Introduction: new to field, IVOA: want to learn if we're doing it right.

FOREST is a project developing a **quick-look semantic search virtual observatory for heliophysics.**
We're approximately 6 months in.

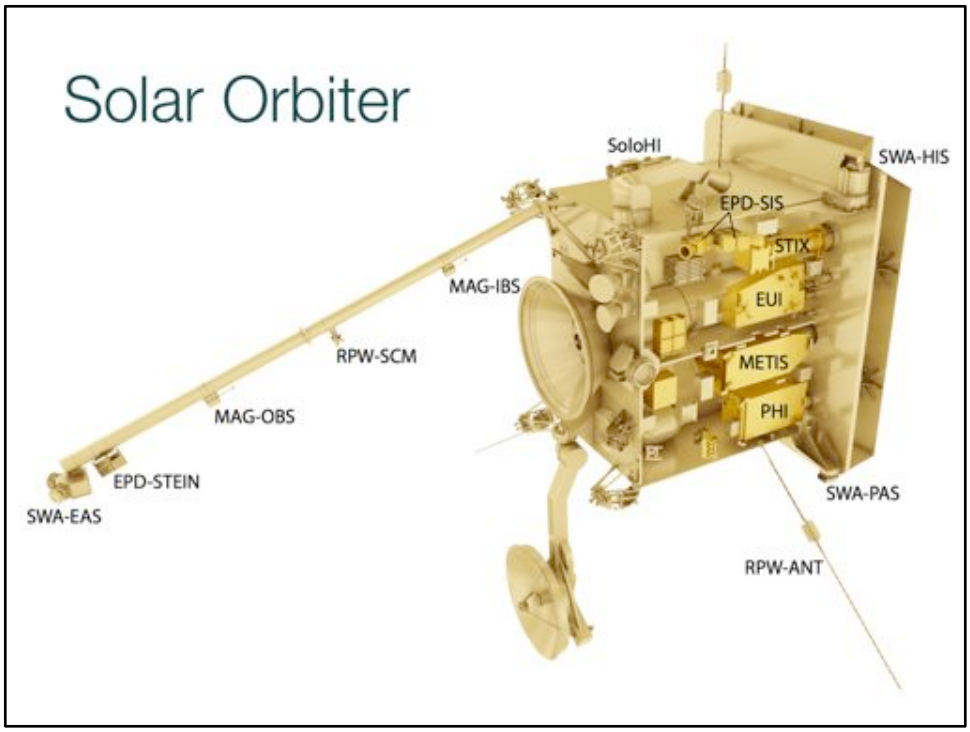
FOREST stands for **Federation of distributed data sources and Scientific Teams**

The aim is to produce a system with easy **"Google-style" searching** of **multi-instrument and multi-spacecraft** data, returning quick-look images so scientists can find interesting events for further research

We aim to provide a system that would be useful for the **Solar Orbiter mission**

ESA Solar Orbiter will be launched in early 2017 and begin its primary science operations three years later, in 2020.

It will approach the Sun **closer than 0.3 AU** in a unique orbit allowing observation of the polar regions and the far side.



Solar orbiter has **ten remote sensing and in-situ instruments** and many science goals, such as

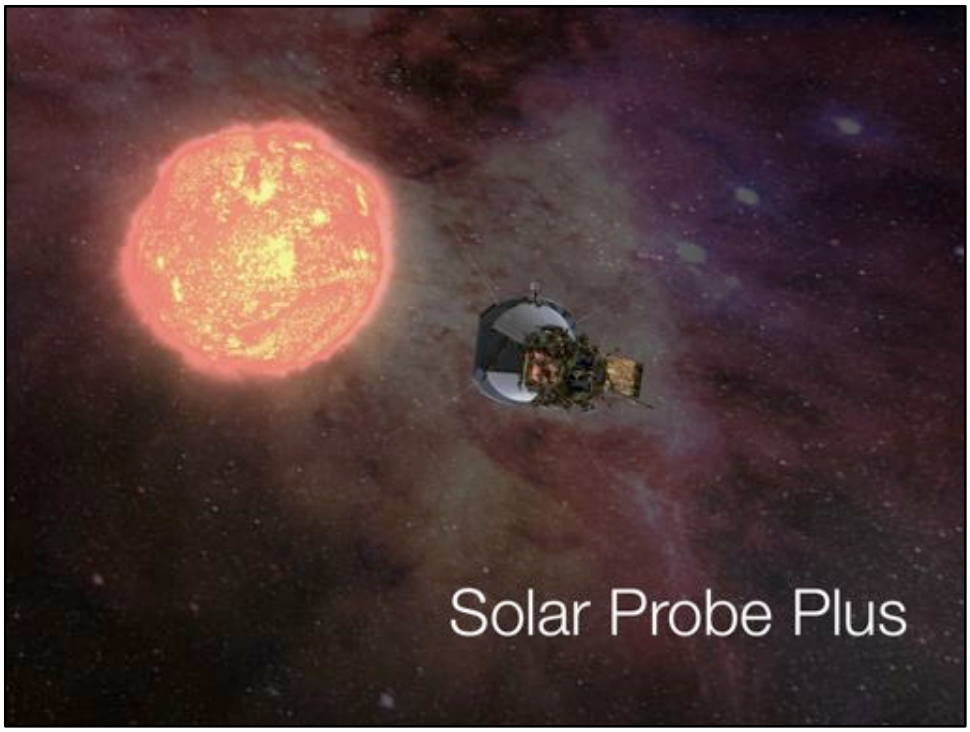
- determining the interaction between **coronal mass ejections** and the **solar wind** in the inner Heliosphere, and
- exploring the structure of the solar wind at a variety of latitudes.

