The Fast Protection System for CSNS Accelerator

Yuliang Zhang

CSNS@IHEP

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Outline

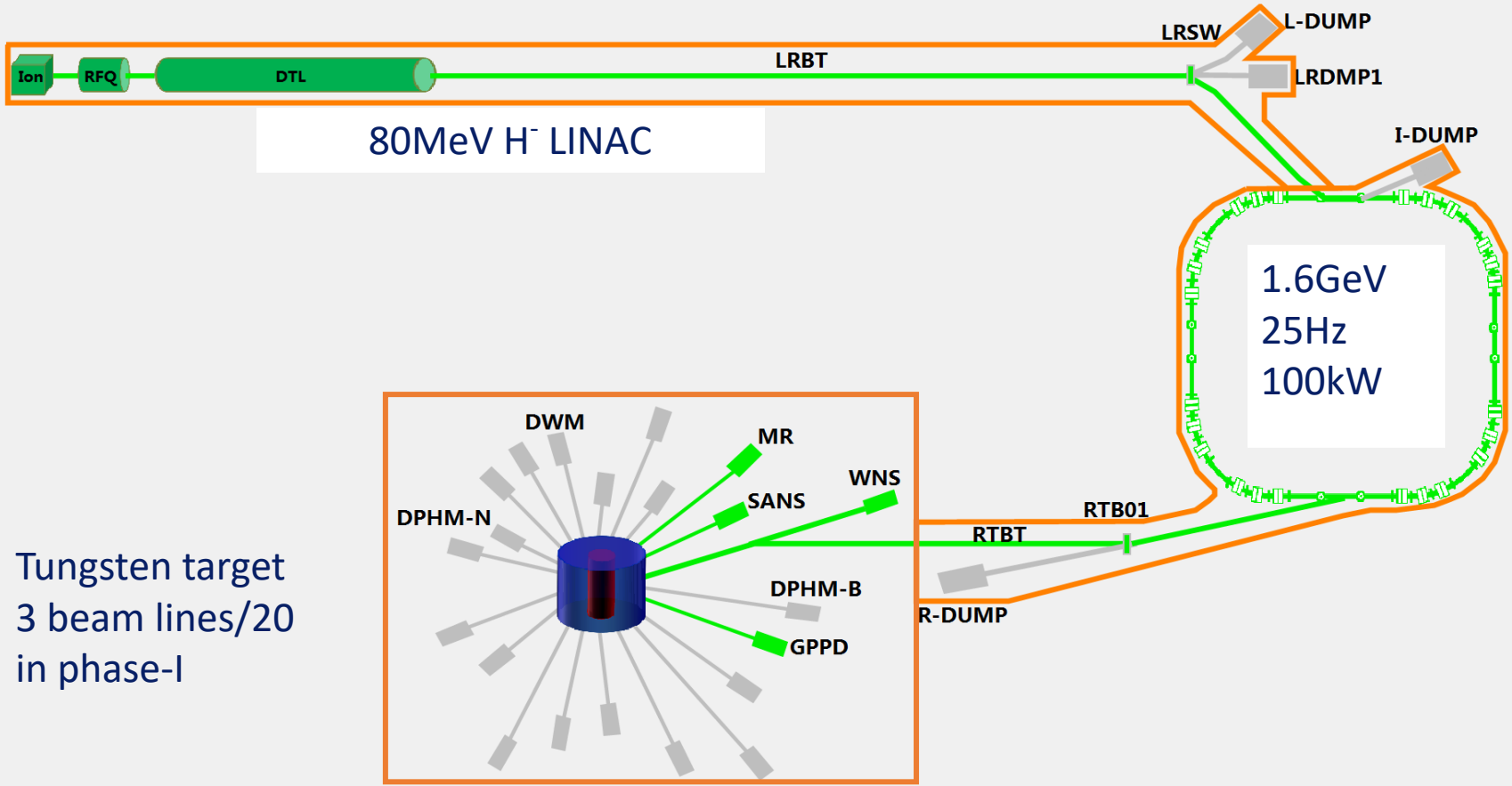
1 Brief Introduction of CSNS Protection Systems

