Comet Siding Spring at Mars Observer’s Workshop
September 19, 2014  JPLAJPL/WebEx
Welcome to the Comet Investigative Observing Campaign’s / Mars Program Office’s
C/Siding Spring at Mars Observer’s Workshop
September 19, 2014

CIOC SOC, LOC from SBAG, MEPAG: Lisse, Seelos, Vervack (APL); Farnham, Kelley, Warner (UMD); Battams (NRL), DiSanti (GSFC), Fernandez (UCF); Knight (Lowell), Lemmon (Texas A&M), Li (PSI), Yanamandra-Fisher (SSI)

Meeting Goals: Comet characterization, observing plans update since Aug 11, 2014 Workshop. Continue to facilitate the maximal science return from dynamically new Oort Cloud Comet Siding Spring’s 2014 passage through the inner solar system by involving every telescope available (mainly Southern telescopes on Earth, high sensitivity s/c, and the Mars Fleet) for observations.

Contact Info: http://www.cometcampaign.org; http://mars.nasa.gov/comets/sidingspring/
A Few Logistical Points

Welcome! The purpose of this workshop is to continue to maximally facilitate collaborative observations of comet C/2013 A1 (Siding Spring) in 2013 – 2014 and their scientific return. The focus of this update meeting is to determine if anything has changed since our August 11th workshop, anything that would cause a change in final observing plans for the October 19th close encounter at Mars.

We are NOT trying to answer all questions about Comet Siding Spring and its close flyby of Mars here. If we optimize, say, 5 new observations or collaborations and their resulting papers this Workshop will have been a success.

This is mostly a web-based Workshop. Members of the audience include professional and amateur astronomers (both ground and spacecraft based), NASA HQ scientists and EPO experts, and media representatives. Most of the attendees are participating remotely, via WebEx.

- The agenda is posted on-line at www.cometcampaign.org/workshop
CIOC  C/Siding Spring Campaign

• **Observing Opportunities from Ground Limited:**
  *Southern Twilight* Comet, Brightest from Earth in mid- to late-September => Good opportunities to characterize the comet pre-Mars, pre-perihelion.

• **Observing focused mainly on (1) Early s/c based** hazard related characterization; (2) **Inside 2 AU Earth-based characterization**; and (3) **Mars encounter observations** Oct 17 – 21.

• **Mars Fleet:** MRO, Mars Odyssey, MEX, MSL, Opportunity, MOM, MAVEN. 2013’s Comet ISON flyby at 0.07 AU was practice for **Comet C/2013 A1 (Siding Spring)**’s *VERY* close Mars approach on 10/19/14

• **Helio Fleet:** *STEREO, SOHO (?)*

• **Astrophysics Spacecraft:** *SWIFT, WISE, HST, Spitzer, Chandra, Kepler*

• **Websites:** CIOC (FAQS, news, lightcurves, schedules/logs)  http://www.cometcampaign.org  
  *Mars Program* (” ”, mission news) http://mars.nasa.gov/comets/sidingspring/

• **PRO-AM COLLABORATIONS:** Facebook, Twitter, and Pinterest groups; COBSA & other “professional amateurs”; Jet Morphology campaign; Ion tail campaign

• **NASA HQ EPO:** Ask an Astronomer; FAQS; Media Point of Contact.
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<td>Lisse</td>
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<td>11:30 AM</td>
<td>Current observing plans</td>
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<td>Latest SSERVI results: Phobos/Deimos ejecta</td>
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<td>01:35 PM</td>
<td>Mars Mission status overview</td>
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<td>Integrated timeline of Mars-project observations of the comet</td>
<td>Diniega</td>
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<td>MAVEN events*</td>
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<td>MRO: CRISM observations</td>
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<td>Mars Orbiter Mission: observation plans*</td>
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<td>Ground-based amateur observations of the Mars-Comet Encounter</td>
<td>Yanamandra-Fisher</td>
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<td>Discussion and Wrap-up</td>
<td>Lisse, Zurek, Fast</td>
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<tr>
<td>05:00 PM</td>
<td>Adjourn</td>
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*These talks are still being confirmed, and will be scheduled based on availability of the speaker.
Comet Siding Spring (C/2013 A1) is racing toward Mars for a close encounter in October 2014.

