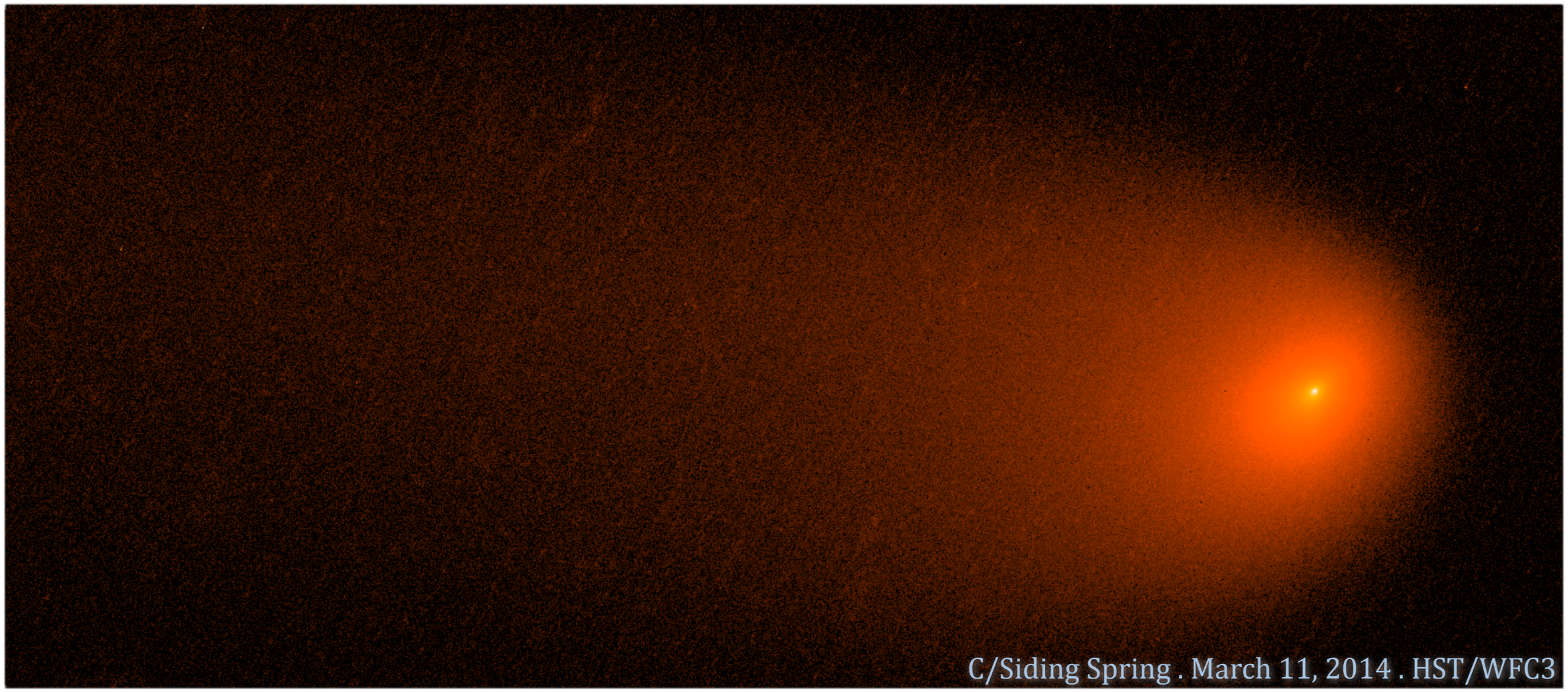



# HST Observations of the Encounter of C/Siding Spring and Mars

Jian-Yang Li (PSI), Carey M. Lisse (APL), John T. Clarke (BU), Max Mutchler (STScI)

On behalf of four HST teams

# What to Watch

- Comet
  - First chance to resolve a dynamically new comet (from Mars)
  - Simultaneous observations with Mars fleet from a different vantage point
  - Long-term monitoring of the comet to study its evolution
- Mars
  - Martian atmosphere, meteorite, cloud…
  - Effect of a close comet encounter with a planet

