SNL/CA Collaborations

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PFC Meeting, Princeton Plasma Physics Laboratory, June 21, 2012

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Laboratory Studies in Support of Collaborations

- **Plasma Surface Interactions Science Center**
  - Plasma driven tritium retention and permeation using the Tritium Plasma Experiment (TPE)
    - Extend permeation experiments to neutron irradiated materials (post-TITAN)
  - Sheath power transmission (see talk on Friday morning)
  - Characterization of nanostructured tungsten
  - Study of early stage growth of nanostructured tungsten
- **Compact Torus Injection Experiment (CTIX)**
  - PSI studies
  - Development of refractory electrodes

PSI Science Center

Japan-US Joint Project TITAN 2007-2012

DIII-D NATIONAL FUSION FACILITY

UCDAVIS COLLEGE OF ENGINEERING
Center for Advanced Laboratory Fusion Science and Engineering (CALFUSE)
COMPACT TORUS INJECTION EXPERIMENT (CTIX)

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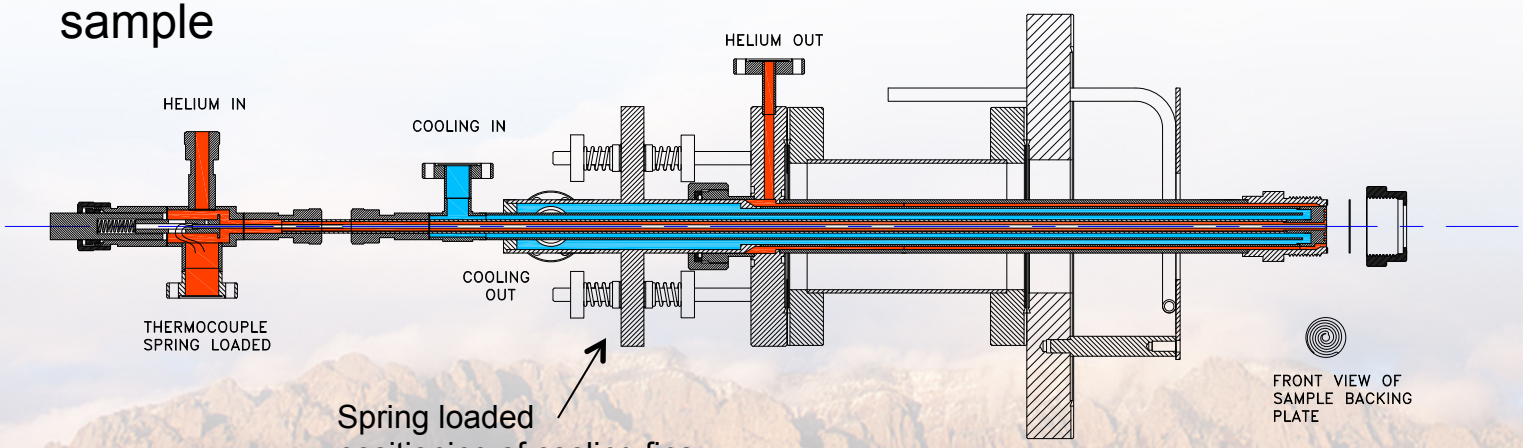
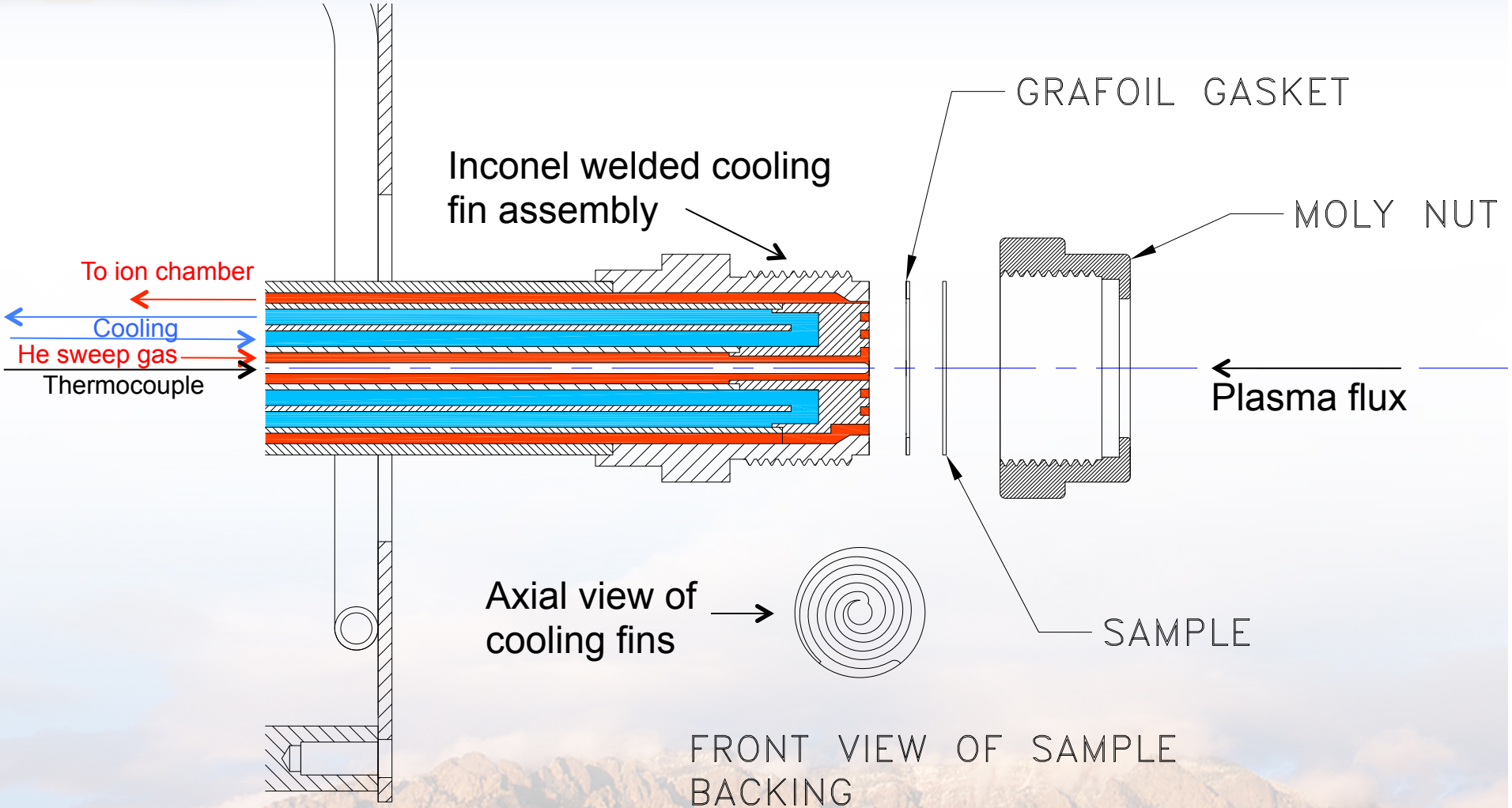
PSI Science Center (Tritium Permeation)

- **Completed thermal testing of high temperature tritium retention stage for TPE**
  - Stable operation at 800 °C for 1 hour (1000 °C for shorter times)
  - Feedback control of He flow to be implemented to reduce thermal ramp up time (now ~ 30 minutes)
- **Design and fabrication of permeation stage in progress**
  - Assembly for testing sample sealing designed and being fabricated
  - Final design in progress (evaluating bellows versus o-ring design)
  - He flow gas to capture permeating D/T between cooling fins and sample



PSI Science Center (Tritium Permeation)



