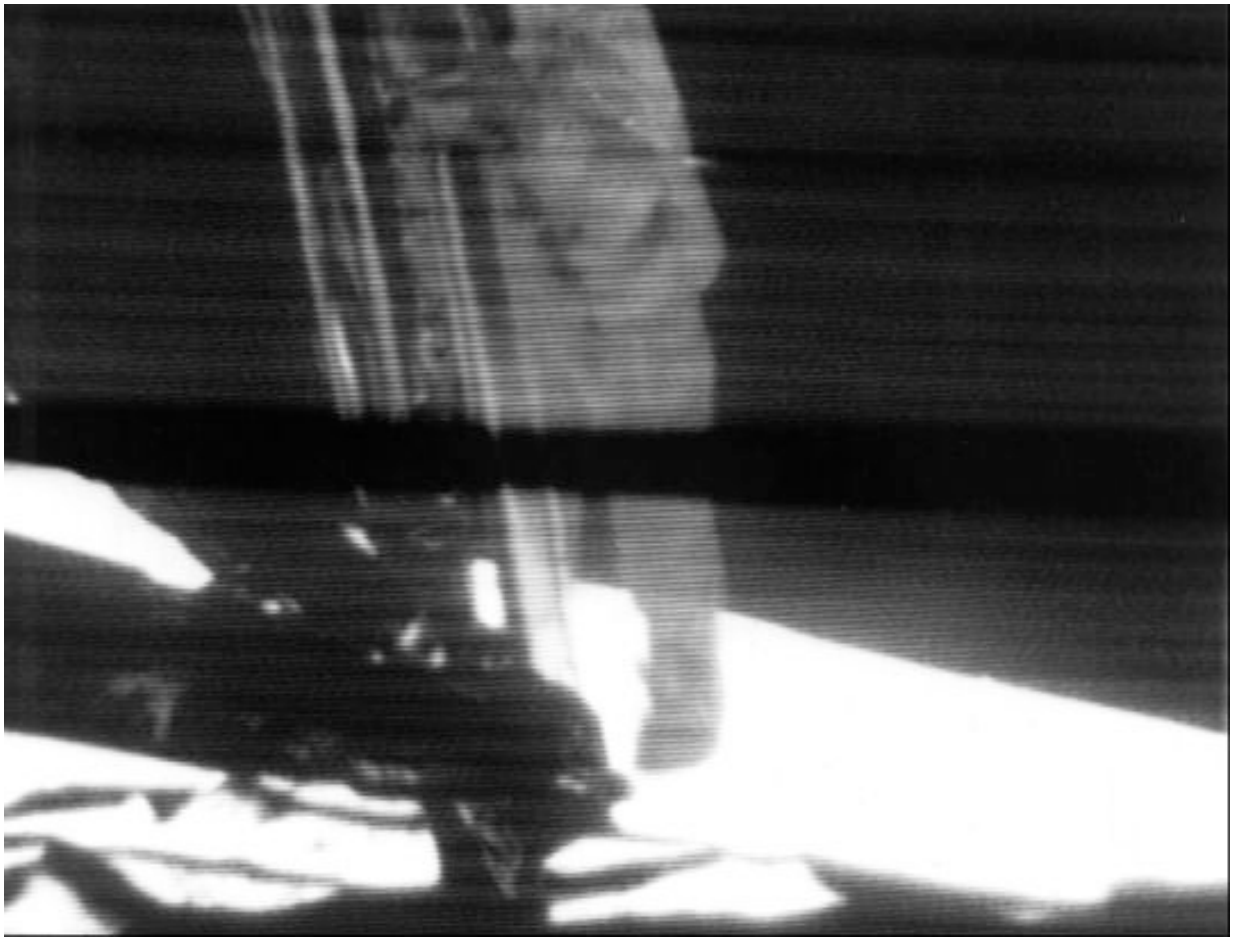
LEND instrument onboard LRO:

the first observations in space

Igor Mitrofanov,

on behalf of LEND Team

July 21, 2009



Congratulations with the 40th anniversary of first step of man on the Moon!
Go LRO!
Go LEND!

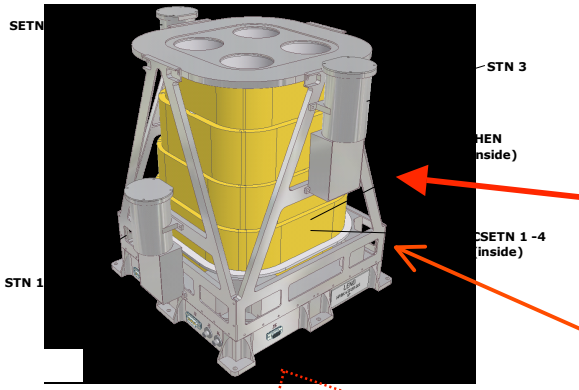
LEND Science Overview

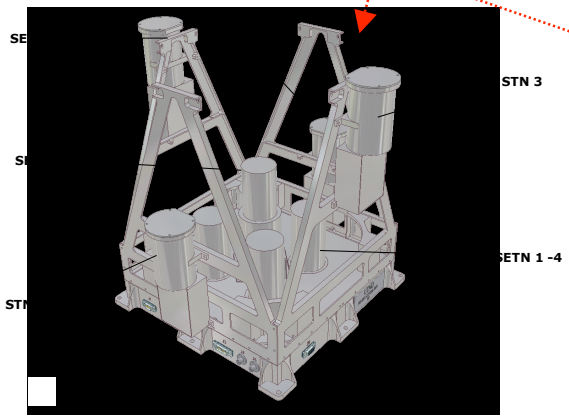
LEND Development for responding the LRO Mission Requirements

LRO Requirements	Instrument Requirement	Level 1: Requirements	
		LRO Mission Requirement	Required LEND Data Products
RLEP-LRO-M110	LEND IMR 1: *Hydrogen mapping*	The LRO shall obtain high spatial resolution hydrogen mapping of the Moon's surface to a 20% accuracy and 5 km resolution at the poles.	*Surface Composition Data Product (I):* The content of Hydrogen in subsurface at polar regions with spatial resolution from 5 km (Half-Width Half-Maximum) and with variation sensitivity from 100 parts per million (ppm)
RLEP-LRO-M070	LEND IMR 2: *Testing for water ice*	The LRO shall identify putative deposits of appreciable surface or near surface water ice in the Moon's polar cold traps at 100m scale spatial resolution	*Surface Composition Data Product (II):* The water ice column density on polar regions of the Moon with spatial resolution from 5-20km.
RLEP-LRO-M010	LEND IMR 3: *Radiation environment*	The LRO shall characterize the deep space radiation environment in lunar orbit, including neutron albedo.	*Radiation Data Product (III):* Global distribution of neutrons at Moon's orbit with spatial resolution of 50 km at different energy ranges from thermal energy up to >15 MeV separately for periods of quiet Sun and for periods of Solar Particle Events.

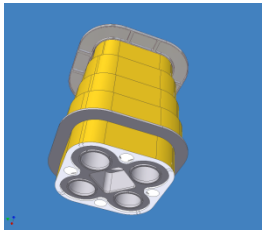
LEND Instrument Overview

LEND consists of nine detectors to measure fluxes of thermal, epithermal, and fast neutrons.

