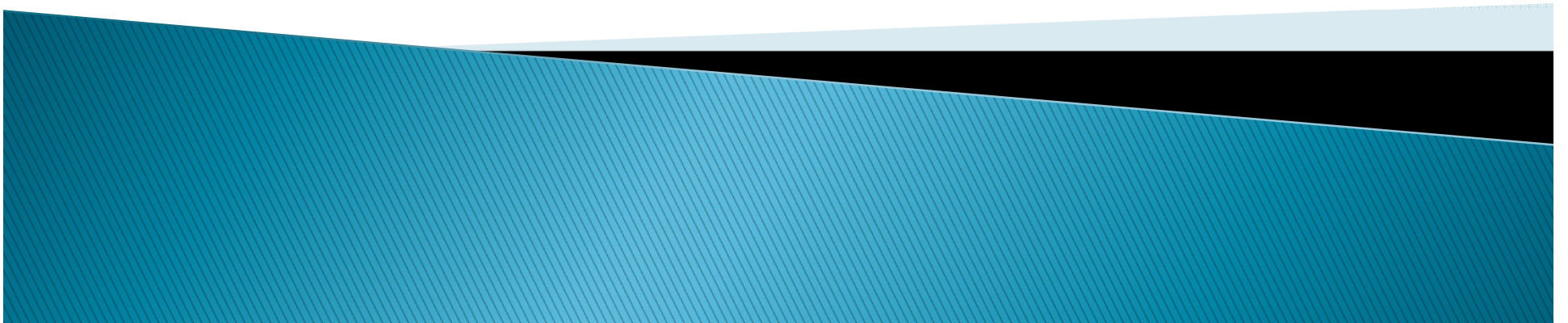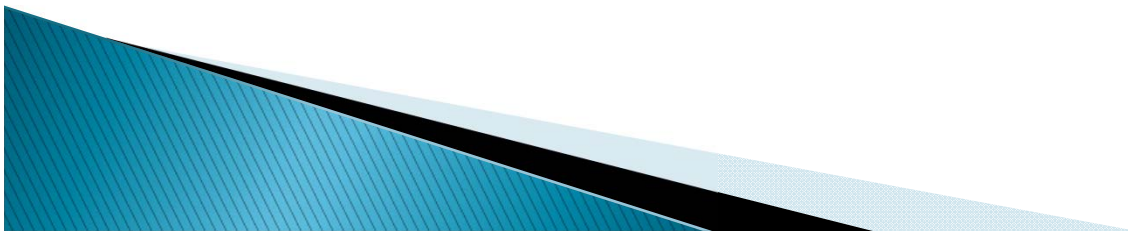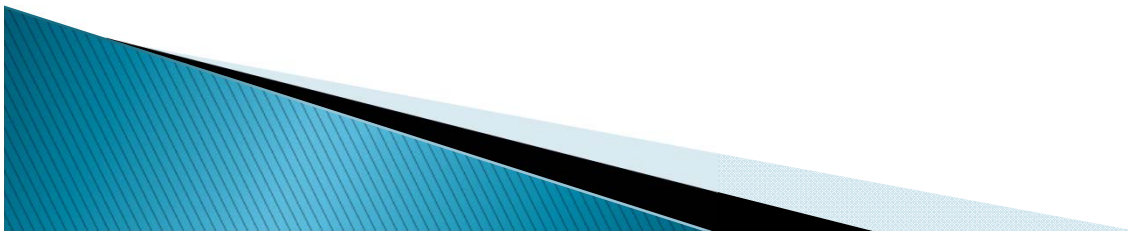# Ultrafast X-ray Detector

Calvin Ebinger

Goals

- Ultimate goal: measure the time profile of an x-ray pulse at the Advanced Photon Source
- Short-term goal: create and optimize the detector and measurement procedure

