http://cdpp.eu/

CDPP activities: Promoting research and education in space physics

V. Génot, C. Jacquey, F. Pitout, B. Cecconi, M. Bouchemit, E. Budnik, M. Gangloff, N. Dufourg, N. André, A. Rouillard, B. Lavraud, D. Heulet, J. Durand, D. Delmas, N. Jourdane

Mikel INDURAIN

CDPP
French Plasma Physics Data Centre

- Established in 1998 from a CNES/CNRS collaboration for natural plasma data distribution and archiving : from the ionosphere to the heliosphere
- About 7 FTE, engineers and scientists, main base in Toulouse
- Since 2006, CDPP is strongly involved in the development of data analysis and visualization tools
  - AMDA, 3DView, the Propagation Tool
- Collaboration with PDS (SPASE) resulted in the access to PDS data within CDPP tools (Galileo, Messenger, Maven, …)
- CDPP expertise in data handling and tool development resulted in taking part to several EU and ESA projects aiming at enlarging data distribution via standards (Virtual Observatory concept)
- Mission support activities increased since 2014 when AMDA was chosen to be the multi-instrument quicklook visualization tool for the Rosetta Plasma Consortium team
- Similar role (+ data distribution to ESA) is planned for ESA Solar Orbiter and JUICE. Support to ESA/Athena is also starting
- These activities help promoting science (papers) and education (hands-on)

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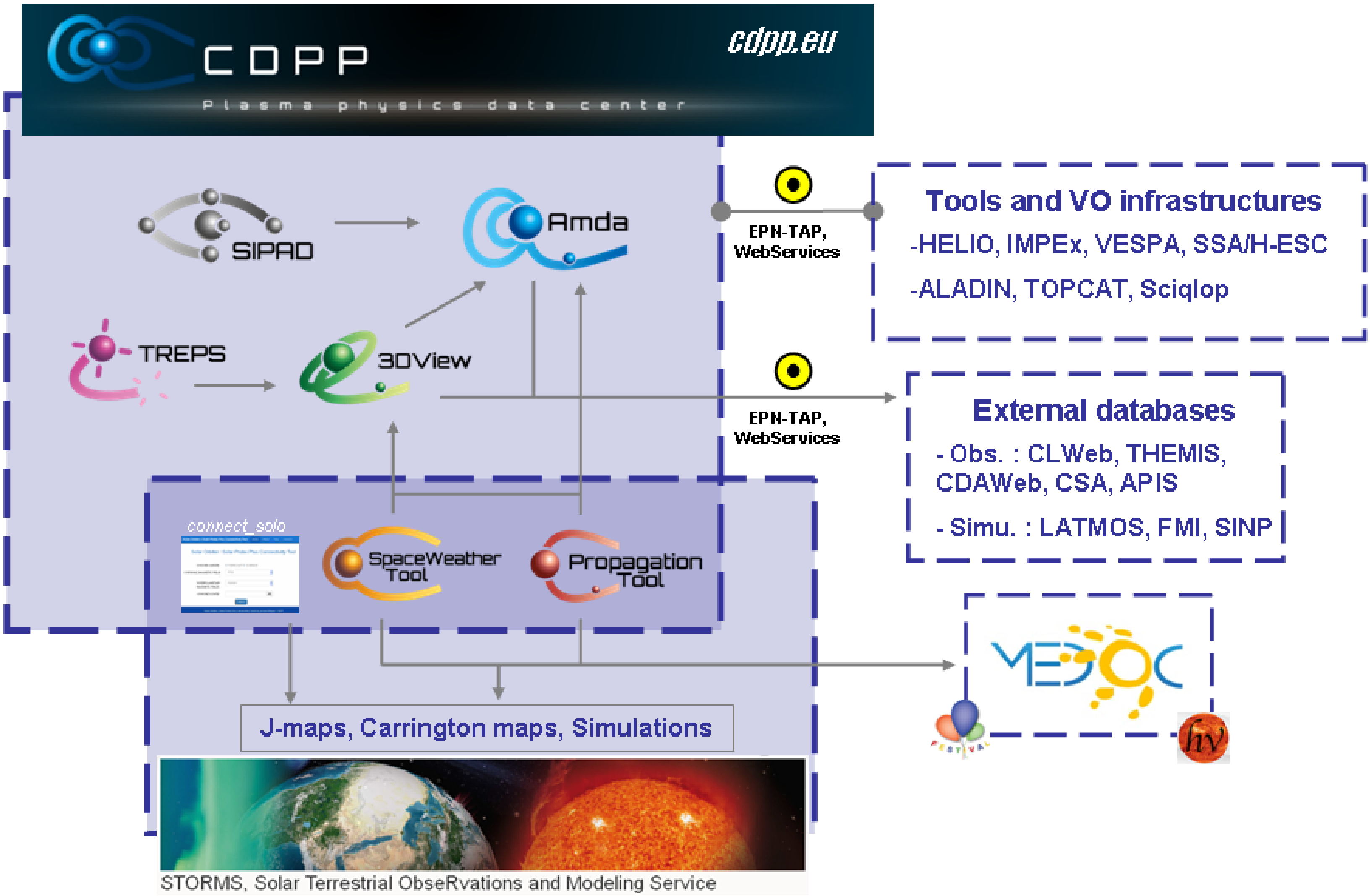
Bases and services at CDPP
the French plasma physics data centre

