Characterization of edge poloidal impurity asymmetries at ASDEX Upgrade

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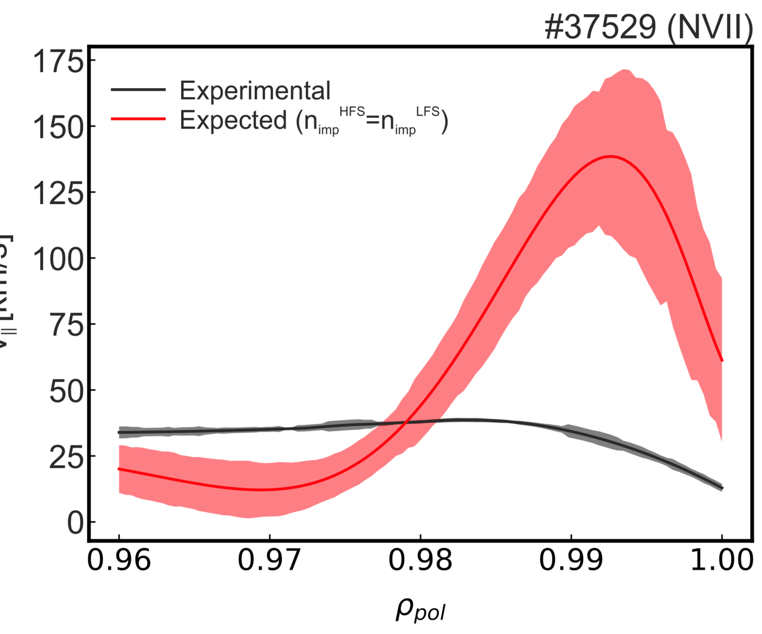
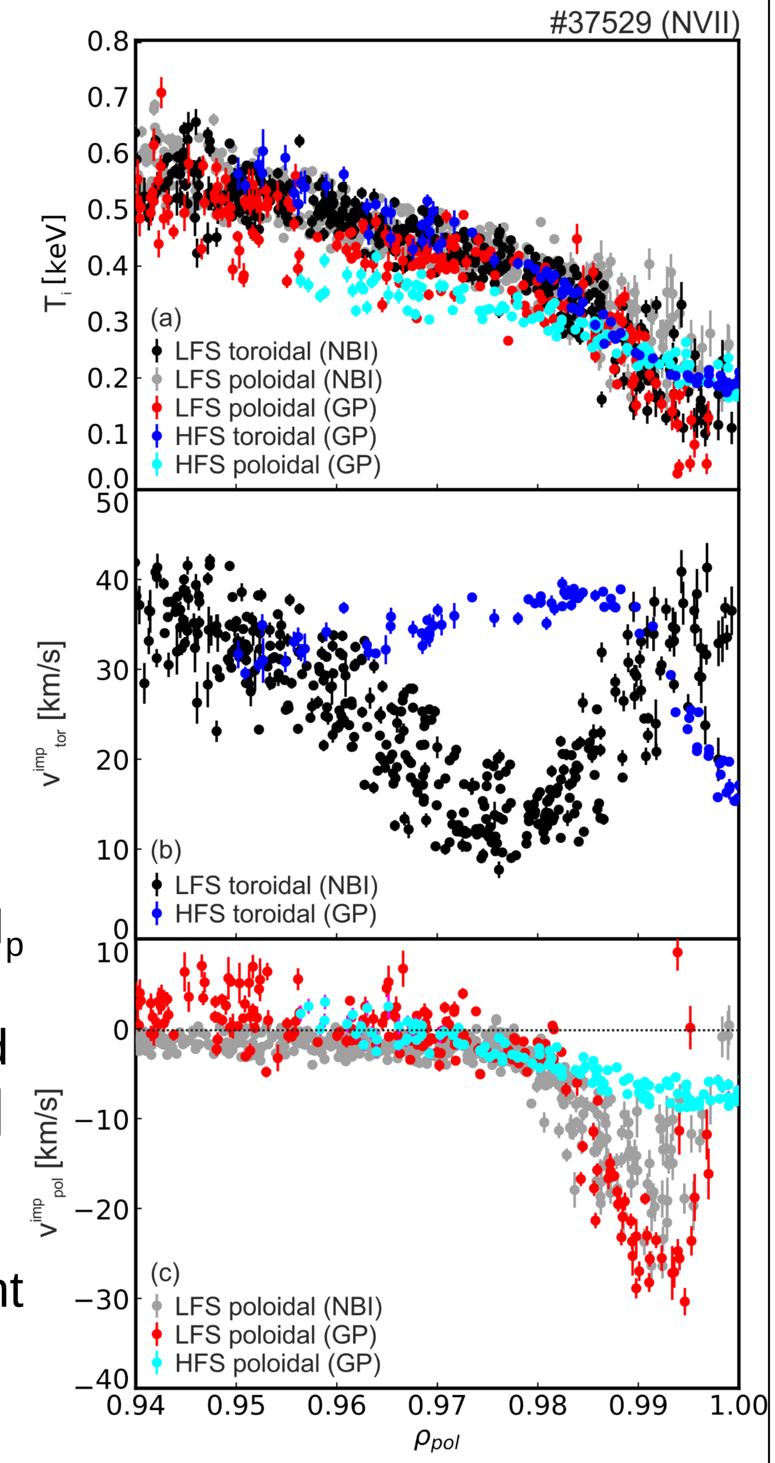
Motivation