# Need for HST

- Super high spatial resolution
  - WFC3/UVIS: 0.04” per pixel, 46 km at Mars/comet
  - Study fine structure in the coma
  - Complementary to MRO/HiRISE observations
- Continuous temporal coverage
  - Solar elongation of comet & Mars 62º, meaning 1-2 hrs from the ground
- Wide spectral range
  - ACS/SBC and STIS for UV capability and spectroscopy
  - Important for studying atmospheric response of Mars

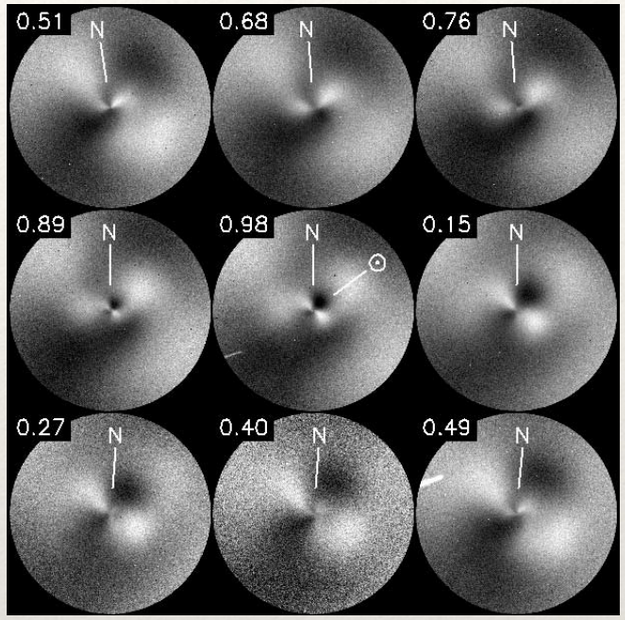
# Encounter Observations

- GO-13675, PI Li
  - 7 orbits with WFC3/UVIS
  - Inner coma morphology, nucleus rotation, coordinated observations with MRO/HiRISE
- Chandra coordinated observation, GO-13934, PI Lisse
  - 10 orbits with WFC3/UVIS
  - Provide context for Chandra x-ray observations, focus on large scale gas coma
- GO-13795, PI Clarke
  - 4 orbits with ACS/SBC and STIS
  - Mars aurora and atmospheric response to comet, focus on Mars atmosphere
- GO-13936, PI Levay
  - 1 orbits with WFC3
  - Heritage (pretty Mars)

