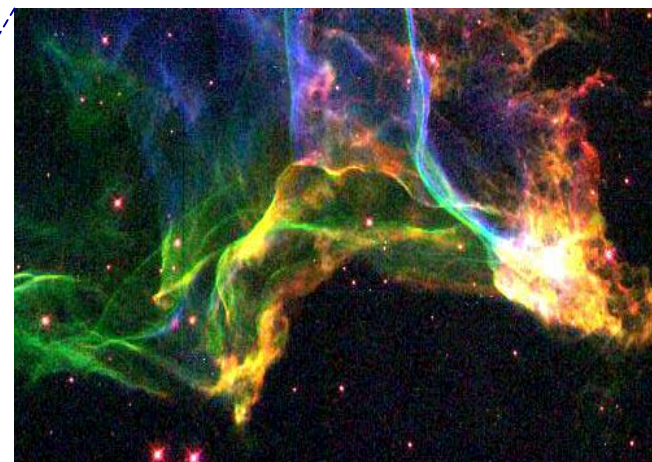


Photoionization of Multiply Charged Metallic Ions



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<http://www.physics.unr.edu/facility/pirf/pirf.html>



Photoionization of Multiply Charged Metallic Ions

- Research Motivations
- Photoionization Process
- Ion-Photon-Beam Endstation on ALS Undulator Beamline 10.0
- Results for Sc^{2+} and Fe^{3+}
- Vision for the Future

Research Motivations: Photon-Ion Interactions



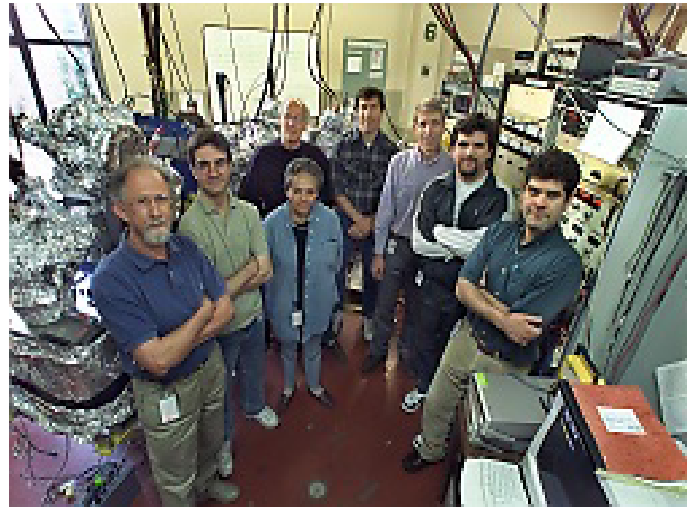
Fundamental:

- VUV photons are a highly selective probe of the internal electronic structure and dynamics of atoms, molecules and their ions.
- Systematization along ionic sequences permits a fine-tuning of structure and interactions.

Applications:

- Most of the known matter in the universe exists in the ionized plasma state.
- Photon opacity data are based almost completely on untested theory.

Collaborators:



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A. Müller, S. Schippers, C. Böhme - Justus Liebig University, Giessen, Germany

N. Berrah - Western Michigan University

G.H. Dunn - JILA, University of Colorado and NIST

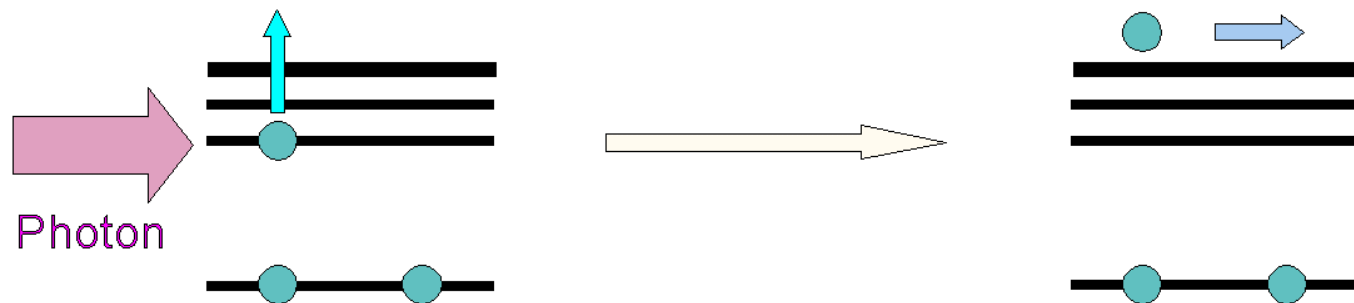
M.E. Bannister - Oak Ridge National Laboratory

