

# Beam drift at a secondary electron emission monitor used for dose control in carbon-ion radiotherapy

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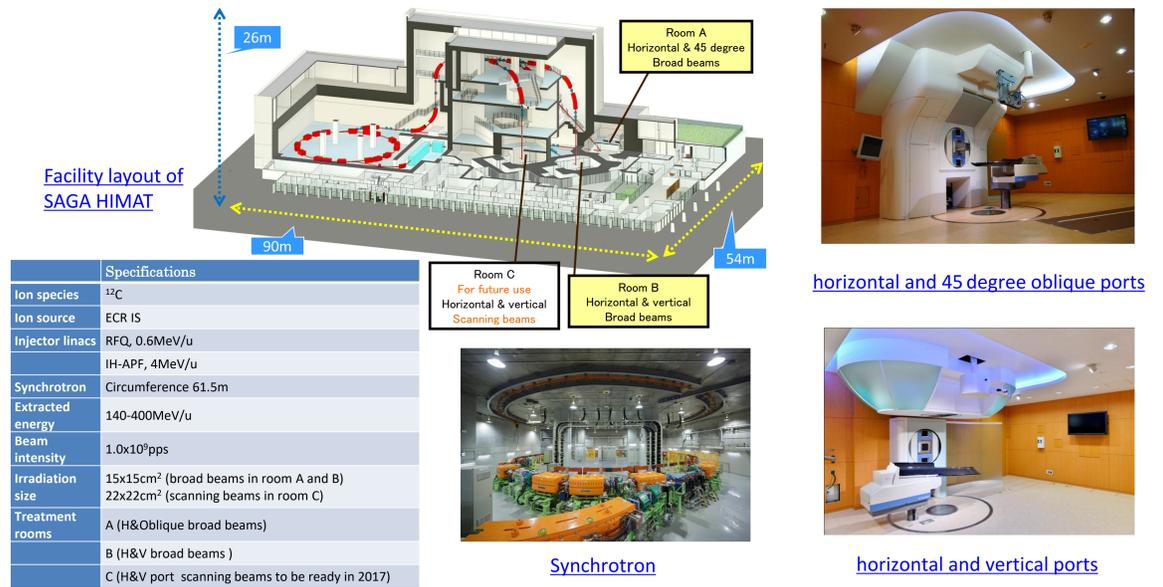
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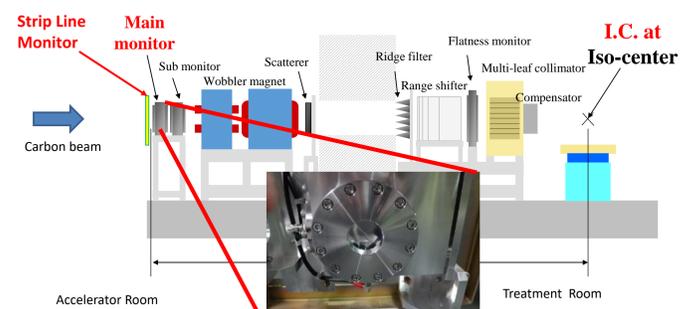
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## HIMAT(Heavy Ion Medical Accelerator in Tosu)

- ◆ SAGA HIMAT is the fourth carbon ion beam therapy facility in Japan and is a standalone outpatient clinic.
- ◆ In our center, accelerators (the linacs and the synchrotron with the maximum energy of 400MeV/u) have been dedicated for carbon beam radiotherapy.
- ◆ The number of treated patients has exceeded 2,000 in this May.
- ◆ Carbon beams are transported to the treatment rooms A and B and irradiated with broad beam method.
- ◆ The treatment room C is now under preparation for the scanning beam irradiation.

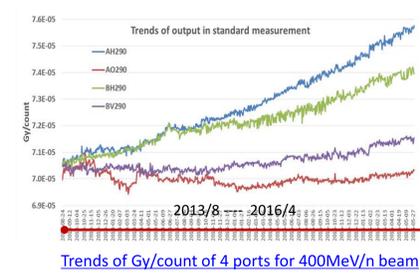
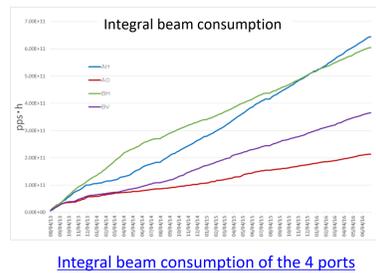
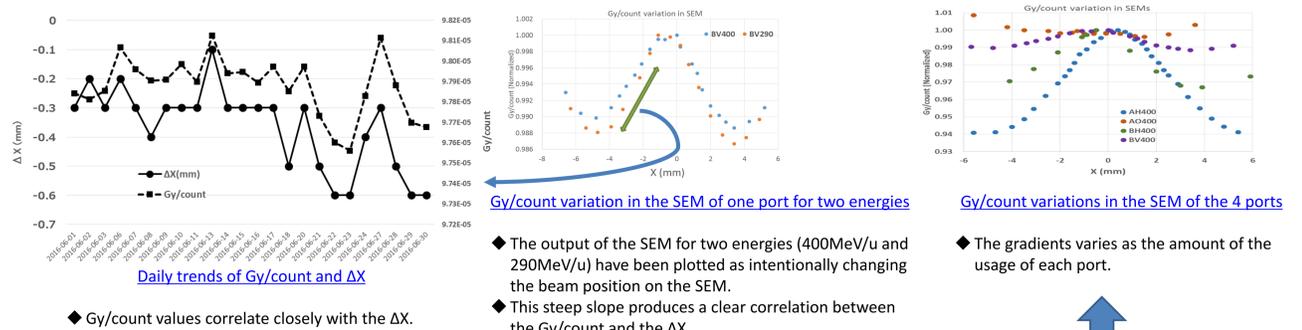