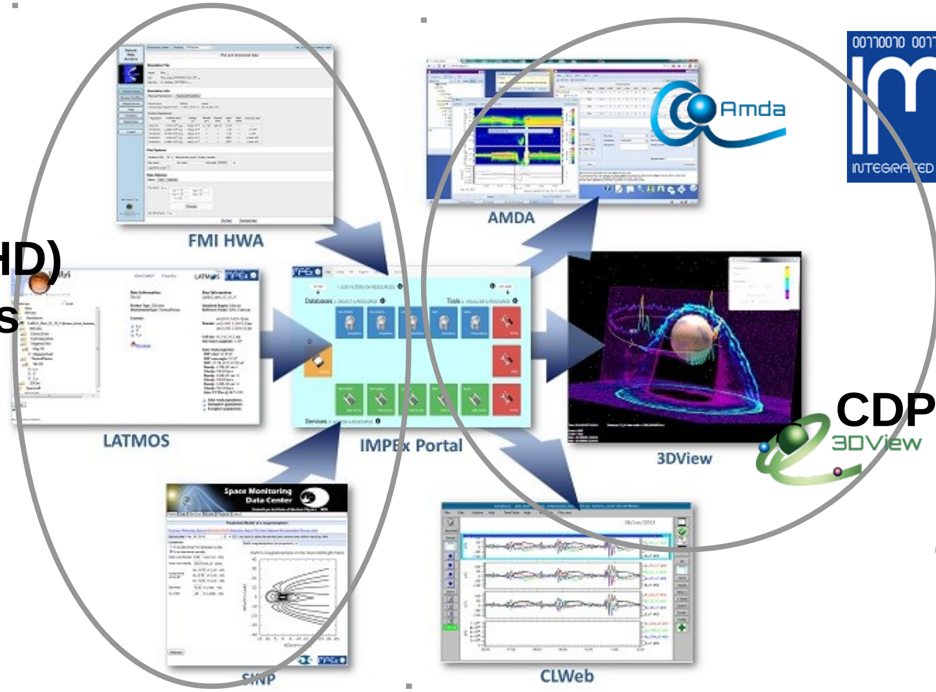


Developping a data + model framework

the experience of the FP7 IMPEx project

2011-2015

Simulation (hybrid, MHD) and model databases



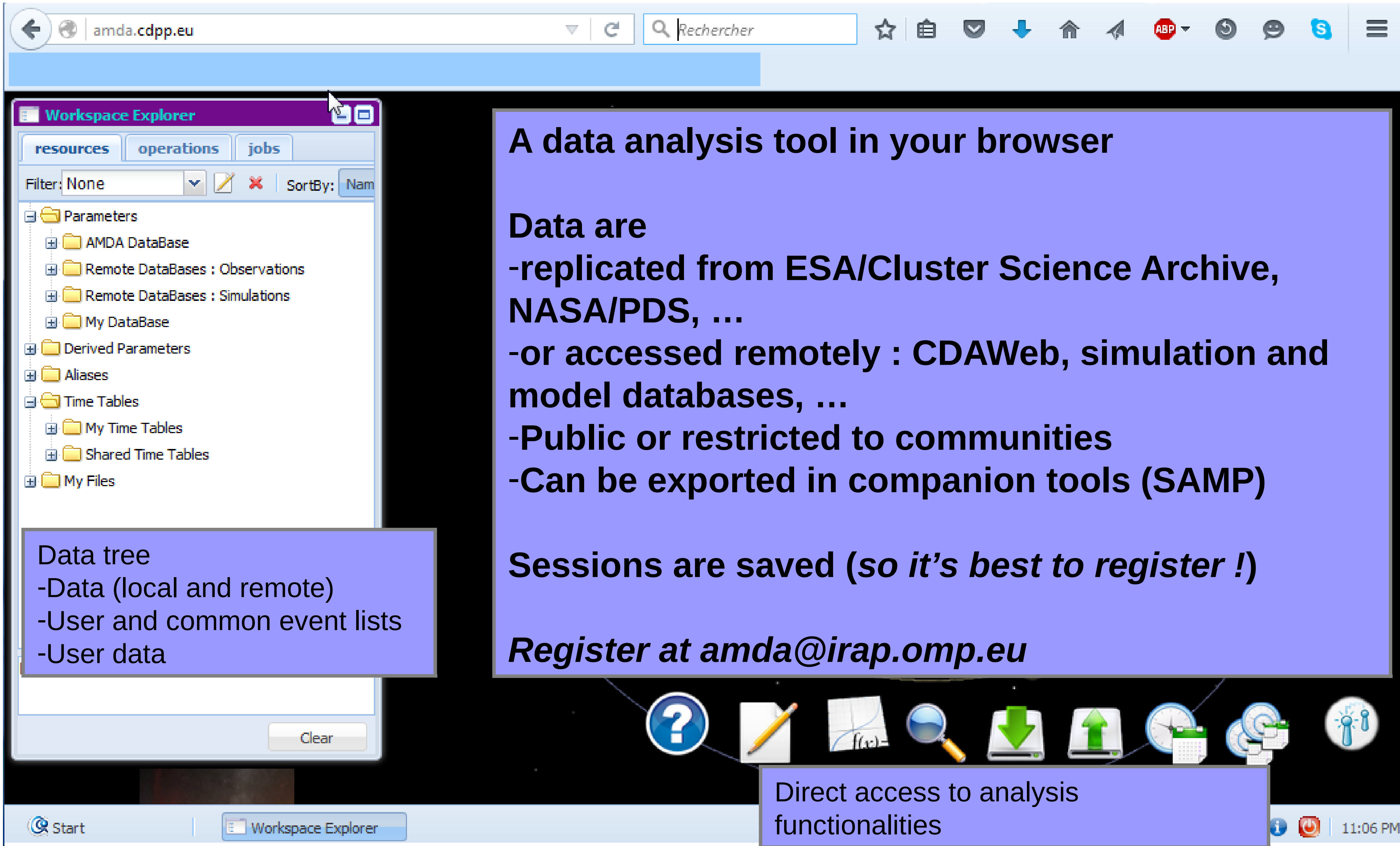
CDPP tools

- **Idea = Access observations and models from the same tools / portal**
- **Moto = Keep expertise local**
- **Approach = Develop**
  - **a light exchange protocol (use of web services)**
  - **common methods for data treatment (interpolation, planar cuts, …)**
  - **a common data model (extend the SPASE model used for observations)**

http://amda.cdpp.eu/

Automated Multi Dataset Analysis

http://amda.cdpp.eu/



A data analysis tool in your browser

Data are
-replicated from ESA/Cluster Science Archive, NASA/PDS, …
-or accessed remotely : CDAWeb, simulation and model databases, …
-Public or restricted to communities
-Can be exported in companion tools (SAMP)

Sessions are saved (*so it's best to register !*)

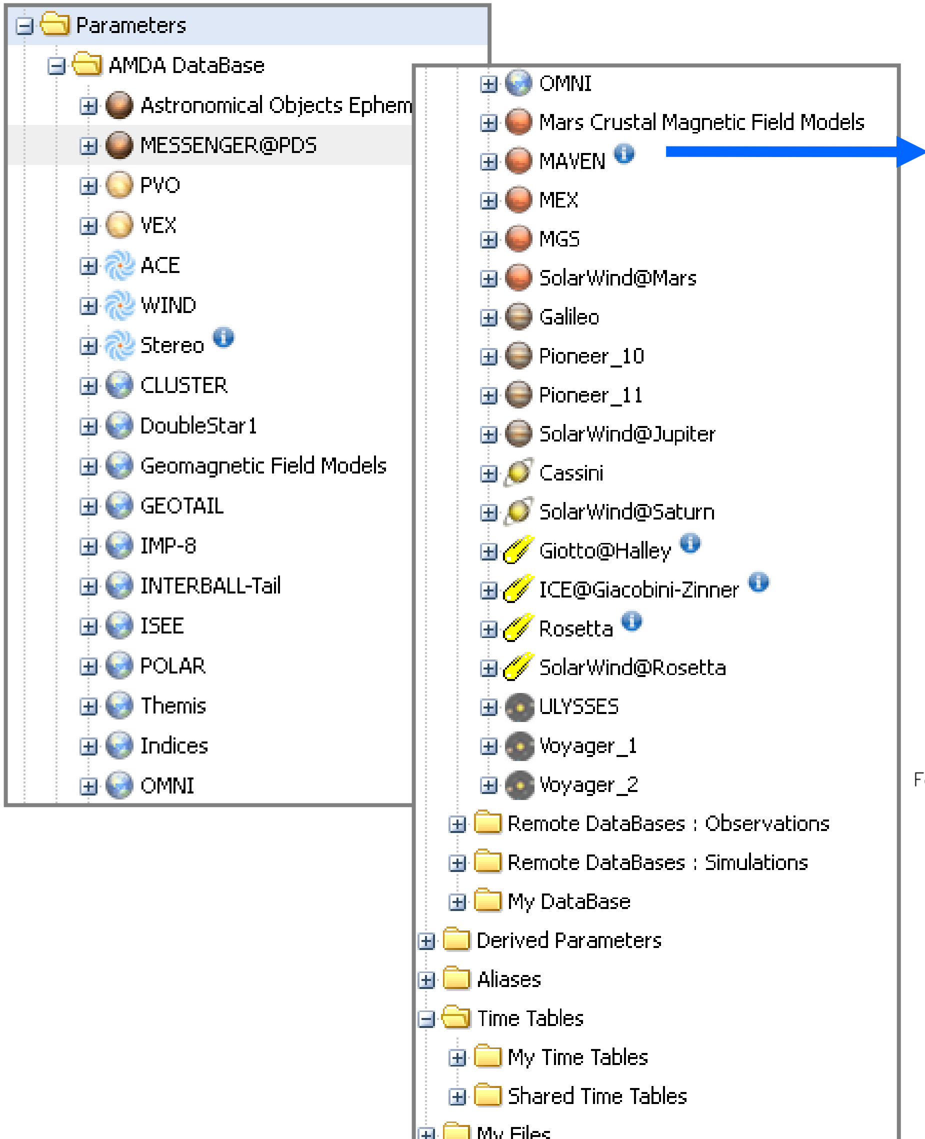
Register at amda@irap.omp.eu

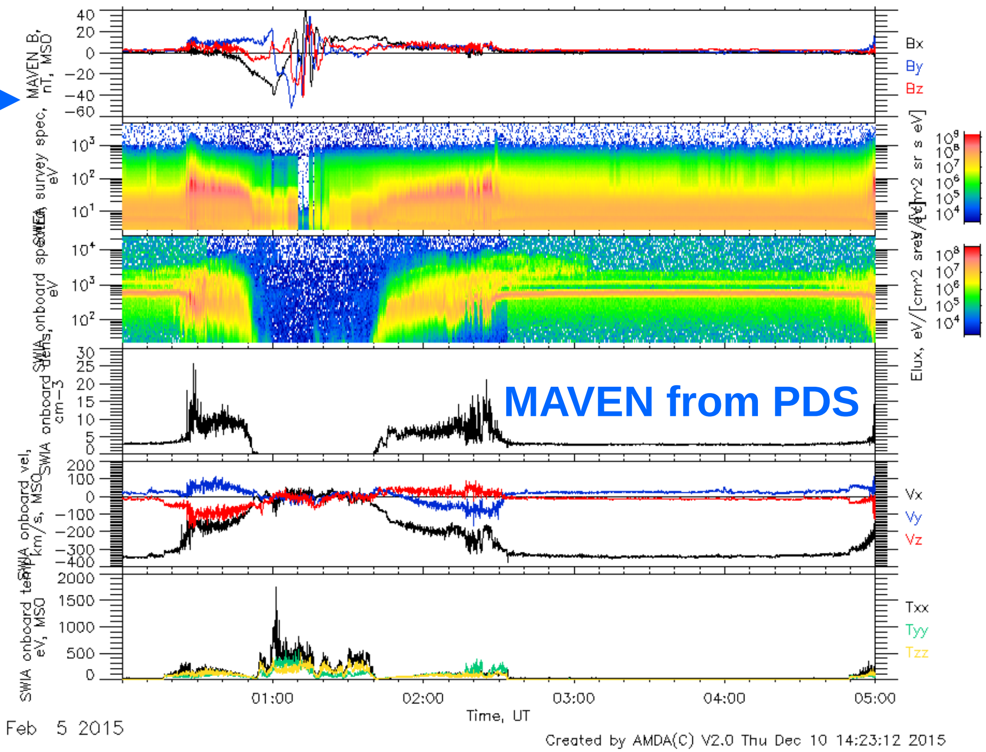
Data tree
-Data (local and remote)
-User and common event lists
-User data

