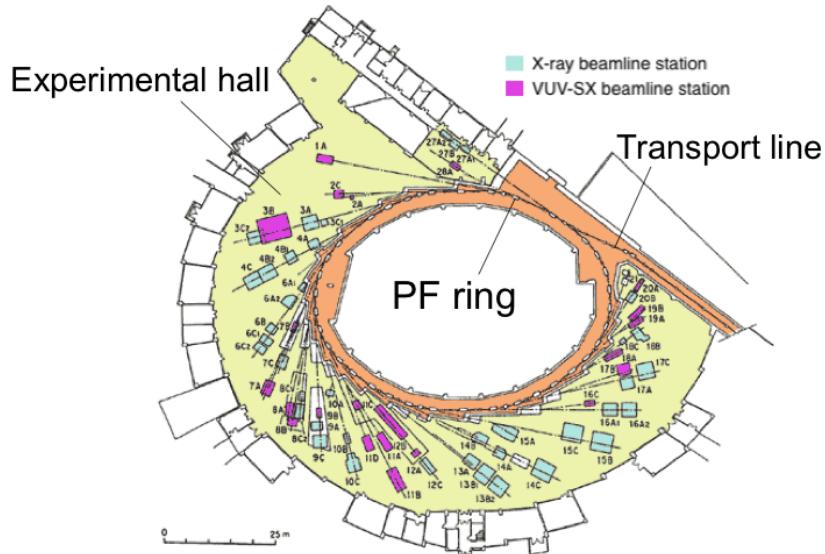


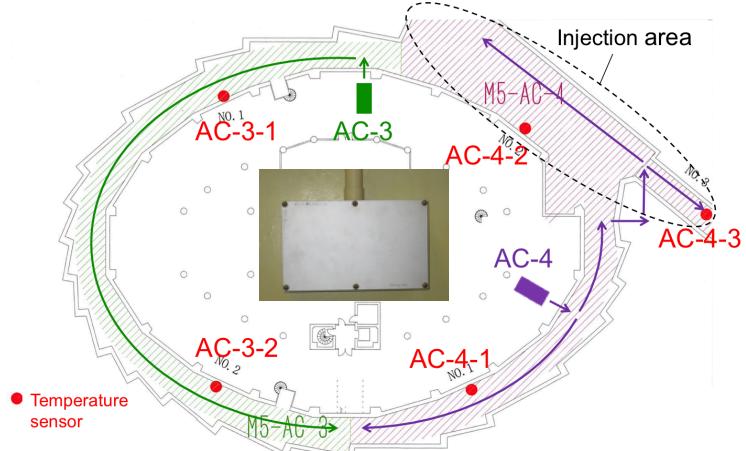
Study of PF-ring Infrastructure Improvements Using Temperature Measurements in the Ring Tunnel

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PF-ring Building & Infrastructure



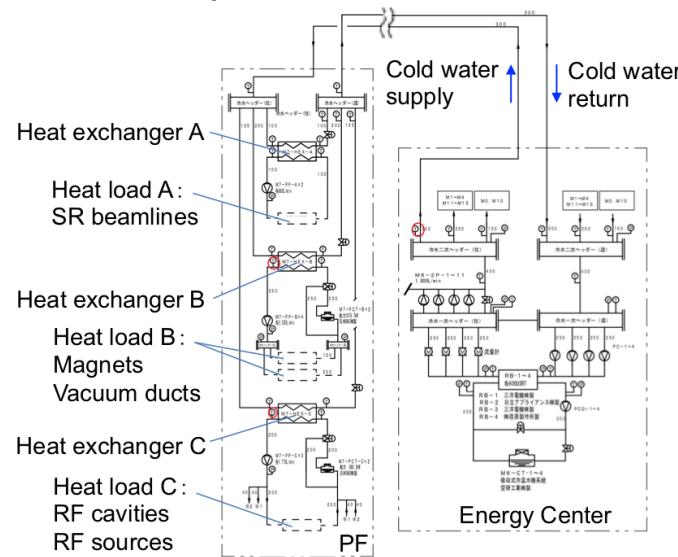
Layout of PF-ring and SR beamlines in the PF Light Source Building.



