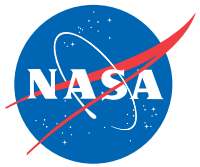
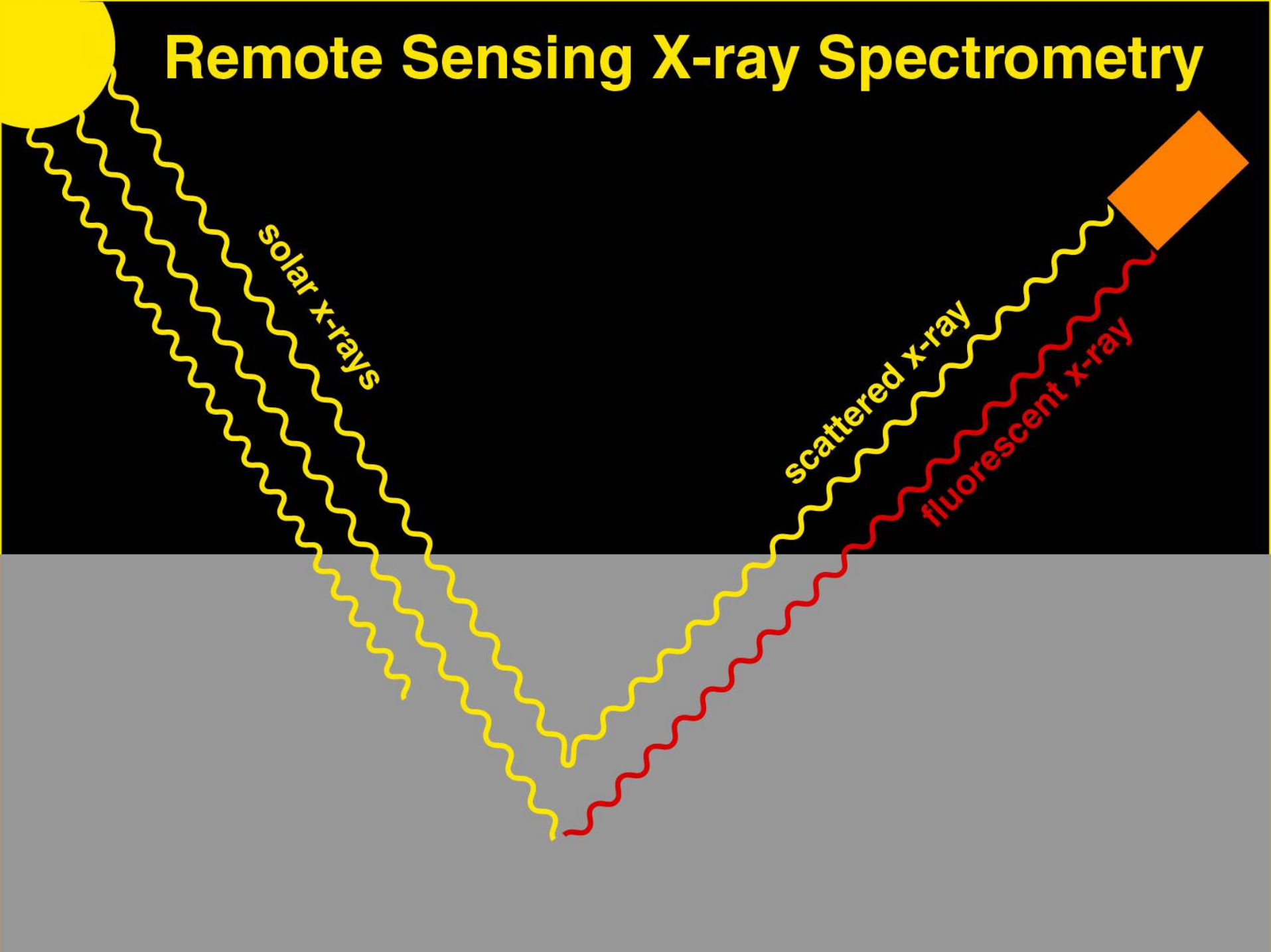
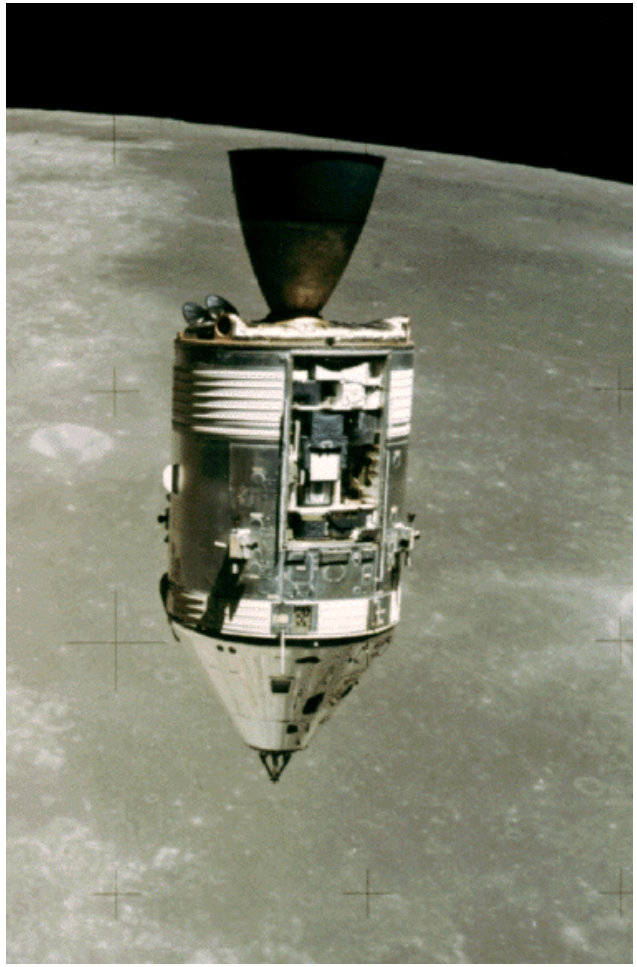


Goddard Space Flight Center
Solar Systems Exploration Division

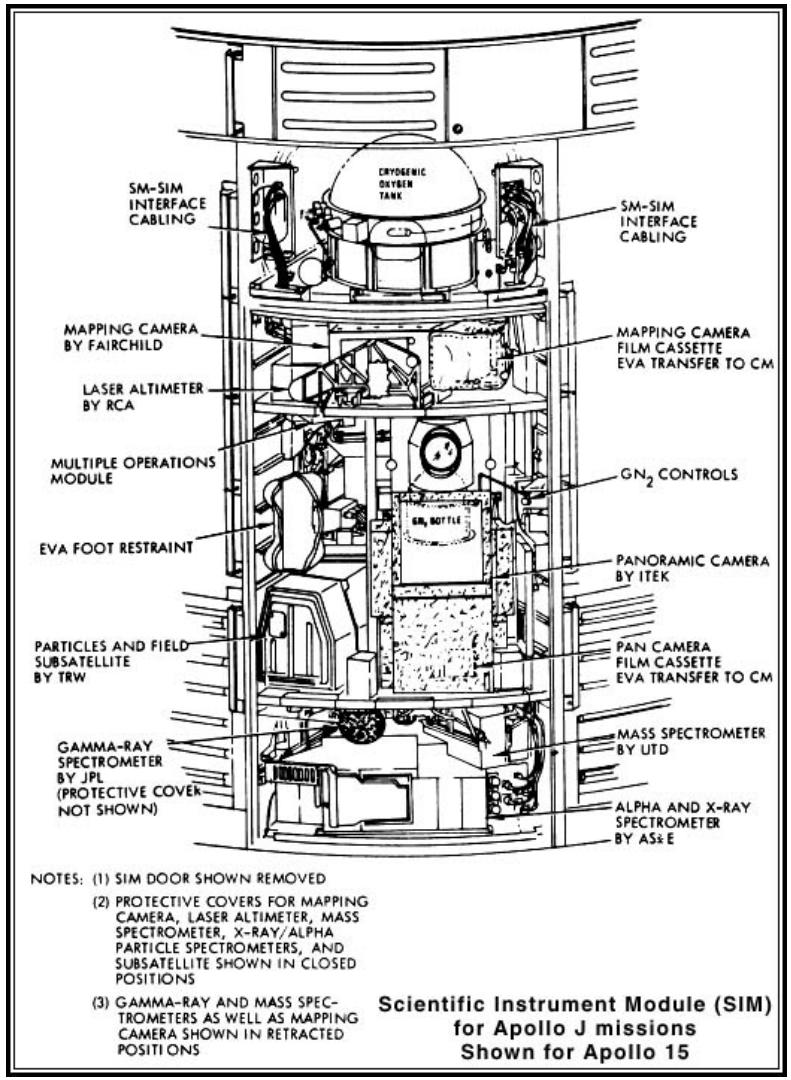
Remote Sensing X-Ray Exploration of Moon and 433 Eros

