



Machine Protection and Accelerator Timing

Coles Sibley

LANL March 15, 2001

SNS Integrated Control System



BROOKHAVEN
NATIONAL LABORATORY



Los Alamos
NATIONAL LABORATORY

ornl

Machine Protection System



- Run Permit System (1 second)
 - » Coordinates machine mode changes.
 - » Scans IOC configurations for Software Configuration errors.
 - » EPS interface for masking equipment inputs.
- Hard Wired Protect (~ 33 msec)
 - » Latched in Hardware
 - » Redundancy through FPLS inputs
- Fast Protect Latched System (20 microseconds)
 - » Latches fault conditions until fault clears and Operator resets condition. FPS_PERMIT_LINK_A carrier interrupted and inhibits beam through front end devices.
- Fast Protect Auto Reset (20 microseconds)
 - » Inhibits beam for duration of macro pulse by disabling FPS_PERMIT_LINK_B carrier to the front end. Restores Fast Protect link for next pulse if fault restored to normal.

Machine Protection System – Mode Definitions

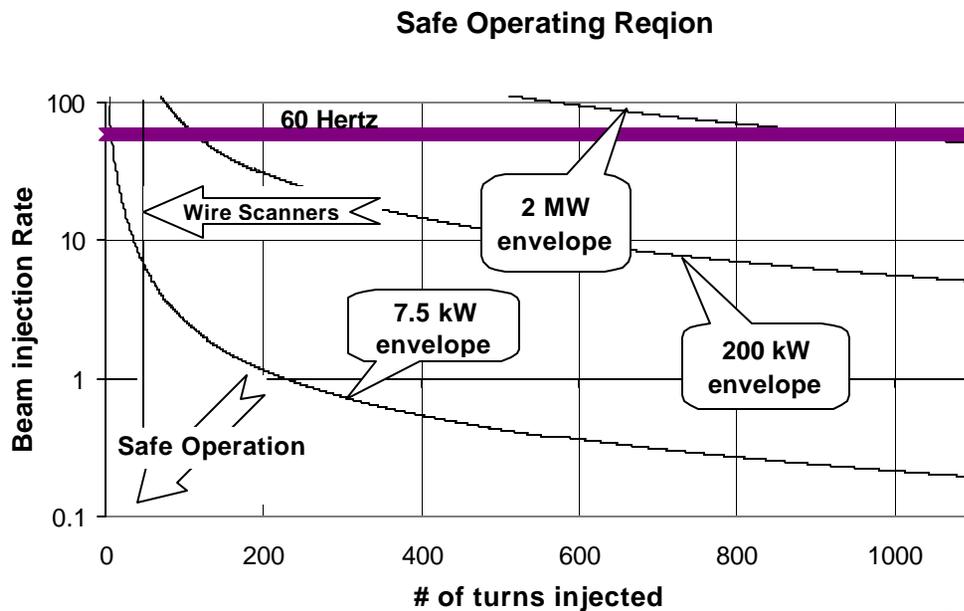


- Machine Modes

- » Front End
- » Linac Dump
- » Injection Dump
- » Extraction Dump
- » Target

- Beam Modes (Maximum Limits)

- » Off
- » RF Only
- » Diagnostics (~20 usec)
- » Diagnostics (~100 usec)
- » Low Power (7.5 kW)
- » Medium Power (200 kW)
- » Full Power (2 MW)



