

DUST ON THE MOON: FROM APOLLO TO CHENG'E-4

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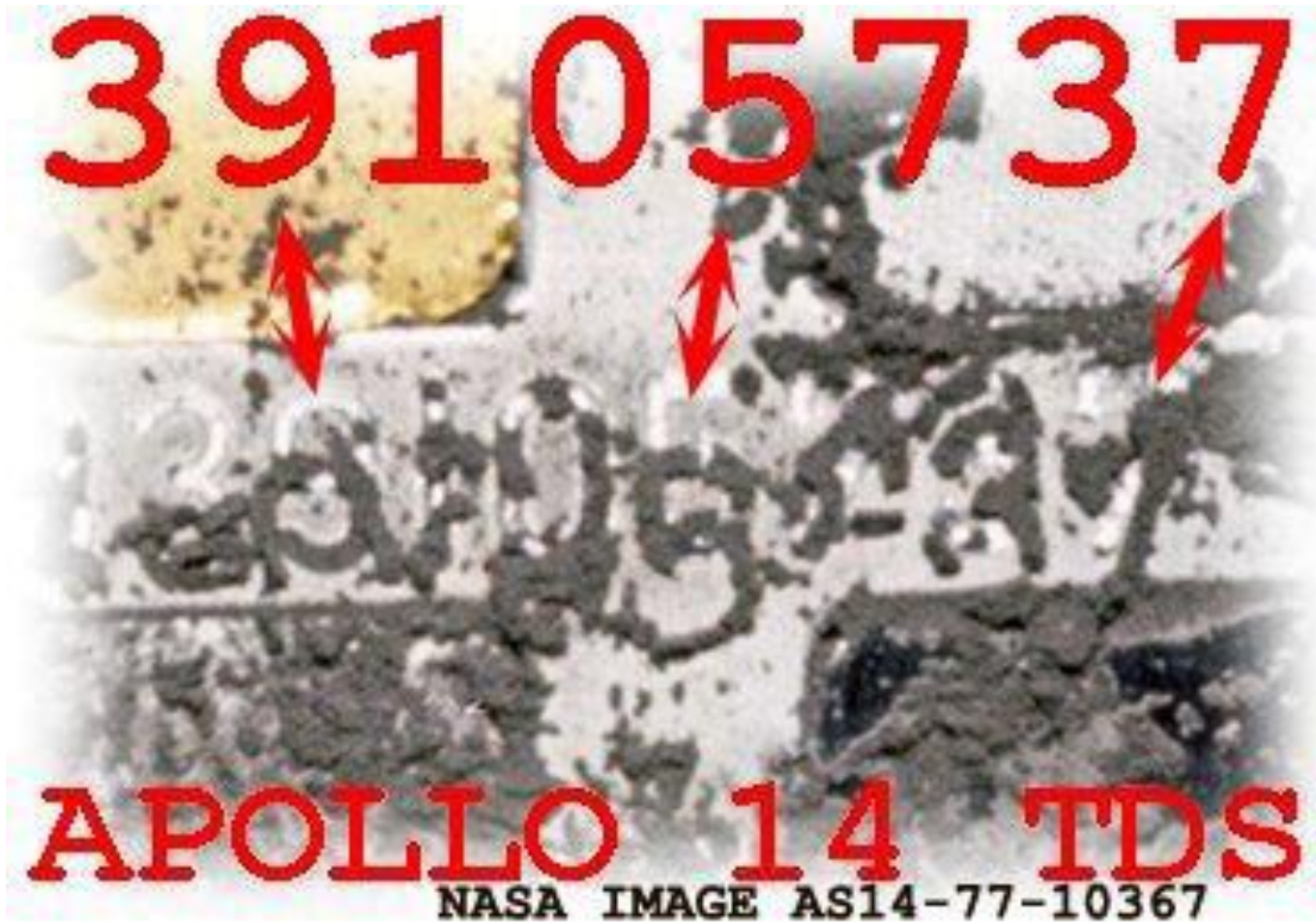
12 January 2017

Presented by courtesy of Dr William M. Farrell, GSFC

LDAP2010: OVERVIEW BY O'BRIEN

1. 1st REVIEW OF DDE, TDS AND LEAM EXPTS
2. DDE: 8 DISCOVERIES O'Brien 1970-2009
3. TDS: FIRST MODERN DISCUSSION GOLD'S DISCOVERY OF COHESIVE FORCES IN 1971
4. LEAM: SUGGESTED ALTERNATIVE CAUSE AS NOISE BITS IN BURSTS, PERHAPS FROM EMI
5. FINAL O'B IN 2011 *"BUT WHO WILL LISTEN?"*
6. LADEE FINDINGS CONSISTENT WITH #3 + #4?

