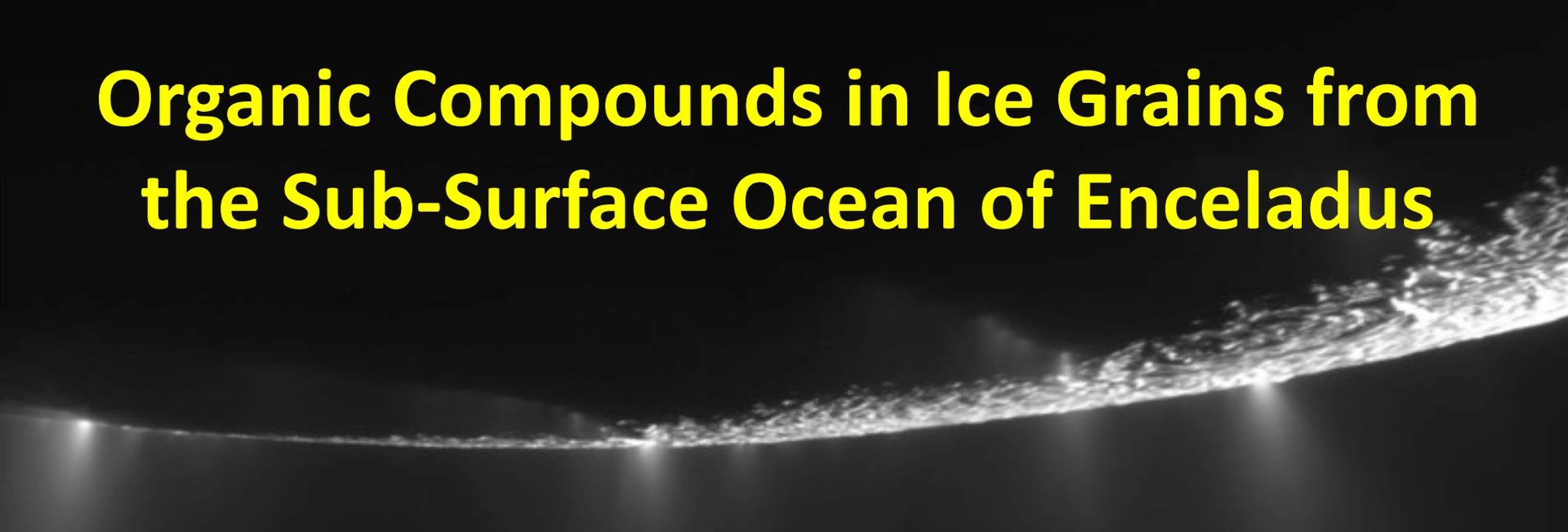


Organic Compounds in Ice Grains from the Sub-Surface Ocean of Enceladus



Nozair Khawaja*; Frank Postberg*

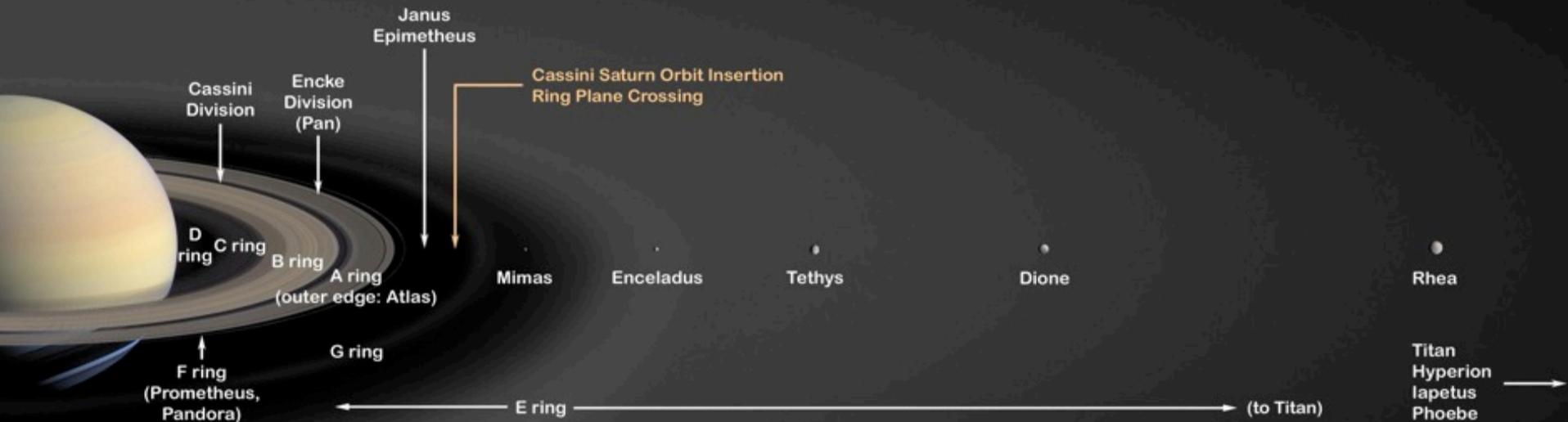
Fabian Klenner*; René Reviol*; Lenz Nölle*; Ralf Srama**

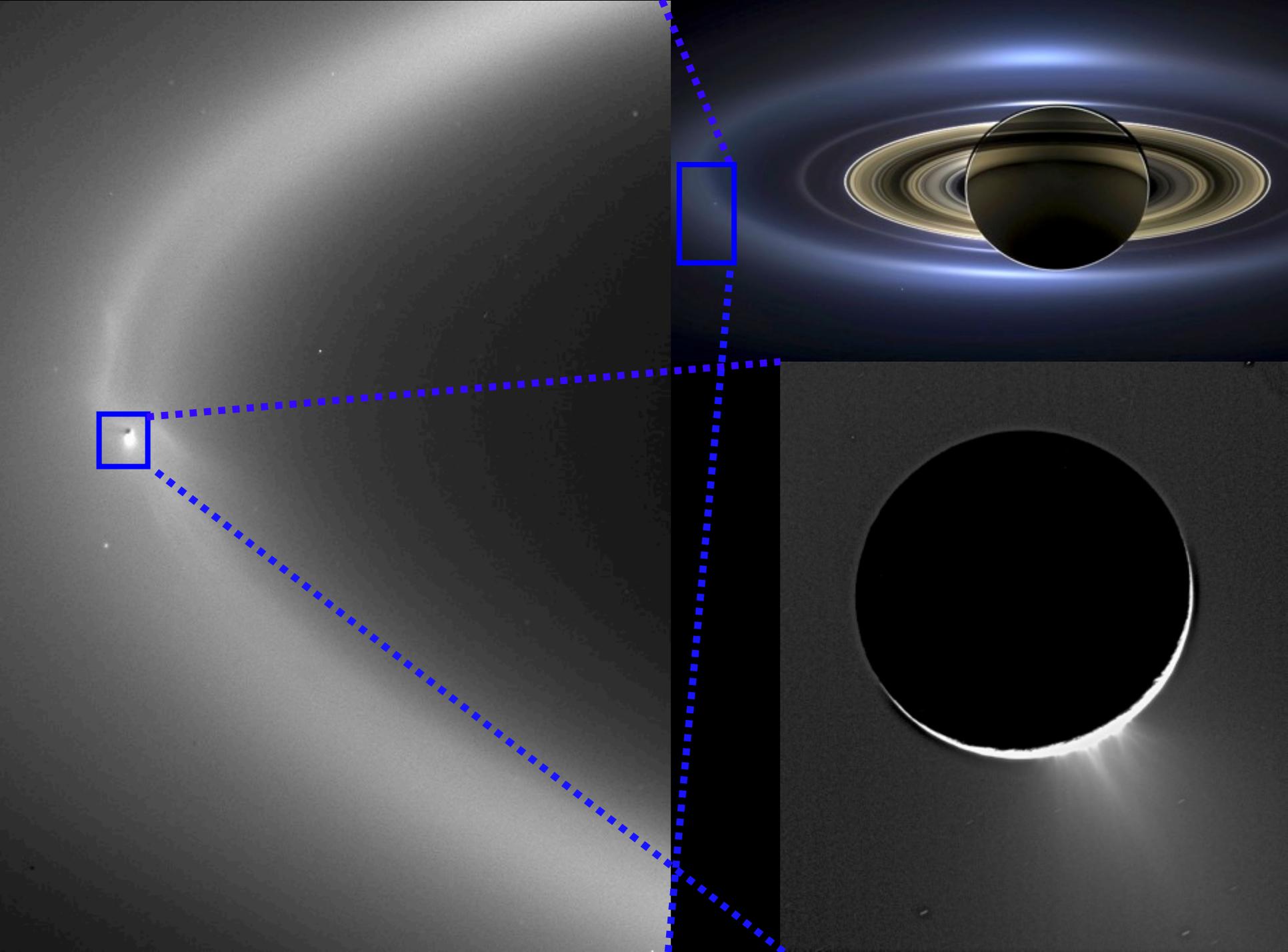
*Institute of Earth Sciences, Uni. of Heidelberg-Germany

