

PULSED POWER SYSTEM PERFORMANCE RHIC 2009

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BOOSTER & AGS PULSED POWER SYSTEMS

- Almost all of the existing systems performed well
- Booster Injection Kicker
 - Remote control interface will be upgraded in the summer with more signal channels
 - System voltage reference, regulation, resistor monitoring circuitry evolution continues ...

BOOSTER & AGS PULSED POWER SYSTEMS

- New AGS Tune Jump Quads Pulsers for polarized proton program
 - Design
 - Prototyping
 - Testing
 - Construction
 - Installation

EBIS PULSED POWER SYSTEMS

- NEW LEBT SOLENOID PULSER
 - Design
 - Construction
 - Installation
 - Testing
- Anode HV Floating Platform Pulser
 - Continued Development and Design, Construction, Testing, ...
- Assorted DC Power Supplies

RHIC BEAM ABORT KICKER SYSTEM PERFORMANCE

Yellow Ring

#1	#2	#3	#4	#5	TIME	DATE	VOLTAGE	BEFORE PREFIRE	ACTIVITY
			1		17:22	2/26/2009	26kV	IN RAMP @ SLOPE, CLOSE TO TOP	
0	0	0	1	0					

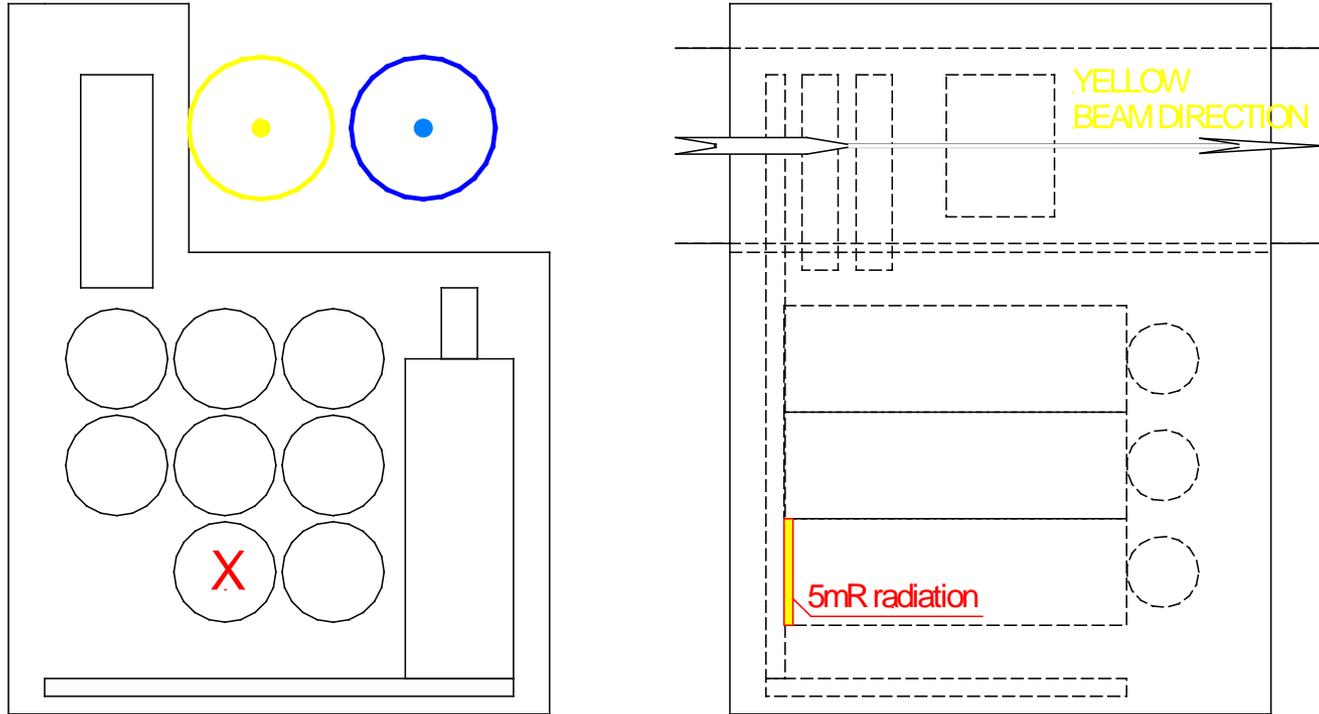
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Blue Ring

#1	#2	#3	#4	#5	TIME	DATE	VOLTAGE	BEFORE PREFIRE	ACTIVITY
1					15:09	2/16/2009	22kV	Ramp	
1					22:06	2/19/2009	27kV	FLAT TOP ~10 MINUTES	
			1		0:36	2/25/2009	27kV	FLAT TOP ~200 MINUTES	
		1			4:38	2/28/2009	20kV	Ramp	No beam
			1		17:07	3/6/2009	27kV	FLAT TOP ~22 MINUTES	
			1		18:04	3/6/2009	27kV	FLAT TOP ~6 MINUTES	PEAK VOLTAGE REDUCED BY 10%
			1		21:07	3/6/2009	24kV	FLAT TOP ~35 MINUTES	CONDITIONED. 4 TIMES @ 28kV. #4 RESERVOIR VOLTAGE REDUCED.
			1		16:18	3/10/2009	12kV	IN RAMP @ SLOP	Lowered Voltage. Changed the B#4 large 5uF capacitor on March 12.
				1	13:44	3/27/2009	27KV	FLAT TOP ~35 MINUTES	
			1		12:14	6/20/2009	10kV	FLAT TOP ~90 MINUTES	#4 REDUNDANT TRIGGER MODULE WAS REPLACED.
2	0	1	6	1					