2 Design and Deployment of Fast Protection System

3 Logic of the Beam Interlock and Mitigation Measures

4 Summary

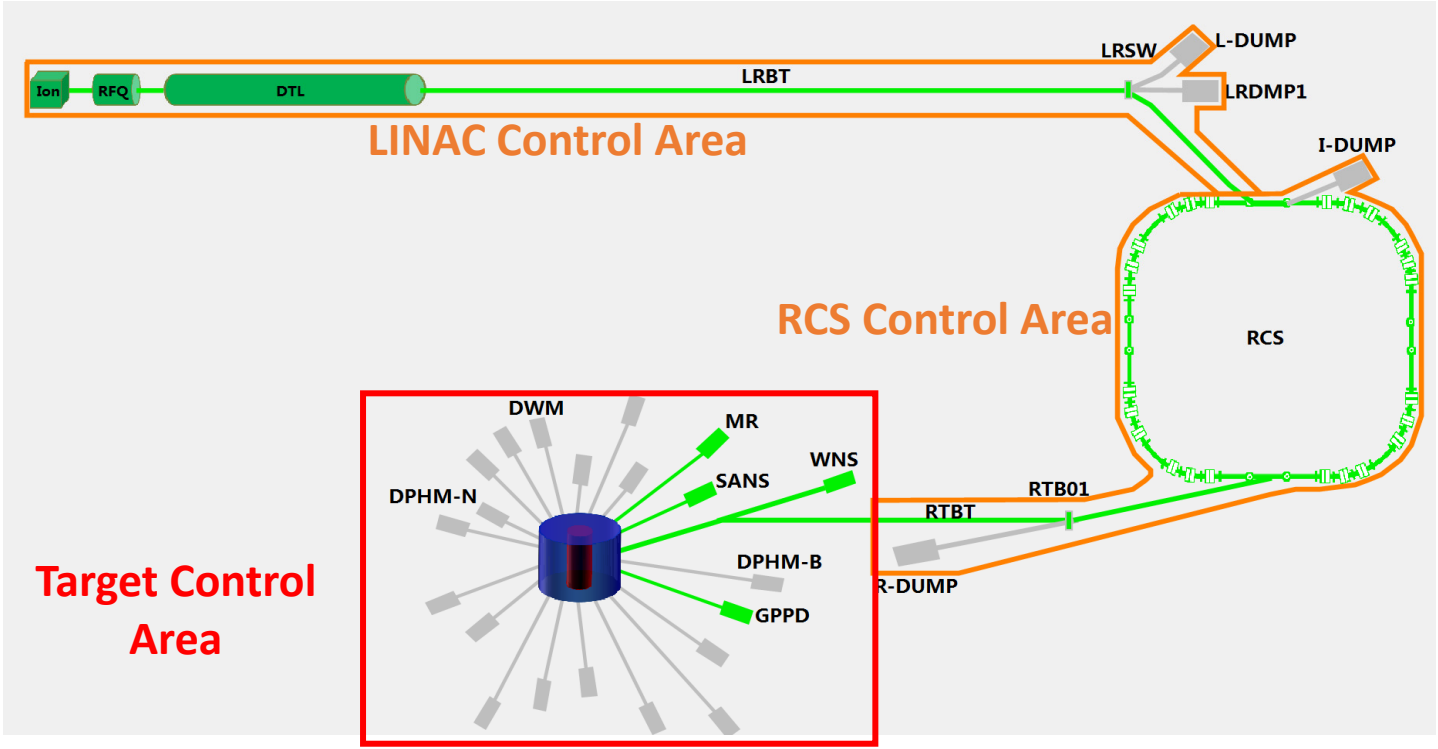
Brief Introduction of CSNS



Tungsten target
3 beam lines/20
in phase-I

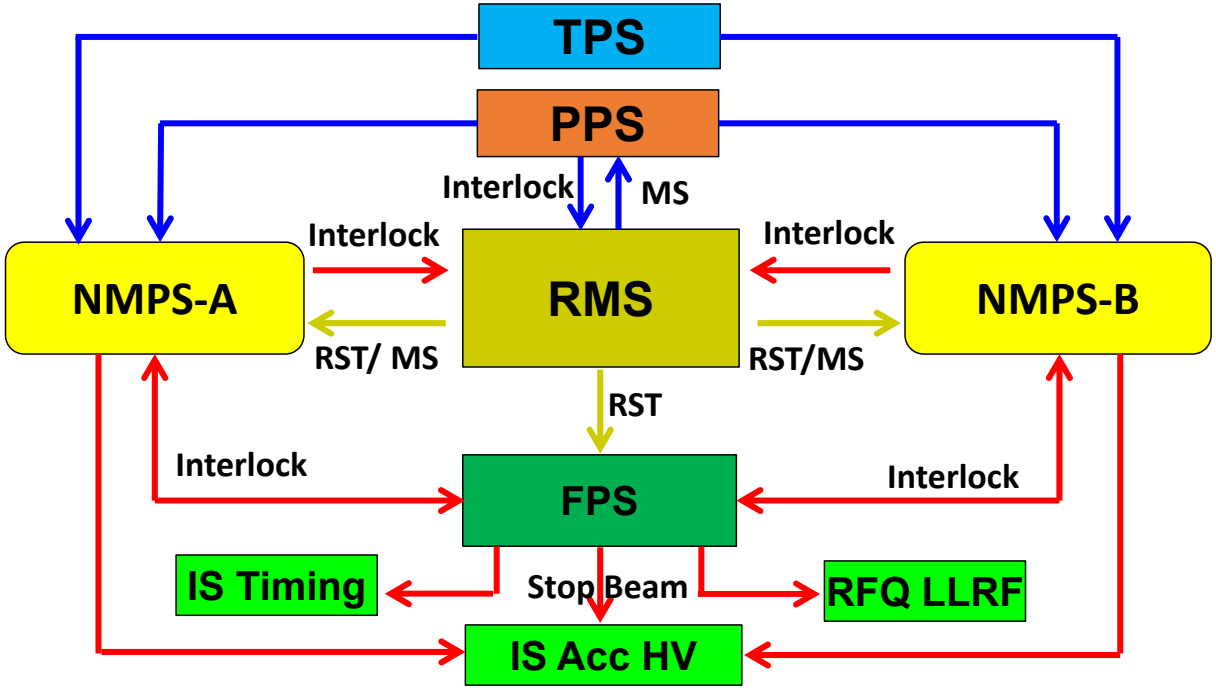
Brief Introduction of CSNS

- Three independent PPS control areas
- Five beam destinations, beam power limit is different for each destination



CSNS Protection Systems

- CSNS accelerator machine protection system consists of NMPS (PLC-based) and FPS (FPGA-based), Normal-MPS consists of two independent systems(NMPS-A and NMPS-B)
- Both NMPS and FPS use independent cable routes to interlock beam.



MS: Machine Status RMS: Run Management System

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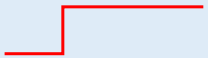
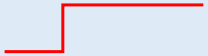
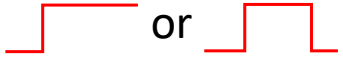
Requirements and Design Rules for FPS

- **Response time: <10μs (from receiving fault signal to switch off the H^- beam)**