Jacob Trombka
Astrochemistry Laboratory


Remote Sensing X-ray Spectrometry
solar x-rays
scattered x-ray
fluorescent x-ray



X-ray Map 20% Lunar Surface
Apollo 15 Launch July 26,1971
Apollo 16 Launch April 16,1972



Apollo 15 & 16 SIM Bay

Apollo X-Ray Detector System

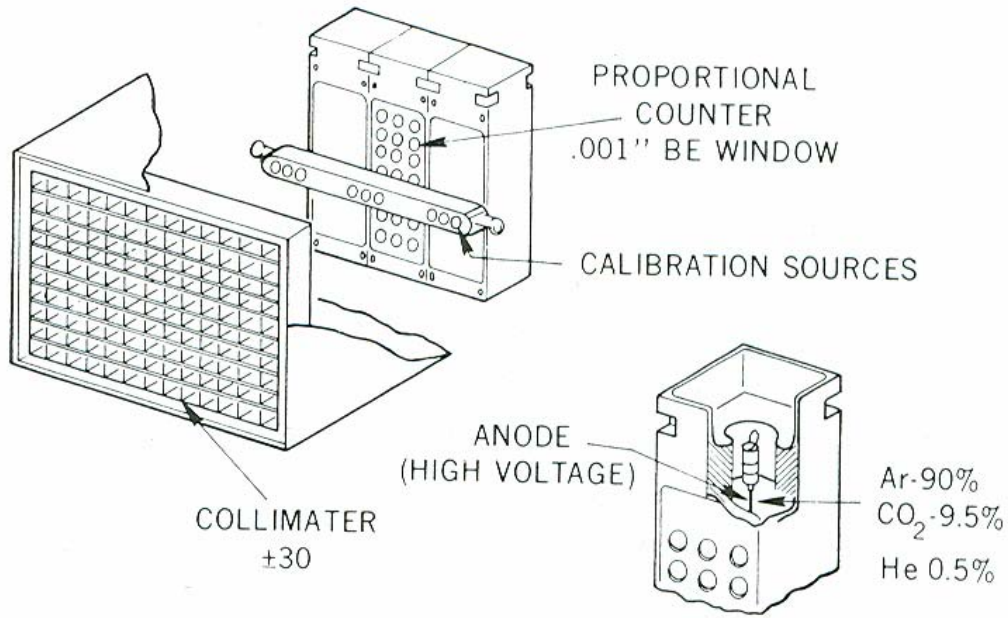


Fig. 4. Functional configuration of the x-ray spectrometer.

Apollo X-Ray Al/SI and Mg/Si Map Northern Trace

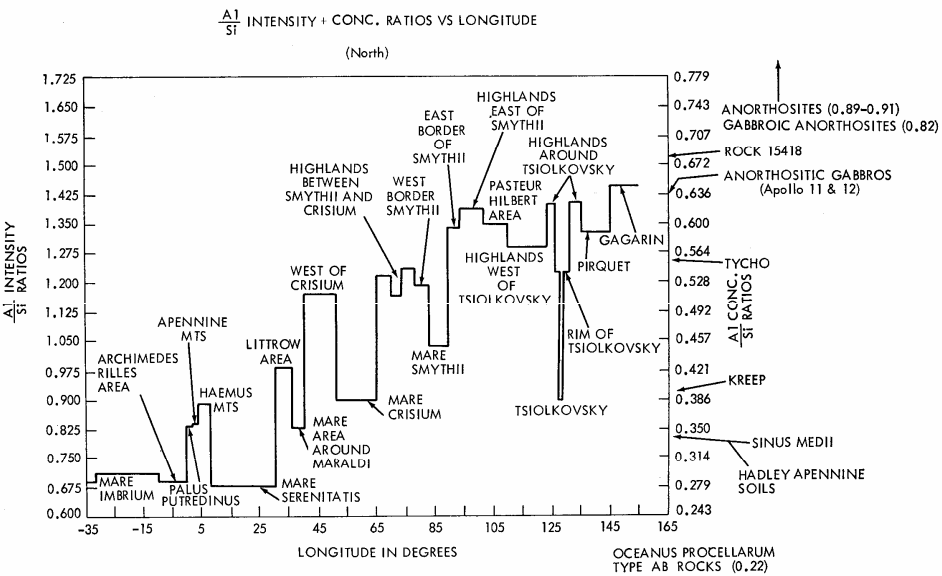


Fig. 7a. Al/Si ratios for a northerly track.

