

A Hybrid architecture for the LLRF system of the Fermilab Mu2e project

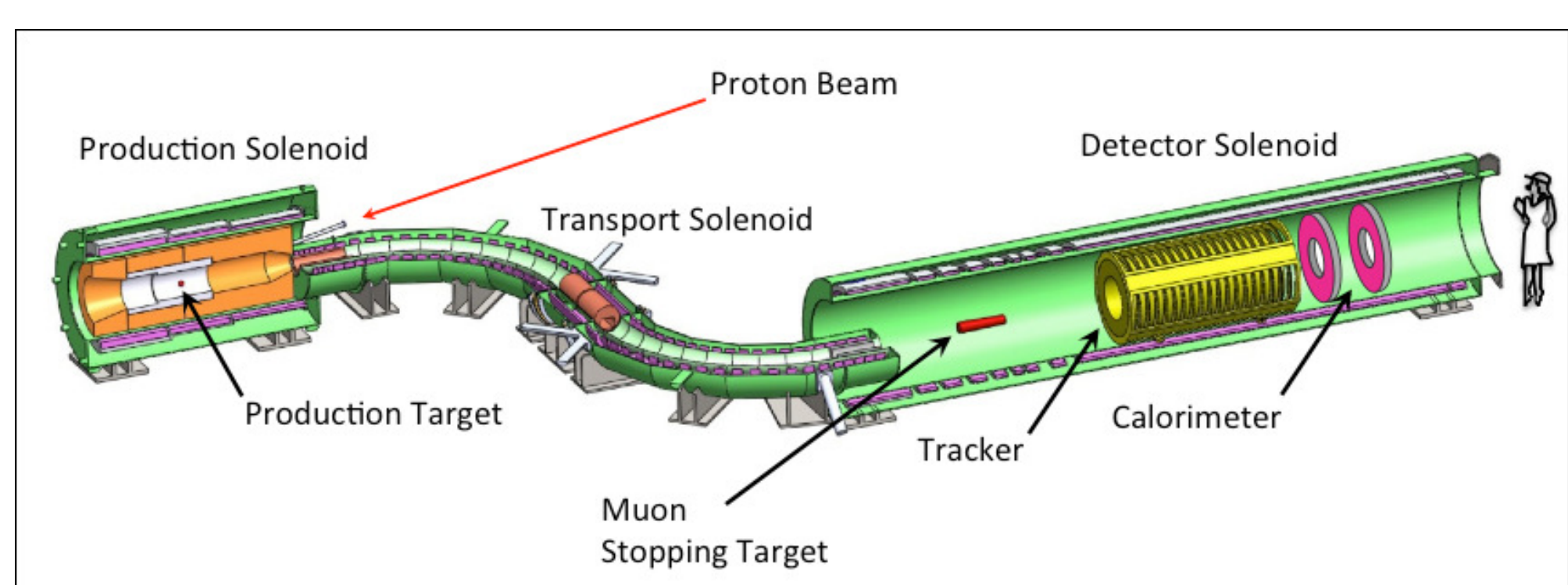
