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Modeling of Halo Neutrals for Neutral Particle Measurements

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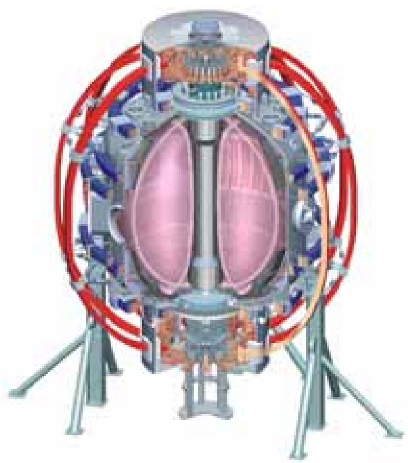

NSTX 2007 Results Review

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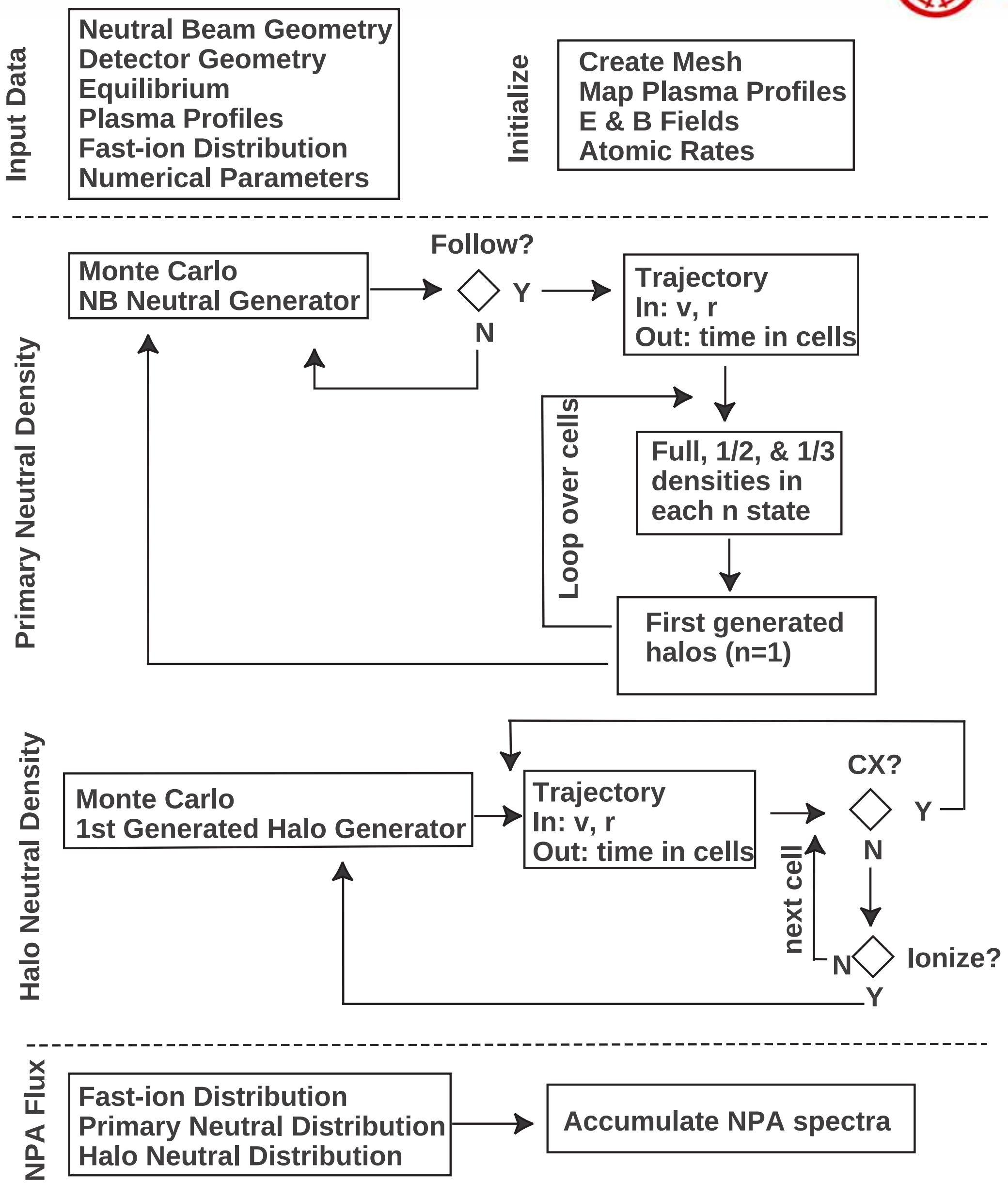
Halo Neutrals May Alter the Neutral Particle Spectrum and Spatial Resolution

