Study of Ion Incident Angle Distribution for Different Plasma Configurations

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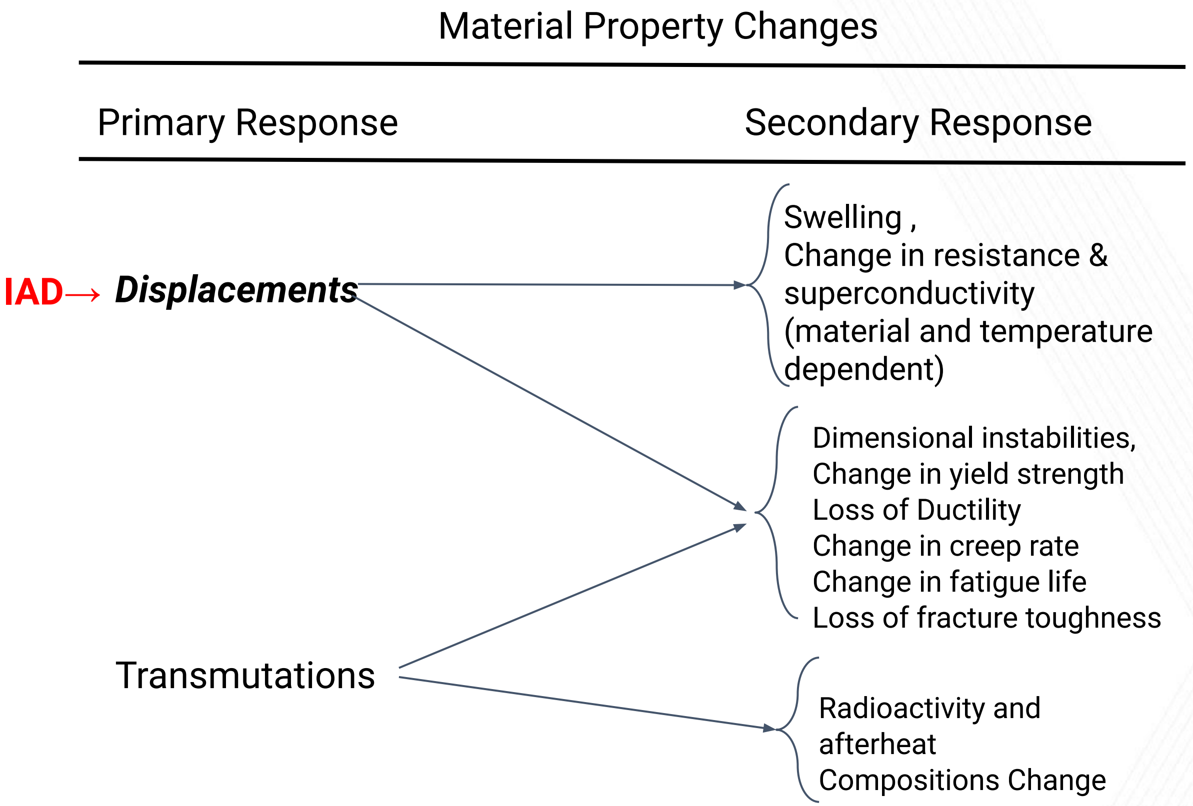
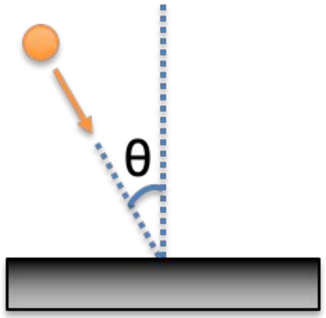
Introduction

- Goal : **Calculate the ion impact angle distribution (IAD) for various plasma devices:**
    - DIII-D (General Atomics)
    - PISCES - A (USCD)
        - Linear (cylindrical) plasma
    - LTX-β and NSTX-U (PPPL)
- Motivation: **Confirming IADs using linear plasma device rather than using complicated tokamak**
    - **PISCES-A**
- Method: **Run IAD Calculation code on IDL**
    - Make use of Chrobak's kinetics IAD calculation code (NF, 2018) for PISCES-A parameters