Air-conditioners AC-3 and AC-4 and their airflows with five temperature sensors.



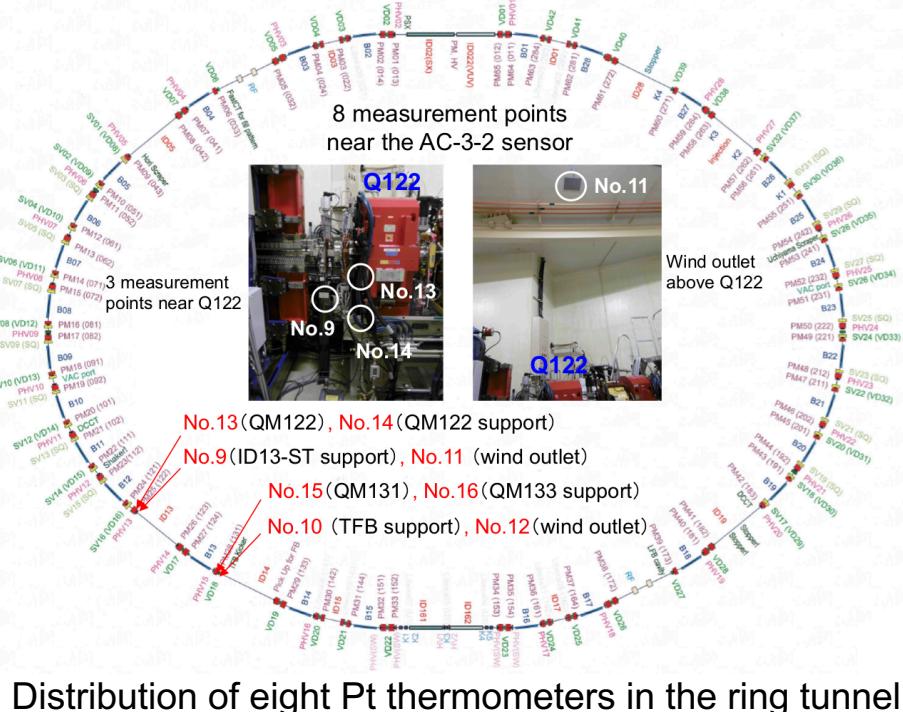
PF Building with the white thermal insulator on the roof.
A red frame part has no thermal insulator for a carry-in route.



Schematic view of the cooling-water system(left) and the plate heat exchanger (right) for the PF ring.