- Impurities play an important role in determining fusion performance
- HFS measurements are necessary to understand the impurity transport along the whole flux surface
- Asymmetries in the impurity density are needed to explain the differences between measured and expected HFS parallel flows [1,2]



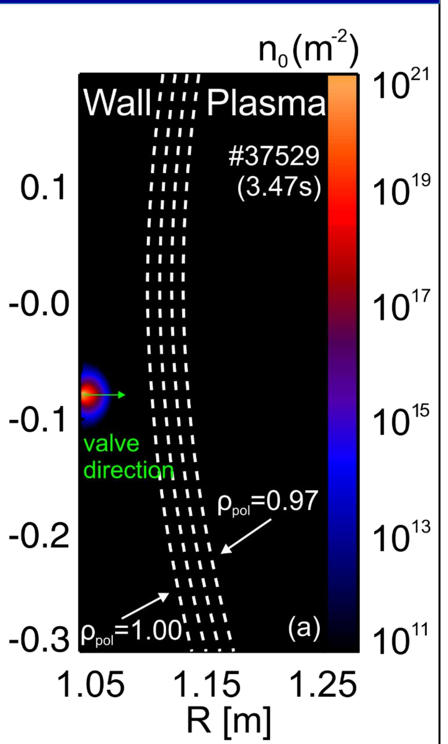
CXRS technique provides impurity profiles at HFS and LFS

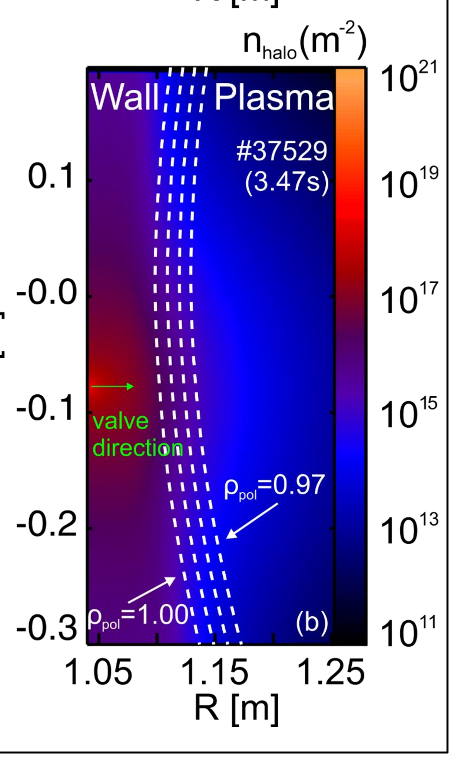
- CXRS suite at AUG:
  - ✓ LFS beam (NBI) based: toroidal and poloidal views
  - ✓ LFS gas puff (GP) based: poloidal view
  - ✓ HFS GP based: toroidal and poloidal views
- The GP based CXRS diagnostic installed at the HFS of AUG has been upgraded with a new piezo driven gas valve [3]:
  - ✓ Higher signal-to-noise ratio
  - ✓ Enables background subtraction
- Measurements in H-mode (B_t = -2.5 T, I_p = 1 MA, P_{NBI} = 4.85 MW, P_{ECRH} = 1.35 MW, $n_e^{ped.\ top}$ = 6.5·10^{19} m^{-3}) show good agreement with previous studies [1,2,4]
  - ✓ Impurity temperature is a flux function
  - ✓ HFS toroidal rotation more co-current than LFS in pedestal region.
  - ✓ Minimum in poloidal velocity at LFS and HFS, but different value

