High Performance Mass Spectrometry System for On-site Analysis for a Mission to Jupiter Trojans

（ソーラー電力セイル探査機への搭載に向けた高性能質量分析装置の開発）

Jun Aoki[1] and Solar Power Sail WG[2]

[1]Graduate School of Science, Osaka University
1-1 Machikaneyama-cho, Toyonaka, Osaka, 562-0043 Japan
[2]Institute of Space and Astronautical Science(ISAS)
3-1-1 Yoshinodai, Sagamihara-shi, chuo-ku, Kanagawa-ken, 252-5210 Japan

ABSTRACT

Deep space exploration is making a great progress by recent successes of landing and sample return missions to the Solar System small bodies such as Hayabusa and Rosetta/Philae. One of the most important problems of the Solar System science is to better understand the evolution of the primitive Solar System right after its formation. Thus direct exploration to small bodies beyond the snow line, in which material and structural information of the primitive Solar System are believed to be still well-preserved, is a next logical step after explorations to the near Earth asteroids. Jupiter Trojan asteroids are ideal examples of these small bodies beyond the snow line, with mysterious D/P spectral taxonomy; they share heliocentric orbits with Jupiter at 5.2 AU, clustering its L4 and L5 Lagrangian Points.

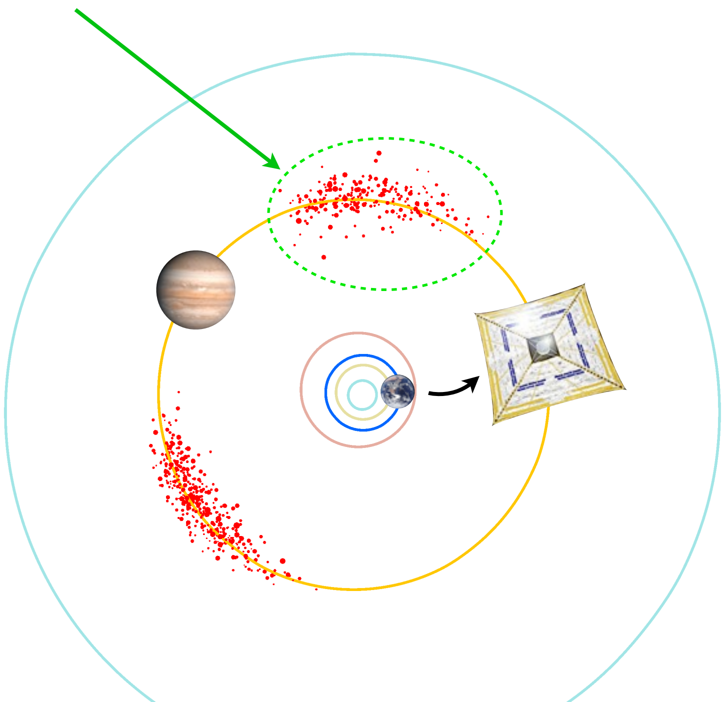
Since 2001, JAXA has been working on designing a rendezvous and landing mission to such Jupiter Trojans by the Solar Power Sail. In this study, we are developing a mass spectrometry system to be onboard the lander element of this mission in early 2020's. After landing on the surface of the target asteroid, on-site analyses of both surface and sub-surface samples will allow to determine isotopic ratios and compositions of organic compounds as well as volatile components that can only survive beyond the snow line, which are clues to reveal the formation regions of their parent bodies and thus to prove or disprove planetary migration theory on the Solar System formation. Our multi-turn time-of-flight mass spectrometer (MULTUM) has already achieved the mass resolution of m/dm ~30000 within 20 x 20 cm dimension for high accuracy measurement. Here we present results of the operational confirmation experiment of the MULTUM system being ready for further development of its prototype model for the Solar Power Sail mission.