# GO-13675, C/Siding Spring Monitoring

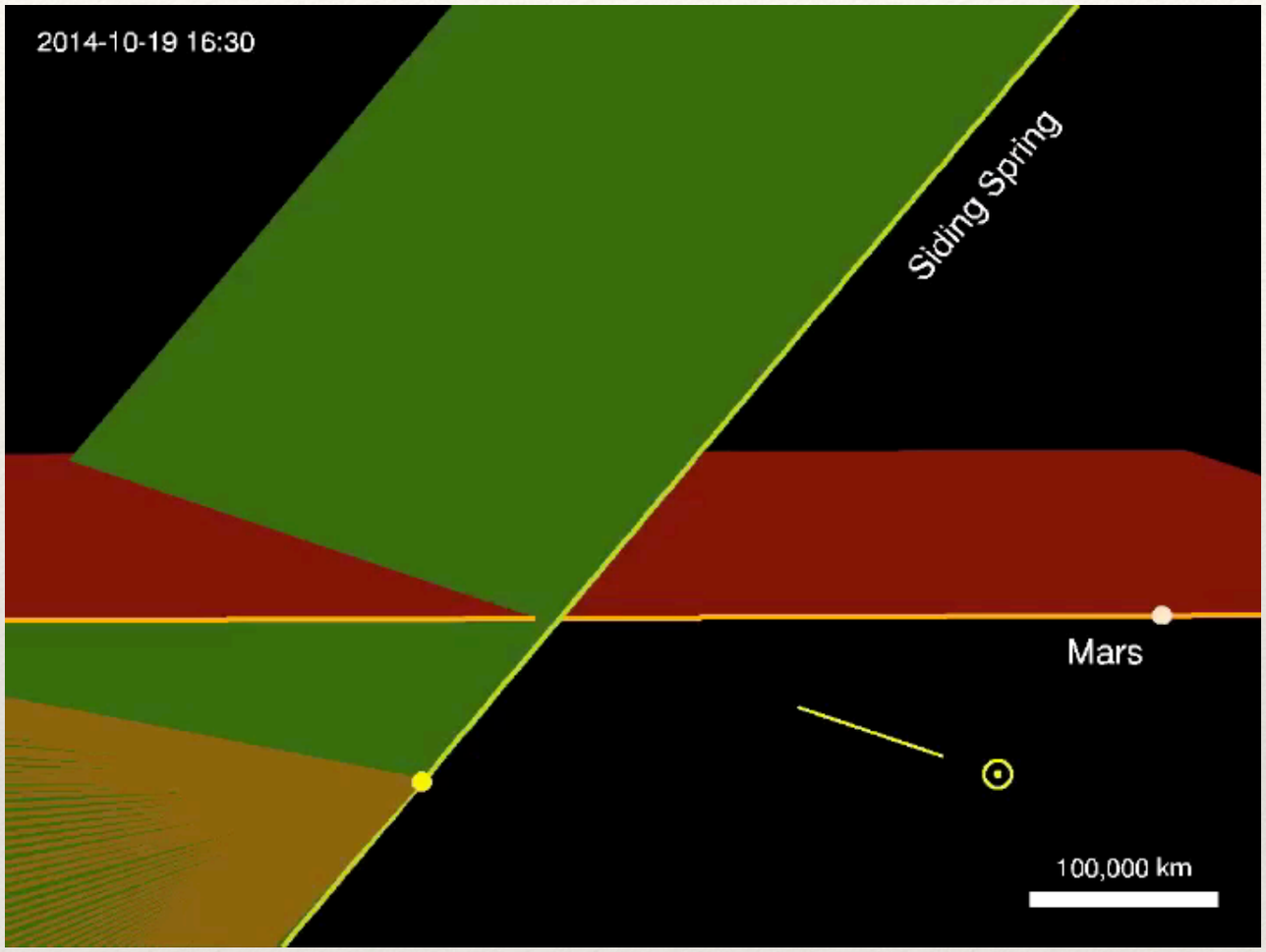
# Objectives

- Characterize the comet near perihelion
  - Dust and gas morphology
  - Dust color
  - Temporal variations - nucleus rotation
- Investigate the evolution of the comet from large heliocentric distances to near perihelion
  - Compare with previous HST observations at large heliocentric distances
- Provide a broad spatial and temporal context for MRO observations
  - Connect coma features observed from various platforms and to the nucleus
  - Reconstruct the 3-D structure of the inner coma
  - Connect MRO observations to long-term observations
  - Provide context to study comet-Mars interactions



C/2004 Q2 (Machholz), Farnham et al. (2007)

# Construct 3-D Structure of Inner Coma




* MRO/HiRISE tracks the comet ~90° from the direction of the Sun and the Earth
* HST/ground-based observers look at the comet at perpendicular direction from MRO/HiRISE
* Once combined, the 3-D structure of the inner coma can be reconstructed

# Context for MRO Observations

| Platform / Instruments | Pixel size @ comet | Pixel scale | Distance |
|---|---|---|---|
| MRO / HiRISE | 0.14 km | 1 $\mu$rad pixel | 131,000 km |
| HST / WFC3 / UVIS | 46 km | 0.04" pixel | 1.6 AU |
| Ground | 1100 km | 1" seeing | 1.6 AU |

