Merged Beams Studies for Astrobiology

Daniel Wolf Savin
Columbia University

Outline

I. Motivation

II. Experiment

III. Results

IV. Thermal data

V. Conclusions

Outline

I. Motivation

II. Experiment

III. Results

IV. Thermal data

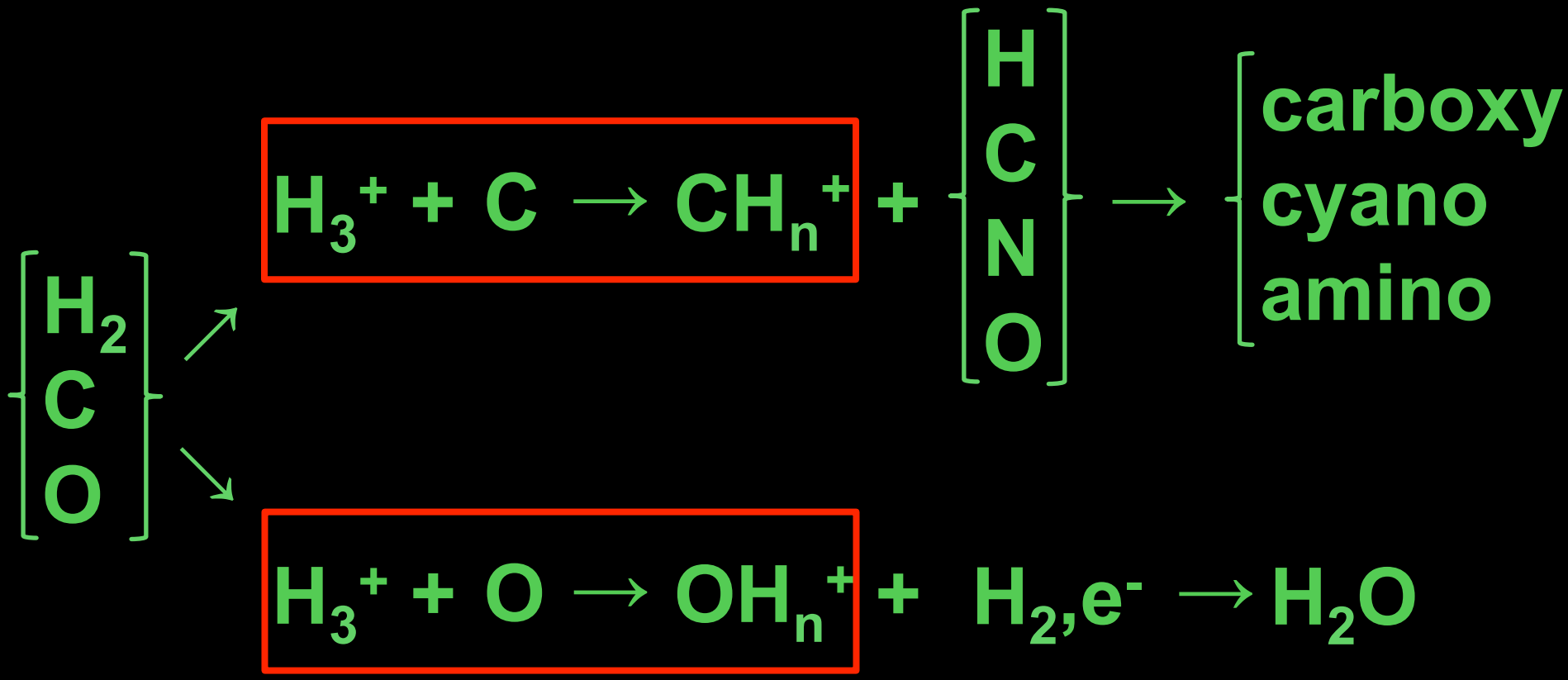
V. Conclusions

Pathway from atoms in space to life on Earth is full of unknowns

?

How far did interstellar chemistry take us along this pathway towards life?

Some gas-phase pathways for forming the chemicals needed for life.



We study some of the first steps towards forming complex organic molecules and water.

