Chamber Surface Roughness and Electron Cloud for the APS SCU

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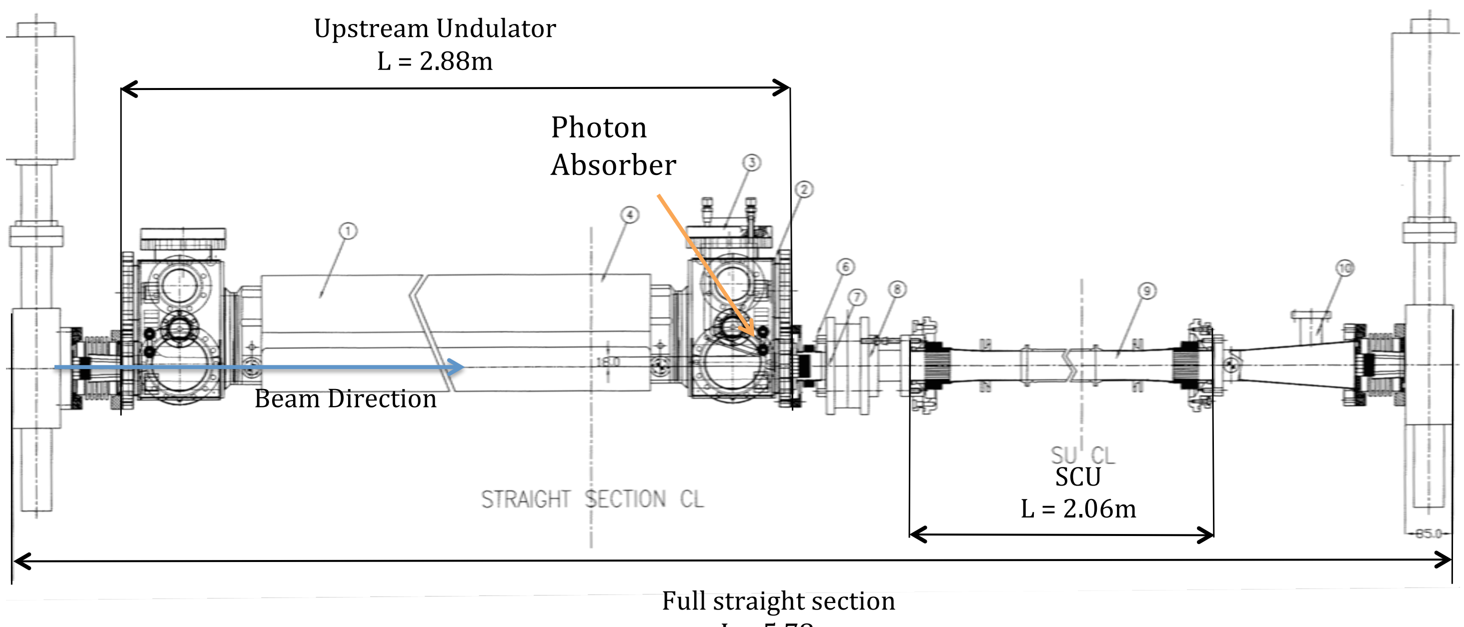
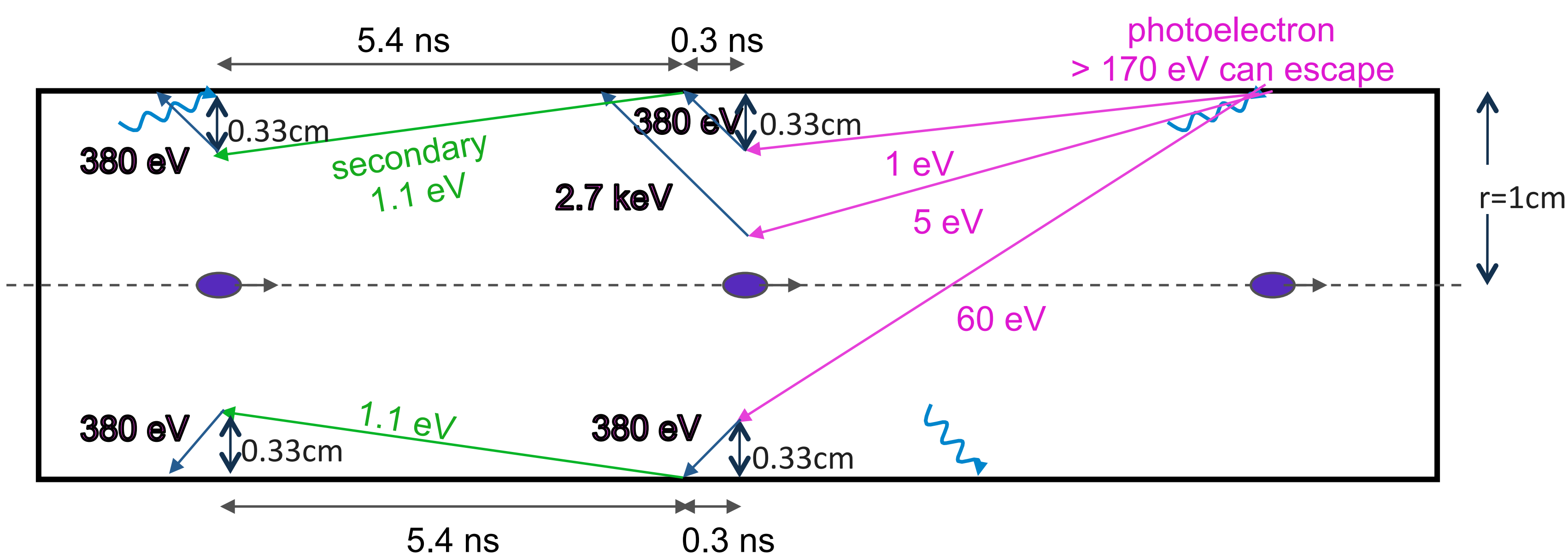
Superconducting Undulator (SCU) at APS