- Bridge observations with various resolutions
- Connect features to the nucleus
- Connect coma features to long-term observations

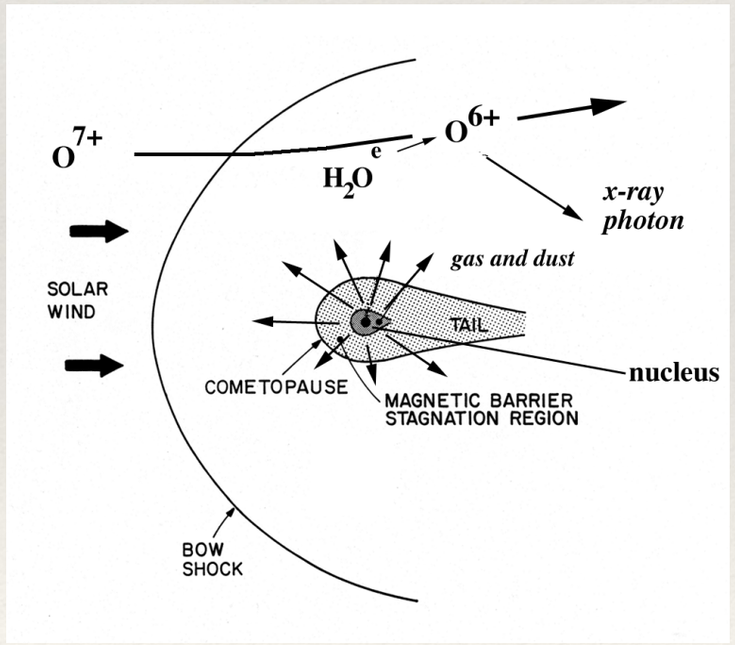
# Observing Plan

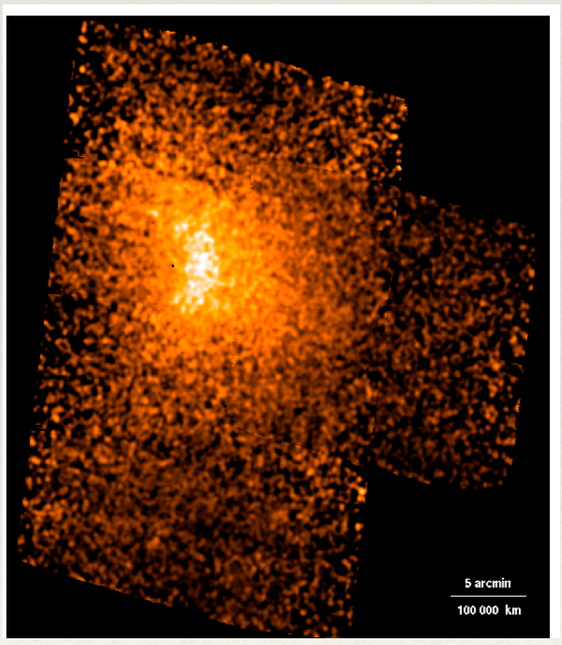
- Monitor the comet simultaneously with MRO observations
- Observe both gas and dust with HST
  - New experiment to image gas with WFC3 narrow / mid-band filters
- Spread out a few orbits to increase the temporal baseline

