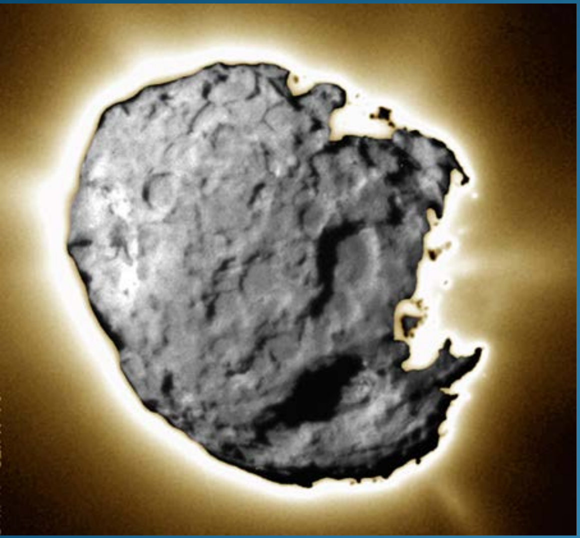
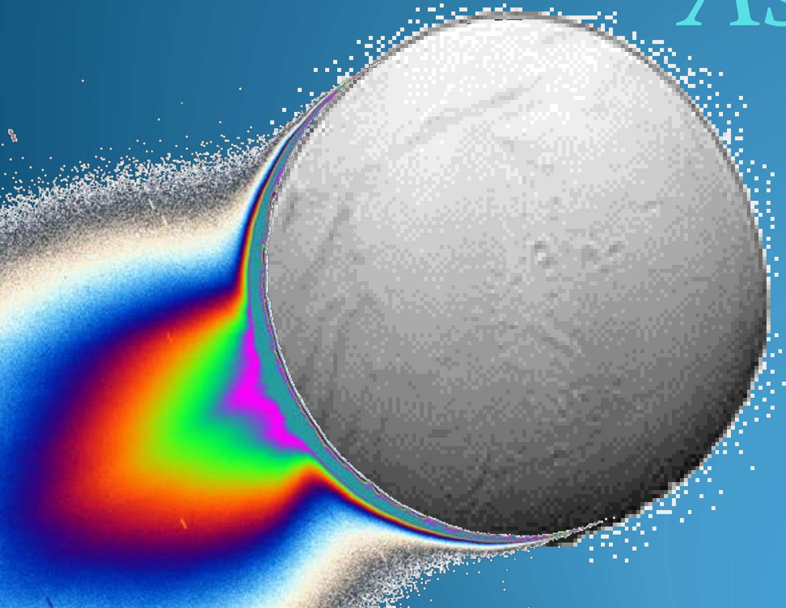
Intact Capture, Aerogel, SOCCER, STARDUST & LIFE

Dreams Realization





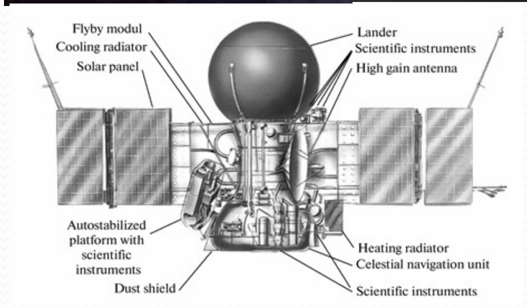
International Astrobiology Workshop

Peter Tsou
Sample Exploration Systems
November 29, 2013
JAXA ISAS Sagamihara, Japan

Status of '80 NASA

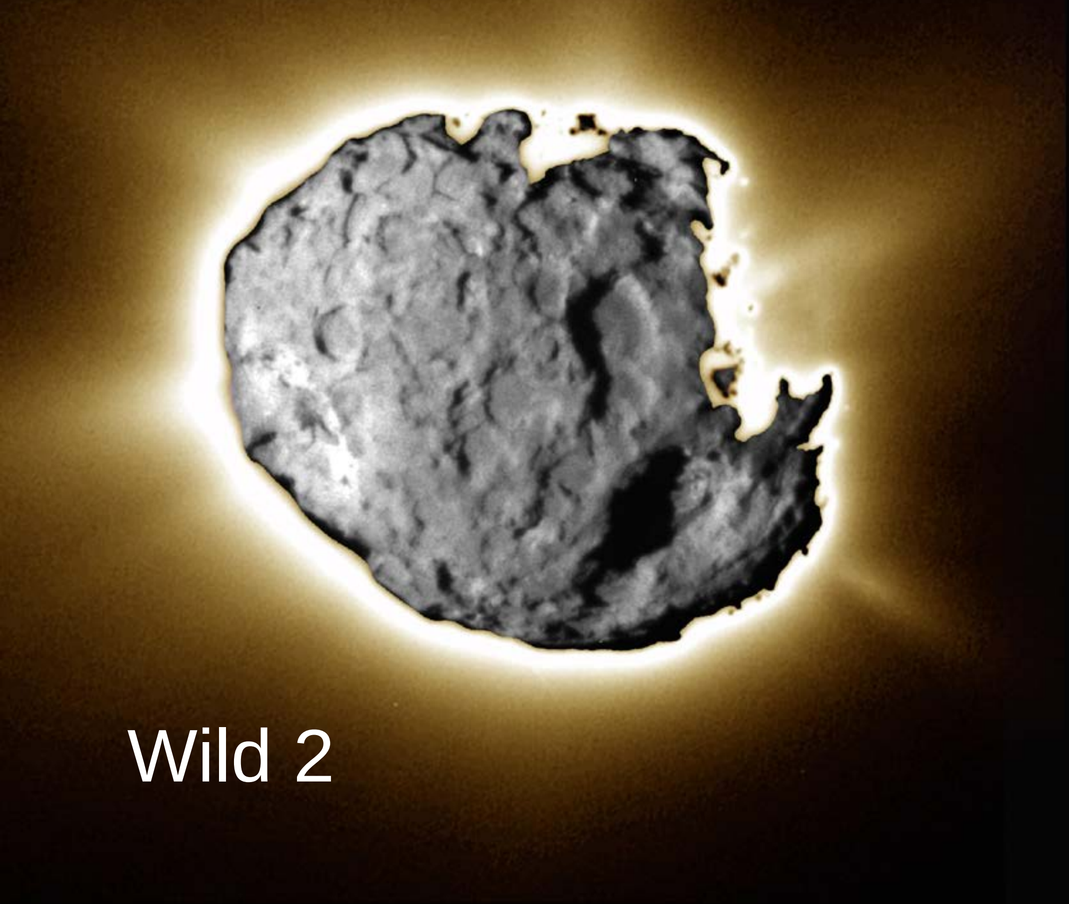
- NASA on large bodies: Venus & Mars
- No dedicated cometary exploration
- No NASA Halley mission
- Halley Armada
  - ESA-Giotto
  - Soviet/France-Vega1 Vega2
  - ISAS 彗星Suisei & Sakigake