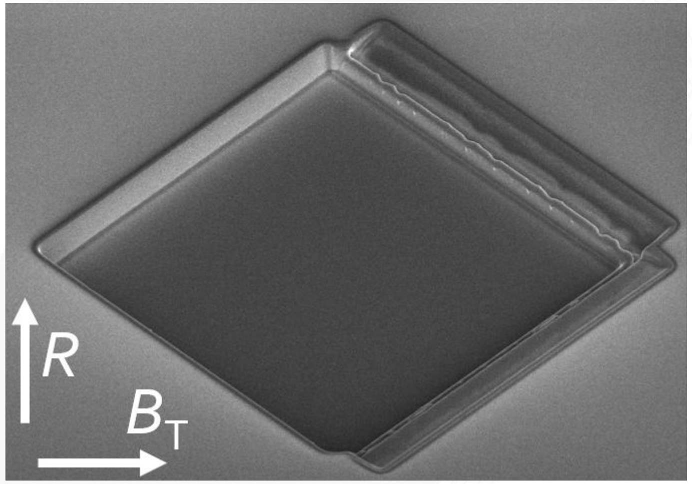


Adaptation from Stacey, *Fusion* (2010)

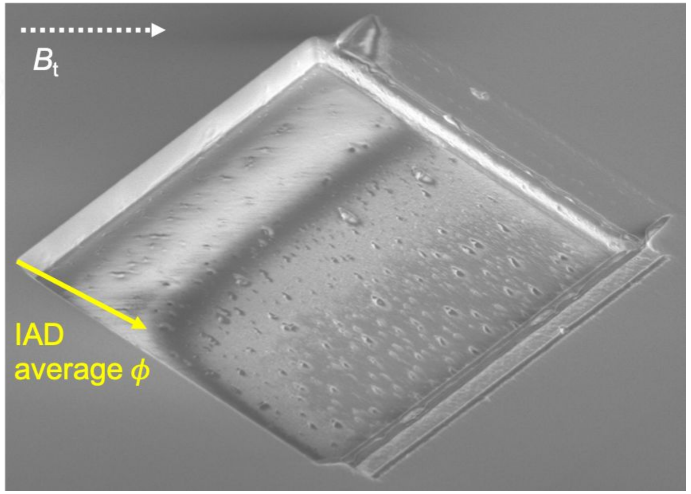


Previous Work

- **DiMES - DIII-D**
  - Use of micro-trench samples to analyze impurity deposition patterns on the floor shadowed from incoming ions by its wall.



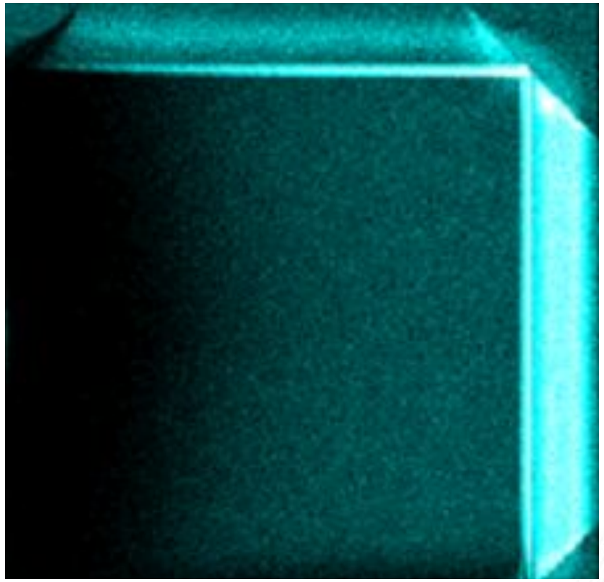
Trench image taken by SEM before exposure



Trench Image taken by SEM after exposure

S. Abe, NME (PSI 24th), submitted (2020)

- **Micro-Patterning and Roughness [(MPR) code]**
  - Calculate 'net erosion yield' of C, Si, and Al sputtered by Deuterium ions.
  - Compared with experimental Results