These goals require use of **multiple instruments in combination**

Instruments range from

- near-disk EUV telescopes, to wide field-of-view Heliospheric imagers, to
- instruments which measure magnetic fields and plasma properties in-situ.

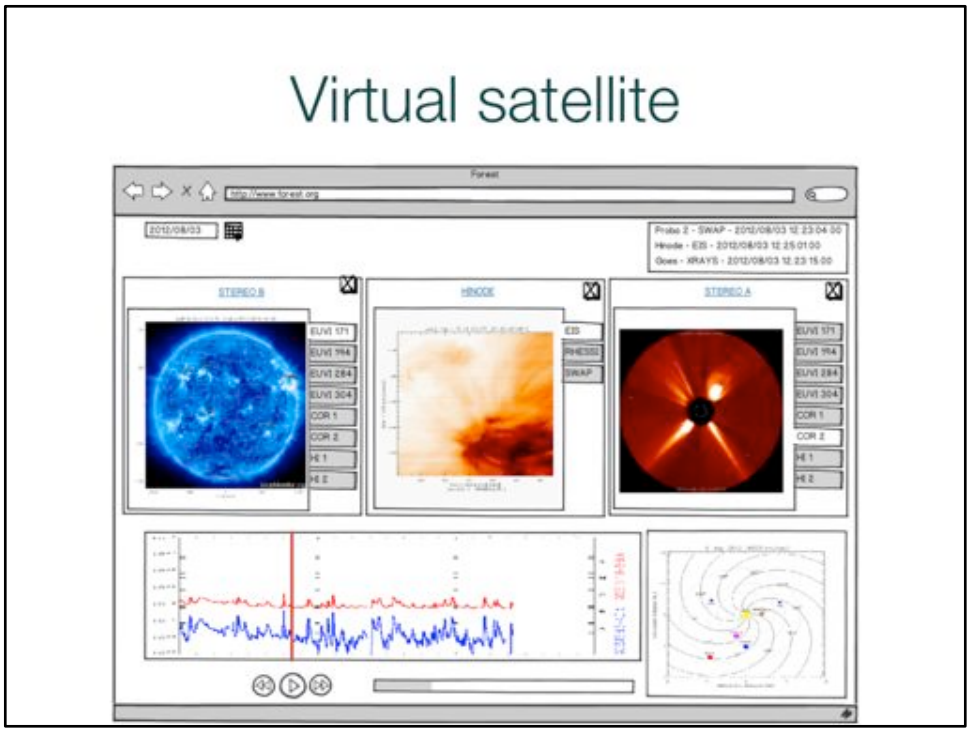
A common data description is therefore essential to facilitate these goals.



Furthermore **NASA Solar Probe Plus** will launch in 2018

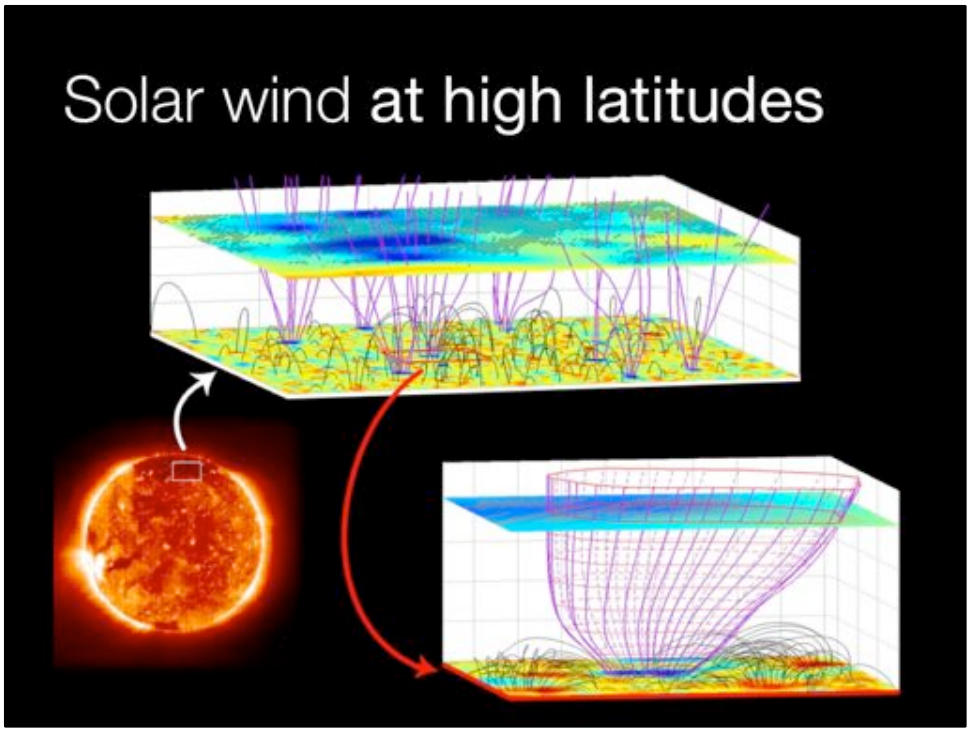
It will get **even closer** to the Sun: **within the orbit of Mercury**.

There is a great opportunity to use **coordinated observations from Solar Orbiter and Solar Probe Plus** to explore the Sun and the heliosphere.



As Solar Orbiter will not be launched for several years, we have devised a **virtual satellite** use case for FOREST.

It combines remote imaging and spectroscopic observation with in-situ solar wind measurements, remote X-ray time series or other time series data.



