CLASSE
Cornell Laboratory for Accelerator-Based Sciences & Education

IPAC18
9th International Particle Accelerator Conference (IPAC'18)
April 29 to May 4, 2018 - JW Marriott Parq Vancouver

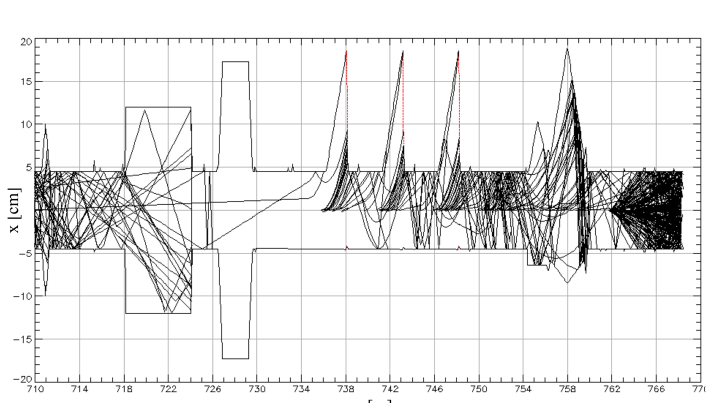
MODELING STUDIES FOR SYNCHROTRON-RADIATION-INDUCED ELECTRON PRODUCTION IN THE VACUUM CHAMBER WALLS AT CESRTA

S. Poprocki, J.A. Crittenden, D.L. Rubin, and D. Sagan
CLASSE*, Ithaca, New York, 14853 USA

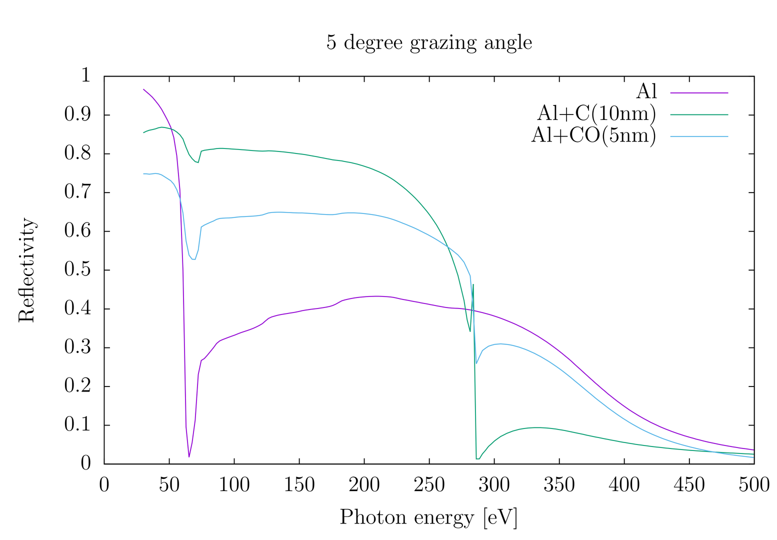
Abstract

We report on calculations of electron production by synchrotron radiation absorbed in the vacuum chamber walls of the Cornell Electron Storage Ring (CESR). These electrons are the source of electron clouds which limit the performance of storage rings by causing betatron tune shifts, instabilities and emittance growth. Until now, cloud buildup modeling codes have used ad hoc models of the production of the seed electrons. We have employed the photon scattering code Synrad3D to quantify the pattern of absorbed photons around the CESR ring, including the transverse distribution on the wall of the beam-pipe. These distributions in absorbed photon energy and incident angle are used as input to Geant4-based simulations of electron emission from the walls. The average quantum efficiency is found to vary dramatically with the location of the absorption site, owing to the distribution in impact energies and angles. The electron production energy spectrum plays an important role in the modeling of electron cloud buildup, where the interplay of production energy and acceleration by the beam bunches determines the time structure and multipacting characteristics of the cloud.

