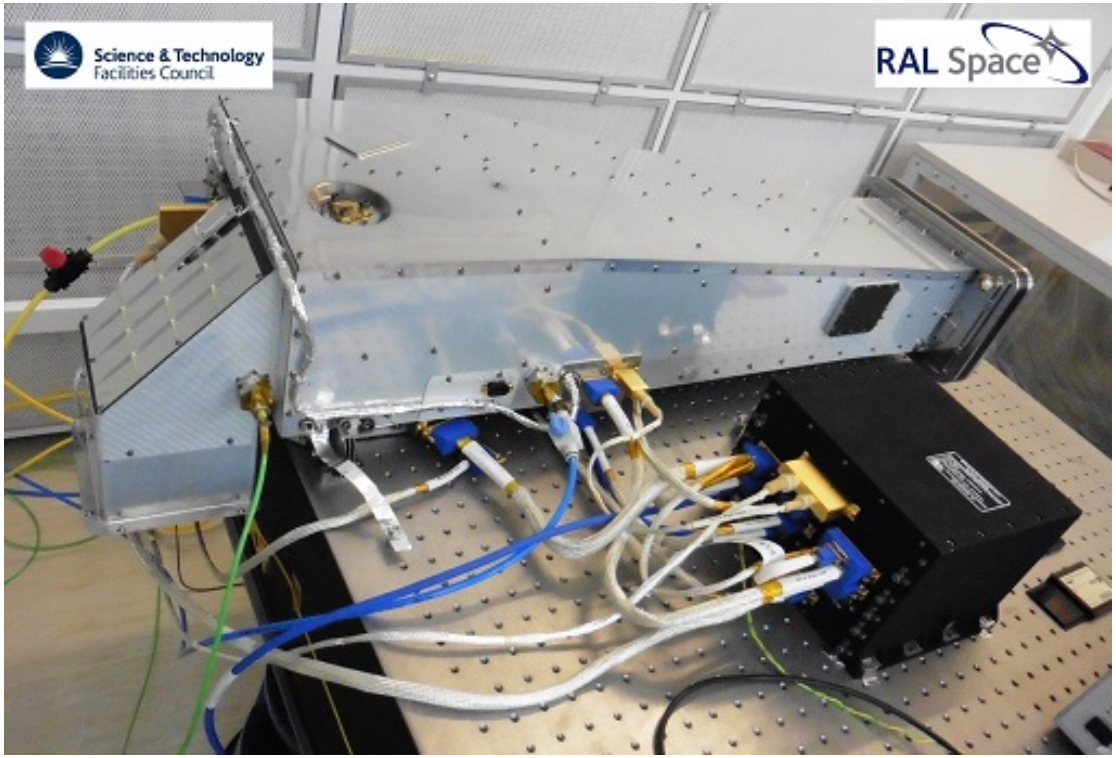
Science Activity Plan
Part 2 – Examples:
SPICE, connectivity, in situ

