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FPGA beam loss monitor system for the SRF facility

By

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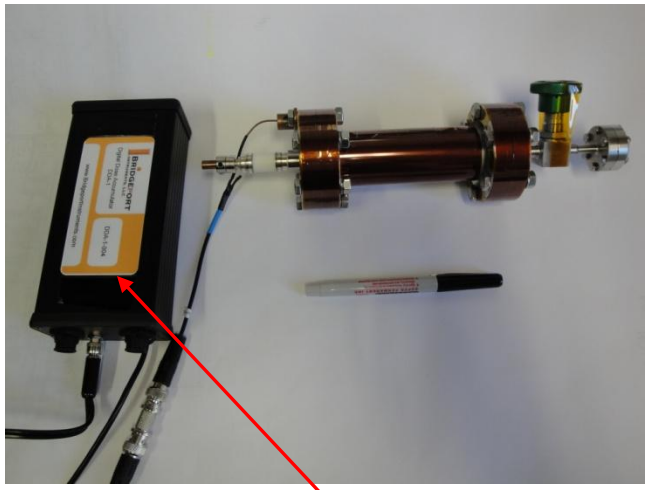
Outline

- ✓ What is a beam loss monitor(BLM) system?
- ✓ Describe Helium Ionization beam loss monitor
- ✓ Recycling Integrator for the signal processing
- ✓ Field Programmable Gate Array (FPGA)-based Time-to-Digital Converter (TDC)
- ✓ Show a brief display of the entire BLM system
- ✓ Test of the FPGA-TDC

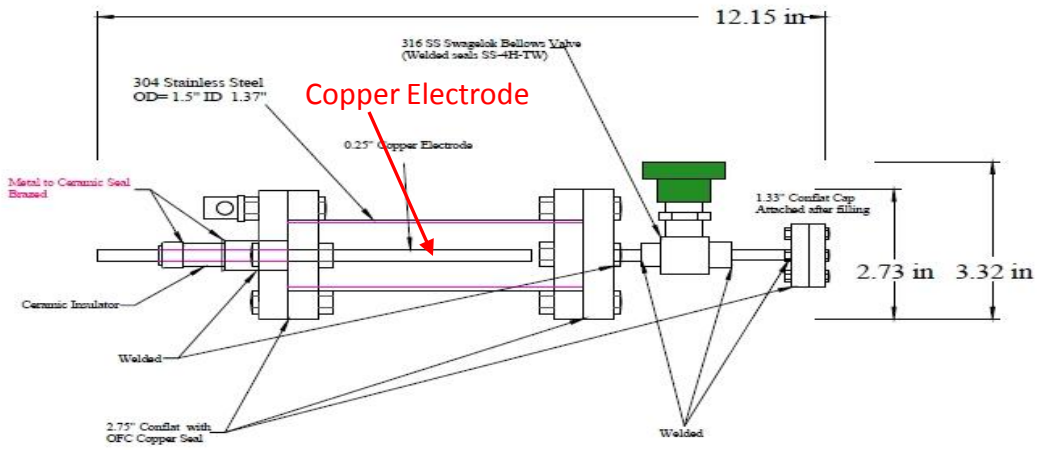
Beam loss monitor system

- The BLM systems are designed for measuring beam losses around an accelerator or storage ring.
- These systems give a useful beam diagnostics and machine protection from radiation damage.

He-Ionization Chamber Beam loss monitor



Electronics(Recycling Integrator)

