2012年度 原子分子データ応用フォーラムセミナー, December 11-13, 2012

大気圧超高純度O_2ガス中における負イオン移動度測定

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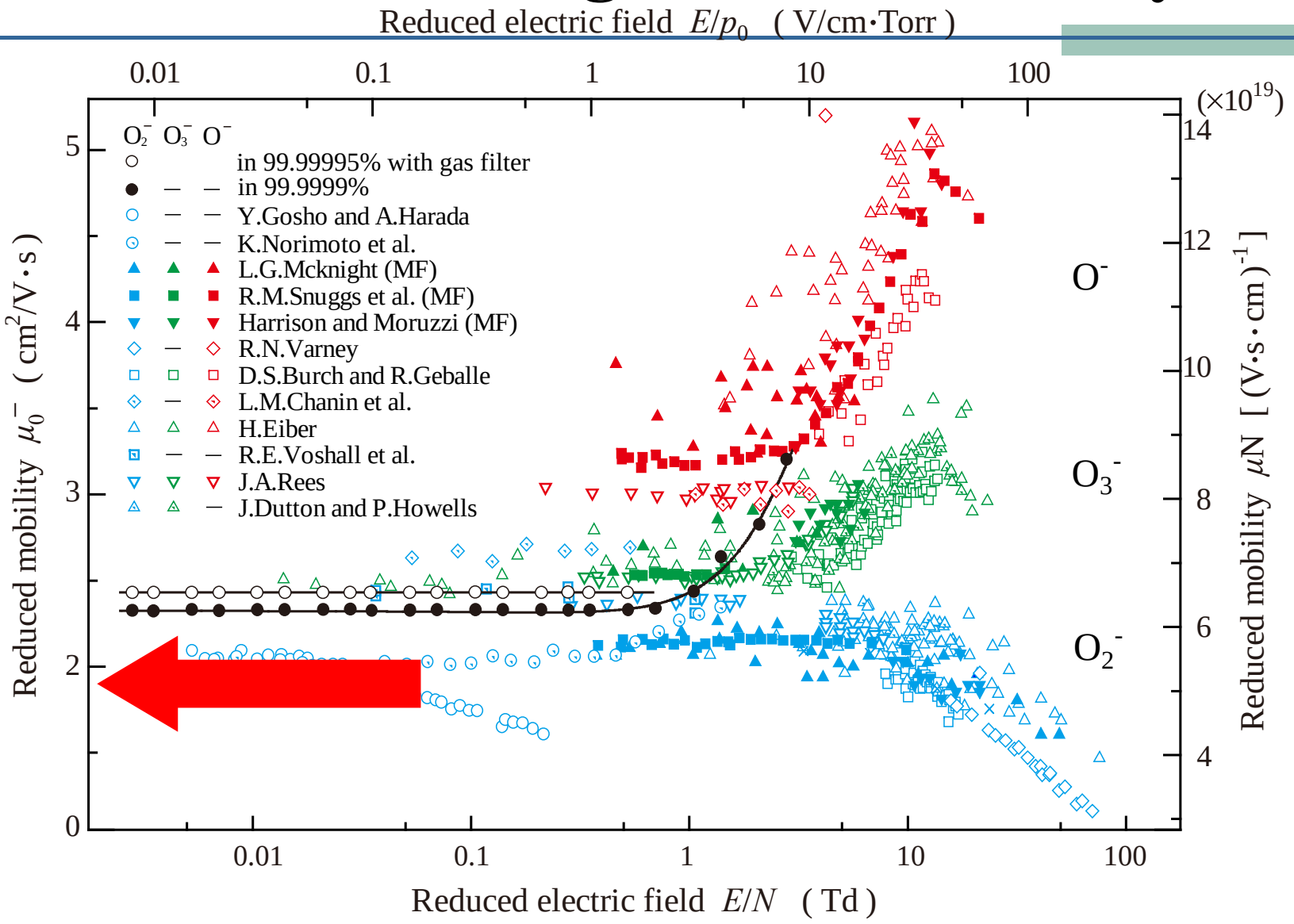
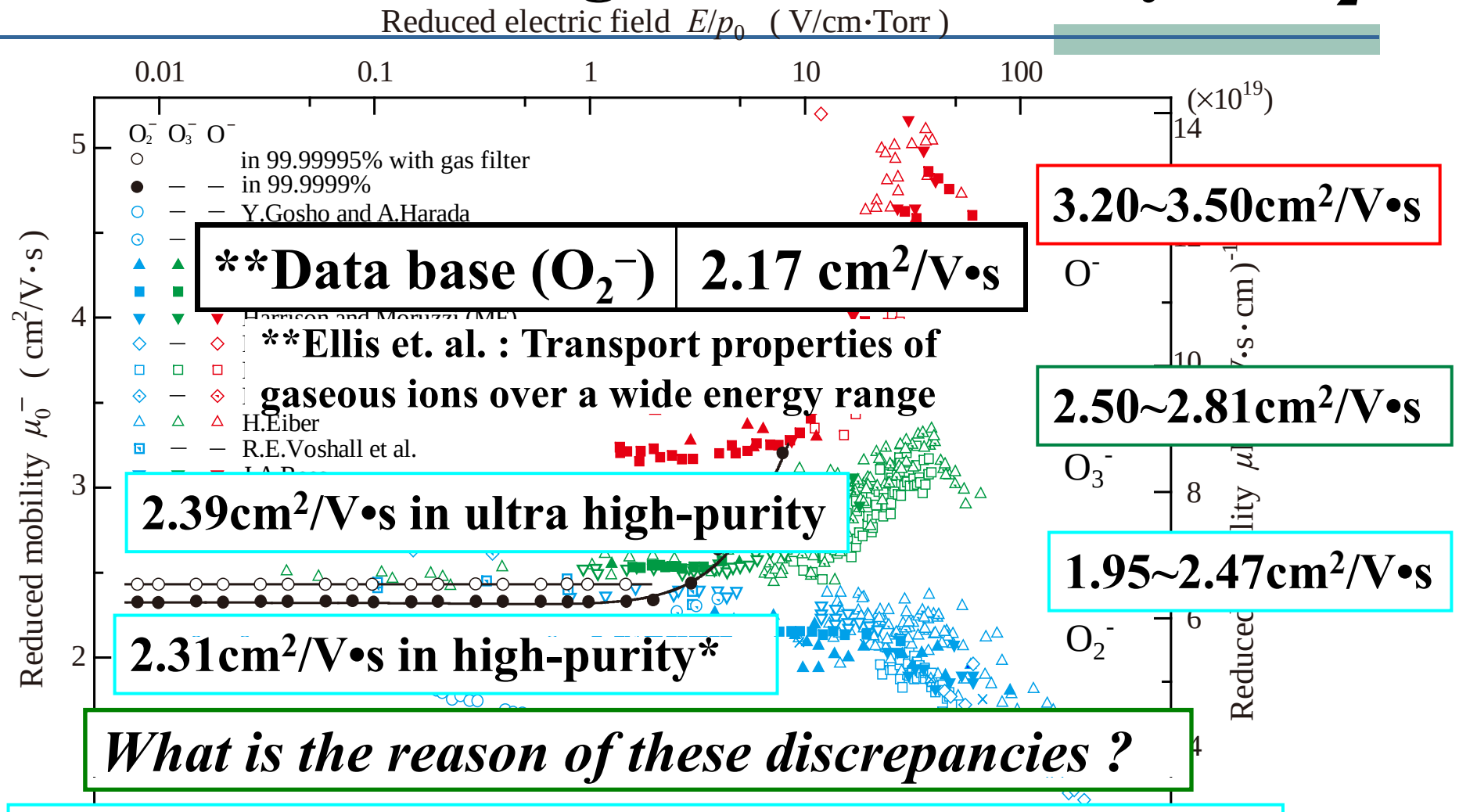
Introduction