S. Ricz - Institute of Nuclear Research, ATOMKI, Debrecen, Hungary

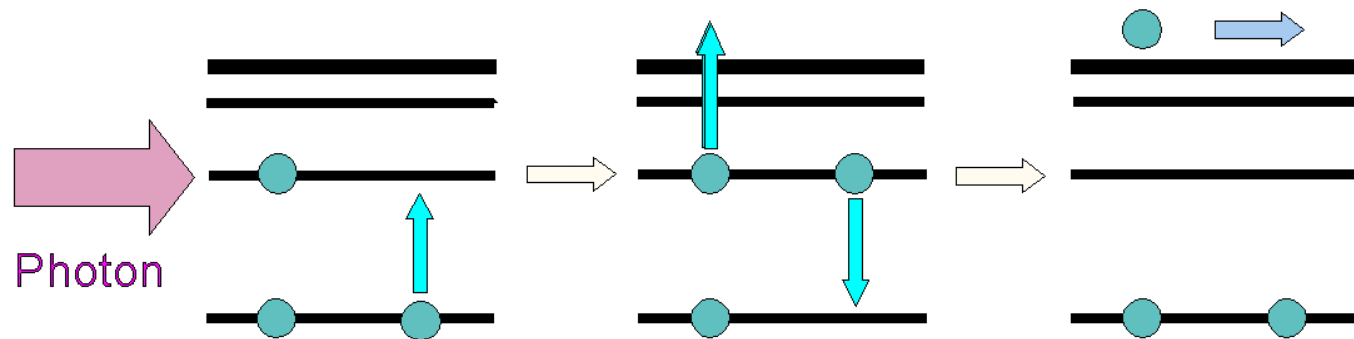
B. McLaughlin – Queen's University, Belfast, U.K. (theory)