Andrzej Fludra

and the RAL SPICE ops team

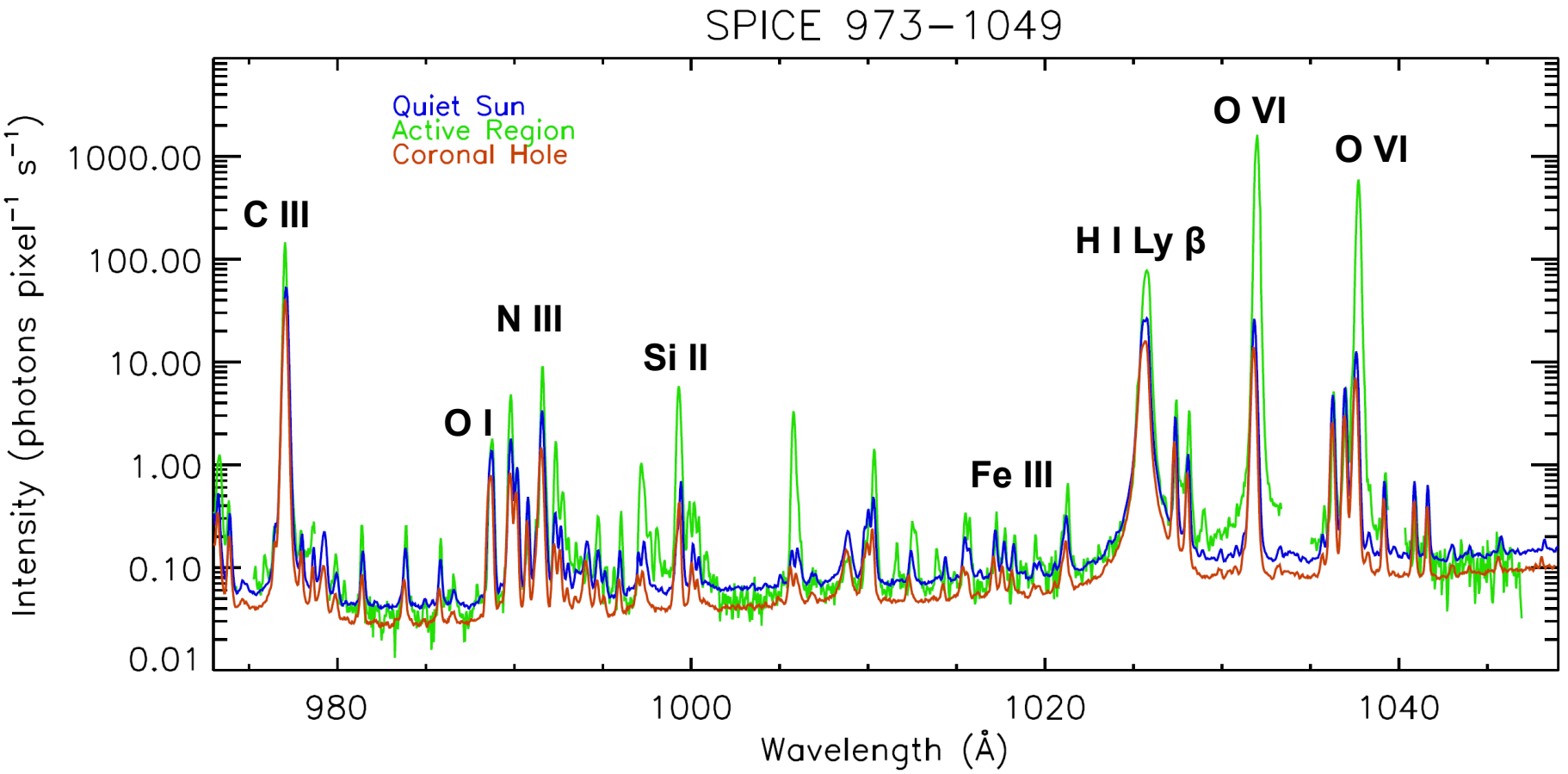
SPICE FM Instrument Delivered



SPICE Optics Unit (SOU)
Delivered 17 May 2017

Electronics box, SWRI
Delivered 1st August 2017, handover 8th August

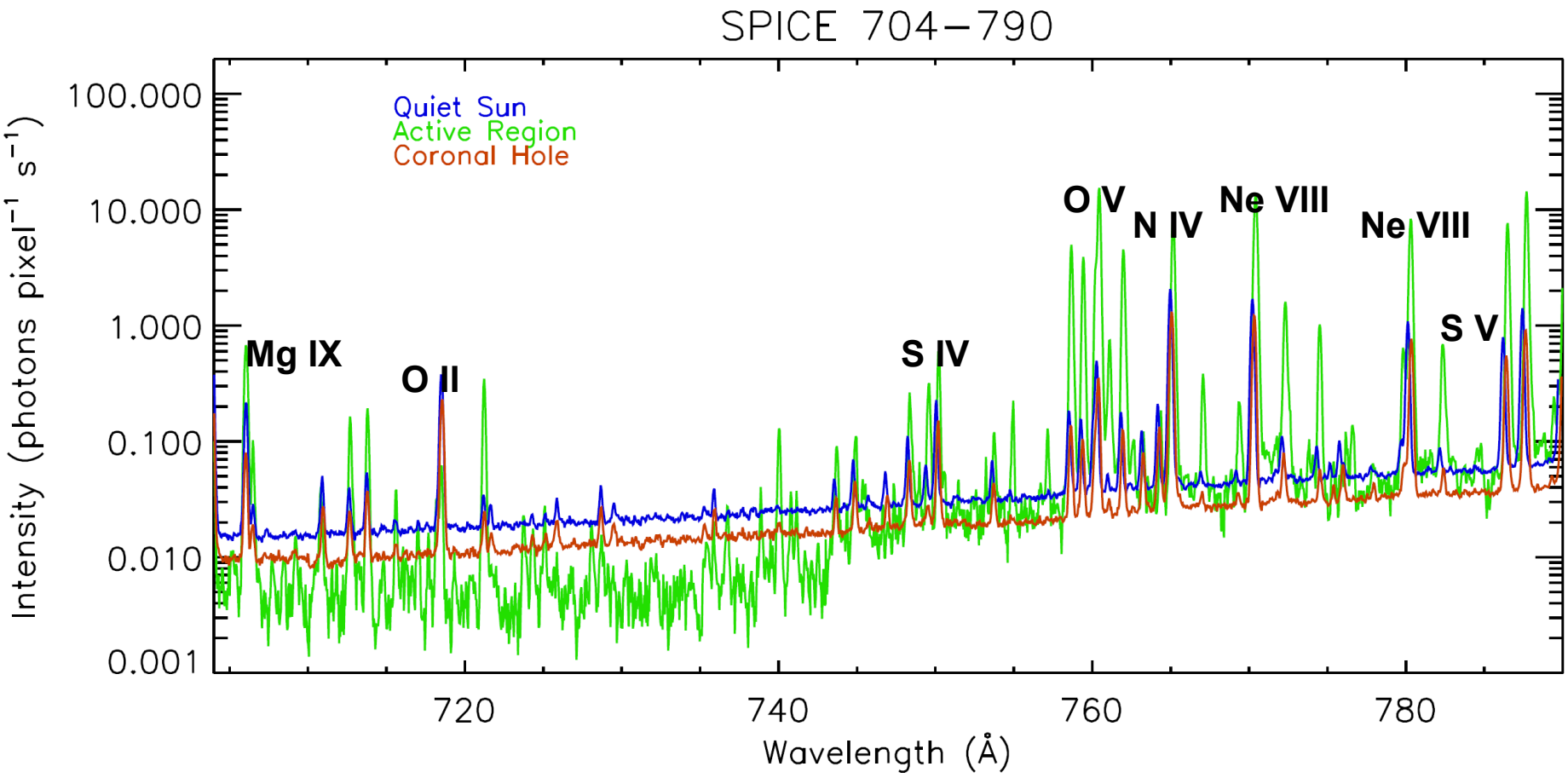
SPICE Spectrum - Long w. band



H I Ly β - chromosphere & bottom of TR
C III – 60,000 K
O VI – 300,000 K

~1- 5 s exposure times,
study plasma dynamics: flows and short term variability

SPICE Spectrum - Short w. band



~30 s – 180 s exposure

Ne VIII – 600,000 K – outflows in coronal holes

Mg IX – 950,000 K – line broadening above the limb

Both bands – composition studies

Operations: some* SPICE parameters

Parameter	Value	binning
