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Notes on Tev BPM offset changes in November 2003.

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Introduction

This is a collection of notes on Tevatron BPM offset changes implemented based on measurements made during the fall of 2003 shutdown. A more complete set of measurements exists, but this memo is limited to the changes made to the offsets used by the Tevatron BPM program T39. A complete list of the changes made to the offsets is given in a separate Excel spreadsheet, including the offsets used by T39 prior to November 2003 and the updated values implemented on November 25th, 2003.

[Note: The changes to the offsets were first implements on 11/17/03 at 11:00, but then a few errors were found. The corrected version of the offsets were implemented on 11/25/03 at 15:00.]

Explanation of Offsets

There are two components to the offset, an electrical offset and a mechanical (or survey) offset. T39 calculates the position from the raw digitized data, D, with the transform

$$X_{T39} = A_0 f(D) - \Delta_{electrical} + \Delta_{survey}$$

where A_0, the lookup table f, $\Delta_{electrical}$, and Δ_{survey} are retrieved from the database. The raw data, D, is an 8 bit number, and is the digitized version of the output voltage of the BPM analog box. The lookup table is shown in Appendix A. For small position offsets from the center of the BPM's the lookup table is approximately linear and the position is equal to X (mm) = 0.15*(128 – D). The offsets for all detectors are from the database and are computed in the manner shown above.

The F0 detectors are also done in this way, but their position scale factors are 2.83 rather than 1.0. The BPMs near F0 have a different scaling factor since the stripline pickups are physically different.

Most detectors use the lookup table to determine their positions. There are four special detectors at E2 (HE24, HE26, VE25, and VE27) which had used a different algorithm altogether. For these, position = (float) (((128.0 - raw_data) / 0.112) / 100.0 + offset. During the fall 2003 shutdown the electronics for these detectors was replaced with the standard type of electronics used elsewhere in the ring. The electrical offsets measured for this shutdown were made after the electronics was replaced with the standard version.

Measurements of the Electrical Offsets

Measurements of the electrical offsets were made by injecting a common signal onto the pbar end of the pickups, thus simulating a beam going through the center of the pickups. The signal was generated with a waveform generator and simulated 30 uncoalesced bunches. The measured position and the raw counts with this signal were recorded and translated into offset numbers. Almost all of the BPMs were measured in this manner except for a few locations (such as the B0 and D0 BPMs) which were inaccessible,

The spreadsheet of offsets contains two sets of data related to the electrical offset. The first is based on the position recorded by T39 when the signal is injected into the pbar plates. From the T39 position and the offsets used by T39 a new electrical offset can be determined. A more straightforward method is to record the raw digital signal produced by the BPMs and then this value becomes the electrical offset. For small values of the beam position the electrical offset = (128-Raw) * 0.15 (Scale to mm). Both of these methods were used, but this resulted in some inconsistencies in the electrical offset and these BPMs were measured again.

There were a number of BPMs which showed a change in the electrical offset of more than 1 mm. These are listed in the table below. Almost all of the BPMs showed a smaller electrical offset now than was previously used by T39. **These are the changes made to the BPM offsets in T39 on November 25th, 2003.** The changes were based on measurements of the electrical offsets and a review of the survey offsets.

With these changes in T39, the reported BPM positions will change by the negative of the amount of the offset in the difference columns. For instance, if actual position of the beam were not moved, then the BPM at T:HPE44 would report a position +1.67 mm further to the radial outside.

	Electrical Offsets		
BPM	**Original**	**After changes**	**Difference**
T:VPA23	3.20	0.00	**-3.20**
T:VPD45	2.89	0.15	**-2.74**
T:HPC15	1.96	0.00	**-1.96**
T:HPD46	1.51	-0.30	**-1.81**
T:HPE44	2.42	0.75	**-1.67**
T:VPA47	1.51	0.15	**-1.36**
T:HPE46	1.66	0.30	**-1.36**
T:HPC34	1.35	0.00	**-1.35**
T:VPD25	0.90	-0.45	**-1.35**
T:HPF44	1.20	0.15	**-1.05**
T:HPA48	0.60	-0.45	**-1.05**
T:VPE43	1.05	0.00	**-1.05**
T:VPF12	0.75	-0.30	**-1.05**
T:VPF27	0.75	-0.30	**-1.05**
T:VPD39	1.35	0.30	**-1.05**
T:HPA13	-0.45	0.60	**1.05**
T:HPD38	-0.15	0.90	**1.05**
T:VPE47	-0.90	0.15	**1.05**
T:VPE45	-1.20	0.00	**1.20**
T:HPA17	-1.51	0.00	**1.51**
T:HPB12	-0.90	0.90	**1.80**
T:HPC11	-2.12	-0.15	**1.97**

Review of the Mechanical Offsets

A review of the mechanical offsets of the BPMs with respect to the center of the quadrupole field was undertaken. There were a number of BPMs which showed a change in the mechanical offset of more than 1 mm. These are listed in the table below. With these changes in T39, the reported BPM positions will change by the amount of the total offset in the difference columns. For instance, if actual position of the beam were not moved, then the BPM at T:VPF11 would report a position 0.73 mm further downwards.