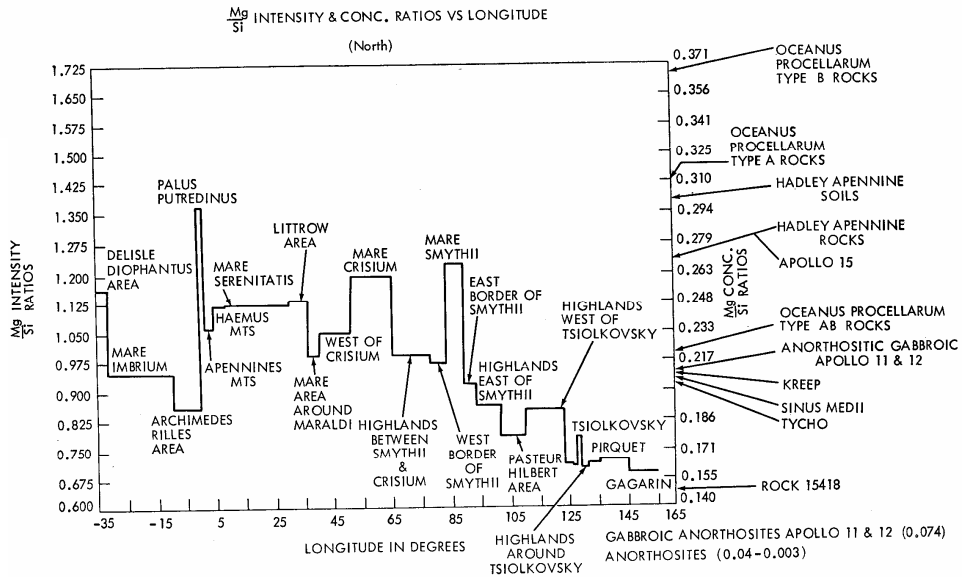
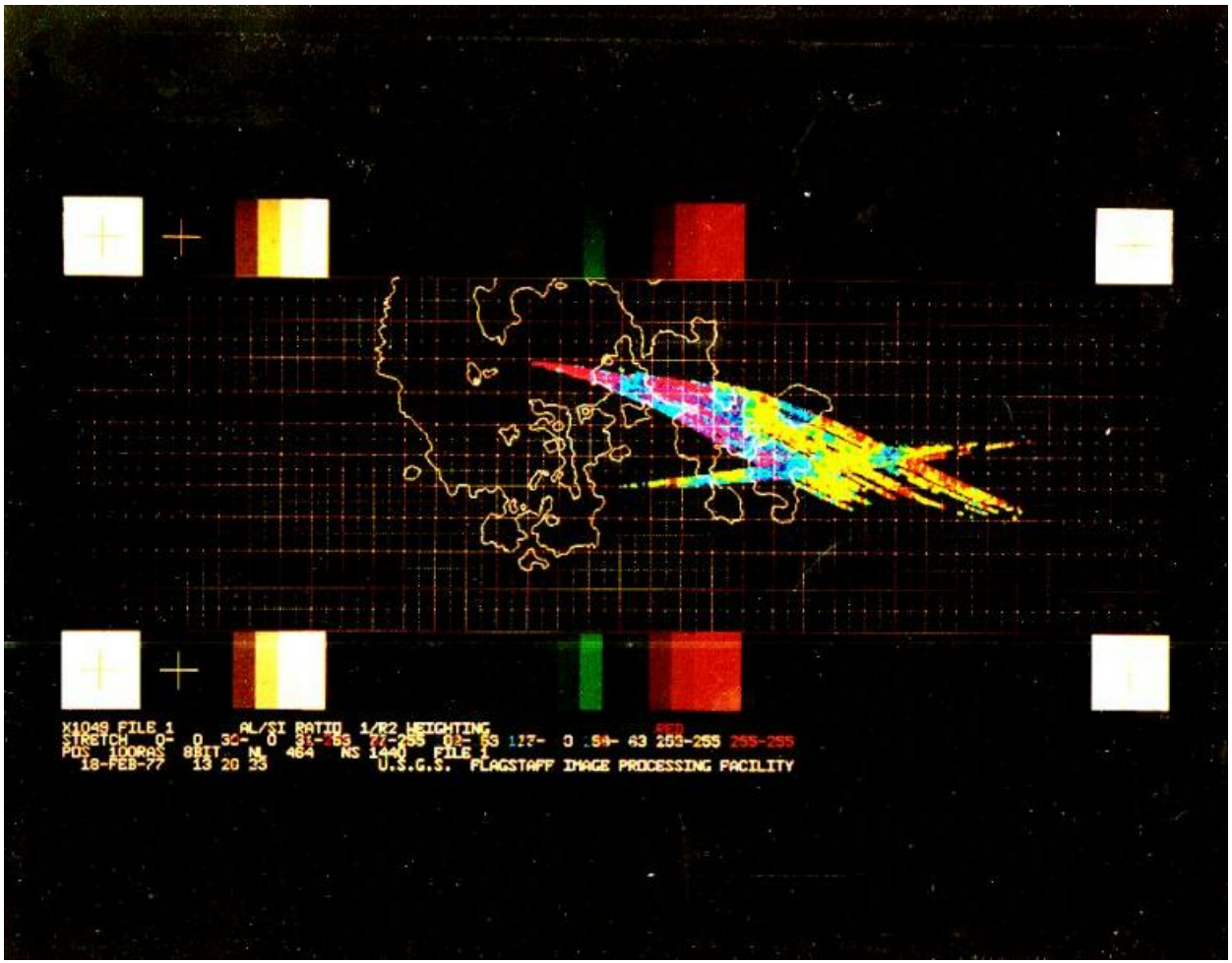
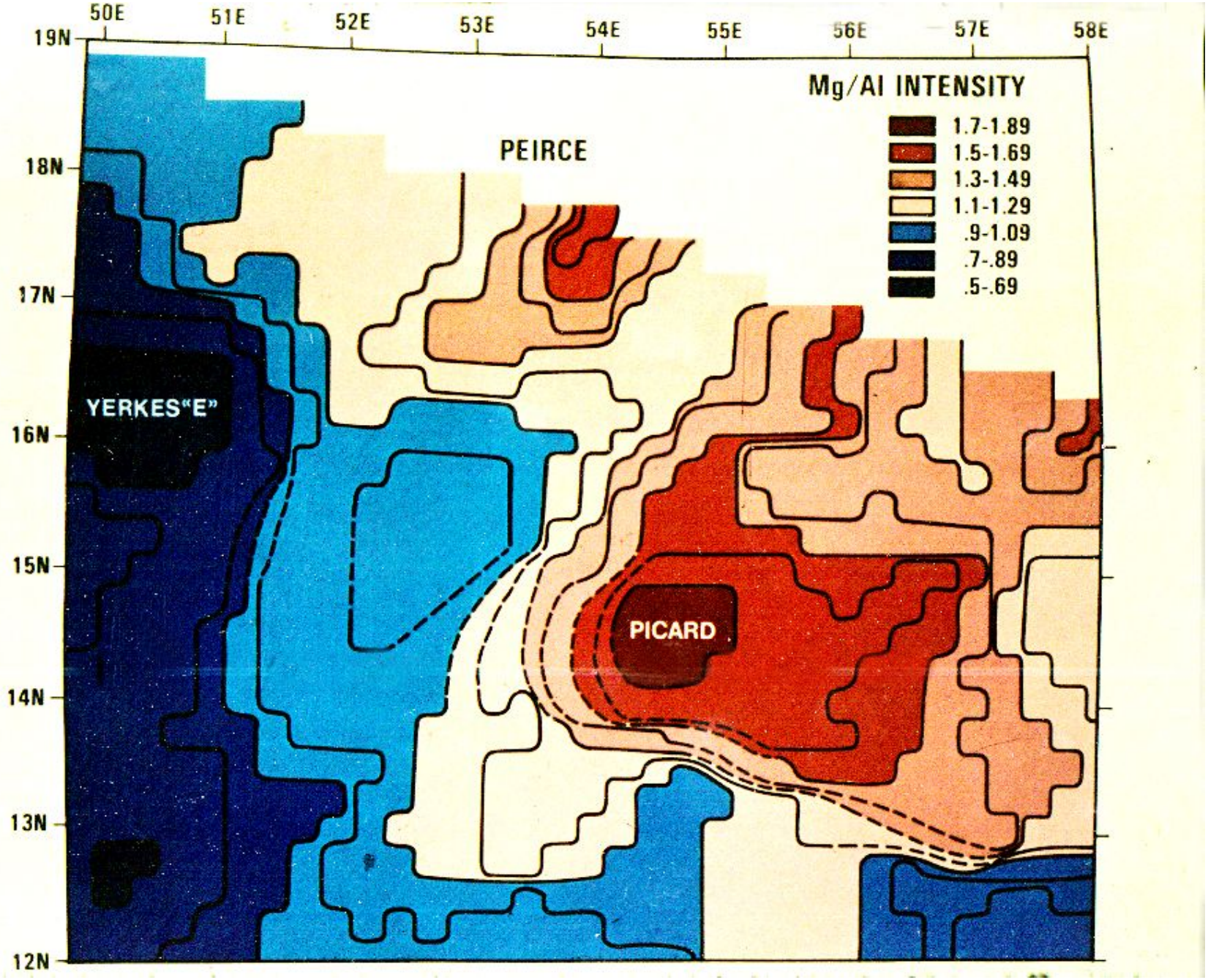


