Extreme Ultraviolet Radiation Spectrometer Design and Optimization

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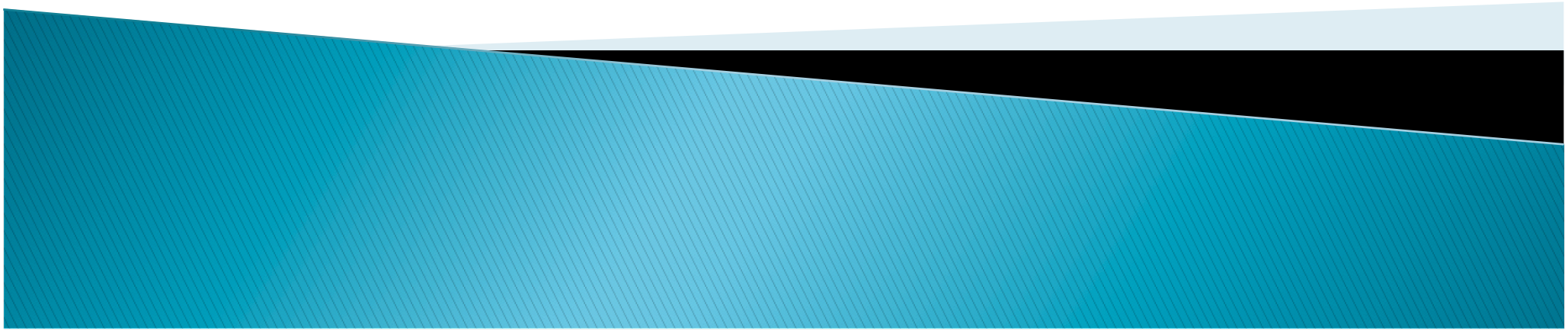
Mentors: Dr. Guillaume Laurent & Wei Cao



Research Project

- Goal 1: Improve the Resolution
- Goal 2: Calibrate the Spectrometer
  - to find wavelengths
  - not intensity profile

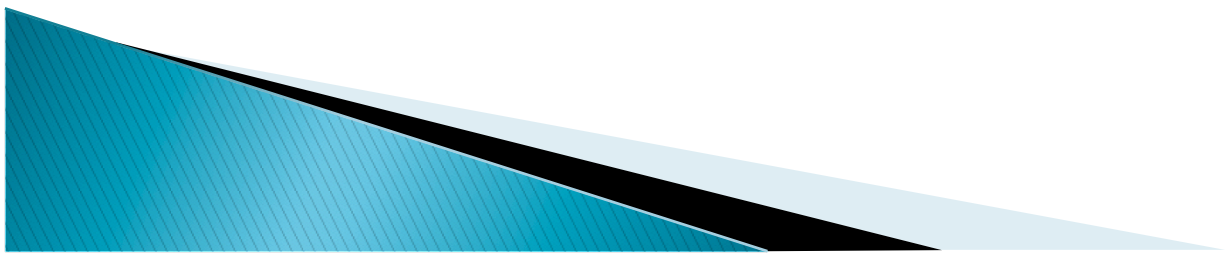
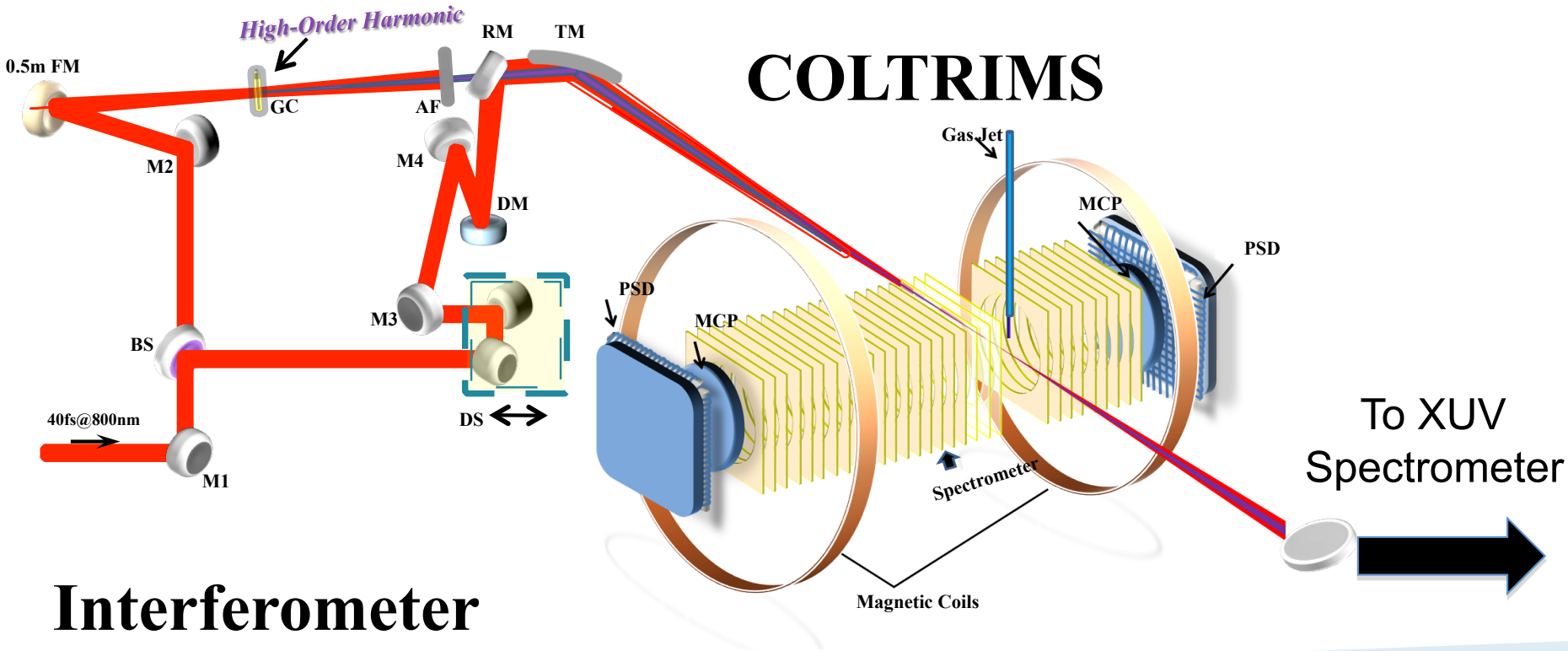