ソーラー電力セイル探査機への搭載に向けた高性能質量分析装置の開発

大阪大学　青木順
JAXA　　ソーラー電力セイルWG

ソーラー電力セイルによる木星トロヤ群への着陸探査

木星トロヤ群：木星のラグランジュ点に存在する小惑星群

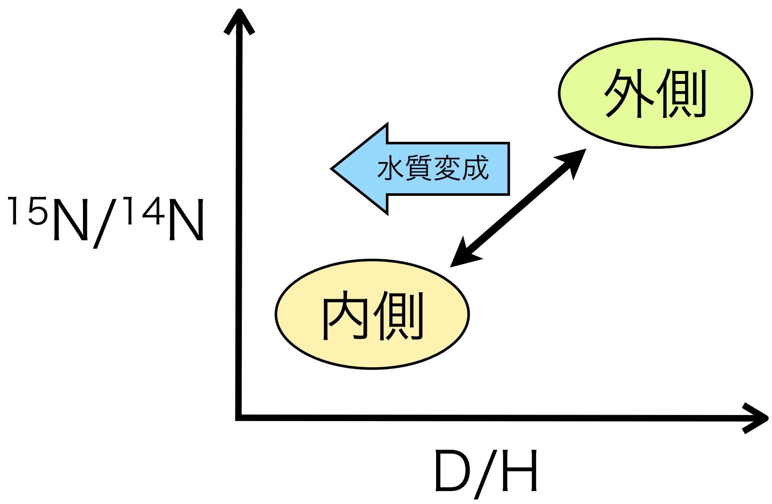


ソーラー電力セイル：ソーラーセイルとイオンエンジンのハイブリッド推進

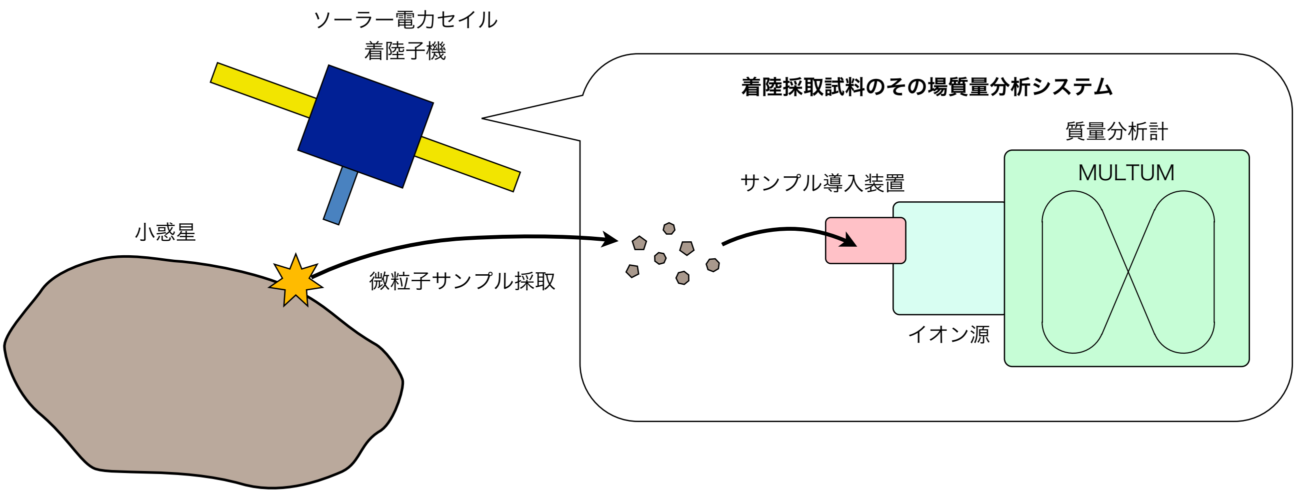
木星トロヤ群におけるサイエンス

始原性の高い小天体であるため原始太陽系の形質が残っている。
太陽系の形成と発展を明らかにする上で重要である。
トロヤ群の起源を調べることで惑星移動説の解明が期待される。

