

Beam Position Monitor Electronics for Fermilab Switchyard *

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Abstract

The beam position monitor (BPM) system for Fermilab Switchyard (SY) provides the position, intensity and integrated intensity of the 53.10348MHz RF bunched resonant extracted beam from the Main Injector over 4 seconds of spill. The total beam intensity varies from 1×10^{11} to 1×10^{13} protons.

The spill is measured by stripline beam position monitors and resonant circuit. The BPMs have an external resonant circuit tuned to 53.10348MHz.

The corresponding voltage signal out of the BPM has been estimated to be between -110dBm and -80dBm.

System Description

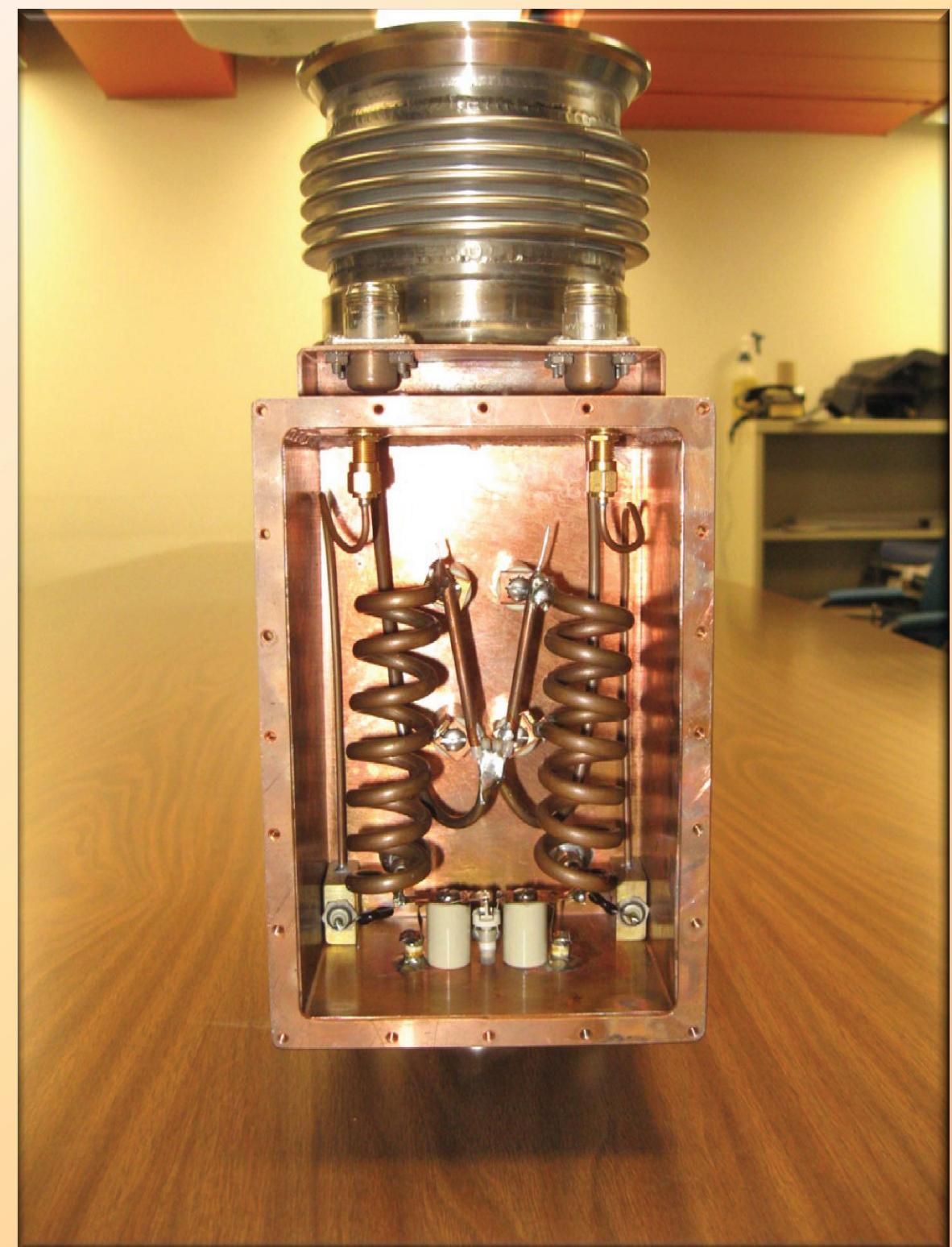
During current operation the Main Injector accelerates beam to 120Gev and extracted to the Switchyard (SY). Extraction uses the half-resonant integer mode and is regulated by a quadrupole circuit (QXR) to resonantly extract beam over 4 seconds. The typical spill intensities vary from 1×10^{11} protons to 1×10^{13} protons per machine cycle with the protons distributed into 486 of the 588 53.10348MHz RF buckets that make up the machine's circumference. The original beam position monitor system for the SY was first designed in 1985 and then installed in 1986.

