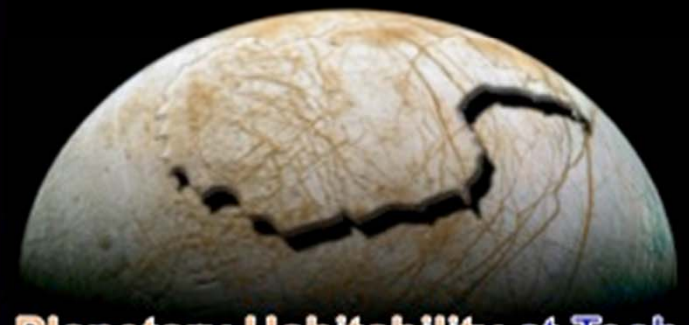


Europa Plume workshop summary

Britney E Schmidt
Georgia Institute of Technology
CAPS
April 1, 2015



Planetary Habitability at Tech

Take Home Messages



- Workshops like this are helpful to the community
 - Cross-disciplinary interaction and *innovation*
- No certain “Life Detection” signature has been agreed upon
- Valuable “biomarker” progress has been made
- Europa Clipper is still our best bet

Europa Plumes Workshop



Planetary Habitability at Tech

Workshop on: The Potential for Finding Life in a Europa Plume

Wednesday, February 18, 2015

8:30am – 5:30pm

NASA Ames Research Center, Building 152, Moffett Field, California



Europa Plumes Workshop



Planetary Habitability at Tech

8:30-8:45

Welcome to Ames, Pete Worden

8:45-9:00

Opening Remarks, John Grunsfeld and Jim Green

9:00-9:30

Europa Clipper Mission, Dave Senske

9:30-10:00

Europa Plume Origins and Formation, Sascha Kempf

10:00-10:30 Plume Forum Brief, Louise Prockter

11:00-11:20

Icy World Plume Sample Return: the LIFE Mission Concept, Isik Kanik

11:20-11:40

Europa Plume: Astrobiological Perspective, Kevin Hand

11:40-12:00

Life Detection Workshop Findings, Cassie Conley

1:00-1:15

An Update on the HST Cycle 22 Campaign to Investigate Europa Water Vapor Plumes, Kurt Retherford

1:15-1:30

Towards the Universal Life Detection System, Leroy Cronin

1:30-1:45

Amino Acids as Evidence for Life in the Plumes of the Outer Solar System, Chris McKay

1:45-2:00

Specificity in Biomolecules: What is Enough and What is Too Much in a Search for Evidence of Life, Andrew Pohorille

2:00-2:15

Europa Plume Chaser: A Small Satellite Approach for Finding Life in a Europa Plume, David Mauro

3:45-4:00

Hypervelocity Dust Impacts: Biosignature Survivability and Preservation for Life Detection in Europa's Plume, Morgan Cable

4:00-4:15

The Role of High-Sensitivity, High Resolution Mass Spectrometry in the Search for Habitability and Life, Jack Waite

4:15-4:30

Time-of-Flight Mass Spectrometry for In Situ Analysis of Biosignatures at Europa, Stephanie Getty

4:30-4:45

SUDA: A Dust Mass Spectrometer for Measuring the Composition of Solid Europa Plume Particles, Sascha Kempf

4:45-5:00

Microfluidic Chemical Analysis for Signs of Life in a Europa Plume, Peter Willis

5:00-5:15

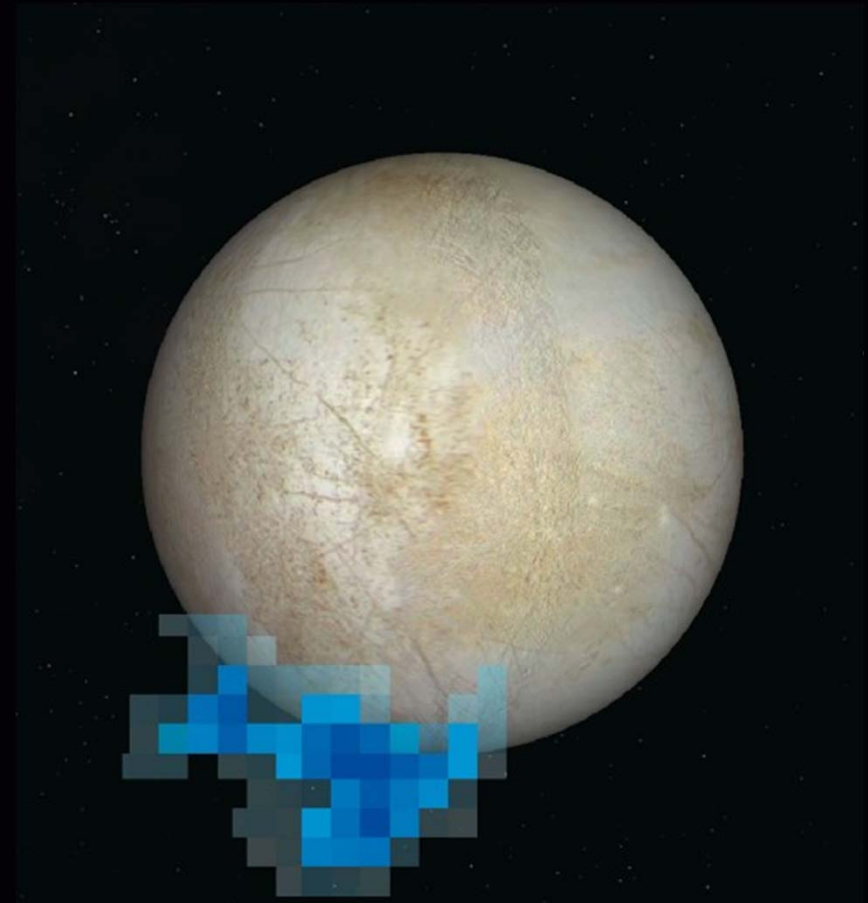
Spectropolarimetry of Biosignatures in Europa's Plumes and at the Surface, William Sparks

