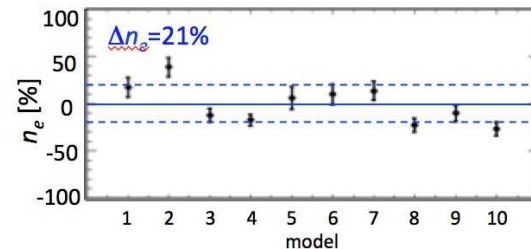
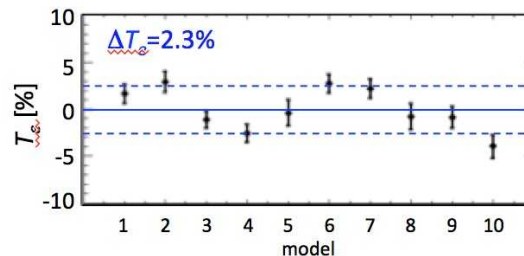
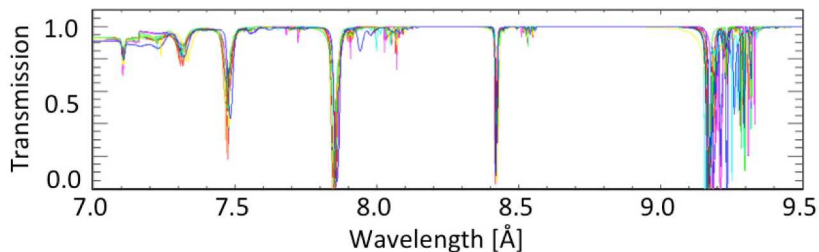


Exceptional service in the national interest



For SNL iron opacity
measurements

**K-shell spectroscopy uncertainty
due to spectral models**
Taisuke Nagayama

K-shell spectroscopy model uncertainty investigation involves universities, national labs, and a private company



J.E. Bailey, S.B. Hansen, G. Loisel, G.A. Rochau
Sandia National Laboratories, Albuquerque, NM, 87185-1196



C.A. Iglesias
Lawrence Livermore National Laboratory, Livermore, CA, 94550



J. Colgan, C.J. Fontes, and D. Kilcrease
Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545



C. Blancard, Ph. Cosse, G. Faussurier, J.-C. Pain, and F. Gilleron
CEA, DAM, DIF, F-91297 Arpajon, France



J.J. MacFarlane and I. Golovkin
Prism Computational Sciences, Madison, WI



R.C. Mancini
University of Nevada, Reno, NV



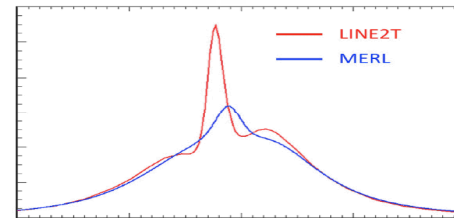
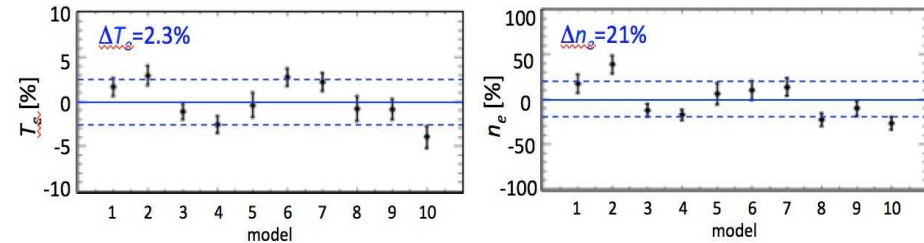
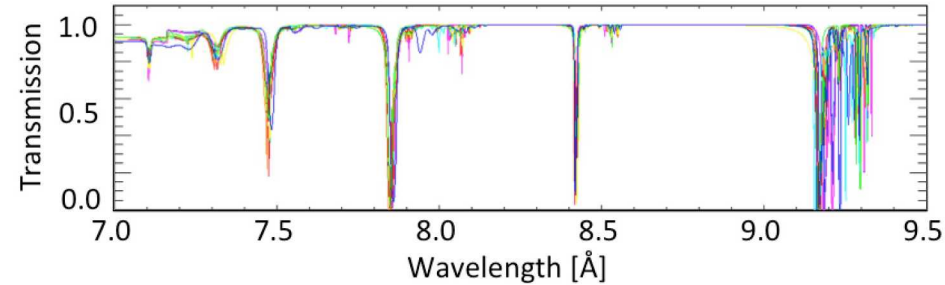
R. Florido
Universidad de Las Palmas de Gran Canaria, 35017 Las Palmas de Gran Canaria, Spain



H.-K. Chung
International Atomic Energy Agency, A-1400 Vienna, Austria

Summary: Model uncertainties in K-shell spectroscopy are 2-4% in T_e and 20-30% in n_e , primarily produced by line shape model differences

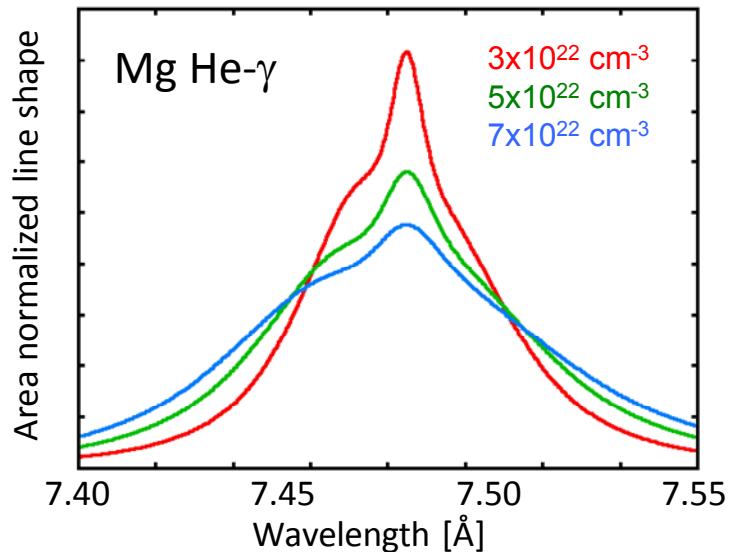
- Mg K-shell spectra are computed:
 - 10 different models
 - Same conditions
- The synthetic spectra are analyzed:
 - $\Delta T_e = 2-4\%$
 - $\Delta n_e = 20-30\%$
- Major source of discrepancy:
 - Stark line shape models



Line shape models need to be scrutinized theoretically and experimentally

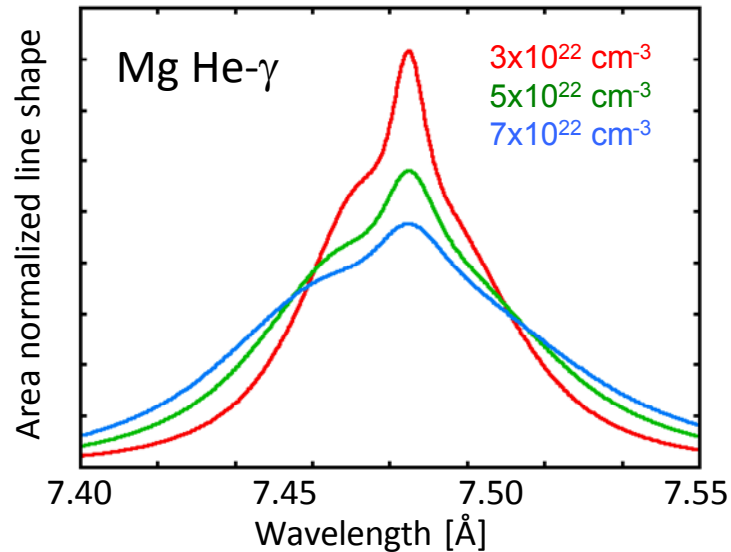
In high energy density plasmas, T_e and n_e can be precisely inferred from measured K-shell spectra

