EUROfusion TSVV-5 Report 2022, Contributions Aalto University, Espoo, Finland

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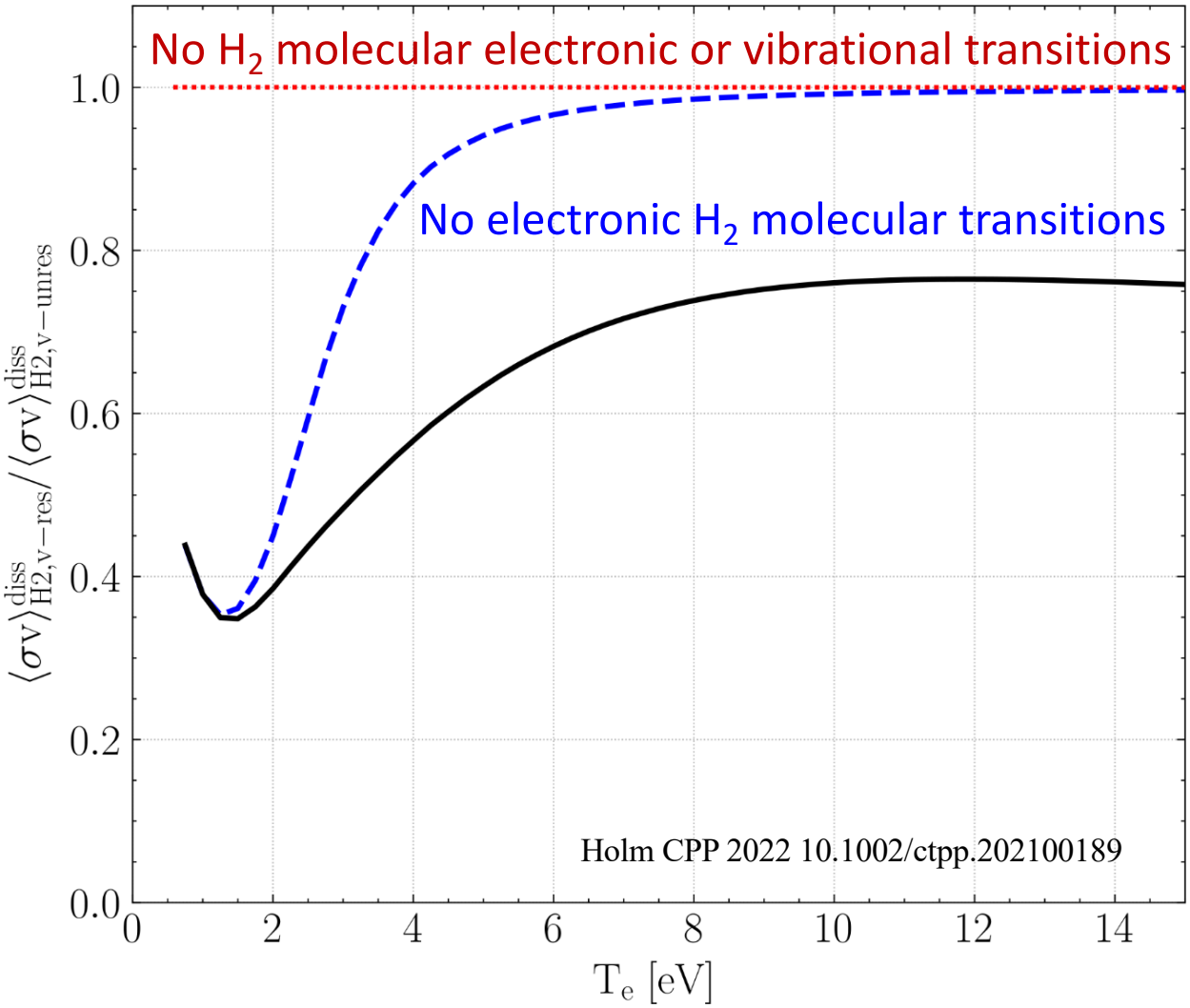
Plans for 2022

- Re-investigation of impact of H_2 vibrational excitation on dissociation, ionisation and recombination rates, isotope effect
- Assessment of H_COLRAD (He_COLRAD, H2_COLRAD) in EIRENE
- Re-implementation of EIRENE photon tracing and opacity model
- Assessment of isotope effect in JET-ILW EIRENE benchmark case

