

# The X Ray Spectrometers on SMART-1 and CHANDRAYAAN-1

**Prof Manuel Grande**

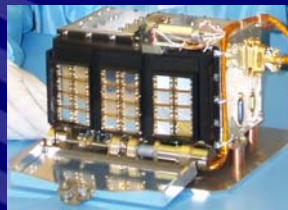
**D-CIXS Principal Investigator**

**University of Wales, Aberystwyth**

# How D-CIXS works

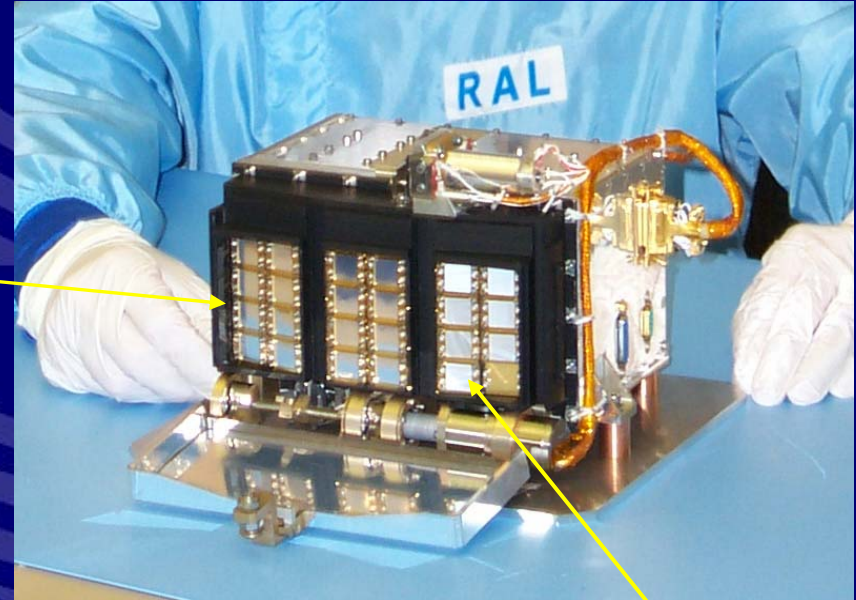
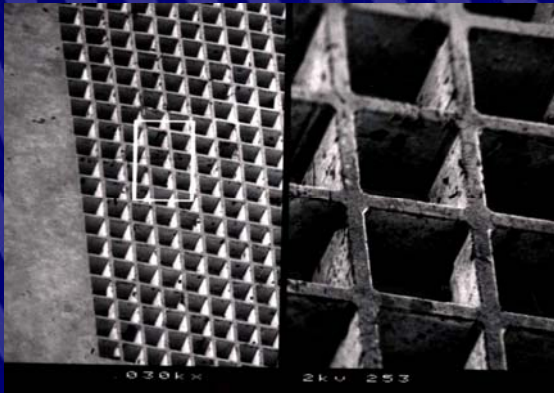
- 1 The Sun shines on the Moon (in X rays)
- 2 The Moon fluoresces
- 3 Each X-ray energy indicates unambiguously the abundance of a particular element
- 4 D-CIXS detects these X-rays
- 5 Solar Monitor for Solar Input required for absolute abundances

