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Nuclear Data Needs for Planetary Nuclear Spectroscopy

WANDA 2021 – Intro to Space Applications Session

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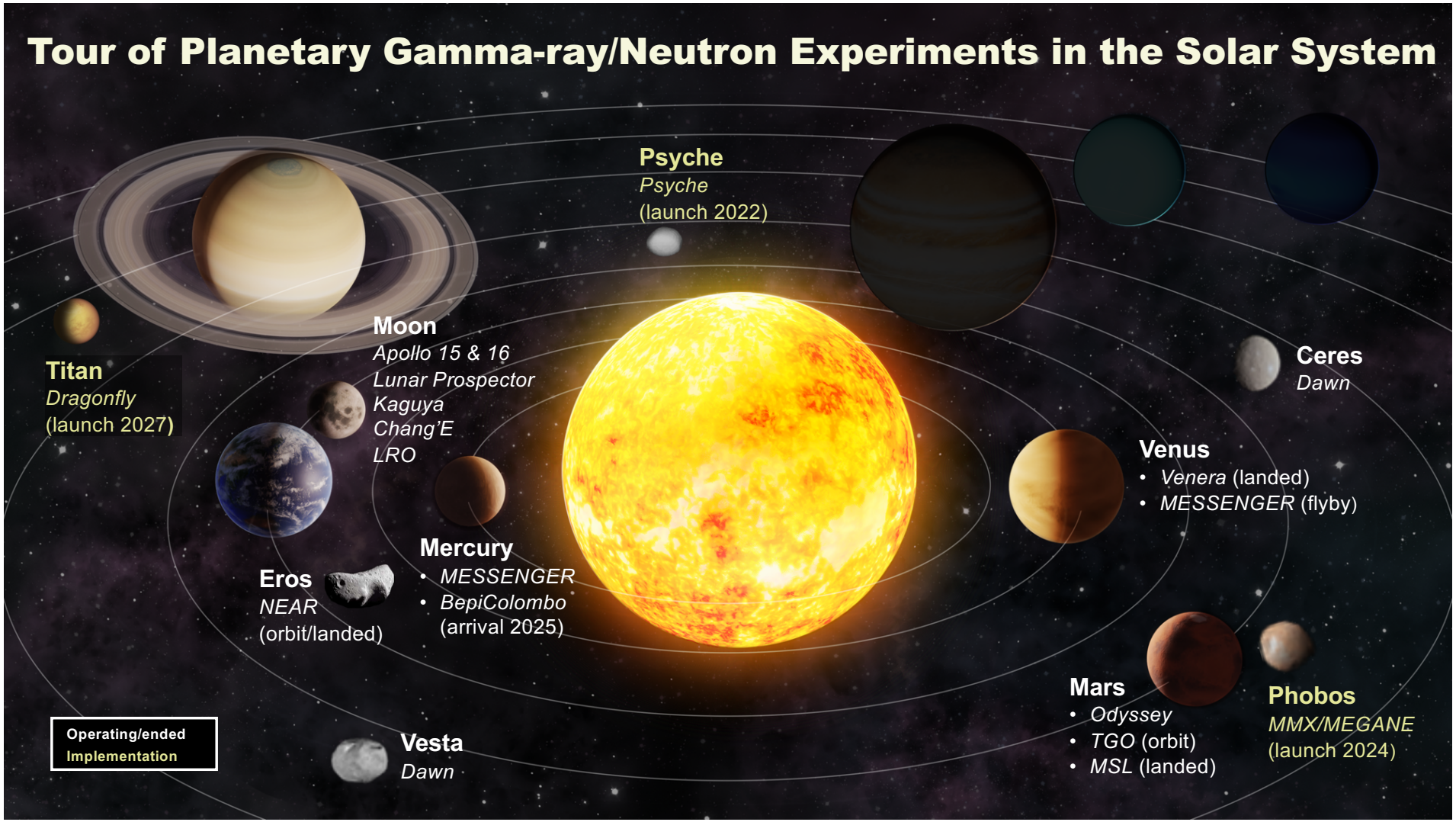