Direct access to analysis functionalities

Datasets available in the online tool CDPP/AMDA

http://amda.cdpp.eu/





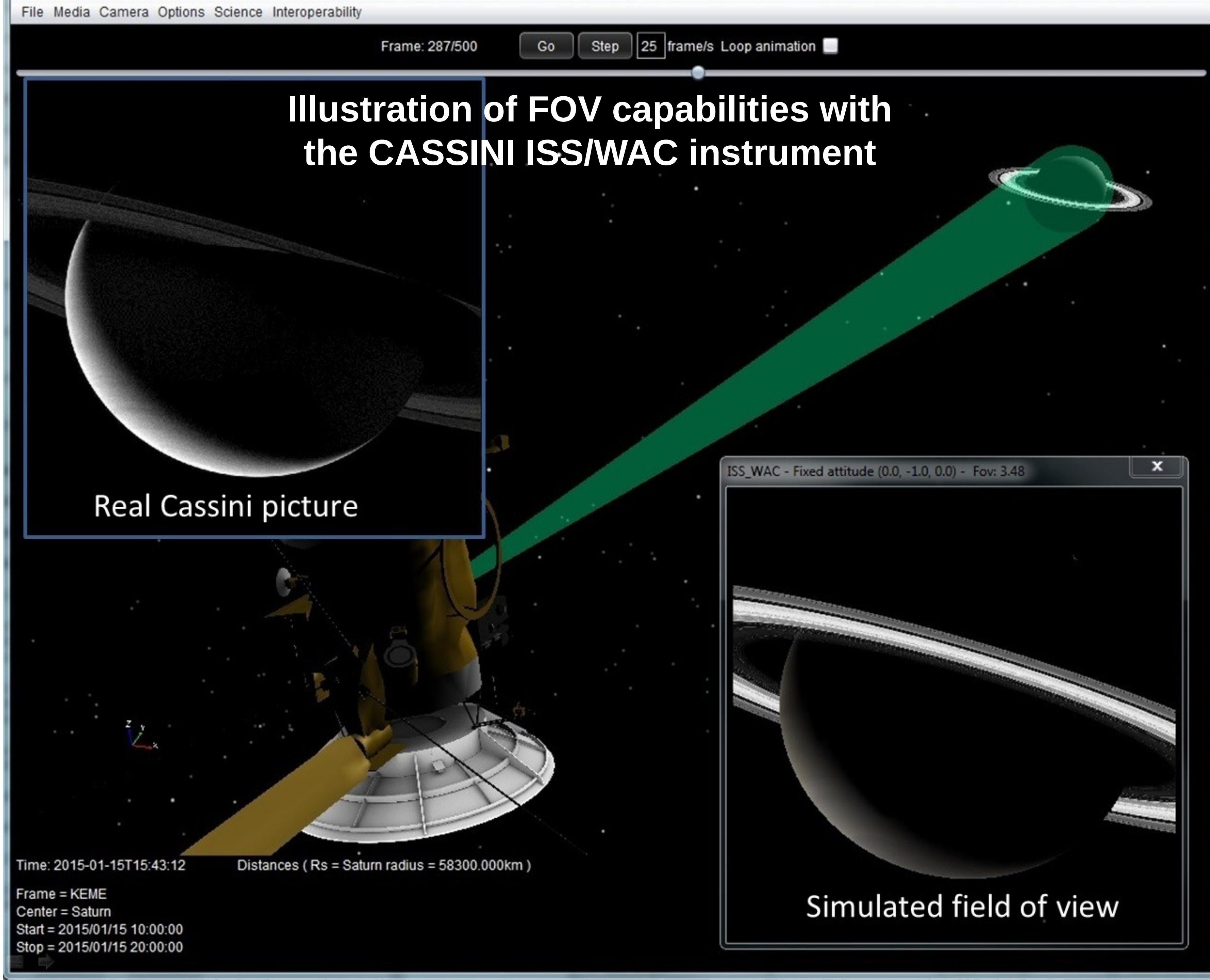
- Plot
- Data mining and combination
- Cataloguing (event lists)
- Upload / download
- Statistics (long term analysis)

http://3dview.cdpp.eu/

3DView

Orbitography in 3DView

- From SPICE kernels
  - From NASA/NAIF, ESA or NASA/SSC
  - Position, attitude, solar array, field of view (FOV)
- From position file uploaded by the user
- Available spacecraft
  - ACE, Wind, Geotail, Cluster, MMS, STEREO, Bepi-Colombo, Solar Orbiter, Solar Probe +, JUICE, Juno, MAVEN, MESSENGER, Mars-Express, Venus Express, THEMIS, Voyager, …

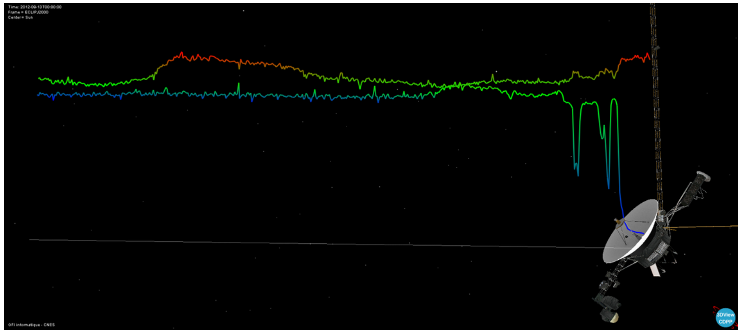

File Media Camera Options Science Interoperability
Frame: 287/500
Go
Step
25 frame/s Loop animation
Illustration of FOV capabilities with the CASSINI ISS/WAC instrument
Real Cassini picture
ISS_WAC - Fixed attitude (0.0, -1.0, 0.0) - Fov: 3.48
Simulated field of view
Time: 2015-01-15T15:43:12
Distances (Rs = Saturn radius = 58300.000km)
Frame = KEME
Center = Saturn
Start = 2015/01/15 10:00:00
Stop = 2015/01/15 20:00:00

Data handling functionalities 1/2

Display of observational data from

- NASA/CDAWeb
- CDPP/AMDA (*to be federated in the SSA/H-ESC*)
- Cluster Science Archive (*soon*)
- User data upload

Scalar, vector and spectrogram along spacecraft trajectories

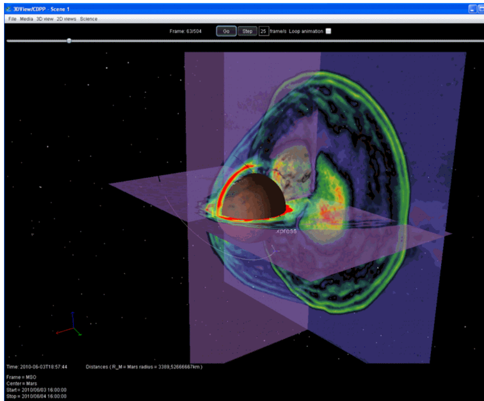


Data handling functionalities 2/2

Display simulation runs (cubes) from hybrid and MHD codes

- From LATMOS (*R. Modolo et al.*)
- From FMI (*Kallio et al.*)

Plane cuts, interpolation along spacecraft trajectory, field/flow line extraction, …



Embedded models

- Tsyganenko 96 and A2000 (magnetic field)

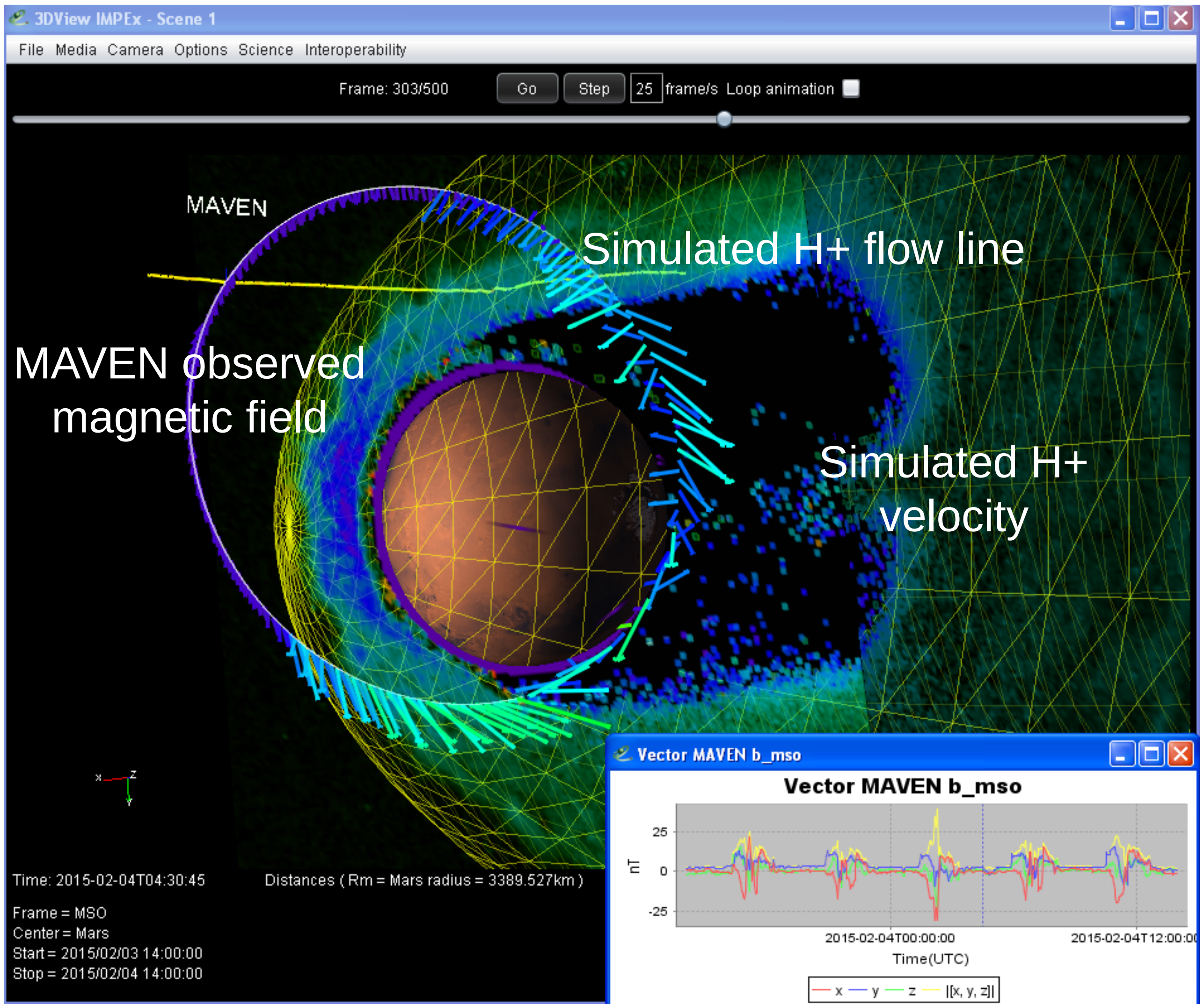
  - dynamic : takes inputs from OMNI
- Parker field lines