- Line shape: sensitive to electron density, n_e

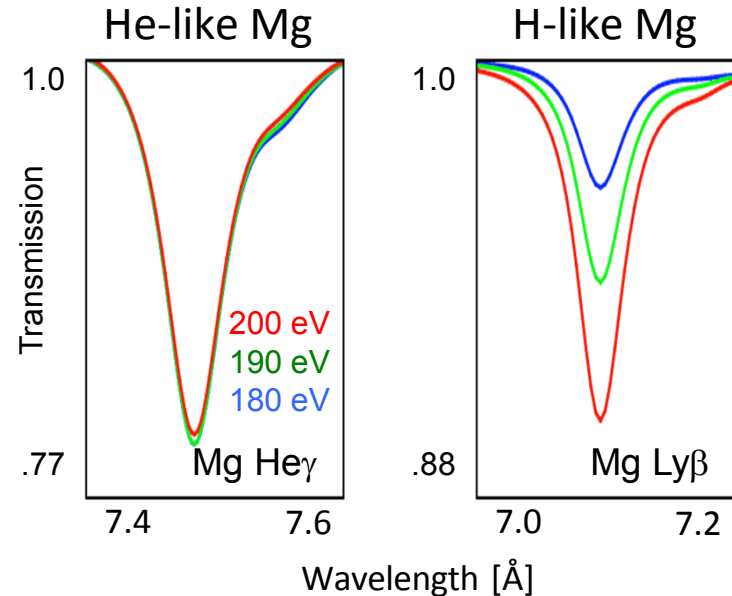


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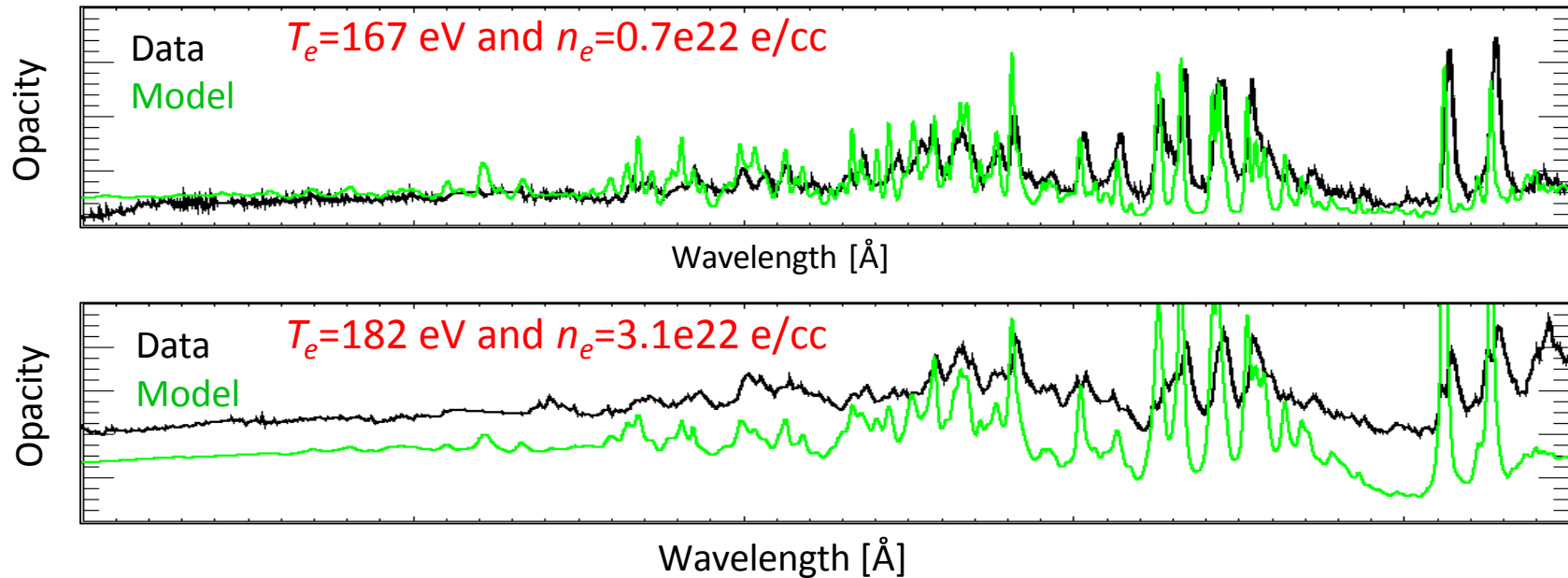
- Line ratio: sensitive to electron temperature, T_e



Plasma T_e and n_e can be extracted by reproducing measured spectra with spectral models

Example: Mg K-shell spectroscopy is used to infer conditions for recent Fe opacity measurements

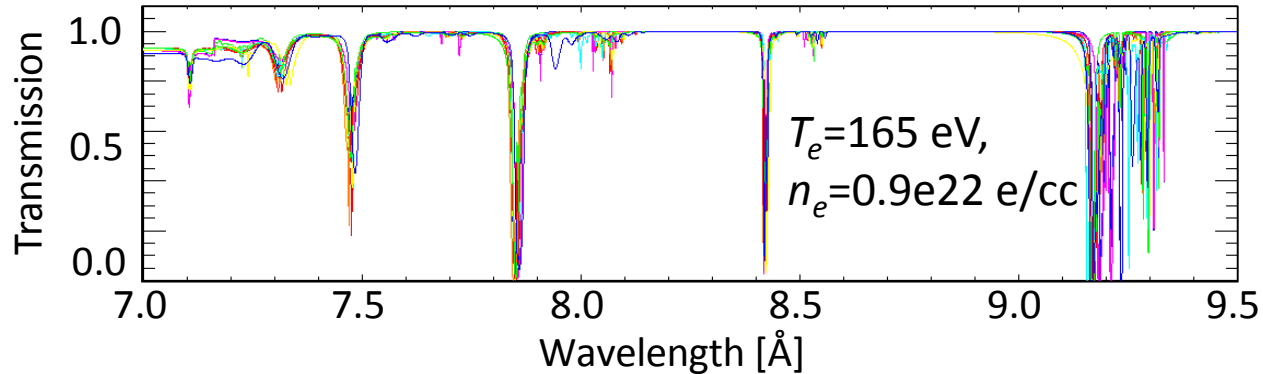
- Recent Fe opacity measurement reveals 30-400% opacity disagreement with models at higher T_e and n_e



How accurate are the inferred T_e and n_e ?

K-shell spectroscopy model uncertainty is studied numerically

- Compute Mg K-shell spectra with different models:

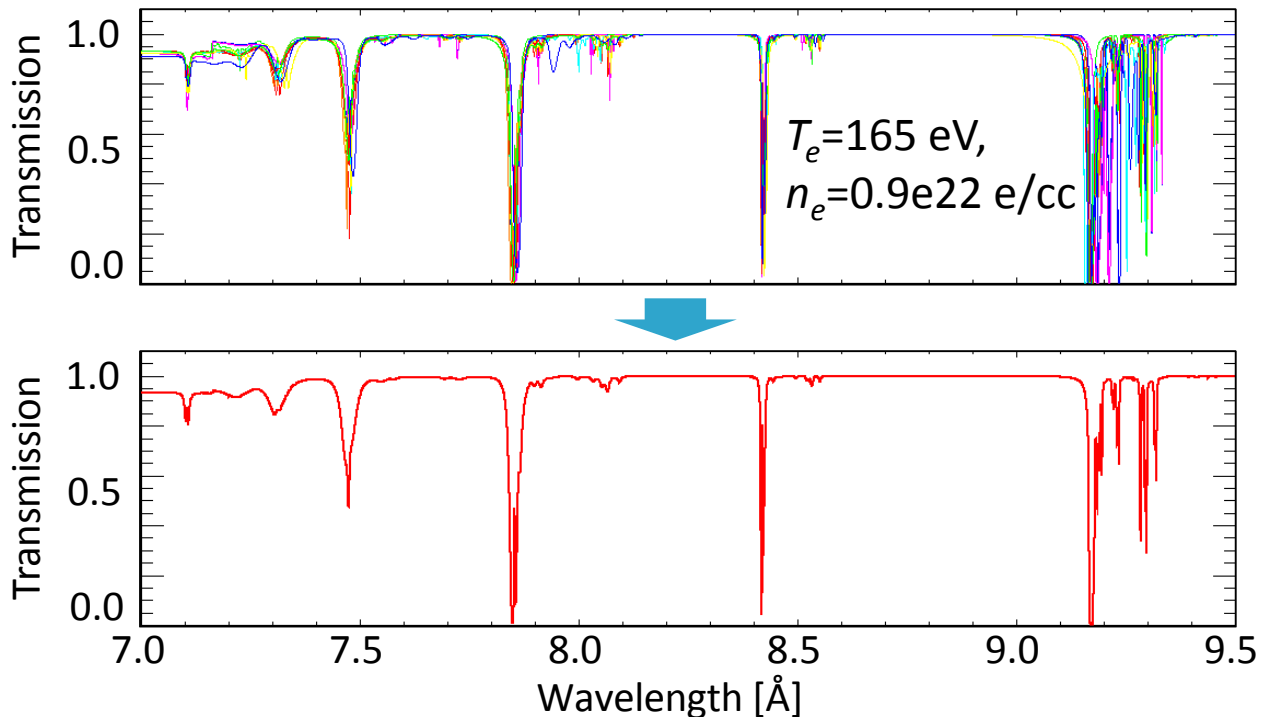


Spectral models (LTE):

- ABAKO
- ATOMIC
- FLYCHK
- OPAL
- OPAS
- PrismSPECT
- SCRAM

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- Compute Mg K-shell spectra with different models:

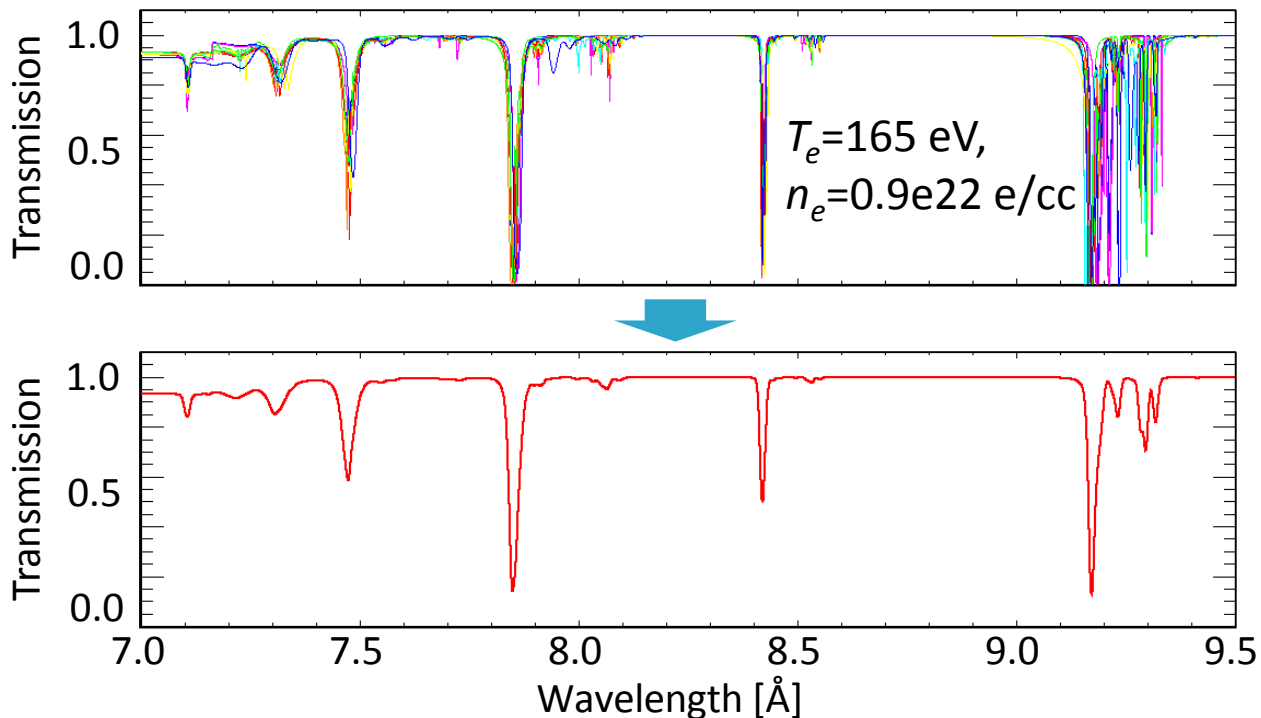


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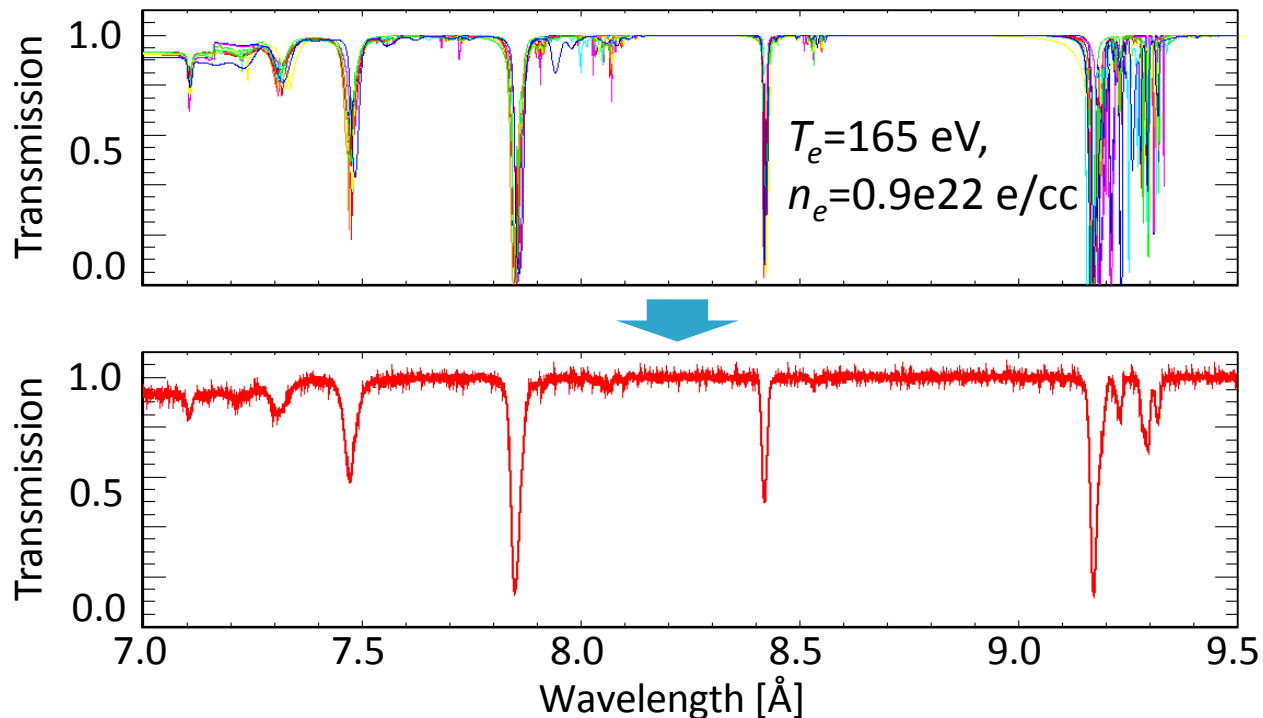


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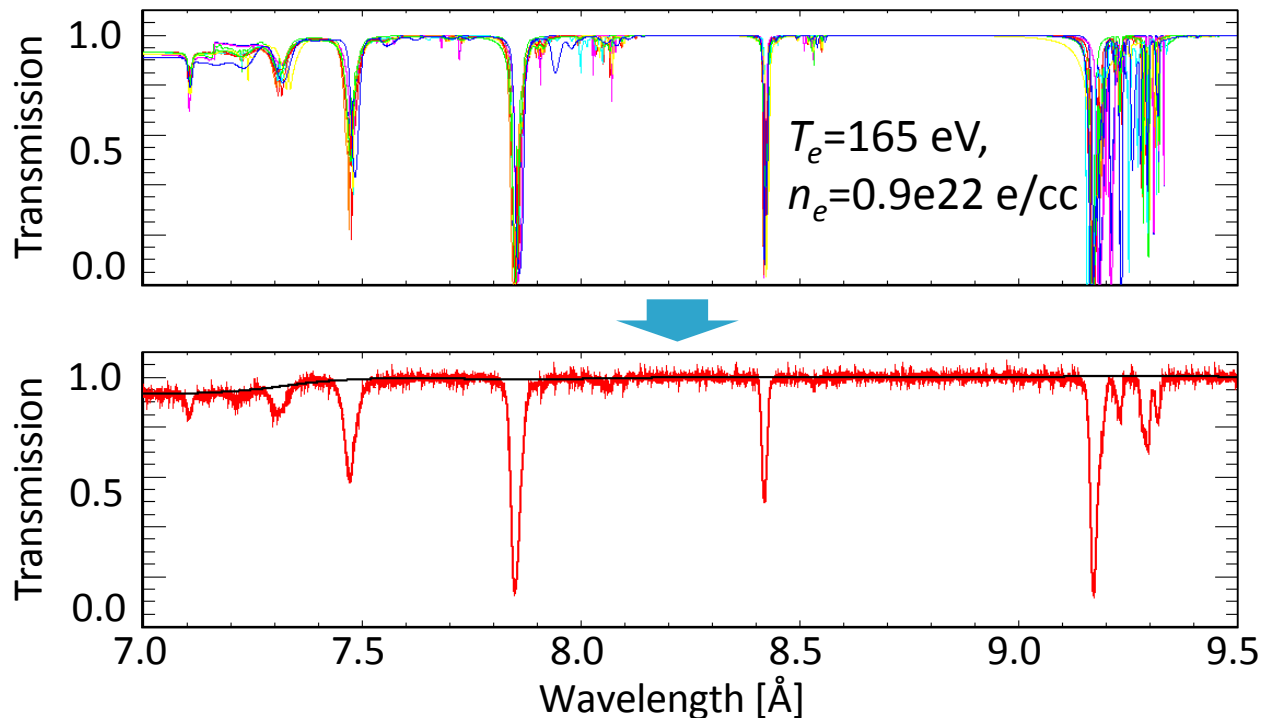


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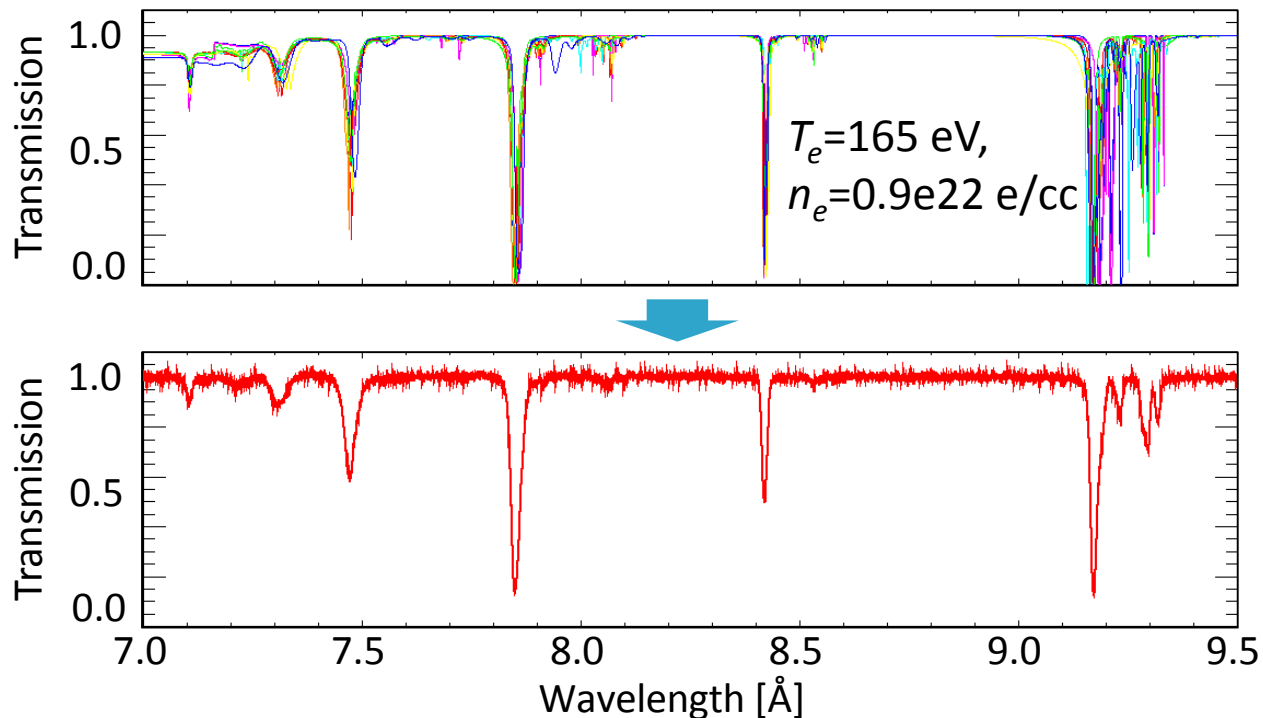


