

Proton and PBar Beam Measurements in the Main Injector

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Introduction

This note presents results of beam measurements made using a Main Injector BPM during proton and pbar transfers to the Tevatron. The measurements capture the BPM response during different portions of the ramp where the bunch length and energy vary directly affecting the intensity of the signal the BPM reports.

Setup

The individual striplines of a Main Injector BPM were brought up to the service building using ½ inch Helix cable. The nominal cable length is 200 ft. The signal from each BPM plate was split using a transformer splitter which introduced a 3 dB loss on each detected signal.

The stripline was connected to an oscilloscope channel terminated into 50 Ω, where the raw signal was monitored. The stripline signal was also viewed through a 53 MHz BandPass Filter (NuMI BPM type, ~3 MHz bandwidth) before connecting it to the scope. The third method used was to use a 10 MHz LowPass Filter followed by 17 dB of gain to observe the 2.5 MHz component on the beam.

Cable Characteristics

Cable attenuation for RG-8 and LDF4 Helix are listed below for various cable lengths. The attenuation listed is in terms of dB's. RG-8 is the cable used in the Main Injector for the BPM's and the ½ inch Helix is the cable used to make the measurements below.

53 MHz	100ft	300ft	500ft	800ft	1000ft
RG-8	0.912	2.7	4.56	7.3	9.12
LDF4 Helix	0.47	1.43	2.3	3.8	4.78
2.5MHz					
RG-8	0.192	0.577	0.961	1.53	1.92
LDF4 Helix	0.102	0.307	0.511	0.817	1.022

Intensities

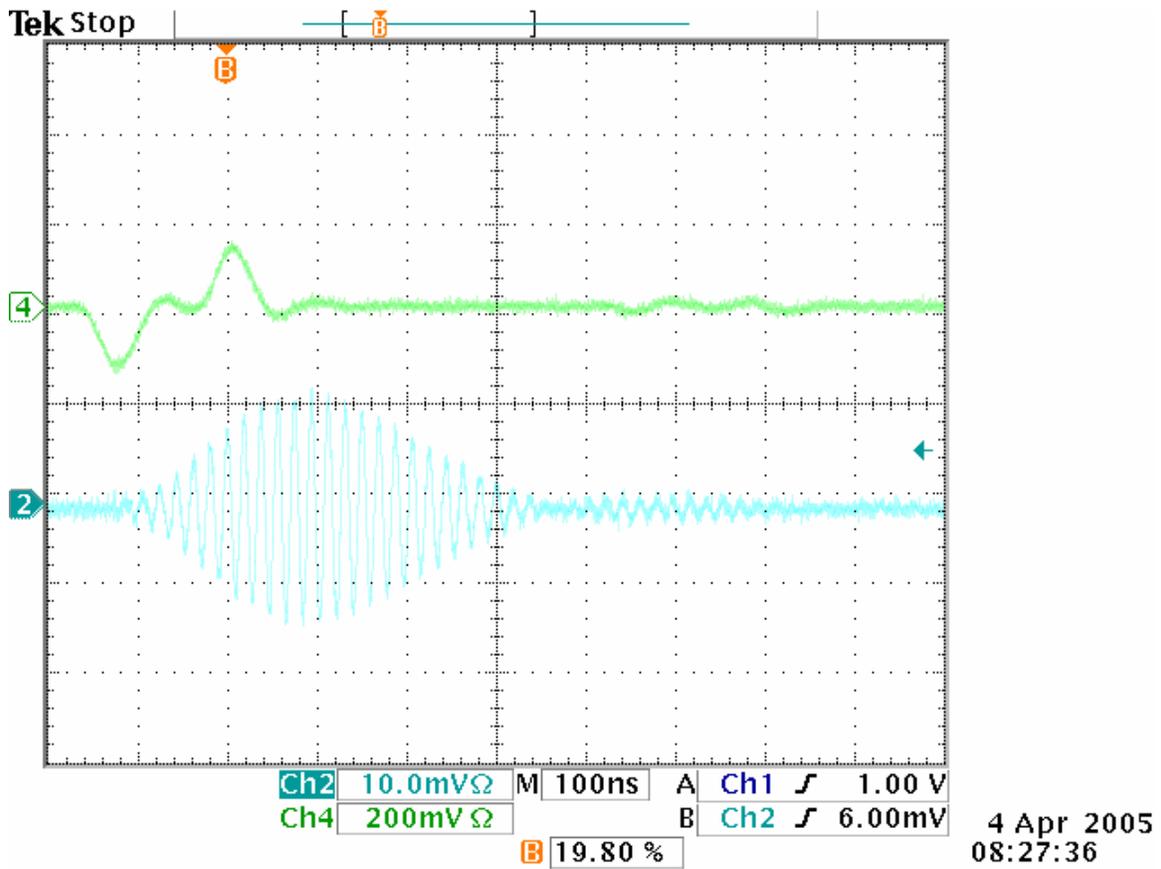
The signal detected by the BPM depends on the initial intensity, frequency component and bunch length. Below is a table listing the measured intensity for different types of beam and different frequency component.