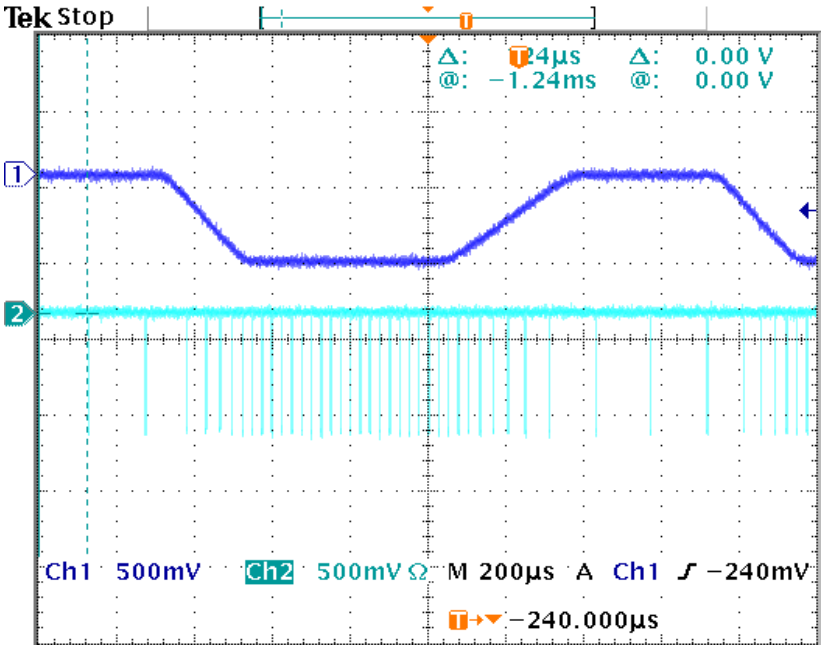


Fill port

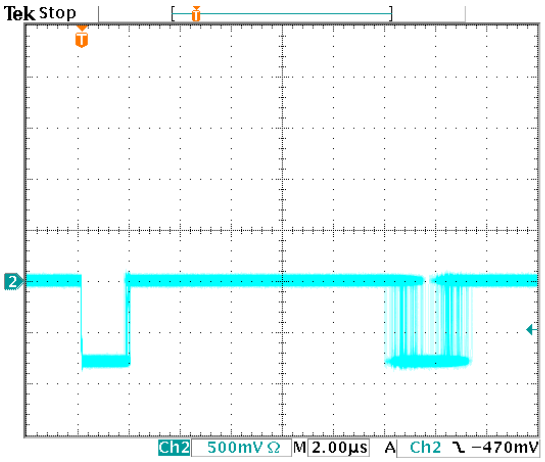
- Operation in air and high vacuum
- Operates from 5K to 350K
- Stainless steel vessel, 120cm^3, filled with He-gas
- He-gas filling at 1.0- 1.5 bar pressure
- Sensitivity: 1.9 pA/(Rad/hr)
- Readout via current-to-frequency converter (1.9 Hz/(Rad/hr)) and FPGA-TDC
- Pulses can be sent through long cables

Recycling Integrator

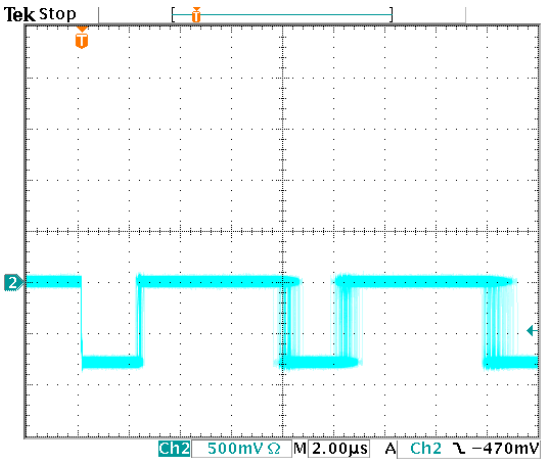
It generates pulses from current signals



