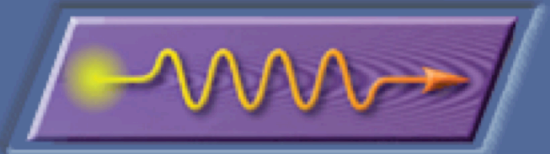
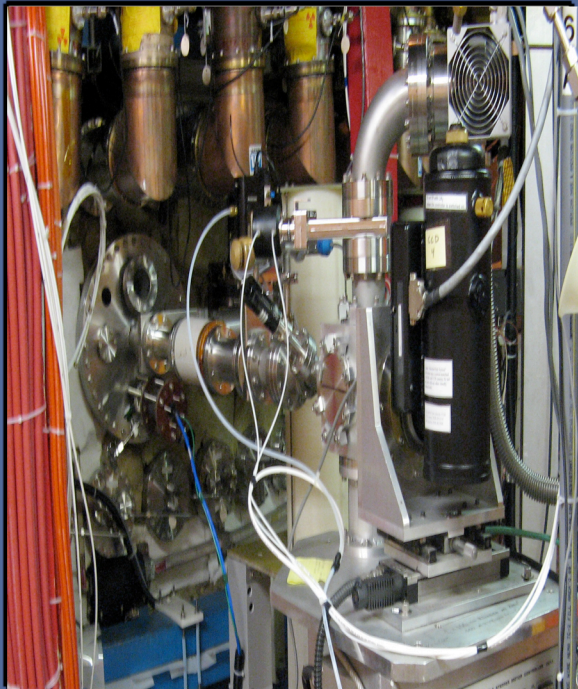


# Unusual emission lines of iron between 170 and 200 Å: Markers for non-thermal processes in the corona?



Physical and Life Sciences Directorate



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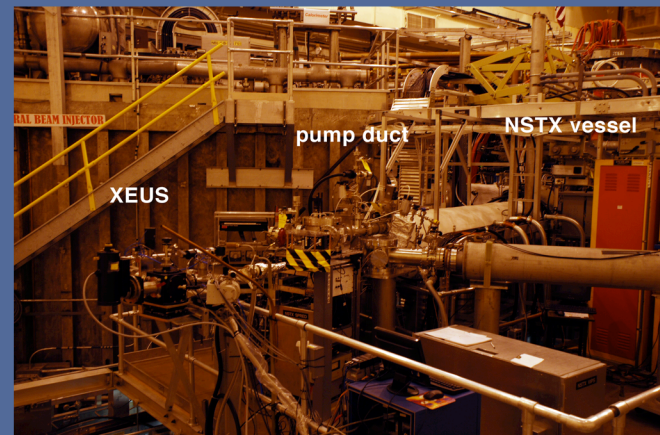
**Lawrence Livermore Nat Lab**

**Princeton Plasma Physics Lab**

**Princeton Plasma Physics Lab**

**Center for Astrophysics**

**Center for Astrophysics**



June 26, 2012

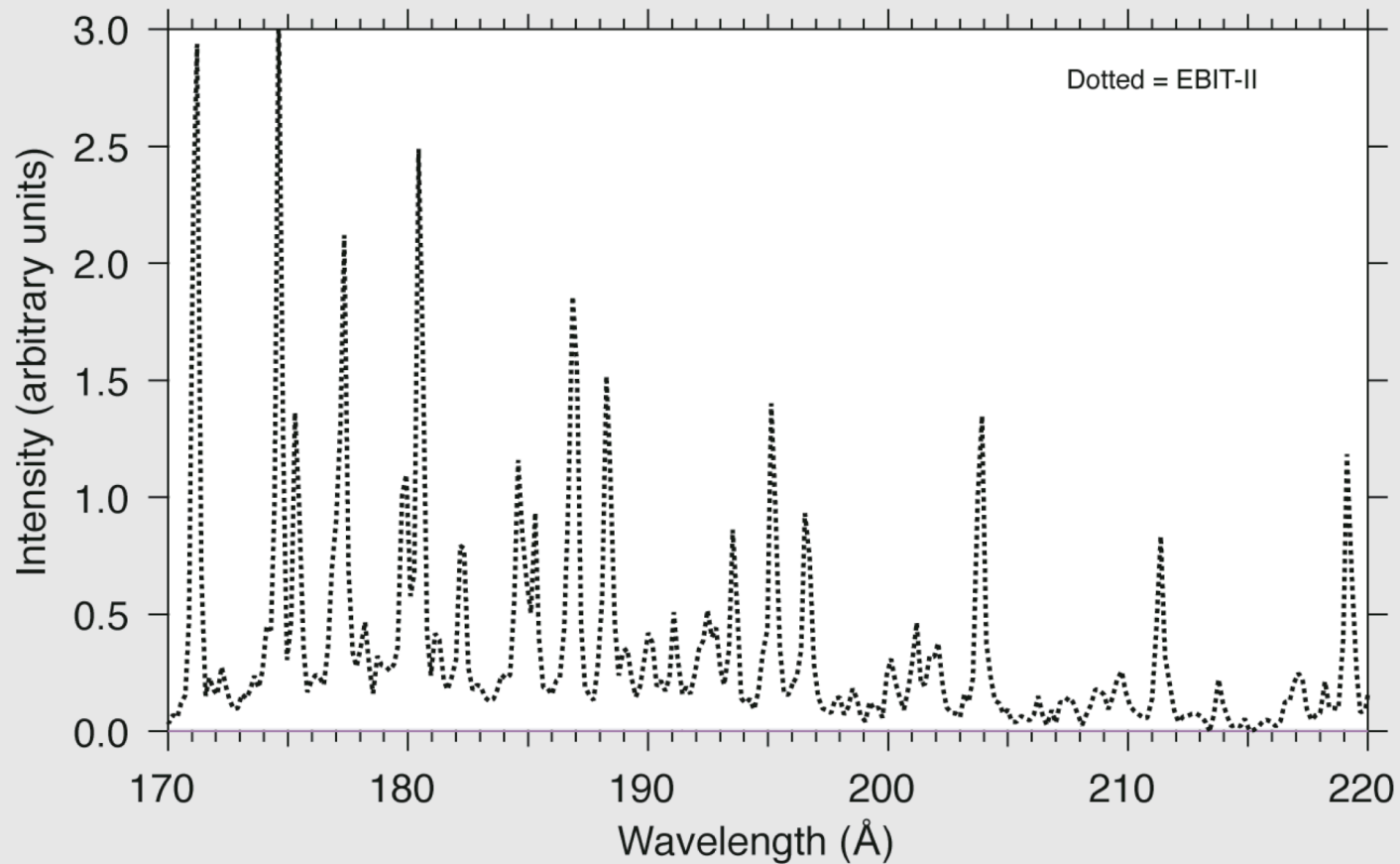
Barcelona

# Outline

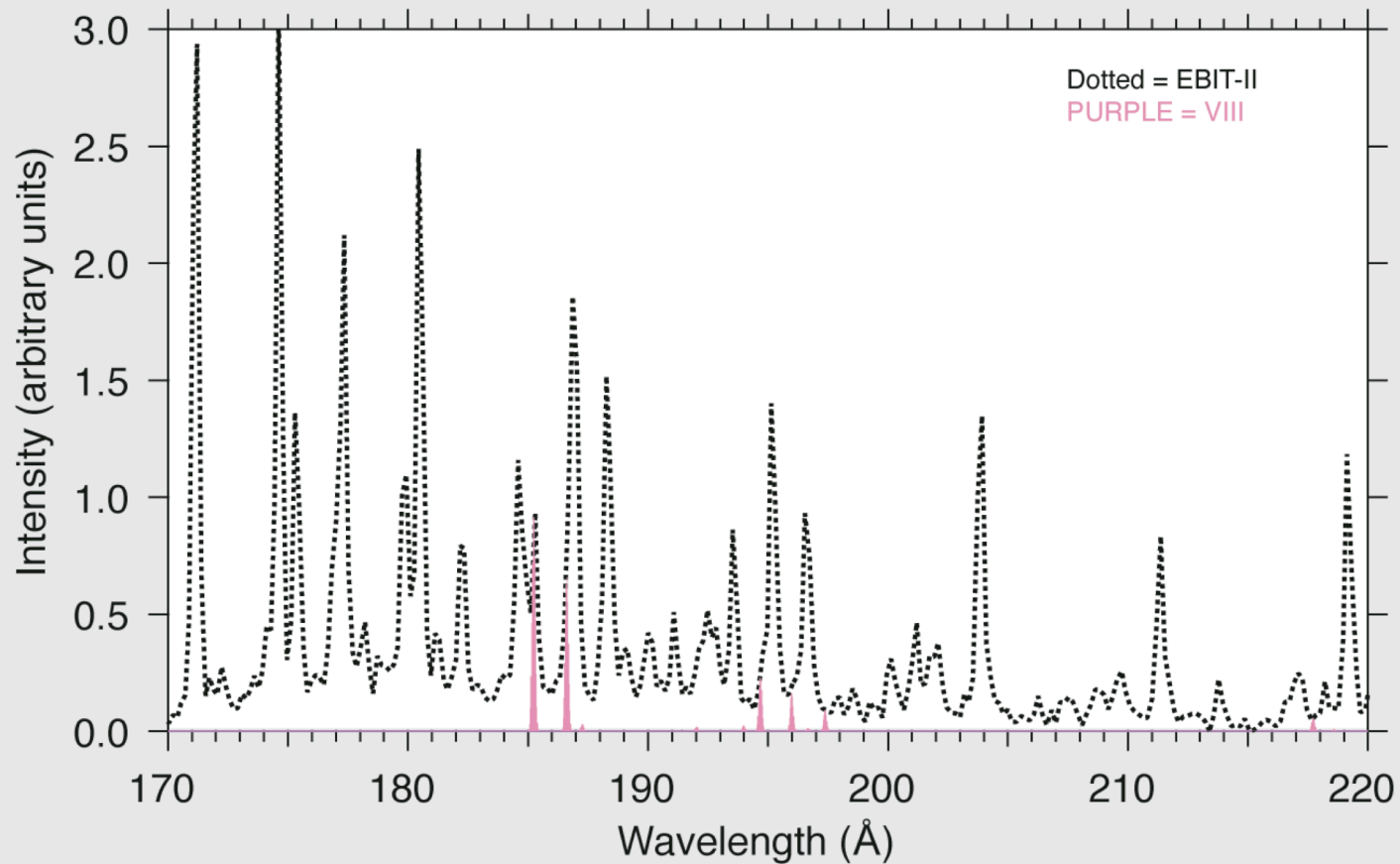
- **How well do we know the iron M-shell emission above 170 Å?**
- **Measurements on the NSTX tokamak:  
New iron or strongly enhanced iron lines**
- **Progress in line identification**
- **Summary**



