# Impurity transport

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# Impurity Content

**What mechanisms determine impurity content?**

- **Impurity influx from the chamber walls, *etc*.**
  - ➡ **Governed by transport at open magnetic field & retention**

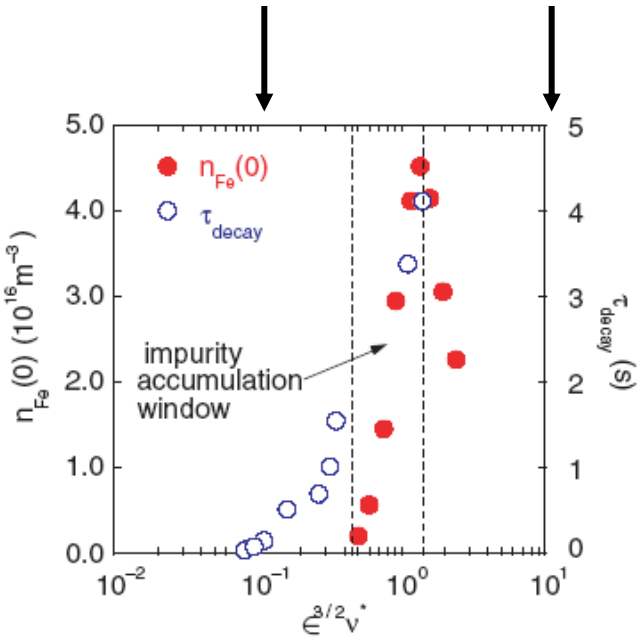
    **Feng I-06 & Kobayashi I-07**
- **Impurity transport inside closed magnetic surface**
  - ➡ **Diffusive, $D$, and convective, $\upsilon$, terms**

    **$\upsilon$ driven by T and n gradients & space potential**

# How to distinguish flux and transport

Intrinsic impurity

transport + influx

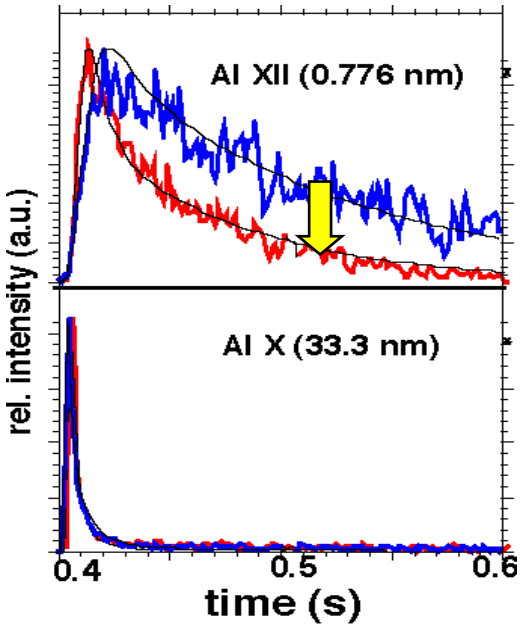



1. Inward convection increases as the collisionality is increased
2. The influx is reduced by the high edge density

Injected impurity

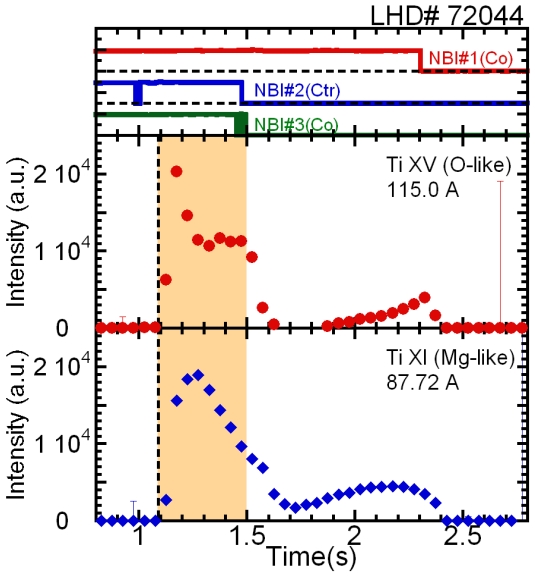
transport

Laser blow off




shallow penetration

Impurity pellet




Deep penetration

# Key issue of Impurity transport

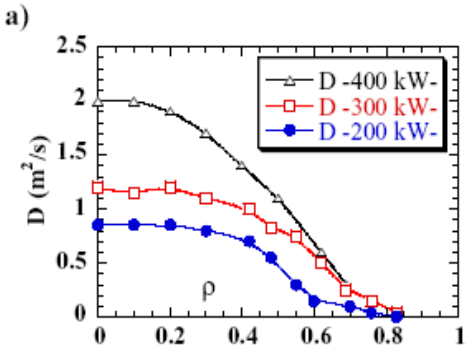
$$\Gamma = \boldsymbol{D}\cdot\nabla\boldsymbol{n} + \boldsymbol{v}\cdot\boldsymbol{n}$$