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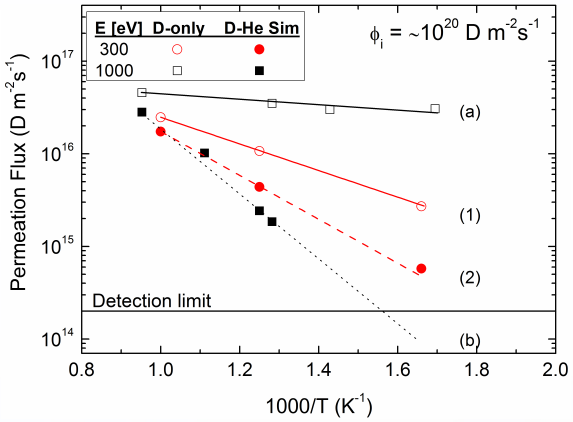
PSI Science Center (Tritium Permeation)

- **Sensitivity estimated from ion driven permeation flux experiments in HiFIT (Osaka Univ.)**
  - $\Gamma_{beam} = 10^{20}$ D m^{2}s^{-1} flux (1 keV)
  - 10^{14} D m^{-2}s^{-1} < Γ_p < 10^{17} D m^{-2}s^{-1}



- **Adjust for TPE**
  - Geometry (sample dia. and thickness)
  - Tritium seeded plasma and higher flux
- **Expected permeation**
  - 2x10^{-10} Ci s^{-1} < I_p < 2x10^{-7} Ci s^{-1}
- **Using 1000 sccm He gas flow in TPE**
  - 10^{-5} Ci m^{-3} < A < 10^{-2} Ci m^{-3} (1000 cc ion chamber covers μC m^{-3} to C m^{-3})
  - Resonance time for this flow would be 60 s
- **Breakthrough times up to 10^4 s observed in HiFIT**
  - Upgrade to TPE tritium gas handling would be required (> 4 hour runs)
  - Less important at higher temperatures expected in a divertor

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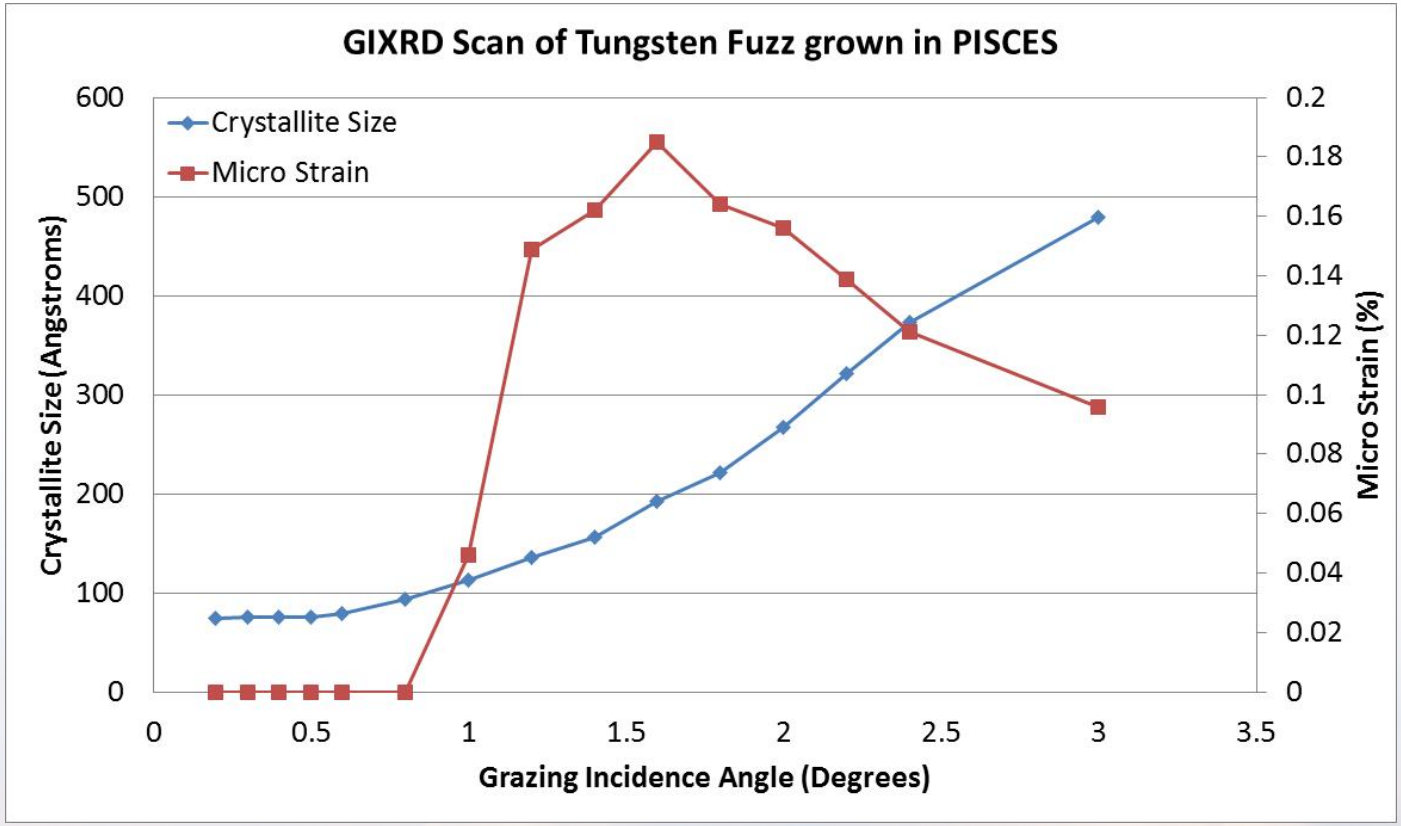
post-TITAN (Tritium Permeation)