- **Performing different actions according to the input signal's type**
- **All interfaces should be fail-safe or online real-time checked to make sure the reliability**
- **Interlock logic should be as simple as possible and developed with reliable tools**
- **Providing software mask for each input channel and friendly operator interface to check the status of the system.**

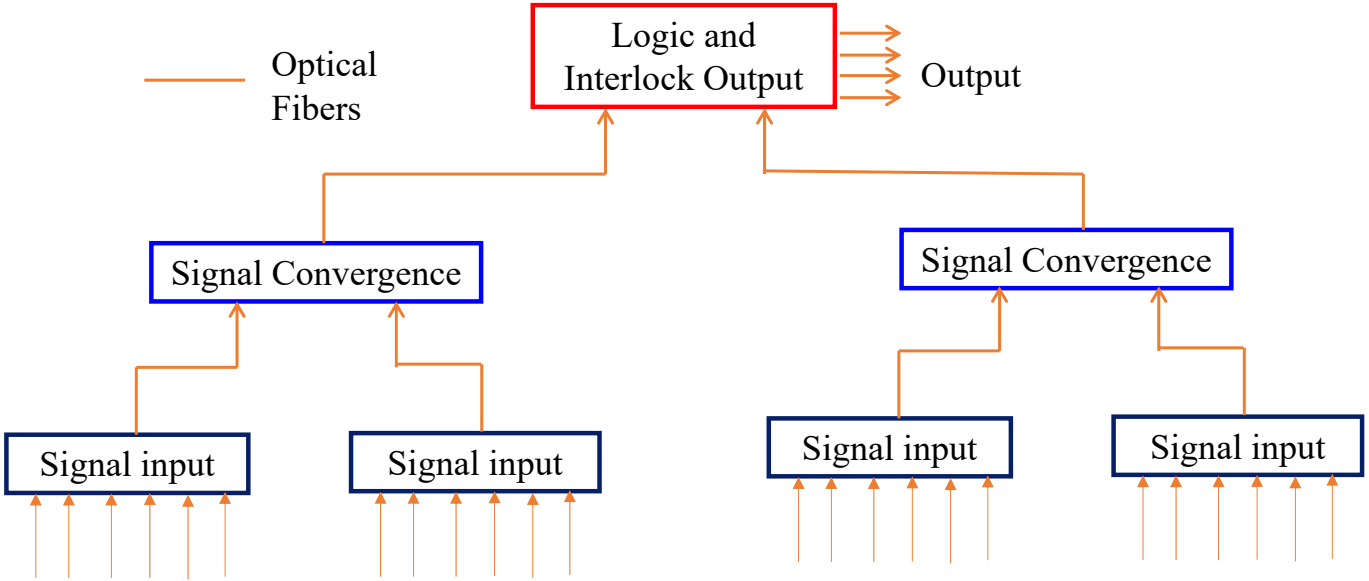
Input Signals Classification

- **All input signals can be masked or unmasked automatically based on the selected beam destination.**

Input Device Name	Number of Input Signals	Input Signal Type	Inhibit Beam Next N Cycle
LEBT Chopper Power Supply	1		
MEBT Power Supply	22		
DTL Power Supply	98		
Linac RF	8		√
Linac Beam Loss Monitor	40		√
RCS Beam Loss Monitor	85		√
RTBT Beam Loss Monitor	50		√
Total	304		

FPS Architecture

- **The tree topology was adopted by FPS, consists of three layers.**
- **All signals are transmitted through optical fibers.**



