PO13

The Beam Diagnostic System in the J-PARC 3 GeV Rapid Cycling Synchrotron

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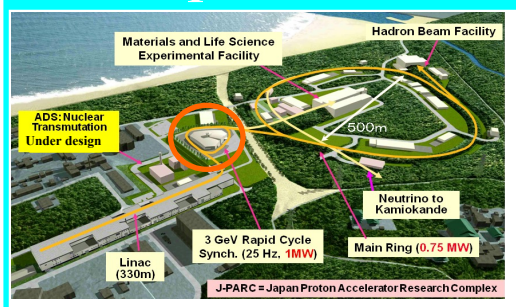
Intro

- The J-PARC 3-GeV Rapid Cycling Synchrotron (RCS) aims to deliver 1 MW proton beam to the materials and life science experimental facility (MLF) and the main ring synchrotron.
- In such a high intensity beam , there is a possibility to cause a severe radiation accident.
- To detect and prevent the radiation accident in the accelerator system, we developed the beam diagnostics system in RCS.

RCS operational status



J-PARC

Consist of 3 accelerators: Linac, **RCS** and Main Ring.

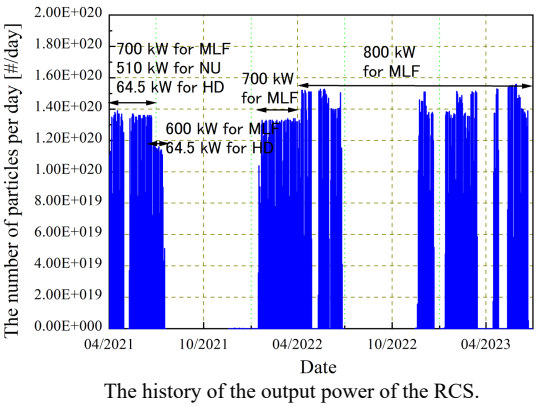
So far, the beam loss **does not** limit the beam power.
We have increased the beam power at a rate of 100 kW/year to check the status of the neutron target.

Beam power

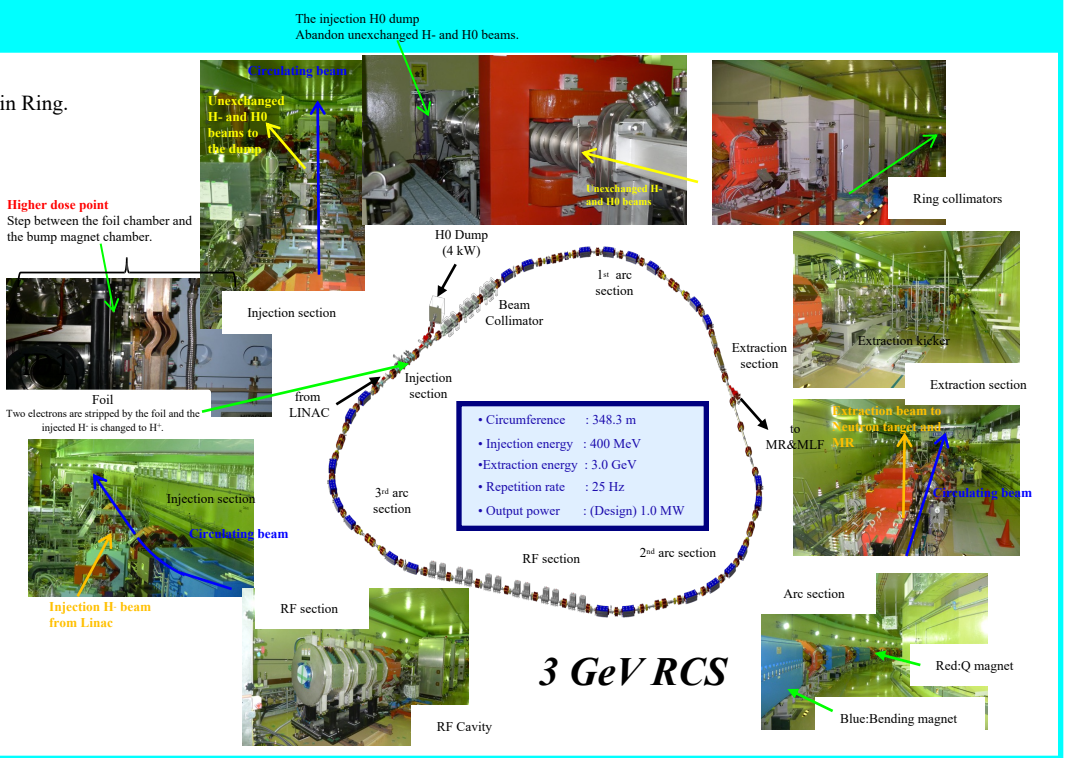
The output power delivered to the MLF had been 700 kW in April 2021.
We reduced the beam power to 600 kW from the end of June to the middle of July thanks to degradation of the cooling water system.
It was increased to 800 kW in April 2022, and kept it up to now.

Higher dose point

The charge-exchange foil chamber ~10 mSv/h after 4-hour cooling with 800 kW beam operation.

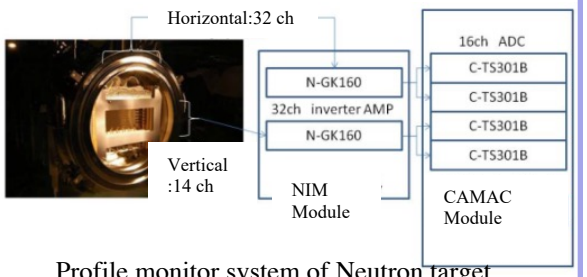


The history of the output power of the RCS.



