BEAM HALO MONITORING at CDF:

WHY and HOW We Provide Additional Beam Quantities to Beams Division from within the CDF Collision Hall?

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2.5 Device Designation within ACNET

BHMs are also used to measure the halo in the abort gaps of one Tevatron cycle (Sec 1.2). Following the setup described in Sec 2.2, duplicates of counter signals are this time gated with CDF_ABORT signal (2.4 $\mu\ s$ wide).

ACNET Device	Device Description	Data Logging Rate ($\geq$)	Saturation Rate(MHz)
C:B0PH(N,T,S,B)	p halo individual	1 min	1.7
C:B0AH(N,T,S,B)	$\bar{p}$ halo individual	1 min	1.7
C:B0PHSM	p halo total	1 Hz	6.8
C:B0AHSM	$\bar{p}$ halo total	1 Hz	6.8
C:B0PB(N,T,S,B)	p abort gap individual	1 min	4.6
C:B0AB(N,T,S,B)	$\bar{p}$ abort gap individual	1 min	4.6
C:B0PBSM	p abort gap total	1 Hz	18.4
C:B0PAGC	2/4 majority coincidence	1 Hz	
C:B0ABSM	$\bar{p}$ abort gap total	1 Hz	18.4
C:B0AAGC	2/4 majority coincidence	1 Hz	

Table 2. Device assignments for the scalers. C:B0*AGC are formed by taking the 2/4 majority coincidence of counters gated by the AG for additional monitoring.

2.6 Performance of the Monitors

BHMs have been tested of their performance: the beam off coincidence rates using ACNET data and the expected values calculated using Table [1] are compared.

Counter		Halo Rate (Hz)		Abort Gap Rate (Hz)	
ID	Device	Measured	Calculated	Measured	Calculated
083	B0A*N	4±2	3±2	22±5	17± 4
059	B0A*T	5±2	5±2	36±6	32± 6
042	B0A*S	2±1	2±1	14±4	11± 3
003	B0A*B	11±3	11±3	78±9	64± 8
054	B0P*N	6± 2	7± 3	45±7	40± 6
066	B0P*T	5± 2	5± 2	43±7	30± 5
014	B0P*S	1± 1	1±1	8± 3	8± 3
040	B0P*B	3± 2	4± 2	21±5	21± 5

Table 3. Beam off coincidence accidentals with statistical errors quoted.

$\Longrightarrow$ The values are in good agreement!

3 Results

3.1 Comparison with CDF Loss Monitors

BHMs are sensitive to p and $\bar{p}$ losses! We also observe features in $\bar{p}$ halo rates that are just visible in $\bar{p}$ loss rates; thus are previously unnoticed (arrows in Fig. 9 below). These structures in $\bar{p}$ monitor are yet to be examined in more detail.

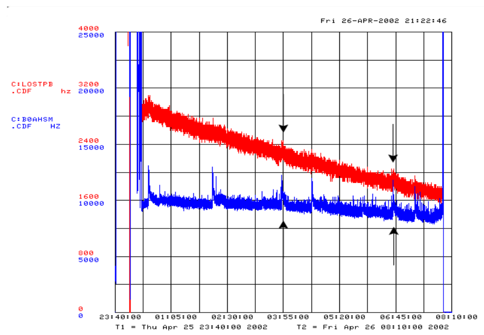

Figure 9. $\bar{p}$ halo sum rates (C:B0AHSM) and loss rates (C:LOSTPB) for store 1243. Note that y-axis scales are different for the superimposed data.

3.2 Correlation with Vacuum Imperfections

$\Longrightarrow$ p halo monitors have a perfect correlation with the imperfections in the Tevatron vacuum!

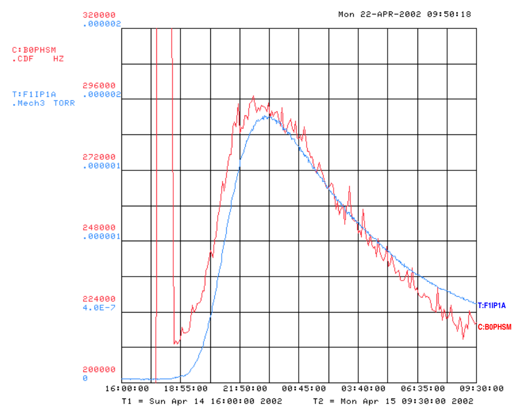

Figure 10. Sensitivity of the proton halo monitor rates (C:B0PHSM) to changes in the beam vacuum in the F11 sector of Tevatron (T:F1IPA) for store 1207. The rates increase following the vacuum imperfection due to temperature changes.

3.3 Sensitivity to Operational Condition Changes

The abort gap BHMs have a clear response to the Tevatron Electron Lens (TEL) operational changes! The rates become more spiky following the lens being turned off (0.0 mA) (Figure 11. below) and just it's turned back on, the rates increase abruptly followed with a subsequent decrease.