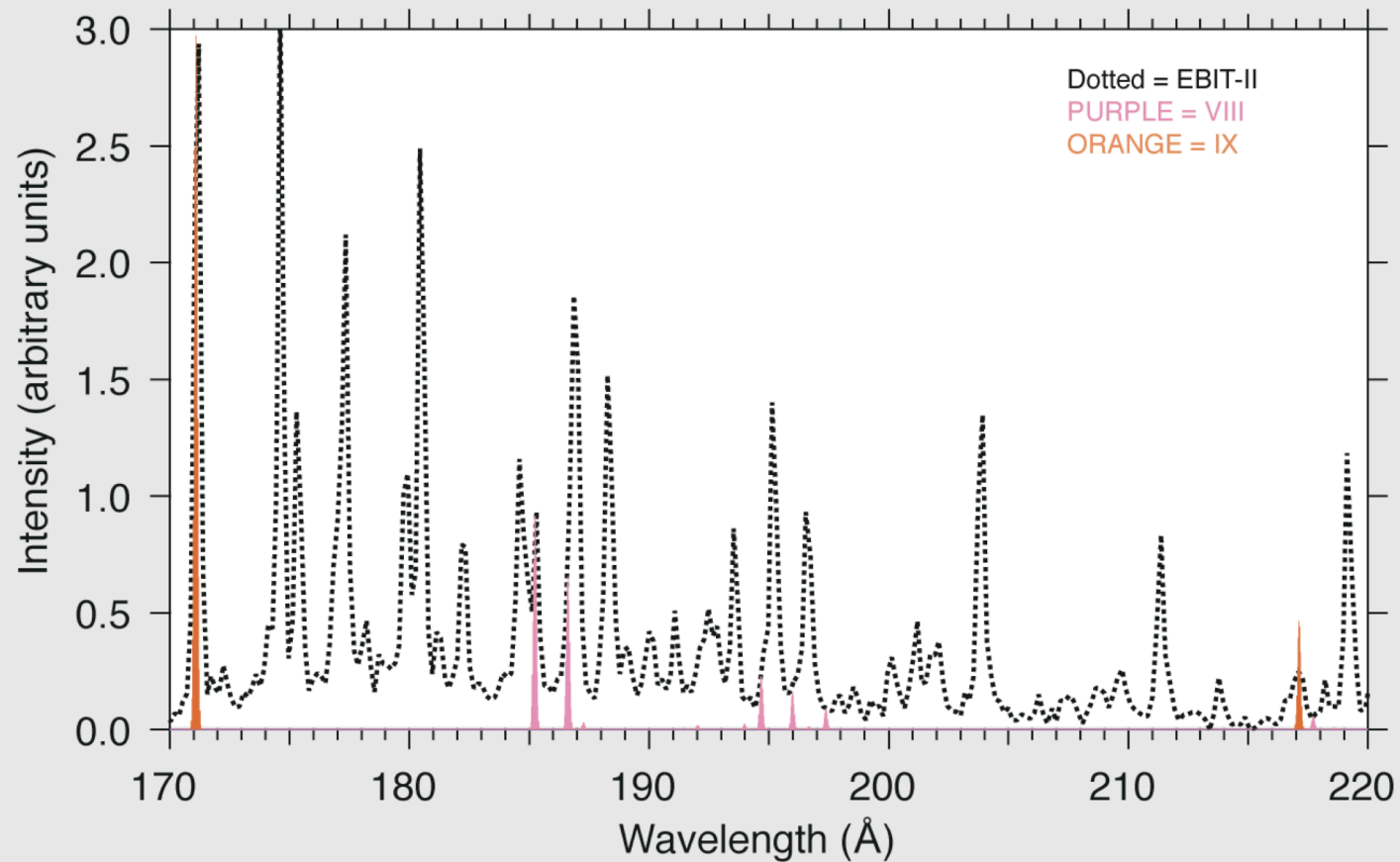
# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI



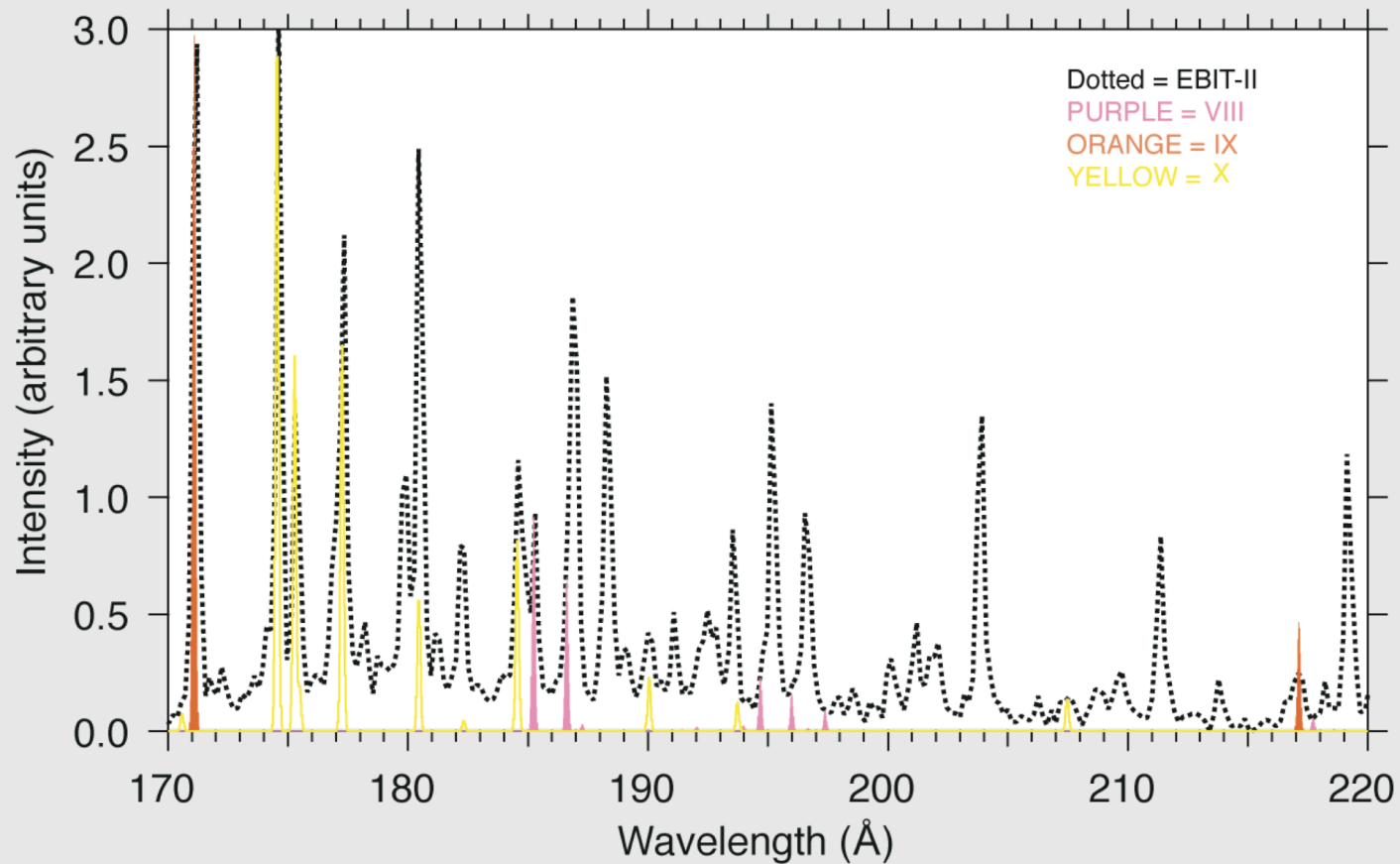
# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI



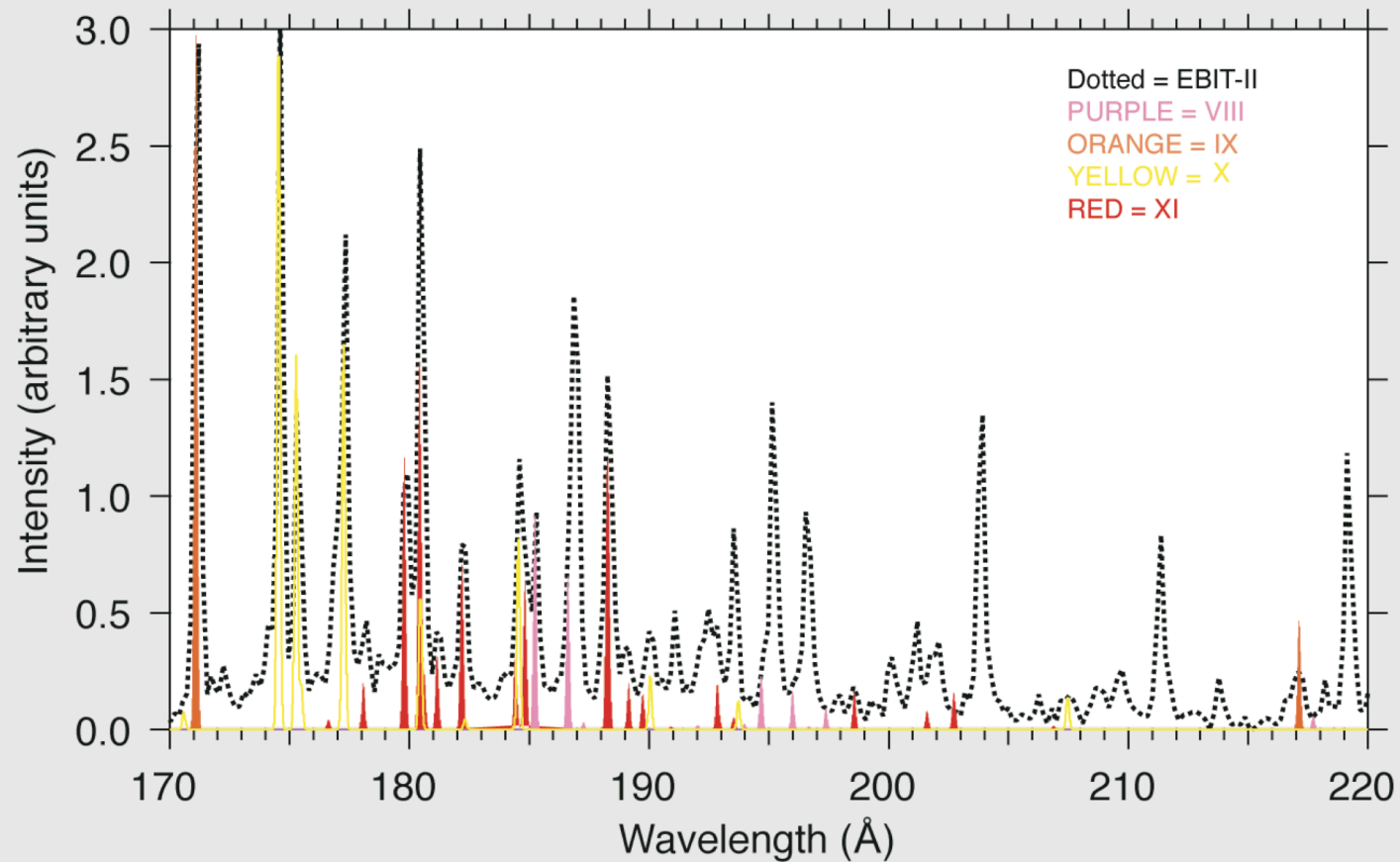
# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI



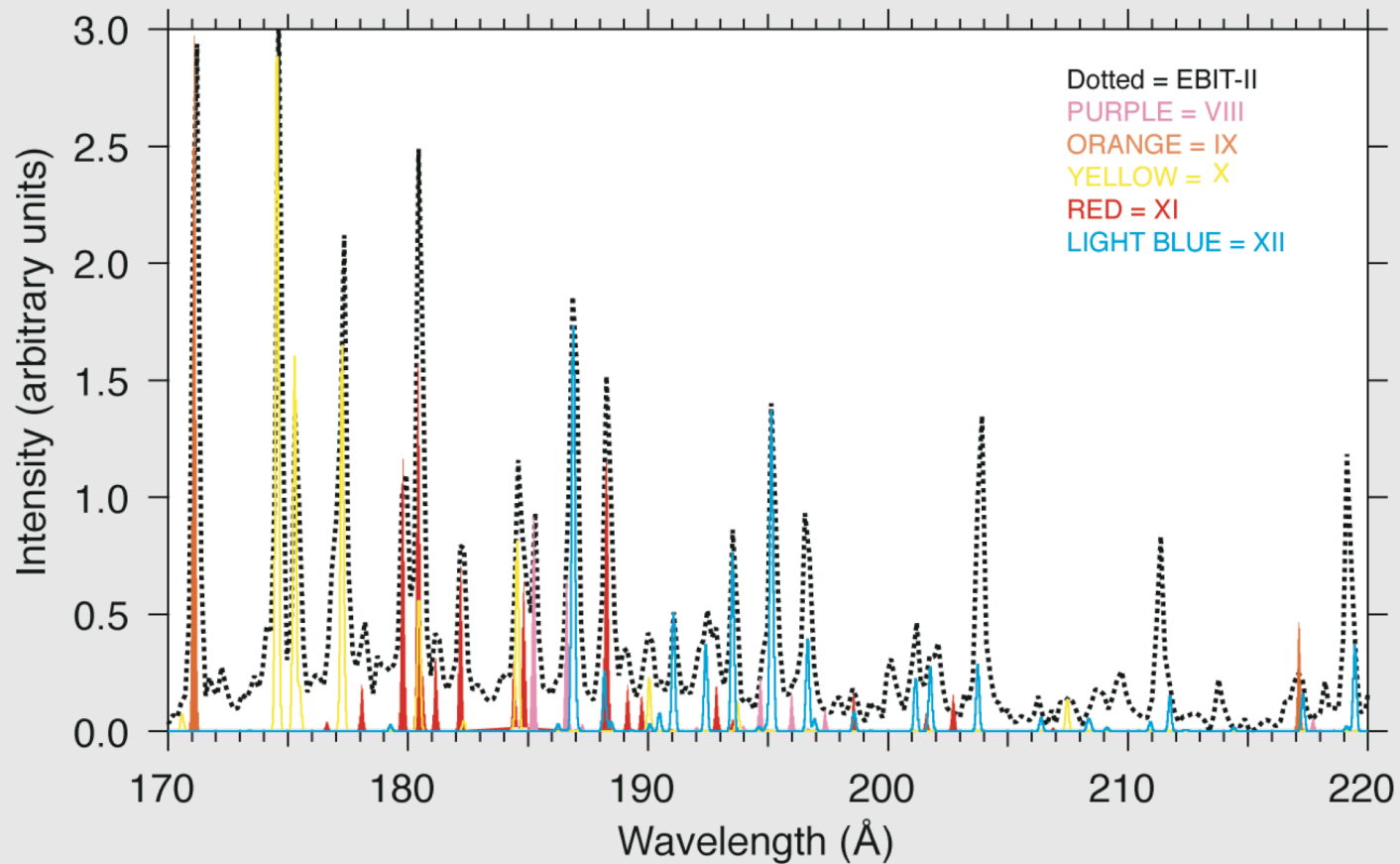
# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI



# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI

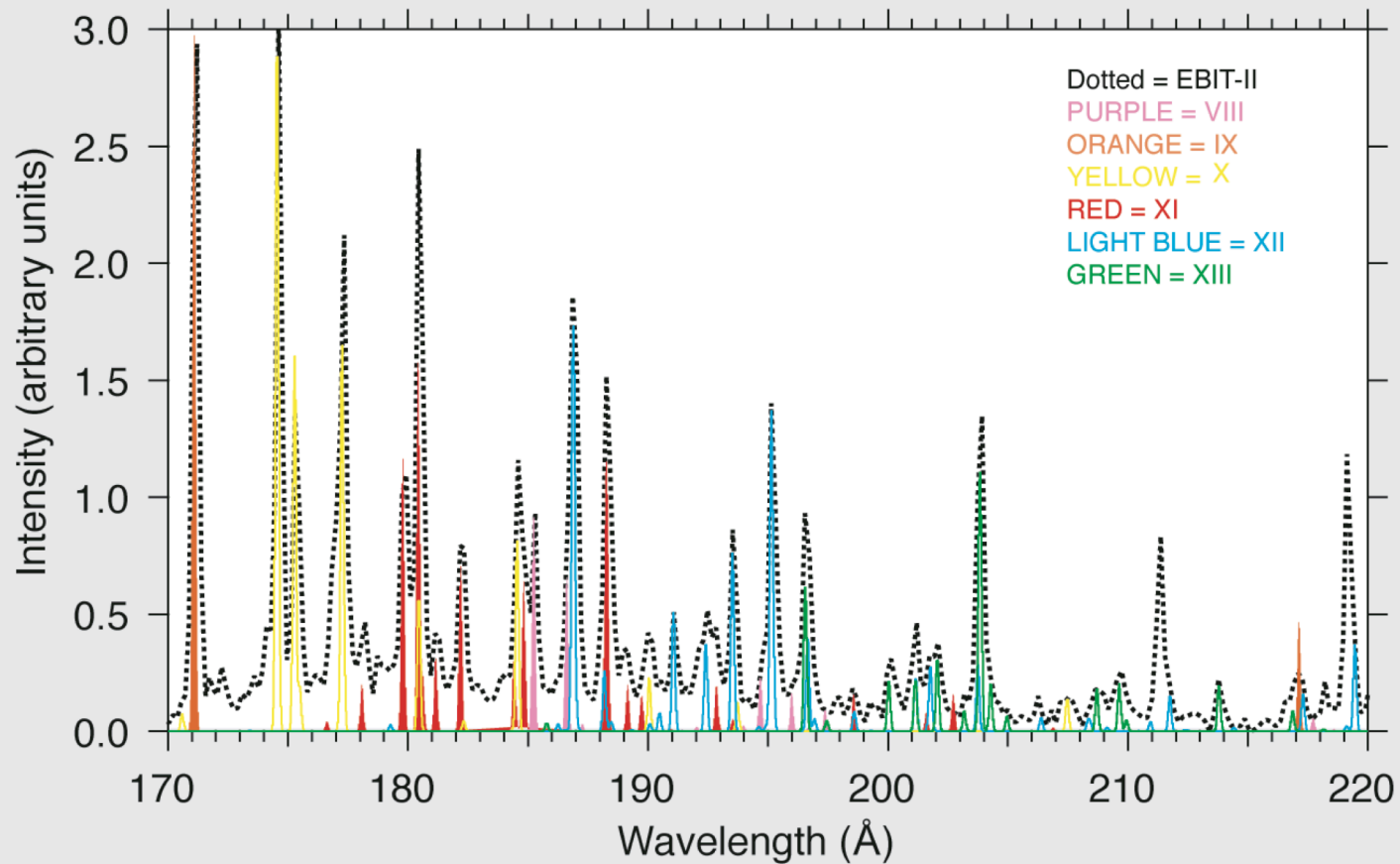


# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI

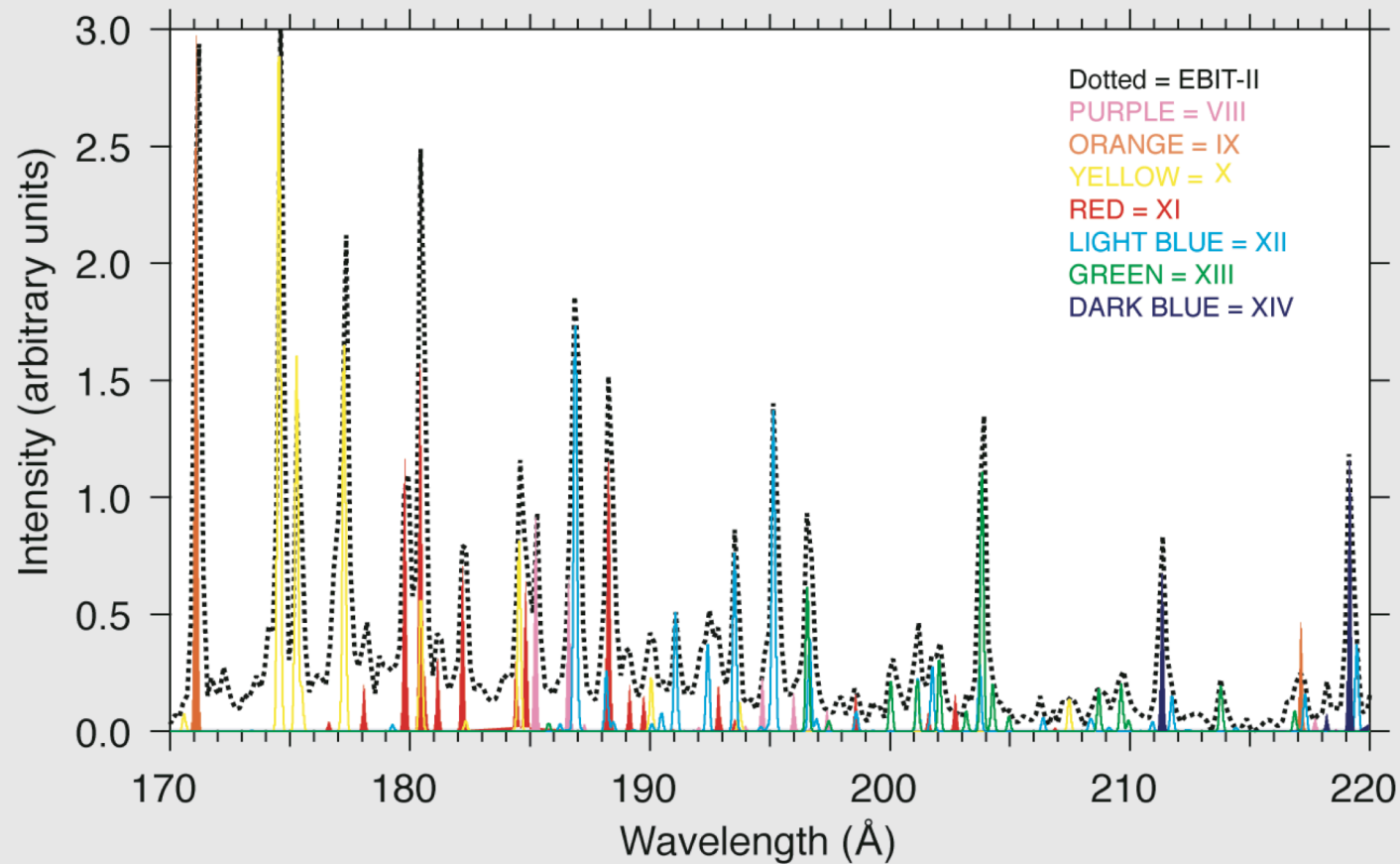




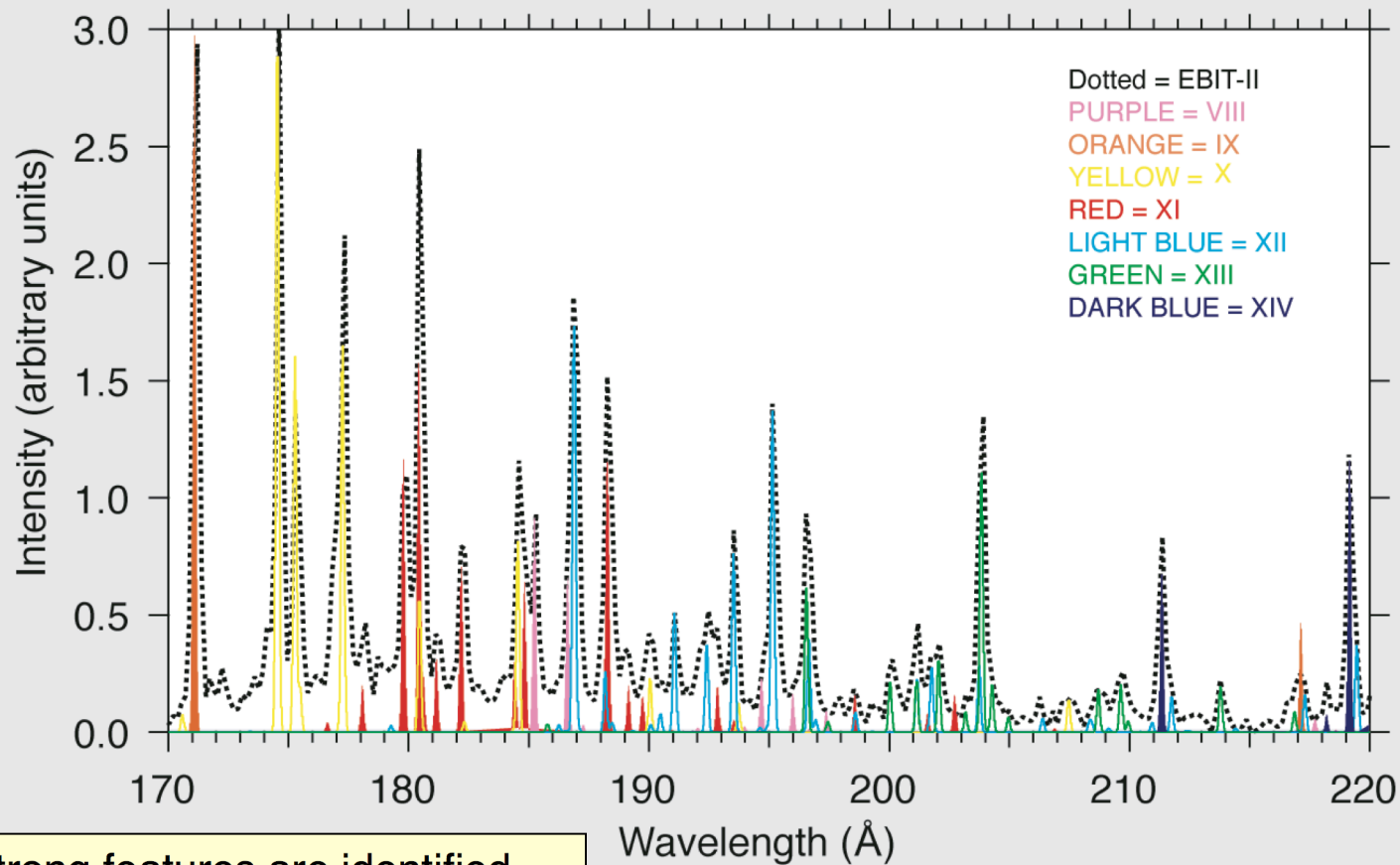
# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI



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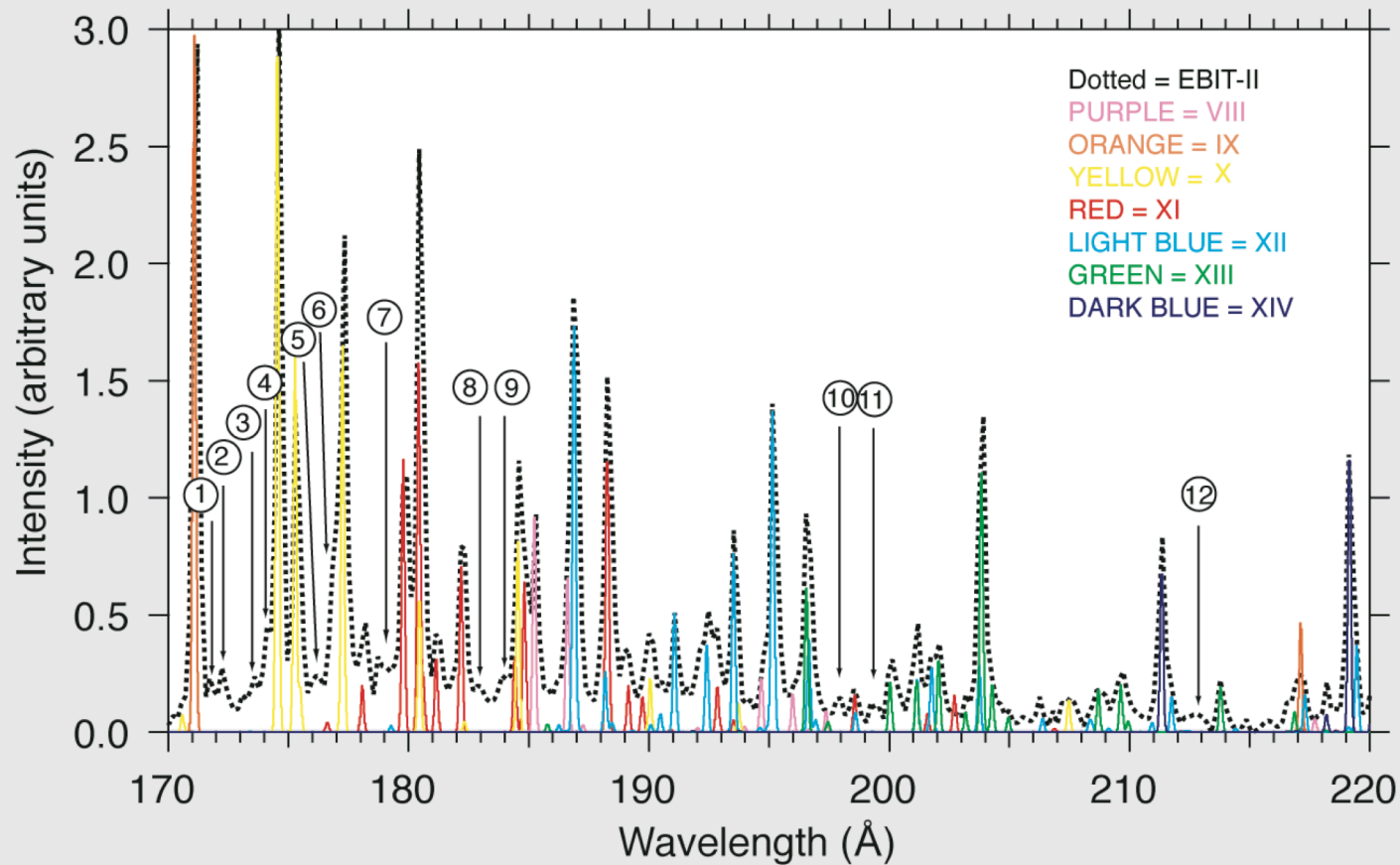
# Laboratory iron M-shell emission survey spectra and predictions from CHIANTI



All strong features are identified –  
only a few weak ones are missing



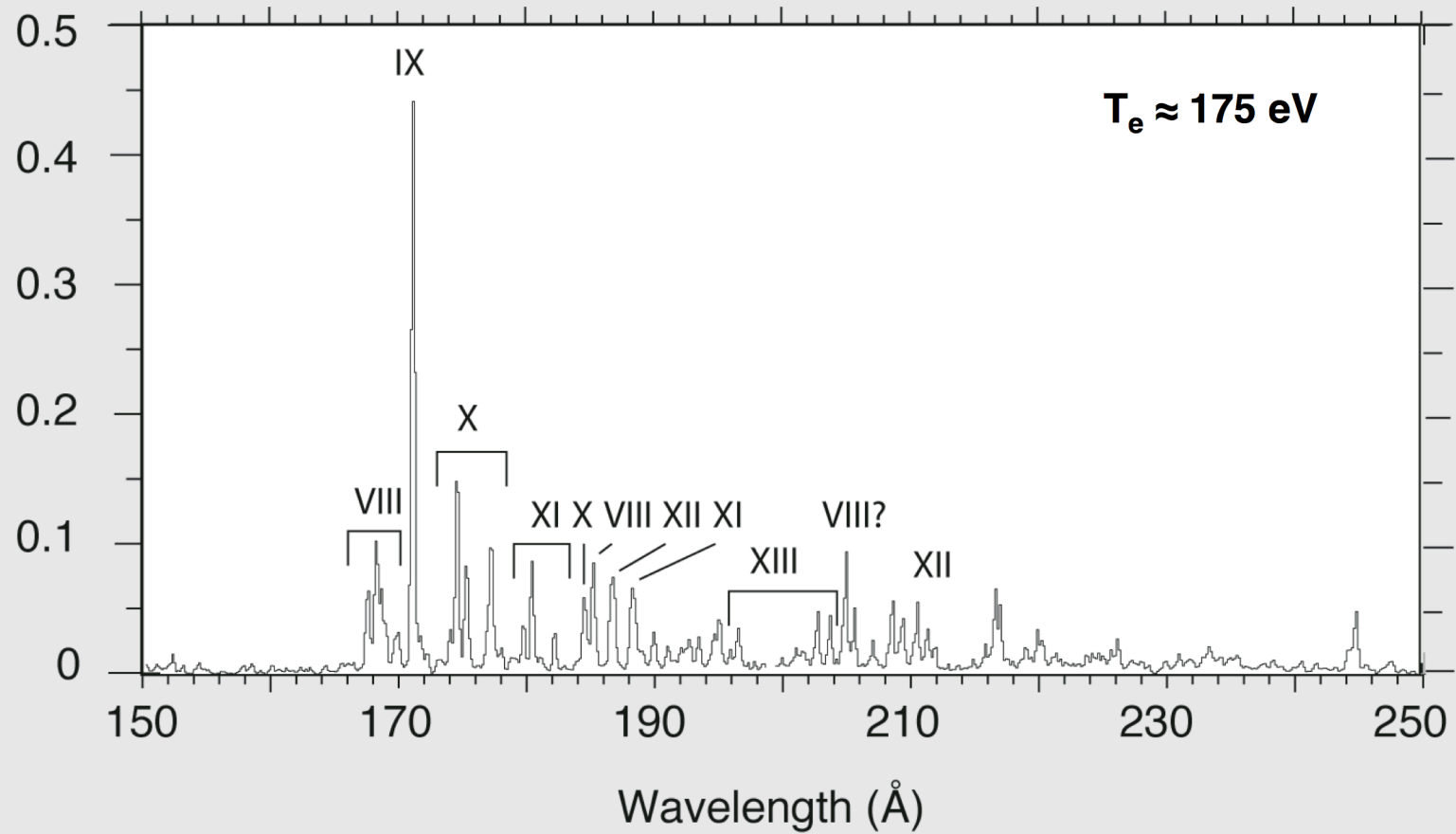
# Twelve weak features have been noted that cannot be reproduced by CHIANTI v7.0



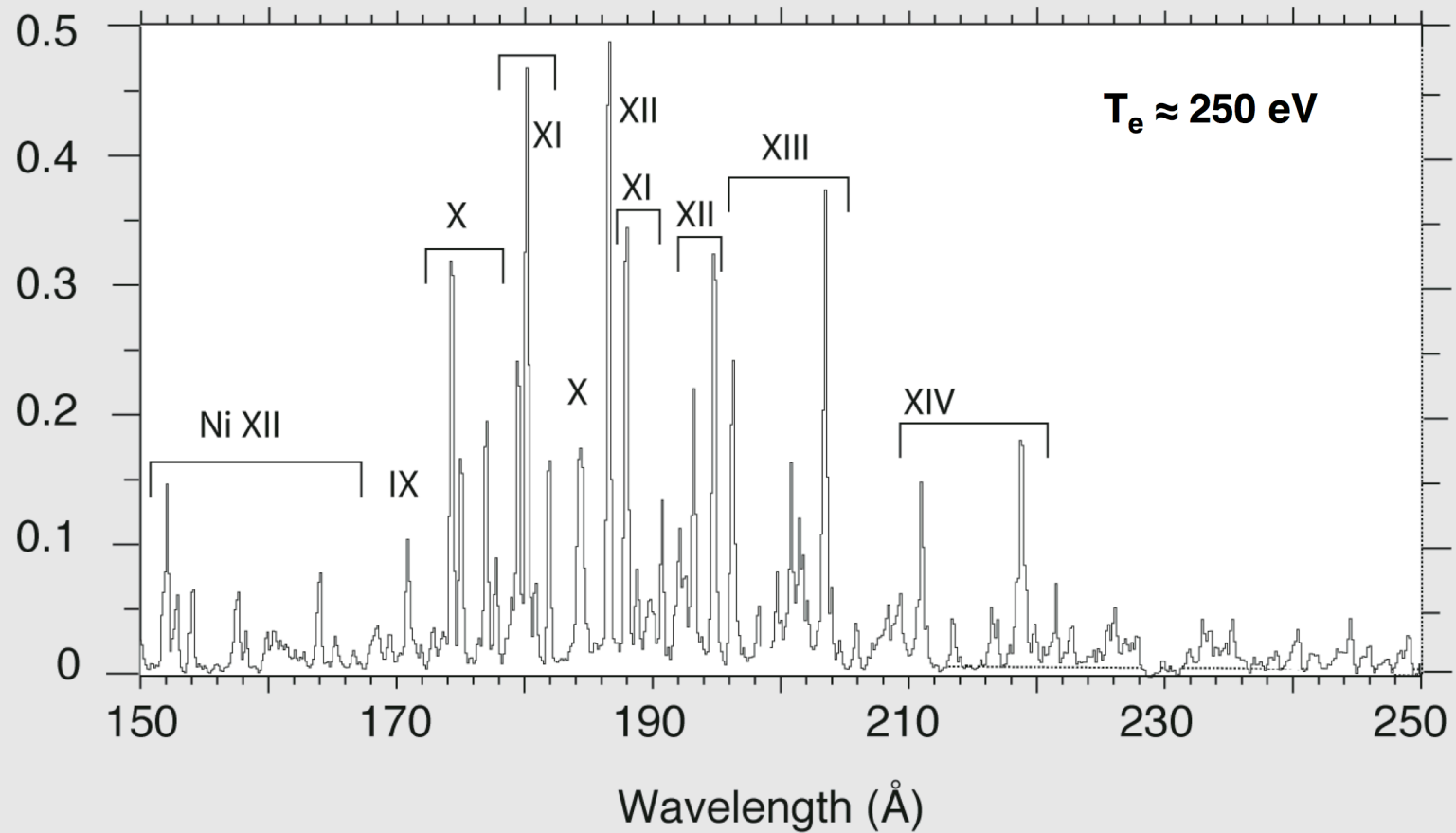
Beiersdorfer & Lepson.,  
ApJS in press (2012)



