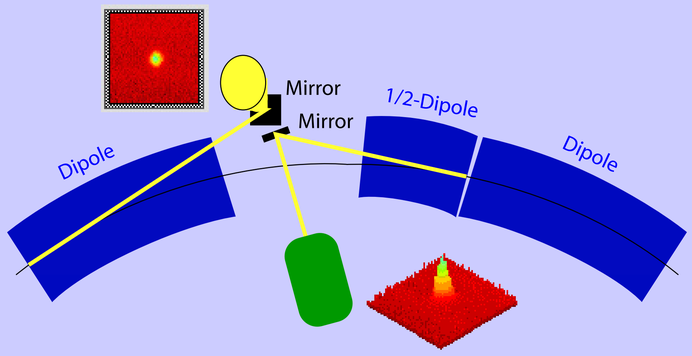
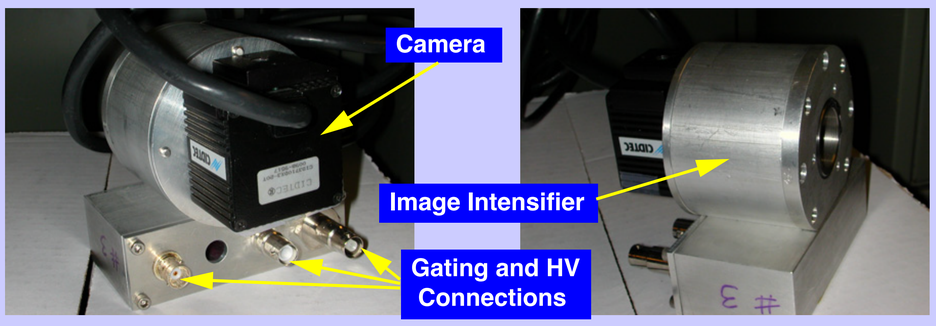
Synchrotron Light Beam Monitor in the Fermilab Tevatron

The system detects (blue) synchrotron light emitted at the edge of a dipole magnet to measure the 2-dimensional transverse profile of the proton and antiproton beams.

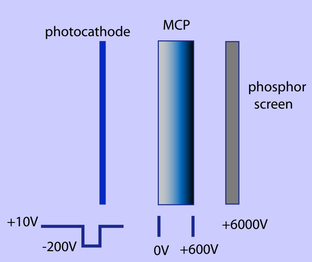


The light is detected via a single lens telescope, a narrow band filter, an image intensifier and a CID camera. The image is captured using a video frame grabber giving 8 bits of intensity for each pixel and is analyzed in LabVIEW.

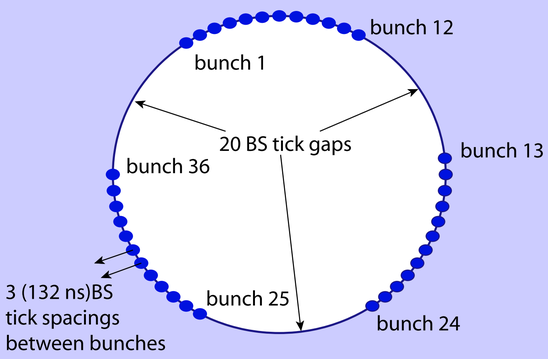
Photographs of the image intensifier and CID camera



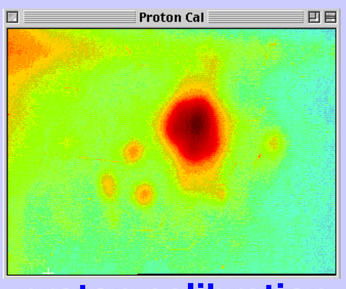
Each of the 36 proton and 36 antiproton bunches in the Tevatron are measured by gating the photocathode of the image intensifier at the proper time for each bunch. A gain of 1000 is achieved in the Multi-Channel-Plate of the image intensifier. The image on the phosphor screen is viewed by a Charge-Injection-Device Camera.



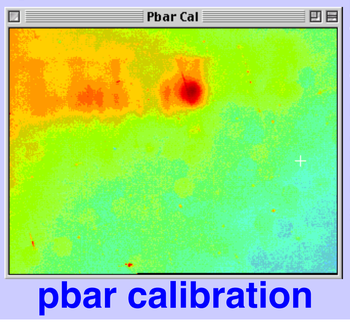
Schematic of image intensifier with gating and HV settings