MPS Inputs from Timing System



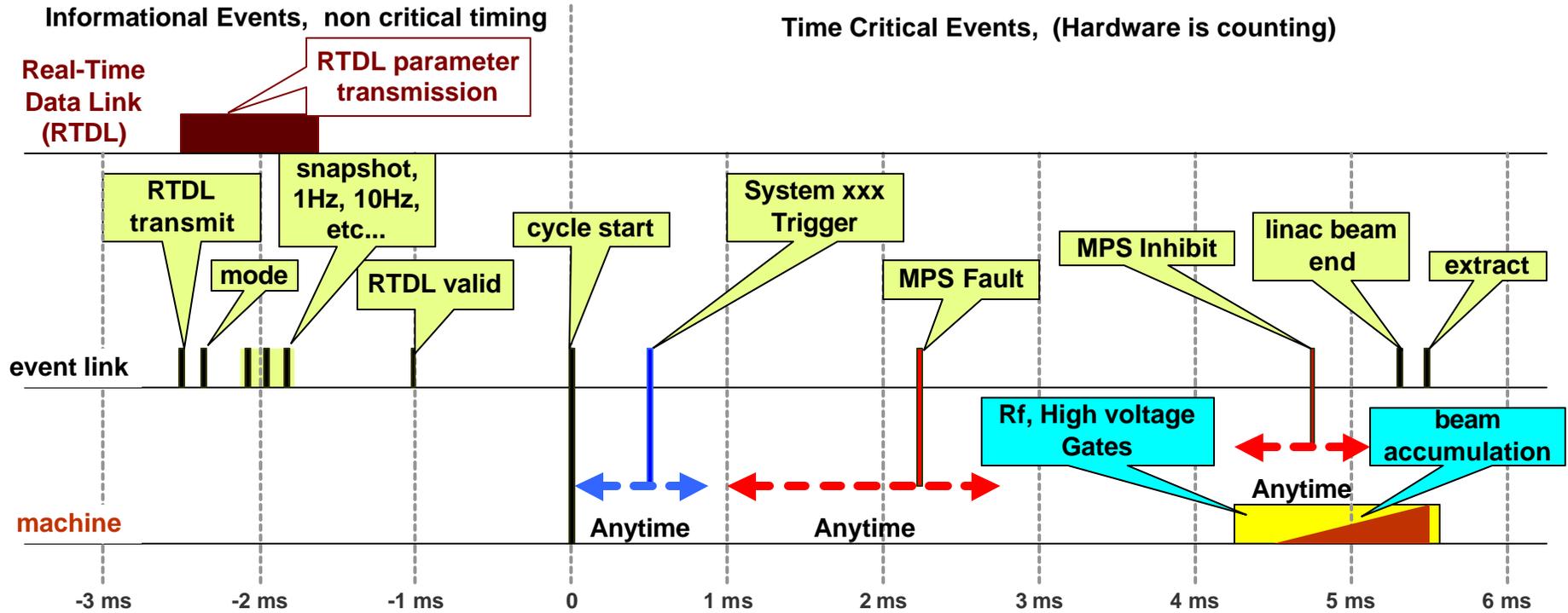
- Phase Window Error – FPS Auto reset input
- Phase Lock Error – FPS Latched input
- Pulse Stealing Veto (MPS fault signal)
- (MPS Latched inputs inhibit beam unit reset received)
- (MPS auto reset inputs are enabled next pulse if input OK)

SNS Links



- RTDL – Real Time Data Link (10 MHz Carrier)
 - » Design based on RHIC RTDL System
 - » Up to 256 Frames (1 start bit, 8 address bits, 24 data bits, 8 CRC bits per frame)
 - » Provides Synchronous data facility wide.
 - » One broadcast per machine cycle
- Event Link (16 x Ring RF frequency)
 - » Phase locked to Ring RF
 - » 256 Events possible
 - » Events Prioritized

SNS Accelerator Timing Sequence



Event Link - Informational Events



event name	Time (msec)	description
RTDL_transmit	-2.5	RTDL master transmits data that is useful for the for the next pulse and data descibing previous pulse. Defines the end of the previous cycle and start of the new beam cycle
10_Hz	-2.5 to -2.0	Occurs every 6 cycles. Allows synchronous data acquisition.
1_Hz	-2.5 to -2.0	Occurs every 60 cycles, in phase with the 10 Hz event.
snapshot	-2.5 to -2.0	This event occurs infrequently. Enables the acquisition of large data sets.
mode1	-2.5 to -2.0	Encoded mode information sent on event link for redundancy. 32 different codes are reserved for this. Only one of the 32 is sent on each cycle. Describes beamline (Beam dump) and Beam power (max pulse width / rep rate)
mode2	"	
... through...	"	
mode32	-2.5 to -2.0	
RTDL_valid	-1	All RTDL receivers latch data on this event. IOC can now send RTDL data to slave modules