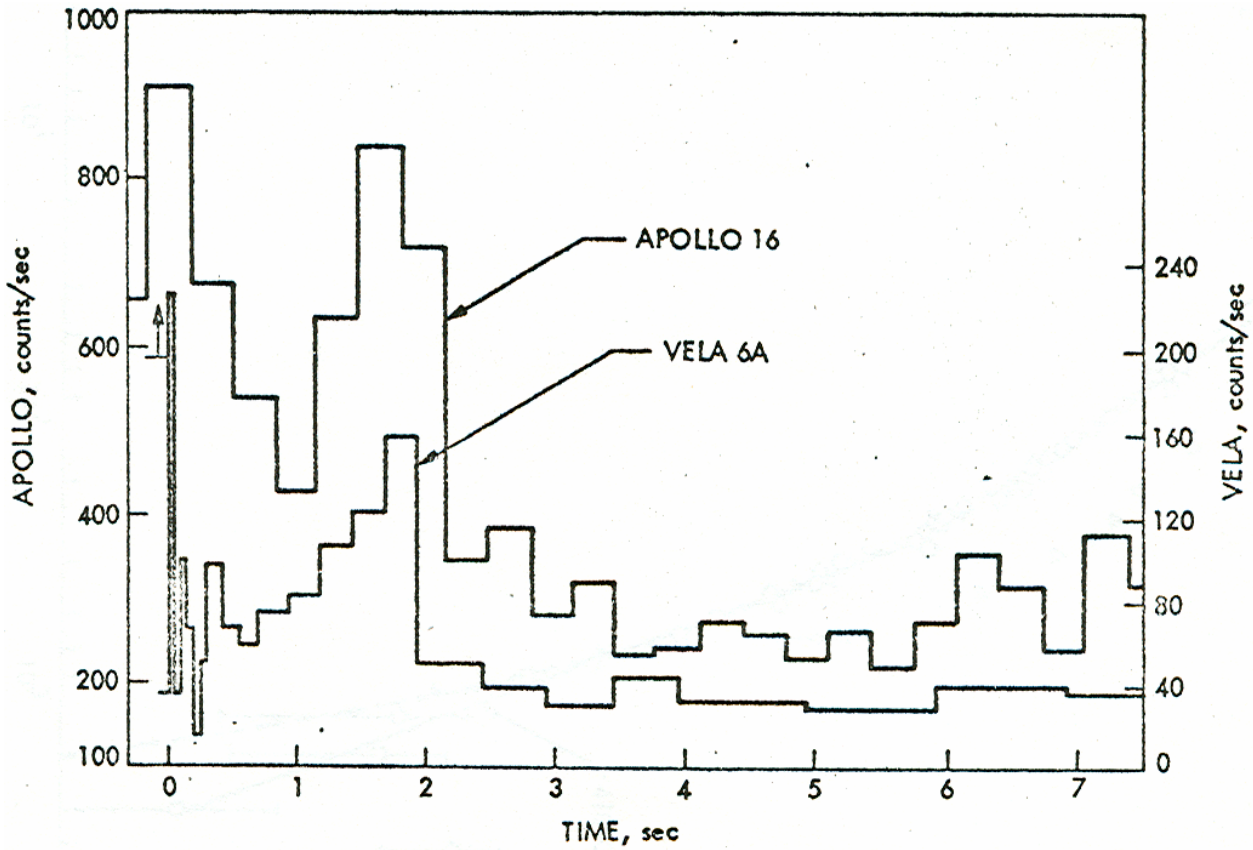
Fig. 7b. Mg/Si ratios for a northerly track.

Apollo 15 & 16 Al/Si Map

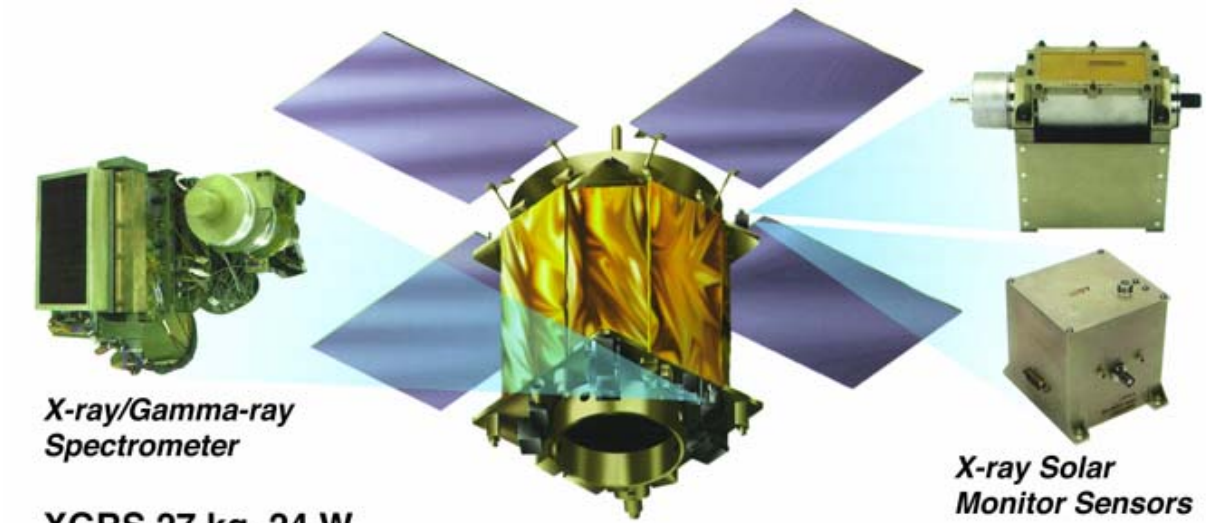



50E
51E
52E
53E
54E
55E
56E
57E
58E
19N
18N
17N
16N
15N
14N
13N
12N
Mg/Al INTENSITY
1.7-1.89
1.5-1.69
1.3-1.49
1.1-1.29
.9-1.09
.7-.89
.5-.69
PEIRCE
YERKES"E"
PICARD