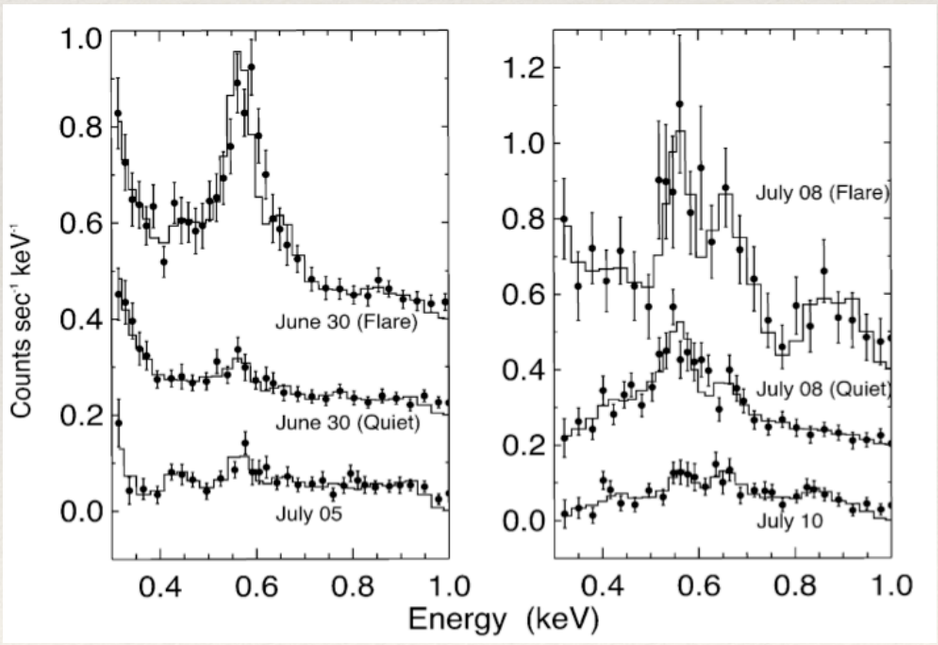
# GO-13934, Chandra Coordinated Observations

# Objectives

- Study the interactions between gas coma and solar wind
- Study the interaction between gas coma and Martian atmosphere