*Sun Shines in X-rays*



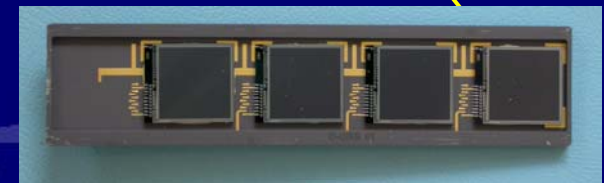
# D-CIXS uses Two New Technologies

- Swept Charge Device (SCD) Detectors
- Advanced Microstructure Collimator



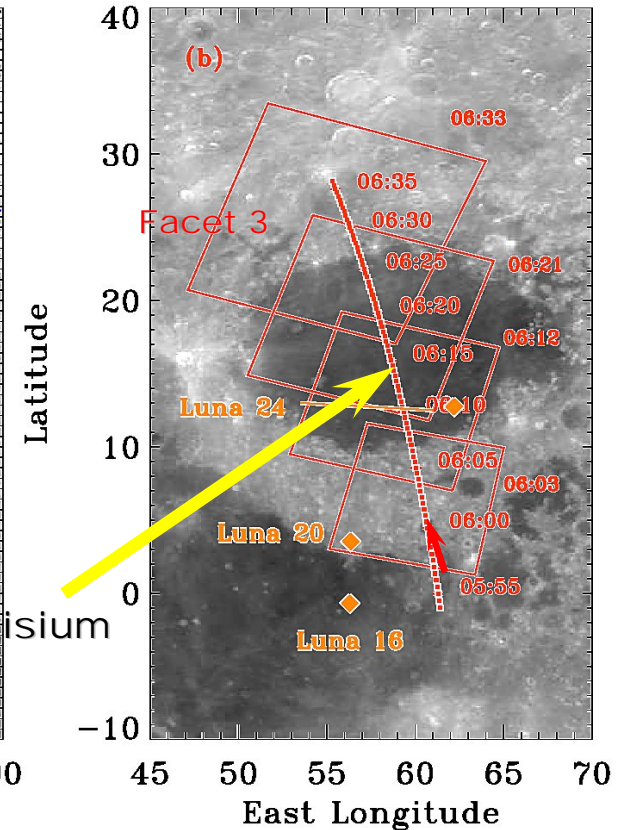
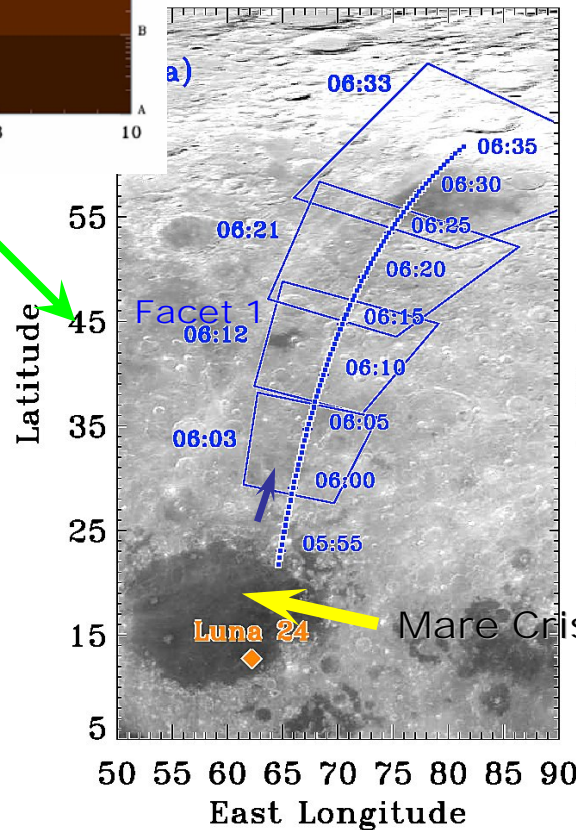
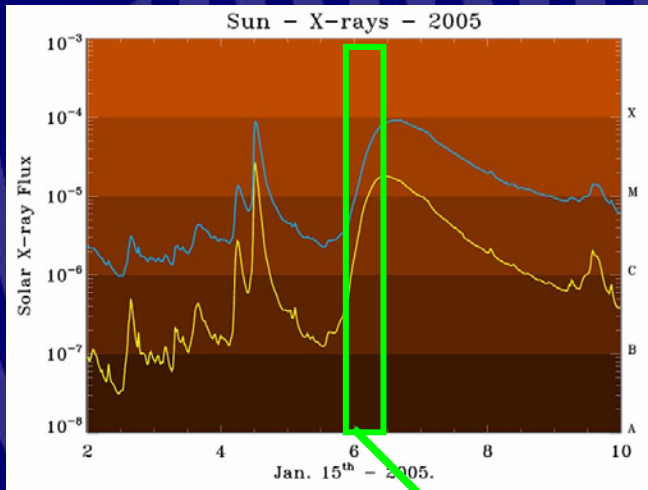
to provide:

- High sensitivity to weak Lunar signal
- Compact, light design
- No need for active cooling