	Mechanical Offset		
BPM	**Original**	**After Changes**	**Difference**
T:VPF11	0.00	-0.73	**-0.73**
T:HPC49	0.32	0.00	**-0.32**
T:VPD11	0.00	-0.15	**-0.15**
T:VPA29	-0.02	0.03	0.05
T:HPE48	0.00	0.53	**0.53**

There are several elements for which the mechanical offsets are still needed:

TSHA315	T:VPA11
TSH345	T:VPB49
TSH387	T:VPC11
TSH314	T:VPE49
TSH386	T:VPF49

Appendix A: Lookup table to convert digital value of BPM readback into millimeters.

This is the Tevatron BPM scaling lookup table. The scaled values should be divided by 100 to convert to millimeters.

raw_value	scaled_value
0	10000
1	10000
2	10000
3	10000
4	10000
5	10000
6	10000
7	10000
8	10000
9	10000
10	6271
11	5165
12	4615
13	4246
14	3967
15	3744
16	3557
17	3397
18	3256
19	3131
20	3018
21	2915
22	2821
23	2733
24	2652
25	2576
26	2505
27	2438
28	2375
29	2315
30	2257
31	2203
32	2151
33	2101
34	2053
35	2006
36	1962
37	1919
38	1878
39	1838
40	1799
41	1761
42	1725

43	1689
44	1655
45	1621
46	1588
47	1557
48	1525
49	1495
50	1465
51	1436
52	1408
53	1380
54	1353
55	1326
56	1299
57	1274
58	1248
59	1223
60	1199
61	1175
62	1151
63	1128
64	1105
65	1083
66	1060
67	1038
68	1017
69	995
70	974
71	953
72	933
73	913
74	893
75	873
76	853
77	834
78	814
79	795
80	777
81	758
82	740
83	721
84	703
85	685
86	667
87	650
88	632
89	615
90	598
91	580
92	563
93	547
94	530
95	513
96	497
97	480
98	464
99	447

100	431
101	415
102	399
103	383
104	367
105	351
106	336
107	320
108	304
109	289
110	273
111	258
112	242
113	227
114	212
115	196
116	181
117	166
118	151
119	135
120	120
121	105
122	90
123	75
124	60
125	45
126	30
127	15
128	0
129	-15
130	-30
131	-45
132	-60
133	-75
134	-90
135	-105
136	-120
137	-135
138	-151
139	-166
140	-181
141	-196
142	-212
143	-227
144	-242
145	-258
146	-273
147	-289
148	-304
149	-320
150	-336
151	-351
152	-367
153	-383
154	-399
155	-415
156	-431

157	-447
158	-464
159	-480
160	-497
161	-513
162	-530
163	-547
164	-563
165	-580
166	-598
167	-615
168	-632
169	-650
170	-667
171	-685
172	-703
173	-721
174	-740
175	-758
176	-777
177	-795
178	-814
179	-834
180	-853
181	-873
182	-893
183	-913
184	-933
185	-953
186	-974
187	-995
188	-1017
189	-1038
190	-1060
191	-1083
192	-1105
193	-1128
194	-1151
195	-1175
196	-1199
197	-1223
198	-1248
199	-1274
200	-1299
201	-1326
202	-1353
203	-1380
204	-1408
205	-1436
206	-1465
207	-1495
208	-1525
209	-1557
210	-1588
211	-1621
212	-1655
213	-1689

214	-1725
215	-1761
216	-1799
217	-1838
218	-1878
219	-1919
220	-1962
221	-2006
222	-2053
223	-2101
224	-2151
225	-2203
226	-2257
227	-2315
228	-2375
229	-2438
230	-2505
231	-2576
232	-2652
233	-2733
234	-2821
235	-2915
236	-3018
237	-3131
238	-3256
239	-3397
240	-3557
241	-3744
242	-3967
243	-4246
244	-4615
245	-5165
246	-6271
247	-10000
248	-10000
249	-10000
250	-10000
251	-10000
252	-10000
253	-10000
254	-10000
255	-10000