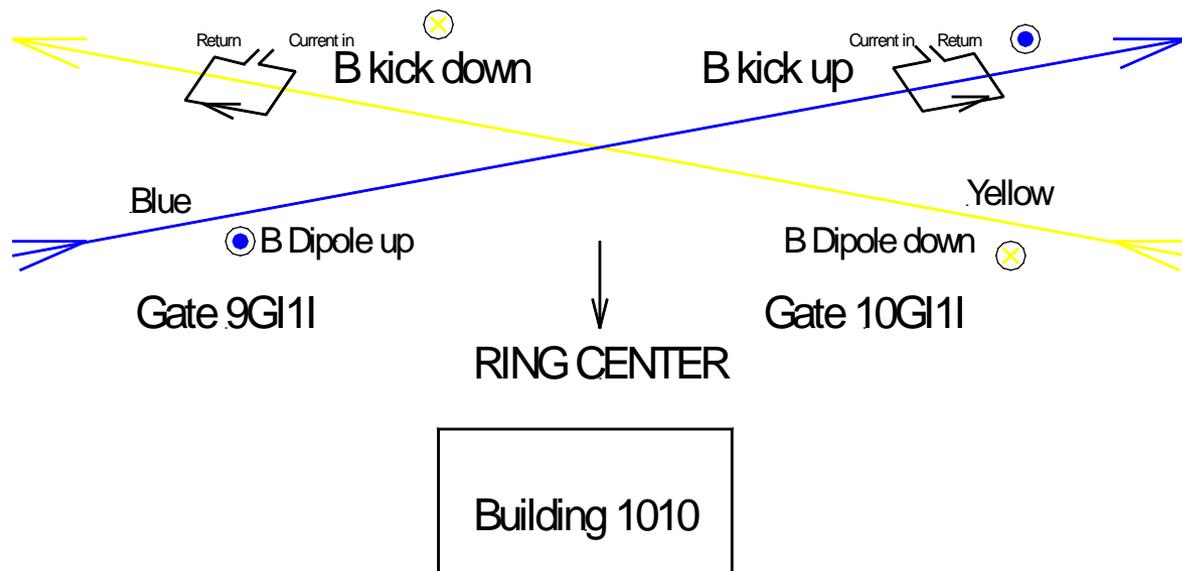
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RHIC BEAM ABORT KICKER RADIATION MEASUREMENTS



One capacitor was replaced at 4/15/2009 due to minor oil leak. The capacitor is located in Yellow Module 4. The capacitor #8 located at lowest row. The leak was at ground end. According to radiologic technician, the radiation at damaged end was about 5mR, and almost nothing at the other end.

RHIC BEAM ABORT KICKER RADIATION MEASUREMENTS



RHIC BEAM ABORT KICKER RADIATION MEASUREMENT

High voltage modulators in the ring



Front view



Back view

RHIC BEAM ABORT KICKER RADIATION MEASUREMENT



Yellow Abort Kicker TLD
placed from back facing
yellow beam

Blue Abort Kicker TLD
placed from back facing
blue beam



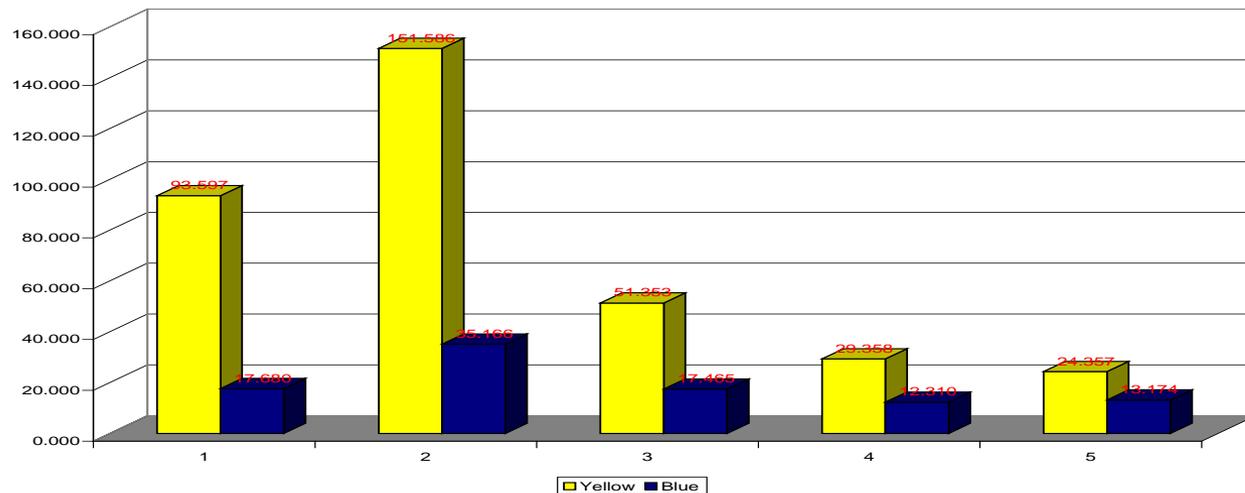
RHIC BEAM ABORT KICKER RADIATION MEASUREMENT

