Progress in RENATE-OD synthetic diagnostic

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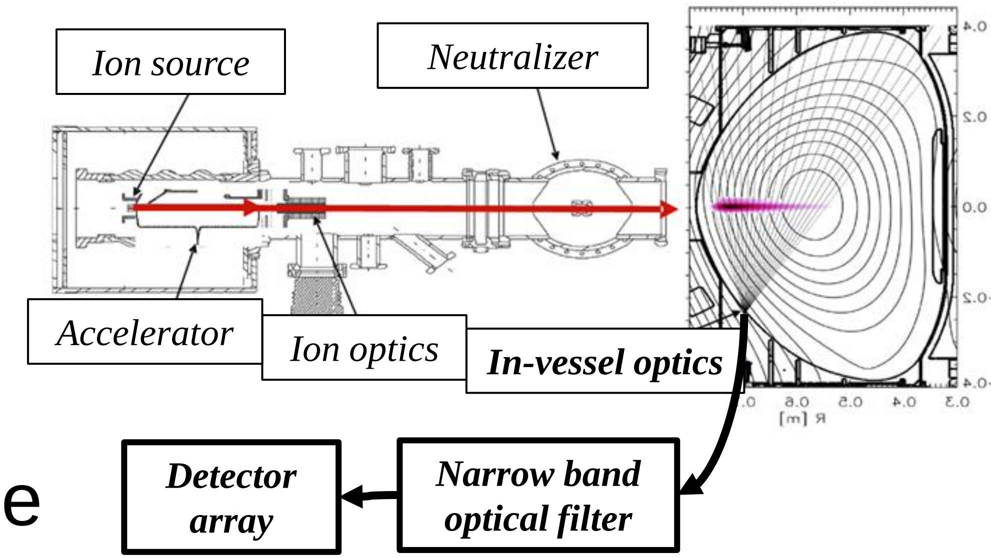
***Consultancy Meeting on the Evaluation of Data for Neutral Beam Modelling,* 18-20 May 2022, IAEA Headquarters**

BES diagnostics

- **Active** plasma diagnostics procedure
- Use of H-like atoms such as D,Li,Na. (which posses **one valence electron**)
  - Heating beams (H, D)
  - Diagnostic beams (Li, Na)
- **Purpose:** density profile and fluctuation measurement

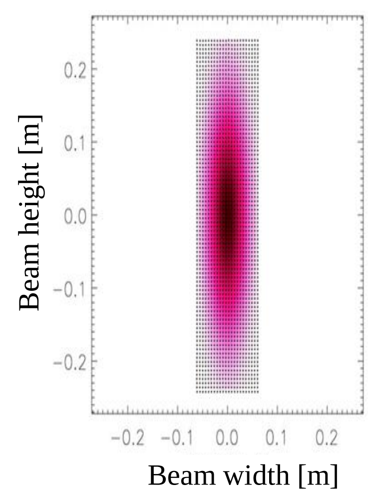


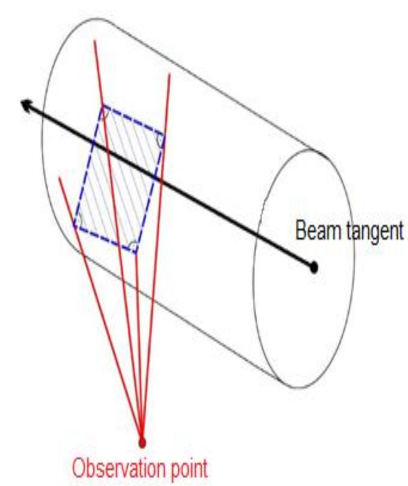
RENATE Simulation code

- Full 3D, based on CR model:
  1. Quasi-static for H from Open ADAS (2010)
  2. Bundled-n for H from ALADDIN (2010) with corrections from E. Delabie, et al. PPCF 2010 → benchmarked with O. Marchuk's CRM (2011)
  3. l-resolved for Li from J. Schweinzer, et al. Atomic Data and Nuclear Data Tables 1999 → benchmarked with J. Schweinzer's simula (2007)
  4. l-resolved for Na from K. Igenbergs, et al. Atomic Data and Nuclear Data Tables 2008

→ Revise cross-section data!

