Upgrade of the Control and Interlock Systems for the Magnet Power Supplies in T2K Primary Beamline

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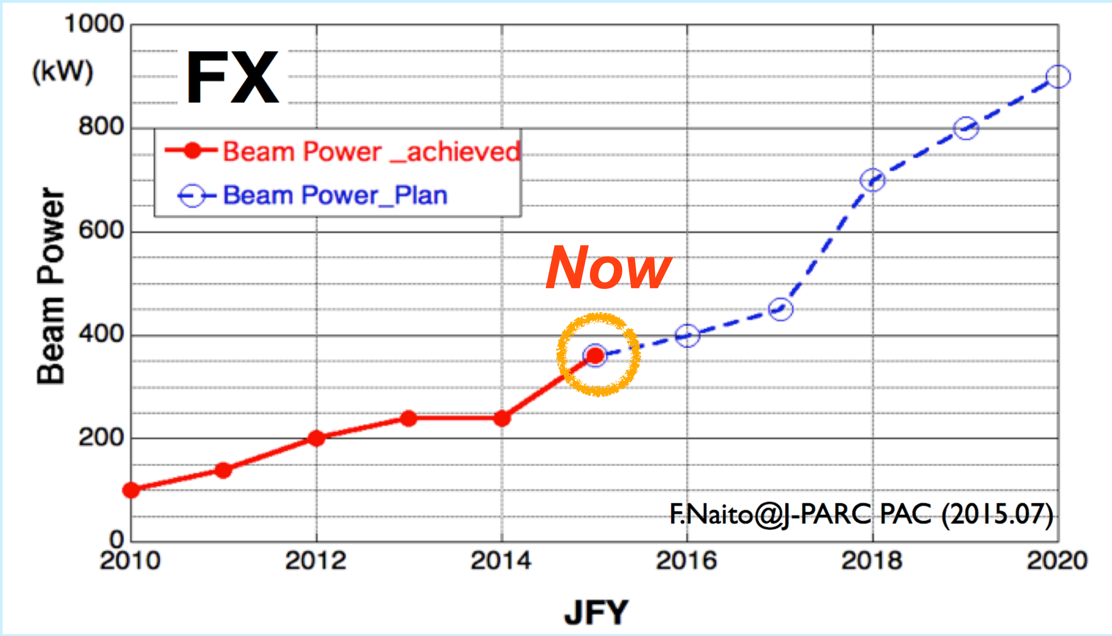
Abstract T2K is a long-baseline neutrino oscillation experiment at J-PARC in Japan. High intensity neutrino/antineutrino beam is generated at J-PARC, and propagates 295km to Super-Kamiokande. High intensity proton beam is extracted from Main Ring (MR) synchrotron, and guided through primary proton beamline to a graphite target using normal-conducting (NC) magnets and super-conducting magnets. The power supplies (PSs) of the NC magnets were made mostly in 80's and needed increasing effort for maintenance. In summer 2014 we replaced all of the old PSs for NC magnets. We also developed a new control system based on EPICS and PLCs, putting emphasis on the safe operation of PSs, and integrated it into the existing interlock system. We also report the actual implementation of these developments.

Motivation

We control the *high intensity proton beam of 2x10^{14} ppp* at primary beamline.