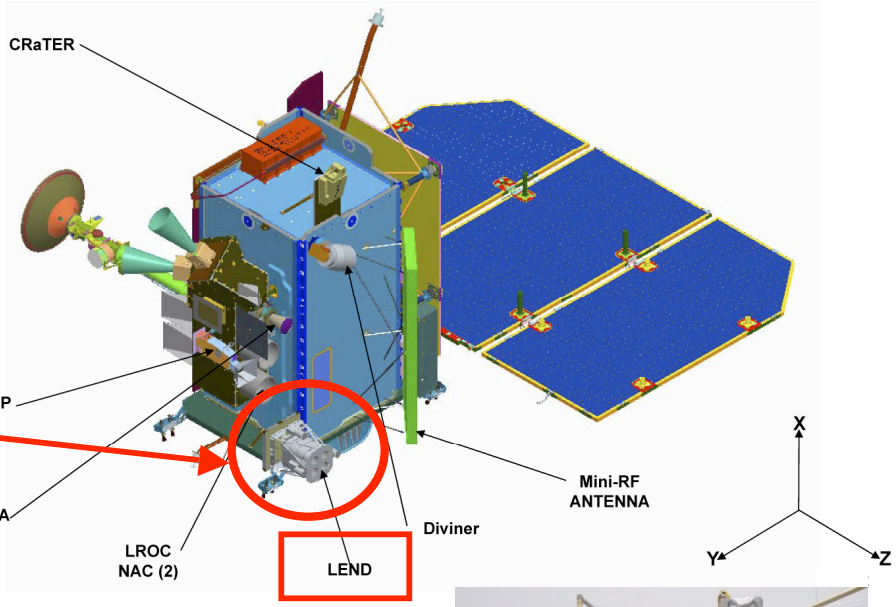




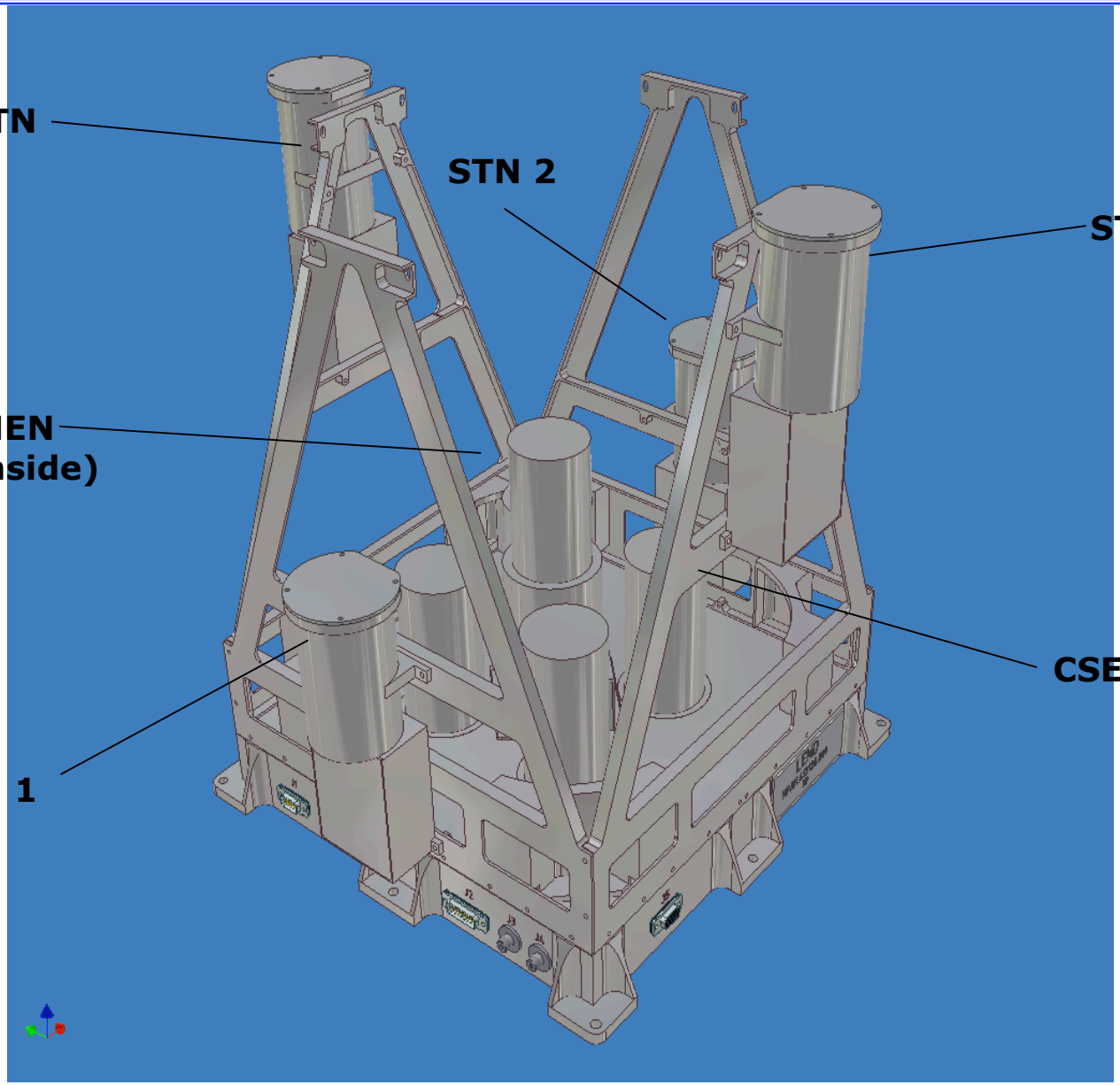
Main Instrument



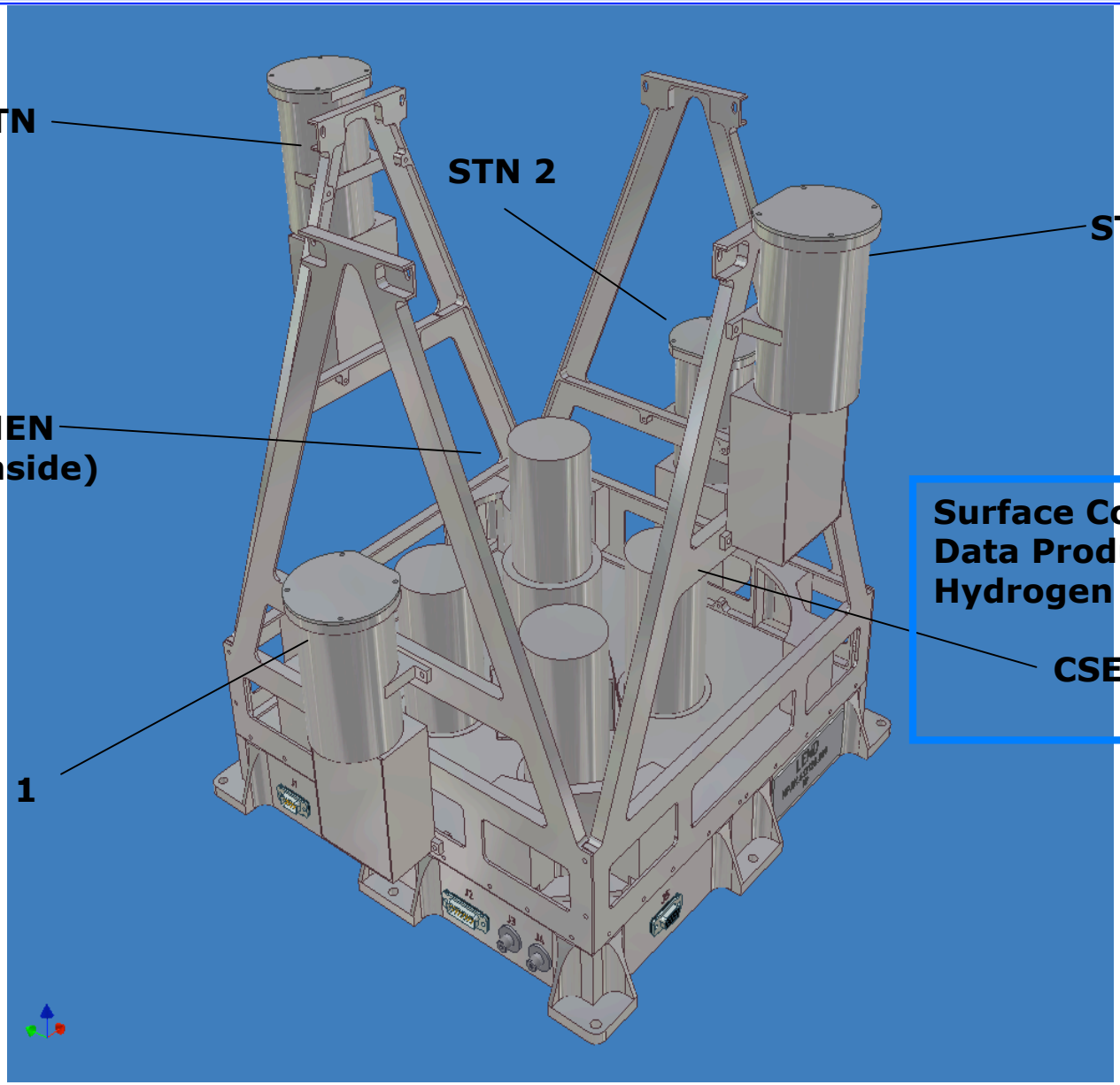
Collimator



Lunar Exploration Neutron Detector