Plans for 2022 - achievements

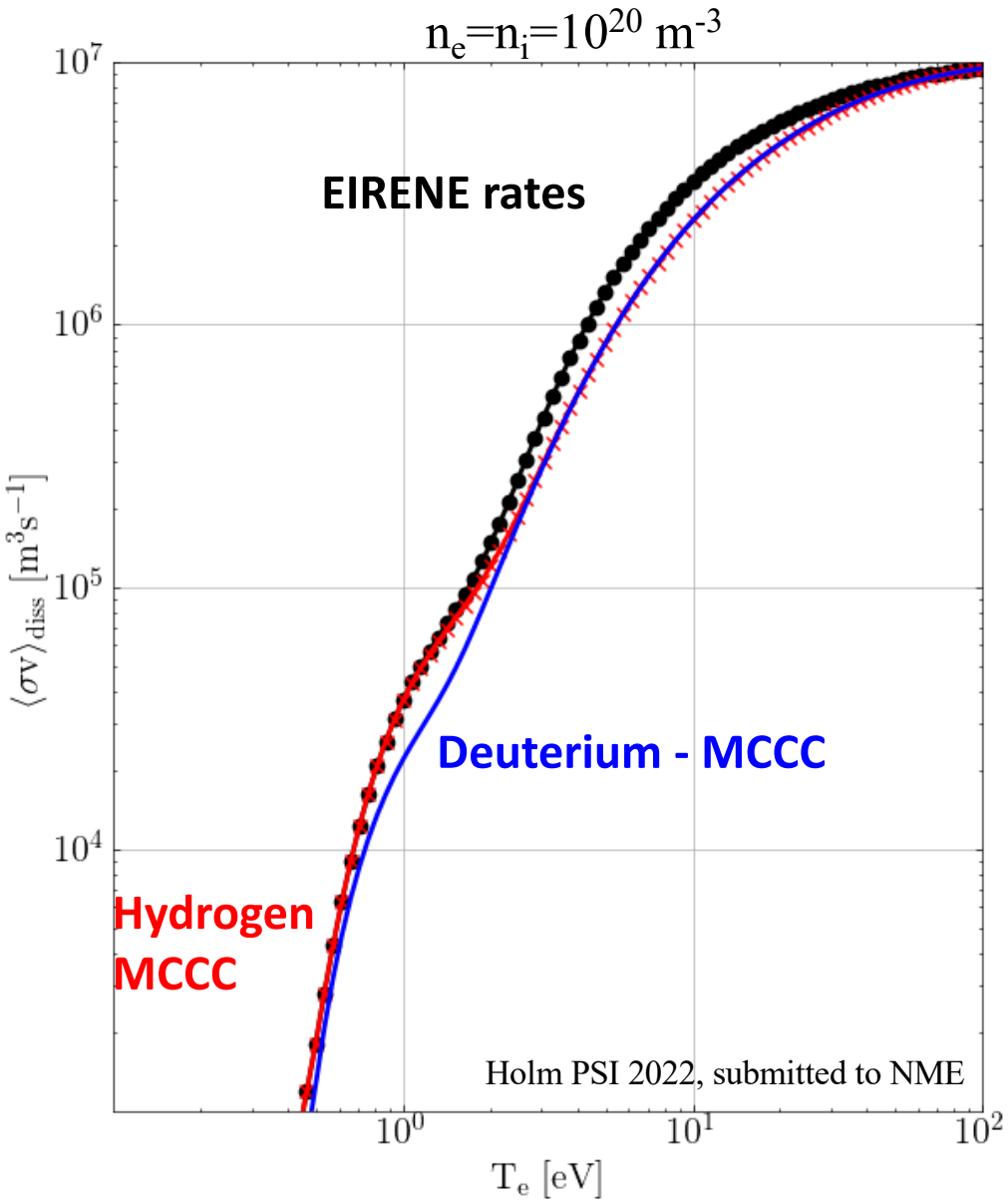
- Re-investigation of impact of H_2 vibrational excitation on dissociation, ionisation and recombination rates, isotope effect (Andreas Holm)
  - Different CR processes cause up to 60% difference in dissociation rates
  - Impact strongest in the T_e = 0.5 – 4 eV range, for which molecular processes strongest
  - Molecular-convergent close-coupling (MCCC) data predicts an isotope effect on dissociation for T_e = 0.7-3 eV
- Assessment of H_COLRAD (He_COLRAD, H2_COLRAD) in EIRENE (Ray Chandra)
  - Resurrect ability to run Sawada 1995 and 2004 models standalone
  - Effective ionization rate of H_COLRAD agrees perfectly with AMJUEL data
  - Proposed H_COLRAD, H2_COLRAD (and He_COLRAD)
- Re-implementation of EIRENE photon tracing and opacity model (Ray Chandra)
  - Cylindric test case for Ly-a and Ly-b opacity ⇒ population escape factor and Planck test
- Assessment of isotope effect in JET-ILW EIRENE benchmark case (Mathias Groth)
  - Higher div. densities for T than for H plasmas observed in JET-ILW L-mode plasmas, both experimentally and in EDGE2D-EIRENE simulations

Vib. resolved EIRENE data considers different collisional-radiative (CR) processes than vib. unresolved data



