Rendering of proposed ATST facility at the primary Mees site on Haleakalā, Maui, Hawai'i by Tom Kaikona, K. C. Environmental, Inc. Original aerial photo by Frank Ricco.

OBSERVING TRANSIENT AND DYNAMIC SOLAR PHENOMENA WITH THE DKI SOLAR TELESCOPE

ALEXANDRA TRITSCHLER
NATIONAL SOLAR OBSERVATORY

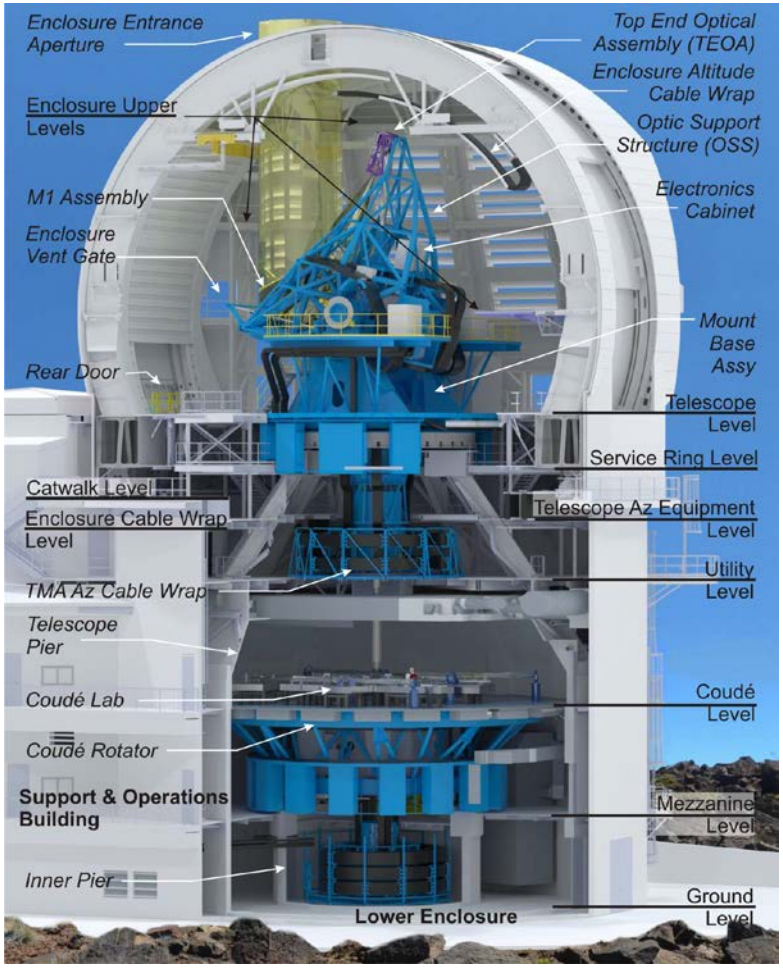
12th Thinkshop:: 26-29 October, 2015, Potsdam, Germany

Overview

- Introduction
  - General Properties; DKIST Project.
- Coudé Level
- **Instrumentation**
  - **Facility Instruments: VBI, ViSP, DL-NIRSP, VTF, Cryo-NIRSP.**
- Some Additional Capabilities
- Operations in a Nutshell
- Critical Science Plan
- Summary

Introduction: General Properties

- **4 m clear aperture**: resolve fundamental spatial scales; 22 km@600 nm, 56 km@1500 nm (factor of 3 improvement).
- **Reflective design**: exploitation of the infrared.
- **Off-axis Gregorian optical design**: reduce scattered light downstream; coronal imaging, spectroscopy and spectropolarimetry.
- **5 arcmin Field-Of-View in prime**.
- Integrated polarization calibration equipment: enable accurate and precise polarimetry of the solar fine structure.
- Integrated active and high-order adaptive optics.
- **Set of facility-class instruments:** covering broad wavelength range; coupling of the atmospheric layers.



