Preview of First Results from Hi-C 2.1 and Coordinated Observations

PS: Sabrina Savage (MSFC)
PI: Amy Winebarger (MSFC)
IS: Laurel Rachmeler (MSFC)

Science Team:
- David Brooks (GMU)
- Jonathan Curtin (BWXT)
- Ken Kobayashi (MSFC)
- Scott McIntosh (HAO)
- David McKenzie (MSFC)
- Leon Golub (SAO)
- Robert Walsh (UCLAN)
- Bart DePontieu (LMSAL)
- Richard Morton (Northumbria)
- Hardi Peter (MPS)
- Paola Testa (SAO)
- Sanjiv Tiwari (BAERI)
- Harry Warren (NRL)

Sabrina.Savage@nasa.gov
Solar Instrumentation Programs at MSFC

SOUNDING ROCKETS

- **SUMI** (J. Cirtain, PI)
  - Launched from WSMR on July 2012
- **Hi-C 1** (J. Cirtain, PI)
  - Launched from WSMR on July 11, 2012
- **Hi-C 2** (J. Cirtain, PI)
  - Launched from WSMR on July 27, 2016
- **Hi-C 2.1** (A. Winebarger, PI)
  - Launched from WSMR on May 29, 2018
- **CLASP 1** (A. Winebarger, PI)
  - Launched from WSMR on September 3, 2015
- **CLASP 2** (D. McKenzie, PI)
  - Scheduled to launch Spring, 2019
- **MaGIXS** (A. Winebarger, PI)
  - Scheduled to launch in August 2019

OPERATIONAL FLOWN

IN DEVELOPMENT

PROPOSED

OBSERVATORIES

- **HINODE (Solar B)**
  - SOT: Solar Optical Telescope
  - XRT: X-Ray Telescope
  - EIS: EUV Imaging Spectrometer

**COSIE**

- Coronal Spectrographic Imager in the EUV

******************************************************

... Cameras & Optics
Solar Instrumentation Programs at MSFC

SOUNDING ROCKETS

- **SUMI** (J. Cirtain, PI)
  - Launched from WSMR on July 2012

- **Hi-C 1** (J. Cirtain, PI)
  - Launched from WSMR on July 11, 2012

- **Hi-C 2** (J. Cirtain, PI)
  - Launched from WSMR on July 27, 2016

- **Hi-C 2.1** (A. Winebarger, PI)
  - Launched from WSMR on May 29, 2018

- **CLASP 1** (A. Winebarger, PI)
  - Launched from WSMR on September 3, 2015

- **CLASP 2** (D. McKenzie, PI)
  - Scheduled to launch Spring, 2019

- **MaGIXS** (A. Winebarger, PI)
  - Scheduled to launch in August 2019

OPERATIONAL
FLOWN
IN DEVELOPMENT
PROPOSED

OBSERVATORIES

- **HINODE** (Solar B)
  - SOT: Solar Optical Telescope
  - XRT: X-Ray Telescope
  - EIS: EUV Imaging Spectrometer

- **COSIE**
  - Coronal Spectrographic Imager in the EUV

*******************************************************
... Cameras & Optics
Hi-C: High-resolution Coronal imager

- Telescope design capable of ~0.2-0.3” (~150 km) spatial resolution imaging of the corona.

- Requires high rocket pointing stability to achieve resolution goal (Sparcs system).

- Capable of high-cadence observations through rapid CCD readout duration (~2 seconds) and data storage system.
Hi-C 1: High-resolution Coronal imager

Hi-C 1 Launch
White Sands, NM
July 11, 2012

Hi-C recovery team

Data available via the Virtual Solar Observatory (VSO).

Guidebooks available at hic.msfc.nasa.gov.