Tour of Planetary Gamma-ray/Neutron Experiments in the Solar System
Psyche
Psyche
(launch 2022)
Titan
Dragonfly
(launch 2027)
Moon
Apollo 15 & 16
Lunar Prospector
Kaguya
Chang'E
LRO
Ceres
Dawn
Venus
• Venera (landed)
• MESSENGER (flyby)
Mercury
• MESSENGER
• BepiColombo
(arrival 2025)
Eros
NEAR
(orbit/landed)
Mars
• Odyssey
• TGO (orbit)
• MSL (landed)
Phobos
MMX/MEGANE
(launch 2024)
Vesta
Dawn
Operating/ended
Implementation

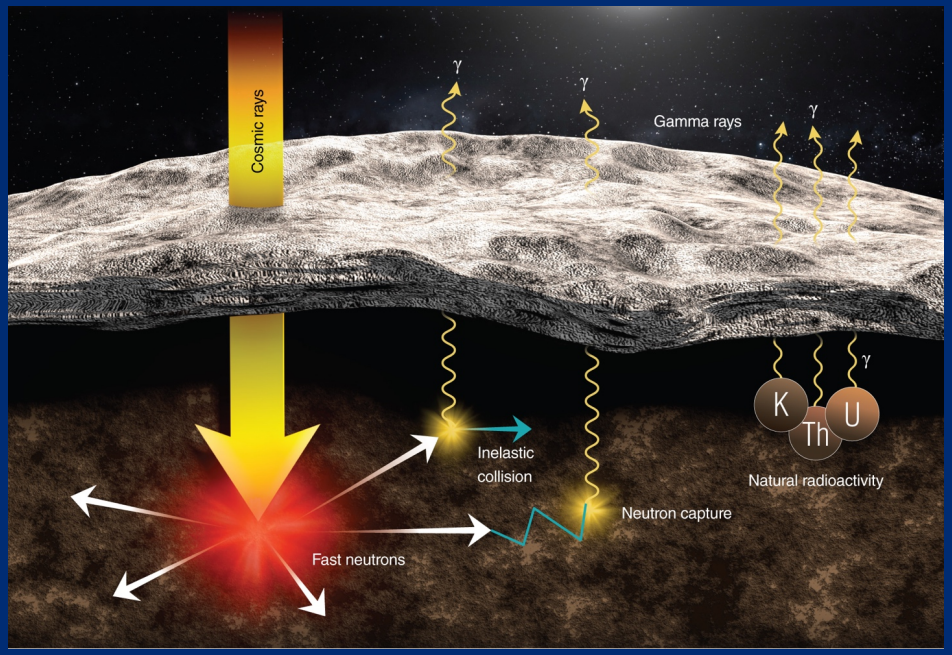
Elements of Interest

- The needs of the planetary nuclear spectroscopy community are:
  - (n,n'γ) and (n,γ) gamma-ray production cross sections,
  - on natural targets of major and minor elements,
  - for each gamma-ray emission of interest,
  - over a wide range of neutron energies.
- This information needs to be accurately provided for use in radiation transport codes (Geant4, MCNP6) via appropriate libraries.
  - To date, no one library works for all gamma-ray lines.
  - New does not mean better – benchmarks show that ENDF VI is better than ENDF VIII!
- The list to the right shows the required element measurements for the three APL-led gamma-ray spectroscopy investigations currently in development.
  - It is complete in terms of elements, but it is not exhaustive in terms of gamma rays.
  - It also doesn't cover the needs of prior missions.
  - The list is not meant to imply that we do or don't have the data we need for these elements.

