Solar Orbiter Archive: New Features – Python/TAP/TOPCAT Access and Docs

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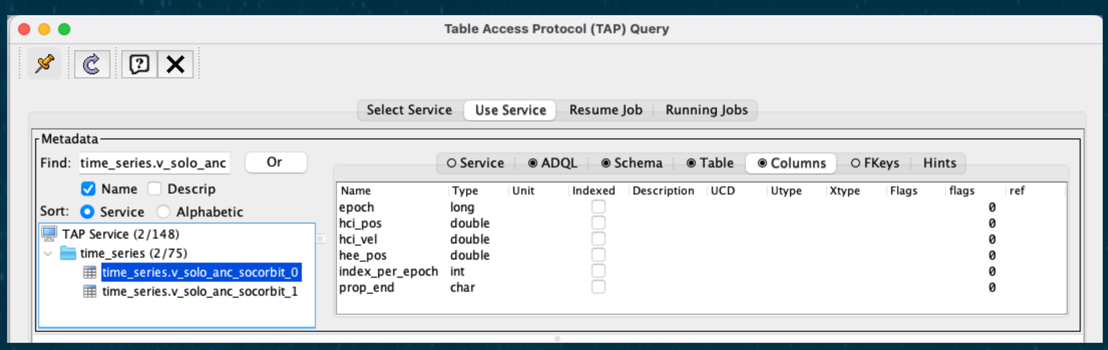
Overview

The ESAC Science Data Centre (ESDC) plays a crucial role in **preserving and providing long-term access to data** from all ESA space science missions.
Recent enhancements to the **Solar Orbiter Archive (SOAR)** aim to provide researchers with more intuitive and powerful tools for data access. These updates include the ability to **search data by solar distance** and utilize **Field of View (FoV) tables**. The contents of the Solar Orbiter mission orbit file have been ingested and is available via our standard **TAP** interface. This allows users to search a rich set of metadata based on Distance and Latitude. Integration with commonly used tools like Python, TOPCAT, and SunPy has further streamlined data access and interoperability.
The **redesigned help page** demonstrates how to interact with these data and includes new tutorials and instrument documentation.

Orbit File

CDF orbit file provides detailed information about the spacecraft's trajectory and position in space over time.

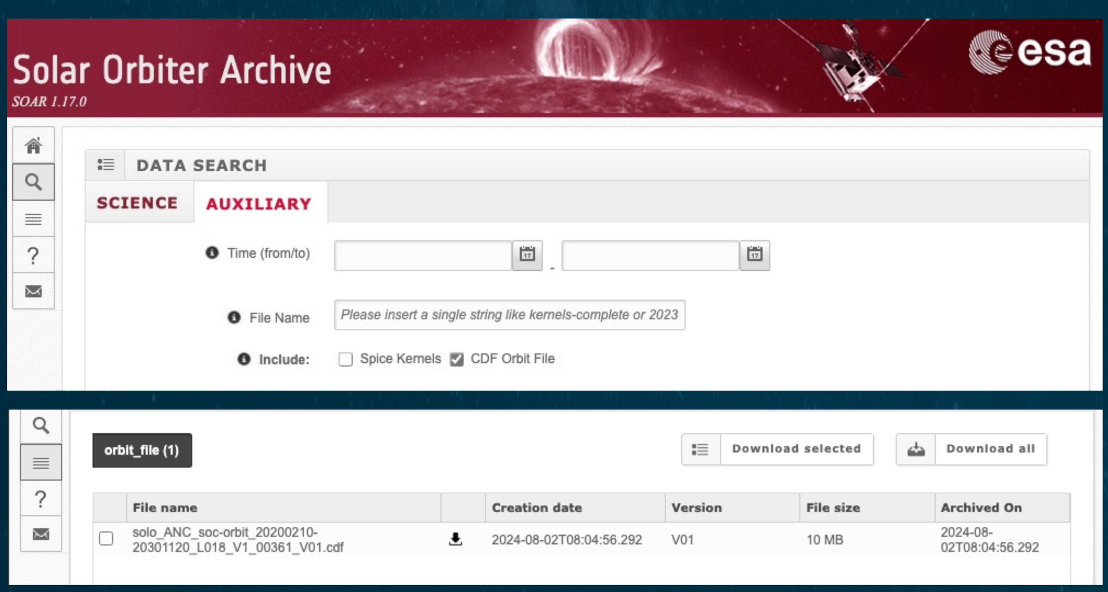
Metadata accessible via **TAP**:



Epoch and Heliocentric distance can be extracted as:

https://soar.esac.esa.int/soar-sl-tap/tap/sync?REQUEST=doQuery&LANG=ADQL&FORMAT=JSON&PHASE=RUN&QUERY=SELECT+epoch,hcentric_dist+FROM+time_series.v_solo_anc_socorbit_1

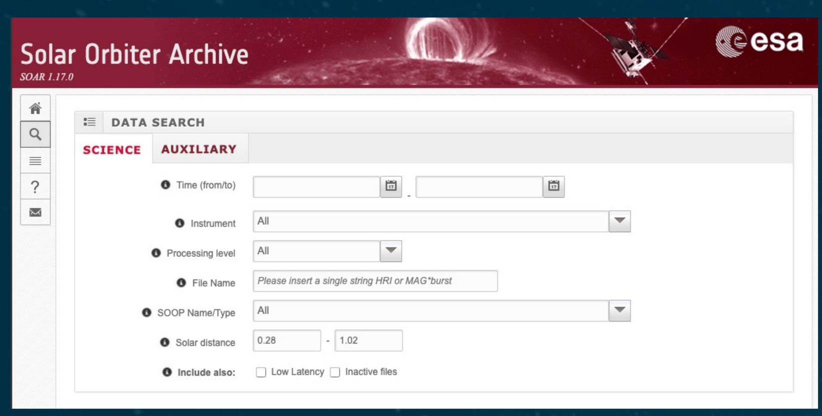
Data accessible via **web interface**:



Solar Distance

Solar distance refers to the distance between the spacecraft and the Sun expressed in Astronomical Units (au). Includes perihelion (0.28 au) and aphelion passes (1.02 au).

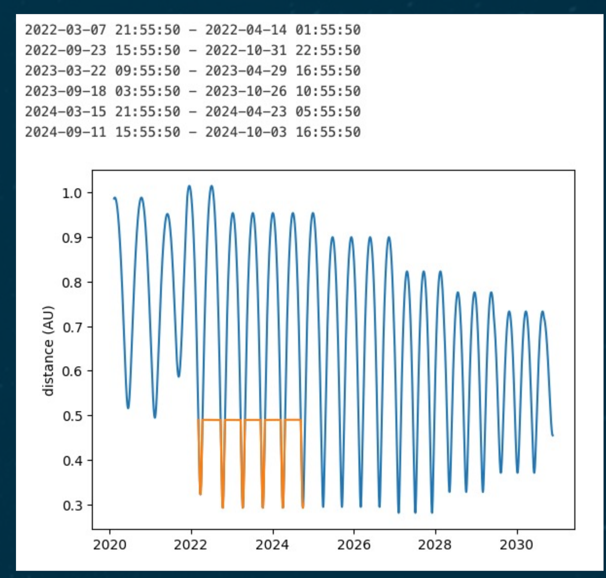
New search option in the **web interface** to retrieve data between a **minimum and maximum** solar distance.



Get the EPOCH and Heliocentric distance directly via **TAP** instead of downloading a CDF file, and easily plot and extract time intervals using a DataFrame for a given solar distance

```python
min_dist = 0.28
max_dist = 0.49

df = pd.DataFrame(data, columns=column_names)
df = pd.DataFrame(
  {
    "epoch": t,
    "datetime": cdflib.cdfepoch.to_datetime(t),
    "distance_km": d,
    "distance_au": d/AU
  }
)
cond1 = df['distance_au'] <= max_dist
cond2 = df['distance_au'] >= min_dist
```