The new designed electronic system consists of:

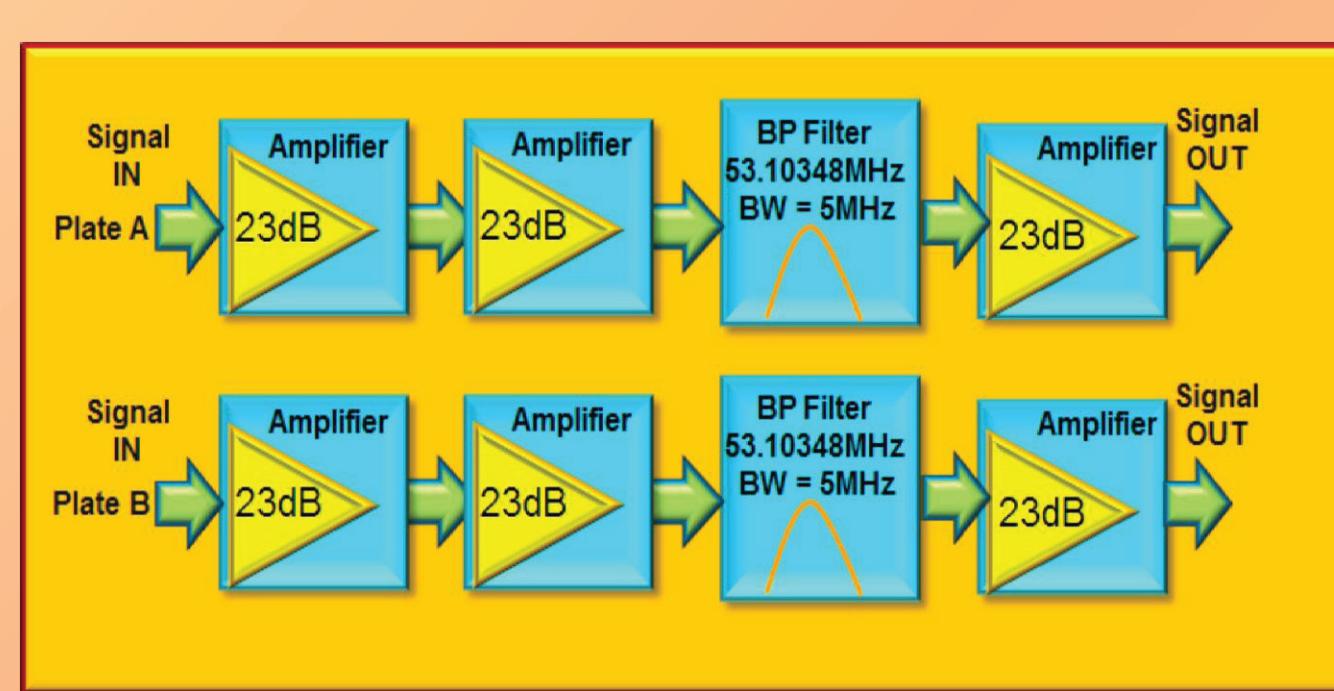
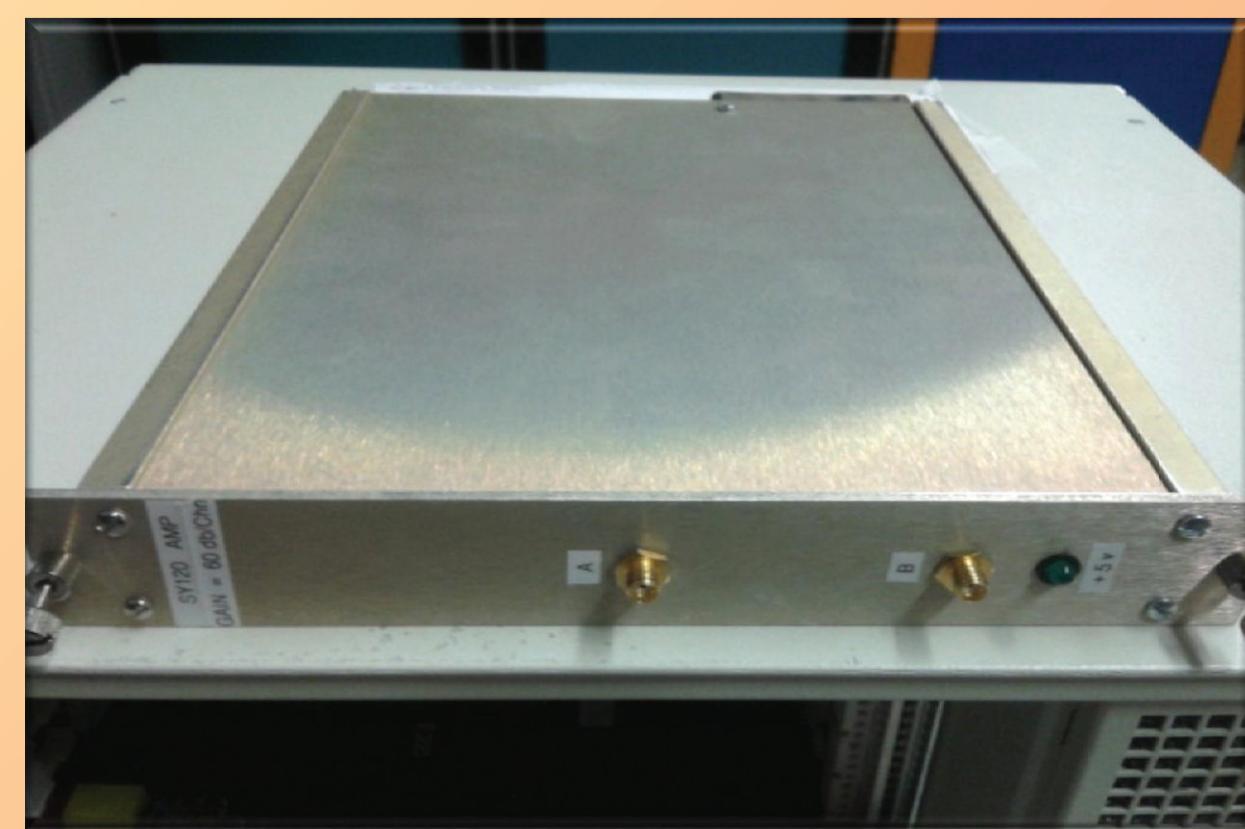
1. Detectors (Resonant BPMs).
2. RF Transition Board (Analog Front-End).
3. Digitizer (Digital Acquisition and Processing).
4. MVME 5500 Single Board Computer (Software Interface).