Event Link - Timing Events



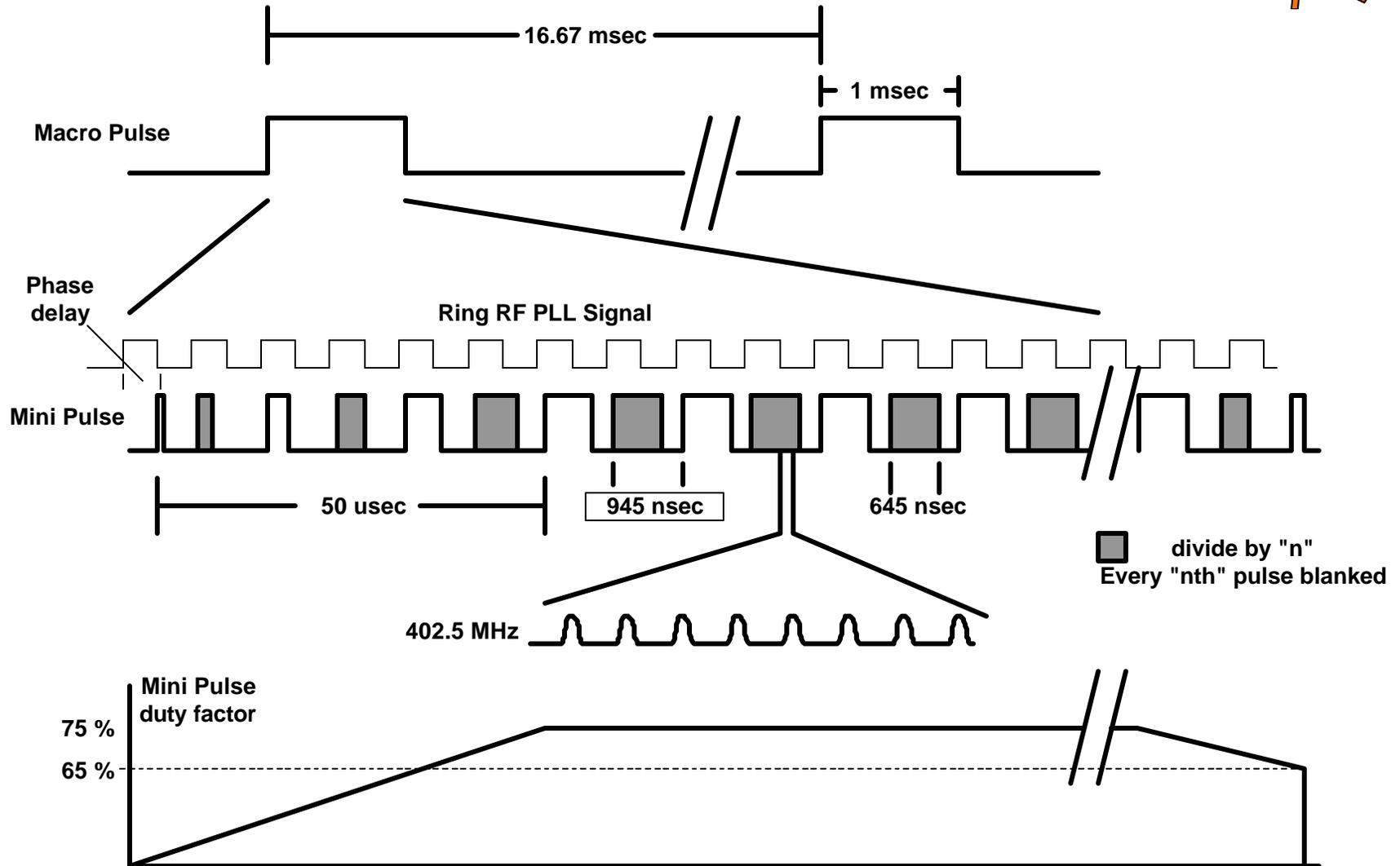
Event name	Time (msec)	Description
Cycle_Start or Tzero	0	Resets fault counters, gate delay counters, etc. Systems with fine timestamp requirements start counting 16 MHz carrier cycles from this event. Time stamp which was received in the RDTL data gets these counters added on for fine resolution
inhibit	anytime	Machine protect has inhibited beam pulse. Future pulses <i>are</i> allowed.
fault	anytime	Machine protect has latched beam inhibit signal. Future pulses <i>are not</i> allowed until fault is cleared.
System xx Trigger	anytime	Subsystem triggers for commissioning / troubleshooting. For example - RF System Triggers
linac beam end	4.2 to 5.2	Precedes anticipated end of linac beam pulse by 300 turns. This event is unaffected by a beam inhibit. Marks the end of a linac cycle.
extract	5.5 msec to many seconds	Precedes actual beam extraction by 8 turns. Used to enable extraction kicker pulse and to trigger RTBT diagnostics. On a beam inhibit, the extract event may be sent earlier than planned. Marks the end of a ring cycle.

SNS RTDL Frames



Frame	Parameter name	Description
1	time of day 1	These parameters are concatenated and then truncated from the LSB to form an EPICS compliant, 64 bit time of day. This timestamps the occurrence of the upcoming cycle
2	time of day 2	
3	time of day 3	
4	event link period	Period (in ps) of the event link carrier. Used to convert carrier counts to elapsed time.
5	Operating mode	Identifies machine area, beam power limits, and macro pulse limits. Identical to mode transmitted on Event Link.
6	Operating mode	Repeats Frame #5
7	60 Phase Error	Beam chopper – Line Phase error (nsec's)
8	Mini_phase_delay	Beam parameters used by LEBT chopper to create upcoming pulse.
9	Mini pulse min_width	“
10	Mini pulse max_width	“
11	Mini ramp cycles	”
12	Macro delay	“
13	Macro Length	“
14	I_max	“ (needed for Beam Power, not adjustable P-P)
15	Previous Pulse Data	
16	data acquisition mode	reserved for future expansion
17	status of previous pulse	status code of previous pulse. Possible status codes: [normal, fast inhibit occurred, ...]
18	User_ID	identifies the requester of the this pulse
19	reset address	address of IOC to reset

Macro Pulse Shape



Timing Issues / Comments



- Some MPS ABORTS require beam dump ASAP (Ring RF trip, Extraction Kicker failure)
- Event link timing phase locked to Ring RF. Fast clocks are ~16 MHz (16 x Ring revolution frequency)
- MPS and Diagnostics count Ring RF X 16 for time stamps
- Instrument Systems can veto next pulse (if desired) through MPS
- Beam timing is frozen 4 msec before pulse.
 - » Can the Chopper timing change “significantly” in the 5+ msec before beam arrives on target?