**Institute of Space Systems, Uni. of Stuttgart-Germany

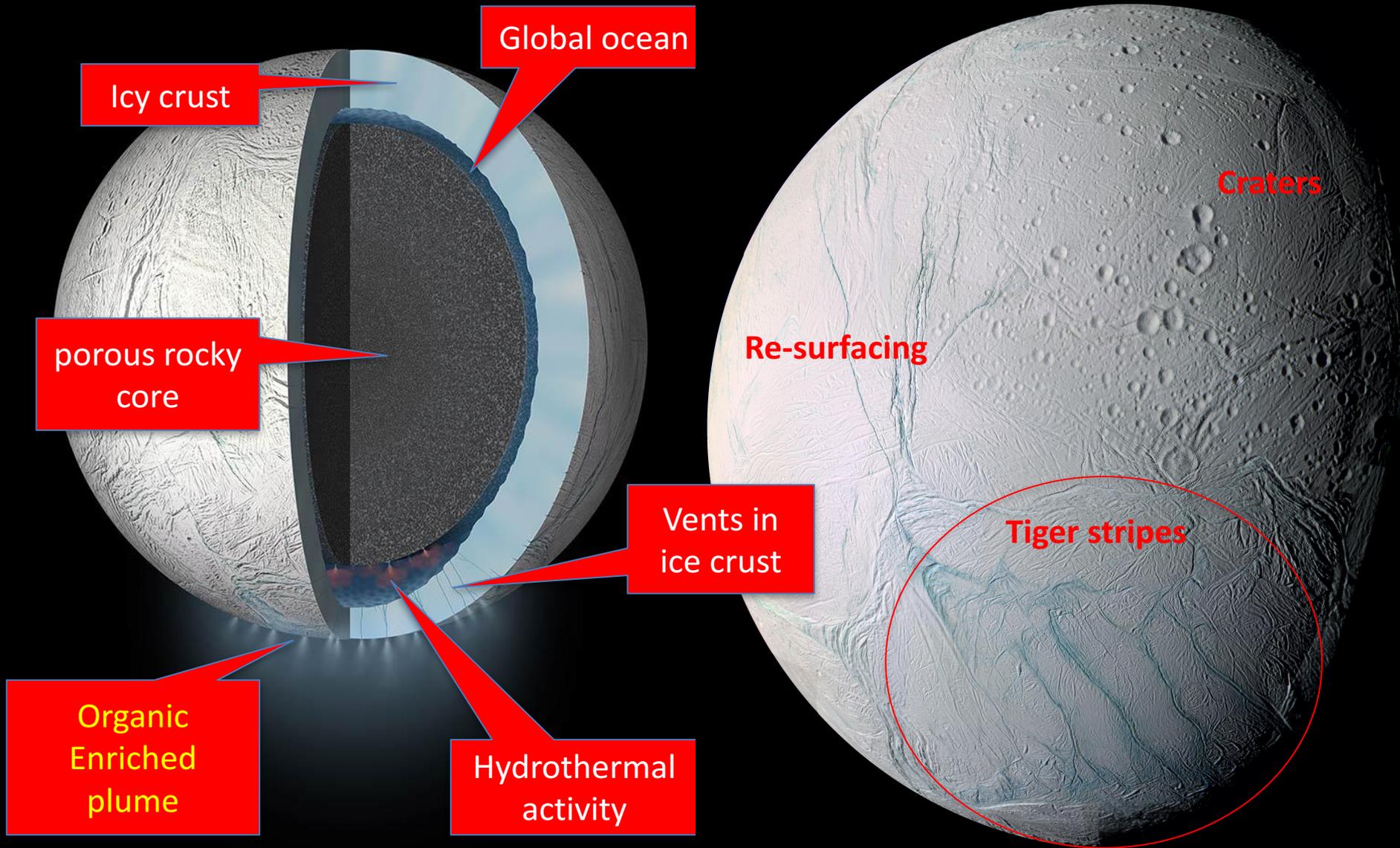
51st ESLAB Symposium - Extreme Habitable Worlds; 4-8 December, 2017

Saturn & its Rings

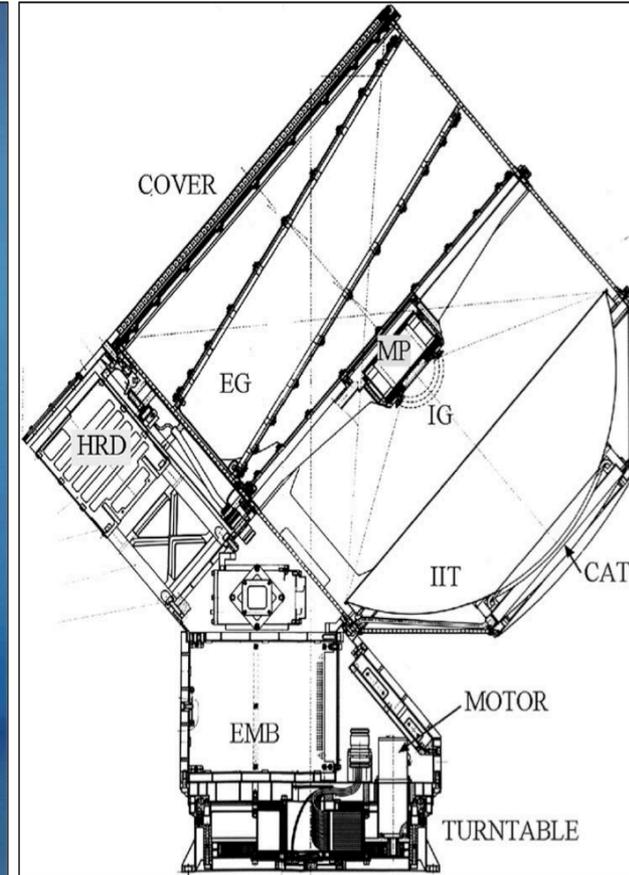
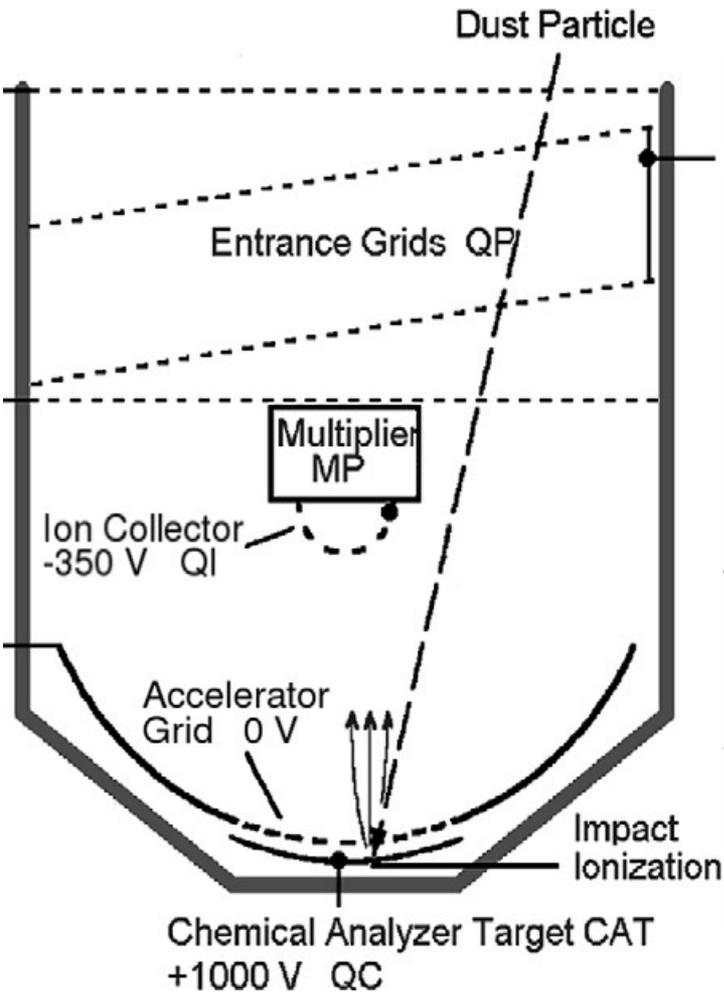