System Implementation

Resonant BPM

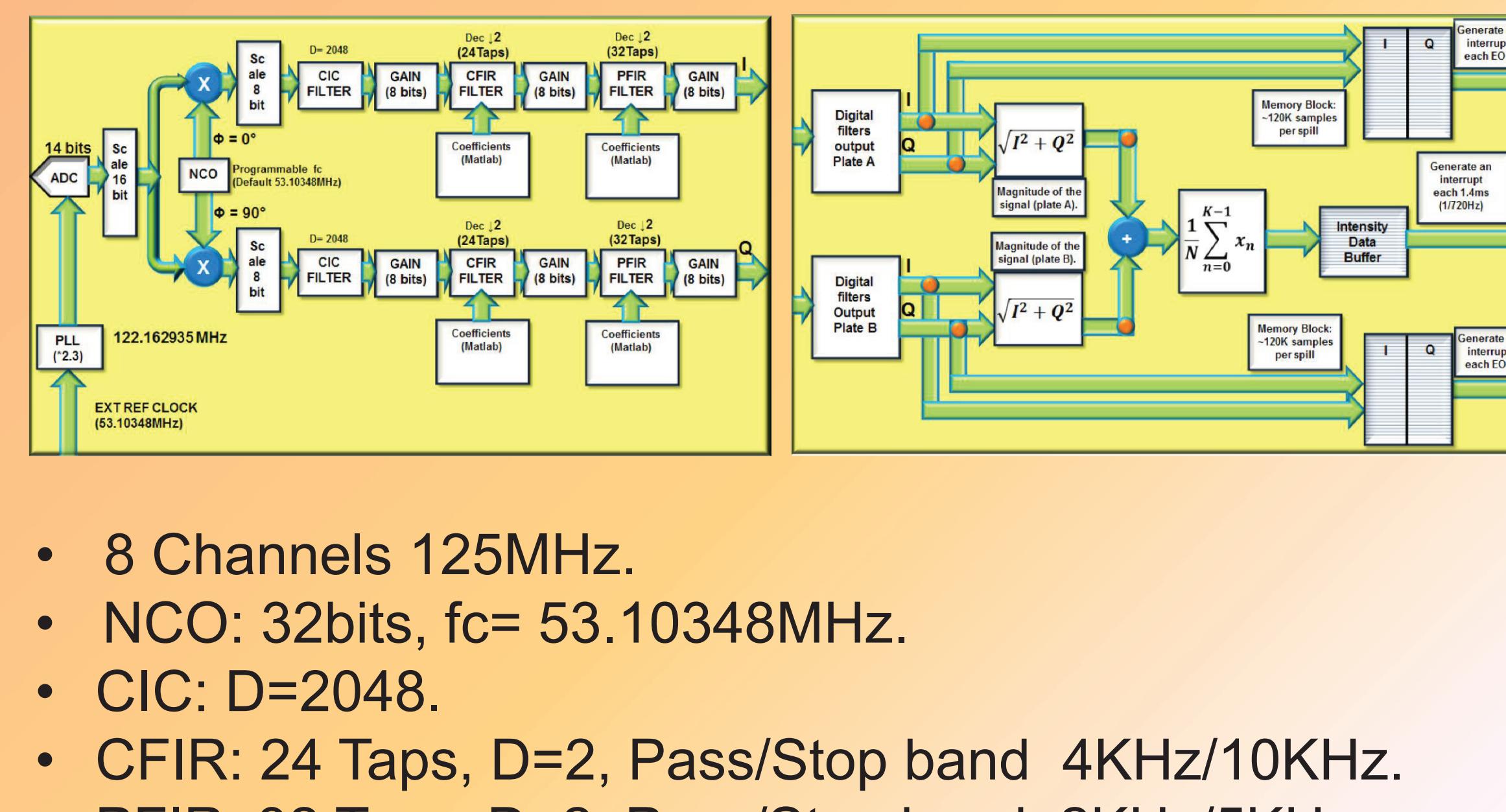
