

AN IONIZATION PROFILE MONITOR FOR THE TEVATRON

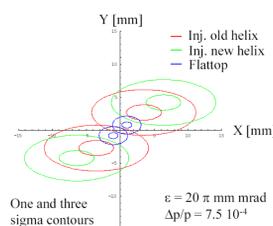
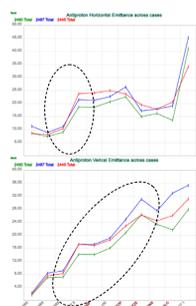
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Abstract

Primarily to study emittance blowup during injection and ramping, an ionization profile monitor has been developed for the Tevatron. It is based on a prototype installed in the Main Injector, although with extensive modifications. In particular, the electromagnetic shielding has been improved, the signal path has been cleaned up, and provisions have been made for an internal electron source. Due to the good Tevatron vacuum, a local pressure bump is introduced to increase the primary signal, which is then amplified by a microchannel plate and detected on anode strips. For the DAQ, a custom ASIC developed for the CMS experiment is used. It is a combined charge integrator and digitizer, with a sensitivity of a few fC, and a time-resolution that allows single bunch measurement. Digitization is done in the tunnel to reduce noise. Preparations for detector installation were made during the long 2004 shutdown, with the installation of magnets, vacuum chambers, vacuum pumps and cabling. The actual detector will be installed during the fall 2005 shutdown. This paper describes the design of the detector and associated electronics, and presents various bench test results.

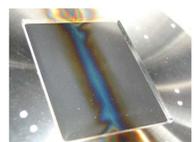
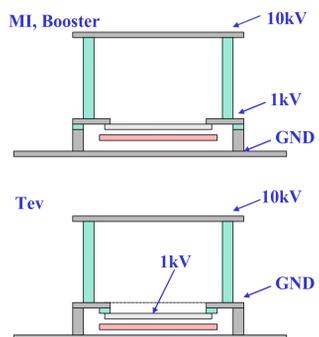
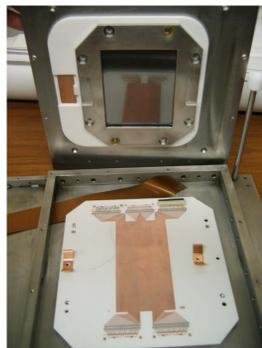
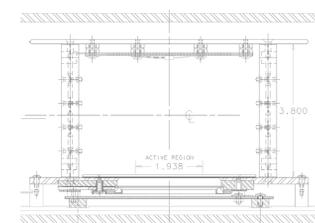
Background

- Directly measure injection matching and emittance growth at injection
 - Turn-by-turn at 10% beam size resolution
- Continuously measure emittance eg on ramp
 - Average at ~% beam size resolution

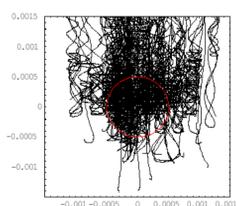
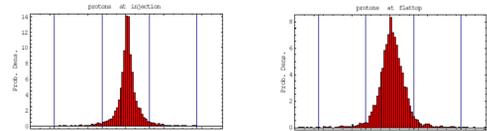


- Projected beam profiles may overlap
- Don't trust to separate beams
- Separate by timing -> single bunch resolution!

Detector

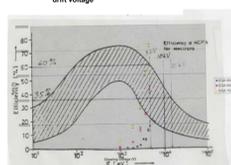
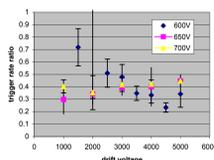


Electron Tracking

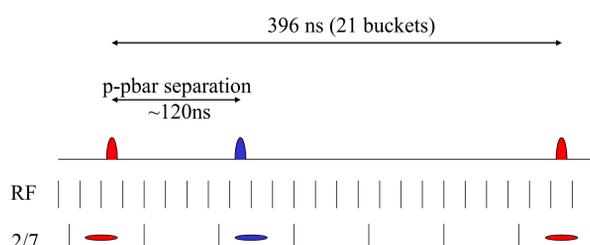


- Ionization electrons simulated in B=0.2T, E=100kV/m.
- Transverse spread from electron momentum less than 1/4 mm pitch
- Small space-charge effect seen for protons at flat-top.