## Secondary electron emission monitor



Schematic diagram of the irradiation devices around a treatment room

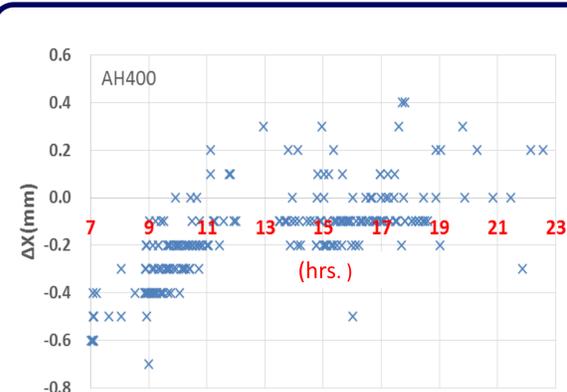
- ◆ Two sets of Secondary-electron Emission Monitor(SEM) are used as a dose monitor.
- ◆ The SEM includes 4 collector electrodes and 5 potential electrodes made of aluminum foils of 7 μm thickness.
- ◆ Beam position is detected at Strip Line Monitor just upstream of these monitors.
- ◆ Each morning the output of the Ionization chamber (I.C.) at an isocenter is divided by that of the SEM under the standard beam condition in order to derive the Monitor-Unit value (Gy/count) of the day.



◆ The integral beam consumption (left figure) and the sensitivity of SEMs (right figure) correlate well.

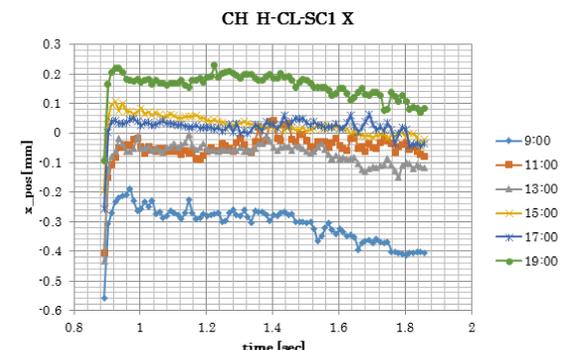
◆ This fact leads in turn to the certain position dependence at the monitor.

## Beam drift caused by the Synchrotron



Beam displacement at SLM

- ◆ The extracted beam position on the Strip Line Monitor is slightly shifting during daytime operation with its length of around 1mm at the horizontal port of room A.
- ◆ After 11 a.m., ΔX show almost stable.
- ◆ This behavior is explained by the following synchrotron stability.



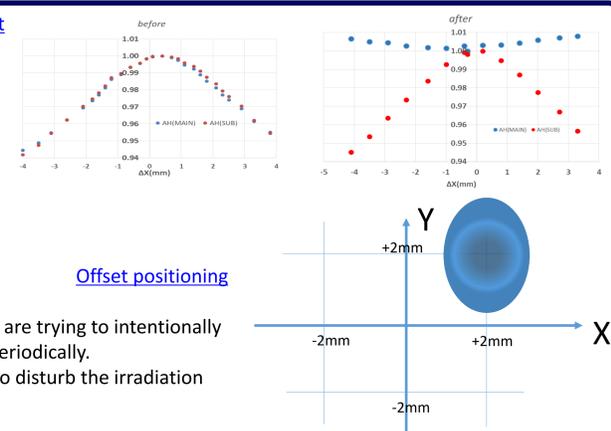
Synchrotron stability

- ◆ Horizontal (X) beam position from 9:00 to 19:00 in a day was measured with a screen monitor at the extraction channel of the synchrotron.
- ◆ The cause of the drift seems to arise from the temperature rise of the dipole magnets in the synchrotron.

## Renewal and control policies

Before and after replacement

- ◆ We have replaced the most frequently used SEM to a new one, which is as the main monitor of the horizontal port of room A.
- ◆ The blue dots represent the main monitor behavior (replaced: old one in the left figure and new one in the right figure), while the red dots represent that of the sub monitor (not replaced).
- ◆ Since it is costly to replace monitors, we are trying to intentionally change the beam position on the SEM periodically.
- ◆ The amount of the offset is limited not to disturb the irradiation field.



## Summary

- ◆ The beam position dependence in standard measurements arise from the sensitivity variation of the SEM.
- ◆ The sensitivity have been varied with the property change of the electrode gradually by the beam sputtering.
- ◆ This effect leads to a dose deposition error.
- ◆ It is hard to suppress the beam drift of the synchrotron.
- ◆ We are trying to change the beam position periodically in order to keep an almost uniform sensitivity.