Outline

I. Motivation

II. Experiment

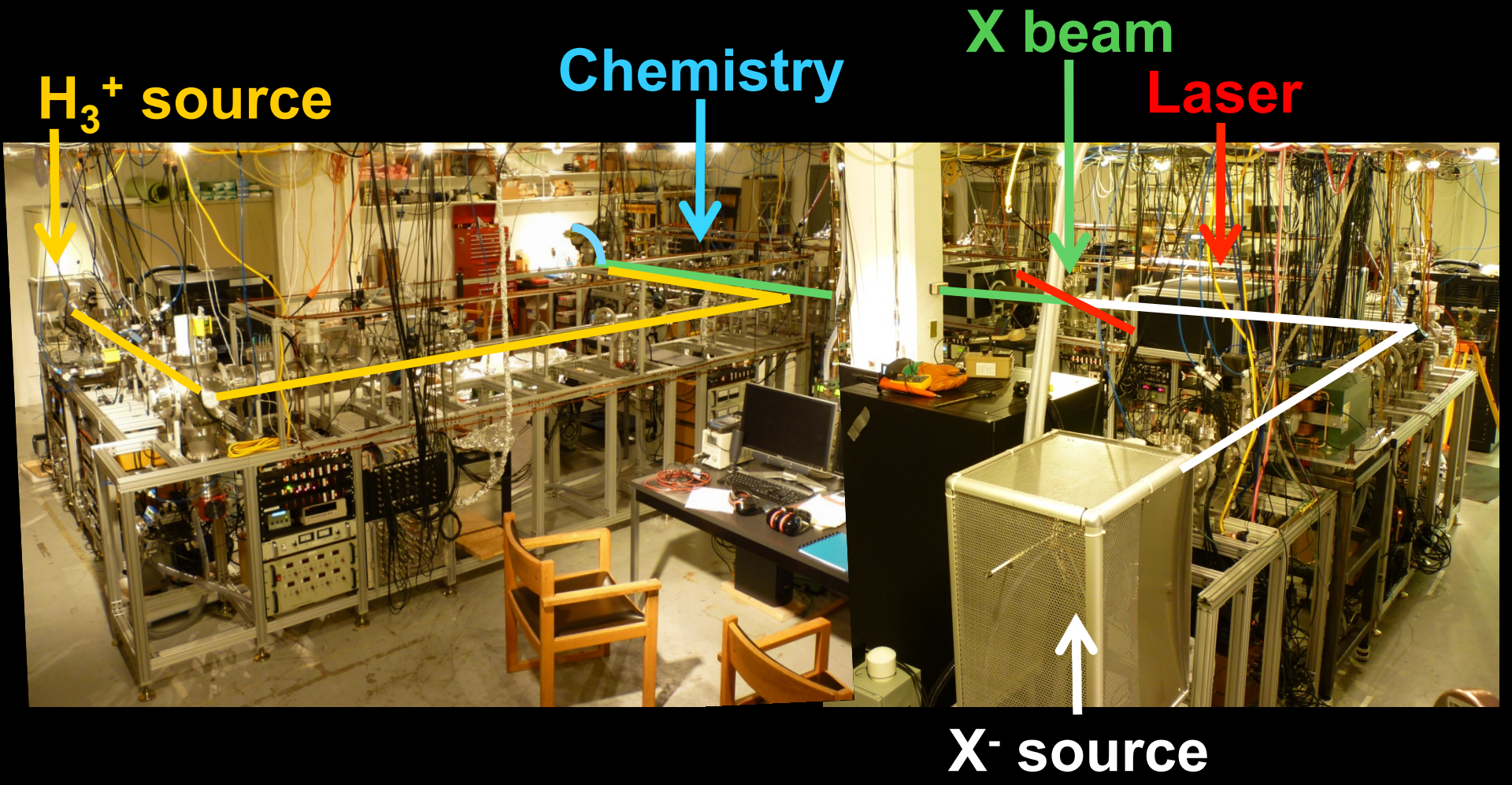
III. Results

IV. Implications

V. Conclusions

We have built an apparatus to study