Initially our virtual satellite will simulate **a single mission multi-instrument case**.

properties of the **solar wind at a variety of solar latitudes** (e.g., Figure 2).
 * **identify a coronal hole in EUV images**
 * combine magnetorgrams to confirm magnetic properties
 * EUV spectra

This picture was constructed from SOHO instruments

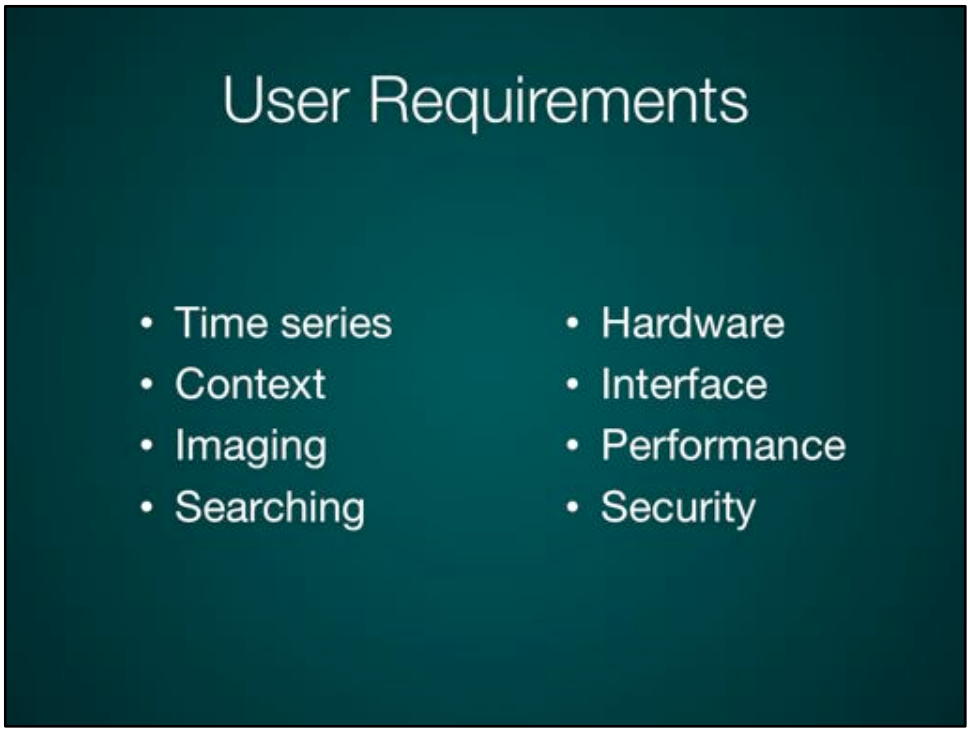
A scientist may want to identify the source of a high speed solar wind stream in the Sun's lower atmosphere. The first step in this process is to observed using the Extreme-Ultraviolet Imager (EUI) instrument by visual inspection or using an image processing technique, such as the HELIO CHARM algorithm. Next, they may want to **combine this with line-of-sight magnetograms** from the Phi instrument in order to confirm that the coronal hole candidate is located within a region of the solar atmosphere that has a dominant polarity. In order to determine the velocity of the nascent solar wind in the transition region, EUV spectra from SPICE will be required. Overall, the scientist will need to select and combine data from three remote sensing instruments (EUI, Phi, and SPICE) in this first step of his/her data analysis. Next, the properties

Our virtual satellite will be extended to include the requirements relating **to multi-point observations**, in this case

to track solar storms and solar wind flows from their origin at the Sun's surface, to their impacts at the planets, and other locations in the Heliosphere.

This can only be achieved using a **fleet of spacecraft located at multiple points** in the Solar System.

Common data description for **solar disk** and **solar coronograph** images.
Use a **Propagation model.**
Identify other affected spacecraft.



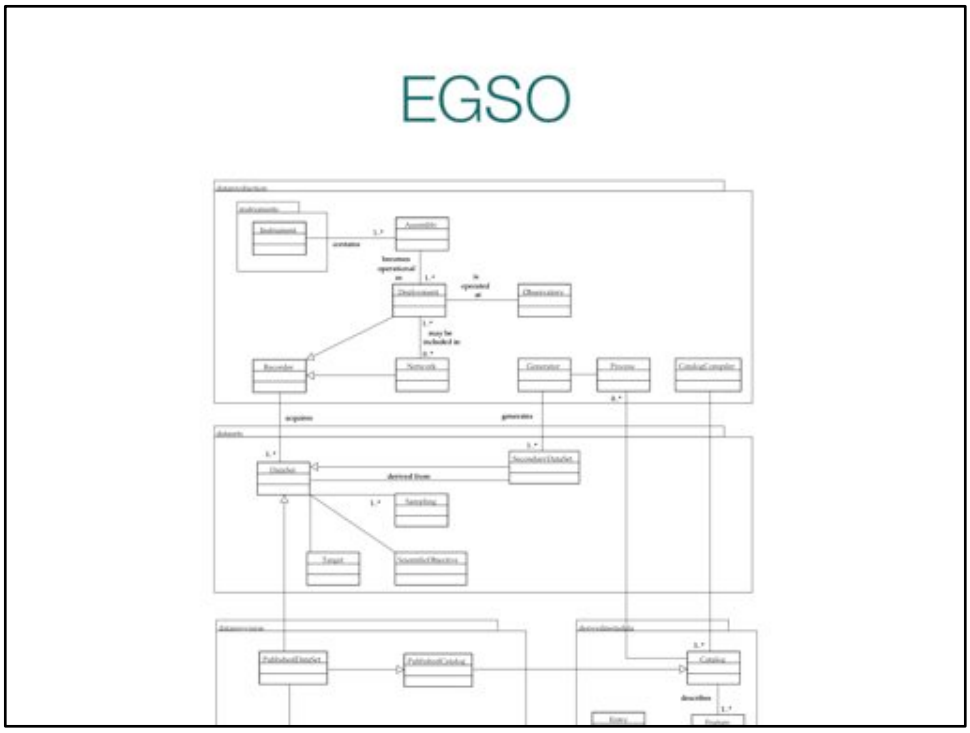
From the use cases we have extracted user requirements

Search by date, instrument, observation type;
Semantic search of features and events;
Display of a variety of images and time-series; and
Display of spacecraft, instrument, observation details.