Closest approach to Mars: ~86,000 miles (138,000 km) OCT 19 2014

Best Earth Observing Time in mid-September; Mars C.A. ~ 138,000 km, @ 16:38 UT, 56 km/sec relative (but max danger maybe 100 min later when Mars + s/c cross comet’s orbit)
Four Currently Bright Comets in the September 2014 Sky:

“TRAPPIST C2 snapshots of (from left to right) C/2013 V5 (Oukaimeden) which is now every bright, CN is impressive too filling the 20x20 FOV, sharp false nucleus, no sign of disruption, C/2012 K1 (PANSTARRS), rising in the morning show a long tail in R band and round compact CN and C2 coma C/2014 E2 (Jacques), only about 10 deg from horizon still has a large and diffuse CN and C2 coma, and C/2013 A1 (Siding Spring), much fainter than the others (10min exptime versus 3 to 5min)” – E.Jehin 9/7/2014
So Just How is Our Patient?

Good news!

While still mainly a Southern hemisphere object, Comet Siding Spring is coming North and is running 0.5 – 0.75 mags brighter than the JPL Horizons Predictions.

Q(H₂O) is also rapidly increasing (SWIFT), expect ~2x10²⁸ mol/sec at Mars.

D/G ~ 1.5 (TRAPPIST)
Siding Spring: Background

• Dynamically new comet with historic close approach to Mars (0.0009 AU = 135,000 km) on 2014 Oct 19
  – 1/3 distance from Earth to Moon
  – 1/35 distance of closest comet approach to Earth of last 200 years (IRAS-Araki-Alcock in 1983)

• Mars will pass within Siding Spring’s gas coma (~10^5-10^6 km)

• Potential hazard to Mars spacecraft (dust impacts at 56 km/s)
C/Siding Spring has likely spent the 4.5 Gyr since its formation far from the Sun and the planets in the deep freeze of the Oort Cloud. For C/SS to come from the depths of the Cloud, with more than a year’s notice, at \( \sim 129^\circ \) inclination to the ecliptic and have an extremely close encounter with Mars at/near perihelion is very rare.
How Close is 138,000 Km?

• 1/3 the average Earth-Moon distance.
• 1/16 the distance of the closest comet to flyby Earth in the last 500 years.
• The C.A. distance of a very good NEA apparition.
• 15x the mean distance of $R = 11$ km Phobos from Mars.
• 6x the mean distance of 6 km Deimos from Mars (note that at $R_{CSS,nuc} = 0.3 – 5$ km, CSS is smaller than the moons by 1.2x to 35x).
• $R_{Hill Sphere, Mars} \sim 577,000$ km
• In the outer coma ($10^5 – 10^6$ km) of an active comet.
Siding Spring: Hazard mitigation

- Studies of dust hazard to Martian fleet (2014):
  - Farnham et al.,
  - Farnocchia et al.,
  - Moorhead et al.,
  - Tricarico et al.,
  - Vaubaillon et al.,
  - Ye and Hui

- Consensus results: despite the very close approach, Mars fleet is likely safe
  - Observations have constrained activity level and trend
    - Dust large enough to cause damage (>50 μm) must have already been released in order to reach Mars
    - Dust tail modeling and outflow velocities indicate hazardous grains unlikely to have been released early enough or with high enough velocity
Issues I Hope the CSS + Mars Observations Will Address:

- Comet Siding Spring will be the largest Km-sized Cometary Object to come within 130,000 km of a planet since ~1 km sized D/Shoemaker Levy 9 hit Jupiter in 1992/1994 and the 0.06 – 0.20 km Toguska [Asteroid or Comet (?)] Bolide hit Earth in 1908