RHIC Abort Kicker Modulator

April 15, 2009 to April 22, 2009

		SHALLOW rem	LENS rem	Low Energy NEUTRON (TLD) rem	Gamma DEEP rem	TOTAL rem	High Energy NEUTRON (CR39) mrem
Y#1	TK335	49.662	66.686	36.074	57.523	93.597	> 25000
Y#2	TK336	109.928	143.156	24.602	126.984	151.586	> 25000
Y#3	TK337	30.686	31.853	20.016	31.337	51.353	14260
Y#4	TK338	15.374	15.726	14.509	14.849	29.358	10700
Y#5	TK339	11.151	11.184	13.241	11.116	24.357	4960
B#1	TK334	11.727	12.202	4.580	13.100	17.680	9040
B#2	TK333	25.523	25.570	8.869	26.297	35.166	12260
B#3	TK332	9.711	9.794	7.901	9.564	17.465	4390
B#4	TK331	4.311	4.280	7.921	4.389	12.310	1820
B#5	TK330	2.641	2.603	10.518	2.656	13.174	2290

RHIC ABORT KICKER TOTAL DOSE (REM)



RHIC BEAM ABORT KICKER

High Voltage Oil Filled Pulsed Capacitors

- Yellow high voltage modulators' plastic case oil filled pulsed capacitors were replaced two years ago. However, minor leak has been detected. A few capacitors were replaced during run 2009.
- Is there any correlation between radiation and oil leak?
- Why radiation is higher in yellow than blue?
- Why #2s are higher in both rings?

RHIC BEAM ABORT KICKER

Smoke Alarm & Beam Intensity

- Blue ring smoke alarms are ionization sensor type. The photoelectric type had been triggered many times for unknown reason in Run 2007. After changing to Ionizing sensor type during Run 2007, they have been working well.
- Yellow ring smoke alarms are the original photoelectric sensor type. During APEX, higher intensity beam triggered smoke alarm a few times.
- Is there correlation of beam intensity and smoke alarm malfunction?

RHIC BEAM ABORT KICKER

Summer Maintenance Plan

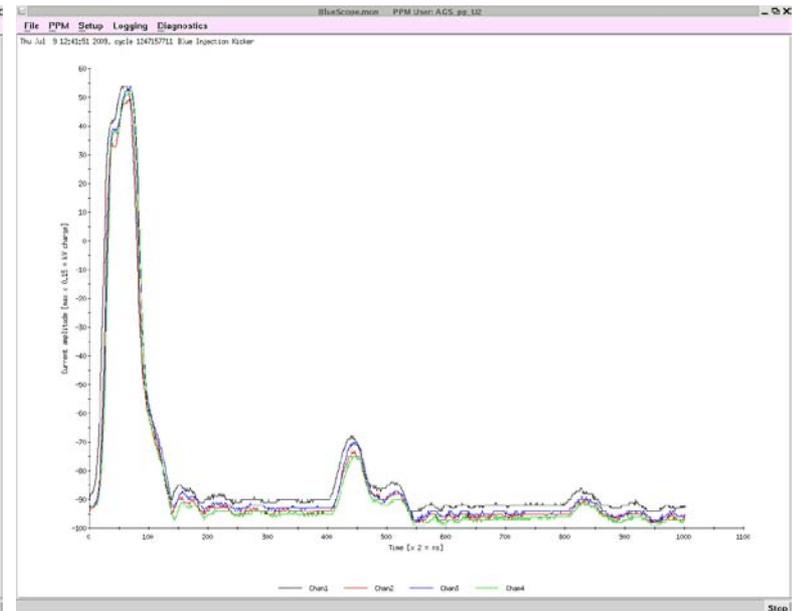
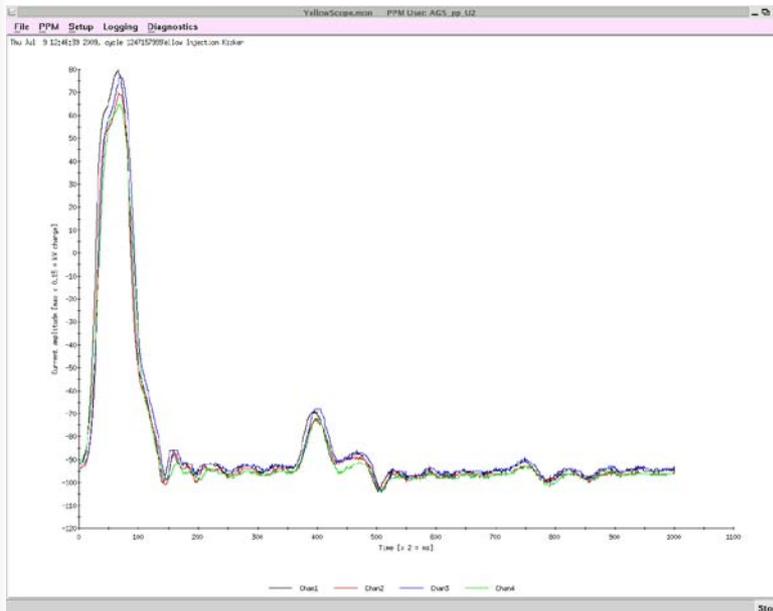
- Visual inspection of Blue #4 high voltage modulator for arcing signs
- Considering change thyatron in Blue #4
- Visual inspection of all high voltage capacitors
- Testing all smoke alarms
- High voltage conditioning before next run.
- ...

RHIC INJECTION KICKER SYSTEMS

Summer Maintenance and Improvement Plan

- To install two dedicated VME PLCs and to implement PLC program change to reduce power dip caused communication interruptions.
- To replace all UPS batteries.
- To replace all thyatron auxiliary power supply fuses.