Synchrotron Radiation Photon Tracking Calculation

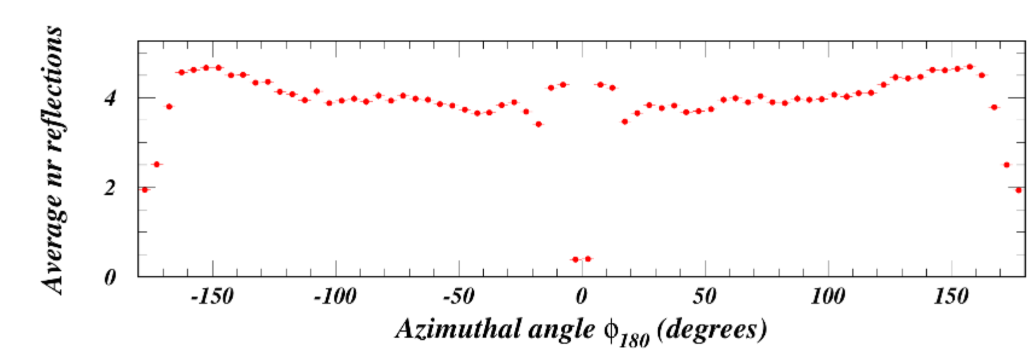


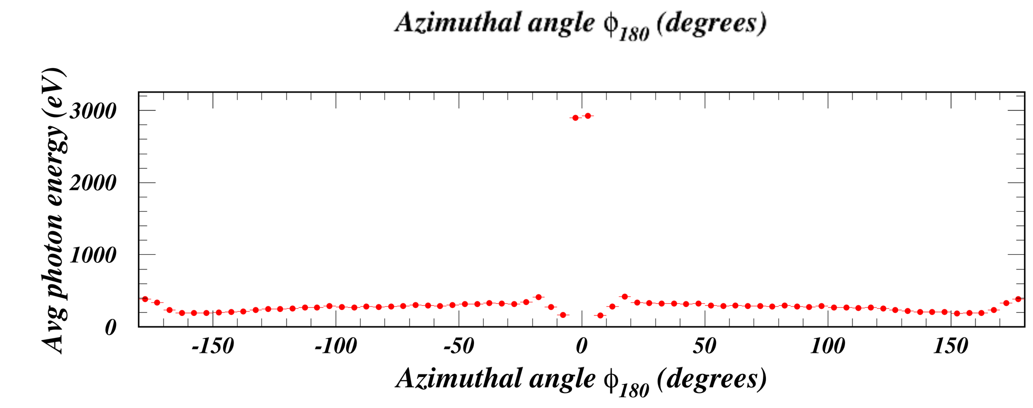
Plan view of photon trajectories in Synrad3D



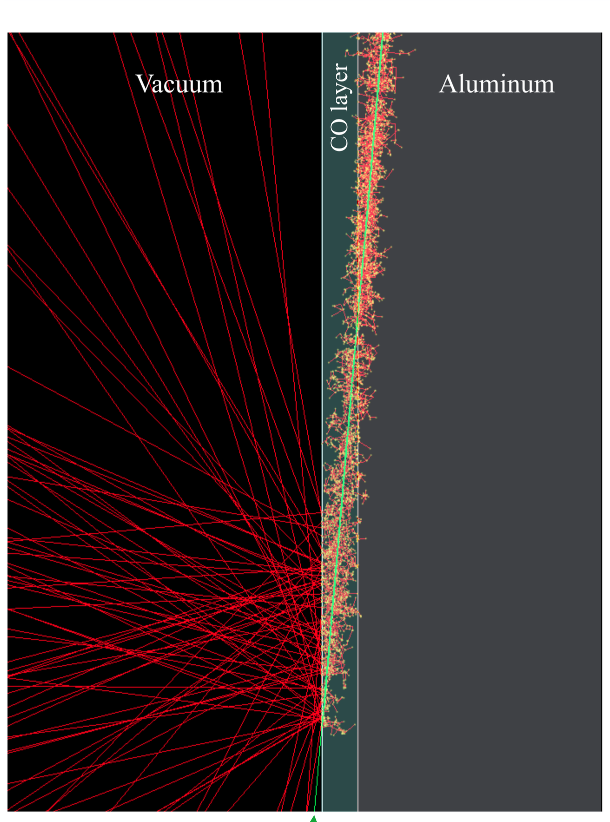
Photon reflectivity data from LBNL database