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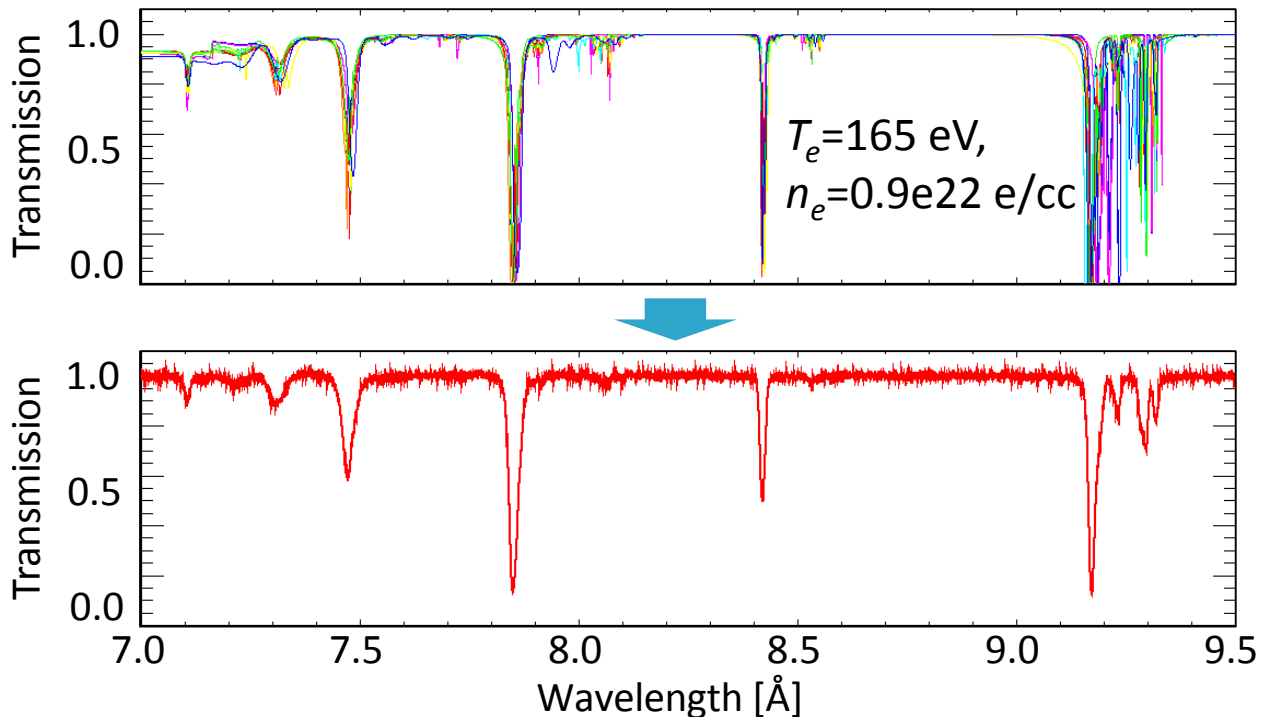


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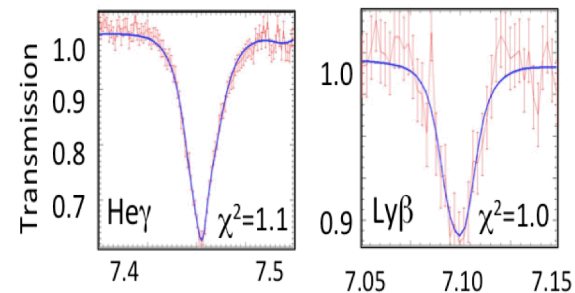
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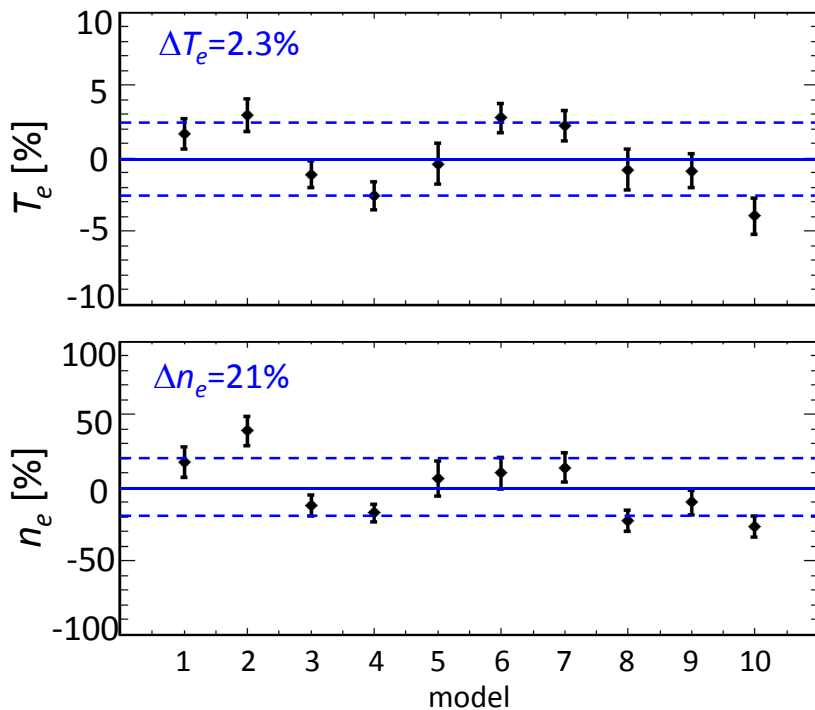
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T_e and n_e model uncertainties are 2-4% and 20-30%, respectively

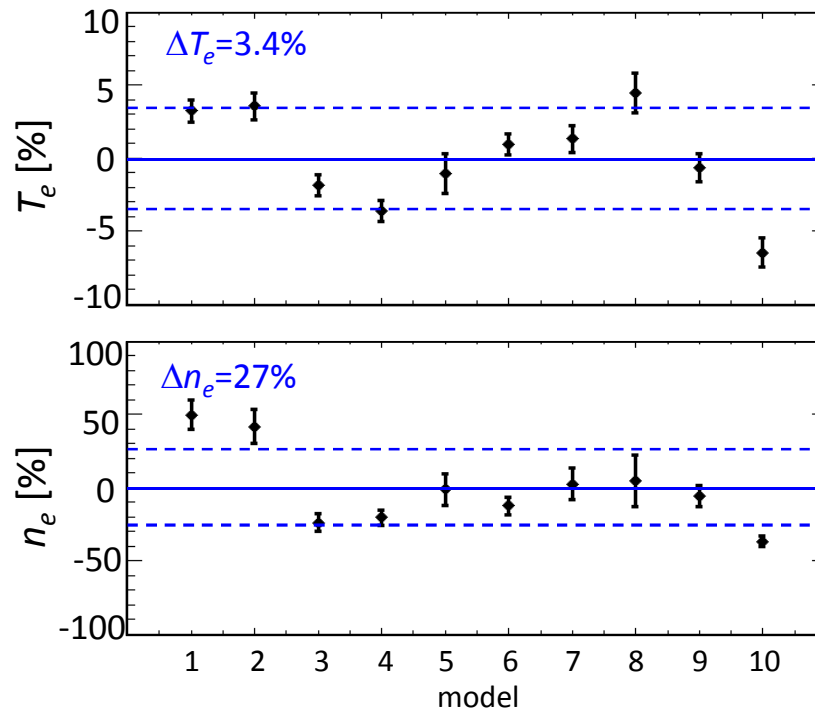
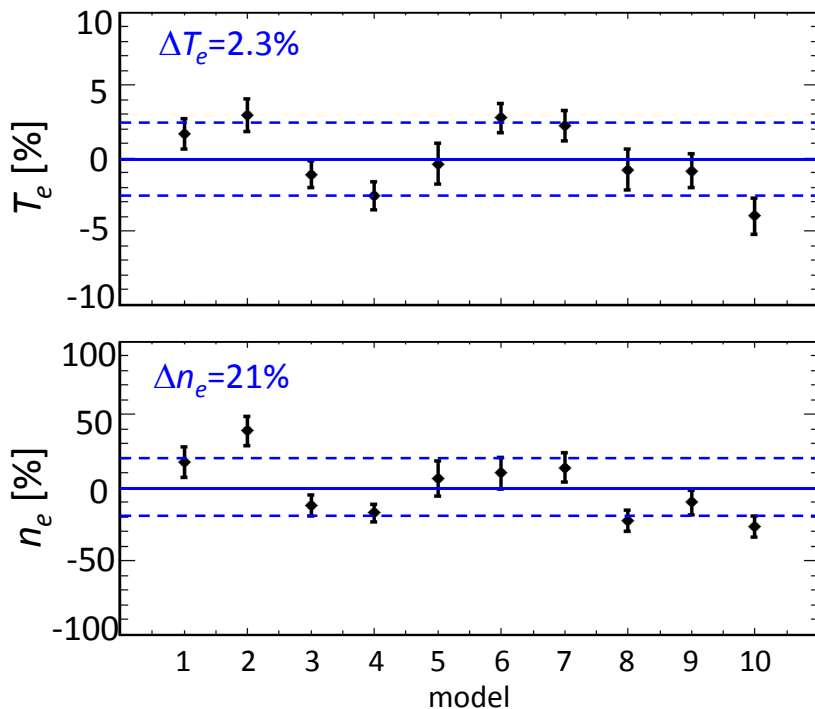
Case1: at $T_e=165$ eV, $n_e=0.9e22$ e/cc