Overarching Themes



Planetary Habitability at Tech

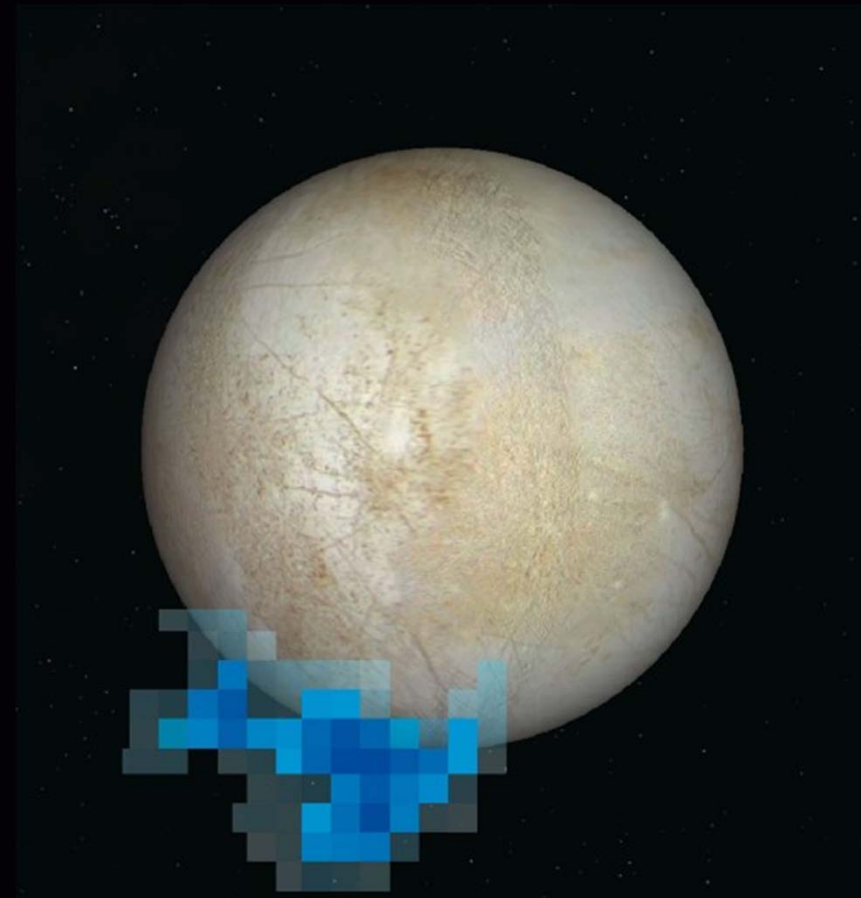
- Discussion of limits of both in situ and sample return missions
- Sampling strategy—does one exist?
- What is a good biomarker?
- What is proof of life?



Europa's Plumes: Fact/Fiction?



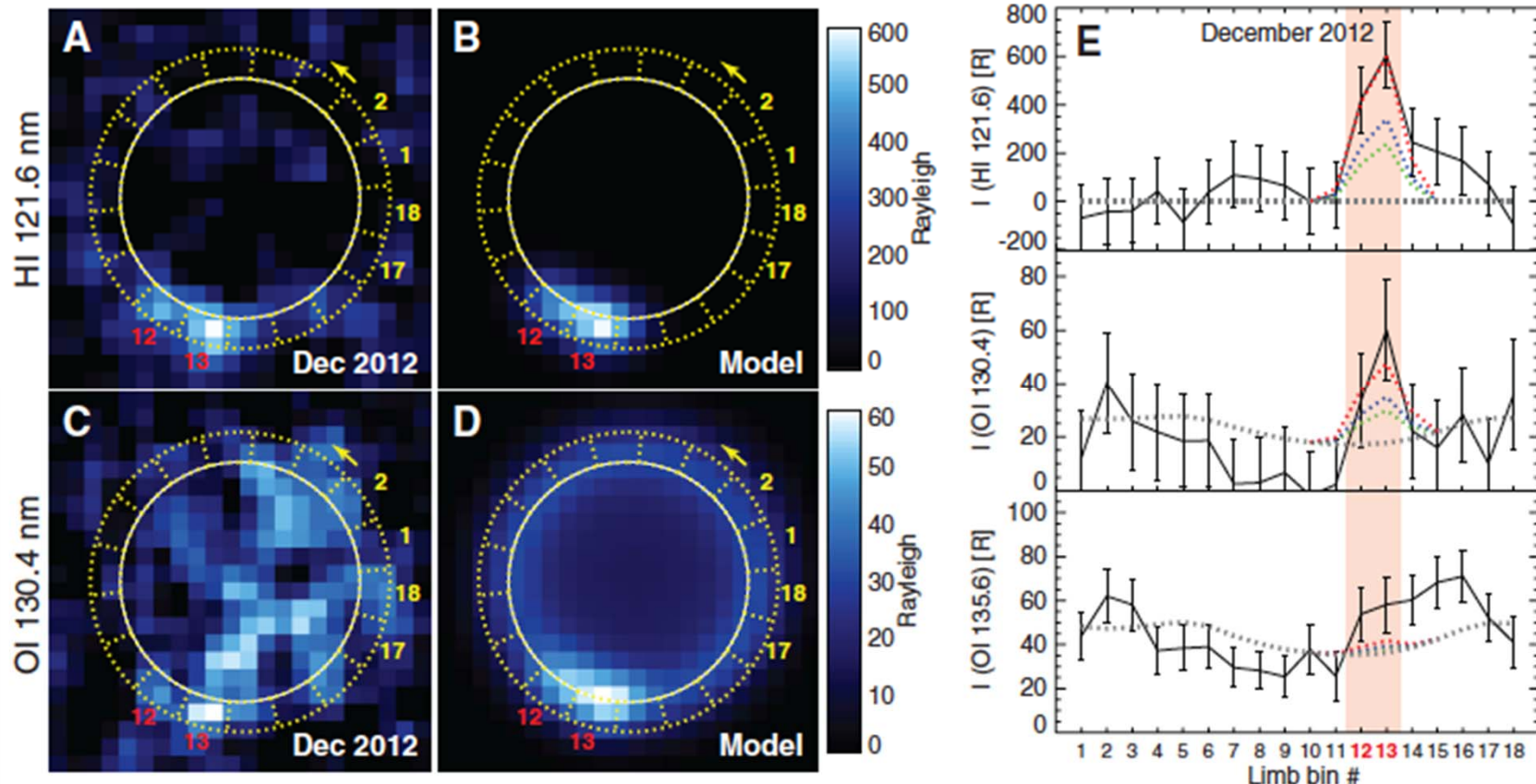
- First observations reported in December 2013 (Roth et al, *Science*)
 - HST observed Europa's Auroral UV signature
 - Excess emission of Lyman α and O 1 130.4 nm
 - Consistent with 'South Polar' Source 3 & 4 σ
 - Two plumes at $\sim 180^\circ$ E 55 S and 75 S
 - Plume would be ~ 200 km high
 - Column density
 $N_{O_2} = 3.5 \times 10^{18} \text{ m}^{-2}$