Exposure time (s)	0.1 – 1000s	0.1s or 0.5s increment
Slits	2'', 4'', 6'', 30'' width	
Spatial resolution along the slit	1.1'' per pixel	sum 2,4,8,16, 32,… pixels
Spatial extent along the slit (vertical field of view)	14' (for 30'' slit) 11' + 2x30'' dumbbell for narrow slits	Can be reduced to a fraction of the slit length
Scan mirror step	2'', 4'', 6'', etc.	
Horizontal field of view	16'. Can be reduced to any (x0,x1), including sit-and-stare (0'' step)	Can make sparse rasters (step greater than the slit width)
Spectral coverage	70.4 – 79.0 nm and 97.3 - 104.9 nm (1st order)	
Spectral windows	Up to 32	Line selection
Window width *(***see SPICE documents for details***)*	e.g., 4,8,**16**,**32** pixels when rastering	Sum 4,8,16,32 pixels (can sum the entire window)
Compression (under development)	(a) 10:1 – 14:1 * (JPEG2000) (b) 20:1 – 26:1 (SHC)	

SPICE Observing Modes

10 modes defined. Two primary modes of SPICE observation:

(a) dynamics studies: rapid on-disk scans over smaller areas a few arcminutes wide, recording profiles of a small number of bright transition region lines,

1-5 s exposure, 20''-60'' area, 2'' or 4'' slit, 1 – 3 minute cadence

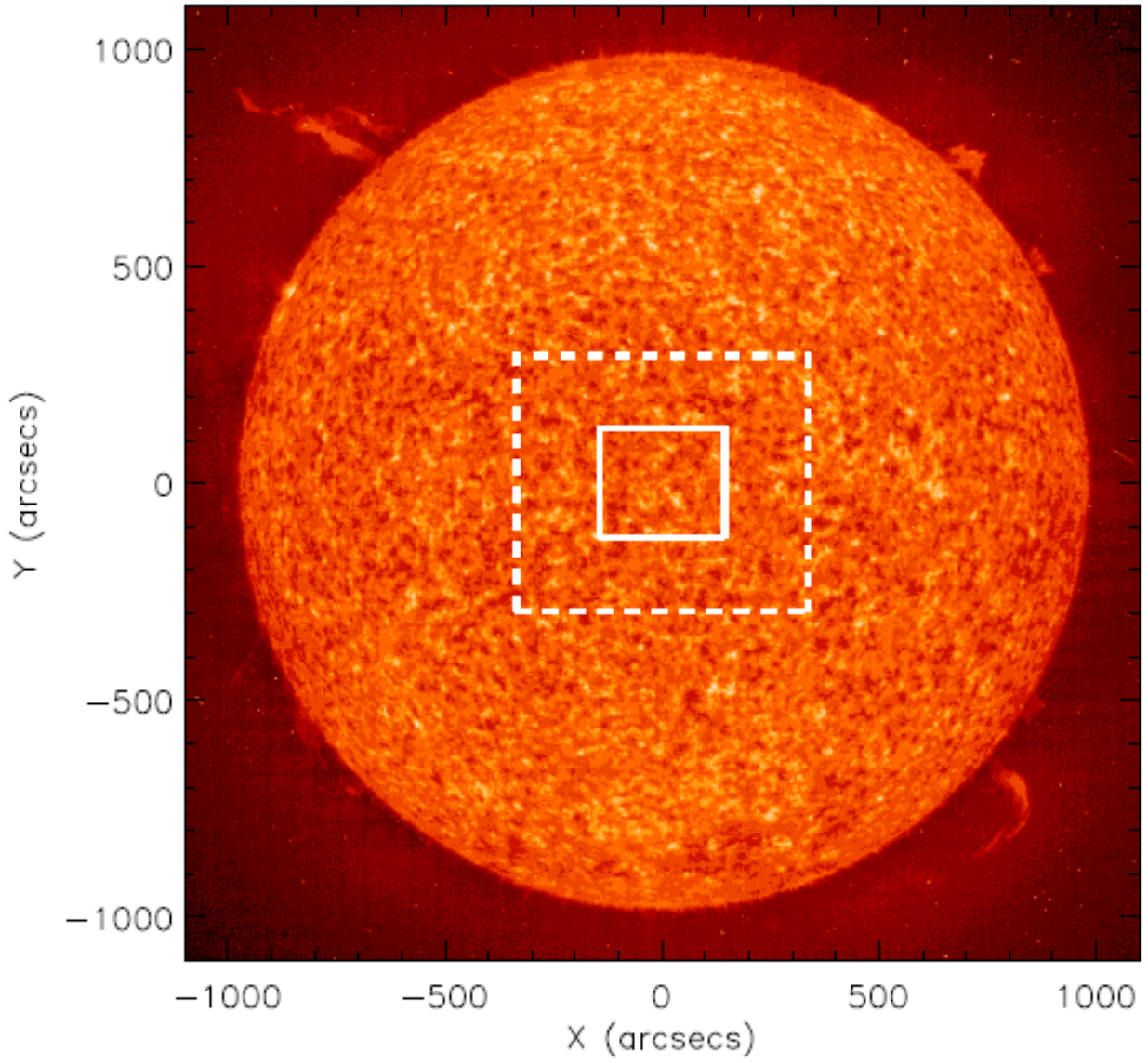
(a) composition scans: longer exposure times, covering large areas up to 16' wide and recording intensities of a larger number of lines and some line profiles. Good for outflows in coronal holes.