- **Synchrotron radiation analysis for CESR lattice and 3D vacuum chamber profile with Synrad3D**
- **Individual photon tracking with specular and diffuse photon reflections**
- **Absorbed photon energies and incident angles vary greatly azimuthally around the vacuum chamber**
- **Absorbed photon information is input to the Geant4 simulation below to generate electrons**

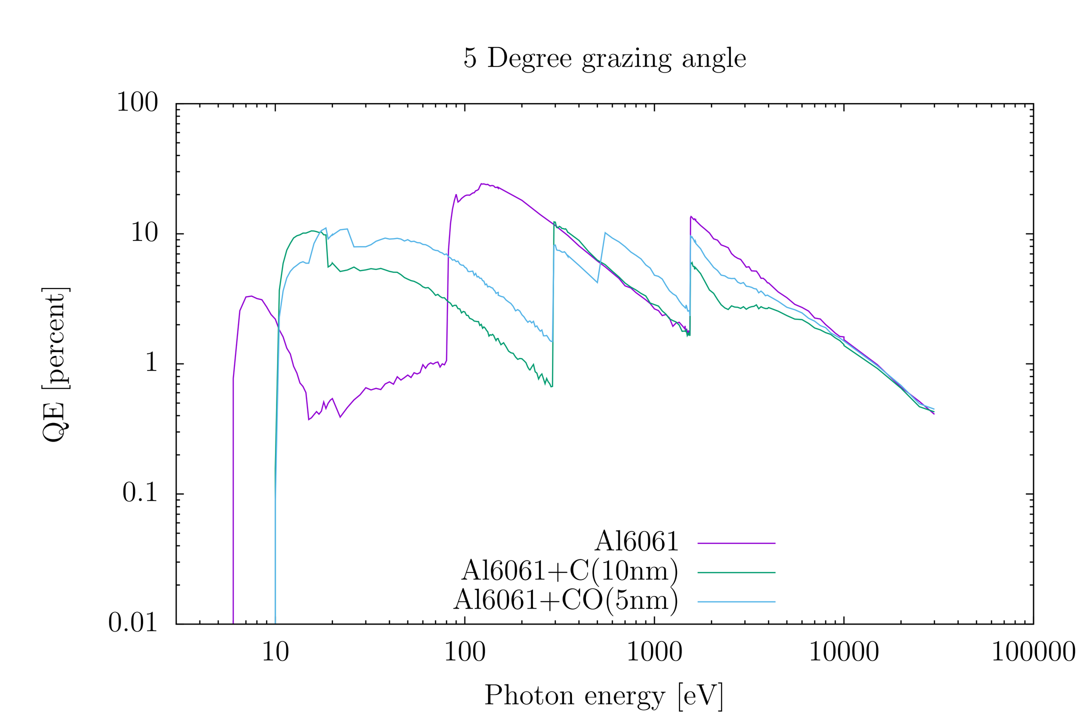




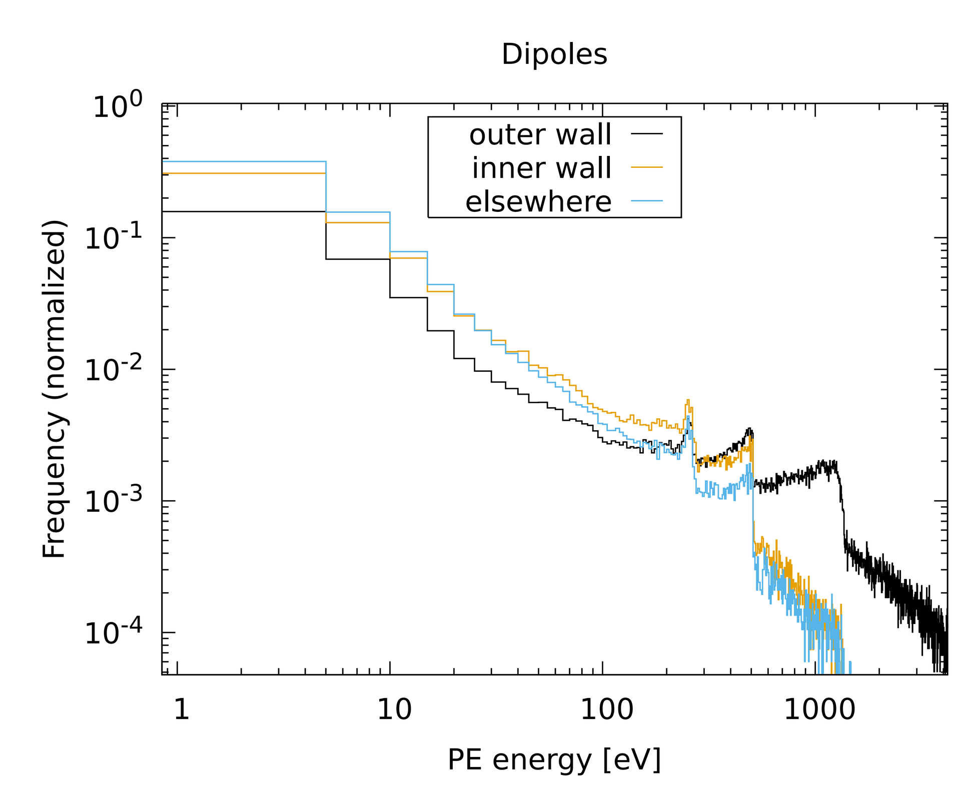
Geant4 Simulation of Photo-produced Electrons