- Different CR processes cause up to 60% difference in dissociation rates
- Impact strongest in the T_e = 0.5–4 eV range, where molecular processes strongest
- Electronic transitions affect T_e > 4 eV
- Vibrational transitions affect T_e < 4 eV

Molecular-convergent close-coupling (MCCC) data [1] predicts an isotope effect on dissociation for T_e=0.7-3 eV



- Predicted isotope effect strongest for temperatures associated with detachment onset and detached conditions
- MCCC data indicates weaker dissociation of both H_2 and D_2 for T_e > 3 eV compared to EIRENE data (AMJUEL, HYDHEL, H2VIBR)

[1] mccc-db.org, accessed July 6th 2022

Assessment of H_COLRAD (He_COLRAD and H2_COLRAD) in EIRENE

- H_COLRAD (and H2_COLRAD) based on the collisional radiative model by Sawada (1995) ⇒ used to built AMJUEL and H2VIBR databases
- Resolve population coefficients for each EIRENE cell
- Derive effective rates such as effective ionization and recombination rates to be used in EIRENE
- Provide population densities of excited species as a bulk ion species for the Photon tracing module

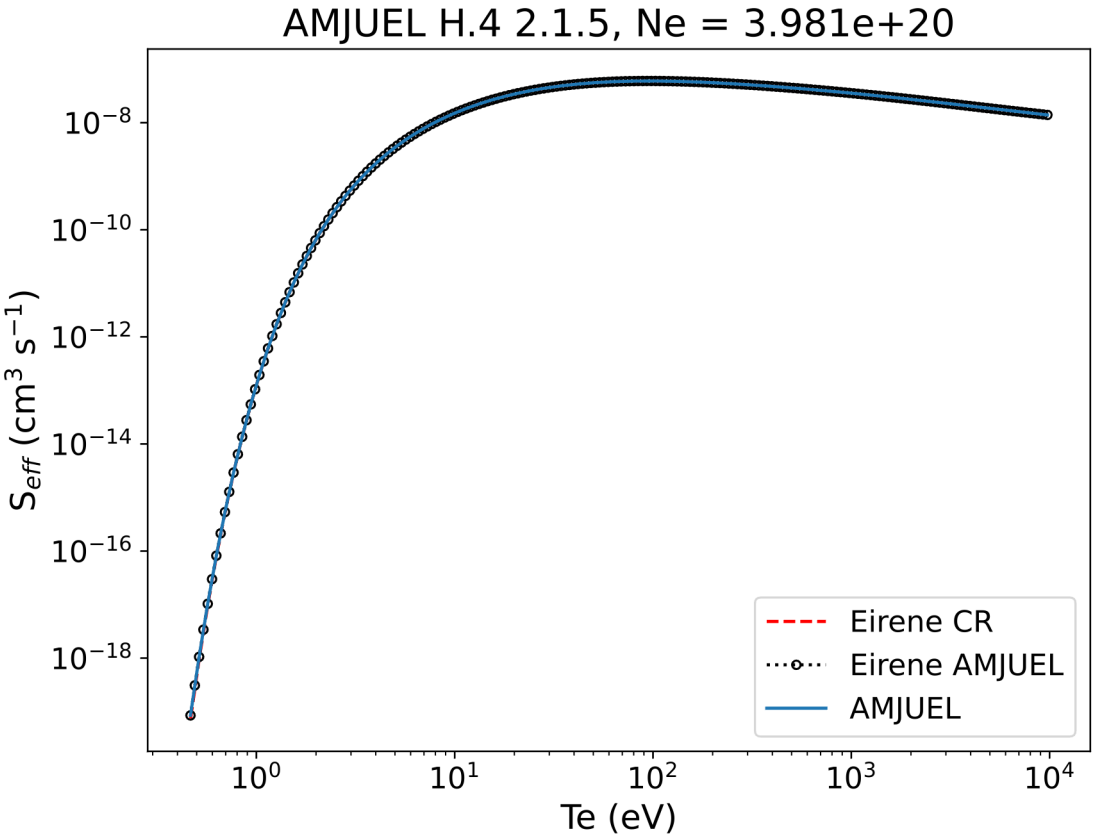
⇒ Resurrect ability to run Sawada 1995 and 2004 models standalone