30 s – 120 s exposure, 10-16 arcmin wide area, 4'' slit, 75 - 120 min cadence

Variations with different FOV, exposures and line lists will be created.

Several other studies defined (e.g., spectral atlas, CME Watch, Wave study)

SPICE FOV at 0.3 AU (solid line) and 0.7 AU (dashed line)



16’ x 14’ area

14’ = slit length incl. dumbbell and wide slit length

11’ = narrow slit length

Target stays inside the FOV for 2.85 day

s/c repointing anywhere on disk, up to the limb

Fast Solar Wind

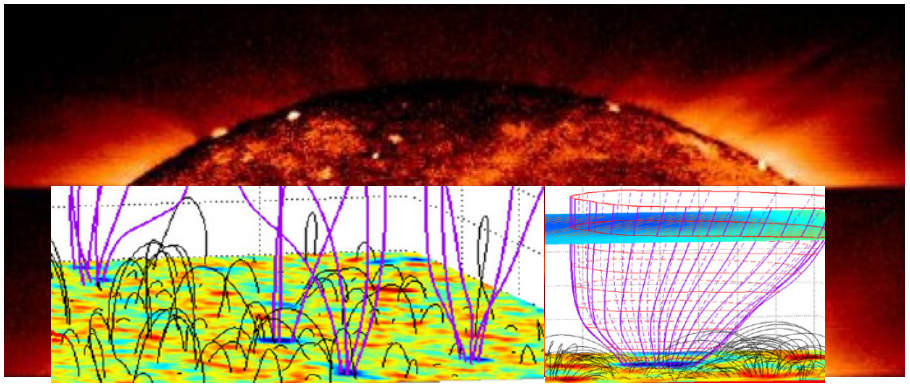
SPICE will provide the first-ever out-of-ecliptic spectral observations of the solar polar regions

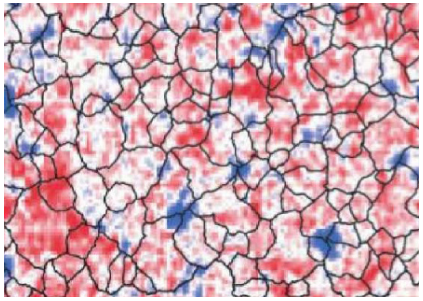
2-D high resolution spectral images and **maps of upflows and downflows** & other plasma signatures in the high latitude polar region: Intensity, line width, elemental composition, FIP-maps.