Plume Model



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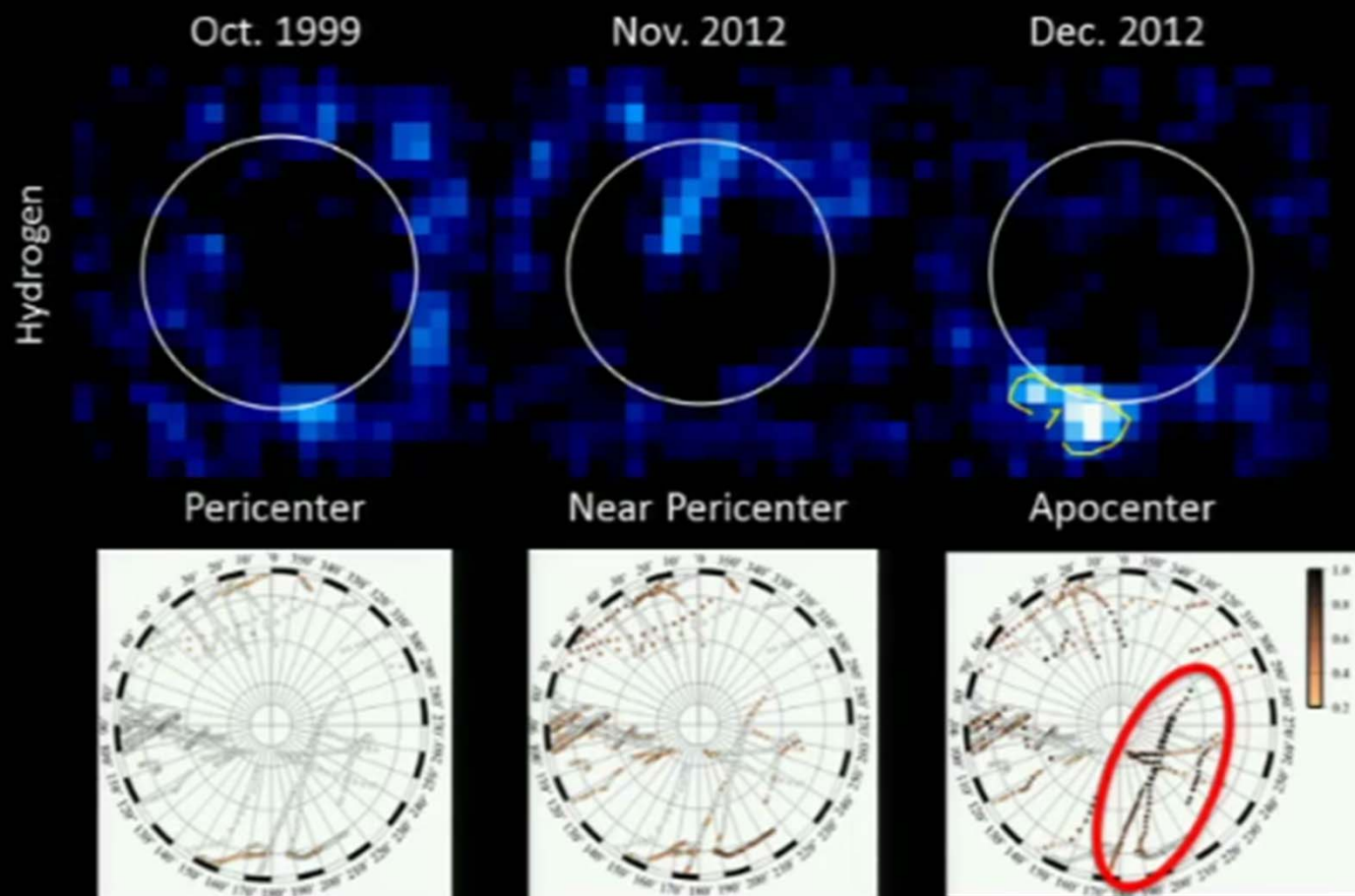