S. Nahar - Ohio State University (theory)

Photoionization Mechanisms



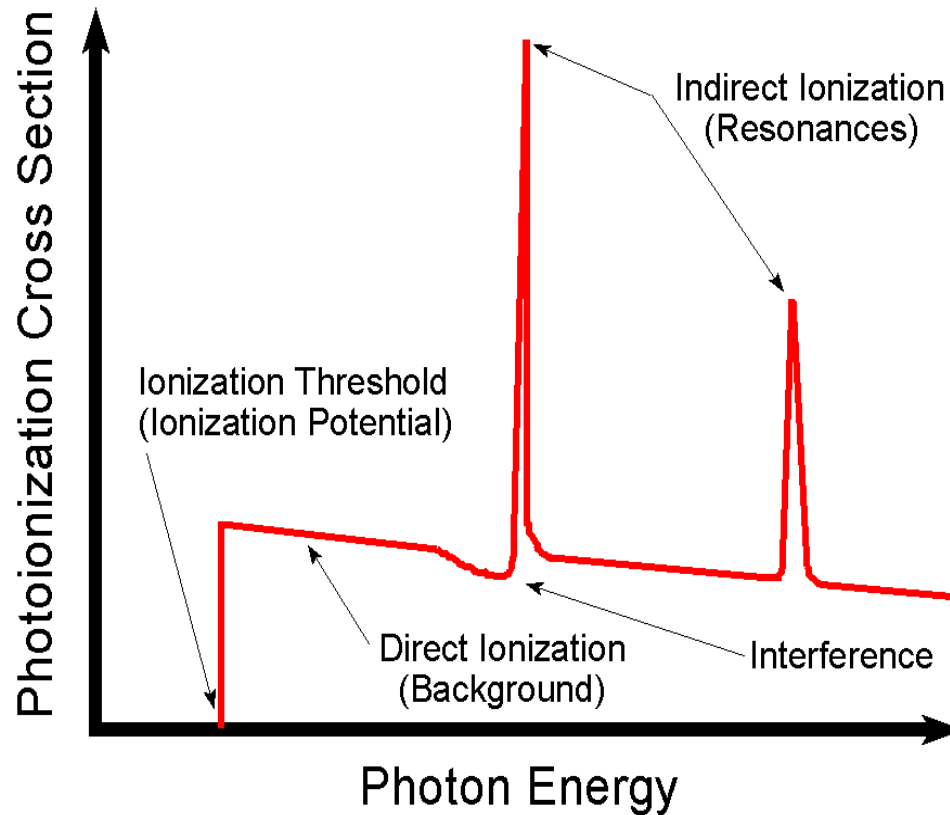
Direct (*non-resonant*) Photoionization



Indirect (*resonant*) Photoionization



Photoionization Mechanisms

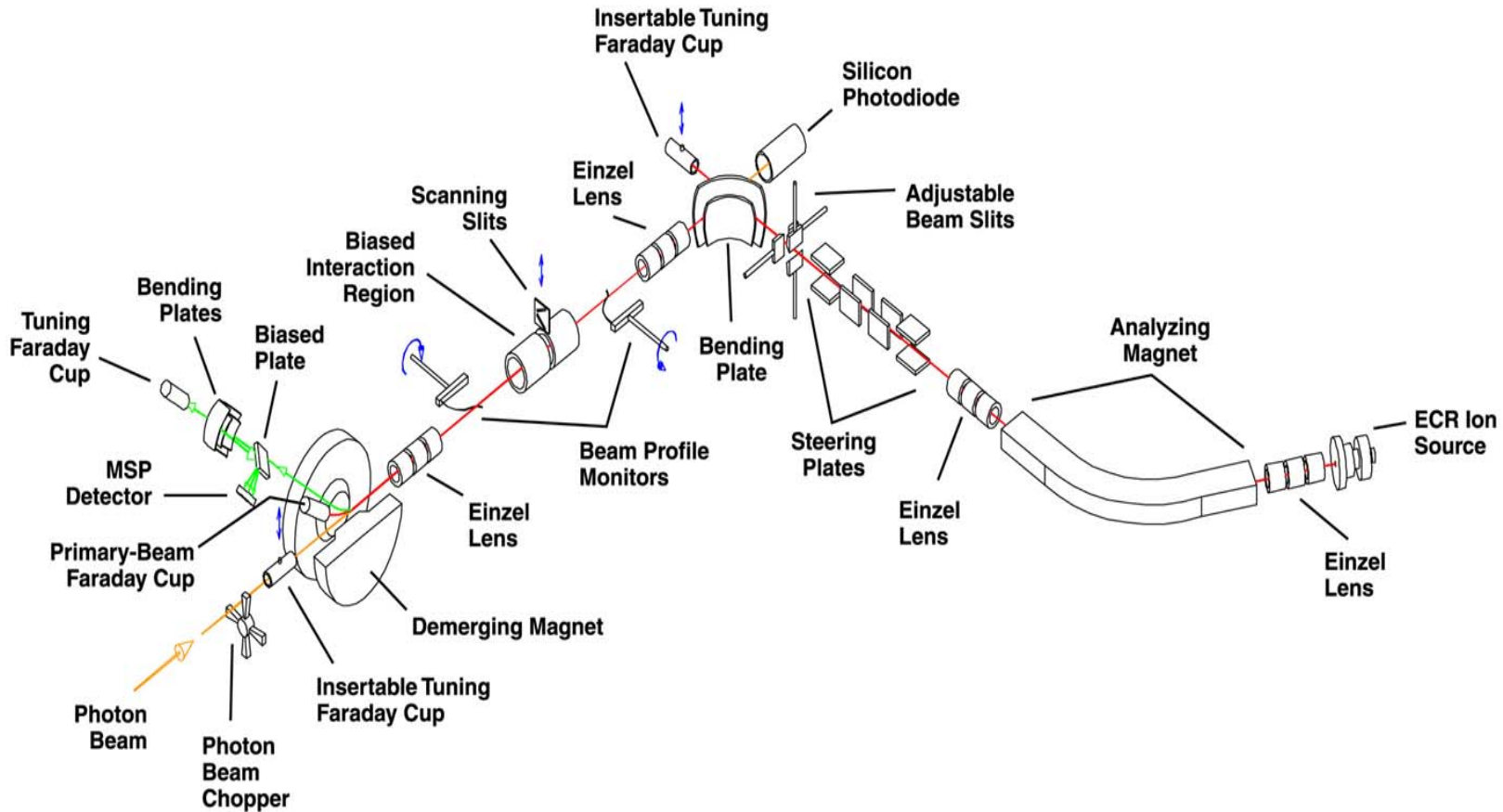