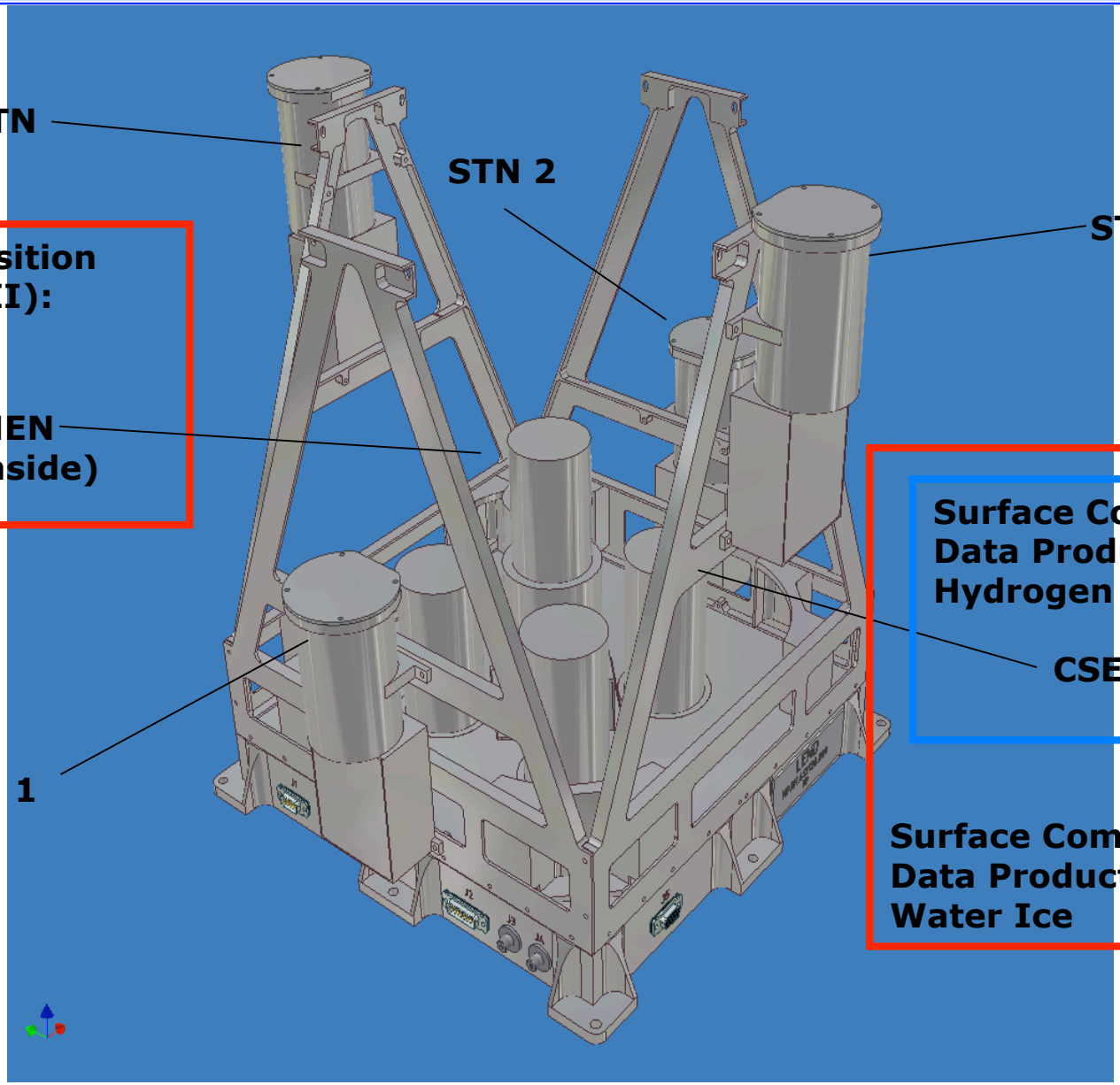
Lunar Exploration Neutron Detector



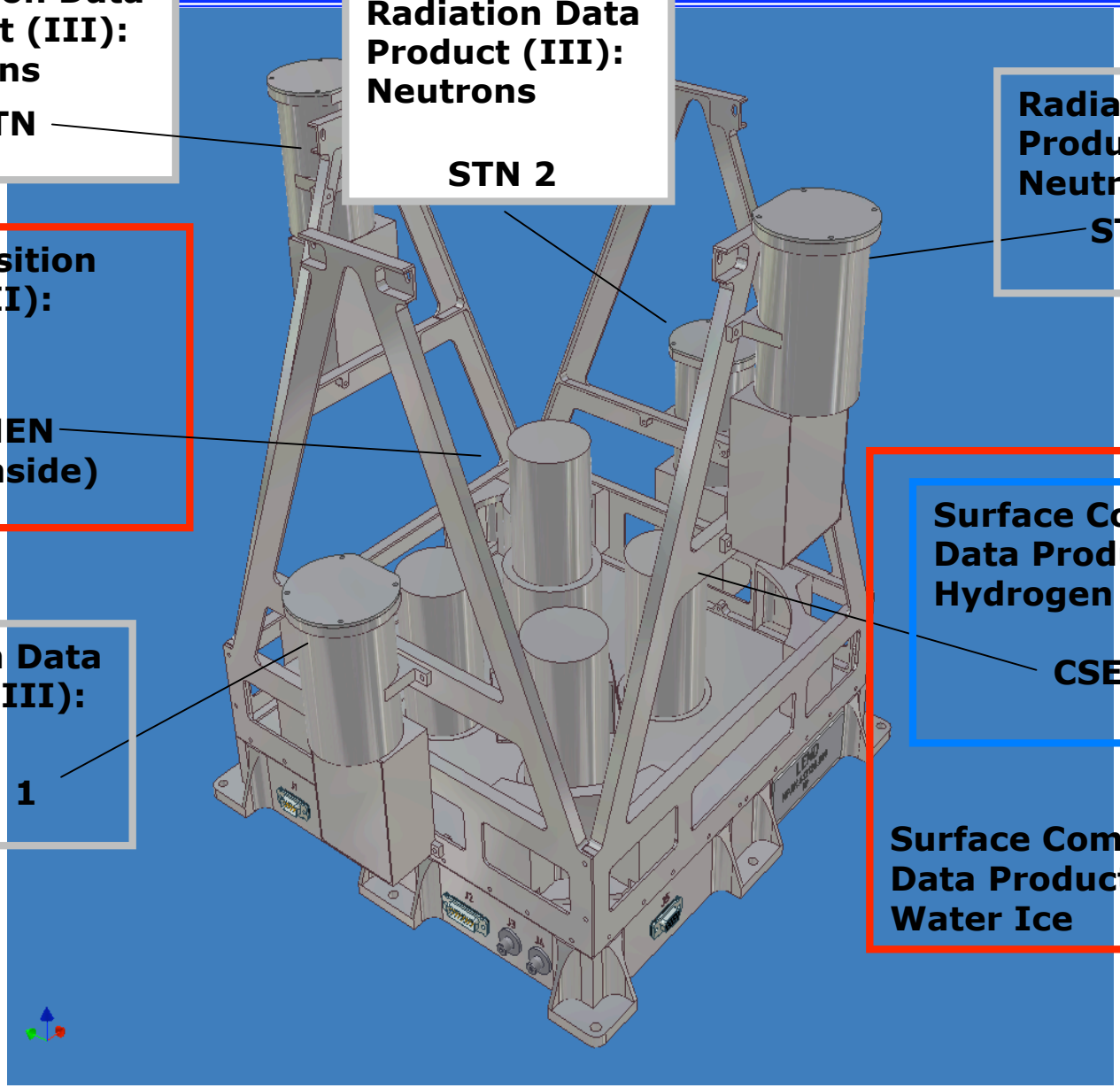
Surface Composition Data Product (I): Hydrogen