This leads into definition of a **data model for FOREST**

We reviewed some of the existing work on **data models for solar Vos**

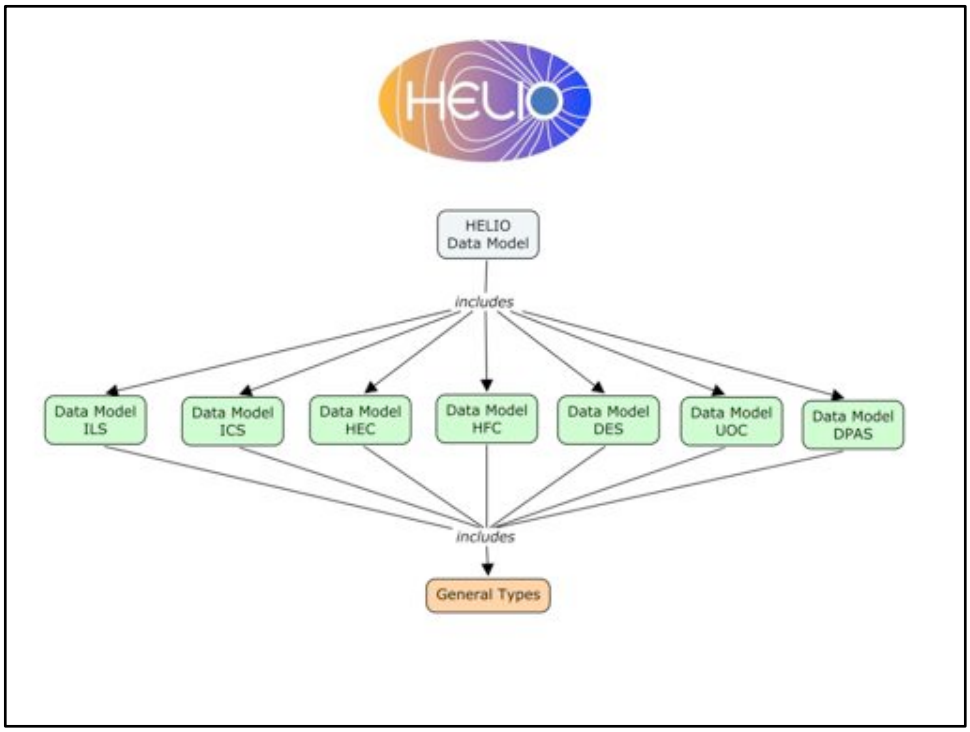
We are also conscious of interoperability with commonly used formats in our datasets, such as **FITS**



European Grid of Solar Observatories

Originated approx 10 years ago.

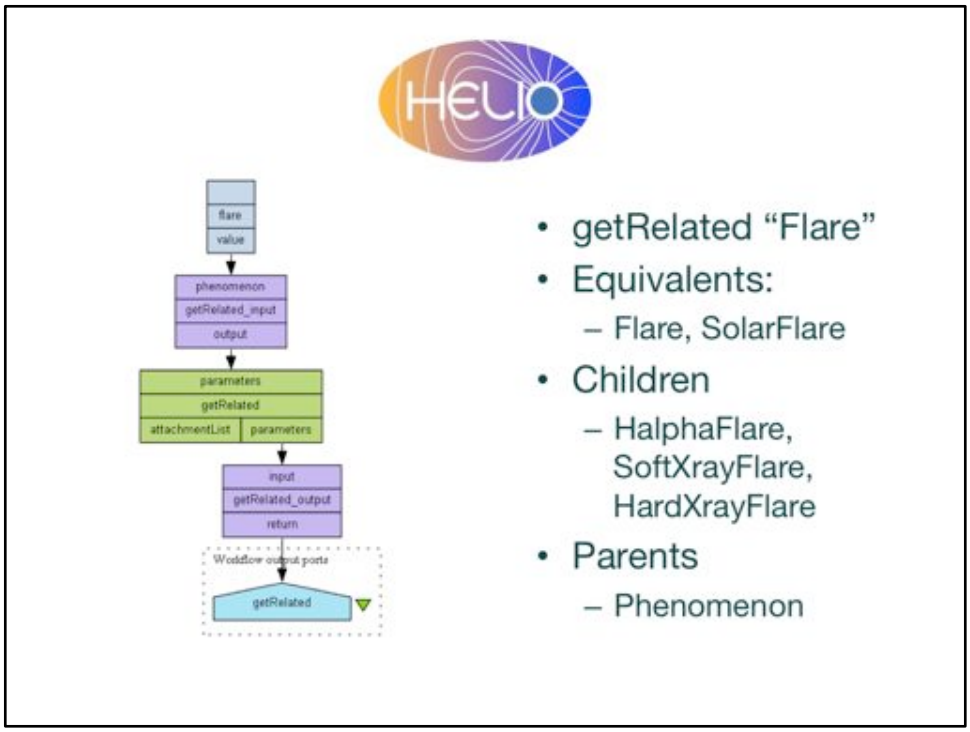
- high-level relationships
- Provenance, access
- Interest in interop, but doesn't provide full semantic info
- **Universal observing catalogue**