- The SCU being installed in the APS, a 7GeV electron storage ring, in September 2012 is an out-of-vacuum undulator. The beam chamber is cooled to 20K.
- The chamber cryo-coolers have a cooling capacity of 40 W for all heat sources.
- A detailed heat load analysis has been done for all sources.
- Preliminary calculations with POSINST predict 2 W of heating from electron cloud, but RFA data (APS, CesrTA) and vacuum data (ANKA) with electron beams do not agree with the simulations.



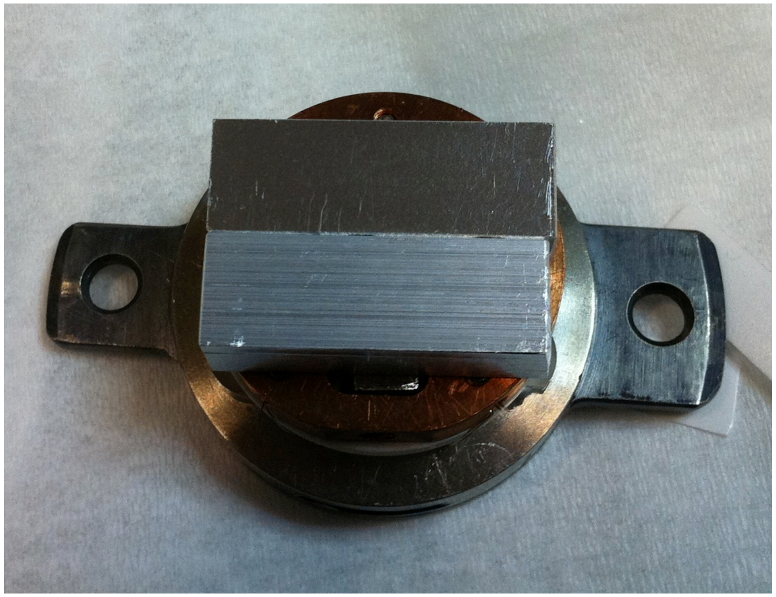
Electron Cloud in SCU

- RFA and vacuum data do show electron cloud with electron beams, although a smaller affect than with positron beams. For the SCU this possible heat load source is important to understand.
- The physics of multipacting due to the secondary electrons has been the focus of R&D and the photoelectrons are assumed to have a very low energy spectrum.
- For electron beams the cloud may not be dominated by secondary electrons so the photoelectron model needs to be better understood.
- Photoelectrons with energy greater then the beam potential can move away from the wall and into the vacuum chamber.