The effective ionization rate of H_COLRAD agrees perfectly with AMJUEL data

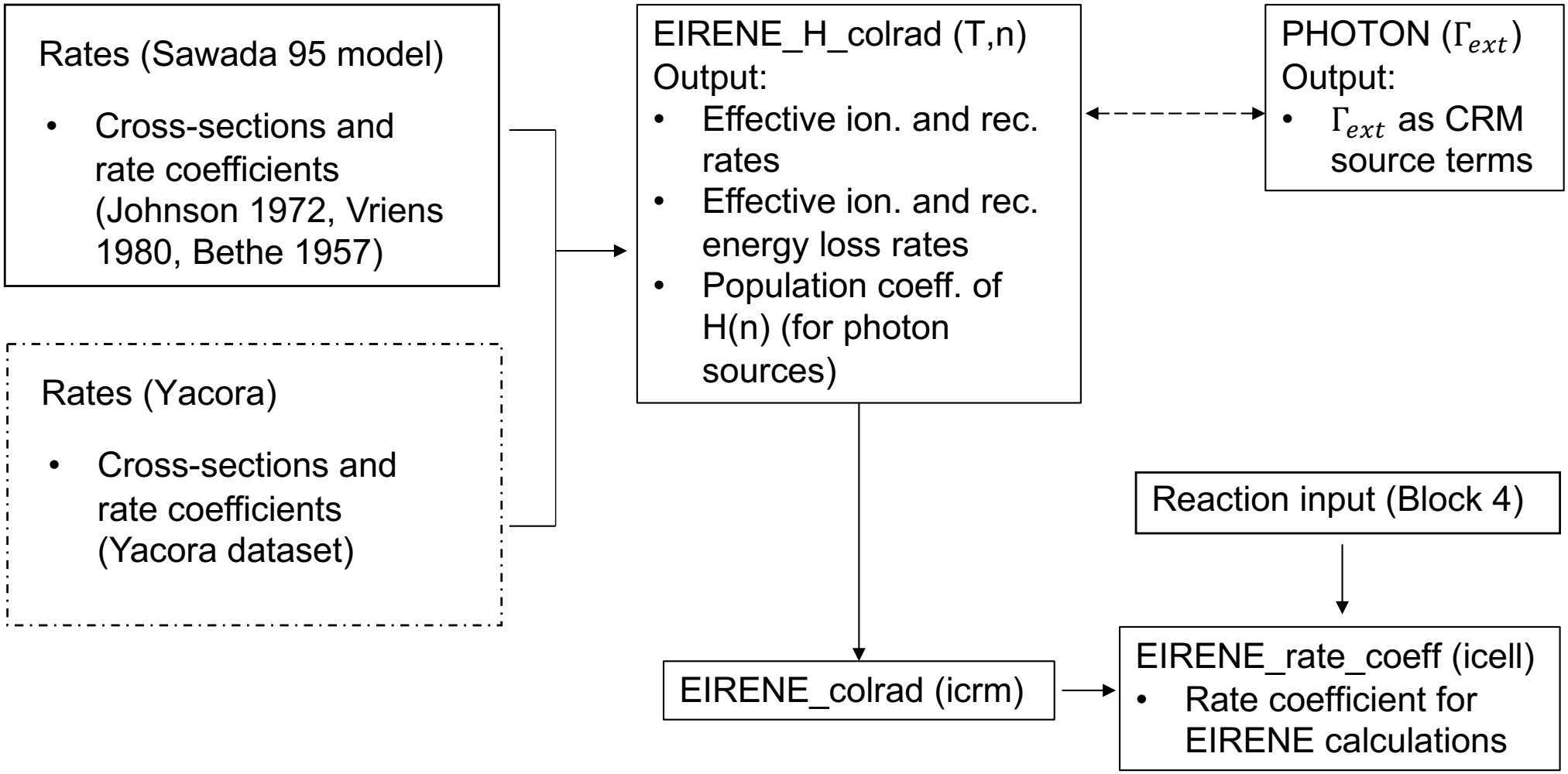
Effective ionization rate S_{eff} :

$$S_{eff} = S_{(1)} + \sum_{p} \left(C_{(1,p)} - R_{1(p)} (F_{(p,1)} + \frac{A_1}{n_e}) \right)$$