  - dynamic : takes velocity inputs from ACE, STEREO, …
- Heliospheric current sheet (*Pei et al., 2012*)
- Mars crustal field models
- Bow shock and magnetopause for planets

  - dynamic : takes SW pressure as input

Combining times series analysis and 3D visualization in context

http://3dview.cdpp.eu/

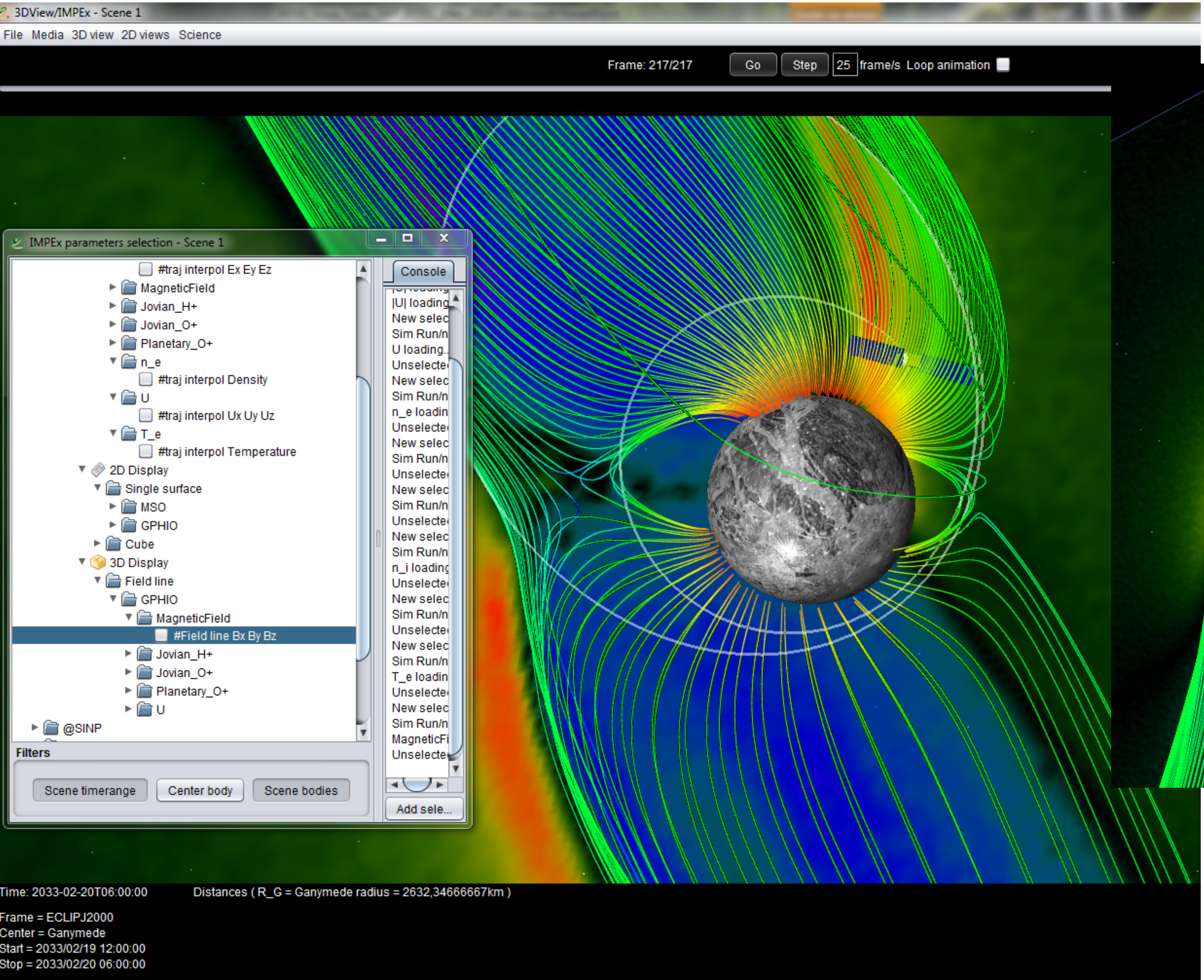


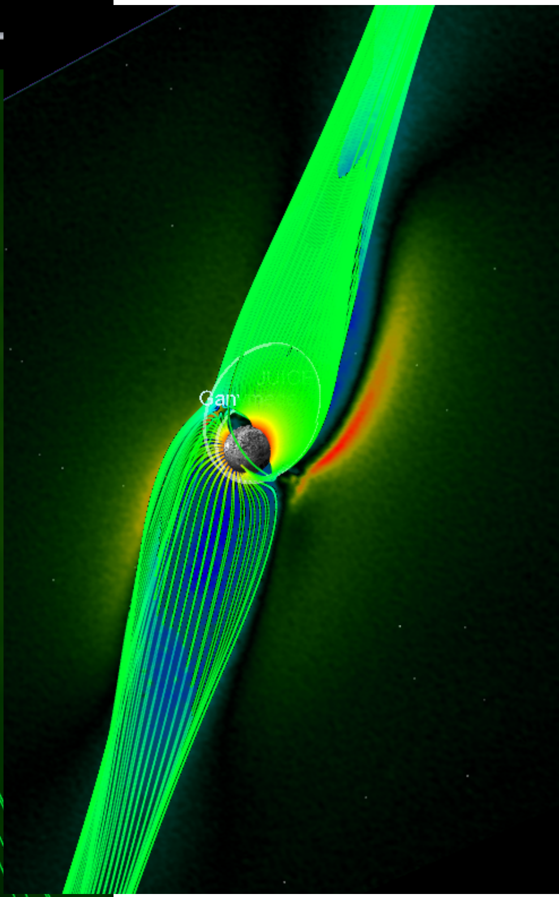
3DView embeds direct connexion to external databases

•Mars simulation from LATMOS database

•MAVEN data from AMDA (PDS)

High level data products: Field/flow lines



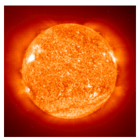


JUICE around Ganymede in 2033

http://propagationtool.cdpp.eu/

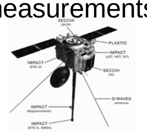
Propagation Tool

The Propagation Tool



Solar perturbation

In-situ measurements



Radial propagation (drag model), co-rotation, SEP propagation

http://propagationtool.cdpp.eu/

Helps -timing structure propagation from source to target
-linking in-situ and remote observations

Propagation Tool

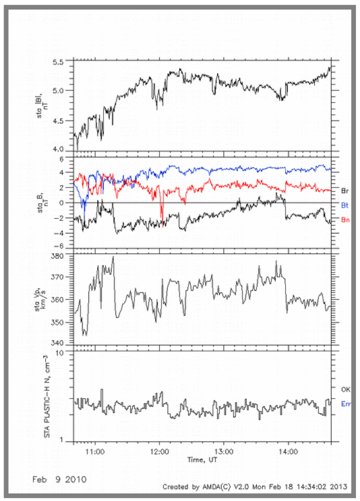
http://propagationtool.cdpp.eu/

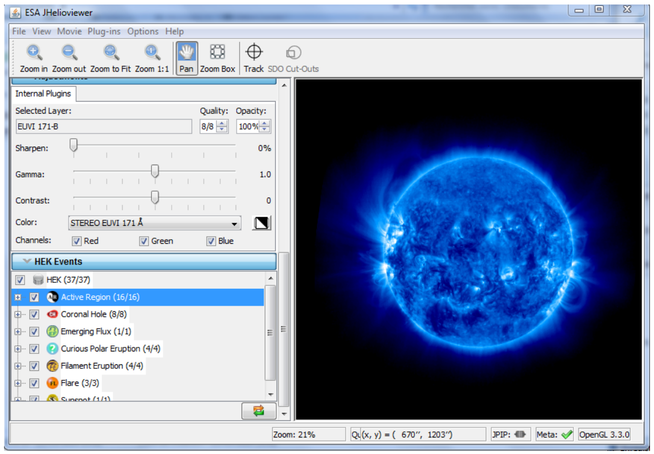
$T_{S/C}$ T_{sun}

AMDA plot

MEDOC database / JHelioviewer

In-situ data





Solar data

- Developed by GFI company under CNES funding
- Designed by A. Rouillard, B. Lavraud and the STORMS team at IRAP based on a FP7 HELIO initial concept
- Used to distribute STEREO catalogues obtained during the FP7 HELCATS projects http://www.helcats-fp7.eu/
- Gives access to J-Maps (real and simulated) and carrington maps,