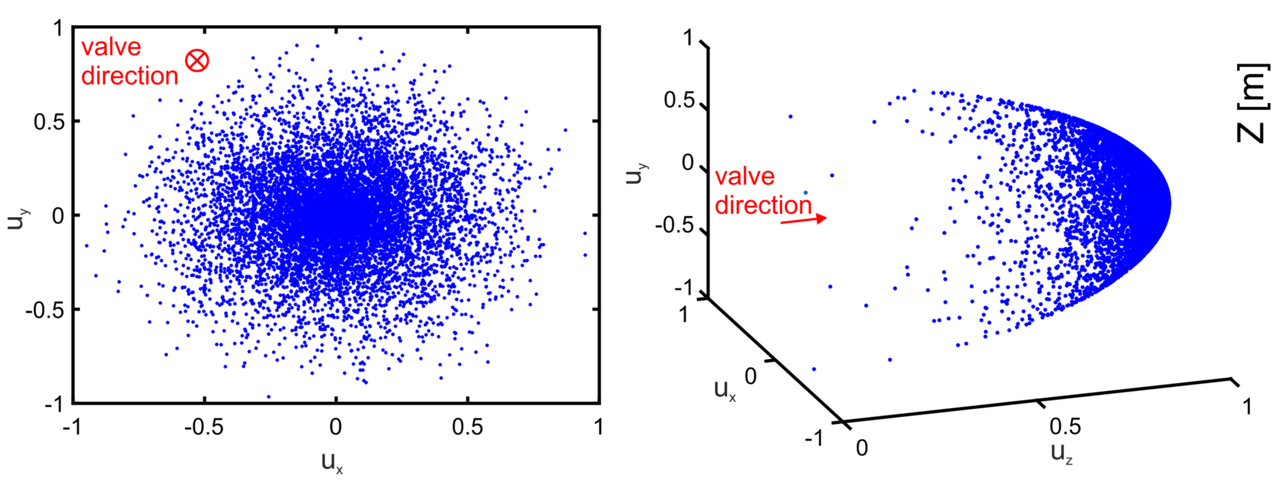


Gas puff modelling in FIDASIM

- Impurity density reconstruction requires particle distribution of the injected neutrals
- A new gas puff module has been included in the FIDASIM code [5] taking into account geometry of HFS and LFS CXRS systems
- This model launches Monte Carlo markers with a distribution similar to the gas cloud observed during laboratory test of the new valve [3]
- Neutral population = first generation of neutrals (injected neutrals, n_0) + halo neutrals (successive generation of neutrals, n_{halo}). Halo neutrals penetrate into the plasma [6]