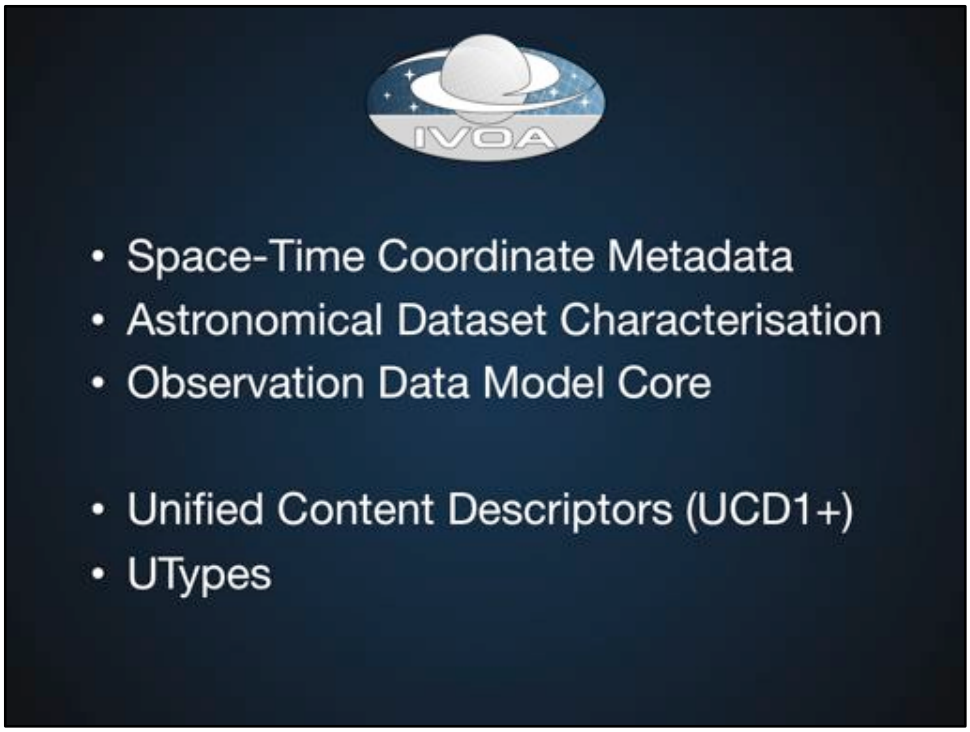
Data model built in parts
Universal observing catalogue idea carried over from EGSO
Hope for re-use in other heliophys projects

Use of VOtables, UCDs: Scope to align with IVOA

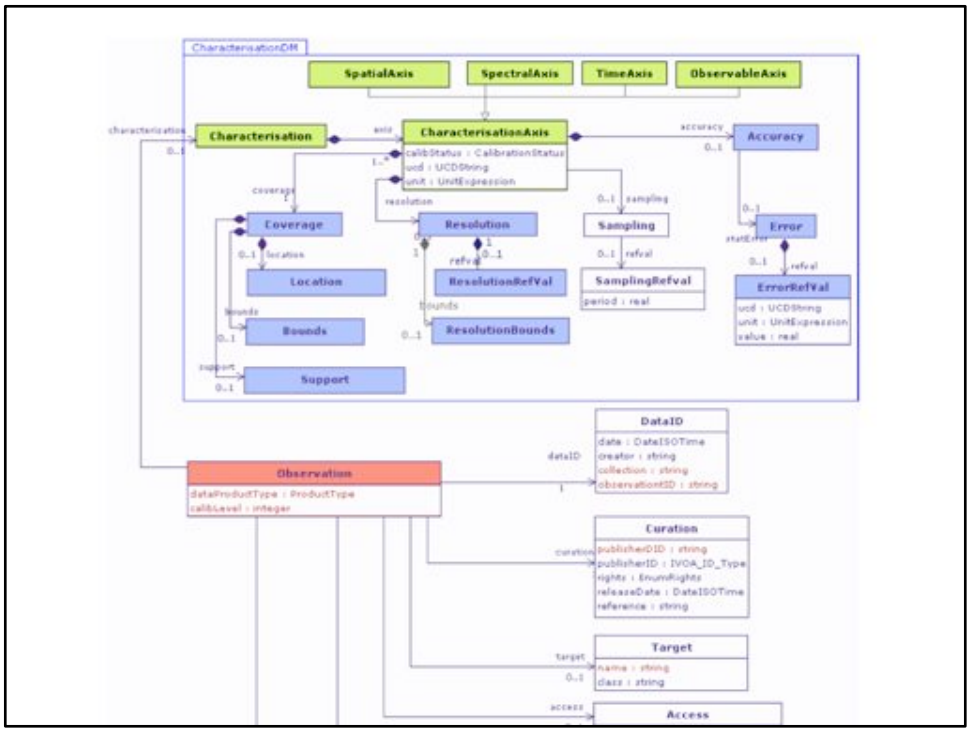
Good semantics for HELIO data, especially events and features.
Semantic links between HELIO and **SPASE**



Example **semantic mapping service**, based on OWL **ontology** of HELIO and SPASE terms