Apollo 16 and Vela 6A Gamma Ray Burst Timing April 27,1972



NEAR X-ray/Gamma-ray Spectrometer

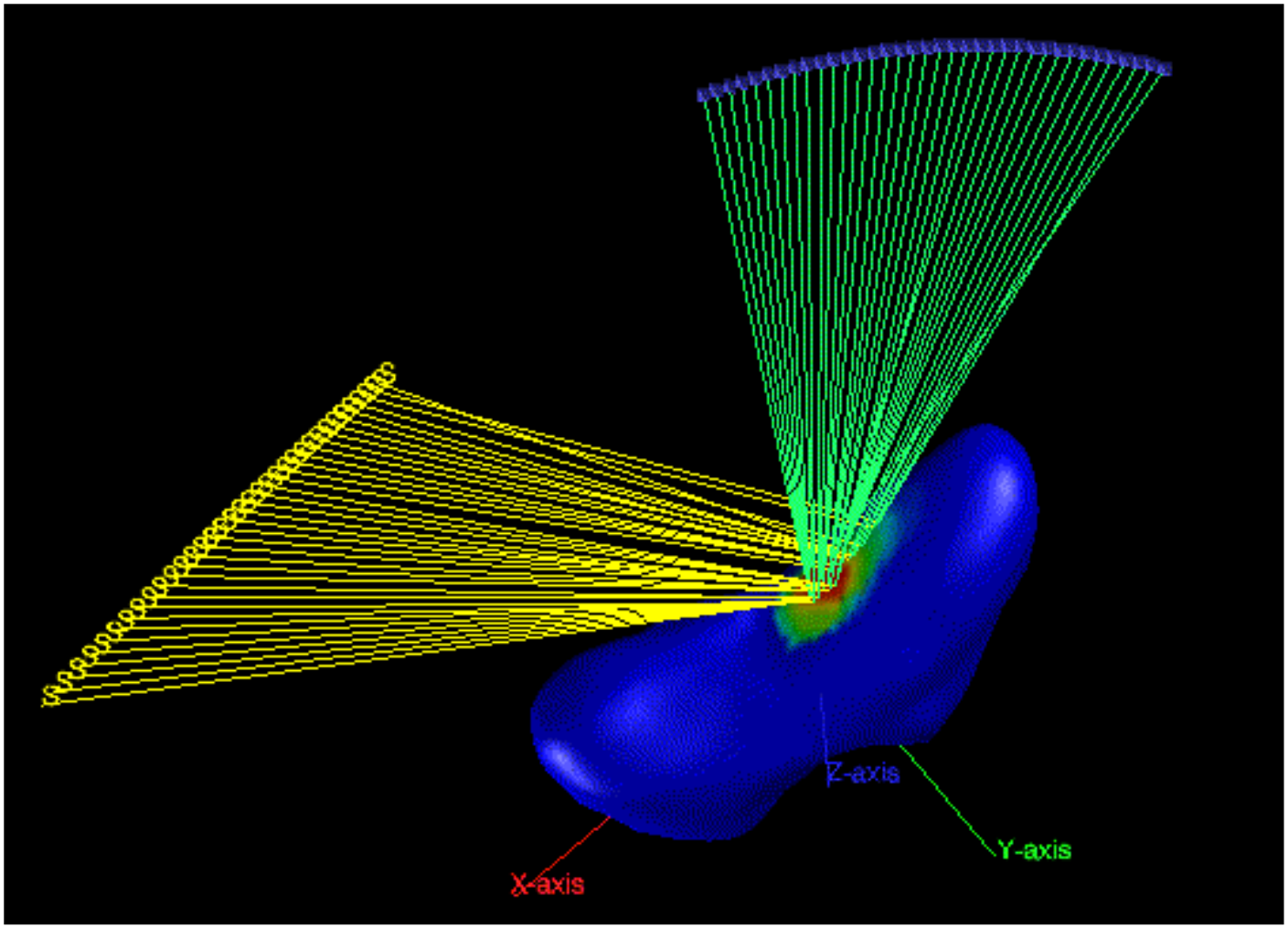


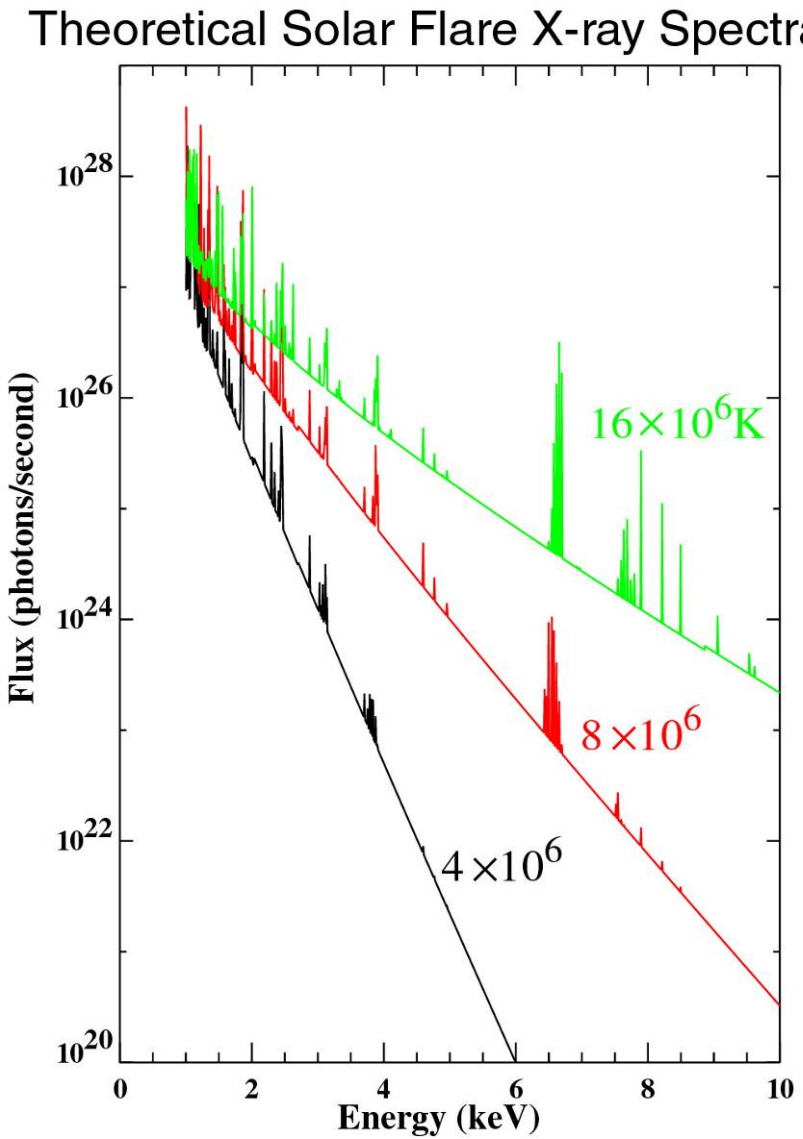
XGRS 27 kg, 24 W
X-ray: Mg, Al, Si (S, Ca, Ti, Fe)
Gamma-ray: K, Th, U - Fe, Si, O, H

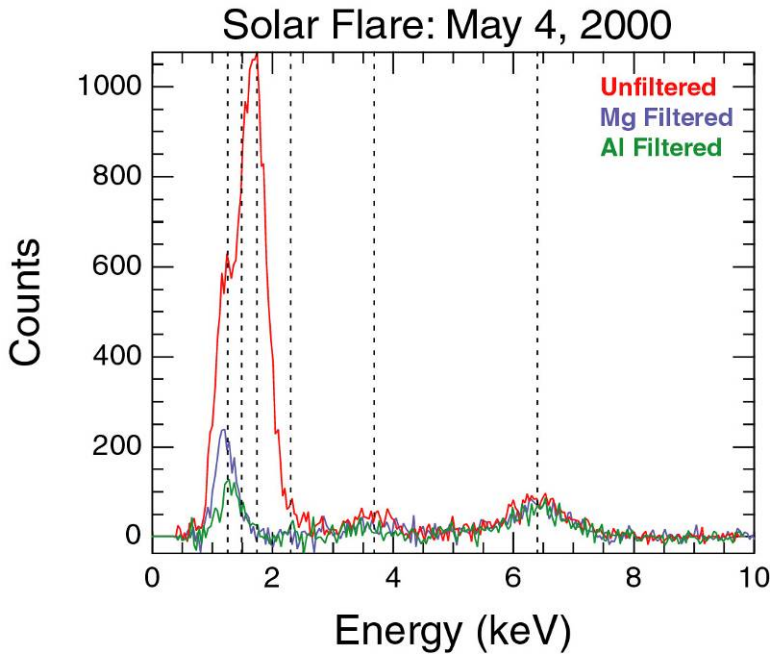
X-ray: 5° FOV
Gamma-ray: 60° FOV

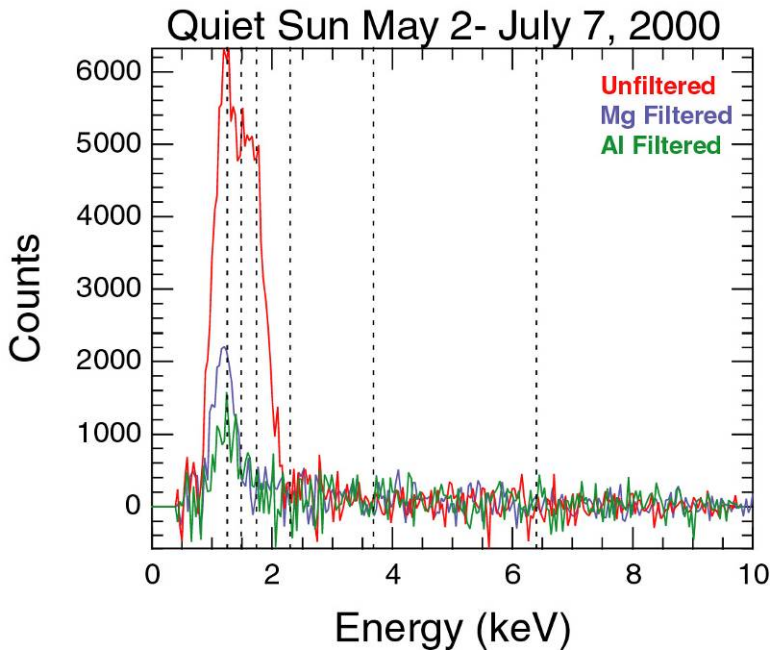
First Gamma-Ray Spectrum on an Asteroid Surface
NEAR Launch February 17,1996