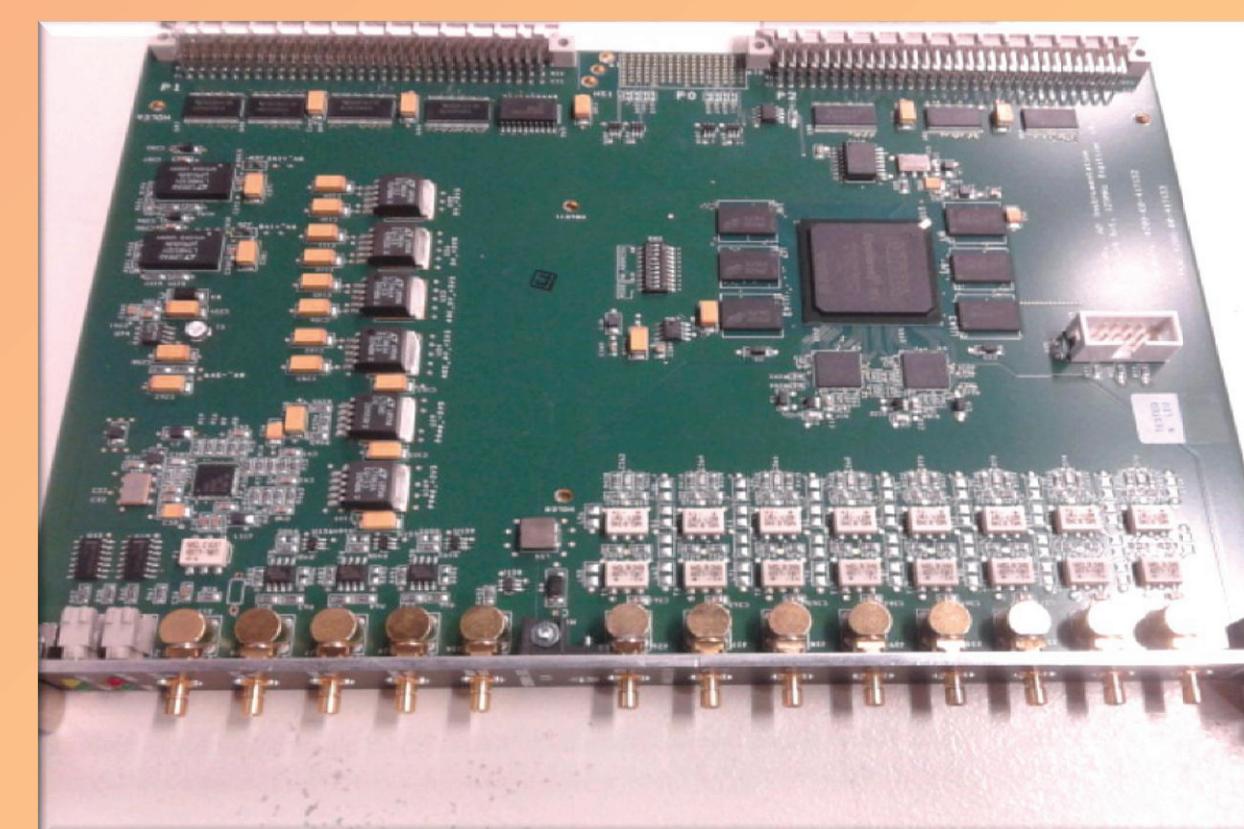