Roth et al 2014, *Science*

Plume Variability



Planetary Habitability at Tech

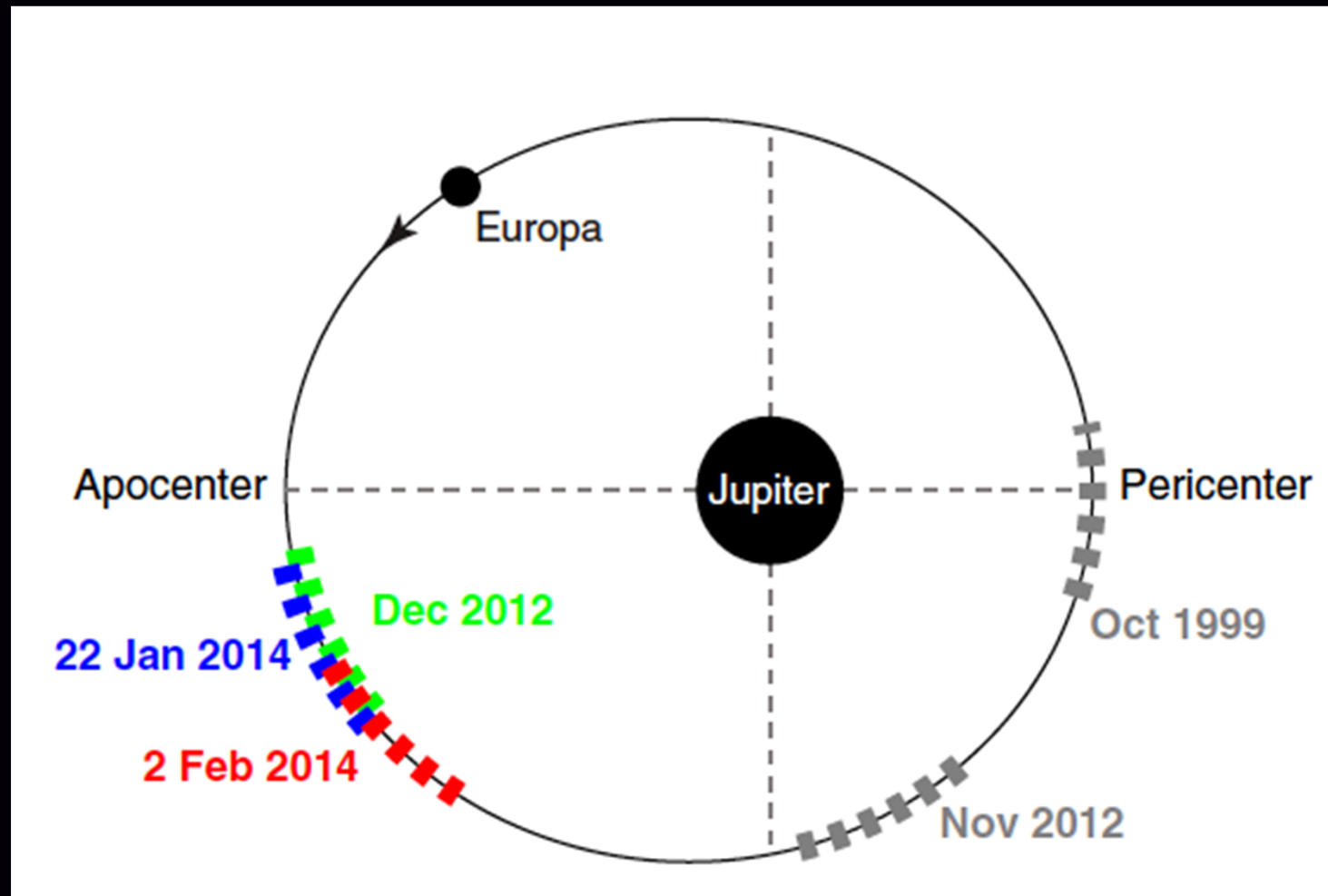


Roth et al 2014, *Science*

Follow Up Observations



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Roth et al 2014, *PNAS*

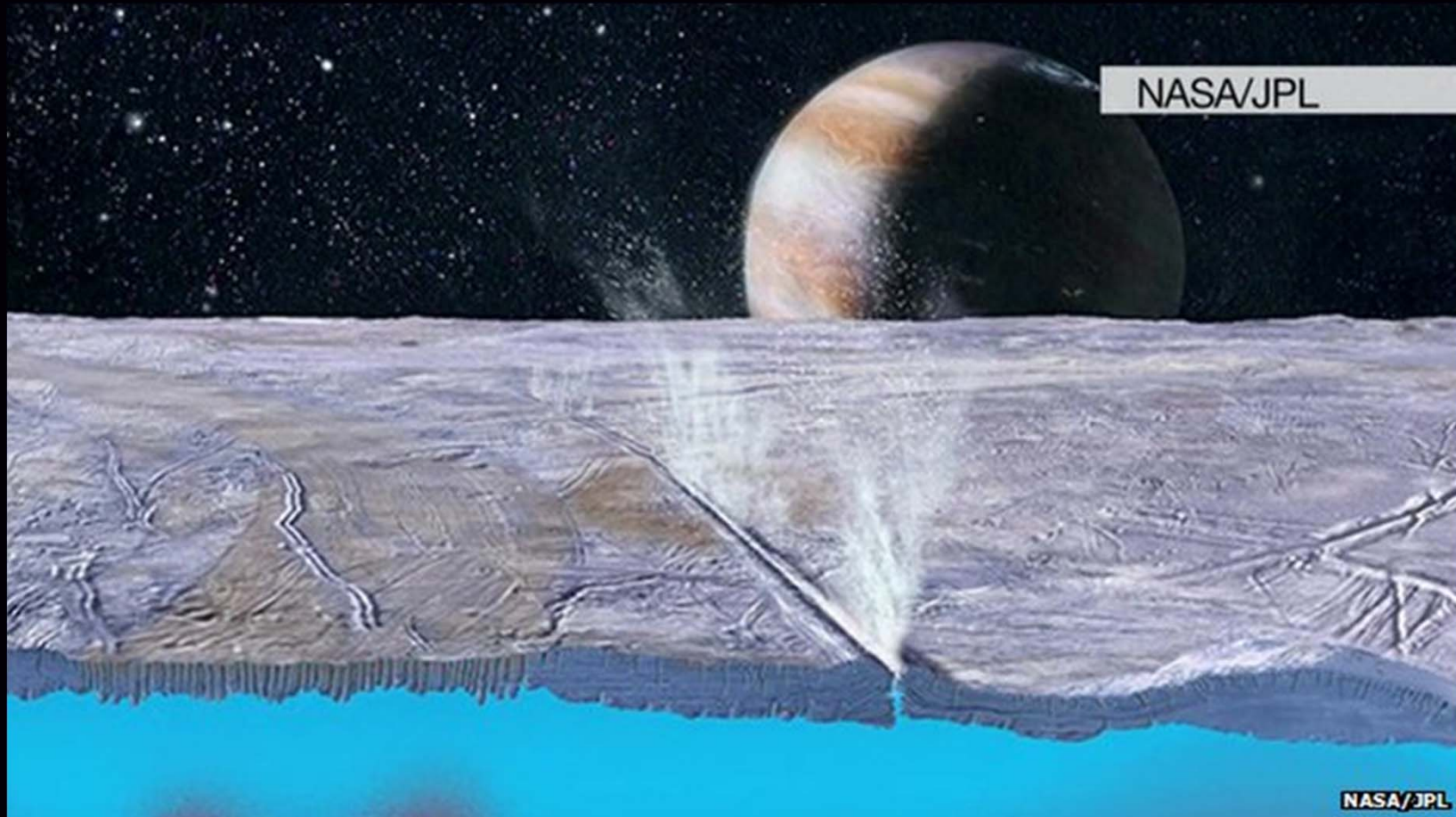