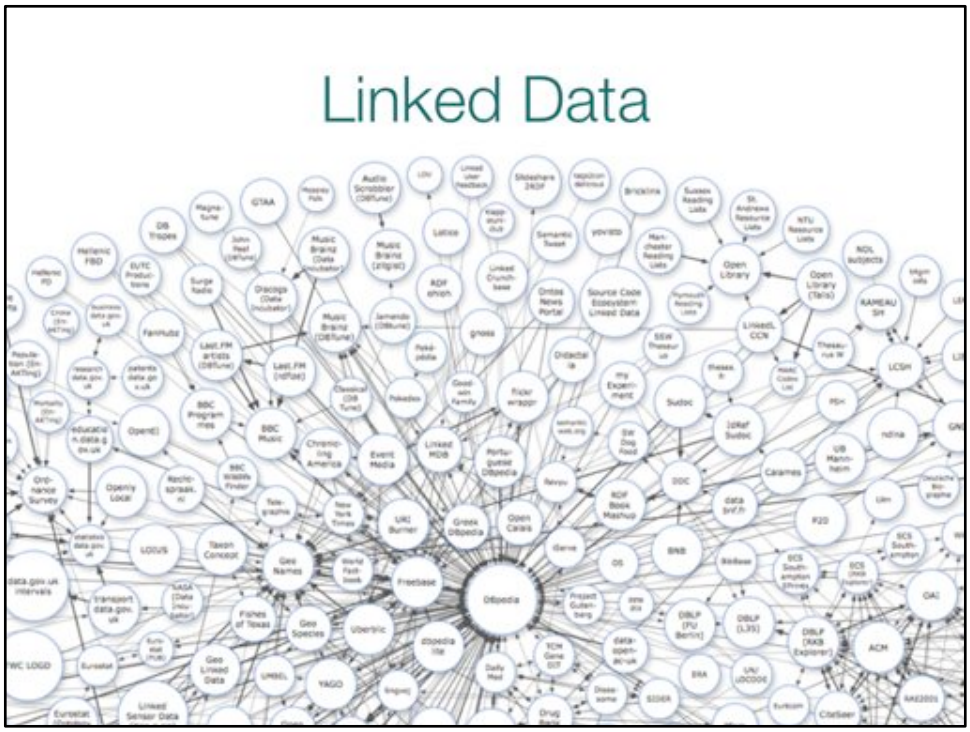
International Virtual Observatory Alliance



Obs Core and Characterization look like a good basis also for heliophysics data

Need different coordinate systems for heliocentric and heliographic and spacecraft centric.

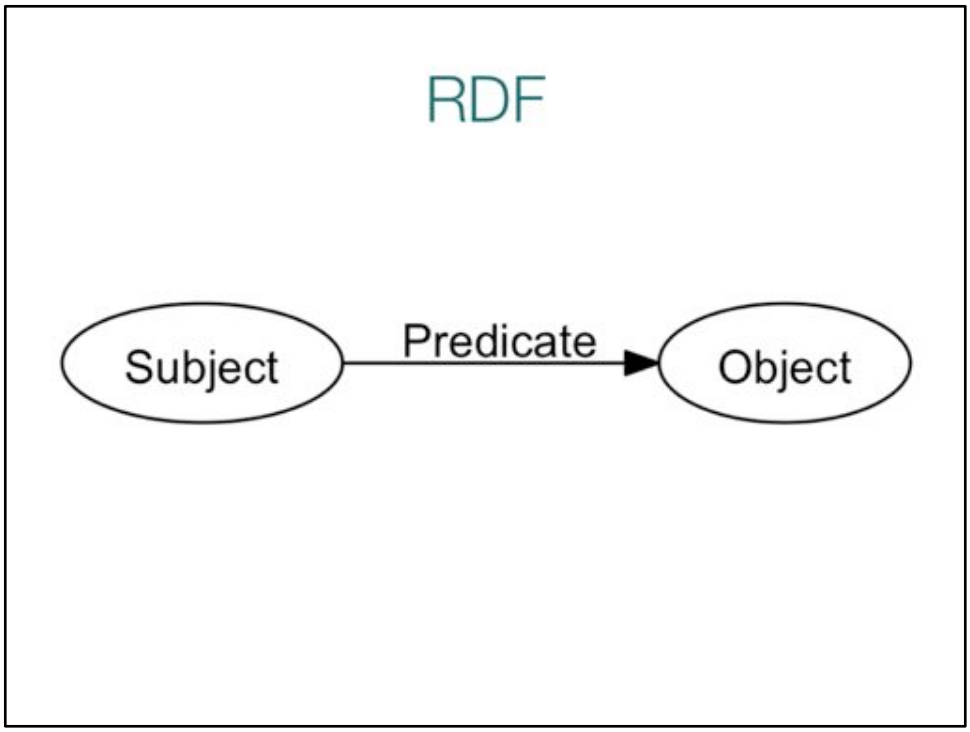
Need to define for in-situ measurements



Interested in bring Solar data into the web of data.

Resolvable URIs, RDF, >1000 triples, >50 links

RDF



Resource Description Framework
A **subject** resource can be described by specifying a number of **predicate–object** relations