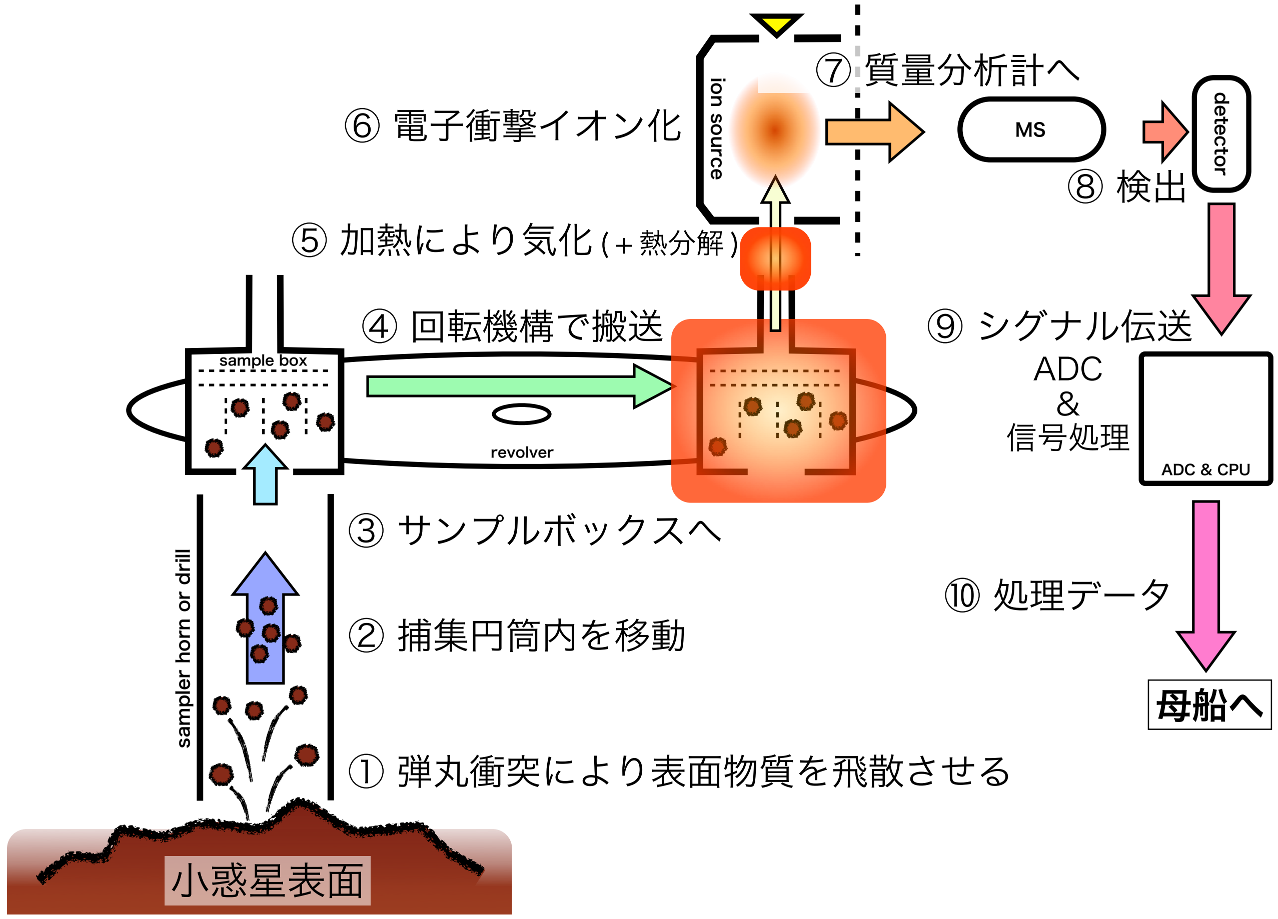
同位体組成から得られる天体の形成情報

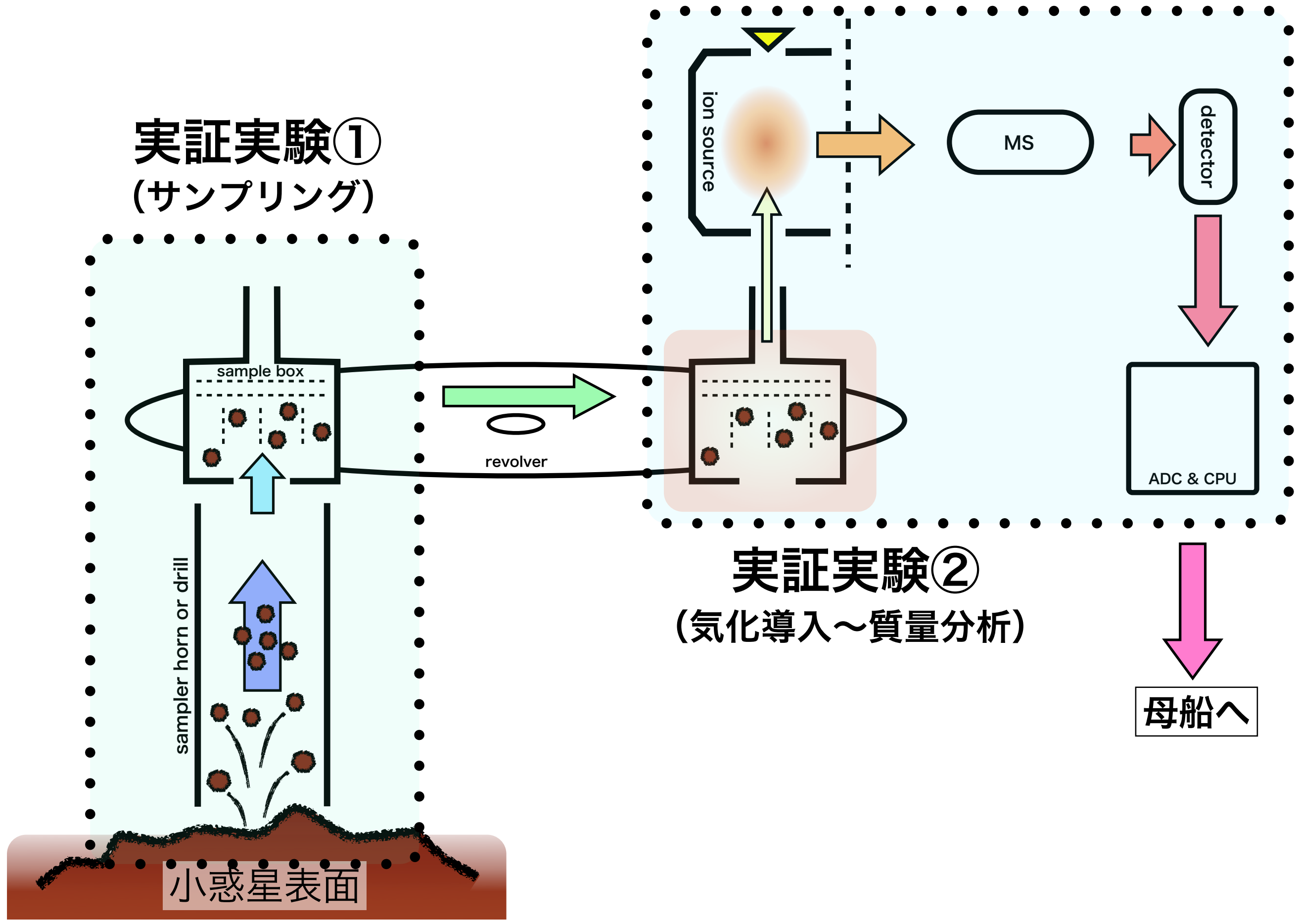


ソーラー電力セイルによる木星トロヤ群への着陸探査

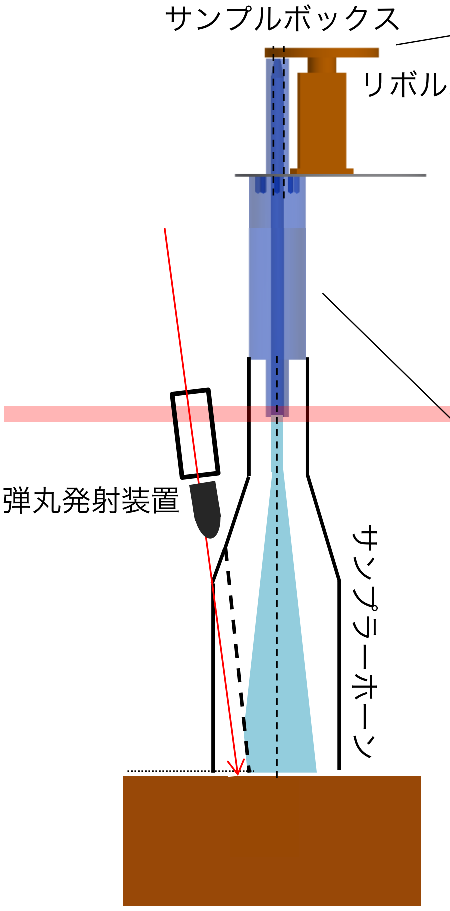


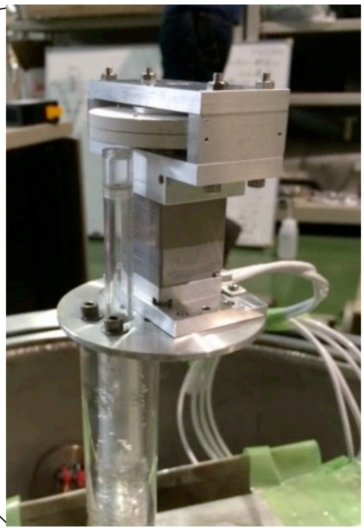
分析シークエンスの概略図