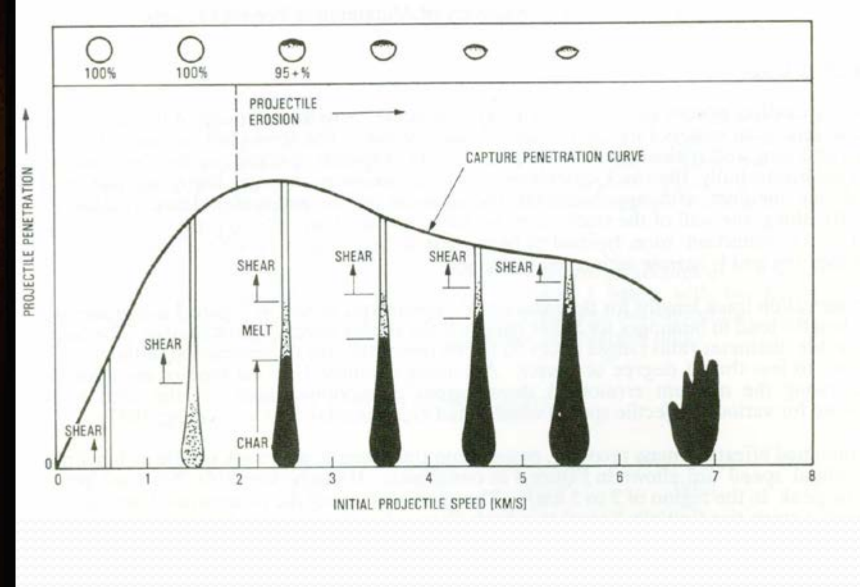
Halley Armada



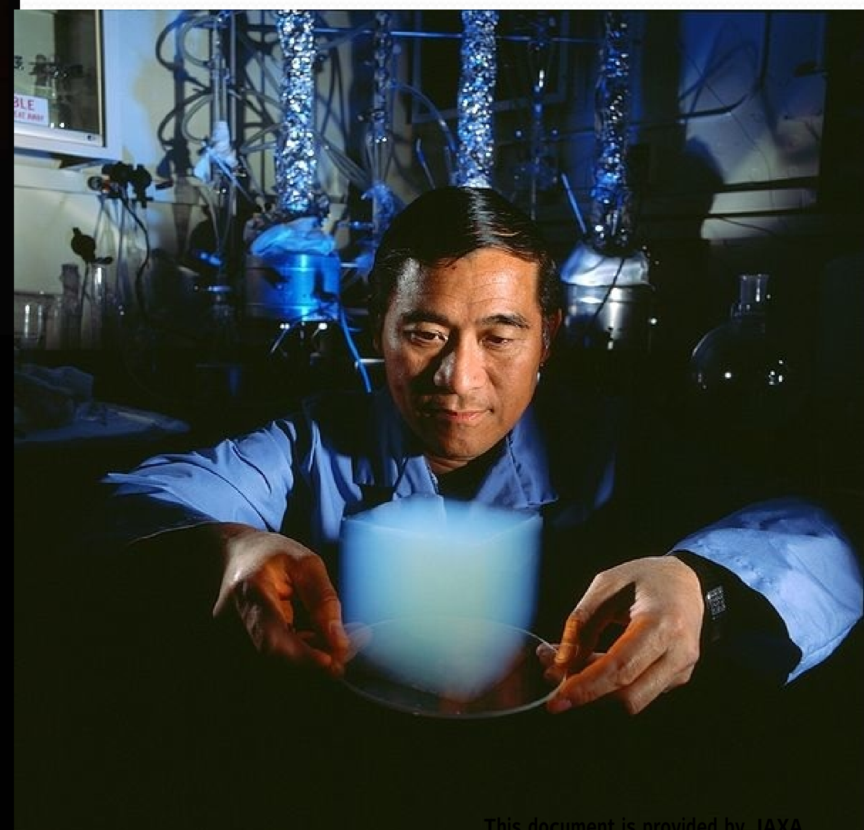
Realize Dream

- NASA/JPL had to sit out on 1986 Halley
  - Temple 2 flyby Halley Rendezvous with Giotto Probe
  - Halley Intercept Mission (HIM)
  - Halley Earth Return (HER)
- Met Tono Kuninori Uesugi on HIM 1982
- An Epiphany to Learn to Realize Dreams
  - Coma Sample Return 1994 – STARDUST
  - Sample from Enceladus 2014 – LIFE
- NASA Sample Returns
  ’70s Apollo, ’94 STARDUST, ‘96 Genesis

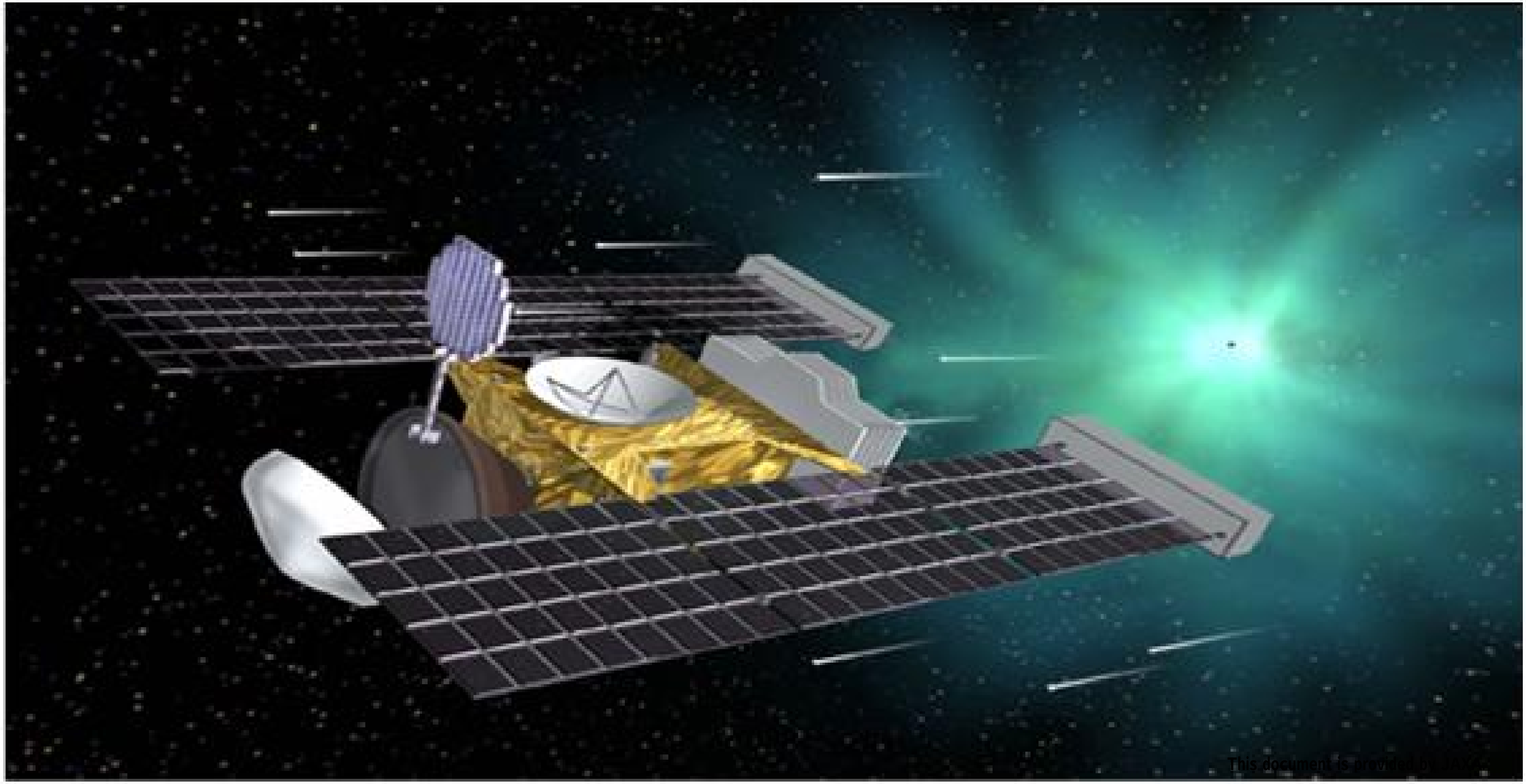

Wild 2


100%
100%
95+%
PROJECTILE EROSION
CAPTURE PENETRATION CURVE
PROJECTILE PENETRATION
SHEAR
SHEAR
SHEAR
SHEAR
SHEAR
SHEAR
MELT
CHAR
0
1
2
3
4
5
6
7
8
INITIAL PROJECTILE SPEED [KM/S]