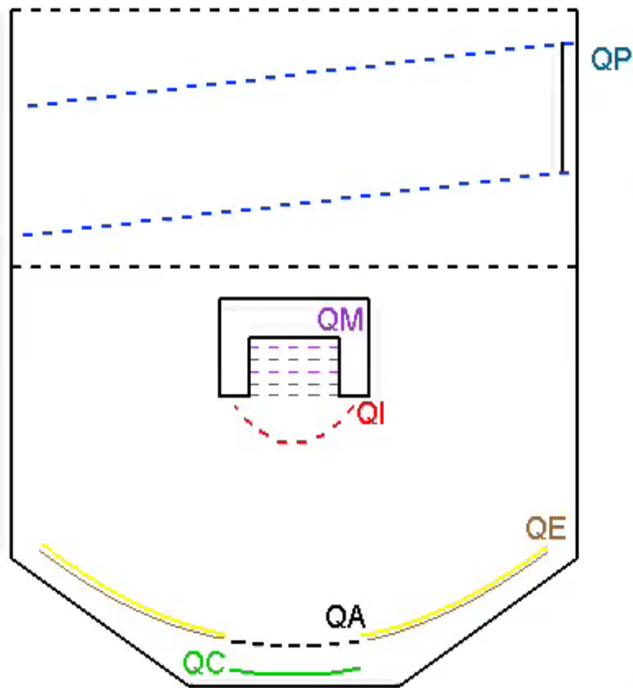
Enceladus—Saturn's Active Ocean World



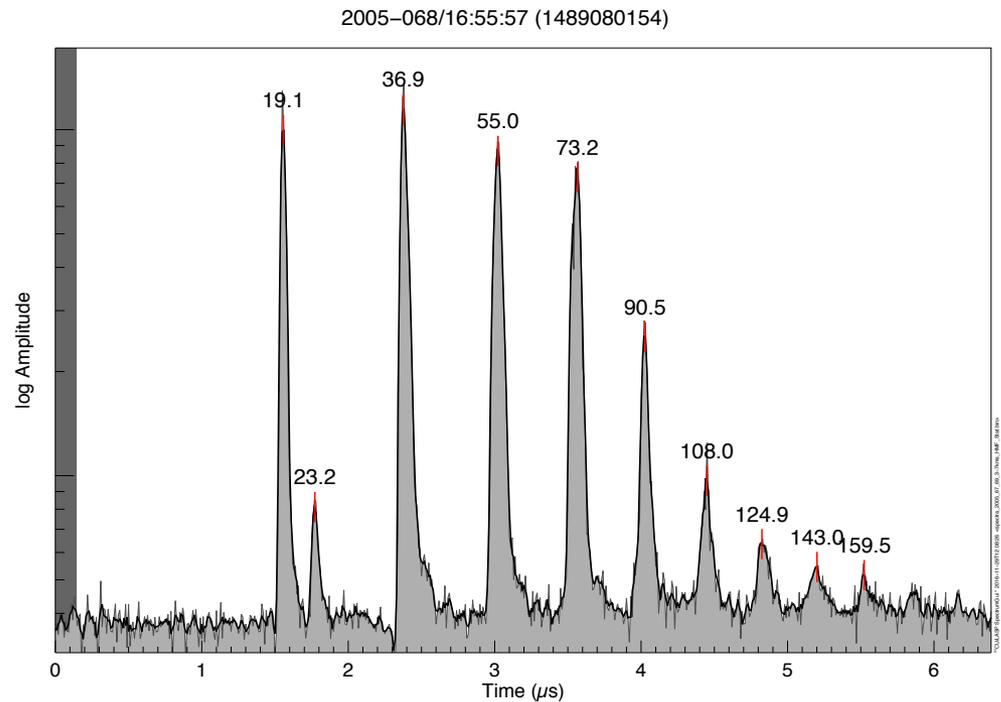
Cosmic Dust Analyzer (CDA)



Cosmic Dust Analyzer (CDA)



Dust Impact-Ionization Mechanism



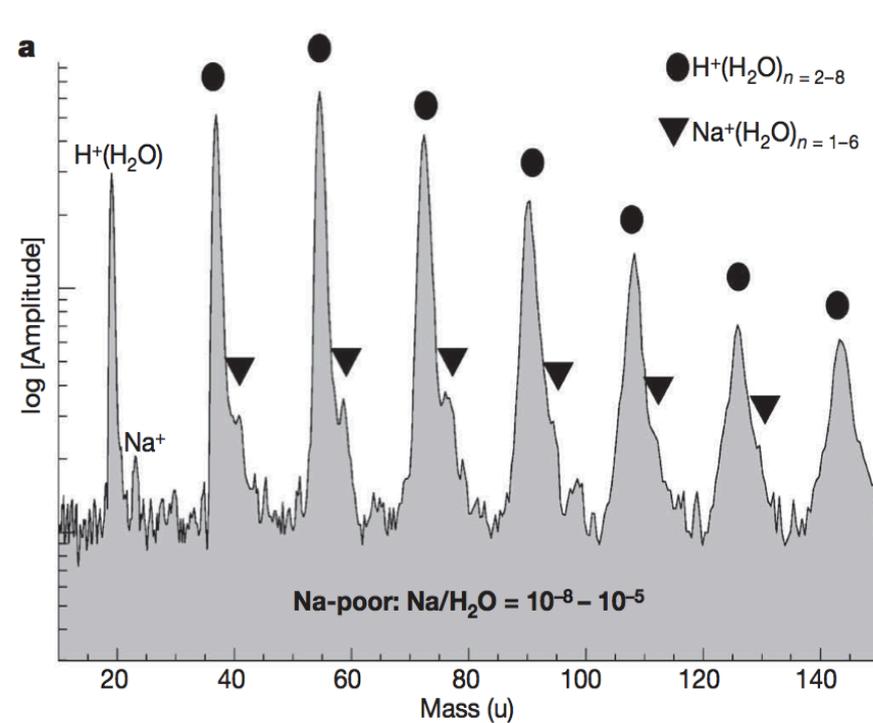
Cationic ToF Mass Spectrum

Compositional Types in the E ring

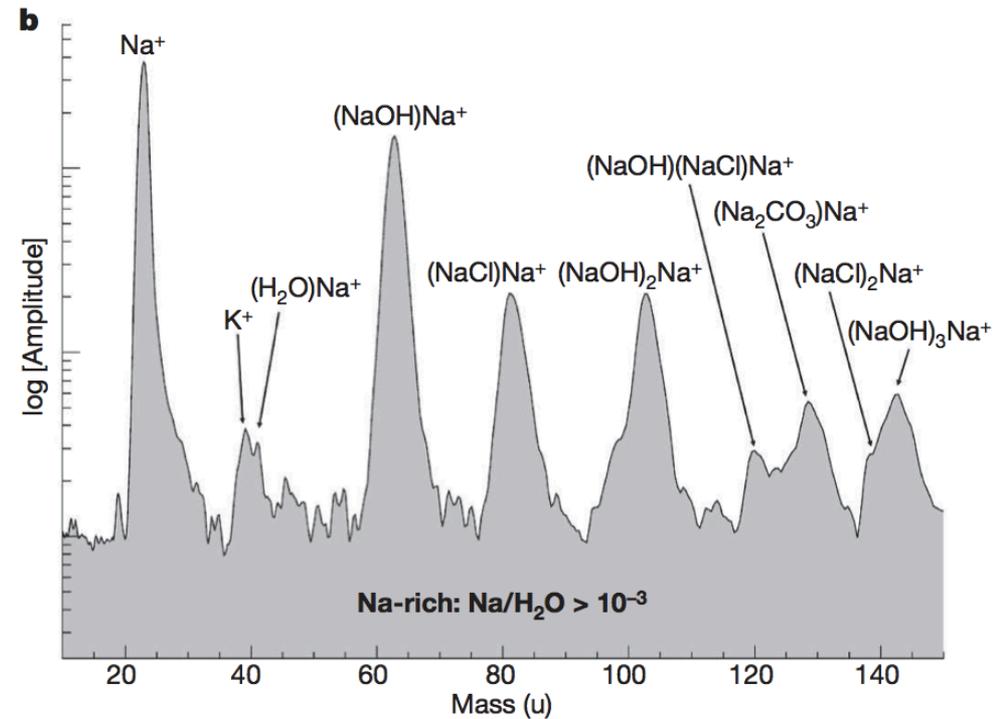
Postberg et al. 2008, 2009, 2011

Type 1 ($\approx 65\%$)

Type 3 ($\approx 10\%$)