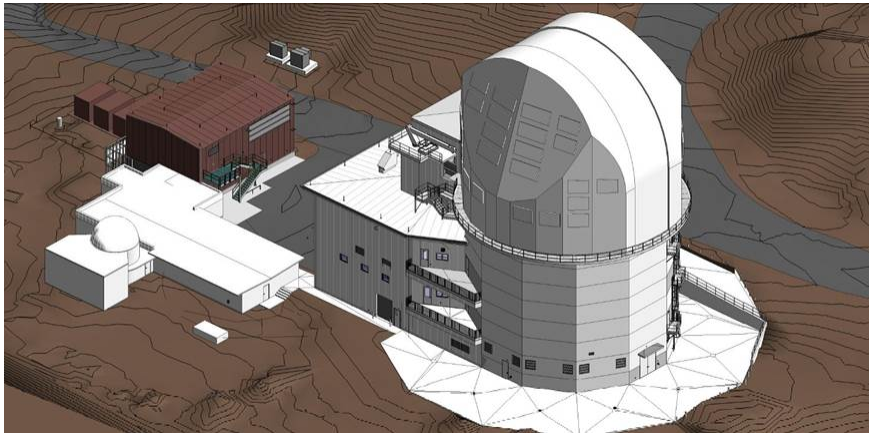
Facility view, cutaway, looking North

Introduction: DKIST Project

DKIST: Daniel Ken Inouye Solar Telescope (formerly ATST).
NSF funded project.
PI Institution: NSO; Co-PIs: HAO, NJIT, UH/IfA, University of Chicago.
Build on Haleakala, Maui, HI @ ~10,000 ft.

Schedule

- Initial funding/start of construction: 2010 January.
- **Permits in place/start of site construction: 2012 December.**
- Site Prep, Excavation, Foundations: 2013-2014.
- Lower Enclosure, Enclosure: 2014-2015.
- Telescope Mount Assembly: 2016-2017.
- **Optics systems installation/Integration: 2017-2018.**
- **Instrument systems commissioning: 2018-2019.**
- **Start of Operations: 2019 September.**



Facility buildings expected to be finished in 2016

Facility Infrastructure on Maui

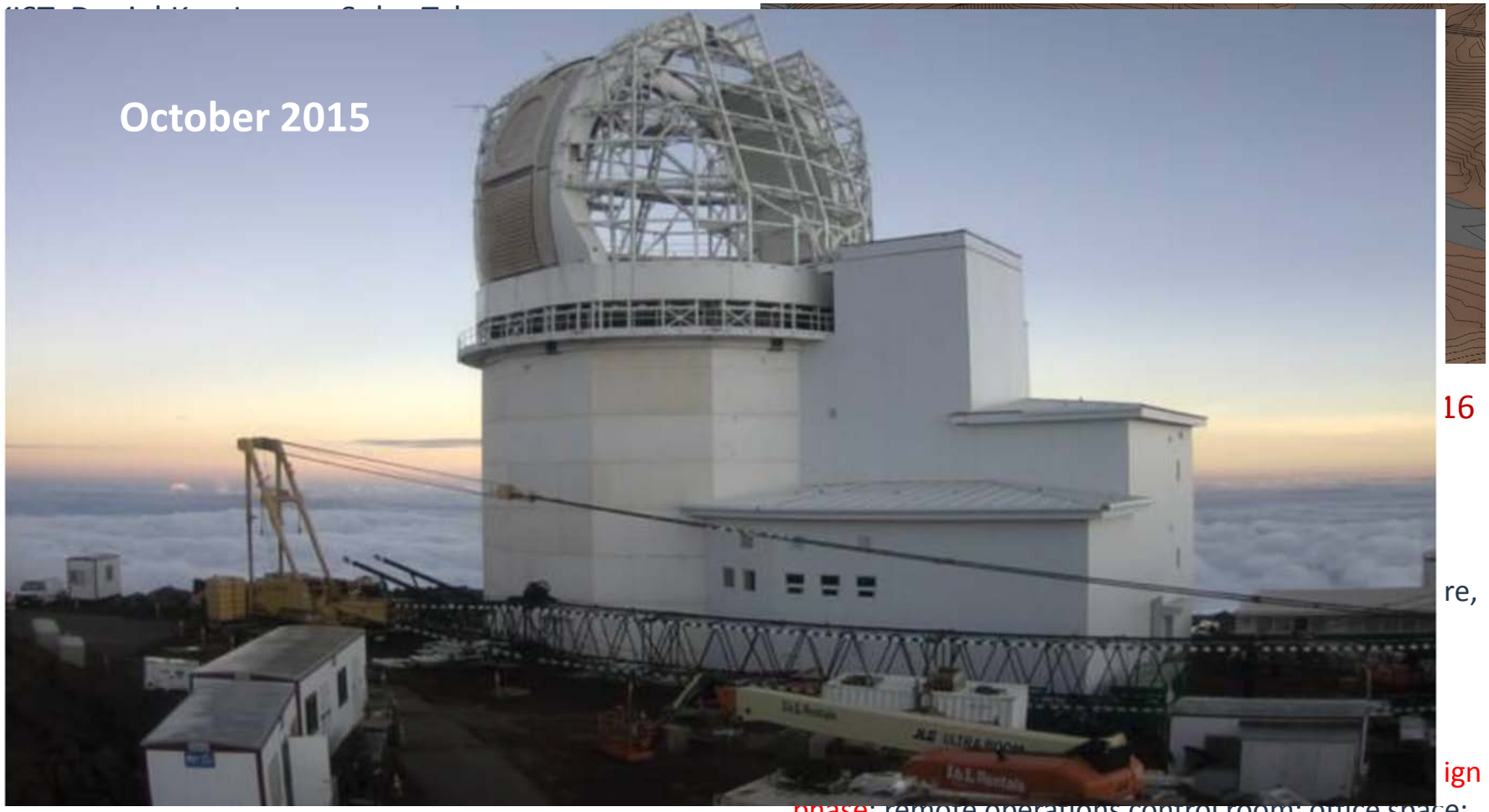
- **Facility Building** : Support and Operations building (S&O) with control room; Telescope: Upper enclosure, lower enclosure.
- **Detached Utility Building**: Mechanical equipment; Electrical equipment.
- **Remote Operations Building** (ROB): Pukalani, in design phase; remote operations control room; office space; temporary data storage.