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B. E. Schmidt, Europa Plumes, CAPS
Meeting

The 'Enceladus Box'



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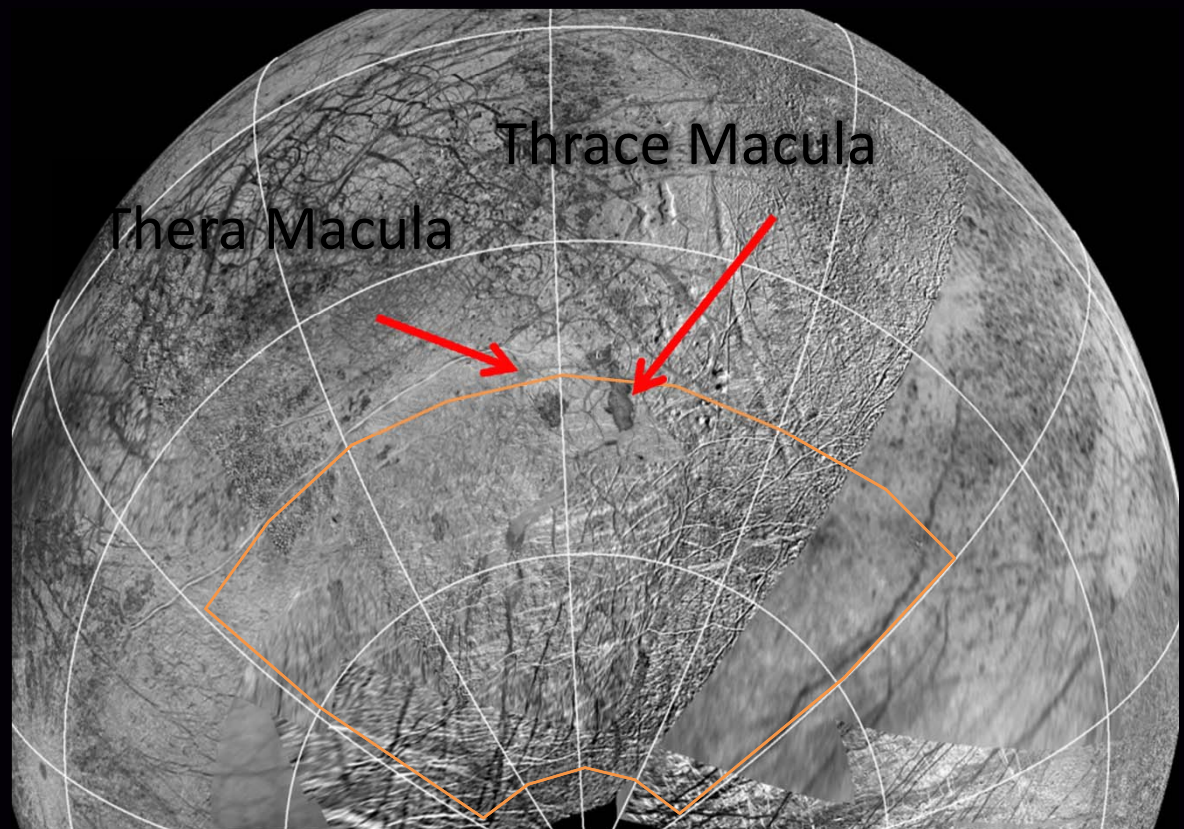
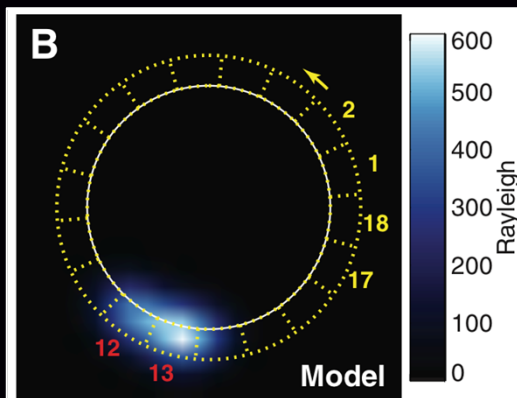
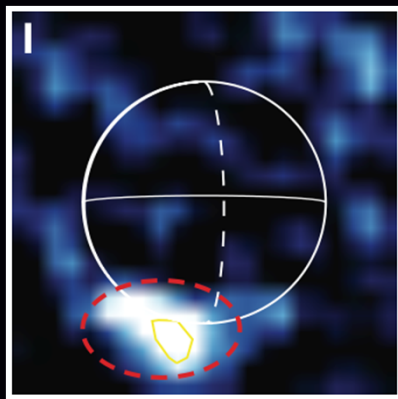