$$X + H_3^+ \rightarrow XH_n^+ + H_{3-n}$$



Outline

I. Motivation

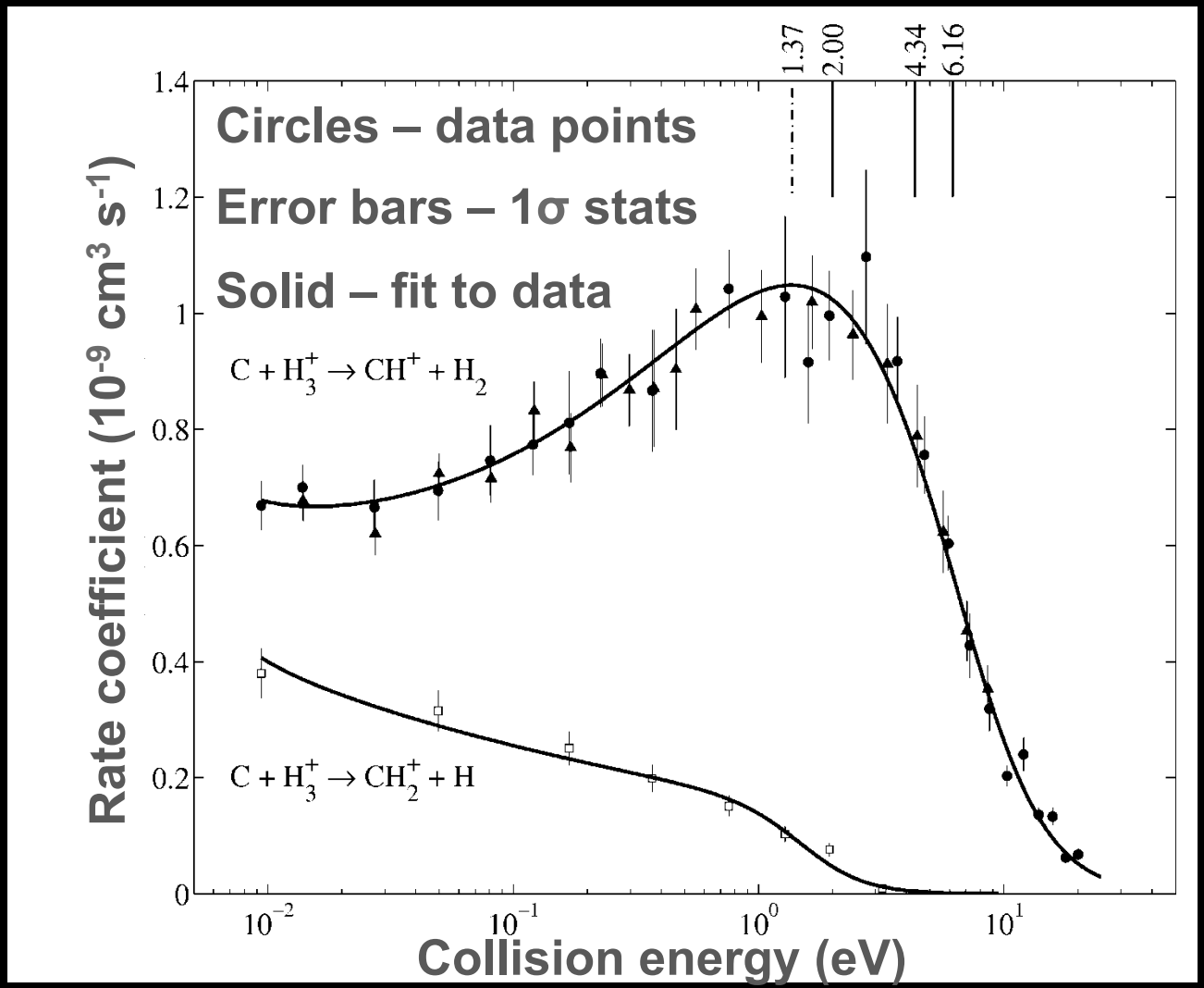
II. Experiment

III. Results

IV. Thermal data