Measurement of negative ion mobility in O_2



Introduction

Measurement of negative ion mobility in O_2



*Y. Okuyama et al. "Measurement of negative ion mobility in O_2 at high pressures using a point plate gap as an ion detector" *J. Phys. D*, **45** (2012) 195202

The substance of this presentation

Obtained negative ion mobility in O_2

- **2.31 $cm^2/V•s$ in high-purity O_2 (99.9999%)**
- **2.39 $cm^2/V•s$ in ultra high-purity O_2 (99.99995% with gas filter)**

The reason of mobility discrepancies

→ impurities contained in O_2

- ***N_2 CO_2 and etc*… released from surface of electrodes and chamber**

→mobility increased at higher *E*/*N* region ($E/N > 1.77\times10^{-1}$ Td)

- ***H_2O* released from chamber, electrodes and contained in O_2**

→forms $O_2^-(H_2O)n$ cluster ions which leads to decrease mobility.

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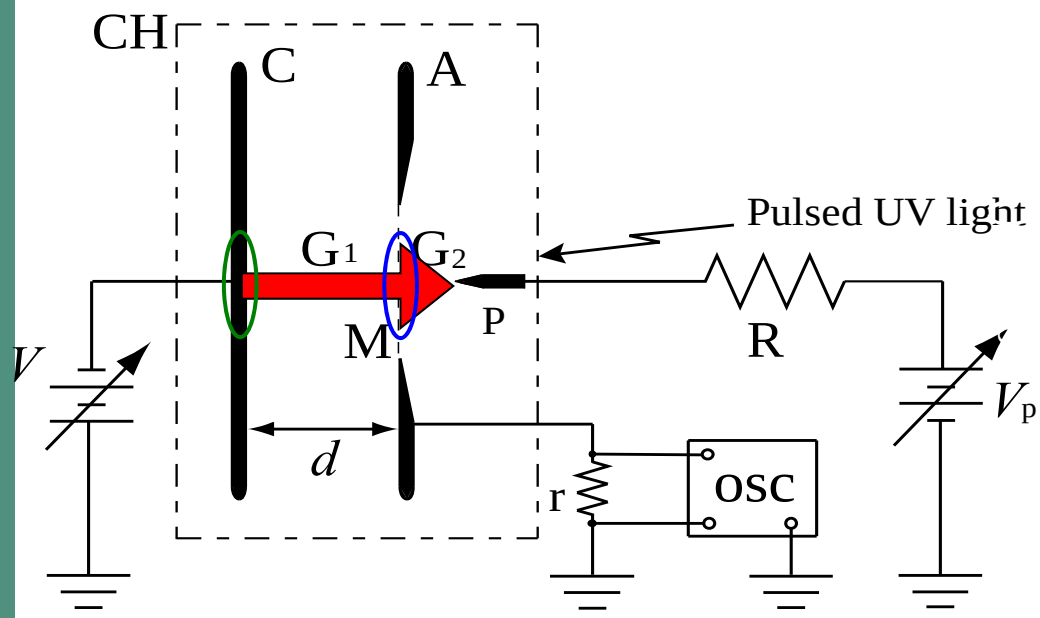
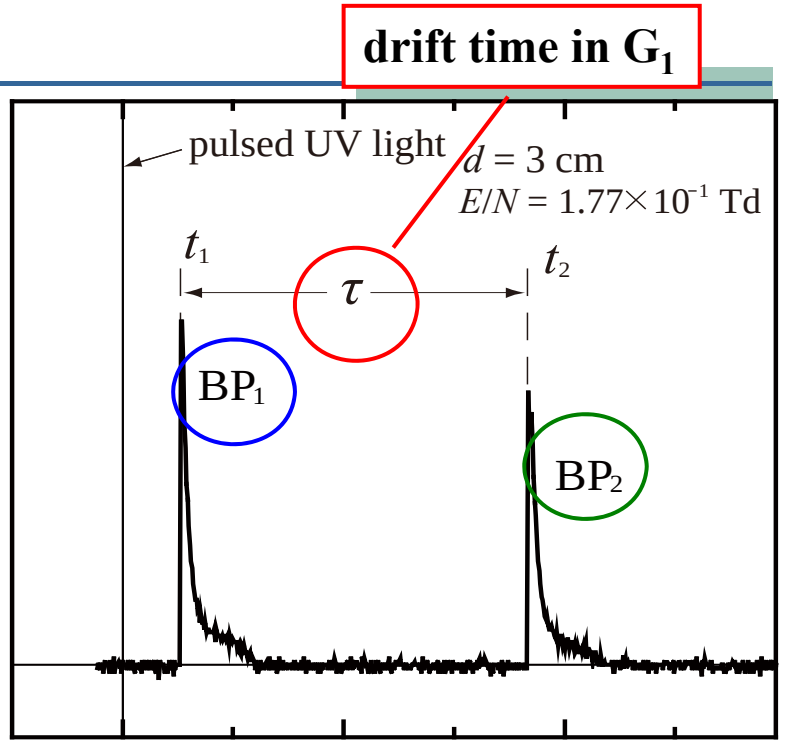
Principle of the mobility measurement



Principle of the mobility measurement



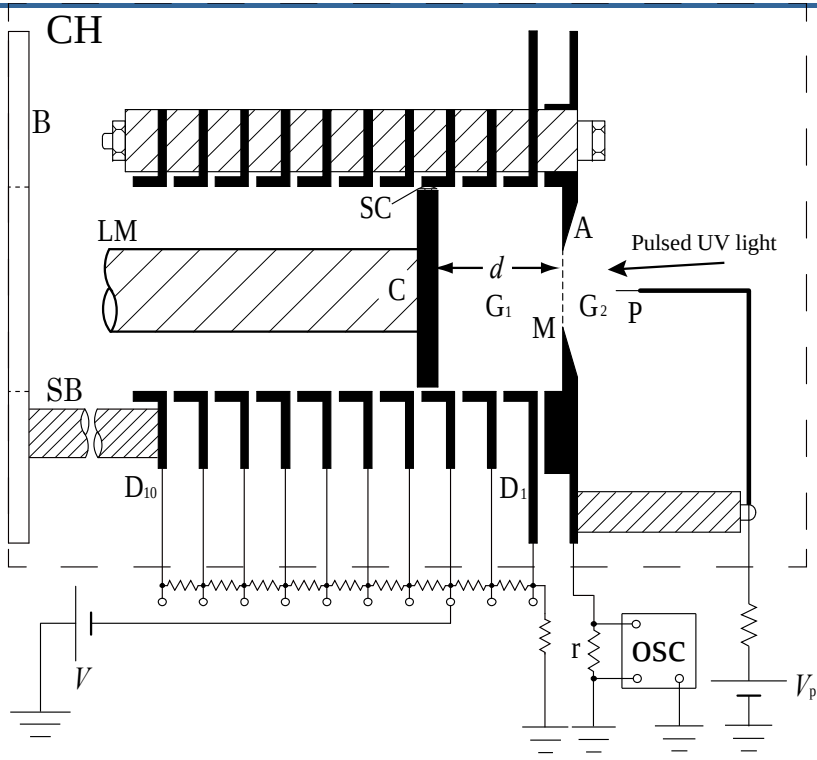
Observed pair of burst pulses

Negative ions are formed by electron attachment which released from surface of M and C.