Ch 1 represents input current, Ch2 output pulses from the recycling integrator



Input current of 150nA

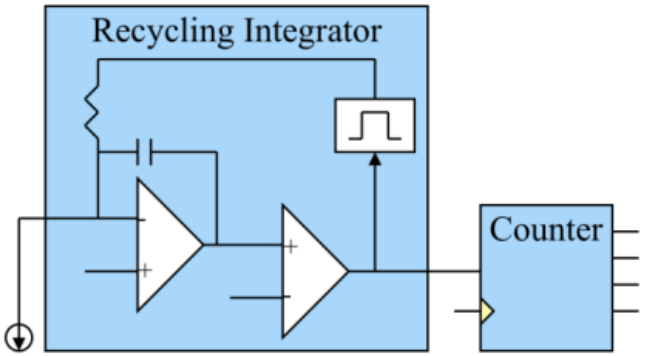


Input current of 300nA

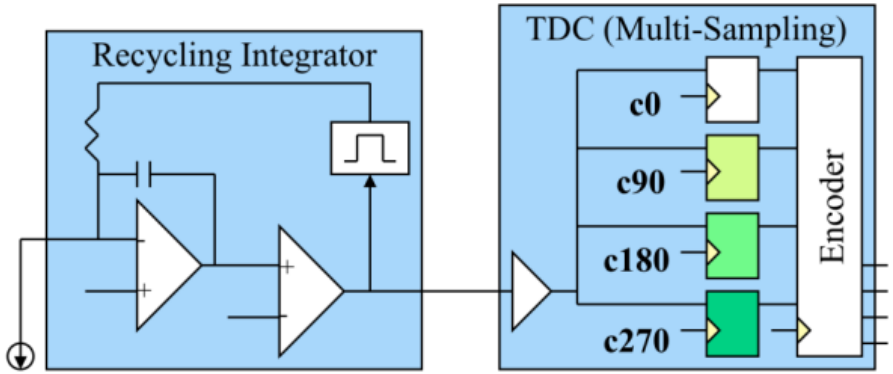
FPGA-based TDC

- Field programmable gate array(FPGA) is a device that can be reconfigured after its fabrication.
- Quartus II as the design software.

- Is needed to measure time between pulses to increase resolution over standard digitalization.
- Time-to-Digital Converter(TDC) gives a time resolution of 1 ns.