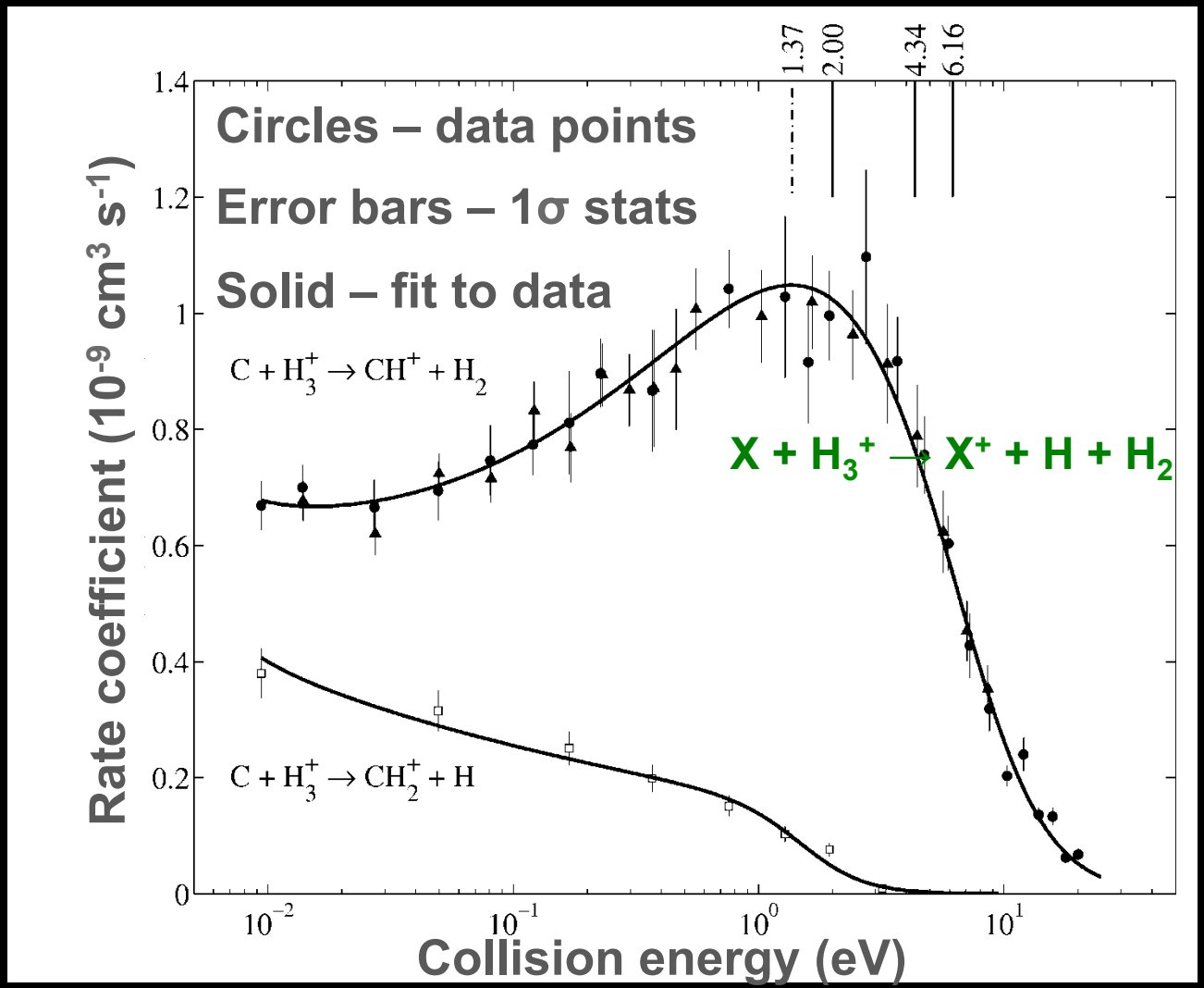
V. Conclusions

$C + H_3^+ \rightarrow$ Products



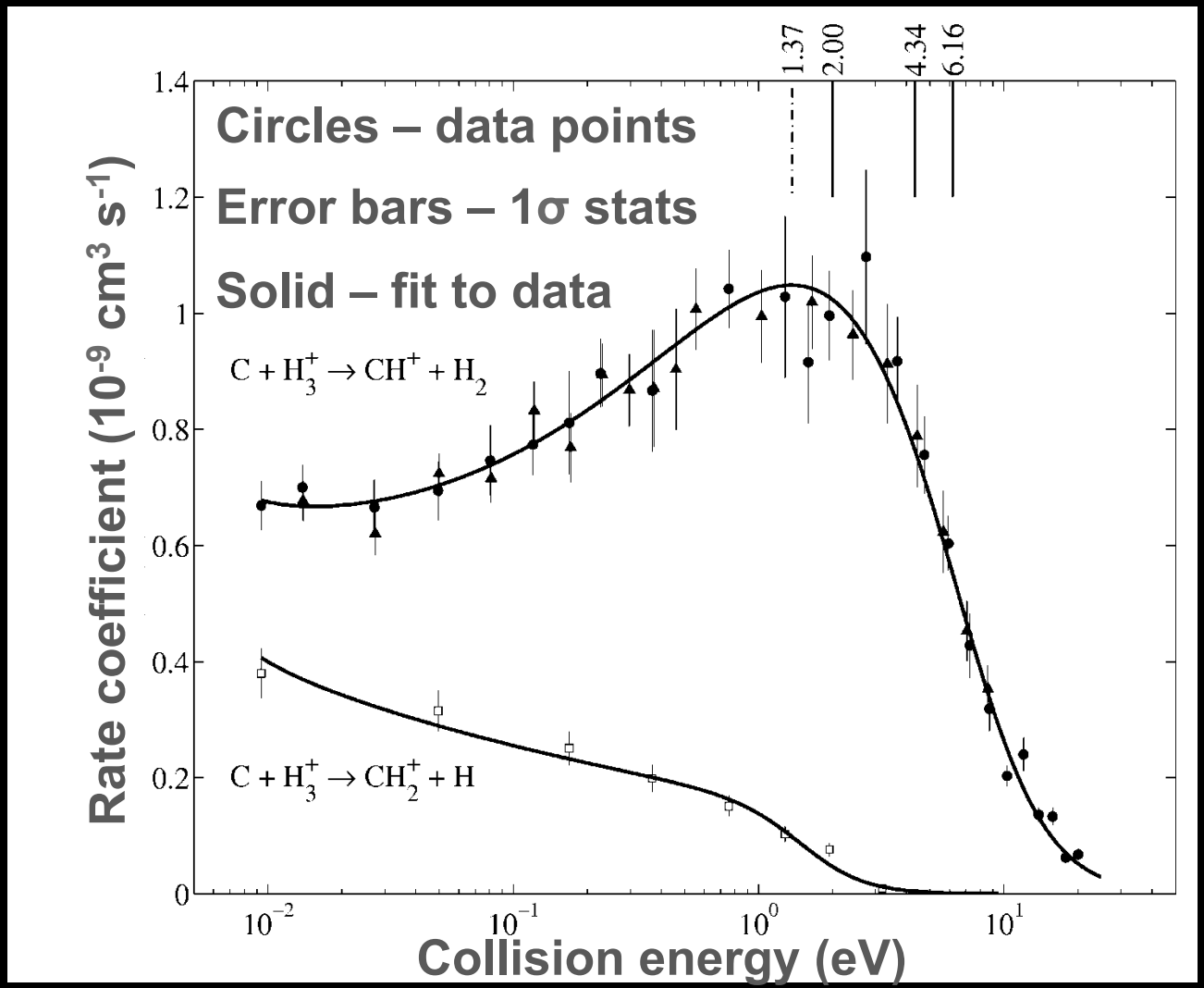
CH^+ grows as new v and R channels open up.