- **The US-Japan TITAN program will transition to post-TITAN in FY13**
  - "Tritium, Irradiation and Thermofluid for American and Nippon"
- **post-TITAN**
  - "Technological Assessment of Plasma Facing Components for DEMO Reactors"
  - Three Tasks
    - Heat Load Tests, Heat Transfer, and System Design
    - Neutron-irradiation Effects, Microstructure, and Physical Properties
    - Plasma-Surface Interactions and Tritium Behavior (INL / SNL-CA)
- **Challenges to study permeation of neutron damaged materials**
  - Damage will increase trapping, hence longer breakthrough times
  - Strength of samples may be compromised
  - Neutron irradiations in HFIR may limit sample diameter to 6 mm. Alternative sealing techniques are being considered

PSI Science Center (Nanostructured W)

- **First GIXRD results of tungsten fuzz (rolled PLANSEE tungsten)**



PISCES growth conditions:
Low energy He plasma, T_s = 1100 K, Growth time ~ 30 min

PANalytical Empyrean
Reflection mode

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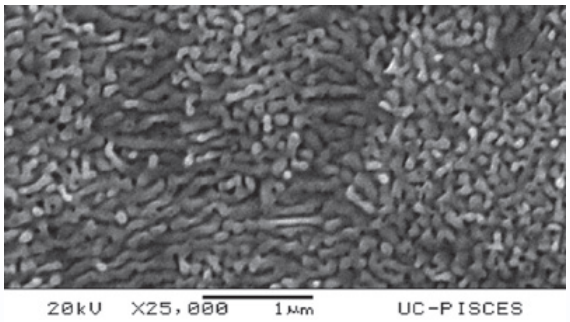
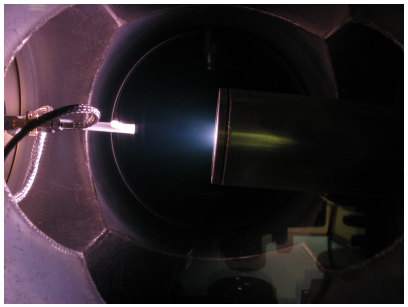
PSI Science Center (Nanostructured W)

- **Continuing to develop an experimental capability to observe early stage growth of nanostructured W (Scanning Tunneling Microscopy)**