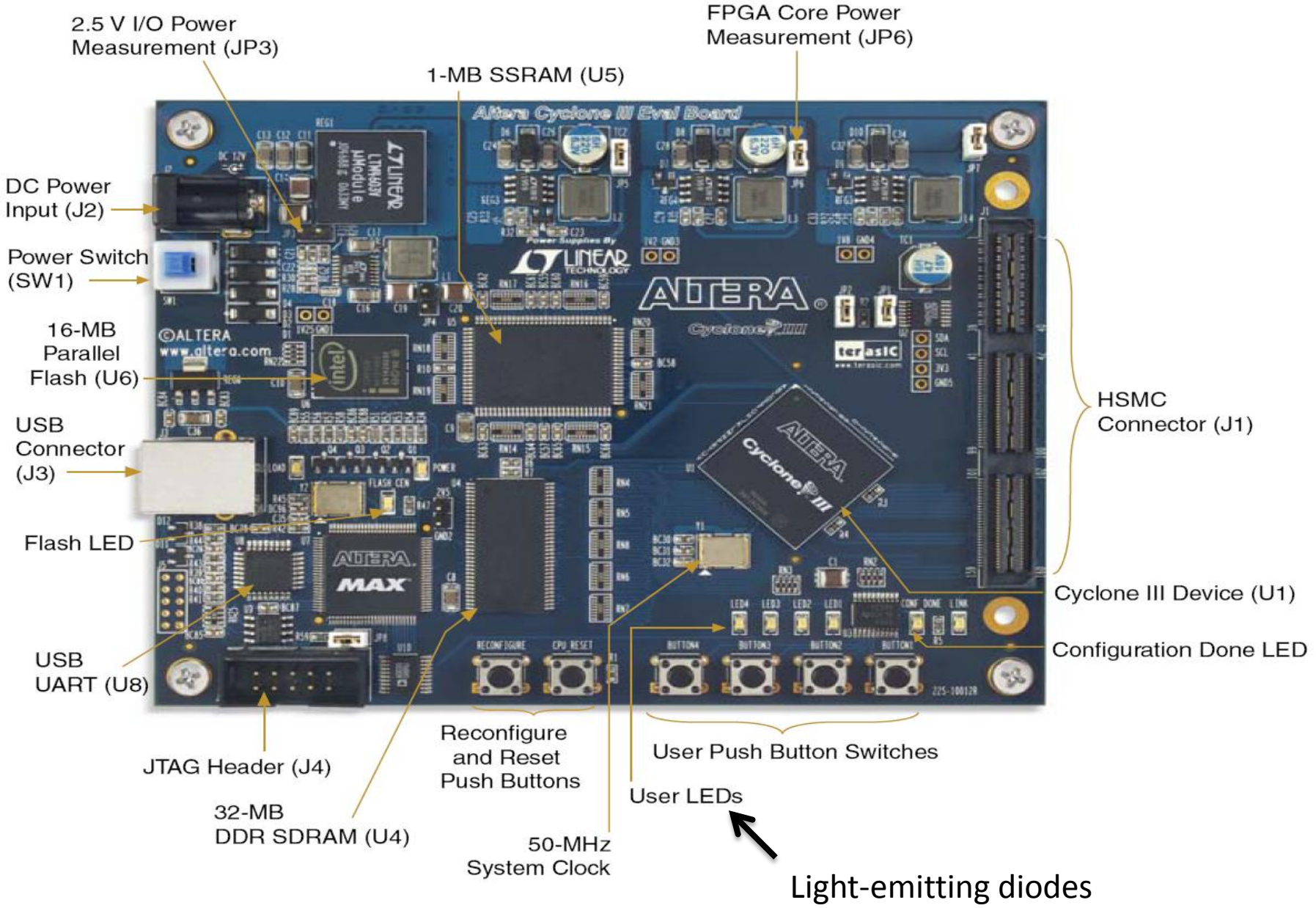


Typical digitalization

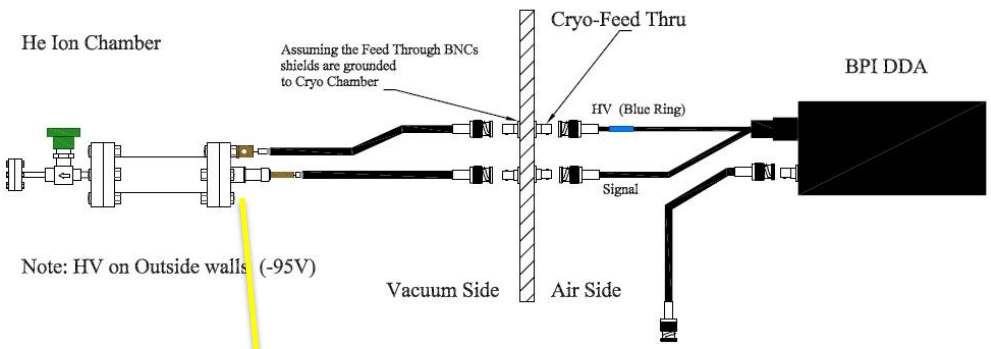


Digitalization with the FPGA

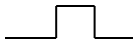
Top View of the Cyclone III FPGA Starter Board