An example would be that a **Person** identified

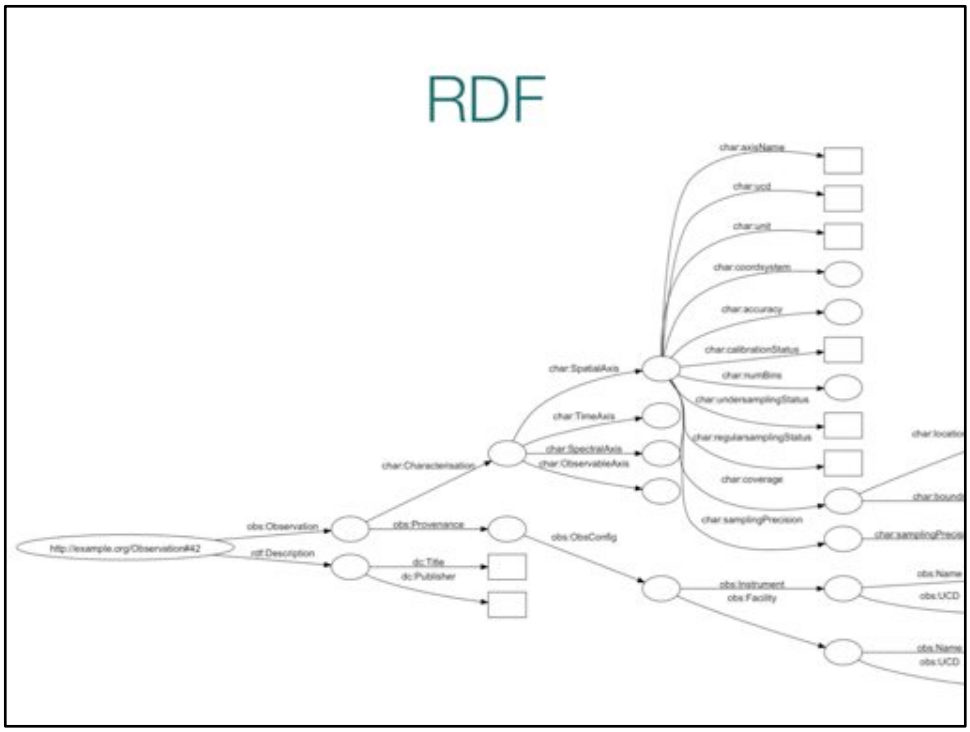
The types of the subject, predicate and object can be specified with reference to external identifiers, definitions or schemata. For example, the 'title' element from the Dublin Core Metadata Set is used to mean the formal name of a resource (e.g. a book) and so it could not be mistaken to mean a personal title (e.g. Miss, Dr, etc.)

Subject and object can be “anonymous” or “opaque”

Dublin Core

- Title
- Creator
- Subject
- Description
- Publisher
- Contributor
- Date
- Type
- Format
- Identifier
- Source
- Language
- Relation
- Coverage
- Rights


FOREST Model



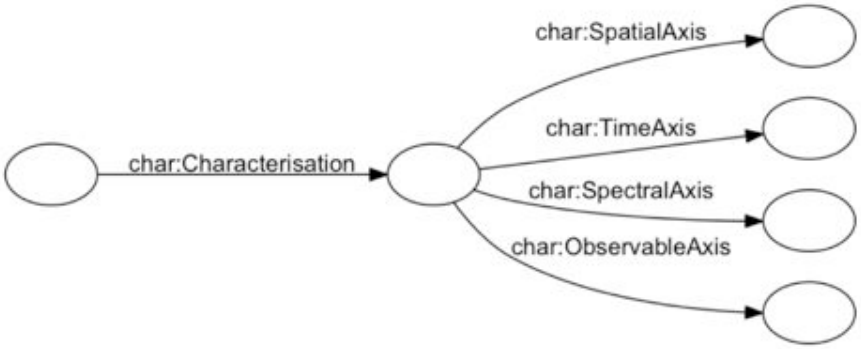
RDF provides the framework for linking data models