COHESIVE FORCES OF LUNAR DUST



SURFACE DUST ON MOON: MAJOR ITEMS SINCE LDAP2010

O'BRIEN 2010-16

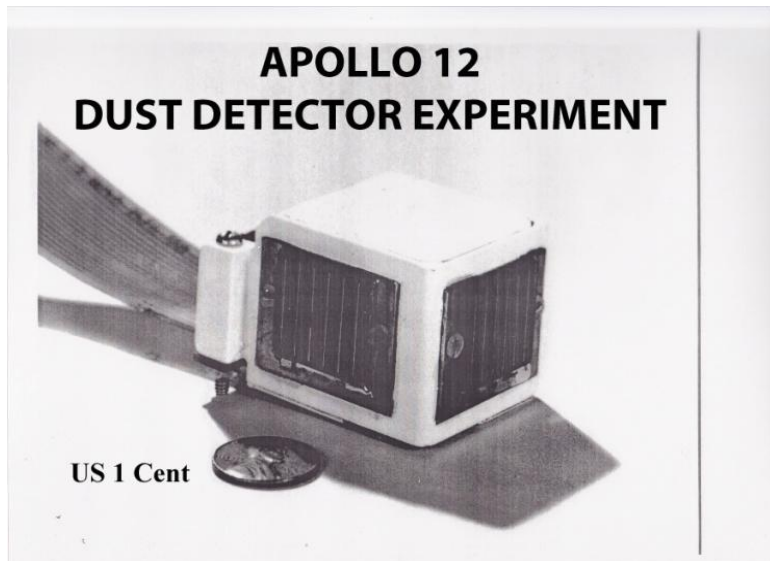
- 2011: O'BRIEN LDAP-2010
doi:10.1016/j.pss.2011.04.016
- 2013: LUNAR WEATHER AT
3 APOLLO SITES
http:dx.doi.org/10.1016/j.pss.
2013.1002/2013SW000978
- 2015: **SUNRISE-DRIVEN
GROUND-TRUTH FACTS**
dx.doi.org/10.1016/j.pss.2015
.09.018

CHENG'E-3 & CHENG'E-4

- **CHENG'E-3 & YUTU**
- YUTU FIFTH LUNAR ROVER
- IN 2013 FIRST IN 40 YEARS
- MOVED 100m LUNAR DAY 1
- NO MOVEMENTS AFTER 1st
SUNRISE: WHY NOT?
- **CHENG'E-4 (2018):**
#1 PRIORITY CHANGED 2016
TO LUNAR DUST STUDIES