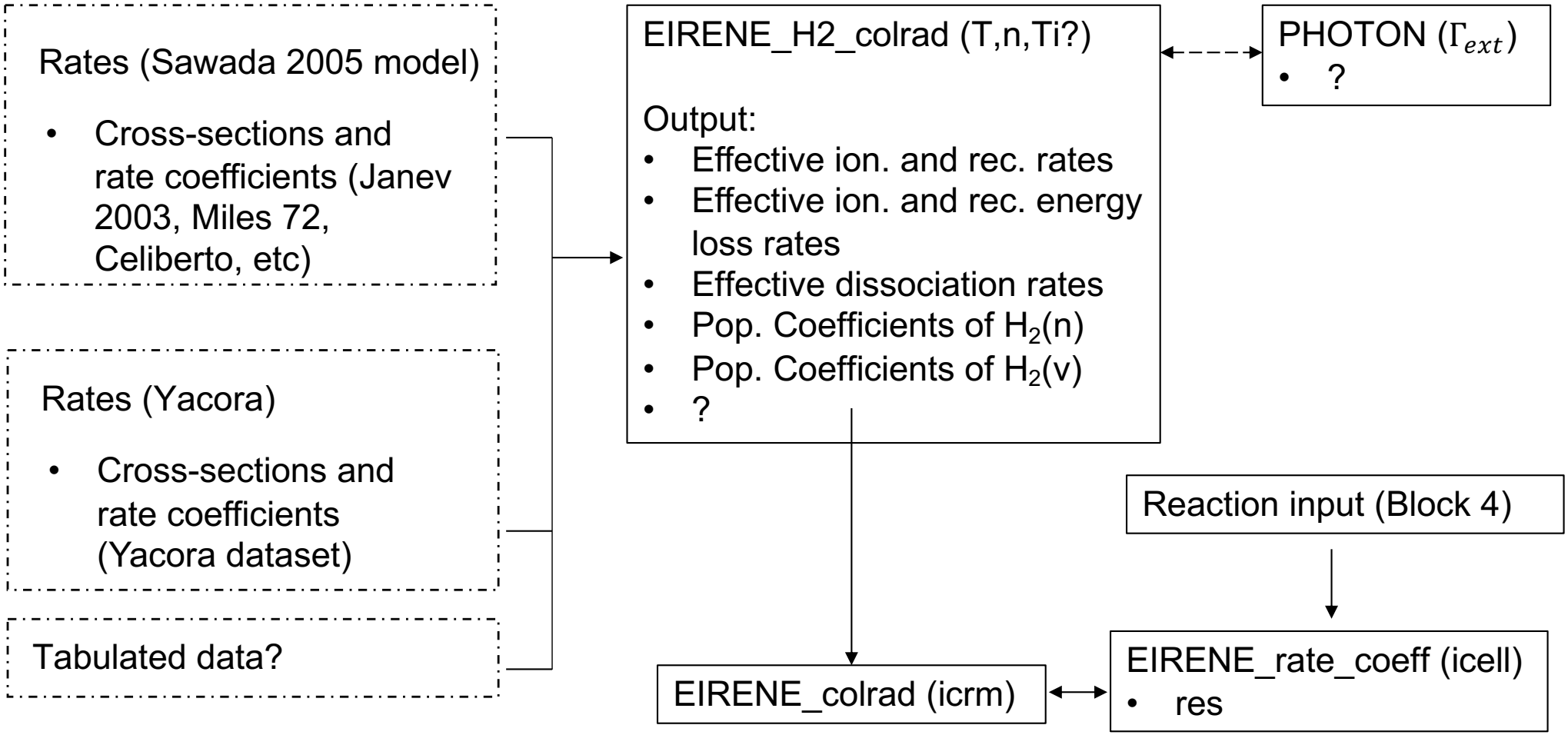
- EIRENE CR = H_COLRAD
- EIRENE AMJUEL = using AMJUEL rates within EIRENE
- AMJUEL – last update entry: May 2018



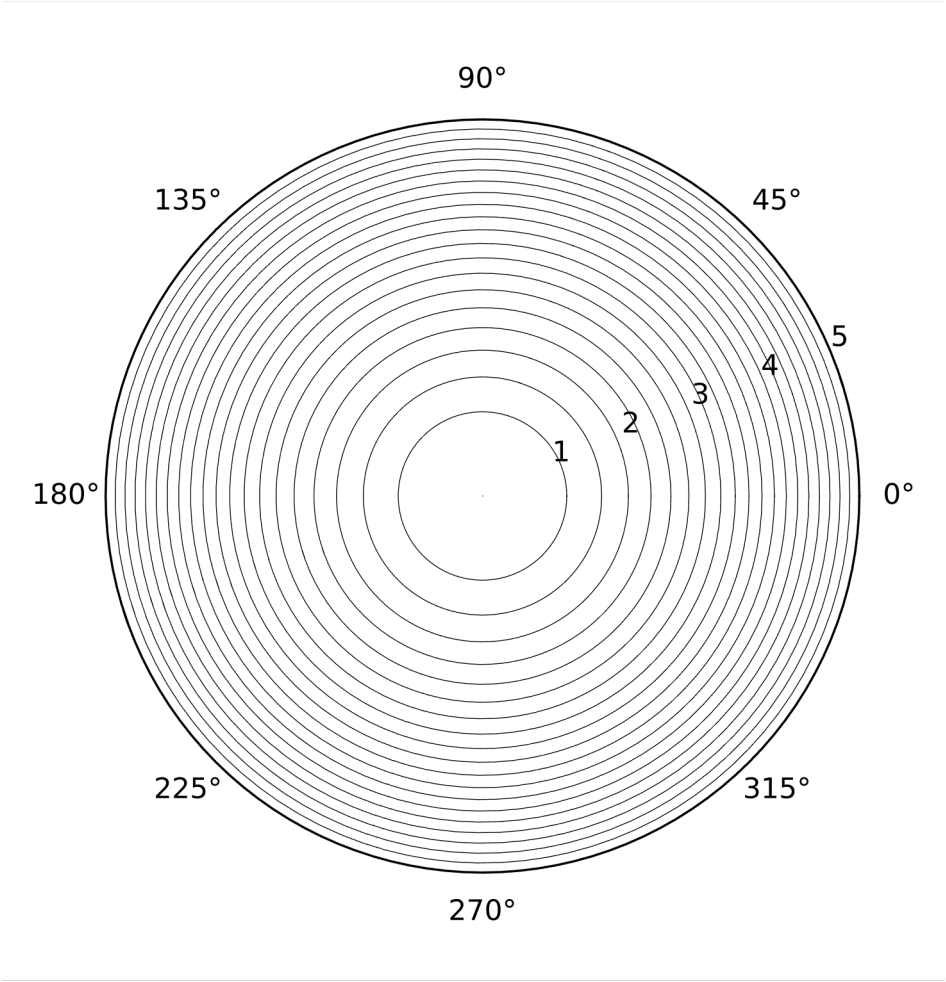
Proposed CRM structure in EIRENE (H_COLRAD)