Enceladus



STARDUST

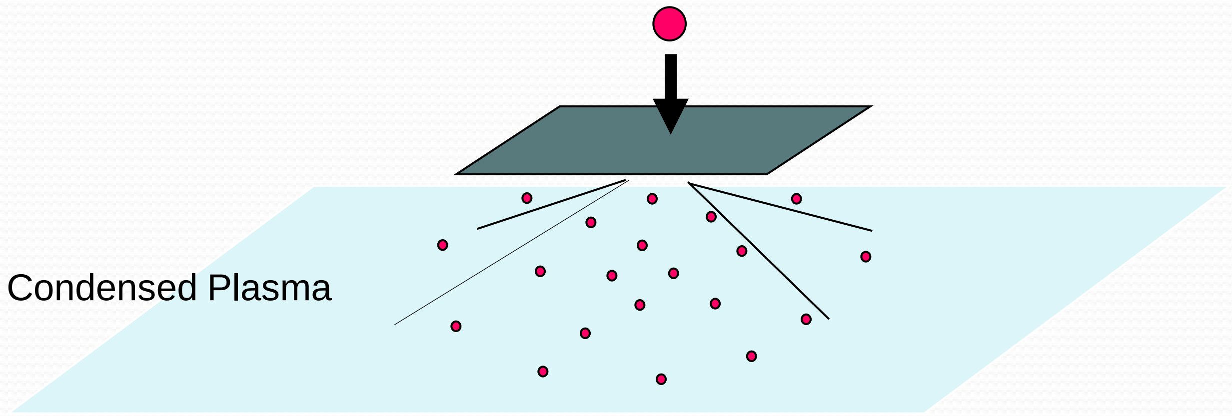


Atomized vs Intact Capture

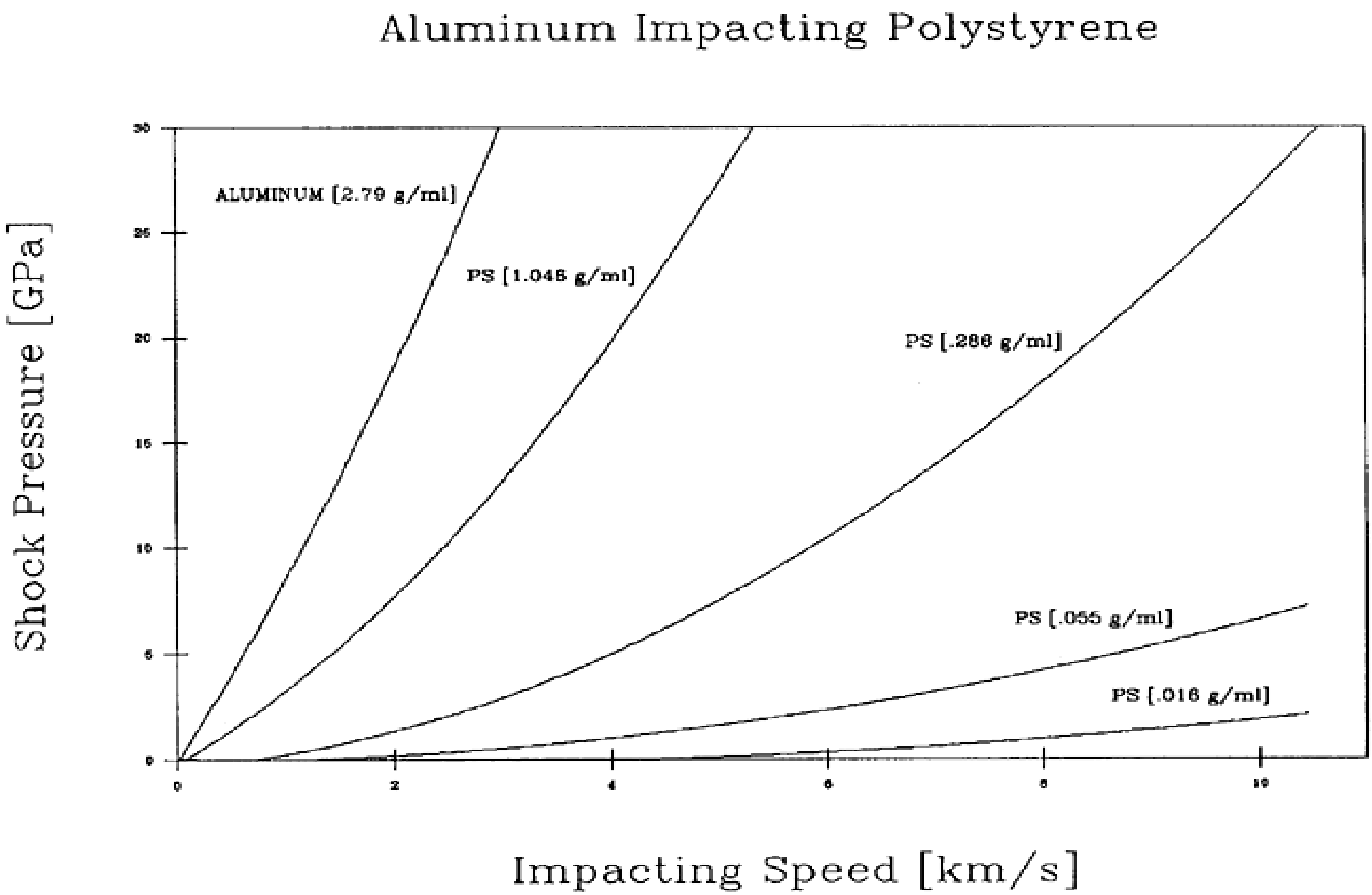
- ’80s atomized capture for hypervelocities
- Atomized no morphology, no organics
- Can’t stop a speeding bullet
- Invent Intact capture to enable a dream

‘80 Hypervelocity Capture

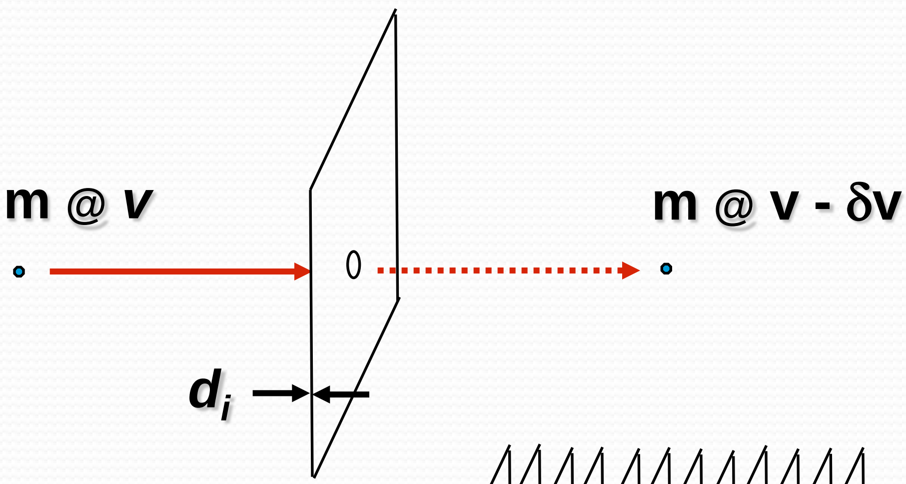
- Hypervelocity atomize particles
- Atomizing capture cell- Herb Zook