SUNRISE DRIVEN EFFECTS

APOLLO 12 DUST DETECTOR DDE INVENTED 12/01/1966

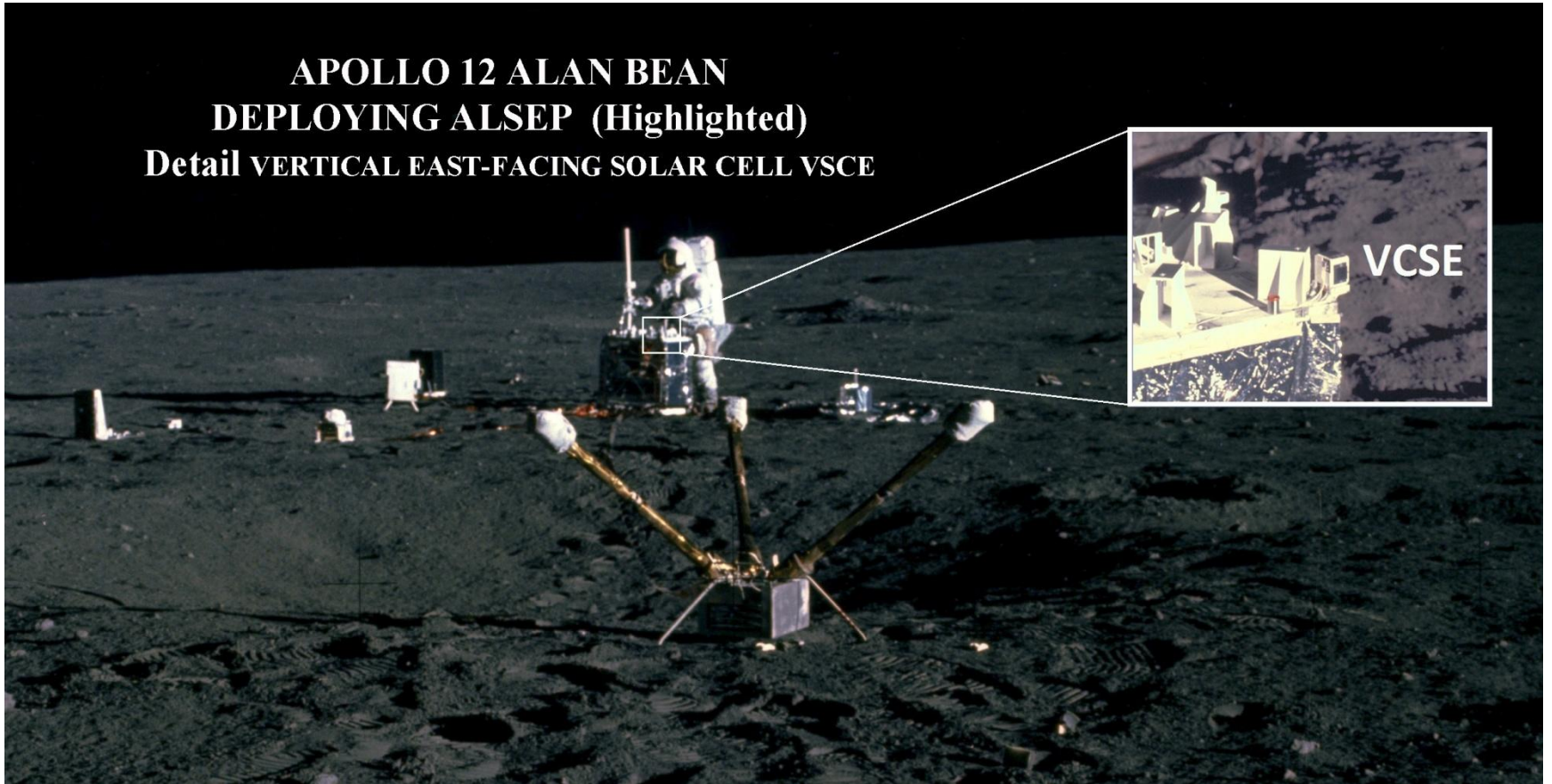


SYNERGIES WITH 2 SOLAR CELLS AT RIGHT ANGLES

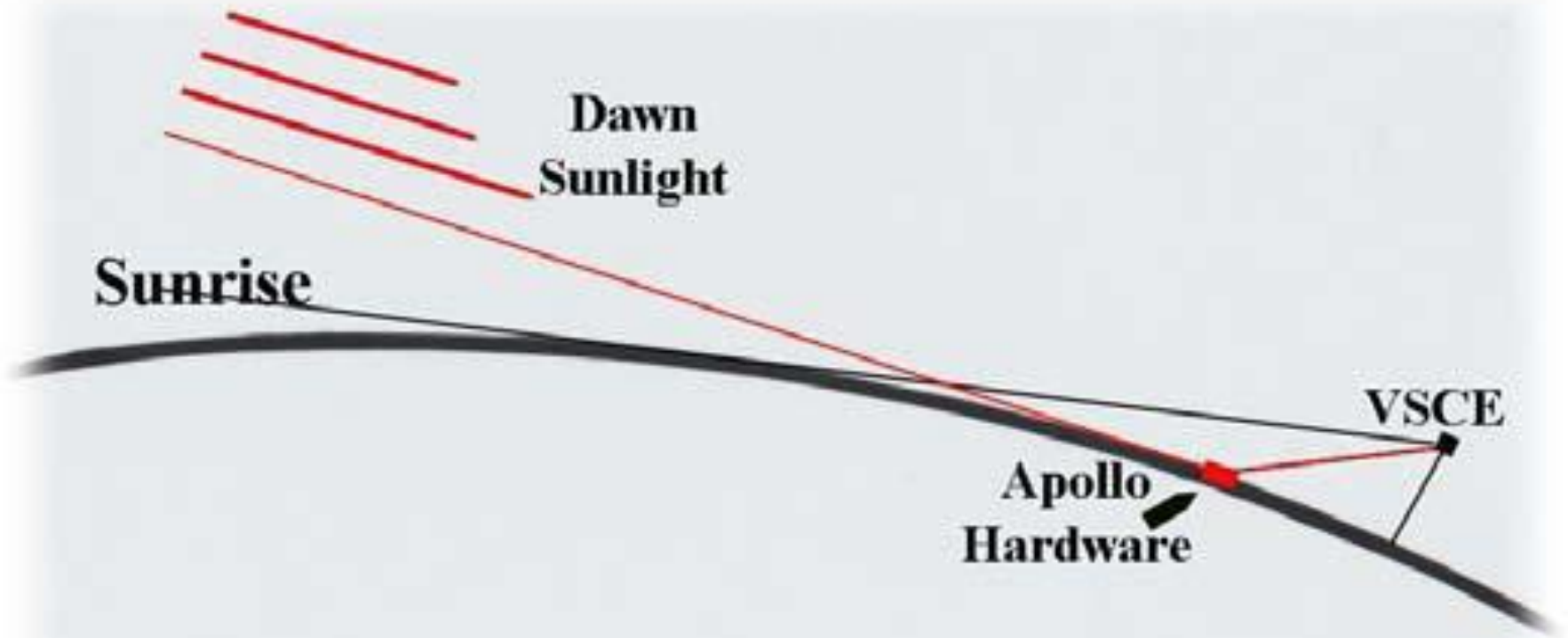
- 1 VSCE VERTICAL SOLAR CELL
FACES EAST (SUNRISE MAX)
 - 2 HSC HORIZONTAL CELL
FACING UP (NOON MAX.).
- APOLLO 12 DDE WAS THE
ONLY 1 OF 4 APOLLO DDEs
LEFT WITH ORTHOGONAL
DESIGN.