Diagram of Apparatus



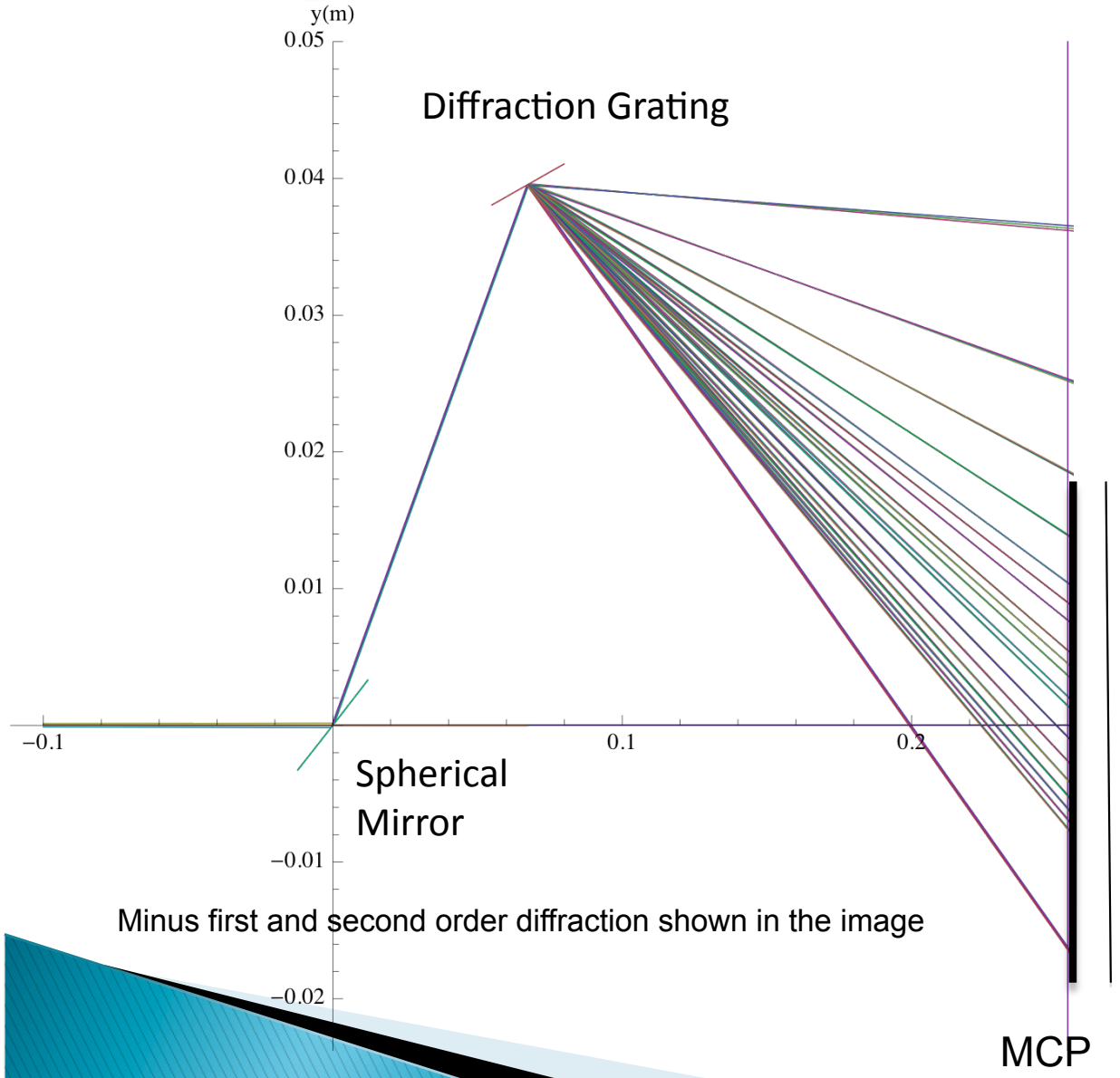
M1~M4: Plane mirror
FM: Focusing mirror
DM: Diverging mirror

BS: Beam splitter
GS: Gas cell
AF: Al filter

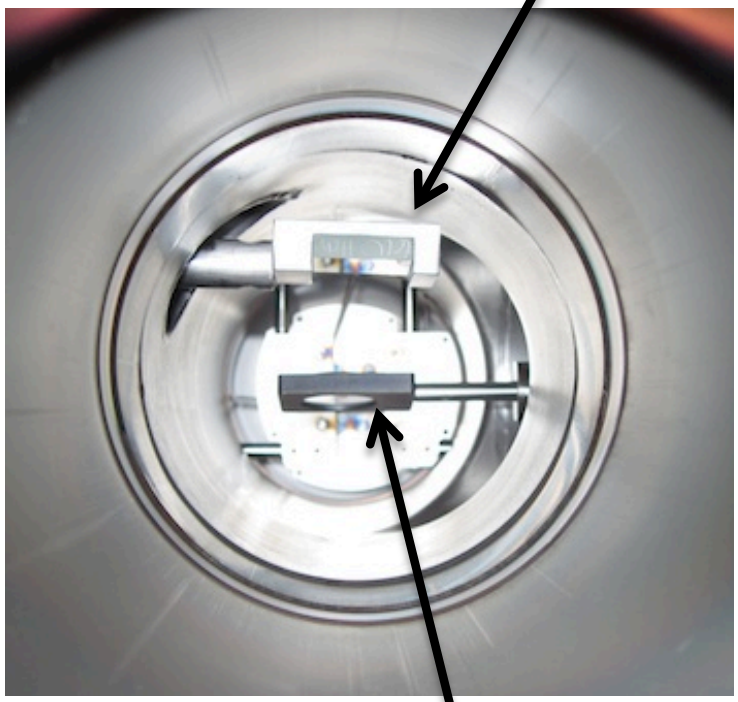
RM: Recombination mirror
DS: Delay stage
TM: Toroidal Mirror

