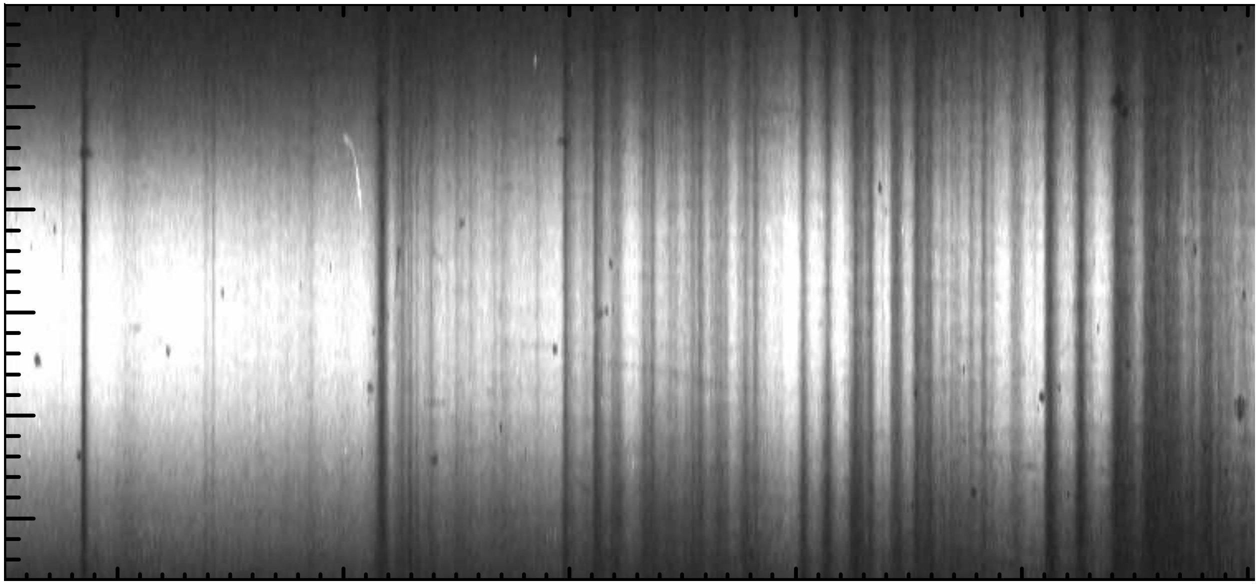
SAND2008-0629C

Iron plasma transmission measurements at temperatures above 150 eV



Fe & Mg absorption spectrum

APS Division of Plasma Physics

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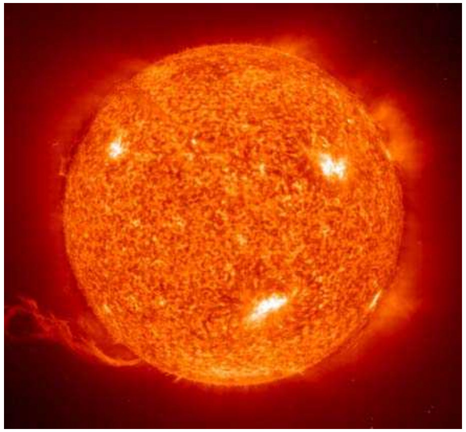
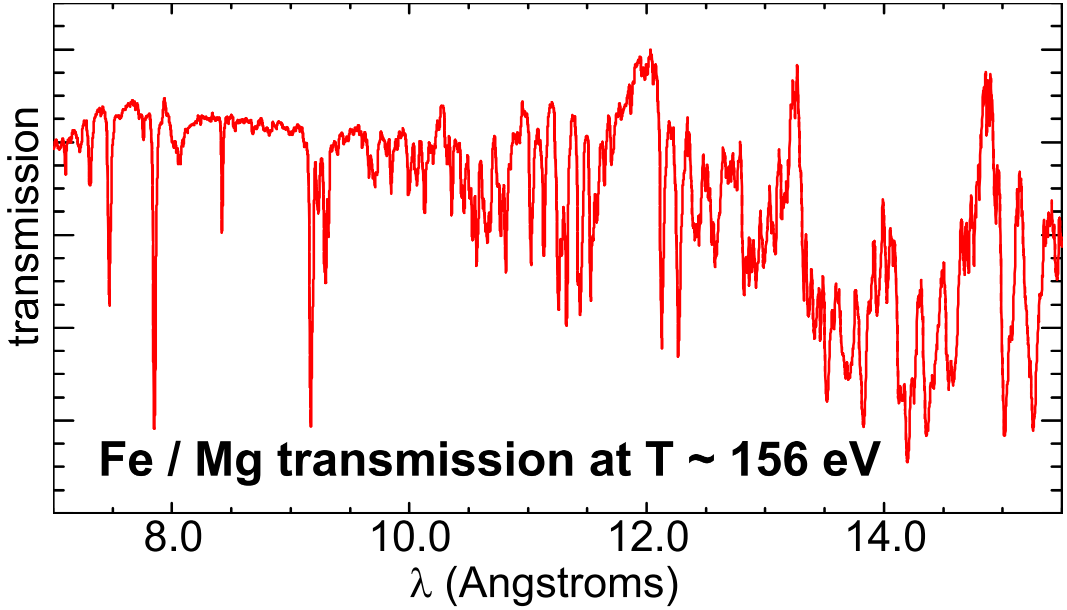
Laboratory experiments test opacity models that are crucial for stellar interior physics



