

Impurity program at UW Madison

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CWGM

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- 1 Role of edge topology on impurity confinement times
- 2 Laser Blow-Off experimental campaign on HSX

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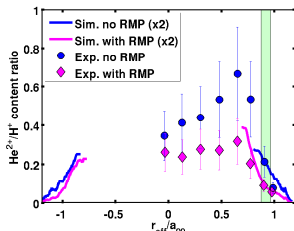
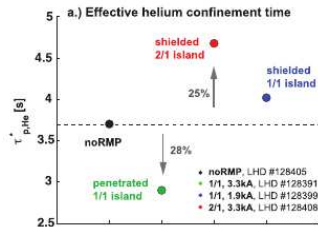
Impurity species dependence on edge is important for future devices

- Helium exhaust from self-generated alpha particles
- Prevent penetration of wall sputtered impurities (W,C) into edge
- Trap seeded impurities for radiative divertor scenarios (F. Effenberg, tomorrow)
- **Are there configurations that allow for all of these in optimized stellarators?**

Background - Experiments on LHD and TEXTOR show presence of edge islands reduce $\tau_{p,He}^*$

- $\tau_{p,He}^* = \tau_{p,He} / (1 - R)$ - effective global confinement time
- Presence of islands in the edge causes a reduction in effective confinement of Helium
- Result - reduction of helium content in plasma with identical sources
- EMC3-EIRENE simulation on LHD also shows impurity reduction

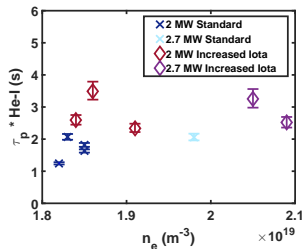
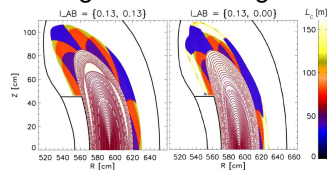
O. Schmitz NF **56** 106011 (2016)
 A. Bader PPCF **58** 124006 (2016)
 K. Ida PPCF **58** 074010 (2016)



Results from W7-X show increased confinement time when islands are present in far SOL

- Experiments done in limiter campaign
- Exp 1 - Standard: 5/6 island just inside limiter. No edge island
- Exp 2 - Increased iota: 5/6 island far inside, 5/5 island in edge
- Increased iota configuration shows longer confinement times
- Empirical evidence for impurity trapping inside 5/5 islands - modeling effort ongoing (F. Effenberg)

No edge isl. Yes edge isl.

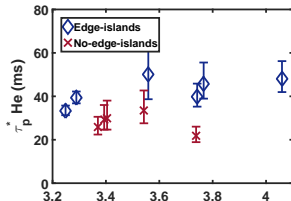
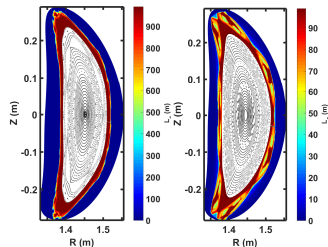


HSX - Configuration with edge islands has *better* He confinement

- Experiments on HSX show better helium confinement with edge islands across a range of densities
- W7-X and HSX in comparison to LHD and TEXTOR highlight importance of island positioning and plasma parameters
- EMC3-EIRENE not yet able to show the proper trends on either W7-X or HSX!

L. Stephey - submitted to PoP

No edge isl. Yes edge isl.



Behavior of edge impurities is sensitive to details of edge topology

- Impurity behavior may be sensitive to -
 - Location of puff relative to island structures
 - Position of island relative to exhaust
 - Size of island relative to ionization scale length
 - Position of island, far SOL, near SOL, just inside SOL
 - Change of $\tau_{p,He}^*$ as a function of R rather than τ_p
 - Electric potential structures
- Multiple machines needed to understand edge impurity behavior
 - LHD - dense plasmas with islands inside SOL - configuration provides improved helium exhaust
 - W7-X - dense plasma with islands in SOL or far SOL - configuration possibly provides impurity trapping
 - HSX - low density plasma but with very flexible configurations - can be a testbed for configuration dependence on edge impurity confinement

