

# LLNL collaboration supports one of the four NSTX-U mission elements – “Develop solutions for the plasma-material interface challenge”

- SOL and Divertor physics
  1. Snowflake divertor
  2. Radiative (detached) divertor and divertor control
  3. SOL and divertor transport and radiation, particle balance, fueling, cryo-pumping
- Plasma-surface interactions and material migration
  - Divertor and wall recycling
  - Divertor and wall erosion, impurity sources
  - Mixed-material interactions (Li, B, C, O, Mo, W)
- Core impurity transport
  - Low and high-Z impurity transport and particle balance
    - Laser blow-off injector

# Structure of LLNL collaboration staff under LAB 12-03

- Vlad Soukhanovskii, Physicist, Principal Investigator
- Peter Beiersdorfer, Senior Physicist
- Filippo Scotti, Postdoctoral Researcher
- Postdoctoral Researcher - Experiment, TBD, mid-FY2014
- Postdoctoral Researcher - Experiment, TBD, mid-FY2014
- Postdoctoral Researcher - Modeling, TBD, mid-FY2014
- Staff member – Modeling
- Technical staff at LLNL, as needed
- Under discussion
  - Graduate Student – Experiment, TBD

Note:

LAB 12-03 funds LLNL collaboration in 2013-2017.

Other sources of funding of LLNL Collaboration on NSTX-U:  
DOE ECRP Award (2010-2015).

# LLNL collaboration supports a number of LLNL- and PPPL-owned edge and core diagnostics

Diagnostic	NSTX or New	Owner
EIES (Edge Impurity Emission Spectroscopy, aka Filterscopes)	NSTX	PPPL
1D CCD arrays	NSTX/New	PPPL, ORNL
LADA (Lyman-alpha AXUV diode array)	NSTX	PPPL
Divertor SPRED (VUV spectrometer)	New	LLNL
UV-VIS imaging spectrometer VIPS2	NSTX	PPPL
UV-VIS imaging spectrometer DIMS	NSTX	PPPL
Divertor imaging cameras (three, Phantom)	NSTX	PPPL
Divertor imaging camera (CIDTEC)	New	LLNL
XUV spectrometer (MonaLisa, 65-250 Å region)	New	LLNL
XUV spectrometer (LoWEUS, 250 - 450 Å region)	NSTX	LLNL
XUV spectrometer (XEUS, 5 - 65 Å region)	NSTX	LLNL
NIRS (near infrared (0.8-2.3 um region) spectrometer)	New	LLNL, PPPL
Optical Penning Gauge	NSTX/New	PPPL, UW

# Status and Plans for LLNL Research in the area of Scrape-off Layer and Divertor Physics (I)

- Support the NSTX-U highest priority goal “Develop and utilize high-flux-expansion “snowflake” divertor and radiative detachment for mitigating very high heat fluxes”
  - Continuing physics expertise since NSTX
    - Using multi-fluid edge code UEDGE to understand NSTX divertor experiments and make projections to NSTX-U and ST-FNSF
      - PSI and IAEA 2014 presentations
  - Snowflake divertor experiments at DIII-D (2012-2015)
    - PSI, EPS 2014 talks and IAEA 2014 presentations
  - Develop snowflake equilibria and scenarios for NSTX-U reduced set of coils (2014)
  - Develop snowflake plasma scenarios with PCS group (2014-2015)
  - Study snowflake divertor transport, turbulence, radiation and ELM/pedestal properties on NSTX-U (2015-2016)
  - Model snowflake divertor transport with UEDGE, XGC and BOUT++ (2014-2017)

# Status and Plans for LLNL Research in the area of Scrape-off Layer and Divertor Physics (II)

- Support the NSTX-U highest priority goal “Develop and utilize high-flux-expansion “snowflake” divertor and **radiative detachment** for mitigating very high heat fluxes”
  - Continuing physics expertise since NSTX
    - Using multi-fluid edge code UEDGE to understand NSTX divertor experiments and make projections to NSTX-U and ST-FNSF
  - Develop and test diagnostic prototypes for radiative divertor feedback control on NSTX-U and DIII-D (2014-2015)
    - PFC surface temperature; Divertor radiation
    - Imaging UV-VIS-NIR spectroscopy for divertor  $T_e$ ,  $n_e$ , and recombination region measurements
      - HTPD 2012 and HTPD 2014 presentations
  - Study heat flux mitigation and detachment using  $D_2$  and impurity seeding in standard and snowflake configurations on NSTX-U (2015-2016)
  - Integrate supersonic gas injector in H-mode fueling scenarios and ELM/pedestal control (2015-2016)
  - Develop conceptual design of divertor Thomson scattering diagnostic
    - HTPD 2014 presentation

# Status and Plans for LLNL Research in the area of Plasma-Surface Interactions

- Support the NSTX-U highest priority goal “Begin to assess high-Z PFCs + liquid lithium to develop high-duty-factor integrated PMI solution for SS-PMI, FNSF, beyond”
  - Develop and install new and upgraded spectroscopic diagnostics that enable recycling, low/high Z impurity erosion flux and profile measurements (2014)
    - New capability: radiation-hardened CEDTEC camera with image splitter enabling simultaneous imaging of divertor PSI at two wavelength (e.g., low-Z/high-Z, Mo I/ Mo II, Li I/Li II, Oxygen,  $T_e$ -dependent line ratios, etc)
  - Support cryo-pump physics design experiments (2015)
  - Assess role of oxygen in lithium coating pumping and effect on recycling (2015-2016)
  - Assess lithium, carbon and high-Z erosion, transport and migration (2015-2016)
  - Collaborate with UIUC on MAPP probe PSI support (2014-2016)
  - Develop modeling capability of lithium coatings and vapor shielding on high-Z substrates using UEDGE, REDEP/WBC, CRETIN (2014-2017)

# Status and Plans for LLNL Research in the area of Impurity Transport

- Support goals 1) understanding transport at reduced collisionality and 2) high-Z impurity transport
- Install three EUV spectrometers (2014)
- Develop and install Laser Blow-Off Impurity Injector (2014-2015)
  - Supported in part by LLNL LDRD for edge impurity transport measurements and code validation on NSTX-U
  - Collaboration with Johns Hopkins University
- Provide routine plasma impurity monitoring (2014-2017)
- Assess high-Z impurity transport (2015-2016) before and after high-Z PFCs are installed



# Ideas to enhance participation in NSTX-U research and/or program by U.S. Universities, early-career researchers, and students

- As an on-site major national lab collaboration, the LLNL group works with University collaborations on NSTX-U
  - Johns Hopkins University, Laser Blow-off Impurity Injector and impurity transport
  - UIUC, MAPP probe, plasma-surface interaction studies
  - U Wisconsin, TBD
- Considering engaging UC Faculty and graduate students for collaboration with NSTX-U via LLNL Education and Outreach Programs
  - A model of an on-site graduate student research project with co-advisors on-site at PPPL and at UC may work well