Design and Engineering of Modern Beam Diagnostics

Optical Transverse Profiler Homework

1A: The LHC has a synchrotron light profile monitor. It makes use of a dipole magnet that is 9.45 m long and bends the beam by 1.57 milliradians. What is the bend radius of the magnet? The kinetic energy of the protons in the ring is 6.5 TeV. What is the critical frequency and angle for the synchrotron radiation from the center of the magnet?

1B: What is the best resolution from diffraction that can be obtained? What is the longitudinal path length that would be observed if you put a 50 mm diameter collection lens 30 meters from the source?

1C: If we assume a visible light imaging system with a magnification of 1, how big is a point image at either end of the longitudinal path length neglecting diffraction?

2A: You must add a transition radiation profile screen to the Fermilab FAST electron linac. The beam has a gamma of 100. The beam size is expected to be gaussian and have a range of rms values of 50 um to 4 mm at the screen location. The pulse will have a charge range of 50 pC to 1 nC. Assume a flat frequency distribution for transition radiation up to a frequency corresponding to far UV at 100 nm wavelength. Over that frequency range assume there is one photon for every 100 electrons. If the camera is sensitive to a wavelength band of 400 nm to 700 nm, fill out this table. In band means within the 400 to 700 nm window. The camera has a pixel size of $3\ \mu m \times 3\ \mu m$.

Number of Photons					
	Max per camera pixel (pixel size is 3 μm) in band			Total	
Beam Charge	50 μm	1 mm	4 mm	In Band	All wavelengths
50 pC					
250 pC					
1 nC					

2B: If the typical camera pixel has an absolute sensitivity threshold (where S/N = 1) of 3 photons per pixel, what can one say about the results above? (There's no right answer, but there are definitely wrong ones)