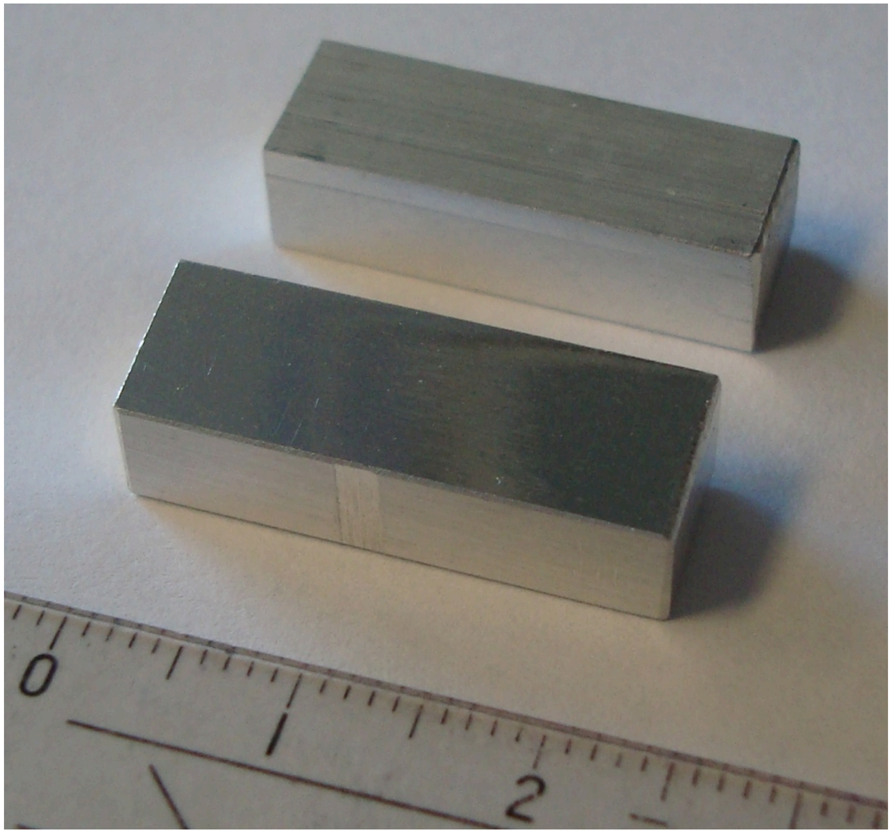
Measurement of QE vs synchrotron radiation energy

- Two samples of APS extruded Al beam chambers.
  - Top: Polished (Smooth), rms = 139nm
  - Bottom: Unpolished (Rough), rms = 1180nm
- All data was acquired at the Australian Synchrotron on their Soft X-Ray beamline, April 2012.
- The sample holder allowed for the sample current to be measured, this measures the number of emitted electrons.
- Four incident photon angles: 3, 5, 10, 50 degrees
- All scans are from 100 eV to 2000 eV in 0.5 eV steps.
- Measurements were taken at 300K and 185K. At several angles.