Proposed H2_COLRAD structure in EIRENE (currently non-existent)



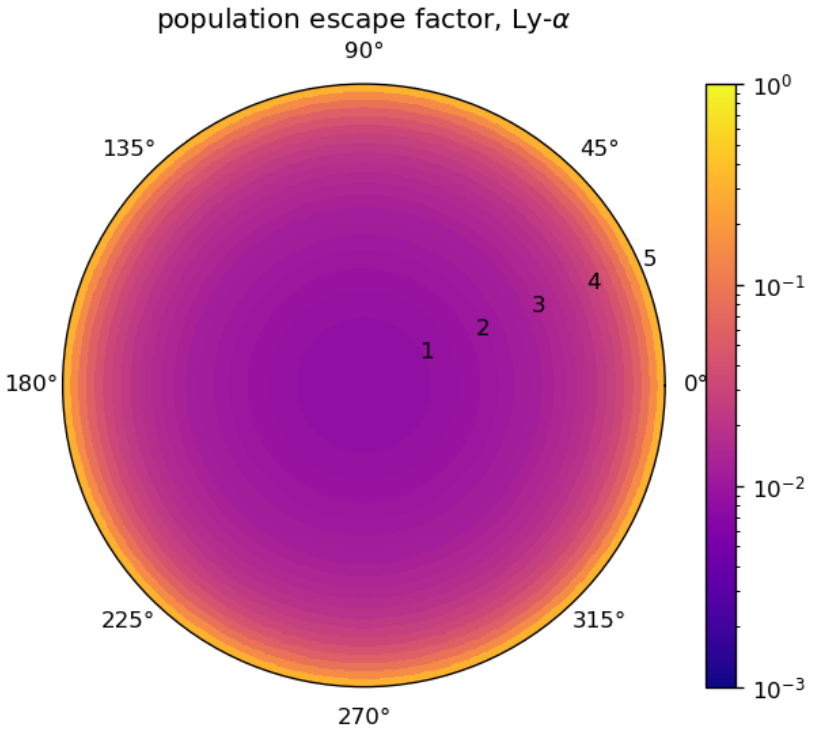
Development of photon tracing test case in simplified geometry