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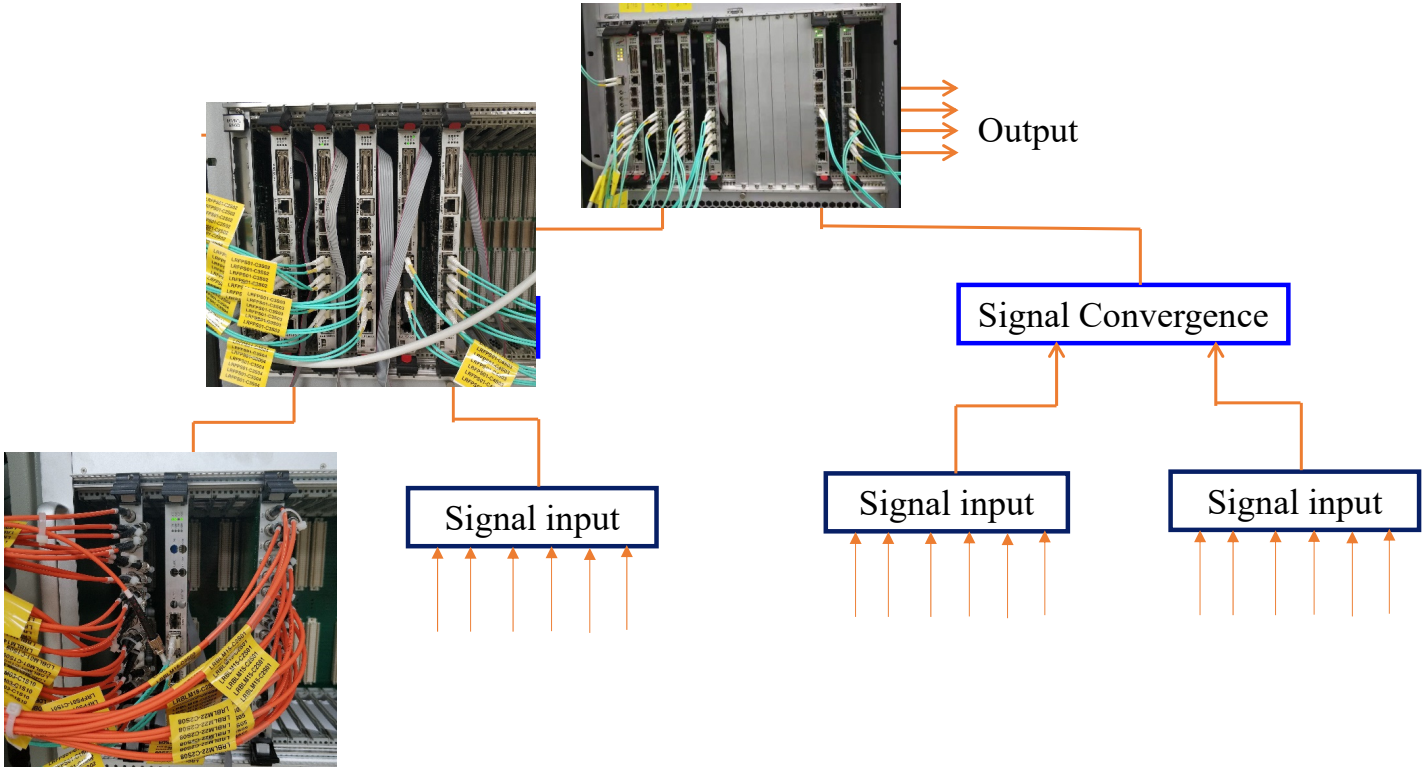
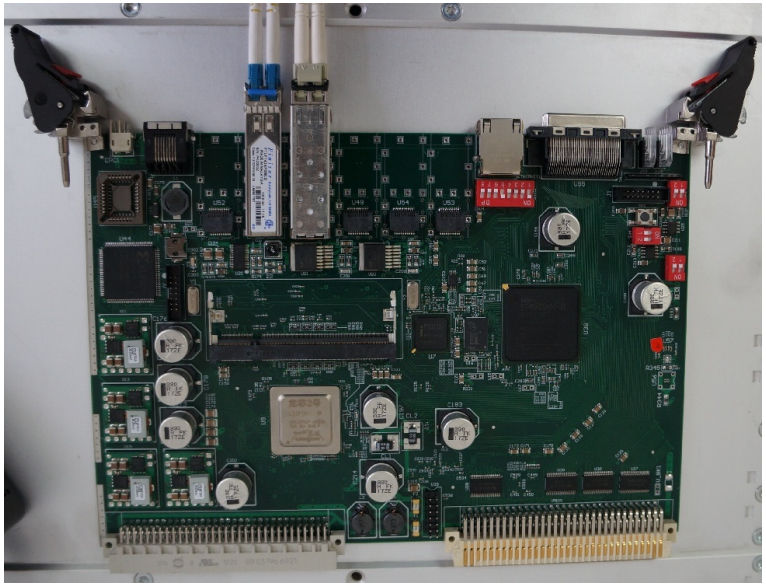
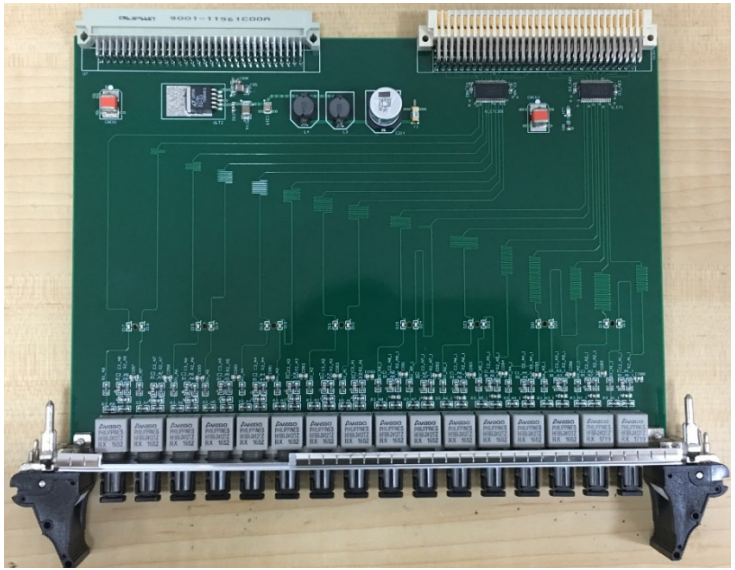