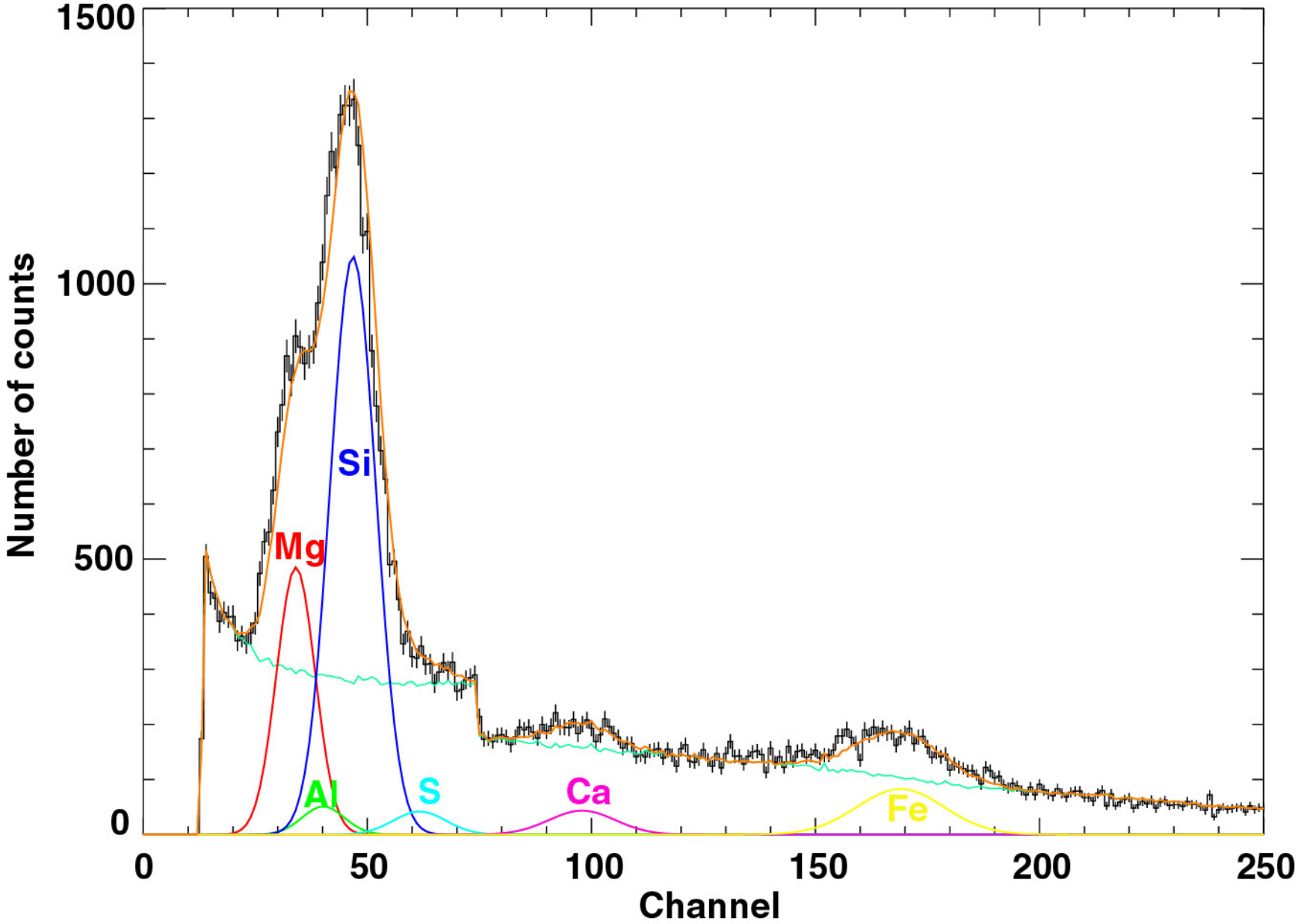
NEAR X-Ray Footprint on the Surface of Eros




Theoretical Solar Flare X-ray Spectra
Flux (photons/second)
10^{28}
10^{26}
10^{24}
10^{22}
10^{20}
0
2
4
6
8
10
Energy (keV)
16×10^6K
8×10^6
4×10^6


Solar Flare: May 4, 2000
Counts
1000
800
600
400
200
0
0
2
4
6
8
10
Energy (keV)
Unfiltered
Mg Filtered
Al Filtered


Quiet Sun May 2- July 7, 2000
Counts
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
Energy (keV)
Unfiltered
Mg Filtered
Al Filtered


May 4 Flare Spectrum (Unfiltered Detector)
Number of counts
1500
1000
500
0
0
50
100
150
200
250
Channel
Si
Mg
Al
S
Ca
Fe

APOLLO GAMMA RAY SPECTROMETER

- NEAR LANDING ACTIVATED THE SHORT LIVED IODINE IN THE CSI DETECTOR
- INCREASE BACKGROUND IN THE .3 TO 3 MEV REGION
- UNABLE TO SEE THE NATURAL ACTIVITY K, U AND TH