- Siding Spring’s Encounter Geometry is the equivalent of a decent comet flyby, at a not-so-good ~90° phase angle throughout – but it is the first ever to resolve an Oort Cloud comet nucleus (except for Halley....) – **MRO/HiRISE**

- Siding Spring’s Immediately Up(Solar)Wind encounter geometry from Mars makes studying the Martian exosphere and mesosphere very interesting – MAVEN, MOM

- Comet Siding Spring is not the first comet to interact closely with Mars. Given the water ice we are finding on other terrestrial planets, and the idea that to terraform Mars we would increase its volatile inventory by dumping comets onto it, it will be very interesting to compare the dirty H₂O+CO₂ Martian polar caps with the dirty H₂O+CO₂ ices in comets. – **MRO/CRISM, MEX**

- While many comet orbit and orbit plane crossings have been studied and predicted to lead observable meteor showers, not even for the Leonid storms of 55P/ Tempel-Tuttle has the Earth passed through the orbit plane within 2 hrs and a few x 10⁵ km of the parent body. While most models suggest only a low rate of meteor hits, we should watch just in case – **Opportunity, MSL**
Example of Cross-Disciplinary Re-use of Assets: 10 of the 15 reported s/c detections of Comet ISON [Out of 20 attempted; other detections include FORTIS, Herschel, ISS, VEX, SOFIA]
Some Recently Updated Observing Plans:

- **Kepler:** 10/20, 10/25-27
- **IRTF/SPeX Support Obs.:** 9/23-27/14
- **HST:** 10/19-20/14 (22 orbits)
- **Chandra:** 10/19-20/14 (15 hrs, 5 pointings)

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**BOPPS**
Balloon Observation Platform for Planetary Science

**+ IRTF/SPeX Support Obs.**
9/23-27/14

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- (1) 25 hrs over a ~1020 pixel-long track 20 Oct 2014 10 UT to 21 Oct 2014 11 UT.
- (2) 41 hrs over a ~1200 pixel-track from 25 Oct 2014 12 UT to 27 Oct 05 UT.

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**MRO Visibility & Planned Obs**

**HST 10/19-20/14 (22 orbits)**
Siding Spring: Mars-based Observations

- **Mars Reconnaissance Orbiter (MRO):**
  - HiRISE may resolve nucleus (few×100 m/pix resolution for ~1 km nucleus)
  - Observations that rival flyby; nearly impossible to do for an Oort Cloud comet otherwise
  - CRISM (&MEX) will return VISIR spectra allowing Mars-comet material comparison
- **MAVEN, MOM:** atmospheric monitoring of coma’s interactions with Martian atmosphere
  - Yelle et al. (2014)
- **Mars Odyssey:** THEMIS thermal IR science
- **MSL, Opportunity rovers:** imaging, meteors

**Practice:**
Comet ISON as viewed by MRO/HiRISE at \( \Delta \approx 0.07 - 0.09 \) AU (Siding Spring will be ~100× closer!)

From: Delamere et al. 2014
C/Siding Spring from MRO/HiRISE: Instrument that gave us the best ISON nucleus size estimate should resolve CSS, but...

Starting with 1P/ Halley Giotto imagery

These are the expected CSS Imaging Results

N.B.: 16 by 16 pixel box used; PSF not applied to simulated images

Delamere et al. 2014
High-level schematic of Comet Siding Spring (CSS) Observation Timeline

Key:
- X = CTX
- S = SHARAD
- C = CRISM
- H = HiRISE
- M = MARCI
- R/A = Ride Along

6-AUG-2014, CRISM/HiRISE stellar scan to check boresite (1 orbit duration)

MCS/M/S nadir observations of atmosphere to determine background atmospheric state

MCS/M/S nadir observations of atmosphere to determine comet particle effect on atm