MCP: Microchannel Plate
PSD: Positon Sensitive Detector

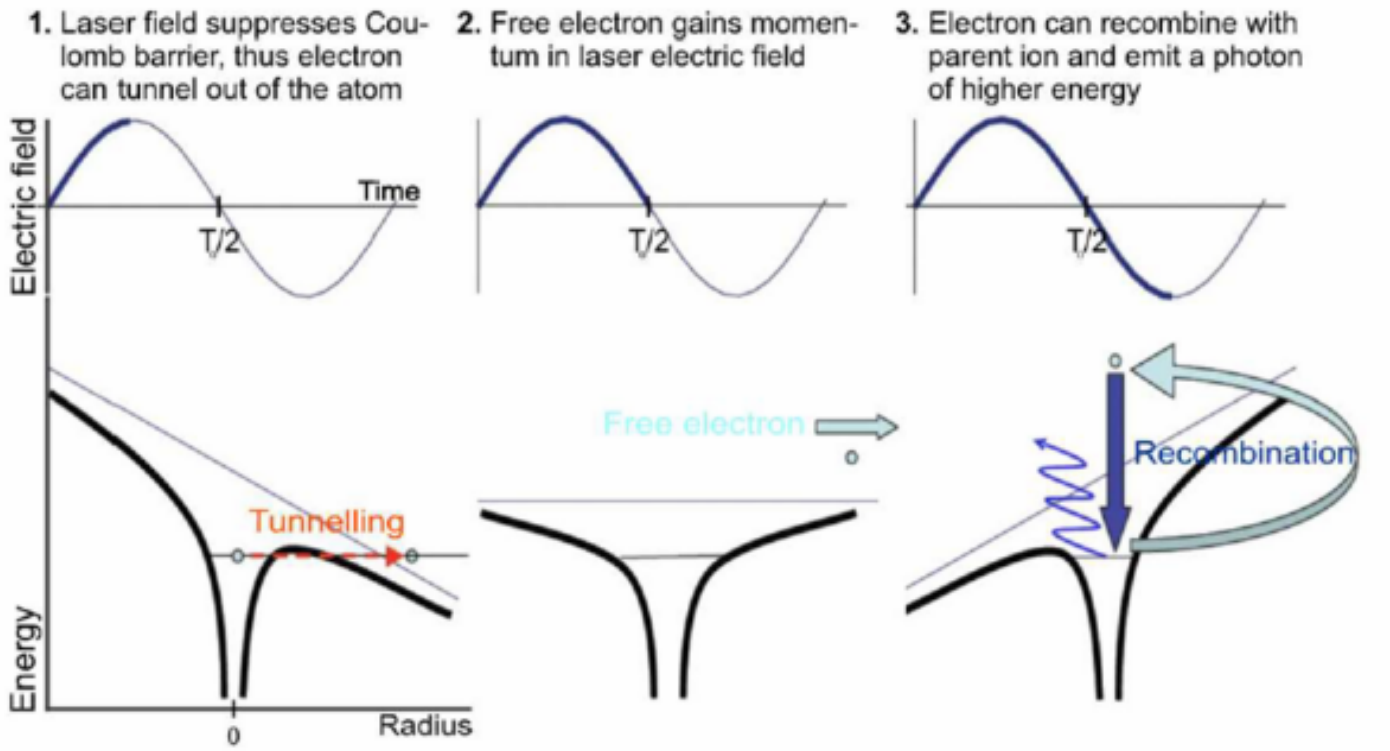
Diagram of Apparatus



Minus first and second order diffraction shown in the image



High Harmonic Generation

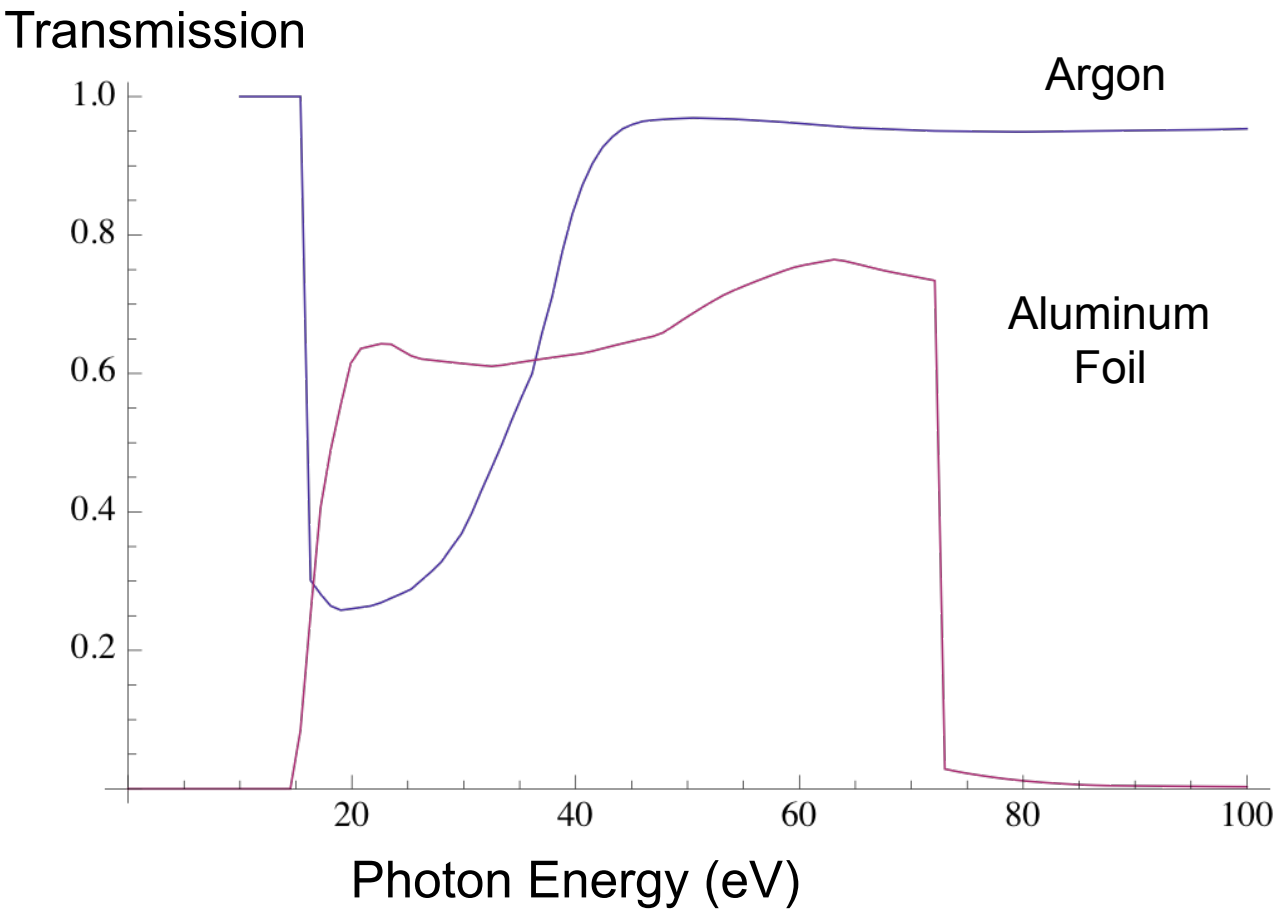


$$E_{emitted\,photon} = n\hbar\omega_0$$

Where n is an odd integer, ω_0 is the fundamental laser frequency,

"High-order Harmonic Generation." *Swineburne4 Aug. 2010.* <*www.swinburne.edu.au/engineering/caous/HHG.htm* >.