A. Lasa and J. Coburn, "MPR" (2018)

Model - IEAD

Sheath modeling

$$n_e = n_{e0} \exp(\psi)$$

Boltzmann relation

$$\psi(z) = \psi_w \exp(-2z/L_{MPS})$$

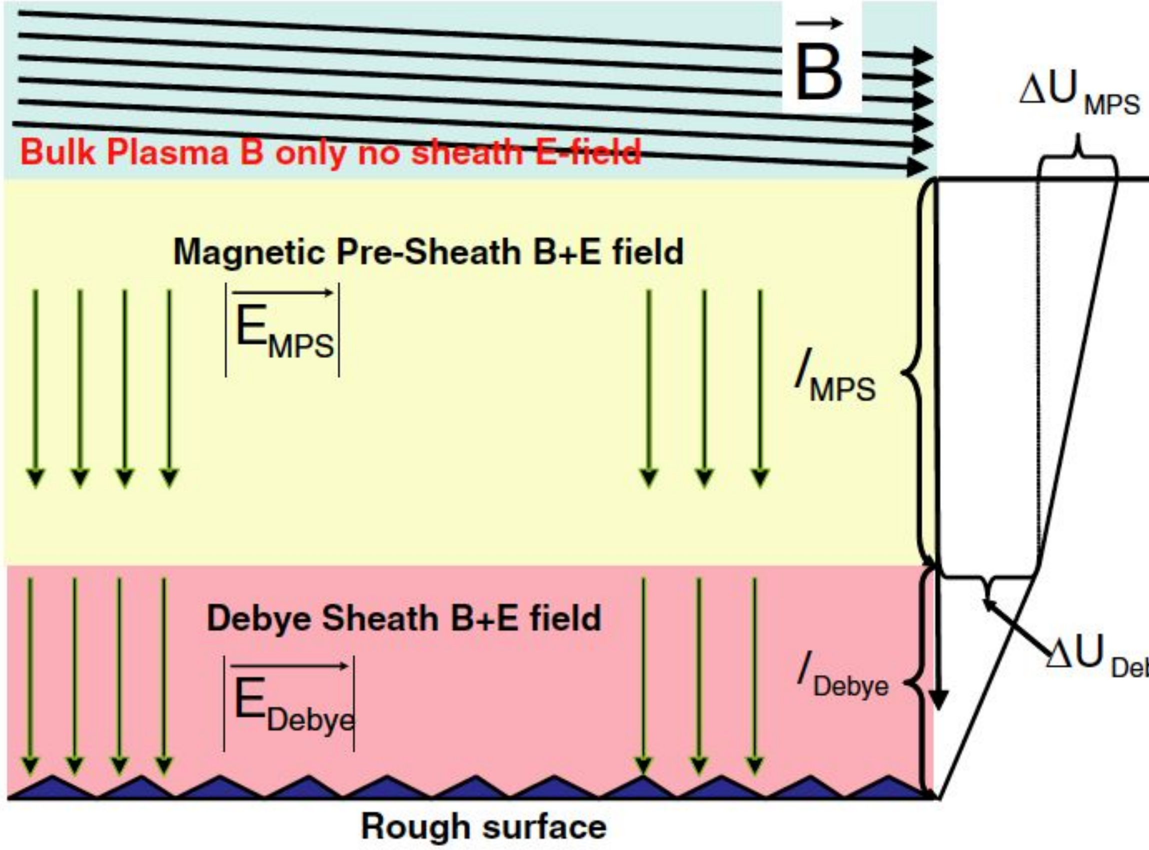
Potential profile

$$\psi_w = \frac{1}{2} \ln\left(2\pi \frac{m_e}{M_i} \frac{T_e + T_i}{T_e}\right)$$

Floating potential at wall

$$L_{MPS} = k\rho_i \cos(\alpha).$$

Length of Magnetic Pre-Sheath



Schmid, NF (2010)