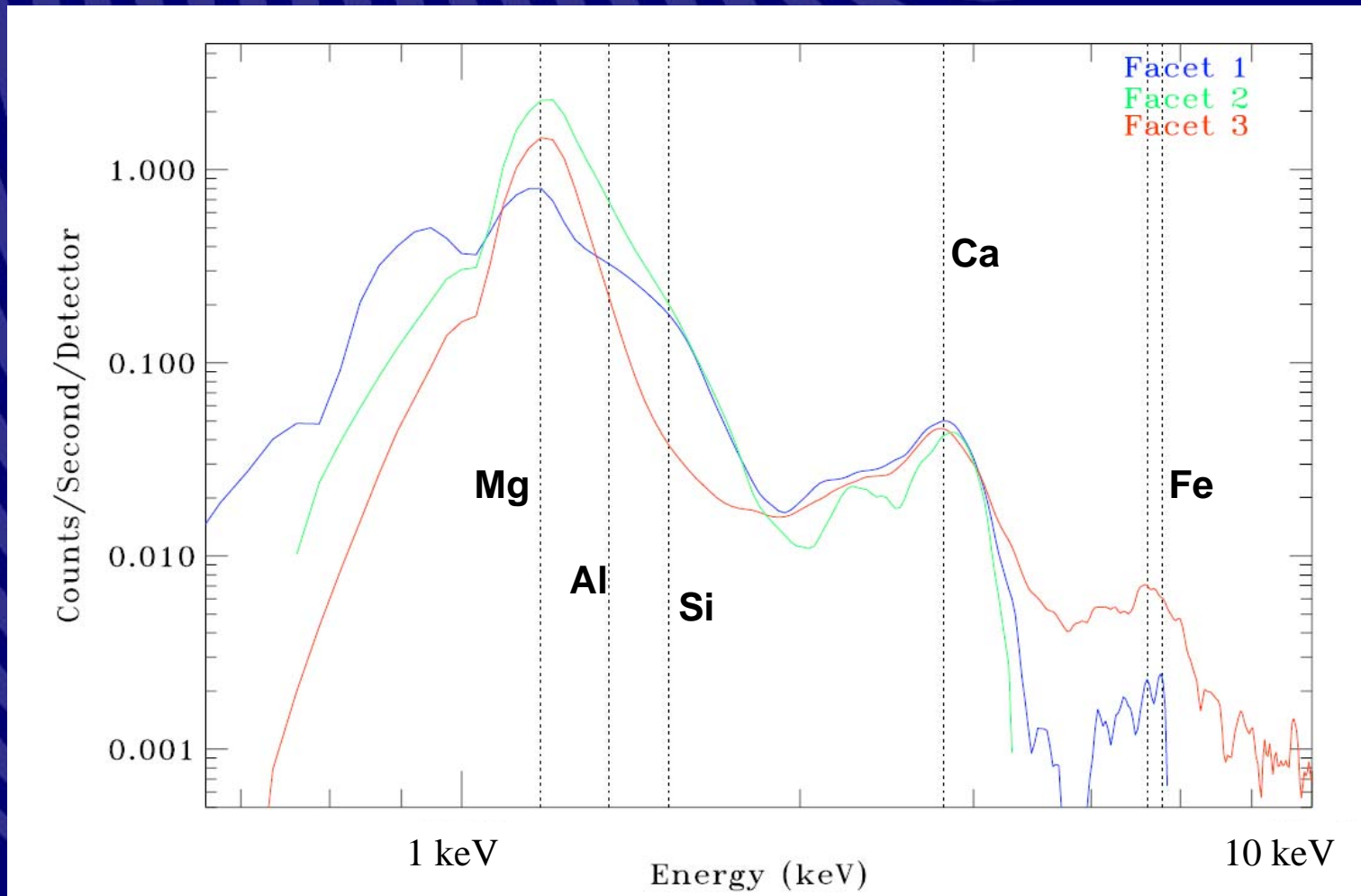
'SMART-1 – end of mission' press conference  
04 September 2006  
ESOC – Darmstadt, Germany

