NSTX-U

Supported by

U.S. DEPARTMENT OF ENERGY | Office of Science

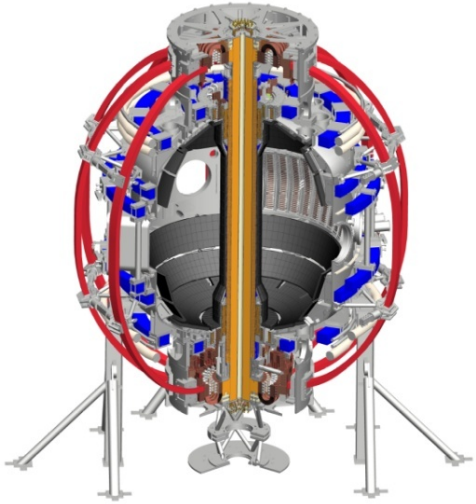
NSTX-U Collaboration Status and Plans for: Local Helicity Injection - U. Wisconsin

R.J. Fonck,B. T. Lewicki, A. J. Redd

University of Wisconsin-Madison

WISCONSIN

NSTX-U Collaborator Research Plan Meetings
PPPL – LSB B318
April / May 2014

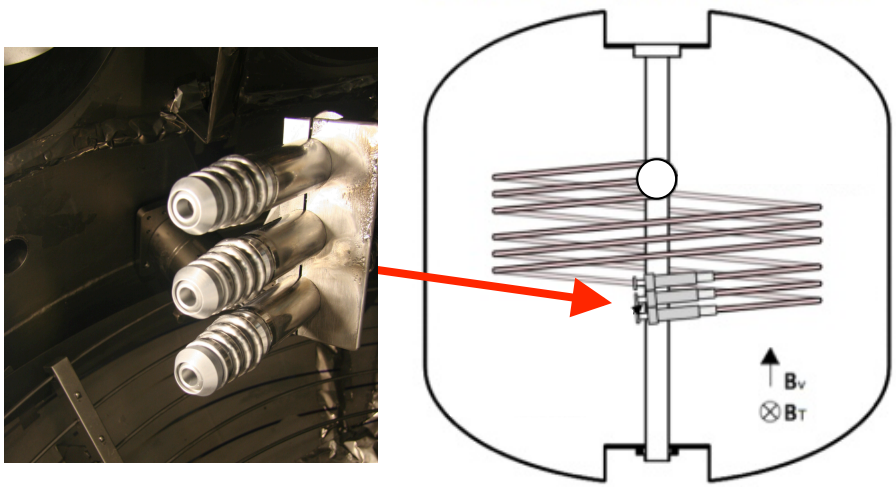


Coll of Wm & Mary
Columbia U
CompX
General Atomics
FIU
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Lehigh U
Nova Photonics
ORNL
PPPL
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Illinois
U Maryland
U Rochester
U Tennessee
U Tulsa
U Washington
U Wisconsin
X Science LLC

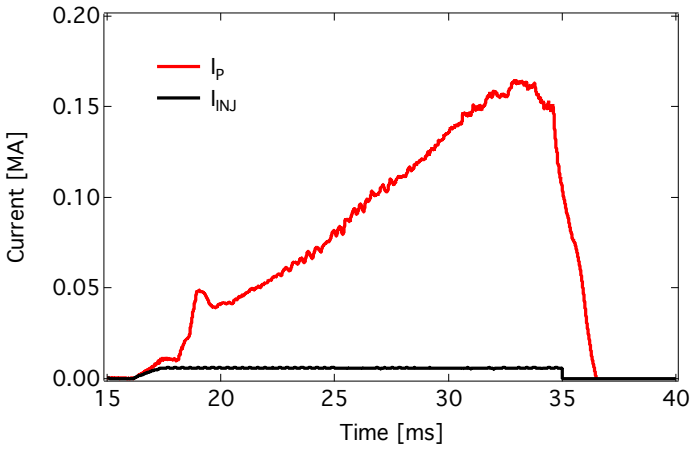
Culham Sci Ctr
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAEA
Inst for Nucl Res, Kiev
Ioffe Inst
TRINITI
Chonbuk Natl U
NFRI
KAIST
POSTECH
Seoul Natl U
ASIPP
CIEMAT
FOM Inst DIFFER
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