1.1.1 What are the source regions of the fast solar wind?

1.2.2 What mechanisms heat and accelerate the solar wind?

Identify source regions on velocity maps. Derive composition, compare to magnetic field and other observations from Solar Orbiter (SWA/HIS).





Ne VIII
Velocity maps

Identify feature types that give rise to the solar wind by correlating Doppler shift to structure and composition

Solar Wind Analyser (SWA)

SWA consists of a suite of sensors which are able to measure **the three-dimensional velocity distribution functions of the major solar wind constituents: protons, alpha particles and electrons, and several minor elements:**

The Electron Analyser System (EAS) - high temporal resolution measurements of the core, halo and 'strahl' electron VDFs and their moments. Electron energy 0 - 5 keV, <10 s time resolution.

The Proton-Alpha Sensor (PAS) to measure the VDFs of protons and alpha-particles at high time resolution and determine their moments. From 200 eV to 20 keV. as well as measuring the bulk plasma parameters at ultra-high time resolution of ~0.1 s

The Heavy Ion Sensor (HIS) to measure the 3-D VDFs and determine the abundance and charge states of prominent minor ion species. **The same elements are observed by SPICE → joint composition studies.**

SWA modes: **normal mode** expected to operate for the majority of the mission, **burst mode** (~5 min/day)

SAP Objectives: 1, 2, 3

Heavy ions: SPICE-SWA/HIS

- Ballistic trajectory

Constant v from the source surface

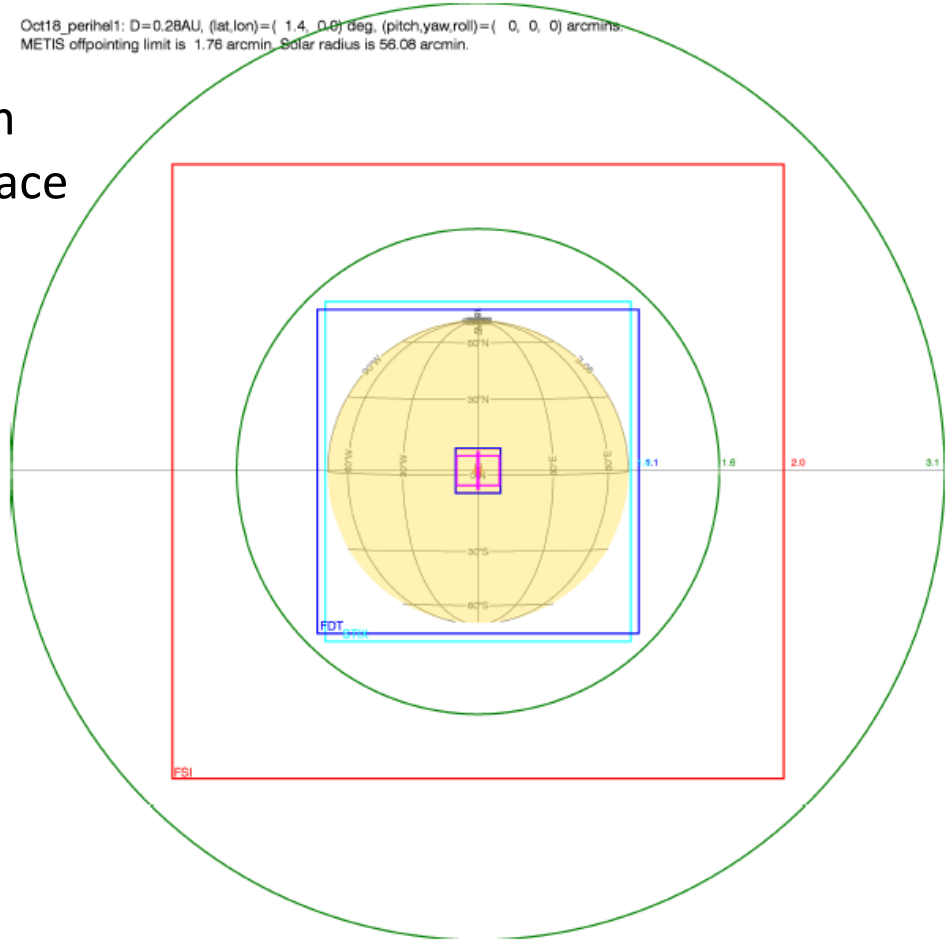
- Slow speeds -> travel time ~1-3 days (over orbit)