Beam power upgrade plan at J-PARC MR

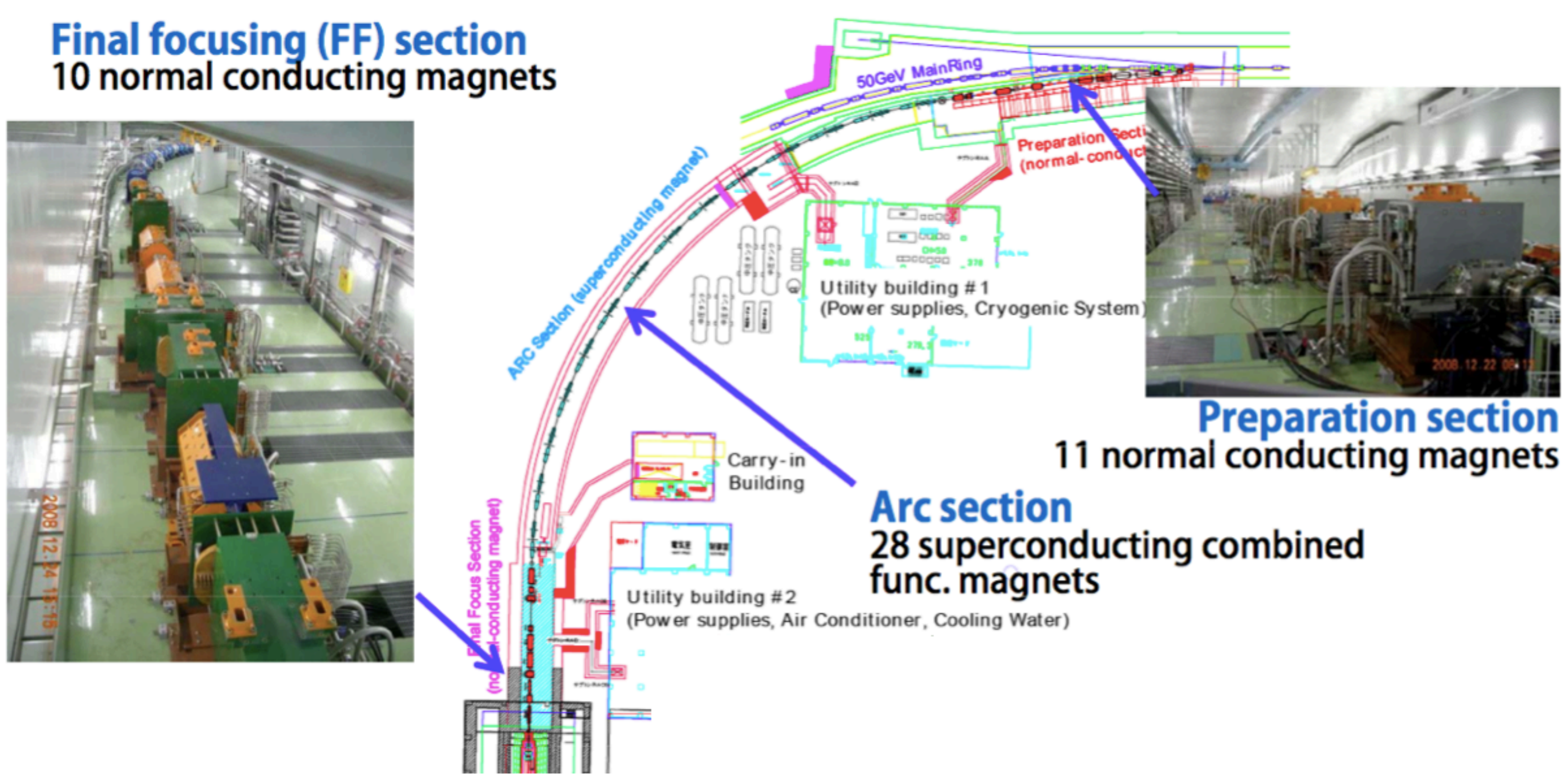
A SINGLE FAILURE SHOT

Serious damage for beamline

In 2012, we have developed the interlock system to protect beamline equipments from high intensity beam by monitoring the output current of NC PSs. However the latency time was large due to large ripple of the old PSs. Toward the high intensity beam operation, we newly

- ***Developed new PSs with PLC/EPICS control system***
- ***Improved the interlock system***

T2K Primary Beamline

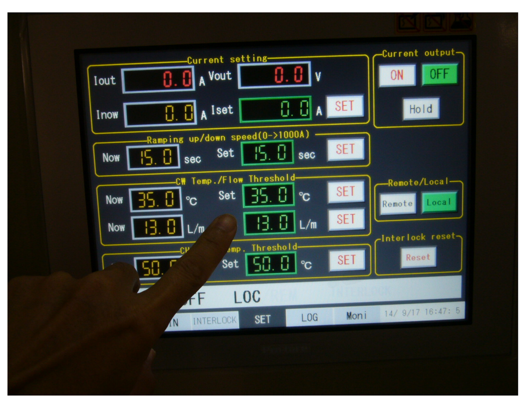


New PSs for NC Magnets

We developed five types of PSs. We installed them to the primary beamline in summer 2014. Each PS has two DCCTs, one is for feedback control and the other is current monitoring for interlock. The current stability of new PSs is superior to old ones.