Introduction: DKIST Project

D
(f
N
Pl
U
B
D
of

Sc

- □
- □
- □
- □
- □
- □
- □
- □ **Start of Operations: 2019 September.**



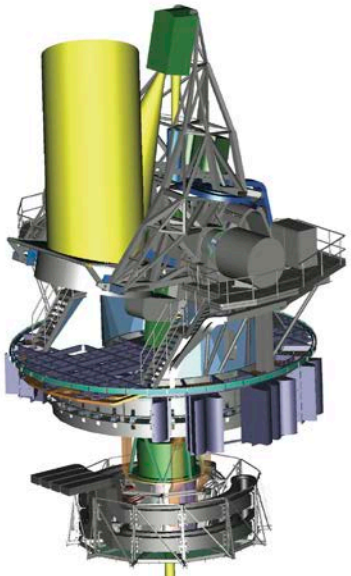
16

re,

ign

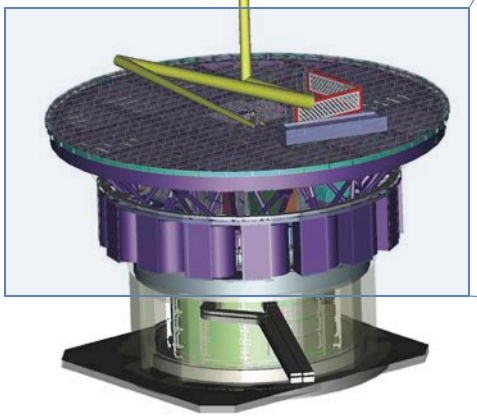
phase; remote operations control room; office space; temporary data storage.