$O_2 + O_2 + e \rightarrow O_2^- + O_2$ (5.8meV)

$O_2 + e \rightarrow O^- + O$ (4.4eV)

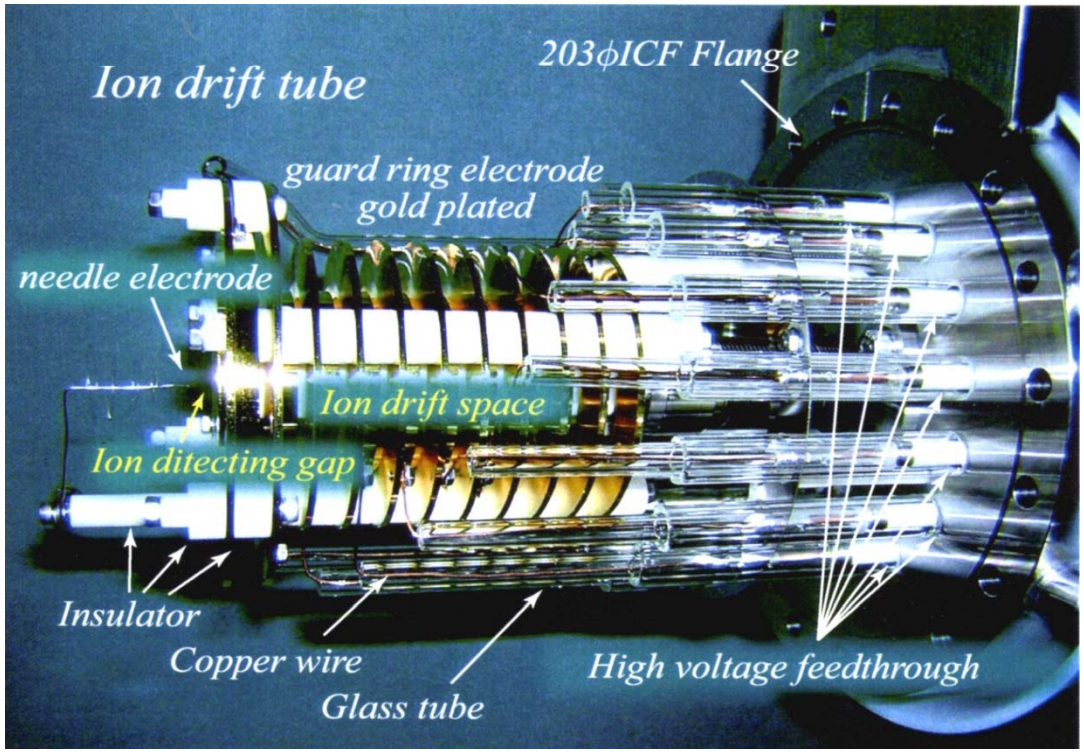
Cross section of electrode system and picture of ion drift tube



G_1: Ion drift space
A : Anode
C : Cathode
P : Point electrode
CH : Discharge Chamber
B : Base plate
r : Current detecting resister

G_2 : Ion-detecting gap
D_n : Guard ring electrodes (n = 1-10)
M : Mesh electrode
LM : Liner motion feedthrough
SC : Sliding contact
SB : Supporting Bar

Cross section of electrode system



Picture of ion drift tube

Details of the experiment

- Repeating measurements were carried out due to removing impurities from surface of electrodes, chamber and gas line.
- Interval of each measurement, chamber was pumped under 10^{-8} Torr and heated at 373 K over 24 hours.

Impurities contained in the used oxygen.

Impurities	high purity cylinder O_2 99.9999%	Ultra high-purity O_2 99.99995% + gas filter
N_2	< 0.2 ppm	< 0.2 ppm
CO	< 0.1 ppm	< 0.02 ppm
CO_2	< 0.1 ppm	< 100ppt
Ar	<0.1 ppm	< 0.05 ppm
H_2O	< 0.522 ppm	< 100ppt

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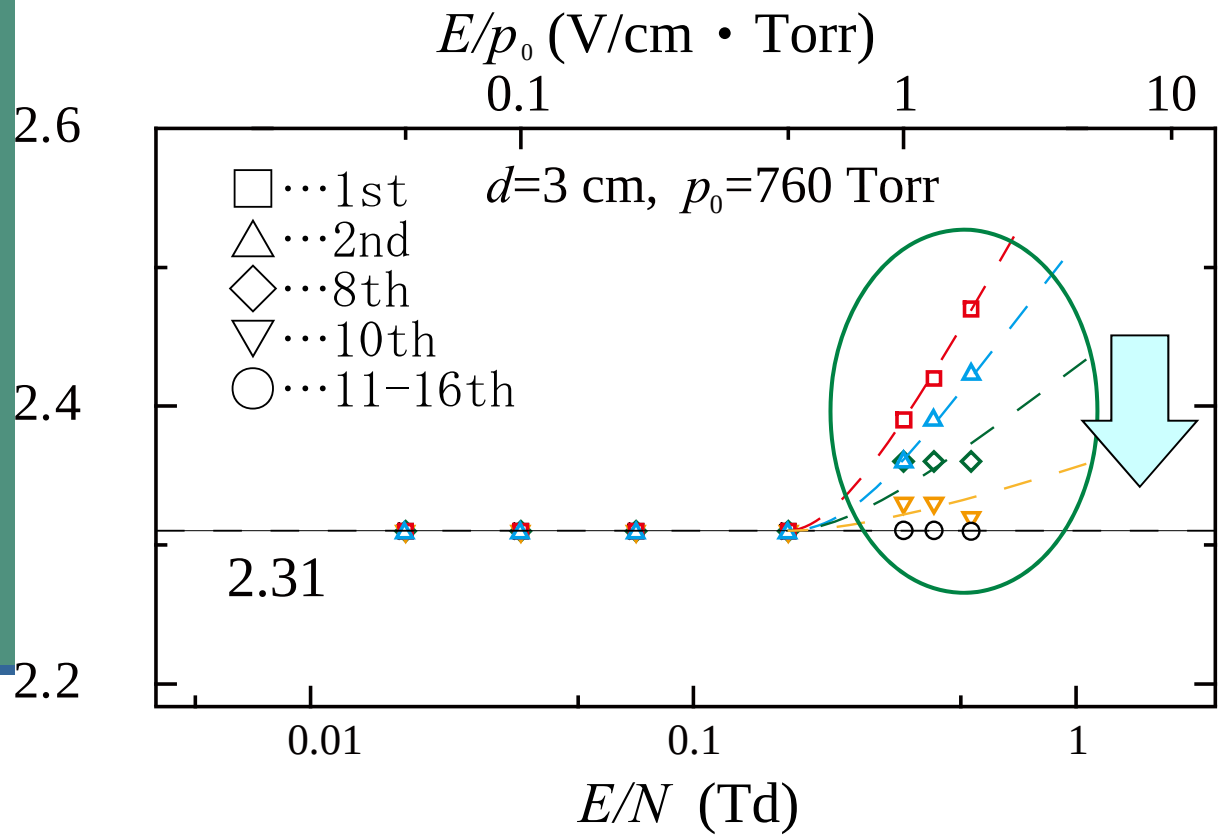
Results and discussions