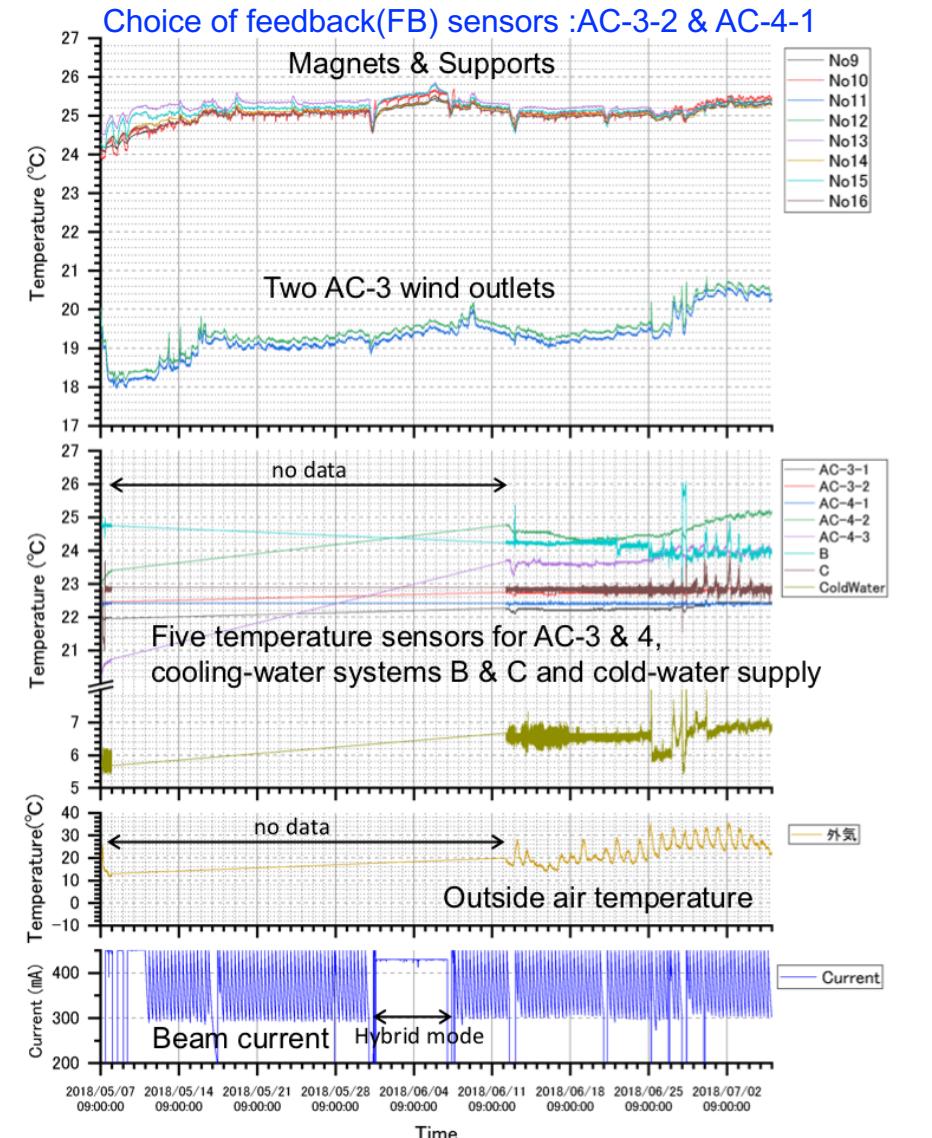
Temperature Measurement in May – July 2018

We started systematic temperature measurements in the ring tunnel from 2018 for the PF upgrade project.

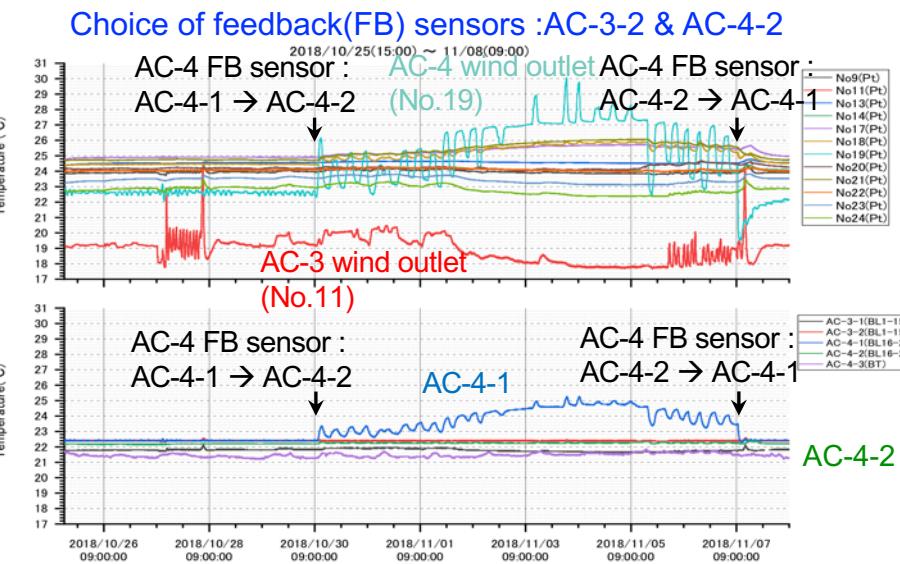
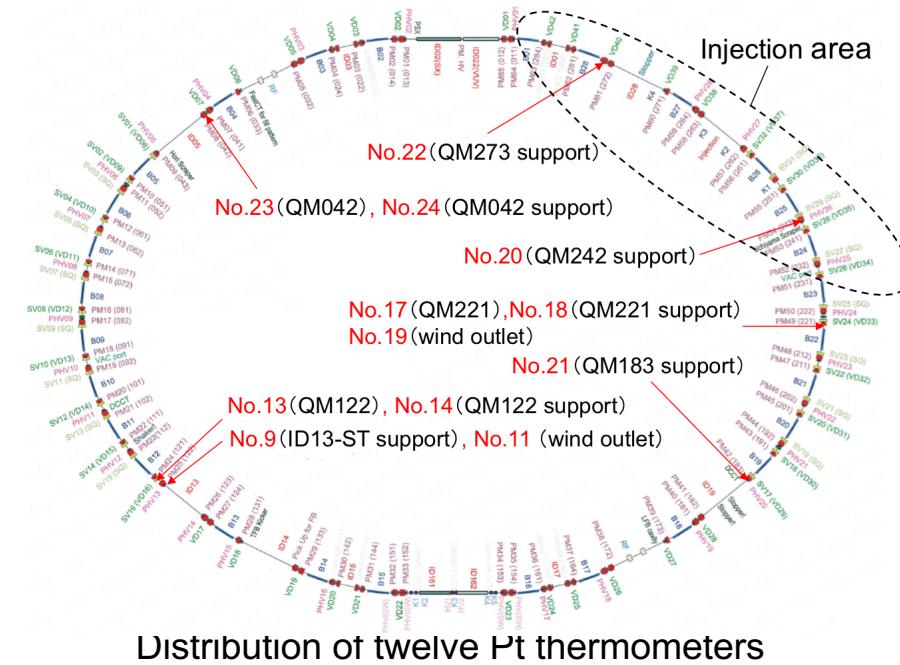