Density vs Shock Pressure

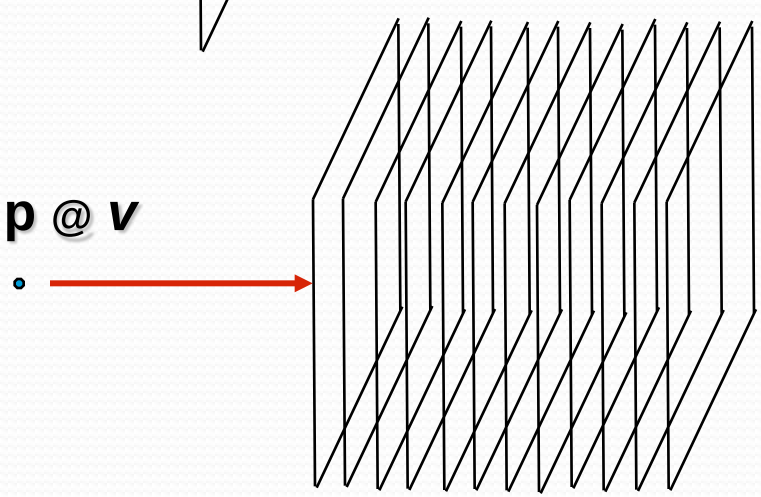


Gedanken Experiment



δv limit $\rightarrow 0$

$d_i \rightarrow 0$



$d_i \rightarrow 0$

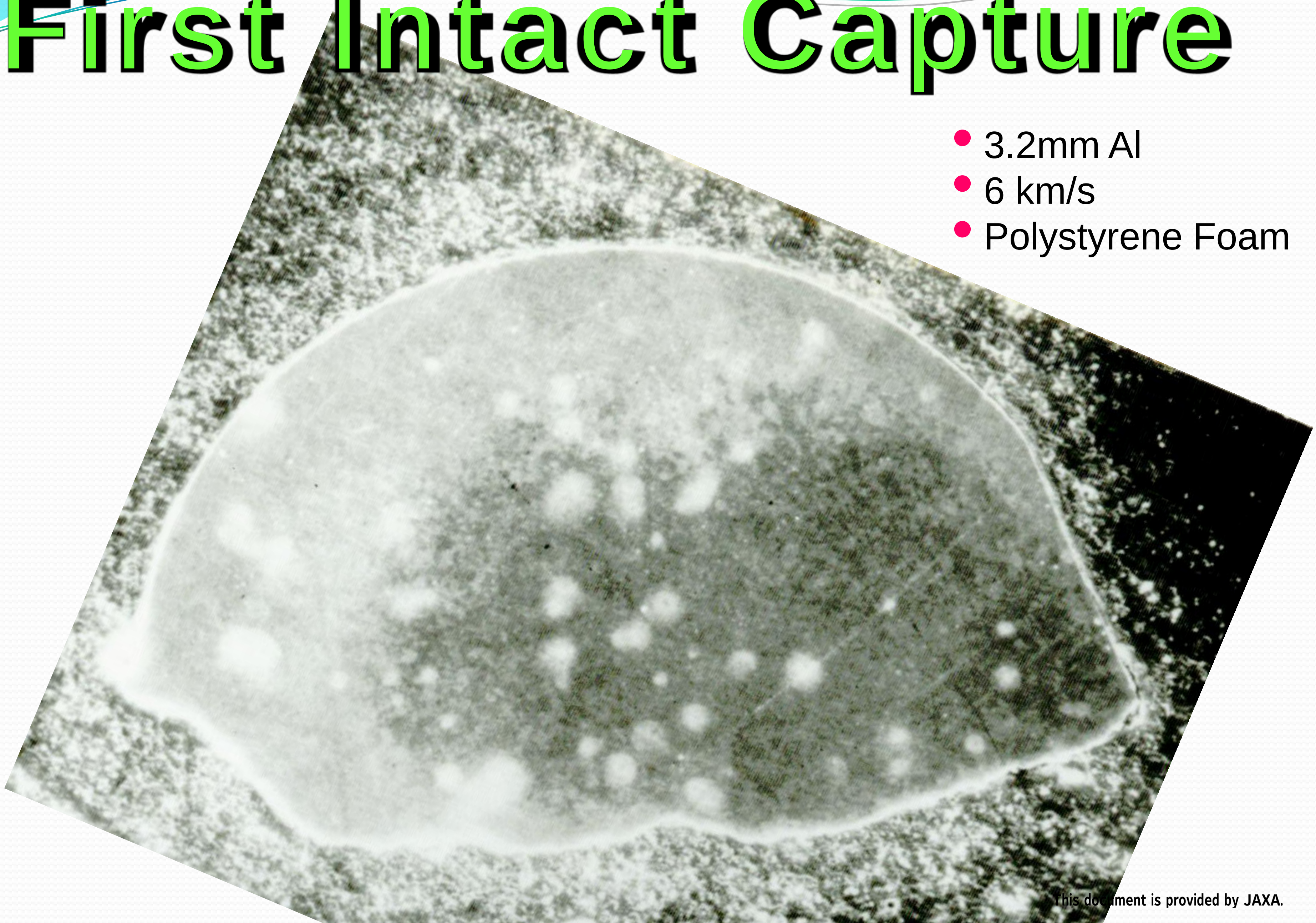
$i \rightarrow \infty$

$\delta E = mv^2$

E = finite; *i* = finite

First Intact Capture

- 3.2mm Al
- 6 km/s
- Polystyrene Foam

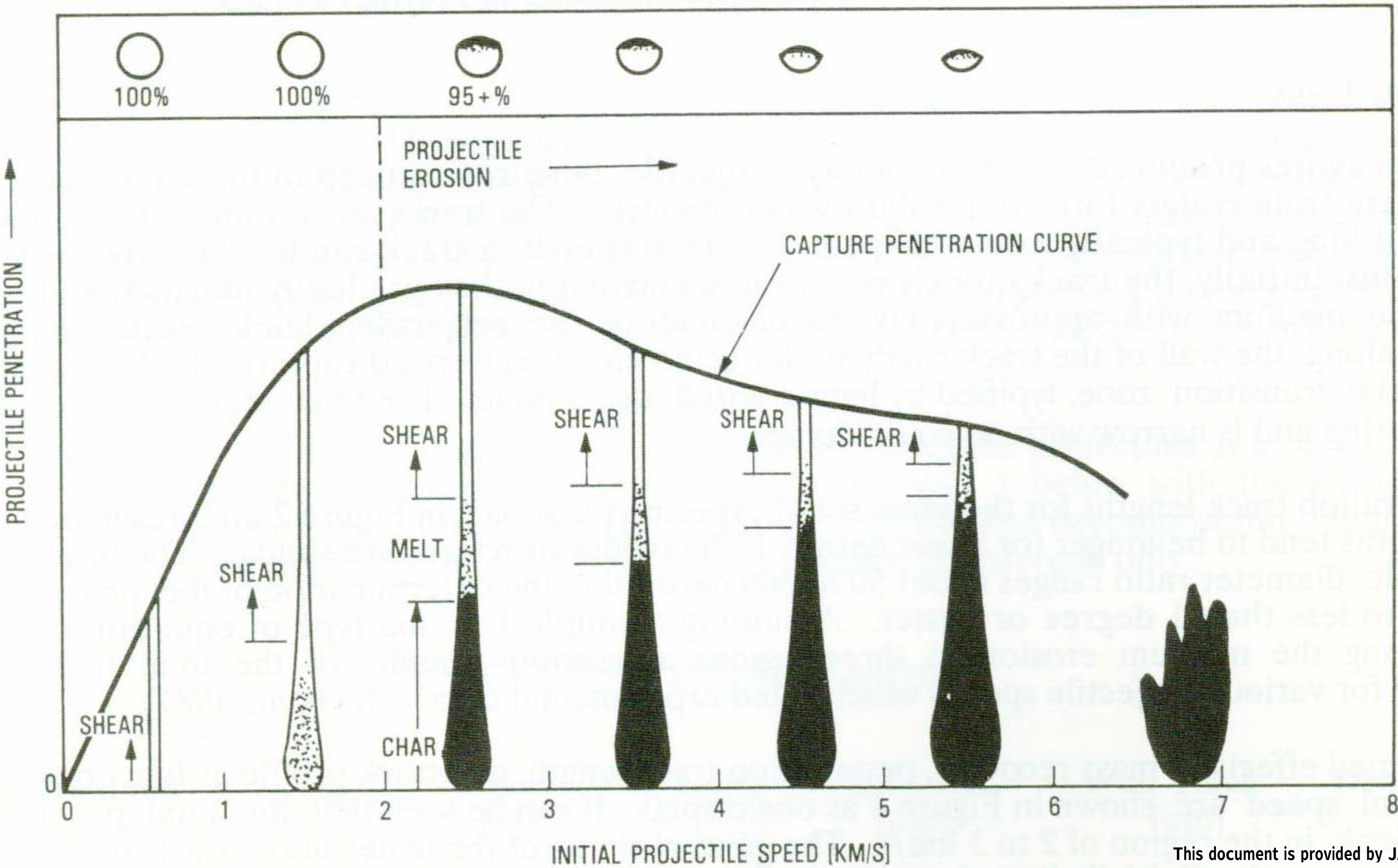


Laboratory Experiments

- **Two Stage Light Gas Gun**
  - **NASA Ames Vertical Gun Range, > 2 km/s**
  - **University of Dayton, Research Institute**
  - **Ernst Mach Institute, Freiberg**
  - **Arnold Engineering Development Center**

- **Plasma Drag Gun**
  - **Technical University of Munich**
- **Electrostatic Accelerator**
  - **Max Plunk Institute, Heidelberg**
  - **Los Alamos Microparticle Impacts Lab**

Intact Capture

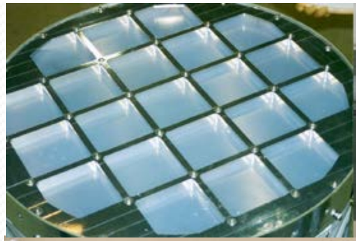


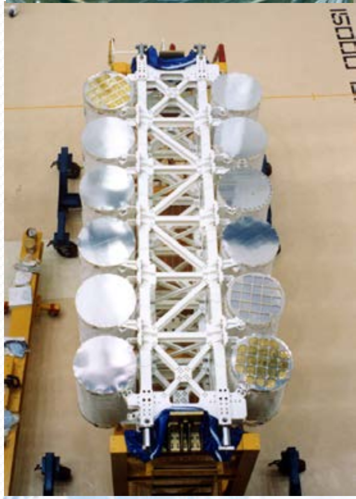
Lab/Space Simulation

- Demonstrate intact capture feasibility
  - varying speed
  - varying projectile
- Proof cometary like capture
- Simulate space environment
- Flight qualify sample instrument

Space Validations

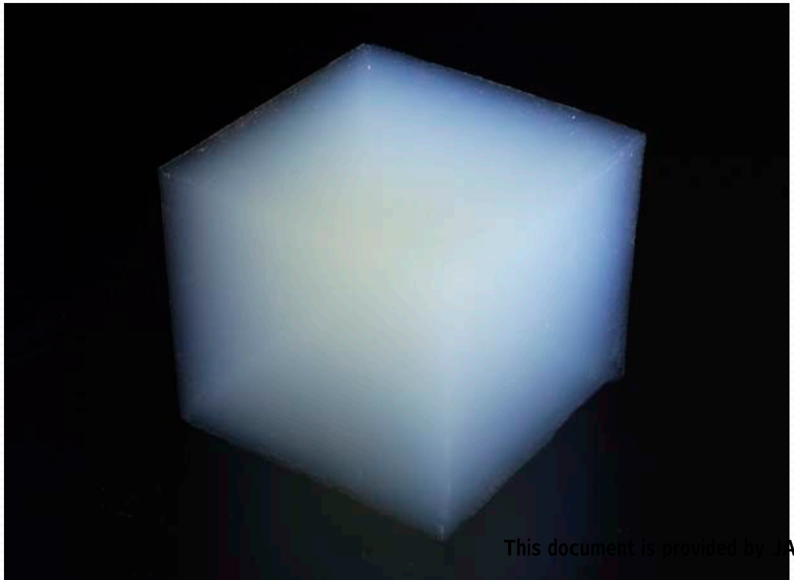
1992 GAS^2 SRE SHUTTLE FLIGHT, STS- 47
1993 GAS^2 SRE SHUTTLE FLIGHT, STS- 57
1994 SPACEHAB FLIGHT, STS- 60
1995 GAS^2 SRE SHUTTLE FLIGHT, STS- 68
1995 WAKEFIELD SHUTTLE, STS- 69
1996 GAS^2 SRE SHUTTLE FLIGHT, STS-72
1997 MIR MSRE FLIGHT
2000 GAS^2 SRE SHUTTLE, STS-101 &-106
2001 GAS^2 SRE SHUTTLE FLIGHT, STS-108





Capture Medium

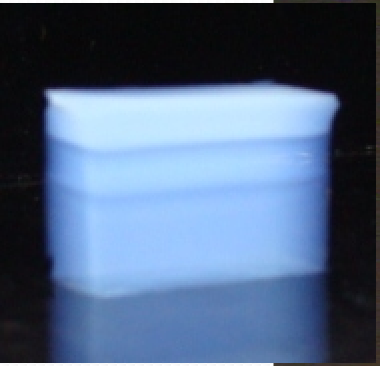
- Space worthy capture medium
  - Suitable mesostructure for intact capture
  - >5X Smooth gradient density profile
  - UV resistant
  - Ionic resistant
  - Sever thermal extremes
  - Sever thermal cycling
- Capture medium must meet science desires
  - Transparency
  - Pure with minimum contamination
  - Low carbon content
  - Be thermal cleaned
- SiO_2 aerogel