FPS Hardware

- **Main logic board: FPGA + Rocket I/O + 6U VME, with embedded EVR**
- **Optical signal input board: 6U VME**





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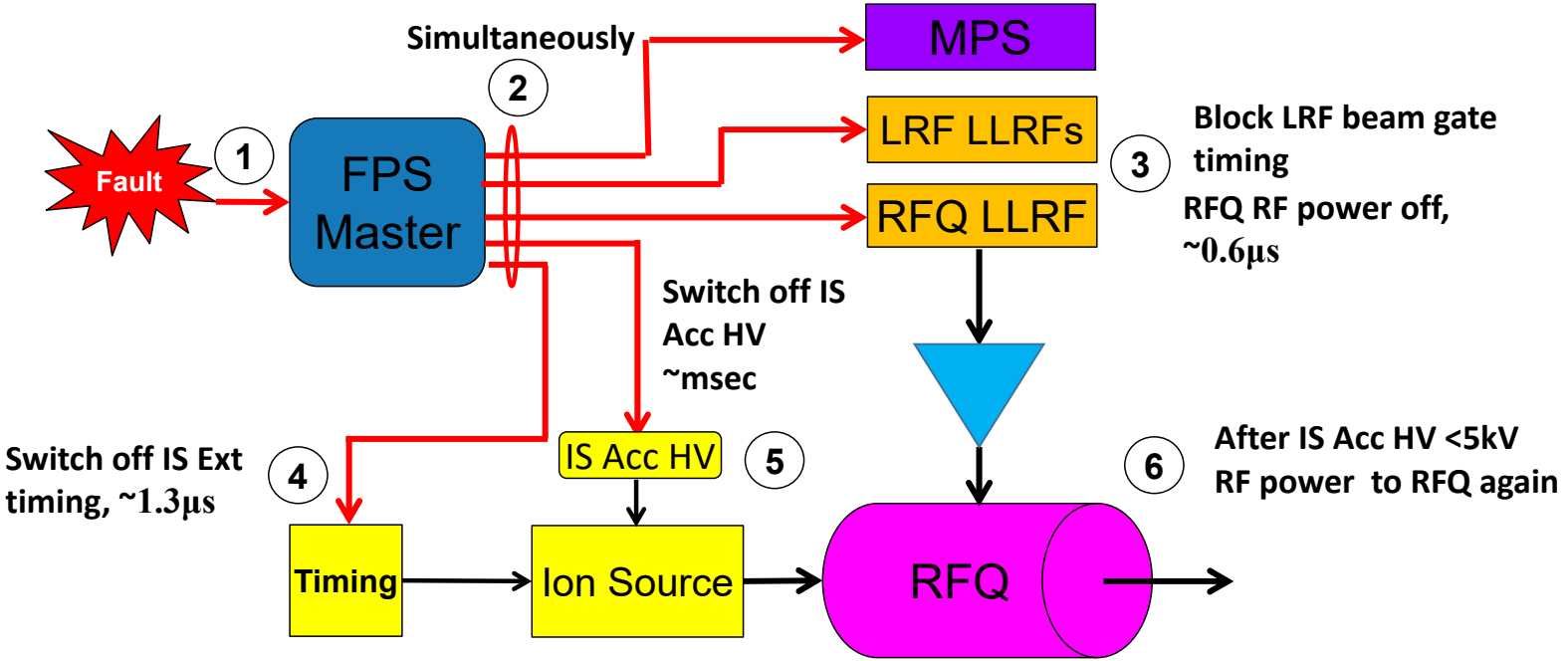
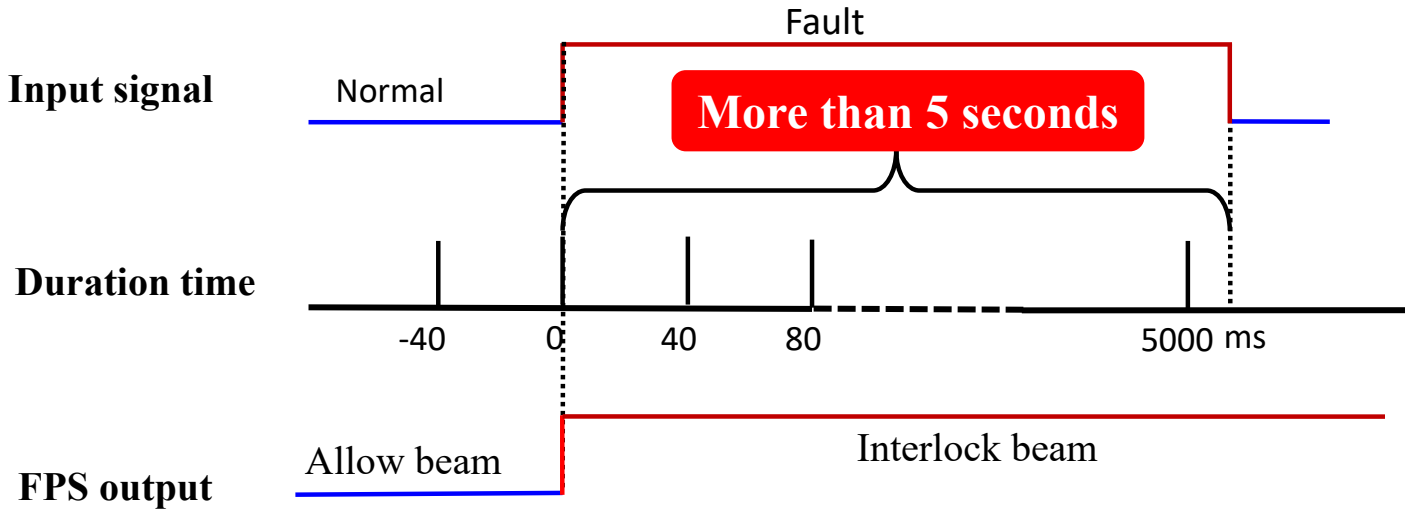
Actions of Shutdown of Beam

