12th MicroTCA Workshop for Industry and Research

#### Status of MTCA at J-PARC in 2023

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### Japan Proton Accelerator Research Complex (J-PARC)



J-PARC Consists of 400 MeV linac, 3 GeV RCS, 30 GeV Main Ring, and experimental facilities (MLF, Hadron, Neutrino).

· It benefits from MTCA in these years

### MTCA applications in J-PARC



### MTCA LLRF are operated stably









Run# 91	Shot# 28952	8 23/11/3	0 19:03:02	DCCT#1
RCStoMR DCCT@K1 DCCT@K2 DCCT@K3 DCCT@K4 DCCT@P2 DCCT@BE	4.42e+13 4.33e+13 8.72e+13 1.30e+14 1.72e+14 1.72e+14 1.72e+14	MR Injection Nb= Bwidth= Thin Ratio= MR Cycle= Macro Puls RCS.EXT.KI	an Candition m 59,8 mA 399 ns 24 /32 1360 ms icker 0	10 average top 4,33e+13 8,72e+13 1,30e+14 1,72e+14
MR@K2/RCS K3/K2 P2/K2 P2/K3 BE/K2 BE/P2	1.972 1.494 1.973 1.321 1.973 1.973 1.000	Bea K1loss ( K2loss ( K3loss 8 K4loss 2 Iloss/Wattl	im loss(ppp) 0.00e+00 0.00e+00 3.26e+10 2.54e+11	10 average data Be am lossipppi 0,00e+00 1.53e+11 3.70e+11
$\begin{array}{l l l l l l l l l l l l l l l l l l l $				184 5.23e+11
MR Power 608.19 kW				
Scheduled Timing				
P0 P1 187m9 197 0 10	K4 P2 317 327 130 140	BE P3 977 977 790 790	978 m9 791	Change DCCT Range
-10 0	120 130	780 780	781	

MR output beam power reached to 610 kW for neutrino experiment.

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# Beam Longitudinal Diagnostics via Oscilloscope

- In J-PARC MR, oscilloscopes are used to record beam pickup signal for longitudinal diag.
  - Multiple scopes are needed to cover various ranges of time frames to be recorded
  - Takes long time to obtain the waveform from scopes to PC and analyze them.
- Digitizer with long memory and high-speed data transfer is desired -> MTCA based digitizer



Pickup signal recorded every 1ms (for whole acceleration cycle)





# MTCA based digitizer for J-PARC MR

- TeledyneSP ADQ14 +Vadatech VT816
- Demonstrated the recording of RF waveform slices for whole acc. cycle. (2500 sample x 150k slice / turn)
- · Beam measurement is under preparation.





Timestamp of slices[ms]



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### Upgrade of intra-bunch feedback for MR



Due to resistive wall impedance, instability occurs at high intensity.

- Bunch motion is different for each of eight bunches
- Countermeasure: chromaticity setting and intra-bunch feedback
- Upgrade project of intra-bunch feedback system ongoing

### Function of intra-bunch feedback



Bunch length:  $\sim 100$  ns. Requires high-speed ADC/DAC and logic  $\rightarrow$  RFSoC is considered.

### Implementation of the FB is ongoing



Medstec (Mitsubishi Defense and Space Tech.) MME-TRX01-B (3EM50084-G01)

#### Xilinx UltraScale+ RFSoC XCZU27DR 8 ADC(4GS/s), 8 DAC (6.4GS/s) 4 GB memory



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### J-PARC timing system:



J-PARC employed a dedicated timing system (not WR or MRF).

- It is a kind of event timing system
- · Functionality is optimized for synchrotron

F. Tamura, H. Takahashi, N. Kamikubota, Y. Ito and N. Hayashi, "Development of Next-Generation Timing System for the Japan Proton Accelerator Research Complex," in IEEE Transactions on Nuclear Science, vol. 68, no. 8, pp. 2043-2050, Aug. 2021, doi: 10.1109/TNS.2021.3083791.

### J-PARC timing system:

#### Existing modules:



Form factor of existing transmitter/receiver modules: VME and PLC.

Project for development of MTCA timing receiver module has been just started.

### Summary

Applications of MTCA at J-PARC slowly but steadily increase.

• LLRF control systems for linac and synchrtrons are operated stably

New applications:

- COTS MTCA digitizer for MR
- Intra-bunch feedback system
- Timing system (project just started)

and...

### Please visit the booth of Japanese exhibitors!





Full-featured MTCA.4 shelf w/ RF backplane

(From my 2020 talk)

## MITSUBISHI ELECTRIC DEFENSE AND SPACE TECHNOLOGIES CORPORATION