- Primarily **IVOA**
- **Dublin Core**
- HELIO data model elements

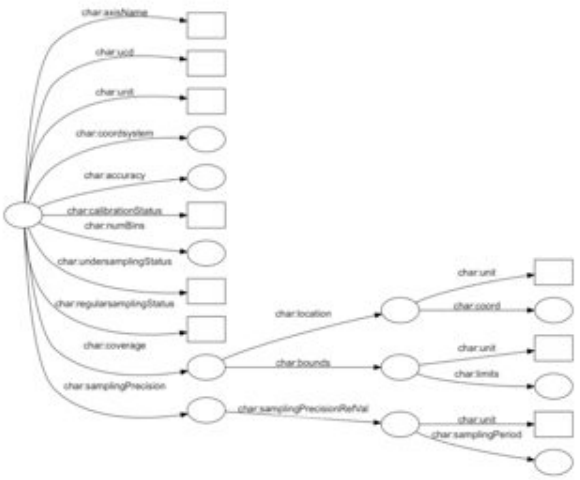
IVOA Observation DM

- **Characterisation**
- **Provenance**
- Access
- Curation
- DataID
- Mapping

Characterisation DM



Characterisation Axis



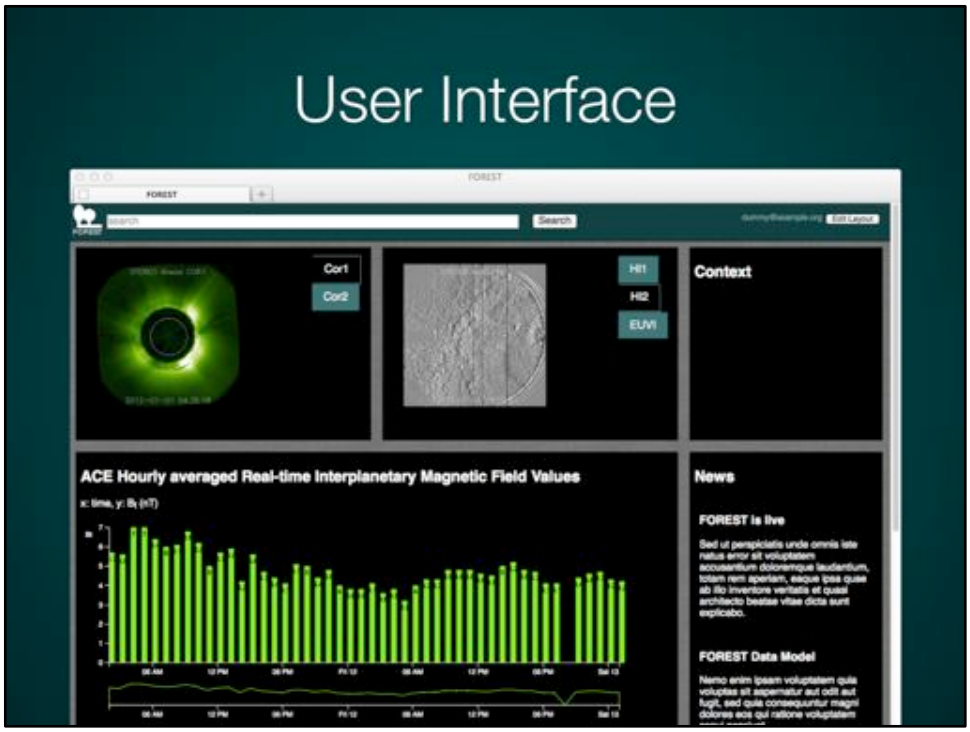
GAVO DaCHS

We have started ingesting data into GAVO Data Center Helper Suite

Provides TAP, ADQL, SIAP
Requires translation of the data model to tables

As mentioned, different **coordinate systems** for heliocentric and heliographic and spacecraft centric.

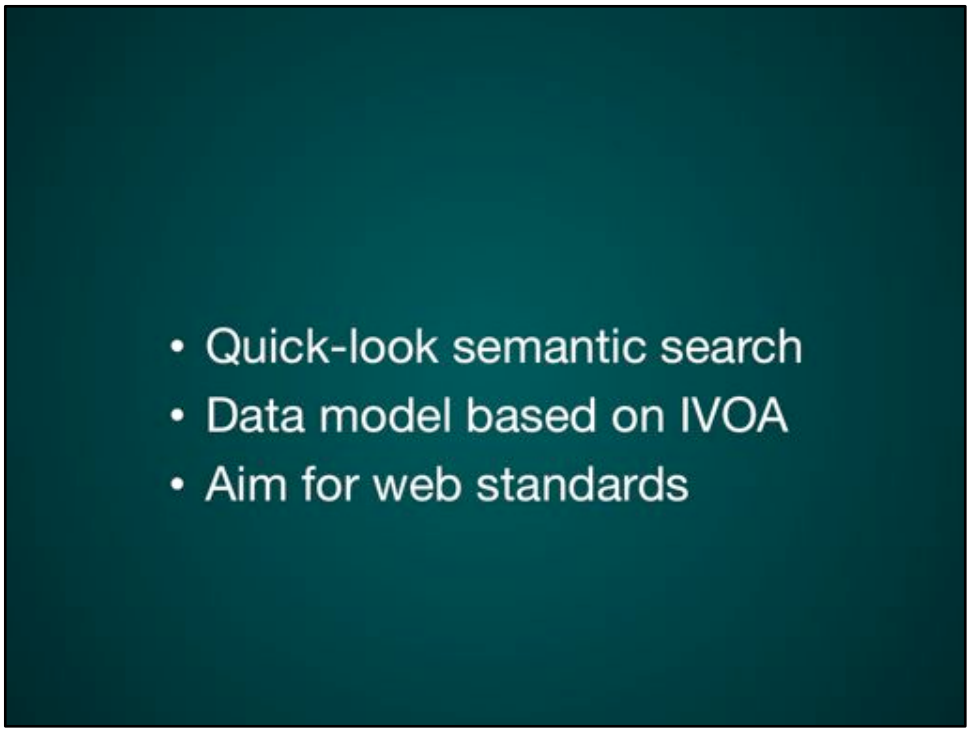
Need to define for in-situ measurements



The “App” bit

User interface that pull quick-look images and TSV data from DaCHS

Uses HTML5, jquery, gridster, bootstrap, d3



FOREST is a project developing a quick-look semantic search virtual observatory for heliophysics

Use of IVOA UCDs and Utypes helps
    Standard mapping for keywords to Utypes in DM
Helio-specific terms in HELIO ontology
    UCD and UTypes in Planetary Science (Baptiste Cecconi)
HELIO semantic mapping service:
    Ontology-based mapping between concepts

Space Physics Archive Search and Extract (SPASE) – Heliophysics community
FITS widely used but very lacking in semantic interop. WCS addresses this for coords.

FOREST

David O'Callaghan, Trinity College Dublin – david.ocallaghan@tcd.ie
Shane Maloney, Skytek Ltd. – shane.maloney@skytek.ie

Image credits
Solar Orbiter: ESA
Solar Probe Plus: NASA
Forest: http://www.sxc.hu/profile/Krappweis
Aurora: http://flic.kr/p/997aqT
Star trails: http://flic.kr/p/5dQdk9
HELIO diagrams: http://helio-vo.eu/
Linking Open Data cloud diagram: Richard Cyganiak and Anja Jentzsch. http://lod-cloud.net/

RESTful Web Services

REST = "Representational State Transfer"

- Resources identified by URIs
- Stateless services (client-state on client)
- Uniform interfaces (HTTP GET, PUT, DELETE, ...)

Prototype REST API

/

/{observatory}

/{observatory}/{instrument}

/{observatory}/{instrument}/{detector}

/{observatory}/{instrument}/{detector}/{year}/{month}/{day}

/{observatory}/{instrument}/{detector}/{year}/{month}/{day}/{id}

- GET (text/html): redirect to ./html
- GET (rdf): redirect to ./rdf
- GET (ttl): redirect to ./ttl
- GET (image/png): redirect to external .png
- GET (image/jpeg): redirect to external .jpeg
- GET (image/fits): redirect to external .fits