Ion-Photon-Beam Endstation on ALS Undulator Beamline 10.0

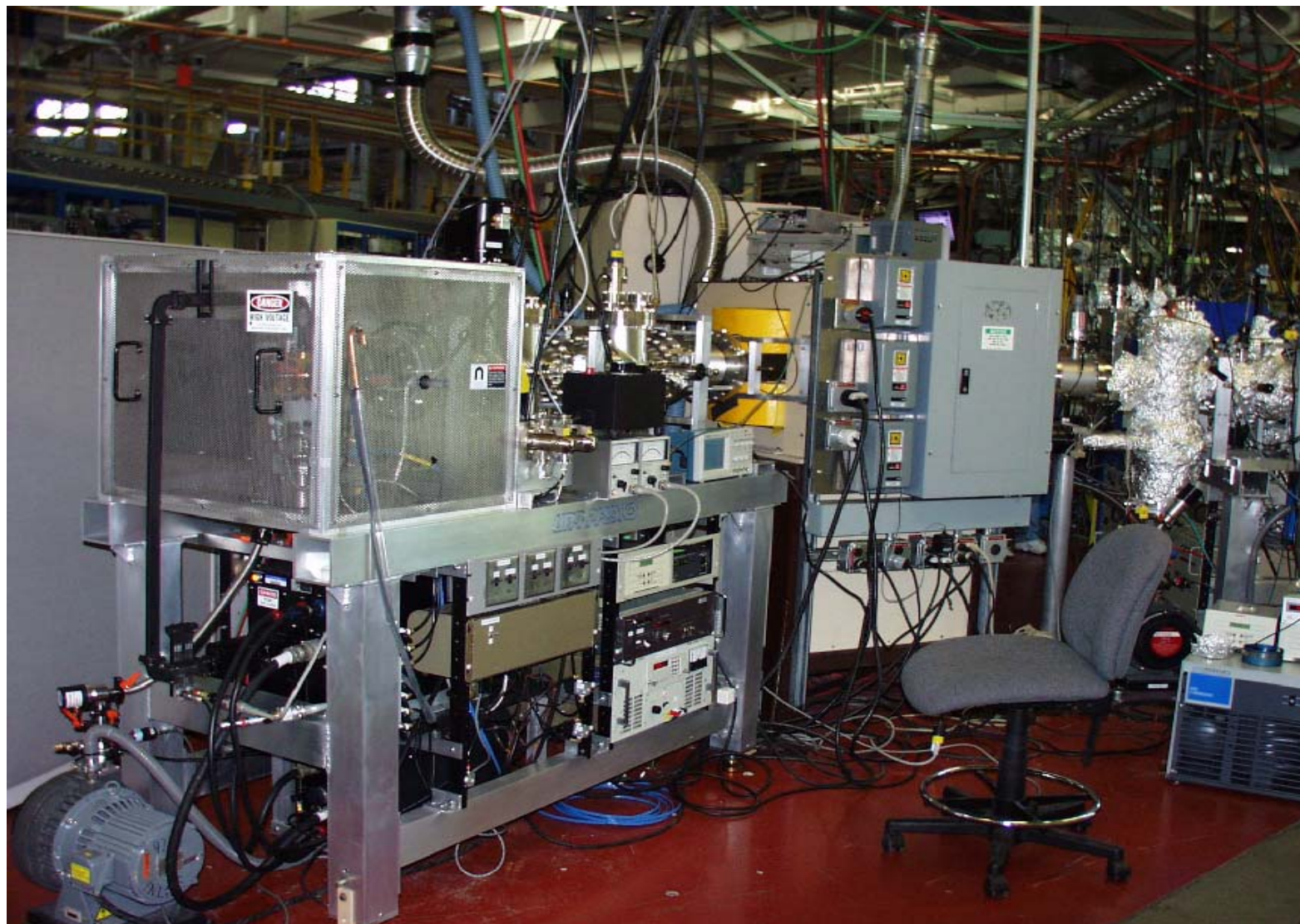


Beamline 10.0.1

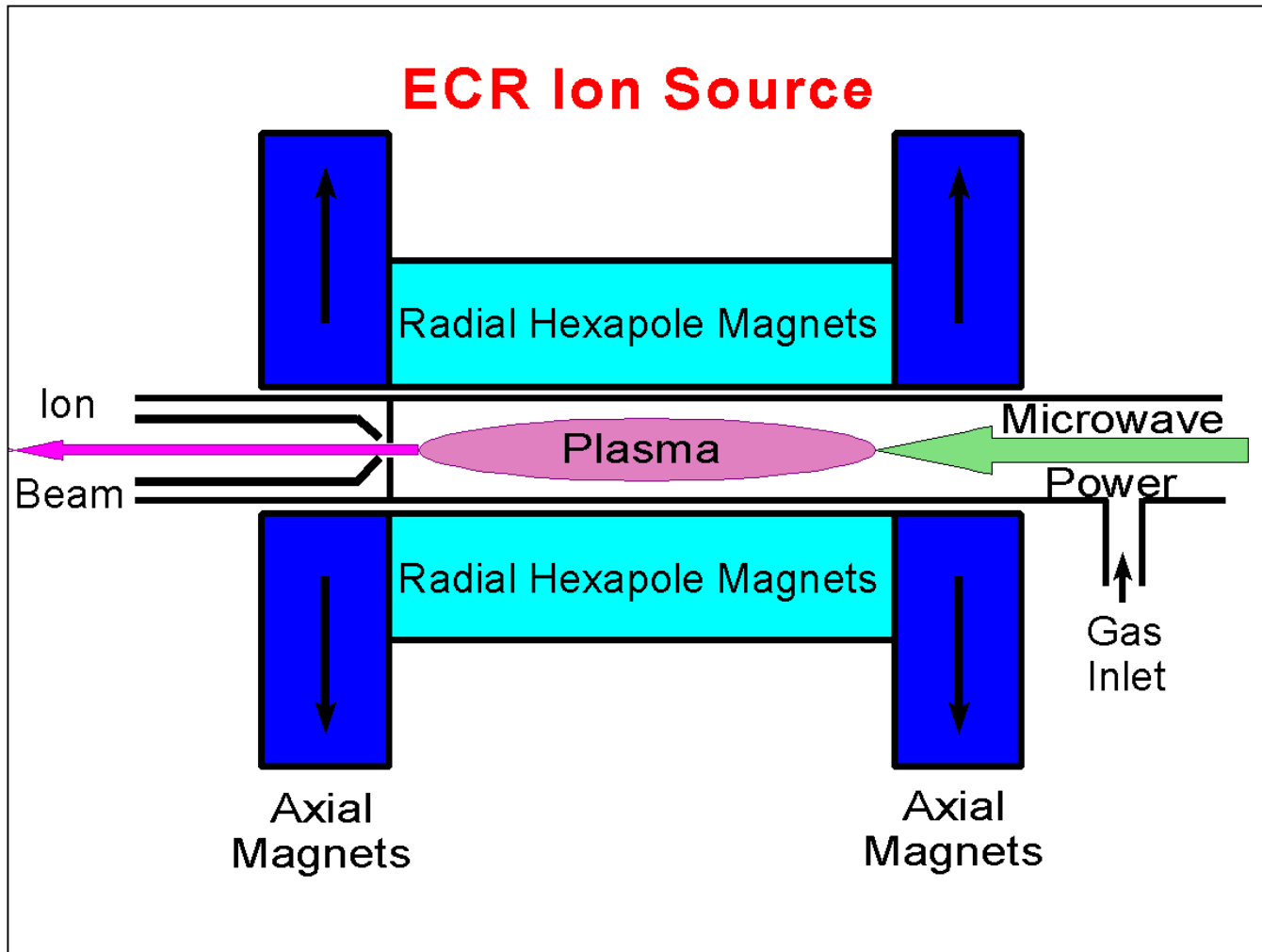
• Merged photon and ion beams



Ion-Photon-Beam Endstation on ALS Undulator Beamline 10.0



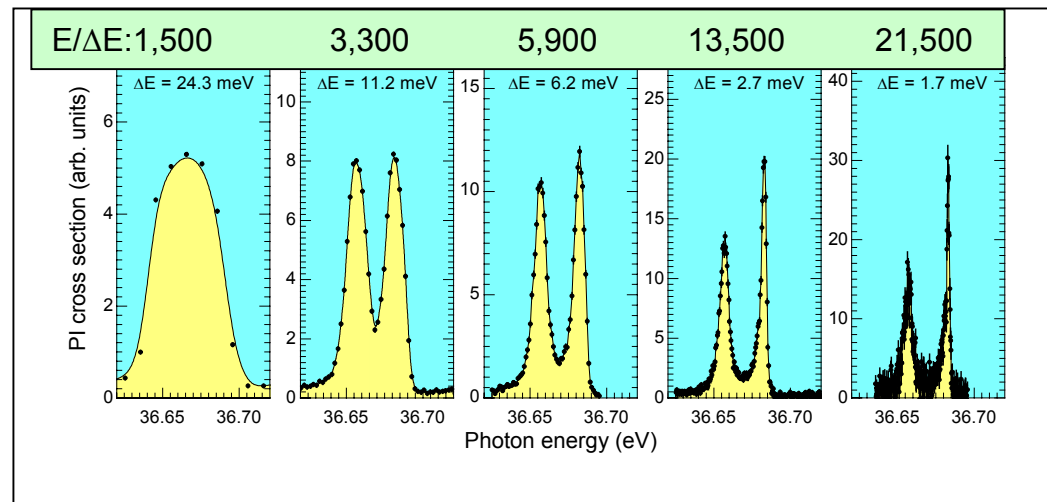
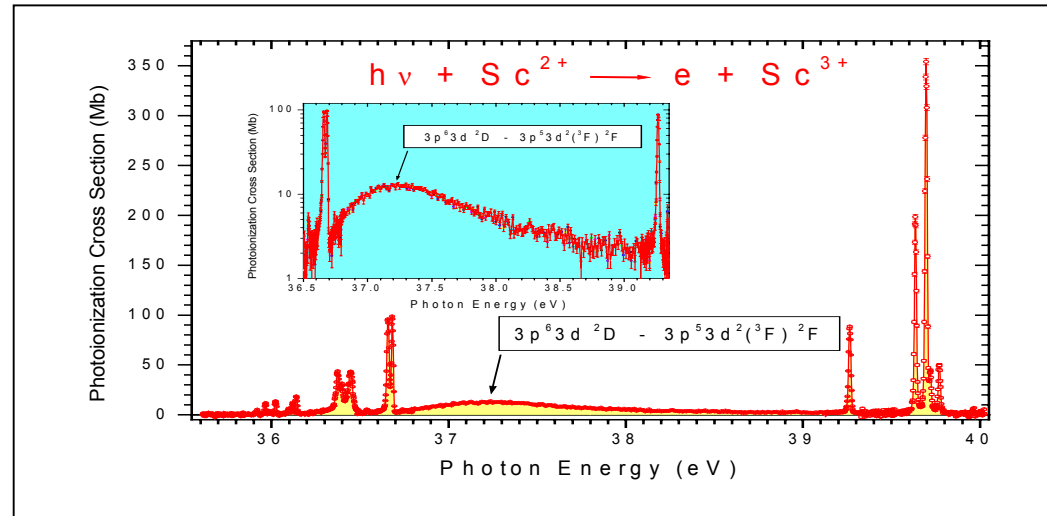
An Electron-Cyclotron-Resonance (ECR) ion source permits photoionization measurements on multiply charged ions.



Photoionization of Potassium-Like Sc^{2+} . *



Overview of part of the Sc^{2+} photoionization cross section measured with a nominal experimental resolution of $\Delta E = 40$ meV. The broad resonance at 37.137 eV is attributed to $3p^6 3d^2 D \rightarrow 3p^5 3d^2 ({}^3F) {}^2F$ excitations predominantly decaying via Super-Coster-Kronig transitions. These transitions have also been observed in the time reversed process of photorecombination of Sc^{3+} ions [1].