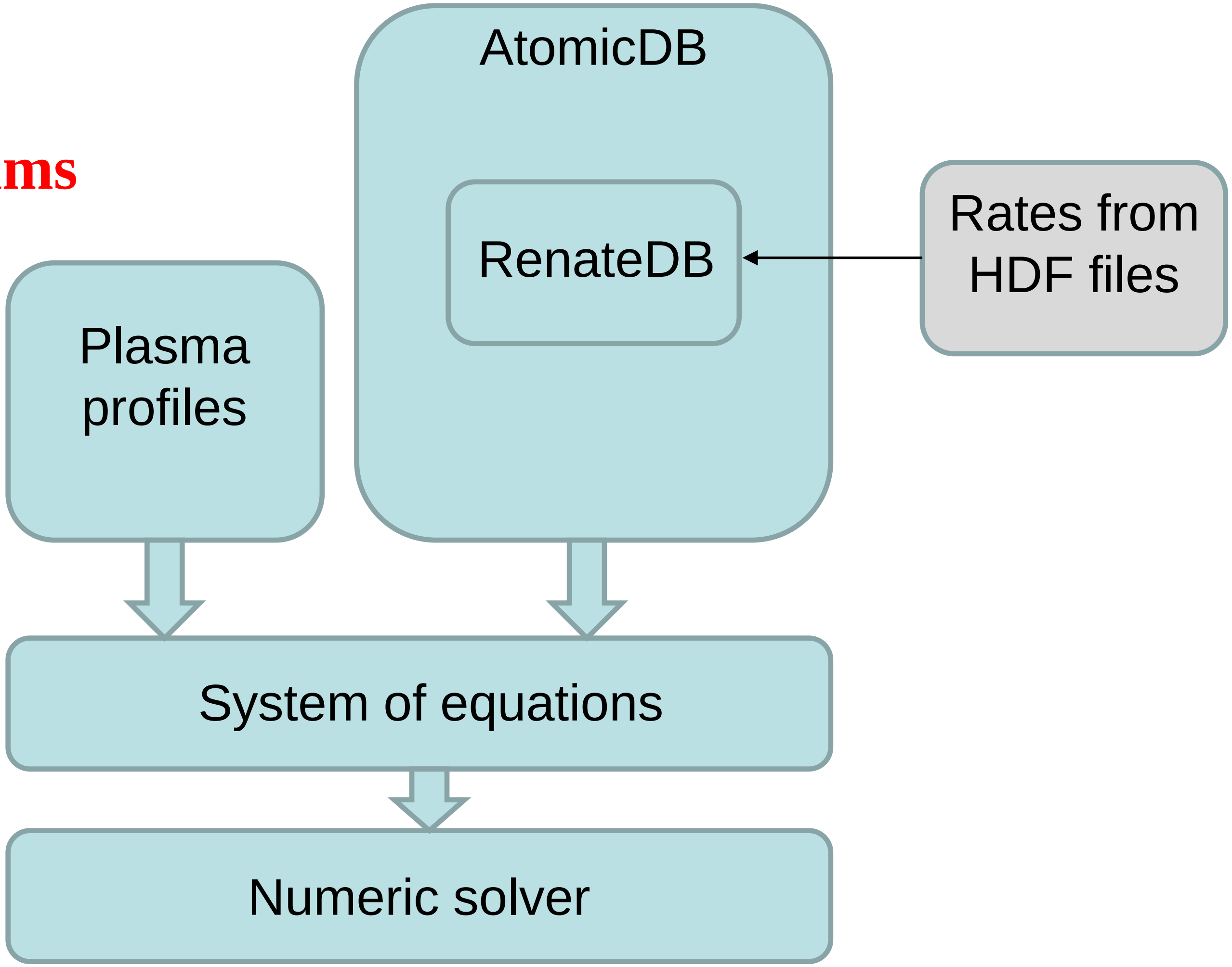
Elliptical beam





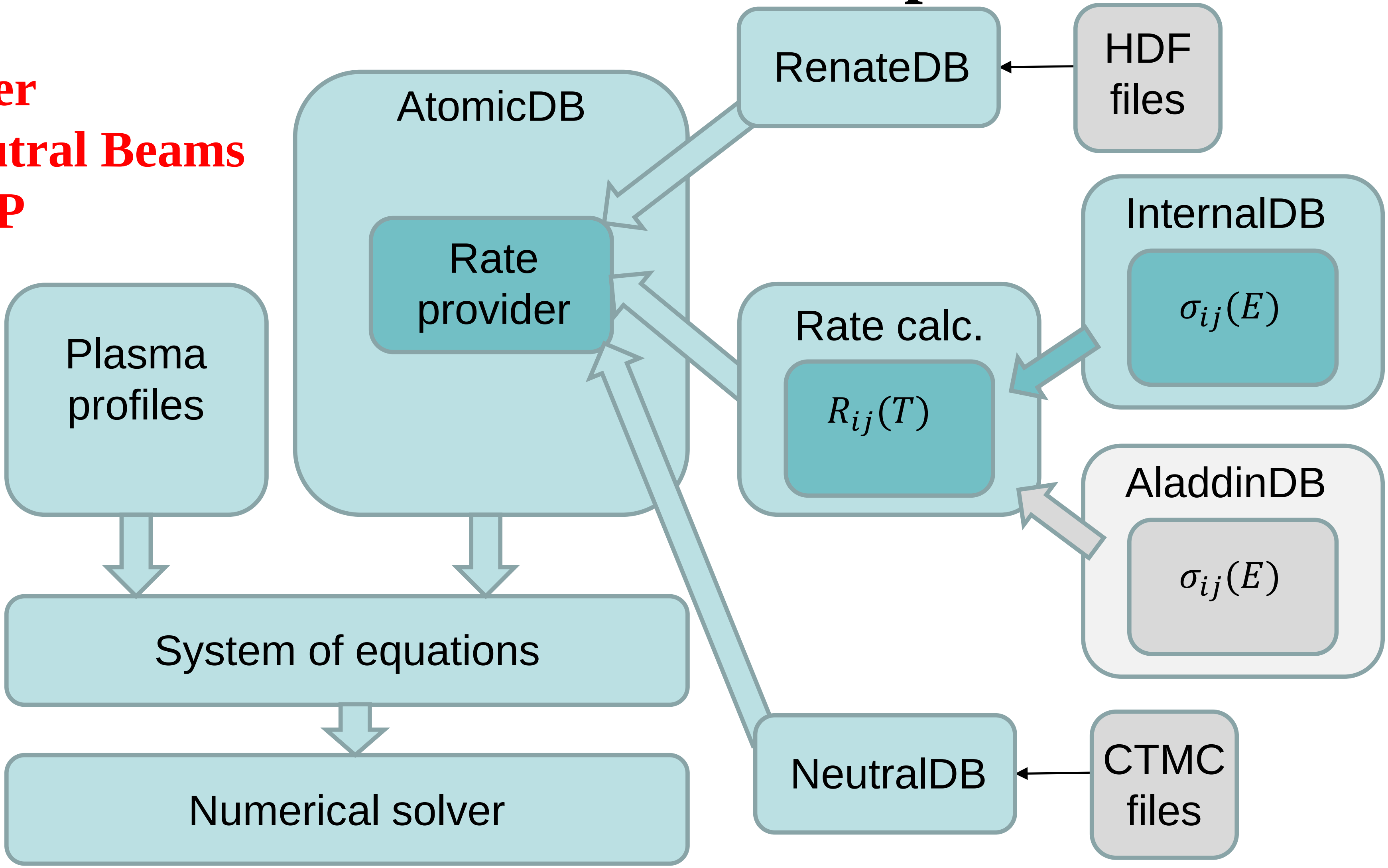
Upgrade RENATE-OD with new rate calculator and cross-section import modules

