PPPL PRINCETON PLASMA PHYSICS LABORATORY

Princeton Plasma Physics Laboratory and the Fusion Industry: Optimal partnership

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Innovation Network for Fusion Energy Workshop
co-host: Electric Power Research Institute (EPRI)
Fusion Industry Association (FIA)

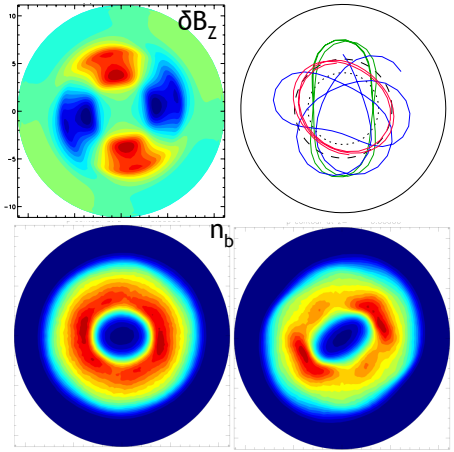
PPPL supporting INFUSE to enable commercial fusion

- Highlights of enhanced capabilities
  - Recent application of HYM stability code to FRC
  - 3D modeling for plasma material interaction
  - Multi Energy-SXR diagnostic capabilities & recent deployment

- Working to develop a **F**usion **R**esearch & **T**echnology **H**ub (FuRTH)

INFUSE PPPL / TAE project : Simulations of global stability in the C-2W (FY2020) device using HYM code

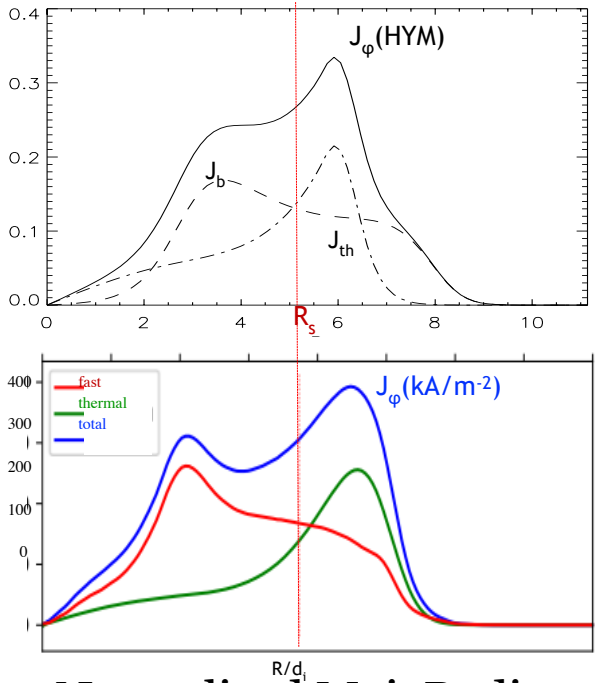
- HYM has been used to study **the end-biasing** and **NBI effects** separately.
- A general form for the beam ion distribution function was implemented and used to match the experimental profiles.
- **Initial 3D linear and nonlinear stability calculations** have been performed and compared with experiment (n=2 mode)