Magnet type	DC OUT (A) / (V)	Converter type	Current stability(A)	Unit
Dipole	1500 / 100	chopper	0.1	4
Quadrupole	1000 / 100	chopper	0.1	9
Steering I	± 400 / ± 40	chopper	0.05	1
Steering II	± 200 / ± 20	switching	0.05	2
Steering III	± 100 / ± 10	switching	0.05	5
			Total	21

Spec. of new NC PSs



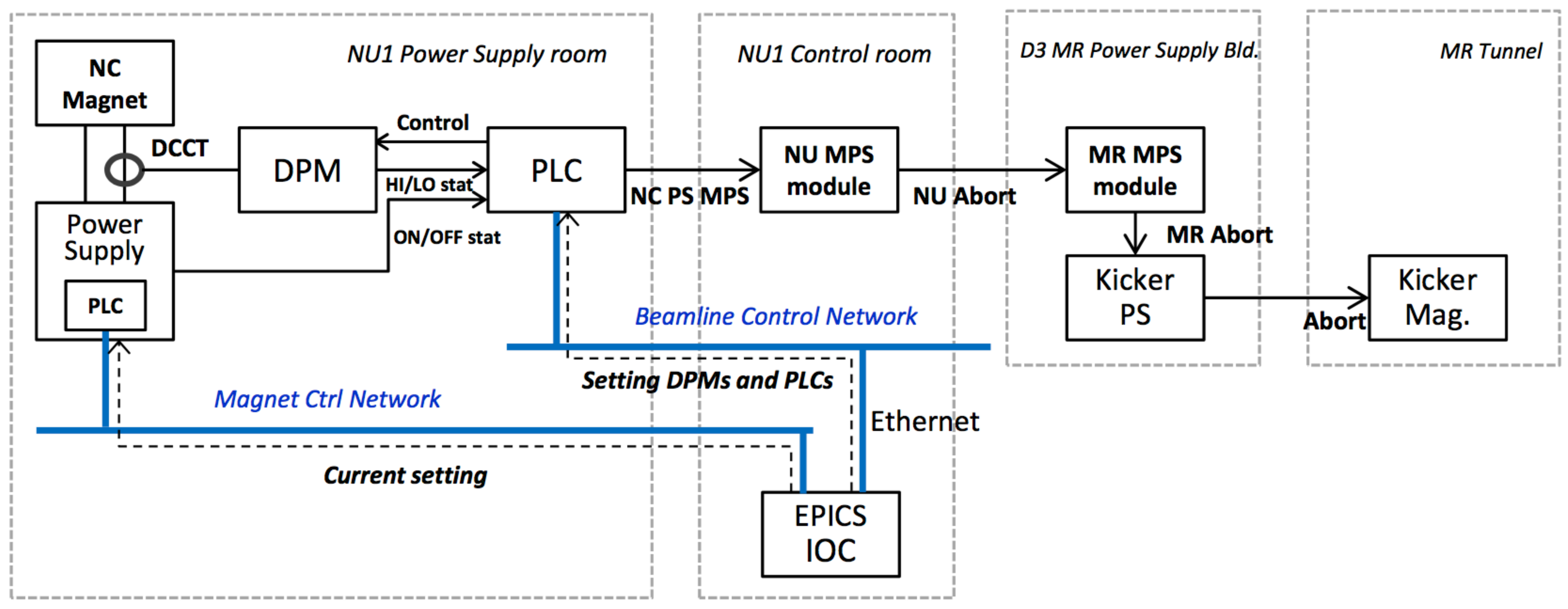
LCD touch panel

New NC PSs

PS of Dipole

4 steerings in a rack

Upgraded Control System for PSs



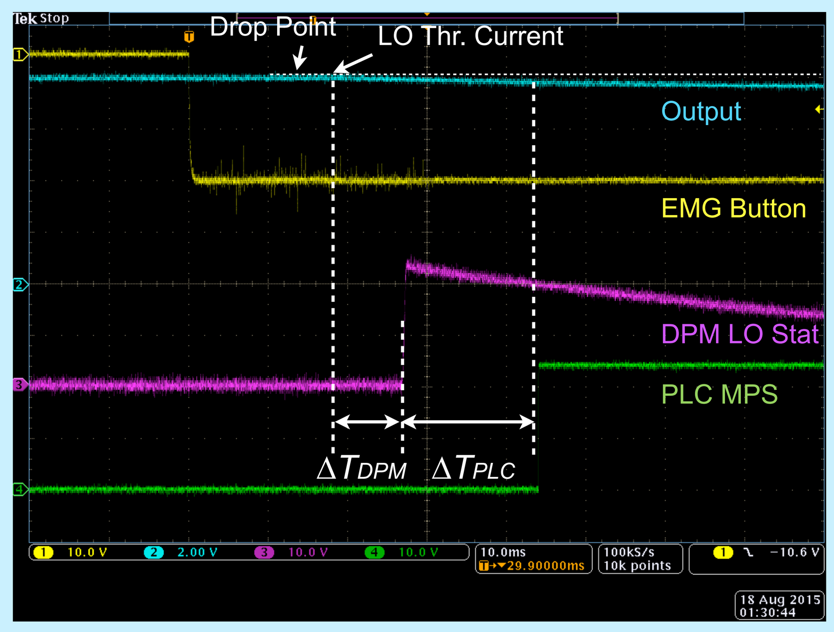
A schematic of control and interlock system for new PSs

The most important concept of the control system for new PSs is operational safety improvements. In the case of new PSs, each PS has PLCs which communicate with an EPICS IOC over Ethernet. We integrated new PSs into present DPM(Digital Panel meter) interlock system.