Days from C/A
-2 -1 0 +1 +2

-60 (2.5 d) to -5 hours: 2 observations every other orbit using ~75% of orbit. H/C observations to determine rotation rate; X R/A

+5 to +14 hours: 2 observations every other orbit using ~75% of orbit. H/C observations to determine rotation rate; X R/A

C/A -12 day observation to refine CSS ephemeris (7-OCT-2014)

C/A (5 orbits, 1 sequence): 19-OCT-2014
See next slide
Closest Approach Observations (Oct. 19, 2014)

C/SS Nucleus Closest Approach  Possible Encounter with C/SS Debris
- 2 days  - 1 day  + 1 day  + 2 days

CSS observations every other orbit…  C/A  cont’d

MRO Example

Center time for C/SS particle encounter with Mars: 20:10 ± 10 min TDB

Most likely time to see atmospheric effects

C/A – 1 orbit:
2 CRISM + 4 HiRISE scans
Various line times to provide different exposures; CTX R/A

C/A orbit (138,000 km +/- 3000 km):
2 CRISM + 6 HiRISE scans + CTX R/A
Shortest line times for best resolution

C/A + 1 orbit:
2 CRISM + 4 HiRISE scans
Various line times to provide different exposures, CTX R/A

TDB - UT = 67.184 s

Key:  C/A = Closest Approach; R/A = Ride-Along

Nadir observations (MCS, M, and/or S)

C/SS observations
Rovers: best viewing pre-dawn and post-dusk on 19 Oct 2014 Sol
The SkyView on 19 Oct 2014, Right After Sunset
Comet Siding Spring at Mars Observer’s Workshop on 11 Aug 2014: Summary Findings & Important Issues

- Some Characterization of CSS Now Made: comet acting like ISON long term, but 0.5-0.75 mags brighter than JPL predicts; H$_2$O has turned on. Much more to come in Sept 2014.

- Range of Predictions for Dust, Gas Effects on Mars from Encounter (most seem low); major effects likely to be from Heating of Mars Meso/Exosphere.

- Pro-Am Collaborative Astronomy (PACA) CSS/Mars Data Available for Scientist Use (but requires dedicated archive location until ingested into PDS after proper review).

- Need to Coordinate HST, MRO/MAVEN/Odyssey Observations.

- Ephemeris Updates Required within C.A. -10.

- Adequate DSN Available for C.A.?

- Quicklook Data Plans for 19 Oct 2014?

- Post 11 Aug 2014 Workshop Talks, Next Meetings to Discuss CSS + Mars.

- Important to continue to foster Mars Project + CIOC cooperation.

- Large, mainly Webex based community forums are of use but of substantially different character to run. Attendance at 30+ at APL + 50+ WebEx + 130+ Livestream for 11 Aug 2014 Workshop.
Upcoming Venues Where Comet C/2013 A1 (Siding Spring) Will be Discussed

- Observer’s Workshop, (11 Aug 2014) APL/JPL/WebEx
- Mars Fleet Tag-Up Workshop, (19 Sept 2014) APL/JPL/WebEx
- AAS/DPS 09-14 Nov 2014, Tucson, AZ USA
- Winter 2014 AGU (14-19 Dec), San Francisco USA
- LPSC 2015 (15-20 March), Houston, TX USA
- AAS/DPS (09-14 Nov 2015), Washington, DC USA

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Discovery of Comet C/2013 A1 (Siding Spring)

- Discovered on 3 January 2013 by Robert H. McNaught (also discoverer of >10 other comets) at V ~ 19.

- Used the 0.5-meter Uppsala Southern Schmidt Telescope at Siding Spring Observatory, Australia

- Orbit determined within a few days, first solutions implied a potential Mars collision. Refinements showed a very near-miss on Oct 19, 2014, Five Days before perihelion. Comet will be coming “up” from the South, and will be passing “almost horizontally” between the Sun and Mars.