Emergent radiation depends on opacity



<u>Challenge: create and diagnose stellar interior conditions on earth</u>

Z opacity experiments reach T ~ 156 eV
High T enables first studies of transitions important in stellar interiors
Measurements establish Z opacity science platform

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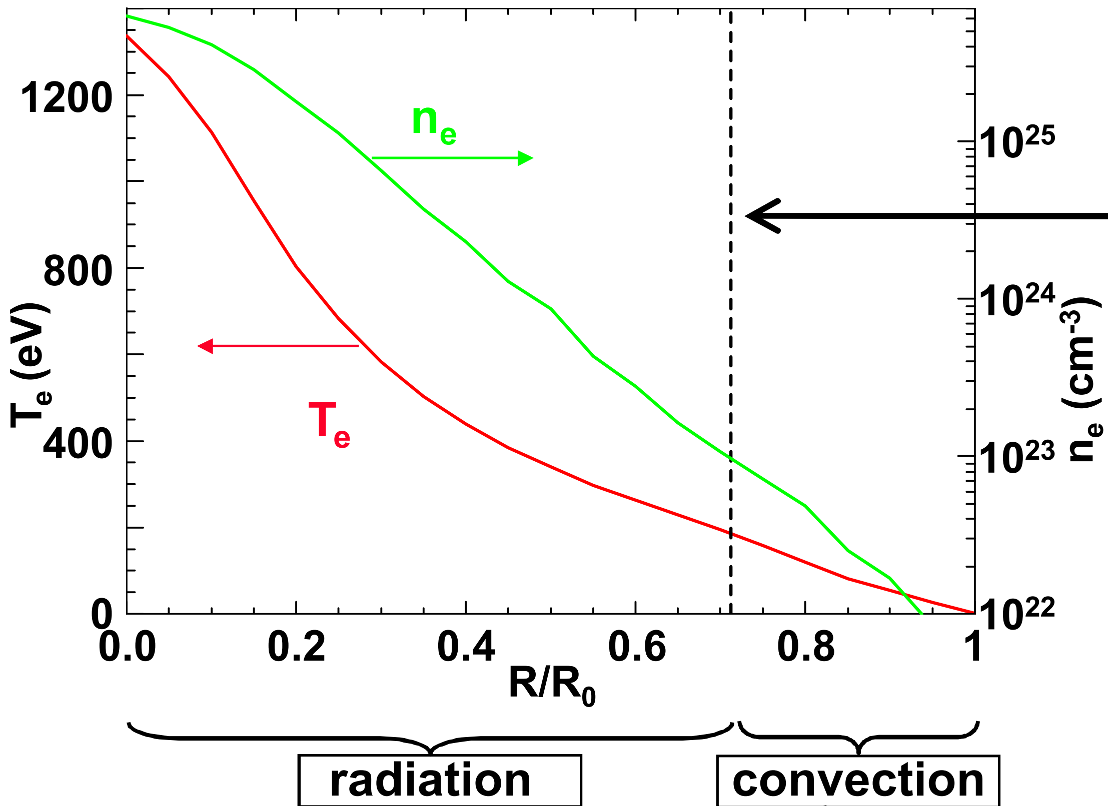
Modern solar models disagree with observations. Why?



- measured boundary $R_{CZ} = 0.713 \pm 0.001$
- Predicted $R_{CZ} = 0.726$
- Thirteen σ difference

Bahcall et al, ApJ 614, 464 (2004).
Basu & Antia ApJ 606, L85 (2004).

- Boundary location depends on radiation transport
- A 1% opacity change leads to observable RCZ changes.
- This accuracy is a challenge – experiments are needed to know if the solar problem arises in the opacities or elsewhere.