Repeated measurement in high-purity O_2

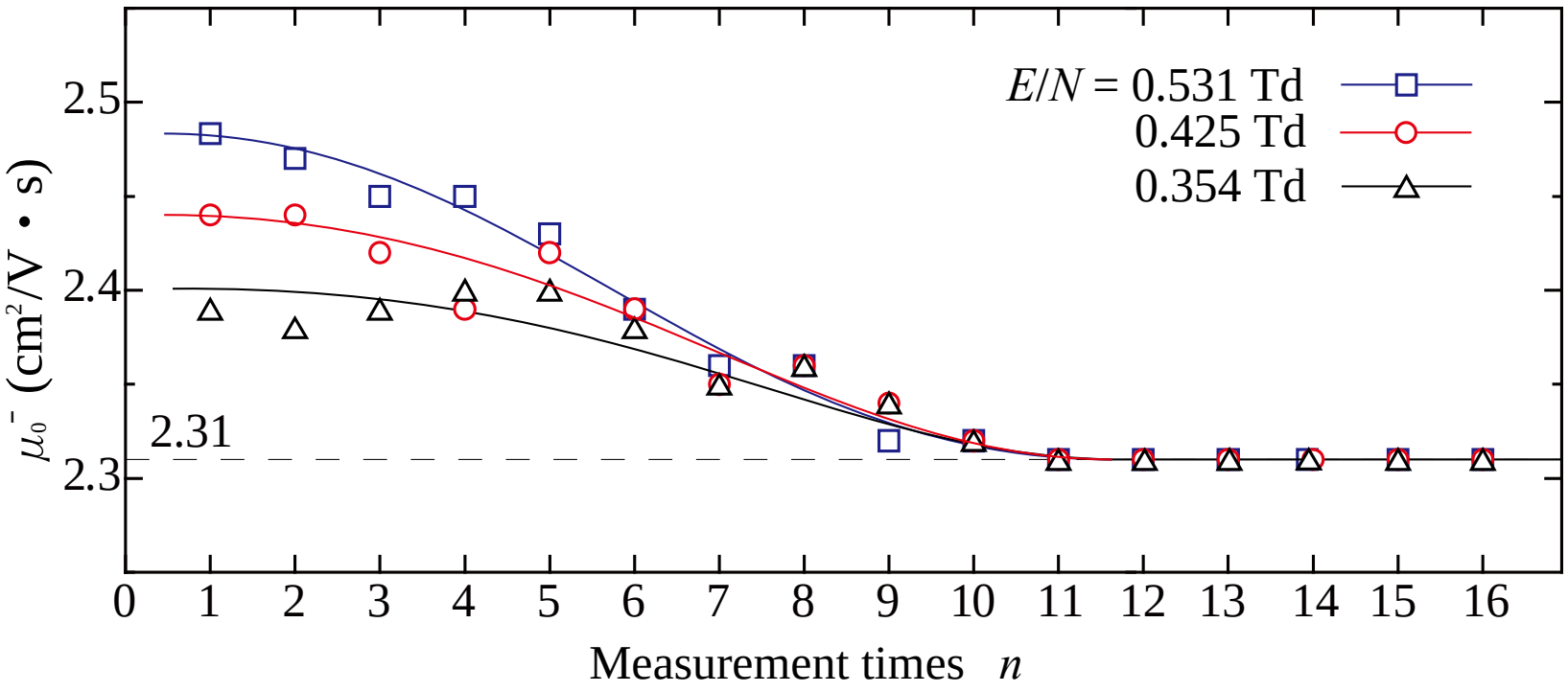


Mobilities of CO_3^-, CO_4^-, NO_2^- and NO_3^-.