SDO/AIA 193 Å

AR 11520
Hi-C 1: High-resolution Coronal imager

Bandpass – 193 Å [~1 & 10MK]

26 publications for 5 minutes of data! [https://hic.msfc.nasa.gov/publications.html]

Science highlights:

- Braided loops triggering energy release through magnetic reconnection (Cirtain et al. 2013, Nature)
- Subflare triggers
- Nanoflare heating
- Loop sub-structure
- Moss dynamics
- Penumbral jets
- Flows along filament threads
- MHD waves
Solar Instrumentation Programs at MSFC

SOUNDING ROCKETS

- **SUMI** (J. Cirtain, PI)
  - Launched from WSMR on July 2012

- **Hi-C 1** (J. Cirtain, PI)
  - Launched from WSMR on July 11, 2012

- **Hi-C 2** (J. Cirtain, PI)
  - Launched from WSMR on July 27, 2016

- **Hi-C 2.1** (A. Winebarger, PI)
  - Launched from WSMR on May 29, 2018

- **CLASP 1** (A. Winebarger, PI)
  - Launched from WSMR on September 3, 2015

- **CLASP 2** (D. McKenzie, PI)
  - Scheduled to launch Spring, 2019

- **MaGIXS** (A. Winebarger, PI)
  - Scheduled to launch in August 2019

OBSERVATORIES

- **Hinode (Solar B)**
  - SOT: Solar Optical Telescope
  - XRT: X-Ray Telescope
  - EIS: EUV Imaging Spectrometer

**COSIE**

- Coronal Spectrographic Imager in the EUV

**************************************************************

... Cameras & Optics
Hi-C 2: High-resolution Coronal imager

Hi-C 2 mirror recoated to explore the important Chromospheric-Coronal Connection by targeting specific candidates likely to contribute to coronal heating:

1. Type II spicules
2. Hot active region core loops

Updates for re-flight:

- Cooler bandpass centered on 172 Å (≈.6 MK)
- Significant improvement in camera quality (new MSFC-build designed for super low noise)
- IRIS!
Hi-C 2: High-resolution Coronal imager

Fantastic flight performance verification of the low-noise MSFC-built camera.

~7e^-  ~7e^-  
~13e^-  ~8e^-
Hi-C 2...: High-resolution Coronal imager

- Cleaned up
- Checked alignment
- Upgraded cooling system
- Added Hall Effect Sensor
- Re-proposed
Solar Instrumentation Programs at MSFC

SOUNDING ROCKETS

- **SUMI (J. Cirtain, PI)**
  - Launched from WSMR on July 2012

- **Hi-C 1 (J. Cirtain, PI)**
  - Launched from WSMR on July 11, 2012

- **Hi-C 2 (J. Cirtain, PI)**
  - Launched from WSMR on July 27, 2016

- **Hi-C 2.1 (A. Winebarger, PI)**
  - Launched from WSMR on May 29, 2018

- **CLASP 1 (A. Winebarger, PI)**
  - Launched from WSMR on September 3, 2015

- **CLASP 2 (D. McKenzie, PI)**
  - Scheduled to launch Spring, 2019

- **MaGIXS (A. Winebarger, PI)**
  - Scheduled to launch in August 2019

OPERATIONAL
FLOWN
IN DEVELOPMENT
PROPOSED

OBSERVATORIES

- **HINODE (Solar B)**
  - SOT: Solar Optical Telescope
  - XRT: X-Ray Telescope
  - EIS: EUV Imaging Spectrometer

- **COSIE**
  - Coronal Spectrographic Imager in the EUV

******************************************************

... Cameras & Optics
Hi-C 2.1: High-resolution Coronal imager

3.5 months after ATP....
Hi-C 2.1: High-resolution Coronal imager

Hi-C 2.1 Launch
White Sands, NM
May 29, 2018
Hi-C 2.1: High-resolution Coronal imager

2018 May 29
18:54 UT

Target: AR 12712

~ 15 minute flight

~ 5 minutes of solar viewing data
SDO/AIA
171 Å
Hi-C 2.1
172 Å
Sharpened

Provided by R. Morton
Hi-C 2.1
172 Å

Without Jitter
Hi-C 2.1
172 Å

Without Jitter
Zoomed in
Hi-C 2.1: What makes this instrument work?