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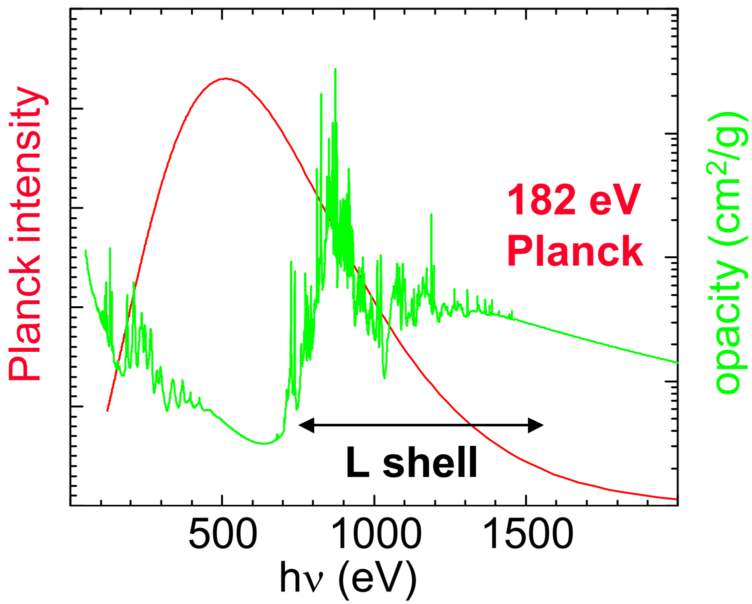
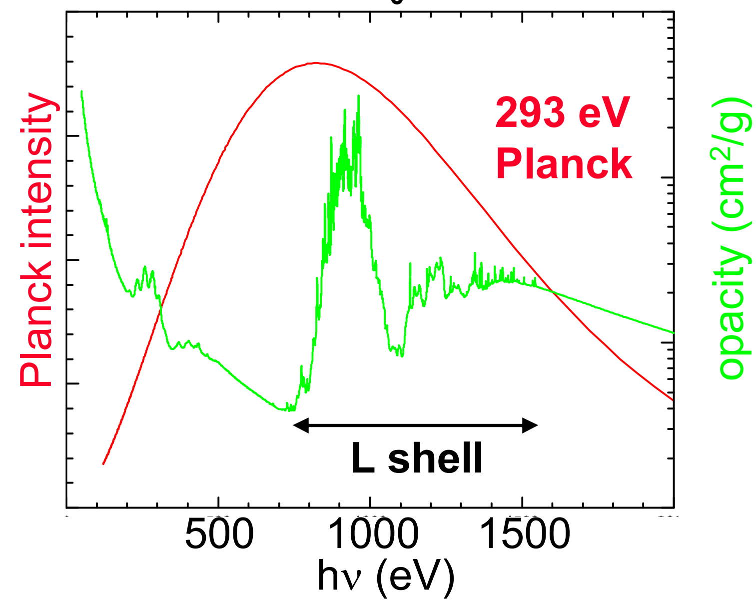
Opacity experiment priority: produce the charge states found in stellar interiors

Fe at 182 eV, 9 x 10 ^{22} cm^{-3}
Radiation/convection boundary



Fe at 293 eV, 4 x 10 ^{23} cm^{-3}
Radius = 0.5 R_0



- **transitions in Fe with L-shell vacancies are important in the sun**
- **First: study this class of transitions**
- **Second: study density effects**
- **Third: study mixtures**