Cryogenic beam loss monitor system display



Recycling Integrator



1.2 µs NIM pulses (1.63 pC or 238 µR @ 1 atm

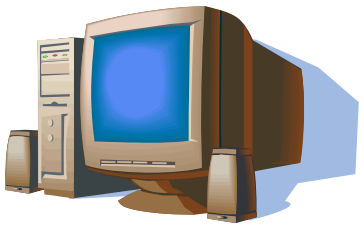
NIM to LVDS

FPGA-TDC

Output signal

Text file using control panel

Low-voltage differential(digital) signaling



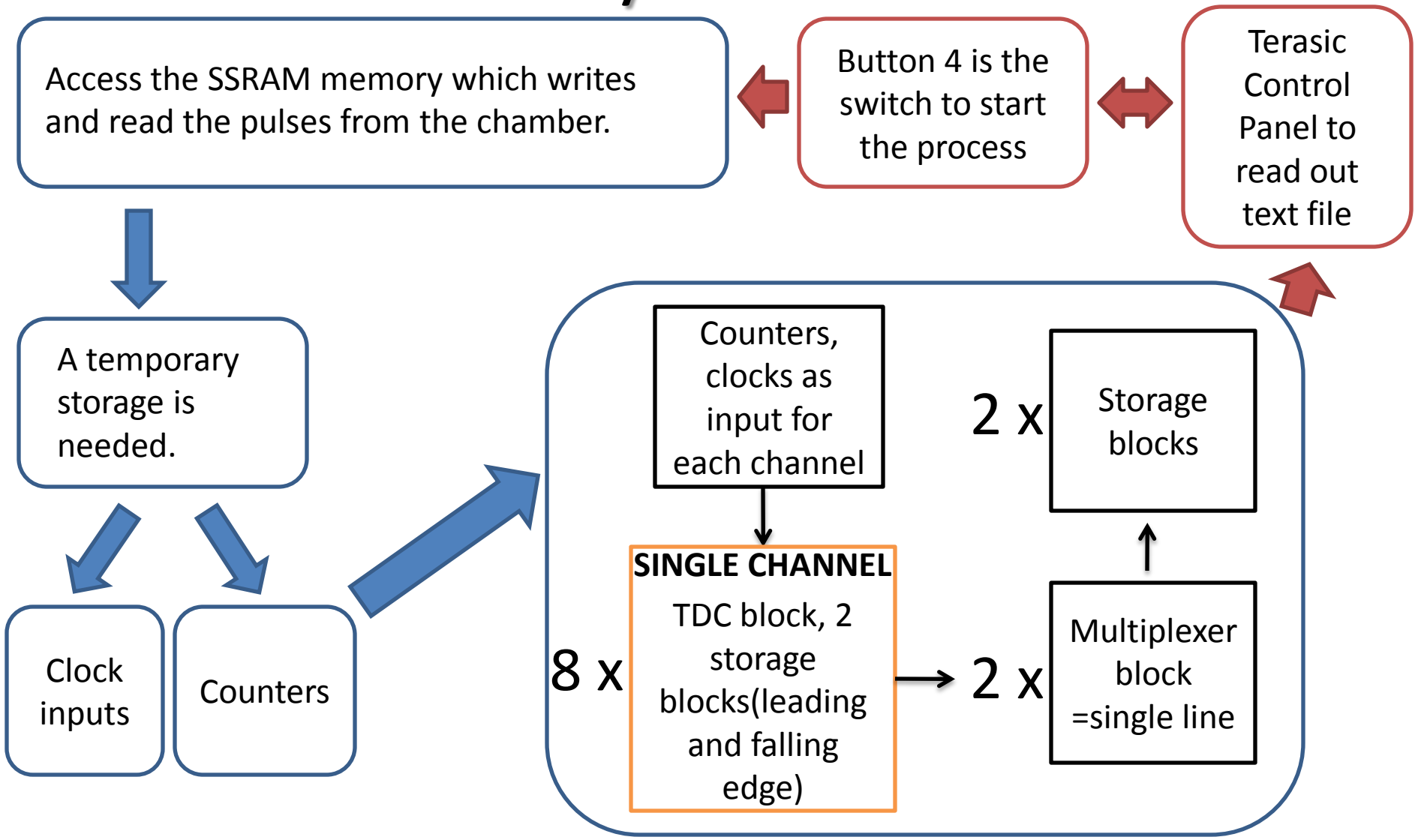
Excel file for analysis

Objective

Increase the output from a single to multiple (8) channels in the FPGA-based TDC.