$C + H_3^+ \rightarrow$ Products



CH^+ decreases as competative channels open up.

$C + H_3^+ \rightarrow$ Products



CH_2^+ drops as time for XH_3^+ rearrangement does.

Outline

I. Motivation

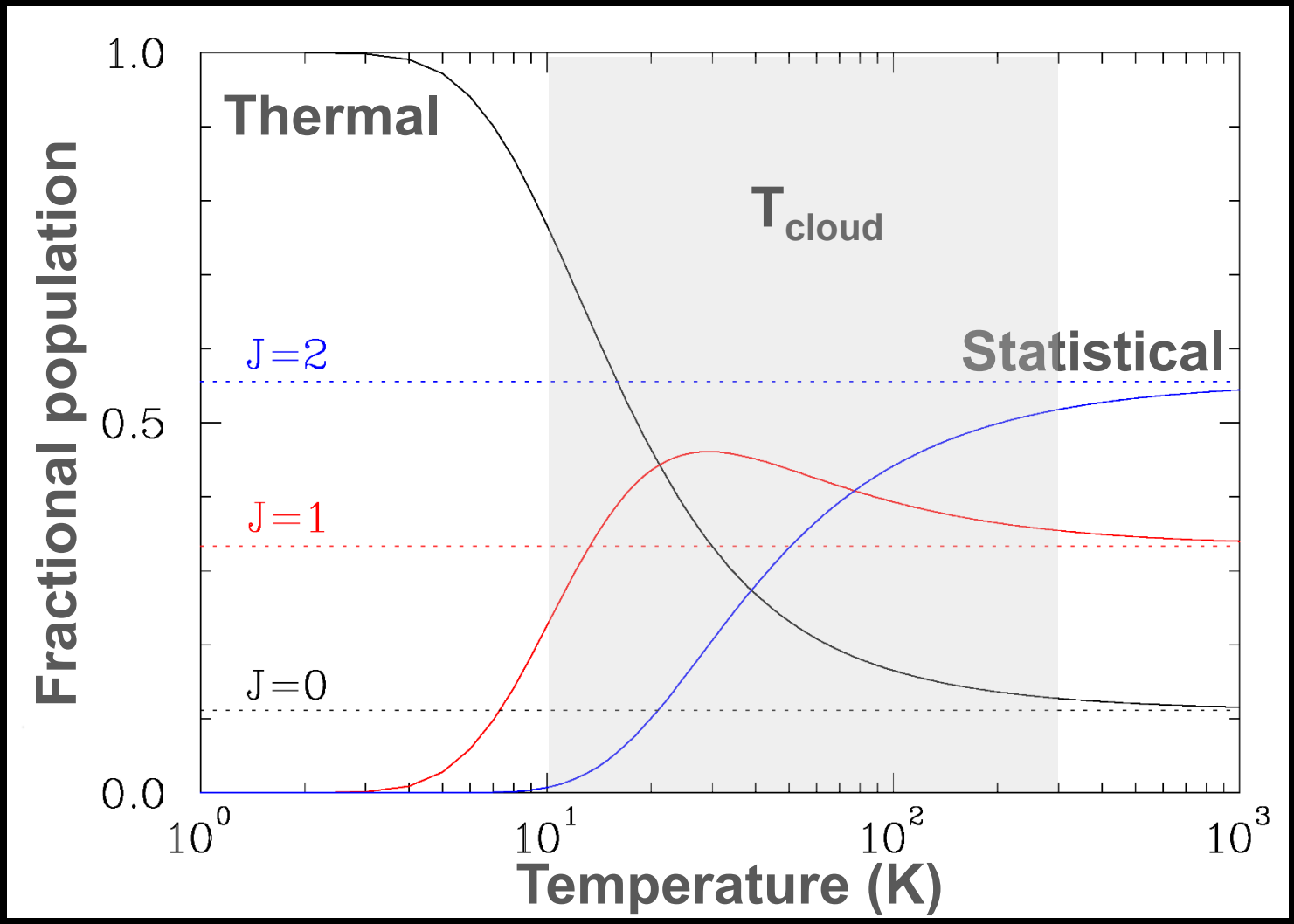