CSETN 1-4

Lunar Exploration Neutron Detector

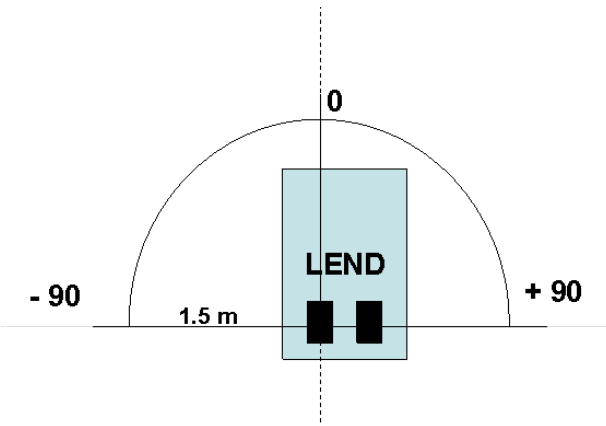


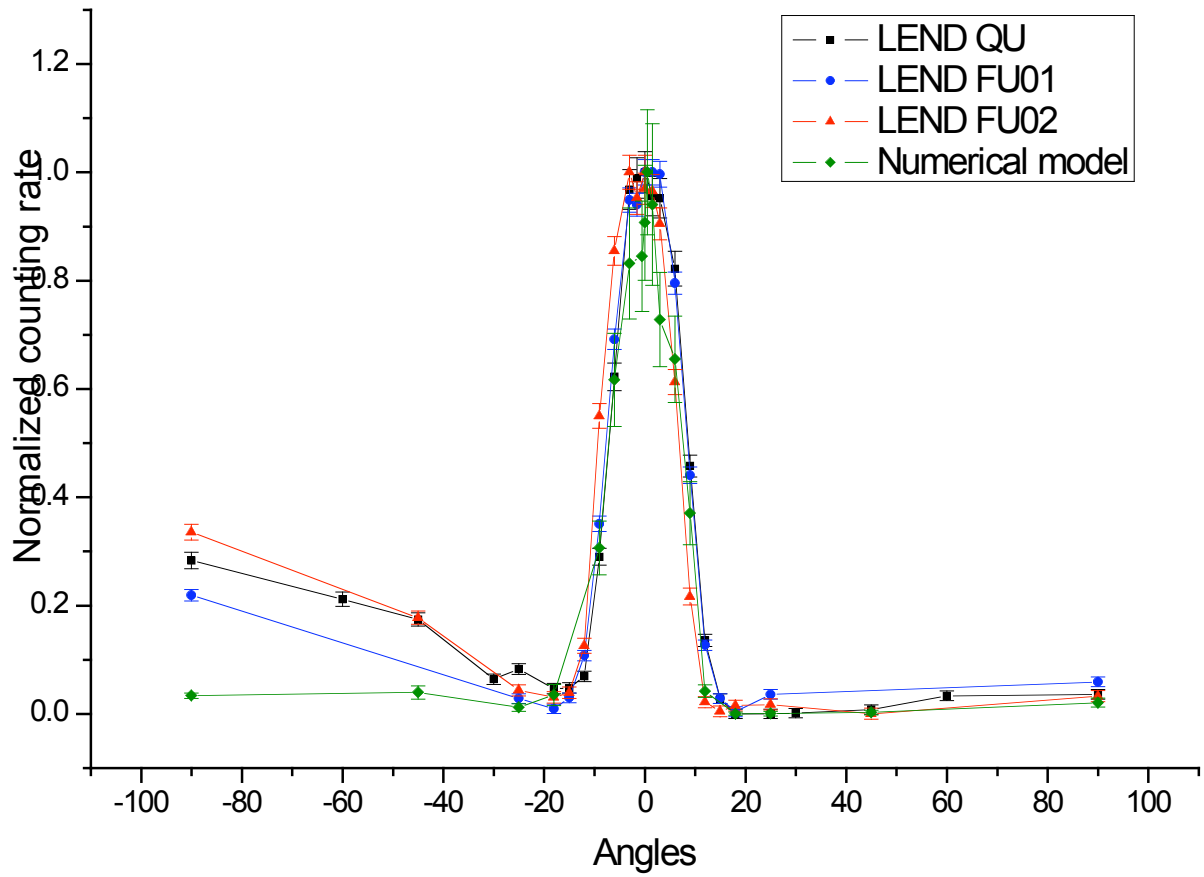
Lunar Exploration Neutron Detector



LEND Data Product Performance

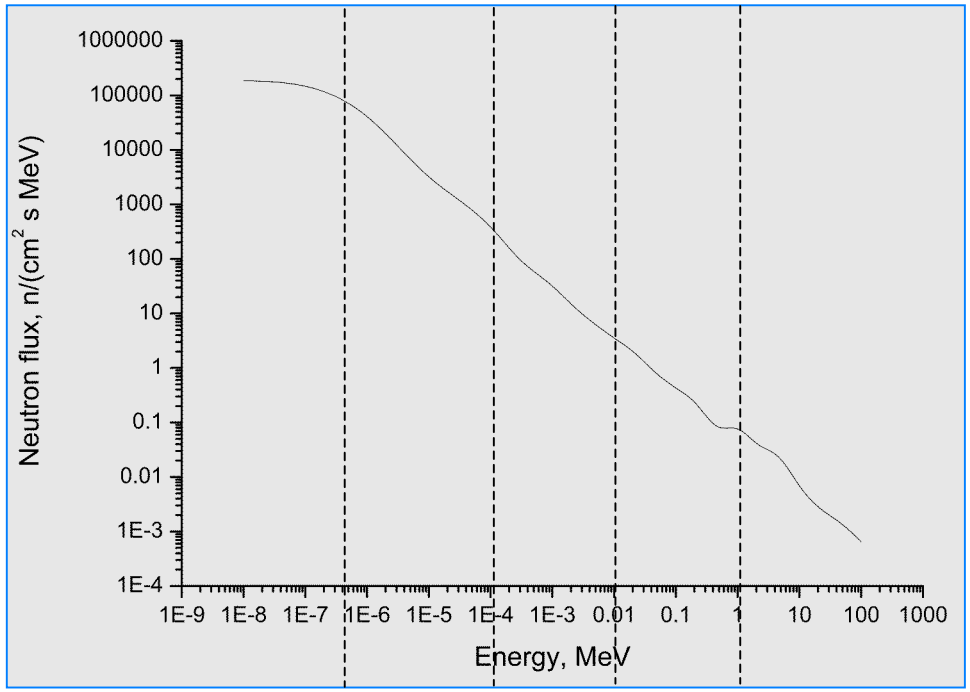
Comparison between physical calibration and numerical modeling proves that LEND Data Products I and II will be delivered by LEND





LEND Data Product Performance

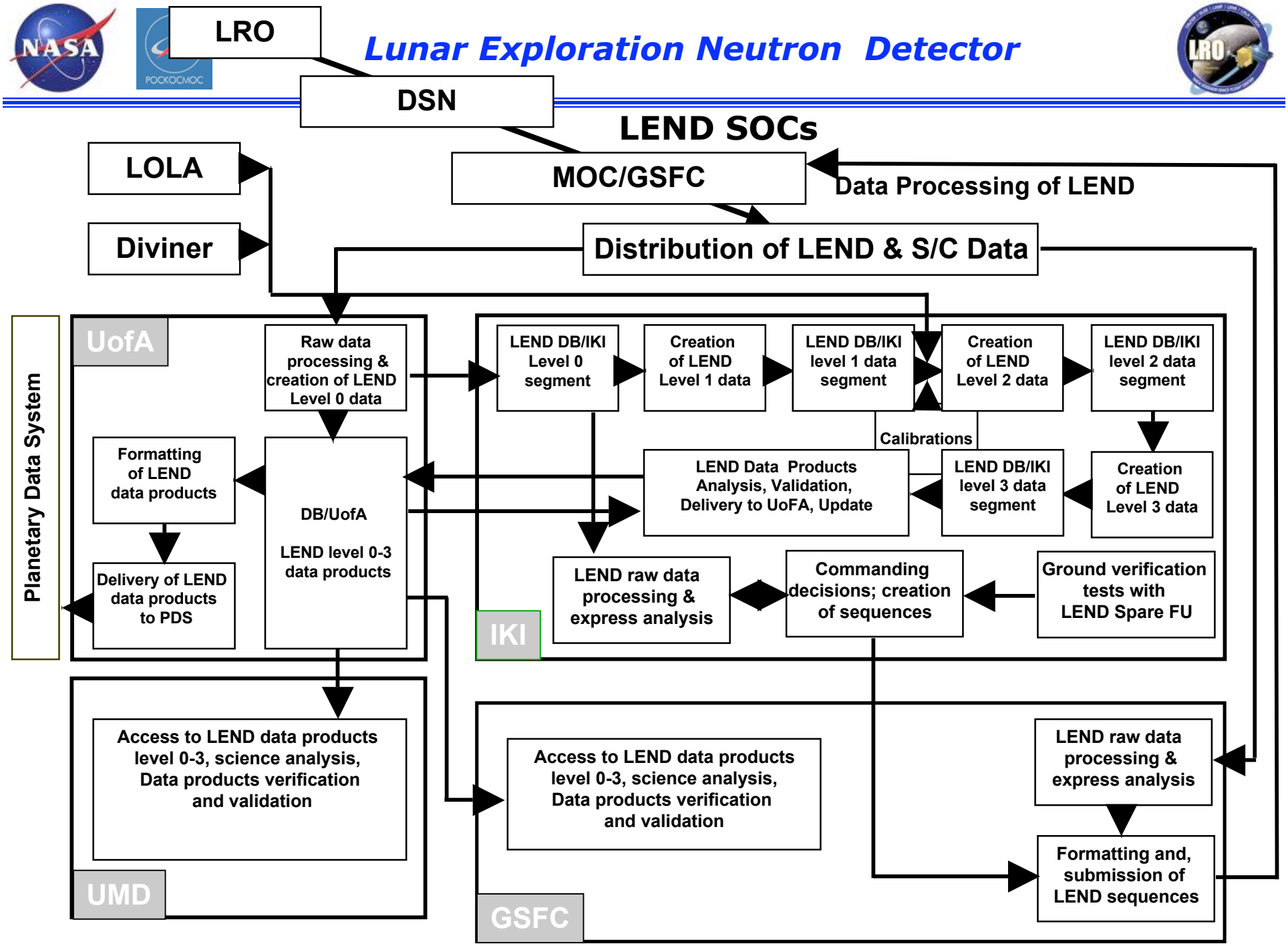
The set of sensors STN 1-3, SETN and SHEN provides the all necessary measurements for LEND Data Products I, II and III



