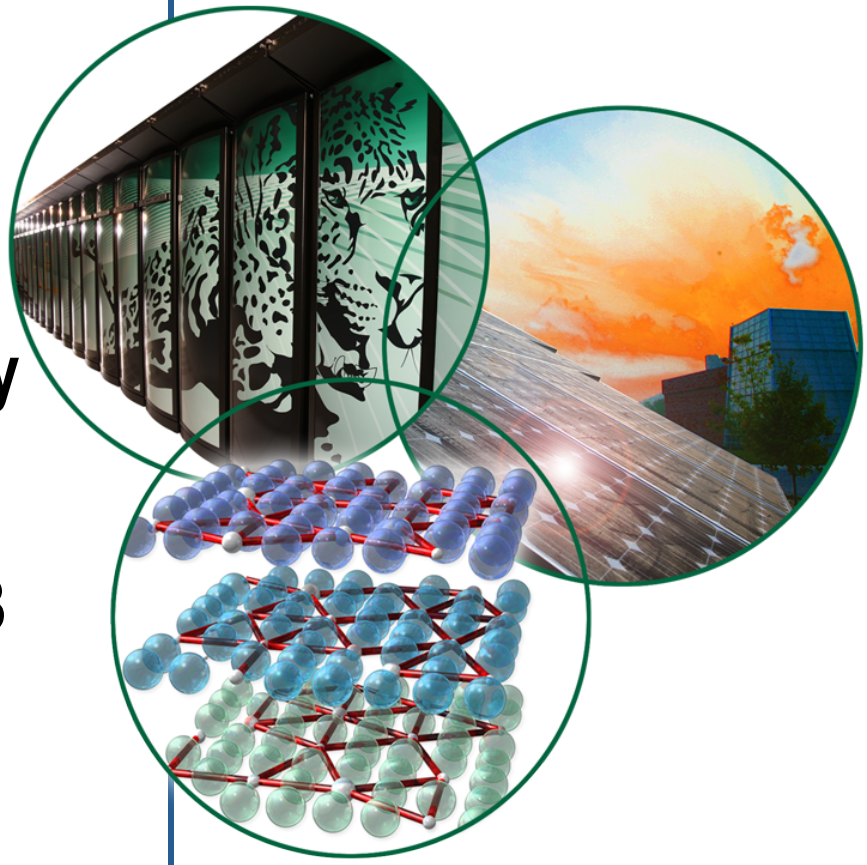
VLT report

Stan Milora, Director

Virtual Laboratory for Technology



Plasma Facing Components 2013 Meeting

September 11, 2013

Oak Ridge, TN

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

The many calls for action:

- 2007 FESAC "*Priorities Gaps and Opportunities" (Greenwald*) identified the major issues
  - Understand and control process that couple plasma with materials
  - PFCs that survive enormous heat, ion fluence and neutron damage
  - Establish and understand effect of PMI/neutron wall loading to design rf antennas and other internal components
- 2009 Research Needs Workshop (ReNeW): Theme 3, "*Taming the Plasma Materials Interface"* identified four research thrusts to address the issues
  - Thrust 9 : Unfold physics of boundary layer plasmas
  - Thrust 10: Decode /advance science of PSI
  - Thrust 11: Improve power handling via engineering innovation
  - Thrust 12: Demonstrate an integrated solution for plasma materials interfaces with optimized core plasma

The many calls for action

- **2012 "*Fusion Materials Sciences and Technology Opportunities Now and in the ITER Era : a Focused Vision on Compelling Fusion Nuclear Sciences Challenges (Zinkle)*" recommendation:**
  - **"to confidently design, build and operate an FNSF requires a multi-pronged scientific research program involving *linear plasma devices*, toroidal confinement devices, and a series of *offline non-nuclear and nuclear testing fa*cilities"**

- **2013 "*Magnetic Fusion Energy Program Priorities (Rosner)*" report ranked ReNeW Theme Three, Thrust 10 amongst is five highest initiative priorities.**

Many nations, stimulated by ITER, have answered the call to action on PSI/PFCs issues

- New dedicated facilities are multiplying in the ITER parties
  - Electron beam/neutral beam/infrared lamp and lasers/plasma guns test stands for steady state and transient heat flux studies and PFC development and qualification
  - Linear devices for basic PSI studies including synergetic effects of radiation damage
  - Linear divertor "simulators" utilizing rf heating that deliver heat and ion fluxes relevant to semi- detached divertor conditions needed for next step devices
  - Upgraded toroidal devices (JET ITER-like wall, WEST) to qualify internal components and develop divertor operating conditions compatible with good core confinement
  - Long pulse confinement devices in Europe and Asia that will necessarily confront PFC issues at high sustained power levels
  - Innovative divertor designs (and experiments) to lower heat and ion fluxes (super X, snowflake, narrow channel highly radiative) to provide engineering margin.