In the Protons for PBar stacking and Protons to TeV (Coalesced and UnCoalesced) measurements they were done using a 53MHz Band-pass filter. The PBars to TeV measurements, the 2.5 MHz signals were filtered using a 10 MHz Low-pass filter.

Protons for PBar Stacking	5e9 ppB (Calc)	83e9 ppB (Measured Intensity)	130 ppB (Calc)
8 GeV	0.021Vpp	0.35 Vpp	0.55 Vpp
60 GeV			
120 GeV	0.072 Vpp	1.2 Vpp	1.87 Vpp

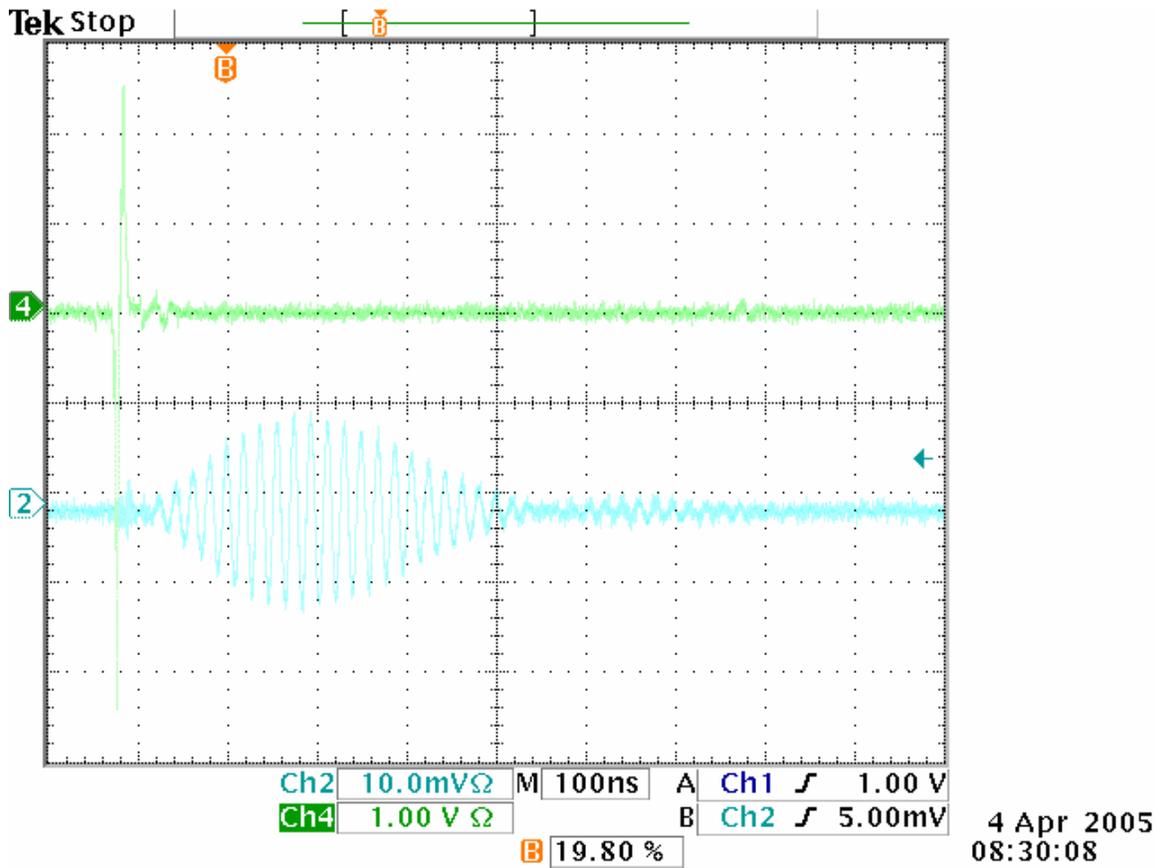
Protons to TeV	50e9 ppB (Calc)	330e9 ppB (Measured)	400e9 ppB (Calc)
Coalesced	0.033 Vpp	0.22 Vpp	0.266 Vpp
UnCoalesced	0.056 Vpp	0.37 Vpp	0.448 Vpp