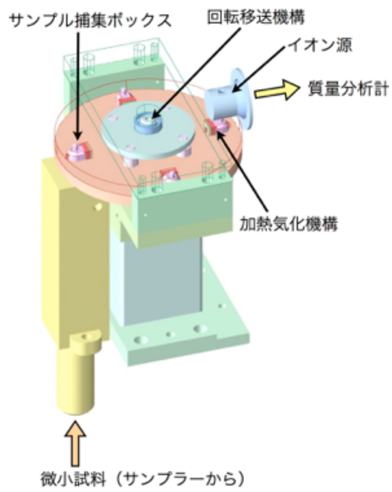


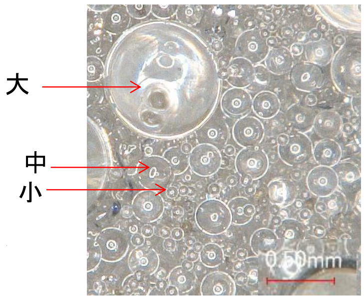


サンプリング実験



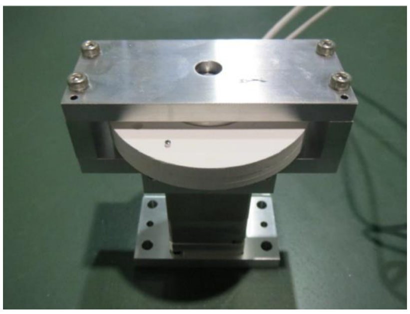






・模擬レゴリス
ガラスビーズ（サイズ３つ）

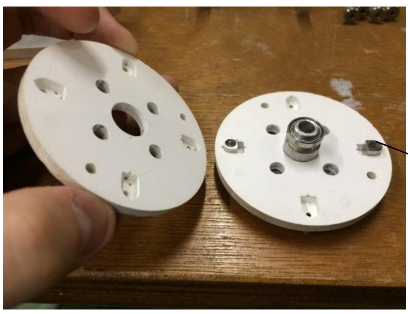
リボルバー（サンプルボックス搬送機構）



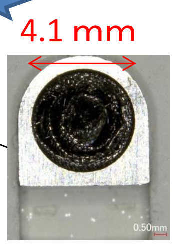
