FIDO TOOL, DATA HANDLING AND INSTRUMENT PERFORMANCE CALCULATORS

DKIST TEAM

NATIONAL SOLAR OBSERVATORY

Overview

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  - What does it look like and how does it work?
- Instrument Performance Calculators
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  - Cryo-NIRSP

Science Use Case Design

- DKIST instruments are complex, diverse, and flexible to support a very broad science portfolio.
- Users must make decisions about:
  - Telescope field-of-view, mosaicking, field sampling, coronagraphy, etc.
  - Coudé table orientation (orientation of solar image on detector).
  - **Spectral distribution of light to instruments.**
  - Spectral/imaging/polarimetric capabilities of facility instruments.
  - **Instrument parameters.**
  - **Cadences and frame rates (limited by DHS capabilities).**

FIDO Tool 1

What is it for?

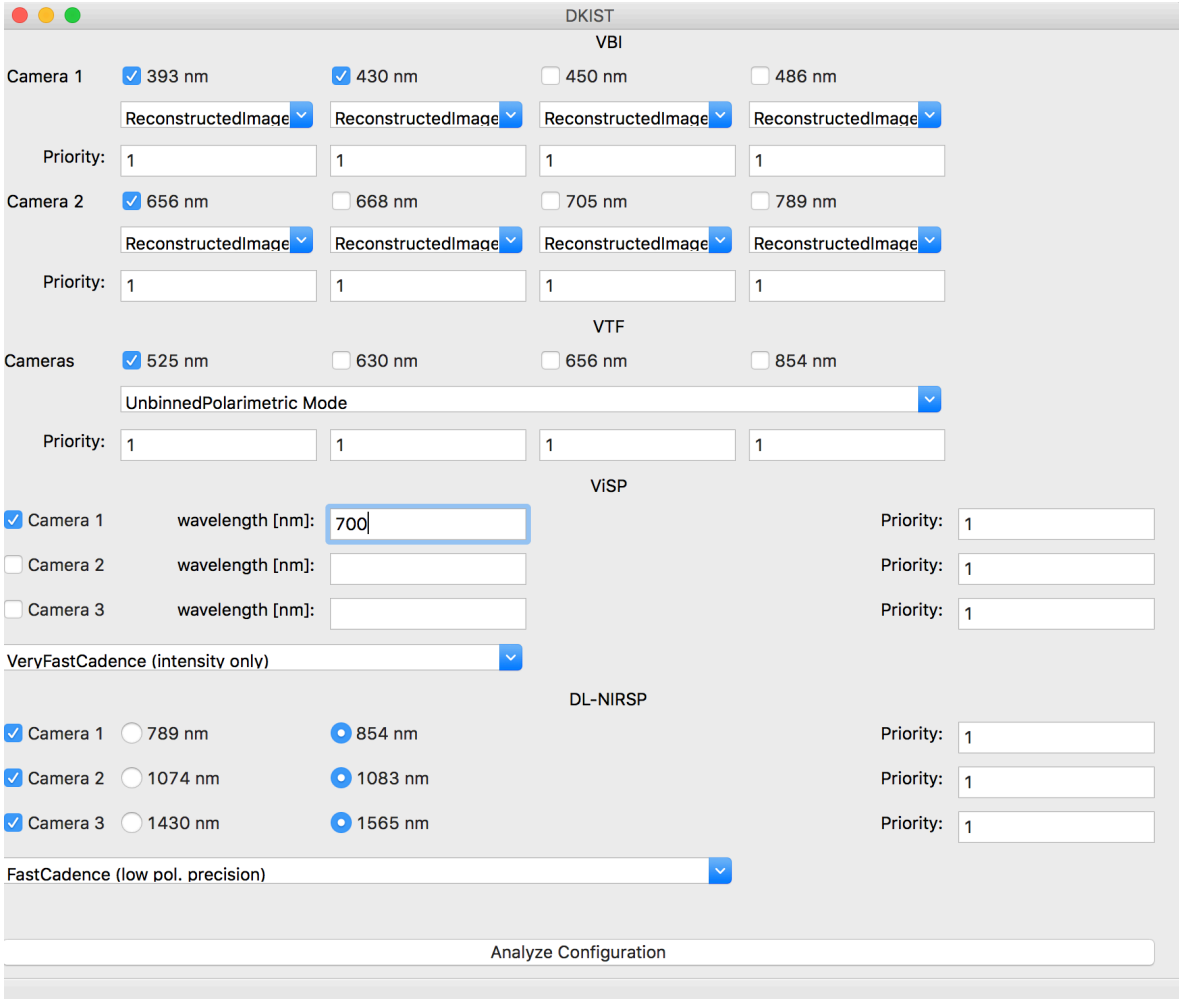
- Verifies whether the proposed wavelength distribution to the instruments is compliant with what FIDO can do.
  - Directive: “Either all light or no light” to an instrument.
  - There is no sharing of the same wavelength range between instruments; there are no grey beamsplitters (e.g. 50/50).
- Verifies whether the DHS can handle the proposed data rates.
  - DKIST is built for very high data rates, but still has limits on rate and volume.
  - First-order estimates of rate/volume calculated by FIDO tool.
  - Detailed rates/volumes are calculated by Instrument Performance Calculators.