almost pure water ice

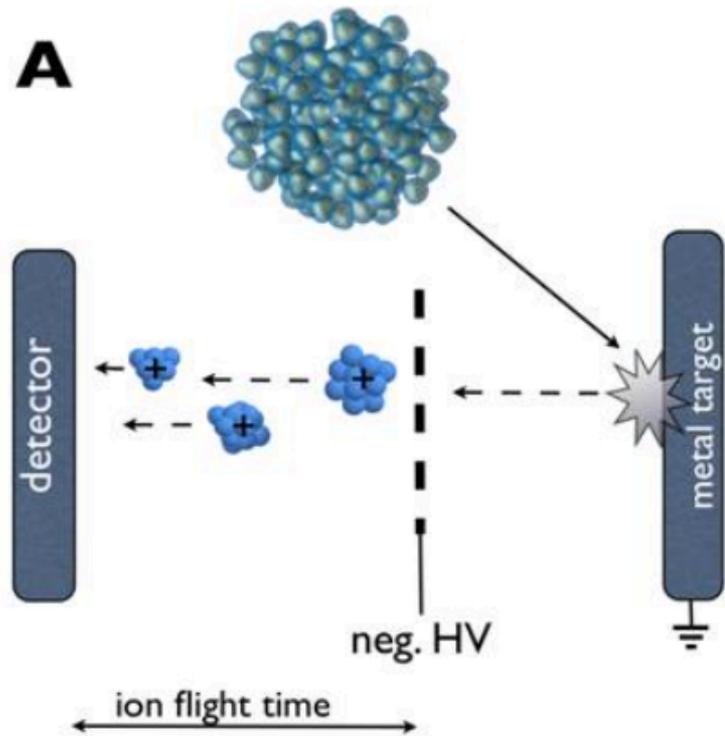


salt-rich water ice

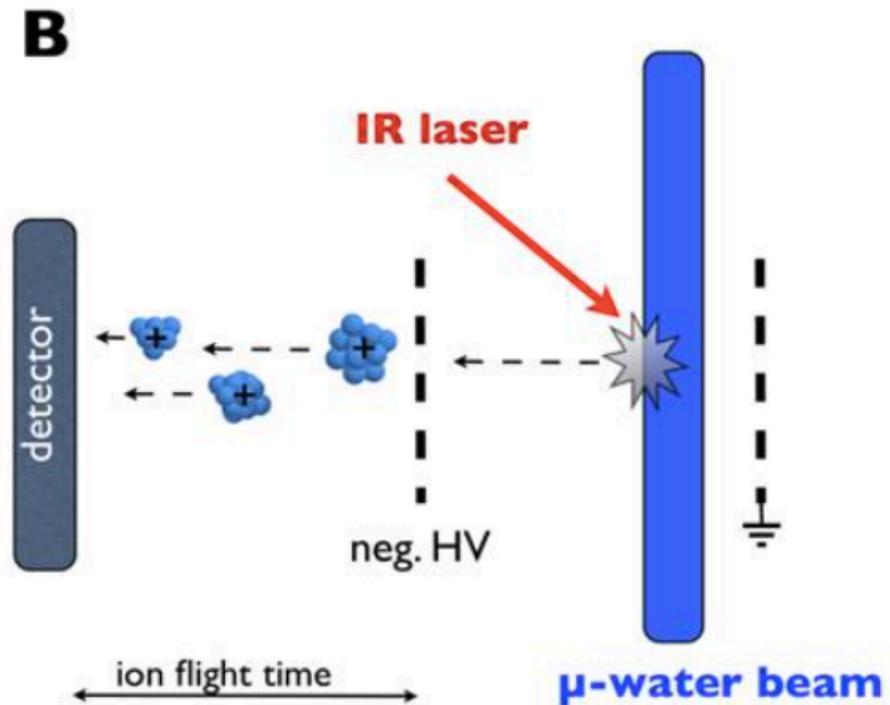
This talk \rightarrow Organic Enriched Ice Grains; Type 2 ($\approx 25\%$)

Comparison of ice impact and laser dispersion

Impact of a micron sized ice grain



Laser dispersion of a liquid water beam



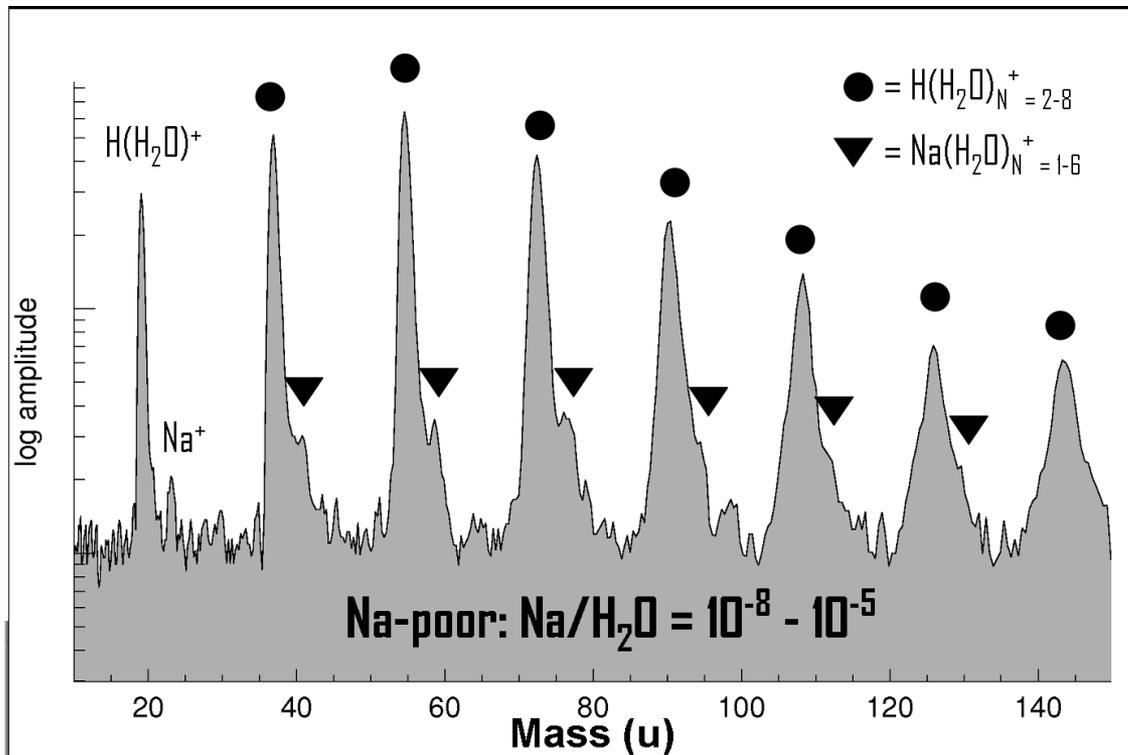
Similar molecular ions and cluster ions are formed