リボルバー外観

裏返した回転部

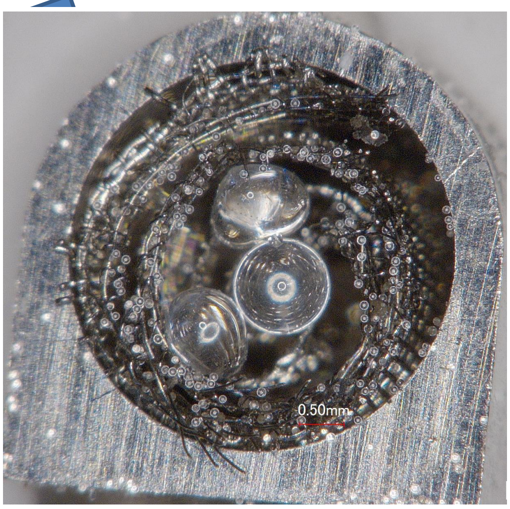
回転部を分解



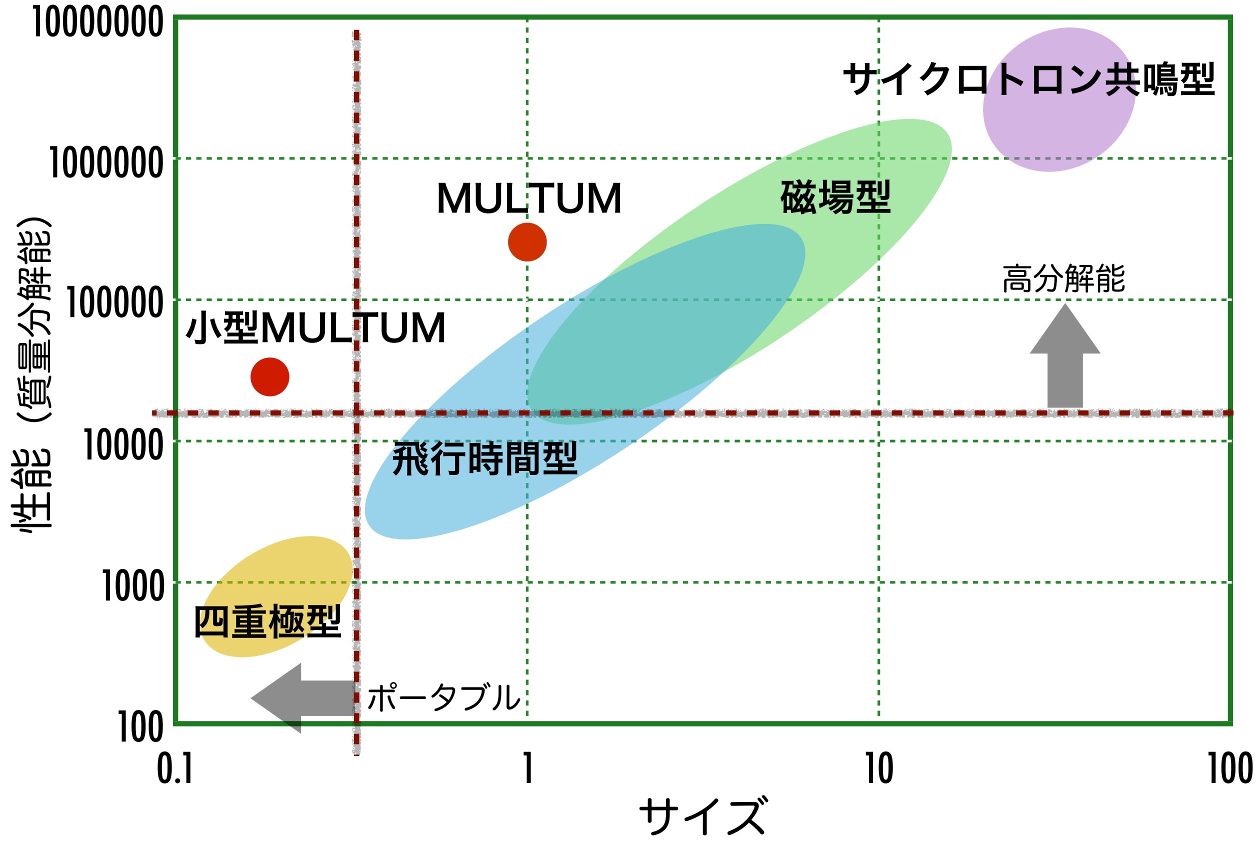
サンプルボックスを4つ収納できる

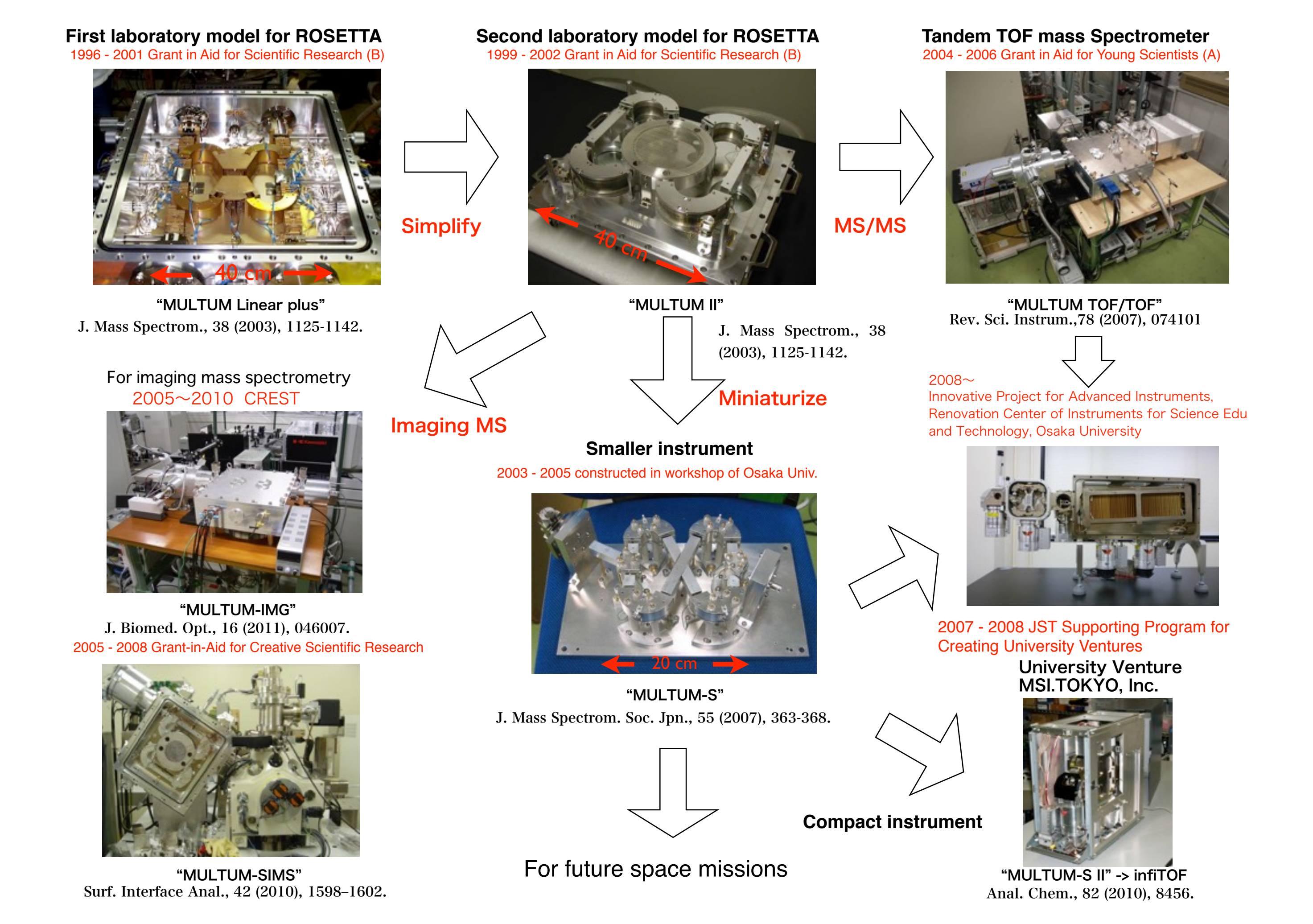


サンプルボックス



質量分析装置のサイズと性能の関係

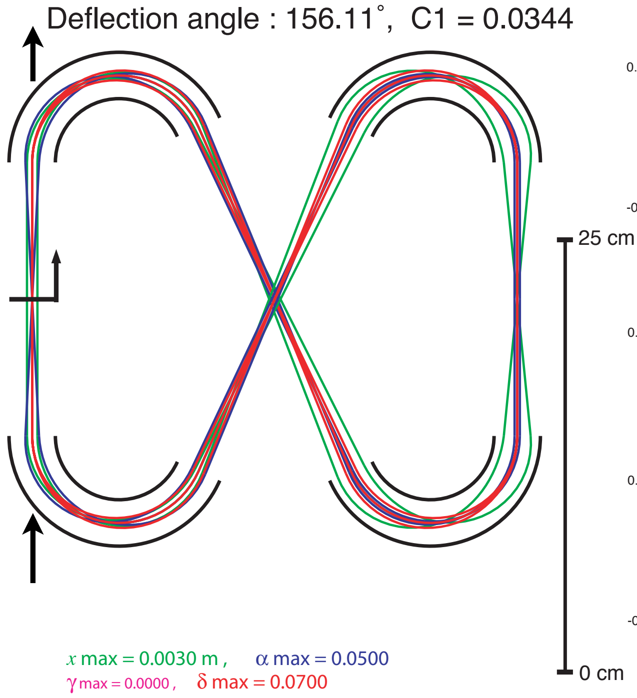