Before
Neutral Beams
CRP



Upgrade RENATE-OD with new rate calculator and cross-section import modules

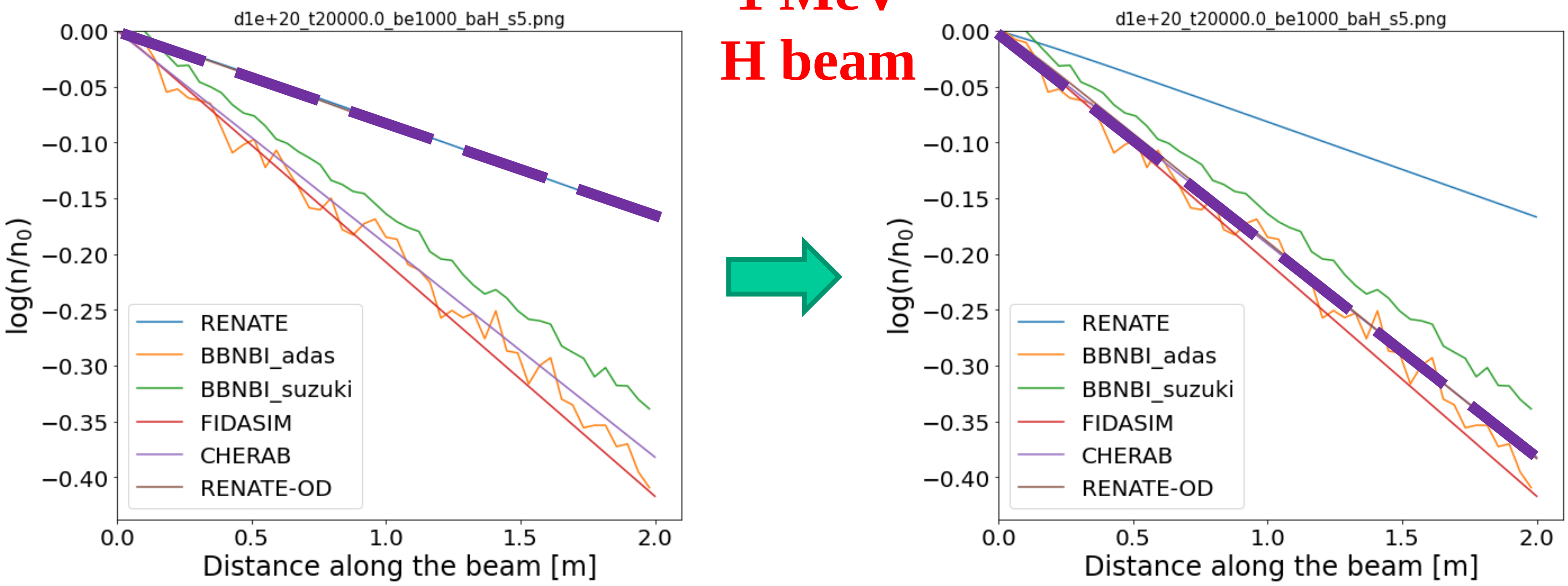
After
Neutral Beams
CRP



Upgrade RENATE-OD with new rate calculator and cross-section import modules

- Improved scaling for impurities
- Corrected rates for high beam energy
- Good agreement with other codes for all cases

1 MeV H beam



Paper being written to Jornal of Physics B

- Need to have discussion on the results to be included
  → scheduled for tomorrow

- Will still request data from some participants

Outcome of the IAEA neutral beam penetration and photoemission benchmark

G.I. Pokol[1,2], O. Asztalos[1,2], P. Balázs[1,2], Dipti[3], M. von Hellerman[4], C. Hill[3], O. Marchuk[4], M. OMullane[5], P.Zs. Poloskei[6], J. Varje[7], M. Tomes[8], K. Tőkési[9]

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Abstract. The benchmark was carried out in the scope of the IAEA Coordinated Research Project F43023 on Data for Atomic Processes of Neutral Beams in Fusion Plasma [1]. In the course of the benchmark, beam attenuation and beam emissivity (where applicable) were compared for the participating codes (RENATE, RENATE-OD, BBNBI, FIDASIM, SOS, CHERAB, CRM by O. Marchuk). These codes apply different level of detail and methodology to solve the governing rate equations. Test cases were designed to evaluate the performance of underlying collisional radiative models with various constant plasma profiles. Emphasis was placed on the handling the isotope effects of the main plasma ions as well as handling a large variety of fusion plasma relevant impurities (He, Be, C, Ne, W). A small number of realistic plasma profiles were also considered, to evaluate the performance of the codes applied to different density gradient scenarios. The study focused on a wide energy range of beams of hydrogen isotopes. We found that while all participating codes agreed in general trends, some differences exist that can be attributed to modelling details or different atomic data sources. The effect of modelling details was analysed and was compared to the effects of the uncertainties in the un[illegible] data. In most

Accepted SOFT 2022 abstract

- Accepted for poster presentation
- May include cases with REANTE-OD runs using the new ALADDIN2 data?

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Abstract.
Coordinated by the IAEA Atomic and Molecular Data Unit, the Coordinated Research Project on Data for Atomic Processes of Neutral Beams in Fusion Plasma is intended to provide evaluated and recommended data of the principal atomic processes relevant for heating and diagnostic neutral beams in fusion plasmas. As an instrument to achieve this goal, a code comparison benchmark on beam penetration and photoemission was organised. The purpose of the benchmark was twofold. First, to evaluate the collisional-radiative models from the perspective of the atomic data applied, level of details and complexity and the method of the closure of the system of equations. Second, to verify and explore the applicability of the different physics models. The participating codes (namely: RENATE, RENATE-OD, BBNBI, FIDASIM, SOS, CHERAB, CRM by O. Marchuk) apply different levels of detail and methodology to solve the governing rate equations. The effect of different approaches to the underlying physics on beam attenuation and beam penetration is analysed. Conclusions on the applicability of the different physics models are presented, along with some code-specific developments. As one of the consequence of the effort, we also introduce the framework that was recently set up by IAEA to store and promote the recommended atomic data.