FIDO Tool 2

What does it look like?
How does it work?

INPUTS:
wavelengths and modes for each requested instrument

priorities can also be used for optimization (instrument selection)



NOTE: the FIDO software has been updated as of August 2018; now includes more λλ for DL-NIRSP

FIDO Tool 3

Outputs 1:
success or failure in wavelength bands

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The following Coude Optics configurations [CL2, CL2a, CL3, CL3a]
deliver the highest ranking:
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[BS_465,BS_950,BS_680,BS_555]; [BS_465,MI_001,BS_680,BS_555];
[BS_465,MI_002,BS_680,BS_555];

::VBI1:: waverange [nm]: [380,440]
-----> Max. Data Rate (successful diagnostics): 960 MB/s
      success: 393; 430;
      fail:
::VBI2:: waverange [nm]: [580,660]
-----> Max. Data Rate (successful diagnostics): 960 MB/s
      success: 656;
      fail:
::VTF:: waverange [nm]: [490,530]
-----> Max. Data Rate (successful diagnostics): 2880 MB/s
      success: 525;
      fail:
::ViSP1:: Channel receives no light!
      success:
      fail:    700;
::DLN1:: waverange [nm]: [700,1800]
-----> Max. Data Rate (successful diagnostics): 67 MB/s
      success: 854;
      fail:
::DLN2:: waverange [nm]: [700,1800]
-----> Max. Data Rate (successful diagnostics): 67 MB/s
      success: 1083;
      fail:
::DLN3:: waverange [nm]: [700,1800]
-----> Max. Data Rate (successful diagnostics): 67 MB/s
      success: 1565;
      fail:

Aggregate Bandwidth (max. 3500-4000 MB/s): 5001 MB/s
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NOTE: the FIDO software has been updated as of August 2018; the output looks different now

Detour: Data Handling System 1

- DHS uses dedicated **physical camera lines** (hardware) for its purposes: transport/transfer of data, display of data, etc.
- Each camera line is supporting a total bandwidth of 960 MiB/s.
- There are 5 camera lines for first light, ergo in theory a total aggregated bandwidth of 5 x 960 MiB/s/4800 MiB/s is supported.
- Caveat: there are 11 cameras in total (+2 for Cryo, but standalone).
  - Camera lines can be configured to share multiple cameras (**virtual camera lines**) within 960 MiB/s limit (e.g. when binned or not running at the highest framerate).
  - Practical max is 3500 to 4000 MiB/s (due to overhead).
- Data acquisition at the max possible rate might have to be limited in duration due to data volume issues; typical daily data volumes of 5-30 TB; total summit capacity is 90/100 TB.

Detour: Data Handling System 2

- **VBI**: 2 x (4096 x 4096) [Andor Balor].
  - Max rates: 2 x 960 MiB/s.
- **VTF**: 3 x (4096 x 4096) [Andor Balor].
  - Max rates: 3 x 960 MiB/s.
- **ViSP**: 3 x (2560 x 2160) [Andor Zyla 5.5].
  - Max rates: 3 x 433 MiB/s.
- **DL-NIRSP**: 1 x (4096 x 4096) [Andor Balor]; 2 x (2048 x 2048) [H2RG].
  - Max rates: 1 x 960 MiB/s; 2 x 240 MiB/s.
- **Cryo-NIRSP**: 2 x (2048x2048) [H2RG].
  - Max rates: 2 x 80 MiB/s.