U. Wisconsin Developing Local Helicity Injection for Plasma Startup and Drive in NSTX-U and FNSF

- Using Pegasus Ultralow-A ST to develop LHI startup
  - Current injected along field lines
  - Unstable current streams relax towards Taylor minimum energy (tokamak-like) state
  - Consistent with Helicity conservation
  - Location of injections in plasma periphery is flexible
    - E.g., divertor (high helicity input rate) vs near-midplane (added poloidal induction boost)

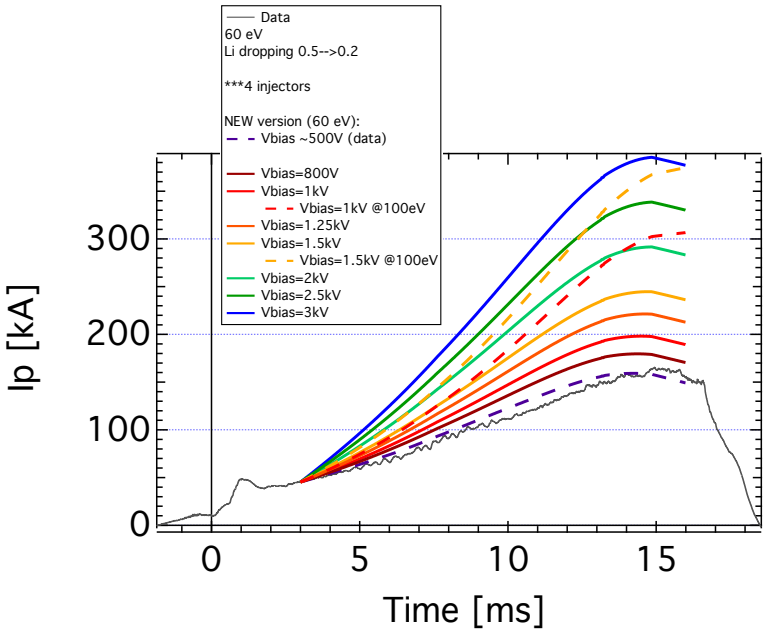


- Present collaboration grant covers NSTX-U specific modeling and design considerations
  - Provide sufficiently realistic 1 MA NSTX-U startup scenarios for both outboard-midplane and divertor-region injection
  - Injector and power systems design compatible with NSTX-U environment
  - Validated against test results on Pegasus

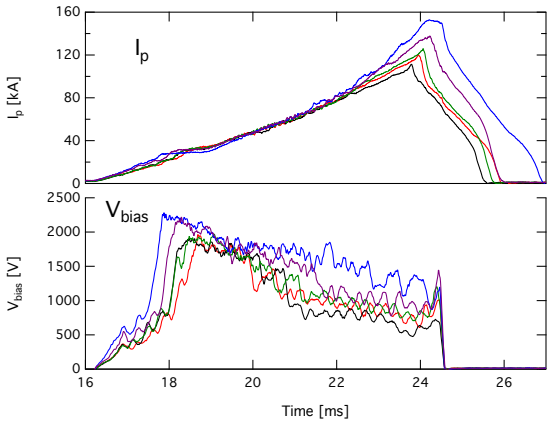


Topic 1: Research plans for this year (FY2014) in preparation for NSTX-U operations in FY2015

- Advancing simulations of LHI-discharges
  - Goal is to provide realistic 1 MA NSTX-U startup scenarios for both outboard-midplane and divertor-region injection
    - 0D Power Balance Modeling: More self-consistent confinement and shape evolution
    - TSC Modeling: Varied transport models, and comparison to PEGASUS MPTS profiles
  - Initial modeling of location of NSTX-U injectors for conceptual design
    - Inform design discussions
- Advancing compact high-V_{inj} injectors
  - Frustum "cathanode" design, frustum shield + floating ring voltage dividers + local scraper limiters permit sustained injector operation with V_{inj} up to 2 kV in vacuum
    - Compared to ~ 0.6 kV maximum without
- Needs: Graduate student support
  - Need to grow students into off-campus collaborations