Use of **sunpy-soar** – A SunPy affiliated package that integrates with Fido to search for Solar Orbiter data using solar distance attributes from the Solar Orbiter Archive.

```python
import astropy.units as u
import sunpy.net.attrs as a
from sunpy.net import Fido
import sunpy_soar # NOQA: F401

instrument = a.Instrument("EUI")
time = a.Time("2022-10-29 05:00:00", "2022-10-29 06:00:00")
level = a.Level(2)
detector = a.Detector ("HRI_EUV")
distance = a.soar.Distance(0.45 * u.AU, 0.46 * u.AU)

result = Fido.search(instrument & level & detector & distance)
result
```

»

1442 Results from the SOARClient:

QueryResponseTable length=1442

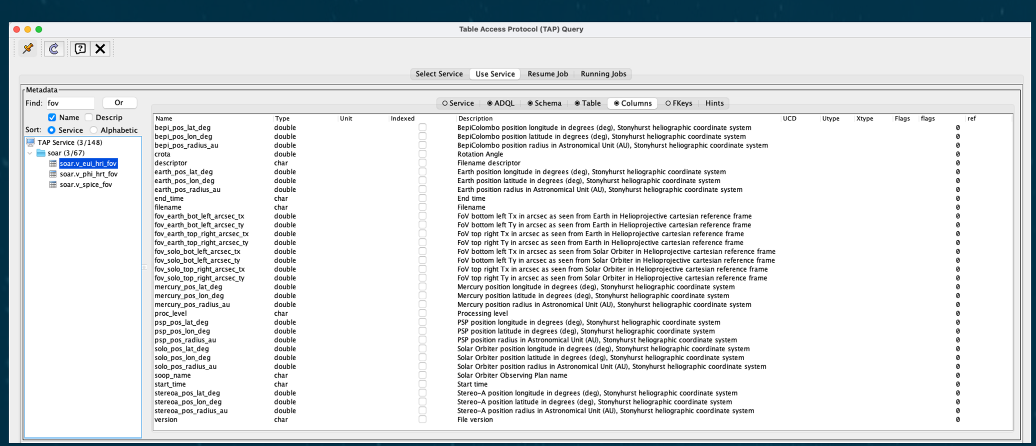
Instrument	Data product	Level	Start time	End time	Filesize	SOOP Name	Detector	Wavelength
					Mbyte			
str3	str19	str2	str23	str23	float64	str48	str7	float64
EUI	eui-hrieuv174-image	L2	2022-10-29 05:00:00.231	2022-10-29 05:00:01.881	5.558	R_SMALL_HRES_HCAD_Atmospheric-Dynamics-Structure	HRI_EUV	174.0
EUI	eui-hrieuv174-image	L2	2022-10-29 05:00:00.231	2022-10-29 05:00:01.881	5.558	R_SMALL_HRES_HCAD_Atmospheric-Dynamics-Structure	HRI_EUV	174.0
EUI	eui-hrieuv174-image	L2	2022-10-29 05:00:05.221	2022-10-29 05:00:06.871	5.532	R_SMALL_HRES_HCAD_Atmospheric-Dynamics-Structure	HRI_EUV	174.0

Field of View

Solar Orbiter has two telescopes and one instrument onboard that target a certain portion of the Sun in high resolution, i.e. within a **Field of View** (FoV)

FoV tables have been extracted from each HRI, HRT and SPICE file. These tables can be accessed via **TAP** and includes

EUI HRI | PHI HRT | SPICE



- FoV in arcsec from a Solar Orbiter perspective.
- FoV in arcsec from an Earth perspective.
- Position of Solar Orbiter, PSP, Bepi, STEREO-A.
- Positions of Earth and Mercury.