# Solar Flare 15 Jan 2005



# X-ray signatures of Chemical Elements

First ever remote sensing measurements of Ca at the Moon

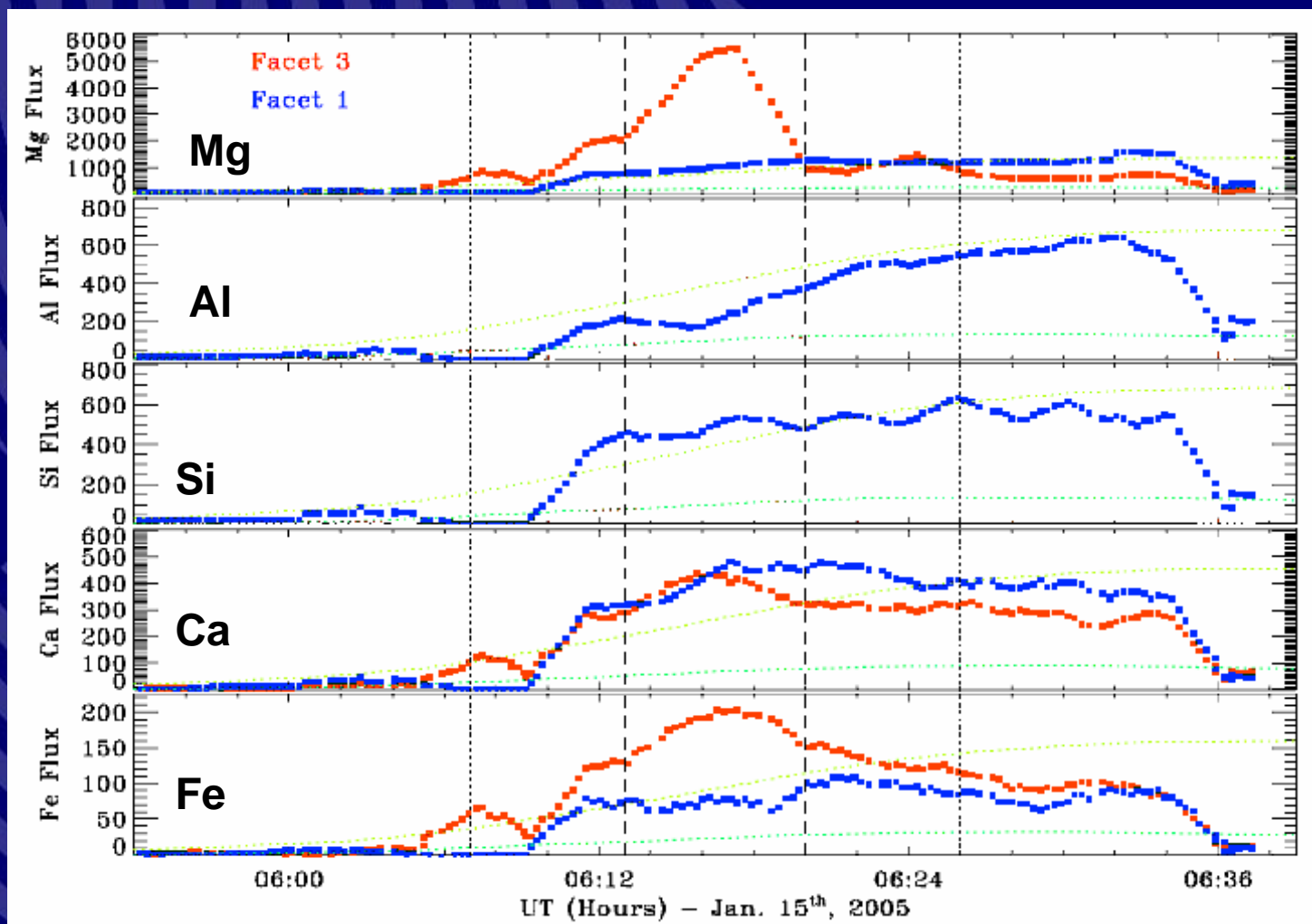