- **Halo neutrals can contribute significantly to the neutral flux measured by NPA diagnostics.**
  - **The densities of primary beam and halo neutrals can be comparable .**
  - **Charge exchange cross section for halo neutrals is larger than that for primary beam neutrals.**

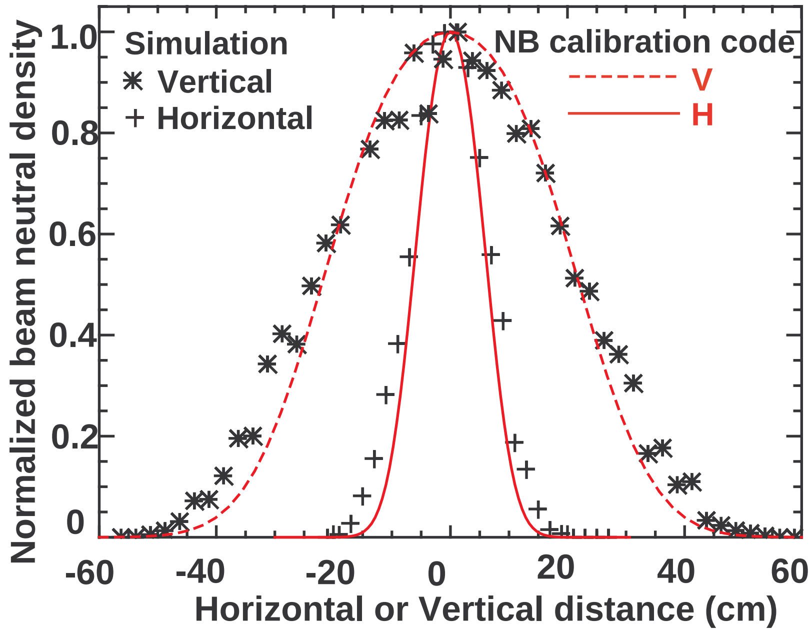
- **TRANSP does not handle halo neutrals properly.**
  - **Halo neutrals are volume averaged both poloidally and toroidally in TRANSP rather than remaining near the beam footprint.**
  - **There are some discrepancy between NPA measurements and TRANSP simulation.**

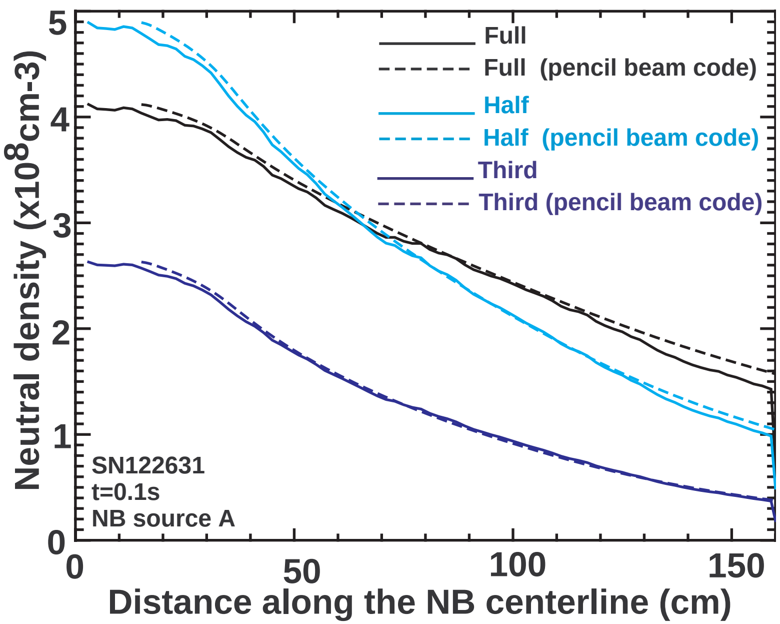
- **Correctly Modeling halo neutrals is important for the simulation of Fast-ion D-alpha (FIDA) diagnostic.**