PBars to TeV	10e9 ppB (Calc)	88e9 ppB (Measured)	150e9 ppB (Calc)
53 MHz Comp.			
1.8 sec	0 Vpp	0 Vpp	0 Vpp
3.5sec.	0.0079 Vpp	0.07 Vpp	0.12Vpp
2.5 MHz Comp.			
1.8 sec	0.0045 Vpp	0.04 Vpp	0.068 Vpp
3.5 sec.	0.0125 Vpp	0.11 Vpp	0.187 Vpp
6.0 sec.	0.017 Vpp	0.15 Vpp	0.255 Vpp



Protons in the MI on a \$2B. Scope triggered 0.5 sec after \$2B, 7 bunches of protons before coalescing, ~275e9 total.

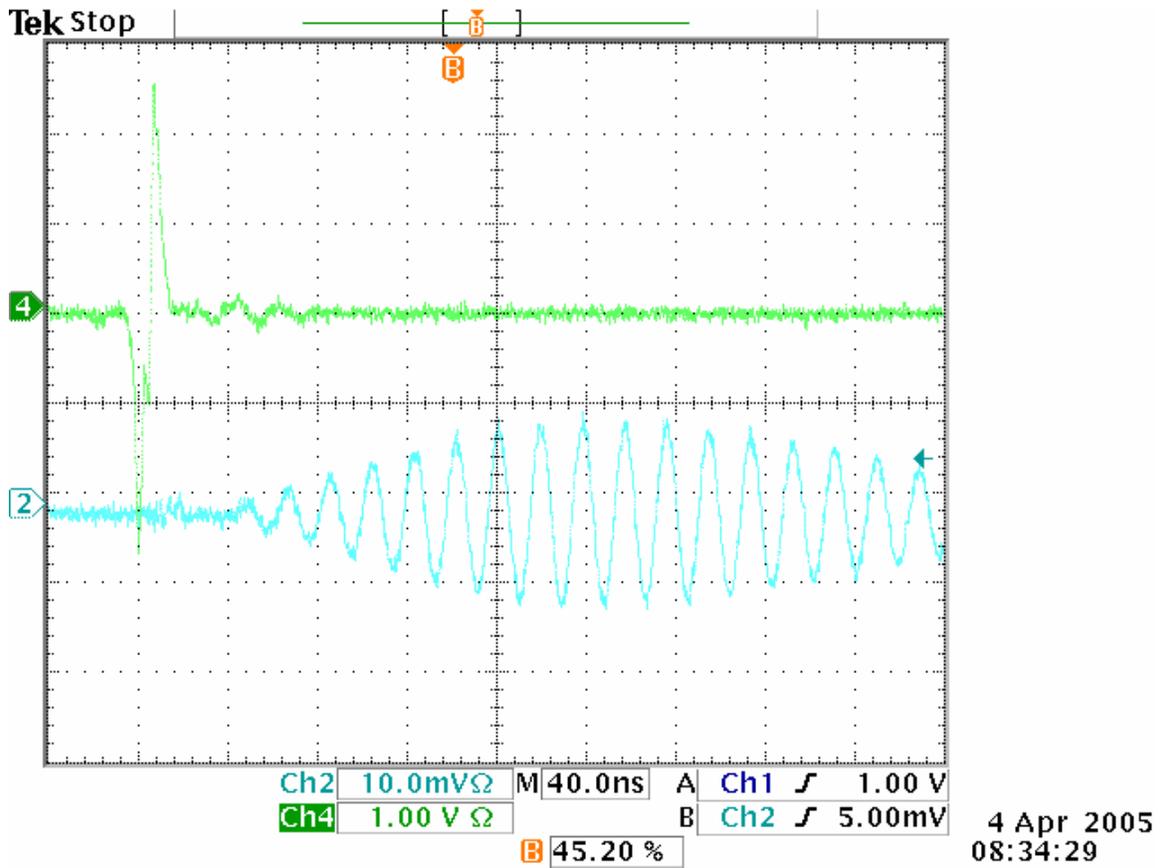
Channel 4 is the output of the 2.5 MHz LPF on the transition board with 17 dB of gain. Channel 2 is the signal from a MI BPM stripline through ~200 ft. of Heliax cable with 20 dB attenuator and 53MHz BPF.



