

Thoughts on TeV BPM Improvements

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Dawnings

Recent considerations of possible improvements to the TeV BPM system have led to my enlightenment by two facts that may be pertinent to realizing an improved system with little hardware development and with pbar measurement capability.

The first fact is that, for Collider operation, there is nothing magic about the 53 MHz component of the signal spectrum. Two fundamental frequencies contribute to the spectrum observed from the proton end of the BPMs with a full Collider: 2.5 MHz, the nominal Collider bunch spacing of the protons (and the pbars), and 141 KHz, three times the revolution frequency due to the three twelve-bunch trains. Nearly all harmonics of these fundamental frequencies are presented. With a full Collider, the 53 MHz signal is little more than one of many harmonics of 2.5 MHz.

The second fact stems from the stunning observation that the Main Ring is no longer operational. This means that in many (most?) TeV locations the old MR BPM cables (same cable type as in TeV system) could be utilized to bring the TeV pbar signals from the tunnel up to the services buildings.

Doodlings

With these great enlightenments, a half-baked scheme for a TeV BPM system falls into place that offers the following features:

- Ability to measure accurate proton closed orbits in the presence of pbars at injection, up the ramp, and through the store in Collider configuration (at today's proton-to-pbar bunch intensity ratio, relying on directionality of BPM pickups) (need to quantify pbar contamination of proton signal, but should be OK)
- Ability to measure closed orbits of either protons or pbars in the absence of the other
- Ability to "see" as few as four bunches and maybe even one single bunch

This scheme involves stealing and using the EchoTek digital receiver boards with 80 MHz digitizers that have been procured for the Recycler BPM system. There are enough boards to fully outfit the TeV, although more VME crates and CPUs would be needed than in RR because of geography. The EchoTek boards would process one or more of the 2.5 MHz harmonics available in the TeV signal. Note the 2.5 MHz comb measured with a spectrum analyzer is relatively flat over frequencies between 20 and 80 MHz. For a proton-only system (that would work in the presence of pbars), only a passive analog filter is required between the BPM cable and the EchoTek board; this

could be implemented without any tunnel access. Add a bunch of software and you've got a new TeV BPM system.

To add pbar capability, the MR cables in the tunnel would need to be (extended? and) connected to the pbar end of the TeV BPM pickup, cabling would need to be re-arranged in the service buildings, and a proton/pbar selection switch (or twice as many EchoTek channels) would need to be added to the system. This would accommodate pbar measurements in the absence of protons. To make a robust system, other issues would also need to be worked out, like system calibration or "health-monitoring" features,.

Operational advantages offered by this scheme over the present TeV BPM system is that for operation in a closed orbit mode there would be minimal error-prone, beam-dependent timing or triggering setup and there would be no requirement for tuning up with "specially prepared" beams, that is 53 MHz bunch trains.

Limitations of this scheme are that it would not cleanly see pbars in presence of protons (I'm not sure any system will be able to meet this objective without some compromise) and it would fail to make even accurate proton measurements when pbar bunch intensities become more nearly equal to proton bunch intensities.

Upgrade paths are possible from this basic system currently envisioned. Enhanced timing capabilities would permit realization of most of these upgrades.

- With suitable triggering the system could be made to measure either beam in presence of other if only a few (~four?) bunches of the undesired beam could be omitted from a Collider fill
- Possibility of bunch-by-bunch position measurements under controlled conditions
- Ability to obtain turn-by-turn positions everywhere
- Fully integrated systems features like calibration, self-test, etc.

Presently, Warren Schappert is working on a demonstration system that will provide a one-location TeV proton closed orbit measurement at 15Hz into ACNET. This demo should be operational in early June.

Decisions

Are the capabilities and upgrade options of such a system adequate to fulfill the needs of the Tevatron for the foreseeable future?

Does it make sense to rob the Recycler system for the TeV even before it sees the light of day?

What "recovery plan" could be made to serve the needs of the poor Recycler Ring? (Note that all the analog channel improvements that are being made in the present Recycler Ring plan are pertinent for any final analog/digital processing scheme, so not all is lost.)