Monte-Carlo Method is Applied to Calculate Beam Primary and Halo Neutral Density



Neutral Beam Profile and Attenuation Agree with Known Models





➢**Neutral beam profile from our simulation code agrees with the calibration data.**

➢**Attenuation of NB three energy components from our code agrees with the prediction from a pencil beam code. (The small discrepancy is probably caused by using different atomic cross sections.)**

Halo Neutral Simulation is Verified by Comparing with a 1-D Diffusion Model

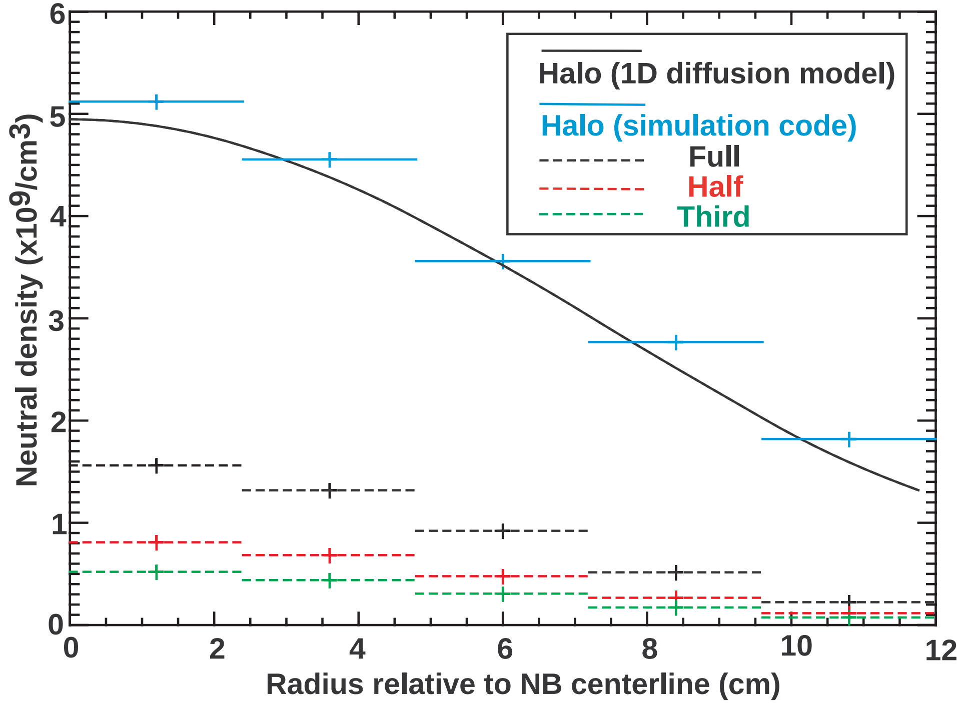
If we assume

- **a uniform plasma with a circular NB beam injection**
- **No beam attenuation along the NB centerline,**

Halo neutrals will diffuse only in the radial direction and the density can be calculated form the following simple 1-D diffusion model

$$D_{n0}\frac{\partial}{r\partial r}\left(r\frac{\partial n_0}{\partial r}\right)=\sum_{k=1}^{3} n_i n_b \langle\sigma v\rangle_{cx,k} - n_0 n_e \langle\sigma v\rangle_{ei}$$