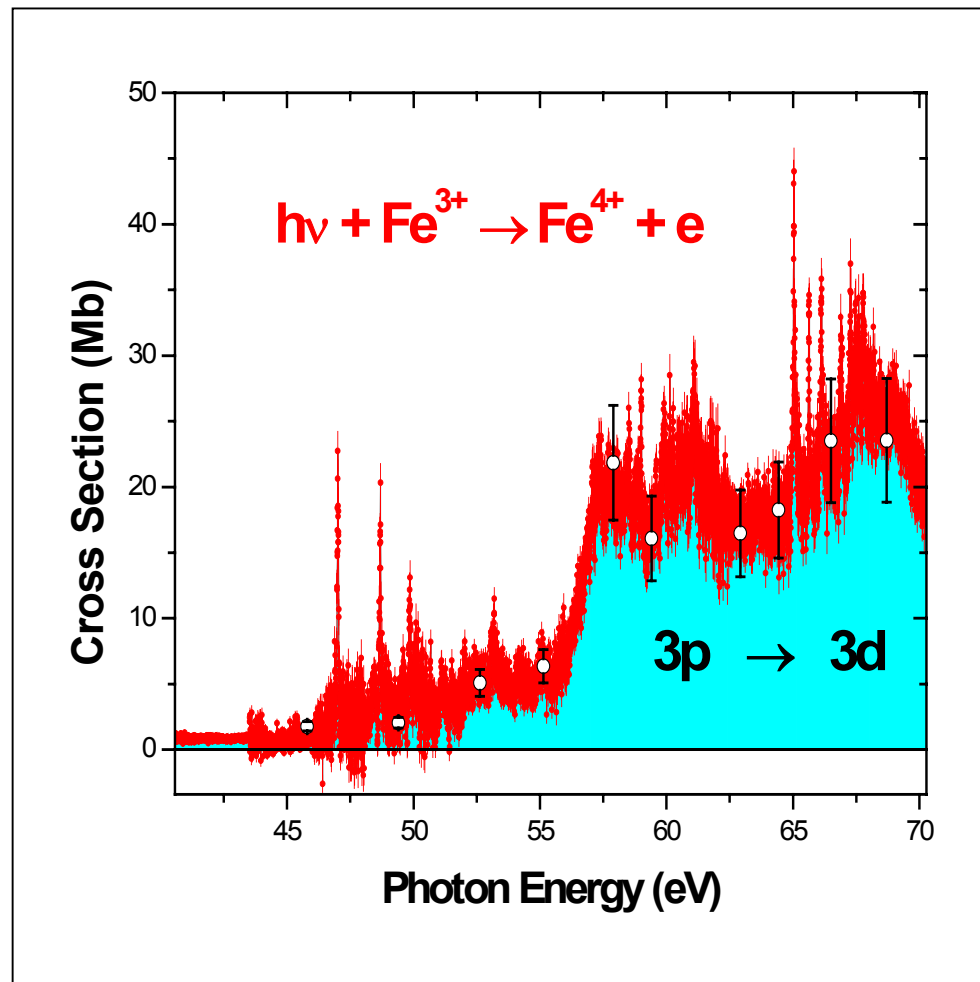
* S. Schippers et al. (Submitted to Phys. Rev. A)

[1] Schippers et al, Phys. Rev. A **65**, 042723 (2002).

Photoionization of Fe^{3+}



Fe^{3+} exhibits a strong and extremely broad resonance feature in the energy range 56-70 eV. Fe^{3+} has a half-filled 3d-shell, and 3p-3d excitation is the likely origin of this feature [2]. The resulting states with $3p^5 3d^6$ configuration may decay by Super-Coster-Kronig transitions, which are extremely fast, and give rise to correspondingly broad resonances in photoionization.



[2] Sultana N. Nahar et al, Phys. Rev. A **58**, 4593 (1998).



Photon – Ion Physics: *A Vision for the Future*

- **The ECR ion source permits studies with atomic ions to be systematized along ionic sequences, permitting a fine-tuning of structure and dynamics (e.g. the N, F and K isoelectronic sequences).**
- **The Fe isonuclear sequence is astrophysically significant, and far more challenging to theorists.**
- **Photoionization and photofragmentation of molecular and cluster ions remain essentially unexplored, and will provide new insights into their structure and dynamics. Interpreting such experiments will be a major challenge!**