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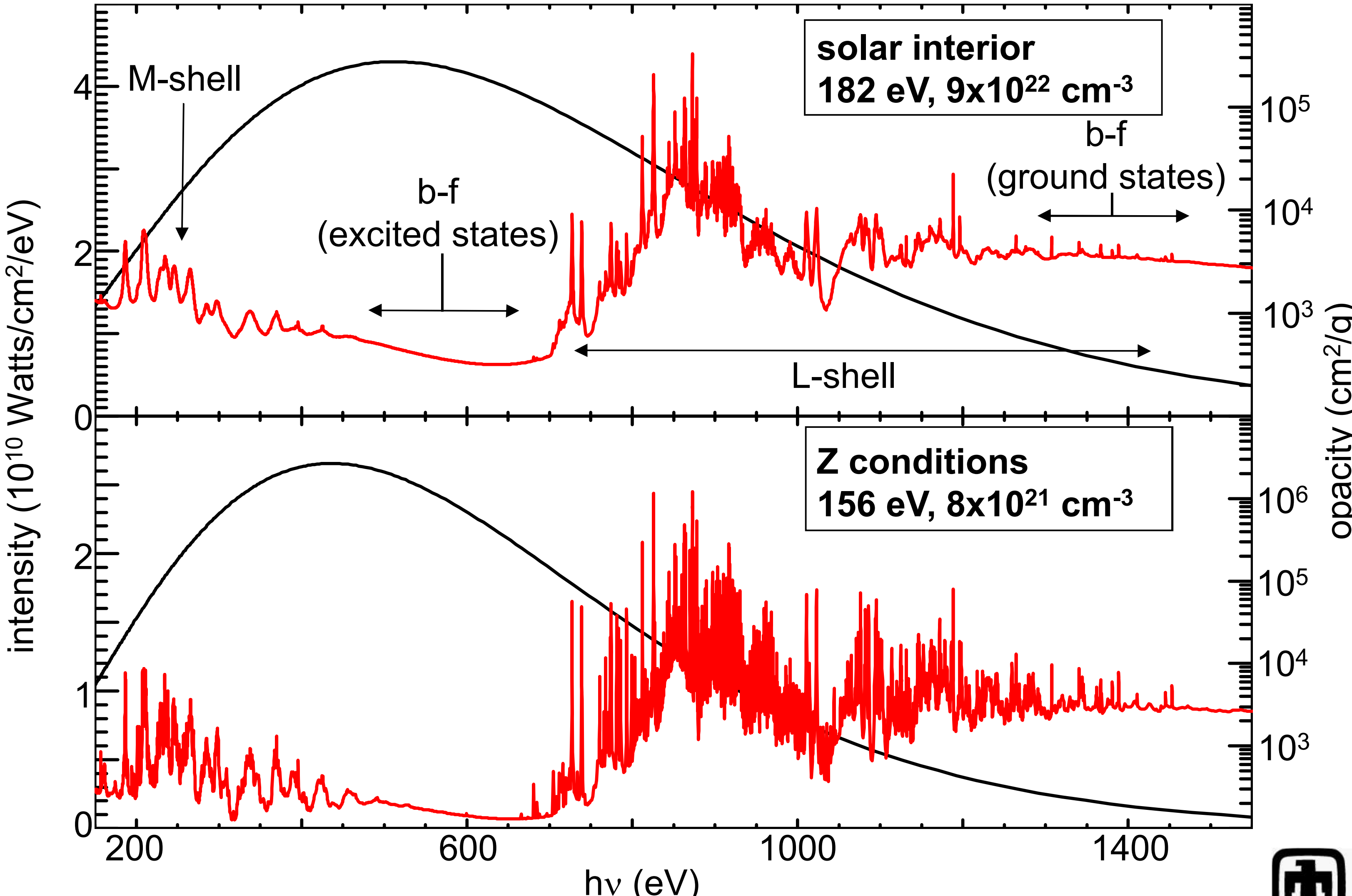
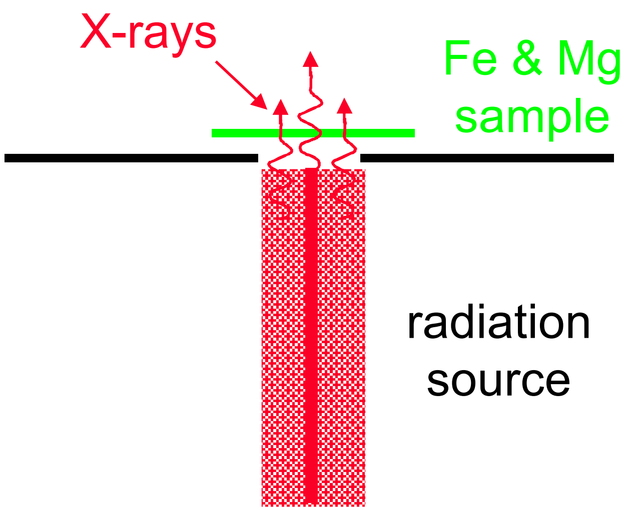
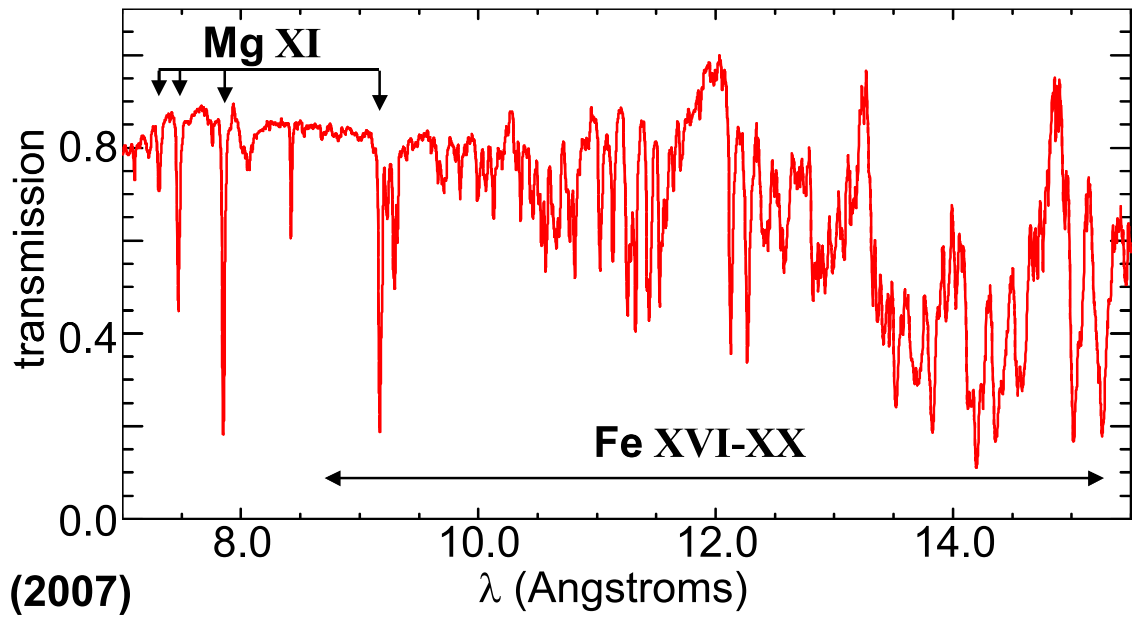
Z experiments investigate Fe L-shell configurations that are important in the sun