Main results from the temperature measurement :

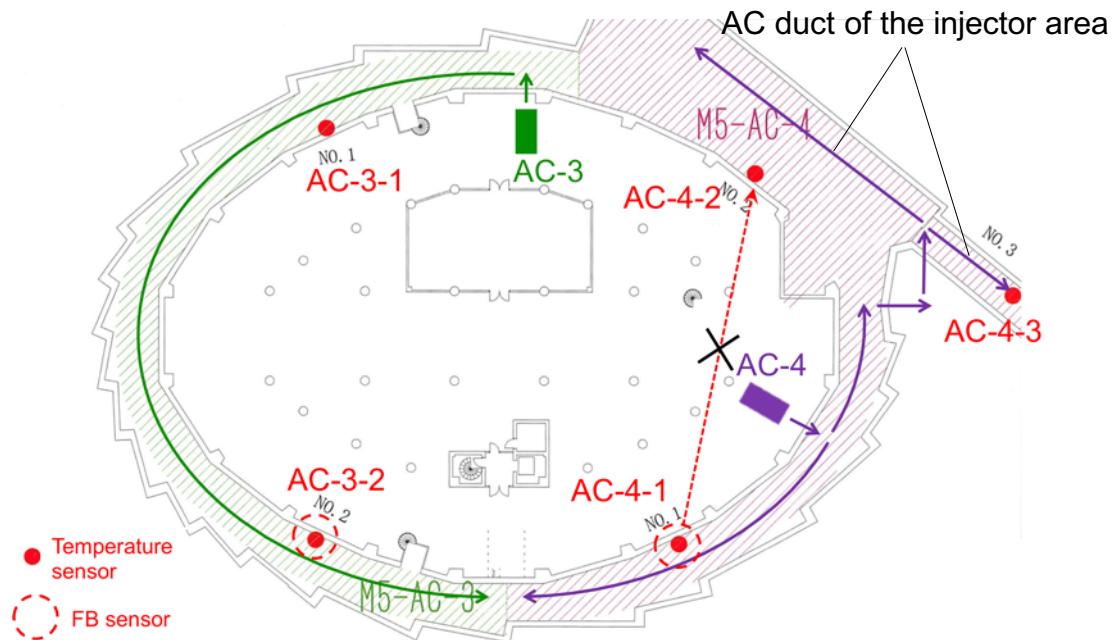
- (1) Temperatures at the two wind outlets increased with those of the ring components after they initially decreased to the minimum.
→ The AC-3 cooling-water valve became fully open.
- (2) Temperatures of AC-4-2 and AC-4-3 largely drifted and varied compared to those of the other sensors. → The AC cooling power in the injection area was insufficient.
- (3) Temperatures of the cooling systems B and C significantly varied with the outside air temperature from July 1st though temperature of the cold-water supply was kept almost constant.
→ Performances of the cooling-water systems B and C were insufficient in July 2018.