DEPLOYMENT OF APOLLO 12 DDE

**APOLLO 12 ALAN BEAN
DEPLOYING ALSEP (Highlighted)
Detail VERTICAL EAST-FACING SOLAR CELL VSCE**

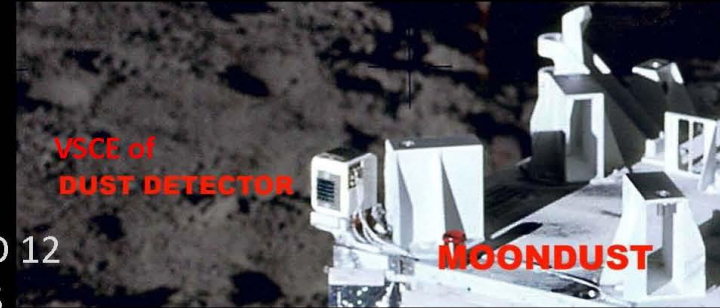
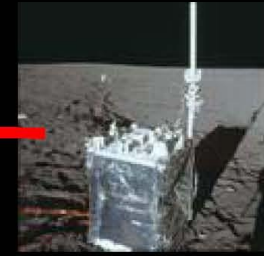
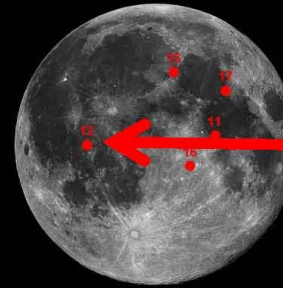
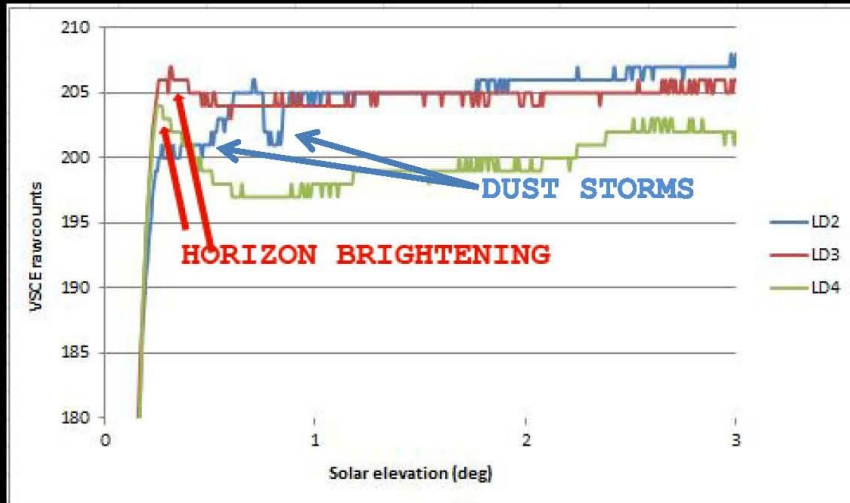


SUNRISE ON VSCE (EXAGGERATED)



SUNRISE – DRIVEN LUNAR DUST STORMS

FIRST SUNRISE MEASUREMENTS BY APOLLO 12 DDE VERTICAL SOLAR CELL FACING EAST



1. SMOOTH LUNAR SURFACE DISTURBED BY APOLLO 12
2. STORMS OCCUR FIRST HOURS OF FIRST SUNRISES
3. LEVITATE FREED DUST GRAINS TO $> 100\text{cm}$
4. LINKED WITH SUNRISE HORIZON BRIGHTENING
5. SUNRISE ANALOGUE OF SUNSET HORIZON GLOW
6. IN FIRST 3 LUNAR DAYS HORIZONTAL CELL MEASURED 30% OF 6-YEAR DUST ACCUMULATION

"Sunrise-driven transport of dust on the Moon"

Brian J. O'Brien & M. Hollick, Accepted for Publication
8 Oct 2015, DOI 10.1016/j.pss.2015.09.018