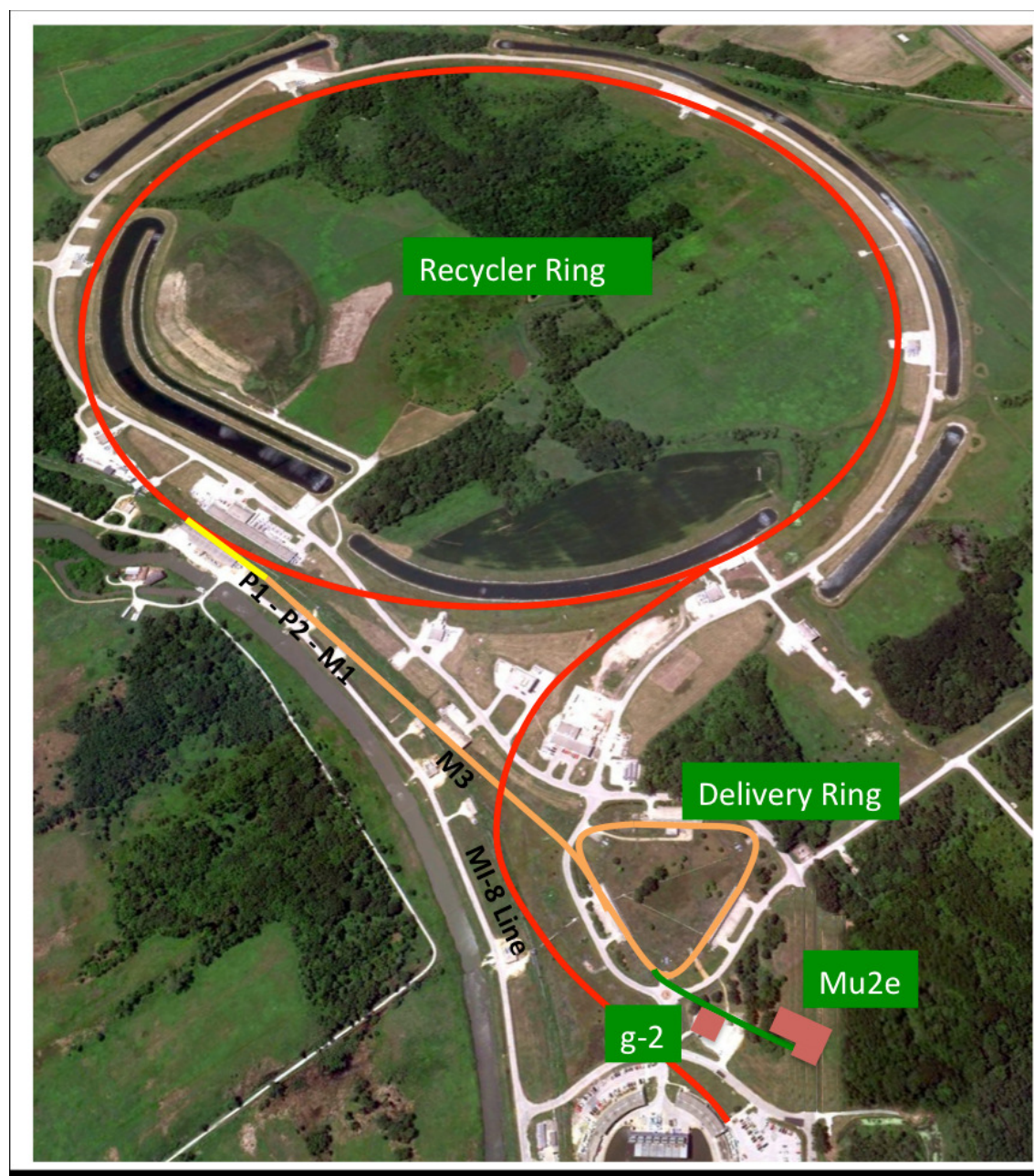
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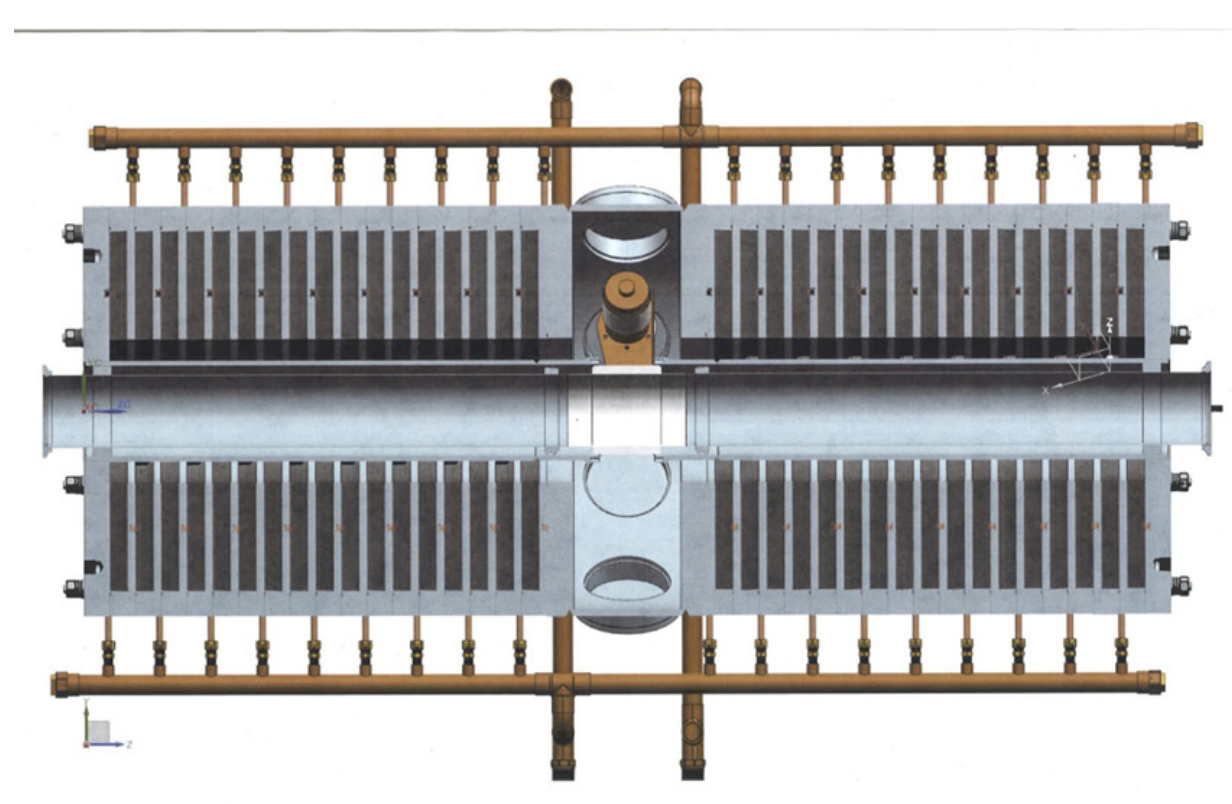
Introduction