Temperature Measurement in Oct. – Nov. 2018



Measured temperatures of ring components, AC wind outlets and temperature sensors before the ring start-up.

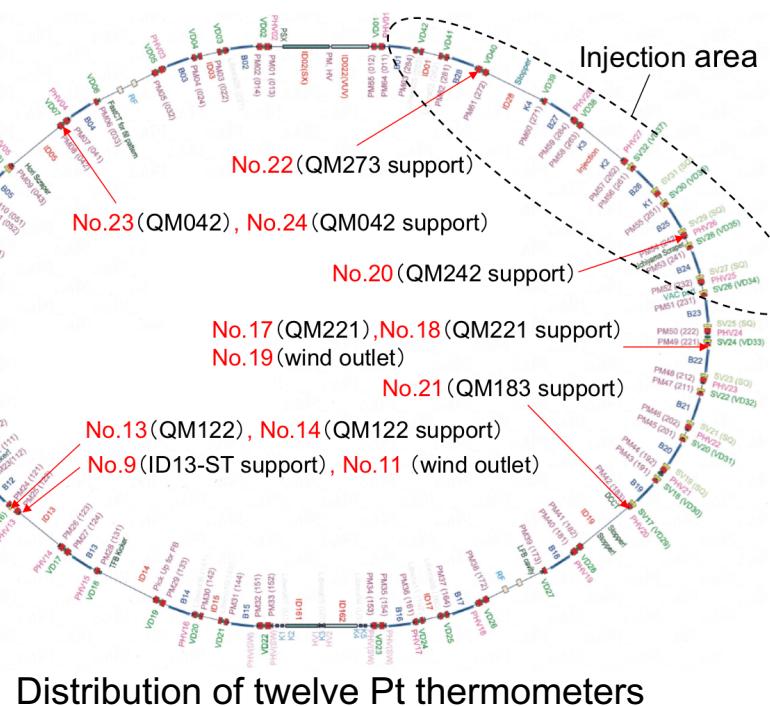


FB temperature sensors of AC-3-2 and AC-4-1 for AC-3 and AC-4. AC-4-1 temperature became unstable when AC-4-2 was used as FB sensor in place of AC-4-1. Therefore, we undid the change of the FB sensor of AC-4.

Result of the temperature measurement :