- Connection @ perihelion: West of central meridian, shift depends on true angular speed and distance (travel time)

Connectivity to in situ instruments:

- Repointing West of central meridian
- N-S mosaics (6 pointings)

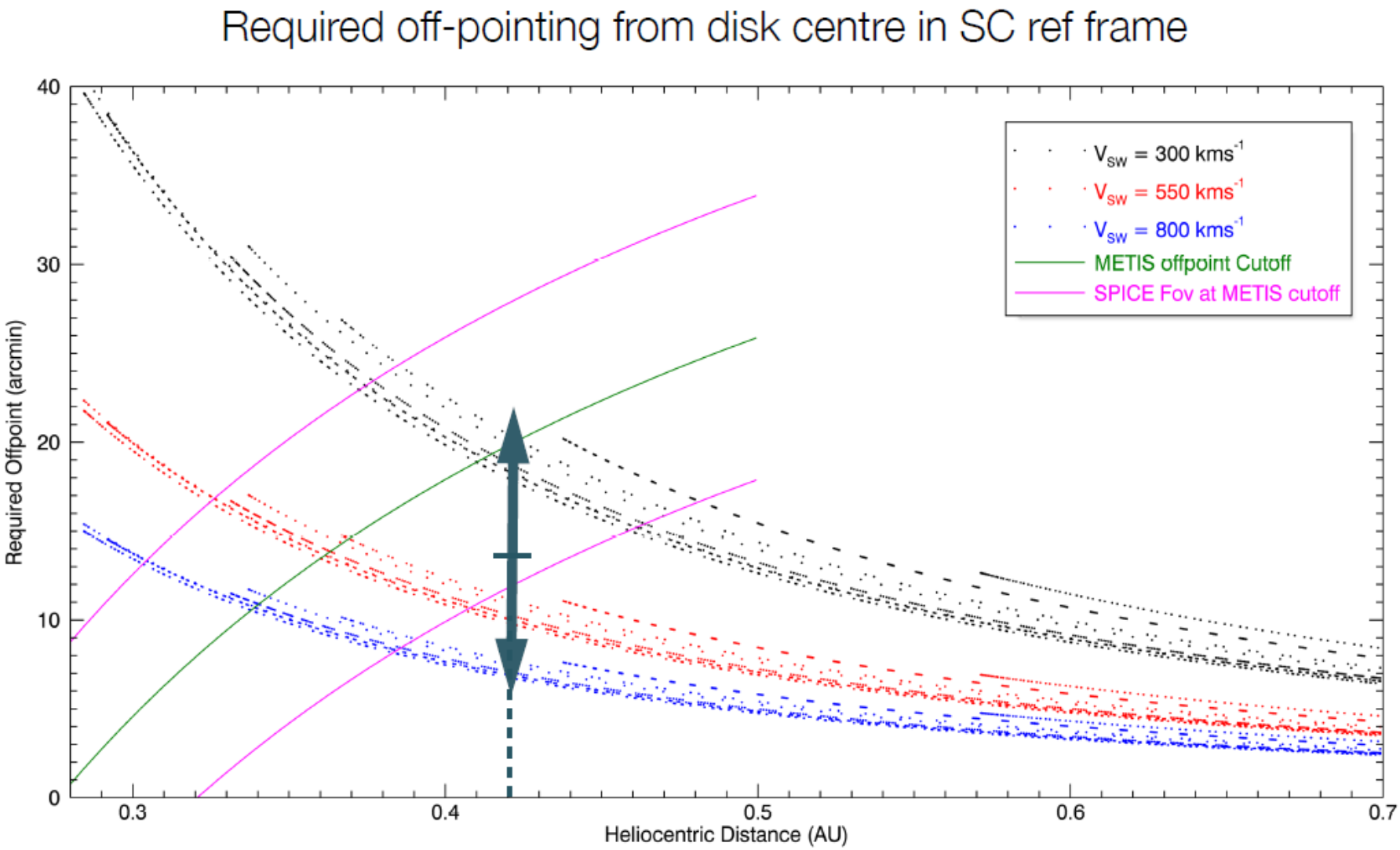
Whenever METIS is crucial for a science observation close to perihelion, S/C will be disk-centre pointed.



