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# Towards Automated Gas Leak Detection through Cluster Analysis of Mass Spectrometer Data

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In order to generate high-performance plasma, it is desirable to keep high quality vacuum during experiment. Mass spectrometer is commonly used to monitor the vacuum quality and to record the amount of atoms and molecules in the vacuum vessel. Leak is the most serious accident to avoid and must be indicated by the recorded events such as an increase in the degree of vacuum and a change in the composition ratio of the particle types in the vacuum vessel. Therefore, we study an effective way to identify leaks in the vacuum vessel by analyzing mass spectrometer data. Our results indicate that clustering the composition ratio is useful. Fig. 1 shows the data of the mass spectrometer at 8:00 AM during a certain experimental period on the *Q-shu university experiment with steady-state spherical tokamak* (QUEST). Fig. 1 (a) shows the degree of vacuum in the vacuum vessel, and Fig. 1 (b) shows the signal strength of each mass number. The QUEST device uses turbo molecular pumps and cryopumps for vacuum pumping, but when there were no experiments, the cryopumps are regenerated. Only the turbo molecular pump was working. As the pumping capability of the cryopump for gas species is different from that of the turbo molecular pump for gas, the trend of both the degree of vacuum and the signal strength of the mass number was modified. The air leak started on the 10th day. It can be seen that the signal intensities of mass number of 18 (m18) and m24 are inverted after the leak took place. These two signals are mainly recognized as water and nitrogen molecule or carbon monoxide, respectively. Since this was an air leak, m28 after the leak is mainly derived from nitrogen molecules. Fig. 2 shows the results of cluster classification using the data of each mass number normalized by degree of vacuum as input data. Hierarchical clustering is adopted in this cluster classification 1, and the Euclidean metric and Ward's method 2 are used. The dendrogram shows that the data for the first 9 days without leaks form one cluster and the remaining data form another cluster. It can be properly classified according to the change in the composition ratio of the components.

We are developing a method that identifies the leaks using this classification method, which uses the data of the mass spectrometer as the main input data. This system collects information in real time from other devices, such as the status of the cryopump and the status of the plasma discharge sequence. Then, by adding this information as input data, we aim to perform more accurate classification.

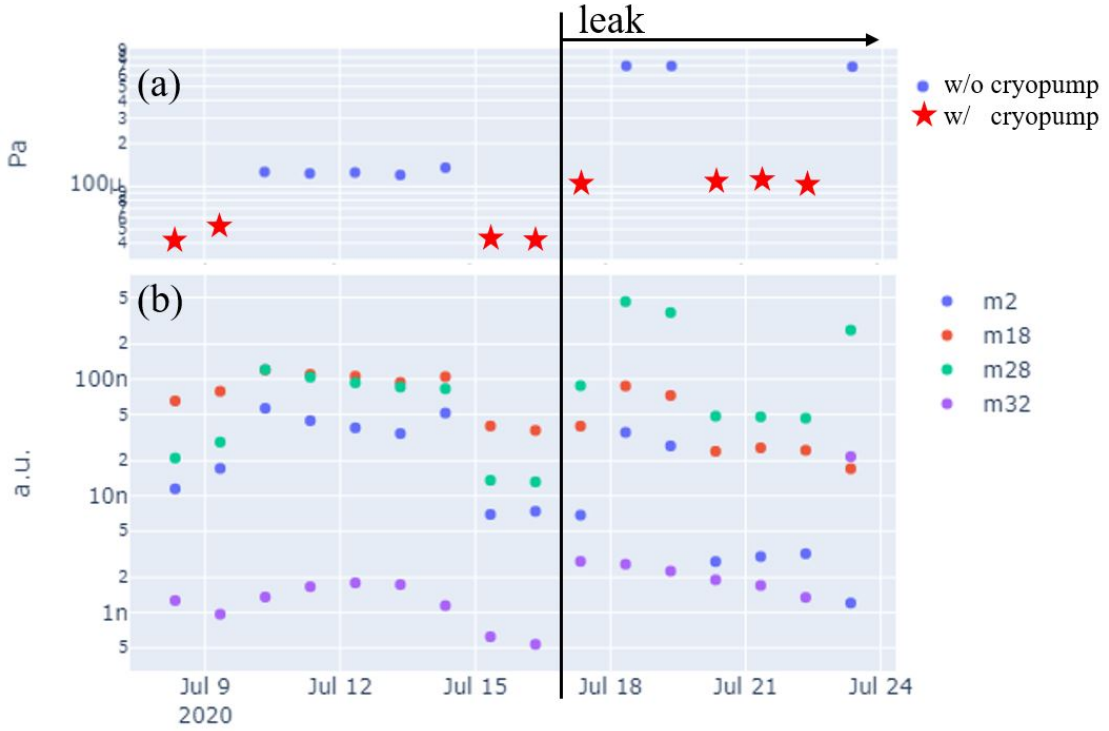


Figure 1: (a) Vacuum degree of QUEST vessel, (b) Signal strength of each mass number by mass spectrometer


![Dendrogram of mass spectrometer data]2 Rokach, Lior, and Oded Maimon. "Clustering methods." Data mining and knowledge discovery handbook. Springer US, 2005. 321-352.

2 Ward, Joe H. (1963). "Hierarchical Grouping to Optimize an Objective Function". Journal of the American Statistical Association. 58 (301): 236–244.


## Speaker's Affiliation


Research Institute for Applied Mechanics, Kyushu University, Kasuga, Fukuoka, Japan


## Member State or IGO

Japan


**Primary author:** Dr HASEGAWA, Makoto (Research Institute for Applied Mechanics, Kyushu University, Japan)

**Co-authors:** Prof. SAKURAI, Daisuke (Pan-Omics Data-Driven Research Innovation Center, Kyushu University, Japan); Ms HIGASHIJIMA, Aki (Research Institute for Applied Mechanics, Kyushu University, Japan); Mr NIIYA, Ichiro (Research Institute for Applied Mechanics, Kyushu University, Japan); Mr MATSUSHIMA, Keiji (Research Institute for Applied Mechanics, Kyushu University, Japan); Prof. HANADA, Kazuaki (Research Institute for Applied Mechanics, Kyushu University, Japan); Prof. IDEI, Hiroshi (Research Institute for Applied Mechanics, Kyushu University, Japan); Prof. IDO, Takeshi (Research Institute for Applied Mechanics, Kyushu University, Japan); Prof. IKEZOE, Ryuya (Research Institute for Applied Mechanics, Kyushu University, Japan); Prof. ONCHI, Takumi (Research Institute for Applied Mechanics, Kyushu University, Japan); Dr KURODA, Kengo (Research Institute for Applied Mechanics, Kyushu University, Japan)

**Presenter:** Dr HASEGAWA, Makoto (Research Institute for Applied Mechanics, Kyushu University, Japan)


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