Coude Level: Instrument Platform



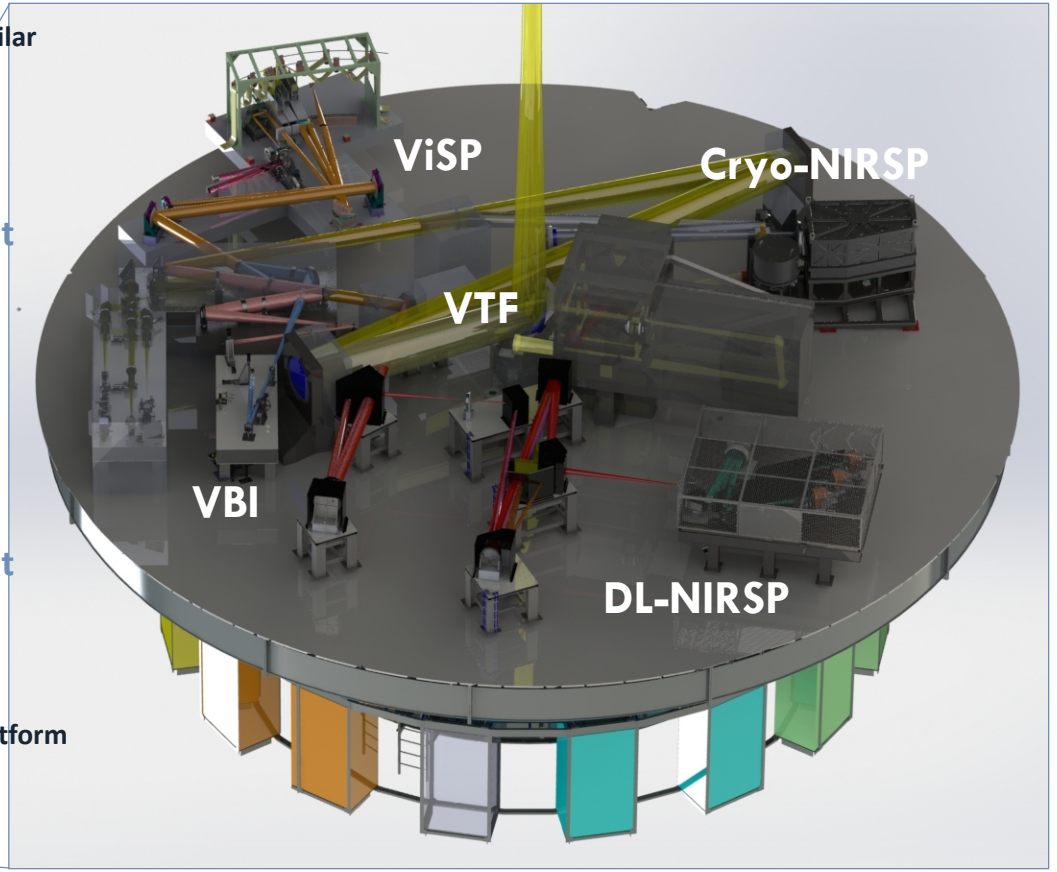
Telescope Mount
Off-axis: structure more similar to 8-m telescope
5 arcsec pointing accuracy (open loop)