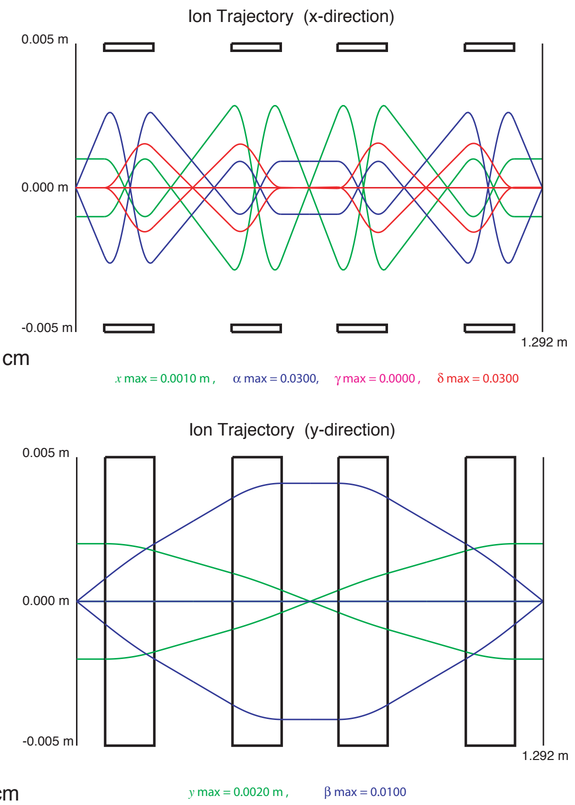


MULTUMのイオン光学系

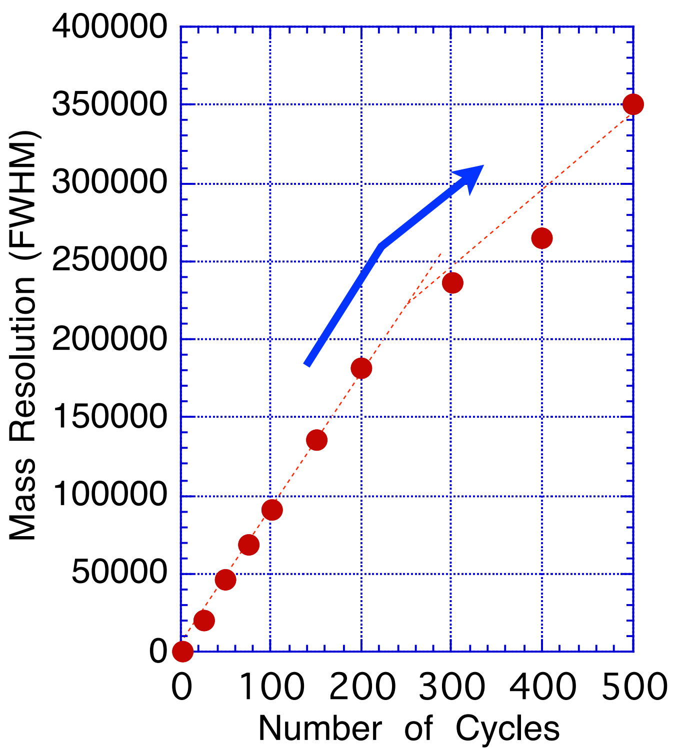
Toroidal Electric Sector

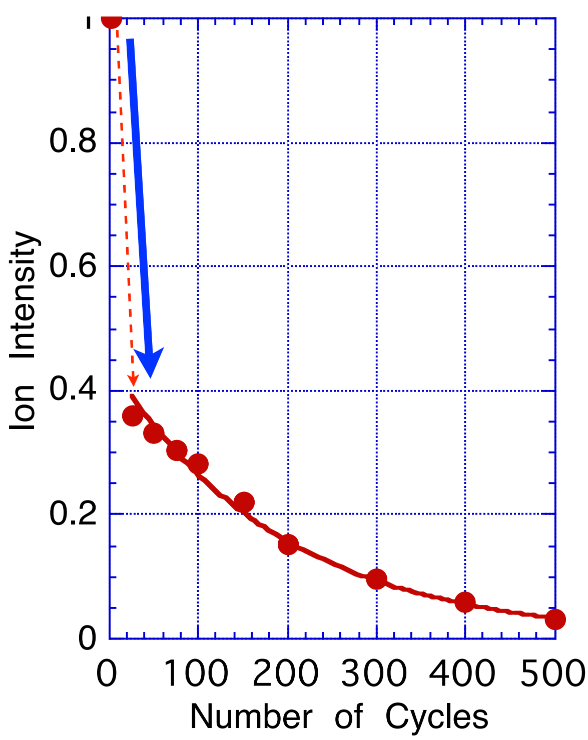
Deflection radius : 50 mm,
Deflection angle : 156.11˚, C1 = 0.0344