- Comet Siding Spring has grown and brightened considerably since its discovery. (COBS @ Crni Vrh reports V~10.8 on 7/28/2014, 2.5’ width, r_h=1.9 AU)
Scientific Importance of Comet C/2013 A1 (Siding Spring):

- **Dynamically New** - First passage through inner system since formation & ejection
  - Icy planetesimal older than Earth likely containing leftover primordial SS material
  - Detailed orbital knowledge for Oort comet perturbed Mya to into inner system
- **On a Mars-grazing Orbit**, with > 1 yr lead time since discovery
  - Peri-Mars on Oct 19, 2014 at \( r_{\text{C.A.}} = 132,000 \text{ km} \), 1/3 Earth-Moon distance and 16 closer than the closest comet has come to Earth in the last 500 yrs.
  - Unlike ISON in 2013, **this is the only very close planetary encounter for CSS**.
  - CSS is coming so close to Mars that MRO should be able to resolve the nucleus, and Mars and the orbiters will be in the outer coma of the comet.

=> A free s/c flyby of the comet starring the Mars fleet of orbiters + rovers.
Comet Siding Spring Observing Campaign Website

New CIOC Website Established: [http://www.cometcampaign.org](http://www.cometcampaign.org)  
(site name purchased from GoDaddy)

- Latest news/updates about the comet
- Updated MPC lightcurve
- Workshop information
- Resources for amateur/pro-amateur/professional astronomers
- Blog posts from CIOC Team members
- Observer on-line schedule
- Observing logs
- List of papers/CBETS published
- Feedback form
- Associated: email news exploder

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Another Message From Our Sponsors --
## Session 1: Setting the Stage; Spacecraft Observations (I) (1h 45m)

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<td>Introduction</td>
<td>Green, Johnson, &amp; Fast</td>
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<tr>
<td>9:00 – 9:25</td>
<td>CSS in Context</td>
<td>Lisse</td>
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<td>9:25 – 9:50</td>
<td>Hazard Overview</td>
<td>Farnham</td>
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<td>9:50 – 10:15</td>
<td>HST</td>
<td>Li team; Clarke team</td>
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<td>Swift</td>
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**Moderator:** Battams

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## Session 2: Suborbital & Spacecraft Observations (II) (1h 45m)

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<td>Herschel</td>
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<td>Spitzer</td>
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<td>11:50 – 12:00</td>
<td>STEREO &amp; SOHO</td>
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<td>12:00 – 12:15</td>
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<td>Lisse</td>
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<td>12:15 – 12:30</td>
<td>BOPPS</td>
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**Moderator:** Farnham

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## Session 3: Earth-based Observations (1h 45m)

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<td>TRAPPIST</td>
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<td>13:45 – 14:05</td>
<td>Crni Vrh/COBS</td>
<td>Černý</td>
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<td>14:05 – 14:25</td>
<td>Pro-Am Collaborations</td>
<td>Yanamandra-Fisher</td>
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<td>14:25 – 14:40</td>
<td>IRTF</td>
<td>Villanueva</td>
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<td>VLT</td>
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<td>14:55 – 15:05</td>
<td>Subaru</td>
<td>Ootsubo or Yanamandra-Fisher</td>
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<td>15:05 – 15:15</td>
<td>Radio Observations</td>
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**Moderator:** DiSanti

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## Session 4: Mars-based Observations; (2h 15m)

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<td>Mars Odyssey</td>
<td>Christensen, Plaut, Hill</td>
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<td>16:50 – 17:15</td>
<td>MSL &amp; Opportunity</td>
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<td>MOM</td>
<td>Bhardwaj or Yanamandra-Fisher</td>
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<td>17:35 – 17:45</td>
<td>MEX</td>
<td>Gondet or Lacombe</td>
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**Moderator:** Yanamandra-Fisher

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### Aug 11th

Observer’s Workshop

Speakers:

Representing Multiple S/C and Ground Based Observing Platforms