Instrument Performance Calculators

- Instrument Performance Calculators (IPCs) are tools (i.e. software programs/applications) intended to help the user familiarizing with and exploring instrument capabilities (e.g. filter/line selection, exposure times, field sampling, scanning, instrument modes, etc.).
- IPCs are developed by instrument partners; different look and feel (this will remain for first light and even beyond); user input on individual functionality is most welcome (please contact Gianna).
  - Each instrument has its own IPC, all run separately; VBI and VTF are Java applications (Java 1.9); ViSP and DL-NIRSP run in IDL (8+); Cryo-NIRSP IPC not yet ready for distribution.
- **Note**: it is useful to run FIDO ahead of the IPCs, to check if the intended spectral distribution is feasible.
- **Recommendation**: if possible use the basic capabilities to fulfill the science; try to avoid the extended or advanced mode of the IPCs.

VBI IPC

- **Features**: comes in Java 1.9; drag and drop functionality; allows defining sub-groups of filter combinations (up to 5 levels) over which can be iterated; saving and loading of parameter settings; basic and expert mode; incorporates limb darkening model for flux budget calculation underneath the hood for observations at different angles (mu values); cadence calculations take into account the filter change times very accurately); manual and online Help.
- **Reminder**: VBI can field sample: either whole field or central field can be selected; VBI can speckle (default), frame select, both, none (non-standard mode).
- **Comments**: red/green color = parameter can/cannot be changed; not all exposure times are possible; in frame selection mode: up to 10 images can be saved out of Y; in frame selection and rec mode: up to 80 images out of Y; binning is not allowed when rec is activated; speckle does only work with the full FOV, no ROI yet (only when robustness is there maybe open up for ROI/binning and speckle); going from expert mode to normal mode clears all settings (and vice versa) coronal SNR corresponds to the continuum.

VTF IPC

- **Features**: comes in Java 1.8+; default/basic/advanced mode; selection of Spectropolarimetric/Doppler/Monochromatic Intensity mode; allows defining combination of filter/spectral scan sequences up to 8 over which can be iterated individually; number of scan steps (equidistant; fixed in default; upper limit); selection of scan pattern (nested or monotonic); allows repetition over whole sequence; saving and loading of parameter settings; adjustable light level (SNR); manual and online Help.
- **Reminder**: VTF does not field sample: if larger FOV is necessary then telescope mosaicking is necessary;
- **Comments**: yellow/green color = parameter can/cannot be changed; ROIs are allowed but predefined; non-equidistant user defined wavelength sampling in advanced mode; binning options in all modes; spectral step size (dependent on filter) with two options in basic mode; number of accumulations; instrument mode applies for all filters/lines in sequence – cannot be changed on a per filter basis; scan position in MI mode is user definable;

ViSP IPC

- **Features**: runs in IDL (8+); has “basic” and “advanced” mode (keyword to be set when starting the program); uses a GUI where selection of parameters can be performed. Can be run in polarimetry (default) or intensity only (fast). Arbitrary line selection in the three arms is allowed – if mechanically feasible. A complementary “optimizer” routine allows this selection. Slit size, slit step and number of steps in raster can be chosen. Allows repetition over whole sequence; saving and loading of parameter settings; adjustable light level as position on disk (mu value). Manual Help.
- **Reminder**: ViSP rasters a 2D FOV by stepping the slit, but slit length is fixed (*and different* in the three arms). If larger (longer..) FOV is necessary then telescope mosaicking is necessary. Uses disk-center solar atlas; currently, no input is provided for coronal observations.
- **Comments**: ROIs are allowed; binning options are available; plots of SNR are provided for I, and Q, U, V

DL-NIRSP IPC

- **Features**: runs in IDL (8+); uses a GUI where selection of parameters can be performed. Can be run in polarimetry (default) or intensity only (fast). Only one line (spectral range)/arm is selectable. Three different “modes” are available, of different spatial resolution and FOV. Calculations can be made by selecting resulting SNR (in continuum) or exp. times and accumulations. Allows repetition over whole sequence; saving and loading of parameter settings; adjustable light level as position on disk (coordinate selection). Allows manual input of coronal intensities. Manual Help.
- **Reminder**: DL-NIRSP does field sample: tiles can be selected to cover up to 2’x2’. Has pre-set coronal intensity (vs. radial distance) only for HeI 1083, FeXIII 1074.7, and SiX 1430.
- **Comments**: no ROIs is allowed; no binning options. Uses disk-center solar atlas for plots, even in corona.