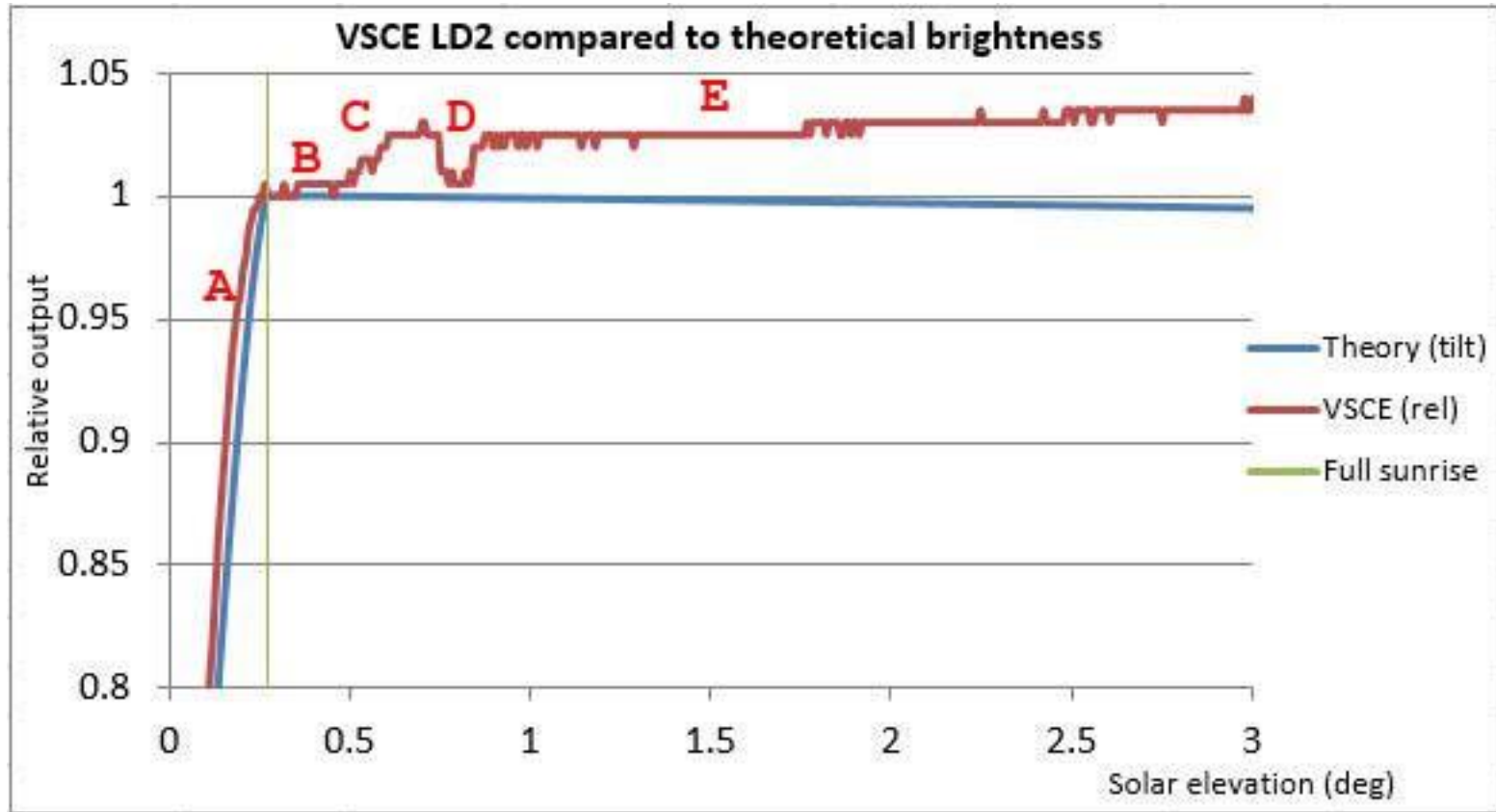


VSCE: VERTICAL EAST-FACING; HSC: HORIZONTAL CELL

- **VSCE MEASURES DAWN BRIGHTNESS OF LIGHT**
 1. MEASURES **DUST STORMS** ON FIRST FEW SUNRISES;
 2. MEASURES **DAWN HORIZON-GLOW** FOR 14 of FIRST 17 LUNAR DAYS THEN NONE FOR NEXT 61 LUNATIONS
- **HSC MEASURES ACCUMULATED DUST AT NOON FOR 6 YEARS**
 - ON FIRST 3 LUNAR DAYS DEGRADATION BY DUST ACCUMULATION WAS ABOUT 30% OF TOTAL OVER 6 YEARS
 - **PROVES LEVITATION TO 100CM HEIGHT OF DDE**

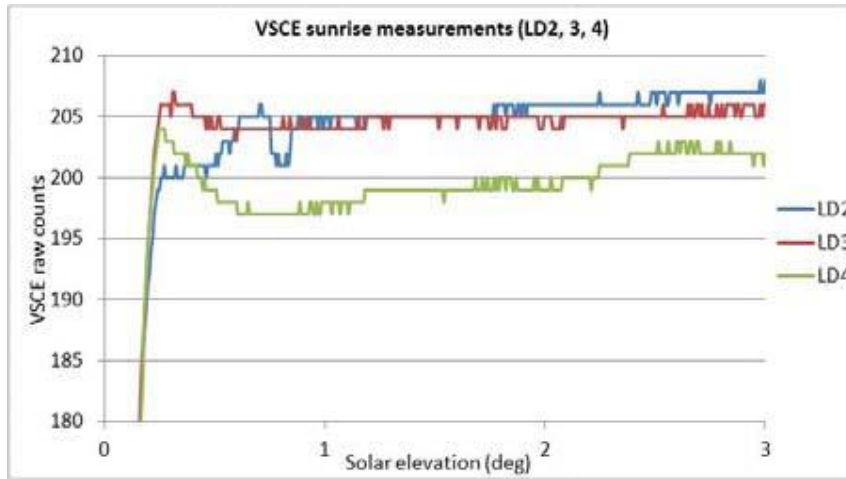
SUNRISE-DRIVEN DUST STORMS

FIRST SUNRISE WAS ON LUNAR DAY 2 (LD2)