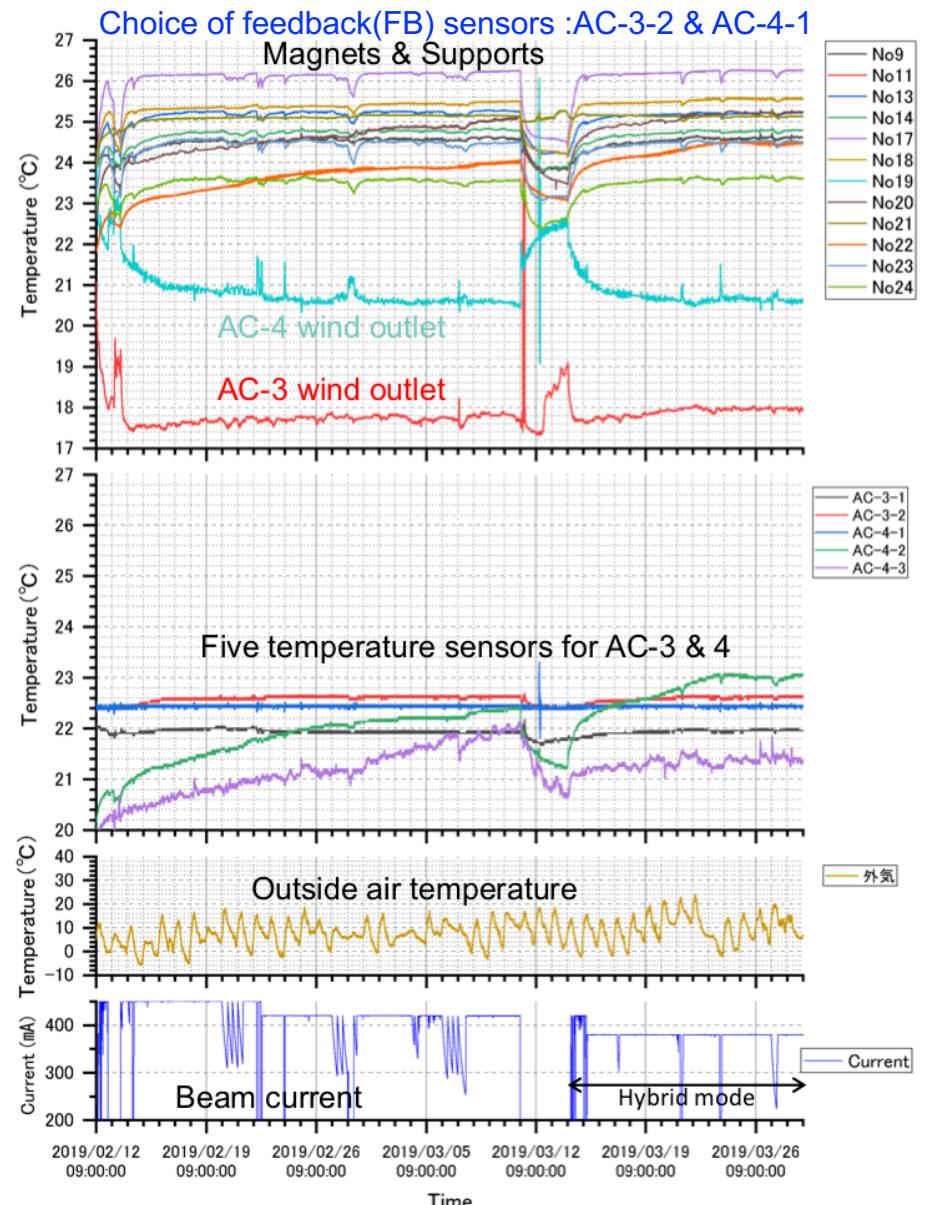
The sensor AC-4-2 was used as the AC-4 FB sensor in place of AC-4-1, but the AC-4-1 temperature became unstable probably because the airflow rate around the injector area is relatively low. The AC air duct of the injector area is very narrow and the number of the wind outlets is small compared to the other areas in the PF-ring tunnel.