Enclosure environment
Active/passive ventilation
Air scavenging
Dehumidification



Coude environment
"Clean" lab space

Coudé Rotator
Rotating instrument platform
16-m diameter



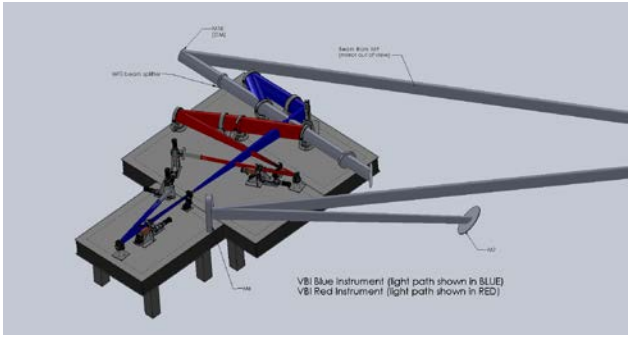
VBI: Visible Broadband Imager

National Solar Observatory
PI: Friedrich Woeger

- Spectral Range: **390-850 nm.**
  - **Blue: CaII K 393.4 nm, G-Band 430.5 nm, blue continuum at 450.4 nm, Hβ 486.1 nm. Red: Hα 656.3 nm, red continuum at 668.4 nm, TiO 705.8 nm, Fe XI 789.2 nm.**
- Filter widths: 0.05–0.6 nm.
- **Spatial FOV: optical design allows for 2 arcmin(squared).**
  - **VBI Blue: 45 arcsec.**
  - **VBI Red: 69 arcsec.**
- Spatial sampling:
  - 0.022 arcsec @ 430.5 nm (blue); 0.034 arcsec @ 656.3 nm (red)
  - Quasi real-time speckle reconstructions.
- **Temporal sampling:**
  - **3.2 sec reconstructed images (standard mode).**
  - **Raw images at 30Hz (full detector).**
- **"Field sampling" capability.**

Rapid Interference Filter Imager

Purpose/Mission: Provide high spatial and temporal resolution image sequences spanning from the photosphere to the chromosphere.



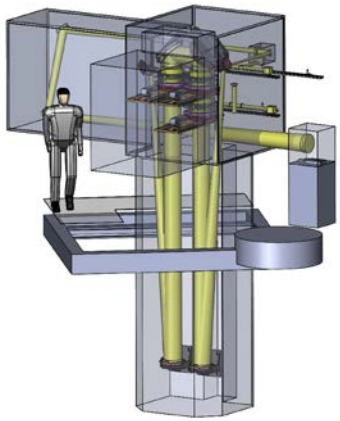
Fast flare dynamics and study of small-scale processes?
(ROSA@DST)

VTF: Visible-Tunable Filter

Kiepenheuer Institut
PI: Oskar von der Luehe

Double Fabry-Perot Spectropolarimeter

Purpose/Mission: Provide rapid cadence spectroscopic and spectropolarimetric imaging from the photosphere to the chromosphere.



Opportunity: spicule physics, small-scale jets above light bridges and sunspot penumbrae?
(IBIS@DST, CRISP@SST, GFPI@GREGOR)

- **Spectral Range: 520 – 870 nm**
  - **Filters (planned): Fe I 525 nm, Fe I 630.2 nm, Hα 656.3 nm, Ca II 854.2 nm.**
- Spectral Field-of-View: ≤ 1 nm (FSR).
- Spatial FOV: 1 arcmin square.
- Spatial sampling
  - 0.028 arcsec @ 520 nm (post-facto image reconstruction using broadband data planned)
- Spectral Resolution: 6 pm (@600 nm), 3 pm sampling.
- **Temporal sampling:**
  - **Spectro-Polarimetric mode: 13 sec.**
  - **Doppler mode: 4 sec.**
  - **Intensity imaging: 0.8 sec.**
- Polarimetric capability: Full Stokes vector polarimetry (dual beam).

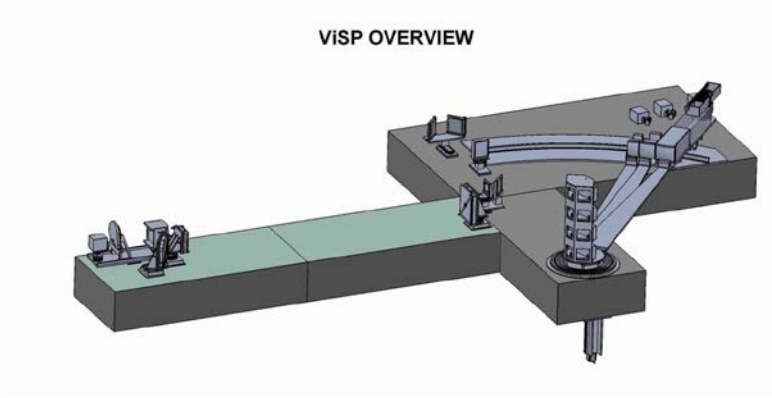
ViSP: Visible Spectro-Polarimeter

High Altitude Observatory
PI: Roberto Casini

- **Spectral Range: 380 – 900 nm**
  - **Continuous spectral coverage.**
  - **Three spectral arms.**
- **Spatial FOV: 2 x 2 arcmin capable.**
- Spatial sampling:
  - 0.07 arcsec @ 630 nm; 2 x telescope resolution.
- Spectral Field-of-View: ≈ 1 nm @ 630 nm.
- Spectral Resolution: ≤ 3.5 pm @ 630 nm or R≳180,000.
- **Temporal Sampling: between 1 – 10 sec (or longer) per single slit position (depending on SNR requirement).**
  - **Slit move time: 200 ms.**
- Polarimetric capability: Full Stokes Vector Polarimetry (dual beam).