At last, negative ion mobility takes a constant value of 2.31 $cm^2/V•s$ of O_2^- same as our previous report

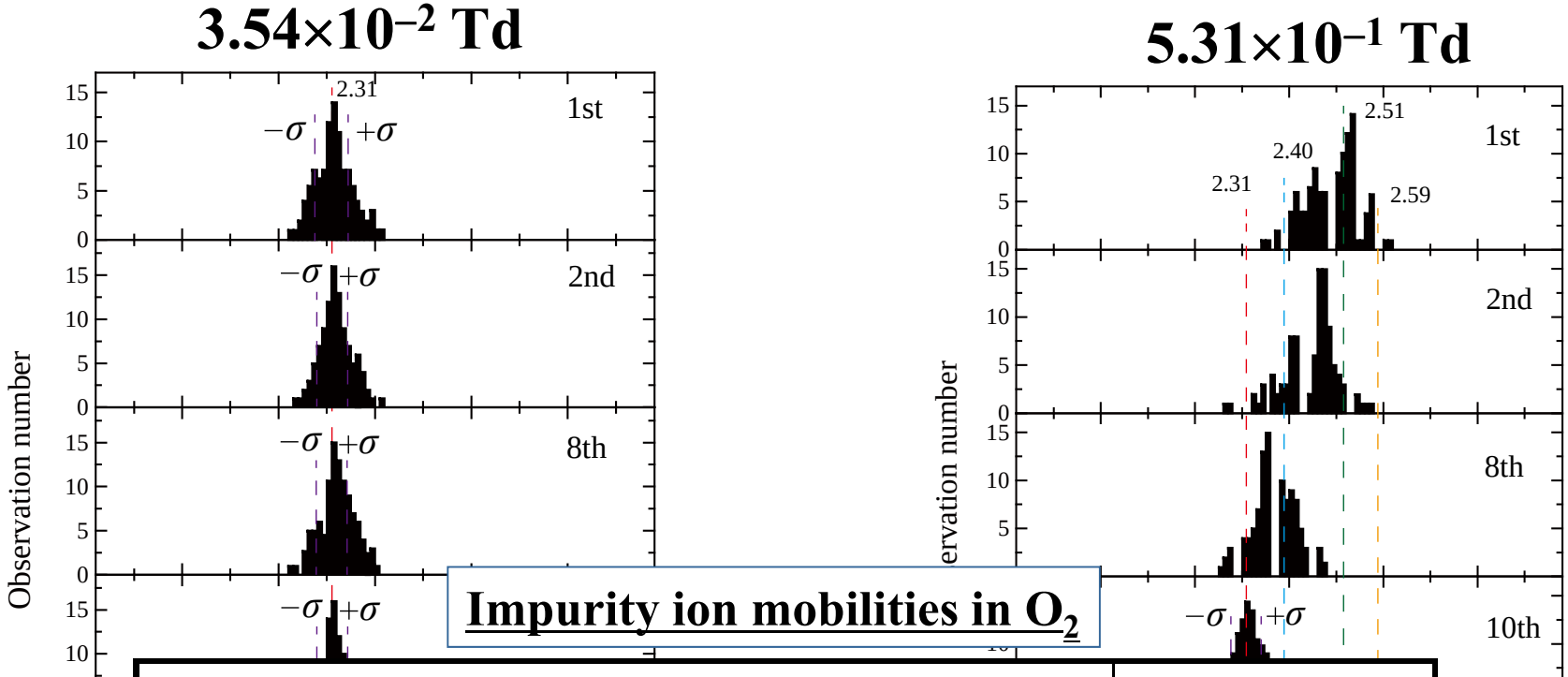
Results and discussions

Decreasing negative ion mobility by repeating measurement



Results and discussions

Observed mobility histograms in high-purity O_2



Impurity ion mobilities in O_2

Ion species and mobility ($cm^2/V \cdot s$)				Presenters
CO_3^-	CO_4^-	NO_2^-	NO_3^-	
2.51	2.40	2.59	2.41	Perkins et al.
2.50	2.45			Snuggs et al.
2.51	2.38			Elford et al.