GLOBAL MAPPS of NEUTRON FLUX at EGHT ENERGY RANGES WITH SPATIAL RESOLUTION 5-30 km

(1)	< 0.4 eV	STN 1 -3
(2)	0.4 – 100 eV	CSETN and SETN
(3)	0.1 keV – 10 keV	CSETN and SETN
(4)	10 keV – 1.0 MeV	CSETN and SETN
(5)	1.0 –2.5 MeV	SHEN
(6)	2.5 – 7.5 MeV	SHEN
(7)	7.5 - 15.0 MeV	SHEN
(8)	> 15.0 MeV	SHEN

Lunar Exploration Neutron Detector



LEND space operations

<u>Main statements after one month of space operations:</u>

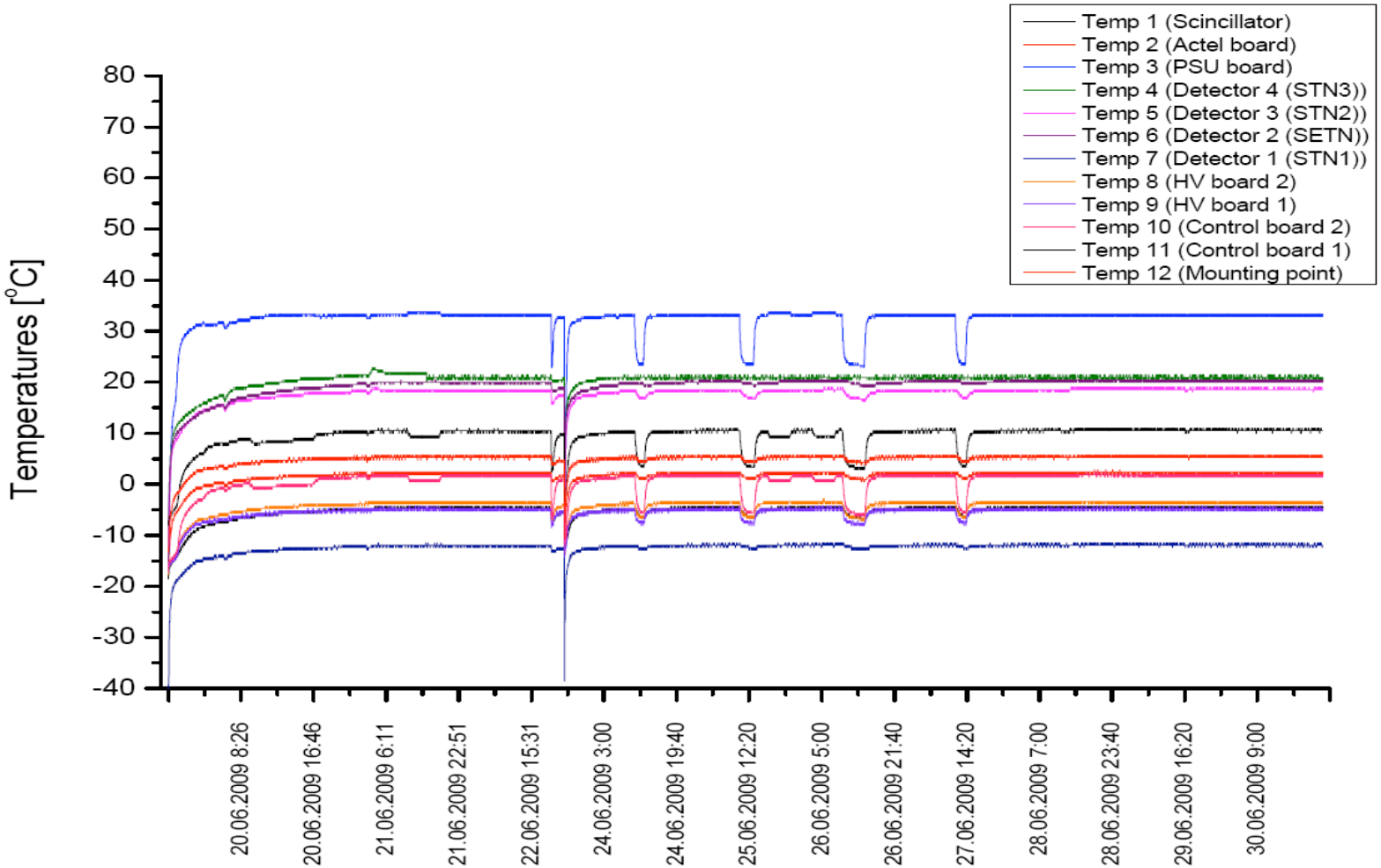
(1) Instrument operates nominally, no problems in sensors, electronic and logic.

(2) All sensors see the Moon properly, we have clear changes of our measurements between different transition orbits.

(3) Epithermal omni-directional sensor SETN and 4 collimated sensors CSETN1 -4 see the "LP effect", as extended depression of epithermal neutrons at both poles.

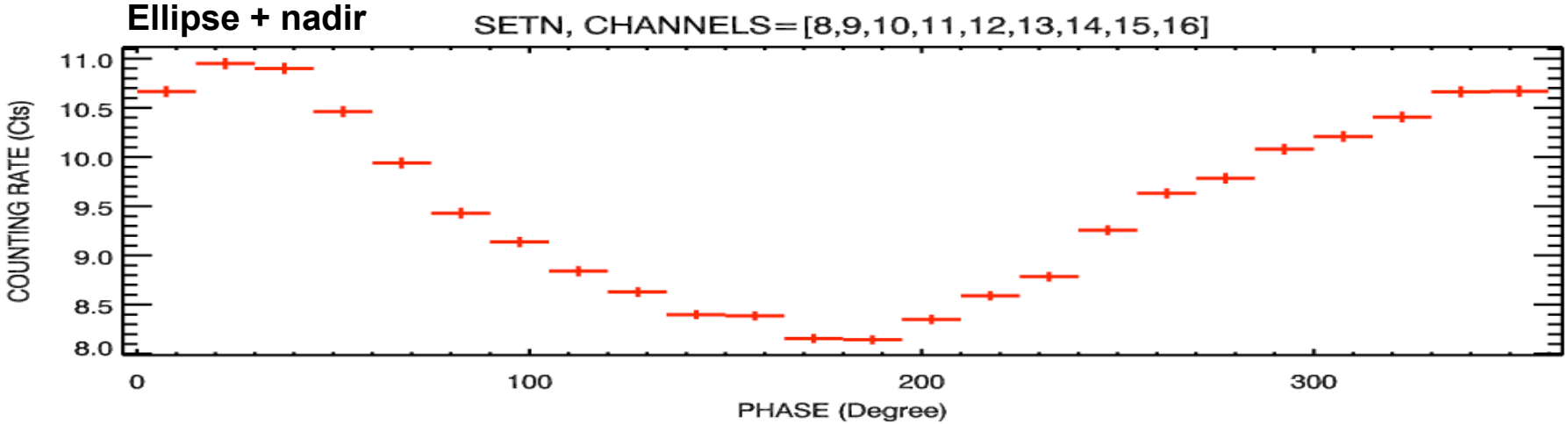
(4) The first maps are produced, which fully cover polar regions. We may make the first estimations for ice signatures at PSRs.