Slit-Based Spectropolarimeter

Purpose/Mission: Provide precision measurements of the full state of polarization simultaneously at diverse wavelengths in the visible spectrum and fully resolving the spectral profiles of lines originating in the solar atmosphere.



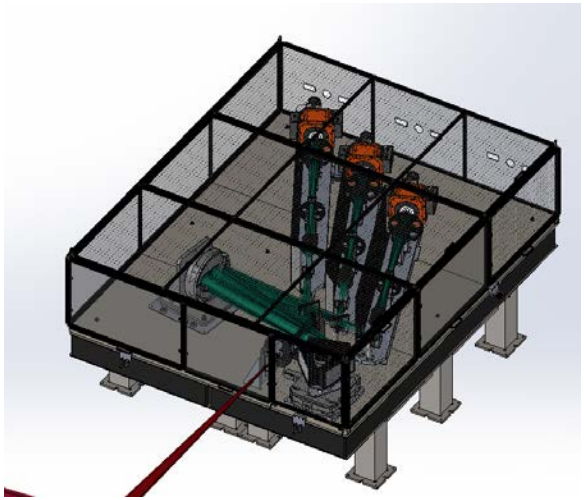
Flare spectroscopy and spectropolarimetry? (SPINOR@DST)

DL-NIRSP: Diffraction-Limited Near-Infrared Spectro-Polarimeter

Institute for Astrophysics/UH
PI: Haosheng Lin

Fiber-Fed 2D Spectropolarimeter

Purpose/Mission: Provide spectropolarimetric measurements from the photosphere to the corona (simultaneous spectral and spatial information!).



Study of chromospheric magnetic fields? (prototype: SPIES@DST)

- **Spectral Range: 500 – 1800 nm.**
  - **Filters: Fe XI 789 nm, Ca II 854.2 nm, Fe XIII 1074.7 nm, He I 1083 nm, Si X 1430 nm, Fe I 1565 nm.**
  - **Three spectral arms.**
- Two IFU's (Integrated Fiber Units):
  - High-Res Mode: f/62 beam, 80 x 60 (0.03 arcsec sampling) imaging array: 2.4 x 1.8 arcsec.
  - Mid-Res Mode: f/24 beam, 80 x 60 (0.077 arcsec sampling) imaging array: 6.16 x 4.62 arcsec.
  - Low-Res Mode: f/24 beam, 60 x 40 (0.464 arcsec sampling, corona) imaging array: 27.84 x 18.56 arcsec.
- **Spatial FOV: 2 x 2 arcmin square**
  - **"Field sampling" capability.**
  - **Field scanning move time: : ≤100 ms.**
- Spectral Field-of-View: ≤ 0.72 nm @ 900 nm.
- Spectral Resolution: R~125,000 @ 900 nm.
- **Temporal Sampling: milliseconds (mid-res on-disk) – seconds (wide-field corona).**
- Polarimetric capability: Full Stokes Vector Polarimetry (dual beam).

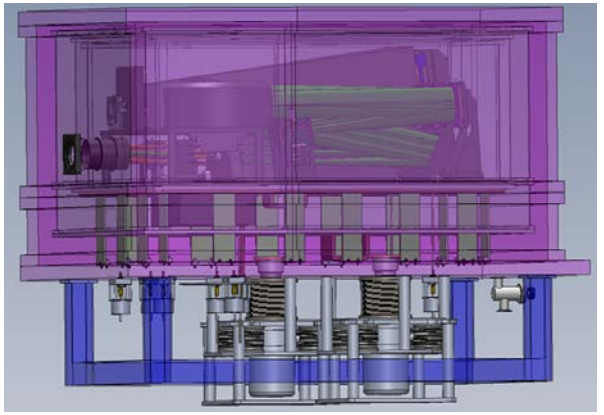
Cryo-NIRSP: Cryogenic Near-Infrared Spectro-Polarimeter