Analog Front-End



- Tuned at 53.10348MHz.
- Two types of BPM:
 - 7" plate length, $L < \lambda/4$.
 - 1m plate length, $L = \lambda/4$.
- Q ~ 190.
- $V_1 = 2.41 \times 10^{-10} N_p$ vrms.
- Sensitivity:
 $0.57 \text{ dB/mm} < S_y < 0.63 \text{ dB/mm}$.

Digitizer



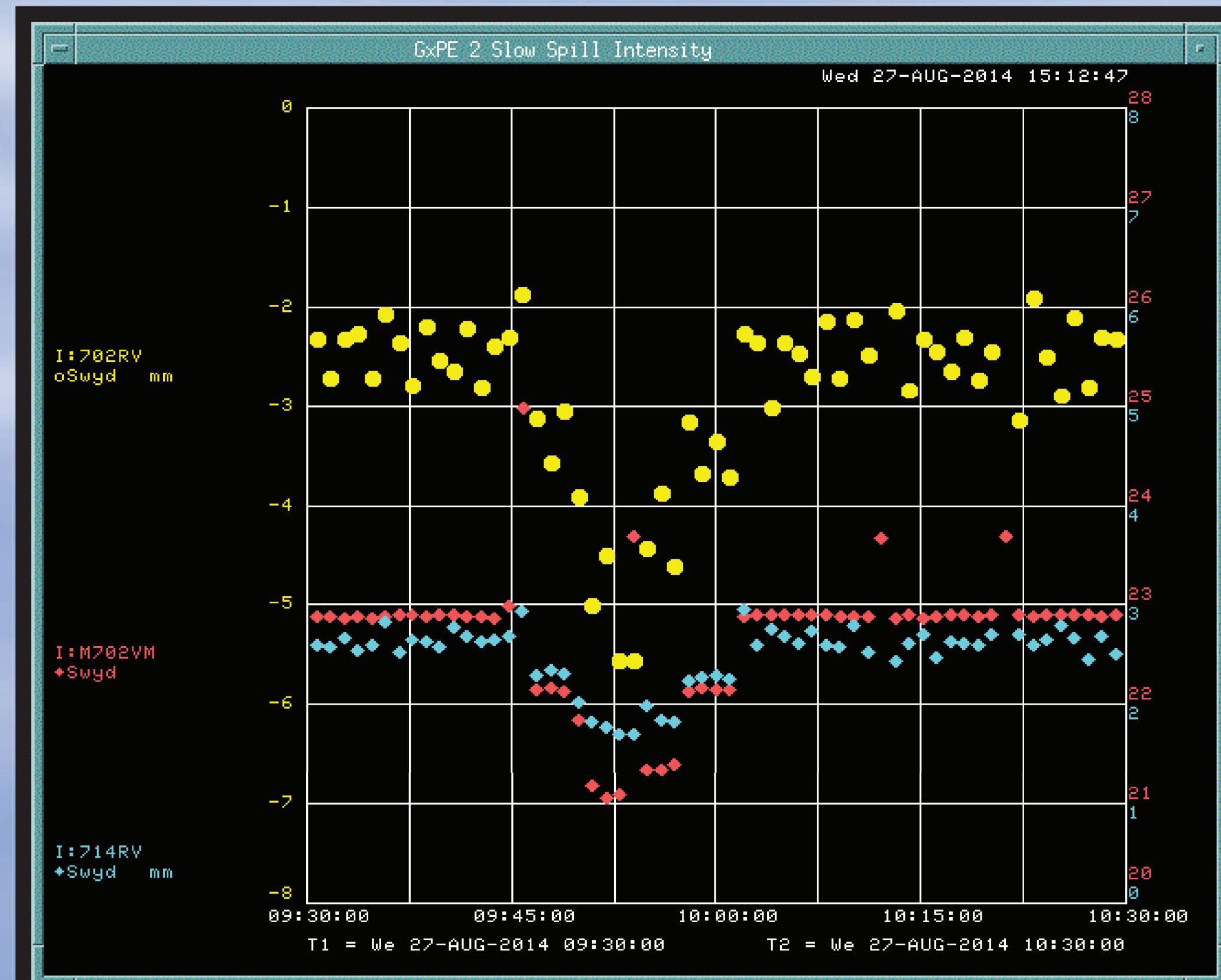
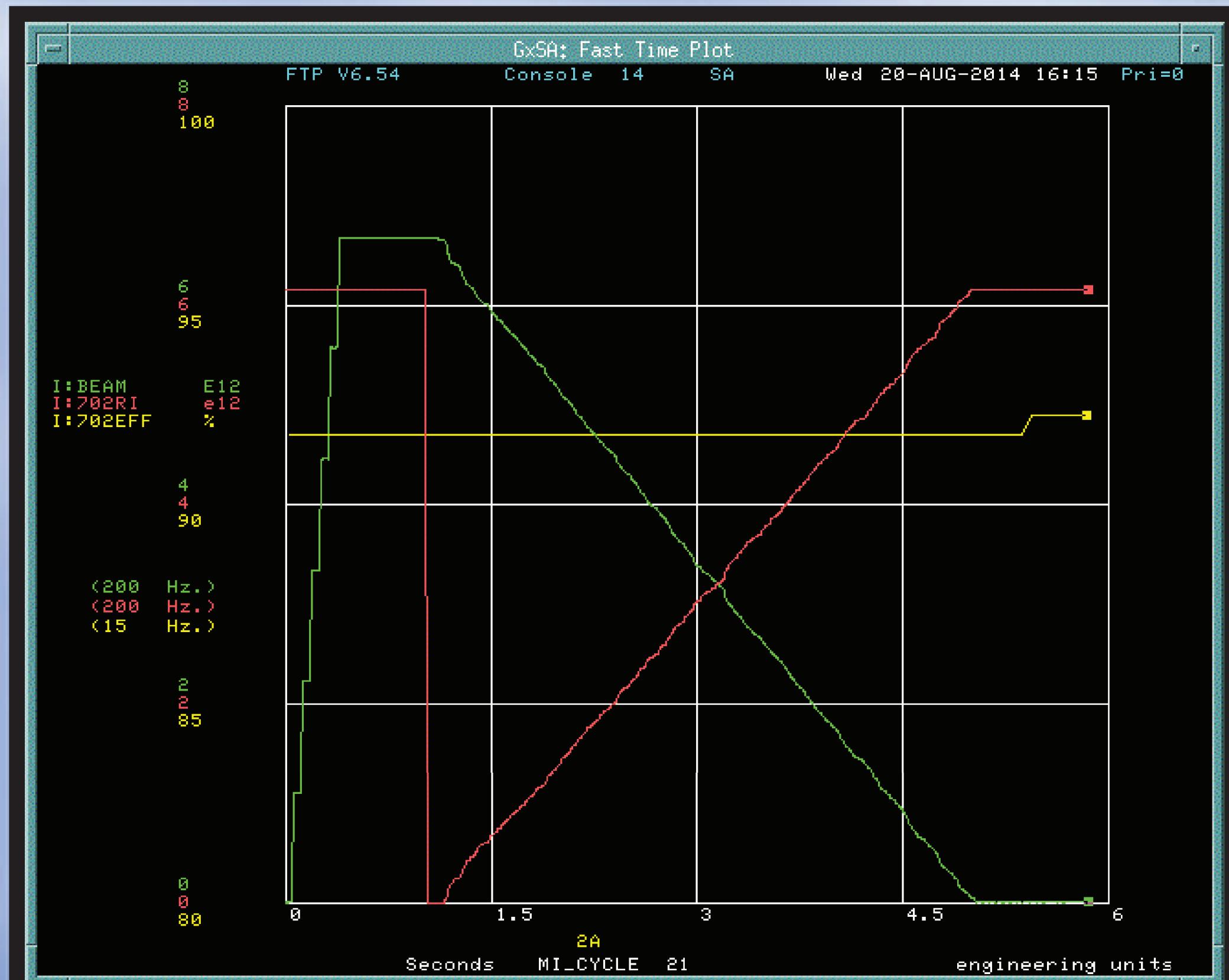
- 8 Channels 125MHz.
- NCO: 32bits, fc = 53.10348MHz.
- CIC: D=2048.
- CFIR: 24 Taps, D=2, Pass/Stop band 4KHz/10KHz.
- PFIR: 32 Taps, D=2, Pass/Stop band 2KHz/5KHz.
- I and Q data saved in memory.
- Intensity data output rate @ 720Hz.

Single Board Computer & VME Crate



- MVME 5500 Single Board Computer (SBC).
- VxWorks real-time OS.
- ACNET interface.
- "Real-time" plot.

Results



- A total efficiency of 93% (I:702EFF) for the Main Injector extraction has been measured.
- Intensity measurements show a resolution around 0.4/0.5%.
- Vertical position resolution matches multiwire measurements.
- Further improvements are ongoing.