Z opacity experiments reach T ~ 156 eV, two times higher than in prior Fe research



Fe + Mg at T_e ~ 156 eV, n_e ~ 6.9×10^{21} cm^{-3}



J.E. Bailey et al., PRL accepted (2007)

- **Mg is the "thermometer", Fe is the test element**
- **Mg features analyzed with PrismSPECT, Opal, RCM, PPP, Opas**

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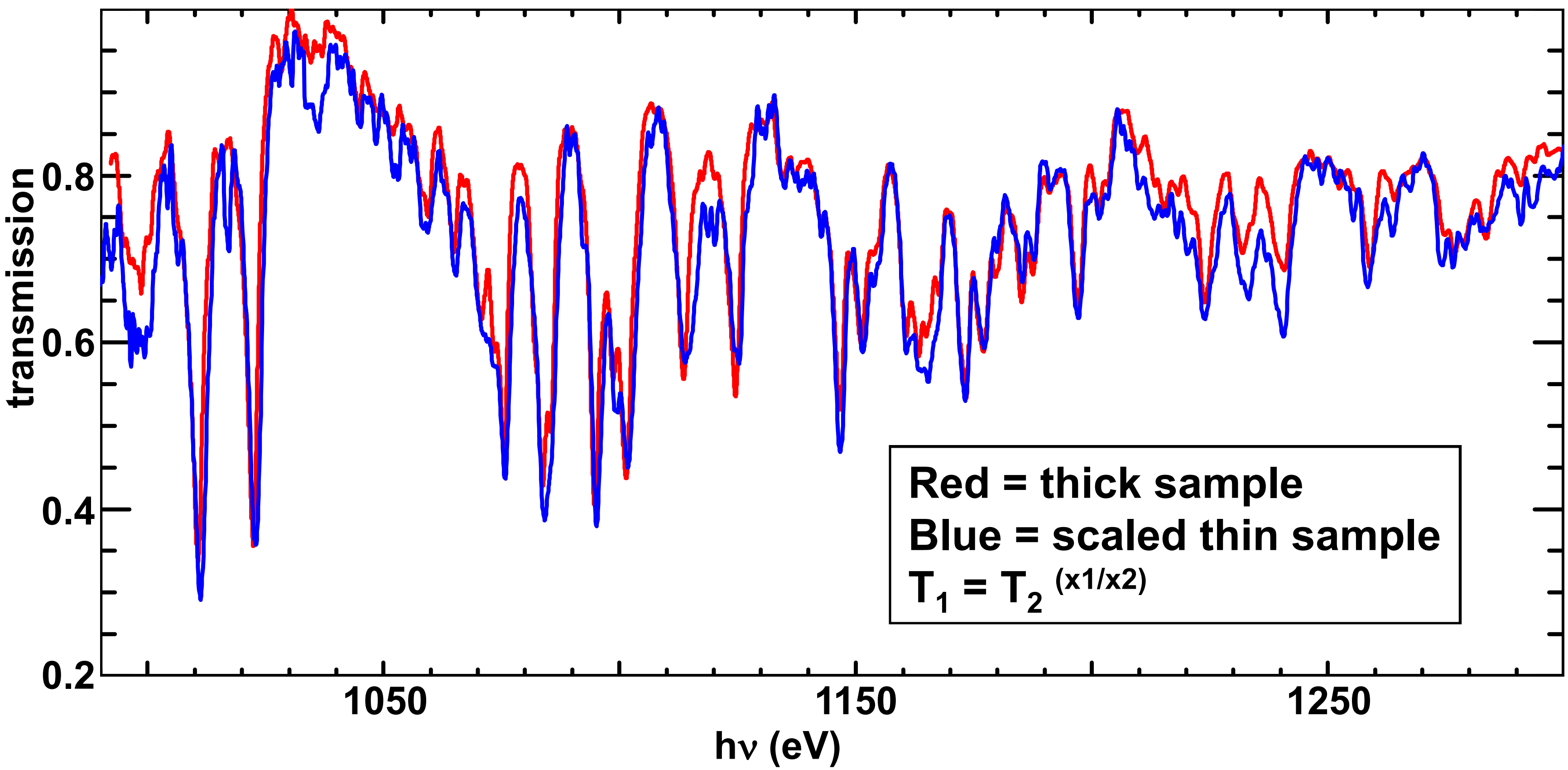
Transmission scaling with thickness is an important test for experiment reliability