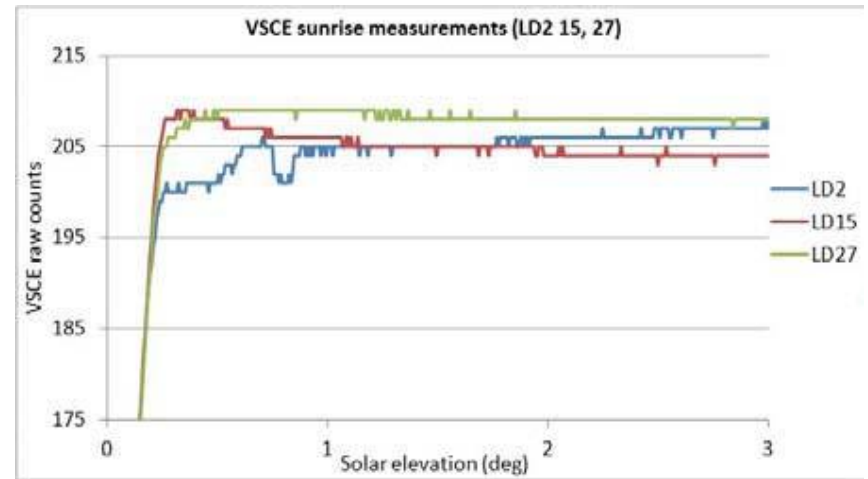


VSCE: DUST STORMS WANED EARLY versus LATER SUNRISES

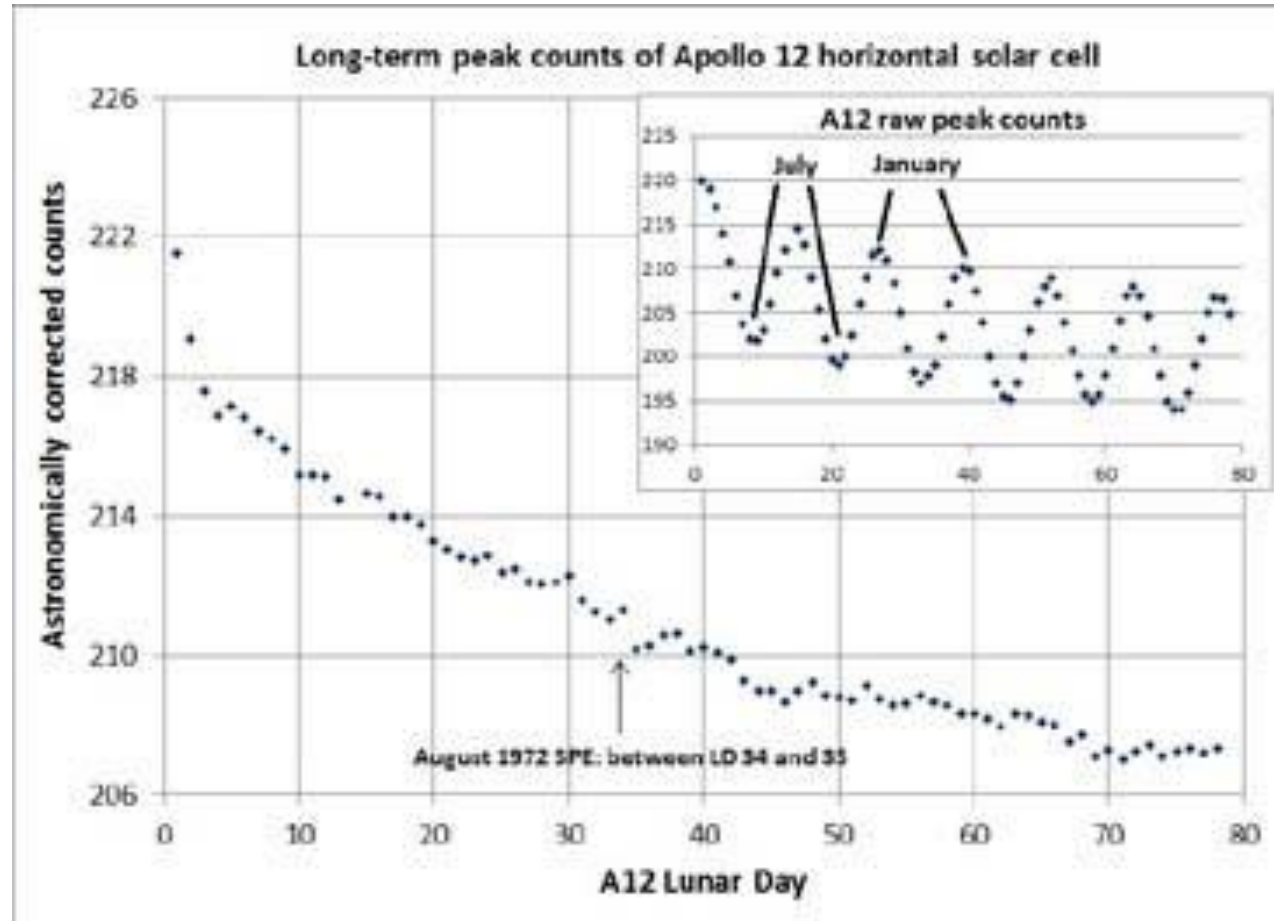
**FIRST 3 SUNRISES:
LD2, LD3 and LD4**



**FIRST 3 PERIHELIONS
LD2, LD15 & LD27**



HSC: LARGEST ACCUMULATION OF DUST IN FIRST FEW DAYS

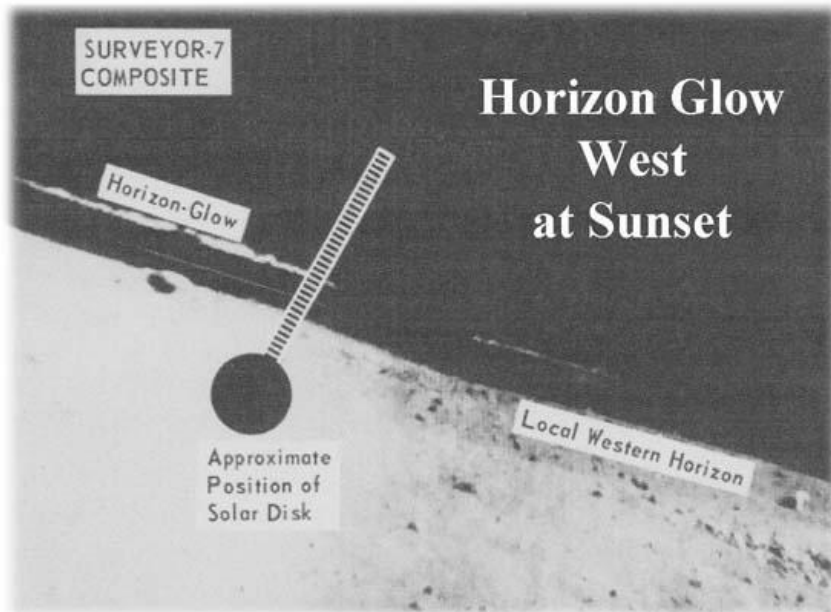


HORIZON BRIGHTENING AT DAWN