3D linear simulation
Mode structure and orbits

3D nonlinear simulation
beam density perturbation

Reproduced C-2W parameters

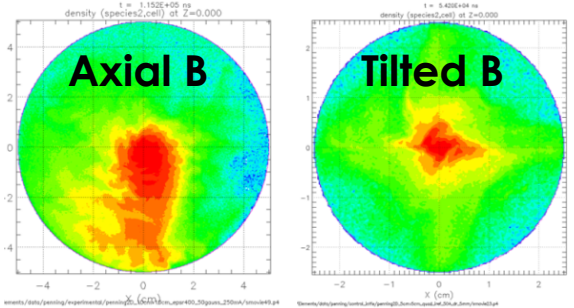


Computational Tools for plasma surface interaction modeling

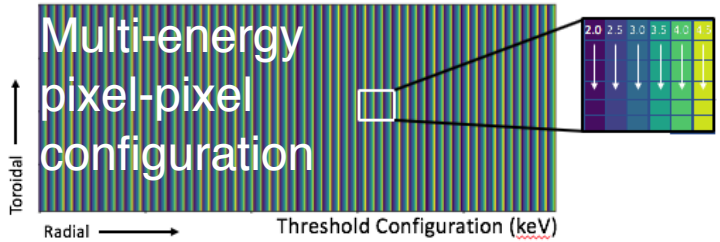
- Particle-in-cell codes (2D EDIPIC, LTPPIC GPU/CPU, **3D** PPPL-modified LSP)
  - state of the art collision models and plasma-surface interaction, validated by numerous benchmarks
- Unique Fluid codes (3D ANSYS) coupled
  - with sheath physics
  - Liquid metal (MHD effects, surface interface)
  - Melting of PFCs
- Molecular Dynamics (DFT-TB) for wall conditioning and arcing
  - DFT codes: full and tight binding approximation, CMD (classical potentials), KMC –kinetic Monte Carlo, and thermodynamic code for chemical composition.

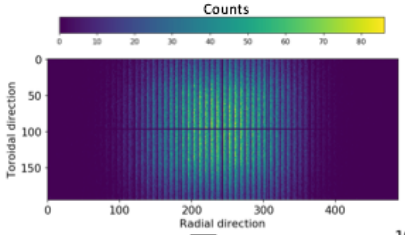
Spoke phenomena simulation

Electron Density

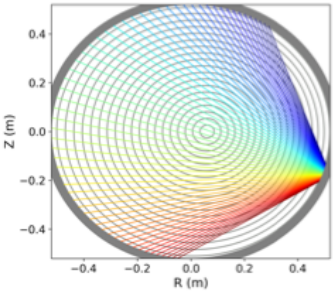


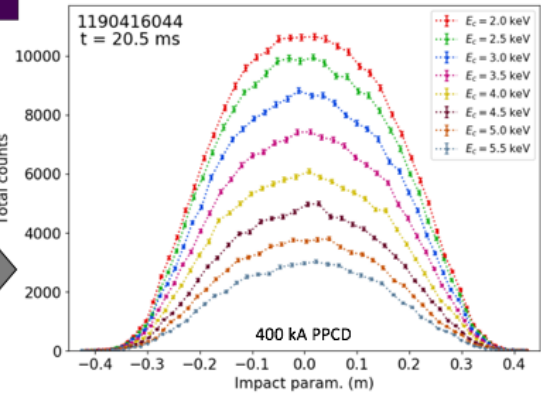
ME-SXR diagnostic tested at WiPPL has demonstrated unprecedented flexibility in the design of x-ray systems



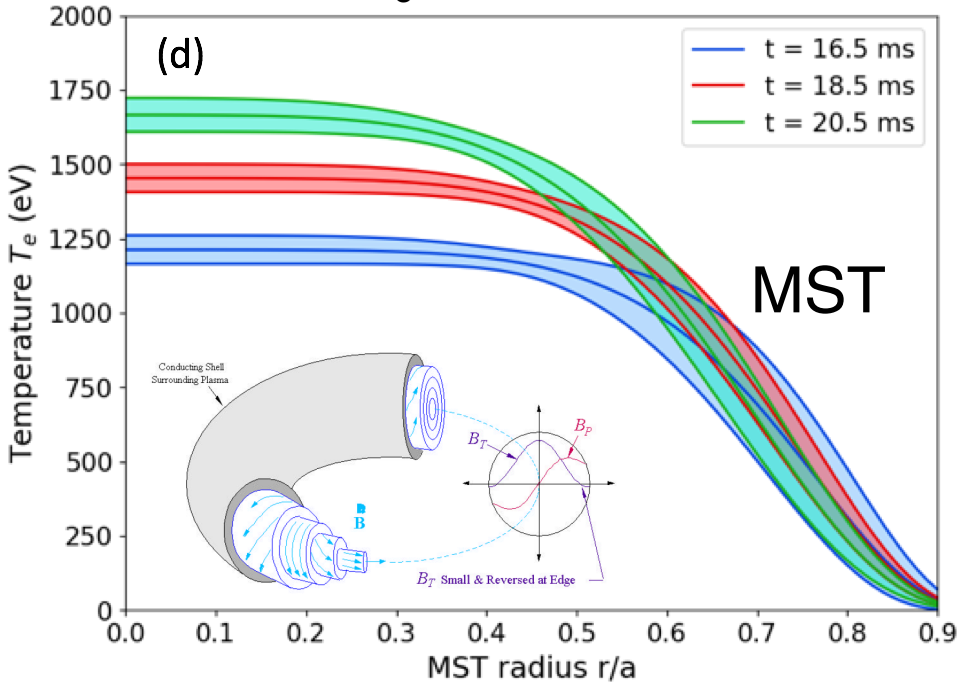


- Separate columns by threshold E_c and sum over the toroidal direction to get multiple simultaneous radial profiles
- Pixels are mapped onto lines of sight, represented by the impact parameter