Institute for Astrophysics/UH
PI: Jeffrey R. Kuhn

- **Spectral Range: 1000 - 5000 nm**
  - **Filters: Fe XIII 1075 nm, He I 1080 nm, S IX 1252 nm, Si X 1430 nm, Fe IX 2218 nm, CO 2326 nm, Si X 2580 nm, Mg VIII 3028 nm, Si IX 3935 nm, CO 4651 nm.**
- **Spatial FOV:**
  - **Coronal Mode: 4 x 3 (scanning) arcmin square.**
  - Disk mode: 1.5 arcmin square.
- Spatial sampling:
  - Coronal Mode: 0.5 arcsec.
  - Disk Mode: 0.15 arcsec.
- Spectral Field-of-View: ≈ 17 nm @ 4651 nm.
- Spectral Resolution: R = 30,000 (corona); R = 100,000 (disk).
- **Temporal Sampling: Frame rate: ≥10 Hz.**
- Polarimetric capability: Full Stokes Vector Polarimetry (dual beam).
- Context imager: will sample the coronal field of view with ≤ 0.5 arc seconds per pixel at wavelengths similar to spectrograph.

Cryogenic Slit-Based Spectropolarimeter

Purpose/Mission: Study of solar coronal magnetic fields over a large field-of-view at near- and thermal infrared wavelengths by measuring the full polarization state of spectral lines originating on the Sun.



Systematic assessment of coronal magnetic fields?
(CYRA@NST/BBSO)

Some Additional Capabilities

It is not easy to provide: large FOV AND high spatial resolution AND high cadence (+spectroscopic/spectropolarimetric information)

- Instruments provide either one or two of those.
- Telescope mosaic mode; either larger FOV's or any pointing sequences can be performed; only limited by length of individual observing sequence and AO lock-point acquisition (if involved).
- Multi-instrument operations (instrument can be combined, depending beamsplitter suite).
- Efficient execution of observing scripts via a directing control system (Observatory Control System); pointing changes fast only limited by AO lock-point acquisition (if involved).

Using the DKIST as the high-resolution zoom-in perspective in synergy with other facilities and missions.

Operations: In a Nutshell

- **Everybody can apply for time!**
- Application for time is proposal based and competitive (proposal review).
- A TAC with NSO, international, and partner representatives.
- Proposal solicitation will happen at least twice per year.
- Science operations model: **service mode operations** in addition to classical/PI mode operations (access mode).
- Different programs: standard, synoptic, **target of opportunity**; coordination with other missions are possible during all of those programs.
- All DKIST data available through DKIST data center (calibrated data, raw data).
- **Open data policy**.

Critical Science Plan

- Initiative that aims at defining the science during early operations that take advantage of the DKISTs (unique) capabilities addressing critical compelling science.
- **Everybody is welcome and invited to participate!**
- Research topics (under which science use cases can be prepared and submitted):
  - Flare Precursors in the Lower Atmosphere
  - Magnetic Field Connectivity Changes in Flares
  - Flare Electron Diagnostics in Visible Light
  - Flare Footpoints at their Fundamental Scales
  - Coronal Mass Ejections
  - Spicule Physics
  - Prominences
  - Formation, Evolution and Eruption of Non-Potential Configuration
- The development of the CSP in advance of first light helps the beyond science definition – it helps in the development of essential operations and data management tools.

For more information and details:

- Please visit: **http//dkist.nso.edu/CSP** .
- Contact: Mark Rast **mark.rast@colorado.edu**

Summary

- Construction of the DKIST is progressing on schedule.
- Operations expected to start in September 2019.
- DKIST will offer a first-light facility instrument suite with unique opportunities and large discovery space (broad wavelength range, multi-instrument operations).
- Open-access to the community offering service mode operations and PI mode operations via a proposal process.
- Calibrated data from the facility instruments served to the community through NSO's DKIST Data Center in Boulder, CO.

Summary

-
-
-
-
-

Courtesy Rob Ratkowski, 8/8/2015.