- MEASURED ON 14 OF FIRST 17 LUNATIONS THEN NOT FOR LAST 61;
- **SUNRISE ANALOG** TO HORIZON GLOW (HG) PHOTOGRAPHED AFTER SUNSET BY SURVEYOR (see next slide);
- DUST CAUSING HG WAS A PRIME OBJECTIVE OF LADEE BUT NOT MEASURED AT 2-250 km
- GROUND TRUTH DDE HERE IS AT 100cm.

HORIZON GLOW (BRIGHTENING)

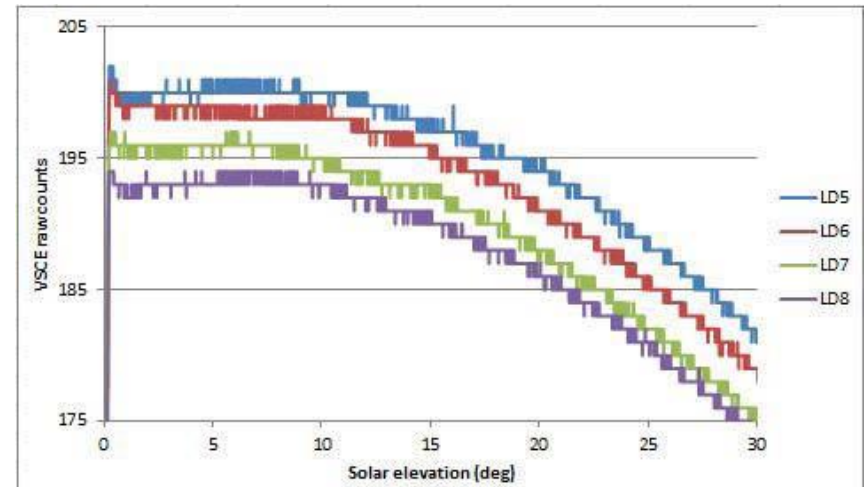
SURVEYOR 7 (SUNSET)