Energies Allowed in Experiment



Aluminum Foil 200 nm thickness

Argon - 200 mTorr for 3 cm followed by 5 mTorr for 1 m

Highest Order cut-off determined by

$E = 3.2U_p + I_p$

I_p is the ionization potential of the gas

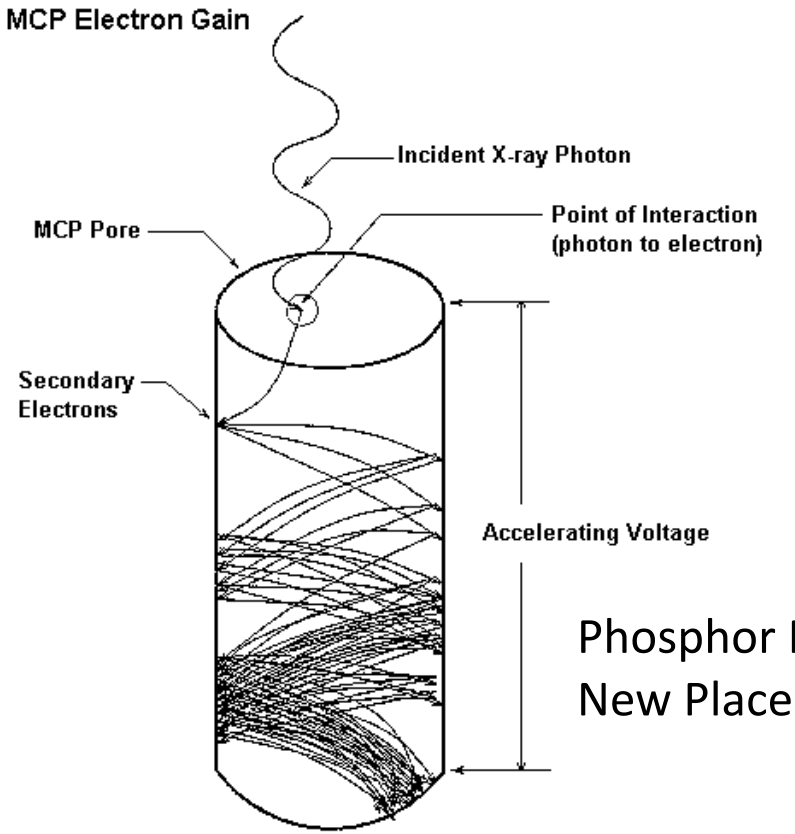
U_p is the mean kinetic energy of the electron

Highest energy seen is 51eV

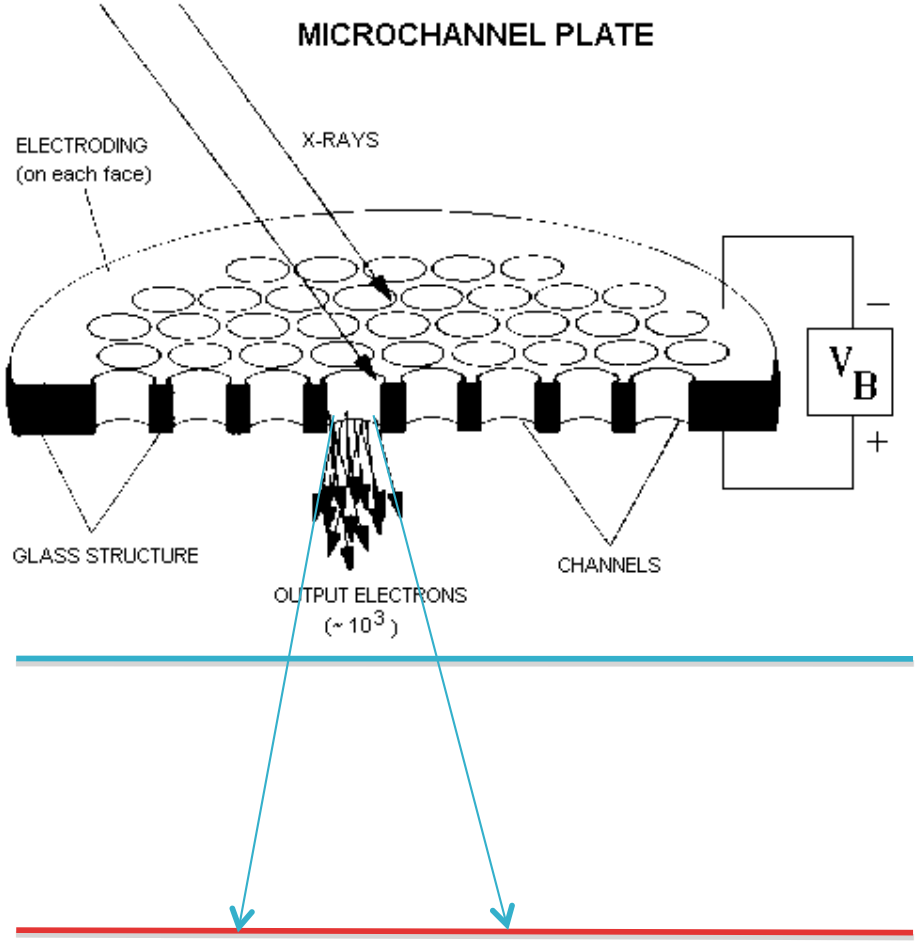
Tong. High-Order Harmonic Generation. <http://www.phys.ksu.edu/personal/xmtong/class/chapter02.pdf>