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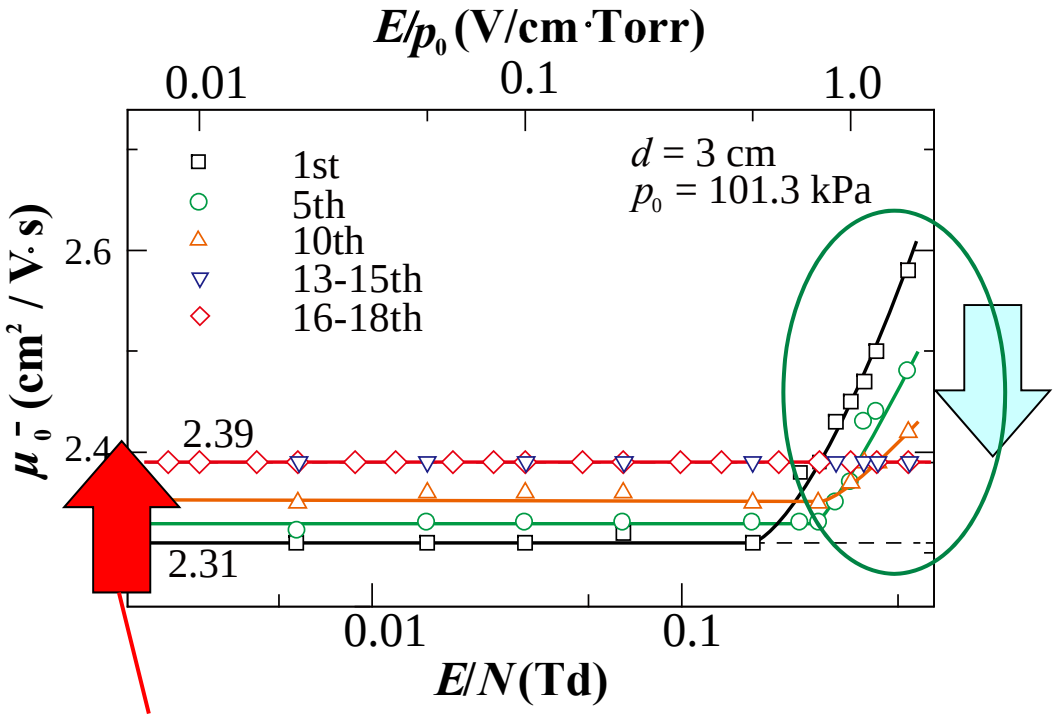
Results and discussions

Varying mobility with repeated measurement

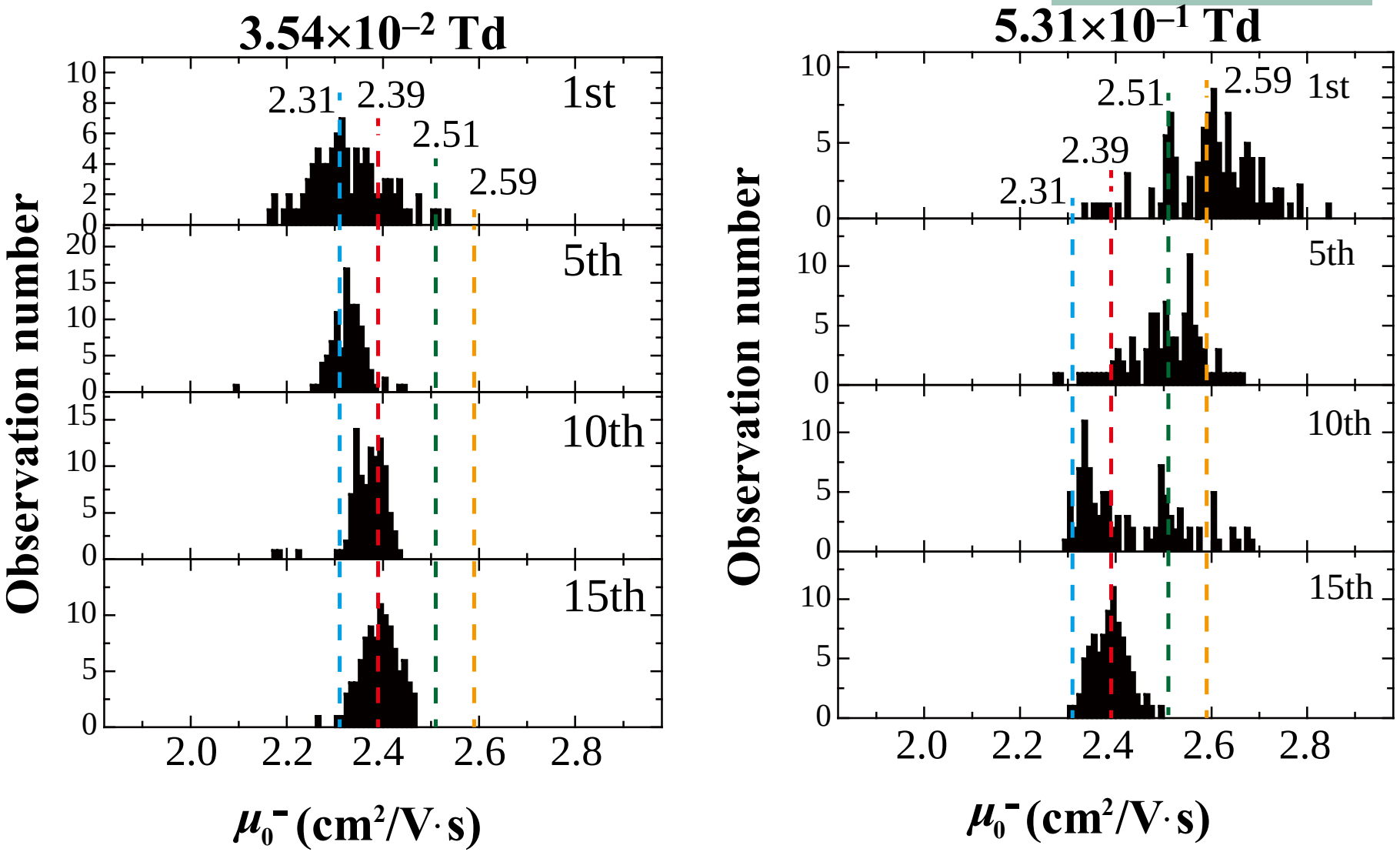


Mobilities of CO_3^-, CO_4^-, NO_2^- and NO_3^-.

by decrease of H_2O concentration
i.e. cluster size of $O_2^-(H_2O)n$ is depend to H_2O concentration.
$O_2^-(H_2O)n$ clusters lead to decrease of ion mobility.