DKIST coronal diagnostics during early operations

- Emphasis on bright line observations with greatest magnetic field sensitivity.
- Corresponding peak temperature coverage: 1 to 1.6 MK
- Filter availability can be expanded in the future.

Maximum FOV: 2.8 arcmin -- Coordinated Operations

DL-NIRSP Spectropolarimetry

Fe XI λ7892 ; Log(T) ~ 6.13
Fe XIII λ10747 ; Log(T) ~ 6.22
Fe XIII λ10797 ; Log(T) ~ 6.22
He I λ10830 ; Log(T) ~ 4*
Si X λ14300 ; Log(T) ~ 6.13

VBI Imaging

Fe XI λ7892 ; Log(T) ~ 6.13

VISP Spectropolarimetry

Various lines: 380 to 900 nm

Maximum FOV: 5 arcmin

Cryo-NIRSP Spectropolar.

Fe XIII λ10747 ; Log(T) ~ 6.22
Fe XIII λ10797 ; Log(T) ~ 6.22
He I λ10830 ; Log(T) ~ 4*
Si X λ14300 ; Log(T) ~ 6.13
Si IX λ39350 ; Log(T) ~ 6.04

Cryo-NIRSP Context Imager

Fe XIII λ10747 ; Log(T) ~ 6.22
He I λ10830 ; Log(T) ~ 4*
Si IX λ39340 ; Log(T) ~ 6.04

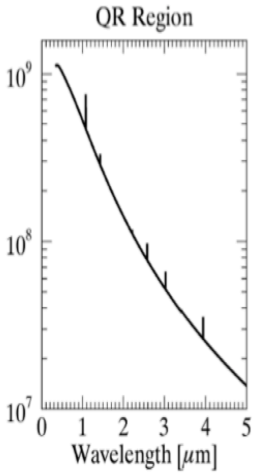
Monte-Carlo Determination of Measurement Sensitivities (Cryo-NIRSP)

Photon-noise only.

Long. Magnetic Field Error assumes weak-field approximation from single point.

Fe XIII and Si IX provides best B sensitivity.

See also Penn et al. (2004) for analytical error estimates.



Cryo-NIRSP Coronal Performance Estimates based on the QUIET REGION (QR) Model of Del Zanna & DeLuca (2017)
R = 1.1 solar radii
Background signals as specified in Figure 4 with read noise of 50 electrons per pixel.
Spatial integration assumes 0.5" slit width and co-addition of 1" along the slit.
Error values given for integration times of 1, 10, and 60 seconds as derived from a Monte Carlo simulation.
Errors represent photon noise only. Calibration limitations not included.

	Line radiance [photons cm^{-2} sec^{-1} $asec^{-2}$]	Inte-gration time [sec]	Integrated Intensity Error (dI/I) [percent]	Deg. of Linear Polarization Error [percent]	Line Width Error [percent]	Azimuthal Angle Error [degrees]	Doppler velocity error [m/sec]	Long. Mag. Field Error [Gauss]
Fe XIII 1074.7	240	1	0.09	0.19	0.13	1.05	11.8	10
		10	0.03	0.05	0.03	0.31	3.3	3
		60	0.01	0.02	0.01	0.12	1.3	2
Fe XIII 1079.7	140	1	0.16	0.31	0.21	1.79	19.7	16
		10	0.05	0.09	0.06	0.5	5.6	5
		60	0.02	0.03	0.02	0.2	2.2	2
Si X 1430	51	1	0.33	0.72	0.46	3.9	41.6	25
		10	0.09	0.19	0.13	1.07	11.7	7
		60	0.04	0.08	0.05	0.43	4.4	3
Fe IX 2218	11	1	1.13	3.81	1.59	59.53	146.9	57
		10	0.3	0.62	0.4	3.39	37.8	15
		60	0.12	0.24	0.16	1.34	15.2	6
Si IX 2580	41	1	0.32	0.7	0.46	3.85	41.8	14
		10	0.08	0.16	0.1	0.92	9.7	4
		60	0.03	0.06	0.04	0.37	4	2
Mg VIII 3028	34	1	0.42	1.19	0.56	15.32	51.4	14
		10	0.09	0.18	0.12	1.08	11.1	4
		60	0.04	0.07	0.05	0.42	4.5	2
Si IX 3935	29	1	0.38	0.74	0.5	4.2	47.6	11
		10	0.08	0.17	0.12	0.96	11.1	3
		60	0.03	0.07	0.04	0.38	4.6	1

Thanks!

http://dkist.nso.edu/