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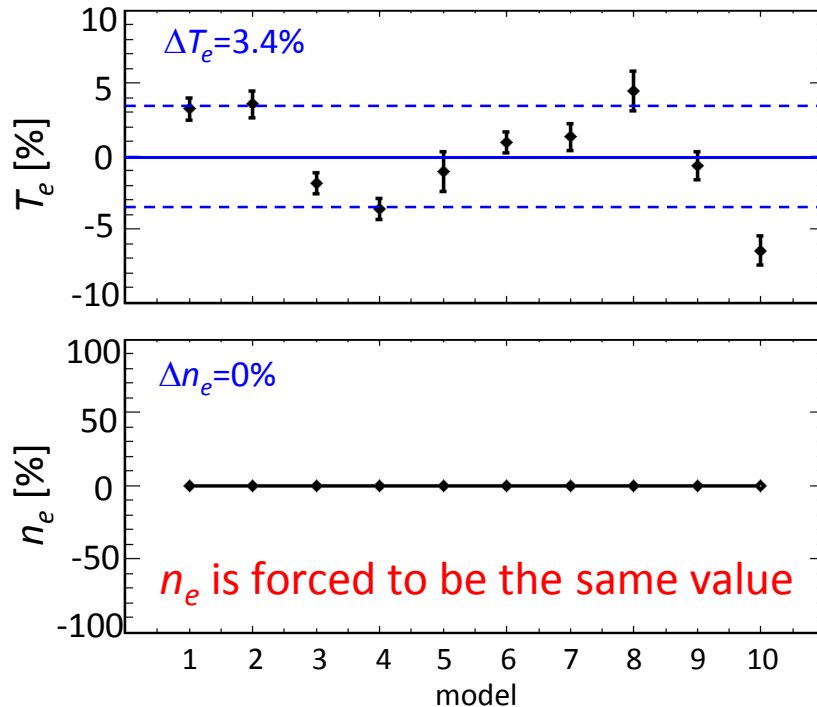
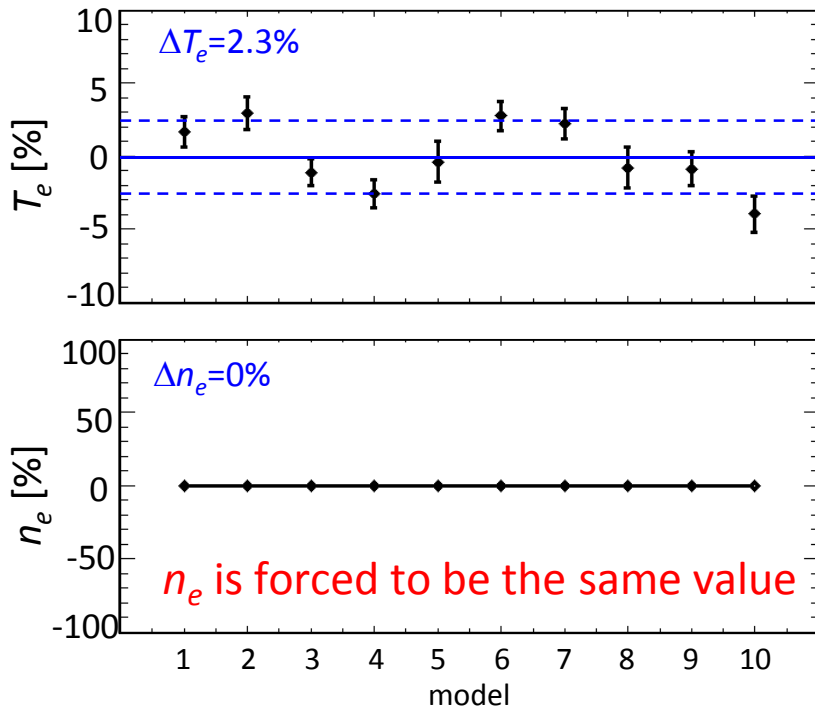
Case2: at $T_e=195$ eV, $n_e=4.0e22$ e/cc



T_e and n_e model uncertainties are 2-4% and 20-30%, respectively

Case1: at $T_e=165$ eV, $n_e=0.9e22$ e/cc

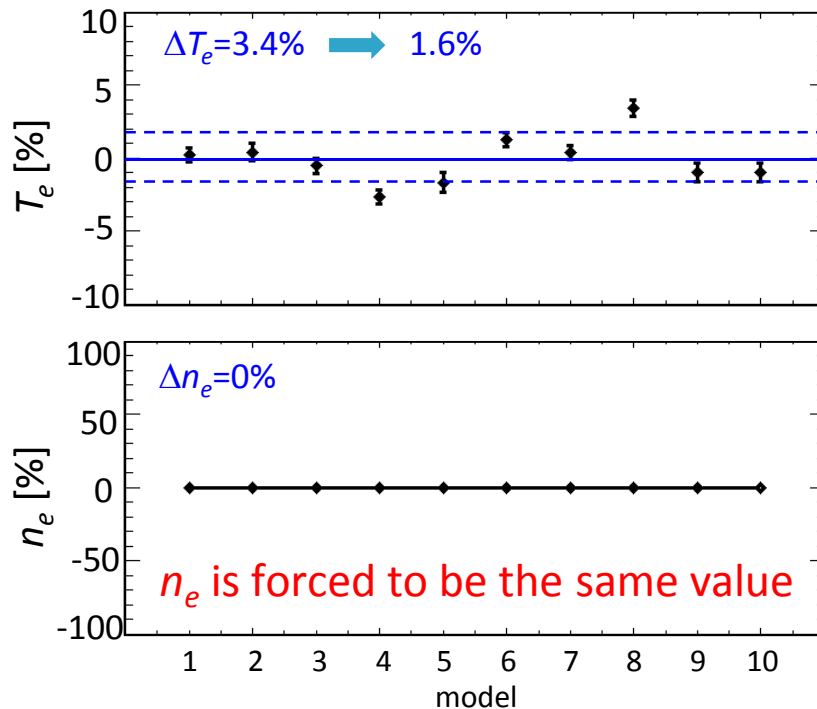
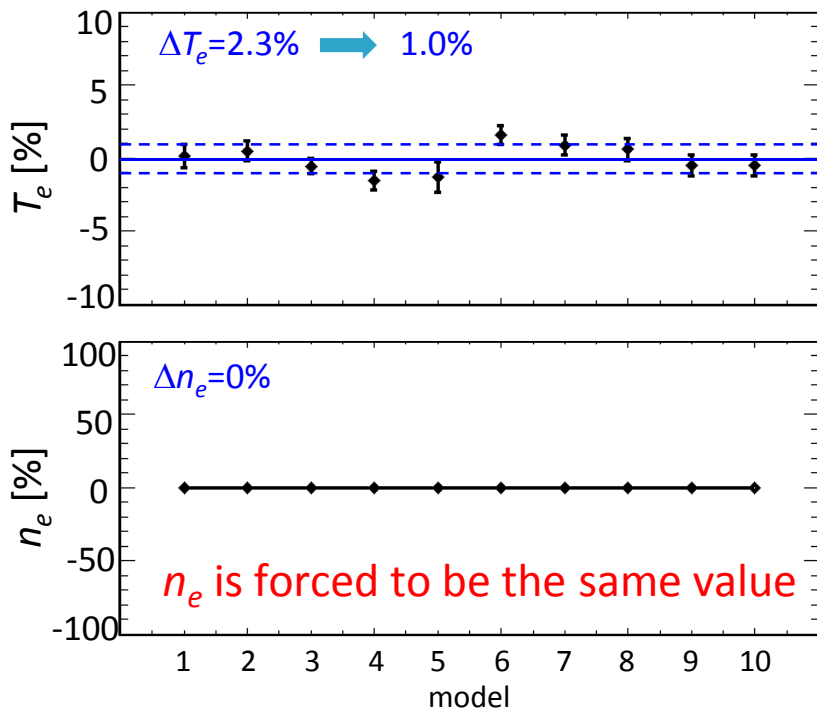
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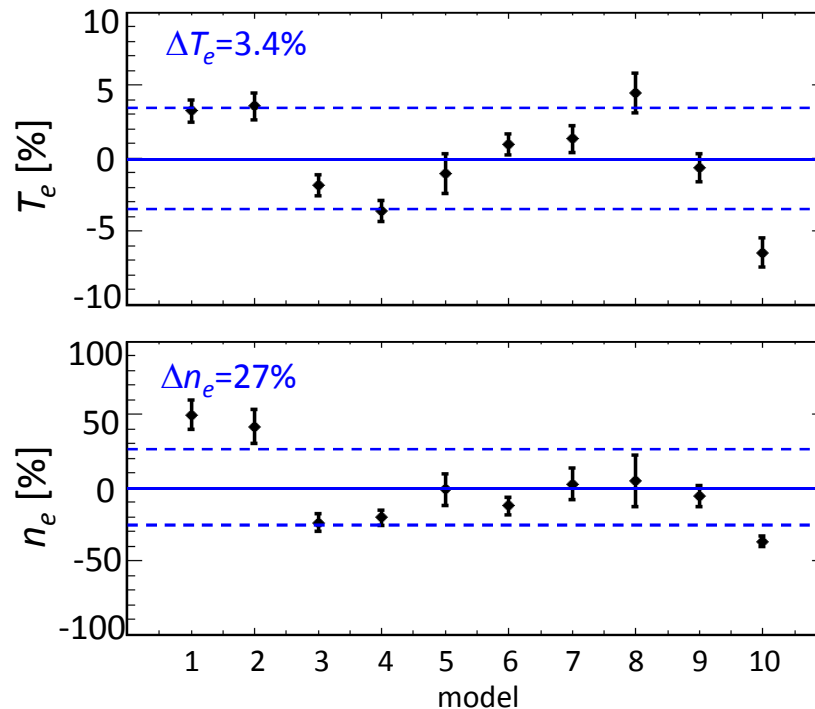
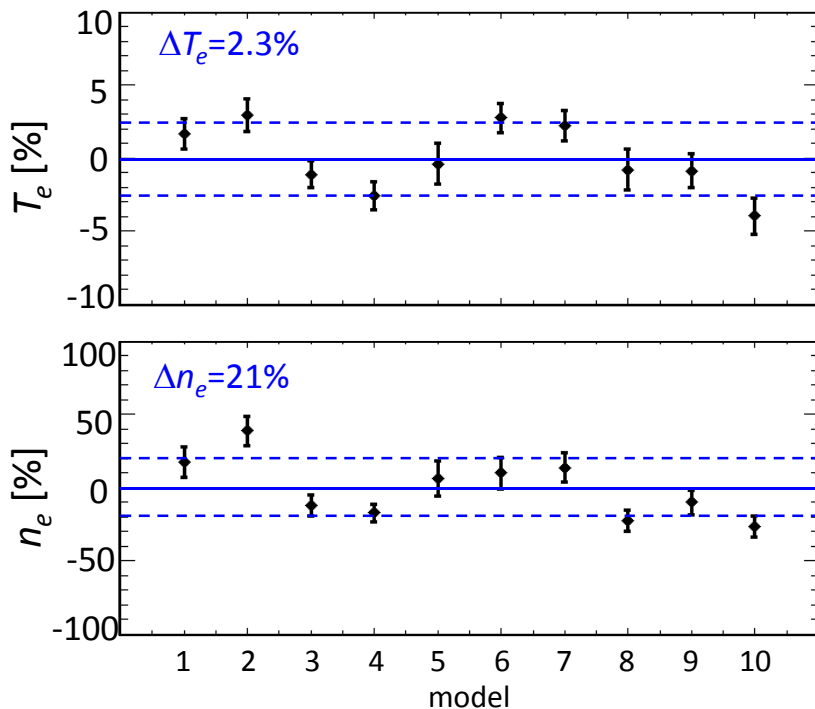