- **Case 1: Shutdown of the beam and sending interlock signal to RMS, accelerator will switch to BEAMOFF status, beam should be recovered manually.**



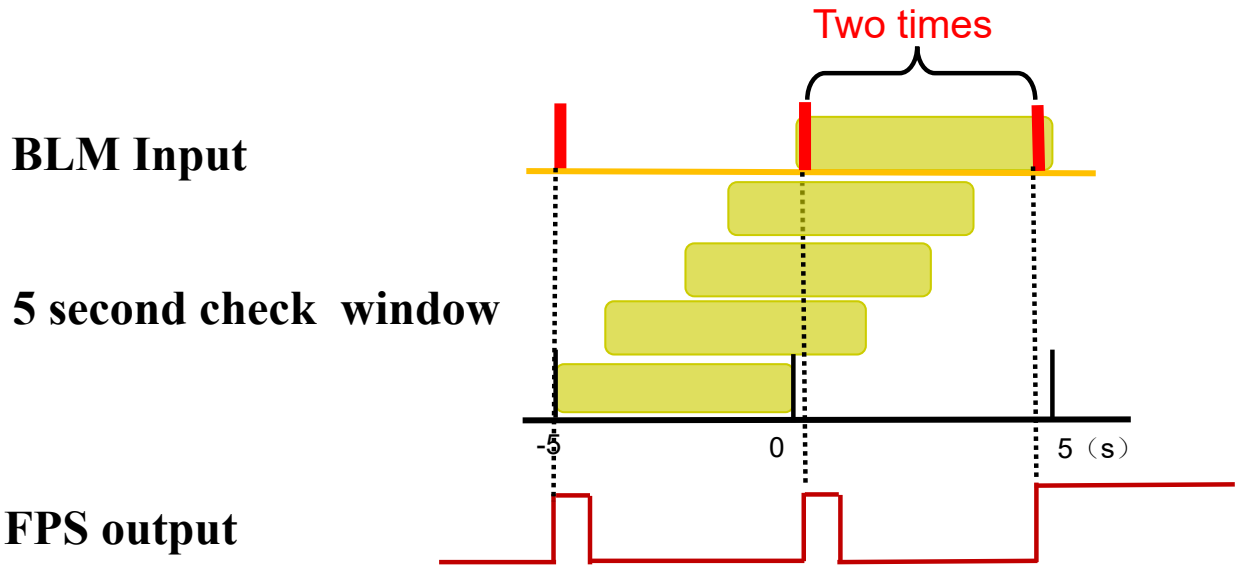
FPS Output for Shutdown of beam

- **When FPS receives a fault signal, the output switches to interlock beam immediately, if the during time of the fault input more than 5 seconds, the output will be locked to interlock status.**