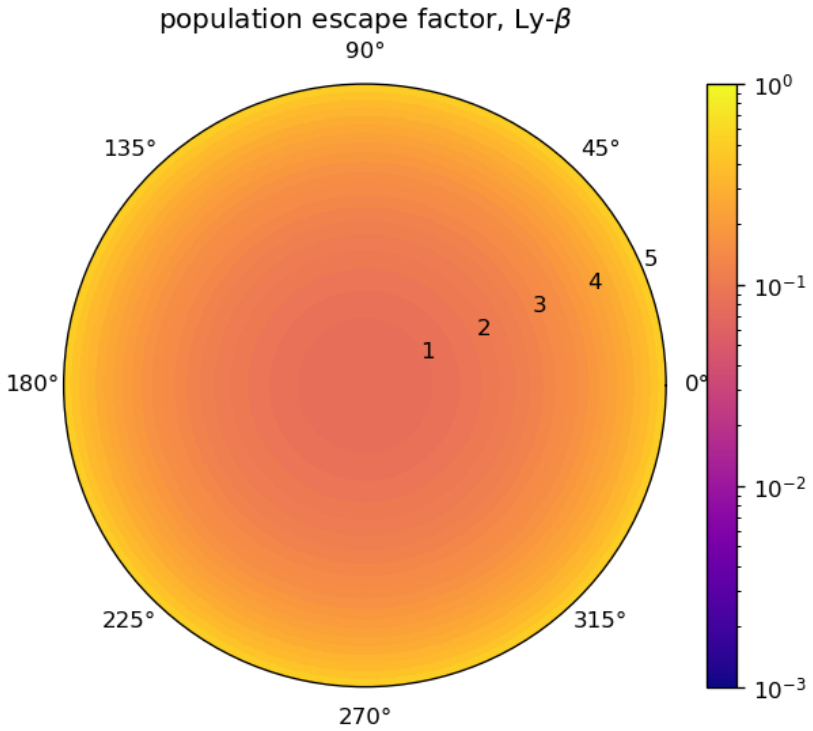


- Cylindrical test case, 20 radial points
- Homogeneous plasma and atomic density
- T_H = 1 eV, $n_H = 10^{14}$ cm^{-3}, b = 5 cm
- Simulated Ly-a and Ly-b photons ($2x10^6$) with volumetric sources (H(n=2,3) as bulk ions)
- Line shape only doppler broadening

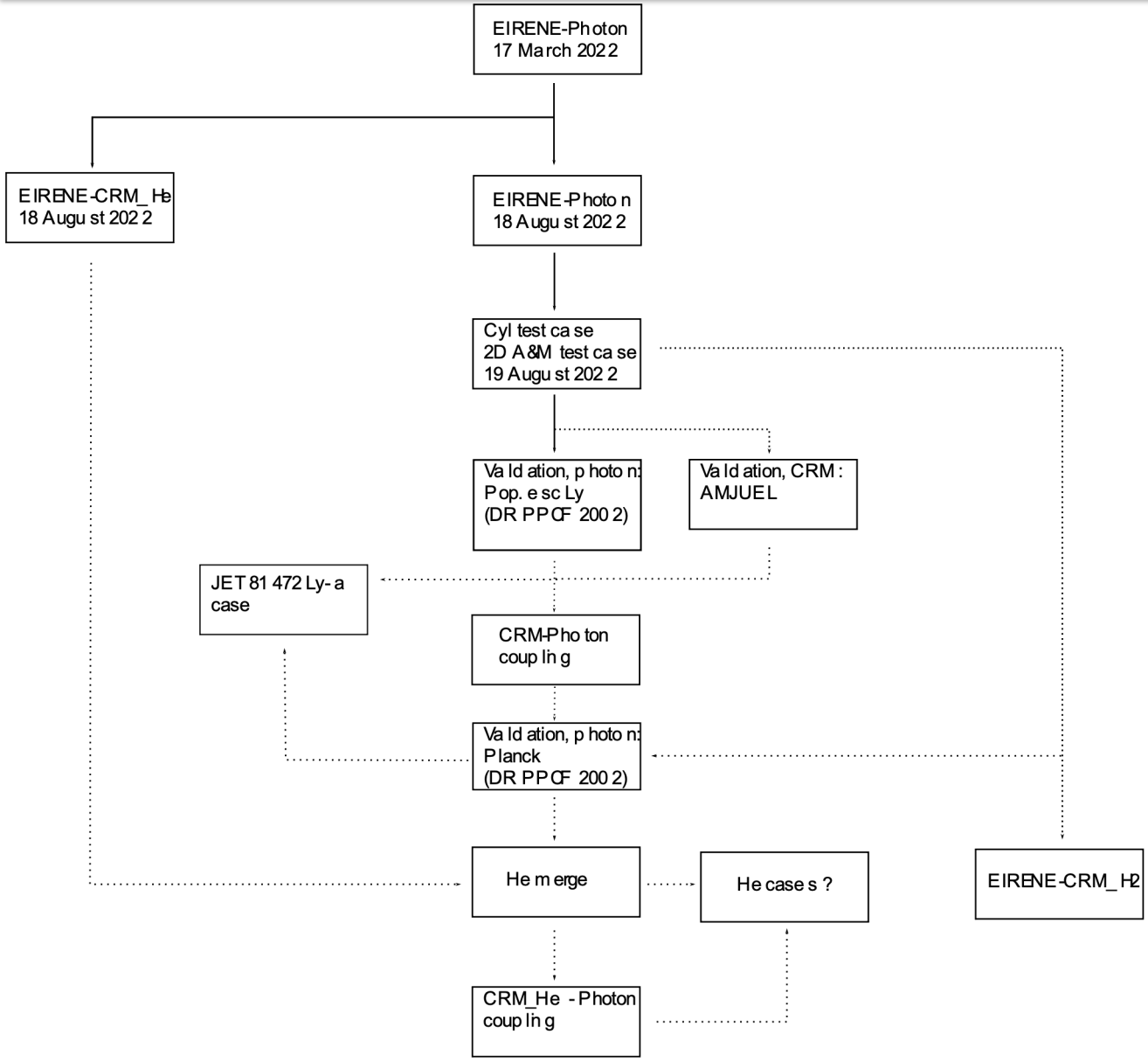
Photon tracing test case: 2D (or 1D) profiles of the population escape factor: Ly-α and Ly-β opaque at the center