Protons in the MI on a \$2B. Scope triggered 1.7 sec after \$2B, 300e9 protons coalesced.

Channel 4 is the output of one MI BPM stripline through splitter. The BPM is in the MI30 straight region.

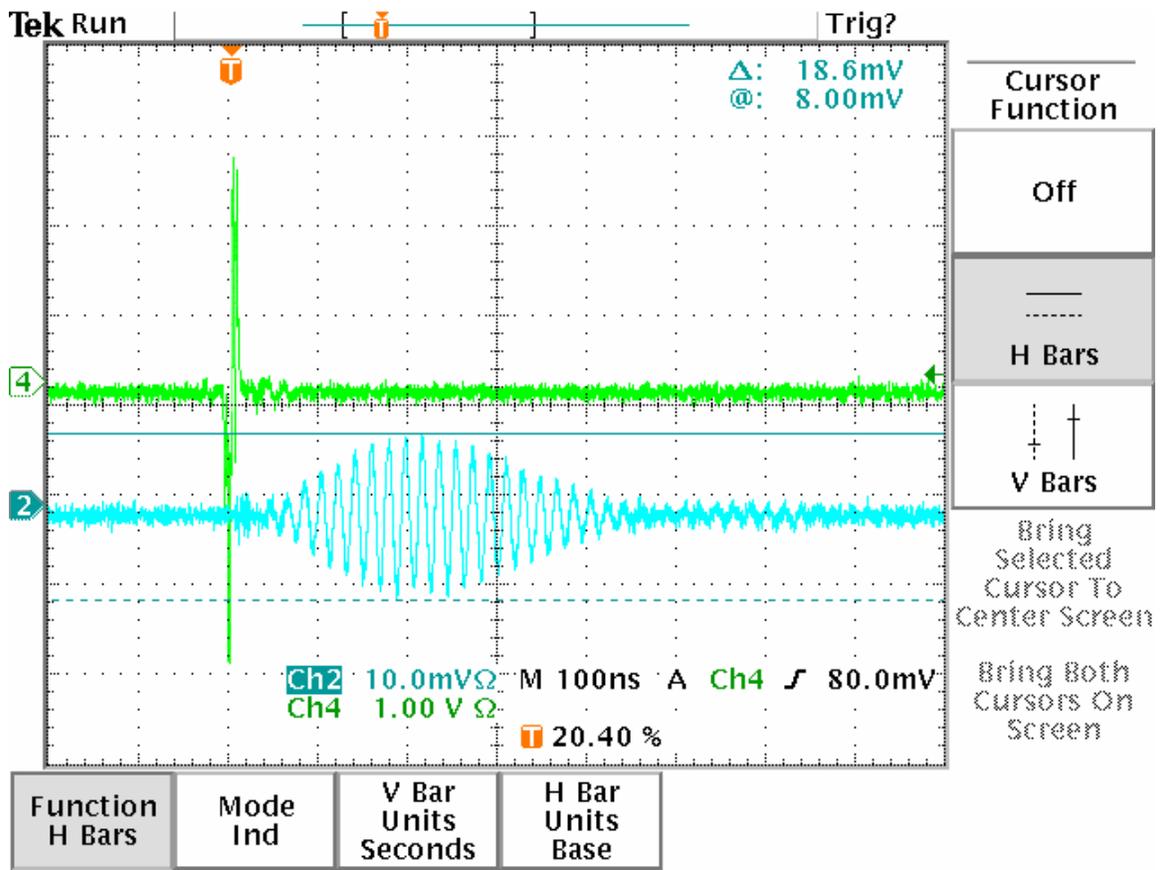
Channel 2 is the signal from one MI BPM stripline through ~ 200 ft. of Helix cable with 20 dB attenuator into a 53MHz BPF.