Gullikson, Eric. "X-Ray Interactions With Matter." *Lawrence Berkeley National Laboratory. N.p., n.d. Web. 4 Aug. 2010. <henke.lbl.gov/optical_constants/>*

Goal 1: Improving the Resolution



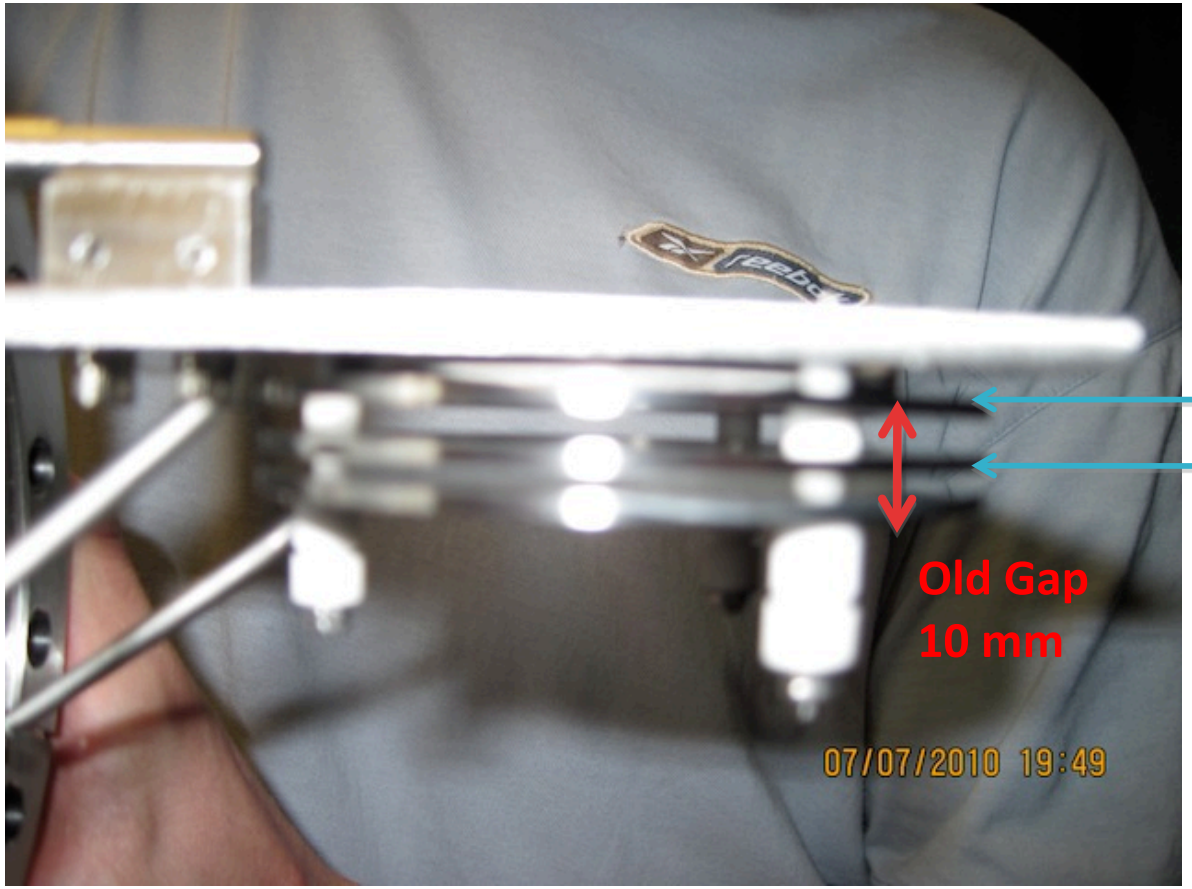
Phosphor Plate
New Placement



Old placement

"Microchannel Plate Principles of Operation." *HRC. Web. 4 Aug. 2010. <hea-www.harvard.edu/HRC/mcp/mcp.html >.*