RHIC INJECTION KICKER SYSTEMS WAVE REFLECTION MEASUREMENTS

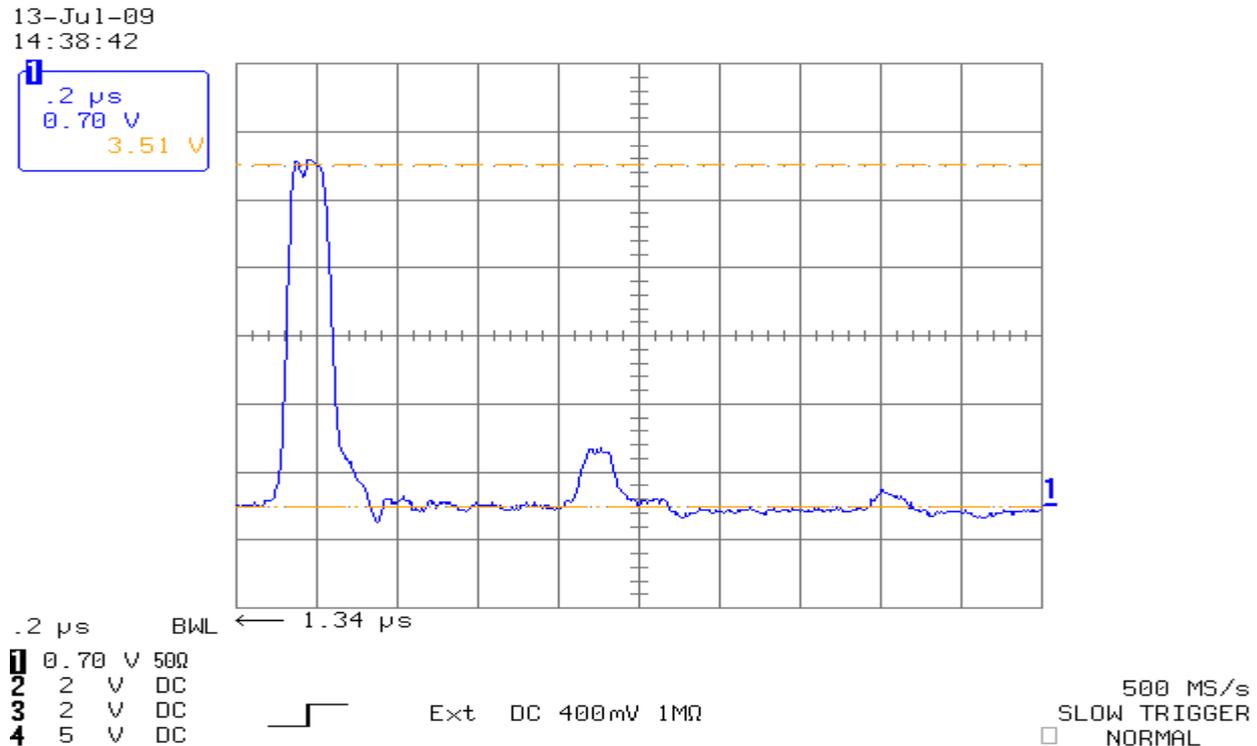


Measurement length: 2000 ns

Second wave reflection: $\sim +6\%$ & $\sim -2\%$

RHIC INJECTION KICKER SYSTEMS

WAVE REFLECTION MEASUREMENTS



Location: Test Setup at 922

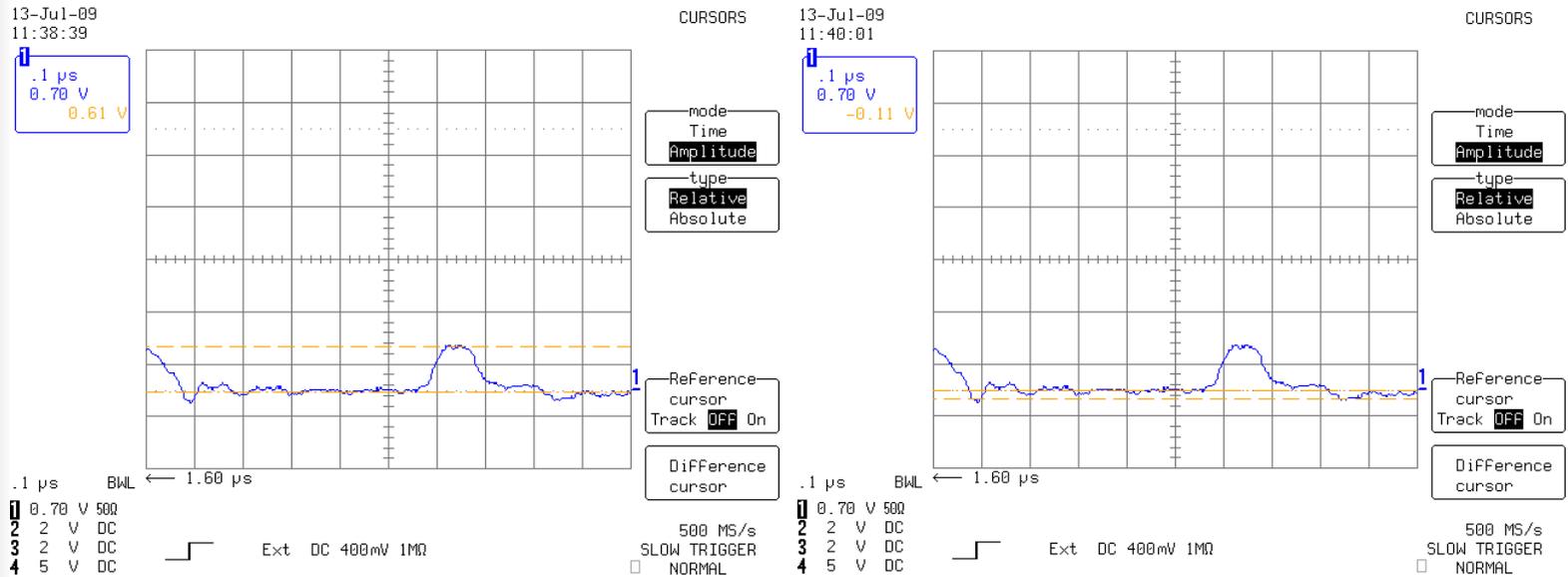
Voltage: 20 kV

Magnet: modified magnet to be installed in Yellow ring

Resistor: 25.2 ohm

RHIC INJECTION KICKER SYSTEMS

WAVE REFLECTION MEASUREMENTS

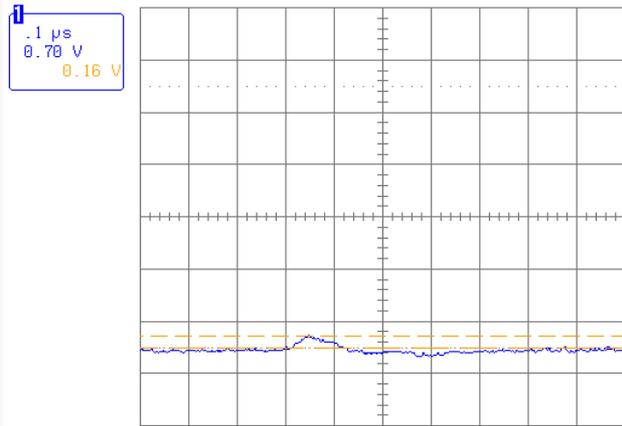


First wave reflection:

$$+0.61/3.51 = 17.38\% \text{ \& } -0.11/3.51 = -3.13\%$$