SXR-inferred $T_e(r,t)$ measurement @ MST

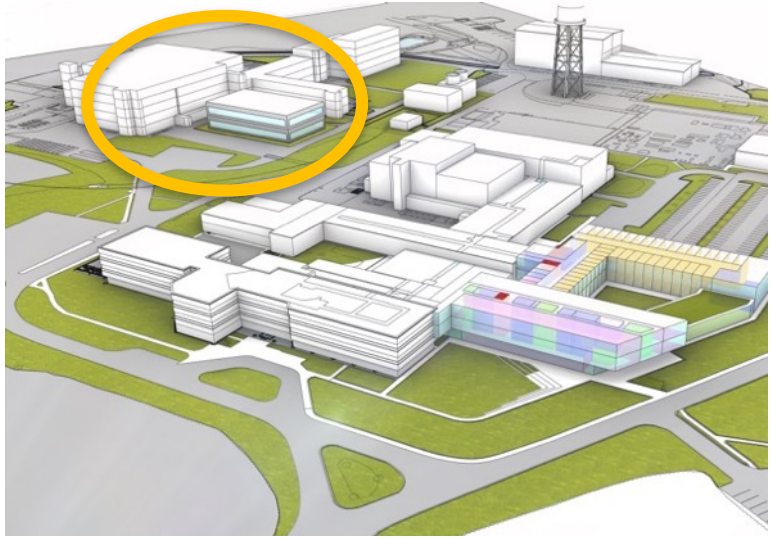


<u>New application</u>: Birth of RE's where successfully characterized in a tokamak experiment @ MST

Developing the Fusion Research & Technology Hub (FuRTH)

Foster the development of fusion start-up companies and other research initiatives through availability of:

- **Large, capable research space; the FuRTH Test Cell**
- **Unique utilities, nearby staging and technical areas**
- **Adjacent FuRTH collaboration/office building**



Making FuRTH a reality:

- Clear out legacy tritium systems and test cell (initiated)
- Build the FuRTH Collaboration building (proposal)
- **Prepare test cell for public/private partnership**

A unique national asset, with premier research space

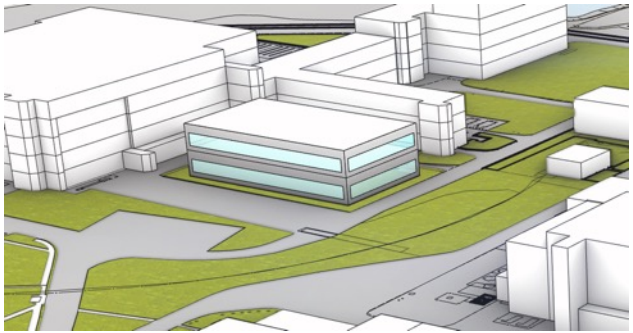
- 17,000 ft^2 with 54 ft ceiling height
- 2 hook 110/25-ton crane
- 4 ft thick concrete walls, ceiling
- Ventilated, air conditioned, humidity-controlled
- Negative pressure

Access to:

- MG set peak pulse power 475 MVA, Power converter peak pulse capacity 1,776 MVA
- Steady-state power 30/40/50 MVA 138/13.8 kV
- LN_2: 11,000-gallon dewar
- LHe Refrigerator: 4.5 K, 700 W capable

FuRTH Collaboration Building - Proposed

- Two-story building, 40,000-50,000 GSF
- Collaboration/office space
- ~$15-19 M
- **Build and occupy by FY23**
- Similar low-cost construction as those built at other labs
- Swing space for those displaced during PPIC construction



Foster public/private partnerships:

- Researchers and technicians employed by these collaborating companies
- PPPL researchers and operations staff supporting this research; and
- Additional PPPL staff necessary for supporting growth of research programs