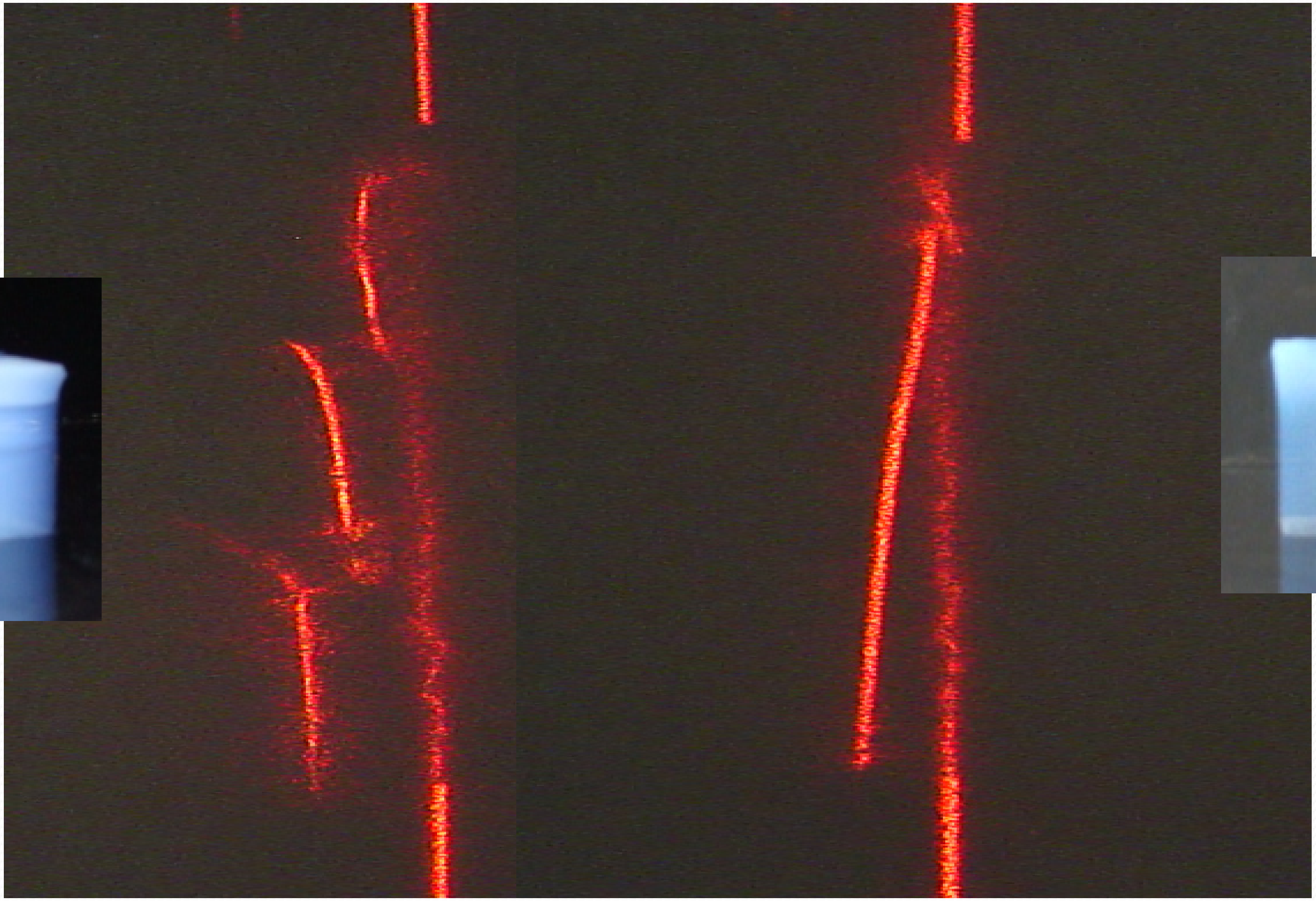


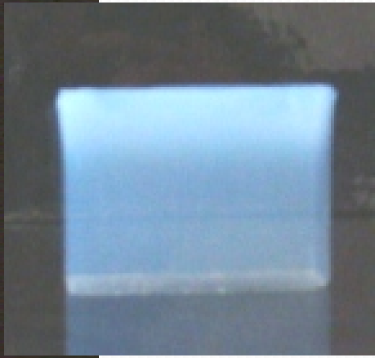
Aerogel For Space

- **HIGH TRANSPARENCY - locate μ sized particles**
- **SUITABLE MESOSTRUCTURE - enable intact capture**
- **WIDEST DENSITY RANGE – gentle capture, shorter track**
- **PARTICLE COATING - particle protection**
- **PURITY - minimize contamination**
- **FLIGHT ROBUSTNESS - launch vibration/landing shock**
- **TEMPERATURE CYCLING - long term stability**
- **TEMPERATURE EXTREMES – thermal shock stability**
- **RADIATION IMMUNITY - UV & radiation resistant**
- **IONIC IMMUNITY – space environment stability**
- **LOW MASS – flexibility, not mass driver**
- **ELASTICITY – compression containment**
- **High Internal Surfaces – trap volatile organics**
- **Smooth Gradient Density – 10X density gradient**