Half of ΔT_e is produced by the large Δn_e

T_e and n_e model uncertainties are 2-4% and 20-30%, respectively

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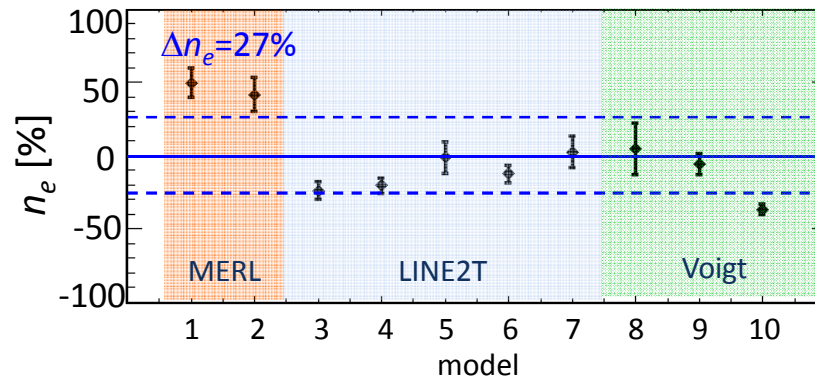
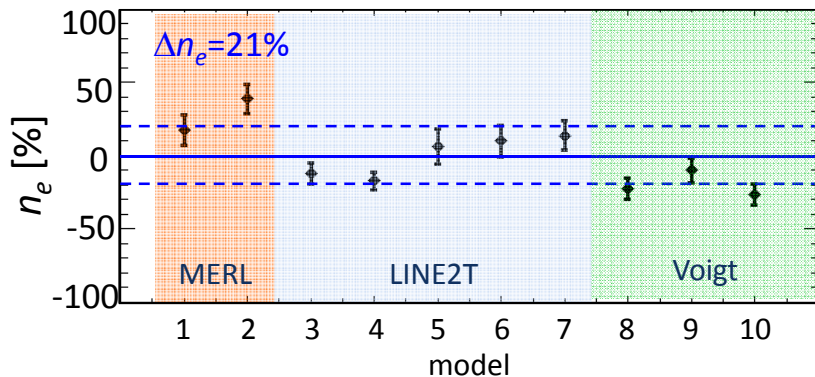
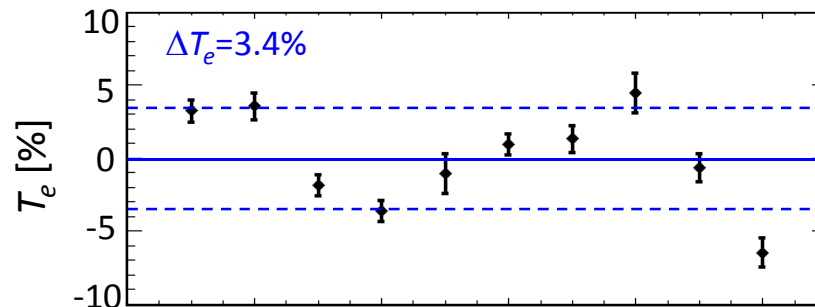
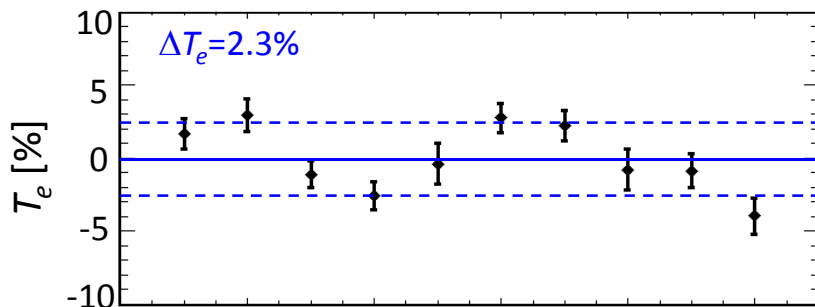
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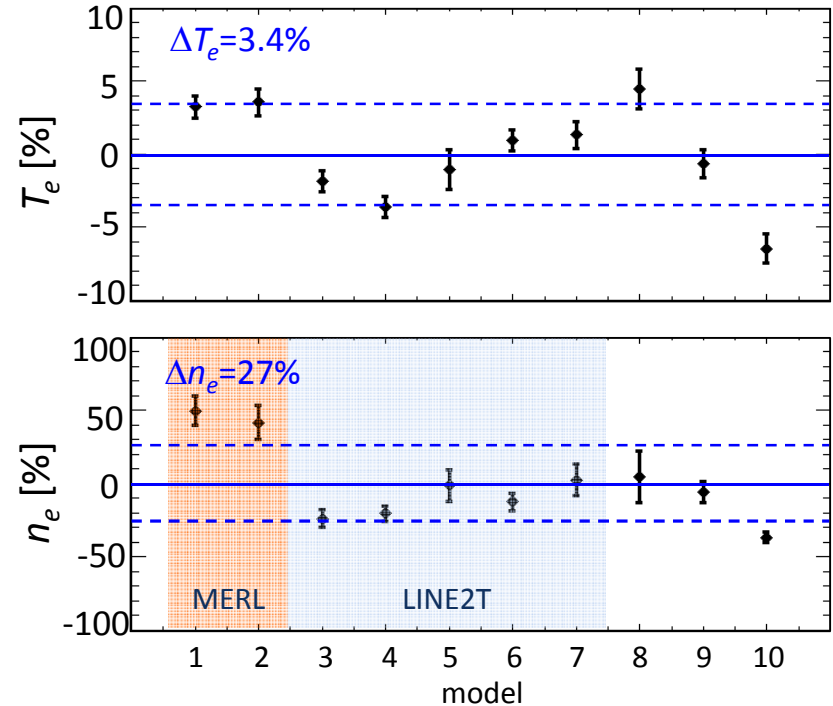
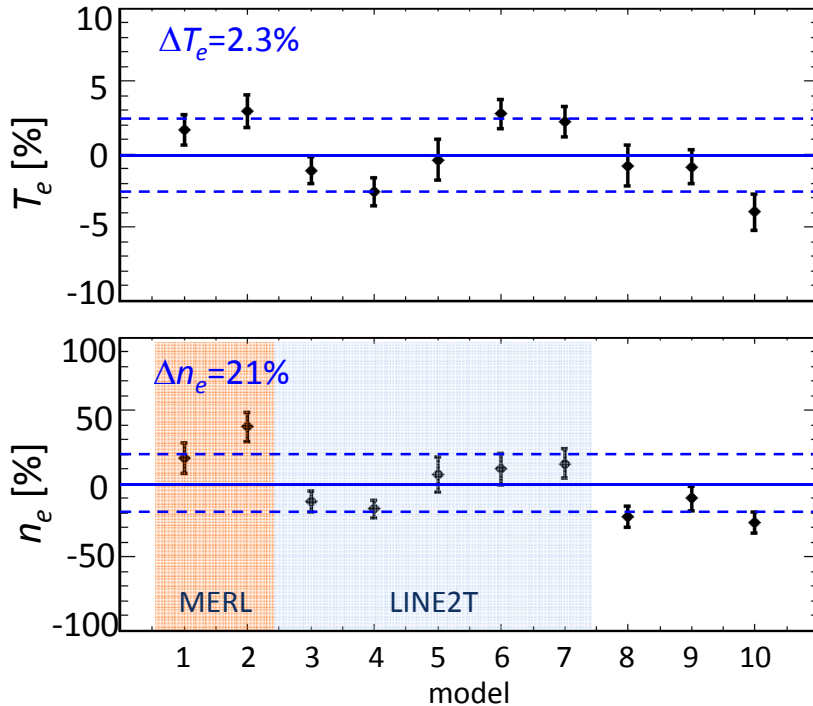
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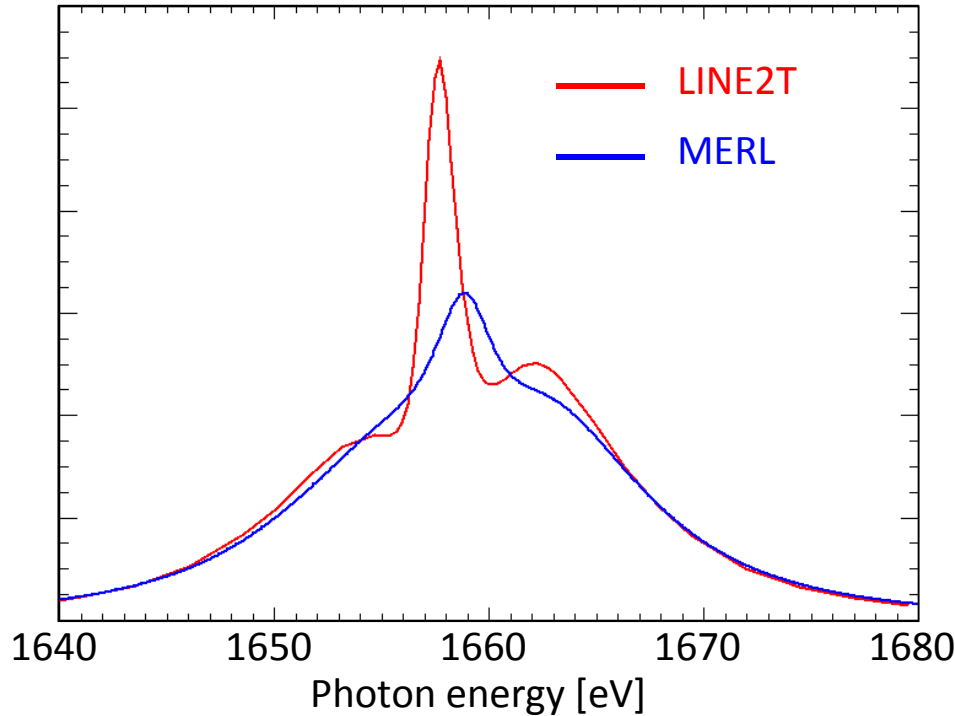
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Line shapes modeled by MERL and LINE2T produce roughly 30-50% difference in n_e