Goal 1: Improving the Resolution



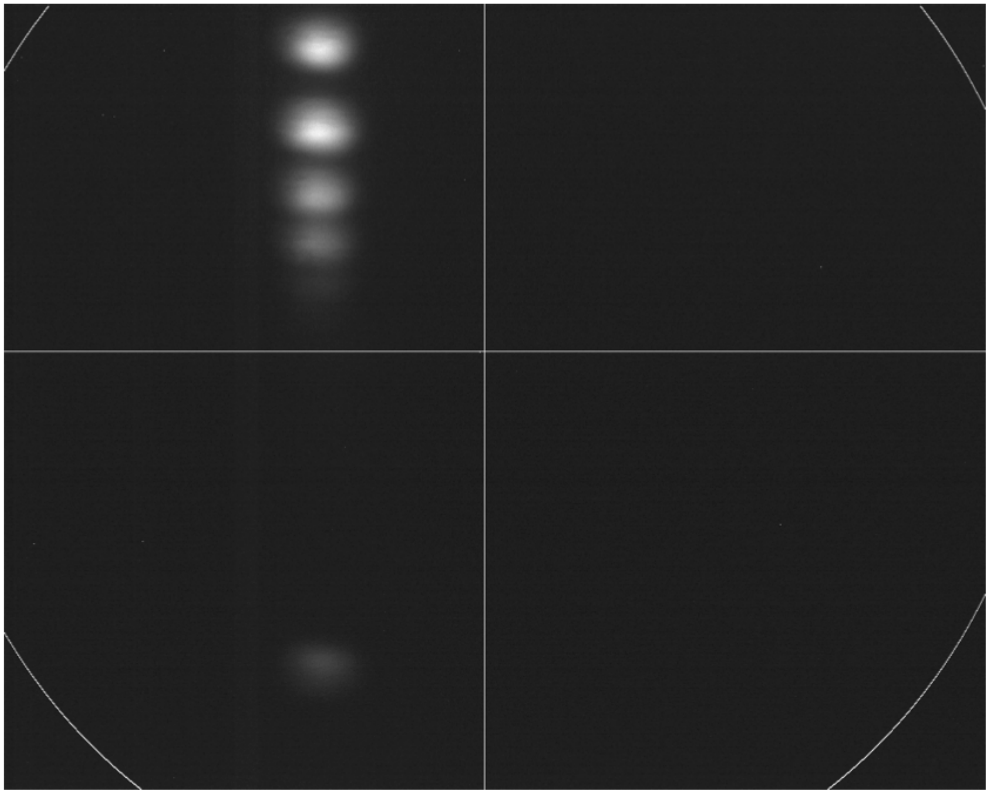
Microchannel Plate

Phosphor plate

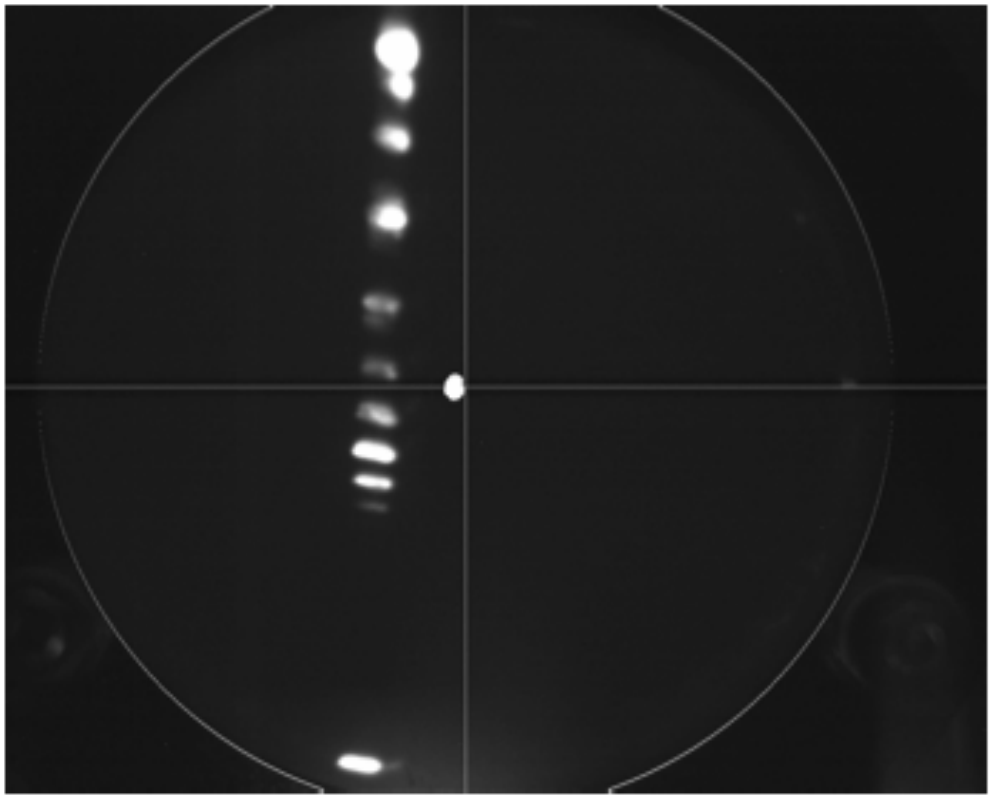
4 mm

Phosphor plate was moved from 10 mm away to 4 mm

Goal 1: Resolution improved

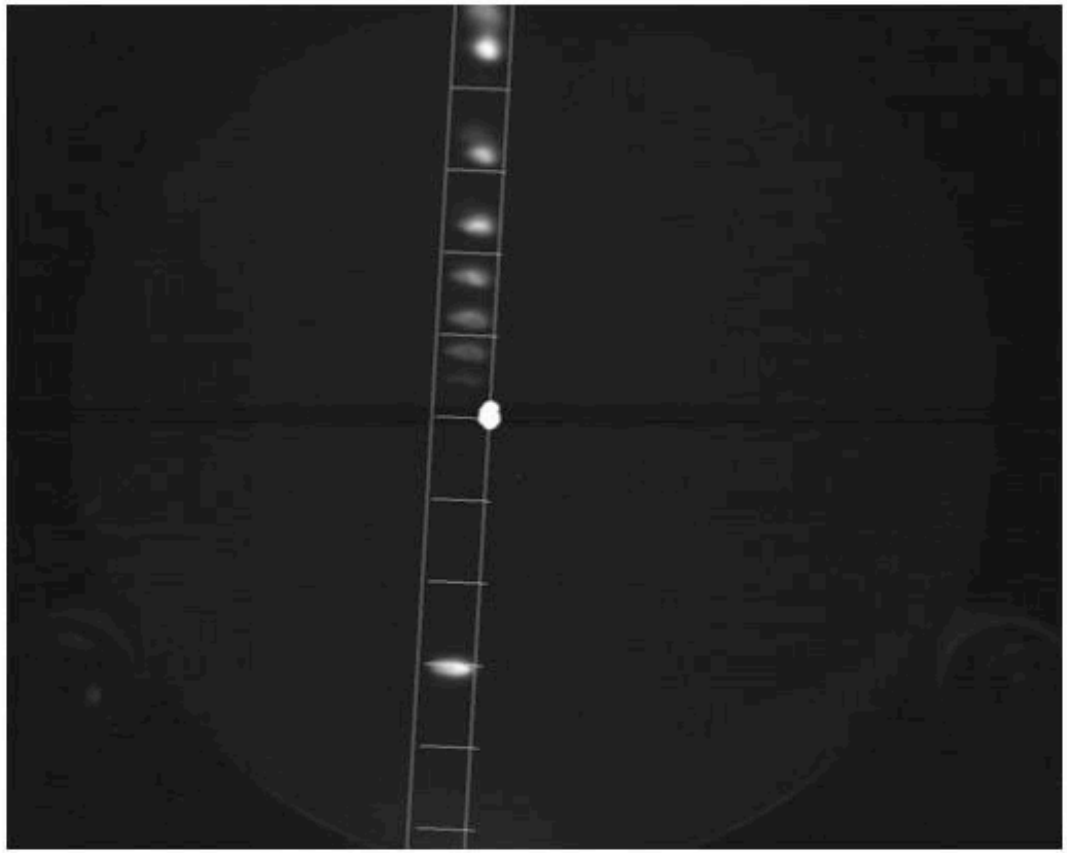


Old Resolution



New Resolution

Goal 2: Calibrating the Spectrum