Sensitive to ∇Ti

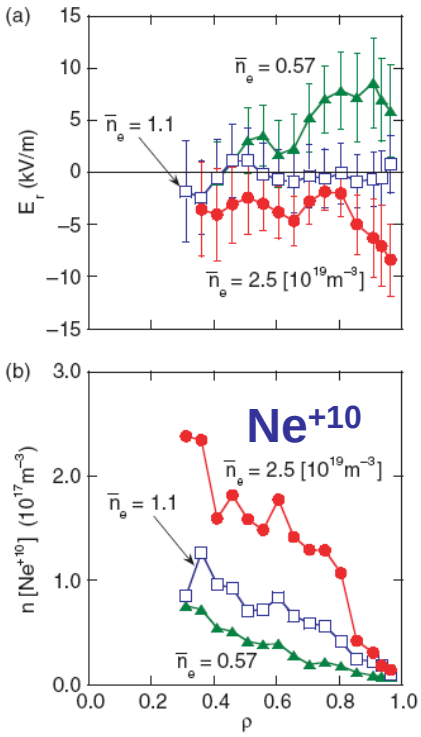
Sensitive to T?

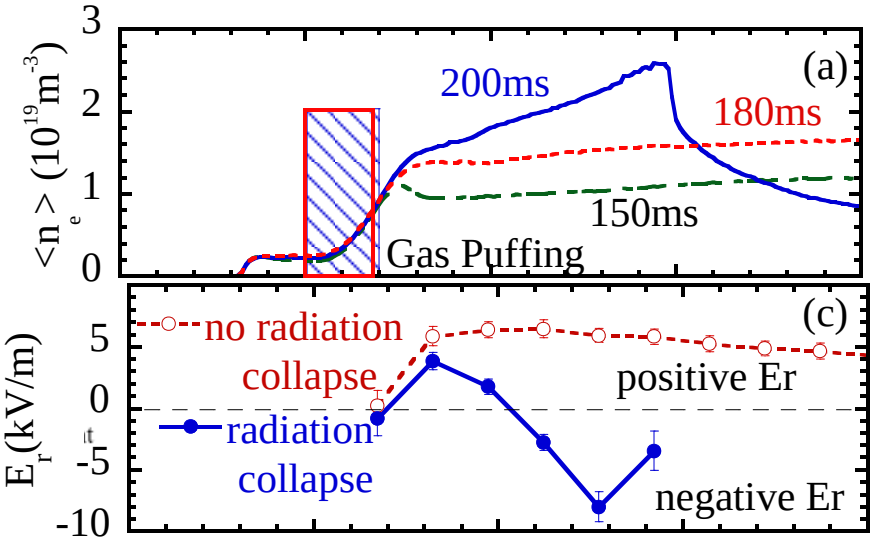
Sensitive to Er

Sensitive to Er




Clear power dependence is observed




Positive Er prevent radiation collapse

Positive electric field tends reduce inward pinch

increased.

Y. Nakamura *et al*., NF 43 (2003) 219

K.Ida et al., NF 45 (2005) 391

# Database requirements

- In DB, data needed for scaling:
  $\tau_{imp}$ (B,n,T,P,i, maximum $E_r$, heating system…)
  D,υ or D(r) ,υ(r) at e.g. 2 radial positions, maximum $E_r$ …
- To achieve a better <u>understanding</u> of physics of transport:
  For comparison need dedicated discharges with well documented
  ($\tau_{imp}$, local D,υ or with profiles of $n_e$,$T_e$,$T_i$,$E_r$, $P_{heat}$, ….)
- Basis for understanding:

1) Consideration of stellarator specific features in neoclassical model (3-D magnetic topology, gradB-drift, D(E,Z, ν*) >> no analytical solution for ambipolarity,..)

   >> strong impact: e.g. no $T_i$-screening

2) When can plasma be described with a neoclassical model and when is it anomalous/turbulent >> key: D(r)

3) $E_r$ diagnostic <u>very important</u> for comparison of experimental υ with neoclassical model.