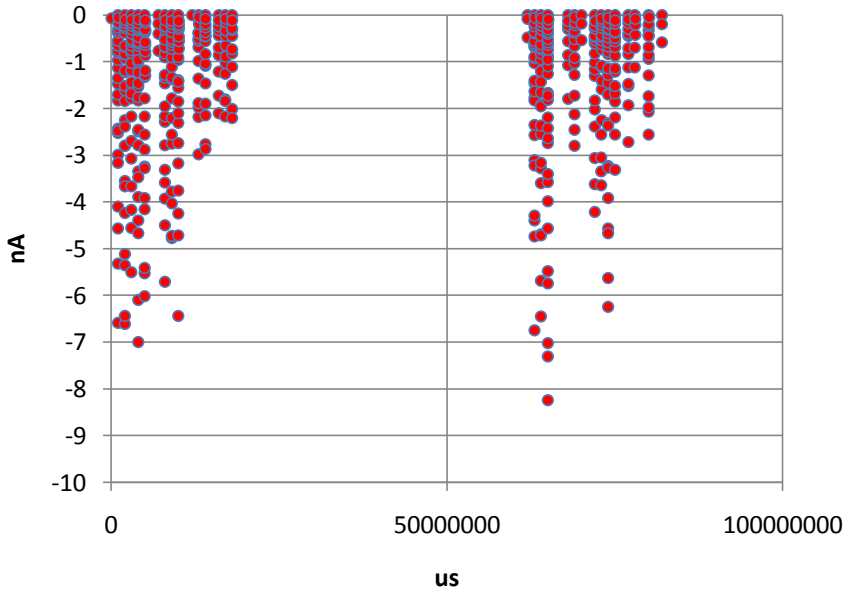
- Single channel design
- Schematics (New Blocks)

Quartus Schematic diagram functionality of the extension

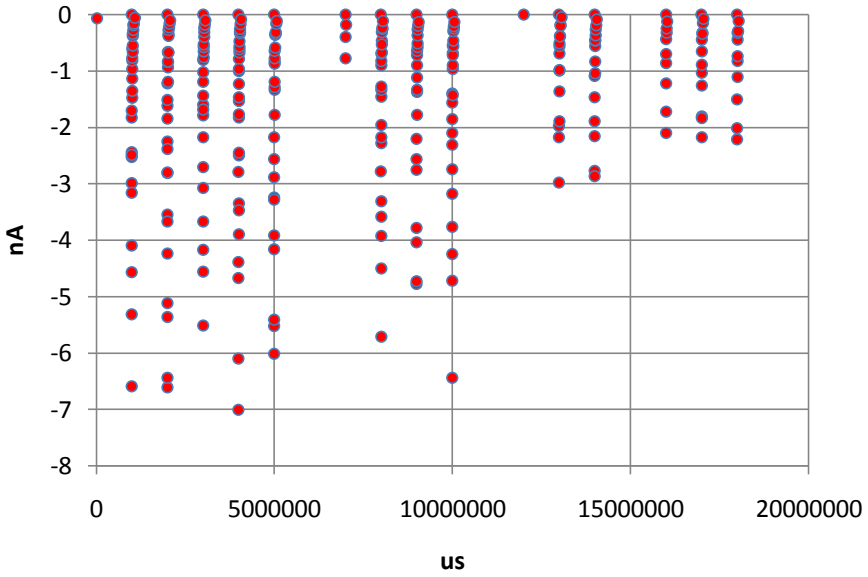


RESULTS

Single Channel



FPGA readout from A0 beam line when a magnet was swiped twice.