U.S. Fusion Energy Sciences: snapshot

U.S. DEPARTMENT OF ENERGY

High Energy Density Plasmas

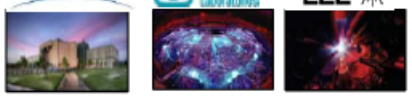
Inertial Fusion Energy Science

Materials in Extreme Conditions Instrument (MECI) @ SLAC-LCLS

NNSA

Joint Program with National Nuclear Security Administration

NIF · Sandia National Laboratories · UR LLE



General Plasma Science

NSF/DOE Partnership in Basic Plasma Science

Max Planck Princeton Research Center for Plasma Physics

Low Temperature Plasma

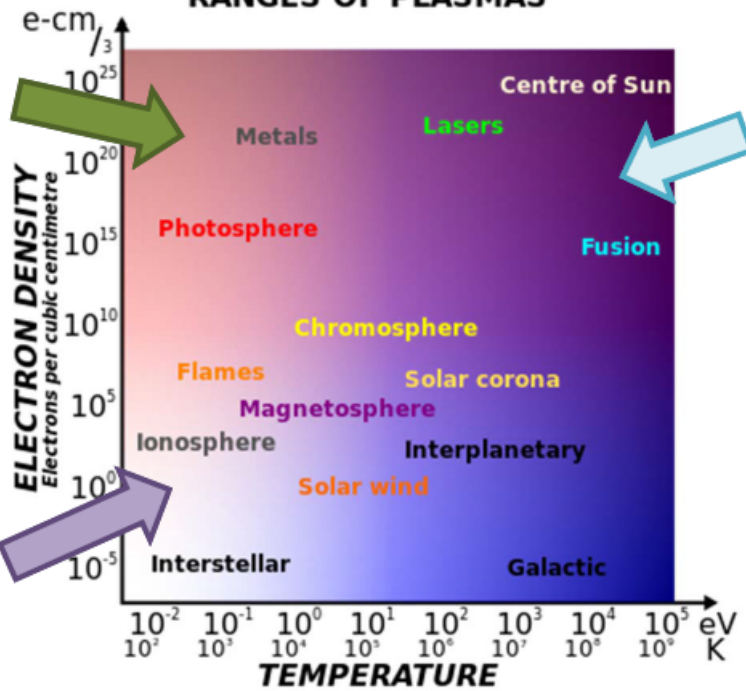
Basic Plasma Science Facility

ITER Project

(international partnership)

iter — china eu india japan korea russia usa

RANGES OF PLASMAS

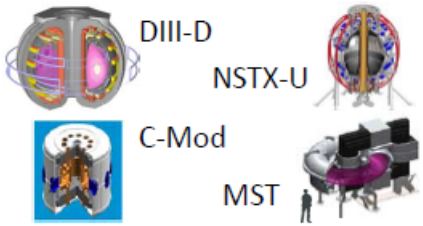


Mission of the Fusion Energy Sciences program

To expand the fundamental understanding of matter at very high temperatures and densities and build the scientific foundations needed to develop a fusion energy source. This is accomplished by the study of the plasma state and its interactions with its surroundings.

Magnetic Confinement Fusion

Facilities



DIII-D · NSTX-U · C-Mod · MST

Experimental Plasma Research

Diagnostics

Theory & Simulation, SciDAC

International collaborations

Enabling R&D

Fusion Materials Science

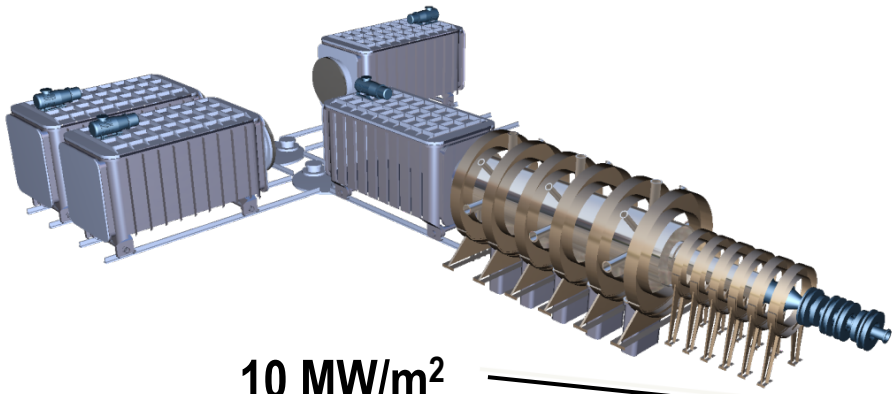
Enabling Technology

Advanced Design

MPEX

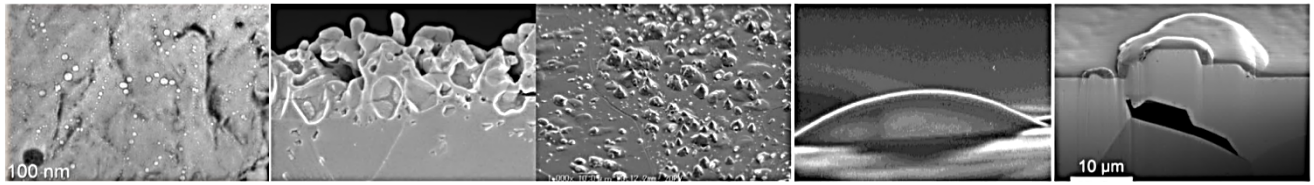
The performance goals of the proposed MPEX linear plasma device were chosen to meet the requirements of the ReNeW Thrust 10 "flagship" facility