Equation of motion for single ion particle

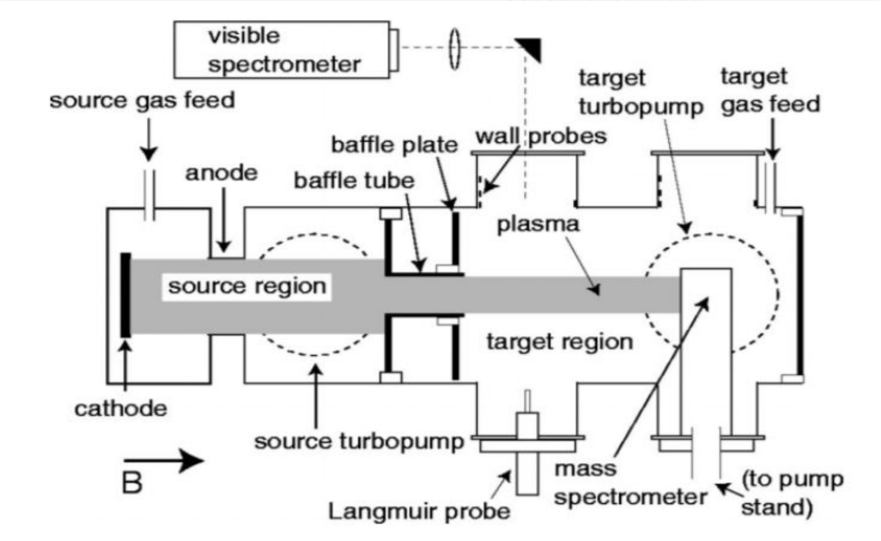
$$F = e(E + v \times B)$$

Collisionless assumption

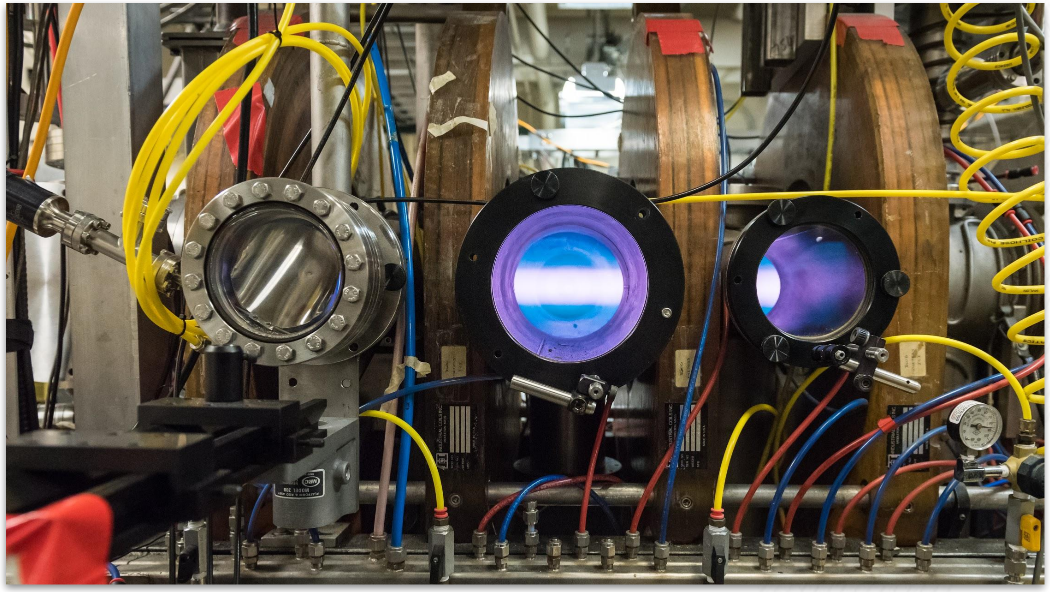
PISCES-A (UCSD) Parameters

- Cylindrical Plasma with 20 cm diameter and 1 m length
- Reflex-arc discharge
- Criteria to apply this model to PISCES-A plasma:

$$L_{MPR} \sim \rho = 16mm\ (T_e = 5eV) < \Lambda_{MFP}\ for\ 1mTorr$$



Device	PISCES-A	DIII-D (L-mode)
p	> 1 mTorr	~mTorr (divertor)
T_e	3 – 7 eV	15-30 eV
N_e	10^{17}-10^{18} m^{-3}	~10^{19} m^{-3}
B	0.8 - 2.3 kG	~2 T