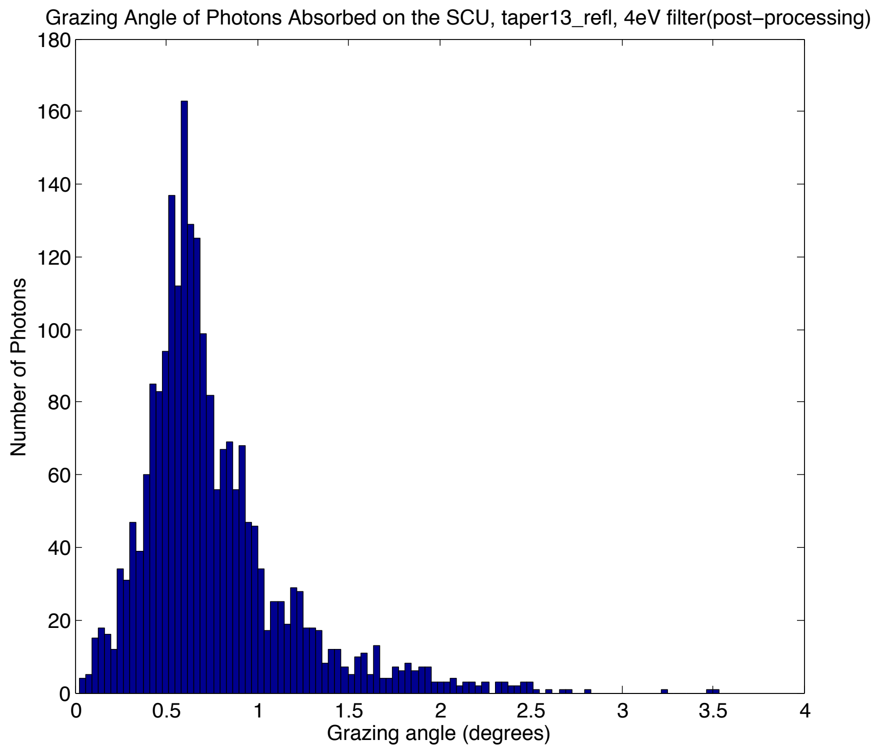
Sample Surfaces

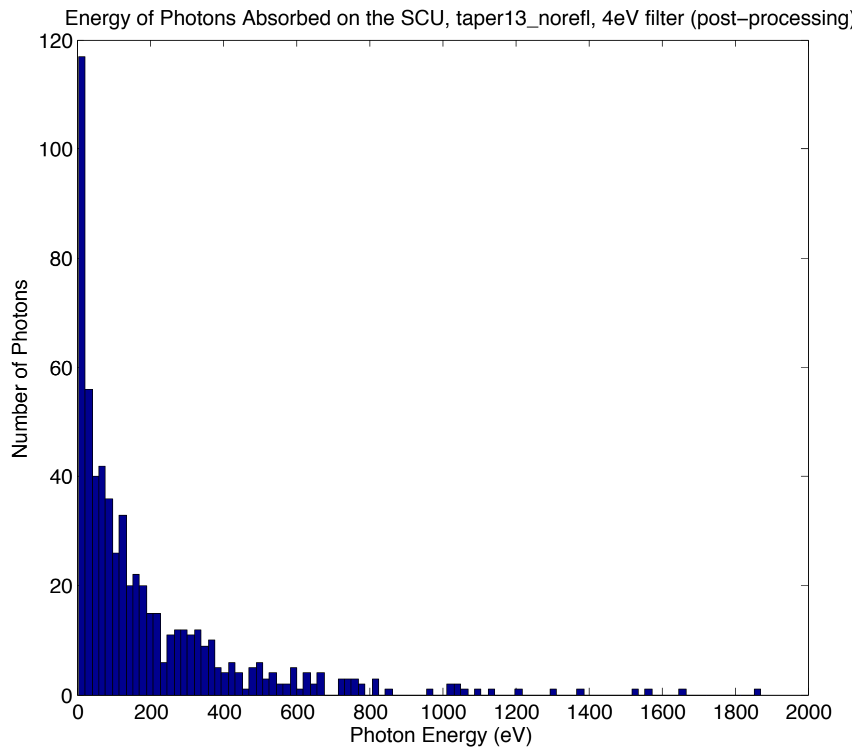
- Two samples were measured, a polished sample(smooth) and unpolished sample (rough)
- The smooth sample was polished using an abrasive flow process, a silicon carbide paste was pushed through the aperture.
- The XPS analysis is in progress to quantify the surface chemistry and the dependence of emission on incidence angle.
- Preliminary analysis shows that the polishing process removes or covers trace elements in the Al alloy, Mg and Si.



Top: Rough sample, Bottom: Smooth sample

Photon energy range from Synrad3d modeling of the APS SCU





- Simulations done assuming no diffuse scattering.
- The grazing angle of the absorbed photons has the highest flux at 0.6 degrees.

- Although the critical energy of the dipole radiation is 19keV at APS, the energy of the photons that are absorbed on the SCU are between 4-700eV.

Analysis Calculation

- I_{Si} = Current from the Si diode at the back of the sample chamber, data was taken with no sample in the path of the photon beam.
- I_{Al} = Sample current from the Al sample.
- $F(E_\gamma)$ = Transmission coefficient.

- Both calculations were normalized to the storage ring beam current.