Beam into gas simulations

- Cross-sections from K. Tőkési by CTMC
- Li projectile 2s → 4f (nl resolved)
- H projectile 1n → 4n (bundled-n)

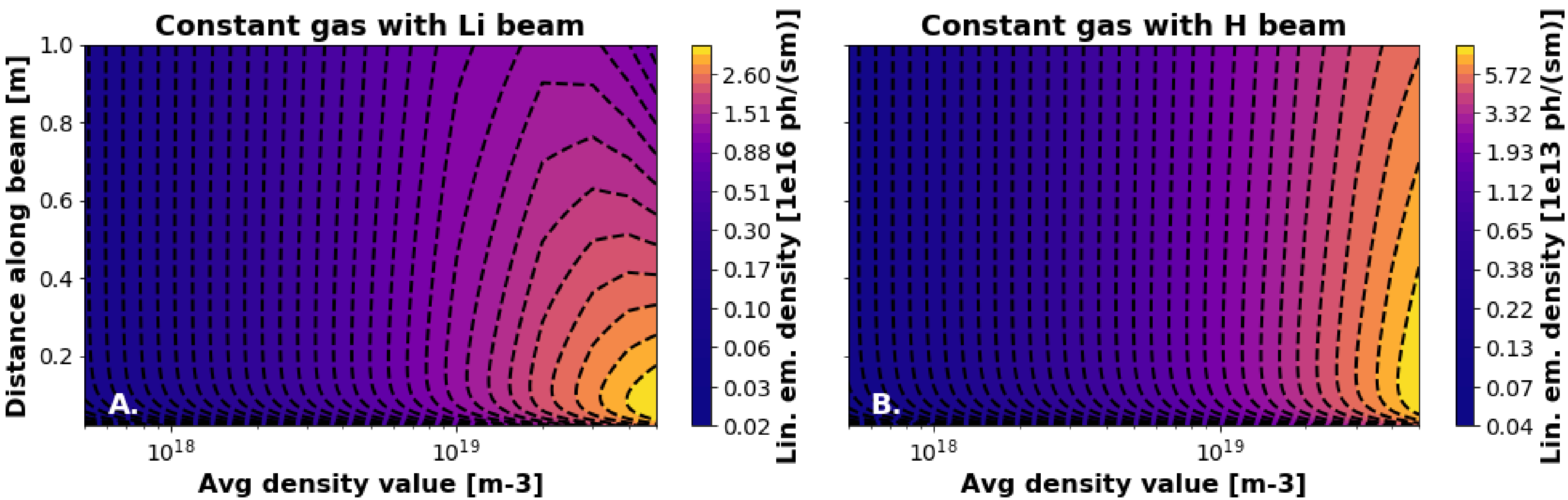
$$\frac{dn_i}{dt} = \sum_a N_a\left(R_a^{s(i)} - R_a^{d(i)}\right) + S^{(i)}$$

$$R_a^{d(i)} = n_i\left(\sum_{j=i+1}^{m} R^{ex}_{i\to j} + \sum_{j=0}^{i-1} R^{dex}_{i\to j} + R^{loss}_{i\to +}\right)$$

$$R_a^{s(i)} = \sum_{j=0}^{i-1} n_j R^{ex}_{j\to i} + \sum_{j=i+1}^{m} n_j R^{dex}_{j\to i}$$

$$S^{(i)} = n_j \sum_{j=i+1}^{m} A_{j\to i} - n_i \sum_{j=0}^{i-1} A_{i\to j}$$

$$R = \langle \sigma v\rangle = \int [f_m(T,\mathbf{v})|\mathbf{v}-\mathbf{v_b}|\sigma_a(\mathbf{v}-\mathbf{v_b})]d\mathbf{v} \approx \sigma \mathbf{v_b}$$



Beam into gas simulations

- **Based on nHESEL simulation on TCV, SOL emission dominated by neutral induced emissions during strong gas-puff**
- **Significant extension in sysntetic diagnostic capabilities**