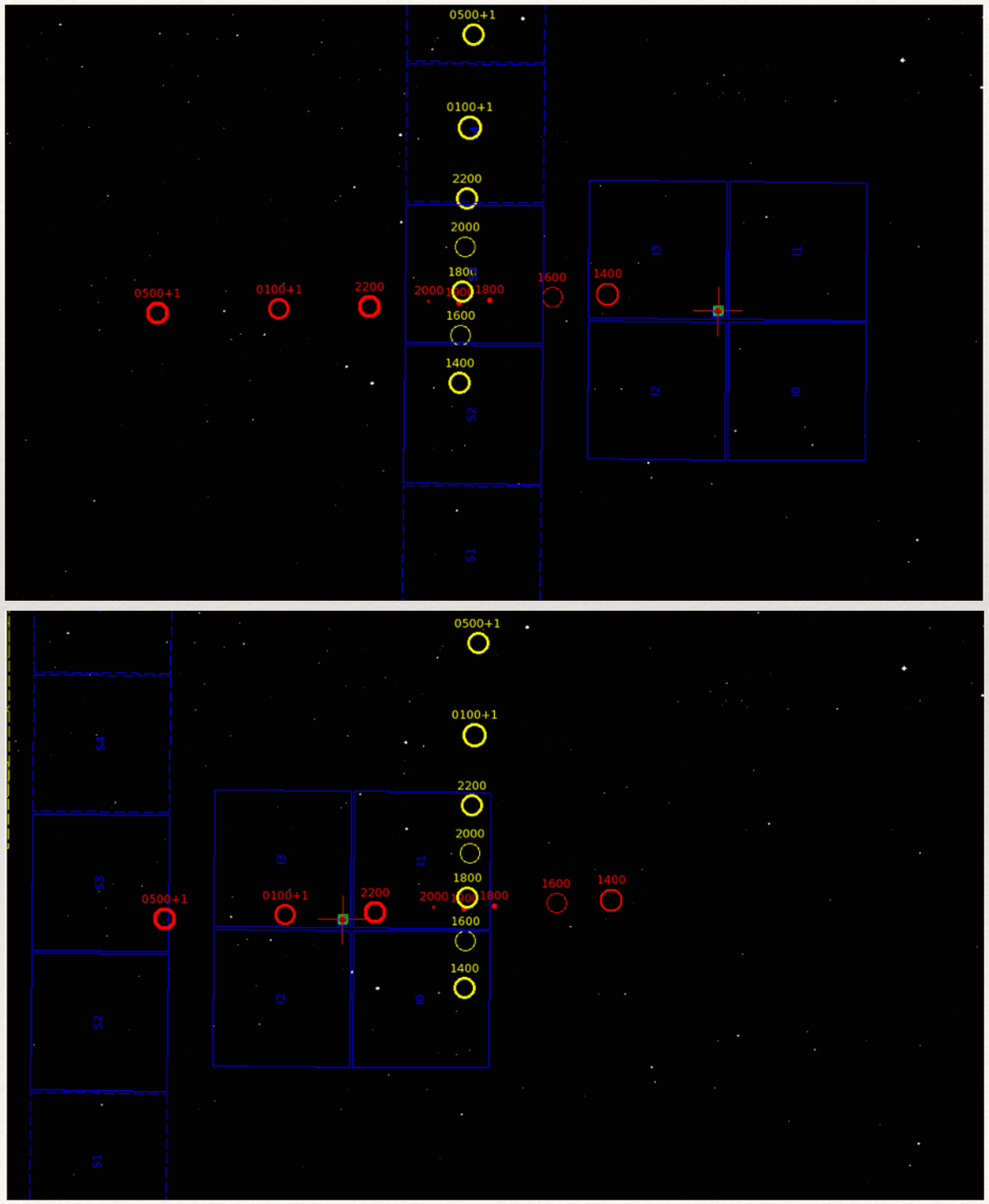


# Chandra Plan

- Start from Oct 19 14:00 UT (CA-4.5 hr), end at Oct 20 05:00 UT (CA+10.5 hr)
- Track both the comet and Mars for the first 10 hrs, then track Mars for the last 5 hrs
- Need Simultaneous monitoring on the gas of comet and Mars to provide context