Protons in the MI on a \$2B. Scope triggered 2.2 sec after \$2B, 300e9 protons coalesced.

Channel 4 is the output of one MI BPM stripline through splitter. The BPM is in the MI30 straight region.

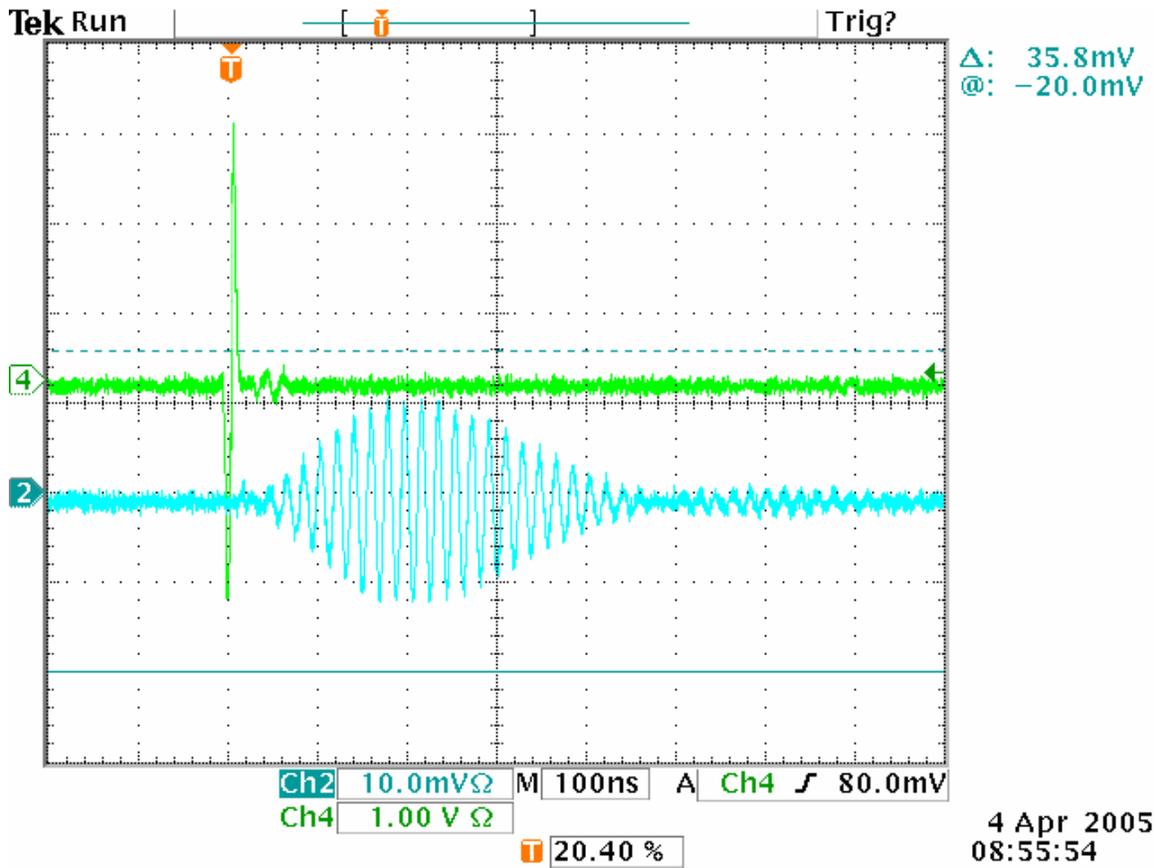
Channel 2 is the signal from one MI BPM stripline through ~ 200 ft. of Heliax cable with 20 dB attenuator into a 53MHz BPF.