The discrepancy is primarily produced by Stark line model differences

Mg Hey line shape at $n_e=4e22$ e/cc



Similarities: standard theory

- Static ion approximation
- Electron impact approximation
- 2nd order perturbation theory

Differences:

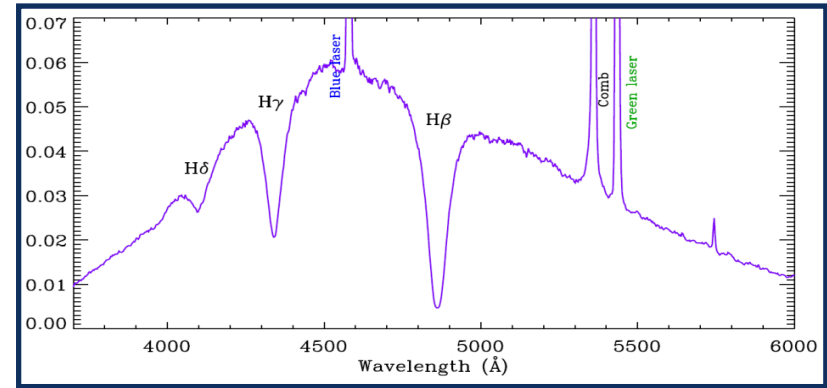
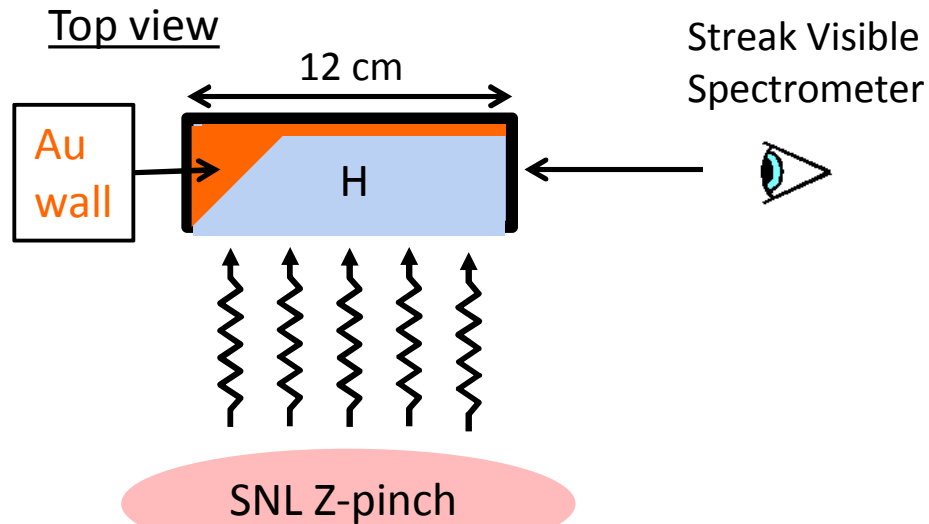
| | LINE2T | MERL |
|---------------------|--------------|--------------|
| Extended basis set | NO | YES |
| Inelastic collision | NO | YES |
| Electron broadening | Semi classic | Gaunt factor |

Line shape formalism should be theoretically scrutinized.

Y. V. Ralchenko et al, JQSRT 81, 371 (2003).

Benchmark line shape measurement is ongoing effort at Sandia National Laboratories (SNL)

- Hydrogen Balmer line shape measurements led by students from University of Texas, Austin

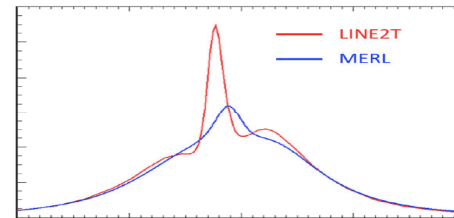
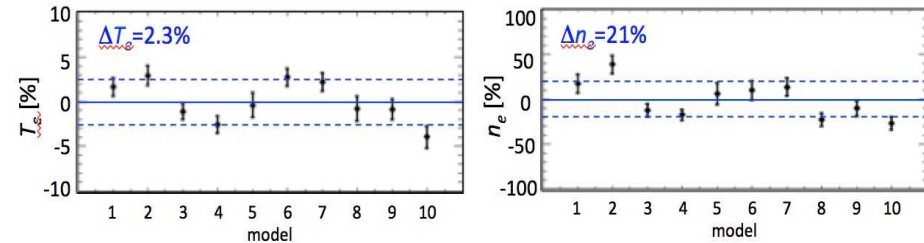
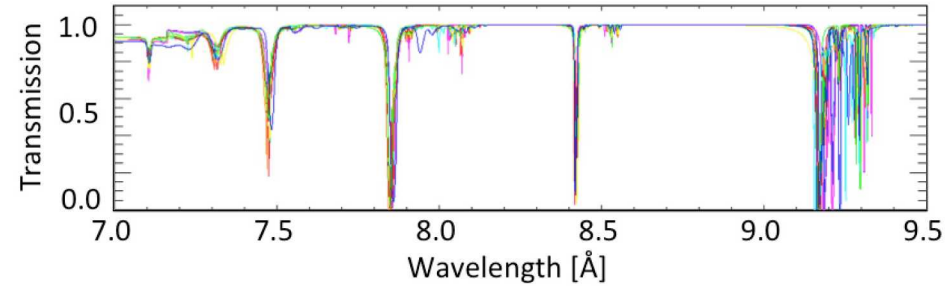


Experiment: R. Falcon, M. Schaeuble
Theory: T. Gomez

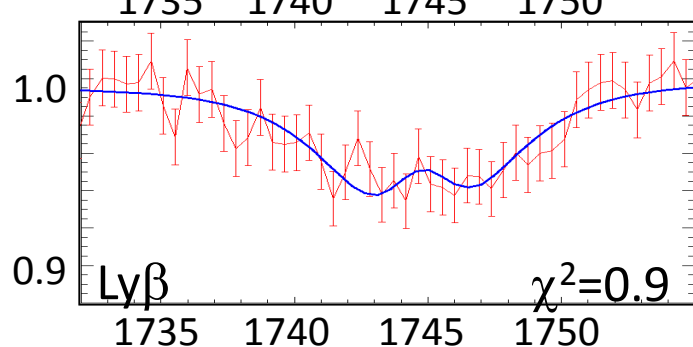
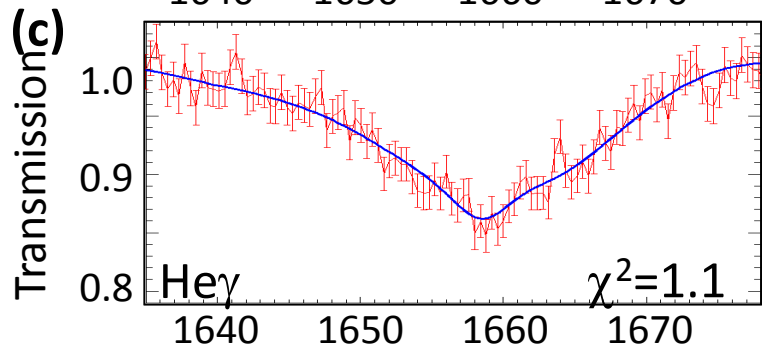
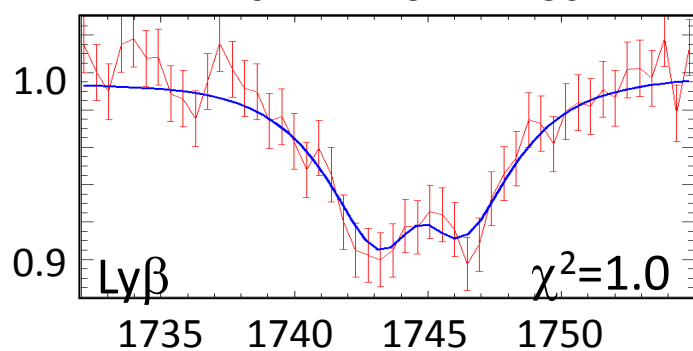
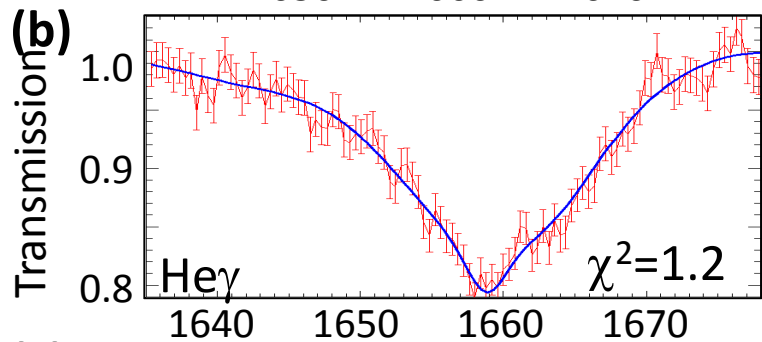
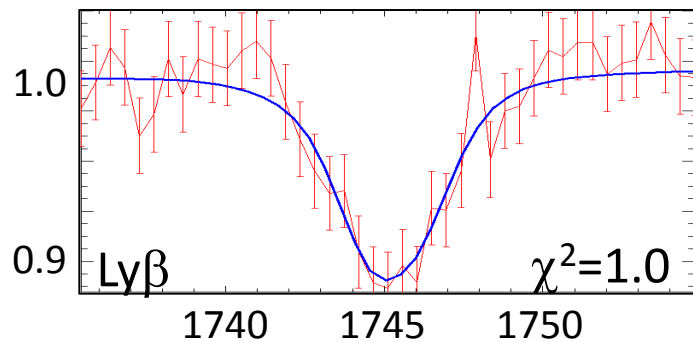
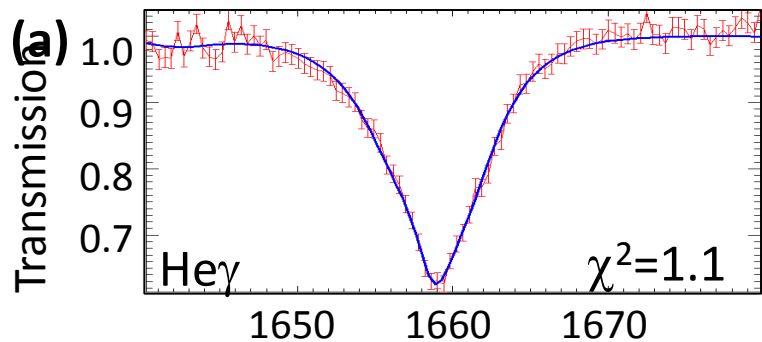
- Mid-Z line shapes measurements will be led by students from West Virginia University (T. Lane, M. Flaugh)