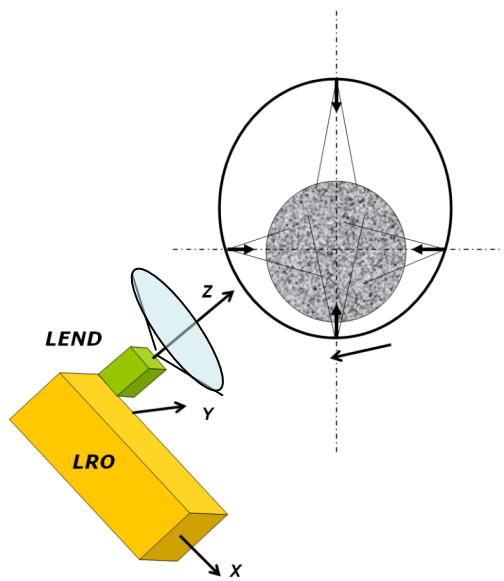
LEND space operations



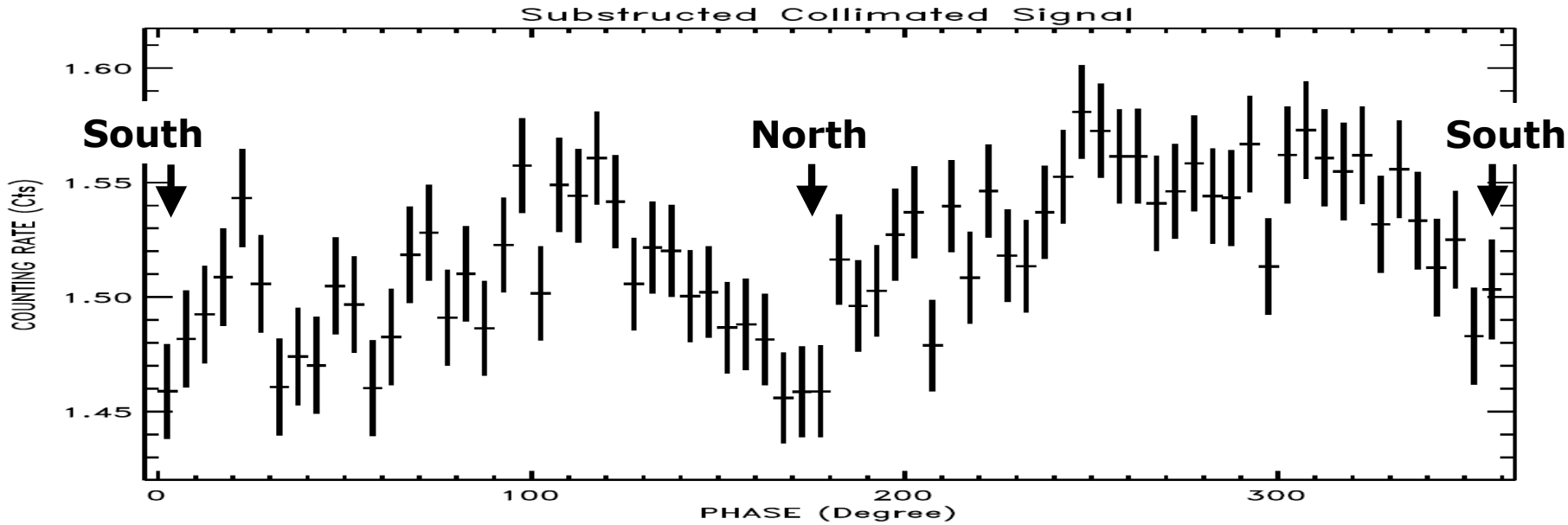
LEND space operations

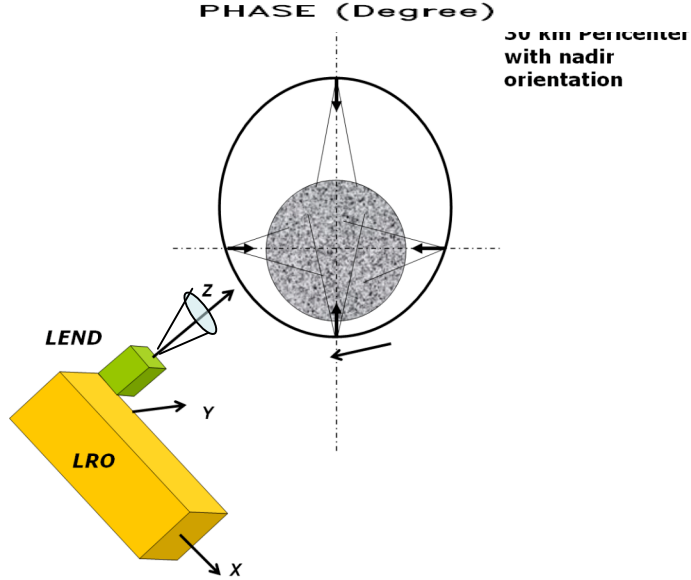
Ellipse + nadir



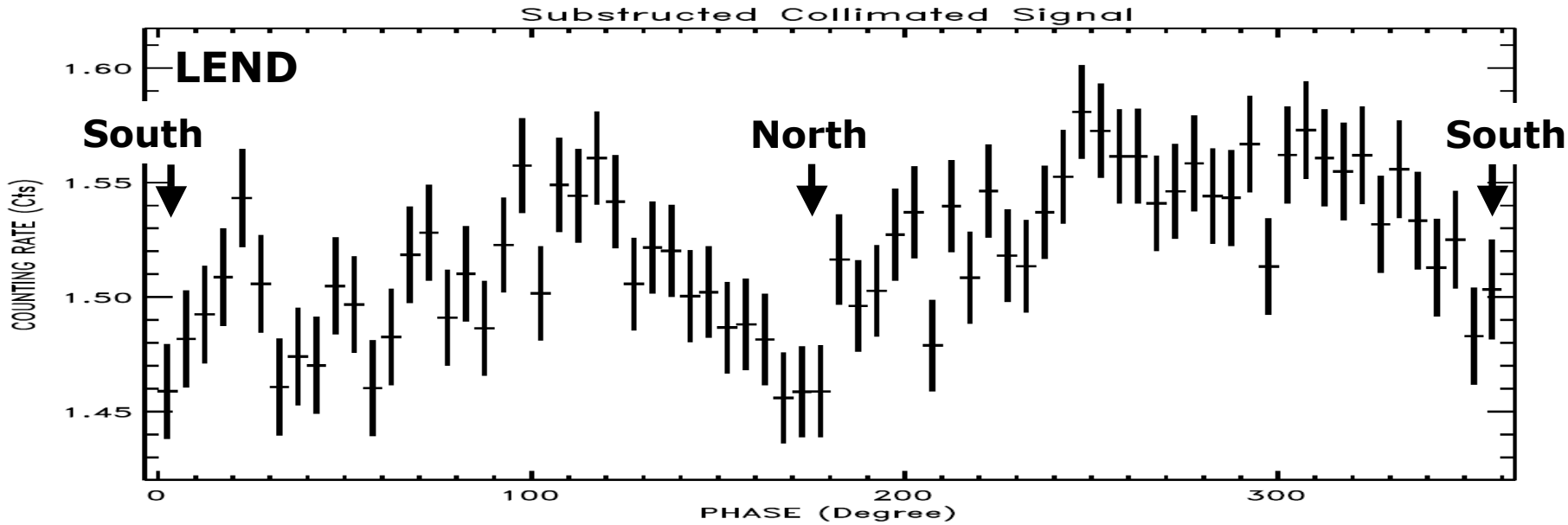


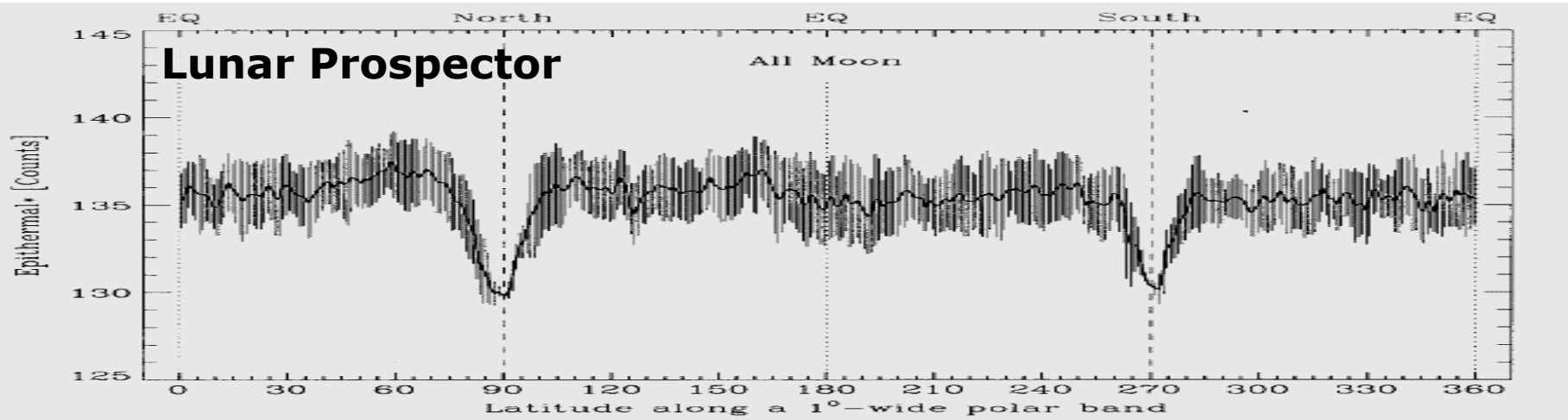