Halo formation **Halo decay**



Plasma parameters

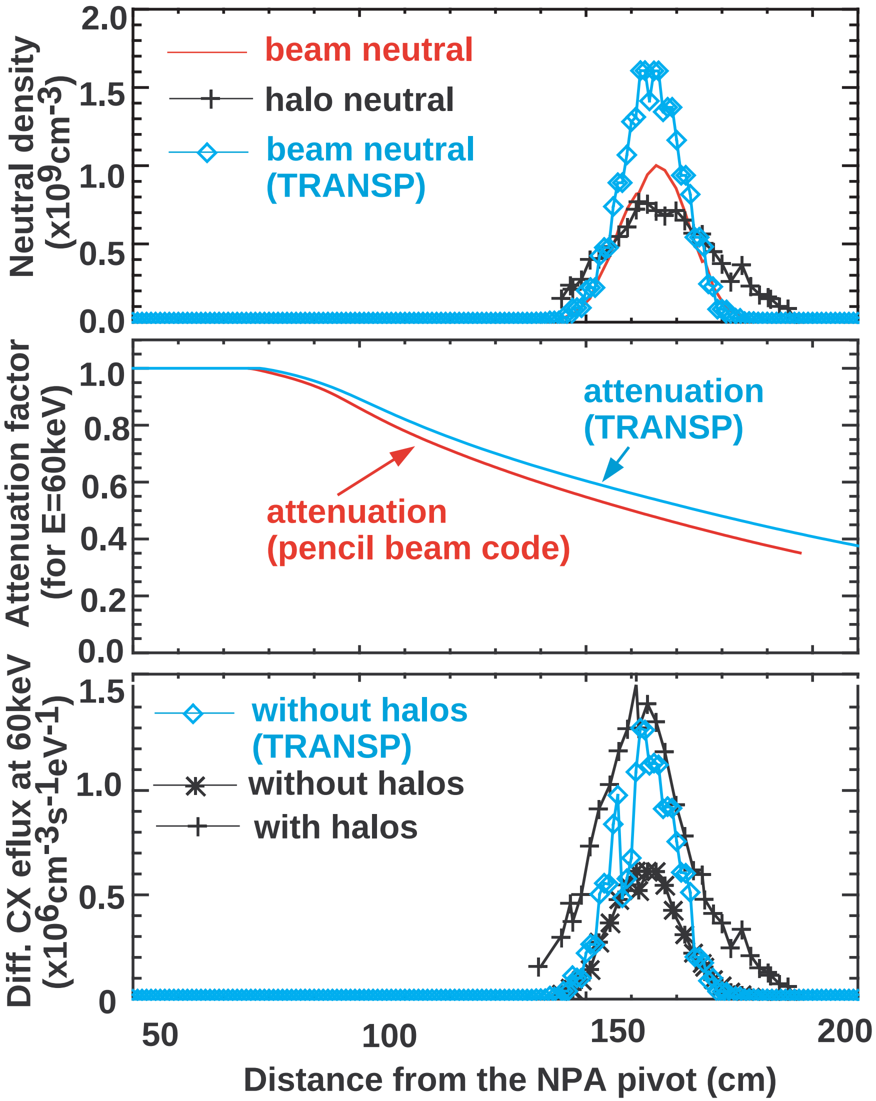
$$n_i = n_e = 1.5\times10^{14}\,cm^{-3} \quad T_e = 2.5keV$$

$$T_i = 1.25keV \quad D_{n0} = k_b T_i / m_d \gamma_{cx}$$

$$\gamma_{cx} = n_i \langle\sigma v\rangle_{cx,mp}$$

Halo Neutrals Contribute Significantly to the NPA Flux, but Some Discrepancies between Our Code and TRANSP Simulation are Found