Summary: Model uncertainties in K-shell spectroscopy are 2-4% in T_e and 20-30% in n_e , primarily produced by line shape model differences

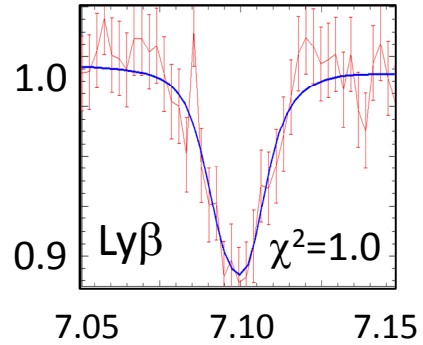
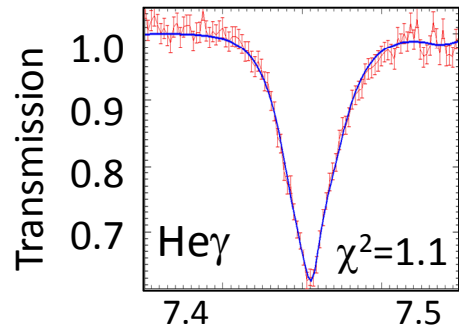
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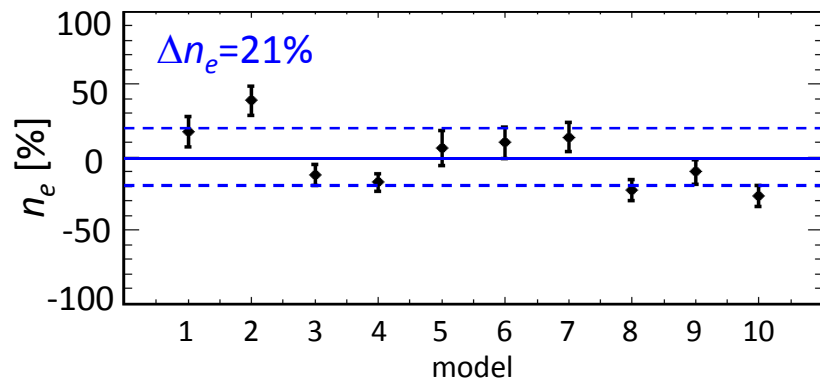
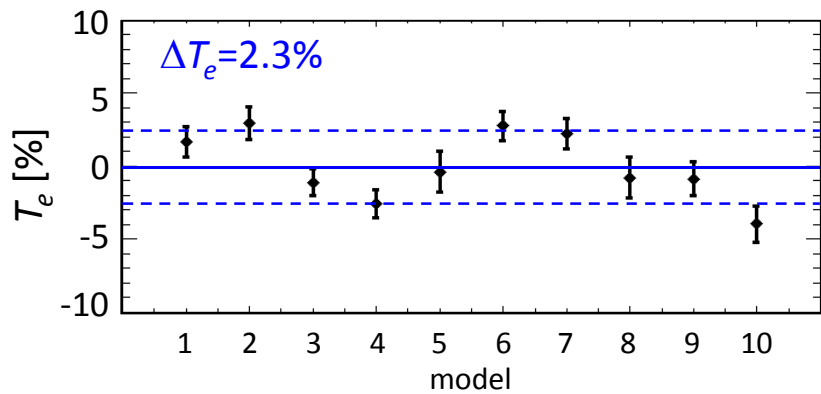


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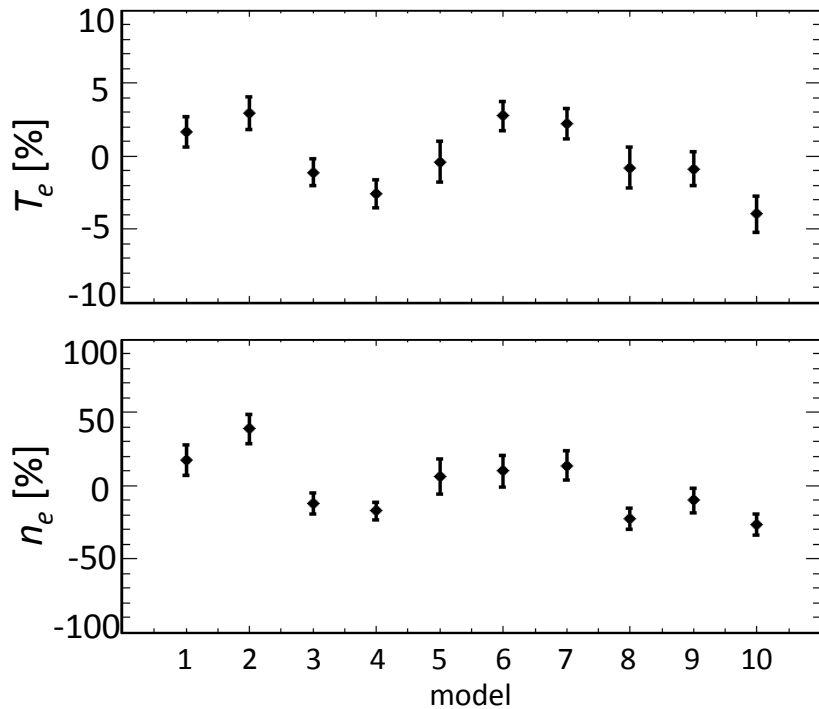


Photon energy [eV]

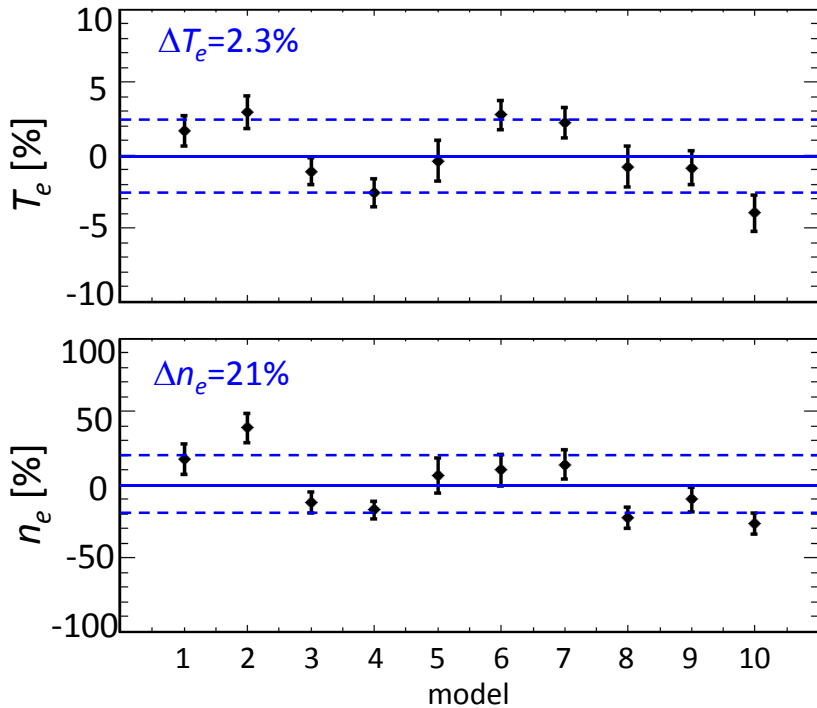




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