The LLRF system for the Mu2e project uses the same primary LLRF hardware as the Muon g-2 experiment that has been running for the past five years. The SSA and RF cavity for the capture of the 2.5 MHz beam bunches in the delivery ring are located about a mile away from the LLRF controller. A local FPGA controller chassis is used to digitize the cavity signals and to coordinate the beam transfer manipulations. The system architecture is described and the results of the initial testing presented..

Mu2e Beamline and Detector

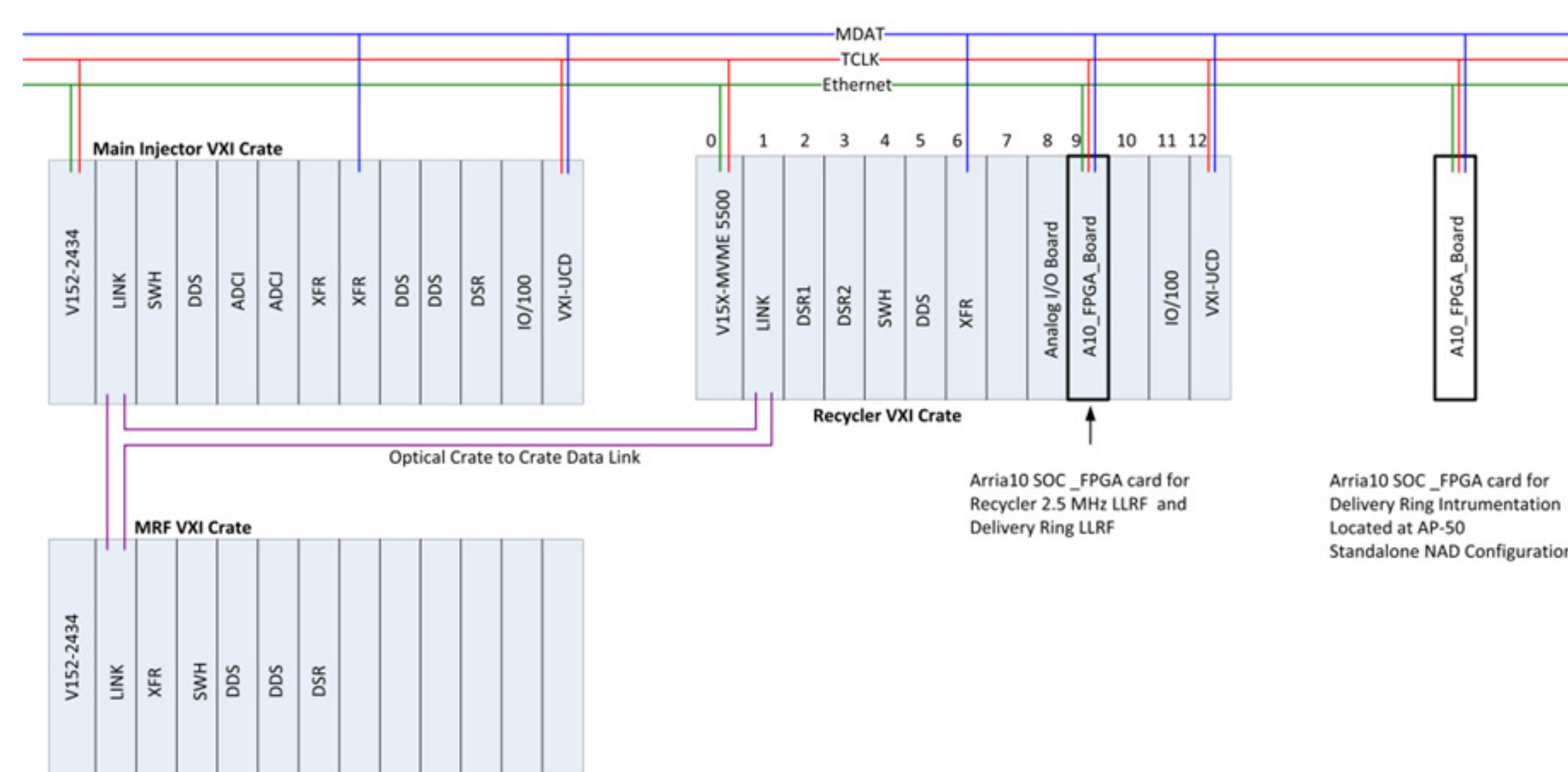


Delivery Ring RF Cavity

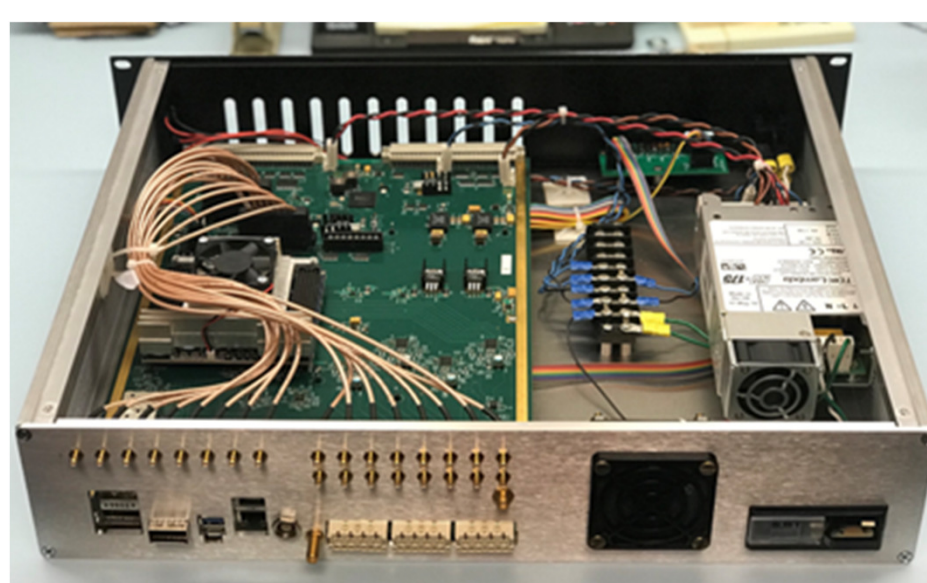


Parameter	Value	Units
Harmonic Number	4	
Frequency	2.360	MHz
Peak Voltage	10	kV
Number of Cavities	1	
R/Q	400	Ω
Q	125	
Bandwidth	18.8	kHz
Time Constant τ	16.9	μ s
90% Rise Time w DRF FB	7.3	μ s
Cavity Power Loss	1.0	kW
SS Amplifier Output	8.0	kW