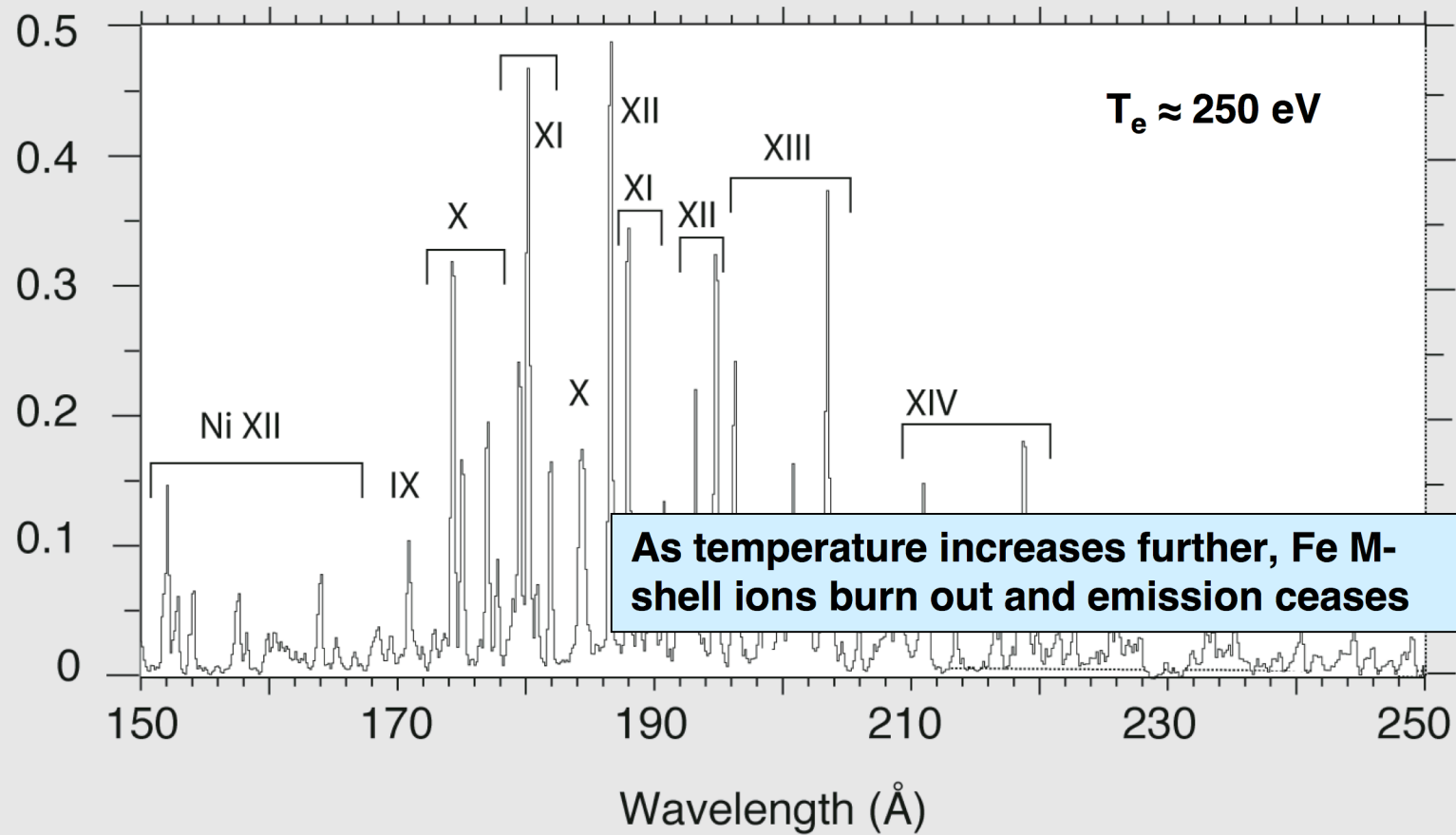
# Measurements on the NSTX tokamak



# Measurements on the NSTX tokamak

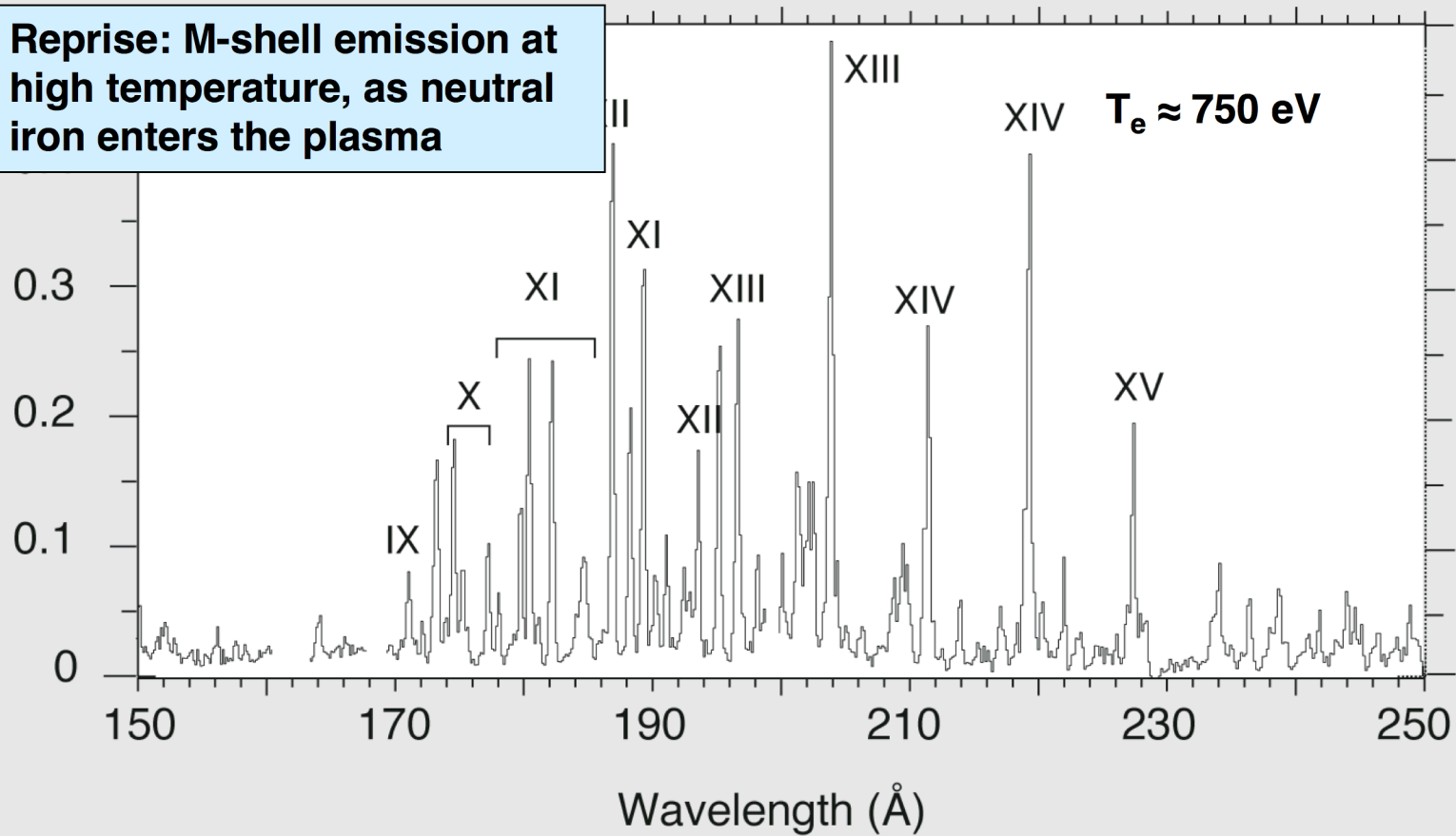


# Measurements on the NSTX tokamak



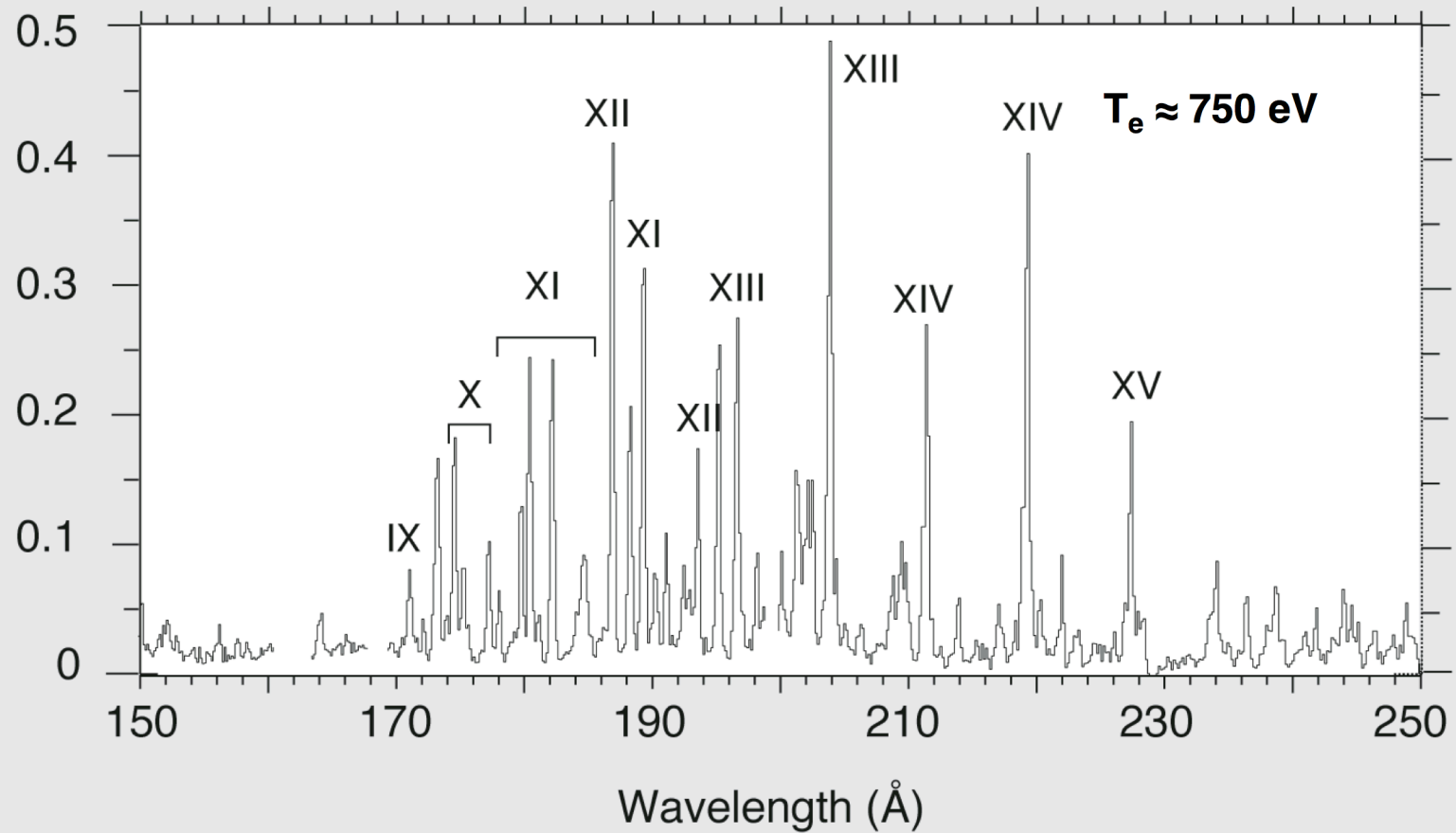
# Measurements on the NSTX tokamak

Reprise: M-shell emission at high temperature, as neutral iron enters the plasma

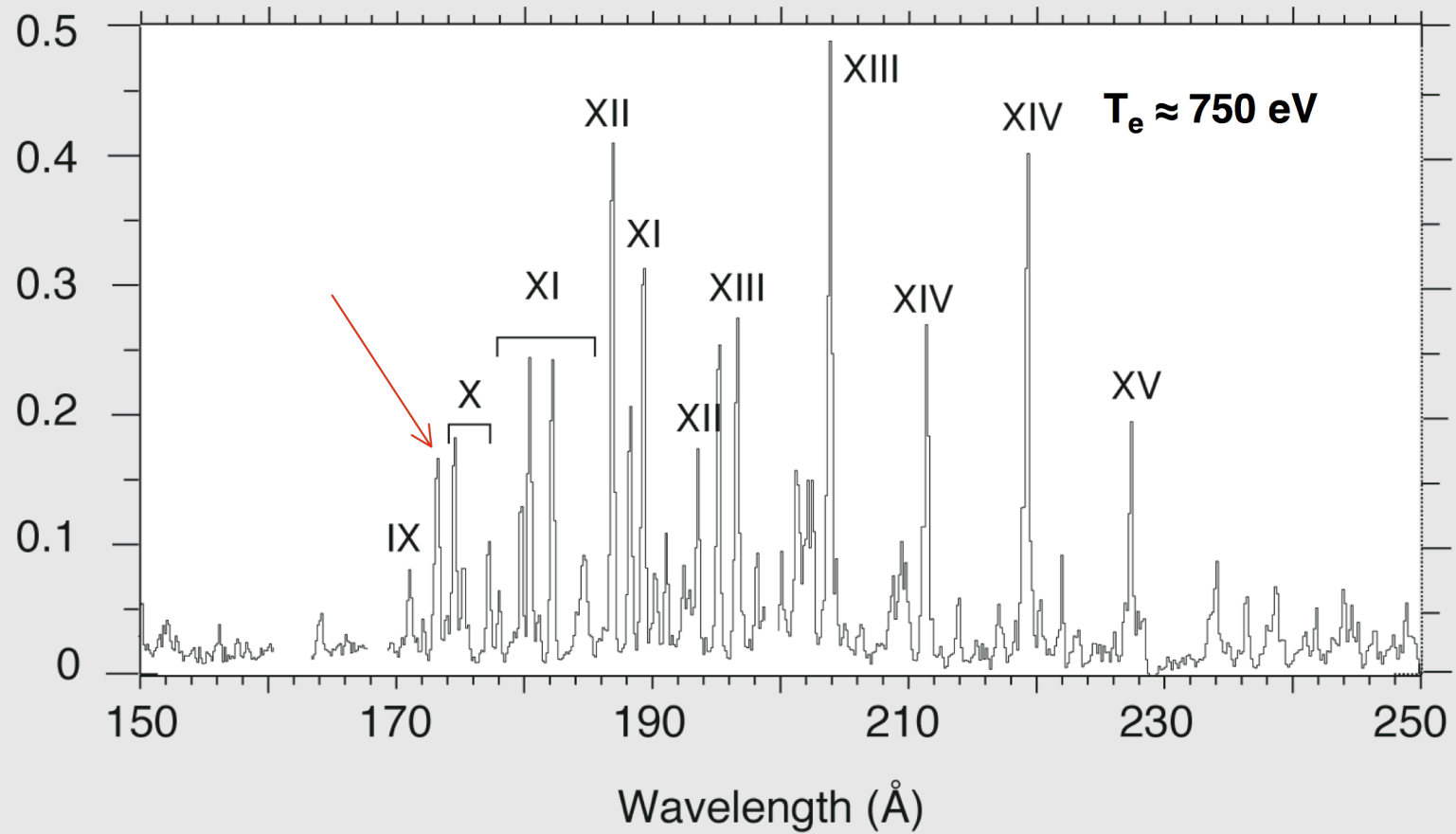




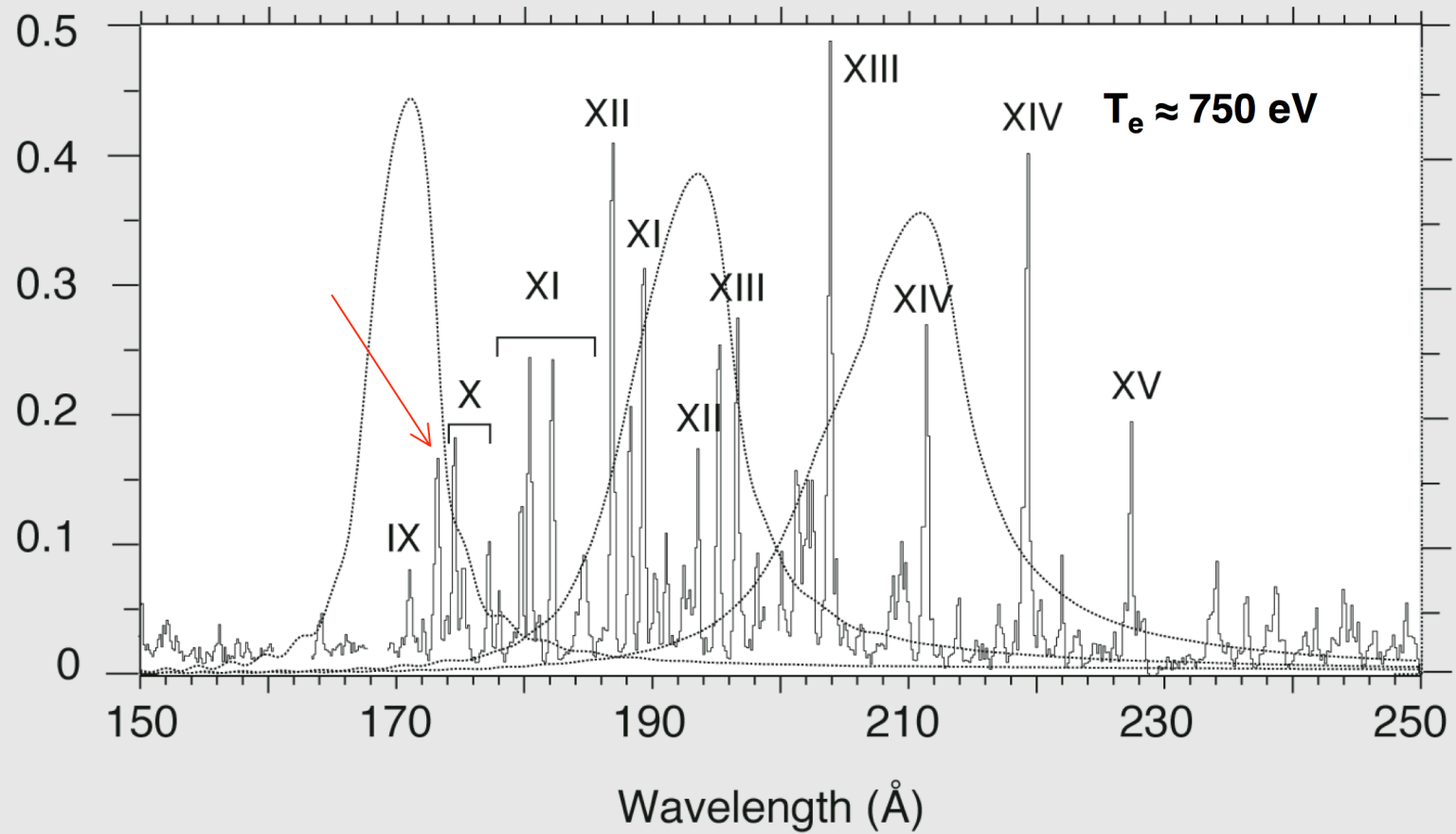