- HIGH SPATIAL RESOLUTION
- HIGH TEMPORAL RESOLUTION
- LOW NOISE CAMERA
- COORDINATED DATA SETS
Hi-C 2.1: IRIS coordinated data

IRIS observations of a subset of the region at high resolution and spectra will be used to tie small features in the chromosphere to those in the corona.
Hi-C 2.1: IRIS coordinated data
Hi-C 2.1: IRIS coordinated data

Provided by B. DePontieu
Hi-C 2.1: IRIS coordinated data

Provided by B. DePontieu
Hi-C 2.1: IRIS coordinated data

Provided by B. DePontieu
Hi-C 2.1: IRIS coordinated data

Provided by B. DePontieu
Hi-C 2.1: IRIS coordinated data

Provided by B. DePontieu
Hi-C 2.1: Hinode coordinated data

All three Hinode instruments successfully captured the Hi-C 2.1 region.

- XRT provides coronal context of the movement of hot plasma in the upper atmosphere above the Hi-C features.
- EIS provides narrowband spectra of the hot coronal loops thereby precisely measuring plasma flow properties.
- SOT-SP provides underlying magnetic field information to high precision.
Hi-C 2.1: Hinode coordinated data

All three Hinode instruments successfully captured the Hi-C 2.1 region.

XRT Be-thin

EIS Fe XIII

SOT-SP Profiles

XRT provided by K. Reeves
Hi-C 2.1: Hinode coordinated data

EIS BACK just in time!
## Hi-C 2.1: Additional Coordinated Data Sets

- NSO / IBIS
- NuSTAR
- BBSO
- Owens Valley
- ~SST
Hi-C 2.1: IBIS coordinated data

- NSO / IBIS
- NuSTAR
- BBSO
- Owens Valley
- ~SST

IBIS Mosaic
14:19 – 15:13 UT
Ca II 8542 Å

Provided by K. Reardon
Hi-C 2.1: IBIS coordinated data

Provided by K. Reardon
Hi-C 2.1: IBIS coordinated data

Hi-C 172 Å
18:56:22 UT

IBIS Ca II 8542 Å
18:56:53 UT

Provided by K. Reardon
Hi-C 2.1: IBIS coordinated data

IBIS Mosaic
14:19 – 15:13 UT
Hα 6563 Å
0.098 “/pixel

Provided by K. Reardon
Hi-C 2.1: IBIS coordinated data

Provided by K. Reardon
Hi-C 2.1: IBIS coordinated data

Hi-C 172 Å
18:56:22 UT

IBIS Hα 6563 Å
18:56:22 UT

Provided by K. Reardon
Hi-C 2.1: NuSTAR coordinated data

- NSO / IBIS
- NuSTAR
- BBSO
- Owens Valley
- ~SST

Hard X-ray Astrophysics Mission
High Sensitivity

5 orbits on day of launch,
primarily targeting AR 12712

Provided by L. Glesener and J. Duncan
Hi-C 2.1: NuSTAR coordinated data

- NSO / IBIS
- NuSTAR
- BBSO
- Owens Valley
- ~SST

Provided by L. Glesener and J. Duncan
Hi-C 2.1: Additional Coordinated Data Sets

- NSO / IBIS
- NuSTAR
- BBSO
- Owens Valley
- ~SST

** Special thanks for assisting with the coordinations goes out to:

L. Glesener,
K. Reardon,
B. Chen,
Y. Chai,
N. Karuda,
P. Antolin,
J. Leenaarts,
G. Vissers
Hi-C 2.1: Science topics being pursued

- Thin, stranded loops [width variations]
- Flows between transition region, chromosphere, and corona
- Spicules
- Nano/microflares
- Moss/Plage brightenings
- Flows along loops
- Waves
- Mini-jets
- Etc.
Hi-C 2.1: AGU plug

Add AGU session approved for highlighting suborbital results.

Hi-C 2.1 science results expected to be presented in this session!
Hi-C 2.1: POCs

Amy Winebarger
Sabrina Savage
Laurel Rachmeler
Leon Golub
Thanks, and stay tuned....