Protons in the MI on a \$2B. Scope triggered ~last turn after \$2B, $325e9$ protons coalesced.

Channel 4 is the output of one MI BPM stripline through splitter. The BPM is in the MI30 straight region.

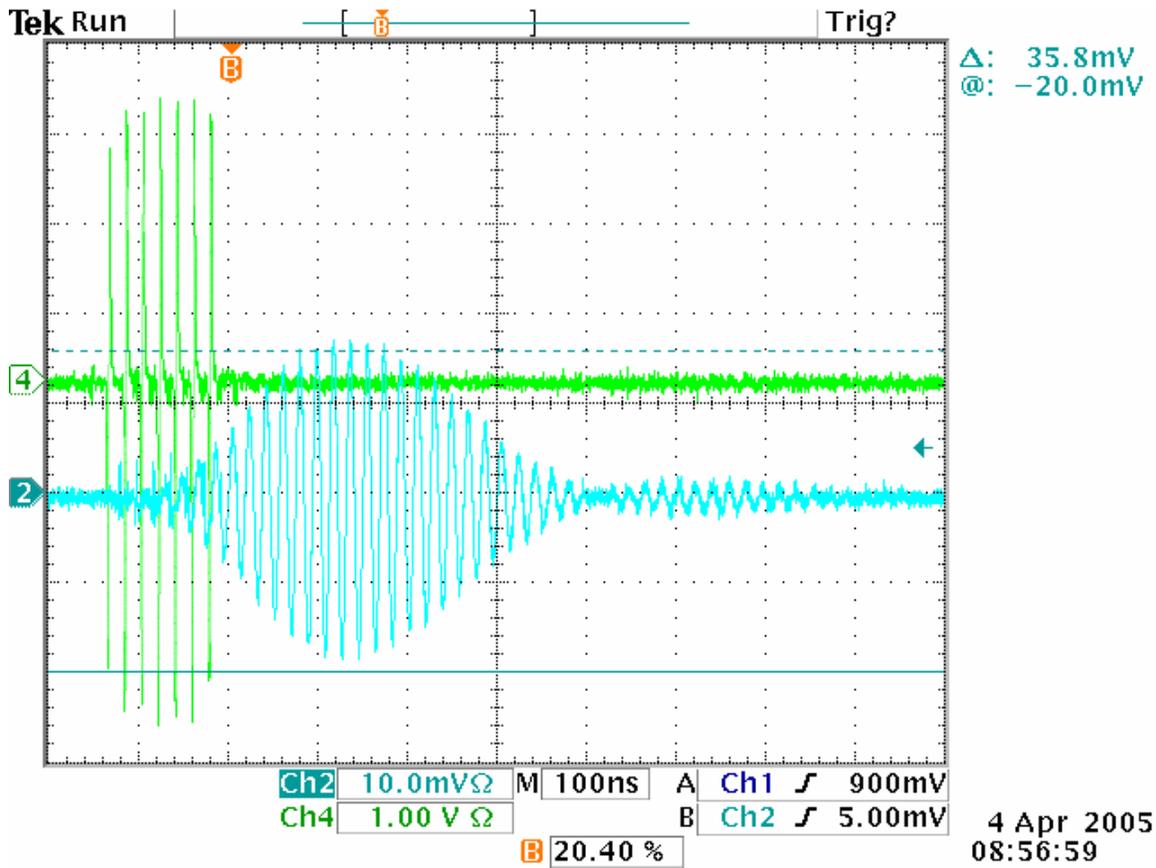
Channel 2 is the signal from one MI BPM stripline through ~200 ft. of Heliax cable with 20 dB attenuator into a 53MHz BPF.



Protons in the MI on a \$2B. Scope triggered ~last turn after \$2B, 280e9 protons coalesced.