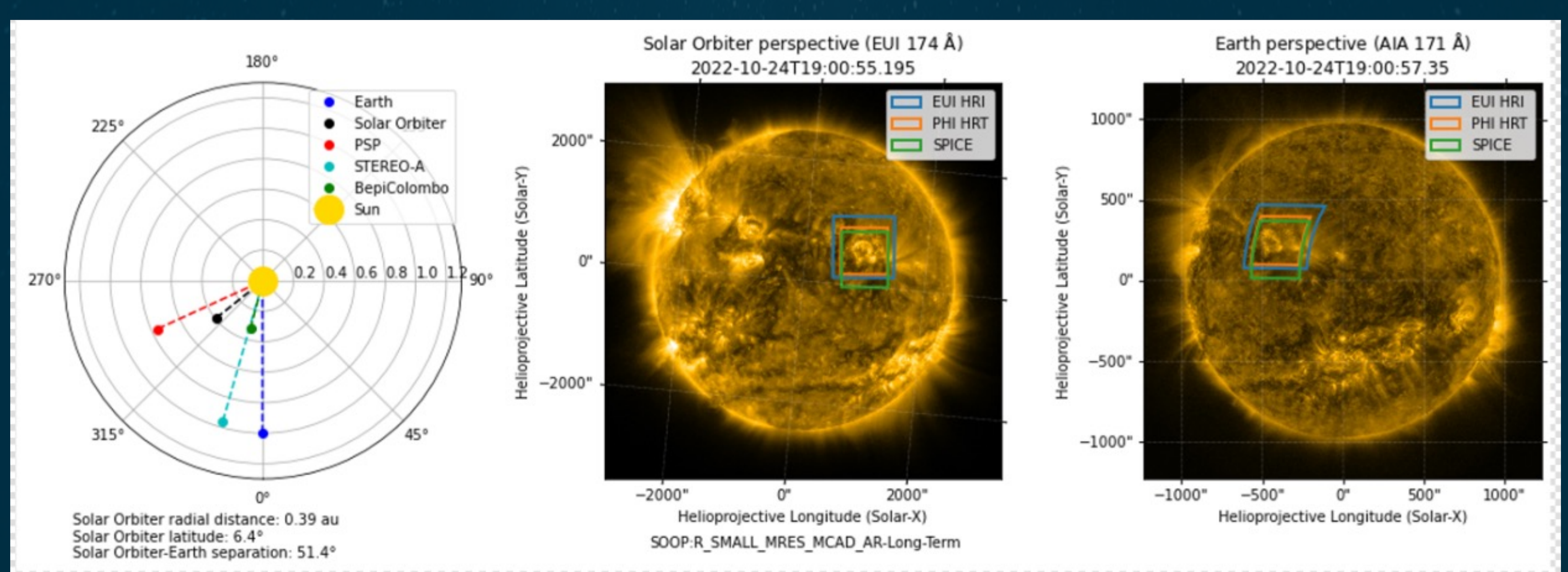
The following queries can be used to access the FoV tables and plot SOAR and Earth based views with help of sunpy.

```python
service = vo.dal.TAPService("https://soar.esac.esa.int/soar-sl-tap/tap")
fits_item_resulset = service.search("SELECT * FROM soar.v_eui_sc_fits WHERE filename='solo_L2_eui-fsi174-image_20221024T190050195_V01.fits'")

first_item = fits_item_resulset[0]
fsi_obs_date = first_item["date_average"]

fov_eui_resultset = service.search("SELECT * FROM soar.v_eui_hri_fov WHERE filename='solo_L2_eui-hrieuv174-image_20221024T190000171_V01.fits'")
fov_phi_resultset = service.search("SELECT * FROM soar.v_phi_hrt_fov WHERE filename='solo_L2_phi-hrt-blos_20221024T191503_V01.fits'")
fov_spice_resultset = service.search("SELECT * FROM soar.v_spice_fov WHERE filename='solo_L2_spice-n-ras_20221024T190134_V05_150995395-058.fits'")
```

Three **different perspectives**: Location of Solar Orbiter and related helio missions; Sun from a Solar Orbiter perspective; Sun from an Earth perspective at the same time (as observed by SDO).