# Measurements on the NSTX tokamak



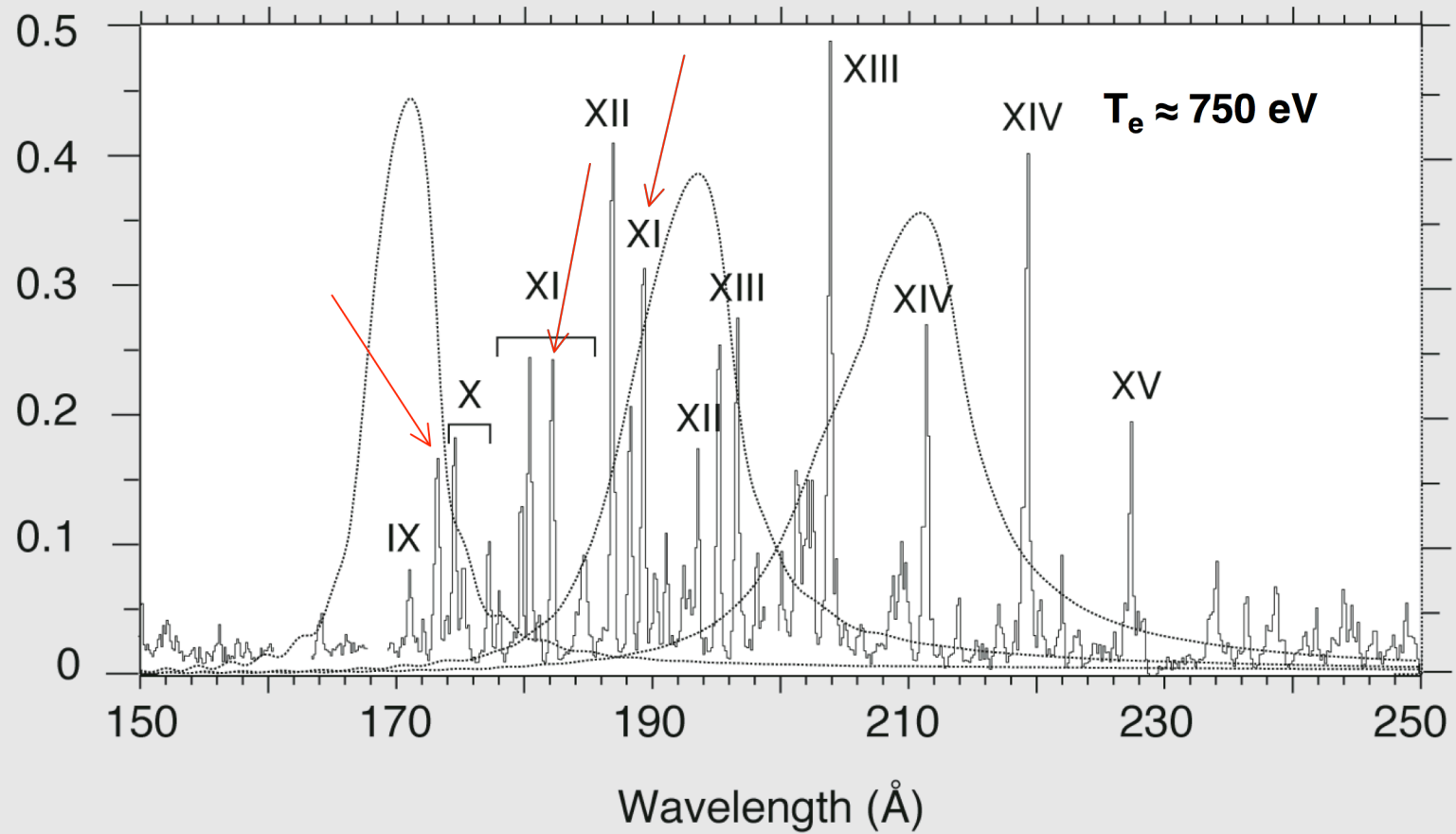
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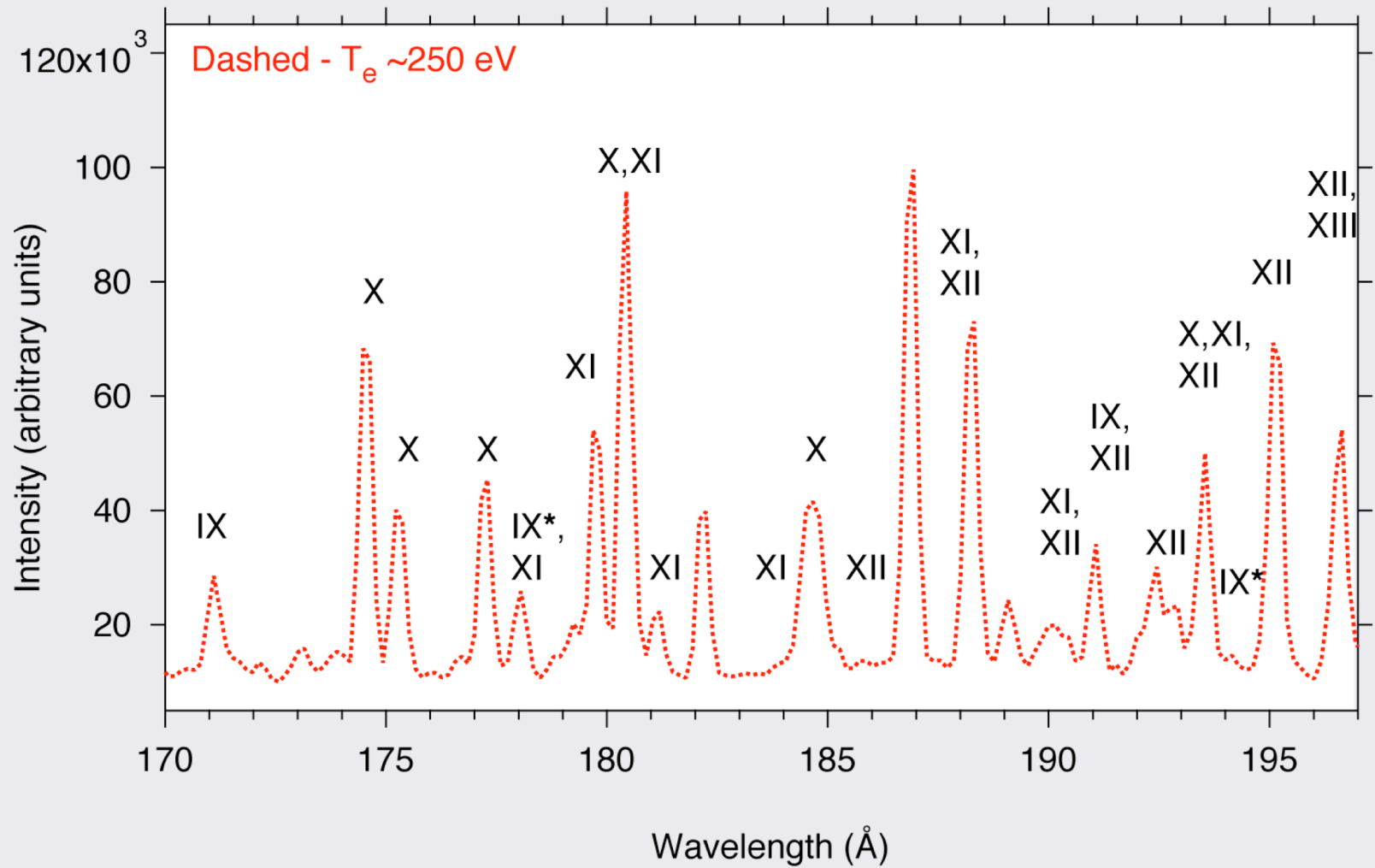
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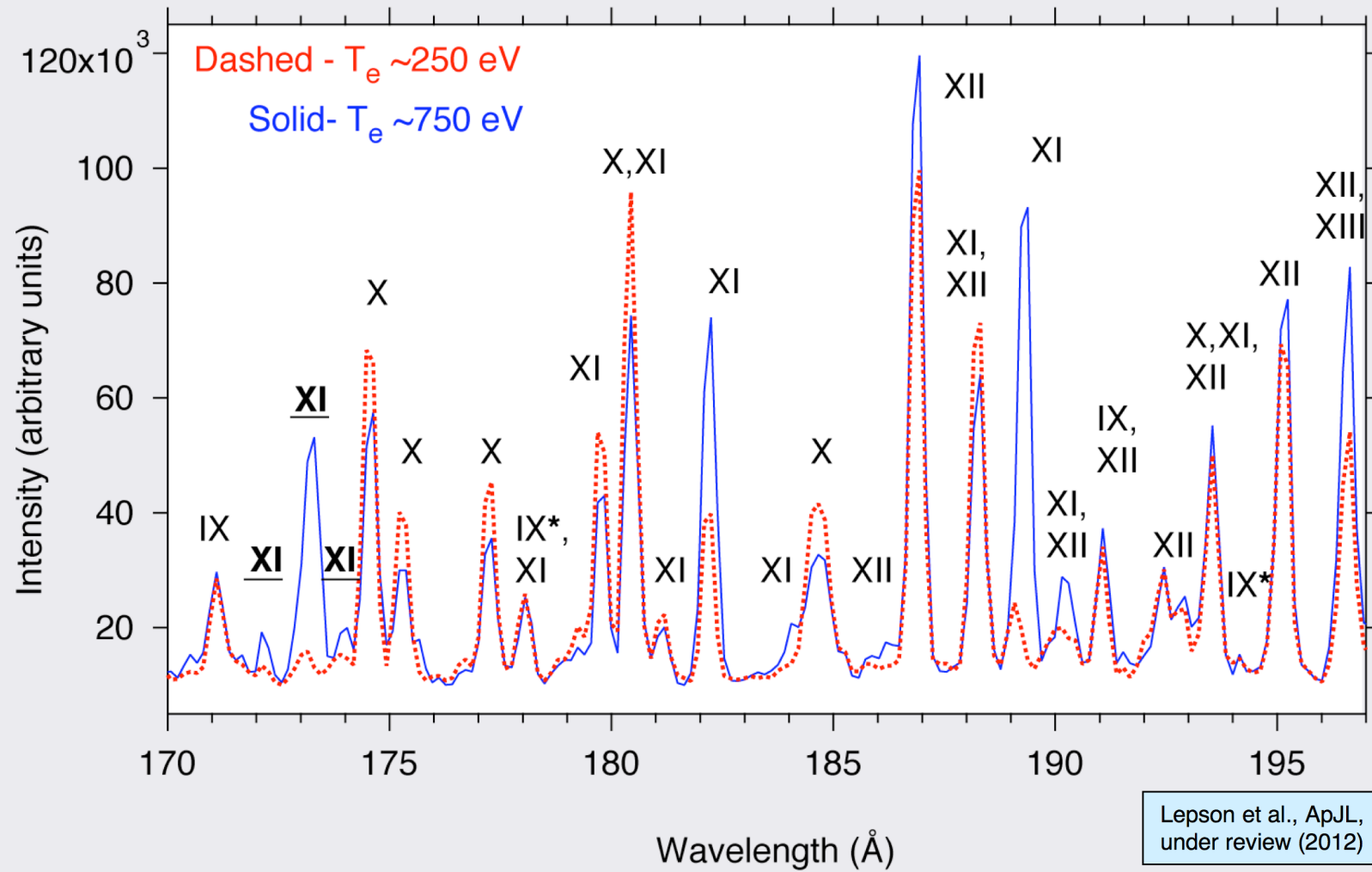
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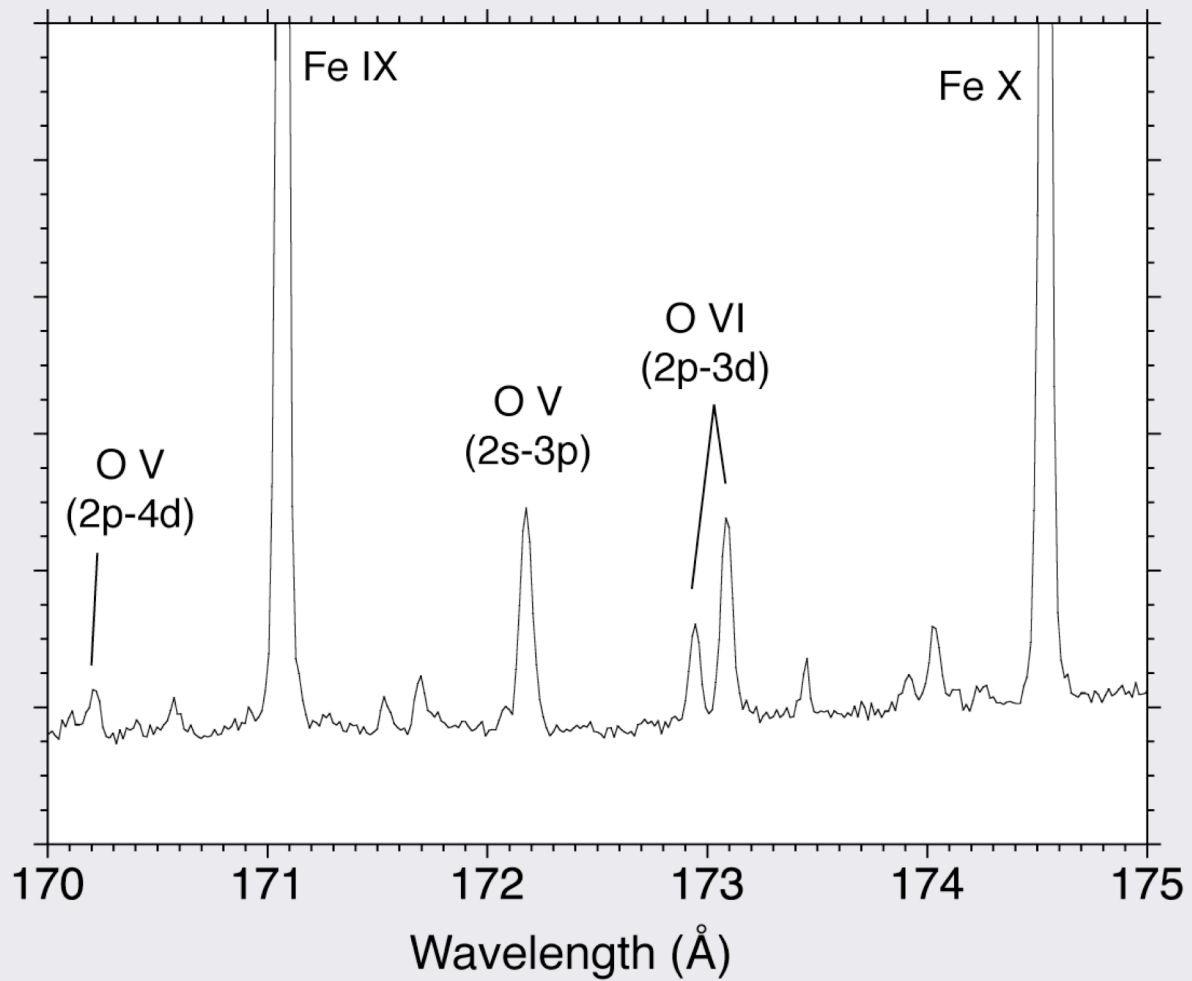


## Summary of line formation conditions

- The new lines or strongly enhanced lines only appear in a hot, dense ( $\approx 4 \times 10^{13} \text{ cm}^{-3}$ ) plasma, where such ionization stages would normally not exist
- Neutral iron must have fallen into the plasma
- The strongly enhanced lines all seem to be Fe XI lines
- The newly seen lines near  $172 \text{ \AA}$  may thus also be Fe XI lines
- The lines may be formed by innershell ionization from a lower charge state of iron, which may not even be in the ground state
- If so, these lines would be markers for hot, dense ionizing plasma - perhaps of early stage flares