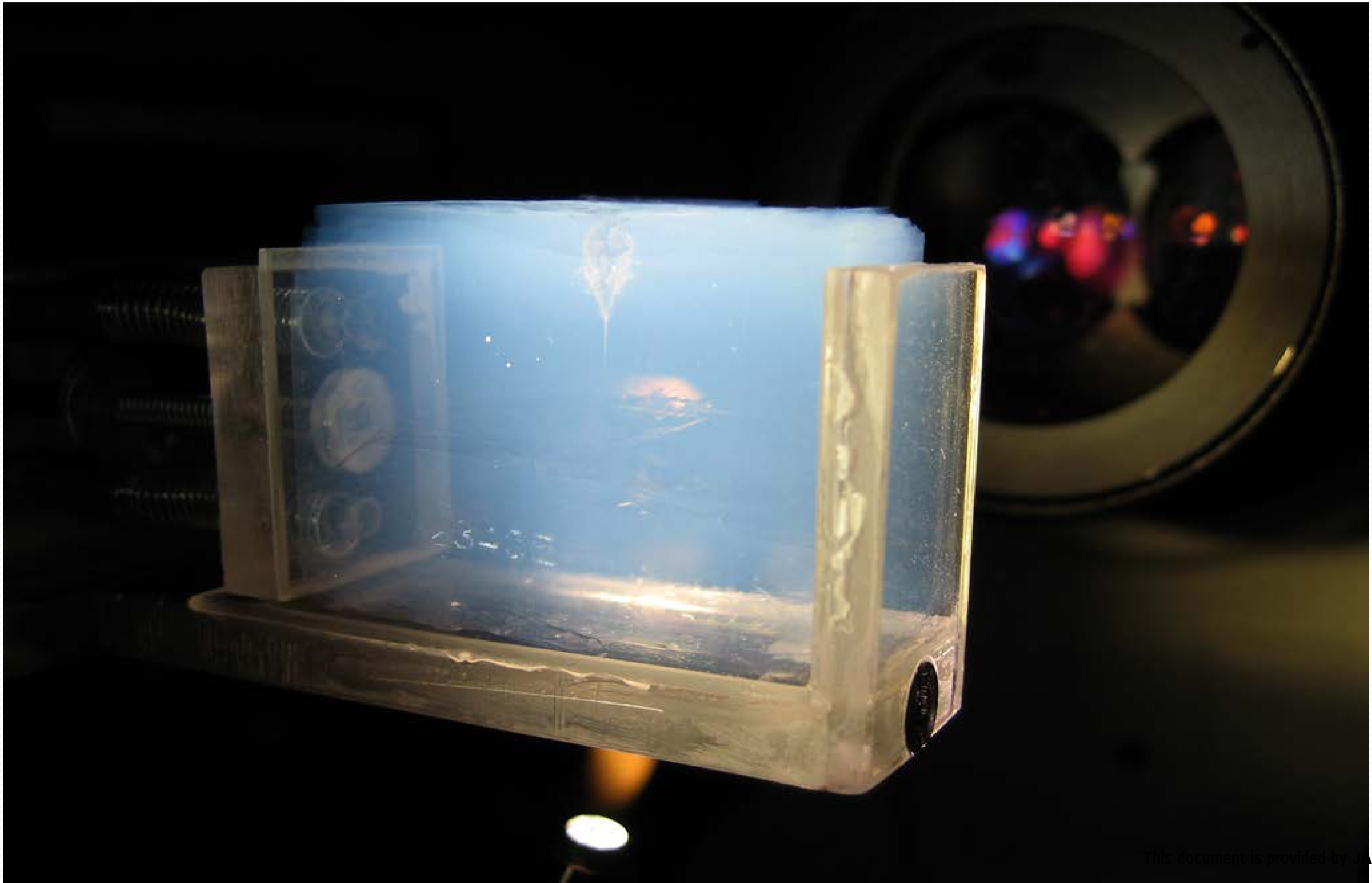
Layered vs Smooth





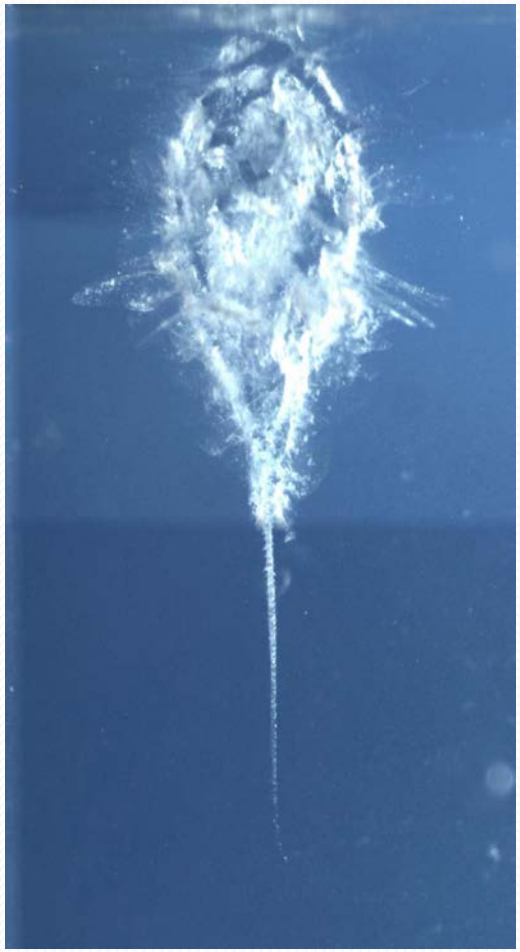


Captured Particle



Track Profiles

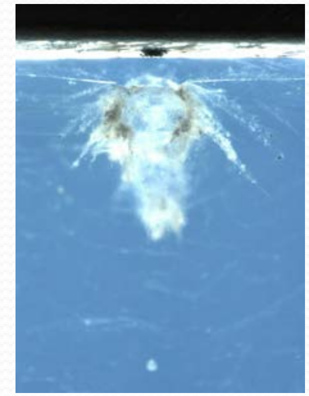
C027T6T7,
8.5 & 11mm



C054T1, 11.7mm

C044T7,
8mm

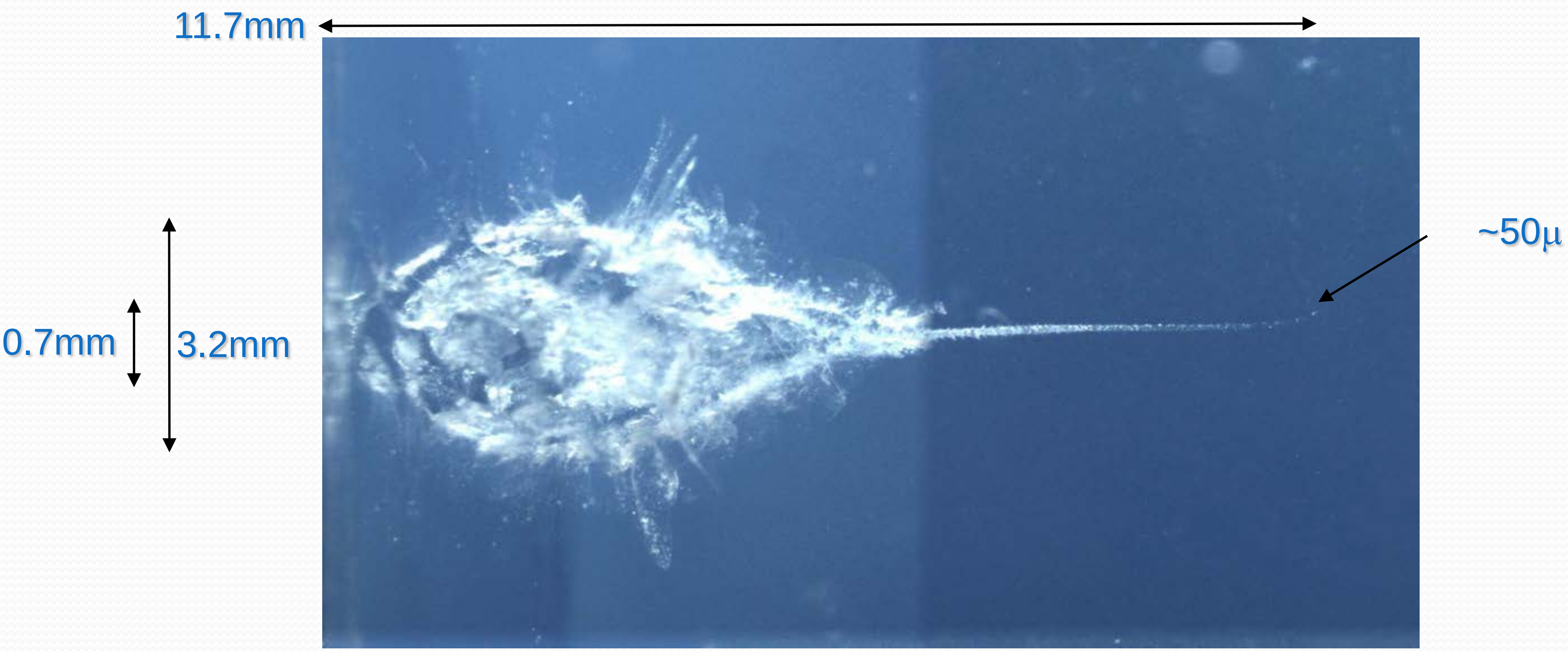
C052T5,
6mm



C084T2,
3.6mm

C027T3
3.7mm

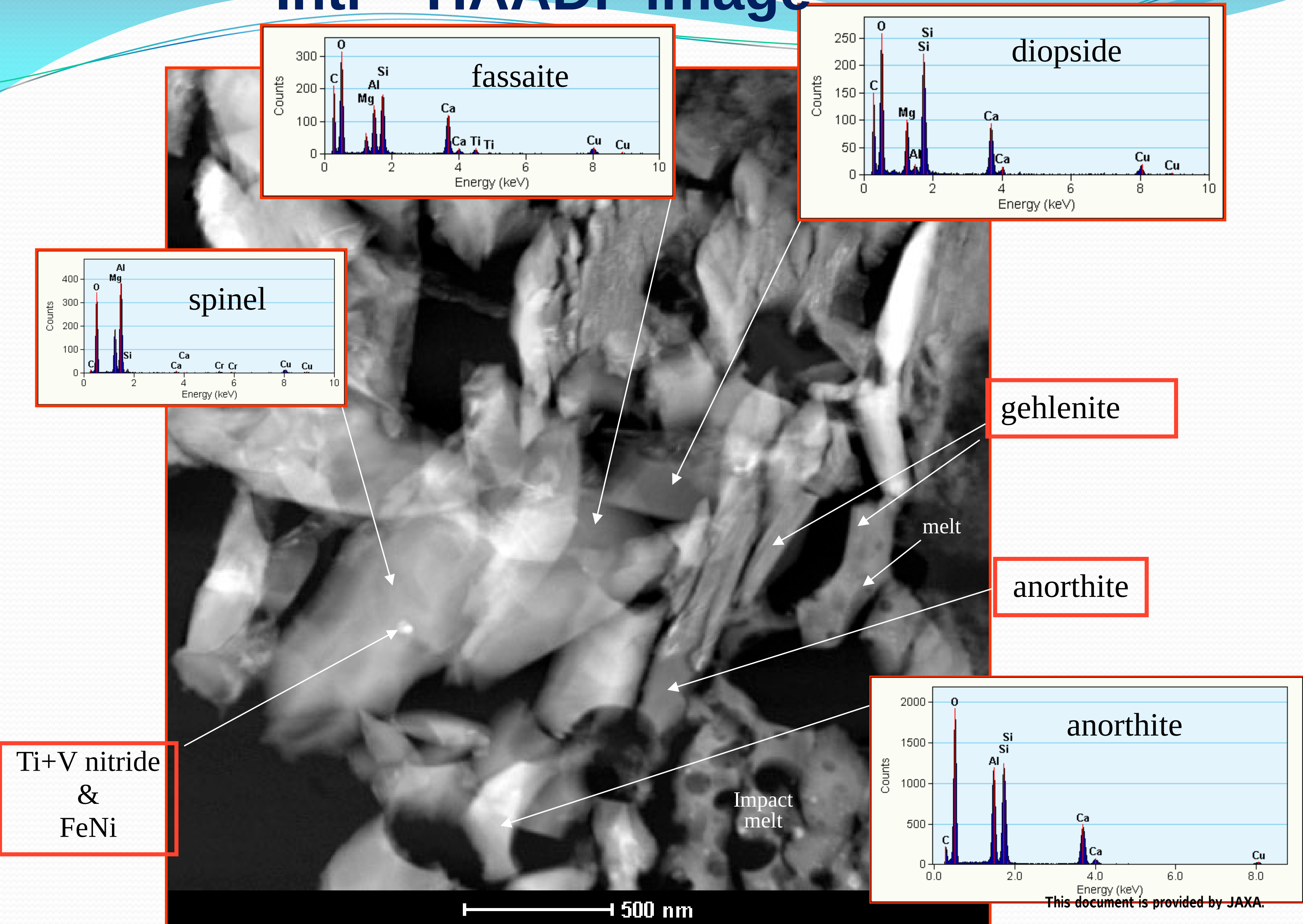
Track Characteristics



V=~0.022 cm^3

TP/V= ~$3x10^{-6}$

Inti – HAADF image



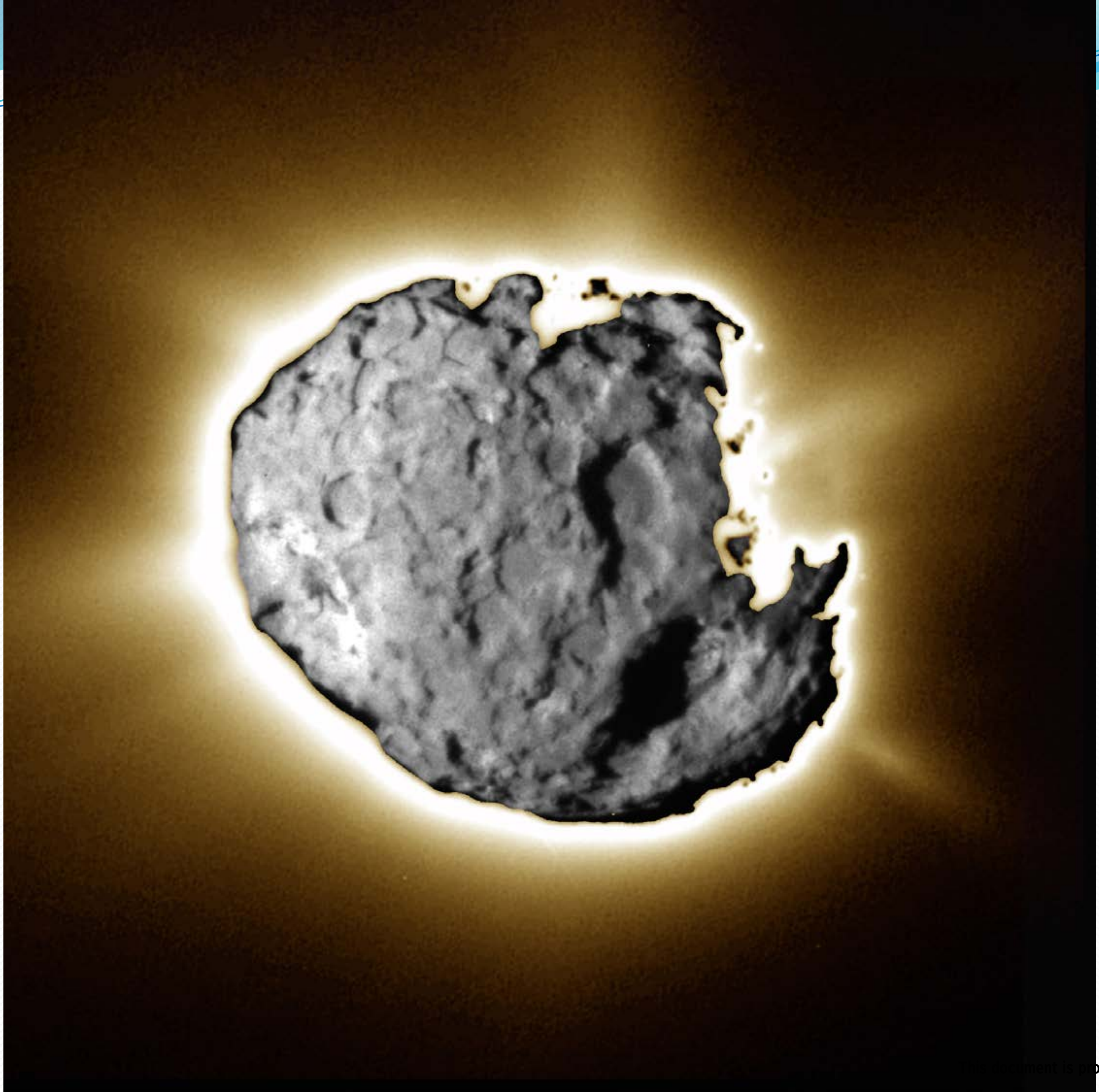
Greenberg Model

Aggregate of submicron core-mantle
Interstellar grains
Submicron amorphous grains
Highly reworked stardust

Isotopically Solar
Very large rocks