II. Experiment

III. Results

IV. Thermal data

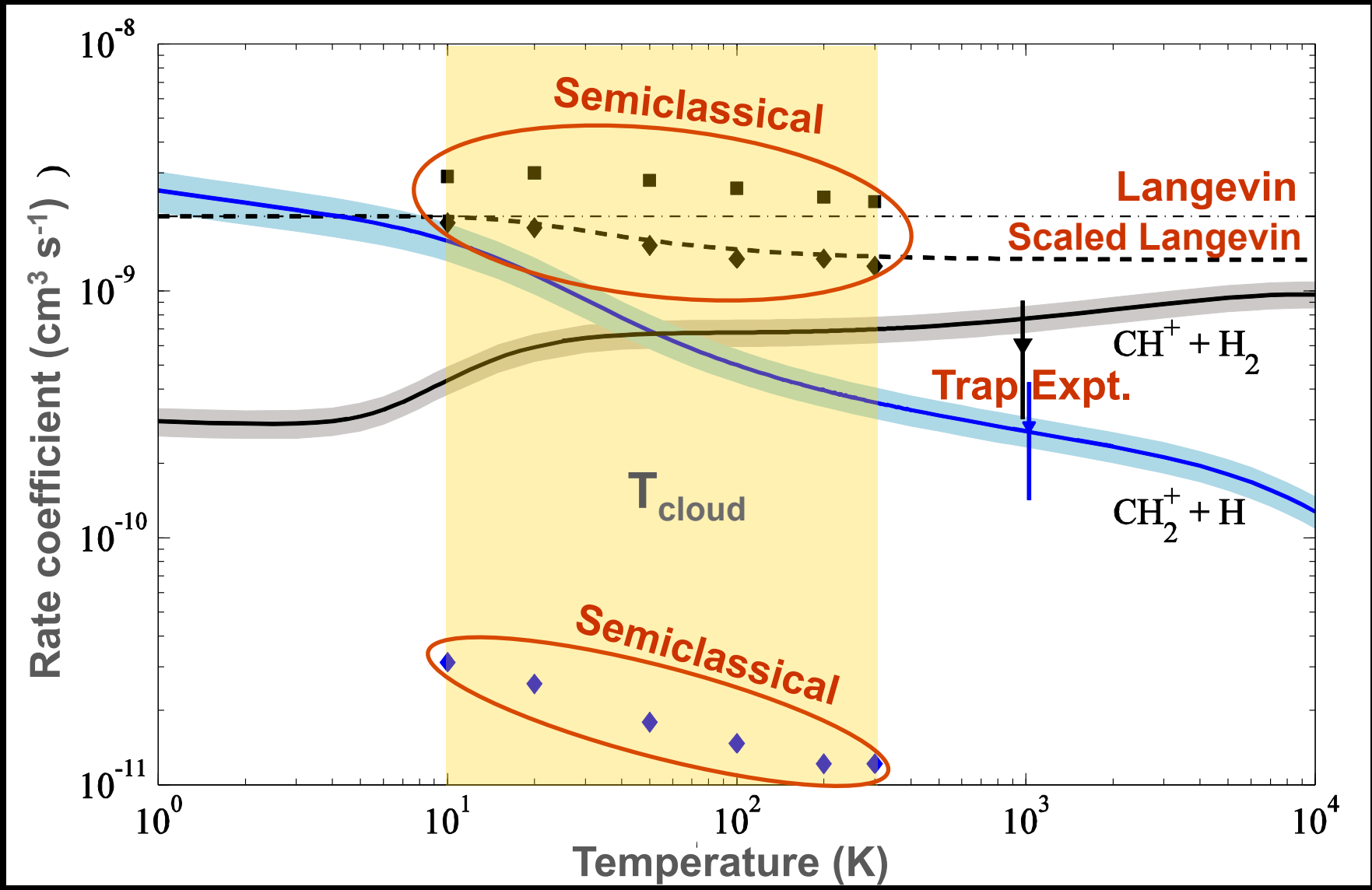
V. Conclusions

$C(^3P_J)$ statistical vs. thermal population



Use adiabatic approximation to connect entrance channel, intermediate complex, and exit channel.