Roth et al 2014, *Science*

Plumes and Geology



Planetary Habitability at Tech

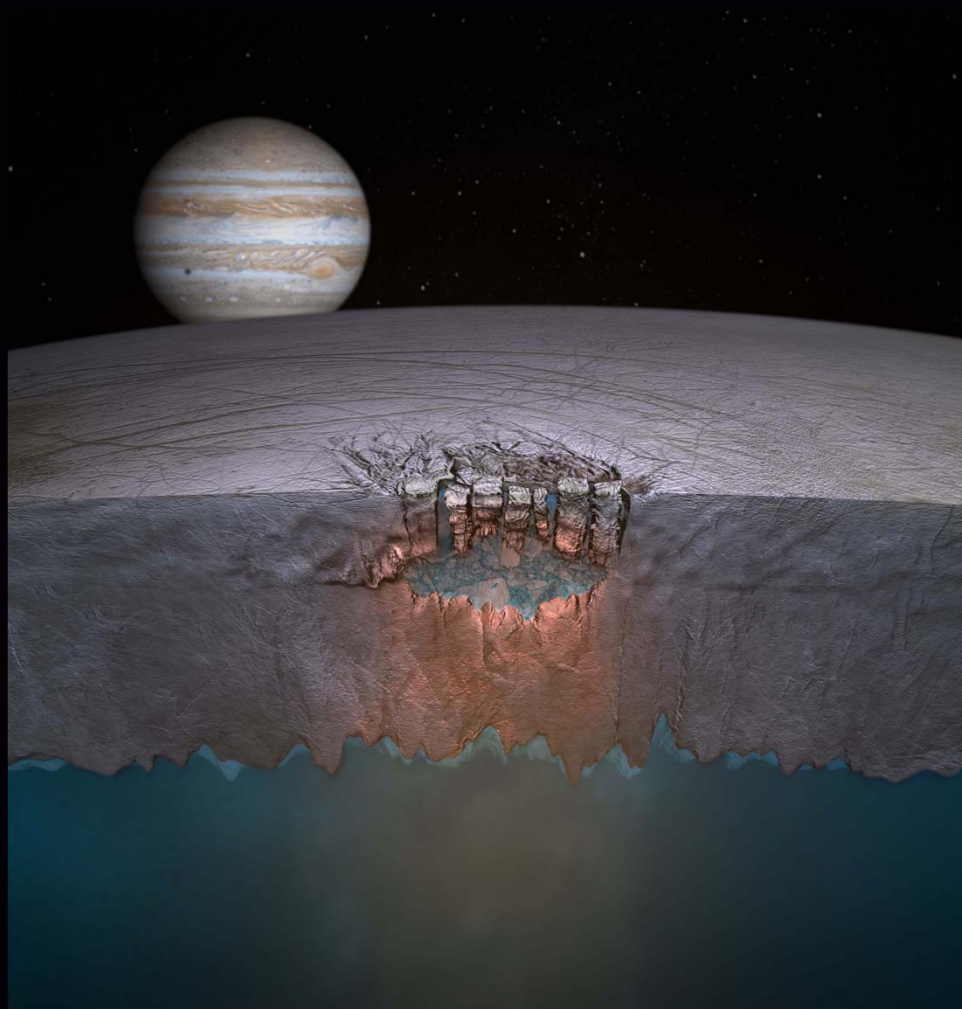


Plumes and Geology



Planetary Habitability at Tech

Europa's Geology is incredibly complex, and requires more data to understand.