Higher V_{bias} = Increased Current Drive



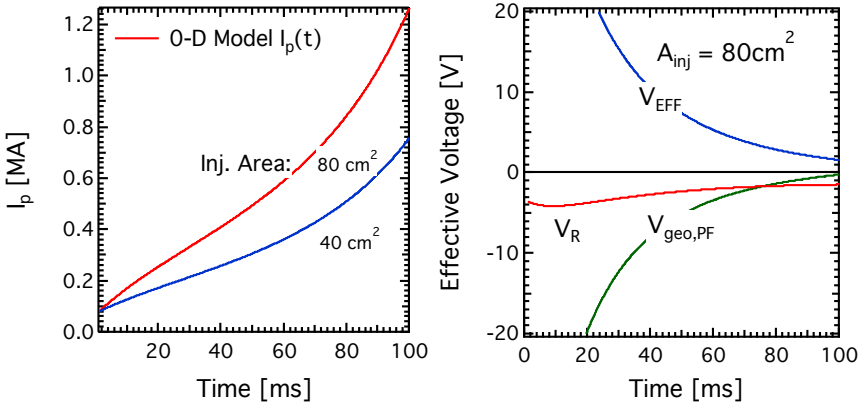
Research Plans for FY2015-FY2017

- Overall Goal: Design for NSTX-U LHI-startup to 1 MA
  - Leading to joint major proposal for implementation on NSTX-U

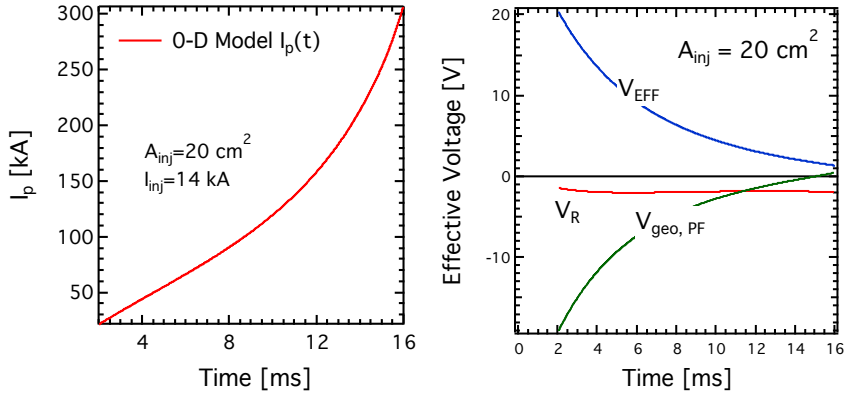
- FY2015 – Predicting performance for NSTX-U LHI startup
  - Extend 0D projections to NSTX-U
    - Calibrate to equilibrium reconstructions in PEGASUS
  - Develop integrated TSC for LHI-startup
    - Include influence of passive plates
  - Pre-conceptual design discussions with NSTX-U for injector locations

- FY2016 – Convergence to Conceptual Design
  - High I_p: 1 MA in NSTX-U > 300+ kA validation in PEGASUS
    - Need to test helicity-input dominated regime expected in NSTX-U
  - 0D and TSC modeling of both outboard midplane and divertor locations
  - Estimation of required helicity input rate
    - Voltage and Current requirements for NSTX-U
  - Tests of NSTX-U-relevant long-pulse injector arrays on PEGASUS

NSTX-U:

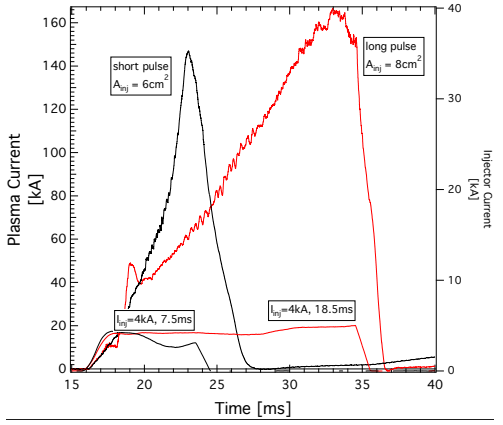


PEGASUS:

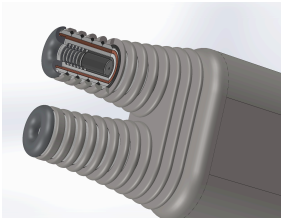


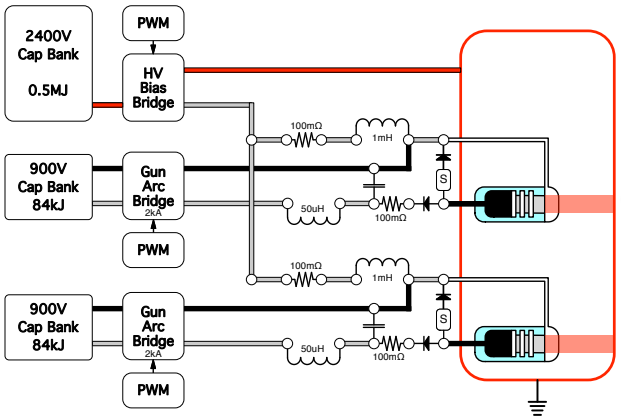
Research Plans for FY2015-FY2017 (cont'd)

- FY2017 – Moving to proposal for implementation on NSTX-U
  - Robust validated, integrated projections for NSTX-U
  - Toroidal field scaling and pulse-duration tests for NSTX-U injectors
    - Need for active cooling, different aperture sizes, etc.
  - Test expanded boundary divertor injection, if needed
  - Design injectors, control, arc and bias power systems
  - Conceptual design discussions with NSTX-U for proposal
  - Submit joint UW/NSTX-U proposal for LHI on NSTX-U

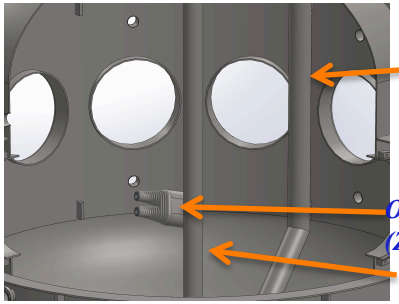


Integrated 2-4 injector Assembly





Simplified Power Systems:
- Common bias voltage
- Programmable arc supplies
- Passive cathode spot mitigation
- Possible active cathode spot suppression



Topic 2: Ideas to enhance participation in NSTX-U research/ program by U.S. Universities, researchers, and students

- Deployment of a new LHI system on NSTX-U offers an opportunity to integrate a university team into the NSTX-U program
  - To offer value and increase the profile of this activity at the university, approach this as a joint team effort
    - Shared governance of both the development and operation: details TBD
    - Raise profile of this activity on campus to enhance value to prospective students
    - Need continuous flow of people between sites
    - Remote operations to engage students early, during classroom phases
  - Have major engineering efforts at UW
    - Injectors, Power systems, control systems
    - Offers students fusion engineering research opportunities
  - UW Team assigned to PPPL
    - Scientist (young), grad students, and engineering support
  - This will all have to be worked out in developing a joint proposal for this activity.

- On other front: enhancing student participation in NSTX-U from UW is a challenge, but important!
  - Geographical separation
  - Local broad fusion science program; off-campus research needs to compete with on-campus
  - Lack of people on campus to motivate and keep students connected to off-campus activities
    - Out-of-sight and out-of-mind problem
  - Some thoughts we're discussing
    - Identify niche areas which we can merge efforts from UW and NSTX-U (& DIII-D)
      - E.g., nonlinear ELM dynamics
      - Use such areas to raise the profile on campus and show seamless evolution from what students do here to what large national facilities offer
    - Set up visits to national facilities during operations for all of our (Pegasus) students to create a context for students with their peers
    - Establish scientists on campus who concentrate on off-campus research to engage students
      - Connective tissue to our on-site collaborators
    - Set aside fraction of ports for "access-churn"
    - "Torkil Jensen" – like runtime allocation to welcome brainstorming exploration
    - This all has to add value to the program to be justified

Topic 3: Additional Measurement Capabilities

- Not generally applicable to this activity

- But, this was somewhat covered by McKee's talk
  - Integration of ELM nonlinear dynamics measurements on PEGASUS to BES measurements on NSTX-U
  - Needs added capabilities at NSTX-U and UW