Typical Quiet Sun X-Ray Emission Spectrum During Apollo Missions

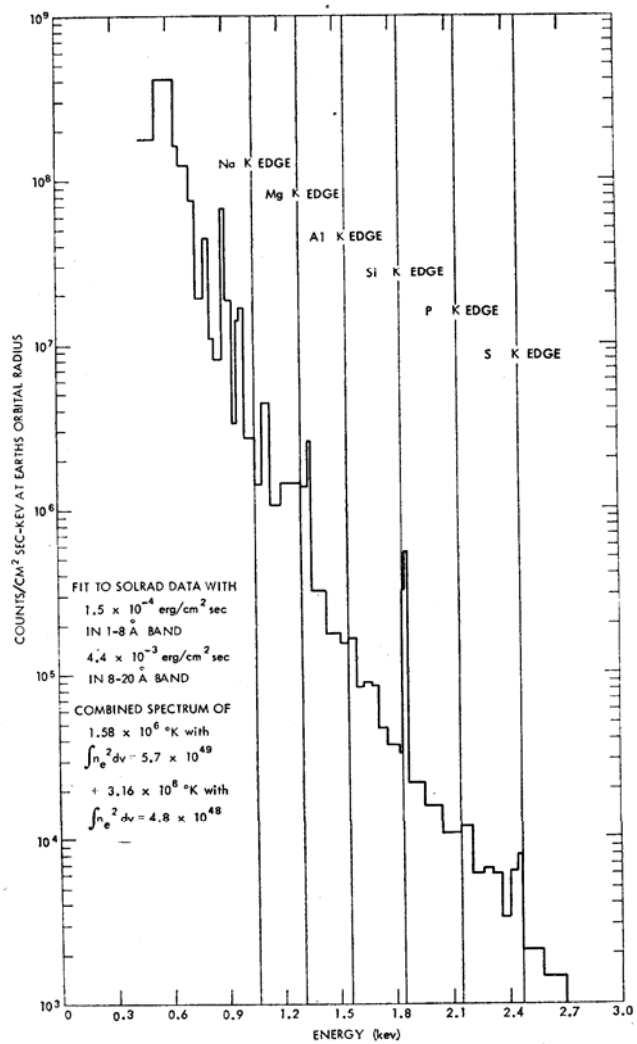
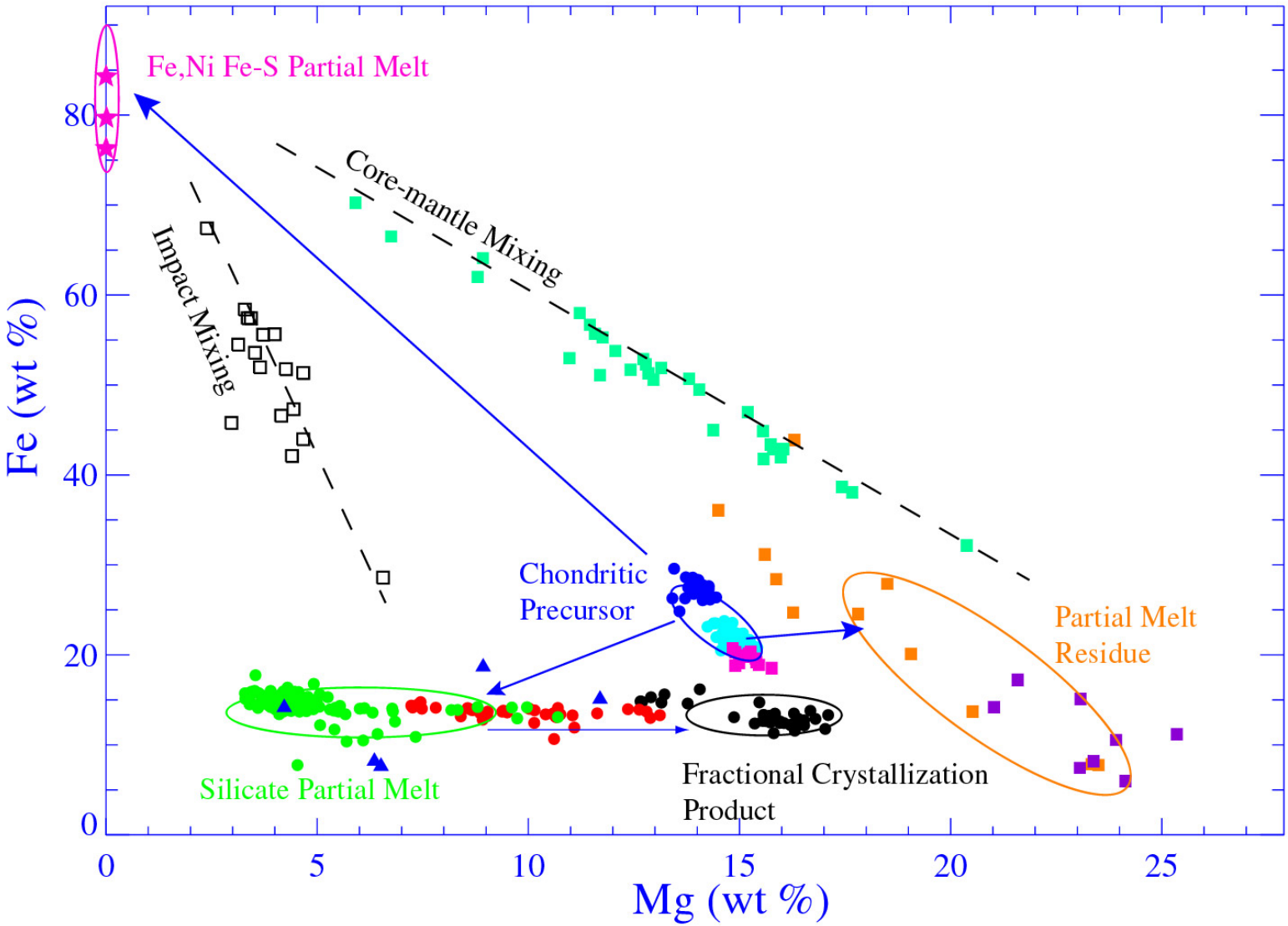
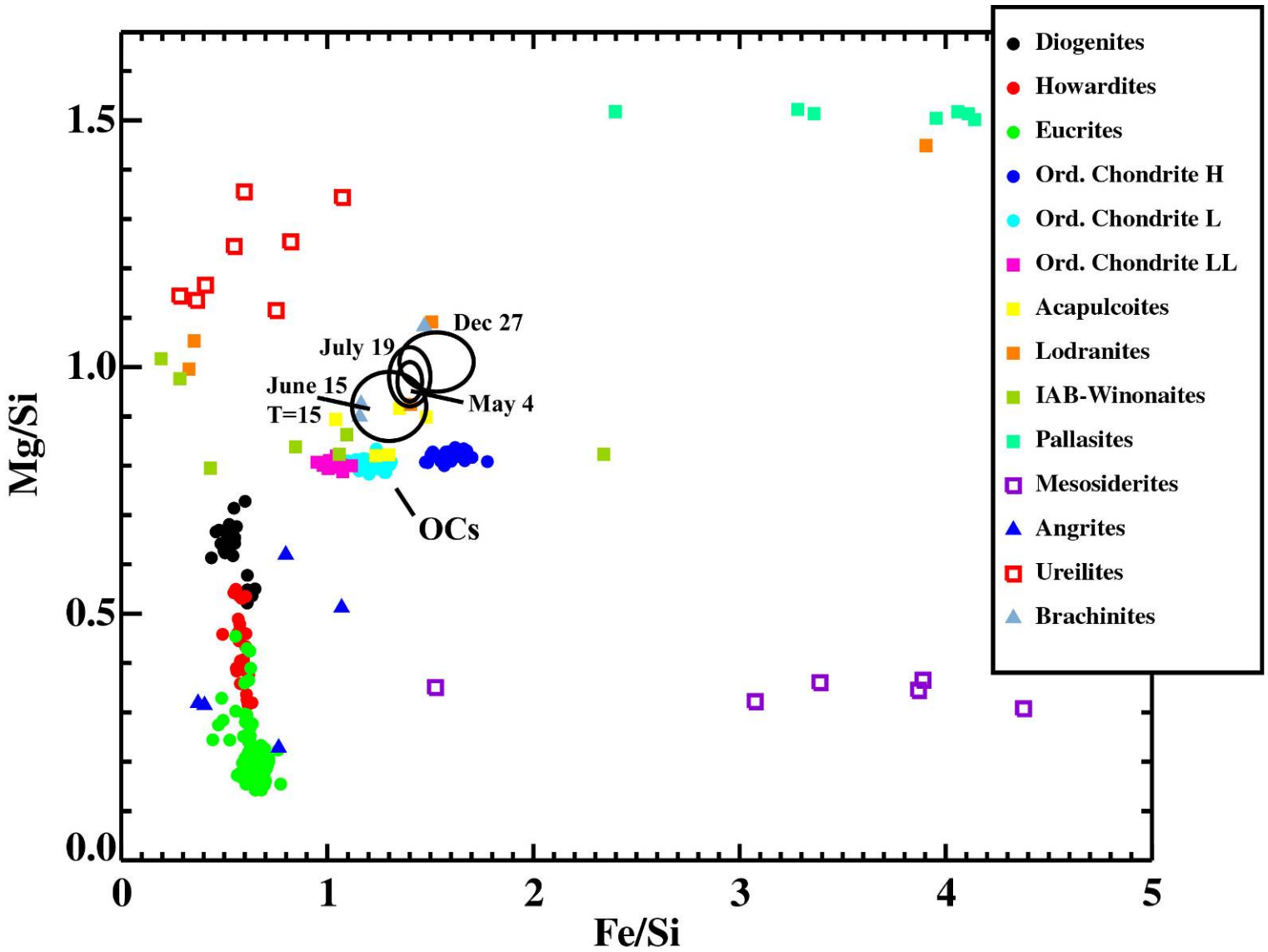


Fig. 3. An estimate of a typical quiet sun x-ray spectrum.