RHIC INJECTION KICKER SYSTEMS WAVE REFLECTION MEASUREMENTS

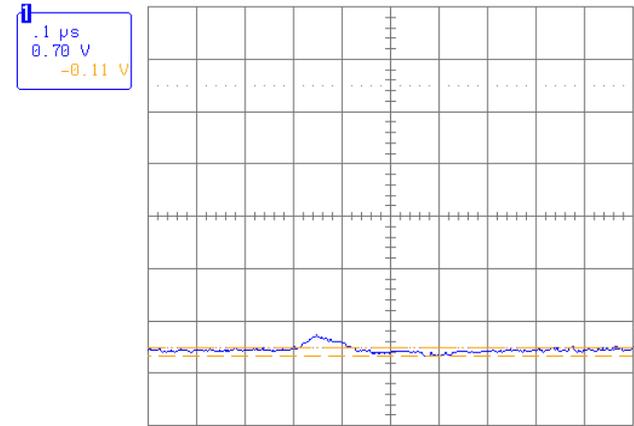
13-Jul-09
11:41:18



.1 μs BWL ← 2.60 μs
 1 0.70 V 500
 2 2 V DC
 3 2 V DC
 4 5 V DC

500 MS/s
 SLOW TRIGGER
 NORMAL

13-Jul-09
11:41:46



.1 μs BWL ← 2.60 μs
 1 0.70 V 500
 2 2 V DC
 3 2 V DC
 4 5 V DC

500 MS/s
 SLOW TRIGGER
 NORMAL

Second wave reflection:

$$+0.16/3.51 = 4.56\% \quad \& \quad -0.11/3.51 = -3.13\%$$

RHIC INJECTION KICKER SYSTEMS

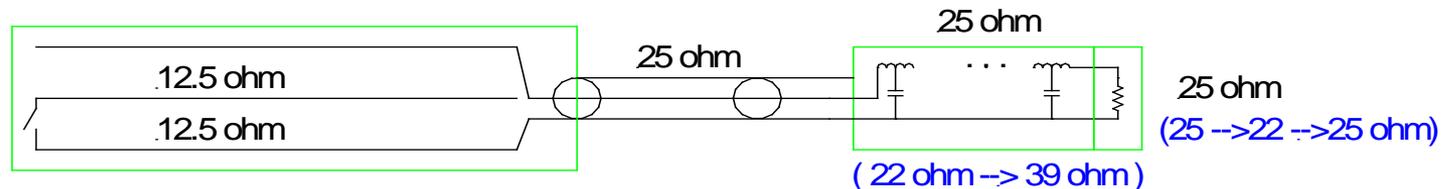
WAVE REFLECTIONS

Ideal System:

Pulser, transmission cable, magnet, and resistor have well matched impedance.