Results and discussions

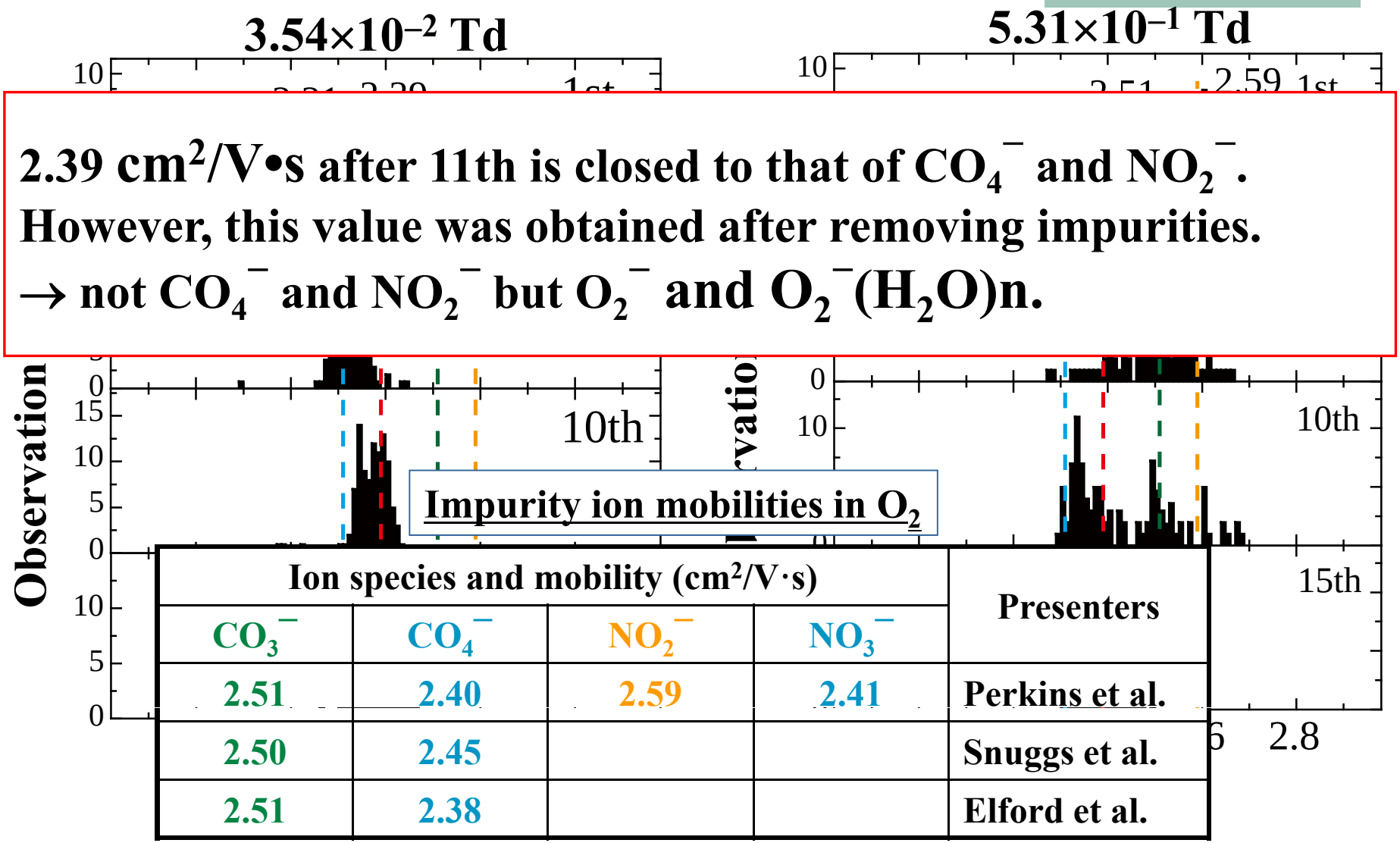
Observed mobility histograms



Results and discussions

Observed mobility histograms

2.39 $cm^2/V•s$ after 11th is closed to that of CO_4^- and NO_2^-.
However, this value was obtained after removing impurities.
→ not CO_4^- and NO_2^- but O_2^- and $O_2^-(H_2O)n$.



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Conclusions

Negative ion mobility was measured in high purity (99.9999%) and ultra high purity (99.99995% with gas filter) O_2. Observed mobility was varied with repeating measurement. Two reasons can be considered for varying negative ion mobility in O_2.

1. **CO_3^-, CO_4^-, NO_2^-, NO_3^- and $N_2O_2^-$ are removed by repeated measurement.**
2. **Removing H_2O in O_2 i.e. decreasing of formation $O_2^-(H_2O)n$ clusters using gas filter.**

In this present, negative ion mobility was observed as 2.39 $cm^2/V•s$ for O_2^- in ultra high purity O_2 .

Thank you very much for your attention