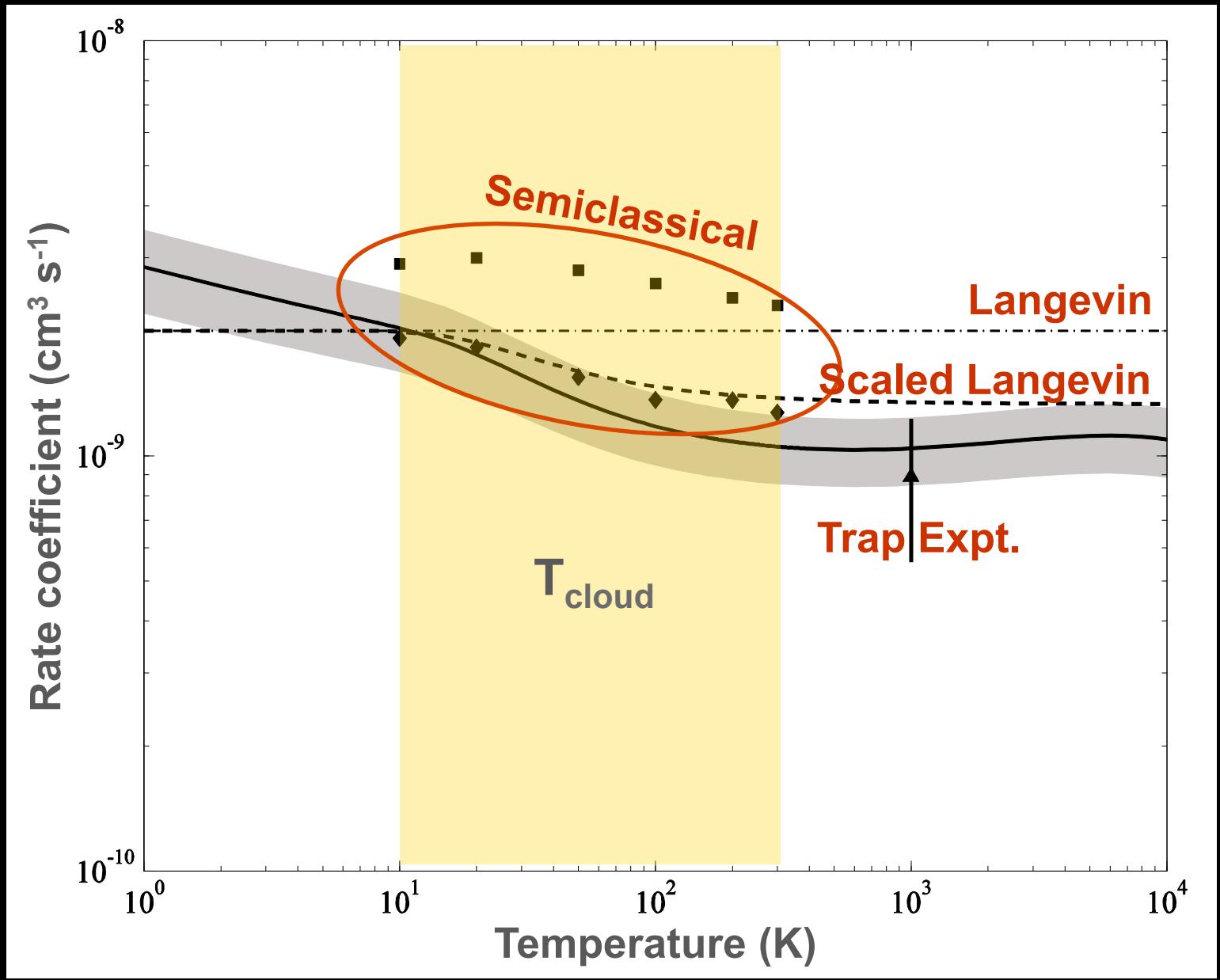
Derived thermal rate coefficients



Implications for COM formation

- CH_3^+ is a bottleneck leading to COMs.
- CH^+ and CH_2^+ rapidly react with H_2 to form CH_3^+.
- Models overestimate $C+H_3^+ \rightarrow CH^+$ channel.
- This implies they overestimate CH_3^+ abundance.
- But they leave out $C+H_3^+ \rightarrow CH_2^+$ channel.
- $C+H_3^+$ leading to CH_3^+ is sum of both channels.