Asteroidal Processes Reflected in Bulk Meteorite Compositions



Mg/Si versus Fe/Si

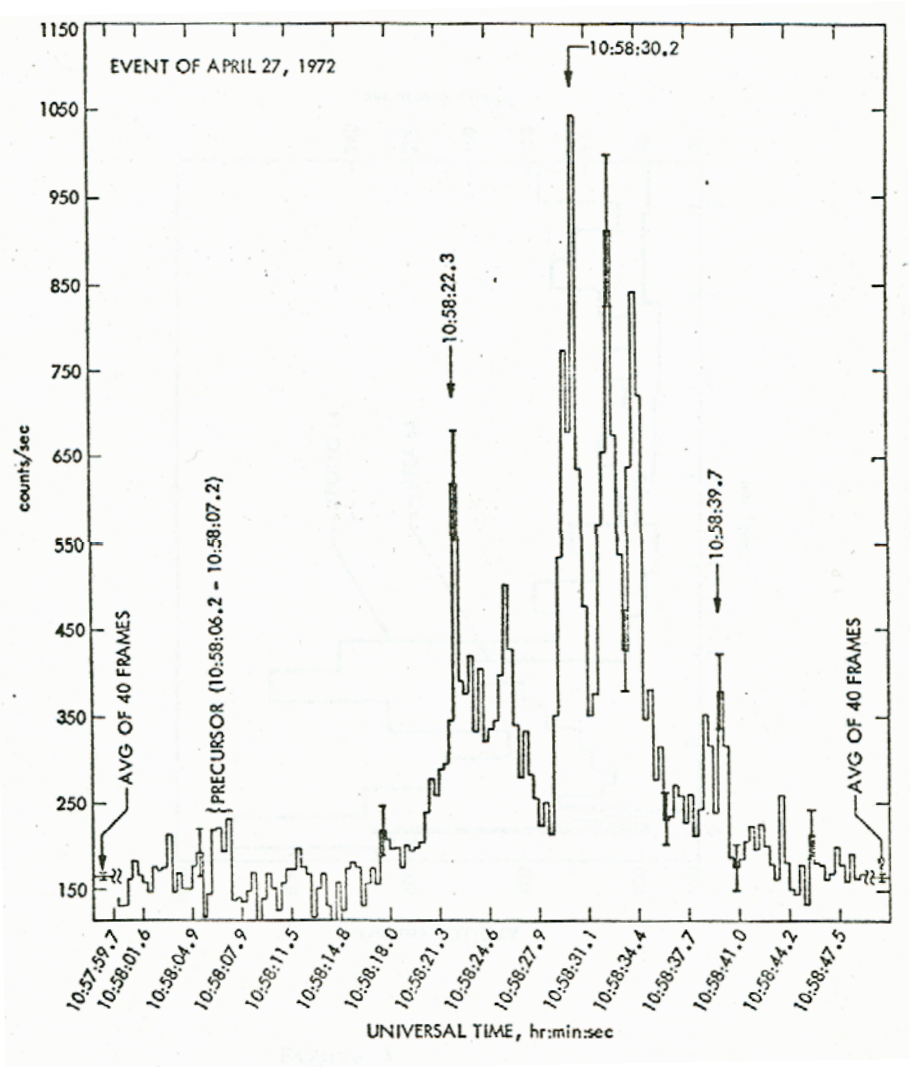


NEAR XGRS Mission

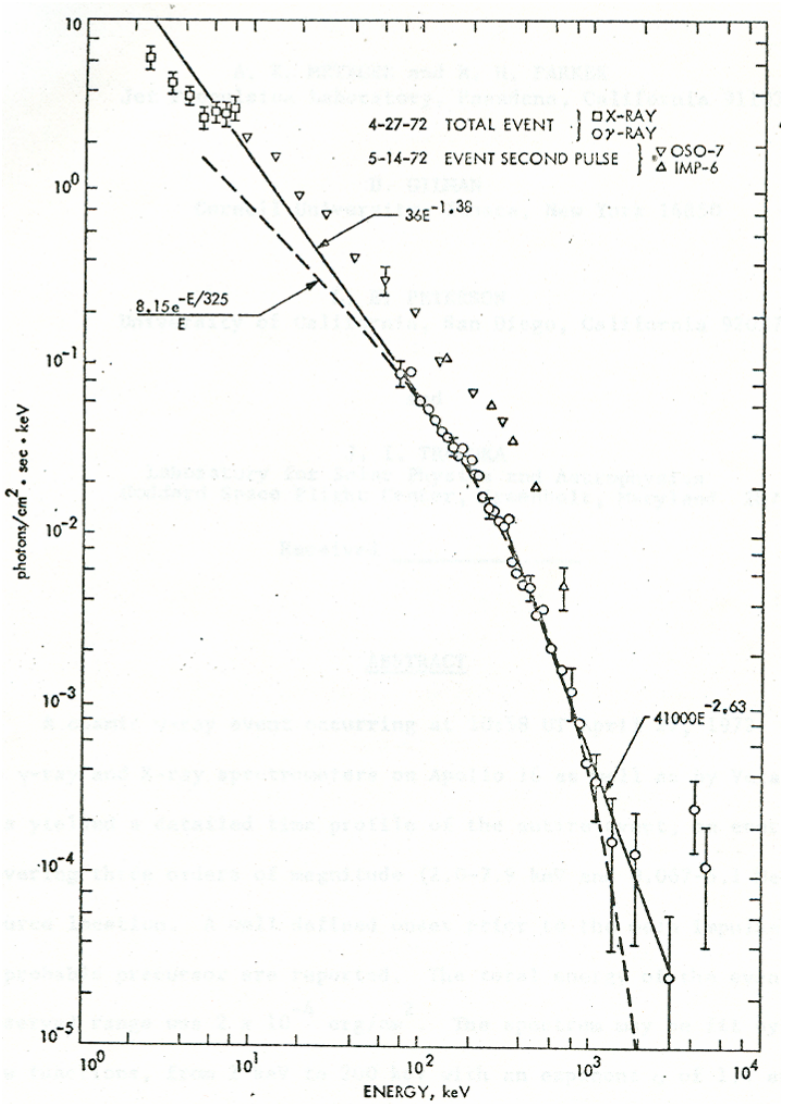
X-Ray Spectrometer

- Obtained orbital x-ray spectra for global and regional surface areas
- The following preliminary results have been obtained
  - The asteroid Eros is a primitive body chondritic in nature
  - Rather homogeneous composition
  - The body seems to be undifferentiated
  - There seems to be a depletion of sulfur when compared with chondritic type meteorites
  - Using x-ray observations, relative elemental abundances have been obtained for Mg, Al, Si, S, Ca, and Fe.

Apollo 16 Gamma Ray Burst Detection
April 27, 1972



Energy Spectrum of the Apollo 16 Detected Gamma Ray Burst April 27, 1972



Apollo X-Ray Lunar Pulse Height Spectra

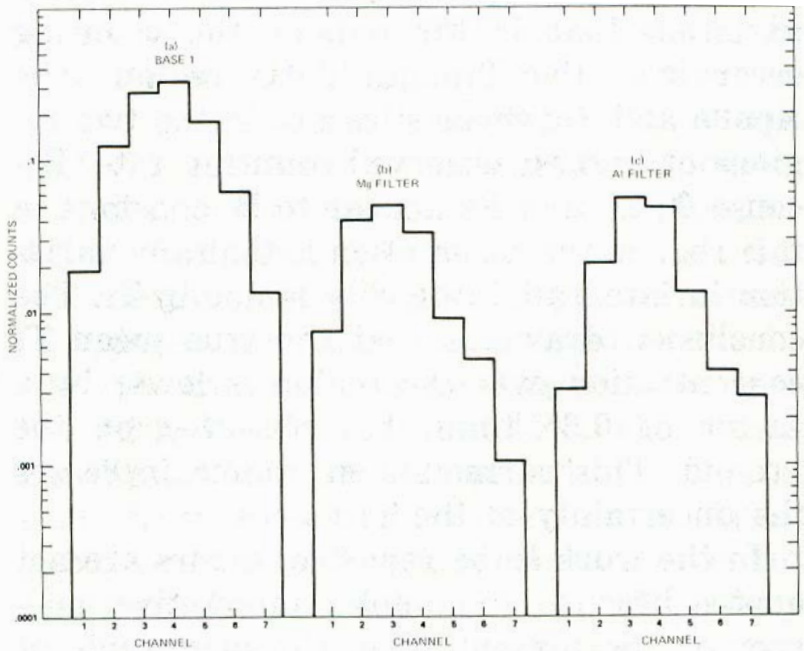


Figure 5a–c.—*Pulse height spectra obtained with the Apollo 15 X-ray spectrometer. The spectrum was taken over Mare Crisium. Spectra shown are from the base detector (a), the detector with the Mg filter (b), and the detector with the Al filter (c). The scale as shown has a lower level of 0.75 keV and is about 0.33 keV/channel. The data have been normalized so that the area under the base detector peak is unity.*