Mission support

- CDPP is formally involved
  - in the data distribution and archiving (in connexion with ESA) of
    - Solar Orbiter / SWA (ions & electrons)
    - JUICE / RPWI (fields & waves)
  - In environment modeling (plasma at L2) for
    - Athena / X-IFU
- The involvement of CDPP in Rosetta Plasma Consortium data visualization from 2014 has been a test-bed for further developments

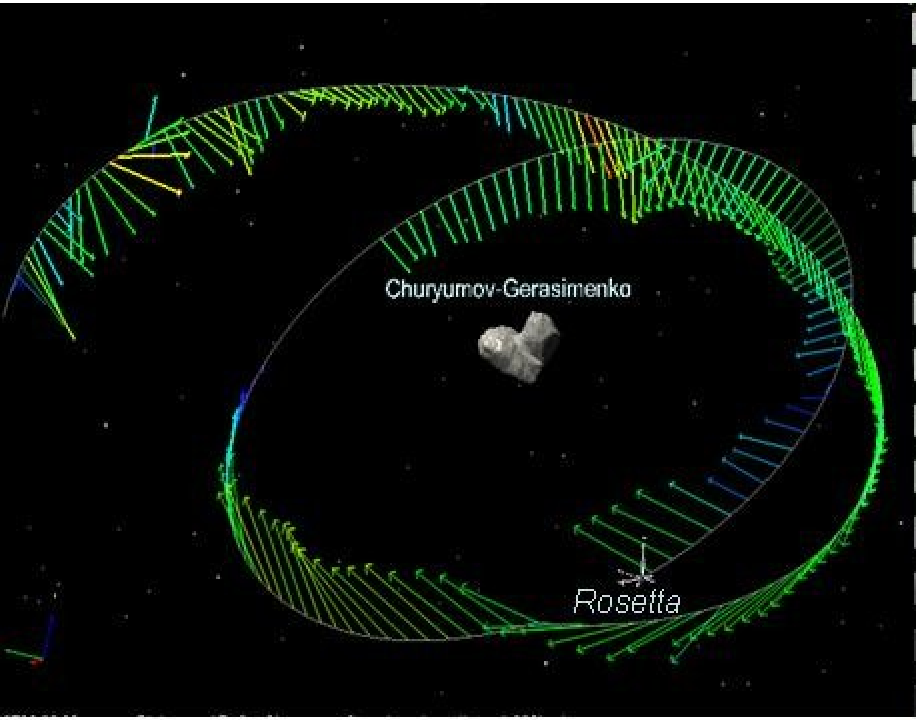
Use of the CDPP tools in the Rosetta context

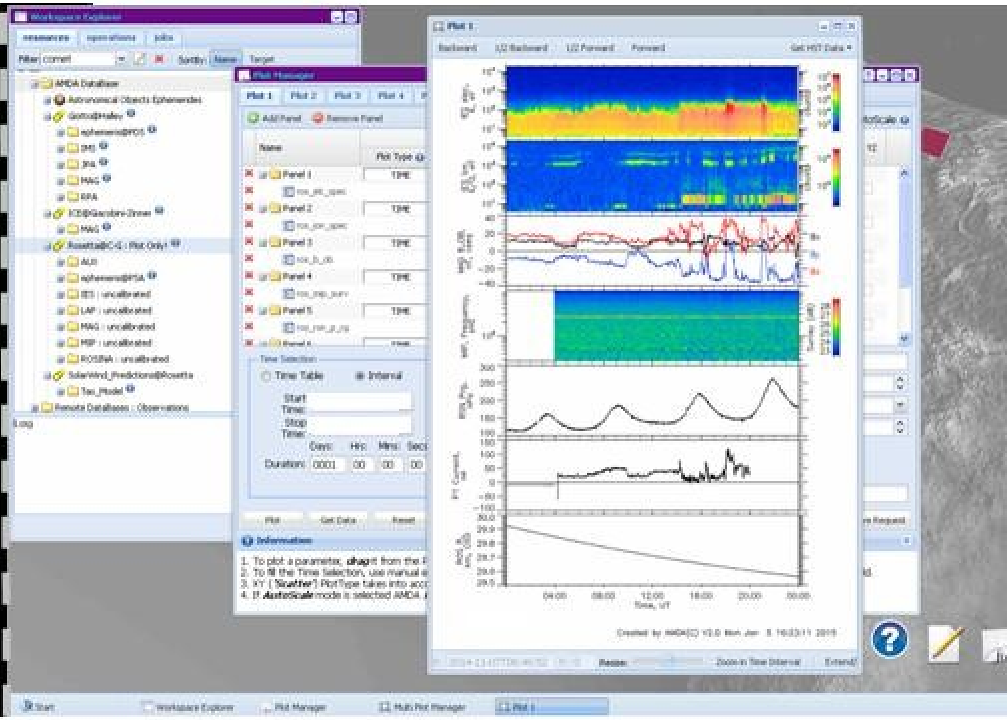
in-situ and model data
in 3D interactive scenes
3dview.cdpp.eu