NSTX



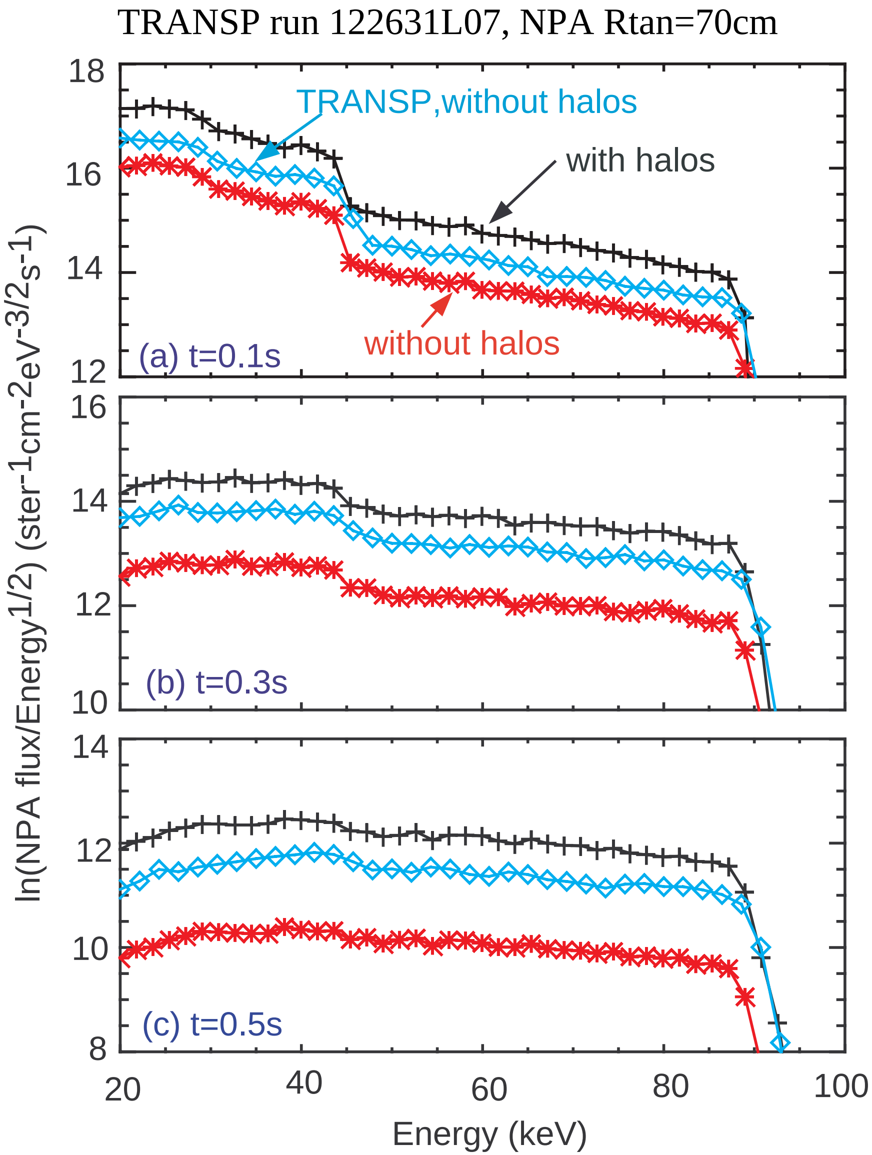
- Halo neutral density is comparable to beam primary neutral density along the NPA sightline.
- Halo neutrals contribute significantly to the NPA flux.
- Halo neutrals reduce the localization of NPA signals.

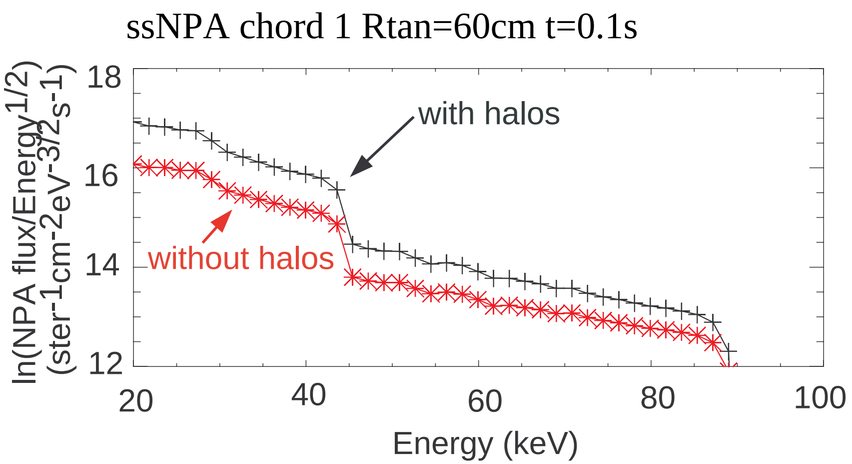
Discrepancies

- Primary neutral density from our code is lower than the prediction by TRANSP.
- Neutrals attenuate faster in our code than the prediction in TRANSP.