Un-desired effects such as self emission, gradients, transmission errors all tend to change the transmission scaling with thickness

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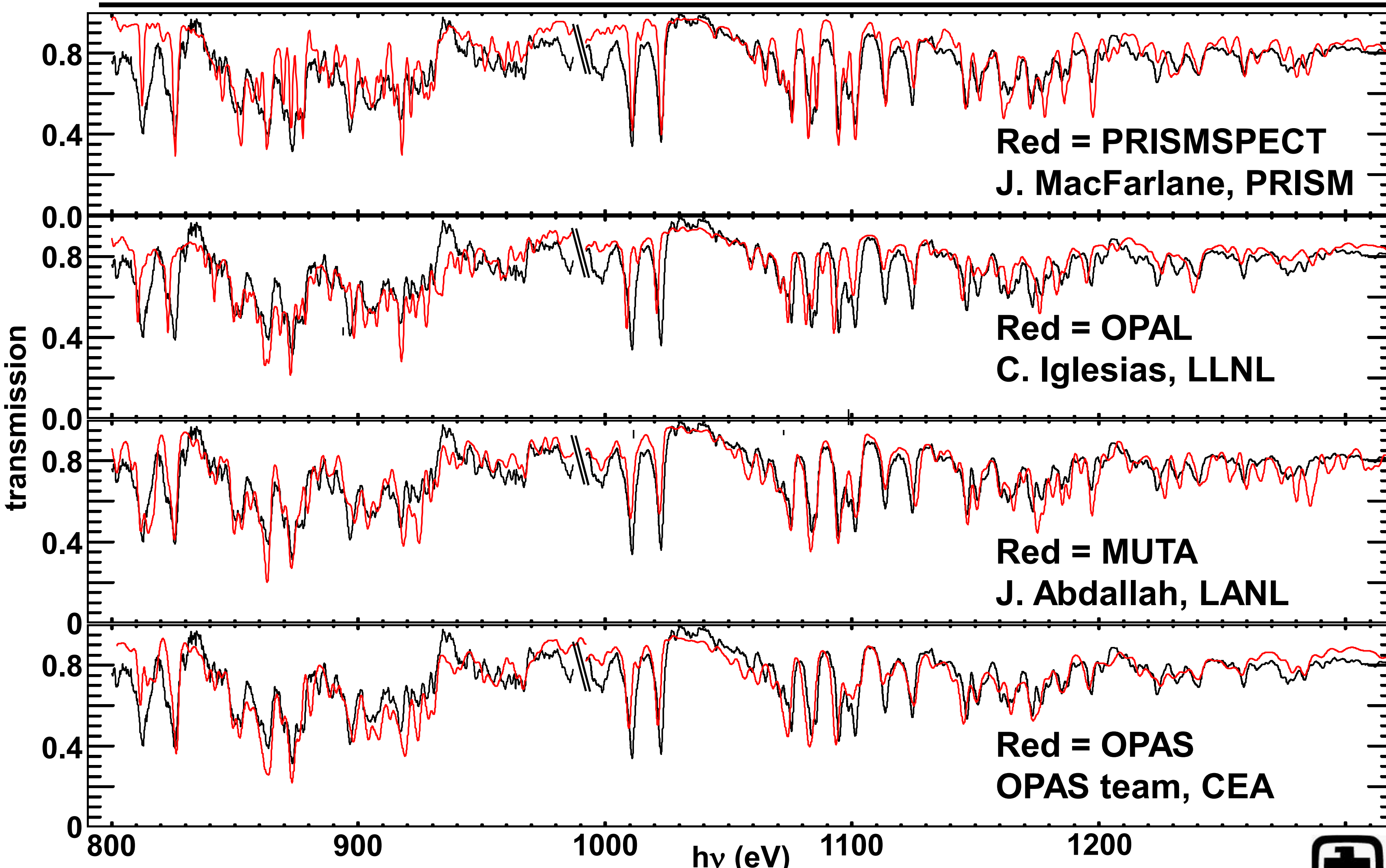
Modern detailed opacity models are in remarkable overall agreement with the Fe data