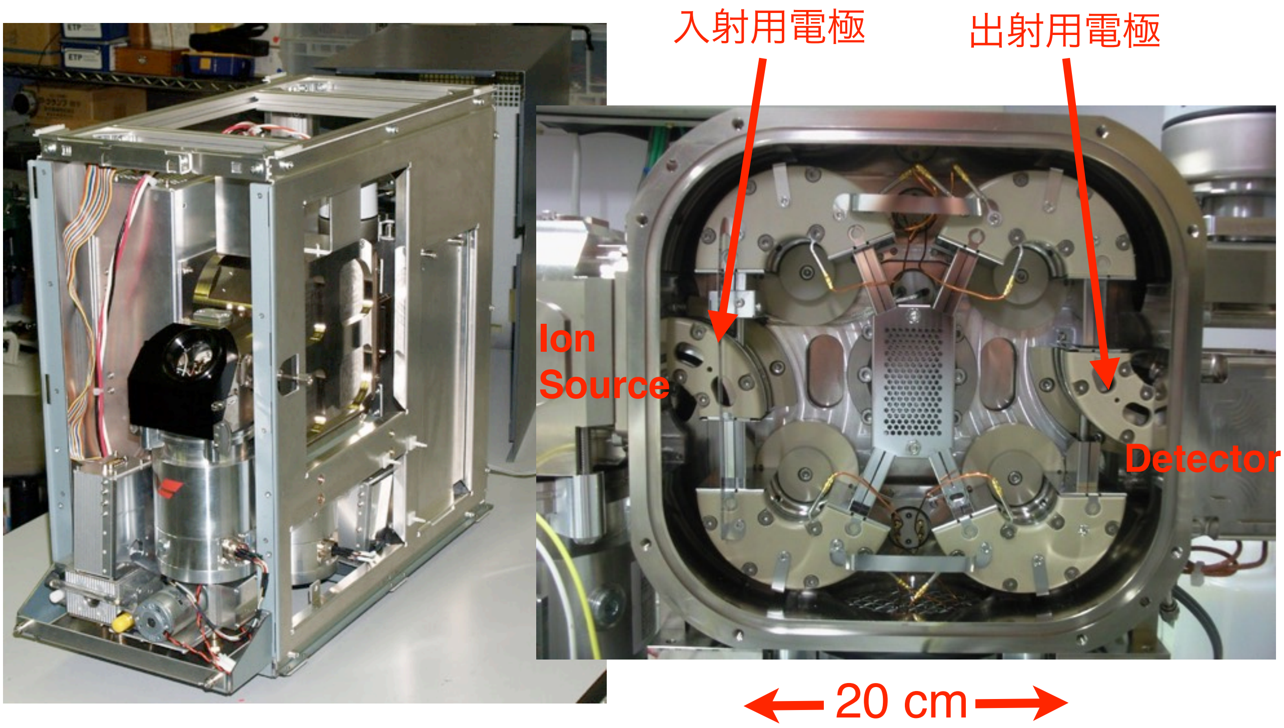


MULTUMにおける周回数と質量分解能/透過イオン量の関係

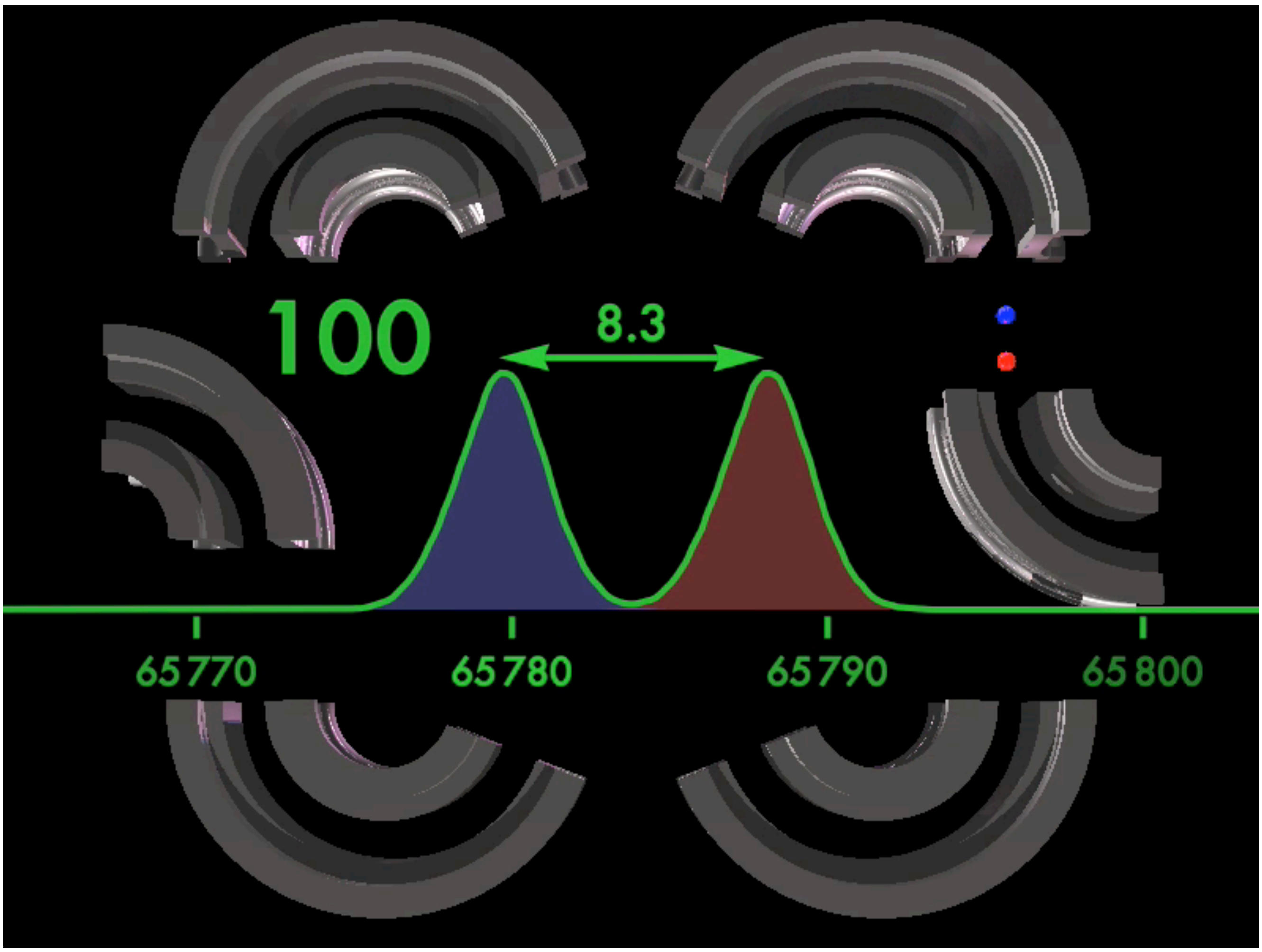




小型MULTUMを用いた質量分析装置の写真

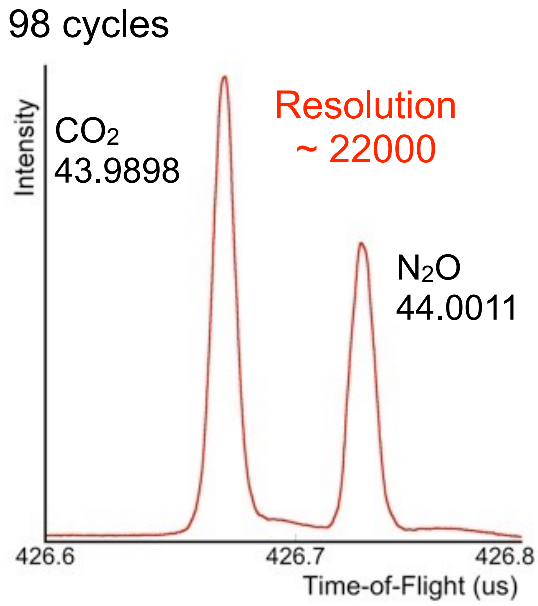


50 (H) cm × 30 (W) cm × 60 (D) cm,　35kg

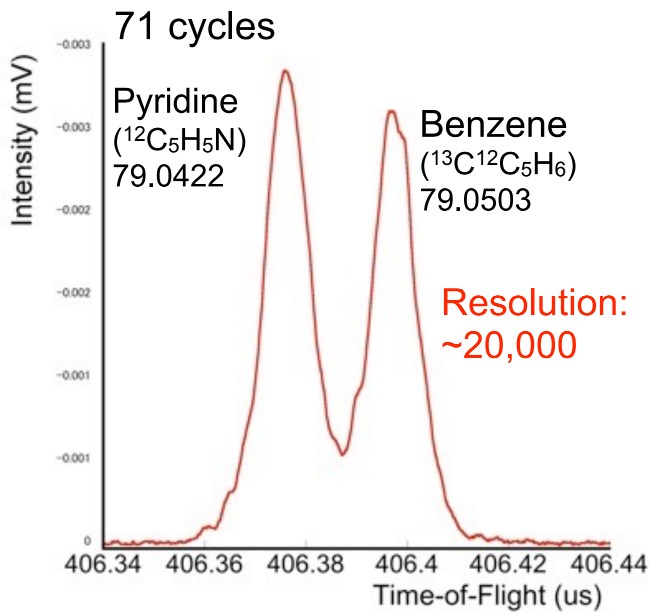


小型MULTUMによる高質量分解能測定

CO_2 - N_2O doublet



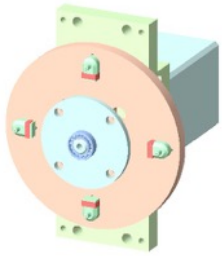
Pyridine - Benzen doublet

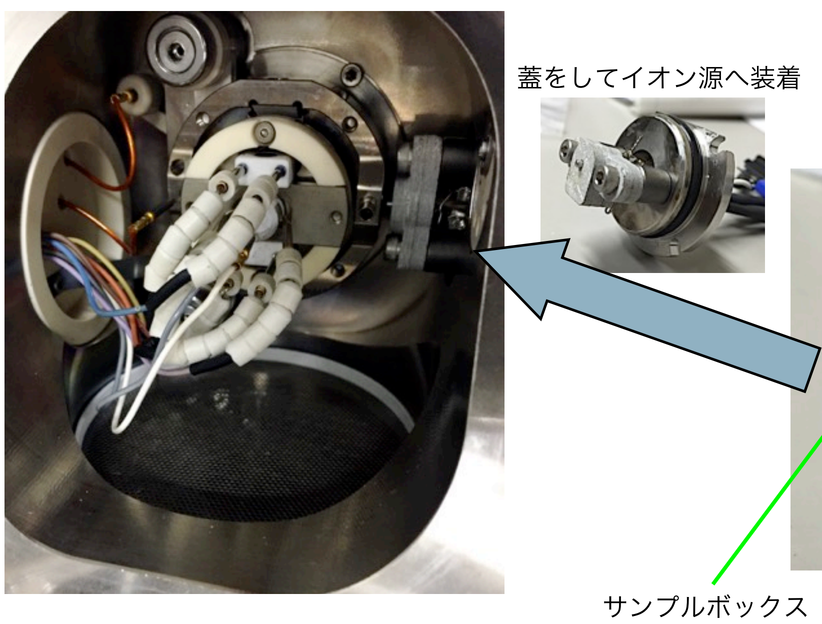