Timings of bunches in the Tevatron



proton calibration

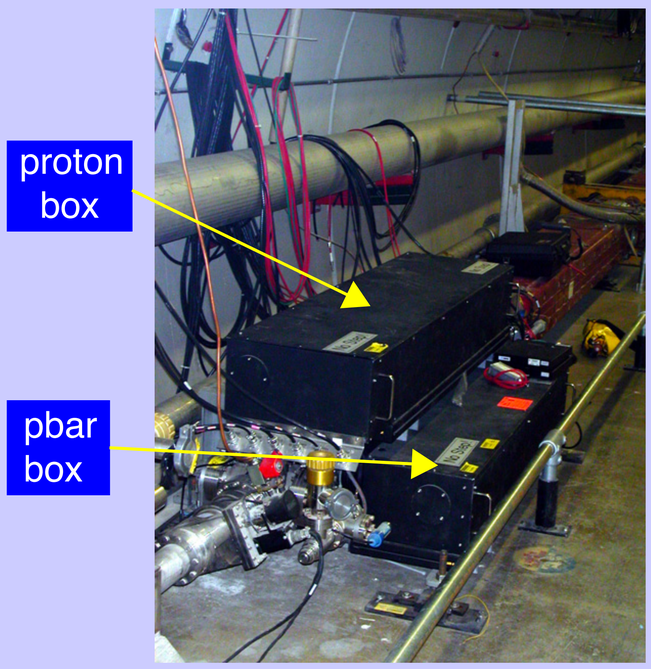


pbar calibration

Low efficiency black and red regions are caused by burn-in of the image over time. The system now gates and the HV is lowered between gating the MCP.

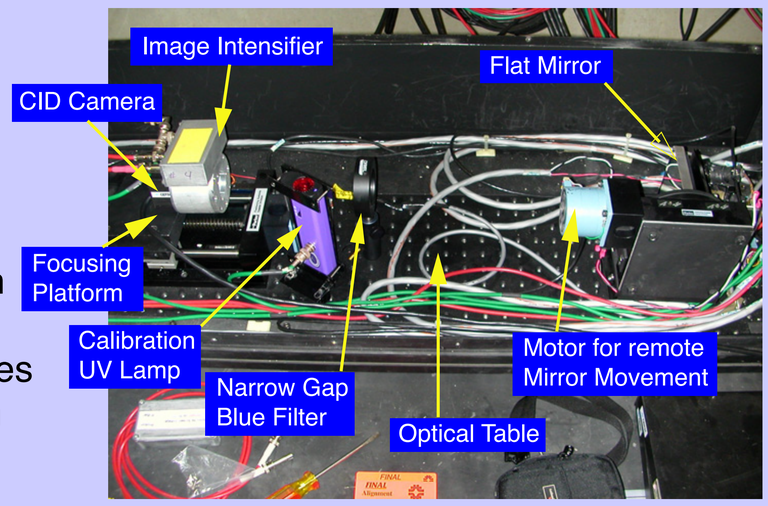
The image intensifier is calibrated with a UV lamp giving an almost uniform intensity across the image intensifier. By also taking an image with the UV lamp off, the background subtracted image is used as a measure of the efficiency of the intensifier (see images, left.) The UV light is flat enough in the small region of the proton and antiproton beam image.

Detection optical tables and light-tight boxes in the Tevatron tunnel



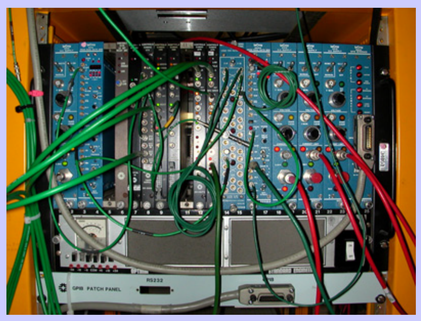
Components and devices in the proton box

Synchrotron light from the protons (pbars) travels about 7.4 (4.7) m before being picked off by an aluminium flat mirror. The light is separated from the proton (pbar) particle beam by 2.6 (1.0) cm at the pick-off mirror. It then passes through a quartz window in the vacuum beam pipe.

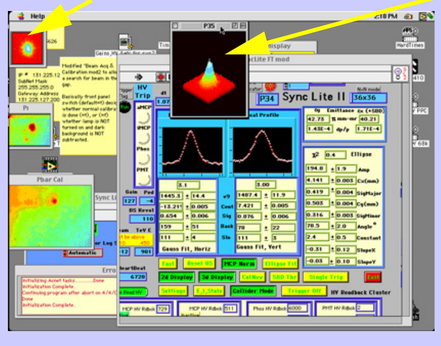


The timing of the Tevatron is received via a custom CAMAC module and the gating, HV and calibration is CAMAC controlled using a Mac through a GPIB interface. The images are captured with a video frame grabber on the Mac giving 640x480 pixels with 8 bits of data per pixel.

Photo of CAMAC Crate

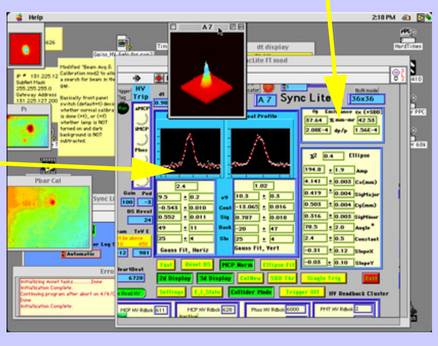


Sidebands in the images are used as background images to determine the background to subtract and to estimate the statistical fluctuations in the image. The background subtracted images are either fit with a 2-dimensional function which gives any rotation in the ellipse or a faster fit is done using the data projected to give the horizontal and vertical positions and sizes. The proton (pbar) beams are almost Gaussian with a horizontal sigma of about 0.055 (0.055) cm and a vertical sigma of about 0.085 (0.070) cm.



Mac desktop showing protons

projections showing Gaussian fits



Mac Desktop showing pbars