Summed thermal rate coefficients



Outline

I. Motivation

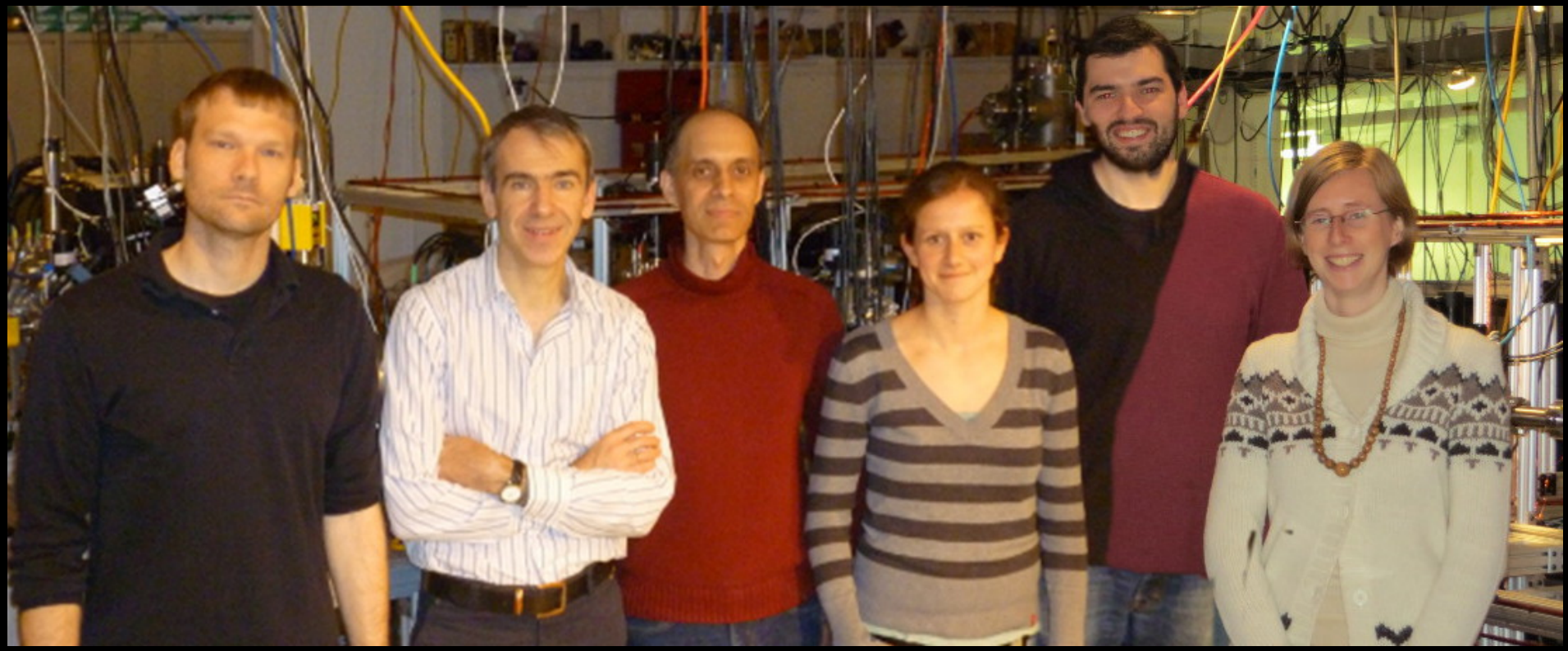
II. Experiment

III. Results

IV. Thermal data

V. Conclusions

The Team Members



K. A. Miller, X Urbain, DWS, J. Stützel, A. O'Connor, N. de Ruette

Conclusions

- Have developed a new apparatus to study astrochemical reactions with atomic C and O.
- We have generated thermal rate coefficients for
  - $C + H_3^+ \rightarrow CH^+$ and CH_2^+ [ApJS, arXiv:1408.4696].
  - $O + H_3^+ \rightarrow OH^+$ and OH_2^+
  - $H + H^- \rightarrow H_2 + e^-$ [Science, 329, 69 (2010)].
  - $e^- + NH^+$ dissoc. recomb. [ApJ, 793, 132 (2014)].
  - $e^- + HCI^+$ dissoc recomb. [ApJ, 777, 54 (2013)].
- $A(T/300)^B \exp(-C/k_B T)$ cannot fit any of these.
- We are investigating the astrochemical implications of our new chemical data.