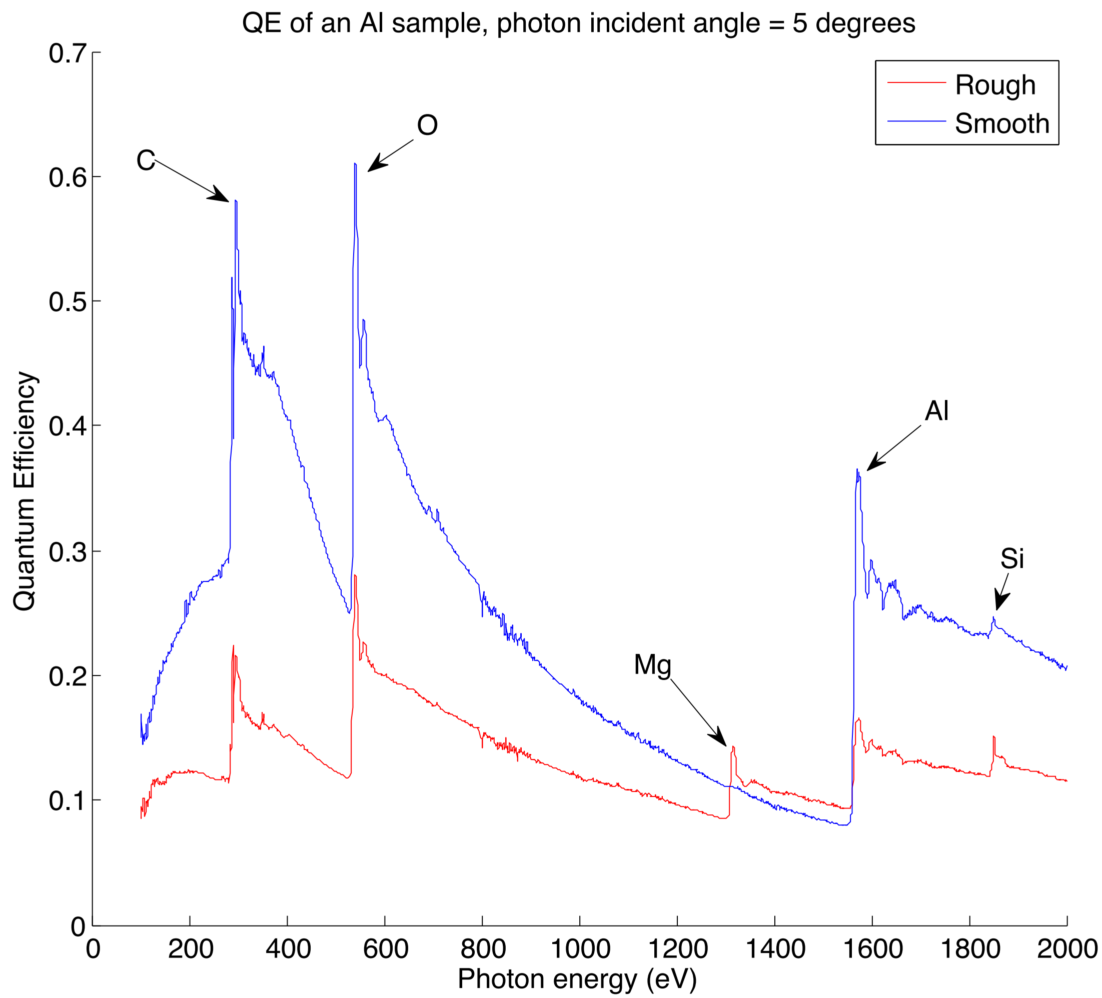
$$Flux = \frac{I_{Si}}{q_e}\frac{3.65eV}{electron}\frac{1}{E_{photon}}F\left(E_\gamma\right)\left[\frac{photons}{\sec}\right]$$