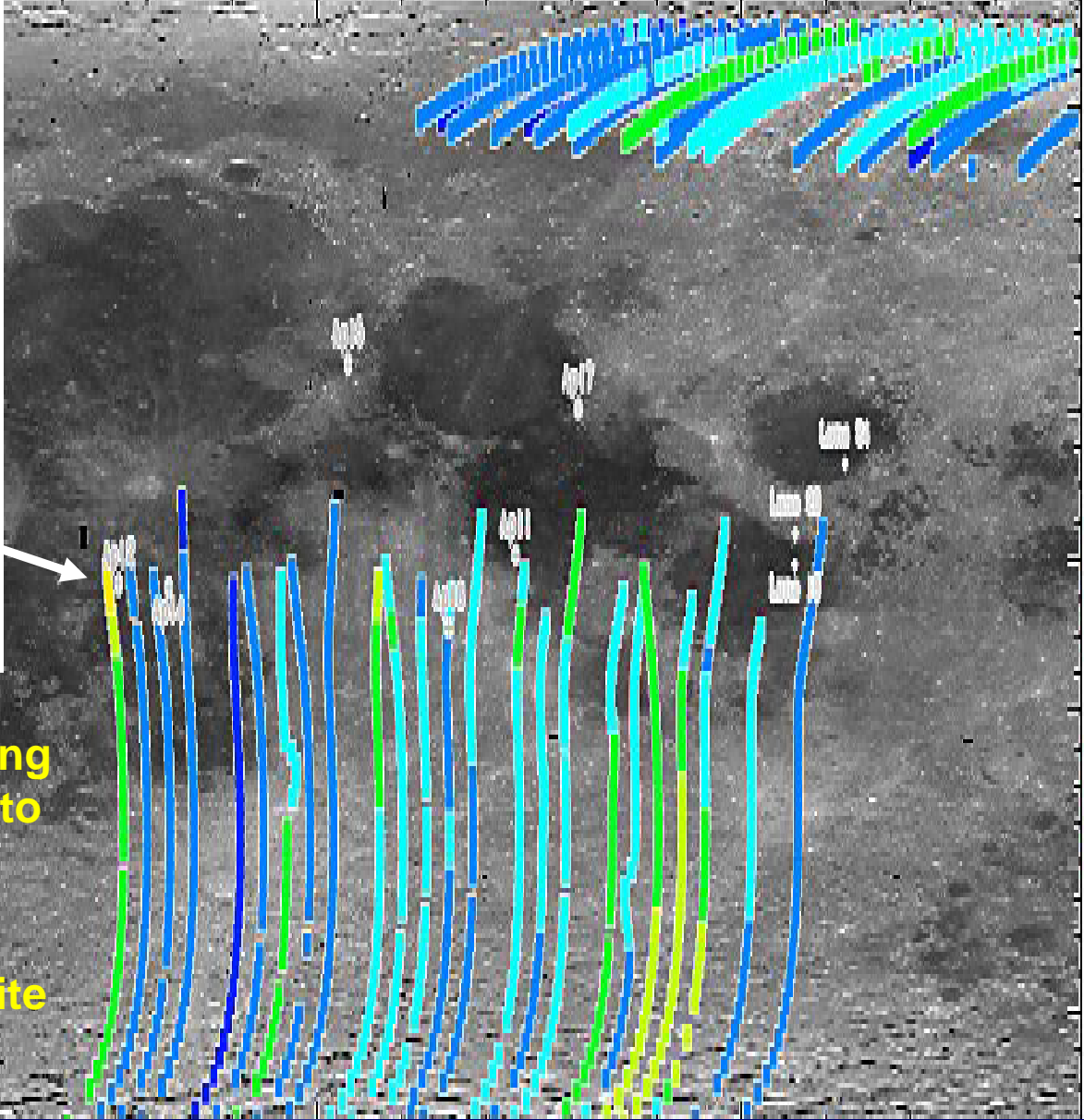
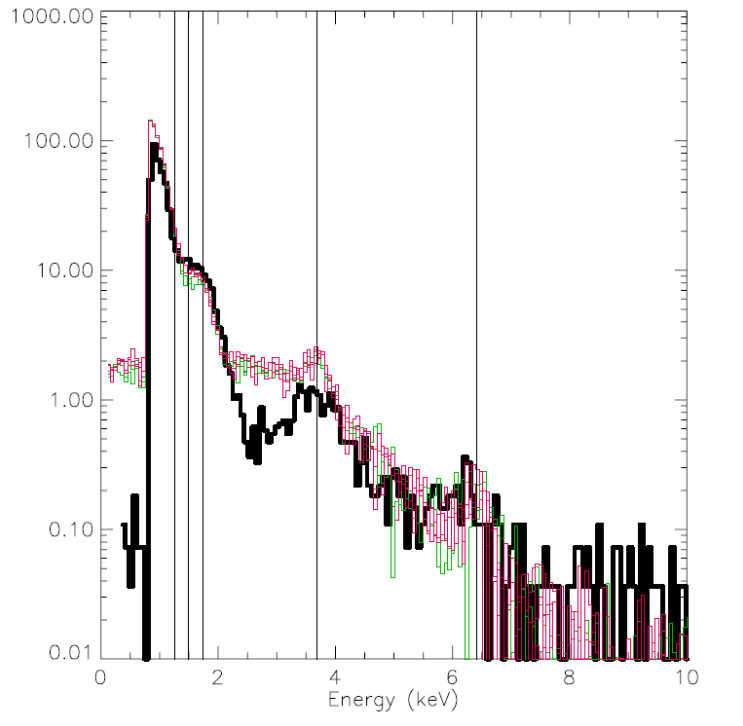
'SMART-1 – end of mission' press conference  
04 September 2006  
ESOC – Darmstadt, Germany

