

#### Effects of low-Z powders on high-confinement plasmas in DIII-D

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# Effects of low-Z powders on high-confinement plasmas in DIII-D

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# Materials are injected in powder form to control plasmamaterial interactions and pedestal at DIII-D and other devices

Lithium, boron, and boron nitride powders were injected into the small angle slot (SAS) divertor in DIII-D H-mode

- Recent applications: ELM & pedestal control, real-time wall conditioning, impurity transport
- This work: low-Z powders injection into C and W divertor dissipate power and improve wall conditions during H-mode
- BN, Li are more efficient than B for divertor power exhaust; BN most suitable for detachment





#### **PPPL Impurity Powder Dropper**

• Li, B, BN powders (40-150  $\mu$ m) • flow rates 3-200 mg/s, atomic rates  $10^{20}$ - $10^{22}$  atoms/s, (1-300) Torr-I/s), particle speed: 5-6 m/s



 EMC3-EIRENE & DIS show Li & BN ablate in divertor, less retention for B

> A. Nagy et al, Rev. Sci. Instrum. 2018 89, 10K121 A. Bortolon et al 2020 Nucl. Fusion 60 126010

# Boron is an effective radiator in colder far scrape-off layer, while lithium radiates close to separatrix

# Boron nitride powder detaches the divertor and reduces ELM fluxes to the divertor targets







#### Vertical view on upper divertor



#### BN at moderate-high rates

- 65 um BN injected at ~50-200 mg/s
- Sustained detachment
- ELM frequency and amplitude reduce at the target

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## New experiments in closed tungsten divertor (SAS-VW) demonstrate suppression of W source and detachment

## Powders also reduce recycling and intrinsic impurities, allowing access to lower collisionality plasmas





Outer strike point located on W coated tiles

- $65 \,\mu\text{m}$  BN injected at ~50 mg/s
- Sustained detachment
- W source (W I) reduces



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The Dust Injection Simulator was coupled to EMC3-EIRENE to enable full-torus treatment of powder & impurity transport

Modeling shows more substantial dilution by boron compared to lithium, boron nitride powders similar to the experiment



Li & B densities and average Z<sub>eff</sub>

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