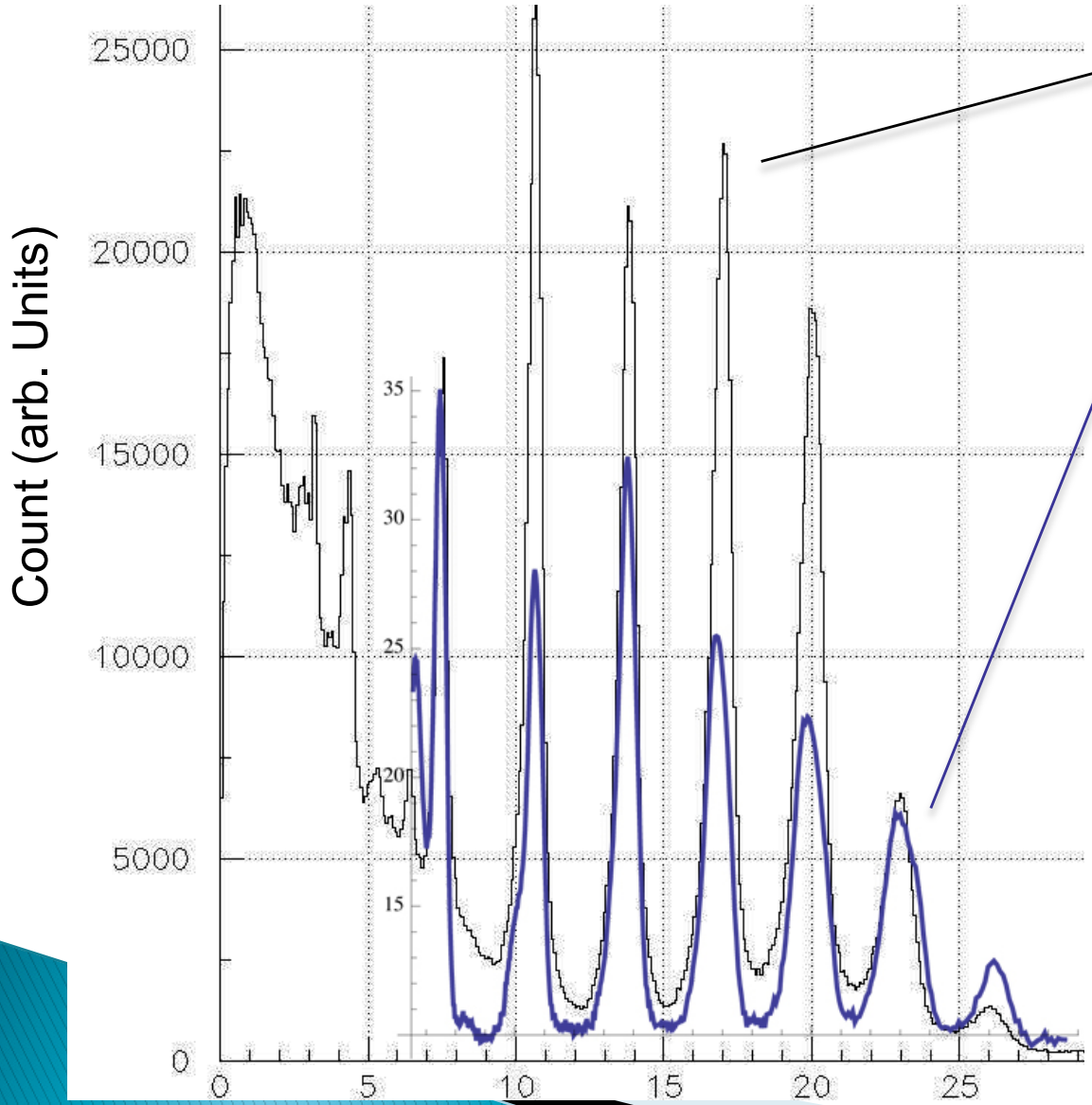
Find distance of each spectral line from zero order

Integrate across the spectral lines to get intensities

$$\lambda = \frac{d}{m}\left(\sin\theta_i - \sin\theta_d\right)$$

d is the slit spacing
m is the diffraction order
θ_i is the incident angle
θ_d is the diffracted angle