Postberg et al. 2009

Beinsen 2008, 2011

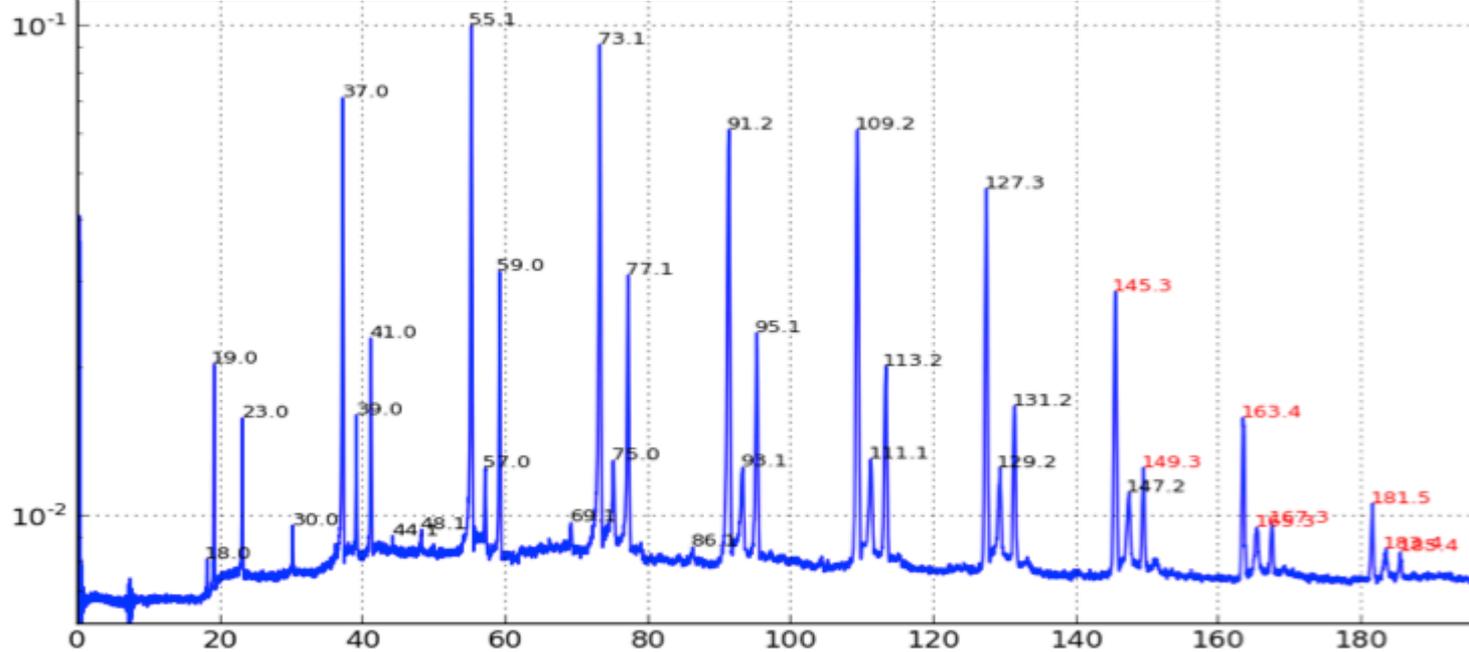
Wiederschein et al. 2015

CDA Spectrum
Type 1



Lab Spectrum

- NaCl 10^{-6} mol/L
- KCl 10^{-8} mol/L

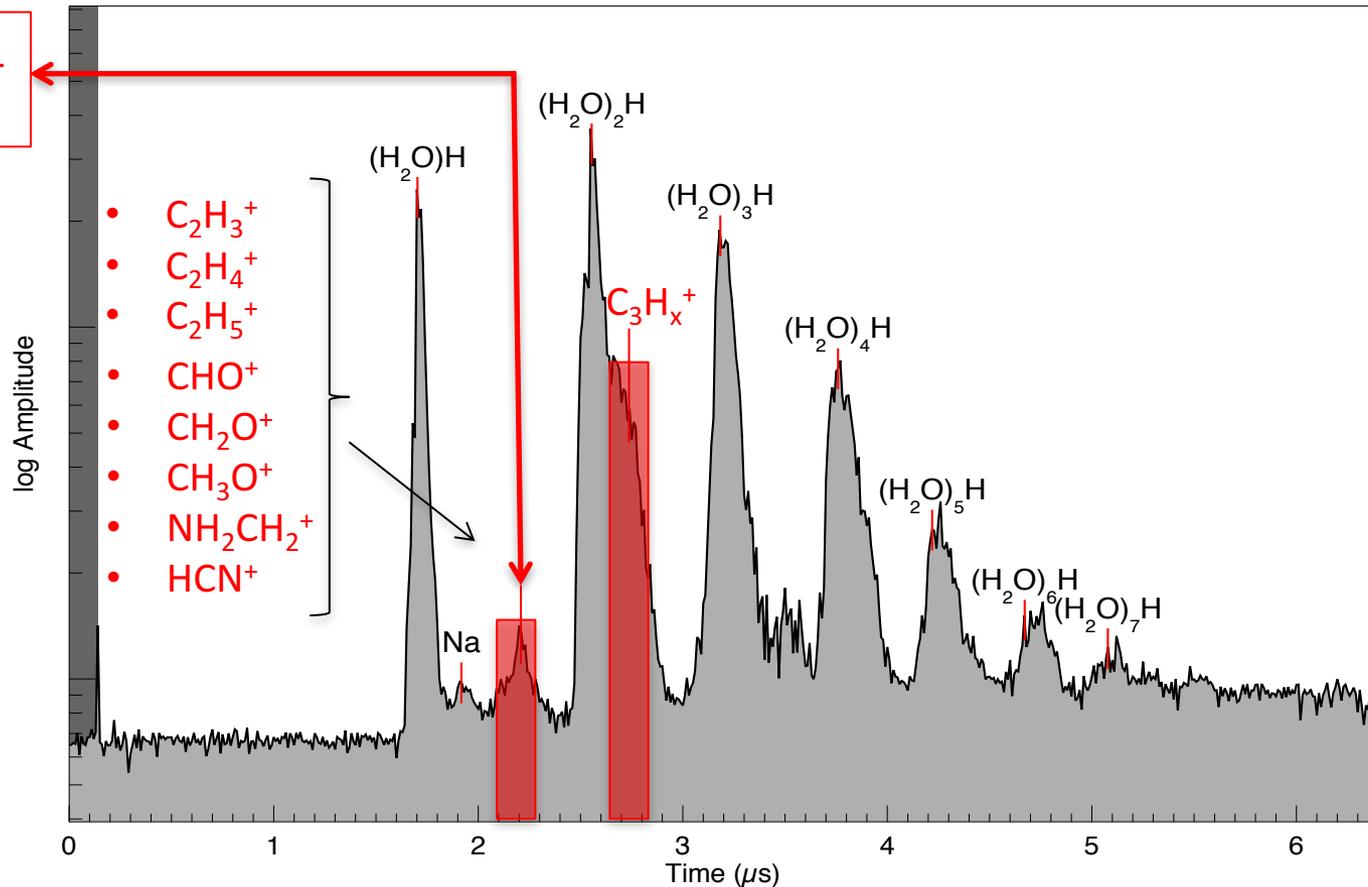


Organic Enriched Ice Grains

Type 2 Grains

2005-303/07:39:04 (1509350871)

$m/z \sim 26-31$
29u feature

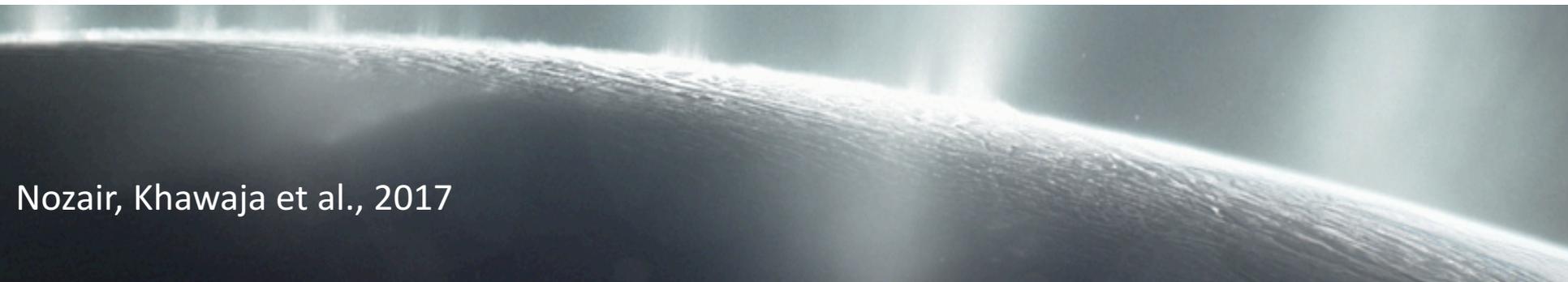
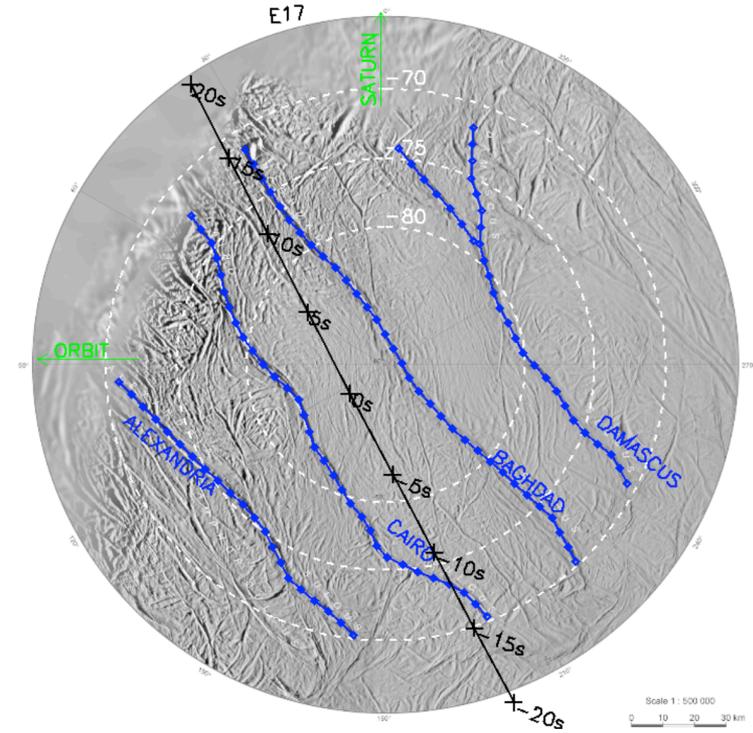
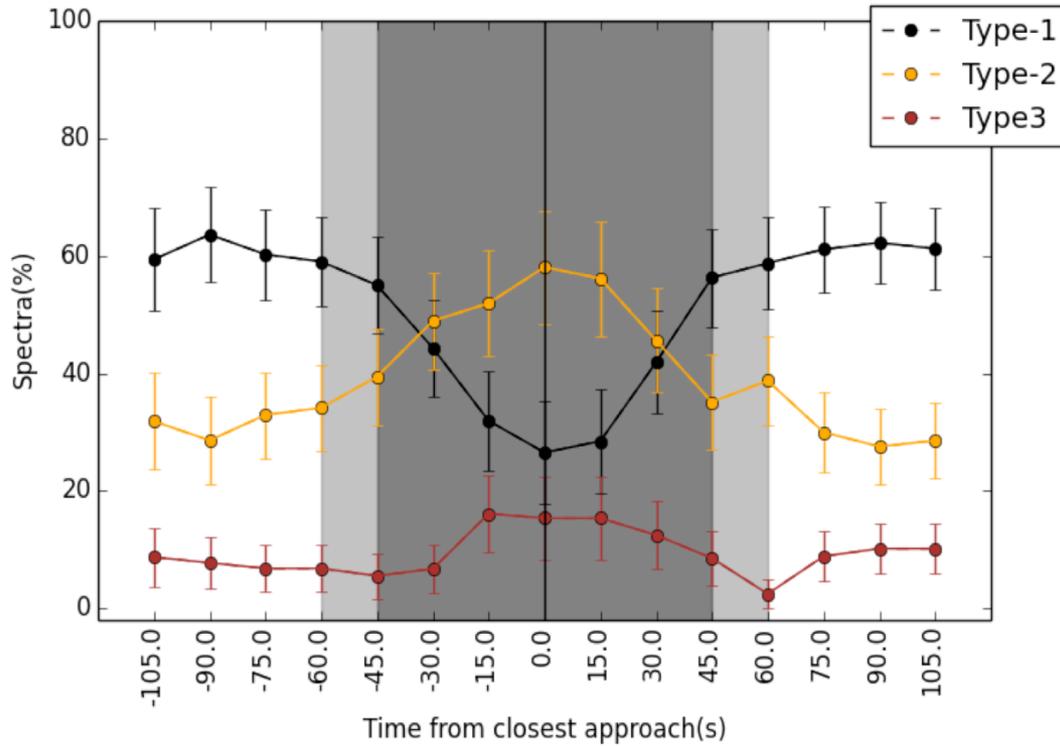


This talk \rightarrow Organic Enriched Ice Grains; Type 2 ($\approx 25\%$)