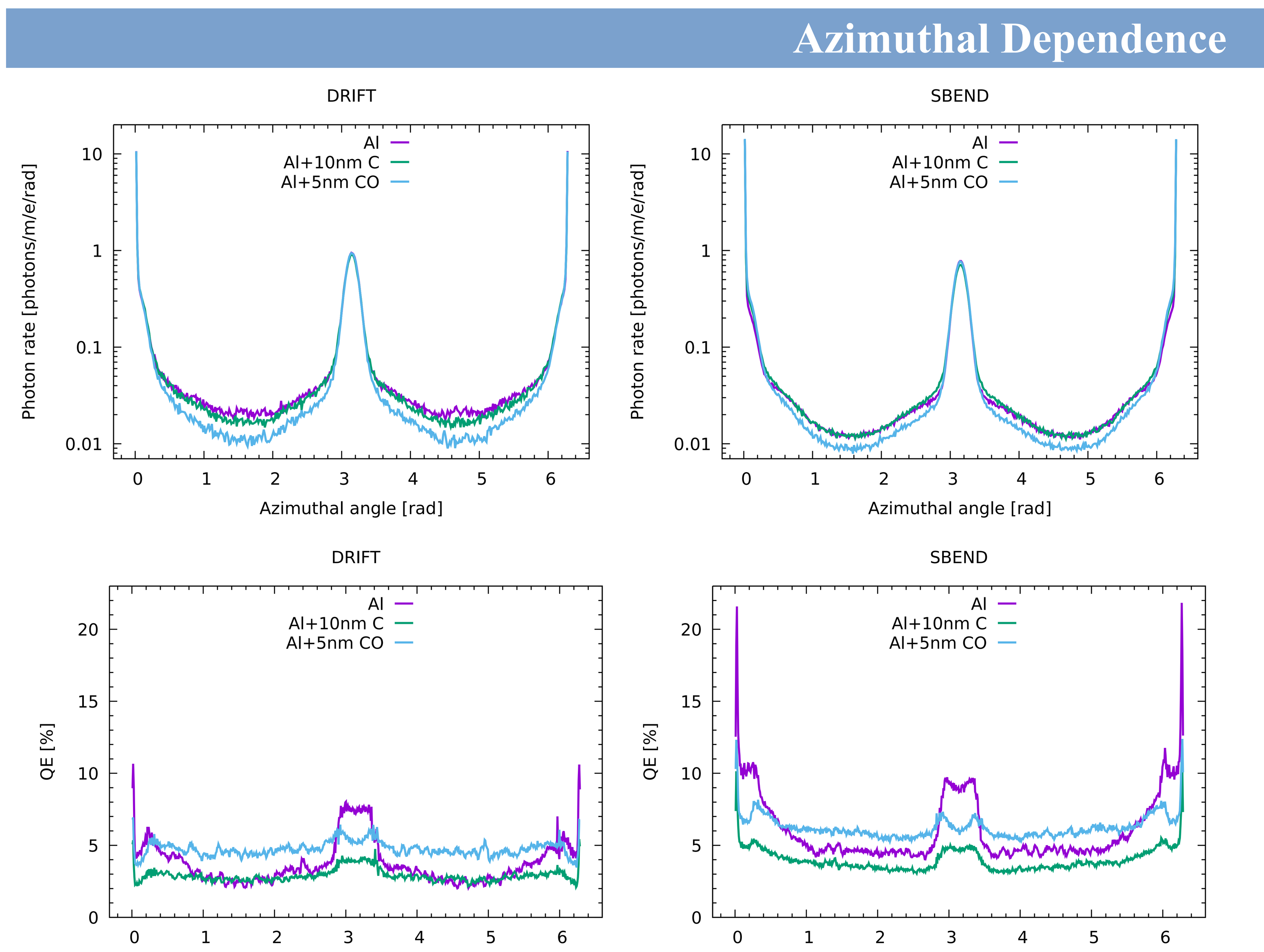
Incident photons



- **Electrons produced by photo-electron effect and atomic de-excitation (Auger electrons)**
- **Simulated with Geant4 simulation toolkit**
- **Quantum efficiency calculated as the # of electrons emitted back into the vacuum chamber divided by the # of incident photons**
- **QE depends strongly on photon energy and incident angle (from above Synrad3D simulation)**
- **Result:**
  - **Photoelectron energy distributions**
  - **Azimuthal quantum efficiency distributions**



Azimuthal Dependence



- **Photon rate distributions (from Synrad3D) are multiplied by quantum efficiency (from Geant4) to yield photoelectron rates to be used in electron cloud buildup simulations:**
  - *S. Poprocki et. al, Progress in Measurement and Modeling of Electron Cloud Effects at CESRTA, IPAC18: THPAF025*
- **Quantum efficiencies vary greatly azimuthally around the vacuum chamber due to differences in absorbed photon energy and incident angle**
- **Carbon or carbon monoxide layer affects absorbed photon rate and quantum efficiencies**
- **Similarly, photon rate and QEs differ between drift and dipole regions**
  - **Photons absorbed in drift regions are more likely to have multiple reflections**

Summary

- **Photon tracking, reflection and absorption simulated with Synrad3D**
- **Absorbed photon information is fed into a Geant4 simulation for electron emission**
- **The resulting photoelectron energies and azimuthal rates can be used in electron cloud build-up simulations**

Future Work

- **Study effect of other vacuum chamber materials and coatings**
- **Further study the effect of scattering off microscopic grooves along vacuum chamber due to the extrusion process**

*Work supported by the U.S. National Science Foundation PHY-1416318, PHY- 0734867, and PHY-1002467, and the U.S. Department of Energy DE-FC02-08ER41538
CLASSE facilities are operated by the Cornell Laboratory for Elementary Particle Physics (LEPP) and the Cornell High Energy Synchrotron Source (CHESS) with major support from the National Science Foundation.