Calibrated Spectrum



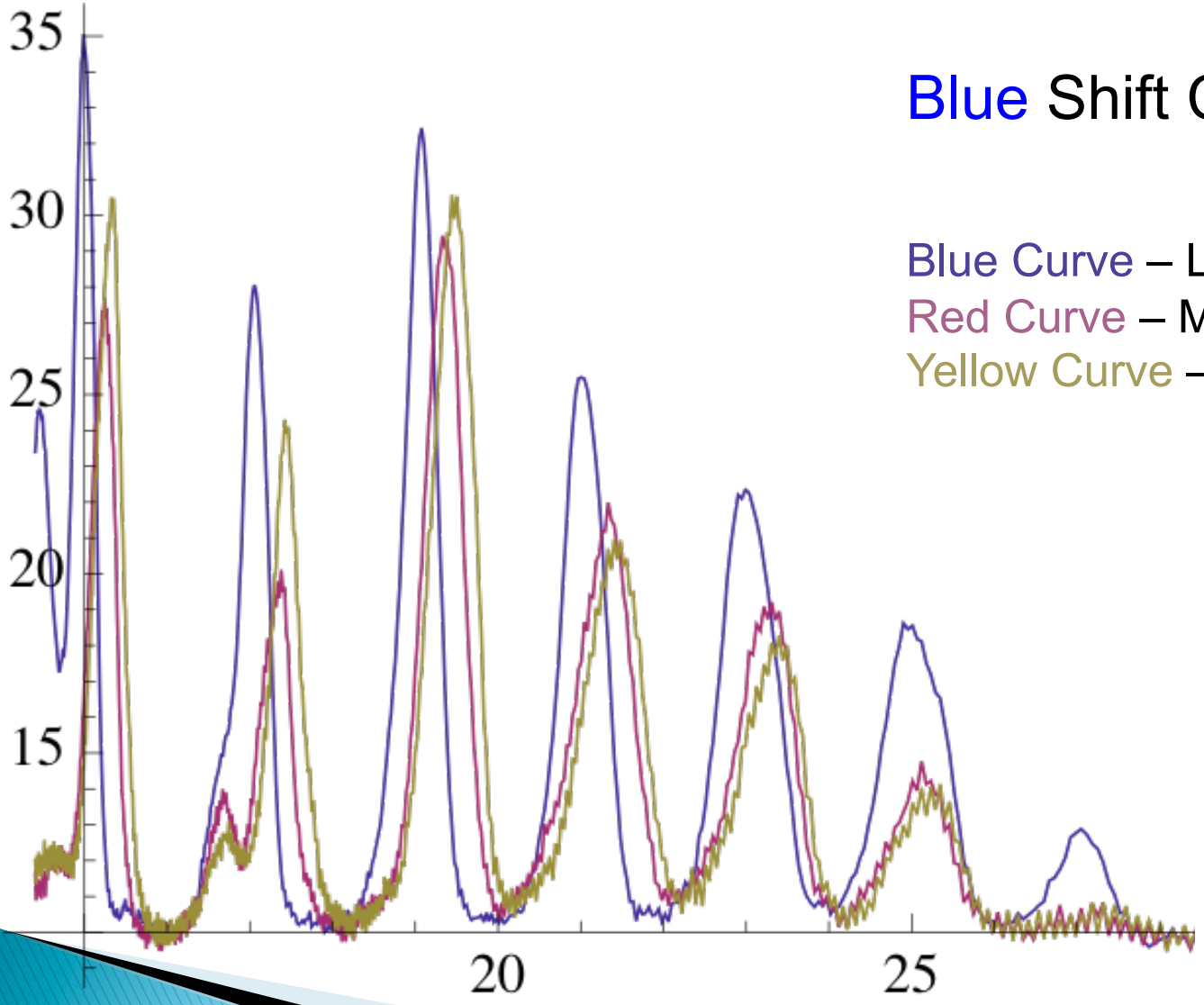
Black Curve is the photoelectron spectrum

Blue Curve is the spectrum from the XUV spectrometer

Energy resolution is comparable to photoelectron spectrum

Photoelectron Energy (eV)

Results and Discussion



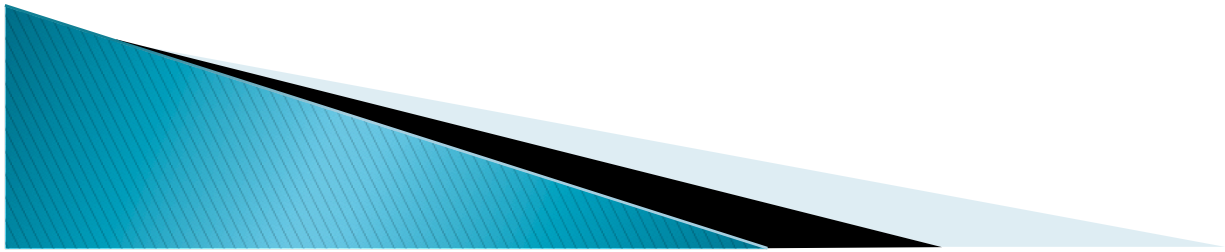
Blue Shift Can be Observed

Blue Curve – Low Intensity, no blue shift
Red Curve – Medium Intensity, blue shift
Yellow Curve – High Intensity, blue shift

Conclusion

- XUV spectrum is now comparable to photoelectron spectrum
- Spectrometer good enough to observe small change in the harmonic wavelength

- Improvements:
  - Calibrate the intensity profile of XUV spectrum



Work Cited

- "High-order Harmonic Generation." *Swineburne4 Aug. 2010. <www.swinburne.edu.au/engineering/caous/HHG.htm >*
- "Microchannel Plate Principles of Operation." *HRC. 4 Aug. 2010. <hea-www.harvard.edu/HRC/mcp/mcp.html >.*
- Gullikson, Eric. "X-Ray Interactions With Matter." *Lawrence Berkeley National Laboratory. Web. 4 Aug. 2010. <henke.lbl.gov/optical_constants>*
- Tong. High-Order Harmonic Generation. <http://www.phys.ksu.edu/personal/xmtong/class/chapter02.pdf>

Questions?