APOLLO 12 DDE (SUNRISE)

LD5 to LD8 (<1 degree)

Samples near aphelion



MODEL OF LEVITATED DUST

- BOTH LEVITATION & TIME VARIATION OF DAWN BRIGHTNESS ARE CONSISTENT WITH O'BRIEN SIMPLE 5-STEP MODEL:
- **STEP 1:** COHESIVE FORCES DISRUPTED BY ROCKET EXHAUSTS DIGGING UNDER SURFACE, FREEING FINE DUST PARTICLES;
- **STEP 2:** SUNRISE SUDDENLY CAUSES PHOTOELECTRIC EFFECTS WHICH CHARGE FREED DUST PARTICLES;
- **STEP 3:** COULOMB FORCES OF REPULSION MOBILISE DUST Laterally & TO CIRCA 100CM HEIGHT, LIKE GROUND MIST;
- **STEP 4:** LUNAR DAY BY LUNAR DAY, POPULATION OF FREED DUST PARTICLES BROADLY DECREASES, SUBJECT TO ORBIT;
- **STEP 5:** CONSEQUENTLY, AFTER ABOUT 1 YEAR, LUNAR SURFACE IS SMOOTH ONCE MORE.

COLLATERAL “NICE” DISCOVERIES FOR HUMAN EXPLORATION OF MOON

- 1. SUNRISE EFFECTS NATURALLY MITIGATE DUST PROBLEMS FROM MINING & EXPLOITATION OF NATURAL RESOURCES;**
- 2. SIMPLE 5-STEP MODEL EXPLAINS SMOOTH SURFACES OF MOON, LEVITATION & OCCASIONAL HORIZON GLOW;**
- 3. “GROUND TRUTH” MEASUREMENTS APPEAR CONSISTENT WITH APOLLO 12 DDE PARTLY-ACHIEVING 2 MAJOR ORIGINAL GOALS OF LADEE**
- 4. AFTER 20 LUNAR LANDING SPACECRAFT, CHENG’E-4 IN 2018 WILL BE THE FIRST GIVING #1 PRIORITY TO MEASUREMENTS OF LUNAR DUST, 50 YEARS AFTER INVENTION OF DDE.**

COLLATERAL “NOT-NICE” DISCOVERIES FOR HUMAN EXPLORATION OF MOON

- **SUNRISE-DRIVEN DUST STORMS MAY INFLITRATE MOVING PARTS CAUSING VERY FINE DUST which “ADHERES TO EVERYTHING, ...ITS RESTRICTIVE, FRICTION-LIKE ACTION TO EVERYTHING IT GETS ON...”**
- **SO WE SPECULATED IN DECEMBER 2015 THAT YUTU MIGHT HAVE BEEN IMMOBILISED BY SUNRISE-DRIVEN DUST;**
- **THE CHENG’E-4 DECISION IN 2016 TO MAKE STUDIES OF LUNAR DUST #1 PRIORITY IMPLIES CHINA GROUP AGREES;**
- **WE INCREASE OUR DUST CAUTIONS TO COMPETITORS IN GOOGLE LUNAR XMEDAL AND PLANNERS OF MOON VILLAGE**

ANSWERING SCHMITT'S QUESTION?

- JACK SCHMITT ASKED FOR DECADES:
“IF DUST IS MOVING AROUND, WHY ARE MOST ROCK SURFACES FREE OF DUST?”
- SUNRISE DDE PAPER TENTATIVELY ANSWERS JACK'S QUESTION, BUT OUR DISCUSSIONS CONTINUE.

EVIDENCE OF VALIDITY OF DDE GROUND-TRUTH MEASUREMENTS

- **DETAILED IN TEXT PLUS SUPPLEMENTARY**
- **ECLIPSE CALIBRATED 6 SENSORS ON DAY 4**
- **Line-detail evidence, see Supplementary on-line of**
<http://dx.doi.org/10.1016/j.pss.2015.09.018>
- **APOLLO 12 DDE HOLDS RECORD OF LONGEST OPERATIONAL SUCCESS (6 Years) OF ANY ACTIVE APOLLO SURFACE EXPERIMENT**

SUMMARY:

NEW APOLLO 12 DDE HIGHLIGHTS

- 1. DISCOVERY SUNRISE-DRIVEN DUST STORMS;**
- 2. FIRST MEASURED LEVITATED DUST AT 100cm**
- 3. MEASURED DUST CAUSE OF SUNRISE
EQUIVALENT OF SUNSET HORIZON GLOW**
- 4. SUNRISE-DRIVEN EVENTS CAUSE NATURAL
SMOOTHING OF LUNAR SURFACES**
- 5. SIMPLE 5-STEP MODEL EXPLAINS ALL ABOVE**
- 6. SURFACE-DUST PRIORITY #1 FOR FUTURE.**