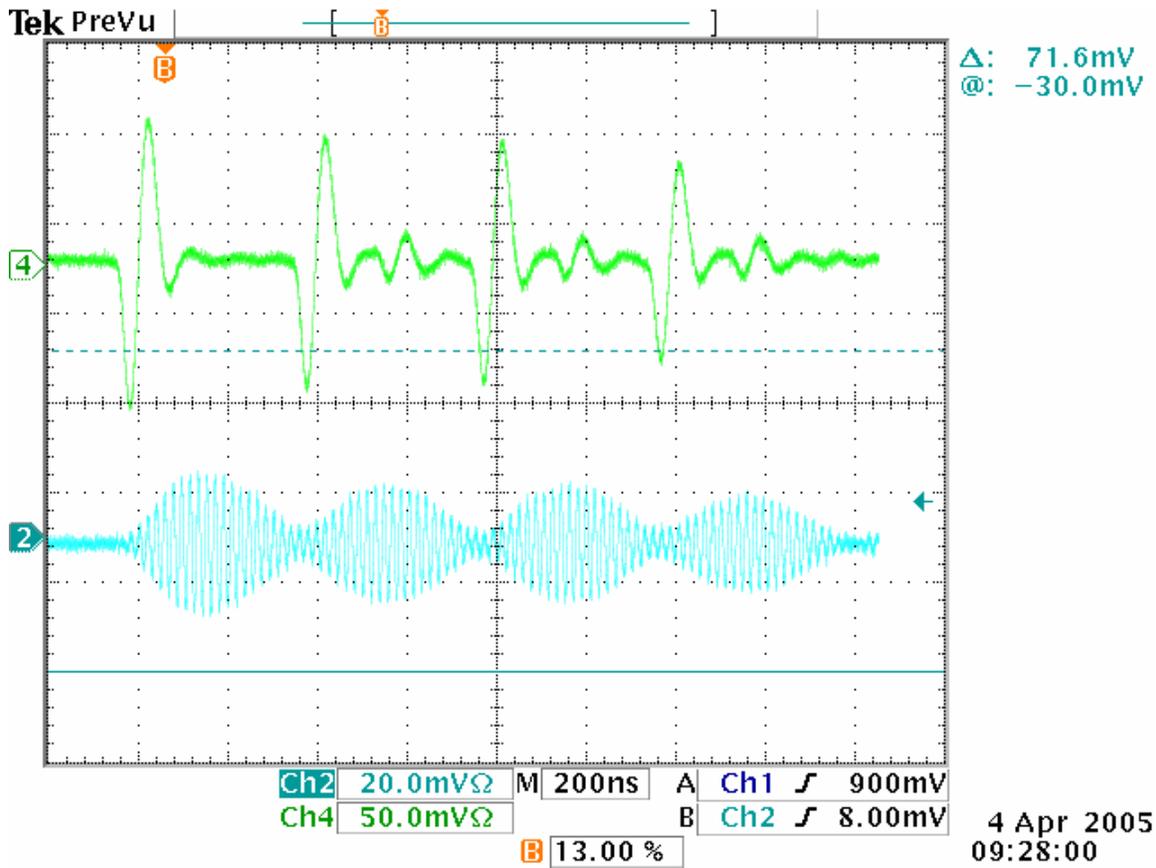
Channel 4 is the output of one MI BPM stripline through splitter. The BPM is in the MI30 straight region.

Channel 2 is the signal from one MI BPM stripline through ~ 200 ft. of Heliax cable with 20 dB attenuator into a 53MHz BPF.



Protons in the MI going to the dump on a \$2B. Uncoalesced protons 330e9.
Scope triggered 1.5 sec after \$2B

Channel 4 is the output of one MI BPM stripline through splitter. The BPM is in the MI30 straight region.
Channel 2 is the signal from a MI BPM stripline through ~ 200 ft. of Heliax cable with 20 dB attenuator and 53MHz BPF.