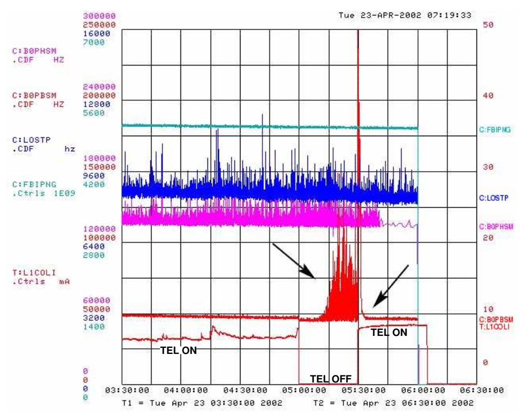

Figure 11. Halo monitor ACNET variables vs. time for a portion of store 1229. The arrows point to the response of the proton abort gap monitor (C:B0PBSM) to the changes in the Electron Lens (T:L1COLI) operation conditions. C:LOSTP is the proton losses as measured with the CDF BSC. Variable C:FBIPNG measures proton beam current in Tevatron.

4 Further Observations

4.1 Lifetime Measurements

The lifetimes of the rates for the duration of a Tevatron store can be measured by a fit to an exponential decay function:

$$y = y_0 \times e^{\frac{t}{\tau}}, \tag{1}$$

where t is in hours and τ is the average lifetime. The half-life, $t_{1/2}$ is $ln(2) \times \tau$. The preliminary results indicate a correlation of abort gap halo decay rates with that of instantaneous luminosity (C:B0ILUM). This information is to be investigated further.

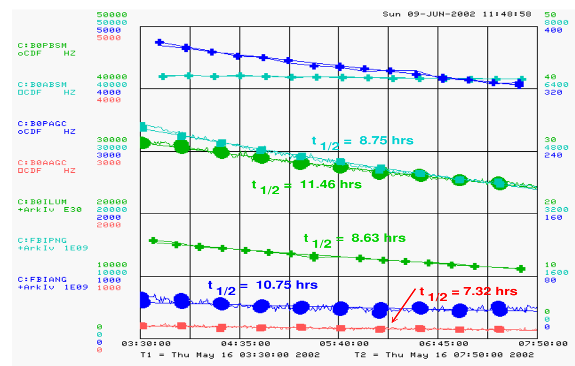

Figure 12. Various halo monitor rates fit to exponentials for Tevatron store 1328. $t_{1/2}$ values are shown on the most relevant BHM variables.

4.2 Decay Rate of Abort Gap Halo Monitors

Abort gap halo monitors appear to be sensitive to *"radiation"* which has a long time component. We have looked at the decay rate of the abort gap BHMs at the end of the store 1328 which was aborted. The ACNET variables B0PBSM and B0ABSM have long tails after the abort. The abort gap halo monitors requiring 2/4 majority coincidence (B0PAGC, B0AAGC) appear to shut off almost instantly with the beam abort.

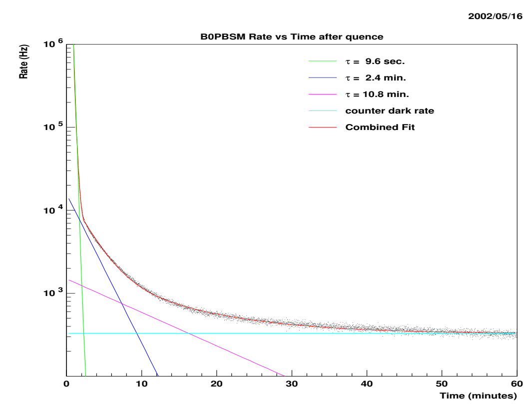

Figure 13. The plot shows data from B0PBSM fit to various exponentials with different time constants.

$\Longrightarrow$ The fits seem to agree with the decays of potassium isotopes!

① $t_{1/2} = 6.65$ sec $\Longrightarrow$ ^{48}K (6.8 sec) through β^-, γ
② $t_{1/2} = 1.66$ min $\Longrightarrow$ ^{46}K (1.7 min) through β^-, γ
③ $t_{1/2} = 7.48$ min $\Longrightarrow$ ^{38}K (7.6.min) through β^+, γ

Decay radiations data for the isotopes are taken from [7].

5 Conclusions

- We installed two counter arrays in CDF collision hall to improve the beam quality monitoring.
- The data from the devices show that they are able to operate properly.
- The data also show that some beam related effects are visible with an enhanced sensitivity when compared with existing detectors and we are observing some new features as well..
- The BHM devices are in CDF's regular beam monitoring list.
- We have been providing feedback to Beams Division about the Tevatron beam halo as measured in the CDF collision hall.
- The information provided by the BHMs is useful to both CDF and D0 experiments on the Tevatron ring.

6 Acknowledgments

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References

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[7] *http://www-cdf.fnal.gov/internal/upgrades/integration/sideview.pdf*, modified for enhanced visibility.

[8] National Nuclear Data Center, *http://www.nndc.bnl.gov/nndc/*.