# Important issue of impurity transport study

Influx

dependence of density (collisionality effect)

effect of ergodic magnetic filed (configuration effect)

Transport

diffusion

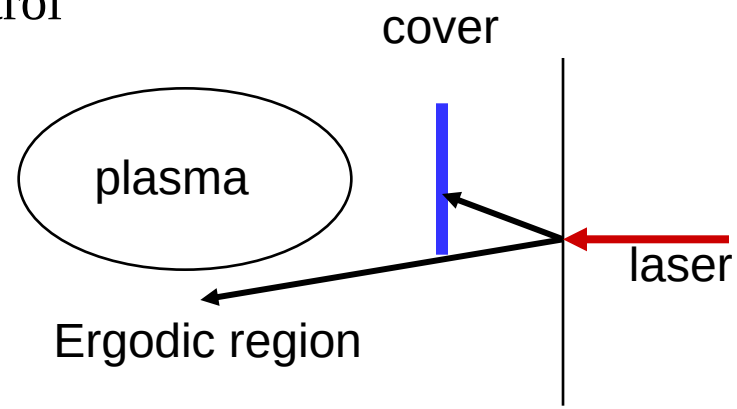
dependence of temperature rather than heating power

convection $V = V(\nabla\Phi, \nabla Ti, \nabla Te)$

dependence of radial electric field  electron and ion temperature gradient should be investigated

# Future collaboration and possible experiment and modeling

1 Laser blow off experiment can be done TJ-II
LHD H-J? H.Funama + +
laser blow off to the ergodic region only by control the direction of blow off → influx study




2 TESPEL can be installed in other devices?
→ Useful tool for heat transport as well as impurity transport N.Tamura + +

3 Modeling
→ How much neoclassical transport can explain the impurity transport? M.Yokoyama + +

4 comparison study K.J.McCarthy did good job in ITC17 next step?

# LHD

## What are the reason(s) for the accumulation window?

Low collisionality

High collisionality

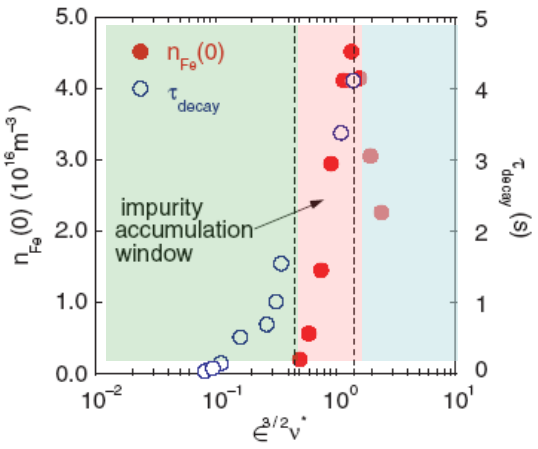



**Figure 12.** Decay time of TiK$\alpha$ emission as a function of normalized collision frequency for impurity ions. The central iron density (●) in a density ramp-up discharge is also indicated to compare the collisionality with that in the impurity accumulation window.

Y. Nakamura *et al.*, ISW 2002, No. OIV:5

## Ambipolar field $E_r$

***Positive Er in „e-root“***

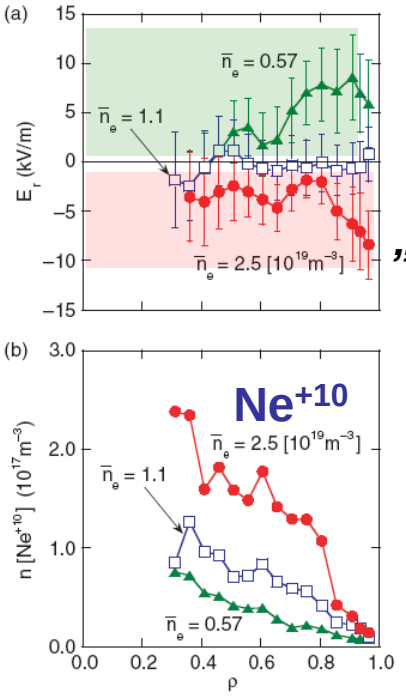



**Figure 13.** Radial profiles of (*a*) radial electric field and (*b*) fully ionized neon density for the discharges with a pulsed neon gas injection. The radial electric field is measured in the midplane at a position where the plasma is vertically elongated. The electric field changes from positive to negative with increasing electron density. The neon density increases monotonically as the density is increased.

Y. Nakamura *et al.*, NF 43 (2003) 219

**outward flux in core**

***„i-root“***

**impurity flux high**

Changing $E_r$ seems to cause „accumulation“

**May be caused by dominant effect of T grad in PS ($n_e$ flat) “Temperature Screening” effect**