LEND space operations





LEND space operations





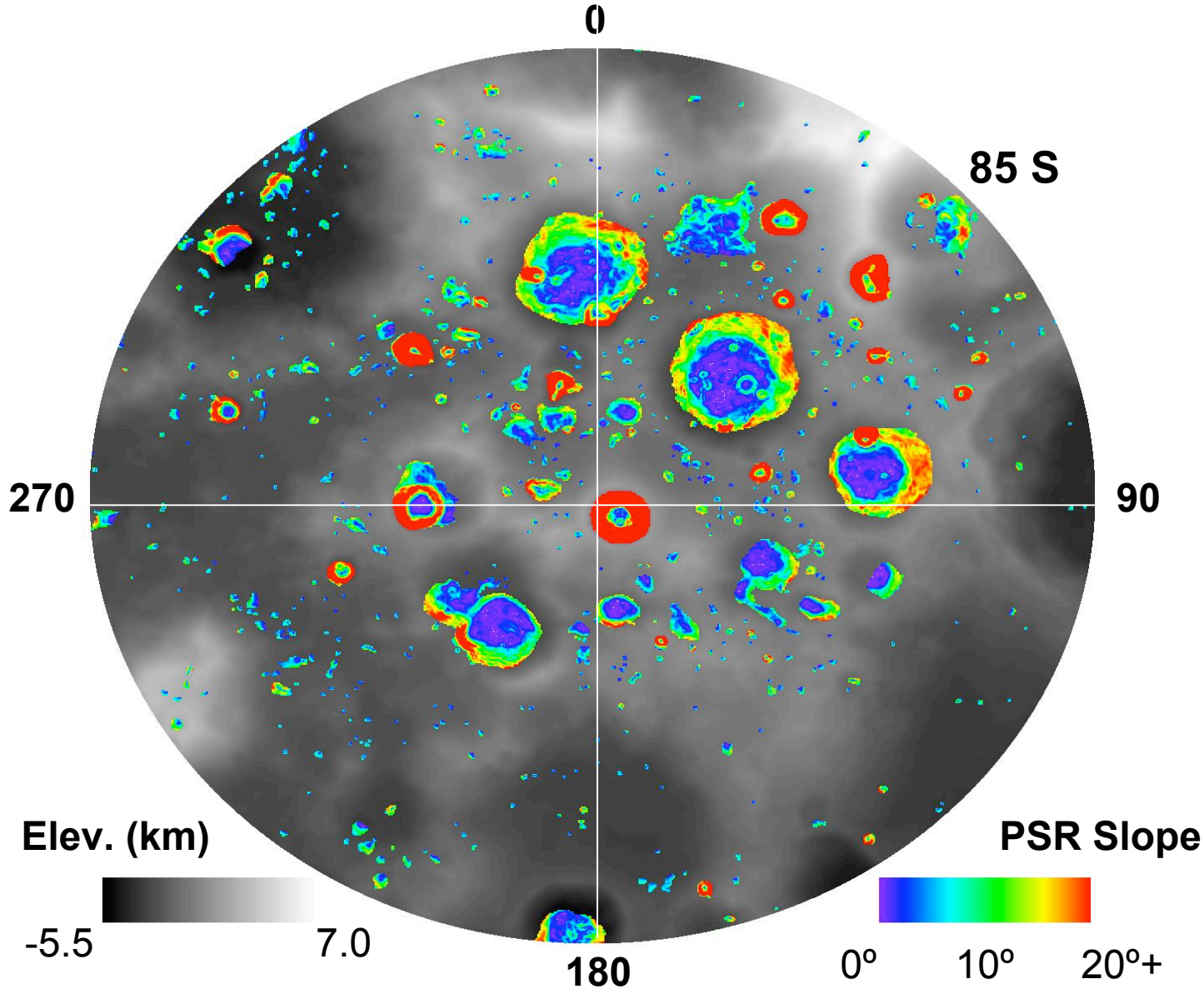
Determination of PSRs at polar regions

Permanently Shadowed Regions on Kaguya DEM

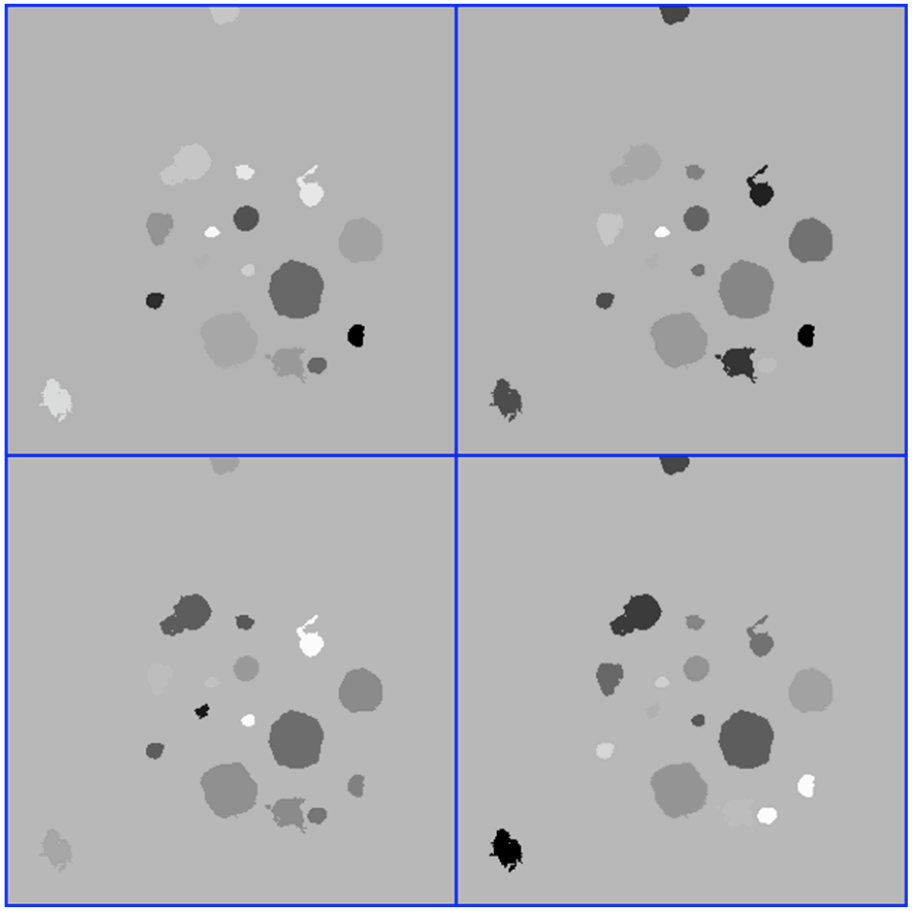
South, –(85-90º)

PSR's Color Coded (slope degrees)