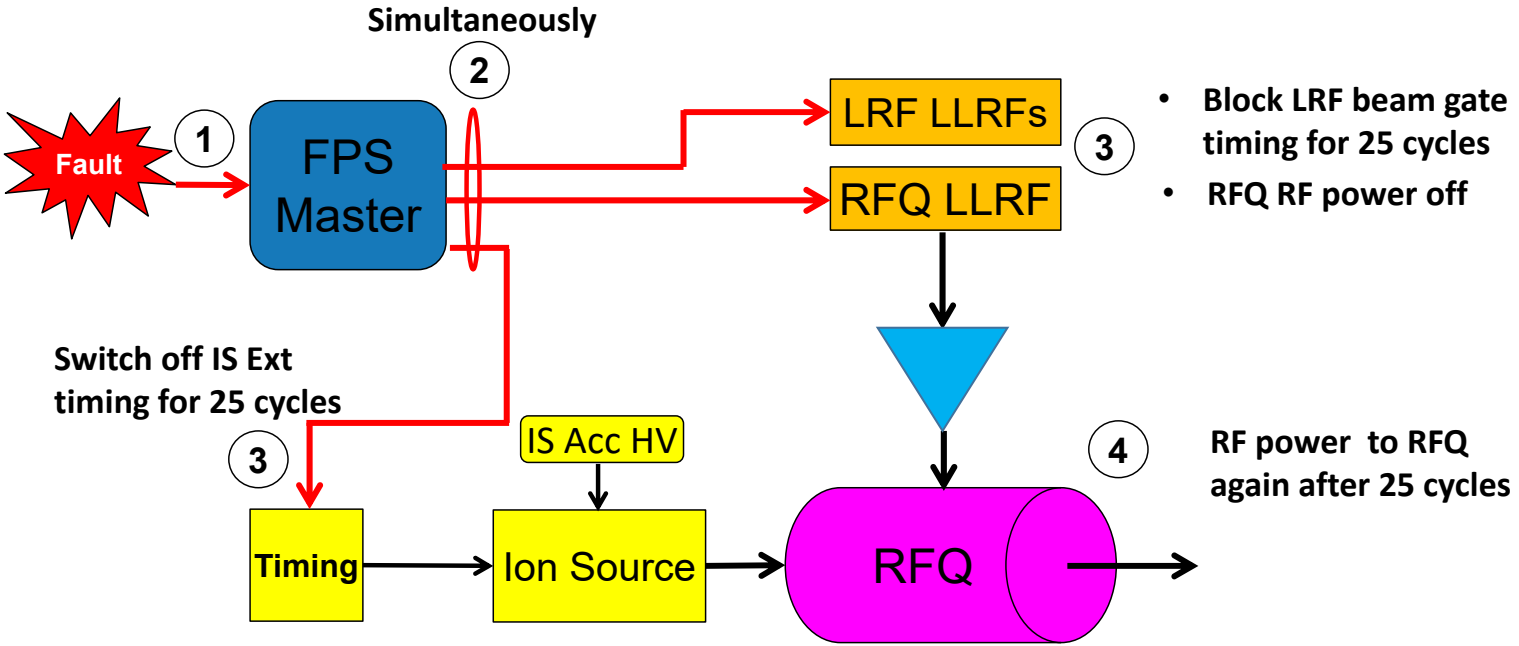
FPS Output for Shutdown of beam

- For the BLM input signal, the over threshold signal is pulsed type.
- If the input only has one pulse in 5 seconds, the mitigation measure will be carried out, if two pulses in 5 seconds, shut down the beam will be taken place.