MCP Measurements



Timing

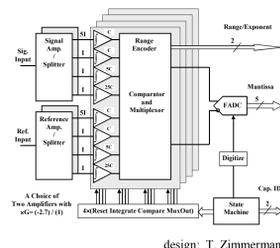


Electronics

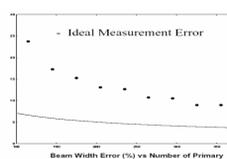
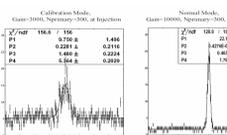


QIE Chip

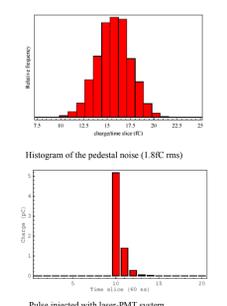
- Charge Integrating Encoder (QIE)
- Developed at Fermilab
- Used by KTeV, CDF, Minos, CMS...
- Frequency range 7-53 MHz
- No deadtime.
- LSB 2.6fC (16000e) in logarithmic mode, 0.9fC (6000e) in linear mode
- Dynamic range $\times 10^4$ in logarithmic mode
- Can achieve noise of Q(1fC)
- Radiation "tolerant"



Signal Simulations



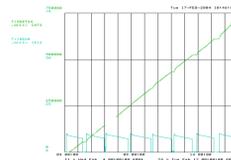
Bench Measurements



Injection is most difficult (fewer counts per channel). Signal per bunch is small, but gain limited by MCP saturation effects from total (proton) signal.

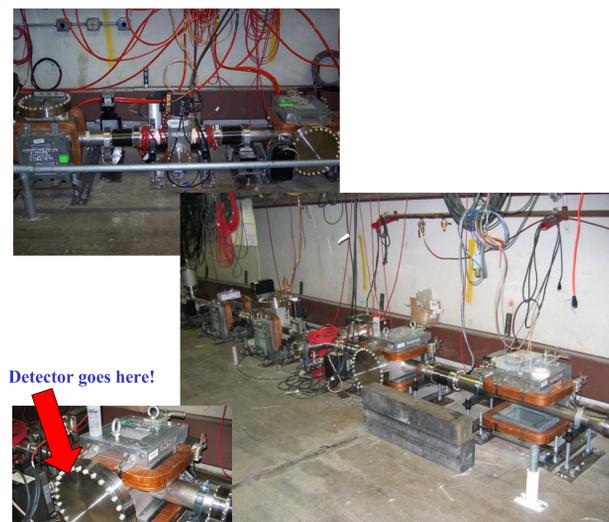
- Need about 300 primaries (per bunch) for 10% beam width accuracy (requires gas injection).
- Higher accuracy can be obtained by averaging many turns (ramp measurement).

Radiation Measurements

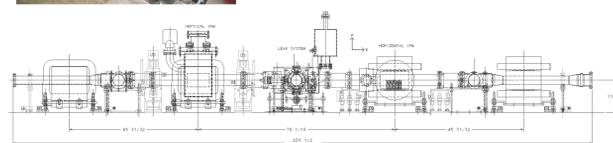


- Reading 125 mrad/h average at ~4.5 feet during normal running
- 18 years to 20 krad!

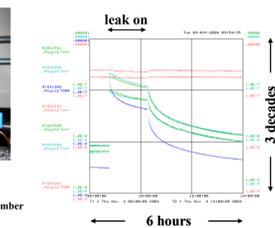
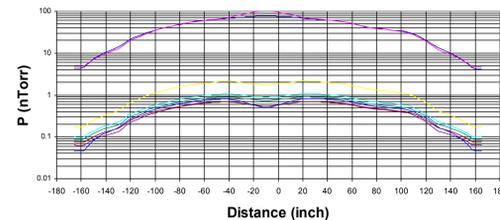
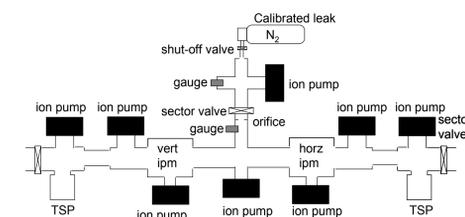
Tunnel Installation



Detector goes here!



Controlled vacuum leak



Red traces: IP and IG in leak chamber
Green, Blue and Cyan: IPs and IG in main chamber

Software