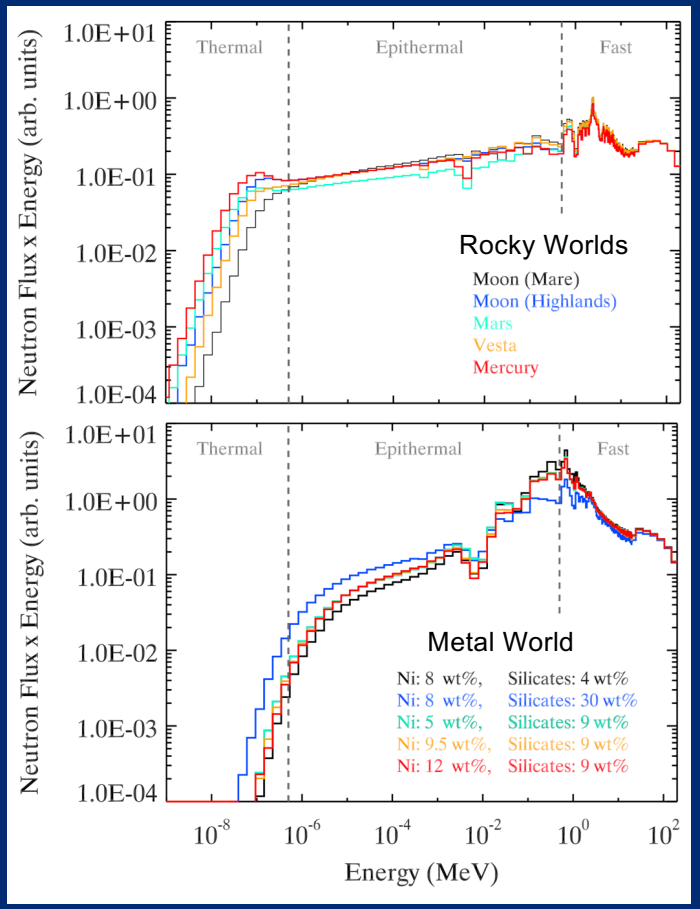
	Typical Gamma Rays (non-inclusive list)	Psyche GRS (Asteroid 16 Psyche)	MEGANE (Mars' Moon Phobos)	DraGNS (Saturn's Moon Titan)
H	(n,γ): 2223 keV		Y	Y
C	(n,n' γ): 4438 keV			Y
N	(n,n' γ): 2312 keV			Y
O	(n,n' γ): 6129 keV (n,n' $\alpha\gamma$): 4438 keV		Y	Y
Na	(n,n' γ): 440 keV		Y	Y
Mg	(n,n' γ): 1369 keV		Y	Y
Al	(n,n' γ): 843, 1014, 2211 keV	Y		
Si	(n,n' γ): 1778 keV (n,γ): 3539, 4934 keV	Y	Y	
P	(n,n' γ) 2233 keV			Y
S	(n,n' γ) 2232 keV	Y		Y
Cl	(n,γ) 1951, 1960, 6111 keV			Y
K	(n,n' γ) 2814 keV		Y	Y
Ca	(n,n' γ) 1940 keV (n,γ) 3736 keV	Y	Y	
Fe	(n,n' γ): 846, 1238, 1408, 1809 keV (n,γ): 7631, 7646, keV	Y	Y	
Ni	(n,n' γ): 1332, 1454 keV	Y		

Energies of Interest (1/2)