Organic Enriched Plume

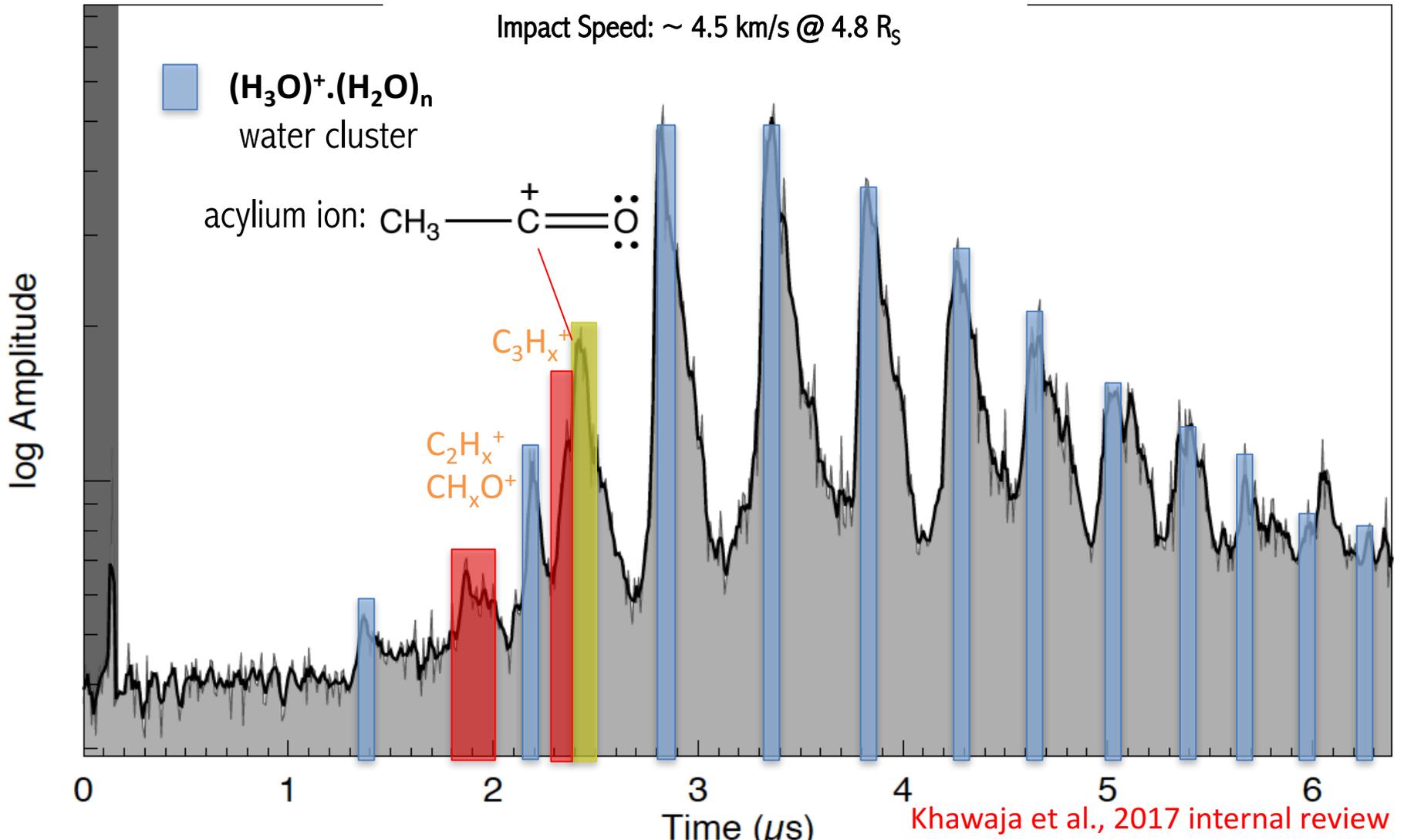
The identification of different classes of organic compounds on the basis of their characteristic fragment cations observed in CDA TOF-MS of Enceladus' ice grains