Temperature Measurement in Feb. – Mar. 2019



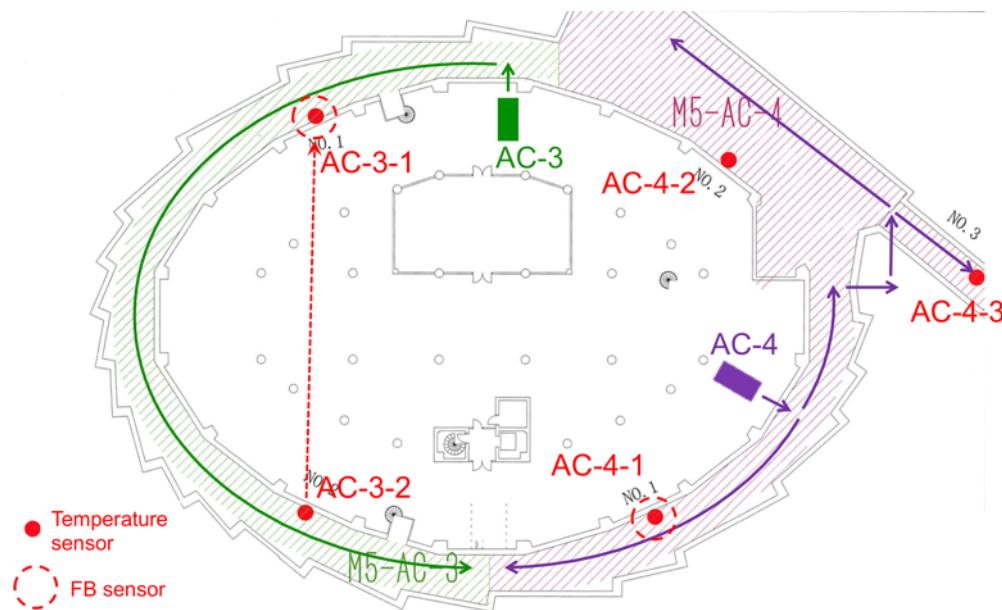
Main results from the temperature measurement :

- (1) Temperature drifts of the two magnet supports (No.20 and 22) in the injector area were relatively large compared to those of the ring components in the other areas and correlated with the AC-4-2 temperature.
- (2) Temperature at the AC-4 wind outlet was well controlled to stabilize temperatures of the ring components, while temperature at the AC-3 wind outlet still showed an abnormal behavior because the AC-3 cooling-water flow rate reached the upper limit.
- (3) The AC-4-2 and AC-4-3 temperatures still greatly drifted in this period.



Measured temperatures of ring components, AC wind outlets, temperature sensors and outside air and stored beam current

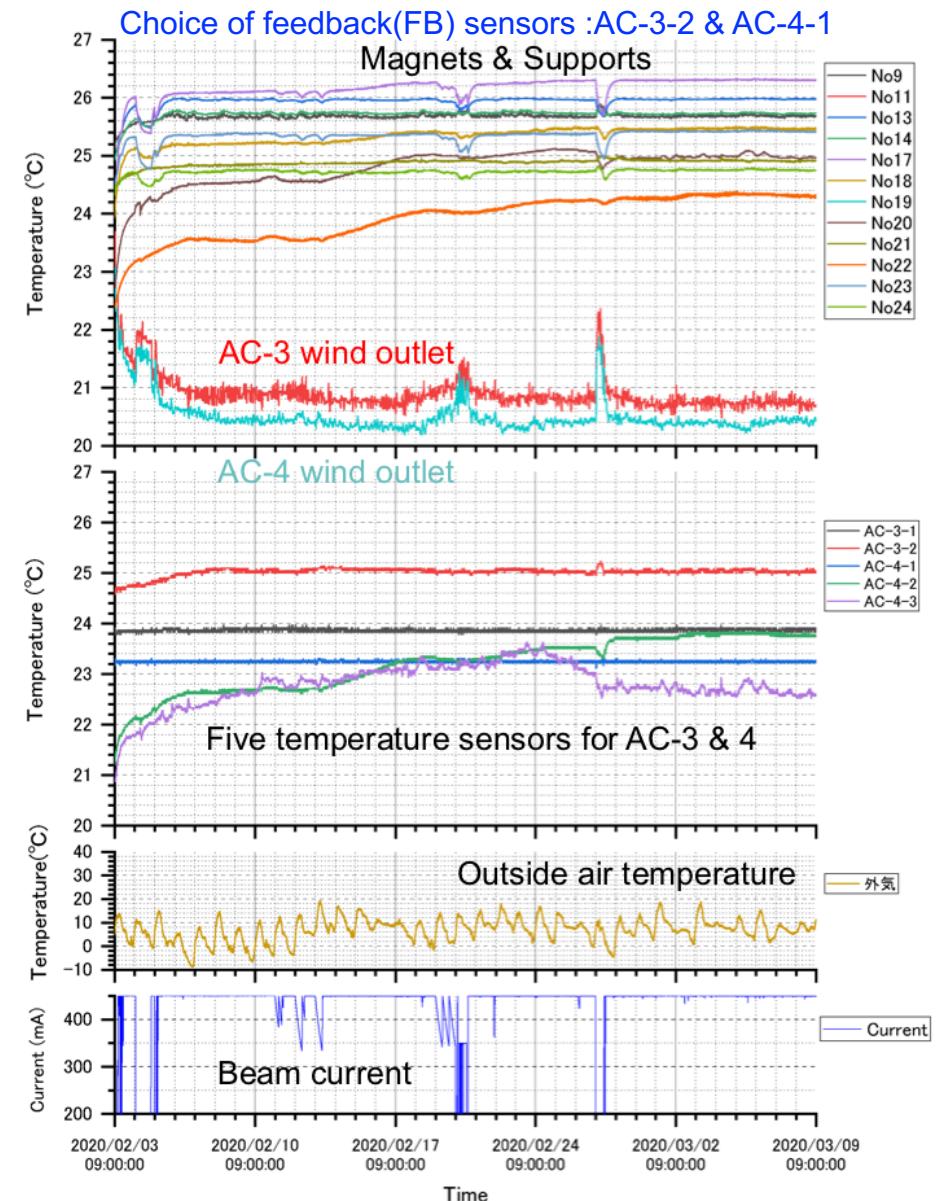
Temperature Measurement in Feb. – Mar. 2020