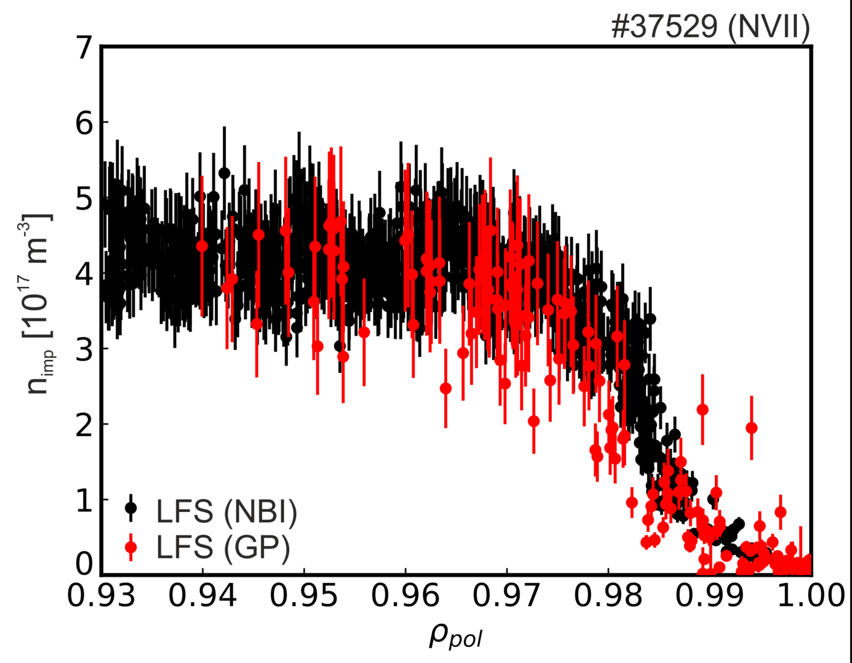


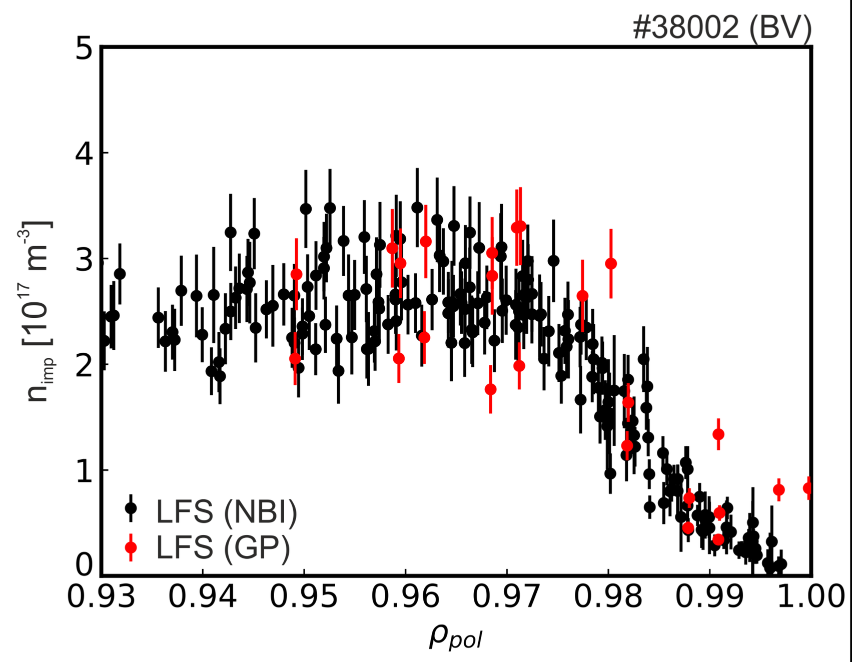
Impurity density calculation

- The new gas puff module has been included in the CHICA code [7]
- CHICA uses the neutral population from FIDASIM and the radiance of the CXRS diagnostic to obtain the impurity density

$$n_z = \frac{4\pi}{h\nu}\frac{L_{CX,z,\lambda}}{\sum_n \int_{LOS} n_{D,n}(s)\langle\sigma_{n,z,\lambda} v_j\rangle_{eff}(s)ds}$$

- The impurity density calculated using the LFS GP based CXRS system has been benchmarked against well established impurity density calculation from NBI based CXRS systems
- Excellent agreement has been found for different impurities: nitrogen (#37529) and boron (#38002)