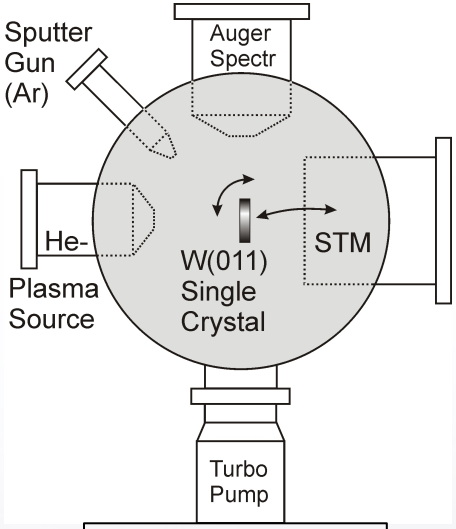


E ~ 47 eV He^+ (V_b = -23 V)
$\Gamma_i = 4\times10^{20}\ m^{-2}s^{-1}$
Baldwin, et. al.
J. Nucl Mater. 2010



Compact ECR plasma source

$\Gamma_i \sim 4\times10^{18}\ m^{-2}s^{-1}$

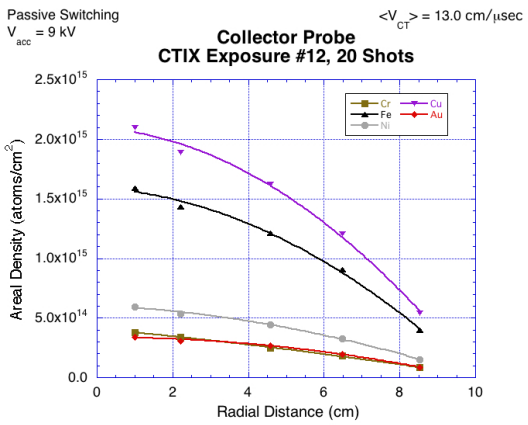


UHV: limit role of oxide

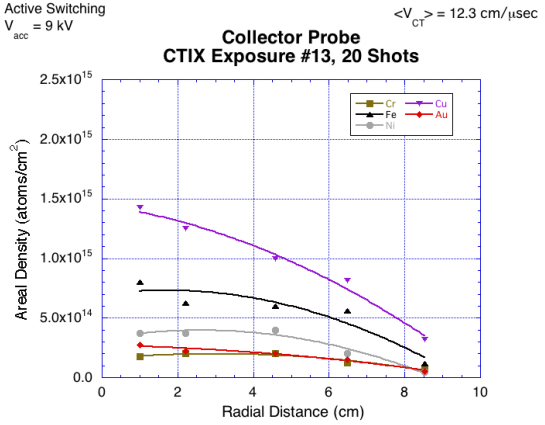
- **Planning for STM availability in FY13**
- **Characterization of compact ECR plasma source in progress**
- **Heater stage will be used to measure growth rates in FY12**

CTIX (PSI Studies and PFC Development)

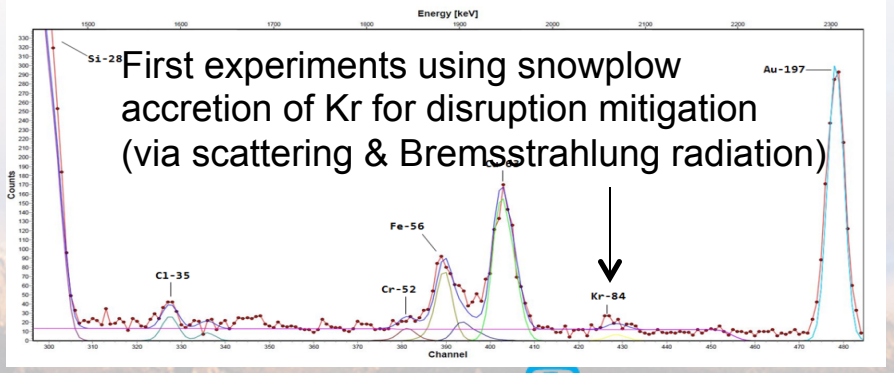
- **Compact Toroid (CT) accelerators can be used for deep fueling of hydrogenic species (CTIX: V_{CT} ~ 200 km/s with n > 10^{14} cm^{-3})**
- **UC Davis and SNL/CA collaboration exploring PSI issues and improvements to PFCs for CTIX**



RBS of collector probes shows reduced impurity production by use of active switching



- **Gas fueling improvements being implemented**
- **New electrodes with tungsten coating will address impurity production**



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