Area Not PSR (grey) Elevation (km) as deviation from 1734.7 km Moon radius



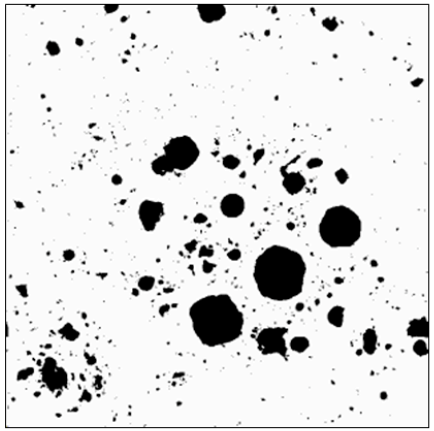
Southern Pole: Water Map Estimation



Trajectory Coverage:
15 days

Four Monte Carlo simulations for the same set of trajectories

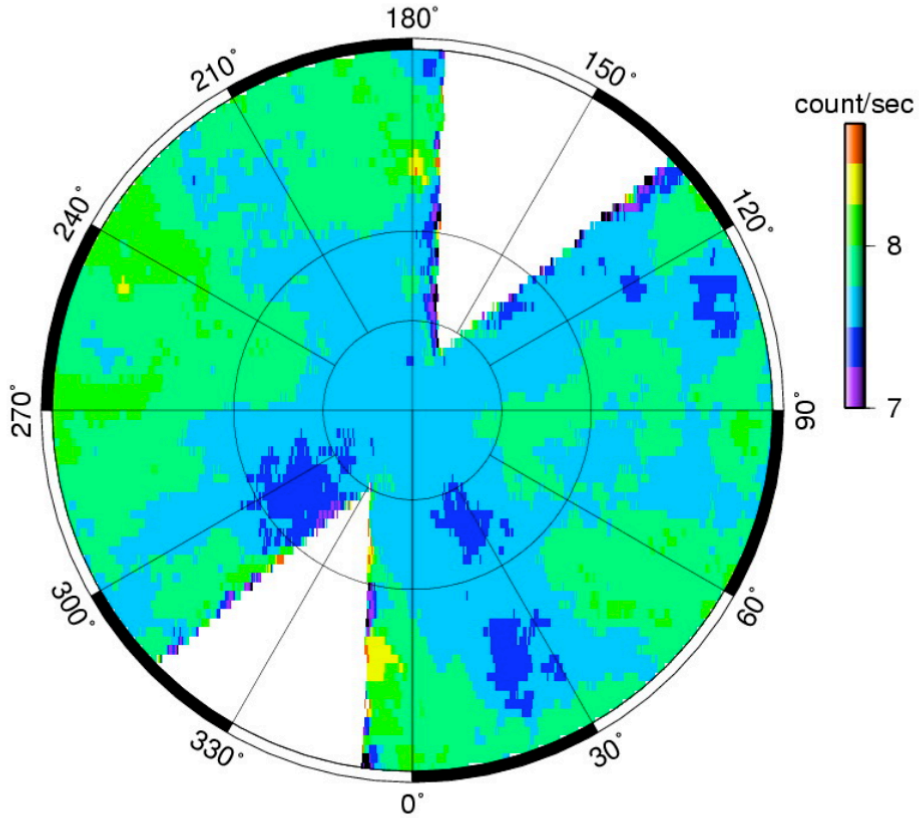
Compare the "survived" areas



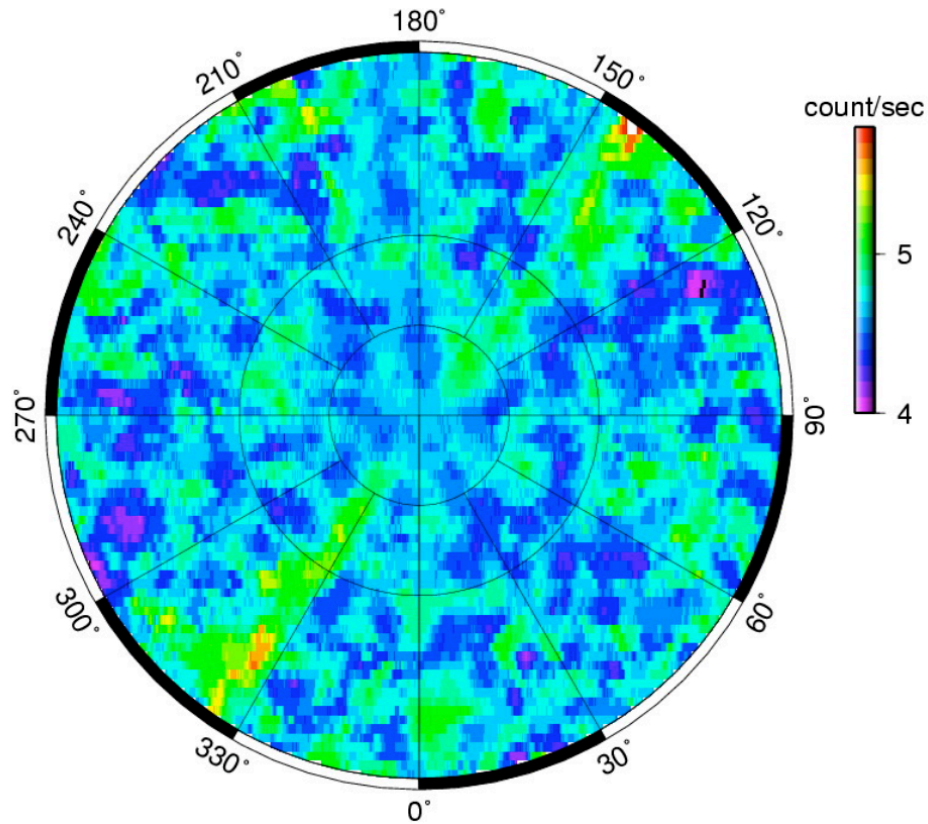
Poster from D.Usikov with LEND team

Mapping for North pole (200 km)

SETN

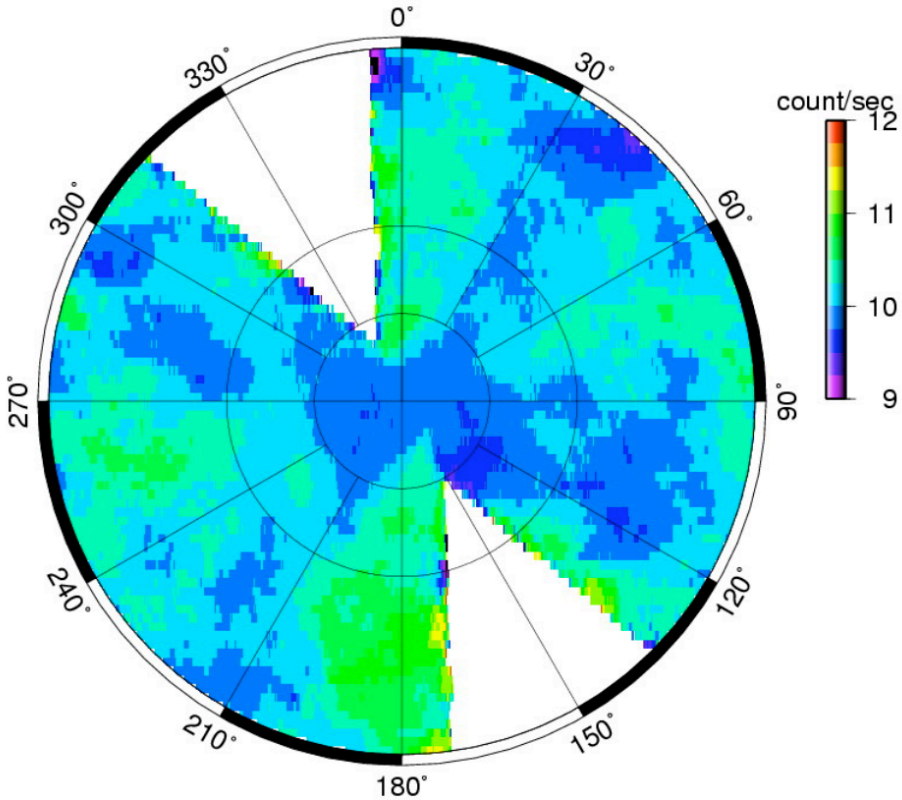


CSETN1-4



Mapping for South pole (30 km)

SETN



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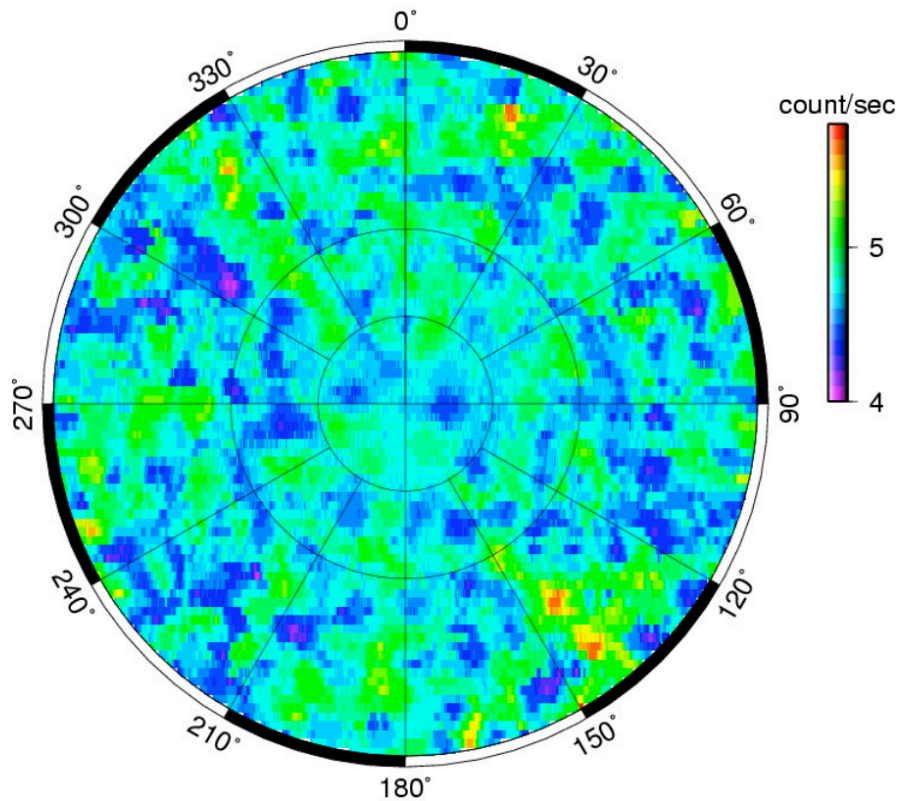

CONCLUSIONS:

The instrument is working nominally; we fully expect we will satisfy the LEND science requirements *M010* (radiation environment), *M070* (testing of water ice) and *M110* (hydrogen mapping).

The LEND data are limited by statistical uncertainty, but we can already confirm the epithermal-neutron flux depression in the polar regions found by Lunar Prospector.

It is too early to discuss scientific results at high spatial resolution, but the data are at least suggestive that the PSRs might be different than the surrounding material.