- Text



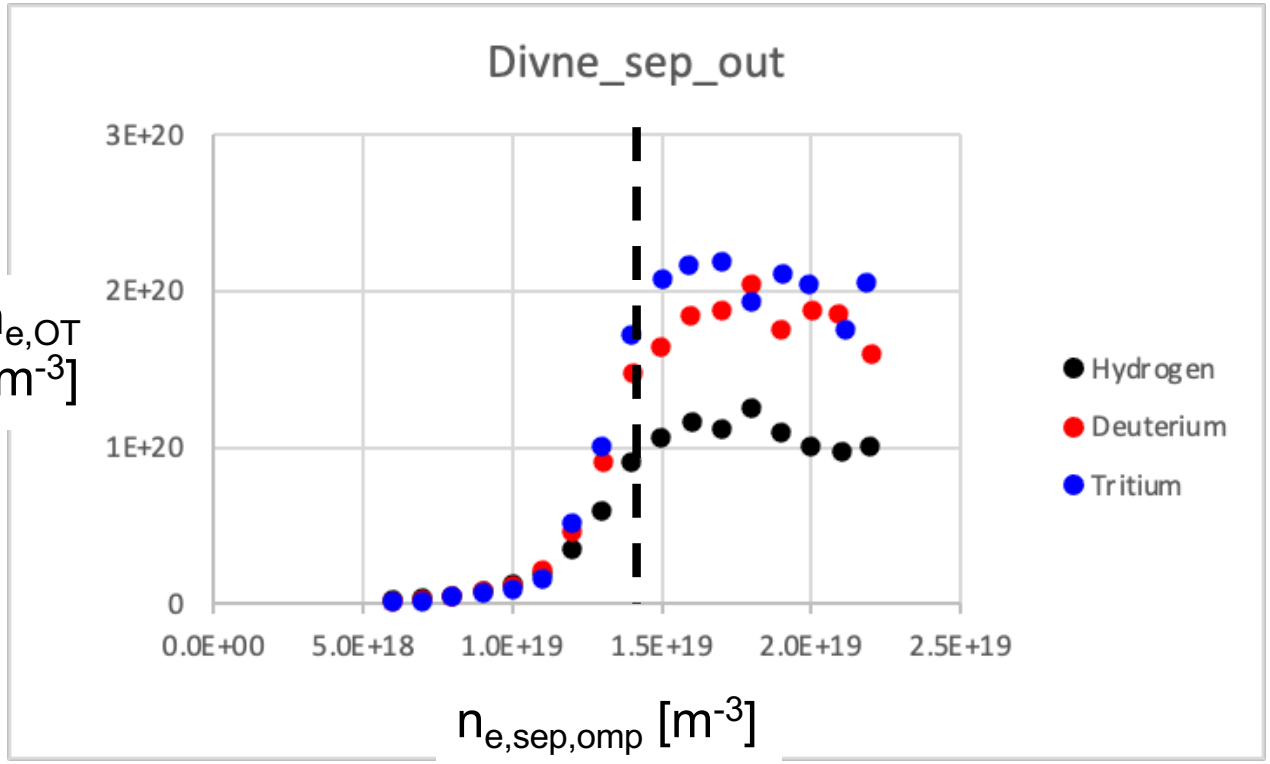


Workflow and timetable for inclusion of CRM and photon opacity in EIRENE



- Currently existing:
  - H colrad, He colrad
  - Photon module
  - A&M and photon cylinder test cases
- Planned for 2023:
  - CRM-photon coupling (for Planck test)
  - Application of model to full geometry (JET 81472)
  - H_COLRAD data update
  - He_COLRAD testing
  - H2_COLRAD creation

Higher div. densities for T than for H plasmas observed in JET-ILW L-mode plasmas, both exp. and in EDGE2D-EIRENE



- Generic density scan with identical transport coeffs., models
- Strong reduction in ion current to outer plate not yet reproduced ⇒ likely to require changes to transport coefficients
- $T_{e,OT}$ least affected by isotope species

Plans for 2023

- Complete development, implementation and verification of H_COLRAD, He_COLRAD and H2_COLRAD in EIRENE (Ray Chandra: PPCF paper and EPS 2023)
  - Front-end development of H2_COLRAD for fundamental data, including hydrogenic isotopes, parameter dependencies (in collaboration with YACORA team)
- Complete development, implementation and verification of photon tracing and opacity model (Ray Chandra: PPCF paper and EPS 2023)
- Application of H2_COLRAD to JET-ILW L-mode plasmas for three primary SOL regimes: $D_2 \rightarrow H_2, T_2$
- Coupling EIRENE CRM and photon module to B2.5 in SOLPS-ITER
  - Re-run SOLPS-ITER cases for H and T (Mathias Groth: IAEA-FEC 2023)