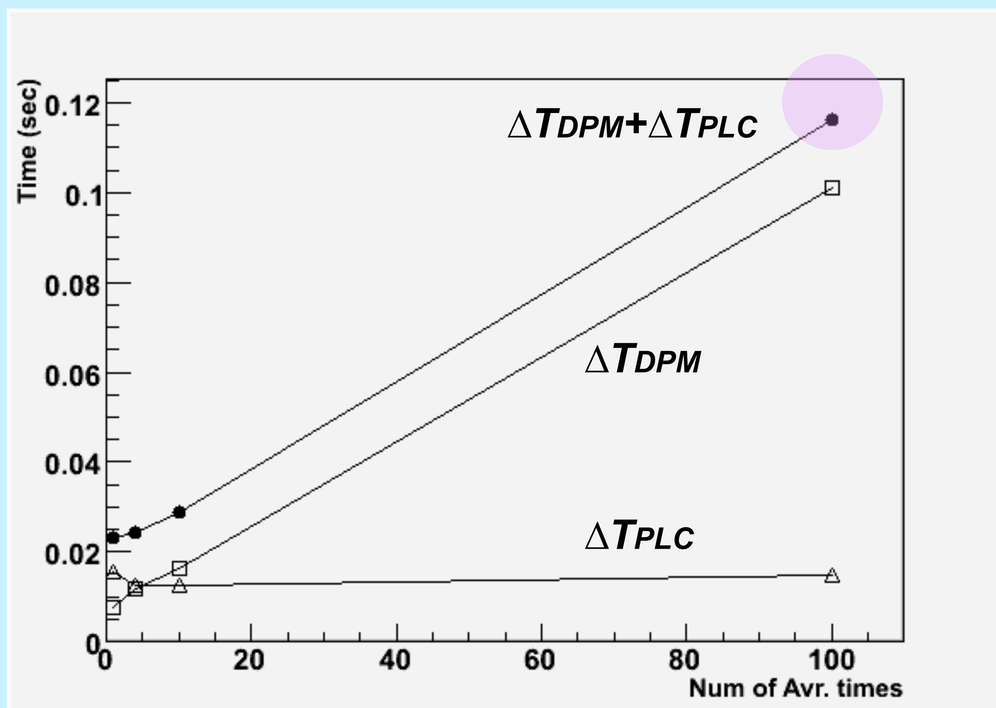
Improvement in Interlock Latency

Interlock Latency Measurement

We have measured the interlock latency time of DPM and PLC using a digital oscilloscope. ΔT_{DPM} and ΔT_{PLC} is defined as right.



Old PSs and the Latency

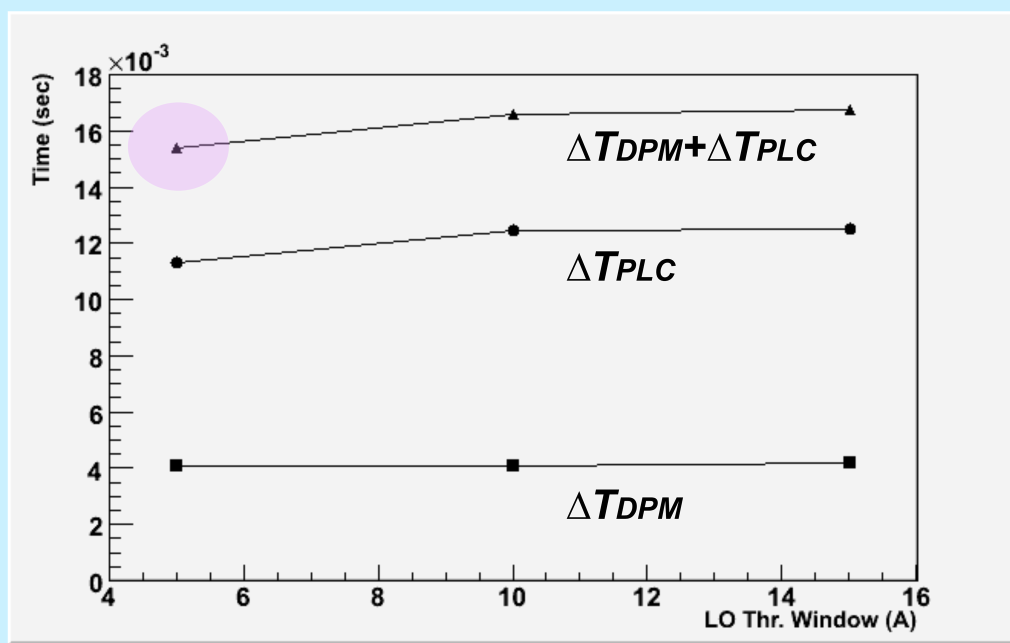


Latency time vs. DMP averaging times in old PS

We measured the latency time of DPM and PLC for old PS by changing the number of averaging times at the DPM. We operated the DPMs with 100-times averaging due to large output current ripple.

It resulted in the latency time of about 120ms.

New PSs and the Latency



Latency time vs. LO Thr. current in new PS

We measured the latency time using a new PS for dipoles by changing the LO threshold value at the DPM. In this case, no averaging was done on DPM due to small ripple. The latency time T_{PLC} was ~15.5ms. T_{DPM} was ~4ms.

Interlock Latency time

~120ms → ~15.5ms

Additional latency time from PLC to Kicker magnet was ~0.07ms. We have drastically reduced latency time of the interlock system of NC PSs. It reduces the risk for damage of beamline equipments by high intensity beams.

SUMMARY

We have developed the new NC PSs with a company and replaced all of the old ones by new ones in summer 2014. Also we upgraded the control system for NC PSs using EPICS and PLCs. We integrated the new PSs to the present interlock system for current fluctuation. The latency time of the interlock system was drastically reduced.