SunPy Access to SOAR Data and Metadata

Search by instrument, detector name, distance to the Sun and Solar Orbiter Observing Plan name using SunPy Fido:

`a.soar.Product`	Name of data product, you can also type `print(a.soar.Product)` e.g. epd_ept_asun_burst_ion, eui_fsi174_image, stix_ql_lightcurve
`a.soar.Distance`	Distance of Solar Orbiter to the Sun, e.g. you want data only when Solar Orbiter is < 0.5AU e.g. `a.Distance(0.3*u.AU, 0.5*u.AU)`
`a.soar.SOOP`	Name of the specific SOOP you are interested in e.g. nanoflare SOOP e.g. `a.soar.SOOP.r_both_hres_hcad_nanoflares`

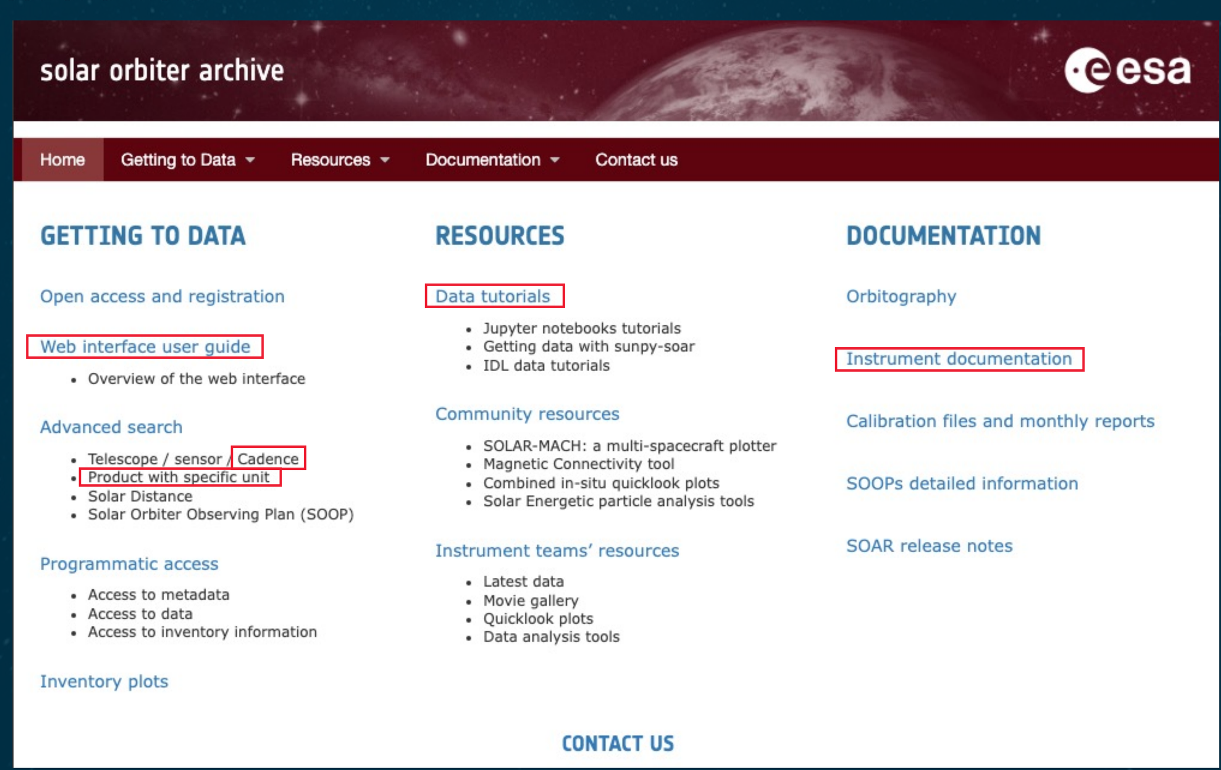
```python
from sunpy.net import Fido, attrs as a
import sunpy_soar

res = Fido.search(
    a.Time("2022-10-29 05:00:00",
"2022-10-29 06:00:00"),
    a.soar.Product.eui_fsi174_image,
    a.Level(2))
res
```

Help Page

→ https://www.cosmos.esa.int/web/soar

Points in red have been redesigned:
- Each Solar Orbiter Instrument provides a Data Product Description Document (DPDD).
- The web interface user guide is up-to-date to include detailed navigation steps.
- Guidance on how to search by cadence for MAG, EPD, SWA 3D and PAD with units.
- Added data tutorials such as finding time intervals when searching by distance, examples with sunpy-soar and more.



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