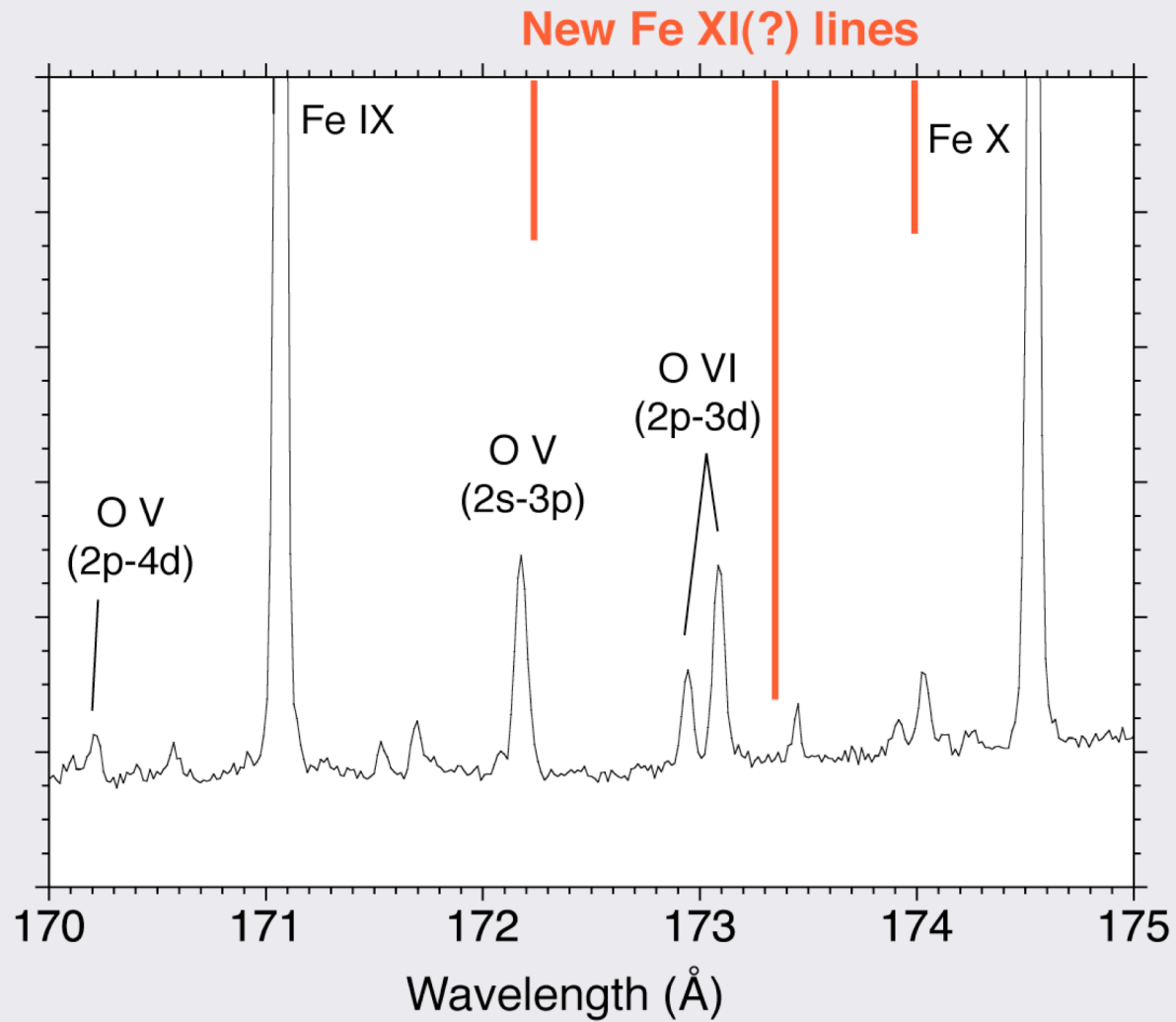


# High-resolution measurement of the SDO Fe IX channel on the Livermore electron beam ion trap

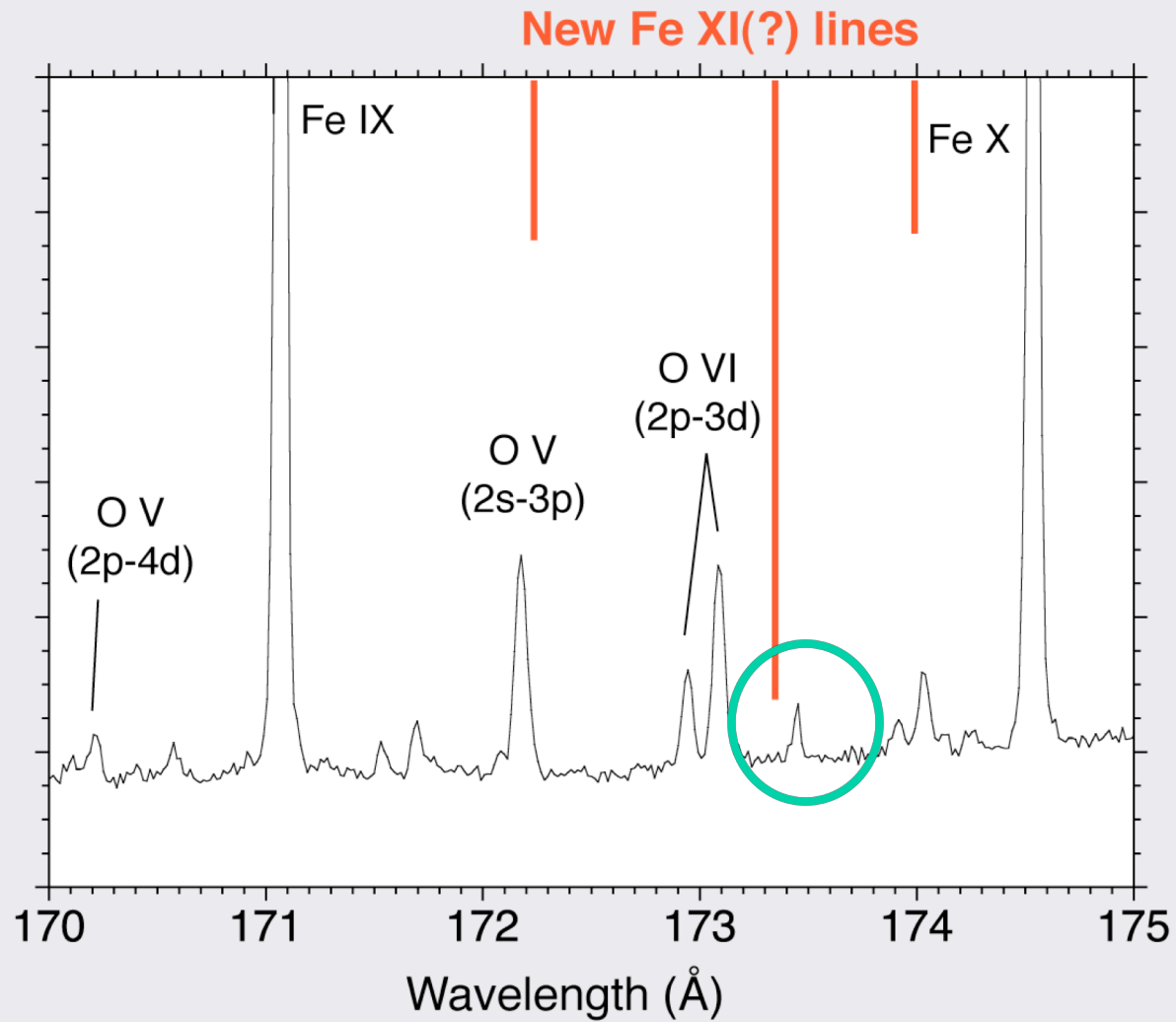




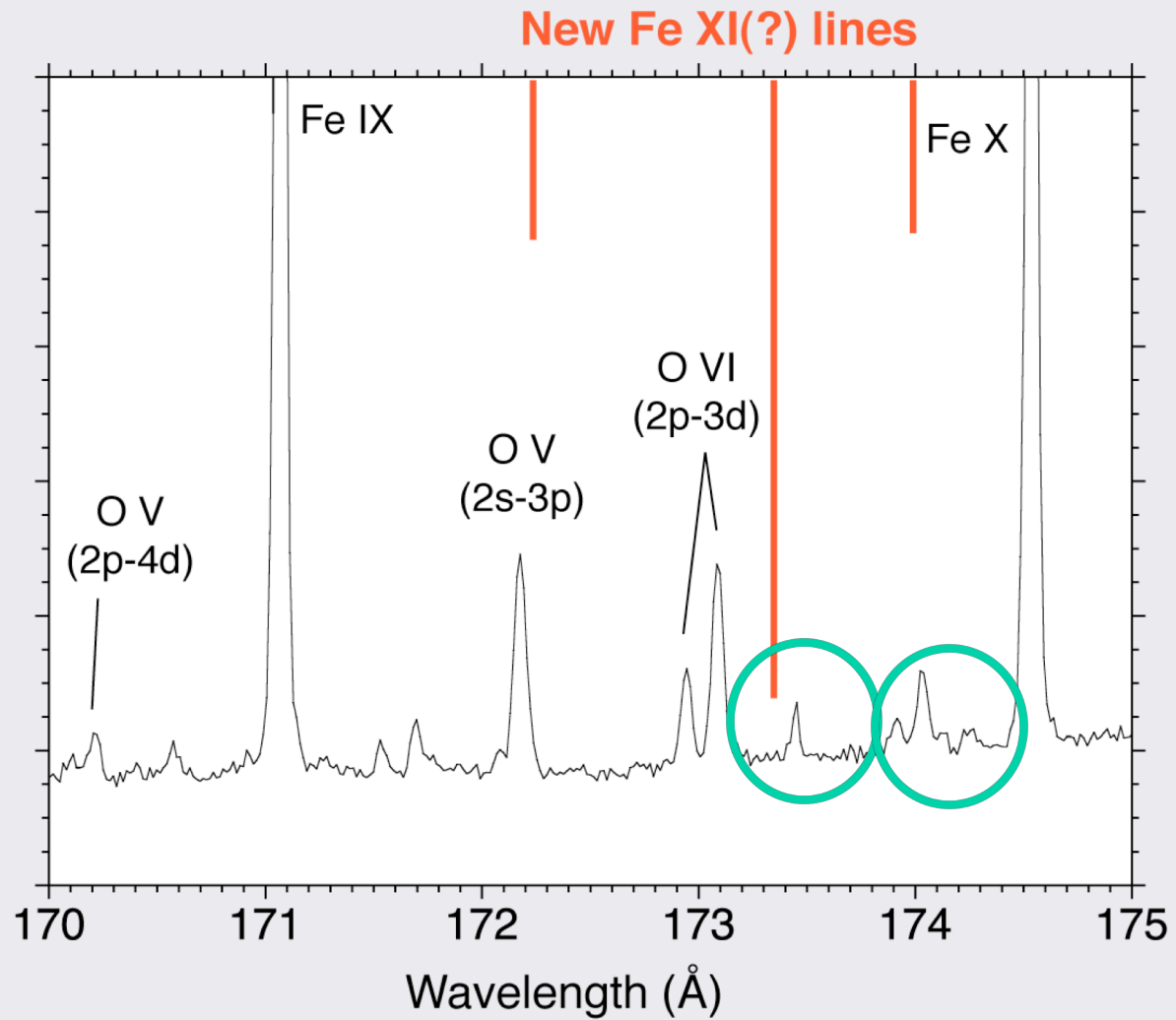
# High-resolution measurement of the SDO Fe IX channel on the Livermore electron beam ion trap



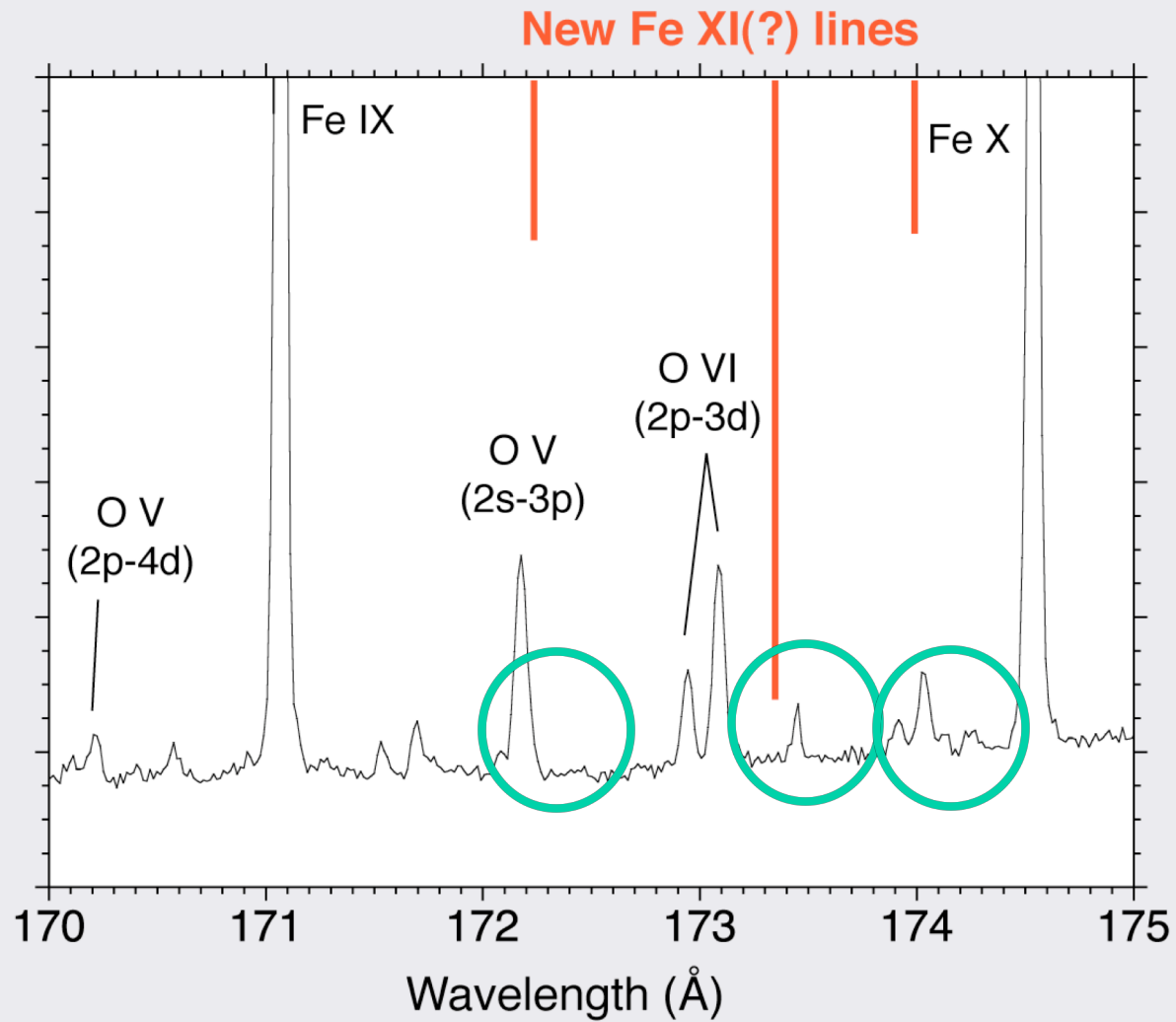
# High-resolution measurement of the SDO Fe IX channel on the Livermore electron beam ion trap



# High-resolution measurement of the SDO Fe IX channel on the Livermore electron beam ion trap



# High-resolution measurement of the SDO Fe IX channel on the Livermore electron beam ion trap



# Summary

- **New lines have been found that are very likely to be from iron**
- **The lines fall within SDO's Fe IX channel**
- **The lines only occur in an ionizing plasma**
- **Strongly enhanced Fe XI lines have also been found**
- **Equilibrium plasmas at the Livermore EBIT give a weak candidate line for the strongest of the new lines, but the wavelengths are not as good of a match as one would like**
- **More work is needed to identify the lines**
- **More work is needed to identify the line formation processes**