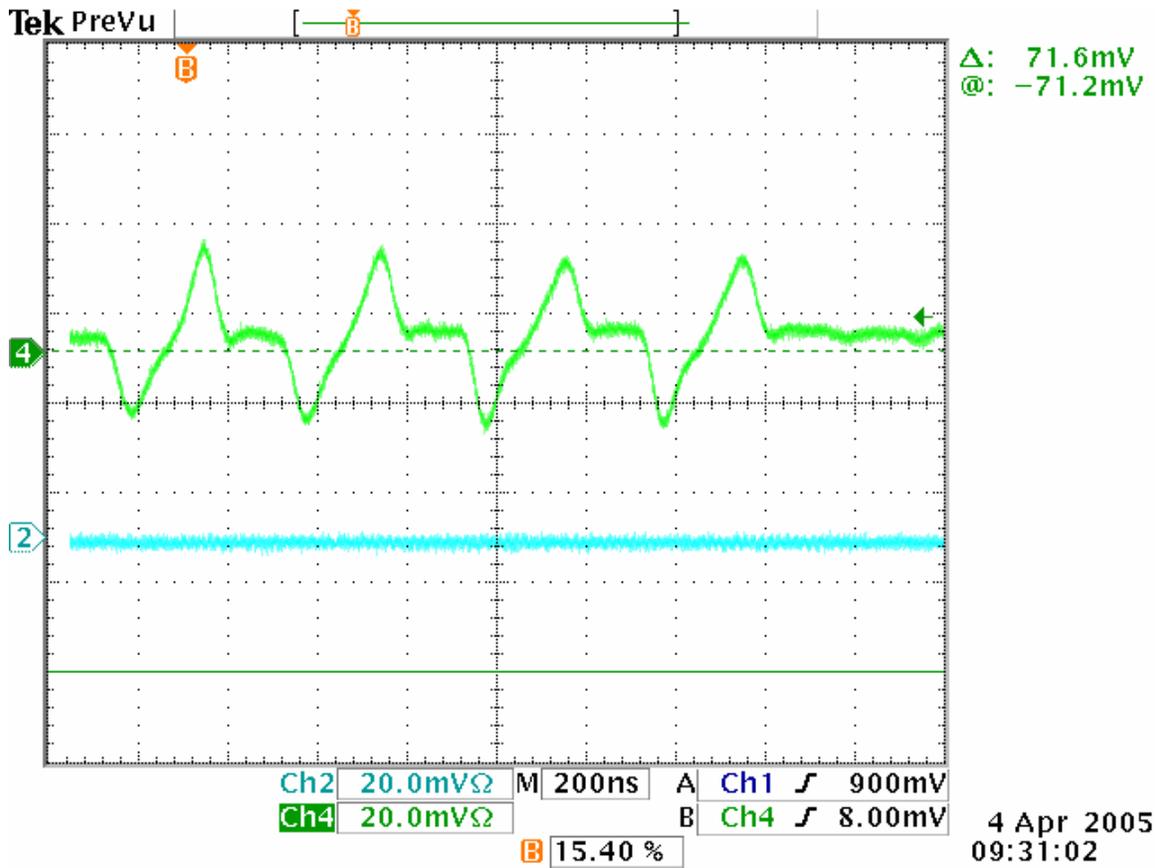


~200E9 coalesced PBars in MI at 6.0 sec after \$2A; headed to the TeV from Accumulator and/or Recycler.

The 2.5 MHz signal source is a transition channel with a 10 MHz LPF and 17 dB of gain (~ 7). The scope is triggered 6.0 sec after \$2A.

Channel 4 is the 2.5 MHz channel signal (after coalescing) from one MI BPM electrode through splitter.

Channel 2 is the signal from one MI BPM stripline through splitter and ~ 200 ft. of Heliac cable with NO attenuator into a 53MHz BPF.



~350E9 coalesced PBars in MI from Accumulator and/or Recycler at 1.8 sec after \$2A. The 2.5 MHz signal source is a transition channel with a 10 MHz LPF and 17 dB of gain (~7). The scope is triggered 1.8 sec after \$2A.

Channel 4 is the 2.5 MHz channel signal from one MI BPM electrode through splitter.

Channel 2 is the signal from one MI BPM stripline through splitter and ~ 200 ft. of Heliac cable with NO attenuator into a 53MHz BPF.

Comparing the amplitude of the 2.5 MHz component at 1.8 sec vs. 6.0 sec after \$2A there is a 3.75 ratio of amplitudes.