# Ground Tracks of Chemical Elements

Red facet  
sees Mare  
Crisium  
between  
dotted lines

Elsewhere  
both facets  
see  
Highlands





Detailed task of fitting  
Lunar composition to  
the data.

This is close to the  
Apollo 12 landing site

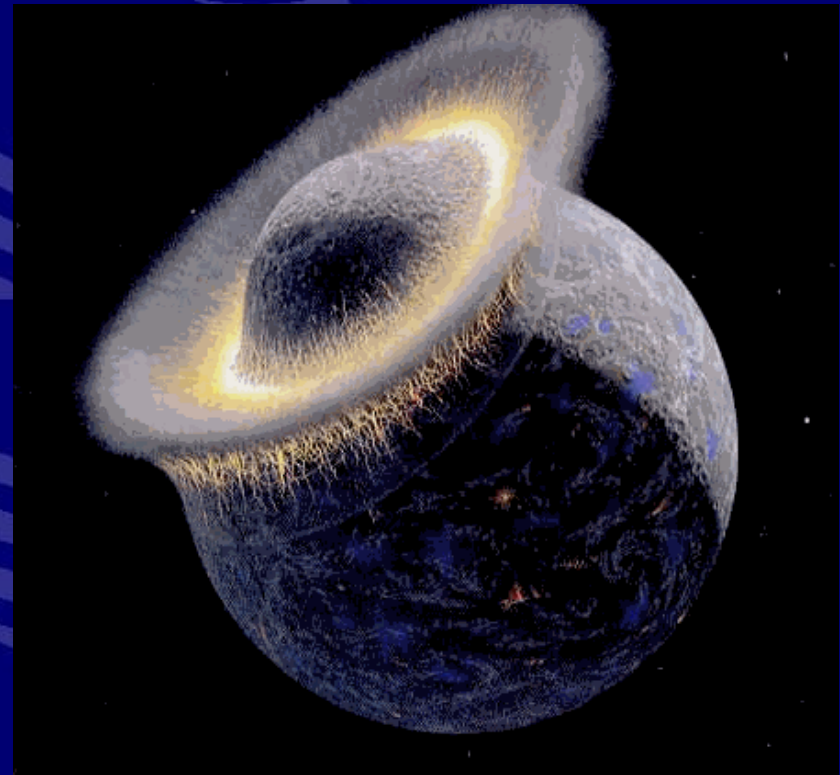
# Lunar observations

- The instrument observes Mg, Al, Si, Ca, Fe at the Moon
- Data match the underlying topography
- Soviet Luna samples give ground truth
- These are the first ever remote sensing measurements of Ca content at the Moon
- D-CIXS was still successfully returning data 2 seconds before impact

# Unanswered questions about the Moon

## What D-CIXS tells us

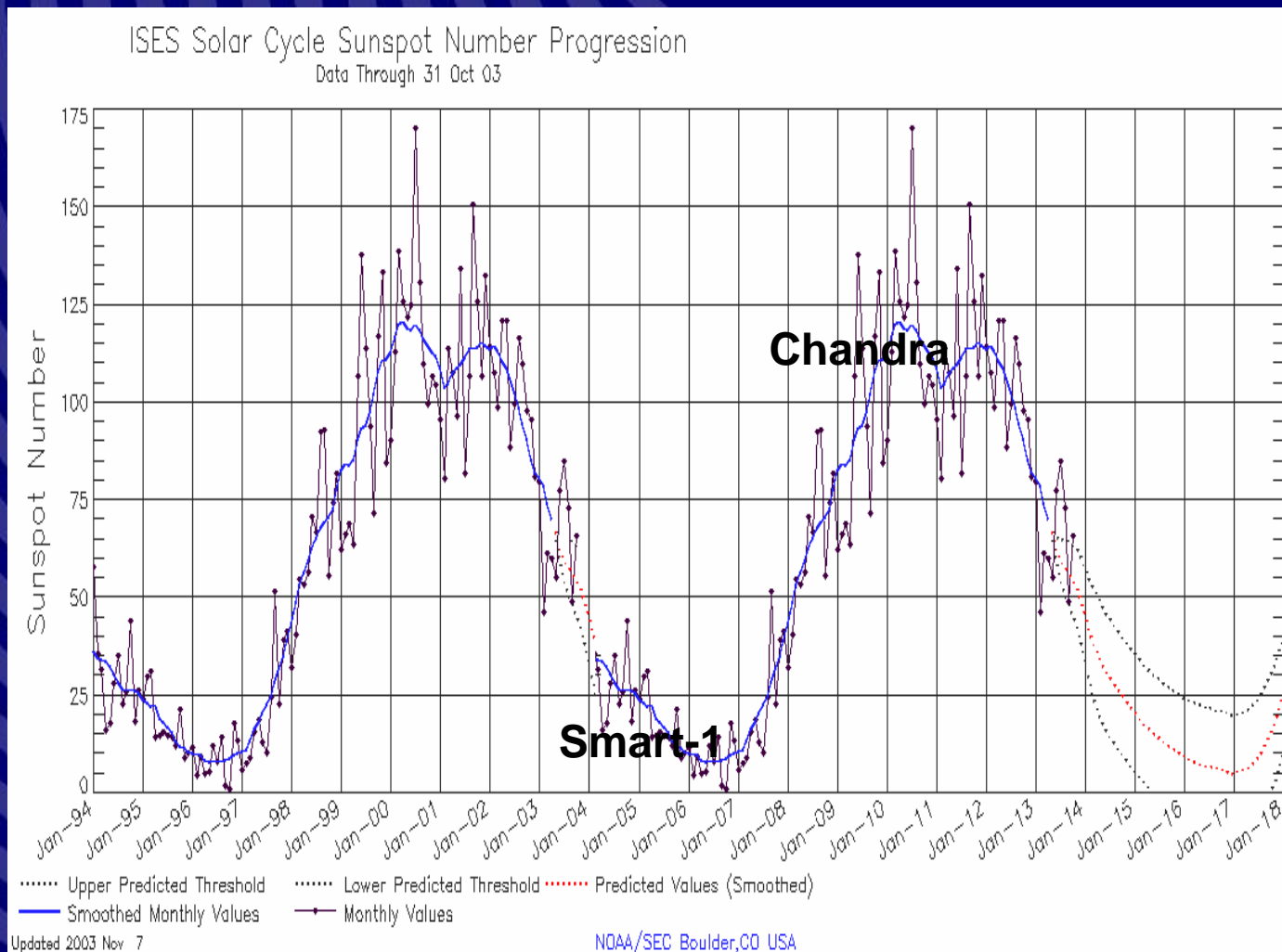
- How did the Earth-Moon system form?
  - *Giant Impact?*
- How has the Moon evolved since?
  - *Magma ocean?*
- Necessary data for the answer
  - *Composition (Mg, Al...)*



# The Solar Cycle of X-ray Illumination

D-CIXS flew at the worst time

C1XS on Chandrayaan-1 will fly at the best!