3DView

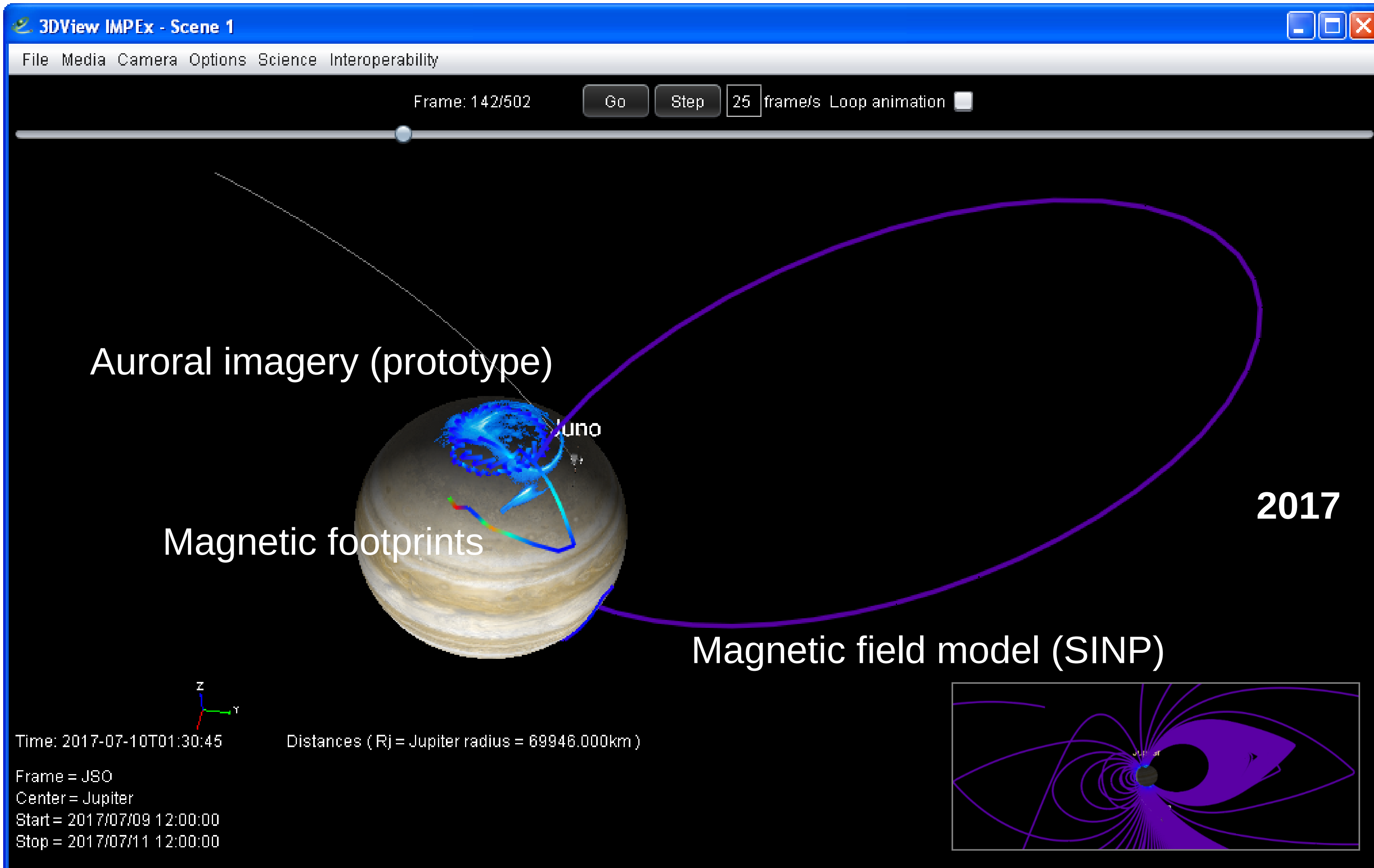
Amda

database and analysis tool
amda.cdpp.eu

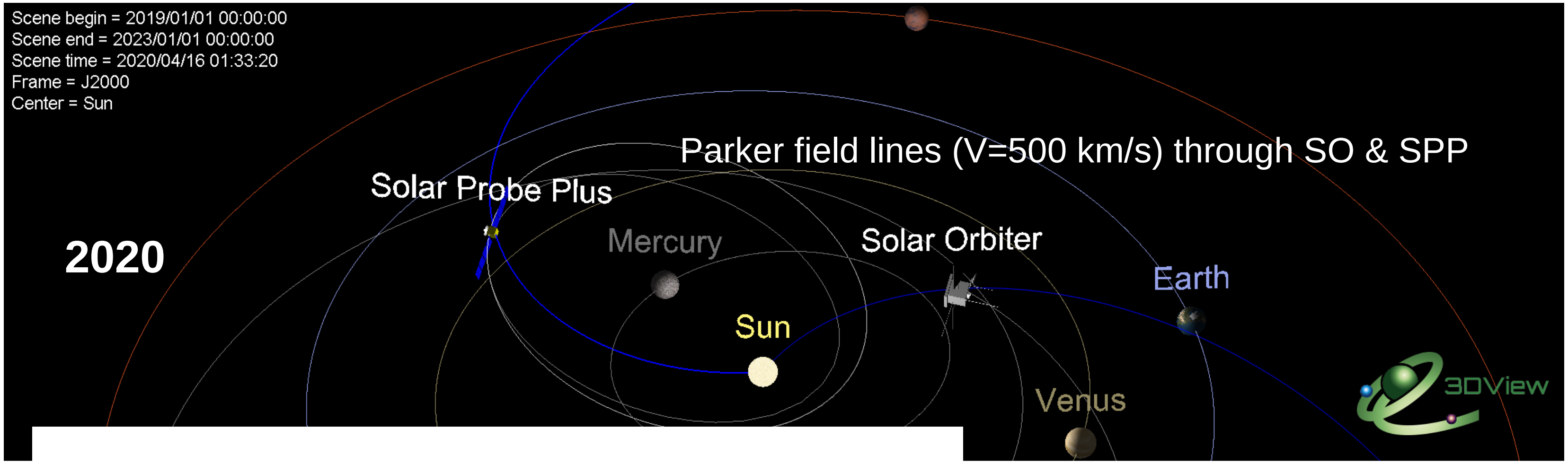


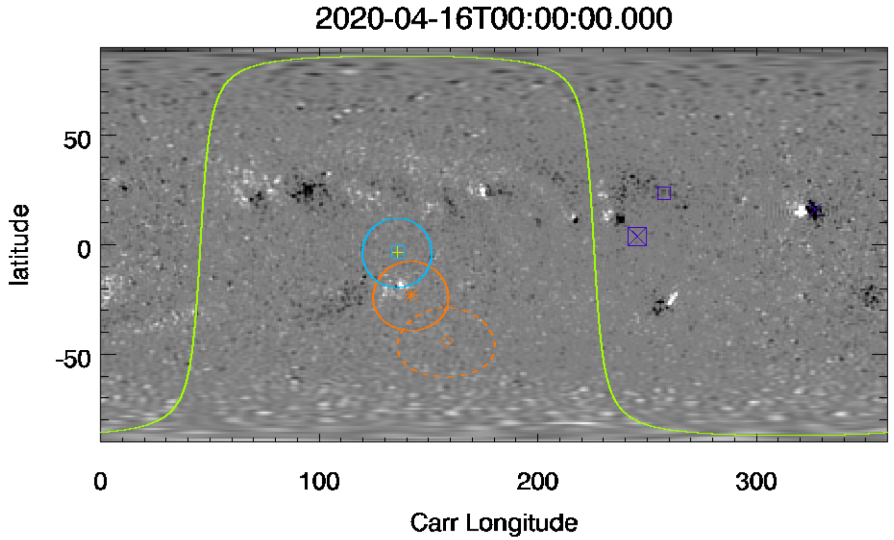


Preparing JUNO : integrating UV images and magnetic field models



Preparing Solar Orbiter : magnetic connectivity





EUI FOV

FOV along field line

- Slow wind (dash)
- Fast wind

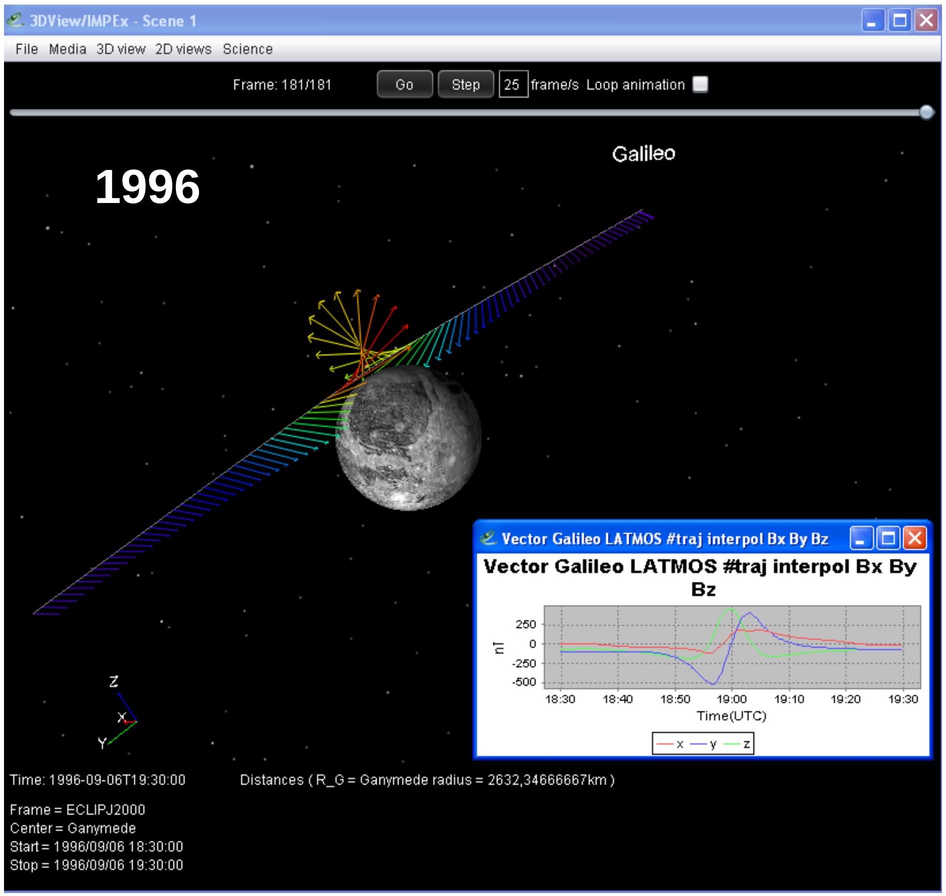
Limb

SPP

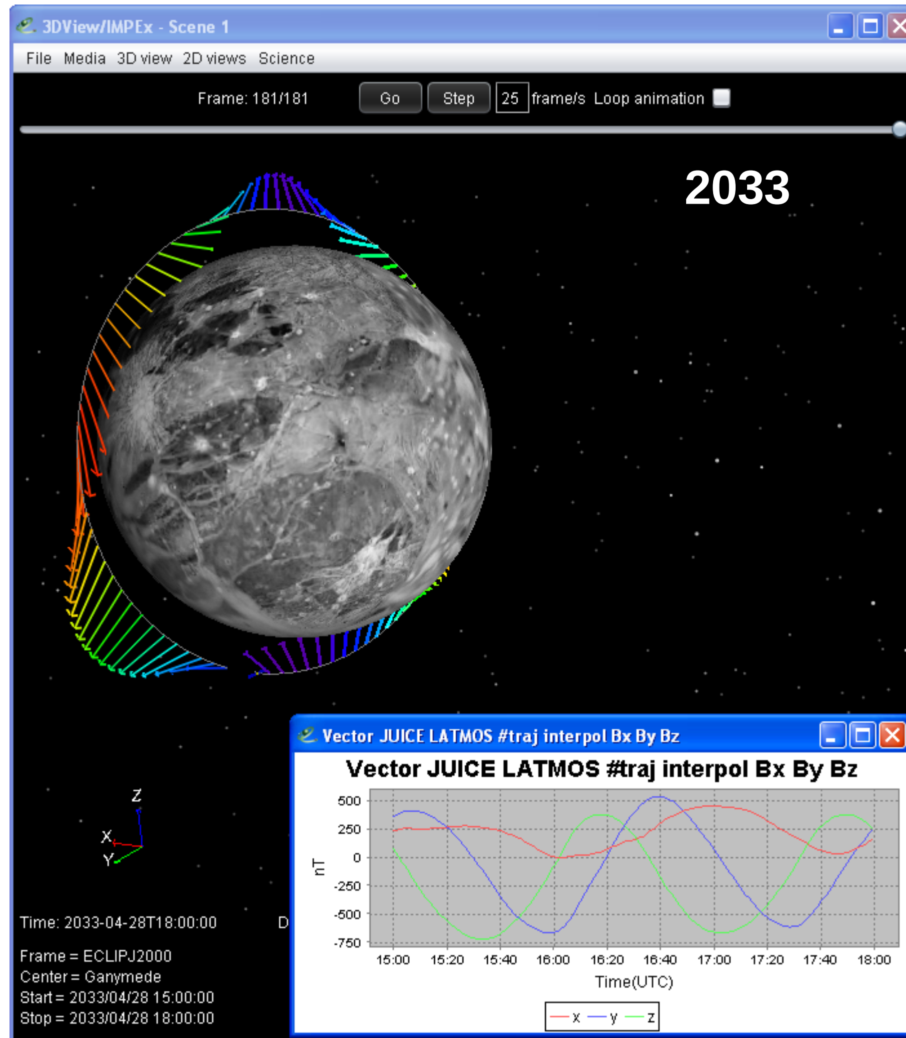
Courtesy ConnectSolo STORMS service http://storms-connectsolo.irap.omp.eu/