Schmidt et al
2011 Nature

Difficulty of Sampling



Planetary Habitability at Tech

- Plumes have low density in both Europa and Enceladus
- Terrestrial cell count examples:
 - 10^3 - 10^5 cells/cc ocean surface
 - 10^7 - 10^9 cells/cc microbial mats
 - 10^2 cells/cc Vostok
- At 200 kg/s, 1500 molecules/cc, biomass 10^7 cells/kg
 - 10^8 grains needed to get 1 cell
 - At 25 km on Enceladus, 2km on Europa- 10^{-5} grains/cc
 - Need to sweep 10^{13} cc- \rightarrow ~ 12000 km of plume fly through
- Worse when considering sampling speed, preservation, handling

K. Hand Presentation

Difficulty of Sampling



Planetary Habitability at Tech

- Any mission must have 10^{-4} chance of contaminating a water body
- Probability set to 1 for sampling
 - Needs developed models
- How do we test?
 - True and False Positives, True and False Negatives
 - Structures, scales and morphology matter
 - Composition and metabolism matters
- Assess two competing hypotheses:
 - There is Europa life in the sample
 - There is no life in the sample
- Difficulty of containment

C. Conley Presentation

Choosing a Target



Planetary Habitability at Tech

- “The opposite of life is not death, the opposite of life is rock”
- “Death” is the longest form of life
 - Look for evidence of death
- Amino Acids
 - Useful even if abiotic
 - Shows organic processing
 - Sets of Chiral amino acids form the basis of biological processes
 - Example: Histadine in catalytic centers
- Need more studies of these in relevant environments
 - We could use these in situ, but we don’t use them as biomarkers/detection on Earth

C. McKay Presentation

Choosing a Target



Planetary Habitability at Tech

- Need a “Universal Biology Detector”
- Chemically agnostic is important
- Life makes “big” molecules
 - 500-1000 molecular weight
- Breakdown of complex molecules has a potentially predictable and measurable pattern
 - Molecular weight vs complexity vs abundance may have a sweet spot in biological systems
 - May be a systematic test for biological processes

L. Cronin Presentation

Choosing a Target



Planetary Habitability at Tech

- Proteins are not the only solution
 - One winning hand in the deck not the only one
- Oligomers and polymers are also information carriers and could be used in similar ways
 - Many possible solutions and functions
- Chirality is still a biomarker
 - Thus far, chiral detection is a function of the chosen molecule
 - Need a generic chirality test that is agnostic to the molecule chosen
- “Pregnancy Test” approach?

A. Pohorille Presentation

Technology Development



- LIFE Mission concept- I. Kanik
- Europa Plume Chaser Small Satellite- D Mauro
- Ion and Neutral Mass Spectroscopy-H. Waite
- TOF Mass Spectroscopy- S. Getty
- Dust Mass Spectrometer- S. Kempf
- Microfluidics- P. Willis; A. Stockton
- Spectropolarimetry- W. Sparks
- Chiral Columns (discussion)
- Ice Penetrating Radar- A. Mousessin, D. Schroeder

A. Pohorille Presentation

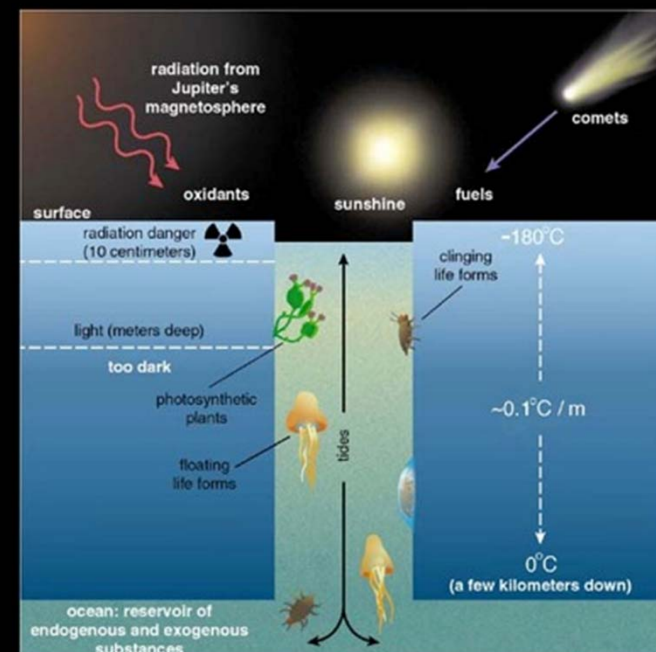
Lessons Moving Forward



Planetary Habitability at Tech

- There is *NO* consensus on:
 - A compelling detection of life
 - Life detection instrumentation
 - Plume location, eruption frequency, eruption rate
 - Source of the plume
 - How or if it's possible to get a sufficient sample