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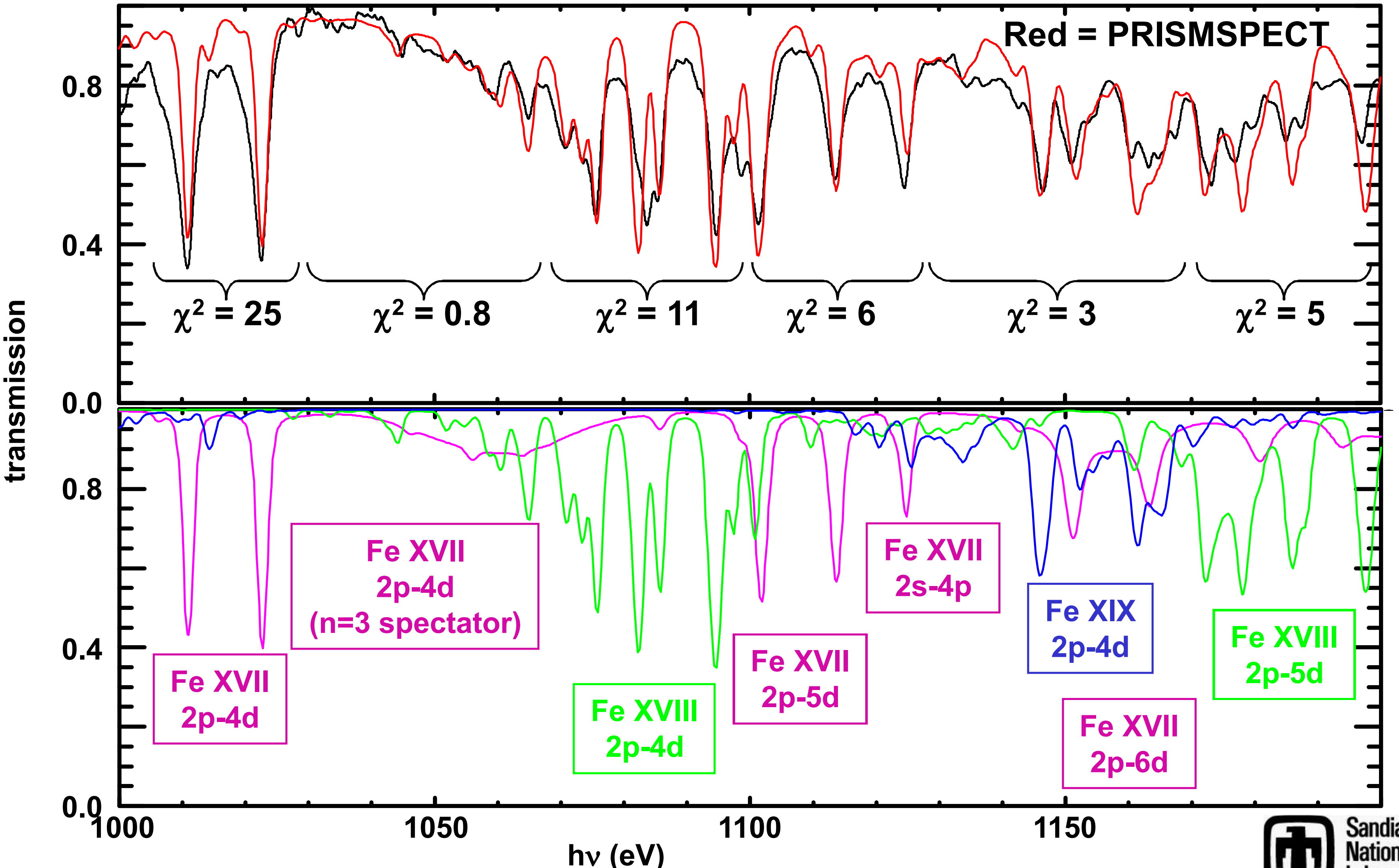
Strategy for stellar opacity evaluation

