1. The production target

The production target at the HD-hall is shown in Figure 2 and as follows:

- To be capable for up to 50-kW proton beams.
- Material: Gold and a copper block with coolant stainless pipes.
- Gold:
  - High density (19.3 > Fe: 7.9, Al: 2.7 x10^3 [kg/m^3]).
  - High thermal conductivity (318 > Al: 237, Fe: 80 [W/m^2/K]).
  - Good chemical stability
- A gold structure: 15.9 x 6 x 6 mm.
- The gold structure is divided into 6 pieces to reduce thermal stress.

Thermocouples were attached as follows:
- The gold pieces x12.
- The copper structure x2.
- The water cooling pipes x2 et al.

2. Measurement and control device

Before the accident the temperature-measurement cycle of 1 second was too slow to detect the rapid temperature rise. Therefore we have upgraded the measurement system as follows:

- The measurement and interlock system of the target temperature has been developed with a Programmable Logic Controller (PLC) shown in Figure 3.
- An embedded EPICS IOC on Yokogawa’s FA-M3 PLC platform.\(^2\)
- An EPICS-IOC can take data from the sequence CPU via the shared memory.
- The start and stop timing of the measurement is synchronized with the beam extraction cycle, using the gate signal synchronized to the accelerator operation.

3. Method to measure temperature data synchronized with beam extraction

- The way of temperature data synchronized with beam extraction is described in Figure 4.
- The EPICS sequencer has been used in order to operate the system synchronized with the beam extraction.

4. Display of temperature data synchronized with beam extraction

Display:
- Program language: wxPython.
- The operators can monitor the current data and inspect the past data if necessary.
- The vertical axis: temperature [degree Celsius].
- The horizontal axis: time [seconds].

Results:
- Maximum temperature:
  - Au piece: 250.0 [degree Celsius] at the forth from the front piece.
  - Cu block: 51.5 [degree Celsius].
- A smooth temperature rise: 0.6 - 2.6 seconds (on spill).
- A smooth temperature descent: 2.7 – 3 seconds (off spill).

5. Summary

- The measurement and the interlock system of the target temperature has been developed with the PLC.
- The sequence-CPU module can handle and control the temperature data and the interlock signals.
- The EPICS-CPU module can handle the data from the sequence-CPU via the shared memory.
- The waveform records of temperature as a function of time can be referred on the EPICS-CPU.
- The operator can monitor the waveform spectra as a function of time in every beam extraction.
- The upgraded system has been successfully and stably operated with up to 33-kW proton beams.
- The details of trend graphs and an interlock system of the production target are mentioned in our proceedings.

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References