$$\#\,Electrons = \frac{I_{Al}}{q_e}\left[\frac{electrons}{\sec}\right]$$

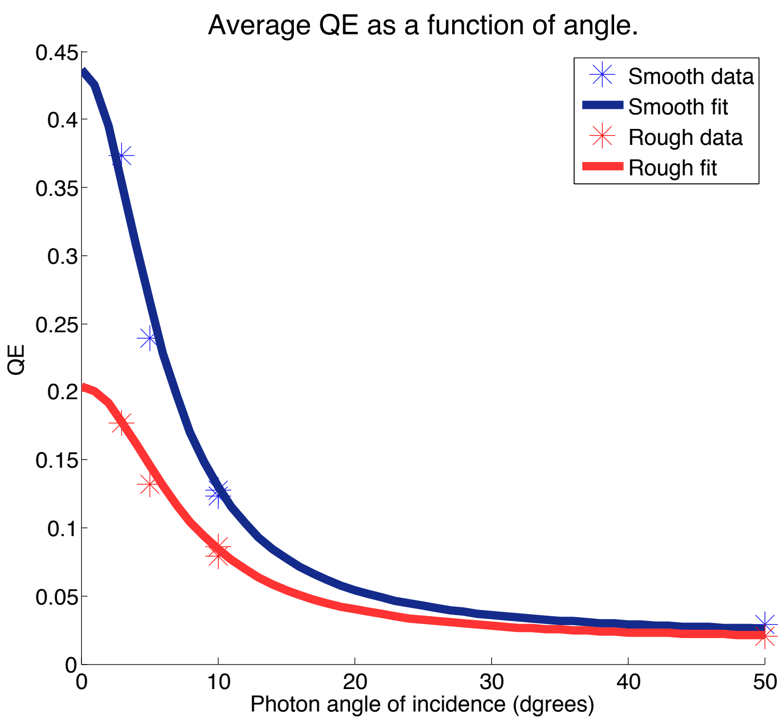
$$QE = \frac{\#\,Electrons}{Flux}$$

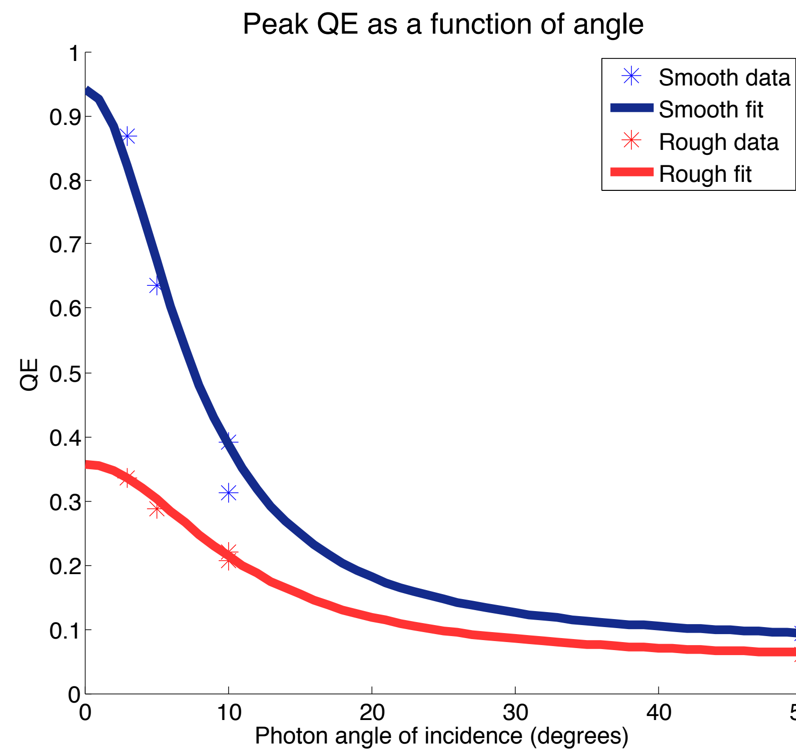
Results from the QE calculation

- Peaks in the QE are present at the binding energy of the elements in the metal.
- A constant QE for all incident photon angles and energies loses some of the complexity of the physics.