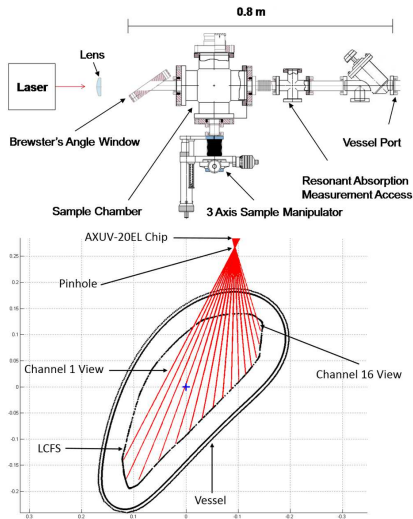
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Goals of the HSX Laser Blow-Off project

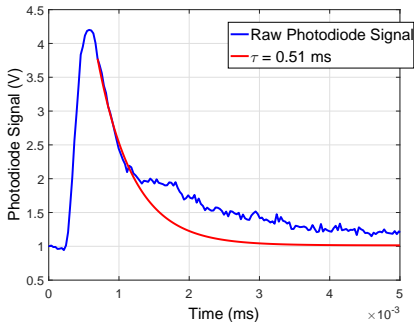
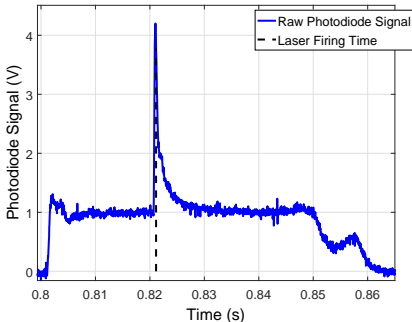
- Measure impurity confinement time in QS and symmetry broken configurations
- Use modeling (STRAHL) to determine diffusivity, D and convective velocity V
- Compare the calculated coefficients with neoclassical models

Diagnostic system and capabilities

- ND:YAG laser - 850 mJ over 4-6 ns
- 7 J/cm^2
- Angle of injection: $2.6 \times 10^{-3} \text{ sr}$
- Lens for spot size adjustment
- Core density $3\text{-}5 \times 10^{18} \text{ m}^{-3}$
- Current spectroscopy is limited to bolometer views

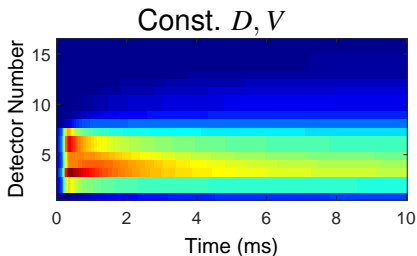
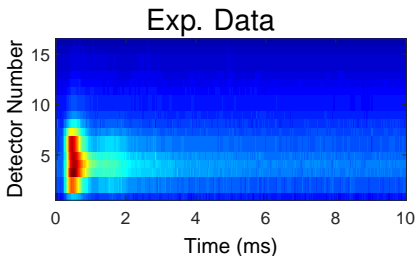


Decay fitting

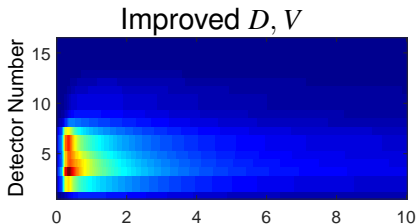


Only initial decay can be fit. Later signal is contaminated, possibly by the arrival of clusters.

STRAHL modeling



Can improve signal modeling.
Need optimization procedures
to determine best fitting
coefficients

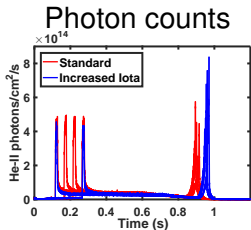


Impurity measurements in both core and edge

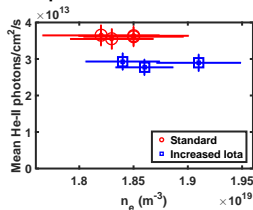
- Core measurements - from Laser Blow-off
 - Currently measuring total radiation with bolometers
 - Analysis with STRAHL
 - Explore the role of core topology on impurity transport
 - Collaboration between HSX and LBO team in the UW-3dPSI group (V. Winters) and W7-X (T. Wegner)
- Edge measurements - role of islands
 - HSX will contribute to a large international collaboration on the role of edge islands on impurity transport
 - Explore sensitivity of edge topology on impurity transport
 - EMC3-EIRENE modeling is routine

Extra slides

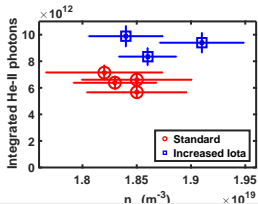
Evidence for impurity trapping in edge



Main plasma mean count



Recomb. Integrated



With edge islands, photon counts during plasma phase are lower, but during recombination phase are higher

Best guess D and V