Science

- X-ray and laser optics
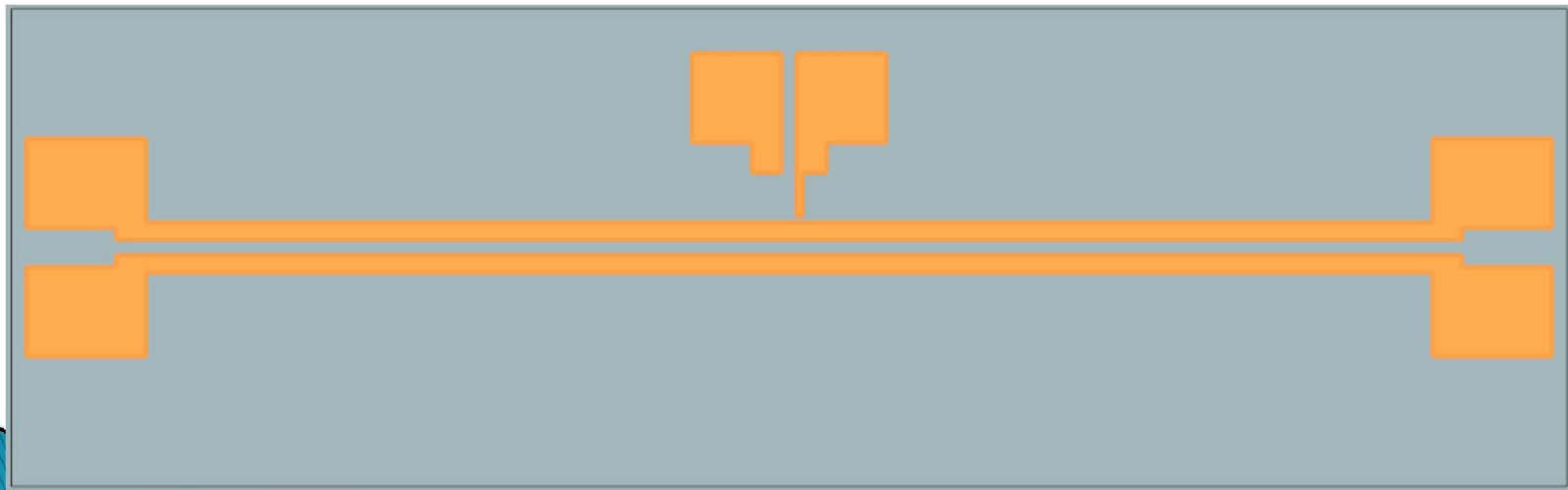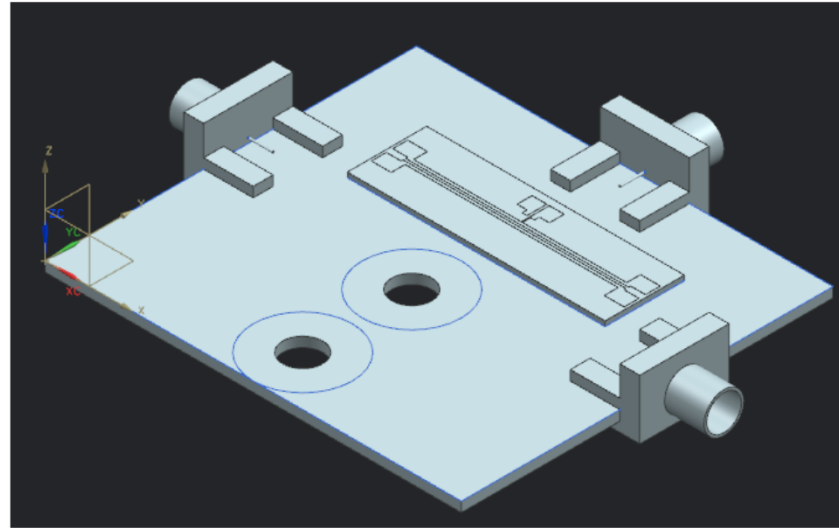- Electrical properties of semiconductors
- Waveguides

Specific Tasks

- Detector optimization
  - Impedance matching
  - Proton implantation
- Measurement techniques
  - Trying to measure current rather than voltage

The Detector

Impedance Matching
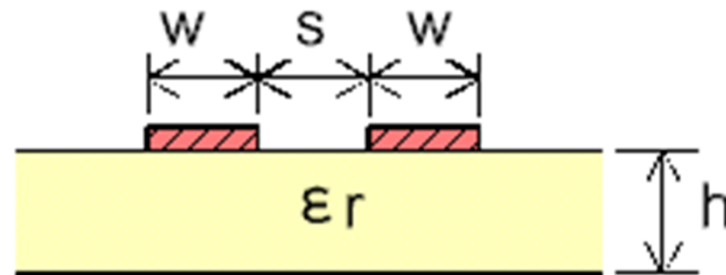
- Important to eliminate EM pulse reflections from changes in impedance
- Impedance determined by geometry of a waveguide (industry standard for BNC coaxial cables is 50 Ω)
- Can use known formulae to calculate impedance in a given waveguide geometry to predict ideal geometry

Impedance Matching (cont.)