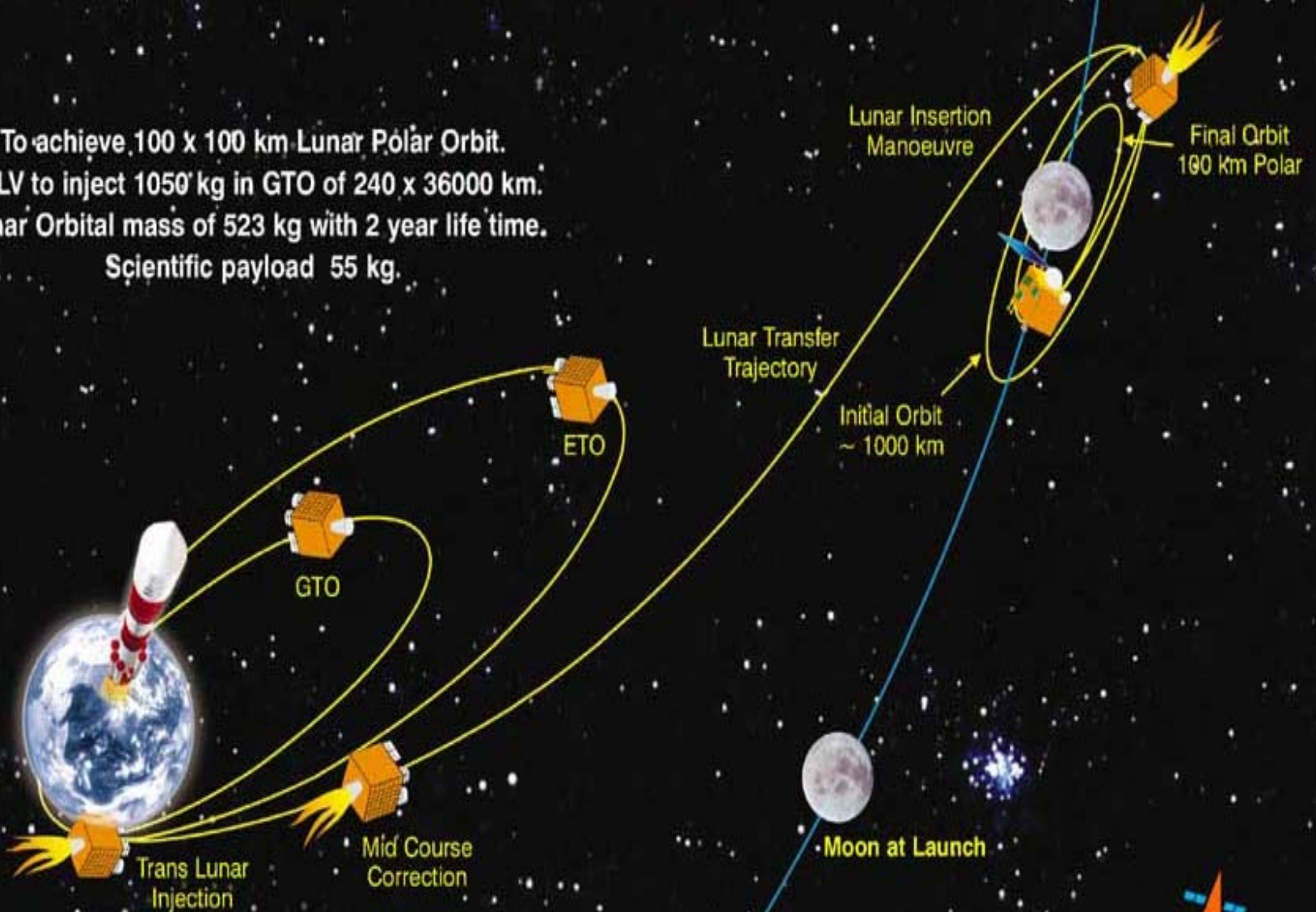


'SMART-1 – end of mission' press conference  
04 September 2006  
ESOC – Darmstadt, Germany

INDIA'S FIRST MISSION TO MOON

# CHANDRAYAAN-1

To achieve 100 x 100 km Lunar Polar Orbit.  
PSLV to inject 1050 kg in GTO of 240 x 36000 km.  
Lunar Orbital mass of 523 kg with 2 year life time.  
Scientific payload 55 kg.