Preparing JUICE : simulation at Ganymede

Galileo – Ganymede flyby #2



JUICE – Ganymede orbit phase



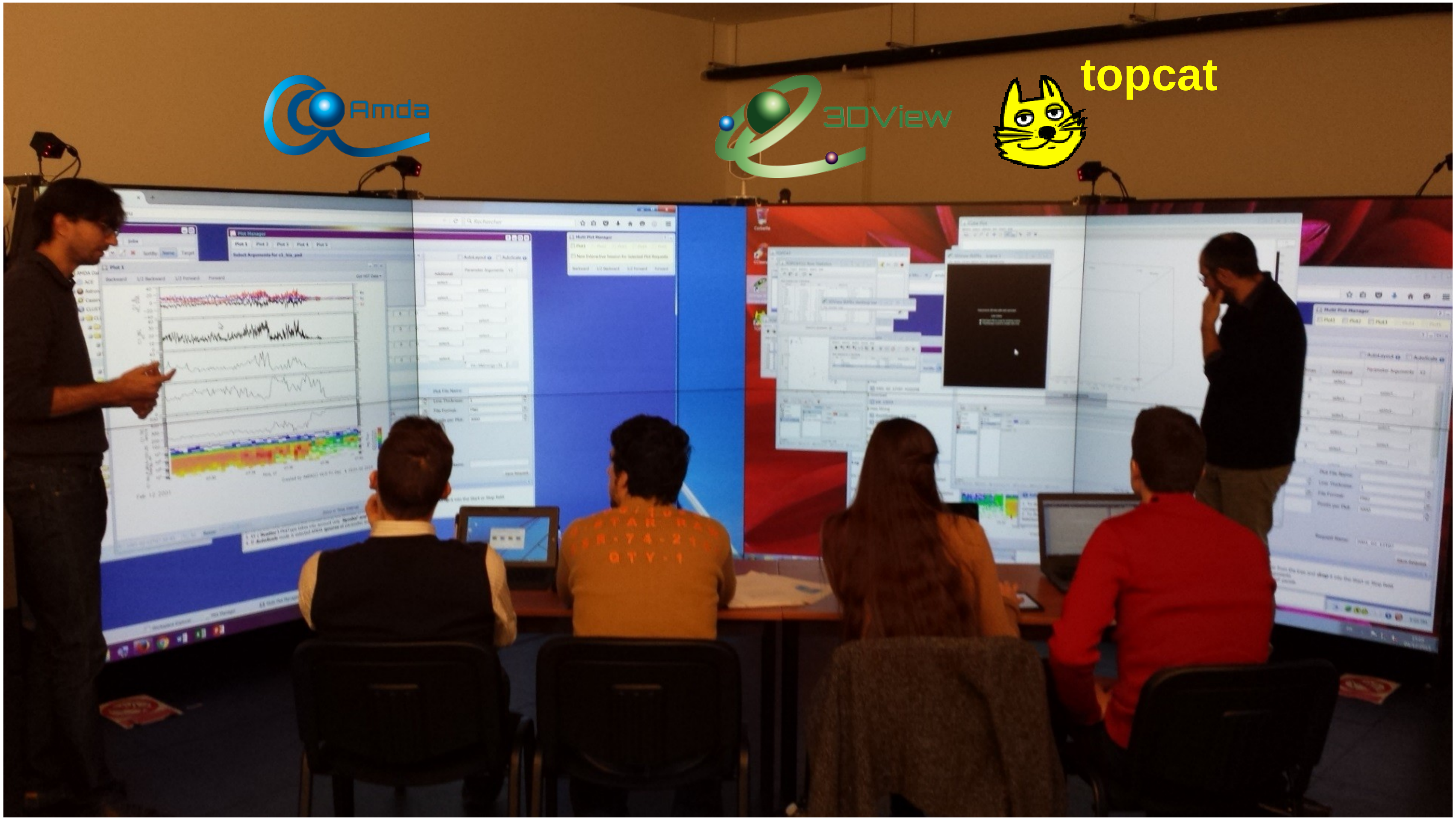
Magnetic field (in GPHIO)

Simulation : R. Modolo (LATMOS)

Hands-on sessions for students

Tools for education in space sciences

- At the Master level, in summer schools, …



Enabling science

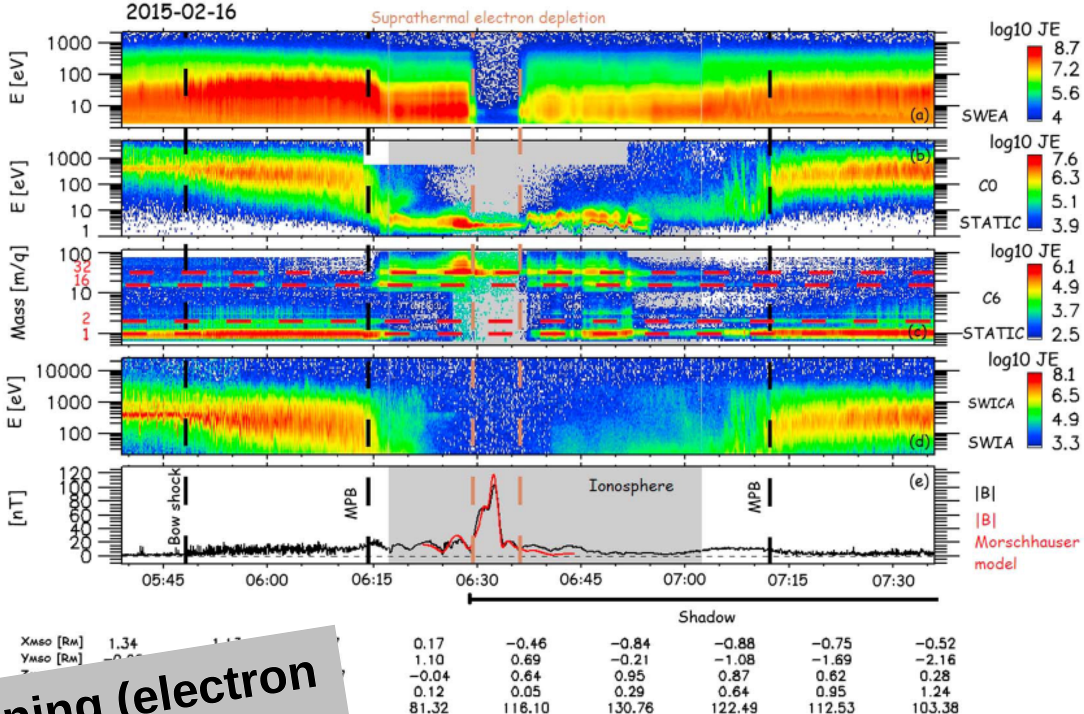
CDPP tools

- Are used by a wide community
  - About 500 AMDA sessions / month
- Are regularly reviewed by a user committee
- Help/facilitate publication
  - 5-10 papers / year
  - See following recent *science cases*

Use of the PDS/MAVEN data from AMDA

Altitude dependence of nightside Martian suprathermal electron depletions as revealed by MAVEN observations, *M. Steckiewicz et al., GRL, 2015*

- MAVEN observes on almost each periapsis in the nightside ionosphere suprathermal electron depletions
- Observed depletions are populated by 6 eV electrons resulting from absorption by CO_2 and by 3 eV O_2
- The geographical distribution of nightside suprathermal electron depleti…



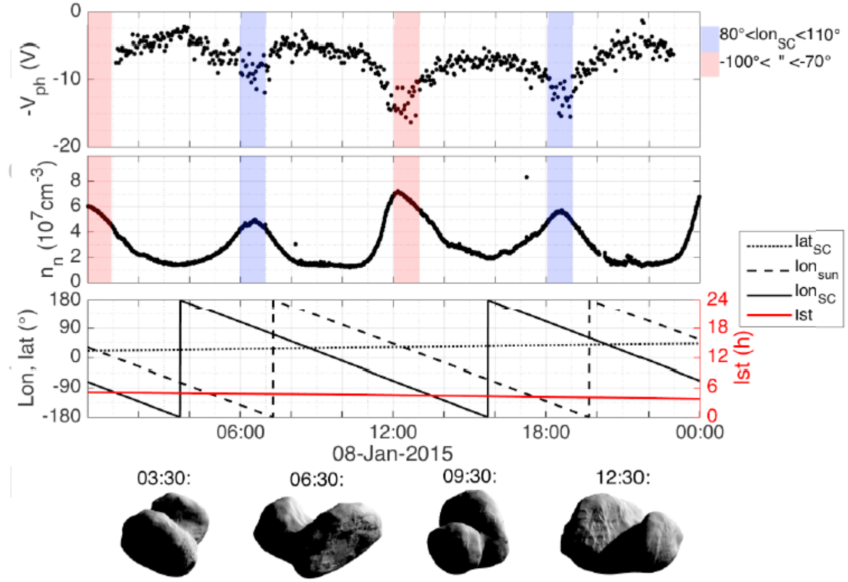
…in its plasma environment observed above a crustal magnetic field anomaly during …uary 2015. (a) SWEA energy-time spectrogram of omnidirectional electron energy flux, (b) STATIC energy-time spectrogram of omnidirectional ion energy flux (C0 mode), (c) STATIC mass-time spectrogram of omnidirectional ion energy flux (C6 mode), (d) SWIA energy-time spectrogram of omnidirectional ion energy flux (SWICA mode), and (e) magnetic field intensity (measured by MAG in black and calculated from the model of *Morschhauser et al.* [2014] in red) versus time. The grey shading highlights the ionosphere. The shadow corresponds to solar zenith angle (SZA) larger than 100°.