Actual System:

	2006-2009	1999(?)-2005	1997-1999?	Notes
Pulser	25 ohm	25 ohm	25 ohm	
Cable	25 ohm	25 ohm	25 ohm	
Magnet	39 ohm	22 ohm	22 ohm	Voltage & impedance
Resistor	25 ohm	22 ohm	25 ohm	



RHIC INJECTION KICKER SYSTEMS

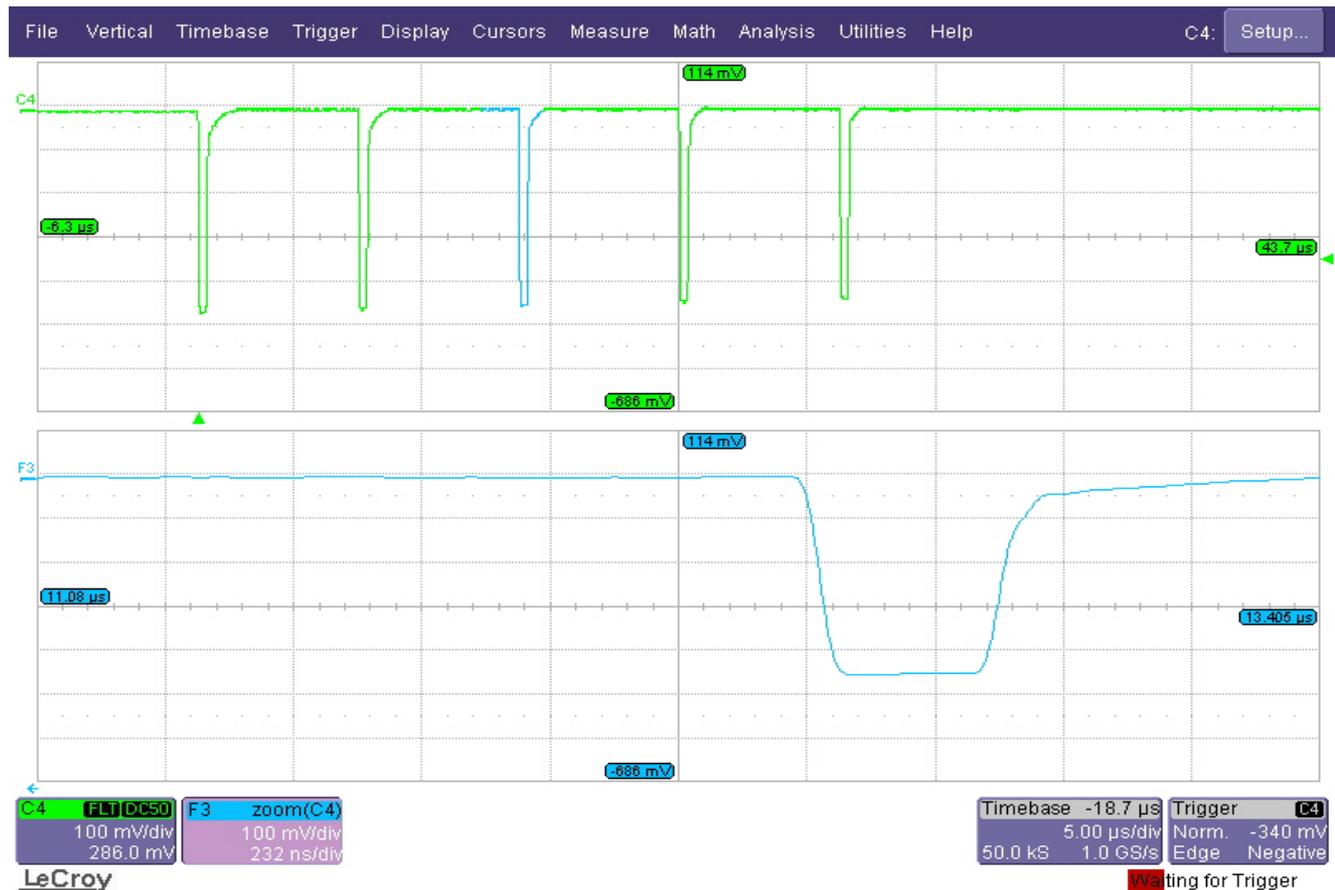
- Evaluating ideas, feasibilities, costs, and schedule, as well as added benefit to future programs.
- What to do with Blumlein pulser, transmission cable, or magnet?
- Pulse Reflection Compensation?
 $5\% * 1280A = 64A$
Is there space for compensation magnets?

Pulsed Power R&D Need

- Pulsar
 - Cable Blumlein Pulsar
 - Advanced topologies
 - Solid state technologies
- Magnet
 - Transmission line magnet
- Applications

Pulsed Power R&D Highlight

Fast pulse train: Upper trace: 5 μ s/div, lower trace: 240 ns/div
~ 20ns rise time, ~ 300 ns pulse width filtered waveform