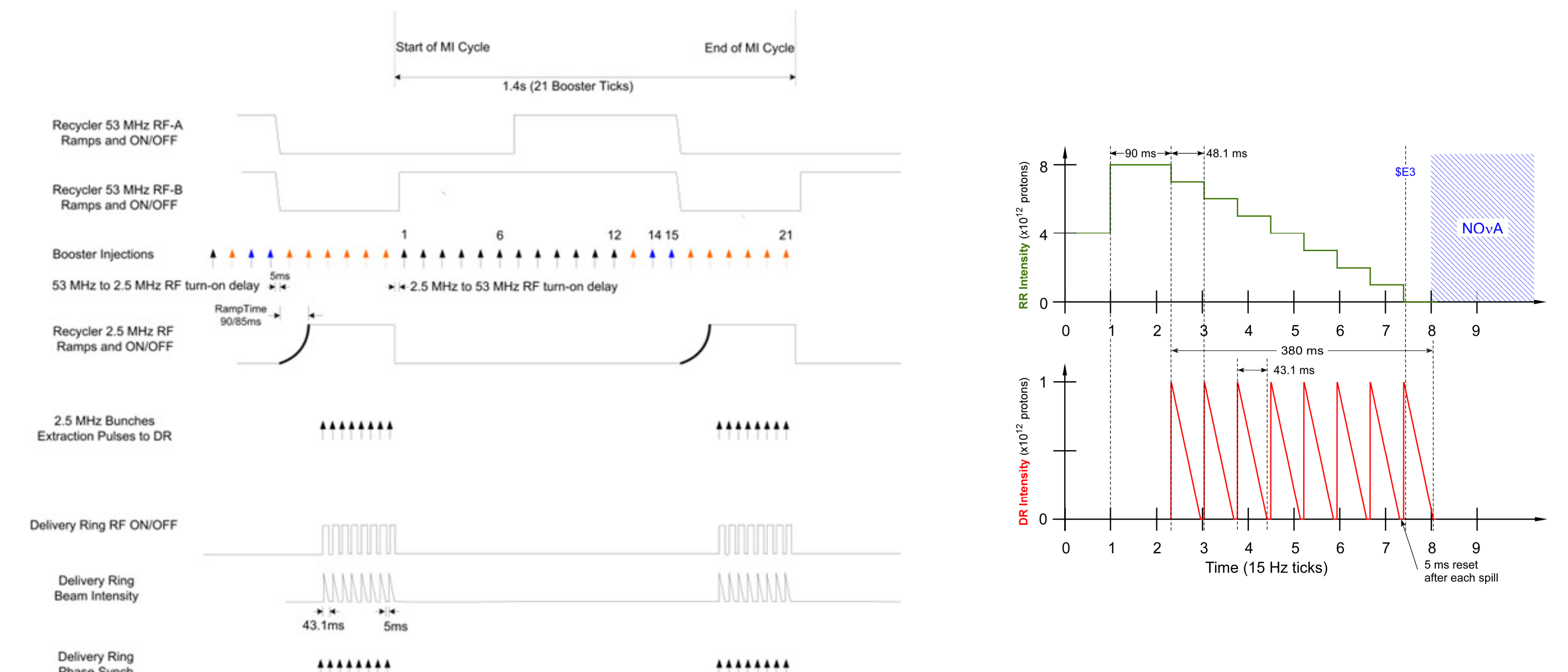
Mu2e LLRF System Hardware



VXI/NAD Compatible Hardware



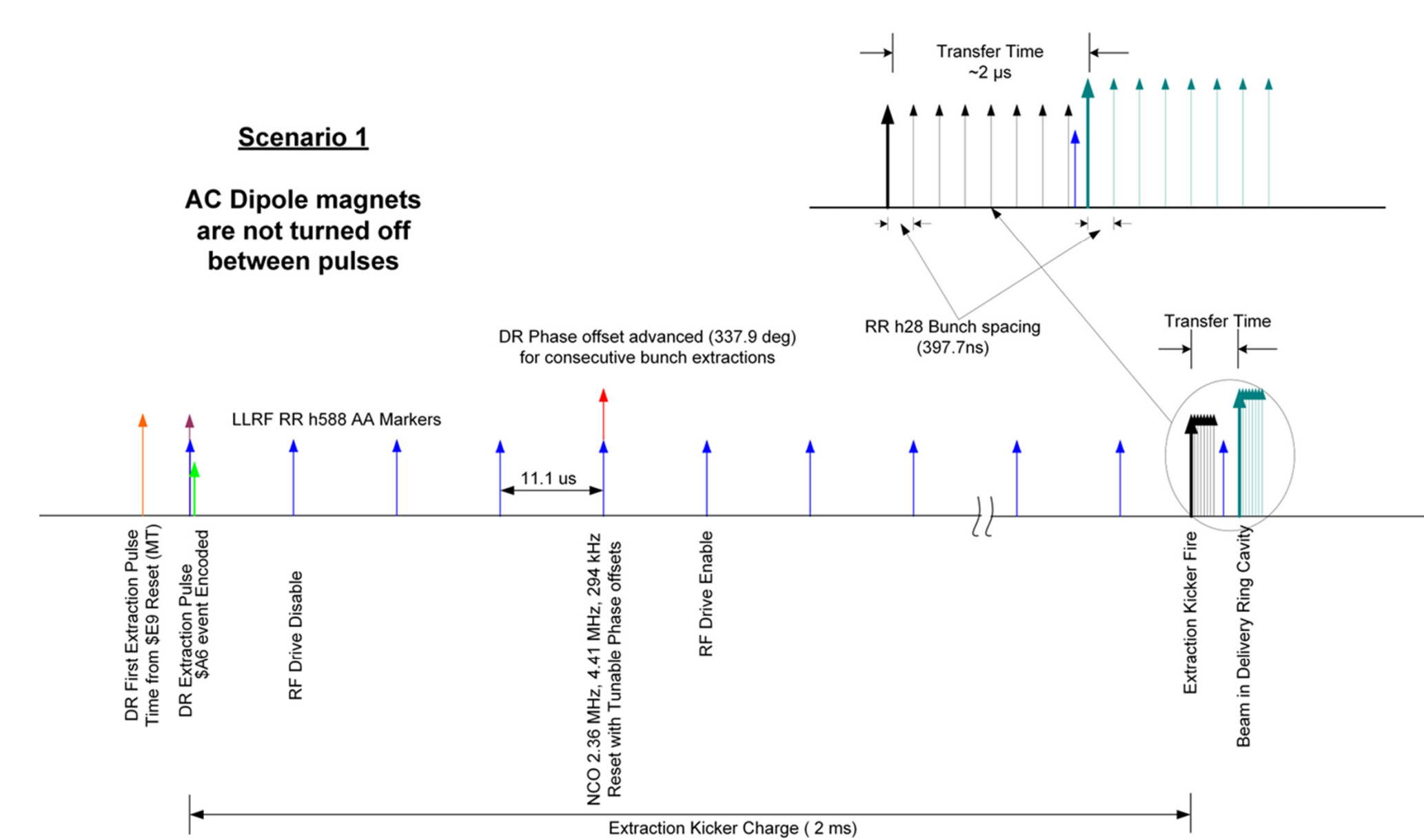
Beam Timeline



Beam Manipulations

1. 8 booster cycles in MI cycle used to provide beam to the Delivery Ring
2. Two batches are captured in 53 MHz buckets. 53 MHz RF is ramped off and 2.5 MHz RF is ramped to 80 kV over 90ms
3. 8, 2.5 Mhz bunches are transferred - one bunch at a time to the Delivery Ring
4. Extraction synch pulses provided for each bunch
5. Delivery Ring frequency of 2.36MHz is non-harmonically related to the RR 2.5 MHz.
6. The frequency drop must be handled by the LLRF system while providing phase alignment at transfer

Transfer Timing with Phase Alignment



Summary

- Beam parameters for Muon g-2 experiment exceed requirements for the Mu2e experiment
- LLRF controller chassis near delivery ring provides digitization and display of delivery ring RF cavity waveforms
- The Mu2e experiment is expected to be commissioned in 2025



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