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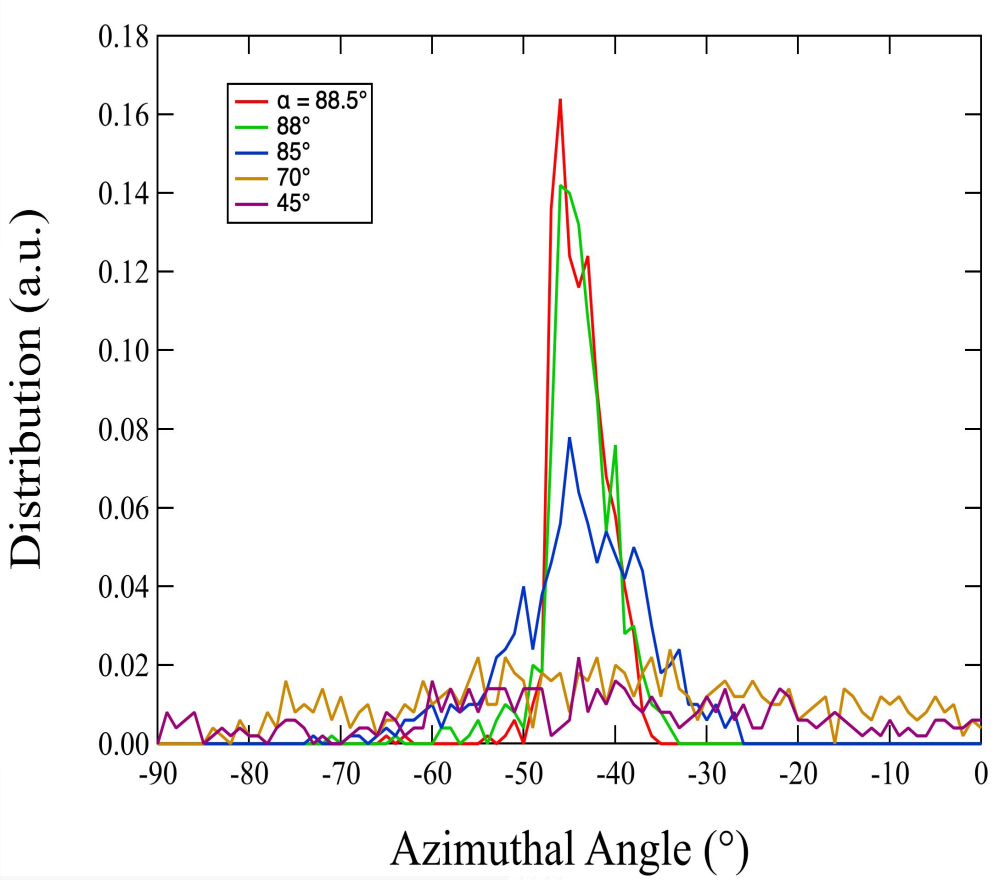
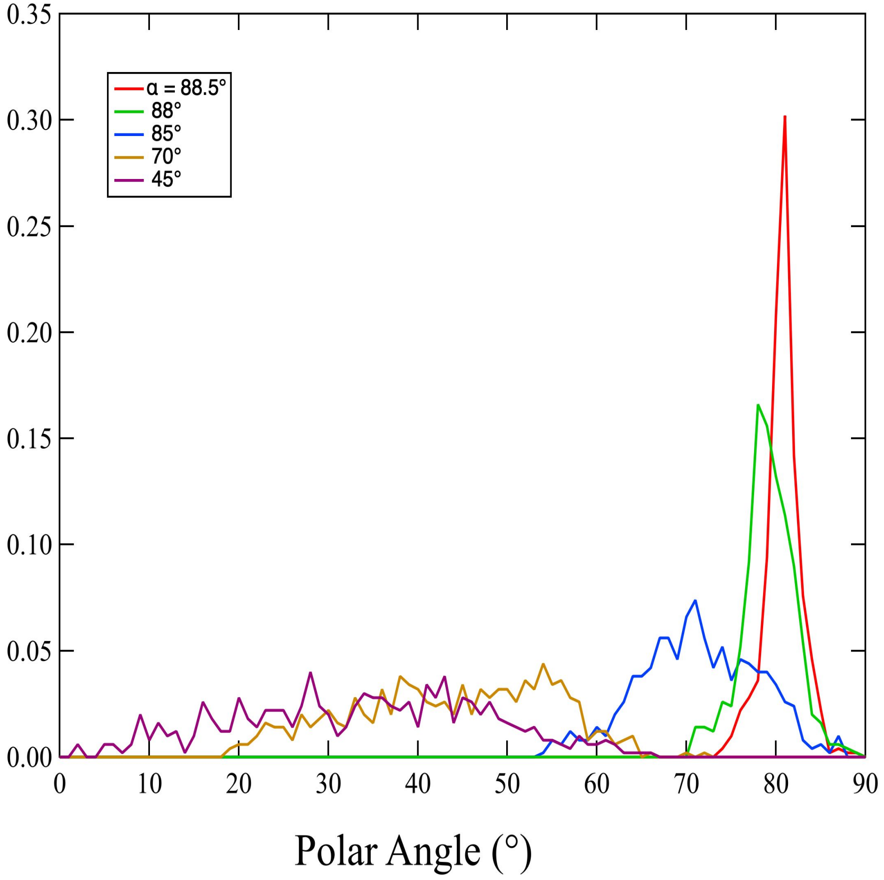
Results





Calculation Conditions:

T_e : 5eV

N_e: **1e17 m^-3**

0.2 T

Alpha (pitch angle):
(45-88.5°)

- Lower pitch angle has broader IAD
- IAD peak angle does not appear to fluctuate with pitch angle.

- Lower pitch angle has broader IAD
- IAD is sensitive with grazing pitch angle.

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Conclusion

- We brought kinetic, collisionless model to calculate IAD.
- Collisionless assumption can be applicable for PISCES-A IAD calculations.
- The IAD calculated for PISCES-A with various pitch angles showed significant dependency on chosen value.

Future Work

- Verify IAD calculation results experimentally through micro-trench samples for PISCES-A.
  - Design micro-trench dimension to capture IAD
  - Use MPR code to verify micro-trench design
  - Fabricate micro-trench sample and sample stage for PISCES-A

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