▸ Formula for our waveguide:

- $Z_0 = \dfrac{\eta_0}{\sqrt{\varepsilon_{eff}}} \dfrac{K(k)}{K(k')}$

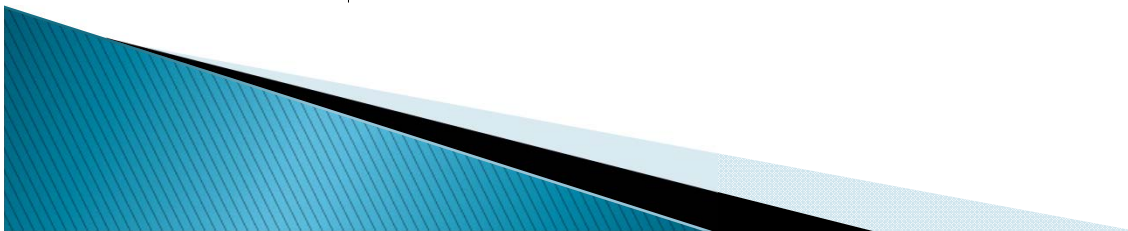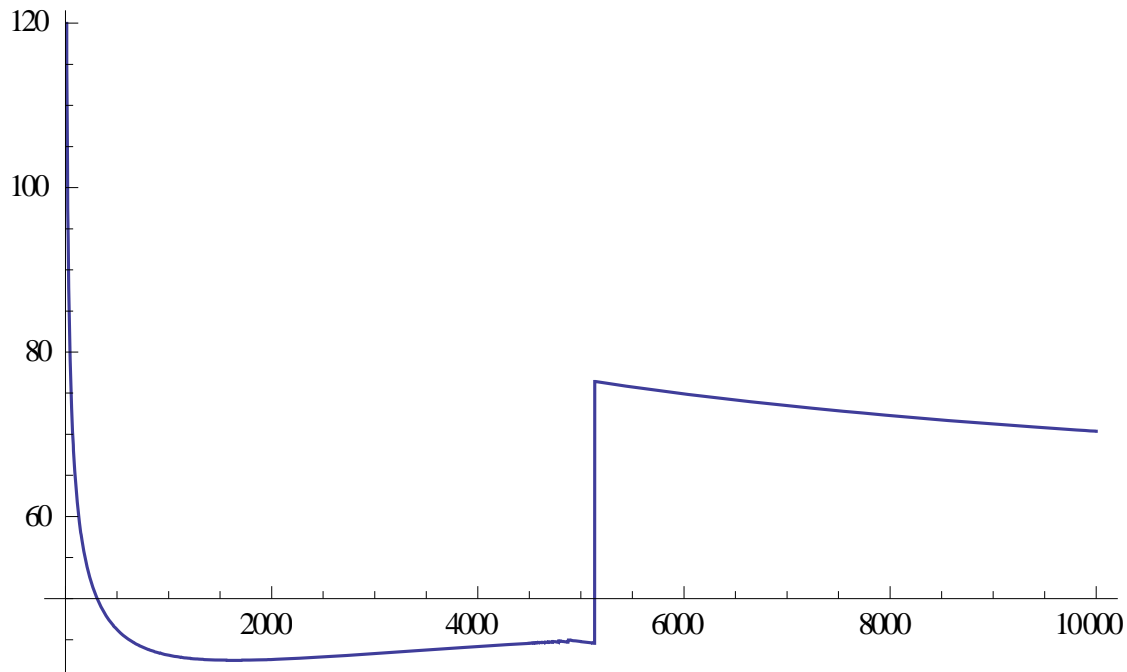- $\varepsilon_{eff} = 1 + \dfrac{\varepsilon_r - 1}{2} \dfrac{K(k')K(k_1)}{K(k)K(k_1')}$

- K(k) are complete elliptical integral of the 1st kind
- k and its various primes and subscripts are related to the spacing between striplines and the width of the striplines

Impedance Calculations

▸ Impedance as a function of stripline thickness

Measuring Impedance

▸ Necessary to check the calculations

▸ Impedance measuring technique called Time Domain Reflectometry (TDR)

  ◦ Sends an EM pulse and measures the reflection which is related to a change in impedance

  ◦ Uses a special machine called a Time Domain Reflectometer (also TDR)

  ◦ Made a makeshift TDR machine using a function generator and an oscilloscope (it works, too!)

Plans for the Future

▸ Proton implantation
  ◦ Make sure implantation worked as expected
  ◦ Decide if the implantation procedure helped or not
▸ Current measurement
  ◦ Make sure the detectors are sensitive enough
  ◦ Create a procedure for the measurement