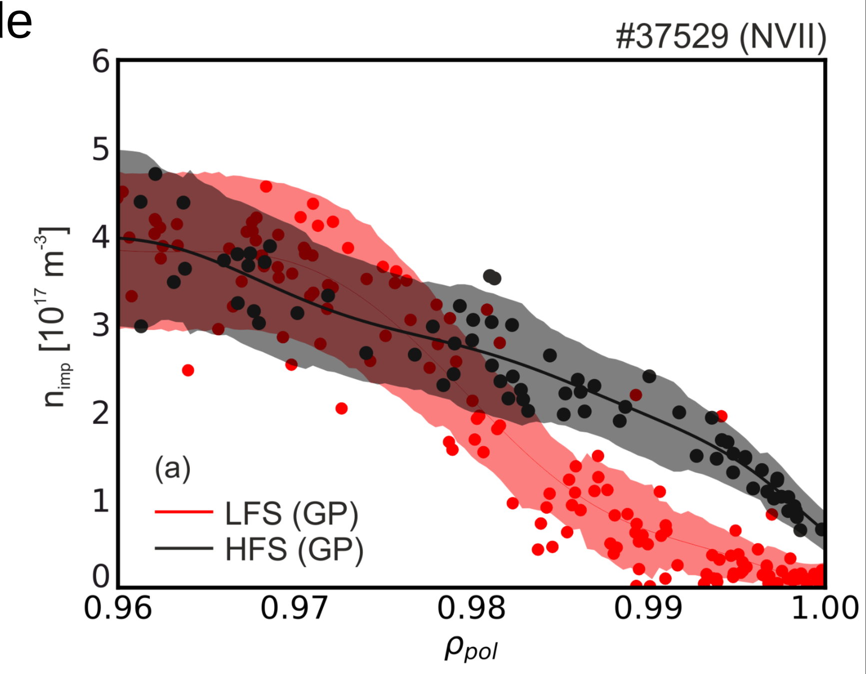


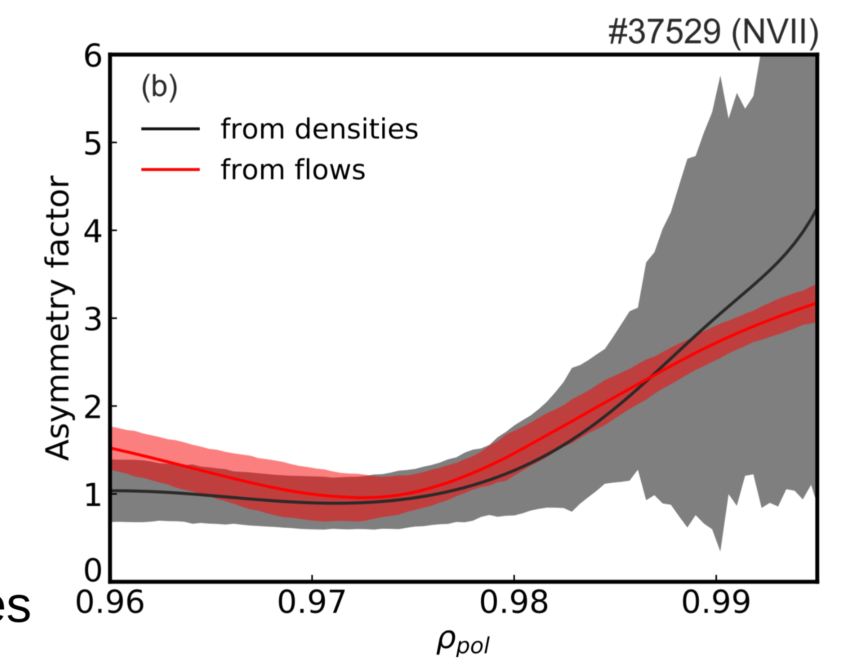
Impurity density asymmetries

- Impurity density asymmetries can be made visible using the HFS and LFS GP based CXRS systems
- Presence of HFSHD may impact the neutral density calculations. No HFSHD was observed in #37529
- Impurities tend to accumulate at the HFS edge region
- Impurity density asymmetries can be calculated from the densities (n_{imp}^{HFS} / n_{imp}^{LFS}) or estimated from the flow measurements [1,2]:

$$\frac{n_{imp}^{HFS}}{n_{imp}^{LFS}}\bigg|_{flows} \approx \frac{\left[v_{\parallel,\alpha,LFS}^{exp} - \frac{v_{\perp,\alpha,LFS}^{exp}}{\sin\delta_{LFS}}\right]\frac{B_{HFS}}{B_{LFS}}}{v_{\parallel,\alpha,HFS}^{exp} - \frac{v_{\perp,\alpha,LFS}^{exp}}{\sin\delta_{LFS}}\frac{R_{HFS}}{R_{LFS}}}$$

- Excellent agreement between asymmetries obtained from densities and from flows





Summary and Conclusions

- Poloidal asymmetries in the impurity profiles have been studied. Asymmetries in the impurity density are needed to explain asymmetries in the flows
- A new module has been included in FIDASIM to enable the impurity density calculation from GP based CXRS measurements. Excellent agreement between impurity density from GP based and NBI based diagnostics
- Impurity density calculations show an accumulation of impurities at the HFS edge region. Good agreement with the asymmetries estimated from flows
- Edge impurity density asymmetry studies are now possible in scenarios without NBI

References

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