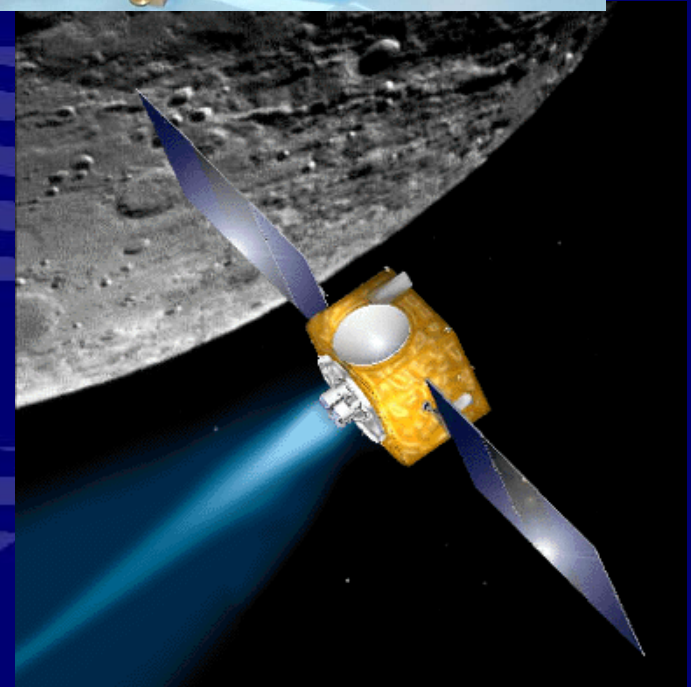
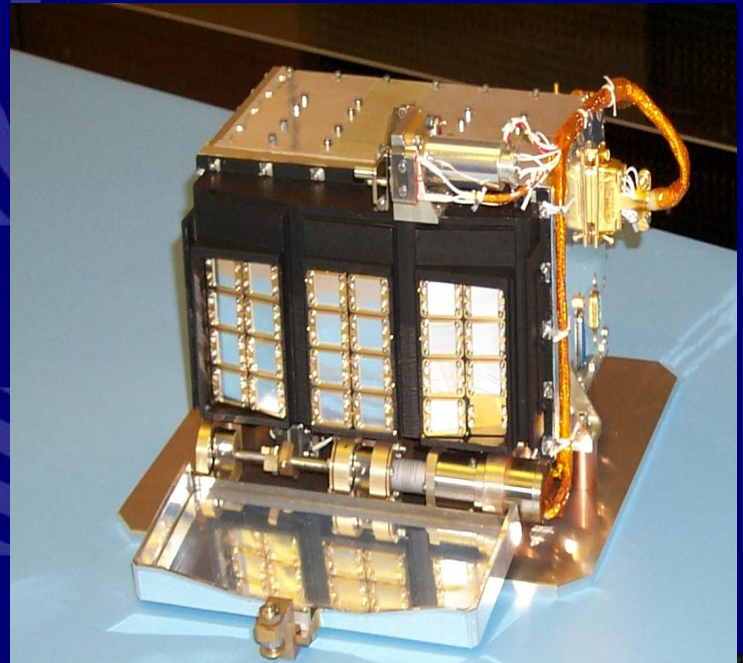
Expanding the scientific knowledge about the moon, upgrading India's technological capability and providing challenging opportunities for planetary research for the younger generation



D-CIXS is a technology experiment

The proof of a technology experiment was to do great science!

Now we have proved the technique, we can use it all round the Solar System



# D-CIXS is dead

**D-CIXS is dead**

**Long Live C1XS!**

# C1XS/DCIXS - The Team

M. Grande, **University of Wales, Aberystwyth, UK**

J. Huovelin, **University of Helsinki Observatory, Finland,**  
P Shreekumar, **ISRO, India,**

B. Kellett, B. Maddison, C. Howe, B. Swinyard, C. H. Perry, S. Dunkin,  
N. Waltham, B. Kent,, D. Parker, **Rutherford Appleton Laboratory, UK**  
I Crawford, K Joy, J. Guest, **University College London, UK,**  
S. Russell, **Natural History Museum, UK,**  
M. Grady, **Open University UK,**  
A Christou, **Armagh Observatory, UK,**  
H. Alleyne, D. Hughes **Sheffield University, UK,**  
C. D. Murray, **QMW, UK**

S Maurice C L Duston , O Gasnaut, **OMP, Toulouse, France**  
N Bhandari, S Narendranath **ISRO, India,**

S. Barabash, **IRF, Kiruna, Sweden,**  
D Lawrence, **Los Alamos National Lab, USA**  
V Fernandes, **U Coimbra, Portugal**  
I Casanova, **UPC, Barcelona, Spain,**  
M.Kato, T. Okada, **ISAS, Japan,**  
U. Mall **MPAE, Germany,**  
P.Clark, **NASA GSFC USA**  
B Foing , D.Heather, **ESTEC, ESA**

'SMART-1 – end of mission' press conference  
04 September 2006  
ESOC – Darmstadt, Germany