- Applications may or may not require “spectroscopic accuracy”
- But we cannot test models under all conditions for all elements
- We need a thorough physical understanding
- Determine χ^2 (λ) for each model
- Evaluate whether residual experiment flaws could cause discrepancies
- Refine model physics to reduce χ^2
- Consider models with lowest χ^2 as benchmark for stellar applications

Detailed comparisons advance understanding of physical processes



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Future : evaluate impact of present data on solar models and design higher density experiments

- Question: Can this work tell us whether prior solar opacities were accurate to better than 20%?
- Construct Rosseland and Planck mean opacities
- Compare:

  Data to modern detailed models

  Data to prior models used in solar application

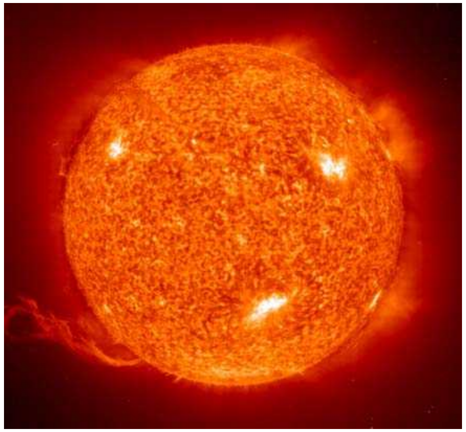
  Modern models to prior models (extend $h\nu$ range)

- With reasonable understanding for this class of L-shell transitions, now we are ready for new experiments:

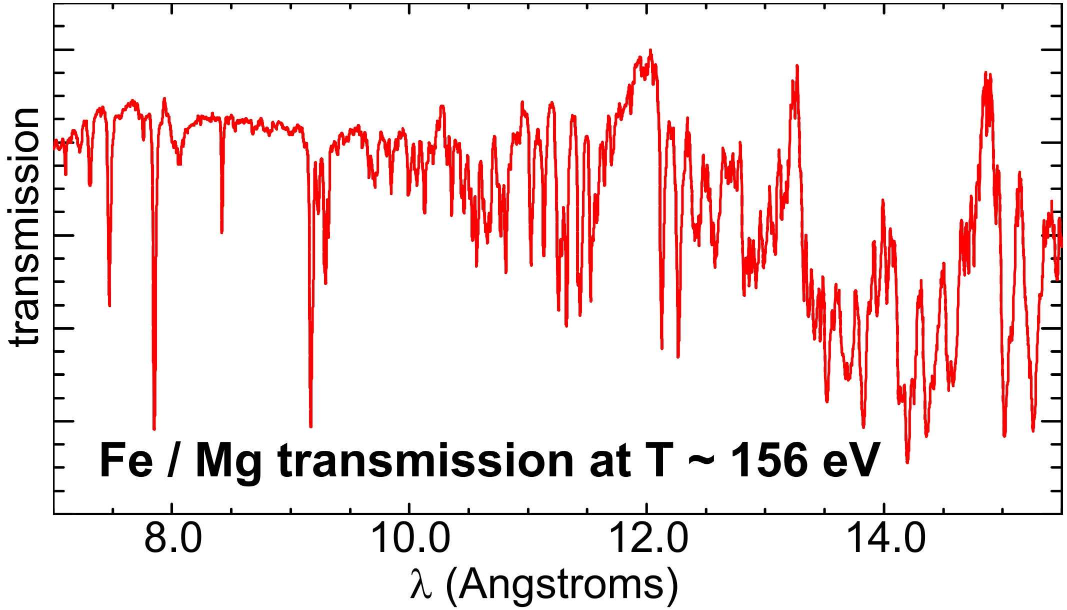
  Increase density

  Alter sample composition (e.g., Fe & O in CH_2 plasma)

Laboratory experiments test opacity models that are crucial for stellar interior physics



Emergent radiation depends on opacity



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