AMDA was used for data mining (electron depletion) and selection of events

Use of the col restricted Rosetta/RPC database in AMDA

Evolution of the plasma environment of comet 67P from spacecraft potential measurements by the Rosetta Langmuir probe instrument, *E. Odelstad et al.. GRL 2015*

$$\frac{n_{e2}}{n_{e1}} = \frac{I_{ph,2}}{I_{ph,1}} \exp\left\{-\frac{e\Delta V_{S/C}}{k_B T_e}\right\}$$



A study of the evolution of the plasma environment of comet 67P using measurements of the spacecraft potential (3.5 to 2.1 AU) obtained by the Langmuir probe (RPC-LAP) instrument.

→ a cometary plasma with a strong radial dependence and the highest densities (i.e the most negative spacecr... observed in the norther... hemisphere above the neck... comet nucleus

Figure 1. RPC-L... ...pper panel) and ROSINA-COPS neutral gas ... ...anuary 8, 2015, at 28 km from the nucleus. ... ...pacecraft and the longitude of the Sun, in ... ...ime (bottom panel). Blue and red colored ... ...imes when the longitude of the spacecraft was between 80° and 110° and -100° and -70°, respectively. Spacecraft perspectives of the partially illuminated nucleus are shown for four different times below the bottom panel.

AMDA was used to visualize data from several instruments while in the early phase of the mission

Use of Venus Express data in the solar wind from AMDA

Inertial range turbulence of fast and slow solar wind at 0.72 AU and solar minimum, *Teodorescu et al., ApJLet., 2015*

We investigate Venus Express observations of magnetic field fluctuations performed systematically in the solar wind at 0.72 Astronomical Units (AU), between 2007 and 2009, during the deep minimum of solar cycle 24. The power spectral densities (PSDs) of the magnetic field components have been grouped according to the type of wind, fast and slow.

AMDA was used to search and statistically analyse long times series by categories

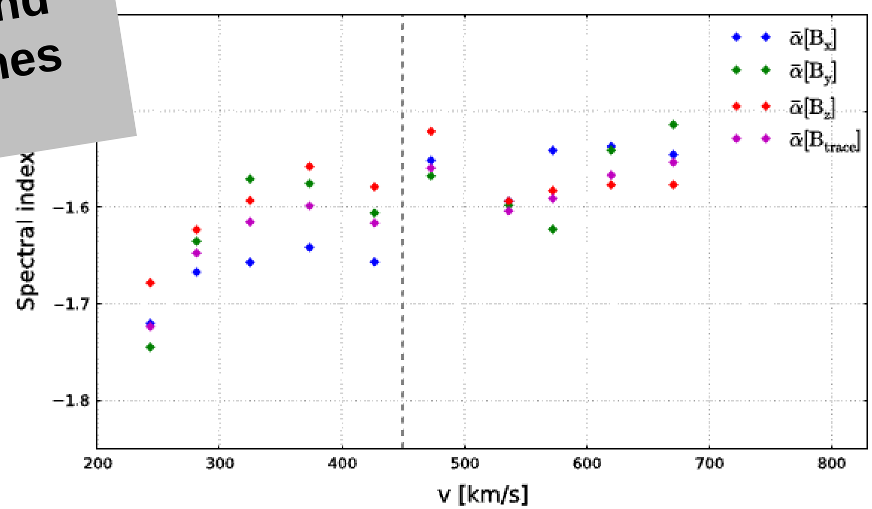
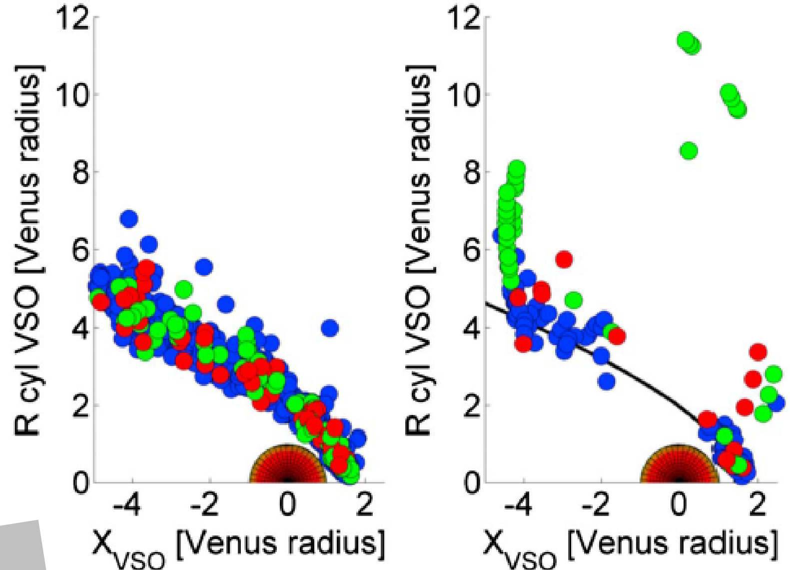


Figure 3. Spectral index as a function of solar wind speed; we show averages over velocity bins of 50 km s^{-1} width. Different colors ilustrate different magnetic field components. Data is collected in the solar wind by VEX between 2007 and 2009. The dotted vertical line represents the threshold we chose to select fast and slow solar wind.

Use of Venus Express multi-datasets from AMDA

Space weather effects on the bow shock, the magnetic barrier, and the ion composition boundary at Venus, *Vech et al., JGR, 2015*

- Statistical study of the ICME-Venus interaction
- Analysis of solar wind and magnetic barrier conditions during ICME passages
- Decreased altitude of the nightside ionosphere during ICME passages



Locations of the bow shock crossing for all the 42 investigated events. ... green marks show the bow shock crossings (including the multiple bow shock crossings as well) on the day when the ICME arrived at Venus, the red dots represent the bow shock location during the following day, and the rest of the days are marked with blue dots. (left) Thirty-six cases when the interaction between the magnetic cloud and the induced magnetosphere was not observed and (right) six cases when the signature of the passing magnetic cloud was detected.

AMDA was used to search extreme events in long time series (9 years)

More recent publications

- **Long-Term Tracking of Corotating Density Structures using Heliospheric Imaging**, Plotnikov et al., Solar Physics, 2016, in press

- **Deriving the properties of coronal pressure fronts in 3D: application to the 17 may 2012 ground level enhancement**, Rouillard et al., 2016 submitted

- **The very slow solar wind: Properties, origin and variability**, Sanchez-Diaz, E.; Rouillard, Alexis P.; Lavraud, Benoit; Segura, Kevin; Tao, Chihiro; Pinto, Rui; Sheeley, N. R.; Plotnikov, Illya, JGR: Space Physics, Volume 121, Issue 4, pp. 2830-2841, 2016

- **Statistical features of the global polarity reversal of the Venusian inducedmagnetosphere in response to the polarity change in interplanetary magnetic field**, Daniel Vech, Gabriella Stenberg, Hans Nilsson, Niklas J. T. Edberg, Andrea Opitz, Károly Szegő, Tielong Zhang and Yoshifumi Futaana, doi: 10.1002/2015JA021995, JGR 2016

- **STEREO database of interplanetary Langmuir electric waveforms**, C. Briand, P. Henri, V. Génot, N. Lormant, N. Dufourg, B. Cecconi, Q. N. Nguyen and K. Goetz, Journal of Geophysical Research - Space Physics, doi:10.1002/2015JA022036, 2016

- **First detection of a diamagnetic cavity at comet 67P/Churyumov-Gerasimenko**, C. Goetz, C. Koenders, I. Richter, K. Altwegg, J. Burch, C. Carr, E. Cupido, A. Eriksson, C. Güttler, P. Henri, P. Mokashi, Z. Nemeth, H. Nilsson, M. Rubin, H. Sierks, B. Tsurutani, C. Vallat, M. Volwerk, K.-H. Glassmeier, A&A, Volume 588, April 2016

- **Solar wind interaction with comet 67P: impacts of corotating interaction regions**, N.J.T. Edberg et al., J. Geophys. Res., 02/2016, DOI : 10.1002/2015JA022147

- **Mass-loading, pile-up, and mirror-mode waves at comet 67P/Churyumov-Gerasimenko**, M. Volwerk, I. Richter, B. Tsurutani, C. Götz, K. Altwegg, T. Broiles, J. Burch, C. Carr, E. Cupido, M. Delva, M. Dósa, N. J. T. Edberg, A. Eriksson, P. Henri, C. Koenders, J.-P. Lebreton, K. E. Mandt, H. Nilsson, A. Opitz, M. Rubin, K. Schwingenschuh, G. Stenberg Wieser, K. Szegö, C. Vallat, X. Vallieres, and K.-H. Glassmeier, Annales Geophysicae, doi:10.5194/angeo-34-1-2016