Pulsed Power R&D Highlight

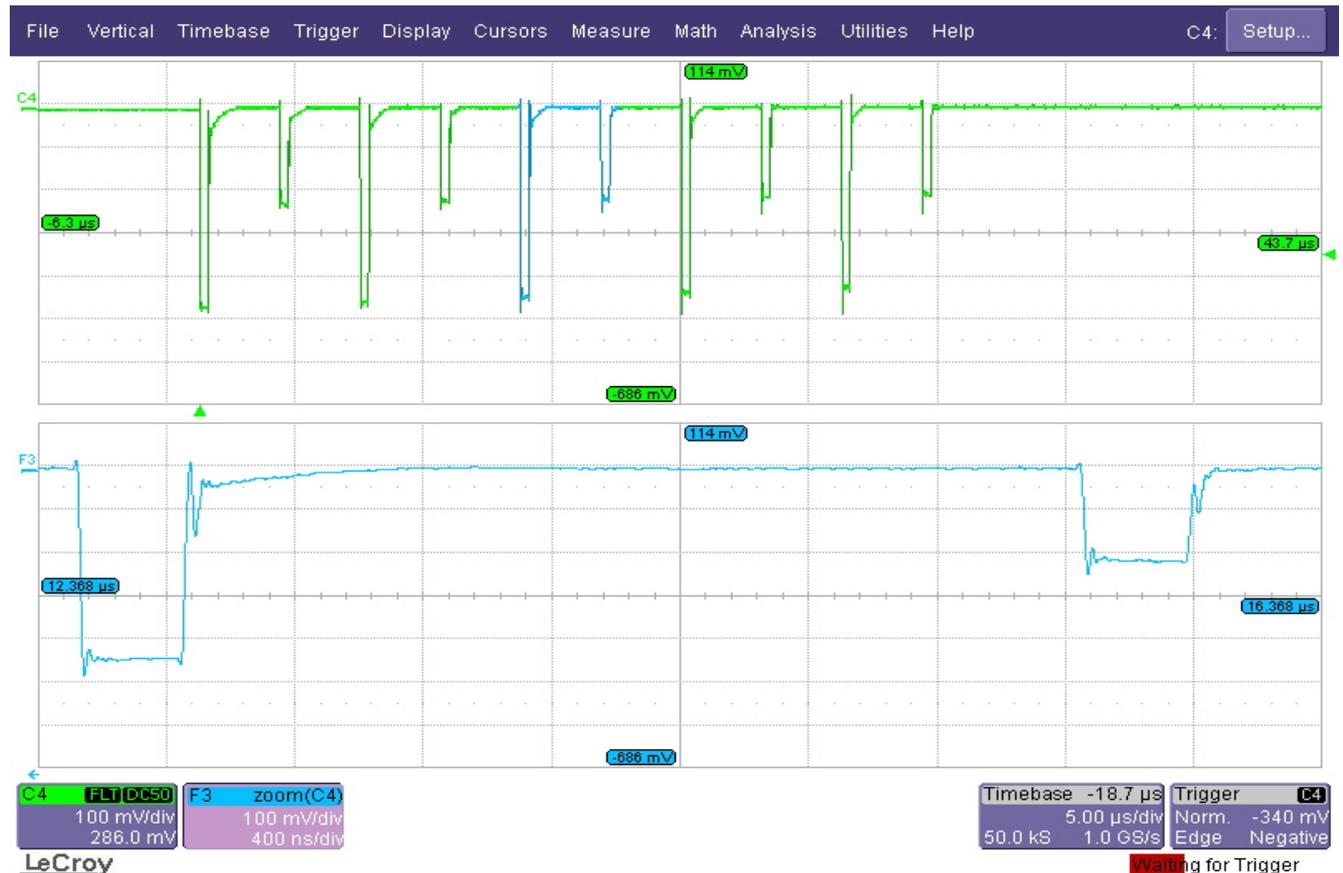
Toward high voltage high
current waveform generator
Lower traces: 200 ns/div
Rise time: ~ 10 ns