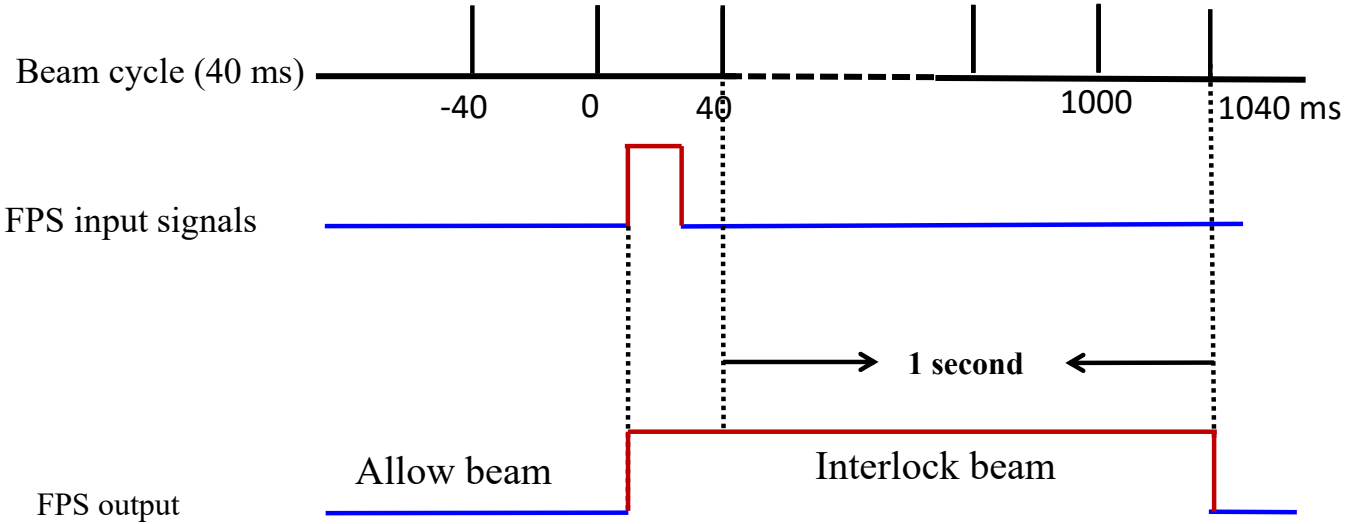
Actions of Mitigation

- **Case 2: Inhibit the beam for the next 25 cycles and beam will be recovered automatically**



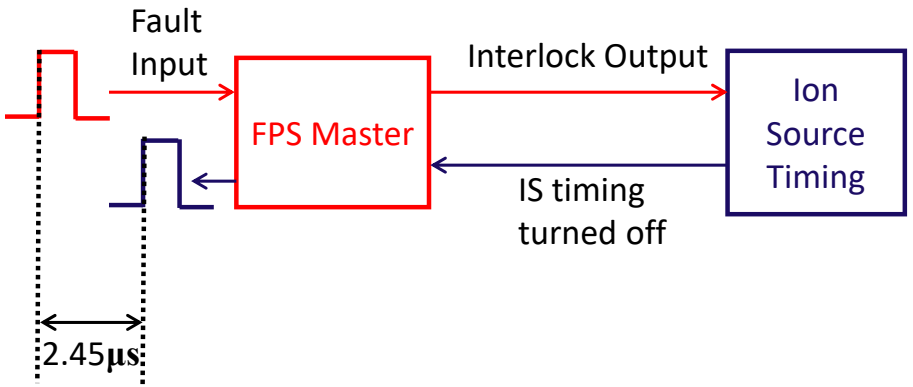
FPS Output for Mitigation

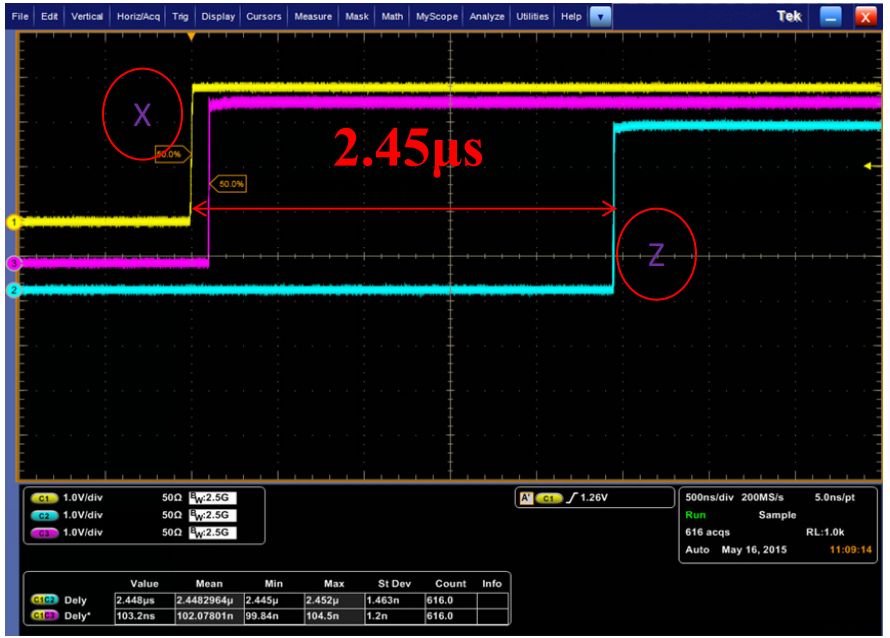
- **When FPS received a fault signal, the output switches to interlock beam immediately, if the during time of the fault less 1 repetition cycle, FPS will inhibit the beam for the next 25 cycles as a mitigation measure.**



Measured Response Time

- From the FPS master receives the fault signal, to the timing trigger for ion source is turned off, the time consumption is no more than 1.3µs





Summary

- **The fast protection system for CSNS accelerator has been put into operation for more than 3 year, the beam interlock logic has improved due to operation requirements.**
- **The response time is much less than the requirement, and different mitigation measures has designed and implemented.**
- **New hardware is under design and will be upgraded in the CSNS-II project.**

Thank you for your attention!