FB temperature sensors of AC-3-1 and AC-4-1 for AC-3 and AC-4. The AC-3 FB sensor was changed from AC-3-2 to AC-3-1 in May 2019 to keep a longer distance between the AC-3 and AC-4 FB sensors.

Main results from the temperature measurement :

- (1) Temperatures of the two magnet supports in the in-jetion area still significantly varied and correlated with the AC-4-2 temperature
- (2) Temperatures of AC-4-2 and AC-4-3 still greatly drifted compared to those of the other sensors.
- (3) The wind-outlet temperature of AC-3 became well controlled by changing the AC-3 FB sensor to AC-3-1 and very similar to that of AC-4, because the cooling-water flow rate of AC-3 was kept below the upper limit.



Measured temperatures of ring components, AC wind outlets, temperature sensors and outside air and stored beam current.

Summary of Temperature Measurements

- 1) In the injection area, temperatures of the ring components drifted and varied largely compared with those of the other tunnel areas.
- 2) The reasons are that the AC airflow rate in the injector area is relatively very low because of the narrower AC airflow duct and smaller wind-outlet number, and that the injection area is more sensitive to the outside air temperature and the solar irradiation.
- 3) The AC-4 became unstable by selecting AC-4-2 as the AC-4 FB sensor for the same reason as 2).
- 4) The AC-3 came to work normally for stabilizing temperatures of the ring components by selecting AC-3-1 as the AC-3 FB sensor because the cooling-water flow rate of AC-3 was below the upper limit.
- 5) Temperatures of the cooling systems B and C significantly varied and correlated with the outside air temperature in July 2018, because the cooling-water systems B and C became insufficient in cooling power.

Proposal of Infrastructure Improvements

We are proposing the following improvements for the PF-upgrade project.

Improvements of air-conditioning systems :

(1) Increase of the AC-4 airflow rate in the injection area

- AC duct size : $400\text{mm} \times 250\text{mm} \rightarrow 450\text{mm} \times 400\text{mm}$ or larger
- Number of AC wind outlets : 4 → 8 or more

(2) Thermal shielding of the injection area

- Heat-shield painting of the outside roof and wall of the injection area
- Heat-insulation by glass-wool boards on the inside roof and wall of the injection area

(3) AC control by averaged temperature of multiple sensors

- Experimental study is needed to check the effectiveness.

(4) Increase of setting temperatures for AC-3 and AC-4 (24 → 25 °C or higher)

- Experimental study is needed to check the effectiveness.

Improvement of cooling-water systems :

(1) Upgrade of plate heat exchangers in the cooling-water systems

- Sizes of cooling water ducts increased at the same time

*) Renewal of the air-conditioning and cooling-water systems is the best, but financially difficult.