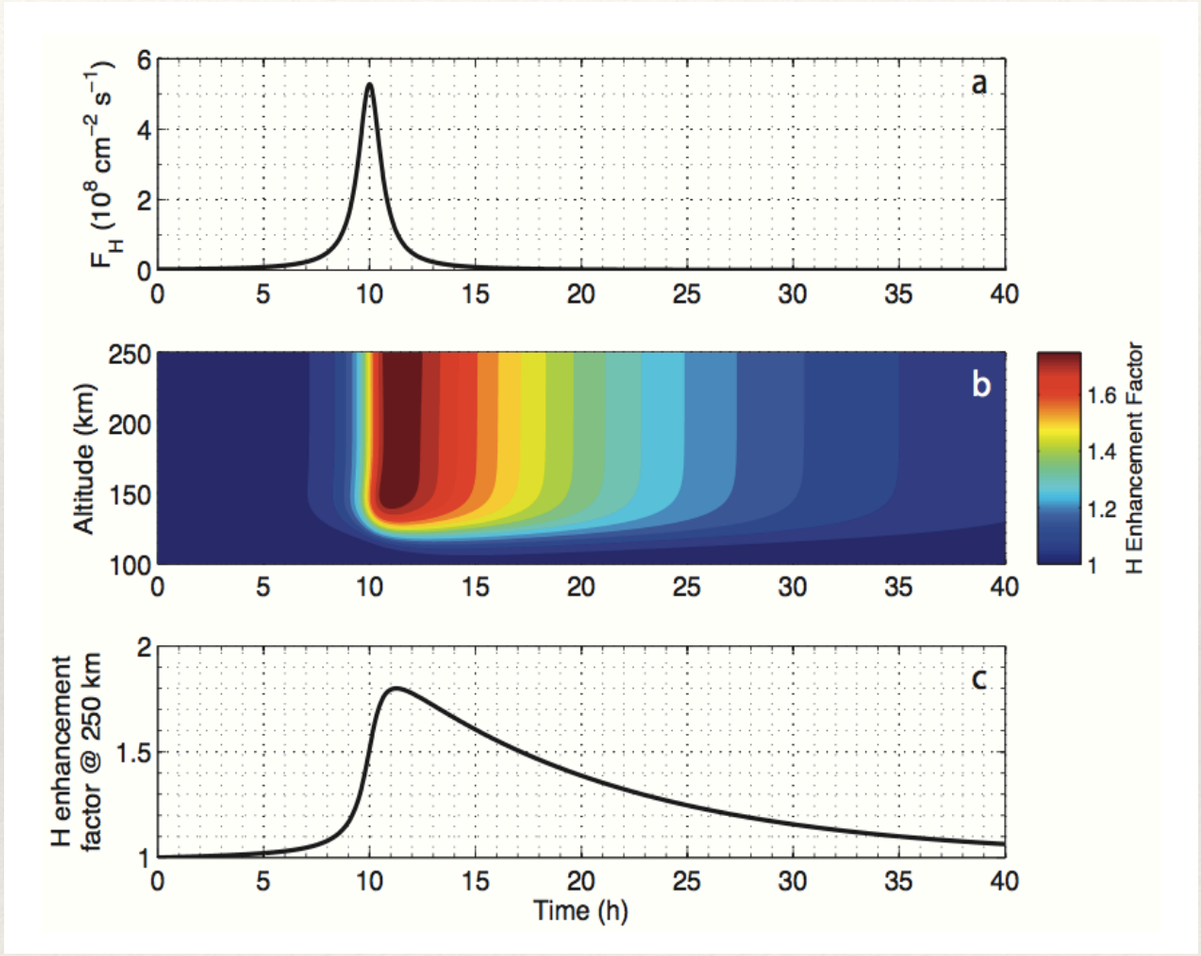


# GO-13795, Mars Atmosphere Observations

# Objectives

Courtesy of John Clarke

- Look for effects of energy input in Mars atmosphere, changes in atmospheric structure (mainly H and O)
- Look for auroral emission on nightside, produced by energetic neutral - main emissions will be NUV




Yelle et al. (2014)