Pulsed Power R&D Highlight

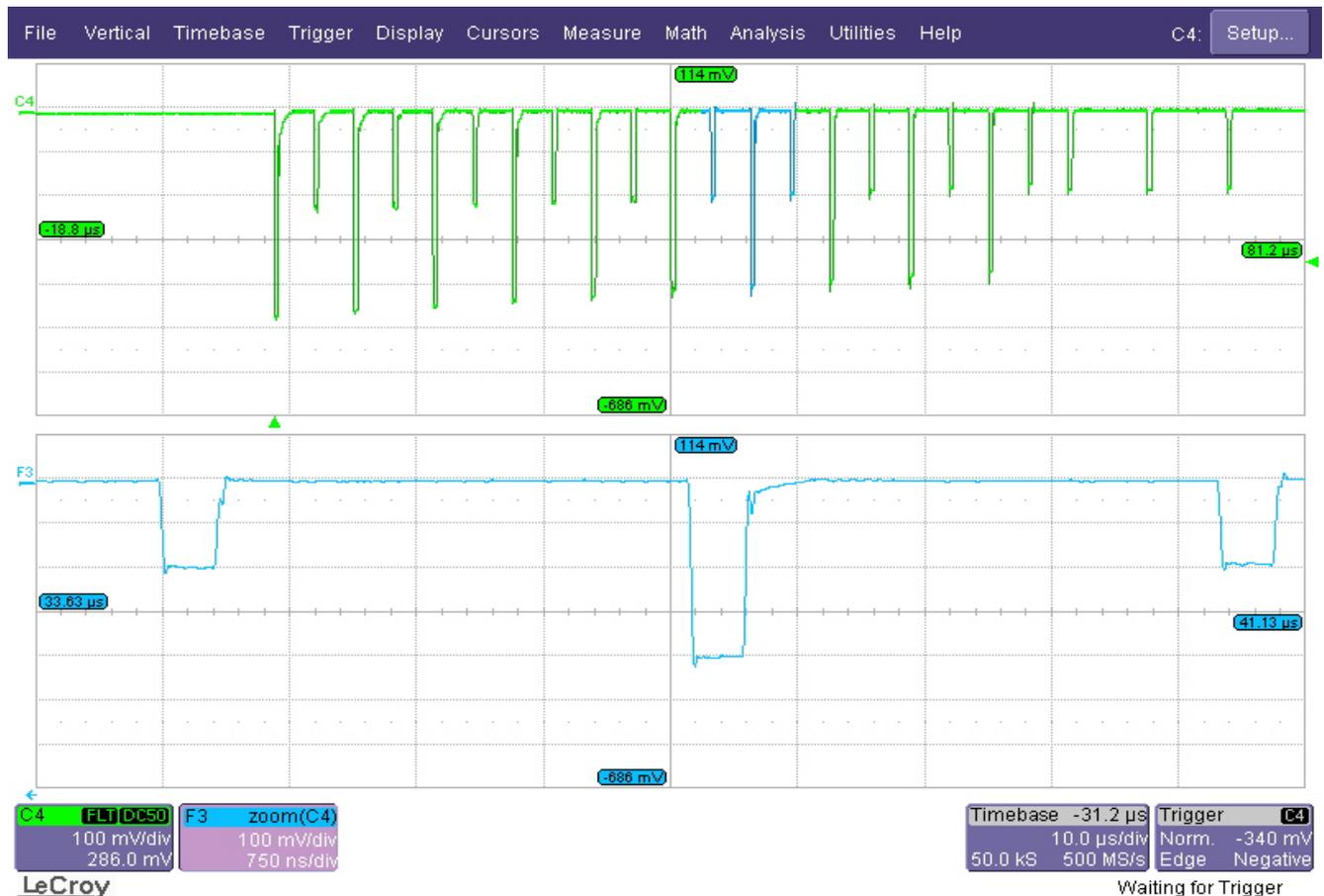
Pulse rep rate = ~ 300 kHz

~ 400 ns pulse width, amplitude interleaved mode



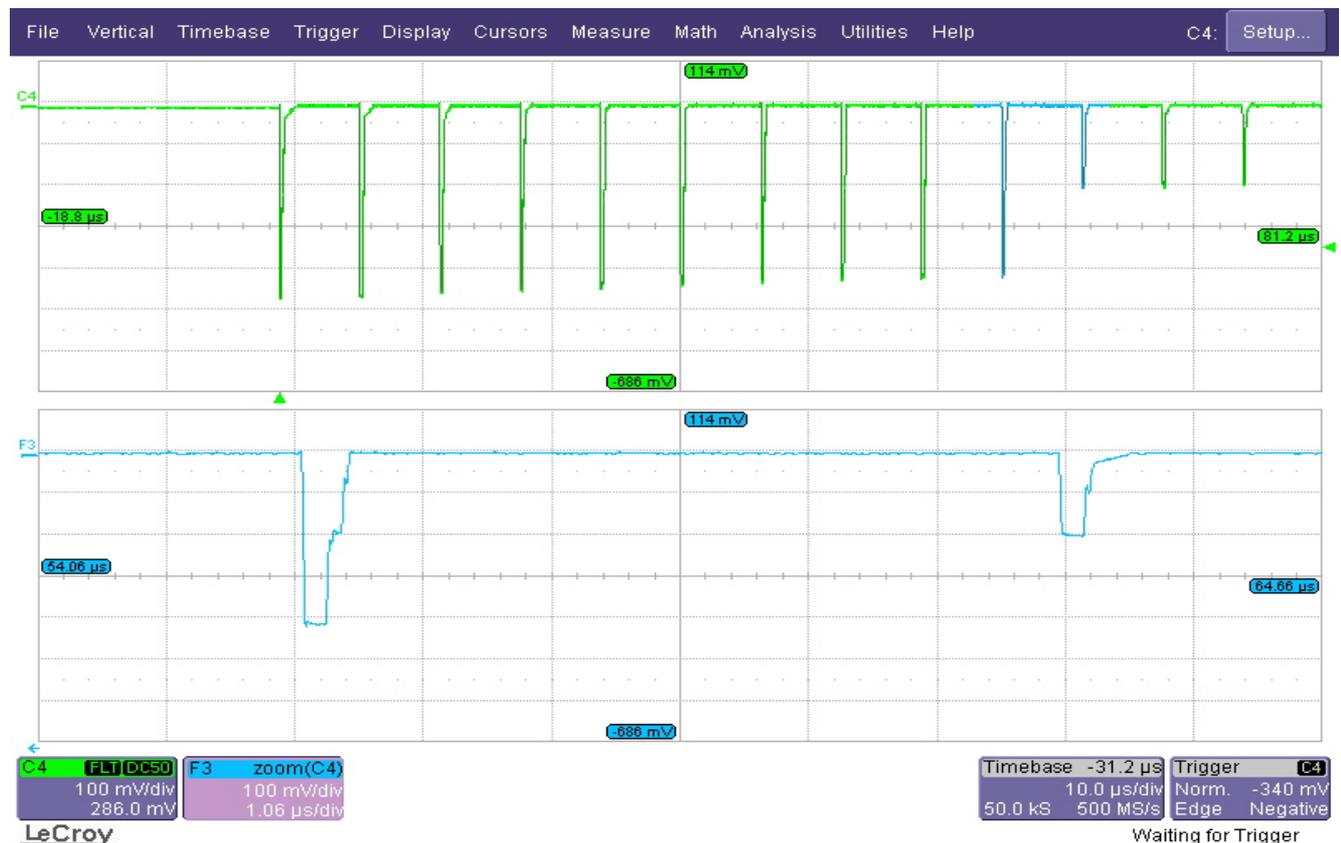
Pulsed Power R&D Highlight

Pulse repetition rate = ~ 300 kHz, ~ 400 ns pulse width, amplitude interleave mode and skip mode.



Pulsed Power R&D Highlight

Pulse train: pulse repetition rate = ~ 160 kHz with fast waveform change and amplitude change





Thank You!