Compositional Profile of Enceladus' Plume



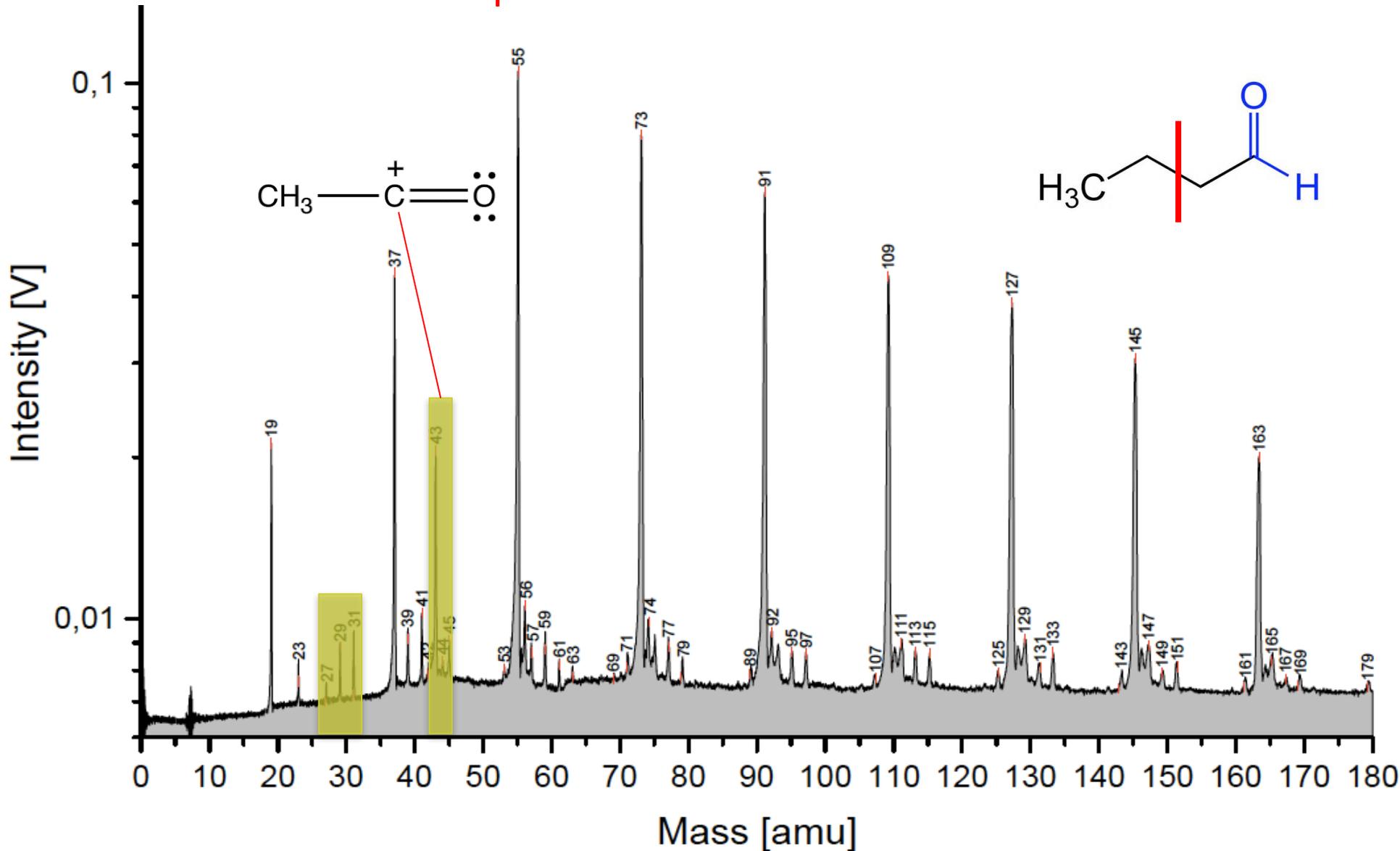
Organic Flavors in Ice Grains

O-Bearing Type 2



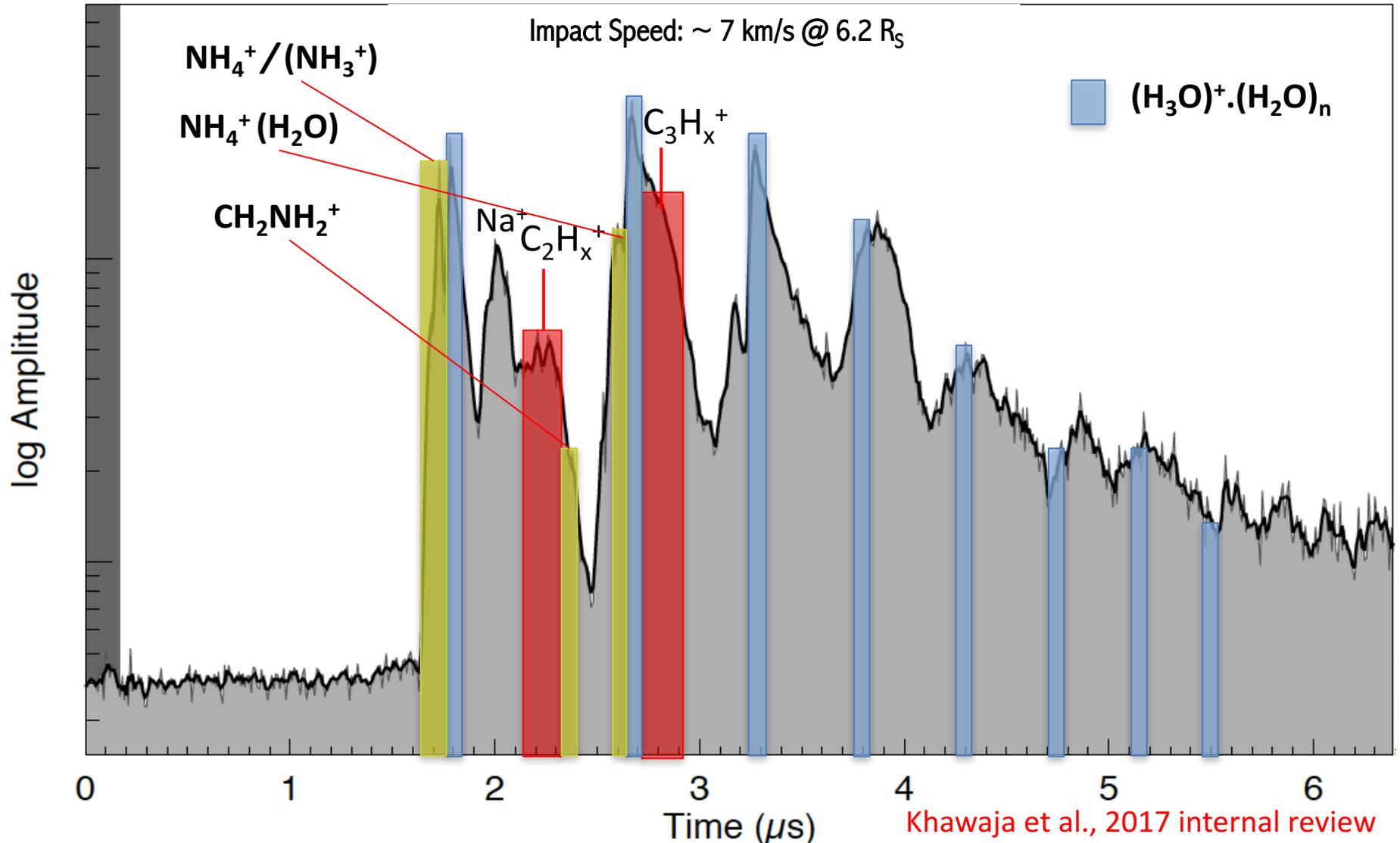
Organic Flavors in Ice Grains

Lab spectrum of butanal in water



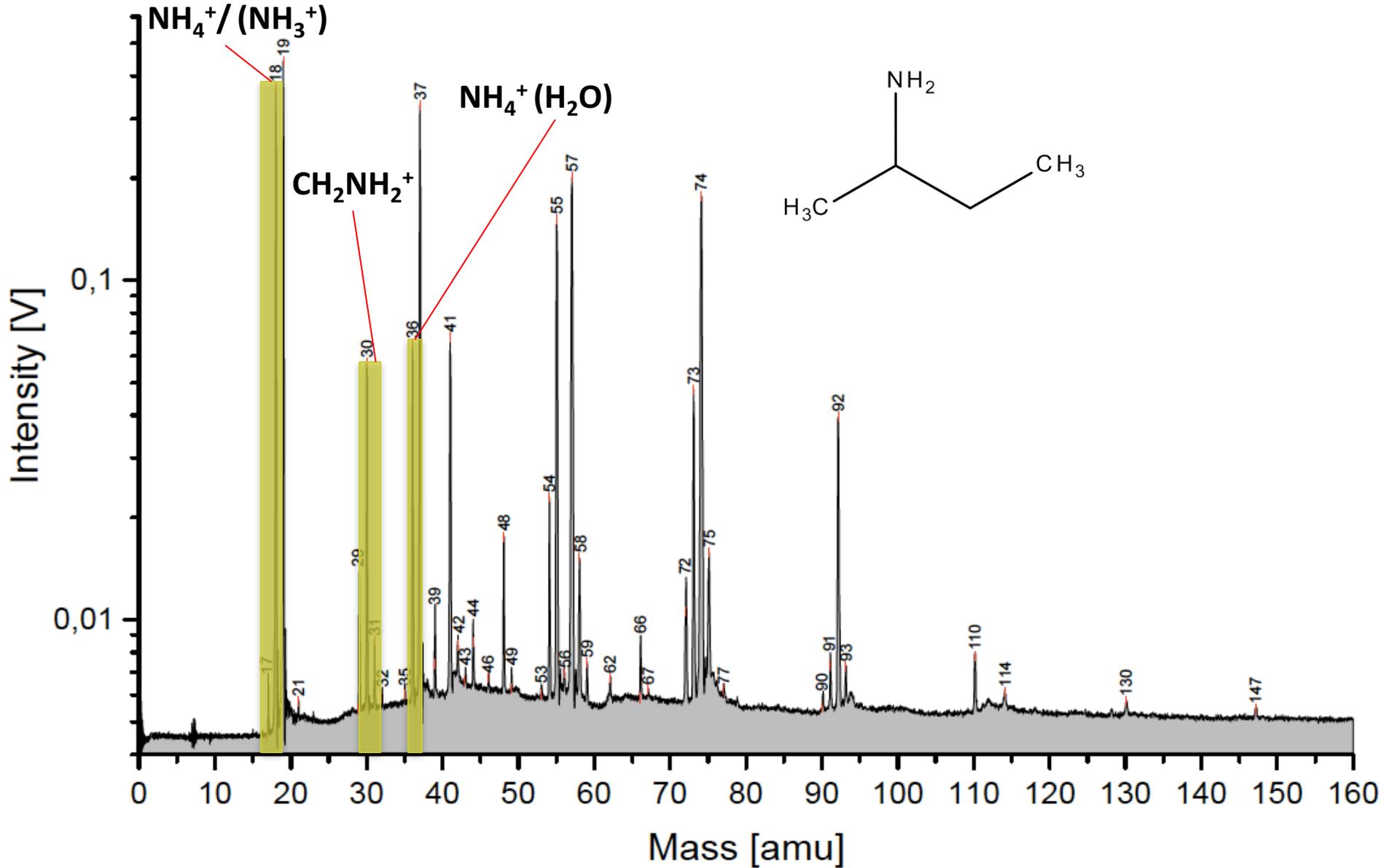
Organic Flavors in Ice Grains

N-Bearing Type 2



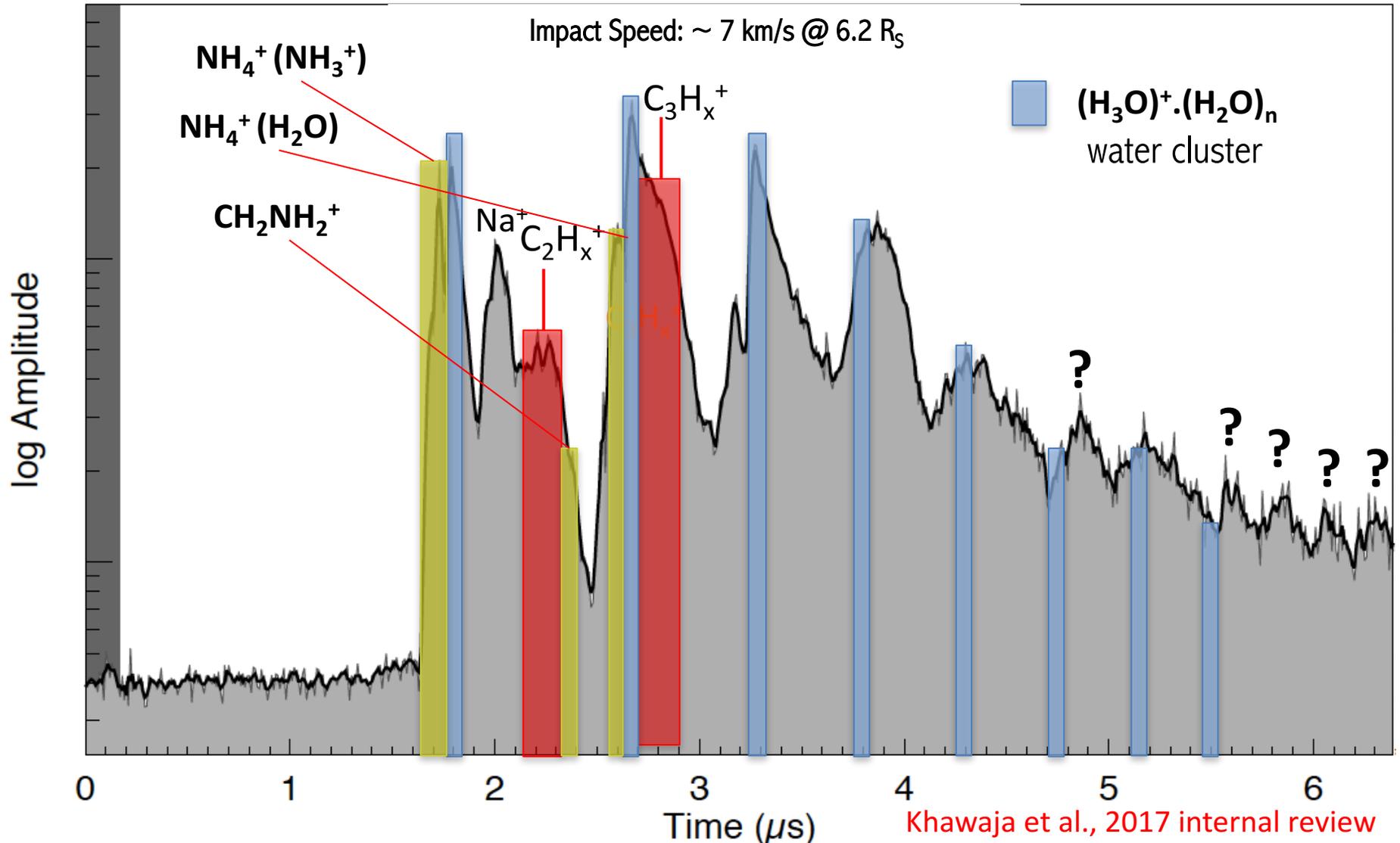
Organic Flavors in Ice Grains

Lab spectrum of butylamine in water



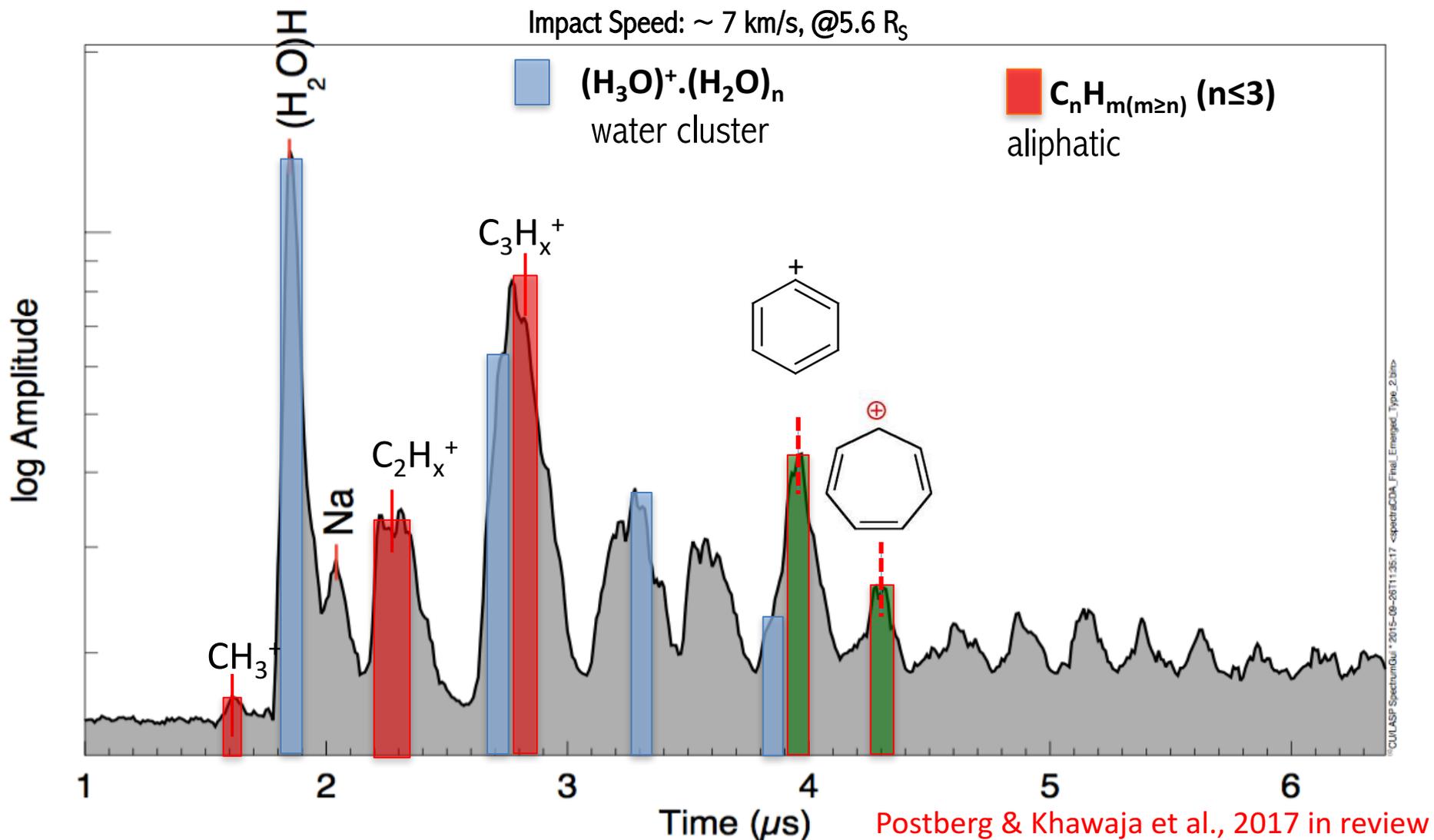
Organic Flavors in Ice Grains

N-Bearing Type 2



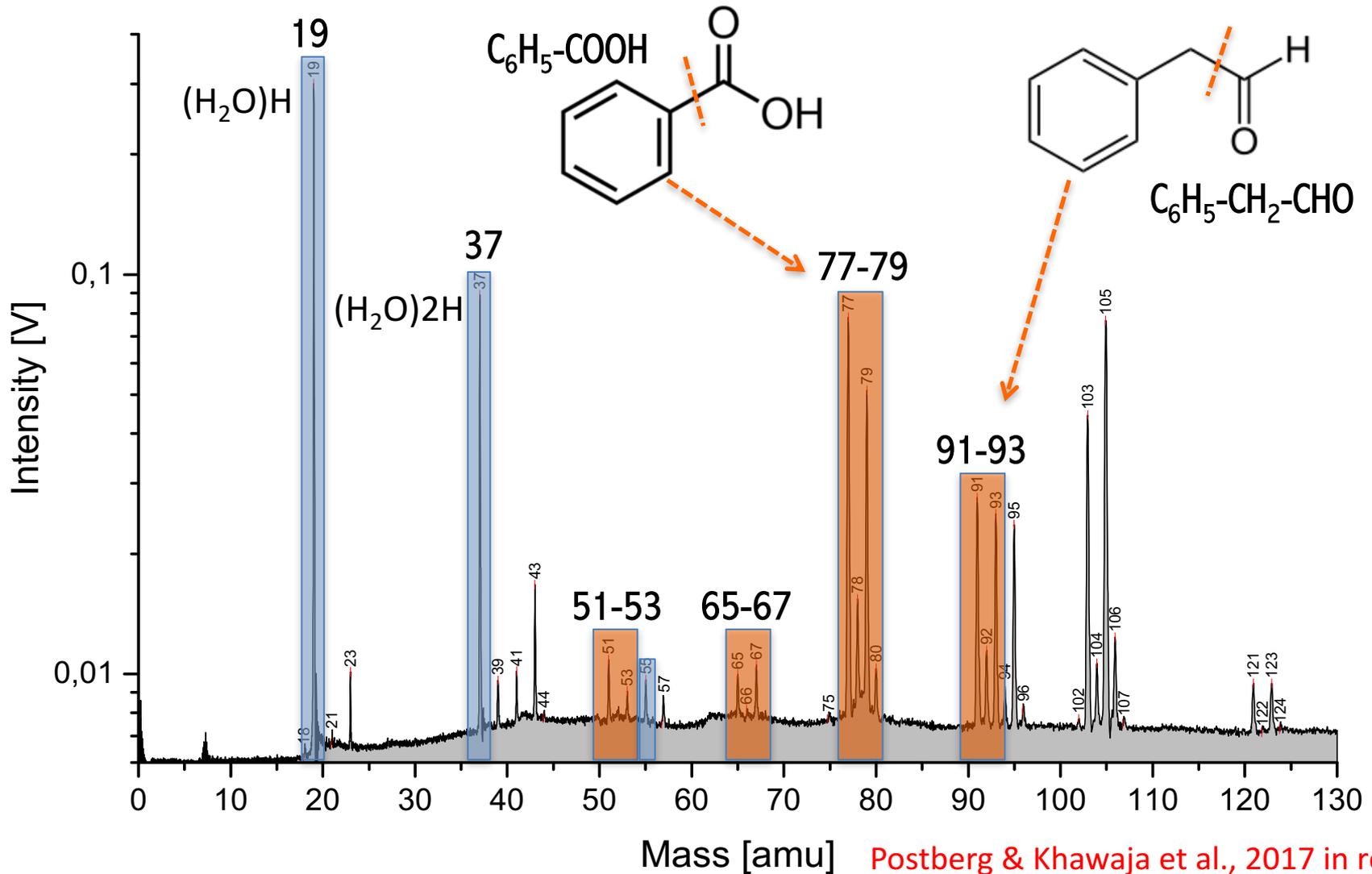
Organic flavors in Ice Grains

Aromatic Type 2



Organic Flavors in Ice Grains

Lab Spectrum of Aromatic compounds



Summary

Organic components exhibit a large variety in quality and quantity:

- About 25% of E ring ice grains bear organic compounds in detectable quantities.
- The concentration varies greatly from grain to grain.
- Most spectra show a mixture of different organics.
- Aromatic, O – and N-bearing species have been identified and verified with analogue experimental setup in Heidelberg (IR-FL-MALDI-MS).
- Occasional cations of more complex organics have been observed and need to be verified.