"Passive" Measurements –
Cosmic-Ray Produced Neutrons

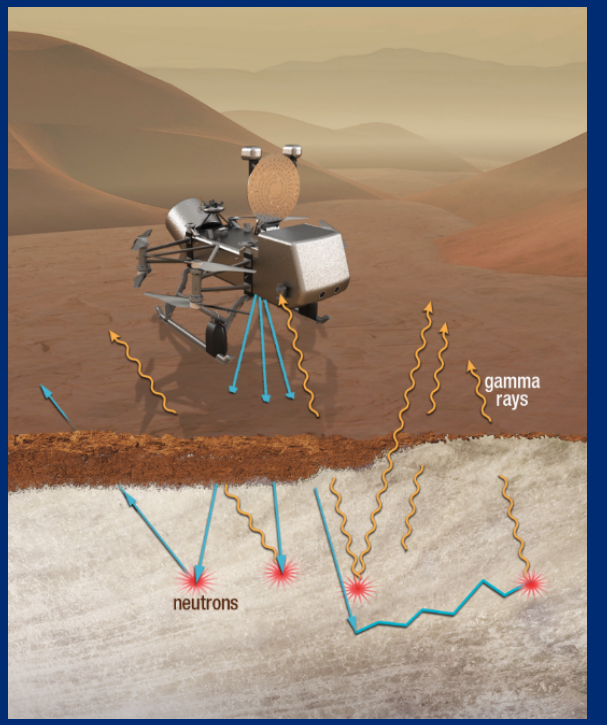


Surface-Escaping Neutron Flux

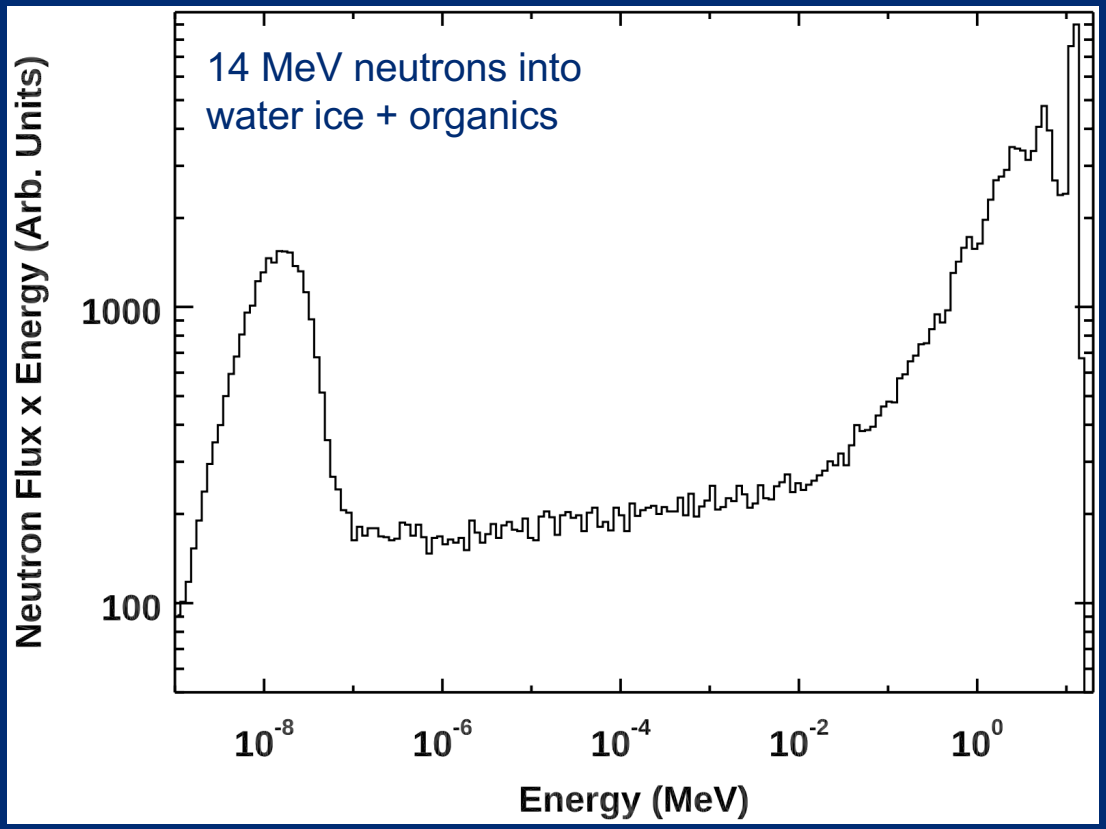


Energies of Interest (2/2)

"Active" Measurements –
Pulsed-Neutron Generators



Surface-Escaping Neutron Flux



See T. Prettyman's Talk for a more detailed discussion of planetary nuclear spectroscopy.