Crystalline
Anhydrous
Ice & Fire

STARDUST Achievements

- First NASA Dedicated Cometary Mission
- First Extra-Earth Robotic Sample Return Mission
- First Flyby (no landing) Sample Return Mission
- First Faster-Better-Cheaper Mantra Discovery Mission
- First Using Silica Aerogel as Primary Science Mission
- First Return of Samples from a known Comet
- First Return of Contemporary Interstellar Samples
- First Mass Spectra of Cometary/Interstellar Dust
- First On Schedule, Under Cost Discovery Mission



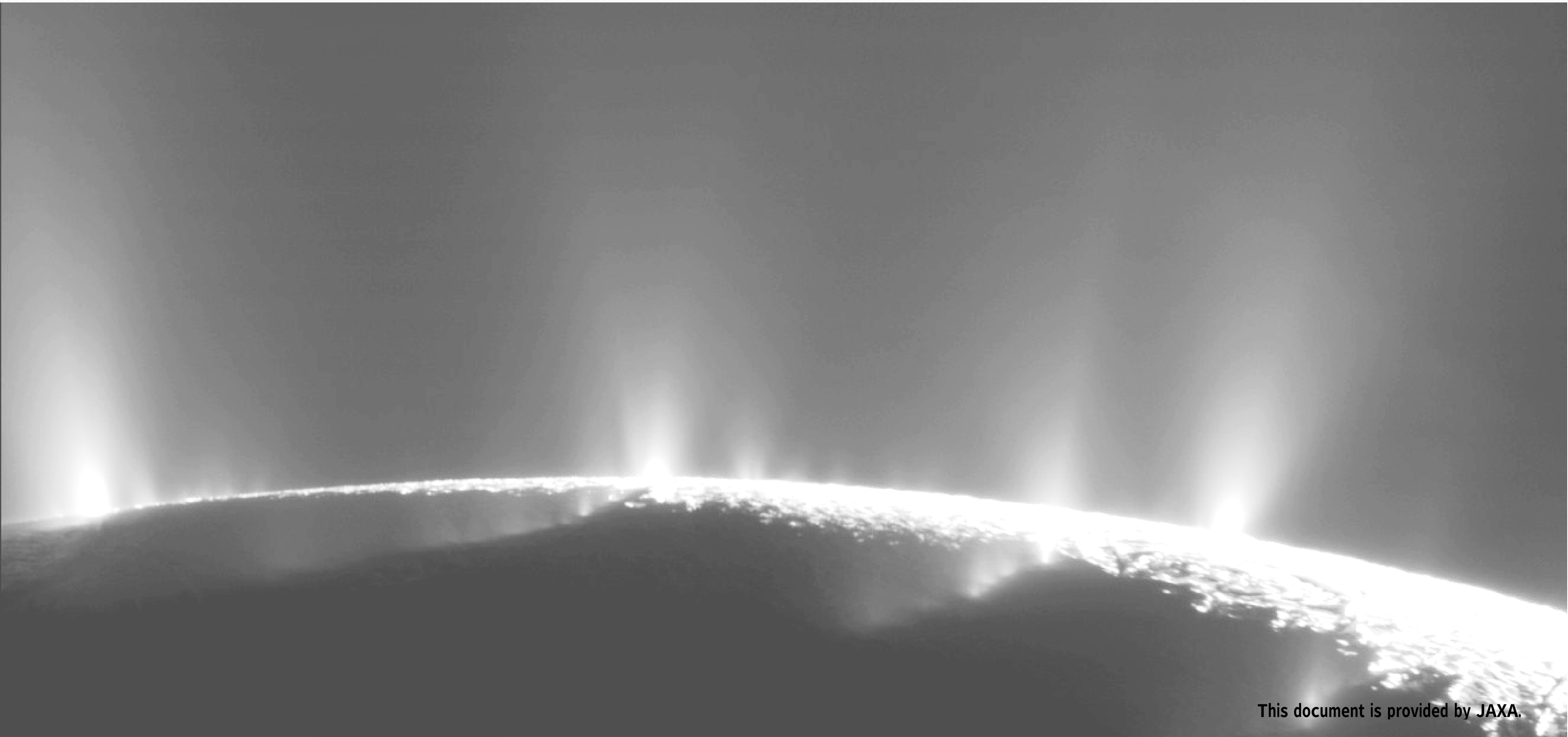
Cassini-Enceladus

- 2005 Discovered Water Plume
- Organics
- Possible Water Ocean
- Nitrogen

Habitable!?