Too Anthropocentric

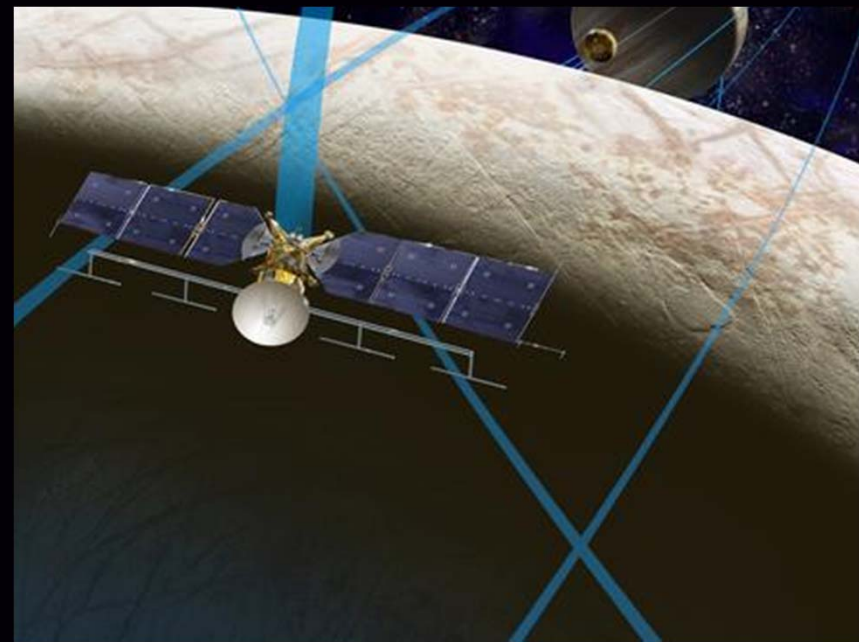


Lessons Moving Forward



Planetary Habitability at Tech

- There *IS* consensus on:
 - Unilateral support for *Europa Clipper*
 - The value of biomarker detection
 - Value of technology investments for life and biomarker detection
 - *More communication and interaction between Astrobiology and Planetary Contingents*

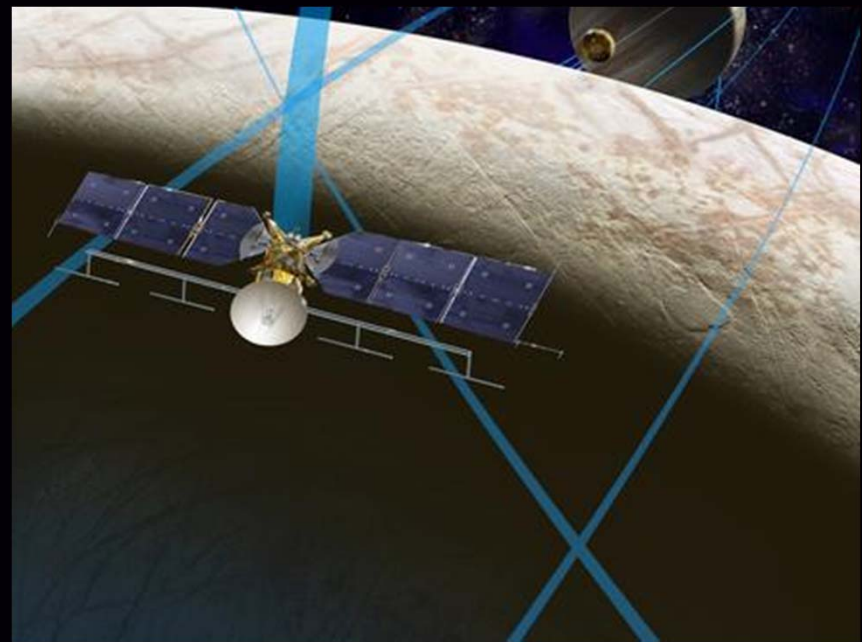


Lessons Moving Forward



Europa Clipper

- Science community *DID* consider plumes and the potential importance
 - This drove the switch to Clipper: INMS, IR Spectrometer, Ice Penetrating Radar
 - This drove the 25 km orbit
 - Helped drive the orbital plan and globally distributed flybys



Europa Plumes Workshop



OPAG Finding on Europa Plumes and Life.

... OPAG urges caution on the part of NASA. As presented at the workshop, and at the Europa Clipper Science Definition Team Meeting Invited Advisory Session on Potential Plume Measurements ...new *HST* observations of Europa have yet to confirm the existence of any plumes on Europa.

- OPAG notes that,
...at present, there is no clear scientific consensus on how to best detect living organisms elsewhere in the solar system, short of bringing back samples to terrestrial laboratories. How to return enough sample to be able to address these questions is also not clear since the volume of sample required to be able to make such detections is immense.

In contrast, assessing the prerequisites for habitability is feasible with planetary spacecraft, as is searching for the signatures of life as we know it. Methods for determining compelling biomarkers and instruments and technology to improve biomarker detection are worthy of further study by NASA and highlight how the Astrobiology and OPAG communities would benefit from collaboration.

Europa Plumes Workshop



- **OPAG finding 1:**

OPAG strongly encourages NASA to move forward with the Europa Clipper. OPAG wishes to be informed at the earliest opportunity of NASA's plans for Europa mission formulation during phase A, including but not limited to the selection of instruments. Modest expansion of instrumentation to do important plume science, should that opportunity exist at Europa, is encouraged, but only if the budget allows, and not at the expense of the core payload or at the price of a significant delay to the launch.

- **OPAG finding 2:**

The PICASSO and Matisse programs are ideally suited for the technology development required for instruments for the payload of a future "biosignature" investigations, anywhere in the Solar System. Because it takes a decade or more to develop and test potential flight instruments, NASA should consider increased funding and annual calls for proposals to these programs.

Take Home Messages



- Workshops like this are helpful to the community
 - Cross-disciplinary interaction and *innovation*
- No certain “Life Detection” signature has been agreed upon
- Valuable “biomarker” progress has been made
- Europa Clipper is still our best bet right now