Angle dependence of QE



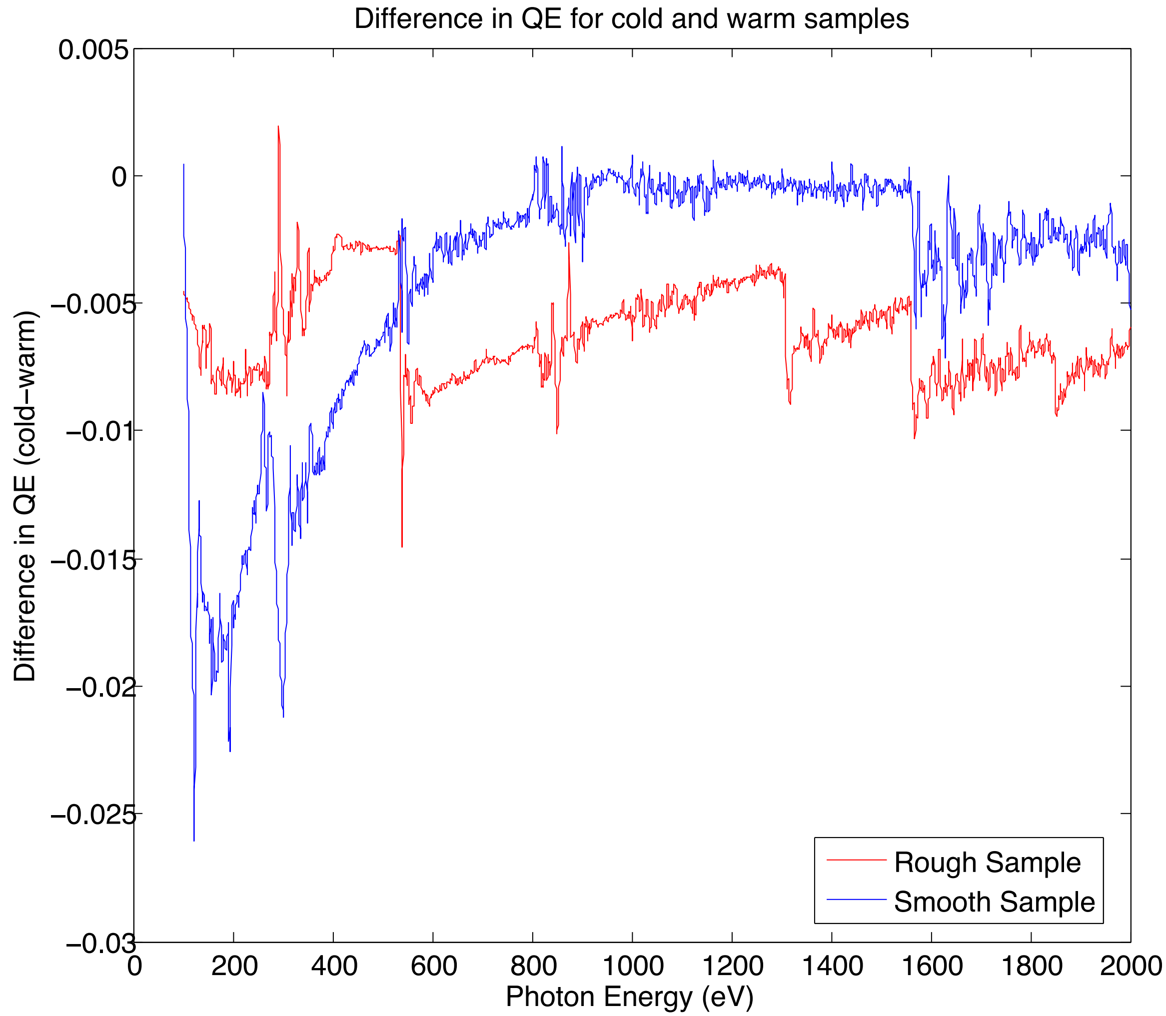


- The QE is strongly dependent on the surface chemistry of the material, the photon incident angle and surface roughness.
- Grazing angles and smooth surfaces have the highest QE's.

Temperature dependence of QE

- The QE was measured at 10 degrees with both a warm and cold sample.
  - Warm sample was at room temperature.
  - Cold sample was cooled to 185K.

- The warm samples always have a slightly higher QE, but the difference is <0.025.
- All of the analysis shown today ignored the temperature of the sample.



Summary and future work

- Utilizing this, and other photoemission data will bridge the gap between Synrad3d and electron cloud simulation codes.
- The QE is more complex than a single value, which should be considered in electron cloud simulations.

- A simulation will be written to calculate the properties of the emitted electrons from synchrotron radiation.
- Photon reflectivity data was taken at BESSY using the same samples, this data will allow for a correlation between photon reflectivity and QE.
- There are plans to measure the emitted electron angle and energy using angle-resolved XPS.

Acknowledgements

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Questions?