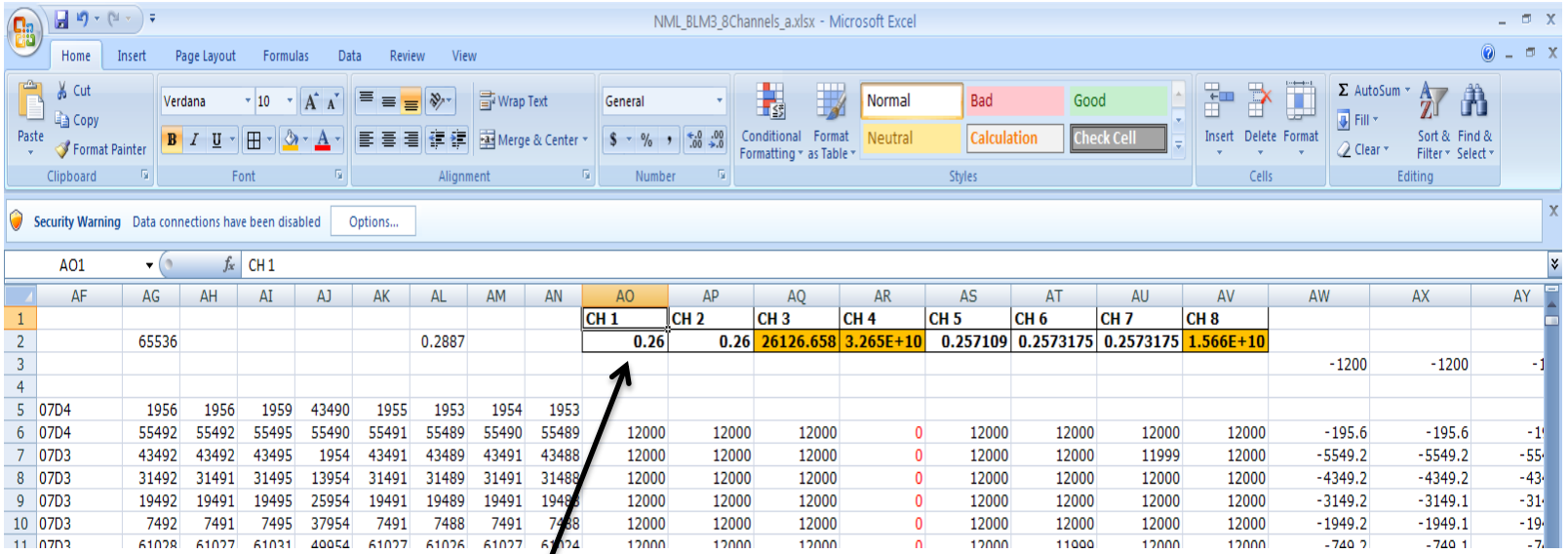


Closest view of the first swipe of the magnet. Beam loss was seen at 1 Hz frequency.

RESULTS

Eight Channels

Digital Pulse Generator



	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY
1										CH 1	CH 2	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8			
2		65536					0.2887			0.26	0.26	26126.658	3.265E+10	0.257109	0.2573175	0.2573175	1.566E+10			
3																		-1200	-1200	-1
4																				
5	07D4	1956	1956	1959	43490	1955	1953	1954	1953											
6	07D4	55492	55492	55495	55490	55491	55489	55490	55489	12000	12000	12000	0	12000	12000	12000	12000	-195.6	-195.6	-1
7	07D3	43492	43492	43495	1954	43491	43489	43491	43488	12000	12000	12000	0	12000	12000	11999	12000	-5549.2	-5549.2	-55
8	07D3	31492	31491	31495	13954	31491	31489	31491	31488	12000	12000	12000	0	12000	12000	12000	12000	-4349.2	-4349.2	-43
9	07D3	19492	19491	19495	25954	19491	19489	19491	19488	12000	12000	12000	0	12000	12000	12000	12000	-3149.2	-3149.1	-31
10	07D3	7492	7491	7495	37954	7491	7488	7491	7488	12000	12000	12000	0	12000	12000	12000	12000	-1949.2	-1949.1	-19
11	07D3	61028	61027	61031	49954	61027	61026	61027	61024	12000	12000	12000	0	12000	11999	12000	12000	-749.2	-749.1	-7

Standard Deviation for the analysis of the distance between pulses has to be between **0 and 0.28**

Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8
0.26	0.26	26126.6582	3.2652E+10	0.25710896	0.25731747	0.25731747	1.5661E+10

CONCLUSION & FUTURE WORK

- From the results we can conclude that the objective is partially achieved due to missing of acceptable standard deviations from three of the eight channels.
- Find the exact problem in channels 3, 4, and 8.
- The final test for the extension will be reading output from the He-Ionization chamber.

Acknowledgments

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Thank you!

Any Questions?