Perihelion 1 - 0.28AU
FOV (16'x11') spans 195Mm x 135Mm
longitude range: [-8°,8°] / latitude range: [-5.5°,5.5°]

Anik DeGroof, ESA, 2015

Heavy ions (& CMEs): source regions on-disk



Anik DeGroof, ESA, 2015

SOOPs (1)

- L_BOTH_HRES_LCAD_CH_Boundary_Expansion
- L_BOTH_LRES_MCAD_Pole-to-Pole
- L_BOTH_MRES_MCAD_Farside_Connection
- L_BOTH_MRES_MCAD_Flare_SEPs
- L_FULL_HRES_HCAD_Coronal_Dynamics
- L_FULL_HRES_HCAD_Eruption_Watch
- L_FULL_HRES_LCAD_MagnFieldConfig
- L_FULL_HRES_MCAD_Coronal_He_Abundance
- L_FULL_LRES_MCAD_Coronal_Synoptic
- L_FULL_LRES_MCAD_ProbeQuadrature
- L_FULL_MRES_MCAD_CME_SEPs
- L_IS_SoloHI_STIX
- L_IS_STIX

SOOPs (2)

- **L_SMALL_HRES_HCAD_Fast_Wind**
- L_SMALL_HRES_HCAD_SlowWindConnection
- L_SMALL_MRES_MCAD_Ballistic-connection
- L_SMALL_MRES_MCAD_Connection_Mosaic
- R_FULL_HRES_HCAD_Density_Fluctuations
- R_FULL_LRES_HCAD_GlobalHelioseismology
- R_SMALL_HRES_HCAD_AR_Dynamics
- R_SMALL_HRES_HCAD_Ephemeral
- R_SMALL_HRES_HCAD_PDF_Mosaic
- R_SMALL_HRES_HCAD_Photospheric_Dynamics_Structure
- R_SMALL_HRES_HCAD_RSburst
- R_SMALL_HRES_HCAD_WaveStereoscopy
- **R_SMALL_HRES_LCAD_Composition_vs_Height**
- R_SMALL_HRES_LCAD_FineScaleStructure
- R_SMALL_HRES_MCAD_PolarObservations
- R_SMALL_MRES_MCAD_AR_LongTerm

SAP Conclusions

- 100+ SAP questions: 4 levels deep and cover most of unanswered problems in solar and heliospheric physics. *Science is in the mind of the beholder.*

- Number of observing modes depend on the instrument:
  - SPICE: 10 studies x many variations (exposure, lines, slits)
  - In-situ: typically, 1 normal mode plus burst mode (short).

- SOOPs: ~27, will grow with time. They ask different science questions but sometimes record similar data. Differences due to s/c pointing and obs. modes of Remote Sensing instruments.

https://issues.cosmos.esa.int/solarorbiterwiki/display/SOSP/SAP-related+work