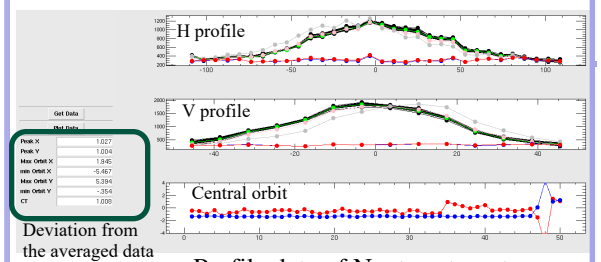
Diagnostic System

Real time monitoring of the beam profile on the neutron target



Profile monitor system of Neutron target.

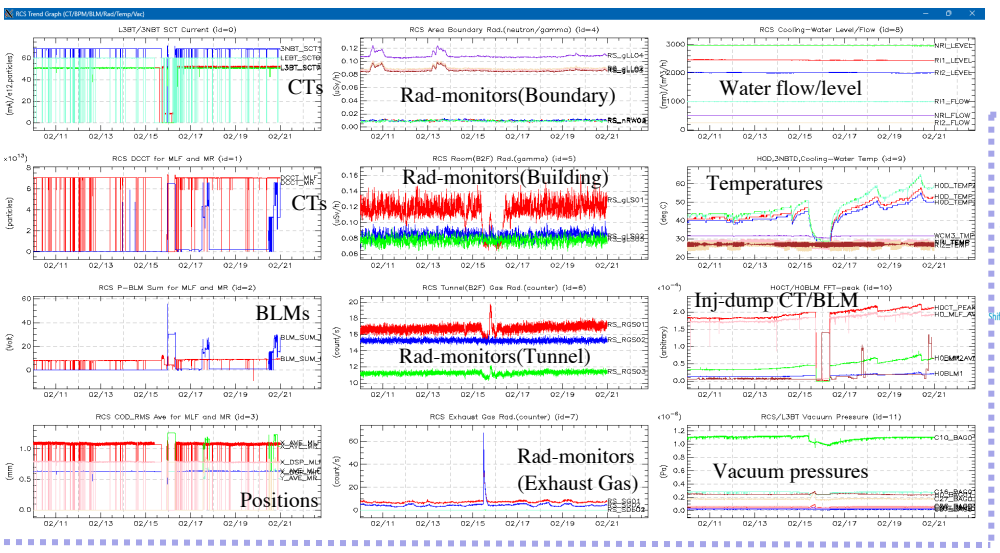
This system can store the profile data up to 50 shots before the beam stop trigger as an EPICS record.



Profile data of Neutron target.

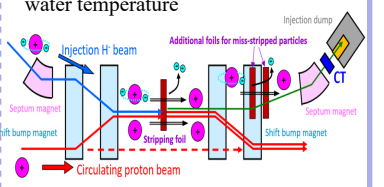
In this case, the horizontal central orbit was gradually moved. Finally, deviation of the orbit became quite large and beam loss occurred.

Trend monitor of various accelerator parameter

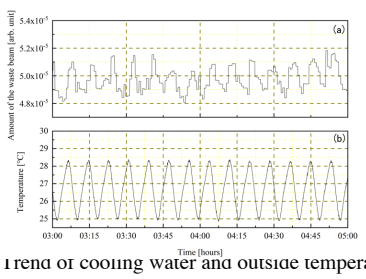


Various kind of parameters, such as dump temperatures, beam currents, beam losses, radiation monitors, beam positions etc. can be checked by one screen to compare the influence each other.

Example : relationship of charge-exchange efficiency and cooling water temperature



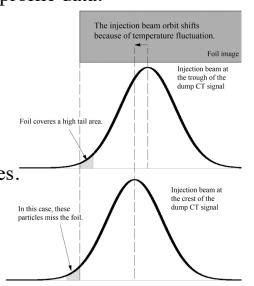
J-PARC RCS adopts the charge-exchange injection scheme. Un-stripped H^0 and H^- are dumped to the injection dump.

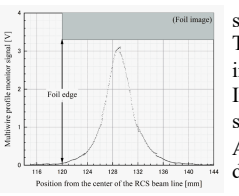


Trend of cooling water and outside temperatures.

We found that the oscillations of the charge-exchange efficiency and cooling water temperature were synchronized.

We evaluated the displacement of the injection point from fluctuation of the dump CT value and profile data.





By using the real profile data and CT values, we obtain the displacement on the injection foil. (0.072 mm)

The temperature fluctuations induce a change in the height of the magnet gap, which results a change in the magnetic field strength of the dipole magnets and shift of the injection beam orbit.
This effect result in a 0.072 mm displacement of the injection point.
In fact, this injection efficiency fluctuation is quite small, and it does not affect the user operation.
All the CTs and BPM in the RCS and BT line cannot detect such small signal fluctuations.

More Detail :
K. Yamamoto *et al.* Dependence of charge-exchange efficiency on cooling water temperature of a beam transport line. *EPJ Techn Instrum* **8**, 9 (2021). https://doi.org/10.1140/epjti/s40485-021-00067-6

Conclusion

- The J-PARC RCS is almost continuing stable user operation with 800-kW beam.
- We developed a real time monitoring system for the beam profile on the neutron target. This system enables monitoring and fast interlock when an abnormal state of the extraction beam was detected.
- Various kind of parameters, such as dump temperatures, beam currents, beam losses, radiation monitors, beam positions etc. can be checked by one screen to compare the influence each other.
- By using this system, we found one interesting phenomenon that the oscillations of the charge-exchange efficiency and cooling water temperature were synchronized. Based on the amount of the particles that failed in the injection and beam profile at the injection point, we evaluated the displacement of the injection beam to be 0.072 mm in total. This value is smaller than the dynamic range of the conventional monitors. This new system enables to find such small variations.