Material Plasma Exposure eXperiment



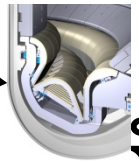
10 MW/m^2
10^{24} ions/m^2 ·s

Plasma-tungsten surface interactions showing all potential defect formations and eventual bulk failures



Void formation | Bubbles in W by He | Blisters within grains | Large Blisters due to voids at grain boundary

ITER transients



ITER Divertor

Power load [MW/m^2]

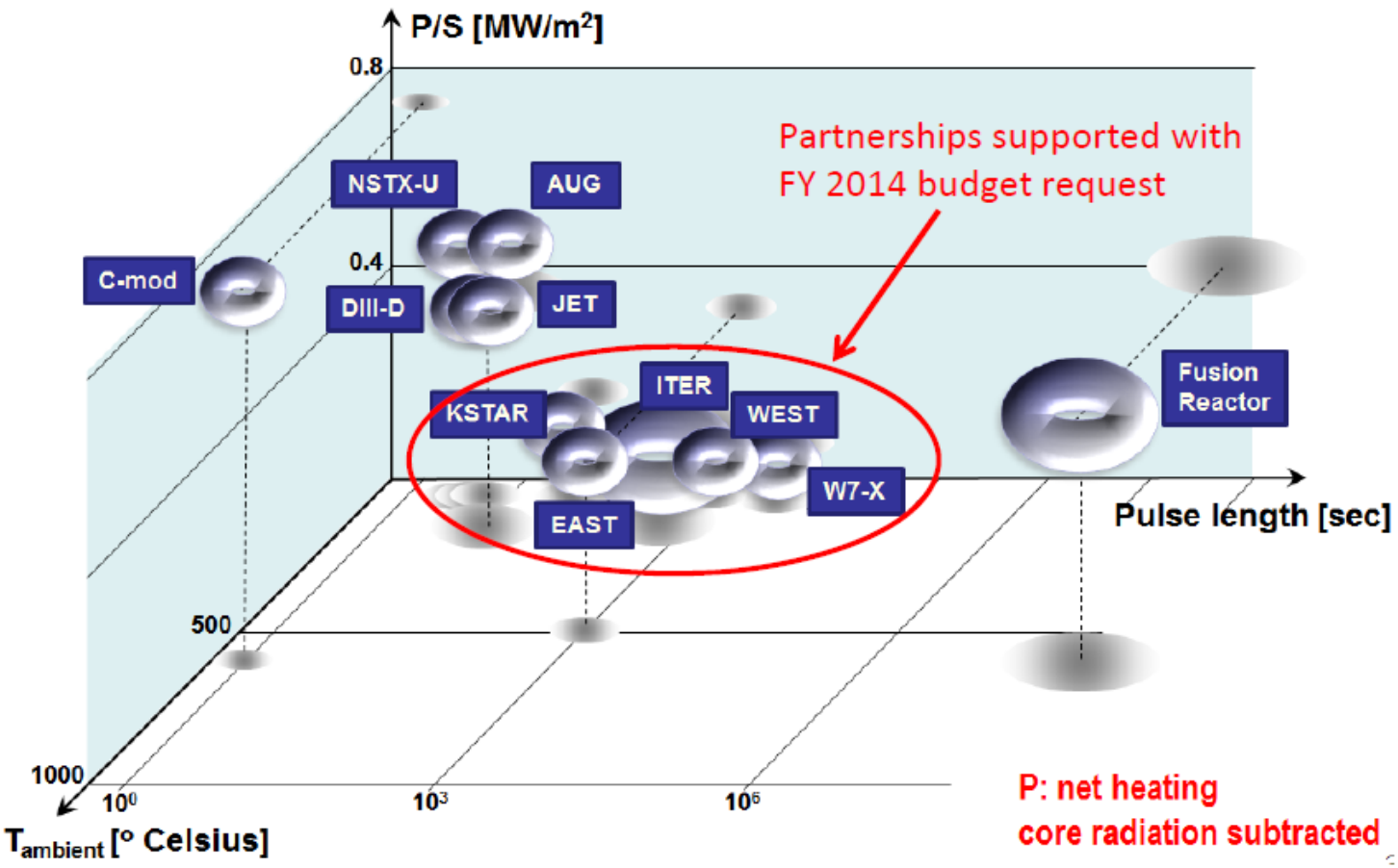
2000

85

<10

~1

International facilities can help study how to handle high heat fluxes in a reactor



Reactor walls will operate hot, will likely be tungsten, and will need to manage many MW/m^2 for long periods of time. Superconducting devices overseas will soon have this capability. International partnerships will be critical for the US.

Conclusion: DOE is listening!