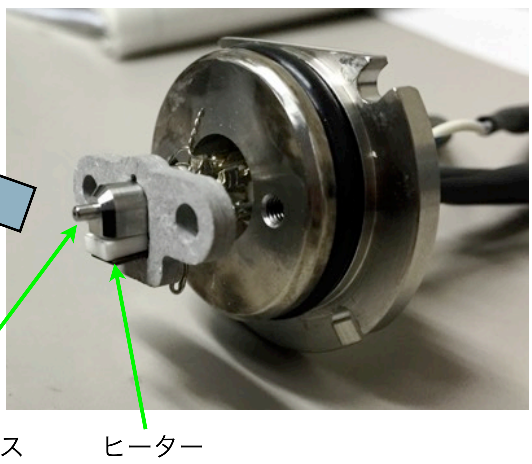
サンプル気化導入実験

・サンプルボックスを１つだけ固定して設置できる構造
・サンプルボックスはリボルバーに装着されるものと同一
・上記の条件は真空チャンバーのサイズによる制約

リボルバー(参考)

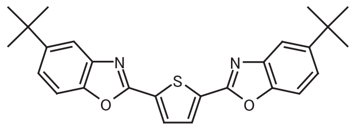






BBOTの測定結果

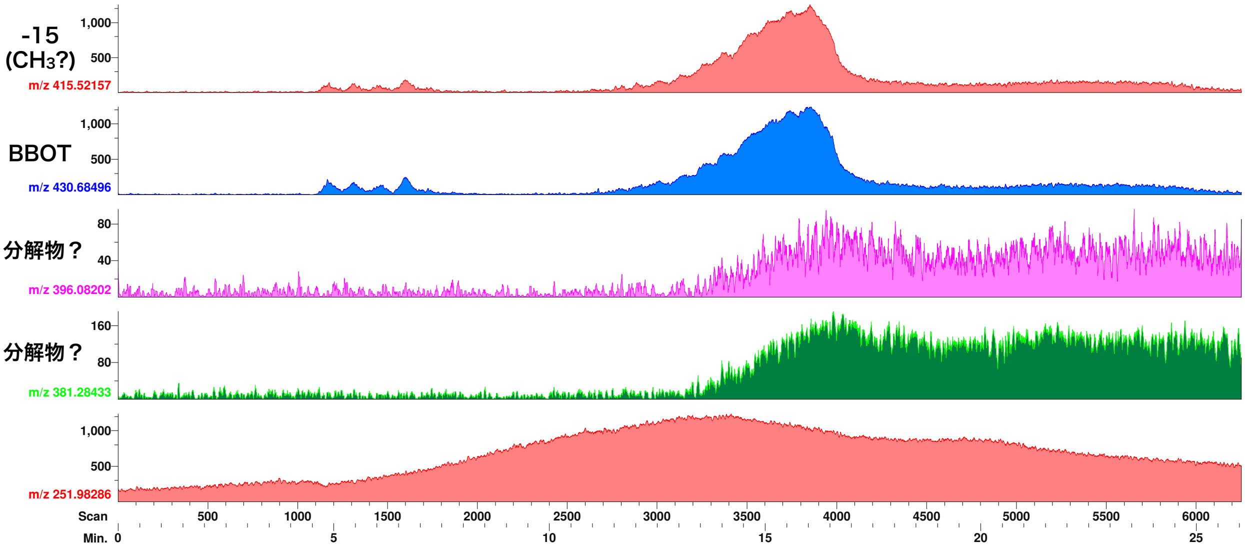
2,5-Bis(5-*t*-butyl-2-benzoxazolyl)thiophene



組成式：$C_{26}H_{26}N_2O_2S$

m/z：430.17

BBOT 4.4mgをエタノール 1.32ml に懸濁し
そこから 3μl をサンプルボックスへ滴下。(BBOT 10μg換算)



※横軸は昇温経過時間だが温度計測がうまくいっていないので温度換算できず

現段階の開発要素：質量分析装置用高圧電源