Because different atomic cross sections are used? (We are using data form ADAS)

NPA Spectral Shape barely changed by Halos

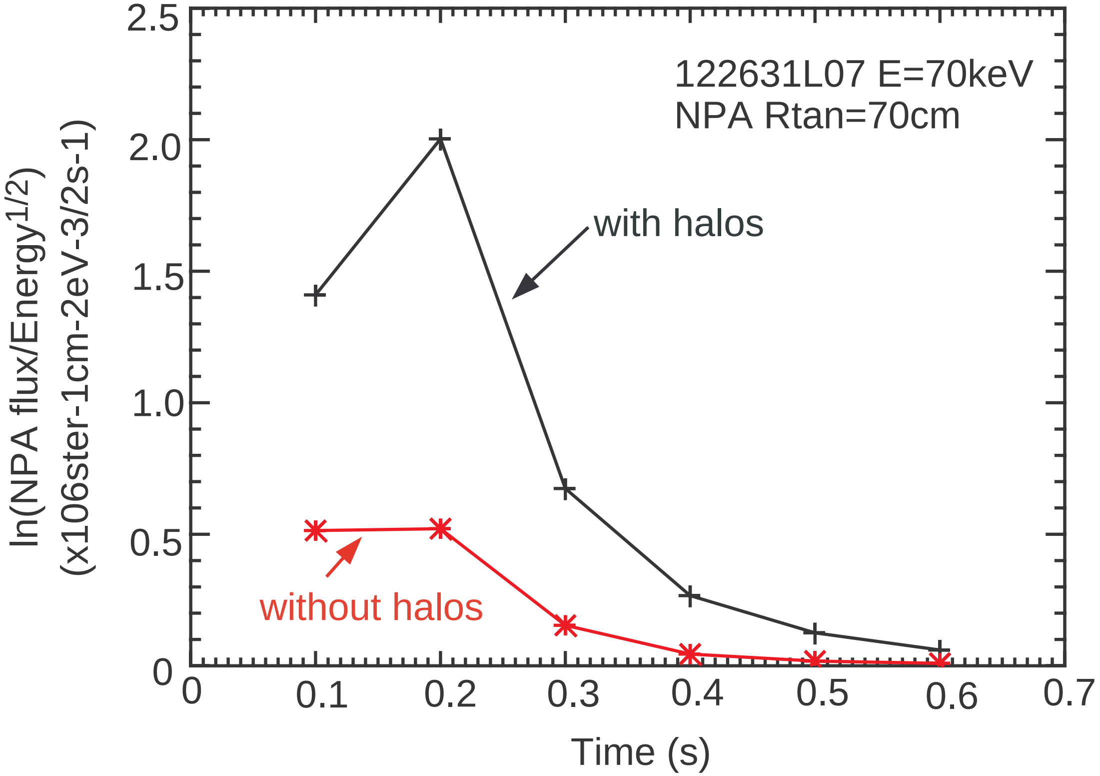




➢**Charge exchange with halo neutrals can double the neutral flux for typical NSTX conditions.**

➢**Halo neutrals have minor effect on the shape of NPA energy spectra.**

Halos can Affect the Temporal Evolution of NPA Flux



Halo neutrals increase significantly the NPA neutral flux, but they depend on plasma profiles. Thus they can change the NPA flux temporal evolution.

Summary

- **The density of halo neutrals around the beam footprint or along the NPA sightline is comparable to that of primary neutrals.**

- **Charge exchange with halo neutrals contribute significantly to the neutral flux and thus change the NPA temporal evolution, but they have minor effect on the shape of the NPA energy spectrum.**

- **Halo neutrals reduce the localization of the NPA diagnostics (FWHM is increased by 40 percent).**

- **There are some discrepancies on the beam neutral density and attenuation factors between our simulation and TRANSP NPA simulation. Due to using different atomic cross sections?**