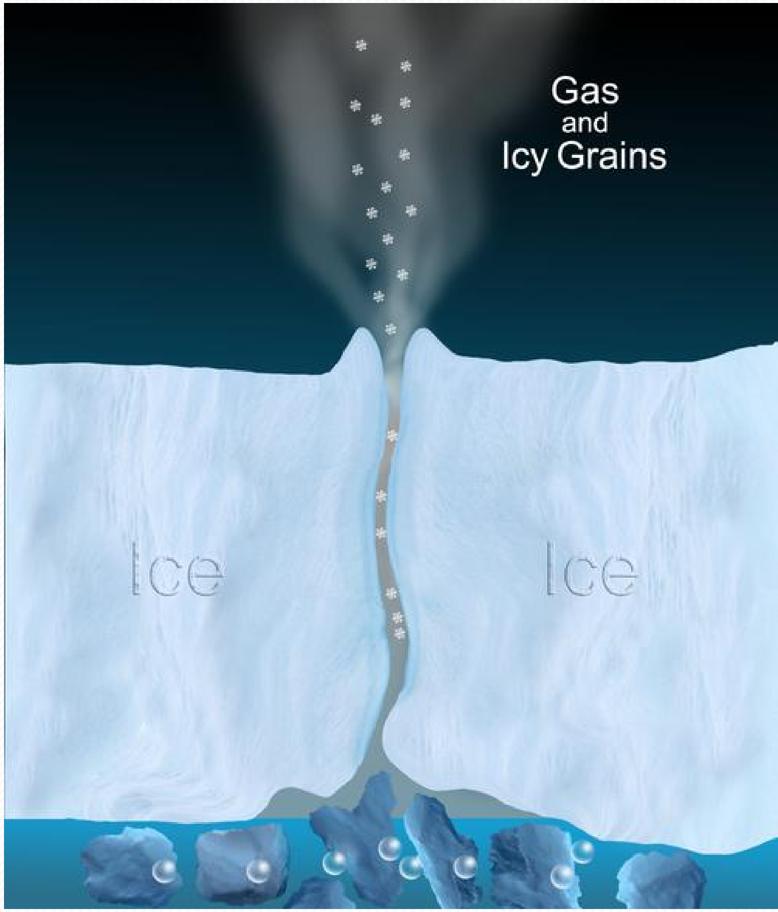
Enceladus H_2O Jets

Where there is water; there is life on Earth!



Enceladus Jets

- Evidence that plume source is liquid water ocean
- Salt-rich particles in plume imply liquid water having contacted rock [Postberg et al., 2009]
- NH_3 detected [Waite et al., 2009] lowers freezing point of water
- Temperatures in excess of 170 K measured in fractures by Cassini CIRS



Astrobiology heaven!

Low Hanging Fruit!

- **NASA, ESA, JAXA, ISRO**
  - **Within the Solar System**
  - **Without the Solar System**
- **Questions**
  - **What is life? How did life begin on Earth?**
  - **Are there habitable bodies?**
  - **Are there “life” different than what’s on Earth?**
- **No Life Meter – need samples to study**
- **Active Jets – amenable to flyby sample return**
- **If No Jets- Where to Land? Where to drill?**

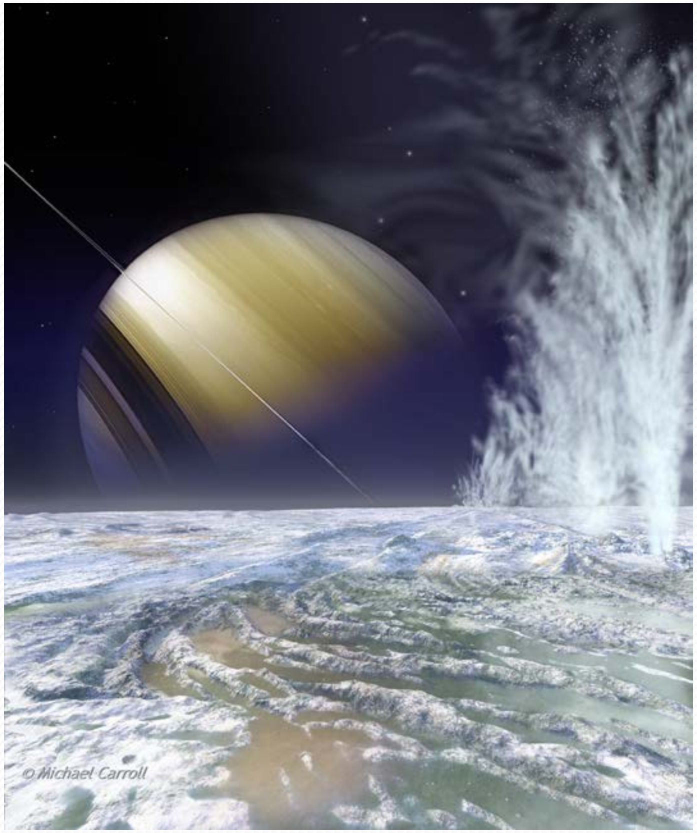
Habitability Factors

- **Liquid Water**
- **Heat Source**
- **Organic Materials**
- **N_2**

McKay et al. Astrobiology submitted

Why Enceladus Now?

- The plume has ~300 years of activity, if the plume ceases, flyby sampling is not possible and even a lander would be difficult. Early sampling is desired.
- Future missions would benefit from early sample analysis results.
- Early sample return from Enceladus would accelerate early life detecting instrument development.
- Early sample return



Challenges

- Cost
- Planetary Protection
- Electrical Power Supply
- High Earth Entry Speed
- Capture/Return Meaningful Samples

- We must be smart to address the question:

Are We Alone on Earth?


1987
1988
1991
1992
Comet Coma Sa
ISAS/NASA Joint W
Japan - U.S. Jo
Missions to Nea
DISCOVERY MISSION WORKSHOP
Flyby Sample Return via SOCCER
Arden L. Albee
Principal Investigator
California Institute of Technology
JPL
Jet Propulsion Laboratory
D-10096 B

Joint Explorations

- Met with Uesugi '82
- 1st '87 10/15-16 Joint workshop
- 2nd '88 1/13-14 Comet Coma Sample Return
- 3rd '88 10/17-18 SOCCER
- 4th '89 10/17-18 SOCCER
- 5th '91 11/21-22 Mission to Near Earth Objects
- 6th '92 9/2 Flyby Sample Return via SOCCER
- 7th' 94 6/14 NEARER;10/21 STARDUST
- LIFE

LIFE Meeting

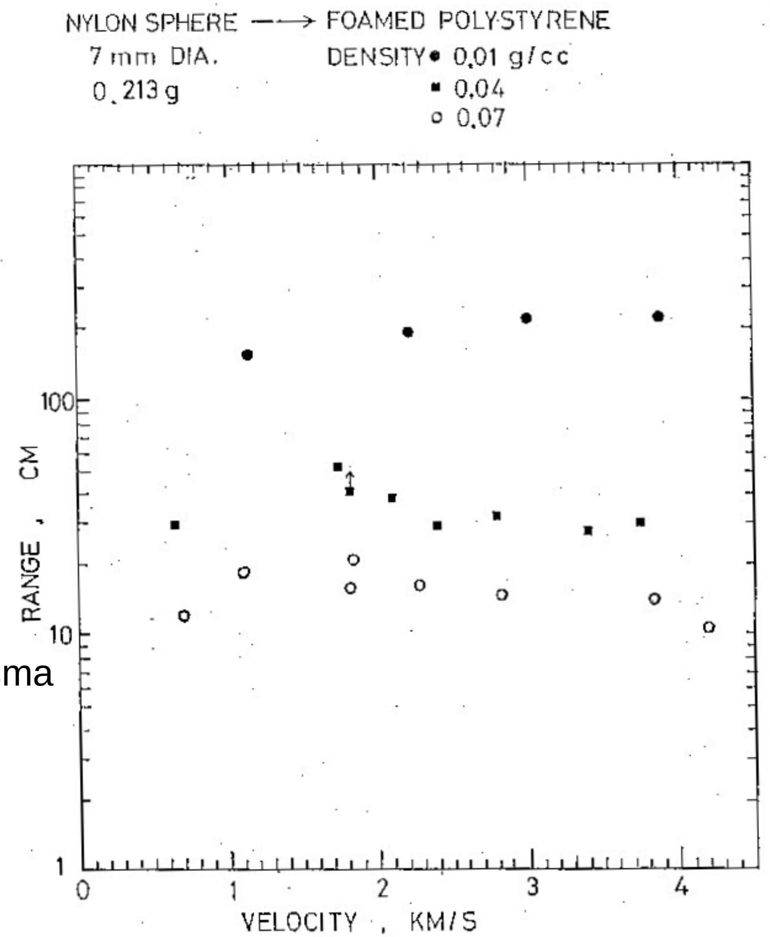
Life Investigation For Enceladus

December 2-4

PRESENTATION TO ISAS/NASA SOCCER MEETING
BY
AKIRA FUJIWARA

OCTOBER 18, 1988

1988



Condensed Plasma