# Observation Plan

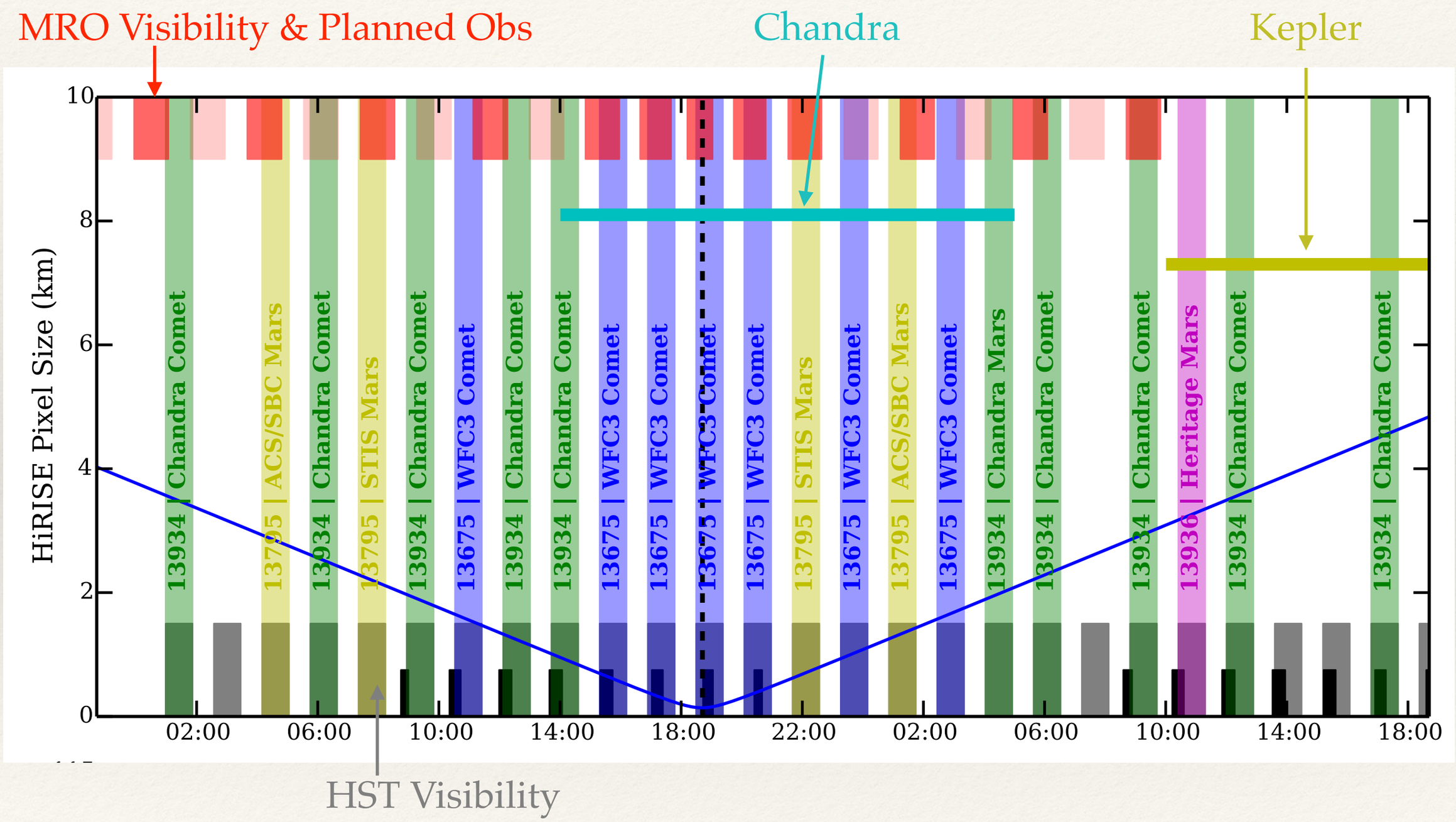
- Two orbit will be before the encounter for background
- Two orbits ideally start from CA+10 hrs to catch the strongest response in Martian atmosphere
- Use ACS/SBC to map Lyman-alpha for Martian exosphere
- Use STIS UV spectroscopy to search for auroral emission

# GO-13936, Hubble Heritage

# Strategy

- Objectives:
  - Ensure every program's science goals are met
  - Enhance each other's science returns
  - Minimize potential conflict among programs
- Approach:
  - Blend all four programs in the planning
  - Work out an overall timeline that meets everyone's requirement
  - Include other program's observations to help each other

# HST Timeline



# Instrument Configurations

- Comet:
  - WFC3/UVIS 80”x80” FOV (94,000 km at comet) for high resolution
    - FQ387N for CN morphology and production rate
    - F689M and F845M for dust morphology and production rate, and CN context
  - WFC3/UVIS 160”x160” FOV (188,000 km at comet) for large FOV
    - F390M for CN, F547M for $C_2$
    - F775W for dust context
    - All images 3x3 binning to save overhead
  - Total duration of ~40 hrs, likely to cover >1/2 of the possible period of the comet
- Mars:
  - ACS/SBC for Lyman-alpha, before and after CA
  - STIS UV spectroscopy for aurora on the nightside, before and after CA
  - WFC3/UVIS for images of Mars at 20”x20” FOV, any time, for Heritage

# Summary

- A total of 22 HST orbits will be dedicated to observe C/Siding Spring and Mars
  - Start on Oct-19 01:00 UT and end on Oct-20 17:40 UT
  - Cover ~40 hrs total baseline
- Track dust and gas (CN and C2) of the comet at both high resolution and large scale
- Fully cover the planned observations of MRO, Chandra, and overlap with the beginning of Kepler
- Characterize Martian atmosphere for the consequence of comet encounter
- Great experience working with everyone to coordinate such an event
- Go Comet Siding Spring!

jyli@psi.edu
http://jyli.me/
@jianyangli